

ABSTRACT

The Wyandotte Limestone (Missourian) of the Kansas City Group is a prominent bench-forming formation typically exposed along the Kansas River near Kansas City. The Wyandotte is composed of five members, three limestones and two shales, which are persistent and recognizable at most localities in the area of study. This formation thins southward at the expense of the shale members and pinches out south of the area in northern Anderson County.

The Frisbie Limestone is the lower member of this formation and typically is a bluish gray, massive unit that contains characteristic "Ottonosia-like" algae. The alternating limestones and shales of the overlying Quindaro Shale locally contain a thin black shale at the base. The most dominant and persistent member is the Argentine Limestone that is typically light colored, wavy, thin bedded, and contains a massive upper "osagite" or fragmental bed. The upper most shale, the Island Creek Shale, thins appreciably southwestward and, with the exception of local fossil fragment zones, contains a near shore biota. Overlying this shale is the Farley Limestone that characteristically exhibits numerous lithologic variations and facies changes throughout the area. The lithology and biota of the Wyandotte record environmental conditions of near shore or shelf type deposition.

The Wyandotte megacycotherm appears to be similar to those recorded in the younger Shawnee beds, although not as complete. Cyclotherms B and C are identifiable, D is obscure, while A and E are absent.

STRATIGRAPHY OF THE WYANDOTTE LIMESTONE
(UPPER PENNSYLVANIAN)
IN THE KANSAS RIVER AREA

by

James A. Wilson
B.S., University of Kansas, 1958

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As a note concerning this report. Many pictures were part of this report, however, the quality of the photos were so poor, after reproduction by the Survey, as to be useless. They were therefore extracted from the report.

INTRODUCTION

PURPOSE OF INVESTIGATION

The purpose of this study is to attempt to clarify further the local stratigraphy of the Wyandotte Limestone in the Kansas River area. A study of this nature involves the megascopic and microscopic examination of lithologic and faunal characteristics as an effort to establish aids in correlation and interpretation of probable environments of deposition.

PREVIOUS WORK

The name Wyandotte Limestone was proposed by Newell (in Moore 1932, p. 92; 1935, p.59) to include beds lying between the Lane Shale and Bonner Springs Shale, as typically exposed on the bluffs along the Kansas River at Kansas City. The Wyandotte Limestone includes five members named in ascending order; Frisbie Limestone, Quindaro Shale, Argentine Limestone, Island Creek Shale, and Farley Limestone. (Fig. 1).

With the naming of the Wyandotte Limestone, and its included members, came the end of a great deal of confusion in stratigraphic classification of rocks in the interval between typical Iola Limestone and Plattsburg Limestone in northeastern Kansas. Prior to the naming of the Wyandotte, confusion as to the proper stratigraphic relationship of the beds in the Kansas River area came from an error in correlation by early geologist while attempting to trace the Iola Limestone northward from its type locality at Iola, Kansas. They apparently became confused in the vicinity of Osawatomie and Paola, in central Miami County, and misidentified as Iola the next higher group of limestone beds. Nowell (1935, p. 58) points out that because of thinning of the Iola Limestone and the overlying Lane Shale, the Iola escarpment is less prominent northward.

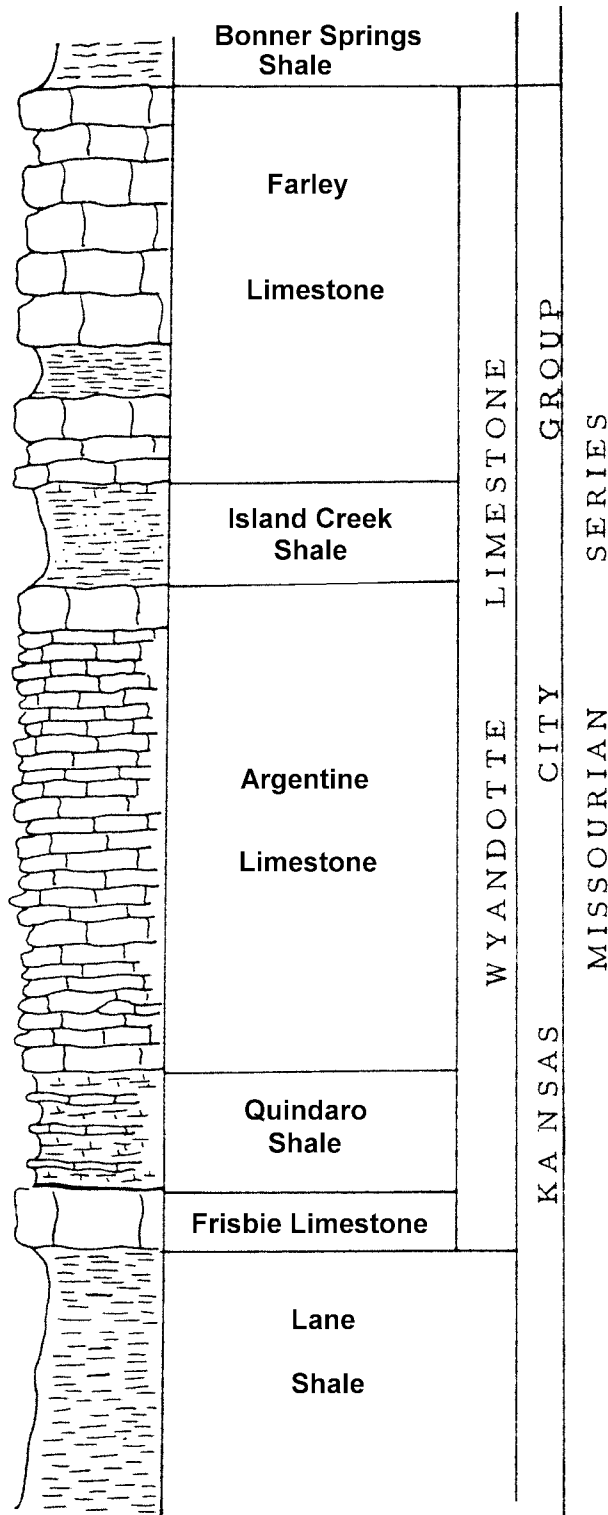


Fig. 1. Generalized columnar section of Wyandotte Limestone in the Kansas River Area

This, plus the fact that the Wyandotte is a good bench-forming unit, is the probable reason for the original miscorrelation. Northward from central Miami County the younger limestones divides into four limestone beds separated by shales. The lower two limestone beds and the separating shale were called "Iola" by Haworth and Bennett (1908, p. 98) and Hinds and Green (1915, p. 29), and were regarded as limestone beds in the Lane Shale. The "Iola" Limestone, as was applied to what now is regarded as the Frisbie-Argentine Limestone interval of the Wyandotte. The Farley Limestone is now considered as the upper member of the Wyandotte Limestone and is not a part of the Lane Shale.

Stemming from the original miscorrelation, the beds which lie between the top of the typical Iola Limestone and the Plattsburg Limestone have been assigned numerous names. A resumé of these names and the intervals for which they were defined can be found in Moore (1935, p. 118).

LOCATION OF AREA

The Wyandotte Limestone crops out widely along a northeast-southwest trend from Iowa, through northern Missouri, into Kansas. The most northern exposure of the Wyandotte in Kansas is found north of the town of Wolcott, in northern Wyandotte County. Towards the south the Wyandotte thins and finally pinches out in northern Anderson County, in the vicinity of the south branch of Pottawatomie Creek.

This study includes an area along the Kansas River from Edwardsville in Wyandotte County to DeSoto in Johnson County, and south to Glathe in central Johnson County, as shown within the shaded area (Fig. 2). The areal coverage of the investigation is approximately 125 square miles, of which only a small portion is comprised of Wyandotte Limestone.

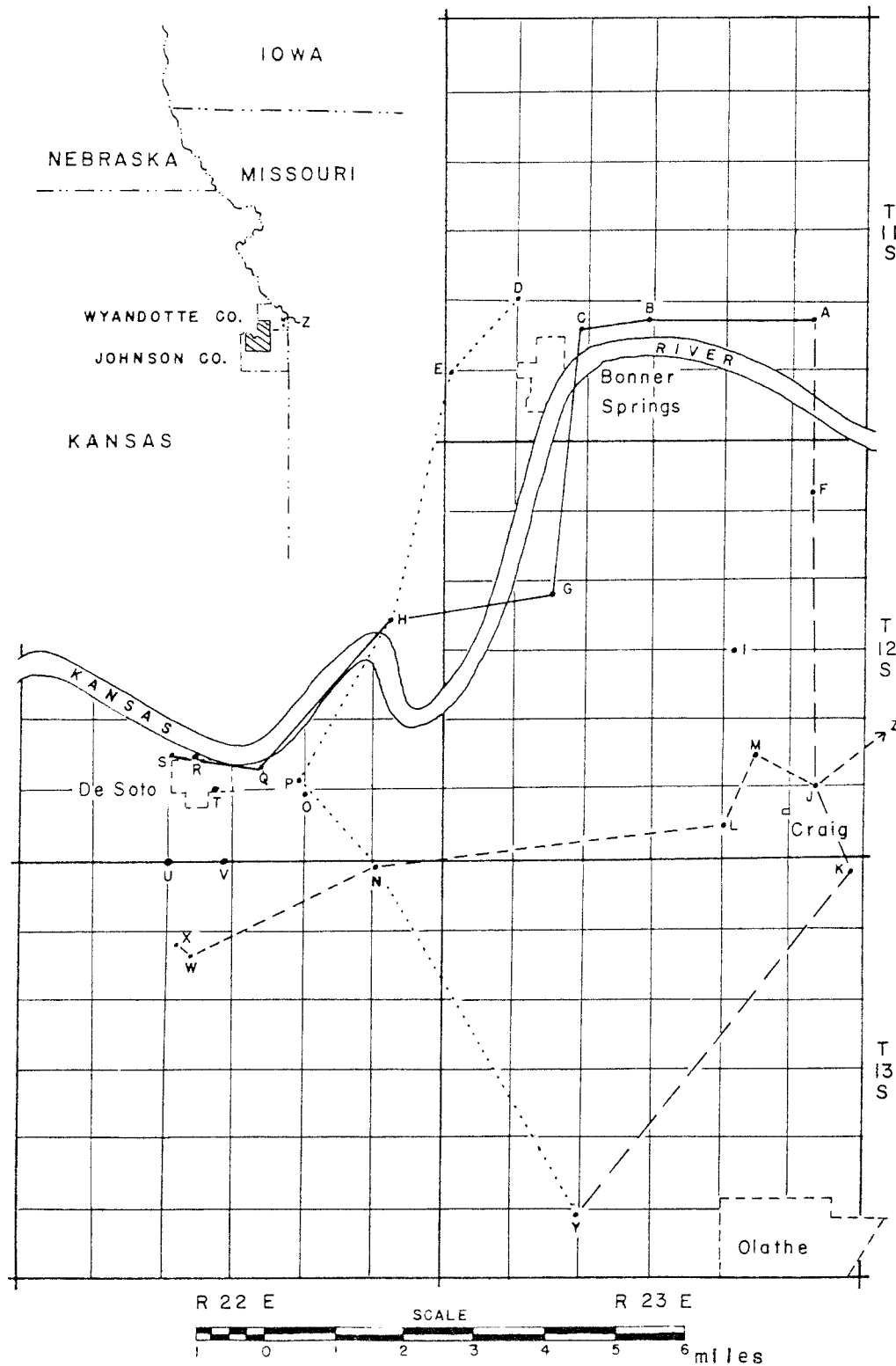


Fig. 2 Location Map

PHYSIOGRAPHIC LOCATION AND TOPOGRAPHY

The Area of investigation is located physiographically along the northern boundary of the Osage Plain in the Central Lowlands Province. A small portion of this area extends into the Dissected Till Plain which is generally located north of the Kansas River, except for a few southern extensions.

Topographically the Wyandotte Limestone is a prominent bench-forming unit. In the vicinity of Kansas City it caps the high river bluffs and forms steep scarps. Further to the west, in the DeSoto area, the Wyandotte is found near river level. The average elevation of the formation at Kansas City is 950 feet, as compared to an elevation of 795 feet at DeSoto. From these facts it is safe to assume that there is a gentle, regional, west component of dip. The scarp formed by the Wyandotte, because of the low dip, is very irregular and the outcrops of the formation extend long distances up the valleys.

With the exception of the exposures along the Kansas River, the outcrops of the Wyandotte Limestone in Leavenworth and Wyandotte Counties are partly covered by glacial deposits. Natural exposures can be found in Johnson County along north flowing streams, but they are not abundant, and usually a complete section cannot be measured because of "float" from younger beds covering portions of the exposure. The best exposures of the Wyandotte throughout the area are found in quarries and along road cuts.

ACKNOWLEDGEMENTS

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TECHNIQUES

FIELD PROCEEDURES

Graphic representations of the exposures were drawn and coordinated with the field notes. Samples were selected from each locality for future laboratory study. The hand specimens of limestone were marked for orientation in relation to the vertical and true North.

Detailed descriptions of the measured sections are contained in Appendix A. The locations of the measured sections are shown on figure 2.

LABORATORY PROCEDURES

The majority of the laboratory study was associated with the limestone samples collected during the field work.

Dry acetate peels. Acetate peels were prepared for each of the limestone hand specimens collected. Preparation of the peel blocks for this study required that a surface be cut normal to the bedding and oriented in a north-south direction to True North. The cut surface was ground smooth. The final surface by immersion in 4 percent hydrochloric acid for a period of 10 to 15 seconds, depending on the density of the limestone.

The technique used in the preparation of the acetate peels was a modification of the process described by Sternberg and Belding (1942, p. 135). The etched block was immersed in acetone for approximately one minute and then applied to the "frosted" side of 0.05mm acetate. After sufficient drying, usually 45 minutes, the acetate was carefully removed from the sample, trimmed to size, and placed between lantern slide glass for later projection.

It was found that acetate peels were very useful in detecting microlithologies, microstructures, small gastropods, and sparse fusulinids which were overlooked during megascopic examination of the sample. The acetate

peel can be used as a negative and very fine positive prints can be reproduced. Examples of this process are found in a later portion of this report.

It is the opinion of the write that acetate peels are one of the most useful tools in detailed stratigraphic description. They are easily prepared from materials readily obtained, and allow excellent photographic representation at variable magnification.

Acid etched blocks. Another technique used in the study of limestones was that of acid etching. Primarily the procedure used was that described by Lamar (1950) and Ives (1955). The blocks which were used in preparing acetate peels were re-immersed in 8 percent hydrochloric acid for approximately eight to ten minutes. After the blocks had been washed gently with water they were studied under the binocular microscope. It was found that for all practical purposes, direct observation of the acetate peel blocks, without further etching, produced as valuable information as the etched blocks.

Shale Study. The shales collected in the field were re-examined in the laboratory both megascopically and microscopically.

GENERAL STRATIGRAPHY

INTRODUCTION

The stratigraphic units of the Wyandotte Limestone are discussed in detail in this report, and general notes on the Bonner Springs Shale are presented. These are the upper two formations of the Kansas City Group of the Missourian Series.

MISSOURIAN SERIES

Rocks belonging to the Missourian Series are named for localities in northwestern Missouri and northeastern Kansas, the best exposure being located along the Missouri and Kansas Rivers in the Kansas City vicinity. These rocks are predominantly limestones which are separated by shales and form an outcrop belt from 50 to 25 miles in width. The Missouri outcrops are noticeably thicker in the south, about 800 feet near Oklahoma, and thin northward to only 260 feet in southeastern Nebraska.

The rocks of the Missourian Series are divided into four groups; in ascending order, Pleasanton, Kansas City, Lansing and Pedee.

KANSAS CITY GROUP

The type locality for rocks of the Kansas City Group is on the river bluffs of the Missouri River and its tributaries at Kansas City, Missouri. The Kansas City Group was named by Hinds (1912, p. 7) and is now defined as including all beds from the base of the Hertha Limestone to the base of the Plattsburg Limestone. Lithologically the Kansas City, in the vicinity of the type exposures, is predominately limestone, but in southeastern Kansas the units become sandy and near the Kansas-Oklahoma border there is a greater percentage of sandstone than limestone. The thickness of the Kansas City Group is greater than those of the other divisions of the Missourian Series. In southeastern Kansas its thickness is approximately 350 feet, while in southwestern Nebraska it measures about 100 feet. Topographically the Kansas City Group forms a very irregular east-facing scarp, with benches being formed by the limestone formations.

The Kansas City Group is divided into subgroups primarily upon lithologic characteristics. In ascending order these divisions are: Bronson, Linn and Zarah.

Zarah Subgroup

The type locality for the Zarah Subgroup is in the vicinity of Zarah, Kansas in north central Johnson County, Kansas. The beds included in this subgroup are those that lie between the top of the Iola Limestone and the base of the Plattsburg Limestone. The beds are divided into three formations, in ascending order; Lane Shale, Wyandotte Limestone and Bonner Springs Shale. This interval is mostly limestone in the Kansas City area and has an average thickness of approximately 100 feet. Further to the south, in northern Anderson County, the Wyandotte formation disappears, and the Zarah Subgroup is predominately a shale, designated as the Lane-Bonner Springs shale. Moore (1949, p. 107) states that this shale interval can be traced nearly to Oklahoma, and is equivalent in Oklahoma to the lower Ochelata beds.

Lane Shale

The type locality of the Lane Shale is above flood plain level of Pottawatomie Creek in S½, Sec. 23, T. 18 S., R. 21 E., (Moore, 1935, p. 117). The Lane was named by Haworth (1895, p. 277) for beds between the Iola Limestone and the Wyandotte Limestone. Northeastward from Lane the boundaries of the shale are easily defined, but to the south where the Wyandotte is absent and the interval is termed Lane-Bonner Springs, the upper contact is difficult to detect. The lithologic character of the Lane Shale is variable not only in composition, but also in color. Moore (1949, p. 108) points out that where the Lane is thin, it is dark bluish gray shale which contains fairly common marine invertebrates, and in the thicker sections it is sandy and micaceous with colors which range from light gray to yellowish brown. The thickness of the Lane Shale

is also quite variable, ranging from an average of about 25 feet in the Kansas City area to approximately 100 feet in the vicinity of the type locality.

