STRATIGRAPHY OF THE UPPER PART OF THE KANSAS CITY GROUP (PENNSYLVANIAN) IN SOUTHEASTERN NEBRASKA AND ADJACENT REGIONS

by

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As a note concerning this report. Some pictures were also a part of this report, and their quality were also poor, after reproduction by the Survey, and were useless. The Above were therefore extracted from the report.

INTRODUCTION

The formations of the upper part of the Kansas City Group (Missourian Series, Upper Pennsylvanian) are very persistent in southeastern Nebraska and in the adjacent regions of south-central Iowa, eastern Kansas, and northwestern Missouri. Reasonably precise correlations have been established for most of the units despite the relatively few natural or artificial exposures from beneath the thick mantle of Pleistocene and a thinner less continous cover of Cretaceous.

This study had as its primary purpose the establishment of better correlations of the units in the upper part of the Kansas City Group between the various outcrops, utilizing both surface and subsurface data. Secondly, the application of modern rhythmic analysis to these sediments gave promise of more precise classification and understanding of ancient depositional environments.

Prof. T. M. Stout of the Department of Geology, University of Nebraska, suggested the problem and also gave much appreciated help and supervision.

Special thanks are due Prof. E. C. Reed, State Geologist of Nebraska, who, together with other members of the Survey staff, gave invaluable assistance.

Grateful acknowledgment is also expressed to Dr. J. M. Jewett and Mr. D. F. Merriam of the Kansas State Geological Survey, who contributed much time to introducing the writer to field relations and outcrops in eastern Kansas.

Recognition is likewise due Mr. T. R. Welp of the Iowa State Highway Commission for his help on quarry locations in southwestern Iowa.

Finally, the encouragement of the writer’s wife, Carol Burchett, made this study possible.

REGION OF STUDY

Outcrops of the upper part of the Kansas City Group were studied in southeastern Nebraska, eastern Kansas, and south-central Iowa (Fig. 1). The type Farley locality was also visited in northwestern Missouri. Geologic sections were measured at only the principal natural and artificial exposures. These data were supplemented by a study of selected deep well records.

Structurally, these regions lie within the Forest City Basin, which is defined by the James Point Deformation (mainly the Redfield Arch) and Richfield Anticline to the north and northwest, by the Table Rock Arch to the west, by the Ozark Uplift and Bourbon Arch to the southeast and south, and less definitely by the gently dipping flanks of the Lincoln Fold to the northeast and east. As extensive literature describes these relationships (Condra and Reed, 1943, Fig. 2; Lee, 1943; Lee et al., 1946, 1948; Condra, 1930, 1935; Condra and Upp, 1933).

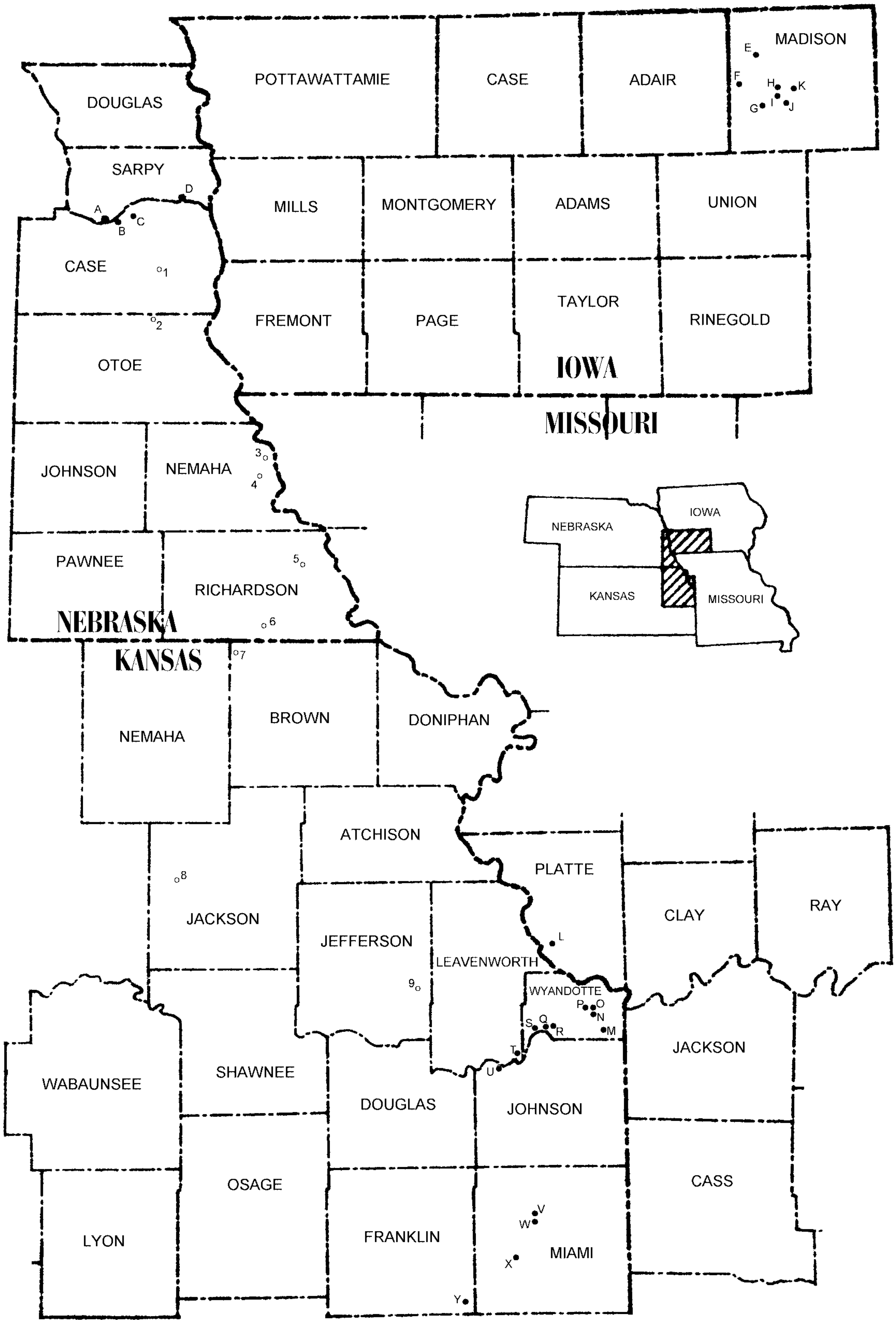


Figure 1. Index Map Showing the Area of Study and Locations of Measured Sections and Deep Wells.

PREVIOUS WORK

The initial recognition and investigation of Carboniferous strat in the northern Mid-Continent region was a little more than a century ago (Owen 1852, pp. 233-238, Sections 20M-40M; Marson, 1864; Prosser, 1897, pp. 12-16; Merrill, 1924, p. 773). However, the first noteworthy report on Pennsylvanian stratigraphy was of C. C. Broadhead's work in the Missouri-Kansas-Nebraska region (1873). Other important early work was reported by Meek and Hayden (1859), Swallow (1866), Meek (1872), Barbouh (1903), Condra (1903), Woodruff (1906), Prosser and Beede (1912), Hinds and Green (1915) and Tilton (1920).

During the past fifty years, but more particularly after the appearance of the important paper on the Pennsylvanian of Nebraska by Condre and Bengteon (1915), the modern Pennsylvanian classification has emerged. The classification for Nebraska and Kansas was revised in 1927 (Condra, 1927) and then almost yearly for about 30 years (see especially Condra and Reed, 1943; Condra, 1949; Moore, 1933, 1936, 1944, 1948, 1949; Moore and Newell, 1937; Moore et al., 1944, 1951; Moore and Nudgem 1956; and Kansas Geol. Sec. 21st Guidebook, for 1957).

Development of Classification

The term *Missouri* (also later modified to *Missourian*) was introduced by Keyes (1893), initially as a "formation" to designate the "Upper Coal Measures" of Broadhead (1873). Pressor (1897) defined the upper boundary at the top of the Cottonwood formation, but left the base somewhat uncertain, below un-named pre-Wabaunsee beds. Keyes (1899, pp. 302-303)placed the lower contact at the base of the Hertha (then called Bethany) limestone, and the upper was left at the top of the Cottonwood Limestone. Pressor (1902) then placed the upper boundary at the base of the Wreford limestone. Hinds and Green (1915) defined the "Missouri Group" with the base of the bottom of the Hertha, but did not give any definite top. Condra (1927) used "Missouri Series" and defined it also as from the base of the Hertha limestone to the top of the Bekridge shale. Moore (1932) likewise used "Missouri Series" and place the lower boundary at the disconformable base of the Hertha limestone, but regarded the upper boundary as at the disconformity that occurs just above the Stanton limestone, Weston shale, or Iatan limestone (now regarded as at the base of the Tenganoxie or “Stalnaker”).

The limits for the “Missouri” that were fixed by Moore (1932, 1936) were adopted by the Geological Surveys of Iowa, Missouri, Nebraska, Kansas and Oklahoma.

The type locality of the “Missouri” or Missourian Series is in northwestern Missouri (Keyes, 1893; Moore, 1936). The thickness of the series ranges from 350 feet in southeastern Nebraska to about 700 feet in eastern Kansas. It consists (from youngest to eldest) of the Pedee, Lansing, Kansas City, and Pleasanton Groups.

The Kansas City “formation” was named and defined by Hinds and Green (1915) for the beds from the top of the “Iola” (Argentine) limestone to the base of the Hertha limestone. Moore (1936) included beds from the base of the Plattsburg limestone to the top of the Winterset member of the Dennis formation in the Kansas City Group. Later, Moore (1948) still placed the upper boundary at the base the Plattsburg, but shifted the lower boundary back to the base of the Hertha limestone.

The type locality of the Kansas City Group is “the sections in the river bluffs at Kansas City,” in Missouri. This group ranges in thickness from 180 to 295 feet in Nebraska and up to 360 feet in Kansas.

PROCEEDURE

The months of June, July and August of 1958, and most of the following week-ends up to November, 1958, were spent measuring geologic sections and examining outcrops of the upper part of the Kansas City Group in Nebraska, Kansas, Iowa and Missouri. Type localities for some of the formational and member units studied, were re-examined.

Approximately fifty outcrops were examined, for which twenty-five sections were measured with hand level and steel tape. Field descriptions of these geologic sections are given in Appendix A.

A study was made of subsurface samples, and electric logs were also utilized, in constructing a detailed correlation chart between the Nebraska and Kansas outcrops (Pl. 2). Subsurface samples descriptions were prepared by use of the binocular microscope, and these are presented as Appendix B.

STRATIGRAPHY AND RHYTHMIC CLASSIFICATIONS

Traditional Classification

The placement of the upper part of the Kansas City Group in the traditional classification of the Pennsylvanian System is shown in the following table (Table 1).

Table 1

Relation of formations studied (*) to the broader classification of Pennsylvanian strata in the northern Mid-Continent

System	Series	Group	Formation
PERMIAN SYSTEM			
	—— Major unconformity ——		
PENNSYLVANIAN SYSTEM	Virgil (or Virgilian) Series	Wabaunsee Group Shawnee Group Douglas Group	
	—— Major unconformity ——		
	Missouri (or Missourian) Series	Pedee Group Lansing Group Kansas City Group* Pleasanton Group	Kansas City Group*: Bonner Spring* Wyandotte* Lane* Iola* Chanute* Drum Quivira Sarpy Fontana Dennis Galesburg Swope Ladore Hertha
	—— Major unconformity ——		
	Des Moines (or Des Moinesian) Series	Marmaton Group Cherokee Group	
	—— Major unconformity ——		
	Atoka (or Atokan) Series Morrow (or Morrowian) Series	Probably not present in Northern Mid-Continent	
MISSISSIPPIAN SYSTEM			

The formational units of the upper part of the Kansas City Group are also shown on the table and these, together with their subdivisions, are discussed in the following pages in ascending order, from eldest to youngest.

Chanute Formation

The Chanute Formation was originally defined by Haworth and Kirk (1894, p. 109) to include beds between the Winterset and Iola limestones. Other definitions were given by Adams et al. (1903) and by many others (see Moore, 1936, pp. 107-111). Haworth and Bennett (1908) redefined this formation to include the shale between the Drum Formation below, and the Iola Formation above. The type locality is near Chanute, Neosho County, Kansas (Iola Quadrangle), in the SE¼, Sec. 33, T. 26 S., R. 18 E., along the highway and at several places in the central part of T. 28 S., R. 18 E. (Moore, 1936, p. 109).

Newell (in Moore, 1936, p. 110) has observed that “there is an important disconformity at the base of the Chanute beds in part of southeastern Kansas … and adjacent territory in northern Oklahoma. This disconformity is observed also in the vicinity of Chanute where the Drum Limestone and underlying shale is eroded, so that sandstone of the basal Chanute rests directly on different beds of the upper Dennis Limestone.”

Moore (1936, p. 110) has also remarked that “a widespread deposit of maroon shale, 1 to 5 feet thick, averaging about 2 feet, occurs in northeastern Kansas and northwestern Missouri near the base of the Chanute,” but he does not relate this to the disconformity or to the basal sandstone of the Chanute. However, the writer has observed that this red shale seems to be at the horizon of the Thayer Coal (see Section W and X, Appendix A).

The Chanute shale ranges in thickness from 12 feet at Kansas City, Kansas, to 165 feet in southern Kansas (Moore et al., 1951, p. 84). Thicknesses in southeastern Nebraska and south-central Iowa range from 5 to 7 feet. The Noxie and Cottage Grove sandstone members of this formation have not been recognized north of Allen County, Kansas but an apparent equivalent of the Thayer Coal does occur.

