STATE GEOLOGICAL SURVEY OF KANSAS

BULLETIN 21

Part I

THE GEOLOGY OF JOHNSON AND MIAMI COUNTIES, KANSAS

Part II

THE GEOLOGY OF WYANDOTTE COUNTY, KANSAS

STATE GEOLOGICAL SURVEY OF KANSAS

RAYMOND C. MOORE
State Geologist

KENNETH K. LANDES
Assistant State Geologist

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NORMAN D. NEWELL

PART II

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JOHN M. JEWETT and NORMAN D. NEWELL

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PART I

The Geology of Johnson and Miami Counties, Kansas

By NORMAN D. NEWELL

INTRODUCTION

During the last decade the State Geological Survey of Kansas has followed the policy of making a systematic, detailed study of the geology of Kansas. Such a study was recently made of Wyandotte county by J. M. Jewett and me,[1] one of the results of which was enlargement of my interest in the stratigraphic problems encountered in various parts of the so-called Kansas City and Lansing groups. Because the formations cropping out in Wyandotte county are also exposed in Johnson and Miami counties, a study of the geology of these counties has been a desirable continuation of the earlier work. Investigations of the formations exposed in the counties have proved fruitful.

PREVIOUS GEOLOGICAL WORK

A comprehensive, detailed study of the stratigraphy of Johnson and Miami counties has not previously been undertaken. Most of the correlations and conclusions published in the reports of the old Kansas Survey were obtained from the field work of Bennett and Haworth. Geological surveys of eastern Kansas were made in the pioneer days of Kansas geology, and although the work was well done considering the difficulties under which the geologist then labored, it is very inadequate for modern needs.

The Missouri Bureau of Geology and Mines and the United States Geological Survey have published reports on areas adjoining Wyandotte, Johnson and Miami counties. These reports are important to the investigator of the stratigraphy and geology of the area described in this report.

The earliest geological work of any note in the Johnson and Miami area was that of G. C. Swallow, second state geologist of Kansas, in 1865. His preliminary report on the geology of Kansas,[2] the value of which lies chiefly in its historical interest, includes a

1. Jewett, J. M., and Newell, N. D., The Geology of Wyandotte county, Kansas: This bulletin, Part II.

2. Swallow, G. C., Geological report of Miami county, Kansas: Kansas Geol. Survey, 1866 (also issued separately in 1865).

chapter entitled, "Geological Report of Miami County." In view of the difficulties attending geological exploration in Kansas at that time, the data recorded are surprisingly accurate. The principal shortcomings of this report lie in its brevity and the fact that Swallow was in many cases misled in his correlation of the various stratigraphic units from place to place within Miami county. These miscorrelations resulted in repetitions and omissions from his generalized section of the rocks exposed in the county.

In 1896 the Kansas University Geological Survey, under direction of Erasmus Haworth, published a series of stratigraphic studies[3] by various invidiuals, treating in an incidental manner the stratigraphy of Wyandotte, Johnson, and Miami counties. This seems to be the last work of importance on these counties, and the correlations then established have persisted with little modification until the present time. Generalized geologic maps of the area were published by the old Kansas Survey, but they are not sufficiently accurate or detailed to fulfill present requirements.

Several important geological reports[4] on adjoining areas have appeared during the last two decades. In these reports much of the nomenclature of the early surveys was changed as a result of more detailed information. To a large extent, however, the correlations of the older workers were not checked, but were accepted at full value.

FIELD WORK

Some detailed work on the geology of Johnson county was done during the months from September, 1929, to June, 1930, by J. M. Jewett and me in connection with studies on the geology of Wyandotte county. This was chiefly in the vicinity of De Soto and Cedar Junction.

It was part of the original plan to continue jointly the work started in Wyandotte county, but Jewett became engaged in stratigraphic studies on the Big Blue series in central Kansas. While the investigation of Wyandotte county was in progress there was no suspicion on our part of the confusion involved in the existing classification of the classic exposures around Kansas City. The work on Wyandotte county was completed and the report written before the several miscorrelations of the Kansas City outcrops were dis-

3. Kansas Univ. Geol. Survey, vol. 1, 1896.

4. Hinds, Henry, and Greene, F. C., Stratigraphy of the Pennsylvanian series in Missouri: Missouri Bur. Geol. and Mines, vol. 13, 2d ser., 1915. Hinds, Henry, and Greene, F. C., Geologic atlas of the United States, Leavenworth-Smithville Folio, Missouri-Kansas, U. S. Geol. Survey, 1917. Condra, G. E., The stratigraphy of the Pennsylvanian system in Nebraska: Nebraska Geol. Survey, Bull. 1, 2d ser., 1927.

covered. Naturally the original classification of the Wyandotte county rocks had to be revised in accordance with later discoveries.

Almost all of the field work on Johnson and Miami counties was done as a project of the Kansas Geological Survey during the latter part of the field season of 1930, and on week-ends and holidays during the academic year 1930-'31.

The stratigraphic sections were measured by means of a Locke level and a hand rule. The mapping was done by making road traverses, taking measurements with the automobile speedometer and by pacing. The contacts of the formations in Johnson county

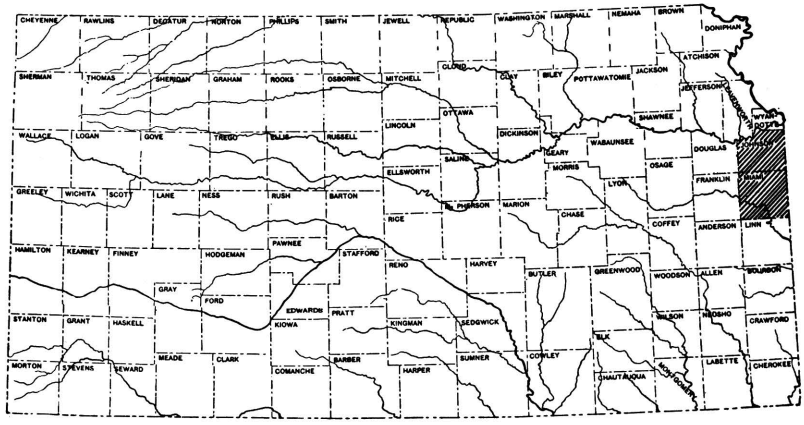


FIG. 1.—Index map of Kansas showing location of Johnson and Miami counties.

were sketched on a large-scale base map which was taken from an accurate plane-table map made by the government Soil Survey. The base for the Miami county map was compiled from postal route maps, county road maps and from field sheets prepared by me.

ACKNOWLEDGMENTS

Acknowledgments are made to the people of Johnson and Miami counties who facilitated the field work. Mr. J. M. Jewett, of Wichita University, has shown unfailing interest in the project. In addition to valuable suggestions, he coöperated with the writer in a study of the difficult stratigraphic problems at De Soto and along Kansas river. The writer is indebted to Dr. R. C. Moore, state geologist of Kansas, for invaluable guidance both in the field and in the preparation of the report. Doctor Moore was in every case consulted regarding changes in nomenclature. In several instances he suggested appropriate terms for unnamed stratigraphic units. Dr.

John Rich on many occasions gave of his intimate knowledge of eastern Kansas stratigraphy.

To Dr. K. K. Landes, Prof. M. K. Elias, Dr. John Ockerman, Miss Edith Hicks, and other members of the survey staff thanks are due for assistance in the preparation of the manuscript. To my wife, Valerie, I am indebted for constant assistance in the field and for suggestions in writing the manuscript.

PROBLEMS OF CORRELATION

Early in the progress of this work it appeared that many of the formations of the so-called Kansas City and Lansing groups of Missouri geologists had been previously miscorrelated in Kansas. Field study during three years had made me familiar with the local geology in Wyandotte, Johnson and Miami counties, and adjoining parts of Missouri. The formations cropping out in these counties were traced across the area mile by mile. Some of them were traced from Platte county, Missouri, across Kansas to the Oklahoma boundary. Hundreds of stratigraphic sections have been studied in detail and compared. Some of the formations in the so-called Lansing and Kansas City groups are much more variable than has been generally supposed. Others display certain features that are remarkably persistent—features which, when known, are easily recognized.

Ever since geological exploration began in eastern Kansas the classic exposures at Kansas City have been considered the standard section of reference for much of the Pennsylvanian strata of the Missouri Valley region. Many of the formations exposed at Kansas City are named, however, from localities in southeastern Kansas. It has developed in the course of recent investigations that the correlation of beds in the Kansas City section and southeastern Kansas localities is erroneous in several particulars. As previously indicated, the pioneer geologists of Kansas are not to be criticized severely for these errors, but it is necessary now to make revisions. Plate XI indicates the somewhat radical departures that are made from the classification of Hinds and Greene.[5] The evidence now in hand seems not only to warrant but to demand a revision of the nomenclature and classification of the older writers.

The series and group terms proposed by R. C. Moore are adopted because they appear to indicate the stratigraphic relations better than the older classification.

5. Hinds, Henry, and Greene, F. C., The stratigraphy of the Pennsylvanian series in Missouri: Missouri Bur. Geol. and Mines, vol. 13, 2d ser., Table Opp. p. 36, 1915.

GEOGRAPHY

Location

Johnson and Miami counties adjoin the eastern boundary of Kansas. Johnson county is about 24 miles from east to west and 16 to 21 miles from north to south. Kansas river, west of Holliday, is the boundary, and makes the north-south dimensions variable. Bordering counties are Wyandotte and Leavenworth on the north, Jackson and Cass in Missouri on the east, Douglas on the west, and Miami on the south. Miami county is nearly square, being 24 miles from north to south and 24½ miles from east to west. It is bounded by Missouri on the east, by Linn county on the south, by Franklin county on the west, and by Johnson county on the north.

Topography

Johnson and Miami counties lie within the physiographic section of the Central Lowlands province called the Osage Plains. This section contains a series of more or less prominent southeastward-facing escarpments which trend irregularly northeast and southwest. The escarpments are produced by the outcropping edges of resistant formations, and in the two counties under consideration are formed especially by the Winterset, Iola, Wyandotte, Plattsburg, and Stanton limestones. The strata dip gently to the northwest in most of eastern Kansas, away from the Ozark Uplift.

The maximum relief in Johnson county is over 350 feet, for surface elevations range from less than 750 feet above mean sea level near Holliday to more than 1,100 feet in the southeastern part of the county. The relief in Miami county is somewhat less, the elevation ranging from more than 1,050 feet in the uplands at the west side of the county to less than 805 feet at the Marais des Cygnes flood plain at the southern boundary of the county. In general, one may distinguish (1) a relatively flat upland, (2) gentle and steep slopes leading down from the upland, and (3) flat lowlands along the streams.

The upland surface, in the greater part of the area, represents the dip slope of the Stanton or Plattsburg limestone formations, but in the eastern part it is produced on the Farley and the Argentine limestones, and in southeastern Miami county by the Winterset limestone. The upland surface above the Stanton in the western part of the area is modified by low, rolling hills consisting of remnants of soft Weston shale and sandstone of the Stranger formation.

The slopes are interrupted by terraces or benches which are produced by the unequal erosion of hard and soft rock layers. The flat upper surface of the benches is made by resistant limestone or sandstone, and slopes by the softer shale.

The lowland area is restricted to the flood plains of the various streams. The part of the flood plain of the Kansas river at the north edge of Johnson county ranges in width from one and a half to two miles. The larger streams have well-developed flood plains, but excepting Kansas, Marais des Cygnes, and Pottawatomie rivers, they are only a fraction of a mile in width. Kill creek, Cedar creek, Captain creek, Mill creek, and Turkey creek in the northern part of Johnson county have been unable to lower their flood plains so as to keep pace with the lowering of Kansas river. Consequently, these streams have distinct alluvial terraces that in some cases rise more than ten feet above the flood plain of Kansas river. Big Blue river, Tomahawk creek, and Indian creek in the eastern part of the county have well-developed flood plains.

In Miami county, Bull and Wea creeks in the northern part, Sugar and Middle creeks in the southeastern part, and Pottawatomie and Marais des Cygnes rivers in the western part are the only streams that have extensive flood plains. The largest of these, Marais des Cygnes river, has an alluvial plain ranging from about one to three miles in width, being widest where the valley is cut in soft shales.

Culture

Johnson and Miami counties are primarily devoted to agriculture, dairying, and stock-raising. The leading crops are wheat, corn, oats, and native hay. Potatoes are grown in large quantities on the flood plains of the larger streams. Truck gardens are numerous in the area adjoining Kansas City in the northeastern part of Johnson county. Dairying is a prominent industry.

The principal towns in Johnson county are Olathe, the county seat, with a population of 3,656, Gardner with 493, Edgerton with 278, Spring Hill with 566, De Soto with 384, Lenexa with 452, and Shawnee with 553. The most densely settled part of the county is the northeast, adjoining Kansas City. In this portion of the county, small hamlets are scattered at short intervals. The greater part of the population is rural. During recent years the county has shown a notable increase in the number of inhabitants. The population has increased from 18,314 in 1920 to 27,199 in 1930.

In Miami county the larger towns are Paola, the county seat,

population 3,762; Osawatomie, 4,440; New Lancaster, 123; Somerset, 140; Fontana, 187; Beagle, 293; Stanton, 100; Hillsdale, 214; Wagstaff, 85; Chiles, 63; Bucyrus, 134; and Louisburg, 616. Since 1920 the population of the county has increased from 19,809 to 21,243 in 1930.

The area is well supplied with steam and electric railroads. The main line of the Atchison, Topeka, and Santa Fe railway follows the valley of Kansas river. At Holliday the "cut-off" to Emporia turns southward to Olathe and thence to the southwest corner of the county, while the other branch of the main line continues westward to Topeka. Two electric lines, the Kansas City and Olathe Electric, and the Missouri and Kansas Interurban, extend from Kansas City to Olathe. A line of the St. Louis and San Francisco railway passes through Paola to Olathe and northeastward to Kansas City. The Kansas City, Clinton, and Springfield railroad crosses eastern Johnson county to Olathe.

Branches of the Missouri Pacific extend from Paola across southwestern Miami county and a line extends from Paola across the northeast part of the county. A line of the Missouri, Kansas and Texas railroad crosses southern Miami county passing through Paola and Louisburg.

Paved roads are relatively numerous in Johnson and Miami counties. Federal highway 73 E traverses the counties from north to south in the eastern part. A paved road extends through South Park, Shawnee, and Lenexa to Olathe, and probably will be extended across the southwestern part of the county. Another reaches from Shawnee to Zarah. Part of state highway 32 in the northern part of Johnson county is paved. The highway between Olathe and Osawatomie is paved. Many of the roads are graveled so that nearly all of the towns can readily be reached in any kind of weather. A recent road-improvement campaign in Miami county has been of great benefit so that now the roads there compare favorably with those of any county in Kansas.

There are many dirt roads, but they are well graded so that they can usually be traveled without inconvenience.

STRATIGRAPHY

The oldest rocks exposed in the Johnson and Miami county area belong to the division of rocks called the Pennsylvanian system, so named because of their great development in Pennsylvania. These rocks consist in eastern Kansas of interbedded layers of shale,

limestone, and sandstone. Most of the formations were deposited in the sea, a conclusion well supported by the occurrence in them of abundant shells of marine animals.

Other deposits are glacial gravels and clay that were brought to the valley of Kansas river by a vast ice sheet, a continental glacier, that covered much of the upper part of the Mississippi Valley region during a part of the Pleistocene epoch. These gravels contain fragments of quartzite of the kind found as bedrock in southwestern Minnesota and adjacent parts of South Dakota and Iowa. Ice-transported boulders and pebbles of this rock are common in glacial deposits of Iowa, Missouri, Nebraska, and northeastern Kansas. Deposits of loess blown from the river flood plains along Missouri and Kansas rivers and redeposited on the uplands bordering the valleys occur in northern Johnson county. The loess of this area is connected in origin with the ice invasion and is composed in part of the finely ground rock dust brought from the northern area by the glacier. Younger deposits of recent age collectively make up the soil covering and flood-plain alluvium.

Pennsylvanian System

The thin beds of alternating shale, limestone, and sandstone that appear at the surface in eastern Kansas and adjacent parts of Missouri, Oklahoma, and Nebraska belong to the Pennsylvanian system. In much of the area of the Mid-Continent Coal Basin the rocks of Pennsylvanian age have generally been divided into two groups or series, the Des Moines series below and the Missouri series above. According to this classification of the strata, the Des Moines series is composed of the Cherokee and Marmaton groups, named in order from older to younger rocks. The Missouri beds, as defined in the past, include five groups, named in order upward, Kansas City, Lansing, Douglas, Shawnee, and Wabaunsee. Each of the groups contains a number of formations and many of these in turn are made up of smaller named units, called members.

The old classification of the Pennsylvanian rocks of the northern Mid-Continent region is unsuitable in several respects, and recent work has shown that it is based in many cases upon false premises. In order to formulate a more natural system of classification, one that is based upon modern knowledge of Mid-Continent stratigraphy, R. C. Moore[6] has advanced a new classification of the Pennsylvanian system for the northern Mid-Continent region.

6. Moore, R. C., Guidebook, Sixth Annual Field Conference, Kansas Geol. Soc., 1932.

Hinds and Greene[7] have made known the occurrence of a major unconformity in the † Pleasanton formation,[8] supposedly coincident with a widespread faunal break. At this unconformity Moore proposes to place the lower limit of the Missouri series as redefined.

In their study of the Pennsylvanian rocks of Missouri, Hinds and Greene[9] also discovered a great channel sandstone lying between the Stanton and Oread formations in Platte county, Missouri, and the region about Leavenworth, Kan. This sandstone deposit was traced by J. M. Jewett and me across Wyandotte county. In the present study it was found that the sandstone, marking the base of the Stranger formation of this report, is continuous across Johnson and Franklin counties, and it has subsequently been traced into Oklahoma. In southeastern Kansas sandstones of the Stranger formation produce a high escarpment that affords an abundance of good exposures. The formation extends almost continuously as a great sandstone sheet across Kansas, resting unconformably upon older rocks, in most places upon the clayey Weston shale, but in Leavenworth, Wyandotte, and northwestern Johnson counties lying in many localities on the upper member of the Stanton. In Leavenworth county the unconformity rises to the northward from the surface of the Stanton to a horizon above the Iatan limestone, showing conclusively that the Iatan was deposited before the widespread emergence. The stratigraphic interval which the unconformable contact overlaps amounts to more than seventy feet in the Leavenworth region. This unconformity has been selected by Moore as the upper limit of his Missouri series as redefined. In most of northeastern Kansas the upper boundary of the Missouri series coincides with the top of the Lansing group of older writers, but in northwestern Missouri and probably in southeastern Kansas strata as young as the Iatan limestone lie below the unconformity. For the Pennsylvanian strata above the unconformity just described, Moore has proposed the term Virgil series.

It was discovered in the study of Johnson and Miami counties that certain miscorrelations have been made by previous geologists between the classic exposures at Kansas City and type localities in southeastern Kansas. My correlations were made by continuous tracing of outcrops, and were verified by Dr. R. C. Moore, state

7. Hinds, Henry, and Greene, F. C., The stratigraphy of the Pennsylvanian series in Missouri: Missouri Bur. Geology and Mines, vol. 13, 2d ser., pp. 75-102, 1915.

8. In accordance with a revised code of Rules of Stratigraphic Nomenclature recently formulated by a national committee of geologists, abandoned stratigraphic terms are designated by a dagger (†) preceding the term.

9. Idem, pp 170-171.

geologist. The evidence for the present correlations is presented under the descriptions of formations in the following pages. J. M. Jewett, who is engaged in a study of the Bronson group, has made certain observations in southeast Kansas which affect the nomenclature of some of the formations.

In a recent publication J. M. Jewett [10] proposed to abandon the term Hertha on the basis that it is a synonym of Bethany Falls. At the same time he introduced a number of terms for what he considered to be several disconnected lenticular limestones of slightly different stratigraphic position. F. C. Greene, R. C. Moore, and I have concluded, from an examination of field evidence, that possibly some errors were made by Jewett. It appeared to us that the Hertha limestone of general usage in the Kansas City is in reality part of the type Hertha. The problem is too involved to discuss at length here, but the classification of the lower Bronson units given in the present report is correct for northeastern Kansas and northwestern Missouri.

Some of the changes in correlation that affect classification and nomenclature of the rocks in Johnson and Miami counties are summarized as follows. The "Drum" limestone of Kansas City does not occur south of Martin City, Jackson county, Missouri (except possibly very locally in Miami county), and is not the equivalent of the type Drum limestone. The Cement City limestone of the Kansas City region is continuous with part of the type Drum, and the name Cement City is retained for the lower member of the Drum formation. The Raytown limestone is the exact equivalent of the upper part of the Iola limestone. The so-called Iola limestone at Kansas City does not occur at Iola, but is a previously unnamed unit. The Farley limestone coalesces in Miami county with the "Iola" of the Kansas City area to form an indivisible unit which contains the so-called Lansing brachiopod *Enteletes* throughout. The Kansas City and Lansing groups of authors cannot be divided either faunally or lithologically over much of eastern Kansas. The original description of the Stanton limestone refers to the previously named Plattsburg. It is proposed here, however, to retain the terms Plattsburg and Stanton in their current usage, because by so doing there is a minimum of confusion. The unconformity that occurs in the part of the section lying between the Stanton and Oread formations is easily recognized throughout most of eastern Kansas

10. Some details of the stratigraphy of the Bronson group of the Kansas Pennsylvanian Kansas Acad. Sci., Trans., vol., 36, pp. 131-136, 1933.

It marks the base of a more or less continuous sandstone sheet older than the Lawrence and younger than the type Iatan. The limestone at Lawrence which marks the lower boundary of the Lawrence shale is not the Iatan, because it is well above the unconformity. Moore has termed this limestone at the base of the Lawrence the Haskell limestone.

Moore[11] has suggested that the beds above the Des Moines-Missouri unconformity to the top of the Pleasanton of authors constitue a natural stratigraphic unit consisting mostly of shale. This he terms the Bourbon formation. For the persistent limestones and shales above the Bourbon to the top of the Winterset he has revived Adams' term, "Bronson," employing it in the original sense as regards stratigraphic boundaries, but classing it as a group rather than a formation. The highly variable and dominantly shaly strata between the top of the Winterset and the base of the Plattsburg formation he calls the Kansas City group. It will be noted that this involves revision of both the lower and upper boundaries of the Kansas City beds as proposed by Hinds and Greene, but it is the view of a large number of Mid-Continent geologists that it is preferable to retain this familiar name in a revised sense rather than to drop it in favor of an entirely new term. The persistent limestone strata between the base of the Plattsburg and the top of the Stanton are termed by Moore the Lansing group.

Generalized section of the Pennsylvanian rocks exposed in Johnson and Miami counties

	Feet.
Virgil series:	
Douglas group:	
Stranger formation:	
Sandstone, buff, soft, cross-bedded, erosion remnant.....	40+
Unconformity	
Missouri series:	
Pedee group:	
Weston shale	0-40
Lansing group:	
Stanton limestone:	
Little Kaw limestone member:	
Limestone, bluish-gray, blocky.....	2±
Victory Junction shale member:	
Shale below, and brown sandstone above.....	3–14
Olathe limestone member:	
Limestone, bluish-gray, thin-bedded, wavy.....	11–15

11. Moore, R. C., A reclassification of the Pennsylvanian system in the northern Mid-Continent region, Guidebook, Sixth Annual Field Conference, Kansas Geol. Soc., pp. 79-97, 1932.

	Feet.
Eudora shale member:	
Shale, carbonaceous, black	4–11
Captain Creek limestone member:	
Limestone, dark-gray, even-bedded	4–10
Vilas shale:	
Shale, gray, arenaceous	5–30
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab or buff, even-bedded	10±
Hickory Creek shale member:	
Shale, yellowish, nodular, locally with a carbonaceous layer,	1±
Merriam limestone member:	
Limestone, gray, blocky, even-bedded	3±
Kansas City group:	
Bonner Springs shale:	
Shale, olive-green, argillaceous, maroon layer near top	25±
Wyandotte limestone:	
Farley limestone member:	
Limestone, light-gray, thin-bedded, wavy	10±
Island Creek shale member:	
Shale, gray, limy, absent in Miami county	0–5
Argentine limestone member:	
Limestone, light-gray, thin-bedded, wavy	25±
Quindaro shale member:	
Shale, gray, argillaceous or limy	3±
Frisbie limestone member:	
Limestone, gray, even, blocky, in one layer	2±
Lane shale:	
Shale, gray or buff, argillaceous, sandy where thick	16–105
Iola limestone:	
Raytown limestone member:	
Limestone, bluish-gray, even-bedded	5–13
Muncie Creek shale member:	
Shale, carbonaceous where thick, argillaceous where thin, with spherical phosphatic concretions	0.5–3
Paola limestone member:	
Limestone, bluish-gray, even, blocky	1.5
Chanute shale:	
Shale, lower half argillaceous, upper half arenaceous (Cottage Grove sandstone), Thayer coal bed near the middle in southern Miami county	8–38
Drum limestone:	
Cement City limestone member:	
Limestone, ferruginous, drab or brown, thick-bedded	2–10
Quivira shale:	
Shale, black, carbonaceous, argillaceous above and below,	4–11
Westerville limestone:	
Limestone, drab, irregular, oölitic where thick	0–20
Wea shale:	
Shale, argillaceous or calcareous, greenish or gray	10–30
Block limestone:	
Limestone and calcareous buff shale, more shaly in Johnson county	6±

	Feet.
Fontana shale:	
Shale, gray or buff, argillaceous or calcareous	5–25
Bronson group:	
Dennis limestone:	
Winterset limestone member:	
Limestone, gray, even, thin-bedded	30
Stark shale member:	
Shale, black, carbonaceous below, argillaceous above	4–7
Galesburg shale:	
Shale, buff, argillaceous or calcareous	2–3
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab, massive, oölitic above	13–27
Hushpuckney shale member:	
Shale, black, platy, with clay layer above and below	5
Middle Creek limestone member:	
Limestone, bluish, even, blocky, two beds generally	2
Ladore shale:	
Shale, buff, argillaceous, calcareous below	7±
Hertha limestone:	
Sniabar limestone member:	
Limestone, thick-bedded, ferruginous	6
Bourbon formation:	
Shale, limy, ferruginous	4±
Limestone, nodular, ferruginous, very persistent	2±
Shale with channel sandstones, which possibly represent the Des Moines-Missouri boundary	80±

MISSOURI SERIES

The term Marmaton was applied by Haworth to a thick limestone and shale succession lying between the Cherokee and the top of the Des Moines series as generally defined. Following the new usage proposed by Moore the upper limit of the Marmaton is lowered to the unconformity some scores of feet below the Kansas City group of current usage.

The Marmaton group is divided into several formations. These are, in ascending order: Fort Scott limestone, Labette shale, Pawnee limestone, Bandera shale, Altamount limestone, Nowata shale, Lenapah limestone, and Dudley shale. Because the Des Moines-Missouri boundary lies within and probably near the base of the Dudley shale it is advisable to abandon the term Dudley.

At one locality in Miami county, described below, there occurs just below the limestones of the Bronson group or lower "Kansas City" a local sandstone, seemingly a channel filling. It has not been determined as yet whether or not this channel marks the Des Moines-Missouri unconformity, but I am inclined to believe that it is stratigraphically higher than the base of the Missouri series. Thin

fossiliferous limestones seen south of the Miami area and apparently occurring below the horizon of the channel sandstone alluded to above have not yielded Des Moines guide fossils. In the present discussion, therefore, it will be assumed that the lowest shale exposed in the area under consideration is the Bourbon shale, belonging in the Missouri series, and that the channel sandstone in southeastern Miami county does not mark the Des Moines-Missouri boundary.

The term Missouri was proposed by Keyes[12] to include the "upper Coal Measures," that is, the higher part of the Pennsylvanian section as developed in northwestern Missouri. Through usage the term has come to be applied to all of the Upper Pennsylvanian rocks in the nothern Mid-Continent. Moore has redefined the term Missouri to apply to strata between the two extensive unconformities in the mid portion of the Mid-Continent Pennsylvanian, namely that above the Marmaton and the break shortly above the Stanton limestone.

The term Pottawatomie, from Pottawatomie creek in eastern Kansas, was applied by Haworth[13] to strata included in Moore's Missouri series. The term Pottawatomie, however, in the original sense does not apply to a natural unit, and the section along Pottawatomie creek is neither a desirable one for a type section nor does it include all of the strata of Haworth's Pottawatomie formation. Moore has deemed it more desirable to retain the widely used name Missouri than to revive Haworth's little-used term.

Hinds[14] proposed to divide the old Pottawatomie formation into two divisions, the Kansas City and Lansing. This course was seemingly substantiated by both lithologic and faunal evidence and the classification has come into general usage. It is shown below, however, that the Kansas City division over great areas cannot be separated from the Lansing, either lithologically or faunally.

It is partly upon evidence presented in the following pages that Moore proposes to divide the redefined Missouri series into five groups, called Bourbon, Bronson, Kansas City, Lansing, and at the top Pedee. Kansas City and Lansing have been previously employed in a somewhat different sense.

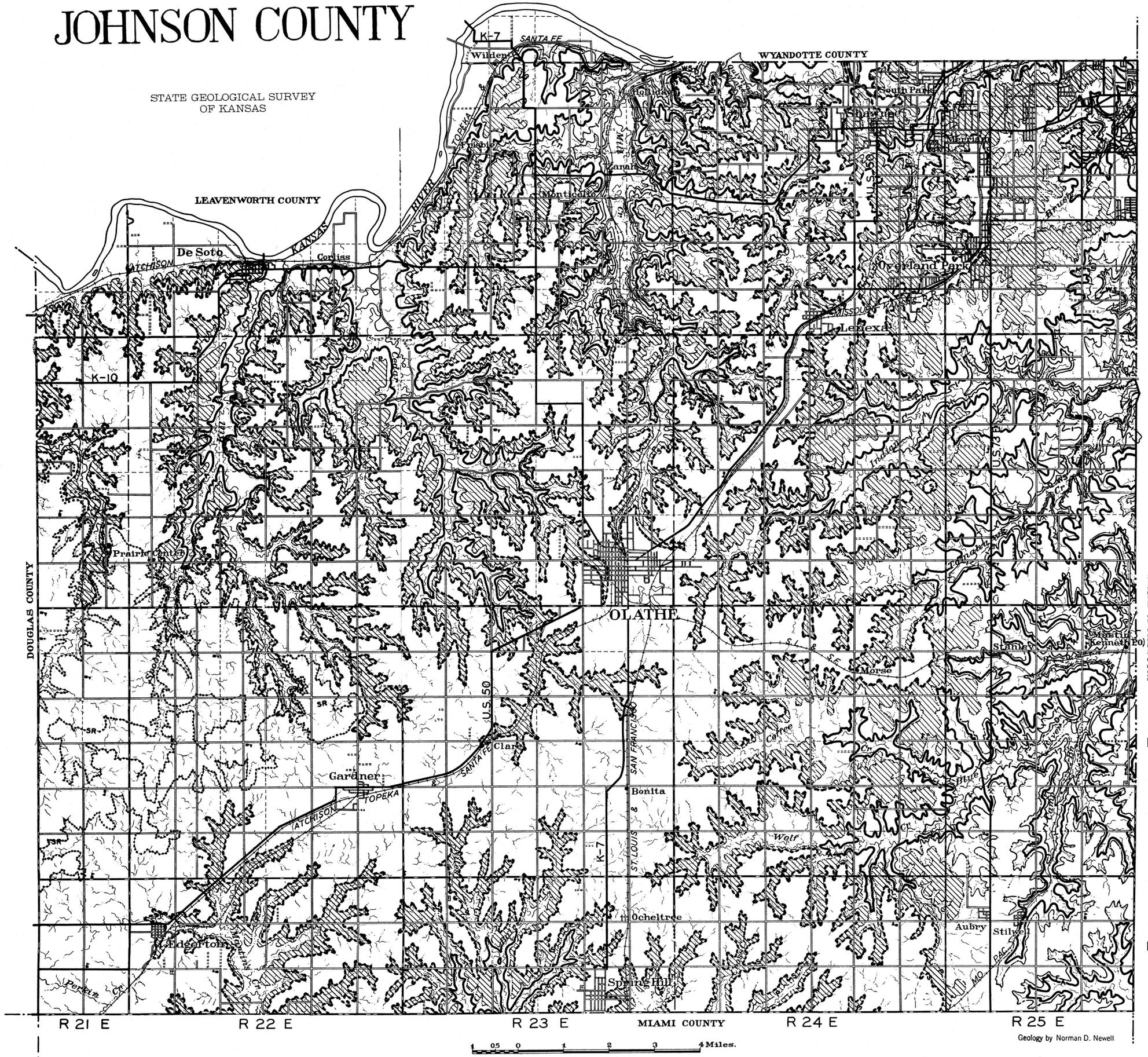
12. Keyes, C. R., The geological formations of Iowa: Iowa Geol. Survey, vol. 1, pp. 85-114, 1893.

13. Haworth, E., Univ. Geol. Survey of Kansas, vol. 3, p. 94, 1898.

14. Hinds, Henry, Coal deposits of Missouri: Missouri Bur. Geology and Mines, vol. 2, 2d ser., p. 7, 1912.

JOHNSON COUNTY

STATE GEOLOGICAL SURVEY
OF KANSAS



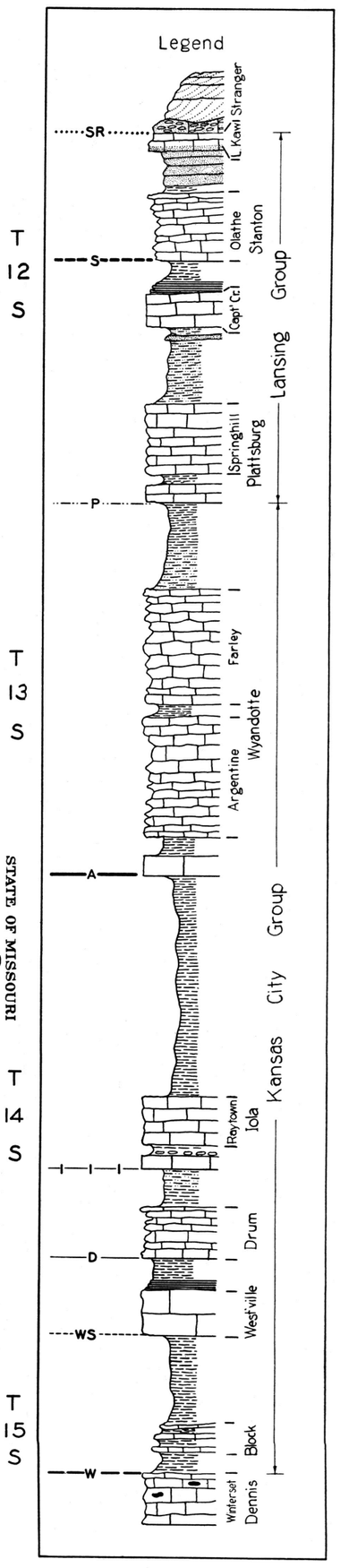


PLATE I. Areal geologic map of Johnson county.

MIAMI COUNTY

STATE GEOLOGICAL SURVEY
OF KANSAS

RAYMOND C. MOORE
STATE GEOLOGIST

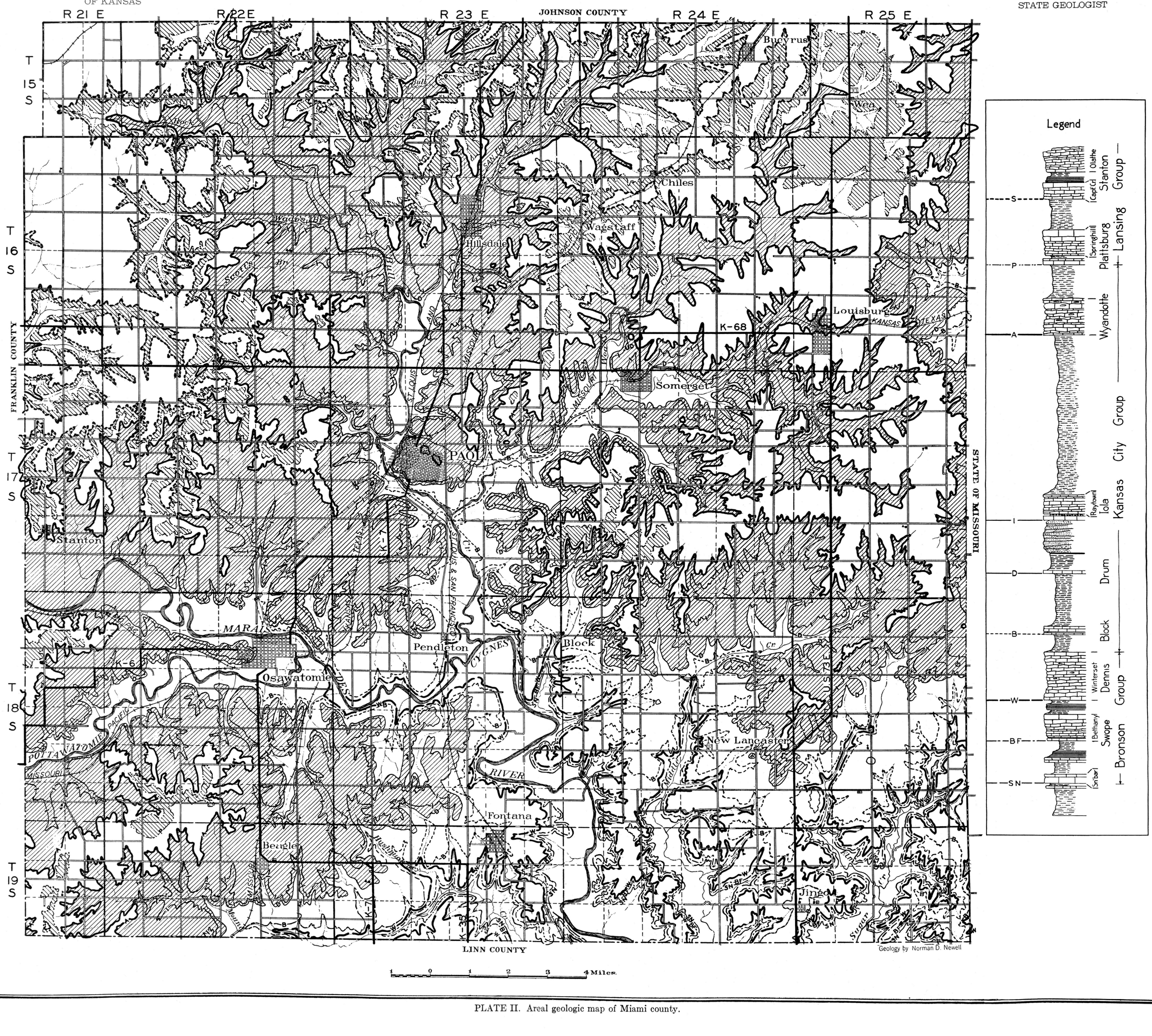


PLATE II. Areal geologic map of Miami county.

Bourbon Formaton

For the beds, consisting chiefly of shale in most places, between the unconformity at the base of the Missouri series and the base of the Hertha limestone, Moore proposes the term Bourbon, from a county in eastern Kansas. As explained under the discussion of the Missouri series, the thick shale around La Cygne and in southeastern Miami county belongs largely or entirely to the Bourbon formation.

Lithologic character and thickness. In Miami county the lower part of the Bourbon is not shown, being below drainage level. A channel sandstone occurs in the upper part of the formation near the middle of the south edge of section 9, T. 19 S., R. 25 E. The deposit consists of soft cross-bedded sandstone having an estimated thickness of possibly fifty feet or more and a breadth at the outcrop of about a quarter of a mile. At other places in southeastern Miami county and at La Cygne, in Linn county, there is at the same horizon buff arenaceous shale and thin beds of sandstone. The shale succeeding the channel deposit in Maimi county is generally arenaceous with intercalated layers of clay. It is about thirty feet or so thick.

The base of the Bourbon is not exposed in the vicinity of Miami county, so it is impossible to obtain the exact thickness from surface data. There is, however, about ninety feet of the formation exposed along the tributaries of Marais des Cygnes river in the southeastern part of the county. Near the top of the Bourbon formation there is a thin bed of nodular, ferruginous tan limestone, one or two feet thick, bearing, at least locally, specimens of a large *Bellerophon,* as does the overlying Sniabar. This limestone is the one called Critizer by Jewett.[16] The term Critizer possibly cannot rightly be applied to this limestone because it seemed to F. C. Greene, R. C. Moore, and me that the limestone near Critizer in Linn county is another one. The upper shale of the Bourbon in Miami county consists of four feet or less of nodular greenish clay.

Since the Bethany Falls limestone is the lowest rock exposed in Johnson county, the Bourbon does not crop out within the limits of that county.

Detailed sections. Sections including part of the Bourbon formation are given under numbers 125, 158, and 159 at the end of the report.

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15. Moore, R. C., Op. cit., p. 90.
16. Jewett, J. M., Kansas Acad. Sci., Trans., vol. 36, p. 134, 1933.

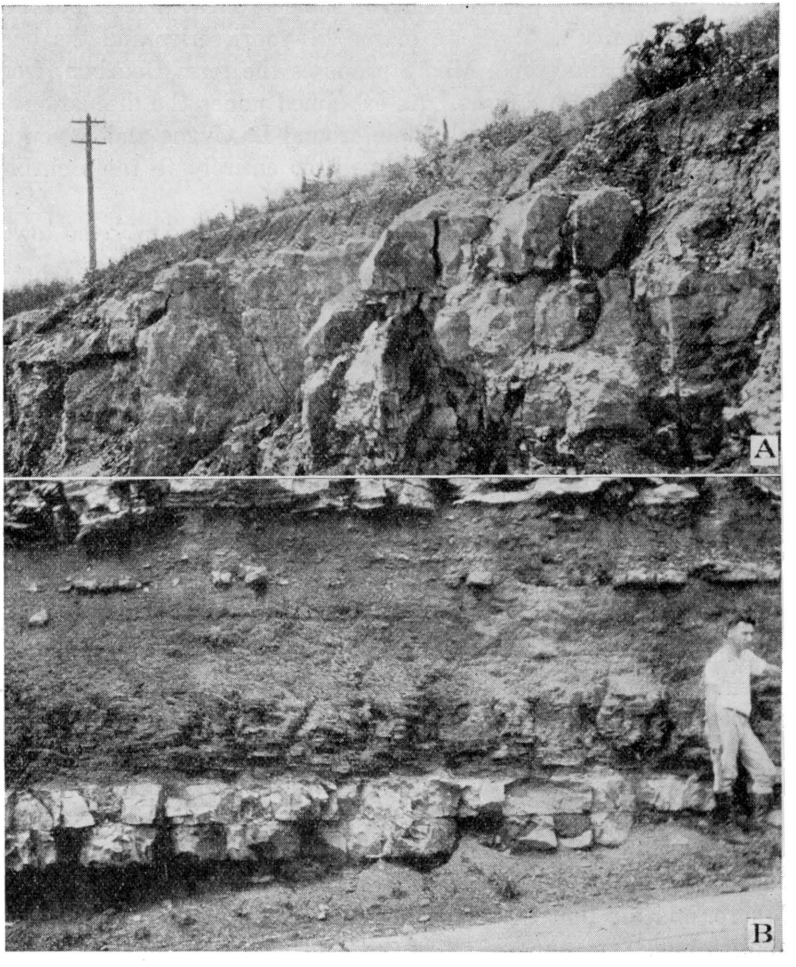

PLATE III. Exposures of the Swope formation, SE. cor. sec. 36, T. 19 S., R. 24 E., Linn county. A—Bethany Falls limestone. B—Middle Creek limestone (type exposure) above pavement and Hushpuckney shale above.

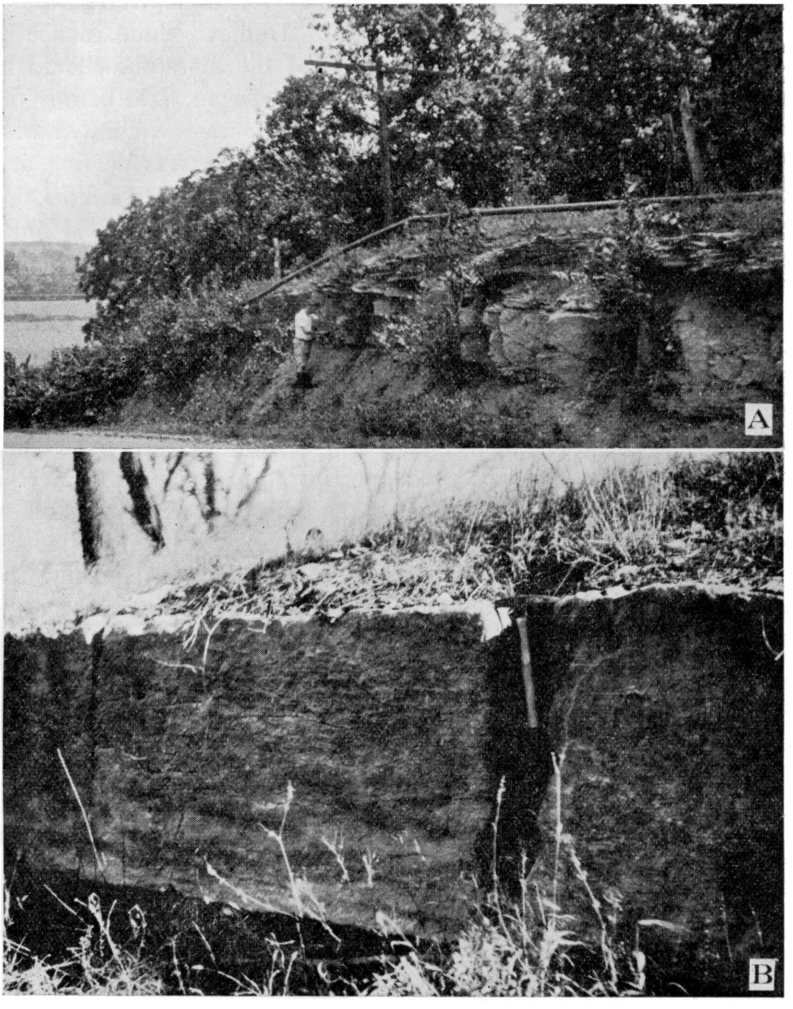

PLATE IV. A—Drum limestone. Local cross-bedded limestone at the top. SE. cor, sec. 31, T. 16 S., R. 24 E., Miami county. B—Characteristic Drum limestone at the middle of the west edge sec. 21, T. 17 S., R. 23 E., Miami county.

Bronson Group

The name Bronson was used by Adams[17] for three principal limestones, and included shales above the "Dudley" shale in southeastern Kansas. At first he thought that the limestone should be correlated with the Hertha, Dennis, and Drum, but before the description of the Bronson was published he was acquainted with the true correlation of the units with which he was dealing and made the proper corrections in an inserted list of errata in this publication. Thus, Adams meant to include three principal limestones and contained shales in his Bronson up to the top of the Dennis limestone, or Winterset of modern writers.

HERTHA LIMESTONE

The name Hertha was introduced by Adams[18] "for the limestones succeeding the upper Pleasanton shales as exposed in the vicnity of Hertha," Neosho county, Kansas. Jewett[19] rightly concluded that the limestone to which the name Hertha was applied at Hertha by Adams in 1903 is the Bethany Falls limestone. It is possible to determine the exact bed at Hertha referred to by Adams in this publication because an areal map of eastern Kansas, showing the distribution of the Hertha and other limestone outcrops, accompanied the original definition.

A year after the first definition of Hertha, Adams[20] published maps of the area immediately north of Hertha in which the first limestone below the Bethany Falls (= Mound Valley limestone) was indicated as Hertha. This lower limestone is the six-foot limestone cropping out at Hertha, and not the one shown as Hertha in the previous publication. The reason for this confusing change in mapping was not given in the accompanying text. In the application of the term Hertha the early Kansas Survey followed this second usage of Adams so that, excepting for the original definition, the name Hertha has been consistently applied to the lower limestone of the Bronson group.

It was discovered by F. C. Greene, R. C. Moore, and me, in a special field investigation of the Hertha problem that the lower limestone cropping out at Hertha is continuous across eastern Kan-

17. Adams, G. I., U. S. Geol. Survey, Bull 238, pp. 17, 18, 1904.

18. Adams, G. I., in Adams, Girty, and White, Upper Carboniferous rocks of the Kansas section: U. S. Geol. Survey, Bull. 211, p. 35, 1903.

19. Jewett, J. M., Kansas Acad. Sci., Trans., vol. 36, p. 134, 1933.

20. Adams, G. I., In Adams, Haworth, and Crane, Economic geology of the Iola quadrangle, Kansas: U. S. Geol. Survey, Bull. 238, pp. 14 and 16, 1904.

sas, and, contrary to Jewett's conclusion,[21] it is in part equivalent to the limestone at Kansas City that has in the past been called Hertha.

It does not seem advisable to suppress the name Hertha on the grounds that it is a synonym of Bethany Falls. In Adam's final usuage and subsequent work it appears that there has been a consistent application of the name to one limestone unit, the lower of the Bronson or "triple system" of the early writers. I propose here to retain the term Hertha in a formational sense for the limestone cropping out at Hertha, and for its immediate correlatives.

In tracing the Hertha southward from Kansas it was discovered by Greene, Moore, and me that the unit is added to above so that over much of eastern Kansas it is divisible into two members of unlike lithologic character, commonly separated by some shale. The upper member was thought to be Jewett's Schubert Creek limestone and the lower one, so well-developed in northeastern Kansas and adjoining parts of Missouri, is here termed the Sniabar limestone from exposures along Sniabar creek in southeastern Jackson county, Missouri. A characteristic exposure may be seen along the highway one half mile north of Knobtown, Jackson county, Missouri.

Lithologic character and thickness. The Sniabar limestone is exposed at a few places in the southeastern part of Miami county. It is commonly covered by the large slumped blocks of the Bethany Falls limestone above. The Sniabar limestone consists of thick-bedded, ferruginous, fine-grained limestone, generally drab or gray where fresh, and brown on weathered surfaces. The uppermost part of the limestone is granular and contains *Osagia* sp. readily visible on fresh surfaces. The member generally consists of a single bed of limestone, and only exceptionally are bedding planes shown. It averages six feet thick in Miami county, although at one locality in sec. 10, T. 19 S., R. 24 E., it is only five feet thick. The unit is rather unfossiliferous. A careful search in Miami county for fusulinids in the Sniabar limestone has been fruitless.

Distribution. The outcrop of the Sniabar limestone is restricted in Miami county to the (1) valley of Sugar creek and the lower part of its principal tributaries, (2) the lower part of Middle creek, (3) the valley of Marais des Cygnes river, extending to the northeast part of township 18 south, range 23 east, and (4) Hushpuckney creek valley in township 19 south, range 23 east. The formation does not crop out in Johnson county.

21. Jewett, J. M., Op. cit., 1933.

Detailed sections. Sections of the Sniabar limestone are given under numbers 122, 124, 125, 152, 157, 158, and 159 in the register at the end of the report.

LADORE SHALE

The term Ladore was applied by Adams[22] to the shale between the Hertha and Mound Valley (Bethany Falls) limestones as shown near Ladore. Since the upper limestone layers of the Hertha appear generally to be lacking in northeastern Kansas, the Ladore shale may include slightly lower beds than in southern Kansas, but, on the other hand, Middle Creek limestone and overlying Hushpuckney shale which may be represented by the upper Ladore in southern sections are excluded from the Ladore in the north. The Ladore shale of northeastern Kansas is not nearly as thick as it is in southeastern Kansas.

Lithologic character and thickness. The Ladore shale crops out in Miami county, where it consists chiefly of buff to gray argillaceous shale. Generally the lower part is limy and nodular. The upper portion locally contains thin lenticular shaly limestones, but more commonly it is argillaceous throughout. The formation ranges in thickness from five to twelve feet, but averages about five and one half feet. A typical section at the west edge of the NE¼ of sec. 10, T. 19 S., R. 23 E. shows two feet of greenish-buff, limy shale, overlain by five inches of soft, gray, argillaceous limestone, and three feet three inches of argillaceous, gray shale with a thin limestone at the middle. The formation is relatively thick at the middle of the south edge of sec. 18, T. 18 S., R. 24 E., where it reaches a thickness of twelve feet.

SWOPE LIMESTONE

The term Swope, from Swope Park, Kansas City, Mo., is proposed by Moore and Newell for the persistent limestones and thin shales from the top of the Ladore shale to the top of the Bethany Falls limestone. The units of the Swope are, in ascending order: Middle creek limestone, Hushpuckney shale, and Bethany Falls limestone.

Lithologic character and thickness. The lowest member of the Swope, the Middle creek limestone, is named from the exposures on the east side of Middle Creek at the highway three miles east of La Cygne, Linn county, Kansas. The member is exceedingly uniform throughout Kansas and Missouri. It consists generally in

22. Adams, G. I., In Adams, Haworth, and Crane, U. S. Geol. Survey, Bull. 238, map opposite p. 14, 1904.

Miami county of two even layers of dark bluish-gray, dense, and brittle limestone. Only locally in the area are the two layers separated by shale, as at the west edge of the NE¼ sec. 10, T. 19 S., R. 23 E., where the section from the base upward is one and one half feet of bluish-gray, lithographic even limestone, five inches of limy buff shale with batostomellids, overlain by four and one half inches of bluish-gray dense limestone. At some localities the upper surface of the lower bed of the Middle Creek limestone is covered with a peculiar twig-like form which recalls certain types of the alga *Lithothamnion.* The member is quite uniform in thickness, ranging in this region from about one foot four inches to a maximum of two feet three inches. Where there is no included shale the Middle Creek is commonly one foot eight inches thick. The Middle Creek limestone strikingly duplicates in its physical characters and in its position immediately beneath black fissile shale the "middle limestone" members of the limestone formations in the Shawnee group, where Moore has defined the typical sequence of units in regularly repeated sedimentation cycles. In terms of this cycle, therefore, the Middle Creek member may be classed as a "middle limestone."

The Hushpuckney shale, here named from a creek south of Fontana, in Miami county, is similar to many of the thin carbonaceous shales in the Mid-Continent region. It is typically shown at a railroad cut, center north side sec. 13, T. 19 S., R. 23 E. (Loc. 124). It consists typically of two parts, the upper half being gray, argillaceous shale, and the lower half black, platy shale. Locally a thin layer of argillaceous, greenish shale underlies the black shale, and less commonly the upper part of the member consists of carbonaceous, blocky shale. The carbonaceous parts of the unit are not very fossiliferous, but in places they yield orbiculoid brachiopods. At Middle creek, about one fourth of a mile east of the SW cor. sec. 22, T. 18 S., R. 24 E., a few impressions of the scales of a large ganoid fish occur in the black platy shale. Small phosphatic nodules are rather common in the carbonaceous part of the shale. The thickness of the Hushpuckney member ranges from four and one half to five and one half feet, the average being closer to the latter figure.

The Bethany Falls limestone, named by Broadhead[23] from exposures at the falls of Big creek, near Bethany, Mo., is an easily recognized unit where it is fairly well exposed. The member in

23. Broadhead, G. C., Coal Measures in Missouri: St. Louis Acad. Sci., Trans., vol. 2, p. 320, 1868 (read May 5, 1862, first issued July 27, 1865).

Miami county is similar to exposures in the vicinity of Kansas City and elsewhere in eastern Kansas. The upper part is massive, drab or light gray, oölitic, and cross-bedded. Locally, there is a thin layer of loose limestone nodules at the top. The uppermost part of the massive bed is at a few places mottled with bluish-gray spots. The oölitic part is quite unfossiliferous, and locally contains peculiar vertical tubular cavities measuring as much as five feet in length by two inches in diameter. Generally the cavities are lined by iron-stained calcite crystals, and less commonly they are nearly or entirely filled with calcite. Where the rock is weathered the oölitic grains have in most cases been removed by solution, leaving minute spherical cavities surrounded by the limestone matrix. The massive upper part of the Bethany Falls weathers in great rounded masses, which creep down the slopes in huge blocks, or it crops out as a massive ledge along valley slopes. There is considerable variation in the thickness of this part of the member. It ranges from about one foot at the center of the south edge of sec. 18, T. 18 S., R. 24 E., to thirteen feet at the west edge of the NE¼ sec. 10, T. 19 S., R. 23 E. In fact, most of the variation in thickness of the member is due to the irregularity of the oölitic part. The upper massive part of the Bethany Falls is commonly about seven feet thick.

The lower part of the member is quite distinct from the upper. It is composed of thin-bedded, even, whitish or light-gray limestone, containing an occasional light-colored chert nodule and a few brachiopods of the *Productus* type. A small fusulinid of the appearance of *Triticites irregularis* occurs here, the first appearance of *Triticites* in the section. This limestone generally weathers buff, especially below, where occur a few thin shale partings. This part of the member ranges between ten and nineteen feet, but most commonly measures about fourteen feet. The greatest thickness of the entire member in Miami county was measured at the west edge of the NE¼ sec. 10, T. 19 S., R. 23 E., where it is twenty-seven feet thick. The member is thinnest at the center of the north edge of sec. 13, T. 19 S., R. 23 E., at a railroad cut, where it measures thirteen feet. Generally the member measures about eighteen feet in Miami county.

The lower thin-bedded *Triticites*-bearing part of the Bethany Falls member is entirely similar in physical and faunal characters and in its position above black platy shale to the so-called "upper limestone" of the limestone formations in the Shawnee group. The remaining upper part of the Bethany Falls, which is irregular in

thickness and in various portions massive, oölitic, or nodular, is probably chiefly of algal origin. It duplicates characters that are typical of what Moore has termed the "super limestones" in the sedimentary cycle exhibited by the Shawnee group limestone formations. The Bethany Falls limestone thus contains both the "upper" and "super" elements of the cyclic succession of beds as described by Moore.

The outcrops of the Bethany Falls limestone extends into Johnson county from Missouri for a short distance along the lower part of Indian creek. Only the upper part of the member is exposed on the Kansas side. Very good exposures of the entire Swope formation occur a short distance to the east along Big Blue river in Jackson county, Missouri. The Bethany Falls limestone, which is the oldest member exposed in Johnson county, shows the characteristic features at the Indian creek exposure. It weathers in large, rounded masses, displaying few joints. The upper few feet of the member consists of drab, soft, highly nodular and rather unfossiliferous limestone. In near-by areas where the entire member is exposed, the upper part of the Bethany Falls is very massive and is oölitic or nodular. This part of the formation has a tendency to form large slumped blocks which hide the lower and less massive part. This peculiar feature of weathering is excellently displayed in the outcrops in Swope Park in Kansas City and to the southward along the valley of the Big Blue. The lower part of the Bethany Falls in the Jackson county exposures resembles the exposures in Miami county, consisting of even-bedded, gray limestone with a few thin shale partings. The entire Swope limestone is about twenty feet thick in the exposures nearest the Johnson county line.

Distribution. The Swope formation crops out in Miami county along the principal streams in the southeastern part. On Sugar and Middle creeks it extends to about the middle of township 18 south, and along Marais des Cygnes river to a point west of the center of township 18 south, range 23 east, where it is seen at the water's edge beneath the highway bridge in section 17. On Mound creek, southeast of Beagle, the formation is exposed as far as the western edge of range 23 east.

In Johnson county the Swope limestone is exposed near stream level on Indian creek at the state line. At other places in the county it is covered by younger formations.

Detailed sections. Sections of the Swope are given under numbers 121, 122, 123, 124, 125, 126, 130, 152, 154, 157, 158, and 159.

GALESBURG SHALE

The Galesburg shale was named by Adams[24] from Galesburg, Neosho county, Kansas. According to Adams' original definition, it includes "the rocks occupying the interval between the Hertha limestone and the Dennis limestone." It has been generally assumed that Adams overlooked the Bethany Falls limestone at Galesburg, since that formation lies between the Hertha and the Dennis. Because the term Ladore was used for the shale between the Hertha and Bethany Falls the name Galesburg was restricted by the early Kansas Survey to apply to the strata between the Mound Valley (Bethany Falls) and the Dennis limestones.

