AN ABSTRACT OF THE THESIS OF

Friday O. Ezerendu for the Master of Science

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Title: Stratigraphic History, Deposition and Ligholologic Study of the Topeka Limestone in Greenwood County, Kansas

Abstract approved: Thomas E Bridge

The Shawnee Group, Virgilian Series of the Upper Pennsylvanian System consists of seven formations. They are, in ascending order: Oread Limestone, Kanwaka Shale, Lecompton Limestone, Tecumseh Shale, Deer Creek Limestone, Calhoun Shale, and Topeka Limestone.

In Northern Greenwood County, the Topeka Limestone consists of the basal two limestone members, Hartford Limestone and Curzon Limestone. In central Greenwood County, The Coal Creek Limestone, which is the upper part of Topeka Limestone, is identified.

From north-central Greenwood County southward, a persistent limestone-to-shale facies change occurs within the Topeka Limestone. The lighology changes are the likely result of an anticlinal feature, the Bourbon Arch. Similar facies changes were also observed within the Howard Limestone.

Many good exposures exist in the northern and central portion of the study area provided by nemerous quarries within the Topeka Limestone and Howard Limestone. Good exposures exist on the southern area from Eureka eastward along Highway 54. These and other measured sections are included within the lithology. Illustrations included as part of this paper indicate thickness variations and facies changes.

STRATIGRAPHIC HISTORY, DEPOSITION AND LITHOLOGIC STUDY OF THE TOPEKA LIMESTONE IN GREENWOOD COUNTY, KANSAS

A Thesis

Presented to

the Division of Physical Sciences

EMPORIA STATE UNIVERSITY

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of the Requirements for the Degree

Master of Science

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by

Friday O. Ezerendu

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Approved for the Major Division

Approved for the Graduate Council

A C K N O W L E D G M E N T S

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PREFACE

Purpose and Scope

The Shawnee Group, Virgilian Series, of the Upper Pennsylvanian System consists of seven formations: they are, in ascending order, Oread Limestone, Kanwaka Shale, Lecompton Limestone, Tecumseh Shale, Deer Creek Limestone, Calhoun Shale, and Topeka Limestone (Figure 1).

The Topeka Limestone is the object of this study. The Topeka Limestone consists of nine members where it is fully developed. They are, in ascending order, Hartford Limestone, Iowa Point Shale, Curzon Limestone, Jones Point Shale, Sheldon Limestone, Turner Creek Shale, DuBois Limestone, Holt Shale, and, lastly, the Coal Creek Limestone. The Topeka Limestone does appear to be fully developed in northern Kansas (Moore, 1949) and in extreme southern Kansas (Fudge, 1974); however, within its outcrop area in the central part of the state, the formation is incompletely developed and many facies changes take place.

This study is principally a field investigation to measure thickness, lithologic changes, and to attempt a stratigraphic correlation between those members of the Topeka Limestone present in Greenwood County.

A total of eighteen sections were measured in order to realistically evaluate the facies changes that take place within Greenwood County. The measured sections are included in the lithology section; and, the postulated correlations are indicated in the correlation chart.

Location

The study areas are concentrated in Greenwood County. The contact of the Shawnee Group with the overlying Wabaunsee Group is shown in Figure 2, indicating the approximate outcrop area of the Topeka Limestone to be totally within a few miles east of this line and found within adjacent counties.

The northern extent of the study area is north of Madison. The Topeka Limestone is not seen in this area; instead, Howard Limestone is fully exposed. The study area also covers Madison through Lamont and five miles west of Lamont. The Topeka Limestone is poorly exposed within this area; and, as such nothing of the sort is found. The study area also covers Madison through Hamilton along Highway 99 down to Highway 54. East-west bound, it covers from Eureka eastward along Highway 54 to the county line (Figure 3).

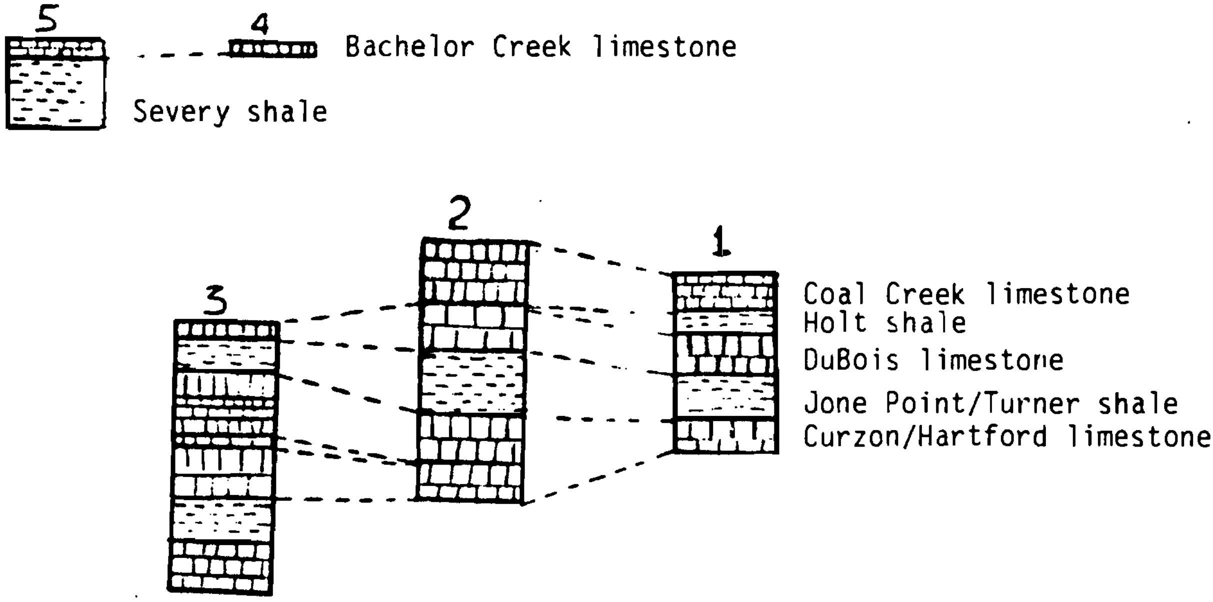
The Topeka Limestone is very well exposed throughout the northern one-third of Greenwood County. The chief reason for the excellent exposures are the numerous quarries which are taking advantage of the massive nature of the Hartford Limestone, the basal member of the formation. Other good exposures exist along U.S. 54 east of Eureka and along channel and gully banks within the study area. The Topeka Limestone in southern Greenwood County is poorly exposed for the reason that much of the limestone within the formation has pinched out or is very much thinner than in the northern and central Greenwood County areas. As the Topeka Limestone pinches out southward, sandstone below it increases in thickness in the southward direction.

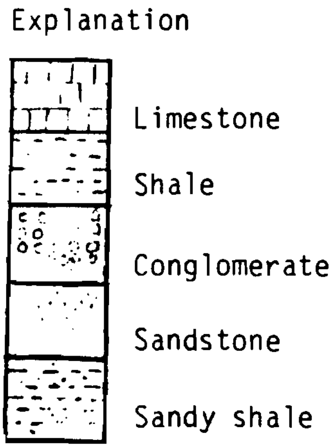
Previous Workers

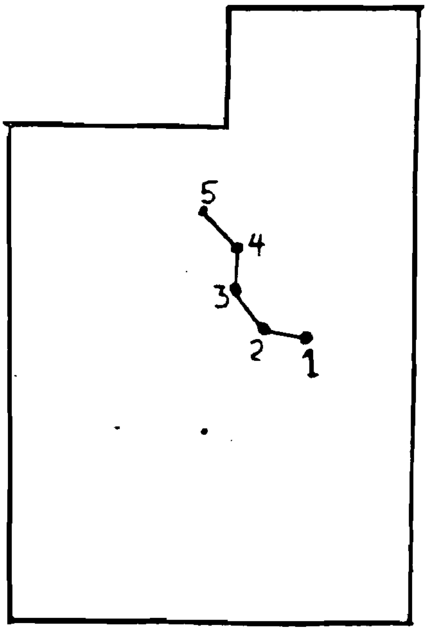
There have been numerous publications with direct bearing on the Topeka Limestone. Almost all have been concerned with the formation in northern Kansas or adjacent areas of neighboring states. Previous studies include: Condra and Bengston, 1915; Condra, 1930; Moore, 1936; Moore, 1948; Moore, 1949; and Moore and et al., 1951. For southern Kansas, there have been but a handful of papers written, including Verville and et al., 1958; and Fudge, 1974. There are not yet any published bulletins on Topeka Limestone in Greenwood County, Kansas.

CONTENTS

LIST OF PLATES







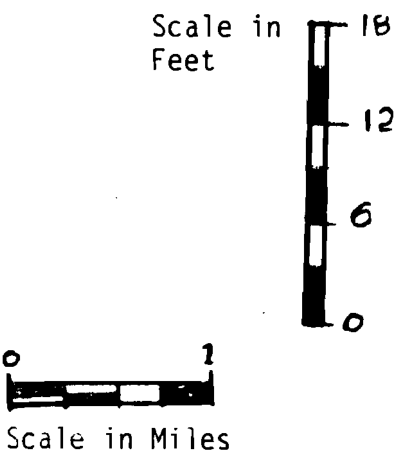


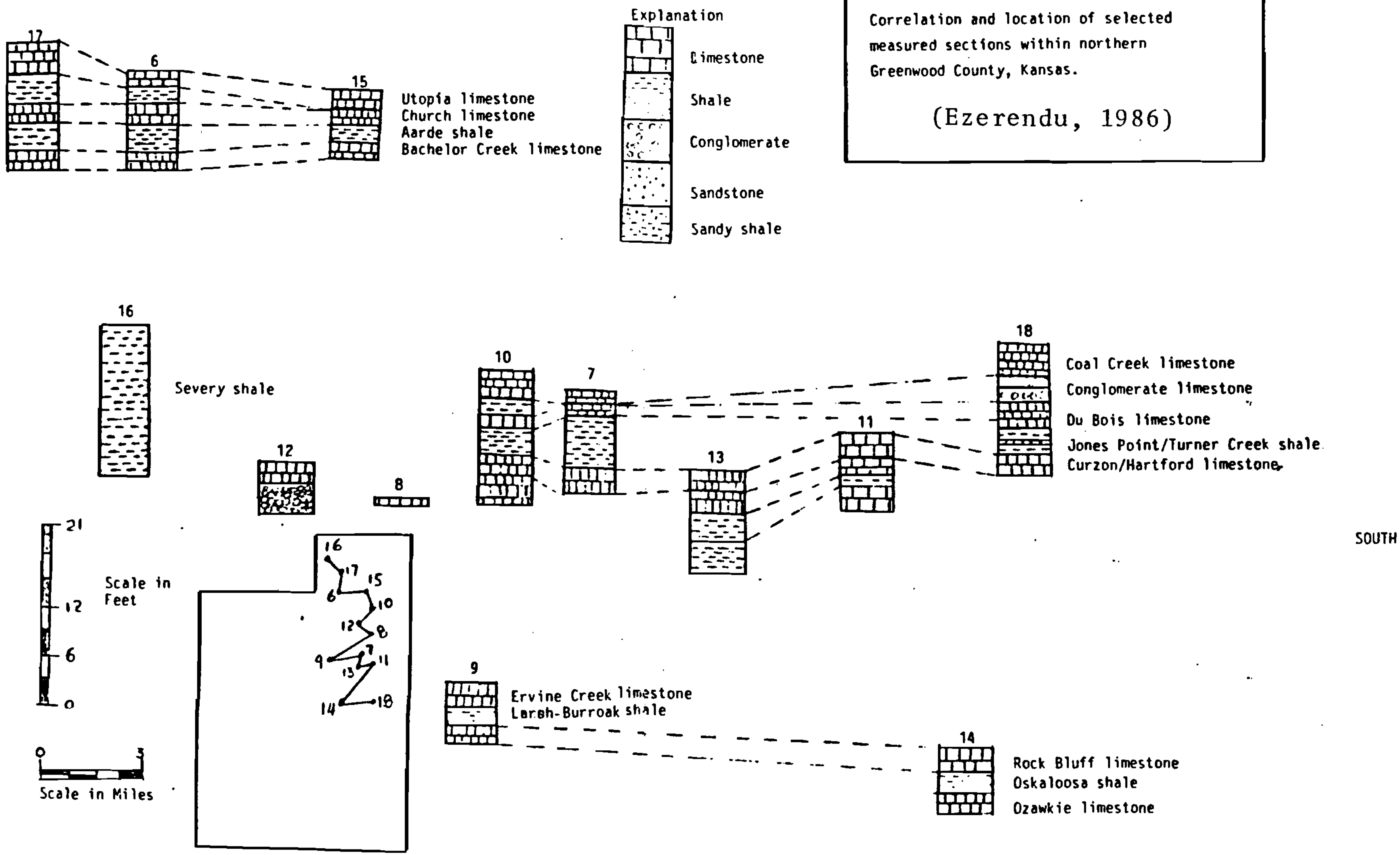
Plate 1

Correlation and location of selected measured sections within central Greenwood County. (Ezerendu, 1986)

Plate 2

Correlation and location of selected measured sections within northern Greenwood County, Kansas.