In the recently filled pit of the new Louisville Quarry (Ash Grove Cement Plant Section); see Fig. 2 and Section B of Appendix A), east of Louisville in Case County, Nebraska, the Chanute is 5.5 feet thick and displays a prominent disconformity 1 to 3 feet above the top limestone of the Drum Formation. In a green shale just below this disconformity, there is a lime enrichment zone with limy nodules. In the upper part of the Chanute (about one foot below the base of the Iola Formation), below the horizon of small corals, there occurs a thin carbonaceous, fissile to laminated, black shale that may be regarded as at the approximate position of the Thayer Coal.

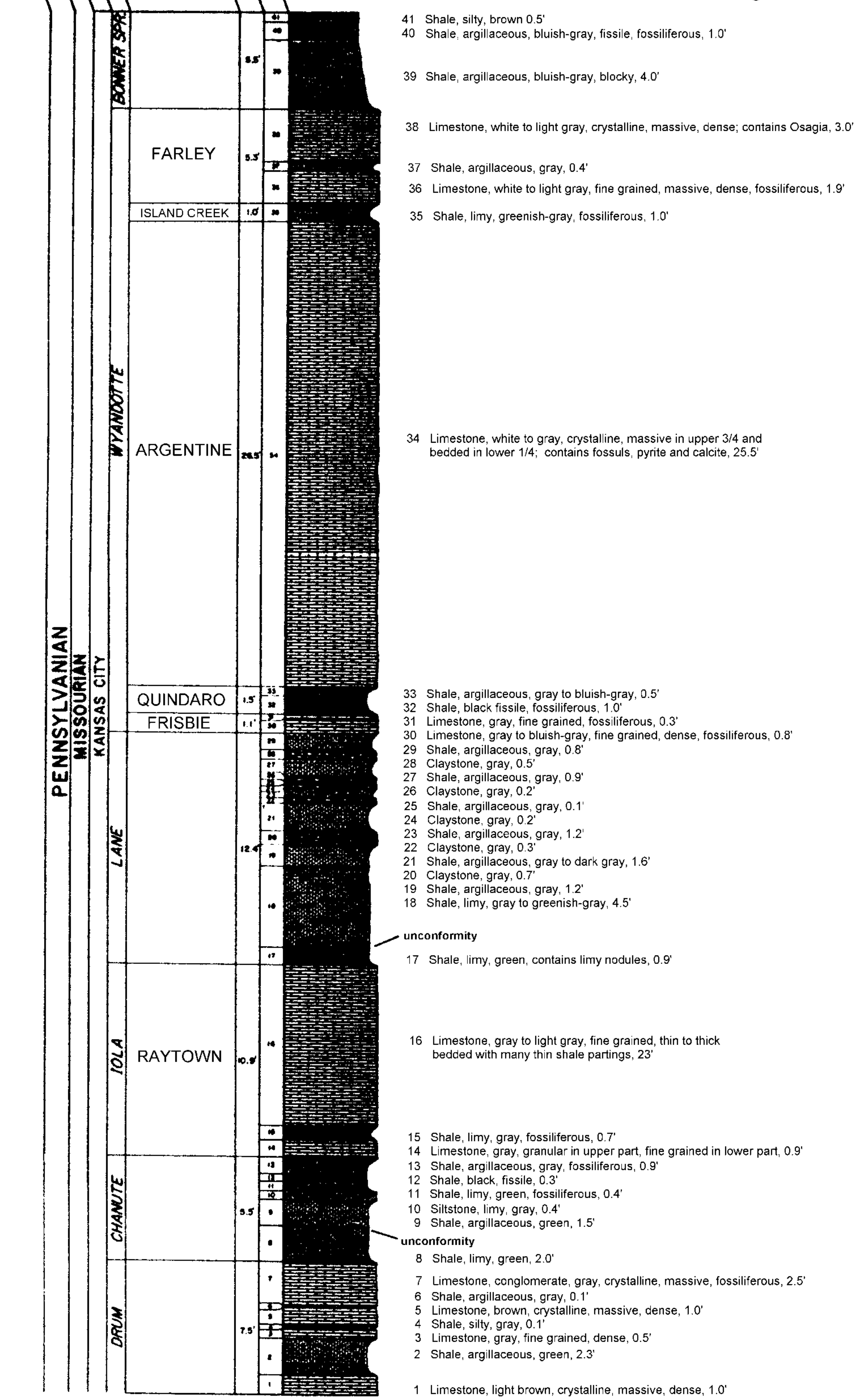
This carbonaceous black shale also occurs at approximately the same level in the Winterset Quadrangle, Madison County, Iowa (see Section M, I, and J of Appendix A), with greenish gray to blocky shales above and below it. The unconformity and lime enrichment zone of the lower part of the Chanute were not observed there. In 1957, (Welp, et al., p. 420) correlate this unit as Quivira but the author prefers to correlate it as Chanute.

Noxie Member (Moore et al., 1937, pp. 40, 42). This member is the basal sandstone unit of the Chanute Formation, but the exact position of the unconformity at the base of the Noxie within the thick shale sections of the Chanute has not yet been determined. The Noxie Member has been recognized only in south-central and in southern Kansas, where it locally attains a thickness of at least 100 feet (Moore et al., 1951, p. 85; Moore, 1936, p. 110).

Unnamed Shale and Thayer Coal (Haworth and Kirk, 1895, p. 276). The thickness of the unnamed shale or shales range from 10 to 75 feet (Moore et al., 1951, pp. 84-85). The position of the Noxie and Cottage Grove Members within the shale in uncertain when these two sandstones are absent, hence several shales may be present (all called Chanute). The Thayer Coal is recognized as a coal only in Kansas where it ranges in thickness from an inch to 2½ feet.

ASH GROVE CEMENT PLANT SECTION
C NE sec. 14, T. 12 N., R. 11 E.
CASS COUNTY, NEBRASKA

Figure 2.



The exact position of the coal is uncertain in both Iowa and Nebraska outcrops, but (see discussion above) it may be near or at the top of a black carbonaceous shale.

Cottage Grove Member (Newell in Moore, 1932, p. 92). In southeastern Kansas, this sandstone member constitutes the upper one-third to one-half of the Chanute Formation. It occurs only locally in northeastern Kansas, and it has not been recognized in Iowa or Nebraska exposures. The type locality is in Cottage Grove Township (Iola Quadrangle), in Allen County, Kansas (Newell, 1935, p. 49; Moore, 1936, p. 111). The thickness ranges from a foot to about 60 feet (Moore et al., 1951, p. 84).

Iola Formation

This formation was named for the limestone exposed in and underlying Iola, Kansas (Haworth and Kirk, 1894, p. 109). It is about 30 feet thick in the quarry area at Iola, Kansas (Iola Quadrangle), according to Moore (1936, p. 112).

The Iola Formation consists of three named units: two limestone members and a shale member, of which the upper limestone is the most prominent. The formation in eastern Kansas ranges in thickness from a feather-edge to 30 feet (Moore et al., 1951, p. 84). It is 9 feet thick in Cass County, Nebraska, and near Winterset, Iowa, the thicknesses are only slightly greater (9 to 11 feet thick).

Paola Member (Newell in Moore, 1932, p. 92). This limestone forms the base of the Iola Formation, and the type locality is just north of Paola, Kansas, where it is well exposed along Highway 169, three miles NNE of Paola, in Sec. 27, T. 16 S., R. 23 E., Miami County (Paola East Quadrangle). The type section has been studied in connection with the present study (see Section V, Appendix A), where it is a bluish gray, massive, vertically jointed, fossiliferous limestone, approximately 2 feet thick, and weathering with small holes.

The Paola has been recognized elsewhere in eastern Kansas and also in south-central Iowa, but it has been clearly distinguished only in the subsurface of the southeastern corner of Nebraska. However, it should be mentioned that a gray, dense silty limestone nearly one foot thick occurs as the basal ledge of the Iola Formation in the pit section of the New Louisville Quarry (Ash Grove Cement Plant Section; see Fig. 2 and section B of Appendix A). Although T. M. Stout (oral communication, 1959) regards this as the Paola with the gray, silty, Muncie Creek just above it, the writer prefers to regard this ledge as simply the basal part of the Iola Formation.

In Madison County, south-central Iowa (Winterset Quad., Sections M, I and J of Appendix A), the Paola is a gray, crystalline, massive limestone with brachiopods, and approximately two feet thick. This interval was correlated (Welp et al., 1957, p. 420) as the Drum Formation.

<u>Muncie Creek Member</u> (Newell in Moore, 1932, p. 92). This black to grayish-buff, silty shale, typically one-half to three feet thick, occur between the Paloa Member below and the Raytown Member above. The type locality (Moore, 1936, pp. 114-115) is along Muncie Creek, Wyandotte County (Shawnee Quad.), Kansas (see Section N, Appendix A), where the typical exposure may be observed in the north bluff of the Kansas River Valley just west of Kansas City, Kansas. The known distribution of this shale is also in eastern Kansas and south-central Iowa, and it has been recognized clearly only in the subsurface of Nebraska (but see remarks above).

In Madison County, south-central Iowa (Winterset Quad., Sections M, I, J of Appendix A), the Muncie Creek is a greenish-gray, fossiliferous shale 3½ to 4 feet thick, with the lower 2 feet consisting of carbonaceous, fissile to platy, black shale, and with limy nodules (lime enriched zone) in the upper 2 feet. However, the phosphatic nodules so diagnostic in many (but not all) Kansas outcrops of the Muncie Creek have not been recognized. This interval was correlated (Welp et al., 1957, p. 420) as the Chanute Formation.

<u>Raytown Member</u> (Hinds and Greene, 1915, p. 27). The Raytown Member is the prominent upper limestone ledge of the Iola Formation. It likewise occurs elsewhere in eastern Kansas, in south-central Iowa, and in southeastern Nebraska (but it is recognized officially in both surface and subsurface). The

type locality (Moore, 1936, pp. 115-116), is at Raytown, in Jackson County, Missouri (Independence Quad.)

In Kansas outcrops (Sections M, N, O, V and W of Appendix A), the Raytown is a medium gray, fine grained to crystalline, limestone that is thin to thick bedded (and often wavy-bedded), with some fossils. The thickness of the Raytown ranges from 5½ to 7 feet. In the recently filled pit section of the New Louisville Quarry (Ash Grove Plant Section; see Fig. 2 and Section B of Appendix A), the main part of the Raytown is about 7 feet thick and consists of numerous thin limestone ledges separated by shales. Below this, there is a gray silty shale 8 inches thick and then a limestone ledge 11 inches thick which may represent respectively, the Muncie Creek an Paola. Alternatively, this lower shale and limestone could be considered as Raytown (the Muncie Creek and Paola then being considered absent). The writer at present prefers the latter alternative, which would make this Iola interval 9 feet thick.

In Iola exposures (Sections H, I, J and K of Appendix A), the Iola interval (Raytown, Muncie Creek and Paola) collectively measures about 14 feet, and the Raytown ranges from 7½ to 8 feet.

Lane Formation

This formation, established by Haworth and Kirk (1895, p. 277), has its type locality at Lane in Franklin County, Kansas (Moore, 1936, pp. 116-118), where it consists of a thick shale in the river bluffs in the S½, Sec. 33, T. 18 S., R. 21 E. (Garnett Quad.). The Lane shale is bounded by the Drum Formation below and by the Wyandotte Formation above.

South of Lane, Kansas, the Wyandotte Formation supposedly pinches out, and the Lane shale there is said to be overlain (with an indefinite contact) by the Bonner Springs shale (Moore et al., 1951, p. 82).

Along the south side of the Platte River east of Louisville, in eastern Nebraska, an unconformity occurs in the lower part of the Lane in the recently filled pit in the floor of the Ash Grove Cement Quarry (fig. 2).

The thickness of the Lane Formation in eastern Kansas outcrops ranges from 15 to 105 feet (Moore et al., 1951, p. 82). It is about 14 feet thick in Sarpy County, Nebraska, but in south-central Iowa it thins to about 10 feet.

In eastern Kansas outcrops (Sections M, O, P, R and Y of Appendix A), the Lane Formation in most places is a bluish-gray, clay, shale ranging thickness from 15 to 105 feet (Moore et al., 1951, p. 82). Near the type section, about four miles south of Lane, the Lane Formation consists of a lower greenish-gray, micaceous shale about 16 feet in thickness; a middle bluish-gray, micaceous shale about 8½ feet thick; and at the top about 25 feet of buff, sandy, and micaceous shale. Moore (1936, p. 118; see also Moore et al., 1951, p. 82) remarks that where the Lane shale is thick (elsewhere in eastern Kansas),

> *"that is, 50 to about 110 feet, most of the shale is sandy and micaceous. … Thin plates and beds of friable sandstone appear, especially near the top where in many places there is a zone of thin alternating bands of gray sandy shale and yellow-brown sandstone. The thick sandy shale contains carbonaceous streaks but coal beds have not been observed. Fossils are mostly lacking, a few plant remains being found at some outcrop."*

In Nebraska, two outcrops were measured (Sections B and C of Appendix A) of the Lane Formation. It consists there of gray shales and claystones approximately 12 feet thick with a disconformity occurring at a level about 2 feet from the base.

Iowa sections (Sections H, I and K of Appendix A) show the Lane Formation to be a greenish-gray, silty shale with a maroon shale occurring at the same approximate horizon as the disconformity in the Nebraska sections. The thickness of the Lane thins to about 10 feet in south-central Iowa.