Wyandotte Limestone

The type locality for the Wyandotte Limestone is in southern Wyandotte County, along the Kansas River, where very good exposures appear east of Bonner Springs in the quarries of the Lone Star Cement Company. The Wyandotte Limestone, as defined by Newell (in Moore, 1932, p. 92; 1935, p. 59), was the name given to the limestone beds which lie between the Lola Limestone and the Plattsburg Limestone, and separate the Lane Shale from the Bonner Springs Shale. Lithologically the Wyandotte is mostly light colored limestone, but contains two and sometimes three shales. These smaller divisions will be discussed later. The average thickness of the Wyandotte in the Kansas City area is approximately 50 feet, but locally it may attain a thickness of over 60 feet. Further to the south, in Miami and Franklin Counties, the Wyandotte thins to about 20 feet, and in northern Anderson County the southernmost exposure is found to be only two to three feet thick. Exposures of the Wyandotte have been recorded in southwestern Iowa and southeastern Nebraska (Moore, 1935, p. 120).

The Wyandotte is divided into the following five members in ascending order; Frisbie Limestone, Quindaro Shale, Argentine Limestone, Island Creek Shale and the Farley Limestone. (Fig. 1). With the exception of the Farley Limestone, Newell (in Moore, 1932, p. 92; 1935, p. 59-60) is accredited for naming the members of the Wyandotte Limestone.

Frisbie Limestone member. The type locality for the Frisbie Limestone is near the village of Frisbie in northern Johnson County, Kansas. The Frisbie is typically exposed in a road cut at center east side of NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 17, T. 12 S., R. 23 E., and is characteristically a dark to medium bluish gray, hard, dense, massive limestone which ranges in thickness from 1.5 feet to 5 feet. There

appears to be a general thickening of the Frisbie towards the south, but locally the bed may thin, as is the case in the spillway at Olathe Lake. Fossils are scarce in the Frisbie, but brachiopods, crinoid stems and algae have been found. There are abundant calcite “veinlets” and cavity fillings which appear to be of organic origin (Moore, 1949, p. 109).

Quindaro Shale member. The Quindaro Shale was named after a political township in northeastern Wyandotte County, but it is more typically exposed in the Kansas River valley near Edwardsville; SW $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 25, T. 11 S., R. 23 E. The Quindaro is one of the most variable members of the Wyandotte. In most exposures it is yellowish, calcareous, and alternates with thin, hard irregular limestone stringers. Locally the Quindaro becomes an impure limestone and the contact with the Argentine is difficult to determine. This unit also ranges a great deal in thickness; from 0.3 feet in the spillway at Olathe Lake in Johnson County to over six feet near Edwardsville. The average thickness for the Quindaro is about four feet. Fossils are relatively scarce, but brachiopods, bryozoans, crinoid stems and shell fragments occur locally, and usually in the limestone structures.

Argentine Limestone member. The type locality for the Argentine Limestone is in the Argentine District of Kansas City, Kansas. Typical exposures are found in abandoned quarries above Twenty-sixth Street and Metropolitan Avenue, and in road cuts along the Eighteenth Street Expressway. The exposures of the Argentine in the abandoned quarries have become overgrown by vegetation, and accessibility to the quarries is limited. Therefore the writer proposes that the exposure located on the Expressway 0.25 miles north of the Steele Road exit be considered as an alternate type section for the Argentine. The Argentine is typically light to medium gray, hard, dense, fine grained, thin, unevenly bedded, with calcite “veinlets” and cavity fillings. The calcite “veinlets” are questionably organically formed. Scattered chert nodules appear locally and are not confined to any particular horizon.

The thickness of the Argentine averages about 25 feet, but may range from 18 feet to over 35 feet. Towards the south this member thins and, like other units of the Wyandotte, disappears south of Lane, Kansas.

Fossils are usually abundant with *Compsita* and other brachiopods, fenestrate bryozoans, and large crinoid stems comprising the majority of the fauna. Rare fusulinids, trilobites, and small gastropods have occasionally been found. Algal material appears locally and in most cases is *Osagia* or other encrusting type algae.

Island Creek Shale member. The type locality for the Island Creek Shale is on Island Creek in northern Wyandotte County, and is typically exposed in a quarry located in the northwest corner of Sec. 11, T. 10 S., R. 23 E. These beds are characteristically medium gray to greenish-gray, silty, and slightly micaceous. Locally the member may be mostly sand, or in some cases a pure shale. Also appearing locally is a highly detrital, fossiliferous zone that does not maintain the same stratigraphic position from one locality to the next.

The thickness of the Island Creek ranges from one foot to about 16 feet in the area of study, but this unit has been reported to be as thick as 43 feet at the type locality. Like other members of the Wyandotte, the Island Creek thins to the south and pinches out in Franklin County.

Farley Limestone member. The Farley Limestone was named by Hinds and Green (1915, p. 29) for beds exposed near the town of Farley, Platte County, Missouri. Later, Moore (1932, p. 92) and Newell (1935, p. 60) recognized beds in the Kansas City area that were lithologically similar to those described by Hinds and Green, and therefore were called Farley. The Farley is quite variable throughout its outcrop; ranging from massive, oolitic, cross-bedded units to thick sequences of medium, uneven beds. The Limestone beds of the Farley are usually separated by a greenish-gray, silty shale. Moore (1935, p. 123) remarks that this variability of the Farley could classify it as a “super” limestone in reference to cyclic sedimentation. The thickness of the Farley is

also quite variable, ranging from about 13 feet (Moore, 1935, p. 123) near the type locality, to an average of 25 feet, and locally to 33 feet, in Johnson County. Southeast of Johnson County the Farley thins and pinches out in the vicinity of Lane, Kansas.

The fauna found in the Farley is not much different from that found in other limestone members of the Wyandotte; *Composita*, *Myalina*, *Dictyoclostus*, few *Echinoeonchus*, crinoid stems, shell fragments and locally large cephalopods.

Bonner Springs Shale

The type locality for the Bonner Springs Shale is at the Lone Star Cement Company quarry 1.0 mile east of Bonner Springs, Kansas on Kansas Highway 32. This unit, as named by Newell (in Moore, 1932, p. 92), was defined to include beds which lie between the top of the Wyandotte Limestone and the base of the Plattsburg Limestone. The Bonner Springs is characteristically a greenish-gray, silty to sandy, micaceous shale which contains plant remains. Near the upper contact is a maroon, nodular shale which is normally overlain by a yellowish "punky", nodular limestone. This limestone may be totally absent, but if not present commonly is replaced by a yellow calcareous shale.

The thickness of the Bonner Springs ranges from about 32 feet to less than 0.5 foot, this variation probably being due to erosion or non-deposition. Locally, either within the Bonner Springs or overlying it, a cross-bedded shell breccia is found. For convenience, this cross-bedded material is considered as part of the Plattsburg Limestone, thus maintaining the definition of the Bonner Springs as basically a shale.

The faunal remains found in the Bonner Springs are rather scarce, but locally *Trepostira* has been found near the maroon zone in the upper portion. Where the Bonner Springs is typically exposed, abundant plant remains are found along the bedding planes.

DETAILED STRATIGRAPHY

INTRODUCTION

The detailed stratigraphy of the Wyandotte Limestone within the area covered by this report will be considered in three geographic localities. These localities are Bonner Springs, Craig and DeSoto, Kansas. The Lithologic characteristics of the Wyandotte are typically expressed in the beds found in the Bonner Springs Area, therefore a detailed discussion will be presented for each of the members in that area. In the Craig and DeSoto areas, since the basic lithologies are the same, only the variations in lithologies, thickness, faunal remains and special features will be considered.

BONNER SPRINGS AREA

The area extends from Edwardsville (Locality A) south to Holliday Quarry (Locality F), and west to Loring Quarry (Locality H). (see Fig. 2)

Wyandotte Limestone

The Wyandotte Limestone is totally exposed in only a few places in the Bonner Springs area, but a complete section can be formed from a composite study of several exposures. The Wyandotte is quite similar to those beds described in the preceding section and has an average thickness of approximately 60 feet. Detailed description of the individual members follows, the members discussed in ascending order.

Frisbie Limestone member. The Frisbie Limestone is one of the most persistent members of the Wyandotte. It is typically dark to medium gray, hard,

massive, fine grained, and contains calcite “veinlets” and filled cavities. It has been suggested that the calcite “veinlets” are of organic origin, which is indeed possible. It is also possible to associate these “veinlets” with fractures which would suggest that they are of secondary origin.

The thickness of the Frisbie is quite regular and averages approximately 1.5 feet. At Locality F, on the southern-most edge of the area, the thickness becomes 3.0 feet. This thickening to the south has been noticed in other exposures and will be discussed in relation to the Craig Area. The lower contact of the Frisbie is straight and regular, whereas the upper contact is uneven and wavy.

The faunal characteristics of the Frisbie are not distinctive, and the fossils are not particularly abundant. The fossils that do occur are in most cases no different than those found in other Wyandotte members. The most easily recognized brachiopod is *Composita subtilita*, but other brachiopods shell fragments cannot be identified. Another distinctive feature is an “Ottonosia-like” algae, which can be recognized in most exposures. Other forms recognized are crinoid stems, fenestrate bryozoans, sparse horn corals and small high-spired gastropods.

A very atypical exposure of the Frisbie is found in an abandoned quarry east of Loring Quarry (Locality H). The Frisbie here is composed of two limestones separated by a thin shale. The lower limestone is characteristically Frisbie, but the upper limestone bed is coarse grained, poorly sorted, and contains abundant crinoid remains.

Quindaro Shale member. The Quindaro Shale is ordinarily considered quite variable, and this is no less true in the Bonner Springs Area. The Quindaro is composed of alternating beds of limestone and shale, of which the limestone appears to be the most persistent beds. Locally, a thin, black, fissile shale appears next to the lower contact.

The shales are characteristically yellowish-brown to greenish-gray, silty, calcareous, and non-fossiliferous. Some of these shales contain limestone

“plates”, while others have high carbonate content and are almost poorly consolidated, “punkky” limestones. The limestones are medium to bluish-gray, hard, dense, fine grained, thin, irregularly bedded, and contain calcite veinlets and filled cavities. Some of these beds are “mottled”, while others contain an abundance of small shell fragments.

The average thickness of the Quindaro Shale in this area is approximately 6.6 feet. The thickness of the individual limestone and shale beds average about 0.3 feet, but some of the shale beds thicken to over 1.0 feet.

Argentine Limestone member. The Argentine Limestone is probably the most prominent and persistent member of the Wyandotte, and its overall characteristics do not change to any appreciable extent throughout the area. Typically the Argentine is light gray to brownish-gray on the weathered surface, but ranges from tan to medium gray when a fresh surface is observed. Other characteristics of the unit are; hard, dense, fine grained, medium to thin, irregular to wavy bedded, and containing calcite veinlets and filled cavities. Chert nodules are randomly located in the Argentine and are not confined to a particular horizon, although in a single exposure they may appear to be zoned.

At most localities it is possible to observe an upper, massive, coarse grained bed that is usually quite persistent. This bed ranges in texture from a “pseudo-breccia” to an oolitic “osagite”, and in some places has an upper zone of shell fragments encrusted with algae. Locally, this unit contains a zone of clam shells replaced with calcite.

The average thickness of the Argentine is approximately 25.0 feet, but locally it may range from 12 to 35 feet. Because of this member’s great thickness it is considered economically important, and has been quarried extensively.

Considering that the Argentine is such a thick unit, it is not overly populated with fossils. Except for a few scattered zones of fossil-mortar material, faunal remains are only sparsely associated. The characteristic fossils of the Argentine are; *Composita*, *Dictyoclestus*, *Echinoconchus*, rare *Neospirifer*, large

crinoid stems, *fenestrate bryozoans*, clam shells (*Myalina*), and shell fragments. Rarely observed are horn coral, small high-spired gastropods and fusulinids.

Island Creek Shale member. The Island Creek Shale is a rather persistent member of the Wyandotte in the Bonner Springs Area. Characteristically this shale is greenish-gray to medium gray, laminated, slightly silty, finely micaceous, locally calcareous. Near the upper contact a thin detrital zone is found.

The thickness of the Island Creek ranges from 15 feet in the northern portion of the area (Locality A) to about 1.5 feet at Loring Quarry (Locality H). This thinning has also been observed in exposures further to the south and is considered indicative of a regional thinning towards the southwest. Another unusual thickness change can be seen at Locality C, 0.3 miles east of Bonner Springs, along the face of the quarry. At this location the Island Creek at the north end of the quarry measures 6.3 feet, while at the south end of the quarry, a distance of approximately 200 yards, it measures 3.5 feet. This exposure is a good example of how rapidly thickness can change.

Fossils are not noticeably abundant in the Island Creek except for a locally appearing detrital zone near the lower contact. This zone contains a great profusion of fauna remains. Fossil remains extracted from this zone are; *Derbyia*, *Dictyoclostus*, *Neospirifer*, *Lingula*, *Aviculopecten*, *Aviculopinna*, *Myalina*, rare *Pleurophorous*, *Pharkidonotus*, *Bellerophon*, crinoid stems and plates, and fenestrate bryozoans. In the other portions of the Island Creek, small fragments of plants have been observed, as well as rare *Lingula*. Locally appearing along the upper contact is a 0.3 foot detrital zone that contains *Punctospirifer*, *Lingula*, crinoid stems, fenestrate bryozoans and shell fragments.

Farley Limestone member. The Farley Limestone is another prominent limestone much like the Argentine. This unit is composed of two limestone units separated by shale. The discussion of the lithologic and faunal characteristics of the Farley will be divided so as to cover each of the minor units.

The lower limestone is quite variable in its lithologic characteristics. Essentially those beds are medium gray to tan on the fresh surface, hard, dense, fine grained, massive to medium unevenly bedded, and contains calcite veinlets and filled cavities. Locally these units might be considered as oolitic "osagites". The fauna observed in these beds are *Composita*, fenestrate bryozoans, crinoid stems, shell fragments, sparse gastropods and fusulinids.

Actually the shale which separates the two limestone units is an alternating series of thin limestones and shales. An exception to this situation is found at Holliday Quarry (Locality F) where there is no separating shale. The limestones are medium to bluish gray, hard, dense, fine grained, thin, uneven to wavy bedded, and contain *Composita*, sparse *Echinoconchus*, and *Myalina* fenestrate bryozoans, shell fragments, and sparse fusulinids. The shales are yellowish-brown to greenish-gray, nodular, silty, calcareous. The Fauna represented in the shales are usually scarce: *Dictyoclostus*, crinoid stems, shell fragments, and locally abundant *Composita* (Locations C & G).

The upper limestone beds are definitely the most prominent of the Farley. These beds are brownish to medium gray, hard, dense, fine grained, massive to medium bedded, with irregular bedding planes. The variation in color, grain size, and bedding is not only noticed from one exposure to the next, but is also recognized in a single exposure. Some beds exhibit a dense fine grained aphanitic texture, while others appear to be oolitic or pseudo-algal. It is interesting to note that wherever the coarser grained rocks are observed, they are either near the base or near the top of the unit, and apparently do not contain abundant calcite veinlets. The faunal content does not appear to be any different than those of other units of the Farley; *Composita*, *Myalina*, *Osagia*, fenestrate bryozoans, locally abundant crinoid stems, and shell fragments. The Farley ranges in thickness from 20 to 25 feet. The lower and upper limestone units maintain a fairly constant thickness of about 3.5 and 15.0 feet respectively, while the middle shale unit ranges from 2.5 to 7.0 feet.

Bonner Springs Shale

The Bonner Springs Shale is typically exposed in this area, but at the same time it is also quite atypically exposed. Typically the Bonner Springs is a greenish-gray to tan, platy, silty to sandy, finely micaceous, contains plant remains and has a thickness of about 30 feet. A maroon shale zone is located near the upper contact and locally this zone is overlain by a “punkky” limestone. At Loring Quarry and also at Locality E, 1.5 miles west of the town of Bonner Springs, the shale is atypically exposed in that it thins to less than a foot. The shale at these localities is gray to greenish-gray, silty, calcareous and has shell remains of *Aviculopecten*. The thinning is probably due to erosion or non-deposition over a structural high, or may be caused by a local thinning of the limestone in this area (Jewett and Newell, 1935, p. 180). A similar thinning is recognized at Holliday Quarry (Locality F) and is considered as being caused by a structural high that is evidenced in this area.

CRAIG AREA

The village of Craig, Kansas is located in north central Johnson County along the southern route of the Santa Fe Railroad, and is situated almost in the center of the area under discussion. Localities J, K, L and M (Fig. 2) are the principle sections, and will be referred to through this discussion.

Wyandotte Limestone

The Wyandotte Limestone is nicely exposed in this area along road and railroad cuts, and portions of the formation have been uncovered during quarrying operations. The average thickness of the Wyandotte is approximately 55 feet, but locally the thickness may range from 43 to 68 feet. Except for local variations in lithology, these beds are quite similar to those exposed in the Bonner Springs Area.

Frisbie Limestone member. The Frisbie is typically exposed in the Craig Area, and as mentioned in the Bonner Springs discussion, suggests a definite thickness increase southwards. The Frisbie is massive and has an average thickness of 4.5 feet, but locally may attain a thickness of 5.0 feet. Lithologically there is essentially no difference between the Frisbie units exposed here and those exposed further to the north. Along Coon Creek in the center of section 34, T. 12 S., R. 23 E. (Locality L) the Frisbie becomes divided near the top by a thin 0.5 foot, sequence of shale and interbedded limestone plates which does not persist laterally along the outcrop. The lower portion of the Frisbie is characteristically massive, but the upper portion, 0.7 foot, is coarse grained, pseudo-oolitic, and algal.

In a railroad cut approximately one mile southeast of Craig (Locality K) some very unusual structures are developed on top of the Frisbie. These structures are "Lime-buildups" that appear locally along the outcrop causing the Frisbie to be down-warped. The overlying Quindaro Shale is affected in that

some of the lower beds pinch out or thin over the top of these structures, and the upper beds have been bowed downward. Normally lying on top of the Frisbie at this location is a black shale marker bed. This bed can be traced with ease and is found to thin over the tops of the structures, suggesting that they had developed prior to the black shale deposition. The origin of the “buildups” has not been determined, but from their pseudo-brecciated appearance they are assumed to be a depositional feature. This is the only exposure where this anomalous condition has been observed.