(Ezerendu, 1986)



LIST OF FIGURES

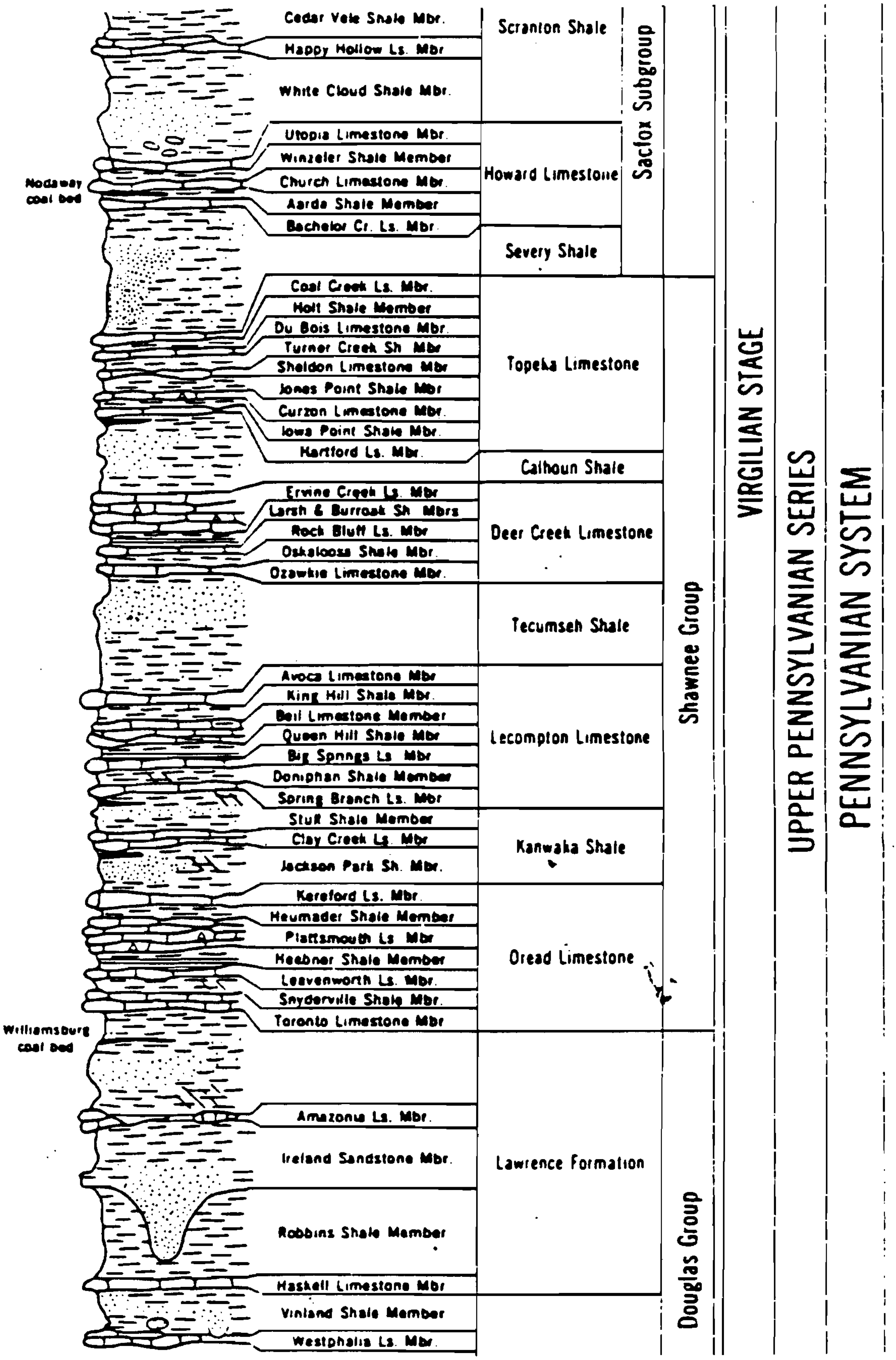


Figure 1. Stratigraphic section of the Topeka Limestone and surrounding formations (after Zeller, 1968).

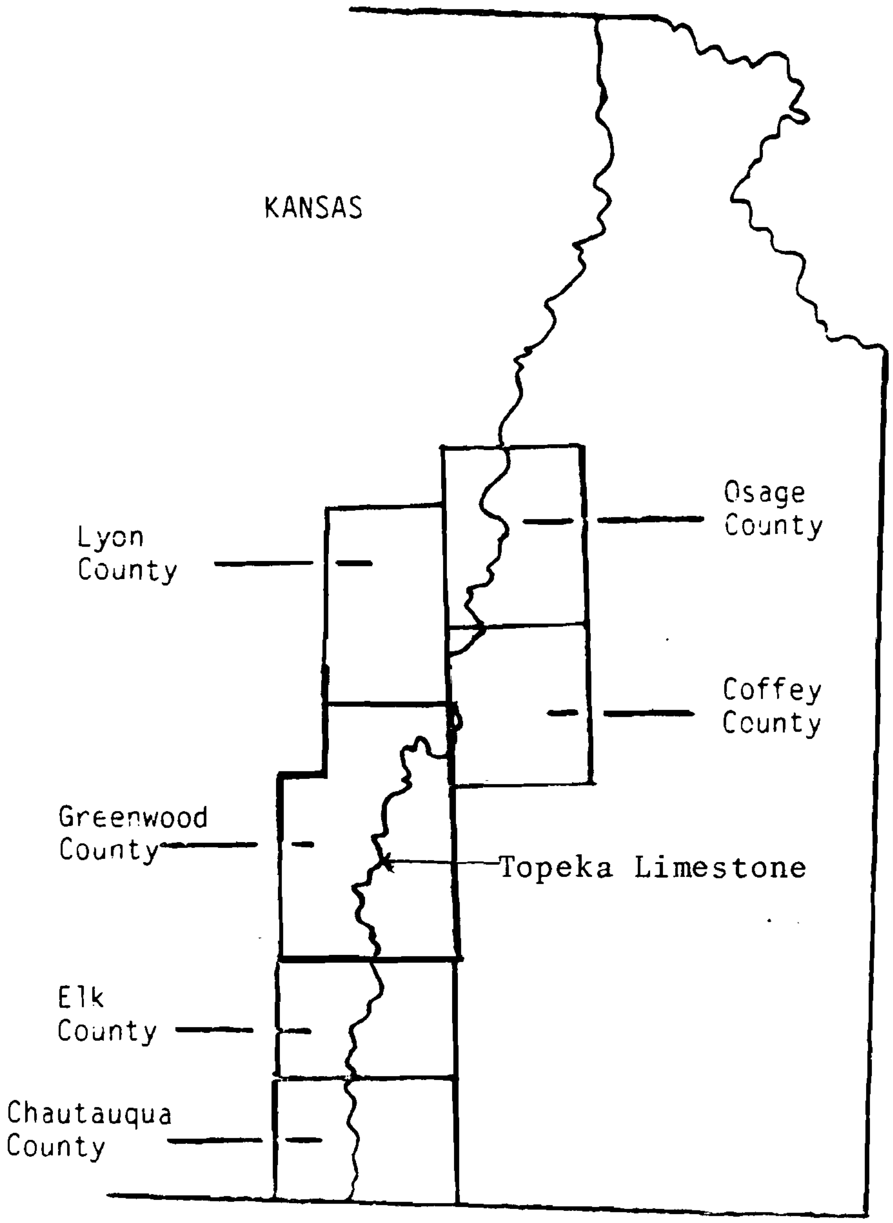


Figure 2. Location map of the study area and generalized outcrop pattern of the Topeka Limestone in Kansas. (Ezerendu, 1986)

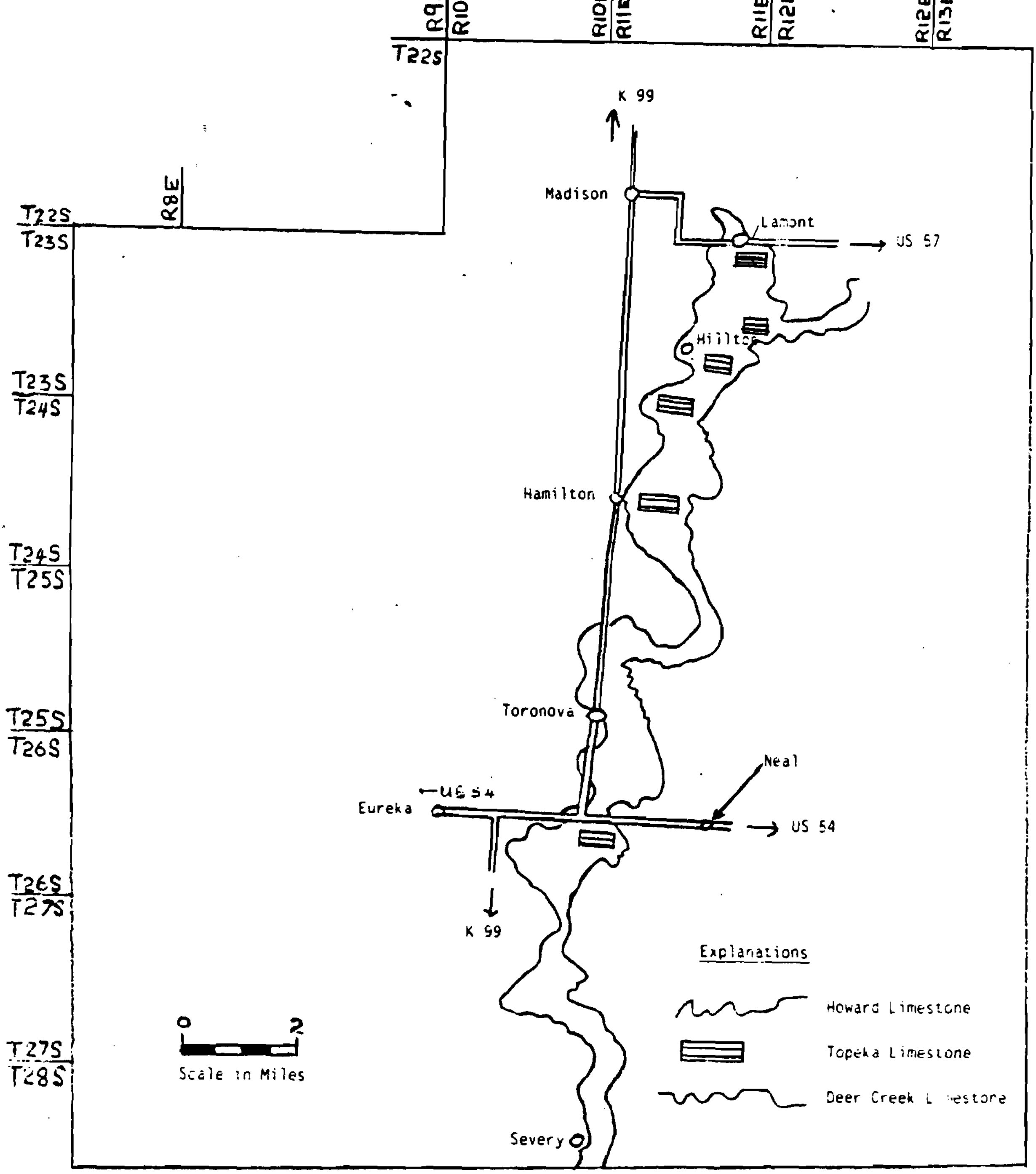


Figure 3. Map of Greenwood County showing some outcrops of the Topeka Limestone in some sites.

(Ezerendu, 1986)

	Condra, 1927	Condra, 1930	Condra, 1933	Moore, 1936
Severy sh.				
Topeka ls.	Coal Creek ls. Holt sh. Dubois ls. Turner Creek sh. Curzen ls.	Coal Creek ls. Holt sh. Dubois ls. (lower subzone of Dubois ls. thought to be Curzen ls.	Coal Creek ls. Holt sh. Dubois ls.	Coal Creek ls. Holt sh. Dubois ls. Turner Creek sh. Hartford ls.
Calhoun sh.	Iowa Point sh. Meadow ls. Jones Point sh.	Iowa Point sh. Sheldon ls. Jones Point sh.	Turner Creek sh. Calhoun sh.	Iowa Point sh. Sheldon ls. Jones Point sh.
Deer Creek ls.	Ervine Creek ls.	Ervine Creek ls.	Sheldon ls. Jones Point sh. Ervine Creek ls.	Ervine Creek ls.