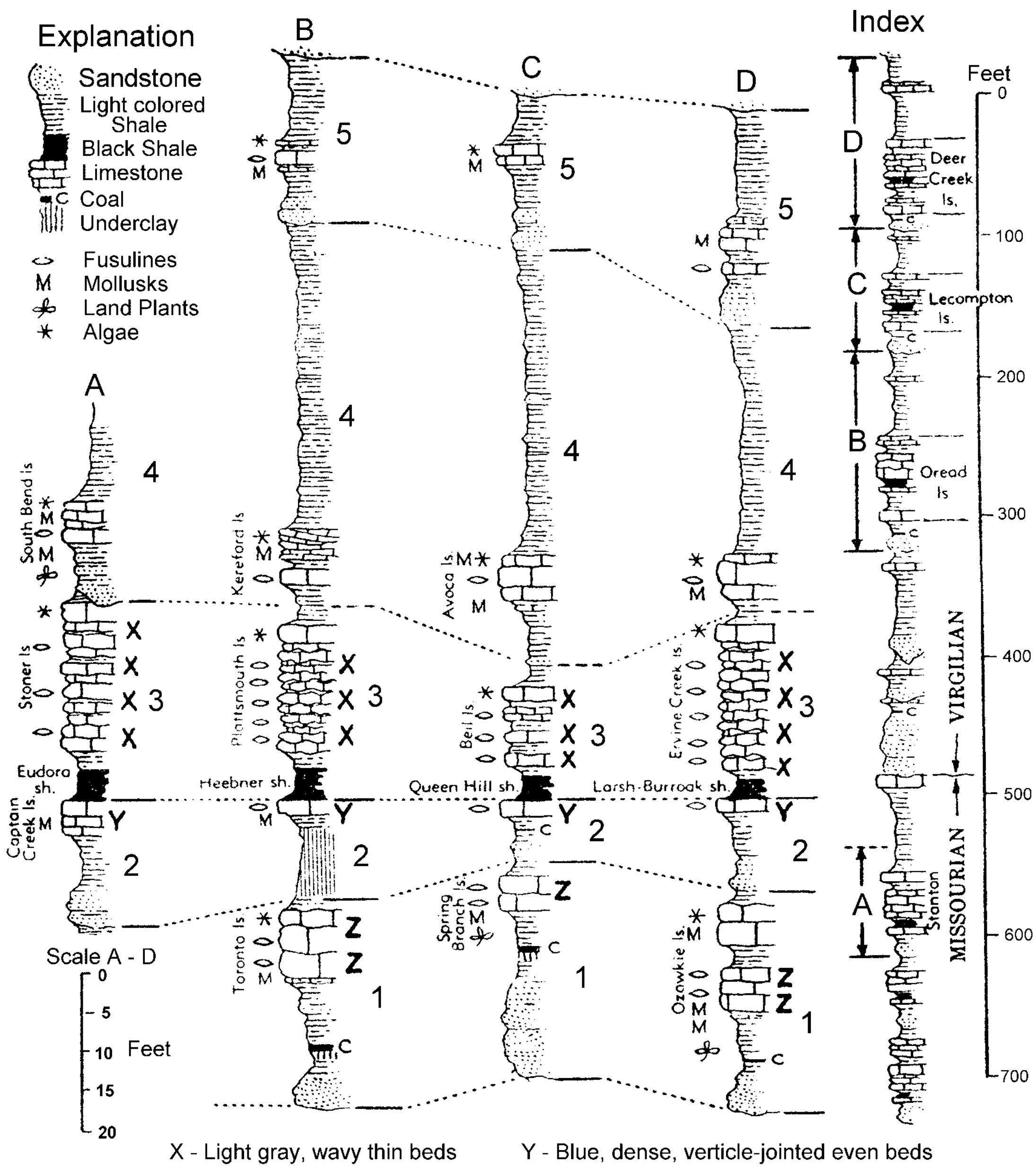
Wyandotte Formation

The Wyandotte Formation, named by Newell in Moore (1932, p. 92), comprises the beds between the top of the Lane Formation and the base of the Bonner Springs Formation. The type locality of this formation is southern Wyandotte County, Kansas, along the Kansas River, in the quarry of the Lone Star Cement Company, at the eastern edge of Bonner Springs (Moore, 1936, pp. 118-119), which is at the west margin of the map of the Edwardsville Quadrangle, in the S½ of the NW½, of Sec. 28, T. 11 S., R. 23 E.

As remarked earlier, this formation perhaps pinches out south of Lane, Kansas, with the shale above and below indefinitely separable. Five named members are contained in this formation, three limestones and two shales. The formations range in thickness from a featheredge to 75 feet in eastern Kansas. In both Cass County, Nebraska, and Madison County, Iowa, the thickness ranges from 20 to 26 feet.

Frisbie Member (Newell in Moore, 1932, p. 92). This persistent limestone can be seen in exposures in eastern Kansas, southeastern Nebraska, and south-central Iowa. It is the basal member of the Wyandotte Formation, and the type locality (Moore, 1936, 0. 120) is at Frisbie, near the center of the north side of Sec. 17, T. 12 S., R. 23 E., in northern Johnson County, Kansas (Bonner Springs Quad.).

In eastern Kansas outcrops (Sections M, O, P, R, W and Y of Appendix A) the Frisbie is a bluish-gray massive, fossiliferous limestone with a thickness ranging from 1 to 3 feet. There, as in Nebraska and Iowa exposures, it is beyond question a “middle” or “No. 2” limestone of Moore’s usage (Moore, 1936, p. 35; 1950, Fig. 3, this figure reproduced as Plate 1 of the present report), and thus to be compared in position and lithology with the well known Leavenworth and Captain Creek limestones.



X - Light gray, wavy thin beds Y - Blue, dense, verticle-jointed even beds
Z - Yellow-brown, ferruginous, massive beds

Figure 3. Typical megacyclothem of the Shawnee and Lansing Groups.
(Cyclothems of each megacyclothem are numbered in upward order)

PLATE 1

In the recently filled pit section of the New Louisville Quarry (Ash Grove Cement Plant Section; see Fig. 2 and Section 3 of Appendix A), east of Louisville, in Cass County, Nebraska, the Frisbie consists of a single ledge of gray to bluish-gray limestone, 13 to 16 inches thick. The basal part is a fossiliferous crystalline limestone, with a diastemic separation.

In Madison County, south-central Iowa (Winterset Quad., Sections G, H, I and K of Appendix A), the Frisbie is somewhat thinner (about six inches to a foot thick) and a single massive finely crystalline limestone ledge throughout, with productid brachiopods.

<u>Quindaro Member</u> (Newell in Moore, 1932, p. 92). The Quindaro lies between the Frisbie Member below and the Argentine Member above. It is typically exposed (Moore, 1936, pp. 120-121) at Boyn's Quarry, in the northwest corner of Sec. 30, T. 10 S., R. 25 E., in Wyandotte County, Kansas (Parkville Quad.). South of this type section, the Quindaro consists of 1½ feet of shale, the lower portion being carbonaceous, fissile and black, with the upper part dark gray and silty (Sections M of Appendix A). Elsewhere in eastern Kansas outcrops (Sections O, P, R, and W) the Quindaro is much the same but it may thin to less than ½ foot of black shale.

In Kansas, as well as in Nebraska and Iowa, there can be no question but that the Quindaro is the typical black shale that overlies a "middle" limestone emphasized by Moore (1936; 1950, Fig. 3, this figure reproduced as Plate 1 of the present report).

In Nebraska and Iowa outcrops, the Quindaro is nearly identical in its development as compared with Kansas exposures, but it was observed to thicken to about 4 feet in Madison County, south-central Iowa (Winterset Quad., Sections G, H, I and K of Appendix A).

In the pit section of the New Louisville Quarry (Ash Grove Cement Plant Section; see Fig. 2 and Section B of Appendix A), the Quindaro is a little more than a 1½ foot thick, with the basal 13 inches a black, fissile shale and the remainder consisting of gray, silty shale.

Argentine Member (Newell in Moore, 1932, p. 92). This is the main limestone member of the Wyandotte Formation, and it is quarried in eastern Kansas, in southeastern Nebraska, and south-central Iowa, for use in the manufacture of cement. The type locality (Moore, 1936, pp. 121-122) is at Argentine Station, in a quarry just south of the junction of 26th Street and Metropolitan Ave., in Kansas City, Kansas (Shawnee Quad.).

In Kansas outcrops (Sections M, O, P, Q, R, S and T of Appendix A), the Argentine consists of a bluish-gray, crystalline, thin to thick bedded limestone, containing numerous productid brachiopods and bryozoans. It ranges in thickness there from a featheredge (as kindly demonstrated by J. M. Jewett to the writer in the area south of Lawrence) to about 35 feet (Moore et al., 1951, p. 82). There is no question concerning the rhythmic placement of the Argentine; it is an "upper" or "No. 3" limestone in the terminology of Moore (1936, p. 34; 1950, Fig. 3, this figure reproduced as Plate 1 in the present report).

In Nebraska, especially along the lower Platte Valley near Louisville (Sections A, B, C, and D of Appendix A), the Argentine is the most important quarry stone for cement manufacture; hence it has been rather intensively studied. It is a light to medium gray limestone, finely to coarsely crystalline, and contains abundant productid brachiopods and bryozoans at certain levels. The Argentine ranges in thickness there from 23 to 26 feet, and it is generally massive and thick bedded (especially in the upper 16 to 18 feet), but shale partings usually occur in the lower 7 to 9 feet.

In Iowa exposures (Sections E, F, G, H, I and K of Appendix A), the Argentine thickness is difficult to determine but it seems to be a little in excess of the 12 feet exposure at a single locality. An estimate of :about 14 feet" was given by Welp et al., 1957, p. 420. It consists of light gray, crystalline, thin to thick and wavy bedded limestone grading into thin shales and limestone ledges at the bottom. Chert nodules are found in the upper 3 feet and large brachiopods are abundantly scattered through this member.

Island Creek Member (Newell in Moore, 1932, p. 92). The Island Creek is likewise recognized in eastern Kansas, southeastern Nebraska, and south-central Iowa. The type locality (Moore, 1936, p. 122) is in a quarry near Wolcott, Wyandotte County, Kansas, at the northwest corner of Sec. 11, T. 10 S., R. 23 E. (Wolcott Quad.).

The Island Creek in Kansas was studied by the writer in several exposures (Section M, Q, S and T of Appendix A). Near Kansas City, Kansas, it consists of 7½ feet of bluish-gray, silty shale. At the Lone Star Cement Plant near Bonner Springs, the Island Creek thins to about 1 foot of greenish gray shale. Locally in several places in Wyandotte County, Kansas, a sandstone ("seemingly a channel filling") several feet thick has been reported to occupy the approximate position of the Island Creek (Moore et al., 1951, p. 82). Alternatively, this sandstone might be regarded as situated within the Island Creek.

In Nebraska outcrops (Sections A, B, C and D of Appendix A), the Island Creek is a bluish or greenish gray, silty and fossiliferous shale with a thickness ranging from 1 to 2.2 feet thick.

The Island Creek exposures in Iowa (Sections E and F of Appendix A) consist of greenish-gray shale with many limy nodules. Abundant fusilinids were noted in the upper part of the shale (total thickness 1 to 2 feet).

Farley member (Hinds and Greene, 1915, p. 29). This limestone is the uppermost member of the Wyandotte Formation. In eastern Kansas, the thickness averages about 15 feet. In Cass County, Nebraska, and in south-central Iowa, the thickness ranges from 2 to 7 feet. The type locality (Moore, 1936, pp. 122-123) is at Farley, in Platte County, Missouri, in exposures north of the bridge situated just north of the center, Sec. 34, T. 52 N., R. 35 W. (Platte City Quad.). It is about 12 feet thick there and consists of three limestone seams separated by shales (see Section L, Appendix A); the limestones are bluish-gray, with abundant *Osagia*, and the shales are buff to brown and silty.

The Farley in Kansas displays some variations in thickness (this ranging from a featheredge to about 35 feet, according to Moore et al., (1951, p. 82), and also in lithology. At the north edge of De Soto, Kansas, it consists of 15 of light gray to buff, granular limestone, in two ledges (with thin partings), both with abundant *Osagia* (see Section U, Appendix A). In the Argentine Station Section (Section M, Appendix A), the intervening shale thickens to 9½ feet, and the lower ledge is oolitic while the upper has abundant *Osagia*. In the Lone Star Cement Plant Section (Section Q, Appendix A), there are four principal ledges (one cross-bedded), but none has abundant *Osagia*.

The Farley outcrops in Nebraska are composed of two limestone ledges separated by a thin gray shale. The lower is a light gray, massive and crystalline limestone with abundant *Osagia*, whereas the upper is a light greenish-gray fine grained limestone, weathering brown and slabby.

Bonner Springs Formation

The type locality of this formation is the same as for the Wyandotte, at the quarry of the Lone Star Cement Company, near Bonner Springs, in the S½ of the NW¼, Sec. 28, T. 11 S., R. 23 E., Wyandotte County (west margin of the Edwardsville Quad.), Kansas (Newell in Moore, 1932, p. 93; Moore, 1936, pp. 123-124). It is bounded by the Wyandotte Formation below and by the Plattsburg Formation above. South of the presumed Wyandotte pinch-out near Lane, Kansas (mentioned previously), the Bonner Springs and Lane shales are supposed to come together with an indefinite contact.

At the type locality in eastern Kansas (see Section Q, Appendix A), the Bonner Springs contains a 3 feet sandstone, just above a red shale band (this observed elsewhere in the area), whereas in south-central Iowa a coal-like carbonaceous shale occurs at approximately the same horizon.