In southeastern Kansas, extending as far north as Linn county, there is a thin, blocky, blue limestone below the Winterset limestone, separated from it by a thin black shale. This limestone was known to the older writers and to Hinds and Greene.[25] Jewett has determined that the limestone is absent in northern Linn county and that it makes its appearance to the southward. This limestone, called Canville by Jewett, and the black shale above lie at the horizon of the upper part of the so-called Galesburg in the Kansas City region. In northeastern Kansas the section above the Bethany Falls is as follows: a thin layer of buff or gray clay shale is overlain by two or three feet of black fissile shale, which is in turn overlain by a thin layer of buff or gray clay. The Winterset overlies this clastic succession.

According to Jewett, the situation at Galesburg is as follows. A thick shale and sandstone section, the Galesburg shale, is overlain by a limestone formation which consists of three parts; a lower thin, blocky limestone, overlain by a thin shale containing a layer of black fissile shale, succeeded by a thick limestone. The older writers did not mention any limestone or black shale in the typical Galesburg, and it is almost certain that the rather obscure black shale layer and basal limestone were grouped with the main limestone above under the term Dennis. This succession, which occurs at Dennis as well as Galesburg, is not easily recognized at all exposures because the lower units are commonly hidden by slumped blocks of the much thicker upper member.

The shale below the thin basal limestone has thinned in the vicinity of Uniontown from over seventy feet to about ten feet.

24. Adams, G. I., Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section: U. S. Geol. Survey, Bull. 211, p. 36, 1903.

25. Op. cit., p. 119, 1915.

Farther north the unit thins even more, to less than three feet in Miami county. The view is here taken that this shale in Miami county is the true Galesburg shale, on the basis of stratigraphic continuity and because the black shale above, which in southeastern Kansas is underlain by a thin limestone, belongs genetically with the limestone above. The thin blocky limestone is replaced by shale to the northward, so that in Miami and Johnson counties the Galesburg is directly overlain by the black shale which Jewett has called the Stark shale. The Canville limestone and Stark shale are classed with the Winterset limestone as members of the Dennis limestone.

Lithologic character and thickness. The Galesburg is fairly uniform in its characters in Miami county. The unit is underlain by the Bethany Falls member of the Swope and overlain by black fissile shale, the Stark. A characteristic section of the Galesburg occurs two and one half miles east of La Cygne, Linn county. From the base upward there is two feet four inches of buff, limy, nodular shale, and four inches of buff, limy, hard shale, rarely bearing *Leiorhynchus rockymountanum.* The hard shale is probably the equivalent of the dense, blue Canville limestone that occurs at this horizon a short distance to the south.

The Galesburg is not well exposed in Johnson county and, like the Bethany Falls, crops out only at the NW cor. sec. 11, T. 12 S., R. 25 E., in the bed of Indian creek. The formation is generally about two feet thick in near-by areas and becomes increasingly argillaceous and less calcareous toward Kansas City.

Distribution. In Miami county the formation crops out along the major streams in the southern part of the county. The Galesburg extends along the forks of Sugar creek almost to the middle of township 18 south. It crops out along Middle creek to a point north of the center of township 18 south, range 24 east, and extends nearly to the west edge of range 23 east on Marais des Cygnes river, where the formation dips below the plain southeast of Henson. On Mound creek the Galesburg crops out upstream to about the west edge of range 23 east.

The only occurrence of the Galesburg in Johnson county is given above.

Detailed sections. Sections of the Galesburg are given under locality numbers 121, 122, 123, 124, 130, 152, 154, and 159.

DENNIS LIMESTONE

The term Dennis, from a town in Labette county, Kansas, was applied by Adams[26] to a formation which he considered to be the same as the previously named Mound Valley limestone. The Kansas Survey, however, maintained that the Mound Valley, or Bethany Falls of modern writers, and the Dennis were different formations. Later it was found that the Winterset[27] limestone of Iowa geologists could be correlated with the Dennis, and the older term Winterset was retained. As explained under the discussion of the Galesburg, Jewett has found that the type Dennis consists of more than the Winterset limestone as interpreted by Missouri geologists. The limestone at Dennis contains three divisions. These are a basal, blocky, thin limestone, overlain by black fissile shale, and thick limestone. This is a duplication of the cycle exhibited by the Swope limestone. The basal limestone at Dennis extends northward along the outcrop as far as southern Linn county, beyond which it changes to limy shale. The black shale member, which Jewett[28] calls the Stark, from a town in Neosho county, has always been considered a part of the Galesburg in the Kansas City region. In northeastern Kansas, including Johnson and Miami countes, the Stark is the lowermost member of the Dennis formation, since the basal limestone found in southeastern Kansas is unrecognizable in the northern area. The uppermost and most persistent member is the Winterset of standard usage. The Dennis formation as here used includes in northeastern Kansas the Stark shale below and the Winterset limestone above. In southeastern Kansas a third member, a basal, thin limestone, the Canville,[29] occurs below the Stark.

Lithologic character and thickness. The Stark shale, lowermost member of the Dennis in northeastern Kansas, is generally quite uniform. It consists of black fissile shale below, overlain by a slightly thicker amount of gray or buff argillaceous shale. In Miami county the carbonaceous part of the member is two and one half to three feet thick and contains an abundance of phosphatic concretions. The upper part of the member consists of four and one half feet of buff and gray limy shale.

The member presents about the same character at the few outcrops in Johnson county. The upper part of the member is generally

26. Adams, G. I., Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section: U. S. Geol. Survey, Bull. 211, p. 36, 1903.

27. Tilton, J. L., and Bain, H. F., Geology of Madison county: Iowa Geol. Survey, vol. 7, pp. 517-519, 1897.

28. Jewett, J. M., Kansas Acad. Sci., Trans., vol. 36, p. 133, 1933.

29. Jewett, J. M., Op. cit., p. 133, 1933

yellowish and underlain by gray argillaceous shale. The entire unit is about four feet at exposures in eastern Johnson county and adjoining parts of Missouri.

The Winterset limestone is more regular in Miami and Johnson counties than the Bethany Falls, with which it might be confused, but has characters less striking. In both counties the Winterset consists of gray, thin-bedded, even limestone, fine-grained or dense at the middle and veined or coarse below. In Miami county the uppermost part consists of dark-gray or nearly black, fine-grained limestone bearing a characteristic faunal assemblage. At one locality, just west of the NE cor. section. 11, T. 18 S., R. 23 E., a relatively thick shale parting was observed near the top of the formation. Elsewhere the member seems to be rather free from shale. Near the top and especially at the middle part there are generally a great many large chert nodules. Locally these may be dark-gray or black, but in Miami county they are mostly buff, brown, or gray. Near the top and below the black limestone stratum a thin layer of oölite, with a few oölitic chert nodules, is observed in many places. Locally below the oölite there are a few thin layers of light-gray, lithographic, siliceous limestone, containing a few silicified pleurotomarids. The lower part of the member is somewhat thicker bedded and consists of dark-gray, fine-grained, veined limestone. The upper part of the member in Miami bears a prolific fauna, consisting chiefly of *Triticites irregularis, Derbya* cf. *crassa, Juresania nebraskensis,* and a very large variety of *Composita.* The fauna of the lower part of the Winterset includes several productids. The member is about thirty feet thick in Miami county.

There are no good exposures of the Winterset limestone in Johnson county. The member crops out for a short distance in the county along Turkey and Indian creeks. The rock is dove-gray for the most part, somewhat argillaceous, even-bedded, and contains a few scattered nodules of black flint near the top. A short distance to the east along Big Blue river in Missouri, in the vicinity of Martin City and elsewhere, the upper part of the Winterset is oölitic and might easily be mistaken for a local facies of the Westerville limestone. In the northern part of Johnson county a prolific molluscan fauna occurs at the top of the member, but the rock is only obscurely oölitic. The complete thickness of the member cannot be measured in Johnson county. A short distance into Missouri it measures a little more than twenty-five feet in thickness.

As was noted in describing the Swope formation, it is easy also to recognize units in the Dennis formation that correspond to the "middle," "upper," and "super" limestones of the Shawnee limestone formations. The Canville limestone is a characteristic "middle." At most outcrops in Johnson and Miami counties the Winterset limestone is an "upper," but where the oölitic limestone is present at the top of the Winterset the "super" also is represented. The Dennis limestone may thus be recognized as containing most of the units of the sedimentation cycle (all of the limestones but the "lower") that are found in the Shawnee group.

Distribution. The Dennis formation crops out in the southeastern part of Miami county along Sugar and Middle creeks for a short distance above the middle of township 18 south, and along Marais des Cygnes river to the west edge of range 23 east. On Mound creek the formation dips beneath the flood plain south of Beagle.

The outcrop of the formation in Johnson county is confined to the middle of the east edge, along Indian creek, and the uppermost part of the Winterset is exposed in the bed of Turkey creek near the northern line of the county.

Detailed sections. See locality numbers 67, 68, 120, 121, 122, 123, 124, 127, 129, 150, 152, 153, 154, and 159.

Kansas City Group

In the reclassification of the Pennsylvanian of the northern Mid-Continent, Moore[30] proposes to restrict the term Kansas City to the irregular and dominantly shaly strata between the Dennis and Plattsburg formations. The Kansas City contrasts strikingly in its greater irregularity with the exceedingly persistent divisions of the Bronson and Lansing groups. The Kansas City group as redefined contains, in ascending order, the Fontana shale, Block limestone, Wea shale, Westerville limestone, Quivira shale, Drum limestone, Chanute shale, Iola limestone, Lane shale, Wyandotte limestone, and Bonner Springs shale. The strata between the top of the Winterset and the base of the Drum limestone are apparently the correlatives of the Cherryvale shale of southeastern Kansas.

The Cherryvale shale was named by Haworth[31] for the thick shale between the Winterset and the Drum limestone at Cherryvale, Kan.

30. Moore, R. C., Kansas Geol. Soc., Guidebook 6th Ann. Field Conference, p. 91-92, 1932.

31. Haworth, E., Stratigraphy of the Kansas Coal Measures: Kansas Univ. Geol. Survey, vol. 3, p. 483, 1896.

The strata at Kansas City for so long classed as Cherryvale are the equivalent of the lower part of the typical Cherryvale. This miscorrelation is one of the results of the misidentification of the Drum limestone in northeastern Kansas. This will be discussed more fully under the description of the Drum limestone. The unit called Cement City[32] in the Kansas City region is the equivalent of the lower part of the Drum limestone of southeastern Kansas. The outcrop is continuous across Kansas and no place is known where the Cement City is less than one foot thick.* Between Paola and Cherryvale, Kan., it is generally less than six feet thick.

The Westerville limestone, or "Kansas City oölite," for so long erroneously correlated with the Drum limestone because of a similar local fauna and lithologic facies, extends no farther to the southwest than Martin City, Jackson county, Missouri, and is equivalent to part of the Cherryvale, since it lies below the Cement City member of the Drum.

In Miami county there occurs a limestone bed of some prominence about fifteen feet, more or less, above the Winterset. This limestone, here called Block after a hamlet in Miami county, has considerable persistence throughout northeast Kansas and adjoining parts of Missouri.

The Block and Westerville limestone provide a five-fold division in northeastern Kansas apparently corresponding to the Cherryvale interval. In order from older to younger these are: Fontana shale, Block limestone, Wea shale, Westerville limestone, and Quivira shale.

The exact limits of Cherryvale equivalents in northeastern Kansas and Missouri may be open to some question, as suggested to me by Moore, on the following basis. In the bluffs west of Coffeyville, Kan., the Winterset limestone is overlain immediately by thin-bedded, bluish, flaggy limestone typical of one variety of "super" bed of the limestone cycle. The Winterset in this area, so far as yet known, does not contain limestone of the "super" type. Northward toward Cherryvale the bluish flaggy limestone beds seem to diverge greatly from the Winterset so that the genetic relationship between these beds and the Winterset is obscure. To the northward from Cherryvale the flaggy beds disappear. It is Moore's suggestion that they may correlate with the oölitic "super" rock which appears in the Winterset in northeastern Kansas. If this interpretation can

32. Hinds, Henry, and Greene, F. C., Op. cit., p. 27, 1915.

* Recent work proves that the Central City locally cut out by unconformity in southeastern Kansas.

be demonstrated the greater part of the type Cherryvale shale might be included in the Winterset limestone.

FONTANA SHALE

The term Fontana is employed here for the fifteen-foot argillaceous shale immediately above the Winterset limestone in the vicinity of Fontana, Miami county, Kansas. Typical exposures occur in road cuts at the NE cor. sec. 11, T. 18 S., R. 23 E., and at the middle of the west side of the NW¼ of sec. 36, T. 18 S., R. 23 E., near Fontana.

Lithologic character and thickness. In Miami county the formation is quite uniform, exhibiting but little variation in lithologic character or thickness. Wherever it is exposed it is a greenish-gray or buff argillaceous shale, and generally contains a few widely scattered and very small calcareous nodules. At one locality, a road-cut west of the NE cor. sec. 11, T. 18 S., R. 23 E., a thin layer of ferruginous, limy shale occurs near the base. The formation is relatively barren of fossils. The minimum thickness measured was at a locality one fourth of a mile west of the center of the west edge of sec. 18, T. 19 S., R. 23 E., where the formation is twelve feet thick. The greatest observed thickness of eighteen feet occurs at the center of the west edge of the NW¼ of sec. 36, T. 18 S., R. 23 E.

The Fontana shale is considerably thinner in Johnson county than it is to the south. In fact, there seems to be a more or less uniform thickening of the member from Kansas City, where it is about five feet, to northern Linn county, where it is over twenty-five feet thick. The Fontana is poorly exposed in Johnson county, cropping out only along the lower parts of Big Blue river, Indian creek, and Turkey creek. In southeastern Johnson county it consists of argillaceous, gray or buff shale, ranging in thickness from six to ten feet. A characteristic zone of *Chonetina flemingi* var. *plebeia* Dunbar and Condra occurs at the top of the shale wherever it is exposed in Johnson county and in the Kansas City region. In the northern part of Johnson county the Fontana is generally buff and somewhat limy with occasional nodules of limestone. In this area the formation is about six feet thick.

Distribution. The Fontana shale crops out in Miami county for a short distance up the eastward flowing streams near the state line in township 16 south, range 25 east. In the southern part of the county the Fontana crops out to the middle of township 18 south on the branches of Sugar creek, and to the northeast part of town-

ship 18 south, range 24 east along Middle creek. On Marais des Cygnes river the shale crops out along the valley walls to Osawatomie and extends a short distance above the fork of Wea and Bull creeks at Paola. The formation crops out along Mound creek to a point south and west of Beagle.

In Johnson county the Fontana shale is generally not well exposed. Consequently its surface distribution must be inferred largely from the outcrop of the Winterset limestone. The outcrop of the Fontana is restricted to the valley of Big Blue river in township 14 south, range 25 east, an area along Kansas river east of Holliday, the valley of Indian creek, in township 13 south, range 25 east, and Turkey creek in township 12 south, range 25 east.

Detailed sections. For sections including the Fontana shale see the following numbers at the end of this report: 40, 67, 68, 117, 120, 127, 129, 150, 153.

BLOCK LIMESTONE

The term Block limestone is here introduced for a thin limestone about fifteen feet above the Winterset limestone cropping out just east of the hamlet of Block in eastern Miami county. In northern Linn and Miami counties this limestone is a fairly prominent unit, attaining a thickness of five feet or more. It thins northward somewhat and splits into several thin beds of limestone, separated by limy shale. The Block includes practically all of the limestone in the lower part of the so-called Cherryvale shale at Kansas City. According to observations by R. C. Moore, this limestone is a compact, clearly recognizable unit near Gallatin and Bethany in northern Missouri, and it probably extends into Iowa.

Lithologic character and thickness. This formation is uniform in Miami county, in contrast to its irregularity in Johnson county. It is characteristically composed of bluish-gray, even, thin-bedded limestone with a few thin, fossiliferous shale partings which are locally absent. Upon weathering the limestone becomes broken into blocky, angular fragments having a light-gray color. The texture of the rock is fine-grained or sugary. There are no particularly characteristic fossils, but *Marginifera wabashensis* and *Triticites irregularis* were noticed at several localities. The Block limestone ranges in thickness from three to eight feet, but is not as irregular as this would suggest, since in most places it is generally about four feet thick. A thickness of three feet was observed at the east side of the NE¼ of sec. 15, T. 19 S., R. 22. E. The greatest thickness of eight feet occurs at a locality one fourth of a mile west

of the middle of the west edge of sec. 18, T. 19 S., R. 23 E. Where the formation is unusually thin it has little or no included shale.

In Johnson county the Block limestone splits up into two or more thin, lenticular, buff limestones, separated by thin shaly partings. It is difficult to correlate these separate limestone beds from place to place, but the base of the lower one is well marked by a persistent zone of *Chonetina flemingi* var. *plebeia* Dunbar and Condra. Since these thin limestones are always closely associated and include about all of the limestone between the Winterset and Westerville, it seems logical to assume that they mark the northern extension of the Block limestone. The most southern outcrop of the Block limestone in Johnson county occurs at the SE cor. sec. 10, T. 14 S., R. 25 E. At this place the *Chonetina* zone underlies a six-inch blocky limestone that resembles in color and texture the Block limestone in Miami county. Apparently there is no more limestone between this thin bed and the Westerville limestone above. The Winterset is not exposed here but crops out a short distance downstream.

Distribution. The Block limestone crops out in eastern Miami county for a short distance up the principal eastward-flowing creeks in township 16 south, range 25 east. In the southern part of the county the member extends to the middle of township 18 south on the main forks of Sugar creek. Along Middle creek the outcrop reaches into section 12, township 18 south, range 24 east. On Marais des Cygnes river and the Pottawatomie the formation crops out as far west as Osawatomie. Along Mound creek it extends to the middle of range 22 east.

In Johnson county the outcrop of the Block is coextensive with that of the Fontana shale; that is, along the lower part of Big Blue river, Indian creek, Turkey creek, and along Kansas river east of Holliday.

Detailed sections. For sections of the Block limestone see numbers 40, 67, 98, 101, 117, 120, 127, 129, 131, 134, 143, 150, and 153, at the end of this report.

WEA SHALE

The term Wea shale from Wea creek in northeastern Miami county is here employed for a shale bed between the Block limestone and the black Quivira shale above. In Johnson county the Westerville limestone separates the Wea and Quivira, but in Miami county the Westerville is only locally present. The Wea is typically exposed at the SE cor. of sec. 31, T. 16 S., R. 24 E. (sec. 166) and at the center of the east side of sec. 12, T. 18 S., R. 22 E. (sec. 129).

Since the Westerville limestone disappears in southwestern Jackson county, Missouri, it is possible that the Wea shale in Miami county is the equivalent of the Westerville limestone and the shale below it in the Kansas City region. There is evidence, on the other hand, that the Westerville is entirely younger than the Wea shale. The limestone does not grade laterally into shale but pinches out rather abruptly. Also there are deposits of conglomerate and indications of at least local disconformity at this horizon in northwestern Miami county. In any case, the Wea shale is a distinct lithologic unit.

The Wea shale is somewhat irregular in Miami county. It consists mostly of olive-green argillaceous shale. Locally, as at the NW cor. of sec. 7, T. 18 S., R. 25 E., there is a thin layer of maroon shale near the top. Excepting one place, the Westerville limestone is absent in Miami county, so that the Wea is in direct contact with the black Quivira shale. The single exception occurs at the locality given just above. Here the Westerville consists of two feet four inches of conglomeratic, thinly cross-bedded limestone. South and west of Paola the Quivira shale loses its characteristic black or maroon color and cannot be distinguished from the Wea. In this case, the two shales may be classed together as the Wea-Quivira shale. A thin sandstone occurs above the middle of the Wea at the south side of the SW¼ sec. 6, T. 18 S., R. 24 E., where the greatest thickness of the Wea-Quivira was measured. The maximum thickness of about twenty-two feet was measured for the Wea at the center of the east edge of sec. 12, T. 18 S., R. 22 E. The Wea shale varies in thickness from place to place in Miami county with little or no regularity.

The Wea shale in southeastern Johnson county consists of argillaceous shale with an increase in calcareous material toward the north. The thickness ranges from about ten to over thirty feet, the greatest thickness being along Indian creek and Big Blue river in the eastern part of the county.

Distribution. In Miami county the Wea shale crops out in the eastern and southern parts of the area in a band nearly coextensive with the outcrop of the Block limestone.

As in the case of the Fontana shale, the Wea is poorly exposed in Johnson county, consequently the distribution is best inferred from the outcrop of the Westerville and Winterset limestones. The Wea shale is exposed along Big Blue river in township 14 south, range 25 east, along Kansas river below Holliday, along Indian

creek in township 13 south, range 25 east, and on Turkey creek in township 12 south, range 25 east.

Detailed sections. Sections of the Wea shale are given under 37, 38, 40, 55, 66, 67, 68, 98, 99, 101, 106, 109, 117, 129, 131, 132, 136, 142, 150, 155, 161, and 166 at the end of this report.

WESTERVILLE LIMESTONE

The Westerville limestone[33] was named by Bain from Westerville, Iowa. For many years an oölitic limestone at Kansas City has been erroneously correlated with the Drum limestone of southeastern Kansas. The correlation has been made chiefly on faunal grounds and lithologic similarity, in spite of the well-known fact that facies faunas like those found in oölitic limestones cannot generally be employed for exact correlations. In recent years the Nebraska Survey has correlated the so-called Drum limestone at Kansas City with the Dekalb[34] of Iowa. Since Dekalb antedates Drum there has been a tendency to drop the term Drum in recent publications. In October, 1932, Dr. R. C. Moore, in company with Dr. G. E. Condra and Dr. F. C. Greene, traced the so-called Drum limestone of the Kansas City area to Winterset, Iowa. They determined that the type Dekalb limestone is the Winterset limestone. The latter name being the oldest, the term Dekalb must be dropped. They also found by study of exposures near Westerville that Bain's Westerville limestone is the same as that called Drum limestone at Kansas City.

Successful attempts have not been made in the past to trace the outcrop of the Westerville southward to the type region of the Drum. Although there is no considerable difficulty attendant to tracing it southward from Kansas City, the Missouri geologists were led into error by overlooking the fact that the Westerville limestone abruptly changes to shale or pinches out at Martin City, Jackson county, Missouri.

The oölitic facies of the upper part of the Westerville at various localities in Kansas City has long been considered highly characteristic of the unit as a whole. Actually few of the exposures in southern Kansas City, Missouri, show the oölitic facies. The non-oölitic lower part of the Westerville, locally called the "Bull ledge," is the most persistent part of the formation and retains its characters fairly well, whereas the upper part is highly irregular or absent.

33. Bain, H. F., Am. Jour. Sci., 4th ser., vol. 5, pp. 437, 439, 1898.
34. Bain, H. F., Geology of Decatur county; Iowa Geol. Survey, vol. 8, p. 278, 1897.

The most recent published work involving the Westerville limestone in Kansas is a faunal study by Sayre[35] which treats of the stratigraphy in rather an incidental manner. Sayre was misled in several instances by his conviction that the oölitic facies is characteristic of the Drum limestone across Kansas. He erroneously correlated the limestone at Kansas City, here called Westerville, with the typical Drum, and at some localities he mistook the oölitic portions of the Bethany Falls and Winterset limestones for the Drum.

The Westerville is one of the most variable units cropping out in Johnson county. Where it is thick it is oölitic and cross-bedded, and where it is thin the formation is very massive and even-bedded, and commonly nonoölitic. In the northern part of Johnson county the upper part of the Westerville consists of thin beds of alternating shale and limestone. The formation ranges in thickness from over twenty feet in section 35, T. 12 S., R. 25 E., to four feet along Big Blue river. The greatest variation takes place apparently in Ts. 12 and 13 S., R. 25 E., and in T. 12 S., R. 23 E. Near the highway just east of Holliday at the creek bridge, the Westerville is fairly well exposed. The upper nine feet consists of gray, calcerous shale and interbedded limestone. After comparing this exposure with the section at the quarry near Morris, Wyandotte county, the upper contact of the Westerville was placed considerably above the main limestone bed, the latter actually representing only the lower part of the formation. The main limestone of the Westerville at Holliday consists of very fossiliferous oölite, underlain by a foot or so of hard, gray limestone. The exposure just off the intersection of the highway with the county line, at the middle of the north edge of sec. 6, T. 12 S., R. 24 E., resembles the exposures at Morris and Holliday. At a quarry near the state line, NW cor. sec. 35, T. 12 S., R. 25 E., the Westerville is unusually thick, although the beds above it are characteristic. At this place the formation consists of about twenty feet of oölitic limestone, cross-bedded on a large scale. The limestone is here rather unfossiliferous, although the Cement City limestone above it is quite fossiliferous. According to drill records at this locality, the Winterset limestone seems to lie unusually close to the base of the Westerville. At a creek bridge near the NW cor. of sec. 15, T. 13 S., R. 25 E., the Westerville is a massive, gray limestone, dense, weathers drab, and has a thickness of four feet. The identification rests on the characteristic aspect of the overlying

35. Sayre, A. N., Fauna of the Drum limestone: Kansas Geol. Survey, Bull. 17, 1930.

beds. Eight feet of fossiliferous cross-bedded oölite are exposed at a creek crossing, NW cor. sec. 25, T. 12 S., R. 23 E. The bed is too poorly exposed to determine its relative position in the Westerville, but it is probably the exact equivalent of the oölite at Holliday. At a road cut near the SE cor. sec. 34, T. 13 S., R. 25 E., the Westerville is a four and one half foot bed of dark-gray, massive limestone.

In much of southeastern Johnson county and adjoining parts of Jackson county, Missouri, the Westerville limestone resembles very closely the Cement City member of the Drum limestone of the same region. In some exposures the only characteristic difference is in the fossil content. A large variety of *Triticites* is sparsely distributed through the Westerville (nonoölitic part) but is totally lacking in the Drum. A variety of *Campophyllum torquium* occurring sparsely in the formation is highly characteristic of the Drum in northeastern Kansas and is lacking from the Westerville.

A fine exposure including strata from the Winterset to the Drum occurs about three and one half miles northeast of Martin City, Jackson county, Missouri. The exposure is seen at a road cut just east of the intersection of the paved roads 1-E and 10-S, about one fourth of a mile east of an entrance to Red Bridge Farm. At this place the Westerville and Drum are each about five feet thick, separated by the characteristic greenish Quivira shale containing a thin carbonaceous layer near the middle. A similar development is seen one half of a mile north and one half mile east of Martin City, about a half mile east of the highway intersection. A maroon layer near the base of the Chanute shale affords a convenient key horizon in this region. At a bluff south of a creek at the pavement intersection two miles south of Martin City, the Westerville limestone is gone, represented only by a few limestone concretion at the base of the black Quivira shale.

Farther to the southwest in Miami county, the Westerville limestone is entirely missing except for one isolated locality, one fourth of a mile south of the NW cor. of sec. 7, T. 18 S., R. 25 E. At this place a gray, conglomeratic, thin-bedded limestone occurs below the black shale of the Quivira. The thickness of the Westerville lentil is about two feet four inches. About five and one half feet below this limestone at the above locality there occurs a thin local layer of maroon clay.

Distribution. The Westerville limestone extends only a short distance west of Holliday before dipping below the flood plain of Kansas river. Rather surprisingly the outcrop of the member ex-

tends far up Mill creek to sec. 35, T. 12 S., R. 23 E., indicating a structural "high" in the lower drainage of the stream. The formation crops out along Turkey creek as far upstream as sec. 5, T. 12 S., R. 25 E., but no good exposures of the Westerville are encountered in this area. A small outcrop of this limestone occurs on Brush creek, secs. 2, 3, and 10, T. 12 S., R. 25 E. The Westerville is well exposed on the valley in secs. 30, 27, 26, and 34, T. 12 S., R. 25 E., but since it is the lowest bed cropping out along the creek within the county, the outcrop extends upstream but a short distance. The Westerville is fairly well exposed along Big Blue river for a short distance from the state boundary. In other parts of Johnson county the formation is buried beneath younger sediments.

As already noted, the Westerville limestone has been found at only one place in Miami county.

Detailed sections. Sections of the Westerville limestone are given at the end of the report under numbers 1, 8, 37, 38, 40, 41, 43, 48, 50, 52, 55, 65, 66, 67, 68, and 161.

QUIVIRA SHALE

The term Quivira, after Quivira Lake on Kansas river east of Holliday where the formation is exposed below the dam, is applied here to the thin argillaceous and bituminous shale lying between the Westerville and Cement City limestones. The formation is also typically shown at the east edge of Holliday, Kan. This unit was erroneously considered to be the lower part of the Chanute shale by Missouri geologists. Since, however, it rests beneath the Cement City member of the Drum, the Quivira is the equivalent to the upper part of the type Cherryvale shale.

The Quivira is somewhat irregular in Miami county, but has characters so striking that it can be readily identified. With but a few exceptions the bed has at the base either a thin layer of black carbonaceous shale or a streak of maroon clay. These two kinds of shale occur at nearly the same horizon, but were not seen together at the same locality. Generally above this horizon the member consists of olive-colored, argillaceous shale. Where the maroon phase occurs the Wea shale below is limy and locally ferruginous and buff. At Paola and south of Hillsdale, and southeast of Osawatomie, the carbonaceous layer occurs at the base of the member. The same facies also occurs at Somerset, northeast of New Lancaster, and at the east side of range 33 east just across the line in Linn county. West of Osawatomie, at Block, south of Beagle, and east of

New Lancaster the black shale is absent and its place is taken apparently by a thin layer of maroon clay. The black layer generally contains brachiopods of the orbiculoid type. The Quivira shale is generally about four feet thick, the upper three feet being greenish, argillaceous shale, and the lower foot either black fissile shale or maroon clay.

In Johnson county the Quivira is characteristically an olive-green, limy or argillaceous shale with a carbonaceous layer near the middle. In some parts of northwestern Missouri as well as to the south of Johnson county a maroon shale layer seemingly takes the place of the carbonaceous bed. Along Big Blue river the formation is about five feet thick, increasing northward to eleven feet at Kansas river.

Distribution. The outcrop of the Quivira shale in Miami county is practically coextensive with that of the Drum limestone. In the northern part of the county the formation extends up the valley of the Wea to the center of the north edge of sec. 32, T. 16 S., R. 24 E., and to sec. 35 of the same township. On Bull creek the bed crops out nearly to the center of township 16 south, range 23 east. A reëntrant of the Quivira occurs along the north edge of township 18 south, ranges 24, 25 east, extending out of the state into Missouri at the north edge of section 14, township 18 south, range 25 east. The formation reaches nearly to the west line of range 22 east on Marais des Cygnes and Pottawatomie rivers. On Mound creek the Quivira crops out to a point southwest of Beagle.

In Johnson county the Quivira crops out along the valley of Kansas river as far west as Holliday and enters Johnson county along Turkey creek and all of the principal streams in the eastern part of the county.

Detailed sections. Sections of the Quivira shale are given under numbers 1, 8, 37, 38, 40, 41, 43, 48, 50, 52, 55, 65, 66, 67, 68, 78, 92, 98, 99, 101, 106, 109, 117, 129, 131, 132, 136, 142, 150, 155, 151, and 166 at the end of this report.

DRUM LIMESTONE

The Drum was named by Adams[36] from Drum creek in the region about Cherryvale and Independence in southeastern Kansas. There is a great deal of variation in the Drum of the type region, for it ranges from eight feet of nonoölitic blue-gray limestone just north of Cherryvale to more than sixty feet of granular and oölitic lime-

36. Adams, G. I., Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section: U. S. Geol. Survey, Bull. 211, p. 37, 1903.

stone near Independence. The oölitic part, for which Moore proposes the term Corbin City, from a suburb of Cherryvale, lies unconformably upon the nonoölitic or Cement City member. It seems that the nonoölitic facies is equivalent to only a lower part of the great mass at Independence, and for this reason the upper limit of the Drum varies considerably in age within the type region. Apparently the formation increases in thickness by replacement of the Chanute shale.

In connection with the study of Miami and Johnson counties it was determined that the unit at Kansas City known as the Cement City limestone is continuous across eastern Kansas with the lower part of the type Drum limestone at Drum creek. The peculiar molluscan fauna of the oölitic facies of the Drum is a facies fauna that is quite as local in its distribution as oölite. Such faunas are far less reliable in correlation than are the faunas of persistent lithologic types. My conclusion that the Cement City is the basal part of the typical Drum was verified in the field by R. C. Moore. From Miami county to Cherryvale the Drum is an obscure unit, exhibiting but poor topographic expression. It is generally a little thicker than two feet.

Lithologic character and thickness. The Drum limestone is one of the most uniform and most easily recognizable units in Miami county. It is well exposed at a number of localities. The formation consists generally of a single layer of massive, fine-grained, drab or brown ferruginous limestone. Locally the upper part of the formation is shaly and granular, and contains a species of *Osagia.* In some artificial exposures the rock breaks up into very thin beds and shows obscure cross-bedding. A characteristic feature of the bed is the occurrence of small, white crinoid segments scattered rather evenly through the limestone. These are quite noticeable against the brown or buff color of the rock in which they occur. Ramose bryozoans are not uncommon on the weathered surface of the formation. Toward the southern border of Miami county the formation tends to become more coarsely granular. In fresh exposures the rock commonly shows a pale olive-drab or drab color, which is changed to a brown on weathered surfaces. At two localities limestone lentils are associated with the formation. One of these, just west of Somerset on the highway, occurs just above the massive ledge of the Drum, separated from it by a thin shale. This upper limestone, which may be considered a northern equivalent of the Corbin City, is cross-bedded and coarse-grained, and about five feet

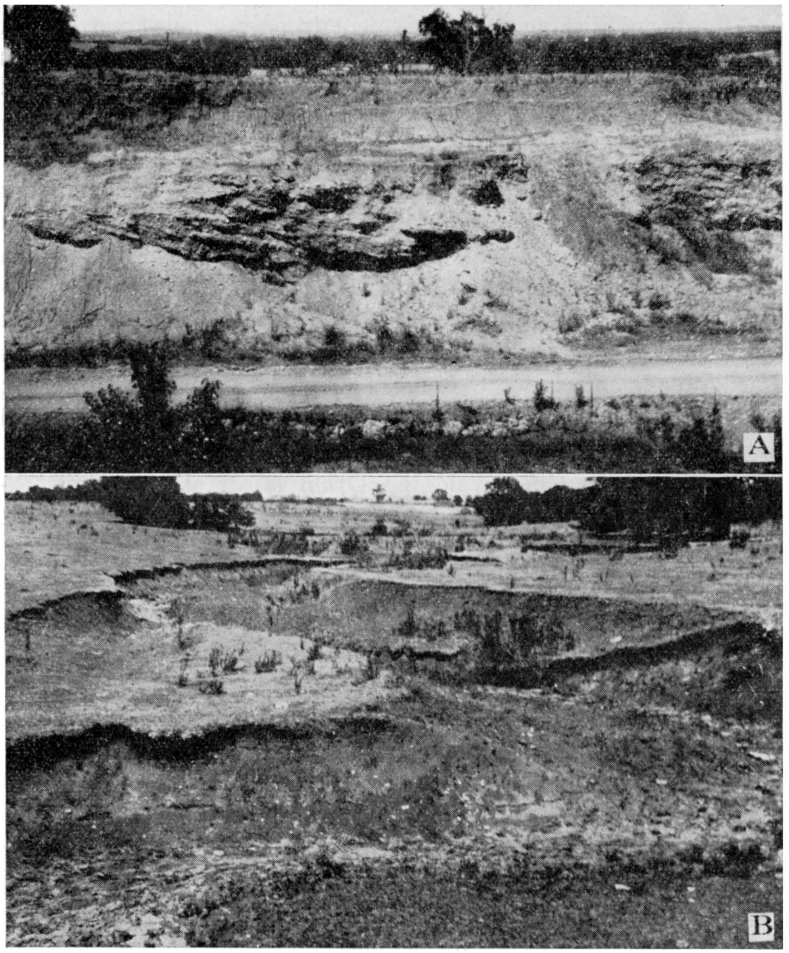

PLATE V. A—High terrace gravel, near Holliday, Johnson county. B—Recent gully, middle south side sec. 22, T. 13 S., R. 24 E. Relief about five feet.

thick. It was not observed at any other place. At a locality one quarter of a mile south of the NW cor. sec. 7, T. 18 S., R. 25 E., a thin-bedded limestone conglomerate occurs below the Drum, separated from it by the thin black shale of the Quivira. This lentil is about two and one half feet thick at the above locality. Since this lies at the horizon of the Westerville limestone, it is probable that it is a southern representative of that formation.

Although these local occurrences of limestones associated with the Drum indicate lack of uniform environment before and after deposition of the Cement City member, the member itself shows little irregularity. The greatest thickness occurs in township 18 south, range 22 east near Osawatomie, where the bed ranges from four to six feet. Generally, however, it averages about two and one half feet. The least thickness observed is one foot nine inches. This occurs about one fourth of a mile south of the NW cor. of sec. 7, T. 18 S., R. 25 E. The formation measures as little as two feet at many localities.

The Drum undergoes changes in thickness and lithologic character from north to south across Johnson county. Along Kansas river, Turkey creek, and part of the valley of Indian creek, in the northeast part of the county, the unit is characteristically light-gray to whitish in color. It is thin-bedded and wavy, with a massive layer at the top and the base. In this area the upper third contains scattered nodules of gray and brown chert. A thin layer of ferruginous or limy, granular, and locally cross-bedded limestone, possibly the Corbin City member, is in places seen above the main part, separated from it by a fossiliferous limy shale which is locally replete with *Teguliferina armata.* A persistent zone of *Campophyllum torquium* appears near the top of the main bed of the Drum throughout the northern part of Johnson county. This coral appears in no other formation in the county and consequently serves as a good horizon marker. Associated with this fossil in the limy shale at the top of the Drum is a faunule of bryozoans. In Johnson county the thickness of the formation is uniformly about ten feet. Toward the south it becomes massive, loses the cherty character and distinctive fossil zones. On Tomahawk creek the bed has a thickness of ten feet, is very massive, drab, weathers buff, and is rather unfossiliferous. Along Big Blue river it is markedly thinner. Here it measures about five feet and is a buff, somewhat ferruginous, and thin-bedded limestone. At this place a massive, gray layer occurs at the top.

Distribution. The Drum limestone crops out over a large part of Miami county, extending up Wea creek to the center of the north edge of sec. 32, T. 16 S., R. 34 E., and to sec. 35 of the same township along a westward-flowing tributary. Along Bull creek the formation crops out nearly to the center of T. 16 S., R. 23 E., and a reentrant occurs along the north edge of T. 16 S., R. 23 E., extending into Missouri at the north edge of sec. 14, T. 18 S., R. 25 E. On Marais des Cygnes and Pottawatomie rivers the formation extends nearly to the west line of range 22 east. In the valley of Mound creek the Drum crops out to a point southwest of Beagle.

The formation extends up Kansas river in Johnson county to the bend in the river at Bonner Springs, where it is fairly well exposed at the flood-plain level on the south side of the river. The formation extends a short distance up Mill creek and crops out in all of the valleys in the northeastern and eastern parts of the county.

Detailed sections. Sections of the Drum limestone are given in the register at the end of the report under numbers 1, 7, 8, 37, 38, 40, 41, 43, 48, 50, 52, 55, 59, 65, 66, 67, 68, 78, 81, 92, 94, 97, 98, 99, 101, 106, 109, 117, 129, 131, 132, 136, 139, 140, 141, 142, 147, 149, 150, 155, 156, 159, 160, 161.

CHANUTE SHALE

The term Chanute was introduced by Haworth and Kirk[37] for the thick shale underlying the town of Chanute in Neosho county, Kansas. The formation as originally defined includes the interval between the Drum and Iola limestones. Because of miscorrelation of both the Drum and Iola limestones at Kansas City, the boundaries of the Chanute shale have been badly confused at that place. The present study has shown that the Cement City limestone of authors is the basal part of the Drum as originally defined, and the Raytown is part of the Iola; consequently the intervening shale is the equivalent of the typical Chanute.

Lithologic character and thickness. The Chanute shale, although somewhat irregular in Miami county, can be recognized easily in most places. Over a large part of the area of outcrop the formation contains a thin coal bed, which has a fairly uniform thickness, but occurs at different positions with respect to the formational boundaries. Where the formation is thin the coal occupies a higher position than otherwise, and the thinning seems to be chiefly the result

37. Haworth, E., and Kirk, M. Z., The Neosho river section: Kansas Univ. Quart., vol. 2, p. 109, 1894.

of lensing out of the sandy layers above the coal. North of Osawatomie and at the north edge of Paola the coal is almost directly overlain by the Iola limestone. The coal bed ranges from about four to eight inches thick in Miami county. The part of the Chanute formation above the coal consists of buff sandstone and sandy shale. The part below the coal is composed of greenish, argillaceous shale with limestone nodules, and locally a layer of maroon shale. At some places the lower division is highly calcareous or slightly arenaceous, and in such cases is buff or greenish-buff. In a few instances a thin, nodular, argillaceous limestone overlies the maroon shale. In general the calcareous nodules are more abundant near the base. The term Thayer, which was a synonym of Chanute, is restricted to the persistent coal bed in the Chanute shale. For the upper sandstone mass the term Cottage Grove is here applied from a township in Allen county, Kansas. The coal bed has been traced as far south as Independence and it may extend farther. This is one of the beds that have long been mined near Chanute and Thayer.

The Cottage Grove sandstone at the top of the Chanute is generally soft, light-buff, and cross-bedded or even-bedded. The member ranges from less than a foot to thirty feet in thickness, being thinnest near Osawatomie and Paola where it wedges out northward. This sandstone thickens southward to a maximum near the county line southwest of Beagle. Locally an obscure coal streak occurs near the top, but this is not to be confused with the thicker persistent coal below. Apparently the sandstone is a deltaic deposit which was formed by sediments derived from the south.

The upper arenaceous part of the formation is about twenty feet thick in most places. The lower and more argillaceous part generally measures about twelve feet or so, although locally it increases to as much as sixteen feet. Where the formation is less than ten feet thick the coal bed is missing and the entire unit consists of greenish, argillaceous shale with calcareous nodules. Were it not for the even contact with the Iola above, one might conclude that the local thinning of the Chanute indicates an unconformity at the top. The formation ranges in thickness from eight and one half feet at the SE cor. of sec. 10, T. 17 S., R. 23 E., to thirty-eight feet in the southwest part of T. 17 S., R. 24 E. A peculiar feature is the distribution of the thinner development of the Chanute. A narrow band reaching from the northeast corner of township 17 south, range 23 east, extending through the northeast and southwest corners of

township 19 south, range 22 east, includes an area where the Chanute is less than fifteen feet thick, and most commonly about ten feet thick. Elsewhere in the county the formation averages about thirty-two feet in thickness.

Although comparatively uniform in most of its characters in Johnson county, the Chanute increases in thickness toward the south. It ranges from about nineteen feet along Kansas river to more than thirty feet along Big Blue river. It is predominantly argillaceous, although an arenaceous shale or sandstone locally occurs near the middle. Of considerable interest is a layer of maroon shale near the base of the formation. This layer ranges in thickness from less than one foot to more than five feet, but it is commonly about two feet thick. It is underlain by a thin layer of olive-green, argillaceous shale, and is overlain commonly by a thin bed of marlite.[38] The term marlite is applied to thin layers of yellowish-brown or greenish, nodular, and "spongy" rock that ranges from a ferruginous, argillaceous limestone to a calcareous shale. Beds of marlite commonly overlie some of the thin and persistent maroon shales in eastern Kansas.

Distribution. The outcrop of the Chanute shale in Miami county occurs in an area about the same as that of the overlying Iola limestone. On Bull creek the formation crops out to the northeast corner of township 16 south, range 22 east, and to Hillsdale. On Wea creek and its tributaries the bed extends a short distance beyond Somerset, follows Bull creek southward to Block and thence eastward around Middle creek to New Lancaster, and northeastward out of the county into Missouri in sec. 11, T. 18 S., R. 25 E. The outcrop of the formation enters the southern part of the county along Mound creek in sec. 16, T. 19 S., R. 22 E., and extends northeastward to about the middle of township 18 south, range 23 east. The outcrop extends up the Marais des Cygnes and Pottawatomie rivers to the west edge of range 22 east.

In Johnson county the Chanute extends up the valley of Kansas river nearly to the mouth of Cedar creek on the south side of the river, considerably farther than on the north side. All of the larger valleys in the northeastern and eastern parts of the county contain the outcrop of the Chanute.

Detailed sections. Sections of the Chanute shale are given under localities 7, 8, 37, 38, 39, 40, 41, 50, 52, 55, 58, 67, 68, 78, 79, 80, 81,

38. Hinds, Henry, and Greene, F. C., U. S. Geol. Survey, Geol. Atlas, Leavenworth-Smithville folio, p. 3, 1917.

92, 93, 94, 96, 97, 98, 99, 100, 106, 108, 109, 111, 117, 118, 129, 131, 132, 135, 136, 137, 139, 140, 141, 142, 147, 149, 150, 156, 161, and 162.

IOLA LIMESTONE

The Iola limestone formation was named by Haworth and Kirk[39] from exposures at Iola, Allen county, Kansas.

Since the early days of geological work in Kansas, there has been a general misunderstanding regarding the Iola limestone and associated formations in northeastern Kansas. Because of excellent exposures of rocks and accessibility the Kansas City area has been visited by many geologists, and the classic section exposed at this place has become the standard section for many units within the Missouri series. Through the work of pioneer investigators, principally that of Bennett, the early Kansas Survey correlated various of the beds exposed at Kansas City with units named from localities in southeastern Kansas a hundred or so miles away. The correlations were made on lithologic similarity, sequence, and presumably by tracing the outcrops in the field.

In the present investigation the so-called Iola limestone (Frisbie-Argentine) was traced southwestward from Kansas City. The limestone was found to pinch out in the vicinity of Greeley, Anderson county, Kansas, therefore not reaching the type locality of the Iola limestone. On tracing the typical Iola limestone northward from Iola, where it is a thick, prominent unit, I found that the main upper part of the formation is continuous with the Raytown limestone of Hinds and Greene.[40] The correlation of Raytown with the upper part of typical Iola limestone was confirmed in the field by Doctors R. C. Moore and John L. Rich.

In the Kansas City area the Raytown is underlain by one to three feet of shale containing a black, fissile layer. Above the carbonaceous layer occurs a few inches of argillaceous shale bearing small phosphatic concretions having a diameter of one half inch to one inch or more. Below the shale is a thin blocky bed of bluish-gray dense to lithographic limestone a foot or less thick. This limestone is characterized by abundant laminated *Cryptozoon*-like structures. Through careful tracing it was discovered that the thin blocky limestone is the basal layer of the typical Iola and therefore the black shale is included in the Iola formation. Because the three divisions of the formation have been recognized throughout almost

39. Haworth, E., and Kirk, M. Z., The Neosho river section: Kansas Univ. Quart., vol. 2, p. 109, 1894.

40. Op. cit., p. 27, 1915.

all of the outcrop in eastern Kansas and adjoining parts of Missouri, I propose to name the basal bed Paola limestone, from the town Paola in Miami county, and the middle shale the Muncie Creek, after a stream in southern Wyandotte county east of the town Muncie. As originally defined the Raytown consists of a single massive layer of dark-gray and buff limestone.

The Iola limestone, especially in the Kansas City region, displays in part the cyclic sequence so typical of the Shawnee limestone formations. The blocky, dense limestone at the base has all of the lithologic characters of a "middle" limestone of such formations as Oread or Deer Creek. The black, fissile layer of the Muncie Creek, as in the Oread or Deer Creek, lies upon dense, blue, blocky limestone. The Raytown limestone is similar to those members of the Oread or Deer Creek which overlie black fissile shale. Locally at the top of the Raytown, as for example at Iola, Kansas, there is a layer of algal limestone containing mollusks. Again this feature has its homologue in the Shawnee formations, where the uppermost limestone, as for example the Kereford member of the Oread limestone, contains algal limestone and remains of mollusks.

Lithologic character and thickness. The black, carbonaceous shale of the Muncie Creek member thins out southward from the northeast corner of Johnson county, and a six-inch bed of gray or buff clay containing spherical phosphatic nodules remains, separating the upper limestone from the lower. I have traced the Iola continuously from Wyandotte county to Mildred, Allen county, Kansas, and thence to Iola. Throughout this wide area the thin Muncie Creek clay with black phosphatic concretions occurs about two feet from the base. The Paola limestone below the shale parting is always darker and more dense than the limestone above. It generally weathers as a single massive layer, whereas the limestone above the shale weathers in irregular thin layers.

In Johnson county the Raytown member is composed of fairly even-bedded, rather massive, gray limestone. This member is generally fossiliferous and is characterized by numerous large productids, especially *Echinoconchus semipunctatus* and *Linoproductus spp.* The species *Spirifer dunbari* is usually abundant and robust at this horizon. The upper part of the limestone becomes brown and is broken down into small angular fragments as a result of prolonged weathering. Fresh exposures of the rock show a very fine-grained and "sugary" texture. The Raytown is about five feet thick throughout Johnson county.

The thin Muncie Creek shale separating the upper and lower Iola members is generally buff or gray and argillaceous. Invariably it contains more or less abundant phosphatic concretions which are small (one half to one inch in diameter) and spherical or ellipsoidal. Weathering changes the black color of the concretions to white or light gray, but the interior remains black or dark gray. The shale ranges from about four to eight inches in thickness in Johnson county.

The Paola limestone is composed of a single layer of very dense, dark, bluish-gray limestone. The rock is very brittle and weathers in angular blocks. The upper surface of the bed is highly irregular and pitted, and generally contains openings to iron-stained tubes which extend a short distance into the rock. This layer is always characterized by the coils and stringers of banded calcite which resemble forms of calcareous algae. The Paola is uniformily one and one half feet thick.

In Miami county the Iola is the most distinctive and one of the most easily traced formations. In the northeastern part of the county and as far south as Paola the formation is in no respects different from the Iola in southeastern Johnson county, but south and west of Paola it thickens uniformly. West of Bull creek the recognition of the Iola is made much easier by the great thickening of the Lane shale, giving the Iola limestone and the Wyandotte limestone above a good topographic expression and separating their outcrops more widely. From Osawatomie or Lane, the formation can be traced southward easily to Mildred and Iola, the outcrop lying east of the prominent Wyandotte and Plattsburg escarpments.

In Miami county, as in Johnson county, the formation consists of three parts: (1) an upper, thick, even-bedded unit, the Raytown, composed of more or less fossiliferous, buff or whitish, fine-grained limestone, (2) a thin gray shale, the Muncie Creek, containing phosphatic nodules, and at the bottom (3) a massive even layer of brittle, blocky, dense, and dark-gray or bluish limestone, the Paola. In the northeastern part of the county the Raytown is typically a thick-bedded gray or buff limestone with a thickness of about six feet. Near the middle there generally occurs a zone of large productids, the same as that which has caused the ledge to be called the "large fossil" bed at Kansas City. Toward the south the Raytown becomes more thinly bedded until at Paola the layers are about six inches thick. In the vicinity of Osawatomie and farther south the member becomes even more thinly bedded.

Throughout the northern half of the county the thin Muncie Creek shale with the phosphatic nodules is about five inches thick and the lower blocky Paola limestone measures about one and one half feet. This lower bed has certain characters which are remarkably persistent and easily recognized. Typically the limestone is bluish-gray, and at the top dense, becoming fine-grained in the lower half. The bed is very brittle, commonly weathers light gray, and breaks into angular blocks. The upper portion contains an abundance of the borings of annelids or some other organism. These are irregular tubes about a quarter of an inch or so in diameter and may be as much as six inches long. They are generally hollow and coated with iron stain, and communicate with the upper surface of the bed. This surface has peculiar low rounded irregularties consisting of pits and knobs, which suggest the term "hummocky." Associated with the lithographic texture occur numerous irregular banded "marklets" of calcite. These are possibly the remains of calcareous algae. Southward from Osawatomie the Paola limestone becomes less distinctive, loses the lithographic texture and weathers into thin plates. The color is dark gray and the algae and "worm-borings" are less obvious. The most constant part of the formation is the thin Muncie Creek shale with its phosphatic nodules. The southward increase in thickness of the Iola takes place mainly by thickening of the Raytown limestone. South of the Marais des Cygnes this member becomes whitish, crystalline, and thin bedded. The most abundant fossil is a species of *Marginifera*. North of Marais des Cygnes river the Iola measures from eight to ten feet, but at the west edge of township 16 south, range 23 east it is thirteen feet thick. South of this river the formation is thicker, becoming fourteen and one half feet thick in township 18 south, range 21 east. At Osawatomie and westward a sponge resembling *Heterocoelia beedei* makes its appearance in the base of the Iola and is locally fairly common.

Distribution. The Iola limestone has an extensive outcrop in Miami county. The outcrop enters the southwestern part of the county in sec. 16, T. 19 S., R. 22 E., and extends into township 18 south and range 23 east in the drainage area of Mound creek, thence following the valley of Pottawatomie creek westward a short distance out of the county. On the Marais des Cygnes the formation dips beneath the flood plain southeast of Stanton, but appears in the river channel at the bridge near the county line. On Bull creek and its tributaries the formation crops out to sec. 2, T. 16 S., R. 22

E., and to a point just northeast of Hillsdale. On the Wea creek drainage it extends to a locality just above Somerset. A small reentrant of Iola enters the county along the creek in township 16 south, range 25 east. From the valley of Marais des Cygnes river the outcrop extends eastward from Block across the northern part of township 18 south around the Middle creek and Sugar creek drainage, passing out of the county in sec. 11, T. 18 S., R. 25 E.

In Johnson county the Iola extends as far up Kansas river as the east shore of the mouth of Cedar creek. It is well exposed as an inlier along an anticline far up the valley of Cedar creek to a point a short distance northwest of Olathe. The Iola is well exposed along Mill creek, Turkey creek and along all the principal streams in the eastern part of the county.

Detailed sections. Sections of the Iola are given under numbers 7, 8, 14, 18, 19, 33, 34, 37, 39, 40, 50, 52, 55, 58, 59, 78, 79, 80, 88, 92, 93, 94, 95, 96, 97, 98, 99, 100, 106, 107, 108, 109, 110, 111, 118, 133, 135, 136, 137, 139, 141, 142, 147, 148, 149, 151, 156, and 162 at the end of the report.

LANE SHALE

The thick shale bed lying between the Iola limestone and the so-called †Allen limestone at the town of Lane, Franklin county, was termed the Lane shale by Haworth.[41]

The Lane shale was erroneously supposed by the early workers in northeastern Kansas to occupy that interval between the Iola limestone and the Allen, or lower Garnett limestone above (Plattsburg). Haworth applied the name Lane to 100 feet of sandy shale between two prominent limestones near the town of Lane. The lower limestone, near flood-plain level, I have found was correctly identified by Haworth as Iola. The upper limestone, capping the scarp at Lane, is not, however, the Allen (Plattsburg limestone) as Haworth thought, but is a third limestone lying between the Iola and Plattsburg. This limestone, the Wyandotte of this report, although very prominent around Lane and northward to Kansas City and beyond, pinches out near Greeley in northeastern Anderson county. It is clear from the writings of the early workers that only two limestone formations were recognized in the section immediately succeeding the Lane shale, whereas there are three in northeastern Kansas.

The shale formation at Iola that is generally called Lane includes

41. Haworth, E., The stratigraphy of the Kansas Coal Measures: Kansas Univ. Quart., vol. 3, p. 277, 1895.

strata between the Iola and Plattsburg limestones and comprises equivalents of the type Lane shale, Wyandotte limestone, and Bonner Springs shale of this report. Adams[42] once applied the geographic name Concreto, from a locality in the outskirts of Iola, to this shale. This name is not synonymous with Lane, as has been supposed by other writers, and may properly be used for beds between the top of the Iola and the base of the Plattsburg. It seems preferable, however, to indicate the combined Lane and Bonner Springs shales by the hyphenated term Lane-Bonner Springs shale, thus avoiding the necessity of using a geographic name that gives no indication of its stratigraphic relation to correlative units. Furthermore, if the practice is adopted of using a different name for every combination of shale units that is encountered through local disappearance of limestones, an almost endless number of new names with only local application would be required.

The shale bed at Kansas City, called the upper Chanute shale by Hinds and Greene,[43] is the exact equivalent of the Lane shale.

Lithologic character and thickness. The Lane shale undergoes considerable change in thickness and character from the east to the west half of Miami county. In the eastern part of the county the formation is a gray or buff argillaceous shale about twenty feet in thickness. Westward, across almost the mid-line of the county, the shale increases to about five times this thickness and assumes a dominantly arenaceous character. The thick sandy shale contains carbonaceous streaks, which, however, are not distinct coal beds. At Paola the formation is a little less than 100 feet thick, but a mile east of town at the SE cor. of sec. 10, it has decreased to thirty-three feet. In many exposures of the formation near the southeast corner of township 17 south, range 23 east, the thickness is twenty feet and reaches the minimum of 16 feet at the NE cor. sec. 2, T. 18 S., R. 23 E. On the other hand, the increase westward from Paola is not so abrupt. The formation measures 105 feet a mile west of Paola, about one fourth of a mile west of the NE cor. sec. 19, T. 17 S., R. 23 E., and does not vary as much as ten feet from this thickness at any observed exposure in the southwestern part of the county. A line drawn from the west edge of Paola north across the county seems to approximate the 100-foot thickness contour, the formation measuring more than this to the west of the line and less to the east of it. At Paola the unit is argillaceous and is used for making

42. Adams, G. I., Economic geology of the Iola quadrangle, Kansas: U. S. Geol. Survey, Bull. 238, p. 20, 1904

43. Op. cit., 407 pp., 1915.

brick. To the west the formation is more arenaceous, especially in the vicinity of Stanton, where the upper part of the formation has many thin layers of soft, buff sandstone. At the top there is generally a zone of sandy, argillaceous, gray shale containing thin flakes of limy, ferruginous shale, giving a peculiar banded effect, the gray being broken by thin knife-edges of brown. Where the Lane shale is thin it has no special characteristics other than the homogeneity of the clay shale and the gray or buff color. Seldom is the shale arenaceous where it is less than thirty feet thick.

In Johnson county the Lane consists of uniform argillaceous, bluish-gray and buff shales more arenaceous toward the south. This formation, which has yielded such a prolific fauna of crinoids at Kansas City, is seemingly barren of invertebrates in Johnson county. Toward the southern part of the county a small amount of fragmental plant material occurs in the Lane. The formation is somewhat irregular in thickness, ranging from seventeen feet in township 14 south, range 24 east to over forty feet in the central and northeastern parts of the county.

Distribution. In the western part of Miami county, where the formation is thick, the band of outcrop is fairly broad, being two or three miles in places, terminating in a high and pronounced eastward-facing escarpment capped by the Wyandotte limestone. In the southwest corner of the county the formation enters on the divide between Pottawatomie creek and Mound creek. Also a small tongue of the outcrop extends into the county between Pottawatomie creek and Marais des Cygnes river. North of the Marais des Cygnes the outcrop enters the county west of Stanton, follows the valley to Paola and extends up the valley of Bull creek almost to the northwest corner of the county and to the western edge of township 15 south, range 24 east. On the Wea and its tributaries the outcrop reaches to the northeast corner of township 16 south, range 24 east, and to a point southeast of Louisburg, extending well up all but the smallest streams. The outcrop follows a sinuous course across the southern part of township 17 south, ranges 24 and 25 east, and then bends northward, following the state line to the northeast corner of the county and leaving the county nearly precisely at the corner.

The Lane shale has a wide outcrop in Johnson county. It extends up the valley of Kansas river nearly to Cedar Junction, dipping below the flood plain at the west side of the valley of Cedar creek. There is a small inlier of the Lane a short distance above the mouth

of Kill creek, exposed by a structural "high." The Lane extends up Mill creek to the northeast part of township 13 south, range 23 E, and enters the county again along Turkey creek. The formation is exposed along all of the principal tributaries in the eastern part of the county.

Detailed sections. Sections of the Lane shale are given under localities 14, 16, 18, 19, 33, 34, 37, 42, 77, 84, 87, 88, 95, 98, 102, 104, 110, 112, 119, 135, 137, 138, 141, 142, 143, 144, 145, 146, 147, 148, 151, 164.

