THE SURFACE EXPRESSION OF THE ZEANDALE DOME

by

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TABLE OF CONTENTS

INTRODUCTION

Location of the Area

This investigation deals with approximately 20 square miles in townships 10 and 11 south and range 9 east (Plate I). The area is rectangular, 6 miles east-west and 3 3/4 miles north-south, and lies astride the boundary between Riley County and Wabaunsee County, Kansas. Zeandale, 8 miles east of Manhattan, is on the northern boundary of the area at a point 2 miles east of the western boundary.

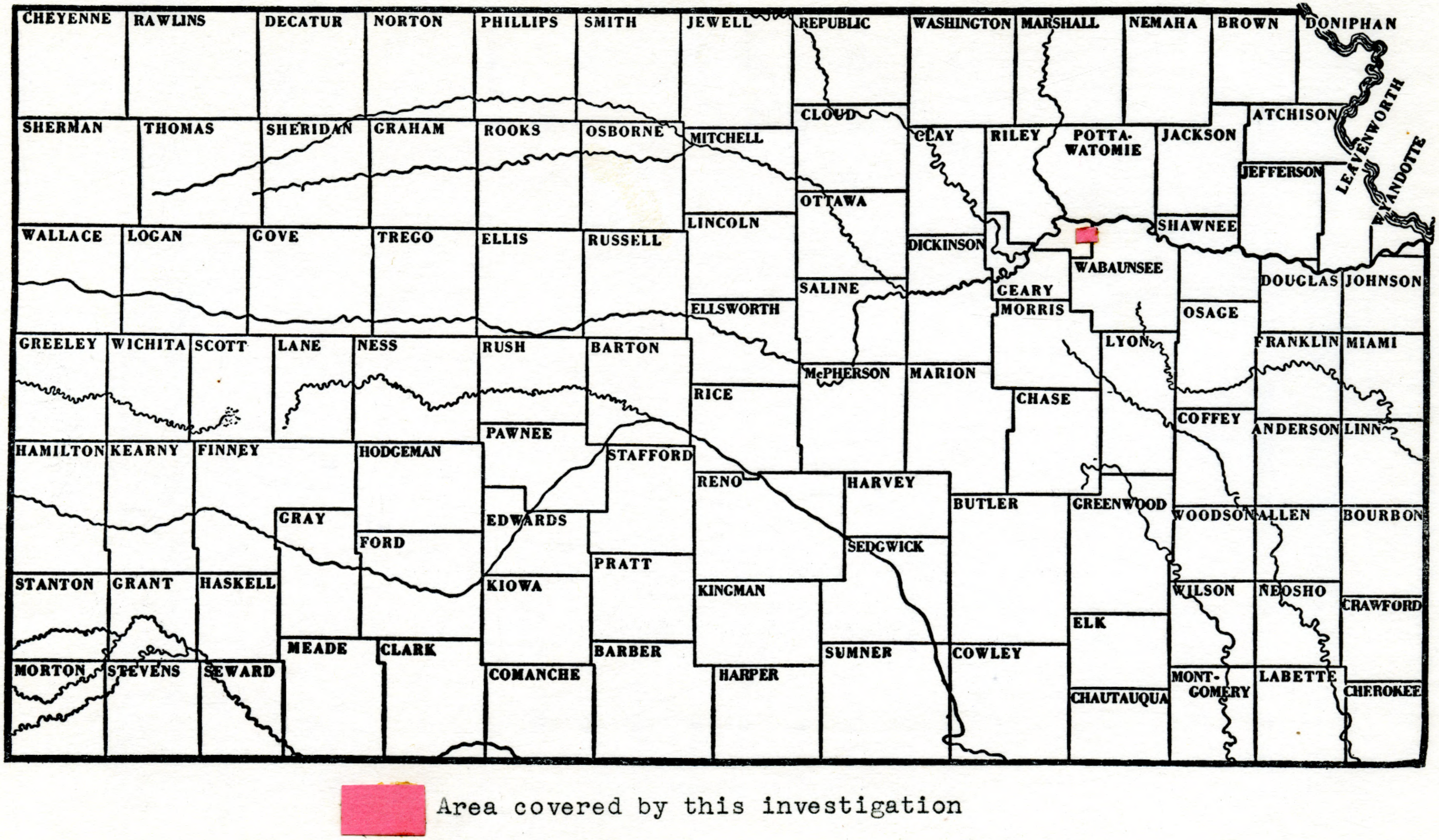
Geologic Setting

The area covered by this investigation lies within the Flint Hills section of the Central Lowlands physiographic province. The cuestas, typical of Flint Hills topography, are well developed on resistant limestones of early Permian age which form the bluffs bounding the area on the west and south. A few outliers and extensions of these bluffs occur within the area investigated but, for the most part, the topography consists of gently rolling hills lying 150 to 250 feet below the Permian bluffs. Unconsolidated Pleistocene silt, sand, gravel and boulder deposits conceal Paleozoic bedrock in much of the area. However, drainage is well developed, and, although recent alluvial and terrace deposits blanket the valley floors, Pennsylvanian sedimentary rocks are exposed in the valley walls of Deep and Emmons creeks and their tributaries.

EXPLANATION OF PLATE I

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

PLATE I



Area covered by this investigation

The area covered by this investigation lies astride the axis of the Nemaha anticline. The Nemaha anticline trends north-northeast across the area and separates the Forest City basin, on the east, from the Salina basin, on the west.

Review of the Literature

The existence of the Nemaha anticline was unknown in 1915. Dr. Erasmus Haworth, then Kansas state geologist, expressed considerable doubt as to the accuracy of the drillers records and their determination of the well cuttings as granite in all of the wells that had been drilled along the Nemaha anticline. Two wells that had been drilled in the area covered by this investigation received his most careful attention. Dr. Haworth visited the Cain Bloom Zeandale wells and personally collected samples of the cuttings (Table 1). He made a careful study of