It should be mentioned also that probably this red shale, 3 feet in thickness, occurs in Sarpy County, Nebraska (SW¼, SE¼, Sec. 28, T. 17 N., R. 13 E.), 4 feet below the base of the Meadow limestone (oral communication from Rollin W. Harden, 1959). This would be at the same approximate position of the lime enrichment zone at the New Louisville Quarry (Ash Grove Cement Plant Quarry, Cass County, Nebraska), and at the level of the disconformity in the New Meadow Quarry northwest of Louisville, also in Sarpy County, Nebraska.

The average thickness in southeastern Nebraska ranges from 6 to 8 feet, with an increase in thickness from 8 to 10 feet in south-central Iowa.

Rhythmic Classification

Nearly fifty years ago, Udden (1912) studied the Pennsylvanian sediments exposed in the Peoria Quadrangle of western Illinois, and he found that certain of these strata could be divided clearly into four parts, repeated above in the same order. Thus, recognition for the discovery of cyclic sedimentation in the United States is given to Udden because of his suggestions for the alteration of non-marine and marine beds, a cycle defined as from the base of a coal to the base of the next younger coal.

Waller (1930; 1931) believed that diastrophism controlled cyclical Pennsylvanian sedimentation. He described (Weller, 1930, p. 163) the ideal cycle as follows:

9. Shale, containing "ironstone" bands in the upper part and thin limestone layers in the lower part.
8. Limestone.
7. Calcareous Shale.
6. Black "Fissile" Shale.
5. Coal.
4. Underclay.
3. Fresh Water Limestone.
2. Sandy and Siliceous Shale
1. Sandstone, with unconformity at the base.

In 1931, the Illinois State Geological Survey held a symposium on cyclic sedimentation in the Pennsylvanian, and the papers submitted were published as Bulletin 60 of the Illinois Geological Survey. This meeting brought together R.C. Moore, F. B. Plummer, D. B. Roger, G. R. Ashley, M. Stout, H. R. Manless and J. M. Weller, among others, and they discussed the development of cyclic sedimentation in their our regions of the central United States.

Only a short time later, Manlees and Weller (1932) suggested that the evidence concerning Pennsylvanian cyclic sedimentation supported the belief that the cyclic repetitions of "cyclothems" could be used to confirm inter-basin and perhaps regional correlations.

Moore (1936, pp. 24, 25) proposed a slightly different method of designation of the units within an ideal cyclothem, from youngest to oldest:

.9 Shale (and Coal).
.8 Shale, typically with molluscan fauna.
.7 Limestone, algal, molluscan, or with mixed molluscan and molluscoid fauna.
.6 Shale, molluscoids dominant.
.5 Limestone, contains fusulinids, associated commonly with molluscoids.
.4 Shale, molluscoids dominant.
.3 Limestone, mollluscan, or with mixed molluscan and molluscoid fauna.
.2 Shale, typically with molluscan fauna.
.1 c. Coal.
.1 b. Underclay.
.1 a. Shale, may contain land plant fossils.
.0 Sandstone.

Moore, in this same fundamental work, also introduced the term "megacyclothem" for "a cycle of cyclothems." He recognized several different types of limestone in the repeated vertical succession, four of which were designated from oldest to youngest as: "lower", "middle", "upper and super", each characterizing a cyclotherm.

Manless and Shepard (1936) published an equally classic study regarding the relation of Late Paleozoic cycles to sea level fluctuation and associated climatic changes imposed by Late Paleozoic glaciations.

Elias (1937) suggested that certain of the fossils found in these strata could be used as indicators of the depths of the sea at the times that they lived, with special regard to interpreting the cyclic nature of the Big Blue (Permian) sediments in Kansas and Nebraska.

The older Pennsylvanian (Marmaton and pre-Marmaton) cyclic sedimentation has been more fully investigated, however, than has that of the later Pennsylvanian or Permian (Big Blue). The Marmaton cycles of Kansas and Missouri have been described by Jewett (1941; 1945) and the pre-Marmaton (Cherokee) episodes have been lately revised by Howe (1956). The Rhythmic succession for the entire Des Moines of Illinois has been recently described by Manless (1950; 1957; 1958) and by Siever (1956), and this has resulted in an important stratigraphic policy ruling concerning cyclic classification by the Illinois State Geological Survey (William, Swann and Frye, 1958). The Desmoines cycles of Missouri, Kansas, Illinois and Oklahoma have been very recently correlated even more precisely in significant guidebooks for field conferences (Searight, 1958; Kansas Geol. Soc. Guidebook, 1957; Branson, 1954). Comparison of these reports allows the conclusion that two Illinois-type cyclothem essentially equal the one Kansas megacyclothem (oral communication, T. M. Stout, 1958).

Moore (1950) revised slightly and remarked the importance of the megacyclothem concept, and this has been reaffirmed recently (Moore in Kansas Geol. Soc. Guidebook, 1951),

> "Those who doubted the actuality of Pennsylvanian-Permian cyclothems have ceased to be vocal, and accordingly, the concept of cyclic sedimentation as applied to very many, if not all, areas of these rocks is almost universally accepted".

Recent literature on Pennsylvanian cyclic sedimentation (Weller, 1956; Wheeler and Murrary, 1957; Weller, Wheeler and Murray, 1958) has revised possible causes, partially the diastrophic vs. the glacial sea level control. Both viewpoints have been concerned, however, with the Illinois-type cyclothem rather than with the megacyclothem.

Moore's concept of a Missouri Series megacyclothem was chiefly developed in Bulletin 22 of the Kansas State Geological Survey (Moore, 1936), but it was more clearly developed for both the Missouri and Virgil Series in a chart published as a contribution to the Symposium on Rhythmic Sedimentation by the Eighteenth Session of the International Geological Congress in 1950 (Moore, 1950, Fig.). This chart has been utilized in developing the following discussion of the rhythmic classification of the upper part of the Kansas City Group, and it has been reported as Plate 1.

Upper Kansas City Megacyclothem[1]

Moore et al. (1951, p. 92, Fig 35) recognized two megacyclothems in the upper part of the Kansas City Group. This has been adopted in the present report, except that the lettering designating the rhythmic units has been modified to bring out repetitions as the writer visualized the (see Fig. 3, and following discussion).

Megacyclothem I (Iola)

This rhythmic division (Fig. 3) is regarded as being composed of five units, A - E.

Unit A (Beds 1 - 3). This unit consists of three beds, all of which are part of the Chanute: (1) the basal sandstone within the Chanute, termed the Noxie Sandstone (Moore et al., 1937, pp. 40, 42); (2) the intermediate Unnamed Shale and Thayer Coal (Haworth and Kirk, 1895, p. 276; Moore, 1936, pp. 107-111; Moore et al., 1951, pp. 84, 85); and (3) the Cottage Grove Sandstone (Newell in Moore, 1932, p. 92; Moore, 1936, p. 111; Moore et al., 1951, p. 84).

Unit B (Bed 4). This consists of the Paola Limestone (Newell in Moore, 1932, p. 92; Moore, 1936, p. 114; Moore et al., 1951, p. 84).

Unit C (Bed 5). This is the gray to black shale termed Muncie Creek (Newell in Moore, 1932, p. 92; Moore, 1936, pp. 114, 115; Moore et al., 1951, p. 84).

Unit D (Bed 6). This is the Raytown Limestone (Hinds and Greene, 1915, p. 27; Moore, 1936, pp. 115-116; Moore et al., 1951, p. 84).

Unit E (Bed 7). This is the lower part of the Lane Shale (Haworth and Kirk, 1895, p. 277; Moore, 1936, pp. 116-118; Moore et al., 1951, p. 82), below the disconformity.

[1] T. M. Stout (oral communication, 1959 would prefer to regard these beds of the upper part of the Kansas City Group as a single megacyclothem in the sense of Moore (1950, Fig. 3, figure reproduced in the present report as Plate 1), but possibly visualized also as split in the middle (at the unconformity in the Lane) to give two Illinois-type cyclothems.

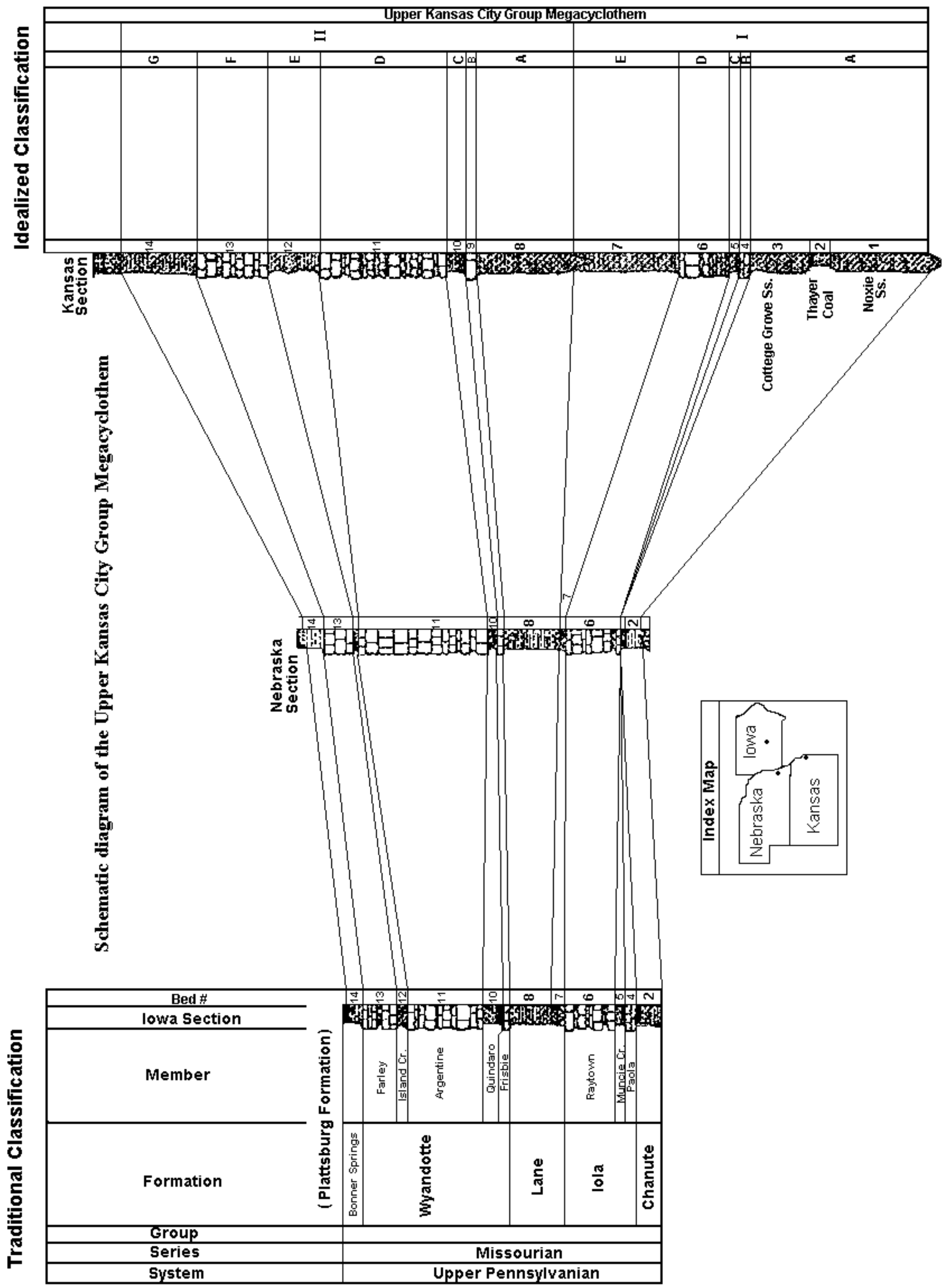

Schematic diagram of the Upper Kansas City Group Megacyclothem
Idealized Classification
Upper Kansas City Group Megacyclothem
II
I
G
F
E
D
C
B
A
Kansas Section
Noxie Ss.
Thayer Coal
Cottege Grove Ss.
Nebraska Section
Index Map
Iowa
Nebraska
Kansas
Traditional Classification
Bed #
Iowa Section
Member
Formation
Group
Series
System
(Plattsburg Formation)
Farley
Island Cr.
Argentine
Quindaro
Frisbie
Raytown
Muncie Cr.
Paola
Bonner Springs
Wyandotte
Lane
Iola
Chanute
Missourian
Upper Pennsylvanian

Figure 3.

Megacyclothem II (Wyandotte)

This second major rhythmic division (Fig. 3) has certain repetitions that seemingly duplicate units of the first division, but there are also several departures. The lettering for these units, A - G, brings out the similarities as well as the dissimilarities.

Unit A (Bed 8). This is the upper part of the Lane Shale, above the disconformity. The importance of this break in the Lane cannot now be fully evaluated, but sandstones have been reported in this part of the Lane south of Lawrence, Kansas (oral communication, J. M. Jewett, 1958).

Unit B (Bed 9). This is the Frisbie Limestone (Newell in Moore, 1932, p. 92; Moore, 1936, p. 120; Moore et al., 1951, p. 82). It is regarded here as repeating the lithology of the Paola, noted earlier.

Unit C (Bed 10). A distinctive black shale, the Quindaro (Newell in Moore, 1932, p. 92; Moore, 1936, pp. 120-121; Moore et al., 1951, p. 82), is thought to repeat the lithology of the before mentioned Muncie Creek Shale.

Unit D (Bed 11). This is the main quarry limestone of the Wyandotte Formation, the Argentine Limestone (Newell in Moore, 1932, p. 92; Moore, 1936, pp. 121,122; Moore et al., 1951, p. 82). It is regarded here as repetitive of the Raytown lithology, and it is clearly an “upper” or “No. 3” limestone (Moore, 1936, p. 34; 1950, Fig. 3, this figure reproduced as Plate 1 of the present report).