WYANDOTTE LIMESTONE

As a result of the miscorrelation by the early Kansas Survey of the Iola limestone with certain beds exposed in the bluffs at Kansas City, several of the adjacent units, both below and above; were also miscorrelated. The shaly beds and limestones between the so-called Drum limestone at Kansas City and the prominent limestone above, thought to be Iola, were classed as Chanute shale regardless of the complete lack of lithologic similarity between these beds and the typical Chanute shale of southeastern Kansas. Because the Lane shale was supposed to lie between the Iola and Plattsburg limestones, all strata lying between the so-called Iola and Plattsburg limestones at Kansas City were classed as Lane shale.

For some reason, not now apparent, the pioneer geologists in attempting to trace and map the Iola limestone northward toward Kansas City from the type locality were confused in the neighborhood of Osawatomie and Paola in Miami county and changed from the typical Iola to the next higher limestone. This confusion which led to mistaking a younger limestone with the true Iola occurred at about the place where the Iola and Lane thin appreciably. The topographic expression of these units northward from central Miami county is less prominent than to the southward. Northward the limestone overlying the Lane shale splits into four limestones separated by thin shales across Johnson and Wyandotte counties and into Missouri. The lower two limestones and included shale, locally missing, were classed by Kansas and Missouri geologists as Iola limestone. The upper two limestones and included shale bed, likewise locally absent, were called Farley limestone by Hinds and Greene[44] from a hamlet in Platte county, Missouri. These limestones were thought to lie within the Lane shale because of their place between the "Iola" and the Plattsburg.

44. Op. cit., p. 29, 1915.

It seems consistent to regard these closely associated limestones in the section between the Iola and Plattsburg limestones as a formational unit correlative with Drum, Iola, Plattsburg, Stanton, etc. There are two reasons why such a procedure seems logical. In the first place the limestone is an indivisible unit across Miami and Franklin counties. There are no shale partings, nor is there other basis, either lithologic or faunal, for a recognition of subdivisions. Secondly, in the area northeast of Miami county where the shale beds appear the limestone divisions exhibit the curious succession shown by many of the other limestone formations in the Missouri series. At the base there is a thin, blocky, bluish-gray limestone similar to the basal member of the Swope, Dennis, Iola, or Stanton limestone formations. Next is a thin shale which is locally carbonaceous at the base, corresponding to the second member, carbonaceous shale, of the Swope, Dennis, Iola, and Stanton formations. Thirdly, ascending in the column, there is a relatively thick, twenty to thirty feet, unit of thin-bedded, wavy, and cherty limestone similar to that of the main limestone member of the Swope, Dennis, Iola, and Stanton limestones. The upper limestone, commonly in two parts and separated from those below by shale, is like the upper limestone layers of the aforementioned limestone formations in being locally oölitic and at such places bearing a molluscan fauna. Because no other name has been suggested for the limestone formation in the interval between the Iola and Plattsburg limestones, I propose to apply to it the name Wyandotte, from the county of that name in northeastern Kansas. The five subdivisions, three of limestone and two of shale, are recognizable throughout northeastern Kansas north of Miami county and far into northwestern Missouri.

The lower blocky limestone, one to three feet thick, is called the Frisbie limestone, from Frisbie, Johnson county, Kansas. It is exposed at the middle of the north side of sec. 17, T. 12 S., R. 23 E. This unit is recognizable farther into northwest Missouri[45] and farther southward into Miami county, Kansas, than any other member of the Wyandotte formation. The next unit above the Frisbie, a thin argillaceous, limy, or carbonaceous shale is called the Quindaro shale, from a political township in Wyandotte county, Kansas. It is typically shown in the floor of Boyn's quarry, near the northwest cor. sec. 30, T. 10 S., R. 25 E. The next member constitutes the main part of the so-called "Iola" limestone of Missouri and northeast Kansas. This limestone, twenty to thirty

45. Hinds, Henry, and Greene, F. C., Op. cit., p. 119, 1915.

feet thick, is named the Argentine limestone, from Argentine railway station, Kansas City, Kan. An exposure in a quarry south of Twenty-sixth and Metropolitan avenue may be considered the type exposure. The shale above the Argentine limestone is commonly less than eight or ten feet thick and is argillaceous or limy. It receives its name from Island creek in northern Wyandotte county. The member is typically exposed west and south of Wolcott. The upper member, with a thin included shale, was named Farley limestone by Hinds and Greene,[46] the name being derived from a hamlet in Platte county, Missouri. Southward from Johnson county the Farley limestone coalesces with the Argentine limestone to form an indivisible unit, which finally disappears near Greeley, in Anderson county.

In the vicinity of Stanton in western Miami county the Wyandotte limestone contains the brachiopod *Enteletes,* and southward beyond Lane this fossil is abundant in the formation. Apparently this brachiopod did not live in the Argentine sea farther north than the Stanton region, but it occurs sparingly in the Farley limestone in Johnson county. The top of the Argentine limestone ("Iola") was selected by Hinds and Greene[47] as the upper limit of the original Kansas City formation. It was claimed that the beds above and below this boundary were lithologically and faunally distinct. The brachiopod genus *Enteletes* was supposed to be specially diagnostic of horizons above the Argentine and had never been cited from lower beds in Kansas or Missouri. *Enteletes* is common in the Wyandotte beds from bottom to top in Miami and Franklin counties, but does not occur farther north except for the rare occurrence in the Farley limestone, mentioned above. Because the upper limit of the Argentine limestone can not be distinguished in Miami county and southward, where the Argentine and Farley come together, there is no lithologic basis for recognition of the boundary of the original Kansas City and Lansing formations.

Lithologic character and thickness. The Wyandotte limestone is generally quite easily identified in Miami county, but it is in some respects highly irregular. Commonly the formation is composed of light-gray or whitish, wavy and thin-bedded limestone, fine-grained and brittle. Locally the formation is very cherty, crystalline, and may have a blocky oölitic or *Osagia* limestone layer at the base. In the central part of Miami county and near the middle

46. Op. cit., p. 29, 1915.
47. Op. cit., p. 7, 1915.

of the western boundary the formation is ferruginous near the middle and weathers in thin, platy fragments. At many localities it is stained buff or brown by the ferruginous partings at the bedding planes. In township 15 south, ranges 23, 24, and 25 east a thin shale parting occurs locally above the middle, probably a southward continuation of the Island Creek shale from Johnson county. South of Louisburg the formation has a basal layer of fine-grained bluish limestone, the Frisbie, separated from the main ledge by a few feet of limy shale. The shale at this place contains a small fauna of sponges. In the eastern part of the county the formation is generally very cherty, and it is interesting to note that in this same area the Plattsburg limestone is also cherty. Throughout the remainder of the outcrop of the Wyandotte in the county it has only a small amount of chert in the form of nodules. In township 17 south, ranges 21, 22 east the formation simulates the Plattsburg in having a basal oölitic bed. This lower bed, however, unlike the lower part of the Plattsburg, rarely contains fossils of any kind, and the remainder of the formation is distinctive. In the southwest corner of the county the formation thickens and becomes more evenly bedded and massive.

Of great interest are certain faunal characteristics of the Wyandotte in Miami county. Fusulinids, which are rare or absent from the formation in Johnson county, and entirely lacking in Wyandotte and in Jackson county, Missouri, make their appearance in considerable abundance in the northeastern part of Miami county. The guide fossils *Enteletes hemiplicatus* var. *plattsburgensis* and *E. pugnoides*[48] make their appearance in the formation just west of Paola and a short distance north of Stanton. Toward the southwest part of the county *Enteletes hemiplicatus* var. *plattsburgensis* becomes abundant and is the most common fossil in the Wyandotte at Lane, in Franklin county. It is rather remarkable that elsewhere in the county the species is unknown below the Plattsburg limestone, although a careful search was made for it. The single known occurrence of *Enteletes hemiplicatus* var. *plattsburgensis* from the Farely limestone in the northeast part of Johnson county is of interest in this connection.

In Miami county the Wyandotte formation ranges in thickness from about twelve feet to over thirty feet. At localities in township 15 south, range 22 east, and township 17 south, range 22 east a minimum thickness of twelve feet occurs. In general, the forma-

48. Newell, N. D., New Schizophoriidae and a trilobite from the Kansas Pennsylvanian: Jour. Paleontology, vol. 5, pp. 260-269, 1931.

tion is not greater than fifteen feet thick throughout the northwest part of the county. In township 15 south, range 23 east the formation thickens to the eastward and a thin shale parting divides the limestone in two parts. This is the southward continuation of the Island Creek shale that occupies a place in the formation to the north. The scarcity of good exposures in this part of the county prevents locating accurately the most southern extension of the shale. The wedging out of the shale, however, takes place three or four miles north of Louisburg, since the member is gone at that town and occurs at the south edge of township 15 south, range 25 east. In the last-mentioned area the upper part of the Wyandotte, the Farley member, is fifteen feet thick, thin-bedded, and composed of whitish and buff limestone. At the base of the Farley there is a thin stratum of oölitic limestone, beneath which lies five inches of argillaceous shale. The upper layer of the Argentine is also oölitic, while the remainder of the member is even, heavy-bedded, and cherty. In the northeast part of the county, north of Louisburg the Wyandotte ranges from twenty to thirty feet in thickness, thinning toward the south so that south of Louisburg the limestone is generally a little less than twenty feet thick.

In Johnson county the Frisbie limestone occurs at the base of the Wyandotte formation as a single layer of fine-grained, bluish-gray even limestone. It ranges in thickness between about one and five feet, but is generally about two feet thick. Fine exposures of this member may be seen at the localities described at the end of the report under sections 16, 19, 21, and 53.

Above the Frisbie in Johnson county occurs a thin layer of greenish, argillaceous, or buff, calcareous shale, the Quindaro. Locally, as at the exposures on Cedar creek west of Olathe, there occurs a thin layer of carbonaceous shale at the base of the Quindaro. Generally the shale ranges between one and six feet in thickness.

The Argentine limestone member is somewhat irregular in thickness and lithologic character in Johnson county. In the northern part, along Kansas river, Cedar creek, and Mill creek, the member is composed of whitish, hard, cherty and thin-bedded limestone, except at the top where it is commonly rather massive. In weathered exposures the lower portion has a tendency to be worn back farther than the upper ledge, the latter locally making bold benches and steep rocky bluffs. The upper layer of the Argentine is generally oölitic or granular, and bears a molluscan fauna. In places this

bed contains an abundance of *Myalina ampla*. Silicified specimens of *Fistulipora* sp. locally occur associated with *Myalina*. The bedding of the members is characteristically wavy and irregular.

The overlying Farley limestone might in many places be easily mistaken for the Argentine. The two members are separated by the Island Creek shale ranging from a foot to fifteen feet in thickness, which thins gradually toward the south and southwest. In the southwest part of the county, where the Argentine and Farley limestones are indistinguishable, the entire interval of limestone is cherty, thin-bedded, and wavy, composed of white, hard limestone, which is generally stained yellowish-brown by numerous thin, ferruginous shaly partings.

In the southeast part of Johnson county the lower massive Frisbie commonly is not separated from the Argentine by a shale parting, and is not as distinctive as it is elsewhere. The Farley limestone is only locally cherty, and is generally more abundantly veined and crystalline than the Argentine. Ordinarily it is thinner than the latter and displays a fragmental or pseudobrecciated appearance. The most positive identification of these two units, as a rule, is based on a recognition of the local stratigraphic sequence. The beds above and below these two limestones can usually be recognized easily.

In the northern and central parts of the county, the Argentine generally has a thickness of twenty-five to twenty-eight feet. In township 14 south, range 25 east it is quite thick, measuring over thirty-five feet in several places along Big Blue river. In this area the Argentine and Farley limestones, separated by a thin shale, make an unusually thick limestone section, measuring as much as sixty feet. In the southwest part of the county the single unit composed of the combined limestone members of the Wyandotte is little more than twenty feet thick.

The Island Creek member throughout Johnson county is quite thin, and uniform in its characters. The shale is generally argillaceous where thickest and is bluish-gray or buff. Where it is thin it is fossiliferous, and in many localities limy. The member ranges in thickness from six to fifteen feet in the northeastern part of the county, and thins to little over a foot toward the south. In the exposures along the upper part of Kill creek and Cedar creek, the unit is generally about two feet thick. It is noteworthy that locally this member contains great numbers of well-preserved fenestrated bryozoans and other invertebrates.

The characters of the Farley limestone are constant over most of the county. The member is, however, irregular in township 12 south, range 23, 24, and 25 east, where it consists of two thin, massive beds of limestone and a thin bed of shale, and in the vicinity of De Soto where variable cross-bedded, irregular limestones make up a considerable part of the member.

In the northeastern part of the county the Farley consists of three beds, two of limestone and one of shale. The lower of these is a massive, bluish-gray limestone, which commonly weathers buff. At the center of sec. 7, T. 12 S., R. 24 E., the thickness is about six feet. The bed is five feet thick at at the NW cor, sec. 10, T. 12 S., R. 24 E., and is suboölitic. This represents an intermediate stage between the oölitic facies found in Wyandotte county and the nonoölitic condition characteristic of the bed in Johnson county. At the west side of sec. 17, T. 12 S., R. 24 E., the lower Farley consists of a two-foot bed of massive, dark, brittle limestone.

The middle of the three beds of the Farley in the northeastern part of the county consists of variable shale. At the center of sec. 7, T. 12 S., R. 24 E., the shale has a thickness of four feet, and is argillaceous. The bed at the NW cor. sec. 10, T. 12 S., R. 24 E., consists of greenish-buff, arenaceous and micaceous shale, with a layer of limonite concretions near the middle. Here the bed is ten feet thick. At a locality on Little Mill creek the shale has the same thickness, but peculiarly contains a thin streak of maroon shale near the middle, overlain by a thin marly layer which in turn is overlain by greenish, argillaceous shale. The occurrence in a small area of the sequence in ascending order of green clay, maroon clay, "marlite," and green clay, so persistent at other horizons, is unusual. To the west the middle Farley thins and finally disappears near the middle of township 12 south, range 23 east.

The upper Farley in the northeast corner of the county is a massive bed of dark-gray limestone, usually brittle, and weathers into thin, irregular plates. The bed has a considerable range in thickness over a distance of a few miles. A short distance southeast of Holliday it has a thickness of nearly ten feet. To the east and north of this locality, into Wyandotte county, the upper Farley thins and becomes uniform in thickness. Northwest of Shawnee it is two feet thick. At the west edge of sec. 17, T. 12 S., R. 24 E., the bed contains *Enteletes hemiplicatus* var. *plattsburgensis*. This is the lowest known occurrence of this fossil in Johnson county.

The Farley limestone underlies layers of limestone conglomerate

and shell breccia in the vicinity of De Soto. It is probable that the conglomerate was derived by the erosion of the upper surface of the Farley bed to the north of Kansas river in the vicinity of Loring, and at De Soto west of Kill creek, since there is evidence of a **post-Farley pre-Plattsburg unconformity** at these places. The breccia and conglomerate are younger than the Farley.

At the quarry near Loring on the north bank of Kansas river the Bonner Springs shale is one foot thick. At De Soto and at a point a mile west of Bonner Springs at the county line, the Plattsburg limestone directly overlies thinly cross-bedded, oölitic and coquina-like limestone. Directly beneath this lies the Farley limestone. A line drawn on a map from the cement plant at Bonner Springs through Wilder, following the south and east bluff of the valley of Kansas river to the mouth of Kill creek, follows a course of moderate variation in thickness of the Bonner Springs shale. Along this line the Bonner Springs is thick, ranging from twenty-five to over thirty-five feet. The course of the river from Bonner Springs to Cedar Junction is at right angles to the direction of convergence of the Farley and Plattsburg limestones. It has been shown by Jewett and Newell [49] that the peculiar course of Kansas river at this place is accordant with anomalies in the structure of the underlying rocks.

It seems probable that during Bonner Springs time slight warping with considerable vertical movement occurred in the area of De Soto, Lenape, and Bonner Springs, slightly to the west of the present course of the river. The amount of uplift was sufficient at least to bring the sea floor locally above wave base and permit the removal of the Bonner Springs shale, if it were ever deposited, and production of shallow water or shoal gravels, contemporaneously with deposition of part of the Bonner Springs shale. By Plattsburg time deposition was once more continuous across the anticline.

Over the greater part of the area in which the Farley limestone crops out, including (1) the area covered by the headwaters of Kill creek and Cedar creek, (2) an area in township 13 south, ranges 22, 23 east, (3) that area drained by the upper half of Mill creek, and (4) the southern half of the county, the member consists of a single limestone bed with no included shale. In lithologic character and locally in thickness the Farley resembles closely the Argentine limestone. Generally the former is thinner, less cherty, more regu-

49. Jewett, J. M., and Newell, N. D., The geology of Wyandotte county, Kansas: This bulletin, p. 151.

larly bedded, less fossiliferous, and darker in color than the latter. The Farley commonly displays a fragmental or pseudo-brecciated character, together with an abundance of veinlets of dark calcite. Generally the layers are wavy, but have a fairly uniform thickness at any single exposure of the member. In general, however, the best method of distinguishing the Farley rests upon the recognition of the beds above and below it. At the fine exposures along Cedar creek, on the highway west of Olathe, the Farley is about twenty feet in thickness, and in the southeast part of the county it measures about the same. The great thickness of limestone in the latter area is largely produced by a local thickening of the Argentine. West of Spring Hill the Farley cannot be differentiated from the lower members of the Wyandotte, the divisions occurring as a single limestone unit with a thickness not greater than twenty-five feet.

Distribution. The Wyandotte limestone crops out widely in Miami county. In township 17 south, ranges 24 and 25 east, the formation occupies much of the high stream divides and is generally exposed along the tributaries in the northeast part of the county. The formation extends out of the county along all of the principal streams in the northern part of the county and occurs along the valley of Bull creek as far as Paola and up the valley of Marais des Cygnes beyond the county line. In the southwest part of the county the formation enters just east of the corner, extends around the head drainage of Mound creek and continues out of the county along Pottawatomie creek to the west. The outcrop of the Wyandotte limestone in Johnson county extends up the valley of Kansas river to De Soto. The formation outcrops far up Kill and Cedar creeks, and extends up Mill creek nearly to Olathe, and occurs in the river bluff as far east as Rosedale with a reëntrant on Turkey creek extending beyond Merriam. In the eastern part of Johnson county the Wyandotte extends a considerable distance up all of the larger streams, and forms a marked bench in the valley walls. In the southwestern part it extends a short distance into the county along the major tributaries.

Detailed sections. For sections of the Wyandotte see numbers 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 21, 22, 24, 27, 29, 30, 31, 33, 34, 36, 37, 42, 46, 47, 49, 51, 53, 56, 62, 69, 71, 75, 77, 82, 83, 84, 85, 87, 88, 90, 91, 95, 102, 104, 110, 112, 113, 114, 119, 135, 137, 138, 139, 142, 143, 144, 145, 146, 147, 148, 151, 163, 164, 165 at the end of this report.

BONNER SPRINGS SHALE

The term Bonner Springs is here applied to the shale between the Farley and the Plattsburg limestones, generally referred to erroneously as the upper Lane shale. The name is derived from a town in Wyandotte county, and is typically exposed at the cement plant northeast of the town. Under the discussion of the Lane it was shown that the Lane shale is an older formation than the unit here called Bonner Springs.

Lithologic character and thickness. Although the Bonner Springs shale is rather irregular in its characters, usually it may be recognized easily. In Miami county a soft, buff sandstone layer ranging from five to ten feet or so in thickness generally occurs at the base. Locally, as at the NE corner of sec. 13, T. 17 S., R. 21 E., and at the SE corner of sec. 19, T. 15 S., R. 23 E., the sandstone is replaced by greenish and argillaceous shale; or, as at the SE corner of sec. 22, T. 15 S., R. 22 E., it is partly replaced by arenaceous shale. Above the arenaceous division there is commonly a bed of olive-green, argillaceous shale, ranging in thickness from approximately four to ten feet. This is succeeded, except south of township 18 south, by a thin layer of maroon clay, generally about a foot thick, but ranging from six inches to sixteen feet, the latter thickness being measured in the SE cor. of sec. 19, T. 15 S., R. 23 E. As a rule the maroon layer is not thicker than one and one half feet. This maroon shale is an extremely important key horizon if it is not confused with similar shales in formations lower in the section. Although the maroon layer is locally lacking, it is extraordinarily persistent from northwestern Missouri to the south boundary of township 18 south in Miami county. The southernmost known occurrence of the maroon layer of the Bonner Springs is one quarter of a mile north of the SW corner of sec. 32, T. 18 S., R. 22 E. Above the maroon bed there is commonly a thin layer of argillaceous nodular limestone or limy shale, generally stained ocher-yellow or greenish. For convenience this highly characteristic rock is called "marlite." The marlite is generally overlain by a six-foot layer of greenish argillaceous shale which locally contains small irregular limestone nodules. At a few places this bed is arenaceous and buff or gray.

The Bonner Springs is highly irregular in thickness in Miami county, ranging from five and one half to thirty-two feet. In Johnson county the formation is fairly uniform in lithologic character, but somewhat irregular in thickness.

Certain peculiarities make the Bonner Springs shale easily recognizable, except locally, wherever it crops out in the county. Although the different parts of the shale are somewhat irregular, the sequence of the parts is practically the same from place to place over a large area in Johnson county, being about the same as in Miami county. The lower half of the formation is generally buff, or greenish-buff, micaceous sandstone or arenaceeous shale. This part frequently contains plant fossils, but no marine shells, and ranges in thickness from five to fifteen feet. The upper part of this portion of the Bonner Springs grades into a more argillaceous, greenish shale which is overlain generally by a thin layer of maroon, argillaceous shale. The latter layer is in most places less than two feet thick. Locally the maroon shale may be absent. Above it is an almost equally persistent layer of marly, ocher or brown, nodular and often spongy limestone. Frequently this "marlite" has a tinge of green. Above the marlite layer generally occurs a bed of olive-green, highly argillaceous shale which ranges up to five feet in thickness. Occasionally this is overlain by a thin layer of limy and arenaceous buff or gray shale. The formation averages about 25 feet in thickness, but locally ranges from 0 to 45 feet. The greatest variation occurs in township 12 south, ranges 22 and 23 east, and in township 13 south, ranges 22 and 23 east. In township 14 south, range 24 east, the formation is quite thick, measuring about forty-five feet. In township 15 south, range 23 east the formation is only thirteen feet thick, while in township 15 south, range 22 east it approximates twenty-five feet. Locally in township 12 south, range 22 east the formation is missing, having been eroded before deposition of the Plattsburg.

At De Soto, exposed along the railroad tracks, the Plattsburg unconformably overlies the Wyandotte limestone, the Bonner Springs being entirely missing. A similar situation occurs a half mile west of Bonner Springs. At both localities there occurs a thin, cross-bedded, granular limestone between limestone of characteristic Farley lithology and the characteristic Merriam member of the Plattsburg.

The key to the difficult stratigraphy of the De Soto region seems to lie in the section at Penner's ford at the east bluff of Kill creek, 0.6 mile west of the NE corner of sec. 4, T. 13 S., R. 22 E. At this locality it is easily demonstrated that the sponge fauna of the De

Soto region occurs in the Merriam member of the Plattsburg. The Merriam limestone is underlain by a five-foot bed of limestone and shell breccia containing a prolific and characteristic pelecypod fauna. At several localities in the De Soto region the Merriam is underlain by this shell breccia. The latter is also well developed at the exposure on the highway one half mile west of Bonner Springs.

Much confusion in identification of beds is introduced by the local thickening of the Hickory Creek shale member of the Plattsburg limestone from the characteristic thicknesss of a foot or so to twenty feet, as at the Kill creek bridge one half mile east of De Soto, on the highway. At the same locality the shale portion of the Bonner Springs is lacking, either from erosion or nondeposition, and the breccia bed of the Bonner Springs lies directly on the Farley.

Along the tracks at De Soto the Hickory Creek shale attains its common thickness of a few inches, and as at the above localities there is no shale in the Bonner Springs. The limestone exposure along the tracks at De Soto includes the Farley and Plattsburg, with the Argentine and Island Creek just below the level of the railroad. The section above the Plattsburg is normal.

Apparently the breccia in the Bonner Springs represents material, perhaps shoal gravels, derived from limestone older than the Bonner Springs formation. The absence locally of the Bonner Springs shale may have been caused either by nondeposition or by erosion.

At the large railroad quarry between Lenape and Loring, northeast of De Soto, the Bonner Springs shale is very thin and apparently contains no limestone.

Distribution. The Bonner Springs shale has a wide distribution in both Miami and Johnson counties. This can best be appreciated by reference to the areal maps. In Miami county the formation crops out along all of the principal streams in the western half and the northern half of the county. Exposures of the Bonner Springs shale may be found in Johnson county along Kansas river and its tributaries below De Soto and on the streams in the eastern part and southern part of the county.

Detailed sections. For sections of the Bonner Springs shale see localities 2, 3, 4, 5, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 29, 31, 35, 42, 47, 49, 53, 54, 56, 60, 62, 69, 70, 72, 74, 75, 77, 82, 83, 84, 85, 86, 88, 90, 91, 102, 103, 105, 113, 114, 115, 148, 165.

Lansing Group

The term Lansing was introduced by Hinds[50] for strata between the top of the Argentine limestone of the present report and the top of the Stanton formation.

The boundary between the Kansas City and Lansing divisions as originally defined cannot be recognized in Kansas south of Johnson county. In northeastern Johnson and south-central Wyandotte counties the middle shale of the Farley wedges out so that the Farley limesotne becomes a single unit to the southward. The Island Creek shale below the Farley limestone thins southward across Johnson county, eventually wedging out completely in northern Miami county. Where the Farley coalesces with the "Iola," or Argentine limestone of this report, the old boundary between the Kansas City and Lansing groups cannot be recognized, either lithologically or faunally. The single limestone, Wyandotte, formed by the union of the Argentine and Farley members changes to shale in Anderson county, to reappear no more to the south.

On the evidence here presented, Moore[51] proposes to redefine the term Lansing to include only the Plattsburg, Vilas, and Stanton formations. This usage corresponds to the old Garnett limestone of the early Kansas Survey. The revival of Garnett might not be desirable, however, inasmuch as the term has been used for several different units and has never had wide acceptance.

The grouping of the persistent and relatively uniform Plattsburg and Stanton formations sets them off from the less regular and generally less persistent units of the Kansas City group below.

PLATTSBURG LIMESTONE

The Plattsburg formation was named by Broadhead[52] in 1862. The type locality is Plattsburg, Clinton county, Missouri. The early Kansas Survey, upon the advice of Bennett, correctly correlated the so-called lower Garnett limestone or Allen limestone with the previously named Plattsburg limestone of Missouri, but for some reason did not adopt Broadhead's term. The correlation was made by Bennett[53] from field studies in Leavenworth, Johnson, Wyandotte, and Miami counties.

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50. Hinds, Henry, Coal deposits of Missouri: Missouri Bur. Geol. and Mines, vol. 2, 2d ser., p. 7, 1912.

51. Moore, R. C., Kansas Geol. Soc., Guidebook 6th Annual Field Conference, pp. 92, 93, 1932.

52. Broadhead, G. C., Coal measures in Missouri: St. Louis Acad. Sci., Trans., vol. 2, pp. 317-327, 1868 (read May 5, 1862).

53. Bennett, John, Kansas Univ. Geol. Survey, vol. 1, p. 71, 1896.

The Plattsburg limestone is strikingly constant in its characters over a wide area in northeastern Kansas and adjacent parts of Missouri. Fossil zones occur at the same relative position in the formation, associated in each case with distinctive lithologic divisions.

The Plattsburg is readily divisible into three parts, a basal, thin, blocky limestone, a thin shale parting, and a relatively thick upper limestone. The lower member is here termed the Merriam limestone, from exposures at the town Merriam, in Johnson county. The middle shale is termed Hickory Creek, from a stream near Peoria in Franklin county. The upper and principal member is named from exposures at the town Spring Hill in southern Johnson county.

Lithologic character and thickness. The Plattsburg limestone is one of the most distinctive formations in the Missouri series. Through most of northwestern Missouri and northeastern Kansas the unit retains its characters with but little variation in lithologic character. The formation displays locally, however, a considerable range in thickness.

At the base is the Merriam member, which is perhaps the most characteristic part of the Plattsburg. Locally the member might be confused with the Paola limestone at the base of the Iola. Where the Plattsburg has undergone considerable weathering, as on hilltops, the lower member is frequently the only recognizable part of the formation.

The Merriam limestone consists in many places of two distinct divisions. The lower of these is a blocky, even layer, less commonly cross-bedded limestone, drab to light gray in color, which generally weathers gray to white. This division is often highly fossiliferous, in which case species of the Productidae are abundant. The small ellipsoidal alga *Osagia* is always present in sufficient quantities to constitute an appreciable part of the limestone. The large pelecypod *Myalina ampla* is characteristic and usually well-preserved as internal molds. A zone of *Composita* sp. in many localities occurs at the base. Locally the bed is oölitic. In some cases this lower layer is absent, especially in southern Miami county. This part of the Merriam ranges from a few inches to five feet or more in thickness, but it is commonly about eighteen inches thick. Locally in northeastern Johnson county the bed makes very good dimension stone.

The next stratum of the Merriam, in ascending order, is quite distinct from that described above. This limestone is fine-grained

to dense, gray, massive, blocky, and occurs in one layer. It is seldom very fossiliferous, but typically contains in the upper part numerous, irregularly-disposed, hollow tubes. These tubes are cylindrical, have a diameter of a fourth of an inch and a length of two to four inches or more. To some extent they seem to be vertically directed, and in some cases open at the upper surface. Generally the walls of the tubes are stained yellowish-brown, and the tubes themselves are frequently filled with ferruginous clay. This layer closely resembles the Paola limestone, but is less dense, lighter in color, and seems to lack the profuse development of *Cryptozoan*-like structures so typical of the former. The upper bed of the Merriam is generally about a foot thick. In its physical characters the upper blocky, dense layer of the Merriam resembles a typical "middle" limestone of the limestone cycle in the Kansas Pennsylvanian, homologous to such beds as the middle Oread, Leavenworth member. Like the Leavenworth the Merriam underlies, at least locally, black fissile shale.

The upper and lower members of the Plattsburg are separated by a foot or so of shale, the Hickory Creek, which only locally is absent. In the northern part of Johnson county, and in Wyandotte county, the shale contains a black carbonaceous layer, but to the south it becomes gray or yellowish and argillaceous. In some instances, as at the south edge of sec. 29, T. 13 S., R. 23 E., the shale is overlain and underlain by a peculiar ochery, shaly limestone or calcareous shale. In such case, for convenience, the yellowish shaly layer is considered as the division between the upper and lower Plattsburg.

The upper limestone, or Spring Hill member, seems to be just as well differentiated into lithologic and faunal zones as the Merriam, but is seldom as accessible to study. The lower part of the member in most of Johnson county consists of thin-bedded and even, bluish-gray, brittle and fine-grained limestone. In fresh exposures this limestone locally is massive, and the bedding planes are marked by narrow carbonaceous streaks. This bed contains a zone of *Enteletes hemiplicatus* var. *plattsburgensis*, and in many places the brachiopod *Marginifera wabashensis* is quite abundant. This division of the Spring Hill averages about five feet in Johnson county, but is rarely over a foot or so thick in Miami county. A bed of oölitic limestone commonly occurs above it. The oölite is thickest in the southern part of Johnson county and is of variable thickness, but is generally about two feet. The upper part of the member is very massive, and

is granular, drab, argillaceous, occasionally dove-colored, and commonly contains a large quantity of fragmental fossil material. The limestone contains an abundance of the spines of *Echinocrinus* spp. and a zone of *Composita* sp. in which is found a particularly large and robust variety. Locally and more particularly toward the southern part of Johnson county, a layer of dark-gray, granular limestone overlies the *Composita* zone. The thickness of the limestone above the oölitic stratum is about five feet.

It is clear that the Spring Hill member is a composite unit in terms of the limestone cycle. The lower half or less consists of even, gray limestone containing brachiopods and bryozoans. This part is lithologically like an "upper" limestone of the cycle, and like homologous units overlies, at least locally, black fissile shale. The remainder of the Spring Hill is oölitic or granular and contains a large molluscan element. Obviously this division is by position, lithologic character, and faunal content a typical "super" limestone of the limestone cycle. Like other limestone formations in the Missouri series, a "lower" limestone of the cycle appears to be lacking.

The thickness of the Plattsburg limestone has a considerable range in both Johnson and Miami counties. In this respect it is more irregular than might be expected. The greatest thickness occurs in the vicinity of De Soto, where the formation is twenty-eight feet thick. Here it resembles the exposure of the Plattsburg at the Loring quarry in Leavenworth county. At Holliday the Plattsburg approximates sixteen feet, and northwest of Shawnee ten and one half feet. The thinnest development of the formation in Johnson county seems to be along Little Mill creek in township 12 south, range 24 east, where a thickness of nine feet and less was measured. The Plattsburg is fifteen feet thick along Mill creek in sec. 13, T. 13 S., R. 23 E.; eleven feet at the head of Cedar creek, T. 13 S., R. 23 E., nine feet at the NW cor. of sec. 22, T. 13 S., R. 22 E., and twelve feet thick in T. 15 S., Rs. 22-23 E. Near Frisbie, in T. 12 S., R. 23 E., the Plattsburg is eleven feet thick. Just east of Prairie Center the formation seems to be uncommonly thick, although the measured thickness of twenty feet may be too great, due to slumpage. The local variation in thickness is likewise considerable in Miami county. The thinnest development observed in the county was ten feet in the NW¼ of sec. 5, T. 16 S., R. 22 E. The thickest Plattsburg section was found at the middle of the west edge of sec.

31, T. 15 S., R. 23 E. Commonly a thickness of eleven or twelve feet is encountered.

In the study of Miami county stratigraphy information was obtained that throws new light on certain correlations made by the early Kansas Survey. In the description of the Stanton limestone, Swallow[54] made the often-quoted statement: "This limestone is well exposed in the eastern bluff of the Marais des Cygnes; in the highest points north of the 'Devil's Backbone' above Stanton." Swallow called the formation which makes the "Devil's Backbone" and upon which the town of Stanton is built the Cave Rock. In his generalized section of Miami county Swallow represented the Stanton limestone as the first limestone above the Cave Rock formation.

Until the present study it has not been realized that there are three limestone formations above the Iola in the vicinity of the towns of Stanton and Lane. The Cave Rock of Swallow, as described in the Stanton region, is the Wyandotte of the present report, and his Stanton limestone is beyond any question the Plattsburg of the modern classification. That Swallow realized the existence of a limestone immediately above his Stanton is clearly shown in his generalized section of Miami county.

Because of established usage, however, the present misapplication of the term Stanton should not be stressed. Broadhead's term Plattsburg was first published in the same year as Swallow's Stanton. The terms Stanton and Plattsburg are both securely established in geological literature and there has never been any serious question as to their usage. Therefore, in spite of the availability of Adams' term Piqua, for the limestone above the Plattsburg, it would obviously be unwise to disturb the present usage of the term Stanton.

Distribution. The Plattsburg formation is widely exposed in the western and northern parts of Miami county. The formation generally produces an escarpment flanking the higher uplands, the closely associated Stanton having been in many cases weathered back from the Plattsburg. On Wea and Bull creeks and their tributaries and along the valley of Marais des Cygnes the Plattsburg is well exposed.

In Johnson county the Plattsburg is exposed far up the valleys of Captain's creek, Kill creek, Cedar creek, Mill creek, and Turkey

54. Swallow, G. C., Geological report of Miami county, Kansas: Kansas Geol. Survey, p. 75, 1865.

creek in the northern part of the county. The formation occurs in the bluffs of Kansas river valley, rising above the flood plain near the mouth of Captain's creek, and finally occupying the highest position in the bluff north of Shawnee. The escarpment crosses the eastern part of the county, extending through township 12 south, range 25 east, and townships 13, 14, and 15 south, range 23 east. The outcrop of the Plattsburg extends into the county a short distance along the strems in township 15 south, ranges 22, 23, and 24 east.

Detailed sections. Sections including the Plattsburg limestone are given at the last part of the report under Nos. 2, 4, 5, 9, 10, 11, 13, 14, 15, 17, 19, 21, 22, 23, 24, 25, 26, 27, 29, 31, 32, 45, 53, 54, 60, 61, 62, 69, 70, 72, 73, 74, 75, 77, 82, 83, 84, 85, 86, 88, 89, 90, 91, 102, 103, 105, 113, 114, 115, 116, 148, and 165.

VILAS SHALE

The Vilas shale was named by Adams[55] in 1898, from Vilas, in Wilson county, Kansas. The formation lies between the Plattsburg and Stanton limestones. The Vilas in Johnson and Miami counties is rather uniform in its characters.

Lithologic character and thickness. As a rule the formation can be readily distinguished from other associated shales. It is grayish-buff in color with, in some localities, a faint greenish tint. Throughout Johnson county the bed is arenaceous, with generally a thin bed of gray, hard, ripple-marked sandstone near the top or at the middle. The Vilas formation is free from fossils, and averages about fifteen feet in thickness. Some variation occurs in township 13 south, ranges 22 and 23 east, where it ranges from thirteen feet to nearly twenty feet.

In Miami county there is somewhat more variation in the formation. At many exposures in the western part of the county it contains a considerable amount of reddish-brown sandstone and sandy shale. In the vicinity of Pressonville there occurs an impure thin limestone near the base, separated from the Plattsburg by four feet of green clay. At a few places, as at the center of the west edge of sec. 31, T. 15 S., R. 23 E., the Vilas is as thin as five and one half feet. Where the formation is thin, it contains but little sand. The thickest section of Vilas in the county occurs at the county line west of Pressonville, where it is over thirty feet thick. This formation seems to be a good reservoir for water at some points in Johnson

55. Adams, G. I., The stratigraphy of the Kansas Coal Measures: Kansas Univ. Geol. Survey, vol. 3, p. 51, 1898.

county and good wells have been secured by drilling at a point down the dip from the outcrop.

Distribution. The outcrop of the Vilas occupies esentially the same area as that of the Plattsburg limestone.

Detailed sections. Sections of the Vilas are given at the end of the report under numbers 2, 4, 10, 13, 15, 17, 20, 21, 22, 23, 24, 25, 44, 54, 70, 72, 73, 86, 89, 90, 113, 115, 116.

STANTON LIMESTONE

The term Stanton was used first by Swallow[56] for a limestone formation at the town of Stanton, Miami county, Kansas. As already indicated, Swallow's original Stanton is equivalent to what is now called Plattsburg limestone. Usage has transferred application of the name Stanton to the limestone formation next above the Plattsburg, and accordingly as used in this report Stanton now applies to three limestone and two shale members that are the exact equivalents of the formation described as Stanton by Hinds and Greene[57] in the Leavenworth-Smithville area. Recently Condra and Bengston, and Condra proposed names for stratigraphic units in Nebraska, which Condra[58] has since correlated with the five members of the Stanton limestone of northeastern Kansas. With but one exception the terms used by the Nebraska Survey for the subdivisions of the Stanton are derived from the Platte Valley region in Nebraska where the beds are isolated in an inlier from the main outcrop in Kansas and Missouri. Since the Platte Valley units cannot be traced into Kansas, and since there is only a vague lithologic resemblance between the Nebraska and Kansas exposures, any correlations between them must be considered as uncertain at the present time. Accordingly it seems better to use local names for the Kansas units. The terms employed here for the subdivisions of the Stanton are, in upward order: Captain Creek, Eudora, Olathe, Victory Junction, and Little Kaw. The term Captain Creek is derived from a stream near Eudora, Douglas county, Kansas, and applies to the lower limestone of the Stanton. Condra[59] named the Eudora shale from exposures near Eudora, Kan. The name Olathe is here suggested for the second of the three limestones of the Stanton. The

56. Swallow, G. C., Geological report of Miami county, Kansas: Kansas Geol. Survey, p. 75, 1865.

57. Hinds, Henry, and Greene, F. C., U. S. Geol. Survey, Geol. Atlas, Leavenworth-Smithville folio, 1917.

58. Condra, G. E., Correlation of the Pennsylvanian beds in the Platte and Jones Point sections of Nebraska: Nebraska Geol. Survey, 2d ser., Bull. 3, 57 pp., 1930.

59. Condra, G. E., Correlation of the Pennsylvanian beds in the Platte and Jones Point sections of Nebraska: Nebraska Geol. Survey, 2d ser., Bull. 3, p. 12, 1930.

name is taken from Olathe, Johnson county, Kansas. The Victory Junction shale is named for the hamlet in western Wyandotte county. The member is well exposed at a number of places just west of Victory Junction. The upper member of the Stanton formation is referred to here as the Little Kaw limestone from Little Kaw creek north of Loring, Leavenworth county, Kansas.

Lithologic character and thickness. The Captain Creek limestone is the most easily recognizable unit of the Lansing group in northeastern Kansas. In the area under discussion it is composed of gray to dark-gray, massive and evenly bedded limestone. The individual beds of limestone are ordinarily more than eight inches thick. In texture the limestone is sugary to dense. The upper layer of the Captain Creek has frequently a peculiar brecciated appearance, looks siliceous, and is mottled bright blue and pink. The color is better described by these terms than is usually the case in limestone. A zone of the striking form *Enteletes pugnoides* is well developed in the Captain Creek in much of the northeastern Kansas. The species is confined to a narrow vertical range in the member, occurring about one fourth to one half of the distance from the top. Locally the limestone at this horizon is largely composed of this brachiopod. Individuals of *Enteletes hemiplicatus* var. *plattsburgensis* are relatively rare. A robust species of *Triticites* occurs on the bedding planes of the member. The Captain Creek limestone is frequently entirely covered by slumped material from the overlying Olathe limestone. The thickness ranges in Johnson county from four and one half to five and one half feet. The member increases southward to ten feet in sec. 3, T. 17 S., R. 22 E., Miami county.

The Eudora shale is remarkably constant in northeastern Kansas. The member consists of argillaceous shale, greenish-gray to gray in color, with a thin layer of black, fissile shale below the middle. Where the member is thinnest, the carbonaceous layer is relatively thick. The thickness of the Eudora shale in Johnson county ranges from six feet in the northeast part to about eleven feet in the central and southeast part. In Miami county there is some variation in thickness. The member is five and one half feet thick in sec. 4, T. 17 S., R. 22 E. and eleven feet in sec. 26, T. 16 S., R. 21 E.

In view of the considerable thickness and wide surface distribution of the Olathe limestone, it is strikingly unfossiliferous as compared to the other limestone members of the Stanton. The unit is composed of thin-bedded and wavy limestone, bluish-gray in color,

and the individual beds are separated by thin limy partings. The limestone is commonly fine-grained, and weathered surfaces are typically dark-buff. The thickness ranges from about fifteen feet along Captain creek, in the northwestern part, to eleven feet in the southwestern corner of Johnson county. Owning to its thinness, the Little Kaw limestone above usually is gone from the dissected uplands, baring the Victory Junction shale and Olathe to erosion. Almost all of the upland surface in the western half of the two counties owes the low relief to the resistance of the Olathe limestone.

In Johnson county the Victory Junction is composed predominantly of reddish-brown to dark-buff standstone. The rock generally is even-bedded and massive. The presence of marine fossils distinguishes the bed from the younger Stranger standstone. Commonly a thin layer of greenish or gray clay underlies the sandstone of the Victory Junction. The sharp and somewhat uneven contact between shale and sandstone suggests a disconformity. Good exposures of the Victory Junction shale are quite uncommon, but the member seems to be very irregular in thickness. Near the mouth of Captain creek it is nearly fourteen feet thick; in sec. 24, T. 13 S., R. 21 E. it is only three feet thick. The member is not exposed in Miami county.

The Little Kaw limestone in Johnson and Miami counties represents the end of a cycle of marine sedimentation. Above the Little Kaw limestone is the obscure but nevertheless widespread Missouri-Virgil unconformity.

The Little Kaw generally is composed of one or two beds of dark-gray, fine-grained limestone, the lower part of which is, as a rule, arenaceous. Locally the unit is made up of two thin beds of limestone and an included thin bed of buff sandstone and arenaceous shale. In this case the limestone is rather arenaceous throughout and is not very fossiliferous. Where the member is fossiliferous, *Meekella striaticostata* and *Triticites* cf. *moorei* generally dominate the fauna. At the west side of township 14 south, range 22 east the Little Kaw consists of two limestone beds and an included shale, which have a total thickness of four feet. In township 13 south, range 21 east the thickness is five feet, the middle shale bed being somewhat thicker in this area. In the vicinity of Edgerton, the member consists apparently of a single limestone bed four feet thick.

Distribution. In Miami county the Stanton occurs only in the northwest and southwest corners of the county, having been stripped

away by erosion in other parts of the county. In all occurrences the formation crops out in the high uplands, generally at some distance from the principal valleys.

In Johnson county the formation underlies the great plain that covers almost all of the western part of the county.

Detailed sections. The sections of the Stanton are given under the following numbers at the end of the report: 2, 4, 15, 17, 20, 21, 23, 24, 25, 28, 44, 54, 70, 72, 73, 86, 89, 90, 113, 115, and 116.

Pedee Group

For the dominantly shaly strata between the Stanton and the base of the Virgil series, Moore[60] is introducing the term Pedee, from a stream near Weston, opposite Leavenworth, on the Missouri river.

The basal formation of the Pedee, the Weston shale, occurs in southwestern Johnson county. The higher formations of the group were eroded before deposition of the basal sandstone of the Virgil series. Northward across Johnson county the Missouri-Virgil unconformity converges with the Stanton, so that in the northern part of township 14 south, ranges 21 and 22 east the Stranger formation of the Virgil rests directly upon some part of the Stanton, generally the Little Kaw. Northward to Lansing and beyond the Stranger rests unconformably upon the Stanton or Weston.

Although exposures are not good in southwestern Johnson county, it was estimated that the Weston reaches a thickness of forty feet or more before the outcrop of the ever-thickening formation leaves the county into Douglas county. The Weston is composed of bluish-gray clay shale, with limonite concretions scattered through it at intervals. It has been eroded from Miami county and the Stanton is now the youngest Pennsylvanian formation exposed.

VIRGIL SERIES

The term Virgil is being introduced by R. C. Moore[61] for the Pennsylvanian strata lying unconformably on the Pedee group. The term Virgil is derived from a town in Greenwood county, Kansas.

Stranger Formation

At the base of the Virgil is the formation here called the Stranger, after Stranger creek near Tonganoxie, Kan. The formation is typically exposed along the east side of sec. 3, T. 12 S., R. 21 E.

60. Moore, R. C., Kansas Geol. Soc., Guidebook, Sixth Ann. Field Conf., p. 93, 1932.
61. Moore, R. C., Kansas Geol. Soc., Guidebook, Sixth Ann. Field Conf., p. 88, 1932.

This is the youngest Pennsylvanian formation cropping out in Johnson county and it is not exposed in Miami county.

Henry Hinds and F. C. Greene, pioneers in the modern school of Mid-Continent stratigraphy, were the first to discover an unconformity in beds which they supposed to be the Lawrence shale. In 1915 these geologists in their scholarly "Stratigraphy of the Pennsylvanian series in Missouri" gave a detailed account of a thick sandstone in the vicinity of Leavenworth, Kan., and adjoining parts of Missouri. This deposit was described as channeling down through the Iatan and Weston formations. Hinds and Greene found that the heavy sandstone is sharply limited on the north, and not knowing its great areal extent to the southward they concluded that the sandstone constitutes the filling of a local channel.

While engaged in a study of areal geology in Wyandotte county just south of the Leavenworth region in 1929 and 1930, J. M. Jewett and I had occasion to trace the divisions outcropping in the Leavenworth quadrangle southward across Wyandotte county into Johnson and Douglas counties. We found that the channel sandstone of Hinds and Greene is a continuous sheet across this area, measuring from 50 to 100 feet or more in thickness. The Weston shale and Iatan formations are absent, except for thin local remnants of Weston just above the Stanton formation, and the sandstone rests unconformably, but with relatively even contact, on the Stanton. Lenses of hard limestone conglomerate, derived from the eroded Iatan limestone, are quite common at the base of the sandstone.

The relatively even contact of the sandstone on the Stanton in the region around Lawrence delayed the recognition of the unconformity and led the earlier geologists to class these beds overlying the Stanton as Weston. A thin limestone at Lawrence for so long classed as Iatan limestone, we concluded must be a younger bed than the Iatan, because at Lawrence the limestone occurs a hundred feet above the unconformity, whereas the Iatan of the type region occurs beneath the break.

In 1930, while engaged in a regional study including the Lansing beds and Weston shale, I continued the earlier investigation on the unconformity begun with Jewett. The heavy sandstone deposits first above the Stanton limestone in Douglas county were traced into Franklin county west of Ottawa, where a thick clay shale like the typical Weston wedges in between the Stanton and the unconformable sandstone. By this time the unconformity at the base of the Stranger formation had been traced almost half way across Kansas

and its continuance southward was anticipated. In 1931 I mapped the scarp formed by the lower part of the Stranger sandstone across Franklin county, and while engaged in other work in Wilson county around Fredonia I incidentally recognized the same sequence as that already worked out in Franklin county. At the same time Doctors Moore and Condra observed unconformable relations at the same horizon in Montgomery county.

In the summer of 1932 I mapped the base of the Stranger entirely across the state and discovered abundant evidence of unconformity at many places. While this mapping was in progress I made a reconnaissance study of the section up to the base of the Oread and discovered an almost equally well-defined and extensive unconformity within the typical Lawrence shale. This unconformity was already known to other geologists, particularly Dr. John L. Rich and several subsurface workers, but it was confused by most of these persons with the one at the base of the Stranger.

The Stranger appears to be a series of more or less disconnected channel deposits of sandstone and sandy shale extending from Leavenworth, Kan., southward into Oklahoma. It is proposed to place the upper limit of the Stranger at the base of the thin limestone which underlies the Lawrence shale at Lawrence, Kan. This limestone is the one which has for many years been incorrectly called Iatan, for as Hinds and Greene[62] have shown, the Iatan is stratigraphically below the unconformity and the limestone at Lawrence below the Lawrence shale is accordingly very much younger than the true Iatan. The term Haskell has been applied by Moore[63] to the thin limestone below the Lawrence shale.

The Stranger sandstone is, of course, limited below by an unconformity and lies on various parts of the Pedee and Lansing groups. In most of Johnson county the formation generally rests directly on the Little Kaw limestone, which is only locally breached by pre-Stranger erosion.

Lithologic character. Good exposures of the Stranger formation in Johnson county are scarce. Although it covers a large area in Johnson county, there generally remains only a thin mantle of sandstone and sandy shale overlying the Stanton limestone. At the southwest edge of the county sandstone at the base of the Stranger produces low, rolling hills. Elsewhere the formation produces but little effect on the topography.

62. Op. cit., p. 170, 1915.
63. Moore, R. C., Kansas Geol. Soc., Guidebook, Sixth Ann. Field Conf., p. 93, 1932.

The sandstone and shale are uniformly buff, soft, and micaceous. The sandstone is usually massive and cross-bedded. In some places fossil plants occur, but fossils of marine invertebrates are lacking. The Stranger resembles to some extent the Victory Junction shale. In good exposures, however, they can be distinguished from one another. The sandstone of the Victory Junction is frequently reddish-brown and locally contains marine fossils. Only a thin remnant of Stranger occurs in Johnson county, probably attaining at no place a thickness greater than twenty or thirty feet.

A persistent coal bed occurs eight to ten feet beneath the Haskell limestone. I have traced this coal from Iatan, Mo., to western Franklin county, Kansas. The name Sibley coal has been applied to this bed by J. M. Patterson.[64] The marine shale between the Sibley coal and the Haskell limestone has been called the Vinland shale.[65] Sibley and Vinland are villages in Douglas county, Kansas, southeast of Lawrence. The dominantly sandy and nonmarine beds from the top of the Sibley coal to the base of the Stranger formation were termed Tonganoxie by Patterson, from a town in Leavenworth county.

Quaternary System

PLEISTOCENE DEPOSITS

Deposits of Pleistocene age, for the most part unindurated, are restricted chiefly to the northern part of Johnson county. These consist of high terrace gravels, near Holliday, and glacial drift consisting of (1) reworked till, on the south side of Kansas river valley, and (2) scattered erratics, very rare south of township 12 south. Loess deposits cover a considerable area near Kansas river, occupying a narrow band of upland adjoining the river valley. It is supposed generally that the greater part of the loess reached its present position soon after the retreat of the glacier.

High Terrace Gravels

A very thick deposit of gravel occurs in the northeast corner of township 12 south, range 23 east in Johnson county. The gravel is composed of rounded fragments of local limestone and shale, intermingled with comparatively rare erratics. The material ranges in size from sand grains to boulders, but small pebbles predominate. The gravel deposit occupies much of the lower part of the valley of

64. Patterson, J. M., The Douglas group of the Pennsylvanian system in Douglas and Leavenworth counties, Kansas; Master's Thesis, University of Kansas, p. 11, 1933. Not published.

65. Patterson, Idem., p. 17.

Clear creek in secs. 2, 3, 10, and 11, T. 12 S., R. 23 E. A gravel pit worked by Edwin Ahlskog in section 11 of the above township affords an opportunity to study the deposit in detail. The thickness of the deposit is unknown, but in the vicinity of the gravel pit it must exceed eighty feet. Near the middle of the deposit occurs a zone of consolidated gravel. Here the gravel has been cemented by calcium carbonate into a hard, firm conglomerate. A section of the deposit at the Edwin Ahlskog gravel pit is given as follows:

Section of the gravel deposit at the Edwin Ahlskog pit, NE cor. sec. 11, T. 12 S., R. 23 E.

	Feet.
Sand; reddish-brown, with clay; contains small subangular cherts and rarely small rounded quartzite pebbles; bedding obscure, glacial till?..	20.0
Gravel; contains small cobbles, pebbles, and sand, steeply cross-bedded, approximately 35°, dips nearly north; upper part of the beds truncated, bedding laminae curve outward below to form thin horizontal bottomset bed; bedding of the foreset beds accentuated by a concentration of the coarser material in regularly recurring zones; no erratics observed,	18.0
Gravel; subhorizontally bedded, lenticular beds; gradation from pebbles and sand near the top to large cobbles and pebbles below; erratics of Sioux quartzite, rhyolite, rotten granite, mica schist; erratics less than 1 percent of total; cobbles mostly of limestone; lower part irregularly consolidated	20.0
Sand; brown and buff, contact with the above irregular, foreset and bottomset bedding, steepest dip about 35°, dips east of north, upper part of beds truncated, grains angular and coarse, consolidated in places	10.0
Sand and gravel; grains rounded, poorly sorted; erratics observed, three feet exposed	3.0
	71±

My attention was recently directed to a reference by Darton[66] in which a possible origin of these terrace gravels is given. The interpretation by Darton is not appreciably different from that here given.

At a stage of glaciation, probably near the end of the Kansas epoch, the ice sheet extended to Loring, Bonner Springs, and Muncie on the north side of Kansas river, as shown by abundant glacial striae along the north side of the valley. No striae have been found on the south side opposite these points. Undoubtedly a great quanity of ice and drift choked the valley wherever the ice sheet extended to, or across it, effectively interfering with the drainage. At times doubtless the river was sufficiently obstructed that long, sinuous temporary lakes were formed.

66. Darton, N. H., Guide-book of the western United States: U. S. Geol. Survey Bull. 613, footnote p. 9, 1915.

A glance at the Kansas City sheet of the topographic maps of the United States Geological Survey shows the interesting topographic feature that Clear creek in secs. 9 and 13, T. 12 S., R. 23 E. makes an abrupt bend directly away from the river, and flows eastward into Mill creek. An obscure gap produced by Pleistocene Clear creek occurs at the center of the south edge of sec. 8, T. 12 S., R. 23 E. It seems likely that this gap was produced in the divide between Clear creek and Kansas river when the dammed up water of Kansas river above Wilder overflowed the valley walls, finding an outlet at the site of the present wind gap above Wilder, flowing eastward through the valley of Clear creek to Mill creek and thence into the normal course at Holliday. The escaping water quickly enlarged the valley of the little tributary to Mill creek, depositing a thick delta near the confluence with the parent stream. The normal channel of Kansas river was not obstructed for long, since the gap of Pleistocene Clear creek is now barely distinguishable in the divide. It is possible that the river overflowed the divide in more than one place. If this occurred, recent erosion has removed recognizable traces of such gaps.

Glacial Drift

Unconsolidated deposits of weathered till occur in Johnson county along the top of the south bluff of Kansas river. The material generally consists of reddish-brown sand and erratic pebbles. The deposits are everywhere thin, commonly less than five feet. Erratics as large as cobbles are rare.

Small erratics, probably stream transported, occur as far south as the middle of township 12 south. No evidence was recognized that establishes beyond question that the ice extended beyond the present valley of Kansas river into Johnson county. The till deposits at De Soto and Cedar Junction resemble closely similar deposits that overlie glacial striae directly across the river at the Loring quarry, but no striae have been discovered in the former area.

Loess Deposits

A thin veneer of loess occupies a narrow band adjoining the valley of Kansas river. The loess is most extensive in the northwestern part of Johnson county. In this area the thickness of the loess attains as much as fifteen feet and consists of a fine, homogeneous, arenaceous material, showing no stratification. In fresh exposures the loess shows a tendency to stand in vertical sections.

The material is reddish-brown to dark-buff, slightly darker than much of the typical loess from the valley of the Missouri.

The deposits of loess in the northern part of Johnson county have been derived mostly from the flood plain of Kansas river. At the end of Pleistocene time, streams draining the glaciated area were heavily burdened with the products of glaciation. This material being deposited on the flood-plain was picked up by winds of ordinary velocity and blown upon the sides of the valleys.

The distribution of the loess in Johnson county has been mapped in detail in a government soil survey of Johnson county.[67] Four types of soil developed over loess have been mapped in the county. These are Marshall silt loam, Knox silt loam, Knox silty clay loam, and Clinton silt loam.

The distribution of loess in Miami county is but imperfectly known. The loess occurs as a thin sheet in the high uplands, possessing a grayish-buff color rather than the familiar reddish or buff of Kansas river loess. Much of the loess in Miami county may be of Recent origin.

RECENT DEPOSITS

The deposits of Recent age in Johnson and Miami counties consist of (1) flood-plain accumulation of alluvium, (2) colluvial deposits of talus and soil at the foot of slopes, and (3) residual soil and clay deposits. The latter type of deposit is particularly widespread and thick on the high upland of the southwest quarter of Johnson and the northwest quarter of Miami counties, where the drainage is not well developed and consequently erosion has been relatively slight. The residual soil derives its characters from the bedrock beneath. Where the soil overlies sandstone or arenaceous shale, it is sandy; and where it overlies argillaceous shale, or limestone, it has a large proportion of lime and clay.

DEPOSITS OF UNKNOWN AGE

In southern Johnson county and Miami county the bedrock of the upland areas is covered with a thin mantle of unconsolidated materials. Overlying the weathered surface of Pennsylvanian rocks occurs a thin zone of scattered chert pebbles not derived from the neighboring rocks. Overlying the chert pebbles is a thin layer, one or two feet thick, of silty gray to buff soil. Because of its position above the layer of transported chert pebbles, the upper

67. Knobel, E. W., and Davis, R. H., Soil survey of Johnson county, Kansas: U. S. Dept. Agr., ser. 1928, no. 17, 32 pp., 1931.

soil covering is certainly not residual. Probably this deposit is loess, even now being accumulated during occasional dust storms. The origin of the chert pebbles is not clear. The fragments are scattered, and all trace of original bedding has been destroyed. It is possible that these pebbles are derived from old stream deposits and have been redistributed by gravity and sheet wash as the general surface is being lowered.