these samples, including thin section inspection and chemical analysis of the granite. Dr. W. H. Twenhofel examined samples from the overlying shale and found it to be ordinary, unmetamorphosed, light-blue shale containing numerous gastropod fragments. Dr. Haworth concluded that the rock in question was quite possibly a, "modified form of hard sandstone with unusually large amounts of feldspar present," because no evidence of metamorphism of the overlying shale, chilling of the border zone of the granite, or inclusion of granitic fragments in the overlying sedimentary rock was found. Dr. Haworth stated that the composition and appearance of the rock was granitic but he thought it was probably not a granite because it occured relatively near the surface (Haworth,

Table 1. Published data on wells drilled in the area covered by this investigation.

Company Farm	Location	Year Completed	Elevation	Total Depth	Depth to Precambrian	Elevation of Precambrian
Cain Bloom[1] No. 1 Zeandale	NWc SW[1] 28-10-9 SW NW[2] 28-10-9	1914[1]	1007?[5]	1020[1]	928[1]	+ 49[2,5,6]
Cain Bloom[1] No. 2 Zeandale	NW NW NE[1] 28-10-9	1915[1]	1007[5]	1020[1]	----	- 13[5,6]
Parker Oil Co.[1] No. 1 Bardwell	SW NE[1,3] 28-10-9 NW NW[2,6] 28-10-9	-----	-----	1093[1,6]	945[1]	+ 155[2,6]
Parker Oil Co.[1] No. 2 Bardwell	NWc[1,7] 28-10-9	1915?[1,7]	-----	1093[1,7]	958[4]	+ 56[6,7]
Empire Oil & Gas[1] No. 1 Root	SW NE[1,7] 1-11-9	1917[1]	-----	1895[1]	1180[4]	- 28[2,3,6,7]

1 Jewett (1954)
2 Koons (1955)
3 Kotyantz (1956)
4 Moore and Haynes (1917)
5 Nelson (1952)
6 Rieb (1954)
7 Smith and Anders (1951)

1915).

Moore and Haynes (1917) also studied the samples collected by Dr. Haworth and definitely identified them as granite not of intrusive origin. Information from these and other early wells was instrumental in the development, by Moore and Haynes, of the "buried Nemaha mountains" hypothesis.

Jewett (1941) referred to the relatively steep westward dip of the lower Permian strata which crops out in the Flint Hills west of Zeandale and stated, "the rocks there lie on the west limb of the Deep creek fold." Jewett explained that the Deep creek fold was a structural dome or anticline on which the valley of Deep creek was superposed and was,

> ....nearly in superposition on the buried Nemaha Mountains and is a part of the anticlinal structure that crosses the state above the buried mountains.