Unit E (Bed 12). This is the Island Creek Shale (Newell in Moore, 1932, p. 92; Moore et al., 1951, p. 82). It is thought perhaps to compare best with the lithology of the basal part of the Lane Shale.

Unit F (Bed 13). This is the distinctive limestone in the upper part of the Wyandotte Formation, termed the Farley Limestone (Hinds and Greene, 1915, p. 29; Moore, 1936, pp. 122-123; Moore et al., 1951, p. 82). It is regarded as having no comparative development in the first rhythmic division, the absence of its equivalent there possibly to be explained (if ever deposited) as removed in the erosional episode recorded by the disconformity in the Lane Shale.

Unit G (Bed 14). This is the lower part of the Bonner Springs Shale (Newell in Moore, 1932, p. 93; Moore, 1936, pp. 123, 124; Moore et al., 1951,

p. 81), below the unconformity. The problem of the Merriam Limestone (Newell in Moore, 1932, p. 93; Moore, 1936, pp. 128, 129; Moore et al., 1951, p. 81) in Kansas enters into any consideration of rhythmic interpretation and position of units in the Bonner Springs Shale. The Merriam has been regarded as the same as the Nebraska member termed Meadow Limestone (Condre and Benoteon, 1915, Condre, 1949, pp. 33, 34), but this cannot be proved or disproved at this time.

DEPOSITIONAL ENVIRONMENT

For present purposes, about five principal classes of depositional environments may be recognized in the upper part of the Kansas City Group, based upon lithologic and faunal associations. Each interpretations involve also consideration of the sedimentary variables, the static variables that reflect environment and the dynamic variables that reflect diagenesis (Loman, 1949). The five environmental groupings recognized for the present report may be defined as follows:

1. Sandstone. The basal "channel" sandstones of Pennsylvanian megacyclothems in inland situations apparently all have characteristics which identify them as of "Pleasantview-type", this term having reference to the Pleasantview sandstone of the Desmoinesian of western Illinois that has recently been studied in great detail (Rusnak, 1957a; Mueller and Manless, 1957; Sanders, 1957; Siever, 1957; Rusnak, 1957b). The somewhat younger Tonganade sandstone (Lins, 1950; Winchell, 1957; Stephenson MS.), as well as the Noxie sandstone of the present report, seem to be of this type. Siever (1957, p. 247) has summarized the probable environment as follows: "This hypothesis is that the sandstones were deposited in a variety of shallow water littoral, lagoonal, deltaic and coastal plain alluvial environments in which the time rate of migration of the strand lime was high".

If one were to picture these basal channels to have been cut at times of eustatic withdrawal (regressive episodes) and then at times of eustatic recovery (transgressive episodes) to be progressively-filled estuaries, the conditions postulated by Siever probably would have all pertained.

The other sandstones of the upper part of the Kansas City Group, by inference, would have had a somewhat similar depositional environment.

2. Green and greenish-gray silty muds. These muds, now shales, are interpreted as having been deposited in shallow marine waters, perhaps near shore at times (Elies, 1937, pp. 426, 427). Such sediments are now being deposited along the central Texas coast in estuarine environments, as well as in bays near rivers and in shallow bays (Shepard and Moore, 1955, pp. 1528-1545). The green color of the muds may be related to the presence of certain clay minerals, such as illite or chlorite, and probably to deposition under general reducing conditions (Grim, 1951, p. 231).

3. Limestones. The limestones of the upper part of the Kansas City Group can be broken down into three groups: a) those with abundant *Osagis* which according to Lane (1958), are deposited in water approximately 60 feet in depth and under conditions of quiet with slow accumulation of shell fragments and conditions favorable for the growth of algae; b) those with productids (part of the “mixed” and “brachiopod” assemblages of Elias, 1937) which probably represent the moderately deep water assemblages (90 to 160 feet depth), perhaps in some miles from the coast, and c) those with fusulinids (deepest phase of Elias and also of Moore), which probably represent deposition in a somewhat deeper water (about 160 to 180 feet depth), a farther off-shore type of environment.

4. Black muds and coals. The depositional environment of the black muds, now black shales and silty shales, in the northern Mid-Continent Pennsylvanian has been much discussed, but present opinion favors very shallow water and tidal-flat environment (Payton and Thomas, 1958, p. 1628). Such black shales probably formed where there was a reduction in oxygen content, and thus organic matter accumulated faster than it could be oxidized. Bacterial activity may be assumed to have been inhibited. These conditions may occur at the mud-water contact according to Pettijohn (1957, p. 626). The coals

where present, would surely represent swamp environments, probably not contaminated by salt water at that time.

Red shales. In the upper part of the Pennsylvanian in the northern Mid-Continent, the present evidence suggests that the red shales for the most part may have resulted from subaerial modifications of green and greenish-gray silty shales. They may have developed, therefore, approximately at the same times that coal swamps still persisted in poorly-drained tidal-flat depressions. Krynine (1949) has analyzed the red shale problem from a more general point of view, that states that “an iron bearing sediment oxidized after deposition may turn red.” It of course seems possible in some situations, to have had some reworking of red shales, and redeposition in shallow near-shore waters, but this should be recorded in flaky and brecciated fragments of red shales in some other background lithology.

SUMMARY

The more important results of this study of the upper part of the Kansas City group may be presented as follows:

1. An attempt has been made to determine more precise correlations by the use of both surface and subsurface data. The results are shown in the various accompanying illustrations. It should be remarked that only one major miscorrelation has been discovered; namely, that in Iowa the units which were termed Chanute, Drum and Quivira by Welp et al. (1957, p. 420) are more likely the Muncie Creek, Paola and Chanute, respectively.

2. The testing of these correlations by the application of modern rhythmic analysis and theory has resulted in the writer's interpretation that two megacyclic units, rather than one, are represented in the interval under study. This is in support of the view proposed by Moore et al. (1951, Fig. 35, columns No and O). It should be noted that, in general, sandstones, most coals, and some red shales progressively come into the sequence at the cyclothemic boundaries in a southerly direction, toward and in Kansas.

3. The depositional environments for each of the principal lithologies represented in the northern Mid-Continent Pennsylvanian can now be reconstructed with fair accuracy. The present study supports the following tentative reconstructions of these environments:

   a. Sandstones. That the sands in the area of study were mostly deposited as fillings of progressively-drowned estuary valleys, during transgressive movements inland of the stream. The valleys had apparently been previously stream valleys during regressive episodes.

   b. Green Shales. That these shales were probably deposited in shallow marine waters, perhaps near shore at times, in keeping with the previous conclusions of Elias (1937, pp. 426,427) and also with those of students of modern Gulf Coast environments (Shepard and Moore, 1955). The green color is interpreted, following Grim (1951, p. 231), as being due probably to the presence of certain clay minerals such as illite or chlorite, and to deposition under general reducing conditions.

c. Limestones. That these were probably deposited in somewhat deeper marine waters than the preceding, perhaps up to the maximum depth of about 180 feet postulated by Elias (1937) and by Moore. The frequent occurrence of Osagia, of productid brachiopods and of fusulinids in these lithologies has led to this conclusion regarding probable depths.

d. Black Shales and Coal. It now seems indisputable that these sediments were deposited in tidal-flat, lagoonal, and even swamp environments in inland situations during the relatively stable times following the maximum transgressive episodes, and during the succeeding regressive times until drainage and dissection destroyed these environments.

e. Red Shales. It is suggested that in the areas and beds of present investigation most of the red shales may have developed by subaerial modifications of green and greenish-gray silty shales rather than as primary deposits in a shallow water marine environment. If developed by subaerial modification, it seems reasonable that these might be interpreted as lateritic, sublateritic or subtropical soils on available land surfaces, perhaps contemporaneous with at least most of the swamps that persisted in the depressions until drained or dissected.

Some future study of the sediments of the upper part of the Kansas City Group might well be devoted to these red shale and coal inter-relations and to their exact position in a cyclic sedimentational reconstruction.

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APPENDIX A

Geological Sections

Section A

NEW MEADOW QUARRY SECTION, C, SW¼, NE¼, Sec. 16, T. 12 N., R. 11 E., Sarpy County (Springfield Quad., 1956 map), Nebraska.

Missourian Series — Thickness (feet)
Kansas City Group
Bonner Springs Formation

Unnamed Member (7.5 ft.)
- c. Shale - yellowish brown, silty; very plastic when wet 0.5
  Disconformity
- b. Shale - greenish gray; limy; hard, brittle; with bryozoans and brachiopods 2.5
- a. Shale - dark gray to black; silty; hard; no fossils observed 4.5

Wyandotte Formation

Farley Member (7.6 ft.)
- b. Limestone - gray; crystalline to granular; massive; contains Osagia 6.0
- a. Limestone - buff to light gray; fine grained; massive, dense; fossiliferous 1.6

Island Creek Member (1.5 ft.)
- Shale - bluish gray; silty 1.5

Argentine Member (17.9 ft exposed)
- Limestone - gray to light gray; fine grained to finely crystalline; massive, dense; contains fossils, pyrite and calcite stringers .. 17.9

Section B

ASH GROVE CEMENT PLANT SECTION (NEW LOUISVILLE QUARRY), C, NE¼, Sec. 14, T. 12 N., R. 11 E., Cass County (Springfield Quad., 1956 map), Nebraska. Measured in a new hand-dug pit below working level, excavated for crusher foundation; pit has now been filled.

Missourian Series Kansas City Group Bonner Springs Formation	Thickness (feet)
<u>Unnamed Member</u> (5.5 ft.)	
c. Shale - brown	0.5
b. Shale - bluish gray; fissile; fossiliferous; lime enriched zone	1.0
a. Shale - bluish gray; silty; blocky	4.0
Wyandotte Formation	
<u>Farley Member</u> (5.3 ft.)	
c. Limestone - white to light gray; crystalline; massive; dense; contains Osagia	3.0
b. Shale - gray, silty	0.4
a. Limestone - white to light gray; fine grained; massive, dense; fossiliferous	1.9
<u>Island Creek Member</u> (1.0 ft.)	
Shale - bluish gray; silty	1.0
<u>Argentine Member</u> (25.5 ft.)	
Limestone - white to gray; crystalline; massive in upper ¾, and bedded in lower ¼; contains fossils, pyrite, and calcite. The lower ¼ has thin shale breaks in it	25.5
<u>Quindaro Member</u> (1.5 ft)	
b. Shale - gray to bluish gray; silty	0.5
a. Shale - black; fissile	1.0
<u>Frisbie Member</u> (1.1 ft)	
b. Limestone - gray; coarse grained or granular; silty; fossiliferous	0.3
a. Limestone - gray to bluish-gray; fine grained; silty; dense; fossiliferous with fusulinid	0.8

Lane Formation

Unnamed Member (12.4 ft)

m. Shale - gray; silty 0.8
l. Claystone - gray; silty 0.5
k. Shale - gray; silty 0.9
j. Claystone - gray........ 0.2
i. Shale - medium gray; silty 0.1
h. Claystone - gray 0.2
g. Shale - medium gray; silty 0.5
f. Claystone - gray 0.3
e. Shale - medium to dark gray 1.6
d. Claystone - gray 0.7
c. Shale - medium gray; silty 1.2
b. Shale - gray to greenish-gray 4.5
Disconformity (with relief of 1.0 to 3.0 ft.)
a. Shale - green; contains limy nodules........ 0.9

Iola Formation

Raytown Member (10.9 ft.)

c. Limestone - light to medium gray; fine grained; silty; thin to thick bedded with many shale partings 9.3
b. Shale - medium gray; with crinoids........ 0.7
a. Limestone - gray; granular in upper part, fine grained in lower part; silty 0.9

Chanute Formation

Unnamed Member (5.5 ft.)

f. Shale - grayish green; with small corals (Lephophyllidium)........ 0.9
e. Shale - black; carbonaceous; fissile to laminated; (possible horizon of the Thayer Coal in Kansas) 0.3
d. Shale - greenish gray; fossiliferous 0.4
c. Siltstone - medium grayish green 0.4
b. Shale - greenish gray 1.5
Disconformity (with maximum relief of 2.0 ft.)
a. Shale - green; lime enriched zone........ 2.0

(Drum Formation underlies the Chanute in Pit)

Section C

QUARRY SECTION EAST OF OLD NATIONAL STONE QUARRY (OLD LOUISVILLE QUARRY), C, sw¼, Sec. 7, T. 12 N., R. 12 E., Cass County (Cedar Creek Quad., 1956 map), Nebraska.

	Thickness (feet)
Missourian Series	
Kansas City Group	
Bonner Springs Formation	
Unnamed Member (7.7 ft.)	
c. Shale - yellowish brown; silty; plastic when wet	0.5
b. Shale - greenish gray; brittle; fossiliferous; lime enriched zone	3.0
a. Shale - bluish gray; silty	4.2
Wyandotte Formation	
Farley Member (7.5 ft.)	
b. Limestone - light gray; granular; massive; dense; contains Osagia	5.5
a. Limestone - light gray to buff; fine grained; massive, dense	1.0
Island Creek Member (2.2 ft.)	
Shale - bluish gray; silty	2.2
Argentine Member (25.5 ft.)	
Limestone - light to medium gray; crystalline; massive in upper 18 ft. , and bedded in lower 7.5 ft.; contains fossils, pyrite, and calcite stringers	25.5
Quindaro Member (2.0 ft)	
b. Shale - bluish gray; silty	0.8
a. Shale - black; carbonaceous; fissile	1.2
Frisbie Member (0.7 ft)	
Limestone - dark gray to bluish-gray; fine grained to finely crystalline; silty; dense; fossiliferous	0.7

Lane Formation

<u>Unnamed Member</u> (12.4 ft)

g. Shale - bluish gray; silty; brittle 0.8
f. Claystone - light gray 0.4
e. Shale - bluish gray,; contains 4 claystone ledges, each
0.1 ft. thick 2.3
d. Claystone - light gray 0.7
c. Shale - gray; silty 1.5
b. Claystone - light gray 0.5
a. Shale - gray; silty 3.0

Section D

DYSON HOLLOW SECTION, NW¼, SE¼, NW½, Sec. 28, T. 13 N., R. 13 E., Sarpy County (Plattsmouth Quad., 1956 map), Nebraska.

