KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 78-10

THE HUMBOLDT FAULT-POTTAWATOMIE COUNTY, KANSAS, PRECAMBRIAN TO PRESETN

by

Ali Seyrafian

Disclaimer

The Kansas Geological Survey does not guarantee this document to be free from errors or inaccuracies and disclaims any responsibility or liability for interpretations based on data used in the production of this document or decisions based thereon. This report is intended to make results of research available at the earliest possible date, but is not intended to constitute final or formal publications.

Kansas Geological Survey
1930 Constant Avenue
University of Kansas
Lawrence, KS 66047-3726

KGS
OF
78-10

THE HUMBOLDT FAULT-POTTAWATOMIE COUNTY, KANSAS, PRECAMBRIAN TO PRESENT

by

Ali Seyrafian
B. S., University of Tehran, Iran, 1971
M. S., Fort Hays Kansas State College, 1975

Submitted to the Department of Geology and the Faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Science.

Chairman

Committee Members

For the Department

ABSTRACT

Contours on the Precambrian surface and subsurface lithologic and stratigraphic correlation of the Lower and Middle Paleozoic rocks in Pottawatomie County, Kansas, reveal two distinctive northeast-southwest oriented zones of displacement along the east flank of the Nemaha Anticline; they join at the northeast corner of the study area. The major displacement occurs along the eastern zone that correlates with the trace of the Humboldt Fault.

Near surface and surface Permian-Pennsylvanian strata dip four to five degrees to the southeast in the vicinity of the subsurface faults but show no evidence of faulting. Although the main channel of Vermillion Creek parallels the trend of the subsurface Humboldt Fault, detailed stratigraphic and lithologic correlations across, and in vicinity of, Vermillion Creek reveal no evidence of displacement. However, the elongated, relatively straight pattern of drainage network of the area may suggest the possible occurrence of wrench-faulting in the subsurface.

The east flank of the Nemaha Anticline was subjected to intensive tectonic movement resulting in subsurface faulting in Late Silurian or Early Devonian through Mississippian times. The gentle dip of Upper Pennsylvanian and Lower Permian strata in vicinity of the subsurface faults near and at the surface suggest that movement along the east flank of the Nemaha Anticline continued but with a very low intensity, causing only develpment of gentle folding of the units overlying the subsurface Humboldt Fault.

ACKNOWLEDGEMENTS

This study of surface and subsurface structure and movement along the east flank of the Nemaha Anticline in Pottawatomie County was supervised by Dr. Louis F. Dellwig and Mr. Frank W. Wilson of Kansas Geological Survey, who accompanied the author in the field on several occasions, critically read the manuscript, and made numerous suggestions throughout the study. Dr. Marion E. Bickford critically read the manuscript and made helpful suggestions. Dr. James R. McCauley and Mr. Richard Young of Kansas Geological Survey helped with field work. The Kansas Geological Survey provided field transportation to the field and well logs.

TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGEMENTS	iii
LIST OF TABLES	v
LIST OF ILLUSTRATIONS	vi
INTRODUCTION	1
RECENT INVESTIGATIONS	1
PROCEDURES	4
STRUCTURAL FEATURES	5
GEOLOGIC AND STRUCTURAL HISTORY	6
STRATIGRAPHY	7
Precambrian Rocks	7
Paleozoic Rocks	7
Cambrian-Ordovician Rocks	8
Silurian-Devonian Rocks	8
Mississippian Rocks	8
Pennsylvanian Rocks	9
Permian Rocks	10
Quaternary Sediments	13
SUBSURFACE STRUCTURE	13
Evidence provided from logs of deep wells	16
Evidence provided from shallow seismic electric logs	26
SURFACE STRUCTURE	27
Surface Fault(s)	37
Nature of the surface structures	38
SUMMARY	41
REFERENCES CITED	43

LIST OF TABLES

		Page
1	Location of the available wells in the area of investigation	14
2	Simplified subdivisions of Paleozoic units used in this study	15

LIST OF ILLUSTRATIONS

		Page
1	Geologic environment of the Humboldt Fault	2
2	Location of the study area	3
3	Permian-Pennsylvanian rocks exposed at the area of investigation	12
4	Contours on Precambrian surface in the study area ..	18
5	Subsurface stratigraphic cross-section in the northeast corner of study area (A-A')	19
6	Three-dimensional diagram showing subsurface units of Paleozoic rocks	21
7A	Subsurface stratigraphic cross-section in southwest corner of area (B-B')	23
7B	The same as 7A	24
8	Diagram showing repeated section of Simpson Group ..	25
9	Index map of shallow seismic traverses and east-west cross-section (C-C')	28
10	East-west stratigraphic cross-section (D-D')	29
11	North-south stratigraphic cross-section (E-E')	30
12	Stratigraphic cross-section (F-F')	31
13	Geologic map of an area one mile southeast of Onaga	33
14	Stratigraphic cross-section through Wabaunsee Group (G-G')	34
15	Stratigraphic cross-section (H-H')	36
16	Stratigraphic cross-section (I-I')	37
17	Stream patterns in the area of investigation	40

INTRODUCTION

Subsurface and even surface faulting along the east flank of the Table Rock Anticline or Nemaha Anticline has been reported by Condra (1927), Lee (1943), Jewett (1951), Kotoyantz (1956), and Merriam (1963). Condra (1927) first named and described the structure in Nebraska as the "Humboldt Fault-the steep dip of the beds on the east flank of the Table Rock Anticline passes into a fault at places. The maximum displacement is just northwest of Humboldt where there is an up-throw of more than 100 feet on the west." Condra and Reed (1943) showed the fault extending into Kansas and indicated intermittent exposure of faulting along the east flank of the Nemaha Anticline throughout much of its length in Kansas (Fig. 1).

The purposes of this research were to study the Humboldt Fault both in the subsurface and at the surface in Pottawatomie County, Kansas. Also to be determined was the correlation between subsurface and surface structure along a zone in which movement along the Humboldt Fault might be expected to have an influence on the structure of the overlying sedimentary rocks. Finally, I wished to determine the time of most recent movement along this trend.

This investigation was confined to an area trending northeast-southwest in Pottawatomie County, Kansas, on the east flank of the Nemaha Anticline along the eastern margin of the Flint Hills (Fig. 2).

RECENT INVESTIGATIONS

Koons (1956) described displacement in the subsurface rocks along the Nemaha trend ranging from 945 m (3100 feet) in Nemaha

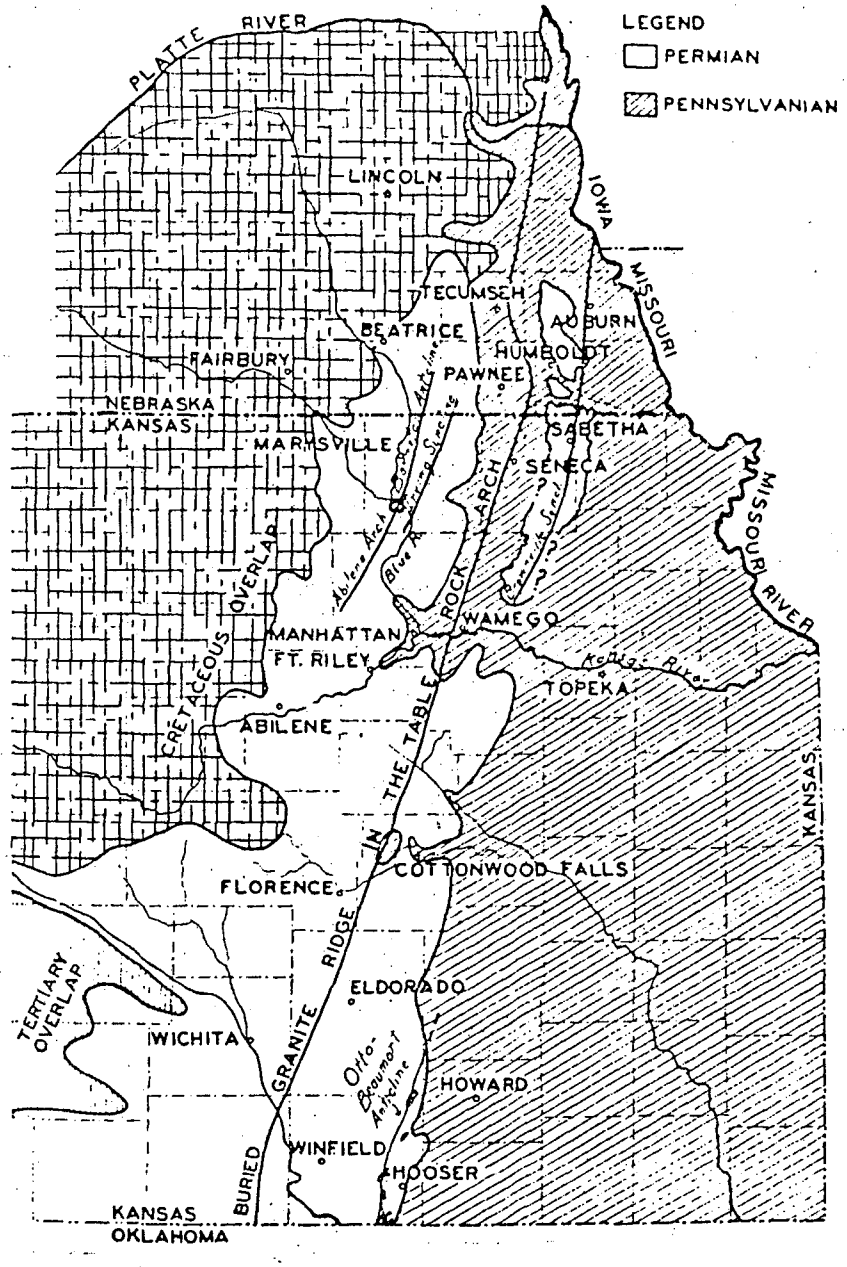


Fig. 1. The geologic environment of the Humboldt Fault. (After Condra and Reed, 1943).

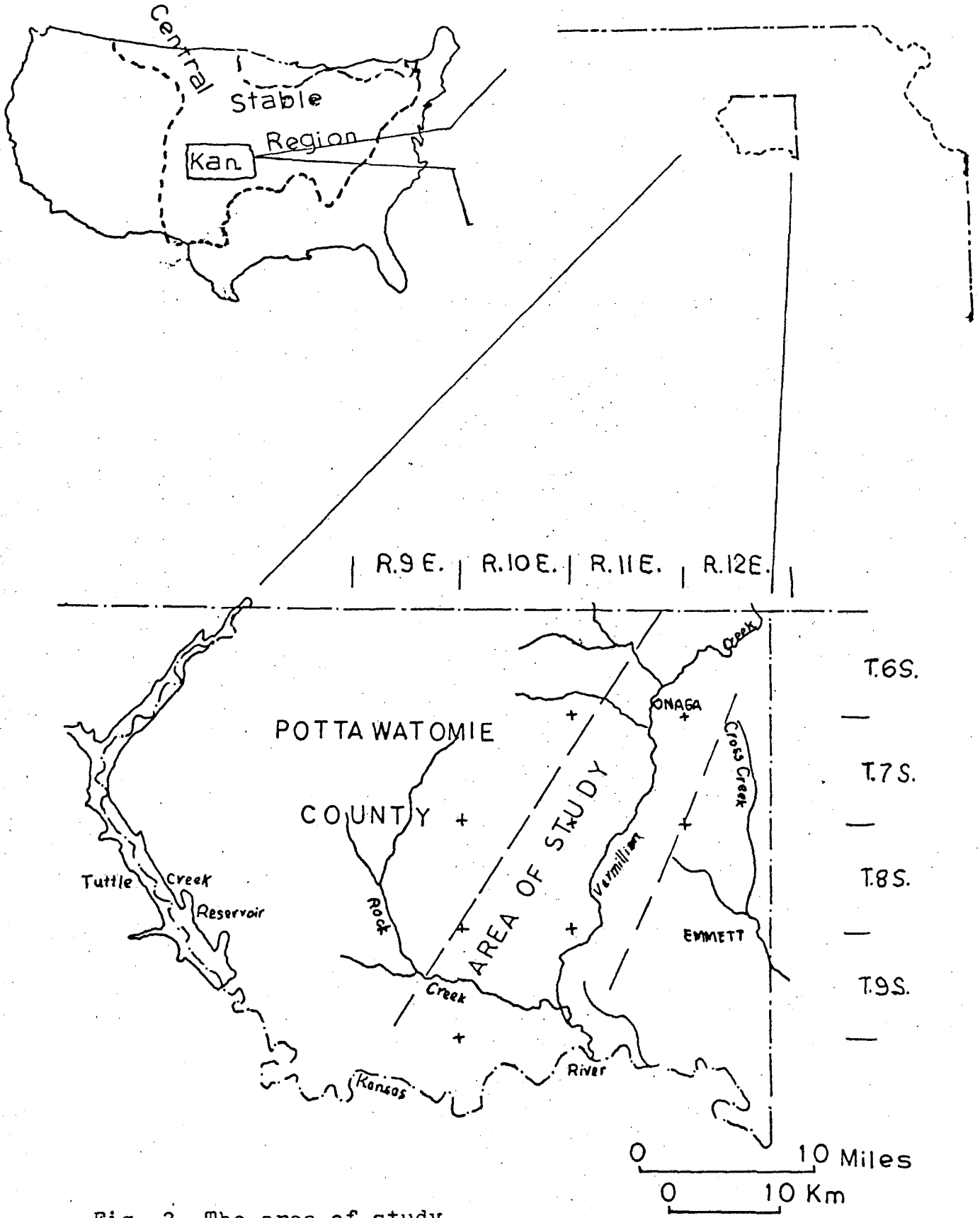


Fig. 2. The area of study.

County to 259 m (850 feet) in Chase County, and assumed that this displacement occurred as late as post-Mississippian time throughout the entire length of the Nemaha Anticline. However, he concluded that a fault origin for this displacement is inferential and not proved beyond doubt.