Mudge (1949) applied the name "Salina Dome" and stated, "the dome is the result of supratenuous folding over the buried Nemaha ridge."

Jewett (1951) in his publication entitled "Geologic Structures of Kansas", did not list Zeandale Dome, Salina Dome or Deep Creek Fold.

Nelson (1952) appears to have been the first to apply the name Zeandale dome when he stated that the Zeandale dome was located on the Nemaha ridge and was believed to be due to cross faulting.

Rieb (1954) stated that the Zeandale dome was faulted on the west flank. The fault mapped by Rieb was in the same position as the one inferred by Koons (1955) along the east flank of the Nemaha anticline.

Koons (1955) listed the Zeandale "anticline" as a "major structure previously mentioned in the geologic literature of Kansas" and stated that it,

> ....appears as a northwest southeast elongated dome with a closure of about 600 feet. The dome was originally elongated parallel to the Nemaha fault, but a short fault cuts the northern half giving an appearance of elongation in a northwest-southeast direction.

Lee (1956) showed a structural and stratigraphic anomaly in the area covered by this investigation. Lee's Plate 6, a pre-Pennsylvanian areal geologic map, showed a granite dome against which the Paleozoic rocks had been turned up and eroded. Lee's Plate 7 entitled "Thickness of pre-Kansas City Pennsylvanian rocks" showed thinning around a local dome in this area. Lee made no mention of this dome as separate from the Nemaha anticline.

Farquhar (1957) showed a structural high in this area on his contour of the Precambrian surface but made no mention of it as a separate structure.

Bruton (1958) applied the name Zeandale dome to the surface structure south of Zeandale on which the valley of Deep Creek was superposed.

The name Zeandale dome has been used in recent Kansas State College Masters theses in reference to both the surface and subsurface expression of the structural anomaly in the area covered by this investigation. That usage will be continued in this thesis.

Statement of the Problem

Subsurface studies by Farquhar (1957), Lee (1956), Koons (1955), Rieb (1954), and Nelson (1955) have indicated the presence of a structural or topographic anomaly on the Precambrian floor underlying southeast Riley County and northwest Wabaunsee County which has been interpreted as a granite dome. A closure of 600 feet has been reported for this dome and, within the area of this investigation, a difference in relief on the granite surface of 168 feet within ½ mile. About 1000 feet of sediments overlie the granite in the area under consideration.

The purpose of this investigation is, (1) to discover if there is, in a 20 square mile area containing exposed sedimentary rocks about 1000 feet above the granite floor, any indication of subsurface structure at the surface, (2) to map and discuss in detail any surface structure encountered, and (3) to determine the origin of this structure by combining available subsurface and surface data.

MAPPING PROCEDURE

The field investigation was conducted in the fall and early winter of 1958. U.S.G.S. 7.5 minute topographic quadrangles, scale 1:24,000, served as the base map.

As initially conceived the purpose of this investigation was to discover any surface evidence of the Zeandale dome and to select and map in detail an area enclosing the apex of the dome.

Geologic investigations by Harned and Chelikowsky (1945), Mudge (1949), Ratcliff (1957) and others, were consulted in an attempt to define the axis of the Nemaha anticline and the location of the Zeandale dome. A general reconnaissance was conducted between Manhattan, Kansas and Wamego, Kansas and north of U. S. 40 to K-24. Formations exposed in this area were identified and geologic sections were measured. A Paulin altimeter survey was made of the exposures of the Tarkio limestone and a structural contour map was constructed which depicted the general attitude of the surface rocks. The portion of the primary reconnaissance area selected to be considered in detail should reveal surface expression of the Zeandale dome because, (1) elevations determined with the Paulin altimeter on the Tarkio limestone delineated a domal structure in the area selected, (2) the contour of the granite surface as reported by previous investigators exhibited a domal structure in the area, (3) sedimentary rock exposures were extensive. Geomorphic, stratigraphic, and structural evidence of the buried dome was expected.