Missourian Series Kansas City Group Bonner Springs Formation	Thickness (feet)
Unnamed Member (9.0 ft.)	
e. Shale - bluish gray; silty	1.0
d. Shale - dark gray	0.5
c. Shale - Bluish gray; limy	4.0
b. Shale - red; silty	1.5
a. Shale - greenish gray; silty	2.0
Wyandotte Formation	
Farley Member (5.0 ft.)	
b. Limestone - gray; granular; shaley	4.0
a. Limestone - dark gray; dense; coquinoid	1.0
Island Creek Member (2.0 ft.)	
Shale - bluish gray; silty	2.0
Argentine Member (5.0 ft exposed)	
Limestone - gray; fine grained; dense; weathers buff	5.0

Section E

QUARRY SECTION ALONG NORTH RIVER, NW¼, Sec. 11, T. 76 N., R. 29 W., Madison County (Winterset Quad., 1952 map), Iowa.

Missourian Series	Thickness
Kansas City Group	(feet)
Bonner Springs Formation	

<u>Unnamed Member</u> (3.0 ft.)

Shale - dark gray; fossiliferous; with limestone nodules 3.0

Wyandotte Formation

<u>Farley Member</u> (7.3 ft.)

c. Limestone - light to medium gray; fine grained; massive; weathers buff to flaggy.. 4.2

b. Shale - gray; fossiliferous 0.2

a. Limestone - light gray; granular; massive; very fossiliferous (contains Osagia)... 2.9

<u>Island Creek Member</u> (1.0 ft.)

Shale - green; fossiliferous (with fusulinids); with limestone nodules... 1.0

<u>Argentine Member</u> (8.1 ft exposed)

Limestone - light to medium gray; finely crystalline; thin to thick bedded; fossiliferous (with brachiopods); contains chert 8.1

Section F

SCHILIBERG QUARRY SECTION ALONG EAST SIDE OF MIDDLE RIVER, NW¼, SE¼,Sec. 5, T. 75 N., R. 29 W., Madison County (Winterset Quad., 1956 map), Iowa (Compare with Thomas, Welp and Dixon, 1957, p. 420).

Missourian Series	Thickness
Kansas City Group	(feet)
Bonner Springs Formation	
<u>Unnamed Member</u> (4.5 ft.)	
c. Shale - Greenish gray to dark gray; fossiliferous	0.6
b. Shale - black; carbonaceous	0.1
a. Shale - greenish gray to dark gray; fossiliferous; contains many limy nodules	3.8
Wyandotte Formation	
<u>Farley Member</u> (7.0 ft.)	
b. Limestone - light gray; fine grained; massive; weathers buff and flaggy	3.0
a. Limestone - light gray; granular; massive; free calcite; very fossiliferous (contains Osagia)	4.0
<u>Island Creek Member</u> (2.0 ft.)	
Shale - greenish gray; blocky, fossiliferous; contains free calcite and thin limestone nodules	2.0
<u>Argentine Member</u> (10.0 ft exposed)	
Limestone - light gray; crystalline; thin to thick bedded; dense; contains brown chert, pyrite and calcite stringers; fossiliferous (with brachiopods)	10.0

Section G

ROADCUT SECTION ALONG CREEK JOINING MIDDLE RIVER, C NW¼, SE¼, NE¼, Sec. 23, T. 75 N., R. 29 W., Madison County (Winterset Quad., 1956 map), Iowa.

Missourian Series Kansas City Group Wyandotte Formation	Thickness (feet)
Argentine Member (12.0 ft exposed)	
c. Limestone - light gray; crystalline; thin to thick bedded; dense; fossiliferous (with brachiopods)	8.0
b. Shale - gray; contains limy nodules	1.3
a. Limestone - light gray; crystalline; thin to thick bedded; dense; fossiliferous (with brachiopods); shale separates the limestone beds	2.7
Quindaro Member (4.0 ft.)	
d. Shale - gray; silty	0.6
c. Shale; gray silty; blocky	0.4
b. Shale - gray	1.5
a. Shale - black; fissile	1.5
Frisbie Member (1.0 ft. exposed)	
Limestone - bluish gray; fine grained to crystalline; massive, dense; vertically jointed; fossiliferous (with productid brachiopods)	1.0

Section H

ROADCUT SECTION, NE¼, SW¼, Sec. 8, T. 75 N., R. 28 W., Madison County (Winterset Quad., 1956 map), Iowa.

Missourian Series — Thickness (feet)
Kansas City Group
Wyandotte Formation

Argentine Member (12.0 ft exposed)
Limestone - medium gray; crystalline; thin to thick bedded; dense; contains shale breaks 12.0

Quindaro Member (3.5 ft.)
b. Shale - greenish gray; fossiliferous 1.5
a. Shale - black; fissile 2.0

Frisbie Member (0.6 ft. exposed)
Limestone - bluish gray; fine grained to crystalline; massive, dense; fossiliferous (with productid brachiopods) 0.6

Lane Formation

Unnamed Member (10.0 ft.)
Shale - greenish gray; silty; poorly exposed 10.0

Iola Formation

Raytown Member (7.7 ft.)
d. Limestone - gray; crystalline; massive, dense; fossiliferous (fusulinids and brachiopods) 2.6
c. Limestone - bluish gray; fine grained; wavy bedded; dense; fossiliferous (with brachiopods and crinoids) 3.4
b. Shale - gray; fossiliferous 0.5
a. Limestone - buff; fine grained; contains shale breaks 1.2

Muncie Creek Member (4.0 ft.)
b. Shale - greenish gray; fossiliferous 2.0
a. Shale - bluish gray to black; fissile 2.0

Paola Member (2.2 ft.)
Limestone - gray; crystalline; massive, dense; fossiliferous (with brachiopods) 2.2

Chanute Formation

Unnamed Member (4.5 ft. exposed)

c. Shale - greenish gray; silty; blocky 0.8

b. Shale - black; carbonaceous (probable horizon of the Thayer Coal in Kansas... 0.1

a. Shale - greenish gray; blocky 3.6

Section I

ROADCUT SECTION, C SE¼, NW¼, Sec. 17, T. 75 N., R. 28 W., Madison County (Winterset Quad., 1956 map), Iowa.

Missourian Series	Thickness
Kansas City Group	(feet)
Wyandotte Formation	
Argentine Member (3.0 ft exposed)	
Limestone - light gray; crystalline; thin to thick bedded; dense; fossiliferous	3.0
Quindaro Member (4.2 ft.)	
d. Shale - gray; silty	0.7
c. Shale - greenish gray; fossiliferous	0.4
b. Shale - gray; silty; fossiliferous	1.1
a. Shale - black; fissile	2.0
Frisbie Member (0.5 ft. exposed)	
Limestone - bluish gray; crystalline; massive, dense; fossiliferous (with productid brachiopods)	0.5
Lane Formation	
Unnamed Member (9.9 ft.)	
c. Shale - greenish gray; silty	7.3
b. Shale - maroon (dark red)	0.6
a. Shale - greenish gray; silty	2.0
Iola Formation	
Raytown Member (8.1 ft.)	
d. Limestone - medium gray; crystalline; wavy bedded, dense; fossiliferous (fusulinids and brachiopods)	2.6
c. Limestone - light to medium gray; crystalline; wavy bedded; dense; fossiliferous (with brachiopods and crinoids)	4.0
b. Shale - gray; silty; contains limy nodules	0.6
a. Limestone - buff; fine grained; contains shale breaks	0.9
Muncie Creek Member (4.0 ft.)	
b. Shale - green; contains limy nodules	2.4
a. Shale - black; fissile	1.6

Paola Member (2.1 ft.)

Limestone - gray; crystalline; massive, dense; fossiliferous (with brachiopods) 2.1

Chanute Formation

Unnamed Member (5.0 ft. exposed)

c. Shale - greenish gray; silty; blocky 0.7

b. Shale - black; carbonaceous (probable horizon of the Thayer Coal in Kansas 0.1

a. Shale - greenish gray; silty; blocky 4.2

Section J

ROADCUT SECTION, C SW¼, NW¼, Sec. 22, T. 75 N., R. 28 W., Madison County (Winterset Quad., 1956 map), Iowa.

	Thickness (feet)
Missourian Series	
Kansas City Group	
Iola Formation	
Raytown Member (5.2 ft. exposed)	
c. Limestone - bluish gray; fine grained to finely crystalline; wavy bedded; dense; fossiliferous (with brachiopods)	3.5
b. Shale - gray; silty; contains limy nodules	0.7
a. Limestone - buff; fine grained; fine bedded	1.0
Muncie Creek Member (3.7 ft.)	
b. Shale - green; contains limy nodules	2.2
a. Shale - black; fissile	1.5
Paola Member (2.0 ft.)	
Limestone - gray to buff; crystalline; massive, dense; fossiliferous (with brachiopods)	2.0
Chanute Formation	
Unnamed Member (4.9 ft. exposed)	
c. Shale - greenish gray; silty; blocky	0.5
b. Shale - black; carbonaceous (probable horizon of the Thayer Coal in Kansas	0.1
a. Shale - greenish gray; silty; blocky	4.3

Section K

RANKIN FARM SECTION, NE¼, NE¼, NE¼, Sec. 10, T. 75 N., R. 28 W., Madison County (Winterset Quad., 1956 map), Iowa.

	Thickness (feet)
Missourian Series	
Kansas City Group	
Wyandotte Formation	
Argentine Member (10.0 ft exposed)	
Limestone - light gray; crystalline; thin to thick bedded; dense; fossiliferous (with brachiopods)	10.0
Quindaro Member (4.4 ft.)	
d. Shale - gray; silty	0.8
c. Shale - greenish gray; fossiliferous, contains pyrite	0.4
b. Shale - gray; silty; fossiliferous	1.2
a. Shale - black; fissile	2.0
Frisbie Member (0.7 ft. exposed)	
Limestone - bluish gray; finely crystalline; massive, dense; vertically jointed; fossiliferous	0.7
Lane Formation	
Unnamed Member (10.0 ft.)	
Shale - gray; silty; mostly talus covered	10.0
Iola Formation	
Raytown Member (5.5 ft. exposed)	
b. Limestone - light to medium gray; crystalline; massive, dense; fossiliferous (fusulinids and brachiopods)	2.5
a. Limestone - bluish gray; fine grained; wavy bedded; dense;	3.0

Section L

TYPE SECTION FARLEY MEMBER, just north of C, Sec. 34, T. 52 N., R. 35 W., Platte County (Platte City Quad., 1948 map),Missouri.

Missourian Series	Thickness
Kansas City Group	(feet)
Wyandotte Formation	
<u>Farley Member</u> (12.2 ft.)	
Limestone - bluish gray; granular; massive; dense; contains Osagia...	3.0
Shale - buff; silty..........	0.5
Limestone - bluish gray; crystalline to granular; thin to thick bedded; dense; fossiliferous (contains Osagia)..........	5.0
Shale - brown to buff; silty; fossiliferous..........	1.7
Limestone - brown to gray; granular; massive, dense; fossiliferous.....	1.0

Section M

ARGENTINE STATION SECTION, South and East of 20th and Metropolitan Ave., Kansas City, Kansas, C SE¼, NE¼, NE¼, Sec. 29, T. 11 S., R. 25 E., Wyandotte County (Shawnee 15 min. Quad), Kansas. (illustration follows)

Missourian Series — Thickness (feet)
Kansas City Group
Bonner Springs Formation

Unnamed Member (15.0 ft. exposed)
Shale - gray silty 15.0

Wyandotte Formation

Farley Member (26.5 ft.)
c. Limestone - light gray; granular; massive; dense; fossiliferous (contains many Osagia) 4.0
b. Shale - gray; fossiliferous 9.5
a. Limestone - light gray to buff; granular; massive; dense; oolitic fossiliferous 13.0

Island Creek Member (7.5 ft.)
Shale - bluish gray; silty 7.5

Argentine Member (28.0 ft.)
Limestone - gray; crystalline; thin to thick bedded; dense; fossiliferous (with brachiopods and bryozoans); contains many shale breaks 28.0

Quindaro Member (1.5 ft.)
b. Shale - dark gray; silty 0.7
a. Shale - black; fissile 0.8

Frisbie Member (2.3 ft.)
Limestone - bluish gray; crystalline; massive, dense; fossiliferous (with productid brachiopods) 2.3

Lane Formation

Unnamed Member (36.5 ft.)
Shale - gray; silty; mostly covered 36.5

Iola Formation

Raytown Member (5.5 ft.)
Limestone - gray; fine grained to crystalline; thin to thick bedded; dense; fossiliferous 5.5

