SURFACE STRUCTURE ON THE EAST FLANK OF THE NEMAHA ANTICLINE IN NORTHEAST POTTAWATOMIE COUNTY, KANSAS

by

GENE A. RATCLIFF

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INTRODUCTION

Location of the Area

The area covered by this investigation is located in the northeast corner of Pottawatomie county, Kansas. The Pottawatomie-Nemaha county line is the northern boundary and township seven south is the southern boundary. The area is approximately two miles wide and 12 miles long in a southwest direction from the extreme northeast corner of Pottawatomie county.

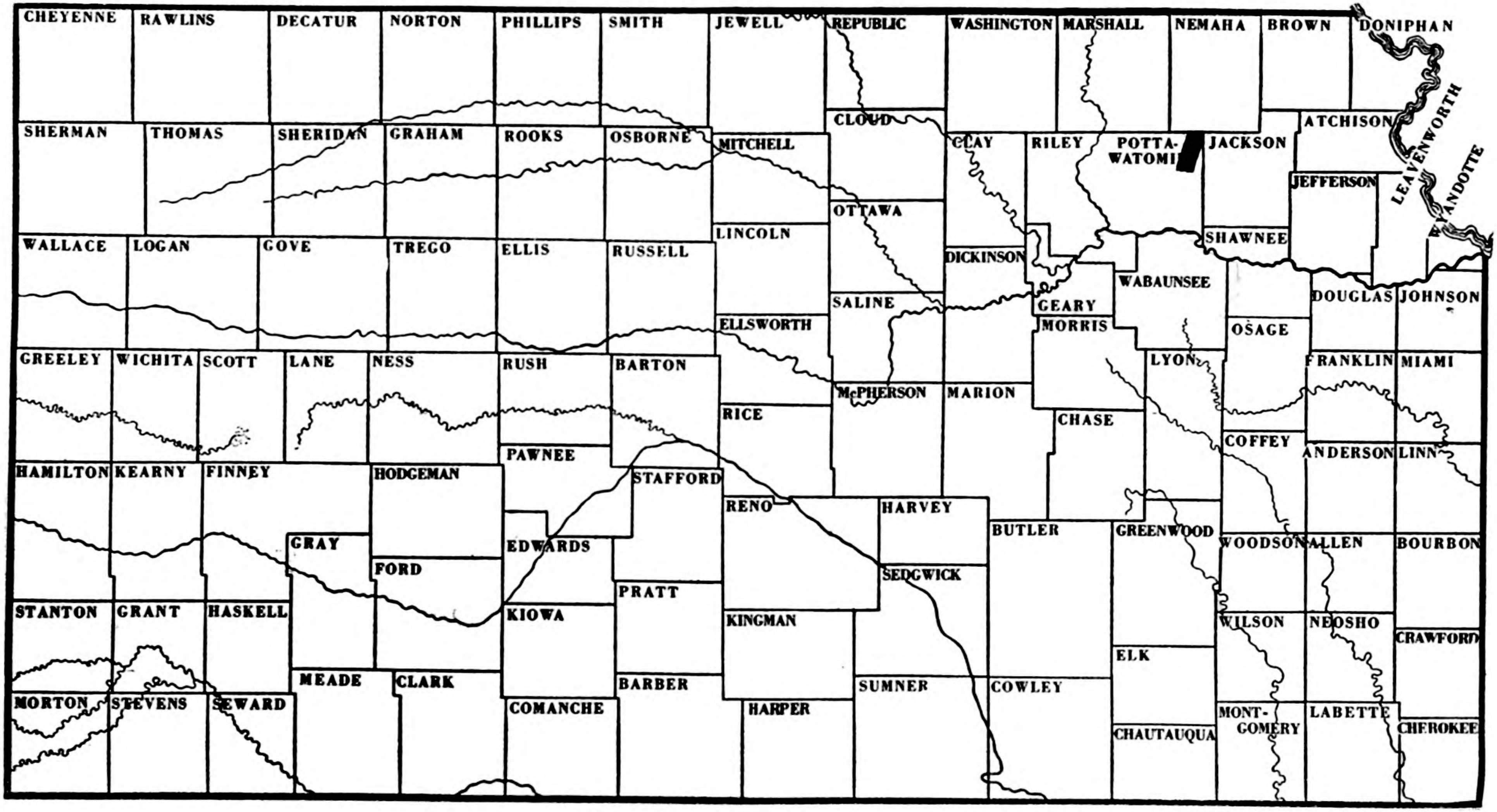
Geologic Setting

The problem area lies within the Western Interior Province and is located on the east flank of the Nemaha Anticline. The two main structural features are the Nemaha Anticline and the Forest City Basin. The "Flint Hills" form a west facing scarp along the east side and upper Pennsylvanian rocks outcrop on the west side of the area. The "Flint Hills" were formed by differential erosion of a resistant series of Permian limestones to produce about 250 feet of relief in northeast Pottawatomie county. The topography consists of rounded hills with well developed drainage. The valleys are filled with recent alluvium and glacial outwash, while glacial till is found on top of many surrounding hills. The glacial materials were deposited during the Nebraskan and Kansan glacial stages.

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
JEFFERSON
WYANDOTTE
OTTAWA
LINCOLN
SHAWNEE
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
DICKINSON
WABAUNSEE
GEARY
SALINE
DOUGLAS
JOHNSON
ELLSWORTH
MORRIS
OSAGE
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
LYON
FRANKLIN
MIAMI
McPHERSON
MARION
RICE
CHASE
COFFEY
ANDERSON
LINN
PAWNEE
HAMILTON
KEARNY
FINNEY
HODGEMAN
STAFFORD
RENO
HARVEY
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
GRAY
EDWARDS
FORD
SEDGWICK
PRATT
STANTON
GRANT
HASKELL
KIOWA
KINGMAN
WILSON
NEOSHO
CRAWFORD
ELK
MEADE
CLARK
BARBER
SUMNER
COWLEY
MORTON
STEVENS
SEWARD
COMANCHE
HARPER
CHAUTAUQUA
MONT-GOMERY
LABETTE
CHEROKEE

Statement of the Problem

Possible faulting in the subsurface of the east flank of the Nemaha Anticline has been inferred in much of the Kansas geological literature. Koons (1956) mapped a subsurface displacement of 3100 feet in Nemaha county to the north, and Kotoyantz (1956) mapped a subsurface displacement of 2400 feet in Wabaunsee county to the south. The fault movement has been dated as pre-Desmoinesian. With the thought of these subsurface displacements in mind, a problem for investigation was evident: "Would the subsurface displacement be reflected on the surface and could the magnitude be measured?" An area in northeast Pottawatomie county, showing evidence of possible faulting on the surface, was selected for the problem area. After selecting the problem area, the stratigraphy was identified, sections measured, and dips and strikes of the formations taken. The dips were plotted graphically to show the impossibility of folding to account for the displacement that was present. With the possibility of folding ruled out, faulting was the only alternative left. The fault was mapped and described in terms of location, type of fault, movement, amount of displacement, strata involved, strike, relationship to regional structures, and the date movement occurred.

