# THE GEOLOGY OF A FAULT AREA IN SOUTHEAST RILEY COUNTY, KANSAS

by

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## INTRODUCTION AND REVIEW OF LITERATURE

### Location of the Area

This investigation deals with a 15 square mile area in the vicinity of Deep Creek in southeast Riley County, Kansas. The area is rectangular in shape, five miles north-south and three miles east-west. It includes part of both ranges 8 and 9 east in township 11 south. The Riley-Wabaunsee county line is the southern border and the Riley-Geary county line is the western border along part of the area. The western border is located two miles east of the intersection of K 13 and US 40 highways south-southeast of Manhattan, Kansas (Plate I).

### Geologic Setting

This area in southeast Riley County is within a section of the Central Lowlands physiographic province known as the Flint Hills Upland. Frye and Leonard (1952) stated that:

> The Flint Hills are classed within the Central Lowlands because of their genetic and geologic similarities to the Osage Cuesta Plains to the east. In fact the Flint Hills can be described as a series of prominent cuesta scarps and dip slopes developed on resistant cherty limestones of early Permian age (primarily Wreford, Florence, Fort Riley, and Herington).

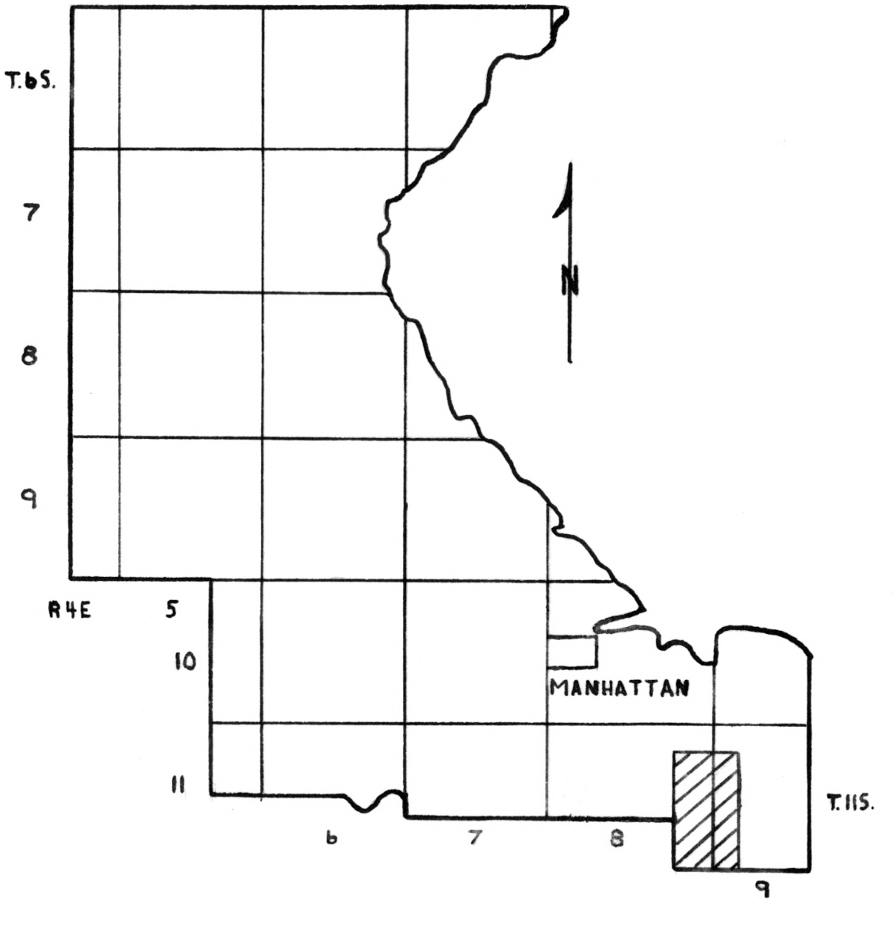
On the east face of the Flint Hills a series of terraces are found. These are caused by the alternating formations of limestone and shale. On the west face the rocks dip to the north of west on a very gentle slope.

The drainage is well-developed throughout the area, and Deep Creek valley and its main tributaries are covered by recent alluvium and terrace deposits. This area is much more dissected by streams than the areas to the west, east, and south. The area to the north has been badly dissected by

## EXPLANATION OF PLATE I

A map of Riley County, Kansas, showing the area covered by this investigation.

PLATE I



Deep Creek and the Kansas River. There is a very small amount of Quaternary sediments covering the upland in the southeast corner of the area (Beck, 1949).

The main structural features near the problem area are the Nemaha anticline and the Zeandale dome (Koons, 1955). To the west are the Abilene anticline and the Salina basin. To the north is the Irving syncline (Jewett, 1951).

### Statement of the Problem

In this area seven faults are present; the strike of six of them are roughly parallel; the seventh, which is some distance from the others, has a strike considerably different from the others. These all occur on the west flank of the Nemaha anticline. These faults have been mentioned previously by Jewett (1941) and Neff (1949). The purpose of this paper is to determine the cause of these faults in the problem area.

## MAPPING PROCEDURE

The field work was started during the early winter of 1957. The problem area and the areas immediately surrounding it were extensively examined at the outset of the study. Using the geologic map of Riley County by Beck (1949) and Mudge (1949) the faults were located. Once located they were checked for extent of length and the possibility of any other adjacent faults. Formations were identified and sections were measured at different locations over the problem area. The structure profiles made across the area were made with a plane table and alidade. All elevations were accurately measured from the U. S. G. S. bench marks in the area and from the bench marks laid out on highway US 40 by the state engineering department.

All outcrops of the four formations mapped were walked out, and then using a sketchmaster, they were traced from aerial photographs. The scale of the thesis maps was enlarged, by use of the sketchmaster, from approximately one thousand feet per inch on the aerial photographs to eight hundred feet per inch. By using a scale this large it was felt that the local structure and topography could be more accurately presented. A contour interval of ten feet was chosen because it would easily show all of the local structure adequately. A vertical scale of 120 feet per inch was used on the cross sections, which gave a vertical exaggeration of 6.67.

## GEOLOGIC HISTORY

### Paleozoic Era

Riley County underwent deposition, erosion, folding, and faulting during the Paleozoic era. Rocks of Cambrian through Permian age were deposited. There are several records of more or less widespread and prolonged erosion when varying amounts of these previously deposited sediments were removed, but the two major times of erosion were during late Ordovician and late Mississippian time. These erosional surfaces are recognizable in the subsurface by the weathered surface of the Arbuckle limestone and the Mississippian "chat." Folding and faulting reached their peak during post-Mississippian and pre-Desmoinesian time. Koons (1955) in his work on the reconstruction of the rock units before deformation has shown that the faulting of the Nemaha anticline followed deformation by folding. Deformation to a much lesser degree continued on into the middle of the Permian time (Lee, 1956).

### Mesozoic Era

In southeastern Riley County there are no Mesozoic rocks present, although they could have been deposited at some time and then subsequently eroded at some later date. The Mesozoic was an era of regional tilting and erosion. A general northwestward dip of the Permian and Pennsylvanian rocks took place during the Mesozoic. This change in direction of dip moved the crest of some of the low anticlines and completely did away with the closure of others (Lee, 1956).

### Cenozoic Era

The Cenozoic era was one of both erosion and deposition in southeast Riley County. During the Tertiary erosion took place over eastern Kansas (Moore and others, 1951). The Quaternary is known as a time of glaciation and deposition; however, neither of the two glaciers that reached Kansas were far enough south to cause glaciation of the problem area. The Sanborn formation, which includes deposits of both Illinoian and Wisconsin stages, was deposited on some of the upland divides (Frye and Leonard, 1952).

## STRATIGRAPHY

The rock units that outcrop in the problem area are all sedimentary and range in age from Pennsylvanian to Permian (Wilmarth, 1957) (Plate II). Unconsolidated material representing the Quaternary is found on some of the upland areas. The oldest rock unit is the Caneyville limestone of the upper Pennsylvanian which outcrops in the problem area. The youngest is the Florence limestone of the Permian system.

