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PENNSYLVANIAN

OF THE

NORTHERN MID-CONTINENT REGION

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PENNSYLVANIAN
OF THE
NORTHERN MID-CONTINENT REGION

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CONTENTS

ILLUSTRATIONS

PENNSYLVANIAN OF THE NORTHERN MID-CONTINENT REGION

By Raymond C. Moore

INTRODUCTION

Eastern Kansas offers one of the best places on the North American continent for study of the Pennsylvanian (Upper Carboniferous) strata. (See pl. 1.) The structure is simple, the beds dipping gently and nearly uniformly westward. The rocks are well exposed. The vertical succession, stratigraphic relations, and changes along the strike are definitely observable. Nonmarine deposits, containing well-preserved fossil plants and in places remains or tracks of land animals, alternate with strata containing a profusion of marine fossils. The rocks thus afford not only a remarkable record of the repeated presence and absence of the sea but an exceptional opportunity for correlation of the plant floras with marine faunas. Comparisons may be made with the dominantly continental sediments of the eastern Pennsylvanian areas, on the one hand, and with the almost wholly marine sections of parts of western North America, on the other. Finally, the presence of important unconformities at certain horizons and evidences in the lithologic character and faunal content of beds permit subdivision of the stratigraphic column into series that define major epochs of sedimentation, which were separated by crustal movements involving general elevation and local mountain building.

This affords a natural basis for the major classification of the Pennsylvanian rocks. Further subdivision is based on lithologic and paleontologic data. The hard rocks, chiefly limestones, are topographically prominent, forming persistent eastward-facing escarpments. Many of these limestone units and the shales between them, which are classed as formations, are subdivisible into smaller units called members, and many of these members are traceable for scores or even hundreds of miles.

THE PENNSYLVANIAN ROCKS

General features.—Outcrops of Pennsylvanian formations occupy almost all of northwestern Missouri, the southeastern part of Nebraska, the eastern fourth of Kansas, eastern Oklahoma, west-central Arkansas, and a part of north-central Texas. The strata dip westward beneath younger formations at the rate of about 25 to 40 feet to the mile (4.8 to 7.6 meters to the kilometer) and by means of well records are known to extend throughout most of the Plains country east of the Rocky Mountains. The Pennsylvanian outcrops of the Mid-Continent region are therefore only the eastern part of a much larger area of Pennsylvanian sediments.

The aggregate thickness of the Pennsylvanian in the northern part of the Mid-Continent region is 2,000 to 3,000 feet (610 to 914 meters). Southward there is a gradual increase in thickness to about 25,000 feet (7,620 meters) in eastern Oklahoma and west-central Arkansas. The total thickness of the Pennsylvanian in north-central Texas is approximately 5,000 feet (1,524 meters).

The general nature of these rocks in the northern and southern parts of the Mid-Continent region is essentially the same. The outstanding characters are the relative abundance of marine sediments, the extreme persistence and lateral uniformity of most of the stratigraphic units, and the occurrence of many comparatively thin formations of alternating shale, limestone, sandstone, and a few coal beds.

The Pennsylvanian territory in central and southern Oklahoma and west-central Arkansas differs in several respects from that of the country to the north and south. Marine sediments are on the whole less prominent, the thickness of the formations is much greater, sandstone and shale greatly predominate over limestone, conglomerate occurs at many horizons, and there are red beds of continental origin, especially toward the top of the section. In much of the area the rocks are steeply folded, the sandstones forming ridges that are thickly forest-covered. Locally unconformities within the Pennsylvanian are prominent.

Lateral persistence of beds.—Many of the limestone, shale, and coal beds of the Mid-Continent region may be traced for as much as 500 miles (805 kilometers) along the outcrop with almost no perceptible change, and this applies to some of the very thin as well as the thicker beds. For example, there are several beds of limestone 6 inches to 2 feet (15 to 60 centimeters) thick which are known to be continuous from Iowa into northern Oklahoma, and the beds show practically the same character throughout this distance. Also there are coal beds 1 to 4 inches (2.5 to 10 centimeters) thick that have been traced similar distances, and a microfossil zone about a quarter of an inch (7 millimeters) thick has been identified in sections 100 miles (160 kilometers) apart. These observations point to very great uniformity in the conditions of sedimentation along the strike of these beds.

