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of

W. L. MOORE

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INTRODUCTION

Objective and Scope of Investigation

The specific purpose of this study is to determine the character, thickness, and chronological sequence of all outcropping sedimentary rocks in Riley County. An effort will be made to summarize the lithologic and paleontologic data for each stratigraphic unit, formulate certain conclusions, and state some of the problems for further more intensive studies of the stratigraphy of the county.

This investigation covers only the rocks that crop out in Riley County, Kansas. The stratigraphic units involved are those of the Pennsylvanian and Permian systems of late Paleozoic age and a few feet of the Dakota sandstone of the Cretaceous system, of Mesozoic age. Three igneous intrusions crop out in this county, and the age of these plugs is believed to be late Cretaceous. Good sections of the formations in the upper Pennsylvanian and lower Permian systems are available for study (Table I).

The presentation of data is based on the chronologic sequence in which the formations of the several systems were deposited. The one who named each stratigraphic unit and designated its type locality will be given. This will be followed by a historical review of the more important earlier descriptions.

The areal distribution of each unit will be stated, and the unit will be described on the basis of its lithology and paleontology as observed in Riley County. Frequent reference will be
made to the measured sections appended to this report.

Location and Size of Area Investigated

Riley County, Kansas, has an area of approximately 560 square miles and is composed of about 16 townships. It lies in the second tier of counties south of Nebraska, and is the fifth county west of the Kansas-Missouri boundary (Fig. 1). Riley County is bordered on the north by Washington and Marshall Counties, on the west by Clay County, on the south by Geary County, and by Pottawatomie and Wabaunsee Counties on the east. Riley County is 36 miles long and is approximately 31 miles wide. The county is L-shaped, the base of the "L" being directed toward the east along the southern boundary. An area of about 50 square miles of Riley County was added to the Fort Riley Military Reservation during the past war. This area lies northwest from Ogden, Kansas.

The principal streams in Riley County are the Kansas and Blue Rivers. The Kansas River enters the county from the southwest, flows northeast to Manhattan, and then turns toward the east. The eastward-flowing part of the river forms the northern boundary of the southeastern extension of the county. The Blue River enters the county from the north and joins the Kansas River 1.5 miles east of Manhattan. The Blue River forms the eastern boundary of the county from the north county line to Manhattan. Other important streams in the county are Deep Creek, Wildcat Creek, Mill Creek, and Fancy Creek. Only Fancy Creek flows the full width of the county.
Fig. 1. Area covered by this thesis.
Investigation Procedure

Preliminary investigations were begun in the fall of 1947 and continued through the spring of 1948. Field work was resumed in the fall of 1948 and completed in the spring of 1949.

A thorough reconnaissance was made of the entire county. Formations were identified and sections were measured. A grid was drawn, on acetate, to the scale of 3 inches equals 1 mile. The grid was based on the 1 inch equals 1 mile Highway Transportation Map provided by the State Highway Commission of Kansas as amended by aerial photographs. Drainage was applied to the base map from the aerial photographs through the use of a sketchmaster. The base map was compiled in units of single townships for convenience in mapping.

The geologic formations, as identified in the field, were traced on the acetate base map from aerial photographs. Two successive formations, a limestone overlain by a shale, were consolidated as a map unit. Such consolidation was thought necessary because, on a map drawn to this scale, a single formation would occupy a band so narrow that its labeling and identification would be almost impossible. Much of the field mapping was done in collaboration with F. V. Peck of the Department of Geology, Kansas State College. Mr. Peck mapped the formations of post-Cretaceous age. The investigation was made possible by its acceptance as a project in the construction materials program of the United States Geological Survey and all data are the property of that organization.
Inasmuch as the geology of the area had been previously mapped by Jewett (1941, Plate I), much field time was saved by referring to this map. The map compiled as the basis of this report, Plate I, is much more detailed than that compiled by Jewett. The two maps differ, further, in that one compiled by Jewett is one of the areal-geology type whereas the map upon which this report is based is one of the surficial-geology type. An areal-geologic map, for the most part, shows only the outcrop areas of consolidated rocks.

Following the delineation of outcrop bands in the field, their contacts were traced on linen. The 16 township maps were combined in this step to the three panels into which Plate I is divided. The geologic cartography is that of Mrs. R. M. Scoetler and C. Powers, both of the United States Geological Survey. Each panel was then reduced photostatically to one-half its original scale and the symbols and color patterns were then added.

Previous Geologic Investigation in the Area

The earliest investigation in the rocks of this area was made by Weck and Hayden (1860). A short time later Swallow (1866) described some of the exposures of rocks in this region. Broadway (1924, pp. 491-493) described some of the rock units in this area and especially the section displayed in K-311 southeast of Manhattan. May (1926) worked the geology of the Fort Riley Military Reservation and vicinity and, during the same year, Adams (1926, pp. 124-126) published a geologic section from Manhattan to
Abilene. Tschernyschew (1902, pp. 302-303) studied a stratigraphic section extending from Manhattan to Fort Riley. The most extensive work in this area was accomplished by Jewett (1941) who mapped the area and described its geology. Three master theses were based on the structural geology of part of Riley County. These were submitted by McMillan (1947), Coombs (1949), and J. Holf (1949).

Other less significant investigations, too numerous to mention, contributed considerable information pertaining to the stratigraphy of this and adjacent areas.
Table I. Generalized Stratigraphic section of Riley County, Kansas
Table I (cont’d). Generalized Stratigraphic section of Riley County, Kansas
The Virgil series was named by Moore (1932, p. 879). It includes the strata between the unconformity that is the upper boundary of the Missouri series and the local unconformity at the base of the Permian system. The Virgil series is composed of the Douglas, Shawnee and Wabaunsee groups of which only a portion of the Wabaunsee group crops out in Riley County, Kans.

The Wabaunsee group was named by Prosser (1296, p. 699). Moore (1932, p. 200) later applied the name to the beds above the top of the Topeka limestone and below the unconformity at the base of the Towle shale, the basal formation in the Permian system.

A thickness of about 190 feet of rocks of the Wabaunsee group is (Table I) present in Riley County. The outcrop area is in the eastern part of the county and extends about 3 miles east and 3 miles south from Zeandale, Kans. The outcrops in this area are a part of an anticline over the buried Nemaha ridge. The Wabaunsee group is composed predominantly of thick shale interbedded with thin limestones.

Auburn Shale

Naming of the Formation. The Auburn shale (Table I) was named by Beede (1898, p. 30). The type locality is in the vicinity of Auburn in Shawnee County, Kans. Good exposures occur along
Takarusa Creek near the northeast corner of sec. 26, T. 13, R. 14 E., a short distance southeast of Auburn.

The Auburn shale was formerly designated as the top bed of the Lumpkey shale member of the Keauhouce formation. The Auburn shale was redefined by Condre (1927, p. 76) and that redefinition is followed here. The Auburn shale lies above the Takarusa limestone and below the Reading limestone.

**Areal Distribution.** Outcrops of the Auburn shale in Riley County are restricted to the eastern part (Plate I). It is the oldest stratigraphic unit cropping out in the county. The formation is well exposed along Deep Creek in the northwest portion of sec. 37, T. 10 N., R. 9 E. Another representative outcrop occurs in a ditch near the center of the NW 1/4 sec. 32, T. 10 N., R. 9 E.

**Description of the Formation.** Only the upper part of the Auburn shale is exposed in Riley County. It is clay shale, with some silt, and is noncalcareous in some zones, calcareous in others. This shale is gray to gray-green and weathers gray. Its structure ranges from laminated to blocky. There are some limonite and carbon stains on the bedding planes. A thin calcareous lens is present in the upper portion of an outcrop found in the center of the NW 1/4 sec. 32, T. 10 N., R. 9 E.

No fossils were found in this formation. The Auburn shale has no particularly distinguishing outcrop expression. The Auburn shale can best be identified by the presence of the Reading limestone immediately above it (for detailed description see measured sections 1 and 3).
Pedicles Changes in the formation. Only two sections were measured of the Auburn shale, both in its upper part. These are located near the center of the area sec. 32, T. 10 N., R. 9 E. (Measured section 1) and in the west half sec. 27, T. 10 N., R. 9 E. (Measured section 2). A pedicle change was noted even though the measured sections are within a mile of each other. The exposure in measured section 1 is the more calcareous of the two and contains a well-defined calcareous lens. The exposure in measured section 3 is clayer and noncalcareous.

Reading Limestone

Naming of the formation. The Reading limestone (Table 1) was named by Smith (1906, p. 180). The type locality is in the vicinity of Reading, Lyon County, Kans. A good exposure of this limestone is exhibited near the northwest corner of sec. 33, T. 17 N., R. 13 E. This location is one mile east and one mile north of Reading.

There has been much discussion as to the proper name for the limestone now called the Reading. At one time it was included in the Emporia limestone. The name "Reading blue limestone" was later given it by Smith (1906, p. 180). Peede (1929, p. 30) had applied the name Wakarussa to this limestone, but Condra (1929, p. 86) later redefined the Wakarussa as the next older limestone formation. This permitted the name assigned by Smith, minus the term "blue," to be reapplied to this unit. The Reading limestone is above the Auburn shale and below the Harveyville shale.
Areal Distribution. The Reading limestone crops out along Deep Creek near the northeast corner of sec. 27, T. 10 N., R. 9 E. (Plate 1). Other outcrops are present at the heads of tributaries draining into Deep Creek in the south part of sec. 32, T. 10 N., R. 9 E. and another exposure occurs above the Auburn shale in a ditch near the center of the NW1/4, sec. 32, T. 10 N., R. 9 E.

Description of the Formation. The Reading limestone is hard, dense, gray and weathers grey. It is a single massive ledge in fresh exposures but weathers to irregularly shaped blocks distributed into three or four distinct zones. Limonite stains and specks are very abundant throughout the rock. The fossils observed in this limestone are: crinoid columnals, trilobite fragments, oocystoid spines, Chonetes setifera, Parkia crassica, Hembopora sp., some algae nodules, Parmeropion sp., fusulinids, Memphilla striatocostata, Hoxophylum pseudovenosum, Rocaepirus sp., and Turikella sp. The average thickness of this limestone is about 2 feet.

The Reading limestone is easily recognized in the field by its characteristic weathering and by its stratigraphic position below the Elmont limestone (For detailed descriptions see measured sections 1 and 3).

Facies Changes in the Formation. No facies changes were noted in the Reading limestone within the limited area of its outcrop in Riley County.
Norwayville Shale

Naming of the Formation. The Norwayville shale (Plate I) was named by Moore (1935). The type locality is near Norwayville, Sedgwick County, Kans. A representative section can be seen in sec. 25, T. 15 S., R. 13 W., Osage County, Kans.

The Norwayville shale was included in the Emporia limestone as defined by Kirk and others (1938, p. 90) and Adams (1938, p. 62) placed it in the Olpe shale. Goodwin and Ferguson (1925, p. 16) placed the Norwayville in the Preston limestone and referred it as part of the Menaba formation. The Norwayville shale overlies the Reading limestone and underlies the Elmont limestone.

Areal Distribution. The upper part of the Norwayville shale can usually be seen wherever the Elmont limestone is exposed (Plate I). A full section of this shale crops out beneath the Elmont limestone near the northwest corner of sec. 30, T. 13 S., R. 14 W.

Description of the Formation. The Norwayville is a clayey and slightly calcareous shale. It is gray-green and weathers light gray-green. The structure of the shale varies from thin-bedded to blocky. Occasional limonite stains occur along the bedding planes and calcareous nodules may be present in the upper portion of the formation. The shale is non-fissile in character. The average thickness of the Norwayville is about 15.5 feet.

Lacking distinctive features, the Norwayville shale can be distinguished from other shales in the Pennsylvanian system only by its association with the Elmont or Reading limestone (for
detailed descriptions see (ordered sections 1, 2, and 3).

**Facies Changes in the Formation.** Two sections were measured of the Surveyville shale. The only noticeable facies change is a slight reduction in thickness toward the southeast. Other features of this shale remain constant.

**Elmont Limestone**

**Naming of the Formation.** The Elmont limestone (Table I) was named by Seede (1907, p. 50). The type locality is in the city of Elmont in the northern part of Clay County, Kans.

The Elmont limestone was included in the Morses limestone by Kirk (1894, p. 80) but Adams (1903) placed it in the Olpa shale. This limestone was referred as the Preston limestone by Condra and Bengston (1915, p. 16). The Elmont limestone overlies the Surveyville shale and underlies the Willard shale.

**Areaal Distribution.** The Elmont limestone crops out in numerous places in the southeastern part of Riley County (Plate I). The most southwestern exposure may be seen in a stream bank in the NE ½ NW ¼ sec. 2, T. 11 S., R. 9 E. At this location, the Elmont limestone creates a small waterfall. Another good exposure occurs in a road cut in the NW ½ NW ¼ sec. 27, T. 10 S., R. 9 E.

Other exposures of this limestone were observed in the center of the NE ¼ sec. 32, T. 10 S., R. 9 E, and on the east side of Deep Creek near the terrace level in sec. 27, 29, and 32, T. 10 S., R. 9 E.

**Description of the Formation.** The Elmont limestone is hard,
dense, blue-gray to gray and weather gray to tan-gray. The un-
weathered rock is massive but weathers to large rectangular blocks. 
A good fracture pattern displayed in this limestone can be observed 
in the NE 1/4 sec. 6, T. 7 N., R. 12 W. and is evident wherever 
the limestone crops out in this county. A thin but persistent lime-
nite zone occurs at the very top of the Pluma limestone and iron 
stains are sometimes present on the fracture planes. The fossils 
present are: worm burrows (?) in the top part, Marginites sp., 
crinoid columnals, Ambeocelis sp., Composita sp., echinoid spines, 
Neospirifer sp., Euliticerion sp., and brachiopod fragments. 
Large and small fusulinids are prominent in this formation. The 
average thickness of this limestone is about 2 feet.

The distinctive characteristics of the Pluma limestone are 
its massiveness, blue-gray color, fracture pattern and its strati-
graphic position beneath the readily recognized Turbid limestone 
(For detailed descriptions see measured sections 1, 2, and 3).

**Facies Changes in the Formation.** There is a slight thickening 
of the Pluma limestone toward the southwest. The thickening 
amounts to only .4 foot but is the only change observed in this 
limestone.

**Willard Shale**

**Naming of the Formation.** The Willard shale (Table I) was 
named by Peade (1909, p. 31). The type locality is in the vicinity 
of the city of Willard, Shawnee County, Kansas.

Adams (1903, p. 52) included this shale as a member of the
Olpe scale. Swartz and Moeott (see p. 111) erroneously placed the Willard shale below the Jasper limestone, thus putting the shale now called the Willard in the Olpe scale. Condra (1927, p. 69) placed the Willard shale beneath the Turkio limestone and above the Burlington limestone. Roark (1935, p. 22) designated this formation as overlying the Devon limestone and underlining the Turkio limestone.

Areal Distribution. The upper part of the Willard shale is usually exposed beneath each outcrop of the Turkio limestone (Plate 1). Most of the exposures of this shale are restricted to the east side of Deep Creek. An outcrop of the full thickness of the formation occurs in a stream bank in the W2, NE4, sec. 3, T. 7, R. 11 W. 9. There is another full outcrop exposure in a road cut in the W4, NE4, sec. E7, T. 10 S., R. 10 W. A partial section of this formation was observed in NE1, NE4, sec. 32, T. 10 S., R. 9 W.

Description of the Formation. The Willard shale is clays, with some silt and is usually calcareous. It is blue-gray to tan-gray and usually weathers tan. The shale is thin-bedded at the top but becomes blocky toward the base. Limestone streaks are present on some of the bedding and fracture planes. There were no fossils observed in the Willard shale. The average thickness of this shale is about 20 feet.

The Willard shale can be identified in the field by its position beneath the easily recognized Turkio limestone (or detailed descriptions see measured sections 2 and 3).

Facies Changes in the Formation. Only a minor amount of thinning was noted in the most southwestern outcrops. The most
important change observed is the change from calcareous shale in southwestern outcrops to noncalcareous shale in the eastern outcrop.

Turkio Limestone

**Naming of the Formation.** The Turkio limestone was named by Calvin (1900, p. 327) and later by Condra and Penranton (1915, p. 8). The new type locality is now designated by Moore (1937, p. 229) is along Mill Creek southwest of Maple Hill, Calhoun County, Iowa. The old type locality is located along Turkio Creek north of Coin, Iowa.

The name "Chocolate limestone" was applied to this limestone by Murrow (1906, p. 27). Calvin (1900, p. 327) designated the Turkio limestone from exposures in Turkio Creek, north of Coin, Page County, Iowa. Newburgh and Bennett (1903, p. 114) placed the Turkio limestone in the "adams shale. Condra and Penranton (1915, p. 8) designated the Turkio limestone as the topmost member in the "Nemaha limestone".

The Turkio limestone, as now defined, overlies the Hillard shale and underlies the Nemaha shale.

**Areal Distribution.** The Turkio limestone forms a very prominent bench in the eastern portion of Alley County (Plate 1). This limestone crops out extensively on both sides of Deep Creek. The extreme southern exposure can be seen in a stream bank in the NW sec. 5, T. 11 N., R. 9 E. Good exposures of this limestone are exhibited in the SE, NE, SE; sec. 27, T. 10 N., R. 9 E.; west
of Deep Creek in the NW\1 NE\3 SW\1 sec. 20, T. 10 S., R. 9 E.; at Pillsbury Crossing in NE\1 SW\3 sec. 5, T. 11 S., R. 9 E.; in a stream cut in NE\1 SW\2 sec. 3, T. 11 S., R. 9 E.; and other exposures of the formation can be seen south of Zeandale and east of Deep Creek. Benches formed by this limestone can be found on most tributaries entering along the eastern edge of the county.

**Description of the Formation.** The Tarkio limestone is composed of two thick limestones usually separated by a thin bed of shale. Both limestones are hard, dense, gray-orange to gray-brown and weather brown to gray-brown. The limestone layers are massive and weather to large blocks which, upon further weathering, tend to break into irregular pieces. The shale parting, when present, is silty, slightly arenaceous and calcareous. The shale bed is olive-drab and weather tan. The shale is thin-bedded and contains limonite stains and calcareous nodules.

Large fusulinids are very abundant in this formation. Crinoid columnals are distributed throughout the two limestones and other fossils present are *Axophyllum rude*, *Lophophyllum proliferum*, echinoid spines, *Composita sp.*, and a few algal nodules. The average thickness of the limestone is about 12 feet.

The Tarkio limestone forms the only really prominent bench among the Pennsylvanian limestones cropping out in this county. The lower limestone bed forms a conspicuous bench on many hill-sides but the upper limestone erodes farther back and is usually concealed beneath colluvium and soil. The peculiarity of erosion creates the impression that only one limestone is present in the Tarkio. Large blocks of the lower Tarkio limestone often slump
over the face of the hillside.

The Tarkio limestone is easily recognized by its thickness, abundance of large fossils, and a coarsely-brown color (for detailed descriptions see unnumbered sections 2 and 3).

**Tarkio Limestone in the Area.** The thickness of the Tarkio limestone at Fillmore Crossing in the N1/2 NW1/4 sec. 5, T. 12 N., R. 9 E., is 14.3 feet. Another exposure of this limestone, with the same parting absent, occurs in a road cut in the NW1/4 SW1/4 sec. 27, T. 10 N., R. 9 E. and is 11.2 feet thick. The thickening of the Tarkio limestone toward the southwest is about 3 feet.

**Vanego Shale**

**Name of the Formation.** The Vanego shale (Table I) was named by Condra and Head (1943, p. 43). The type locality is the bluffs north of U. S. Highway No. 40, 4 miles west of Vanego, Pottawatomie County, Kansas.

Lawson and Bennett (1907, p. 114) included shale now known as Vanego in the Adair shale. This shale was named the Pierson Point by Condra (1923, pp. 74, 80), and was part of the McKissick Grove shale. Condra, Moore, and Dumber (1932, p. 19) assigned the Pierson Point shale as part of the McKissick shale. This classification and nomenclature was never accepted by Moore (1933, p. 202). The use of the name, Vanego shale, in place of Pierson Point shale, was introduced by Condra and Head (1943, p. 42). This nomenclature has generally been accepted in this region.
Areal Distribution. The Members of the Lelandy (Plate 1). Usually, wherever the Turbidite Limestone is present, a part or all of the Lelandy shale can be seen. Good exposures of the Lelandy shale can be observed in a road cut in NE U. N., sec. 27, T. 10 N., R. 9 E.; in a ditch in the NE U. N., sec. 26, T. 10 N., R. 9 E.; and in a road cut in NW U. S., sec. 4, T. 11 N., R. 9 E.

Description of the Formation. The Lelandy shale is close to silty and is a noncalcareous in the northeastern outcrop area but is calcareous elsewhere in the county. It is tan-gray to blue-gray and weathered tan to tan-gray. Its structure ranges from thin-bedded to blocky with numerous limonite-stained zones and plates present in this shale. Carbon stals were observed on some of the bedding planes. No fossils were found in this formation. The average thickness of this formation is about 15 feet.

The Lelandy shale can be recognized most readily by limonite plates on the weathered surface and by the presence of the Turbidite limestone beneath it (see detailed description see measured sections 2 and 3).

Trends Changes in the Formation. Only minor thickening of the Lelandy shale toward the northeast was observed in Will County. The shale also changes from calcareaous to noncalcareous toward the northeast.
Maple Hill Limestone

Nature of the Formation. The Maple Hill limestone (Table I) was named by Cochrane (1907, p. 93). The type exposure is along Mill Creek southeast of Maple Hill, Washington County, Kansas.

The limestone, now known as the Maple Hill, was included in the Emporia limestone by Moore (1933, p. 38) and in the Cherokee shale by Lemont and Ferrandt (1901, p. 174). Cochrane (1907, pp. 74, 93) named this limestone the Maple Hill and referred it to the McJeeick Grove shale. Cochrane, Moore and Gunter (1932, p. 16) again placed this limestone as part of the McJeeick shale although this classification later was rejected by Moore (1933, p. 233).

Areal Distribution. The Maple Hill limestone does not form a prominent bench and its outcrops, therefore, are relatively inconspicuous (Plate I). It is present above the Turic limestone south of Kansas but is generally concealed beneath the unconsolidated mantle. Good exposures of the Maple Hill limestone were noted in a road cut in the 32 N, 3 E, sec. 39, T. 10 N., R. 2 E., in a tributary of Mill Creek in the 50 N, 4 E., sec. 39, T. 10 N., R. 2 E.; and in a stream bank in the 33 1/2 sec. 3, T. 11 N., R. 9 E.

Description of the Limestone. The Maple Hill limestone is gray to gray-brown and weather tan. It is hard, massive, and the upper part weathers into irregular plates. This limestone shows a tendency to fracture at an angle of nearly 30 degrees from the vertical plane. Limonite stains are common on weathered surfaces.
Small and large fusulinids are abundant in the Maple Hill. Cri-noid columnals, Ambocoelia sp., crinoid spines, and brachiopod fragments were also observed in the Maple Hill. The thickness of this limestone is about 1 foot.

Although this formation forms only a small and usually indistinct bench, it is easily recognized in the field by its thickness, massiveness, abundance of fusulinids and light-gray color (For detailed descriptions see measured sections 3, 4, and 5).

Facies Changes in the Formation. The only change in the Maple Hill limestone, and it is a minor one, is a thickening facies toward the southwest.

Langdon Shale

Naming of the Formation. The Langdon shale (Table I) was named by Condra and Reed (1943, pp. 42-44). The type locality is along the bluffs of the Missouri River Valley southeast of Langdon, Mo., or northwest of Craig, Mo.

The shale was identified as the Langdon, was included as a part of the Emporia limestone by Adams (1903, p. 52). Inworth and Bennett (1908, p. 114) included it in the Admire shale and Condra (1927, pp. 74, 81) named this shale Langdon and referred it to the Colissick Grove shale. Condra, Moore, and Dunbar (1932, p. 18) retained the Table Creek shale as a member of the Colissick shale although Moore did not accept this classification. Condra and Reed (1943, pp. 43, 44) changed the name from Table Creek to Langdon shale which classification is generally accepted.
Areal Distribution. The Langdon shale can be observed along tributaries east of Deep Creek (Plate I). A good section of this shale is exhibited in a stream bank in the NE NE NW sec. 32, T. 10 N., R. 9 E. Another section typical of this shale can be observed in a road cut in the NW NE sec. 27, T. 10 N., R. 8 E.

Description of the formation. The Langdon shale is composed of clay and silt, and is usually noncalcareous but becomes calcareous in the southwestern part of the outcrop area. The color ranges from blue-gray to gray-green and the shale generally weathers to gray-green or tan-gray. The structure varies from blocky to thin-bedded. Limestone stains and plates are present in most of the exposures. No fossils were observed in the Langdon shale in Riley County. The average thickness of this limestone is about 11 feet.

The Langdon shale can best be identified in the field by its stratigraphic position beneath the easily recognized Dover limestone and above the Maple Hill limestone (For detailed descriptions see measured sections 3, 4, 5, and 6).

Facies Changes in the Formation. The Langdon shale thins from 13.6 feet in its eastern outcrops to 6.5 feet toward the west. As its thickness decreases, the shale changes from noncalcareous to calcareous.

Dover Limestone

Naming of the Formation. The Dover limestone (Table I) was named by Beede (1901, p. 31). The type locality is in the vi-
cinity of Dover, Pawnee County, Neb.

Adams (1903, p. 32) included the limestone now known as the Dover as part of the Kemptin limestone and Penworth and Bennett (1908, p. 114) placed it in the Adair shale. Condra (1927, pp. 74, 80) referred the Dover limestone as part of the Mcissick Grove shale. Condra, Moore, and Dunbar (1932, p. 10) placed the Dover in the Mcissick shale. This classification later was rejected by Moore (1932, p. 235) who reassigned the original name, Dover limestone.

Areal Distribution. The Dover limestone forms a small hillside bench east of Deep Creek (Plate I). It forms numerous knolls in that area and crops out near the heads of most tributaries flowing into Deep Creek from the west. Small knolls and hillside benches formed by this limestone occur south of Pillsbury Crossing.

Description of the Formation. The Dover limestone is usually soft and argillaceous in the upper and lower parts but is quite hard and dense in the middle part. This limestone is green to gray and weathers to light gray but locally there is a brown layer in the middle part. The limestone is massive in fresh cuts but becomes blocky to nodular when weathered. Weathered surfaces are usually covered with small plates and nodules, and iron stains may be present on joint planes. Large fusulinids are the most conspicuous fossils in the formation. They are very abundant and are scattered throughout the limestone. Small fusulinids are also present and algae are quite abundant. Other fossils noted in the Dover are Aviculopecten occidentalis, Iocella striatocostata,
Neospiriferas sp., Rhabdopora sp., crinoid columnals, echinoid spines, Dictyoclostus portlockianus, Ambocoea sp., Jureanias nebrascensis, Conetes crumalifera and Derbyia erassa. The average thickness of the Dover limestone is about 2.3 feet.

The Dover limestone is easily recognized by the abundance of large fusulinids and by the unusual number of algal nodules. The light gray color of the Dover limestone readily distinguishes it from the brown Parkia limestone (for detailed descriptions see measured sections 3, 4, 5, and 6).

Facies Changes in the Formation. The thickness of the Dover limestone varies little over the county. Brown zones are developed locally in this limestone. Fusulinids are not as abundant toward the south as they are in the northern exposures of the formation.

Dry Shale

Naming of the Formation. The Dry shale (Table I) was named by Moore (1935, pp. 22, 23c). The type locality is along Dry Creek, southwest of Emporia, Kans., in sec. 5, T. 20 S., R. 11 E.

The bed now known as the Dry shale was included in the Emporia limestone by Adams (1903, p. 52). Haworth and Bennett (1908, p. 114) referred this unit to the Adair shale and Moore (1935, p. 236) defined it as the shale underlying the Grandview limestone and overlying the Dover limestone.

Areal Distribution. The Dry shale crops out in the southeastern part of Riley County only (Plate I). Exposures of the formation are not numerous but the following are considered to be
representative: a road cut in the NW sec. 5, T. 11 N., R. 9 E.; a stream bank in the NE NE sec. 11, T. 15 N., R. 9 E.; and a stream bank in the NE NE sec. 27, T. 10 N., R. 9 E.

Description of the formation. The Dry shale is silty and calcareous in the lower part and clays and noncalcareous in the upper part. It is gray-green to a yellow-gray in fresh exposures and weathers tan to yellow in the lower part and gray in the upper part. This shale is thin-beded and there are a few calcareous nodules and limonite stains present on bedding planes. The Dry shale is nonfossiliferous in Riley County. The average thickness of this shale is about 11 feet.

The Dry shale can be recognized by its position above the easily identified lower limestone and by its yellow color when weathered (for detailed descriptions see measured sections 4, 5, 6, and 9).

Facies Changes in the Formation. No facies changes were observed in the Dry shale in this county.

Grand Haven Limestone

Naming of the formation. The Grand Haven limestone (Table I) was named by Gore (1935, p. 237). The type locality is in sec. 31, T. 13 N., R. 14 E. near Grand Haven, Nemaha County, Kans.

The limestone, now called the Grand Haven, was included as part of the Emporia limestone by Adams (1903, p. 22). Raworth and Bennett (1904, p. 114) referred this limestone as part of the Adair shale. Moore defined the Grand Haven as the limestone
occurring above the Dry shale and below the Riedrich shale.

Areal Distribution. The Grand Haven limestone caps most of the hill east, west, and south of Deep Creek (Plate 1). This limestone was studied in the following places: a stream bank in the SW ¼ sec. 23, T. 10 N., R. 9 E.; a stream bank in the NE ¼ sec. 29, T. 10 N., R. 9 E.; a road cut in the SE ¼ sec. 6, T. 11 N., R. 9 E.; a stream bank in the NE ¼ sec. 31, T. 11 N., R. 9 E.; and in a road cut in the NW ¼ sec. 30, T. 10 N., R. 9 E.

Description of the Formation. The Grand Haven limestone generally consists of two limestones separated by a shale. The limestones are hard, dense, and somewhat argillaceous. They are brown to gray and weather light brown to light gray. Both of the limestones are massive and usually weather to irregular blocks or small plates. The intervening shale bed is usually clayey, calcareous, and gray-green. Fossils observed in the Grand Haven are crinoid columnals, _Brytia_ sp., _Chinonculus_ sp., scall and large fusulimides and _Goniatites granulifera_. The average thickness of the Grand Haven limestone is about 2 feet.

The Grand Haven can easily be recognized in the field by its thickness, color, and stratigraphic position above the readily identified lower limestone (for detailed description, see measured sections 5, 6, 7, and 8).

Facies Changes in the Formation. As the measured sections show, at least two atypical sections of the Grand Haven occur in Riley County. These exposures are located in a stream bank in the NE ¼ sec. 4, T. 11 N., R. 9 E., and in a road cut in the NE ¼ sec.
sec. 6, T. 11 S., R. 9 E. The upper beds included in the Dry
shale are thought to be a transitional stage of the Grand Island
limestone. This conclusion is supported by:

1. The absence of the lower bed of the Grand Island limestone.
2. The presence of typical Grand Island fossils in this shale
zone.
3. The thickness of the shale zone compared with that of
the lower Grand Island limestone.
4. The extremely calcareous nature of the shale zone and the
presence of thin limestone lenses in it.

Friedrich Shale

Naming of the Formation. The Friedrich shale (Table I) was
named by Moore (1936, p. 232). The type locality is along Fried-
rich Creek in sec. 6, T. 11 S., R. 11 E., Greenwood County, Kans.

The shale, here designated as the Friedrich, was included
in the Adair shale by Adams (1903, p. 52). Condra (1927, p. 14,
81) recognized these beds between the Dover and Brownsville limestones
as the Pony Creek shale, and referred it to the McKissick Grove
shale. Condra, Moore, and Gunbar (1932, p. 10) included this
shale as part of the McKissick shale. During the same year, Moore
and Condra (1932) placed the Friedrich shale in the Trench shale.
Moore (1936) assigned the name, Friedrich shale, to the shale
between the Grand Island and Jim Creek limestones which is the pre-
sently accepted practice.

Areal Distribution. The Friedrich shale is represented in
Mile County by erosional remnants, which are only 2 or 3 feet thick and lie on top of the Grand Haven limestone (Plate I). A full section of this shale was observed in a stream bank in the NW ¼ sec. 4, T. 11 N., R. 9 W. and the upper part of the formation was found cropping out in a stream bank in NE ¼ NW ¼ sec. 30, T. 10 N., R. 9 W.

Description of the Formation. The Friedrich shale is clayey and varies from calcareous to noncalcareous. It is gray-green to gray and weathers tan to tan-gray. The upper half of the shale has a very yellow appearance on the weathered surface. The structure of the shale is thin-bedded to blocky. Calcareous nodules and limonite stains occur locally in the formation. No fossils were found in the Friedrich shale exposed in Miley County. The average thickness of this shale is about 12 feet.

The Friedrich shale can best be identified by its stratigraphic position beneath the persistent Jim Creek limestone and overlying the Grand Haven limestone (for detailed descriptions see measured sections 6, 7, and 8).

Facies Changes in the Formation. The Friedrich shale is calcareous in the western part of its outcrop area, but becomes non-calcareous on the eastern part.

Jim Creek Limestone

 Naming of the Formation. The Jim Creek limestone (Table I) was named by Moore (1938). The type locality is on Jim Creek in sec. 23, T. 7 N., R. 11 E., Pottawatomie County, Kansas.
The limestone here designated as the Jim Creek was first listed as part of the Adirondack shale by Ames (1903, p. 72). Candrea (1921, pp. 74, 76) placed this limestone in the Pony Creek shale and referred it as part of the Wallisville Grove shale. Candrea, Moore, and Humber, in 1932, referred the layer to the Wallisville shale. Moore and Candrea, later in 1932, stated that the name Jim Creek was erroneously applied to a limestone member in the Canoeville limestone, therefore, they listed the Jim Creek limestone as a member in the Rench shale. Moore, in 1934, raised the Jim Creek limestone to the rank of a formation. This definition of the Jim Creek is now generally accepted.

Areal Distribution. The Jim Creek limestone was observed in two exposures in the county. (Plate I). The first outcrop is exhibited in a stream bank in 31A, sec. 4, T. 11 N., R. 9 E.

Description of the formation. The Jim Creek limestone is hard and dense. Its color is gray with a purplish tint and it weathers gray. A brown limonite zone develops at the top. The unweathered limestone is massive but it weathered into blocks which further decompose to small chips. Fossils noted in the Jim Creek limestone are: Chonetes granulifera, crinoid columns, Echinopora sp., Dictyonectes mackieanus, Aviculopecten percuta, Composita sp., and fusulinids. The average thickness of the formation is about 1.1 feet.

This limestone can readily be identified by its thickness, massiveness, purplish tint, and variety of fossils. For detailed description see assured section 8.

Facies Changes in the formation. No noteworthy facies changes
were observed in the Jim Creek limestone in Riley County.

**French Creek Shale**

**Remina of the Formation.** The French Creek shale (Table I) was named by Moore (1931). The type locality is along French Creek, which is located in northeastern Pottawatomie County, Kansas.

The shale, now called the French Creek shale, was included as part of the Admire shale by Adams (1928, p. 72). Condra (1930, pp. 74, 81) redefined the beds between the Dover and Brownville limestone as the Pony Creek shale, and listed it as part of the McKissick Grove shale. Condra, Moore, and Munson (1932) placed the shale, here called the French Creek, in the McKissick shale.

Later in the same year, Moore and Condra (1932) designated this shale as the upper part of the French shale. Moore (1933) named this unit the French Creek shale. The French Creek shale overlies the Jim Creek limestone and underlies the Brownsville limestone.

**Areal Distribution.** Only two partial exposures of the French Creek shale were observed in Riley County (Plate I). One exposure of this shale was observed in the bank of a small stream in the NW\(\frac{1}{4}\) sec. 31, T. 10 S., R. 9 E. The other exposure is exhibited in a stream bank in the SW\(\frac{1}{4}\) sec. 4, T. 11 S., R. 9 E.

**Description of the Formation.** The French Creek shale is composed of noncalcareous, slightly argillaceous clay. This shale is gray to tan-gray and weather tan to yellow. The structure of the unit varies from thin-bedded to blocky. Limonite stains are
abundant on the bedding and fracture planes and limonite nodules and plates are present on the weathered surface. Carbon stains are locally present in a part of the French Creek and an 0.4 foot impure coal lens occurs near the top. The coal bed has been called the Lorton coal and is overlain by a very calcareous, fossiliferous shale. *Dendrionites* predominates in this calcareous zone. The average thickness of the exposed part of the French Creek shale is about 20 feet. This unit, in its full thickness, was not found in Riley County.

This shale can be identified by the persistent coal bed in the top and its stratigraphic position above the easily recognized Jim Creek limestone (For detailed descriptions see measured sections 8 and 9).

**Racies Changes in the Formation.** Because of limited outcrops, no significant racies changes were noted in the French Creek shale in the area investigated.

**Caneville Limestone**

**Naming of the Formation.** The Caneville limestone (Table I) was named by Moore (1935). The type locality is sec. 11, T. 32 S., R. 9 W. It was named from the Caneville Township, Chautauqua County, Kans.

The limestone, here designated as the Caneville limestone, was included in the Admire shale by Adams (1908, p. 2). Bowen (1910, p. 138) gave the name of Grayhorse limestone to the upper member of the Caneville limestone. Beds of limestone and shale,
now known as part of the Caneyville limestone, were placed in the McKissick Grove shale by Condra (1927, pp. 74, 21). A limestone layer, the Nebraska City, was classified by Condra (1927, p. 116) as a subdivision of the Pony Creek shale and was later reclassified by Moore (1935) as the lower member of the Caneyville limestone. Condra, Moore and Dunbar (1932) listed the Caneyville limestone as part of the McKissick shale. Moore (1935) then named the beds from the base of the Nebraska City limestone to the top of the Grayhorse limestone of the Caneyville limestone, which definition is now followed. The Caneyville limestone overlies the French Creek shale and underlies the Pony Creek shale.

Areal Distribution. The Caneyville limestone occurs only in the western and southwestern part of the Pennsylvanian outcrop area of Riley County (Plate I). A full exposure of the limestone can be observed in a stream bank in the NW 1/4 NE 1/4 sec. 31, T. 10 S., R. 9 E. and a part of this limestone is exposed in a stream bank in the SE 1/4 NE 1/4 sec. 6, T. 11 S., R. 9 E.

Description of the Formation. The Caneyville limestone, as observed in Riley County, Kans., is composed of a limestone underlain by a shale.

The shale is clayey, calcareous, thin-bedded, gray and weathers tan-gray. There is an 0.5 foot calcareous zone near the middle of the unit and a thin carbonaceous zone, which contains wood fragments at the top. Limonite stains are abundant on many of the bedding planes. Limonite nodules and concretions covered with fine flakes of mica appear on weathered surfaces.

The limestone, overlying the shale, is hard, tan to brown,
and weathers tan-gray. It is massive and weathers loosely. lime-
nite nodules and stains are abundant and a few clay balls are
present. Fossil fragments are also abundant. The average thick-
ness of the Caneyville limestone in Riley County is about 2.4 feet.

The Caneyville limestone can be identified by its position
above the Lorton coal bed in the French Creek shale, by the
fossiliferous zone at its base, and by stratigraphic position
beneath the easily identified Brownville limestone (for detailed
description see measured section 9).

Facies Changes in the Formation. No facies changes were
noted in the Caneyville limestone in this region.

Pony Creek Shale

Naming of the formation. The Pony Creek shale (Table I) was
named by Condra (1927, p. 71) but was placed in its present
stratigraphic position by Moore (1933). The type locality is
along Pony Creek between the Kansas-Nebraska boundary and a point
2 miles south of Falls City, Nebr.

The shale here designated as Pony Creek was first placed in
the Adair shale by Adams (1953, p. 32). Condra (1927, pp. 74,
81) defined the Pony Creek shale to include the beds from the top
of the Dover limestone to the base of the Brownville limestone,
and referred it as part of the McMissick Grove shale. Condra,
Moore, and Hambur (1932, p. 19) listed the Pony Creek as part of
the McMissick shale. This classification was later rejected by
Moore (1933, p. 243) at which time he reverted the shale to the
position between the Canepville and Brownville limestones.

**Axial Distribution.** Only two outcrops of the Pony Creek shale were noted in Riley County, Kans. (Plate I). This shale can be observed in a small tributary in the NW 1/4 sec. 31, T. 10 N., R. 9 E. and in a road cut in the NE 1/4 sec. 7, T. 7, R. 11 S., R. 9 E. It is known to be present but is covered with slope wash in the NE 1/4 sec. 6, T. 11 S., R. 9 E.

**Description of the Formation.** The Pony Creek shale is silty, calcareous, and varies from blue-gray to tan in color. It is thin-bedded and has numerous limyite stains on the bedding planes. No fossils were found in this shale. Its average thickness is about 9 feet.

The Pony Creek shale can best be identified in the field by its position beneath the easily recognized Brownville limestone (For detailed descriptions see measured sections 9 and 10).

**Racial Changes in the Formation.** No important facies changes were observed in the Pony Creek shale in Riley County.

**Brownville Limestone**

**Naming of the Formation.** The Brownville limestone (Table I) was named by Condra and Ferguson (1915, p. 17). The type locality is in the bluffs of the Missouri River just south of Brownville, Nemaha County, Nebr.

The limestone, here known as Brownville, was first included as part of the Adair shale by Adey (1903, p. 92). It is now
classed, by Moore (1931), as the youngest unit of the Pennsyl-
vanian system which classification has gained general acceptance.
The Brownville limestone overlies the Pony Creek shale and under-
lies the Rowlie shale.

Areal Distribution. The Brownville limestone is exposed in
the bank of a small stream in the 29, 30, sec. 31, T. 10 N., R. 9 E. (Plate 1). Another exposure of this limestone is exhibited
in a road cut in the 37, 38, sec. 7, T. 11 N., R. 2 E. This
limestone is known to be present but covered by slope wash in
the 17, 18, sec. 6, T. 11 N., R. 2 E.

Description of the Formation. The Brownville limestone is
medium hard and slightly argillaceous. It is tan to brown and
weathers gray. This limestone is blocky and weathers to nodules.
Numerous limonite stains are present on fracture planes.
Chonetes gracilis, crinoid columns, and Haplinella wahlau-
rensis are abundant in this limestone and 1ib Họppera sp. Lino-
chonetes gracilis, and Ambonella sp. occur less numerous.
The average thickness of the Brownville limestone is about 1.5
feet.

The limestone is easily recognized by its thickness, color,
and content of fossils (For detailed descriptions see measured
sections 9 and 10).

Pecies Changes In the Formation. The Brownville limestone
was found to thin toward the south in this area.
Stratigraphy of the Permian System

Introduction

The Permian system, in descending order, consists of the Guadalupian, Leonardian, and Wolfcampian series. Only the basal part of the Leonardian series is represented locally in Riley County, but outcrops of the Wolfcampian series are present over most of the county. The strata from the Towle shale to the Wellington shale, inclusive, are part of the Permian system. The Indian Cave sandstone is locally present at the base and marks the unconformity between the Permian and Pennsylvanian systems. This unconformity, discovered by Moore and Ross (1933, p. 100) is decipherable in eastern Riley County.

The Wolfcampian series (Table I), in descending order, consists of the Chase, Council Grove, and Admire group. It includes, in part, the formations that were once listed by Cragin (1896, pp. 3, 5) in the "Big Blue" series. The "Big Blue" series, as defined, contained all formations of the Wolfcampian series and the Leonardian series is defined at the top of the Nolans formation.

Admire Group. Adams (1933, p. 2) placed the units here included in the Admire group in the Admire shale. Conrad (1927, pp. 71, 82) adopted Adam's term, the Admire shale, for those beds between the American and Brownville limestones. Moore (1922, p. 43) defined the "Admire shale" as to include the Willard shale, Tarkio limestone, McFissick Grove shale, and the Admire shale
(restricted). Later, Moore (1932) restricted the Admire shale to the strata between the Brownsville and Americus limestones. Condra (1932, pp. 8 and 9) assigned to the Admire group the same stratigraphic units he defined in 1927.

The Admire group, as the term is here used, includes the following formations (descending order): Wemlin shale, Five Point limestone, West Branch shale, Falls City limestone, Jawby shale, Aspinwall limestone, and Towle shale.

**Towle Shale**

The Towle shale (Table I) was named by Moore and Condra (1932). The type locality is at Towle farm, two miles south and three miles west of Falls City, in the 111 sec. 20, T. 1 N., R. 16 W., Richardson County, Nebr. The Indian Cave sandstone member and an unnamed shale member, which overlies the sandstone, comprise the Towle shale.

**Indian Cave Sandstone Member**

*Maxima of the Member.* The Indian Cave sandstone (Table I) was named by Moore and Moss (1933, p. 100). The type locality is near Indian Cave, Nebr. The maximum thickness of this unit so far encountered, 230 feet, was recorded in Pottawatomie County by Bernet and Chelikowsky (1942, p. 351).