MAPPING PROCEDURE

Field work was started in the spring of 1956 and was finished in the fall of 1956. A thorough reconnaissance was made of the entire area and the problem area was mapped in detail. Formations were identified, sections were measured, and the dips and strikes of the formations were taken with a Brunton compass. Inasmuch as the geology of northeast Pottawatomie county had been mapped by Scott (1949), much time was saved by referring to his map. Scott's map was used as a base map and was supplemented with aerial photographs. The map compiled for this thesis has more details, a larger scale, and composes a smaller area than the one compiled by Scott.

The geologic formations, as identified in the field, were traced on the thesis map from the base map and the aerial photographs. The scale of the base map was enlarged, from two inches to the mile to three inches to the mile, with a pantograph.

Locating the fault was accomplished in two ways: (1) By studying the dips on each side of the suspected fault and projecting them graphically to see if the difference in elevation of the formations could be due to folding. In every instance where it was impossible to account for the difference in elevation in terms of folding, a fault was indicated. (2) The stratigraphy was correlated from a known formation on one side of the suspected fault to a known formation on the opposite side. Where a gap in the stratigraphy was evident, a fault line was drawn.

Three structural profile sections, approximately three miles apart, were mapped across the fault with a plane table and alidade. These structural profile sections show the location of the fault, the amount of stratigraphic throw, and the dip change of the formations on each side of the fault (Fig. 2, Appendix).

GEOLOGIC HISTORY

Paleozoic Era

The Paleozoic was an era of deposition, erosion, folding, and faulting in Pottawatomie county. Rocks of Cambrian to Permian age were deposited. Periods of erosion occurred at intervals throughout the era, but the two major intervals occurred during late Ordovician and late Mississippian time. The erosion is revealed in the subsurface by the weathered surface of the Arbuckle limestone and the Mississippian "chat". The greatest amount of folding and faulting occurred during post Mississippian and pre-Desmoinesian time. Subsurface work by Koons (1956) on the reconstruction of the pre-Cambrian granite shows that folding occurred before faulting. Deformation continued through the Permian, but with a much lesser magnitude than in pre-Desmoinesian time, as the rocks of the Wolfcampian series show over 100 feet of displacement and dips up to six degrees in northeast Pottawatomie county.

Mesozoic Era

The Mesozoic was predominantly an era of erosion and regional tilting to the west (Lee, 1943). No rocks of Mesozoic age occur in Pottawatomie county, but possibly Cretaceous rocks were deposited and later removed by erosion.

Cenozoic Era

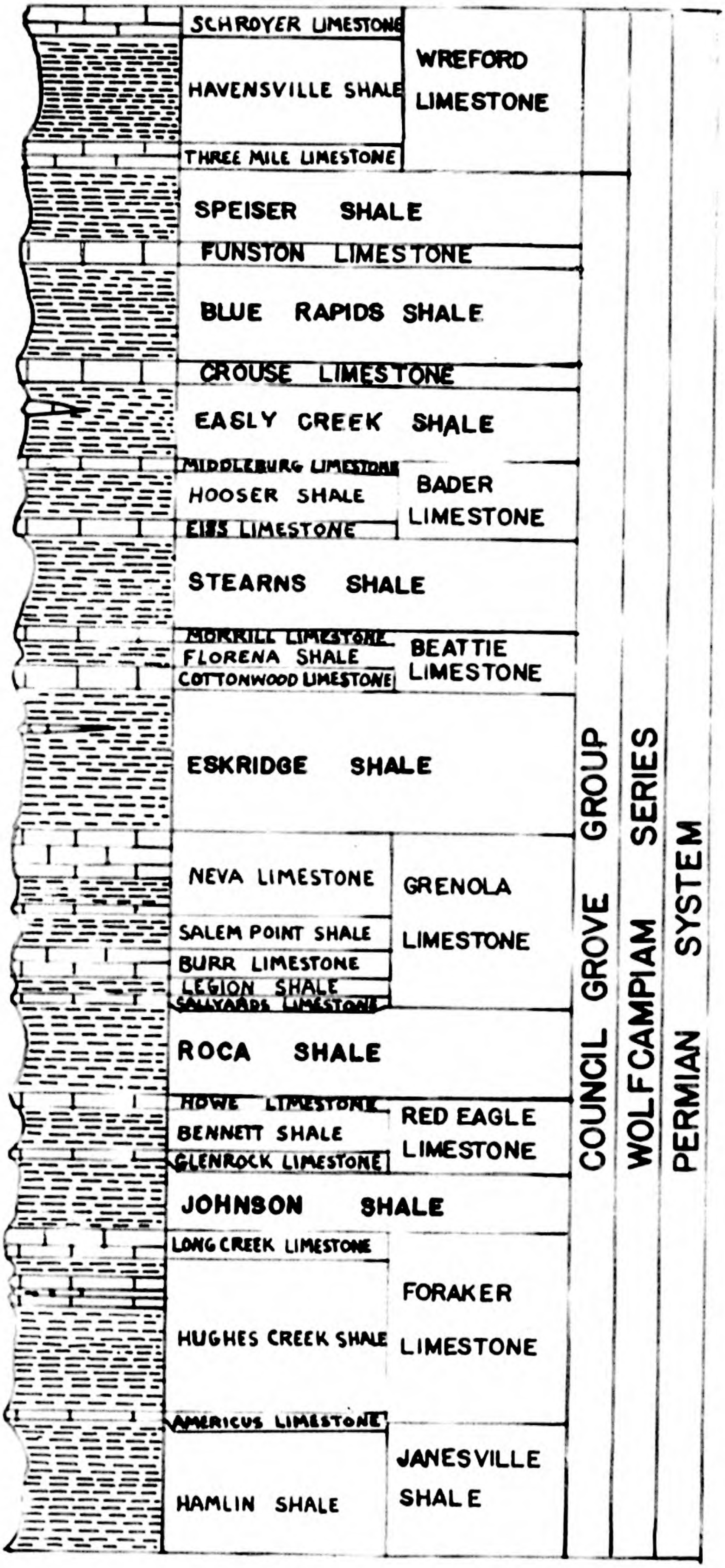
The Cenozoic is an era of erosion and deposition in Pottawatomie county. The Tertiary was a period of erosion. Any Cretaceous rocks that may have been deposited and many feet of older sediments were stripped away by erosion. The Quaternary is a period of glaciation and deposition. The first Pleistocene ice sheet, the Nebraskan, probably did not extend into Pottawatomie county. The only known glacial deposits of Nebraskan age in Kansas are found at a considerable distance north and east of Pottawatomie county (Frye and Leonard, 1952). The Kansas glacier, which was the second and last to invade Kansas, extended approximately as far south as the Kansas River and as far west as the Big Blue River. The surface developed in northeast Pottawatomie county after the close of the Tertiary was mantled by thick deposits of glacial drift. Some loess was possibly deposited on the flat uplands after the glacier had retreated.

