Geology of Franklin County, Kansas

By Stanton M. Ball, Mahlon M. Ball, and Dwight J. Laughlin

STATE GEOLOGICAL SURVEY OF KANSAS

BULLETIN 163

1889
STATE GEOLOGICAL SURVEY of KANSAS

THE UNIVERSITY OF KANSAS
LAWRENCE, KANSAS - 1963

STATE GEOLOGICAL SURVEY of KANSAS 1889

BULLETIN 163

Geology of Franklin County, Kansas

By Stanton M. Ball, Mahlon M. Ball, and Dwight J. Laughlin

Printed by authority of the State of Kansas
Distributed from Lawrence

UNIVERSITY OF KANSAS PUBLICATIONS
JUNE 1963

CONTENTS

	PAGE
Abstract	3
Introduction	6
Location and area	6
Previous work	6
Methods of investigation	6
Acknowledgments	6
Stratigraphy	6
General	6
Pennsylvanian System—Missourian Stage	7
Kansas City Group—Linn Subgroup	7
Chanute Shale	7
Iola Limestone	7
Paola Limestone Member	7
Muncie Creek Shale Member	8
Raytown Limestone Member	8
Kansas City Group—Zarah Subgroup	8
Lane Shale	8
Wyandotte Limestone	8
Frisbie Limestone Member	10
Argentine Limestone Member	10
Island Creek Shale Member	12
Farley Limestone Member	12
Bonner Springs Shale	12
Lansing Group	12
Plattsburg Limestone	12
Merriam Limestone Member	13
Hickory Creek Shale Member	13
Spring Hill Limestone Member	14
Vilas Shale	18
Stanton Limestone	18
Captain Creek Limestone Member	20
Eudora Shale Member	20
Stoner Limestone Member	20
Rock Lake Shale Member	22
South Bend Limestone Member	22
Pedee Group	22
Weston Shale	22
Pennsylvanian System—Virgilian Stage	23
Douglas Group	23
Stranger Formation	23
Tonganoxie Sandstone Member	23
Westphalia Limestone Member	25
Vinland Shale Member	25
Haskell Limestone Member	27
Robbins Shale Member	27
Lawrence Shale	28
Ireland Sandstone Member	28
Upper part of Lawrence Shale	30
Shawnee Group	32
Oread Limestone	32
Toronto Limestone Member	32
Snyderville Shale Member	34
Leavenworth Limestone Member	34
Heebner Shale Member	34
Plattsmouth Limestone Member	34
Heumader Shale Member	35
Kereford Limestone Member	36
Kanwaka Shale	36
Jackson Park Shale Member	36
Clay Creek Limestone Member	36
Stull Shale Member	36
Lecompton Limestone	36
Spring Branch Limestone Member	36
Doniphan Shale Member	37
Neogene System	37
High-level stream deposits	37
Younger alluvium	37
Structural geology	37
Regional structure	37
Faulting	37
Coal "conglomerate"	38
Economic geology	40
Ground water	40
Oil and gas	40
Limestone, sandstone, and gravel	40
Coal	40
Shale	40
Stratigraphic sections	41
References	56

ILLUSTRATIONS

PLATE	PAGE
1. Geologic map of Franklin County, Kansas.	(pocket)
2. Correlated stratigraphic sections in Franklin County, Kansas.	(pocket)
3. Argentine Limestone. A, Massive osagite. B, Nodular chert.	11
4. A, *Composita*-myalinid zone in Merriam Limestone. B, "Worm-eaten" surface of Merriam Limestone. C, Cross-stratified Merriam Limestone.	15
5. Microlithology of middle unit of Merriam Limestone.	17
6. Spring Hill Limestone. A, *Composita* zone. B, Peel print of clam concentration.	19
7. A, Even-bedded Captain Creek Limestone. B, Disconformable contact between Stoner Limestone and Rock Lake Shale.	21
8. Microlithology of Tonganoxie Sandstone.	24
9. Plant fossils from Tonganoxie Sandstone.	26
10. A, Disconformity at base of Ireland Sandstone. B, Cross-stratified Ireland Sandstone.	31
11. A, Atypical Toronto Limestone. B, Coal seam in Snyderville Shale.	33
12. A, Tilted sandstone beds of Lawrence Shale. B, Coal "conglomerate" in Ireland Sandstone.	39

FIGURE	PAGE
1. Index map of Kansas showing Franklin County.	6
2. Thickness map of Wyandotte Limestone.	9
3. Sequence, thickness, and lithology of units of the Merriam Limestone.	14
4. Map of surface distribution of middle unit of Merriam Limestone.	16
5. Composite sequence of lithologies of Spring Hill Limestone.	18
6. Columnar section of uppermost Missourian and lowermost Virgilian rocks.	23
7. Map of subsurface distribution of Haskell Limestone.	28
8. Size analyses of Ireland Sandstone.	29
9. Map of southern Douglas County and northern Franklin County showing distribution of Toronto Limestone and locations of stratigraphic anomalies in Oread Limestone members.	35

STANTON M. BALL
MAHLON M. BALL *Shell Oil Company, Coral Gables, Florida*
DWIGHT J. LAUGHLIN *Continental Oil Company, Los Angeles, California*

Geology of Franklin County, Kansas

ABSTRACT

Rocks exposed in Franklin County have an aggregate thickness of about 700 feet and all are sedimentary. Bedrock of Late Pennsylvanian (Missourian and Virgilian) age comprises mostly shale, sandstone, limestone, and siltstone; the section extends from the Chanute Shale at the base to the Doniphan Shale Member of the Lecompton Limestone at the top. These strata are nearly flat lying; dips approximate 10 to 30 feet per mile.

Lateral continuity of thin stratigraphic units is characteristic although the Wyandotte Limestone formation, absent in the western half of the county, and the locally absent Toronto Limestone, Snyderville Shale, and Leavenworth Limestone Members of the Oread Limestone are exceptions. Facies change is thought to have been the causative factor in the former case, that of the Wyandotte Limestone, whereas faulting and erosion were probably principal causes in the latter case. Most of the bedrock represents sediment deposited in marine and marine-nonmarine, or mixed, environments. Surficial deposits of Neogene age comprise mostly alluvium and loess and are exclusively nonmarine.

Franklin County lies within the Forest City Basin. Strata exposed in the county are a small part of the Prairie Plains Monocline, which dips westwardly and northwestwardly away from the Ozark Dome area of Missouri. Numerous local and minor flexures are superimposed on the regional structure. Faulting is uncommon, but two faults affecting the upper part of the Lawrence Shale, the Oread Limestone, and the lower part of the Kanwaka Shale, were mapped in the northwest part of the county. Vertical displacement ranges from approximately 15 to 40 feet. Tracing of the faults is possible only for distances of about a mile; the trend of fault traces ranges from generally north-south to generally northeast-southwest. A coal "conglomerate" thought previously to be largely the result of erosion and redeposition is attributed herein to structural phenomena.

Alluvial deposits in the Marais des Cygnes and Pottawatomie River valleys yield large supplies of ground water and constitute the most important aquifers in the area. Bedrock aquifers are scant in eastern Franklin County but Douglas Group sandstone beds are commonly suitable aquifers in western Franklin County. Oil, limestone, sand and gravel, coal, and shale are other mineral resources exploited in Franklin County.

Data upon which the report is based include about 200 well logs, logs of 2 test holes, and records of 100 measured sections.

Résumé: Les roches exposées en Franklin County ont une épaisseur agrégée de 210 mètres approximativement, et toutes ces roches sont sédimentaires. La roche de fond de l'âge Late Pennsylvanian (Missourian et Virgilian) comprend principalement schiste, grès, calcaire, et "siltstone"; l'aire s'étend du Chanute Shale à la base au Doniphan Shale Member du Lecompton Limestone au toit. Ces couches reposent à peu près plates; les inclinaisons se trouvent de 2 à 6 mètres approximativement, le kilomètre.

La continuité latérale d'unités stratigraphique minces est caractéristique quoique la formation Wyandotte Limestone, absente dans la moitié Ouest du county, et le Toronto Limestone, le Snyderville Shale, et le Leavenworth Limestone Members du Oread Limestone, qui ne se trouvent pas localement, sont des exceptions. On croit que le changement des faciès a été le facteur causatif dans le cas précédent, celui du Oread Limestone, tandis que la faille des couches l'érosion étaient probablement les causes principales dans le cas dernier. La plupart de la roche du fond représente le sédiment déposé dans les environnements marins et non marins, ou mêlés. Les dépôts subaériens de l'âge Néogène comprend pour la plupart l'alluvion et le loess et sont exclusivement non marins.

Le Franklin County se trouve dans le Forest City Basin. Les couches exposées dans le county, sont une petite partie du Prairie Plains Monocline, qui incline vers l'Ouest et le Nord-Ouest à distance du Ozark Dome de Missouri. Des flexures mineures, qui sont numéreuses et locales, sont surimposées sur la structure régionale. La faille des couches n'est pas commune, mais deux failles, affectant la partie supérieure Lawrence Shale, le Oread Limestone, et la partie inférieure du Kanwaka Shale étaient tracées dans la partie Nord-Ouest du Franklin County. Le déplacement vertical varie d'approximativement 4, 5 à 12 mètres. Il n'est possible de tracer les failles que pour les distances de près de 2 kilomètres; la direction des traces de faille varie de Nord-Sud en général à Nord-Est Sud-Ouest en général. Un conglomérat de houille qu'autrefois on a cru être pour la plupart le résultat d'érosion et de matière redéposée, on attribue ici aux phénomènes structuraux.

Les dépôts alluviens dans les vallées du Marais des Cygnes River et du Pottawatomie River produisent de grandes quantités de nappe superficielle et constituent les nappes aquifères de la plus grande importance de l'aire. Les nappes aquifères de roche de fond sont modiques dans l'Est de Franklin County mais les couches de grès du Douglas Group sont souvent des nappes aquifères convenables dans l'Ouest de Franklin County.

Les données sur lesquelles on base ce rapport comprennent à peu près 200 journaux de sondages, les journaux de 2 sondages d'essai, et les notes de 100 sections mesurées.

Resumen: Las rocas expuestas en Franklin County son todas sedimentarias y tienen un espesor agregado de cerca de 210 metros. La roca sólida de edad del Late Pennsylvanian (Missourian y Virgilian) se compone mayormente de lutitas, areniscas, calizas, y limolitas; la sección se extiende desde el Chanute Shale en la base, hasta el Doniphan Shale miembro de la Lecompton Limestone en la parte superior. Estos estratos están casi horizontales; con echados (buzamientos) de aproximadamente 2 a 6 metros por kilómetro.

La continuidad lateral de las unidades estratigráficas delgadas es característica, aunque hay excepciones tales como la formación Wyandotte Limestone, ausente en la parte occidental del distrito, y los miembros Toronto Limestone, Snyderville Shale, y Leavenworth Limestone de la formación Oread Limestone ausentes localmente. Cambio de facies parece ser el factor causante en el caso de la Wyandotte Limestone, mientras que fallas y erosión son probablemente las causas principales en el caso de la Oread Limestone. Casi toda la roca sólida representa sedimentos depositados en ambientes marinos, y marinos y no-marinos mezclados. Depósitos superficiales de edad Neógene se componen principalmente de aluviones y loess que son exclusivamente continentales.

El Franklin County está localizado en la Forest City Basin. Los estratos expuestos en el county son una porción pequeña de la Prairie Plains Monocline, que se inclina hacia el oeste y noroeste de la área del Ozark Dome de Missouri. Pliegues numerosos, locales y sin significado, están sobrepuestos en la estructura regional. El fallamiento es raro, pero dos fallas que afectan la parte superior de el Lawrence Shale, la Oread Limestone, y la parte inferior de el Kanwaka Shale, fueron delineadas en el mapa de la parte noroeste de el county. El desplazamiento vertical de las fallas es aproximadamente de 4.5 a 12 metros. Trazamiento de las fallas es posible solamente por distancias de aproximadamente unos 2 kiometros. La orientación de las líneas de fallas es generalmente norte-sur a noreste-suroeste. Un "conglomerado" de carbón, que se creyó previamente ser mayormente el resultado de erosión y deposición subsiguiente, es atribuído en este informe a un fenómeno estructural.

Los depósitos aluviales en los valles de los Marais des Cygnes y Pottawatomie Rivers producen grandes cantidades de agua subterránea. Estos depósitos aluviales son los acuíferos más importantes en la región. Acuíferos en roca sólida son escasos en la parte oriental de el Franklin County, pero los estratos areniscos de el Douglas Group son frecuentemente acuíferos satisfactorios en la parte occidental de el Franklin County. Otros recursos minerales que se explotan en el county son petróleo, piedra de cal, arena y cascajo, carbón de piedra, y lutita.

Los datos en los cuales este reporte está basado incluyen cerca de 200 perfiles de sondeo de pozos de petróleo y de 2 pozos de prueba, y records de 100 secciones estratigráficas.

Zusammenfassung: Gesteine, die im Franklin County zutage treten, haben eine gesamte Dicke von ungefähr 210 Metern und sind durchweg sedimentären Ursprungs. Bodengestein aus dem Late Pennsylvanian (Missourian und Virgilian) Alter besteht zumeist aus Schieferton, Sandstein, Kalk und Schlammgestein; die Schichtenfolge geht vom Chanute Shale an der Basis bis zum Doniphan Shale Member des Lecompton Limestone. Diese Schichten liegen fast flach; Neigungen ungefähr zwei bis sechs Meter pro Kilometer.

Seitliche Kontinuität dünner stratigraphischer Einheiten ist charakteristisch, wiewohl die Wyandotte Limestone formation, die in der westlichen Hälfte des County nicht auftritt, und die örtlich fehlenden Toronto Limestone, Snyderville Shale und Leavenworth Limestone Members des Oread Limestone Ausnahmen bilden. Es wird angenommen, dass Facie veränderungen der Anlass dafür im ersteren Fall, dem des Wyandotte Limestone, waren, wohingegen Verwerfung und Erosion wahrscheinlich die Hauptursache im letzteren Fall gewesen sind. Der Grossteil des Bodengestein besteht aus Sediment, das in mariner und mariner-nichtmariner oder gemischter Umgebung abgelagert wurde. Oberflächenablagerungen Neogene Alters umfassen grossenteils Alluvium und Löss und sind ausnahmslos nichtmarin.

Franklin County liegt im Forest City Basin. Schichten, die im County auftreten, sind ein kleiner Teil des Prairie Plains Monocline, das sich von der Ozark Dome-Gegend in Missouri nach Westen und Nordwesten neigt. Zahlreiche örtliche und kleinere Flexuren sind der regionalen Struktur übergelagert. Verwerfung stellt eine Ausnahme dar, jedoch wurden zwei Verwerfungen im nordwestlichen Teil des County aufgenommen, die den oberen Teil des Lawrence Shale, den Oread Limestone, und den unteren Teil des Kanwaka Shale beeinflussen. Vertikale Versetzung beträgt ungefähr 45 bis 12 Meter. Verfolgung von Verwerfungen ist nur auf eine Entfernung von ungefähr 2 Kilometern möglich; der Trend der Verwerfungsspuren geht von generell Nord-Süd bis generell Nordost-Südwest. Ein Kohle-"Konglomerat", von dem früher angenommen wurde, es sei das Ergebnis von Erosion und Wiederablagerung, wird hier strukturellen Phänomenen zugeschrieben.

Alluviale Ablagerungen in den Tälern des Marais des Cygnes und des Pottawatomie Rivers liefern sehr viel Grundwasser und stellen die bedeutendsten Wasserträger der Gegend dar. Untergrund-Wasserträger sind rar in Ost-Franklin County, doch sind in West-Franklin County Sandsteinbetten der Douglas Group gewöhnlich gute Wasserträger. Öl, Kalkstein, Sand und Kies, Kohle und Schiefer sind im Franklin County ausgebeutete Mineralvorkommen.

Daten, auf die sich der Bericht stützt, umschliessen ungefähr 200 Brunnenvermessungen, Vermessungen von zwei Testlöchern und Berichte von 100 vermessenen Schichtenfolgen.

INTRODUCTION

Location and Area

Franklin County, which extends from about lat 38°7′N to lat 38°44′N and from about long 95°4′W to long 95°31′W, includes a nearly square area of 576 square miles. It is bounded on the north by Douglas County, on the east by Miami County, on the south by Anderson County, and on the west by Osage and Coffey Counties (Fig. 1).

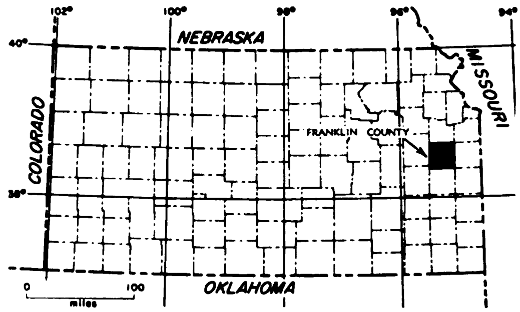


Figure 1.—Index map of Kansas showing the location of Franklin County.

Previous Work

Many geologists have contributed to the understanding of the geology of Franklin County. Only the works particularly pertinent to this study are cited here. J. L. Rich (1933a, 1933b) described local structural and stratigraphic relationships of Douglas and Oread rocks near Baldwin in southeastern Douglas County and near Pamona in northwestern Franklin County. Coal resources of the Douglas Group were comprehensively studied by A. L. Bowsher and J. M. Jewett (1943), and their report includes excellent stratigraphic descriptions. Geologic maps of Douglas, Miami, and Osage Counties, prepared by H. G. O'Connor (1960), N. D. Newell (1935), and H. G. O'Connor (O'Connor and others, 1955), respectively, were utilized in this study along the boundaries of Franklin County. The most detailed account of oil and gas resources in Franklin County appears in a report by J. M. Jewett (1954). Soils of Franklin County were described and mapped by R. C. Dunmire and others (1946); their soils map was utilized in placement of dashed contact lines on the geologic map. The authors also consulted reports by R. C. Moore (1936) and Moore and others (1951), which include classification and description of Kansas strata, as well as unpublished data collected by several members of the State Geological Survey of Kansas. Particularly useful were measured sections by W. B. Hladik, J. M. Jewett, R. C. Moore, H. G. O'Connor, and Norman Plummer, and a reconnaissance geologic map and sections by N. D. Newell.

Methods of Investigation

During the summer of 1956 and in shorter periods between October 1956 and June 1957 details of the stratigraphy were studied and areal geologic maps were prepared by the authors. Rocks in the eastern half of the county, in the southwestern quarter, and in the northwestern quarter were mapped by Stanton M. Ball, Mahlon M. Ball, and Dwight J. Laughlin, respectively. Additional field studies were made by S. M. Ball and H. A. Mendoza during August and September 1958.

The areal geology of the county was mapped on aerial photographs (scale 1:20,000) and transferred by means of a Focalmatic desk projector to a base map (scale 1:40,000) adapted from a U. S. Soil Conservation Service drainage and base map. Corrections for distortion due to parallax and tilt were judged to be unnecessary because of the area's low relief and because of the quality of the photographs.

In November 1957, test holes were drilled with a portable hydraulic-rotary drilling machine owned by the State Geological Survey and operated by E. L. Reavis and William Gellinger.

Acknowledgments

The authors are grateful for the suggestions and criticisms made by J. M. Jewett, who, as supervisor of this project, has contributed to the report in many ways. H. A. Ireland and Walter Youngquist guided The University of Kansas graduate study during which a part of the data was collected. Several other geologists, especially H. G. O'Connor, shared their knowledge of the stratigraphy of eastern Kansas. Throughout the work the cooperation of Franklin County residents was of great assistance to the authors.

STRATIGRAPHY

General

The following discussion of subsurface rocks in Franklin County is abstracted from Lee (1943) and Jewett (1954).

Sedimentary rocks of Pennsylvanian and

older Paleozoic age and of Cenozoic age underlie Franklin County. Cambrian rocks comprise the Lamotte Sandstone, Bonneterre Dolomite, and Eminence Dolomite (lower part of the Arbuckle Group), and range in thickness from approximately 150 feet in the southwestern part of Franklin County to 260 feet in the northeast. Ordovician strata include the upper part of the Arbuckle Group, St. Peter Sandstone, Platteville Formation, and Viola Limestone; and they range in thickness from approximately 435 to 705 feet. A maximum of slightly less than 100 feet of limestone and dolomite is included in the "Hunton" Group, which in Franklin County is thought to be Devonian in age but which may contain some undifferentiated Silurian strata. The Chattanooga Shale, Devonian or Mississippian in age, is believed to underlie all of Franklin County and is about 50 feet thick. Mississippian rocks in Franklin County are almost exclusively limestone and range from slightly less than 250 to 400 feet in thickness. The subsurface Pennsylvanian section has an aggregate thickness of approximately 900 feet and consists of shale, sandstone, limestone, and coal.

Extensive erosion surfaces within the subsurface section include the sub-Paleozoic surface, sub-Chattanooga surface, and sub-Pennsylvanian surface. Numerous intrasystemic unconformities are firmly documented or suspected.

Upper Pennsylvanian rocks cropping out in Franklin County are approximately 700 feet thick. Neogene surficial deposits include floodplain and terrace alluvium along the streams, river-laid chert gravels locally on the upland areas, and soils, which mantle broad upland bedrock areas to a depth of 3 feet or less.

Exposed bedrock in Franklin County is exclusively sedimentary. About 70 percent of the outcropping pre-Neogene rocks consists mainly of shale and sandstone but includes lesser amounts of claystone, siltstone, and coal; the other 30 percent is marine limestone that probably formed in shallow water (Moore, 1929). Fossils, physical aspects of lithology, and what is known of the dimensions and shapes of the stratigraphic units indicate that most of the noncarbonate rocks were deposited in marine and mixed environments. Mixed environments (Dunbar and Rodgers, 1957, p. 67) are defined as those environments transitional between the marine and nonmarine. Some of the terrigenous detritus represents nonmarine deposits.

Salient features of the strata exposed in the county, excepting Douglas Group rocks, are: (1) continuity of the individual stratigraphic units, (2) lack of marked lateral variation in lithology, and (3) vertical sequences of strata in which rock types are repeated in the same relative order, which Moore (1936, p. 29) has termed megacyclothems. Of the 17 stratigraphic units mapped (Pl. 1), 11 have continuous lines of outcrop and 9 are known to be essentially continuous in the subsurface. Even many of the individual members are continuous. Shale and sandstone units show the greatest thickness ranges; limestone and black fissile shale show the least.

Relation of bedrock to topography is well shown by generally east-facing escarpments of relatively resistant limestone which are separated by gently sloping plains developed on less resistant shale. The regional landform which includes Franklin County is called the Osage Plains (Schoewe, 1949, p. 280). The present stream pattern of Franklin County is thought to have evolved during Pleistocene time from a generally southwestward-flowing to a generally eastward-flowing drainage (Frye and Leonard, 1952, p. 194-195).

PENNSYLVANIAN SYSTEM-MISSOURIAN STAGE

Kansas City Group-Linn Subgroup

CHANUTE SHALE

The upper part of the Chanute Shale (Haworth and Kirk, 1894, p. 109) is the oldest bedrock exposed in Franklin County, but its outcrop area is so small as to preclude mapping. Only one outcrop (SW¼ SW¼ SE¼ sec. 27, T. 17 S., R. 21 E.) was found. Approximately the upper 10 feet of the formation is exposed on the outside of a meander along the Marais des Cygnes River. Moderate-brown silty shale, containing plant remains and a 0.1-foot coal streak, grades upward into medium-gray clayey shale.

IOLA LIMESTONE

The main area of Iola outcrops is in the vicinity of Lane (Pl. 1), and there only the upper part of the formation, an incomplete thickness of the Raytown Limestone Member, is exposed. Successively older Iola members, Muncie Creek Shale and Paola Limestone, apparently crop out at only one locality (SW¼ SW¼ SE¼ sec. 27, T. 17 S., R. 21 E.) A three-fold division of the Iola Limestone is recognized throughout the county in drillers logs.

PAOLA LIMESTONE MEMBER.—In its only known exposure the Paola Limestone (Newell, *in* Moore, 1932, p. 92) is a light-gray, vertically jointed ledge devoid of shale breaks or partings and about 2.5 feet thick. The uniformly microcrystalline matrix contains randomly distributed fossils, including brachiopod, crinoid, and algae remains. Irregular tubules filled with argillaceous limestone occur in the uppermost 0.2 to 0.3 foot of the unit and may represent worm borings. Surfaces of the member are relatively even and contacts with adjacent shale are relatively sharp.

MUNCIE CREEK SHALE MEMBER.—The Muncie Creek Shale (Newell, *in* Moore, 1932, p. 92), as seen in only one exposure, is light-olive-green silty shale. No black fissile shale occurs but phosphatic nodules are present. Commonly the Muncie Creek is chiefly black fissile shale and is recorded as such in some of the drillers logs. The thickness of the member is about 0.5 foot.

RAYTOWN LIMESTONE MEMBER.—The Raytown Limestone (Hinds and Greene, 1915, p. 27) is the upper member of the Iola Limestone. The best exposure of the Raytown in Franklin County is along a small tributary to Pottawatomie Creek, and a section measured there is given below.

Measured section of the Iola Limestone in NW¼ SE¼ SW¼ sec. 34, T. 18 S., R. 21 E.

	Thickness, feet
Lane Shale (not exposed)	
Iola Limestone	
Raytown Limestone Member	
Limestone, light gray, thin to thick bedded and wavy bedded, shale partings along bedding surfaces, fine grained, compact; *Punctospirifer*, productid brachiopods, fenestrate bryozoans, horn corals, crinoid columnals, echinoid spines; member contacts concealed; thickness exposed	9.5
Muncie Creek Shale Member (not exposed)	

The thickness of individual beds ranges from 2 inches to 2 feet but is rarely more than 6 inches. Relief on bedding planes of about 0.2 foot in a lateral distance of 1 foot is common and, in general, thicker parts of a bed are vertically contiguous with thinner parts of adjoining beds. Discontinuous shale partings separate some of the beds. Shell fragments in the fine-grained matrix weather into relief and are visible in cross section on fresh surfaces of the limestone. Since both lower and upper contacts of the unit are concealed, complete thickness of the member was not measured. Drillers logs indicate a thickness range of 8 to 11 feet in the subsurface.

Kansas City Group-Zarah Subgroup

LANE SHALE

The Lane Shale (Haworth, 1895, p. 277) is exposed near the town of Lane in the southeast part of the county. The type exposure (S½ sec. 33, T. 18 S., R. 21 E.) is covered by vegetation and colluvium, but about the upper two-thirds of the formation is well exposed 1½ miles south of Lane. The basal 5 to 10 feet of the Lane is not exposed.

The Lane Shale consists of gray, green, and red shale and claystone, tan siltstone, and tan sandstone. Shale in the upper half of the formation is silty and micaceous and locally includes beds of red shale and claystone not more than 2 feet thick. Locally, sandstone beds form the middle part of the Lane. *Lepidodendron, Calamites,* and unidentified remains of other land plants are sparsely distributed in the silty shale and the siltstone in the upper half; sparse brachiopod and pelecypod casts are found in the clayey to silty shale in the lower half of the Lane. The upper two-thirds of the formation has been eroded into steep slopes broken by ledges of more resistant siltstone; the lower third forms a gradual slope down to the Raytown Limestone escarpment and is concealed by vegetation. Sections measured on the outcrop and subsurface data indicate that the Lane Shale is about 60 feet thick.

WYANDOTTE LIMESTONE

The Wyandotte Limestone is best exposed in bluffs near Marais des Cygnes River and Pottawatomie Creek in the eastern part of the county. As shown in Figure 2, it pinches out in the subsurface near the north-south center line of Franklin County.

In Kansas the formation comprises five members, in ascending order: Frisbie Limestone, Quindaro Shale, Argentine Limestone, Island Creek Shale, and Farley Limestone. In Franklin County the Quindaro Shale is absent in all outcrops studied and is not indicated in available drillers logs. A section measured where the entire formation is exposed is given below.

Measured section of the Wyandotte Limestone in NE¼ SE¼ sec. 9, T. 19 S., R. 21 E.

	Thickness, feet
Plattsburg Limestone	
Bonner Springs Shale	0.3
Wyandotte Limestone	
Farley Limestone Member	
Limestone, light gray, thin to thick bedded	

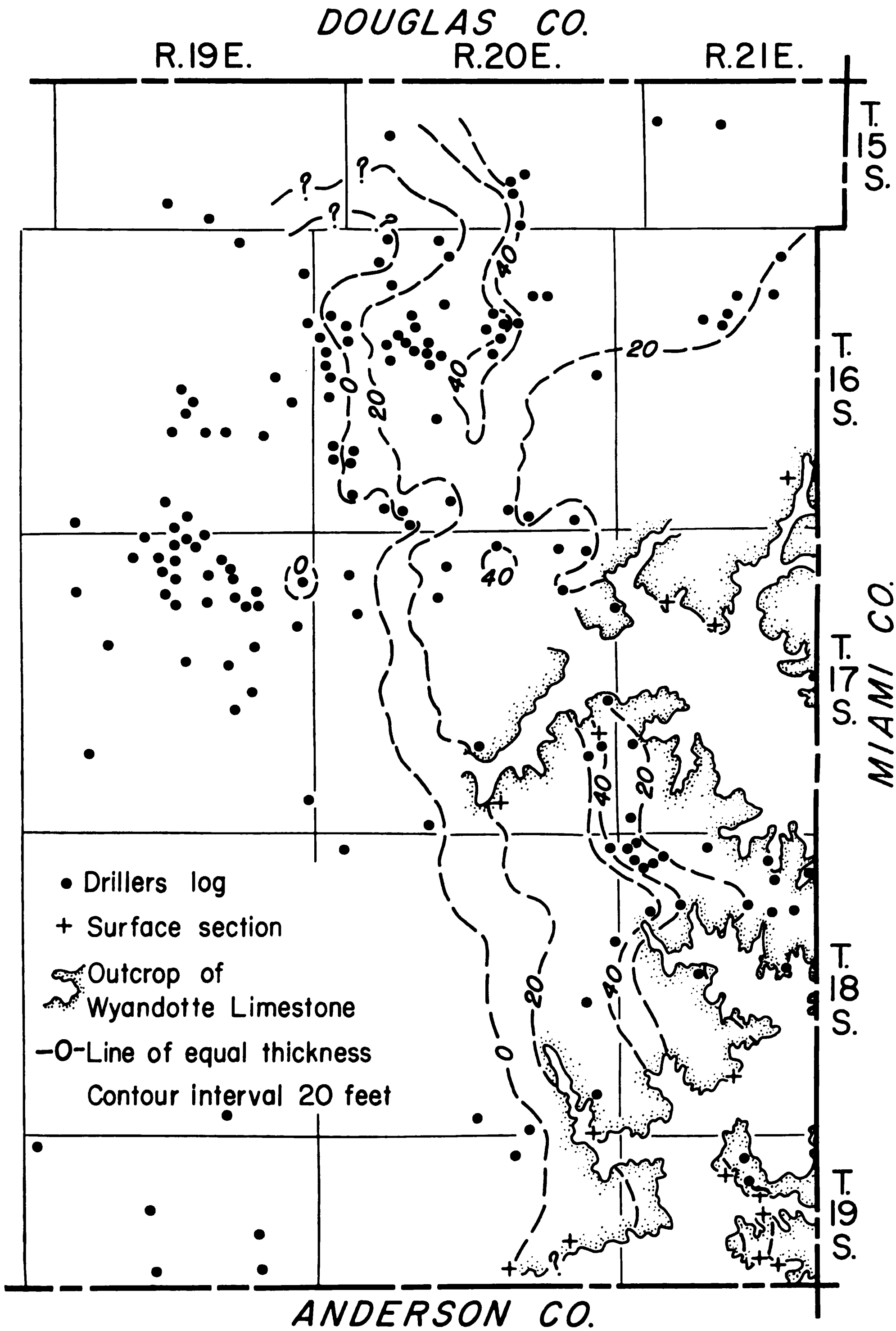


FIGURE 2.—Thickness map of the Wyandotte Limestone in eastern Franklin County.

and irregularly to relatively even bedded, microcrystalline; *Osagia*-oolith layer in central part of upper 3 feet; *Composita, Enteletes, Neospirifer,* bryozoan fragments; about	5.0
Island Creek Shale Member	
Limestone-limonite conglomerate; brachiopod, bryozoan, and crinoid remains; about	2.0
Argentine Limestone Member	
Limestone, light gray to brown on fresh surfaces, weathers tan, thin to thick bedded and wavy bedded, fine grained, compact; algae, abundant *Enteletes,* productid brachiopods, bryozoans, crinoids; about	33.0
Frisbie Limestone Member	
Limestone, chocolate brown on both fresh and weathered surfaces, dense, single vertically jointed bed devoid of shale breaks or partings, fractures to massive blocks, breaks conchoidally; *Enteletes,* productid brachiopod fragments, *Lophophyllidium,* robust fusulinids, sparse crinoid remains	3.5
Total thickness of Wyandotte Limestone	43.5
Lane Shale	

FRISBIE LIMESTONE MEMBER.—The Frisbie Limestone (Newell, *in* Moore, 1932, p. 92) is the lowermost member of the Wyandotte Limestone. The Frisbie is well exposed in only a few places. Bedding characteristics and, in some exposures, color differences, both of which are modified by weathering, facilitate differentiation of the Frisbie from the overlying Argentine Limestone. Drillers logs of holes in eastern Franklin County also show a continuous limestone section from the top of the Argentine to the base of the Wyandotte Limestone, as at the surface. Until core data are available, little knowledge can be gained of the subsurface distribution of the Frisbie in Franklin County.