Quindaro Shale member. The beds which comprise the Quindaro Shale interval do not deviate greatly from those described in the Bonner Springs Area. Locally a dark gray to black shale is found in contact with the underlying Frisbie, but normally the entire sequence is composed of alternating thin limestones and yellowish-brown, calcareous shales. In the railroad cut south of Craig the middle limestone varies in thickness along the exposure, ranging from 0.6 to 2.3 feet. The thickness of the Quindaro maintains a fairly consistent average thickness of 3.5 feet, but 0.5 miles northeast of Craig along a road cut (Locality J), this interval is found to thin considerably over a very short distance.

The fauna of the Quindaro is not abundant and basically is the same as that reported in the Bonner Springs Area.

Argentine Limestone member. The Argentine Limestone is typically exposed in this area, and with the exception of minor thickness differences, the only noticeable variation is concerned with the nature of the upper massive beds.

The average thickness of the Argentine is 20 feet, but it may range from 15 to 25 feet. There appears to be no trend to the thickness variations and the writer considers them to be of only local consequence, perhaps due to surface irregularities in the depositional area. Considering the average thickness differences between the Bonner Springs and Craig Areas, there does appear to be a slight thinning of the Argentine southward.

The upper massive beds of the Argentine northeast of Craig and in the railroad cut further south, are typically coarse grained, oolitic "osagites". At Locality J, a molluscan zone is associated with this massive bed similar to that which was recorded at the Holliday Quarry (Locality F). Along the Western margin of the area these beds become fragmental or crinoidal and contain a small percentage of algal material. Underlying the massive upper unit along the road cut in the center of section 26, T. 12 S., R. 23 E. is a bed that is composed of abundant shell fragments set in an aphanitic matrix. The fragments stand out in relief on the weathered surface and presents a very rough appearance to the rock.

Island Creek Shale. Except for a noticeable thickness difference, the Island Creek Shale is similar to that described at Bonner Springs. The average thickness of the Island Creek is about 5 feet. Along the eastern margin of the area this interval is noticeably greater than that recorded along the western edge. This evidence, supported by that observed at Bonner Springs, strengthens the assumption of a thinning trend towards the southwest.

The fossil fragmental zone that has been recorded for this unit elsewhere is found only at the railroad cut south of Craig, and is not as abundantly fossiliferous as described earlier. Fenestrate bryozoans, crinoid stems, unidentified brachiopods, shell fragments, and sparse trilobites have been collected from this zone. At other exposures in this area the faunal content is much the same as observed in the Bonner Springs Area.

Farley Limestone member. With the exception of the Farley Limestone exposure in the railroad cut south of Craig (Locality K) this sequence of beds has close affinities to those described in the Bonner Springs Area. The thickness of the Farley ranges from 24 to 37 feet and has an average of approximately 28 feet.

The only complete exposure of the Farley are at Localities J & K. Along the road cut northeast of Craig (Locality J) the Farley is characteristically

massive at the base and top with the central portion being composed of alternating limestone and calcareous shales. The limestone-shale sequence is somewhat thicker than normal, but this abnormality is compensated by a thinner upper unit.

The Farley at Locality K differs greatly from any of the other exposures in the area. The lower massive beds have a total of 9.5 feet as opposed to a normal thickness of 3.5 feet. The limestone-shale sequence is replaced by a "punky" limestone separated from the upper and lower limestone units by brownish-green calcareous shale. The upper massive units are coarse grained, pseudo-oolitic, algal and show small scale cross-bedding on the weathered surface. The lowest bed of the upper unit is arenaceous and weathers with a peculiar arrangement of unoriented holes. The upper surface of the Farley is very irregular and a maximum relief of 2.0 feet has been exposed.

Bonner Springs Shale

Complete exposures of the Bonner Springs Shale are difficult to locate in the Craig Area, but from information gathered at numerous locations it appears that the formation in this area is similar to the type section. The maroon zone is characteristically located near the upper contact and is overlain locally by a thin "punky" limestone. The thickness of the Bonner Springs averages 20.0 feet in this area, which is about 10.0 feet less than further to the north.

The Bonner Springs is not completely exposed along the railroad cut south of Craig, but in the lower portion two limestone conglomerates are developed. The upper conglomerate maintains essentially the same stratigraphic horizon while the lower conglomerate descends through the section and intersects the upper surface of the Farley. This conglomerate can be traced laterally for several feet before it pinches out.

DE SOTO AREA

De Soto is located in the northwestern corner of Johnson County along the Kansas River and approximately marks the westernmost surface exposure of the Wyandotte Limestone in the Kansas River valley. Several exposures were studied in the area (Fig. 2) in an attempt to clarify the local stratigraphy.

Wyandotte Limestone

Because of a regional west dip and local structure, complete exposures of the Wyandotte Limestone are seldom obtained. The Argentine member and younger beds, in most cases, are the only beds exposed in quarries, road cuts and streams. Therefore the discussion will be principally confined to these units. The thickest section exposed measures 58.0 feet and does not include the Quindaro Shale and the Frisbie Limestone. This would indicate that the Wyandotte could have an average thickness of over 60.0 feet.

Frisbie Limestone member. The Frisbie Limestone is exposed at only one locality in this area, that being in a ditch located at SE $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 1, T. 13 S., R. 22 E. At this location the Frisbie is lithologically similar to that which has been described in the Bonner Springs Area, but there has been a noticeable increase in thickness over the short distance. The Frisbie at this exposure is 3.0 feet thick while approximately 3.0 miles to the northeast, at Loring Quarry, it measures 1.5 feet.

Quindaro Shale member. There is no known exposure of Quindaro shale in the De Soto Area.

Argentine Limestone member. Good exposures of the Argentine Limestone are restricted to quarries in the De Soto vicinity. Detailed study of the

rocks show that they do not deviate greatly from the original description of Argentine beds in the Bonner Springs Area. The upper massive bed, which is typically exposed at Sunflower Quarry (Locality W) has abundant crinoid and shell fragments, some of which have been encrusted by algae. This same bed at the Perry Jones Quarry (NW corner, Sec. 1, T. 13 S., R. 22 E.) and the auxiliary quarry north of the main Sunflower Quarry has a pseudo-brecciated appearance rather than being coarse grained. The thickness of the Argentine averages 30.0 feet, but this figure is an estimate since the base has not been uncovered.

Island Creek Shale. In the De Soto vicinity the Island Creek is very thin, averaging approximately 1.0 feet. The unit is essentially dark gray to greenish-gray, silty, and slightly micaceous. At the Perry Jones Quarry, the lower 0.2 foot of this bed is a detrital zone of fossil fragments. (Locality N).

Farley Limestone member. The erratic variations illustrated by the Farley in the area surrounding De Soto are of great interest. Because of the variation detailed descriptions will be presented for several localities.

An interesting facies relationship occurs in an abandoned quarry in the northwest corner of De Soto. Typical Farley comprises the beds in the lower portion of the quarry, while the upper beds belong to the Plattsburg Limestone. The basal 15.0 feet of the rock is characteristically Farley-type lithology, but the upper 2.0 feet becomes a coarse grained, cross-bedded, oolitic "osagite" which when traced along the quarry face is replaced stratigraphically by fine grained, pseudo-breccia or mottled zone. The only other location in the De Soto area, to the writer's knowledge, where such as oolitic bed appears at the top of the Farley, is at Penner's Ford (Locality V) 1.0 mile south of the De Soto. In the past there has been confusion as to where the cross-bedded material belongs, but from evidence observed at this locality, plus the Holliday Quarry (Locality F) and a locality south of Craig in the railroad cut (Locality K) it is apparent that these beds belong at the top of the Farley.

The section of rocks exposed in the Sunflower Quarries (Localities W & X; NW corner Sec. 9, T. 18 S., R. 22 E.) affords another opportunity to observe a local facies change. In the main quarry the Farley is 25.3 feet thick and is composed of two limestone units separated by 3.0 feet of shale. Less than a quarter of a mile to the northwest, in an abandoned auxiliary quarry (Locality X), the Farley thickness totals 35.0 feet and displays no apparent shale breaks, however near the middle of the sequence the limestone beds are separated by thin zones of fossiliferous, calcareous shales and mudstones. It is assumed that the middle shale bed in the main quarry has undergone a facies change to the northwest and is now represented by the thin shale and mudstone partings observed at Locality X.

One of the most interesting sections of the Farley Limestone exposed in this area is that which is located at Kill Creek Bridge on Kansas Highway 10, east of De Soto (Locality Q). Along the east bank of Kill Creek the Farley is partially exposed. The top is covered by debris while the base is below stream level. Near the base of the exposure lies a massive, medium grained, fossiliferous bed which has a very irregular upper surface. Overlying the surface is a thin, 0 to 0.5 foot, limestone bed that contains abundant *Composita*. The thickness of the upper bed varies in that it is thin or absent over "highs", but fills in the areas between. The units above and below this feature are considered typical Farley Limestone, therefore the irregular surface has been classified as an intraformational unconformity of minor temporal value.

Approximately 0.7 miles west of the Kill Creek section is another Farley exposure along the north bank of the Kill Creek (Locality T). At this location the small unconformity described previously is recognized, but even more outstanding is the unusual 14 degrees of dip expressed by the lower beds. It is also noticed that the dip decreases upward until near the top of the exposure the beds are nearly horizontal. From the evidence observed, this feature might be assumed to be a minor flexure or simply caused by deposition in a small local basin.

The faunal content of the Farley, as a whole, is no different than described earlier, but locally in this area cephalopod remains occur. Although cephalopods occur in other members of the Wyandotte Limestone, they do not attain the abundance found in the Farley. It was with the aid of these remains that the beds overlying the unconformity were considered Farley.

Bonner Springs Shale

the Bonner Springs Shale is another variable formation in the De Soto Area. The thickness of this unit ranges from 40.0 feet at the northeast corner of the Sunflower Ordnance Works (Locality U) to 1.2 feet in the northwest corner of De Soto. Lithologically there are variations in the Bonner Springs that range from a typical exposure at the Sunflower Quarry (Locality W) to one that contains lenses of siltstone (Locality P) or cross-bedded shell-breccia (Locality U). Along the railroad tracks on the north side of De Soto, the Bonner Springs is greenish-gray to brown, silty, micaceous, slightly calcareous, and has an average thickness of 1.3 feet. In exposures where the formation is closely similar to the type section the "maroon" zone in present (Locality W) and is overlain locally by a "punky" limestone. There occur in the Bonner Springs, lenses of microcross-bedded, siltstone (Localities O & P) which do not persist laterally for any distance. It should be pointed out that in other sections, although siltstone beds are not developed, the formation is much more silty than normal, and contains abundant plant remains.

In the northeast corner of the Sunflower Ordnance Works (Locality U) there occurs a local development of cross-bedded shell breccia. This bed is situated 16 feet below the Plattsburg Limestone and approximately 17 feet above probable Farley Limestone that is found in the creek bed. It is the writer's belief that because of the stratigraphic relationships of the cross-bedded breccia it is best to consider it as a localized lens developed in the Bonner Springs Shale and having very limited lateral persistence. Another possibility in considering these beds is to maintain the definition of the Bonner Springs as strictly a shale,

for convenience, and to place the cross-bedded material in one of the limestone formations, preferable Wyandotte.

The cross-bedded material can be traced eastward to Penner's Ford where it has associated with shell fragments, some plant remains and coral fragments. This bed is found to be above the Farley, as based on cephalopod remains, and approximately in the same stratigraphic horizon as the cross-bedded shell breccia described at the previous locality.

Also at Penner's Ford another shell breccia bed that includes limonite pebbles appears. This bed lies in the same stratigraphic location as does the cross-bedded material west of Bonner Springs (Locality E), and therefore is considered as part of the Merriam Limestone member of the Plattsburg Limestone. This bed can be traced northeastward and is last encountered at Locality O (NW $\frac{1}{4}$, Sec. 35, T. 12 S., R. 22 E.) where it lies beneath the Merriam Limestone and above the "punky" limestone zone in the upper Bonner Springs.

The fauna of the Bonner Springs is essentially the same as that described in the vicinity of the type section, but there is an increase in plant remains. Approximately 5.0 feet below the upper contact there is locally a zone that includes abundant *Trepostira*.

ENVIRONMENTS OF DEPOSITION

INTRODUCTION

When considering the environments under which the various members of the Wyandotte Limestone were deposited, it is necessary to observe the Wyandotte and its relationship with subjacent and superjacent units. Underlying the Wyandotte Limestone is a very thick sequence of beds which are predominately shale, while overlying the Wyandotte is a second, normally thick, sequence of shale. These beds are the Lane and Bonner Springs Shale formations, respectively. Both of these shale sequences are considered to be deltaic or very shallow marine. The Wyandotte thins to the south and eventually pinches out in northern Anderson County. It is evident that south of the "pinch out" area the conditions and supply were conducive for shale deposition, while to the north conditions were favorable for predominately carbonate deposition. Parkhurst, R.W. (personal communication), in his subsurface work with the Kansas City - Lansing Groups, has constructed three east-west cross sections through northeastern Kansas and has found that the Wyandotte is presumably restricted to the Forest City Basin. These beds might be considered to represent a major transgression of the sea which then had minor fluctuations or, as is more likely the case, changes in the rate of supply by streams, resulting in the fluctuations in the abundance of lime secreting animals or conditions conducive to inorganic carbonate precipitation. The length of time required for deposition of the Wyandotte Limestone, and discussion of the Lane-Bonner Springs interval south of the pinch out area is beyond the scope of this report.

DETAILED DESCRIPTION OF ENVIRONMENTS

The Frisbie Limestone represents the initial deposition of carbonate material in the area of study, and from observation of the lower contact it can justifiably be assumed that deposition was upon a nearly planar surface. The thickness variations noted under detailed stratigraphy are gradual and are perhaps indicative of a greatly undulating surface that resulted in thickening towards the southwest. The Frisbie is persistent in lithology, and notably has an aphanitic texture. Upon microscopic examination this unit shows numerous shell fragments of which a few have been encrusted by algae. "Ottonosia-like" algae are also characteristic of this unit and are dispersed throughout. Lane (1954) has indicated, from his study of the Grenola Formation in southern Kansas, that calcareous algae are an indication of shallow (less than 60 feet deep), clear, moderately quite water, while Hattin (1957) has pointed out that hypersaline conditions are conducive to algae development. Other than the algae, *Composita* occurs most frequently, but even it was not abundant. The reason for this lack of other fauna is a matter of conjecture, but possibly depth and salinity were factors.

From the above evidence it appears logical that essentially similar conditions existed throughout the area during deposition of the Frisbie, and that these conditions were such that abundant lime secreting animals were active. The water was shallow, clear, above normal salinity, and moderately quiet. The fact that shell fragments are abundant indicates that currents were active and were able to disperse the fragments throughout the area from the point of initial breakage.

The upper surface of the Frisbie Limestone is characteristically irregular possibly because of increased wave action, or a minor regressive factor is favored, for locally overlying this unit is a thin, 0.3 to 0.5 foot, black fissile shale, indicating local restriction of the seas. Moore (1929, p. 469) states that conditions for black shale accumulation might develop as a result of restricted circulation due to abundant plant matter. This plant life, perhaps sea weed,

developed as a result of shallowing of the water thereby allowing greater light penetration. The black color is due to finely divided iron sulfide and partly decomposed plant material. Where these local restrictions were not in effect the circulation was more open and normal greenish-gray shale was deposited. Such are the conditions that existed during deposition of the lower Quindaro Shale.

Typically the Quindaro, above the thin black shale zone, is a series of irregular limestones alternating with silty calcareous shales and shaley limestones. The yellowish calcareous shales are almost devoid of fossils, while the thin aphanitic limestones contain shell fragments, sparse echinoid spines, and a species of small sponge. Moore (1929, p. 468) associates sponges and echinoids with an environment of shallow, clear, open, warm water,

It would appear that, following the initial shale deposition, the sea remained fairly shallow and clear, allowing the deposition of the thin limestones. Wave and current action were probably effective during periods of carbonate deposition as is evidenced by the irregularity of these beds and the abundance of shell fragments. The deposition of carbonate material apparently was interrupted from time to time by the influx of fine clastics, with the result that calcareous shales or shaley limestone were deposited. The high mud content during these periods would explain the absence of marine fossils.

It is difficult to determine when the conditions described above ceased and the environment was again conducive for predominately carbonate deposition. Locally, the contact between the Quindaro Shale and the Argentine Limestone is one of gradation. It is believed by the writer that this transition zone is indicative of a decrease in the fine clastic content of the basin or suggests a transgression of the seas.

The Argentine, for the most part, is aphanitic in texture, but contains abundant small shell fragments. The fauna represented in the unit is rather sparse, with brachiopods, large crinoid stems, and fenestrate bryozoans being most commonly found. This fauna is characteristic of shallow, clear, warm, agitated water. Locally there are zones of fossil-mortar material that contain fragments of many faunal types. The bedding surfaces of the Argentine are

irregular to wavy, which according to Cooley (1952), indicates the presence of strong currents. Chert nodules, which are characteristic of the Argentine, are randomly dispersed throughout the unit and are considered to be of primary origin. The observations upon which this statement is based are; (1) the ellipsoidal shape of the nodules which are always found to be elongate to the bedding, (2) the fact that the nodules are not necessarily confined to the bedding planes, and (3) that they contain shell fragments and other particles. It is assumed that the silica accumulated as gelatinous nodules which were moved about the floor of the basin by currents. This movement allowed the silica gel to incorporate foreign material prior to solidification. The thickness variations often noticed from one locality to another appear to be reflections of local irregularities on the basin floor, but the overall thickening towards the north indicates a longer period of deposition in that portion of the basin.

The sea that existed in this area during deposition of the Argentine Limestone appears to have been shallow, clear, warm, and agitated by waves and strong currents. The overall aphanitic texture and light color of these rocks is considered as being diagnostic of clear water conditions, while the abundant shell fragments, fossil-mortar material, fauna, and wavy-bedded character indicate warm water with strong currents. The fact that these conditions existed for a relatively long period is indicated by the noticeable thickness of these units.