REGISTER OF DETAILED SECTIONS

DETAILED SECTIONS, JOHNSON COUNTY

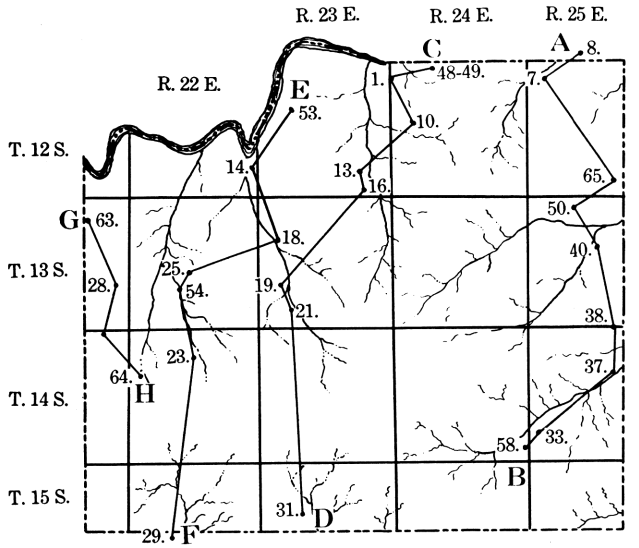
1. *Section at highway bridge at east edge of Holliday, Kansas*

	Feet.
Chanute shale, covered.	
Drum limestone:	
Limestone, whitish to buff, thin-bedded, wavy at the middle, massive at top and base, contains *Campophyllum torquium* and *Marginifera* sp.	10.5
Quivira shale:	
Shale, greenish, argillaceous, thin carbonaceous zone three feet from the top	11.0
Westerville limestone:	
Shale, gray, and interbedded thin, argillaceous limestone beds	9.0
Limestone, drab, oölitic, very fossiliferous	1.5
Shale, gray, limy	1.0
Limestone, drab, oölitic, massive, cross-bedded, fossiliferous, lenticular, about	1.5
Shale, gray, limy	0.2
Limestone, dark gray, hard, massive, pyritiferous, veined with dark gray calcite, base covered	2+

2. *On road, middle of east edge sec.* 12, *T.* 12 *S., R.* 23 *E.*

Stanton limestone:	
Captain Creek limestone member:	
Limestone, white, makes bench, mostly covered.	
Vilas shale:	
Shale, light buff, arenaceous	10.0
Sandstone, soft, buff	5.5
Sandstone, gray, hard, "quartzitic" above, and buff, soft, cross-bedded below	5.5
Shale, bluish-gray, arenaceous	4.5
(Total Vilas shale, 25.5 feet)	
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, brown, soft, ferruginous	5.0
Limestone, gray, granular	2.0
Limestone, gray, dense above, and buff, thin-bedded below	5.5
Hickory Creek shale member:	
Shale, buff, ferruginous	0.5

Sketch of Johnson county showing location of sections.



The numbers refer to sections described at the end of the report.

8. 1/4 mile N. center N. edge sec. 4, T. 12 S., R. 25 E.
7. 1/4 mile W. center E. edge sec. 6, T. 12 S., R. 25 E.
65. NW. cor. sec. 35, T. 12 S., R. 25 E.
50. 1/4 mile S. of NW. cor. Sec. 9, T. 13 S., R. 25 E.
40. SW. cor. sec 15, T. 13 S., R. 25 E.
38. SE. cor. sec. 34, T. 13 S., R. 25 E.
37. SE. cor. sec. 10, T. 14 S., R. 25 E.
33. Center sec. 30, T. 14 S., R. 25 E.
58. SE. cor. sec. 25, T. 14 S., R. 24 E.
48-49. North part sec. 5, T. 12 S., R. 24 E.
1. Highway bridge east of Holliday, Kansas.
10. Center W. edge sec. 17, T. 12 S., R. 24 E.
13. Middle S. edge sec. 25, T. 12 S., R. 23 E.
16. SE. cor. sec. 35, T. 12 S., R. 23 E.
19. SW. cor. sec. 20, T. 13 S., R. 23 E.
21. Center S. edge sec. 29, T. 13 S., R. 23 E.
31. NE. cor. sec. 17, T. 15 S., R. 23 E.
53. Center N. edge sec. 17, T. 12 S., R. 23 E.
14. Center sec. 25, T. 12 S., R. 22 E.
18. SE. cor. sec. 7, T. 13 S., R. 23 E.
25. NW. cor. sec. 22, T. 13 S., R. 22 E.
54. Middle S. edge sec. 21, T. 13 S., R. 22 E.
23. NW. cor. sec. 10, T. 14 S., R. 23 E.
29. 2/10 mile S. of SW. cor. sec. 33, T. 15 S., R. 22 E.
63. E. bank Captain's Creek, highway 10.
28. Middle S. edge sec. 24, T. 13 S., R. 31 E.
64. NW. cor. sec. 1, T. 14 S., R. 21 E.
57. Middle S. edge sec. 7, T. 14 S., R. 22 E.

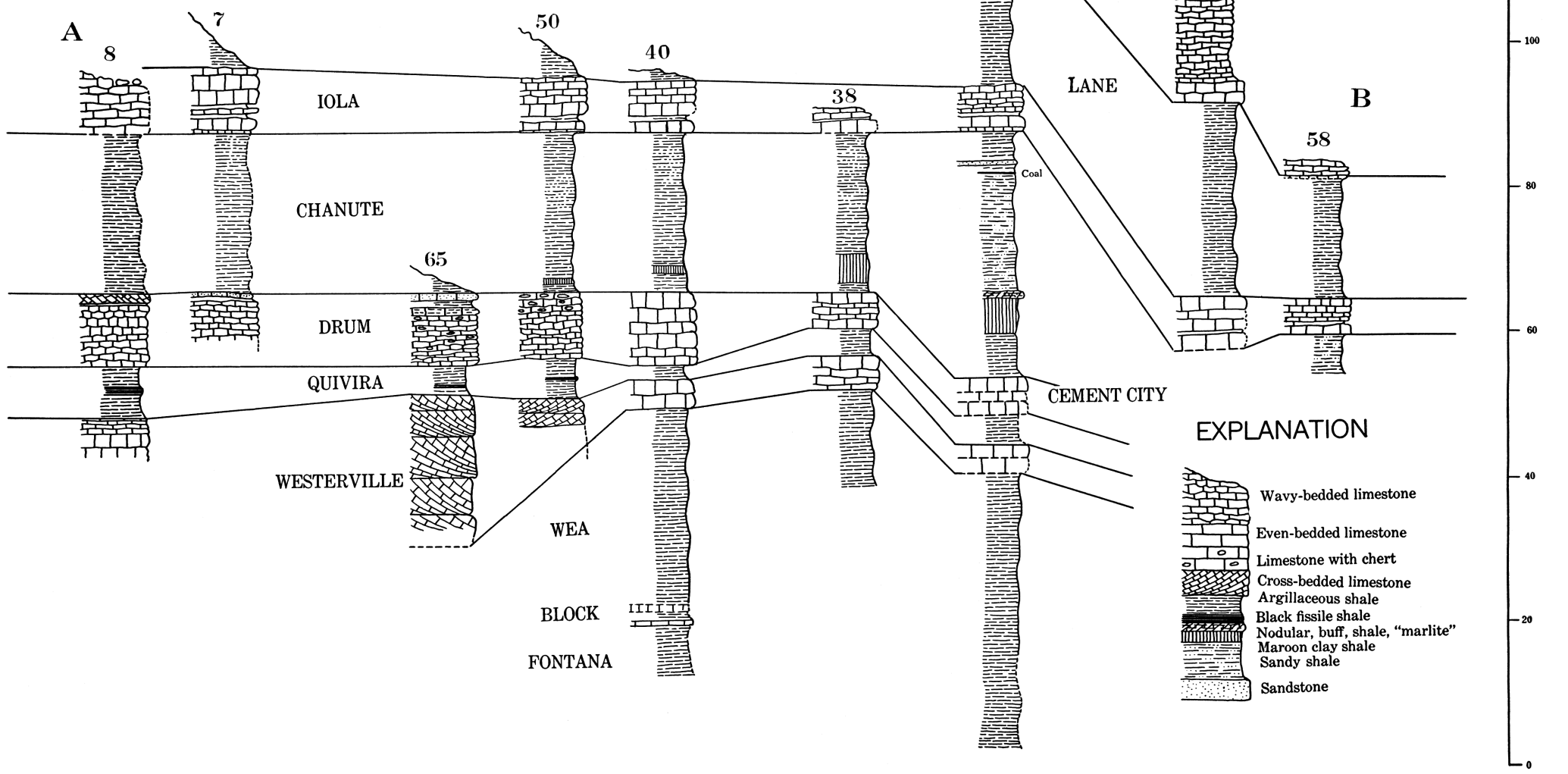


PLATE VI. Stratigraphic sections in Johnson county along line A-B.

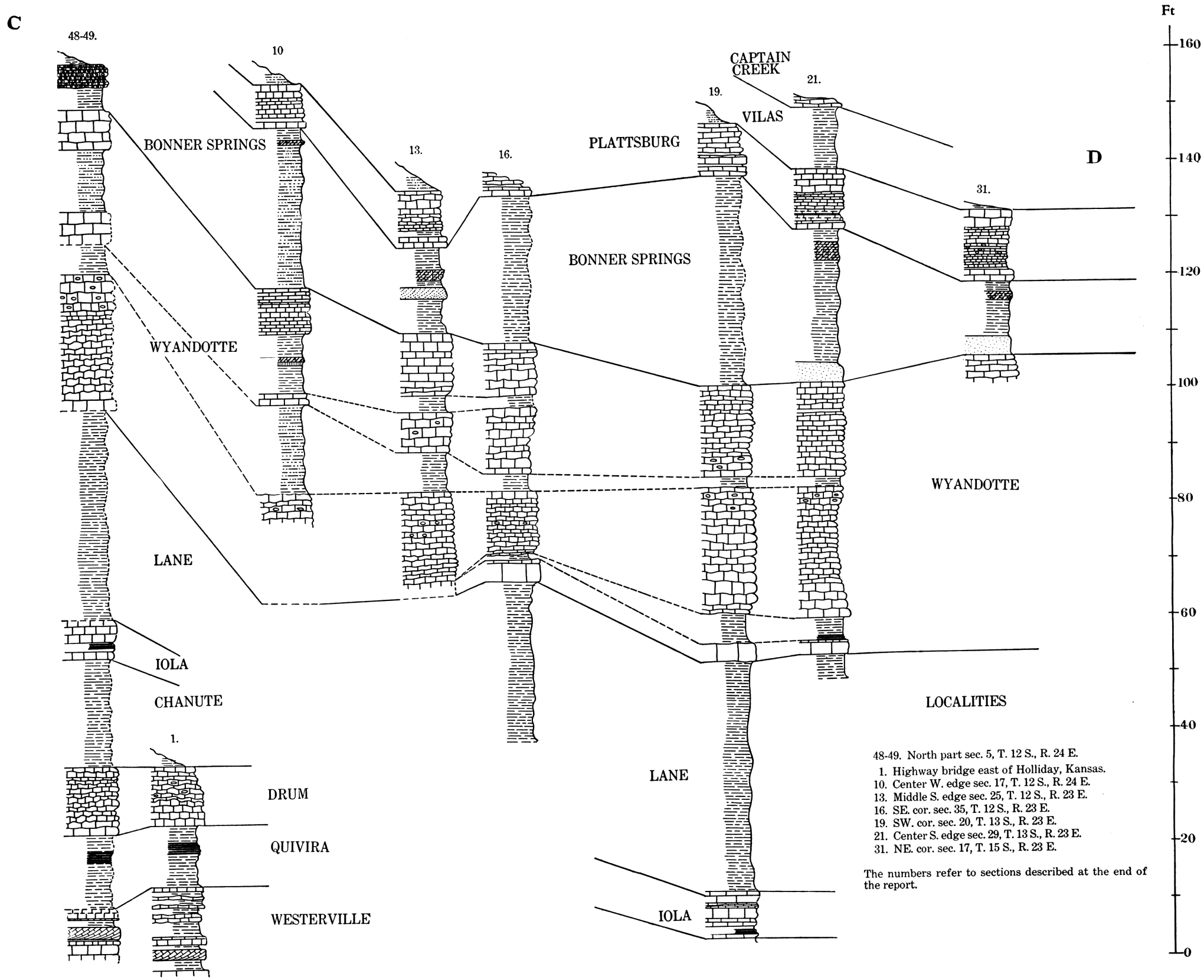


PLATE VII. Stratigraphic sections in Johnson county along line C-D.

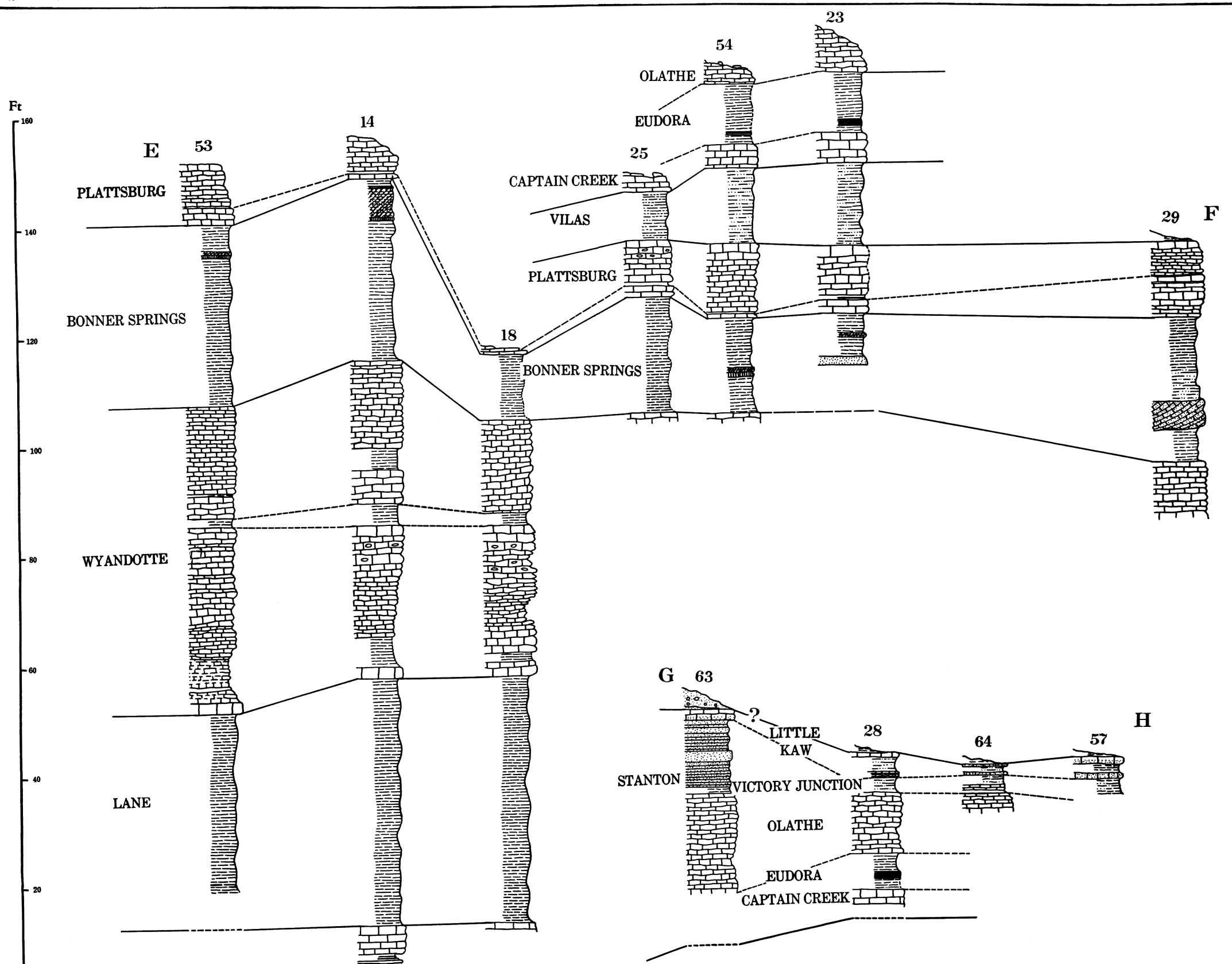


PLATE VIII. Stratigraphic sections in Johnson county along lines E-F and G-H.

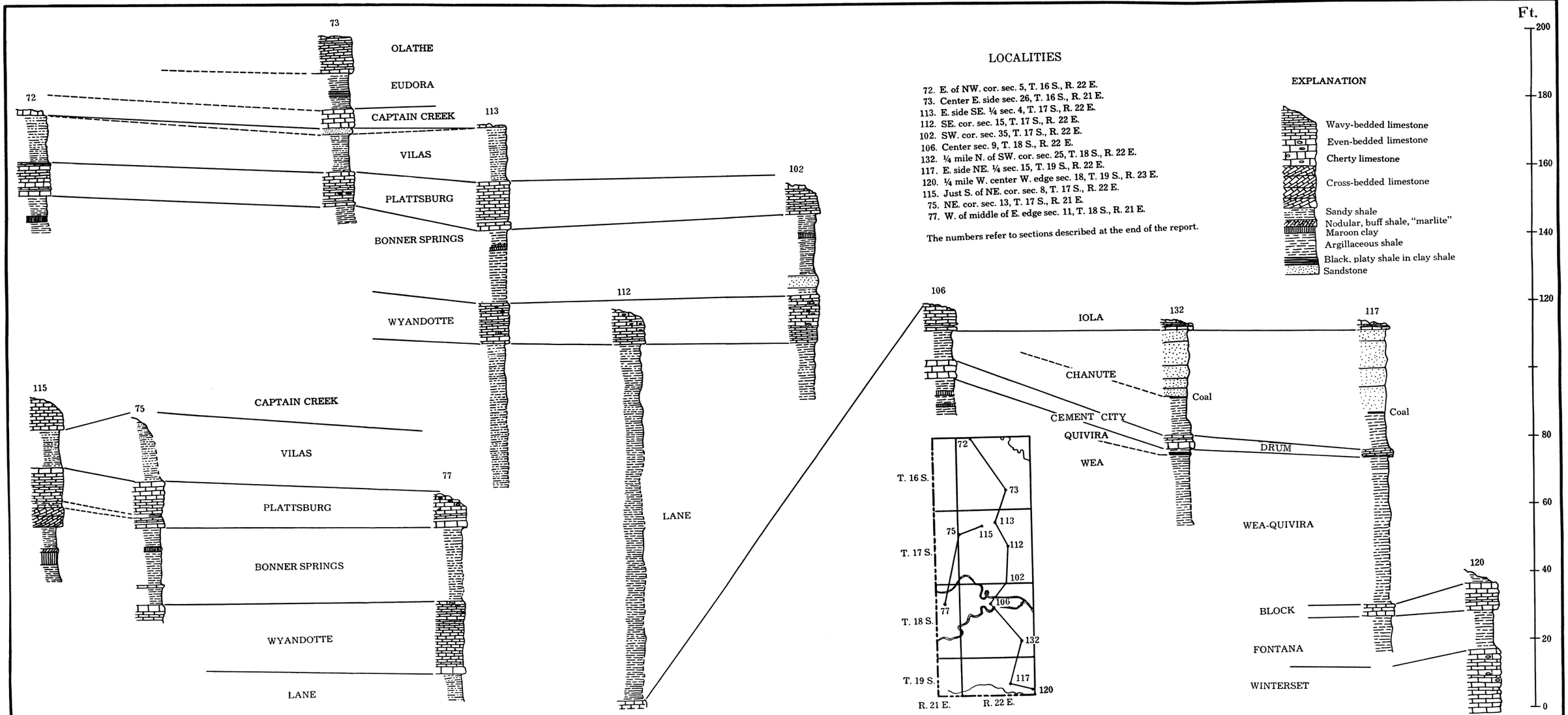
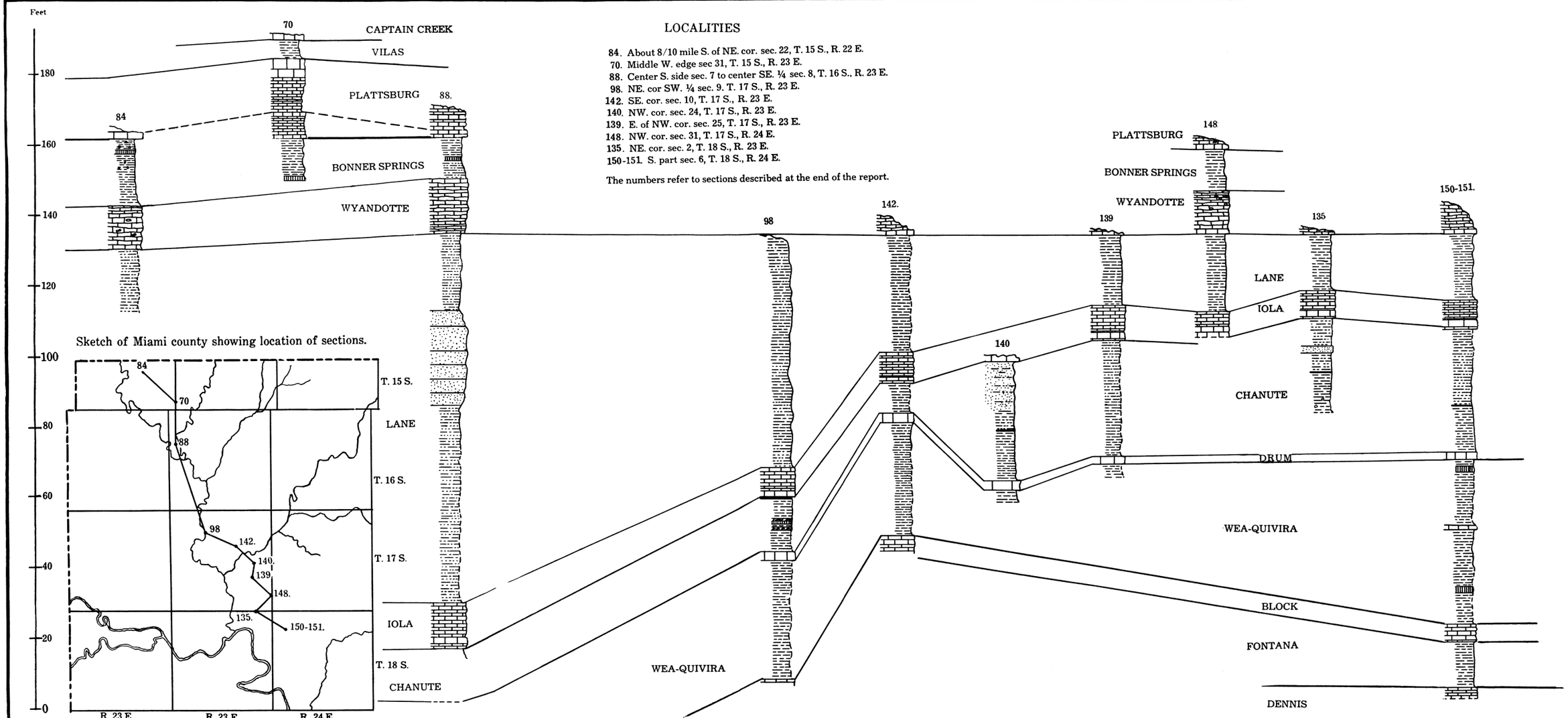


PLATE IX. Stratigraphic sections in southwestern Miami county.



Sketch of Miami county showing location of sections.

LOCALITIES

84. About 8/10 mile S. of NE. cor. sec. 22, T. 15 S., R. 22 E.
70. Middle W. edge sec 31, T. 15 S., R. 23 E.
88. Center S. side sec. 7 to center SE. ¼ sec. 8, T. 16 S., R. 23 E.
98. NE. cor SW. ¼ sec. 9. T. 17 S., R. 23 E.
142. SE. cor. sec. 10, T. 17 S., R. 23 E.
140. NW. cor. sec. 24, T. 17 S., R. 23 E.
139. E. of NW. cor. sec. 25, T. 17 S., R. 23 E.
148. NW. cor. sec. 31, T. 17 S., R. 24 E.
135. NE. cor. sec. 2, T. 18 S., R. 23 E.
150-151. S. part sec. 6, T. 18 S., R. 24 E.

The numbers refer to sections described at the end of the report.

PLATE X. Stratigraphic sections across central Miami county.

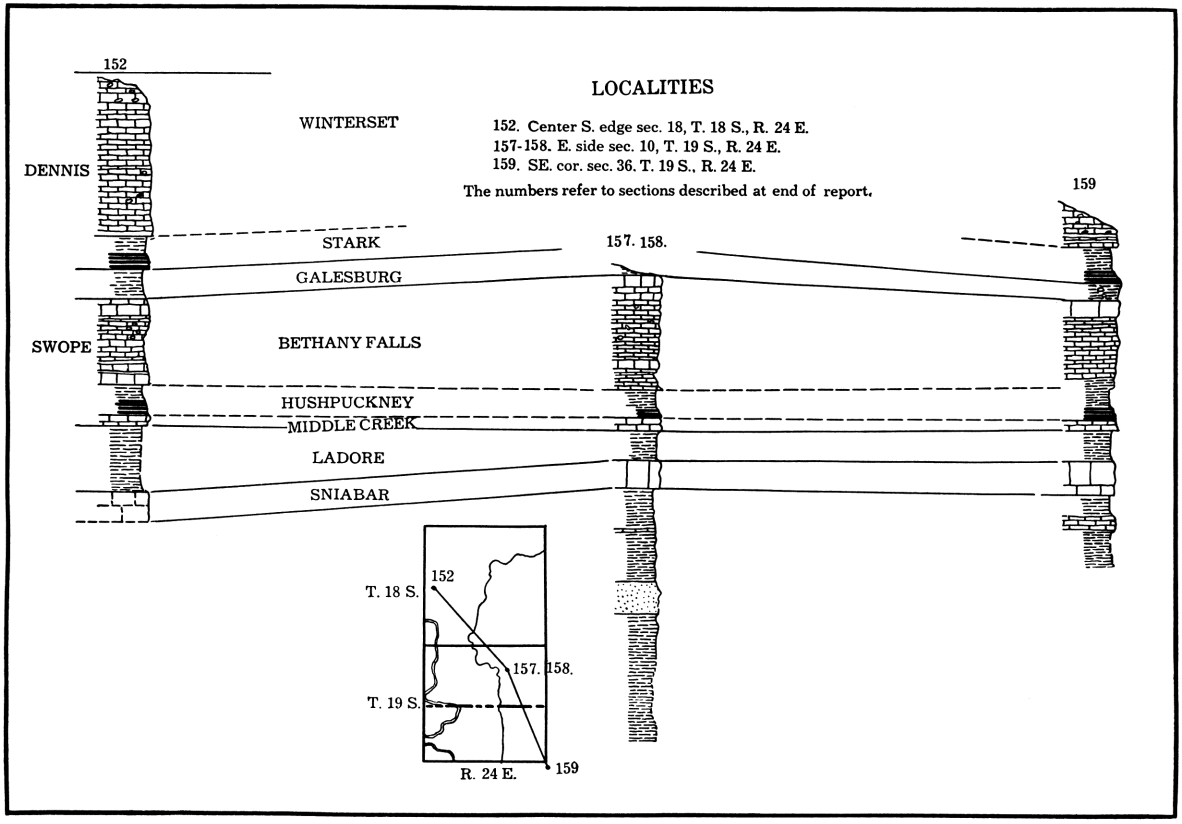


PLATE XI. Stratigraphic section in southeastern Miami and northeastern Linn counties.

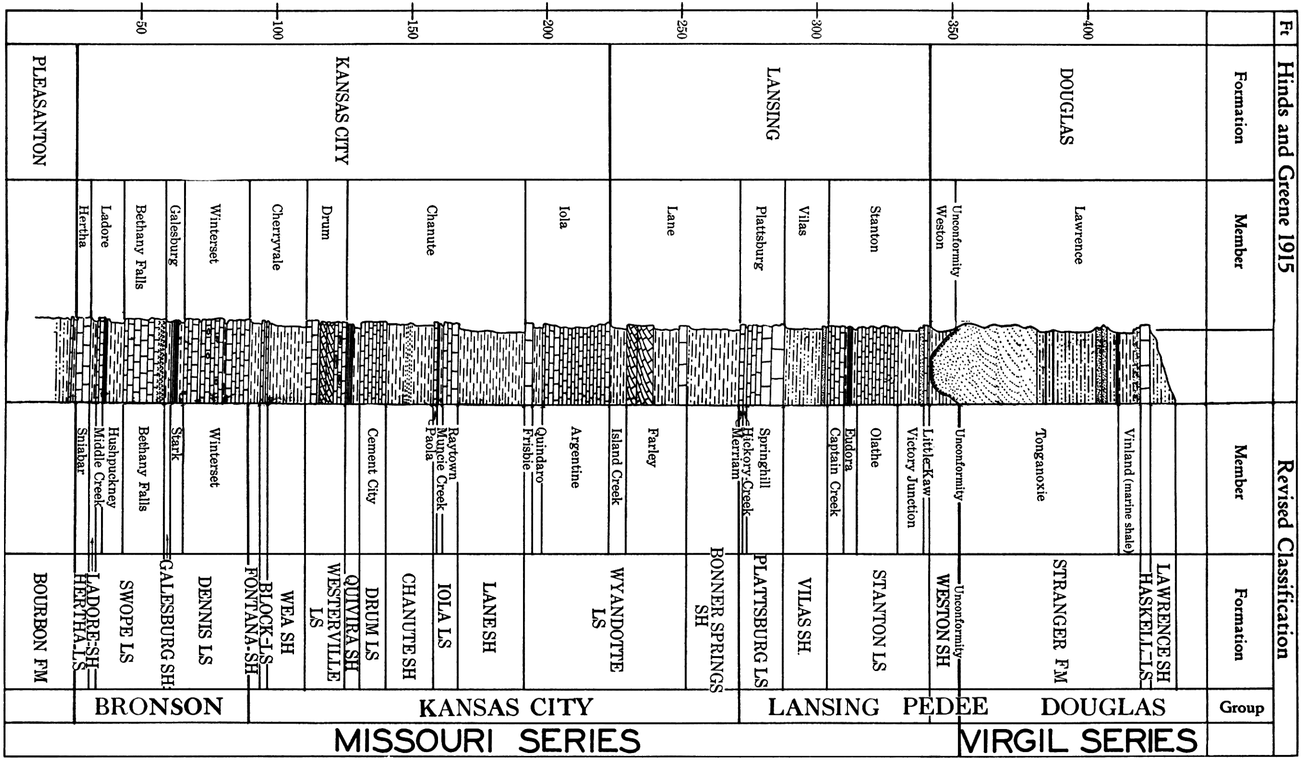


PLATE XII. Comparison of standard and revised classification of the classic section in the Kansas City area.

	Feet.
Merriam limestone member:	
Limestone, gray, granular, even, blocky	1.5
Limestone, drab, *Osagia-Myalina ampla* zone	1.0
Limestone, buff, contains many *Osagia* and *Composita*	0.6
(Total Plattsburg limestone, 16.1 feet)	
Bonner Springs shale:	
Shale, olive-green, argillaceous	6.0
Shale, maroon, argillaceous	0.5
Shale, covered.	

3. *On road, center sec. 7, T. 12 S., R. 24 E.*

Plattsburg limestone:	
Limestone, mainly covered.	
Bonner Springs shale:	
Shale, bluish-gray, limy	1.0
Shale, buff, limy	3.0
Shale, olive-gray, argillaceous	5.0
Shale, maroon, argillaceous	0.5
Shale, greenish-gray, argillaceous	15.0
(Total Bonner Springs shale, 24.5 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, gray, thin-bedded	9.5
Shale, gray, argillaceous	4.0
Limestone, bluish, hard, massive, buff at top	6.0
(Total Farley limestone member, 19.5)	
Island Creek shale member:	
Shale, argillaceous, greenish	6.0
Argentine limestone member:	
Limestone, drab, cross-bedded, oölitic	2.0
Limestone, whitish, wavy-bedded, cherty, crystalline, base covered	15+

4. *Railroad cut, NW cor. De Soto, composite section*

Stanton limestone formation:	
Eudora shale member, covered.	
Captain Creek limestone member:	
Limestone, whitish, massive, even-bedded, contains zone of *Enteletes pugnoides*	5.0
Vilas shale:	
Shale, mostly covered	20.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, gray, even-bedded, cherty, fossiliferous, poorly exposed	25.0
Hickory Creek shale member:	
Shale, gray, argillaceous	1.5
Merriam limestone member:	
Limestone, dark gray, blocky, fine-grained	2.0
(Total Plattsburg limestone, 28.5 feet)	

	Feet.
Bonner Springs equivalent:	
Limestone, whitish, cross-bedded, oölitic	5.8
Wyandotte limestone:	
Limestone, whitish, crystalline, massive, even-bedded, fossiliferous, bases covered	16+

5. *On road, one fourth mile east of the NW cor. sec.* 10, *T.* 12 *S., R.* 24 *E.*

Vilas shale, covered.	
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab, massive, granular, soft, contains spines of *Echinocrinus* spp.	1.5
Limestone, gray, hard, even, thin-bedded, contains zone of *Enteletes hemiplicatus* var. and *Marginifera wabashensis*	3.0
Limestone, buff, soft	2.0
Shale, buff, ferruginous	0.2
Limestone, buff, soft	1.5
Hickory Creek shale member:	
Shale, black, carbonaceous	0.2
Merriam limestone member:	
Limestone, drab, massive, contains *Pinna* sp., *Myalina ampla, Osagia* sp., and *Composita* sp.	2.0
(Total Plattsburg limestone, 10.4 feet)	
Bonner Springs shale:	
Shale, upper part covered, lower part greenish-buff, arenaceous, contains a few plant fossils	30.0
Wyandotte limestone:	
Farley limestone member:	
Limestone, drab, massive, hard, weathers into thin laminae	2.0
Shale, greenish-buff, arenaceous, micaceous, zone of limonite concretions near the middle	10.0
Limestone, gray and buff, massive, upper part dark gray, subоölitic, lower part even-bedded, contains *Composita subtilita,*	5.0
(Total Farley limestone member, 17.0)	
Island Creek shale member:	
Shale, gray to buff, argillaceous, zone of rhomboporoids at the top	12.0

6. *Quarry, SE cor. sec.* 1, *T.* 12 *S., R.* 24 *E.*

Wyandotte limestone:	
Island Creek shale member, covered.	
Argentine limestone member:	
Limestone, bluish-gray, rather thin-bedded wavy, fine-grained, some chert nodules, base covered	23+

7. *On the road, starting at bridge, one fourth mile west of the center of the east side sec.* 6, *T.* 12 *S., R.* 25 *E.*

Lane shale:

Shale, buff and gray, argillaceous, covered.

Iola limestone:

	Feet.
Raytown limestone member:	
Limestone, buff, hard, ferruginous	1.0
Limestone, buff and gray, dense, zone of productids	2.0
Limestone, dark-gray, brecciated, hard, with coarse crystals of calcite	2.0
Shale, buff, argillaceous	0.7
Limestone, drab, argillaceous	0.5
Muncie Creek shale member:	
Shale, dark gray, platy, contains phosphatic spherical nodules	0.5
Paola limestone member:	
Limestone, dark-bluish, lithographic, contains abundant "marklets," massive, blocky	1.5
Limestone, gray, granular	0.3
(Total Iola limestone, 8.5 feet)	

Chanute shale:

Shale, buff, arenaceous, mostly covered	23.0

Drum limestone:

Limestone, whitish, thin-bedded, wavy, hard, weathers light brown, base covered	5+

8. *Quarry, west of road, one fourth mile north of the center of north edge sec.* 4, *T.* 12 *S., R.* 25 *E.*

Lane shale, covered.

Iola limestone:

Limestone, brownish, brecciated, mostly covered, forms bench.

Chanute shale:

Shale, covered, gray and buff, argillaceous, to top of Iola bench,	30—

Drum limestone:

Limestone, buff, massive, granular, cross-bedded, fossiliferous	1.2
Shale, buff, limy	0.3
Limestone, thin-bedded, wavy, whitish to drab, shaly at top with zone of *Composita* sp. and bryozoans	8.5
(Total Drum limestone, 10.0 feet)	

Quivira shale:

Shale, olive, argillaceous	3.0
Shale, black, carbonaceous, fissile, soft	0.8
Shale, olive, contains small nodules of brown limestone	4.0
(Total Quivira shale, 7.8 feet)	

Westerville limestone:

Limestone, buff, nodular, soft	2.0
Limestone, gray, mottled brown, massive, dense, lower part covered	4+

9. *Kill Creek bridge, one half mile east of De Soto on the highway*

Plattsburg limestone:
Spring Hill limestone member:
Limestone, gray, forms bench.
Hickory Creek shale member: Feet.
Shale, gray, argillaceous, contains *Worthenia tabulata?* 20.0
Merriam limestone member:
Limestone, bluish, lithographic, brittle, contains *Cancrinella boonensis* and *Heterocoelia beedei* 1.0
Bonner Springs equivalent:
Limestone breccia, soft, and shale, covered..... 9.0
Wyandotte limestone:
Farley limestone member:
Limestone, drab, massive, soft, suboölitic, obscurely cross-bedded; largely composed of fossil fragments, contains a faunule of nautiloids at the base..... 11.0
Limestone, whitish, massive, even-bedded, fossiliferous..... 5.0
Island Creek shale member:
Shale, bluish-gray, exposed at water's' edge..... 1+

10. *Center of west edge sec.* 17, *T.* 12 *S., R.* 24 *E.*

Vilas shale:
Shale, and buff micaceous sandstone, covered.
Plattsburg limestone:
Spring Hill limestone member:
Limestone, gray and brown, mostly covered..... 6.0
Hickory Creek shale member:
Shale, gray 0.5
Merriam limestone member:
Limestone, drab, zone of *Osagia* and *Myalina ampla*..... 1.0
(Total Plattsburg limestone, 7.5 feet)
Bonner Springs shale:
Shale, olive, argillaceous 2.0
Limestone, nodular, argillaceous, brown, "marlite"..... 0.2
Shale, greenish, with a thin bluish streak, argillaceous..... 4.0
Shale, brown, arenaceous 20.0
(Total Bonner Springs shale, 26.2 feet)
Wyandotte limestone:
Farley limestone member:
Limestone, dark-bluish, hard, thin-bedded, contains *Enteletes hemiplicatus* var. 8.0
Shale, greenish, argillaceous 4.0
Limestone, brown, nodular, spongy, "marlite"..... 1.0
Shale, maroon, argillaceous 0.5
Shale, greenish-buff, limy 5.0
Limestone, blue, hard, massive..... 2.0
(Total Farley limestone member, 20.5)

	Feet.
Island Creek shale member:	
Shale, gray to buff, arenaceous, zone of rhomboporoids at the top,	15.6
Argentine limestone member:	
Limestone, whitish, cherty, covered.	

11. *Center west edge sec.* 20, *T.* 12 *S., R.* 24 *E.*

Plattsburg limestone:	
Limestone, gray and brown, mostly covered, upper part eroded away	5+
Shale, gray	0.5
Limestone, drab, zone of *Osagia* and *Myalina ampla,* blocky, even	1.0
Bonner Springs shale:	
Shale, greenish-gray, limy	4.0
Limestone, brownish, nodular, spongy, "marlite"	0.5
Shale, maroon, argillaceous	0.7
Shale, greenish, argillaceous	16.0
(Total Bonner Springs shale, 21.2 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, dark gray, massive, granular	5.0
Shale, buff and greenish-gray, argillaceous, with 6 inches of maroon clay below the middle, underlying a thin, ferruginous limy layer	12.0
Limestone, bluish at the top, dark gray, weathers buff, massive, granular, contains *Osagia*	4.5
(Total Farley limestone member, 21.5)	
Island Creek shale member:	
Shale, gray, arenaceous, platy, zone of rhomboporoids at the top,	13.0
Argentine limestone member:	
Limestone, upper layer dark gray, hard, granular, contains *Osagia,* base covered	2+

12. *Railroad cut, one half mile south of Craig, center west edge sec.* 36, *T.* 12 *S., R.* 23 *E.*

Wyandotte limestone:	
Argentine-Frisbie members:	
Limestone, mostly covered.	
Lane shale:	
Shale, buff and bluish-gray, platy soft	25+

13. *On road, middle of south edge sec.* 25, *T.* 12 *S., R.* 23 *E.*

Vilas shale:	
Shale, light-buff, arenaceous, mostly eroded	8+
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, brown and gray, mostly covered	8+
Hickory Creek shale member:	
Shale, gray, argillaceous	0.5

	Feet.
Merriam limestone member:	
Limestone, drab, massive, even, blocky, zone of *Osagia* and *Myalina ampla*, contains productids	2.0
(Total Plattsburg limestone, 10.5 feet)	
Bonner Springs shale:	
Shale, greenish, argillaceous	4.0
Limestone, brownish, nodular, spongy, "marlite"	0.5
Shale, maroon, argillaceous	0.5
Sandstone and sandy shale, buff, micaceous	4.0
Shale, greenish-gray, argillaceous	6.0
(Total Bonner Springs shale, 15.0 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, dark-gray, suboölitic, massive, even-bedded, weathers into thin laminae	11.0
Shale, covered, about	3.0
Limestone, dark gray, blocky, massive, dense, brittle, even-bedded, chert nodules rare	7.0
(Total Farley limestone member, 21.0)	
Island Creek shale member:	
Shale, mostly covered, gray, argillaceous	7.0
Argentine limestone member:	
Limestone, light gray, thin-bedded, wavy, cherty, dark and granular at the top, base covered	15+

14. *From railroad track over bluff to highway, east of the center of sec. 25, T. 12 S., R. 23 E.*

Plattsburg limestone:	
Limestone, buff, even-bedded, upper part mostly covered, blocky even layer at base	10+
Bonner Springs shale:	
Shale, buff, limy	2.0
Shale, maroon, argillaceous	0.1
Shale, yellowish-brown, nodular, limy	7.0
Shale, maroon, argillaceous	0.5
Shale, gray, covered	33.0
(Total Bonner Springs shale, 42.6 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, gray to pinkish, massive, crystalline, even-bedded	16.0
Shale, buff, argillaceous	4.0
Limestone, gray, massive, about	6.0
(Total Farley limestone member, 26.0)	
Island Creek shale member:	
Shale, covered, greenish, argillaceous	4.0
Argentine-Frisbie members:	
Limestone, light gray, thin-bedded, massive at top and base, cherty	28.0
(Total Wyandotte limestone, 58.0 feet)	

	Feet.
Lane shale:	
Shale, olive-gray to buff, argillaceous	45.0
Iola limestone:	
Raytown limestone member:	
Limestone, buff, evenly bedded, fossiliferous, massive	5.0
Muncie Creek shale member:	
Shale, gray at top with phosphatic nodules, black, fissile below	2.0
Paola limestone member:	
Limestone, dense, bluish-gray, covered.	

15. *West end of bridge, center of the north edge sec.* 13, *T.* 13 *S., R.* 23 *E.*

Stanton limestone:	
Captain Creek limestone member:	
Limestone, white to gray, fine-grained, zone of *Enteletes pugnoides,* partly eroded	4+
Vilas shale:	
Shale, gray to light buff, arenaceous, micaceous. An eight-inch bed of hard sandstone occurs near the top	13.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, bluish-gray, weathers buff, massive, argillaceous, weathers into thin, wavy laminae, zone of *Composita* sp. at the top	4.9
Shale, buff	0.1
Limestone, massive, granular	2.0
Shale, gray	0.2
Limestone, gray, streaked with buff, hard, brittle, zone of *Enteletes hemiplicatus* var. and *Marginifera wabashensis* near the middle	4.9
Hickory Creek shale member:	
Shale, gray and buff	0.3
Merriam limestone member:	
Limestone, gray, blocky, very fine-grained	1.0
Limestone, drab, granular, massive, zone of *Osagia* and *Myalina ampla, Composita* sp. at the base	2.0
(Total Plattsburg limestone, 15.4 feet)	
Bonner Springs shale:	
Shale, mostly covered, greenish-gray, argillaceous	21.0
Wyandotte limestone.	

16. *On road, starting north of the SE cor. sec.* 35, *T.* 12 *S., R.* 23 *E.*

Plattsburg limestone, remnant.	
Bonner Springs shale:	
Shale, covered, greenish-gray, argillaceous	26.0
Wyandotte limestone:	
Farley limestone member:	
Limestone and shale, partly covered, upper part is dark gray, massive limestone and weathers in thin laminae, lower part crystalline, drab, fragmental	23.0

	Feet.
Island Creek shale member:	
Shale, greenish-gray, argillaceous	3.0
Argentine limestone member:	
Limestone, whitish, hard, wavy, massive at top, becoming ferruginous at the base, cherty	11.0
Quindaro shale member:	
Shale, greenish-gray, argillaceous	1.0
Frisbie limestone member:	
Limestone, gray, massive, dense, evenly-bedded	4.0
(Total Wyandotte limestone, 42.0 feet)	
Lane shale:	
Shale, olive and argillaceous above, buff and arenaceous below, base covered	17+

17. *On road, center sec.* 12, *T.* 13 *S., R.* 22 *E.*

Stanton limestone:	
Captain Creek limestone member:	
Limestone; weathered remnant, zone of *Enteles pugnoides.*	
Vilas shale:	
Shale, grayish-buff, arenaceous, about	20.0
Plattsburg limestone:	
Limestone, poorly exposed, basal layer blocky and oölitic with *Osagia*	10.0±
Bonner Springs shale:	
Shale, not well exposed, buff, arenaceous, micaceous	12.0
Wyandotte limestone:	
Limestone, poorly exposed, whitish, hard, upper part crystalline, lower part cherty, irregular	39.0
Lane shale, covered.	

18. *Southeast cor. sec.* 7, *T.* 13 *S., R.* 23 *E.*

Plattsburg limestone.	
Bonner Springs shale:	
Shale, buff, arenaceous, poorly exposed	12.0
Wyandotte limestone:	
Farley limestone member:	
Limestone, thin-bedded, wavy, crystalline, pitted with brown, ferruginous inclusions	17.0
Island Creek shale member:	
Shale, greenish, argillaceous	2.0
Argentine-Frisbie members:	
Limestone, white and gray, massive, hard, wavy, thin-bedded at the middle, cherty, upper layer dark bluish, granular	27.5
(Total Wyandotte limestone, 46.5 feet)	
Lane shale:	
Shale, buff and gray, mostly argillaceous, some arenaceous material, blocky	44.0
Iola limestone:	
Limestone, gray, massive, mostly covered.	

19. *On road, by bridge, SW cor. sec.* 20, *T.* 13 *S., R.* 23 *E.*

Vilas shale.

Plattsburg limestone:

	Feet.
Spring Hill limestone member:	
Limestone, brown and gray, covered	6.0
Hickory Creek, shale member:	
Limestone, yellowish-brown, ferruginous, shaly	0.5
Shale, grayish-buff, argillaceous	0.3
Shale, brown, limy, ferruginous	0.2
Merriam limestone member:	
Limestone, gray, massive, block, dense, large "worm-borings"	1.3
Shale, gray, argillaceous	0.2
Limestone, drab, blocky, hard, in two layers, zone of *Osagia*	1.5
(Total Plattsburg limestone, 10.0 feet)	

Bonner Springs shale:

Shale, greenish, mostly covered, argillaceous in upper part	37.0

Wyandotte limestone:

Farley limestone member:	
Limestone, whitish, crystalline, thin-bedded, more massive at the top, fragmental, brecciated, somewhat cherty, abundant brown limonite inclusions	16.0
Island Creek shale member:	
Shale, gray, argillaceous	2.0
Argentine limestone member:	
Limestone, drab to bluish-gray, massive, suboölitic, contains silicified *Fistulipora* sp., *Myalina ampla, Allorisma* sp	2.0
Limestone, whitish to buff, thin-bedded and wavy, becoming massive and coarsely crystalline below the middle, again thin-bedded below, rather brittle and shattered throughout where not massive	22.0
Quindaro shale member:	
Shale, limy, buff	5.5
Frisbie limestone member:	
Limestone, gray, dense, very massive, in one layer	3.0
(Total Wyandotte limestone, 50.5 feet)	

Lane shale:

Shale, gray and buff, argillaceous, partly covered	40.0

Iola limestone:

Raytown limestone member:	
Limestone, ferruginous, soft, massive at the top, and in descending order, buff thinly laminated; gray, massive, granular, zone of productids; gray, shattery	6.0
Muncie Creek shale member:	
Shale, upper one foot gray clay, with phosphatic nodules, lower seven inches hard, black, platy shale	1.6
Paola limestone member:	
Limestone, bluish, dense, contains "marklets"	1.0
(Total Iola limestone, 8.6 feet)	

Chanute shale.

20. *North of the middle of each side sec. 28, T. 13 S., R. 23 E.*

Stanton limestone:

	Feet.
Olathe limestone member:	
Limestone, bluish, thin-bedded, weathers buff, partly eroded....	10+
Eudora shale member:	
Shale, argillaceous, olive-green, a thin carbonaceous layer near the base	6.0
Captain Creek limestone member:	
Limestone, bluish-gray, at top dense, blue and pink, siliceous; below, bluish-gray, finely granular, contains zone of *Enteletes pugnoides* and a few *Osagia*	5.0
Vilas shale:	
Shale, light-buff, faintly greenish, arenaceous, mostly covered, base covered	16+

21. *Road cut, west side of east branch of Cedar Creek, center south edge sec. 29, T. 13 S., R. 23 E.*

Stanton limestone:

Captain Creek limestone member:	
Limestone remnant, dark gray, fine-grained, zone of *Enteletes pugnoides.*	
Vilas shale:	
Shale, grayish-buff, arenaceous	11.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab, granular, massive.....	4.0
Limestone, gray, dense, hard, even-bedded, zone of *Enteletes hemiplicatus* var. and *Marginifera wabashensis*	3.0
Hickory Creek shale member:	
Limestone, ferruginous, shaly	1.0
Shale, dark greenish-gray, argillaceous	0.2
Limestone, ochery, argillaceous, soft	1.0
Merriam limestone member:	
Limestone, dark gray, dense, blocky.....	0.7
Limestone, dark gray, fine-grained, blocky, zone of *Osagia* and *Myalina ampla*	0.8
(Total Plattsburg limestone, 10.7 feet)	
Bonner Springs shale:	
Shale, buff, arenaceous, micaceous	1.5
Shale, dark-gray, argillaceous	1.0
Shale, limy, brown, nodular, "marlite".....	3.0
Shale, greenish-gray, argillaceous	5.5
Shale, buff, arenaceous	16.0
(Total Bonner Springs shale, 27.0 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, brown or buff, drab when fresh, pinkish at top, thin-bedded, granular	5.0
Shale, yellowish, argillaceous and limy.....	0.2
Limestone, drab, thin-bedded, *Schizostoma catilloides*.....	5.5

	Feet.
Limestone, light-gray, massive, finely crystalline, with large crystals of calcite, abundant brown inclusions of limonite, fragmental	5.5
Limestone, drab, massive, dense, fossiliferous	5.5
(Total Farley limestone member, 21.7)	
Island Creek shale member:	
Shale, bluish-gray, argillaceous, fossiliferous	2.0
Argentine limestone member:	
Limestone, buff, upper part thin-bedded, wavy, cherty, *Myalina ampla* in granular dark layer near the top, lower part irregular, massive, pinkish to white	23.0
Quindaro shale member:	
Shale, buff to gray, hard, limy; carbonaceous at base	4.0
Frisbie limestone member:	
Limestone, buff, fragmental, shaly	0.5
Limestone, gray, massive, dense, even-bedded	2.0
(Total Wyandotte limestone, 53.2 feet)	
Lane shale.	

22. *Road cut, west side of west branch of Cedar Creek, east of the center of south edge of sec.* 30, *T.* 13 *S., R.* 23 *E.*

Vilas shale:	
Shale, buff, arenaceous, covered.	
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, mostly covered	5.0
Hickory Creek shale member:	
Shale, greenish-gray, argillaceous	0.2
Merriam limestone member:	
Limestone, gray, blocky, fine-grained, large "worm-borings"	1.0
Limestone, gray to white, oölitic, zone of *Myalina ampla* and *Osagia*	2.5
Limestone, brown, contains *Myalina ampla, Juresania nebraskensis,* and *Composita* sp.	2.0
(Total Plattsburg limestone, 10.7 feet)	
Bonner Springs shale:	
Shale, greenish, argillaceous, covered, contains ferruginous, limy "marlite" zone	2.0
Shale, maroon, argillaceous	1.0
Shale, buff and arenaceous below, greenish and argillaceous above,	16.5
(Total Bonner Springs shale, 19.5 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, gray, dense, even-bedded, blue and pink at the top, siliceous	5.0
Shale, greenish-gray, argillaceous	1.0
Limestone, granular, drab, thin-bedded	5.5
Limestone, light drab, crystalline, brown limonite inclusions, cherty near the middle, fossiliferous	5.5
(Total Farley limestone member, 17.0)	

	Feet.
Island Creek shale member:	
Shale, buff and gray, argillaceous, fossiliferous	2.0
Argentine limestone member:	
Limestone, whitish, irregularly bedded, cherty, base covered	20+

23. *At creek, NW cor. sec.* 10, *T.* 14 *S., R.* 23 *E.*

Stanton limestone:	
Olathe limestone member:	
Limestone, gray, thin-bedded, wavy, chert rare, crystalline, upper part eroded	8+
Eudora shale member:	
Shale, greenish-gray, argillaceous, thin carbonaceous zone near the base	11.0
Captain Creek limestone member:	
Limestone, gray, weathers white, massive, even-bedded, zone of *Enteletes pugnoides,* upper part brecciated, pink and blue, mottled, siliceous	5.5
Vilas shale:	
Shale, light buff, arenaceous	15.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab and gray, mostly covered	9.0
Hickory Creek shale member:	
Shale, yellow, limy, ferruginous	0.2
Shale, black, carbonaceous	0.2
Shale, yellow, limy, ferruginous	0.2
Merriam limestone member:	
Limestone, gray, dense, even, blocky, contains "worm-borings"	1.0
Shale, gray, limy	0.1
Limestone, drab, blocky, zone of *Osagia* and *Myalina ampla*	1.0
(Total Plattsburg limestone, 11.7 feet)	
Bonner Springs shale:	
Shale, gray, argillaceous	1.6
Shale, dark gray, carbonaceous	1.0
Shale, greenish-buff, arenaceous, "marlite" at top	5.0
Sandstone, greenish-buff, micaceous, base covered	1+

24. *Road cut west of center north edge sec.* 32, *T.* 13 *S., R.* 22 *E.*

Stanton limestone:	
Captain Creek limestone member:	
Limestone, gray and buff, zone of *Enteletes pugnoides,* eroded.	
Vilas shale:	
Shale, grayish-buff, arenaceous	12.0
Plattsburg limestone:	
Limestone, buff and gray, even-bedded, oölitic near the top below a *Composita* sp. bed, lower part covered, zone of *Enteletes hemiplicatus* var. *plattsburgensis* near the middle	25±

	Feet.
Bonner Springs shale:	
Shale, mostly covered, greenish, argillaceous at top, arenaceous in lower part, contains plant fossils	22.0
Wyandotte limestone:	
Limestone, bluish-gray, upper surface shown.	

25. *On road, south of the NW cor. sec. 22, T. 13 S., R. 22 E.*

Stanton limestone:	
Captain Creek limestone member:	
Limestone, dark gray, weathers buff, "sugary" texture, blocky and even-bedded, contains *Enteletes pugnoides,* partly eroded...	4+
Vilas shale:	
Shale, grayish-buff, arenaceous, faint greenish tint	14.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab, granular, massive above, thin-bedded and even below, cherty, weathers buff and brown, zone of *Enteletes hemiplicatus* var. *plattsburgensis* and *Marginifera wabashensis* at the middle	6.5
Hickory Creek shale member:	
Shale, buff to yellow, ferruginous	0.7
Merriam limestone member:	
Limestone, massive, gray, blocky, hard, contains "worm-borings,"	2.0
(Total Plattsburg limestone, 9.2 feet)	
Bonner Springs shale:	
Shale, covered	21.0
Wyandotte limestone.	

26. *Middle east edge sec. 14, T. 13 S., R. 22 E., west of schoolhouse*

Vilas shale.	
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, brown and buff, thin-bedded except at top, contains *Triticites irregularis, Enteles hemiplicatus* var. *plattsburgensis, Marginifera wabashensis*	5.5
Hickory Creek shale member:	
Shale, greenish-buff, argillaceous	0.3
Merriam limestone member:	
Limestone, gray, hard, blocky, fine-grained	1.0
Limestone, drab, blocky, contains *Osagia*	2.0
Limestone, drab, oölitic, *Osagia*	1.0
(Total Plattsburg limestone, 9.8 feet)	
Bonner Springs shale:	
Shale, greenish-buff, argillaceous	1.0
Shale, buff, marly	2.0
Shale, maroon, argillaceous	1.0
Shale, greenish, covered	29.0
(Total Bonner Springs shale, 33.0 feet)	
Wyandotte limestone.	

27. *East bluff of Kill Creek, Penner's ford, three fifths of a mile west of NE cor. sec.* 4, *T.* 13 *S., R.* 22 *E., on road*

	Feet.
Plattsburg limestone:	
Limestone, upper part brownish, cherty, covered, lower part (Merriam) gray, even-bedded with upper layer bluish, brittle, siliceous, containing "worm-borings," *Heliospongia ramosa* and *Heterocoelia beedei*	10+
Limestone, shaly, brown	1.0
Limestone, brown, soft	1.0
Bonner Springs shale:	
Shale, buff, limy	1.0
Conglomerate, cross-bedded, yellow and gray limestone pebbles in a matrix of dark gray, granular limestone, very fossiliferous, *Aviculopecten* n. sp., *Myalina* sp., *Hypselentoma perhumerosa,*	5.0
Shale, greenish-gray, argillaceous, sandy at places	25.0
Limestone, drab, thinly cross-bedded, coarsely granular, unfossiliferous	8.0
Shale, gray, argillaceous, mostly covered	14.0
(Total Bonner Springs shale, 53.0 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, gray, massive, cross-bedded, composed of fossil fragments, weathers drab to brown, contains numerous nautiloids, base covered	10+

28. *Middle south edge sec.* 24, *T.* 13 *S., R.* 21 *E.*

Stranger sandstone:	
Shale, buff, arenaceous, remnant.	
Stanton limestone:	
Little Kaw limestone member:	
Limestone, bluish, even-bedded, brittle, fine-grained, *Cancrinella boonensis, Composita* sp., algal "marklets"	1.0
Shale, buff, arenaceous, and sandstone	3.0
Limestone, platy, in thin, even laminae, peculiar light gray, chalky appearance	1.0
(Total Little Kaw limestone member, 5.0)	
Victory Junction shale member:	
Sandstone, reddish-brown, micaceous, fossiliferous	3.0
Olathe limestone member:	
Limestone, bluish-gray, thin-bedded, wavy, crystalline, more dense at the top, weathers gray except near the base, which is buff, contains *Aviculopecten* sp., *Triticites secalicus* (robust variety), *Marginifera wabashensis*	11.5
Eudora shale member:	
Shale, gray, argillaceous	3.0
Shale, black, carbonaceous, fissile	1.5
Shale, covered	1.5
(Total Eudora shale member, 6.0)	
Captain Creek limestone member:	
Limestone, dark gray, finely granular, siliceous, zone of *Enteletes pugnoides*	2+

29. *At bridge, two tenths of a mile south of SW cor. sec.* 33, *T.* 15 *S., R.* 22 *E.*

Vilas shale.
Plattsburg limestone:

	Feet.
Spring Hill limestone member:	
Limestone, buff, thin-bedded, partly covered	6.0
Merriam limestone member:	
Limestone, gray, blocky, hard, "worm-borings"	1.0
Shale, gray, argillaceous	0.2
Limestone, light-gray, oölitic, thin-bedded, zone of *Osagia* and *Myalina ampla*	3.5
Limestone, dark gray, blocky, crystalline, contains many *Composita* sp.	0.7
Limestone, granular, contains *Osagia*	1.5
(Total Merriam limestone member, 6.9)	
(Total Plattsburg limestone, 12.9 feet)	
Bonner Springs shale:	
Shale, greenish, argillaceous, brown limestone nodules in the upper part	9.0
Sandstone, gray and buff, thin-bedded, and micaceous	5.5
Limestone, arenaceous, cross-bedded, fossiliferous	5.0
Shale, covered	6.0
(Total Bonner Springs shale, 25.5 feet)	
Wyandotte limestone:	
Limestone, whitish, wavy-bedded, fossiliferous, base covered	10+

30. *At bridge, one tenth of a mile north of SW cor. sec.* 35, *T.* 15 *S., R.* 22 *E.*

Wyandotte limestone:	
Limestone, whitish, massive, crystalline with a fine ground mass, weathers brown with a pitted surface, upper part eroded	23+
Lane shale:	
Shale, bluish and buff, arenaceous, base covered	12+

31. *Road cut, NE cor. sec.* 17, *T.* 15 *S., R.* 23 *E.*

Vilas shale.	
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, brown, massive	3.0
Limestone, light-gray, oölitic	3.0
Limestone, bluish-gray, thin-bedded, cherty in the upper part	4.0
Merriam limestone member:	
Limestone, gray, dense, blocky, "worm-borings" at the top	1.0
Limestone, drab, *Myalina ampla-Osagia* zone, *Composita* sp. abundant at base	1.0
(Total Plattsburg limestone, 12.0 feet)	
Bonner Springs shale:	
Shale, greenish, argillaceous, soft	2.0
Limestone, brown, nodular, "spongy," marlite	1.0
Shale, maroon, argillaceous, streaked with vertical veins of ocher clay	3.0
Sandstone, buff, micaceous with some buff sandy shale at the top,	7.0
(Total Bonner Springs shale, 13.0 feet)	

	Feet.
Wyandotte limestone:	
Limestone, massive, gray, bluish at the top, hard, lower part covered	7+

32. *Railroad cut at Spring Hill, SE cor. sec.* 14, *T.* 15 *S., R.* 23 *E.*

Vilas shale.	
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab, granular, weathers buff	1.8
Shale, gray and brown, limy	0.2
Limestone, drab, soft, argillaceous, fossiliferous, weathers buff	1.0
Limestone, bluish-gray and buff, massive, granular, composed largely of minute fossil fragments, numerous thin, wavy streaks of carbonaceous limestone, *Composita* zone at top	4.0
Limestone, drab, massive, oölitic, fossil fragments	1.3
Shale, gray, limy	0.2
Limestone, drab, dense	0.6
Limestone, drab, hard, massive, wavy carbonaceous streaks, zone of *Enteletes hemiplicatus* var. *plattsburgensis* and *Marginifera wabashensis,* base covered	3+

33. *Road cut, center sec.* 30, *T.* 14 *S., R.* 25 *E.*

Wyandotte limestone:	
Farley limestone member:	
Limestone, partly eroded, gray, hard, wavy-bedded	27+
Island Creek shale member:	
Shale, covered, about	2.0
Argentine-Quindaro members:	
Limestone, whitish, massive, crystalline, irregularly bedded, cherty at top	16.0
Limestone, yellowish-brown, weathers massive, drab	20.0
Frisbie limestone member:	
Limestone, whitish to buff, massive, crystalline, soft, brown solution pits	3.0
Lane shale:	
Shale, buff and gray, argillaceous, uniform	27.5
Iola limestone:	
Limestone, gray, massive, blocky, weathers buff, bottom part covered.	