This rock is uniformly brown and dense and is a single, massive, vertically jointed bed devoid of shale partings. Where well exposed, the Frisbie weathers into a sharp-cornered ledge, overhanging the steep slope of the underlying Lane Shale. Close examination, however, shows that the contact between the two rocks is relatively gradational through a thickness of 0.1 to 0.2 foot. The upper contact of the Frisbie (with the Argentine) is sharp. Fossils include algae, *Enteletes,* productid brachiopods, lophophyllid corals, and robust fusulinids. Because of the denseness of the Frisbie Limestone, the fracture is smooth and conchoidal. In cross sections, fusulinids and other shells appear to dot the fine-grained matrix. The obesity and the abundance of fusulinids in the Frisbie contrasts sharply with the slender, rodlike form and paucity of fusulinids in the Argentine. The thickness of the Frisbie ranges from 0 to 6 feet and averages 4 feet.

ARGENTINE LIMESTONE MEMBER.—The Argentine Limestone (Newell, *in* Moore, 1932, p. 92) is the most persistent member of the Wyandotte Limestone. It crops out in all exposures of the Wyandotte, except in the immediate vicinity of NW corner sec. 13, T. 19 S., R. 20 E., but is best exposed in bluffs and quarries near Lane and in bluffs bordering the Marais des Cygnes River floodplain in the eastern part of the county.

This light-gray limestone weathers into thin to thick wavy beds 2 inches to 2 feet thick, but the thickness of individual beds rarely exceeds 8 inches. The uppermost bed is massive and algal in many exposures (e.g. Pl. 3A). In some places elliptical chert nodules 2 to 12 inches in long dimension and 2 to 8 inches in short dimension (Pl. 3B) are distributed randomly in the upper 15 feet of the unit. Silicified invertebrate fossils are enclosed in the chert nodules. On fresh surfaces of the rock the uniformly fine-grained matrix is interrupted by acicular stringers of coarsely crystalline calcite 1 to 4 inches long. Differential etching of the matrix imparts a distinctive relief to weathered surfaces of the Argentine. The fossil assemblage consists of algae (including an *Osagia* coating on shell fragments in the upper massive bed), *Enteletes, Composita,* productid brachiopods, bryozoans, crinoids, and sparse, slender, rodlike fusulinids. The abundance of *Enteletes,* especially in the southeast part of the county, distinguishes the Argentine faunally from all other limestone in Franklin County. The thickness of the member ranges from approximately 15 to 34 feet except in T. 19 S., R. 20 E., where the Argentine is very thin.

Abrupt thinning and facies change in the Argentine in T. 19 S., R. 20 E., and southwestward are striking. A traverse of exposures southwestward from Lane (see Pl. 2, sections A13, A15, and A7) shows a thinning from 34 to 0 feet in a distance of about 4 miles. At section A15, midway between A13 and A7 and approximately 2 miles from each, the Frisbie and Argentine Limestones crop out in a prominent escarpment. At that place the Frisbie is 6 feet thick, and 12 feet of the overlying Argentine is exposed below a soil mantle. Nowhere in its outcrop area is more than 3 feet of the Argentine weathered to soil; therefore, complete thickness of the Argentine here was probably about 15 feet. An almost uniform rate of thinning of 8 feet to the mile between sections A13 and the immediate vicinity of A7 is thus

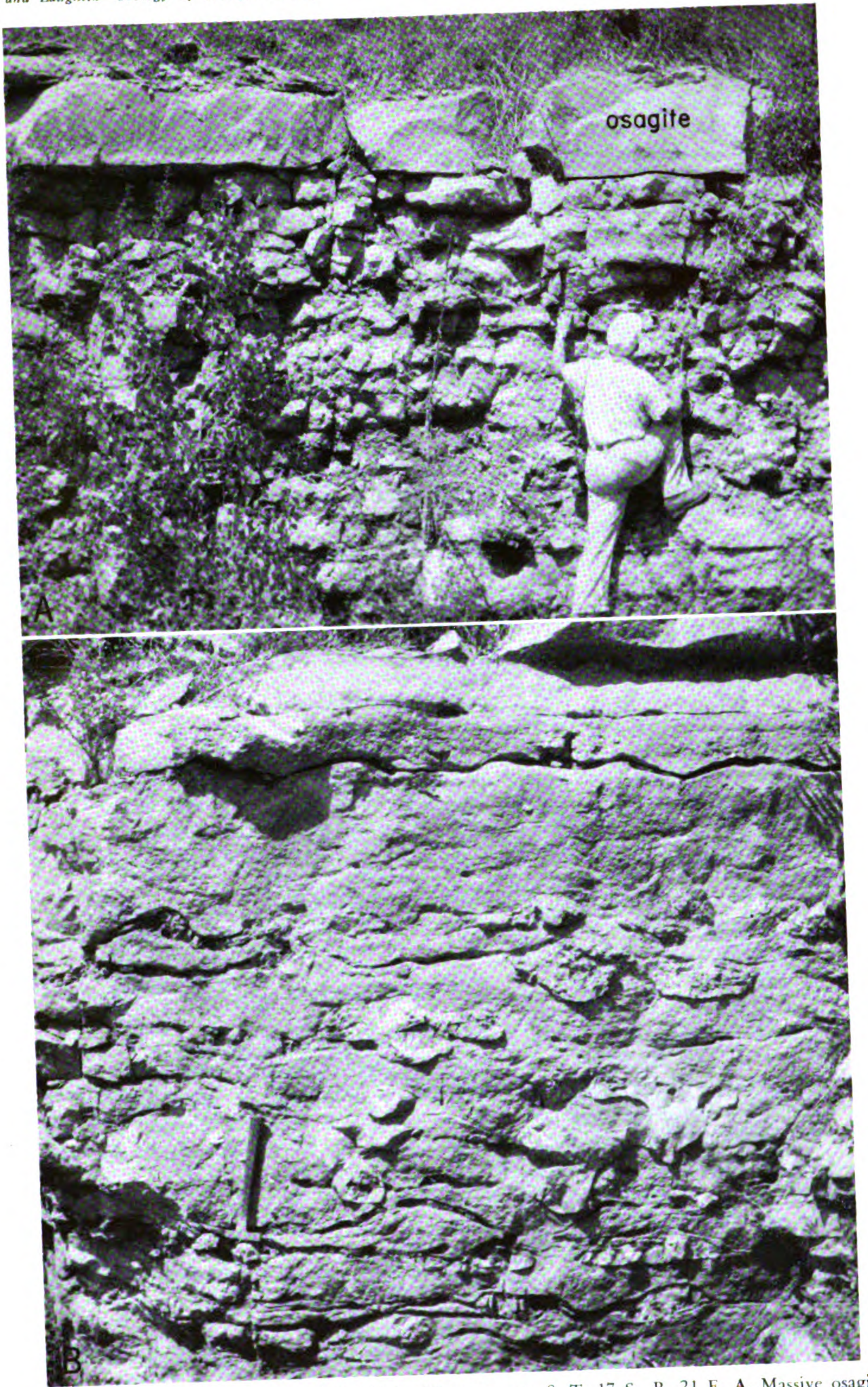


PLATE 3.—Road cut exposure (section A2) in SE corner sec. 8, T. 17 S., R. 21 E. **A,** Massive osagite in the upper part of the Argentine Limestone Member of the Wyandotte Limestone. **B,** Chert nodules in the Argentine Limestone.

indicated. Limy siltstone and impure limestone at sections A8, A9, and A10 (Pl. 2) occupy the stratigraphic position of the Wyandotte and, on the basis of their fossil assemblages, are regarded as Argentine.

ISLAND CREEK SHALE MEMBER.—The Island Creek Shale (Newell, *in* Moore, 1932, p. 92) is identified only in the vicinity of Lane (Pl. 2, sections A6 and A12-A14), and even here only tentatively. Recognition is possible only where the overlying discontinuous Farley Limestone is present. Where Farley is absent, all strata between the Argentine and the Merriam Limestones are assigned to the Bonner Springs Shale.

The Island Creek Shale includes tan silty shale and tan quartzose sandstone between the Argentine Limestone and the Farley Limestone. At section A6, a sandstone bed 1 to 2 feet thick crops out 5 feet below the top of the Island Creek, which there is 14 feet thick. A fossiliferous limonitic limestone conglomerate, about 2 feet thick, in sections A12 and A13 is classed as Island Creek. Except for fossils in this conglomerate, the Island Creek is apparently nonfossiliferous in Franklin County.

FARLEY LIMESTONE MEMBER.—The uppermost member of Wyandotte Limestone is the Farley Limestone (Hinds and Greene, 1915, p. 29). Classification of strata as Farley Limestone in Franklin County is based wholly on the fact that these beds have about the same stratigraphic position (i.e., in the lower part of a predominantly shale section between Argentine and Merriam Limestones) as the type Farley in Platte County, Missouri. Outcrops of Farley Limestone are restricted to a small area, in which four exposures were found (Pl. 2, sections A6 and A12-A14).

Light-gray and brown, detrital, cross-stratified limestone beds that have an aggregate thickness of about 7 feet are assigned to the Farley at section A6. Ooliths, foraminifers (including sparse fusulinids), crinoid debris, and predominantly sand-size shell fragments coated with *Osagia* are firmly cemented by microspar calcite. Sparse nautiloid cephalopods weather into relief in the lower part of the unit. In other exposures, the Farley Limestone is about 5 feet thick and is lithologically similar to the Argentine—color, bedding, textural details, and general fossil assemblage are nearly identical—but an abundance of *Neospirifer* and the absence of *Enteletes* differentiate the strata from the Argentine.

BONNER SPRINGS SHALE

Clean exposures of the Bonner Springs Shale (Newell, *in* Moore, 1932, p. 93) are scarce. It is well exposed just east of Middle Creek bridge on the road west from Rantoul (NW¼ NE¼ sec. 26, T. 17 S., R. 20 E.). Thickness ranges from a featheredge to approximately 45 feet. Where it is less than 20 feet thick, the Bonner Springs is predominantly gray-green silty shale. Where the thickness of the formation exceeds 20 feet, the lower half consists of interlayered tan and gray-green silty shale, tan siltstone, and tan quartzose sandstone. Individual siltstone and sandstone beds are not more than 2 feet thick. The upper half of the formation, described in ascending order, consists of tan clayey and silty shale, red shale 1 to 2 feet thick, a yellow-tan claystone bed 1 foot thick, and tan silty to clayey calcareous shale. In Miami, Johnson, Wyandotte, and Leavenworth Counties (Newell, 1935, p. 67; Jewett and Newell, 1935, p. 179), as in Franklin County, the claystone, which weathers to a distinctive boxwork, and the red shale are useful markers. One or both of these units characterize the upper 10 feet of the formation in most surface exposures and are recorded on many drillers logs.

Sparse remains of land plants in the silty shale and sparse gastropods in the claystone bed probably are in place. Minute fossil debris, sparsely distributed throughout the shale in exposures south of the town of Lane, where the formation is less than 1 foot thick (e.g., section A12), probably are not indigenous to the Bonner Springs.

Lansing Group

PLATTSBURG LIMESTONE

The Plattsburg Limestone comprises the Merriam Limestone, Hickory Creek Shale, and Spring Hill Limestone Members, which were named by N. D. Newell (*in* Moore, 1932, p. 93). The three members are continuous at the surface and probably in the subsurface. However, the formation is recorded on most drillers logs as a uniform limestone section. Salient characteristics of the Plattsburg are summarized in the two measured sections given below.

Measured section of the Plattsburg Limestone exposed in a road cut near the cen. S line sec. 29, T. 16 S., R. 21 E.

	Thickness, feet
Vilas Shale (not exposed)	
Plattsburg Limestone	

Spring Hill Limestone Member

Limestone, light gray on both fresh and weathered surfaces, weathers into thin to thick irregular beds, microcrystalline, compact; *Composita,* productid brachiopods, crinoid fragments; thickness exposed	6.0

Hickory Creek Shale Member

Shale, tan, calcareous, and limestone, tan; limestone stringers oriented parallel to bedding in shale; limestone weathers to a rubble of fragments predominantly 0.1 to 0.5 foot in long dimension and 0.1 foot in short dimension; sparse crinoid fragments	0.4-1.5

Merriam Limestone Member

Limestone, gray on fresh surfaces, weathers tan, weathered surface pitted or "worm eaten", a single bed; brachiopods, crinoids; upper contact within gradational rubble zone of overlying member	0.5
Limestone, gray on fresh surfaces, weathers tan, a single massive bed, vertically jointed; prominent *Composita*-myalinid zone in lower half; basal contact within underlying rubble zone	0.9
Limestone, tan on both fresh and weathered surfaces, impure, shaly; grades into underlying shale	0.3
Total thickness of Merriam Limestone	1.7

Bonner Springs Shale

Measured section of the Plattsburg Limestone exposed in a road cut near the cen. S line sec. 27, T. 16 S., R. 21 E.

	Thickness, feet
Vilas Shale (not exposed)	

Plattsburg Limestone

Spring Hill Limestone Member

Limestone, light gray on both fresh and weathered surfaces, weathers into thin wavy beds; microcrystalline matrix interrupted by randomly oriented coarsely crystalline calcite stringers; brachiopod, bryozoan, and crinoid remains; thickness exposed	6.0

Hickory Creek Shale Member

Shale, yellow brown, calcareous, and limestone, tan, 0.1- to 0.2-foot stringers intercalated with shale	2.3

Merriam Limestone Member

Limestone, gray, weathered surface pitted or "worm eaten", a single bed; microcrystalline matrix contains scattered brachiopod and crinoid remains	0.5
Limestone, gray, weathers tan, thin cross-stratified bedding, *Osagia*-oolite texture; foraminifers, clams, brachiopods; coarse fraction cemented by coarsely crystalline calcite	7.0
Limestone, gray, a single massive bed, vertically jointed, fine grained, compact; prominent *Composita*-myalinid zone in lower half; upper surface is an erosion surface; basal contact gradational through 0.2 foot	1.5
Total thickness of Merriam Limestone	9.0

Bonner Springs Shale

MERRIAM LIMESTONE MEMBER.—Where it has been studied, the Merriam Limestone weathers into a prominent ledge. A uniform gray and, in some cases, a bluish-gray color is common on fresh surfaces. The four units which commonly compose the Merriam are, in ascending order: (1) basal impure limestone, 0.3 foot or less thick; (2) a compact lower limestone unit, 0.7 to 1.5 feet thick; (3) an upper limestone unit, 0.4 to 0.7 foot thick; and (4) a topmost impure limestone crust, 0.3 foot or less thick. The basal and topmost units are absent in some exposures. Distinctive characteristics of the member are a *Composita*-myalinid zone in the compact lower limestone unit, and the pitted or "worm-eaten" surface of the upper limestone unit (Fig. 3 and Pl. 4). Upper and lower contacts of the Merriam are commonly within gradational zones of impure limestone and calcareous shale.

An additional limestone unit is present in some Merriam exposures. Stratigraphic relationships and inferred distribution of this unit (referred to as the middle unit) are shown in Figures 3 and 4. The middle unit is a number of cross-stratified limestone lentils, which crop out in narrow, sinuous belts as much as 6 miles long and 2 miles wide (Fig. 4). Maximum thickness of the lentils is 6 feet. Sets of cross strata are as much as 3 feet thick, and the cross strata range from paper-thin to about 1 foot in thickness and measure as much as 20 feet in length (Pl. 4C). The cross strata are composed of predominantly sand-size ooliths, foraminifers, and shell fragments, some of which are coated with algae, moderately to tightly packed and cemented by coarsely crystalline calcite (Pl. 5A). Mollusk fragments larger than sand size are common (Pl. 5B). The texture and sedimentary structures of the middle Merriam indicate that it was heaped together by currents powerful or persistent enough to winnow away any microcrystalline ooze that otherwise might have accumulated as a matrix, and that the interstitial pores were filled by directly precipitated calcite cement.

HICKORY CREEK SHALE MEMBER.—The Hickory Creek Shale is named for Hickory Creek in eastern Franklin County. Exposures along Hickory Creek are concealed by vegetation, slump material, and colluvium. The section described on page 13 (center south line, sec. 29, T. 16 S., R. 21 E.) is typical of this member in Franklin County.

The Hickory Creek Shale has a maximum thickness of 6 feet (Pl. 2, A12), but it is less than 1.5 feet thick in most exposures studied.

Its lithology is characteristically ochery shaly limestone or calcareous shale and is gradational with the underlying Merriam Limestone and the overlying Spring Hill Limestone.

SPRING HILL LIMESTONE MEMBER. — The Spring Hill Limestone, which is persistent west of its outcrop in Franklin County, comprises two limestones and an intervening shale; only the lower limestone, which has an aggregate thickness of 11 to 16 feet, is present in most exposures. Fossils and other aspects of lithology allow ready separation of the lower or principal limestone of the Spring Hill into three units. The lowermost unit ranges from 6 to 7 feet in thickness and consists of evenly to slightly irregularly bedded, fine-grained, gray limestone. Individual beds are 0.2 to 1 foot thick. *Enteletes*, productid brachiopods, and bryozoans are the common faunal elements. The middle unit ranges from 2 to 4 feet in thickness and its strata are from 0.5 to 1 foot thick. A foraminiferal osagite and an overlying 2- to 6-inch concentration of robust *Composita* form the gray limestone of the middle unit. This *Composita* zone (Fig. 5 and Pl. 6A) is a widespread and useful marker throughout the county. Newell (1935, p. 72) noted a persistent oolite bed in southern Johnson County in that part of the Spring Hill herein designated the middle unit; however, no oolite was observed in the Spring Hill in Franklin County. The upper unit is darker gray than the middle and lower units

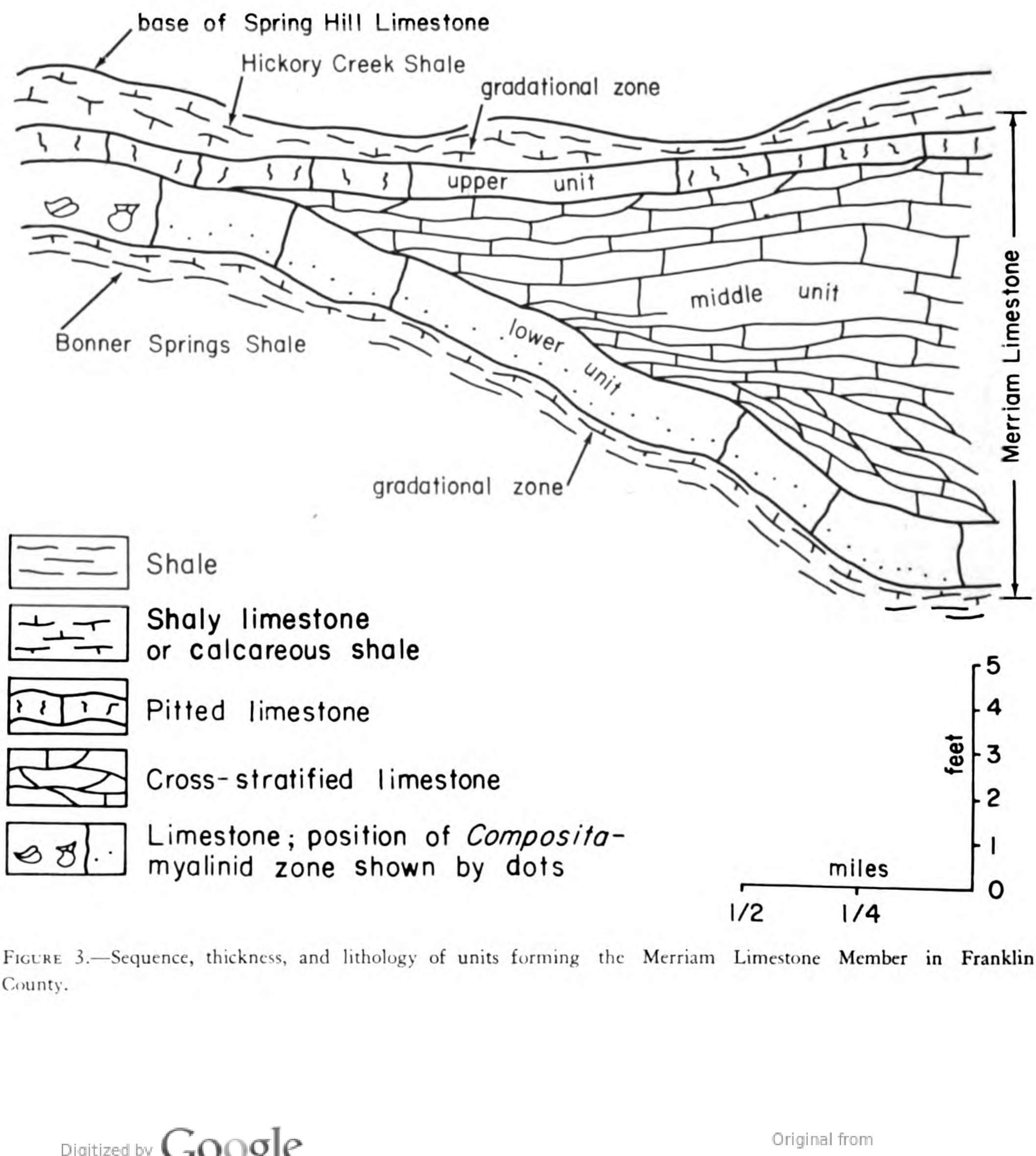
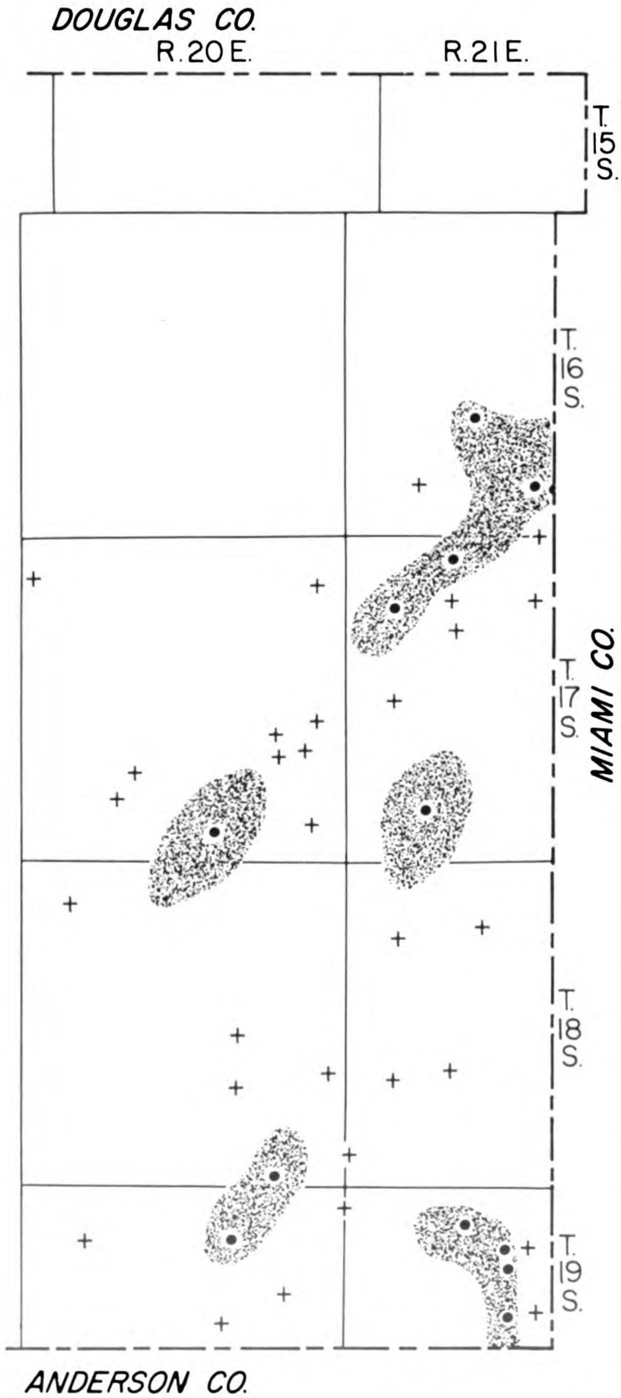


FIGURE 3.—Sequence, thickness, and lithology of units forming the Merriam Limestone Member in Franklin County.

PLATE 4.—Typical Plattsburg Limestone, described in measured sections on page 13. **A,** *Composita*-myalinid zone in lower unit of Merriam Limestone Member at center south line sec. 27, T. 16 S., R. 21 E. **B,** Pitted or "worm-eaten" surface of upper unit of Merriam Limestone at center south line sec. 29, T. 16 S., R. 21 E. **C,** Cross-stratified middle unit of Merriam Limestone, same locality as A. Dot indicates position of sample shown in Plate 5A.



LOCATIONS OF SECTIONS

● middle Merriam present

	Sec.	T. S.	R. E.
SE SW	21	16	21
CSL	27	16	21
SE cor.	27	16	21
Near cen.	34	17	20
CEL	5	17	21
CEL	7	17	21
CSL	29	17	21
Near CSL	35	18	20
NE	10	19	20
SE NW SW	4	19	21
SE NE	9	19	21
NE SE	9	19	21
SE NE	16	19	21
+ middle Merriam absent			
CSL	29	16	21
SW cor. SE	34	16	21
CSL	1	17	20
SW cor.	6	17	20
SE SW SE	23	17	20
Near cen.	24	17	20
SW SW	24	17	20
NE cor.	26	17	20
SW NW	28	17	20
SE	29	17	20
SE NW	36	17	20
SE NE NE	8	17	21
SE cor.	8	17	21
SW cor. NW NE	10	17	21
SE cor. NE NE	17	17	21
SE	6	18	20
SE cor. NE NE	22	18	20
SW cor. SE SE	24	18	20
SE cor. NE NE	27	18	20
SE cor. NE SE	7	18	21
Cen.	9	18	21
SE cor.	20	18	21
NE cor.	30	18	21
CWL	31	18	21
NW cor.	8	19	20
NW cor	13	19	20
CEL	15	19	20
SW cor. NW NW	7	19	21
SE cor. NE NW	10	19	21
SE NW	15	19	21

FIGURE 4.—Map of eastern Franklin County showing approximate areas (shaded) in which the middle unit of the Merriam Limestone Member is present. Outcrop control.

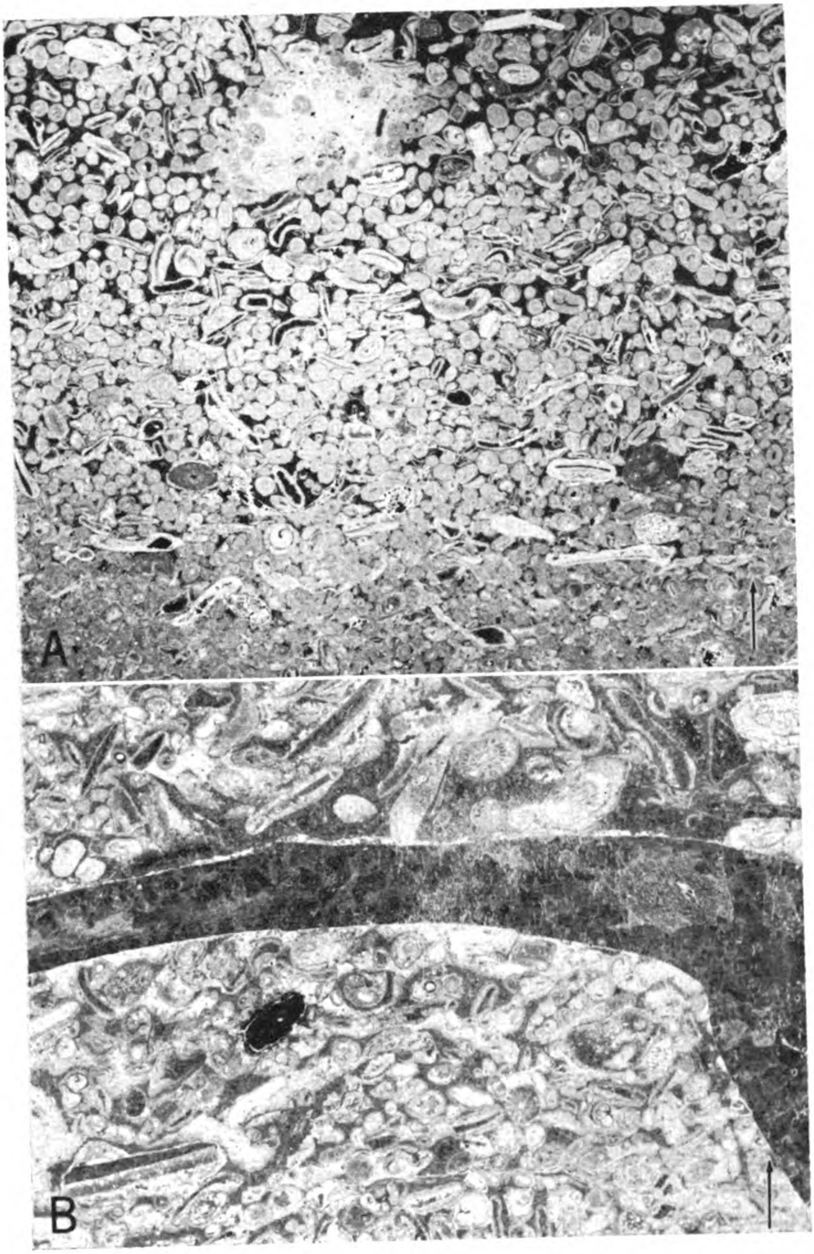


PLATE 5.—Middle unit of Merriam Limestone Member of Plattsburg Limestone. **A,** Negative print of thin section (X4) of sample collected at center south line sec. 27, T. 16 S., R. 21 E. (see Pl. 4C). **B,** Peel print of osagite texture (X5) of sample collected from section A6, near center south line sec. 35, T. 18 S., R. 20 E. Vertical surfaces, orientation as shown.

and measures 3 to 5 feet thick. The lower 2 to 4 feet of the upper unit consists of fusulinids, algae, echinoid spines, and brachiopod remains in a microcrystalline calcite matrix. The uppermost foot of the upper unit contains a prolific clam and bryozoan faunule. *Myalina, Fistulipora,* and *Meekoporella,* in order of abundance, are the predominant genera (Fig. 5 and Pl. 6B). Clam valves are arranged parallel to the bedding and are embedded in quartzose silt cemented with calcite.