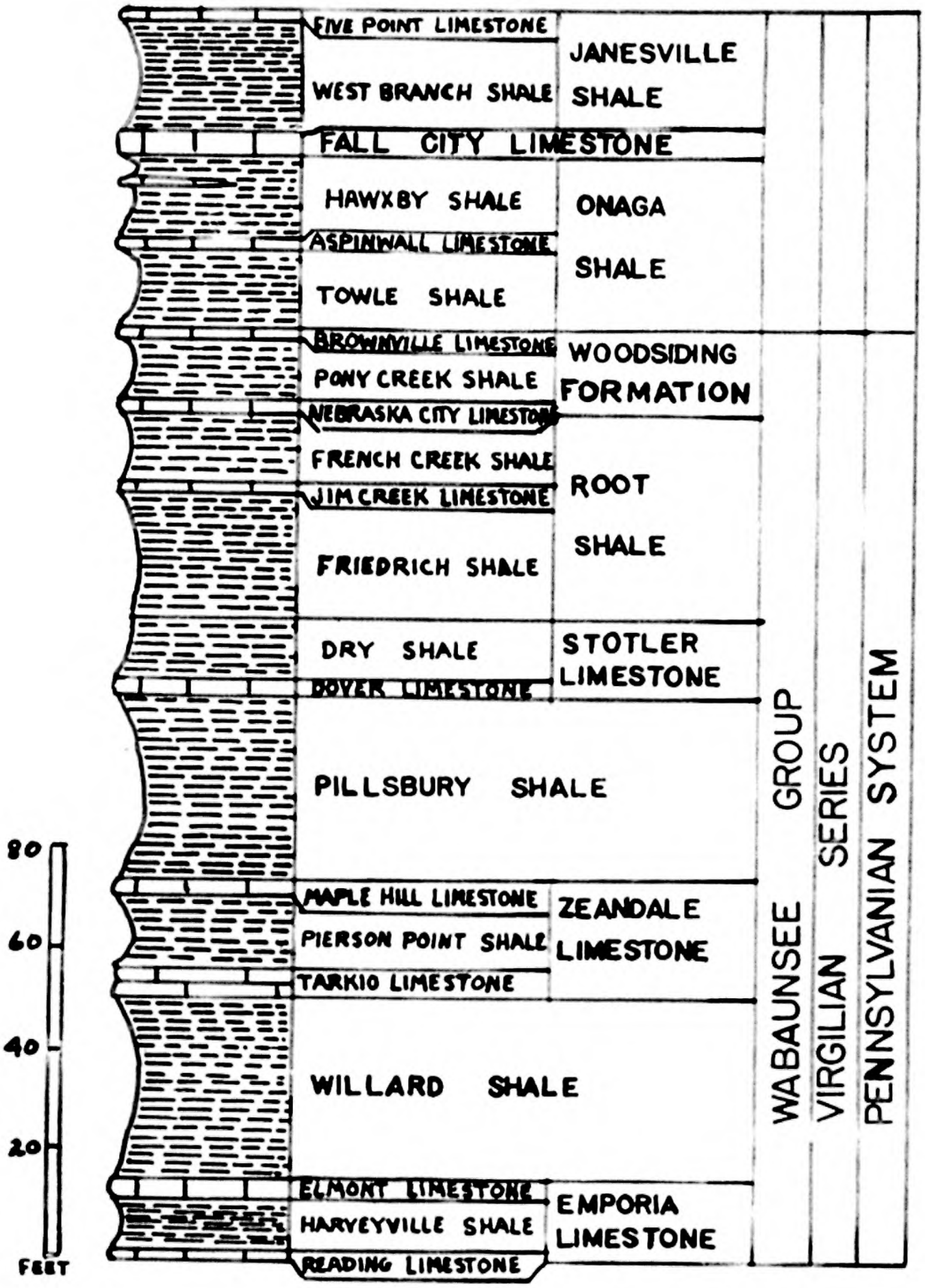
Since the close of the Kansas stage, streams have eroded their valleys to their present levels and have deposited alluvium and terrace materials along their courses.

EXPLANATION OF PLATE II

Generalized stratigraphic column of northeast Pottawatomie county, Kansas.

PLATE II


SCHROYER LIMESTONE
HAVENSVILLE SHALE
THREE MILE LIMESTONE
WREFORD LIMESTONE
SPEISER SHALE
FUNSTON LIMESTONE
BLUE RAPIDS SHALE
CROUSE LIMESTONE
EASLY CREEK SHALE
MIDDLEBURG LIMESTONE
HOOSER SHALE
EISS LIMESTONE
BADER LIMESTONE
STEARNS SHALE
MORRILL LIMESTONE
FLORENA SHALE
COTTONWOOD LIMESTONE
BEATTIE LIMESTONE
ESKRIDGE SHALE
NEVA LIMESTONE
SALEM POINT SHALE
BURR LIMESTONE
LEGION SHALE
SALLYARDS LIMESTONE
GRENOLA LIMESTONE
ROCA SHALE
HOWE LIMESTONE
BENNETT SHALE
GLENROCK LIMESTONE
RED EAGLE LIMESTONE
JOHNSON SHALE
LONG CREEK LIMESTONE
HUGHES CREEK SHALE
AMERICUS LIMESTONE
FORAKER LIMESTONE
HAMLIN SHALE
JANESVILLE SHALE
COUNCIL GROVE GROUP
WOLFCAMPIAM SERIES
PERMIAN SYSTEM


FIVE POINT LIMESTONE
WEST BRANCH SHALE
JANESVILLE SHALE
FALL CITY LIMESTONE
HAWXBY SHALE
ASPINWALL LIMESTONE
TOWLE SHALE
ONAGA SHALE
BROWNVILLE LIMESTONE
PONY CREEK SHALE
WOODSIDING FORMATION
NEBRASKA CITY LIMESTONE
FRENCH CREEK SHALE
JIM CREEK LIMESTONE
FRIEDRICH SHALE
ROOT SHALE
DRY SHALE
DOVER LIMESTONE
STOTLER LIMESTONE
PILLSBURY SHALE
MAPLE HILL LIMESTONE
PIERSON POINT SHALE
TARKIO LIMESTONE
ZEANDALE LIMESTONE
WILLARD SHALE
ELMONT LIMESTONE
HARVEYVILLE SHALE
READING LIMESTONE
EMPORIA LIMESTONE
WABAUNSEE GROUP
VIRGILIAN SERIES
PENNSYLVANIAN SYSTEM
80
60
40
20
FEET

STRATIGRAPHY[1]

The geologic formations that crop out in northeastern Pottawatomie county are all of sedimentary origin, and range in age from Pennsylvanian to Quaternary. The Wreford limestone crops out along the eastern edge of the area and is the youngest outcropping Paleozoic formation. The Emporia limestone crops out along the western edge of the area and is the oldest outcropping Paleozoic formation. Much of the Paleozoic bedrock is covered by deposits of Pleistocene glacial materials and Recent alluvium.