*Areal Distribution.* The Indian Cave sandstone, a channel deposit, is only locally present although exposures are numer-
ous in southeastern Pike County (Plate I). A typical exposure of the Indian Cave was observed in a road cut in NE\(^1\) 32\,\, sec. 30, T. 10 S., R. 9 E. The sandstone, in this exposure, is in contact with the Jim Creek limestone. Another exposure is well displayed in a drainage ditch in the NE\(^1\) 32\,\, sec. 9, T. 11 S., R. 9 E. and in this outcrop the sandstone rests on the French Creek shale. An outlier of the Indian Cave sandstone occurs in the NE\(^1\) 32\,\, sec. 28, T. 10 S., R. 9 E. At this place the sandstone rests on the lower part of the dolomite. In the NE\(^1\) 32\,\, sec. 31, T. 11 S., R. 9 E., the Indian Cave overlies the lower part of the Friedrich shale as it does also in the NE\(^1\) 31\,\, sec. 29, T. 10 S., R. 9 E. and to the north of this location it cuts below the Grand Haven limestone.

**Description of the Member.** The Indian Cave sandstone is a fine-grained quartz and mica sand cemented with iron oxide and possibly calcium carbonate. As described by Jewett (1941 p. 41):

> The quartz grains are extremely angular and range from approximately 0.025 mm. to 0.175 mm. size. The mica flakes are larger and make up about 0.20 of 1 percent of the whole. The quartz grains are deeply stained with iron oxide.

The sandstone is cross-bedded and contains numerous limonite concretions. It varies from an arenaceous shale in part, to a loosely cemented sandstone with an occasional firmly cemented bed. Small ripple marks, fossil wood, and leaves are sometimes found in this member and carbon and limonite stains are common in its upper part. The maximum thickness of the Indian Cave sandstone is about 76 feet.
This member can be identified by its distinctive and non-conformable position in older units (for detailed descriptions see measured sections 7 and 9).

**Unnamed Shale Member**

**Areal Distribution.** The unnamed shale underlies the Aspinwall limestone and overlies either the Indian Cave sandstone or the Brownsville limestone (Table I).

Outcrops of this shale were studied in the eastern part of Riley County where it extensively, crops out most (Plate I). A well exposed section was observed in a drainage ditch in the NW 1/4 NE 1/4 sec. 9, T. 11 N., R. 9 W., in which the Indian Cave sandstone grades up into the unnamed shale member. It is difficult to determine the exact contact between these two units. Another exposure of the shale member can be seen in a ditch in the NE 1/4 SE 1/4 sec. 31, T. 10 N., R. 9 W. The Indian Cave sandstone is absent at this location and the shale rests directly upon the Brownsville limestone.

**Description of the Member.** This shale is usually clayey, varies from noncalcareous to calcareous, is tan-gray to blugray, and usually weathers tan. The shale is thin-bedded and occasionally contains one or more thin calcareous zones. A thin impure coal lens sometimes occurs near the base. Limonite stains and nodules are usually present on weathered surfaces. The thickness of the unnamed shale member in Riley County, varies from 4.9 feet to 11.2 feet.
This shale is best identified in the field by its stratigraphic position beneath the Aspinwall limestone (for detailed descriptions see measured sections 1, 2, and 10).

Facies Changes in the Member. The thickness of the Towle shale is variable and is dependent on the presence or absence of the Indian Cave sandstone.

Aspinwall Limestone

Naming of the Formation. The Aspinwall limestone (Table I) was named by Condra and Hengsten (1915, pp. 9, 17, 29). The type locality is at Aspinwall, Nebr.

Condra (1927, pp. 73, 92, 29) assigned all beds between the Falls City and Brownsville limestones to the Aspinwall shale. Moore and Condra (1932) named the intervening shale the Haxby and restored the name Aspinwall to the lower limestone. Condra (1935, p. 9) designated the Aspinwall limestone formation as underlying the Haxby shale and overlying the Towle shale.

Areal Distribution. The Aspinwall limestone crops out in the southeastern part of Riley County (Plate I). All of the observed outcrops were found in the area southwest of Zenda, Kans. A small knoll located in the NW$^1$ NW$^1$ sec. 27, T. 10 S., R. 9 E., is capped by the Aspinwall limestone and another good exposure of this limestone was observed near the top of an isolated hill in the NW$^1$ NW$^1$ sec. 31, T. 10 S., R. 9 W. The Aspinwall is present, but under cover, in the NE$^1$ SW$^1$ sec. 30, T. 10 S., R. 9 E. and in the SW$^1$ NE$^1$ sec. 9, T. 11 S., R.
Description of the Formation. The Aspinwall limestone is hard, oolitic or crystalline, and locally exhibits a brecciated appearance. It is gray-orange and weather gray. The limestone is massive and weather blocky. Limonite stains and nodules, clay zones, and clay balls are distributed throughout the limestone. Forails found in the Aspinwall limestone are crinoid columnals, Hallirapton sp., and Pleurophorus albequius. The thickness of the Aspinwall limestone in Mieo County varies from 1.1 feet to 1.7 feet. The Aspinwall limestone makes a small hillside bench.

This limestone is easily distinguished from the Brownville and Walls City limestones by its gas liveness and the presence of small clay balls and limonite nodules (for detailed descriptions see measured sections 9, 9, and 10).

Facies Changes in the Formation. Because exposures are so few, it is difficult to determine facies changes in the Aspinwall limestone but the unit appears to diminish in thickness toward the south.

Lawry Shale

 Naming of the Formation. The Lawry shale (Table I) was named by Moore and Conra (1932). The type locality of the shale is the Lawry farm in the 14 sec. 7, T. 4 N., R. 15 W., Nemaha County, Nebra. This shale overlies the Aspinwall limestone and underlies the Walls City limestone.
Arcos Distribution. The Jawby shale is well exhibited in many exposures in the southeastern part of Riley County (Plate I). A good exposure of this shale was observed in a road cut in the 16, NW 1/4 sec. 3, T. 11 N., R. 9 E., and another is exhibited in a road cut in the 16, NW 1/4 sec., T. 11 N., R. 9 E. Part of the Jawby shale crops out in a road cut in the 16, NW 1/4, sec. 16, T. 11 N., R. 9 E.

Description of the Formation. The Jawby shale is a thick shale containing numerous thin limestone lenses. The shale is clayey, varies from noncalcareous to calcareous, and is usually gray but ranges from gray-green to tan. The limestone lenses are hard, dense, massive, usually argillaceous, and are highly fossiliferous. Iron stains are present on the bedding planes of the shales and on the joint planes of the thin limestones. Fossils found in the Jawby are Pleurophorites albagious, Collina sp., Tomostella sp., Derbina crassa, D. crassula, Thamnites sp., Pecantilus vetulus, Orthocerasina subquadrate, Aviculopecten occidentalis, Felleropites sp., Hirtolobatus sp., Pseudomontia hami, Pteropluma parodoosa, Laxumena sp., and Harthemia sp. Pleurophorites albagious is very abundant in most of the thin limestones. The average thickness of the Jawby shale in Riley County is about 23 feet.

The Jawby shale is easily recognized in the field by the presence of the thin, very fossiliferous limestones (for detailed descriptions see measured sections 10, 11, and 12).

Facies Changes in the Formation. The only facies change noted in this unit is the variation in the vertical positions of
the lenticular limestone layers. No one of them could be correlated from one out to another.

Falls City Limestone

Naming of the Formation. The Falls City limestone (Table I) was named by Condra and Singleton (1916, pp. 9, 17, 20). The type locality is in the Leiner quarry, 2½ miles south and 1½ miles west of Falls City, Richardson County, Nebr.

Areal Distribution. Only two exposures of the Falls City limestone were observed in Alley County (Plate I). This limestone was found in a road ditch in the 16-NW-1 sec. 8, T. 11 N., R. 9 E. and in a road cut in the 16-NE-1 sec. 9, T. 11 N., R. 9 E.

Description of the Formation. The Falls City limestone is soft, porous, and has a fibrous appearance. It is gray-brown and weathers a tan. Thin shale partings are present in this limestone and a plaly zone was observed near the base. Juracanina nebraensis and Pleurotomaria albecens are present in the basal part of the formation. The average thickness of the Falls City is about 2.5 feet. This limestone forms a small and poorly developed hillside bench.

The Falls City limestone is identified by its distinctive color, weathering characteristics, and by its stratigraphic position below the easily identified Five Point limestone (For detailed descriptions see measured sections 10, 11, and 12).

Facies Changes in the Formation. The two exposures of the
Falls City limestone suggest only that it thickens toward the southeast.

**West Branch Shale**

**Naming of the Formation.** The West Branch shale (Table I) was named by Condra (1927, pp. 74, 92, 99, 111, 113) from outcrops in West Branch Township, Preece County, Nebr. The West Branch shale overlies the Falls City limestone and underlies the Five Point limestone.

**Areal Distribution.** Two good exposures of the West Branch shale were observed in eastern Riley County (Plate I). West Branch shale is exhibited along a trail on the south side of a hill in the SW 1/4 NW 1/4 sec. 30, T. 10 N., R. 7 E. A full exposure of this shale was observed in a ditch in the NE 1/4, sec. 2, T. 10 N., R. 9 E. This shale is present, but covered, along the base of the escarpment in the northern portion of sec. 15, 16, 17, T. 11 N., R. 9 E. It crops out, also, along a hill capped by the amorous limestone in the SE 1/4, sec. 9, T. 11 N., R. 9 E.

**Description of the Formation.** The West Branch shale is clayey, somewhat silty, and contains a zone of sandy shale near the middle. There is a thin massive limestone lens in the upper part and a thin sandstone lens in the middle part. This shale varies from gray through greenish-gray to gray-brown, and weather from tan-gray to tan-brown. The formation is thin-bedded and limonite stains and plates, usually, are present. Fossil leaves
of Neuroptera sp. and wood fragments occur in the middle part
and the following invertebrate fossils were found in the thin
limestone lens: Correa sp., Composite sp., Rhodopora sp.,
echinid spines, crinoid columnals, Ambacoalia sp., and others.
The average thickness of the West French shale is about 20 feet.

The West French shale can be identified in the field by its
arenaceous slates which contain wood and leaves fragments and by
its stratigraphic position beneath the easily identified Five
Point limestone (For detailed descriptions see measured sections
10 and 12).

Facies Changes in the formation. The only obvious facies
change noticeable in this shale is the absence of the thin
limestone lens in the northern part of the outcrop area.

Five Point Limestone

Naming of the formation. The Five Point limestone (Table
I) was named by Moore and Gendra (1932). The type locality is
in Five Point Valley, near the Five Point school in sec. 23,
T. 1 N., R. 19 E., Richardson County, Nebr. This location is
2 miles south and 4½ miles west of Folse City, Nebr. The Five
Point limestone overlies the West French shale and underlies
the EastLin shale.

Areal Distribution. The Five Point forms an identifiable
hillside bench west and south of Leandale, Kans., but is covered
in other parts of the county (Plate I). This formation was
studied in an old quarry in the center of the sec. 30, T.
10 ft., N. 9 E. and in the center of sec. 3 and in the W. sec. 9, T. 11 N., R. 9 E. Low benches of this limestone are present along the face of a valley wall in secs. 9 and 10, T. 11 N., R. 9 E.

Description of the Formation. The Five Point limestone is hard and massive near the base but becomes platy and argillaceous in its upper part. The limestone is gray and usually weathers tan-gray. The following fossils were found in the Five Point: Climeetae craniulifera, crinoid columnals and plates, Marginifera brachiata, Pleurocorus alboguttus, Aviculopecten occidentalis, Niobopora sp., Dictyonella americana, D. portlockianus, Loxonema sp., Polyplaca sp., Axopilus rude, Untolates hemiplicatus, Blindiaella cartesialis, Mecopterites sp., Nephyta sp., Diadema aarmoni, Composita ovata, Issoclonetes geinitzianus, and Amphopodia sp. All the fossils listed above occur in the massive portion of the formation. It is also the massive portion that forms the prominent1 hillside bench. The total thickness of the Five Point limestone in Riley County is 3.8 feet.

This limestone is easily identified by the massiveness, thickness, and stratigraphic position below the previous limestone. (For detailed description see measured section 10).

Facies Changes in the Formation. No important facies changes were noted in the Five Point limestone as it occurs in this county.
Paulin Shale

Naming of the Formation. The Paulin shale (Table I) was named by Conners (1935, pp. 5, 9) but no type locality was specified by him. The Paulin shale overlies the Five Point limestone and underlies the Amorius limestone member of the Fordham limestone. The Paulin shale is composed of the following members in descending order: Oaka shale, the Louden Creek limestone, and the Stine shale. The Louden Creek limestone is absent in this county and the contact between the Oaka and Stine shales is difficult to determine.

Areal Distribution. Part of the Paulin shale is usually present wherever the Amorius limestone crops out (Plate I). The Paulin shale is mapped south and west of Leona, Kansas. The upper part of this shale was observed at the base of K-311 in NW 1/4, sec. 20, T. 10 S., R. 8 E., and extending south from that point for 1/2 miles. The Paulin shale is present, but covered, near the base of the valley wall in secs. 25, 26, 27, T. 10 S., R. 8 W. The upper part of the Paulin crops out in a railroad cut in the NE 1/4, sec. 7, T. 10 S., R. 9 E.

Description of the Formation. The Paulin shale is calcareous and generally silty except in the basal part which is clayey. The middle part of this shale is arenaceous. The color is gray to gray-green. The Paulin is blocky but becomes thin-beded toward the base. Calcareous lenses are present in its upper part. Iron stains occur along the fracture planes and limonite stains and nodules are common near the base. The
average thickness of the Emlin shale in Riley County is about 27 feet.

The Emlin shale can be recognized by its stratigraphic position below the American limestone (for detailed descriptions see measured sections 12, 13, and 14).

Eacies Changes in the Formation. The only significant aspect of the Emlin shale in Riley County is the absence of the Touchens Creek limestone member.

The Council Grove stage was named by Prosser (1926, p. 709) and includes these stratigraphic units from the base of the Ford limestones down to the Eakridge shale. The type locality is in the vicinity of Council Grove, Morris County, Kans. Made (1922) lowered the base of the Council Grove stage to include the Nova limestone and Moore (1932) expanded the Council Grove group to the base of the American limestone.

The Council Grove group includes the following formations in descending order: peiser shale, Funston limestone, Blue Rapidia shale, Crouse limestone, Easter Creek shale, Eader limestone, Stearns shale, Petitic limestone, Eakridge shale, Granola limestone, Nova shale, Red Marle limestone, Johnsen shale, and the Foraker limestone (Table I).

Foraker Limestone

The Foraker limestone (Table I) was named by Keal (1916, pp. 21-25). The type locality is near Foraker, Osage County, Okla. The initial use of this classification is credited to
pass (1929, p. 46). The upper member of the Foreker limestone was included in the Eudale formation by Condra (1927), a practice not now followed.

The Foreker limestone is composed of the following members, in descending order: Lang Creek limestone, Hughes Creek shale, and Americanus limestone.

Americanus Limestone Member

Naming of the Member. The Americanus limestone (Table I) was named by Kirk (1929, p. 10). The type locality is near Americanus in Lyon County, Iowa.

Salt (1902) listed this limestone in the Americanus limestone system. Prosser (1902, pp. 722, 737) and Ames (1903) defined the Americanus as two limestones separated by a shale and underlying the Eudale formation. Hoexter (1902, pp. 14, 32) designated this limestone unit and 125 feet of underlying beds as the Americanus beds. Nasa (1920, pp. 1, 203) listed the Americanus limestone as the basal member of the Foreker limestone. He was followed in this by Moore (1936) who included it in the Permian system. The Americanus limestone overlies the Muslin shale and underlies the Hughes Creek shale member.

Areal Distribution. The Americanus limestone is exposed in numerous places south of the Kansas River in eastern Riley County (Plate I). It crops out near the base of T-1 in the NE 4 NW 4, sec. 20, T. 10 N., R. 2 W., in a railroad cut in the NW 4 SE 4, sec. 7, T. 10 N., R. 2 W., and other exposures were
found in T. 10 S., R. 5 E., and T. 11 S., R. 9 E. along the valley walls south of the Keuper River and Deep Creek. A small knoll capped by the American occurs in the NW 3 sec. 9, T. 11 S., R. 9 E.

Description of the Member. The American limestone consists of two limestones separated by a shale. Both limestones are hard, dense, and dark gray to blue-gray in color. The limestones are massive and weather blocky to platy. The shale parting is clayey, noncalcareous, and thin-bedded to fissile. It is black to dark gray in color. Fossils found in the limestones are: crinoid columnals, Marginifera hystricula, Herpia erecta, Ame-
coelia sp., echinoid spines, fusulinids, Pellegrinopora sp., Avic-
ulopecten occidentalis, Aviculopinna perscuta, Balina sp., and
Hemphalus sp. No fossils were observed in the shale parting.
The average thickness of this member is about 3 feet. The Ameri-
cus limestone forms a good hillside bench bordered by nu-
merous rounded light gray field stones marked by numerous cri-
noid columnals showing on weathered surfaces (For detailed de-
scriptions see measured sections 13 and 14).

Facies Changes in the Member. There were no facies changes observed in the American limestone member as it occurs in Riley County.

Hughes Creek Shale Member

Naming of the Member. The Hughes Creek shale (Table I) was named by Condra (1927, pp. 64, 65, 69) and included it in the Midvale shale. The type locality is along Hughes Creek,
Wemaha County, Nebr. Bass (1929) listed the Hughes Creek shale as the middle member of the Foraker limestone formation. Condra (1937, p. 8) accepted this classification of the Hughes Creek shale and extended it into Nebraska. The Hughes Creek shale overlies the Americanos limestone member and underlies the Long Creek limestone member, both of the Foraker limestone.

**Areal Distribution.** The Hughes Creek shale member is exposed, or is present near the surface, south and west of Zenda, Kans. (Plate I). Exposures occur along both sides of Deep Creek and near the base of the valley walls of the Blue and Kansas Rivers in the vicinity of Manhattan. Good exposures were studied in road cuts in SW 1/4 NE 1/4 sec. 7, T. 10 S., R. 2 E.; at E-Will in NW 1/4 NW 1/4 sec. 20, T. 10 S., R. 2 E., and in a road cut in the NW 1/4 SW 1/4 sec. 23, T. 10 S., R. 7 E.

**Description of the Member.** The Hughes Creek shale is principally silty and calcareous with numerous interbedded thin, fossiliferous lenses of limestone. The shale beds are predominantly gray, but include some tan, olive drab, and black zones. The structure of the shale varies from fissile to blocky. Fossils are exceptionally abundant in the Hughes Creek shale and the following fossils can be found in most outcrops of the member: Dicyclocestus americanus, D. portlockianus, Composita subtilita, C. ovata, crinoid columnals, Marginifera frigida, M. bistricina, Orbiculoides missouriensis, Derbyia crassa, D. cambula, Echinocoelus moorei, Jureanaria nebrascensis, Aviculopecten occidentalis, Juastedia mormoni, Ambacoelia planoconvexa, and Lingula carbonaria. Fusulinids are very abundant, especially
in the shales and limestones of the upper part. The total
thickness of the Hughes Creek shale is about 40 feet (for de-
tailed descriptions see measured sections 14 and 15).

Facies Changes in the Member. No important facies changes
were observed in this member of the Foraker Formation.

Long Creek Limestone Member

Naming of the Member. The Long Creek limestone (Table I)
was named by Condra (1927, pp. 84, 95, 96). The type locality
is along the base of the valley wall of Long Creek near Auburn,
Nemaha County, Neb.

The Long Creek limestone was designated a member of the
Flintdale shale by Condra (1927, pp. 84, 95, 96). Mass (1929,
pp. 1-203) included the Long Creek limestone as the upper mem-
ber of the Foraker limestone. Condra (1935, p. 3) extended the
subdivision of the Foraker limestone made by Mass into Nebraska.
The Long Creek overlies the Hughes Creek shale member of the
Foraker limestone and underlies the Johnson shale.

Areal Distribution. The Long Creek limestone crops out
south and west of Nemaha, principally along the south branch
of Deep Creek (Plate I). Other exposures were observed in the
vicinity of Manhattan and for a few miles south, where the lime-
stone forms a continuous outcrop on the east of the Kansas River
valley wall. The most southerly outcrop noted in the field was
formed at the base of a stream bank in the 11N NE 1/4, sec. 12,
T. 11 S., R. 7 W. Good exposures of the limestone were studied
Description of the Member. The Long Creek limestone is soft and slightly dolomitic. It is fine-grained, massive, and usually contains slate partings. It is usually tan to gray-orange and weathers tan. The slate partings are dark gray and thin-bedded. The Long Creek is very massive in a railroad cut in the NW 1/4 SW 1/4 sec. 34, T. 10 N., R. 7 E. Fossils are rare or absent in the Long Creek. The average thickness of this limestone is about 9.5 feet.

The Long Creek limestone is identified by celestite found on the weathered field stones, the abundance of fusulinids present in the very top of the Hughes Creek shale and by its position above the easily recognized Amorican limestone (for detailed descriptions see measured sections 14 and 15).

Facies Changes in the Member. There were no facies changes observed in this limestone.

Johnson Shale

Remains of the Formation. The Johnson shale was named by Coddra (1937, pp. 84, 86, 91) and included in the Pludale shale (Table I). The type locality is 1½ miles north of Johnson, Johnson County, Nebr. He later abandoned the term "Pludale shale" and elevated the Johnson shale to the rank of a formation.
The Johnson shale overlies the Long Creek limestone member of the Foraker limestone and underlies the Clearrock limestone member of the Red Eagle limestone.

**Areal Distribution.** Exposures of the Johnson shale are not numerous in Riley County and the only exposures found in the field occur in the vicinity of Manhattan (Plate I). Complete sections of the shale are exhibited in a road cut at the east end of Bluemont Hill in the 14 1/2 T. 10 S., R. 9 E., and in a railroad cut in 13 1/4 T. 10 S., R. 7 E.

**Description of the Formation.** The Johnson shale is a thick, silty, and calcareous shale and contains numerous thin, highly calcareous lenses and limestones. It is gray-green and olive drab and varies from thin bedded to blocky. There is a tendency for local structure to be present in some outcrops. This structure is shown in the calcareous lenses and does not reflect in the beds above or below them. This structure is possibly penecontemporaneous and might be the result of flowage on the sea floor during Johnson time. No fossils were observed in the Johnson shale. The thickness of this formation is about 25 feet.

This shale is easily recognized by the color, many limestone beds, and stratigraphic position above the Long Creek limestone (for detailed descriptions see measured sections 14 and 14).

**Facies Changes in the Formation.** Because outcrops of the Johnson are not numerous in Riley County, no comparative bases exist for stating facies changes.
Red Eagle Limestone

**Naming of the Formation.** The Red Eagle limestone (Table I) was named by Veald (1919 p. 24) after its type locality in the vicinity of Red Eagle School southwest of Poncher, Okla.

Liser (1946) indicated that the Chasing limestone is the same unit now called the Red Eagle limestone. Condra (1955, p. 8) defined the Red Eagle limestone as a formation underlying the Roca shale and overlying the Johnson shale.

The Red Eagle limestone is composed of three members. They are, in descending order, Howe limestone, Bennet shale, and Glenrock limestone.

**Glenrock Limestone Member**

**Naming of the Member.** The Glenrock limestone (Table I) was named by Condra (1927) on the basis of an outcrop (Fig. 1) on a valley wall northwest of Glenrock, Latah County, Nebr.

Condra (1935, p. 9) defined the Red Eagle limestone with the Howe limestone member as the basal unit of the same formation, the classification that is followed in this report. The Howe limestone underlies the Bennet shale member and overlies the Johnson shale.

**Ar al Distribution.** Most of the exposures of the Glenrock limestone are found in the vicinity of Manhattan (Plate I). Its area of outcrop extends from a short distance north of Manhattan to about 4 miles south of that city. This limestone crops out
south of the Kansas River in the eastern part of the county and on both sides of the valley at Deep Creek in T. 11 S., R. 2 E. The best exposures were observed in a road cut along the east side of Bluegill Hill in the NE 1/4 SW 1/4 sec. 7, T. 10 S., R. 8 E., and in a railroad cut in NE 1/4 SW 1/4 sec. 24, T. 10 S., R. 7 E.

Description of the Member. The Glenrock limestone is hard, massive, gray-brown and usually weathers tan. Fusulinids are abundant in all exposures of the Glenrock and other fossils noted in the field are: Amphoecelia sp., Euphialus sp., Helicoceras sp., and numerous for all fragments.

The Glenrock is more resistant to weathering than the other members of the Red Eagle and is therefore the bench former of the formation. The thickness of the Glenrock limestone is consistently 1.5 feet.

This limestone is easily recognized by its thickness, abundance of fusulinids, and stratigraphic position (for detailed descriptions see measured sections 14 and 15).

Facies Changes in the Member. No facies changes were observed in the Glenrock in Riley County.

Bennett Shale Member

Naming of the Member. The Bennett shale (Table I) was named by Condra (1927, pp. 54, 56, 57, 185). The type locality is along the Little Konza River and its branches south of Bennett, Lancaster County, Nebr. Condra (1933, p. 4) included
the Bennett shale as the middle member of the Red Eagle limestone. The Bennett shale thus lies between the Glenrock and Howe limestone members.

**Areal Distribution.** Outcrops of the Bennett shale almost invariably are associated with those of the Glenrock limestone (Plate I).

**Description of the Member.** The Bennett is a dark-gray to black, fissile to thin-bedded, clay shale. It is usually carbonaceous, slightly silty, and calcareous. Fossils found in this unit are: *Composita ovata*, *Marginifera tristicula*, *Jutedia mormoni*, *Lissoclonon gelnitzianus*, *Riptiroclustus americanus*, *Polypora sp.*, *Pleuroclora albecka*, *Amboecelia planoconvexa*, *Aviculopenten occidentalis*, *Bellerella tetradra*, *Dorystia crassa*, *Orbiculidea misauriensis*. The thickness of the Bennett shale is almost constant at 5 feet.

The Bennett shale is easily identified by its dark, fossiliferous shale and its position above the easily identified Glenrock limestone.

**Facies Changes in the Member.** No important facies changes were observed in the limited exposures of the Bennett shale in Niobrara County.

**Howe Limestone Member**

**Naming of the Member.** The Howe limestone (Table I) was named by Condra (1927, pp. 24, 96, 94). The type locality is south of Howe, Nebr. Condra (1931, p. 9) designated the Howe
limestone as the top member of the Red Eagle limestone formation. The Rowe limestone underlies the Boca shale and overlies the Bennett shale.

**Areal Distribution.** Outcrops of the Rowe limestone almost invariably are associated with those of the Gleneck limestone (Plate 1).

**Description of the Member.** The Rowe limestone is tan, massive, soft and weathers rotten and porous. It is heavily limonite stained and, in most exposures, it usually contains some maroon stains derived from the overlying shales. Ostracods are very abundant in some zones of this limestone. *Neostrigifera* sp., and *Eviculopina* perecuta are the macrofossils noted in the field. The average thickness of this limestone is about 4 feet.

This limestone is recognized by its weathering characteristics, color, presence of ostracods and stratigraphic position below the Boca shale (for detailed descriptions see measured sections 17 and 18).

**Facies Changes in the Member.** The only local facies change observed in the Rowe limestone is a slight thickening toward the south.

**Boca Shale**

**Name of the Formation.** The Boca shale (Table I) was named by Condra (1927, pp. 84, 86, 88). The type locality is at Boca, Lancaster County, Nebr.
Condra (103, p. 9) later separated the Hoca shale from
the Neva limestone with which it previously had been grouped.
The Hoca shale overlies the Red Eagle limestone and underlies
the Burr limestone member of the Grenola limestone.

Areal Distribution. Outcrops of the Hoca shale are most
numerous in the vicinity of the Manhattan, Kans. (Plate I).
The outcrop area extends north as far as Rocky Ford, west to
Stag Hill, east and south of the Kansas River, and along both
sides of the valley at Deep Creek in T. 11 N., R. 4 E. Good
exposures of this shale were at the top of the road cut in the
NW 1/4 SE 1/4, sec. 7, T. 10 N., R. 8 E. and at the top of the
railroad cut in the NW 1/4 NE 1/4, sec. 24, T. 10 N., R. 7 E.

Description of the Formation. The Hoca shale is a vari-
colored shale with a thin layer of limestone in the upper part
and, in some places, a very thin limestone lens in the lower
part. Maroon and tan shales occur locally but green and gray
shales predominate in the formation. The only fossils found
in the Hoca shale are crinoid columnals in the upper limestone
lens. The thickness of this unit is about 24 feet.

The Hoca shale is the lowest, stratigraphically, of the
vari-colored Permian shales. This shale is easily identified
in the field by its vari-color and its position beneath the
easily recognized Grenola limestone (for detailed descriptions
see measured sections 12 and 13).

Facies Changes in the Formation. Two thin limestone lenses
are present in the northern part of the outcrop area but were
not found in the southern exposures of the Hoca.
Grenola Limestone

The Grenola limestone (Table I) was named by Condra and Rusby (1933) from outcrops in ravines and creeks north and south of Highway 160, 4 to 5 miles east of Grenola, Finney County, Kan.

Condra (1933, p. 2) divided the Grenola formation into the following members, in descending order: Weva limestone, Salem Point shale, Burr limestone, Legion shale, and Tallyards limestone. Moore (1933, p. 50) revised this classification by discarding the terms Legion shale and Tallyards limestone; this revision of the Grenola limestone is followed here.

Burr Limestone Member

Eponym of the Member. The Burr limestone (Table I) was named as a formation by Condra and Rusby (1933). The type locality is the bluffs and ravines west of the south fork of Little Laramie River at a point 1 mile west of a north-south road and 2 miles northeast of Burr, Otoe County, Neb. Later, Condra (1933, p. 2) reclassified the Burr limestone as a member of the Noca shale but Moore (1933, p. 50) placed it in the Grenola formation. Moore's assignment of the Burr is generally accepted today. The Burr limestone underlies the Salem Point shale and overlies the Noca shale.

Areal Distribution. Most of the Finney County exposures of the Burr limestone are restricted to the vicinity of Manhattan (Plate I). Some outcrops of the shale, however, were observed
in the area east and south of the Kansas River. The Burr limestone crops out as far as 4 to 5 miles north of Manhattan. Other exposures were observed along Deep Creek in T. 10 N., R. 8 E., and road cuts into this unit are exhibited in NE 3/4 SE 1/4, sec. 7, T. 10 N., R. 8 E.

Description of the Member. The Burr limestone is a thick limestone interrupted by shale partings. Some of the beds of limestone are hard, dense, massive, and others are soft and porous. The limestone ledges are usually tan-gray and weather tan. The shale partings are clayey, usually noncalcareous, gray, and thin-beded. The following fossils were found in the limestone layers: eocrinoid spines, Δionaster granuliferus, eocrinoid columnals, Aviculopecten occidentalis, Aviculopectina peracuta, Pleurophorus alboqueus, Epinaia sp., and microfossils. The total thickness of the Burr limestone is about 8 feet.

The Burr limestone is easily recognized by its stratigraphic position below the Neva limestone (For detailed descriptions see measured sections 15, 16, 17, 18, and 22).

Facies Changes in the Member. The Burr limestone, in the vicinity of Manhattan and southwest along Highway 49, consists of three beds of limestone and two black fissile shale partings. Southward, in sec. 7, T. 11 S., R. 0 E., an additional thin calcareous shale appears in the top limestone ledge.

Salem Point Shale Member

Setting of the Member. The Salem Point shale (Table I) was
named by Gendra and Pushy (1935) from exposures in road cuts near Salem Point, 1½ miles north of Salem, Richardson County, Neb. Gendra, in 1937, placed the Salem Point shale member in the Grenola limestone. The Salem Point shale overlies the Murr limestone and underlies the Neva limestone.

**Area Distribution.** Outcrops of the Salem Point shale are almost invariably associated with those of the Neva limestone (Plate I).

**Description of the Member.** The Salem Point is a thin-bedded, usually silty and calcareous shale. Numerous calcareous plates appear on weathered surfaces, a feature that can be used in identifying this shale. A calcareous lens is present locally. The color of the shale varies from tan to gray-green. There were no fossils observed in the Salem Point shale. The average thickness of this unit is about 3 feet.

The Salem Point shale is easily recognized in the field by the abundance of small calcareous plates on the weathered surface and by its position below the easily recognized Neva limestone (for detailed descriptions see measured sections 17, 19, and 22).

**Facies Changes in the Member.** The only facies change noted in this shale were minor variations in thickness. There is an apparent tendency of the Salem Point to thicken toward the south.
Nevada Limestone Formation

Naming of the Formation. The Nevada limestone (Table I) was named by Brosser (1908, p. 191). The type locality is in the valley of the Cottonwood River approximately 4 miles west of Strong City, Chase County, Kansas. This limestone was named after Nevada railroad station which at one time existed at the above location. A good exposure of the Nevada can be seen in the NE sec. 11, T. 10 N., R. 7 E.

Beede (1908, p. 180) first described the Nevada limestone, and Cordes and Babb (1933, p. 39) extended this unit into Nebraska and defined it as the top member of the Glencoe formation. Moore (1937, p. 70) revised the classification of the Glencoe limestone into the Nevada limestone (restricted), Point Black shale, and Kunn limestone. Moore listed the Nevada limestone as underlying the Kebride ridge and overlying the Rosa shale. Passa (1933) included in the Nevada limestone, a shale and limestone which lie above the massive bed described as the Nevada at the type locality. It underlies the Kebride ridge and overlies the Salem Point shale.

Areal Distribution. The Nevada limestone crops out in the vicinity of Manhattan and extend south nearly to the county line (Plate I). The limestone dips beneath the present land surface about 6 miles north of Manhattan and at a point about 2½ miles west of Manhattan. Prominent benches of the Nevada limestone are especially conspicuous in the area south of Manhattan. Good exposures were observed in a road cut in the Nevada limestone, which is about 25 feet thick.
sec. 30, T. 10 N., R. 7 E., along a bench high on F-\nCull in the No. No. sec. 10, T. 10 N., R. 2 E., and in a road \ncut in the No. No. sec. 27, T. 10 N., R. 2 E.

Description of the Member. The Neva limestone is usually \ncomposed of thick limestone with a shale bed near the base and, \nin some exposures, other thin shales may occur also in the mid-
dle and upper parts of this member. The limestone layers are \nhard in the upper part of this unit but become soft in the lower \npart and are usually gray. The shales vary from gray to \nblack.

Crinoid spines are abundant in some zones and other fos-
sils commonly found in this member are: crinoid columns, \nAspidopora, Goniatites alternipennis, Marginata sp., Tabulocellia \nexpansa, Polypropora sp., Composita ovata, and other fossil frag-
ments. Lingula carinaria and Orthiculoidea missouriensis are \npresent only in the shales. The average thickness of the Neva \nlimestone is about 16 feet. The top limestone bed forms the \nprominent bench which is characteristic of outcrops of the Neva. \nThis member is identified in the field by its west are light-
gray limestone plates and blocks which, when broken, disclose \nnumerous fossil fragments and crinoid spines. It is further \nrecognized by its stratigraphic position beneath the easily \nidentified Cottonwood limestone (for detailed description see \nmeasured sections 17, 18, 19, 20, and 29).

Features Delineate the Member. The Neva limestone becomes \nmore massive in the eastern part of the county and lacks the \nnumerous shale partings which are distinctive of the unit in
the western outcrop area. This limestone tends to thin to the south.

Fafbridge Shale

Origin of the Formation. The Fafbridge shale (Table I) was named by Proctor (1902, p. 707) from outcrops near Fafbridge, Washakie County, Wyo. Reed (1902, p. 111) described the Fafbridge shale as overlying the Beaver limestones and underlying the Cottonwood limestone.

Areal Distribution. The Fafbridge shale is exposed beneath the Cottonwood limestone in the vicinity of Manhattan (Plate I). Numerous outcrops of the Fafbridge occur along Highway 1-13 between Manhattan and Stockdale. Excellent exposures of the shale were studied in a road cut in sec. 10, T. 10 N., R. 9 E., along an old road west of Highway U.S. 40 in the NE\4 sec. 26, T. 13 N., R. 7 E., south of the Ravina River in T. 11 E., R. 7 and R. 8 E., and along the east side of Deep Creek in T. 11 E., R. 9 E. The uppermost part of this shale is present in a ditch in the southeastern corner of the county.

Description of the Formation. The Fafbridge shale is predominantly shale with a few limestone lenses. The shale beds vary from close to silt which may be calcareous or noncalcareous. Maroon, purple, green and tan-gray zones constitute the lower three-fourths of the Fafbridge but the upper part is usually tan or gray. The limestone lenses are hard, dense, massive, and some are argillaceous. Fossils usually are found
only in some of the limestone lenses. The common fossils are: *Vincula* *seten* accidentalis, *Xainia* sp., *Pandermia* *seten*, ostracods, and occasional bryozoans, plants and insects. Fossils occurring in a single zone of the *Fabri* price were observed in a road cut in the TH, 21 sec. 9, T. 11 , R. 7 E. The average thickness of the *Fabri* price is about 30 feet.

This unit is best identified in the field by its varicolored shales, pelmets, bearing limonites, and its position beneath the readily recognized Cottonwood Limestone (for detailed descriptions see measured sections 17, 19, 10, 23, and 27).

Flores Limestone in the Formation. The *Fabri* price shale thickens toward the north and northeast and in the same direction, the limestone lenses become thicker and more numerous. The position of limestones is extremely variable. The shale beds are predominantly calcareous in the northern and western outcrop areas and are noticeably less calcareous in the southern outcrop area.

Beattie Limestone

The Beattie limestone (Table I) was named by Condra and Busby (1933, p. 13). The type locality is near Beattie, Marshall County, N. 3. They subdivided the formation into the following members (in descending order): *Merrill* limestone, *Florence* shale, and *Cottonwood* limestone.
Cottonwood Limestone Member

**Naming of the Member.** The Cottonwood limestone (Table I) was named by Hawort! and Kirk (1904, p. 112-114). The type locality is the valley of the Cottonwood River, Chase County, Kans. Prosser (1902, pp. 711, 712) was the first to describe the limestone adequately at its type locality. The limestone here classified as the Cottonwood appears in early reports as the Cottonwood stone, "Musoline limestone," "Cottonwood Falls limestone," "Alma limestone," and the "Manhattan limestone."

The Cottonwood limestone overlies the Eskridge shale and underlies the Florene shale.

**Areal Distribution.** Outcrops of the Cottonwood limestone are especially prominent in the vicinity of Manhattan (Plate I). This limestone forms a continuous bench on both sides of the Kansas River, and extends almost as far south as the Geary County line and in at least one place, along McDowell Creek, into Geary County. Outcrops of this member extend along the Blue River to a point one mile north of Stockdale where it passes beneath the present land surface. Outcrops were observed in the southeastern part of the county. This unit is exhibited on both sides of Wildcat Creek to a point 5 miles west of Manhattan.

**Description of the Member.** The Cottonwood limestone is a single massive layer with a thin argillaceous zone in the basal part. In most outcrops this limestone weathers into three more or less distinct ledges. Two to three thin lenses of chert
nODULES are usually present in the massive part of the lime-
stone. The limestone is gray and contains tan-gray. Fusulinites.
are abundant in this member, and solution channels occasionally
are present. Other fossils noted in the Cottonwood are: Histro-
clostum americanum, ephippid shells, grinnell columns, Nowellia
sp., Composita sp., Niruparalus sp., and Polythara sp. The
average thickness of this limestone is about 5.5 feet.

The massive bed of the Cottonwood limestone forms the most
prominent hillside bench in the vicinity of Manhattan. A heavy
growth of bushes at the base of this limestone usually marks
its position on the hillside. The 'growth' of this line of bush,
at this contact, is the result of movement of subsurface water
along fracture planes.

The Cottonwood is easily identified in the field by its
thickness, lassiveness, abundance of fusulinite, cord nodules,
and "rustling" outcrop (for detailed descriptions see measured
sections 17, 18, 19, 20, 21, and 22).

Facies Changes in the Member. No significant facies changes
were noted in the Cottonwood limestone in Riley County; this
member is perhaps the most constant lithologically and palaeon-
tologically of all the sedimentary units cropping out locally.

Florence Shale Member

NAMING OF THE MEMBER. The Florence shale (Table I) was
named by Prosser (1932, p. 712). The type locality is in quar-
riers near Florence, Merrill County, Iowa, The United States
Geological Survey classifies the Florenz shale as the lowest member of the Garrison formation but Moore (1933, p. 10) discarded the name Garrison and substituted Fleatlie, a practice now widely followed. The Florenz shale underlies the Morrill limestone and overlies the Cottonwood limestone.

**Areal Distribution.** The Florenz shale almost always is exposed above outcrops of the Cottonwood limestone (Plate I). One of the best fossil-collecting locations in the shale is an old quarry just north of Kansas State College in the NE 1/4 SE 1/4 sec. 7, T. 70 N., R. 5 W.

**Description of the Formation.** The Florenz is a thin-bedded to blocky clay shale predominantly calcareous, and containing numerous calcareous plates and nodules. The shale varies from tan to gray to olive drab but it weatherers tan. In some exposures, fossils are abundant in the lower 3 or 4 feet only. *Gonatae granulifera* is exceptionally abundant in the shale. Other fossils that may be abundant or numerous are: *Herbsia crassa*, *M. wabaunseeensis*, *Conocylis ovata*, *C. subtilita*, *Raspenid*, *Diplocladus amaristanus*, *D. portlockianus*, *Perkella striata*, *Polyspora* sp., *Gonastella* sp., *Omioida* columnar and calyx plates, *Allorina terminale*, *Atheonopora* sp., *Plenopora* sp., *Hissacشنosa* gaetznianus, *Crista modesta*, trilobite, and microfossil.

The average thickness of the Florenz shale is about 7 feet.

This shale can best be identified in the field by the abundance of *Gonatae granulifera*, plus other fossils and its position above the easily recognized Cottonwood limestone (For
detailed descriptions seeassured sections 13, 19, 20, 21, and 22).

Facies Changes in the Member. The Florensa shale, in the
northern outcrop area, becomes a dark gray to olive drab. This
shale is predominantly clayey in the southeastern outcrop area.

Morrill Limestone Member

Naming of the Member. The Morrill limestone (Table I) was
named by Condra (1927, pp. 234, 235, 237). The type locality
is west and 1 mile north of Morrill, Linc. Condra and Upp (1931,
p. 17) redesignated the type locality as an outcrop about 1
mile north of the original type locality and east of a north-
south road in the northwest corner of sec. 27 and southwest cor-
ner of sec. 22. The Morrill limestone overlies the Florensa
shale and underlies the Fierros shale.

Areal Distribution. The outcrop area of the Morrill lime-
stone is almost the same as that of the Cottonwood limestone
(Plate I). Outcrops of the Morrill, however, are not so clear-
ly exposed and are fewer in number. This limestone is exhib-
ted in a road cut in the [34 W1 NN] sec. 34, T. 10 N., R. 9
W., and another good exposure of this limestone was observed in
a road cut in the [32 NN] sec. 33, T. 9 N., R. 7 W.

Description of the Member. The Morrill limestone varies
greatly in hardness, is slightly argillaceous, and is tan to
gray-orange and weathers tan. The limestone is massive in
a fresh exposure but weathers quite porous and irregular wit
the top part developing an almond-like appearance. Three well-defined ledges are usually present in most exposures of the Morrill. None were observed in this study in Riley County. The average thickness of this limestone is about 2.5 feet.

The Morrill limestone can be identified in the field by its stratigraphic position above the easily recognized Cottonwood limestone (for detailed descriptions see measured sections 16, 20, 21, and 22).

Facies Changes in the Street. The only facies change noted in the Morrill limestone in Riley County is a tendency to thicken slightly toward the south.

Searsna Shale

Naming of the Formation. The Searsna shale (Table I) was named by Conrad (1927, p. 233, 234, 254, 235, 257). The type locality is north of Searsna School, west of Humboldt, Nebr. Conrad and Upp (1931, p. 16) redesignated the type locality as along a north-south road 6 miles south and 1 mile east of Humboldt, Nebr. The Searsna shale overlies the Morrill limestone and underlies the Mississippian limestone.

Geological Distribution. The Searsna shale outcrop area in Riley County extends 9 miles north of Manhattan, 4 miles toward the west, and south along both sides of the LaSalle River to the Cherry County line (Plate 1). Good exposures of the Searsna were found in road cuts in the 34, 32, 31, 30, and 29, T, 10 W. 1.

In the Nw1/4 sec. 33, T. 7 N., R. 1 W., and in the Ne1/4 sec. 9, T. 11 N., R. 2 W.

Description of the Formation. The Stearns is mostly a silty, calcareous, gray to olive gray slate that weathers light-gray to tan. It is thin-beded to blocky, and thin calcareous lenses and plates are usually present near the base. Limonite stains are frequently present on the bedding planes. No fossils were observed in the Stearns slate in Riley County. The average thickness of this slate is about 14 feet.

The Stearns slate is best recognized in the field by its stratigraphic position below the Blue limestone (for more detailed descriptions see restored sections 19, 20, 21, and 22).

Faces Changes in the Formation. The lower half of the Stearns slate, in the southern part of the outcrop area, consists of dark gray to olive gray slates but changes to a series of black fissile and serpentine beds in the northern part of the outcrop area.

Bader Limestone

The Bader limestone (Table 1) was named by Condra (1936, pp. 4, 7) from outcrop near Bader in Clay County, Iowa.