Overlying the lower or principal limestone of the Spring Hill, a shale and a limestone, each approximately 1 foot thick, crop out below the Vilas Shale in the SE¼ sec. 6, T. 18 S., R. 20 E., and are recorded on several drillers logs. The shale is gray blue, clayey, and calcareous; the limestone is gray blue to gray brown and fossiliferous. These units (Fig. 5) are included in the Spring Hill because they crop out at the type locality of the member (Newell, 1935, p. 102) and because of practicality in mapping, but they are not observed in most Kansas outcrops of the Spring Hill.

In the southeasternmost part of Franklin County, southeast of Pottawatomie Creek, the lower part of the principal limestone of the Spring Hill is mantled with chert. Silicified forms of the fossils characteristic of the Spring Hill throughout the county, especially *Girtyocoelia,* are included in the chert pebbles, cobbles, and boulders. The chert is angular and poorly sorted, showing no indication of stream transportation. Obviously the chert originated *in situ* by replacement of the Spring Hill. In the exposures studied, the chert mantle ranges from about 2 to 6 feet in thickness and immediately overlies incomplete thicknesses of the Spring Hill Limestone. Interpolation between exposures of the Spring Hill north of Lane in Franklin County (maximum thickness 18 feet) and exposures north of Garnett in Anderson County (average thickness about 25 feet) indicates a probable thickness of about 22 feet of Spring Hill Limestone in southeastern Franklin County prior to chertification. This chert residuum is restricted to the uplands, does not extend into the subsurface, and is not a remnant of an alluvial terrace.

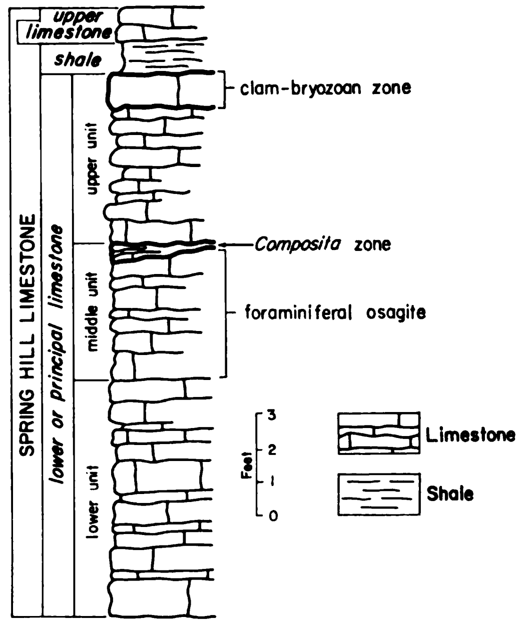


FIGURE 5.—Composite sequence of lithologies forming the Spring Hill Limestone Member in Franklin County.

VILAS SHALE

The Vilas Shale (Adams, 1898, p. 96), the middle formation of the Lansing Group, is continuous throughout Franklin County west of its outcrop. Few characteristics of the Vilas Shale and of shale next older and younger than the Lansing Group can be regarded as diagnostic. Identification of the Vilas is aided by its position in sequence between the escarpment-forming Plattsburg and Stanton Limestones, by its intermediate percentage of silt as compared to the next older and siltier shale formation (Bonner Springs) and the next younger and less silty shale formation (Weston), and by its general lack of fauna.

Blue-gray, green, and gray-brown shale laminae, which weather into flakes, characterize the Vilas. Where the laminae are extremely thin, the bedding is indistinct and the formation weathers into blocks of irregular size and shape as much as 3 inches long. The thickness of the Vilas Shale is quite variable (from approximately 1 to 23 feet) and shows no directional trends that can be related to its geographic distribution.

STANTON LIMESTONE

The Stanton Limestone is the uppermost formation of the Lansing Group. The Stanton is continuous in the subsurface in Franklin County. Members of the formation are, in ascending order: Captain Creek Limestone, Eudora Shale, Stoner Limestone, Rock Lake Shale, and South Bend Limestone, which locally is absent in the subsurface. A stratigraphic

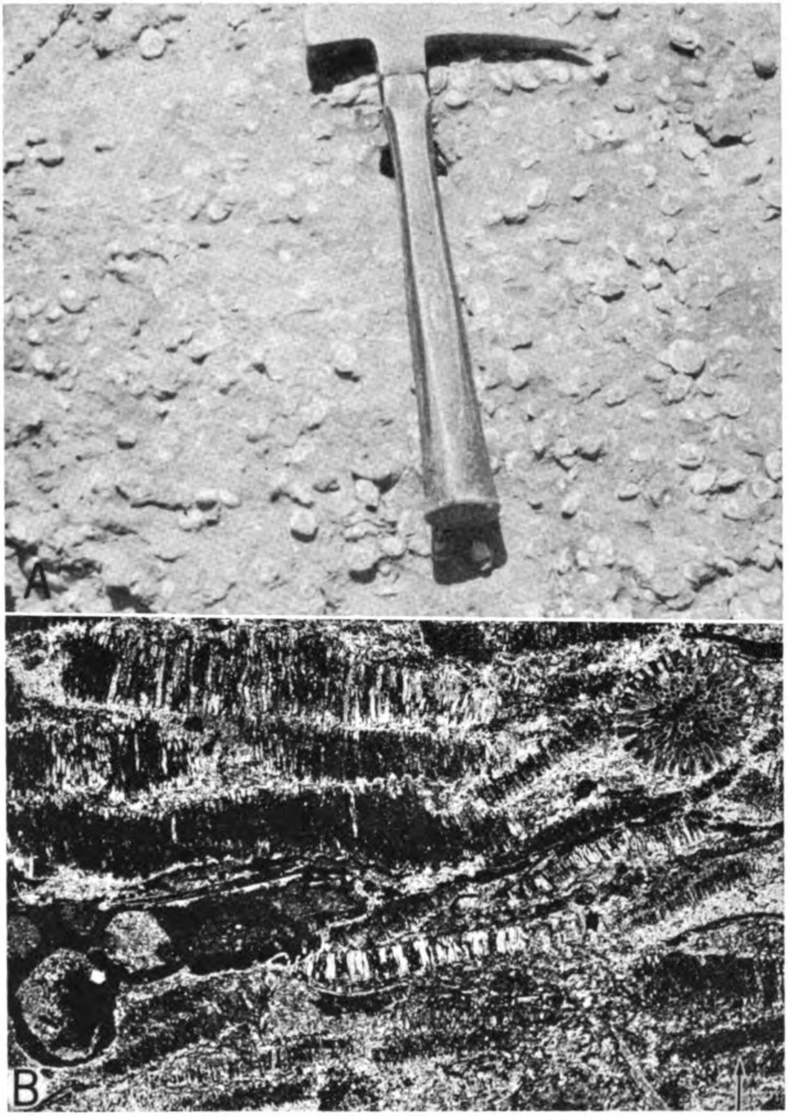


PLATE 6.—Spring Hill Limestone Member of Plattsburg Limestone. **A,** *Composita* zone at top of middle unit of Spring Hill. Bedding surface of limestone block on quarry floor in SE¼ SE¼ sec. 27, T. 16 S., R. 20 E. **B,** Peel print (X2) of clam concentration at top of upper unit (section B3). Vertical surface, orientation as shown. Sample collected in quarry near center east line SE¼ sec. 6, T. 18 S., R. 20 E.

section typical for Franklin County is given below.

Measured section of the Stanton Limestone exposed in an abandoned quarry in the SE¼ sec. 27, T. 16 S., R. 20 E. (Captain Creek Limestone and Eudora Shale) and in the NW cor. sec. 22, T. 16 S., R. 20 E. (Stoner Limestone, Rock Lake Shale, and South Bend Limestone).

	Thickness, feet
Weston Shale (not exposed)	
Stanton Limestone	
South Bend Limestone Member	
Limestone, gray blue mottled brown on fresh surfaces, weathers tan, thin to thick bedded and even bedded, extremely dense, fractures conchoidally; *Dielasma, Derbyia, Meekella, Neospirifer,* distinctive *Chonetes* crust atop lowest bed, fusulinids, crinoid and bryozoan fragments; thickness exposed	3.2
Rock Lake Shale Member	
Shale, gray green, clayey to silty, weathers into flakes	0.3
Coal stringer	0.1
Shale, gray green, weathers into irregular blocks	1.0
Limestone, gray on both fresh and weathered surfaces, nodular, silty	1.0
Limestone, blue gray, finely brecciated; pleurotomariid gastropods; thickness variable	1.8
Total thickness of Rock Lake Shale	4.2
(Disconformity)	
Stoner Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin to thick bedded and slightly wavy bedded, upper surface hummocky; *Composita, Derbyia, Punctospirifer,* algal remains, crinoid columnals and calyx plates, echinoid spines, euomphalid gastropods	19.0
Eudora Shale Member	
Shale, gray green, clayey to slightly silty, weathers into flakes; sparse crinoid fragments	4.5
Shale, black, clayey to silty, weathers platy or into fissile laminae; conodonts	4.3
Shale, gray green, clayey; paper-thin strata weather to flakes	1.5
Total thickness of Eudora Shale	10.3
Captain Creek Limestone Member	
Limestone, light gray to tan, thin bedding extremely even in lower half, wavy in upper half, microcrystalline; *Enteletes,* crinoid columnals, echinoid spines, abundant *Ottonosia* in upper 3 feet	7.2
Vilas Shale	

CAPTAIN CREEK LIMESTONE MEMBER.—The Captain Creek Limestone (Newell, 1935, p. 76) is continuous both at the surface outcrop and in the subsurface in Franklin County, and it is uniform lithologically in all exposures studied. On the basis of fossil content and gross lithology the Captain Creek can be divided into two units, which persist across the county. The lower unit ranges from blue gray to brown and weathers into extremely even beds (Pl. 7A) from 0.3 to 1 foot thick, which have a maximum aggregate thickness of approximately 3 feet. Its texture is compact and it contains fossil debris embedded in microcrystalline calcite. Algae, sparse foraminifers (including fusulinids), crinoid fragments, fenestrate bryozoans, lophophyllid corals, *Enteletes,* and other brachiopods are present. The rock is hard and brittle and breaks with conchoidal fracture.

In the upper unit a mottling in shades of blue, gray, and brown is characteristic. Franklin County quarrymen call this mottled unit the "Calico Rock". It is compact, brittle, slightly irregularly bedded, and sparingly fossiliferous. Largely algal, it also contains brachiopod and echinoid remains. Individual beds range from about 0.3 to 0.7 foot in thickness and the aggregate thickness averages about 5 feet. The contact of the upper unit with the overlying Eudora Shale is gradational in some exposures and sharp in others. Where the black fissile part of the Eudora is in contact with the Captain Creek Limestone, blue parts of the mottled Captain Creek are abnormally dark, almost black.

EUDORA SHALE MEMBER.—The Eudora Shale (Condra, 1930, p. 12) is continuous west of its outcrop in Franklin County and is the oldest black fissile shale exposed in the county. The black shale of the Eudora is slightly silty but is predominantly clayey shale. In most exposures the black shale is contiguous with the underlying Captain Creek Limestone, but elsewhere the two are separated by 1.5 feet or less of gray-green shale that weathers into flakes. In all sections studied 4.5 feet or less of gray-green clayey shale separates the black fissile part, which ranges from 1.5 to 4.5 feet thick, and the overlying Stoner Limestone. Locally the upper gray-green shale is abundantly fossiliferous. The average thickness of the entire member is about 7 feet.

Carbonate-phosphate nodules and concretions formed around fossils or small aggregates of pyrite are found in the black shale, which also contains low-spired gastropods, some pyritized; *Lingula* and *Orbiculoidea;* the conodonts *Hindeodella, Lochodina,* and *Ozarkodina;* pyritized pectinoid clams; sparse articulate brachiopods; *Conularia;* and sparse carbonized land plants.

STONER LIMESTONE MEMBER.—The Stoner Limestone (Condra, 1930, p. 11) has a relatively large number of surface exposures because it is extensively quarried. Drillers logs

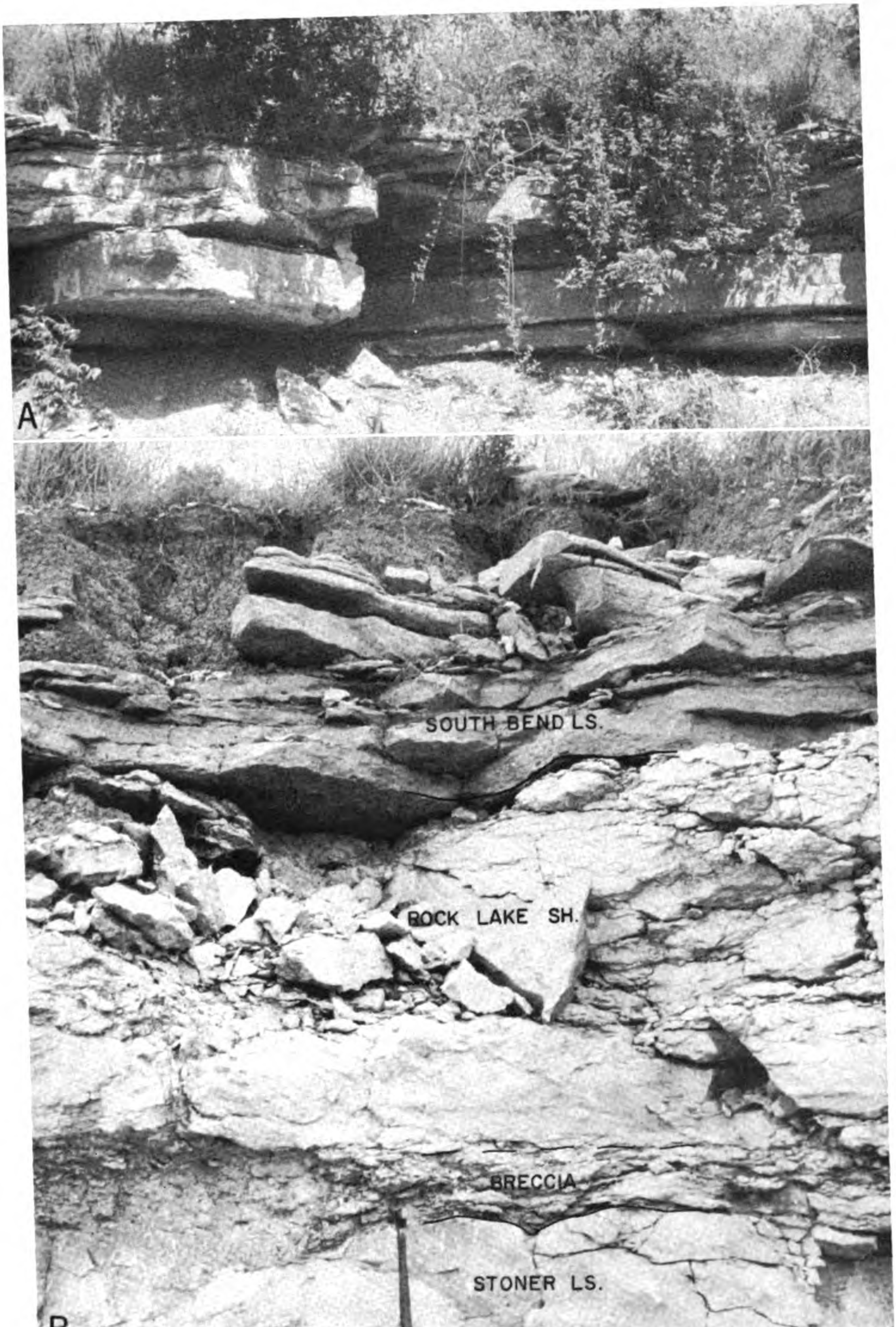


PLATE 7.—Quarry exposures of Stanton Limestone. **A,** Even-bedded Captain Creek Limestone Member (section B7), SE¼ SE¼ sec. 27, T. 16 S., R. 20 E. **B,** Disconformable contact between Stoner Limestone Member and Rock Lake Shale Member (section B1), center east line sec. 23, T. 18 S., R. 19 E.

indicate that the Stoner is continuous in the subsurface in Franklin County.

Light-gray fine-grained limestone, which weathers into thin to thick irregular beds, forms the Stoner. Individual beds range from about 3 inches to 2 feet in thickness and have an aggregate thickness of about 18 feet. Fossils of a number of phyla are represented, but individuals in any one phylum are not abundant. Algae, pygidia of the trilobite *Ameura*, productid and other brachiopods, crinoid stem fragments and calyx plates, echinoid spines, fenestrate bryozoans, foraminifers (including fusulinids), and gastropods are common in the Stoner.

At localities B1 and B8 (Pl. 2) breccia in the lowermost foot of the overlying Rock Lake Shale and marked relief of 1 to 3 feet on the upper surface of the Stoner indicate disconformity. Where the breccia is developed, the Stoner-Rock Lake contact is gradational (Pl. 7B) because of reworking. Disconformity at the top of Stoner Limestone, within the Rock Lake Shale, or at the base of South Bend Limestone is apparent in most exposures of these strata between Leavenworth County and central Wilson County, Kansas.

ROCK LAKE SHALE MEMBER.—Surface study of the Rock Lake Shale (Condra, 1927, p. 59) in Franklin County is limited almost entirely to quarry and road-cut exposures, since natural exposures are covered by colluvium and residual soil. Except for possible local absence, the Rock Lake is continuous in the subsurface of western Franklin County.

Variable lithology is the most noteworthy characteristic of the Rock Lake Shale. Near Ottawa the Rock Lake contains sandstone, limestone, and shale (NW¼ SW¼ sec. 5, T. 17 S., R. 20 E., Concrete Materials Quarry, and NW¼ SW¼ sec. 12, T. 17 S., R. 19 E., Fogle's Quarry). In both exposures the lower 0.2 to 1.5 feet is a limestone breccia or "mortar" bed composed of minute limestone fragments and fossil gastropods in a shaly limestone matrix. Overlying the breccia is 0.5 foot or less of arenaceous limestone or limy sandstone that is discontinuous along the quarry faces. Additional units form parts of the Rock Lake in the Concrete Materials Quarry but are absent in Fogle's Quarry. These additional units are a 2.6-foot shaly limestone, which contains mollusks and brachiopods, and an overlying 1-foot brachiopod-bearing calcareous shale.

A quarry section measured near Princeton includes the Rock Lake Shale. There the succession is: a 0.5- to 1-foot breccia that grades upward into approximately 4 feet of shaly limestone, which is overlain by 0.7 foot of gray-green nonfossiliferous clayey shale. In all exposures studied the thickness of the member is variable, ranging from 0.2 to 5.4 feet.

SOUTH BEND LIMESTONE MEMBER. — The South Bend Limestone (Condra and Bengston, 1915, p. 23) is the uppermost member of the Stanton Limeston. Drillers logs indicate that the member is absent locally in the subsurface. Complete thicknesses of the South Bend are exposed only in quarries and road cuts.

The South Bend Limestone is gray blue and brown banded on fresh surfaces, and it weathers brown. Color, an extremely dense texture in the upper part, even bedding, and an arenaceous lower part distinguish the South Bend from limestone within the underlying Rock Lake Shale. Individual beds range from 0.3 to 1.4 feet in thickness, are thinner in the lower half than in the upper half of the member, and have an average aggregate thickness of about 4 feet. *Meekella striatocostata* and abundant *Chonetes* are common in the upper part of the South Bend but were not found elsewhere in Franklin County. Fusulinids are locally abundant, as are crinoids, echinoids, and bryozoans.

Pedee Group

WESTON SHALE

The Pedee Group includes the Weston Shale (Keyes, 1899, p. 300) below and the Iatan Limestone (Keyes, 1899, p. 300) above. Because no Iatan Limestone is recognized in Franklin County and because the Weston Shale commonly grades upward into the Stranger Formation, the upper contact of the Pedee is represented by a dashed line in most places on the geologic map (Pl. 1).

The Weston Shale is gray blue, clayey, and relatively free of silt. Locally (e.g., sec. 23, T. 17 S., R. 19 E.) it contains well-preserved plant remains in the middle and upper parts. Discontinuous layers of ironstone concretions are found in the upper one-third of the Weston, and locally upper parts of the formation are tan and silty. Lentils of fossiliferous limestone conglomerate crop out in a zone approximately 15 feet below the top of the Weston at the center west line SW¼ sec. 14, T. 17 S., R. 19 E. (A columnar section measured at this locality and the stratigraphic classification applied to rocks exposed there are shown in Figure 6.) This zone of limestone-shell "hash" conglomerate lentils in silty shale (Fig. 6, lithology 3), considered by Bowsher and Jewett (1943, p.

30-31) to be the proper contact between the Weston Shale and Tonganoxie Sandstone, was not observed elsewhere in Franklin County. In this report the contact between the Weston and the Tonganoxie is placed at the base of a siltstone-sandstone or a coal, whichever is lowermost in local exposures.

A complete thickness of the Weston Shale could not be measured accurately along the outcrop. Data from drillers logs, test drilling, and surface measurements indicate a thickness range of about 45 to 110 feet. The average thickness of the formation is about 60 feet.

Pennsylvanian System—Virgilian Stage

Douglas Group

STRANGER FORMATION

The Stranger Formation (Newell, *in* Moore, 1932, p. 93) includes all strata from the base of Virgilian rocks to the base of the Lawrence Shale (Moore, 1949, p. 129). Both of its stratigraphic boundaries are locally disconformable. In ascending order the members of the Stranger are: Tonganoxie Sandstone, Westphalia Limestone, Vinland Shale, Haskell Limestone, and Robbins Shale (Pl. 2).

TONGANOXIE SANDSTONE MEMBER.—It is not possible to delimit accurately the Tonganoxie Sandstone (Moore and others, 1934) throughout most of Franklin County. Evidence of a disconformity separating Missourian and Virgilian strata is scanty. The Westphalia Limestone, which overlies the Tonganoxie Sandstone in most exposures of these strata in Kansas south of Franklin County, crops out in only one place (SE corner sec. 17, T. 19 S., R. 18 E.) within the county. Consequently, the name Tonganoxie is applied to the lower part of the section between the Weston Shale below and the Haskell Limestone above. The approximate thickness range of the Tonganoxie is 3 to 50 feet. In some parts of northeastern Kansas the contact between Tonganoxie Sandstone and older strata is sharp; however, no such exposures were noted in Franklin County, although the Weston Shale-Tonganoxie Sandstone part of the section is well exposed at the following localities: NW corner SW¼ sec. 34, T. 15 S., R. 20 E.; center south line sec. 7, NE¼ NW¼ sec. 16, and center west line SW¼ sec. 14, T. 17 S., R. 19 E.; and SW¼ NW¼ sec. 19, T. 18 S., R. 19 E.

Sandstone-shale pebble conglomerate, massive sandstone, sandy and silty shale, siltstone,

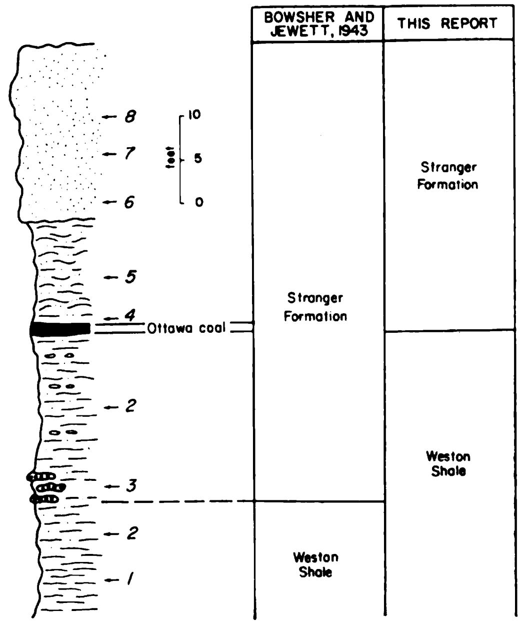


FIGURE 6.—Section exposed at the center west line SW¼ sec. 14, T. 17 S., R. 19 E. Numbers designate positions of lithologies referred to in the text.

and coal form the Tonganoxie, which comprises one or more of these lithologies in its exposures in the county. Possibly the Tonganoxie is absent in the greater part of T. 15 S. At one locality (near center east line SE¼ sec. 25, T. 15 S., R. 20 E.) a sandstone-shale pebble conglomerate is poorly developed near the base of the Tonganoxie. Massive, in part cross-stratified, very fine to fine-grained quartzose siltstone and sandstone constitute a part of the Tonganoxie in many exposures (e.g., sections C3, C7, and C8).

Samples taken at the center west line SW¼ sec. 14, T. 17 S., R. 19 E., were studied petrographically. Near perfect size gradation from clayey shale devoid of silt (Fig. 6, lithology 1), through silty shale (Fig. 6, lithology 2), micaceous fine- to medium-grained siltstone (Fig. 6, lithology 4; Pl. 8A), medium- to coarse-grained siltstone (Fig. 6, lithology 5; Pl. 8B), very fine to fine-grained sandstone (Fig 6, lithology 6; Pl. 8C), fine-grained sandstone (Fig. 6, lithology 7; Pl. 8D), and fine- to medium-grained sandstone (Fig. 6, lithology 8; Pl. 8E), was noted. Continuity of gradation is interrupted by limestone-shell "hash" conglomerate (Fig. 6, lithology 3; Pl. 8F) and the Ottawa coal (Fig. 6, just below lithology 4).

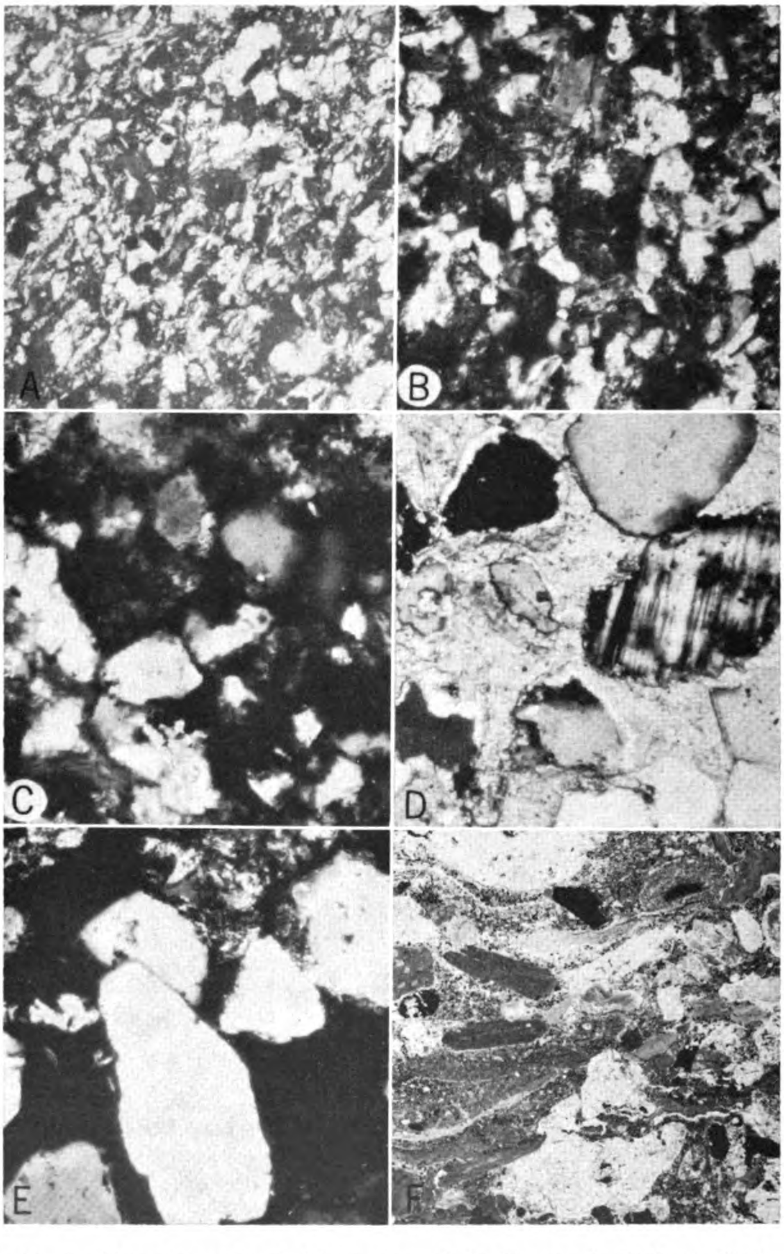


PLATE 8.—Photomicrographs of thin sections of the Tonganoxie Sandstone Member of the Stranger Formation (Fig. 6). **A-E,** X150, crossed nicols. **A,** Lithology 4, micaceous fine- to medium-grained siltstone. **B,** Lithology 5, medium- to coarse-grained siltstone. **C,** Lithology 6, very fine to fine-grained sandstone. **D,** Lithology 7, fine-grained sandstone. **E,** Lithology 8, fine- to medium-grained sandstone. **F,** Negative print of lithology 3, silt-cemented limestone-shell "hash" conglomerate, X4. Note absence of shell "hash" from limestone granules and pebbles.

The quartz grains of lithologies 4 through 8 (Fig. 6 and Pl. 8) are well sorted, subangular to rounded to quite irregular in shape, and moderately to tightly packed. Many quartz particles contain impurities and have quartz overgrowths; most grains exhibit uniform extinction under crossed nicols but some show a mosaic pattern and may be metaquartzite. In these 5 samples the amount of mica flakes ranges from about 1 to 10 percent. Feldspars form from 1 to 3 percent and unidentified heavy minerals about 2 percent of each sample. Silica is the main cementing material, but the quartz grains of lithology 7 (Fig. 6) are calcite cemented.

