GEOLOGY OF THE WINKLER AREA
RILEY COUNTY, KANSAS

by

RALEIGH JACK MERRYMAN

B. S. Kansas State College
of Agriculture and Applied Science, 1956

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology and Geography

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1957

TABLE OF CONTENTS

INTRODUCTION

Location of the Area

This investigation covers an area of 24 square miles immediately surrounding the small village of Winkler in northcentral Riley county, Kansas. Range five east is the eastern boundary. The area is rectangular in shape being four miles east-west and six miles north-south and extends into both townships six and seven south (Fig. 1, Appendix).

Geologic Setting

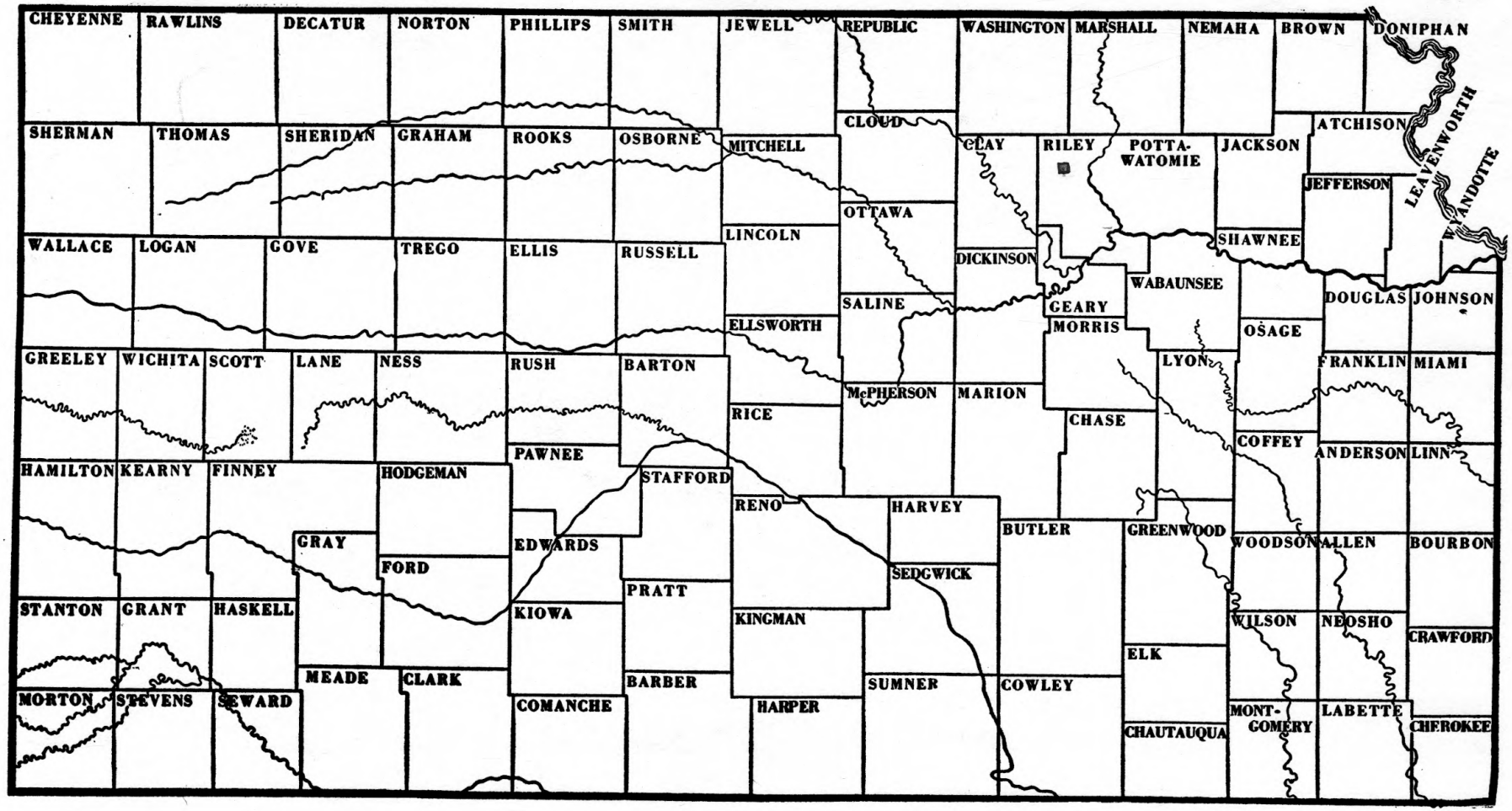
Northcentral Riley county lies within the Central Lowlands physiographic province in a subdivision named the Osage Plains. The Osage Plains have been described as an area in which strata dipping to the north of west have been beveled by an erosional plain sloping east. The upper Permian strata are resistant and form eastward facing escarpments which are called the "Flint Hills" (Jewett, 1941). The problem area is located along the western edge of the "Flint Hills". Directly west are the high prairies which are also dip slopes but do not form noticeable escarpments. Drainage is well developed throughout the area and creek valleys are filled with recent alluvium, terrace deposits and glacial outwash. Unconsolidated Quaternary sediments also cover wide areas of the uplands. The glacial materials were deposited during the Nebraskan and Kansan glacial stages (Beck, 1949).