	Moncrief, 1936	Condra & Reed, 1937	Condra, 1949	Moore, 1949
Severy sh.				
Topeka ls.	Coal Creek ls. Holt sh. Dubois ls. Turner Creek sh. Hartford ls. Jones Point sh. Dashner ls.	Coal Creek ls. Holt sh. Dubois ls. Turner Creek sh. Sheldon ls. Jones Point sh. Curzen ls. Iowa Point sh. Wolf River ls.	Coal Creek ls. Holt sh. Dubois ls. Turner Creek sh. Sheldon ls. Jones Point sh. Curzen ls. Iowa Point sh. Hartford ls.	Coal Creek ls. Holt sh. Dubois ls. Turner Creek sh. Sheldon ls. Jones Point sh. Curzon ls. Iowa Point sh. Hartford ls.
Calhoun sh.	Calhoun sh.			
Deer Creek ls.	Ervine Creek ls.	Ervine Creek ls.	Ervine Creek ls.	Ervine Creek ls.

Figure 4. Development of the stratigraphic classification of the Topeka limestone.

(Ezerendu, 1986)

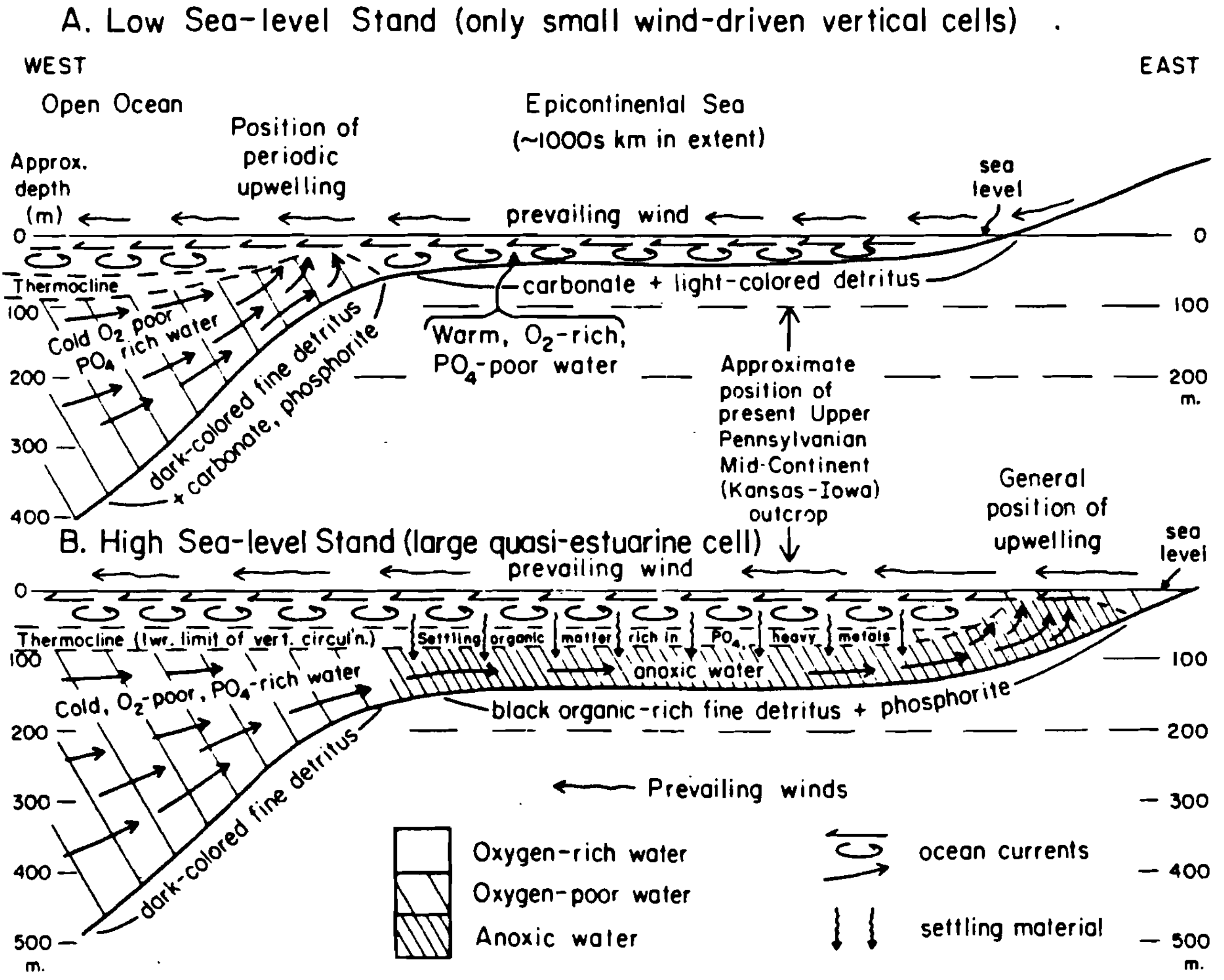


Fig.5. -- Expected patterns of vertical circulation in west-facing tropical epicontinental sea: A, Low sea-level stand when vertical circulation and algal photosynthesis maintain bottom oxygen; B, High sea-level stand when thermocline allows prevailing trade winds to establish large quasi-estuarine circulation cell, which results in depletion of bottom oxygen and concentration of phosphate. (from Heckel, 1977).

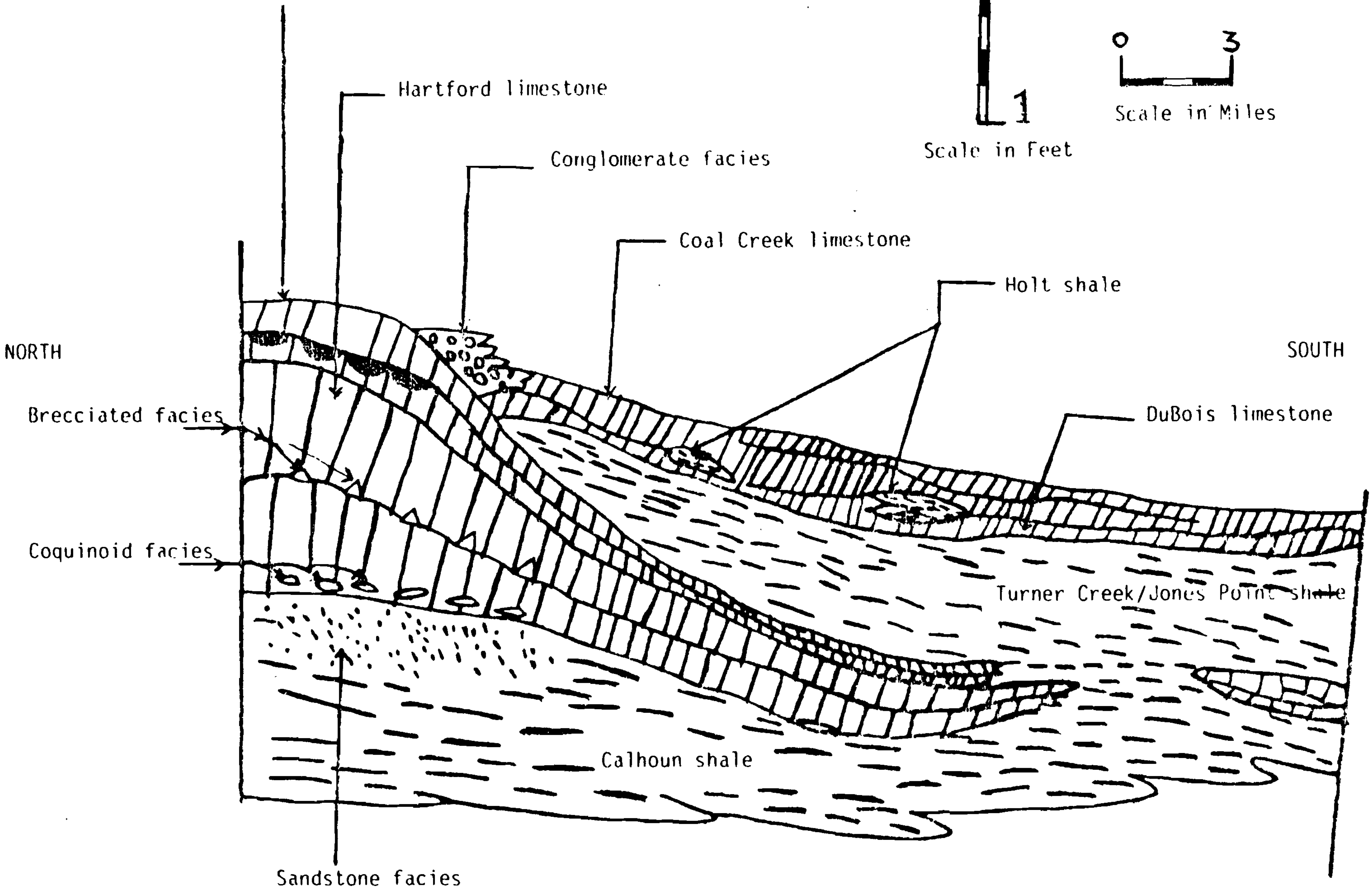
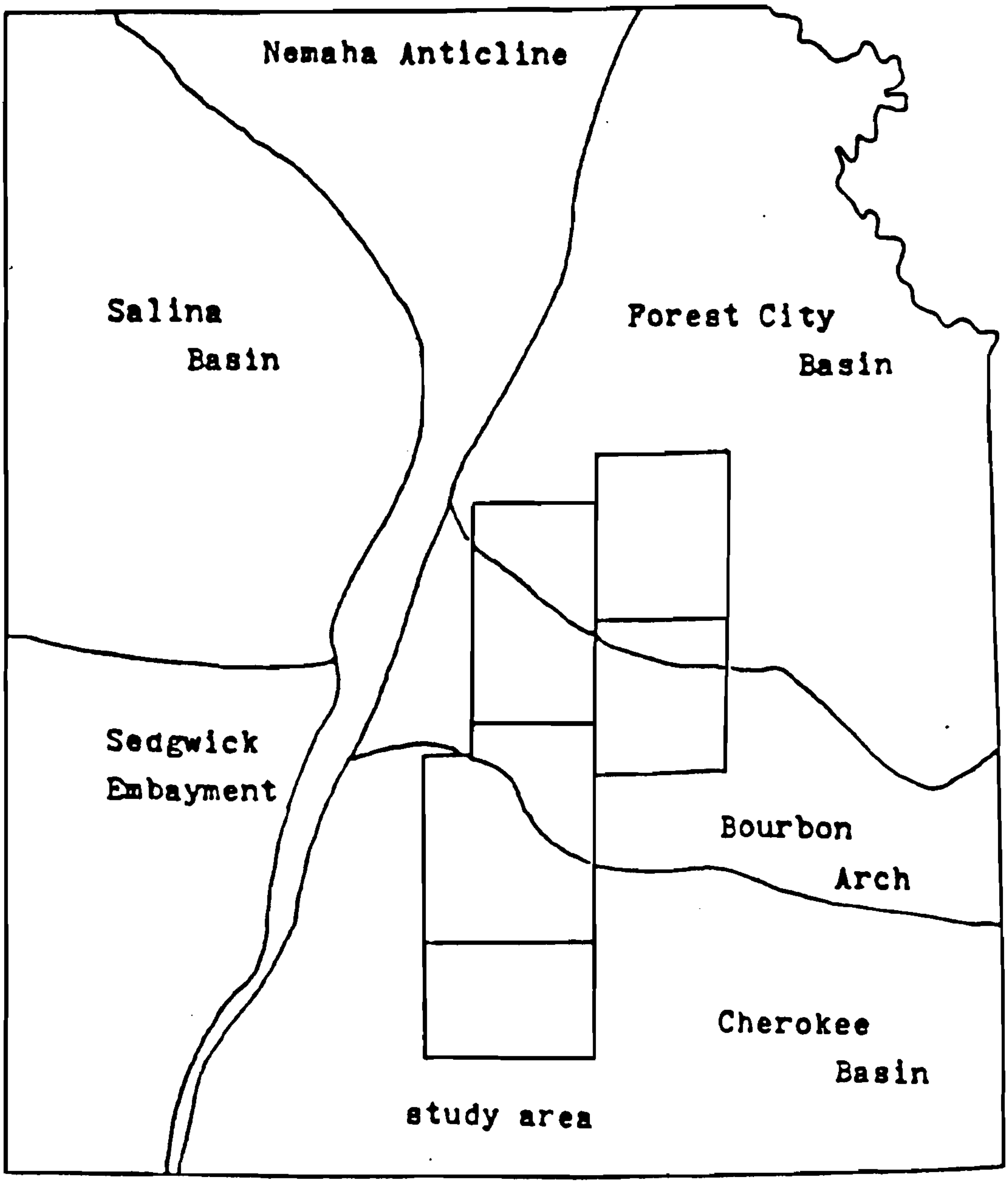
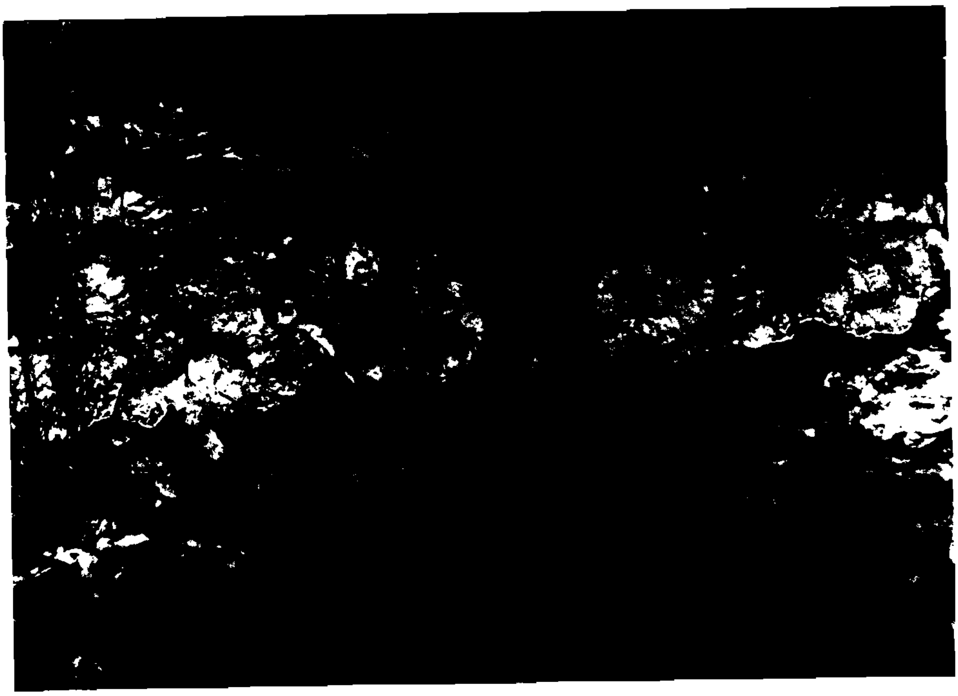