Trough-type cross stratification in the sandstone parts of the Tonganoxie comprises lenticular and wedge-shaped sets of cross strata that range from about 0.5 to 5 feet in thickness. The cross strata are medium scale (length 1 to 20 feet), low angle (less than 20 degrees), and they have a maximum thickness of about 2 inches. Measurements of cross-strata trends in the Tonganoxie of Franklin County indicate a dominant trend approximately S 43°W and another trend approximately S 27°E (Richard Bower, 1960, written communication). Siltstone parts of the Tonganoxie Sandstone are even to wavy bedded. Individual siltstone beds range from 0.1 to 0.5 foot in thickness and commonly are cross laminated. The cross lamination is of such small scale that it is not readily apparent on the outcrop.

The Ottawa coal lentil of the Tonganoxie Sandstone is a bituminous coal and ranges in thickness from about 0.3 to 0.8 foot. A detailed lithologic description of this coal was given by Bowsher and Jewett (1943, p. 41-42).

Fossils in the Tonganoxie include abundant and well-preserved land plant remains (Pl. 9) and sparse fragments of either pelecypod or brachiopod valves. The invertebrate fossils were noted only in a thin section made from a sample of lithology 7 (Fig. 6). Original shell structure has been entirely obliterated by recrystallization, leaving only the shell outline bounding a mosaic of coarsely crystalline calcite.

The exposure at the center west line SW¼ sec. 14, T. 17 S., R. 19 E., has long been known for its excellent plant fossils. The possibility that this siltstone and sandstone which contain the well-preserved plant fossils should be assigned to the Ireland Sandstone Member of the Lawrence Shale and not to the Tonganoxie Sandstone Member of the Stranger Formation has been brought to the attention of the authors by several geologists. The apparent absence of the Westphalia and the Haskell Limestones in the immediate vicinity, both of which are younger stratigraphically than the Tonganoxie but older than the Ireland, precludes unequivocal settlement of the question. However, stumps and trunks of trees rooted in the Ottawa coal, which no one has ever doubted to be a part of the Tonganoxie, were preserved in the upright position of growth, having been buried before they had time to rot away or fall. One such tree was illustrated by Bowsher and Jewett (1943, p. 28). Also, at this exposure a number of fossilized twigs and branches, which cut stratification surfaces at angles of about 90 degrees, were collected by S. M. Ball and others from the basal 5 to 10 feet of the siltstone and sandstone. The age of the siltstone and sandstone and that of the Ottawa coal are, geologically speaking, very nearly the same. Therefore, all strata exposed at this locality (center west line SW¼ sec. 14, T. 17 S., R. 19 E.) above the base of the Ottawa coal are classed in this report as Tonganoxie Sandstone.

WESTPHALIA LIMESTONE MEMBER.—The only outcrop of the Westphalia Limestone (Moore and Newell, *in* Moore, 1936, p. 150) definitely recognized in Franklin County is on the Franklin-Anderson county line (SE corner sec. 17, T. 19 S., R. 18 E.). There the member is a dense, brown, flaggy-bedded, argillaceous limestone 2.4 feet thick. It grades upward from shaly limestone that contains profuse crinoid remains and bryozoan and brachiopod fragments into lamellar, pseudobrecciated, dense limestone. This dense upper part of the limestone bears fusulinids and other foraminifers, *Osagia*, and mollusks. *Composita* is the only genus that was identified among the shell fragments in the lower shaly part. At several other exposures (e.g., center north line NW¼ sec. 22, T. 15 S., R. 20 E.) a gray, laminated, silty and carbonaceous limestone crops out and is thought to be correlative with the Westphalia. This rock is exposed as far south as one-half mile into Franklin County, but only poorly so. The stratigraphic position of the Westphalia at all places observed between these two areas is occupied by plant-bearing silty shale and sandstone with septarian concretions.

VINLAND SHALE MEMBER.—Where the Westphalia Limestone is missing, the Vinland Shale (Patterson and Addison, 1933, p. 17) is considered the upper part of the section between the base of Haskell Limestone above and the top of the Weston Shale below. Strata to which the name Vinland Shale is applied range in thickness from about 11 to 13 feet.

PLATE 9.—Plant fossils from Tonganoxie Sandstone Member of Stranger Formation. **A** and **B,** ***Calamites*** (X½). **C,** *Annularia* (X⅜). **D,** *Cordaites* (X⅜). **E** and **F,** *Alethopteris* (X½). **G,** ***Daubreeia*** (X½). **H, I,** and **J,** *Stigmaria* (X½). **K,** *Sigillaria* (X⅜). **L,** *Lepidodendron* (X½). **M,** ***Neuropteris*** (X⅜). **N,** *Sphenophyllum* (X⅜). Specimens, except D, collected from center SW¼ sec. 14 and center north line sec. 23, T. 17 S., R. 19 E. Specimen D collected from center south line SW¼ sec. 9, **T. 17** S., R. 19 E. A, C, D, F, G, and **K** loaned from the personal collection of A. C. Carpenter, Ottawa, Kansas.

In one exposure (center north line sec. 31, T. 17 S., R. 19 E.), what is probably Vinland Shale contains *Aviculopecten, Chonetes, Crurithyris,* and sparse lophophyllid corals. The upper 10 feet of the Vinland is exposed, bounded above by the Ireland Sandstone, but the base of the member was not identified at this location.

Near the center west line of sec. 19, T. 18 S., R. 19 E., the Vinland consists of nonfossiliferous, sandy to silty, micaceous, gray shale with a distinctive zone of large blue-gray calcareous septarian nodules near its base. There the Vinland is approximately 13 feet thick; it is immediately below the Haskell Limestone and overlies the Tonganoxie Sandstone.

In outcrops of the Vinland Shale in T. 15 S., R. 19 E. and R. 20 E., a zone abundant in *Myalina* and other clams forms the uppermost 2 feet of the member. Even-bedded, highly resistant, fine-grained to very fine grained, quartzose sandstone beds, and a red tinge on fresh bedding surfaces of the shale are characteristic of the Vinland in this area.

In the SW¼ sec. 12, T. 18 S., R. 18 E., the Vinland Shale is approximately 11 feet thick and contains the previously mentioned zone of large calcareous septarian nodules near its base. The shale is bluish and clayey, and it is poorly bedded in the basal part. Higher it is calcareous and is almost a shaly limestone at the top, where there is a development of good shaly bedding. This exposure is paleontologically one of the most interesting in the county. Profuse clams, gastropods, michelinoceroid cephalopods, brachiopods, and land plant remains are distributed throughout the upper half of the Vinland. Bits of bryozoans and crinoids are also common. Genera identified include the clams *Astartella, Aviculopecten,* and *Myalina;* the spired gastropod *Worthenia;* the cephalopod *Mooroceras;* and the brachiopods *Chonetes, Composita,* and *Derbyia. Derbyia* occur throughout the shale and some are pasted like stamps on an envelope on the upper surface of a small number of ellipsoidal septaria. No *Derbyia* are found within the septaria or on their lower surfaces. In the only case in which a *Derbyia* was found covering a part of the junction between a septarian crack and the nodule periphery, the fossile was uncracked. Therefore, the nodule apparently formed and a crack system developed before the *Derbyia* was emplaced.

HASKELL LIMESTONE MEMBER.—The Haskell Limestone (Moore, 1932, p. 93) is the most persistent marker between the top of the Stanton Limestone and the base of the Oread Limestone in Franklin County. Its absence in the subsurface (Fig. 7) and apparent absence locally at the surface (center north line NW¼ sec. 19, T. 15 S., R. 20 E.; center north line sec. 31, and SW¼ sec. 7, T. 17 S., R. 19 E.; SE corner NW¼ SE¼ sec. 11, and the greater part of sec. 12, T. 17 S., R. 18 E.) may be the result of erosion prior to deposition of the Ireland Sandstone. In many parts of Kansas the Haskell caps a prominent escarpment, but in Franklin County this member is topographically inconspicuous. The Ireland Sandstone immediately overlies the Haskell in some exposures, but in others a small thickness of Robbins Shale separates these members. A great volume of colluvial material derived from the Ireland Sandstone tends to conceal the Haskell outcrop, making it appear to be more discontinuous than it is.

The Haskell Limestone forms a slabby, vertically jointed ledge of dense blue-gray limestone about 2 feet thick. The upper and lower parts of the member weather through a thickness of about 6 inches into irregular plates 1 inch or less thick. Commonly the upper surface is covered by weathered brown clayey shale containing goethite shards derived from the overlying Robbins Shale. The fauna of the Haskell differs from the base to the top of the member. Profuse small fusulinids in the lower half of the Haskell and a mixed fauna of crinoids, brachiopods, and planispiral gastropods in the upper half are characteristic. The brachiopods *Meekella, Neospirifer, Composita, Derbyia,* and *Chonetes,* in order of apparent abundance, were identified. The agla *Ottonosia* is distributed throughout the member.

ROBBINS SHALE MEMBER.—Robbins Shale (Moore and Newell, *in* Moore, 1936, p. 155) is represented in much of its area of outcrop by scattered occurrences of highly weathered shale and goethite overlying the Haskell Limestone. Only the lower 1 foot or less of the Robbins is exposed in most outcrops. At such places the shale is highly weathered, brown, and clayey with poorly defined lamination. In most places the upper contact of the Robbins is concealed by colluvial material slumped down from the Lawrence Shale. Local absence of the Robbins Shale in surface exposures (e.g., SW¼ SE¼ sec. 13, T. 17 S., R. 18 E.) is the result of pre-Ireland erosion (Pl. 10A). At several localities (e.g., SE corner sec. 15, T. 17 S., R. 18 E., and SE¼ sec. 26, T. 15 S., R. 19 E.) where a definite Robbins top is defined by basal Ireland strata,

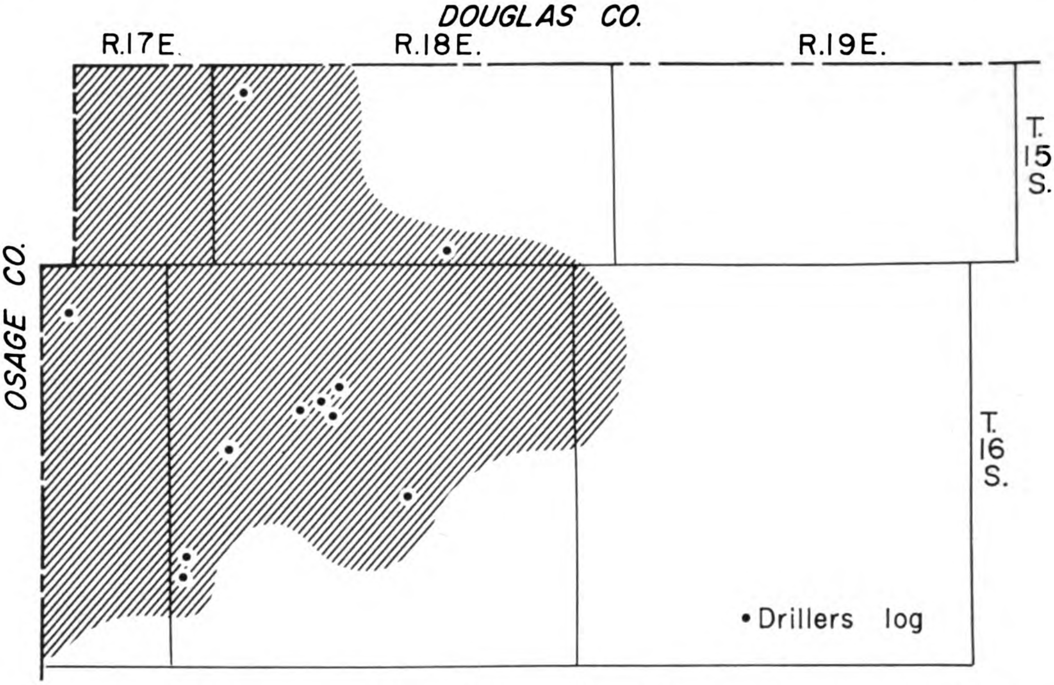


FIGURE 7.—Map of the northwestern part of Franklin County showing locations of wells for which drillers logs indicate absence of Haskell Limestone, and generalized area (shaded) in which the Haskell is probably absent in the subsurface.

the Robbins consists of blue-gray clayey shale that ranges from 0 to 17 feet in thickness.

Despite its state of weathering, the Robbins has certain distinctive characteristics, and, as pointed out by Miller and Swineford (1957), the member is of paleontologic interest. A zone of white-weathering phosphatic concretions at the base of the unit contains various parts of paleoniscid fish, small ammonoid cephalopods, fish brain casts, and coprolitic material. The nodules are most commonly found loose in weathered shale above the Haskell Limestone, along with numerous bits of goethite, which constitute a second characteristic. A goethite layer commonly overlies the nodulose zone, but in places the goethite is in contact with the Haskell.

LAWRENCE SHALE

Haworth (1894b, p. 122) introduced the term Lawrence Shale. Moore and Newell *(in* Moore, 1936, p. 154) redefined the formation to include only those beds between the bases of the Ireland Sandstone and the Oread Limestone. The Lawrence Shale contains two named members, the Ireland Sandstone and the Amazonia Limestone. In Kansas the Amazonia Limestone has been definitely recognized only in Doniphan and Atchison Counties; the Amazonia was not identified in Franklin County. In the southern half of T. 18 S. and in T. 19 S. the Ireland Sandstone is not recognized and the term Lawrence Shale is applied to all strata between the Haskell and Toronto Limestones.

IRELAND SANDSTONE MEMBER.—In this report the term Ireland Sandstone (Moore, 1932, p. 93) applies to predominantly sandstone lithology in the lower part of the Lawrence Shale. The base of the Ireland Sandstone is locally either gradational or disconformable; it is mapped at the top of Robbins Shale, at the top of Haskell Limestone, and as low stratigraphically as the upper part of Vinland Shale. Silty shale bounds the Ireland laterally and above. Neither the upper nor lower contact represents a single stratigraphic horizon.

Sandstone, siltstone, silty shale, claystone, clayey shale, coal, and sandstone-limestone-shale pebble conglomerate (in order of decreasing volume) constitute the Ireland. Tan subangular to subrounded quartz sand and silt particles and flakes of mica, cemented by both calcium carbonate and silica, form the sandstone. The matrix commonly has been leeched and the sandstone is extremely friable. Outcrop examination and size analyses (Fig. 8) indicate that very fine sand is the predominant size grade. Sand of the Ireland is extremely well sorted (sorting coefficients for samples analyzed range from 1.1 to 1.2). Locally the sandstone is disconformable on and separated from older strata by a sharp contact (e.g., SE corner sec. 15, and near center SE¼ sec. 12, T. 17 E., R. 18 E.; and center south line sec. 7, T. 17 S., R. 19 E.). At the last of these localities the lower 2 feet of the Ireland consists of a limestone - sandstone - shale pebble conglomerate. Chonetid brachiopods within the conglomerate at this and nearby exposures (Pl. 10A) indicate that part of the conglomerate was probably derived from the Haskell Limestone.

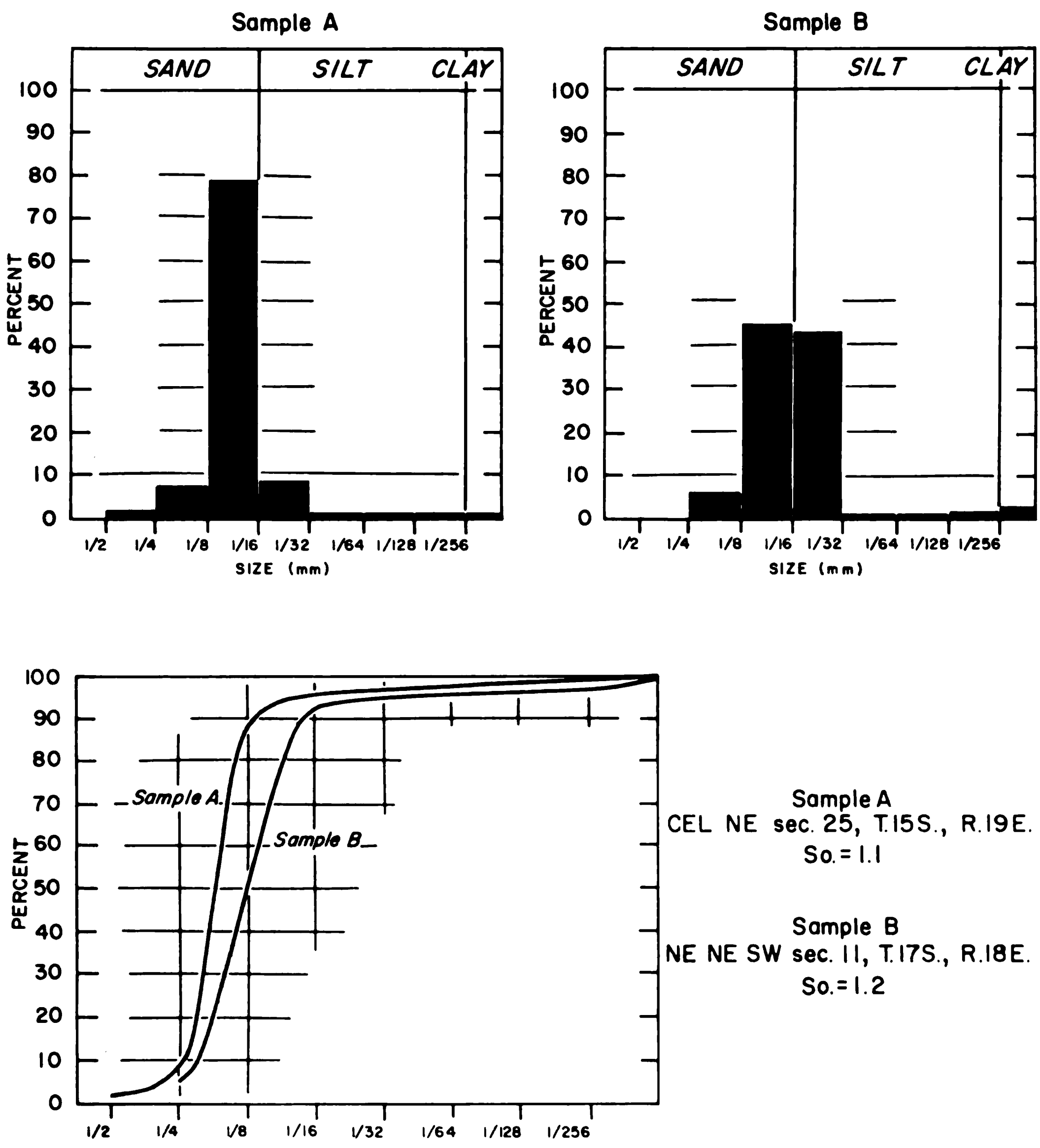


FIGURE 8.—Size analyses of sandstone of the Ireland Sandstone Member. Histograms above and cumulative curves below. Sorting coefficients indicated by So.

In a number of places (west side NW¼ sec. 13, SE corner SW¼ SW¼ sec. 15, and near center west line sec. 15, T. 17 S., R. 18 E.) strata above the Haskell Limestone grade upward from clayey shale through silty shale and siltstone to sandstone within the Ireland Sandstone. The sandstone of the Ireland grades laterally and upward into siltstone and silty shale.

Bedding varies from very thin to thin, relatively even beds, ranging from 2 inches to 2 feet in thickness, to massive, in part cross-stratified, beds as much as 10 feet thick. Only a few exposures (e.g., NW¼ NE¼ sec. 14, T. 16 S., R. 19 E.) offer an opportunity for obtaining enough measurements to determine a range of the scale of cross stratification. Cross stratification in the Ireland is of the trough type (Pl. 10B) and comprises lenticular and wedge-shaped sets of cross strata that range from about 0.7 to 5 feet in thickness. The medium-scale (length 1 to 20 feet), low-angle (less than 20 degrees) cross strata are 2 inches or less in thickness; most of the cross strata are less than 1 inch thick. The dominant trend of cross stratification approximates S 48°W (Richard Bower, 1960, written communication). Examination of the internal structure of individual cross strata and individual strata in which bedding is even revealed microscopic cross lamination in many exposures.

The lower Williamsburg coal, which occurs locally about 20 to 40 feet below the top of the Ireland, is the most persistent coal within the member. The lower Williamsburg is commonly a shaly bituminous coal which contains many thin clayey shale partings and ranges from 0 to 1.6 feet in thickness.

In the southern half of T. 18 S. and in T. 19 S. the Ireland Sandstone is not recognized; there gray and tan silty shale and minor amounts of siltstone occupy its stratigraphic position. The Ireland Sandstone ranges from 0 to about 100 feet in thickness.

UPPER PART OF LAWRENCE SHALE.—The section above the Ireland Sandstone and below the Toronto Limestone comprises silty shale, clayey shale, sandstone, a number of limestone lenses, and a number of coal lenses (Pl. 2C); gray silty shale is the dominant rock type. Where the upper part of the Lawrence Shale can be recognized in Franklin County, north of the east-west center line of T. 18 S., it ranges from about 40 to 60 feet in thickness.

In Franklin County and several other counties in Kansas south of Doniphan County, the occurrence of a zone of limestone lenses in the upper part of the Lawrence Shale is common and characteristic. It has become common practice to correlate these limestone lenses with the Amazonia Limestone (Hinds and Greene, 1915, p. 31, 170) whose type section is in southern Andrew County, Missouri. Limestone lentils in the upper Lawrence Shale of Franklin County and the southernmost definite Amazonia Limestone are widely separated geographically. Lithologic aspects of these limestone lenses in Franklin County differ radically from one another and from the lithologically quite uniform Amazonia Limestone. The practice of correlating a number of different limestone lenses in the upper part of the Lawrence Shale across Kansas to the Amazonia is not justifiable.

Along the Franklin-Anderson county line (SW¼ SE¼ sec. 18, T. 19 S., R. 18 E.) a limestone lense which is brownish gray, devoid of internal bedding, and 1 foot thick crops out; it contains *Neospirifer,* myalinid clams, crinoid stems, and bryozoans. There the upper contact of the limestone is about 26 feet below the base of the Toronto Limestone and about 8 feet below the base of the upper Williamsburg coal.

About 1 mile southwest of Williamsburg (near center east line NW¼ sec. 24, T. 18 S., R. 17 E.) a lenticular limestone crops out about 37 feet below the base of the Toronto Limestone and about 1 foot below the base of the upper Williamsburg coal. There the limestone is about 1.6 feet thick, light gray, and dense; it contains many small pellets which may be ostracodes, algae, or both.

In the SW¼ SE¼ sec. 15, T. 17 S., R. 18 E., a gray, arenaceous, platy limestone, 1 foot thick, crops out about 13 feet below the Toronto Limestone and about 5 feet below the upper Williamsburg coal. No fossils were observed in the limestone at that locality. At the center of the south line sec. 32, T. 15 S., R. 18 E., a 0.6-foot, blue-gray arenaceous limestone occurs less than 1 foot above a coal thought to be the upper Williamsburg, and about 39 feet below the base of the Toronto Limestone.

The upper Williamsburg coal is a somewhat persistent marker south of the Marais des Cygnes River. This coal is about 18 inches thick in the vicinities of Ransomville and Williamsburg, but it thins and is discontinuous to the north and south in Franklin County. Relatively hard, massive and thinly bedded, bituminous coal, which has variable clay content and is rather shaly in places, forms the upper Williamsburg.

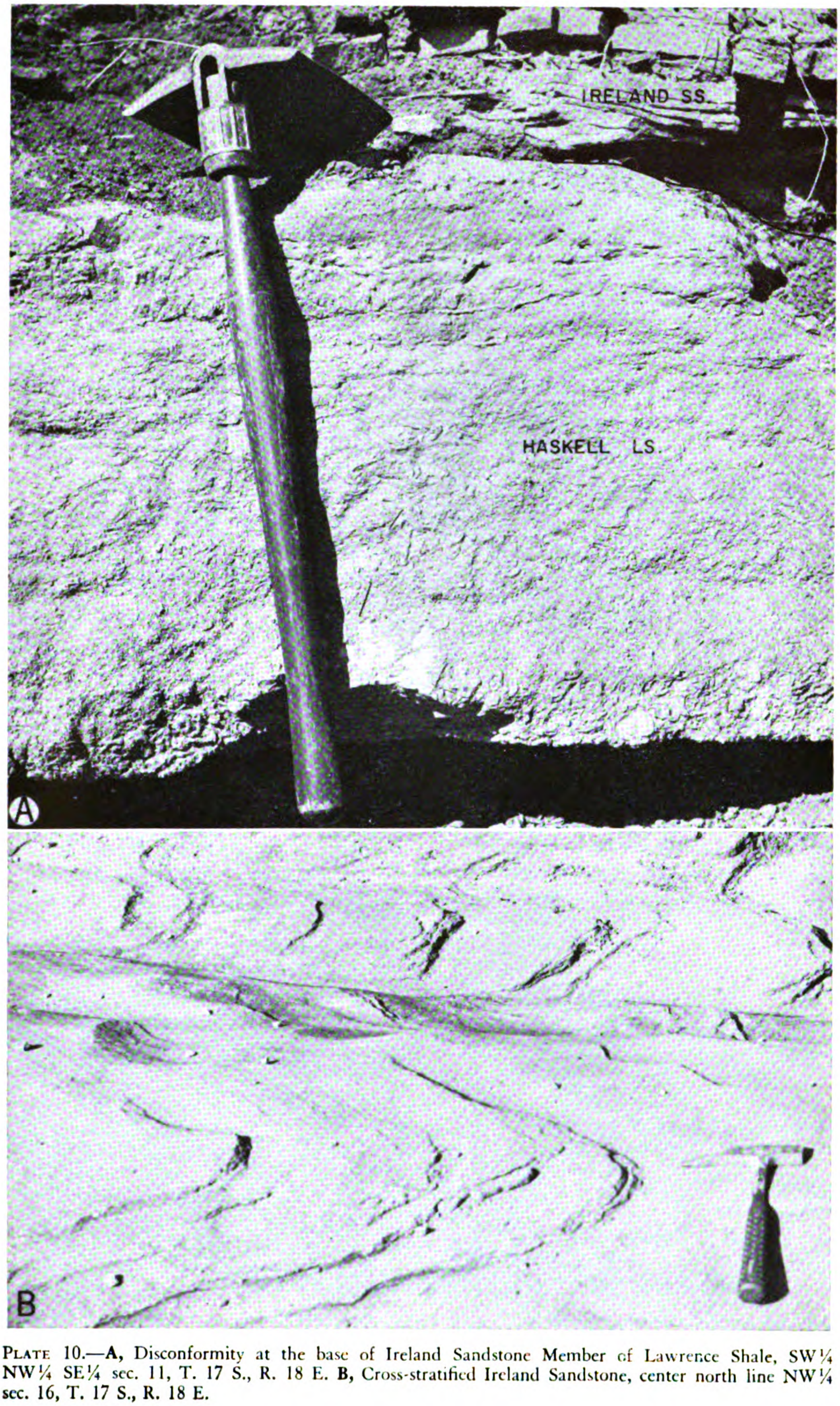


PLATE 10.—**A,** Disconformity at the base of Ireland Sandstone Member of Lawrence Shale, SW¼ NW¼ SE¼ sec. 11, T. 17 S., R. 18 E. **B,** Cross-stratified Ireland Sandstone, center north line NW¼ sec. 16, T. 17 S., R. 18 E.

Tan silty shale, siltstone, and coal seams compose the section between the upper Williamsburg coal and the Toronto Limestone. Of these lithologies only the silty shale persists throughout the county (Pl. 2C).

A zone of red shale or mudstone crops out locally in the upper part of the Lawrence Shale; in the NW corner sec. 32, T. 15 S., R. 18 E., this zone is about 13 feet below the base of the Toronto Limestone. Red shale in approximately the same stratigraphic position is common across the state.

Shawnee Group

OREAD LIMESTONE

General continuity and relatively unchanging lithology are salient features of the Oread Limestone in Franklin County. However, missing beds, minor faulting, and facies change within the formation are noted (Pl. 2D). Representative measured sections are given below.

Measured section of the Oread Limestone exposed in a road cut along the E line SE¼ SE¼ sec. 7, T. 16 S., R. 18 E.

	Thickness, feet
Kanwaka Shale (not exposed)	
Oread Limestone	
Kereford Limestone Member	
Limestone, gray to tan on both fresh and weathered surfaces, bedding indistinct, weathers into irregular thin slabs, microcrystalline and compact in upper 3 feet, shaly in lower 3 feet; *Composita, Dielasma*, bryozoans, crinoids, abundant fusulinids; thickness exposed	6.0
Heumader Shale Member	
Shale, gray, clayey to silty, weathers into flakes; sparse limonite concretions in upper half; lower 10 feet covered; about	26.0
Plattsmouth Limestone Member	
Limestone, light gray on both fresh and weathered surfaces, thin wavy bedding, microcrystalline; brachiopods, bryozoans, crinoids; thickness exposed.	5.0

Measured section of the Oread Limestone exposed in a road cut near the cen. E line sec. 31, T. 18 S., R. 18 E.

	Thickness, feet
Kanwaka Shale (not exposed)	
Oread Limestone	
Plattsmouth Limestone Member	
Limestone, light gray on both fresh and weathered surfaces, fine grained, compact, thin irregular bedding; *Chonetes, Derbyia, Lophophyllidium, Neospirifer*, bryozoans, crinoids; thickness exposed	6.0
Heebner Shale Member	
Shale, dark gray to black, clayey to silty, weathers into fissile to platy beds; conodonts; about	4.0
Leavenworth Limestone Member	
Limestone, blue gray, extremely dense, fractures conchoidally, vertically jointed; weathers into 2 distinct beds, a lower 0.5-foot bed and an upper 1.5-foot bed; brachiopods, clams, crinoids, fusulinids, *Osagia*-coated shell fragments in lower bed	2.0
Snyderville Shale Member	
Shale, gray green, clayey to silty, bedding indistinct, weathers into flakes in upper part; about	9.0
Toronto Limestone Member	
Limestone, gray to brown on both fresh and weathered surfaces, fine grained, compact, thin to thick rubbly beds in lower 3 feet, thick beds above; *Chonetes*, dictyoclostids, *Composita, Derbyia, Neospirifer, Punctospirifer, Syringopora*, abundant fusulinids, ramose bryozoans; about	11.0
Lawrence Shale	

TORONTO LIMESTONE MEMBER.—The lowermost member of the Oread Limestone is the Toronto Limestone (Haworth, 1894a, p. 117). Except for a small area in the northwestern part of the county (T. 15 and 16 S., R. 18 E.) the Toronto is continuous across Franklin County. Typically the Toronto is a massive, thin- to thick-bedded, ochroid, ferruginous limestone, 8 to 12 feet thick, which weathers into slabs and irregular fragments, thus imparting a false aspect of thin irregular bedding, especially in the uppermost 2 to 3 feet of the ledge. Fusulinids, brachiopods, and crinoids are distributed throughout the member; these fossils weather white in marked contrast to the brown matrix. The fusulinids are concentrated mainly in the lower and upper few feet of the Toronto. The lowermost and uppermost parts of the member are gradational into adjacent strata through thicknesses of about 0.5 foot.