The main structural feature is the Abilene anticline. To the east are the Irving syncline and the Nemaha anticline. To

EXPLANATION OF PLATE I

Map of Kansas showing the area covered by this investigation

PLATE I


CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTA-
WATOMIE
JACKSON
ATCHISON
LEAVENWORTH
WYANDOTTE
JEFFERSON
OTTAWA
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
LINCOLN
DICKINSON
SHAWNEE
WABAUNSEE
SALINE
GEARY
DOUGLAS
JOHNSON
ELLSWORTH
MORRIS
OSAGE
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
McPHERSON
MARION
LYON
FRANKLIN
MIAMI
RICE
CHASE
COFFEY
PAWNEE
HAMILTON
KEARNY
FINNEY
HODGEMAN
STAFFORD
RENO
HARVEY
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
GRAY
EDWARDS
SEDGWICK
FORD
PRATT
STANTON
GRANT
HASKELL
KIOWA
KINGMAN
WILSON
NEOSHO
CRAWFORD
ELK
MEADE
CLARK
BARBER
SUMNER
COWLEY
MORTON
STEVENS
SEWARD
COMANCHE
HARPER
MONT-
GOMERY
LABETTE
CHEROKEE
CHAUTAUQUA

the west is the Salina basin (Jewett, 1951).

Statement of the Problem

The Abilene anticline is described in much of the Kansas geological literature as a subsurface ridge which parallels the Nemaha anticline through the counties of Clay, Riley and Marshall in Kansas. In Nebraska the structure is referred to as the Barneston anticline. The surface expression of this structure has been briefly described by Jewett (1951), Lee (1956), Nelson (1952), Neff (1949) and others. The purpose of this paper is to describe the surface expression of the Abilene anticline in the problem area.

MAPPING PROCEDURE

An extensive reconnaissance was made of the problem area and adjacent areas to obtain information concerning the stratigraphy and structural expression of the anticline. Formations were identified, sections were measured, and dips and strikes of the formations were taken with a Brunton compass. A structure profile section was made across the area with a plane table and alidade. The section shows the surface expression of the anticline and the steepening of dip on the east side (Fig. 2, Appendix). The plane table and alidade were also used with photographs to determine relative elevations of the strata in the area (Plate 4).

Beck (1949) and Mudge (1949) mapped Riley county in geologic detail and their map supplemented by aerial photographs served as a base map. The only topographic map available was a United States

Geological Survey map dated 1898. The United States Geological Survey map was not used and the elevations on the maps and plates are relative. The strata, as identified by field examination, were traced on the thesis map from the base map and aerial photographs. The base map was enlarged from two inches to the mile to three inches to the mile by the use of a sketchmaster.

STRATIGRAPHY

The strata that outcrop in the problem area of northcentral Riley county are all of sedimentary origin. The Paleozoic outcrops are all of Permian age and much of the upland area is covered with Quaternary deposits.

Permian System

Council Grove Group: Crouse Limestone. The Crouse limestone consists of about seven feet of tan-gray limestone. The upper part is thin bedded and platy separated by shale partings while the lower part is massive.

Blue Rapids Shale. The Blue Rapids shale is unfossiliferous, vari-colored green to maroon in the lower part and gray to tan in the upper. The thickness is about 20 feet.

Funston Limestone. The Funston limeston consists of three layers of limestone and a gray shale parting in the lower and middle part. The limestones are rather soft and weather blocky and porous. They are tan to gray and weather tan. The total thickness is about five feet.

Speiser Shale. The Speiser shale consists of vari-colored shale in the lower part and a persistent limestone layer about one foot thick just below the upper three feet of gray shale. The total thickness is about 18 feet.

Chase Group: Wreford Limestone. The Wreford limestone consists of two limestones and a shale member. They are the Threemile limestone, the Havensville shale and the Schroyer limestone in ascending order. The Threemile limestone is about six feet thick and is rather massive having less chert than is usual for this member. The Havensville shale is a gray shale about eight feet thick. The Schroyer limestone member, about six feet thick, is massive in the immediate area and contains a few chert nodules. The formation overall is noticeably thinner over the axis of the anticline than in areas to either side.

Matfield Shale. The Matfield shale is divided into two shale members and a thin limestone which are, in ascending order, the Wymore shale, the Kinney limestone, and the Blue Springs shale. The Wymore shale is a vari-colored blocky shale about 35 to 40 feet thick. The Kinney limestone is a soft, massive, tan-gray limestone about two feet thick. The Blue Springs shale is a vari-colored shale commonly containing small limestone lenses. The Blue Springs shale is about 22 feet thick.

Barneston Limestone. The Barneston limestone consists of the Florence limestone, the Oketo shale and the Fort Riley limestone in ascending order. The Florence limestone has an abundance of chert and a small amount of shale. The Florence limestone does not make an outcrop and is about 27 feet thick. The Oketo shale