The upper massive beds of the Argentine show a marked change in environmental conditions. These beds, as noted earlier, are characteristically fragmental or "osagites" and in some cases show a mottled aphanitic texture. The fragmental beds have associated with them sparse to abundant algal encrusted remains. It was noted previously that shallow, clear, quite water conditions were necessary for algae to flourish. Currents or waves must have been operative upon occasion in order to turn over shell fragments so that algal growth could be on all sides. *Myalina* has been noted as being associated with the oolitic "osagite" bed in two places. Moore (1929, p. 464) points out that heavy shelled pelecypods are considered as being associated with shallow water conditions and that these forms are dominant when associated with oolites.

Moore also states that mottled limestones are associated with algal conditions and may be caused by selective dolomitization. It is therefore assumed that the seas were shallower, quieter, and more saline than before, but currents must have been locally strong in order to transport shell remains from the point of maximum breakage into the depositional area. The oolitic "osagite" zone is essentially characteristic of the eastern margin of this area while the fragmental zone is associated with the central and western portions.

The upper surface of the Argentine is undulatory which may be indicative of wave and current action upon the depositional floor.

Following the conditions favorable to carbonate deposition, the area was again the site of dominantly fine clastics that were supplied by streams of increased competence and capacity. These shales characteristically thicken northward into the basin and are greenish-gray to medium gray, silty, and micaceous. The diagnostic fossil remains found are *Lingula*, fenestrate bryozoans, and plant remains. Environmental conditions presumed to have existed during this period are ones of near shore, quiet, shallow water. The basis for these conclusions are plant remains present along bedding planes indicating that they settled out under quiet water conditions. The linguloid brachiopods, according to Moore (1929, p. 469), prefer shallow sub-saline water and usually indicate a nearby fresh water source. These conditions coincide closely with the lithological character of the shales. The fossils in the detrital zone which occurs locally in the lower portion of this sequence are thought to have been carried into the depositional area.

Locally along the upper contact of the Island Creek Shale occurs a thin, 0.5 foot, detrital zone composed of fossil fragments. This zone is interpreted as representing small local depressions on the basin floor that were accumulation sites for the detrital material. Transportation of this material is considered to have been by currents operative along the bottom or by gentle wave action that moved across this shallow area.

The Farley Limestone represents the final phase of predominately carbonate deposition. The environmental history of this sequence is complicated

and represents a relatively long period of deposition as indicated by the extreme thickness of these beds.

The lower Farley beds maintain an average thickness of about 3.5 feet, but locally may thicken to 10.0 feet. Characteristically these rocks possess an aphanitic texture, but abundant shell fragments are found in the fine grained matrix. *Composita* and other brachiopods, fenestrate bryozoans, crinoid stems, sparse echinoid spines and fusulinids occur in the Farley. With the exception of a very local area near Edwardsville, the seas during this period of deposition were clear, open, shallow, and normally saline. The abundant shell fragments and fenestrate bryozoans attest to the fact that currents were probably strong and the bottom was composed of shells and rock (Moore, 1929, p. 468). The localized accumulations of fusulinids near the base of these beds might indicate that conditions were conducive for their existence insitu or that they were carried into the area. Which ever possibility is accepted, it is important to note that fusulinids never become abundant in the Farley and are absent in younger beds of this unit. Therefore, if conditions were such that fusulinids could exist, these conditions did not persist over a large area or for any length of time.

In the Edwardsville area the lower Farley bed is typically oolitic and algal. It is therefore concluded that within a very small area the conditions tended towards clear, partially restricted, saline, and essentially more quite water. This condition existed for only a relatively short time, since the next younger bed is similar to the lower Farley units.

During the remainder of the Farley deposition, conditions throughout the basin were variable. Facies changes abound, and environments range from strictly shale deposition, to alternating limestones and shale, to continuous carbonate deposition. Following the initial deposition of the lower Farley, fine clastics again were carried into the basin from the south. These shales do not exist everywhere at this horizon, but are assumed to have been supplied to some areas and excluded from others by welts that were appearing on the basin floor. A continuous accumulation of this fine clastic material was recorded at the main Sunflower Quarry (Locality W) south of De Soto and its facies relationship

with Locality X, a short distance northwest was described in the section covering detailed stratigraphy. Further north in the De Soto area, although the sections are not completely exposed, it appears that continuous carbonate deposition took place. From other sections studied to the east of De Soto it appears that the shale materials extend further northward into the basin and were excluded from the De Soto area by a local high in the basin. In this area the middle Farley is marked by alternating limestones and shales which presumably indicate minor oscillations of the sea or intermittent periods of fine clastic invasion. At Locality K, along the railroad out south of Craig, carbonate deposition was essentially continuous, but the beds are poorly consolidated, silty, unfossiliferous limestones, indicating that the water was "dirty" during the majority of time. Further north, from Locality Z to Bonner Springs, the demarcation between clastic and carbonate deposition is more marked. Carbonate deposition took place under normally clean, open, shallow water conditions as indicated by the fauna and texture of the rocks. The wavy, irregular character of the beds and scattered shell fragments suggest that strong currents were present. These conditions were interrupted from time to time by an increase in the amount of fine clastic material supplied to the area. Faunal representatives collected from the shales were commonly *Composita*, shell fragments, fenestrate bryozoans, and crinoid stems.

The environments continued to be variable during the deposition of the upper Farley beds. Conditions favorable to carbonate deposition returned, but small, local structures continued to exist and facies changes are numerous. Considering the aphanitic texture, the light color and the fauna of these rocks, it appears that clear, open, normally saline water existed over most of the area, but shell fragments found in these rocks suggest that strong currents were effective in moving the materials along the basin floor. The units become increasingly more fragmental upwards, indicating that wave and current action tends to become more of a factor. The erratic distribution of shell fragments from one section to the next is thought to be due to unequal current distribution or accumulation of fragments into small local depressions.

Near De Soto a small intraformational unconformity was noted at two localities. The cause for this feature is not known, but apparently the area was at least above wave base and perhaps even above sea level. The material from this surface has not been definitely located, but taking into consideration the south dip recorded at Locality T, along the south edge of De Soto, and the north dip noticed at Sunflower Quarry, it is presumed that at least part of the eroded material was carried into a local structural low apparently located in the Penner's Ford area.

The trend toward shallowing of the water continued and is demonstrated by the algal encrusted shell fragments. These encrusted fragments suggest that locally the water was shallow, quiet, and marine enough to allow algal growth. The presence of *Myalina* and other thick shelled clams is also characteristic of shallow water conditions, and they are the dominant fauna existing in an environment conducive to algal growth.

Numerous cephalopods occur locally in the De Soto vicinity. Moore (1929, p. 471) states that these forms, during the Pennsylvanian, are benthonic in habit and have more than normal susceptibility to environmental changes. From this it could be assumed that these cephalopods occur in their natural habitat and were able to tolerate the proposed changes in environment. It might also be suggested that, because of the chambered nature of these forms, they were buoyant enough to have been carried into the area by currents after death.

Rocks that compose the uppermost beds of the Farley, range from fragmental algal units, to cross-bedded oolitic "osagites" to units that appear to be mottled or nodular. Hattin (1957) suggests that inorganically precipitated oolites may occur in areas where there is above normal salinity and plant life has reduced the carbon dioxide content of the water. As noted earlier, mottled limestones are assignable to algal origin and indicate selective dolomitization by algae. Environmentally this evidence suggests that the water was clear, relatively quiet, shallow, and above normal salinity. There was apparently some current action which resulted in the level cross-bedding of the "osagites". Such features are also characteristic of shallow water conditions.

Locally the upper surface of the Farley is very irregular and presumably was either above wave base or perhaps even above sea level. There does appear to have been a period during which conditions were constant for a relatively long time. Following this period fine clastic deposition was dominant throughout the area. This predominantly shale sequence, the Bonner Springs, has been considered to be representative of a deltic deposit (McManus, 1956). The sea must have been shallow and quiet since fine plant remains are found along the bedding planes. During the early phase of clastic deposition the Farley was either not entirely covered or portion were exposed after initial deposition. This is evidenced at Locality K where a limestone conglomerate in the Bonner Springs descends through the section and is in contact with the Farley. It might also be considered that waves or currents were locally effective in order to transport this conglomerate material.

During the other periods in the depositional history of the Bonner Springs, wave and current action was effective as shown by cross-bedded shell breccia and micross-bedded siltstone. It is interesting to note that the cross-bedded shell breccia occurs in approximately the same area as proposed earlier for the deposition of fragmental material stripped from pre-existing Farley. It is assumed that the Penner's Ford area was a continually subsiding local basin for a considerable length of time and accumulated a thick sequence of sediments. During the deposition of the shell breccia, which is thought to have been transported into the basin, the water was shallow and current action caused the material to become cross-bedded.

When considering the Bonner Springs deposition, notice should be called to the anomalous situation that exists along the western margin of the area. Trending in a northeast-southwest direction, from the exposure along Kansas Highway 32 (Locality E) through Loring Quarry (Locality H) and into De Soto, there is an extreme thinning of the shale. The Bonner Springs at these localities average about 1.5 feet in thickness as opposed to an overall average of 30.0 feet elsewhere.

This situation could perhaps be explained in several ways, but two alternatives are; (1) a high, parallel to this trend, was in existence prior to Bonner Springs deposition and the thinning was due to non-deposition, and (2) a flexure occurred along this trend, after deposition of the Bonner Springs, causing the shale to be stripped from the area. The writer found no evidence to definitely support either idea.

The marly, "punky", limestone locally found in the upper portion of the Bonner Springs represents, according to McManus (1956) an oxidizing environment relatively free of clastic materials so that carbonate deposition is not masked.

Normal shallow water conditions existed during the final stages of the Bonner Springs deposition. The water was somewhat clearer than usual as evidenced by the limy composition in the upper portion of the sequence. Geologists consider this zone to represent the start of the marine transgressive phase that culminates during the Merriam cyclothem.

CYCLIC SEDIMENTATION

Anyone observing the Pennsylvanian strata in Kansas cannot help but to be impressed by the repetitious nature of these beds. Moore, Jewett, and others have carried out extensive work in this area and have illustrated the remarkable similarity between these beds. It has been indicated from their work that these strata represent an apparently orderly cycle of sedimentation. The Wyandotte Limestone comprises only a small portion of this sequence.

Moore (1936, p. 34) points out that cyclothem of the Missouri Series are, in general, similar to those of the Shawnee Group. Therefore it might readily be assumed that the megacyclothem, cycle of cyclothem, are also similar.

For a detailed description of the members that comprise the typical Shawnee type megacycle the reader is referred to Moore (1931, p. 251). Only those members considered similar to the beds of the Wyandotte megacyclothem will be described in this report. Those members are, in ascending order:

Member 3 - "middle" Limestone; bluish-gray, hard, dense, blocky, and occurs as a thin massive layer (Frisbie Limestone).

Member 4 - shales; consists of two parts, lower black fissile shale and upper gray to yellowish calcareous shale. Thickness is about 3.0 to 5.0 feet. (Quindaro Shale)

Member 5 - "upper" limestone; white, fine grained, calcite veinlets and filled cavities, thin and wavy bedded, and containing random chert nodules. Thickness ranges from 15 to 30 feet. (Argentine Limestone)

Member 6 - shales; when this shale separates “upper” limestone from another limestone above it a short distance, it is variable. Often sandy and contains marine fossils. Thickness ranges from about 0.5 foot to approximately 12 feet. (Island Creek Shale)

Member 7 - “super” limestone; marked irregular lithology and bedding. Ranges from hard, dense limestone to cross-bedded oolite. Exceedingly fossiliferous and ranges in thickness from 2.0 feet to 8.0 feet. (Farley Limestone)

Figure 3 illustrates the general relationships just described.

Megacyclothems, as noted previously, are composed of several individual cyclothems. The cyclothems of the typical Shawnee type megacyclothem have been assigned the letter designations of A through E, in ascending order, by Moore (1936, p. 31). Because of the general similarity of the Missourian megacyclothems the individual cycles, where recognized, have been assigned the same letter designation. Cyclothems equivalent to B and C are definitely recognized in the Missouri Series, while those corresponding to A, D, and E are either obscure or absent.

With respect to the Wyandotte megacyclothems; B and C cyclothems are readily identifiable, D cyclothem is obscure, while A and E cyclothems are absent. Individual cyclothems may further be divided into emergent, transgressive, and regressive phases by use of the decimal system.

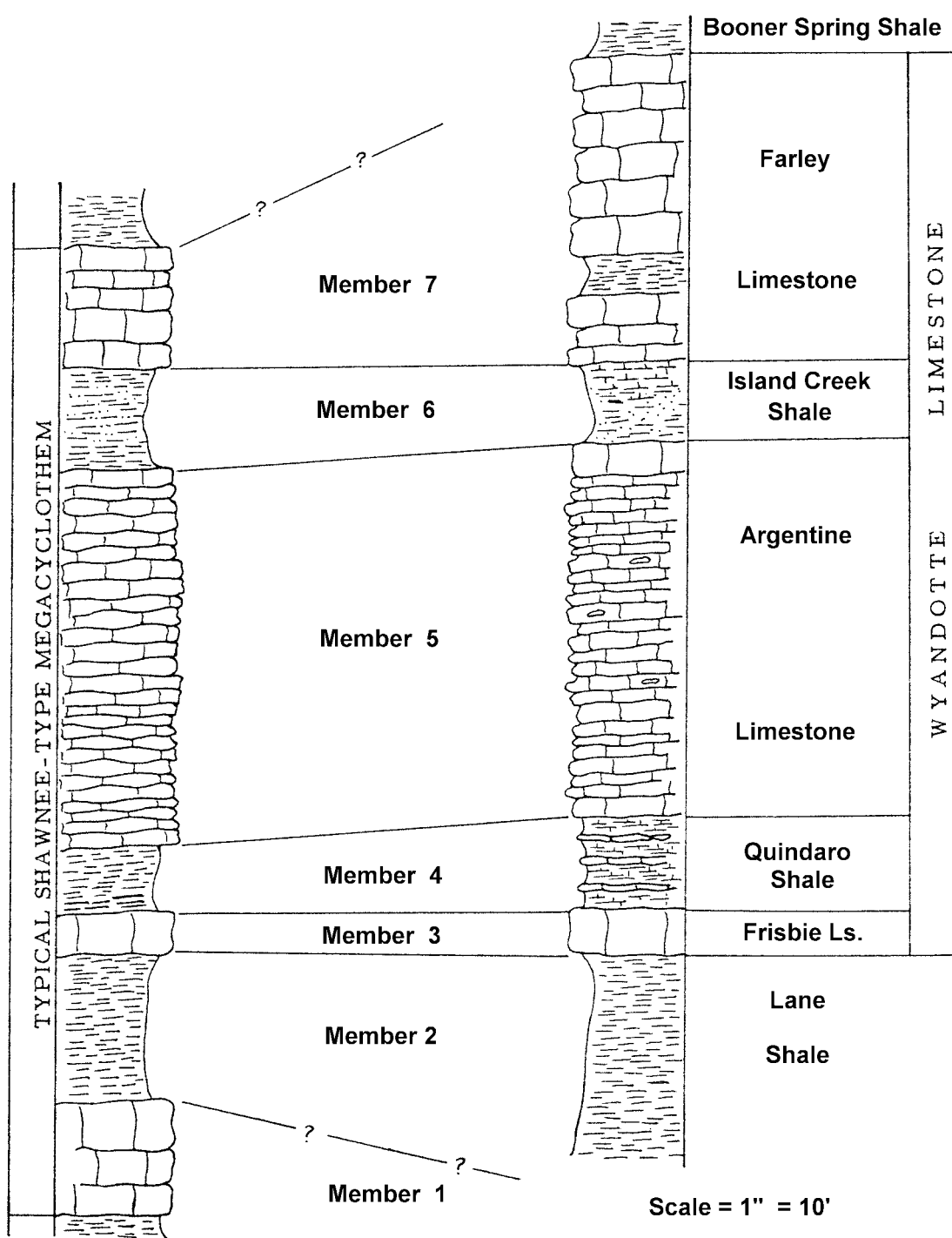


Fig. 3. Generalized columnar section showing the relationship between the typical Shawnee megacyclothem and the Wyandotte megacyclothem.

The minor subdivisions and their decimal equivalents, as related to the ideal cyclothem proposed by Moore (1936, p. 24) are presented below in ascending order.

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

A composite columnar section of the Wyandotte megacyclothem is illustrated in figure 4. Individual cyclotherms B and C are readily identifiable, and minor subdivisions have been proposed. Cyclothem D is assumed to be represented by the Farley Limestone and portions of the subjacent and superjacent shales. Because of the variable nature of the Farley, smaller subdivisions of this cyclothem are unreliable. The sequence of beds represented by the Farley have been considered as being equivalent to the "super" limestone of the Shawnee type megacyclothem, but the overall lithology and thickness suggests that this is not entirely true. It is possible that the Farley is the expression of several minor cycles.