The Toronto is atypically developed in a number of places in northwestern Franklin County. The lower 2 to 4 feet of the Toronto in some exposures (e.g., SW corner sec. 29, and SE corner NE¼ sec. 31, T. 15 S., R. 18 E.) consists of a gray, dense, sparsely fossiliferous limestone (Pl. 11A). In the southern part of T. 17 S., R. 17 E. (center SW¼ sec. 23 and SW corner sec. 25), a gray limestone about 10 feet thick is correlated tentatively with the Toronto. This rock contrasts with typical Toronto Limestone in that it has a higher silt content, is more fossiliferous, lacks abundant fusulinids, and contains *Lingula* and ostracodes in the upper part. A gray, dense, coarsely crystalline limestone 2 feet thick occupies the stratigraphic

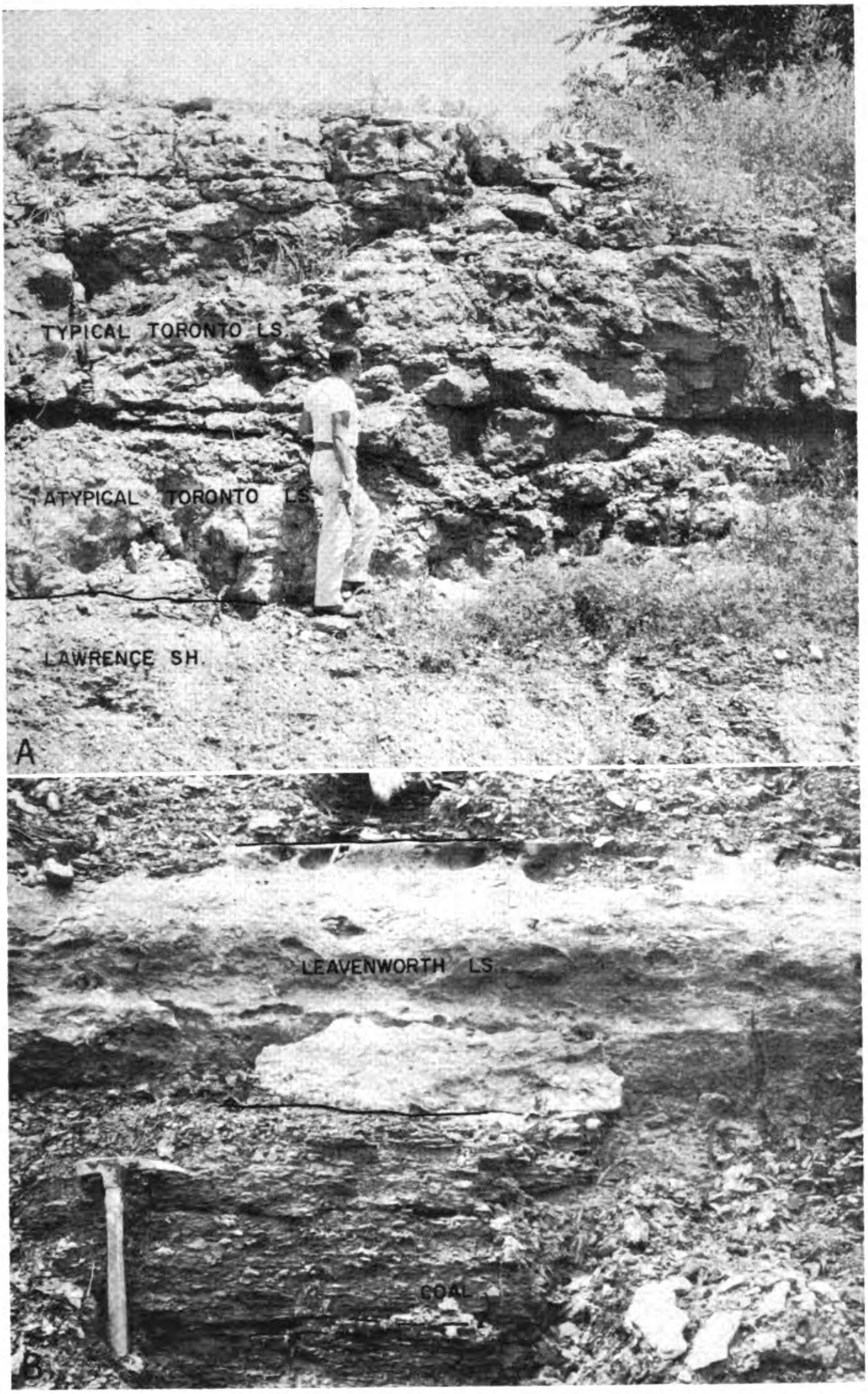


PLATE 11.—Road cut exposures of Oread Limestone. **A,** Atypical lithology in lower part of Toronto Limestone Member (section D15), SW corner sec. 29, T. 15 S., R. 18 E. **B,** Coal seam in Snyderville Shale Member, NW corner sec. 5, T. 16 S., R. 18 E.

position of the Toronto at the center east line sec. 4, T. 18 S., R. 18 E. There the limestone is composed primarily of tiny crinoid columnals and lesser amounts of algal and foraminiferal material. O'Connor (1960, p. 38) has noted exposures of atypical Toronto north of Baldwin in southern Douglas County.

The area in southern Douglas County and northern Franklin County in which the Toronto Limestone is absent, known exposures of atypical Toronto Limestone, and locations of other stratigraphic anomalies within the Oread Limestone are shown in Figure 9.

SNYDERVILLE SHALE MEMBER.—The Snyderville Shale (Condra, 1927, p. 38) immediately overlies the Toronto Limestone or, where the latter is absent, the Lawrence Shale. Except at one exposure (Pl. 2, section D15), the member is apparently continuous throughout the county, ranging in thickness from about 9 to 30 feet.

Alternating layers of tan to gray-green silty shale, tan silty claystone, siltstone, and nodular, relatively impure, fossiliferous limestone make up the Snyderville. The claystone, siltstone, and limestone are discontinuous units. However, in the majority of well-exposed sections north of Williamsburg, at least one of these lithologies is present. Where the upper few feet of the Snyderville is well exposed (see Pl. 11), it consists of a thin coal seam overlain by gray shale, which contains sparse fossil brachiopods and clams.

At D11 and D12 (see Stratigraphic Sections), where the Toronto Limestone is absent, 0.5 foot of fossiliferous limestone crops out 2 feet below the top of the Snyderville. The possibility that this limestone is the Toronto is precluded by the presence of both limestones in the same exposure in the SW¼ NW¼ sec. 18, T. 18 S., R. 18 E.

Claystone in the central part of the Snyderville in outcrops D2, D4, and D6 (Pl. 2) is 8.5, 3.5, and 17 feet thick, respectively, and probably is the result of weathering soon after deposition. A sample of the claystone was subjected to a standard clay-mineral analysis by x-ray diffraction. Examination disclosed that the sample contained approximately 85 percent illite, 8 percent calcite, quartz (minor), and an interlayered hydrated-mica unit (minor). Solely on the basis of the x-ray examination, it would seem that the sample does not represent altered shale. The source of the claystone was possibly a limestone (C. F. Kahle, 1959, written communication). O'Connor (1960, p. 40) noted this "fossil soil" of the Snyderville in southern Douglas County and suggested that it is the result of weathering of a part of the Toronto Limestone. The claystone at localities D4 and D6 (Pl. 2) was not derived by alteration of Toronto Limestone but may have been derived by weathering of limestone known to exist locally within the Snyderville Shale.

LEAVENWORTH LIMESTONE MEMBER. — The Leavenworth Limestone (Condra, 1927, p. 38) is the best "key bed" in Franklin County. Thickness and other lithologic aspects of the Leavenworth are almost unchanging. Except at one locality (Pl. 2, D 15), this member is continuous in Franklin County.

The following description is applicable to the Leavenworth in all exposures studied. This blue-gray limestone is a single, massive, even-surfaced ledge, which fractures conchoidally. When struck with a sledge, the bed commonly breaks along joints through its complete thickness into smooth-sided slabs. The fauna comprises sparse fusulinid, clam, snail, brachiopod, echinoid, and crinoid remains. *Allorisma, Aviculopecten,* and *Ottonosia* were identified from the Leavenworth. Thickness of the member ranges from 1.3 to 2.3 feet.

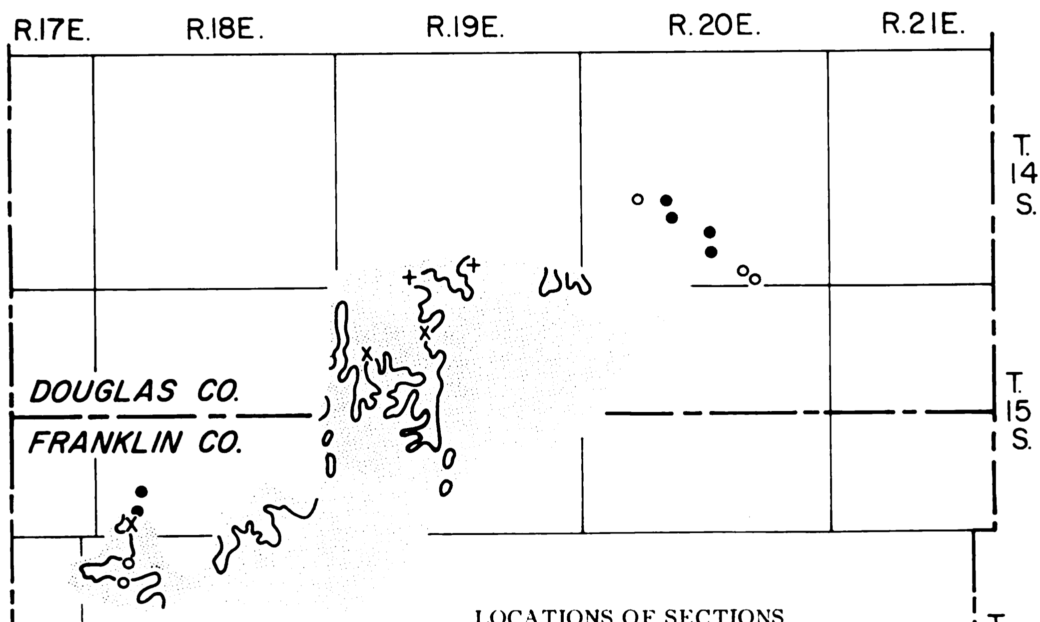
HEEBNER SHALE MEMBER.—The Heebner Shale (Condra, 1927, p. 37) is continuous in Franklin County. Black platy to nearly fissile shale in the lower 1 to about 3 feet, overlain by gray to green clayey shale, forms the Heebner. The lower, dark part of this shale commonly is contiguous with the underlying Leavenworth, but in some exposures the two rocks are separated by 1 to 3 inches of gray siltstone. A conodont fauna which has numerous individuals but few genera occurs in the black shale. The genera *Hindeodella, Streptognathodus, Ozarkodina,* and *Lonchodina* are represented. The bar type conodonts, *Hindeodella,* are preserved with little distortion on the bedding surfaces of the shale, but many blade and platform-bearing *Streptognathodus* are bent or broken. The brachiopods *Chonetes* and *Productella* are found in the upper, gray to green part of the member. The thickness of the Heebner ranges from approximately 4 to 18 feet and averages about 6 feet.

PLATTSMOUTH LIMESTONE MEMBER. — The Plattsmouth Limestone (named by Keyes, 1899, p. 306, and more specifically defined by Condra, 1927, p. 37) is continuous throughout Franklin County. A complete thickness of the Plattsmouth is rarely accessible for study.

This light-gray, thin, and irregularly bedded, mostly aphanitic limestone typifies "upper" (Moore, 1936, p. 27-28) limestones. The gross lithology of the Plattsmouth is strikingly similar to that of the older Stoner, Spring Hill, Argentine, and Raytown Limestones. Position in sequence is the most distinguishing characteristic of the Plattsmouth. Individual beds range from about 2 inches to 1 foot in thickness, and thicker parts of a bed are commonly contiguous with thinner parts of adjacent beds. A variety of brachiopod genera, bryozoans, coelenterates, echinoderms, mollusks, and algae are present. The thickness of the Plattsmouth is approximately 20 feet.

HEUMADER SHALE MEMBER.—Because of the susceptibility of the overlying Kereford Limestone to weathering, good exposures of the Heumader (Moore, 1932, p. 94-96) are rare. The member is apparently continuous in Franklin County.

Where observed, the Heumader consists of weathered calcareous shale with indistinct bedding. Examination in excavated outcrops revealed no fossils, and it is concluded that fossils apparently indigenous to the Heumader have weathered out of the overlying Kereford Limestone. Float in some exposures indicates the



LOCATIONS OF SECTIONS

● Toronto Limestone X Heebner Shale
o Snyderville Shale + Leavenworth Limestone

	Sec.	T. S.	R. E.		Sec.	T. S.	R. E.
● SW	21	14	20	o SE SW	20	14	20
SW SW NW	27	14	20	NE SE	34	14	20
SW cor. NW SW	27	14	20	SW SW	35	14	20
NW	28	14	20	SE SE	6	16	18
SW SW	29	15	18	CEL	7	16	18
SE SE NE	31	15	18	X Near cen. SE	7	15	19
NW NE SE	30	16	18	NW NW	9	15	19
Cen. SW	23	17	17	CWL	32	15	18
SW SW	25	17	17	+ Cen. SE	32	14	19
Near CEL	18	17	18	SE SE NW	34	14	19

FIGURE 9.—Map of southern Douglas County (from O'Connor, 1960, p. 66-67) and northern Franklin County showing generalized area (shaded) in which Toronto Limestone Member is absent, and locations of stratigraphic anomalies in Oread Limestone members. Outcrop pattern of Leavenworth Limestone Member is shown within the shaded area.

presence of thin, fucoidal, gray limestone somewhere in the Heumader. Thickness ranges from about 9 to 25 feet.

KEREFORD LIMESTONE MEMBER.—The uppermost member of the Oread Limestone is the Kereford Limestone (Condra, 1927, p. 45). Although apparently continuous in Franklin County, exposures of the Kereford are few and nowhere was a complete thickness observed.

The lower half of the member is buff to gray wavy-bedded limestone which, because of impurities, weathers more like a shale than a limestone. Marly limestone fragments commonly weather free from the upper half of the Kereford. Brachiopods, bryozoans, small planispiral gastropods, profuse *Osagia,* and robust fusulinids are abundant in the Kereford, especially in the upper part of the member.

Because of this rock's susceptibility to weathering, an exposure showing a total thickness of the Kereford was not found. Data from drillers logs and measured sections indicate an average thickness of about 11 feet. Being much less resistant to weathering than the Plattsmouth Limestone Member, Kereford outcrops are usually far back on the dip slope of the Oread cuesta. Where the underlying Heumader Shale is less than 10 feet thick, the Kereford is especially inconspicuous in the Oread Limestone escarpment.

KANWAKA SHALE

A predominantly terrigenous detritus section, the Kanwaka Shale (Adams and others, 1903, p. 45), is subdivided into three members—Jackson Park Shale, Clay Creek Limestone, and Stull Shale—which are rarely well exposed in Franklin County.

JACKSON PARK SHALE MEMBER. — Moore (1932, p. 94) designated the Jackson Park Shale as the lower member of the Kanwaka Shale. The member is continuous throughout Franklin County. Exposures are restricted to T. 15 and 16 S., R. 17 E., and a small area in T. 15 S., R. 18 E. Soil and vegetation cover the Jackson Park in most places. Where exposed, a gradually receding slope delimits its outcrop.

The Jackson Park conformably overlies the Kereford Limestone and is conformably overlain by the Clay Creek Limestone. The entire member averages approximately 25 feet in thickness. The lower 10 to 15 feet of the member is gray, clayey to silty shale that contains land plant fossils. Tan calcareous shale with marine invertebrates such as brachiopods, bryozoans, and crinoids constitutes the upper part of the Jackson Park.

CLAY CREEK LIMESTONE MEMBER.—The middle member of the Kanwaka Shale is the Clay Creek Limestone (Moore, 1932, p. 96). Few exposures of the member were observed, but it is apparently continuous in Franklin County. Fresh and weathered exposures of this member contrast sharply. In fresh exposures a single ledge with prominent vertical joints and devoid of shale partings is characteristic. In weathered exposures rapid disintegration causes jointing to become ill-defined. The fossils present are algae, brachiopods, bryozoans, and crinoids. The thickness of the Clay Creek ranges from 2 to about 4 feet. In an exposure at the center east line NE¼ NE¼ sec. 14, T. 16 S., R. 17 E., where the Clay Creek is nearly 4 feet thick, it is cross bedded in the upper 2 feet.

STULL SHALE MEMBER.—Strata between the Clay Creek Limestone below and the Spring Branch Limestone of the Lecompton above form the Stull Shale (Moore, 1932, p. 96). The member is apparently continuous in Franklin County. The Stull consists mainly of tan silty to clayey shale that is locally sandy. Its thickness is approximately 30 feet. In the exposures studied it lacks megafossils, except for brachiopods and bryozoans in the upper 5 feet. In some exposures ironstone concretions are noted in the upper part of the member.

LECOMPTON LIMESTONE

Only the lower two members of the Lecompton are exposed in Franklin County: the Spring Branch Limestone and the Doniphan Shale.

SPRING BRANCH LIMESTONE MEMBER.—The lowermost member of the Lecompton Limestone is the Spring Branch Limestone (Condra, 1927, p. 27). Lithologic aspects of the Spring Branch include dark-brown color, massive bedding, and abundant slender fusulinids. This limestone is compact but relatively impure, containing clay and quartzose sand impurities. The prominence of fusulinids on weathered surfaces and the abundance of fusulinids that weather free from the matrix are striking. Brachiopods and crinoids are common at most exposures. The thickness of the Spring Branch ranges from 5 to 7 feet.

Grossly the Spring Branch Member of the Lecompton and the Toronto Member of the Oread are strikingly similar, but in addition to position in sequence they differ in several respects. The Spring Branch is thinner, apparently has more fusulinids and fewer crinoid fragments, and is less pure.

DONIPHAN SHALE MEMBER.—The Doniphan Shale (Condra, 1927, p. 47) is apparently the youngest bedrock unit exposed in Franklin County, and it is continuous. Tan clayey, silty, and sandy shale that is generally nonfossiliferous composes the Doniphan. Sparse mollusks were observed on shale slopes of the Doniphan in some exposures, but the position of these fossils in the shale was not ascertained. The thickness of the Doniphan in Franklin County is approximately 15 feet, which is slightly more than is common farther northeast in Kansas.

Neogene System

High-level stream deposits

Deposits of late Pliocene? and early Pleistocene age are mapped as chert gravels on Plate 1. The higher accumulations, which are remnants of stream-laid beds, are chert, sand, and gravel in a gray-green to red-brown clayey matrix. The lower deposits comprise chert, sand, gravel, silt, and clay. Loess deposits as much as 3 feet thick are found locally on the uplands. Colluvium and "soil" are locally as much as 25 feet thick. Loess, colluvium, and "soil" conceal much of the Pennsylvanian rocks but are not mapped on Plate 1 or discussed in the text.

The higher chert-gravel deposits containing no glacial erratics and lying at altitudes of 970 to 990 feet, about 85 to 100 feet above the Marais des Cygnes River floodplain, along bluffs north of the river (Pl. 1) between Ottawa and Richter, are judged to be of late Pliocene or early Pleistocene age. These chert gravels are well exposed in gravel pits northwest of Richter (sec. 27, T. 16 S., R. 18 E.). There the chert gravel, predominantly pebble size, and chert sand are included in a red-brown clayey matrix. No calcareous material was observed in these deposits, which probably correspond to the terrace remnants of intermediate elevation noted by O'Connor (O'Connor and others, 1955, p. 7) in Osage County.

Lower chert gravel and sand in a red-brown to gray-green clayey matrix overlie Pennsylvanian bedrock along the bluffs both north and south of the Marais des Cygnes River east of Ottawa. These terrace remnants lie at altitudes of 900 to 920 feet and are about 55 to 70 feet above the floodplain. They contain few glacial erratics, appear to be thoroughly leached, and are well exposed in several gravel pits (e.g., NE¼ SW¼ sec. 33, T. 16 S., R. 20 E.).

Younger Alluvium

Valley-fill material younger than the chert gravels described above was mapped as "younger alluvium" (Pl. 1). A skull and jaw of *Bison bison* was collected from alluvial deposits along Middle Creek (NW¼ sec. 19, T. 18 S., R. 19 E.) by the J. E. Halleys, who stated that these vertebrate fossils were found at a depth of about 15 feet. Staff members of the Museum of Natural History, The University of Kansas, identified the skull and estimated its age as late Wisconsinan to early Recent.

STRUCTURAL GEOLOGY

Regional Structure

Franklin County is in the structural province known as the Forest City Basin (Jewett, 1951, p. 135). Strata exposed in the county are a small part of the Prairie Plains Monocline (Jewett, 1951, p. 152), which comprises a great number of contiguous stratigraphic units dipping westwardly and northwestwardly away from the Ozark Dome of Missouri. The monocline is thought to be pre-Cretaceous and chiefly post-Permian in age. Numerous local dip reversals are superimposed on the regional dip, which is generally about 10 to 30 feet per mile.

Faulting

Several faults have been reported in southern Douglas County, northwestern Franklin County, and eastern Osage County (Rich, 1933a; O'Connor, *in* O'Connor and others, 1955; and Laughlin, 1957). O'Connor (1960, p. 63-69) has summarized these articles and has discussed in detail faulting in southern Douglas County. Two of the faults in northwestern Franklin County were mapped (Pl. 1).

West of Centropolis, in sec. 24 and 25, T. 15 S., R. 18 E., a generally north-trending fault was mapped. The stratigraphic sequence on the upthrown and downthrown sides of the fault is well exposed along the east-west county road between sections 24 and 25. There, a normal thickness of Toronto Limestone crops out on the west (upthrown) side. On the east (downthrown) side, the Toronto Limestone is absent and the rock section comprises Lawrence-Snyderville Shale, Leavenworth Limestone, Heebner Shale, and Plattsmouth Limestone. The Heebner Shale, which regionally averages about 6 feet in thickness, is about 17 feet thick on the downthrown side; the base of the Toronto on the upthrown side is about 30 to 40 feet above the top of the Leavenworth on the downthrown side.

A second fault affects upper Lawrence Shale and lower Oread Limestone strata near the center south line of sec. 19, T. 16 S., R. 18 E. On the southeast (upthrown) side of the fault (SW corner SE¼ sec. 19, T. 16 S., R. 18 E.) the Toronto Limestone forms a prominent escarpment; 60 feet west of the escarpment, on the northwest (downthrown) side of the fault, the Leavenworth Limestone crops out 6 feet below the base of the Toronto when projected across the fault line. Thus, if an average thickness of Snyderville Shale is assumed, displacement approximates 30 feet, and the youngest unit definitely displaced is the Plattsmouth Limestone.

Near the center west line of sec. 32, T. 15 S., R. 18 E., faulting has affected the lower 3 members of the Oread Limestone and the upper part of the Lawrence Shale. There, on the east side of the road, strata from the upper part of the Snyderville Shale upward to within the Plattsmouth Limestone are exposed. The Heebner Shale, which regionally averages 6 feet in thickness, measures about 18 feet and comprises alternating black and gray-green shale (Pl. 2, section D14). West of the road, sandstone in the upper part of the Lawrence Shale and the Toronto Limestone have an apparent dip of about 25 degrees to the north (Pl. 12A). The Leavenworth Limestone on the east side of the road is at about the same elevation as that of the Toronto Limestone on the west side of the road. The probable age of the tilting and faulting is post-Leavenworth pre-Plattsmouth.

The upper part of the Lawrence Shale and the lower part of the Oread Limestone are well exposed at the SW corner of sec. 29, T. 15 S., R. 18 E. (Pl. 2, D15). There, the Oread sequence comprises, in ascending order: Toronto Limestone, Heebner Shale, and Plattsmouth Limestone. The Leavenworth Limestone and the Snyderville Shale are absent, but these rocks crop out in normal succession less than one-half mile in all directions from this exposure. Faulting may be in part responsible for the anomalous stratigraphic conditions seen at this locality, but the authors cannot explain adequately this stratigraphic sequence.

Coal "Conglomerate"

For a distance of 50 feet along the west bank of Coal Creek (SE corner sec. 15, T. 17 S., R. 18 E.) the contact between the Ireland Sandstone and the Robbins Shale is well exposed. Angular coal fragments, clay pebbles, limestone pebbles, and laminae of coaly material are incorporated in the lowermost 4 feet of the Ireland; the limestone pebbles are restricted to the lowermost foot. Deformed stratification in the underlying Robbins Shale (Pl. 12B) in the northern half of the exposure indicates lateral sliding along the sandstone-clayey shale contact. Coaly material and sandstone laminae along bedding surfaces of the deformed Robbins Shale were not observed along bedding surfaces of the undeformed Robbins Shale in the southern part of the exposure. The deformed Robbins terminates abruptly at a fault surface (Pl. 12B). Apparently the sandstone laminae are intercalations of Ireland Sandstone injected along bedding surfaces of Robbins Shale during lateral sliding in water-rich semiconsolidated sediment. Similar structures, believed to have developed without the application of tectonic forces, have been described by Hills (1955), Richter-Bernburg (1953), and Fisk (1955).

Rich (1933b), after studying this exposure, concluded that: (1) the coal was not formed in place, (2) the unconformity at the base of the Lawrence Shale is stratigraphically below the Haskell Limestone Member of the Stranger Formation, and (3) the unconformity at the base of the Lawrence represents considerable geologic time.

The present authors' interpretations differ from those of Rich. The coal now seen at this exposure was probably deposited as vegetal matter prior to deposition of the sand and was formed essentially in place. The shape and angularity of the coal fragments is clearly associated with postdepositional deformation rather than with erosion and redeposition; many of the coal fragments, which have been greatly deformed, may be fitted like puzzle pieces. The apparent disconformable relationships and the aspect of an erosional "conglomerate" at this exposure are largely the results of a slump-fault breccia type of adjustment. Records of test drilling at this location and 0.8 mile to the north (center east line NE¼ sec. 15, T. 17 S., R. 18 E.), included in the Stratigraphic Sections, indicate that the base of the Lawrence Shale at this locality immediately overlies the Robbins Shale, which is stratigraphically next above the Haskell Limestone. Therefore, the amount of the section that may be missing is about 50 feet less than Rich postulated. Neither local nor regional stratigraphic relationships indicate that locally developed disconformity at the base of the Lawrence Shale is of considerable time magnitude.

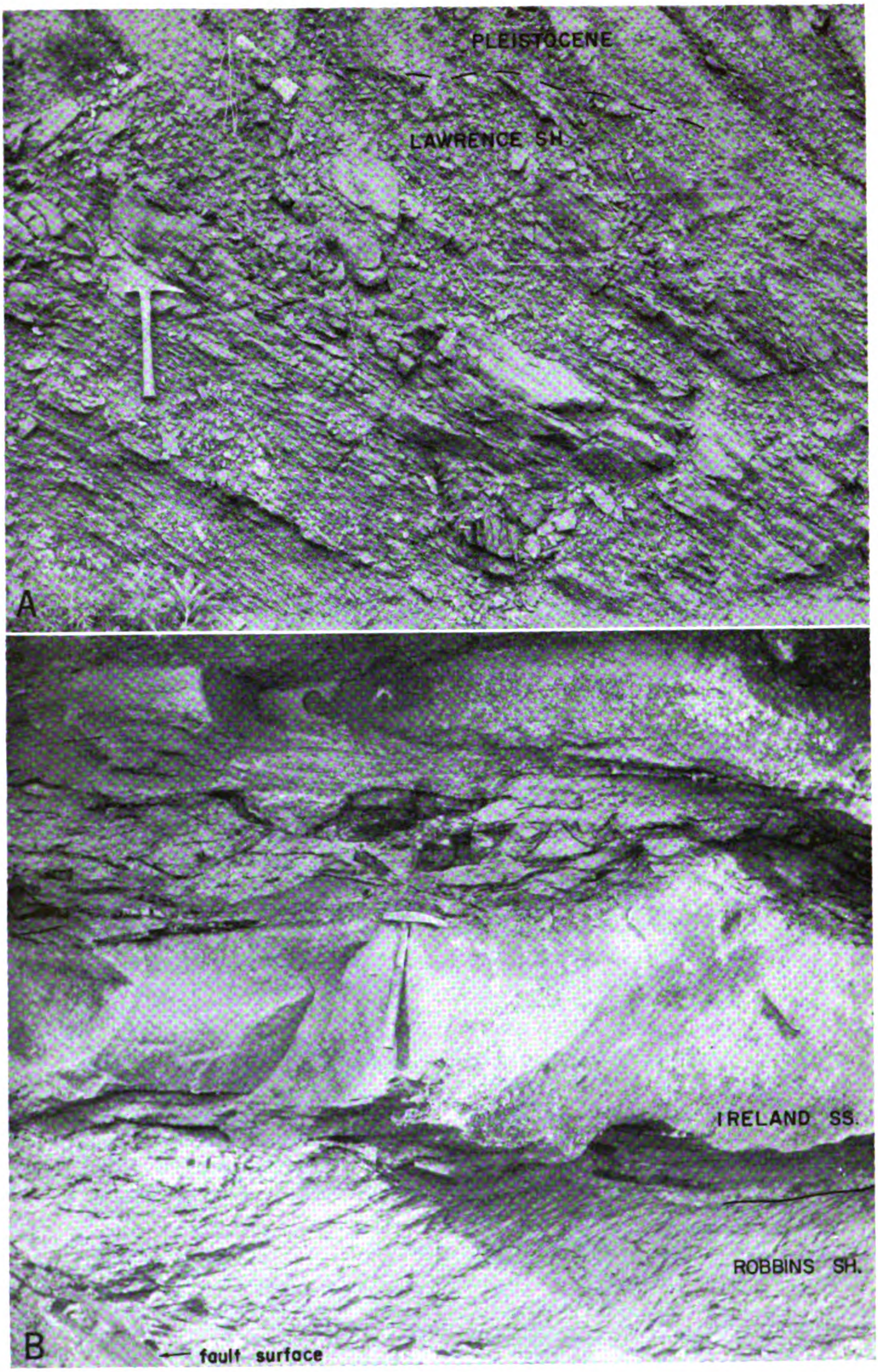


PLATE 12.—**A,** Apparent dip, about 25°N, of sandstone beds in upper part of Lawrence Shale at center east line sec. 31, T. 15 S., R. 18 E. Road cut exposure. **B,** Deformed stratification in Robbins Shale Member of Stranger Formation and coal fragments in Ireland Sandstone Member of Lawrence Shale at SE corner sec. 15, T. 17 S., R. 18 E. Streambank exposure.

ECONOMIC GEOLOGY

Because the livelihood of the area's population is dependent upon it, soil is the resource of greatest importance in Franklin County (Dunmire and others, 1946). Ground water, oil and gas, limestone, sand and gravel, coal, and shale are other mineral resources exploited.

GROUND WATER

In the eastern and especially the southeastern part of the county, good quality ground water for domestic and livestock use is difficult to obtain. Wells that obtain ground water from porous surficial deposits and fissured near-surface bedrock furnish limited supplies. Large quantities of ground water for municipal use are generally not available. Small municipal supplies are obtained from wells in the alluvium of the larger streams and from artificial lakes such as the one at Richmond.