Ratcliff (1957) studied the surface structure in the extreme northeast part of the Pottawatomie County, Kansas. He concluded that: 1) The Humboldt Fault is visible at the surface and represents the last major structural movement of the east flank of the Nemaha Anticline, this occurring as early as post-Wolfcampian time. 2) The fault has a vertical displacement of slightly over 30.48 m (100 feet) with the up-thrown side on the west. 3) The fault strikes north 20 degrees east (N 20° E) and parallels the crest of the Nemaha Anticline.

König (1971) constructed a magnetic profile across the Nemaha Anticline and adjusted that profile to the configuration of the Precambrian basement. He showed that two normal faults are present in the Precambrian rocks and both are up-thrown on the west but differ in amount of displacement. It is the eastern of the two faults that is associated with the major displacement of the rocks on the east flank of the Nemaha Anticline.

PROCEDURES

Available logs of deep and shallow wells were used to define the subsurface distribution of the Paleozoic rocks through the problem area. These well logs are filed at the Kansas Geological

Survey in Lawrence and at the Well Sample Library and Kansas Geological Society Library in Wichita.

Detailed observation of aerial photos and study of the stream patterns both on photos and topographic sheets of the area of investigation were conducted. Stream patterns could be controlled by the fault and indicate time and place of most recent movement. Field work was done to locate and correlate exposed sedimentary strata. Sections were measured carefully and the strike and dip of the strata were recorded. The area had been mapped by Scott, et. al. (1949), and this aided in recognition of the rock units.

STRUCTURAL FEATURES

The most prominent subsurface feature in this area is the Nemaha Anticline. The anticline, underlain by Precambrian rocks, is named for Nemaha County, Kansas (Lee, 1943). It extends across the entire state of Kansas in a general direction of S 20° W. The Nemaha Anticline exhibits an asymmetrical cross-section with a much steeper side to the east.

The steep eastward-dipping sediments which constitute the west flank of the Forest City Basin are cut by the fault. The Forest City Basin extends from northeastern Kansas into southern Nebraska, Missouri, and Iowa. It is an asymmetrical basin with the deepest part on the west, adjacent to the subsurface Humboldt Fault.

GEOLOGIC AND STRUCTURAL HISTORY

The area under investigation is part of a large tectonic province of North America called Central Stable Region (Moss, 1936). Prior to accumulation of the Paleozoic rocks, the surface of the Precambrian basement underwent extensive erosion. Subsequently Pottawatomie County and adjacent areas were the site of deposition of rocks ranging from Cambrian to Permian age. Periods of erosion, folding, and faulting occurred at intervals throughout the Paleozoic. During Late Cambrian and Early Ordovician time a marine environment prevailed in the area and marine sediments were deposited. At the end of this period a major structural movement associated with extensive erosion occurred (Lee, 1956). The erosion is documented in the subsurface by the weathered surface of the Arbukle Limestone of Cambrian-Ordovician age. As a result of this structural movement Pottawatomie County and adjacent areas were subjected to general uplift (Jewett and Merriam, 1956).

The rise of Nemaha Anticline was initiated in the Early Mississippian and culminated at the end of this period. During this time major extensive erosion occurred. The erosion is revealed in the subsurface by the weathered surface of the Mississippian Chattanooga Shale. Movement continued through the Middle Permian but with less magnitude than in previous time.

According to Lee (1943), regional tilting and erosion were two major processes active during Mesozoic time. Westward tilting of the Permian-Pennsylvanian rocks occurred during pre-Cretaceous time. No rocks of Mesozoic age are present in Pottawatomie County.

Tilting and erosion continued through the Tertiary period and the present eastward slope of the surface rocks developing during that period (Jewett and Merriam, 1959).

During the Quaternary, Kansan glaciation extended as far south as the Kansas River and as far west as the Big Blue River (Frye and Leonard, 1952), forming the thick deposits of glacial drift which to a large degree mask the bedrocks.

STRATIGRAPHY

Precambrian Rocks.

Buried Precambrian rocks in the area of investigation consist predominantly of granite with minor metamorphic rocks (Merriam, Cole, and Hambleton, 1961). The shallowest known Precambrian rocks in the study area occurs in SE SE SW, Sec. 29, T. 8 S., R. 10 E., where the basement surface rises to 0.304 m (one foot) above sea level at a depth of 351.5 m (1153 feet); the deepest occurrence is in NE NW SW, Sec. 29, T. 8 S., R. 12 E., where the basement is 713.4 m (2340 feet) below sea level (1058 m or 3470 feet below the surface).

Paleozoic Rocks.

The Paleozoic sedimentary sequence consists of a number of rock units which are essentially horizontal and parallel to one another. Paleozoic rocks in the study area are nonconformable on the Precambrian basement rocks and are overlain unconformably by Quaternary sediments of Cenozoic. Within the Paleozoic, major unconformities occur between Upper Pennsylvanian and Mississippian

rocks and Mississippian-Devonian units from the older Paleozoic rocks. The Paleozoic rocks mainly occur in the subsurface. Exposed units range in age from Pennsylvanian to Permian in addition to the Quaternary deposits. The Paleozoic rocks include marine limestone, dolomite, shale, and sandstone. Minor coal beds, black shale, and evaporites are also present in the cyclothemic Permian-Pennsylvanian rocks. Thickness of the Paleozoic rocks in the study area range from 314 m (1030 feet) in SE SE SW, Sec. 15, T. 8 S., R. 10 E., Where the Cambrian-Ordovician age Simpson Group is overlain by Pennsylvanian Kansas City Group, to the maximum thickness of 701.2 m (2300 feet) in NE NW SW, Sec. 29, T. 8 S., R. 12 E., where almost all representative Paleozoic strata are present.

Cambrian-Ordovician Rocks. The Cambrian-Ordovician rocks nonconformably overlie the Precambrian basement complex. They consist mainly of dolomite but contain some limestone, and shale. The thickness of these rocks range from a few meters up to 426.6 m (1400 feet).

Silurian-Devonian Rocks. Rocks of Silurian-Devonian age are predominantly composed of limestone and dolomite. These rocks lie unconformably below the Mississippian and unconformably on Ordovician deposits. The term "Hunton Group" refers to these undifferentiated deposits. The thickness of the Hunton Group ranges from 47.5 m (150 feet) to almost 182.9 m (600 feet).

Mississippian Rocks. The lower Mississippian rocks consist of a sequence of shale ("Kinderhook Shale") which is overlain by a limestone sequence. Mississippian rocks are completely absent on

west side of the faults that parallel the east flank of the Nemaha Anticline (Fig. 6). The thickness of the Mississippian rocks attains a maximum of 128 m (420 feet) on the east side of this trend.

Pennsylvanian Rocks. In the area of study the Pennsylvanian rocks cover sediments unconformably and are in graditional contact with Permian deposits. Lower and Middle Pennsylvanian deposits are absent at the crest of the Nemaha Anticline, having been eroded during uplift and erosion. The Pennsylvanian deposits are formed under cyclic conditions; each cycle consist of marine limestone and shale, alternating with nonmarine clastic deposits (Lee, 1954).

The Upper Pennsylvanian Wabaunsee Group is the only Pennsylvanian deposit that crops out in Pottawatomie County. It is exposed parallel to the crest of the Nemaha Anticline along the northern tributaries of Vermillion Creek. The thickness of the Pennsylvanian rocks range from about 244 m (800 feet) to some 609 m (2000 feet).

The Wabaunsee Group contains shale with interbedded thin limestones, local sandstone lenses and thin coal beds. Most of the shale units are similar and are mainly characterized by gray to tan-gray limonitic shale. Generally associated are one or more thin-bedded silty or sandy variegated shales interbedded with layers of tan or gray sandy limestone. The limestones are light gray to brownish in color, slightly crystalline, blocky to thin bedded. Some, including the Tarkio, Maple Hill, and Dover Limestones, show a great concentration of fusulinids. Thickness, location in the sequence, fossils, and lithology are the major characteristics

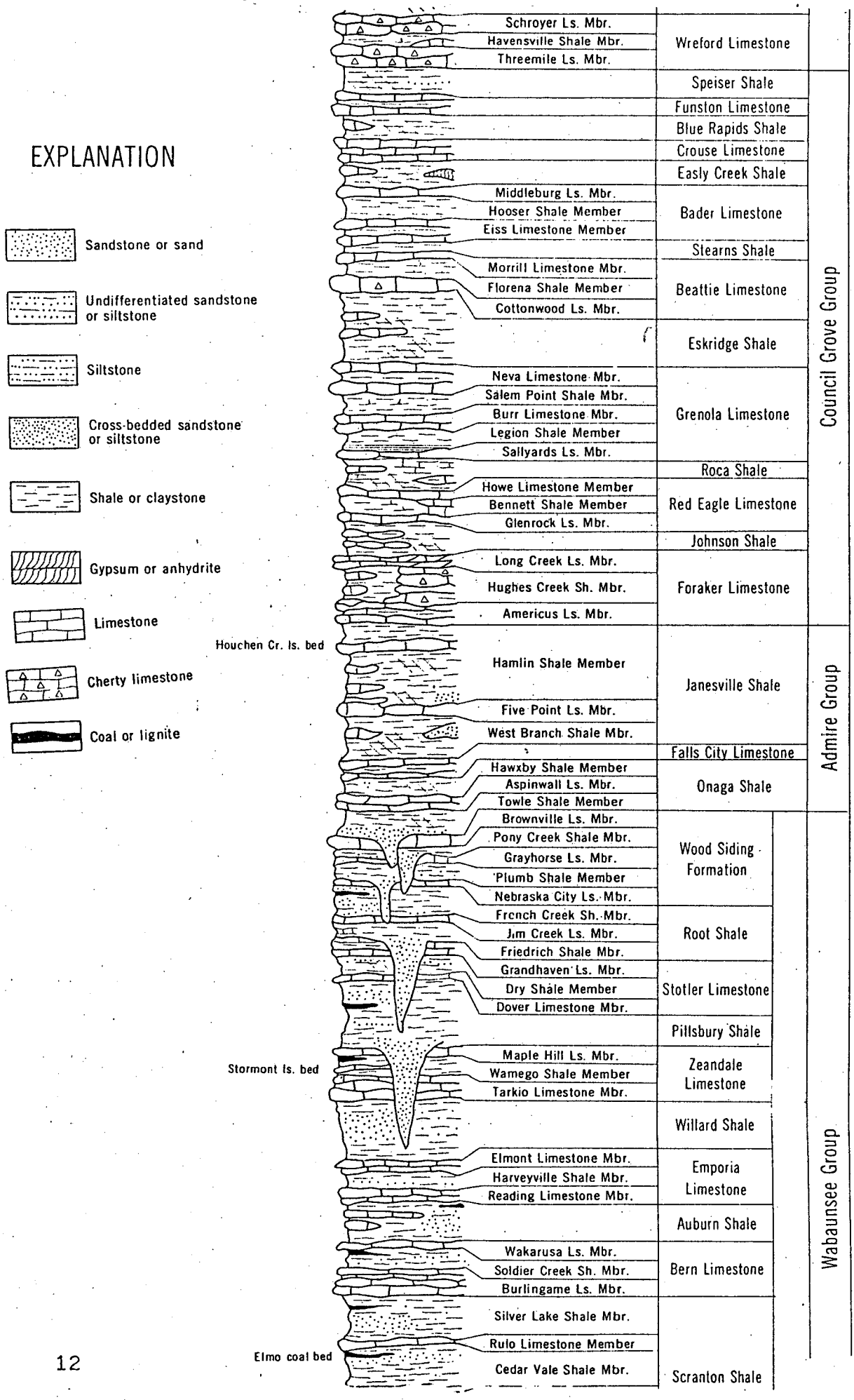
for identification of the various units of the Wabaunsee Group. Channel sandstones are abundant in almost all shale units (Mudge, 1956). The thickness of the Wabaunsee Group ranges from 76 to 152 m (250 to 500 feet). It is thinner at the crest of the Nemaha Anticline than to the west of this trend (Merriam, 1963). The most distinctive limestone units that are present in this area are: Reading Limestone Member of Emporia Limestone, Tarkio and Maple Hill Limestone Members of Zeandale Limestone, and Dover Limestone Member of Stotler Limestone.

Permian Rocks. The only Permian deposits that are present in Pottawatomie County are of the Wolfcampian Series and belong to the following three groups (in ascending order): Admire, Council Grove, and Chase. Their thickness is about 244 m (800 feet) collectively. Lower Permian rocks formed under conditions similar to those of the Upper Pennsylvanian deposits described earlier. Thus, alternating shale and limestone are expected as a common feature in Wolfcampian Series.

The Admire Group is composed of shale but includes some limestone beds. The Fall City and Five Point Limestones are recognized both in logs and surface.

The Council Grove Group underlies the Chase Group and conformably overlies the Admire Group. Like the Admire Group it consists chiefly of shale but the limestones are relatively thicker. The limestone units contain chert and varicolored shale units. The most distinctive limestone units that are present in the study area are: Cottonwood Limestone Member of Beattie Limestone, Neva

Fig. 3. The Permian-Pennsylvanian rocks exposed in the area of investigation. (From Kansas Geol. Survey Bull. 189, Plate 1).