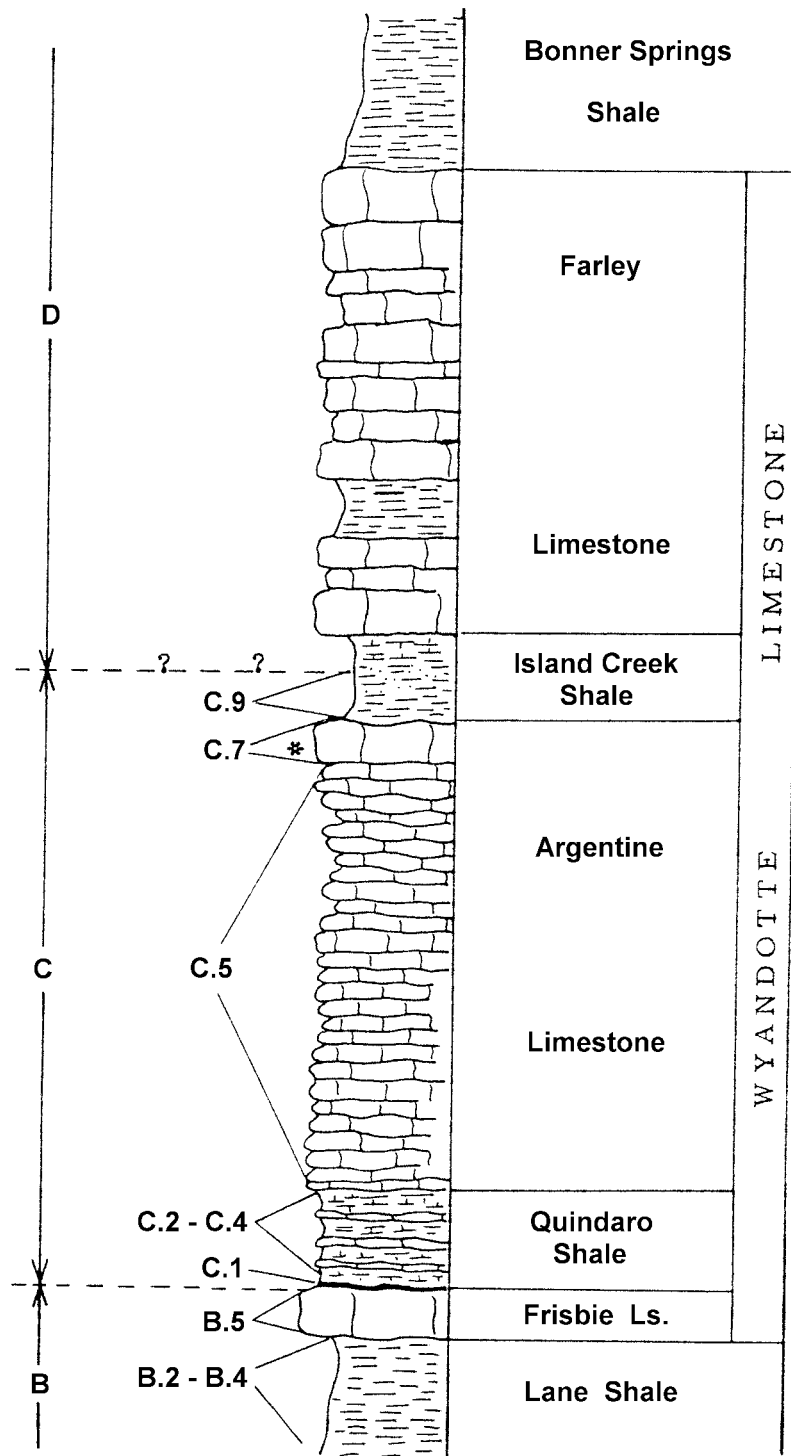


Fig. 4. Generalized columnar section of the Wyandotte Limestone megacyclothem. Individual cyclothem are designated by letters, and smaller divisions by the decimal system.

SUMMARY AND CONCLUSIONS

1. The Wyandotte Limestone is divisible into five members; three limestone and two shales.

2. The members of the Wyandotte are persistent and recognizable throughout the area.

3. The best criteria for field identification of this formation are topographic expression and stratigraphic sequence.

4. Acetate peels are considered to be one of the most important methods by which to study carbonate rocks.

5. Frisbie Limestone member is a typical "middle type" limestone that thickens gradually to the south and southwest from the Kansas River Area. The unit contains characteristic "Ottonosia-like" algae.

6. Quindaro Shale member is characteristically alternating limestone and shales which locally contain a thin basal black shale.

7. Argentine Limestone is the most persistent member of the formation. Typically an "upper" limestone, it is characterized by thin, wavy beds, and chert nodules. A massive upper bed is recognized throughout the area.

8. The Island Creek Shale member thins rapidly towards the southwest from its type locality in northern Wyandotte County. Locally, this unit contains zones of detrital fossil remains.

9. The Farley Limestone is the most variable member of the formation. Facies changes abound, lithologic variations are numerous, and stratigraphic relationships are complex.

10. The Wyandotte was deposited under near shore conditions or shelf type environment and records the alternating conditions conducive to fine clastic and carbonate deposition.

11. Small local welts or "highs" are considered as having been present on the basin floor during deposition of the Farley, causing local restrictions of current movement and sediment accumulation.

12. A small local depression developed south of De Soto, at Penner's Ford, and accumulated a relatively thick sequence of beds.

13. The Wyandotte megacyclothem is, in general, similar to the Shawnee megacyclothem.

14. Cyclothem B and C are divisible into smaller units, while cyclothem D is obscure.

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APPENDIX A

MEASURED SECTIONS OF THE WYANDOTTE LIMESTONE IN
 THE KANSAS RIVER AREA, EASTERN KANSAS

Locality A

SW $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 26, T. 11 S., R. 23 E., Wyandotte County; measured in road cut along south side of Kansas Highway 107, 0.5 mile northwest of Edwardsville.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (2.7')	
20. Limestone, medium brown weathered, dark reddish brown fresh, hard, dense, resistant, fine grained, massive, very fossiliferous; abundant shell fragments, clams, brachiopods, crinoid stems, and fusulinids	2.7
Bonner Springs Shale (25.6')	
19. Siltstone, yellowish brown weathered, same color fresh, blocky, weakly resistant, coarse grained, calcareous, micaceous; no fossils observed	2.5
18. Shale, light gray and rust mottled, laminated, nonresistant, calcareous; no fossils observed. Base covered	4.9
17. Covered interval, probably shale	18.2

Wyandotte Limestone (63.2')

Farley Limestone member (20.3')

16. Limestone, orange-brown weathered, brownish-gray mottled fresh, hard, dense, resistant, fine grained, pseudo-brecciated, calcite veinlets, algae/, medium bedded, irregular contact; *Composita*, *Myalina*, and shell fragments. Base covered. 1.1
15. Covered interval, probably limestone, questionable shale at base. 12.3
14. Limestone, medium gray weathered, rust to reddish brown fresh, hard, resistant, coarse grained, oolitic, algal, massive; *Osagia*, *Composita* 1. 7
13. Limestone and shale, alternating; medium gray weathered, bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets, thin, wavy-bedded, irregular to nodular; *Composita* and other brachiopod shells, Limestones are near the base and top, and are separated by shale; rust-yellow to greenish-gray, blocky to modular, weakly resistant, calcareous; no fossils observed in shale 2.5
12. Limestone, light bluish-gray weathered, tan fresh, hard, dense, resistant, fine grained, calcite veinlets, algal, massive, irregular upper contact; algae, *Composita*, and rare small gastropods. Lower 0.1 foot is a green, calcareous shale 1.1
11. Limestone, yellowish-gray weathered, grayish-tan fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, massive; *Composita*, shell fragments, and rare gastropods..... 1.3
10. Limestone, yellow weathered, grayish-brown fresh, hard, resistant, coarse grained, oolitic, algal, very thin bedded; algae, rare gastropods and fusulinids 0.3

Island Creek Shale member (15.8')

9. Shale, dark gray to brownish-gray, fissile, non-resistant, micaceous, grades down into a micaceous, calcareous zone. In the lower portion, a fossiliferous, detrital zone with; *Derbyia*, *Dictyoclostus*, *Neospirifer*, *Myalina*, *Aviculopinna*, rare *Pleurophorous*, *Pharidonotus*, *Bellerophon*, *Conulariid*, and crinoid stems..... 10.4

- 8. Shale, greenish-gray, blocky, non-resistant, slightly micaceous; no fossils observed. Base covered5.4

Argentine Limestone member (18.2')

- 7. Limestone, Yellowish-brown weathered, yellowish to grayish-brown fresh, hard, dense, resistant, fine grained, calcite veinlets, massive, irregular surface; brachiopod shell fragments, *Composita*, crinoid stems, and rare gastropods. Top covered4.3
- 6. Limestone, Yellowish-gray weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and inclusions, thin, wavy-bedded, irregular upper contacts, becomes darker gray near base; fossils are relatively scarce, few brachiopod shells and other shell fragments, and crinoid stems. Beds are often separated by very thin shale partings 13.9

Quindaro Shale member (7.2')

- 5. Shale, yellowish-brown weathered, reddish-gray fresh, nodular, weakly resistant, calcareous, thin, irregular limestone plates; sparse fenestrate bryozoans2.5
- 4. Limestone and shale, alternating; buff weathered, bluish-gray fresh, hard, dense, resistant, calcite veinlets, thin, wavy-bedded; *Composita*, rare gastropods, and fenestrate bryozoans. Limestones are separated by shale, tan weathered, yellowish-gray fresh, blocky, non-resistant, calcareous, scattered limestone nodules4.2
- 3. Shale, black, fissile, non-resistant, grades into gray calcareous zone 0.5

Frisbie Limestone member (1.7')

- 2. Limestone, light tan to buff weathered, bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets, massive, irregular upper surface; algae, *Composita*, encrusted shell fragments 1.7

Lane Shale

- 1. Shale, light gray weathered, medium gray fresh, blocky, non-resistantunmeasured

Locality B

SE¼, SE¼, NE¼, Sec. 28, T. 11 S., R. 23 E., Wyandotte County; measured in road cut along north side of Camp Naish Road in Boy Scouts of America camp 1.5 miles east of Bonner Springs.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (1.6')	
14. Limestone, medium brown weathered, light gray fresh, hard, fine to medium grained, massive, <i>Osagia</i> , <i>Composita</i> , and rare <i>Myalina</i> ...	1.6
Bonner Springs Shale (22.0')	
13. Shale, light gray weathered, greenish-gray fresh, blocky, non-resistant, slightly micaceous, scattered plant remains. Upper 0.3 foot is a reddish-brown, micaceous, calcareous siltstone or a very silty shale. Top 10.0 feet covered by slump	22.0
Wyandotte Limestone (53' exposed)	
Farley Limestone member (21.9')	
12. Limestone, brown weathered, dove gray to reddish-blue fresh, hard, dense, resistant, fine grained, calcite veinlets and inclusions, massive; few fossils scattered mostly in the lower beds. Upper bed is very massive 5.0'	12.0
11. Shale, green-gray, nodular, calcareous, limonitic stained, graded contact with unit 10. Upper 0.1 foot composed of very poor dark brown shale containing high percentage of vegetable material	0.7
10. Limestone, rusty yellow weathered, yellowish-orange fresh, "punky", silty, unfossiliferous: separated from unit 11 by a green, slightly calcareous shale	2.9
9. Limestone and shale, alternating; bluish-gray, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, thin bedded; <i>Composita</i> , fenestrate bryozoans, and shell fragments. Limestones	

separated by shale; dark green to greenish-gray, calcareous, clayey;
Composita appears in the middle shale parting2.7

8. Limestone, medium gray weathered, bluish-gray fresh, hard, dense, resistant, fine grained, calcite replaced fossils and cavities, medium bedded; *Composita*.....3.6

Island Creek Shale member (13.8')

7. Siltstone, green-yellow, micaceous, grades into dark gray, weakly resistant, micaceous, silty, slightly calcareous shale. Upper 0.5 foot; green-black, shaley, detrital zone contains abundant marine fossil fragments 1.0
6. Shale, brownish-gray weathered, greenish-brown fresh, blocky, non-resistant, silty, micaceous, slightly calcareous; plant remains parallel to bedding. Upper 4 feet becomes very silty6.7
5. Covered interval, probably shale..... 6.1

Argentine Limestone member (17.2')

4. Limestone, dark gray weathered, brownish-gray fresh, hard, dense, resistant, fine grained, massive, wavy upper surface; *Composita*, scattered fenestrate bryozoans..... 1.5
3. Limestone, dark gray weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite inclusions and veinlets, medium, wavy-bedded; fossils relatively scarce, *Composita*, crinoids columnals, fenestrate bryozoans, rare high spired gastropods, and scattered shell fragments3.2
2. Covered interval; probably limestone 4.7
1. Limestone, dark gray-brown weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite inclusions and veinlets, medium, wavy-bedded; scattered shell fragments, rare high spired gastropods. Base covered.7.8

Locality C

NE¼, NE¼, SE¼, Sec. 29, T. 11 S., R. 23 E., Wyandotte County; measured in abandoned quarry 0.3 mil east of Bonner Springs, and approximately 300 yards north of Kansas Highway 32.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member (1.7' exposed)	
Lower limestone unit	
17. Limestone, dark gray weathered, blue-gray fresh; hard, dense, resistant, fine grained, massive; <i>Composita</i> , fenestrate bryozoans, crinoid stems, rare gastropods, abundant shell fragments	1.7
Bonner Springs Shale (27.0')	
16. Covered interval; probably shale	17.0
15. Shale, buff to light tan weathered, greenish-brown fresh, blocky, weathers papery, clayey, micaceous; plant remains on surface	10.0
Wyandotte Limestone (56.4')	
Farley Limestone member (26.1')	
14. Limestone, light tan weathered, grayish-tan fresh, hard, resistant, coarse grained, massive, wavy upper surface; abundant crinoid and shell fragments.....	2.4
13. Limestone, brownish-yellow weathered, tan fresh, hard, dense, resistant, fine grained, calcite inclusions and veinlets, medium bedded; fenestrate bryozoans, scattered brachiopods	9.6
12. Covered interval; probably limestone	1.0

- 11. Limestone, medium gray weathered; light blue-gray fresh, hard, dense, resistant, coarse grained, medium bedded, irregular lower contact; crinoid stems, fenestrate bryozoans, brachiopods, rare gastropods, abundant shell fragments 1.7
- 10. Limestone and shale, alternating; yellow-brown weathered, bluish-gray fresh, , hard, dense, resistant, fine grained, calcite veinlets and filled cavities, thin wavy-bedded; *Composita*. Limestone separated by shale; green to yellow-brown, nodular well consolidated, non-resistant, slightly silty, calcareous; *Composita*, *Dictyoclostus*, fenestrate bryozoans, crinoid stems7.7
- 9. Limestone, rust-brown weathered, medium bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets and replaced fossils, medium to thin bedded, irregular bedding planes; *Composita*, scattered shell fragments3.7

Island Creek Shale member (6.3')

- 8. Shale, green, non-resistant, poorly consolidated, silty, detrital; *Punctospirifer*, *Lingula*, crinoid stems, fenestrate bryozoans, ramose bryozoans, shell fragments0.5
- 7. Siltstone, medium gray, thinly laminated, non-resistant, very fine grained, micaceous, grades into unit 82.3
- 6. Shale, greenish-black, blocky, non-resistant, micaceous, upper contact grades into unit 7; *Derbia*, *Lingula*, *Aviculopecten*, *Ditonopyge*, crinoid stems, fenestrate bryozoans3.5

Argentine Limestone member (31.3' exposed)

- 5. Limestone, buff to light tan weathered, brownish-gray fresh, hard, dense, fine grained, calcite veinlets and scattered chert nodules, massive; upper 0.3 foot, coarse grained, detrital zone, weathers flaggy4.2
- 4. Limestone, gray-brown weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, medium, wavy-bedded, scattered chert nodules and discontinuous bands; *Composita*, *Dictyoclotus*, *Echinoconchus*, fenestrate bryozoans, crinoid stems20.6
- 3. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, thin bedded, apparent banding, upper 0.1 foot a fossil mortar; *Composita*, crinoid stems, fenestrate bryozoans 1.0

2. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, calcite inclusions, massive, abundant fossils near top; *Neospirifer*, *Composita*, fenestrate bryozoans, clam shells, small horn coral.....4.3
1. Limestone, medium gray to light brown, hard, weakly resistant, fine grained, laminated, silty; weathers slabby. Base is covered1.2

Locality D

East line of SE¼, SE¼, Sec. 19, T. 11 S., R. 23 E., Wyandotte County;
measured in ditch along east side of north-south road.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member (1.7' exposed)	
Lower limestone unit	
14. Limestone, dark gray weathered, bluish gray fresh, hard, dense, resistant, fine grained, massive; crinoid stems, sparse fusulinids and small high spired gastropods, algae.....	unmeasured
Bonner Springs Shale (19.1')	
13. Shale, grayish-tan weathered, greenish-gray to tan fresh, blocky, non-resistant, silty, slightly micaceous	8.0
12. Siltstone, grayish-tan weathered, reddish-brown fresh, weakly resistant, fine grained.....	2.6
11. Shale, gray weathered, yellowish-green to black fresh, laminated, weathers out fissile, slightly silty, slightly micaceous; scattered plant remains	8.5
Wyandotte Limestone (40.1')	
Farley Limestone member (25.1')	
10. Limestone, orange-brown weathered, brown fresh, hard, dense, resistant, fine grained, thin bedded, shell fragments.....	1.5
9. Limestone, yellowish-gray, weathered, bluish-gray to brown fresh, hard, dense, resistant, fine grained, medium bedded; shell fragments, no fossils. Top covered	2.0

8. Limestone, Yellowish-gray weathered, dark gray to yellow mottled fresh, hard, resistant, fine grained, medium bedded; unidentified brachiopods, ramose byozoans, fenestrate bryozoans, and shell fragments. Grades into poorly consolidated "punky" limestone5.6
7. Limestone, yellow fresh, poorly consolidated, weakly resistant, very thin bedded, shaley0.5
6. Limestone, Yellowish-brown weathered, light brown fresh, hard, dense, resistant, fine grained, calcite filled cavities; *Composita*, fenestrate bryozoans, echinoid spines and plates 12.0
5. Limestone, yellowish-brown weathered, brownish yellow fresh, , hard, dense, resistant, fine grained, calcite veinlets, massive; unidentifiable brachiopods, crinoid stems, shell fragments and ramose bryozoans3.5

Island Creek Shale member (5.6')

4. Shale, gray weathered, black to greenish-gray fresh, thinly laminated to platy, non-resistant; black in lower portion grades to greenish-gray and calcareous. Base covered..... 5.6 exposed

Argentine Limestone member (9.4' exposed)

3. Limestone, buff to yellowish-gray weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite filled cavities, massive, irregular bedding planes; *Composita*, high spired gastropods, fenestrate bryozoans, shell fragments. Top covered 3.2 exposed
2. Limestone, buff to yellowish-gray, dove gray fresh, hard, resistant, coarse grained, few calcite filled cavities, massive, irregular bedding surface; *Composita*, and fenestrate bryozoans.....1.0
1. Limestone, light gray weathered, pinkish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, massive to medium bedded, irregular bedding planes; *Composita*, fenestrate bryozoans, and scattered shell fragments. Base covered.....5.2 exposed