Pennsylvanian System

<u>Wabaunsee Group</u>. Emporia Limestone. The Emporia limestone consists of the Reading limestone member, the Harveyville shale member, and the Elmont limestone member in ascending order. The Reading limestone is a hard, gray limestone in three beds. Crinoid stems and a few pelecypods are the only conspicuous fossils. The average thickness is two feet. The Harveyville shale is a calcareous, greenish-gray, blocky shale about nine feet thick. The Elmont limestone comprises three limestone beds separated by thin shale layers. The lower limestone bed is massive and has well developed vertical joints. The upper limestone beds are conglomeritic and the intervening shales are calcareous and greenish-gray. The total thickness is about three feet.

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[1] Moore and Mudge's new stratigraphic classification is used.

Willard Shale. The Willard shale consists of 35 feet of dark gray to brown, sandy shale with some cross-bedded sandstone in the upper part.

Zeandale Limestone. The Zeandale limestone consists of the Tarkio limestone member, the Pierson Point shale member, and the Maple Hill limestone member in ascending order. The Tarkio limestone is a massive, brown limestone in two beds with a small shale parting. Large fusulinids stand out on the weathered surfaces and impart a very rough appearance. The Tarkio limestone is about five feet thick. The Pierson Point shale is yellow in the lower part and dark gray in the upper part. Shaly sandstones are common in the top half. The thickness is about 13 feet. The Maple Hill limestone is a single bed of massive, gray limestone that weathers brown. Slender fusulinids are numerous. The thickness is about three feet.

Pillsbury Shale. The Pillsbury shale is a light brown and light gray, sandy shale. The thickness is about 36 feet.

Stotler Limestone. The Stotler limestone consists of the Dover limestone member, and the Dry shale member in ascending order. The Dover limestone is a single bed of massive, brown limestone, containing large fusulinids and many algal remains, that is separated from an upper conglomeritic limestone by a thin shale. The thickness is about three feet. The Dry shale is a sandy, tan shale about 12 feet thick.

Root Shale. The Root shale consists of the Friedrich shale member, the Jim Creek limestone member, and the French Creek shale member in ascending order. The Friedrich shale is a sandy, tan shale with some cross-bedded sandstone near the top. The thickness is about 23 feet. The Jim Creek limestone is a single bed of dark, fossiliferous limestone about one foot thick. The French Creek shale is a brownish-yellow, sandy shale with some sandstone in the upper part. The thickness is about 14 feet.

Wood Siding Formation. The Wood Siding Formation consists of the Nebraska City limestone member, the Pony Creek shale member, and the Brownville limestone member. The Plumb shale and the Grayhorse limestone were not recognized in northeast Pottawatomie county. The Nebraska City limestone is a soft, impure, tan limestone that contains many shell fragments. The thickness is about one foot. The Pony Creek shale is red in the lower half and the upper part is a tan, sandy shale. The thickness is about 13 feet. The Brownville limestone is the uppermost member of the Pennsylvanian system in Kansas. The Brownville limestone occurs as one bed of impure, tan limestone containing well preserved, brachiopod shells. The thickness is about two feet.

Permian System

Admire Group. Onaga Shale. The Onaga shale consists of the Towle shale member, the Aspinwall limestone member, and the Hawxby shale member in ascending order. The lower half of the Towle shale is red and the upper half is a gray to tan shale.

The thickness is about 14 feet. The Aspinwall limestone is a medium-hard, gray, unfossiliferous limestone about one foot thick. The Hawxby shale is a gray, blocky shale about 16 feet thick.

Falls City Limestone. The Falls City limestone is a massive bed about five feet thick with many shell fragments that give it a rough or coquina-like appearance.

Jamesville Shale. The Janesville shale consists of three members in ascending order. The West Branch shale, the Five Point limestone, and the Hamlin shale. The West Branch shale consists mostly of sandy, gray shale and some shaly sandstone. The thickness is about 21 feet. The Five Point limestone consists of a single, one foot bed of hard, gray limestone with some small fusulinids. The Hamlin shale is sandy in the lower part with some nodular limestones in the middle; the upper part consists of gray and green shales. The thickness is about 35 feet.

Council Grove Group. Foraker Limestone. The Foraker limestone consists of the Americus limestone member, the Hughes Creek shale member, and the Long Creek limestone member in ascending order. The Americus limestone is a single bed of hard, gray limestone about one foot thick. Numerous crinoid stems are weathered in relief in many exposures. The Hughes Creek shale consists of about 35 feet of yellow and gray, fossiliferous shale with some impure limestone beds. The Long Creek limestone is a series of cellular limestone beds with abundant chalcedony nodules. The thickness is about five feet.

Johnson Shale. The Johnson shale consists mostly of gray shale with some impure limestone beds. The thickness is about 15 feet.

Red Eagle Limestone. The Red Eagle limestone is composed of two limestone members and an intervening shale member. The lower limestone member, the Glenrock, is a hard, gray, massive limestone about two feet thick. The Bennett shale member consists of eight feet of shale and impure limestone. The lower part of the member is a black shale and this black shale is separated from the gray shale of the upper part by about one foot of impure limestone. The Howe limestone consists of three feet of massive, gray, unfossiliferous limestone.

Roca Shale. The Roca shale consists of about 20 feet of gray-green, calcareous shale. There is about four feet of red shale in the middle of the formation.

Grenola Limestone. The members of the Grenola limestone, in ascending order, are the Sallyards limestone, the Legion shale, the Burr limestone, the Salem Point shale, and the Neva limestone. The Sallyards limestone is a single, hard, limestone bed about two feet thick. The Legion shale consists of about five feet of gray and black shale. The Burr limestone consists of two beds of hard, gray limestone separated by two feet of black shale. The total thickness is about six feet. The Salem Point shale is a gray shale about seven feet thick. The Neva limestone is composed of two limestone beds separated by a gray shale. The lower limestone bed is about one foot thick, the shale is about six feet thick, and the upper limestone bed is about 10 feet thick. The Neva limestone is a good bench-forming unit that is about 17 feet thick.

Eskridge Shale. The Eskridge shale is red in the lower part and gray to green in the upper part. A thin limestone bed separates the upper and lower parts. The thickness is about 33 feet.

Beattie Limestone. The Beattie limestone consists of the Cottonwood limestone member, the Florena shale member, and the Morrill limestone member in ascending order. The Cottonwood limestone is a hard, massive, gray limestone that weathers almost white. Abundant fusulinids and chert nodules, weathering in relief, impart a very distinctive appearance. The thickness is about six feet. The Florena shale is a dark gray, fossiliferous shale about five feet thick. The Morrill limestone is a non-resistant, brown limestone that contains much crystalline calcite. On weathered exposures the limestone is almost entirely weathered away and only large calcite lined cavities remain. The thickness is about three feet.

Stearns Shale. The Stearns shale consists of about 20 feet of gray to pale green, calcareous shale with some chalky limestone beds.