34. *Road cut, SE cor. sec.* 24, *T.* 14 *S., R.* 24 *E.*

Wyandotte limestone:	
Lane shale:	
Shale, olive to gray, argillaceous, mostly covered	22.0
Iola limestone:	
Limestone, upper part exposed, evenly bedded, gray, fine-grained, upper layer gray to white and crystalline, base covered	6+

35. *Near bridge, SE cor. sec.* 16, *T.* 14 *S., R.* 24 *E.*

Plattsburg limestone:	
Limestone, brown and gray, even-bedded, mostly covered.	
Bonner Springs shale:	
Shale, buff and gray, argillaceous, mostly covered	20+

36. *On road, one fourth mile west of NE cor. sec.* 19, *T.* 14 *S., R.* 25 *E.*

	Feet.
Wyandotte limestone:	
Farley limestone member:	
Limestone, white to bluish-gray, lower part very crystalline, "fragmental," *Juresania nebraskensis* and *Marginifera* sp. abundant, lower one and one half feet blocky and even.....	19.0
Island Creek shale member:	
Shale, gray, limy, fenestrated bryozoans abundant.....	6.0
Argentine limestone member:	
Limestone, light-gray, wavy-bedded, massive, except near the middle, where it is thin-bedded, fine-grained	38+

37. *On road, SE cor. sec.* 10, *T.* 14 *S., R.* 25 *E.*

Wyandotte limestone.	
Lane shale:	
Shale, grayish to buff, argillaceous	22.0
Iola limestone:	
Raytown limestone member:	
Limestone, evenly-bedded, gray, crystalline, more thin-beded below	4.5
Muncie Creek shale member:	
Shale, gray, with phosphate nodules.....	0.2
Paola limestone member:	
Limestone, dark bluish-gray, lithographic, blocky, contains abundant "marklets" and some worm-borings.....	1.5
Limestone, drak-gray, granular	0.3
(Total Iola limestone, 6.5 feet)	
Chanute shale:	
Shale, buff, argillaceous	4.0
Sandstone, buff, micaceous, soft	0.7
Shale, bluish-gray and buff, arenaceous, carbonaceous streak near the top with *Neuropteris* and *Cordaites*	15.0
"Marlite," greenish-brown, nodular, spongy	1.0
Shale, maroon, flaky, argillaceous	5.0
Shale, olive, argillaceous; small calcareous nodules.....	6.0
(Total Chanute shale, 31.7 feet)	
Drum limestone:	
Limestone, gray, upper surface gray, blocky.	
Quivira shale, covered.	
Westerville limestone, covered.	
Covered interval, to top of Drum limestone about.....	12±
Wea shale:	
Shale, gray, argillaceous, top and base covered.....	32+

38. *On road, SE cor. sec.* 34, *T.* 13 *S., R.* 25 *E.*

Chanute shale:	
Shale, brownish and buff, micaceous, arenaceous, upper part eroded	17+
Shale, maroon, argillaceous, flaky	4.0
Shale, olive, argillaceous, about	1.0

	Feet.
Drum limestone:	
Limestone, buff, thin-bedded, gray, massive at the base and top..	5.0
Quivira shale:	
Shale, olive, calcareous, and argillaceous	4.0
Westerville limestone:	
Limestone, dark-gray, massive, dense.....	4.5
Wea shale:	
Shale, argillaceous, gray and buff, lower part covered.....	11+

39. *On road, NE cor. sec.* 34, *T.* 13 *S., R.* 25 *E.*

Lane shale.	
Iola limestone:	
Raytown limestone member:	
Limestone, gray, weathers buff, massive, even-bedded, zone of large productids near the top	5.5
Muncie Creek shale member:	
Shale, gray, contains numerous phosphatic concretions.....	0.2
Paola limestone member:	
Limestone, dark bluish-gray, lithographic, "marklets" abundant, blocky	1.0
(Total Iola limestone, 6.7 feet)	
Chanute shale:	
Shale, limy, fossiliferous	1.0
Shale, buff, arenaceous, lower part covered.....	15+

40. *On road, SW cor. sec.* 15, *T.* 13 *S., R.* 25 *E.*

Lane shale.	
Iola limestone:	
Limestone, poorly exposed, gray and blocky above and lithographic, bluish, brittle below, with abundant algal "marklets,"	7.0
Chanute shale:	
Shale, gray, argillaceous, mostly covered, layer of maroon shale near base	22.0
Drum limestone:	
Limestone, gray, massive, irregularly bedded, weathers drab and buff	10.0
Quivira shale:	
Shale, gray, limy	2.0
Westerville limestone:	
Limestone, massive, drab, base covered.....	4.0
Wea shale:	
Shale, bluish-gray, argillaceous, base covered.....	30.5
Block limestone:	
Limestone, buff, *Chonetina* zone at base, probably represents only basal Block	0.5
Fontana shale:	
Shale, gray, argillaceous, base covered.....	6+

41. *On road, center of east edge sec.* 21, *T.* 13 *S., R.* 25 *E.*

Chanute shale:	
Shale, brown, arenaceous above, maroon and olive near base, mostly covered	25+

	Feet.
Drum limestone:	
Limestone, gray, weathers buff, massive, irregularly bedded, base covered	7±
Quivira shale:	
Shale, upper part maroon, lower half olive, nodular, limy, upper contact covered	4±
Westerville limestone:	
Limestone, drab, massive, weathers platy, base covered	5+

42. *On road, one fourth mile north of SW cor. sec.* 7, *T.* 13 *S., R.* 25 *E.*

Plattsburg limestone.	
Bonner Springs shale:	
Shale and sandstone, mostly covered	28.0
Wyandotte limestone:	
Limestone, mostly covered	22.0
Limestone, gray, massive, even-bedded	5.5
Lane shale:	
Shale, buff to gray, argillaceous, some sand	27.0
Iola limestone:	
Limestone, dark-gray, blocky, hard, only the upper surface exposed.	

43. *On road, SW cor. sec.* 4, *T.* 13 *S., R.* 25 *E.*

Drum limestone:	
Limestone, gray, thin-bedded, hard, cherty at top, contains *Campophyllum torquium*	6+
Quivira shale:	
Shale, upper part greenish with a thin carbonaceous, fissile layer, lower part buff with a brown marlite layer	10.5
Westerville limestone:	
Limestone, drab, massive, hard, makes a bench.	

44. *On road, near center sec.* 14, *T.* 13 *S., R.* 22 *E.*

Stanton limestone:	
Captain Creek limestone member:	
Limestone, dark-gray, blocky, zone of *Enteletes pugnoides,* upper part eroded	3+
Vilas shale:	
Shale, light-buff, arenaceous	16.5
Plattsburg limestone.	

45. *On road, NE cor. sec.* 23, *T.* 13 *S., R.* 22 *E.*

Plattsburg limestone:	
Limestone, upper part brown, massive, even-bedded, contains *Enteletes hemiplicatus* var., lower beds blocky, even, poorly exposed	10+

46. *On road, SW cor. sec.* 14, *T.* 12 *S., R.* 23 *E.*

Wyandotte limestone:	
Farley limestone and Island Creek shale members, covered.	
Argentine limestone member:	
Limestone, white, massive, wavy, cherty	11.0

	Feet.
Quindaro shale member:	
Limestone, buff, thin-bedded, shattered, shaly	5.0
Frisbie limestone member:	
Limestone, whitish, massive, dense	5.5
Lane shale.	

47. *Center west edge sec. 5, T. 12 S., R. 24 E., quarry at Quivira*

Plattsburg limestone.	
Bonner Springs shale:	
Shale, gray, argillaceous and buff, sandy, covered	27.5
Wyandotte limestone:	
Farley limestone member:	
Limestone, gray and brown, brittle, massive	6.5
Shale, gray, argillaceous	10.0
Limestone, light-gray, covered.	

48. *North edge sec. 5, T. 12 S., R. 24 E., at north end of Quivira Lake, beneath the dam*

Chanute shale.	
Drum limestone:	
Limestone, gray to whitish, thin-bedded and wavy, shaly at the top, contains *Campophyllum torquium*	12.0
Quivira shale:	
Shale, covered, includes shaly part of Westerville	13.0
Westerville limestone:	
Limestone, covered	2.0
Limestone, drab, fossiliferous	0.3
Shale, gray, calcareous, fossiliferous	1.0
Limestone, drab, oölitic, cross-bedded	2.0
Shale, gray, limy	0.2
Limestone, gray, argillaceous, fossiliferous, base covered	3+

49. *Bluff west of Quivira Lake, sec. 5, T. 12 S., R. 24 E.*

Plattsburg limestone, covered.	
Bonner Springs shale:	
Shale, covered, about	18.0
Conglomerate, drab, weathers buff, thin-bedded	4.0
Shale, buff, argillaceous	4.0
Wyandotte limestone:	
Farley limestone member:	
Limestone, drab, massive, dense and bluish-gray at base	7.0
Shale, buff, somewhat arenaceous	11.0
Limestone, brown, thin-bedded, covered, makes bench.	
Island Creek shale member:	
Shale, covered; from top of limestone above to top of Argentine,	11±
Argentine limestone.	

50. *On road, one fourth mile south of NW cor. sec.* 9, *T.* 13 *S., R.* 25 *E.*

Lane shale.
Iola limestone:

	Feet.
Raytown limestone member:	
Limestone, gray, massive, even-bedded, contains *Marginifera* sp. and *Heliospongia ramosa?*	5.0
Muncie Creek shale member:	
Shale, gray and buff, limy, contains *Chonetes* sp. and ellipsoidal phosphatic nodules	0.7
Paola limestone member:	
Limestone, dark, bluish-gray, lithographic, blocky, brittle, contains abundant algal "marklets"	1.5
(Total Iola limestone, 7.2 feet)	
Chanute shale:	
Shale, buff, partly covered, argillaceous, platy at top	20.0
Shale, maroon, platy, argillaceous	1.0
Shale, olive, platy, argillaceous	1.0
(Total Chanute shale, 22.0 feet)	
Drum limestone:	
Limestone, light-gray, thin-bedded, wavy, cherty near the top, *Campophyllum torquium* zone at the top	9.0
Quivira shale:	
Shale, olive, limy, carbonaceous, fissile near the base	5.5
Westerville limestone:	
Limestone, drab, massive, cross-bedded oölite, only the upper part exposed.	

51. *Quarry, SE cor. sec.* 14, *T.* 13 *S., R.* 24 *E.*

Wyandotte limestone:	
Limestone, drab, thin-bedded and oölitic, cross-bedded, upper part eroded	6+
Limestone, bluish-gray, thin-bedded, wavy, with thin yellowish shaly breaks	10.0
Lane shale.	

52. *On road near SW cor. sec.* 21, *T.* 13 *S., R.* 25 *E.*

Lane shale:	
Shale, olive, argillaceous, covered.	
Iola limestone:	
Raytown limestone member:	
Limestone, gray, even-bedded, massive, upper part buff, zone of large productids near top	4.0
Muncie Creek shale member:	
Shale, gray, limy, contains phosphatic nodules	0.5
Paola limestone member:	
Limestone, dark gray, lithographic, contains algal "marklets"	1.0
(Total Iola limestone, 5.5 feet)	
Chanute shale:	
Shale, covered	22.0

	Feet.
Drum limestone:	
Limestone, gray, mostly covered, thin-bedded, cherty, weathers buff, to base of Quivira shale	14—
Quivira shale, covered.	
Westerville limestone:	
Limestone, gray, massive, brittle, mostly covered.	

53. *On Frisbie road, center north edge sec.* 17, *T.* 12 *S., R.* 23 *E.*

Plattsburg limestone:	
Spring Hill and Hickory Creek members:	
Limestone, covered	8+
Merriam limestone member:	
Limestone, gray, massive, blocky, dense, "worm-borings"	1.0
Limestone, drab, blocky, in two layers, *Osagia-Myalina ampla* zone	2.0
Bonner Springs shale:	
Shale, green, argillaceous	5.0
Limestone, brown, nodular, spongy, "marlite"	0.2
Shale, maroon, argillaceous	0.5
Shale, covered, greenish-gray at top	27.0
(Total Bonner Springs shale, 32.7 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, buff or gray, thin-bedded, crystalline, "fragmental"	10.0
Shale, buff, argillaceous	0.5
Limestone, massive, light gray, crystalline, contains an abundance of productids	4.0
(Total Farley limestone member, 20.5)	
Island Creek shale member:	
Shale, buff, argillaceous, fossiliferous	1.5
Argentine-Quindaro members:	
Limestone, pinkish or blue, dense at top, remainder drab, gray, thin-bedded, chert nodules rare, wavy	22.0
Limestone, yellowish, partly covered, thin-bedded, shaly	10.0
Frisbie limestone member:	
Limestone, gray, hard, blocky, dense, "marklets"	2.0
(Total Wyandotte limestone, 56.0 feet)	
Lane shale.	

54. *On road, middle south edge sec.* 21, *T.* 13 *S., R.* 22 *E.*

Stanton limestone:	
Olathe limestone member:	
Limestone, gray, thin-bedded, wavy, crystalline, *Triticites secalicus, Spirifer dunbari,* and large crinoid stems, upper part eroded	6+
Eudora shale member:	
Shale, grenish-gray and argillaceous at top, mostly covered	11.0
Captain Creek limestone member:	
Limestone, gray, sugary textured, even-bedded, bright-blue mottled at upper surface, siliceous, zone of *Enteletes pugnoides*	4.5

	Feet.
Vilas shale:	
Shale, light grayish-buff, arenaceous	14.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, dark gray, granular, massive, *Composita* sp. zone	5.0
Limestone, drab, fine-grained	1.5
Limestone, gray, thin-bedded and even, dense, zone of *Enteletes hemiplicatus* var. *plattsburgensis*	5.0
Limestone, brown, ferruginous, fossiliferous	1.0
Hickory Creek shale member:	
Shale, buff, limy	0.2
Merriam limestone member:	
Limestone, bluish-gray, brittle, blocky, "worm-borings"	0.8
(Total Plattsburg limestone, 13.5 feet)	
Bonner Springs shale:	
Shale, greenish-gray, argillaceous, "marlite" near the lower part,	9.0
Shale, maroon, argillaceous	1.0
Shale, greenish-gray, platy, argillaceous	2.0
Sandstone, buff, micaceous, ripple-marked, and sandy shale	5.0
(Total Bonner Springs shale, 17.0 feet)	
Wyandotte limestone.	

55. *Road cut, concrete highway, just north of the middle north edge sec.* 6, *T.* 12 *S., R.* 24 *E.*

Lane shale:	
Shale, gray, argillaceous, mostly covered.	
Iola limestone:	
Limestone, brown and gray, hard, massive	2.0
Limestone, brown, shaly, shattery, sugary-textured	1.0
Limestone, brown, massive, mottled, lower part covered	2+
Limestone, bluish-gray, lithographic, and black fissile shale, covered.	
Chanute shale:	
Shale, covered, about	19.0
Drum limestone:	
Shale, very limy, nodular, fossiliferous, contains *Composita* sp., *Derbya crassa, Campophyllum torquium,* and numerous fenestellids and ramose bryozoans	1.0
Limestone, white, evenly-bedded, fine-grained, contains *Marginifera splendens,* base covered	5+
Quivira shale:	
Shale, covered, from top of main bed of Westerville to exposed part of Drum	22±
Westerville limestone:	
Limestone (not the top of the Westerville), gray, hard, dense	0.7
Limestone, drab, massive, suboölitic, fossiliferous	5.5
Wea shale.	
Shale, drab, limy, upper part exposed	4+

56. *On road, one tenth of a mile north of fork just southwest of Craig, NE cor. sec.* 35, *T.* 12 *S., R.* 23 *E.*

Plattsburg limestone.
Bonner Springs shale:

	Feet.
Shale, covered, upper part greenish-gray, argillaceous	16.0

Wyandotte limestone:
Farley limestone member:

Limestone, dark-gray, massive, granular	5.0
Limestone, gray, thin-bedded, "fragmental," limonite inclusions	16.0

Island Creek shale member:

Shale, greenish, argillaceous	5.0

Argentine limestone member:

Limestone, pinkish to white, thin-bedded, wavy, lower part cherty, contains *Heliospongia ramosa,* upper layer granular, *Myalina ampla*	15.0

Quindaro shale member:
Shale, covered.

57. *On road, middle south edge sec.* 7, *T.* 14 *S., R.* 22 *E.*

Stranger sandstone.
Stanton limestone:
Little Kaw limestone member:

Limestone, bluish-gray, arenaceous, blocky	1.5
Shale, buff, and sandstone	1.5
Limestone, bluish-gray, arenaceous, blocky	1.0

Victory Junction shale member.

58. *By bridge, on north-south road, near SE cor. sec.* 25, *T.* 14 *S., R.* 24 *E.*

Wyandotte limestone.
Lane shale:

Shale, olive-drab, argillaceous	17.0

Iola limestone:
Raytown limestone member:

Limestone, gray, even-bedded, hard, crystalline, contains *Marginifera splendens* and *Squamularia perplexa*	4.0

Muncie Creek shale member:

Shale, limy, buff, contains phosphatic nodules	0.5

Paola limestone member:

Limestone, bluish-gray, lithographic, contains numerous "marklets," blocky, brittle	1.5
(Total Iola limestone, 6.0 feet)	

Chanute shale:

Shale, buff, micaceous, arenaceous, contains a few plant fossils, upper part exposed	6+

59. *Bluff west of Choteau siding, east of the center sec.* 35, *T.* 12 *S., R.* 23 *E.*

Iola and Chanute:

Limestone bench, to the top of the Drum limestone	33±

Drum limestone:

Limestone, light-gray, thin-bedded, wavy, cherty, weathers drab, contains *Campophyllum torquium,* lower part covered	6+

60. *West of the center south edge sec. 5, T. 13 S., R. 22 E.*

Plattsburg limestone:
Spring Hill limestone member.
Hickory Creek shale member: Feet.
Shale, covered 20.0
Merriam limestone member:
Limestone, lithographic, bluish-gray, zone of *Heterocoelia beedei* and *Cancrinella boonensis* 1.0
Limestone, massive, even-bedded, gray 3.0
Bonner Springs shale:
Limestone, conglomerate, yellowish and gray limestone pebbles in a dark matrix, fossiliferous 0.6
Shale, gray, argillaceous, covered.

61. *Along creek near center of sec. 32, T. 12 S., R. 22 E.*

Plattsburg limestone:
Spring Hill limestone member.
Hickory Creek shale member:
Shale, gray, argillaceous, limestone nodules, mostly covered.... 20.0
Merriam limestone member:
Limestone and shale, mostly covered, upper layer lithographic, bluish-gray, zone of *Heterocoelia beedei* and *Cancrinella boonensis,* lower part cross-bedded, conglomeratic..... 15.0
Shale, gray, argillaceous, covered.

62. *NW cor. sec. 4, T. 13 S., R. 23 E.*

Plattsburg limestone:
Spring Hill limestone member.
Hickory Creek shale member:
Shale, yellowish-buff, argillaceous, contains abundant limestone nodules 20.0
Merriam limestone member:
Limestone, lithographic, bluish-gray, brittle, zone of amblysiphonellids and *Cancrinella boonensis*..... 0.8
Bonner Springs shale:
Shale, covered 3.0
Limestone breccia, drab to brown, thinly cross-bedded, small pebbles of yellow and gray limestone and fossil fragments, *Aviculopecten* n. sp., *Hypselentoma perhumerosa,* and trilobites, base covered ..... 13+
A few yards up the creek from 61 the next lower shale bed is exposed due to a reversal dip.
Limestone breccia (same as above), upper part eroded..... 7+
Shale, gray, argillaceous 15.0
Wyandotte limestone:
Farley limestone member:
Limestone, drab, soft, suboölitic, nautiloid zone, exposed in bed of creek.

63. *East bank of Captain creek on highway No.* 10, *Johnson-Douglas county line*

Glacial drift.
Stanton limestone:

	Feet.
Little Kaw limestone member:	
Limestone, gray, blocky, arenaceous below	1.5
Victory Junction shale member:	
Sandstone, brown, soft, micaceous	11.5
Shale, greenish-gray, argillaceous, streaked	1.2
Olathe limestone member:	
Limestone, gray, thin-bedded, wavy, fossiliferous, base covered	15+

64. *NW cor. sec.* 1, *T.* 14 *S., R.* 21 *E.*

Weston shale:
Shale, gray, argillaceous, upper part eroded.
Stanton limestone:

Little Kaw limestone member:	
Limestone, bluish-gray and buff, arenaceous	0.3
Shale, buff, arenaceous	1.0
Limestone, bluish, granular, blocky	0.3
(Total Little Kaw limestone member, 1.6)	
Victory Junction shale member:	
Shale, buff, micaceous, arenaceous	1.5
Shale, gray, argillaceous, platy	1.0
Shale, whitish, brecciated, limy	1.0
(Total Victory Junction shale member, 3.5)	
Olathe limestone member.	

65. *Quarry west of road, NW cor. sec.* 35, *T.* 12 *S., R.* 25 *E.*

Chanute shale.
Drum limestone:

Limestone, brown, arenaceous	1.0
Shale, brown, arenaceous	1.0
Limestone, greenish-gray, shaly, very fossiliferous, contains *Marginifera splendens, Teguliferina armata, Squamularia perplexa, Campophyllum torquium,* and bryozoans, about	1.0
Limestone, gray, dense, thin-bedded, wavy, cherty, contains *Marginifera splendens*	7.0
(Total drum limestone, 10.0 feet)	
Quivira shale:	
Shale, greenish, argillaceous, contains a six-inch carbonaceous layer near the base	4.0
Westerville limestone:	
Limestone, drab, oölitic, cross-bedded, weathers buff with a faint greenish tint, contains a few small mollusks, base covered	19.0

66. *Section two miles south of Martin City, Jackson county, Missouri, by concrete slab, south of creek*

Chanute shale, covered.
Drum limestone:

Limestone, ferruginous, granular, massive, weathers thin-bedded; contains *Campophyllum torquium*	3.2

	Feet.
Quivira shale:	
Shale, carbonaceous, some black and fissile	2.5
Wea shale:	
Shale, gray, argillaceous, base covered; limestone concretions near top (Westerville)	15.0

67. *Composite section eastward from concrete slab intersection one half mile north and one half mile east of Martin City, Mo.*

Chanute shale:	
Shale, covered.	
Shale, maroon, argillaceous	5+
Shale, olive, argillaceous	1.0
Drum limestone:	
Limestone, gray, thin-bedded, wavy, weathers brown, has crinoid stems, *Campophyllum torquium, etc.*	5.0
Quivira shale:	
Shale, light olive, argillaceous	1.5
Shale, black, fissile	0.5
Shale, greenish, argillaceous, some calcareous nodules	4.5
Westerville limestone:	
Limestone, heavy-bedded, drab, brown near top, upper foot nodular and mottled; contains large *Triticites irregularis*	5.0
Wea shale:	
Shale, bluish-gray below, buff above	35±
Block limestone:	
Limestone and shale, even, contains *Ambocoelia*	0.5
Shale, limy, dark	0.9
Limestone, ferruginous, granular, *Chonetina* zone at base	0.9
Fontana shale:	
Shale, gray, limy, fossiliferous, with algal nodules	5.7
Dennis limestone:	
Winterset limestone member:	
Limestone, massive, dark-gray, cross-bedded, oölitic, contains *Osagia*	8.5
Limestone, fine-grained, dove-colored, with black flint nodules, base covered	5.5

68. *Section at road cut on highway* 10-*S just east of the intersection with highway* 1-*E at Red Bridge farm, about four miles northeast of Martin City, Mo.*

Chanute shale:	
Shale, base exposed, maroon, argillaceous	4+
Shale, greenish, argillaceous	2.5
Drum limestone:	
Limestone; gray to buff, wavy and thin-bedded; *Campophyllum torquium* at the top	5.0
Quivira shale:	
Shale, greenish clay, with a foot of black fissile shale at the middle and calcareous nodules below	5.5

	Feet.
Westerville limestone:	
Limestone, upper layer oölitic, massive below, drab and buff, contains large *Triticites irregularis*	5.1
Fontana-Wea interval:	
Shale, mostly covered, upper fifteen feet gray and argillaceous..	37.0
Dennis limestone:	
Winterset limestone member:	
Limestone, poorly exposed, heavy bedded below, shaly zone above the middle, above dove limestone with black chert	25+
Stark shale member:	
Shale, with black fissile layer, base covered	7+

DETAILED SECTIONS, MIAMI COUNTY

69. *Section one fourth mile north of SE cor. sec.* 19, *T.* 15 *S., R.* 23 *E.*

Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, buff and brown, thin-bedded, upper part eroded, contains *Echinocrinus* sp., *Enteletes hemiplicatus* var. *plattsburgensis, Triticites irregularis*	3+
Merriam limestone member:	
Limestone, bluish-gray, dense, blocky, contains "worm borings"..	1.0
Bonner Springs shale:	
Shale, greenish-gray and buff, with green clay at top	7.0
Shale, nodular, ochery, limy, marlite	3.0
Shale, reddish-maroon and green, argillaceous	16.0
Shale, covered	5.5
(Total Bonner Springs shale, 31.5 feet)	
Wyandotte limestone:	
Limestone, drab, mottled, brittle, thin-bedded, wavy, contains *Cypridellina* sp., *Astartella* sp., *Composita* sp., base covered..	10+

70. *Middle west edge sec.* 31, *T.* 15 *S., R.* 23 *E.*

Stanton limestone:	
Limestone, dark-gray, blocky, fine-grained, mainly covered	2+
Vilas shale:	
Shale, gray and buff, argillaceous	5.5
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab, massive, granular, covered	5.5
Limestone, white above, brown below, thin-bedded, brittle, partly covered	5.5
Limestone, brown, thin-bedded	4.0
Merriam limestone member:	
Limestone, gray, hard, blocky	1.0
Limestone, white, oölitic, fossiliferous, contains *Osagia* and cephalopods	5.5
Limestone, dark gray, contains *Osagia*	1.0
(Total Plattsburg limestone, 22.5 feet)	

	Feet.
Bonner Springs shale:	
Shale, buff and gray at the top, argillaceous, mostly covered but maroon layer exposed eleven fee from the top, lower part covered	11+

71. *At bridge, near the SW cor. sec.* 1, *T.* 16 *S., R.* 24 *E.*

Wyandotte limestone:	
Limestone, gray, even-bedded, crystalline, lower part granular, upper part eroded	4+
Shale, buff, limy, contains numerous gastropods (Island Creek shale?)	2.0
Limestone, dark gray to drab, upper layer very dark, filled with fragmental shells; irregularly bedded, thin-bedded, finely crystalline	15.0
Limestone, gray, brittle, shattery, weathers back underneath the more massive ledge above	4.0
Limestone, gray, massive, irregularly bedded, wavy, base covered,	6+

72. *About two tenths of a mile east of the NW cor. sec.* 5, *T.* 16 *S., R.* 22 *E.*

Stanton limestone:	
Limestone, dark gray, hard, finely granular, mostly eroded	2+
Vilas shale:	
Shale, brownish to reddish buff, micaceous, very arenaceous	14±
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, brownish, thin-bedded, oölitic layers near the top, partly covered	6.0
Limestone, gray and buff, massive, irregularly bedded, contains *Enteletes hemiplicatus* var. *plattsburgensis* and *Marginifera wabashensis*	1.5
Hickory Creek shale member:	
Shale, yellowish, nodular, marly, with three inches of dark-gray shale at the middle	1.0
Merriam limestone member:	
Limestone, bluish-gray, dense, blocky, contains "worm-borings"..	1.5
(Total Plattsburg limestone, 10.0 feet)	
Bonner Springs shale:	
Shale, green, argillaceous, with a maroon layer below, base covered	6+

73. *Near the middle of the east side sec.* 26, *T.* 16 *S., R.* 21 *E.*

Stanton limestone:	
Olathe limestone member:	
Limestone, gray, thin-bedded, weathers white, not very fossiliferous, upper part eroded	11+
Eudora shale member:	
Shale, upper part greenish-gray, argillaceous, thin layer of black platy shale at the middle, lower part coveerd	11.0
Captain Creek limestsone member:	
Limestone, dark gray, massive, even-bedded, fine-grained, contains *Enteletes pugnoides* and *E. hemiplicatus* var. *plattsburgensis* and *Triticites* n. sp.	5.0

	Feet.
Vilas shale:	
Sandstone, buff, thin-bedded, hard, limy	2.0
Shale, gray, slightly arenaceous	11.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, brown covered	4.5
Limestone, gray and buff, *Composita* sp. zone	1.5
Limestone, drab, oölitic, contains oölitic chert nodules	1.8
Limestone, brownish, hard, oölitic	1.9
Merriam limestone member:	
Limestone, drab to whitish, blocky, oölitic, *Osagia* zone, fossiliferous	1.0
(Total Plattsburg limestone, 10.7 feet)	
Bonner Springs shale.	

74. *Just north of the SE cor. sec.* 2, *T.* 17 *S., R.* 21 *E.*

Vilas shale.	
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, gray, brittle, thin-bedded, wavy, some oölitic layers near the top	6.0
Hickory Creek shale member:	
Shale, yellowish-brown, limy	4.0
Merriam limestone member:	
Limestone, dark gray, brittle, blocky	1.5
Limestone, gray, brittle, hard, zone of *Composita* sp. at the base,	1.0
(Total Plattsburg limestone, 12.5 feet)	
Bonner Springs shale:	
Shale, greenish-gray, argillaceous, thin layer of maroon clay below, bottom part covered	5+

75. *NE cor. sec.* 13, *T.* 17 *S., R.* 21 *E.*

Vilas shale:	
Shale, grayish, arenaceous, mostly covered, about	20+
Plattsburg limestone:	
Spring Hill limestone and Hickory Creek shale members:	
Limestone, brownish and gray, thin-bedded, mostly covered, contains *Echinocrinus* sp. and *Fustulipora* sp	7.0
Limestone, yellowish-brown, shaly, grading above into harder limestone	3.5
Merriam limestone member:	
Limestone, gray, blocky, hard, "worm-borings"	1.0
Shale, gray, limy	0.2
Limestone, drab, full of fragmental fossils	0.7
Limestone, gray, hard, blocky, has a zone of *Composita* sp. at the base	1.2
(Total Plattsburg limestone, 13.6 feet)	
Bonner Springs shale:	
Shale, greenish, argillaceous	6.0
Shale, maroon, argillaceous	1.0

	Feet.
Shale, greenish-gray, argillaceous	10.0
Sandstone, brown, micaceous, contains fossil plant material	0.3
Shale, greenish-gray, argillaceous	5.5
(Total Bonner Springs shale, 22.8 feet)	
Wyandotte limestone:	
Limestone, gray and white, upper part somewhat pinkish, overlain by a drab, suboölitic layer; bottom part covered	3+

76. *About two tenths of a mile north of the SW cor. sec.* 4, *T.* 17 *S., R.* 22 *E.*

Stanton limestone:	
Olathe limestone member:	
Limestone, gray, crystalline, thin-bedded, wavy, uniform, upper part eroded	8+
Eudora shale member:	
Shale, buff and gray, argillaceous	5±
Shale, black, fissile	0.5
Captain Creek limestone member:	
Limestone, pink and blue at the top, "brecciated," hard, lower part covered.	

77. *About three tenths of a mile west of the center of the east edge sec.* 11, *T.* 18 *S., R.* 21 *E.*

Plattsburg limestone:	
Limestone, mostly covered, upper part eroded, contains abundant chert nodules and silicified specimens of *Heliospongia ramosa*?, basal beds blocky, suboölitic, upper part eroded	10+
Bonner Springs shale:	
Shale, greenish-buff, argilaceous with small irregular limestone nodules, mostly covered	21.0
Wyandotte limestone:	
Limestone, gray and whitish, weathers buff and brown, irregularly bedded, massive at the base, contains *Enteletes hemiplicatus* var. *plattsburgensis* and *Dielasma bovidens,* cherty at the top,	21.5
Lane shale:	
Shale and sandstone, buff, covered.	

78. *About a quarter of a mile west of the center east edge sec.* 23, *T.* 18 *S., R.* 21 *E.*

Iola limestone:	
Limestone, upper part covered, lower two feet (Paola) dark bluish-gray above and purplish below, dense, brittle, blocky, contains "worm-borings" and "marklets"	4+
Chanute shale:	
Shale, buff and arenaceous above, greenish and argillaceous below,	7.5
Shale, buff, limy, contains small yellowish limestone nodules	5.5
(Total Chanute shale, 13.0 feet)	
Drum limestone:	
Limestone, greenish-drab, weathers thin-bedded, small fragments of crinoid stems	3.0
Quivira shale:	
Shale, greenish, argillaceous, base covered	8+

79. *At NE cor. sec.* 24, *T.* 16 *S., R.* 22 *E.*

Lane shale.

Iola limestone:

	Feet.
Raytown limestone member:	
Limestone, gray, weathers buff to brown in the upper part, crystalline, sugary, even-bedded, in beds eight inches thick, veined, contains *Marginifera splendens* and a few *Osagia* in a layer near the top	10+
Muncie Creek shale member:	
Shale, gray, argillaceous, contains abundant dark-gray phosphatic nodules, some *Chonetes* sp.	0.7
Paola limestone member:	
Limestone, dark gray, brittle, blocky, contains "worm-borings" at top, "marklets" abundant, hummocky at the top	2.5
(Total Iola limestone, 13.2±)	
Chanute shale:	
Shale, gray and buff, arenaceous, papery, lower part not exposed,	20+

80. *Along railroad track, near center sec.* 33, *T.* 16 *S., R.* 23 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, brownish, even-bedded, weathered	4+
Muncie Creek shale member:	
Shale, gray, argillaceous, contains gray phosphatic concretions	0.3
Paola limestone member:	
Limestone, dark gray, lithographic, brittle, blocky, contains "worm-borings" at the upper part, and "marklets," top hummocky	2.5
Chanute shale:	
Shale, bluish-gray, arenaceous and micaceous	20.0
Coal, soft, impure (Thayer)	0.5
Shale, arenaceous, hard, buff, base covered	5+

81. *Railroad cut near the center of north edge sec.* 33, *T.* 16 *S., R.* 23 *E.*

Chanute shale:	
Sandstone, buff and gray, upper part eroded, thin-bedded, soft (Cottage Grove)	8+
Coal, soft, impure (Thayer)	0.3
Shale, greenish-gray, argillaceous	8.0
Shale, maroon, argillaceous	2.0
Shale, covered	11.0
Drum limestone:	
Limestone, drab, massive, base covered	2+

82. *At SE cor. sec.* 34, *T.* 16 *S., R.* 22 *E., road cut*

Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, tan, shaly, nodular, very soft, upper part eroded	2+
Limestone, gray, hard	0.7
Hickory Creek shale member:	
Shale, dark-greenish, silghtly carbonaceous	1.0

	Feet.
Merriam limestone member:	
Limestone, gray, massive, hard, *Osagia* abundant	3.0
Bonner Springs shale:	
Shale, buff, limy	1.0
Shale, greenish, argillaceous	4.0
Shale, maroon and yellow, argillaceous	0.5
Shale, greenish-yellow, limy, nodular	1.0
Shale, greenish, argillaceous	4.0
Sandstone, buff, soft, massive	5.5
(Total Bonner Springs shale, 16.0 feet)	
Wyandotte limestone:	
Limestone, pinkish and blue at the top, irregularly bedded, massive, slightly ferruginous, lower part covered	5+

83. *About two tenths of a mile south of NE cor. sec.* 22, *T.* 15 *S., R.* 22 *E.*

Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab and brown, oölitic zone near the top	10+
Hickory Creek shale member:	
Shale, tan, limy, nodular	1.5
Merriam limestone member:	
Limestone, drab, even-bedded, oölitic, *Osagia* zone	4.0
Bonner Springs shale:	
Shale, greenish, argillaceous, with small limestone nodules	6.0
Shale, maroon, argillaceous, with vertical streaks of yellowish clay,	1.5
Shale, olive-green, argillaceous	6.0
Sandstone, buff, micaceous	11.0
(Total Bonner Springs shale, 24.5 feet)	
Wyandotte limestone:	
Limestone, bluish and pink at the top, massive, dense, only the top exposed.	

84. *About four fifths of a mile south of NE cor. sec.* 22, *T.* 15 *S., R.* 22 *E.*

Plattsburg limestone:	
Limestone, upper part eroded, drab, blocky, contains large numbers of *Osagia*	2+
Bonner Springs shale:	
Shale, greenish, argillaceous, with small limestone nodules	3.0
Shale, maroon, argillaceous	1.5
Shale, green, small limestone nodules	5.0
Shale and sandstone, buff	10.0
(Total Bonner Springs shale, 19.5 feet)	
Wyandotte limestone:	
Limestone, pinkish and blue at the top; mostly massive, irregularly bedded, weathers buff, cherty; lower stratum brown, soft, pitted, nodular, contains *Echinoconchus semipunctatus* and pitted, nodular, contains *Echinoconchus semipunctata* and *Composita* sp.	12±
Lane shale:	
Shale, covered	18+

85. *SE cor. sec. 27, T. 16 S., R. 22 E., composite section*

	Feet.
Vilas shale:	
Shale, brown and buff, arenaceous, upper part eroded	15+
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, gray, oölitic near the top, with bed of *Composita* sp.; cherty and thin-bedded near the middle, with *Triticites irregularis, Heliospongia ramosa,* poorly exposed	13+
Hickory Creek shale member:	
Shale, tan, limy, nodular	1.0
Merriam limestone member:	
Limestone, gray, blocky, fine-grained, contains "worm-borings" at the top	1.0
Limestone, buff and gray, thin-bedded, arenaceous below, grading upward into an *Osagia* bed	4.0
Bonner Springs shale:	
Shale, gray, argillaceous	5.5
Wyandotte limestone:	
Limestone, bluish and pink at the top, sugary; massive, whitish, irregularly bedded, and at the bottom ferruginous	14±
Lane shale:	
Shale, gray and buff, argillaceous, streaked by thin, hard, and brown ferruginous laminae	7.0
Sandstone, buff, soft	1.0
Shale, buff, sandy	13.0
Sandstone, buff, soft, micaceous	2.0
Shale, buff, sandy, lower part covered	15+

86. *Near the center south side sec. 27, T. 16 S., R. 21 E., road cut*

Stanton limestone:	
Limestone, whitish, poorly exposed.	
Vilas shale:	
Shale, brown, arenaceous, micaceous	20±
Sandstone, hard, gray, blocky	1.0
Shale, reddish-brown, arenaceous	5.0
Limestone, dark gray, granular, thin-bedded	1.0
Shale, green, argillaceous	4.5
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, gray, massive, rather even-bedded, some oölitic layers near the top, contains *Naticopsis altonensis, Pithodea broadheadi, Enteletes hemiplicatus* var. *plattsburgensis,* and others,	8.0
Hickory Creek shale member:	
Shale, tan, limy, nodular	4.5
Merriam limestone member:	
Limestone, drab, cross-bedded, oölitic, contains much fragmental fossil material	8.0
Limestone, gray, blocky, contains a zone of *Composita* sp. and *Myalina ampla*	1.5
(Total Plattsburg limestone, 22.0 feet)	

	Feet.
Bonner Springs shale:	
Shale, greenish-gray, argillaceous with a carbonaceous streak near the middle	5.0
Limestone, buff, nodular, "marlite"	0.2
Shale, greenish and maroon, argillaceous	1.5
Limestone, buff, nodular, "marlite"	0.2
Shale, maroon, argillaceous	1.0
Shale, greenish, bottom part covered	6+

87. *Near SW cor. sec.* 30, *T.* 16 *S., R.* 22 *E.*

Wyandotte limestone:	
Limestone, white, massive, irregularly bedded, weathers into thin laminae in places and where more massive becomes pitted with ferruginous spots	7+
Limestone, gray, weathers buff, oölitic, even, massive, not fossiliferous	4.0
Lane shale:	
Shale, gray and buff, arenaceous, lower part covered, upper part with thin streaks of hard, flaky limonite	45+

88. *Composite section, from center south side sec.* 7 *to center of the SW quarter sec.* 8, *T.* 16 *S., R.* 23 *E., along road*

Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, upper part covered, middle part yellowish-buff, soft, thin-bedded, has *Triticites irregularis, Hustedia mormoni,* and *Enteletes hemiplicatus* var. *plattsburgensis*	4+
Hickory Creek shale member:	
Shale, ton, limy	1±
Merriam limestone member:	
Limestone, gray, blocky, *Osagia* zone	2±
Bonner Springs shale:	
Shale, greenish, with a maroon streak at the bottom, poorly exposed	6.5
Sandstone and shale, gray, micaceous	5.0
(Total Bonner Springs shale, 11.5 feet)	
Wyandotte limestone:	
Limestone, gray, at the top bluish and pinkish, irregularly bedded, massive; fine-grained, brittle, thin-bedded below	15.5
Lane shale:	
Shale, gray, arenaceous, streaked with thin sheets of interbedded limonite	22.0
Sandstone, ferruginous, buff, micaceous, soft, with limonite concretions	27.0
Shale, gray and buff, blocky, arenaceous and micaceous, lower part covered	16.0
Shale, covered	40.0
(Total Lane shale, 105± feet)	
Iola limestone:	
Raytown limestone member:	
Limestone, gray, even-bedded, sugary-texture, fossiliferous	10.0

	Feet.
Muncie Creek shale member:	
Shale, gray, argillaceous, contains phosphatic nodules.....	0.7
Paola limestone member:	
Limestone, gray, brittle, blocky, "worm-borings" at the top, abundant "marklets"	2.5
(Total Iola limestone, 13.2 feet)	
Chanute shale.	

89. *About one tenth of a mile north of center of the east side of the SE one fourth sec.* 8, *T.* 16 *S., R.* 23 *E.*

Stanton limestone:	
Limestone remnant, whitish, contains *Triticites* sp.	
Vilas shale:	
Shale, gray, arenaceous	10.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, whitish, hard, even-bedded, with *Enteletes hemiplicatus* var. *plattsburgensis* and *Marginifera* sp.....	5.0
Hickory Creek shale member:	
Shale, tan, limy, nodular, with crinoid stems.....	5.0
Merriam limestone member:	
Limestone, dark gray, "worm-borings" at the top, blocky, brittle,	1.3
Limestone, gray, granular, contains *Osagia*.....	0.2
(Total Plattsburg limestone, 11.5 feet)	
Bonner Springs shale:	
Shale, greenish, argillaceous, mostly covered.	

90. *At the SE cor. sec.* 8, *T.* 16 *S., R.* 23 *E.*

Stanton limestone:	
Limestone, dark gray and pinkish, even-bedded, sugary, contains *Enteletes pugnoides, Heliospongia ramosa, Trachydoma wheeleri?, Triticites* n. sp., upper part eroded.....	5+
Vilas shale:	
Shale, covered	9±
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, tan and whitish, even-bedded, contains *Triticites irregularis,* large productids, *Enteletes hemiplicatus* var. *plattsburgensis*	5±
Hickory Creek shale member:	
Shale, tan, limy, nodular	5.0
Merriam limestone member:	
Limestone, blocky, even, upper layer brittle, dark gray, contains "worm-borings," lower layer gray, zone of *Osagia*.....	1.2
(Total Plattsburg limestone, 11.2± feet)	
Bonner Springs shale:	
Shale, greenish-gray, argillaceous, some sand.....	6.0
Shale, maroon and yellow clay.....	2.0
Shale, olive-green, argillaceous	8.0
Sandstone, cross-bedded, soft, buff.....	7.0
(Total Bonner Springs shale, 23.0 feet)	

	Feet.
Wyandotte limestone:	
Limestone, bluish-gray and pink, massive, irregularly bedded, veined, fine-grained	7+

91. *About one fourth mile east of the SE cor. sec.* 8, *T.* 16 *S., R.* 23 *E.*

Plattsburg limestone:	
Limestone, upper part covered, *Osagia* bed drab, thin-bedded, about three feet, with an eight-inch bed full of *Composita* sp. and *Myalina ampla*	10+
Bonner Springs shale:	
Shale, buff, argillaceous	5.0
Sandstone, buff, soft	1.0
Shale, dark-greenish, argillaceous	4.0
Shale, maroon, argillaceous, overlain by a thin layer of brown, marly shale	1.0
Shale, olive-green, with a thin layer of maroon clay at the middle, argillaceous	4.5
Sandstone, buff, cross-bedded, soft, micaceous, contains a few poorly preserved plants	9.0
Shale, olive-green, argillaceous	2.0
(Total Bonner Springs shale, 26.5 feet)	
Wyandotte limestone:	
Limestone, whitish, irregularly bedded, crystalline, pink and blue at the top surface, lower part not exposed.	

92. *Near the center of the SW one fourth sec.* 22, *T.* 16 *S., R* 23 *E.*

Iola limestone:	
Limestone, light-gray, remnant.	
Chanute shale:	
Sandstone, brown, thin-bedded	1.0
Shale, dark greenish-gray, argillaceous	2.0
Marlite, nodular, yellowish, spongy	0.7
Shale, greenish-gray, micaceous, arenaceous, papery	11.0
(Total Chanute shale, 14.7 feet)	
Drum limestone:	
Limestone, buff, with a faint greenish tint, ferruginous, massive, in one layer, contains numerous small crinoid segments, also *Spirifer dunbari, Chonetes* sp., *Marginifera splendens*	2.8
Quivira shale:	
Shale, greenish, argillaceous, with a thin layer of carbonaceous shale at the top, lower part covered.	

93. *Center of the east edge of sec.* 31, *T.* 16 *S., R.* 23 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, whitish to gray, even-bedded, weathers in thin beds, crystalline, sugary-texture, contains *Echinoconchus semipunctatus, Dictyoclostus americanus,* and *Marginifera splendens*	6±
Muncie Creek shale member:	
Shale, gray, argillaceous, with black phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark gray, even, blocky, "worm-borings" at the top, "marklets" abundant	2.5
(Total Iola limestone, 8.7± feet)	

	Feet.
Chanute shale:	
Shale, argillaceous, gray, base covered	21+

94. *South of the center sec.* 32, *T.* 16 *S., R.* 23 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, whitish, mostly eroded, sugary.	
Muncie Creek shale member:	
Shale, gray, argillaceous, has gray phosphatic concretions	0.2
Paola limestone member:	
Limestone, bluish-gray, dense, brittle, blocky, "worm-borings" at the top, abundant "marklets"	3.0
Chanute shale:	
Shale, buff and gray, arenaceous, with ferruginous material filling joint openings	16.0
Sandstone, buff, thin-bedded, soft	3.0
Shale, gray, arenaceous, contains a few gastropods, *Worthenia tabulata?*	1.0
Coal, soft, impure (Thayer)	0.2
Shale, argillaceous, greenish with small limestone nodules, lower part covered	16.0
(Total Chanute shale, 36.2 feet)	
Drum limestone:	
Limestone, light brown, massive, weathers in thin laminae, crinoid segments	3.0
Quivira shale.	

95. *Along the east edge of the SE one fourth sec.* 22, *T.* 16 *S., R.* 23 *E.*

Wyandotte limestone:	
Limestone, pinkish and brown, sugary, hard, irregularly bedded, cherty, contains *Wellerella osagensis* and *Dictyoclostus americanus*, mostly eroded	5+
Lane shale:	
Shale and sandstone, buff, gray, and greenish, not well exposed	83±
Iola limestone:	
Raytown limestone member:	
Limestone, gray, even-bedded, sugary, contains large productids,	7.0
Muncie Creek shale member:	
Shale, gray, argillaceous, has phosphatic nodules	0.2
Paola limestone member:	
Limestone, bluish, lithographic, "worm borings" at the top, numerous "marklets," base covered	1+

96. *Just west of the center of the east edge sec.* 22, *T.* 16 S., *R.* 23 *E.*

Lane shale.	
Iola limestone:	
Raytown limestone member:	
Limestone, whitish, sugary, even-bedded, blocky, contains large productids	7.0
Muncie Creek shale member:	
Shale, gray, with dark gray phosphatic nodules	0.2

Paola limestone member: Feet.
Limestone, bluish, dense, blocky, "worm-borings" at the top, "marklets" abundant 2.5
(Total Iola limestone, 9.7 feet)
Chanute shale:
Shale, greenish, with papery limonite laminae, arenaceous above, argillaceous below, chiefly covered ..... 20+

97. *At highway bridge, center of the south edge sec.* 15, *T.* 16 *S., R.* 23 *E.*

Iola limestone:
Raytown limestone member:
Limestone, gray, even-bedded, sugary, blocky, upper part eroded, 4+
Muncie Creek shale member:
Shale, gray, argillaceous, with black phosphatic nodules..... 0.7
Paola limestone member:
Limestone, bluish-gray, lithographic, blocky, brittle, upper part with "worm-borings," "marklets" abundant 2.5
Chanute shale:
Shale, gray, arenaceous and micaceous, with papery ferruginous laminae near the top 9.0
Sandstone, buff and gray, ripple-marked, soft, even-bedded:..... 4.0
Shale, greenish, argillaceous, with small calcareous concretions, poorly exposed 16.0
(Total Chanute shale, 29.0 feet)
Drum limestone:
Limestone, brown, ferruginous, massive, weathers in thin laminae, base covered ..... 2+

98. *At NE cor. of SW one fourth sec.* 9, *T.* 17 *S., R.* 23 *E., composite section from railroad cut to top of shale quarry, at Paola, Kansas; type exposure of Paola limestone.*

Lane shale:
Shale, gray and grayish-buff, blocky, somewhat arenaceous, more argillaceous toward the top where papery limonite laminae occur parallel to the bedding, top covered..... 68+
Iola limestone:
Raytown limestone member:
Limestone, light gray, even-bedded in beds about a foot thick, crystalline, sugary, very fossiliferous, *Cypridellina* sp., *Dictyoclostus portlockianus* var. *crassicostatus, Dielasma bovidens, Cancrinella boonensis, Chonetes granulifer?, Chonetes* sp., *Heliospongia ramosa,* etc. 6.0
Muncie Creek shale member:
Shale, gray, argillaceous, with black, phosphatic nodules..... 0.4
Paola limestone member:
Limestone, dark bluish-gray, dense, brittle, blocky, "worm-borings" at top, "marklets" numerous 1.5
(Total Iola limestone, 7.9 feet)
Chanute shale:
Coal, soft, impure (Thayer) 0.2
Shale, dark olive-green, argillaceous, poorly stratified..... 5.5
Limestone, brown, nodular, impure, "marlite"..... 1.0

	Feet.
Shale, maroon, argillaceous	1.0
Shale, greenish, argillaceous	1.0
Limestone, brown, nodular, "marlite"	1+
Shale, covered	6.0
(Total Chanute shale, 15.7 feet)	
Drum limestone:	
Limestone, buff, ferruginous, massive, has numerous small crinoid segments	2.5
Wea-Quivira shale:	
Shale, covered	34±
Block limestone:	
Limestone, bluish-gray, fine-grained, blocky, brittle, exposed in the creek bed.	

99. *At the center of the west edge sec.* 21, *T.* 17 *S., R.* 23 *E.*

Iola limestone:	
Limestone, upper part eroded, lower part dense, bluish-gray, has "worm-borings" and numerous "marklets"	1.5
Chanute shale:	
Shale, dark olive-green, small calcareous nodules	1.0
Shale, maroon, argillaceous	0.8
Shale, greenish-buff, marly	3.0
Shale, buff, arenaceous	5.0
(Total Chanute shale, 9.8 feet)	
Drum limestone:	
Limestone, brown, ferruginous, massive, in one layer, has small crinoid segments	3.0
Wea-Quivira shale:	
Shale, greenish, argillaceous, mostly covered	25+

100. *About one fourth of a mile east of the SW cor. sec.* 26, *T.* 17 *S., R.* 22 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, gray, crystalline, veined, sugary, even-bedded, has *Marginifera splendens* and large productids	7.0
Muncie Creek shale member:	
Shale, gray, limy, has black phosphatic nodules	0.4
Paola limestone member:	
Limestone, bluish-gray, lithographic, brittle, blocky	0.8
(Total Iola limestone, 8.2 feet)	
Chanute shale:	
Shale, buff, arenaceous	0.2
Coal, soft, impure (Thayer)	0.7
Shale, gray, argillaceous, underclay	2+

101. *SW cor. sec.* 35, *T.* 17 *S., R.* 22 *E.*

Drum limestone:	
Limestone, greenish-buff, weathers thin-bedded, has *Composita* sp. and *Osagia* at the top, small crinoid segments abundant	3+
Wea-Quivira shale:	
Shale, variegated greenish and maroon, some ferruginous layers with plant fossils, lower part covered	39+

Block limestone:

Limestone, dark gray, granular, blocky, brittle, just exposed in the creek.

102. *SW cor. sec.* 35, *T.* 17 *S.*, *R.* 22 *E.*

	Feet.
Plattsburg limestone:	
Limestone, upper part eroded, lower stratum drab, blocky, one foot thick, has abundant *Osagia*	9+
Bonner Springs shale:	
Shale, greenish-buff, argillaceous, has small calcareous nodules	5.5
Shale, maroon, argillaceous	1.5
Shale, buff, limy	0.5
Shale, olive-green, argillaceous	11.0
Sandstone, buff, and shale, gray, below	5.5
(Total Bonner Springs shale, 24.4 feet)	
Wyandotte limestone:	
Limestone, upper part whitish, irregularly bedded, cherty, with a dark granular layer at the top, lower third ferruginous, brown, shattery	14.0
Lane shale:	
Shale, gray and buff, argillaceous, some sandy material, lower part covered	15+

103. *At NW cor. sec.* 19, *T.* 17 *S.*, *R.* 22 *E.*

Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, upper part eroded, gray, even-bedded, hard, fine-grained, has *Enteletes hemiplicatus* var. *plattsburgensis*	3+
Hickory Creek shale member:	
Limestone, tan, nodular, shaly	2.0
Shale, gray, and yellow, argillaceous	0.3
Limestone, tan, shaly, nodular	1.0
Merriam limestone member:	
Limestone, gray, fine-grained, blocky, has "worm-borings" at the top	1.0
Limestone, drab, oölitic, has *Osagia*	1.2
Bonner Springs shale:	
Shale, greenish-gray, argillaceous, with small calcareous nodules,	6.0
Shale, maroon, argillaceous	1.0
Shale, greenish, argillaceous.	

104. *About two tenths of a mile west of northeast cor. sec.* 13, *T.* 17 *S.*, *R.* 22 *E.*

Bonner Springs shale.	
Wyandotte limestone:	
Limestone, whitish, stained brown and buff, irregularly bedded, crystalline near the top, cherty, has *Heliospongia ramosa*	11.0
Limestone, brown, ferruginous, massive, has zone of large productids	2.0
Limestone, drab, suboölitic	1.0
(Total Wyandotte limestone, 14.0 feet)	

	Feet.
Lane shale:	
Shale, gray, slightly arenaceous	22.0
Sandstone and shale, buff and gray	4.0
Sandstone, buff, with limonite concretions and plant fossils	3+

105. *At the center of the west edge of sec.* 19, *T.* 17 *S., R.* 22 *E.*

Plattsburg limestone:	
Spring Hill and Hickory Creek members:	
Limestone, white, hard, with a layer of yellowish, shaly, nodular limestone below, mostly eroded	5+
Merriam limestone member:	
Limestone, gray, blocky, fine-grained, has "worm-borings" at the top	1.5
Bonner Springs shale:	
Shale, olive-green, argillaceous, with small calcareous nodules	6.5
Shale, maroon, argillaceous	1.0
Shale, greenish, argillaceous	5.5
Sandstone and shale, buff	5.5
(Total Bonner Springs shale, 18.5 feet)	
Wyandotte limestone.	

106. *At the center of sec.* 9, *T.* 18 *S., R.* 22 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, upper part eroded, whitish and buff, even-bedded, sugary, has large productids and *Marginifera splendens*	6+
Muncie Creek shale member:	
Shale, buff, limy, has phosphatic nodules	0.3
Paola limestone member:	
Limestone, bluish-gray, lithographic, has *Heterocoelia beedei*, "marklets," and "worm-borings"	0.7
Limestone, bluish-gray, brittle, fine-grained	1.5
Chanute shale:	
Shale, buff, with a greenish tint, limy, with small calcareous nodules, rather poorly exposed	9.0
Drum limestone:	
Limestone, buff, with a greenish tint, massive, has two inches of shale a third from the base, *Osagia* at the top, small crinoid segments	5±
Wea-Quivira:	
Shale, greenish-gray and maroon, argillaceous, mostly covered	10+

107. *About one fourth of a mile west of the center sec.* 13, *T.* 18 *S., R.* 21 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, upper surface eroded, gray, even-bedded, fine-grained, crystalline, weathers buff, has a zone of *Dictyoclostus portlockianus* var. *crassicostatus* at the top, *Marginifera splendens*,	11+

	Feet.
Muncie Creek shale member:	
Shale, covered, with phosphatic nodules	0.4
Limestone, bluish-gray, lithographic, "worm-borings," "marklets" and *Heterocoelia beedei,* upper surface humocky	0.7
Limestone, dark gray, brittle	2.0
Chanute shale.	