Alternation of marine and nonmarine beds.—An especially interesting character of the Pennsylvanian deposits in much of the continental interior of North America is the repeated alternation of marine and nonmarine deposits. The Pennsylvanian strata of Kansas, about 2,500 feet (762 meters) thick, show not less than 50 changes from marine to nonmarine sediments or vice versa. As these alternating marine and nonmarine strata are traceable for hundreds of miles along the outcrop and beneath the surface by means of well records, the advances and retreats of the Pennsylvanian sea were not mere local oscillations. The same sort of alternation is observed in Illinois and in part of the Pennsylvanian as far east as Pennsylvania.

Sedimentation cycles.—The very numerous changes in the character of the Pennsylvanian beds in vertical sequence contrast strongly with their lateral uniformity and indicate very frequent changes in the nature of the physical conditions that governed sedimentation. Nonmarine shale, commonly sandy, in places containing sandstone beds and at certain horizons coal beds, is overlain by marine limestone and shale. The marine beds in several places show a definite sequence of four different types of limestone separated by thin shale beds, each with distinctive lithologic characters. These sequences are repeated several times with surprising fidelity, and the evidence clearly points to a cyclic rhythm of sedimentation.

A similar repetition of a certain definite sequence of beds is also a distinguishing feature of the Pennsylvanian deposits in the East.[1] Beginning with sandstone, which commonly rests unconformably on the beds beneath, the sequence includes sandy or micaceous shale, underclay, coal, marine shale, and limestone. The beds from the sandstone to the coal inclusive are nonmarine, and those above the coal are marine. Nonmarine sand above the marine rocks begins a new cycle, which includes coal and marine rocks, and so on many times.

Depth of Pennsylvanian seas of the continental interior.—Physical characters and the nature of fossils contained in the marine Pennsylvanian formations of the continental interior indicate that the seas were of shallow depth. Because of the repeated alternation of sea and land conditions that is evident in this region, it is especially desirable to ask whether, on the one hand, the depth of the Pennsylvanian seas was of the order of 500 to 600 feet (152 to 183 meters) and accordingly whether there were repeated up and down movements of the earth crust approximating this amount; or whether, on the other hand, the depth of the seas was very small and the amount of crustal movement correspondingly slight. In the latter but not the former case it is possible that movement of the crust may have been almost wholly downward, change from sea to land being effected by sedimentation. The assumption that large parts of the conti-

[1] Weller, J. M., Cyclical sedimentation of the Pennsylvanian period and its significance: Jour. Geology, vol. 38, pp. 97–135, 1930.

nental areas were many times evenly raised and lowered some hundreds of feet is much less reasonable than the assumption that the vertical movements of the crust were small, and perhaps mainly movements of sinking. Thus the observed alternation of marine and nonmarine formations in the Pennsylvanian stratigraphic column favors a conclusion that the average depth of the seas was slight, possibly less than 100 feet (30 meters).

Suess and other leading geologists have held that the gentle dip of the Pennsylvanian strata in the Mid-Continent region of North America is original. The nearly uniform westward inclination of these beds supposedly represents the slope of the Pennsylvanian sea bottom. If this is true, however, the sea must have been 4,000 feet (1,200 meters) or more deeper in the west than in the east, inasmuch as the beds are traced by means of well borings to at least this much below the outcrop altitude. The presence of nonmarine formations at similar depths below the outcrop can only mean, on the hypothesis of initial dip, that the sea level was lowered thousands of feet. Marine strata above the nonmarine, both continuous from the outcrop to great depth, require a corresponding great rise of sea level. The number of alternations and kinds of deposits and their deeply and irregularly interfingered relations render entirely untenable the hypothesis that these beds were laid down in their present attitude. Taking into account also the evidence of fossils and lithology, we may say confidently that the Pennsylvanian continental seas were never thousands of feet deep and that vertical shifting of the strand line was never of this order. We may conclude, rather, that the seas were shallow, vertical movements of the sea level small, the original attitude of the beds practically horizontal, and the present dip of the rocks due to a later regional tilting. A slight depression of the almost perfectly horizontal surface of sedimentation or a corresponding elevation of the sea level would cause a very widespread but shallow submergence; and the deposition of a small thickness of sediments would displace the sea throughout a large area.