Bader Limestone. The members of the Bader limestone, in ascending order, are the Eiss limestone, the Hooser shale, and the Middleburg limestone. The Eiss limestone is a massive, unfossiliferous limestone that weathers pitted. The thickness is about three feet. The Hooser shale consists of 11 feet of red and gray shale. The lower third of the formation is mottled with streaks of red. The Middleburg limestone is a tan, platy weathering, fossiliferous limestone about two feet thick.

Easly Creek Shale. The Easly Creek shale is a light gray shale with a red zone in the middle. The thickness is about 17 feet.

Crouse Limestone. The Crouse limestone consists of about six feet of gray limestone. The lower half of the formation is massive and fossiliferous while the upper half is composed of unfossiliferous, platy limestone.

Blue Rapids Shale. The Blue Rapids shale is varicolored in the lower part and gray in the upper part. The thickness is about 22 feet.

Funston Limestone. The Funston limestone consists of about five feet of limestone and shale. The upper bed is a hard, massive, gray limestone about two feet thick. The lower three feet is composed of gray shale and platy limestone.

Speiser Shale. The Speiser shale consists of 13 feet of varicolored shale in the lower part, a very prominent one foot limestone, and three feet of gray shale at the top. The total thickness is about 17 feet.

Chase Group. Wreford Limestone. The Wreford limestone consists of the Three Mile limestone member, the Havensville shale member, and the Schroyer limestone member in ascending order. The Three Mile limestone is composed of about six feet of cherty limestone with a massive, non-cherty zone in the middle. The Havensville shale is a calcareous, tan shale with some impure limestone beds. The thickness is about 24 feet. The Schroyer limestone consists of about six feet of cherty limestone with a massive, non-cherty zone at the top.

Quaternary System

Pleistocene Series. Kansas Till and Associated Deposits. Kansas glacial till and glacial outwash blankets most of the divide areas in northeast Pottawatomie county. The glacial deposits consist of clay, sand, gravel, and boulders. The coarser materials consist chiefly of limestone, sandstone, quartzite, schist, and granite.

Sanborn Formation. The Sanborn formation consists of silt, sand, and gravels. Most of the materials are stream terrace deposits. There are small amounts of eolian silt deposits on some of the hills.

Alluvium. The alluvium of the streams is of late Pleistocene age (Recent) and consists of sand, gravel, silt, and clay.

STRUCTURE

Regional Structures

The two major regional structures, that lie in part, in northeast Pottawatomie county are the Nemaha Anticline and the Forest City Basin.

Nemaha Anticline. The Nemaha Anticline is a truncated anticline that plunges to the south. The Nemaha Anticline came into existence in post-Mississippian time and extends from southeastern Nebraska to central Oklahoma in a slightly west of south direction. After the initial folding, the area was peneplaned. At the close of the peneplanation, the area west of the Nemaha Anticline was raised above the area on the east by faulting (Lee, 1943). The fault has been mapped in the subsurface in Nemaha and Wabaunsee counties by Koons (1956) and Kotoyantz (1956). Early Permian deformation is shown on the surface in some areas by folding and faulting.

Forest City Basin. The Forest City Basin is both a structural and a topographic basin that lies between the Ozark uplift on the east and the Nemaha Anticline on the west. The basin was formed during post-Mississippian time by the sharp displacement on the east side of the Nemaha Anticline and the downwarping of the peneplaned Mississippian surface. The basin is asymmetrical with the deepest part adjacent to the Nemaha Anticline. The deepest part of the basin is expressed on the surface by the outlier of Permian rocks that extend southward from northern Nemaha and Brown counties to the Kansas River. This deepest part of the basin is known as the Brownville Syncline (Jewett, 1951). The Forest City Basin did not come into existence until after the development of the Mississippian peneplane surface (Lee, 1943).

Local Structures

The surface rocks in northeast Pottawatomie county strike approximately north 20 degrees east and range in dip from zero to six degrees. The strike and dip are presumably due to the drape effect of the sediments over the Nemaha Anticline. The crest of the Nemaha Anticline parallels the area covered by this thesis and is located approximately three miles to the west. The surface rocks on the east flank of the Nemaha Anticline dip in a south 70 degrees east direction. The southeast dip changes to a northwest dip approximately five miles east of the problem area. The line where this change in dip occurs is the axis of the Brownville Syncline in Jackson county.

Humboldt Fault. The problem area fault, as it was finally mapped, (Fig. 1, Appendix) will be referred to as the Humboldt Fault. The Humboldt Fault was named and described by Condra (1927) in the vicinity of the Kansas-Nebraska line in Nemaha county, Nebraska. Condra stated that the steep dip of the beds on the east flank of the Nemaha Anticline passes into a fault at places. The maximum displacement is just northwest of Humboldt, Nebraska where there is an upthrow on the west side of more than 100 feet. Jewett (1951) stated that Humboldt may be regarded as the proper name for the fault that is believed to be present intermittently on the east flank of the Nemaha Anticline along much of its length across Kansas.

Fault Description. The Humboldt Fault in northeast Pottawatomie county is a high angle normal fault that strikes generally north 20 degrees east and parallels the crest of the Nemaha Anticline. The west is the upthrown side and it has a constant displacement of slightly over 100 feet throughout the area. Surface faulting was not observed south of township seven south and it is assumed that the fault passes into a fold which is present a few miles further south. The fault is expressed on the surface for approximately 11 miles in northeast Pottawatomie county.

Relationship to Regional Structures. The Humboldt Fault is directly related to the Nemaha Anticline. As the Nemaha Anticline was uplifted after initial folding and peneplanation in post- Mississippian time, normal faulting occurred in the east flank to produce an east facing escarpment. Well logs and surface structures show some minor vertical movements along the Nemaha Anticline during the Pennsylvanian and Permian (Lee, 1943), and it is not uncommon to have normal faults develop along planes of weakness initiated by previous folding and faulting (Nevin, 1949). The strike of the surface fault parallels the crest of the Nemaha Anticline and the subsurface fault mapped by Koons (1956) through

EXPLANATION OF PLATE III

Diagrams show how steep dips can occur on the downthrown side of a fault and not be due entirely to drag.

Fig. 1. Structure before later faulting.

Fig. 2. Structure after last fault.