Sandstone beds in the Douglas Group are the principal aquifers in the western part of the county. Sandstone in the Lawrence Shale is the main source of ground water in northwestern Franklin County; in southwestern Franklin County, Stranger sandstone is the main aquifer. Farmers of western Franklin County generally have little trouble in obtaining suitable water supplies.

OIL AND GAS

Oil and gas have been produced commercially in Franklin County since 1904 (Jewett, 1954, p. 208). Most oil and gas production has been from that part of the Paola-Rantoul field in T. 16 and 17 S., R. 21 E. All production reported from Franklin County has been from rocks of Pennsylvanian age. In 1961, 379,674 barrels of oil were produced in Franklin County (Goebel and others, 1962, p. 16-17). No gas was reported produced from Franklin County during 1961.

LIMESTONE, SANDSTONE, AND GRAVEL

Near the turn of the century and for some 30 years following, many tons of limestone were delivered by team and wagon to Ottawa and surrounding towns for use as building stone. In the early years much stone was given away to inspire trade (Bert Ross, 1957, personal communication). The use of trucks and the increasing demand for limestone caused quarrying to flourish. Because of increased rigidity of specifications and decrease in the demand for limestone in road construction and as local building stone, growth in the early 1920s was followed by a steady decline in the business until about 1940. In the 1950s, however, the industry expanded. In 1958, 8 active and 20 inactive quarries were noted in the county. Strata quarried extensively are the Argentine, Spring Hill, Captain Creek, Stoner, and Plattsmouth Limestones. Chemical analyses of these ledges in Franklin and adjacent counties were given by Runnels and Schleicher (1956). The limestone of the area has been utilized as agricultural limestone, crushed rock and riprap, concrete aggregate, building stone, and in cement manufacture.

Sandstone has been quarried in sec. 14, T. 16 S., R. 19 E., for use as subgrade material for paving projects in Ottawa. Pits in terrace chert gravels have supplied gravel for many of the all-weather county roads.

COAL

The Ransomville shaft mine (Haworth, 1898, p. 187) was the first of many mines in the Williamsburg mining district. In the 1890s and the early 1900s this mine, located mid-way between Williamsburg and Homewood on U.S. Highway 50, was operated with a horse hoister and supplied fuel for trains which ran between Ottawa and Burlingame. The Ransomville mine produced from the upper Williamsburg coal of the Lawrence Shale.

According to Bowsher and Jewett (1943, p. 72) the Williamsburg mining district is the best proved reserve of coal in rocks of the Douglas Group. They estimated reserves of more than 800,000 tons in sec. 8, T. 18 S., R. 18 E., where the greatest known coal deposits of the county are located. Numerous other coal beds and stringers are found in the Lawrence Shale and Stranger Formation. Very small, long-abandoned strip pits indicate that these thin discontinuous coals have been used locally. Although substantial coal reserves are known in Franklin County, the coal is not being mined commercially.

SHALE

The Weston Shale is used for the manufacture of lightweight concrete aggregate (pit located in NW¼ sec. 23, T. 17 S., R. 19 E.). Potential Weston Shale quarry sites located near rail and highway transportation are in the NW¼ SW¼ sec. 34, T. 15 S., R. 20 E., and near the center west line SW¼ sec. 30, T. 15 S., R. 21 E. Thicknesses of Weston Shale approximating 75 feet are available at these localities, and quarrying would not result in appreciable loss of farm land.

Runnels (1949, p. 39) has mentioned the Eudora Shale, one of several phosphatic shales, as a possible source material for the production of phosphate fertilizers. Crushed Eudora Shale has been used with good results as fertilizer for fields and small garden tracts in and around Ottawa.

STRATIGRAPHIC SECTIONS

Each stratigraphic unit shown on Plate 2 is represented here by at least one measured section description. All descriptions pertain to Franklin County exposures with the exception of A9 and A10, which were measured and described in Anderson County.

A1.—Composite section of a streambank exposure near cen. sec. 34, T. 16 S., R. 21 E. (Argentine Limestone and lower Bonner Springs Shale), and a road cut exposure near cen. S line sec. 27, T. 16 S., R. 21 E. (upper Bonner Springs Shale and Merriam Limestone).

	Thickness, feet
Plattsburg Limestone	
Hickory Creek Shale Member	
Merriam Limestone Member	
Limestone, gray, a single massive bed, microcrystalline, weathers to a "worm-eaten" surface; scattered brachiopods and crinoid remains	0.5
Limestone, gray tan, cross stratified, calcarenite, osagite-oolite texture; brachiopods, bryozoans, mollusks, foraminifers; about	7.0
Limestone, gray, a single massive bed, microcrystalline; prominent *Composita*-myalinid zone in lower half	1.5
Total thickness of Merriam Limestone	9.0
Bonner Springs Shale	
Shale, gray green to tan, very thin beds weather to flakes, silty; seemingly barren of macrofossils; pellets of limonite in upper part	5.1
Limestone, yellow brown, impure "boxwork"	0.4
Shale, red, thinly laminated yet blocky	1.3
Covered interval; about	32.0
Total thickness of Bonner Springs Shale	38.8
Wyandotte Limestone	
Argentine Limestone Member	
Limestone, gray to white, thin irregularly bedded; brachiopods and crinoids; nodular chert in lower part; thickness exposed	2.5

A2.—Composite section of road cut exposures in the SE cor. sec. 8, T. 17 S., R. 21 E. (Lane Shale and Argentine Limestone), and along the N½ E line sec. 8 (Bonner Springs Shale and Merriam Limestone).

	Thickness, feet
Plattsburg Limestone	
Merriam Limestone Member	
Limestone, light brown on fresh surface, weathers yellow brown, thin and even bedded, microcrystalline; *Composita*-myalinid zone in lower part, *Osagia*, crinoids; upper contact covered; thickness exposed	2.8
Bonner Springs Shale	
Shale, yellow to brown, paper-thin strata weather into flakes, silty; seemingly barren of macrofossils	26.0
Wyandotte Limestone	
Frisbie-Argentine Limestone	
Limestone, gray to brown on fresh surfaces, weathers brown, single thick massive bed devoid of shale breaks or partings, osagite texture	2.0
Limestone, white to brown on fresh surfaces, weathers brown, thin to thick and irregularly bedded, microcrystalline matrix marked with minute stringers of coarsely crystalline calcite; roughly elliptical chert nodules, 2 inches to 1 foot in long dimension and 2 to 8 inches in short dimension in upper 6 feet of unit; *Derbyia*, echinoconchids, dictyoclostids, crinoids, fenestrate bryozoans, lophophyllid corals	21.1
Total thickness of Wyandotte Limestone	23.1
Lane Shale	
Shale, yellow to brown in lower part, gray in upper part, paper-thin strata weather into flakes, silty in the lower part; lower contact covered by alluvium of Marais des Cygnes River; thickness exposed	24.0

A3.—Section of a road cut exposure near the cen. E line sec. 7, T. 17 S., R. 21 E.

	Thickness, feet
Plattsburg Limestone	
Hickory Creek Shale Member	
Merriam Limestone Member	
Limestone, gray on fresh surfaces, weathers brown, thin and even bedded, fine grained and compact; *Composita*-myalinid zone in lower part, crinoids, lophophyllid corals; about	6.0
Bonner Springs Shale	
Shale, yellow to brown, micaceous, silty; seemingly barren of megafossils	24.0
Wyandotte Limestone	
Argentine Limestone Member	
Limestone, gray on fresh surfaces, weathers brown, thin and wavy bedded; fine-grained matrix contains abundant crystalline calcite; sparse chert nodules; *Enteletes*, dictyoclostids, marginiferids, *Lophophyllidium*, crinoids	5.0
Total thickness of Wyandotte Limestone	5.0
Lane Shale	
Shale and sandstone, yellow brown, alternating silty shale and fine-grained quartzose sandstone; sparse brachiopod molds and casts in lower part; thickness exposed about	40.0

A4.—Section of a road cut exposure at NW cor. NW¼ sec. 26, T. 17 S., R. 20 E.

Plattsburg Limestone — *Thickness, feet*

Hickory Creek Shale Member

Merriam Limestone Member

Limestone, brown, marly; no megafossils observed 1.0
Claystone, brown, ferruginous 0.2
Limestone, gray, single even bed, microcrystalline, weathers to a "worm-eaten" surface; brachiopods, crinoids 1.2
Limestone, dark gray to gray blue, single even bed, microcrystalline; *Osagia, Composita*-myalinid zone in lower half 1.0

Total thickness of Merriam Limestone 3.4

Bonner Springs Shale

Shale, greenish, alternating silty shale and siltstone layers 7.0
Limestone, brown, nodular, marly; no megafossils observed 1.0
Shale, gray to buff, paper-thin strata weather into flakes; silty throughout, more so in the lower part 37.0
Siltstone and silty shale, tan and gray, quartzose 5.0
Shale, gray green, clayey 5.5

Total thickness of Bonner Springs Shale 55.5

Wyandotte Limestone

Argentine Limestone Member

Limestone, brown on fresh surfaces, weathers gray, thin to thick and irregularly bedded; fine-grained matrix contains abundant crystalline calcite; chert nodules in upper part; *Neospirifer*, fusulinids, crinoids; lower contact covered; thickness exposed 20.0

A5.—Section of a road cut exposure near the cen. sec. 34, T. 17 S., R. 20 E.

Plattsburg Limestone — *Thickness, feet*

Merriam Limestone Member

Limestone, yellow tan on both fresh and weathered surfaces, cross stratified; foraminifers, shell fragments coated by *Osagia*, ooliths cemented by sparry calcite, clams, brachiopods, crinoids; upper contact covered; thickness exposed 7.0
Limestone, dark gray on fresh surfaces, weathers yellow tan, a single vertically jointed even bed, microcrystalline; *Composita*-myalinid zone in lower part 1.5

Bonner Springs Shale

Shale, green in upper part, gray in lower part, paper-thin beds weather into flakes, silty, micaceous; seemingly barren of megafossils .. 3.0
Limestone, yellow to brown, marly "boxwork" 0.7
Shale, gray green, paper-thin beds weather into flakes and irregularly shaped blocks, silty, micaceous; seemingly barren of megafossils 35.3

Total thickness of Bonner Springs Shale 39.0

Wyandotte Limestone

Argentine Limestone Member

Limestone, gray white on both fresh and weathered surfaces, thin and irregularly bedded, fine grained, compact; brachiopods, fenestrate bryozoans, corals, crinoids; crops out in creek at base of hill; lower contact covered; thickness exposed 16.0

A6.—Section of road cut exposure from near cen. S line sec. 36 to near cen. S line SW¼ sec. 35, T. 18 S., R. 20 E.

Plattsburg Limestone — *Thickness, feet*

Merriam Limestone Member

Limestone, gray blue on fresh surfaces, weathers tan, even bedded in lower half foot, remainder poorly cross stratified; basal surface highly irregular; microcrystalline in lower half foot, remainder comprises clam fragments, foraminifers including abundant fusulinids, and *Osagia* "beans" cemented by sparry calcite; abundant myalinid clams, abundant *Composita*, sparse productids, *Lophophyllidium*, planispiral gastropods; thickness exposed 4.0

Bonner Springs Shale

Shale and siltstone-sandstone, shale gray green to tan, siltsone-sandstone tan to brown 24.0

Wyandotte Limestone

Farley Limestone Member

Limestone, gray to tan on fresh surfaces, weathers yellow brown; thin beds rudely cross stratified; crinoidal debris and sparse *Osagia* cemented by finely crystalline calcite; *Composita*, nautiloid cephalopods, abundant crinoid columnals, bryozoans; contacts poorly exposed; about 7.0

Island Creek Shale Member

Shale and sandstone, tan; shale silty and sandstone quartzose; seemingly barren of megafossils 14.0

Argentine Limestone Member

Limestone, gray to white on fresh surfaces, weathers yellow brown, thin to thick and slightly wavy bedded, microcrystalline matrix contains abundant crystalline calcite; *Chonetes, Composita*, abundant *Enteletes*, crinoid stems and calices; best exposed in abandoned quarry north of road; lower contact covered; thickness exposed 18.0

A7.—Section of road cut exposure along N¼ W line NW¼ sec. 13, T. 19 S., R. 20 E.

Plattsburg Limestone — *Thickness, feet*

Spring Hill Limestone Member

Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded, fine grained, compact; abundant crystalline calcite; chert nodules in upper half; *Composita*, dictyoclostids, crinoids, fenestrate and ramose bryozoans, sparse fusulinids; upper contact covered; thickness exposed 21.0

Hickory Creek Shale Member

Shale, highly weathered nodular limestone in lower part, yellow brown to gray upward on both fresh and weathered surfaces; sparse shell fragments in uppermost 1 foot 3.0

Merriam Limestone Member

Limestone, gray on fresh surfaces, weathers tan, bedding discontinuous and indistinct, microcrystalline; brachiopods, crinoids, corals 1.5

Limestone, brown, weathers to a rubble 0.9

Limestone, gray blue on fresh surfaces, weathers buff, even bedded, fine grained, compact; *Dielasma, Composita,* crinoids 1.9

Total thickness of Merriam Limestone 4.3

Lane-Bonner Springs Shale

Shale, gray green, silty to clayey upward; poorly preserved plant fossils in lower part 13.0

Shale and siltstone, tan, calcareous; *Cordaites, Neuropteris;* about 22.0

Shale, olive to gray, clayey to silty; poorly preserved plant remains; basal contact covered; thickness exposed 7.0

A8.—Section of a road cut exposure near cen. SE¼ sec. 15, T. 19 S., R. 20 E.

Plattsburg Limestone — *Thickness, feet*

Spring Hill Limestone Member

Limestone, gray to white on fresh surfaces, weathers buff, thin and irregularly bedded, fine grained; nodular chert in upper part; brachiopods, crinoids, echinoids, fenestrate and ramose bryozoans, sparse fusulinids; upper contact concealed; thickness exposed 20.0

Hickory Creek Shale Member

Shale; mostly covered 0.5

Merriam Limestone Member

Limestone, brown, weathers to a rubble; brachiopods, crinoids 0.7

Limestone, gray blue on fresh surfaces, weathers buff, slightly irregularly bedded, microcrystalline; abundant veinlets of coarsely crystalline calcite; abundant *Composita,* crinoids 2.5

Total thickness of Merriam Limestone 3.2

Bonner Springs Shale

Shale, gray green, clayey to slightly silty; poorly preserved plant fossils 10.0

Limestone, brown, marly "boxwork" crack system healed with green clay 0.7

Shale, gray green, silty; seemingly barren of megafossils 15.0

Total thickness of Bonner Springs Shale 25.7

Wyandotte Limestone

Argentine Limestone Member

Siltstone, brown, calcareous, in part conglomeratic; *Composita,* dictyoclostids, crinoids, fenestrate bryozoans, *Baylea, Cordaites* 6.0

Total thickness of Wyandotte Limestone 6.0

Lane Shale

Shale and siltstone, brown, calcareous; sparse plant and invertebrate fossils; lower contact covered; thickness exposed 32.0

A9.—Section of a road cut exposure at NW cor. sec. 6, T. 20 S., R. 20 E., on U.S. Highway 59 about 3 miles north of Garnett, Anderson County.

Plattsburg Limestone — *Thickness, feet*

Spring Hill Limestone Member

Limestone, gray to white on both fresh and weathered surfaces, thin to thick and irregularly bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; brachiopods, crinoids, echinoids 14.0

Hickory Creek Shale Member

Shale, tan, clayey to silty 0.3

Merriam Limestone Member

Limestone, yellow brown, distinctive weathered surface pocked by irregular vugs; brachiopods, crinoids 0.6

Limestone, gray to blue on fresh surfaces, weathers buff, slightly irregularly to evenly bedded, fine grained, compact; brachiopods, crinoids, sparse clams 3.0

Total thickness of Merriam Limestone 3.6

Total thickness of Plattsburg Limestone 17.9

Bonner Springs Shale

Shale and siltstone, gray-green shale and green to tan siltstone interbedded, paper-thin strata weather to flakes and irregular blocks, shale clayey to silty upward; siltstone in central part contains plant fossils including *Mariopteris, Neuropteris,* and *Pecopteris,* and clams including *Aviculopecten* 11.0

Wyandotte Limestone

Argentine Limestone Member

Shale and siltstone, discontinuous zones of dense limestone nodules, shale weathers into flakes, calcareous; shale contains pockets of abundant *Pleurophorus* 3.5

Limestone and shale, gray to blue, alternating silty limestone and shale; marine invertebrates and sparse wood fragments, abundant small *Composita* in lower part, clams, crinoids, fenestrate and ramose bryozoans 5.0

Sandstone to siltstone, brown, poorly cross stratified; sparse clams; about 5.0

Total thickness of Wyandotte Limestone 13.5

Lane Shale

Shale and siltstone interbedded, gray, shale clayey to silty and micaceous; sparse clams, *Lepidodendron, Calamites;* basal contact covered; thickness exposed 40.0

A10.—Section of road cut exposure at SW cor. sec. 6, T. 20 S., R. 20 E., on U.S. Highway 59 about 2.5 miles north of Garnett, Anderson County.

Plattsburg Limestone — *Thickness, feet*

Hickory Creek Shale Member

Merriam Limestone Member

Limestone, gray to blue on fresh surfaces, weathers buff, thin to thick and even bedded, microcrystalline; echinoconchids, *Aviculopinna,* crinoids 4.0

Bonner Springs Shale

Shale, gray, paper-thin strata weather into flakes and irregular blocks, clayey to slightly silty 8.0

Wyandotte Limestone

Argentine Limestone Member

Limestone, gray, discontinuous and indistinct bedding, numerous scour surfaces; ooliths and *Osagia*-coated shell fragments cemented by coarsely crystalline calcite, ***Composita, Derbyia, Hustedia, Neospirifer,*** crinoids, clams 2.0

Total thickness of Wyandotte Limestone 2.0

Lane Shale

Siltstone, gray; poorly preserved plant fossils 6.0

Shale and siltstone, tan to gray green, shale silty; 1.0-foot impure oolitic limestone about 10 feet above base of exposed section; poorly preserved plant fossils; thickness exposed 90.0

A11.—Section of quarry face in the cen. SW¼ sec. 4, T. 19 S., R. 21 E.

Plattsburg Limestone — *Thickness, feet*

Spring Hill Limestone Member

Limestone, gray to white on both fresh and weathered surfaces, thin and irregularly bedded, microcrystalline; brachiopods, crinoids, echinoids; abundant residual chert mantles the lower part; poorly exposed on receding slope above quarry face 5.0

Hickory Creek Shale Member

Covered interval; cleft in slope appears to represent shale section 1.5

Merriam Limestone Member

Limestone, gray white to brown upward on fresh surfaces, weathers gray brown, poorly cross stratified; shell fragments, *Osagia*-coated shell fragments, and ooliths cemented by coarsely crystalline calcite; ***Allorisma, Aviculopinna, Bellerophon, Myalina,*** abundant crinoid and echinoid debris, sparse fusulinids 8.0

Limestone, yellow brown, very thin bedded, silty; brachiopods, clams, crinoids, fenestrate bryozoans, gastropods; lower contact extremely gradational; about 3.0

Total thickness of Merriam Limestone 11.0

Bonner Springs Shale

Shale, gray green, hard, platy, clayey to silty, micaceous, calcareous 4.0

Wyandotte Limestone

Frisbie-Argentine Limestone

Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline matrix contains abundant coarsely crystalline calcite, solution caverns in quarry walls; ***Composita, Enteletes,*** bryozoans, corals, crinoids; base concealed; thickness exposed 31.0

A12.—Section of a road cut exposure near cen. E line NE¼ sec. 9, T. 19 S., R. 21 E.

Plattsburg Limestone — *Thickness, feet*

Spring Hill Limestone Member

Limestone, gray to white on both fresh and weathered surfaces, thin and irregularly bedded, fine grained, compact; ***Composita,*** *Enteletes, Neospirifer, Girtyocoelia, Wewokella,* crinoids, echinoids, fenestrate and ramose bryozoans; michelnoceriod cephalopods; cencentration of residual chert as much as 6 feet thick mantles unsilicified parts of the member in the area 13.0

Hickory Creek Shale Member

Shale, tan to gray green to gray upward, paper-thin strata weather to flakes and irregular blocks, clayey to slightly silty; ***Hustedia,*** sparse fragments of productid brachiopods 6.0

Merriam Limestone Member

Limestone, gray on fresh surfaces, weathers tan, single even bed, fine grained, compact; brachiopods, crinoids 1.0

Limestone, yellow brown, impure, weathers to a "boxwork" surface; limonite-replaced euomphalid, worthenid, and bellerophontid gastropods 0.7

Limestone, gray blue on fresh surface, weathers tan, two prominent even beds, extremely compact, conchoidal fracture, prominent vertical joints; ***Composita, Hustedia,*** crinoids 1.5

Total thickness of Merriam Limestone 3.2

Bonner Springs Shale

Shale, gray to tan upward, calcareous, silty to clayey; sparse minute shell fragments; basal contact gradational 0.5

Wyandotte Limestone

Farley Limestone Member

Limestone, gray, thin and moderately even bedded, surface pocked with irregular masses of reprecipitated $CaCO_3$; foraminifers, ooliths, and *Osagia*-coated shell fragments cemented by coarsely crystalline calcite; ***Composita, Neospirifer*** 2.0

Limestone, gray to tan on both fresh and weathered surfaces, thin slightly irregular well-defined beds separated by shale partings; abundant ***Composita, Neospirifer,*** crinoids, fenestrate bryozoans 3.7

Total thickness of Farley Limestone 5.7

Island Creek Shale Member

Shale, gray green, clayey to silty, weathers into irregular blocks, grades downward into limestone-limonite conglomerate 2.5

Argentine Limestone Member

Limestone, gray to tan on fresh surfaces, weathers buff, thin to thick and irregularly bedded, fine grained, compact, matrix contains abundant crystalline calcite which may be linear algae, chert nodules in the upper part, uppermost 0.5 foot a fossiliferous limestone-limonite conglomerate; ***Composita, Enteletes, Linoproductus, Neospirifer,*** dictyoclostids, crinoids, echinoids, fenestrate bryozoans 34.0

Frisbie Limestone Member

Limestone, chocolate brown, indistinct bedding, massive, fine grained, compact; *Composita, Enteletes,* robust fusulinids, crinoids 3.0

Total thickness of Wyandotte Limestone 45.2

Lane Shale

Shale, gray green to tan, silty to clayey; mostly covered; thickness exposed 30.0

A13.—Section of a road cut exposure in the NE¼ SE¼ sec. 9, T. 19 S., R. 21 E.

	Thickness, feet
Plattsburg Limestone	
Spring Hill Limestone Member	
Limestone, gray on both fresh and weathered surfaces, thin and slightly wavy bedded, microcrystalline; brachiopods, crinoids, echinoids; mantle of residual chert, which contains silicified *Wewokella, Girtyocoelia,* brachiopods, and crinoids	19.0
Hickory Creek Shale Member	
Limestone, yellow brown, impure, marly	0.7
Shale, green, weathers into irregular blocks, clayey	2.5
Limestone, yellow brown, impure, marly	1.0
Total thickness of Hickory Creek Shale	4.2
Merriam Limestone Member	
Limestone, blue gray, compact, brittle; brachiopods, crinoids; upper contact gradational within yellow-brown impure limestone crust	1.5
Bonner Springs Shale	
Shale, gray green, paper-thin strata weather into flakes, clayey to silty	0.3
Wyandotte Limestone	
Farley Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and relatively even bedded, microcrystalline except in a nebulously defined central part which comprises ooliths, foraminifers, and *Osagia*-coated shell fragments cemented by coarsely crystalline calcite; brachiopods, bryozoans	3.0
Limestone, gray to white, thin and irregularly bedded, fine grained, compact; *Composita, Enteletes, Neospirifer,* fenestrate bryozoans	2.0
Total thickness of Farley Limestone	5.0
Island Creek Shale Member	
Conglomerate, yellow brown, limestone-limonite conglomerate; brachiopods, bryozoans, crinoids	2.0
Argentine Limestone Member	
Limestone, brown to gray to white upward on fresh surfaces, weathers buff, thin and irregularly bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; profuse *Enteletes,* marginiferids, crinoids, bryozoans	33.0
Frisbie Limestone Member	
Limestone, chocolate brown on both fresh and weathered surfaces, even bedded, microcrystalline, abundant solution voids on weathered surfaces; *Enteletes, Linoproductus, Lophophyllidium,* robust fusulinids, sparse crinoids	3.5
Total thickness of Wyandotte Limestone	43.5
Lane Shale	
Shale, tan, silty; poorly preserved plant remains in upper part, thickness exposed	33.0

A14.—Section of a road cut exposure along the cen. part E line sec. 16, T. 19 S., R. 21 E.

	Thickness, feet
Plattsburg Limestone	
Spring Hill Limestone Member	
Limestone, gray to white on fresh surfaces, weathers tan, very thin and irregularly bedded, beds show a tendency to spall; foraminifers, ooliths, and *Osagia*-coated shell fragments cemented by coarsely crystalline calcite; coquinoid, profuse crinoid columnals and calyx plates, abundant echinoid spines and plates; about	10.0
Hickory Creek Shale Member	
Shale; poorly exposed slope break	0.3
Merriam Limestone Member	
Limestone, blue gray on fresh surfaces, weathers buff, thin and even bedded, fine grained, compact, highly weathered upper surface; *Composita,* crinoids	2.0
Wyandotte Limestone	
Farley Limestone Member	
Limestone, gray on fresh surfaces, weathers buff, thin and wavy bedded, microcrystalline excepting a band in the central part which comprises foraminifers, ooliths, and *Osagia*-coated shell fragments cemented by coarsely crystalline calcite; brachiopods, crinoids, gastropods	2.0
Limestone, gray on both fresh and weathered surfaces, even bedded, microcrystalline; shell pavement of a robust species of *Composita* in upper part, dictyoclostids, marginiferids, *Punctospirifer,* crinoids, gastropods	3.0
Total thickness of Farley Limestone	5.0
Island Creek Shale Member	
Shale, gray green; mostly covered	15.0
Argentine Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and irregularly bedded, microcrystalline matrix contains abundant crystalline calcite; brachiopods, crinoids; contacts poorly exposed; about	18.0
Frisbie Limestone Member	
Limestone, chocolate brown, a single thick vertically jointed bed, microcrystalline; robust fusulinids, corals, brachiopods	4.0
Total thickness of Wyandotte Limestone	42.0
Lane Shale	
Shale, gray green to tan, paper-thin strata weather into flakes, silty to clayey; thickness exposed	20.0

A15.—Section of an escarpment exposure in NE¼ SW¼ NW¼ sec. 8, T. 19 S., R. 21 E.

	Thickness, feet
Wyandotte Limestone	
Argentine Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded; sparse slender fusulinids, *Composita, Enteletes,* crinoids, echinoids; thickness exposed	12.0
Frisbie Limestone Member	
Limestone, chocolate brown, single massive vertically jointed bed, microcrystalline; *Enteletes,* echinoconchids, crinoids, echinoids, robust fusulinids	6.0
Lane Shale	

Shale, gray green, paper-thin strata weather into flakes, clayey to slightly silty; sparse poorly preserved plant fossils; thickness exposed 59.0

B1.—Section in an abandoned quarry at cen. E line sec. 23, T. 18 S., R. 19 E.

	Thickness, feet
Stanton Limestone	
South Bend Limestone Member	
Limestone, blue gray to brown on fresh surfaces, weathers brown, thin to thick and relatively even bedded, microcrystalline, brittle; *Chonetes, Composita, Derbyia, Dielasma, Meekella, Punctospirifer,* marginiferids, fusulinids, crinoids, fenestrate bryozoans, trilobite pygidia	5.1
Rock Lake Shale Member	
Shale, gray green, paper-thin beds weather into irregular blocks, clayey to slightly silty	0.7
Limestone, gray on fresh surfaces, weathers buff, slightly irregularly bedded, clayey; *Aviculopinna, Linoproductus, Neospirifer,* crinoids, trilobite pygidia	2.7
Limestone, gray to white on both fresh and weathered surfaces, a single bed, grades downward into a breccia of limestone and shell fragments in a microcrystalline matrix; *Aviculopinna, Composita, Neospirifer,* crinoids	2.0
Total thickness of Rock Lake Shale	5.4
Stoner Limestone Member	
Limestone, gray to white on fresh surfaces, weathers gray to tan, thin irregularly bedded, microcrystalline; *Composita, Enteletes, Linoproductus, Neospirifer,* dictyoclostids, crinoids, trilobite pygidia	11.0
Eudora Shale Member	
Shale, black, platy to fissile; conodonts; basal contact concealed; thickness exposed	0.5

B2.—Section of a streambank and road cut exposure near the cen. S line sec. 7, T. 18 S., R. 20 E.

	Thickness, feet
Stanton Limestone	
Stoner Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline matrix contains abundant crystalline calcite; *Enteletes,* productids, crinoids, slender fusulinids; incomplete thickness	6.5
Eudora Shale Member	
Shale, tan to green downward, paper-thin strata weather to flakes, clayey to silty	2.0
Shale, black, platy to fissile; conodonts	1.5
Total thickness of Eudora Shale	3.5
Captain Creek Limestone Member	
Limestone, yellow to brown on fresh surfaces, weathers tan, even bedded, microcrystalline, abundant crystalline calcite; *Enteletes,* productids, fenestrate bryozoans, sparse fusulinids	8.5
Vilas Shale	
Shale, gray green, clayey to silty; mostly covered; about	20.00
Plattsburg Limestone	
Spring Hill Limestone Member	
Limestone, gray on fresh surfaces, weathers tan, thin and wavy bedded, fine grained, compact; *Composita* shell pavement about 3 feet below top, productids, crinoids, echinoids, bryozoans, slender fusulinids concentrated along bedding surfaces in lower part; basal contact covered; thickness exposed	11.0

B3.—Section of an abandoned quarry in the NE¼ SE¼ sec. 6, T. 18 S., R. 20 E.