EXPLANATION OF PLATE II

Generalized stratigraphic column of northcentral Riley county, Kansas

PLATE II

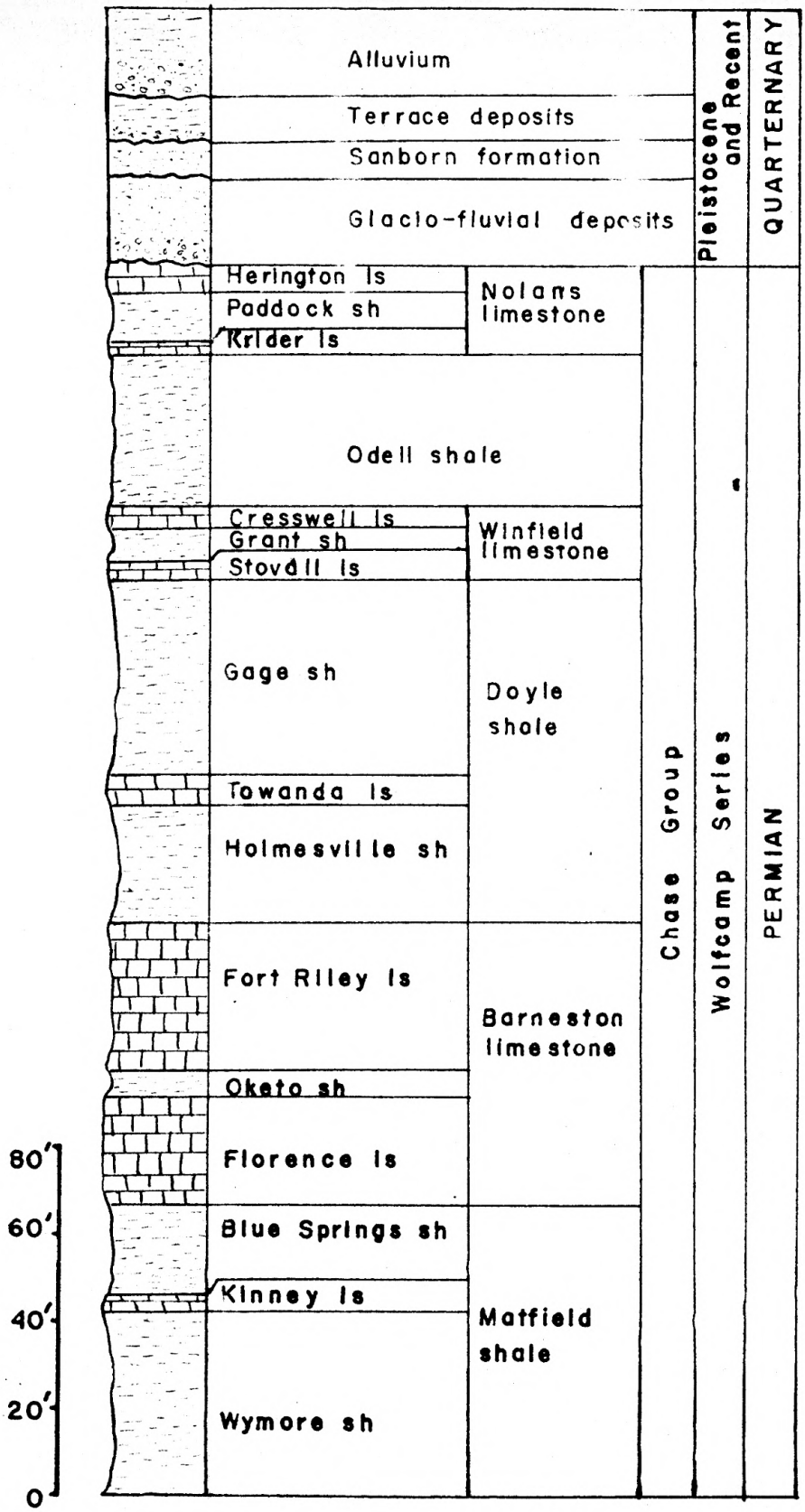
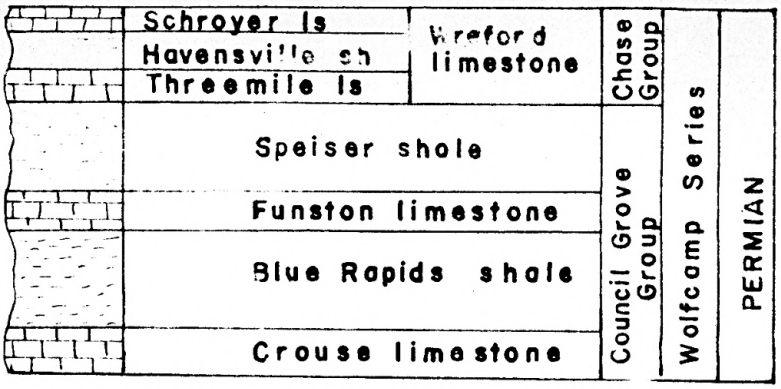

Alluvium
Terrace deposits
Sanborn formation
Glacio-fluvial deposits
Pleistocene and Recent
QUARTERNARY
Herington ls
Paddock sh
Krider ls
Nolans limestone
Odell shale
Cresswell ls
Grant sh
Stovall ls
Winfield limestone
Gage sh
Towanda ls
Holmesville sh
Doyle shale
Fort Riley ls
Oketo sh
Florence ls
Barneston limestone
Blue Springs sh
Kinney ls
Wymore sh
Matfield shale
Chase Group
Wolfcamp Series
PERMIAN
80'
60'
40'
20'
0

PLATE II (Continued)



is a gray shale about six feet thick between the two limestones. The Fort Riley limestone forms the prominent dip slope of the problem area. The Fort Riley limestone is gray to tan, massive in lower part, thin bedded upper part, with massive layer making the conspicuous outcrop. Total thickness is about 30 feet.

Doyle Shale. The Doyle shale consists of two shale members separated by a limestone member. They are in ascending order the Holmsville shale, the Towanda limestone and the Gage shale. The Holmsville shale is a vari-colored shale containing impure limestone and "box work". The "box work" is the result of differential weathering of the limestones and shale. The thickness is about 23 feet. The Towanda limestone is a hard, dense, limestone that weathers to form blocks in the lower part and plates in the upper. The thickness is about 10 feet. The Gage shale is vari-colored, gray in the upper part and almost 40 feet thick.