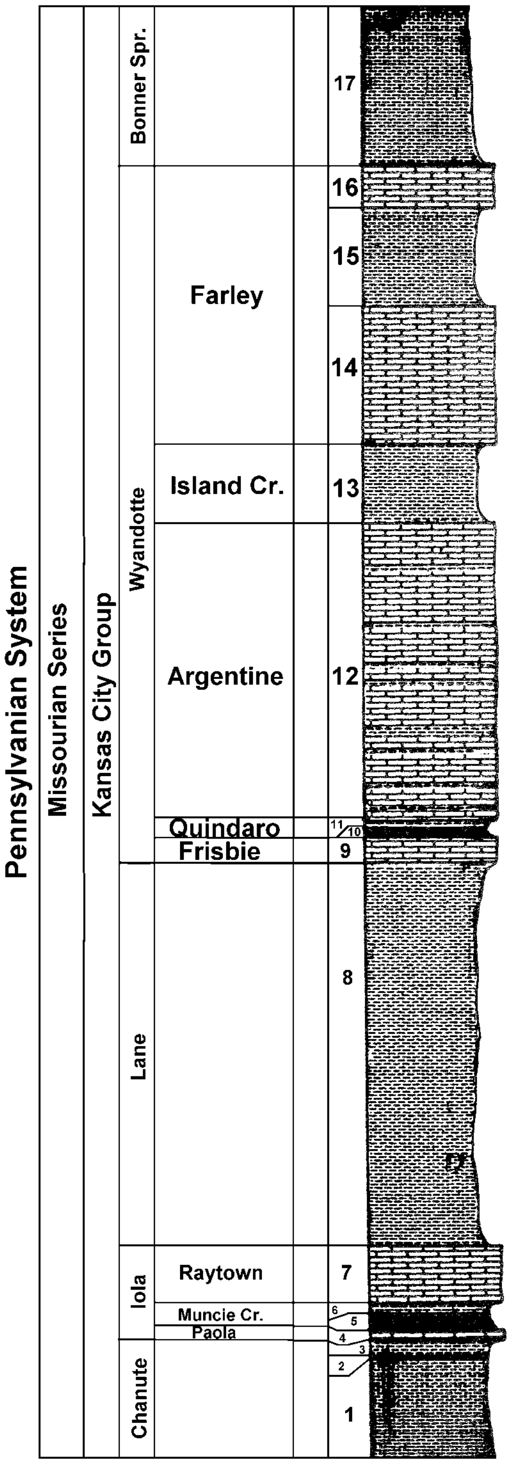
Muncie Creek Member (2.5 ft.)
b. Shale - gray; silty; contains many phosphate nodules 1.0
a. Shale - black; fissile.. 1.5

Paola Member (1.0 ft.)
Limestone - gray; fine grained; massive, dense; weathers with small holes.. 1.0

Chanute Formation

Unnamed Member (12.0 ft.)
c. Shale - greenish gray; silty; 4.0
b. Shale - black; carbonaceous, fissile 0.5
a. Shale - greenish gray; silty 7.5

Argentine Station Section - Wyandotte County, Kansas



17. Shale, argillaceous, gray, 15.0'

16. Limestone, gray, granular, massive, dense contains Osagia, 4.0'

15. Shale, argillaceous, gray, fossiliferous, 9.5'

14. Limestone, gray-buff, granular, fossiliferous, 13.0'

13. Shale, argillaceous, bluish-gray, 7.5'

12. Limestone, gray, crystalline, thin-thick bedded, dense; contains many shale breaks, 28.0'

11. Shale, argillaceous, dark gray, 0.7'
10. Shale, black fissile, 0.8'
9. Limestone, bluish-gray, crystalline, massive, dense, fossiliferous, 2.3'

8. Shale, argillaceous, gray, partly covered, 36.5'

7. Limestone, gray, thin-thick bedded, dense fossiliferous, 5.5'
6. Shale, argillaceous, gray, contains phosphatic nodules, 1.0'
5. Shale, black, fissile, 1.5'
4. Limestone, bluish-gray, massive, dense, 1.0'
3. Shale, argillaceous, greenish-gray, 1.5'
2. Shale, black, carbonaceous, 0.5'
1. Shale, argillaceous, greenish-gray, 9.5'

Section N

TYPE SECTION FOR MUNCIE CREEK MEMBER, SE¼, Sec. 12, T. 11 S., R. 24 E., Wyandotte County (Shawnee 15 min. Quad), Kansas.

Missourian Series Kansas City Group Iola Formation	Thickness (feet)
Raytown Member (6.0 ft.)	
Limestone - dark gray; fine grained to crystalline; thin to thick bedded; dense; fossiliferous	6.0
Muncie Creek Member (2.3 ft.)	
b. Shale - buff; silty; contains many phosphate nodules	0.3
a. Shale - black; fissile	2.0
Paola Member (1.0 ft.)	
Limestone - dark bluish gray; fine grained to finely crystalline; massive, dense; weathers with small holes	1.0
Chanute Formation	
Unnamed Member (11.0 ft. exposed)	
Shale - dark greenish gray; silty; poorly exposed	11.0

Section O

TURNPIKE ROADCUT SECTION, C SE¼, SW¼, Sec. 1, T. 11 S., R. 24 E., Wyandotte County (Shawnee 15 min. Quad), Kansas.

	Thickness (feet)
Missourian Series	
Kansas City Group	
Wyandotte Formation	
<u>Argentine Member</u> (7.0 ft exposed)	
Limestone - gray; crystalline; thin to thick bedded; dense; fossiliferous; some interbedded argillaceous shale	7.0
<u>Quindaro Member</u> (0.9 ft.)	
Shale - black; fissile	0.9
<u>Frisbie Member</u> (2.5 ft.)	
Limestone - bluish gray; crystalline; massive, dense; fossiliferous	2.5
Lane Formation	
<u>Unnamed Member</u> (32.6 ft.)	
Shale - bluish gray	32.6
Iola Formation	
<u>Raytown Member</u> (6.0 ft.)	
Limestone - dark gray; fine grained to crystalline; thin to thick bedded, dense; fossiliferous	6.0

Section P

TURNPIKE ROADCUT SECTION, C SE¼, SW¼, Sec. 2, T. 11 S., R. 24 E., Wyandotte County (Shawnee 15 min. Quad), Kansas.

	Thickness (feet)
Missourian Series	
Kansas City Group	
Wyandotte Formation	
Argentine Member (12.0 ft exposed)	
Limestone - light gray; crystalline; thin to thick bedded; dense; many shale partings	12.0
Quindaro Member (0.9 ft.)	
Shale - black; fissile	0.9
Frisbie Member (1.8 ft.)	
Limestone - bluish gray; crystalline; massive, dense; fossiliferous	1.8
Lane Formation	
Unnamed Member (6.0 ft. exposed)	
Shale - bluish gray	6.0

Section Q

LONE STAR CEMENT PLANT SECTION, type section of Bonner Springs Formation, S½, NW¼, Sec. 24, T. 31 S., R. 23 E., Wyandotte County (Edwardsville Quad., 1951 map), Kansas.

	Thickness (feet)
Missourian Series	
Kansas City Group	
Bonner Springs Formation	
<u>Unnamed Member</u> (29.1 ft.)	
h. Shale - buff	0.3
g. Limestone - buff; sandy and shaley; fossiliferous	1.5
f. Limestone - nodular zone	0.5
e. Sandstone - light gray to buff; shaley	3.0
d. Shale - greenish gray; silty	1.5
c. Shale - maroon	0.5
b. Shale - dark gray; silty	6.0
a. Shale -greenish gray; sandy	15.6
Wyandotte Formation	
<u>Farley Member</u> (31.6 ft.)	
e. Limestone - medium gray; granular; massive, dense	11.3
d. Shale - gray; fossiliferous	0.5
c. Limestone - light brown to buff; sandy; cross-bedded	7.5
b. Limestone - gray; granular; dense; some interbedded bluish gray, limy shale	7.5
a. Limestone - bluish gray; crystalline; massive; dense	4.8
<u>Island Creek Member</u> (1.0 ft.)	
Shale - greenish gray	1.0
<u>Argentine Member</u> (11.0 ft exposed)	
Limestone - light gray; crystalline; thin to thick bedded; dense; fossiliferous (with brachiopods)	11.0

Section R

HIGHWAY 107 ROADCUT SECTION, C Sw¼, NE¼, Sec. 26, T. 11 S., R. 23 E., Wyandotte County (Edwardsville Quad., 1951 map), Kansas.

Missourian Series Kansas City Group Wyandotte Formation	Thickness (feet)
<u>Argentine Member</u> (6.0 ft exposed)	
Limestone - gray; crystalline; thin to thick bedded; dense; fossiliferous; some shale breaks	6.0
<u>Quindaro Member</u> (0.5 ft.)	
Shale - dark gray to black; fissile	0.5
<u>Frisbie Member</u> (1.8 ft.)	
Limestone - bluish gray; crystalline; massive, dense; fossiliferous (crinoids)	1.5
Lane Formation	
<u>Unnamed Member</u> (12.2 ft. exposed)	
Shale - bluish gray; becomes softer from bottom to top	6.0

Section S

BOY SCOUT CAMP SECTION ALONG EAST SIDE OF MIDDLE RIVER, C SW¼, SE¼, Sec. 5, T. 75 N., R. 29 W., Madison County (Winterset Quad., 1956 map), Iowa (Compare with Thomas, Welp and Dixon, 1957, p. 420).

	Thickness (feet)
Missourian Series	
Kansas City Group	
Bonner Springs Formation	
<u>Unnamed Member</u> (11.2 ft.)	
Shale - Greenish gray; micaceous	11.2
Wyandotte Formation	
<u>Farley Member</u> (19.0 ft.)	
e. Limestone - gray; crystalline to granular; medium to thick bedded dense; fossiliferous	10.0
d. Shale - gray; silty	1.0
c. Limestone - buff; granular; massive, dense	1.5
b. Limestone - gray; crystalline; dense; some interbedded greenish gray shale	3.5
a. Limestone - pinkish gray; crystalline; medium bedded; dense; fossiliferous	3.0
<u>Island Creek Member</u> (10.5 ft.)	
Shale - dark gray; silty	10.5
<u>Argentine Member</u> (4.0 ft exposed)	
Limestone - pinkish gray; crystalline; thick bedded; dense; fossiliferous (with brachiopods, crinoids and bryozoans)	4.0

Section T

LORING QUARRY SECTION, C SW¼, Sw¼, Sec. 13, T. 12 S., R. 22 E., Leavenworth County (Bonner Springs Quad., 1951 map), Kansas.

Missourian Series — Thickness (feet)
Kansas City Group
Bonner Springs Formation

<u>Unnamed Member</u> (1.0 ft.)
Shale - Light gray to buff; silty 1.0

Wyandotte Formation

<u>Farley Member</u> (20.0 ft.)
d. Limestone - buff; granular; massive dense; fossiliferous.................. 3.1
c. Limestone - gray; crystalline; wavy bedded, dense; fossiliferous; weathers buff 12.5
b. Shale - bluish gray; fossiliferous.. 0.9
a. Limestone - dark gray; granular; massive; dense; fossiliferous........ 3.5

<u>Island Creek Member</u> (0.9ft.)
Shale - greenish gray 0.9

<u>Argentine Member</u> (18.5 ft exposed)
Limestone - bluish gray; fine to coarsely crystalline; thin to thick bedded; dense; fossiliferous (with brachiopods, crinoids and bryozoans)... 18.5

Section U

DE SOTO KANSAS SECTION, C SW¼, SW¼, NW¼, Sec. 28, T. 12 S., R. 22 E., Johnson County (De Soto Quad., 1951 map), Kansas.

	Thickness (feet)
Missourian Series	
Kansas City Group	
Bonner Springs Formation	
<u>Unnamed Member</u> (1.2 ft.)	
Shale - green to buff; micaceous; fossiliferous	1.2
Wyandotte Formation	
<u>Farley Member</u> (15.2 ft.)	
b. Limestone - buff; granular; massive dense; contains Osagia	3.0
Unconformity	
a. Limestone - light gray; finely crystalline; massive; dense; fossiliferous (with bryozoans and pelecypods)	12.2

Section V

TYPE SECTION FOR PAOLA LIMESTONE, SE¼, SE¼, SW¼, Sec. 27, T. 16 S., R. 23 E., Miami County (Paola East Quad., 1956 map), Kansas.

Missourian Series	Thickness
Kansas City Group	(feet)
Iola Formation	

Raytown Member (6.9 ft.)

Limestone - medium gray; fine grained to crystalline; thin to thick and wavy bedded, dense; fossiliferous (with brachiopods)........ 6.9

Muncie Creek Member (0.5 ft.)

Shale - dark gray; contains many phosphatic nodules......................... 0.5

Paola Member (2.2 ft. exposed)

Limestone - bluish gray; fine grained; massive, dense; weathers with small holes 2.2

Section W

HIGHWAY 169 ROADCUT SECTION, NE¼, Sec. 35, T. 17 S., R. 22 E., Miami County (Paola West Quad., 1957 map), Kansas.

Missourian Series Kansas City Group Iola Formation	Thickness (feet)
Raytown Member (7.0 ft.)	
Limestone - medium gray; fine grained to crystalline; thin to thick and wavy bedded, dense; fossiliferous	7.0
Muncie Creek Member (0.4 ft.)	
Shale - buff; contains many phosphatic nodules	0.4
Paola Member (1.9 ft. exposed)	
b. Limestone - medium gray; finely crystalline; massive, dense; fossiliferous	1.0
a. Limestone - bluish gray; fine grained; massive, dense; weathers with small holes	0.9
Chanute Formation	
Unnamed Member (15.6 ft)	
d. Shale - buff; silty	0.5
c. Shale - bluish gray; micaceous; weathers somewhat fissile	3.4
b. Shale - black; fissile (Thayer Coal horizon)	0.6
a. Shale - bluish gray; blocky	11.1

Section X

HIGHWAY 169 ROADCUT SECTION, S½, Sec. 35, T. 17 S., R. 22 E., Miami County (Paola West Quad., 1957 map), Kansas.