PLATE III

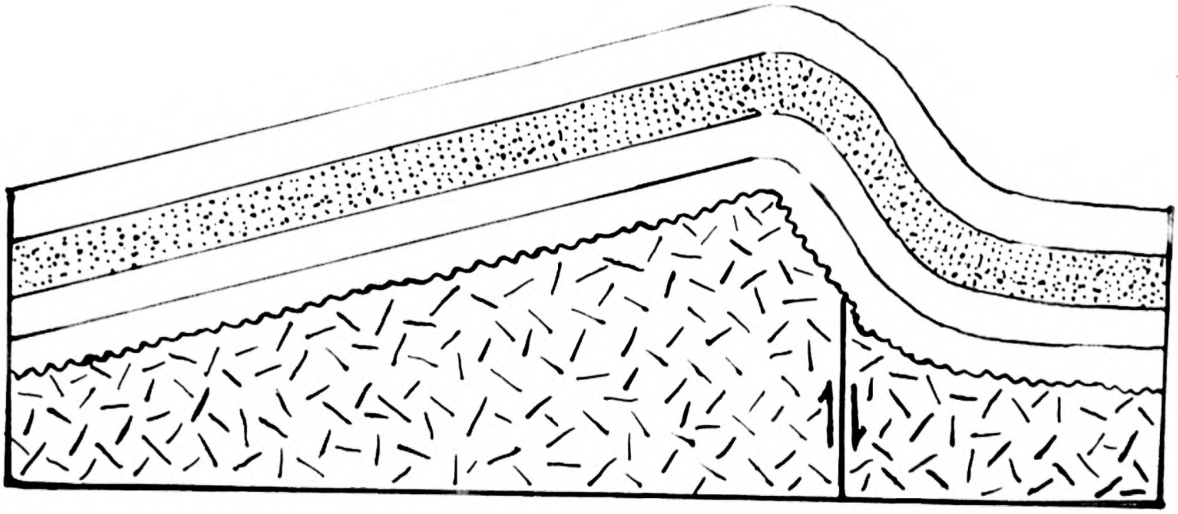

FIG. 1

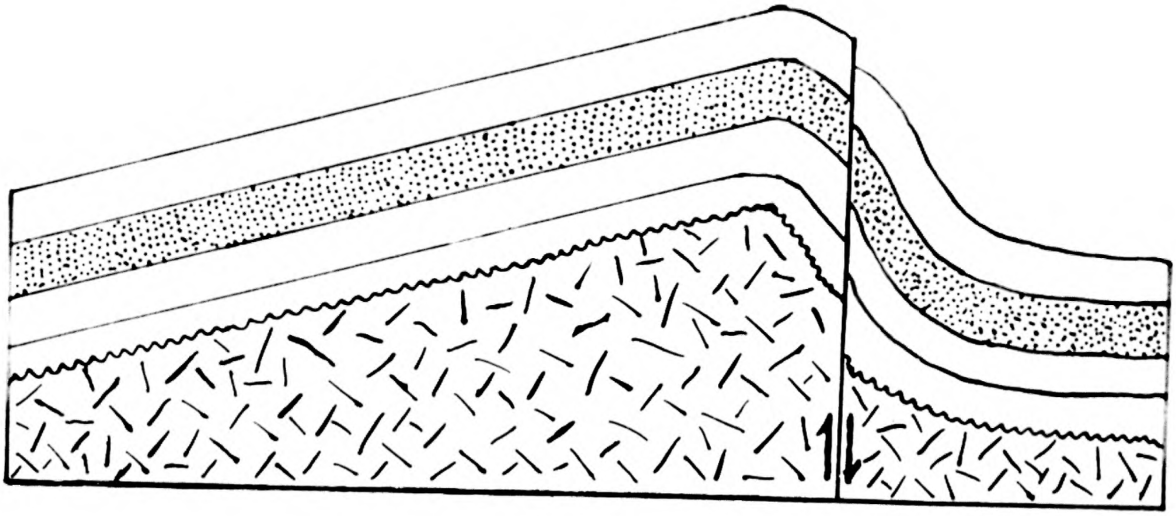

FIG. 2

most of the problem area. There is only one place where the fault does not parallel the crest of the Nemaha Anticline. It is in the area where the fault is apparently controlled by well developed joints that trend away from the general strike of the fault. In this one area the fault strikes north 70 degrees east and is parallel to a well developed set of joints. The deviation holds only for a few miles and then the fault trends back to the general strike of north 20 degrees east. The Humboldt Fault has a close relationship to the Nemaha Anticline and the master set of joints in northeast Pottawatome county.

Age of Faulting. The faulting in the east flank of the Nemaha Anticline began in post-Mississippian time and presumably continued intermittently into the Permian. The greatest displacement was pre-Desmoinesian, as the rocks of Desmoinesian age and younger show much less displacement than the rocks of Mississippian age and older. Surface faulting in northeast Pottawatomie county shows deformation as late as early Permian. There is no evidence of faulting later than early Permian as the youngest rocks to be displaced belong to the lower Chase group of Wolfcampian age. The Pleistocene material that is present on the divide areas on both sides of the fault seem to be undisturbed. Consequently, no Plaistocene displacement can be inferred; however, the area is known to have been the epicenter of several earthquakes within historic times. The amount of erosion that has occurred since the last faulting could possibly be used to determine the age of the last major movement. The fault is revealed on the surface by the presence of an obsequent fault line scarp. For this condition to develop, erosion must cut the upthrown side of the fault below the level of the downthrown side. (Plate IV.) The downthrown side of the fault is approximately 100 feet higher in elevation than the upthrown side, so consequently erosion has had to remove approximately 200 feet more sediment from the upthrown side to produce the obsequent fault line scarp. The amount of erosion suggests that the last major faulting, in northeast Pottawatomie county, occurred millions of years ago. The subsurface work by Koons (1956) and the surface work done in this thesis supports the evidence that the post-Desmoinesian faulting developed along planes of weakness initiated by pre-Desmoinesian folding and faulting. Nevin (1949) states that normal faults may form along planes of weakness initiated by previous folding, faulting, and jointing and that the newly developed fault will have the same strike and dip as the controlling structure, but the displacement will be less. This statement seems to hold true in northeast Pottawatomie county.

CONCLUSION

This surface investigation has shown that the last major structural movement occurred in the east flank of the Nemaha Anticline as early as post-Wolfcampian time. This last major movement is revealed by a fault on the surface in the problem area. The youngest rocks showing displacement belong to the Chase group of the Wolfcampian series. There is no evidence of

EXPLANATION OF PLATE IV

Diagrams show four stages in the development of an obsequent fault line scarp.

Fig. 1. True fault scarp.

Fig. 2. No reflection in topography.

Fig. 3. A fault line scarp.

Fig. 4. An obsequent fault line scarp.