EXPLANATION
Sandstone or sand
Undifferentiated sandstone or siltstone
Siltstone
Cross-bedded sandstone or siltstone
Shale or claystone
Gypsum or anhydrite
Limestone
Cherty limestone
Coal or lignite
Houchen Cr. ls. bed
Stormont ls. bed
Elmo coal bed
Schroyer Ls. Mbr.
Havensville Shale Mbr.
Threemile Ls. Mbr.
Wreford Limestone
Speiser Shale
Funston Limestone
Blue Rapids Shale
Crouse Limestone
Easly Creek Shale
Middleburg Ls. Mbr.
Hooser Shale Member
Eiss Limestone Member
Bader Limestone
Stearns Shale
Morrill Limestone Mbr.
Florena Shale Member
Cottonwood Ls. Mbr.
Beattie Limestone
Eskridge Shale
Neva Limestone Mbr.
Salem Point Shale Mbr.
Burr Limestone Mbr.
Legion Shale Member
Sallyards Ls. Mbr.
Grenola Limestone
Roca Shale
Howe Limestone Member
Bennett Shale Member
Glenrock Ls. Mbr.
Red Eagle Limestone
Johnson Shale
Long Creek Ls. Mbr.
Hughes Creek Sh. Mbr.
Americus Ls. Mbr.
Foraker Limestone
Hamlin Shale Member
Five Point Ls. Mbr.
West Branch Shale Mbr.
Janesville Shale
Falls City Limestone
Hawxby Shale Member
Aspinwall Ls. Mbr.
Towle Shale Member
Onaga Shale
Brownville Ls. Mbr.
Pony Creek Shale Mbr.
Grayhorse Ls. Mbr.
Plumb Shale Member
Nebraska City Ls. Mbr.
Wood Siding Formation
French Creek Sh. Mbr.
Jim Creek Ls. Mbr.
Friedrich Shale Mbr.
Root Shale
Grandhaven Ls. Mbr.
Dry Shale Member
Dover Limestone Mbr.
Stotler Limestone
Pillsbury Shale
Maple Hill Ls. Mbr.
Wamego Shale Member
Tarkio Limestone Mbr.
Zeandale Limestone
Willard Shale
Elmont Limestone Mbr.
Harveyville Shale Mbr.
Reading Limestone Mbr.
Emporia Limestone
Auburn Shale
Wakarusa Ls. Mbr.
Soldier Creek Sh. Mbr.
Burlingame Ls. Mbr.
Bern Limestone
Silver Lake Shale Mbr.
Rulo Limestone Member
Cedar Vale Shale Mbr.
Scranton Shale
Council Grove Group
Admire Group
Wabaunsee Group

Limestone Member of Grenola Limestone, and Americus Limestone Member of Foraker Limestone.

The Threemile Limestone Member of Wreford Limestone is the distinctive limestone unit of the Chase Group present in the area of study. The Threemile Limestone is composed of 1.8 m (six feet) of cherty limestone with a massive, non-cherty zone in the middle. Figure 3, shows the Permian-Pennsylvanian rocks exposed in the study area. For detailed lithologic and stratigraphic characteristics of these units the reader is referred to Scott, et. al. (1949).

Quaternary Sediments. Glacial deposits and alluvium are the major Quaternary deposits. Glacial deposits were laid down during Kansan glaciation (Frye and Leonard, 1952), and attain a maximum thickness of 30.4 m (100 feet).

SUBSURFACE STRUCTURE

The determination of the nature of the subsurface structure and types and age of subsurface movement in the problem area has been based on:

1. Precambrian surface configuration.
2. Three dimensional isopachous maps.
3. Cross-sections based on surface and subsurface data.

The information concerning the nature of the subsurface structure is basically available from electric well logs. Table 1 and 2, show the location of the available wells in the study area, and the generalized subdivisions of the Paleozoic column used in this study.

Table 1. Location of wells used in this study.

NE	NE	NW	S 8-T6S-R10E
C	SW	NW	S34-T6S-R11E
NE	SW	SE	S 1-T6S-R12E
SW	NE	NW	S14-T7S-R10E
SW	SW	NW	S17-T7S-R10E
C	NW	SE	S25-T7S-R10E
C	NE	NE	S28-T7S-R10E
NW	NW	SE	S12-T7S-R11E
NW	NW	SW	S19-T7S-R11E
C	NE	NE	S 6-T7S-R12E
SE	NE	SE	S 9-T7S-R12E
N2	SE	SE	S 9-T7S-R12E
SE	SE	SE	S 9-T7S-R12E
SE	NW	SE	S 9-T7S-R12E
SW	NE	SW	S10-T7S-R12E
W2	W2	SW	S10-T7S-R12E
NE	SW	NE	S16-T7S-R12E
NW	NW	NW	S15-T7S-R12E
C	SW	SW	S36-T7S-R12E
SW	SW	SW	S 6-T8S-R 9E
NW	NW	SE	S22-T8S-R 9E
C	NE	SW	S32-T8S-R 9E
SW	SE	SE	S 1-T8S-R10R
NW	SE	NW	S10-T8S-R10R
SE	SE	NW	S13-T8S-R10E
SE	SE	SW	S15-T8S-R10E
SW	SE	SE	S23-T8S-R10E
SW	NW	SE	S26-T8S-R10E
C	NE	NW	S26-T8S-R10E
C	SE	NE	S30-T8S-R10E
NE	NE	SE	S14-T8S-R11E
C	NW	SE	S20-T8S-R11E
C	NW	NE	S26-T8S-R11E
N2	NE	NW	S28-T8S-R11E
NW	NW	SW	S 8-T8S-R12E
NW	NW	SW	S22-T8S-R12E
NE	NW	SW	S29-T8S-R12E
S2	SE	NW	S 1-T9S-R10E
W2	SW	SW	S 6-T9S-R10E
C	NE	SW	S16-T9S-R10E
NW	NW	NE	S19-T9S-R10E
N2	NW	SE	S30-T9S-R10E
SE	NW	SE	S31-T9S-R10E
NE	NE	NE	S32-T9S-R10E
NE	NE	NE	S36-T9S-R10E
SE	SE	SE	S 5-T9S-R11E
SE	SE	SE	S29-T9S-R11E
SW	SW	NW	S34-T9S-R12E

Table 2.

GEOLOGIC SYSTEM	SUBDIVISIONS USED IN THIS STUDY
Pennsylvanian	-Topeka Limestone -Heebner Shale Member -Lansing Group -Kansas City Group
Mississippian	-Mississippian Limestone
Silurian-Devonian	-Hunton Group
Cambrian-Ordovician	-Viola Limestone -Maqueketa Shale -Simpson Group
Precambrian	-Granite and Metamorphic Rocks

Evidence Provided From Logs of Deep Wells.

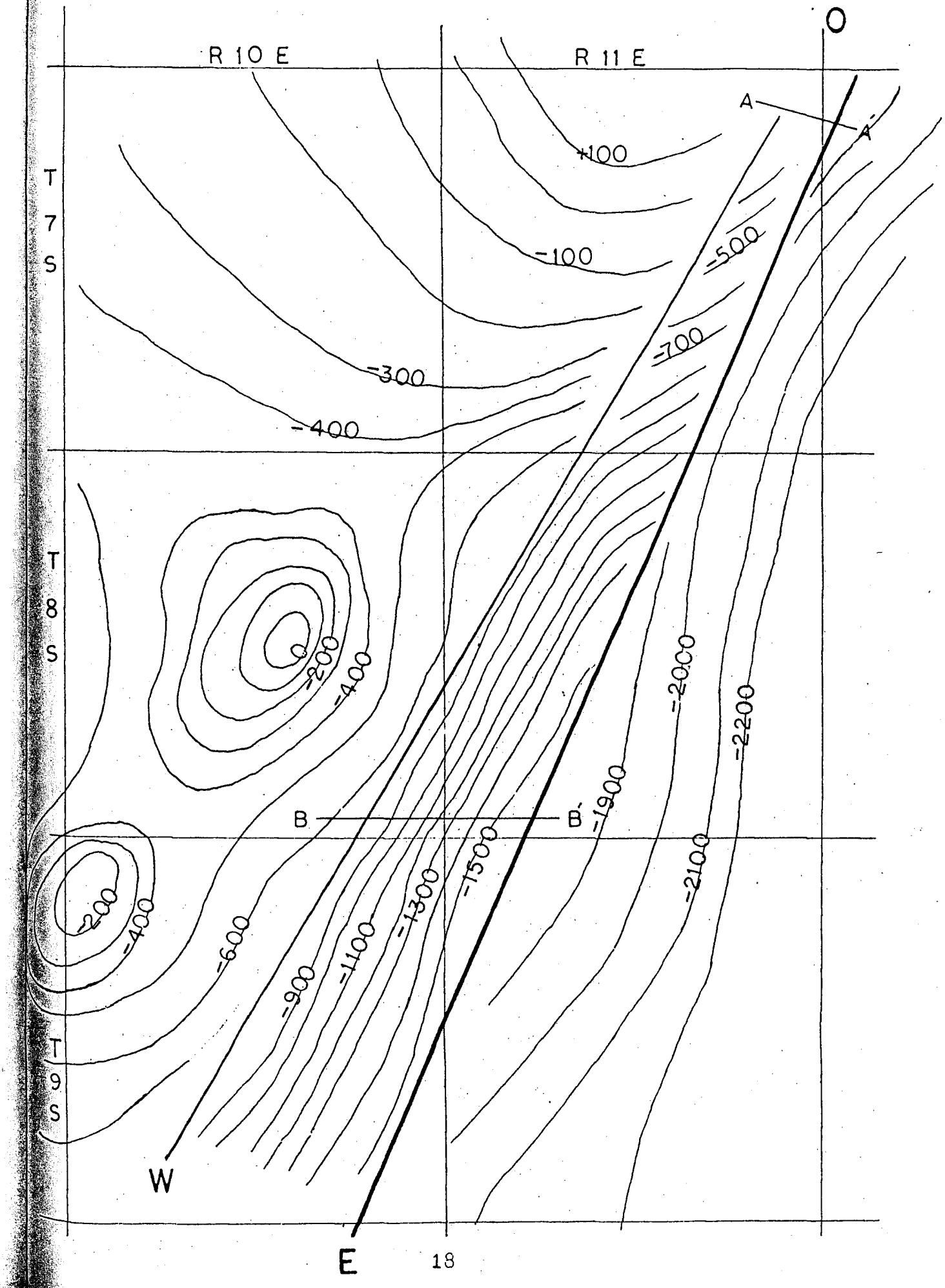
Contours on the Precambrian surface of the study area reveal a distinctive northeast-southwest oriented zone of displacement in Precambrian rocks. Displacement ranges from 152 m (500 feet) to the southwest to 610 m (2000 feet) to the northeast. Cross-section AA' (Fig. 5) prepared from the northeast corner of the study area from the well data between Sec. 12, T. 7 S., R. 11 E., and Sec. 6, T. 7 S., R. 12 E., clearly indicates displacement in Precambrian rocks along a zone OE (Fig. 4), and its effect on thickness (through erosion or non-deposition) of the overlying Paleozoic sequence.

A three dimensional subsurface lithologic cross-section of Paleozoic units reveals that the Mississippian and Upper Silurian-Devonian rocks (Upper part of the Hunton Group) are missing to the immediate west of the main fault (Fig. 6).

Cross-section BB' (Fig. 7A) prepared from southwest corner of the study area from three wells in Sec. 26, T. 8 S., R. 10 E., Sec. 20, T. 8 S., R. 11 E., and Sec. 28, T. 8 S., R. 11 E., shows a similar displacement in the Precambrian rocks which affects the thickness of the overlying Paleozoic sequence, including the absence of Mississippian and Silurian-Devonian rocks to the west.

Direct evidence of subsurface faulting along the east flank of the Nemaha Anticline is observed from the well samples of Precambrian basement rocks in Jackson County, Kansas. The well was drelled 91.5 m (300 feet) into Precambrian basement and associated samples reveal extensive brecciation. Apparently the well was drilled directly through a fault zone in Precambrian

Fig. 4. The Precambrian surface at the study area. Contour interval 100 feet or 30.4 m. (Modified from Cole, 1976).


R 10 E
R 11 E
O
A
A'
T 7 S
T 8 S
T 9 S
+100
-100
-300
-400
-500
-700
-200
-400
-200
-400
-600
-900
-1100
-1300
-1500
-1900
-2000
-2100
-2200
B
B'
W
E