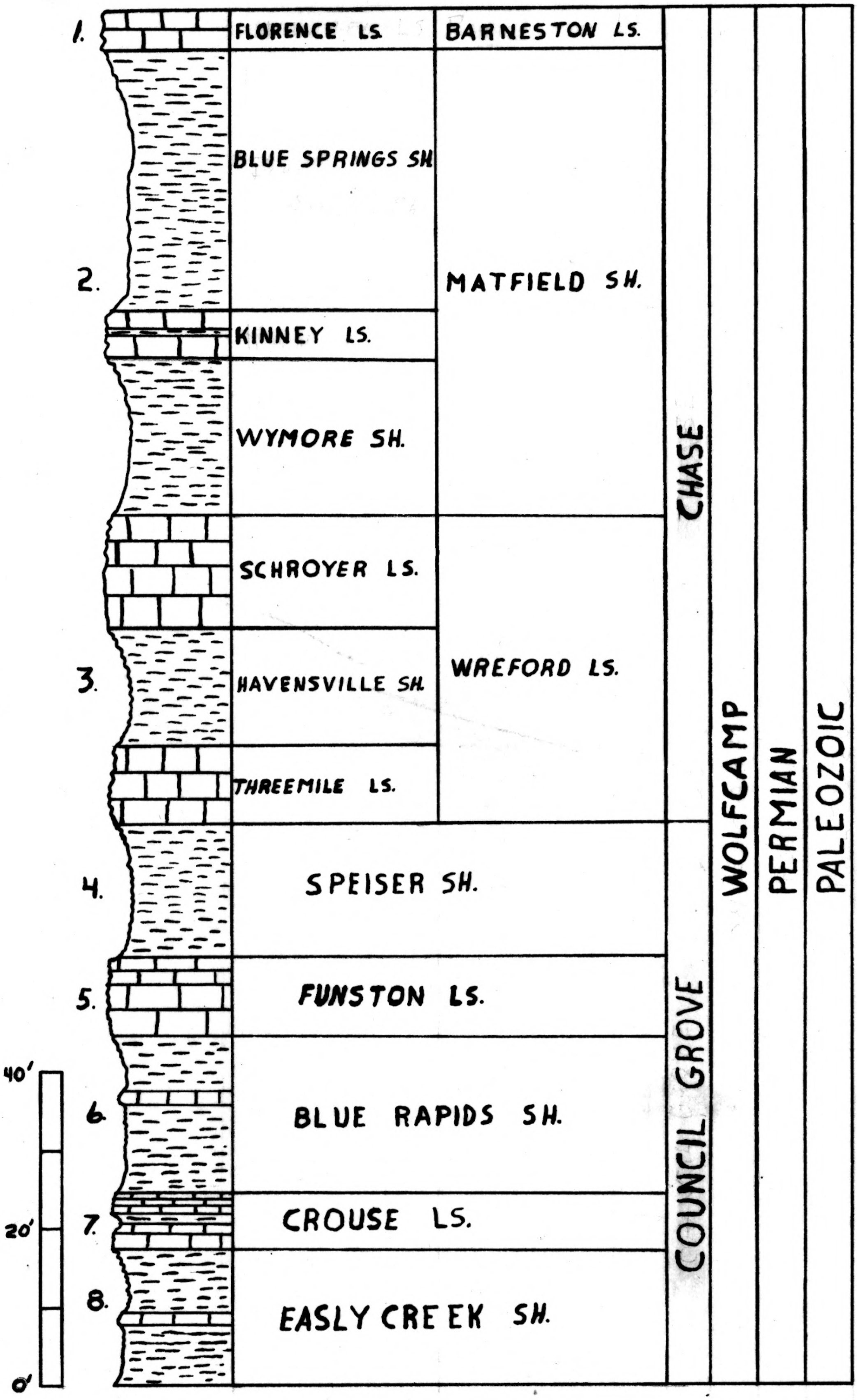
### Pennsylvanian System

Only the upper part of the Virgilian series is present in the problem area as an outcrop. Of this, only the Wabaunsee group is outcropping.

EXPLANATION OF PLATE II

Generalized stratigraphic column of southeast Riley County, Kansas.

PLATE II



1.
2.
3.
4.
5.
6.
7.
8.
40'
20'
0'
FLORENCE LS.
BARNESTON LS.
BLUE SPRINGS SH.
MATFIELD SH.
KINNEY LS.
WYMORE SH.
SCHROYER LS.
HAVENSVILLE SH.
WREFORD LS.
THREEMILE LS.
SPEISER SH.
FUNSTON LS.
BLUE RAPIDS SH.
CROUSE LS.
EASLY CREEK SH.
CHASE
COUNCIL GROVE
WOLFCAMP
PERMIAN
PALEOZOIC

PLATE II (Continued)