The Bader limestone consists of the Middleburg limestone member in the upper part, the Stearns slate member in the middle part, and the Stearns limestone member in the lower part. The total thickness of this formation is about 12 feet.
Mississippian Limestone Member

*Hemina of the Member.* The Mississippian Limestone (Table I) was named by Condra (1927, pp. 252, 253, 234, 223, 227). The type locality is located in the 11th sec. 3, T. 1 S., R. 13 W. on the Miss form 6 miles south of Humboldt, Nebr. The Miss limestone underlies the Lower shale and overlies the Stearns shale.

*Areal Distribution.* The outcrop area of this limestone extends 2 miles northwest and 3 miles west of Manhattan and south to the Gage, County line (Plate I). Good exposures of this limestone were studied in road cuts in the 11th sec. 34, T. 10 N., R. 9 E., in the 10th, 11th sec. 33, T. 10 N., R. 7 E., and in the 11th sec. 9, T. 11 N., R. 7 E.

*Description of the Member.* The Miss limestone usually consists of two limestones separated by a shale. The limestones are hard, massive but weathering blocky or porous, and are gray to tan-gray in color. The intermediate shale is thin-bedded, clayey to silty, calcareous, and usually tan or tan-gray. Fossils found in the limestone layers are: *Aulacoplectan occidentalis*, *Pseudomutis lata*, *Myalina sp.*, *Nucella striatocostata*, *Perthia creusa*, *Conopita sp.*, *crinoid calicles*, and *crinoid columnals*. The average thickness of this limestone is about 5 feet. The Miss Limestone forms the first prominent hillside bench above the Cottonwood Limestone. This bench is usually covered with weathered, porous, square blocks, which are one to two feet in diameter.

This limestone can easily be identified in the field by...
there weathered blocks, and its position above the readily identified Cottonwood limestone (For detailed descriptions see measured sections 19, 20, 21, 22, and 23).

**Facies Changes in the Member.** The Elas limestone, in the northern outcrop area, is composed of three limestone separated by two beds of dark shale; but in the southern part of the outcrop area there are only two limestone beds separated by a shale and there are four thin limestones and three shales comprising the Elas in the eastern outcrop area. This unit thickens southward because of thickening of the shale parting.

**Sooner Shale Member**

**Naming of the Member.** The Sooner shale (Table I) was named by Condra and Upp (1931, pp. 20, 21). The type locality is a highway cut and ravine just east of Sooner, Cowley County, Kansas. The Sooner shale underlies the Middleburg limestone and overlies the Elas limestone.

**Areal Distribution.** The Sooner limestone almost invariably are associated with those of the Elas limestone (Plate I). Good exposures of this shale were observed in road cuts in the 5 1/2 W 1/2 sec. 34, T. 10 S., R. 9 E., and in the 5 1/2 W 1/2 sec. 29, T. 10 S., R. 9 E., as well as in a bank of a stream in the 5 1/2 W 1/2 sec. 36, T. 11 S., R. 8 E.

**Description of the Member.** The Sooner consists of varicolored shale (maroon, green, gray, and olive brown) zones composed of silt, clay, and are predominantly calcareous and blocky.
There were no fossils found in this member. The average thickness of the looser shale is about 4 feet.

This shale can be identified in the field by its stratigraphic position between the Miss and Middleburg limestones (for detailed description, see measured sections 20, 21, 22, and 23).

Facies Changes in the Member. The looser shale thickens slightly toward the southeast.

**Middleburg Limestone Member**

**Name of the Member.** The Middleburg limestone (Table I) was named by Condra and Peck (1931, pp. 20, 22). The type locality is along Little Creek, 1 mile south of Middleburg school in the 1/4 sec. 36, T. 1 N., R. 13 W., in the southwestern Mercer County, W.Va.

**Areal Distribution.** The Middleburg limestone is almost invariably associated with outcrops of the Miss limestone (Plate I). The Middleburg is well exposed in road cuts in the NE 1/4 SW 1/4 sec. 34, T. 10 N., R. 17 W. and in the NW 1/4 SW 1/4 sec. 7, T. 11 N., R. 8 W.

**Description of the Member.** The Middleburg limestone consists of two limestones which are usually separated by a shale. The limestones are massive, hard, dense, and somewhat crystalline. They are gray to olive drab and usually weather light gray but in most exposures the weathered surface is covered with maroon stains. The intervening shale bed is silty, calcareous,
grey to black, and thin-bedded. The basal limestone layer contains the following fossils: *Aviculopecten occidentalis*, *Plectopora* sp., *Pseudomontis hemi*, *Pleuroptorius* sp., and crinoid columnals. Algae occur locally in the upper limestone. The average thickness of this limestone is about 4 feet.

The Middleburg seldom crops out conspicuously but occasionally a small bench can be identified between the Crouse and Miss limestones.

The Middleburg can best be identified in the field by two limestones with a dark shale parting and by its presence above the Miss limestone (For detailed descriptions see measured sections 21, 22, and 23).

**Facies Changes in the Member.** There were no important facies changes noted in the Middleburg limestone in Riley County.

**Easley Creek Shale**

** Naming of the Formation.** The Easley Creek shale (Table I) was named by Condra (1927, pp. 228-237). The type locality is on Easley Creek, in the NW1/4 sec. 36, T. 1 N., R. 13 E., 10 miles south and 1½ miles east of Humboldt, Richardson County, Nebr.

**Areal Distribution.** The Easley Creek shale is almost invariably associated with the Crouse limestone (Plate I). The Easley Creek shale is exposed in a road cut in the SW1/4 SE1/4 sec. 34, T. 10 S., R. 9 E. Another good exposure can be observed in an old road cut in the NW1/4 NW1/4 NW1/4 sec. 7, T. 11 S., R. 8 E. A third exposure of this shale is exhibited in a road cut.
in the NE 44, sec. 23, T. 10 N., R. 8 W.

Description of the formation. The Early Creek shale is variable in color. Gray, greenish-gray, and maroon predominate. The upper part is green-gray to gray and lower part is mostly maroon. This shale is composed predominantly of calcareous silt and is thin-beded to black. A thick, hard, massive limestone occurs in the upper part of the Early Creek. There were no fossils observed in this formation. The average thickness of this shale is about 20 feet.

This shale can be identified in the field by its position beneath the easily recognized Crouse limestone (For detailed descriptions see measured sections 21, 22, 23, and 31).

Facies Changes in the Formation. The limestone lens varies in its vertical position in the Early Creek shale. Although the limestone thickens toward the north, the shale thickens toward the southeast.

Crouse Limestone

Setting of the Formation. The Crouse limestone (Table 1) was named by Mead (1918, pp. 21, 25). The type locality is Crouse Hill in the Foraker quadrangle, Osage County, Okla. Goudre (1925, pp. 4, 6) included the Crouse Limestone as the basal member of the Fiegelow formation but later removed the Fiegelow as a formational unit.

Area Distribution. The Crouse limestone crops out south and west of Manhattan (Plate 1). Crouse benches at a point a
short distance north of the town, and are exposed, in the vicinity of Cleburne, in a stream bank in the NW 1/4 sec. 17, T. 8 N., R. 1 E., and at the base of a road cut just north of that city. This limestone is well exposed in road cuts in the NW 1/4 NE 1/4 sec. 7, T. 12 N., R. 3 E., and in the SE 1/4 SW 1/4 sec. 80, T. 12 N., R. 3 E.

Description of the Formation. The upper part of the Crouse limestone consists of thin-bedded limestone separated by numerous thin shale partings, whereas the lower part is massive. The limestones are hard, dense, weather blocks to platy, and are gray and brown and weather tan to gray. There are a few fossil fragments present in this limestone. The average thickness of the Crouse limestone is about 7 feet.

The Crouse limestone forms a prominent bench above the Blue limestone. Thin limestone plates are abundant on the weathered surface and usually cover the more massive beds. Two hillside benches are formed by this limestone in the south-eastern part of the county. A platy limestone bench lies a few feet above a second small bench covered by blocks of weathered limestone.

This limestone can be easily identified in the field by the numerous limestone plates present in the weathered surface (for detailed descriptions see measured sections 22, 23, 24, and 31).

Faults Changes in the Formation. There were no faults changes observed in the Crouse limestone in this county.
The Blue Rapids Shale

**Naming of the Formation.** The Blue Rapids shale (Table I) was named by Getchell and vip (1871, p. 22). The type locality is in a road cut along County R, northwest about 1/2 mile north of Blue Rapids, Kansas. Getchell (1871, pp. 7, 6) designated the Blue Rapids shale as the middle member of the Manhattan limestone. He later discarded the Manhattan and redefined the Blue Rapids shale as a formation.

**Areal Distribution.** A good exposure of the Blue Rapids shale was observed in a road cut in the 1714 NW 4 sec. 30, T. 21 N., R. 7 E. This shale is exhibited in a road and railroad cut in the 1856 NW 4 sec. 17, T. 21 N., R. 7 E., and a very good section of this shale is exposed in a road cut in the SW 1/4 NW 4 sec. 33, T. 10 N., R. 8 E.

**Description of the Formation.** The Blue Rapids shale is predominantly gray in color but contains brown and green zones in the middle part. This unit is thin-bedded to blocks of silt and clay shale. Calcium carbonate streaks and thin aragonite limestone lenses occur in the upper part of this shale in the northern outcrop area. There were no fossils observed in the Blue Rapids shale. The average thickness of this formation is about 20 feet.

The Blue Rapids shale is easily identified in the field by its stratigraphic position between the Osage and Kansas limestones both of which usually crop out conspicuously (for detailed descriptions see measured sections 25, 24, 21, and


**Indian Cuestas in the Formations.** A thin limestone lens is present in the northern outcrop area. The thickness of the Blue Beds varies is nearly constant in Tiller County. The limestones predominate in the northern part of the county, whereas gray-green, gray and maroon shales are more abundant in the center and southern parts of the outcrop area.

**Funston Limestone**

**Origin of the Formation.** The Funston limestone (Table I) was named by Cen duo and Fow (1931, p. 89). The type locality is at Camp Funston, Riley County, Kansas. Cen duo (1931, pp. 4, 6) designated the Funston limestone as the youngest member of the Pistol Formation. He later discarded this classification and redefined the Funston limestone as a formation.

**Areal Distribution.** The Funston limestone crops out in the eastern half of the county (Plate I). Exposures of this limestone were observed along the Blue River and for parts of Claymore and over the area lying immediately south and west of Manhattan. A good exposure of this limestone was observed in a road cut in the NE 1/4 sec. 33, T. 19 N., R. 9 E., and another good section is exhibited in a road cut in the NE 1/4 sec. 29, T. 8 N., R. 7 E.

**Description of the Formation.** The Funston limestone consists of two limestone beds with a shale parting in the lower or middle part. The limestones are soft, sandy-applestone, massive
and reflect blocks to help understand. They are tan to gray-brown and weather tan but a venter of green stain usually conceals the surface of the upper limestone. Calciteous nodules are sometimes present in this unit in the southern outcrop area and short nodules were noted in the lower limestone in the P. E. No fossils were observed in this formation. The average thickness of the Funston limestone is about 3 feet. The Funston limestone forms a hillside bench just below the prominent terrace formed by the Three Mile limestone bench.

This limestone can easily be identified in the field by its position below the Three Mile limestone (For detailed description see measured sections 23, 24, 25, 26, and 21).

Regional changes in the formation. The Funston limestone thickens and becomes very massive toward the southwest. One bed 14 to 20 feet thick and forms a very prominent hillside bench as can be observed in the S. E. sec. 16, T. 11., R. 49. The Funston limestone thinning in the southeastern and northern outcrop areas. In the latter, the Funston is composed of three limestones with two conspicuous scale partings.

**Spieoler Shale**

**Measurement of the formation.** The Spieoler shale (Table 1) was named by Cordura (1927, pp. 232, 234). The type locality is in the S. E. sec. 35, T. 11 N., R. 13 E., Spieoler Township, Ashland county, Neb.
Condra and Upp (1931, p. 83) divided the Speiser shale into the following: Speiser shale (restricted), Funston limestone, and Blue Rapids shale members. Condra later discarded this classification and designated each member as a formation.

Areal Distribution. Outcrops of the Speiser shale almost invariably are associated with those of the Threemile limestone (Plate 2). Good exposures of the Speiser shale were observed in road cuts in the N W 1/4 sec. 35, T. 10 S., R. 2 E., in NE 1/4 sec. 21, T. 11 S., R. 7 E., in the SW 1/4 sec. 29, T. 9 S., R. 8 E., in the NE 1/4 sec. 6, T. 6 S., R. 7 E., and in the NW NE 1/2 sec. 15, T. 6 S., R. 7 E. The Speiser shale was studied in Kitten Creek east of Beals and Winkler along fancy Creek.

Description of the Formation. The Speiser shale is tan-gray, gray, green, purple and maroon in color. There is a persistent limestone one foot thick about 3 feet from the top and in most exposures there is a second thin limestone just below the base of the Threemile limestone, which are thin-bedded to blocky, from silty to clayey and most of the beds are calcareous. The layers of limestone are hard, massive, and gray to gray-orange. The following fossils were found in the top part of the Speiser: crinoid columnals, echinoid spines, Juresania nebrascensis, Beryx crassa, Clonettes gregulisfera, Dictyocloactus americana, and trilobites. The average thickness of the Speiser shale is about 15 feet.

This shale can best be identified in the field by its vertical colors, fossiliferous zone, a thin persistent limestone in the
upper part, and by its position below the readily identified Three Mile limestone (for detailed descriptions see measured sections 23, 24, 25, 26, 27, and 31).

**Facies Changes in the Formation.** The懂厚e shale thick-ens gradually toward the north. The maximum difference being about 4 feet throughout the north-south extent of the county. In the southern part of its outcrop area a second limestone occurs below the persistent limestone of this shale. The top shale bed becomes dark gray to olive drab in the northern out-crop area.

The Chase group was first called a formation by Prosser (1908, pp. 771-786) and included in it all units from the Winfield limestone down to the base of the *Wreford* limestone. The Chase formation was later given the rank of group. Moore (1933, p. 17) placed the top of the Chase group so as to in-clude the Lute limestone. Moore, Frye, and Jewett (1944, p. 109) define the Chase group to include the following formations (descending order): Nolan limestone, Odell shale, Winfield limestone, Doyle shale, Hartnesson limestone, Hartfield shale, and the *Wreford* limestone.

**Wreford Limestone**

The *Wreford* limestone (Table I) was named by *Iny* (1898, p. 104). The type locality is near Wreford, Geary County, Kans. Prosser (1908, p. 713) defined the *Wreford* limestone as overlying
the Garrison formation and underlying the Wetfield shale.

The Bredford limestone is composed of the Schuyler limestone member in the upper part, the Havenville shale member in the middle, and the Threemile limestone member in the basal part.

Threemile Limestone Member

**Setting of the Member.** The Threemile limestone (Table I) was named by Moore (1930, p. 12) and designated as the basal member of the Bredford limestone. The type locality is along Threemile Creek on the Fort Riley Military Reservation.

May (1905) is usually given credit for the name Threemile through his suggestion of it as a possible name for this stratum. Combs and Upp (1931, p. 31) recommended that the lowest member of the Bredford limestone be named the Fourmile limestone. This name was rejected, however, since it previously had been applied to a sandstone in the Pennsylvanian system.

**Areal Distribution.** The Threemile limestone crops out in many places in the eastern half of Riley County (Plate I). It is exposed extensively along the Blue River from Manhattan to within a few miles of the Marshall County line and south of Manhattan as far west as Ness. The Threemile is exposed in the vicinity of McIntler on Fancy and Otter Creeks. A road exposure was studied in a road cut in the [N 1/2] sec. 33, T. 10 S., R. 6 W. Other excellent outcrops of this limestone are exhibited in Litter Creek, east of Leas and in a road cut in
Description of the Formation. The Threemile limestone usually consists of a thick nonflinty bed in the upper part and flinty beds in the lower part, although in some exposures, chert nodules and lenses are present throughout the full thickness of the limestone. A thin shale parting is present in the lower part. Shale partings were observed in the upper part of one exposure of this limestone. The limestones are light gray and weather light gray to tan-gray and are massive but weather blocky. The shale parting near the base of the member is silty, calcareous, thin-bedded, and fossiliferous. The fossils present in the Threemile limestone are: echinoid spines, crinoid columnals, Allorisma terminalis, Dictyoclostus americanus, Aviculopecten peracuta, Aviculopecten occidentalis, Hombergia crassa, D. tocaniensis, Composita ovata, Jurocapnia nebrascensis, and Ambocoelia sp. The average thickness of the Threemile limestone is about 8 feet.

The non-cherty upper part of the Threemile limestone is more resistant to weathering than the chert-bearing beds and, therefore, forms a prominent bench on most of the hillsides in its area at outcrop.

This member is easily identified in the field by its cherty limestones, persistent fossiliferous shale near the base, by the light gray limestones which forms the hillside bench (For more detailed descriptions see measured sections 23, 24, 25, 26, 27, and 31).

Sections Changes in the Formation. The Threemile limestone
thickens toward the south. A shale zone at the top and two shale partings near the base were observed in the Three-mile in the area north of Randolph. In this locality most of the chert is restricted to four well defined bands. The position and quantity of chert varies locally.

Ravensville Shale Member

Naming of the Member. The Ravensville shale (Table I) was named by Condra and Upp (1931, p. 32). The type locality is in a road cut on Highway U.S. 63 about 2 miles south of Ravensville, Kans. The Ravensville shale overlies the Three-mile limestone and underlies the Schroeper limestone.

Areal Distribution. Outcrops of the Ravensville shale almost invariably are associated with those of the Schroeper limestone (Plate I).

Description of the Member. The Ravensville is composed predominantly of shale with limestone lenses present in the upper part. The shale is mostly clay but contains some silt. It is calcareous, thin-bedded and olive green to dark gray. The calcareous zone near the top is massive and soft and varies in thickness throughout the county. The fossils found in this shale are: Ambocoelis sp., Aviculopectina peracuta, Allorina terminale, Polypora sp., crinoid columnals, Myalina sp., Pleurophorus sp., Pertusa crassa, Aviculopecten occidentalis, and Juresenia nebrascensis. The average thickness of the Ravensville shale is about 21 feet.
This shale is best identified in the field by its stratigraphic position between the Frankville and Schroyer limestones (for detailed descriptions see measured sections 23, 24, 25, 26, 27, and 31).

Radiolaria in the Shale. In a stream cut in the NE, sec. 16, T. 7 N., R. 6 E. There is a thin limestone bed near the middle of the Frankville with two thin limestone lenses in the upper part and two thin limestone lenses near the base. Aulacopleura occidentalis and Melongena sp. are very abundant in the middle limestone layer. The shales and limestone at this location are dark gray in color. In the southern outcrop area, there are two thin limestone lenses in the upper part of this unit and four thin limestone lenses are present in the upper part and two lenses in the basal part in the vicinity of Manhattan. Only one limestone lens was observed in this shale in the vicinity of Stockdale. Near Winkler, the upper part of the Frankville contains 6 to 8 feet of massive limestone. The total thickness of the Frankville shale varies but little over the area of outcrop.

Schroyer Limestone Member

Naming of the Member. The Schroyer Limestone (Table I) was named by Condra and Tipp (1931, p. 33). The type locality is on the east side of the valley at the Big Pine River about 1/2 miles below Schroyer, Marshall County, Kansas. The Schroyer limestone overlies the Frankville shale and underlies the
Areal Distribution. The outcrop areas of the Schroyer limestone are nearly the same as those of the Three-mile limestone (Plate I). In most of the outcrop areas, this limestone forms a bench higher, and back from that formed by the Three-mile limestone. The Schroyer limestone was studied in road cuts in the NE 1/4 NW 1/4 sec. 21, T. 11 S., R. 3 E., and in the NW 1/4 NE 1/4 sec. 29, T. 8 S., R. 7 E., as well as in a stream bank in the SE 1/4 NW 1/4 sec. 15, T. 7 S., R. 6 E. Other exposures of this limestone are well displayed in the vicinity of Jinkler and Cleburne.

Description of the Member. The Schroyer limestone is usually a massive limestone bed in which thin chert bands and occasional shale partings are intercalated. Chert nodules are usually scattered throughout most of the limestone beds. The limestones are hard, dense, and usually light gray. fossils noted in this limestone are: crinoid columns, Clasitica granulifera, Fenestella sp., echioid spines, Astococelia plano-convexa, Juresania nebrascensis, Dictyocephalus sp., Composita sp., and Allorisma sp. Ostracods are very abundant in the very top part of the Schroyer. The average thickness of this limestone is about 1 foot.

The upper, usually non-flinty, limestone bed forms a prominent hillside bench.

This limestone is readily identified in the field by its chert limestones, and by its position above the easily recognized Three-mile limestone. (For detailed descriptions see
measured sections 25, 26, 27, and 31).

**Decline Changes in the Limestone.** The Otterger, north of Stockdale, is a massive cherty limestone with only a single thin shale parting. Part of north of Stockdale, and toward the south as well, the shale had increases markedly in its thickness. A shale parting is also present in the middle of the limestone in the northern area of outcrop. The position and quantity of short bosses and nodules vary locally. The thickness of the Otterger limestone is nearly constant in this county.

**Watfield Shale**

The Watfield shale (Table I) was named by Prosser (1932, p. 714). The type locality is in Watfield Township, Chase County, Mo. The Watfield shale is composed of the Blue Springs shale member in the upper part, the Kinney limestone member in the middle part, and the Tymore shale member in the lower part.

**Tymore Shale Member**

**Mapping of the Member.** The Tymore shale (Table I) was named by Condra and Upp (1931, p. 37). The type locality is in ravines on the west side of a creek 2½ miles east of the south side of Tymore, Chase County, Mo. The Tymore shale underlies the Kinney limestone and overlies the Otterger limestone.
Areal Distribution. Outcrops of the Tynoro shale almost invariably are associated with those of the Florence limestone (Plate I). Good exposures of the Tynoro were observed in road cuts in the W 1/2 W 1/2 sec. 21, T. 11 N., R. 7 E., in the W 1/2 W 1/2 sec. 29, T. 9 N., R. 7 E., and in the NE 1/4 NE 1/4 sec. 32, T. 6 N., R. 7 W.

Description of the Shale. The Tynoro is a calcareous, clayey but somewhat sily, blocky, to thin-bedded shale. Tan-gray, green-gray and maroon shales predominate in the lower part of the member and gray-green, olive drab, and sometimes maroon shales in the upper part. Two thin fossiliferous limestone beds are usually present in most exposures of the Tynoro. The fossils found in the limestone beds are: Aviculopithecus occidentalis, Cyalina sp., and Orthosyalina quadrata. The average thickness of this member is about 43 feet.

This shale can easily be identified in the field by its stratigraphic position below the Florence limestone and above the Wilcox limestone (for detailed description see measured sections 27, 22, 29, 30, and 51).

Facies Changes in the Member. The Tynoro shale thins northward from the central part of the outcrop area. The fossiliferous limestone lenses are present in the middle of this shale in the southern and northern outcrop area and these limestones thin northward. Very fossiliferous shales occur above the limestone lenses in the southeastern outcrop area. The fossils found commonly in these shale are: Dervia crassa, Composite ovata, and Rhodopora sp. Less numerous are: Termini
wabaunseeensis, D. deercreekensis, "linesia nebrasconia", eocrinoid spines, and crinoid columnals. Mercon scales are also present in the top part of this shale but they occur only in the southern outcrop area.

Kinney Limestone Member

 Naming of the Member. The Kinney limestone (Table I) was named by Condra and Upp (1931, p. 37) from outcrops along the Burlington railroad cut just east of Kinney, Nebr. The Kinney limestone overlies the Wymore shale and underlies the Blue Springs shale.

 Areal Distribution. Outcrops of the Kinney limestone almost invariably are associated with those of the Florence limestone (Plate I). See the Wymore shale member for the location of good exposures.

 Description of the Member. The Kinney is a soft, massive, and slightly dolomitic limestone. The color is either light gray or tan with abundant black specks dispersed throughout the rock. Falls or nodules of clay occur locally and a line of chert nodules was found in one exposure of the Kinney. The fossils found in this limestone are: eocrinoid spines, crinoid columnals, Derbyia s., and Allorilama terminale. Microfossils are abundant in the very top part of this unit. The average thickness of the Kinney limestone is about 2.5 feet in Riley County.

 The Kinney limestone sometimes forms a small hillside
bench but its outcrop expression usually is a weak one.

This limestone can best be identified in the field by its soft, massive limestone and to the position below the Florence limestone (for detailed descriptions see prepared sections 27, 28, 29, 30, and 31).

**Tucker Limestone In the Kansas.** The Chinoey limestone thickens all the toward the southwest and north. A thin shale cutting in the basal part of this unit was noted in the northern outcrop area and rare fossils were found only in the southeastern outcrop. Microfossils are present in the top part of the Chinoey in nearly all exposures. Gastropods were observed in the limestone in the NE SW sec. 27, T. 11 N., R. 7 E.

**Blue Springs Shale Member.**

**Naming of the Member.** The Blue Springs shale (Table I) was named by Lindsey and Upp (1931, p. 3). The type locality is at the base of the type along the Blue River, southeast of Blue Springs, York County, Helm. The Blue Springs shale overlies the Chinoey limestone and underlies the Florence limestone.

**Regional Distribution.** Outcrops of the Blue Springs shale almost invariably are associated with those of the Florence limestone (Plate I). Good exposures of the Blue Springs were observed in road cuts in the SW SE sec. 21, T. 11 N., R. 7 E., in the NW SW sec. 29, T. 11 N., R. 7 E., and just north of Chinoey.
Description of the Member. The Blue Springs shale is predominantly clayey and calcareous in most exposures. Its color varies from maroon and green at the base to gray, green and sometimes tan in the upper part. Lenses of hard, massive, tan-gray limestone commonly occur near the top of the member. There were no fossils observed in this shale. The average thickness of the Blue Springs is about 30 feet.

This shale is easily identified in the field by its stratigraphic position immediately below the Florence limestone (for detailed descriptions see measured sections 29, 20, 30, 31, and 32).

Facies Changes in the Member. The Blue Springs shale thickens toward the west. It is thin in the southern part of the county but thickens slightly toward Randolph and was more in the vicinity of Cleburne. A very thick outcrop is exposed just east of Ogden. Three limestones occur near the top of this shale in the southern outcrop area and one in the middle part but only two limestone beds are present in the northern area of outcrop. Calcareous lenses are present in the top part in the exposure east of Ogden. Maroon and more silty shales predominate in the northern outcrop area.

Barneston Limestone

The Barneston limestone (Table I) was named by Condra and Upp (1931, p. 41). The type locality is in the bluffs, west and southwest of Barneston, Cass County, Neb. The Barneston
limestone consists of the Fort Riley limestone member in the upper part, the Oketo shale member in the middle part, and the Florence limestone member in the lower part.

Florence Limestone Member

**Naming of the Member.** The Florence limestone (Table I) was named by Prosser (1902, pp. 774-780, 792). The type locality is near Florence, Marion County, Kans. Prosser (1902) included the shaly limestone above and below the originally defined limestone bed as part of the Fort Riley limestone. He stated also that the Fort Riley rested on the Florence and included part of the main ledge of the Fort Riley shale in the Florence. These conclusions led Prosser to abandon the name Florence limestone. Moore, in 1932, redefined the units and designated the Florence as the limestone overlying the Blue Springs shale and underlying the Oketo shale.

**Areal Distribution.** The Florence limestone crops out principally in a wide belt extending from Cleburne toward the southwest corner of the county (Plate I). Exposures in the southern part of the county are confined to the area along the county line as far east as Highway K-13. Because of an anticlinal fold, the Florence limestone reappears at the surface in the vicinity of Pinklin. The Wetfield shale crops out, in numerous exposures, beneath the prominent bench formed by the Florence. Excellent sections of the Florence limestone were studied in road cuts along Highway K-13 at the southern boundary.
of the county, in the NW 1/4 sec. 29, T. 9 S., R. 7 W., and just north of Cleburne. It is well exposed in a stream bank north of Winkler and along north Otter Creek.

Description of the Member. The Florence is composed of massive beds of limestone containing numerous bands and nodules of chert. A thin shale parting is usually present near the top of this member but, in an exposure west of Winkler, three shale partings occur. The limestone is hard, massive, and weathers blocky. It is usually light gray to gray and weathers light gray to tan-gray. The shale partings are tan-gray to gray and include thin calcareous lenses. Fossils are more abundant in the shales than in the limestones. Fossils noted in the Florence are: Distoclostus americanus, Heridina crassa, Polyvora sp., Actinocolla sp., Conocilia ovata, Rhombopora sp., crinoid columnals, Peneistella sp., Aviculopecten occidentalis, Nockella striatocostata and Istenopora sp. The average thickness of this limestone is about 22 feet. The Florence limestone forms a very prominent hillside bench topographically higher than that formed by the Wreford limestone. Outcrops of the Florence limestone are characterized by well-rounded shoulders usually high on the hills. Chert nodules are especially conspicuous on weathered surfaces.

The Florence limestone can easily be identified in the field by its cherty limestone, round shoulder benches and its position above the Wreford bench. (For detailed descriptions see measured sections 29, 28, 30, 31, 32, 33, 34, 35, and 36).

Facies Changes in the Member. Shale partings are present in the top part of the Florence limestone west of Winkler and
southwest or northeast but are absent north of Bisker and north of Tooldale. The Tooldale limestone is quite thin in the vicinity of Bisker, becomes thinner near Tooldale, and thickens again in the southern end of Buttepop.

Monte Vale Member

Peleur of the Member. The Monte Vale (Table I) was named by Vose (1920) from exposures found near Monte in Marshall County, S. Dak. Haxby (1927) has subsequently included this member in part of the Fort Miles limestone.

Lithologic Distribution. Outcrops of the Monte shale almost invariably are associated with those of the Fort Miles limestone (Plate I). Good exposures of the Monte shale were observed in a road cut in the 80°W sec. 28, T. 2 S., R. 7 W., in a stream bank in the 80°W sec. 24, T. 2 S., R. 7 W., and in a road cut in the 80°W sec. 28, T. 2 S., R. 7 W.

Description of the Member. The Monte shale is composed of the various shale sections are separated by a layer of limestone lens. The shale is tan to light-gray, whitish, clayey, calcareous and are thin-bedded in structure. Several thin calcareous lenses usually are present in the upper shale, the middle one of which is thin, tan to gray, massive, and weather to block and step-like planes, and is here to gray to color. The fossils observed in the Monte shale are: **bortogenus** americana, **cassilina** cornua, **holbrookia** sp., **microura** sp., **regularia** sp., **endurus** columna, **lithoconia** columna,
Darwin acacia, L. acacia, L. ferruginea, L. leucothrix var., L. julina var., L. principis var., L. stipellata, L. sulphurea, L. sulphurea, and L. trilocularis. The overall thickness of this unit is approximately 6 feet.

The Frio unit is easily recognized in the field by the stratigraphic position between the Bart Aline and the Florence limestone and by the abundance of its fossils (for detailed descriptions see references pages 22, 23, 24, 25, 26, and 27).

Pleistocene in the South. The Frio unit thins slightly toward the west-southwest. The limestone beds described above are absent in the northern, eastern, and central areas, and are replaced by carbonate units of calcareous limestone. In the southern, eastern, and central areas, the unit is thinner with more sand and contains calcareous breccia in the uppermost part.

Fort Riley, Linn County, Kansas

Historical of the member. The Fort Riley limestone (Table 1) was named by Swallow (1900, p. 24). The type locality is Fort Riley, Geary County, Kansas. Proctor (1919, p. 731-733) described the Fort Riley as including the Florence limestone. Proctor later (1922) redetermined the Fort Riley limestone to include the units now comprising the Linnecor limestone. Moore (1956) revised the terminology of the unit and included the Fort Riley limestone as the upper member of the Linnecor limestone. The Fort Riley limestone overlies the Ottawa shale and underlies the Holsteinville shale.
**Areal Distribution.** The Fort Riley limestone crops out in the central part of the county (Plate I). The principal outcrop belt of the Fort Riley extends from Cleburne, south to Randolph, and west to Leets where the belt leaves the county. Two outlines of the Fort Riley limestone are present two miles east of Ogden. Partial exposures of this limestone can be seen anywhere on this outcrop line. This limestone was examined in a road cut in the NW\(\frac{1}{4}\) NW\(\frac{1}{4}\) sec. 6, T. 7 E., R. 5 E., in an old quarry in the NW\(\frac{1}{4}\) NW\(\frac{1}{4}\) sec. 28, T. 9 E., R. 6 E., and in a road cut and stream bank in the center of the NE\(\frac{1}{4}\) sec. 4, T. 6 S., R. 6 E.

**Description of the Member.** The Fort Riley consists of massive limestones in which there may be shale partings. Some of the limestone ledges usually weather to form blocks, others to form plates. The limestones range from fairly hard to soft and are somewhat dolomitic. They are usually tan to gray-orange and weather tan-gray. A shale parting is usually present near the base of this limestone member. There are three "rim rock" ledges present in the Fort Riley at the type locality but any two were noted in Riley County exposures, one near the base and the other in the middle part of this limestone. The "rim rock" is a massive ledge of limestone and, being more resistant to weathering and erosion, it forms a conspicuous rim on the shoulders of many hillsides. This massive part varies from 3 to 6 feet thick and usually becomes porous when weathered. Fossils identified in the Fort Riley limestone are: *Ambocoelia expense*, echinoid spines, *Derbisia crassa*, *Dicyoclostus* e.
crinoid columnals, *Rhombopora* sp., *Fenestella* sp., *Meekella striatocostata*, and brachiopod fragments. The average thickness of the Fort Riley limestone is about 35 feet.

The Fort Riley is easily recognized by its thickness, "rim rock" exposures, and stratigraphic position above the Florence limestone (For detailed descriptions see measured sections 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, and 42).

**Facies Changes in the Member.** The full thickness of the Fort Riley limestone was obtained in only one exposure (measured section 30) and variations in the thickness of the unit could not be determined. The part of the Fort Riley known as the "rim rock" is variable in its position within the member and may occur either at or near the base or in the middle part. In most exposures in this county, however, the "rim rock" occurs near the base of the Fort Riley. The "rim rock" attains a thickness of 6 feet near the center of the outcrop area and thins slightly toward both the north and south. This member is made up of soft, shale-weathering limestones in the northern outcrop area but becomes more massive and harder limestones in the southern outcrop area. It is difficult to define the contact between the Fort Riley and the shale that overlies it. The blue-gray color, which is characteristic of some exposures, is only local.

**Doyle Shale**

The Doyle shale (Table I) was named by Prosser (1920,
p. 715). The type locality is along Doyle Creek southwest of Florence, Marion County, Iowa.

Pass (1929) included all beds below the Winfield limestone in the Doyle slate. Condra and Upp (1931) divided the Doyle slate into three members, in descending order: Gage shale, Towanda limestone, and Holmesville shale. Moore (1936, p. 12) dropped the name Doyle slate and raised the members proposed by Condra and Upp to formation rank. Moore, Frye, and Jewett (1944, p. 103) reverted to the classification of Condra and Upp, which decision is followed in this report.

Holmesville Slate Member

**Naming of the Member.** The Holmesville shale (Table I) was named by Condra and Upp (1931, p. 43). The type locality is 1/4 mile west and 1/4 mile north of Holmesville, Gage County, Nebr. The Holmesville shale overlies the Fort Riley limestone and underlies the Towanda limestone.

**Areal Distribution.** Outcrops of the Holmesville shale almost invariably are associated with those of the Towanda limestone (Plate 1). Good exposures of the Holmesville shale were observed in road cuts in the NE 1/4 NW 1/4 sec. 6, T. 7 S., R. 6 E., in the NW 1/4 SW 1/4 sec. 17, T. 7 S., R. 6 E., and northwest of Stockdale in the SE 1/4 SW 1/4 sec. 31, T. 9 S., R. 5 E. A portion of the Holmesville crops out in a road cut west of Keats in the NE 1/4 SE 1/4 sec. 29, T. 9 S., R. 6 E.

**Description of the Member.** The Holmesville consists
predominantly of shales but usually contains one or more thin lenses of limestone most often present in the middle or lower part of the member. The shales are silty with some clay intermixed, are generally calcareous, and are gray, gray-green, olive drab and occasionally maroon. The maroon zone is usually in the middle part of the Holmesville but is absent in some exposures. The limestones are soft and usually argillaceous but locally may be dolomitic and arenaceous. The limestone lenses show penecontemporaneous folding in the northern part of the outcrop area and may contain microfossils. The average thickness of the Holmesville shale is about 19 feet.

The Holmesville shale is readily identified by its stratigraphic position between the Fort Riley and Towanda limestones (For detailed descriptions see measured sections 36, 37, 39, 40, 41, and 42).

**Facies Changes in the Member.** The Holmesville shale is thickest in the center of the outcrop area and thins toward the northeast. Its thickness is a constant thickness in the southern half of the outcrop area. The lenses of limestone are thickest in the south but disappear in the area west of Kesta and in the northeastern part of the county. The limestones correlate with three thin lenses southwest of Winkler.

**Towanda Limestone Member**

**Naming of the Member.** The Towanda limestone (Table I) was named by Moore (1920, p. 61). The type locality is in
the western part of the El Dorado oil field near Towanda, Butler County, Kans. Fath (1921, p. 54) designated the Towanda limestone as a bed in the Doyle shale. Condre and Upp (1931, p. 44) designated the Towanda limestone as the middle member of the Doyle shale, the classification followed in this report. The Towanda limestone overlies the Holmesville shale and underlies the Cane shale.

**Areal Distribution.** The Towanda limestone forms the first prominent bench above the Fort Riley limestone (Plate I). It crops out in the northern half of the county and forms prominent benches east of Riley and west of Kees. This limestone crops out also near the southwestern corner of the county. The Towanda limestone is well displayed in road cuts west of Kees in the NE 2/4 SW 1/4 sec. 29, T. 9 S., R. 6 E., in the SW 1/4 22 1/2 sec. 16, T. 7 S., R. 5 E., and in the NE 1/4 SE 1/4 sec. 17, T. 7 S., R. 6 E.

**Description of the Member.** The Towanda limestone is hard, dense in some zones, massive, and weathers to small blocks and plates. It is gray-orange to tan-brown and limonite stains and nodules appear abundantly on the surface. Very thin shale partings are locally present. Penecontemporaneous folding is exhibited in the southern and northern outcrops. Jewett (1939, p. 81) reported flint in this limestone in an exposure north of Leonardville. Microfossils are abundant in the basal ledge of this member. The average thickness of the Towanda limestone is about 12 feet.

It is easily recognized by its thickness, color, by small
blocks and plates found on the weathered surface, and its position above the Fort Riley limestone (For detailed descriptions see measured sections 36, 37, 38, 39, 40, 41, 42, 43, and 44).

**Facies Changes in the Member.** A tendency to become somewhat thicker toward the south is the only facies changes observed in the Towanda limestone as it is developed in Riley County.

**Gage Shale Member**

**Naming of the Member.** The Gage shale (Table I) was named by Condra and Upp (1931, p. 45) from outcrops between one and two miles south of the west side of Wymore, Gage County, Nebr. The Gage shale overlies the Towanda limestone and underlies the Stovall limestone.

**Areal Distribution.** Outcrops of the Gage shale almost invariably are associated with those of the Crosswell limestone (Plate I). The upper part of the Gage shale, in most outcrops, is exposed beneath the Stovall limestone. Good exposures of this shale were found in road cuts in the NE § SE ¹ sec. 19, T. 7 S., R. 5 E., and in the NE § NE ¹ sec. 25, T. 7 S., R. 5 E. The upper 15 feet of this shale were observed in a roadside ditch in the SW § NE ¹ sec. 31, T. 9 S., R. 5 E.

**Description of the Member.** The Gage shale is predominantly maroon in the lower two-thirds and tan-gray to gray-green in the upper third. The maroon zone is mottled with green and contains some well-defined thin green lenses. This shale is composed of
silt with some clay and is thin-bedded to blocky. The maroon zones are non-calcareous but the others are at least slightly calcareous. Thin limestone lenses occur in the upper part of the Gage in the eastern part of its outcrop area. The following fossils are generally present in the upper tan-gray to gray-green shales: Derbyia crassa, P. cymbula, P. boeserensis, crinoid columnals, Menopora sp., Polyposa sp., Aviculopecten occidentalis, Rhombopora sp., calcinoid spines, and Dictyoclostus americanus. The average thickness of this member is about 30 feet.

The Gage shale is recognized in the field by its position beneath the easily recognized Winfield limestone. (For detailed descriptions see measured sections 42, 43, 44, 45, 47, 48, and 49).

**Facies Changes in the Member.** The Gage shale thickens toward the northwest. Two thin limestone lenses are present in this shale in an exposure northeast of Riley but only one limestone was found in an exposure in the northern part of the county.

**Winfield Limestone**

The Winfield limestone (Table I) was named by Prosser (1927, pp. 64-66). Its type locality is in the vicinity of Winfield, Cowley County, Kans. Prosser (1927, pp. 64-66), in naming this limestone, called it the Winfield concretionary limestone, and later (1922, p. 715) classified it as a formation.
Baas, (1929, p. 27) defined the Winfield limestone to include only the beds now known as the Cresswell limestone. Condra and Upp (1931, p. 49-61) divided the Winfield limestone into the Cresswell limestone in the upper part, the Grant shale in the middle part, and the Stovall limestone as the basal part. Moore (1936, p. 12) gave the name of Luta limestone member to the uppermost beds of the Winfield limestone. Moore, Frye, and Jewett (1944) accepted the definition of the Winfield limestone made by Condra and Upp and, in so doing, dropped the Luta as a separate stratigraphic unit.

Stovall Limestone Member

Naming of the Member. The Stovall limestone (Table I) was named by Condra and Upp (1931, p. 49). The type locality is in the valley bluffs of Doyle Creek southeast of the Stovall elevator and farm and 7 miles southwest of Florence, Marion County, Kans. The Stovall limestone overlies the Sage shale and underlies the Grant shale.

Areal Distribution. Outcrops of the Stovall limestone almost invariably are associated with those of the Cresswell limestone (Plate I).

Description of the Member. The Stovall limestone is hard, dense, massive, and weathers blocky. It is gray to tan-gray in fresh exposures and weathers light gray to tan. Chert nodules, usually iron stained, are abundant in this limestone. Fossils found in the Stovall are: crinoid columnals, Dictyocleistus
americanum, A. portlockiurus, coiled spines, Polypora sp.,
Composita ovata and Bradal iod fragments. The average thickness of this member is about 1 foot.

This limestone is easily recognized in the field by the presence of a chart band and by its relative thinness (For detailed descriptions see measured sections 42, 43, 44, 45, 47, 48, and 49).

Facing Changes in the Member. The thickness of the Stovall limestone varies from 2.5 feet in the southern part of its outcrop area to 0.25 foot south of May Day in the northern part of the county where it may be represented by a line of chart nodules only. Although there are minor local variations in thickness, the regional tendency is toward thickening toward the southwest.

Grant Shale Member

Naming of the Member. The Grant shale (Table I) was named for Grant Township in Marion County by Gendric and Upp (1931, p. 90). The type locality is between 3 and 6 miles north of Florence, Kan. This unit overlies the Stovall limestone and underlies the Cresswell limestone.

Areal Distribution. Outcrops of the Grant shale almost invariably are associated with those of the Cresswell limestone (Plate I).

Description of the Member. The Grant is silty and calcareous, thin-bedded to blocky shale. It is tan-gray and weathers
The fossils observed in this shale are: *Composite ovata*, *C. subtillate*, *Morbyia crania*, *P. cephalica*, *Dictyoclostus americanus*, *P. portlockiyanus*, crinoid columnals, acroicoid spines, *Physopora* sp., *Rhabdopora* sp., *Allorissa terminale*, *Chonetes granulifer*, *Aviculopedon occidentatia*, and an excellent ostracod microfauna. The average thickness of the Grant Shale is about 1.7 feet.

This shale is best recognized by its stratigraphic position in the Winfield limestone (for detailed descriptions see measured sections 42, 45, 44, 46, 47, 48, 49, 50, and 51).

**Facies Changes in the Member.** The Grant shale thickens and thins locally. The maximum thickness is 11.5 feet, in the southwest corner of the county, and the minimum thickness, 7.7 feet was found near the northern boundary of the county. Small secondary structures locally developed in the underlying tovall limestone tend to give inaccurate indications of the thickness of the Grant shale. Fossils vary in abundance from one exposure to the next but that of a railroad cut west of Falls contains a most unusual abundance of fossils.

**Cresswell Limestone Member**

**Name of the Member.** The Cresswell limestone (Table I) was named by Condru and Upp (1931, p. 51). The type locality is on the east side of a golf course in the NE, sec. 18, T. 34 S., R. 4 E., at the eastern edge of Arkansas City, Cresswell Township, Cowley County, Kansas. As previously stated, Moore
(1936, p. 12) designated the Luta limestone as the top member of the Winfield limestone. Later, however, Moore, Prue, and Jewett (1944, p. 183) abandoned the Luta limestone as a unit in the Winfield limestone. There has been much controversy over the definition of the Cresswell and Luta limestones. Jewett (personal communication) stated that the contact between these two limestones is seldom evident and favors dropping the term Luta entirely. Fresh exposures of the upper Winfield in this county exhibit no possible line of distinction between these two limestones and weathered outcrops only suggest a break between a massive basal limestone ledge overlain by a layer of badly weathered marlstone and platy limestone.