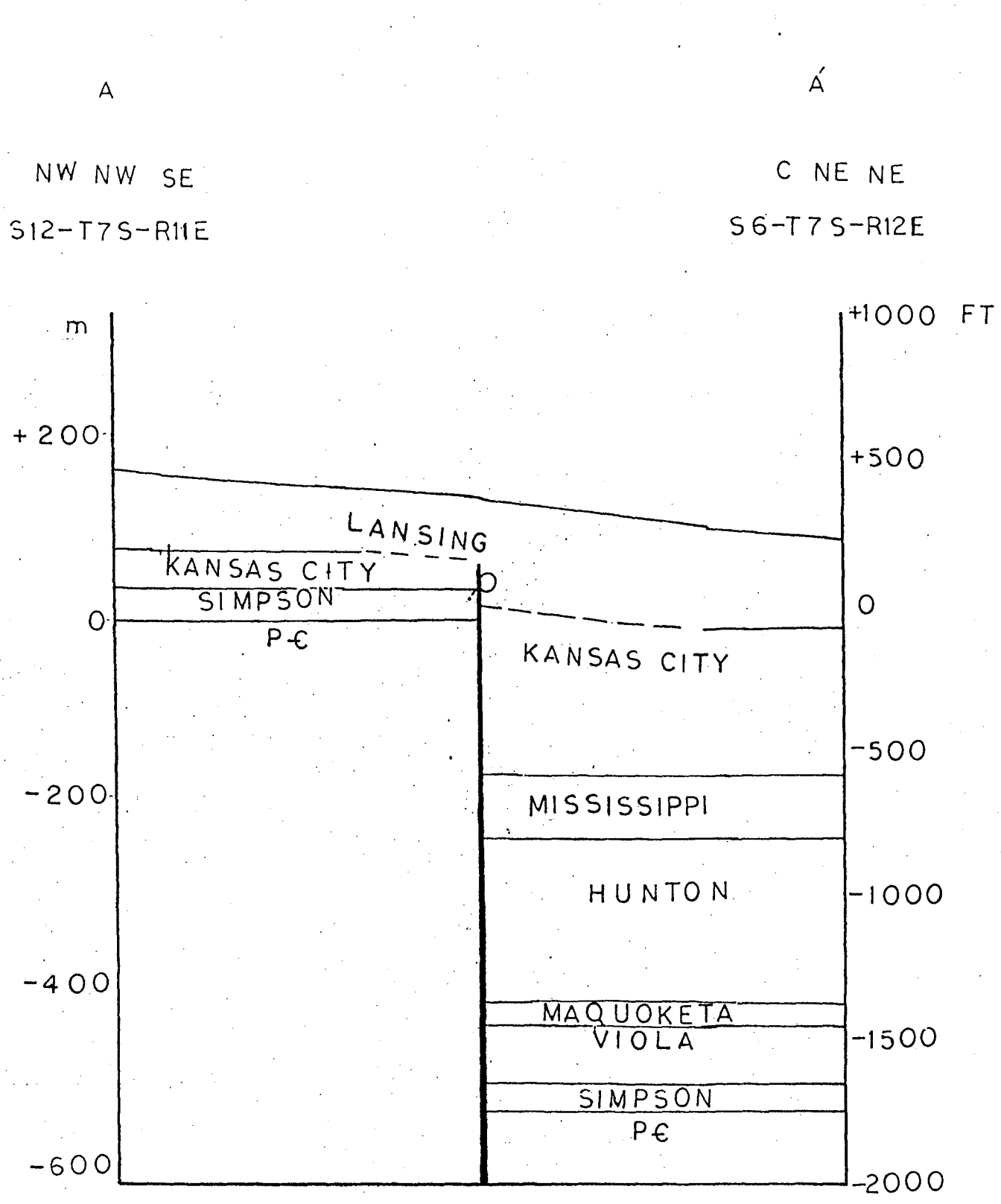
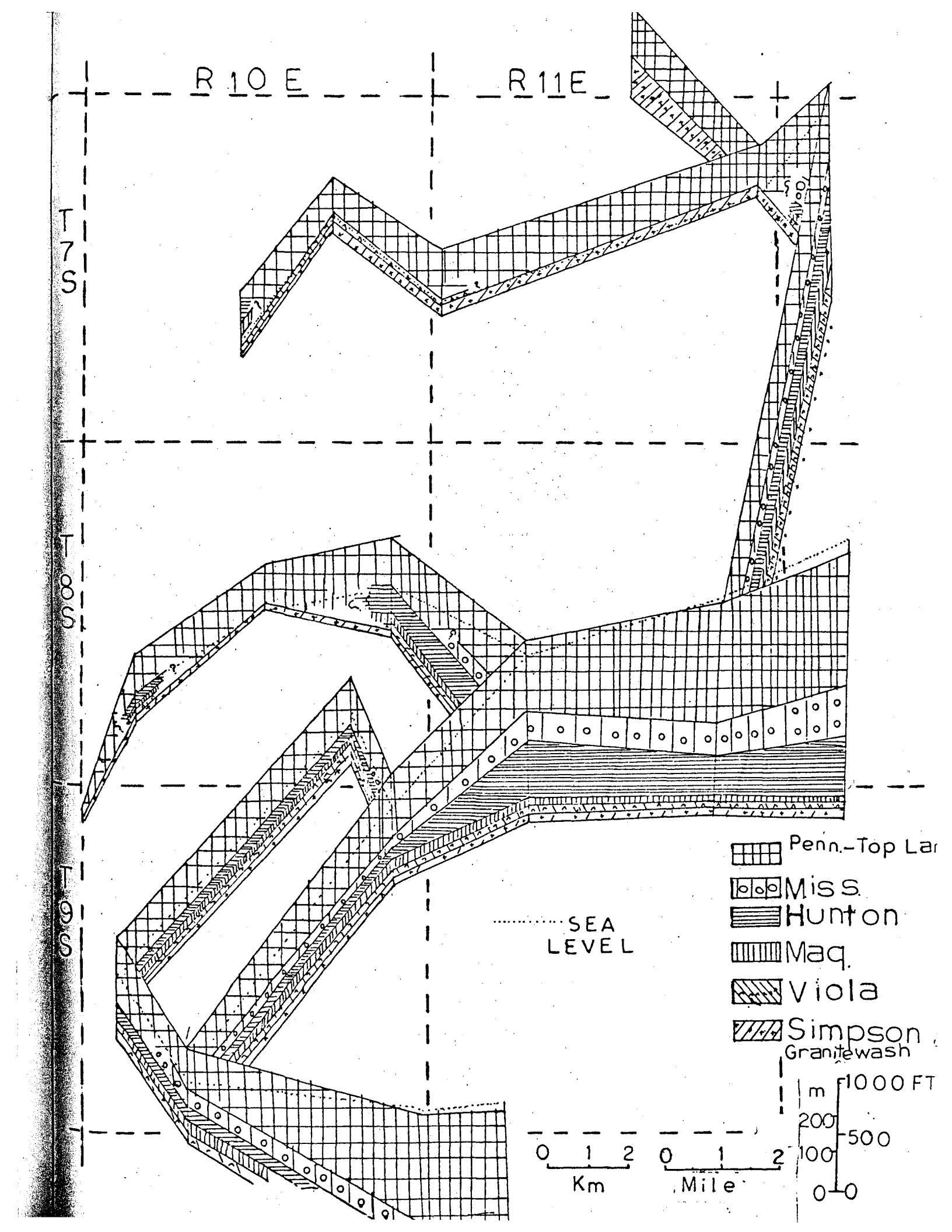


Fig. 5. Cross-section A-Á. Interpretation of logs from two wells located at northeast corner of the study area. Vertical exaggeration is about 2. The position of the fault may vary within a distance of 0.8 Km (0.5 mile).

Fig. 6. Three-dimensional subsurface Paleozoic cross-section of the problem area.


R 10 E
R 11 E
T 7 S
T 8 S
T 9 S
SEA LEVEL
Penn.–Top Lar
Miss.
Hunton
Maq.
Viola
Simpson
Granitewash
0 1 2
Km
0 1 2
Mile
m
200
100
0
1000 FT
500
0

basement rocks (M. E. Bickford, personal communication).

Furthermore, evidence of subsurface faulting is to be observe in the repeated section of the Cambrian-Ordovician Simpson Group in a well located along the fault zone in SW NW SE, Sec. 26, T, 8 S., R. 10 E., (Fig. 8).

From data provided in Figure 7A, two hypotheses concerning the subsurface structure of the study area along the east flank of the Nemaha Anticline are suggested. The first hypothesis (illustrated in Fig. 7A) is that, because subsurface faulting is observed in the repeated section of the Cambrian-Ordovician Simpson Group in a well in SW NW SE, Sec. 26, T. 8 S., R. 10 E., and brecciated basement rocks are known in Jackson County, faulting in the subsurface is certain. Therefore, a major movement along the east flank of the Nemaha is attributed to faulting which occurred duing Late Silurian or Early Devonian through Mississippian times. There was later faulting with reduced intensity causing the development of gentle folding of the overlying Upper Pennsylvanian and Lower Permian rocks.

The other hypothesis (illustrated in Fig. 7B) is that, inasmuchas the thickness of Paleozoic rocks in the subsurface decreases from east to west and Upper Silurian-Devonian and Mississippian rocks are absent along the Nemaha Ridge, the Nemaha Ridge may have been a rising topographically high feature from which these formations were eroded. As mentioned earlier, however, as the occurrence of subsurface faulting along the east flank of the Nemaha Anticline has been observed in well logs and samples, the latter hypothesis is less acceptable.

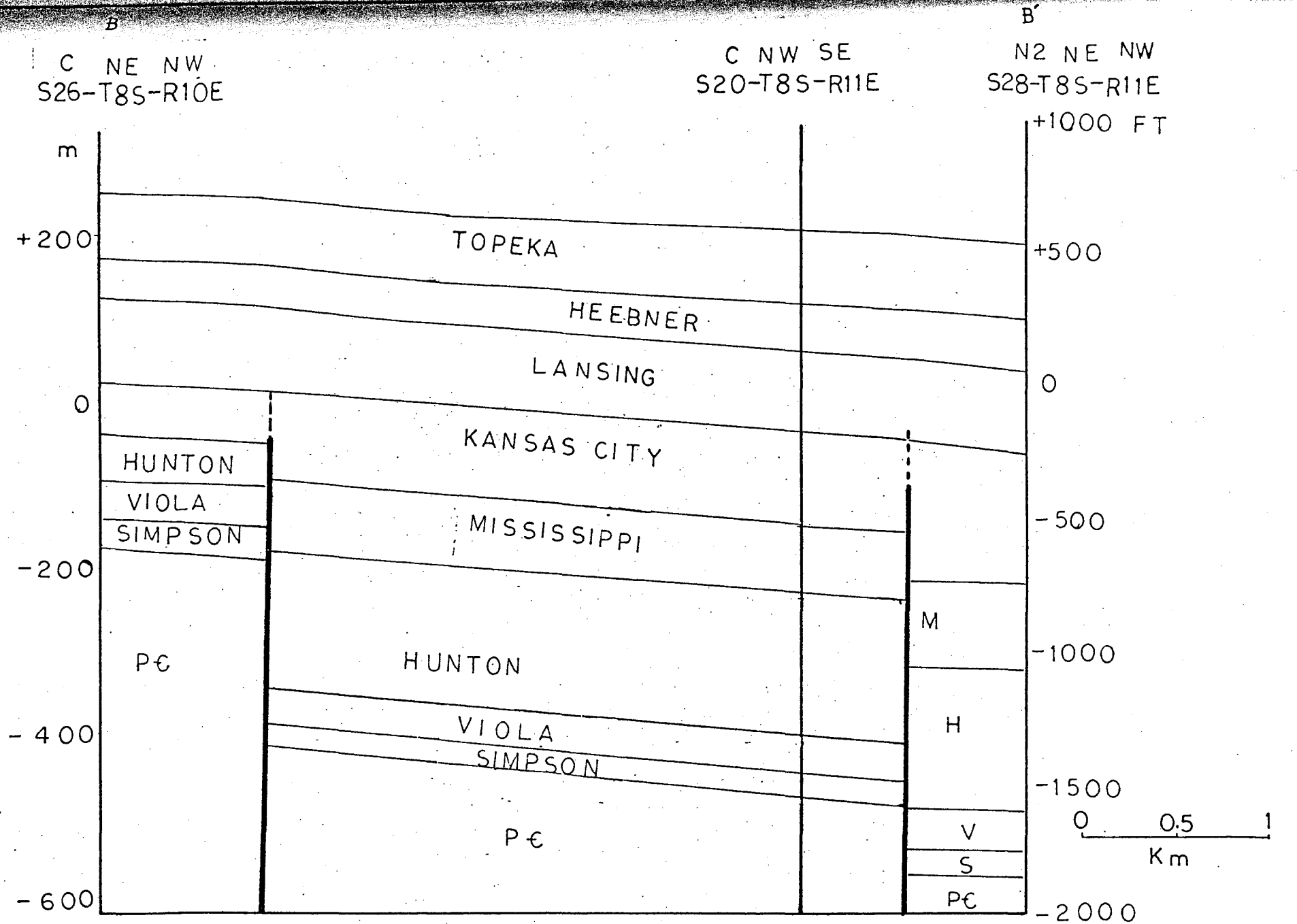


Fig. 7A. Cross-section B-B'. Interpretation of logs from three wells located at southeast part of the study area. Vertical exaggeration is about 2. The position of the faults may vary within a distance of 1.6 Km (one mile) respectively.

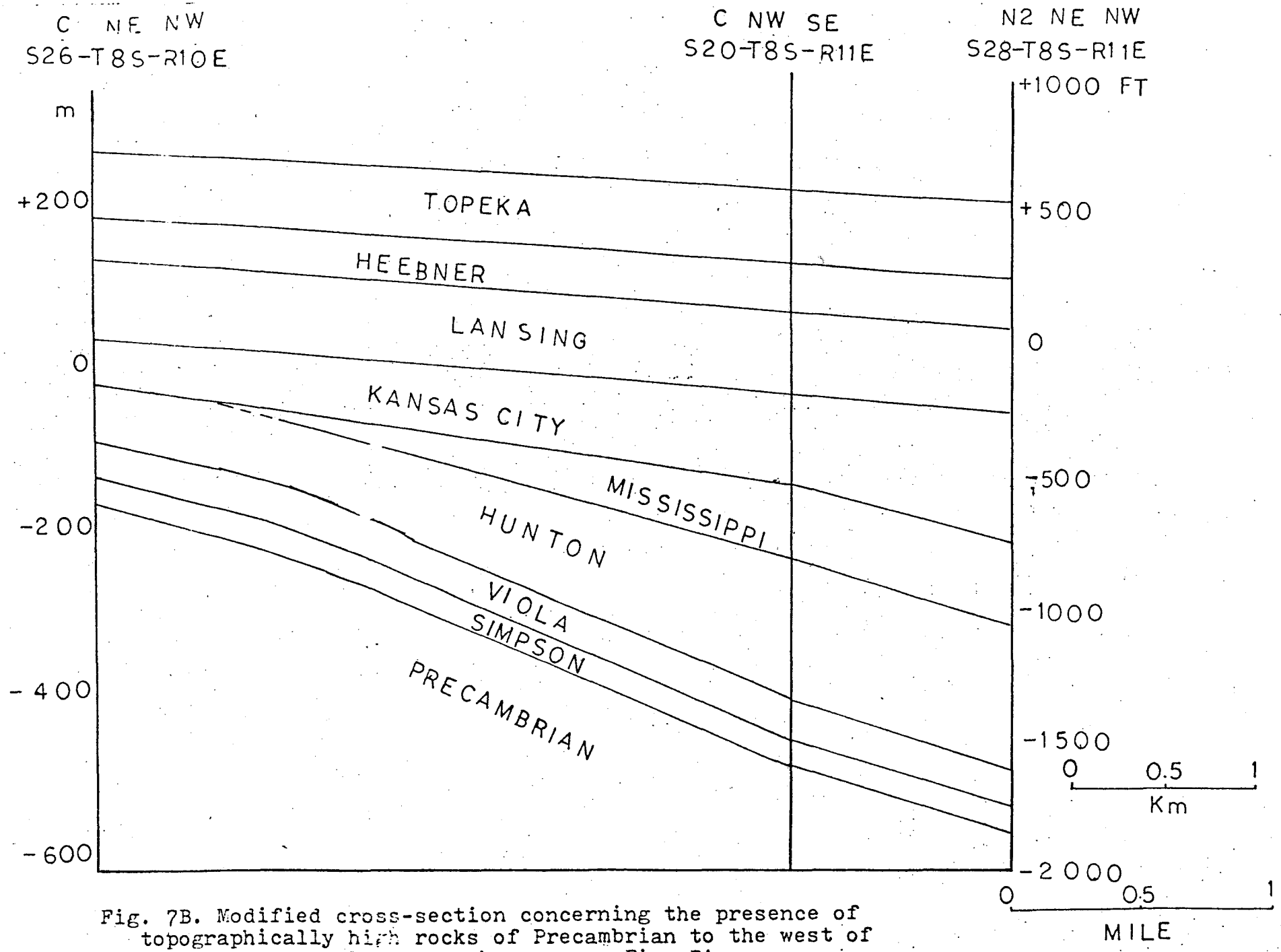


Fig. 7B. Modified cross-section concerning the presence of topographically high rocks of Precambrian to the west of the study area. Data are the same as Fig. 7A.