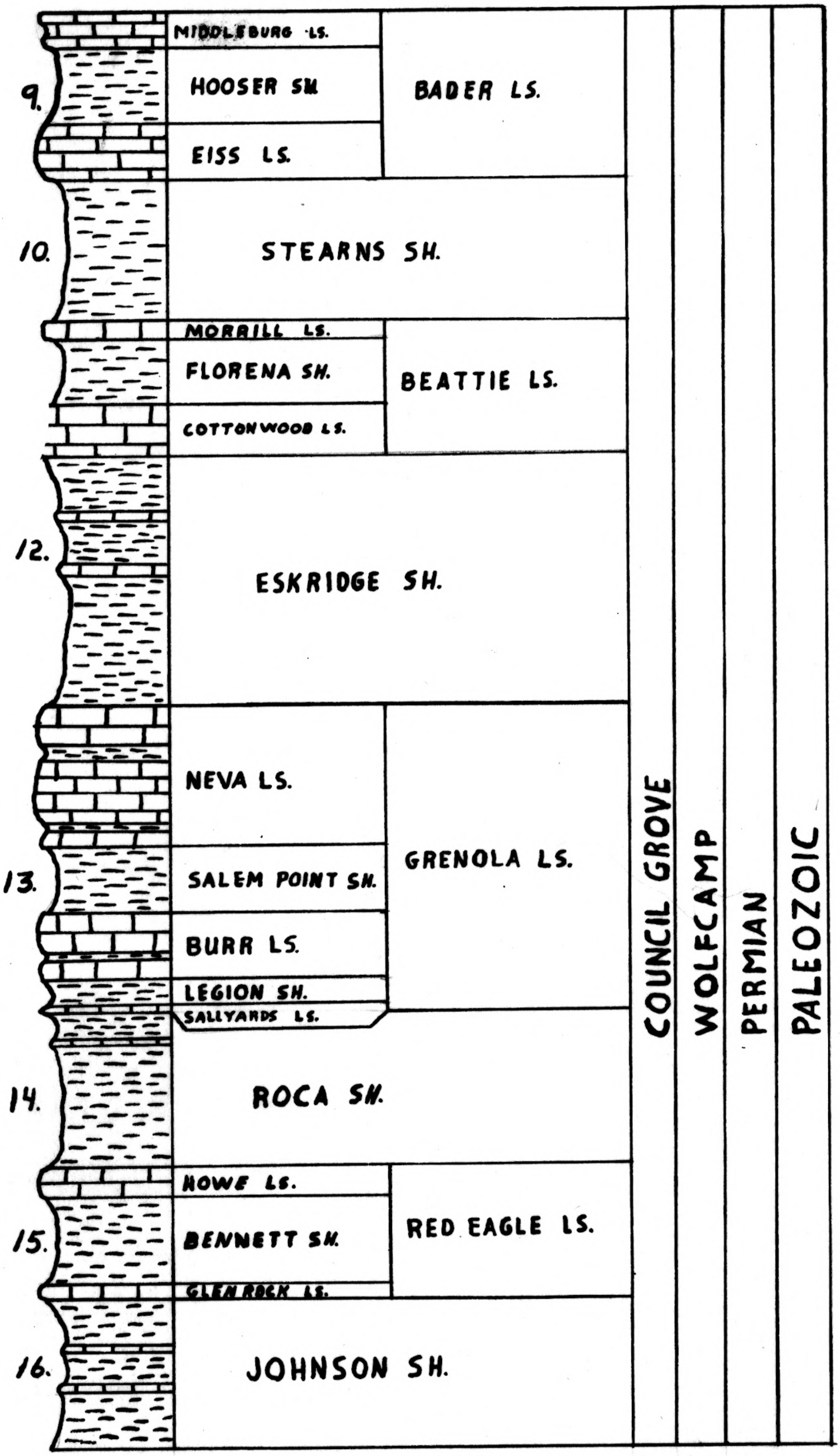
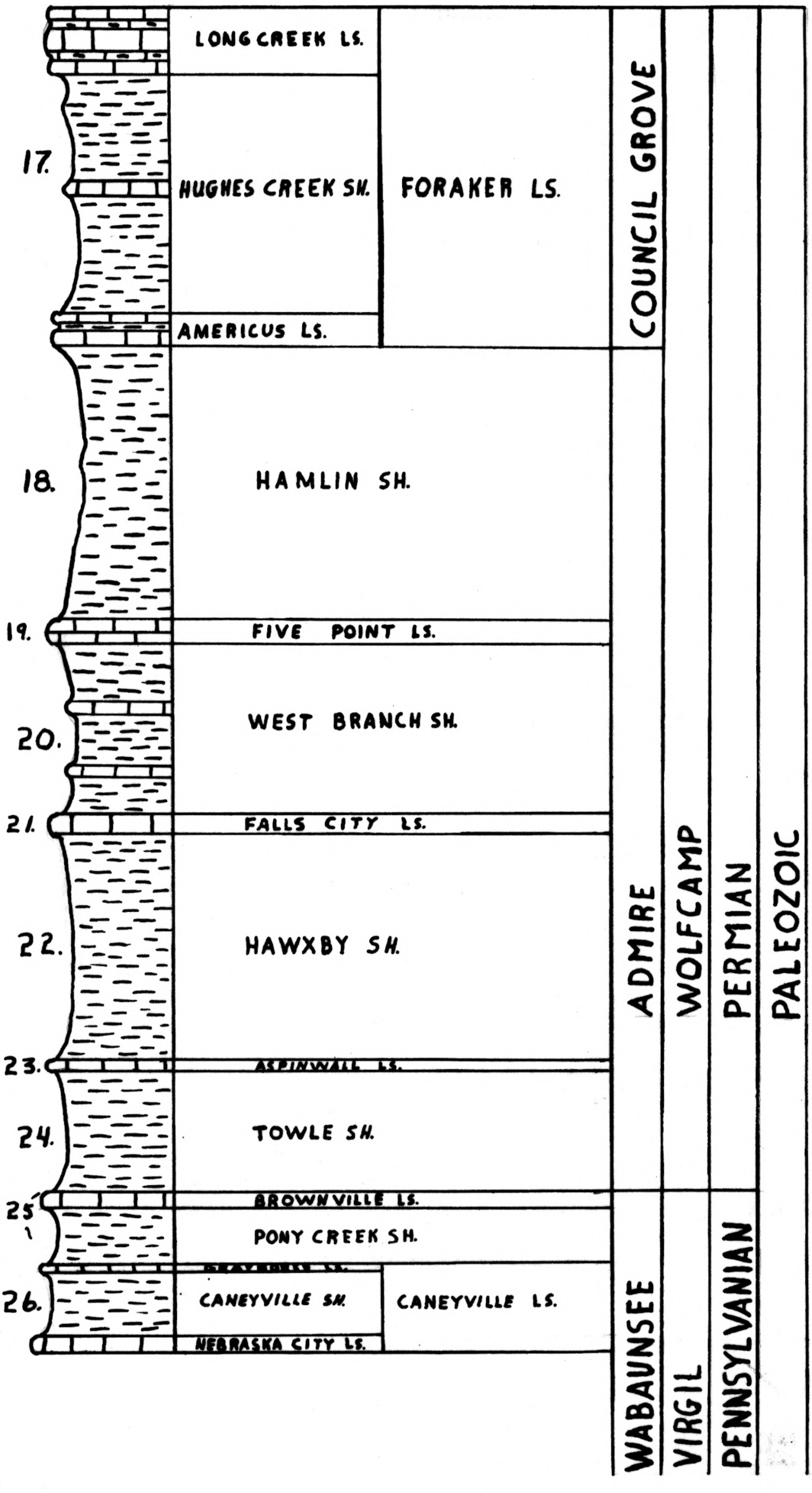


PLATE II (Continued)



Wabaunsee Group. The Wabaunsee group, the upper group of the Virgilian series, was named from exposures in Wabaunsee County, Kansas, by Prosser (1895). This uppermost group of the Virgilian series is immediately below the unconformity which separates Permian and Pennsylvanian. The Wabaunsee group consists mainly of gray and brown shales and thin but persistent blue and brownish limestones. The lower boundary of the Wabaunsee group is the Severy shale. The upper boundary is the Brownville limestone.

Richardson Subgroup. This is the upper subgroup of the Wabaunsee group. It is comprised of the rock units from the top of the Brownville limestone to the top of the Tarkio limestone. The type locality is in the Big Nemaha Valley of southern Richardson County between Humboldt and Falls City, Nebraska (Condra, 1935).

Caneyville Limestone Formation. In ascending order the members of the Caneyville limestone formation are the Nebraska City limestone, Caneyville shale, and the Grayhorse limestone. This formation was named by Moore (1936) for the type locality in Caneyville Township, Chautauqua County, Kansas.

Nebraska City Limestone Member. Smith (1919) named this member for its outcrop at Nebraska City, Nebraska. It is a gray, soft, fossiliferous limestone. The thickness of the Nebraska City limestone is one foot in the problem area.

Caneyville Shale Member. This gray shale overlies the Nebraska City limestone (Condra, 1935). Its thickness is nine feet.

Grayhorse Limestone Member. The Grayhorse limestone was named by Heald (1918) from an outcrop on the crest of Little Grayhorse anticline in Osage

County, Oklahoma. This is a gray, coarse-grained limestone which has a fragmental appearance. This limestone has a thickness of approximately one foot.

Pony Creek Shale Formation. The Pony Creek shale was named by Condra (1927) from the exposures near Pony Creek south of Fall City, Nebraska. A bluish-gray shale with some red shale locally, it overlies the Caneyville limestone and underlies the Brownville limestone.

Brownville Limestone Formation. This formation was named by Condra and Bengston (1915) for exposures near Brownville, Nebraska, and was assigned as the basal member of the Admire formation. Condra (1935) revised his classification and included the Brownville limestone as the top formation of the Wabaunsee group. This is a bluish-gray limestone that weathers brownish-red. It is fairly fossiliferous and is one foot thick.

## Permian System

Only the Wolfcampian series of the Permian system is present in the problem area. In the Wolfcamp all three groups are outcropping in the area. These are, in ascending order, the Admire, Council Grove, and Chase groups.

Admire Group. The Admire group, the lower group of the Wolfcampian series, was named from exposures near Admire, Lyons County, Kansas, by Adams (1903). It was first called Admire shale; then Condra (1935) and Moore (1936) renamed it Admire group. This group is composed mainly of clastic deposits, but does contain a few thin limestones; however, shale predominates. The lower boundary is the Hamlin shale.

Towle Shale Formation. The Towle shale was named by Moore and Condra (1932) for outcrops on the Towle farm near Falls City, Nebraska. The shale is gray-green and is sandy and clayey locally. The thickness in the problem area is about 15 feet.

Aspinwall Limestone Formation. Condra and Bengston (1915) named this limestone for exposures near Aspinwall, Nemaha County, Kansas. Productid brachiopods predominate in this gray, dense, one-foot thick limestone.

Hawxby Shale Formation. The Hawxby shale was named for outcrops on the Hawxby farm five miles west of Nemaha, Nemaha County, Kansas, by Moore and Condra (1932). The shale is yellowish-gray, and has several thin layers of hard, dense limestone which are highly fossiliferous. The shale has a thickness of about 28 feet.

Falls City Limestone Formation. The Falls City limestone outcropping near Falls City, Richardson County, Nebraska, was named by Condra and Bengston (1915). The two and one-half foot thick limestone is yellow-brown and weathers gray. Unweathered it is soft, porous, and has a fibrous appearance.

West Branch Shale Formation. Condra (1927) named this shale for its exposure in West Branch Township, Pawnee County, Nebraska. This is a vari-colored shale with a sandstone seam near the middle. A limestone seam is also found near the bottom. The thickness of this formation is about 22 feet.