Locality E

South line of SW $\frac{1}{4}$, SW $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 30, T. 11 S., R. 23 E., measured on north side of Kansas Highway 32, 1.5 miles west of Bonner Springs.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member (7.8' exposed)	
Lower limestone unit	
9. Limestone, medium gray weathered, bluish gray fresh, hard, dense, resistant, fine grained matrix, massive to medium bedded; <i>Composita</i> at base, crinoid stems common, clams, brachiopods, rare encrusted algae, and shell fragments.....	1.5
8. Shale, greenish-yellow, non-resistant, silty, calcareous; shell fragments.....	0.3
7. Limestone, Yellowish-gray weathered, bluish-gray fresh, hard, resistant, coarse grained to conglomeratic, coquinoid (?), thin, cross-bedded in upper units, becomes more evenly bedded near base; highly fossiliferous, gastropods, and abundant shell fragments.....	6.0
Bonner Springs Shale	
6. Shale, yellowish-green nodular, non-resistant, silty, calcareous; shell fragments, <i>Aviculopecten</i>	0.5
Wyandotte Limestone	
Farley Limestone member (15.2' exposed)	
5. Limestone, Yellowish-brown weathered, same for fresh, "punky", weakly resistant, fragmental, arenaceous, calcite veinlets, variable thickness; shell fragments.....	1.0
4. Limestone, medium gray weathered, bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, medium bedded, irregular bedding planes; <i>composita</i> , fenestrate bryozoans, and shell fragments.....	11.2

3. Shale, greenish-yellow, thinly laminated, non-resistant, calcareous; fenestrate bryozoans and shell fragments2.0
2. Limestone, tan weathered, bluish-brown fresh, hard, dense, resistant, fine grained, algal structures; Algae (?). Only top exposed.....1.0
1. Covered, probably limestone

Locality F

NE¼, NW¼, SW¼, Sec. 1, T. 12 S., R. 23 E., Johnson County; measured in abandoned quarry, 0.5 mile southwest of Holliday.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (2.0' exposed)	
13. Limestone, bluish-gray weathered, brownish-blue fresh, hard, dense, resistant, coarse grained, massive; <i>Composita</i> , <i>Osagia</i> , and shell fragments	2.0
Bonner Springs Shale (5.1')	
12. Shale, greenish-black, blocky, non-resistant, slightly silty; <i>Lingula</i> and plant remains along bedding planes. Grades into green-gray calcareous shale	5.1
Wyandotte Limestone (39.2')	
Farley Limestone member (11.1')	
11. Limestone, medium gray weathered, bluish-gray fresh, hard, dense, resistant, coarse grained, "pseudo-oolitic," massive; <i>Osagia</i> (?), rare fusulinids	0.9
10. Limestone, light gray weathered, grayish-brown fresh, hard, dense, resistant, coarse grained, "pseudo-oolitic," massive, weathered surface appears cross-bedded; relatively unfossiliferous except for scattered, small brachiopods, and some shell fragments	3.8
9. Limestone, orangish-brown weathered, medium to light gray fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, upper units massive and lower units medium to thin bedded, irregular bedding planes; <i>Composita</i> and shell fragments	3.0

- 8. Limestone, medium gray weathered, light gray and yellow, mottled, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, lower unit massive, upper units thin bedded, irregular bedding planes; *Composita*, *Dictyoclostus*, and scattered shell fragments.....3.4

Island Creek Shale member (4.9')

- 7. Shale, light gray weathered, dark gray fresh; blocky, non-resistant, silty, finely micaceous, calcareous; crinoid stems, and shell fragments. Grades upwards into green and yellow mottled, finely micaceous shale4.9

Argentine Limestone member (11.2')

- 6. Limestone, orange-brown weathered, tan fresh, hard, dense, resistant, coarse grained, oolitic, massive, irregular upper contact; fenestrate bryozoans, clams, crinoid stems, rare horn coral, and shell fragments. Calcite replaced zone of clam shells in center of unit ...2.2
- 5. Limestone, rust-brown weathered, medium brownish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets, medium, wavy-bedded, chert nodules in upper half of unit; crinoid stems, clam shells and scattered fenestrate bryozoans.....7.0
- 4. Limestone, light gray weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, massive lower unit, thin wavy-bedded upper units, scattered chert nodules; large crinoid stems.....2.0

Quindaro Shale member (9.4')

- 3. Limestone and shale, alternating; yellow-brown weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, thin, wavy-bedded; ramose bryozoan, echinoid spines, scattered crinoid columnals, and shell fragments. Limestone separated by shale; greenish-brown, nodular, non-resistant, silty, calcareous.....2.3
- 2. Covered interval; probably alternating limestone and shale..... 7.1

Frisbie Limestone member (2.7')

- 1. Limestone, tan-gray weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, massive; crinoid stems and rare algae.....2.7

Locality G

Center east side NE¼, NW¼, Sec. 17, T. 12 S., R. 23 E., Johnson County;
 measured in ditch along west side of Frisbie Road. Type locality of Frisbie
 Limestone member.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (2.3' exposed)	
12. Limestone, bluish-gray weathered, light blue-gray fresh, hard, dense, resistant, fine grained, massive, osagite; <i>Osagia</i>	2.3
Bonner Springs Shale (32.3')	
11. Covered interval. Probably shale.....	32.3
Wyandotte Limestone (57.3')	
Farley Limestone member (23.3')	
10. Limestone, white weathered, light bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, medium bedded; fenestrate bryozoans, questionable <i>Composita</i> , and shell fragments	0.7 exposed
9. Covered interval; probably limestone	7.7
8. Limestone, buff weathered, brownish-gray fresh, hard, dense, resistant, medium grained, calcite inclusions, veinlets, and filled cavities, medium bedded, irregular surfaces; <i>Composita</i> , crinoid stems, rare echinoid spines and small gastropods, and shell fragments	5.0

- 7. Limestone and shale, alternating; yellowish-gray weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, thin, irregularly bedded; small gastropods, fenestrate bryozoans, rare fusulinids, and shell fragments. Limestone units separated by shale; yellowish-brown to gray, well consolidated, non-resistant, calcareous, “punky” limestone nodules; abundant *Composita*6.5
- 6. Limestone, medium gray weathered, blue-gray to gray fresh, hard, dense, resistant, fine grained; calcite inclusions and cavity fillings, massive, irregular bedding planes; *Composita* and shell fragments 3.4

Island Creek Shale member (1.4')

- 5. Shale, blue-gray and yellow, mottled, nodular, non-resistant, slightly silty, micaceous; *Neospirifer*, fenestrate bryozoans, questionable plant remains 1.4

Argentine Limestone member (26.9')

- 4. Limestone, Yellowish-gray weathered, brownish-gray fresh, hard, dense, resistant, fine grained, “pseudo-breccia” appearing, calcite veinlets and cavity fillings, massive; *Composita*, fenestrate bryozoans and scattered shell fragments2.7
- 3. Limestone, yellowish-gray weathered, light gray to light tan fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, medium to thin, wavy-bedded; fenestrate bryozoans and shell fragments24.2

Quindaro Shale member (4.4')

- 2. Limestone and shale alternating; light buff weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite filled cavities, thin, irregular bedded; relatively unfossiliferous, scattered ramose bryozoan and shell fragments. Limestone separated by shale; yellowish-brown to gray, mottled, silty, calcareous4.4

Frisbie Limestone member (1.5')

- 1. Limestone, grayish-tan weathered, medium gray fresh, hard, dense, resistant, fine grained, massive, irregular upper surface; algae, few brachiopods, crinoid stems and shell fragments 1.5

Lane Shale (unmeasured)

Locality H

Center Sec. 13, T. 12 S., R. 22 E., Leavenworth County; measured in a series of quarries on north side of private road leading to Loring Quarry.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (3.5')	
14. Limestone, yellowish-brown weathered, bluish-brown fresh, hard, dense, resistant, fine grained, massive, no fossils observed	3.5
Bonner Springs Shale (0.7')	
13. Shale, black to gray fresh, fissile, non-resistant, silty, calcareous; medium gray, platy limestone stringers.....	0.7
Wyandotte Limestone (67.8')	
Farley Limestone member (24.3')	
12. Limestone, dove gray weathered, light gray fresh, hard, dense, resistant, fine grained matrix, calcite veinlets and filled cavities, massive to medium bedded; fenestrate bryozoans, <i>Composita</i> , and a straight cephalopod.....	16.5
11. Shale, gray weathered, black fresh, blocky, non-resistant, slightly silty	1.2
10. Limestone and shale, alternating; yellowish-gray weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets, and filled cavities, thin bedded, irregular bedding surfaces; <i>Composita</i> , <i>Myalina</i> , <i>Echinoconchus</i> , shell fragments and rare fenestrate bryozoans. Limestones are separated by shale; medium gray to orange-yellow fresh, platy, non-resistant, silty, calcareous; <i>Composita</i>	5.0

- 9. Limestone. yellowish-gray weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, massive to medium bedded, irregularly bedding surface; *Composita*, fenestrate bryozoans, crinoid stems, and shell fragments3.9

Island Creek Shale member (1.7')

- 8. Shale, greenish-gray to Yellowish-green fresh, laminated, silty, calcareous..... 1.7

Argentine Limestone member (34.0')

- 7. Limestone, Greenish-gray weathered, medium gray fresh, hard, dense, resistant, coarse grained, algal, detrital zone, thin bedded, irregular upper surface; *Osagia* (?) or other encrusting algae, crinoid stems, *Myalina*, and other shell fragments.....0.5
- 6. Limestone, yellowish-gray to medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, algal structure in top unit, massive to medium bedded, irregular bedding planes, scattered chert nodules mostly concentrated in the middle of the unit; *Juresania*, very large crinoid stems, fenestrate bryozoans and shell fragments. Near upper contact is a 0.1 foot, fragmental, crinoidal bed33.5

Quindaro Shale member (6.3' exposed)

- 5. Limestone and shale alternating; yellowish-gray weathered, medium gray and yellow fresh, mottled, hard, dense, resistant, fine grained, calcite veinlets and replaced shell fragments, thin, wavy-bedded; fenestrate bryozoans, crinoid stems, shell fragments. Limestone separated by shale; greenish-gray fresh, nodular, calcareous, containing reddish-blue limestone nodules6.3

Frisbie Limestone member (1.5')

- 4. Limestone, medium gray weathered or fresh, fairly consolidated, resistant, coarse grained, fragmental, medium bedded, grades into unit 5; abundant crinoid stems, fenestrate bryozoans and shell fragments0.5
- 3. Shale, greenish-black, fissile, non-resistant, calcareous, non-fossiliferous0.3
- 2. Limestone, yellowish-gray weathered, medium gray fresh, hard, dense, resistant, fine grained, algal, massive to medium bedded, lower

portion not as well consolidated; algae (*Ottonosia* cf.), rare horn coral
and shell fragments.....0.7

Lane Shale

1. Shale, greenish-black to black fresh, thinly laminated, non-resistant,
grades into unit 2unmeasured

Locality I

South line, SW¼, Sec. 14, T. 12 S., R. 23 E., Johnson County; measured in a ditch on north side of east-west road.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (1.8')	
11. Limestone, yellowish-gray weathered, blue-gray fresh, hard, fossiliferous, resistant, fine grained matrix, medium bedded; <i>Osagia</i> , <i>Composita</i> , small gastropods, and shell fragments	1.8
Bonner Springs Shale (22.0')	
10. Shale, tan-gray weathered, green fresh, laminated, non-resistant, slightly silty, micaceous; plant remains along bedding planes. Grades upwards into 0.5 foot maroon, nodular, shale and then into a green-gray nodular, clayey shale. Lower portion partially covered.....	22.0
Wyandotte Limestone (45.5')	
Farley Limestone member (20.0' exposed)	
9. Limestone, brownish-gray weathered, gray-brown fresh, hard, dense, resistant, fine grained matrix, breccia appearing, lower portion of bed covered; no fossils observed.....	6.4
8. Covered interval, probably limestone	1.3
7. Limestone, dark brown fresh, hard, dense, resistant, fine grained, base and top covered	1.2
6. Covered interval, probably limestone	5.5
5. Limestone, medium bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets. Measured in road top and base covered .	5.6

Island Creek Shale member (5.6')

4. Covered interval, probably shale in upper portion and limestone at base 5.6

Argentine Limestone member (11.2')

3. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, thin to medium bedded, scattered chert nodules; scarce fossils, crinoid stems, fenestrate bryozoans, scattered shell fragments 11.2

Quindaro Shale member (4.3')

2. Limestone and shale, alternating; buff-brown weathered, rusty yellow to bluish-yellow fresh, mottled, "punkly", weakly resistant, fine grained, thin bedded, limonitic; fossils rare, small high spired gastropods, crinoid stems, fenestrate bryozoans, and shell fragments. Limestone separated by shale; rust-yellow, blocky, non-resistant, calcareous, limonitic 4.3

Frisbie Limestone member (4.2')

1. Limestone, medium gray weathered, brownish-blue fresh, hard, dense, resistant, fine grained, massive; crinoid stems, unidentified brachiopods, upper unit contains abundant fossil fragments 4.2
exposed

Locality J

South line, SE¼, SE¼, SW¼, Sec. 25, T. 12 S., R. 23 E., Johnson County;
measured in road cut on south side of county road.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit	
22. Limestone, buff weathered, medium gray fresh, hard, dense, resistant, medium to coarse grained, medium bedded; <i>Composita</i> , <i>Osagia</i> , clam shell fragments.....	unmeasured
Bonner Spings Shale (22.0')	
21. Shale, yellowish-green, blocky, non-resistant, silty, slightly micaceous; pectens and other small clams. Yellowish-green, "punky", very thin, nodular limestone zone 2.0 feet above unit 20	5.4
20. Shale, maroon, blocky, non-resistant, small clam shell fragments and gastropods	0.8
19. Shale, yellowish-brown weathered, yellowish-green fresh, laminated, non-resistant, small shell fragments.....	12.2
18. Shale, medium gray fresh, laminated, weakly resistant, slightly micaceous.....	3.6
Wyandotte Limestone (46.8')	
Farley Limestone member (24.0')	
17. Limestone, light gray weathered, medium gray fresh, mottled, hard, dense, resistant, fine grained, calcite veinlets , massive; <i>Composita</i> , and fenestrate bryozoans. Pseudo-brecciated appearance near top of the upper bed.....	5.6
16. Shale, yellowish-gray, thinly laminated, non-resistant, silty, calcareous, shell fragments	0.3

- 15. Shale, dark gray fresh, laminated, non-resistant, silty, calcareous; abundant shell fragments.....0.3
- 14. Limestone, buff-tan weathered, medium gray fresh, hard, dense, resistant, coarse grained, calcite veinlets and inclusions, massive, irregular upper bedding surface; crinoid stems and shell fragments 1.7
- 13. Limestone, light tan weathered, light gray fresh, hard, dense, resistant, fine grained, massive; separated from unit 14 by a thin (0.1 foot) red clay 1.3
- 12. Limestone and shale, alternating; medium bluish-gray, hard, dense, resistant, fine grained, calcite veinlets, thin, wavy-bedded; abundant *Composita*. Limestone separated by shale; greenish-gray and gray mottled, thinly laminated, slightly silty 11.2
- 11. Limestone, light gray weathered, medium gray fresh, hard, dense, fine grained, calcite veinlets, massive; *Composita* and fenestrate bryozoans3.6

Island Creek Shale member (8.5')

- 10. Shale, light gray weathered, yellowish-gray fresh, blocky, non-resistant, slightly silty; crinoid stems, ramose bryozoan, fenestrate bryozoans, and rare *Lingula*..... 1.0
- 9. Shale, dark gray weathered, yellowish-gray fresh, blocky, non-resistant, silty, micaceous; crinoid stems, and small amounts of plant remains 1.9
- 8. Shale, yellowish-green fresh, platy, non-resistant, silty, micaceous; plant remains on bedding planes5.6

Argentine Limestone member (15.3')

- 7. Limestone, bluish-tan mottled weathered, bluish-gray fresh, hard, dense, resistant, coarse grained, oolitic appearing, massive; *Osagia*, layer of abundant calcite replaced clam shells at base of bed..... 1.4
- 6. Limestone, bluish-tan mottled weathered, bluish-gray fresh, hard, dense, resistant, medium grained, calcite veinlets and cavity fillings, massive 1.7
- 5. Limestone, light gray weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and scattered chert nodules;

thin bedded, irregular bedding planes; sparse fossils, fenestrate bryozoans12.2

Quindaro Shale member (3.9')

4. Limestone and shale, alternating; bluish-gray, hard, resistant, medium grained, thin bedded, irregular bedding planes. Limestone separated by shale; yellowish-brown, non-resistant, silty, calcareous. Along outcrop, Frisbie-Argentine interval narrows at the expense of the limestone-shale sequence3.0
3. Shale, medium gray weathered, dark gray fresh, mottled, thinly laminated, non-resistant.....0.9

Frisbie Limestone member (5.1')

2. Limestone, buff weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets, massive; *Osagia*, and crinoid stems5.1

Lane Shale

1. Shale, gray weathered, greenish-gray fresh, platy, non-resistantunmeasured

Locality K

E½,, NE¼, Sec. 1, T. 13 S., R. 23 E., Johnson County; measured in railroad cut
1.0 mile southeast of Craig.