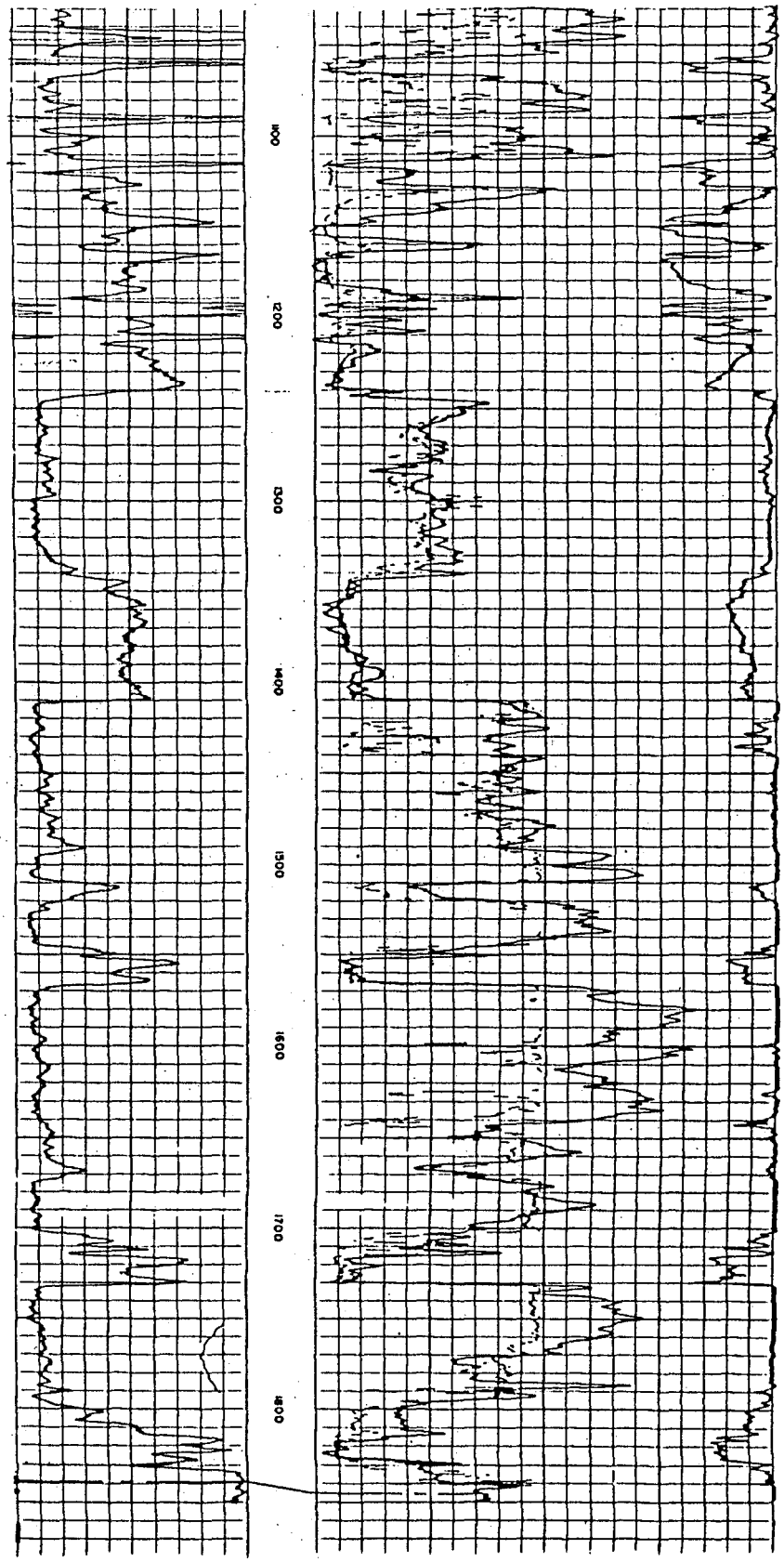


Fig. 8. Gamma ray and neutron log showing repeated section of Cambrian-Ordovician Simpson Group from well located in SW NW SE, Sec. 26, T. 8 S., R. 10 E.

In summary, although data are sparse and some problem remain to be solved, electric well log data are sufficient to document displacement along a fault trending northeast-southwest along the east flank of the Nemaha Anticline. To the northeast, displacement is greater and the absence of Paleozoic rocks more pronounced. Southwestward, it bifurcates into two distinctive trends (OE and OW) with major displacement occurring along the eastern branch OE (Fig. 4), which correlates with the trace of the Humboldt Fault. The uncertainity of the fault line determination varies with the distance between the wells, which in this area ranges from two to six miles. This study substantiates the positioning of the faults by König (1971).

Evidence Provided From Shallow Seismic Electric Logs.

A series of shallow seismic traverses conducted by Phillips Petroleum Company in 1961-62, which are now in the files of the Kansas Geological Survey, provided data for correlation of the rock units which occur above the level that generally has not been recorded on a electric logs of deep wells. The absence of logging of upper formations in deep wells is due in part to presence of surface casing and in part to a lack of interest in the near surface strata. The Phillips data consists of company-correlated electric logs of the shallow seismic shot holes. Due to relatively close spacing of these holes (10 within a distance of approximately one mile), near-surface or even concealed surface extension of the subsurface fault should be recognizable. This in conjunction with stratigraphic correlation aids in precise positioning of the fault.

Correlation of Permian-Pennsylvanian strata using the shallow seismic traverses data revealed that near-surface units dip anomalously in the vicinity of the subsurface faults. Thus, continuing movement along the faults on the east flank of the Nemaha Anticline apparently continued through Late Pennsylvanian and Early Permian times. Dipping strata are observed in the near surface at Sections 17, 18, 24, and 25, at T. 8 S., R, 10 E., (Fig. 11, Cross-section EE'). In one location dipping beds are associated with rather small gentle folds (Cross-section CC').

Moreover, dipping beds have been observed at the surface in close proximity to the faults along the east flank of the Nemaha Anticline as will be described later. Generally, Permian-Pennsylvanian strata on the either side of the Nemaha Anticline are characterized by their almost horizontal attitude (Fig. 12).

SURFACE STRUCTURE

The area of investigation has generally reached a submature to matu stage of erosion. Bedrock in general is poorly exposed due to heavy vegetation associated with well-developed a soil profile or the existence of relatively thick and extensive Kansan glacial till. Bedrock exposures are most generally located in road cuts and along stream channels.

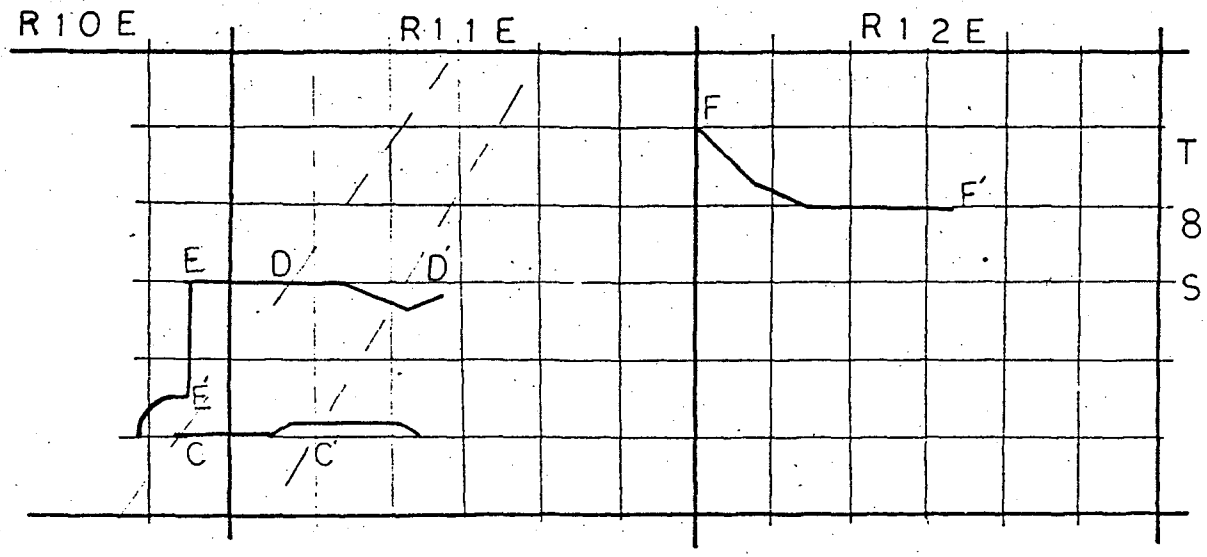
The exposed Permian-Pennsylvanian rocks have been studied to determined:

1) The likelihood of faulting extending to the surface.

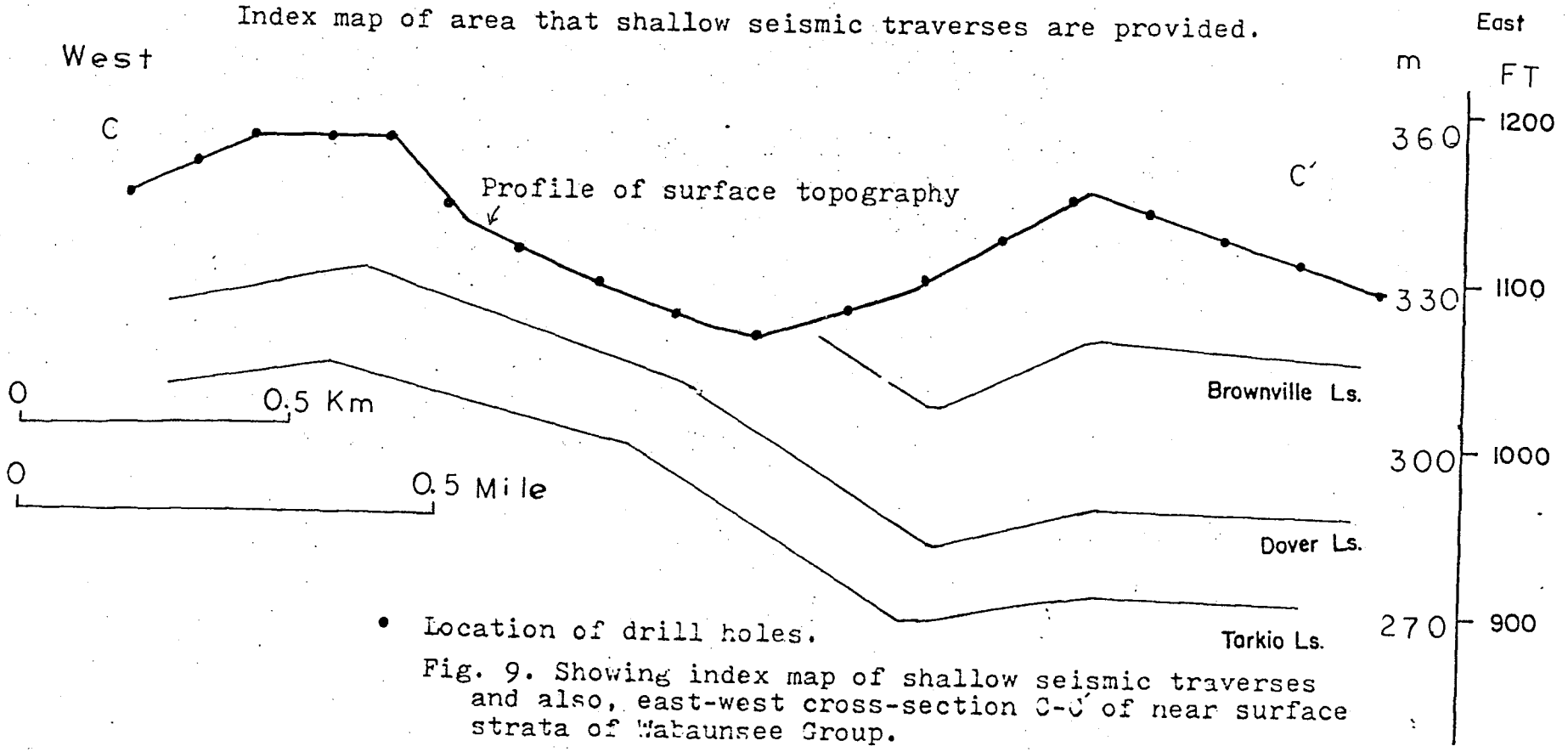
2) The nature and origin of surface structure.

Surface Fault(s).