Five Point Limestone Formation. This limestone was named by Moore and Condra (1932) for Five Point Creek which is southwest of Falls City, Nebraska. This is a three-foot thick limestone that is tan in color. It makes a very good outcrop in the northeast corner of the problem area. The formation is quite fossiliferous and appears algal in part.

Hamlin Shale Formation. The Hamlin shale consists of two shales and a limestone that may be absent locally. It was named by Condra (1935). In southeast Riley County the Houchen Creek limestone member is missing. Thus the Oaks shale member and the Stine shale member are in contact. This makes it hard to distinguish the limit of each shale on a grass covered surface. The upper part of the Hamlin shale is gray while the lower portion is vari-colored. The total thickness of the formation is 34 feet.

Council Grove Group. The Council Grove group is the middle group of the Wolfcampian series. It is composed of more limestone and less shale than in the lower Admire group. The group was named by Prosser (1902) for the area around Council Grove, Kansas. This group was extended downward to include the Americus limestone by Moore and Condra (1932). The lowest member in the group is the Americus limestone member of the Foraker formation. The upper boundary is the top of the Speiser shale formation.

Foraker Limestone Formation. This formation consists of two limestones and a shale member. The Foraker limestone was named for Foraker, Osage County, Oklahoma, by Heald (1916).

Americus Limestone Member. Kirk (1896) named this limestone for its out-crop near Americus, Lyon County, Kansas. This member is composed of two lime-stones with a shale separating them. The upper limestone is a one-foot thick, gray, highly fossiliferous, massive unit. Below this is one and one-half feet of gray shale. This shale overlies one and one-half feet of brown, argilla-ceous limestone. The total thickness of the Americus is four feet.

Hughes Creek Shale Member. The Hughes Creek shale was named by Condra (1927) for exposures on Hughes Creek, Nemaha County, Nebraska. This shale, approximately 30 feet thick, is gray and contains several thin limestone beds. In the upper portion of the shale are found great numbers of fusulines.

Long Creek Limestone Member. Condra (1927) named the Long Creek limestone for its outcrop along Long Creek near Auburn, Nemaha County, Nebraska. This yellow-tan, argillaceous limestone contains celestite and a small amount of quartz. Thin shale partings are present in the limestone. The thickness of the formation is about six to eight feet.

Johnson Shale Formation. This formation was named by Condra (1927) for exposures north of Johnson, Johnson County, Nebraska. The shale is gray with thin limestone beds within it. The thickness varies from 16 to 20 feet.

Red Eagle Limestone Formation. The Red Eagle limestone was named by Heald (1916) for exposures near Red Eagle School southwest of Foraker, Oklahoma. The limestone is divided into three members: the Glenrock limestone, Bennett shale, and Howe limestone, in ascending order.

Glenrock Limestone Member. The Glenrock limestone member was named by Condra (1927) for exposures just northwest of Glenrock, Nemaha County, Nebraska. This member is a gray, dense limestone about one and one-half feet thick.

Bennett Shale Member. Condra (1927) named the Bennett shale for its outcrops south of Bennett, Lancaster County, Nebraska. The shale is dark gray to black with a thin limestone near the center. The thickness of the shale is about 10 feet.

Howe Limestone Member. This limestone was named for its exposures south of Howe, Nebraska, by Condra (1927). The Howe limestone is a massive, gray member four feet thick that makes a very good outcrop.

Roca Shale Formation. Condra (1927) named this formation for its outcrop near Roca, Lancaster County, Nebraska. The Roca is a varicolored shale of red, green, and gray with thin limestone seams within it. The thickness of this formation ranges from 16 to 22 feet.

Grenola Limestone Formation. The Grenola limestone was named for its exposure near Grenola, Elk County, Kansas, by Condra and Busby (1933). It is composed of, in ascending order, the Sallyards limestone, Legion shale, Burr limestone, Salem Point shale, and Neva limestone members.

Sallyards Limestone Member. Condra and Busby (1933) named the Sallyards limestone for exposures northeast of Sallyards, Greenwood County, Kansas. The Sallyards limestone is a light gray unit that is fossiliferous. The thickness of the limestone is about one foot.

Legion Shale Member. The Legion shale was named by Condra and Busby (1933) for its outcrop near the American Legion Golf Club southwest of Manhattan, Kansas. The shale is gray and has a thickness of four feet.

Burr Limestone Member. The Burr limestone was named by Condra and Busby (1933) for exposures northwest of Burr, Otoe County, Nebraska. The Burr has two gray limestones separated by a black, highly fossiliferous limestone. The lower limestone is massive and is also fossiliferous. The thickness of the Burr limestone member is approximately eight feet.

Salem Point Shale Member. Condra and Busby (1933) named the Salem Point shale for its outcrop at Salem Point northwest of Salem, Richardson County, Nebraska. This is a gray shale, non-fossiliferous, and calcareous. The thickness of the member is about six to eight feet.

Neva Limestone Member. The Neva limestone was named by Beede (1902) for its exposure near Neva Station, Cottonwood River Valley, Chase County, Kansas. The Neva is made up of five limestones separated by thin shale breaks. The upper limestone is most easily identified by its "honeycombed" structure. The other limestones are platy and separated by gray shales. The overall thickness of the Neva is between 16 and 20 feet.

Eskridge Shale Formation. The Eskridge shale was named by Beede (1902) for exposures near Eskridge, Wabaunsee County, Kansas. The Eskridge is a varicolored shale with two thin limestone beds in the top half. The thickness of the Eskridge shale is 28 to 32 feet.

Beattie Limestone Formation. This formation was named by Condra and Busby (1933) for its outcrop at Beattie, Marshall County, Kansas. It consists of two limestones and one shale.

Cottonwood Limestone Member. Haworth and Kirk (1894) named this limestone for its exposure at Cottonwood Falls, Chase County, Kansas. This member is a massive, light buff limestone that weathers buff. It is easily recognizable by the small fusulines present. The limestone makes a very prominent outcrop that can be identified easily by the fringe of bushes on the hillsides. The thickness of the Cottonwood limestone is about five to six feet.

Florena Shale Member. The Florena shale was named by Prosser (1902) for exposures near Florena, Marshall County, Kansas. The shale is a gray, highly fossiliferous bed, easily recognizable by the numerous brachiopods present. The thickness of the Florena varies from six to eight feet.

Morrill Limestone Member. Condra (1927) named this limestone for its outcrop northwest of Morrill, Kansas. This unit is a yellow-brown, cellular limestone that weathers gray. The thickness of this member is about one to three feet.

Stearns Shale Formation. This formation was named by Condra (1927) for exposures south of Stearns School northeast of Humboldt, Nebraska. The Stearns is a varicolored shale with a thin limestone bed near the center of the formation. The thickness of the formation varies from 16 to 20 feet.

Bader Limestone Formation. The Bader limestone was named by Condra (1935). It includes two limestones and one shale member.

Eiss Limestone Member. Condra (1927) named the Eiss limestone for its exposure on the Eiss farm south of Humboldt, Nebraska. The unit is composed of two limestones and a shale; the upper limestone is a "honeycombed," massive rock. The shale is gray, and the lower limestone is a massive, gray rock. The thickness of the formation is five to seven feet.

Hooser Shale Member. This member was named for its outcrop just east of Hooser, Kansas, by Condra and Upp (1931). This member is varicolored with a thin argillaceous limestone near the center. The thickness of this shale is about eight or nine feet.

Middleburg Limestone Member. Condra and Upp (1931) named this member for its outcrop south of the Middleburg School, Richardson County, Nebraska. The Middleburg is three to five feet thick and is a massive, light buff colored limestone.

Easly Creek Shale Formation. The Easly Creek shale was named by Condra (1927) for its outcrop on Easly Creek, Richardson County, Nebraska. This varicolored shale contains several thin limestones. The thickness of this formation varies from 19 to 23 feet.

Crouse Limestone Formation. Heald (1916) named the Crouse limestone after exposures near Crouse Hill, Osage County, Oklahoma. The Crouse limestone is thin and platy in the upper part, but the lower part is massive. The unit, which weathers tan, is about seven to nine feet thick.