Areal Distribution. The Cresswell limestone outcrop band is west of a line extending from Keats to Swede Creek (Plate I). The Cresswell is covered by younger stratigraphic units in the vicinity of Leonardville and near the northwest corner of the county. The Stovell limestone and Grant shale are present almost everywhere that Cresswell crops out. The Cresswell limestone was studied in a road cut in the NE 1/4 SE 1/4, sec. 31, T. 9 S., R. 5 E., in a railroad cut east of Ola in the NW 1/4 SW 1/4, sec. 1, T. 9 S., R. 4 E., in a road cut in the NE 1/4 SW 1/4, sec. 25, T. 7 S., R. 6 E., and numerous exposures were noted in road cuts about 5 miles north of Leonardville.

Description of the Member. The Cresswell limestone is massive, medium hard, and dolomitic in part. It weathers blocky in the lower part and platy or blocky in the upper part. The upper part often becomes porous and cavernous when it is badly
weathered and usually contains numerous calcite-filled geodes. The Cresswell is tan-brown to light gray and usually weathered tan-gray. The following fossils occur only in its lower part: abundant of eocrinoid spines and numerous crinoid columnals and brachiopod fragments. The average thickness of the Cresswell limestone is about 12 feet. A prominent though irregular bench formed by the Cresswell limestone and a second smaller bench is developed when the full thickness of the limestone is present. Numerous sink holes occur in the Cresswell in the SW\(^1\) sec. 6, T. 9 S., R. 6 E. In recent years, many of the older sinks have become filled in with silt and new ones have appeared.

The Cresswell limestone is easily recognized by its massive light gray limestone, abundance of eocrinoid spines in basal part, and its position above the easily identified Stovall limestone (For detailed descriptions see measured sections 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51).

Facies Changes in the Formation. No obviously significant facies changes were observed in the Cresswell limestone in this county.

Odell Shale

Naming of the Formation. The Odell shale (Table I) was named by Condra and Upp (1931, p. 59). The type locality is in a ravine and along highway cuts 1/36th of a mile south and 2.5 miles east of Odell, Gage County, Nebr. Condra and Upp (1931, p. 49) designated the Odell shale as the basal member.
of Enterprise formation. Moore (1936, p. 12) elevated the Odell shale to the rank of a formation, which assignment is accepted here. The Odell shale overlies the Crosswell limestone and underlies the Krider limestone.

**Areal Distribution.** Outcrops of the Odell shale almost invariably are associated with those of the Alamawon limestone (Plate I). The Odell shale is well exposed in a road cut south-west of May Day in the 9\(\frac{1}{4}\) W\(\frac{1}{4}\) sec. 36, T. 6 S., R. 4 E., and the upper part crops out in a road cut in the N\(\frac{3}{4}\) in S\(\frac{3}{4}\) sec. 15, T. 6 S., R. 6 E. The upper part of the Odell shale usually is exposed beneath most of the outcrops of the Nolan limestone.

**Description of the Formation.** The Odell shale is gray-green to maroon, often mottled with green, in the lower part and tan-gray to gray-green in the upper part. This shale is a noncalcareous silt with some clay. The average thickness of the Odell is about 25 feet.

The Odell shale is easily recognized in the field by the thick maroon shales and its stratigraphic position below the easily identified Nolan limestone (For detailed descriptions see measured sections 32, 33, 54, 25, 66, and 57).

**Facies Changes in the Formation.** Limited observations indicate the thickening of the Odell shale toward the northwest. The thickness ranges from 21 feet in the southwestern part of Riley County to 33 feet in the northeastern part.
Nolans Limestone

The Nolans limestone was named by Moore (1930, pp. 5-9). The type locality is in the vicinity of the Nolans railway siding near Parsons, Washington County, Kansas. Moore (1930, p. 12) defined this formation as overlying the Odell shale and underlying the Pearl shale. The Nolans limestone is composed of the Herington limestone member in the upper part, the Paddock shale member in the middle part, and the Krider limestone member in the lower part.

Krider Limestone Member

Naming of the Member. The Krider limestone member (Table I) was named by Condra and Upp (1931, p. 60). The type locality is in a road cut 1 mile south of Krider, Gage County, Nebraska. Condra and Upp (1931, p. 60) included the Krider limestone as the middle member of the Enterprise formation. Moore (1930, p. 12) discarded the Enterprise formation and placed the Krider limestone as the lower member of the Nolans limestone. The Krider limestone overlies the Odell shale and underlies the Paddock shale.

Areal Distribution. Outcrops of the Krider limestone almost invariably are associated with those of the Herington limestone (Plate I).

Description of the Member. The Krider is a soft, tan-gray, dolomitic limestone that has a sugary texture. This member is
usually composed of two thin limestones separated by a very thin shale parting but locally the Krider becomes a single massive bed of limestone. Fossils found in this unit are: Pleuroceras sp., *Jaline* sp., *Pseudornatita* lawnii and *Vulcanicnactia occidentalia*. The average thickness of this limestone is about 1.0 foot and so does not form a conspicuous hillside bench.

This limestone is best identified in the field by its stratigraphic position below the Moreton limestone (for detailed descriptions see measured sections 52, 53, 64, 55, 56, 7, and 8).

**Facies Changes in the Member.** The thickness of the Krider limestone remains nearly constant in this county although it appears to be slightly less thick in the eastern part of its outcrop area.

**Paddock Shale Member**

**Naming of the Member.** The Paddock shale (Table I) was named by Condra and Upp (1931, p. 61) from outcrops in a road cut 1 mile south of Krider, Paddock Township, Gates County, N.C. They listed the Paddock shale as the top member of the Enterprise formation. Moore (1931, p. 12) later discarded the Enterprise as a formalional unit and designated the Paddock shale as the middle member of the Molans formation. The Paddock shale overlies the Krider limestone and underlies the Moreton limestone.
Areal Distribution. Outcrops of the Paddock shale almost invariably are associated with those of the Kerington limestone (Plate I).

Description of the Member. The Paddock is a thin-bedded to blocky gray to olive green shale that weathers tan. It is composed either of noncalcareous clay or calcareous silt. There is a conspicuous calcareous zone in the southern outcrop area in the lower part of the member. Molds of Aviculopacton occidentalis occur on some of the bedding planes. The average thickness of this unit is about 12 feet.

The Paddock shale is easily recognized by its nearly constant thickness, generally gray color, and its stratigraphic position within the Melans limestone (for detailed descriptions see measured sections 52, 53, 54, 55, 56, 57, and 58).

Facies Changes in the Member. The thickness of the Paddock shale varies somewhat over the county. There is evidence of slight thickening toward the northwest and thinning toward the southeast. The Paddock is clayey and noncalcareous in the southern part of the county, but becomes progressively more silty and calcareous toward the north.

Kerington Limestone Member

Ending of the Member. The Kerington limestone (Table I) was named by Beede (1909, p. 253) and included as a part of the Marion stage. The type locality is in the vicinity of Kerington, Dickinson County, Kansas. Beede (1927) abandoned the Marion
formation as a stratigraphic unit and elevated the Wellington limestone to the rank of a formation on the Kansas group.

Moore (1936, p. 12) later defined the Wellington limestone as the top member of the Nolans limestone. The Wellington limestone overlies the Paddock shale and underlies the Wellington formation.

**Areal Distribution.** The Wellington limestone is exhibited in numerous exposures in the eastern half of the county (Plate I). This limestone crops out along the Osage-Kiley County boundary and its area of outcrop extends as far east as Riley, Walsburg, Randolph, and Otsego. The upper part of the Odell shale, the Krider limestone, and the Paddock shale are present in almost all of the outcrops in which the Wellington limestone appears. Good sections of the Wellington were noted in road cuts in the NE\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 3, T. 9 N., R. 6 E., in the NE\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 2, T. 9 N., R. 6 E., in the SW\(\frac{1}{4}\) NE\(\frac{1}{4}\) sec. 1, T. 9 N., R. 6 E., the SW\(\frac{1}{4}\) NE\(\frac{1}{4}\) sec. 14, T. 6 N., R. 4 E., and in the SW\(\frac{1}{4}\) NE\(\frac{1}{4}\) sec. 36, T. 6 N., R. 4 E.

**Description of the Member.** The Wellington is a medium-hard dolomitic limestone in which there are thin shale partings. The limestone is massive, porous, and is blocky to platy, and has a sugary texture. The Krider limestone resembles the Wellington limestone. For its observed in the Wellington are: *Placoporites* sp., *Nelana* sp., *Pseudofractis* luteus, *Avismillopecten* occidentalis, and *Loxonema* sp. The average thickness of this limestone is about 7 feet.

The Wellington limestone is easily recognized by its
thickness, color, by its soft dolomitic texture, molluscan fauna, and by the prominent hillside bench it forms (for detailed descriptions see measured sections 52, 53, 54, 55, 56, 57, 58, 59, and 60).

The Leonardian series (Table I) includes strata from the top of the Nolan limestone to the base of the Whitehorse sandstone. The Leonardian series is composed of the Hippewalla and Sumner groups of which only the basal part of the older, underlying Sumner group crops out in Riley County.

The Sumner group (Table I) was named by Cragin (1936). A thickness of about 50 feet of the Wellington shale represents this group in Riley County.

Wellington Shale

Naming of the Formation. The Wellington shale (Table I) was named by Cragin (1936, pp. 55-56) from outcrops in the vicinity of Wellington, Sumner County, Kans.

Cragin (1936, pp. 3, 16) described the Wellington shale and classified it as the top formation of the Big Blue series and Prosser (1937, pp. 94-96) included the same shale as a part of the Marion formation. Numerous authors included the Wellington shale in the "salt measures" and others defined it as a member of the Marion formation. Bass (1935) redefined this sequence of strata and included all beds between the "Red
beds" and the Ferington limestone in the Wellington shale, thus
discarding the "Marion formation". Moore (1936, p. 12) divided
the Ferington limestone into the Wellington shale at the top,
the Donegal limestone in the middle, and the Pearl shale at the
base. Moore, Frye and Jessee (1944, p. 129) classified the
Wellington shale as the basal formation of the Summerville
Group. This formation overlies the Bollans limestone and in one expo-
sure in Allen County it underlies the Dakota sandstone but
elsewhere it is overlain by Pleistocene formations.

Areal Distribution. The Wellington shale crops out locally in areas that lie east and northeast of Leonardville,
and somewhat more extensively near the northwestern corner of
the county (Plate 1). This formation was studied in road cuts
in the 5\textdeg1 and sec. 1, T. 8 N., R. 6 E., and the 5\textdeg1
15, T. 9 N., R. 5 E., as well as in a stream bank in the 5\textdeg1
sec. 1, T. 6 S., R. 4 E.

Description of the Formation. The part of the Wellington
exposed in this county consists of tan-gray shales in the upper
and lower part and maroon, gray and green shales in the middle
part. The shales are thin-bedded to blocky and are mostly
silty and calcareous. There is a tan-brown limestone at the
top of most exposures of this shale. This limestone is hard,
finely-grained, massive, and weathers porous to flinty. Pulver
banding appears in this limestone in the northeastern part of
the outcrop area. The limestone bed is thought to be the
equivalent to the "Hellemberg limestone" a unit cited extensive-
ly by earlier writers. Recently, however, the Kansas Geological
Survey has discarded the lower units of the Wellington shale. Only fragments of fossils were found in this limestone. The Wellington shale attained maximum thickness in this county of about 10 feet.

The Wellington shale can best be identified in the field by its stratigraphic position above the Springfield limestone and by the "Follenberg" limestone present in the top part of most outcrops (for detailed descriptions see measured sections 22 and 23).

Facing Changes in the Formation. The shale beneath the "Follenberg" zone becomes appreciably thicker toward the south.
The Colorado group is composed of the following formations, in descending order: Niobrara chalk, Carlile shale, Greenhorn limestone, Graneros shale, and Dakota sandstone. Only the Dakota sandstone crops out in Riley County.

Dakota Sandstone

**Naming of the Formation.** The Dakota sandstone (Table I) was named by Meek and Hayden (1902, pp. 419-420). The sandstones of the Dakota are the youngest consolidated rocks cropping out in Riley County. The Dakota sandstone immediately overlies the lower part of the Wellington shale.

**Areal Distribution.** The only outcrops of the Dakota sandstone in Riley County are exposed west of Pocatillo in secs. 1 and 2, T. 6 S., R. 4 E. (Plate I). A good exposure of this formation was studied in a road cut in the 5¼ N 4½ sec. 1, T. 6 S., R. 4 E.

**Description of the Formation.** The Dakota is represented locally by sandstones and conglomerates. The formation is composed of fine to coarse sand-size grains of quartz, predominantly, cemented by interstitial deposits of calcium carbonate. The conglomeratic zones are composed of iron-cemented sands, iron-stone concretions, and clay balls. The beds of sandstone are massive, weather blocky to nodular, and show some cross-bedding. Both the conglomerates and sandstones are dark-brown.
in color. The exposed thickness of the Dakota varies from 2 to 5 feet and the formation can easily be recognized in the field by its sandy lithology (For detailed description see measured section 60).

Facies Changes in the Formation. No facies changes were observed in that portion of the Dakota sandstone which crops out in this county.

Igneous Intrusives

There are three exposures of igneous rock in Riley County which are located in the NW\(\frac{1}{4}\) NE\(\frac{1}{4}\) sec. 6, T. 9 N., R. 5 E., in the SE\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 22, T. 9 S., R. 5 E., and in a stream cut in the SW\(\frac{1}{4}\) NE\(\frac{1}{4}\) sec. 23, T. 9 S., R. 6 E. (Plate I).

The exposure located in the NW\(\frac{1}{4}\) NE\(\frac{1}{4}\) sec. 6, T. 9 N., R. 5 E., is known locally as the Dale plug. R. C. Moore and W. P. Haynes (1930, pp. 183-197) described the petrography of this intrusion as a serpentinized, carbonized, porphyritic, peridotite breccia containing numerous stakes xenoliths, and phenocrysts of altered olivine with some altered augite and biotite. The groundmass is essentially serpentine and calcite with considerable chromeite and some magnetite. This rock gives a physiographic expression of a small knob 15 feet high and about 200 feet long.

The other two intrusives, differ from the one above, by the presence of small garnets and numerous limestone, shale, and chert fragments. There are no physiographic expressions
of these two intrusives.

The age of these igneous rocks is believed to be late Cretaceous.
The purpose of this section on structural geology is to record new structures located in the course of the field work in Riley County, to compile a listing of structures previously recorded in the county, and to indicate the relationship of stratigraphy to existing structures.

The consolidated rocks of Paleozoic age are included in the Prairie Plains monocline and the north Kansas Basin (J. W. Jewett, 1941, p. 93). These rocks show a regional dip toward the northwest of about 10 feet to a mile. The two major structures present in this county are the Abilene anticline and the Salina dome. The Salina dome is present in the vicinity of Zeandale and causes the Pennsylvanian rocks to crop out in that area. The dome is the result of supratenuous folding of strata over the buried Nemaha Ridge and its apex is believed to be located about 1½ miles south of Zeandale. The dip of the Permian strata on the west flank of the dome is clearly shown along the south valley wall of the Kansas River in the NE 25, T. 10 S., R. 9 E., and a steep southward dip can be seen in the strata south of Zeandale in secs. 15, 16, 17, and 11, T. 11 S., R. 9 E., as well as in a small knoll capped by the Americus limestone in sec. 9, T. 11 S., R. 9 E. A steep southeasterly dip is evident in the Grenola and Peattie limestones along the east side of sec. 22, T. 11 S., R. 9 E. Two small overthrust faults were observed south of Zeandale. One of these is a small overthrust fault, discovered by Neff
(1949), affecting the Terkio limestone as it is exposed in a stream bank in the E1 SW1 NW1 sec. 3, T. 11 S., R. 9 E. The other known overthrust is exhibited in the Caneyville limestone in an outcrop in a stream bank in the SW1 SW1 sec. 7, T. 11 S., R. 9 E.

Major faults occur in secs. 12, 13, 14, 25, 26, and 36, T. 11 S., R. 8 E. (Plate I). Eight faults are mapped in this area and the maximum displacement, about 10 feet, is developed along a normal fault in sec. 13, T. 11 S., R. 8 E. Strata from the Neva limestone to the Three mile limestone have been displaced by this mile-long fault. Another major fault, which is about 1½ miles long and shows a displacement of about 5 feet, was found in secs. 26 and 36, T. 11 S., R. 8 E. All of the faults in this area trend toward the northwest.

The Abilene anticline is the largest of the major structures in Riley County. The axis of this anticline extends along a line from Marshall County south through Winkler, west of Leonardville, and southwest of Malo. This anticline is responsible for the outcrop of older Permian strata in areas in which they would otherwise be covered by younger overlying rocks. Steep southeasterly dips of the Fort Riley limestone were observed on a hillside in the southern part of sec. 1, T. 6 S., R. 6 E. Other changes in the regional dip of the Fort Riley limestone were found along north Otter Creek and, in the Florence limestone, north and northeast of Winkler. Significant changes in dip have been observed in the vicinity of Winkler and along Fancy Creek (Plate I).
A small syncline in the northwestern corner of Riley County was discovered in the course of this field work and is probably responsible for the continued existence of the Dakota outlier. This structure is also reflected in the Nolan limestone cropping out west of Bedaville. Other structures related to the Abilene anticline were observed southwest of Winkler. Reversals of regional dip are well displayed in secs. 2, 10, 11, 14, 15, 21, 22, and 23 and parts of adjacent sections in T. 7 S., R. 5 E. A steep eastward dip, possibly the west limb of a syncline is responsible for the presence of the Wellington shale in sec. 6, T. 8 S., R. 6 E. and secs. 1, 2, 3, 10, 11, 12, and 13, T. 8 S., R. 5 E. (Plate I).

Another structure, also a part of the Abilene anticline, extends from Laka south to the Geary County line. The dip in this area is toward the southeast. This fold probably accounts for the presence of the Nolan limestone in this area (Plate I).

There is some evidence that a small dome may be present in secs. 23 and 24, T. 9 S., R. 4 E.

Small faults and flexures were observed in most exposures of the Stovall limestone and some of the outcrops of the Krider limestone but are not usually reflected in the thicker limestone above and below these units. A small overthrust fault occurs in the Stovall limestone in a railway cut in the NE 1/4 SE 1/4 and other similar minor structures are far too numerous to be cited here. A small normal fault was found in the Gaye shale in the NE 1/4 SE 1/4 sec. 19, T. 7 S., R. 3 E. A possible
extension of the Abilene anticline is reflected in the Winfield limestone south of Riley.
Pennsylvaniaian Period

The seas of the Pennsylvaniaian period covered almost all of midcontinental United States. In Kansas outcrops of the rocks deposited in these seas are restricted to the eastern part of the state but extend as far west as the southeastern part of Riley County. The small area of outcrop in Riley County affords little evidence of regional variation in the character of the rocks of the Pennsylvaniaian system and is productive of no more than meager indication of changes in the marine depositional environment of the midcontinental area.

The bulk of the sediments deposited in the Pennsylvaniaian seas apparently was eroded from land area toward the east and southeast. The shales of the Pennsylvaniaian system in Riley County are either constant in thickness or thicken slightly toward the northeast whereas the limestone thicken slightly toward the southwest or, too, are constant in thickness. Most of the shales in the local area of outcrop change from calcareous in the southwest to noncalcareous in the northeast. This evidence indicates that the shoreline lay northeast of Kansas during most of late Pennsylvaniaian time. The shoreline of the Pennsylvaniaian seas fluctuated to the extent that alternating thick shales and thin limestone were caused to be deposited over this region. The thickness of the Willard shale and
Tarkio limestone indicates that the shoreline was relatively stable for a longer interval during the deposition of each of these units. None of the shales exhibits any evidence of marked tectonic disturbances during the time of deposition. The color of the shales varies from tan-gray to gray, with thin interbedded gray-green zones and may indicate depth of deposition, a factor of minor fluctuations in the shoreline of the sea. An important series of oscillations of the Pennsylvanian shoreline apparently occurred during the time of deposition of the upper part of the French Creek shale and the Caneyville limestone. A coal lens, indicative of a swamp environment, occurs near the top of the French Creek shale. The shoreline must then have lain to the west of this region inasmuch as swamps are non-marine. A carbonized zone, which contains numerous wood fragments, occurs in the top part of the Caneyville limestone. This may indicate another short-lived retreat of the Pennsylvanian shoreline toward the west or may represent an unusual influx of stream-carried plant material into the sea. The argillaceous Brownville limestone shows that the shoreline lay to the east of the close of the Pennsylvanian period.

Permian Period

The seas of the Permian period for the most part, were restricted, in the United States, to the midcontinental region centered about Texas, Oklahoma, and Kansas. All of Kansas,
except possibly the extreme southeastern part of the state, was submerged beneath marine waters at the beginning of the period. The rocks deposited in these seas, however, crop out only in a wide belt extending from Marysville toward the south and southeast across the state. Permian strata conspicuously exposed over all of Riley County except the southeastern part from which they were subsequently eroded. These same strata are concealed beneath Cretaceous and younger rocks throughout the north-central and western parts of the state.

The evidence recorded in this county is only local indication of the paleogeographic events that ensued during the time of deposition of the Permian sediments. It can not portray the complete regional picture but should contribute to it. An example of the way in which a stratigraphic unit studied only over a small area may lead to an inaccurate regional interpretation is found in the Eskridge shale as it is developed in Riley County. This shale indicates, by its thickness, that the Permian shoreline was toward the north or northwest, but fossil leaves, lenses of coal, and dark-colored littoral shales, which characterize this shale in Morris County, clearly indicate the shoreline to have been toward the south or southeast. Complete regional information must be obtained to interpret accurately the paleogeographic conditions extant during Permian times.

The bulk of the Permian sediments deposited in this region came from the land areas toward the east and southeast. The thick limestones and well developed faunas of the Wolfcampian
series indicate deposition in quiet offshore waters. The thick red and green shales indicate deposition only a short distance from the shoreline and very likely include some non-marine zones. Occasional local thin seams of coal, as in the West Branch shale in Pottawatomie County and the Blue Springs shale in Geary County, indicate deposition in coastal swamps. Such oft-repeated changes in the lithology of the Permian strata are conclusive evidence of a widely and rapidly oscillating shoreline.

The data on variations in the thickness of the local Permian units also lead to the concept of a shifting shoreline. Most of the limestones are either constant in thickness or thicken toward the south and the shales thicken toward the north or are constant in thickness. Directional thickening of the following limestone and shale units indicates that the shoreline during their deposition lay immediately to the north of this area: Falls City limestone, West Branch shale, Lone limestone, Morena shale, Stevens shale, Miss limestone, Fannston limestone, Speiser shale, Three mile limestone, Pt. Miley limestone, Stovall limestone and the Herington limestone. Directional thickening of the Rooser and Blue Rapids shales indicates a southeastern shoreline and the units which indicate a southern shoreline are the Aspinwall limestone, Perr limestone, Salem Point shale, Nova limestone, Havensville shale, Wymore shale, and Grant shale. Evidence of a southwest shoreline is recorded in the Early Creek and Gage shales. Those units which indicate a northeastern shoreline are the Eskridge
shale, Morrill limestone, Odell shale, and Paddock shale.

Fairly definite evidence of the axis of a local Permian embayment during Havensville time is found in the area from Winkler to Handolp and extending toward the east into Pottawatomie County. This axis is clearly indicated in the Havensville shale, which in this area, includes many thick beds of limestones most of which grade laterally into shales toward the north and south. In the vicinity of Winkler, the uppermost 6 feet of the Havensville shale is all limestone. Evidence of the axis of a local embayment in the vicinity of Stockdale is found in the Brogan and Florence limestones but additional field study in adjacent areas will be required to establish the axis of this embayment more accurately.

The evidence of numerous minor retreats and advances of the Permian shoreline is clearly reflected in the shales and limestones of this area. Such minor oscillations undoubtedly occurred many times during the deposition of a single stratigraphic unit. The major phases in the retreat and advance of the shoreline is shown by alternating limestone and shales. Sharp, clearly defined contacts between most limestones and shales indicate abrupt changes in the depositional environment. But gradual changes are reflected in some of the local units in the presence of transitional zones of the contacts of limestones and shales. The Lewsby shales show evidence of a gradual advance and two sharp retreats of the shoreline.

Slow spreading of Permian seas is indicated at the end of the time of deposition of the Stearns, Blue Rapids, and Blue
Long intervals of uniform deposition, with only minor environmental changes, are evident in the units deposited above the oliveville shale and below the wellington shale. Such evidences as these appear to indicate quite conclusively that the shoreline of the early Permian embayment in this part of Kansas oscillated widely and irregularly.

Although only suggested by studies over an area as small as Riley County, the same evidence indicates a general shifting of the shoreline toward the south or southwest in the later stages of the Wolfcampian epoch. It is hoped that the investigation of the paleogeography of Kansas during the Permian period can be continued beyond the limits of Riley County in order that the regional pattern may be more accurately established.

Cretaceous System

The seas of the Cretaceous period covered most of the midwestern part of the United States including all of Kansas but the southeastern part. An outlier of the Dakota sandstone, which is the oldest formation of the upper Cretaceous, Gulfian series, is present in northwestern corner of Riley County and lies nonconformably on the wellington shale. The Dakota presumably was stream deposited on a coastal plain at the margin of the spreading late Cretaceous sea. The coarse conglomeratic zone containing ellipsoidal to spheroidal particles indicates deposition by fairly strong water currents and the
beds of sandstone probably were laid down by currents of moderate transporting power. The scant development of the Dakota sandstone in Riley County precludes a more complete paleogeographic interpretation.
ACKNOWLEDGMENTS

The writer desires to express appreciation and gratitude to Dr. Frank Byrne of Kansas State College who supervised the work throughout and offered many valuable suggestions during the course of the study; to other members of the Department of Geology, Kansas State College; to L. V. Beck and H. H. Burton for their advice on certain field problems; to Dr. J. F. Jewett, State Geological Survey of Kansas, for information on the upper Permian formations in this area; and to Mrs. R. C. Scalter and C. Powers for drafting the final map.
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This section from the Elmont limestone to the Auburn shale, inclusive, is exposed in a road cut and ditch in the center of the NW\(\frac{1}{4}\) sec. 32, T. 10 S., R. 9 E.

Feet

Soil, silty; dark; rock fragments at base. .......... 1.1

Elmont limestone. (2.0 feet)
Limestone, hard, dense; gray, weathers tan; massive, weathers blocky; fractures at nearly 90°; limonite stains and nodules. Fusulinids abundant, crinoid columnals, eocrinoid spines, Neospirifera sp., Pellerophon sp., and fossil fragments. .... 2.0

Harveyville shale. (15.2 feet)
Shale, clayey, slightly calcareous; gray-green; thin-bedded to blocky; calcareous nodules and limonite stains in upper part. .......... 5.5
Covered interval. ............. 9.7

Reading limestone. (2.1 feet)
Limestone, hard, dense; gray, weathers tan; massive, weathers irregularly; limonite stains and nodules. Crinoid columnals, Rhombopora sp., eocrinoid spines, fusulinids, and numerous brachiopod fragments. .......... 0.4
Limestone, hard, dense; gray, weathers tan; massive, weathers irregularly; limonite stains and nodules. Crinoid columnals, Euomphalus sp., Neospirifera sp., Rhombopora sp., eocrinoid spines, fusulinids, Loxonema sp., and numerous brachiopod fragments. .......... 5
Limestone, hard, dense; gray, weathers tan; massive, weathers blocky and irregularly; limonite specks, limonite stains, and nodules in upper part. Eocrinoid spines, crinoid columnals, Rhombopora sp., fusulinids, Neckella striatocostata, and sharks' teeth. .......... 6
Limestone, hard, dense; gray, weathers tan; massive, weathers irregularly; limonite specks in upper part. Ambocelilia sp., Loxonema sp., crinoid columnals, eocrinoid spines, Pellerophon sp., and numerous fossil fragments. .......... 6

Auburn shale. (6.6 feet exposed)
Shale, silty, calcareous; tan-gray; blocky; iron stains on fracture planes. .......... 3
Limestone, argillaceous in middle, hard, dense; dark gray, weathers tan; thin-bedded; lenticular; porous; limonite-stained. .......... 5
Shale, silty, with some clay, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; carbon stains on bedding and fracture planes, calcareous nodules in upper part. . . . . 3.3

Base covered.
Section 2

This section from the Tarkio limestone to the Harveyville shale, inclusive, is exposed in a stream cut in the NE 1/4 NW 1/4 sec. 5, T. 11 N., R. 9 E.

Feet

Tarkio limestone. (14.5 feet)
Limestone, hard; gray-orange, weathers brown; massive, weathers irregularly; porous; small, calcareous nodules in lower part. Large fusulinids very abundant, crinoid columnals, and brachiopod fragments. Fossils weather lighter than matrix... 5.6
Shale, silty, calcareous; olive-brown, weathers tan; thin-bedded; contains calcareous nodules, deeply limonite-stained in lower part. Crinoid columnals, fusulinids, and brachiopod fragments... 0.8
Limestone, shale; gray-orange, weathers tan; thin-lenticular limestone with lenticular shale partings. Crinoid columnals and fossil fragments... 6.5
Limestone, hard, dense, somewhat crystalline; light gray to gray-orange, weathers tan-gray; massive. Large fusulinids, which weather lighter than the matrix, are exceedingly abundant in the middle and lower parts. Crinoid columnals, *Axophyllum rude*, *Lophophyllum proliferum*, echinoid spines, *Composita sp.* and other brachiopod fragments are also present... 7.25

Willard shale. (27.6 feet)
Shale, clayey with some silt, calcareous; blue-gray, to tan-gray; thin-bedded to blocky; limonite stains on fracture and bedding planes... 27.6

Elmont limestone. (2.3 feet)
Limestone, hard, dense; blue-gray, weathers light blue-gray; massive, weathers to large elongated blocks; iron stains on fracture planes. Worm burrows? in the upper part, *Marginifera sp.*, large and small fusulinids abundant, crinoid columnals, *Ambocoelia sp.*, *Composita sp.*... 2.3

Harveyville shale. (4.5 feet)
Shale, blue-gray, weathers light gray; thin-bedded. (exposed only beneath waterfall)... 4.5
Section 3

This section from the Dover limestone to the Auburn shale, inclusive, is exposed in a road cut in SW\(1/4\) NW\(1/4\) NW\(1/4\) sec. 27, T. 10 S., R. 9 E.

<table>
<thead>
<tr>
<th>Soil, silty, gray; rock fragments</th>
<th>2 1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dover limestone. (2.5 feet exposed)</strong></td>
<td></td>
</tr>
<tr>
<td>Limestone, only blocky and nodular fragments, gray, weathers light gray. Fusulinids abundant, algal nodules common. Forms small hillside bench</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Largdon shale. (16.0 feet)</strong></td>
<td></td>
</tr>
<tr>
<td>Covered interval</td>
<td>6.5</td>
</tr>
<tr>
<td>Shale, clayey with some silt, noncalcareous; blue-gray, weathers gray-green; thin-bedded; limonite stains on bedding planes, limonite plates on the weathered surface</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Maple Hill limestone. (0.9 feet)</strong></td>
<td></td>
</tr>
<tr>
<td>Limestone, hard; gray-brown, weathers tan; massive, weathers irregular plates and blocks; fractures about a 30° angle from the vertical. Crinoid columnals, small and large fusulinids abundant, brachiopod fragments, the fossils weather the same color as the matrix. Forms small, but not too conspicuous, hillside bench</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Wasego shale. (14.3 feet)</strong></td>
<td></td>
</tr>
<tr>
<td>Shale, clayey, calcareous; tan to gray, weathers orange-gray; thin-bedded; contains abundance of limonite stains and plates, thin limonite plates abundant on the weathered surface</td>
<td>14.8</td>
</tr>
<tr>
<td><strong>Tarkio limestone. (11.2 feet)</strong></td>
<td></td>
</tr>
<tr>
<td>Limestone, hard; brown, weathers gray-brown; massive, fractures into irregular blocks and fragments; limonite-stained. Large fusulinids abundant, algae, crinoid columnals, some brachiopod fragments and echinoid spines. This limestone is not well exposed as a hillside bench, but tapers down to the more resistant underlying limestone bed</td>
<td>5.5</td>
</tr>
<tr>
<td>Limestone, hard, very dense in upper part; tan-brown, weathers gray-brown; massive, weathers in large irregular blocks; styolites present in upper part. Large fusulinids very abundant, crinoid columnals, echinoid spines. The upper 3 feet is nonfossiliferous. Forms very prominent hillside bench with large blocks slumped down upon the underlying shale</td>
<td>5.7</td>
</tr>
</tbody>
</table>
Willard shale. (22.1 feet)
Stale, clayey, noncalcareous; tan-gray to tan, 
weathers tan; thin-bedded to blocky; limonite 
stains on bedding planes. ................. 22.1

Elmont limestone. (1.9 feet)
Limestone, hard, dense; blue-gray, weathers light 
blue-gray; massive, fractures at nearly 45° to 
elongated blocks; some limonite stains on weathered 
surface, with a calcareous, illite-stained 
zone, 0.2 foot thick, present at very top. Small 
 fusulinids common, large fusulinids, small crinoid 
columnals, few echinoid spines, few brachiopod fragments. Forms small hillside bench. . . 1.9

Harveyville shale. (19.1 feet)
Stale, clayey, slight calcarceous; gray-green; 
thin-bedded to blocky; some limonite stains on 
bedding planes. ......................... 19.1
Covered interval. ....................... 2.2

Reading limestone. (2.0 feet)
Limestone, hard, dense; blue-gray, weathers tan-
gray; three definite beds of the same lithology; 
massive, weathers to irregular blocks; some 
limonite stains. Crinoid columnals, brachiopod 
fragments, echinoid spines, Conoceratites 
gracilis, Derbyia crassa, Rhombopora sp., and some else. . 2.0

Auburn shale. (6.5 feet exposed)
Stale, clayey, noncalcareous; dark gray, weather 
gray; thin-bedded; some limonite stains on bedding 
planes. ......................... 6.5

Base covered.
This section from the Dry shale to the top of the Tarkio limestone, inclusive, is exposed in a tributary in the center of the SW1 sec. 32, T. 10 S., R. 9 E.

**Section 4**

<table>
<thead>
<tr>
<th>Soil, silty; dark; some colluvium</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry shale. (3.3 feet)</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded; heavily limonite-stained with some limonite nodules and numerous calcareous nodules. Algae and large fusulinids abundant, small fusulinids, crinoid columnals, Darbyia sp., Hombopora sp. (This shale might be a transitional phase of the upper part of the Dover limestone rather than true Dry shale).</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Dover limestone. (2.7 feet)
Limestone; basal part: hard; gray, weathers light gray; massive, weather nodular; somewhat limonite-stained. Algae and large fusulinids abundant, some small fusulinids, crinoid columnals, Darbyia sp., small Neospirifer sp., Hombopora sp., Hustedia mormoni, and fossil fragments.

Langdon shale. (2.5 feet)
Shale, silty, calcareous; gray-green, weathers light green; blocky; some limonite and carbon stains.

Maple Hill limestone. (1.2 feet)
Limestone, hard; gray, weathers tan; massive to blocky, weathers to irregular plates in the upper part; limonite-stained. Small fusulinids abundant, large fusulinids common, crinoid columnals, Ambgogetia sp., crinoid spines. Forms small, inconspicuous hillside bench.

Wamego shale. (12.2 feet)
Shale, silty, calcareous; blue-gray to tan-gray, weathers tan; thin-bedded to blocky; heavily limonite-stained, some carbon stains, numerous limonite plates on weathered surface.

Top of Tarkio limestone.
This section from the Grandleven to the top of the Tarkio limestone, inclusive, is exposed in a ditch in the NE 1/4 sec. 5, T. 11 S., R. 9 E.

Feet

Soil, silty; dark. ................................................. 1 +

Grandleven limestone. (1.4 feet)
Limestone, hard; gray, weathered tan; massive, weathers to irregular plates. Crinoid columnals abundant, Allorisma terminalis, Aviculopecten peracuta, Chonetes granulifera, small and large fusulinids. ........ 1.4

Dry shale. (11.9 feet)
Shale, silty, very calcareous; tan to gray, weathers gray; thin-bedded to nodular; contains thin, gray-brown limestone lenses; iron stains on bedding planes. .................. 2.5
Shale, clayey, noncalcareous; gray-green, weathers gray; thin-bedded; limonite-stained. .................. 3.6
Shale, silty, calcareous; gray to yellow-gray, weathers yellowish-tan; thin-bedded; contains some calcareous nodule; iron-stained. .................. 4.3
Shale, silty, very calcareous; gray-green, weathers tan-gray; nodular; iron-stained. Dictyoclostus sp., Juresania nebrascensis, eocrinoid spines and plates, Ambococlia sp., Chonetes granulifera, Berbyra crassa, crinoid columnals, Nombopora sp. (This shale might be a transitional phase of the upper part of the Dover limestone rather than true Dry shale). .................. 1.5

Dover limestone. (1.6 feet)
Limestone, somewhat argillaceous; gray, with a greenish tint, weathers light gray; massive, weathers nodular to blocky; iron stains on bedding and fracture planes. Algae abundant, fusulinidae common, and eocrinoid spines. .................. 1.6

Langdon shale. (13.6 feet)
Shale, (partly covered by slump), clayey, noncalcareous; greenish-gray, weathers light gray; thin-bedded; some limonite stains. .................. 13.6

Maple Mill limestone. (0.9 feet)
Limestone, (poorly exposed), hard, dense; gray-brown, weathers tan; massive, weathers irregularly. Crinoid columnals abundant, large and small fusulinids abundant. .................. 0.9
Wamago shale. (11.6 feet)
Shale, clayey, noncohesive; blue-grey to tan,
weathers tan; thin-beded; numerous limonite
plates on the weathered surface. ............... 5.5
Covered interval. .................................. 0.1

Tarkio limestone. (1.5 feet exposed)
Limestone, hard, somewhat dense; tan-brown, weathers
brown; massive, weathers plasty. Large fusulinids
abundant. ....................................... 1.5
This section from the Friedrich shale to the Langdon shale, inclusive, is exposed near the east of a tributary in the SW 1/4 NE 1/4, sec. 36, T. 10 N., R. 9 E.

<table>
<thead>
<tr>
<th>Foot</th>
<th>Soil, silty and clay; dark; some weathered chert gravel.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2±</td>
<td>Friedrich shale. (0.9 feet exposed)</td>
</tr>
<tr>
<td></td>
<td>Shale, clayey, noncalcareous; gray-green, weathers</td>
</tr>
<tr>
<td></td>
<td>light gray-green; thin-bedded; iron stains on</td>
</tr>
<tr>
<td></td>
<td>bedding planes.</td>
</tr>
<tr>
<td>0.9</td>
<td>Grand Haven limestone. (4.7 feet)</td>
</tr>
<tr>
<td></td>
<td>Limestone, somewhat argillaceous, light gray-green,</td>
</tr>
<tr>
<td></td>
<td>weathers light gray; massive, weathers with</td>
</tr>
<tr>
<td></td>
<td>rounded corners. Numerous crinoid columnals</td>
</tr>
<tr>
<td></td>
<td>which weather white on the surface, small and</td>
</tr>
<tr>
<td></td>
<td>large fusulinids, Crinoid granuliferus.</td>
</tr>
<tr>
<td>0.7</td>
<td>Shale, clayey, noncalcareous; gray-green, weathers</td>
</tr>
<tr>
<td></td>
<td>light gray-green; blocky; limonite stains on</td>
</tr>
<tr>
<td></td>
<td>fracture planes.</td>
</tr>
<tr>
<td>2.1</td>
<td>Limestone, hard, dense; brown, weathers light brown;</td>
</tr>
<tr>
<td></td>
<td>massive, weathers to irregular plates; limonite</td>
</tr>
<tr>
<td></td>
<td>stains abundant. Crinoid columnals, Doryidin sp.</td>
</tr>
<tr>
<td>1.9</td>
<td>and echinococcus sp.</td>
</tr>
<tr>
<td></td>
<td>Dry shale. (6.9 feet)</td>
</tr>
<tr>
<td></td>
<td>Covered interval.</td>
</tr>
<tr>
<td>6.8</td>
<td>Dover limestone. (3.6 feet exposed)</td>
</tr>
<tr>
<td></td>
<td>Limestone, soft, argillaceous, certain areas are</td>
</tr>
<tr>
<td></td>
<td>hard; gray-green, weathers light gray; massive,</td>
</tr>
<tr>
<td></td>
<td>weathers to irregular blocks and nodules; the</td>
</tr>
<tr>
<td></td>
<td>middle zone becomes hard, brown, and massive; iron</td>
</tr>
<tr>
<td></td>
<td>stains on fracture planes. Small and large</td>
</tr>
<tr>
<td></td>
<td>fusulinids and algae abundant, Vaccilocopites</td>
</tr>
<tr>
<td></td>
<td>occidentalis, Mackella straitocostata, and</td>
</tr>
<tr>
<td></td>
<td>echinoid spines. The middle part resembles the</td>
</tr>
<tr>
<td></td>
<td>Turkio limestone in color. The Dover limestone forms</td>
</tr>
<tr>
<td></td>
<td>small hillside bench.</td>
</tr>
<tr>
<td>3.6</td>
<td>Langdon shale. (5.5 feet exposed)</td>
</tr>
<tr>
<td></td>
<td>Shale, silty, noncalcareous; gray-green, weathers</td>
</tr>
<tr>
<td></td>
<td>tan-gray; thin-bedded; limonite and iron stains on</td>
</tr>
<tr>
<td></td>
<td>bedding and fracture planes.</td>
</tr>
<tr>
<td>5.5</td>
<td>Base covered.</td>
</tr>
</tbody>
</table>
**Section 7**

This section from the Indian Cave sandstone member of the Towle shale to the Grandhaven limestone, inclusive, is exposed in a road cut in the NE 34 sec. 30, T. 10 S., R. 9 E.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Soil, silty, with limestone fragments; gray</th>
<th>2.1</th>
</tr>
</thead>
</table>

Towle shale. (41.0 feet exposed)

Indian Cave sandstone member. (41.0 feet exposed)

- Sandstone, fine quartz grains; tan to tan-brown;
- Thin-bedded and cross-bedded; numerous mica flakes;
- Iron cemented, limonite stains and plates numerous, limonite concretions, some carbon stains.

**Covered interval...**

<table>
<thead>
<tr>
<th>Feet</th>
<th>12.2</th>
</tr>
</thead>
</table>

Friedrich shale. (3.6 feet exposed)

- Slate, clayey, calcareous; gray, weathers light gray; blocky; some calcareous nodules.

**Grandhaven limestone. (2.8 feet)**


**Base covered.**
**Section 2**

This section from the Aspinwall limestone to the Dry shale, inclusive, is exposed in a stream bank in the NE 1/4 NE 1/4 sec. 9, T. 11 S., R. 9 W.

<table>
<thead>
<tr>
<th>Limestone Type</th>
<th>Exposure</th>
<th>Characterization</th>
<th>Carbon Stains</th>
<th>Iron Stains</th>
<th>More Carbon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspinwall limestone</td>
<td>(0.6 feet)</td>
<td>Limestone, hard, somewhat crystalline; ray-brown, weathers tan-brown; massive, weathers in irregular blocks. Crinoid columnals, Dictyocestus sp., Fenestella sp., Menopora sp., Clionetes granuliferus, Rhombopora sp., and Marginifera sp.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>0.6</td>
</tr>
<tr>
<td>Towle shale</td>
<td>(33.5 feet)</td>
<td>Unnamed shale member. (11.2 feet) Shale, clayey, noncalcareous; gray to blue-gray; thin-bedded; thin coal lens near base, numerous carbon stains on bedding planes in lower part, iron and limonite stains.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>11.2</td>
</tr>
<tr>
<td>Indian Cave sandstone member.</td>
<td>(21.3 feet)</td>
<td>Sandstone, gray in upper part; fine, well-sorted quartz grains; tan to tan-brown; thin-bedded with some crossbedding; nice flakes numerous, limonite stains and concretions, few carbon stains.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>21.3</td>
</tr>
<tr>
<td>Covered interval</td>
<td></td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td>11.0</td>
</tr>
<tr>
<td>French Creek shale</td>
<td>(5.5 feet)</td>
<td>Shale, clayey, noncalcareous; gray-brown, weathers yellow-tan; thin-bedded to blocky; numerous limonite stains.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>5.5</td>
</tr>
<tr>
<td>Jim Creek limestone</td>
<td>(1.1 feet)</td>
<td>Limestone, hard, dense; gray with a purplish tint, weathers gray with a brown zone near the top; massive, weathers to form blocks which weather further into small chips; iron stained in upper part. Crinoid columnals, Clionetes granuliferus, Rhombopora sp., Dictyocestus americanus, Aviculochina sp., and Composita sp.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>1.1</td>
</tr>
<tr>
<td>Friedrici shale</td>
<td>(12.3 feet)</td>
<td>Shale, clayey, noncalcareous; gray-green at base becoming tan-green in upper part, weathers yellowish-tan; thin-bedded; limonite-stained.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>8.2</td>
</tr>
<tr>
<td>Covered interval</td>
<td></td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td>4.1</td>
</tr>
</tbody>
</table>
Grand Haven limestone. (1.6 feet)
Limestone, hard; gray with a green tint, weathers tan-gray; massive, weathers to form irregular blocks or small chips; iron stains. Crinoid columns abundant, small and large fusulinids, echinoid spines, and Allorica sp. ................ 1.6
Dry shale. (9.8 feet exposed)
Shale, silty, very calcareous; gray-green, weathers tan; thin-bedded; thin limestone lens near base. Conchites granuliferus, Nitrobonara sp., crinoid columns, Berthia sp., Pluraplorus sp., and Aviculopetctis accidentally lig. This shale is possibly a transitional plane between the Dry shale and the Grand Haven limestone. .................. 2.1
Shale, clayey, noncalcareous; gray-green weathers light gray-green; thin-bedded; numerous calcareous nodules at base; some limonite stains. ........... 3.6
Shale, silty, calcareous; tan-brown, weathers yellow-brown; thin-bedded; iron stains and calcareous nodules. .................. 4.3
Base covered.
This section from the top of the Aspinwall limestone to the French Creek shale, inclusive, was secured in a small stream bank in the NE $\frac{1}{4}$ sec. 31, T. 10 S., R. 7 E.