PLATE IV

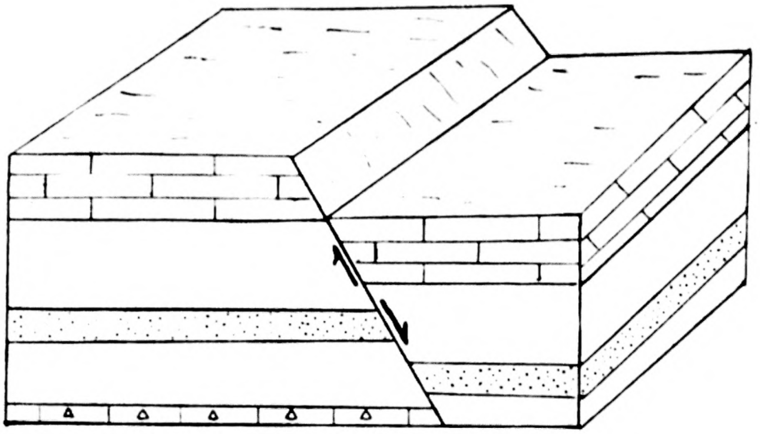

Fig. 1

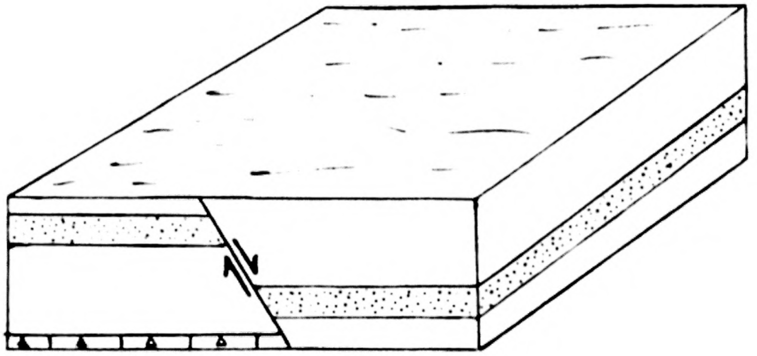

Fig. 2

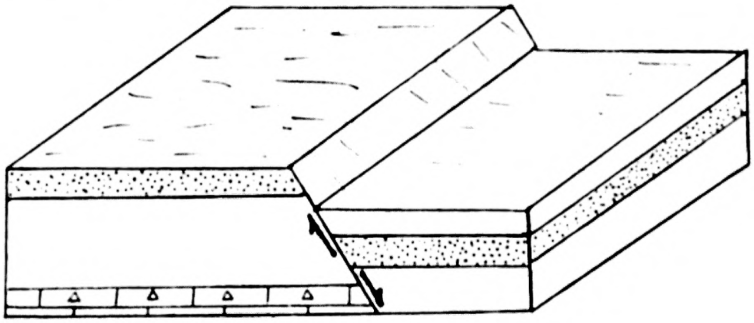

Fig. 3

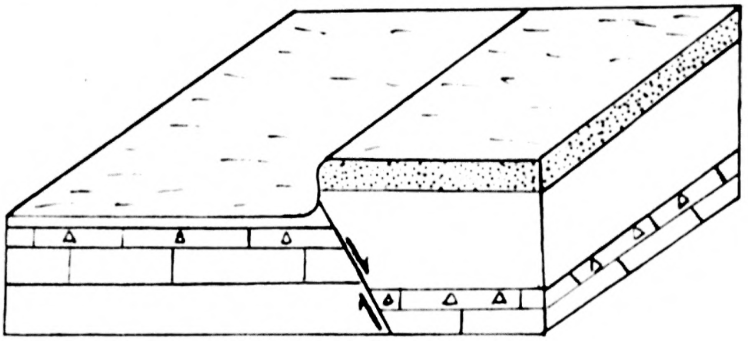

Fig. 4

major movement during the Pleistocene, as the glacial deposits show no displacement. The last major movement had to occur millions of years ago, as erosion has had time to produce an obsequent fault line scarp along the entire length of the fault.

The fault is present across the entire length of the problem area. It has a vertical displacement of slightly over 100 feet, with the upthrown side on the west. The strike of the fault is generally north 20 degrees east and parallels the crest of the Nemaha Anticline. The strike was controlled by pre-existing jointing and faulting. The fault was produced by movement along planes of weakness initiated by post-Mississippian folding and faulting.

ACKNOWLEDGMENT

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LITERATURE CITED

Condra, G. E.
The stratigraphy of the Pennsylvanian system in Nebraska. Nebraska Geol. Survey Bull. 1, 2nd Ser., pp. 15, 212, 1927.

Condra, G. E. and E. C. Reed
The geological section of Nebraska. Nebraska Geol. Survey Bull. 14, 2nd Ser., Fig. 1-2, 1943.

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

Jewett, J. M.
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, 1956.

Kotoyantz, A. A.
Geologic factors influencing oil production in Wabaunsee county. Masters thesis, Kansas State College, Manhattan, Kansas, 1956.

Lee, Wallace
The stratigraphy and structural development of the Forest City Basin in Kansas. State Geol. Survey of Kansas, Bull. 51, pp. 7-136, 1943.

Moore, R. C. and M. R. Mudge
Reclassification of some lower Permian and upper Pennsylvanian strata in northern Mid-Continent. Am. Assoc. Petrol. Geol. Bull., Vol. 40, No. 9, pp. 2271-2277, 1956.

Nevin, C. M.
Principles of structural geology. 4th Ed., New York: John Wiley and Sons, 1949.

Scott, G. C., C. F. Crumpton, and J. Foster
Pre-publication geologic map of Pottawatomie county, Kansas, 1949.

APPENDIX

GEOLOGIC MAP OF NORTHEAST POTTAWATOMIE COUNTY KANSAS

G. RATCLIFF 56

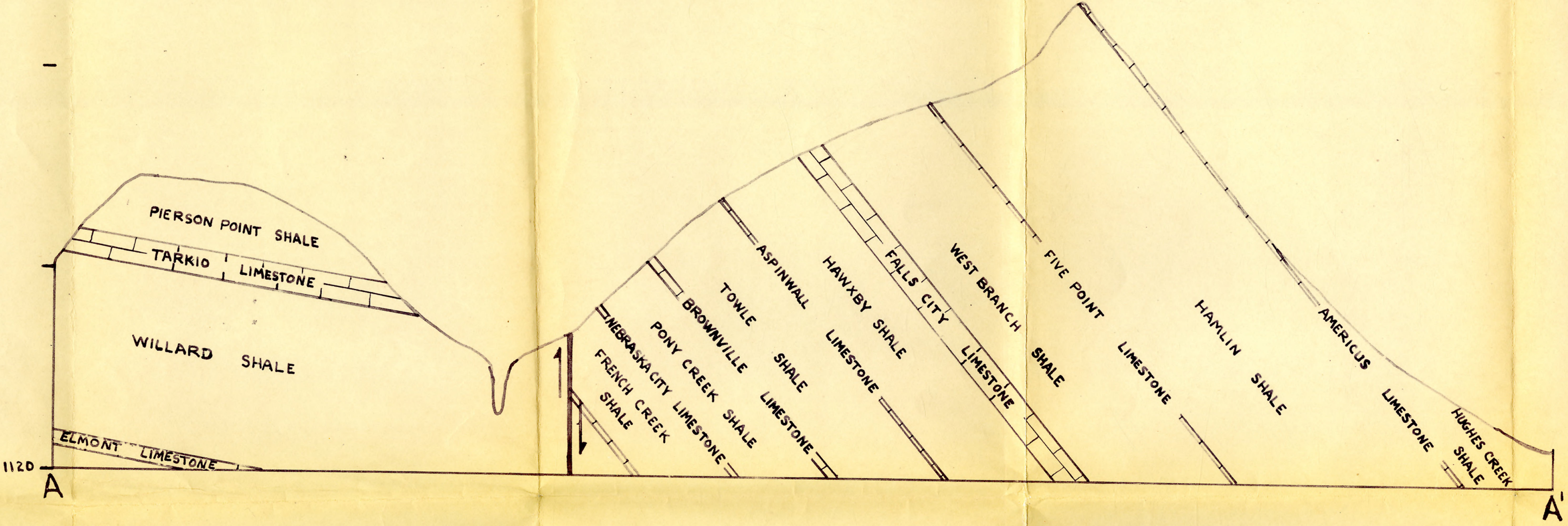

FIG. 2.