Blue Rapids. This formation was named for its outcrop north of Blue Rapids, Kansas, by Condra and Upp (1931). The shale is varicolored, gray, red, green, and buff, and about 18 to 20 feet thick.

Funston Limestone Formation. Condra and Upp (1931) named this formation for its outcrop at Camp Funston, Riley County, Kansas. The Funston, which makes a good outcrop, has a thin shale break near the middle. The upper limestone is fairly thin, while the lower is a tan, massive unit. The thickness of the Funston is about ten feet.

Speiser Shale Formation. The Speiser shale was named for its outcrop in Speiser Township, Richardson County, Nebraska, by Condra (1927). The shale has a one-foot thick limestone within two or three feet of the top. The upper shale is gray and is very highly fossiliferous. The lower shale is varicolored. The formation has a thickness of about 16 to 18 feet.

<u>Chase Group</u>. This is the uppermost group of Wolfcampian rocks and was named by Prosser (1895) for Chase County, Kansas. In the lower and middle parts of this group several chert-bearing limestones are found. The shales

tend to be red and green in color. The top of the Nolans limestone is the upper boundary of the group and the bottom boundary is the bottom of the Wreford limestone. Moore, and others (1944) defined the Chase group to extend from the Wreford limestone through the Nolans limestone formations.

Wreford Limestone Formation. Hay (1893) named this formation after its exposure at Wreford, Geary County, Kansas. The formation is composed of two limestones and one shale member.

Threemile Limestone Member. Condra and Upp (1931) named this member the Fourmile limestone. Moore (1936) changed the name to Threemile limestone. This limestone has a massive zone containing gray chert in the upper two-thirds. Below a thin shale break is a massive zone of limestone containing no chert. The thickness of the unit varies from 10 to 11 feet.

Havensville Shale Member. Condra and Upp (1931) named this shale for its exposures south of Havensville, Kansas. This member is composed of a buff shale and a reeflike limestone. At no place in the problem area is the outcrop good enough to measure the thickness of the reef. The reef is observed only in those areas where the Havensville and the top of the Threemile have been eroded. The reef material is only found lying on top of the non-cherty zone of the Threemile limestone. The total thickness of the Havensville is approximately 15 feet.

Schroyer Limestone Member. The Schroyer was named by Condra and Upp (1931) for its exposure near Schroyer, Marshall County, Kansas. The Schroyer is a massive chert-bearing limestone with a total thickness of about 12 to 14 feet. The upper two or three feet of the member contains no chert in the limestone.

Matfield Shale Formation. This formation was named for its outcrop in Matfield Township, Chase County, Kansas, by Prosser (1902). The Matfield shale is composed of two varicolored shales separated by a limestone member.

Wymore Shale Member. This member was named by Condra and Upp (1931) for exposures near Wymore, Gage County, Nebraska. This shale is a varicolored unit of about 20 to 22 feet in thickness.

Kinney Limestone Member. Condra and Upp (1931) named this member for exposures east of Kinney, Nebraska. The Kinney consists of two limestones separated by a thin shale. This member has a thickness of about five or six feet.

Blue Springs Shale Member. Condra and Upp (1931) named this shale for its outcrop southeast of Blue Springs, Gage County, Nebraska. The shale is varicolored and has a total thickness of approximately 33 feet.

Barneston Limestone Formation. This formation of two limestones that are separated by a thin shale member was named by Condra and Upp (1931) for its exposure west of Barneston, Gage County, Nebraska. The only member of this formation that is outcropping in the problem area is the Florence limestone.

Florence Limestone Member. Prosser (1895) named this member for Florence, Marion County, Kansas. The limestone is massive and contains many chert nodules. Only the lower five feet of this member's total thickness outcrops in the problem area.

## Quaternary System

Pleistocene. The Pleistocene has been mainly responsible for the topography of the area. The only Pleistocene deposit is the Sanborn formation.

The terrace deposits are very likely late Pleistocene and recent.

Sanborn Formation. Elias (1931) named this material for the deposits near Sanborn, Nebraska. This is a reddish-brown silt found on the upland divides. Nowhere in the problem area is it more than a few feet thick.

Terrace Deposits. The terrace deposits are found along Deep Creek and all of its tributaries. It is mostly silt and sand-size material and was stream deposited.

## STRUCTURE

### Regional Structures

Two major regional structures are present near the area of this investigation. They are the Nemaha anticline to the east and the Salina basin to the west (Plate III).

Nemaha Anticline. The Nemaha anticline is a regional structure to the east of the problem area. It extends from south of Oklahoma City, Oklahoma, north-northeast to a point near Omaha, Nebraska. Deformation started along this anticline in early Mississippian time, reached its peak at the end of Mississippian time, then continued intermittently through the Pennsylvanian and into the middle of Permian time (Lee, 1956). The subsurface expression of this fault has been mapped by Rieb (1954), Koons (1955), and Lee (1956).

Salina Basin. During early Mississippian time the North Kansas basin started to become divided by the Nemaha anticline, thus forming the Forest City basin on the east and the Salina basin on the west. Deformation continued at intervals until post-Cretaceous time. The Abilene anticline was formed in the post-Mississippian time (Lee, 1956).

## Local Structures

The local structures that are present near the area of investigation are the Abilene anticline, Irving syncline, and the Zeandale dome (Plate III).

Abilene Anticline. The Abilene anticline was formed at the same time as the surrounding structures during and after the post-Mississippian deformation. The subsurface of the anticline has been mapped by Koons (1955), Rieb (1954), Nelson (1952), and Lee (1956). The surface geology has been mapped by Merryman (1957) and Mendenhall (1958).

Irving Syncline. The Irving syncline found in Riley and Marshall counties is a synclinal fold east of the Abilene anticline and west of the Nemaha anticline (Jewett, 1951).

Zeandale Dome. The Zeandale dome is located in southeast Riley County. By the attitude of the rocks it appears that the crest of the dome is located a few miles southeast of Zeandale, Riley County, Kansas. The valley of Deep Creek is superimposed upon this dome. The extensive alluvium deposits in the valley make it difficult to observe the bedrock in many places (Jewett, 1941). The subsurface of this area has been mapped by Koons (1955). According to him (Koons) it is a northwest-southeast elongated dome that originally paralleled the Nemaha anticline. A short fault cuts the northern half changing the direction of elongation. The truncation of the dome on the north and east give it a chopped-off appearance. The dome has about 600 feet of closure.