**Feet**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black, silty; limestone fragment</td>
<td></td>
<td>2 ½</td>
</tr>
<tr>
<td>Aspinwall limestone.</td>
<td>Limestone, hard, brecciated, somewhat crystalline, gray-orange, weathers gray, massive, weathers blocky; limonite stains and nodules abundant; clay balls and lenses, limonite zone at base; crinoid columnals abundant, Bellanopterus sp.</td>
<td>1.1</td>
</tr>
<tr>
<td>Towle shale.</td>
<td>Shale, clayey, calcareous; tan-gray, weathers tan; thin-beded; contains calcareous nodules. Calcareous zone in middle, some limonite stains on bedding planes.</td>
<td>6.9</td>
</tr>
<tr>
<td>Brownville limestone.</td>
<td>Limestone, soft; argillaceous gray-green to tan, weathers tan; blocky, weathers nodular; heavily limonite-stained; Conodonta (argillis) abundant, <em>Hansinifera</em> sp., common, crinoid columnals abundant, <em>Benthosporus</em> sp., <em>Lumoscolites</em> (clinitus) and <em>Boscolites</em> sp.</td>
<td>1.9</td>
</tr>
<tr>
<td>Pony Creek shale.</td>
<td>Shale, (mostly covered) silty, calcareous; tan, weathers tan; thin-beded; heavily limonite-stained</td>
<td>6.9</td>
</tr>
<tr>
<td>Coneyville limestone.</td>
<td>Limestone, hard; tan-brown, weathers tan-gray; massive, weathers blocky; limonite nodules and stains abundant, clay balls incorporated. Fossil fragments abundant.</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Shale, clayey, calcareous; gray, weathers tan-gray; thin-beded; calcareous zone present at base. Another calcareous zone occurs 4 ft. from base (zone is .5 ft. thick), on top of which is a thin, carbonaceous lens containing wood fragments. Limonite stains occur on bedding planes. Limonite nodules and concretions are present on weathered surface with some minute mica flakes. <em>Botrylisceras</em> and <em>D. cambula</em> are abundant in the calcareous zones, the rest of the shale is non-fossiliferous.</td>
<td>9.6</td>
</tr>
</tbody>
</table>
French Creek shale. (20.8 feet exposed)
Shale, silty to clayey, noncalcareous; slightly arenaceous in center part; gray to tan-gray weathers tan; thin-bedded to blocky; limonite stains on bedding and fracture planes, limonite nodules and plates appear on weathered surface, carbon stains in places. . . . . . . . . . . . 19.1
Base covered.
## Section 10

This section from the base of the Five Point limestone to the Pony Creek shale, inclusive, is exposed in a ditch along a road in the NE\(_4\) SW\(_4\) sec. 7, T. 11 S., R. 9 E.

### Base of Five Point limestone

**West Branch shale. (19.6 feet)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, clayey, calcareous; gray, weathered tan-gray; thin-bedded; numerous limonite stains on bedding planes.</td>
<td>5.5</td>
</tr>
<tr>
<td>Limestone, hard; gray-brown, weathered tan; massive, weather to small blocks; lenticular. Fossil fragments of <em>Derbyia</em> sp., <em>Composite</em> sp., <em>Rhomboptora</em> sp., <em>Echinoid</em> spines, crinoid columnals, <em>Ambocoolia</em> sp., and others vary abundant.</td>
<td>0.1</td>
</tr>
<tr>
<td>Shale and two thin limestones, arenaceous; tan-brown; thin-bedded; mica flakes present; heavily limonite stained. Neuropteris sp., and wood fragments.</td>
<td>7.1</td>
</tr>
<tr>
<td>Shale, clayey, calcareous, arenaceous; blue-gray, weathered blue-gray to tan; thin-bedded; iron stains on fracture planes.</td>
<td>0.9</td>
</tr>
<tr>
<td>Shale, silty, calcareous, arenaceous; tan-brown; thin-bedded; heavily limonite-stained, numerous limonite places. Neuropteris sp., and wood fragments.</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Falls City limestone. (2.8 feet)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, hard; gray-brown, weathered tan-brown; massive, weathered to thin blocks, weathering exposes thin bedding planes; limonite-stained. <em>Rhomboptora</em> sp.</td>
<td>2.2</td>
</tr>
<tr>
<td>Limestone, soft; gray-brown weathered tan; porous with fibrous appearance, cavernous; limonite-stained.</td>
<td>2.6</td>
</tr>
</tbody>
</table>

**Rawsville shale. (27.6 feet)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, clayey, slightly calcaroeous; gray-green; thin-bedded; limonite stains on bedding planes.</td>
<td>4.9</td>
</tr>
<tr>
<td>Limestone, hard, argillaceous; gray to gray-brown, weathered tan-gray; massive weathered in blocks; limonite stains present. <em>Pleuroptora</em> albequina, <em>Yoldia</em> sp., <em>Peneasteilla</em> sp., <em>Derbyia</em> crassa, <em>Emondia</em> sp., <em>Myallina</em> sp., <em>Aviculopodites</em> occidentalis, numerous fossil fragments.</td>
<td>0.55</td>
</tr>
<tr>
<td>Shale, clayey, slightly calcaroeous; gray-green; thin-bedded; iron stains on bedding planes, few calcaroeous nodules present.</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Limestone, hard, dense, somewhat argillaceous; blue-gray to tan, weathers tan; massive, weathers in irregular blocks; iron stains on fracture planes;
Worthenia sp., Myalina sp., Euomphalus sp., abundant, Acululopseten occidentalis, Pleurophorus albequis abundant, and Pseudo calla tawna.  0.4
Shale, clayey with some silt, noncalcareous; gray, weathers tan-gray; thin-beded; limonite stains.  5.5
Limestone, hard, argillaceous; tan, weathers tan; massive, weathers nodular; iron stains Pleurophorus albequis, Euomphalus sp., and few fossil fragments.  0.4
Shale, clayey, noncalcareous; tan-gray, weathers tan; thin-beded; iron-stained.  1.4
Limestone, hard, gray-brown; massive, weathers to small blocks; iron-stained.  Loxonema sp., Pleurophorus albequis sp., Bellanopon sp., and Myalina sp.  0.1
Shale, clayey, noncalcareous; blue-gray weathers tan; thin-beded; limonite stains.  1.4
Limestone, hard, dense; gray-brown, weathers tan; massive; iron stains on fracture planes, Bellanopon sp., Pleurophorus albequis abundant, and Myalina sp.  0.15
Limestone, hard, crystalline; gray to brown, weathers tan; massive, weathers blocky; limonite nodules and clay balls in upper part, Bellanopon sp., Pleurophorus albequis, Myalina sp., Acululopseten occidentalis, and Euomphalus sp.  0.3
Shale, clayey, noncalcareous; tan to tan-gray weathers tan; thin-beded; limonite stains.  0.5
Limestone, soft; tan; porous, cavernous, gives fibrous appearance; heavily limonite stained.  2.1
Shale, clayey, noncalcareous; tan; thin-beded; limonite stains on bedding planes.  1.7

Aspinwall limestone. (0.3 feet)
Limestone, hard; gray-brown with a greenish tint, weathers tan; massive, weathers blocky; septarian-like appearance on top; limonite stains and iron specks present.  0.3

Towlie shale. (7.1 feet)
Shale, silty with some clay, calcareous, green, weathers tan; few calcareous nodules and limonite stains.  7.1

Brownsville limestone. (0.7 feet)
Limestone, hard, argillaceous, crystalline in part; gray-brown with green tint in places weathers light gray; massive weathers blocky; lenticular, some limonite specks are present.  0.7

Pony Creek shale (5.5 feet exposed)
Shale, clayey, somewhat silty, calcareous, blue-gray, weathers tan; thin-beded; iron stains present.  5.5

Base covered.
section II

This section from the Falls City limestone to the Pauwby shale, inclusive, was measured in a road cut in the 7\' 57\', sec. 9, T. 11 S., R. 2 E.

Feet

Soil; gray-brown. .................................................. 2

Falls City limestone. (4.1 feet exposed)
Limestone with thin shale partings, soft; tan-brown, weathered tan; porous, cavernous, weathering produces thin-beded appearance, portions have a fibrous appearing texture, weathers nodular. *Jurassia nebrascensia*, *Pleurophorus albicans* common in basal part. .. 4.1

Pauwby shale. (21.35 feet exposed)
Shale, clayey, slightly calcareous; gray to tan weathers tan; thin-beded, thin siltstone-like plates appear on weathered surface; limonite stain. ........ 3.6
Limestone, argillaceous, slightly crystalline; gray-brown weathers tan; nodular with a thin platy limestone on top; iron stains on fracture planes. *Aviculopecten occidentalis*, *Pleurophorus albicans*, *Yoldia* sp., small fossil fragments very abundant in upper part. .................. 0.8
Shale, clayey, slightly calcareous; gray-brown, weathers tan; thin-beded. .................. 1.7
Limestone, hard, dense, argillaceous; gray-brown, weathers tan to gray; massive, weathers blocky. *Pleurophorus albicans* very abundant, some are quite long (0.15 feet). *Bipchatus pernodosus*, *Myalina* sp., and *Aviculopecten occidentalis* .......... 0.2
Shale, clayey, noncalcareous; gray to brown, weathers tan; thin-beded; limonite stains. .... 4.1
Limestone, hard, somewhat crystalline, argillaceous in upper part; gray-brown, weathers tan; massive, weathers in rounded blocks. *Myalina subquadrate*, *Myalina* sp., *Bipchatus pernodosus*, *Pleurophorus albicans*, fossil fragments very abundant. ........ 0.9
Shale, clayey, calcareous; blue-gray, weathers tan-gray; thin-beded to blocks; small limestone lens 2.5 feet from the base. The limestone lens contains the following fossils: *Pleurophorus albicans*, *Belleroph'on* sp., *Bipchatus pernodosus*, *Myalina* sp., and *Montania* sp. The shale is nonfossiliferous. ........ 5.3
Limestone, hard, crystalline; dark gray, weathers tan; massive, weathers in irregular blocks; iron-stained. *Belleroph'on* sp. abundant, *Pleurophorus albicans* abundant, *Aviculopecten occidentalis*, *Myalina* sp., *Bipchatus pernodosus*. Fossils compose the bulk of this limestone. ........ 35
Shale, clayey, calcareous; tan to gray, weathers tan to gray, weathers tan-gray; thin-bedded to blocky; some limonite and iron stains on bedding planes. . . . 4.6

Base covered.
This section from the base of the Americus limestone to the 
Hawxby shale, inclusive, was measured in an old trail, on 
the south side of a hill in the center of the 34th sec. 30, 
T. 10 S., R. 9 E.

Feet

Americus limestone, only basal part exposed.

Hamlin shale. (37 feet)
Covered interval. ........................................ 31.5
Shale, clayey, calcareous; gray-green weathers, light
gray-green; thin-beded; numerous limonite nodules. 3.5

Five Point limestone. (3.2 feet)
Limestone, hard, argillaceous; gray, weathers gray;
thin-beded, weathers blocky; some limonite stains. 2.2
Limestone, hard; gray, weathers gray; massive, weathers
blocky; some limonite stains; Marginifera marginata,
Pleurocyporus albequus, Ambocoella sp., Neospirifer sp.,
echinoid spines, Cinctes granuliforms, aréinoid
columnals, Aviculopecten occidentalis, Dictyoclostus
hemiplicatus, Fibroidella carbonaria, Darbyla sp.,
Helcionella margini, Composita ovata, Lissoclones
geinitzianus. Forms hillside bench. .................. 1.6

West Branch shale. (11.1 feet exposed)
Shale, silty with some clay, calcareous; gray-brown to
blue-gray, weathers tan-gray, thin-beded with a fine
grain; thin-beded sandstone lens containing limonite
stains and mica flakes occurs in the middle of this
shale; limonite stains and plates are common; wood
and leaf fragments occur in the upper part. ..... 11.1
Covered interval. ........................................ 6.5

Malls City limestone. (0.35 feet exposed)
Limestone, soft, porouis; tan-brown; blocky, shows bed-
ding planes on weathed surface; lenticular; heavily
limonite-stained. .................................... 0.35

Hawxby shale. (10.9 feet exposed)
Shale, clayey, noncalcareous; gray-green; thin-beded
to blocky. ........................................ 2.5
Limestone, soft; gray-brown, weathers brown; massive,
weathers in small chips; limonite stains abundant;
Polyenos sp., Aviculopecten occidentalis abundant,
Pleurocyporus albequus abundant, Euomphalus sp.,
common, Pseudomontia lawni, Promitilus vetulus. 0.3
Shale, clayey, calcareous; gray-green; thin-beded;
limonite-stained. .................................. 0.9
Limestone, soft, argillaceous; gray-brown, weathers tan-brown; massive, weathers nodular and blocky; limonite stains abundant; Aviculopecten occidentalis and Pleurophorus alboqueus abundant, Notthenia sp., Vyalina sp., Polyplora sp., Locusalus sp.

Stale, clayey with stratified, calcareous; gray-green, weathers tan-brown; thin-bedded; limonite stains common.

Limestone, soft, gray-brown, weathers brown; massive, weathers blocky and irregular; limonite stains common; Pleurophorus alboqueus, Vyalina sp., Aviculopecten occidentalis.

Base covered.
Section 13

This section from the American limestone member of the Foraker lime- stone to the Salmi silt, inclusive, is exposed in a stream cut in the Me. N., sec. 20, T. 10 S., R. 9 E.

Colluvium.

Foraker limestone

American limestone member. (4.1 feet)

Limestone, hard, dense; dark gray, weathers tan-gray; massive, weathers blocky, with somewhat shaly appearance. Marginifera sp., Serpula crassa, Loboella sp., crinoid columnals, echinoid spines, and fusulinids. 0.95

Shales, clayey, noncalcareous; black becoming tan-gray at base, weathers gray; thin-beded to massive; calcareous zone in upper part. 2.1

Limestone, hard, dense; dark gray, weathers tan-gray; massive, weathers blocky to shaly. Dellerop' on sp., fusulinids, Aviculoposten occidentalis, crinoid columnals, Aviculoposten peracuta, Salmi sp., Bucinula sp. 1.1

Salmi silt. (13.9 feet exposed)

Shale, silty, calcareous; gray, blocky; calcium carbonate stains in upper part. 1.2

Shale, silty, calcareous; gray-green; blocky; calcareous lenses in middle and upper parts; iron stains on fracture planes. 7.6

Shale, silty, with some clay, calcareous; light gray-green weathers light gray; blocky; calcareous lens near base; iron stains abundant on fracture planes. 5.1

Base covered.
This section from the base of the Bone limestone member of the Red Eagle limestone to the Berlin shale, inclusive, is exposed in a railroad embankment and road cut in the SW 1/4 SW 1/4 sec. 7, T. 10 S., R. 5 E.

### Red Eagle limestone

#### Base of the Bone limestone member.

**Pennett shale member.** (1.2 feet)

| Shale, clayey, slightly silty, slightly calcareous; olive drab, weathered tan; thin-bedded. Brachiopod fragments. | 2.0 ft |
|-------|-------------------------------------------------|-------|

| Shale, silty, carbonaceous, calcareous; black, weathered gray; thin-bedded. Composite ovata, Aviculopina percuta, Ambocoelia planocynx, Darbyia crassa, and Aviculopina occidentalis. | 0.5 ft |

| Shale, silty, calcareous, carbonaceous; black, weathered gray; thin-bedded. Composite ovata, Marginifera wabaekensis, Astadina poronii, Hissochonetes grinitzianni, and Dictyocoptus sp. | 1.05 ft |

**Glenrock limestone member.** (1.45 feet)

| Limestone, hard, dense; gray-brown, weathered tan; massive, weathered blocky; some small clay nodules. | 1.45 ft |

**Johnson shale.** (24.0 feet)

| Shale, clayey, with some silt, slightly calcareous, carbonaceous in lower part; olive-drab, grading downward to black; thin-bedded to blocky in upper part; thin-bedded in lower part. | 3.2 ft |

| Shale, silty, calcareous; olive drab, weathered tan; thin-bedded. | 0.9 ft |

| Shale, clayey, with some silt, slightly calcareous; olive drab, weathered tan; thin-bedded; carbon-stained. | 1.75 ft |

| Limestone, medium hard, argillaceous; tan-gray, weathered tan; massive to platy in lower part; platy in upper part; lenticular. | 1.9 ft |

| Shale, silty, calcareous; olive drab, weathered light gray; thin-bedded; two thin calcareous leaves in the middle; limonite-stained. | 1.9 ft |

| Limestone, argillaceous; tan-gray; massive to platy; lenticular. | 0.9 ft |

<p>| Shale, clayey with some silt, calcareous; olive drab, weathered tan; thin-bedded to blocky; limonite-stained. | 0.6 ft |</p>
<table>
<thead>
<tr>
<th>Formation</th>
<th>Characterization</th>
<th>Depth (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Creek limestone member.</td>
<td>Limestone, soft, fine-grained; gray-orange; weathers tan; massive, weathers gray;</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>in bedded and irregularly calcite nodules in bedding planes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, soft, fine-grained; gray-orange; weathers tan; massive; porous,</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>celestite nodules.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, soft, dolomitic; tan-gray, weathers light tan; massive; contains</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>some celestite nodules.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; gray, weathers tan; thin-hedded, lenticul. Orthiculoida</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>sp.; and organic material.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; blue-gray to olive drab, weathers tan; thin-hedded</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>to blocky; lenticul.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; gray-orange, weathers tan; massive; lenticul.</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Fusulinids very abundant.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; gray, weathers light gray; thin-bedded. Fusulinids</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>very abundant; crinoid columns.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; gray, weathers light gray; thin-bedded. Fusulinids</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>and crinoid columns at very base.</td>
<td></td>
</tr>
<tr>
<td>Hughes Creek shale member.</td>
<td>Limestone, very calcareous; olive drab, with tan streaks, weathers tan; blocky.</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; dark gray, weathers gray; thin-bedded to blocky.</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; gray, weathers tan; thin-hedded, lenticul. Orthiculo</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>ioida sp.; and organic material.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; blue-gray to olive drab, weathers tan; thin-hedded</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>to blocky; lenticul.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; gray-orange, weathers tan; massive; lenticul.</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>Fusulinids very abundant.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone, very calcareous; gray, weathers light gray; thin-bedded. Fusulinids</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>and crinoid columns at very base.</td>
<td></td>
</tr>
<tr>
<td>Lithology</td>
<td>Characteristics</td>
<td>Plant Life</td>
</tr>
<tr>
<td>-----------</td>
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<td>------------</td>
</tr>
<tr>
<td>Shale, silty, very calcareous; gray</td>
<td>thin-bedded to blocky; Fusulinids abundant. Crinoid columnals, Neoepiphrigera sp., Ambococelia planococonvexa. More resistant to weathering than adjacent shales</td>
<td></td>
</tr>
<tr>
<td>Shale, clay with some silt, calcareous; gray-green,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>weathers gray; thin-bedded.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray-brown, weathers gray-orange; thin-bedded; lenticular; limonite-stained.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray, weathers tan-gray; thin-bedded to blocky.</td>
<td>Alloriona terminalis, Ambococelia planococonvexa, Rhipidocella carbonaria, oestinoid spines, crinoid columnals, Fusulinids, Composite ovata, and Marginifera sp.</td>
<td></td>
</tr>
<tr>
<td>Shale, carbonaceous, noncalcareous; black, weathers blue-gray; thin-bedded; occasional clay inclusion, some limonite-stained zones.</td>
<td>Orbiculoidea missouriensis, Ambococelia planococonvex, and Ctenites granulifera.</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray-orange to gray, weathers gray-orange; thin-bedded; some limonite stains.</td>
<td>Orbiculoidea missouriensis abundant.</td>
<td></td>
</tr>
<tr>
<td>Limestone, hard; tan, weathers tan-gray; massive, Algae, brachiopod fragments, and Fusulinids.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale, clay in upper part grading downward to silt, calcareous; dark gray grading downward to gray-orange, weathers tan to gray; thin-bedded to fissile.</td>
<td>Dictyoclostus americus, Derbyia crassa, and Marginifera sp.</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; dark gray, weathers gray; thin-bedded to blocky; calcareous nodules in upper part.</td>
<td>Large crinoid columnals. Derbyia sp.</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; olive drab, weathers tan; thin-bedded.</td>
<td>Ambococelia planococonvexa, Derbyia sp., crinoid columnals and Fusulinids.</td>
<td></td>
</tr>
<tr>
<td>Limestone, argillaceous; gray; massive, weathers with a shaly appearance; lenticular.</td>
<td>Ambococelia planococonvexa and Liasochoanetes geinitzianus.</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; dark gray, weathers gray; thin-bedded.</td>
<td>Ambococelia sp.</td>
<td></td>
</tr>
<tr>
<td>Limestone, argillaceous; gray; massive, weathers with a shaly appearance; lenticular.</td>
<td>Tellerella sp., crinoid columnals, Rhipidocella carbonaria, Dictyoclostus sp., Derbyia crassa, and Neoepiphrigera sp.</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, slightly calcareous; olive drab, weathers gray; thin-bedded.</td>
<td>Derbyia deercreekensis, Nespiphrigera triplicatus, Rhombopora sp., crinoid columnals, Ambococelia planococonvexa, Polypora sp., and Lingula carbonaria.</td>
<td></td>
</tr>
<tr>
<td>Limestone, argillaceous; dark gray, weathers gray-orange; thin-bedded.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray, weathers light gray; thin-bedded.</td>
<td>Ambococelia sp., and Marginifera hystricula.</td>
<td></td>
</tr>
</tbody>
</table>
Limestone, hard; tan-gray; massive. Some brachiopod fragments 0.3

Shale, silty, calcareous; gray; block; limonite-stained in lower part. Dictyoclostus americanus, Derbilia crassa, Ichnococclus sp., Linoproducstus sp.; Ambocella planocconvexa, and Marginifera sp. 0.5

Shale, clayey, slightly calcareous; dark gray to black, weathers dark gray; blocky to thin-beded. Dictyoclostus sp., and Derbilia crassa 1.5

Limestone, argillaceous; gray-orange; blocky. Dictyoclostus americanus, Hustadia mormoni, Marginifera sp., Ambocella planocconvexa, and Derbilia crassa 1.3

Shale, silty, calcareous in upper part; gray grading downward to black, weathers gray; thin-beded to fissile. Composita subtilitae, Dictyoclostus americanus, P. portlocklopus, Fusulinae, Chonetes granulifera, Marginifera sp., Ichnococclus sp., Linoproducstus margaripinus, Juresania petrosana, Ambocella planocconvexa, Derbilia crassa, Orbiculoidea missouriensis, and Aviculopetend occasitalis 9.2

Shale, silty, very calcareous; gray-brown, weathers gray; thin-beded; lenticular, limonite-stained 3.3

Shale, silty, calcareous; dark gray, weathers gray with orange spots; thin-beded. Crinoid columnals, Dictyoclostus americanus, Composita subtilitae, and Chonetes granulifera 3.3

Amuricous limestone member. (3.65 feet)

Limestone, hard, slightly crystalline; blue-gray, weathers tan; massive. Large crinoid columnals, echnocid spines, brachiopod fragments, Wellerella tetrode, Stenopora sp., and fusulinids 1.0

Shale, slightly silty, calcareous; black, weathers gray; thin-beded 2.2

Shale, silty, calcareous; gray, weathers light gray; thin-beded 0.55

Shale, silty, noncalcareous; dark gray, weathers light gray; thin-beded to fissile; carbon stains on bedding planes 1.0

Limestone, dense, hard, argillaceous in the lower part; dark gray, weathers tan-gray; massive. Algae abundant in the lower part. Crinoid columnals and brachiopod fragments 0.8

Dalmia shale. (3.2 feet exposed)

Shale, silty, calcareous; red-brown, weathers tan-gray; thin-beded. Some algae 1.1

Limestone, arenaceous; gray-orange, weathers tan; massive; lenticular 3.3

Shale, clayey, calcareous; gray-orange, weathers tan; thin-beded to blocky 0.35

Shale, silty, calcareous; dark gray, weathers light gray; blocks; limonite stains in upper part 1.55

Shale, clayey with some silt, calcareous; dark gray, weathers light gray; thin-beded 2.9

Base covered.
Section 13

This section from the base of the Burr limestone member of the Grenola limestone to the Hughes Creek shale member of the Foraker limestone, inclusive, is exposed in a railroad cut in the NW\(^4\) SW\(^4\) NE\(^4\) sec. 24, T. 10 N., R. 7 W.

<table>
<thead>
<tr>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colluvium</td>
</tr>
<tr>
<td>Grenola limestone</td>
</tr>
<tr>
<td>Burr limestone member</td>
</tr>
<tr>
<td>Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky and irregular. Crinoid columnals, echinoid spines and brachiopod fragments</td>
</tr>
<tr>
<td>Roca shale</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; tan-gray; thin-bedded; calcite carbonate and limonite-stained</td>
</tr>
<tr>
<td>Limestone, hard, dense, somewhat argillaceous; gray, weathers tan-gray; massive, weathers blocky and platy at top; iron stains on fracture planes. Small crinoid columnals abundant</td>
</tr>
<tr>
<td>Shale, silty, noncalcareous; green, weathers gray-green; thin-bedded to blocky; iron stains on fracture planes</td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan, weathers light gray; thin-bedded; iron stains on bedding planes</td>
</tr>
<tr>
<td>Shale, silty, slightly calcareous; green, weathers gray-green; thin-bedded to blocky; limonite stains on fracture planes</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; purple, weathers light purple; thin-bedded</td>
</tr>
<tr>
<td>Shale, silty with some clay, calcareous; gray, weathers tan-gray; thin-bedded; iron stains on bedding planes, calcareous nodules</td>
</tr>
<tr>
<td>Shale, silty, calcareous; maroon; thin-bedded</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; green, weathers light green; thin-bedded</td>
</tr>
<tr>
<td>Limestone, soft, argillaceous; gray-green, weathers gray; massive to blocky, weathers blocky; iron stains on fracture planes</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; green, weathers light green; blocky</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; maroon grading down into gray-maroon and purple, weathers maroon to gray; thin-bedded to blocky; iron stains on bedding planes</td>
</tr>
<tr>
<td>Shale, clayey with some silt, slightly calcareous; light green to green, weathers gray-green; thin-bedded; iron stains on bedding planes</td>
</tr>
<tr>
<td>Member</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td><strong>Red Eagle limestone</strong></td>
</tr>
<tr>
<td><strong>Perrinett shale member</strong></td>
</tr>
<tr>
<td><strong>Glenrock limestone member</strong></td>
</tr>
<tr>
<td><strong>Johnson shale</strong></td>
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<td></td>
</tr>
</tbody>
</table>
Foraker limestone

Long Creek limestone member. (8.5 feet)
Limestone, soft, lightly dolomitic; gray-orange, weathers tan-gray; massive, weathers in irregular blocks and plates; iron stains abundant on fracture planes... 8.5

Hughes Creek shale member. (4.5 feet exposed)
Shale, silty, calcareous; tan to blue-gray; thin-bedded to blocky; some limonite stains. ... 1.7
Limestone, soft, argillaceous; tan-gray, weathers tan; massive, weathers platy in the top part; lenticular; some iron stains on fracture planes. Crinoid columnals, Pleurophorus sp., Polygros sp., and fossil fragments. ... 4
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; limonite-stained. Rhombopora sp., Pleurophorus sp., Chonetes granulifera, and numerous fossil fragments. ... 4
Limestone, soft; tan-gray; massive weathers irregular. Fusulinida very abundant, crinoid columnals, and Chonetes granulifera. ... 2.0

Base covered.
### Section 16

This section from the Burr limestone member of the Grenola limestone to the base of the Lowe limestone member of the Red Eagle limestone, inclusive, is exposed in a road cut in the NE 1/4 SE 1/4, sec. 7, T. 10 S., R. 9 E.

#### Feet

| Silt, gray-brown | 2 |

#### Grenola limestone. (12.5 feet exposed)

<table>
<thead>
<tr>
<th>Burr limestone member. (12.5 feet exposed)</th>
<th>0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, soft; gray-orange, weathers tan; platy; lenticular.</td>
<td></td>
</tr>
<tr>
<td>Limestone, soft; gray, weathers tan; massive; cavernous at base; lenticular.</td>
<td>0.3</td>
</tr>
<tr>
<td>Limestone, dense; gray-orange, weathers tan; massive, weathers platy at base.</td>
<td>0.9</td>
</tr>
<tr>
<td>Shale, clayey, slightly calcareous; olive drab, weathers tan; thin-bedded to blocky; iron-stained.</td>
<td>3.2</td>
</tr>
<tr>
<td>Limestone, soft; red-brown, weathers tan; massive; porous and lenticular. Ostracods very abundant.</td>
<td>2.25</td>
</tr>
<tr>
<td>Limestone, hard, dense; gray-orange, weathers tan; massive. Some brachiopod fragments.</td>
<td>1.3</td>
</tr>
<tr>
<td>Limestone, hard, dense; light gray, weathers tan; massive. Ichnoid soines.</td>
<td>2.1</td>
</tr>
<tr>
<td>Limestone, slightly crystalline; gray, weathers tan; massive. Brachiopod fragments and some algae.</td>
<td>0.2</td>
</tr>
<tr>
<td>Shale, clayey, noncalcareous; gray grading downward to black; weathers gray; fissile; some carbon stains.</td>
<td>1.25</td>
</tr>
<tr>
<td>Limestone, hard, dense; tan; massive, weathers blocky. Crinoid columnals, Clonette granulifera, Myalina subquadratus, and brachiopod fragments.</td>
<td>2.4</td>
</tr>
</tbody>
</table>

#### Roca shale. (23.45 feet)

<table>
<thead>
<tr>
<th>Shale, silty, calcareous; dark gray with light gray bands, weathers light gray; thin-bedded. Worm burrows? abundant.</th>
<th>0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, hard, dense; gray-brown, weathers tan; massive; lenticular. Worm burrows?</td>
<td>0.1</td>
</tr>
<tr>
<td>Shale, silty, calcareous; dark gray, weathers light gray; thin-bedded; lenticular.</td>
<td>0.5</td>
</tr>
<tr>
<td>Limestone, argillaceous; gray, weathers light gray; blocky; lenticular.</td>
<td>0.3</td>
</tr>
<tr>
<td>Shale, silty, calcareous; dark gray, weathers light gray; blocky to fissile.</td>
<td>0.85</td>
</tr>
<tr>
<td>Shale, clayey with some silty, calcareous; white, motiled with dark gray-green, weathers tan; blocky.</td>
<td>0.65</td>
</tr>
<tr>
<td>Shale, clayey with some silty, calcareous; dark gray, weathers gray with light gray bands; blocky.</td>
<td>1.05</td>
</tr>
<tr>
<td>Shale, clayey, noncalcareous; tan banded with gray, weathers tan; thin-bedded to blocky.</td>
<td>0.7</td>
</tr>
<tr>
<td>Limestone, hard; tan; massive. Fragments tentatively identified as fossil plants.</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Shale, clayey, with some silt, noncalcareous; light green in the upper part grading downward to a dark green, weathers light green; blocky; iron-stained. 3.2
Shale, silty, very calcareous; light cream; blocky; heaviest iron-stained. 0.9
Shale, clayey with some silt, calcareous; gray-green, weathers light green; blocky; iron stains and clay nodules. 1.9
Shale, silty, noncalcareous; purple in upper part grading downward to dark green, blocky; iron stains on the fracture planes. 2.8
Shale, silty, noncalcareous; dark gray, weathers gray; blocky; lenticular; limonite stains on bedding planes. .45
Shale, silty, very calcareous; maroon mottled with light gray; blocky. 1.05
Shale, silty, calcareous; maroon mottled with green; blocky. 0.95
Shale, clayey, noncalcareous; gray-green, weathers light gray; blocky. 0.5
Limestone, argillaceous; light gray; massive; lenticular. .5
Shale, silty, calcareous; light green; banded with various shades of green; thin-bedded. .4
Shale, clayey with some silt, slightly calcareous; maroon; thin-bedded to blocky; some parcontemporaneous folding. 1.65
Shale, silty, noncalcareous; light green; blocky. 1.05
Shale, clayey, slightly calcareous; light gray; thin-bedded to blocky; limonite stains on bedding planes. .15
Shale, silty, calcareous; dark gray, weathers gray; thin-bedded; lenticular. .15
Shale, silty, slightly calcareous; light gray banded with various shades of gray; thin-bedded; limonite stains on fracture planes. .3
Shale, clayey with some silt, noncalcareous; gray, weathers light gray; blocky. .2
Shale, clayey with some silt, noncalcareous; gray-green, banded with various shades of gray, weathers gray; iron-stained. .35
Shale, clayey, noncalcareous; gray-green, weathers light gray-green; blocky. .35
Shale, silty, calcareous; gray; blocky; lenticular. .3
Shale, clayey with some silt, slightly calcareous; gray to gray-green, weathers gray; blocky; lenticular. .4
Shale, silty, calcareous; gray-green, weathers gray; blocky; lenticular; limonite stains in basal part. .7

Red Eagle limestone. (4.45 feet exposed)

Some limestone member. (4.45 feet)

Limestone, soft; tan, weathers tan-gray; massive; lenticular. .8
Limestone, soft; gray-orange, weathers tan; massive; limonite-stained and maroon stains. .3.65

Base covered.
Section 17

This section from the Cottonwood limestone member of the Beatrice limestone to the Nova limestone member of the Grenada limestone, inclusive, is exposed in a road cut in the NE 1/4 sec. 10, T. 10 S., R. 7 E.

<table>
<thead>
<tr>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil, silty; dark gray; some gravel.</td>
</tr>
</tbody>
</table>

Beatrice limestone. (5.1 feet exposed)

<table>
<thead>
<tr>
<th>Cottonwood limestone member. (5.1 feet exposed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, hard; gray-orange; massive, weathered to a shaly appearance. Composite sp., and brecciated fragments.</td>
</tr>
<tr>
<td>Limestone, hard, dense; light gray, weathered tan; massive, weathered blocky; chert nodules in the middle. Facchinellides abundant. Heteromorphic sp., eocrinoid spines, crinoid columns, Composite sp., Strasparus sp.</td>
</tr>
</tbody>
</table>

Falmichael shale. (35.6 feet)

| Slate, silty, noncalcareous; light green to tan; thin-bedded to blocky; iron stains, maroon stains at the base, calcareous nodules. | 2.75 |
| Slate, silty, very calcareous; white; thin-bedded; lenticular. | 3.3 |
| Slate, clayey, noncalcareous; olive drab, weathered light gray; blocky. | 1.2 |
| Slate, silty, calcareous; light gray to gray with violet stains; thin-bedded to blocky; calcareous lens near the top. | 1.2 |
| Slate, clayey with some silt, calcareous; maroon; thin-bedded to blocky. | 2.5 |
| Slate, clayey with some silt, calcareous; light gray; thin-bedded. | .75 |
| Slate, silty, very calcareous; gray, weathered light gray; blocky; iron-stained. | .5 |
| Slate, clayey, calcareous; maroon mottled with green; blocky. | 2.95 |
| Slate, clayey with some silt, calcareous; gray mottled with maroon; thin-bedded to blocky. | 1.05 |
| Slate, clayey, calcareous; gray, weathered light gray; thin-bedded. | .55 |
| Limestone, somewhat argillaceous; light gray; massive, weathered blocky; lenticular. | .65 |
| Slate, clayey with some silt, calcareous; dark gray, weathered light gray; thin-bedded to blocky; some calcareous lenses. | 2.75 |
| Limestone, argillaceous; dark gray, weathered light gray; massive, weathered blocky; thin shale parting; lime-nite-stained. | .3 |
Shale, clayey with some silt, calcareous; gray with
light gray streaks; thin-beded to blocky. 2.2
Limestone, argillaceous; gray, weathers light gray;
massive, weathers block; lenticular; limonite
stains on weathered surface. Aviculopecten occi-
dentalis, Mytilina sp. 1.5
Shale, silty, calcareous; gray-brown, weathers tan;
thin-beded; thin calcareous lens near top. 1.45
Shale, silty, calcareous; gray-green, weathers light
green; blocky. 1.0
Shale, silty, calcareous; brown; blocky. 0.8
Shale, silty, calcareous; gray-green, weathers light
green; blocky. 0.2
Shale, clayey, calcareous; dark brown; blocky; some
calcite stains. 1.25
Shale, silty, slightly calcareous; dark purple to
maroon mottled with green and gray; blocky; columnar
structure. 5.8
Shale, clayey with some silt, calcareous; dark green
mottled with purple; thin-beded to blocky. 0.85
Shale, silty, calcareous; gray; thin-beded to blocky. 0.4
Shale, silty, calcareous; gray-green, weathers light
green; thin-beded; calcareous lens in lower part. 1.25

Granite limestone. (3.9 feet exposed)
Novia limestone member. (3.9 feet exposed)
Limestone, hard, dense; tan-gray; massive weathers
blocky; conchoidal fracture. Composite sp., Amboccia
sp., crinoid columnals, echioid spines, and ?beckella
stratocostata. 1.5
Shale, silty, calcareous; dark gray, weathers light
green; thin-beded; very lenticular. Crinoid
columnals, Composite sp., Amboccia sp., and echioid
spines. 1.5
Limestone, hard, dense; tan-gray, weathers tan; massive,
weathers blocky; crinoid columnals, echioid spines,
and brachiopod fragments. 1.9

Base covered.
**Section 13**

This section from the Florene shale member of the Peattie limestone to the top of the Burr limestone member of the Grenada limestone, inclusive, is exposed in an old road cut in the NW\#1 sec. 26, T. 10 N., R. 7 E.

### Feet

**Florene shale member. (8 feet)**
- **Florene shale member. (8 feet)**
  - **White, silty, calcareous; tan to gray, weathers tan-gray; thinly-bedded; some calcareous plates in the lower part.**
  - **Chonetes granulifera very abundant.**
  - **Mackella striatoolocata, Polyopora sp., Rhombopora sp., Fenestella sp., Composita ovata, Xenopora sp., Fistulopora sp., crinoid columnals, echinoid spines, and trilobites.**

### Feet

**Cottonwood limestone member. (6.5 feet)**
- **Limestone, hard, dense; gray, weathers tan-gray; massive, weathers blocks; lens of chert nodules in middle with chert nodules scattered throughout.**
- **Fusulinids very abundant in upper half, crinoid columnals, echinoid spines, Polyopora sp., Composita sp., brachiopod fragments, corals common near base.**
- **Limestone fractures irregularly and where exposed, large blocks are slumped on the face of the underlying shale.**
- **Sor's prominent hillside bench. Growth of bushes at base is characteristic.**

### Feet

**Limestone, soft; light gray, weathers tan; massive, weathers with a shaly appearance; lenticular.**
- **Crinoid columnals.**
- **Limestone, hard; gray-orange, weathers gray; massive; lenticular.**
- **Brachiopod fragments.**

### Feet

**Eskridge shale. (27.30 feet)**
- **Shale, clayey, noncalcareous; light green; thinly-bedded;**
  - **calcium carbonate stains and nodules.**
- **Shale, silty with some clay, very calcareous; light gray; thinly-bedded to blocky; small clay nodules; lenticular.**
- **Shale, clayey, noncalcareous; gray, weathers light gray; blocky; lenticular.**
- **Shale, clayey with some silt, very calcareous; light gray to light violet; blocky to thin-bedded.**
- **Limestone, argillaceous; light gray, weathers tan; massive; oolitic in part. Aviculopecten occidentalis.**
- **Shale, clayey with some silt, calcareous; light green, weather light gray; blocky.**
- **Shale, silty, calcareous; maroon; blocky.**
<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, clayey, calcareous; gray-brown; blocky</td>
<td>0.3</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; maroon; blocky</td>
<td>0.4</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; olive-gray; weathers ten; blocky</td>
<td>1.55</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray, mottled with maroon; thin-beded to blocky</td>
<td>1.1</td>
</tr>
<tr>
<td>Shale, clayey, slightly calcareous; dark gray, weathers light gray; thin-beded</td>
<td>0.5</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; maroon; blocky to thin-beded</td>
<td>2.15</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; dark gray in upper part grading downward to tan-gray, weathers ten; thin-beded</td>
<td>3.45</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; dark gray-green, weathers light gray-green; blocky</td>
<td>1.1</td>
</tr>
<tr>
<td>Shale, silty, calcareous; carom mottled with gray and green; thin-beded to blocky</td>
<td>2.6</td>
</tr>
<tr>
<td>Shale, silty, calcareous; dark violet, weathers light purple; blocky; lenticular</td>
<td>2.25</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; maroon; blocky; lenticular</td>
<td>0.9</td>
</tr>
<tr>
<td>Shale, silty, noncalcareous; violet; block; lenticular.</td>
<td>1.2</td>
</tr>
<tr>
<td>Shale, clayey, slightly silty, calcareous; light gray-green, weathers gray-green; thin-beded</td>
<td>0.5</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; maroon; lenticular.</td>
<td>0.2</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray-green, weathers light gray; thin-beded.</td>
<td>0.4</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; maroon and gray-green; thin-beded; lenticular</td>
<td>0.3</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; gray-green, weathers light gray-green; thin-beded.</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Grenada limestone. (25.8 feet measured)

Nova limestone member. (14.2 feet)

<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, hard; light gray; massive, weathers platy; shale parting in upper part. Echinoid spines, Polypora sp., and brachiopod fragments</td>
<td>2.5</td>
</tr>
<tr>
<td>Limestone, hard, dense; light gray, weathers ten; massive, weathers blocky. Crinoid columnals, echinoid spines, Composita sp., and brachiopod fragments. Forms Willaima bone.</td>
<td>5.3</td>
</tr>
<tr>
<td>Shale, silty, very calcareous; light gray; thin-beded to blocky; lenticular. Lingula carbonaria, Composita ovata, and Orthoculina missouriensis.</td>
<td>0.9</td>
</tr>
<tr>
<td>Limestone, hard, dense; gray-orange, weathers ten; massive, weathers blocky; cavernous in lower part. Brachiopod fragments.</td>
<td>5.0</td>
</tr>
<tr>
<td>Limestone, soft; tan; massive, weathers blocky; lenticular.</td>
<td>0.9</td>
</tr>
<tr>
<td>Limestone, soft; light gray, weathers ten; massive; lenticular.</td>
<td>0.6</td>
</tr>
<tr>
<td>Shale, clayey, slightly calcareous; dark gray, weathers blue-gray; thin-beded. Crinoid columnals.</td>
<td>1.5</td>
</tr>
<tr>
<td>Limestone, hard; gray-orange, weathers ten; massive, weathers blocky. Echinoid spines, and brachiopod fragments.</td>
<td>1.4</td>
</tr>
</tbody>
</table>
**Salem Point shale member. (7.6 feet)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, silty, calcareous; tan with gray stains, weathers light tan; blocky.</td>
<td>0.65</td>
</tr>
<tr>
<td>Shale, silty, calcareous; olive drab, weathers light gray; blocky to thin-bedded. Pleurochirus sp.</td>
<td>2.45</td>
</tr>
<tr>
<td>Shale, clayey, slightly calcareous; black and gray; weathers gray; thin-bedded.</td>
<td>0.5</td>
</tr>
<tr>
<td>Limestone, argillaceous; light gray, weathers tan; platy at top becoming massive at base.</td>
<td>0.6</td>
</tr>
<tr>
<td>Shale, silty, calcareous; light tan; blocky; lenticular.</td>
<td>0.25</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray, weathers light gray; thin-bedded.</td>
<td>0.8</td>
</tr>
<tr>
<td>Shale, silty, calcareous; olive drab, weathers light gray; blocky to thin-bedded.</td>
<td>2.35</td>
</tr>
</tbody>
</table>

Top of Burr limestone member.
Section 19

This section from the Mieville limestone member of the Pader limestone to the Burr limestone member of the Green Lake limestone, inclusive, was measured in a road cut in the T 10 S., R. 9 W.

Feet

Soil, silty; gray-brown. .................. ........................................ 3.

Pader limestone. (4.3 feet exposed)

Miss limestone member. (4.3 feet)

Limestone, hard, argillaceous; tan-gray, weathers tan; massive, weathers blocky to platy. Aviculopecten occidentalis abundant, Pseudomantis bawni, Salina sp., Meckella striatostates, Dermila crease.