CROSS-SECTION AA'

FIG. 3.

CROSS-SECTION BB'

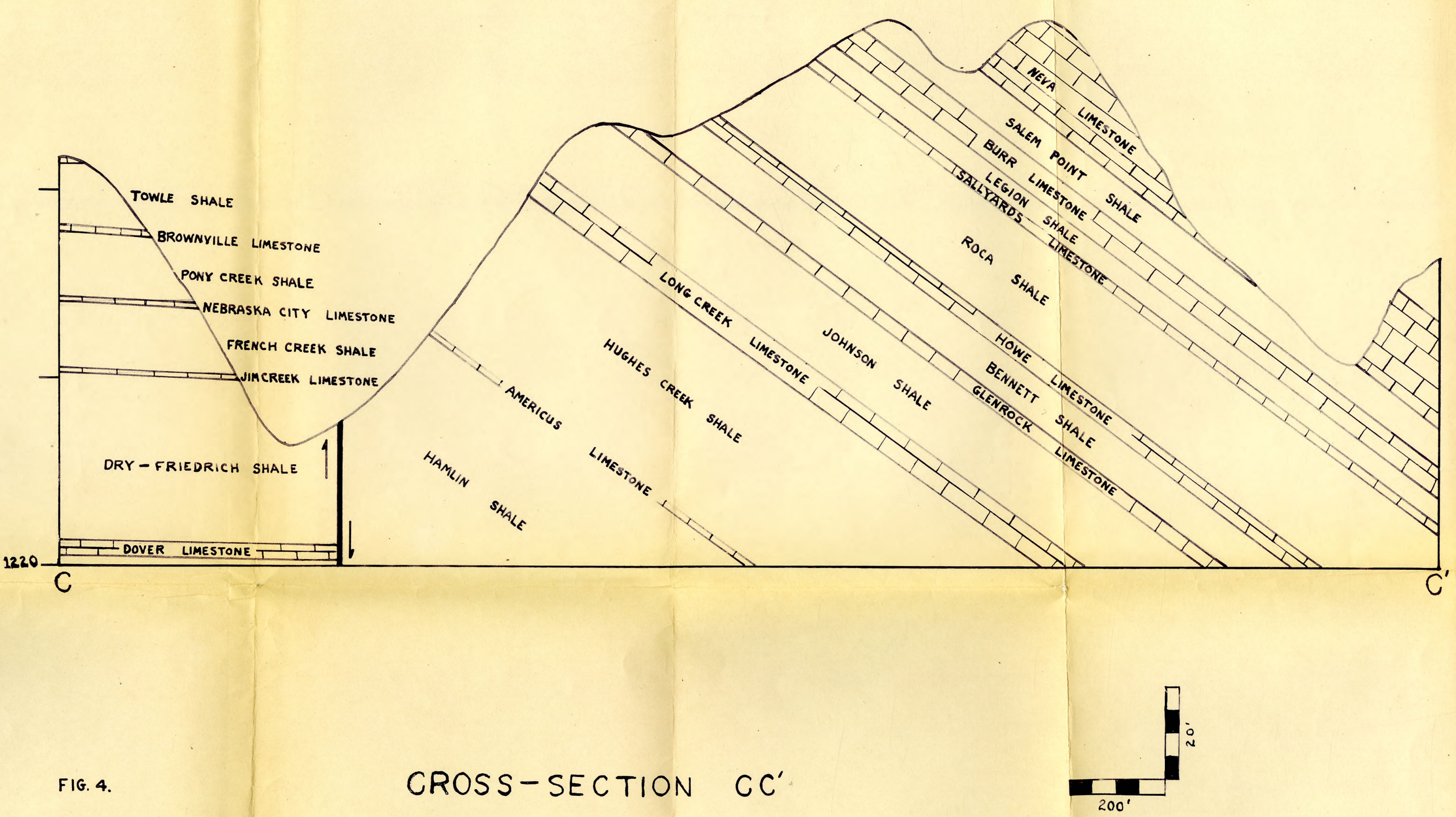

FIG. 4.

CROSS-SECTION CC'

SURFACE STRUCTURE ON THE EAST FLANK OF THE NEMAHA ANTICLINE IN NORTHEAST POTTAWATOMIE COUNTY, KANSAS

by

GENE A. RATCLIFF

B. S. Kansas State College
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AN ABSTRACT OF THE THESIS

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ABSTRACT

The area covered by this investigation consists of approximately 30 square miles in the northeast part of Pottawatomie county, Kansas. The area parallels, and is approximately two miles east of the crest of the Nemaha Anticline.

Faulting in the subsurface on the east flank of the Nemaha Anticline has been inferred in much of the Kansas geological literature. Several geologists have tentatively shown a fault in the subsurface, but evidence that a fault exists has not been proved conclusively. Also, it was assumed by many of the geologists, that the last major movement along the Nemaha Anticline was pre-Desmoinesian. The purpose of this investigation was to see if the supposed subsurface faulting is revealed on the surface and if the date of the last major movement could be younger than previously thought. An area in northeast Pottawatomie county, showing evidence of possible faulting on the surface, was selected for the problem area. After the selection of the problem area, the stratigraphy was identified, sections were measured, and dips and strikes of the formations were taken.

Locating the fault, if one was present, was accomplished in two ways: (1) The dips were studied on each side of the suspected fault. The dips were then plotted graphically to show the impossibility for folding to account for the difference in elevation of the formations. (2) The stratigraphy was correlated from a known formation on one side of the suspected fault to a known formation on the opposite side. When a gap occurred in the

stratigraphic sequence, a fault was inferred. The line of the fault was established through the area and three structural profile sections were mapped across the fault zone. These sections indicated conclusively that a fault existed.

The fault is probably an extension of the Humboldt Fault that is present in southeastern Nebraska. The fault strikes generally north 20 degrees east and has an upthrow on the west of slightly more than 100 feet. The fault was produced by movement along planes of weakness that existed in pre-Desmoinesian rocks. By using the evidence that is present in the problem area, the date of the last major movement, in the east flank of the Nemaha Anticline, has to be at least early Permian. Rocks belonging to the Chase group of Wolfcampian series are the youngest rocks that show any displacement. There has been enough erosion in the area, since the last major movement, to produce an obsequent fault line scarp. The amount of erosion is evidence that the movement occurred millions of years ago.