Figure 6.
Schematic diagram showing facies changes within the Topeka limestone within Greenwood County.
(Ezerendu, 1986)

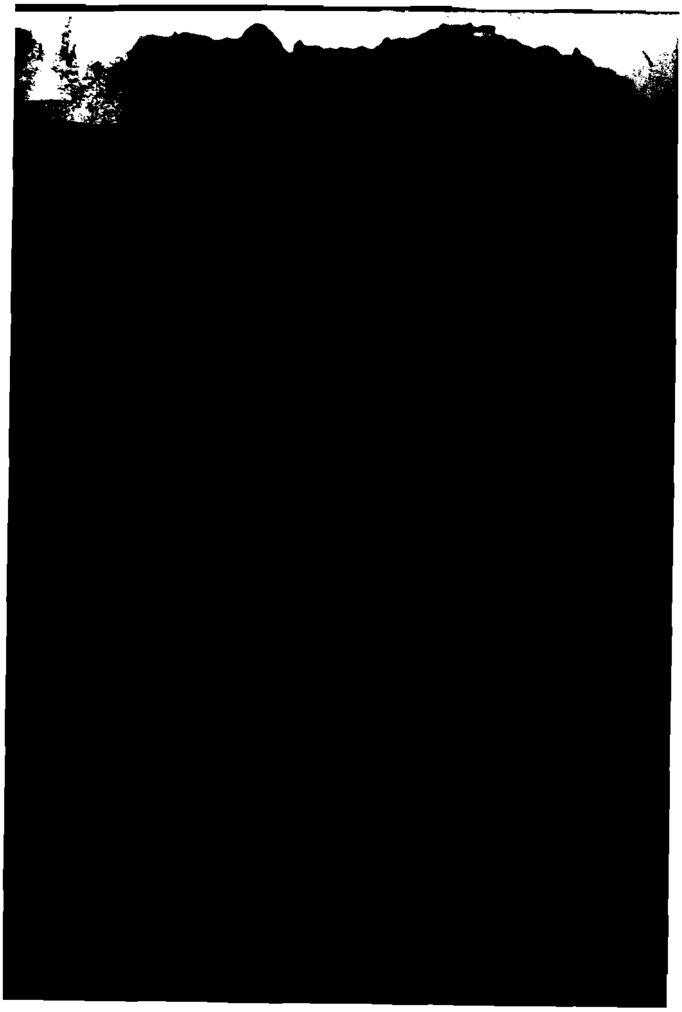
Figure 7. Paleotectonic map of eastern Kansas showing the structures which exerted a direct influence on the deposition of the Topeka limestone. The southern border of the Bourbon Arch along the outcrop width of the Topeka limestone is the site of a significant southerly limestone to shale facies change. See Figure 5 for a generalized representation of the lithologies present within the study area (After Baker, 1962).



1. Photograph of Topeka limestone showing Coal Creek limestone member. This outcrop is along U.S. 54 in Greenwood County, Kansas



2. Photograph of Topeka limestone showing Curzon limestone at top and Hartford limestone member below. This outcrop is along U.S. 54 in Greenwood County, Kansas



3. Photograph of Topeka limestone showing Coal Creek limestone member at the top, Du Bois limestone member below, thin undifferentiated Turner Creek/Jones Point shale member below and Hartford limestone member at the bottom. This outcrop is found on active quarry four and one-half miles east of Hamilton in Greenwood County, Kansas.

4. Photograph of Topeka limestone showing Curzon limestone member, highly oxidized. This outcrop is in active quarry four and one-half miles east of Hamilton, in Greenwood County, Kansas.

5. Photograph of Topeka limestone showing Curzon limestone member above and Hartford limestone member below. This outcrop is on active quarry four and one-half miles east of Hamilton in Greenwood County, Kansas.

CHAPTER ONE

GENERAL STRATIGRAPHY

Stratigraphy is a branch of historical geology dealing with the sequence of events in the earth's history as interpreted from evidence found in sedimentary rocks. Included in stratigraphy are the records of sediment deposition, of past geographic distributions of land and sea, and of past conditions of climate and terrain. The pursuit of stratigraphy depends on paleontology, the study of ancient life based on fossil remains of animals and plants.

Howard Limestone

The Howard Limestone consists of three limestone and two shale members being named by Haworth (1898) for exposures near Howard, Kansas. Total thickness of this formation may vary between eight and thirty feet (Moore, 1949).

There are several exposures of Howard Limestone, but there is only one within the study area in which all of the members are exposed. In northern Greenwood County, one and one-half miles south of Lamont, the Howard Limestone attains a total thickness of 14.0 feet, indicating a slight thinning trend in a northerly direction.

Utopia Limestone Member

The Utopia Limestone was named for exposures near Utopia

Limestone consists of up to sixteen feet of light-brown weathering, very fossiliferous limestone. The Utopia Limestone is not entirely exposed in Greenwood County. At one-half mile west of Lamont, the total interval measures 4.0 feet thick, being generally unfossiliferous except for the uppermost 0.6 feet, which has an abundance of fusulinids.

Winzeler Shale Member

The Winzeler Shale member was named by Moore (1932) for exposures on the Winzeler farm in south-central Greenwood County, Kansas. The Winzeler Shale consists of up to twelve feet of bluish-gray to yellowish-gray clayey shale (Moore, 1949).

In northern Greenwood County, one-half mile west of Lamont, the Winzeler Shale is represented by a poorly exposed interval of 4.0 feet thick. A definite northerly thinning trend exists here.

Church Limestone Member

The Church Limestone member was named for exposures near DuBois, Nebraska (Condra, 1927). It varies in thickness between one and six feet and consists of a bluish-gray limestone. "Crinoid remains, productid brachiopods, and bryozoans are common." (Moore, 1949). On one-half mile west of Lamont in Greenwood County, the Church Limestone is two feet thick, consisting of an orange-brown weathering, crinoid-rich, massive limestone.

Aarde Shale Member

The Aarde Shale member was named by Moore (1932) from exposures on the Aarde farm in south-central Greenwood County, Kansas. The Aarde Shale consists of a bluish-gray to yellowish-gray clayey to sandy shale (Moore, 1949). A persistent marker bed within the Aarde Shale, the Nodaway Coal, has been traced throughout Kansas and into neighboring states.

The Aarde Shale was observed in one section within the study area. At the section within Greenwood County, the Aarde Shale appears light brown in the uppermost one foot and is dark gray in lower three feet.

Bachelor Creek Limestone Member

The Bachelor Creek Limestone member was named by Moore (1932) from exposures on Bachelor Creek in Greenwood County, Kansas. It is poorly fossiliferous, sandy limestone, and is dark gray to dark bluish-gray on a fresh surface. The thickness of Bachelor Creek Limestone may vary up to eight feet (Moore, 1949); however, in Greenwood County, this member maintains a rather constant thickness between one and two feet. Some exposures of Bachelor Creek Limestone were measured and are included in Plates 1 and 2.

Severy Shale

The Severy Shale was named for exposures near Severy, Kansas, by Haworth (1898). The total thickness of Severy

(Moore, 1949). The Severy Shale is never entirely exposed, making the determination of the total thickness by surface measurements inadequate; however, the thickness of this formation could be easily determined by drilling a hole through the suspected area or by carrying out a subsurface stratigraphy of the suspected area.

The Severy Shale is well exposed in Greenwood County. The Severy Shale consists of a yellowish-green to olive-gray clayey to silty shale. Along K-57 in Greenwood County, a 20-foot thick section of Severy Shale exists.

CHAPTER TWO

DEER CREEK LIMESTONE

The Deer Creek Limestone was named for exposures along Deer Creek in Shawnee County, Kansas by Beede (1898). The Deer Creek Limestone consists of three limestone and two shale members. There are limited exposures of Deer Creek Limestone within the study area. In northern Greenwood County, about five miles south of Lamont and along a river bank west of Hilltop, the Deer Creek Limestone attains a total thickness of nine feet.

Ervine Creek Limestone

The Ervine Creek Limestone was named for exposures along Ervine Creek in Cass County, Nebraska, by Condra (1927). The Ervine Creek Limestone consists of from five to thirty-two feet of very fossiliferous, white to bluish-gray limestone.

The Ervine Creek Limestone was observed in central Greenwood County to be a massive, white to light-gray limestone with numerous fusulinids present. Excellent exposures exist along a river bank west of Hilltop. Also, there is another exposure along a creek south of K-54, two miles east of the junction of K-99 and K-54.

Larsh-Burroak Shale Member

The Larsh-Burroak Shale member was named for exposures along Ervine Creek Valley, two and one-half miles east and a

Condra (1927). The Larsh-Burroak Shale member contains two persistent subdivisions, the lower half consisting of hard, black fissile shale, and the upper half of gray to yellowish-brown, soft clay (Condra, 1927:40), (Condra and Reed, 1943:48). Excepting conodonts, fossils are rare or lacking in the black shale, and they are not generally found in the upper part. In places, however, the latter contains calcareous slabs (Condra, 1927).

Rock Bluff Limestone Member

The Rock Bluff Limestone was named for the town of Rock Bluff on the Missouri River in Cass County, Nebraska, by Condra (1927). "The Rock Bluff Limestone is one of the most persistent, uniform and distinctive members of the Deer Creek Formation in the northern Midcontinent region." (Condra, 1927). It is a dense, blue bed which, as seen in most exposures is a single, massive stratum one to five feet thick. The top of the bed is very even, but the base may be slightly uneven. Vertical joints are well developed two systems which intersect approximately at right angles and cause the bed to separate in rectangular blocks along the outcrop. The rock is not broken into small fragments by weathering, but the sharp edges of the blocks are gradually rounded by selution so as to produce bouldery shapes. Fusulinids are the most common fossils in most outcrops of this member. Also, brachiopods, bryozoans and mollusks are present. There are some chert nodules. This outcrop was exposed along the

Oskaloosa Shale Member

The Oskaloosa Shale was named from the type locality at Oskaloosa, Kansas, by Moore (1936). It lies between Ozawkie Limestone below, and the dense blue middle Deer Creek bed (Rock Bluff Limestone). It is normally five to ten feet thick in the northern part of Kansas. It is bluish-gray or yellowish, and consists of blocky clay containing one or two calcareous, somewhat ferruginous siltstones in northern Kansas (Moore, 1936). The Oskaloosa Shale member is mostly unfossiliferous, but, excepting possibly the red shale, appears to be marine in origin (Moore, 1949).