Winfield Limestone. The Winfield limestone consists of the Stovall limestone, the Grant shale and the Cresswell limestone. The Stovall is a gray, hard, dense limestone about 1.5 feet thick which locally contains chert. The Grant shale is a gray, calcareous and fossiliferous shale about 11 feet thick. The Cresswell limestone is a massive, resistant limestone that weathers blocky in the lower part and thin plates in the upper part. The upper part commonly becomes porous and cavernous when badly weathered. Near Riley, Kansas, the Cresswell has been eroded by percolating waters to form a number of limestone sinks. The thickness is about 10-12 feet.

Odell Shale. The Odell shale is a vari-colored green to maroon in the lower part and gray to green in the upper part. The thickness is about 35 feet.

Nolans Limestone. The three members that compose the Nolans limestone are the Krider limestone, Paddock shale and the Herington limestone. The Krider limestone is a soft, sugary, gray limestone about 1.5 feet thick. The Paddock shale is a thin bedded to blocky gray shale about 12 feet thick that commonly contains calcite veinlets. The Herington limestone is a porous, sugary, soft limestone containing thin shale and weathers blocky. The thickness is about seven feet.

Quaternary System

Pleistocene Series. The glacial deposits are represented by the Glacio-Fluvial outwash material that is prominent in the higher reaches of the stream valleys of the area. These deposits consist of clay, sand and gravels. The larger particles are mainly chert and limestone.

Sanborn Formation. The Sanborn formation blankets most of the divide areas in the problem area. The Sanborn formation consists of materials deposited by wind, slopewash and the process of soil creep. Upland and valley slope soils have developed on materials called the Sanborn formation.

Terrace Deposits. The Terrace deposits mapped are the gravel and sand materials laid down by present day streams in earlier cycles of deposition.

Alluvium. The Alluvium of the present cycle of erosion consists of sand, gravel and silt.

GEOLOGIC HISTORY

The discussion of the geologic history includes works by Koons (1955), Nelson (1952), and Lee(1956). The major portion of the material was derived from Lee (1956). Lee's interpretation of the structural movements is based on the premise: that if a sequence of rocks is deposited on an originally flat surface, and if this sequence of rocks is warped and folded before the later development of a second flat horizontal surface, the variations in thickness of the rocks between the two surfaces will reveal the amount and place of deformation.

Paleozoic Era

The Paleozoic was an era of deposition, folding, erosion and faulting in Riley county. Rocks of Cambrian to Permian are represented. Three different periods of folding are indicated during the era. The first period affected the rocks between the Pre-Cambrian surface and the base of the St. Peter sandstone of middle Ordovician. The second between the St. Peter and the base of the Mississippian. The third and most important period of folding started in early Mississippian and increased in intensity until early Pennsylvanian and continued with decreasing emphasis through the Permian. Movement along the Nemaha anticline started slowly in early Mississippian and was greatly accellerated at the close

of the period. The deformation produced the Nemaha anticline, the Salina basin and the Abilene anticline. The lack of subsurface data on the Abilene anticline restricts accurate determination of the structural forming sequence. The structures continued to develop throughout the era. Erosional breaks are numerous all through the Paleozoic, the most prominent is responsible for the Mississippi "chat" below the Pennsylvanian rocks. The "chat" is the residual chert derived from the weathering of the Mississippian chert-bearing limestones.

Mesozoic Era

The events of this era are, for the most part, unknown in eastern Kansas because no Mesozoic rocks are present east of the extreme western part of Riley county. The Mesozoic rocks present in the eastern section of the state belong to the Dakota formation. However, in the western part of the Salina basin pre-Dakota warping was downward to the southwest, and in post-Dakota (Cretaceous) time the warping was downward to the northwest.

Cenozoic Era

The Cenozoic era in eastern Kansas was a period of predominantly erosion. Deposition occurred only in the Quaternary period. In Riley county all of the sediments younger than Permian were almost completely stripped away by erosion during the Tertiary period. The only remaining rocks of the Mesozoic are a few outliers of the Dakota formation along the western edge of the county.

The Pleistocene epoch of the Quaternary is known as the ice age. The first two of the four ice sheets of this period extended into Kansas, but only the second, called the Kansan glacier, penetrated as far south as the Kansas River and as far west as the Big Blue River. The meltwaters draining from the glaciers deposited glaciofluvial sediments extensively in Riley county. The deposits of the Sanborn formation were laid down during the latter part of this epoch. Since the close of this epoch the streams have eroded their valleys and now are flanked by deposits of terrace materials and alluvium (Beck, 1949).

STRUCTURE

Regional Structures

Nemaha Anticline. The Nemaha anticline is a regional structure to the east of the problem area. It is a truncated anticline that plunges to the south and extends from a point near Omaha, Nebraska, southward beyond Oklahoma City, Oklahoma. The anticlinal movement started early in the Mississippian period and was eroded and faulted after the close of the period. Deformation continued intermittently to the close of the Paleozoic era (Lee, 1956). The fault in the subsurface has been mapped by Lee (1956), Koons (1955) and Rieb (1954). Permian deformation is visible on the surface and Ratcliff (1957) mapped the surface expression of the fault.