	Thickness Feet
Bonner Spings Shale (7.5')	
16. Siltstone, greenish-yellow, laminated, weakly resistant, poorly consolidated, micaceous.....	unmeasured
15. Limestone, dark gray to black, weakly resistant, conglomeratic.....	0.7
14. Shale, greenish-black, blocky, non-resistant, thinly laminated	3.6
13. Limestone, bluish-gray fresh, hard, dense, resistant, conglomeratic, clay and limonite pebbles. This unit laterally comes into contact and pinches out on the Farley member of the Wyandotte Limestone.....	1.1
12. Shale, bluish-gray and yellow mottled fresh, platy, non-resistant; grades into yellowish-green, calcareous zone	0 to 2.1
Wyandotte Limestone (60.6')	
Farley Limestone member (27.7')	
11. Limestone, light gray weathered, medium bluish-gray, hard, resistant, coarse grained, massive, very uneven upper surface, small scale cross-bedding on weathered surface, pseudo-oolitic appearing; crinoid and shell fragments.....	3.5
10. Limestone, yellowish-brown weathered, bluish-gray fresh, hard, dense, resistant, coarse grained, massive, small scale cross-bedding, pseudo-oolitic; <i>Composita</i> , crinoid stems, clams, and rare gastropods	6.2
9. Limestone, yellowish-brown weathered, tan fresh, hard, dense, resistant, medium to coarse grained, arenaceous appearing, weathers with large unoriented holes, massive; no visible fossils	4.5

- 8. Limestone and shale, alternating; brownish-green to reddish-gray, poorly consolidated, weakly resistant, thin bedded, slightly silty. Limestone separated by shale; brownish-green, non-resistant, silty, very calcareous; no fossils observed5.0
- 7. Limestone, yellowish-brown weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, massive upper and lower beds, thin bedded middle bed, irregular bedding planes; *Composita*, fenestrate bryozoans, few crinoid stems, and rare gastropods9.5

Island Creek Shale member (7.6')

- 6. Shale, medium gray, thinly laminated, non-resistant, silty, slightly micaceous; grades down into medium gray to black, calcareous, siltstone that grades into; shale, yellowish-green, calcareous, silty, that contains a fossil mortar of fenestrate bryozoans, shell fragments, crinoid stems, brachiopods, and rare trilobites.....7.6

Argentine Limestone member (18.3')

- 5. Limestone, light to medium gray weathered, bluish-gray fresh, hard, resistant, coarse grained, osagitic, oolitic, massive; few crinoid stems and fenestrate bryozoans 1.5
- 4. Limestone, light gray weathered, light to medium gray fresh, mottled, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, chert nodules in the upper beds, thin bedded, irregular bedding planes; large crinoid stems, fenestrate bryozoans, abundant *Composita* in the upper bed, other brachiopod shell fragments, rare horn corals. Upper contact is almost a mortar of shell fragments and fenestrate bryozoans remains 16.8

Quindaro Shale member (3.3')

- 3. Limestone and shale, alternating; yellowish-brown weathered, bluish-gray and yellow mottled fresh, hard, resistant, fine grained, shell fragments, thin bedded; along outcrop this bed thickens at the expense of the upper and lower shale, black and fissile at contact grades up to yellowish-green, silty, calcareous zone; upper shale, yellow, silty, calcareous, with very thin limestone plates3.3

Frisbie Limestone member (3.7')

2. Limestone, brown weathered, bluish gray to brownish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets, massive; very few fossils, algae, and shell fragments. Along the outcrop, small local build-ups on top of the limestone, causing the overlying black shale to thin3.7

Lane Shale

1. Shale, dark gray unmeasured

Locality L

Center of Sec. 34, T. 12 S., R. 23 E., Johnson County; measured on bluff, south side of stream, and in ditch along north-south road.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (1.8')	
16. Limestone, tan weathered, bluish-gray fresh, hard, dense, resistant, fine grained, calcite filled cavities, medium bedded; <i>Composita</i> , <i>Myalina</i> , shell fragments, rare fusulinids	1.0
Bonner Springs Shale (18.4')	
15. Shale, yellowish-tan weathered, yellowish-green to maroon fresh, platy to laminated, non-resistant, slightly micaceous; scattered plant remains on bedding planes. Nodular, maroon layer appears approximately 3.2 feet from top	18.4
Wyandotte Limestone (68.0')	
Farley Limestone member (34.0')	
14. Limestone, brownish-gray weathered, tan-gray fresh, hard, dense, resistant, fine grained, pseudo-breccia, calcite filled cavities, base covered; <i>Composita</i> , fenestrate bryozoans, and rare shell fragments	6.0
13. Limestone, yellowish-gray weathered, tan-gray fresh, hard, dense, resistant, fine grained matrix, calcite veinlets and filled cavities, medium bedded; in ditch, no fossils observed	7.2
12. Covered interval, probably limestone	2.0
11. Limestone, yellowish-gray weathered, tan-gray fresh, hard, dense, resistant, fine grained matrix, calcite veinlets and filled cavities, thin bedded, irregular bedding planes; few brachiopods and rare fusulinids	13.0

- 10. Limestone, buff to medium gray weathered, tan fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, medium bedded, base covered; *Composita*, and shell fragments. Unit is overlain by 0.3 foot yellow nodular, calcareous shale2.8

Island Creek Shale member (3.3')

- 9. Shale, medium gray and yellow fresh, mottled, non-resistant, silty, calcareous. Upper and lower contacts are covered3.3

Argentine Limestone member (22.6')

- 8. Limestone, dark gray weathered, tan-gray fresh, hard, resistant, coarse grained, pseudo-oolitic, massive, irregular upper contact; abundant crinoid stems, rare fusulinids.....7.0
- 7. Limestone, yellowish-gray weathered, medium gray to tan fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, chert nodules in upper half, medium bedded, irregular bedding surface; large crinoid stems, scattered fenestrate bryozoans..... 15.6

Quindaro Shale member (3.4')

- 6. Limestone and shale, alternating; rusty-yellow weathered, rust and medium gray fresh, mottled, hard, dense, resistant, fine grained, calcite cavity fillings, thin bedded; shell fragments, and scattered ramose bryozoan and crinoid columnials. Limestone separated by shale, yellow, chunky, weakly resistant, very silty, calcareous, contains thin limestone plates2.2
- 5. Shale, dark gray to black fresh, finely laminated, slightly calcareous; shell fragments, crinoid stems, plant remains. Grades into rusty yellow nodular, non-resistant, silty, calcareous 1.2

Frisbie Limestone member (4.7')

- 4. Limestone, buff weathered, grayish-tan fresh, resistant, fine grained matrix, pseudo-oolitic, algal, medium bedded, irregular upper surface, algae and shell fragments0.7
- 3. Limestone and shale, alternating; rust-yellow and gray weathered, grayish-brown and yellow fresh, hard, resistant, fine grained, very thin, wavy-bedded. Limestone separated by shale; yellow to green, thinly laminated, non-resistant; no fossils observed. This zone is not present continuously along the outcrop0.5

2. Limestone, yellowish-brown weathered, tan fresh, hard, dense, fine grained, calcite filled cavities, massive; scattered algae3.5

Land Shale

1. Shale, dark grayunmeasured

Locality M

Center of Sec. 26, T. 12 S., R. 23 E., Johnson County; measured on east-west road, 1.5 miles east of highway jct., Kansas 10 and 7.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (1.3' exposed)	
11. Limestone, rust-gray weathered, medium gray fresh, hard, resistant, coarse grained, massive, fossiliferous; <i>Osagia</i> , <i>Composita</i> , <i>Myalina</i> , and shell fragments.....	1.3
Bonner Springs Shale (36.0')	
10. Shale, grayish-tan weathered, yellowish-green to maroon, mottled, blocky, non-resistant, slightly micaceous, occasional thin carbonaceous zones. Yellowish-brown, "punky", nodular, limestone 3.0 feet from upper contact	7.0
9. Covered interval, probably shale and limestone	29.0
Wyandotte Limestone (43.8')	
Farley Limestone member (4.5' exposed)	
8. Limestone, yellowish-brown weathered, grayish-brown fresh, hard, dense, resistant, fine grained, calcite filled cavities and replacement brachiopods, medium to thin bedded; abundant <i>Composita</i> , rare <i>Echinochonus</i> , and fenestrate bryozoans	4.5
Island Creek Shale member (5.1')	
7. Shale, grayish-green to yellowish-green fresh, laminated, non-resistant, silty, micaceous, calcareous; plant remains at bedding planes	5.1

Argentine Limestone member (25.2')

- 6. Limestone, brownish-gray weathered, brown to gray fresh, hard, resistant, coarse grained, oolitic, algal, calcite filled cavities, massive; Osagia, abundant shell fragments in the lower unit, weathers out in a very rough surface4.2
- 5. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, medium, wavy-bedded, chert nodules in upper half; abundant crinoid stems, fenestrate bryozoans, rare brachiopods and small gastropods.....21.0

Quindaro Shale member (4.4')

- 4. Limestone and shale, alternating; medium gray and rust-yellow fresh, mottled, hard, resistant, fine grained matrix, thin, irregularly bedded; shell fragments, rare echinoid spines. Limestone separated by shale; yellow, nodular, weakly resistant, very calcareous, with crinoid stems4.4

Frisbie Limestone member (4.6')

- 3. Limestone, yellow fresh, "punky", weakly resistant, thin bedded 0.5
- 2. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, massive, irregular upper surface; rare brachiopods4.1

Lane Shale

- 1. Shale, dark gray unmeasured

Locality N

Composite section; Wyandotte Limestone and Bonner Springs Shale, Camp Creek Area, Johnson County; 3.0 miles southeast of De Soto, Kansas. Exact location given in description.

Thickness
Feet

Center Sec. 35, T. 12 S., R. 22 E., Johnson County.

Plattsburg Limestone

Merriam Limestone member

Lower limestone unit (1.2')

- 12. Limestone, brownish-gray to medium gray fresh, hard, resistant, fine grained, calcite veinlets, medium bedded. Lower 0.1 foot a yellow, coarse grained, detrital zone..... 1.2

Bonner Springs Shale (22.6')

- 11. Shale, greenish gray, blocky, non-resistant, clayey, grades into thin, calcareous zone at upper contact 1.8
- 10. Limestone, yellowish-brown weathered, reddish-brown to orange, mottled, fresh, hard, weakly resistant, porous, "punky", clay nodules, grades upwards into yellowish-green, calcareous shale 0.9
- 9. Shale, greenish-gray, platy to blocky, non-resistant, micaceous, silty at base and diminishes upwards; plant remains abundant at base, becoming less common upwards..... 14.3
- 8. Covered interval, probably shale underlain by limestone 5.6

NW¼, NW¼, NW¼, Sec. 1, T. 13 S., R. 22 E., Johnson County

Wyandotte Limestone

Farley Limestone member (14.0' exposed)

7. Limestone, yellowish-brown weathered, brown fresh, hard, resistant, fine grained, calcite replaced shell fragments, thin to medium bedded. Rubble on hill side, top covered5.0
6. Limestone, yellowish-brown weathered, tan to bluish-gray fresh, hard, dense, resistant, fine grained, calcite filled cavities, massive to medium bedded becoming thinner bedded in the upper 4.0 feet, irregular bedding planes; Composita, shell fragments, fenestrate bryozoans, crinoid stems, rare horn corals, Echinoceonous, crinoid plates, and fusulinids9.0

Island Creek Shale member (1.2')

5. Shale, black weathered, yellowish-green to greenish-gray fresh, nodular, non-resistant, silty, calcareous, micaceous. Lower 0.2 foot is a detrital zone composed of fossil fragments; ramose and fenestrate bryozoans, other shell fragments 1.2

Argentine Limestone member (29.0')

4. Limestone, yellowish-brown weathered, medium gray to brown fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, scattered chert nodules, pseudo-brecciated appearance, massive, irregular bedding planes; fenestrate bryozoans, crinoid stems, scattered shell fragments 1.4
3. Limestone, gray to yellowish-brown weathered, light gray to tan fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, massive to medium bedded, irregular bedding planes; fenestrate bryozoans, crinoid stems, scattered shell fragments, rare *Myalina* and trilobites. Near top of unit a massive, coarse grained, oolitic, bed 27.6

SE¼, NE¼, NW¼, Sec. 1, T. 13 S., R. 22 E.

2. Covered interval, probably limestone and shale (of the Quindaro Shale member).....5.0

Frisbie Limestone member (3.0')

1. Limestone, Yellowish-brown weathered, grayish-brown fresh, hard, dense, resistant, fine grained, calcite filled cavities, algal, massive; algae, and crinoid stems3.0

Locality O

NW corner of Sec. 35, T. 12 S., R. 23 E., Johnson County; measured in ditch on the south side of east-west road.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit	
9 Limestone, bluish-gray fresh, hard, resistant, coarse grained, thin bedded. Upper unit is same color, hard, dense, fine grained, calcite veinlets , massive.....	unmeasured
Bonner Springs Shale (19.1' exposed)	
8. Shale, greenish-gray fresh, chunky, silty, calcareous, with limestone plates or nodules.....	0.3
7. Limestone, yellowish-brown weathered, dark gray-brown fresh, hard, conglomeratic, thin bedded, clay and limonite fragments	0.3
6. Covered interval, probably shale.....	1.0
5. Limestone, yellowish-brown weathered, yellowish-brown and brown mottled fresh, "punky", fine grained, calcite veinlets, thin bedded, irregular bedding surface	0.8
4. Shale, dark pink weathered, maroon fresh, blocky to nodular, non-resistant. Near the upper contact is a very thin, yellow, "punky", porous, irregular limestone. Grades down into a greenish-gray, blocky shale	9.7
3. Siltstone, dark greenish-gray weathered, tan-gray fresh, weakly resistant, coarse to medium grained, quartzitic, micaceous, thin bedded	0.9
2. Siltstone, medium gray, weathered, same color fresh, hard, resistant, medium grained, slightly calcareous, micaceous, thin to very thin bedded	1.6

1. Siltstone, greenish-brown weathered, grayish-tan fresh, weakly resistant, medium to coarse grained, micaceous; plant remains on bedding planes. Base covered.....4.4

Locality P

West line of SW $\frac{1}{2}$, SW $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 26, T. 12 S., R. 22 E., Johnson County;
measured in creek bed and in ditch on the west side of north-south road.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit	
11 Limestone, bluish-gray fresh, hard, resistant, coarse grained, thin bedded.....	unmeasured
Bonner Springs Shale (29.5' exposed)	
10. Covered interval, probably shale	2.3
9. Limestone, rust-yellow weathered or fresh, "punky", weakly resistant, fine grained, calcite veinlets , irregular bedding surfaces.....	0.2
8. Shale, medium gray weathered, greenish-gray fresh, blocky to nodular, non-resistant, micaceous; plant remains on bedding planes. Grades down into yellowish-green, coarse grained micaceous siltstone	13.2
7. Siltstone, bluish-gray fresh, weakly resistant, coarse grained, micaceous, calcareous, cross bedded	0.4
6. Siltstone, greenish-brown fresh, blocky to nodular, weakly resistant, fine to medium grained, friable, micaceous	5.1
5. Siltstone, brownish-gray weathered or fresh, weakly resistant, coarse grained, micaceous, calcareous, cross bedded	2.7
4. Siltstone, greenish-brown weathered, same color fresh, non- resistant, coarse grained, friable, micaceous	1.6

Wyandotte Limestone

Farley Limestone member (20.0')

- 3. Limestone, grayish-brown weathered, orange-brown fresh, hard, dense, resistant, fine grained, calcite cavity fillings, massive, irregularly bedded; lower units lighter in color and contain more fossils. Base covered 10.0
- 2. Covered interval, probably limestone 10.0

Island Creek Shale member (4.1' exposed)

- 1. Shale, medium gray weathered, greenish-gray fresh, platy, non-resistant, silty, micaceous; very large fenestrate bryozoans found on bedding planes.....4.1

Locality Q

Center of Sec. 27, T. 12 S., R. 22 E., Johnson County; measured on east bank of Kill Creek, 0.5 mile east of De Soto, and along west side of Kill Creek Road south of Kansas Highway 10 intersection.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit	
13. Limestone, light bluish-gray fresh, hard, resistant, medium to coarse grained, thin bedded; crinoid stems and echinoid spines. Rubble, top covered	1.0
Bonner Springs Shale (30.6')	
12. Shale, greenish-tan, platy, non-resistant, calcareous, becomes nodular near top; fenestrate bryozoans, <i>Trepostira</i> , no other observed	9.5
11. Limestone, yellowish-brown weathered, brown to yellow mottled fresh, hard, weakly resistant, fine grained, calcite veinlets, thin, irregular bedded	0.1
10. Shale, yellowish-gray fresh, platy, slightly silty, calcareous; no fossils observed. Base covered	7.0
9. Covered interval, probably shale with approximately the 5.0 feet being limestone.....	14.0
Wyandotte Limestone	
Farley Limestone member (20.4' exposed)	
8. Limestone, Yellowish-gray weathered, medium gray fresh, hard, dense, resistant, fine grained, thin bedded, irregular bedding planes; crinoid stems, ramose and fenestrate bryozoans, shell fragments, and rare high spired gastropods	2.8

7. Limestone, medium gray weathered, grayish-tan fresh, hard, resistant, coarse grained, fragmental, massive; fenestrate bryozoans, rare spirifers and trilobites 1.3
6. Limestone, medium gray weathered, grayish-tan fresh, hard, resistant, coarse grained, fragmental, massive bed at base, medium bed above; abundant fenestrate bryozoans, common crinoid stems, *Punctospirifera*, few horn corals and cephalopods. Unit overlain by 0.5 foot orange-brown, “punky”, coarse grained limestone 4.8
5. Limestone, yellowish-tan weathered, light tan fresh, dense, fairly resistant, fine grained, silty, massive, irregular bedding surface; abundant fenestrate bryozoans, common *Punctospirifera*, crinoid stems, shell fragments, and rare ramose bryozoan 1.2
4. Limestone, yellowish-brown weathered, same color fresh, very rough weathered surface, fairly resistant, fine to medium grained, arenaceous, calcite filled cavities and replacement shells, thin bedded, very irregular lower bedding plane; abundant *Composita*, common fenestrate bryozoans, *Myalina*, and shell fragments. Overlies intraformational disconformity 0.0 to 0.5
3. Limestone, medium gray weathered, light gray fresh, hard, resistant, fine grained matrix, fragmental to coarse grained, calcite veinlets and filled cavities, massive, very irregular upper bedding surface; fenestrate bryozoans, crinoid stems, *Composita*, shell fragments, and rare small gastropods. Upper surface is a disconformity 3.7
2. Shale, medium gray weathered, light gray fresh, nodular, non-resistant, silty, calcareous; *Composita*. Thickness varies along outcrop. 1.0
1. Limestone, yellowish-gray weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite cavity fillings, irregular upper surface; crinoid stems, fenestrate bryozoans, shell fragments, and rare spirifers. Base Covered..... 4.6