Ozawkie Limestone Member

The Ozawkie Limestone was named from the type locality in Jefferson County, Kansas, by Moore (1936). This exposure was seen along Wilder Creek. It is a massive and thick-bedded limestone, which resembles the lowermost member of Topeka Limestone. In contrast to the higher limestone members of the Deer Creek, the Ozawkie appears somewhat sandy and impure. There are calcite nodules present. Fossils are not very common in most places. Locally, however, there are numerous fusulinids, crinoid stem fragments and fairly common brachiopods, small black bryozoans and even corals are present. Some outcrops show that the member consists locally almost wholly of fusulinid-bearing limestone; but, elsewhere, the upper half or more of the member is an oolitic, granular, algal rock which contains gastropods and other mollusks. Un-

Warthia, and *Knightites* have been described from Ozawkie Limestone (Moore, 1949). The thickness is about two feet.

For location, township and range of all measured sections, see pp. 36-47.

CHAPTER THREE

DETAILED STRATIGRAPHY

Topeka Limestone

The Topeka Limestone (Bennett, 1896) is named for exposures near Topeka, Kansas, and has nine members where it is fully developed. The Topeka Limestone consists of five limestone and four shale members, commencing Coal Creek Limestone at the top of the formation, and extending down and in order of occurrence through Holt Shale member, DuBois Limestone member, Turner Creek Shale member, Sheldon Limestone member, Jones Point Shale member, Curzon Limestone member, Iowa Point Shale member, and ending with the Hartford Limestone member at the base of the formation (Figure 1). The Topeka Limestone is overlain by the Severy Shale formation, which is a basal unit of the Wabaunsee Group and underlain by the Calhoun Shale formation. In order to visualize more clearly the development, a diagram (Figure 6) is given.

The Topeka Limestone has a very slight thinning trend in a southerly direction. Within northern Greenwood County, Kansas, the Topeka Limestone is 90% limestone and less than 10% shale, and it is entirely comprised of the basal two members of the formation, Curzon Limestone and Hartford Limestone. In central Greenwood County, the upper two limestone members, the Coal Creek Limestone and DuBois Limestone, be-conglomerate facies, the significance of which will be further discussed with the "Coal Creek Limestone Member" under "Detailed Stratigraphy." From central Greenwood County southward, the limestone members of the Topeka Limestone progressively diminish in thickness, whereas the shale members thicken considerably.

Coal Creek Limestone Member

The Coal Creek Limestone is the uppermost member of the Topeka Limestone formation. The Coal Creek Limestone was initially named the Union Limestone (Condra and Bengston, 1915) for exposures near Union, Nebraska. However, the stratigraphic term of Union Limestone was dropped for the reason that it was already in use (Condra, 1927) to describe a Mississippian unit exposed in Virginia and West Virginia. It is interesting to note that the Union Limestone of Nebraska was named in 1915, and that of Virginia in 1926, indicating that the Union Limestone as a stratigraphic name should have been retained in Nebraska rather than be changed to the Coal Creek Limestone.

The Coal Creek Limestone has always been within the proper stratigraphic position, resting beneath the Severy Shale formation and above the Holt Shale member of the Topeka Limestone. The Coal Creek Limestone tends to be a massive, very fossiliferous limestone, weathering orange-brown in northern Kansas. Fusulinids and other invertebrates are very abundant (Moore, 1949).

Within the study area, the Coal Creek Limestone is found only in one area in northern Greenwood County. The Coal Creek Limestone is absent in southern Osage County, Lyon County, Coffey County and northern Greenwood County (O'Connor, 1953, et al.). O'Connor did not recognize the Coal Creek Limestone in Lyon or Osage Counties, but Zeller (1968) stated that Coal Creek Limestone is only locally present in southern Kansas.

In Greenwood County, the Coal Creek Limestone is very persistent, averaging six feet where it is fully developed. The Coal Creek Limestone is typically a pale orange-brown, massive limestone, weathering to a moderate orange-brown. Diagnostic features include flaggy lenticular parting, and the relative abundance of fusulinids, brachiopods and bryozoans.

In Greenwood County, there are many places where this limestone exists, such as abandoned quarries and roadcuts. In all these areas, there exists a unique facies of the Topeka Limestone that is stratigraphically equivalent to the Coal Creek Limestone.

The Coal Creek Limestone is extremely persistent in the southern two-thirds of Greenwood County. In Greenwood County, the Coal Creek Limestone is seen at these exposures: abandoned Hamilton quarry, quarry west of Hilltop, Hilltop area, on active quarry east of Hamilton and two miles east of the junction of K-99 and K-54.

Conglomerate Limestone

This conglomerate limestone was first seen by the writer about four hundred yards north of Hamilton Quarry. Here the conglomerate is made up of small-sized pebble, fine sand, course and medium-sized sand, gravels and granule-size fragments. As one goes south, the size of the pebbles, sand, and other fragments increase in size. This Conglomerate Limestone is found to be more than six feet thick along a river bank east of Hamilton. The elevation of this Conglomerate Limestone along the river bank east of Hamilton Quarry shows that the Conglomerate Limestone exists below Coal Creek Limestone. In the abandoned Hamilton Quarry, it seems that the Conglomerate Limestone cuts through Curzon Limestone and Hartford Limestone. It is also found on the active quarry east of Hamilton Quarry. Here, it cuts through and mixes with Curzon Limestone and rests on top of Hartford Limestone that is on the bottom. It is not found on the surface beyond two miles south of the new active quarry.

It is the opinion of the writer that the Conglomerate Limestone represents a subaqueous debris flow. Reasons for this interpretation are fourfold: 1) flowage characteristics indicated by the linear features already mentioned; 2) the Conglomerate Limestone appears to have a lower topographic position than the more typical, nearby deposits of the Coal Creek Limestone, indicating flowage below the Coal Creek Limestone and possibly cutting into Curzon and Hart-

Topeka Limestone are very rapid in the immediate vicinity of the Conglomerate Limestone, indicating a change in environment; and, finally, 4) the local nature of the Conglomerate Limestone.

Holt Shale Member

The Holt Shale is the uppermost shale member of the Topeka Limestone, residing below the Coal Creek Limestone and above the DuBois Limestone. The Holt Shale was first identified from exposures south of Forest City, in Holt County, Missouri (Condra, 1927). The Holt Shale has always been placed within the proper stratigraphic position, and is, perhaps, the easiest of any of the members of the Topeka to identify.

The Holt Shale consists of bluish-gray shale overlying black fissile shale attaining a maximum thickness of three feet (Moore, 1949). The Holt Shale is absent in northern Greenwood County, but present in central Greenwood County. Moore (1949) indicates that the Holt Shale is not easily identified for the reason that the overlying and underlying limestone members disappear.

Across central Greenwood County, the Holt Shale varies in thickness. The distinctive black, fissile shale portion of the Holt Shale does not have a constant stratigraphic position, but rather may vary from the top to the base of the member. It is found two miles east of the junction of U.S. 54 and K-99. The Holt Shale in Greenwood County is very selcorrect stratigraphic interval, the overlying Coal Creek Limestone and underlying DuBois Limestone are also present and fully developed.

DuBois Limestone Member

The DuBois Limestone is the third member from the top of the Topeka Limestone. The DuBois Limestone was initially described for exposures near DuBois, Nebraska (Condra, 1927), and has always been included as part of the proper formation. The stratigraphic position of the DuBois Limestone has not varied as many of the members within the Topeka Limestone have, perhaps because of the easy recognizability of the limestone (see Figure 6).

The DuBois Limestone consists of massive, flat blocks with a characteristic vertical jointing. It resides beneath the Holt Shale and above the Turner Creek Shale (Moore, 1949).

The lower limestone bed exhibits prominent vertical jointing, which is a characteristic of this member. The DuBois Limestone has a characteristic vertical jointing in which the overlying black shale of the Holt Shale has been squeezed into the overburden. It is considered likely that the DuBois Limestone pinches out in the southernmost part of Greenwood County.

Turner Creek Shale Member

The Turner Creek Shale is the second shale member from is true for the most part of the entire upper portion of the Topeka Limestone, was originally placed into the correct stratigraphic position. The Turner Creek Shale rests below the DuBois Limestone and above the Sheldon Limestone. The Turner Creek Shale was initially described by Condra (1927), the type section being near DuBois, Nebraska. The only stratigraphic complications occurred when the Turner Creek Shale appears to have been simply removed from the literature; and, the DuBois Limestone was placed upon the Curzon Limestone (Condra, 1930).

At a later date, the Turner Creek Shale was considered to be the upper member of an undifferentiated Topeka-Calhoun interval (Condra, 1933). For the most part, all complications were temporary and relatively minor, as indicated by the correct placement of the Turner Creek Shale underlying the DuBois Limestone and overlying the Sheldon Limestone by Moore (1936).

In northern Kansas, the Turner Creek Shale varies between one and five feet in thickness, consisting of blue-to-gray, sparsely fossiliferous, clayey-to-calcarous shale (Moore, 1949). The Turner Creek Shale was not recognized in northern Greenwood County.

In Central Greenwood County, in an abandoned quarry, there does exist a shale interval corresponding to the Turner Creek Shale. For the reason that the underlying Sheldon Limestone is absent, the Turner Creek Shale will not be difhere is three and one-half feet thick, but may be slightly more as the result of this being an incomplete section. Along U.S. 54 in Greenwood County, the undifferentiated Turner Creek/Jones Point Shale is fourteen and one-half feet thick, indicating a rapid thickening trend in a southerly direction.

Sheldon Limestone Member

The Sheldon Limestone is the middle member of the Topeka Limestone, being the third limestone member from both the top and the base of the formation. The Sheldon Limestone was originally called Meadow Limestone, which is the lower limestone member of the Plattsburg Limestone formation (Condra and Bengston, 1915). The Meadow Limestone was later miscorrelated as being the middle member of the Calhoun Shale, underlying the Iowa Point Shale and overlying the Jones Point Shale (Condra, 1927). The Meadow Limestone was replaced by the Sheldon Limestone as the middle member of the Calhoun Shale, the type section being located east of Nehawka, Nebraska, in the Sheldon Quarry (Moore, 1936).

In 1933, the reclassification of the Deer Creek Limestone formation caused the Sheldon Limestone to be temporarily placed as the uppermost member of this formation (Condra, 1933). Later the Sheldon Limestone reverted to the original placement within the Calhoun Shale as the third middle member (Moore, 1936). Also, at this time, the Sheldon Limestone appears to have been dropped as a stratigraphic unit entirely placed into previously occupied stratigraphic position as part of the Topeka Limestone. The Sheldon was later placed into the proper position, above the Joines Point Shale and underlying the Turner Creek Shale (Condra and Reed, 1937).

The Sheldon Limestone in northern Kansas varies up to two feet in thickness. It is marked by algal growths, termed *Osagia* (Moore, 1949).

The Sheldon Limestone was not observed throughout the study area of Greenwood County. O'Connor (1953, et al.) believed it to be present in both Lyon and Osage Counties. Moore (1949) stated that the Sheldon Limestone was absent from south of Topeka to Greenwood County.

Jones Point Shale Member

The Jones Point Shale member is the Fourth member above the base of the Topeka Limestone, and is the sixth member in descending order. For five years after the initial description (Condra, 1927), the Jones Point Shale was classified as the basal member of the Calhoun Shale. A temporary change in classification occurred in 1932, when the Jones Point Shale became the second member from the top of the Deer Creek Limestone (Condra, 1933).

However, the initial classification returned in 1936 (Moore, 1936). It seems clear that, during this time interval, the Jones Point Shale represented what is today the Calhoun Shale, as indicated by the stratigraphic position occupied above the Ervine Creek Limestone. Also, in 1936 and above the Dashner Limestone (Moncrief, et al., 1936). This marked the first time that the Jones Point Shale was classified as part of the Topeka Limestone. In 1937, the Jones Point Shale was placed into the correct stratigraphic position, resting above the Curzon Limestone and below the Sheldon Limestone (Condra and Reed, 1937).

The type section of the Jones Point Shale member is along Jones Point, about four miles east of Union, Nebraska. The Jones Point Shale in northern Kansas varies from a clayey-to-calcareous shale, with platy limestone beds. Locally, it may be fossiliferous, and its thickness ranges up to ten feet.

The Jones Point Shale and Turner Creek Shale are not differentiated in this study for the reason that the Sheldon Limestone is absent throughout the study area. For more complete information on Jones Point Shale from central Greenwood County, see the discussion under the "Turner Creek Shale Member." Jones Point Shale was not observed in northern Greenwood County.

Curzon Limestone Member

The Curzon Limestone is the seventh member of the Topeka Limestone. "Initially, the Curzon Limestone was used by the Missouri Geological Survey." (Gallaher, 1900) in a columnar section, but was not mentioned in the text. There was no type section listed, and was therefore unidentifiable. The incorrect spelling is presumably the result of a publication error.