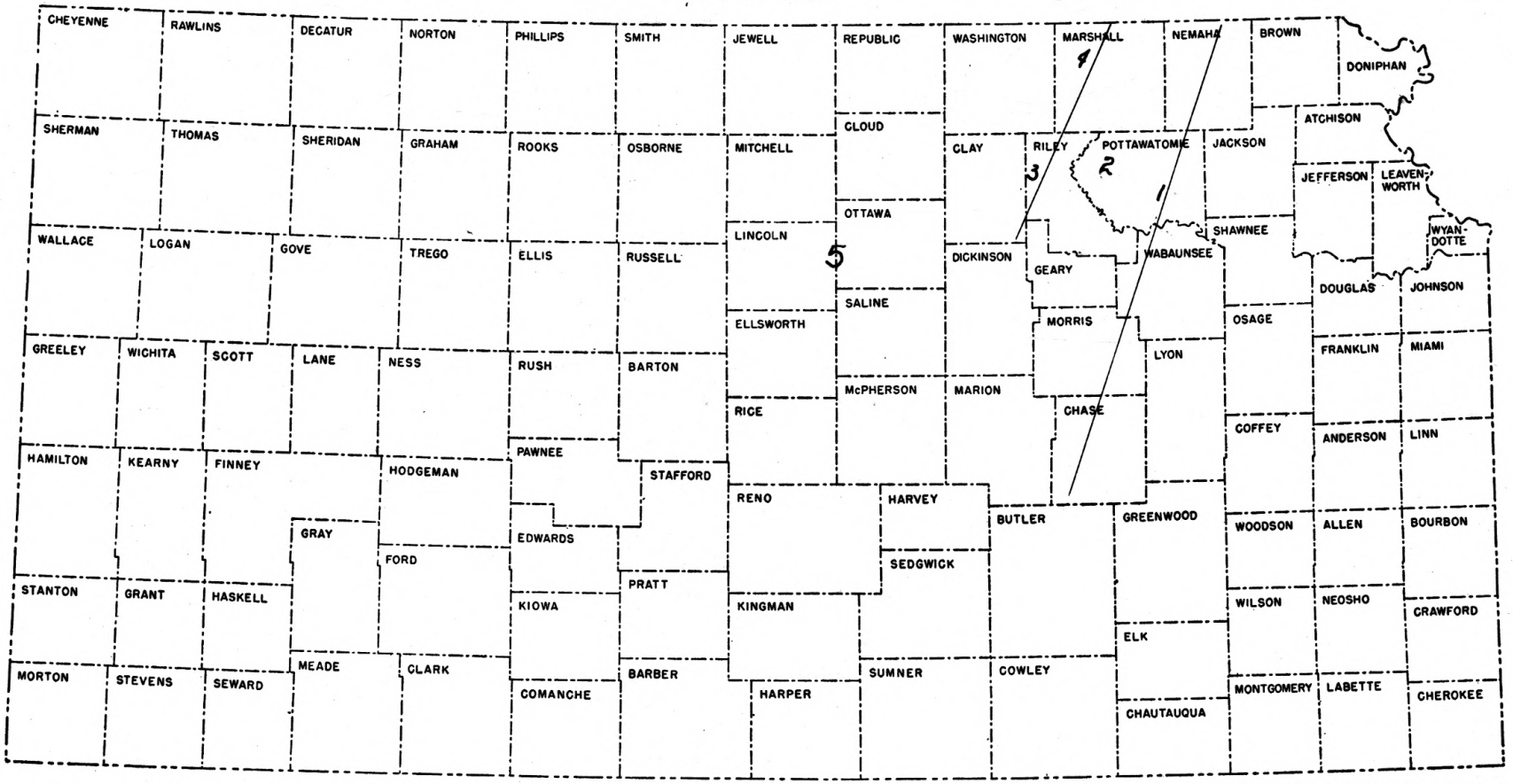
Salina Basin. The Salina basin was formed both as a structural and topographic basin to the west of the Nemaha anticline. It

EXPLANATION OF PLATE III

Regional and local structures

1. Nemaha anticline
2. Irving syncline
3. Abilene anticline
4. Barneston anticline
5. Salina basin

PLATE III



State Geological Survey of Kansas

is bordered on the west by the Central Kansas Uplift. The sequence of formation is parallel to that of the Nemaha. During post-Mississippian deformation several northeast trending structures were formed in the basin with strikes parallel to the Nemaha anticline. These structures are the Voshell anticline, the Abilene anticline and the Barneston anticline (Lee, 1956).

Irving Syncline. A synclinal fold east of the Abilene or Barneston anticline and west of the Nemaha anticline has been named the Irving syncline (Jewett, 1951).

Barneston Anticline. The Barneston anticline in extreme northern Kansas and southern Nebraska is considered to be the northern extension of the Abilene anticline.

Local Structures

Abilene Anticline. The Abilene anticline is an anticlinal structure trending northeast in Clay, Riley and Marshall counties of Kansas, almost parallel to the larger Nemaha anticline to the east. This anticline was formed contemporaneously with the surrounding regional structures formed during and after the post-Mississippian period of deformation. The most recent movement being expressed in the surface Permian strata as a low anticline (Lee, 1956). Subsurface data is lacking due to the inactivity of well drilling in the northern reaches of the Salina basin. Subsurface maps have been made with the date available by Koons (1955), Rieb (1954), Nelson (1950) and Lee (1956). A fault of some magnitude is indicated. It has been called a hinge fault by Koons (1955), having 400 feet of displacement upward to the west in Marshall

county and disappearing completely in Clay county. The younger beds were draped over the escarpment to produce a supratenuous fold. Nelson (1952) described it as a normal fault with oblique slip movement. The strike slip element was minor and affected a clockwise rotation of the joint pattern of the area. Rieb (1954), who proposed the fault be named the Big Blue fault, called it a rotational fault, the west side being elevated to the north and depressed to the south. The work by Lee (1956) is of a regional nature and indicates the presence of the anticline since the end of Mississippian time. Lee also calls attention to the probable existence of a reverse fault along the Voshell anticline to the south. Here a downward displacement of 400 feet may exist on the west side of the structure. Neff (1949) describes the causual stresses of the Abilene and Nemaha faults to be the result of tension resulting from the subsidence of the basins to either side of the Nemaha anticline.