Review of published geological data of exposed Permian-Pennsylvanian

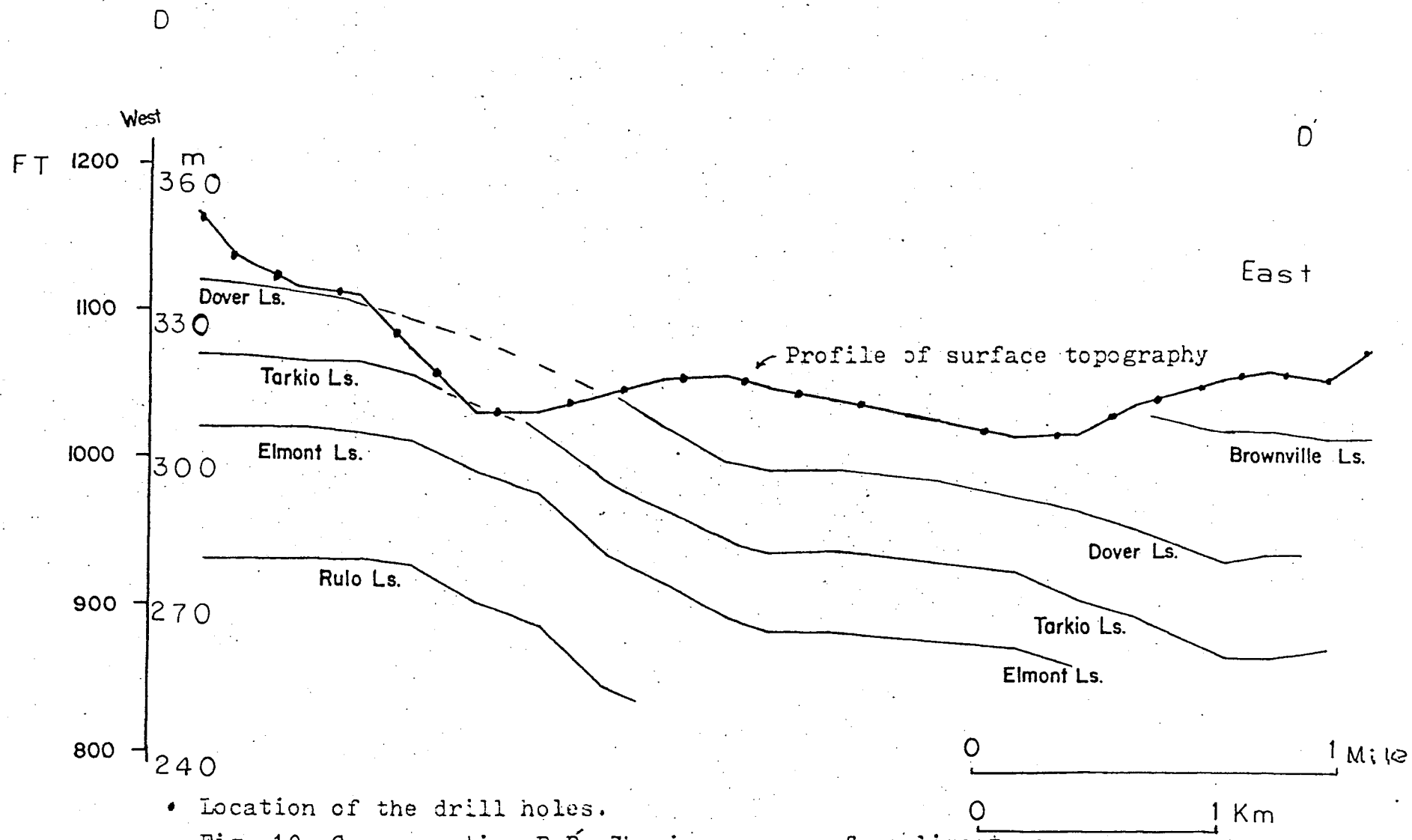


Index map of area that shallow seismic traverses are provided.



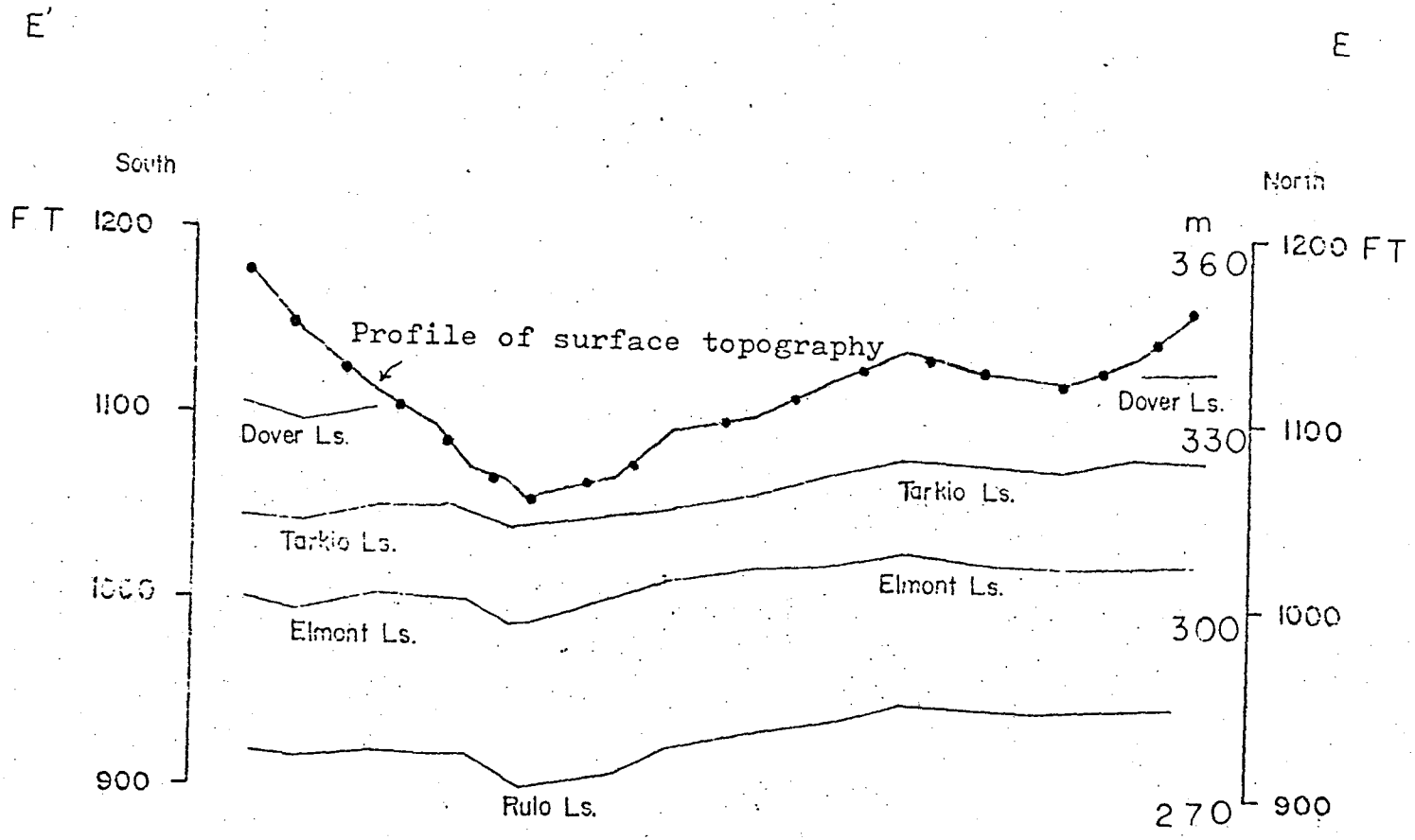
• Location of drill holes.

Fig. 9. Showing index map of shallow seismic traverses and also, east-west cross-section C-C' of near surface strata of Nebraunsee Group.



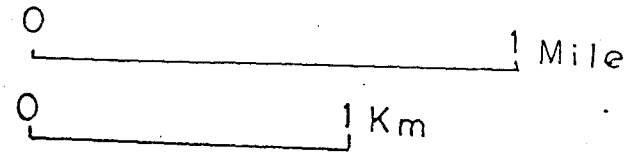
• Location of the drill holes.

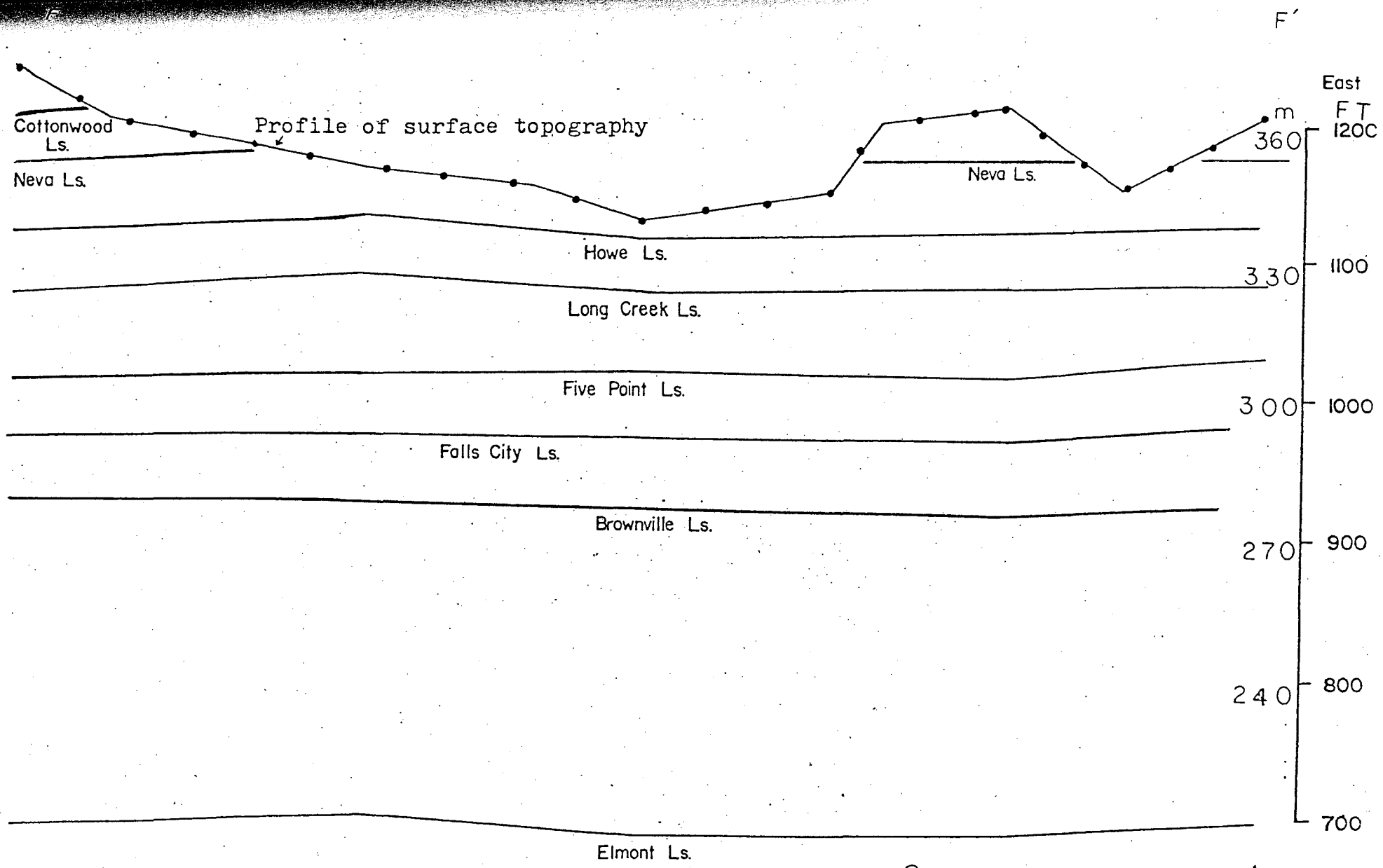
Fig. 10. Cross-section D-D'. Showing near-surface limestones of Upper Pennsylvanian Wabaunsee Group across the indicated fault.



• Location of the drill holes.

Fig. 11. Cross-section E-E'. Showing near-surface strata of Upper Pennsylvanian Wabaunsee Group almost along the fault zone.





• Location of drill holes.

Fig. 12. Cross-section F-F'. Showing the horizontal attitide of Permian-Pennsylvanian strata further to the east of Nemaha Anticline.

rocks revealed no evidence of faulting occurring at the surface throughout the area of study (see index map).

Outcrops were closely examined and no characteristic features such as slickensides, brecciation, missing or doubled section resulting from faulting were observed.

As the Humboldt Fault occurs on the east flank of the Nemaha Anticline in the subsurface, continuity or lack of continuity of exposed Permian-Pennsylvanian units across this trend should provide some information concerning the upward extension of the fault to the surface. For this purpose three cross-sections in an area between Onaga and a point 3.2 Km (2 miles) south of Havensville almost along the Highway 16 were prepared from field examiantion and correlation of exposed rocks. As is shown in Figs. 14, 15, and 16, rock succession across the east flank of the Nemaha reveals no evidence of faulting.

As stated earlier, the occurrence of faulting at the surface in extreme northeast part of the Pottawatomie County has been reported by Ratcliff (1957). To test his hypothesis, three locations across the indicated fault were carefully traversed. The strikes and dips of the exposed strata occurring at either side of the indicated fault at all these locations were carefully measured using alidade and plane table. No change in strike or dip was observed at either side of the reported fault location. For example, at 91 m (100 yards) south of Havensville along the Highway 63, strata on either side of the proposed fault dip southeast 5.04 degrees with a strike of N 64° E. The strata correlated at this

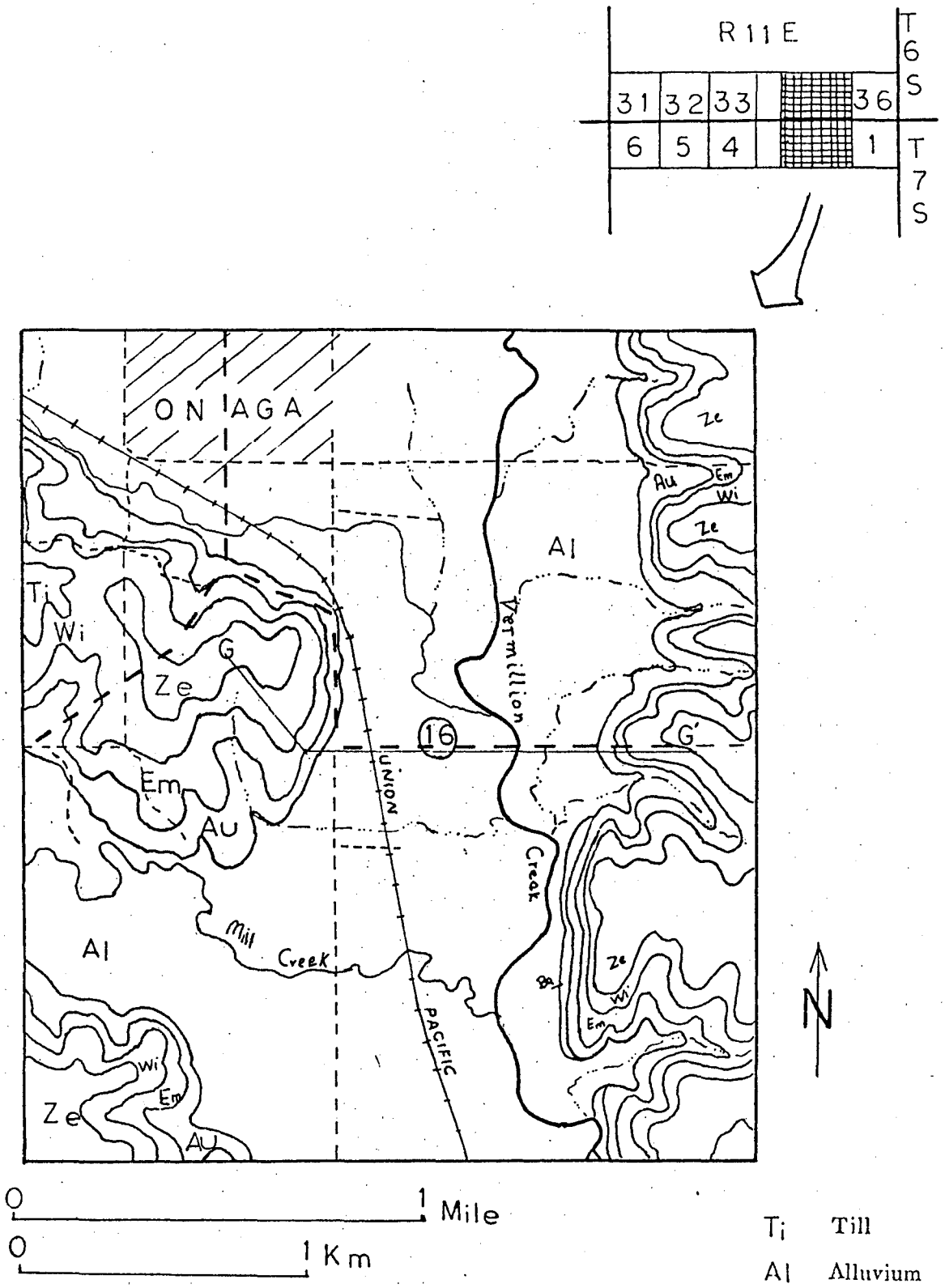


Fig. 13. Geologic map of an area 1 mile southeast of Onaga, showing Upper Wabaunsee Group strata at either side of Vermillion Creek.