108. *About one fourth of a mile south of northeast cor. sec.* 18, *T.* 18 *S., R.* 22 *E.*

Lane shale.	
Iola limestone:	
Raytown limestone member:	
Limestone, gray to whitish, massive, even-bedded, brittle, weathers into small angualr fragments, contains large productids, *Spirifer dunbari, Marginifera splendens,* etc	12.0
Muncie Creek shale member:	
Shale, gray, has phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark gray, upper half lithographic, with "marklets," "worm-borings," and *Heterocoelia beedei;* upper surface humocky, lower part granular	2.2
(Total Iola limestone, 14.4 feet)	
Chanute shale:	
Shale, greenish, some maroon streaks, argillaceous, mostly covered	8+

109. *Road cut center sec.* 20, *T.* 18 *S., R.* 22 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, gray, crystalline, poorly exposed	10+
Muncie Creek shale member:	
Shale, covered	0.3
Paola limestone member:	
Limestone, dark gray, lithographic, "worm-borings," "marklets," *Heterocoelia beedei*	1.5
Chanute shale:	
Shale, greenish, argillaceous, has small calcareous nodules	9.5
Drum limestone:	
Limestone, drab to buff, granular, cross-bedded with thin beds, has numerous small crinoid segments	4±
Wea-Quivira:	
Shale, covered	16+

110. *SW cor. sec.* 20, *T.* 18 *S., R.* 22 *E.*

Wyandotte limestone:	
Limestone, buff and white, crystalline, irregularly bedded, large chert nodules, has *Enteletes hemiplicatus* var. *plattsburgensis,*	5+
Lane shale:	
Shale, upper part gray and buff, arenaceous, with ferruginous laminae near the top, lower two-third greenish-gray, argillaceous	100+

	Feet.
Iola limestone:	
Limestone, gray, sugary, even-bedded, veined, has numerous large brachiopods, base covered	14+

111. *About one fourth of a mile south of the NE cor. sec.* 34, *T.* 18 *S., R.* 22 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, buff to gray, even-bedded, blocky, fine-grained, has *Marginifera splendens* and large productids	7+
Muncie Creek shale member:	
Shale, gray, has phosphatic nodules	0.2
Paola limestone member:	
Limestone, drak gray, upper six inches lithographic, with "worm-borings" and "marklets"; lower part fine-grained	3.5
Chanute shale:	
Shale, gray, calcareous, sandy, thin knife-edge of coal near the top, lower part not exposed	6+

112. *SE cor. sec.* 15, *T.* 17 *S., R.* 22 *E.*

Wyandotte limestone:	
Limestone, whitish and buff, cherty, irregularly bedded, has *Enteletes hemiplicatus* var. *plattsburgensis,* partly eroded	10+
Lane shale:	
Shale and sandstone, buff, mostly covered	106±
Iola limestone:	

113. *At the east side of the SE one fourth sec.* 4, *T.* 17 *S., R.* 22 *E.*

Stanton limestone.	
Vilas shale:	
Shale and sandstone, gray and buff	16.0
Plattsburg limestone:	
Spring Hill and Hickory Creek members:	
Limestone, mostly covered, brown and gray, with a tan nodular layer at the base	12.0
Merriam limestone member:	
Limestone, gray, blocky, even, "worm-borings" at the top, *Osagia* zone below	2.0
(Total Plattsburg limestone, 14.0 feet)	
Bonner Springs shale:	
Shale, dark olive-green, argillaceous, with small calcareous nodules	5.0
Limestone, nodular, yellowish, shaly, "marlite"	0.5
Shale, maroon, argillaceous	1.0
Shale, covered	16.0
(Total Bonner Springs shale, 22.5 feet)	
Wyandotte limestone:	
Limestone, buff, cherty, poorly exposed, irregularly bedded	12.0

	Feet.
Lane shale:	
Shale, gray, argillaceous, with thin ferruginous laminae, slightly arenaceous	10.0
Shale, buff, arenaceous	5.0
Sandstone and shale, buff	6.0
Shale, covered, to creek bed	22+

114. *About one fourth of a mile south of the NE cor. sec.* 4, *T.* 17 *S., R.* 22 *E.*

Plattsburg limestone:	
Hickory Creek shale member:	
Limestone, mostly eroded, tan, shaly, nodular	3+
Merriam limestone member:	
Limestone, gray, fine-grained, blocky, "worm-borings" at the top,	1.0
Limestone, drab, blocky, *Osagia* abundant	1.5
Bonner Springs shale:	
Shale, greenish-buff, arenaceous	2.0
Shale, olive-green, argillaceous	3.0
Shale, olive-green, argillaceous, with small calcareous nodules	4.0
Shale, maroon, argillaceous	0.3
Shale, light-greenish, argillaceous	2.0
Sandstone and sandy shale, ripple-marked and cross-bedded	10.0
(Total Bonner Springs shale, 21.3 feet)	
Wyandotte limestone:	
Limestone, whitish and buff, hard.	

115. *Just south of NE cor. sec.* 8, *T.* 17 *S., R.* 22 *E.*

Stanton limestone:	
Captain Creek limestone member:	
Limestone, whitish, thin-bedded, arenaceous toward the base, sugary, upper part eroded, poorly exposed	10+
Vilas shale:	
Shale, gray, arenaceous	11.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, drab and buff, massive at the top and more thin-bedded at the middle, not well exposed, has spines of *Echinocrinus* sp. at the top and *Enteletes hemiplicatus* var. *plattsburgensis*	10+
Hickory Creek shale member:	
Shale, tan, nodular, limy	2.0
Merriam limestone member:	
Limestone, gray, oölitic, cross-bedded, *Osagia* zone	5.5
(Total Plattsburg limestone, 17.5± feet)	
Bonner Springs shale:	
Shale, greenish-gray, arenaceous	6.5
Shale, buff, nodular, limy, "marlite"	0.2
Shale, variegated, maroon, yellow and green, argillaceous	4.0
Shale, greenish, argillaceous	5.5
Shale and sandstone, greenish-buff.	

116. *Just north of the center of the west edge sec.* 12, *T.* 17 *S., R.* 21 *E.*

Stanton limestone:
Captain Creek limestone member: Feet.
Limestone, drab and buff, sugary, brown chert nodules, thin-bedded, has *Triticites* n. sp. and *Enteletes pugnoides,* upper part eroded ..... 7+
Vilas shale:
Shale, gray-buff, arenaceous, micaceous..... 27.0
Plattsburg limestone:
Limestone, drab, massive, has echinoid spines, only the upper surface exposed.

117. *At the east side of the NE one fourth sec.* 15, *T.* 19 *S., R.* 22 *E.*

Iola limestone.
Chanute shale:
Sandstone and sandy shale, buff, micaceous ..... 25±
Coal, soft, impure (Thayer) 0.5
Shale, dark greenish-gray, argillaceous 3.0
Shale, greenish, argillaceous, with small calcareous nodules..... 8.0
(Total Chanute shale, 36.5 feet)
Drum limestone:
Limestone, greenish-drab, thin-bedded, has numerous small crinoid segments, granular, poorly exposed ..... 2±
Wea-Quivira shale:
Shale, gray and greenish, argillaceous, with layer of maroon shale, poorly exposed 6.0
Shale, greenish-buff, limy, with thin ferruginous laminae..... 11.0
Shale, covered 27.0
(Total Wea-Quivira shale, 44.0 feet)
Block limestone:
Limestone, dark gray, brittle, even-bedded, blocky, fine-grained.. 3.0
Fontana shale:
Shale, gray, argillaceous ..... 10±

118. *At NW cor. sec.* 16, *T.* 19 *S., R.* 22 *E.*

Iola limestone:
Raytown limestone member:
Limestone, covered ..... 6+
Limestone, gray, veined, even-bedded 2.5
Muncie Creek shale member:
Shale, gray, with phosphatic nodules..... 0.2
Paola limestone member:
Limestone, dark gray, even, blocky, "worm-borings" obscure at top, fine-grained 2.5
Chanute shale:
Sandstone and shale, buff and gray..... 30±
Coal, soft, impure (Thayer) 0.2
Shale, gray, argillaceous, covered.

119. *Just south of the NW cor. sec.* 13, *T.* 19 *S., R.* 21 *E.*

	Feet.
Wyandotte limestone:	
Limestone, whitish and buff near the top, brown and ferruginous near the bottom, irregularly bedded, crystalline, thin-bedded, contains *Lophophyllum profundum, Enteletes hemiplicatus* var. *plattsburgensis, Triticites irregularis, Squamularia perplexa,* etc.	20+
Lane shale:	
Shale, greenish-buff and gray, arenaceous, lower part not exposed,	15+

120. *About one fourth of a mile west of center west edge sec.* 18, *T.* 19 *S., R.* 23 *E.*

Wea-Quivira shale.	
Block limestone:	
Limestone, dark gray, blocky, fine-grained, even-bedded, brittle, *Triticites* sp., *Magnifera wabashensis,* bryozans	8.0
Fontana shale:	
Shale, greenish-gray, argillaceous, has small calcareous nodules..	12.0
Dennis limestone:	
Winterset limestone member:	
Limestone, drab and gray except at top where it is nearly black; fine-grained to dense, brittle, cherty, thin-bedded, even; has zone of *Triticites irregularis,* large variety of *Composita, Derbya crassa, Echinoconchus semipunctata* and *Juresania nebraskensis* at the top; base covered	18+

121. *SW cor. sec.* 3, *T.* 19 *S., R.* 23 *E.*

Dennis limestone:	
Winterset limestone member:	
Limestone, light gray, thin-bedded, even, dense, brittle, upper stratum nearly black, dark-gray and black chert nodules numerous in the upper half, thin layer of oölite below the middle, underlain by a layer of dense light-gray siliceous rock with silicified pleurotomarids (*Hypselentoma perhumerosa?*); lower part granular, crystalline, and veined; not very well exposed	30+
Galesburg-Stark interval:	
Shale, covered, contains some black platy layers	11.0
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab, massive, cross-bedded, oölitic, weathers in large, rounded pitted masses, lower part covered	10+

122. *At the west edge of the NE one fourth sec.* 10, *T.* 19 *S., R.* 23 *E.*

Fontana shale.	
Dennis limestone:	
Winterset limestone member:	
Limestone, black and dark gray, even-bedded, fine-grained, contains *Triticites irregularis,* large *Composita, Derbya crassa*....	5.5
Limestone, gray, fine-grained, thin-bedded, even, contains small nodules of black and gray chert	5.5

	Feet.
Limestone, gray, fine-grained, thin-bedded, even, with black and gray chert nodules, thin layer of oölite at the top	11.0
Limestone, drab, heavy-bedded, even, crystalline	5.5
(Total Winterset limestone member, 27.5 feet)	
Galesburg-Stark interval:	
Shale, covered	7±
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab, cross-bedded, oölitic, very massive, weathers in pitted rounded masses	13±
Limestone, gray to bluish, soft, thin-bedded, even, a few light-gray, chert nodules	14.0
Hushpuckney shale member:	
Shale, covered, has a layer of black platy shale	4±
Middle Creek limestone member:	
Limestone, bluish-gray, lithographic, blocky	0.4
Shale, buff, calcareous, with ramose bryozoans	0.4
Limestone, bluish-gray, lithographic, blocky	1.5
(Total Middle Creek limestone member, 2.3 feet)	
Ladore shale:	
Shale, gray, argillaceous, platy, thin limestone layer at the middle,	3.2
Limestone, gray, soft, argillaceous	0.4
Shale, greenish-buff, limy	2.0
(Total Ladore shale, 5.6 feet)	
Sniabar limestone:	
Limestone, brown, soft, massive, mostly covered.	

123. *Railroad cut, near center south edge of NW one fourth sec.* 12, *T.* 19 *S., R.* 23 *E.*

Dennis limestone:	
Winterset limestone member:	
Limestone, gray, hard, veined, mostly eroded, about	3+
Shark shale member:	
Shale, buff, argillaceous and limy, with a thin layer of black, platy shale at the base	6.0
Galesburg shale:	
Shale, buff, limy	3.5
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab, cross-bedded, oölitic, upper part nodular, shaly and irregular, purplish; has calcite-lined vertical cylindrical cavities, iron-stained, and measuring as much as two inches across by three feet long	5.5
Limestone, gray, thin-bedded, even, fine-grained, a small amount of white and gray chert, has many large productids, *Meekella striatocostata, Derbya crassa, Triticites irregularis?*, etc.	4+

124. *Center north edge of sec.* 13, *T.* 19 *S., R.* 23 *E., railroad cut*

Dennis limestone:	
Winterset limestone member:	
Limestone, buff and gray, veined, blocky	3+

	Feet.
Stark shale member:	
Shale, gray, argillaceous above, thin layer of carbonaceous shale at the base	5.5
Galesburg shale:	
Shale, buff, limy	4.5
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab at top, and oölitic with nodular layer above	3±
Limestone, gray, fossiliferous, even-bedded, cherty, thin-bedded, some buff shaly partings below	10.0
(Total Bethany Falls limestone member, 13.0± feet.)	
Hushpuckney shale member:	
Shale, gray, argillaceous, with a black platy layer at the middle	4.0
Middle Creek limestone member:	
Limestone, bluish, dense, lithographic, blocky, in two layers	2.0
Ladore shale:	
Shale, covered, about	5±
Sniabar limestone:	
Limestone, brown, ferruginous, massive, poorly exposed	6±

125. *Center of the west edge of sec.* 13, *T.* 19 *S., R.* 23 *E.*

Swope limestone:	
Bethany Falls limestone member:	
Limestone, white, cherty, makes bench.	
Hushpuckney shale member:	
Shale, covered, to top of B. F. bench	14±
Middle Creek limestone member:	
Limestone, bluish-gray, lithographic, blocky, in two layers	2.0
Ladore shale:	
Shale, covered, to top of limestone above	11±
Sniabar limestone:	
Limestone, ferruginous, brown, massive, base covered.	
Bourbon shale:	
Shale, covered, to top of Sniabar	10.0
Limestone, tan, nodular, ferruginous	2.0
Shale, greenish-buff, arenaceous, limy and nodular at the top	31.0
Sandstone, olive-gray, micaceous, lower part not exposed	5+

126. *At road intersection just east of the middle of the west edge of the NE one fourth sec.* 36, *T.* 18 *S., R.* 23 *E.*

Galesburg shale.	
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab, oölitic, cross-bedded, weathers in large pitted and rounded masses, unfossiliferous	7.0
Limestone, gray, even-bedded, thin-bedded, contains *Dictyoclostus portlockianus* var. *crassicostatus* and *Triticites irregularis*	11.0
Shale, buff, limy, fossiliferous	0.5

	Feet.
Limestone, dark gray, fine-grained	0.7
Shale, buff, limy	0.2
Limestone, gray, hard, fine-grained	2.0
(Total Bethany Falls limestone member, 21.4 feet)	
Hushpuckney shale member:	
Shale, gray, argillaceous above, lower half black, platy	4.5
Middle Creek limestone member:	
Limestone, bluish-gray, lithographic, blocky, weathers whitish	2.1
Ladore shale:	
Shale, gray, argillaceous, lower part covered	5+

127. *Near center west edge of NW one fourth sec.* 36, *T.* 18 *S., R.* 23 *E.*

Block limestone:	
Limestone, bluish-gray, fine-grained, even, thin-bedded, blocky, upper part eroded	3+
Fontana shale:	
Shale, olive-green, argillaceous, with a few small calcareous nodules	18±
Dennis limestone:	
Winterset limestone member:	
Limestone, black and dark gray, brittle, fine-grained, zone of *Triticites irregularis, Derbya crassa, Juresania nebraskensis,* and a giant variety of *Composita;* only the upper part exposed.	

128. *Just west of the SE cor. sec.* 1, *T.* 18 *S., R.* 22 *E.*

Chanute shale.	
Drum limestone:	
Limestone, greenish-buff, ferruginous, weathers brown and thin-bedded, has a large number of small crinoid segments	2.5
Wea-Quivira shale:	
Shale, buff, argillaceous	1.0
Shale, black, carbonaceous, fissile	1.0
Shale, covered	32.0
Block limestone:	
Limestone, dark gray, even, thin-bedded, fossiliferous, only upper surface exposed.	

129. *Just west of the center of the east edge sec.* 12, *T.* 18 *S., R.* 22 *E.*

Chanute shale:	
Shale, upper part eroded, greenish-buff, limy	8+
Drum limestone:	
Limestone, greenish-buff, and interbedded shale, thin-bedded, has a few *Osagia,* granular	2.5
Limestone, brown, drab where fresh, fine-grained, massive, in one layer, a few small crinoid segments	3.5
(Total Drum limestone, 6.0 feet)	

	Feet.
Quivira shale:	
Shale, buff, limy	0.4
Shale, olive-buff, blocky, argillaceous	1.4
Shale, black, carbonaceous, blocky, contains orbiculoids in unusual abundance	1.0
Shale, black, fissile, hard	1.8
(Total Quivira shale, 4.6 feet)	
Wea shale:	
Shale, buff and gray, argillaceous	4.0
Shale, gray, argillaceous, hard, with a layer of pyritiferous nodules at the top, lower part covered	16.0
(Total Wea shale, 20.0 feet)	
Block limestone:	
Limestone, forms bench, covered.	
Fontana shale:	
Shale, covered, to top of Block limestone	17±
Dennis limestone:	
Winterset limestone member:	
Limestone, poorly exposed, drab to gray, rather thick-bedded, even, has *Triticites irregularis,* only upper part exposed.	

130. *At bridge, center east side sec.* 17, *T.* 18 *S., R.* 23 *E.*

Winterset limestone:	
Limestone, light-gray, cherty, weathered remnant.	
Galesburg-Stark interval:	
Shale, gray, argillaceous above, and black, fissile below the middle; due to slumping the thickness cannot be measured, estimated at	9±
Bethany Falls limestone:	
Limestone, drab, oölitic, cross-bedded, very massive, weathers in great blocks, pitted, lower part not exposed	12+

131. *About one fourth mile west of the center of the east side sec.* 20, *T.* 18 *S., R.* 23 *E.*

Chanute shale:	
Shale, buff, platy, arenaceous, upper part eroded	6+
Coal, soft, impure (Thayer)	0.2
Shale, gray, underclay	0.5
Shale, olive-buff, argillaceous, lower part nodular and limy	16.0
Drum limestone:	
Limestone, drab with a faint greenish tint, weathers brown, fine-grained, massive, has numerous small crinoid segments	2.0
Quivira shale:	
Shale, olive-green, agrillaceous	3.0
Shale, block, carbonaceous, blocky	1.0
(Total Quivira shale, 4.0 feet)	
Wea shale:	
Shale, buff, and olive, argillaceous, layer of limonite concretions about five feet from the top	28.0
Block limestone:	
Limestone, dark gray, thin-bedded, even, some thin, limy shale partings, not very fossiliferous, base covered	3+

132. *About one fourth of a mile north of SW cor. sec.* 25, *T.* 18 *S., R.* 22 *E.*

	Feet.
Iola limestone.	
Chanute shale:	
Shale, buff and gray, arenaceous	5.0
Coal, soft, impure	0.05
Shale, buff and gray, arenaceous, platy, has some plant fragments	15.0
Coal, soft, impure (Thayer)	0.2
Shale, dark gray, underclay	6.0
Shale, buff, ferruginous and limy, nodular	5.0
(Total Chanute shale, 31.25 feet)	
Drum limestone:	
Limestone, greenish, and thin beds of arenaceous shale	2.0
Limestone, greenish-gray, massive, in one bed, has numerous small crinoid segments, also *Heliospongia ramosa?*	2.0
(Total Drum limestone, 4.0 feet)	
Wea-Quivira interval:	
Shale, mostly covered, with a thin layer of black, carbonaceous shale at the top, base covered	22+

133. *About one fourth mile south of NE cor. sec.* 35, *T.* 18 *S., R.* 22 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, whitish, thin-beded, even, sugary, contains large productids, upper surface eroded, overlain by residual chert cobbles	6+
Muncie Creek shale member:	
Shale, buff, limy, has a few phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark gray, blocky, even-bedded, fine-grained, upper surface hummocky and with "worm-borings," has "marklets"	3.0
Chanute shale.	

134. *NE cor. sec.* 3, *T.* 18 *S., R.* 23 *E.*

Wea shale.	
Block limestone:	
Limestone, bluish-gray, dense, blocky	0.8
Shale and interbedded thin limestone, gray, fossiliferous	1.2
Limestone, gray, blocky, fine-grained	0.8
Shale, gray, fosiliferous, has *Cyclotrypa?, Marginifera wabashensis,* etc.	0.3
Limestone, gray, hard, has "marklets"	0.7
Shale and thin limestone, gray	1.8
Limestone, buff, granular, argillaceous, lower part covered.	

135. *At the NE cor. sec.* 2, *T.* 18 *S., R.* 23 *E.*

Wyandotte limestone:	
Limestone, pinkish, and gray, crystalline, irregularly bedded, erosion remnant.	
Lane shale:	
Shale, olive-buff, argillaceous	16.0

Iola limestone:

	Feet.
Raytown limestone member:	
Limestone, gray, even, thin-bedded, fine-grained	5.0
Muncie Creek shale member:	
Shale, gray, has phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark gray, massive, "worm-borings" at the top, "marklets"	2.0
(Total Iola limestone, 7.2 feet)	
Chanute shale:	
Shale, olive and buff, argillaceous	8.0
Sandstone, limy, buff, soft	2.0
Shale, olive, argillaceous and arenaceous	5.5
Coal, soft, impure (Thayer)	0.2
Shale, olive, argillaceous, underclay	5.0
Shale, yellowish-green, marly, nodular, base covered	5+

136. *About one fourth mile north of SE cor. sec.* 2, *T.* 18 *S., R.* 23 *E.*

Iola limestone:	
Limestone, basal bed (Paola) remaining, dark gray, fine-grained, blocky, has "worm-borings" and "marklets"	2.0
Chanute shale:	
Shale, buff and gray, arenaceous, flaky	20.0
Coal, soft, impure (Thayer)	0.2
Shale, dark olive, argillaceous, underclay	5.5
Shale, buff, limy, nodular	5.5
(Total Chanute shale, 31.2 feet)	
Drum limestone:	
Limestone, olive-drab, massive, fine-grained, weathers brown, has abundant small crinoid segments	2.0
Wea-Quivira interval:	
Shale, gray and buff, arenaceous, not well exposed	11+

137. *About one fourth mile west of the NE cor. sec.* 36, *T.* 17 *S., R.* 23 *E.*

Wyandotte limestone:	
Limestone, whitish, coarsely crystalline, irregularly bedded, erosion remnant.	
Lane shale:	
Shale, gray and buff, argillaceous, slightly arenaceous in places	20.0
Iola limestone:	
Raytown limestone member:	
Limestone, whitish, thin-bedded, even, fine-grained, poorly exposed	5.0
Muncie Creek shale member:	
Shale, gray, with numerous phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark-gray, sugary, "worm-borings" and "marklets," hummocky at top	2.0
(Total Iola limestone, 7.2 feet)	
Chanute shale:	
Shale, buff and gray, arenaceous	22+

138. *About one fourth mile west of NE cor. sec.* 25, *T.* 17 *S., R.* 23 *E.*

	Feet.
Wyandotte limestone:	
Limestone, whitish, cherty, wavy-bedded, coarsely crystalline, upper part gone	4+
Lane shale:	
Shale, buff and gray, argillaceous	20.0
Iola limestone.	

139. *East of NW cor. sec.* 25, *T.* 17 *S., R.* 23 *E.*

Wyandotte limestone:	
Limestone, whitish, crystalline, wavy-bedded, weathers buff, mostly eroded.	
Lane shale:	
Shale, buff and olive, argillaceous	20.0
Iola limestone:	
Raytown limestone member:	
Limestone, gray, thin-bedded, even, weathers brown, fine-grained, fossiliferous, about	7.5
Muncie Creek shale member:	
Shale, gray, argillaceous, has phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark gray, sugary, has "worm-borings" at the top, "marklets"	2.5
(Total Iola limestone, 10.2 feet)	
Chanute shale:	
Shale, covered	33.0
Drum limestone:	
Limestone, brown, massive, fine-grained, weathers in thin laminae, has many small crinoid segments	2.0
Wea-Quivira shale.	

140. *At NW cor. sec.* 24, *T.* 17 *S., R.* 23 *E.*

Iola limestone.	
Chanute shale:	
Sandstone, buff, and sandy shale, even-bedded, micaceous	14.0
Shale, argillaceous, gray, sandy in places	5.5
Coal, soft, impure (Thayer)	0.3
Shale, gray, argillaceous, blocky, underclay	4.0
Shale, ferruginous, limy, with limonite concretions	2.0
Shale, olive and buff, arenaceous, platy	8.0
(Total Chanute shale, 33.8 feet)	
Drum limestone:	
Limestone, drab and brown, massive, ferruginous, has many small crindid segments	2.5
Wea-Quivira shale.	

141. *About three tenths of a mile west of the NE cor. sec.* 14, *T.* 17 *S., R.* 23 *E.*

Wyandotte limestone:	
Limestone, white, coarsely crystalline, erosion remnant.	
Lane shale:	
Shale, covered	38+

	Feet.
Iola limestone:	
Raytown limestone member:	
Limestone, whitish, thin-bedded, even, sugary, has many productids	6.5
Muncie Creek shale member:	
Shale, gray, contains phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark gray, sugary, "worm-borings," "marklets," upper surface hummocky	2.5
(Total Iola limestone, 9.2 feet)	
Chanute shale:	
Shale, covered	9.0
Drum limestone:	
Limestone, brown, drab where fresh, massive, in one layer, fine-grained, has many small crinoid segments	2.5
Wea-Quivira shale.	

142. *At the SE cor. sec.* 10, *T.* 17 *S., R.* 23 *E.*

Wyandotte limestone:	
Limestone, whitish, coarsely granular, irregularly bedded, blocky bed at base, upper part eroded	6+
Lane shale:	
Shale, covered	33.0
Iola limestone:	
Raytown limestone member:	
Limestone, whitish, fine-grained, thin-bedded, even, fossiliferous,	7.0
Muncie Creek shale member:	
Shale, covered, with phosphatic nodules	0.2+
Paola limestone member:	
Limestone, upper part bluish-gray, lithographic, with "marklets" and "worm-borings," lower part dark-gray and sugary	1.5
(Total Iola limestone, 8.7± feet)	
Chanute shale:	
Shale, covered	8.5
Drum limestone:	
Limestone, brown, ferruginous, massive, has many small crinoid segments	2.5
Wea-Quivira shale:	
Shale, olive and gray, argillaceous, mostly covered	32.0
Block limestone:	
Limestone, dark gray, fine-grained, even-bedded, blocky, some thin shale partings, base covered	5+

143. *About one fourth of a mile west of NE cor. sec.* 19, *T.* 17 *S., R.* 23 *E.*

Wyandotte limestone:	
Limestone, whitish, crystalline above; brown, ferruginous below, shattery	7+
Lane shale:	
Shale, olive-buff, argillaceous above grading to arenaceous below,	10.0
Sandstone, micaceous, buff	0.2
Shale, buff, arenaceous, flaky	5.0

	Feet.
Sandstone, buff, micaceous	0.2
Shale, buff, arenaceous, micaceous, flaky	6.0
Sandstone, buff, even-bedded, micaceous	2.0
Shale, olive-drab to buff, argillaceous, only slightly sandy	82.0
(Total Lane shale, 105.4 feet)	

Iola limestone.

144. *Near center sec.* 29, *T.* 16 *S., R.* 24 *E.*

Wyandotte limestone:

Limestone, white, thick-bedded, irregular, coarsely crystalline, with brown inclusions of limonite, upper part eroded, basal bed blocky, gray, fine-grained	12+

Lane shale:

Shale, olive-buff, argillaceous, uniform, base covered	50+

145. *Road cut at SE cor. sec.* 14, *T.* 16 *S., R.* 24 *E.*

Wyandotte limestone:

Limestone, brown and whitish, thin-bedded, irregular, with shaly partings, cherty, upper part eroded	16+
Limestone, whitish and pink, mottled brown, fine-grained with larger calcite specks, massive	7.0

Lane shale:

Shale, covered	38+

146. *At NE cor. sec.* 14, *T.* 16 *S., R.* 24 *E.*

Bonner Springs shale.

Wyandotte limestone:

Limestone, white and massive at the top; thin-bedded and wavy with ferruginous shaly partings and chert nodules below, *Dielasma bovidens, Marginifera* sp., and *Echinoconchus semipunctatus*	22.0
Limestone, light-gray, thick-bedded, even, massive, coarse grains in a fine matrix	6.0
(Total Wyandotte limestone, 28.0 feet)	

Lane shale:

Shale, olive, argillaceous, lower part covered	8+

147. *At the SE cor. sec.* 30, *T.* 17 *S., R.* 24 *E.*

Wyandotte limestone:

Limestone, whitish to pink, soft, irregularly-bedded, crystalline, with a single layer of blocky, gray limestone at base, upper part eroded	4+

Lane shale:

Shale, olive-drab, argillaceous, flaky	23.0

Iola limestone:

Raytown limestone member:

Limestone, gray, blocky, sugary, weathers buff and mottled, even-bedded, has many productids	5.0

Muncie Creek shale member:

Shale, gray, with phosphatic nodules	0.2

	Feet.
Paola limestone member:	
Limestone, dark bluish-gray, sugary, upper part with "worm-borings," has a few "marklets"	2.0
(Total Iola limestone, 7.2 feet)	
Chanute shale:	
Shale, covered, argillaceous, greenish	37.0
Drum limestone:	
Limestone, brown, ferruginous, massive, has many small crinoid segments, only upper surface exposed.	

148. *At the NW cor. sec.* 31, *T.* 17 *S., R.* 24 *E.*

Plattsburg limestone:	
Limestone, gray, hard, cherty, contains spines of *Echinocrinus* sp., *Triticites irregularis,* and many silicified specimens of *Heliospongia ramosa,* erosion remnant.	
Bonner Springs shale:	
Shale, greenish, argillaceous, mostly covered	12±
Wyandotte limestone:	
Limestone, light gray, upper part thin-bedded and cherty, lower half massive, wavy-bedded, crystalline, with a single blocky layer at the base	12.5
Lane shale:	
Shale, drab to light-olive, argillaceous, uniform	22.0
Iola limestone:	
Limestone, dark gray, sugary, even-bedded, with bluish-gray, dense, blocky bed (Paola) at the base, contains "worm-borings" and "marklets," base covered	7+

149. *About one fourth of a mile west of the SE cor. sec.* 31, *T.* 17 *S., R.* 24 *E.*

Iola limestone:	
Raytown limestone, Muncie Creek shale, covered.	
Limestone, whitish, sugary, erosion remnant.	
Paola limestone member:	
Limestone, bluish-gray, fine-grained, has phosphatic nodules at the upper surface, has "worm-borings" and "marklets"	1.0
Chanute shale:	
Shale, gray and buff, argillaceous	3.0
Shale and sandstone, buff, micaceous	22.0
Coal, soft, impure (Thayer)	0.2
Shale, olive, argillaceous	13.0
(Total Chanute shale, 38.2 feet)	
Drum limestone:	
Limestone, brown, or greenish where fresh, massive, has many small crinoid segments, lower part covered	2+

150. *At the south side of the SW one fourth sec.* 6, *T.* 18 *S., R.* 24 *E., type locality of Block limestone*

Chanute shale:	
Shale, greenish-gray and buff, upper part eroded	11+
Coal, soft, impure	0.05
Sandstone and shale, buff, less sandy at top	11.0
Coal, soft, impure (Thayer)	0.25

	Feet.
Shale, dark olive, argillaceous, underclay	4.0
Shale, greenish-buff, limy, nodular	9.0
Drum limestone:	
Limestone, brown, drab where fresh, massive, has many small crinoid segments	2.0
Wea-Quivira shale:	
Shale, gray, argillaceous, some maroon shale near the top, poorly exposed	19.0
Sandstone, brown, fine, slabby	1±
Shale, mostly covered, trace of maroon in the middle, olive-buff at the top	27.0
(Total Wea-Quivira shale, 47.0± feet)	
Block limestone:	
Limestone, bluish-gray, fine-grained, blocky, has *Syringopora* sp. and *Triticites* sp.	5.0
Fontana shale:	
Shale, gray and buff, argillaceous	13.0
Dennis limestone:	
Limestone, black, dense at top, with zone of *Composita* sp. (giant variety), *Triticites irregularies, Derbya crassa, Dictyoclostus portlockianus* var. *crassicostatus, Juresania nebraskensis, Neospirifer dunbari,* etc., gray and even-bedded below, cherty	10+

151. *At the east side of the SE one fourth sec.* 6, *T.* 18 *S., R.* 24 *E.*

Wyandotte limestone:	
Limestone, whitish, irregularly-bedded, crystalline, veined, with a single blocky gray layer at the base	10+
Lane shale:	
Shale, olive, argillaceous, uniform	19.0
Iola limestone:	
Raytown limestone member:	
Limestone, gray, sugary, even-bedded, blocky, fossiliferous	5.5
Muncie Creek shale member:	
Shale, gray, with a few phosphatic nodules	0.2
Paola limestone member:	
Limestone, dark gray, fine-grained, "worm-borings" at the top and "marklets," hummocky at the top	3.0
(Total Iola limestone, 8.7 feet)	
Chanute shale.	

152. *Center of the south edge sec.* 18, *T.* 18 *S., R.* 24 *E.*

Dennis limestone:	
Winterset limestone member:	
Limestone, light gray, thin-bedded, even, oölitic at the top with some chert oölites, lower part coarse, very cherty, zone of silicified pleurotomarids thirteen feet from the base in a lithographic light-gray bed	28+
Stark shale member:	
Shale, gray above, argillaceous, black, fissile at the base	6.0
Galesburg shale:	
Shale, gray, argillaceous	5.0

Swope limestone:
Bethany Falls limestone member: Feet.
Limestone, gray, mottled, nodular, upper half made of loose nodules, soft 1.0
Limestone, light gray, dense, siliceous? 2.0
Limestone, thin-bedded, gray, a small amount of chert..... 7.5
Limestone, gray, blocky, sugary 1.0
Shale, buff, fossiliferous 0.2
Limestone, gray, hard, an occasional nodule of gray chert..... 1.3
Shale, buff, fossiliferous 0.2
Limestone, gray, hard, blocky, sugary, even..... 1.6
(Total Bethany Falls limestone member, 14.8 feet)
Hushpuckney shale member:
Shale, upper half gray, argillaceous, lower half black, fissile, carbonaceous 5.5
Middle Creek limestone member:
Limestone, bluish-gray, dense, blocky, even, in two layers, has fucoids?, *Derbya crassa, Chonetes* cf. *armatus* 1.3
Ladore shale:
Shale, gray and buff, argillaceous, poorly exposed..... 12±
Sniabar limestone:
Limestone, drab, soft, granular, massive, in a single layer, base covered ..... 4+

153. *Just west of the NE cor. sec.* 11, *T.* 18 *S., R.* 23 *E.*

Wea-Quivira shale.
Block limestone:
Limestone, bluish-gray, even, blocky, a few thin shaly partings, about 6.0
Fontana shale:
Shale, gray to buff, argillaceous, flaky, ferruginous streak near the base 14.5
Dennis limestone:
Limestone, black and dark-gray, even, fine-grained, zone of *Derbya crassa, Composita* sp. (very large), *Triticites irregularis* 6.0
Limestone, dark-gray, even, thin-bedded, separated from the above by a thin shale parting, very fossiliferous 6.0
Shale and thin soft limestone, buff..... 5.8
Limestone, gray, massive, even, black and gray chert nodules, lower part covered ..... 6+

154. *About one fourth mile east of SW cor. sec.* 22, *T.* 18 *S., R.* 24 *E.*

Fontana shale.
Dennis limestone:
Winterset limestone member:
Limestone, dark gray above with *Composita* sp. and *Derbya crassa,* cherty oölite at the middle and fine-grained, light gray below 6.0
Limestone, bluish-gray, mottled 0.5

	Feet.
Limestone, light gray, fine-grained, even, thin-bedded, blocky...	5.0
Limestone, light gray, fine-grained, even, thin-bedded, blocky, has white and gray chert nodules, veined	5.5
Limestone, gray, massive, even-bedded, veined, has many productids	11.0
(Total Winterset limestone member, 28.0 feet)	
Galesburg-Stark interval:	
Shale, mostly covered, black, fissile below the middle.....	9.0
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab, massive, oölitic, cross-bedded, massive, weathers in large, pitted, gray masses	4.5
Limestone, gray, shaly, thin-bedded.....	6.0
Limestone, gray, massive, weathers shattery	5.5
Limestone, gray, blocky, with an occasional chert nodule.....	0.8
Shale, buff, limy	0.3
Limestone, buff, wavy	0.1
Shale, buff	0.05
Limestone, gray, blocky, weathers drab to buff, has "worm-borings" at the top.....	1.3
(Total Bethany Falls limestone member, 18.55 feet)	
Hushpuckney shale member:	
Shale, black soft, carbonaceous	1.8
Shale, black, hard, fissile, has fish scales and skin impressions, phosphatic nodules, lower part covered	1+

155. *Just north of the SW cor. sec.* 24, *T.* 18 *S., R.* 24 *E.*

Chanute shale.	
Drum limestone:	
Limestone, drab, massive, has many small crinoid segments....	2±
Wea-Quivira shale:	
Shale, olive-buff, argillaceous	7.0
Shale, maroon, argillaceous	1.0
Shale, olive-drab, argillaceous, with a layer of calcareous nodules near the top, lower part covered	8+

156. *Just east of the SW cor. sec* 24, *T.* 18 *S., R.* 24 *E.*

Iola limestone:	
Raytown limestone member:	
Limestone, gray, crystalline, even, upper part eroded.....	5+
Muncie Creek shale member:	
Shale, gray, with phosphatic nodules.....	0.2
Paola limestone member:	
Limestone, bluish-gray, some "worm-borings," a few "marklets," weathers corrugated	1.5
Chanute shale:	
Shale, buff, argillaceous	4.0
Coal, soft, impure (Thayer)	0.3
Shale, drab, argillaceous, sandy near base.....	12.0
(Total Chanute shale, 16.3 feet)	

	Feet.
Drum limestone:	
Limestone, buff, massive, has many small crinoid segments	2+

157. *At NE cor. sec.* 10, *T.* 19 *S., R.* 24 *E.*

Galesburg shale.	
Swope limestone:	
Bethany Falls limestone member:	
Limestone, drab, soft, massive oölitic	2.0
Limestone, thin-bedded, even, whitish, some small nodules of gray chert, not very fossiliferous	15.0
Limestone, gray, blocky, hard	1.5
Limestone, gray, interbedded with buff shale	3.5
(Total Bethany Falls limestone member, 22.0 feet)	
Hushpuckney shale member:	
Shale, gray, argillaceous	3.5
Shale, black, hard, fissile	1.5
(Total Hushpuckney shale member, 5.0 feet)	
Middle Creek limestone member:	
Limestone, bluish-gray, dense, blocky, brittle, in two layers, fucoids? at the base	1.7
Ladore shale:	
Shale, gray, argillaceous	5.5
Sniabar limestone:	
Limestone, light gray, weathers light brown, massive, sugary, lower part covered	3+

158. *About one fourth mile north of the SE cor. sec.* 10, *T.* 19 *S., R.* 24 *E.*

Swope limestone:	
Bethany Falls limestone member.	
Hushpuckney shale member:	
Shale, upper part gray, argillaceous, lower one and one half feet black, fissile	4.5
Middle Creek limestone member:	
Limestone, bluish-gray, dense, in two layers	1.7
Ladore shale:	
Shale, covered	5.0
Sniabar limestone:	
Limestone, brown, gray where fresh, massive, ferruginous, fine-grained	5.0
Bourbon shale:	
Shale, bluish-gray, streaked with yellow, upper one foot greenish,	5.5
Shale, buff, nodular, slightly greenish	2.5
Limestone, brown, nodular	0.5
Shale, greenish-buff, argillaceous, slightly sandy in places	9.5
Sandstone, buff, massive, soft	4±
Sandstone and arenaceous shale, buff, mostly covered	24+

159. *Just west of the SE cor. sec. 36, T. 19 S., R. 24 E., Linn county, about two and one half miles east of La Cygne. Type exposure of the Middle Creek limestone.*

	Feet.
Dennis limestone:	
Winterset limestone member:	
Limestone, gray, thin-bedded, crystalline, veined, many large nodules of gray chert, mostly eroded	7+
Limestone, buff, even and interbedded, shale	1.3
Stark shale member:	
Shale, buff and gray, limy	4.5
Shale, black, fissile, hard, with a few phosphatic concretions	2.7
(Total Stark shale member, 7.2 feet)	
Galesburg shale:	
Shale, buff, calcareous, hard	0.3
Shale, buff, limy, nodular	2.3
Swope limestone:	
Bethany Falls limestone member:	
Limestone, dark gray, with loose calcareous nodules at the top, oölitic, massive, with peculiar vertical cylindrical cavities lined with iron-stained calcite	3+
Limestone, thin-bedded, light-gray, even, mottled and fine-grained above, crystalline below, a small amount of chert	10.0
Shale, gray and buff, limy, hard	1.6
Limestone, buff, argillaceous	0.2
Shale, gray, limy, fossiliferous	0.3
Limestone, gray, soft, impure	0.4
(Total Bethany Falls limestone member, 15.5± feet)	
Hushpuckney shale member:	
Shale, black, carbonaceous, soft, flaky	3.0
Shale, black, fissile, hand	2.0
Shale, gray, limy	0.4
(Total Hushpuckney shale member, 5.4 feet)	
Middle Creek limestone member:	
Limestone, bluish-gray, dense, in two even layers, blocky, has small brachiopods and at the base fucoids?	1.8
Ladore shale:	
Shale, buff, argillaceous and limy	1.0
Shale, gray above and olive below, argillaceous	4.5
(Total Ladore shale, 5.5 feet)	
Sniabar limestone:	
Limestone, brown or where fresh drab, massive, granular at the top with *Osagia*	6.0
Bourbon shale:	
Shale, olive-drab, argillaceous, with limestone nodules	3 5
Limestone, pale buff, nodular, soft	2 3
Shale, buff, nodular, limy, covered.	

160. *About one fourth mile south of the NE cor. sec.* 17, *T.* 18 *S., R.* 25 *E.*

Chanute shale.
Drum limestone:
- Limestone, brown, ferruginous, granular, thin-bedded..... 1+
- Limestone, brown to drab, massive, fine-grained, has many small crinoid segments 1.8

Wea-Quivira shale.

161. *About one fourth mile south of the NW cor. sec.* 7, *T.* 18 *S., R.* 25 *E.*

Iola limestone.

Chanute shale:	Feet.
Shale, olive, limy, mostly covered.....	22.0
Shale, maroon, argillaceous	0.2
Limestone, nodular, brown, soft	0.4
Shale, olive-buff, argillaceous	8.0
(Total Chanute shale, 30.6 feet)	
Drum limestone:	
Limestone, buff, massive, fine-grained, has many small crinoid segments	1.8
Quivira shale:	
Shale, gray, argillaceous, flaky	2.0
Shale, black carbonaceous, fissile	1.0
Westerville limestone?	
Limestone, gray, conglomeratic, with fossil fragments and limestone pebbles, crinoid segments numerous, very thin-bedded..	2.3
Wea shale:	
Shale, olive, argillaceous, papery	2.0
Shale, buff, limy, nodular, "marlite"	0.5
Shale, olive, argillaceous, limy	3.0
Shale, maroon, argillaceous, flaky, base covered.....	1±

162. *At the SE cor. sec.* 6, *T.* 18 *S., R.* 25 *E.*

Iola limestone:
- Raytown limestone member:
  - Limestone, light gray, weathers buff, crystalline, heavy-bedded, even, upper part eroded ..... 6+
- Muncie Creek shale member:
  - Shale, gray and buff, limy, many phosphatic nodules..... 0.5
- Paola limestone member:
  - Limestone, bluish-gray, lithographic, "marklets" and *Heterocoelia beedei* 1.4
  - Limestone, dark gray, fine-grained, blocky, with "marklets".... 0.8

Chanute shale:
- Shale, buff, limy, argillaceous..... 1.3
- Limestone, dark gray, cross-bedded, granular, thinly laminated.. 1.7
- Sandstone, buff, limy, thin-bedded 1.5
- Coal, soft, impure (Thayer) 0.25
- Shale, dark olive, argillaceous, with intersecting veins of calcareous clay 5.0
- Shale, gray and buff, limy, hard, nodular.

163. *About one fourth mile north of the SE cor. sec.* 18, *T.* 17 *S., R.* 25 *E.*

Wyandotte limestone:

Limestone, whitish and brown, cherty, thin-bedded, wavy, many thin shaly partings, crystalline, upper part eroded ..... 14+

Limestone, gray, fine-grained, thick-bedded 3.0

Lane shale:

Shale, bluish-gray, argillaceous.

164. *Center east side sec.* 6, *T.* 17 *S., R.* 25 *E.*

Wyandotte limestone: Feet.

Limestone, thin-bedded, wavy, gray, weathers buff or is stained from the many ferruginous shaly partings, cherty, upper part eroded ..... 10+

Shale, buff above, gray below, fossiliferous, limy, zone of sponges below, including *Heliospongia ramosa* and *Heterocoelia beedei*, 3.5

Limestone, dark gray, fine-grained, even, has "marklets" and *Heterocoelia beedei* 1.5

Lane shale:

Shale and sandstone, hard, buff and gray..... 4.2

Shale, gray, micaceous and slightly sandy, flaky, lower part covered ..... 8+

165. *North edge of sec.* 4, *T.* 16 *S., R.* 25 *E.*

Plattsburg limestone:

Limestone, brown and gray, mostly eroded, cherty, with *Heliospongia ramosa* and *Enteletes hemiplicatus* var. *plattsburgensis.*

Bonner Springs shale:

Shale, olive, argillaceous, mostly covered..... 12.0

Shale, buff, arenaceous, papery 16.0

(Total Bonner Springs shale, 28.0 feet)

Wyandotte limestone:

Limestone, whitish and buff, thin-bedded above and more massive below, wavy, oölitic at the basal layer..... 15.0

Shale, gray, argillaceous (Island Creek?)..... 0.4

Limestone, whitish, heavy-bedded, wavy, cherty, upper six inches oölitic, crystalline, base covered ..... 11+

166. *Section at road cut, SE cor. sec.* 31, *T.* 16 *S., R.* 24 *E.*

Chanute shale:

Shale, covered.

Drum limestone:

Limestone, brown and drab, cross-bedded, granular, in thin beds, 4.0

Limestone and limy shale, gray, fossiliferous 1.0

Limestone, massive, ferruginous, buff 3.2

(Total Drum limestone, 8.2 feet)

Quivira shale:

Shale, gray and buff, argillaceous 1.5

Shale, black, fissile, hard 2.0

(Total Quivira shale, 3.5 feet)

Wea shale:

Shale, gray, argillaceous, blocky 3.0

Shale, sandy, papery, buff, base covered ..... 5+

PART II

Geology of Wyandotte County, Kansas

By JOHN M. JEWETT and NORMAN D. NEWELL

INTRODUCTION

This report is the outgrowth of studies of Pennsylvanian rocks and other geologic features of Wyandotte and parts of adjoining counties carried on during a period of approximately two years. It describes in detail the rocks which are exposed, and gives a map showing the distribution of these rocks. The structural conditions are discussed and they are illustrated by means of a structural geologic map. The topography and economic geology are briefly treated.

FIELD WORK

Most of the field work of the writers in this county and adjacent areas was done during the months from September, 1929, to June, 1930. The stratigraphy was studied in detail and the units were traced into adjacent areas, including parts of Platte, Clay, and Jackson counties in Missouri, and Leavenworth, Johnson and Douglas counties in Kansas. The stratigraphy was rather well known to the writers before work on the areal geologic map was undertaken. The areal and structural geologic maps were made entirely from field observations of the writers. Later studies by Jewett on the Bronson group and by Newell on the stratigraphy of Johnson and Miami counties and on the Missouri series, in general, has enabled the writers to trace the formations exposed in Wyandotte county completely across Kansas.

The areal geologic map of Wyandotte county was made from data obtained by making automobile traverses over all roads and keeping check on distances by speedometer. Data on the distribution of outcrops away from the roads were obtained through use of a plane-table and open-sight alidade, and by pacing distances.

ACKNOWLEDGMENTS

The writers are greatly indebted to Dr. R. C. Moore, state geologist, for the facilities of the Kansas Geological Survey, including transportation. Doctor Moore gave indispensable advice and helpful criticism both in the field and office while the report was in preparation. Dr. J. W. Ockerman, Kansas Geological Survey, gave information relative to correlation of rocks revealed by well logs,

and prepared the chart shown as plate XXII. Dr. K. K. Landes offered suggestions regarding the preparation of the illustrations. Residents in the county were courteous and helpful on every occasion. Clifton Roberts, assistant manager of the Kansas City Chamber of Commerce, supplied information concerning industries. R. S. Collins, roadmaster, Atchison, Topeka, and Santa Fe Railroad, Topeka; E. A. Hadley, chief engineer, Union Pacific Railroad, St. Louis; and G. L. Adamson, chief engineer, Union Pacific Railroad, Omaha, were helpful in supplying information concerning bench marks.

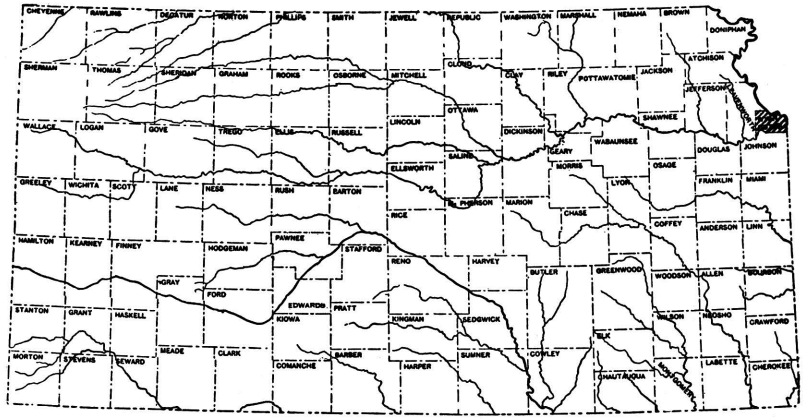


FIG. 2.—Index map of Kansas showing location of Wyandotte county.

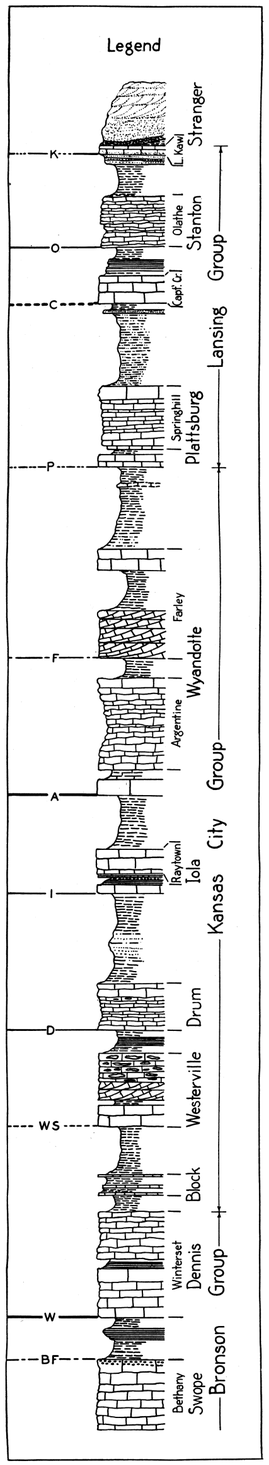
GEOGRAPHY

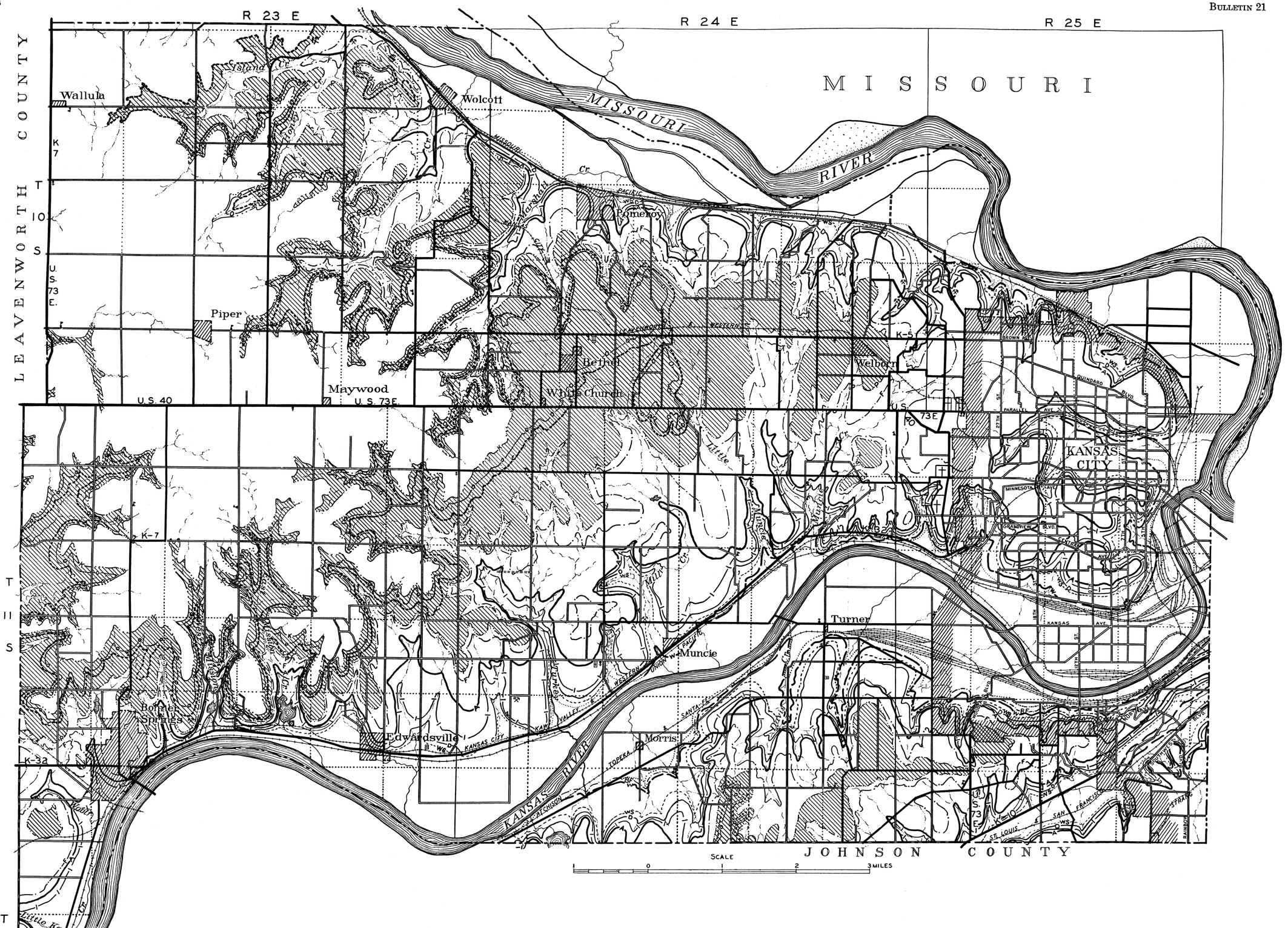
Wyandotte is one of the northeasternmost counties of Kansas. It is roughly triangular in shape, and lies principally between Missouri and Kansas rivers. It is bounded on the north and west by Leavenworth county, on the north and east by Missouri river; on the east by Jackson county, Missouri; and on the south by Johnson county and Kansas river. Although Wyandotte county has the largest population of any in Kansas, it is the smallest county in the state, having an area of about 143 square miles.

History and Development[1]

The early history of Wyandotte county is inseparable from that of the settling of the first town in the area, Wyandotte, which with several other communities is now called Kansas City, the state's largest city, with a population of nearly 125,000.

1. The writers have drawn freely upon the work of Dr. F. W. Blackmar, Kansas, A Cyclopedia of State History, 1912, for this section.





WYANDOTTE COUNTY

STATE GEOLOGICAL SURVEY
OF KANSAS

RAYMOND C. MOORE
STATE GEOLOGIST

PLATE XIII. Areal geologic map of Wyandotte county.

When whites first visited northeastern Kansas, the country was in the possession of the Kaw or Kanza tribe, whence came our name for the river and indirectly for the state and city. It is tradition that the ancestors of these Indians had separated from the Omaha, or upstream people, who had come here from the region of the Ohio and Wabash rivers. The separation is supposed to have taken place at the mouth of Kansas river, and the tribe was prevented from extending beyond the present northern boundary of Kansas by the Iowa and Sauk tribes, who had already received firearms from white traders in the north. The Kanza people had probably not been in contact with civilization. The Kanza tribe occupied twenty or more villages along the rivers before they were settled at Council Grove in 1847. They were removed to Indian Territory in 1873. The Delawares had been assigned a reservation "in the fork of the Kansas and Missouri rivers" in 1829, and in 1832 they were given land including the present Wyandotte, most of Leavenworth and Jefferson, and some of Jackson and Shawnee counties. The Wyandots, the last Indians to hold land in Wyandotte county, did not come until 1843.

In their exploration of Missouri river the French reached as far north as the mouth of Kansas river early in the eighteenth century, and soon there were numerous *couriers des bois* in the region of what is now greater Kansas City. These Frenchmen were in contact with an Indian tribe to whom they gave the name Kaw. The name Kanza is the most widely accepted designation of this tribe as used by the people themselves before contact with the French. Lewis and Clark were within the area of the present Wyandotte county in 1804. In 1812 the Chouteau brothers built a trading post on the north bank of Kansas river. They were the first permanent white settlers. Missionaries who established a mission among the Delawares in 1831, and built a church in 1832, were the second whites to settle permanently. This first church was erected at the site of the present village White Church, on United States highway 40, some eight miles west of Kansas City.

The Wyandots came from Ohio in 1843. They were a civilized people and the institutions which they established were as good or better than those of the white frontiersmen. They purchased land from the Delawares where the city of Wyandotte was later built, and a settlement was at once established. Their interpreter, J. W. Armstrong, built the first house of the settlement in 1843 and the following year he established the first free school. Of the seven

stockholders of the town company which founded Wyandotte, three were Wyandots. The first sale of lots took place in 1857 and a post office was established the same year. In 1858 a town government was granted and Wyandotte was established. The area in which the town was built was then a part of Leavenworth county. Wyandotte county was established the next year from the southeastern part of Leavenworth county and that portion of Johnson county lying north of the township line between townships 11 and 12 south and east of range 23 east.

Several other towns have merged with Wyandotte to form the present Kansas City. Armstrong, an early settlement on the north side of Kansas river and south of Wyandotte, was soon absorbed by the latter. Quindaro was north of Wyandotte. Armourdale, north of Kansas river, still has its identity, as to a greater degree have Argentine and Rosedale south of the river. The business districts of these last two are quite distinct from that of Kansas City proper. Rosedale was the last city to be annexed, the merger taking place 1922.

The conflict over slavery affected Wyandotte soon after its birth. The Methodist Church was soon divided, causing it to lose its hold upon the Indians, with the result that drunkenness and disorder became prevalent. The first temperance society in Kansas was founded among the Indians and a log jail was built at Wyandotte. When the gold rush to California began in 1849, thousands passed through the county. The Chouteau trading post and other business institutions flourished. Many Mormons in their westward migration also passed through.

In 1859 a constitutional convention meeting in Wyandotte framed the constitution under which Kansas was admitted to the Union. Like other early eastern Kansas towns, Wyandotte suffered much during and immediately after the Civil War. The city and county were represented in many Kansas regiments.

The growth of the remainder of the county has been rapid and several other towns have developed simultaneously with greater Kansas City. Bonner Springs is in the southwest corner of the county on the north bank of Kansas river, seventeen miles west of Kansas City. The town was originally called Tiblow and soon developed into a banking center for that part of Wyandotte county. Edwardsville is on the north side of Kansas river about thirteen miles west of Kansas City. Muncie, a small village, is on the same side of the river about eight miles from Kansas City. Turner, an-

other small village, is seven miles west of Kansas City on the south side of Kansas river. Maywood and White Church are small hamlets in the western part of the county on United States highway 40. A few miles west of the northwestern part of Kansas City is the village of Welborn, and a little farther west is the little hamlet, Bethel. Wolcott is a village in the northern part of the county, eleven miles northwest of Kansas City. Pomeroy, a few miles southeast of Wolcott, has now nearly lost its identity due to the shifting of local traffic from the railroad to the highway. Nearman is a little village on the Missouri Pacfic Railway a few miles northwest of Kansas City.