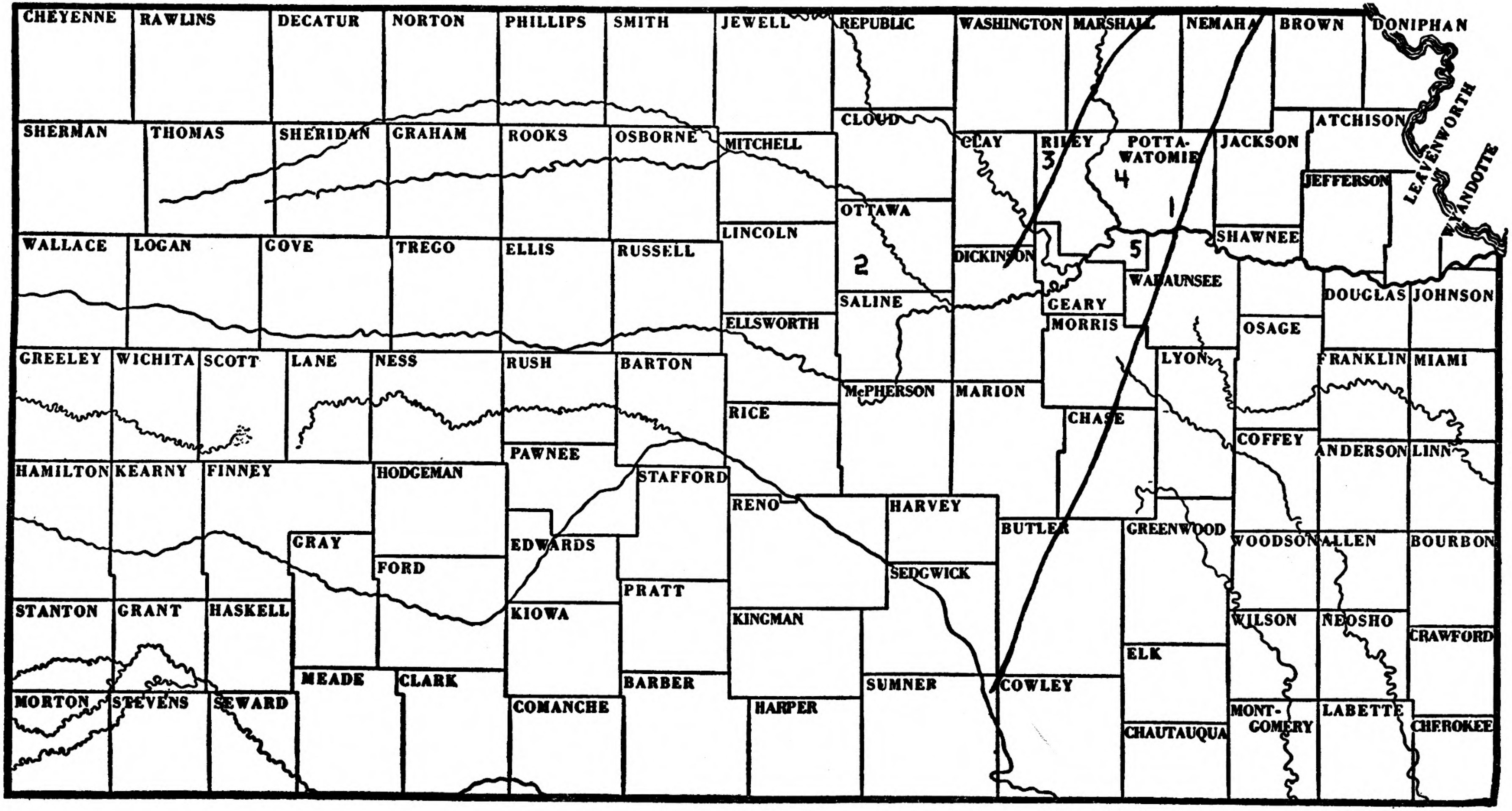
Surface Geology of the Zeandale Dome. The local structural dip in the problem area has a general trend to the southwest instead of the northwest as

## EXPLANATION OF PLATE III

Regional and local structures.

1. Nemaha Anticline
2. Salina Basin
3. Abilene Anticline
4. Irving Syncline
5. Zeandale Dome

PLATE III


CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTAWATOMIE
JACKSON
ATCHISON
JEFFERSON
LEAVENWORTH
WYANDOTTE
OTTAWA
LINCOLN
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
DICKINSON
SHAWNEE
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
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STAFFORD
RENO
HARVEY
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
GRAY
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the regional dip is in most of Riley County (Fig. 1, Appendix). The structural high is reached in the northeast corner of the area while the structural low is in the southwest corner. A difference of approximately 200 feet is found between the structural high and low. This is an average dip of 40 feet per mile, as compared with the average regional dip in the Manhattan area of 14 feet per mile. The average of 40 feet per mile is misleading, because there is not a continual even slope. Most of the dip occurs over a distance of slightly more than a mile; the dip in this distance is approximately 140 feet (Plate IV, Fig. 1).

The topographic high and low is almost the opposite of the structural high and low. The high is found in the southeast corner with an elevation of slightly more than 1520 feet; the low is in the northeast corner of the problem area and has an elevation of nearly 1050 feet. The topographic low is nearer the Kansas River and is in the valley of Deep Creek which is responsible for the erosion of the area. Deep Creek has been superimposed upon the Zeandale dome.

Seven normal faults with vertical displacement are found in the problem area. They vary in length from a half mile to approximately one and two-thirds miles. The maximum displacement of any of the faults is 25 feet. Five of the faults have their east side higher than the west, one has the west wall higher than the east (Plate IV, Fig. 2), and the seventh is a pivotal fault, having the east side higher at the south end and the west side higher at the north end. The displacement of these faults was determined by the use of a hand level and stadia rod. The strike was measured with a Brunton compass and was found to be northwesterly in direction. The strike of the faults is parallel to the structural contours on the pre-Cambrian granite in the basement complex. The pre-Cambrian granite was mapped by Nelson (1952). The structural elevation is approximately 100 feet higher on the east side of the fault zone than on the west. This is within the distance of a mile. South of the structural high the rocks have not been faulted but are steeply inclined while those on the west with slightly less difference in elevation have been faulted.

There is only one possibility of faulting controlling drainage in the area and that is on the South Branch of Deep Creek. This stream is the only one that is exactly parallel to an adjoining fault. It is possible that a fault is present because there are several feet of difference in the elevation of the Cottonwood limestone on the opposite sides of the stream. The east side is the higher, but it is impossible to tell whether the difference in elevation is due to faulting or dip across the valley.

As Neff (1949) discovered, the north-south jointing in the area of the faults is essentially parallel to the strike of the faults (Plate V, Fig. 1 and 2). The jointing adjacent to the faults is exactly parallel to the strike of the faults. It is probable that the joint system developed first in the area. Later when faulting occurred, it took place along the already developed joints. The main east-west joints are at $90^{\circ}$ angles to the main north-south joints.

Jointing was measured on different limestones in the same area at several points. Even though the lithology differed considerably in the limestones all measurements indicated no important variation due to lithologic causes (Neff, 1949).

## DISCUSSION

The faults in southeast Riley County, while having been described by Neff (1949) and Nelson (1952) who also attempted to determine their origin, have not been investigated extensively by others. Much work has been done with

EXPLANATION OF PLATE IV

Fig. 1. View of inclined strata, ink line on
Cottonwood limestone.
Sec. 18, T. 11S., R. 9E.

Fig. 2. Fault in Cottonwood limestone, with
west side higher than the east side.
Sec. 23, T. 11S., R. 8E.

PLATE IV

Fig. 1

Fig. 2

## EXPLANATION OF PLATE V

Fig. 1. Brunton compass on joints in Crouse limestone.
Compass reading on joint N 24°30'W
Located between two faults whose strike is
N 13°30'W and N 23°30'W.
Sec. 24, T. 11 S., R. 8 E.

Fig. 2. Brunton compass on joints in Crouse limestone.
Compass reading N 34°W
Located near a fault whose strike is
N 40°45'W.
Sec. 36, T. 11 S., R. 8 E.

PLATE V

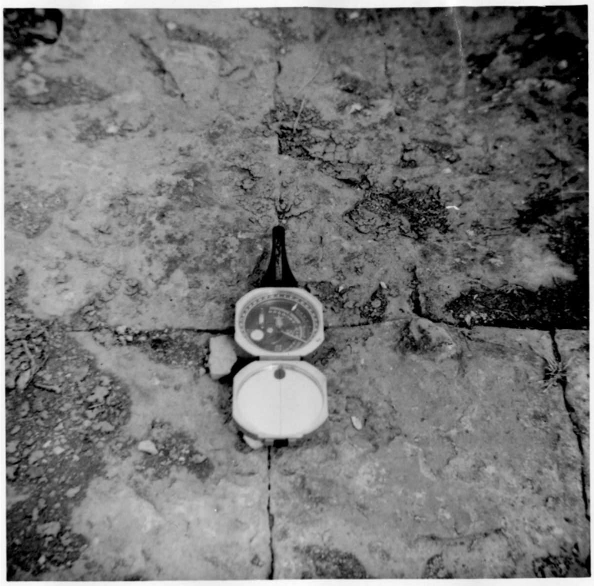

Fig. 1

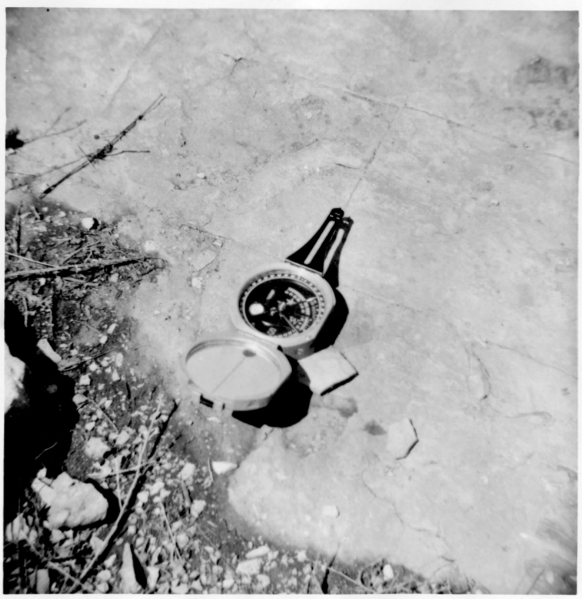

Fig. 2

similar faults on the east flank of the Nemaha anticline in Oklahoma. Sherrill (1929) has written a description of the faults in Oklahoma that coincides remarkably with a description of the faults here in Riley County.