Classification of the Pennsylvanian rocks.—Stratigraphic classification of the Pennsylvanian beds in different parts of North America and in different parts of individual districts has in the past been almost altogether local. Recently [2] a classification based on the section of the Mid-Continent region has been advanced, which it is thought will be generally applicable to subdivision of the Pennsylvanian rocks of North America. Major interruptions of sedimentation, which are recorded

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[2] Moore, R. C., A new type section for the Pennsylvanian system in North America: Geol. Soc. America Bull., vol. 43, pp. 279–280, 1932.

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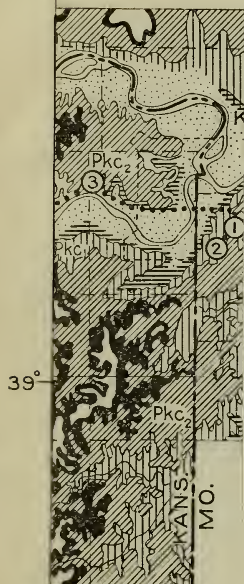

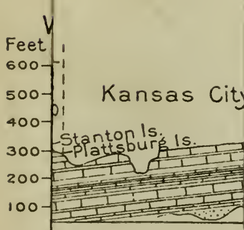

R BETWEEN

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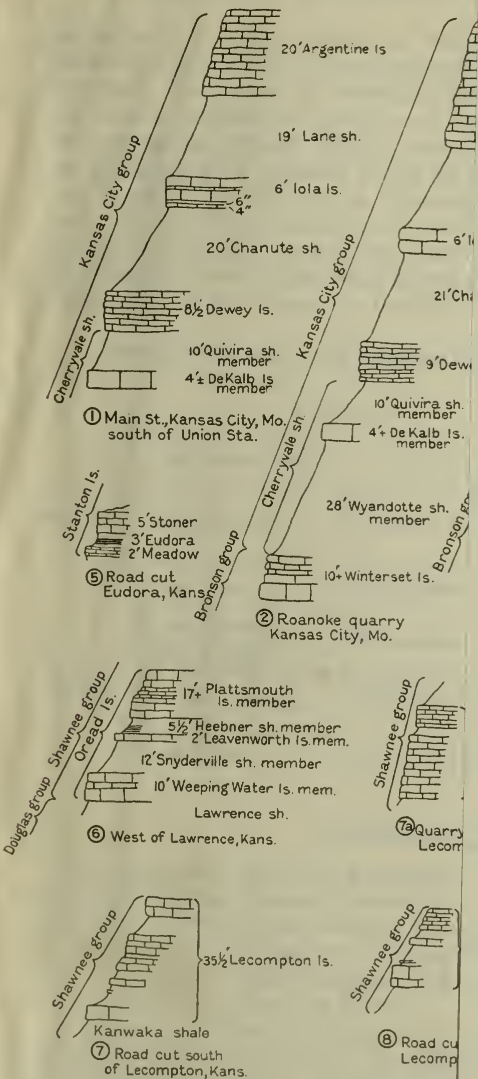
GEOLOGIC SKETCH MAP AND SECTION OF THE PENNSYLVANIAN ROCKS ALONG THE KANSAS RIVER BETWEEN KANSAS CITY AND TOPEKA, KANSAS

Numbers inclosed in circles indicate stops along the route as described in text.