Shales, clayey with some silt, calcareous; tan-gray, weathers tan; thin-bedded to blocky; some limonite stains. .......................................... 0.4

Limestone, hard; gray, weathers light gray; massive, weathers platy to blocky; slightly porous. Gonoceras granulifera, Microbore ap., Derbina sp., Meckella striatostates, Aviculopecten occidentalis, Lusulina, and Polynoro ap. ........................................... 1.1

Stearns shale. (16.7 feet)

Shale, silty, calcareous; gray, weathers light gray; thin-bedded to blocky. ........................................... 2.3

Limestone, very argillaceous; gray, weathers light gray; blocky; few limonite stains. .................. 0.3

Shale, silty, calcareous; gray, weathers light gray; blocky. ........................................... 1.3

Limestone, very argillaceous; gray, weathers light gray; blocky; limonite stains on fracture planes. .... 0.7

Shale, silty, very calcareous; gray, weathers light gray; thin-bedded to platy; thin calcareous plates on weathered surface. ........................................... 5.7

Shale, clayey, slightly calcareous; gray-green, weathers tan; thin-bedded to blocky; few calcareous plates, some limonite stains. ........................................... 1.3

Limestone, soft; gray, weathers tan; cavernous, porous, with a fibrous appearance. ........................................... 0.3

Covered interval. ........................................... 4.8

Fessleic limestone. (16.3 feet)

Morrill limestone member. (3.1 feet)

Limestone, soft; ten, weathers tan-gray; massive, blocky, porous, weathers irregular; small calcite crystals on weathered surface; algal appearance. ........................................... 0.8

Limestone, hard, dense; gray, weathers tan; massive, weathers irregular; lenticular; some secondary calcite clusters present. ........................................... 1.2
Limestone, hard, argillaceous; gray-orange, weathers ten, numerous brown specks present; massive, westlers porous, rotten & porous.  
1.1

Florence shale member.  (7.3 feet)
Shale, silty with some clay, lightly calcareous; tan to gray, westlers tan; thin-bedded to blocky; calcareous nodules and plates present.  Fossils present only in the lower 2.4 feet, Chlorites gray, abundant, Ammonites crassa, D. cymula, echinoid spines, Hapaloparia sp. common, alvus Composita ovata common, crinoid columns, trilobites, Lissoclitates geinitzianus, Lincula carbonaria, Polypora sp., Almhbopora sp.  
7.3

Cottonwood limestone member.  (6.4 feet)
Limestone, hard; light gray, westlers gray; massive, westlers in large irregular blocks; solution channels present, chalk nodules present in the upper part.  Fusulinids exceptionally abundant, in the upper half, crinoid columns, echinoid spines, Lopetoparia pro- liferum, Composita ovata, and numerous small fossil fragments.  
5.3

Limestone, hard; light gray, westlers gray; massive, westlers in thin plates; some limonite stains.  
1.1

Ruskridge shale.  (2.8 feet)
Shale, clayey, calcareous; gray-green, weathers light gray-green; blocky to thin-bedded; limonite streaks in upper part.  
1.1

Shale, silty, very calcareous; gray, weathers light gray; block; some iron stain on fracture planes.  
3.3

Limestone, hard, somewhat argillaceous, gray, westlers gray; massive; numerous fine white specks.  Jurecania nebrascania, Aviculopecten occidentalis, and Myalina concil.  
0.4

Shale, silty with some clay, calcareous; gray-green, westlers gray; thin-bedded.  
4.1

Shale, clayey, calcareous; maroon to maroon-gray, westlers maroon; thin-bedded.  
1.9

Shale, clayey, calcareous; gray-green; thin-bedded to blocky; some limonite stains.  
6.3

Shale, silty, calcareous; maroon; some green stains; blocky.  
3.3

Covered interval.  
7.6

Grenola limestone.  (2.3 feet exposed)
Nova limestone member.  (12.6 feet)
Limestone, hard, dense; gray-orange, westlers gray; massive, porous, westlers blocks; limonite-stained cavities.  Echinoid spines, crinoid columns, fusulinids, and numerous brachiopod fragments.  Forms prominent hillside bench.  
5.6
Limestone, hard; gray, weathers tan-gray; thin-bedded, weathers platy. Echinoid spines and plates abundant, Ctenates granulifera, and fusulinids. 1.6

Limestone, soft lenticular; hard at base; tan-gray, weathers gray; massive; porous, has rotten appearance; limonite stains common. Echinoid spines, Marginifera sp. 4.3

Shale, silty with some clay, calcareous; tan-gray, weathers tan; thin-bedded. Crinoid columns. 2.4

Limestone, with thin shale parting near base, hard, somewhat argillaceous; tan; massive. Amphocoelia sp. and numerous fossil fragments. 1.5

Salem Point shale member. (7.9 feet)

Shale, mostly covered, clayey and silty, calcareous; tan to gray-green, weathers tan; thin-bedded; numerous calcareous plates on weathered surface, a very calcareous lens three feet from the base. 7.9

Burr limestone member. (4.3 feet exposed)

Limestone, hard somewhat argillaceous; tan-gray, weathers gray; massive to platy. Aviculoptena occidentalis, Aviculopinna sp., Pleurophorus albaeoma abundant, Myalina sp. Most fossils are limonite-stained. 2.1

Shale, silty, very calcareous; tan; blocky. 1.5

Limestone, hard, argillaceous nodules present; tan-gray, weathers light gray; massive, blocky, limonite-stained. Osagia and microfossils present. 1.7

Base covered.
This section from the looser slate member of the Bader limestone to the Mona limestone member of the Grandis limestone, inclusive, is exposed in a road cut in the NE 34 sec. 9, T. 11 S., R. 7 E.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil, silty; dark; some colluvium</td>
<td>2</td>
</tr>
<tr>
<td>Bader limestone, (14 feet exposed)</td>
<td></td>
</tr>
<tr>
<td>Shale, exposed in road, varicolored</td>
<td>5.5</td>
</tr>
<tr>
<td>Miss limestone member, (8.5 feet)</td>
<td></td>
</tr>
<tr>
<td>Limestone, hard; tan-gray; massive, weathers to rectangular blocks; porous. Brachiopod fragments.</td>
<td>1.6</td>
</tr>
<tr>
<td>Limestone, tan-gray, weathers tan; massive, weathered near the base; porous; 11 quite-stained.</td>
<td>1.7</td>
</tr>
<tr>
<td>Hacellia striatocostata and Herdfy crassa</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded.</td>
<td></td>
</tr>
<tr>
<td>Herdfy crassa, Allobacopa sp., very abundant, Polyplora sp., Hacellia</td>
<td></td>
</tr>
<tr>
<td>striatocostata, eocrinoid spines, Composita sp., and crinoid columnals.</td>
<td>3.9</td>
</tr>
<tr>
<td>Limestone, argillaceous; olive drab, weathers tan; blocksy, weathered</td>
<td></td>
</tr>
<tr>
<td>stony and nodulated</td>
<td>1.3</td>
</tr>
<tr>
<td>Stearns shale, (14.4 feet)</td>
<td></td>
</tr>
<tr>
<td>Shale (mostly covered), clayey with some silt, calcareous; olive drab;</td>
<td></td>
</tr>
<tr>
<td>weathers grey; thin-bedded; contains calcareous nodules and a few thin</td>
<td>14.4</td>
</tr>
<tr>
<td>limestone lenses</td>
<td></td>
</tr>
<tr>
<td>Beatrice limestone, (13.9 feet)</td>
<td></td>
</tr>
<tr>
<td>Morrow limestone member, (1.2 feet)</td>
<td></td>
</tr>
<tr>
<td>Limestone, soft; tan-brown, weathers tan; massive, weathers rotton; porous.</td>
<td>1.2</td>
</tr>
<tr>
<td>Flores shale member, (6.9 feet)</td>
<td></td>
</tr>
<tr>
<td>Shale (partly covered), silty, calcareous; tan-gray, weathers tan; thin-bedded. Chonetes granulifera very</td>
<td></td>
</tr>
<tr>
<td>abundant, Herdfy crassa, D. cymbula, Polyplora sp., fusulinids, Allobacopa sp.,</td>
<td></td>
</tr>
<tr>
<td>crinoid columnals, eocrinoid spines, Composita ovata, Ca. subtilita,</td>
<td></td>
</tr>
<tr>
<td>Stenopora sp., Dictyoclostus americanus, and trilobites.</td>
<td>6.9</td>
</tr>
<tr>
<td>Cottonwood limestone member, (5.7 feet)</td>
<td></td>
</tr>
<tr>
<td>Limestone, hard; gray; massive, weathers to large blocks; somewhat</td>
<td></td>
</tr>
<tr>
<td>porous, solution channels, occasional short nodules.</td>
<td></td>
</tr>
<tr>
<td>Fusulinids abundant, Dictyoclostus americanus, eocrinoid spines,</td>
<td></td>
</tr>
<tr>
<td>crinoid columnals and Herdfy crassa.</td>
<td>5.5</td>
</tr>
</tbody>
</table>
Limestone, soft, argillaceous; gray-brown, weathered; massive, weathered shaly; iron-stained, bioclastic. *Polypora* sp., ostracods and other microfossils... 0.4

Nakridge shale. (30.3 feet)

| Shale, silty, very calcareous; light gray; thin-bedded to blocky; calcareous nodules and stains; iron stains near base. | 4.7 |
| Shale, silty, calcareous; violet; thin-bedded to blocky; iron stains on fracture planes. *Euglypha alba* and *Aviculopecten occidentalis* | 3.1 |
| Limestone, hard, dense; gray, weathered tan-gray; massive, weathered shale on top; iron stains on fracture planes. | 1.1 |
| Shale, clayey, calcareous; tan-gray; blocky; calcareous nodules, limonite-stained. | 3.9 |
| Shale, clayey, calcareous; gray-green; blocky. | 0.3 |
| Shale, silty, calcareous, numerous calcareous lenses; maroon-gray, weathered light maroon; thin-bedded to blocky; iron stains on bedding planes. | 4.7 |
| Limestone, hard, argillaceous; gray; massive, weathered blocky; limonite stains on fracture planes. *Myalina* sp., *Aviculopecten occidentalis*. | 0.4 |

| Shale, clayey with some silt, calcareous; olive drab, weathered gray; thin-bedded; thin limestone lens in the upper part; limonite stains on bedding planes. | 2.1 |
| Shale, silty, calcareous; gray-green, weathered light green; blocky; heavily limonite-stained in the top part. | 1.3 |
| Shale, clayey with some silt, calcareous; purple grading down to maroon, weathered purple; blocky. | 2.1 |
| Shale, clayey with some silt, very calcareous; light gray; thin-bedded; lentilicated; iron stains. | 0.2 |
| Shale, silty with some clay, calcareous; gray-brown, weathered gray; thin-bedded; limonite-stained, some purple stains. | 1.2 |
| Shale, clayey, calcareous; violet with some purple stains, weathered light gray; thin-bedded. | 1.0 |
| Shale, silty, calcareous; purple; blocky. | 1.7 |
| Covered interval. | 3.9 |

Grenola limestone. (9.7 feet exposed)

| Wava limestone member. (9.7 feet exposed) |
| Limestone, hard, slightly argillaceous at base; tan-gray, weathered light gray; massive, weathered blocky. Ball-recrystallized opaline and occasional brachiopod fragments. | 0.9 |
| Shale, silty, calcareous; tan-gray, weathered tan; thin-bedded; calcareous nodules. | 2.4 |
| Limestone, hard; tan, weathered tan-gray; massive. | 4.1 |
| Shale, silty, calcareous; tan-gray, weathered gray; thin-bedded. | 1.1 |
| Limestone, soft, tan-gray, weathered gray; massive; porous, heavily limonite-stained. | 1.2 |

Base covered.
Section 21

This section from the Easley Creek shale down to the Cottonwood limestone member of the Reattle limestone, inclusive, is exposed in a road cut in the Ill. P, sec. 29, T. 2 S., R. 10 E.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colluvium, silt and rock fragments</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Easley Creek shale, (13.35 feet exposed)</td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td>- Shale, clayey with some silt, calcareous; tan-gray, weathers tan; thin-bedded.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Limestone, hard, dense in upper part; tan-gray, weathers tan; massive, weathers blocky; limonite stains and nodules. <em>Atrichopleura occidentalis</em> and fossil fragments.</td>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td>- Shale, silty with some clay, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; calcareous zone near the base, iron-stained.</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>- Shale, silty calcareous; maroon, weathers purple; blocky.</td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td>- Shale, silty, calcareous; green, weathers light green; blocky to thin-bedded; iron and carbon stains on the bedding planes.</td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>- Shale, silty, calcareous; maroon mottled with purple at the base and top; blocky.</td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>- Shale, clayey, calcareous; green mottled with maroon in upper part; thin-bedded.</td>
<td></td>
<td>1.4</td>
</tr>
<tr>
<td>- Shale, clayey, calcareous; brown, weathers tan; thin-bedded; calcareous lens in upper part.</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>Bader limestone, (17.0 feet)</td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>- Middleburg limestone member, (3.6 feet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Limestone, hard, somewhat crystalline, dense in part; olive drab, with maroon stains on the weathered surface; massive.</td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>- Shale, silty, calcareous; gray becoming black at the base; thin-bedded; calcareous zone in the upper part.</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>- Booser shale member, (7.7 feet)</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>- Shale, clayey with some silt, slightly calcareous; olive-drab, weathers tan; blocky; some calcareous lenses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Shale, silty, calcareous; maroon; blocky to thin-bedded.</td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>Limestone, argillaceous; gray, weathers light gray; massive, limonite-stained.</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Slate, clayey with some silt, calcareous, olive drab, weathers tan; blocky.</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>Limestone, argillaceous; gray, weathers light gray; massive; lenticular.</td>
<td>.65</td>
<td></td>
</tr>
<tr>
<td>Slate, silty, calcareous; tan; blocky; limonite-stained.</td>
<td>.45</td>
<td></td>
</tr>
<tr>
<td>Slate, clayey with some silt, slightly calcareous; dark olive drab with some orange streaks, weathers gray; blocky.</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>Limestone, argillaceous; gray, weathers light gray; massive; weathers irregularly; lenticular.</td>
<td>1.95</td>
<td></td>
</tr>
</tbody>
</table>

Steam silt, (12.9 feet)

| Slate, silty, calcareous; tan, weathers tan-gray; blocky to thin-bedded; thin calcareous lenses. | 4.2 |
| Slate, silty, calcareous; gray-orange with black and gray areas, weathers tan; blocky; iron and carbon nodules. | .2 |
| Slate, silty, calcareous; olive drab, weathers tan; thin-bedded. | .35 |
| Slate, clayey, calcareous, carbonaceous; black; fissile. | .85 |
| Slate, silty, slightly calcareous; olive drab, weathers tan; blocky. | 2.05 |
| Limestone, argillaceous; tan-gray, weathers tan; massive; fractures easily; lenticular; iron-stained. | .4 |
| Slate, clayey with some silt, noncalcareous; dark gray, weathers light gray; thin-bedded to blocky; iron-stained. | 3.2 |
| Slate, silty, calcareous; maroon; thin-bedded; lenticular; stained light gray. | .4 |
| Slate, clayey, all with calcareous; olive drab with maroon streaks in the upper part, weathers light gray; thin-bedded. | 1.3 |

Seattle limestone, (15.2 feet exposed)

| Morrow limestone member. (6.8 feet) | Limestone, argillaceous; gray, weathers light gray; massive; limonite-stained. | 1.35 |
|---|---|
| Slate, clayey with some silt, calcareous, olive drab, weathers tan; blocky. | .3 |
| Limestone, argillaceous; gray, weathers light gray; massive; lenticular. | .65 |
| Slate, silty, calcareous; tan; blocky; limonite-stained. | .45 |
| Slate, clayey with some silt, slightly calcareous; dark olive drab with some orange streaks, weathers gray; blocky. | .3 |
| Limestone, argillaceous; gray, weathers light gray; massive; weathers irregularly; lenticular. | 1.95 |
Limestone, angillaceous; dark gray, weathered tan; massive, weathered platy in upper part. Crinoid columnals, echinoid spines, and brachiopod fragments. ... 0.75

Florene shale member. (7.0 feet)
Shale, clayey with some silt, calcareous; olive drab, weathered tan; thin-bedded. \textit{Fenestella} sp., \textit{Lechella stratiocostata}, \textit{Berthia crassa}, \textit{and Composita} sp. ... 1.2
Shale, silty, very calcareous; gray, weathered light gray; blocky to platy. \textit{Chamaeceras granuliferus, Berthia crassa, and Composita ovata}. ... ... ... ... ... ... ... ... 2.2
Shale, silty, calcareous; olive drab, weathered tan; thin-bedded to blocky. \textit{Chamaeceras granuliferus, Dictyo- clastus mericamus, Trisperrum} sp., \textit{Alloria terminalis}, \textit{Lechella stratiocostata, Composita ovata, crinoid columnals, fusulinids, echinoid spines, Berthia wabauncensis, E. cymbala, Rhombopora} sp., \textit{Polypora} sp., and \textit{Fenestella} sp. ... ... ... ... ... ... ... ... 5.0

Cottonwood limestone member. (5.2 feet exposed)
Limestone, hard, dense; light gray, weathered tan; massive; short nodules in middle and upper parts. Fusulinids very abundant in upper part. ... ... ... ... ... ... ... ... 5.9

Base covered.
This section from the Grouse Limestone to the pure limestone member of the Fremola limestone, inclusive, is exposed in a road cut in the 16th N. 1/4 E. 1, sec. 7, T. 11, R. 9 W., Foot.

Top covered, colluvium and lue Rapids shale

Grouse limestone. (7.2 feet exposed)

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, hard, dense; tan-brown, weathers tan; platy to thin-bedded.</td>
<td>0.2</td>
</tr>
<tr>
<td>Limestone, hard, crystalline; gray, weather tan; massive, weathers siltly.</td>
<td>0.5</td>
</tr>
<tr>
<td>Shale, muddy, calcareous; tan-gray, weather tan; thin-bedded.</td>
<td>0.2</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathers tan; platy with numerous shale partings.</td>
<td>0.5</td>
</tr>
<tr>
<td>Shale, muddy, noncalcareous; tan-gray, weathers tan; thin-bedded.</td>
<td>0.1</td>
</tr>
<tr>
<td>Limestone, hard; gray-brown, weather tan; platy.</td>
<td>0.1</td>
</tr>
<tr>
<td>Shale, muddy, calcareous; gray, weathers tan; thin-bedded.</td>
<td>0.4</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathers tan; massive, weathers platy; thin shale parting.</td>
<td>0.2</td>
</tr>
<tr>
<td>Shale, muddy, calcareous; gray, weathers tan; thin-bedded.</td>
<td></td>
</tr>
<tr>
<td>Limestone, hard; gray, weathers light gray; massive, weathers platy to a shale appearance.</td>
<td>1.15</td>
</tr>
<tr>
<td>Limestone, hard, dense; gray, weathers light gray; massive, weathers blocky at the top and plathy at the base; thin shale parting in middle.</td>
<td>0.7</td>
</tr>
<tr>
<td>Shale, muddy, noncalcareous; tan-gray, weathers tan; thin-bedded.</td>
<td>0.05</td>
</tr>
<tr>
<td>Limestone, hard; gray-brown, weathers light gray; massive, weathers small thin chips.</td>
<td>0.3</td>
</tr>
<tr>
<td>Shale, muddy, calcareous; tan; thin-bedded to plathy.</td>
<td>0.2</td>
</tr>
<tr>
<td>Limestone, hard, crystalline; tan-gray, weathers gray; massive, weathers blocky. Fossil fragments in the upper part. Forms hillside bench.</td>
<td>1.3</td>
</tr>
<tr>
<td>Shale, muddy, slightly calcareous; tan; thin-bedded.</td>
<td>0.1</td>
</tr>
<tr>
<td>Limestone, hard; gray, weathers tan; massive, weathers blocky.</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Possy Creek shale. (23.5 feet)

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, clayey, slightly calcareous; gray-green, weathers light green; thin-bedded.</td>
<td>6.7</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathers tan; massive, weathers plathy. Microbore sp., and some algae.</td>
<td>0.3</td>
</tr>
<tr>
<td>Shale, muddy, slightly calcareous; tan-gray, weathers tan; thin-bedded.</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Limestone, hard; light gray, weathered tan; massive, weathered slabby. Rhombopora sp., Euparapora sp., algae; Derbyla sp., and brachiopod fragments. 1.7
Shale, slightly silty, slightly calcareous; gray-green, weathered light green; thin-bedded. 4.2
Shale, silty, calcareous; variegated, block and irregular. 1.5
Shale, silty, calcareous; gray-green, weathered; blocky to thin-bedded. 1.45
Shale, silty, noncalcareous; variegated, blocky to thin-bedded. 2.9
Shale, silty, calcareous; variegated; blocky to thin-bedded. 3.3
Shale, silty, slightly calcareous; gray-green, weathered tan-gray; thin-bedded. 1.5

Bader limestone. (17.65 feet)
Middleburg limestone member. (13.45 feet)
Limestone, hard, crystalline; tan-gray, weathered light gray; massive, weathered blocky. Algae. 0.75
Limestone, hard, argillaceous; tan-gray, weathered tan; massive, weathered blocky and platy. 2.7

Oosier shale member. (7.0 feet)
Covered interval. 7.0

Miss limestone member. (44 feet)
Limestone, hard; gray; massive, weathered blocky and porous; limonite and iron-stained. Some for all fragments. 1.9
Limestone, soft, argillaceous; tan-brown, weathered tan; massive, weathered blocky to platy; porous; calcite-lined cavities, limonite-stained. Derbyla erana, Aviculopecten occidentalis, and Neekella striatostratata. 1.2
Shale, silty, calcareous; tan-gray, weathered gray; thin-bedded; limonite-stained in upper part. Neekella striatostratata, Derbyla erana, Dicyoclostus sp., Clonotes granuliferus, crinoid columnals, Composita sp., Rhombopora sp., and Fenestella sp. 1.6
Limestone, medium hard; gray; weathered light gray; massive, weathered in small chips; limonite-stained. Lexonoma sp., few ostracods, crinoid columnals, and Fenestella sp. 1.5

Stearns shale. (17.6 feet)
Shale, silty, calcareous; olive drab, weathered gray; thin-bedded becoming slightly platy. 8.7
Covered interval. 8.5

Beattie limestone. (13.1 feet)
Morrill limestone member. (9.8 feet exposed)
Limestone, soft; tan-brown; massive, weathered porous and rotten; calcite crystals common on the top surface. 8
Florence shale member. (6.5 feet)
Shale, clayey with some silt, noncalcareous in middle; tan-gray, weathers tan; thin-bedded; calcarceous plates and nodules in upper part. Fossils rare. ... 6.5

Cottonwood limestone member. (5.7 feet)
Limestone, hard, fine-grained; tan-gray; massive, weathers to large blocks; oolitic nodules common in upper part with a few nodules in lower part. Fusulindids are abundant in the upper half, crinoid columnals, echinoid spines, Berlyia sp., and brachiopod fragments. ... 5.1
Limestone, hard; tan-gray, weathers tan; massive, weathers a sley. ... 0.6

Eskridge shale. (22.3 feet)
Shale, (partly covered) silty, calcarceous; gray-green; thin-bedded to block; calcium carbonate and limonite stains in upper part. ... 9.3
Limestone, hard, slightly argillaceous; gray, weathers light gray; massive, weathers blocky. A. calceopecten occidentalis, Muralina sp., and Pseudomontia dawni. ... 0.2
Shale, silty, calcarceous; gray, weathers light gray; thin-bedded. ... .3
Shale, clayey, noncalcareous; maroon; blocky; iron-stained. ... .5
Shale (partly covered), clayey, calcarceous; gray-green to tan; thin-bedded to blocky. ... 12.5

Greenbush limestone. (33.5 feet)
Nevan limestone member. (16.6 feet)
Limestone, hard; tan-gray, weathers gray; massive, weathers blocky to porous in upper part; limonite-stained. Numerous fossil fragments. ... 1.3
Limestone, medium hard; tan-gray, weathers gray; massive, weathers in small chips; two shale partings. Crinacea grallitifera, Fusulindids, crinoid columnals, echinoid spines and Berlyia sp. ... 4.7
Limestone, hard, dense; light gray, weathers gray; massive, weathers blocky. Echinoid spines are abundant. ... 1.7
Limestone, soft, slightly trachelested; tan-gray, weathers tan; massive, weathers with a rotten, porous, nodular appearance; more resistant in basal part. Fossil fragments. ... 5.7
Shale, silty, with some clay, calcarceous; tan-gray, weathers tan; thin-bedded. ... 2.3
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers platy; iron-stained. Few microfossils. ... 4

Saem Point shale member. (3.5 feet)
Shale, silty with some clay, calcarceous; tan-gray, weathers tan; thin-bedded. ... 5.1
Limestone, soft, argillaceous; gray, weathers tan; massive, weathers blocky; some limonite speck. ... 0.3
**Burr limestone member. (3.4 feet)**

<table>
<thead>
<tr>
<th>Sample Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, hard; gray-brown, weathers gray; massive, weathers thin-bedded; heavily limonite-stained at top, porous.</td>
<td>1.1</td>
</tr>
<tr>
<td>Slate, silty, calcareous; gray, weathers light gray; thin-bedded.</td>
<td>0.2</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathers tan; massive, weathers blocky; two thin shale parts.</td>
<td>2.3</td>
</tr>
<tr>
<td>Slate, silty, calcareous; tan-gray, weathers tan; blocky.</td>
<td>0.5</td>
</tr>
<tr>
<td>Limestone, soft, calcareous; tan-gray; massive, weathers blocky. <em>Pleuropleurus albequis</em> and <em>Aviculopecten occidentalis</em> very abundant.</td>
<td>0.2</td>
</tr>
<tr>
<td>Slate, clayey, calcareous; dark gray, weathers gray; thin-bedded to blocky.</td>
<td>1.5</td>
</tr>
<tr>
<td>Limestone, hard, argillaceous in upper part; gray; massive, weathers blocky to platy in top part; limonite-stained. <em>Aviculopecten occidentalis</em>, and fossil fragments.</td>
<td>2.6</td>
</tr>
</tbody>
</table>

*Mass covered.*
## Section 23

This section from the Threemile limestone member of the Waco limestone to top of the Threemile limestone member of the Waco limestone, inclusive, is exposed in a road cut in the NE sec. 23, T. 10 S., R. 1 W.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 feet exposed</td>
<td>Waco limestone.</td>
</tr>
<tr>
<td>2.5 feet exposed</td>
<td>Threemile limestone member.</td>
</tr>
<tr>
<td>3</td>
<td>Top covered, soil, silty, black; some chert gravel.</td>
</tr>
<tr>
<td>0.2</td>
<td>Limestone, hard, dense; gray, weathered light gray; massive, weathered blocky; short nodules; crinoid columnals and fossil fragments.</td>
</tr>
<tr>
<td>0.5</td>
<td>Limestone, hard, dense; gray, weathered tan; massive, weathered blocky.</td>
</tr>
<tr>
<td>0.3</td>
<td>Limestone, hard, dense; light gray, weathered tan; massive, weathered blocky. Numerous fossil fragments.</td>
</tr>
<tr>
<td>0.5</td>
<td>Slate, silty, calcareous; gray, weathered tan; thin-bedded to platy. Dictyoclostus sp., Derbyia sp., crinoid columnals and Composita sp.</td>
</tr>
<tr>
<td>0.85</td>
<td>Limestone, hard, dense; tan-gray, weathered tan; massive, weathered blocky; two chert lenses. Wallerella sp., crinoid columnals, crinoid spines, Derbyia crassa, and fossil fragments.</td>
</tr>
<tr>
<td>1.9</td>
<td>Slate, silty, calcareous; gray, weathered light gray; thin-bedded; numerous small limonite nodules.</td>
</tr>
<tr>
<td>0.05</td>
<td>Limestone, hard, dense; tan-gray weathered light gray; massive, weathered blocky; lenticular. Fossil fragments.</td>
</tr>
<tr>
<td>1.1</td>
<td>Slate, silty, calcareous; tan-gray to gray, weathered gray-green; thin-bedded. Crinoid columnals, Cerianites granuliferus, Dictyoclostus virgianus, D. portlockianus, Juresusia nebrascensis, Macella striatocostata, Composita sp., Neocapriterus sp., and Derbyia crassa.</td>
</tr>
<tr>
<td>2.7</td>
<td>Limestone, hard, dense; tan-gray, weathered tan; massive, weathered irregularly. Numerous fossil fragments.</td>
</tr>
</tbody>
</table>

**Pepper shale.** (11.4 feet)

<table>
<thead>
<tr>
<th>Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>Slate, silty, noncalcareous; tan-gray, weathered tan; thin-bedded to blocky.</td>
</tr>
<tr>
<td>1.2</td>
<td>Slate, silty, slightly calcareous; dark gray to tan-gray, weathered tan; thin-bedded to blocky.</td>
</tr>
<tr>
<td>1.5</td>
<td>Limestone, hard; gray, weathered tan-gray; massive, weathered blocky; small calcite nodules.</td>
</tr>
<tr>
<td>2.75</td>
<td>Slate, silty, noncalcareous; green, weathering light green; blocky.</td>
</tr>
</tbody>
</table>
Shale, clayey, noncalcareous; purple, mottled with green in middle; blocky. .......................... 1.4
Shale, clayey, noncalcareous; green grading downward to gray-brown; thin-bedded. .................. 0.8
Shale, silty, slightly calcareous; brown; blocky to thin-bedded. ....................................... 0.7
Shale, silty, calcareous; gray, weathered light gray; thin-bedded to blocky. ............................ 0.4
Shale, silty, noncalcareous; greenish-purple, weathered light purple; blocky. ............................ 1.1
Shale, clayey, noncalcareous; green, weathered light green; blocky. .................................... 1.4

Funston Limestone. (0.5 feet)
Limestone, medium hard; tan-gray, weathered tan; massive, weathered blocky in upper and lower parts, and sandy to platy in middle part; very porous at base; two thin shale partings with a more massive shale in upper part. ........................................... 5.9
Shale, clayey, slightly calcareous; gray, weathered tan-gray; thin-bedded; numerous limonite stains. ............................................................ 1.1
Limestone, hard, fine-grained; tan, weathered tan-gray; massive, weathered blocky and porous; calcite-filled pore spaces ........................................... 1.5

Blue Rapids shale. (0.4 feet)
Shale, clayey and silty, noncalcareous to calcareous; maroon and green at the base becoming tan-gray in the upper half; thin-bedded to blocky; some limonite stains; thin argillaceous limestone in lower part. ................................. 20.4

Crouse Limestone. (0.4 feet)
Limestone, hard, fine-grained; tan-gray, weathered tan; massive, weathered platy; numerous thin shale partings ............................................. 5.7
Limestone, hard, dense; tan-gray; massive; weathered blocky and porous, numerous fossil fragments in top part. ....................................................... 2.7

Eddy Creek shale. (0.2 feet)
Shale (mostly covered), silty, calcareous; tan to gray, weathered tan; thin-bedded; limonite-stained. ................................................................. 7.1
Limestone, hard; tan-gray, weathered tan; massive, weathered blocky to shale; some iron stains; Numerous brachiopod fragments, Palaeonora sp., Rhombopora sp., and crinoid columnals ........................................... 0.9
Shale, silty, calcareous; tan-gray; grading downward to gray-green at base; blocky; limonite stains on fracture planes. ........................................... 2.9
Shale, silty, calcareous; maroon mottled with gray-green in the upper part; blocky. ...................... 1.7
Shale, clayey with some silt; calcareous; gray to light green; blocky. ...................................... 0.9
Shale (mostly covered), gray-green and maroon. ................................................................. 6.7
Badger limestone, (13.8 feet covered)

Middleburg limestone member, (3.5 feet)
- Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; limonite-stained. Numerous fossil fragments.
- Shale, clayey, calcareous; block to gray, weathers gray; fissile; limonite-stained.
- Limestone, hard; tan to gray, weathers tan-gray; massive, weathers block to shaly near the base; some limonite stains.

Looser shale member, (10.1 feet)
- Shale, silty, calcareous; tan-gray to gray-green, weathers tan-gray; blocky; iron stains on fracture planes.
- Shale, silty, calcareous; maroon settled with green lenses; blocky; iron stains on the fracture planes.

Covered interval.

Top of Xi'an limestone.
Section 24

This section from the Havensville shale member of the Wreford limestone to the Crouse limestone, inclusive, is exposed in a road and railroad cut in the SW\(\frac{1}{4}\) NE\(\frac{1}{4}\) sec. 6, T. 5 S., R. 7 E.

<table>
<thead>
<tr>
<th>Soil and colluvium</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wreford limestone. (10.0 feet)</td>
<td>2.1</td>
</tr>
<tr>
<td>Havensville shale member. (5.0 feet)</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan-gray; thin-bedded; calcium carbonate nodules; limonite-stained.</td>
<td>3.0</td>
</tr>
<tr>
<td>Three mile limestone member. (7.0 feet)</td>
<td></td>
</tr>
<tr>
<td>Limestone, hard, dense; gray, weathers tan-gray; massive, weathers blocky; chert nodules; limonite-stained.</td>
<td>0.2</td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan-gray; thin-bedded; chert nodules. Ectinoid spines.</td>
<td>.8</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky; three definite chert lenses, chert nodules; limonite-stained. Allorisma sp., and Dictyocloestus americanus.</td>
<td>4.0</td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan-gray, thin-bedded.</td>
<td>.1</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky to shaly at base; chert nodules. Aviculopinna sp., Aviculopecten occidentalis, Derbyia crassa, D. Fooseriensis, and Composita sp.</td>
<td>.7</td>
</tr>
<tr>
<td>Shale, silty, calcareous; olive drab; thin-bedded; some limonite stains.</td>
<td>.3</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive; chert lens; limonite-stained.</td>
<td>.95</td>
</tr>
<tr>
<td>Speiser shale. (17.0 feet)</td>
<td></td>
</tr>
<tr>
<td>Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded. Crinoid columnals, echinoid spines, Jurasquia nebraeensis, Derbyia crassa, and brachiopod fragments.</td>
<td>2.0</td>
</tr>
<tr>
<td>Limestone, hard; gray-brown, weathers tan; massive, weathers blocky; some limonite stains. Microfossils in basal part.</td>
<td>.9</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray-green with purple tint at base, weathers light gray-green; thin-bedded; some limonite stains on bedding planes.</td>
<td>2.9</td>
</tr>
<tr>
<td>Shale, clayey, with some silt, calcareous; maroon; thin-bedded to blocky.</td>
<td>2.0</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; gray-green, weathers light gray-green; blocky.</td>
<td>.4</td>
</tr>
<tr>
<td>Shale, silty, slightly calcareous; maroon to purple, weathers purple; blocky.</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Shale, clayey with some silt; calcareous; gray-green, weathers light gray-green; blocky .......... 0.3
Shale, silt, calcareous; maroon; blocky ........... 2.6
Shale, silt, calcareous; purple; blocky ........... 1.2
Shale, silt, calcareous; gray-green, weather light gray-green; thin-bedded; true iron stains .......... 0.6
Shale, silt, very calcareous; purple to maroon; blocky to massive .......... 1.2
Shale, silt, calcareous; maroon mottled with green; thin-bedded .......... 0.7
Shale, clayey, calcareous; green, weathers gray-green; thin-bedded; limonite-stained .......... 0.3

Punston limestone. (3.6 feet)
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky to porous at top; maroon-stained .......... 1.5
Shale, clayey, calcareous; green with maroon and purple stains, weathers gray-green; thin-bedded .......... 1.1
Limestone, hard, slightly dense; gray, weathers tan-gray, massive, weathers blocky; maroon stains on weathered surface .......... 1.1
Shale, clayey with some silt, calcareous; gray-green to light green at the base, weathers gray-green; thin-bedded; some limonite stains .......... 0.7
Limestone, hard, dense, argillaceous in upper part; gray, weathers tan-gray; massive, weathers rotten and blocky in middle part .......... 1.2

Blue Rapids shale. (19.2 feet)
Shale (partly covered), silt, calcareous; tan; thin-bedded to blocky; numerous thin arenaceous limestone lenses and nodular in upper part .......... 11.3
Shale, clayey, calcareous; tan-gray, weathers tan; thin-bedded; numerous thin calcareous lenses .......... 1.1
Shale, silt, calcareous; tan-gray, weathers tan; thin-bedded; numerous thin calcareous lenses .......... 0.4
Shale, silt, calcareous; purple to gray-green, weathers purple; blocky; iron-stained .......... 2.9

Grouse limestone. (3.5 feet exposed)
Limestone, hard to soft, dense; tan to gray, weathers tan; massive, weathers in thin beds in the top part and is blocky in lower part; iron-stained .......... 8.3
This section from the Schoyer limestone member of the Wreford limestone to the top of the Crouse limestone, inclusive, is exposed in a road cut in the Sec. 35, T. 10 S., R. 8 E.

Feet

Weathered limestone and flint. ........................................ 1

Wreford limestone. (35.05 feet exposed)

Schoyer limestone member. (2.05 feet exposed)

Limestone, hard, dense; light gray to gray-orange, weathered tan-gray; massive, weathered blocky and irregular; flint nodules common. Echinoid spines and brachiopod fragments. .................................................. 0.9

Limestone, medium hard; light gray, weathered tan; massive, weathered irregular; porous. Fossil fragments. ........................................ 0.5

Limestone, hard; tan to light gray; massive, weathered blocky; flinty. ................................................................. 0.15

Limestone, hard; light gray, weathered tan; massive, weathered irregular. Echinoid spines, and brachiopod fragments. ............................................... 0.4

Limestone, hard; light gray to gray-orange; massive, weathered irregular; cherty. Brachiopod fragments. .......................... 0.3

Ravensville shale member. (24.3 feet)

Shale, silty, slightly calcareous; light gray, weathered tan; thin-bedded. .......................................................... 1.1

Shale, silty, calcareous; gray-green; blocky. .......................... 0.2

Celestite, (lentil) light cream; weathered gray-orange. ........... 0.1

Shale, silty, calcareous; tan-gray; thin-bedded; numerous nodules of celestite and celestite, some geodes of celestite. .................................................. 2.8

Limestone, crystalline; gray-orange, weathered tan; massive, weathered irregular; lenticular; geodol and some small nodules of celestite, limonite stains. .......................... 1.1

Shale, silty with some clay, noncalcareous; gray-brown, weathered tan; blocky. ......................................................... 1.3

Limestone, hard; gray-brown, weathered tan; lenticular. ........ 0.2

Shale, silty, calcareous; tan; thin-bedded; limonite stains on bedding planes. ......................................................... 0.3

Limestone, hard; gray, weathered tan; massive, weathered blocky; limonite stains. Some fossil fragments. .......................... 0.4

Shale, silty to clayey, calcareous; gray, weathered light gray; thin-bedded. .......................................................... 0.1

Limestone, medium hard; light gray, weathered tan; massive, weathered blocky. Numerous fossil fragments. ..................... 1.0

Shale, silty to clayey, calcareous; tan-gray; thin-bedded. ........... 0.4

Shale, silty with some clay, calcareous; dark gray, weathered gray; thin-bedded to fissile; limonite stains 2.4
Limestone, hard, crystalline; gray; massive, weathers blocky; lenticular. *Aviculopecten occidentalis* abundant and *Myalina* sp. .......................... 0.5
Shale, clayey, calcareous; tan-gray, weathers light gray; thin-bedded to blocky; limonite stains on bedding planes. .......................... 1.6
Limestone, hard; tan; massive, weathers platy; lenticular. Numerous fossil fragments. ................ 0.8
Shale, clayey with some silt, calcareous; gray, weathers tan; thin-bedded; limonite stains. .......... 1.0

Threemile limestone member. (8.7 feet)
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky. ....................... 1.2
Chert, dark gray to light gray; massive, weathers blocky; interbedded limestone lenses; limonite-stained. .................... 0.9
Limestone, hard; light gray; massive, weathers blocky; porous. Forms hillside bench. ............. 2.6
Chert; light gray to dark gray; massive, weathers blocky; lenticular, limonite-stained. ........ 0.2
Limestone, medium hard; light gray, weathers tan; massive, weathers blocky; porous. ............ 0.8
Chert; light gray to dark gray; massive, weathers blocky; lenticular; limonite-stained. .......... 0.3
Limestone, dense; tan; massive, weathers blocky. Fossil fragments abundant. ..................... 0.4
Shale, silty, very calcareous; gray, weathers tan-gray; thin-bedded. *Crinoid columnals, Jurcsania nebrascensis, Composits ovata,* and numerous fossil fragments. .. 0.5
Limestone, hard; light gray, weathers tan; massive, weathers blocky; numerous chert nodules. *Crinoid columnals, echinoid spines,* and fossil fragments. ... 1.8

Speiser shale. (16.2 feet)
Shale, silty, calcareous; gray, weathers tan; thin-bedded; lenticular. *Dictyoclostus americus, Chonetes granulifera,* and trilobites. ...................... 0.1
Limestone, dense; gray, weathers tan; massive, weathers blocky; lenticular. *Echinoid spines.* .................. 0.5
Shale, silty, calcareous; olive drab, weathers tan; thin-bedded. *Dictyoclostus* sp., *Chonetes granulifera, Derbyia crassa, Jurcsania nebrascensis,* crinoid columnals, *Polyphora* sp., *Composits ovata,* 0.8
Shale, silty, very calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; limonite stains on fracture planes. *Ambocoelia* sp., crinoid columnals, *echinoid spines,* and *Derbyia* sp. .................. 0.3
Shale, silty, calcareous; tan-gray, weathers tan; blocky; limonite stains on fracture planes. *Derbyia* sp., and *Ambocoelia* sp. .................. 1.1
Limestone, hard, dense, slightly crystalline; gray, weathers tan; massive, weathers blocky. Few fossil fragments. ...................... 1.2
| Shale, silt, calcareous; gray, weathers tan-gray; blocky; limonite stains. 0.6 |
| Shale, silt, calcareous; dark gray, weathers gray-green; blocky; limonite stains on fracture planes. 0.5 |
| Shale, silt, calcareous; tan-green, weathers tan-gray; blocky; few limonite stains. 0.2 |
| Shale, silt, calcareous; green with a purple tint, weathers light green; blocky. 0.4 |
| Shale, silt, yellow-green mottled with purple in basal part, weathers tan-green; thin-bedded to blocky. 1.1 |
| Shale, silt, calcareous; purple, weathering purplish-green; blocky; iron stains on fracture planes. 0.4 |
| Shale, silt, very calcareous; green, weathers light green; blocky. 0.4 |
| Shale, silt, calcareous; purple and green, weathers light green. 0.2 |
| Shale, silt, calcareous; dark purple, weathers purple; blocky. 0.7 |
| Shale, silt, calcareous; green, weathers light green; blocky; lenticular. 0.2 |
| Shale, silt, noncalcareous; purple mottled with green; blocky. 1.8 |
| Shale, silt, slightly calcareous; maroon; blocky. 1.5 |
| Shale, silt, slightly calcareous; green mottled with maroon, weathers gray-green; blocky. 1.1 |
| Shale, silt, calcareous; gray-green; blocky; numerous calcium carbonate nodules, limonite stains on nodules. 0.4 |
| Shale, silt, with some clay, noncalcareous; maroon mottled with green, weathers light maroon; blocky. 0.7 |
| Limestone, hard, argillaceous; tan; massive, weathers blocky; iron stains on fracture planes. 0.4 |
| Shale, silt, calcareous; tan; blocky; iron stains on fracture planes. 0.6 |
| Shale, silt with some clay, noncalcareous; dark green, weathers light green; blocky. 1.0 |

Fusulinid limestone. (10.7 feet)
| Limestone, soft; tan; massive, weathers blocky. 2.0 |
| Limestone, medium hard; cream; massive, weathers platy and blocky. 2.2 |
| Limestone, hard, argillaceous; tan; massive weathers blocky; maroon stains on surface. 0.2 |
| Limestone, medium hard; tan-brown, weathers tan; massive, weathers blocky. 1.8 |
| Shale, silt, calcareous; tan; weathers light tan; thin-bedded. 0.3 |
| Shale, silt, calcareous; tan, weathers light gray; blocky. 0.5 |
| Shale, silt, noncalcareous; dark green mottled with brown, weathers light gray-green; thin-bedded. 1.0 |
| Limestone, hard, dense; tan-green, weathers tan; thin-bedded. 0.3 |
| Shale, silt, calcareous; tan, weathers tan with maroon stains; thin-bedded. 0.4 |
| Limestone, hard, semi-crystalline; light gray, weathers tan; massive, weathers blocky. Fusulinidae and fossil fragments. 0.6 |
**Limestone, medium hard; gray, weathers tan; massive, some small geodes. Fossil fragments abundant. . . . 0.9**

**Blue Rapids shale. (19.6 feet)**

<table>
<thead>
<tr>
<th>Strata Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, clayey with some silt, calcareous; gray to yellow-gray, weathers tan-gray; blocky; contains calcareous lenses; limonite stains on fracture planes.</td>
<td>2.6</td>
</tr>
<tr>
<td>Shale, silty with some clay, calcareous; dark gray, weathers gray; blocky; limonite stains on fracture planes.</td>
<td>4.8</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; maroon; blocky to thin-bedded.</td>
<td>2.6</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray mottled with maroon, weathers light gray; blocky; limonite stains.</td>
<td>1.6</td>
</tr>
<tr>
<td>Shale, silty, calcareous; maroon to gray to purple at the base, weathers gray-maroon; blocky.</td>
<td>1.9</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray-green, weathers light gray; blocky.</td>
<td>1.4</td>
</tr>
<tr>
<td>Shale, silty, slightly calcareous; speckled gray-green, weathers light gray; thin-bedded; limonite stains.</td>
<td>.9</td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded; contains thin calcareous lenses.</td>
<td>3.8</td>
</tr>
</tbody>
</table>

**Crouse limestone (0.2 feet exposed)**

<table>
<thead>
<tr>
<th>Strata Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, hard, dense; tan-gray weathers tan; massive, weathers platy.</td>
<td>.8</td>
</tr>
</tbody>
</table>

**Base covered.**
Section 26

This section from the Wyomere shale member of the Matfield shale to the Pungston limestone, inclusive, was measured in a road cut in the NE\(^4\) NE\(^4\) sec. 21, T. 11 S., R. 8 E.