	Thickness, feet
Stanton Limestone	
Stoner Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and irregularly bedded, microcrystalline matrix contains abundant crystalline calcite; brachiopods, crinoids, echinoids; incomplete thickness	5.0
Eudora Shale Member	
Shale, tan, paper-thin strata weather into flakes	4.0
Shale, black, platy to fissile; conodonts	1.5
Total thickness of Eudora Shale	5.5
Captain Creek Limestone Member	
Limestone, white on fresh surfaces, weathers gray, thin to thick and even bedded, abundant coarsely crystalline calcite in a microcrystalline matrix; fusulinids, brachiopods, crinoids, corals, bryozoans	11.0
Vilas Shale	
Shale, gray brown to yellow, clayey, calcareous in upper 2 feet	6.5
Limestone, yellow, earthy, surface weathers to a "boxwork"	1.0
Shale, gray to brown, weathers into flakes and irregular blocks	4.0
Limestone, gray blue on fresh surfaces, weathers tan, thin and even bedded; poorly preserved plant fossils	1.5
Shale, gray to blue, weathers into flakes and irregular plates, clayey	6.0
Total thickness of Vilas Shale	19.0
Plattsburg Limestone	
Spring Hill Limestone Member	
Limestone, gray blue to black on fresh surfaces, weathers gray to brown, a single bed; brachiopods	0.6
Shale, gray blue, clayey, calcareous	0.7
Limestone, gray to white on fresh surfaces, weathers blue gray, thin to thick and irregularly bedded, fine grained, compact; ferruginous weathering rind caps unit; *Aviculopinna, Allorisma, Ameura, Composita, Enteletes, Ditomopyge, Fistulipora, Juresania, Linoproductus, Mooroceras, Myalina, Septopora,* dictyoclostids, echinoconchids, crinoids	15.0
Total thickness of Spring Hill Limestone	16.3
Hickory Creek Shale Member	
Shale, gray, calcareous	0.5
Merriam Limestone Member	
Limestone, gray on fresh surfaces, weathers	

gray blue, thin and wavy bedded, extremely compact and brittle, fractures conchoidally; brachiopods, abundant crinoid remains, sparse fusulinids; basal contact covered; thickness exposed 3.0

B4.—Composite section of road cut exposures in the NE¼ sec. 29, T. 17 S., R. 20 E. (Spring Hill Limestone to Captain Creek Limestone), and in the SE¼ sec. 29, T. 17 S., R. 20 E. (Merriam Limestone to Spring Hill Limestone).

	Thickness, feet
Stanton Limestone	
Captain Creek Limestone Member	
Limestone, gray to yellow brown on fresh surfaces, weathers buff, even bedded, microcrystalline; *Enteletes, Lophophyllidium,* fusulinids, crinoids; incomplete thickness	2.0
Vilas Shale	
Shale; covered interval; about	13.0
Plattsburg Limestone	
Spring Hill Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline matrix contains abundant coarsely crystalline calcite, nodular chert in upper 3.5 feet; *Composita, Juresania, Lophophyllidium,* echinoid spines, fenestrate bryozoans, crinoids; about	11.0
Hickory Creek Shale Member	
Shale, yellow, calcareous, contains yellow limestone stringers	2.5
Merriam Limestone Member	
Limestone, gray on fresh surfaces, weathers gray brown, even bedded, microcrystalline; prominent *Composita*-myalinid zone in lower bed, marginiferids, crinoids; both contacts within impure limestone gradational zones	3.0
Total thickness of Plattsburg Limestone	16.5
Bonner Springs Shale	

B5.—Section of a road cut exposure in the SW¼ sec. 24, T. 17 S., R. 20 E.

	Thickness, feet
Stanton Limestone	
Captain Creek Limestone Member	
Limestone, gray to blue on fresh surfaces, weathers tan, even to slightly wavy and thin bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; fusulinids, brachiopods, crinoids, corals; incomplete thickness	2.0
Vilas Shale	
Shale, gray green, paper-thin strata weather to flakes, silty to clayey upward, calcareous; about	15.0
Siltstone, yellow brown	1.0
Shale, gray green to brown, clayey	7.0
Total thickness of Vilas Shale	23.0
Plattsburg Limestone	
Spring Hill Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline; *Osagia,* sparse ooliths, and a shale pavement of robust *Composita* about 1 foot below top; crinoids, productids, bryozoans, slender fusulinids	8.0
Hickory Creek Shale Member	
Shale, yellow green, impure limestone and calcareous shale	2.0
Merriam Limestone Member	
Limestone, gray blue on fresh surfaces, weathers tan, even bedded, microcrystalline; *Composita*-myalinid zone in lower bed; contacts within impure limestone gradational zones	3.4
Total thickness of Plattsburg Limestone	13.4
Bonner Springs Shale	
Shale, gray green, silty; basal contact covered; thickness exposed	1.0

B6.—Section in an abandoned quarry in the SW¼ sec. 6, T. 17 S., R. 20 E.

	Thickness, feet
Stanton Limestone	
Stoner Limestone Member	
Limestone, white on fresh surfaces, gray to white in the lower part and brown in the upper part on weathered surfaces, thin and wavy bedded, microcrystalline; *Enteletes,* dictyoclostids, fusulinids, crinoids, fenestrate bryozoans; thickness exposed	18.0
Eudora Shale Member	
Shale, green to brown, paper-thin strata weather to flakes	3.4
Shale, black, platy to fissile; phosphatic nodules containing pyrite nuclei; conodonts, *Orbiculoidea, Lingula, Conularia,* sparse pyritized *Composita,* gastropods, and pectenoid clams	5.0
Total thickness of Eudora Shale	8.4
Captain Creek Limestone Member	
Limestone, blue gray on fresh surfaces, weathers yellow brown, thin to thick and moderately even bedded, microcrystalline; brachiopods, bryozoans, echinoid spines, *Triticites*	9.0
Vilas Shale	
Shale, gray to brown, weathers to flakes	1.0
Plattsburg Limestone	
Spring Hill Limestone Member	
Limestone, blue gray on fresh surfaces, weathers gray brown, thin and irregularly bedded, microcrystalline matrix contains abundant crystalline calcite; *Composita* shell pavement 2.7 feet below top overlies a foraminiferal *Osagia*-bearing bed which contains sparse ooliths; productids, crinoids, *Enteletes,* fenestrate bryozoans; basal contact concealed; exposed thickness	9.0

B7.—Section in an abandoned quarry in the SE¼ sec. 27, T. 16 S., R. 20 E.

	Thickness, feet
Stanton Limestone	
Stoner Limestone Member	
Limestone, gray to white on both fresh and	

weathered surfaces, thin and wavy bedded, microcrystalline; brachiopods, crinoids, bryozoans, sparse fusulinids; incomplete thickness 5.0

Eudora Shale Member

Shale, tan, fissile	4.5
Shale, black, platy, clayey	4.3
Shale, olive green, platy, clayey	1.5
Total thickness of Eudora Shale	10.3

Captain Creek Limestone Member

Limestone, gray to blue on fresh surfaces, weathers tan, uppermost 3 feet slightly irregularly bedded, lower 4.2 feet extremely even bedded, microcrystalline, largely algal; *Ottonosia, Enteletes,* crinoids, echinoid spines 7.2

Vilas Shale

Shale, lower part blue, upper part green to brown, weathers to flakes, clayey 3.0

Plattsburg Limestone

Spring Hill Limestone Member

Limestone, gray to white on fresh surfaces, weathers gray brown, thin to thick and wavy bedded, microcrystalline; clam and bryozoan concentration in uppermost 1 foot, *Composita* shell pavement about 3 feet below top of member; *Aviculopinna, Derbyia,* dictyoclostids, crinoids, fenestrate bryozoans; basal contact concealed; thickness exposed 10.5

B8.—Section in an abandoned quarry at the NW cor. sec. 22, T. 16 S., R. 20 E.

Stanton Limestone — *Thickness, feet*

South Bend Limestone Member

Limestone, blue to brown on fresh surfaces, weathers tan, thin to thick and even bedded, microcrystalline, brittle, fractures conchoidally; *Dielasma, Derbyia, Meekella, Neospirifer, Chonetes* crust caps lower bed of member; marginiferids, crinoids, echinoid spines, ramose and fenestrate bryozoans 3.2

Rock Lake Shale Member

Shale, green to tan, weathers into irregular blocks, clayey	0.3
Coal, discontinuous smut	0.1
Shale, gray green, weathers into irregular blocks, clayey	1.0
Limestone, gray on fresh surfaces, weathers tan, nodular, impure	1.0
Limestone, gray blue on both fresh and weathered surfaces, single bed, "mortar" breccia; *Baylea, Bellerophon;* basal contact disconformable; thickness irregular, maximum	1.8
Total thickness of Rock Lake Shale	4.2

Stoner Limestone Member

Limestone, gray on both fresh and weathered surfaces, thin to thick and slightly irregularly bedded, microcrystalline; *Composita, Derbyia, Punctospirifer,* crinoids, fenestrate bryozoans, planispiral gastropods, echinoid spines, sparse fusulinids; upper contact hummocky, basal contact mostly covered 19.0

Eudora Shale Member

Shale, tan, weathers into flakes	1.2
Shale, black, fissile; basal contact concealed; thickness exposed in streambank east of quarry	2.0

C1.—Composite section of exposures from near cen. S line SE¼ sec. 17, T. 19 S., R. 18 E., to cen. S line sec. 18, T. 19 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Toronto Limestone Member

Limestone, brown, thin to thick and moderately even bedded, microcrystalline; brachiopods, crinoids, fusulinids; incomplete thickness 11.0

Lawrence Shale

Shale, upper 14 feet tan and silty, lower 4 feet gray and clayey	18.0
Coal, soft, bituminous	1.0
Shale, upper 1.5 feet gray, middle 4.5 feet green, basal 2 feet tan, silty to clayey	8.0
Limestone, gray to brown, single bed; *Myalina, Neospirifer,* bryozoans, crinoids	1.0
Shale, gray to tan, silty; mostly covered	25.0
Siltstone, brown, single thick bed	4.0
Shale and siltstone, tan, small amounts of very fine grained sandstone; about	60.0
Total thickness of Lawrence Shale	117.0

Stranger Formation

Haskell Limestone Member

Limestone, blue gray, single even bed, microcrystalline matrix contains abundant *Ottonosia; Chonetes, Neospirifer,* marginiferids, fusulinids; sparse phosphatic nodules weathered free from section immediately above the Haskell 1.5

Vinland Shale Member

Covered interval; about 12.0

Westphalia Limestone Member

Limestone, brown, microcrystalline, surface weathers hummocky; fusulinids, *Osagia*	0.5
Limestone, brown, shaly; bryozoans, *Composita,* crinoids	2.5
Total thickness of Westphalia Limestone	3.0

Tonganoxie Sandstone Member

Shale, tan, bedding indistinct, weathers into irregular blocks, septarian concretions and thin sandstone stringers in the basal part; exposed thickness 8.0

C2.—Water well log of section near the cen. S line sec. 30, T. 18 S., R. 18 E. (State Geological Survey of Kansas files). Description, generalized, is shown by symbols on Plate 2.

C3.—Composite section of an escarpment exposure near the cen. W line SW¼ sec. 14, T. 18 S., R. 18 E. (Toronto Limestone and Lawrence Shale); a road cut-streambank exposure near the cen. W line sec. 19, T. 18 S., R. 19 E. (Weston Shale to Haskell Limestone); and a drillers log (Stanton Limestone and 75 feet of Weston Shale) of section near cen. sec. 12, T. 18 S., R. 18 E. (Drillers log in State Geological Survey of Kansas files.) Description, generalized, is shown by symbols on Plate 2.

Oread Limestone — *Thickness, feet*

Toronto Limestone Member

Limestone, brown, thin and even bedded, ferruginous; brachiopods, corals, crinoids, fusulinids 9.0

Lawrence Shale

Shale, gray, paper-thin strata weather into irregular flakes, clayey; goethite concretions 30.0

Limestone, light gray on fresh surfaces, weathers tan, bedding indistinct, pseudobrecciated .. 2.5

Claystone, drab, weathers into irregular blocks 1.5

Siltstone, tan, weathers into plates, micaceous 3.0

Shale, drab, weathers into irregular flakes and blocks, clayey; poorly preserved plant fossils; about 5.5

Limestone, blue gray, nodular, micaceous, silty; poorly preserved plant fossils 2.0

Shale, tan to gray, paper-thin strata weather into irregular flakes, silty, micaceous; goethite concretions; poorly preserved plant remains 5.5

Coal; contains claystone stringers 0.2

Siltstone and silty shale, gray green to tan, bedding indistinct, weathers into irregular blocks; goethite concretions; mostly covered; about 40.0

Total thickness of Lawrence Shale 90.2

Stranger Formation

Haskell Limestone Member

Limestone, blue gray, single vertically jointed bed, microcrystalline, fractures conchoidally; *Meekella, Neospirifer,* crinoids, echinoid spines, fusulinids, spired gastropods 1.0

Vinland Shale Member

Shale, tan, weathers to irregular flakes, silty, micaceous; about 5.0

Shale, tan, paper-thin strata weather to flakes, silty, micaceous; contains large blue-gray septarian limestone concretions 4.0

Shale, drab, weathers to flakes, silty, micaceous 4.0

Total thickness of Vinland Shale 13.0

Tonganoxie Sandstone Member

Sandstone, tan, massive, cross stratified, quartzose, very fine to fine grained, friable 40.0

Coal, discontinuous 0.5

Total thickness of Tonganoxie Sandstone 40.5

Total thickness of Stranger Formation 54.5

Weston Shale

Shale, blue gray to gray green upward, micaceous, clayey to silty upward, grades into overlying unit; exposed thickness 2.0

C4.—Drillers log of section near the cen. NE¼ SW¼ sec. 7, T. 18 S., R. 18 E. (State Geological Survey of Kansas files). Description, generalized, is shown by symbols on Plate 2.

C5.—Composite section of a streambank exposure in the NE¼ sec. 33, T. 17 S., R. 18 E. (Toronto Limestone and upper part of Lawrence Shale) and a road cut exposure near the cen. N line sec. 31, T. 17 S., R. 19 E. (Ireland Sandstone to Haskell Limestone).

Oread Limestone *Thickness, feet*

Snyderville Shale Member

Toronto Limestone Member

Limestone, brown, thin to thick and even bedded, ferruginous, microcrystalline; *Chonetes, Composita, Punctospirifer,* crinoid columnals, fenestrate and ramose bryozoans 8.0

Lawrence Shale

Shale, covered interval 3.0

Coal 0.3

Shale, covered interval 2.5

Shale, tan, weathers into plates, silty, micaceous; poorly preserved plant fossils common 5.5

Coal 1.0

Shale, drab, paper-thin strata flake upon weathering, clayey, micaceous; siltstone stringers 14.0

Shale, covered interval 5.5

Claystone, drab 6.5

Shale, covered interval 10.0

Shale, tan, weathers into irregular flakes, silty 13.0

Conglomerate, reddish, limestone and limonite pebbles in a quartzose sandstone matrix; sparse invertebrate fossil fragments 1.5

Siltstone, brown, weathers into plates; limonitic concretions 9.0

Shale, gray, paper-thin beds; profuse poorly preserved plant fossils 2.0

Limestone, brown, shaly, arenaceous, micaceous; plant and invertebrate fossils 2.0

Ireland Sandstone Member

Sandstone, brown, massive, cross stratified, quartzose, very fine to fine grained, micaceous; poorly preserved plant fossils 40.0

Conglomerate, gray, weathers into irregular slabs, limestone and limonite pebbles, sparse phosphatic nodules, quartzose sandstone matrix; *Chonetes, Meekella, Neospirifer,* fusulinids, and sparse plant fossils; fragile spines on chonetids intact; probably derived from Robbins Shale and Haskell Limestone 5.0

Total thickness of Lawrence Shale 120.8

Stranger Formation

Vinland Shale Member

C6.—Composite section of a road cut exposure along the S line SE¼ sec. 15, T. 17 S., R. 18 E. (Toronto Limestone to Robbins Shale); a log of a test hole drilled at the SE cor. sec. 15, T. 17 S., R. 18 E. (Robbins Shale to Haskell Limestone); and a test hole drilled in the NE¼ SE¼ NE¼ sec. 15, T. 17 S., R. 18 E. (Haskell Limestone to Stoner Limestone).

Oread Limestone *Thickness, feet*

Toronto Limestone Member

Limestone, gray on fresh surfaces, weathers tan, bedding indistinct, weathers into a slabby rubble; brachiopods, crinoids; incomplete thickness 1.0

Lawrence Shale

Shale, gray to tan, silty to sandy; poorly preserved plant fossils 8.0

Coal, upper Williamsburg	0.5
Shale, gray to tan, bedding indistinct, weathers into irregular blocks, clayey to silty	5.0
Ireland Sandstone Member	
Limestone, gray, weathers into plates	1.0
Sandstone, light gray to tan, very fine to medium grained, massive, cross stratified	31.0
Coal	1.5
Shale, gray, clayey to silty	2.5
Sandstone, light gray, cross stratified, fine grained	13.0
Shale, gray, silty to sandy	1.0
Sandstone, gray to tan, a single thick bed	2.0
Shale, gray, silty to sandy	0.5
Sandstone, gray to tan, massive, cross stratified, very fine to medium grained; about	28.0
Coal, fragmented and included in basal part of Ireland Sandstone; about	3.0
Total thickness of Lawrence Shale	97.0
Stranger Formation	
Robbins Shale Member	
Shale, gray blue, clayey, carbonaceous films along bedding surfaces in uppermost foot	5.0
Shale, gray, clayey to slightly silty	2.0
Shale, gray, extremely clayey, plastic	11.0
Total thickness of Robbins Shale	18.0
Haskell Limestone Member	
Limestone, gray on fresh surfaces, weathers gray to tan, even bedded, microcrystalline matrix contains cross sections of abundant "heads" of *Ottonosia;* brachiopods, crinoids, fusulinids	2.1
Rock Lake-Vinland Shale	
Siltstone-sandstone, tan, even bedded, quartzose; basal contact gradational	19.0
Shale and siltstone, gray, alternating silty shale and siltstone, carbonaceous streaks at several horizons	116.0
Shale, gray, clayey to slightly silty	5.0
Siltstone-shale, gray	20.0
Sandstone, tan, very fine grained	2.5
Coal	0.7
Total thickness of Rock Lake-Vinland Shale	163.2

(Westphalia and South Bend Limestones absent from this locality. Section between Haskell Limestone base and Stoner Limestone top could not be subdivided.)

Stanton Limestone	
Stoner Limestone Member	
Limestone, gray to white; penetrated by drill	1.0

C7.—Composite section of road cut exposures from near cen. W line sec. 12 to near cen. W line sec. 13, T. 17 S., R. 18 E. (upper part of Tonganoxie Sandstone to Toronto Limestone) and streambank exposures near cen. sec. 11, T. 17 S., R. 18 E. (Weston Shale to Haskell Limestone).

Oread Limestone	*Thickness, feet*
Toronto Limestone Member	
Limestone, gray; brachiopods, crinoids; incomplete thickness	2.0
Lawrence Shale	
Shale, tan, clayey to silty	12.0
Sandstone, siltstone, and silty shale, tan, alternating beds	26.0
Ireland Sandstone Member	
Sandstone, tan, massive, cross stratified, very fine grained, friable	53.0
Total thickness of Lawrence Shale	91.0
Stranger Formation	
Robbins Shale Member	
Shale, gray, clayey to silty upward	5.5
Haskell Limestone Member	
Limestone, gray, even bedded, prominent vertical jointing, microcrystalline, fractures conchoidally; productids, *Meekella, Neospirifer, Ottonosia;* poorly exposed; about	1.7
Vinland Shale Member	
Shale, gray, clayey to silty	4.0
Coal smut	0.05
Shale, gray to tan, clayey to silty	10.0
Coal stringer	0.3
Shale, gray, silty, grades downward into siltstone	10.0
Total thickness of Vinland Shale	24.35
Tonganoxie Sandstone Member	
Sandstone and silty shale, tan, very fine grained, massive sandstone cross stratified, silty shale platy	45.0
Coal stringer	0.3
Siltstone to sandstone; thickness irregular	0.0 to 1.0
Total thickness of Tonganoxie Sandstone	46.3
Total thickness of Stranger Formation	77.85
Weston Shale	
Shale, gray blue, clayey; base covered; exposed thickness	1.5

(On the basis of outcrop and drillers log data, the thickness of Weston Shale at this locality is approximately 80 feet.)

D1.—Composite section of road cut exposures at the SE cor. sec. 13, T. 19 S., R. 17 E. (Plattsmouth Limestone to Snyderville Shale), and near the cen. S line sec. 18, T. 19 S., R. 18 E. (Toronto Limestone).

Oread Limestone	*Thickness, feet*
Plattsmouth Limestone Member	
Limestone, gray on fresh surfaces, weathers buff, thin and irregularly bedded, microcrystalline; crinoid columnals, ***Composita, Enteletes, Hustedia, Neospirifer;*** thickness exposed	5.0
Heebner Shale Member	
Shale, tan, weathers flaky, calcareous; brachiopods	3.0
Shale, black, platy; conodonts	1.2
Total thickness of Heebner Shale	4.2
Leavenworth Limestone Member	
Limestone, gray blue, a single bed devoid of	

partings, extremely dense, fractures conchoidally; brachiopods, tiny spired gastropods, *Aviculopecten*, fusulinids 1.3

Snyderville Shale Member

Covered interval 12.0

Toronto Limestone Member

Limestone, brown, ferruginous, thin to thick and relatively even bedded, fine grained, compact; brachiopods, crinoids, abundant fusulinids 11.0

D2.—Section measured in road ditch along cen. part E line sec. 31, T. 18 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member

Limestone, brown to gray upward on fresh surfaces, weathers tan, thin and wavy bedded, compact; *Chonetes, Derbyia, Lophophyllidium, Neospirifer*, massive bryozoans; exposed thickness about 6.0

Heebner Shale Member

Shale, dark gray to black, platy, clayey to slightly silty; about 4.0

Leavenworth Limestone Member

Limestone, blue gray, single thick bed, extremely dense; brachiopods, clams, crinoids, fusulinids 1.5

Limestone, gray, bedding indistinct, weathers shaly; *Osagia*-coated shell fragments, sparse ooliths, and limestone granules in a slightly silty limestone matrix; about 0.5

Total thickness of Leavenworth Limestone 2.0

Snyderville Shale Member

Shale, olive to gray, bedding indistinct, weathers to irregular blocks in lower part and to flakes in upper part, calcareous nodules in lowermost 2 to 3 feet; no megafossils observed 9.0

Toronto Limestone Member

Limestone, gray blue to brown on fresh surfaces, weathers brown, thin to thick relatively even beds weather to a rubble in uppermost and lowermost parts of member, microcrystalline, earthy in uppermost foot; *Chonetes, Composita, Derbyia, Neospirifer, Punctospirifer, Syringopora*, corals, dictyoclostids, abundant fusulinids, ramose bryozoans 11.0

Lawrence Shale

Shale, gray green, bedding poor, very clayey and plastic, low silt content; seemingly barren of megafossils 2.0

Shale and siltstone, tan, cross stratified; about 15.0

Coal smut 0.2

Shale, green to tan, weathers into irregular blocks, clayey to silty; no megafossils observed; thickness exposed about 35.0

D3.—Section of road cut exposures along the W line NW¼ sec. 30, T. 18 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member

Limestone, gray on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline matrix contains randomly oriented coarsely crystalline calcite veinlets; *Composita, Hustedia, Neospirifer*, lophophyllid corals; thickness exposed 5.0

Heebner Shale Member

Covered interval 5.0

Leavenworth Limestone Member

Limestone, blue gray, single thick vertically jointed bed, extremely dense, fractures conchoidally; brachiopods, clams, crinoids, fusulinids 1.0

Snyderville Shale Member

Covered interval; about 21.0

Toronto Limestone Member

Limestone, brown on both fresh and weathered surfaces, thin to thick and relatively even bedded, fine grained, compact; brachiopods, crinoids, fusulinids; about 12.0

D4.—Section of road cut exposures in the SW¼ NW¼ sec. 18, T. 18 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member

Limestone, gray on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; *Composita, Derbyia, Hustedia, Neospirifer, Rhipidomella*, marginiferids, crinoid stems, lophophyllid corals; thickness exposed 22.0

Heebner Shale Member

Claystone, tan, structureless 1.5

Claystone, drab, weathers into irregular blocks 2.0

Shale, black, platy bedding; conodonts 8.0

Total thickness of Heebner Shale 11.5

Leavenworth Limestone Member

Limestone, blue gray, single thick vertically jointed bed, extremely dense, fractures conchoidally; brachiopods, crinoids, echinoid spines, sparse fusulinids 1.0

Snyderville Shale Member

Covered interval 6.5

Limestone, white, nodular, impure; no megafossils observed 0.5

Shale, gray, paper-thin strata weather to irregular flakes 3.0

Claystone, ochre, structureless 0.4

Claystone, drab, weathers into irregular blocks 1.5

Claystone, ochre; contains minute calcareous nodules 2.5

Shale, light gray, weathers into flakes; about 4.5

Total thickness of Snyderville Shale 18.9

Toronto Limestone Member

Limestone, brown; brachiopods, crinoids; only the top exposed.

D5.—Section of a road cut exposure near the cen. W line sec. 4, T. 18 S., R. 18 E.

Oread Limestone	Thickness, feet
Plattsmouth Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and irregularly bedded, abundant coarsely crystalline calcite in a fine-grained matrix; *Composita, Ottonosia,* crinoid remains; exposed thickness	8.0
Heebner Shale Member	
Covered interval	4.0
Leavenworth Limestone Member	
Limestone, blue gray on fresh surfaces, weathers buff, single vertically jointed thick bed, extremely dense; brachiopods, clams, fusulinids	2.0
Snyderville Shale Member	
Shale, drab, clayey; nodular "boxwork" limestone float whose position within the member was not determined exactly; mostly covered; about	23.0
Toronto Limestone Member	
Limestone, upper 2 feet gray, remainder brown on both fresh and weathered surfaces, microcrystalline; *Chonetes,* dictyoclostids, abundant crinoid stems, abundant fusulinids; about	11.0

D6.—Section of a road cut exposure at the SW cor. sec. 25, T. 17 S., R. 17 E.

Oread Limestone	Thickness, feet
Plattsmouth Limestone Member	
Limestone, gray to white on fresh surfaces, weathers buff, thin and wavy bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; brachiopods, crinoids, corals; exposed thickness	6.0
Heebner Shale Member	
Covered interval	5.0
Leavenworth Limestone Member	
Limestone, blue gray on fresh surfaces, weathers buff, single thick vertically jointed bed, extremely dense, fractures conchoidally; brachiopods, small spired gastropods, sparse fusulinids	1.2
Snyderville Shale Member	
Covered interval	2.0
Siltstone, gray to tan, platy, calcareous; seemingly barren of megafossils	1.0
Claystone, gray green to yellow tan upward, bedding poor, highly weathered, earthy, silty; contains irregular minute calcareous nodules	17.0
Total thickness of Snyderville Shale	20.0
Toronto Limestone Member	
Limestone, yellow to tan on both fresh and weathered surfaces, platy, silty; abundant small clams such as *Pleurophorus* and *Nucula*	2.0
Limestone, gray, dense, silty; *Lingula,* ostracodes, clams	1.0
Siltstone, gray on fresh surfaces, weathers tan, finely laminated, calcareous; seemingly barren of megafossils	1.0
Limestone, gray on both fresh and weathered surfaces, thin to thick and relatively even bedded, fine grained, compact, slightly silty; sparse chert nodules in upper part; abundantly fossiliferous, *Aviculopinna, Chonetes, Composita, Derbyia, Hustedia, Lophophyllidium, Meekella, Myalina, Neospirifer, Punctospirifer, Ottonosia,* dictyoclostids, marginiferids, pectenoid clams, fenestrate and ramose bryozoans, crinoid fragments, echinoid spines, tiny spired gastropods; about	11.0
Total thickness of Toronto Limestone	15.0
Lawrence Shale	

D7.—Section of road cut exposure near the cen. SW¼ sec. 23, T. 17 S., R. 17 E.

Oread Limestone	Thickness, feet
Plattsmouth Limestone Member	
Limestone, white on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; sparse chert nodules; brachiopods, bryozoans, crinoids, corals, fusulinids; thickness exposed	9.0
Heebner Shale Member	
Covered interval	1.3
Shale, black, fissile; conodonts	2.5
Total thickness of Heebner Shale	3.8
Leavenworth Limestone Member	
Limestone, medium gray, single vertically jointed bed, extremely dense; brachiopods, fusulinids	1.5
Snyderville Shale Member	
Shale, tan to gray, clayey; poorly exposed	5.0
Claystone, gray to yellow tan, massive in upper part, silty and shaly in lower part; contains small calcareous nodules; about	8.5
Shale, gray, paper-thin bedding	1.0
Limestone, yellow, earthy, gray blebs of dense limestone in upper part	0.5
Shale, light gray, papery bedding, calcareous	5.0
Limestone, light to medium gray, laminated as though it might be algal, dense	0.5
Siltstone, yellow to light gray, weathers to a "boxwork" surface, calcareous	2.5
Limestone, light gray to tan, a single dense bed; sparse snails and pectenoid clams	0.5
Shale, yellow to tan, thin hard siltstone beds in upper 3 feet; mostly covered	4.0
Total thickness of Snyderville Shale	27.5
Toronto Limestone Member	
Siltstone, medium gray, platy, calcareous, dense; sparse clams, abundant ostracodes; about	2.0
Limestone, medium gray, thick and even bedded, fine grained, compact, brittle; sparse brachiopods and ostracodes	2.0
Covered interval, mostly limestone	7.0
Limestone, gray to brown on fresh surfaces, weathers gray, thick and relatively even bedded, dense, basal surface very uneven; *Enteletes,* crinoid fragments	2.0
Total thickness of Toronto Limestone	13.0
Lawrence Shale	

Shale, gray to tan, weathers into flakes, clayey ... 0.5
Coal' ... 2.0
Shale, gray to tan, weathers to irregular blocks ... 2.0
Limestone, gray to gray brown, sublaminated as in some algal beds; veinlets of green clayey material in the upper part ... 1.0
Shale, tan to gray; poorly exposed ... 1.0

D8.—Section of a road cut exposure near the cen. E line sec. 18, T. 17 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member
Limestone, gray to white on both fresh and weathered surfaces, thin and irregularly bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; brachiopods, crinoids; thickness exposed ... 5.0

Heebner Shale Member
Covered interval ... 4.0

Leavenworth Limestone Member
Limestone, gray blue on fresh surfaces, weathers buff, single thick vertically jointed bed, extremely dense; brachiopods, clams, sparse fusulinids ... 1.3

Snyderville Shale Member
Covered interval; about ... 13.0

Toronto Limestone Member
Limestone, yellow, thin and even bedded, silty, surface weathers to irregular large nondescript forms which may be fucoids; *Aviculopecten*, ostracodes, fenestrate bryozoans ... 1.5
Shale parting, silty ... 0.2
Limestone, light gray on fresh surfaces, weathers tan, granular; *Juresania* ... 1.0
Limestone, tan to brown, thin bedded; sparse fossil fragments ... 3.5
Limestone, gray to tan on fresh surfaces, weathers brown, thin to thick and relatively even bedded, microcrystalline; dictyoclostids, crinoid fragments ... 7.0
Total thickness of Toronto Limestone 13.2

Lawrence Shale
Shale, gray green, papery bedding, clayey ... 1.0
Coal smut, poorly developed ... 0.1
Shale, gray to tan, silty to sandy; contains sandstone stringers ... 9.0
Coal ... 0.3
Claystone, tan ... 0.4
Shale, tan, silty to sandy, interbedded with thin sandstone beds; about ... 17.0

Ireland Sandstone Member
Sandstone and sandy to silty shale, tan, sandstone thin to thick bedded and massive, shale bedding poor; thickness exposed ... 35.0

D9.—Section of a road cut exposure at the SW cor. sec. 35, T. 16 S., R. 17 E.