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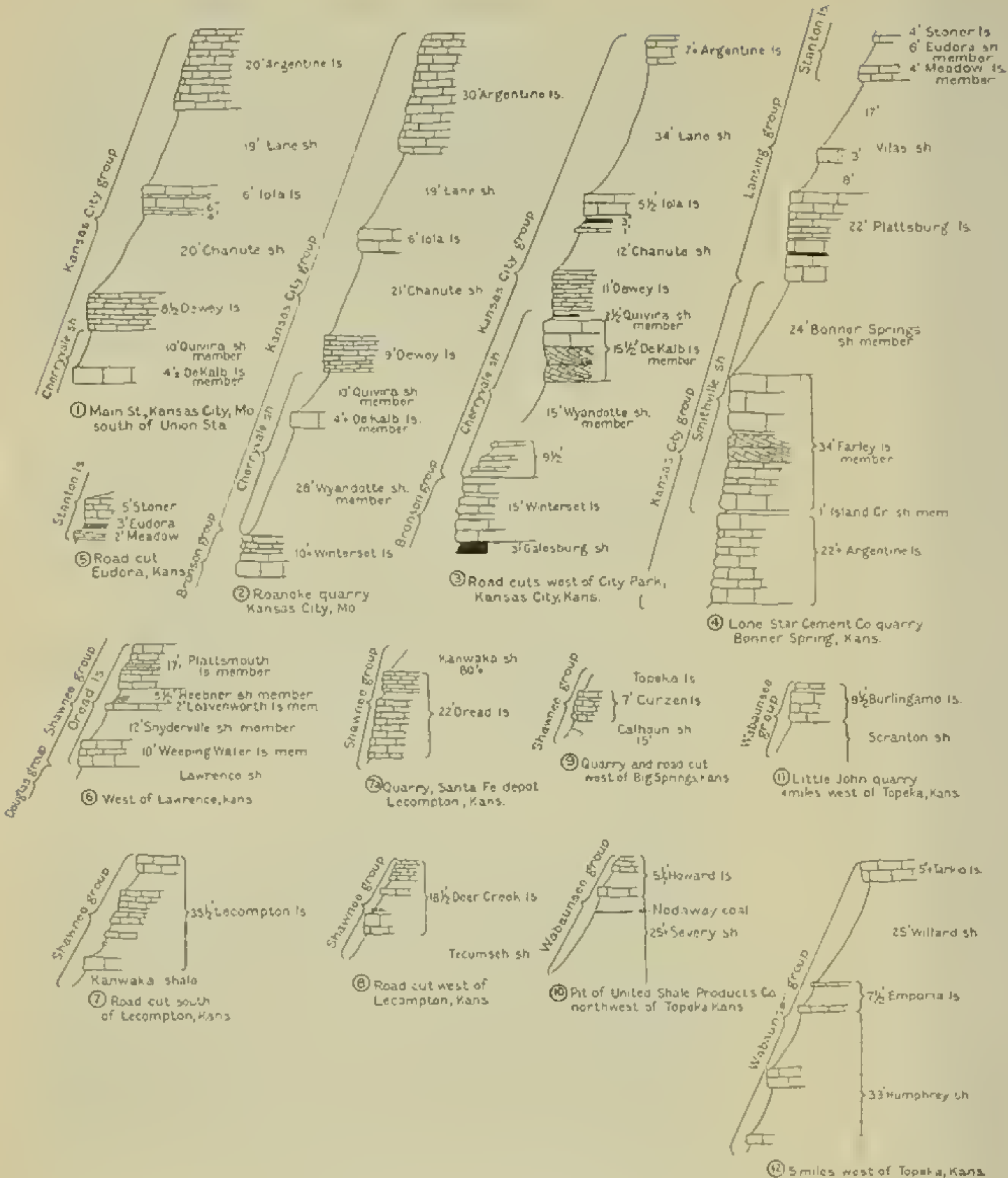

SECTIONS ALONG ROUTE OF EXCURSION

Numbers indicate locations so marked on Plate 1.

geologically by deformation of beds (chiefly seen in southern Oklahoma and Texas), occurrence of unconformities, changes in lithologic character of deposits, and modification of faunas and floras, permit recognition of four main divisions of the Pennsylvanian strata, which are called series. These series are designated in upward order Bend, Des Moines, Missouri, and Virgil. The relation of these major divisions to the main parts of the Pennsylvanian of eastern North America, which are based primarily on relative abundance of coal beds, and the approximate correlation with European divisions of the Upper Carboniferous are shown in the following table:

Correlation of American and European Carboniferous major divisions

	North America		Europe
	Mid-Continent region	Appalachian region	
Permian.	Big Blue series.	Dunkard series.	*Schwagerina* zone, *Productus cora* beds.
Pennsylvanian.	Virgil series.	Conemaugh series.	Stephanian, Uralian.
	Unconformity		
	Missouri series.	Monongahela series.	Westphalian, Moscovian.
	Unconformity		
	Des Moines series.	Allegheny series.	
	Unconformity		
	Bend series.	Pottsville series.	Namurian.

ITINERARY

The party will travel by automobile from Kansas City, Missouri, to Topeka, Kansas, where it will entrain. Stops are so arranged as to give the visiting geologists a very good idea of the nature and succession of Pennsylvanian stratigraphic units in the northern Mid-Continent region. The sections at the several stops are shown in Plate 2.

1. Union Station, Kansas City, Missouri. Kansas City stands at the confluence of the Missouri and Kansas Rivers, most of the city being on high uplands formed by limestone and shale of the Missouri series. Continuous with Kansas City, Missouri, but on the west side of the State boundary, is Kansas City, Kansas. There are many good exposures of the stratified rocks and of thick loess of Pleistocene and Recent origin which caps the bluffs.

A good section of the middle portion of the Missouri series is exposed opposite the Union Station in the Main Street cut. This shows the beds from the De Kalb limestone to the Argentine limestone, inclusive. Fossils are fairly common in the limestone beds and in part of the shale. The Lane shale, near the top of the section, has yielded a large number of perfect crinoids (*Phialocrinus*) with arms and stem connected with the calyx.

2. Roanoke quarry. Opportunity will be given at this point to examine the beds of the Missouri series from the Winterset to Argentine limestones, inclusive.

3. Road cuts west of City Park, Kansas City, Kansas. Along the highway that follows the north side of the Kansas River Valley are good exposures of the shale and thin limestone beds of the middle portion of the Missouri series. Some of the beds are very fossiliferous. The rocks dip gently westward, so that lower beds gradually disappear beneath the flood plain of the river, and higher beds appear low in the bluffs. Glacially striated limestone representing work of the Kansan (Mindel) glaciation may be seen here. The route of travel proceeds west along the north side of the Kansas River.

4. Bonner Springs. Quarry of Lone Star Portland Cement Co. This exposes a good section of beds belonging to the upper Missouri series, including Plattsburg to Argentine limestones.

5. Eudora. A stop will be made to examine outcrops of the Stanton limestone (near the top of the Missouri series) just east of Eudora. This is one of the very persistent and prominent escarpment-making limestones of eastern Kansas. The lower limestone bed contains a profusion of beautifully preserved brachiopods, especially *Enteletes pugnoides* Newell. In its lithologic characters this bed is typical of "middle" limestone beds in the stratigraphic cycle to be seen in other exposures. The overlying black fissile shale and the light-colored thin and irregularly bedded upper Stanton limestone are also typical members of the cycle.

Between Bonner Springs and Lawrence the most prominent unconformity in the Upper Pennsylvanian may be seen in several exposures. It is marked by nonmarine sandstone that rests on Stanton limestone and other formations of the upper Missouri series in this region. This break corresponds to the time of important mountain building in the Arbuckle Mountains and adjacent region in southern Oklahoma.

6. Lawrence. The party will visit the campus of the University of Kansas, located on a spur of the escarpment made by the Oread limestone, which is the first prominent marine formation of the Virgil series. Exposures of the limestone at the west edge of Lawrence will be examined. Fusulinids (*Triticites*) are

first really abundant in the Oread limestone. The succession of limestone and shale beds at this horizon clearly illustrates the cycle of sedimentation, which is strikingly repeated at higher horizons. Shales above and below these marine strata contain abundant fossil land plants.