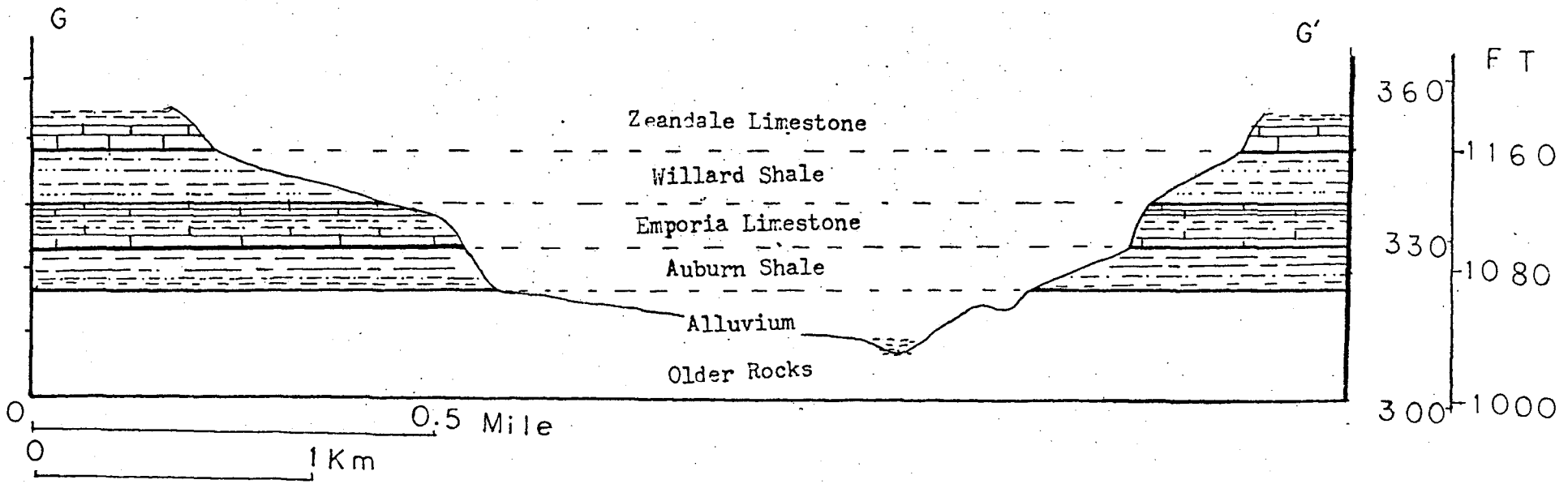


Fig. 14. Cross-section G-G'. Showing similarity of the strata at either side of Vermillion Creek.

location were the Onaga Formation to the north of the fault and the Americus Limestone to the south of it. The measured thickness of the section between the tops of these two units was 30.8 m (115.5 feet) which is essentially what would be expected in a normal sequence (see index map).

Vermillion Creek is the major stream and as a general rule, the course of the stream lies in an area which includes the transitional zone of Permian and Pennsylvanian rocks, which includes relatively thick units of shale in the Woodsiding and Onaga Formations. However, in some cases exceptions exist where Vermillion Creek passes through the Upper Pennsylvanian rocks. For example, the Upper Wabaunsee Group which includes Auburn Shale, Emporia Limestone, Willard Shlae, and Zeandale Limestone are present at either side of Vermillion Creek about 1.6 Km (one mile) to the east of Onaga.

Vermillion Creek does cut across the strike of the transitional zone of Permian and Pennsylvanian strata to parallel the trend of the subsurface Humboldt Fault. However, stratigraphic maps reveal no evidence of vertical displacement. The strata on either side of the creek are identical both in lithologic characteristics and elevation (Figs. 13 and 14).

A review of the pattern of the drainage network (Fig. 17) of the area revealed that the tributaries are commonly elongated and terminate abruptly. This may well illustrate the occurrence of strike-slip faulting throughout the area shown. In their discussion of the theory of wrench-fault tectonics, Moody and Hill

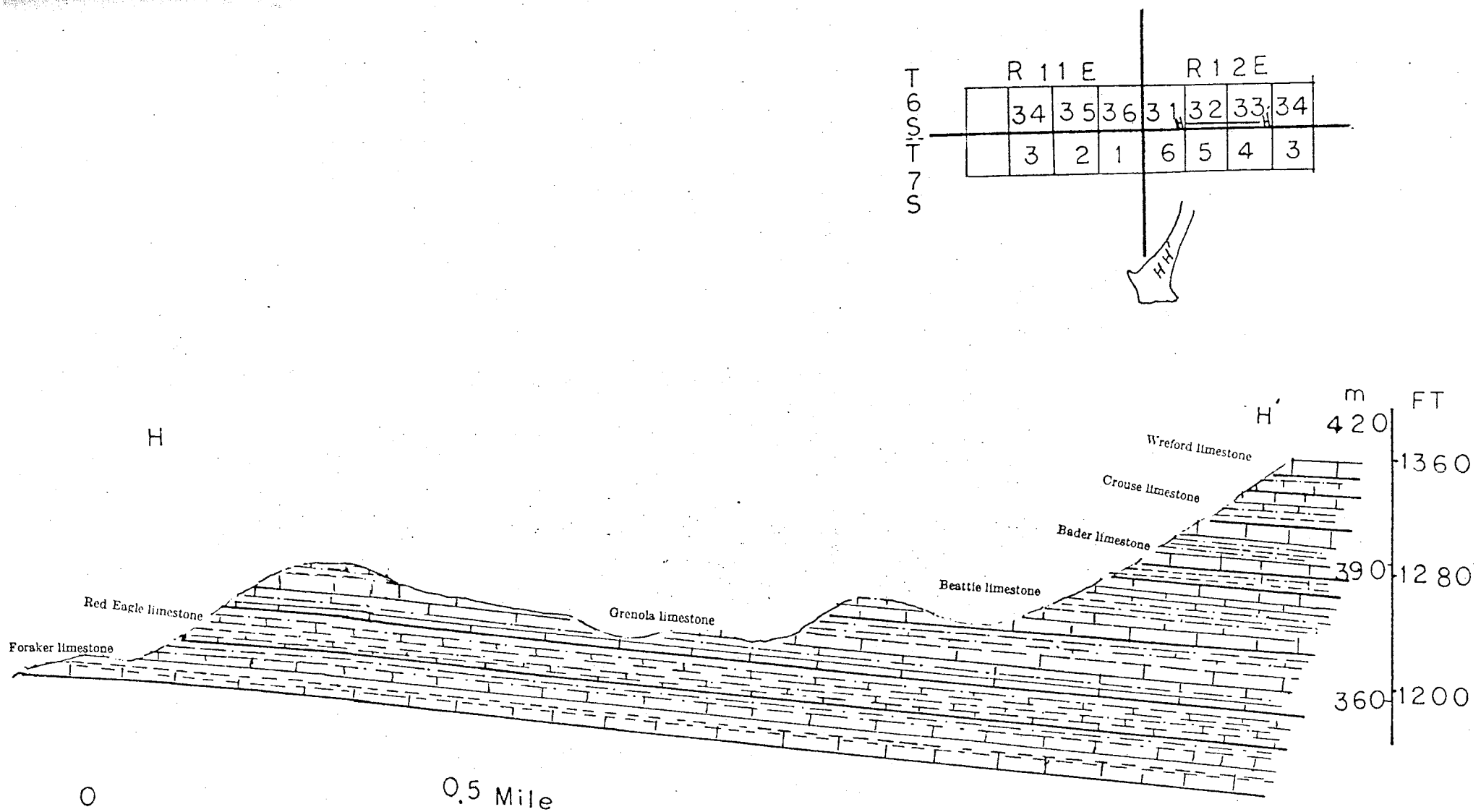


Fig. 15. Cross-section H-H'. Showing exposed rocks along Highway 16.