Oread Limestone — *Thickness, feet*

Leavenworth Limestone Member
Limestone, blue gray on fresh surfaces, weathers tan, single thick bed, extremely dense; brachiopods, crinoid fragments; thickness exposed ... 1.0

Snyderville Shale Member
Shale, gray green, finely laminated, clayey to silty ... 7.0

Toronto Limestone Member
Limestone, brown on both fresh and weathered surfaces, thin to thick and even bedded, fine grained, compact; sparse chert nodules in upper part; brachiopods, crinoids; about ... 11.0

D10.—Composite section of road cut exposures near the cen. S line sec. 19, T. 16 S., R. 18 E. (Leavenworth Limestone to Plattsmouth Limestone) and near the SW cor. SE¼ sec. 19, T. 16 S., R. 18 E. (Lawrence Shale to Toronto Limestone). (Fault exists between the two parts of this section.)

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member
Limestone, gray on fresh surfaces, weathers tan, thin to thick and irregularly bedded, microcrystalline matrix contains abundant crystalline calcite; brachiopods, crinoids; thickness exposed ... 8.0

Heebner Shale Member
Covered interval; about ... 10.0

Leavenworth Limestone Member
Limestone, blue gray on fresh surfaces, weathers tan, single vertically jointed bed, extremely dense; brachiopods, crinoids, clams, corals, echinoids, sparse fusulinids ... 1.2

(Snyderville Shale Member is not exposed in either section; average thickness of the Snyderville in nearby exposures is about 11 feet.)

Toronto Limestone Member
Limestone, brown on both fresh and weathered surfaces, thin to thick and relatively even bedded; *Chonetes, Derbyia, Meekella,* crinoid columnals and calyx plates, abundant fusulinids ... 8.0

Lawrence Shale
Shale, siltstone, and sandstone interbedded, gray green to tan, silty to clayey upward ... 13.0
Shale, gray green to tan, platy, silty; no megafossils observed; thickness exposed ... 20.0

D11.—Composite section of road cut exposures along the E line SE ¼ SE¼ sec. 7, T. 16 S., R. 18 E. (upper part of the Plattsmouth Limestone to the Kereford Limestone) and near the cen. E line sec. 7, T. 16 S., R. 18 E. (lower part of the Plattsmouth Limestone to the Snyderville Shale).

Oread Limestone — *Thickness, feet*

Kereford Limestone Member
Limestone, mottled in shades of gray and tan on both fresh and weathered surfaces, weathers into irregular plates, slightly silty; *Beecheria, Composita,* bryozoans, crinoids, abundant fusulinids; exposed ... 3.0

Shale, tan, calcareous; brachiopods, bryozoans, crinoids 3.0

Heumader Shale Member

Shale, light gray, silty to clayey; limonite concretions; lower part covered; about 26.0

Plattsmouth Limestone Member

Limestone, light gray to tan on both fresh and weathered surfaces, thin and irregularly bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; *Composita*, bryozoans, crinoids; about 20.0

Heebner Shale Member

Shale, tan to gray, paper-thin strata weather into irregular flakes, silty to clayey; brachiopods; about 3.0

Shale, dark gray to black, platy to nearly fissile; conodonts; about 6.0

Total thickness of Heebner Shale 9.0

Leavenworth Limestone Member

Limestone, blue gray on both fresh and weathered surfaces, a single vertically jointed dense bed; *Chonetes, Marginifera, Punctospirifer*, sparse fusulinids 1.5

Snyderville Shale Member

Shale, gray, silty, calcareous 1.3

Limestone, gray, fine grained, compact, lensing and nodular; fossiliferous 0.5

Shale, gray to tan, silty; thickness exposed 5.0

D12.—Section of a road cut exposure at the SE cor. sec. 6, T. 16 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member

Limestone, gray to white on both fresh and weathered surfaces, thin and irregularly bedded, weathers to a rubble, fine grained, compact; abundant crystalline calcite; sparse fossiliferous chert nodules; *Chonetes, Derbyia, Hustedia*, massive bryozoans, abundant crinoid fragments, corals; thickness exposed 10.0

Heebner Shale Member

Shale, tan, weathers into irregular flakes, clayey 4.0

Shale, black, platy; conodonts 7.0

Total thickness of Heebner Shale 11.0

Leavenworth Limestone Member

Limestone, blue gray on fresh surfaces, weathers tan, single vertically jointed bed; *Ottonosia*, marginiferids, crinoids, minute clams, fusulinids, tiny spired gastropods 1.4

Lawrence-Snyderville Shale

Shale, gray to green to yellow brown upward, weathers flaky, clayey to silty 1.0

Limestone, brown mottled with blue on fresh surfaces, weathers brown, nodular; abundant *Chonetes, Juresania, Ottonosia*, crinoids, sparse fusulinids 0.6

Shale, tan, silty to clayey 0.1

Limestone, gray on fresh surfaces, weathers tan, nodular, silty; productids, crinoids 0.3

Shale, tan to gray green, silty, zone of septarian concretions about 7 feet below top, zone of ironstone nodules about 15 feet below top; no megafossils observed; thickness exposed about 35.0

D13.—Section of a road cut exposure in the SW¼ SE¼ sec. 31, T. 15 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member

Limestone, gray to white on fresh surfaces, weathers tan, thin and irregularly bedded, microcrystalline; brachiopods, crinoids, corals; thickness exposed 10.0

Heebner Shale Member

Shale, tan, paper-thin strata weather into irregular flakes, clayey 2.0

Shale, black, fissile, weathers into flakes and plates 4.5

Total thickness of Heebner Shale 6.5

Leavenworth Limestone Member

Limestone, blue gray on fresh surfaces, weathers tan, extremely dense, fractures conchoidally, a single thick bed, vertically jointed; brachiopods, crinoids, sparse fusulinids 1.7

Lawrence-Snyderville Shale

Limestone, brown, silty; crinoids, ramose bryozoans; contacts gradational; thickens to east in road cut 0.5-0.7

Limestone, gray, nodular, silty; *Myalina* 0.7

Coal 0.2

Shale, gray, clayey to silty 1.5

Shale, gray green to brown, flaky, silty; thickness exposed 31.0

D14.—Section of a road cut exposure near the cen. W line sec. 32, T. 15 S., R. 18 E.

Oread Limestone — *Thickness, feet*

Plattsmouth Limestone Member

Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline; brachiopods, crinoids, corals, sparse fusulinids; thickness exposed 10.0

Heebner Shale Member

Shale, gray to brown, flaky, clayey to silty 3.0

Shale, gray, brown, and black shale interbedded; phosphatic nodules; about 15.0

Total thickness of Heebner Shale 18.0

Leavenworth Limestone Member

Limestone, blue gray on fresh surfaces, weathers tan, single thick vertically jointed bed; brachiopods, clams; poorly exposed, only on east side of road 1.0

Snyderville Shale Member

Shale, gray to tan, bedding indistinct, irregular clay blobs dot surface; about 15.0

Toronto Limestone Member

Limestone, gray to brown upward on both fresh and weathered surfaces, thin to thick and relatively even bedded, microcrystalline; brachiopods, crinoids, fusulinids; dipping north, thickness exposed in ditch west of the road about 3.0

Lawrence Shale

	Thickness, feet
Shale, siltstone, and sandstone; thickness exposed	7.0

D15.—Section of a road cut exposure near the SW cor. sec. 29, T. 15 S., R. 18 E. (Leavenworth Limestone and Snyderville Shale are not present in this exposure, but crop out within ½ mile in all directions.)

Oread Limestone	Thickness, feet
Plattsmouth Limestone Member	
Limestone, gray to white on both fresh and weathered surfaces, thin and wavy bedded, microcrystalline; brachiopods, corals, crinoids; thickness exposed	5.0
Heebner Shale Member	
Shale, gray brown, flaky, clayey to silty	2.0
Shale, black, weathers into irregular blocks	2.0
Total thickness of Heebner Shale	4.0
Toronto Limestone Member	
Limestone, yellow brown on both fresh and weathered surfaces, thin to thick and relatively even bedded; dictyoclostids, marginiferids, abundant crinoid fragments, ramose bryozoans, echinoid spines and plates, abundant slender fusulinids	9.0
Limestone, gray to white on fresh surfaces, weathers tan, bedding indistinct, fine grained, compact; brachiopods, crinoids, sparse fusulinids	4.0
Total thickness of Toronto Limestone	13.0
Lawrence Shale	
Shale, gray green to brown upward, flaky, clayey to silty	13.0
Shale, red, weathers into irregular blocks, silty	2.0
Shale, gray green, weathers into flakes and irregular blocks; poorly exposed; about	10.0

D16.—Section of a road cut exposure near the cen. E line sec. 30, T. 15 S., R. 18 E.

Oread Limestone	Thickness, feet
Plattsmouth Limestone Member	
Limestone, tan to gray on both fresh and weathered surfaces, thin and irregularly bedded; abundant brachiopods, crinoid fragments; thickness exposed.	6.0
Heebner Shale Member	
Shale, tan and silty in upper part, remainder covered	6.0
Leavenworth Limestone Member	
Limestone, blue gray on both fresh and weathered surfaces, single vertically jointed extremely dense bed; brachiopods, tiny spired gastropods	1.5
Snyderville Shale Member	
Covered interval	3.0
Toronto Limestone Member	
Limestone, brown on both fresh and weathered surfaces, thick bedded, microcrystalline; brachiopods, crinoids, bryozoans, fusulinids; thickness exposed	2.0

D17.—Section of a road cut exposure near the cen. N line sec. 30, T. 15 S., R. 18 E.

Oread Limestone	Thickness, feet
Plattsmouth Limestone Member	
Limestone, tan to gray, thin and wavy bedded, microcrystalline matrix contains abundant coarsely crystalline calcite; productids, *Enteletes,* crinoid fragments; thickness exposed	5.0
Heebner Shale Member	
Shale, tan, weathers into irregular flakes, clayey to silty	2.0
Shale, black, fissile to platy	3.0
Total thickness of Heebner Shale	5.0
Leavenworth Limestone Member	
Limestone, blue gray on both fresh and weathered surfaces, single vertically jointed extremely dense bed; brachiopods, crinoids, tiny spired gastropods, sparse fusulinids	1.5
Snyderville Shale Member	
Covered interval	8.5
Toronto Limestone Member	
Limestone, brown on both fresh and weathered surfaces, thin to thick and relatively even bedded; brachiopods, crinoids; thickness exposed	5.0

D18.—Section in abandoned quarry near the cen. NE¼ sec. 24, T. 15 S., R. 17 E.

Oread Limestone	Thickness, feet
Kereford Limestone Member	
Limestone, tan, weathered to rubble; *Dielasma, Composita, Neospirifer;* thickness exposed	1.0
Heumader Shale Member	
Shale, tan, calcareous, flaky; brachiopod and crinoid fragments	1.0
Shale, blue gray, clayey, weathers into irregular blocks	11.5
Total thickness of Heumader Shale	12.5
Plattsmouth Limestone Member	
Limestone, light gray, thin and wavy bedded, microcrystalline matrix; abundant coarsely crystalline calcite; productids, crinoids, sparse fusulinids	18.0
Heebner Shale Member	
Covered interval	7.0
Leavenworth Limestone Member	
Limestone, blue gray, extremely dense; brachiopods, sparse fusulinids	1.2
Snyderville Shale Member	
Shale, gray, clayey to silty, flaky; thickness exposed	1.0

REFERENCES

Adams, G. I., 1898, Physiography of southeastern Kansas: Kansas Univ. Quart., v. 7, p. 87-102.

————, Girty, G. H., and White, David, 1903, Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section: U.S. Geol. Survey Bull. 211, p. 1-123.

Bowsher, A. L., and Jewett, J. M., 1943, Coal resources of the Douglas Group in east-central Kansas: Kansas Geol. Survey Bull. 46, p. 1-94.

Condra, G. E., 1927, The stratigraphy of the Pennsylvanian System in Nebraska: Nebraska Geol. Survey, 2nd ser., Bull. 1, p. 1-291.

————, 1930, Correlation of the Pennsylvanian beds in the Platte and Jones Point sections of Nebraska: Nebraska Geol. Survey, 2nd ser., Bull. 3, p. 1-57.

————, and Bengston, N. A., 1915, The Pennsylvanian formations of southeastern Nebraska: Nebraska Acad. Sci. Pub., v. 9, no. 2, p. 1-60.

Dunbar, C. O., and Rodgers, John, 1957, Principles of stratigraphy: John Wiley and Sons, Inc., New York, p. 1-356.

Dunmire, R. C., and others, 1946, Physical land conditions affecting use, conservation, and management of land resources, Franklin County, Kansas: U.S. Dept. of Agriculture, Soil Conservation Service and Kansas Agriculture Experiment Station, Manhattan, Kansas, p. 1-26.

Fisk, H. N., 1955, Sand facies of Recent Mississippi delta deposits: Proc. 4th World Petroleum Cong., Rome, sec. 1, p. 377-398.

Frye, J. C., and Leonard, A. B., 1952, Pleistocene geology of Kansas: Kansas Geol. Survey Bull. 99, p. 1-230.

Goebel, E. D., and others, 1962, Oil and gas developments in Kansas during 1961: Kansas Geol. Survey Bull. 160, p. 1-254.

Haworth, Erasmus, 1894a, A geologic section along the Verdigris River from the state line to Madison: Kansas Univ. Quart., v. 2, p. 115-118.

————, 1894b, A geologic section along the A. T. and S. F. R. R. from Cherryvale to Lawrence, and from Ottawa to Holliday: Kansas Univ. Quart., v. 2, p. 118-126.

————, 1895, The stratigraphy of the Kansas Coal Measures: Kansas Univ. Quart., v. 3, p. 1-309.

————, 1898, Special report on coal: Kansas Univ. Geol. Survey, v. 3, p. 1-347.

————, and Kirk, M. Z., 1894, A geologic section along the Neosho River from the Mississippian formation of the Indian Territory to White City, Kans., and along the Cottonwood River from Wyckoff to Peabody: Kansas Univ. Quart., v. 2, p. 109.

Hills, E. S., 1955, Outline of structural geology: Methuen & Co. Ltd., London, p. 1-182.

Hinds, Henry, and Greene, F. C., 1915, The stratigraphy of the Pennsylvanian Series in Missouri: Missouri Bur. Geol. and Mines, 2nd ser., v. 13, p. 1-407.

Jewett, J. M., 1951, Geologic structures in Kansas: Kansas Geol. Survey Bull. 90, pt. 6, p. 105-172.

————, 1954, Oil and gas in eastern Kansas: Kansas Geol. Survey Bull. 104, p. 1-397.

————, and Newell, N. D., 1935, The geology of Wyandotte County, Kansas: Kansas Geol. Survey Bull. 21, pt. 2, p. 151-205.

Keyes, C. R., 1899, The Missourian Series of the Carboniferous: Am. Geologist, v. 23, p. 298-316.

Laughlin, D. J., 1957, Geology of northwestern Franklin County, Kansas: Unpub. master's thesis, Kansas Univ., p. 1-87.

Lee, Wallace, 1943, The stratigraphy and structural development of the Forest City Basin in Kansas: Kansas Geol. Survey Bull. 51, p. 1-142.

Miller, H. W., and Swineford, Ada, 1957, Paleoecology of nodulose zone at top of Haskell Limestone (Upper Pennsylvanian) in Kansas: Am. Assoc. Petroleum Geologists Bull., v. 41, no. 9, p. 2012-2036.

Moore, R. C., 1929, Environment of Pennsylvanian life: Am. Assoc. Petroleum Geologists Bull., v. 13, no. 5, p. 459-487.

————, 1932, A reclassification of the Pennsylvanian System in the northern Midcontinent Region: Kansas Geol. Soc. Guidebook, 6th Ann. Field Conf., p. 79-97.

————, 1936, Stratigraphic classification of the Pennsylvanian rocks of Kansas: Kansas Geol. Survey Bull. 22, p. 1-256.

————, 1949, Divisions of the Pennsylvanian System in Kansas: Kansas Geol. Survey Bull. 83, p. 1-203.

————, Elias, M. K., and Newell, N. D., 1934, Graphic stratigraphic section of the Pennsylvanian and Permian rocks of Kansas: Kansas Geol. Survey, chart.

————, and others, 1951, The Kansas rock column: Kansas Geol. Survey Bull. 89, p. 1-132.

Newell, N. D., 1935, The geology of Johnson and Miami Counties, Kansas: Kansas Geol. Survey Bull. 21, pt. 1, p. 1-150.

O'Connor, H. G., 1960, Geology and ground-water resources of Douglas County, Kansas: Kansas Geol. Survey Bull. 148, p. 1-200.

————, and others, 1955, Geology, mineral resources, and ground-water resources of Osage County, Kansas: Kansas Geol. Survey, v. 13, p. 1-50.

Patterson, J. M., and Addison, C. C., 1933, The Douglas Group of the Pennsylvanian in Douglas and Leavenworth Counties, Kansas: Unpub. master's thesis, Kansas Univ., p. 1-35.

Rich, John L., 1933a, Mid-Pennsylvanian structural disturbances near Baldwin, Kansas, and their significance *(abs.)*: Geol. Soc. America Bull., v. 43, no. 1, p. 140.

————, 1933b, Angular coal fragments as evidence of a long time break in Pennsylvanian sedimentation in eastern Kansas: Geol. Soc. America Bull., v. 44, no. 4, p. 865-870.

Richter-Bernburg, Gerhard, 1953, Salzlagerstatten: Frühjahrstagung der Deutschen Geologischen Gesellschaft: in Goslar vom. 13, bis 16, p. 634-641.

Runnels, R. T., 1949, Preliminary report on phosphate-bearing shales in eastern Kansas: Kansas Geol. Survey Bull. 82, pt. 2, p. 37-48.

————, and Schleicher, J. A., 1956, Chemical composition of eastern Kansas limestones: Kansas Geol. Survey Bull. 119, pt. 3, p. 81-103.

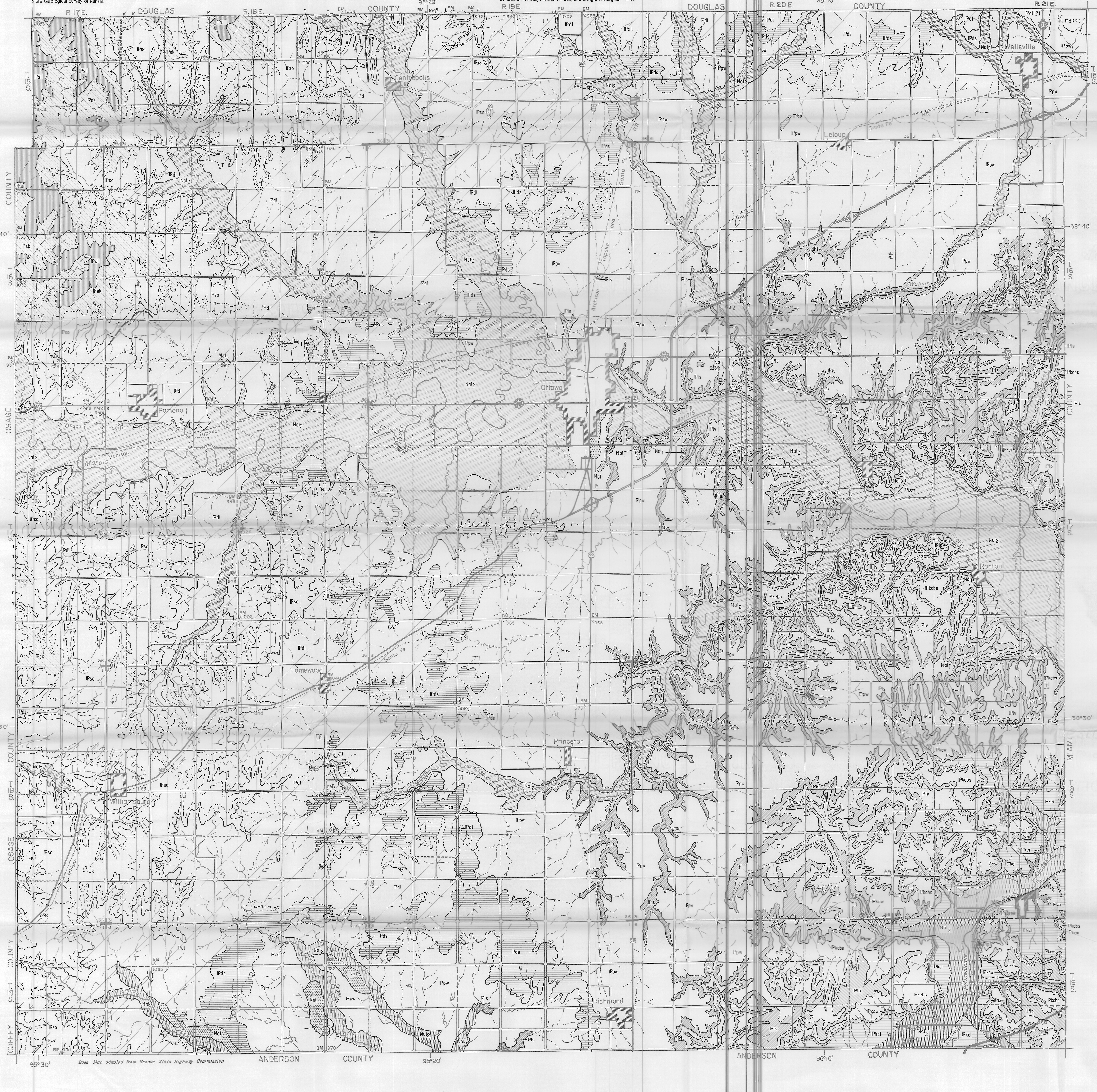
Schoewe, W. H., 1949, The geography of Kansas; Part II, Physical Geography: Trans. Kansas Acad. Sci., v. 52, no. 3, p. 261-333.

State Geological Survey of Kansas

Bulletin 163
Plate 1

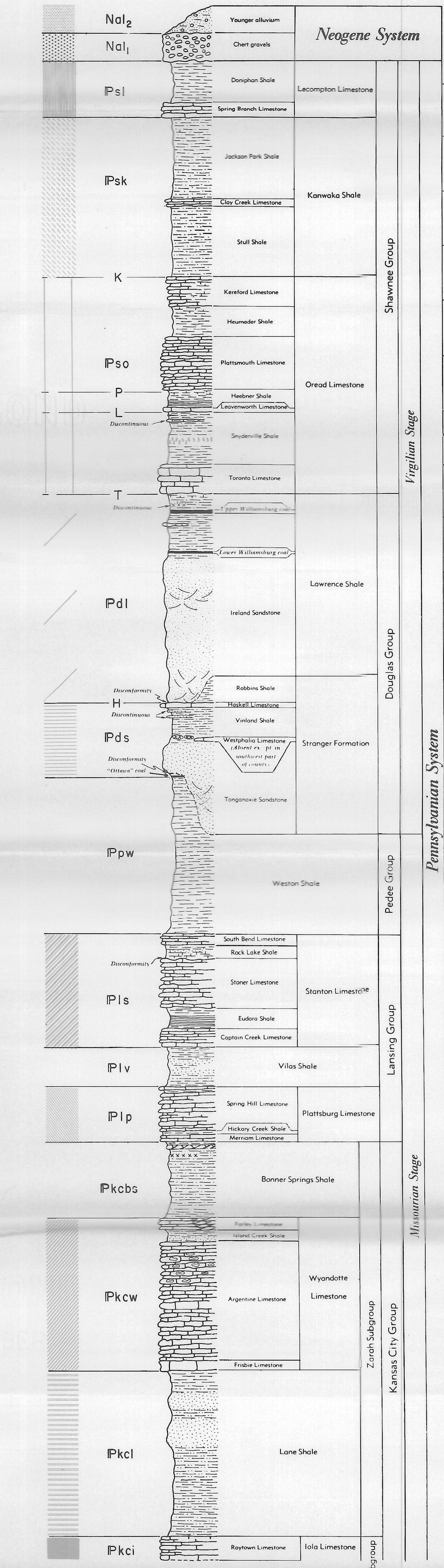
GEOLOGIC MAP OF FRANKLIN COUNTY, KANSAS

By Stanton M. Ball, Mahlon M. Ball, and Dwight J. Laughlin 1959

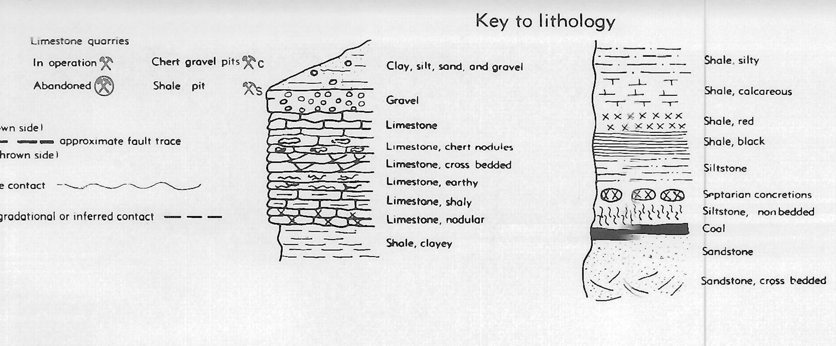


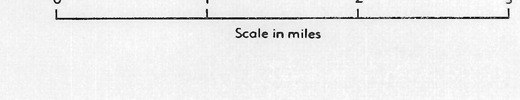
EXPLANATION

Generalized stratigraphic column of outcropping rocks



Key to lithology

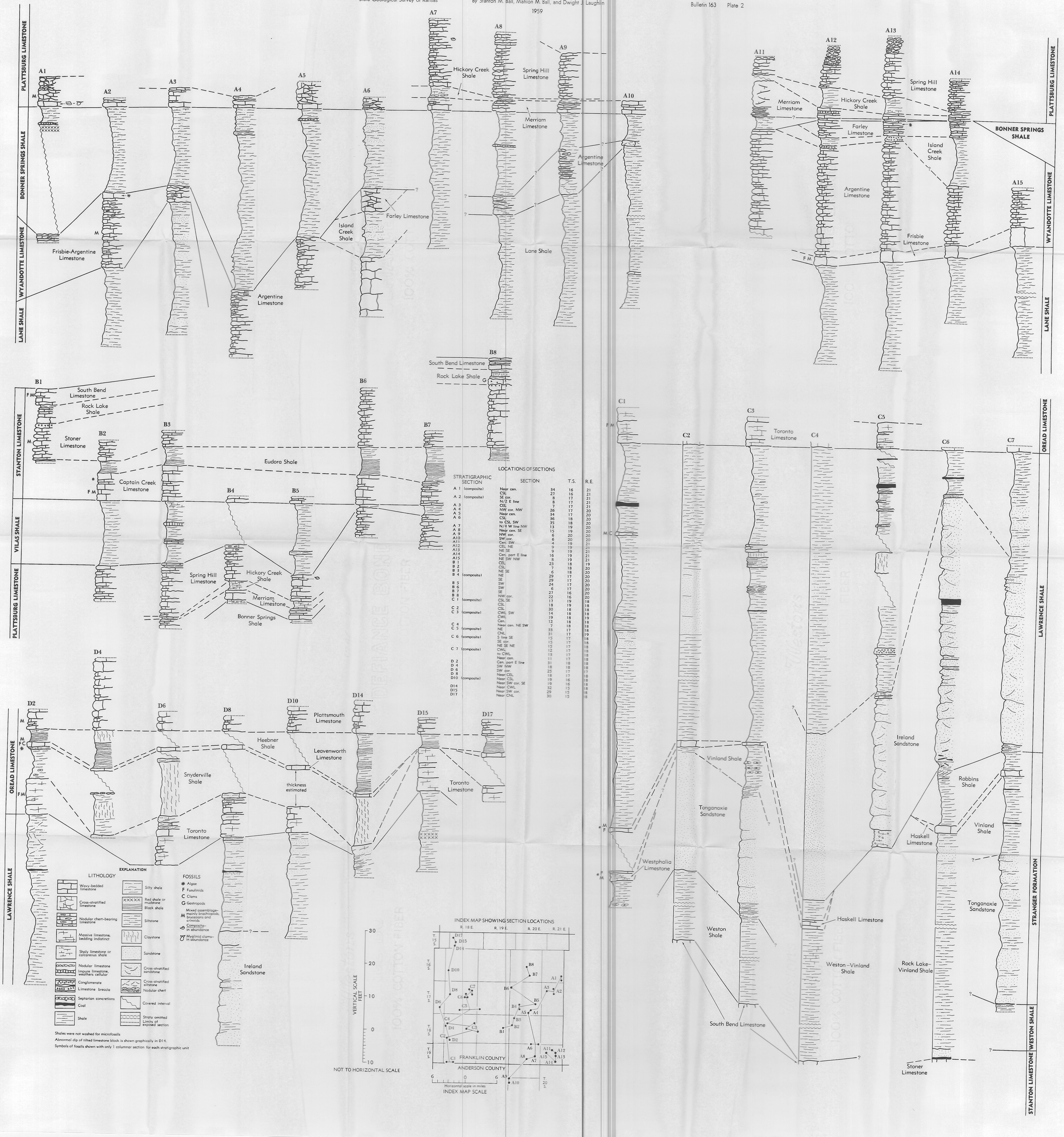




CORRELATED STRATIGRAPHIC SECTIONS IN FRANKLIN COUNTY, KANSAS

State Geological Survey of Kansas — Bulletin 163, Plate 2 — 1959

By Stanton M. Ball, Mahlon M. Ball, and Dwight J. Laughlin



LOCATIONS OF SECTIONS

STRATIGRAPHIC SECTION	SECTION		T.S.	R.E.
A 1 (composite)	Near cen.	34	16	21
	CSL	27	16	21
A 2 (composite)	SE cor.	8	17	21
	N/2 E line	8	17	21
A 3	CEL	7	17	21
A 4	NW cor. NW	26	17	20
A 5	Near cen.	34	17	20
A 6	CSL	36	18	20
	to CSL SW	35	18	20
A 7	N/4 W line NW	13	19	20
A 8	Near cen. SE	15	19	20
A 9	NW cor.	6	20	20
A10	SW cor.	6	20	20
A11	Cen. SW	4	19	21
A12	CEL NE	9	19	21
A13	NE SE	9	19	21
A14	Cen. part E line	16	19	21
A15	NE SW NW	8	19	21
B 1	CEL	23	18	19
B 2	CSL	7	18	20
B 3	NE SE	6	18	20
B 4 (composite)	NE	29	17	20
	SE	29	17	20
B 5	SW	24	17	20
B 6	SW	6	17	20
B 7	SE	27	16	20
B 8	NW cor.	22	16	20
C 1 (composite)	CSL SE	17	19	18
	CSL	18	19	18
C 2	CSL	30	18	18
C 3 (composite)	CWL SW	14	18	18
	CWL	19	18	19
	Cen.	12	18	18
C 4	Near cen. NE SW	7	18	18
C 5 (composite)	NE	33	17	18
	CNL	31	17	19
C 6 (composite)	S line SE	15	17	18
	SE cor.	15	17	18
	NE SE NE	15	17	18
C 7 (composite)	CWL	12	17	18
	to CWL	13	17	18
	Near cen.	11	17	18
D 2	Cen. part E line	31	18	18
D 4	SW NW	18	18	18
D 6	SW cor.	25	17	17
D 8	Near CEL	18	17	18
D10 (composite)	Near CSL	19	16	18
	Near SW cor. SE	19	16	18
D14	Near CWL	32	15	18
D15	Near SW cor.	29	15	18
D17	Near CNL	30	15	18