> Most of the individual faults in any zone are approximately parallel and strike in a northwesterly direction. Few of them exceed three miles in length and most of them are nearer one mile. The throw, which is rarely more than 100 feet and generally nearer 50 feet, is commonly greatest near the center of the faults and diminishes towards the ends. The number of faults with the downthrow toward the southward seems to be about the same as the number with the downthrow in the opposite direction. In most of the faults some rotational movement between the opposing walls is present, and in a considerable number this has been carried to such an extent that a pivotal fault has resulted.

Moore (1918) and Powers (1922) expressed belief that lateral compression in the basement complex would cause faulting in the sedimentary strata above. This type of movement would very likely give thrust faults instead of vertical faults.

Horizontal slip along zones of weakness in the basement complex was the idea that Fath (1920) had for the origin of the faults in Oklahoma. This movement would cause fractures at about a $45^{\circ}$ angle from the main fault. An objection to this is that a source of horizontal stress would be needed, which very likely was not present in this area.

Nelson (1952) thought that the faults were caused by vertical uplift caused by the retreat of the glaciers toward the northeast, and by the deposition of material in the Salina basin to the west. It is doubtful if the glaciers' burden would have affected an area so far south as the problem area. If it had, the fault scarps of these faults should be much more prominent than they are since not too great a time, geologically speaking, has passed since the glaciers' retreat.

Gardner (1922) expressed his opinion that the vertical stresses present in the Mid-Continent area are the result of deep-seated rock flowage.

> It is believed that the local folds of the Mid-Continent oil fields are not the result of tangential pressure moving outward from an area of maximum lift, such as the Ozark and Arbuckle areas, but that these smaller folds are the result of the same pressure that produced the larger lift; that they are smaller expressions of the same thing and not secondary results; that they were probably coincident and represent areas of failure to withstand deforming forces, the components of which were essentially vertical.

Sherrill (1929) suggests that if brittle sedimentary rocks are subjected to torsion, breaks will be formed. If these forces are such as to move the northeast and southwest areas downward in respect to the southeast and northwest, then a twisting occurs that will form fractures with a general northwesterly direction. If uplift occurred during this time adding to the stresses, faults should occur in an en echelon fashion.

Tensile stresses developed by settling basins has been proposed by McCoy (1921) as the possible origin for the en echelon faults in Oklahoma. As the sediments compacted, tension developed over the high creating breaks. Later sediments draped over these faults with high dips. These too would fault as time passed.

A theory for the origin of domes was that of differential compaction by Blackwelder (1920). The weight of overlying beds more or less compresses vertically the sediments below in proportion to the weight of the overlying beds. This compaction varies in amount among clay, sands, and other types of sediments. If this compaction were to take place over buried hills or ridges, faulting could occur as the thickness of the rocks varied.

Neff (1949) makes the statement about the faults in the problem area that:

> In Riley County many of the normal faults appear to die out upward and some of them appear to die out with depth. The throw of the largest fault is greatest in the Cottonwood and begins to lessen in the Neva limestone. No faulting was found below the

> Howe limestone. None of the normal faults in the southeast part of the county can be traced upward beyond the Funston limestone. This would indicate a peculiar stratigraphic zonal selectivity....

There are several erroneous facts stated here. First, as well as could be observed, there was no evidence of the faults dying out upward or with depth. The lowest rock unit that outcropped in the fault zone exhibited 22 feet of displacement; the highest rock unit had a displacement of 17 feet. Secondly, faulting was noted as high as the Threemile limestone and as low as the Long Creek limestone. The fact that the maximum displacement of 25 feet occurred in the Cottonwood and then lessened in the Neva limestone appears to have been a mere happenstance.

It would seem that thinning of beds should occur over the Zeandale dome in order to support the settling basin and compaction of beds theories. It is entirely possible that it occurs, but the outcrops that extend up over the more steeply dipping area are eroded away higher up, and it is impossible to observe whether there is measurable thinning or not.

## CONCLUSION

No one theory can explain the origin of the faults in southeast Riley County. It must be a combination of several forces, all of which act in a vertical direction. Following is a list of the possible components which are believed to have caused the faults: (1) Intermittent uplift and deformation are associated with the Zeandale dome. Lee (1956) wrote that deformation was taking place at intervals on the east edge of the Salina basin until the middle of Permian time. This would account for the time of the faulting which was post-Wolfcampian. (2) The differential compaction of sediments especially the shales could vary a great deal over granite ridges. If the shales compacted no more than 10 per cent, and if a ridge was 200 feet high, a difference of 20 feet would occur. (3) Granite ridges bounded by ancient faults in the basement complex could, by rotation, cause faulting in the surface rocks.

A combination of the three above while working separately might not produce the en echelon type faults present in southeast Riley County, but working together and coincidentally, it is very plausible that they could produce just such structures.

## ACKNOWLEDGMENT

The writer wishes to thank Dr. J. R. Chelikowsky for his assistance in the selection of the problem area, in procuring the base map, in the preparation of this manuscript, and for his personal advice.