Abilene Anticline Surface Geology. The surface rocks of the problem area strike approximately north 30 degrees east and dip from three to six degrees on the southeast and from one to two degrees to the northwest. The strike and dip are presumably due to the drape effect of the sediments over the Abilene anticline. This trend approximates the subsurface placement of the fault previously mentioned. The axis of the anticline is located slightly southeast of the center of the problem area. The strata to the west dip away from the crest at low angles while on the east the dips increase to a maximum of six plus degrees and give the structure a monoclinal appearance. The strikes and dips on the east

EXPLANATION OF PLATE IV

Structure contour map of the Fort Riley limestone at Winkler, Kansas. The elevations indicated are relative from the crest of the anticline. Anticlinal crest is the zero elevation.

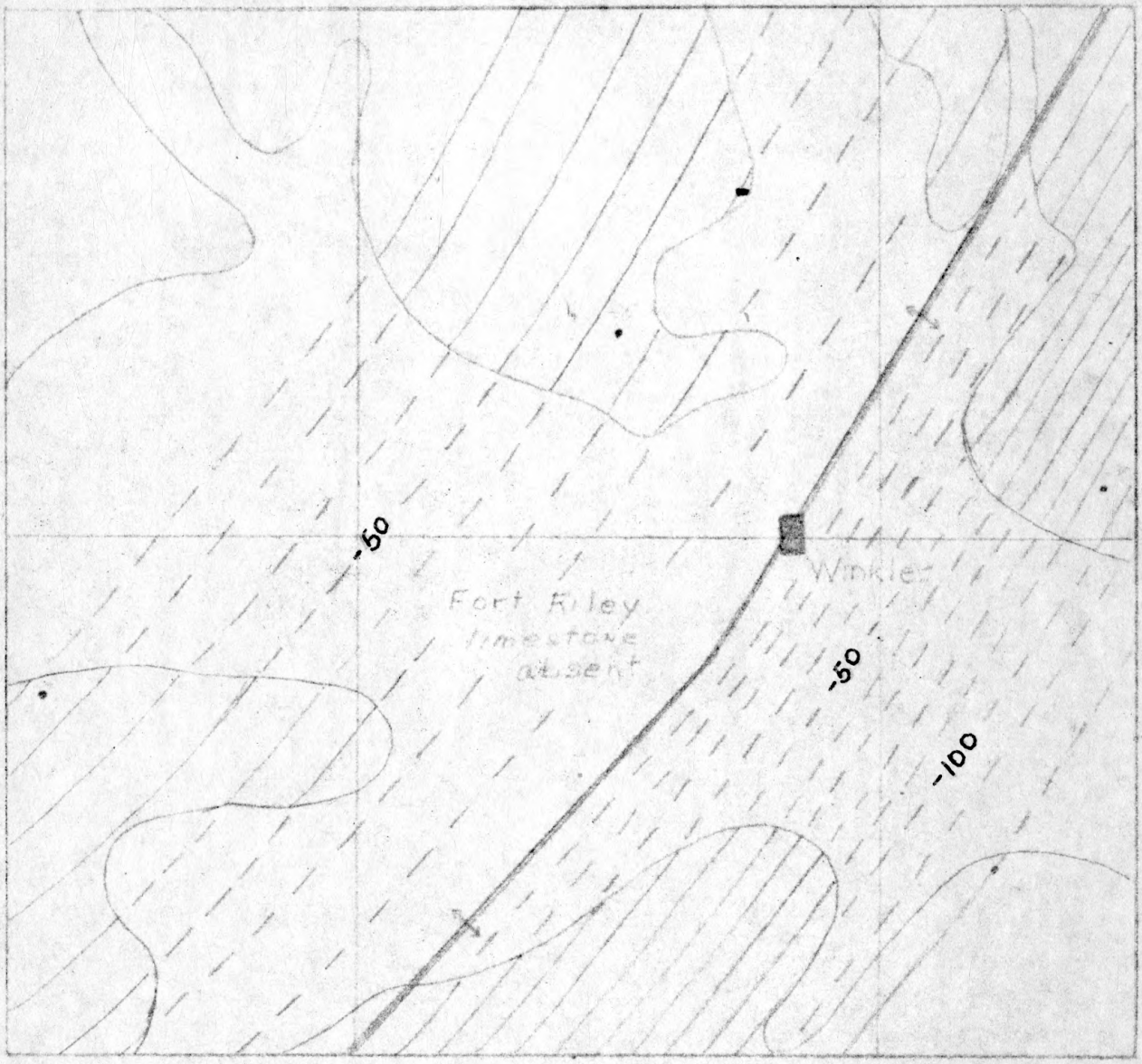
Contour Lines _____

Estimated Contour Lines - - - - - -

Anticlinal Axis, zero elevation _____

Contour Interval = 10 feet

PLATE IV



side change rapidly to indicate a horizontal warping which can easily be seen in the outcropping limestone members of the Barneston and Winfield formations. The Towanda limestone and the Stovall limestone are locally warped and the Stovall is observed to be faulted in a number of roadcuts. Neff (1949) has ascribed these intense local structures to compaction-sliding downward from the crest of the anticline. Reverse faulting in the Stovall can be observed on both sides of the structural axis with the upper bed projecting away from the crest. No doubt there are numerous faults present in the area. None, however, of magnitude greater than those found in the Winfield formation were discovered. The dips appear to decrease both north and south of the problem area in the overlying thick shales and reappear along the trend of the anticline where the limestone beds outcrop. In a comparison of the strata thicknesses of the area to those some distance on either side there appears to be a thinning over the crest, especially in the Wreford formation. Fancy Creek drains the area flowing east toward the Big Blue River. Several smaller creeks drain into Fancy Creek from the north and south.