Curzon Limestone as the basal member of the Topeka Limestone, though a type section was not yet specified. The Curzon Limestone was dropped from stratigraphic nomenclature upon realizing that the Hartford Limestone had priority over the Curzon Limestone as a stratigraphic unit (Moore, 1936).

> ... The abandonment of the Curzon Limestone as a stratigraphic term was temporary for the reason that the Topeka Limestone expanded and the Hartford Limestone was moved, replacing the Wolf River Limestone as the base of the formation. ... (Condra and Reed, 1937).

The Curzon Limestone filled the void caused by the final movement of the Hartford. See Figure 6 for clarification.

The Curzon Limestone in the type area within Holt County, Missouri, varies between seven and nine feet of bluish-gray-to-brown, very fossiliferous limestone. It is marked by fusulinids in the middle and lower parts, and has thin interbedded shales along the wavy, irregular bedding planes (Moore, 1949).

The Curzon Limestone is persistently present in northern Greenwood County. Previous work in Lyon County and Osage County indicates that Curzon Limestone and Hartford Limestone comprise the majority of the Topeka Limestone. The Curzon Limestone and Hartford Limestone have been extensively quarried in northern Greenwood County. The Curzon Limestone is characterized by an abundance of fusulinids, brachiopods, bryozoans, and crinoid stems are also common.

In central Greenwood County, the Curzon Limestone appears to thin in a southerly direction. The member is conobserved on the abandoned quarries that exist there. On the quarry located at SW¼ NE¼ sec. 7, T.23S., R13E., is found a pronounced folding. As one looks at this folding from a distance, one sees that the Curzon Limestone thickens away from the fold and thins towards the apex of the fold, creating a miniature form of anticline syncline feature within the outcrop. Slabs of horizontal limestone beds fill in the syncline section of the outcrop and maintain the horizontal position. These limestone slabs are not affected by this folding. Also, on the quarry located at NW¼ sec. 31, T.22S., this feature is present. The cause of this fold might be tectonic or algal growth. If the fold is tectonic in origin, it should have affected other features in the area and beyond; but, this is not the case: it seems that the fold is localized and, therefore, might be algal growth.

During the Pennsylvanian period, phylloid algae locally influenced sedimentation and dominated biotic communities. Although incapable of producing a rigid wave-resistant structure, the calcareous plants functioned as efficient sediment particle producers and sediment agents.

Phylloid algae grew as erect plants,which attained a maximum height of about 5 in., consisted of relatively broad potato-chiplike "leaves," and utilized a "holdfast" to anchor themselves to the seafloor (Toomey and Babcock, 1983). The plant body consists of an outer cortical zone and central medullary cone (Toomey, 1981). According to Wray (1977), cal-

Numerous physical environmental factors (temperature, light intensity, water circulation, salinity and nutrients) and various outside chemical and biological controls influenced the growth rate of phylloid algae (Wray, 1977). According to Toomey and Babcock (1983), these forms thrived most prolifically in shallow, warm, normal marine waters in a zone somewhat below wave action. Under favorable conditions, the "leafy" calcareous plants produced a new generation every few weeks (Toomey, 1981). It is the opinion of the writer that these folds that are seen in these areas were caused by the deposition of aragonite by the phylloid algae. This aragonite eventually changes into stable calcium carbonate which is the stable form of limestone.

The differentiation of Curzon Limestone from the Hartford Limestone becomes very difficult as one moves southwards in Greenwood County. It is considerably likely, however, that Curzon Limestone pinches out entirely or is only locally present in southern Greenwood County. The Curzon Limestone in central Greenwood County is only sparsely fossiliferous, contrasting with the abundance of fossils found in a northerly direction.

Iowa Point Shale Member

The Iowa Point Shale member is the last shale found within the Topeka Limestone. The type locality of this member is in Iowa Point, Kansas (Condra, 1927). Until 1932, the Iowa Point Shale was classified as the uppermost member of as a stratigraphic unit and replaced by the Calhoun Shale (Condra, 1933), giving the Calhoun Shale both formational and member status. However, this usage was temporary and stratigraphic nomenclature reverted to the previous classification, grouping the Iowa Point Shale as the uppermost member of the Calhoun Shale (Moore, 1936). The Iowa Point Shale was soon placed within the proper position of the Topeka Limestone, overlying the Wolf River Limestone (Condra and Reed, 1937).

The Iowa Point Shale in northern Kansas, and at the type section, varies up to fourteen feet in thickness. It consists of light, bluish-gray argillaceous shale with carbonaceous flakes. A coal bed and sandstone layer may be present (Moore, 1949).

The Iowa Point Shale was not observed throughout the area studied. This observation has been verified by a number of previous workers. O'Connor indicated the Iowa Point Shale to be absent in both Lyon and Osage Counties. In Greenwood County, the Curzon Limestone appears to rest directly upon Hartford Limestone (Moore, 1949). In central Elk County, an alternating sandstone and shale sequence rests upon the Hartford Limestone (Verville, et al., 1958). This section is equivalent to the Iowa Point Shale; however, as the Curzon Limestone appears to be absent, this interval is included as part of the undifferentiated Turner Creek/Jones Point Shale.

Hartford Limestone Member

The Hartford Limestone member, the basal member of the misplaced in stratigraphic classification and cast aside. The type section of the Hartford Limestone exists "... under the river at Hartford ... ." (Kirk, 1898) in Lyon County. The type section seems to have been largely destroyed since its initial measurement. Today, the section there is only a few feet, and roughly half of that consists of a rippled sandstone which belongs stratigraphically to the Calhoun Shale.

It was not until 1936 that Hartford Limestone was placed into the correct stratigraphic position. During the forty-year interval in which the Hartford Limestone was not in use, the Curzon Limestone was thought to be the basal member. The Curzon Limestone appears to have originated from the Missouri Geological Survey (Gallaher, 1900), where it is shown only in a columner section. Condra (1927) utilized the Curzon Limestone as the basal member of the Topeka Limestone, neglecting to give a type section. The Dashner Limestone was first used by Moore (1936) to represent the basal member of the Topeka Limestone. The type section of the Dashner Limestone was on the Dashner farm near Haynies Station, Iowa. Poor exposures there caused the type section and name of Dashner to be dropped and replaced by Wolf River (Condra and Reed, 1937)--the type locality being near the mouth of the Wolf River in Doniphan County, Kansas. The name of Wolf River was not valid for the reason that the initial type section was already in Hartford, Kansas, and was, thus, dropped.

From northern Greenwood County southwards, a brecciated cobble-sized clasts in a light, bluish-gray, finely crystalline matrix. At the base of the Hartford Limestone in northern and central Greenwood County, a coquinoid limestone is present. This coquinoid limestone outcrops on the west side of the county road in northern Greenwood County and along U.S. 54 of Eureka. Immediately above the coquinoid limestone in northern Greenwood County, there exists a four- or five-foot dark gray, clayey shale. This shale lies beneath the light, bluish-gray, massive portion of the Hartford Limestone, and appears to be a localized facies. It is the opinion of the writer that the Curzon Limestone pinches out in a southerly direction; and, the majority of the shared interval is completely Hartford Limestone.

Sponges are the major fossils found in Hartford Limestone, and Amblysiphonella is abundant and distinct in Hartford Limestone.

For lateral variation and stratigraphic sections of all member limestones, see Plates 1 and 2. Also, see lithology sections for all measurements.

Calhoun Shale

The Calhoun Shale was named for exposures at Calhoun Bluffs in Shawnee County, Kansas, by Beede (1898). The Calhoun Shale is a sandy to clayey shale with a variable amount of sandstone. In northern Greenwood County, along a channel three miles northeast of Hamilton, a 2.5-foot, poorly exposed interval belongs to the Calhoun Shale. A 10.5-foot thick southwards from this location, the sandstone thins out, while the shale thickens up to 12.5 feet--then, it starts thinning out. In central Greenwood County, on the north side of Highway 54 and extending to the south side of the highway to where the Hartford Limestone is exposed along the railroad tracks, a 6-foot, poorly exposed interval belongs to Calhoun Shale. The Calhoun Shale has a definite thinning trend in a southerly direction throughout the area investigated. This has been verified by Moore (1949).

CHAPTER FOUR

LECOMPTON LIMESTONE

The name, Lecompton, was first used by Bennett (1896) for three limestone units and the intervening shales that crop out near Lecompton, Kansas. In 1927, Condra extended the Lecompton Limestone to include the uppermost limestone and the shale below it. The seven members are named, in ascending order, the Spring Branch Limestone, Doniphan Shale, Big Spring Limestone, Queen Hill Shale, Beil Limestone, King Hill Shale, and Avoca Limestone members. Names for subdivision of the Lecompton Limestone were given by Condra (1927), except for the Beil Limestone, which he then referred to as the Cullom Limestone. Subsequent work revealed that rocks exposed at the Cullom-type locality were not correlative to the Lecompton Limestone, and the Beil was adopted for the formation's second limestone member from the top (Condra, 1930). At the type locality near Lecompton, Kansas, the Lecompton Limestone is thirty-five to forty feet thick (Moore, 1936). The thickness ranges from forty to sixty-six feet in eastern Kansas (Zeller, 1968). Lecompton Limestone appears to be absent throughout the study area.

CHAPTER FIVE

THE TOPEKA LIMESTONE DEPOSITIONAL CYCLE

Cyclotherms have long been identified in the repetitive Middle-Upper Pennsylvanian sequence of eastern Kansas (Moore, 1936, 1949). Typical Kansas cyclotherms are the depositional results of transgression and regressions of the sea. The transgression defined as the migration of the shorelines in a landward direction results from an eustatic rise in sea level, or a faster rate of basin subsidence to that of sediment influx. The regressive state or migration of the shoreline seaward results from a lowering of sea level, either eustatic, or with a rate of sediment influx greater than the subsidence rate of the basin (Busch, 1974).

Heckel (1977) recognizes five depositional units in a simple, single transgressive cycle: in ascending order, 1) outside shale; 2) middle limestone; 3) core shale; 4) upper limestone; and, 5) outside shale. These single cycles were grouped to form a cycle of cyclotherms. Megacyclotherms, thus, are complex but distinctive successions of different shale-limestone couplets that are repeated several times upward in the sequence (Moore, 1936). The outside shale is a nearshore deposit, typically thick and sandy, with deposits of nonmarine origin, or with sparse marine fauna (Heckel, 1977).

The "middle" limestone represents a transgressive limestone that is typically thin in nature, dense, and contains abundant marine biota. These characteristics are common only to open-marine environments far enough offshore to be below photic zone. Transgressive limestones undergo little lateral facies changes, either northward or southward, thereby depicting a widespread marine inundation of the Midcontinent (Heckel, 1978).

The "core" shale is indicative of far-offshore environment achieved during maximum transgression (Heckel, 1977). Characteristically, this shale member is thin and occurs laterally. It is gray in color with black shale facies. The black shale is rich in heavy metal and organic matter. The offshore shales, according to Heckel, are the result of a depositional period in which the sedimentation process was slow, or a settling which was isolated from detrital influx, such as that in a far offshore environment. The black shale facies is the result of an anaerobic condition, confirmed by lack of benthic fossil remains. Heckel (1978) explained the anaerobic depositional environment during maximum transgression by the formation of a thermocline which prevents oxygenation of the bottom by vertical circulation.

The "upper" limestone is a regressive form of calcite deposition. These limestones, generally, are thicker than the "middle" transgressive limestone, and, characteristically, have a greater variety of facies. Lower parts of the abundant in diverse marine biota. The upper, younger, transgressive limestone deposits generally exhibit more diversity in lithology because of shallow water and increasing agitation. As the regression of the shoreline proceeds, the cycle is completed with the occurrence of the nearshore "outside" shale.

The interpretation of a depositional cycle of the Topeka Limestone is based upon the properties of the rock sequence, as seen in sample observation and stratigraphic interpretations. The base of the Topeka Limestone is marked by a thin, clayey and sandy shale deposited in an offshore environment during maximum transgression. Stratigraphically, this initial stage is represented by the Calhoun Shale which is found below Hartford Limestone. The Calhoun Shale is clayey and sandy and has one or more coal beds. The sandstone beds are typically fine grained, well sorted, micaceous, cross bedded and contain terrestrial plant fossils. The Hartford member of Topeka Limestone is thick--"dense, laterally persistent"--characteristic of a "middle" transgressive limestone which normally should follow a "core" shale deposit. This resulted as the sea transgressed due to "eustatic sea level change, the deltaic environment shifted landward." As this happened, the basin received less sediment since clastic detritus slowly accumulated in landward-shifted deltas.

> ... The attendant increased in depth of the sea promoted the migration of marine fauna landward which allowed biogenic carbonate production in areas of formerly clastic sedi-

Deposition of the Hartford Limestone and Curzon Limestone occurred during this period of initial transgression. The fine-grained texture and faunal content of the unit imply deposition below wave base but within the photic zone.