<table>
<thead>
<tr>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil, silty; gray-brown; chert fragments</td>
</tr>
<tr>
<td>Matfield shale. (5.5 feet exposed)</td>
</tr>
<tr>
<td>Wyomere shale member. (5.5 feet exposed)</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; vari-colored; thin-bedded to blocky</td>
</tr>
<tr>
<td>Wreford limestone. (39.2 feet)</td>
</tr>
<tr>
<td>Schroyer limestone member. (7.1 feet)</td>
</tr>
<tr>
<td>Limestone, hard; shale parting in the middle part and near the base; tan; some limonite stains. Ostracods abundant in upper 0.2 feet</td>
</tr>
<tr>
<td>Shale, silty, very calcareous; gray, weathers tan-gray; thin-bedded; thin limestone lenses and nodules. Dictyoclostus americanus, Composita sp., Allorisma terminale</td>
</tr>
<tr>
<td>Chert, with some limestone; dark gray to gray; massive, weathers blocky</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathers tan; massive, weathers blocky</td>
</tr>
<tr>
<td>Chert, dark gray to gray; massive, weathers in large blocks</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathers tan; massive; lenticular, occasional fossil fragments</td>
</tr>
<tr>
<td>Chert, dark gray, weathers gray; massive, weathers blocky; lenticular; limonite stains</td>
</tr>
<tr>
<td>Limestone, hard, shale bed in middle part; tan-gray, weathers tan; chert nodules. Composita ovata, Rhaebopora sp., Derbyia crassa, crinoid columnals, and fossil fragments</td>
</tr>
<tr>
<td>Chert, dark gray, weathers gray; massive, weathers blocky; lenticular; limonite stains</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathers tan; massive; contains numerous chert nodules; limonite stains. Derbyia sp.</td>
</tr>
<tr>
<td>Havensville shale member. (22.3 feet)</td>
</tr>
<tr>
<td>Shale, clayey with some silt, slightly calcareous; olive drab to blue-gray, grading laterally into an olive drab shale, weathers tan; calcareous nodules at the base; some limonite stains</td>
</tr>
<tr>
<td>Limestone, argillaceous; gray; massive, weathers irregular and platy. Aviculopinna sp., Allorisma terminale, Polypora sp., crinoid columnals, Ambocoelia sp., and numerous fossil fragments</td>
</tr>
</tbody>
</table>
Shale, clayey, calcareous; dark gray, weathers blue-gray; thin-bedded. ........................ 1.9
Limestone, argillaceous; tan-gray, weathers tan; platy to massive; some limonite stains; massive zone occurs in central part; above it is a thin-bedded shale zone which grades into a platy zone. Myalina sp., and Pleurophorus sp., and at the very top there is a conglomeratic zone containing sharks teeth, microfossils, limonite nodules and clay balls. ................ 2.1
Shale, clayey with some silt, calcareous; olive drab, weathers tan-gray; thin-bedded. .................. 5.5
Shale, clayey, slightly calcareous; dark gray, weathers gray; thin-bedded. ............................... 4.5
Shale, silty, calcareous; olive drab to gray, weathers light gray; thin-bedded; very calcareous plates weather out; limonite stains. Aviculopecten occidentalis abundant, Derbyia crassa, Myalina sp., and Pleurophorus sp. ................ 2.6

Three mile limestone member. (2.6 feet)
Limestone, hard; tan-gray, weathers tan; massive; chert nodules numerous in the basal part and occasional nodules scattered throughout with a prominent lens of chert in the upper part. Echinoid spines, crinoid columns, occasional brachiopod fragments. ........ 3.3
Limestone, hard; tan-gray, weathers tan; massive; porous; some limonite stains; chert nodules in the upper part. .......................... 1.5
Chert, dark gray to light gray; massive; lenticular. .... 1.2
Limestone, soft; tan-brown, weathers tan; porous in central part. .......................... 0.5
Limestone, somewhat shaly toward base; hard; gray, weathers tan; massive; two chert bands in upper part; occasional limonite stains. Echinoid spines. .... 1.4
Shale, silty, calcareous; gray-green, weathers tan-gray; thin-bedded. Dictyocelisus americanus, Composita ovata, crinoid columns, and Ambocealia sp. .... 0.4
Limestone, hard; light gray, interbedded bands of dark gray; massive; chert nodules. .................. 2.0

Speiser shale. (17.3 feet)
Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded; some limonite stains. Crinoid columns, Derbyia sp., Chonetes granulifera, and Aviculopecten occidentalis. ................ 2.9
Limestone, hard; gray, weathers tan; massive; thin shale parting near base. .................. 1.0
Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded; numerous clay balls and limonite nodules; limonite stains in basal part. .......... 0.3
Limestone, argillaceous; gray, weathers light gray; massive to nodular; limonite stains. .... 0.3
Shale, silty, highly calcareous; dark green, weathers light green; thin-bedded; heavily limonite-stained in the top part. .... 0.4
Shale, silty, noncalcareous; dark green, weathers green; blocky; iron stains on fracture planes. 0.4
Shale, silty, calcareous; light to dark green; weathers green; thin-bedded at top becoming blocky at base; limonite stains on fracture planes. 3.6
Shale, silty, calcareous; purple; blocky. 0.3
Shale, silty, calcareous; green; blocky; limonite stains in basal part. 3.3
Shale, silty, calcareous; maroon with purple and green mottling in upper part; blocky; some stains and nodules of limonite. 1.3
Shale, clayey, calcareous; gray-green; thin-bedded; limonite stains. 1.1
Limestone, argillaceous; gray, speckled with green, weathers tan to light gray; massive, top part weathers to small plates. 1.3
Shale, clayey, calcareous; gray-green, weathers light green; thin-bedded to blocky. 0.7
Shale, silty with some clay, calcareous; tan-gray, weathers tan. 2.1

Frunton limestone. (3.0 feet exposed)
Limestone, hard, dense; gray, weathers tan; massive. 0.6
Limestone, hard; gray, weathers tan; massive, blocky weathers irregularly; clay nodules, porous. 2.4

Base covered.


### Section 27

This section from the Kinney limestone member of the Matfield shale to the Speiser shale, inclusive, is exposed in a stream bank in the SE 1/4 NW 1/4 sec. 15, T. 7 S., R. 6 E.

<table>
<thead>
<tr>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel, chert and limestone.</td>
</tr>
<tr>
<td>Matfield shale. (34.3 feet exposed)</td>
</tr>
<tr>
<td>Kinney limestone member. (1.7 feet exposed)</td>
</tr>
<tr>
<td>Limestone, soft, arenaceous appearance; gray-green; massive; porous</td>
</tr>
<tr>
<td>Wymore shale member. (32.6 feet)</td>
</tr>
<tr>
<td>Shale, clayey, slightly calcareous; gray-green; thin-bedded</td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan; thin-bedded</td>
</tr>
<tr>
<td>Limestone, hard, partly argillaceous; gray, weathers tan; massive, weathers blocky; iron-stained</td>
</tr>
<tr>
<td>Shale, clayey and silty, noncalcareous; tan-gray, weathers tan; thin-bedded to blocky; carbon and limonite stains</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray-green, weathers light green; blocky; limonite-stained</td>
</tr>
<tr>
<td>Shale, silty and clayey, calcareous; maroon with green and purple stains in middle; blocky</td>
</tr>
<tr>
<td>Shale, silty, slightly calcareous; purple with maroon tint, weathers purple; blocky; iron-stained</td>
</tr>
<tr>
<td>Shale, clayey, calcareous; gray-green, weathers tan-gray; thin-bedded; iron-stained</td>
</tr>
<tr>
<td>Wreford limestone. (39.9 feet)</td>
</tr>
<tr>
<td>Schroder limestone member. (10.6 feet)</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive; weathers blocky. Microfossils abundant in upper part</td>
</tr>
<tr>
<td>Shale, silty, with some clay; calcareous; gray-brown, weathers tan-gray; thin-bedded to blocky; some limonite stains</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive, weathers nodular; numerous chert nodules</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray-brown, weathers tan-gray; thin-bedded. <em>Dictyoceras portlockianus</em></td>
</tr>
<tr>
<td>Chert, light gray to dark gray; massive, weathers blocky and irregularly</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive, weathers irregularly and blocky. Fossil fragments</td>
</tr>
<tr>
<td>Chert, some limestone at base; light gray to dark gray; massive, weathers blocky and irregularly</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky; some chert nodules, chert lens at top</td>
</tr>
</tbody>
</table>
Chert, light gray to dark gray; massive, weathered blocky. ........................................... 0.3
Limestone, hard; light gray, weathered tan-gray; massive, weathered blocky. ......................... .7

Ravensville shale member. (21.2 feet)
Shale, silty, calcareous; gray-green to olive drab, weathered tan-gray; thin-bedded; numerous calcareous nodules. ................................................................. 1.0
Limestone, medium hard; tan-gray; massive, weathered platy and to irregular blocks. ............ .6
Shale, silty, calcareous; gray-green, weathered tan; thin-bedded; lenticular. ........................ 2.2
Limestone, soft, fine-grained; tan, weathered tan-gray; massive, weathered to irregular blocks; some iron stains. Some brachiopod fragments. ........................................... .6
Shale, silty, calcareous; olive drab, weathered tan; thin-bedded; calcareous lenses; limonite-stained. ................................................................. .5
Limestone, medium hard, fine-grained; tan-gray; massive, weathered blocky to platy; iron stains abundant; slightly porous. Aviculopecten occidentalis and Bucanophilus sp. .................. 4.9
Shale, silty, with some clay, calcareous; dark gray, weathered gray; thin-bedded to fissile; calcareous lens in middle part and at top. ........................................... 5.2
Limestone, hard, argillaceous; gray, weathered tan to gray; massive, shows thin bedding planes, weathered blocky to platy. Aviculopecten occidentalis very abundant, Jurczenka nebrascensis and Myalina sp. ... 2.2
Shale, clayey with some silt, calcareous; dark gray, weathered gray; thin-bedded to blocky; some iron stains. ................................................................. 1.0
Limestone, argillaceous; dark gray, weathered gray; massive, weathered shaly; thin shale beds. ................................................................. 1.5
Shale, clayey, calcareous; dark gray, weathered gray; thin-bedded to fissile. ........................ 3.5

Threemile limestone member. (8.1 feet)
Limestone, hard; tan; massive, weathered shaly; some chert nodules in middle part. Crinoid columnals and brachiopod fragments. ........................................... 1.4
Chert, light gray to dark gray; massive, weathered blocky; some iron stains; lenticular. ........ 1.4
Limestone, hard; light gray, weathered tan-gray; massive, weathered blocky and irregularly; porous. ................................................................. 1.2
Chert, light gray to dark gray; massive, weathered blocky; numerous limonite stains; lenticular. ................................................................. .2
Limestone, soft; tan-gray; massive, weathered porous and rotten at the base; numerous limonite stains. ................................................................. .2
Limestone, hard; light gray, weathered tan-gray; massive, weathered blocky; slightly porous. ................................................................. 1.4
Chert, light gray to dark gray; massive, weathered blocky; lenticular. ................................ .2
Limestone, hard, dense; light gray, weathered tan-gray; massive, weathered blocky. .............. .6
Shale, silty, very calcareous; dark gray, weathers gray; thin-bedded; limestone lens in middle part. Crinoid columnals, and Derbyia sp. ........................................ 1.3
Limestone, hard, somewhat crystalline; gray, weathers tan-gray; massive, weathers blocky; chert lens in middle part. ........................................ 1.2

Speiser shale. (3.3 feet exposed)
Shale, silty, calcareous; gray; thin-bedded; calcareous lens in middle part. Crinoid columnals, Ehipidemella carbonaria, Polypora sp., Dietyoclostus americanus, Derbyia crassa, and Chonites granulifera. ........................................ 2.0
Limestone, hard, dense; gray with numerous black specks; massive, weathers blocky. ........................................ 0.6
Shale, silty very calcareous; vari-colored shale with purple, green, and gray beds in upper part and maroon in lower part; blocky. ........................................ 5.7

Base covered.
This section from the Florence limestone member of the Barneston limestone to the top of the Schroyer limestone member of the Wreford limestone, inclusive, is exhibited in a road cut in SW1/4 SE1/4 sec. 19, T. 11 S., R. 7 E.

Soil, silty, dark. ........................................... 1 foot

Barneston limestone. (15.5 feet exposed)

Florence limestone member. (15.5 feet exposed)

Limestone and weathered chert, individual beds not measurable. ........................................... 4.9 feet

Limestone, hard; tan-gray, weathers tan; massive, weathers blocky; porous, limonite stains. Crinoid columnals, Eucaphalus sp., Dictyoclostus americanus. ........................................... 0.9

Chert, light gray to dark gray, massive, weathers blocky; fractures conchoideal; lenticular. ........................................... 0.25

Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; lenticular; limonite-stained. ........................................... 0.3

Chert; light gray to dark gray; massive, weathers to irregular blocks; fractures conchoideal; lenticular; limonite-stained areas. Trilobites, numerous fossil fragments on surface. ........................................... 0.4

Limestone, hard, dense; gray to tan-gray, weathers tan; massive, weathers blocky; chert nodules in thin lenses 2.3

Chert; light gray to dark gray; massive, weathers blocky; fractures conchoideal; lenticular; limonite-stained. Fenestella sp. and fossil fragments on outer surface. ........................................... 0.3

Limestone, soft; tan, weathers tan-gray; massive; porous in upper part; numerous chert nodules; iron-stained. Rhombopora sp., Fenestella sp., and Dictyclostus americanus. ........................................... 2.1

Shale, silty, calcareous; tan; thin-bedded. ........................................... 0.1

Limestone, hard, dense; tan, weathers tan-gray; massive; some chert nodules in upper part; iron streaks. Fusulinids and echinoid spines. ........................................... 1.0

Chert, hard, dense; gray to light gray; massive, weathers in thin blocks; limonite-stained. ........................................... 0.3

Limestone, hard, dense; tan, weathering tan-gray; massive, weathers blocky; some chert nodules; lenticular. Echinoid spines. ........................................... 0.7

Chert; light-gray to dark gray; massive, weathers in small blocks; lenticular; conchoideal fracture. ........................................... 0.35

Limestone, hard; tan-gray, weathers tan; massive; a thin chert lens in middle part; occasional chert nodules scattered throughout; thin shale parting near the base. Possibly microfossils, Polyplora sp., Fenestella sp., Ambocoelina sp., echinoid spines, and crinoid columnals. 1.6
Matfield shale (76.2 feet)
Blue Springs shale member. (33.2 feet)
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; lenticular; calcareous nodules. Dictyoclostus sp., crinoid columnals, Derbyia sp., Homobopora sp., and numerous fossil fragments.

1.7
Shale, silty, calcareous; gray-green grading down to tan, weathers tan; thin-bedded to blocky; grades laterally into a thin limestone; iron-stained. Allorissa terminale, Dictyoclostus sp., and Derbyia cymbula.

1.6
Shale, silty, calcareous; gray-orange; thin-bedded; limonite stains on fracture planes.

0.2
Shale, silty, calcareous, gray, weathers light gray; blocky; iron stains on bedding planes. Pleuroporus albequus.

0.8
Shale, silty, calcareous; tan-gray; thin-bedded; very lenticular; large calcium carbonate nodules; iron stains.

1.4
Shale, silty, slightly calcareous; gray-green, weathers light green; blocky.

1.1
Shale, clayey, calcareous; gray-green, weathers light green; thin-bedded; iron stains on bedding planes.

5.9
Shale, clayey, calcareous; violet, green stains throughout; thin-bedded.

1.1
Shale, silty, calcareous; green, weathers light green; some violet stains in upper part; thin-bedded; iron stains on bedding planes.

1.2
Shale, silty, calcareous; maroon; blocky; lenticular.

0.5
Shale, silty, calcareous; light green; blocky; some calcareous lenses present; maroon stains on surface.

0.6
Shale, silty, calcareous; maroon; thin-bedded to blocky.

1.2
Shale, clayey, slightly calcareous; green; blocky.

0.45
Shale, silty, calcareous, maroon; thin-bedded to blocky.

2.4
Covered interval.

15.5

Kinney limestone member. (2.1 feet)
Limestone, soft, slightly dolomitic; tan; massive, weathers blocky; numerous black spots. Forms a small hillside bench.

2.1

Wyoming shale member. (30.9 feet exposed)
Shale, clayey, slightly calcareous; green; blocky; limonite stains on fracture planes.

0.4
Shale, clayey, calcareous; maroon, tinted purple at the base; thin-bedded.

1.4
Shale, clayey, calcareous; greenish-gray to gray; weathers gray-green; thin-bedded.

2.7
Shale, clayey, calcareous; maroon; thin-bedded.

0.9
Shale, clayey, calcareous; yellowish-gray, weathers tan; thin-bedded.

6.9
Limestone, argillaceous, soft; tan-gray, weathers tan; massive, weathers blocky, iron stains on bedding planes. Myalina subquadrate, Aviculopecten occidentalis, and Myalina sp.

0.7
<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, silty, very calcareous; tan-gray, weathers tan; thin-bedded; thin limestone lens in the middle part; limonite-stained areas.</td>
<td>5.2</td>
</tr>
<tr>
<td>Limestone, argillaceous, clay nodules; tan-gray, weathers tan; massive, weathers blocky; porous; heavily limonite-stained; lenticular.</td>
<td>1.3</td>
</tr>
<tr>
<td>Shale, silty, calcareous, tan-gray, weathers tan; thin-bedded; calcareous nodules.</td>
<td>9.5</td>
</tr>
<tr>
<td>Covered interval, colluvium.</td>
<td>11.9</td>
</tr>
</tbody>
</table>

Top of Schroyer limestone member of the Wresford limestone.
Section 29

This section from the Florence limestone member of the Barneston limestone to the Wynona shale member of the Matfield shale, inclusive, is exposed in a road cut in the NE 1 SW 1 sec. 10, T. 6 S., R. 7 E.

Feet

Soil, silty, gray-brown. ................................................................. 2

Barneston limestone. (19.2 feet exposed)
Florence limestone member. (19.2 feet exposed)

Limestone, hard; tan to light gray, weathers tan; massive, weathers blocky; numerous chert lenses and nodules. Echinoid spines, crinoid columnals and few fusulinids. ................................................................. 16.7

Shale, silty, calcareous; gray to gray-green, weathers tan; thin-bedded; numerous calcareous nodules. Echinococclus sp., crinoid columnals, echiroid spines, and Derbyia sp. ................................................................. 0.6

Limestone, hard; tan-gray, weathers tan; massive, weathers blocky to shaly; some limonite stains; chert nodules. Crinoid columnals, Derbyia crassa, D. embulata, Juracania nebrascensis, fusulinids, Chonetes granulifera, Marginifera hystricula, and Kehmbopora sp. ................................................................. .7

Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; calcareous nodules. Echinoid spines, and brachiopod fragments. ................................................................. .4

Limestone, hard; tan-gray, weathers tan; massive, weathers blocky; chert nodules; some limonite stains. Fenestella sp., Derbyia crassa and numerous brachiopod fragments. ................................................................. .8

Matfield shale. (44.1 feet exposed)
Blue Springs shale member. (23.6 feet)

Shale, silty, calcareous; gray, weathers light gray; thin-bedded; iron stains on bedding plane. .................. 2.8

Shale, silty, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; numerous iron stains on bedding and fracture planes. .................. 3.4

Shale, clayey with some silt, calcareous; maroon mottled with purple and gray-green; thin-bedded; iron-stained. ................................................................. 4.7

Shale, silty, calcareous; gray-green, weathers light gray-green; thin-bedded. ................................................................. .9

Shale, silty, very calcareous; maroon; massive and very calcareous in the upper part, blocky in the lower part. ................................................................. 2.7

Shale, silty, calcareous; green, weathers gray-green; blocky. ................................................................. .8
Shale, silty, calcareous; maroon with a purple tint in the upper part; thin-bedded.  
1.7
Shale, clayey, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; iron stains on bedding planes.  
1.1
Shale, clayey, calcareous; maroon becoming purple toward base, mottled with gray and light green in the middle; thin-bedded to blocky.  
5.5

Kinney limestone member. (2.5 feet)
Limestone, soft; tan to light gray, weathers tan-gray with maroon stains; massive, weathers to irregular rounded blocks; chalky at the base. Microfossils abundant.  
1.9
Shale, clayey, calcareous; gray-green, thin-bedded.  
0.2
Limestone, soft; tan; massive, weathers blocky; maroon-stained; numerous small calcite crystals.  
.4

Wymore shale member. (12.0 feet exposed)
Shale, clayey, noncalcareous; gray-green, weathers light gray-green; blocky to thin-bedded; contains numerous thin calcareous lenses.  
3.3
Shale, clayey, calcareous; olive drab mottled with gray, weathers tan; thin-bedded.  
9.2
Shale, silty, calcareous; gray to gray-brown, weathers tan; thin-bedded to blocky; numerous calcareous lenses, cone-in-cone.  
5.5

Base covered.
Section 30

This section from the Florence limestone member of the Barneston limestone to the Wymore shale member of the Matfield shale, inclusive, is exposed in a road cut in the SW^1/4 SE^1/4 sec. 21, T. 11 S., R. 8 E.

<table>
<thead>
<tr>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weathered limestone and soil</td>
</tr>
<tr>
<td>Barneston limestone</td>
</tr>
<tr>
<td>Florence limestone member</td>
</tr>
<tr>
<td>Limestone, hard; tan-gray, weathered tan; massive, weathers platy and irregularly. Crinoid columnals, Rhombopora sp., echinoid spines, Meckella striatocostata, Polypora sp., and Derbia crassa</td>
</tr>
<tr>
<td>Limestone, cherty; gray, weathering light gray; massive, weathers blocky; limonite-stained. Dictyoclostus portlockianus, crinoid columnals, echinoid spines</td>
</tr>
<tr>
<td>Limestone, hard; tan to gray, weathers tan; massive weathers irregular; limonite-stained, contains chert nodules. Dictyoclostus sp., and Polypora sp</td>
</tr>
<tr>
<td>Limestone, hard; gray, weathers tan to light gray; massive, weathers irregularly; porous; chert nodules. Polypora sp., and echinoid spines</td>
</tr>
<tr>
<td>Shale, silty, calcareous; light gray weathers tan; fissile; lenticular</td>
</tr>
<tr>
<td>Limestone, hard; tan; massive, weathers irregularly and blocky; chert lenses and nodules. fusulinids, echinoid spines, crinoid columnals, Polypora sp., Rhombopora sp., and fossil fragments</td>
</tr>
<tr>
<td>Shale, silty, calcareous; tan-gray, weathers tan; platy. Derbyia sp., Dictyoclostus sp., Polypora sp., and echinoid spines</td>
</tr>
<tr>
<td>Limestone, medium hard, argillaceous; gray, weathers tan; massive weathers platy to shaly. Dictyoclostus americanus, crinoid columnals, echinoid spines, and Derbyia sp</td>
</tr>
<tr>
<td>Shale, silty, calcareous; light tan; thin-bedded</td>
</tr>
<tr>
<td>Limestone, hard, argillaceous; gray, weathers tan-gray; massive weathers to very irregular blocks; some iron stains. Derbyia sp., Juracania nebrascensis, Dictyoclostus portlockianus, echinoid spines, Derbia dear-creekensis, D. crassa</td>
</tr>
</tbody>
</table>

Matfield shale | (60.9 feet exposed) |
| Blue Springs shale member | (12.3 feet) |
| Shale, clayey, slightly calcareous; tan-gray, weathers tan; blocky. Allorhina terminale, Entelites hemiplicatus, and Derbyia crassa | .7 |
| Limestone, medium hard, argillaceous; gray, weathers tan; massive, weathers blocky. Echinoid spines | .7 |
Shale, silty, calcareous; gray, weathers light gray; fissile. Microfossils. .................. 0.5
Limestone, hard, argillaceous; tan-green, weathers tan; massive, weathers irregularly; lenticular. .... 0.4
Shale, silty slightly calcareous; tan-gray, weathers tan; blocky; lenticular. .......................... 0.4
Limestone, medium hard, argillaceous; tan-gray, weathers tan; massive, weathers irregularly; lenticular. . 0.2
Shale, silty, calcareous; gray, weathers light gray; blocky; limonite-stained. .......................... 2.1
Shale, clayey, slightly calcareous; gray, weathers tan; blocky. Upper part is more resistant to weathering. 2.6
Shale, clayey, calcareous; maroon to gray, weathers maroon; blocky; limonite-stained. ................ 1.4
Limestone, hard, argillaceous; gray, weathers light gray; massive, weathers shaly; lenticular. ........ 0.8
Shale, clayey, slightly calcareous; maroon; blocky to platy. ............................................. 1.8
Shale, clayey, slightly calcareous; olive-green weathers light green; thin-bedded to fissile. ............ 0.3
Shale, clayey, slightly calcareous; maroon; blocky to platy. ............................................. 1.2
Shale, clayey, slightly calcareous; green, weathers light green; thin-bedded. ........................... 0.35
Shale, clayey, noncalcareous; maroon; thin-bedded to blocky. ............................................. 2.4
Shale, slightly silty, slightly calcareous; green mottled with maroon, weathers light green; blocky. .... 1.3
Shale, silty, slightly calcareous; maroon with green lenses, weathers maroon; blocky. ................... 0.4
Shale, silty, noncalcareous; green, weathers light green; blocky to thin-bedded. ......................... 1.3

Kinney limestone member. (2.3 feet)
Limestone, soft, fine-grained; tan with green tint, weathers tan; massive weathers blocky and porous, the lower part weathers platy; surface is stained-maroon. Microfossils in upper part. ................. 2.3

Wymore shale member. (30.8 feet exposed)
Shale, clayey, noncalcareous; green, weathers light green; blocky. ........................................ 0.6
Shale, clayey, noncalcareous; green, weathers light green; thin-bedded to fissile; limonite stains in lower part, thin secondary calcite lenses. .......................... 1.7
Shale, clayey, slightly calcareous; green grading downward to yellow-green, weathers light green; thin-bedded; limonite stains on bedding planes. .................. 2.1
Shale, clayey with some silt, calcareous; maroon; thin-bedded; thin calcite lenses. ....................... 7.7
Shale, clayey, slightly calcareous; green grading downward to yellow-green, weathers light green; thin-bedded to fissile. Composite sp., Rhombozoa sp., Jurcagania nebrascensis, echinoid plates and spines, crinoid columnals, Derbyia deercreekensis, D. wabaunseensis, and D. crassa. ......................... 13.4
Limestone, hard; tan-gray, weathers tan; massive, weathers irregularly; lenticular. Crinoid columnals, Derbyia sp., microfossils abundant... 0.4
Shale, silty, calcareous; tan-gray, weathers tan; fissile to thin-bedded. Allorisma sp., and crinoid columnals... 1.2
Limestone, hard; light gray weathers tan; massive, weathers blocky; small clay balls in lower part. Crinoid columnals, echinoid spines. Derbyia crassae, and Allorisma sp. Forms small hillside bench... 2.4
Shale, silty, slightly calcareous; tan-green, weathers light gray; fissile to thin-bedded... 10.3

Base covered.
This section from the Fort Riley limestone member of the Barneston limestone to the Easy Creek shale, inclusive, is exposed in a road cut in the NE\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 29, T. 9 S., R. 7 E.

Feet

Soil, silty and clayey; brown to gray. .......................... 2

Barneston limestone (40.8 exposed)

Fort Riley limestone member. (10.0 exposed)

Limestone, hard; tan to tan-gray, weathers gray; massive, weathers blocky and platy at top; porous, some limonite stains. Echinoid spines abundant, Derbyia crassa, D. cymbula, crinoid columnals, Aviculopecten occidentalis, Dictyoclostus portlockianus, Ambocella expansa, Composita ovata, Polypora sp., Fenestella sp., Euomphalus sp., Rhabopora sp. .......................... 5.0

Shale, silty, calcareous; tan, weathers tan-gray; thin-bedded; contains a calcareous lens; some limonite stains. Composita ovata, Derbyia cymbula, echinoid spines, and crinoid columnals. .......................... 2.0

Limestone, hard, dense, somewhat crystalline; gray-orange, weathers tan; massive, weathers in irregular blocks; some iron stains. Echinoid spines, Fenestella sp., Rhabopora sp., Derbyia crassa, Dictyoclostus americanus, and Ambocella expansa. .......................... 2.1

Oketo shale member. (9.5 feet)

Shale, silty with some clay, very calcareous; tan-gray to blue-gray, weathers tan; thin-bedded; numerous calcareous lenses. Derbyia crassa, Composita ovata, Meckella striatocostata, Dictyoclostus americanus, crinoid columnals, Polypora sp., Ambocella expansa, Rhabopora sp., echinoid spines, Aviculopecten occidentalis. .......................... 5.0

Limestone, hard, dense; tan-gray; massive, weathers blocky. Echinoid spines abundant, crinoid columnals and brachiopod fragments. .......................... .9

Shale, silty with some clay, calcareous; tan; thin-bedded. Echinoid spines, crinoid columnals, Derbyia crassa, Ambocella expansa, Fenestella sp., Rhabopora sp., and Fistulipora sp. .......................... 3.6

Florence limestone member. (21.3 feet)

Limestone, hard, dense; tan, weathers tan-gray; massive, weathers blocky; numerous chert nodules; some limonite stains. Crinoid columnals, Meckella striatocostata, echinoid spines, Derbyia cymbula, and Astartella sp. .......................... 2.9

Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded. Echinoid spines. .......................... .4
Limestone, hard, dense; tan-gray; massive, weathers blocky and irregularly; numerous chert lenses and nodules; iron-stained. *Compositea* *sp.*, *Peneastecca* *sp.*, *Polyporaa* *sp.*, echinoid spines, *Derbyaa cymbula*, *D. sp.*, *Meckella striatocostata*, and crinoid columnals.......................... 11.9

Limestone, hard, dense; tan to gray, weathers tan-gray; massive, weathers blocky; alternating limestone and chert with massive chert lens at top, chert nodules; limonite-stained. Crinoid columnals, echinoid spines, fusulinids and *Rhombopora* *sp.*........... 6.1

Matfield shale. (71.0 feet)

Blue Springs shale member. (24.9 feet)

Shale, silty with some clay, calcareous; tan; thin-bedded; calcareous nodules abundant, some limonite stains.......................................................... 3.3

Limestone, hard; tan-gray, weathers tan; massive, weathers blocky........................................ 0.9

Shale, silty, calcareous; tan; thin-bedded.......................................................... 3.0

Shale, silty, slightly calcareous; gray-green, weathers dark gray; thin-bedded.......................................................... 1.0

Shale, clayey, calcareous; light gray-green; thin-bedded; iron stains.......................................................... 4.9

Shale, silty, calcareous; green, weathers light green; blocky; iron stains on fracture planes................... 0.7

Shale, clayey, calcareous; light gray; mottled with maroon at base; thin-bedded.......................................................... 2.1

Shale, silty with some clay, calcareous; maroon; mottled with light green; blocky.......................... 1.4

Shale, silty, calcareous; gray-green; thin-bedded; some iron stains.......................................................... 0.5

Shale, silty, calcareous; maroon with a few green stains; blocky; calcareous lenses.......................................................... 2.1

Shale, clayey, calcareous; green; thin-bedded.......................... 0.4

Shale, clayey, calcareous; maroon mottled with green; blocky to thin-bedded.......................... 5.2

Shale, silty with some clay, slightly calcareous; green, weathers light green with a purple tint in upper part; thin-bedded to blocky; iron stains in middle part.......................... 2.1

Kinney limestone member. (3.1 feet)

Limestone, medium hard, dense; light gray, weathers tan; massive weathers blocky; some fine black specks.
A zone (0.2 foot thick) at very top contains ostracode 3.1

Wymore shale member. (43.0 feet)

Shale, clayey somewhat silty, noncalcareous; green, weathers light gray-green; purple stains in the middle; thin-bedded becomes blocky at base; some limonite stains.......................... 6.6

Shale, very silty, slightly calcareous; tan with some gray zones; blocky to thin-bedded; numerous limonite stains.......................... 20.9
Shale, silty, calcareous; olive drab weathered gray; blocky; numerous limonite stains, and some carbonaceous; lenticular. 1.1

Shale, silty, calcareous; olive drab to gray-green mottled with maroon, weathered gray; thin-bedded to blocky; some iron stains, maroon nodules on weathered surface. 3.8

Shale, clayey, calcareous; gray-green to dark green, weathers tan-gray; blocky; numerous limonite stains. 4.3

Shale, clayey, calcareous; maroon; blocky. 0.4

Shale, clayey, calcareous; gray; blocky. 0.5

Covered interval. 5.4

*Wrexford limestone. (36.1 feet)*

*Schroyer limestone member. (9.1 feet)*

Limestone (covered at base), hard, slightly crystalline; tan weathers tan-gray; massive, weathers blocky; limonite stains common. 2.3

Limestone, hard, dense; light gray, weathers tan-gray; massive, weathers blocky; numerous chert lenses and nodules. Crinoid columnals, Chaenetes granuliferus, Fenestella sp., echinoid spines, Ambocelia plane-convex, and numerous fossil fragments. 2.5

Limestone, hard, dense; light gray, weathers tan-gray; massive, weathers blocky; thick chert lens in middle, numerous chert nodules. Crinoid columnals, Chaenetes granuliferus, Juracania nebrascensis, echinoid spines, Dictyoclostus sp., brachiopod fragments. 1.8

Shale, silty, very calcareous; tan; platy, lenticular. 0.15

Limestone, hard, dense; light gray, weathers tan-gray; massive weathers blocky; chert lenses in upper part. *Compositea sp.* and *Ambocelia sp.* 1.6

*Havenesville shale member. (20.3 feet)*

Shale, silty, calcareous; tan; thin-bedded; calcareous lenses. 3.3

Limestone, soft, dense, argillaceous in basal part; tan to tan-gray, weathers tan-gray; massive weathers shaly; porous, numerous limonite stains. 0.9

Shale (mostly covered), silty, calcareous; tan to tan-gray, weathers tan; thin-bedded to blocky; few calcareous lenses in upper part, some limonite stains. 16.6

*Three mile limestone member. (7.6 feet)*

Limestone, medium hard; tan, weathers tan-gray; massive, weathers blocky. Crinoid columnals and few small fusulinida. 0.4

Chert, hard, dense; light gray to dark gray; massive, weathers blocky; lenticular. 0.35

Limestone, hard, dense; tan-gray; massive, weathers blocky; slightly porous, some limonite stains in pores; thin shale lens at base. 1.2

Chert, hard, dense; light gray to dark gray; massive weathers to small blocks. 0.2
<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Thickness (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Limestone, hard, dense; tan-gray; massive, weathered blocky; porous, limonite stains in pores.</td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td>Chert, hard, dense; light gray to dark gray; massive, weathered blocky; lenticular.</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Limestone, hard; tan-gray, weathered tan; massive, weathered blocky; porous, limonite stains in pores; some chert nodules in lower part, thin shale parting in the middle part.</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Shale, silty, calcareous; tan-gray; thin-bedded. Crinoid columnals, echinoid spines, <em>Derbyia</em> sp., and <em>Composita</em> sp.</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Limestone, hard; light gray, weathered tan; massive; one chert lens and few chert nodules; some limonite stains. Crinoid columnals and echinoid spines.</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Speiser shale. (13.6 feet) Shale, silty with some clay, calcareous; tan to tan-gray, weathered tan-gray; thin-bedded; some limonite stains on bedding planes. Crinoid columnals, echinoid spines, and <em>Derbyia</em> sp.</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Limestone, hard, argillaceous; tan-gray, weathered tan; massive, weathered blocky.</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Shale, clayey, some silt, calcareous; tan-brown weathered tan; thin-bedded; some limonite stains.</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Shale, clayey, calcareous; green, weathered light green; thin-bedded to blocky.</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Shale, silty, calcareous; maroon mottled with green; blocky to thin-bedded to blocky; iron stains on fracture planes.</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>Shale, clayey, calcareous; light green; blocky; some iron stains.</td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>Shale, silty, calcareous; maroon mottled with green in upper part; thin-bedded to blocky.</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>Shale, silty, noncalcareous; green mottled with purple and grading downward to purple at base; blocky; limonite-stained.</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>Shale, clayey with some silt, calcareous; green mottled with purple and maroon at base; thin-bedded; iron-stained.</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>Shale, silty, calcareous; maroon; blocky.</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Funston limestone. (6.3 feet) Limestone, hard; light gray weathered tan-gray; massive, weathered blocky.</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>Shale, clayey, some silt, calcareous; gray with purple in middle; thin-bedded; some limonite stains.</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Limestone, soft; gray-orange, weathered tan-gray; massive; porous, sandy appearance, rotten, a band of chert nodules present in upper part.</td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>Blue Rapids shale. (17.6 exposed) Shale, silty, very calcareous; tan-gray mottled with maroon, weathered light gray; thin-bedded; calcium carbonate stains abundant, calcareous nodules and limonite stains common, thin, clayey limestone bed zone is near the base.</td>
<td></td>
</tr>
</tbody>
</table>
Stale, clayey, calcareous; grey-green; thin-bedded; limonite-stained.  
1.4
Stale, clayey, noncalcareous; gray-green, weathered light grey-green; thin-bedded to blocky; limonite-stained.  
3.2
Stale, clayey, noncalcareous; maroon mottled with purple and some light gray; thin-bedded to blocky.  
1.1
Stale, silty with some clay, calcareous; light grey-green mottled with purple in upper part, weathers light gray; thin-bedded; iron stains abundant.  
2.8
Stale, silty, calcareous; purple with maroon tint, weathers purple; thin-bedded; some limonite stains.  
0.8
Stale, silty, calcareous; gray-green weathers light gray-green; thin-bedded.  
0.7
Stale, silty, slightly calcareous; purple; thin-bedded; numerous small calcareous nodules at base.  
2.4
Stale, silty, calcareous; green becoming gray-green at base; thin-bedded; numerous calcareous nodules, limonite-stained.  
1.5

Covered interval, colluvium, thin limestone plates on surface 11.7

Crouse limestone. (1.9 feet exposed)
Limestone, hard; tan-gray; massive, weathers blocky; porous.  
1.9

Early Creek shale. (12 feet exposed)
Stale, silty, calcareous; gray-green, weathers tan-gray; thin-bedded; limonite-stained.  
4.7
Limestone, hard, dense; gray to tan-gray, weathers tan-gray; massive; numerous small limonite and clay balls in lower part, give conglomeratic appearance. Numerous fossil fragments and some microfossils.  
1.8
Stale, clayey with some silt, calcareous; gray-green grading downward to maroon at base; thin-bedded; numerous calcium carbonate nodules in upper top part.  
5.5

Base covered.
This section from the Fort Riley limestone member of the Barneston limestone to the Blue Springs member of the Matfield shale, inclusive, is exhibited in a road cut in the NW 1/4 NE 1/4 sec. 17, T. 6 S., R. 6 E. 

Foot

Soil, silty; gray-brown. .......................... 1

Barneston limestone. (32.9 feet exposed)
  Fort Riley limestone member. (5.3 feet exposed)
    Limestone, hard, dense; light gray, weathers tan-gray; massive, weathers blocky; porous. Derbyia sp., Neckella striatocoastata, eocrinoid spines, crinoid columnals, and Composite sp. Forms hillside bench known locally as "rim rock". .......................... 5.3

Oketo shale member. (11.2 feet)
  Shale, silty, calcareous; tan-gray to gray, weathers tan-gray; thin-bedded to blocky; limestone lens in middle part; iron stains. Derbyia sp., Dictyoclostus americanus, Composite ovata, Derbyia crassa, crinoid columnals, eocrinoid spines, Neckella striatocoastata, Polypora sp., Penastella sp., Rhombopora sp., Ambocoelia sp., and Aviculopecten occidentalis. .......................... 11.2

Florence limestone member. (22.4 feet)
  Limestone (partly exposed), hard, dense; tan to gray, weathers tan-gray; massive, weathers blocky; numerous clay lenses and nodules. Eocrinoid spines, crinoid columnals, and brachiopod fragments. .......................... 22.4

Matfield shale. (19.2 feet exposed)
  Blue Springs shale member. (12.2 feet exposed)
    Shale, silty and clayey, mostly calcareous; gray-green and tan-gray in upper part; maroon in the lower part; thin-bedded to blocky; thin limestone lens in upper part; some limonite stains. .......................... 12.2

Base covered.
Section 33

This section of the Earneston limestone is exposed in a road cut in the SE 1/4 sec. 10, T. 3 S., R. 2 E.

Feet

Soil, gray-brown, silty. .......................... 2

Earneston limestone. (27.9 feet exposed)
Fort Riley limestone member. (7.5 feet exposed)
Limestone, hard, dense; tan-gray, weathers light gray; massive, weathers in large blocks; porous.
- Echinoid spines. .......................... 4.1
- Shale, silty, calcareous; tan; thin-bedded; numerous calcareous plates. Echinoid spines, crinoid columnals, Derbia crassa, Dictyclostus sp., and Ambocella expansa. .......................... 2.2
- Limestone, hard; gray-orange, weathers tan; massive, weathers platy; some limonite stains. Rhombopora sp., crinoid columnals, and echinoid spines. .......................... 1.2

Oketo shale member. (9.2 feet)
- Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded; calcareous lenses. Dictyclostus americanus, Composita ovata, Rhombopora sp.,
- Limestone, hard; tan-gray, weathers tan; massive, weathers in blocks and irregular fragments. Crinoid columnals, echinoid spines; Rhombopora sp., Derbysia sp., and Dictyclostus sp. .......................... 1.3
- Shale; silty, calcareous; gray-brown, weathers tan; thin-bedded; some calcareous lenses; limonite stains. .......................... 2.6

Florence limestone member. (11.2 feet exposed)
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; short lenses and nodules. Echinoid spines, Rhombopora sp., Ambocella sp., crinoid columnals and few brachiopod fragments. .......................... 11.2

Base covered.
Section 34

This section of the Barneston limestone is exposed in a road cut in the NE\(1_4\) SE\(1_4\) sec. 15, T. 7 S., R. 6 E.

| Soil, silty; black | 2.0 feet |

Barneston limestone. (40.4 feet exposed)

| Fort Riley limestone member. (6.4 feet exposed) | 1.1 feet |

| Limestone, hard; gray-brown, weathers tan-gray; massive, weathers blocky; porous; limonite-stained. Crinoid columnals | 1.1 feet |

| Limestone, hard, dense; tan-gray; massive, weathers in large blocks; porous; few iron stains. Derbyia crassa, crinoid columnals, and brachiopod fragments. Forms hillside bench known locally as "rim rock" | 5.3 feet |

Oketo shale member. (8.7 feet)

| Shale, silty, calcareous; gray to tan-gray, weathers tan-gray; thin-bedded; numerous calcareous lenses. Dictyoclostus americanus, D. portlockianus, Polypora sp., Rhombopora sp., Derbyia crassa, D. cymbula, D. focaerionsis, Ambocelidia expansa, Composita ovata, Fenuaella sp., and Wyolina copei | 8.7 feet |

Florence limestone member. (25.3 feet exposed)

| Limestone, hard, crystalline in part; gray, weathers tan-gray; massive, weathers blocky and shaly at top. Some chert nodules. Echinoid spines, crinoid columnals and Derbyia sp. | 2.3 feet |

| Shale, silty, calcareous; tan-gray; thin-bedded; some iron stains. Derbyia crassa, Rhombopora sp., Fenuaella, crinoid columnals, Polypora sp., Aviculopecten occidentalis, and echinoid spines | 3.3 feet |

| Limestone, hard; tan-gray; massive, weathers blocky; chert nodules; some limonite stains. Derbyia crassa, Dictyoclostus americanus, echinoid spines, and brachiopod fragments | 3.6 feet |

| Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded, Derbyia crassa, crinoid columnals, and echinoid spines | 0.4 feet |

| Limestone, hard; gray, weathers tan-gray; massive, weathers shaly and blocky; chert nodules | 1.4 feet |

| Limestone, hard, dense; tan-gray to gray; weathers tan-gray; massive, weathers blocky and nodular; numerous chert lenses and nodules; some iron stains | 14.3 feet |

Base covered.
This section of the Barneston limestone is exposed in a road cut in the SW\(\frac{1}{4}\) sec. 33, T. 6 S., R. 5 E.