7. South of Lecompton. After climbing the escarpment of the Oread limestone the highway follows the dip slope of the limestone for a few miles, then climbs to the next prominent limestone (Lecompton) in the Virgil series. Exposures of these beds, showing extremely abundant fusulinids, will be seen along the highway. The Lecompton limestone is characterized by abundance of the corals *Campophyllum* and *Syringopora*.

7a. Lecompton. At the town of Lecompton very good exposures of the upper Oread limestone just above river level are to be seen. Lecompton limestone caps the bluffs above the river.

8. Three miles (4.8 kilometers) west of Lecompton. The Deer Creek limestone, which occurs next above the Lecompton, is well exposed a few miles west of Lecompton and shows in remarkable detail an almost exact duplication of the stratigraphic sequence seen in the Oread.

9. Big Springs. The Topeka limestone, containing large productids and other fossils, may be seen between this point and Topeka.

The route between Lecompton and Topeka shows very clearly the successive escarpments made by prominent limestones in this part of the Pennsylvanian system.

10. Topeka. Topeka, the capital city of Kansas, is located on a limestone rich in productids, echinoid spines, bryozoans, and various other fossils and known as the Topeka limestone.

At the northwest edge of Topeka are exposures of the Howard limestone and underlying shale and coal. The coal is mined a few miles south of Topeka. This limestone, although only 2 feet (0.6 meter) thick, and also the thin coal beneath it have been traced with almost no change for a distance of fully 300 miles (483 kilometers) along the outcrop. This bed therefore furnishes a good example of the lateral persistence of thin stratigraphic units.

11. West of Topeka. The Burlingame limestone, one of the prominent escarpment-making beds, is exposed 3 or 4 miles (4.8 to 6.4 kilometers) west of Topeka and can be studied in quarried sections. It is a massive brown, rather impure limestone.

12. The next higher beds, called the Emporia limestone and the Tarkio limestone, the latter noteworthy on account of the profusion of very large fusulinids (*Triticites ventricosus*), are the highest beds seen on the trip. *Chonetes granulifer* and *Linoproductus prattenianus* (*Productus cora*) are especially common

in associated shaly limestone and shale beds. This general horizon corresponds to the "*Productus cora*" zone of the Russian Upper Carboniferous section. This continues 450 feet (137 meters) above the Emporia limestone to the base of the Neva limestone, which marks the beginning of the overlying *Schwagerina* zone.

LOCAL DIVISIONS

The names now applied by the writer in the northern Mid-Continent region to divisions of the Pennsylvanian rocks are shown below.

Permian: Americus limestone.
Conformity.
Virgil series:
- Wabaunsee group—
  - Admire shale.
  - Brownville limestone.
  - McKissick Grove shale.
  - Tarkio limestone.
  - Willard shale.
  - Emporia limestone.
  - Humphrey shale.
  - Burlingame limestone.
  - Scranton shale.
  - Howard limestone.
  - Severy shale.
- Shawnee group—
  - Topeka limestone.
  - Calhoun shale.
  - Deer Creek limestone.
  - Tecumseh shale.
  - Lecompton limestone.
  - Kanwaka shale.
  - Oread limestone.
- Douglas group—
  - Lawrence shale and sandstone.
  - Haskell limestone.
  - Stranger shale and sandstone.

Unconformity.
Missouri series:
- Pedee group—
  - Shale.
  - Iatan limestone.
  - Weston shale.
- Lansing group—
  - Stanton limestone.
  - Vilas shale.
  - Plattsburg limestone.
  - Bonner Springs shale.
  - Wyandotte limestone.
- Kansas City group—
  - Lane shale.
  - Iola limestone.
  - Chanute shale.
  - Drum limestone.
  - Cherryvale shale.
- Bronson group—
  - Dennis limestone.
  - Galesburg shale.
  - Swope limestone.
- Bourbon group—
  - Shale and channel sandstone.

Unconformity.
Des Moines series:
- Marmaton group.
- Cherokee formation.

Unconformity.
(Bend series absent.)