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# APPENDIX

Fig. 1. Structure Contour Map of the Deep Creek Area, Riley County, Kansas

CHAMPION CLASP No. 55 6x9

# STRUCTURE CONTOUR MAP OF THE DEEP CREEK AREA, RILEY COUNTY KANSAS

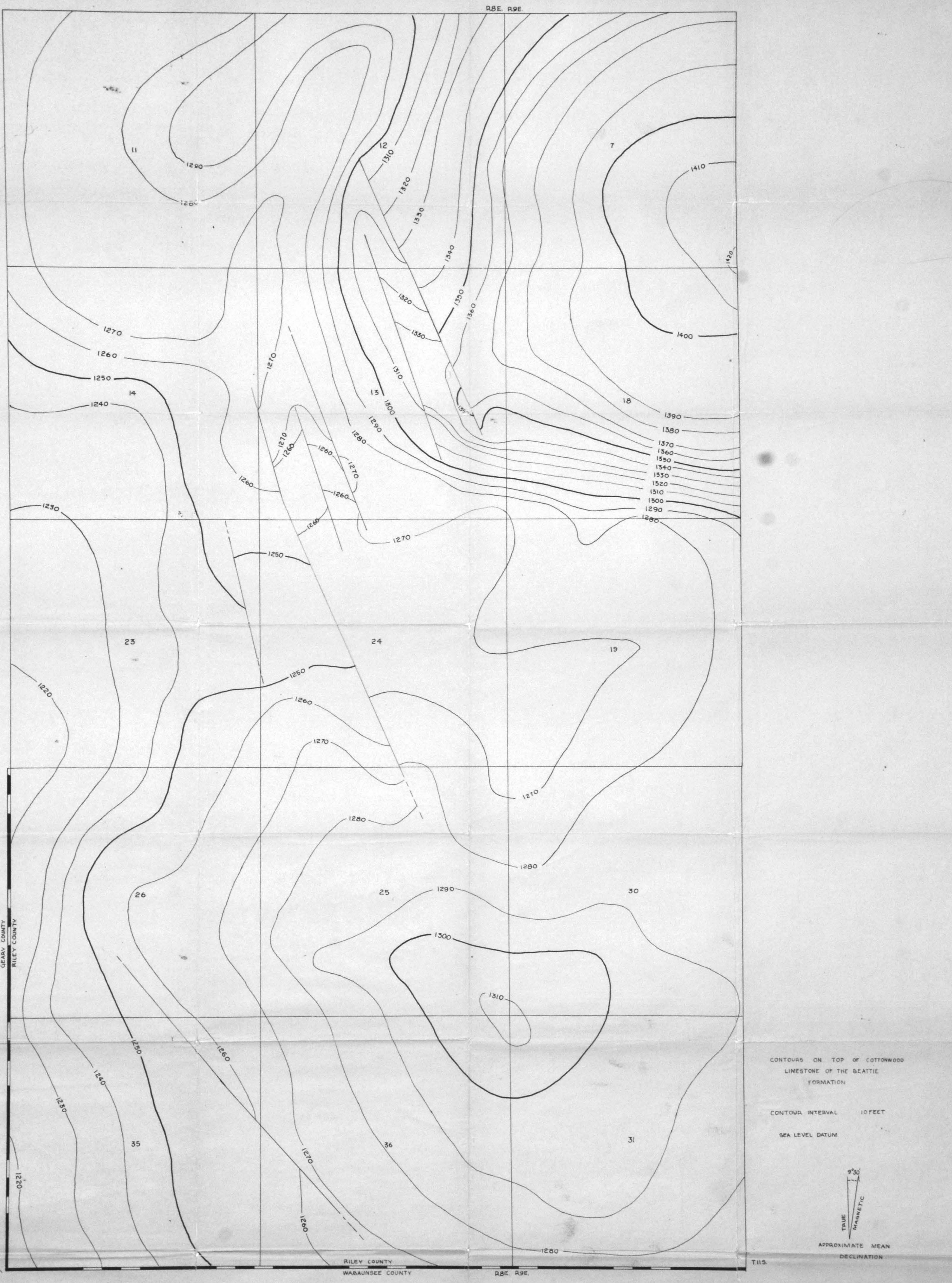


FIG. I.

ROGER L. BRUTON 1958

Fig. 2. A Geologic Map of the Deep Creek Area, Riley County, Kansas

CHAMPION CLASP No. 55 6x9

# A GEOLOGIC MAP OF THE DEEP CREEK AREA
# RILEY COUNTY, KANSAS

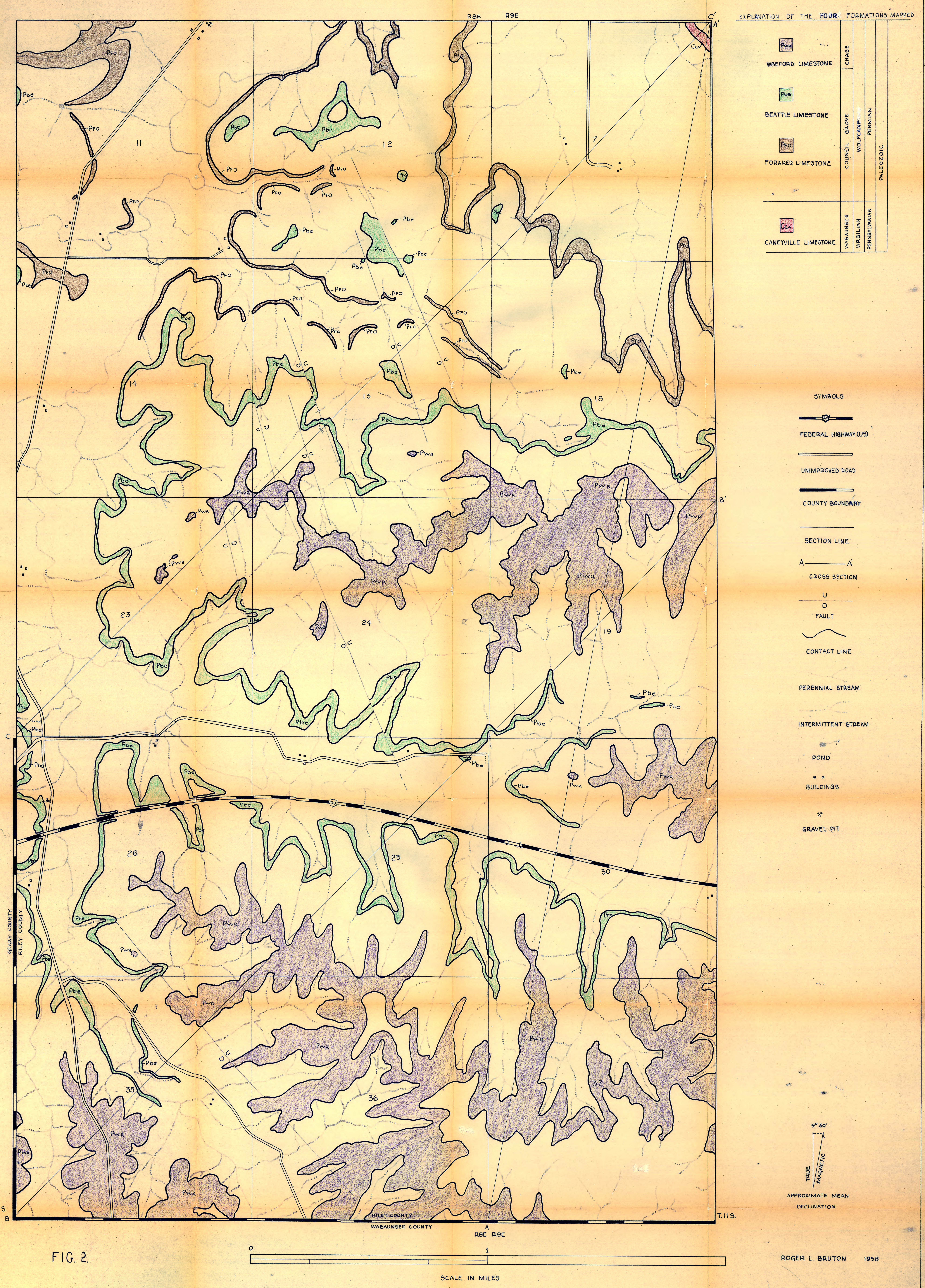


FIG. 2.

ROGER L. BRUTON 1958

Fig. 3. Structure Cross Sections

CHAMPION CLASP NO. 55 6X9

# STRUCTURE CROSS-SECTION


EXPLANATION OF STRATIGRAPHY
FOUND ON PLATE II

SCALE

HORIZONTAL 1" = 800'-0"

VERTICAL 1" = 120'-0"

FAULT MOVEMENT ↓↑

FIG. 3.

Roger L. Bruton 1958

# THE GEOLOGY OF A FAULT AREA IN SOUTHEAST RILEY COUNTY, KANSAS

by

ROGER LEE BRUTON

B. S. Kansas State College
of Agriculture and Applied Science, 1957

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AN ABSTRACT OF THE 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

1958

This investigation covers an area of 15 square miles in southeast Riley County, Kansas. The western border of the area is two miles east of the intersection of highways K 13 and US 40 south-southeast of Manhattan, Kansas. A few miles northeast of the problem area is the crest of the Zeandale dome, an uplift on the Nemaha anticline. Steeply tilted strata and normal faults are believed to be the surface expression of the flank of the dome.

There are seven faults in the problem area, and the purpose of this investigation was to (1) make a geologic map of the area, (2) determine the origin of the faults. The length of these vary from one-half mile to one and two-thirds miles, and the maximum displacement is 25 feet. Six of these faults are within one mile of each other and seem to be of the en echelon type. The seventh fault is a mile south of the six and has a slightly different strike.

The faults seem to be of the same type and possibly of the same origin as similar faults in Oklahoma. The faults in Oklahoma are located on the east flank of the Nemaha anticline. Geologists have written many and varied possibilities as to the origin of the faults in Oklahoma.

The strike of the faults is parallel to the structural contours on the pre-Cambrian granite in the basement complex. The jointing near the faults is essentially parallel to the strike of the faults and has a vertical dip as do the faults. The main joints occur at 90° angles.

In the problem area the stratigraphy was identified and measured, and then elevations were obtained by use of the plane table and alidade. Using this data a map of rock outcrops was made, in addition to a contour map on top of the Cottonwood limestone, and three cross sections of the area.

The outcropping rocks are all of sedimentary origin ranging in age from the Wabaunsee group of the Pennsylvanian system to the Wolfcampian group of the Permian system.

It is believed that the faults were caused by three things acting together and coincidentally: First, intermittent uplift; second, differential compaction of sediments; third, granite ridges rotated in the basement complex by faulting.