**Top eroded**

**Barneston limestone. (38.0 feet exposed)**

*Fort Riley limestone member. (5.3 feet present)*

Limestone, hard; tan, weathers tan-gray; massive, weathered blocky at top and platy at base; porous. Echinoid spines, crinoid columnals, *Derbyia* sp., and brachiopod fragments. Forms hillside bench known locally as "rim rock". .......... 3.5

Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; numerous calcareous lenses. Echinoid spines, and crinoid columnals. .......... 0.9

Limestone, hard; tan-gray, weathers tan; massive, weathered blocky. Crinoid columnals, crinoid spines, *Rhombopora* sp., *Fenestella* sp., *Meekeella straticostata*, and brachiopod fragments. .......... 1.2

**Oketo shale member. (9.1 feet)**

Shale, silty, calcareous; tan; thin-bedded; some iron stains. *Polypora* sp., *Derbyia crassa*, crinoid columnals, *Rhombopora* sp., *Composite ovata*, *Fenestella* sp., and *Dictyoclostus americanus*. .......... 9.1

**Florence limestone member. (23.6 feet exposed)**

Limestone, hard, dense; tan-gray; massive, weathers blocky; chalk nodules. *Composite* sp., echinoid spines, crinoid columnals, *Ambocella* sp. .......... 1.0

Shale, silty, calcareous; tan-gray; weathers tan; thin-bedded; calcareous lenses. *Dictyoclostus americanus*, D. *portlocki anus*, *Rhombopora* sp., *Fenestella* sp., and *Fistulipora* sp. .......... 2.0

Limestone, hard, dense; tan-gray; massive, weathers blocky; numerous chalk nodules; iron-stained. *Dictyoclostus portlocki anus*, *Derbyia crassa*, echinoid spines, crinoid columnals, and *Ambocella* sp. .......... 3.4

Shale, silty, very calcareous; tan-gray; weathers tan; thin-bedded; numerous calcareous lenses. *Dictyoclostus portlocki anus*, *Meekeella straticostata*, *Eryalina copei*, *Derbyia* sp., *Polypora* sp., *Rhombopora* sp., *Astartella* sp., *Derbyia crassa*, echinoid spines, crinoid columnals, *Stenopora* sp., and *Fenestella* sp. .......... 1.4

Limestone, hard, dense; light gray; weathers tan-gray; massive, weathers blocky; numerous chalk nodules and lenses; some iron stains. Echinoid spines and crinoid columnals. .......... 2.8
Shale, silty, calcareous; tan-gray, weathers tan; thin-beded; numerous calcareous nodules and lenses.  
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky to nodular; numerous chert lenses and nodules. Echinoid spines, crinoid columnals, Rhombopora sp., Fenestella sp., Ambocoelia sp., and Derbyia sp.  
Base covered.
Section 36

This section from the Towanda limestone member of the Doyle shale to the Florence limestone member of the Barneston limestone, inclusive, is exhibited in a road cut in the NE 1/4 NW 1/4 sec. 6, T. 7 S., R. 4 E.

Feet

Soil, silty; gray; limestone and chert fragments. .............................. 1

Doyle shale. (23.4 feet exposed)
   Towanda limestone member. (7.6 feet exposed)
   Limestone, hard, dense; gray-brown, weathers tan-gray; massive, weathers blocky to platy; porous and cavernous in part; iron stains; small structure. 7.6

Holmesville shale member. (13.8 feet)
   Shale, silty calcareous; ten-gray to gray-green; thin-bedded to blocky; heavily limonite-stained zone near the base. ......................... 11.2
   Limestone, argillaceous, hard; tan-gray; massive, weathers blocky; penecontemporaneous folding. ... 0.5
   Shale, silty, very calcareous; gray-brown, weathers tan; blocky to thin-bedded; limonite stains, calcareous nodules. ........................ 1.6
   Shale, silty, calcareous; gray-green; blocky. ............................ 5.5

Barneston limestone. (43.5 feet exposed)
   Fort Riley limestone member. (32.2 feet)
   Limestone, soft; tan-gray to gray, weathers tan; massive, weathers shaly in lower part and blocky in upper part; porous; numerous limonite stains. .... 25.1
   Limestone, soft, dolomitic; gray-orange, weathers tan-gray; massive, weathers blocky; limonite-stained, porous. Forms hillside bench locally called "rim rock". ..................... 7.1

Oketo shale member. (8.9 feet)
   Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; calcareous lenses and plates. Composita sp., Diatryocolatus americanus, Polypora sp., Derbyia crassa, Ambocoella sp.; crinoid columns, crinoid spines, Rhombopora sp., and Penestella sp. .... 8.9

Florence limestone member. (2.4 feet exposed)
   Limestone, hard; tan-gray, weathers tan; massive weathers shaly and blocky; some chert nodules. Echinoid spines, crinoid columns, Rhombopora sp., Composita sp. ................... 2.4

Base covered.
Section 37

This section of the Towanda limestone member of the Boyle shale to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a stream bank and quarry in the NE\(^4\) 
NW\(^4\) sec. 11, T. 9 S., R. 4 E.

Feet

Soil, silty and clayey; dark gray; some limestone gravel. . . . . 1

Doyle shale. (41.2 feet interval)
  Towanda limestone member. (13.7 feet exposed)
    Limestone, hard, dense in part; gray-orange to gray,
    weathers gray-orange; massive, weathers blocky and
    platy; limonite stains abundant; porous in part. . . . . 13.7

Holmestville shale member. (20.5 feet interval)
  Shale (middle and basal parts covered), silty, cal-
  careous; tan; thin-bedded. . . . . . . . . . . . . . . . . . 20.5

Barneston limestone. (3.3 feet exposed)
  Fort Riley limestone member. (3.3 feet exposed)
    Limestone, medium hard, dolomitic; gray; massive,
    weathers blocky; porous. . . . . . . . . . . . . . . . . . 3.3

Base covered.
This section from the Towanda limestone member of the Doyle scale to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a road cut in the 5R 5W 5SW sec. 17, T.7 S., R. 6 E.

Soil; and weathered limestone........................ 1

Doyle shale. (29.5 feet exposed)
   Towanda limestone member. (3.6 feet exposed)
   Limestone, hard, dense; gray-orange to tan-gray,
   weathers tan-gray; massive, weathers blocky to
   platy; limonite-stained. Microfossils abundant
   in the basal part.................................... 3.6

Holmeville shale member. (24.9 feet)
   Shale, silty, calcareous; gray-green to light gray
   at the top; thin-bedded to blocky; two calcareous
   lenses; heavily limonite-stained in upper part....... 5.1
   Shale, silty with some clay, slightly calcareous;
   maroon mottled with green and gray; thin-bedded to
   blocky; some iron stains on fracture planes........... 5.2
   Shale, silty, calcareous; gray-green, weathers tan-
   gray with maroon stains on the surface; thin-bedded. 3.9
   Limestone, soft, dolomitic; tan-orange, weathers gray-
   brown; massive, weathers porous and rotten; limonite-
   stained. Pleurophorus sp., and microfossils........... 0.4
   Shale, silty, calcareous; olive drab mottled with
   blue-gray; blocky; some iron stains.................... 1.8
   Limestone, soft, argillaceous; olive drab, weathers
   tan-gray; massive, weathers blocky and shaly......... 0.8
   Shale, silty, calcareous; gray-green to tan-gray;
   blocky to thin-bedded; some limonite and carbon
   stains.................................................. 1.7
   Limestone, medium hard, arenaceous; gray-brown; mas-
   sive, weathers irregularly; heavily limonite-stained;
   penecontemporaneous folding............................ 0.6
   Shale, clayey, slightly calcareous; gray-green to tan-
   gray, weathers light gray-green; thin-bedded to
   blocky; some iron stains............................... 1.6
   Shale, clayey, noncalcareous; gray; thin-bedded to
   blocky; some iron stains.............................. 3.6

Barneston limestone. (26.8 feet exposed)
   Fort Riley limestone member. (28.8 feet exposed)
   Limestone, soft, dolomitic; tan-gray to dark gray;
   massive, weathers blocky; porous........................ 1.5
   Shale, silty, calcareous; gray to blue-gray, weathers
   tan-gray; thin-bedded................................. 0.2
<table>
<thead>
<tr>
<th>Description</th>
<th>222</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, soft, dolomitic; gray to blue-gray; weathers tan-gray; massive, weathers blocky; porous; some limonite stains</td>
<td>5.5</td>
</tr>
<tr>
<td>Limestone, hard, argillaceous; gray to blue-gray; massive, weathers platy; some iron stains</td>
<td>3.7</td>
</tr>
<tr>
<td>Limestone, hard; gray-orange, weathers tan-gray; massive, weathers blocky; thin shale parting</td>
<td>3.7</td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky; porous. Echinoid spines, crinoid columnals. Forms hillside bench locally called &quot;rim rock&quot;</td>
<td>5.2</td>
</tr>
<tr>
<td>Limestone, medium hard; gray to tan-gray, weathers tan-gray; massive, weathers blocky to shaly; shale partings; iron stains. Composite evate, echinoid spines, Aviculopecten occidentalis, Stonopora sp., crinoid columnals, and Ambacoelia sp.</td>
<td>6.3</td>
</tr>
</tbody>
</table>
Section 39

This section from the Towanda limestone member of the Doyle shale to the Fort Riley limestone member of the Barneaton limestone, inclusive, is exposed in a road cut in the 32\(^{\circ}\) 30' sec. 31, T. 6 S., R. 5 E.

Feet

Soil, silty; dark gray. .................................. 2.5

Doyle shale, (21.2 feet exposed)
  Towanda limestone member, (3.8 feet exposed)
    Limestone, hard, dense in part; gray-orange, weathers tan-gray; massive, weathers blocky and platy; porous in middle part. ........................................ 3.8

Holmesville shale member, (17.4 feet)
  Shale (partly covered), silty with some clay, calcareous; tan-gray to gray-green; thin-bedded to blocky. ................................................................. 11.2
  Limestone, medium hard; tan-gray; massive, weathers blocky; porous. Loxonema sp., Pleurophorus sp., and microfossils. ........................................ 0.7
  Shale, silty, noncalcareous; tan-gray to gray-green; thin-bedded; some limonite stains on bedding planes. ........................................ 5.5

Fort Riley limestone member, (30.3 feet exposed)
  Limestone, soft, dolomitic; tan-gray, weathers tan; massive, weathers blocky; some iron stains. ........................................ 0.7
  Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; limonite stains on bedding planes. ........................................ 2.4
  Limestone, soft, fine-grained; gray-orange, weathers tan-gray; massive, weathers blocky; porous. ........................................ 2.3
  Limestone, medium hard, fine-grained, slightly dolomitic; gray to gray-orange, weathers tan-gray; massive, weathers blocky to platy to shaly; iron-stained. Pleurophorus sp., Myalina sp., and few fossil fragments. ........................................ 14.8
  Limestone, hard; tan-orange, weathers tan-gray; massive, weathers blocky to shaly at the top; porous. Crinoid columnals and echinoid spines. Forms a hillside bench locally called "rim rock". ........................................ 4.6
  Limestone, hard; olive drab, weathers tan-gray; massive, weathers shaly; shale parting. Crinoid columnals and echinoid spines. ........................................ 5.5

Base covered.
## Section 40

This section from the Towanda limestone member of the Doyle shale to the Fort Riley limestone member of the Earneston limestone, inclusive, is exposed in a road cut in the NE\(\frac{3}{4}\) SE\(\frac{1}{4}\) SE\(\frac{1}{4}\) sec. 29, T. 9 S., R. 6 E.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Soil, silty, dark.</th>
<th>Doyle shale. (12.3 feet exposed)</th>
<th>Towanda limestone member. (12.3 feet exposed)</th>
<th>Holmesville shale member. (19.1 feet)</th>
<th>Earneston limestone. (27.8 feet exposed)</th>
<th>Fort Riley limestone member. (27.8 feet exposed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Limestone, hard, dense, somewhat crystalline in places; gray-orange, weathers light gray; massive, weathers blocky to platy in the upper part; thin shale parting near middle; limonite stains and nodules abundant; porous. Badly fractured, some folding. Some actinoid spines in basal part.</td>
<td>Limestone, argillaceous, soft; gray-green, weathers light gray; nodular; cavernous.</td>
<td>Shale, silty, calcareous; maroon at base grading up into gray, weathers maroon to tan; thin-bedded; calcareous nodules and lenses common, heavily limonite-stained in upper part.</td>
<td>Limestone, soft, argillaceous; tan-gray; nodular; cavernous.</td>
<td>Limestone, soft, argillaceous; tan-gray; nodular; cavernous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.3</td>
<td>7.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Covered interval.</td>
<td></td>
<td></td>
<td></td>
<td>1.8</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Covered interval.</td>
<td></td>
<td></td>
<td></td>
<td>2.1</td>
<td>2.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Covered interval.</td>
<td></td>
<td></td>
<td></td>
<td>5.5</td>
<td>5.5</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Limestone, hard, argillaceous, dense; tan to blue-gray; massive, weathers blocky and platy.  7.5
Limestone, hard, dense; gray-orange, weathers gray; massive weathers to large blocks; porous. Echinoid spines, crinoid columnals, and Derbyia crassa. Forms a prominent hillside bench, known locally as the "rim rock".  4.2

Base covered.
Section 41

This section from the Towanda limestone member of the Doyle shale to the Fort Riley limestone member of the Bernaston limestone, inclusive, is exposed in a road cut in the 6th SE; sec. 24, T. 8 S., R. 6 E.

Feet

Soil, silt and clay; brown to gray. ........................................ 15 +

Doyle shale. (13.6 feet exposed)
Towanda limestone member. (13.6 feet exposed)
Limestone, hard, dense, argillaceous in part; gray-orange, weathers tan; massive, weathers platy to blocky; numerous iron stains, slightly porous. Some microfossils in the lower part. .......................... 13.6

Clovisville shale member. (19.1 feet)
Shale, silty, calcareous, slightly arenaceous in the upper part; green to tan-gray, becoming green, gray and maroon at the base; thin-bedded to blocky; limonite stains abundant, calcareous zone near the middle. ...................... 19.1

Limestone, hard, dense in part; tan-gray to tan; massive, weathers irregular and blocky; porous at the base. Some microfossils present. .................. 1.5

Shale, silty, calcareous; tan-gray; thin-bedded, becoming blocky and massive at base. ............... 1.5

Bernaston limestone. (30.2 feet exposed)
Fort Riley limestone member. (30.2 feet exposed)
Limestone, soft; tan-gray to tan; massive, weathers irregular, blocky, staley, and in thin plates; on the weathered surface this limestone looks like a shale; porous, numerous limonite stains. ........................ 30.2

Limestone, soft; gray-orange, weathers tan-gray; massive, weathers in small blocks; limonite-stained. The following fossils occur abundantly: *Tuculopecten occidentalis*, *Pleurophorus alequensis*, and other pelecypods. .................. 2.2

Limestone (mostly covered). .................................................. 7.1

Limestone, soft; gray-orange to gray, weathers tan-gray; massive, weathers blocky to platy on top; numerous limonite stains; porous. *Pleurophorus alequensis* abundant; *Pleurophorus sp.*; and *Tuculopecten occidentalis* .................................................. 10.2

Face covered.
Section 42

This section from the Cresswell limestone member of the Winfield limestone to the Fort Riley limestone member of the Darneisen limestone, inclusive, is exposed in a road cut in the NE^4 SW^4 sec. 14, T. 6 S., R. 6 E.

Feet

Soil, silty, gray; weathered shale. ....................... 3

Winfield limestone. (10.0 feet)

Cresswell limestone member. (1.4 feet exposed)

Limestone, hard; gray-brown, weathers tan-gray; massive, weathers blocky; iron-stained. Benthoid spines abundant, crinoid columnals, Derbria sp., and Rhombopora sp. ....................... 1.4

Grant shale member. (7.7 feet)

Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; limonite-stained. Crinoid columnals, Derbria crassa, Rhombopora sp., echioid spines, Codetes granulifera, and Dictyocloaster americanus. 7.7

Stovell limestone member. (0.9 feet)

Limestone, hard; tan, weathers tan-gray; massive, weathers blocky; numerous chart nodules; some limonite stains. Dictyocloaster americanus, Derbria crassa, and echioid spines. ....................... 0.9

Doyle shale. (63.7 feet)

Gage shale member. (36.6 feet)

Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; numerous limonite stains. Derbria crassa, D. cambria and D. Họsaproiensis. 6.8

Limestone, soft, arenaceous; tan to tan-gray, weathers tan; massive, weathers blocky; limonite-stained. 6

Shale, silty, calcareous; maroon to gray-green, gray in upper part; thin-bedded to blocky; thin calcareous zone in upper part. 7.8

Covered interval. 21.2

Towanda limestone member. (12.8 feet)

Limestone, hard, dense in part; tan-brown, weathers tan to tan-gray; massive, weathers platy to blocky. 12.8

Holmesville shale member. (14.3 feet)

Shale (partly covered), silty, calcareous; tan with some maroon and green in upper part becoming gray and tan at basal part; thin-bedded to blocky. 14.3
Barneston limestone. (20.3 feet exposed)
Fort Riley limestone member. (20.3 feet exposed)

Limestone, soft; tan-gray, weathers tan; massive,
weathers shaly to thin-bedded; some limonite
stains.................................................. 0.7
Shale, silty, very calcareous; tan; thin-bedded;
numerous calcareous lenses.................. 5.5

Limestone, soft; tan-gray, weathers tan; massive,
weathers blocky; some limonite stains in pore
spaces.................................................. 6.1

Base covered.
Section 43

This section from the Cresswell limestone member of the Winfield limestone to the Towanda limestone member of the Doyle shale, inclusive, is exposed in an old road cut in the NE 1/4 SW 1/4 sec. 19, T. 7 S., R. 5 E.

Feet

Soil, dark gray, silty, with weathered limestone fragments. 2

Winfield limestone. (20.3 feet exposed)

Cresswell limestone member. (10.5 feet exposed)
Limestone, soft; tan to gray-orange, weathers tan-gray; massive, weathers in thin plates at the base and cavernous in the top part; numerous geodes. 8.3
Limestone, soft, dolomitic; tan-gray to gray-orange, weathers tan-gray; massive, weathers blocky. 2.4

Grant shale member. (9.1 feet)
Shale, silty, calcareous; tan-gray to gray, weathers tan; thin-bedded; limonite-stained on bedding planes, numerous calcareous plates. 9.1

Stovall limestone member. (0.5 feet)
Limestone, medium hard; tan-gray; massive, weathers platy and nodular; chert nodules. *Myalina* sp., and *Polypora* sp. 0.5

Doyle shale. (42.2 feet exposed)

Gage shale member. (40.2 feet)
Shale, partly covered, mostly silty and noncalcareous; maroon with mottled gray-green in lower half, tan-gray and gray-green, thin-bedded to blocky; a thin limestone lens in the top half. 40.2

Towanda limestone member. (2.0 feet exposed)
Limestone, hard, dense; gray-orange, weathers tan-gray; massive, weathers to form irregular blocks; limonite stains. 2.0

Base covered.
Section 44

This section from the Cresswell limestone member of the Winfield limestone to the Towanda limestone member of the Doyle shale, inclusive, is exhibited in a road cut in the NE 1/4 NE 1/4 secs. 24 and 25, T. 7 S., R. 5 E.

Feet

Soil, silty, with some clay; gray. ................... 1 +

Winfield limestone. (16.6 feet exposed)
Cresswell limestone member. (6.1 feet exposed)
Limestone, soft, arenaceous in the lower part; tan-gray to light gray; massive, weathers blocky to platy; some iron stains. Fossil fragments in lower part. Small fault. ............... 6.1

Grant shale member. (10.1 feet)
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded. Crinoid columnals, echinoid spines, Rhombopora sp., and few brachiopod fragments. .... 10.1

Stovall limestone member. (0.4 feet)
Limestone, hard, dense; light gray to dark gray; weathers tan-gray; massive, weathers blocky to nodular; numerous chert nodules; some iron stains. Rhombopora sp., and a few fossil fragments. .... 0.4

Doyle shale. (47.4 feet exposed)
Gage shale member. (37.6 feet)
Shale, silty, with some clay, calcareous; tan-gray becoming gray-green in basal part. .......... 8.7
Shale, clayey, with some silt, silty in upper part, noncalcareous; maroon, mottled with green and contains green lens; blocky to thin-bedded; some iron stains on fracture planes. .......... 23.9

Towanda limestone member. (9.8 feet exposed)
Limestone, hard, becoming soft and dolomitic at the top; gray-orange to tan-gray; massive, weathers blocky to platy. .......... 9.8

Base covered.
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Section 45

This section frosj the Cresewcll limestone member of the Winfield
liiaestone to the Gage shale member of the Doyle shale, inclusive,
r
.
is exoosed in a railroad cut in the WW$ IE£ I:b£ sec. 1, T. 9
R. 4

.

Feet
-

Soil, silty, dark; weathered limestone fragments

5

Winfield limestone. (19.3 feet exposed)
Cres swell limestone member. (8.9 feet exposed)
Limestone, soft, slightly dolomitic; lirht gray to
cream, weathers tan; massive, weathers blocky to
shaly
limestone, hard, fine-grained} light gray, weathers
tan-rra;, ; massive, weathers blocky to platy in upper
part. Echinoid spines and crinoid columnals. ...

2 «6

,

f.3

Grant shale member. (9*1 feet)
ale, silty with some clay, calcareous} ten-graj,
weathers tan} thin-bedded} calcareous zone near the
top} limonite-stained. Derby la crass , £. cymhula ,
Diet: oc ost us americanus, D. portl o ckianua , Composite ovata, C." subtlYIta , crinoid columnals,
AstsrtcTla sp., Pol:rpora sp., hci oabo pora sp. , 'tya lina
sp., ^yal'ina c ope 1 , and A v 1 cul ope c t en occidentalis . .

9.1

Stovall limestone member. (1.3 feet)
Limestone, herd, dense} gray, weathers tan-gray j massive, weather-; blocky; numerous crert nodules; llstonite-s'ained. Stenopora sp., Dictyoclostua ameri canus , and Derbyls cressa .

1*3

Doyle shale. tl*l feet exposed)
Gage shale member, (l."7 feet exposed)
ale, silty, very calcareous; ten-.rrsy, west hers
tan; thin-bedded to platy

1.7


Section 46

This section from the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exhibited in a road cut in the SE\2 SW\1 sec. 13, T. 7 S., R. 5 E.

Weathered limestone and dark silty soil. .................................. 1

Winfield limestone. (15.05 feet)
  Cresswell limestone member. (6.6 feet exposed)
    Limestone, hard, dolomitic; tan-gray; massive, weathers blocky to shaly in upper part; limonite stains and shale parting near base. .................. 6.6

Grant shale member. (3.2 feet)
  Shale, silty, noncalcareous; tan-gray to olive drab, weathers tan; thin-bedded; calcareous lens in the middle, some limonite stains. Fossils rare or absent. .................. 3.2

Stovall limestone member. (0.25 feet)
  Chert nodules in a limestone matrix, limonite-stained. 0.25

Doyle shale. (1.8 feet exposed)
  Gage shale member. (1.8 feet exposed)
    Shale, silty, slightly calcareous; olive drab; blocky; iron stains on fracture planes. .................. 1.8

Base covered.
Section 47

This section of the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exposed in a road cut in the SW\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 34, T. 7 S., R. 6 E.

Feet

Soil, silty, dark gray-brown. ........................................ 1

Winfield limestone. (11.0 feet exposed)
  Cresswell limestone member. (1.5 feet exposed)
    Limestone, hard; tan, weathers tan-gray; massive, weathers thin-bedded to blocky. Echinoid spines and crinoid columnals. ........................................ 1.5

Grant shale member. (8.7 feet)
  Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; limonite stains. Echinoid columnals, echinoid spines, Derbyia crassa, Rhombopora sp., Polyopora sp., Composita sp., and Dictyoclostus americanus. ........................................ 8.7

Stovall limestone member. (0.8 feet)
  Limestone, hard, dense; gray, weathers gray to light gray; massive, weathers blocky; numerous chert nodules; few iron stains. Echinoid spines and crinoid columnals. ........................................ 0.8

Doyle shale. (7.3 feet exposed)
  Gage shale member. (7.3 feet exposed)
    Shale, clayey with some silt, calcareous; tan-gray, weathers tan; thin-bedded; limonite-stained. Derbyia crassa and D. cymbula. ........................................ 7.3

Base covered.
Section 48

This section from the Crosswell limestone member of the Minfield limestone to the Gage shale member of the Doyle shale, inclusive, is exhibited in a road cut in the NW 1/4 sec. 31, T. 9 N., R. 5 E.

Feet

Weathered limestone. ........................................ 3

Minfield limestone. (21.6 feet exposed)

Crosswell limestone member. (7.25 feet exposed)
Limestone, soft; tan, weathers tan-gray; massive, weathers platy and cavernous; becomes shaly in middle part. ...................................................... 3.1
Limestone, hard, dense; gray, weathers tan-gray; massive, weathers blocky; maroon stains on fracture planes. Belemnite spines. ......................................................... 0.9
Limestone, hard, dense; tan to gray, weathers tan; massive, weathers blocky; maroon stains on fracture planes; crinoid spines, crinoid columnals, and some brachiopod fragments. ........................................ 3.1

Grant shale member. (11.5 feet)
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded. Copanita ovata, Derbyia crassa, crinoid columnals, Polypora sp., Praxobopora sp., Dictyoclostus americanus, and organic burrows? .... 11.5

Stovall limestone member. (2.7 feet)
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; numerous chert nodules. Polypora sp., Dictyoclostus americanus, D. portlockianus, crinoid spines, crinoid columnals. Extremely folded and faulted. ........................................ 2.3

Doyle shale. (10.3 feet exposed)
Gage shale member. (10.3 feet exposed) 
Shale, silty, calcareous; tan to gray, weathers tan; thin-bedded; some limonite stains on bedding planes. Derbyia crassa, D. crassa, D. boosicornis, crinoid columnals, Ectonora sp., Polypora sp., Praxobopora sp., Aviculoposten occidentalis, and crinoid spines. 10.3

Base covered.
Section 49

This section from the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exposed in a road cut in the NW 1/4 NE 1/4 sec. 33, T. 3 S., R. 6 E.

Feet

Soil and weathered limestone. ........................................... 1

Winfield limestone. (24.3 feet exposed)
Cresswell limestone member. (14.4 feet exposed)
  Limestone, partly covered; hard, dense; gray to tan-gray, weathers tan-gray; massive, weathers blocky to platy; porous, cavernous; some iron stains.
  Forms second Cresswell hillside bench. .......................... 12.2
  Limestone, hard; tan-gray; massive, weathers blocky to shaly at base. Echinoid spines, crinoid columnals and brachiopod fragments. Forms a hillside bench.  2.2

Grant shale member. (9.1 feet)
  Shale, silty, calcareous; gray to tan-gray; thin-bedded to blocky; iron stains. Derbyia crassa, Dictyclorostus americanus, Composita ovata, crinoid columnals, Rhombopora sp., Allorisma sp., and Polypora sp. .............................. 9.1

Stovall limestone member. (1.3 feet)
  Limestone, hard, dense; gray to tan-gray, weathers tan-gray; massive, weathers blocky; numerous chert nodules which are heavily iron-stained. Crinoid columnals. Fault, with about 4 feet displacement, is present and reflects into Cresswell limestone.  1.3

Doyle shale. (21.2 feet exposed)
Gage shale member. (21.2 feet exposed)
  Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; calcareous lens in middle; iron stains. Dictyclorostus americanus, Derbyia crassa, D. cymbula, D. Hoosierensis, crinoid columnals, echinoid spines, and Arviculopsechn occidentalis.  5.4
  Limestone, hard, argillaceous; tan-gray, weathers tan; massive, weathers blocky; iron stains. Derbyia crassa, crinoid columnals, echinoid spines, and Dictyclorostus americanus. .................. 0.4
  Shale, silty, silty with clay, calcareous; gray-green, weathers tan; thin-bedded. Derbyia crassa and crinoid columnals. .................. 2.3
  Limestone, hard, argillaceous; gray, weathers tan; massive, weathers blocky to shaly. Some micro-fossils. .................. 0.4
Shale, silty, calcareous; gray-green to tan, weathers tan-gray; thin-bedded; limonite stains on bedding planes; calcite-filled fractures.

Shale, silty, calcareous; maroon mottled with green and contains green lenses; thin-bedded to blocky.

Base covered.
This section of the Winfield limestone is exposed in a road cut in NW¼ SW¼ sec. 36, T. 6 S., R. 4 E.

Feet

Limestone weathered.

Winfield limestone. (10.1 feet exposed)
Cresswell limestone member. (1.7 feet exposed)
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky. Echinoid spines, crinoid columnals, and brachiopod fragments.

Grant shale member. (7.7 feet exposed)
Shale, silty, calcareous; olive drab to tan-gray, weathers tan; thin-bedded to blocky; iron-stained. Crinoid columnals, Derbyia crassa, echinoid spines, Aviculopecten occidentalis, Dictyoclostus americanus, Composita ovata, and Ambocoelia sp.

Stovall limestone member. (0.7 feet)
Limestone, hard, dense; light gray to dark gray, weathers tan-gray; massive, weathers blocky; numerous chert nodules. Echinoid spines, Dictyoclostus americanus, crinoid columnals, Derbyia cymbula, and D. portlockianus.

Base covered.
This section of part of the Winfield limestone, including the Cresswell limestone member and the Grant shale member, was measured in a road cut in the NW¼ NE¼ sec. 30, T. 9 S., R. 5 E.

Feet

Soil, silty; gray-brown. ........................................ 1.5

Winfield limestone. (15.3 feet exposed)
Cresswell limestone member, (11.2 feet exposed)
Limestone, soft becoming hard in basal part; fine-grained; tan-gray, weathers tan; massive, weathers blocky to platy; shale zone near base; calcium carbonate-lined caverns, iron stains on fracture planes. 7.5
Limestone, hard, dense; tan, weathers tan-gray; massive; slightly porous. Echinoid spines, Composite sp., crinoid columnals, and brachiopod fragments. 3.7

Grant shale member. (4.1 feet exposed)
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; some limonite stains. Crinoid columnals, Allorisma terminale, Derbyia cymbula, and D. crassa. 4.1

Base covered.
Section 52

This section from the Herington limestone member of the Holdans limestone to the Cresswell limestone member of the Winfield limestone, inclusive, is exhibited in a road cut in the SW 1/4 SW 1/4 sec. 36, T. 6 S., R. 4 E.

<table>
<thead>
<tr>
<th>Soil, silty; dark gray; limestone fragments</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nolans limestone. (14.4 feet exposed)</strong></td>
<td></td>
</tr>
<tr>
<td>Herington limestone member. (1.5 feet exposed)</td>
<td></td>
</tr>
<tr>
<td>Slate, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; iron-stained.</td>
<td>1.2</td>
</tr>
<tr>
<td>Limestone, soft, argillaceous; gray, weathers tan-gray; massive, weathers blocky; iron-stained. Derbysia umbula, D. isoscelisns, Aviculopecten occidentalis, and Mytilina sp.</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Paddock shale member. (12.0 feet)</strong></td>
<td></td>
</tr>
<tr>
<td>Slate, silty, slightly calcareous; tan-gray to gray weathers tan; thin-bedded to blocky; iron-stained. Molds and casts of Aviculopecten occidentalis.</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>Krider limestone member. (0.9 feet)</strong></td>
<td></td>
</tr>
<tr>
<td>Limestone, soft, dolomitic; tan-gray, weathers tan; massive, weathers blocky; slate parting. Aviculopecten occidentalis and few small pelacypods.</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Odell shale. (22.7 feet)</strong></td>
<td></td>
</tr>
<tr>
<td>Slate, silty, slightly calcareous; gray-green to tan-gray mottled with maroon in basal part; thin-bedded to blocky; iron-stained.</td>
<td>2.9</td>
</tr>
<tr>
<td>Slate, silty, noncalcareous; maroon with some gray and green mottled areas; blocky to thin-bedded.</td>
<td>12.4</td>
</tr>
<tr>
<td>Slate, clayey and silty, noncalcareous; gray-green mottled with maroon; thin-bedded; limonite-stained.</td>
<td>7.4</td>
</tr>
<tr>
<td><strong>Winfield limestone. (11.2 feet exposed)</strong></td>
<td></td>
</tr>
<tr>
<td>Cresswell limestone member. (11.2 feet exposed)</td>
<td></td>
</tr>
<tr>
<td>Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky at base and platy to block in upper part. Peltinoid spines in basal part.</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Base covered.
This section from the Herington limestone member of the Nolan limestone to the Cresswell limestone member of the Winfield limestone, inclusive, is exposed in a road cut in the NW\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 15, T. 6 S., R. 6 E.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Section 53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil and weathered limestone.</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Noan limestone. (16.4 feet exposed)
- Herington limestone member. (0.6 feet exposed)
  - Limestone, hard; gray-orange, weathers tan-gray; massive, weathers blocky; limonite stains. Small pelecypods very abundant. | 0.6 |

Paddock shale member. (14.6 feet)
- Shale, silty, calcareous; tan-gray to gray, weathers tan-gray; thin-bedded to blocky; iron stains on bedding planes, cone-in-cone, calcareous planes near the base. Molds and casts of *Aviculopecten occidentalis*. | 14.6 |

Krider limestone member. (1.2 feet)
- Limestone, soft, dolomitic; tan, weathers tan-gray; massive, weathers blocky; porous; numerous limonite stains. | 1.2 |

Odell shale. (20.9 feet)
- Shale, silty, calcareous; tan-gray to gray-green, weathers tan-gray; limonite-stained. | 3.7 |
- Shale, silty, slightly calcareous; maroon mottled with green and green lenses; blocky to thin-bedded; some iron stains on fracture planes. | 9.7 |
- Covered interval. | 16.5 |

Winfield limestone. (12.0 feet exposed)
- Cresswell limestone member. (12.0 feet exposed)
  - Limestone, soft, dolomitic; light gray to gray-orange; weathers tan-gray to light gray; massive, weathers blocky; limonite-stained. Microfossils in upper part, *Pleurophorus* sp., and *Yoldia* sp., abundant. | 5.9 |
  - Shale, silty, calcareous; tan to gray; blocky to thin-bedded; numerous limonite stains. | 6.1 |

Base covered.
Section 34

This section from the Herington limestone member of the Molans limestone to the Odell shale, inclusive, is exposed in a road cut in the NE ¼ NL ¼ NE ¼ sec. 8, T. 9 S., R. 5 E.

Feet

Soil, silty; black. ........................................... 2

Molans limestone. (19.4 feet exposed)
Herington limestone member. (5.0 feet exposed)
Limestone, hard; gray-orange; massive, weathers blocky; limonite-stained. Paleocopods abundant in certain zones. ......................................................... 0.4
Shale, silty, calcareous; tan; thin-bedded to blocky; calcareous nodules, iron-stained. ................................. 0.9
Limestone, soft, argillaceous; tan-gray; massive, weathers blocky, some iron stains. ............................. 0.7
Shale, silty with some clay, calcareous; tan; thin-bedded, some iron stains. ........................................... 0.2
Limestone, hard, slightly dolomitic, dense in part; tan-gray, weathers tan; massive, weathers blocky; two thin shale partings; limonite-stained; small geodes. Pleurophorus sp., and Yoldia sp. .................. 2.9

Paddock shale member. (12.2 feet)
Shale, clayey, noncalcareous; gray-brown, weathers tan; thin-bedded to blocky; few calcareous plates and iron stains. Aviculopecten occidentalis .................................................. 12.2

Krider limestone member. (0.9 feet)
Limestone, soft, dolomitic; gray-orange; massive weathers blocky and in chips; iron stains. Pseudomontis hawaii, Pleurophorus sp., and Aviculopecten occidentalis ........................................................................ 0.9

Odell shale. (1.5 feet exposed)
Shale, silty, calcareous; tan-gray, weathers tan; blocky; some iron stains on fracture planes. ............... 1.5

Base covered.
Section 55

This section from the Kerington limestone member of the Molans limestone to the Odell shale, inclusive, is exposed in a road cut in the SE\(\frac{1}{4}\) SW\(\frac{1}{4}\) sec. 1, T. 9 S., R. 5 E.

<table>
<thead>
<tr>
<th>Soil, silty; black; rock fragments</th>
<th>1 ft</th>
</tr>
</thead>
</table>

**Molans limestone.** (14.35 feet exposed)

- **Herington limestone member.** (4.05 feet exposed)
  - Limestone, medium hard, dolomitic; tan, weathers tan-gray; massive, weathers blocky. Pelecypod fragments very abundant. *Pleurophorus* sp., *Aviculopecten occidentalis*, and *Myalina* sp. 1.0 feet
  - Shale, silty, calcareous; tan; thin-bedded. 0.25 feet
  - Limestone, medium hard, dolomitic; light gray, weathers tan-gray; massive, weathers blocky; porous; limonite-stained. *Pleurophorus* sp., *Myalina* sp., *Loxonema* sp. .9 feet

- Limestone, medium hard, fine-grained, dense in the upper part; tan-gray; massive; weathers blocky to thin chips limonite-stained. Numerous small *Pleurophorus* sp., *Myalina* sp., and *Pseudomontisia longa.* 1.9 feet

**Paddock shale member.** (9.5 feet)

- Shale, silty, slightly calcareous; tan to gray, weathers tan-gray; thin-bedded to blocky; numerous limonite stains; thin calcareous lens near base. *Aviculopecten occidentalis*, *Myalina* sp., and *Derbyia crassa.* 9.5 feet

**Kriider limestone member.** (0.8 feet)

- Limestone, soft, sugary texture; tan-gray; massive, weathers to form irregular blocks; limonite-stained. *Pleurophorus* sp. .8 feet

**Odell shale.** (12.2 feet exposed)

- Shale, silty, noncalcareous; maroon at the base becoming gray-green in the upper part; thin-bedded to blocky; some limonite stains in the upper part. 12.2 feet

Base covered.
This section from the Herdston line to a border of the Nolan limestone to the Odell shale, inclusive, is exposed in a road cut in the NW 1/4 sec. 8, T. 2 S., R. 6 E.

| Soil, silty, dark gray. | 3 ½ |

Nolan limestone. (19.6 feet exposed)

Herdston limestone member. (3.5 feet exposed)

- Limestone, medium hard; tan, weathered tan-gray; massive, weathered blocky; porous; thin shale parts.
- Numerous limonite specks.

Paddock shale member. (13.5 feet)

- Shale, clayey with some silt, noncalcareous; gray to tan, thin-bedded; thin calcarious zone near the base.
- Limonite stains. Some fossil fragments.

Rider limestone member. (0.6 feet)

- Limestone, hard, dense; tan-gray; massive, weathered block; limonite stains common.
- Aviculopetalus occidentalis, Pleuroclorus sp., and other pelecypods.

Odell shale. (13.5 feet)

- Shale, silty, calcareous; tan-gray, weathered tan; thin-bedded in upper part, blocky in middle of lower part.
- .3

- Shale, silty, calcareous; olive drab, weathered tan-gray; blocky to thin-bedded; iron stains common on the fracture planes.
- 2.5

- Shale, silty, calcareous; gray-green, weathered light gray-green; block; iron-stained.
- .6

- Shale, silty, noncalcareous; gray to gray-brown with maroon stains at the base; blocky to thin-bedded; iron and carbon stains.
- .9

- Shale, silty, calcareous; maroon with green lenses and mottled areas; thin-bedded to blocky; slightly arenaceous; some carbon stains.
- 9.7

Base covered.
Section 57

This section from the Lorington limestone member of the Molans limestone to the Odell shale, inclusive, is exhibited in a road cut in the NW, NE, sec. 14, T. F., R. 4 E.

Feet

Soil, silty; dark; weathered limestone fragments. ....... 2 \frac{1}{2}

Molans limestone. (21.2 feet exposed)
Lorington limestone member. (5.3 feet exposed)
Limestone, medium hard, slightly dolomitic; tan-brown, weathers tan-gray; massive, weathers blocky with a thin shale parting. Fleurophorus sp., Malinga sp., and Aviculadopecten occidentalis. ....... 5.3

Paddock shale member. (14.9 feet)
Shale, silty with some clay, calcareous; tan-gray to gray, weathers tan; thin-bedded. Casts and molds of Aviculadopecten occidentalis. ........... 14.9

Kridar limestone member. (1.0 feet)
Limestone, soft, dolomitic; tan-gray, weathers tan; massive, weathers blocky; li onite specks. Fleurophorus sp. ........... 1.0

Odell shale. (4.1 feet exposed)
Shale, silty, calcareous; tan and gray-green in upper part becoming maroon at base; thin-bedded. ....... 6.1

Base covered.
Section 03

This section from the Hermiton limestone member of the Molena limestone to the Odell shale, inclusive, is exposed in a road cut in the NE 1/4 sec. 32, T. 7 N., R. 16 E.

Feet

Limestone weathered. ....................................................... 1

Molena limestone. (10.0 feet exposed)

Hermiton limestone member. (0.5 feet exposed)
Limestone, medium hard, dense in part, dolomitic; gray-orange, weathers tan-gray; massive, weathers blocky; limonite-stained. .................. 0.5

Paddock shale member. (14.7 feet)
Shale, clayey with some silt, non-calcareous; gray to olive drab, weathers tan; thin-bedded to blocky; iron stains on bedding and fracture planes, calcareous zone in the lower part. Melinae sp. ............. 14.7

Krider limestone member. (0.9 feet)
Limestone, medium hard, sugary texture; tan-gray; massive, weathers blocky; heavily limonite-stained in upper part; porous. Aviculopacten occidentalis and Pleurophorus sp. ............. 0.9

Odell shale. (4.9 feet exposed)
Shale, silty, calcareous; maroon at the base, gray-green in the upper part; blocky to thin-bedded. .. 4.9

Base covered.
Section 59

This section from the Wellington shale to the Nolans limestone member of the Nolans limestone, inclusive, is exhibited in a stream bank in the NE\% sec. 1, T. 6 S., R. 4 E.

<table>
<thead>
<tr>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil, silty, red-brown to gray.</td>
</tr>
<tr>
<td>Wellington shale. (39.2 feet exposed)</td>
</tr>
<tr>
<td>Limestone, hard, dense; tan-orange with purple bands,</td>
</tr>
<tr>
<td>weathers tan-orange; massive, weathers porous and</td>
</tr>
<tr>
<td>platy. Fossil fragments.</td>
</tr>
<tr>
<td>Shale, silty with some clay; calcareous; tan-gray,</td>
</tr>
<tr>
<td>weathers light tan; thin-bedded; calcareous lenses,</td>
</tr>
<tr>
<td>limonite-stained.</td>
</tr>
<tr>
<td>Shale, silty, calcareous; maroon with gray and gray-green lenses;</td>
</tr>
<tr>
<td>thin-bedded to blocky; iron-stained.</td>
</tr>
<tr>
<td>Shale, silty, calcareous; gray to light gray; thin-beded to blocky;</td>
</tr>
<tr>
<td>limonite stains, calcareous lenses.</td>
</tr>
<tr>
<td>Shale, silty with some clay; calcareous; maroon; thin-beded to blocky.</td>
</tr>
<tr>
<td>Shale, clayey, noncalcareous; gray to tan-gray, weathers tan-gray;</td>
</tr>
<tr>
<td>thin-bedded to blocky; heavily limonite-stained calcareous zone</td>
</tr>
<tr>
<td>near the top.</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; maroon;</td>
</tr>
<tr>
<td>thin-bedded.</td>
</tr>
<tr>
<td>Shale, clayey with some silt, calcareous; light to dark gray-green</td>
</tr>
<tr>
<td>mottled with maroon and purple; blocky; limonite stains on</td>
</tr>
<tr>
<td>bedding planes.</td>
</tr>
<tr>
<td>Shale, silty, calcareous; maroon; thin-bedded; iron</td>
</tr>
<tr>
<td>stains on fracture planes.</td>
</tr>
<tr>
<td>Shale (partly covered), silty, calcareous; tan-gray to</td>
</tr>
<tr>
<td>gray, weathers tan; thin-bedded; limonite stains,</td>
</tr>
<tr>
<td>carbon stains, and some calcareous plates.</td>
</tr>
</tbody>
</table>

Nolans limestone. (5.1 feet exposed)

Paddock limestone member. (5.1 feet)

Limestone, soft, dolomite; tan-brown; massive, weathers blocky; porous; limonite-stained. 5.1

Paddock shale.
## Section C3

This section of the Dakota formation to the Herington limestone member of the Holons limestone, inclusive, is exposed in a road cut in the NW 1/4 sec. 1, T. 71 S., R. 41 E.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 +</td>
<td>Soil, silty, arenaceous; gray-brown.</td>
</tr>
<tr>
<td>4 +</td>
<td>Dakota formation. (44 feet) Sandstone and conglomerate, fine to coarse sand;</td>
</tr>
<tr>
<td></td>
<td>mostly quartz, hard in part; dark brown; cross-bedded in part; massive</td>
</tr>
<tr>
<td></td>
<td>weathers block; iron-stained, some ironstones, clay balls and limestone</td>
</tr>
<tr>
<td></td>
<td>nodules.</td>
</tr>
<tr>
<td>0.8</td>
<td>Wellington shale. (39.3 feet, interval) Limestone, hard; gray-orange;</td>
</tr>
<tr>
<td></td>
<td>platy, porous.</td>
</tr>
<tr>
<td>5.7</td>
<td>Covered interval.</td>
</tr>
<tr>
<td>4.1</td>
<td>Holans limestone. (4.1 feet exposed) Herington limestone member. (4.1 feet</td>
</tr>
<tr>
<td></td>
<td>exposed) Limestone, medium tan, dolomitic; tan-brown, weathers</td>
</tr>
<tr>
<td></td>
<td>tan; massive, weathers block, and porous; iron-stained.</td>
</tr>
<tr>
<td></td>
<td>Note covered.</td>
</tr>
</tbody>
</table>