The Jones Point/Turner Creek Shale member is the result of a reversal to a far offshore maximum transgression environment. The undifferentiated shale is clayey and laterally persistent and is the image of a thick nearshore, "outside" shale typical of a delta-plain environment containing nodular or platy limestone beds. Thinness in conjunction with great lateral persistence, fineness of grain size, presence of marine fauna, and nonskeletal phosphorite all indicate slow sedimentation distal from detrital influx far offshore in deeper water (Hecket, 1977).

The DuBois Limestone member could represent algal-mound formation and is an area in which the water level remained deeper. It is observed to contain lots of mollusks and brachiopods. The Holt Shale member separates the Coal Creek Limestone and the DuBois Limestone members. It marks maximum transgression of the "core" shale. The uppermost Coal Creek Limestone member is then a regressive limestone. The limestone is massive, fossiliferous, and laterally persistent. The return of the continental fluviate and deltaic environments marked the close of the Topeka Limestone depositional cycle.

CHAPTER SIX

PALEOTECTONIC FRAMEWORK

Major structural features during the late Pennsylvanian time within eastern Kansas included the Salina Basin, Sedgwick Embayment, Nemaha Anticline, Forest City Basin, Bourbon Arch, and the Cherokee Basin (Figure 7). The latter two listed, the Bourbon Arch and the Cherokee Basin, had direct bearing on the limestone-to-shale percentage present within the Topeka Limestone in Greenwood County.

The Bourbon Arch trends northwest-southeast, connecting with the Nemaha Anticline on the west and separating the Forest City Basin to the north from the Cherokee Basin to the south. The Bourbon Arch became an active structure during early Pennsylvanian time (Merriam, 1963). McMillan (1956) found the Aarde Shale member of the Howard Limestone in late Pennsylvanian time to be affected by the rising of the Bourbon Arch, thus causing a thinning of the shale member as it passed over the structural high. McMillan's findings were verified within the study area. Lee (1943) indicates that the Forest City Basin was subsiding during the time of deposition of the Shawnee Group. This study indicates the Cherokee Basin to also be subsiding, relative to the Bourbon Arch, during the time of Topeka Limestone deposition.

The southern border of the Bourbon Arch very closely outlines the initial massive appearance of the Hartford Lime-

Facies changes within the Hartford Limestone are traceable within northern Greenwood County and are found to be the basal coquinoidal zone and, also, white brecciated clastic limestone are found at the central part of the Hartford Limestone. The upper surface of the Hartford Limestone in northern Greenwood County is gently undulatory, representing the initial outline of the sea bottom. Beneath the Hartford Limestone, in the uppermost part of the Calhoun Shale, a sandstone is present within the area occupied by the Bourbon Arch.

Baker (1962) indicates the northern boundary of the Bourbon Arch to terminate within Coffey County. In time represented by Topeka Limestone deposition, it is likely that the northern border of the Bourbon Arch extended northwards beyond Greenwood County. Merriam (1963) believed the limits of the Bourbon Arch to be only vaguely placed. It is possible that the limits of the Bourbon Arch migrated through time.

In addition to the facies changes within the Aarde Shale member of the Howard Limestone mentioned by McMillan (1956), the Winzeler Shale, Church Limestone, and Bachelor Creek Limestone are also affected. An outcrop of the entire Howard Limestone exists in northern Greenwood County in which the limestone members are fully developed, and the Winzeler Shale is only a few feet thick.

The Cherokee Basin is bordered on the north by the Bour-

A primary indicator that the Cherokee Basin was actively subsiding relative to the Bourbon Arch during Topeka time is the significant decrease in the limestone-to-shale percentage within a relatively small area in central Greenwood County. This signifies the transition from shallow water to the north and deeper water to the south. The boundary between the two structural features also manifests itself by the presence of a localized conglomerate facies near Hamilton in Greenwood County (Figure 6). The material which makes up the clasts within the conglomerate are believed to originate from the Bourbon Arch.

CHAPTER SEVEN

LITHOLOGY

Measured sections in the area studied.

1. This section is two miles east of junction of U.S. 54 and K99.

Location: NE¼ sec. 34, T.25S., R.11E
Pennsylvanian System
Topeka Limestone

Topographic elevation	1050.00	ft.
Horizontal distance	20.00	ft.
Total thickness	14.25	ft.

A. Coal Creek limestone member
Limestone, moderate brownish-gray, weathers light yellowish-gray with lenticular parting. Fusulinids are abundant, crinoid stems and bryozoans.
Thickness: Many slabs of 3.00 in.

B. Holt shale member
Shale, black, weathers black, covered by grass and weeds, nonfossiliferous.
Thickness: 3.00 ft.

C. DuBois limestone member
Limestone, light bluish-gray, weathers yellowish-orange, very finely crystalline, slabby, vertical jointing, lots of fossils including brachiopods.
Thickness: 1.00 ft.

D. Undifferentiated Turner Creek/Jones Point shale member
Shale, dark gray, weathers light gray, clayey, covered by grass and weeds, unfossiliferous.
Thickness: 3.00 ft.

E. Curzon limestone member
Limestone, brownish-gray, weathers to yellow. Calcite crystals in cavities, massive with wavy parting planes, extensively oxidized, fossils include brachiopods and crinoid stems, corals.

F. Hartford limestone member
Limestone, light gray, weathers tannish yellow, massive and dense.
Thickness: 1.75 ft.

G. Calhoun shale
Shale, dark gray, badly weathers and partly covered, unfossiliferous.
Thickness: 2.50 ft.

2. This section is along U.S. 54 about two hundred yards west of #1.

Location: SW¼ SE¼ sec.26, T.25S., R.11E.
Pennsylvanian System
Topeka Limestone
Topographic elevation 1050.00 ft.
Horizontal distance 5.00 yds.
Total Thickness 6.5 ft.

A. Coal Creek limestone member
Limestone, light gray and weathers brownish yellow. Lots of fusulinids.
Thickness: 2.00 ft.

B. DuBois limestone member
Limestone, light bluish-gray when fresh and weathers brownish yellow, no vertical jointing.
Thickness: 2.50 ft.

C. Undifferentiated Turner Creek/Jones Point shale member
Shale, dark gray, weathers light gray, clayey to silty shale, no fossils.
Thickness: 2.00 ft.

3. This is a composite section beginning on the north side of U.S. 54 and extending to the south side of the highway to where the Hartford Limestone is exposed along the railroad tracks and the Ervine Creek Limestone is exposed in the bank of the creek.

Location: NW¼ NE¼ sec.36, SW¼ SE¼ sec.25, T.25S., R.11E.
Pennsylvanian System
Topeka Limestone
Topographic elevation 1050.00 ft.
Horizontal distance 800.00 yds.
Total thickness 21.00 ft.

A. Coal Creek limestone member
Limestone, moderate to brownish-gray, weathers light yellowish-gray with lenticular parting. Fusulinids are abundant, crinoid stems and bryozoans.
Thickness: 3.00 ft.

B. Holt shale member
Shale, black, weathers black, covered by grass and weeds, nonfossiliferous.
Thickness: 3.00 ft.

C. DuBois limestone member
Limestone, light gray, weathers orange-gray. Slabby parting to platy limestone. Fossils include brachiopods and bryozoans.
Thickness: 2.50 ft.

D. Undifferentiated Turner Creek/Jones Point shale member
Shale, dark gray, weathers same, clayey to silty, shale, covered by grass and weeds. Unfossiliferous.
Thickness: 3.00 ft.

E. Curzon limestone member
Limestone, brownish-gray, weathers to a light whitish-orange, lots of fusulinids, calcite crystals in cavities, massive with parting planes, extensively oxidized. Brachiopods and crinoid stems are present.
Thickness: 3.50 ft.

F. Hartford limestone member
Limestone, tan when fresh, weathers to light gray. Massive to dense.
Thickness: 1.75 ft.

G. Calhoun shale member
Shale, dark gray, badly weathered and covered. Unfossiliferous.
Thickness: 2.50 ft.

H. Deer Creek limestone/Ervine Creek limestone member
Limestone, light gray to white, weathers to whitish-gray, massive, irregular parting planes. Lots of fusulinids.
Thickness: 8.00 ft.

4. This section is an exposure along U.S. 54 east of #3.

Location: NE¼ sec.34, T.25S., R.11E.
Pennsylvanian System
Howard limestone
Topographic elevation 1060.00 ft.
Horizontal distance 100.00 yds.
Total thickness 2.50 ft.

A. Bachelor Creek limestone member
Limestone, moderate bluish-gray, weathers light grayish-brown, massive, unfossiliferous, sand aspect to the exposed surface.
Thickness: 2.50 ft.

5. This section is along U.S. 54 about 100 yds. northeast of #2.

Location: NE¼ sec.34, T.25S., R.11E.
Pennsylvanian System
Howard limestone
Topographic elevation 1059.00 ft.
Horizontal distance 50.00 yds.
Total thickness 16.00 ft.

A. Bachelor Creek limestone member
Limestone, moderate bluish-gray, weathers light grayish-brown, massive, poorly fossiliferous.
Thickness: 2.00 ft.

B. Severy shale
Shale, moderate grayish-yellow, weathers to a pale olive-yellow, badly weathered and partly covered, clayey to silty shale. Highly fossiliferous.
Thickness: 14.00 ft.

6. Section of Topeka Limestone. This section is an active gravel pit found one and one-half miles south of Lamont.

Location: NE¼ NW¼ sec.31, T.22S., R.13E.
Pennsylvanian System
Topeka Limestone
Topographic elevation 1080.00 ft.
Horizontal distance 150.00 yds.
Total thickness 26.00 ft.

A. Cover. Appears to be light brownish gray shale. Looks like limmy shale mixed with clay silt.
Thickness: 2.00 ft.

B. Coal Creek limestone member
Limestone, light gray, weathers deep gray. Flagg and lenticular parting. Fusulinids present.
Thickness: 2.50 ft.

C. Holt shale member
Shale, light gray weathers to brownish gray; unfossiliferous; clayey to silty.
Thickness: 6.50 ft.

D. Curzon limestone member
Limestone, gray when fresh and weathers light tan to tannish gray. Dense, massive, fossils include brachiopods, long thin slender black string thought to be algae, lots of calcite nodules. Slightly folded.
Thickness: 15.00 ft.

E. Hartford limestone member
Limestone. Exists as the floor of the quarry as such no measurements are made.

7. This exposure makes up a hilltop along the country road.

Location: NW¼ sec.12, T.23S, R.12E.
Pennsylvania System
Topeka limestone
Topographic elevation 1050.00 ft.
Horizontal distance 100.00 yds.
Total thickness 12.25 ft.

A. Coal Creek limestone member
Limestone, light orange-brown, weathers to a whitish-gray, lenticular partings, lots of crinoid stems.
Thickness: 1.50 ft.

B. DuBois limestone member
Limestone, light grayish-brown, weathers to a light brown, blocky to massive parting, some vertical jointing, exposed surface feels sandy to touch.
Thickness: 1.75 ft.

C. Jones Point shale member
Shale, clayey, calcareous and silty gray shale. Few fossils present.
Thickness: 6.00 ft.

D. Curzon limestone
Limestone, light gray, weathers to a pale gray, platy to blocky parting, fusulinids are extremely abundant.
Thickness: 3.00 ft.

8. This section is southeast of #7 along a country road.

Location: SE¼ sec.13, T.23S., R.12E.
Pennsylvania System
Topeka limestone

Topographic elevation	1050.00 ft.
Horizontal distance	50.00 yds.
Total thickness	2.00 ft.

A. Curzon limestone member
Limestone, light gray, weathers to a dark orange-brown, prominent vertical jointing, very dense with angular edges on the face of the outcrop. Few brachiopods present.
Thickness: 2.00 ft.

9. This section is along a river bank about four-hundred yards west of Hilltop.

Location: NW¼ sec.13, T.23S., R.12E.
Pennsylvanian System
Deer Creek limestone

Topographic elevation	1000.00 ft.
Horizontal distance	400.00 yds.
Total thickness	9.00 ft.

A. Ervine Creek limestone member
Limestone, gray to whitish-gray, fine grained, fossils include fusulinids, corals, crinoid stems, brachiopods, bryozoans.
Thickness: 4.00 ft.

B. Larsh-Burroak shale member
Shale, grayish clay shale; nonfossiliferous.
Thickness: 3.00 ft.

C. Rock Bluff limestone member
Limestone, bluish gray, massive, vertical jointing. Fossils include fusulinids, brachiopods, and other marine fossils.
Thickness: 2.00 ft.

10. This section is an abandoned quarry located five miles west of Hilltop.

Location: NW¼ sec.11, T.23S., R.12E.
Pennsylvanian System
Topographic elevation 1050.00 ft.
Horizontal distance 150.00 yds.
Total thickness 17.50 ft.