Missourian Series	Thickness
Kansas City Group	(feet)
Iola Formation	
Paola Member (1.5 ft. exposed)	
Limestone - bluish gray; finely crystalline; massive, dense; weathers with small holes	1.5
Chanute Formation	
Unnamed Member (14.6 ft)	
c. Shale - bluish gray; micaceous	2.3
b. Shale - red; silty (horizon of Thayer Coal)	0.8
a. Shale - gray; sandy	11.5

Section Y

ROADCUT SECTION, 4 miles south of Lane, Kansas, Sec. 4, T. 19 S., R. 21 E., Franklin County (Garnett 15 min. Quad.), Kansas.

Missourian Series Kansas City Group Wyandotte Formation	Thickness (feet)
Frisbie Member (2.5 ft. exposed)	
Limestone - bluish gray; crystalline; massive, dense; contains calcite; weathers buff	2.5
Lane Formation	
Unnamed Member (50.0 ft. exposed)	
c. Shale - buff; sandy; micaceous; blocky	25.5
b. Shale - bluish gray; weathers micaceous	8.5
a. Shale -greenish gray; micaceous	16.0

APPENDIX B

Subsurface Sample Descriptions

Well No. 1

SHROEDER NO. 1 AMERADA, NE¼, SW¼, Sec. 26, T. 21 N., R. 12 E., Cass County, Nebraska. Surface elevation 1120 ft. Lithology adapted from Condra (1939, pp. 5-6), age determinations modified by E. C. Reed (1958, personal communications)..

Missourian Series Kansas City Group Bonner Springs Formation	Depth in feet from	to
Unnamed Member (8.9 ft.)		
Shale - gray to dark gray; argillaceous; very fossiliferous (with bryozoan, pelecypods, brachiopods, etc.)	179.0	187.9
Wyandotte Formation		
Farley Member (6.7 ft.)		
Limestone - light gray; massive; dense	187.9	194.6
Island Creek Member (2.5 ft.)		
b. Shale - bluish gray; limy; massive; fossiliferous (1.5 ft.)	194.6	196.1
a. Shale - dark bluish gray; massive; limy; pyritiferous; fossiliferous (1.0 ft)	196.1	197.1
Argentine Member (22.5 ft.)		
d. Limestone - medium light gray; largely massive and dense; fossiliferous (15.8 ft.)	197.1	212.9
c. Limestone - medium dark gray; argillaceous, with thin shale seams and many fossils (5.0 ft.)	212.9	217.9
b. Shale - dark gray; limy; fossiliferous (1.0 ft.)	217.9	218.9
a. Limestone - dark gray; fossiliferous (0.7 ft.)	218.9	219.6
Quindaro Member (1.8 ft.)		
b. Shale - dark gray and black; calcareous-arenaceous; fossiliferous (1.0 ft.)	219.6	220.6
a. Shale - black, with gray specks (0.8 ft.)	220.6	221.4
Frisbie Member (0.9 ft.)		
Limestone - dark gray; very fossiliferous	221.4	222.3

Lane Formation

<u>Unnamed Member</u> (14.9 ft.)

f. Shale - bluish gray; indurated; fine textured; brittle; with pyrite and fossil fragments (10.3 ft.)	222.3	232.6
e. Mudstone - dark gray (0.2 ft.)	232.6	232.8
d. Shale - dark gray, carbonaceous-argillaceous (0.4 ft.)	232.8	233.2
c. Limestone - gray; impure (0.2 ft.)	233.2	233.4
b. Shale - dark gray; with limy seams and many fossils (0.4 ft.)	233.4	233.8
a. Shale - bluish gray, argillaceous (3.4 ft.)	233.8	237.2

Iola Formation

<u>Raytown Member</u> (9.5 ft.)

c. Limestone - dark gray, yellowish at top; largely massive with fossil fragments (8.0 ft.)	237.2	245.2
b. Shale - gray,; limy (0.5 ft.)	245.2	245.7
a. Limestone - gray; fossiliferous (1.0 ft.)	245.7	246.7

Chanute Formation

<u>Unnamed Member</u> (7.0 ft.)

Shale - gray; argillaceous; crumbly (1.8 ft.)	246.7	248.5
Shale - black; coal-like (0.7 ft.)	248.5	249.2
Shale - bluish gray; argillaceous (4.5 ft.)	249.2	253.7

Well No. 2

STROUT NO. 1 STANOLIND, SE¼, SE¼, SE¼, Sec. 3, T. 9 N., R. 12 E., Otoc County, Nebraska. Kelly bushing elevation 1172 ft.

	Depth in feet from	to
Missourian Series		
Kansas City Group		
Bonner Springs Formation		
<u>Unnamed Member</u> (9.0 ft.)		
Shale -green, gray, black and red; micaceous	300	309
Wyandotte Formation		
<u>Farley Member</u> (9.0 ft.)		
Limestone - white to light gray; fine grained to granular; fossiliferous (contains Osagia)	309	318
<u>Island Creek Member</u> (3.0 ft.)		
Shale - greenish gray; micaceous; fossiliferous	318	321
<u>Argentine Member</u> (29.0 ft.)		
Limestone - light to medium gray; fine grained to crystalline; dense; fossiliferous also dark gray to black shale	321	350
Lane Formation		
<u>Unnamed Member</u> (15.0 ft.)		
Shale - dark gray to black, micaceous	350	365
Iola Formation		
<u>Raytown Member</u> (8.0 ft.)		
Limestone - white to light gray; fine grained to crystalline, dense; micaceous shale	365	373
Chanute Formation		
<u>Unnamed Member</u> (7.0 ft.)		
Shale - red, green and gray; micaceous	373	380

Well No. 3

SNYDER NO. 1 GULF, SE¼, NE¼, NE¼, Sec. 34, T. 6 N., R. 15 E., Nemaha County, Nebraska. Kelly bushing elevation 942 ft.

Missourian Series Kansas City Group Bonner Springs Formation	Depth in feet from	 to
Unnamed Member (11.0 ft.)		
Shale -dark to bluish gray; silty	709	720
Wyandotte Formation		
Farley Member (13.0 ft.)		
Limestone - white to light gray; fine grained to granular; fossiliferous	720	733
Island Creek Member (4.0 ft.)		
Shale - bluish gray; silty	733	737
Argentine Member (38.0 ft.)		
Limestone - medium to dark gray; crystalline; dense; fossiliferous also dark gray silty shale	737	775
Lane Formation		
Unnamed Member (17.0 ft.)		
Shale - bluish gray; silty, fossiliferous; contains pyrite	775	792
Iola Formation		
Raytown Member (7.0 ft.)		
Limestone - medium to bluish gray; fine grained to crystalline, dense; fossiliferous. Also dark gray argillaceous shale	792	799
Chanute Formation		
Unnamed Member (7.0 ft.)		
Shale - dark gray, green and red; finely micaceous	799	806

Well No. 4

MAGOR NO. 1 ISAACAC, C, NE¼, NE¼, Sec. 25, T. 5 N., R. 15 E., Nemaha County, Nebraska. Kelly bushing elevation 1,108 ft.

	Depth in feet	
Missourian Series Kansas City Group Bonner Springs Formation	from	to
Unnamed Member (10.0 ft.)		
Shale - bluish gray, red and green; silty	1,016	1,026
Wyandotte Formation		
Farley Member (11.0 ft.)		
Limestone - light to medium gray; granular; dense; fossiliferous	1,026	1,037
Island Creek Member (3.0 ft.)		
Shale - gray; silty; fossiliferous	1,037	1,040
Argentine Member (44.0 ft.)		
Limestone - medium gray; fine grained to crystalline; dense; fossiliferous; contains light gray chert	1,040	1,084
Lane Formation		
Unnamed Member (15.0 ft.)		
Shale - dark to bluish gray; silty	1,084	1,098
Iola Formation		
Raytown Member (7.0 ft.)		
Limestone - light to dark gray; finely crystalline; dense; fossiliferous	1,098	1,105
Chanute Formation		
Unnamed Member (9.0 ft.)		
Shale - medium to dark gray and bluish gray; silty	1,105	1,114

Well No. 5

ROESCH NO. 1 SKELLY, C, N½, NW¼, Sec. 36, T. 3 N., R. 16 E., Richardson County, Nebraska. Kelly bushing elevation 1,099 ft.

Missourian Series Kansas City Group Bonner Springs Formation	Depth in feet from	 to
Unnamed Member (17.0 ft.)		
Shale - green and gray; micaceous	950	967
Wyandotte Formation		
Farley Member (17.0 ft.)		
Limestone - white to light gray; fine grained to granular; dense; fossiliferous (contains Osagia)	967	984
Island Creek Member (5.0 ft.)		
Shale - green and gray; micaceous	984	989
Argentine Member (30.0 ft.)		
Limestone - light to medium gray; fine grained to crystalline; dense; fossiliferous; contains brown chert	989	1,019
Lane Formation		
Unnamed Member (11.0 ft.)		
Shale - gray to black; micaceous	1,019	1,030
Iola Formation		
Raytown Member (9.0 ft.)		
Limestone - light to dark gray; fine grained to finely crystalline; dense; fossiliferous	1,030	1,039
Chanute Formation		
Unnamed Member (8.0 ft.)		
Shale - green and gray; micaceous	1,039	1,047

Well No. 6

MEYER NO. 1 PAWNEE ROYALTY COMPANY, C, NW¼, NW¼, Sec. 24, T. 1 N., R. 15 E., Richardson County, Nebraska. Kelly bushing elevation 945 ft.

	Depth in feet	
Missourian Series		
Kansas City Group	from	to
Bonner Springs Formation		
Unnamed Member (13.0 ft.)		
Shale - dark gray, bluish gray, greenish gray; finely micaceous	957	970
Wyandotte Formation		
Farley Member (12.0 ft.)		
Limestone - light to medium gray; granular to finely crystalline, dense; fossiliferous (contains Osagia)	970	982
Island Creek Member (3.0 ft.)		
Shale - greenish gray; micaceous; fossiliferous	982	985
Argentine Member (52.0 ft.)		
Limestone - buff to light gray; fine grained to granular; dense; fossiliferous	985	992
Limestone - light to medium gray; fine grained to crystalline; dense; fossiliferous	992	1,037
Lane Formation		
Unnamed Member (10.0 ft.)		
Shale - dark gray to black; micaceous	1,037	1,047
Iola Formation		
Raytown Member (9.0 ft.)		
Limestone - medium to bluish gray; finely crystalline; dense; fossiliferous. Also gray; micaceous shale and black, fissile, shale	1,047	1,052

Chanute Formation

Unnamed Member (10.0 ft.)

Shale - medium to dark gray and red; calcareous...............1,052 1,062

Well No. 7

TURNER NO. 1 WOODS, SW¼, NW¼, SW¼, Sec. 7, T. 1 S., R. 15 E., Brown County, Nebraska. Kelly bushing elevation 1,211 ft.

	Depth in feet from	to
Missourian Series		
Kansas City Group		
Bonner Springs Formation		
Unnamed Member (29.0 ft.)		
Shale - bluish gray, green and gray; silty	1,242	1,271
Wyandotte Formation		
Farley Member (12.0 ft.)		
Limestone - buff to light gray; finely crystalline to granular; dense; fossiliferous	1,271	1,283
Island Creek Member (5.0 ft.)		
Shale - medium to dark gray; silty	1,283	1,288
Argentine Member (49.0 ft.)		
Limestone - light to dark gray; fine grained to coarsely crystalline; dense; fossiliferous. Also dark gray to black; silty shale	1,288	1,337
Lane Formation		
Unnamed Member (13.0 ft.)		
Shale - dark gray; finely micaceous	1,337	1,350
Iola Formation		
Raytown Member (8.0 ft.)		
Limestone - light to medium gray; finely crystalline; dense; fossiliferous. Also gray and black shale	1,350	1,358
Chanute Formation		
Unnamed Member (10.0 ft.)		
Shale - gray; silty. Also black, carbonaceous shale	1,358	1,368

Well No. 8

BRIGHTEL NO. 1 STANOLIND, C, SW¼, Sec. 21, T. 7 S., R. 13 E., Jackson County, Kansas. Kelly bushing elevation 1,309 ft.

Missourian Series Kansas City Group Bonner Springs Formation	Depth in feet from	to
Unnamed Member (21.0 ft.)	1,463	1,484
Wyandotte Formation		
Farley Member (14.0 ft.)	1,484	1,498
Island Creek Member (3.0 ft)	1,498	1,501
Argentine - Frisbie interval (29.0 ft.)	1,501	1,530
Lane Formation		
Unnamed Member (32.0 ft.)	1,530	1,562
Iola Formation		
Raytown - Paola interval (10.0 ft.)	1,562	1,572
Chanute Formation		
Unnamed Member (26.0 ft.)	1,572	1,598

Well No. 9

JONES NO. 1 FEES, SW¼, SW¼, NE¼, Sec. 19, T. 10 S., R. 20 E., Jefferson County, Kansas. Kelly bushing elevation 1,167 ft.

Missourian Series Kansas City Group Bonner Springs Formation	Depth in feet from	 to
Unnamed Member (33.0 ft.)	610	643
Wyandotte Formation		
Farley Member (17.0 ft.)	643	660
Island Creek Member (12.0 ft)	660	672
Argentine - Frisbie interval (20.0 ft.)	672	692
Lane Formation		
Unnamed Member (36.0 ft.)	692	728
Iola Formation		
Raytown - Paola interval (12.0 ft.)	728	740
Chanute Formation		
Unnamed Member (10.0 ft.)	740	750