Age of Folding. The folding along the crest of the Abilene anticline presumably originated in post-Mississippian time contemporaneously with the formation of the Nemaha anticline and the movements continued intermittently along fault zones until the end of the Paleozoic era. The subsurface data available places the time of maximum displacement during the post-Mississippian - pre-Pennsylvanian period of deformation. Due to the erosion that has occurred and the unconsolidated character of the Quaternary

sediments in the problem area folding later than the Permian is not recognizable.

CONCLUSION

This surface investigation has shown that a low anticline exists in the area considered to be the axis of the Abilene anticline, a post-Mississippian deformation feature west of the Nemaha anticline along the eastern limb of the Salina basin. The youngest rocks folded belong to the Wolfcamp series of the Permian period. There is no recognizable evidence of movement during the Quaternary period. The anticline has a general strike of north 30 degrees east and approximately parallels the Nemaha anticline. The dips of the lower Permian outcrops are considered to be the result of a drape effect over the fault scarp and periodic movement along this zone of weakness. The thinning of the Wreford formation and the lack of considerable chert in the Schroyer and Threemile limestones are indications that the immediate area of the problem was possibly elevated above the zone of maximum chert deposition (Pettijohn, 1957).

EXPLANATION OF PLATE V

Fig. 1. Aerial view from southwest of Winkler, Kansas, looking northeast.

Fig. 2. Aerial view from north of Winkler, Kansas, looking south.

PLATE V

Fig. 1

Fig. 2

EXPLANATION OF PLATE VI

Fig. 1. Barneston formation outcrop showing Fort Riley limestone, Oketo shale and Florence limestone in descending order Sec. 1, T. 7 S., R. 5 E.

Fig. 2. Dip slopes northeast of Winkler, Kansas
Sec. 36, T. 6 S., R. 5 E.

PLATE VI

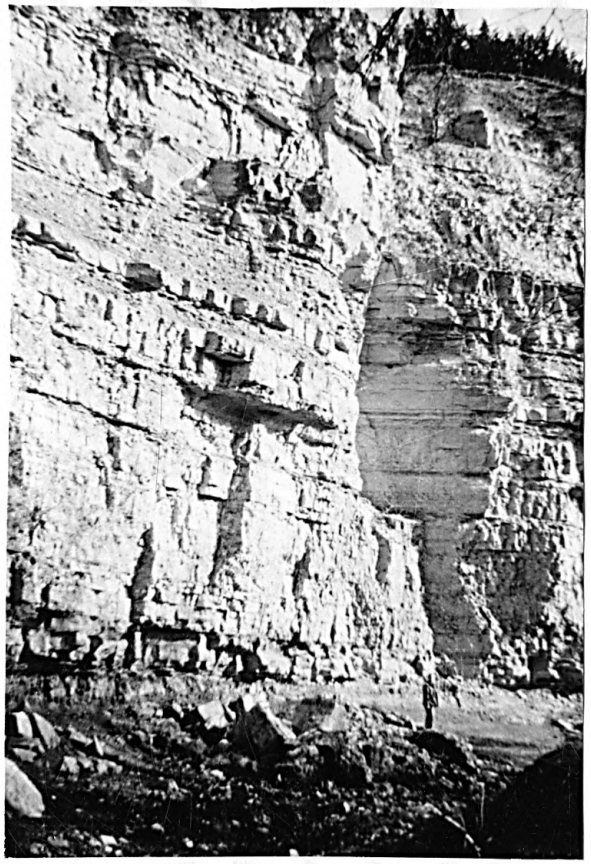


Fig. 1

Fig. 2

EXPLANATION OF PLATE VII

Fig. 1. Stovall limestone
Sec. 17, T. 7 S., R. 6 E.

Fig. 2. Towanda limestone
Sec. 12, T. 6 S., R. 5 E.

PLATE VII

Fig. 1

Fig. 2

ACKNOWLEDGMENT

The writer wishes to thank Dr. H. V. Beck for his assistance in procuring the base map and aerial photographs of the problem area, personal conferences, and in the preparation of this manuscript.

The writer also extends his appreciation to Dr. J. R. Chelikowsky for his help in the selection of the problem area and his personal advice.

REFERENCES

Beck, H. V.
The Quaternary geology of Riley county, Kansas. Masters thesis, Kansas State College, Manhattan, Kansas, 1949.

Frye, J. C. and A. B. Leonard
Pleistocene geology in Kansas. State Geol. Survey of Kansas, Bull. 99, pp. 7-144, 1952.

Jewett, J. M.
The geology of Riley and Geary counties. State Geol. Survey of Kansas, Bull. 39, pp. 13-153, 1941.

_____.
Geologic structures in Kansas. State Geol. Survey of Kansas, Bull. 90, Part 6, 1951.

Koons, D. L.
Faulting as a possible origin for the formation of the Nemaha anticline. Masters thesis, Kansas State College, Manhattan, Kansas, 1955.