A. Coal Creek limestone member
Limestone, light gray, weathers to a drab whitish-gray, platy to flaggy parting, badly weathered. Lots of fusulinids.
Thickness: 3.00 ft.

B. Holt shale member
Shale, black, weathers dark gray, light gray, weathers grayish-blue to yellowish-gray, fissle.
Thickness: 2.00 ft.

C. DuBois limestone member
Limestone, light gray, weathers to a light brownish-gray; very finely crystalling; massive; prominent vertical jointing; sandy surface.
Thickness: 1.50 ft.

D. Undifferentiated Turner Creek/Jones Point shale member
Shale, dark gray, weathers to a slightly lighter shade; unfossiliferous; thinly laminated and badly weathered.
Thickness: 4.50 ft.

E. Curzon limestone member
Limestone, light gray; weathers to a drab gray; platy to blocky parting; fusulinids are extremely abundant.
Thickness: 2.50 ft.

F. Hartford limestone member
Limestone, light gray; weathers same; dense, hard and resistant; massive; bracciated appearance with white limestone clasts in a light gray matrix; fossils include sponges.
Thickness: 4.00 ft.

11. This section is an exposure along the channel north of abandoned quarry (Hamilton).

Location: SE¼ sec.5, T.24S., R.12E.
Pennsylvanian System
Stratigraphic elevation 1050.00 ft.

A. Curzon limestone member
Limestone, light gray, weathers to a pale gray to orange-brown, prominent vertical jointing, very dense with angular edges, fusulinids are present.
Thickness: 3.50 ft.

B. Hartford limestone member
Limestone, light gray, weathers gray to yellowish-orange, dense, hard and resistant, massive, sponges common.
Thickness: 2.50 ft.

C. Shale, dark gray, weathers slightly lighter color, thinly laminated, unfossiliferous.
Thickness: 2.50 ft.

D. Limestone, white and light gray; weathers to a whitish gray; unfossiliferous; massive, brecciated.
Thickness: 1.50 ft.

E. Sandstone, light gray to brownish-gray, fossils include petrified wood, bryozoans, brachiopods.
Thickness: 3.50 ft.

12. This section is an exposure three miles east of Hamilton.

Location: SE¼ sec. 5, T.24S., R.12E.
Pennsylvanian System
Topeka limestone

Topographic elevation	1050.00 ft.
Horizontal distance	400.00 yds.
Total thickness	3.50 ft.

A. Limestone, light brownish-gray, weathers to a darker grey, well sorted; appears coquinoid, fusulinids, coarse sand to granule-sized fragments.
Thickness: 2.00 ft.

B. Limestone conglomerate, light brownish-gray to moderate gray, weathers to a darker gray, pebble-sized clasts of limestone, coarsely lineated, poorly sorted, few fossils.
Thickness: 3.50 ft.

13. This section is an exposure along a channel east of Hamilton quarry.

Topeka limestone
Topographic elevation 1050.00 ft.
Horizontal distance 100.00 ft.
Total thickness 13.00 ft.

A. Curzon limestone member
Limestone, light gray, weathers to grayish-tan, fusulinids abundant, dense, massive, vertical jointing.
Thickness: 2.50 ft.

B. Hartford limestone member
Limestone, light gray to white, weathers to a light gray, unfossiliferous except sponges and massive.
Thickness: 2.50 ft.

C. Calhoun shale member
Sandstone, light yellowish-brown, weathers to light brown to fine sand, thin laminated.
Thickness: 3.50 ft.

D.
Shale, light gray, weathers to a light yellowish-gray, thinly laminated, clayey to calcareous, unfossiliferous.
Thickness: 4.50 ft.

14. This section is along Wilder Creek River, south of Hamilton quarry.

Location: SE¼ sec. 8, T.24S., R.12E.
Pennsylvanian System
Deer Creek limestone
Topographic elevation 1029.00 ft.
Horizontal distance 50.00 yds.
Total thickness 7.00 ft.

A. Rock Bluff limestone member
Limestone, massive, vertical jointing, gray and weathers yellowish-gray. Fossils include brachiopods and other marine invertebrates.
Thickness: 3.50 ft.

B. Oskaloosa shale member
Shale, bluish, thinly laminated; unfossiliferous.
Thickness: 1.50 ft.

C. Ozawkie Limestone member
Limestone, tannish-gray, weathers to brownish-orange, dense, massive, fossils are sparse but fusulinids and other marine fossils are present.
Thickness: 2.00 ft.

15. Section of Topeka Limestone. This section is an active gravel pit found five and one-half miles south of Lamont.

Location: SW¼ NE¼ sec.7, T.23S., R.11E.
Pennsylvanian System
Topeka Limestone
Topographic elevation 1080.00 ft.
Horizontal distance 100.00 yds.
Total thickness 10.00 ft.

A. Coal Creek limestone member
Limestone, light grayish, weathers to a light orange-brown; platy to flaggy lenticular partings. Fossils include fusulinids in abundance.
Thickness: 5.50 ft.

B. Holt shale member
Shale, yellow; badly weathered, unfossiliferous.
Thickness: 0.50 ft.

C. Curzon limestone member
Limestone, gray when fresh and weathers to dark tan. Has about six feet thick, dense and massive section at the base. Lots of fossils and calcite nodules. About four feet of heavily folded near the top. Thin strings of black fossils thought to be algae.
Thickness: 10.00 ft.

D. Hartford Limestone member
Limestone, exists as the floor at the quarry as such no measurements are made.

16. This section of Severy shale is located three miles west of Lamont, Kansas, north of K57.

Location: NE¼ sec.22, T.22S., R.12E.
Pennsylvanian System
Severy shale
Topographic elevation 1100.00 ft.
Horizontal distance 200.00 yds.
Total thickness 20.00 ft.

A. Severy shale
Shale, olive-green to gray, weathers to yellowish, clayey to silty shale. Unfossiliferous.
Thickenss (approximately due to cover) 20.00 ft.

17. This exposure is on top, one-half mile west of Lamont, Kansas.

Location: SW¼ SE¼ sec.24, T.22S.
Pennsylvania System
Howard limestone

Topographic elevation	1125.00 ft.
Horizontal distance	100.00 ft.
Total thickness	16.50 ft.

A. Utopia limestone member
Limestone, light gray, weathers to light brownish-gray, dense, lots of fusulinids.
Thickness: 4.00 ft.

B. Winzeler shale member
Yellowish-gray to light blue, clayey shale, no good fossils.
Thickness: 4.00 ft.

C. Church limestone member
Limestone, massive, bluish-gray, weathers to brown, very fine crystalline, fossils include crinoid stems.
Thickness: 2.00 ft.

D. Aarde shale member
Shale, light brown, weathers light yellowish-brown, thinly laminated, slaty, badly weathered, unfossiliferous.
Thickness: 4.00 ft.

E. Bachelor Creek limestone member
Limestone, dark gray, weathers orange-brown, coarsely crystalline, abundant fossil fragments, appears coquinoid, massive.
Thickness: 2.50 ft.

18. This section is an exposure with an active quarry five and one-half miles southwest of Hamilton, Kansas.

Location: SE¼ sec.8, T.24S., R.12E.
Pennsylvanian System
Topeka limestone
Topographic elevation 1050.00 ft.

A. Coal Creek limestone member
Limestone, gray to orange, weathering orange-brown, platy to slabby parting, some thin lenticular partings, fossils include fusulinids, brachiopods, bryozoans.
Thickness: 5.00 ft.

B.
Limestone, conglomerate, light brownish-gray, weathers to dark gray, coarsely lineated, poorly sorted, consists of coarse sand to granule-size fragments.
Thickness: 1.50 ft.

C. DuBois limestone member
Limestone, light gray, weathers orange-gray, very finely crystalline, lenticular parting, fossils include fusulinids and crinoid stems.
Thickness: 1.50 ft.

D.
Limestone, dark gray, weathers light brown, slabby, dense, evenly bedded, unfossiliferous.
Thickness: 0.50 ft.

E.
Shale, moderate yellowish-gray, weathers to a shade lighter, unfossiliferous.
Thickness 0.33 ft.

F.
Limestone, dark gray, weathers to orange to light brown, calcite crystals present.
Thickness: 0.25 ft.

Undifferentiated Turner Creek/Jones Point shale member

A. Shale, bluish-gray to dark blue, weathers moderate gray, clayey to calcareous.
Thickness: 0.66 ft.

Undifferentiated Curzon/Hartford limestone member

A. Limestone, dark gray to tan when fresh, weathers reddish brown, dense, massive, prominent vertical jointing, hard and resistant. Fossils include sponges and fusulinids.
Thickness: 2.00 ft.

CHAPTER EIGHT

EPILOGUE (CONCLUSIONS)

Greenwood County is the site of a southward limestone-to-shale facies change within the Topeka Limestone. The very persistent basal two limestone members, the Curzon Limestone and Hartford Limestone, are everywhere present from northern Greenwood County into the central part of the country.

The Hartford Limestone member of the Topeka Limestone is believed to have been largely deposited in very shallow water. There are numerous reasons for this explanation. The basal conquinoid facies, the brecciated limestone facies, and the wavy nature of the upper surface of the member are all likely to have been caused by current and/or wave energy provided by the paleoenvironment.

The dominant lithology in the Topeka Limestone within central Greenwood County is shale belonging to the undifferentiated Turner Creek/Jones Point Shale. This shale, indicating an environment with less mechanical energy, is believed to have been deposited in deeper water. Black shale, as is present within the Holt Shale of the study area, can only have been deposited in oxygen deficient, stagnant waters. The conglomerate facies in central Greenwood County is believed to represent a subaqueous debris flow which originated from the shallow water deposits, cuts through and mixed with Cur-

Coal Creek Limestone. The reason for this interpretation can be seen under the Coal Creek Limestone member on page 12. The conglomeratic debris flow was deposited concurrently with the Curzon Limestone. This is indicated by the fusulinids within the uppermost portion of the debris which likely originated from the fusulinid-rich Curzon Limestone rather than the Coal Creek Limestone. Although the Coal Creek Limestone is usually extremely rich in fusulinids, the nearest outcrop is unfossiliferous.

> ... The Coal Creek Limestone member of the Topeka Limestone was thought to be only locally present south of the Kansas River. ... (Moore, 1949).

However, this study has found the Coal Creek Limestone to be persistent throughout the central portion of Greenwood County but absent around northern Greenwood County.

Another interesting result of this study is the local presence of the Holt Shale member of the Topeka Limestone. The Holt Shale was seen at two exposures in central Greenwood County. At many outcrops, however, the Holt Shale is absent. Prior to this study, the Holt Shale was believed to be absent "entirely south of the Kansas River" in Kansas (Zeller, 1968; Moore, 1949).

A possible mechanism for allowing the lithology changes that do take place within the Topeka Limestone and Howard Limestone is a sporadically uplifting arch, such as the Bourbon Arch. The Severy Shale and Calhoun Shale do not appear to be affected by the structural high. The Calhoun Shale thicken, indicating it to be a shallow water deposit. The Severy Shale appears to maintain a rather constant thickness in the vicinity of seventy feet. The massive thickness of the Hartford Limestone indicates that the Bourbon Arch was a cominant feature for an extended period of time.

Structural features such as those mentioned within this study are not only important from an academic viewpoint but, in addition, may heavily influence the economic interests of an area. For example, drilling activity for petroleum could be worthwhile along the axis or flanks of the Bourbon Arch. Also, numerous quarries exist within northern Greenwood County which are today taking advantage of the massive nature of the Hartford Limestone.

This study indicates that the "layerlike" stratigraphy proposed for Pennsylvanian deposits by previous workers (Moore, 1964) within Kansas is not totally justified. During Pennsylvanian time, Kansas was not a featureless shelf environment allowing for uniform deposition throughout its areal extent but rather had active tectonic features which had a noticeable influence on sedimentation. This is very likely the case for all of the Pennsylvanian as well as the Permian deposits. A paleoecological investigation would be very beneficial in confirming or altering the paleoenvironments suggested within this paper. A study of this kind would serve an additional purpose of delineating relative times of deposition for the Curzon Limestone and Coal Creek Limestone, as

Abundant material is available to work with as both limestone members are extremely fossiliferous.

A second investigation which is possible is the conglomerate facies itself. Because the quarry in which the conglomerate is located is flooded, very little information presented itself for this paper. Such things as lateral extent, lateral and vertical facies changes, sedimentary structures, amount of fossiliferous materials, origin of the angular clasts, and number of episodes of deposition are all significant factors in precisely delineating the origin of this conglomerate.

A final study is the necessity of one worker to tie together the northern, central, and southern facies within the Topeka Limestone within this study area to their respective structural features, the Forest City Basin, the Bourbon Arch, and the Cherokee Basin. Available exposures are listed with the previous literatures, so searching for outcrops should be minimized and tectonic/paleogeographic interpretation could be stressed.

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