According to the 1930 census the population of Wyandotte county is 141,211. The population of Kansas City, Kan., is 121,857.

Industries

Agriculture, including truck-farming, is the important industry of the rural part of Wyandotte county. Truck-farming and fruit-growing are largely confined to the loess-covered eastern part of the county and to the Kansas river valley. The western part of the county is largely devoted to dairying and to general farming. A considerable percentage of the rural population is employed in greater Kansas City. The chief industries of Kansas City, Kan., are, in order of relative importance: meat-packing, flour-milling, manufacture of soap, structural steel, repair and construction of railroad cars, oil-refining, druggists' preparations, and the manufacture of ice cream. In 1927 the total value of the city's manufactured output was $304,000,000. This is forty-four percent of the entire manufactured output of Kansas. Approximately sixty-six percent of this is from the meat-packing industry.

Transportation

The Atchison, Topeka, and Santa Fe Railroad crosses the county from east to west along the south side of Kansas river. This road enters Kansas City by way of Argentine. Paralleling the Santa Fe are the tracks of the Union Pacific, which are on the north side of the river. Trains of the Chicago, Rock Island and Pacific also pass over the Union Pacific tracks. The Missouri Pacific Railway passes along the northeastern side of the county along Missouri river. The Chicago Great Western trains also use the Missouri Pacific tracks. The Saint Louis and San Francisco Railroad crosses the southeast corner of the county and enters Kansas City by way

of Rosedale. The Missouri, Kansas and Texas trains use these tracks. The proximity of Kansas City, Mo., lends the rail facilities of that city to Wyandotte county and to Kansas City, Kan., so that the county has by far the best shipping facilities of the state. The service of the Kansas City and Northwestern Railroad, which formerly traversed the county from east to west, has been discontinued for some time and the tracks have been removed. An electric railroad operating between Kansas City, Mo., and Olathe in Johnson county crosses the southeast corner of Wyandotte county. Another enters the Rosedale area from the west, operating a short distance into the suburban district of Johnson county. An electric line from Lawrence parallels the Union Pacific tracks along the north side of Kansas river. Another operates between Kansas City and Leavenworth. Kansas City, situated at the confluence of Missouri and Kansas rivers, will benefit, as will all of Wyandotte county, by the river improvement now being conducted by the federal government. Steam and electric railroads are shown on the map showing areal geology.

There were fifty-eight miles of hard-surfaced roads in the county's rural area in 1930. Almost all of the others are all-weather roads. Much concrete pavement is now being laid and many of the side roads are concrete. Four United States highways enter Kansas City, Kan. These are paved across the county and beyond. A recent survey of the State Highway Department indicates that approximately 6,500 vehicles pass over the highways entering Kansas City, Kan., each day. Automobile stage lines operate from Kansas City in all directions. Kansas City, Kan., has one of the country's leading airports. Passenger-carrying planes of several companies operate on regular schedules to various parts of the United States.

Climate

Over a period of twenty-four years the mean annual precipitation in Kansas City, Mo. (adjacent to Wyandotte county), has been 37.28 inches. In Leavenworth, just north of Wyandotte county, for a period of eighty-six years the mean annual precipitation has been 34.30 inches. The annual mean temperature in Kansas City, Mo., based on long records is 53.2 degrees F. The mean for January, the coldest month, is 26.2 degrees F., and for July, the hottest month, is 77 degrees F. Over a period of twenty-four years the length of the growing season (from last to first killing frost) in Kansas City, Mo., ranged from 164 to 216 days.

Elevations

Geologists and engineers working in Wyandotte county will find the bench marks described below easy to locate. Elevations are based upon mean sea-level datum.

Location and description of bench mark.	Elevation, Feet.
Kansas City:	
Top of rail on Union Pacific R. R. bridge over Kansas river.....	578.31
Culvert 3.87, Union Pacific R. R., × on north end, wall east side,	755.15
Culvert 4.03, Union Pacific R. R., × on north end, wall east side,	756.14
Culvert 5.92, Union Pacific R. R., × on north end, wall east side,	764.42
Bridge 6.87, Union Pacific R. R., × on west backwall south side,	757.76
Argentine station, Santa Fe R. R., west end stone sill west door in north side of depot.....	753.62
Argentine station, Santa Fe R. R., top northeast corner concrete base first semaphore west of depot.....	753.35
Kansas City University, south end lowest step, entrance to Wilson Hall	947.17
Turner:	
Signal tower, Santa Fe R. R., northeast corner concrete door sill north end	771.12
Crossing bell, Santa Fe R. R., mile post 7 plus 6215, northeast corner of the concrete base.....	763.24
Muncie:	
Bridge 9.63, Union Pacific R. R., × on east abutment north wing wall	776.28
Bridge 11.38, Union Pacific R. R., × on east back wall north end,	762.40
Bridge 13.42, Union Pacific R. R., × on north end wall east end,	771.84
Morris:	
Bridge 10-B, Santa Fee R. R., square cut in top of northwest corner parapet east abutment.....	767.92
Edwardsville:	
Bridge 14.66, Union Pacific R. R., × on north end wall east end,	774.84
Holliday:	
Water tank, Santa Fe R. R., base of tank.....	762.36
Semaphore, Santa Fe R. R., top of concrete base of first semaphore west of signal tower.....	764.57
Forest Lake:	
Culvert 16.28, Union Pacific R. R., × on north end wall east corner	778.85
Bonner Springs:	
Signal No. 171, Union Pacific R. R., × on south side of signal foundation. (About 1,200 feet east of A. T. & S. F. crossing..	789.50
Bridge 19.87, Union Pacific R. R., × on east backwall north end,	782.93
Loring:	
Depot, Union Pacific R. R., B. M. on southwest corner west side foundation of depot.....	786.74
On U. S. highway 40:	
Cement floor at gas pump, Standard Oil filling station, two tenths of a mile east of SW cor. sec. 34, T. 10 S., R. 24 E.....	1,151

Numerous other bench marks in this area are described in Bulletin 571 of the United States Geological Survey. However, many of these are gone because of changes in cultural features. For general elevations the topographic map of the Kansas City quadrangle, published by the United States Geological Survey, should be consulted.

Topography

The topographic features of Wyandotte county are in the main produced by the two major streams, Missouri and Kansas rivers, and their tributaries, the surface being deeply dissected. The rocks of this region, as in adjoining parts of the state, consist of beds of limestone, shale, and sandstone, dipping gently to the northwest. The relief is not unlike that of adjacent areas, the maximum difference of elevation being approximately 320 feet, ranging from less than 740 feet above sea level at Missouri river on the east to about 1,060 feet on the upland of the western part of the county. The stream pattern is typically a dendritic one, with occasionally a suggestion of a trellis pattern in the tributaries of Kansas river. The course of Kansas river across the county appears to be controlled largely by the attitude of the underlying rocks, as can be seen by referring to the accompanying structural map of Wyandotte county.

The land surface consists of rolling upland occupying the divide between the two rivers, and a relatively large area occupied by the stream valleys. The county lies just within the boundary of the Glaciated Plains and presents the topographic features of early maturity, modified but slightly by the Pleistocene glaciation.

As a result of the proximity of the two rivers, which bound the county on three sides, the uplands are restricted to a comparatively narrow divide, which in general is somewhat closer to the Missouri than to Kansas river. This is especially true in eastern Leavenworth county where the divide swings northward with Missouri river, and the tributaries to the Missouri are shorter than the southward flowing streams.

Part of the uplands are modified by thick deposits of loess and drift, especially in the eastern and northern parts of the county adjoining Missouri river, where the surface presents the rolling aspect typical of many loess-covered regions.

The area covered by the valleys of the two rivers and their principal tributaries includes a considerable part of the county. The flood plain of Missouri river ranges from two to more than three miles in width adjoining the county, while that of Kansas river

averages slightly over a mile, being somewhat narrower than in many areas to the west of Wyandotte county. High bluffs rise above the flood plains of both rivers.

The exposed strata control the configuration of the valley walls, the limestone beds forming terraces and the shale beds producing more or less gentle slopes. In general, the distinct benches are formed by the Dennis, Westerville, Drum, Argentine (in particular), Plattsburg and Stanton limestones. The remainder of the limestone and sandstone beds are either too thin or not sufficiently resistant to produce distinct terraces.

In a few places alluvial terraces occur along tributaries of Kansas and Missouri rivers, principally along those of Kansas river. The tributaries to Missouri river within the area are relatively short and have correspondingly high gradients. The streams following into Kansas river may be divided into two categories, those having a low gradient, a wide open valley, and a broad plain; and those having a relatively high gradient, narrow, steep valley, and no flood plain. Streams of the former class include Big Stranger creek, Wolf creek, and Little Turkey creek on the north side of Kansas river, and Wakarusa creek, Kill creek, Cedar creek and Mill creek on the south side of the river. These streams have terraced valley walls in places and wide flood plains, into which in some cases the streams are now actively cutting. Kill creek, for example, near De Soto, Johnson county, is now cutting its bed for a considerable distance in solid rock, whereas the alluvial terraces indicate that the valley was previously filled to a considerable depth and is now being excavated again. Several causes may be considered in seeking the origin of these stream terraces. Among other agencies may be listed (1) regional uplift resulting from the ice retreat, (2) climatic change with consequent change in the amount of precipitation, (3) and recent cultivation of the soil producing a corresponding increase in the surface runoff. It seems probable that the last of these agencies could produce many of the alluvial terraces observed in northeastern Kansas.

STRATIGRAPHY

The nomenclature here employed for the indurated rock formations in Wyandotte county departs in many respects from previous usage. In their report on the stratigraphy of the Missouri Pennsylvanian, Hinds and Greene[2] based their classification and correla-

2. Hinds, Henry, and Green, F. C., Stratigraphy of the Pennsylvanian series of Missouri: Missouri Bur. Geology and Mines, vol. 13, 2d ser., 407 pp., 1915.

tions to a considerable extent on the reports and maps of the early Kansas Geological Survey. Certain errors in correlation made by the Kansas Survey were introduced into the classification of the Missouri Pennsylvanian. The errors in correlation chiefly involve certain units in the Kansas City, Lansing, and Douglas formations of Hinds and Greene.[3] The changes in correlation involving the Kansas City and Lansing groups as here employed were made by Newell as a result of field work in Johnson and Miami counties and southeastern Kansas. Certain changes in the correlation of parts of the Bronson group are based on studies by Jewett, who is making a detailed investigation of those formations. The classification of the major stratigraphic units follows the revision of the Mid-Continent Pennsylvanian by Moore.[4] His classification is based on diastrophism as recorded in unconformities and the cyclic recurrence of lithologic types. The essential field observations on which revision of names in the Wyandotte county area are based have been checked by Doctor Moore, and in part they include his independent studies in eastern Kansas and adjoining areas.

The formations exposed in Wyandotte county were traced by the writers from good exposures in Jackson county, Missouri, and from the well-known Leavenworth-Smithville[5] area. More recently the writers either jointly or separately traced all of the formations excepting the Westerville, Bethany Falls and Winterest limestones to the localities from which they were named. In October, 1932, Doctor Moore, in company with Dr. G. E. Condra, state geologist of Nebraska, and Mr. F. C. Greene, of the Missouri Bureau of Geology and Mines, traced subdivisions of the Bronson and Kansas City groups from Kansas City, Mo., to Winterest, Iowa. They determined, among other things, that the type "DeKalb" limestone is really Winterest limestone, and that the beds called Drum by the Missouri Survey at Kansas City, and later identified tentatively as DeKalb, should properly be termed Westerville.

No attempt has been made in this work to prepare faunal charts of the stratigraphic units within the county. The reader is referred particularily to the work of Girty,[6] which is readily applicable to Wyandotte county. The species found in the Pennsylvanian rocks

3. Op. cit.

4. Moore, R. C., Kansas Geol. Soc., Guidebook, Sixth Annual Field Conference, pp. 80-97, 1932.

5. Hinds, Henry, and Greene, F. C., Geologic Atlas of the United States, Leavenworth-Smithville Folio, Missouri-Kansas, United States Geol. Survey, 1917.

6. Girty, G. H., Invertebrate Paleontology. The stratigraphy of the Pennsylvanian series in Missouri: Missouri Bur. Geol. and Mines, vol. 13, pp. 263-375, 1915.

of Kansas and Missouri have been generally regarded as long-ranging in both vertical and areal distribution. To a great extent their value as horizon markers and index fossils has been underestimated. It is the experience of the writers that certain species are of great value in stratigraphical work, either because of their local abundance or occasionally because of their restriction to a particular bed. When these local peculiarities are known, the fossils become of great value in field determination of the various beds. In the following pages such fossils are noted as have proved of value to the writers in identifying the stratigraphic units at different points within the area.

Generalized section of rocks exposed in Wyandotte county

	Thickness in feet.
Quaternary system:	
Recent series:	
Alluvium; stream deposits of sand, silt, clay in valley bottoms,	0–100
Colluvium; fragmental talus deposits, humic soil	0–15
Residual soil; humic soil, clay	0–5
Recent and Pleistocene series:	
Loess, fine, locally arenaceous, clayey, buff to red, wind-blown material	0–50
Pleistocene series:	
Kansas drift:	
Glacial erratics, worn local boulders, sand, gravel	0–8
Unconformity.	
Pennsylvanian system:	
Virgil series:	
Douglas group:	
Stranger formation:	
Sandstone and shale, massive, soft, micaceous, fine-grained sandstone, some arenaceous shale, generally with a limestone conglomerate at base	30±
Unconformity.	
Missouri series:	
Lansing group:	
Stanton limestone:	
Little Kaw limestone member:	
Limestone, generally massive, gray, buff, or blue	3±
Victory Junction shale member:	
Shale, arenaceous and argillaceous, gray or brown	7±
Olathe limestone member:	
Limestone, wavy- and thin-bedded, crystalline, gray to dark	12±
Eudora shale member:	
Shale, gray or buff, with black, slaty, middle zone	6±

	Thickness in feet.
Captain Creek limestone member:	
Limestone, fine-grained, dark, massive	5.5
Vilas shale:	
Shale, arenaceous, buff to gray with layer of calcereous, rippled sandstone near top	24±
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, brown to yellow, soft argillaceous	14±
Hickory Creek shale member:	
Shale, yellowish-brown with a thin layer of black shale,	0.5±
Merriam limestone, member:	
Limestone, massive, gray, hard, evenbedded, lower part with abundance of *Osagia* and *Myalina*	3±
Kansas City group:	
Bonner Springs shale:	
Shale, arneaceous, gray to buff, with fossil plants, near top argillaceous, and green with red zone and limestone nodules	25±
Wyandotte limestone:	
Farley limestone member:	
Limestone, massive, dark, even-bedded	5–10
Shale, buff, limy, gray, locally with an abundance of *Myalina subquadrata*	0–5
Limestone, massive, cross-bedded, fossiliferous, argillaceous and thin-bedded below	10–28
Island Creek shale member:	
Shale, argillaceous, bluish-gray	1–40
Argentine limestone member:	
Limestone, thin-bedded, whitish gray, cherty, buff and shaly below	25±
Quindaro shale member:	
Shale, buff, limy	1±
Frisbie limestone member:	
Limestone, bluish, blocky, even-bedded	2±
Lane shale:	
Shale, argillaceous, bluish-gray to buff	25±
Iola limestone:	
Raytown limestone member:	
Limestone, even-bedded, massive, dark-gray, large productids near the middle	6
Muncie Creek shale member:	
Shale, argillaceous, buff, with platy, carbonaceous layer at the middle	3
Paola limestone member:	
Limestone, bluish-gray, dense, even	1
Chanute shale:	
Shale, argillaceous, dark-gray, maroon layer near middle	12±
Drum limestone:	
Limestone, thin-bedded, light-gray, locally cherty, with *marginifera* sp. and *Campophyllum torquium*	10±

	Thickness in feet.
Quivira shale:	
Shale, argillaceous, green to gray, carbonaceous near the midle	5±
Westerville limestone:	
Limestone, drab, brown at top, upper layer of brown chert, locally underlain by oölite, or oölitic throughout, or hard, gray limestone and oölite	14±
Wea shale:	
Shale, argillaceous, buff	10±
Block limestone:	
Limestone, thin with interbedded buff, calcareous shale	6±
Fontana shale:	
Shale, buff, limy shale	3±
Bronson group:	
Dennis limestone:	
Winterset limestone member:	
Limestone, argillaceous, drab to blue, soft, with black chert in upper part, thin, platy shale near the middle part, dark gray, hard and massive below	30±
Stark shale member:	
Shale, buff above and black below	3±
Galesburg shale:	
Shale, gray to buff, argillaceous	6±
Swope limestone:	
Bethany Falls limestone member:	
Limestone, upper part nodular, drab to gray, weathers into small fragments, lower part massive, gray and hard	24±

The formations cropping out in Wyandotte county comprise most of the Bronson group, all of the Kansas City and Lansing groups, the basal part of the Douglas group, all of Pennsylvanian age, and deposits of Pleistocene and Recent age.

The formations exposed in the area are also exposed in Johnson and Miami counties. In a report on the stratigraphy of these counties, one of the authors has discussed in detail the nomenclature and classification that is here adopted. It is deemed unnecessary to repeat here those discussions, and the reader is referred to the report on Johnson and Miami counties.[7]

7. Newell, N. D., The stratigraphy of Johnson and Miami counties, Kansas: This bulletin, Part I.

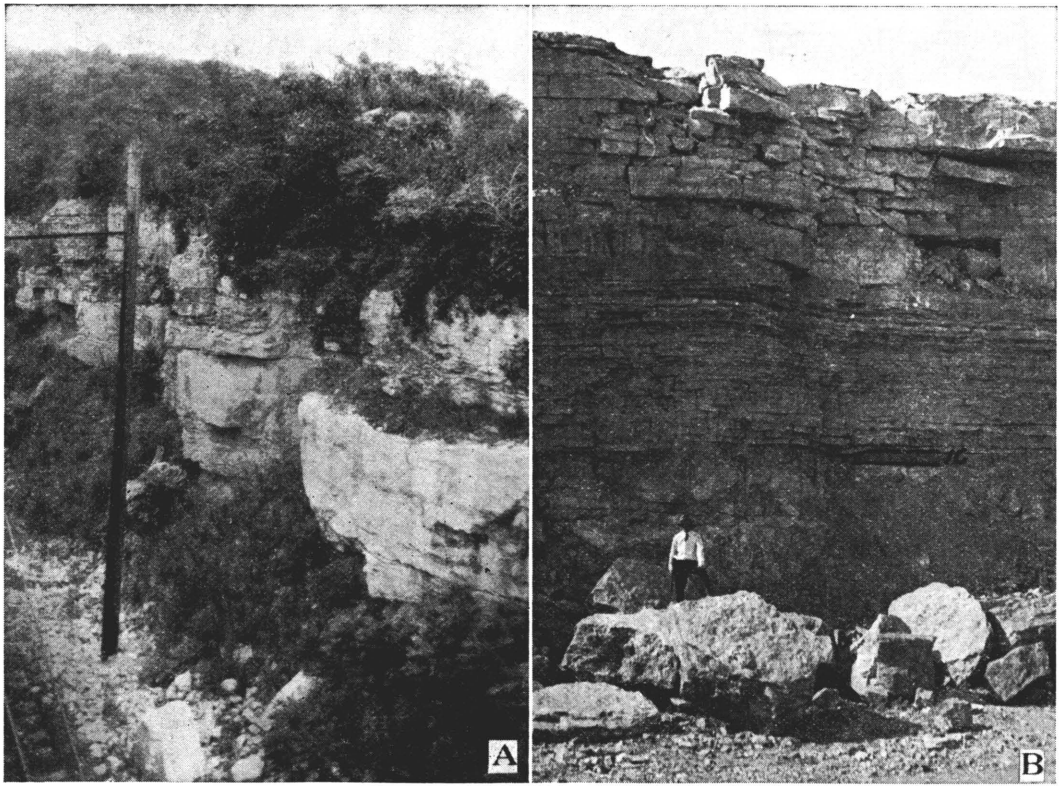


PLATE XIV. A—Westerville limestone at west edge of City Park, Kansas City, Kan. B—Exposure at quarry of Lone Star Cement Company, near Bonner Springs; Island Creek shale (ic) with Argentine below and Farley above.

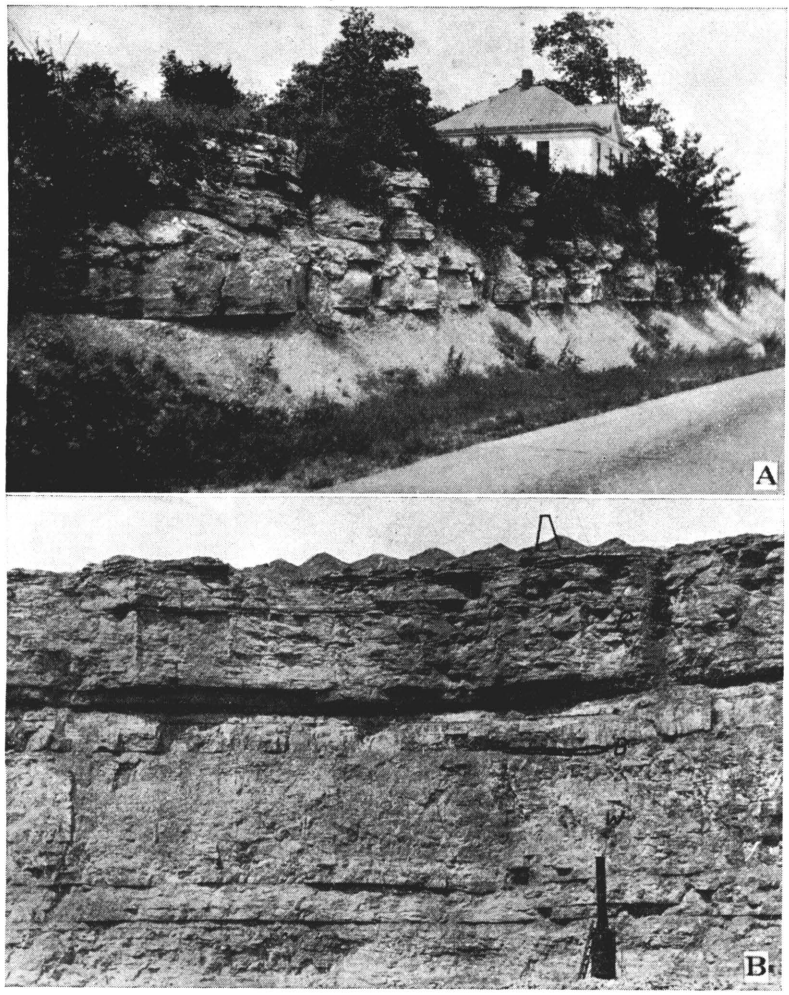


PLATE XV. A—Basal members of the Wyandotte limestone, three fourths of a mile west of Argentine station, Kansas City. B—Exposure at quarry about one mile southwest of Loring, Leavenworth county. W, Wyandotte; B, Bonner Springs; P, Plattsburg.

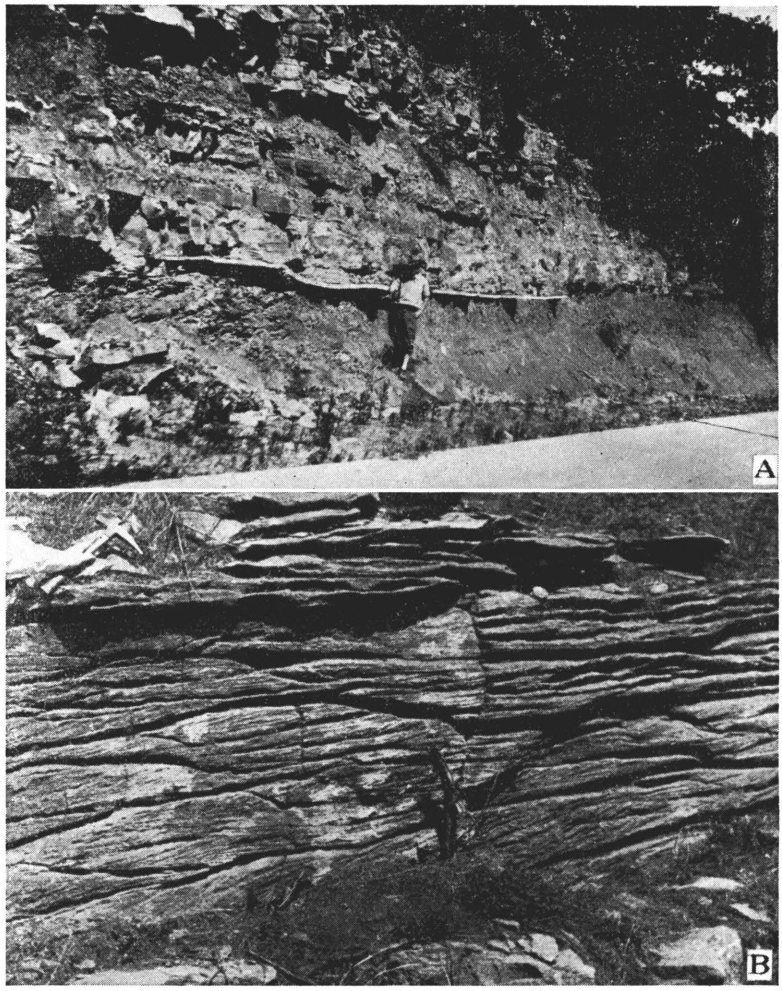


PLATE XVI. A—Bonner Springs shale and Plattsburg limestone above, at turn in highway in sec. 8, T. 10 S., R. 23 E. B—Local conglomeratic limestone at the Bonner Springs horizon, one mile west of Bonner Springs.

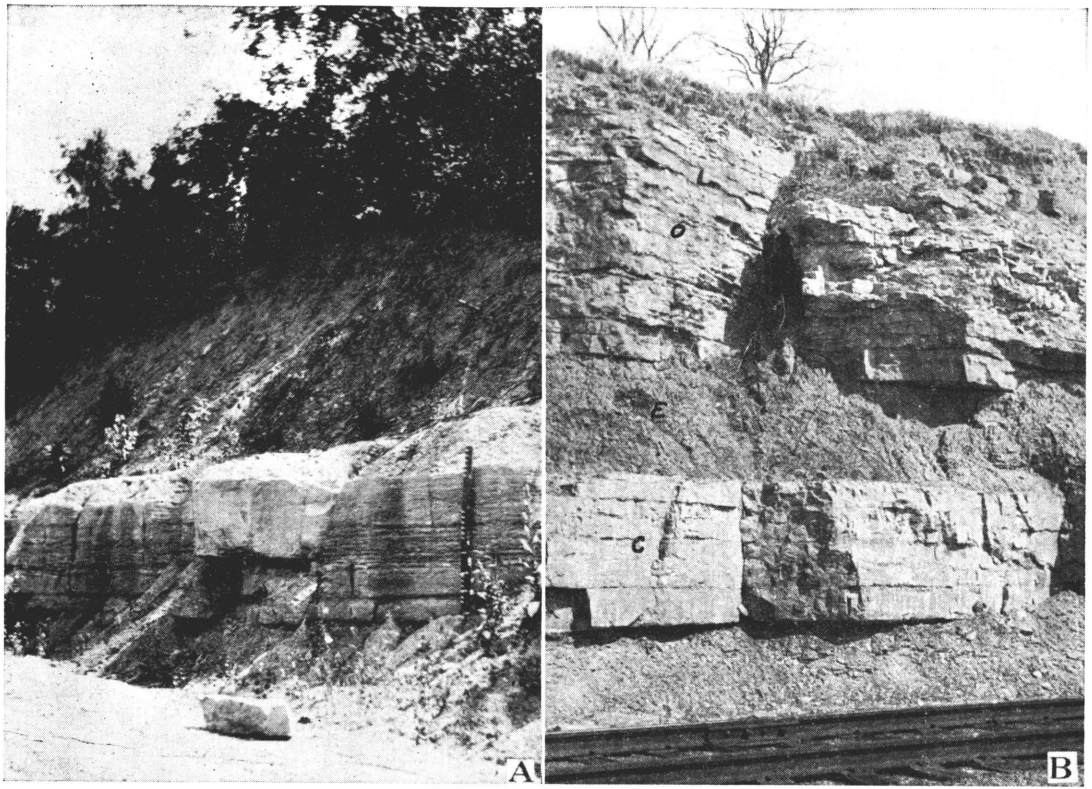


PLATE XVII. A—Upper Farley limestone in a road cut one half mile southeast of Pomeroy. B—Stanton limestone, Union Pacific railroad, one half mile east of Linwood, Leavenworth county. C, Captain Creek; E, Eudora; O, Olathe.

Pennsylvanian System

MISSOURI SERIES

BRONSON GROUP

The formations of the Bronson group that crop out in Wyandotte county are the Swope limestone, Galesburg shale, and the Dennis limestone. Formations of the Bronson group underlie the entire county, but the beds below the Bethany Falls do not come to the surface within the limits of the county. Exposures of rocks belonging to the Bronson group appear in the bluffs near the confluence of Missouri and Kansas rivers, and in the vicinity of Morris and Edwardsville on Kansas river.

SWOPE LIMESTONE

The Bethany Falls member of the Swope formation is the oldest stratigraphic unit exposed in Wyandotte county.

Lithologic character and thickness. The Bethany Falls limestone is quite distinct in its lithologic character from the other limestone beds within the county. The limestone is light gray in color, and very massive in fresh exposures, having in the upper part but few bedding planes and vertical joints. Partly because of the massive character it has been found practicable to mine the Bethany Falls limestone, thus saving the cost of stripping the overlying rock. At a quarry east of Morris a few feet of the upper part of the member has been found to be sufficient, with only a few pillars, to support a large thickness of overlying limestone and shaly material. Upon weathering, the upper part of the Bethany Falls limestone breaks up quickly into small fragments. Due to a nodular structure the upper part presents a peculiar spotted appearance. It is generally believed that these nodular masses indicate the work of lime-secreting algae. The complete thickness of the Bethany Falls limestone is not exposed in the county. On weathered slopes the massive upper part of the limestone weathers out in large rounded masses that slump down over the underlying strata. The lower part of the formation is not exposed in Wyandotte county, but in adjoining counties it is composed of even-bedded, gray or buff limestone.

A generalized section at Kansas City, Mo., by Hinds and Greene[8] is as follows:

8. Hinds, Henry, and Greene, F. C., Stratigraphy of the Pennsylvanian series in Missouri: Missouri Bur. Geology and Mines, vol. 13, 2d ser., p. 124, 1915.

	Feet.
Limestone, nodular, shelly	2–4
Limestone, oölitic	1
Limestone, grayish; upper six feet mottled, lower crystalline, fine-grained	18-21
Total thickness of Bethany Falls	21–26

Distribution. The Bethany Falls is exposed at only a few places in Wyandotte county. The member appears above the flood plain on the south side of Kansas river a short distance west of Morris, and it is well-exposed in the quarry just east of that town. It is exposed at this place by a structural "high" and dips below the flood plain about a mile west of Turner not to reappear until a point is reached a short distance above Argentine. The limestone is not seen above the flood plain on the north side of Kansas river or at any other place within the county.

Detailed sections. For sections of the Bethany Falls see localities 1, 2, 7, at the end of the report.

GALESBURG SHALE

The term Galesburg has commonly been used in the Kansas City region for a thin shale separating the Bethany Falls from the Winterset limestone. Much of this shale interval consists of black fissile shale, but the lower five feet or so is gray or buff and argillaceous. J. M. Jewett has found that the typical Galesburg shale at Galesburg, Kan., is the correlative of the five-foot shale above the Bethany Falls limestone at Kansas City. The overlying black fissile shale is regarded as a member of the Dennis limestone.

Lithologic character and thickness. Wherever the Galesburg is exposed in Wyandotte county and adjacent areas it consists of gray to buff argillaceous shale. The thickness ranges from four to six feet.

Distribution. The outcrop of the Galesburg is coextensive with that of the Bethany Falls limestone, cropping out in the south bluff of Kansas river from Morris to a point along the railroad track about a mile west of Turner, and again from a short distance west of Argentine eastward beyond the limits of the county.

Detailed sections. Sections of the Galesburg are given under localities 1, 2, and 7 at the end of the report.

DENNIS LIMESTONE

In recent years the Dennis limestone of the old Kansas Survey has been correlated with the previously named Winterset. Investigations by J. M. Jewett have shown that there are two limestones at Dennis, separated by a thin black shale. The latter was traced northward and found to be the black shale commonly correlated with part of the Galesburg in the Kansas City area. It is undesirable to redefine the term Winterset to include strata other than the limestone that has so long been called Winterset. Furthermore, the basal limestone at Dennis does not extend into northeastern Kansas and forms no part of the typical Winterset. The basal limestone is a distinct unit of the cyclic succession of strata that characterizes the main limestone formations in this part of the Pennsylvanian section.

In northeastern Kansas the Dennis formation thus consists of two members, the black Shark shale below, and the Winterset limestone above.

Lithologic character and thickness. The Stark shale consists in Wyandotte county of two parts, the lower half being black, fissile shale and the upper part gray or buff, argillaceous shale. The member ranges in thickness from two to four feet. The black, fissile layer is uniform in thickness and generally measures about a foot in thickness.

The Winterset is characterized by a persistent zone of flint nodules in the upper part. Wherever the upper part of the member is exposed in the county the flint is predominantly black or bluish in color with occasional streaks of white chert. No other limestone in the area contains flint of this color. In the main, the member is argillaceous, drab or bluish-dove in color, and contains a shaly zone near the middle. At some places, such as Morris, the shale in the Winterset is black and platy. At a few places the limestone below the shale parting was observed to be granular and cross-bedded at the top. The upper part of the Winterset is thin-bedded and flaggy whereas the lower part is massive and generally light gray. The thickness of the Winterset member in Wyandotte county is about thirty feet.

Distribution. The Dennis limestone is exposed only along the lower part of the river bluffs and in the larger valleys in the eastern part of the county. The formation rises above the flood plain of Missouri river a short distance above the Kansas City, Kan., waterworks. In Kansas City, Kan., along the Missouri, the formation

is covered by a thick mantle of loess. On Kansas river on the north side, the upper part of the Winterset member can be seen along the base of the bluff from Eighteenth street to City Park and again near the interurban stop of Serridge. The farthest extension to the west, on the north side of the river, is at the bridge over Mill creek at the town of Muncie. At this place the cherty upper part has been removed by erosion, and the lower portion of the Winterset rests upon the slaty Stark shale. Very probably the Dennis dips to the east for a short distance from here, as it does on the south side of the river. The formation first appears above the flood plain on the south side of Kansas river a short distance above Morris where it rises rapidly and dips again abruptly to the east for a short distance before reaching Turner. It is again well above the flood plain at Argentine. The upper part of the Winterset is well-exposed at many places along Turkey creek, extending beyond the county line to the south.

At many places, as along Turkey creek, the Winterset is very fossiliferous, bearing an interesting molluscan fauna near the top. From this zone extensive collections, including an interesting group of nautiloids, have been made in the past.

Detailed sections. For sections containing the Dennis formations see numbers 1, 2, and 7 at the end of the report.

Kansas City Group

The Kansas City group, according to the present classification, includes the Fontana shale, Block limestone, Wea shale, Westerville limestone, Quivira shale, Drum limestone, Chanute shale, Iola limestone, Lane shale, Wyandotte limestone, and Bonner Springs shale. The group includes the upper part of the Kansas City formation of authors, and the lower part of the old Lansing group.

It has been shown elsewhere[9] that the so-called Cherryvale shale of the Kansas City region constitutes only the lower part of the true Cherryvale shale, and that the typical Cherryvale shale is the correlative of strata between the Winterset and the limestone generally called Cement City in the Kansas City section. These divisions have about the same distribution in Wyandotte county, so that a single paragraph will be devoted to the discussion of their areal extent.

9. Newell, N. D., The stratigraphy of Johnson and Miami counties, Kansas: This bulletin, p. 13.

FONTANA SHALE

At the type locality near Fontana, Miami county, the Fontana shale consists of fourteen feet of argillaceous, bluish shale. In Wyandotte county, however, the shale is generally buff and somewhat calcareous. A persistent zone of *Chonetina plebeia* occurs at the very top of the member. The thickness is not constant in Wyandotte county, ranging from less than two to over six feet.

BLOCK LIMESTONE

The Block limestone in Wyandotte county consists of two or more thin beds of soft, buff limestone, with intercalated layers of buff, limy shale. The thickness of the formation is about six or seven feet.

WEA SHALE

The Wea shale ranges from about five to fifteen feet in Wyandotte county. Generally it consists of buff or gray argillaceous shale. The formation is generally not very fossiliferous.

WESTERVILLE LIMESTONE

The Westerville limestone, which has been erroneously correlated with the Drum limestone of southeastern Kansas, is equivalent to part of the type Cherryvale shale. The limestone in northwestern Missouri that has been called Drum was correlated with the Dekalb of Iowa by Tilton[10] and by Condra,[11] but recently Moore, Condra, and Greene determined that the DeKalb is the same as the type Winterset and Bain's term Westerville should be employed for the unit at Kansas City that has for so long been called Drum. Field work by N. D. Newell has shown that this unit is replaced by shale a mile or so southeast of Martin City, Mo., and for many miles to the southwest does not reappear. On the other hand, the overlying Cement City of Missouri geologists continues somewhat diminished in thickness to Drum creek in Montgomery county, Kansas.

The Westerville limestone in Wyandotte county is characteristically a massive, drab limestone with a thin oölitic layer near the top, above which occurs a lenticularly bedded chert bed composed of irregular layers of pinkish and brown chert. A good exposure of characteristic Westerville limestone occurs along the highway at the bluffs of Kansas river for a mile west of City Park, Kansas City,

10. Tilton, J. L., The Missouri series in southwestern Iowa: Iowa Geol. Survey, vol. 29, pp. 230, 231, 1920.

11. Condra, G. E., The stratigraphy of the Pennsylvanian system in Nebraska: Nebraska Geol. Survey, 2d ser., Bull. 1, p. 29, 1927.

Kan. The Westerville is variable in its characteristics. At the county line below the pavement east of Holliday the upper part of the Westerville is shaly, while the lower six feet is a massive, suboölitic and fossiliferous limestone. The same is true at the quarry just east of Morris on the south side of Kansas river. A determination of the upper contact was possible by the distinctive character of the overlying Quivira shale. A half mile west of Turner, on the bluff along the railroad tracks, the entire Westerville is a strongly cross-bedded and oölitic limestone bearing a prolific molluscan fauna. The thickness at this place is from eighteen to twenty feet.

QUIVIRA SHALE

The Quivira shale member, named after Quivira Lake Resort near Holliday, consists of unfossiliferous, dark or olive-green argillaceous shale, generally with a thin layer of black, platy shale near the middle. It commonly has a thickness ranging between three and seven feet, and is generally unfossiliferous. It is well-exposed above the Westerville limestone in a cut along the interurban about a mile east of Edwardsville north of the concrete highway. At a road cut along Kansas river a mile west of City Park this member is carbonaceous, almost black to greenish, and has a thickness of three feet. At the quarry east of Morris the Quivira has a thickness of about four feet and retains its peculiar greenish tint, being somewhat darker at the middle. Beneath the dam at Forest Lake near Edwardsville the shale is poorly exposed, but appears to be nearly seven feet thick.

Distribution. The beds between the Winterset and Drum limestones crop out along Missouri river to a point beyond Nearman, extending a short distance up all of the tributary valleys. On Kansas river they extend to Forest Lake on the north side of the river where the upper part of the section is exposed beneath the dam. Because of the loess cover on the north side of Kansas river, good exposures of these beds in the western and central parts of the county are scarce. Good outcrops of them are more abundant on the south side of the river, especially between Turner and Holliday. Excellent exposures occur along the interurban track all the way from City Park, Kansas City, Kan., to the station Serridge, some distance to the west.

Detailed sections. Stratigraphic sections containing the formations discussed above may be found under numbers 1, 3, 4, 5, 6, 7, 8, at the end of the report.

DRUM LIMESTONE

Lithologic character and thickness. The Drum, for so long known around Kansas City as the Cement City limestone, or the "building ledge" on account of its extensive commercial use, is remarkably uniform in its characteristics. It is everywhere a thin-bedded and wavy-bedded, whitish to gray limestone, rarely cherty in Wyandotte county, commonly assuming an appearance somewhat similar to that of the Argentine limestone. As a rule the formation is not very fossiliferous, but typically contains *Marginifera* sp. and *Campophyllum torquium,* and usually has a zone of *Composita subtilita?* and ramose bryozoans in the shaly layer at the top. The formation is generally about ten feet thick. Locally there is a thin oölitic or granular layer at the top. R. C. Moore has used the term Corbin City for this layer and retains the term Cement City for the main part of the formation.

Distribution. The Drum is exposed in the road cut along the bluff of Kansas river along the south edge of sec. 12, T. 11 S., R. 24 E.; also at the quarry east of Morris, at the dam level at Forest Lake, at City Park, and numerous other places.

Detailed sections. The Drum limestone is given in sections 1, 3, 6, 7, 8, given at the last part of the report.

CHANUTE SHALE

This unit, lying below the Iola and above the Drum, constitutes the Chanute shale. This is the same as the lower part of the "middle Chanute" of Missouri geologists.

Lithologic character and thickness. The Chanute shale in Wyandotte county is typically argillaceous, buff to gray and commonly barren of fossils. Near the middle of the formation there locally occurs a thin band of maroon clay shale. This layer has been noted at several places in Missouri by Hinds and Greene.[12] The formation ranges from about nine to thirteen feet. At the top of the formation there occurs locally the northern extension of the Thayer coal, as in sec. 12, T. 11 S., R. 24 E.

Distribution. Good exposures of the Chanute shale are not common in Wyandotte county, the best being along the south edge of sec. 12, T. 11 S., R. 24 E. The Chanute extends up Missouri river approximately to Pomeroy and occurs in the river bluffs to Kansas

12. Hinds, Henry, and Greene, F. C., The stratigraphy of the Pennsylvanian series in Missouri: Missouri Bur. Geology and Mines, vol. 13, p. 118, 1915.

City. On Kansas river the formation remains above the flood plain as far west as Bonner Springs.

Detailed sections. Sections of the Chanute are given under numbers 1, 3, 7, 8, in the register of localities at the end of this report.

IOLA LIMESTONE

It has been demonstrated that the Raytown limestone of the Kansas City region constitutes the upper and main part of the Iola limestone.[13] In northeastern Kansas the black shale and blocky limestone just underneath the Raytown represents the lower and less conspicuous part of the formation.

The Iola has been divided into three members, in ascending order, Paola limestone, Muncie Creek shale, and Raytown limestone.

Lithologic character and thickness. The Paola member consists in Wyandotte county of a single layer, rarely more, of dense, dark bluish-gray, blocky limestone. It is generally about a foot thick. This member is characterized by abundant stringers and coils of parallel-banded markings or "marklets" of calcite. These are possibly deposits formed by calcareous algae.

The Muncie Creek shale member consists principally of black fissile shale with a thin layer of gray or buff shale above and below. At the top of the member occurs a zone of spherical and elongate gray, phosphatic concretions, some of which contain shark teeth or the conularid, *Conularid crustula.* This zone of concretions is the most constant feature of the entire Iola formation in Kansas, having been observed by Newell as far south as the Kansas-Oklahoma line. The Muncie Creek is commonly about three feet thick in Wyandotte county.

The Raytown member is a massive bed of gray to brownish limestone which commonly weathers buff, light gray, or brown. This is the bed known locally in Kansas City as the "Calico ledge," so-called because of the mottled appearance of the rock. The presence of numerous fossils, chiefly large brachiopods, and the brecciated character of the rock produce a characteristic spotted appearance in both weathered and fresh exposures. The thickness of the unit in the county is about five feet. The bedding is characteristically even, the layers commonly attaining a thickness of about a foot.

Distribution. Good exposures of the Iola are not common. The best outcrops occur at the fine exposure along the south side of sec. 12, T. 11 S., R. 24 E. The Iola extends up Missouri river nearly to

13. This bulletin, p. 51.

Wolcott before it dips below the flood plain. It occurs high in the bluff at Kansas City. Along Kansas river the formation extends nearly as far as Bonner Springs. On the south side of the river the Iola appears in the bluff all the way to Cedar creek in Johnson county, where it is well exposed along the railroad track just east of the mouth of the creek. The Iola extends well into Johnson county along Turkey creek and is exposed at a number of places in the bluff about Southwest Boulevard. The formation extends well up the tributary valleys in the eastern part of the county and commonly forms a minor bench in the valley walls.

Detailed sections. Stratigraphic sections of the Iola are given under localities 1, 3, 7, 8, at the end of the report.

LANE SHALE

Lithologic character and thickness. The Lane shale, equivalent to the "upper Chanute" of the Missouri geologists, is a bluish or buff argillaceous shale. The thickness is rather irregular, ranging between twenty and thirty-eight feet. This formation has yielded a remarkable fauna of crinoids at localities in Kansas City, Mo., where twenty-five or more species have been found, in addition to other fossil invertebrates. In Wyandotte county, however, the formation seems to be rather barren of fossils at the few places where it is well-exposed. The outcrop of the Lane may be considered as being approximately coextensive with that of the Argentine limestone above.

Distribution. The Lane extends up Missouri river valley from Kansas City nearly to Wolcott before dipping beneath the flood plain. Along Kansas river the formation extends to Loring on the north side of the river and to Corliss on the south side. In the eastern part of the county and along Turkey creek the Lane extends far up each tributary valley.

Detailed sections. Sections of the Lane are included under sections 1, 3, 7, 8, in the register at the end of the report.

WYANDOTTE LIMESTONE

The Wyandotte limestone is treated as a formation, because in much of eastern Kansas its subdivisions form a single indivisible limestone unit. The members of the Wyandotte, in ascending order, are: Frisbie, Quindaro, Argentine, Island Creek, and Farley. The Frisbie, Quindaro, and Argentine constitute the unit that has for so long been called the Iola limestone in the Kansas City region.

Lithologic character and thickness. The lowermost member of the Wyandotte limestone is the Frisbie limestone. In Wyandotte county it consists generally of a single layer of fine-grained, bluish-gray limestone. As a rule the unit is quite even-bedded. Commonly the member is from one to two feet thick.

The next member, in ascending order, is the Quindaro, consisting of a few inches to four feet of shale. Where the member is thin it consists of buff calcareous shale, and where thick of greenish clay shale.

The Argentine limestone member is one of the most easily recognizable formations in Wyandotte county. The member is a thin-bedded, whitish or gray to pinkish, cherty and rather crystalline limestone. The bedding is generally somewhat irregular and wavy. In the most characteristic development it is buff and shaly at the base. Generally the abundant gray and brown chert is concentrated in the form of nodules in the upper part of the member. The thickness is not the same throughout the county, but everywhere the Argentine is one of the thickest limestones exposed in the area. The member is generally about twenty-eight feet thick, although it ranges from about twenty-two to thirty feet.

The Island Creek shale, which lies between the Argentine and Farley limestones, has in Wyandotte county rather a wide range in thickness. The type exposure of the member occurs at the quarry in the NW cor. sec. 11, T. 10 S., R. 23 E. Along the concrete highway a quarter of a mile southeast of Wolcott near the south side of section 12, where the Argentine and Farley are both well-exposed, the Island Creek has a thickness of forty-three feet. Southward to Bonner Springs the member thins rather uniformly. At a point north of the middle of the east edge of sec. 25, T. 10 S., R. 23 E., on the concrete highway, the member is fifteen and one half feet thick. In the quarry on the high hill southeast of Twenty-sixth and Metropolitan Ave., Argentine, the member has a thickness of seven and one half feet. At Forest Lake, west of the dam near Edwardsville, the bed is six and one half feet thick. In a road cut about a mile east of Bonner Springs on the road leading to a camp of the Boy Scouts of America, the Island Creek shows a local thickening to thirteen feet, while a short distance to the west, at the cement plant, the shale has dwindled to about a foot. The member is also quite thin at the quarry of the Union Pacific railway west of Loring. The member is quite thin in Johnson county, but it is easily recognizable as far south as the Miami county line.

The Farley limestone attains an important development in Wyandotte county. A general lack of recognition of this member has caused considerable confusion in the past. In much of Wyandotte county the Farley consists of two distinct limestone units separated by a fairly prominent shale. The lower limestone of the Farley is fairly constant in lithologic character, but has a considerable range in thickness. It is, in the main, a massive, cross-bedded, oölitic, and fossiliferous limestone. In color the unit is commonly brown or drab. Curiously, in spite of the great thickness attained in some places by this bed, it is broken up by the processes of weathering so that it is not commonly seen in natural exposures and in some cases leaves but a slight terrace to show its position, while the Argentine below stands out in bold relief, producing a prominent bench. At those places where the lower Farley is exposed, notably near Wolcott, it seldom shows any joints whatever. In common with many other oölites of the region, the fauna is chiefly molluscan with a good representation of bryozoans and brachiopods, however. Of notable interest is the cephalopod fauna to the south in Johnson county, where, near De Soto, a great many species are assembled together within a small area.

Near Wolcott the lower Farley reaches a maximum development, the greatest thickness noted being at a good exposure of the bed on Island creek at the center of section 23, T. 10 S., R. 23 E. At this place the unit is about thirty feet thick. At a quarry near the concrete highway at the northwest corner of section 11, T. 10 S., R. 23 E., the bed is fifteen feet thick. A fourth of a mile southeast of Wolcott by the highway a thickness of sixteen feet was measured. At the fork in the road just south of Pomeroy the lower Farley is eight feet thick, and is even thinner northeast of Welborn. At the quarry above Argentine, near Twenty-sixth and Metropolitan avenue, it is thirteen and one half feet thick. West of the dam at Forest Lake near Edwardsville the lower sixteen feet of the Farley is believed to represent the lower Farley bed. West of this exposure along Kansas river it is impractical to try to differentiate the parts of the Farley in Wyandotte county.

The middle Farley is usually a calcareous or argillaceous gray to buff shale. In thickness it is rather constant in the northern part of the county, ranging between about seven and twelve feet. At Argentine this bed has a thickness of ten feet. From Forest Lake to Loring along Kansas river the unit is barely distinguishable, the two limestone beds having been brought together. At many places

this shale bed was observed to be replete with a species of *Myalina,* bearing practically no other fossils.

The upper Farley limestone is characteristically a massive, hard, dark limestone, bearing but few fossils. Where the bed coalesces with the one below, it takes on a drab, granular appearance. At exposures near Wolcott the upper Farley is about two feet thick, increasing to three and one half feet south of Pomeroy and about the same at Argentine. At Forest Lake the upper twelve feet of the Farley is believed to represent the upper Farley bed and at the cement plant quarry near Bonner Springs the upper eleven feet.

Distribution. The Wyandotte formation is widely distributed in Wyandotte county. Throughout the eastern part of the county the formation caps most of the hills and directly underlies the upland surface, covered often with a layer of loess and glacial drift. Generally the hard layers at the top of the Argentine form a prominent bench plainly visible in the valley walls of the rivers and smaller streams. The Wyandotte crops out up the Missouri valley as far as Wolcott. Between Nearman and Quindaro it is well-exposed in quarries along the river bluff. In Kansas City, Kan., and along Turkey creek the formation is well shown in numerous quarries and road cuts. Along Kansas river it extends to a point just west of the mouth of Kill creek in Johnson county and on the north side to a point opposite De Soto.

Detailed sections. Sections of the Wyandotte are shown under numbers 1, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, at the end of the report.

BONNER SPRINGS SHALE

This formation, the so-called "upper Lane" of the Kansas City region, is typically exposed at the cement plant quarry near Bonner Springs. It is highly irregular in Wyandotte county, but can generally be identified with little difficulty.

Lithologic character and thickness. From the absence of marine fossils, except near the top, and the abundance locally of *Cordaites* and other plant forms, attended by a predominantly arenaceous character in Wyandotte county, it may be supposed that the Bonner Springs shale is a near-shore deposit. Near the top of the formation occurs a thin layer of maroon shale, which is persistent over a large area in Missouri and Kansas. Locally this maroon layer is absent, apparently having been removed by erosion near the end of Bonner Springs time. At the cement plant quarry near Bonner Springs and

at other places the disconformable contact between the partially removed maroon shale and an overlying sandstone was recognized. At the county line a mile west of Bonner Springs this thick shale formation has been entirely removed by erosion before deposition of later deposits. At this locality the upper part of the Farley is directly overlain by a cross-bedded deposit of shell fragments and limestone pebbles, overlain in turn by the Plattsburg. At Loring, in the face of the quarry, the Bonner Springs is represented by a few inches of shale. The cross-bedded layer was not recognized at Loring, but it is well-developed at De Soto, where it is predominantly a limestone conglomerate. The abrupt lensing out of the Bonner Springs takes place in a narrow band which extends southwest by northeast, paralleling the course of Kansas river between Bonner Springs and De Soto by way of Loring, but restricted wholly to the west side of the valley, and crossing the river opposite De Soto. In a line parallel to the river, but on the east side of the valley between the cement plant quarry at Bonner Springs and the east bluff of Kill creek at De Soto, by way of the east and south bluff of the river, the Bonner Springs shale retains its normal characters. Apparently this abrupt thinning of the shale, together with the occurrence of a limestone conglomerate, indicates a local disconformity. Very probably the course of the river at this place is partly controlled by the thinning of the Bonner Springs, since the removal of the shale formation in the west bluff of the river has left nearly a hundred feet of limestone with but little included shale. In passing, it is of interest to note that the great thickness of limestone, including the Wyandotte and the Plattsburg, has in this part of the river's course resulted in the valley being unusually narrow.

The Bonner Springs is thickest in the northern part of Wyandotte county and thins regularly toward the south. At the east fork in the road leading southward out of Pomeroy the formation is thirty-eight feet thick, argillaceous below and arenaceous above, with a gray to buff color. In exposures near Wolcott the formation contains some sandstone, as it does northeast of Welborn, resembling in places the cross-bedded sandstone of the Stranger formation. This resemblance is somewhat heightened at the latter locality by an included conglomeratic bed at the top of the Farley, the latter being quite thin at this place. At Argentine the Bonner Springs is thirty-three feet thick, thinning westward to twenty-four feet at Bonner Springs, where the formation is dominantly gray and somewhat arenaceous.

Distribution. The Bonner Springs crops out along all of the larger valleys in the western half of the county. In the eastern part the formation has been generally stripped away by erosion. In a few places, however, as at Argentine, the entire thickness of the formation is preserved.

Detailed sections. Sections of the Bonner Springs are given under numbers 7, 8, 12, 13, 14, 15, 16, 17, 18, 19, at the end of this report.

Lansing Group

PLATTSBURG LIMESTONE

Field work by Newell throughout the Plattsburg outcrop in Kansas has shown the desirability of a three-fold division of the formation into members. The members are called Merriam limestone, Hickory Creek shale, and Spring Hill limestone.

Lithologic character and thickness. The Plattsburg is one of the best key horizons in the northeastern part of the state. Over large areas in this region persistent lithologic and faunal peculiarities appear in the formation. In all parts of Wyandotte county the Plattsburg is evenly bedded, containing thicker beds above and below the middle.

The lower member, the Merriam limestone, consists of two or three blocky, even beds or gray or bluish-gray limestone. In parts of the county these layers are utilitized for building stone of high quality. The entire member ranges generally between two and three feet in thickness. Commonly the lower beds are largely composed of the ellipsoidal algal remains of *Osagia,* which resemble in section large compressed oölite grains, differing in that they occur in brittle limestone, breaking through the grains rather than around them as generally is the case in oölitic limestones. This layer always bears a rich molluscan fauna in which *Myalina subquadrata* is the dominant form. The upper layer or layers of the member are dense, hard beds, relatively unfossiliferous. The upper of these commonly bears abundant large iron-stained tubes resembling the borings of some organism.

Separating the Merriam from the upper and main part of the Plattsburg is the thin Hickory Creek shale. This member is quite thin, ranging generally between three and twelve inches or so. Where the shale is thin it is carbonaceous and platy, especially in the northern part of the county. Where it is thicker the member is generally argillaceous or brown and limy, with small, brown calcareous nodules.

The upper Plattsburg, called the Spring Hill limestone member, weathers characteristically light brown or yellowish. The surface color carries deeply into the large blocks that have been long exposed to weathering. Near the base of the member occurs a layer of hard, gray limestone that bears *Marginifera wabashensis* and an occasional specimen of *Enteletes hemiplicatus* var. *plattsburgensis*. The remainder of the Spring Hill owes its characteristic color to the oxidation of the highly impure limestone. In fresh exposures the limestone generally presents a grayish, argillaceous and granular appearance. Generally the member is somewhat shaly toward the middle and is locally cherty. Generally silicified specimens of *Heliospongia ramosa* are associated with the chert nodules. A very slender variety of *Triticites irregularis* characterizes the Spring Hill This little fusulinid is readily distinguished in the field from the more robust variety of this species that occurs in the Stanton. Particularly abundant in the Spring Hill are the spines of a species of the echinoid *Echinocrinus;* also the calices of a species of *Delocrinus* are common. As a rule the member ranges between ten and fourteen feet, although locally, as at the road cut along the highway a mile west of Bonner Springs, it may be somewhat thinner than this.

Distribution. The Plattsburg crops out widely in the western three fourths of Wyandotte county, where it is exposed in all of the larger valleys. The most eastern exposure of the formation in the county occurs south of Kansas river, at Argentine. The eastward extent of the Plattsburg should be looked upon as the continuation of the Plattsburg-Stanton escarpment which crosses into Wyandotte county from the south near the southeast corner. The high degree of dissection and the thick covering of loess and till contribute to effectively efface any distinct Plattsburg-Stanton escarpment which may have formerly existed in the county.

Detailed sections. Sections of the Plattsburg formation are given under numbers 7, 12, 13, 14, 15, 16, 18, 19, 25 at the end of the report.

VILAS SHALE

In Wyandotte county the Vilas is quite uniform in its characters and may be recognized easily. This is the same formation that has long been known as the Vilas shale in northeastern Kansas. Newell has verified this correlation by tracing the formation from its type locally in southeastern Kansas.

Lithologic character and thickness. Throughout Wyandotte county the Vilas is a more or less arenaceous shale, bluish-gray in the north-

ern part of the county and light-buff over most of the remaining part of the area. The thickness ranges from sixteen to thirty feet, being thickest in the western part of the county. A persistent layer of calcareous sandstone a foot or so thick occurs near the top of the formation.

Distribution. The outcrop of the Vilas is confined chiefly to the uplands in the western part of the county, extending as a thin band between the outcrop of the Plattsburg and Stanton.

Detailed sections. Stratigraphic sections of the Vilas are shown under localities 13, 15, 21, 23, 25, and 26, at the end of the report.

STANTON LIMESTONE

Five members of the Stanton formation are recognized in Wyandotte county. They are, in ascending order: Captain Creek limestone, Eudora shale, Olathe limestone, Victory Junction shale, and Little Kaw limestone.

Lithologic character and thickness. The Captain Creek limestone member is probably the most uniform in character of any unit exposed in Wyandotte county. It is a massive, gray limestone, composed of three or four even layers, which turn light gray to white upon weathering. The limestone is brittle, breaking up into small, angular fragments upon weathering. Markings occur in the form of small concentrically banded growths like those found in the Paola member of the Iola. The limestone is commonly dense or fine-grained, but in some places is crystalline. Everywhere in the county the Captain Creek limestone is about five and one half feet thick.

The Eudora shale member is quite characteristic. The upper and lower parts are generally composed of buff or gray, argillaceous shale, separated by about a foot of platy, black shale. The member is uniformly about six feet thick. The Eudora is characteristically devoid of fossils.