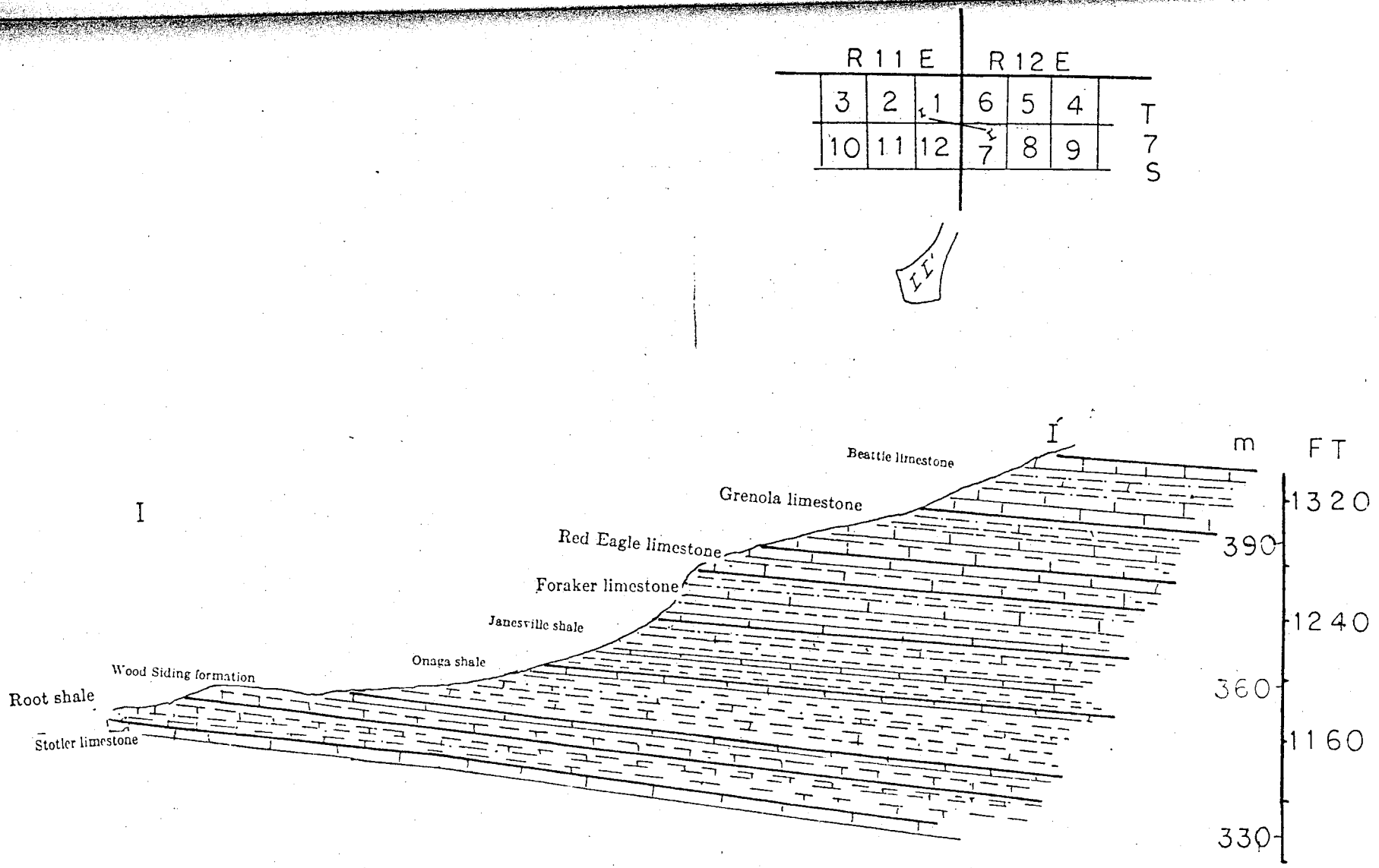


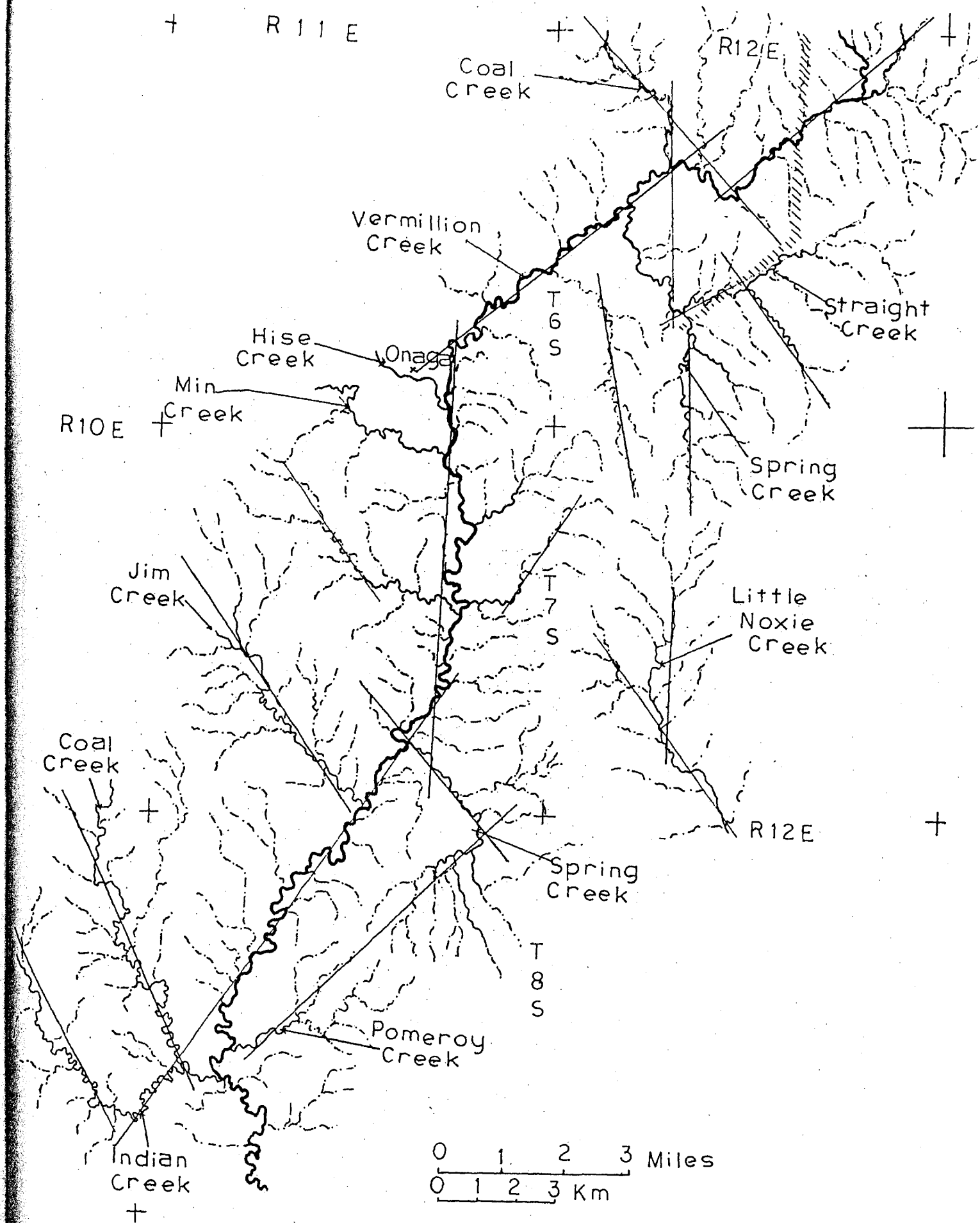
Fig. 16. Cross-section I-I'. Showing exposed rocks along Highway 16.

(1956) suggested a mechanism by which, in continuation of relief of original stresses on the main fault through folding, thrusting, and wrench-faulting, a lesser magnitude stress reoriontation occurs, resulting in secondary and tertiary stress systems. As a result, the deep fault can be expressed in overlying sedimentary cover by a complex of secondary and tertiary wrench-faults and other structures rather than a single distinct fault trace over the main fault. The pattern of linearly displayed by Vermillion Creek and its tributaries as shown in Figure 13 may be correlated with the pattern primary, secondary, and tertiary structural features described by Moody and Hill (1956). Based of this hypothesis, the subsurface Humboldt Fault formed as a result of principally vertical stresses that occurred during Late Silurian or Early Devonian through Mississippian and possibly Early Pennsylvanian times. Then local stresses continued through Late Pennsylvanian and Early Permian times to produce strike-slip faulting causing the formation of secondary or possibly tertiary wrench-faults. Thus, I assume, Vermillion Creek which follows the trace of subsurface Humboldt Fault coincides the primary-stress direction and the trace of the elongated relatively straight tributaries show the direction of the secondary and tertiary structural features. Although the above discussion may well be accepted there is lack of certainity of the correlation of these linears, as well as the absence of any direct evidence of faulting at the surface rocks of study area.

Nature of the Surface Structures.

Dips in excess of the regional dip of approximately three meters per kilometer (fifteen feet per mile) or less than one-half

Fig. 17. Stream patterns of the study area.
——— Lineaments suggested by drainage pattern.
\\\\\\\ Position of indicated fault at the surface of northeast corner of the area.


R 11 E
R12E
Coal Creek
Vermillion Creek
Straight Creek
T 6 S
Hise Creek
Onaga
Min Creek
R10E
Spring Creek
Jim Creek
T 7 S
Little Noxie Creek
Coal Creek
R12E
Spring Creek
T 8 S
Pomeroy Creek
Indian Creek
0 1 2 3 Miles
0 1 2 3 Km

degree (Lee, 1943), occur along the fault zone and suggest the upward extension of subsurface faults. Beds dip four to five degrees to the southeast and, in general, strike N 20° E. Thus, upward movement in the subsurface is assumed to have produced stresses which increased the dip of the strata at the surface.

Locally isolated areas of deformed rocks including folding and intense fracturing are also numerous throughout the study area.

SUMMARY

Examination of the subsurface structure along the east flank of the Nemaha Anticline in Pottawatomie County, Kansas, based on three-dimensional lithologic cross-sections and logs of deep wells has shown the presence of a distinctive northeast-southwest oriented zone of displacement of the rocks in the subsurface. To the northeast, the amount of displacement is greater and the absence of Paleozoic rocks more pronounced. Southwestward the zone bifurcates into two distinct trends with the major displacement occurring along the eastern branch which is correlated with the trace of Humboldt Fault. Evidence of subsurface faulting has also been observed in a repeated section of Cambrian-Ordovician Simpson Group and from brecciated Precambrian rocks in well-samples.

Correlation of the Permian-Pennsylvanian strata using shallow seismic traverses data revealed that near-surface units dip abruptly in the vicinity of the faults along the east flank of the Nemaha Anticline. Surface rocks across and along this trend show no evidence

of faulting but display four to five degrees of dip to the southeast.

Movement along the east flank of the Nemaha Anticline occurred during Late Silurian or Early Devonian through Mississippian times. Then, there was a reduction in intensity of faulting which caused only gentle folding of overlying units. Continuing movement along the fault on the east flank of the Nemaha Anticline is inferred through Permian-Pennsylvanian times.

The course of the main-stream Vermillion Creek cuts across the strike of the transitional zone of Permian and Pennsylvanian strata to parallel the ternd of the subsurface Humboldt Fault.

Although, surface rocks at the area of investigation revealed no evidence of faulting the possible occurrence of wrench-faulting in the subsurface may well be expressed in the stream patterns throughout the area.

REFERENCES CITED

Cole, V. B., 1976, Configuration of the Precambrian Rocks in Kansas: Kansas Geol. Survey, map M-7.

Condra, G. E., 1927, The Stratigraphy of Pennsylvanian in Nebraska: Nebraska Geol. Survey Bull. 1, P. 15-212.

_____ and Reed, E. C., 1943, The Geologic Section of Nebraska: Nebraska Geol. Survey Bull. 14, P. 1-82.

Frye, J. C., and Leonard, A. B., 1952, Pleistocene Geology of Kansas: Kansas Geol. Survey Bull. 99, 230 pp.

Jewett, J. M., 1951, Geologic Structure in Kansas: Kansas Geol. Survey Bull. 90, P. 105-172.

_____ and Merriam, D. F., 1959, Geologic Framework of Kansas--A Review for Geophysicists, in Symposium on Geophysics in Kansas: Kansas Geol. Survey Bull. 137, P. 9-52.

König, Michael, 1971, A Magnetic Profile across the Nemaha Anticline, in Pottawatomie and Western Jackson Counties, Kansas: M. S. Thesis, Kansas State University, 87 pp.

Koons, D. L., 1956, Faulting as a Possible Origin for the Formation of the Nemaha Anticline: M. S. Thesis, Kansas State University, 33 pp.

Kotoyantz, A. A., 1956, Geologic Factors Influencing Oil in Wabaunsee County: M. S. Thesis, Kansas State University, 58 pp.

Lee, Wallace, 1943, The Stratigraphy and Structural Development of the Forest City Basin in Kansas: Kansas Geol. Survey Bull. 51, P. 7-138.

_____ 1956, The Stratigraphy and Structural Development of the Salina Basin area: Kansas Geol Survey Bull. 121, 167 pp.

Merriam, D. F., 1963, The Geologic History of Kansas: Kansas Geol. Survey Bull. 162, 317 pp.

_____, Cole, V. B., and Hambleton, W. W., 1961, Distribution of Precambrian Basement Rock Types in Kansas: Am. Assoc. Petroleum Geologists Bull., V. 45, P. 2018-2024.

Moody, J. D., and Hill, M. J., 1956, Wrench-Fault Tectonics: Geol. Soc. America Bull., V. 67, P. 1207-1246.

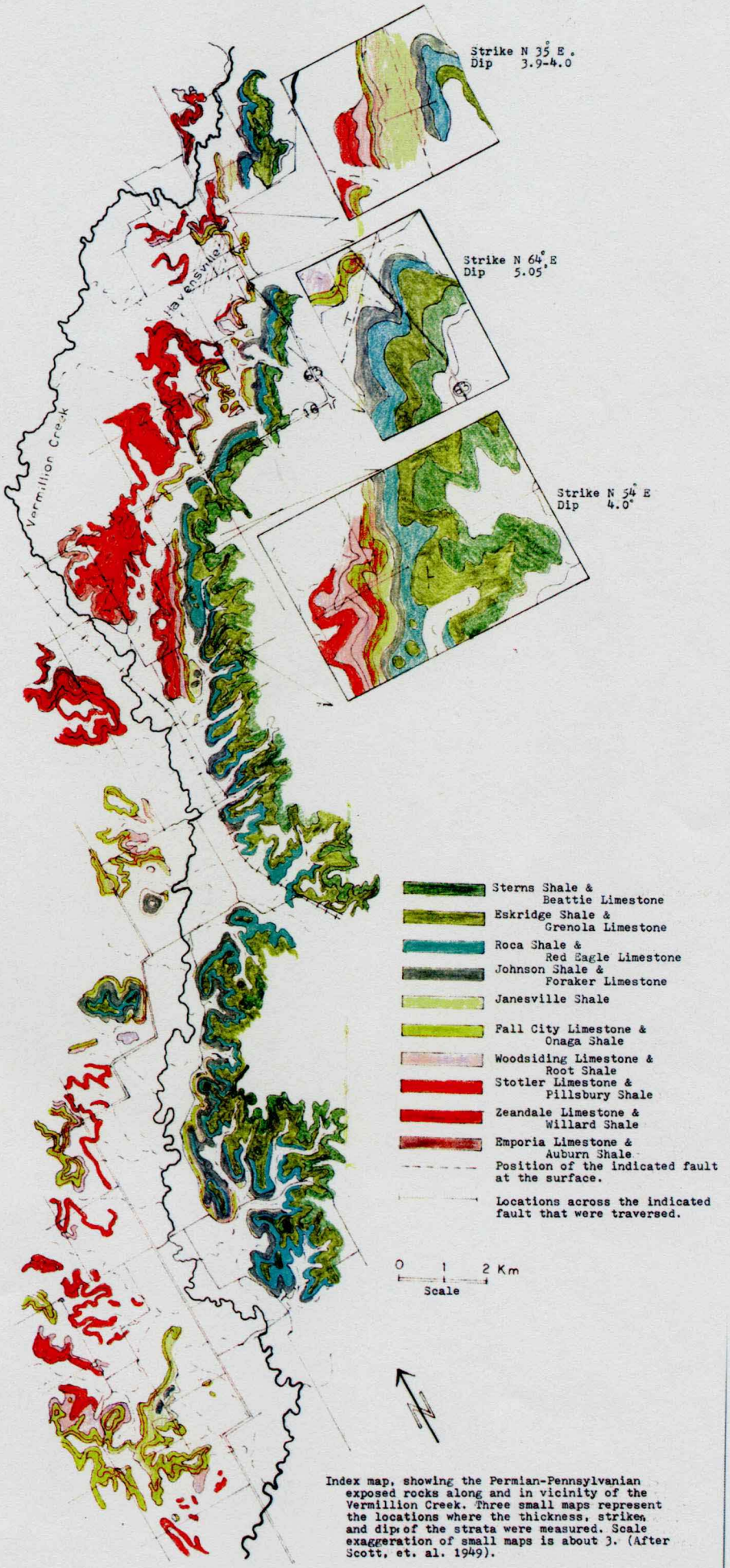
Moss, R. G., 1936, Buried Precambrian Surface in the United States: Geol. Soc. America Bull., V. 47, P. 936-966.

Mudge, M. R., 1956, Sandstone and Channels in Upper Pennsylvanian and Lower Permian Rocks in Kansas: Am. Assoc. Petroleum Geologists Bull., V. 40, P. 654-678.

Ratcliff, G. A., 1957, Surface Structure on the East Flank of the Nemaha Anticline in Northeast Pottawatomie County, Kansas: M. S. Thesis, Kansas State University, 33 pp.

Scott, G. R., Crumpton, C. F., and Foster, F. W., 1949, Geology and Construction-Material Resourses of Pottawatomie County. Kansas: Geol. Survey Bull. 1060-C, 179 pp.

Zeller, D. E., 1968, The Stratigraphic Succession in Kansas: Kansas Geol. Survey Bull. 189, 81 pp.



Index map, showing the Permian-Pennsylvanian exposed rocks along and in vicinity of the Vermillion Creek. Three small maps represent the locations where the thickness, strikes, and dips of the strata were measured. Scale exaggeration of small maps is about 3. (After Scott, et. al. 1949).