Locality S

NW¼, SE¼, NE¼, Sec. 28, T. 12 S., R. 22 E., Johnson County; measured in abandoned quarry in northwest corner of De Soto, Kansas near bench mark 796.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (1.6' exposed)	
4. Limestone, medium gray weathered, bluish-gray fresh, hard, dense, resistant, fine grained, massive, even lower contact; <i>Myalina</i> , <i>Composita</i> and shell fragments.....	1.5 exposed
Bonner Springs Shale (1.2')	
3. Shale, greenish-gray fresh, laminated, shale 0.5 foot thick; grades into yellowish-green fresh, non-resistant, silty, slightly micaceous, shale 0.7 foot thick. In the center of the unit are found abundant clam casts.	1.4
Wyandotte Limestone	
Farley Limestone member (9.3' exposed)	
2. Limestone, brownish-gray weathered, light brown fresh, hard, dense, resistant, coarse grained, osagite, oolitic texture, massive, cross bedded; Osagia, rare small gastropods and shell fragment.....	2.0
1. Limestone, yellowish-gray weathered, medium gray fresh, hard, dense, resistant, fine grained, calcite veinlets and inclusions, massive; fenestrate bryozoans and scattered brachiopod and clam remains, rare small gastropods and horned coral.....	15.0

Locality T

NW¼, SE¼, SE¼, Sec. 28, T. 12 S., R. 22 E., Johnson County; measured on the north bank of Kill Creek and in road cut on north side of Kansas Highway 10, at De Soto, Kansas.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (3.5')	
10. Limestone, yellowish-brown weathered, light tan fresh, hard, dense, resistant, fine grained, calcite veinlets, thin bedded, upper unit separated by thin shale; crinoid stems, fenestrate bryozoans, unidentified brachiopods	3.5
Bonner Springs Shale (0.6')	
9. Shale, yellowish-brown to gray mottled fresh, laminated, non-resistant, silty, slightly micaceous; <i>Aviculopectan</i>	0.6
Wyandotte Limestone	
Farley Limestone member (34.0')	
8. Limestone, reddish-brown weathered, white to light gray fresh, hard, dense, resistant, fine grained, calcite veinlets , mottled appearance, massive, irregular surface; algae, Composita, fenestrate bryozoans	3.1
7. Covered interval, probably limestone	5.7
6. Limestone, greenish-gray weathered, yellowish-tan fresh, hard, dense, resistant, fine grained, "vuggy" honeycombed appearance, massive; fenestrate bryozoans	5.2
5. Limestone, light reddish-brown weathered, reddish-brown fresh, hard, dense, resistant, fine grained, calcite veinlets, massive to medium bedded; fenestrate bryozoans	2.6
4. Limestone, light to medium gray weathered, yellowish-tan fresh, hard, resistant, fine grained, fragmental, breccia-appearing, massive to	

- think-bedded; Composita, some spirifers, and fenestrate bryozoans9.3
- 3. Limestone, dark gray weathered, grayish-brown fresh, hard, resistant, coarse grained, calcite filled cavities, thin to medium bedded, very irregular bedding surfaces; abundant Composita, scattered crinoid stems 1.3
- 2. Shale, greenish-black to greenish-yellow, blocky, non-resistant, silty, slightly micaceous; few to common shell fragments0.6
- 1. Limestone, dark gray weathered, medium gray fresh, hard, dense, resistant, fine grained, thin to medium bedded, irregular bedding surfaces; crinoid stems, and rare echinoid spines. Base covered ..6.2

Locality U

Southwest corner of Sec. 33, T. 12 S., R. 22 E., Johnson County; measured along abandoned north-south road, approximately 50 yards west of railroad tressel, northeast corner of Sunflower Ordnance Works.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (2.0')	
11. Limestone, buff weathered, bluish-brown fresh, hard, dense, resistant, fine grained, calcite veinlets and inclusions, massive; crinoid stems	2.0
Bonner Springs Shale (49.9')	
10. Shale, greenish-tan to greenish-yellow, slightly calcareous; <i>Trepostira</i> . Interval mostly covered	16.8
9. Limestone, brownish-gray weathered, dark bluish-gray fresh, hard, dense, resistant, fine grained, small calcite filled cavities, thin bedded; few brachiopods, <i>Neospirifer</i> , and rare ramose bryozoans.....	0.8
8. Shale, greenish-yellow, non-resistant	0.5
7. Limestone, medium gray weathered, bluish-gray fresh, hard, dense, resistant, fine grained, small calcite veinlets , thin bedded; crinoid stems, and clam shells.....	0.8
6. Limestone, grayish-tan weathered, dark bluish-gray fresh, hard, resistant, coarse grained, conglomeratic, thinly cross-bedded; abundant gastropods, clam shell fragments, crinoid stems, and other fossil fragments.....	12.0
5. Shale, greenish-gray fresh, platy to thinly laminated, silty, micaceous, calcareous.....	1.2
4. Shale, light green to tan weathered, medium gray fresh, platy, weathers out fissile, silty, micaceous	17.3

Wyandotte Limestone

Farley Limestone member (18.8')

3. Limestone, gray weathered, bluish-gray fresh, hard, resistant, medium to coarse grained, slabby; *Composita*, *Enteleles*, fenestrate bryozoans, and clam shells. Bottom portion covered 16.0
2. Limestone, bluish-gray to bluish-brown, hard, dense, resistant, fine grained, calcite filled cavities, massive; *Composita*, crinoid stems, and shell fragments.....2.3
1. Shale, greenish-gray to medium gray, laminated, non-resistant; covered by stream.....0.5

Locality V

North line of NE¼, Sec. 4, T. 13 S., R. 22 E., Johnson County; measured on north side of east-west road, 0.2 mile east Kill Creek.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (3.8')	
16. Limestone, rust-brown weathered, same color fresh, hard, dense, resistant, fine grained, thin bedded; <i>Composita</i> , crinoid stems, and shell fragments.....	unmeasured
15. Shale, yellowish-green fresh, nodular, non-resistant, calcareous ..	0.3
14. Limestone, grayish-yellow weathered, yellowish-brown fresh, hard, resistant, very coarse grained, conglomeratic, thin bedded; shell fragments and limonite pebbles	3.5
Bonner Springs Shale (52.0')	
13. Shale, greenish-black to greenish-yellow, platy, non-resistant, micaceous.....	5.6
12. Sandstone, orange-yellow, weakly resistant, coarse grained, slightly calcareous, micaceous	1.0
11. Shale, greenish-tan, laminated, non-resistant, micaceous, silty; scattered plant remains.....	1.0
10. Sandstone, yellowish-brown, hard, resistant, coarse grained, slightly calcareous; few plant remains.....	1.1
9. Siltstone and shale, alternating; greenish-yellow to medium gray, very coarse grained silt, micaceous, plant remains; grades down into similar silty shale	18.5

- 8. Limestone, buff-gray weathered, reddish-blue to bluish-gray fresh, hard, resistant, coarse grained, detrital, massive units which weather out flaggy; abundant shell fragments in middle portion, coal fragments5.5
- 7. Covered interval, probably shale..... 15.5

Wyandotte Limestone

Farley Limestone member (22.9' exposed)

- 6. Limestone, grayish-tan weathered, bluish-tan fresh, hard, resistant, coarse grained, calcite veinlets and inclusions, massive; fenestrate bryozoans, unidentified brachiopods., rare cephalopods and shell fragments. Top covered6.0
- 5. Covered interval, probably limestone 7.8
- 4. Limestone, yellowish-brown weathered, bluish-tan fresh, hard, dense, resistant, fine grained, thin bedded; crinoid stems, rare cephalopods and questionable brachiopods. Limestone separated by very thin shale; yellowish-brown, silty, calcareous.....4.3
- 3. Limestone, dark gray weathered, medium bluish-gray fresh, hard, dense, resistant, fine grained, massive.....2.3
- 2. Shale, yellowish-brown, nodular, non-resistant, calcareous 0.5
- 1. Limestone, dark gray weathered, brown to tan mottled fresh, hard, resistant, fine grained, calcite veinlets and cavity fillings, thin bedded; shell fragments. Base covered..... 1.9

Locality W

NE¼, SE¼, NW¼, Sec. 9, T. 13 S., R. 22 E., Johnson County; measured at the south end of the main Sunflower Quarry.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (2.5')	
7. Limestone, brown weathered, bluish-gray fresh, hard, resistant, medium grained, osagite, massive; <i>Osagia</i> , <i>Composita</i> , <i>Myalina</i> , and crinoid stems.....	2.5
Bonner Springs Shale (25.0')	
6. Shale, grayish-tan weathered, medium gray to greenish-gray fresh, blocky to laminated, non-resistant, slightly calcareous; grades into maroon, nodular to blocky, slightly calcareous zone, which in turn grades into a greenish, blocky, shale. A poorly consolidated, nodular, limy stringer appears approximately 2.0 feet from the upper contact	25.0
Wyandotte Limestone (58.9' exposed)	
Farley Limestone member (25.3')	
5. Limestone, buff to brown weathered, brown to bluish-brown fresh, hard, dense, resistant, fine grained, calcite veinlets, massive, uneven upper surface, upper units appear to be mottled or pseudo-brecciated; <i>Composita</i> , and fenestrate bryozoans. Lower unit is dark gray, sub-conglomeratic, fragments encrusted by algae, abundant shell fragments	13.0
4. Shale, medium gray fresh, laminated, non-resistant, nodules present near top, abundant secondary limonite	3.0
3. Limestone, brownish-gray weathered, medium to light tan fresh, hard, dense, resistant, fine grained, abundant shell fragments in lower unit, massive; <i>Composita</i> , fenestrate bryozoans, and large crinoids	9.3

Island Creek Shale member (1.0')

2. Shale, medium gray fresh, laminated, non-resistant, slightly micaceous; fenestrate bryozoans 1.0

Argentine Limestone member (32.6')

1. Limestone, buff to light tan weathered, medium to light gray fresh, hard, dense, resistant, fine grained, calcite veinlets, chert nodules in middle portion, thin to medium bedded; *Echinoconcous*, *Dictyoclostus*, other brachiopods, large crinoid stems, and fenestrate bryozoans. Upper two beds are medium gray, coarse grained, detrital, shell fragments in abundance. Base is covered. 32.6

Locality X

SE¼, NW¼, NW¼, Sec. 9, T. 13 S., R. 22 E., Johnson County; measured in small, abandoned quarry north of the main Sunflower Quarry. Argentine Limestone member of the Wyandotte Limestone measured at the south end of quarry, all other units measured at the north end.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit (2.3' expose)	
9. Limestone, yellowish-brown weathered, reddish-brown fresh, hard, dense, resistant, fine to medium grained, massive; <i>Composita</i> , <i>Myalina</i> , <i>Osagia</i> , shell fragments and crinoid stems	2.3
Bonner Springs Shale (8.2)	
8. Shale, yellowish-gray to medium gray, platy, micaceous; scattered plant remains	2.0
7. Siltstone, bluish-gray fresh, weakly resistant, coarse grained, calcareous, micaceous	0.6
6. Shale, yellowish to medium gray fresh, blocky, non-resistant; grades into unit 7. Lower 0.2 foot composed of thin, coarse grained, shale; with a poor coal at contact with unit 5.	5.6
Wyandotte Limestone (44.4' exposed)	
Farley Limestone member (35.0')	
5. Limestone, medium gray to buff weathered, bluish-gray to tan fresh, hard, dense, resistant, medium to fine grained, arenaceous, massive; <i>Aviculopincia</i> , scattered gastropods, crinoid stems	5.0

4. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, shell fragments and calcite veinlets, thin bedded; *Myalina*, crinoid stems, echinoid spines, fenestrate bryozoans, *Composita*, and other brachiopods. Units separated by dark gray, fine grained, silty, mortar of fossil fragments..... 15.0

3. Limestone, medium gray weathered, dove gray fresh, hard, dense, resistant, fine grained, shell fragments and calcite veinlets and filled cavities, medium to thin bedded, rare chert nodules in lower beds; *Myalina*, *Composita*, *Dictyoclostus*, fenestrate bryozoans, shell fragments, few crinoid stems, rare fusulinids and horn corals. Upper beds separated by dark gray, silty, mortar-like shale which contains large fossil fragments..... 15.0

Island Creek Shale member (0.4')

2. Shale, dark gray to black, laminated, non-resistant, slightly silty, calcareous; shell fragments, crinoid columnals. Limy plates near upper contact.0.4

Argentine Limestone member (9.0' exposed)

1. Limestone, light gray weathered, dark gray and tan fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, massive, pseudo-brecciated appearance; shell fragments, fenestrate bryozoans, and rare gastropods. Base covered.....9.0

Locality Y

NE¼, NE¼, Sec. 32, T. 13 S., R. 23 E., Johnson County; measured along the north side of the New Olathe Lake spillway, 2.2 miles west of Olathe, Kansas.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit	
13. Limestone, rubble and float on hillside	unmeasured
Bonner Springs Shale (28.0')	
12. Covered, small bench just below proposed Merriam suggests thin limestone unit.....	28.0
Wyandotte Limestone (57.1')	
Farley Limestone member (23.0')	
11. Limestone, buff weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets , thin bedded, irregular surfaces; <i>Composita</i> , and other brachiopods, clam shell fragments, echinoid spines.....	10.0
10. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, massive to thick bedded, upper surface is very irregular; <i>Composita</i> and fenestrate bryozoans. Stylolites are found in the upper massive units	13.0
Island Creek Shale member (0.9')	
9. Shale, medium blue-gray weathered, black fresh, blocky, silty to arenaceous, slightly calcareous; detrital fossil fragments	0.9

Argentine Limestone member (31.1')

- 8. Limestone, medium gray weathered, light gray fresh, hard, dense, resistant, fine grained, calcite veinlets and filled cavities, scattered small chert nodules, thin bedded, irregular bedding planes; Composita, shell fragments, crinoid stems, and fenestrate bryozoans. Gray and blue-gray mottled, pseudo-brecciated appearance in upper 3.0 feet. Very detrital, coarse grained, fossil fragmental zone, which varies in thickness and stratigraphic position7.0
- 7. Limestone, tan weathered, tanish-gray fresh, hard, resistant, coarse grained, massive, irregular bedding planes; shell fragments of brachiopods and clams2.1
- 6. Limestone, light gray weathered, medium bluish-gray fresh, hard, dense, resistant, fine grained, thin to medium bedded, irregular bedding planes; crinoid stems, brachiopod shell fragments, rare horn corals2.0
- 5. Covered interval, probably limestone 6.0
- 4. Limestone, light gray weathered, medium bluish-gray fresh, hard, dense, resistant, fine grained, massive near base becoming thin bedded in the upper portion, irregular upper bedding surface; brachiopod shell fragments, and crinoid stems. Lower 3.0 feet appears slightly arenaceous while the upper 7.0 feet has a mottled appearance 14.0

Quindaro Shale member (0.3')

- 3. Shale, light gray weathered, brownish-black fresh, non-resistant, coarse fossil fragments, calcareous.....0.3

Frisbie Limestone member (1.9')

- 2. Limestone, buff tan weathered, brownish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets, massive, very irregular upper surface; crinoid stems, algal appearing material, brachiopod shell fragments. Locally there are highs on the upper surface over which the Quindaro Shale thins or pinches out..... 1.9

Lane Shale

- 1. Shale, dark gray unmeasured

Locality Z

NE¼, SE¼, Sec. 29, T. 11 S., R. 25 E., Wyandotte County; measured in road cut along east side of the new Eighteenth Street Expressway, 0.25 mile north of Steele Road exit. Farley Limestone and younger beds were measured in an abandoned quarry at SW¼, NW¼, NE¼ of the same section.

	Thickness Feet
Plattsburg Limestone	
Merriam Limestone member	
Lower limestone unit	
14. Limestone, yellowish-brown weathered, same fresh, hard, dense, fine grained. Rubble on hill top	unmeasured
Bonner Springs Shale (25.0')	
13. Covered interval probably shale	26.0
Wyandotte Limestone (71.4')	
Farley Limestone member (22.6')	
12. Limestone, medium gray weathered, reddish-gray fresh, hard, dense, resistant, coarse grained "osagite", massive, very irregular upper surface; <i>Osagia</i> , abundant productids at base (<i>Dictyoclostus</i>), scattered crinoid stems, and shell fragments.....	2.9
11. Shale, yellowish-gray weathered, brownish-gray fresh, platy, non-resistant, slightly silty, slightly micaceous; plant remains. Very thin platy limestone about 2.8 feet from top. Base covered.....	7.6
10. Limestone, medium gray weathered, light gray to reddish-gray fresh, hard, resistant, coarse grained, oolitic to sub-oolitic, massive, cross-bedded; <i>Osagia</i> , fenestrate bryozoans, rare crinoid stems, shell fragments	12.1

Island Creek Shale member (8.2')

9. Shale, medium gray weathered, dark gray fresh, laminated, weakly resistant, silty, slightly micaceous, varved appearance; no fossils found2.4
8. Shale, light gray weathered, medium gray fresh, platy, weakly resistant, silty, micaceous; crinoid stems, shell fragments, *Composita*, fenestrate bryozoans, *Punctospirifer*, and crinoid plates5.8

Argentine Limestone member (31.3')

7. Limestone, buff weathered, medium and dark gray mottled fresh, hard, dense, resistant, calcite veinlets, algal, fine grained, massive, irregular bedding; *Composita*, Algae4.6
6. Limestone, buff to gray mottled weathered, medium gray fresh, hard, dense, resistant, calcite veinlets, medium to massive bedded, irregular surface; large *Composita*, *Dictoclostus*, crinoid stems, fenestrate bryozoans, sparse brachiopods20.3
5. Limestone, dark gray weathered, same fresh, hard, dense, resistant, medium grained, sandy to silty, massive, weathers out platy, irregular contacts; *Composita*.....6.4

Argentine Limestone-Quindaro Shale member Interval (8.5')

4. Limestone, yellowish-brown weathered, dark bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, thin to massive bedded; crinoid stems, scattered brachiopod shells — grades into unit 58.2
3. Shale, dark gray to black, nodular, silty, no fossils found, just fragments0.3

Frisbie Limestone member (0.8')

2. Limestone, dark bluish-gray fresh, hard, dense, resistant, fine grained, calcite veinlets and cavity fillings, medium bedded, irregular contacts; "Ottonosia-like" algae, *Marginifera*, and shell fragments.....0.8

Lane Shale

1. Shale, dark gray, finely laminated, clayey unmeasured