The Olathe member is composed of thin-bedded and wavy, gray, granular and crystalline limestone. The member is comparatively uniform throughout the county. In a few instances, as at Victory Junction, the member appears massive and thick-bedded. Such instances are generally found at artificial exposures where the rocks have not long been weathered. In natural exposures the Olathe is commonly the only member of the Stanton to be seen, on account of its thickness and relative resistance to erosion. The member is generally about twelve feet thick.

The Victory Junction member is generally made up of buff to light-gray shale, argillaceous in the north and arenaceous in the

southern part of the county, where it contains some sandstone in the upper part. The thickness of the member ranges from seven feet along the northern edge of the county to about ten feet farther south.

The Little Kaw Limestone is quite irregular in Wyandotte county. Generally, however, the lower layers are buff, arenaceous limestone, and the upper part is composed of blocky, even beds of dark gray, brittle limestone. The thickness of the member ranges from one to four feet. The Little Kaw member is commonly overlain by an irregular layer of limestone conglomerate, in places separated from the limestone below by a thin parting of shale. The conglomerate is the basal bed of the Virgil series.

Distribution. The Stanton formation is exposed only in the western part of the county where it underlies most of the flat upland plain.

Detailed sections. Sections of the Stanton limestone are given under numbers 15, 21, 22, 23, and 26 at the end of the report.

VIRGIL SERIES

Stranger Sandstone

The lower part of the Stranger sandstone is the highest indurated deposit in Wyandotte county. The formation unconformably overlies various parts of the Stanton, generally the Little Kaw limestone member.

Lithologic character. In Wyandotte county the Stranger consists of soft, buff, cross-bedded sandstone which weathers in massive rounded slopes. At some localities thin coal beds occur between layers of sandy shale. Exposures were too poor to enable us to determine whether or not any of the coal beds are persistent. Generally the sandstone overlies a thin layer of hard limestone conglomerate, which in turn directly and evenly overlies the little Kaw limestone. Locally more than one conglomerate bed occurs near the base of the Stranger. In section 8, township 10 south, range 23 east, near the middle of the south edge there is a thin bed of limestone overlying the Vilas shale. This limestone probably is the lower part of the Captain Creek. It is overlain by a conglomerate bed followed by a sandstone succession containing thin coal beds. This is the only known occurrence in Wyandotte county where the basal beds of the Virgil cut down into the Stanton. The original thickness of the Stranger in Wyandotte county is unknown, since the upper part has been removed from the area by erosion. It is probable that at least

forty or fifty feet of the formation still occurs in the upland area in the western part of the county.

Distribution. The sandy deposits of the Stranger cover the upland plain and stream divides in the western and central part of the county.

Detailed sections. Sections of the basal Stranger are given under numbers 15, 22, 23, 24, 25, and 27, at the end of this report.

Quaternary System

PLEISTOCENE DEPOSITS

The oldest deposits of Pleistocene age recognized in Wyandotte county are isolated remnants of till of Kansan age occurring in places on the hilltops. These deposits are rare and consist of a heterogeneous association of erratics, worn boulders of local limestone, and sand. The foreign boulders and pebbles consist mainly of Sioux quartzite, with numerous granites and metamorphic rocks. Many of the latter are in an excellent state of preservation, although crumbling igneous erratics are not uncommon in the area. It is possible that these partially decomposed boulders were derived from an earlier stage of glaciation, and later included in the Kansan drift. Numerous localities occur within the county where excellently preserved glacial striae occur at the surface of limestone beds. In appearance, the planation and scratching of the limestone is as fresh as though produced during a late stage rather than the Kansan stage of the Pleistocene. At the quarry of the Union Pacific Railway just west of Loring well preserved striae occur beneath stratified drift. The striae occur in two sets, equally distinct in the limestone, one of which has a bearing of S. 10° E. and the other S. 34° E. to S. 42° E., showing two directions of ice advance. At this place the striated rock with the overlying drift occurs at a comparatively low place in the valley wall, since bedrock rises immediately to the west above this horizon. The bearing of the striae need not necessarily be the same as the general movement of the ice, since irregularities in the land surface affect the direction of movement. At the county line on the highway one mile west of Bonner Springs, numerous striated blocks of the upper layer of the Plattsburg have been taken from the road cut. This is the same stratigraphic horizon at which the striae occur at Loring, and likewise the striae are bounded immediately to the west by topographically higher hard-rock formations. Unfortunately, the blocks have been moved so

that a reading of the bearing of the striae could not be obtained at this place. A large area of beautifully preserved striae has been exposed at the surface of the Raytown near the interurban stop of Serridge, in the SW cor. of sec. 12, T. 11 S., R. 24 E., as a result of extensive road excavations along the Muncie bluffs. The striated blocks were piled along the interurban track, where hundreds of square yards of polished surface could have been studied. The striae at this locality occur at a low point on the east side of the valley of Muncie creek. At Boynes quarry northeast of Welborn on the bluff of Missouri river a considerable area of striated limestone has been uncovered at the top of the quarry. As in the other cases the scratches occur at a point topographically below bed rock in the surrounding hills. The striae at this place for the most part have a bearing of about S. 5° E.

At each of the localities cited the striated rock is overlain by drift which has been to a greater or less extent worn by the action of water. It is probable that these deposits represent outwash from the melting glacier. It may be noted that the topographically low position of the glacial striae along Kansas river points to the fact that Kansas river drainage had been established before the ice advance.

The youngest deposits of probable Pleistocene age include the widespread loess. This material is peculiar in its tendency to stand in vertical walls. The loess of this area commonly contains a high percentage of fine sand. The loess covering is thickest along the edge of the bluff of Missouri river where in some places it attains a thickness of more than fifty feet. Back from the river a short distance it quickly thins out, becoming indistinguishable from the soil covering. On Kansas river the loess is absent between Edwardsville and Bonner Springs on the north side of the river, probably having been removed here by erosion, because the loess is continuous along the south wall of the valley. South of Bonner Springs loess covers the indurated formations to Loring and beyond. The eastern part of the county is covered by an irregular layer of loess, effectively hiding the underlying formations in the vicinity of Kansas City. The loess commonly has a brown to slightly reddish color, while the loess along Missouri river is usually light buff to grayish. It is generally believed that the loess of this region has been derived from the river silt of the valley bottoms, deposited by the overloaded streams during the ice retreat and later blown by the wind onto the neighboring uplands.

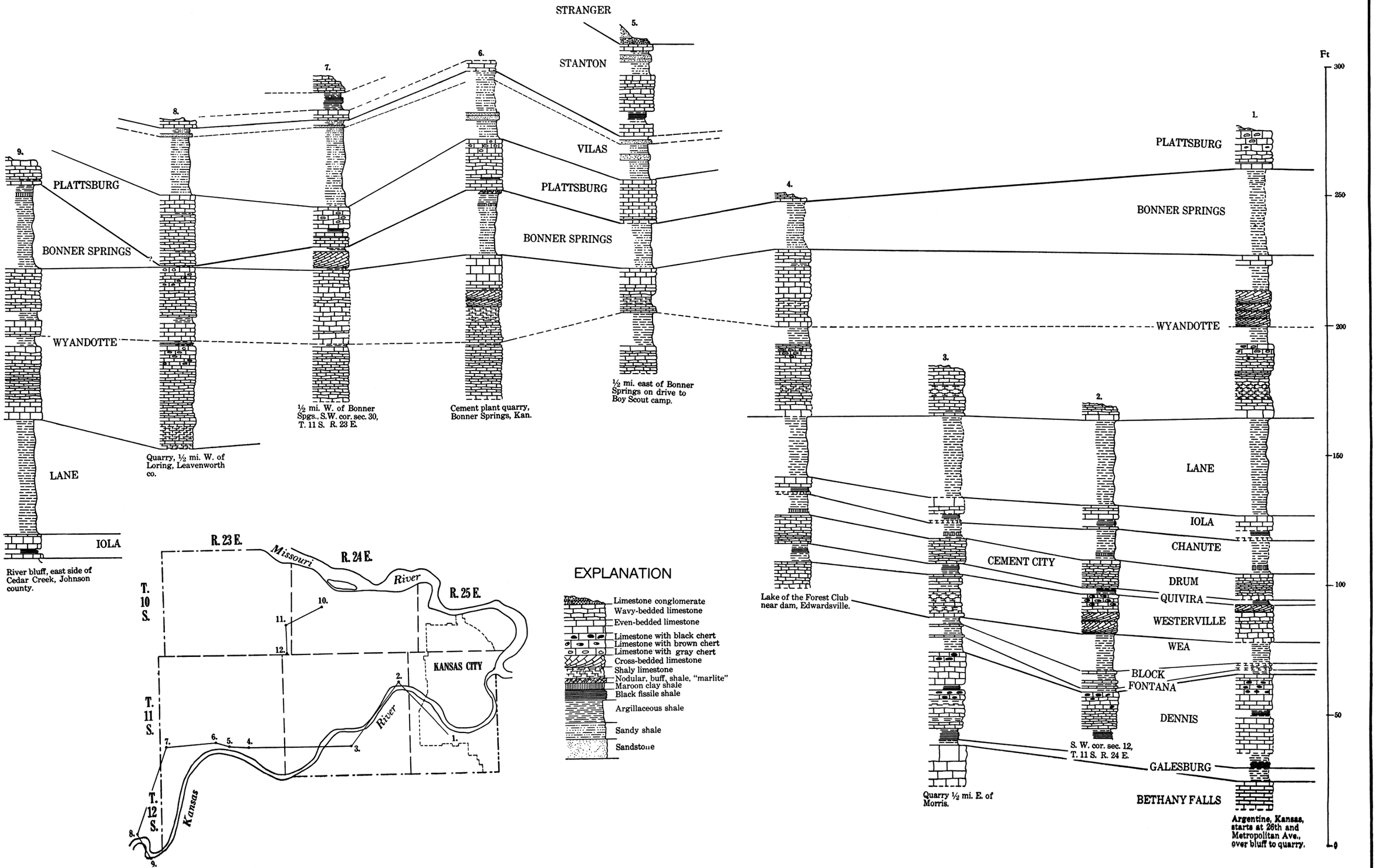


PLATE XVIII. Stratigraphic sections along Kansas river.

RECENT DEPOSITS

The Recent deposits of Wyandotte county consist of (1) obscure alluvial terraces along some of the tributaries of the Kansas, (2) residual soil, (3) wash deposits, and (4) flood-plain deposits. Residual soil of a region is formed by the processes of weathering on the

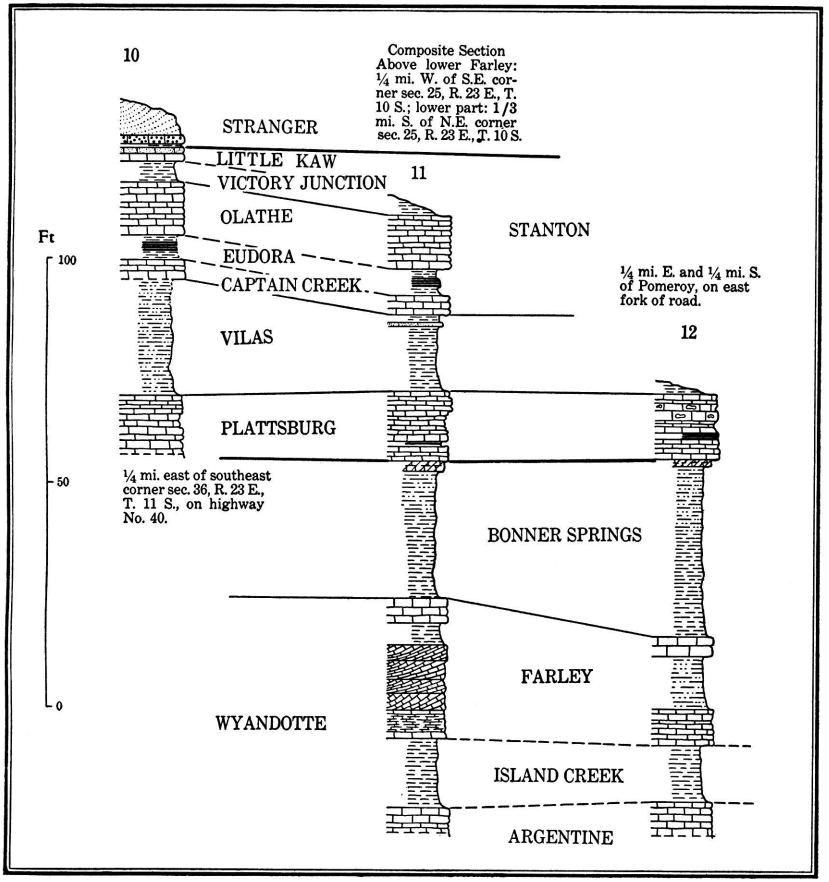


PLATE XIX. Stratigraphic sections in northern Wyandotte county.

rocks. In Wyandotte county thin deposits of residual soil occur over part of the upland area, but are of small areal importance. The colluvial or slope wash deposits likewise constitute but a small part of the Recent deposits. By far the greater part of the Recent deposits in the area include the alluvium of the river flood plains and the flood plains of the principal tributaries. This is accumulat-

ing rapidly in the valleys of the Missouri, which is aggrading its channel. According to Hinds and Greene[14] the valley filling of the Missouri at Quindaro extends to a depth of 107 feet before bedrock is reached. The valley filling, however, is not all of Recent age, since the aggrading of the channel probably started before Pleistocene time. The valley deposits of Kansas river are much the same as those of the Missouri. Undoubtedly the cultivation of the soil in eastern Kansas has resulted in a great amount of loess and soil being dumped into the streams. By breaking the sod the surface runoff of the water is greatly increased, producing intensive gullying which is frequently seen in this area. Since the Missouri throughout its course extends through a greater amount of loess-covered territory than the Kansas, it receives a much greater amount of this soft material than the latter stream.

STRUCTURAL GEOLOGY

By structure the geologist means the arrangement of the various rock units in the earth's crust. The rocks of this area were deposited for the most part under water and upon surfaces that were nearly level. Since their deposition the rocks have been uplifted and tilted. The deformation of the rock beds took place probably over a long period of time, although the first uplift and tilting occurred relatively soon after the deposition of the muds, animal remains, and sands which now compose the indurated rocks.

The rock units as described in the first part of this report are layers of different thicknesses. Each rock layer or stratum is overlain by a younger stratum, and the whole in Wyandotte county dips to the north of west, so that any one unit which occurs at a certain elevation in the eastern part of the area is at a much lower elevation in the western part. The land surface is not parallel to the dipping rock layers, but is inclined to the east, which accounts for the cropping out of the older rocks in the eastern part and the younger ones in the western part of the area. This dip of the rock layers to the north of west is prevalent over all of eastern Kansas and parts of neighboring states, and is the structural condition known as the Prairie Plains monocline. In Wyandotte county the general or regional dip is about ten feet to the mile.

The area is occupied by a series of small folds in which the rock layers are bowed upward into arches or "structures" which are

14. Hinds, Henry, and Greene, F. C., The Leavenworth-Smithville folio: U. S. Geol. Survey, p. 8, 1917.

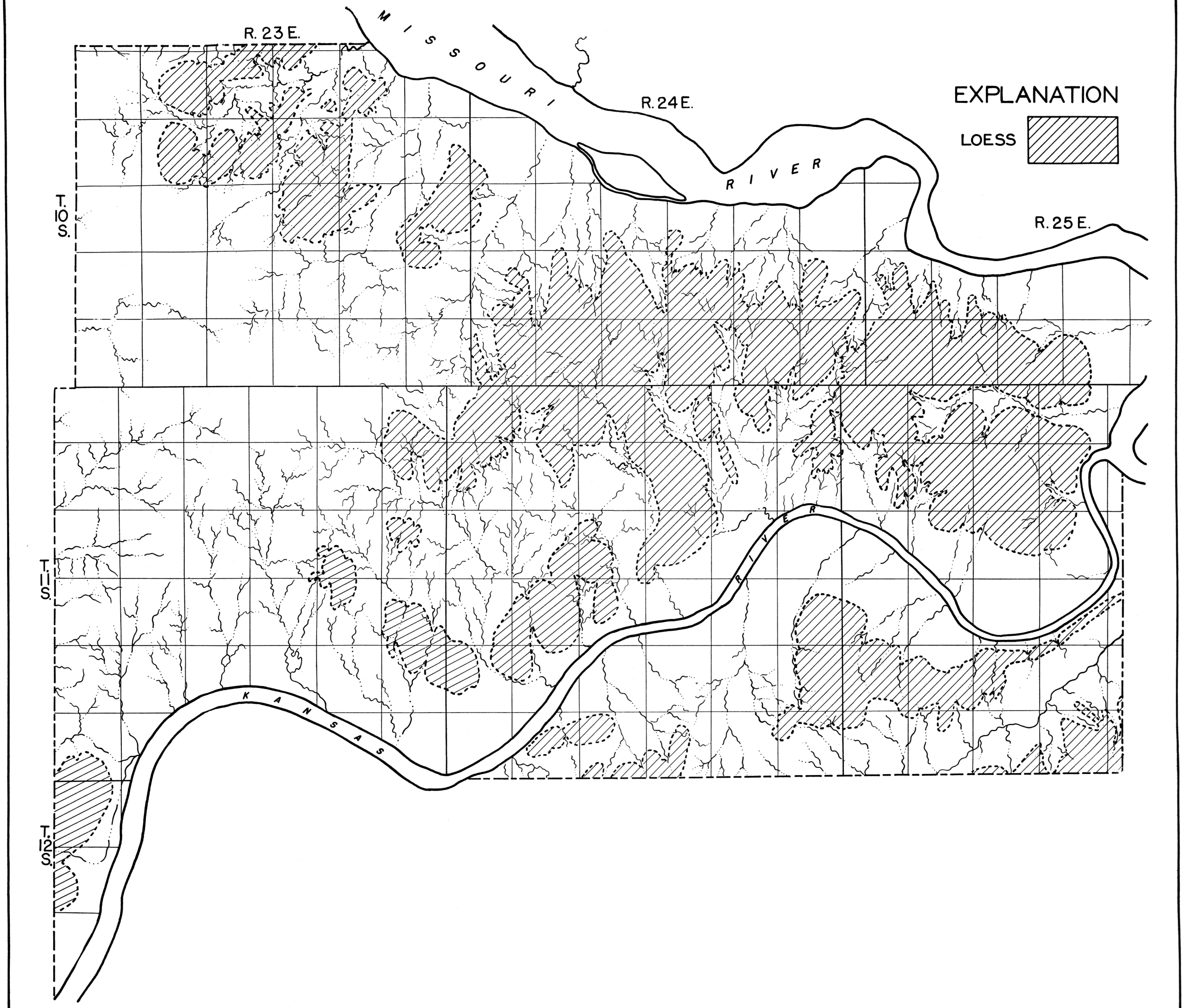


PLATE XX. Map of loess area in Wyandotte county.

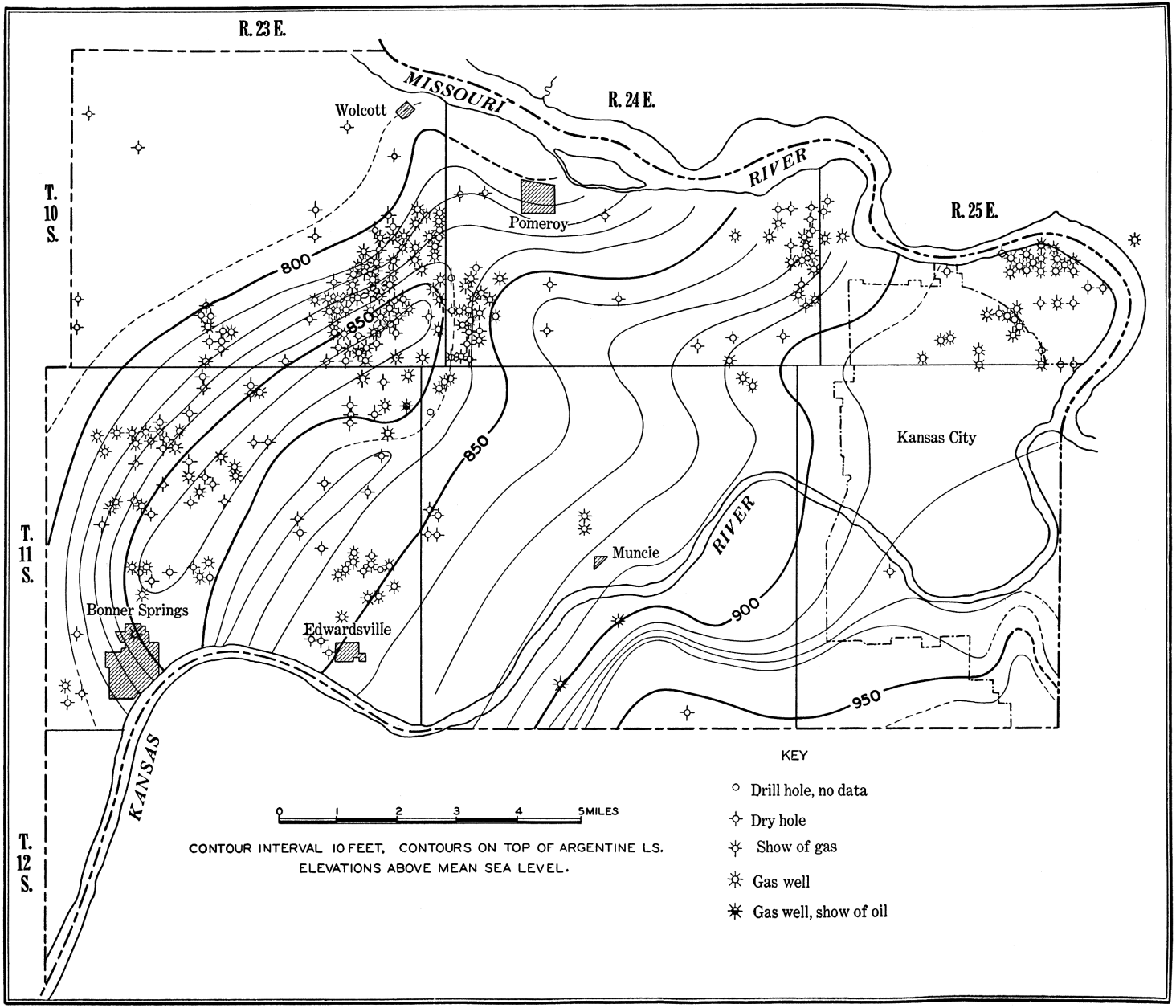
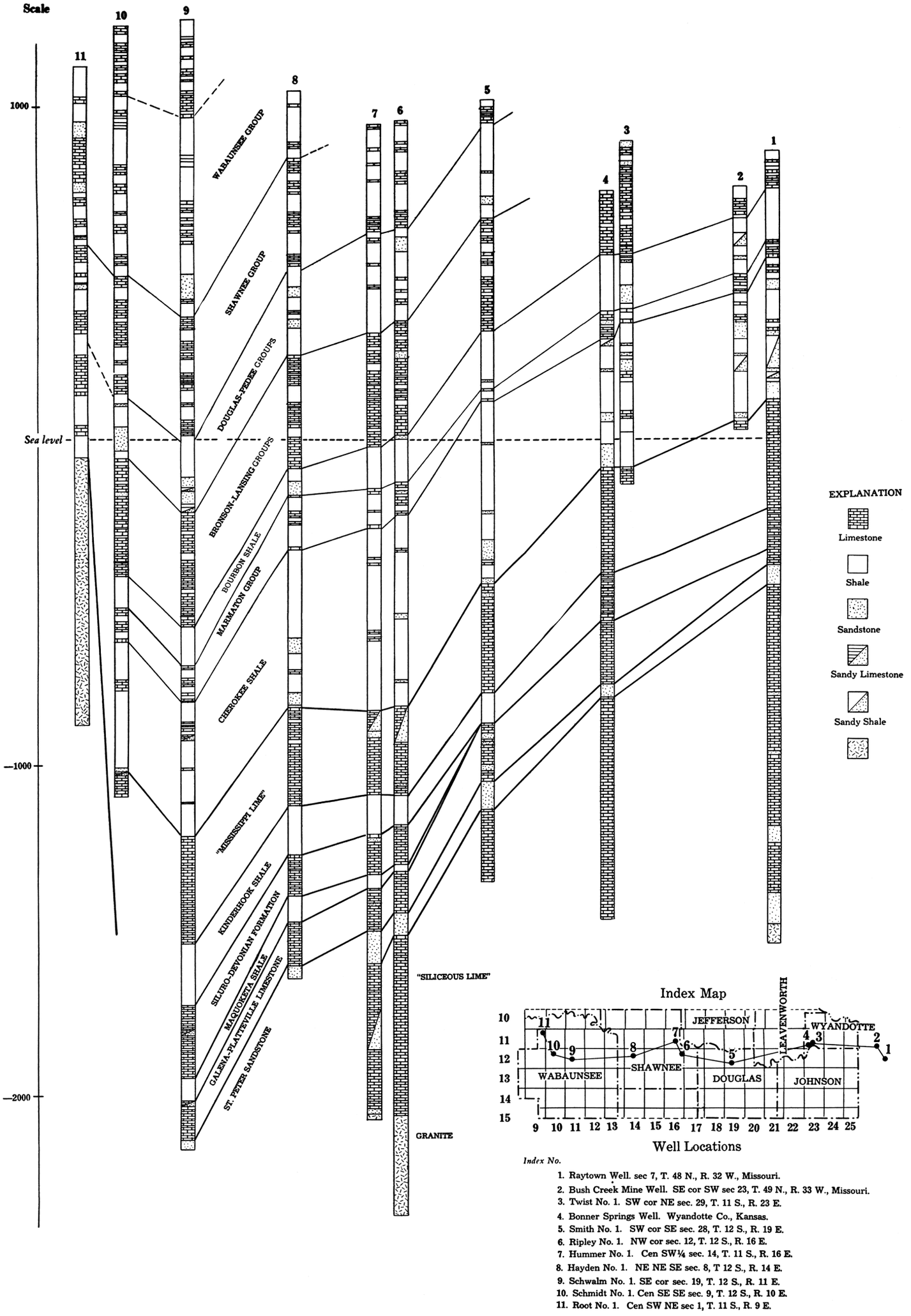


PLATE XXI. Reconnaissance structural map of Wyandotte county.



Index No.

1. Raytown Well. sec 7, T. 48 N., R. 32 W., Missouri.
2. Bush Creek Mine Well. SE cor SW sec 23, T. 49 N., R. 33 W., Missouri.
3. Twist No. 1. SW cor NE sec. 29, T. 11 S., R. 23 E.
4. Bonner Springs Well. Wyandotte Co., Kansas.
5. Smith No. 1. SW cor SE sec. 28, T. 12 S., R. 19 E.
6. Ripley No. 1. NW cor sec. 12, T. 12 S., R. 16 E.
7. Hummer No. 1. Cen SW¼ sec. 14, T. 11 S., R. 16 E.
8. Hayden No. 1. NE NE SE sec. 8, T 12 S., R. 14 E.
9. Schwalm No. 1. SE cor sec. 19, T. 12 S., R. 11 E.
10. Schmidt No. 1. Cen SE SE sec. 9, T. 12 S., R. 10 E.
11. Root No. 1. Cen SW NE sec 1, T. 11 S., R. 9 E.

PLATE XXII. Correlation of well records in northeastern Kansas.

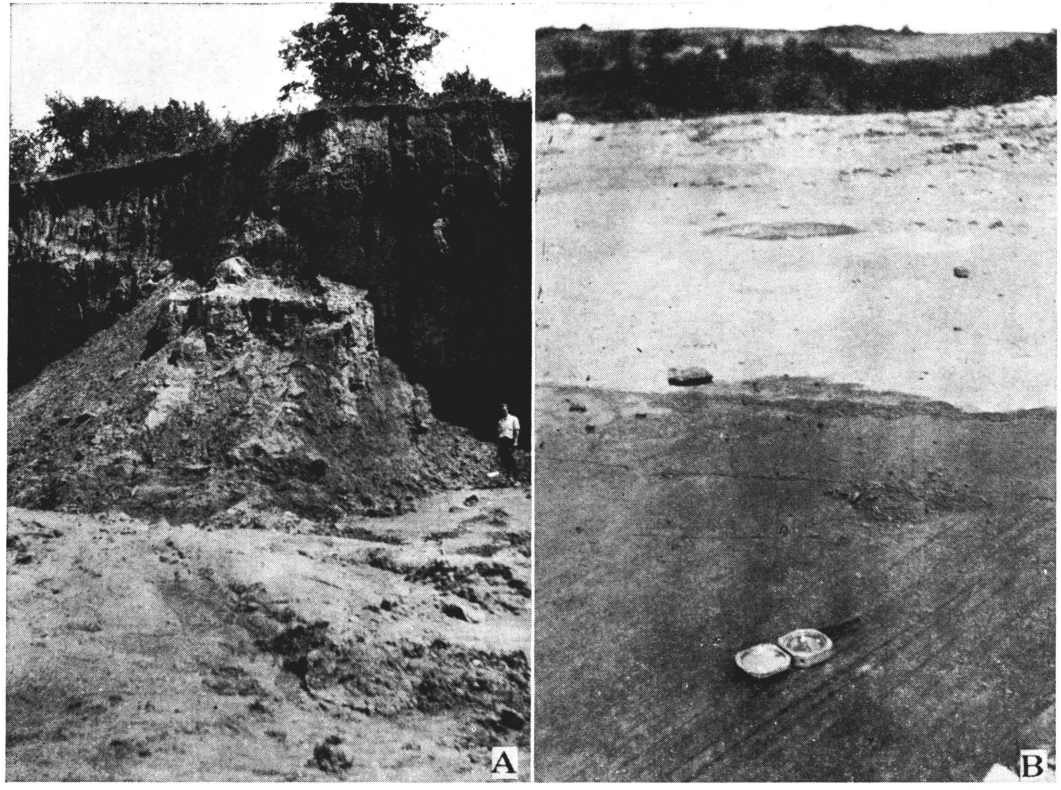


PLATE XXIII. A—Loess along Missouri river bluff near the foot of Fifth street, Kansas City, Kan. B—Glacial pavement on Argentine limestone at Boyn's Quarry, NE sec. 25, T. 10 S., R. 24 E.

called anticlines, and into down-folds which are called synclines. These local structures in places dip as steeply as fifty or more feet to the mile. Such an anticline extends nearly across the county from southwest to northeast, from near Bonner Springs to sec. 25, T. 10 S., R. 23 E., the Maywood anticline. Another conspicuous upfold is near Morris on the north side of Kansas river and probably extends into Johnson county. The Morris anticline brings the Winterset limestone high above the flood plain of the river and has a dip of nearly forty feet to the north and northwest within a quarter of a mile. This series of folds is perhaps of economic importance in this and neighboring counties.

The structural map included in this report was prepared from field observations made with a Paulin altimeter. The map is accurate insofar as it shows all of the more pronounced structural features, including the local folds, the Maywood and Morris anticlines and others. The structure is shown on the map by the usual method of drawing contour lines through points of equal elevation on the surface of the given rock bed. The upper surface of the Argentine limestone is the datum plane. The contour interval or the difference in elevation as represented by two adjacent contour lines in ten feet.

Relation of the attitude of rock beds to the occurrence of oil and gas. Most geologists are of the opinion that oil and gas, as found in the earth, have originated from organic matter which was buried along with the other materials which have been changed into rocks. The organic materials may have been either plants or animals or perhaps both. When one sees the vast quantity of fossil shells, such as are so common in rocks in Wyandotte county, he does not deny the possibility that such organisms contribute to the formation of oil or gas.

Commercial accumulations of oil and gas are generally found in more or less minute openings in rocks buried some depth below the surface. Porous rocks are generally the best "oil sands," but they are not in all cases sandstones. Since oil and gas are lighter than water they will rise to the surface, and since gas is lighter than air it will escape into the atmosphere if free to do so. As water occurs almost everywhere in the rock openings, it is necessary that something prevent the upward trend of the lighter materials if oil and gas are to accumulate in natural reservoirs. It is believed that oil and gas, if present, will be forced upward by ground water in a dipping bed of porous rock until stopped by some obstruction. Hence,

if a bed of sandstone containing water, oil and gas lies under a bed of impervious shale, and is arched into a dome or an anticline, the gas will accumulate below the impervious shale at the crest of the upfold, the oil will collect a little farther down, and the water will remain in the lower parts of the sandstone. For reasons stated above the petroleum geologist looks for anticlines in his quest for the location of new fields. There are several other types of structure which are favorable for the accumulation of gas and oil, some of which may be detected by the scientific investigation of the surface conditions. Cox, Dake, and Muilenburg[15] give a concise explanation of the favorable structure. It is worthy of note that considerable accumulation in eastern Kansas has taken place in irregularly shaped buried layers of sandstone. Such structural conditions are known as "shoestrings" and cannot readily be detected by surface observations.

A considerable quantity of natural gas has been produced in Wyandotte county. There is little doubt that the accumulation of these materials has been to some extent controlled by structure, and it is hoped that the descriptions and identification of rock strata, as well as the more general structural features as described and illustrated in this section, are of value to petroleum geologists in locating whatever deposits of gas and oil exist undiscovered below the surface of the county.

ECONOMIC GEOLOGY

SOILS

The natural resource of greatest value in Wyandotte county is the soil. It is somewhat beyond the scope of this report to minutely describe the soils, as they differ in various local areas, and no attempt has been made to map other than the flood-plain alluvium of the larger streams, and the loess. The soil in the county is partly the product of the disintegration of bedrock, and partly the product of water-deposited, wind-deposited, or ice-deposited materials. In any one place the soil may be derived from any combination of these materials. The loess is principally confined to the eastern part of the county, and to the hills bordering the river valleys. It has been described in an earlier part of this report. The loess is well adapted to fruit growing. Truck farming, including potato growing, is important in the loess-covered area. At the present time very little

15. Cox, G. H., Dake, C. L., and Muilenburg, G. A., Field methods in petroleum geology, pp. 3-12.

of the loess area is given to the growing of general farm crops as wheat and corn. The alluvium of the valleys of Kansas and Missouri rivers is fertile, although Kansas river valley far exceeds that of Missouri river in extent of fertile soil. Missouri river flood plain is generally swampy and is partly covered by oxbow lakes, while in general that of Kansas river is a well-drained, fertile area. Potatoes are important products of the valley farms. The acreage of potatoes varies with the market conditions over a period of a few years, and at the present the acreage is reduced. There is a portion of the valley farms utilized for general farming, but trucking prevails. The largest area of alluvial soil along Kansas river occurs in the neighborhood of Edwardsville, where the river has swung far over to the right side of its valley. Another such area lies north and east of Turner on the south side of Kansas river, but here the land is used for other industries as well as for agriculture. The alluvial soil of the smaller streams is generally less sandy than that of the rivers. Most of the smaller streams have comparatively large flood plains growing good crops. The flood plains of these smaller streams are mostly built up of material washed down from the valley walls. In the western part of the county the soil is partly residual and partly transported. Considerable of the transported material has not been moved far since it was deposited directly from the ice sheet. Some of the material seems to have been water-worked to a large extent, having the appearance of a valley alluvium but now found on the uplands. Much of the residual soil is derived from the Stranger formation and is sandy. The soil in the western part of the county is utilized for general farming and dairying.

LIMESTONE

Limestone suitable for nearly all of the many uses to which the rock may be put is abundant in Wyandotte county. There are several large and many small quarries producing principally crushed stone for the enormous demand of greater Kansas City. No small amount of crushed stone is being used in the construction of concrete highways and in graveling roads. The Argentine limestone is extensively being quarried for crushing. Because of the thickness of this ledge, it is a good one in which to locate quarries. The Bethany Falls is suitable, but outcrops over a very small area. The great amount of flint embedded in the Winterset and in most places in the Westerville makes those two limestones especially good for the production of rubble in which flint is desired. The massive beds

of the Farley limestone were quarried near Wolcott and used in the river-improvement work conducted by the federal government. Generally the Farley is too soft for some of the purposes of crushed stone, but in some areas it is quite hard. The demand for dimension blocks is much less than for crushed stone and fewer of the limestones are adapted for that purpose. However, the Meadow and Merriam limestones, which crop out in the western part of the county, produce durable building stone. This is true generally of the other thinner ledges, especially the Paola limestone of the Iola formation. Limestone and shale suitable for making Portland cement are abundant. Cement is being manufactured at Bonner Springs in one of the large plants of the state. Argentine, Farley, and Plattsburg limestones and Bonner Springs shale are being quarried at that plant.

SHALE AND LOESS

As stated above, enormous quantities of shale, especially in the Bonner Springs and Lane formations, are adapted to be used with limestone in cement manufacture. These shales, and probably the thick loess deposits, are suitable for making clay products, although Wyandotte county has no such industry. There is a large plant producing clay products in Kansas City, Mo., and the same raw materials are available in Wyandotte county. Some loess is being used for the filling of low places, but uses more profitable than for the production of crops are not being made.

Loess erodes rapidly and it is difficult to keep unsurfaced roads in repair where the grade is steep. Deep gullies develop during a single rainy season, and the presence of the loess should be considered in all construction operations. A case was observed where a comparatively new schoolhouse of brick has been built on a small loess hill in the northern part of the county. The soft material is already gullied near the building and there is little doubt that action will have to be taken to prevent the building from being undermined before it is old.

SAND

Five sand companies are taking sand from Kansas river and loading it into dump-bottom railway cars. Much sand is also trucked away. There are two other sources of sand in the county. One is the higher glaciofluvial sand, which perhaps would fulfill many of the purposes for which the river sand is used. Such a deposit

would be more easily moved than the sand in the river's bed, but the supply is readily exhaustible, while the sand removed from the river is replaced. The other source is the massive, loosely cemented sandstone at the base of the Stranger formation, which covers most of the western part of the county. This sand is fine and perhaps not suitable for many uses.

GRAVEL

There is much glacial gravel and coarse sand in the county. These gravels are composed mostly of very hard rock fragments and hence are durable. By screening, excellent road gravel could be obtained.

COAL

The small amount of coal known to occur in the rocks which crop out in this area is now of no commercial value, because the beds are very thin and apparently local in distribution. There are workable deposits of coal in the buried rocks and its recovery may be profitable at some future time. The most important coal-bearing rocks of the state are deeply buried in Wyandotte county. These are the Cherokee and the Marmaton groups which underlie the rocks exposed at Kansas City. In the coal fields of southeastern Kansas the Cherokee group ranges from 400 to 550 feet, and is perhaps thicker at Kansas City. The coal being produced in the Cherokee-Crawford district, much of that produced in Labette county, and from the deep mines at Leavenworth and Lansing is taken from this horizon. In the State Penitentiary mine at Lansing the coal is two feet thick and occurs at a depth of 709 feet. This coal should be about 150 feet nearer the surface at Kansas City. At Raytown, Mo., a diamond drill hole revealed several beds at depths ranging from 294 to 525 feet. The bed which is being mined at Leavenworth and Lansing is believed to be 454 feet below the surface at Raytown and is one foot eight inches thick. The same bed was formerly mined at Randolph in Clay county, Missouri, and south of Kansas City, at Bush Creek, Mo. It is well to state that the presence of workable beds of coal everywhere in the buried Cherokee strata is not proven, yet it is rather certain that these rocks contain several beds throughout the Wyandotte county area. The presence of important coal beds in buried rocks above the Cherokee in this area is doubtful.

Register of Detailed Sections, Wyandotte County

1. *Section at and above a quarry one half mile west of Morris, Kan.*

	Thickness in Feet.
Wyandotte limestone:	
Argentine-Frisbie members:	
Limestone, thin-bedded, light in color, cherty	30.0
Lane shale:	
Shale, gray, argillaceous	37.0
Iola limestone:	
Limestone, massive, blocky, dark-gray, partly covered	8+
Chanute shale:	
Shale covered	7.0
Drum limestone:	
Limestone, thin-bedded, massive at top	11.0
Quivira shale:	
Shale, carbonaceus	7.0
Westerville limestone:	
Shale and interbedded limestone	5.0
Shale, buff, limy	5.0
Limestone and interbedded shale, buff	4.0
Limestone, oölitic, buff	2.0
(Total Westerville limestone, 16.0 feet)	
Wea shale:	
Shale, buff, argillaceous, thin-bedded near top	6.0
Block limestone:	
Limestone, buff, soft	0.7
Fontana shale:	
Shale, buff, limy, *Chonetina flemingi* var. *plebeia* zone near top, a thin coal seam near base	6.0
(Total Cherryvale shale, 35.7 feet)	
Dennis limestone:	
Winterset limestone member:	
Limestone, black nodular chert near top, massive at top, thin-bedded and argillaceous below, drab to gray	12.0
Shale, dark, platy	2.5
Limestone, massive, gray to buff, upper part cross-bedded with some chert	5.5
Shale	7.6
Limestone, gray, massive	7.3
Stark shale member:	
Shale, gray, argillaceous	1.0
Shale, black, carbonaceous, platy	1.0
(Total Dennis limestone, 36.9 feet)	
Galesburg shale:	
Shale, gray, argillaceous	4.0
Swope limestone:	
Bethany Falls limestone member.	

2. *Section at a quarry near Twenty-eighth street and Southwest Boulevard, Kansas City, Mo.*

	Thickness in Feet.
Dennis limestone:	
Winterset limestone member:	
Stark shale member:	
Shale, gray, argillaceous	3.0
Shale, black, platy	1.0
(Total Stark shale member, 4.0 feet)	
Galesburg shale:	
Shale, gray, argillaceous	6.0
Swope limestone:	
Bethany Falls limestone member.	

3. *Section in a road cut at the SW. corner of sec. 12, T. 11 S., R. 24 E.*

Argentine limestone:	
Lane shale:	
Shale, argillaceous, covered	30.0
Iola limestone:	
Raytown limestone member:	
Limestone, gray, massive, even-bedded	6.0
Muncie Creek shale member:	
Shale, black, platy, gray near top and bottom	3.0
Paola limestone:	
Limestone, hard, blue, dense, calcite "marklets"	1.0
(Total Iola limestone, 10.0 feet)	
Chanute shale:	
Shale, dark-gray, argillaceous, red zone near base, thin coal locally at top	12.0
Drum limestone:	
Limestone, soft, gray, thin-bedded	10.0
Quivira shale:	
Shale, calcareous, greenish-gray, dark at middle	3.0
Westerville limestone:	
Chert, pink and brown, lenticular seams	3.0
Oölite, fossiliferous, irregular	0.3
Limestone, gray to white, massive	12.0
(Total Westerville limestone member, 15.3 feet)	
Wea shale:	
Shale, argillaceous buff	25.0
Block limestone:	
Limestone, buff, soft	1.0
Shale, buff	3.0
Limestone, gray	1.0
Shale, gray	1.0
Limestone, gray, soft	1.0
(Total Block limestone member, 7.0 feet)	
Fontana shale:	
Shale, covered	2.0

4. *Section about one half mile west of Turner, Kan.*

	Thickness in feet.
Westerville limestone:	
Limestone, oölitic, cross-bedded, very fossiliferous	18.0

5. *Section near railway station, Nearman, Kan.*

Quivira shale:
Shale.
Westerville limestone:
Limestone, thin and wavy-bedded, buff, with brown nodular chert at top 11.0
Wea shale.

6. *Section along interurban railway, near Matoon, west of City Park, Kansas City, Kan.*

Drum limestone:
Limestone, thin-bedded, gray, weathers light in color, with *Campophyllum torquium, Marginifera splendens* and Rhomboporoids at top 8.0
Quivira shale:
Shale, greenish-gray, argillaceous 3.5
Westerville limestone:
Chert and limestone, pink to brown, massive with banded and irregular structure 5.0
Limestone, thin-bedded, buff, with little chert 2.5
Shale, argillaceous, gray 0.3
Oölite, cross-bedded, massive, drab and buff, fossiliferous, lower part more evenly bedded 8.3
(Total Westerville limestone member, 16.1 feet)
Wea shale.

7. *Section along bluff south of Twenty-sixth street and Metropolitan avenue, Argentine, Kansas City, Kan., type exposure of Argentine limestone.*

Plattsburg limestone:
Limestone, brown and gray, massive 15.0
Bonner Springs shale:
Shale, arenaceous, covered 33.0
Wyandotte limestone:
Farley limestone member:
Limestone, massive, dark-gray, composed of fossil fragments, and with *Osagia* 3.5
Shale, argillaceous, covered 10.0
Limestone, oölitic, cross-bedded, fossiliferous massive, drab to buff, 14.5
(Total Farley limestone member, 28.0 feet)
Island Creek shale member:
Shale, bluish-gray, argillaceous 7.5
Argentine-Frisbie limestone members:
Limestone, whitish-gray, thin-bedded, cherty in upper part, shaly in middle part, and massive below 30.0
Lane shale:
Shale, buff to gray 38.5

	Thickness in Feet.
Iola limestone:	
Limestone, gray, hard, covered	6.5
Chanute shale:	
Covered	6.0
Drum limestone and Quivira shale member:	
Covered	11.5
Westerville limestone:	
Limestone, cross-bedded, granular	16.0
Wea shale:	
Shale	6.0
Block limestone and Fontana shale:	
Covered	4.0
Dennis limestone and Galesburg shale:	
Winterset limestone member:	
Limestone with black chert	10.0
Lower part of Winterset limestone member and Galesburg shale:	
Covered	39.0
Swope limestone:	
Bethany Falls limestone member:	
Limestone, poorly exposed	3.0

8. *Section near the dam at Forest Lake, west of Edwardsville, Kan.*

Bonner Springs shale:	
Shale, covered.	
Wyandotte limestone:	
Farley limestone member:	
Limestone, hard, dense, weathers white to buff, massive, with brecciated appearance on weathered surface	12.0
Shale, gray, argillaceous	2.0
Limestone, gray to buff, granular, limonitic, slightly cross-bedded, friable	6.3
Shale, greenish-gray, arenaceous	0.2
Limestone and shale in thin beds	5.6
Shale, gray, arenaceous	0.3
Limestone, gray to drab, oölitic	4.4
(Total Farley limestone member, 30.8 feet)	
Island Creek shale member:	
Shale, arenaceous, buff and fossiliferous	6.5
Argentine-Frisbie limestone members:	
Limestone, whitish-gray, irregular beds	25.0
Lane shale:	
Shale, gray, argillaceous	37.0
Iola limestone:	
Limestone, blocky, massive, light gray, partly covered	8+
Chanute shale:	
Shale, covered	7.0
Drum limestone:	
Limestone, thin-bedded, gray, massive at top	11.0

	Thickness in Feet.
Quivira shale:	
Shale	7.0
Westerville limestone:	
Limestone, thin- and cross-bedded, argillaceous, granular, gray and buff	4.0

9. *Section at Boynes Quarry, NW corner sec. 30, T. 10 S., R. 25 E., on Missouri river bluff, northeast of Welborn, Kan., type exposure of Quindaro shale.*

Kansan drift:	
Loess, arenaceous, buff to brown	50±
Drift, gravel, erratics, sand, etc.	5+
Wyandotte limestone:	
Argentine limestone member:	
Limestone, hard, dark, cross-bedded, granular, with abundance of pelecypods, surface planed and scratched by glaciation	1.5
Limestone, dark-gray, hard, little chert, thin- and wavy-bedded	19.0
Quindaro shale member:	
Shale, buff and dark gray	3.0
Frisbie limestone member:	
Limestone, dense, bluish-gray	2.0
Lane shale.	

10. *Section at quarry near Rainbow Avenue and Southwest Boulevard, Rosedale, Kansas City, Kan.*

Wyandotte limestone:	
Argentine-Frisbie limestone members:	
Limestone, thin-bedded and wavy-bedded, gray, hard, cherty	38.0

11. *Section in a road cut, center of sec. 32, T. 11 S., R. 25 E.*

Wyandotte limestone:	
Argentine limestone member:	
Limestone, massive and pink at top, cherty, lower half buff, shaly, argillaceous	33.5

12. *Section in quarry along Union Pacific railway, center of sec. 32, T. 12 S., R. 23 E.*

Plattsburg limestone:	
Limestone (highest in quarry), cherty and thin-bedded at top, surface of which shows excellent glacial planation and scratches, massive and buff in lower part	21.5
Shale, dark, argillaceous	1.0
Limestone, very massive, gray to buff, hard, with *Enteletes hemiplicatus* var., base? of Plattsburg	5.0
(Total Plattsburg limestone, 27.5 feet)	
Bonner Springs shale:	
Shale, greenish-gray to buff with *Cordaites*	0.5
Wyandotte limestone:	
Farley limestone member:	
Limestone, massive, gray to buff	18.0
Shale, gray, arenaceous	1.5
Limestone, massive, gray, argillaceous	6.7
(Total Farley limestone member, 26.2 feet)	

	Thickness in Feet.
Island Creek shale member:	
Shale, gray to buff, argillaceous	1.0
Argentine limestone member:	
Limestone, white to pink blue zone at top, massive at top, shaly below	32.5

13. *Section at cement plant quarry, Bonner Springs, Kan.*

Kansan:	
Drift.	
Vilas shale:	
Sandstone, buff	3.0
Shale	7.0
Plattsburg limestone:	
Spring Hill limestone member:	
Limestone, arenaceous, buff, with pelecypods and trilobites	1.5
Limestone, massive	5.0
Limestone, gray to buff, crystalline	8.0
Hickory Creek shale member:	
Shale, black	0.3
Shale, buff	0.3
Merriam limestone member:	
Limestone	1.1
Shale	0.2
Limestone	1.3
(Total Plattsburg limestone, 17.7 feet)	
Bonner Springs shale:	
Shale, green	0.3
Marlite	2.7
Shale, dark gray	6.0
Shale, arenaceous	7.0
Shale, less sandy	9.0
(Total Bonner Springs shale, 25.0 feet)	
Wyandotte limestone:	
Farley limestone member:	
Limestone, massive, hard, dark-gray, cherty	11.0
Shale, gray, fossiliferous	0.6
Limestone, massive	0.6
Limestone, arenaceous, locally cross-bedded	7.0
Shale and limestone, interbedded	13.5
(Total Farley limestone member, 32.7 feet)	
Island Creek shale member:	
Shale, greenish-gray, calcareous	1.0
Argentine limestone member:	
Limestone, light in color	10+

14. *Section on Island creek, center sec. 23, T. 10 S., R. 23 E.*

	Thickness in Feet.
Plattsburg limestone:	
Limestone, covered	13.0
Bonner Springs shale:	
Shale, covered	25.0
Wyandotte limestone:	
Farley limestone member:	
Limestone, brecciated, pebbles of brown limestone in dark, granular matrix	5.0
Limestone, dense, bluish-gray, massive	3.0
Shale, buff, limy, partly composed of species of *Myalina*	6.0
Limestone, massive, drab, oölitic, fossiliferous	30.0
(Total Farley limestone member, 44.0 feet)	
Island Creek shale member:	
Shale, argillaceous, buff, covered to creek	3+

15. *Section at Camp Naish, Boy Scouts of America, one mile east of Bonner Springs, Kan.*

Stranger sandstone:	
Sandstone, micaceous, buff	15+
Limestone, conglomerate, brown	1.0
Unconformity.	
Stanton limestone:	
Little Kaw limestone member:	
Limestone, buff, micaceous, arenaceous, pelecypods	2.4
Victory Junction shale member:	
Shale, arenaceous, covered	8.5
Olathe limestone member:	
Limestone, thin-bedded, crystalline, hard, gray, weathers buff	15.0
Eudora shale member:	
Shale, gray, argillaceous above, below; black and fissile near middle,	5.0
Captain Creek limestone member:	
Limestone, massive, gray to white, hard, even-bedded	5.5
Vilas shale:	
Shale, arenaceous	1.0
Sandstone, "quartzitic," gray, rippled	1.8
Shale, gray, arenaceous, blocky at base	13.8
Plattsburg limestone:	
Limestone, gray to buff, massive beds, abudance of algal form, *Osagia*, at base	17±
Bonner Springs shale:	
Shale, gray, micaceous, arenaceous, with plant fossils	20.2
Wyandotte limestone:	
Farley limestone member:	
Limestone, massive, even-bedded, hard, gray	10.0
Shale, argillaceous, gray, dark at top	1.2
Limestone, yellow, graular at top, shaly near middle, gray at base,	10.3
(Total Farley limestone member, 21.5 feet)	
Island Creek shale member:	
Shale, gray, argillaceous	14.0
Argentine limestone.	

16. *Section at a quarry east of concrete road near the NE corner of sec. 10, T. 10 S., R. 23 E.*

	Thickness in Feet.
Plattsburg limestone:	
Limestone in covered bench	14±
Bonner Springs shale:	
Shale, buff, arenaceous, covered	25.0
Wyandotte limestone:	
Farley limestone member:	
Limestone, dense, dark	2–3
Shale, gray, argillaceous	7.0
Limestone, massive, cross-bedded, drab to gray	15.0
(Total Farley limestone member, 25.0 feet)	
Island Creek shale:	
Shale, gray, argillaceous, mostly covered	40.0
Argentine limestone:	
Limestone, white, thin-bedded, only top exposed	5+

17. *Section along concrete road one fourth mile southeast of Wolcott, Kan.*

Plattsburg limestone.
Bonner Springs shale and upper Farley limestone member:
Covered slope.
Wyandotte limestone:
Lower Farley limestone:
Limestone, massive except near the middle where it is shaly, oölitic, cross-bedded, fossiliferous 16.0
Island Creek shale:
Shale, argillaceous, covered 43.0
Argentine limestone:
Limestone, thin-bedded, light in color, dense, base covered ..... 17+

18. *Section along road cut of Pomeroy, near center of sec. 20, T. 10 S., R. 24 E.*

Plattsburg limestone:
Limestone, marlite at base 15.0
Bonner Springs shale:
Shale, gray and buff, argillaceous below, arenaceous, with fossil plants above 38.0
Wyandotte limestone:
Farley limestone member:
Limestone, massive, granular, gray, weathers into thin plates 3.5
Shale, arenaceous, buff 12.0
Limestone, thin-bedded, dark, oölitic 8.0
(Total Farley limestone member, 23.5 feet)
Island Creek shale:
Shale, argillaceous, greenish-gray to buff 11.0
Argentine limestone:
Limestone, white, thin-bedded, only upper part exposed.

19. *Section one fourth mile west of the SW corner of sec. 25, T. 10 S., R. 23 E.*

	Thickness in Feet.
Plattsburg limestone:	
Limestone, brown, marlite at base	15.0
Bonner Springs shale:	
Shale, arenaceous, buff	28.0
Wyandotte limestone:	
Farley limestone member:	
Limestone, massive, gray, dense, weathers into thin plates, with an abundance of *Myalina subquadrata*	5.5
Shale, argillaceous, gray	5.0
Limestone, oölitic, gray to drab, only upper part shown	4+

20. *Section along concrete road near the NE corner of sec. 25, T. 10 S., R. 23 E.*

Wyandotte limestone:	
Farley limestone member:	
Limestone, massive in upper part, thin-bedded, and argillaceous, below cross-bedded and oölitic, buff to gray	20.0
Island Creek shale:	
Shale, greenish-gray, argillaceous, few fossils	15.5
Argentine limestone:	
Limestone, light gray or white, dense, massive, hard.	

21. *Section along concrete road at the SW corner of sec. 30, T. 10 S., R. 23 E.*

Kansan:	
Drift, cobbles, etc.	
Stanton limestone:	
Captain Creek limestone member:	
Limestone, hard, gray, dense, massive, evenly-bedded	6.5
Vilas shale:	
Shale, buff to gray, arenaceous	24.0
Plattsburg limestone:	
Limestone, brown, even-bedded.	

22. *Section one half mile west of Victory Junction, on U. S. Highway 40*

Stranger sandstone:	
Sandstone and arenaceous shale.	
Unconformity.	
Stanton limestone:	
Victory Junction shale:	
Sandstone, calcareous, micaceous, buff, with an abundance of molluscan remains	1.0
Shale, arenaceous, buff, unfossiliferous	10.0
Olathe limestone:	
Limestone, massive, light gray, base covered	10+

23. *Section in an old quarry one fourth mile west of the SE corner of sec. 26, T. 10 S., R. 23 E.*

	Thickness in Feet.
Stranger sandstone:	
Conglomerate, yellow limestone pebbles in a gray and buff arenaceous matrix	1.0
Shale, arenaceous	1.0
Unconformity.	
Stanton limestone:	
Little Kaw limestone member:	
Limestone, bluish-gray, micaceous	1.0
Victory Junction shale member:	
Shale, arenaceous, buff	12.0
Olathe limestone member:	
Limestone, massive, gray to buff, irregular-bedded	12.0
Eudora shale member:	
Shale, gray, argillaceous above and below, black and fissile near the middle	5.0
Captain Creek limestone member:	
Limestone, dark, massive, even-bedded, blocky	5.0
(Total Stanton limestone, 35.0 feet)	
Vilas shale:	
Shale covered to pavement	11+

24. *Section one fourth mile east of the SW corner of sec. 8, T. 10 S., R. 23 E.*

Stranger sandstone:	
Conglomerate, limestone pebbles in gray, arenaceous, matrix, interbedded with gray, hard, calcareous sandstone, cross-bedded	4.0
Shale, covered	9.0
Sandstone and interbedded laminae of coal, cross-bedded, buff, with thin coal seam at base	2.0
Conglomerate, limestone pebbles in arenaceous matrix, limy sandstone at top	1.5
Unconformity.	
Stanton limestone:	
Captain Creek limestone member:	
Limestone, massive, bluish-gray, very brittle, very few fossils	3.0

25. *Section at the south side of sec. 8, T. 10 S., R. 23 E. (A continuation of section 24)*

Stranger sandstone:	
Conglomerate, limestone pebbles in a brown or gray, sandy matrix, cross-bedded	3.0
Unconformity:	
Stanton limestone:	
Captain Creek limestone member:	
Limestone, gray, brittle, massive, blocky	3.0
Vilas shale:	
Shale, gray, argillaceous	17.3

	Thickness in Feet.
Plattsburg limestone:	
Spring Hill limestone and Hickory Creek shale members:	
Limestone, argillaceous, massive, with thin shale partings, with carbonaceous shale at base	15.0
Merriam limestone member:	
Limestone, blocky, even-bedded with *Osagia, Myalina,* and *Pinna,*	3.0

26. *Section one fourth mile west of the NW corner of sec. 36, T. 10 S., R. 23 E.*

Loess:	
Stanton limestone:	
Olathe limestone member:	
Limestone, thin- and wavy-bedded, gray, crystalline	12.0
Eudora shale member:	
Shale, upper part buff, lower part gray, black and fissile and carbonaceous in middle part	6.0
Captain Creek limestone member:	
Limestone, massive, dark gray, even-bedded	6.0
Vilas shale:	
Shale, gray and buff, arenaceous	17.7
Plattsburg limestone:	
Limestone, even-bedded, brown.	

27. *Section west of the road by creek, south edge of sec. 8, T. 11 S., R. 23 E.*

Stranger sandstone:	
Sandstone, covered.	
Conglomerate, yellow limestone pebbles in gray and brown matrix,	2.0
Unconformity.	
Stanton limestone:	
Little Kaw limestone member:	
Limestone, massive, dark, brittle, fossiliferous	4.0
Victory Junction shale member:	
Shale, arenaceous, upper part exposed	1+

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ERRATA

Page 10, line 32—	"Plate XI"	Change to "Plate XII"
Page 25, line 11—	"Kansas"	Change to "Kansas City"
Page 26, line 31, 33—	"Middle creek"	Change to "Middle Creek"
Page 31, line 19—	*"rockymountanum"*	Change to *"rockymontanum"*
Page 32, line 19—	"countes"	Change to "counties"
Page 35, footnote—	Central City locally	Change to Cement City locally
Page 42, line 29—	"concretion"	Change to "concretions"
Page 44, line 31—	"151"	Change to "161"
Page 52, line 36—	*"Spirifer dunbari"*	Change to *"Neospirifer dunbari"*
Page 65, footnote—	"p. 151"	Change to "p. 188"
Page 70, line 8—	"limesotne"	Change to "limestone"
Page 162, last line—	*"marginifera"*	Change to *"Marginifera"*
Page 171, footnote—	"p. 13"	Change to "p. 35"
Page 174, line 26—	"middle"	Change to "bottom"
Page 175, line 22—	*"Conularid"*	Change to *"Conularia"*

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