Lee, Wallace
The stratigraphy and structural development of the Salina basin. State Geol. Survey of Kansas, Bull. 121, pp. 9-163, 1956.

Moore, R. C. and others.
The Kansas rock column. Kansas Geol. Survey Bulletin No. 89, pp. 13-14, 41-46, 1951.

Mudge, M. R.
The pre-Quaternary stratigraphy of Riley county, Kansas. Masters thesis, Kansas State College, Manhattan, Kansas, 1949.

Nelson, P. D.
The reflection of the basement complex in the surface structures of the Marshall-Riley county area of Kansas. Masters thesis, Kansas State College, Manhattan, Kansas, 1952.

Pettijohn, F. J.
Sedimentary Rocks. New York: Harper & Brothers, pp.432-448, 611-644, 1957.

Ratcliff, G. A.
Surface structure on the east flank of the Nemaha anticline in northeast Pottawatomie county, Kansas. Masters thesis, Kansas State College, Manhattan, Kansas, 1957.

Rieb, S. L.
Structural geology of the Nemaha ridge in Kansas. Masters thesis, Kansas State College, Manhattan, Kansas, 1954.

APPENDIX

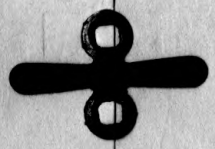


Fig. 1. Geologic Map of the Winkler area Riley county, Kansas.

GEOLOGIC MAP OF THE WINKLER AREA, RILEY COUNTY, KANSAS

R 5 E

T 6 S

Winkler

Otter Creek

Fancy Creek

Scale 1/2 0 1 2 Mile

True 9° Magnetic

EXPLANATION

PLEISTOCENE AND RECENT — QUATERNARY — CENOZOIC

- Qal — Alluvium
- Qt — Terrace deposit
- Qs — Sanborn formation
- Qgf — Glacio-fluvial deposit

WOLFCAMP — PERMIAN — PALEOZOIC

CHASE

- Pn — Nolans limestone
- Pwi — Odell shale; Winfield limestone
- Pb — Doyle shale; Barneston limestone
- Pwr — Matfield shale; Wreford limestone

COUNCIL GROVE

- Pf — Speiser shale; Funston limestone
- Pc — Blue Rapids shale; Crouse limestone

Symbols

- Strike and Dip — Generalized
- Contact Lines
- Roads
- Permenant Stream
- Intermittent Stream
- A — A' Cross Section
- Anticlinal Axis

J Merryman 57

Fig 1

Fig. 2. Structure Cross-Section of the anticline.

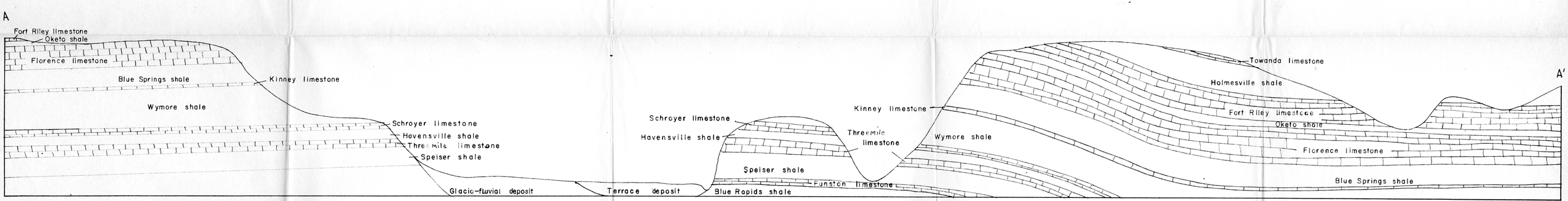


Fig. 2

CROSS SECTION AA'

50'
400' 200' 0'

VE = 4

35

GEOLOGY OF THE WINKLER AREA RILEY COUNTY, KANSAS

by

Raleigh Jack Merryman

B. S. Kansas State College
of Agriculture and Applied Science, 1956

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology and Geography

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1957

The area covered by this investigation consists of 24 square miles immediately surrounding the town of Winkler in northcentral Riley county, Kansas. An anticlinal structure crossing the area and trending northeast is thought to be the expression of the subsurface Abilene anticline.

The Abilene anticline is described in much of the Kansas geological literature as a subsurface ridge that parallels the larger Nemaha anticline to the east through the counties of Clay, Riley and Marshall in Kansas. The surface expression of this structure has been noted and briefly described by numerous geologists. The purpose of this investigation is to describe the surface geology of the Abilene anticline in the problem area which is located approximately on the crest of the subsurface structure.

The surface structure was located by plotting strike and dip readings and the construction of a structure profile section. An anticline with low dips on the west and steeper dips on the east trending north 30 degrees east was established.

The rock outcrops in the area are of lower Permian age and are covered by unconsolidated Quaternary sediments.

The folding along the crest of the Abilene anticline presumably originated in post-Mississippian time contemporaneous with the formation of the Nemaha anticline and the movements continued intermittently along the fault zones until the end of the Paleozoic era. Due to the erosion that has occurred and the unconsolidated character of the Quaternary sediments in the problem area folding later than the Permian is not recognizable.

The dips of the strata in the lower Permian outcrops are considered to be the result of a drape affect over the fault scarp and periodic movement along this zone of weakness. The thinning of the Wreford formation and the lack of considerable chert in the Schroyer and Threemile limestones are indications that the immediate area of the problem was possibly elevated above the zone of maximum chert deposition.