Geologic sections were measured to determine, (1) the nature and sequence of the outcropping formations, (2) the thickness of the exposed stratigraphic section, and (3) any relationship between the character and distribution of the sedimentary rocks and the buried dome.

The Willard shale, a thick unit in the outcropping stratigraphic section, was easily identified and fully exposed in widespread locations within the area. Thickness of the Willard shale was measured in various locations in an attempt to determine any thickening or thinning trends related to the Zeandale dome. No other shale unit was well enough exposed to permit widespread thickness determination within the area. The structural attitude of the top of the Tarkio limestone should reveal the surface expression of the Zeandale dome because it has a large outcrop area and is easily identified.

Plane table traverses, originating from U.S.G.S. benchmarks, were planned to cover the outcrop area of the Tarkio limestone, and the outcrops of younger formations which could be identified, and to traverse the Zeandale dome in an east-west and a north-south direction. The upland deposits of unconsolidated silt, sand, gravel, and boulders between Deep and Emmons creeks conceal the sedimentary bedrock and the elevation of the Tarkio limestone could not be determined. Extensive areas blanketed by glacio-fluvial and alluvial material were also found in Deep Creek valley and isolated, poorly exposed, outcrops could not be identified with certainty. Areas of inadequate control are indicated on the structural contour map (Plate IX in appendix) by dashed contour lines.

In the western part of the area the Tarkio limestone dips under the Permian hills and is concealed by younger formations. Elevations were recorded on top of the Five Point, Caneyville, and Grandhaven limestones. The stratigraphic intervals from the top of the Five Point limestone to the top of the Grandhaven limestone and from the top of the Grandhaven limestone to the top of the Tarkio limestone were measured approximately along the strike of the rocks (Measured Sections 2 and 9). The interval from the top of the Caneyville limestone to the top of the Grandhaven limestone was computed by adding the average thickness of the Caneyville limestone, French Creek shale, Jim Creek limestone, and Friedrich shale. The appropriate stratigraphic interval was subtracted from the elevations recorded on the top of the Five Point limestone, Caneyville limestone, and Grandhaven limestone, and the elevation of the top of the Tarkio limestone was determined.

A structural contour map (Plate IX in appendix) was prepared on the top of the Tarkio limestone from the data thus obtained. A 10 foot contour interval was selected because it was believed that possible errors in elevation, not exceeding 5 feet, would have negligible effect and the structure would be accurately depicted.

Formation contacts were drawn on the base map and plane table sheets in the field, and a geologic map (Plate VIII in appendix) was constructed by extending and connecting these contacts along prominent breaks in slope. The geologic map was designed to show the first recognizable sediment to be encountered in a well drilled in any particular location. Previous geologic maps of Riley County by Jewett (1941), Mudge (1949), and Beck (1949) were consulted.

The geologic and structural maps were converted to a 1:12,000 scale and combined to produce a geologic cross section

(Plate X in appendix). Topography on the cross section was taken from the base map and enlarged with a pantograph.

STRATIGRAPHY

The stratigraphic units which crop out in this area are all of sedimentary origin and range in age from Pennsylvanian to Quaternary. The oldest rock unit represented is the Auburn shale of the upper Pennsylvania system and the youngest is the Foraker limestone of the lower Permian system.

Pennsylvanian System

The Pennsylvanian system consists of, in descending order, the Virgilian, Desmoinesian, Atokan, and the Morrowan series. The Virgilian series consists of, in descending order, the Wabaunsee, Douglas and Shawnee groups. Only the upper part of the Wabaunsee group outcrops in this area.

Wabaunsee Group. The Wabaunsee group consists of, in decending order, the Richardson, Nemaha, and Sacfox subgroups. The lower part of the Nemaha subgroup and the Sacfox subgroup do not crop out in this area but are present in the subsurface. Exposed Pennsylvanian strata is chiefly non-fossiliferous, green or brown shale which weathers lighter in color. Relatively thin but persistent limestones are numerous and are abundantly fossiliferous with fusulinids predominating.

Nemaha Subgroup. This is the middle subgroup of the Wabaunsee group and consists of strata between the top of the Tarkio

EXPLANATION OF PLATE II

Generalized stratigraphic column of southeast Riley County and northwest Wabaunsee County, Kansas.

PLATE II

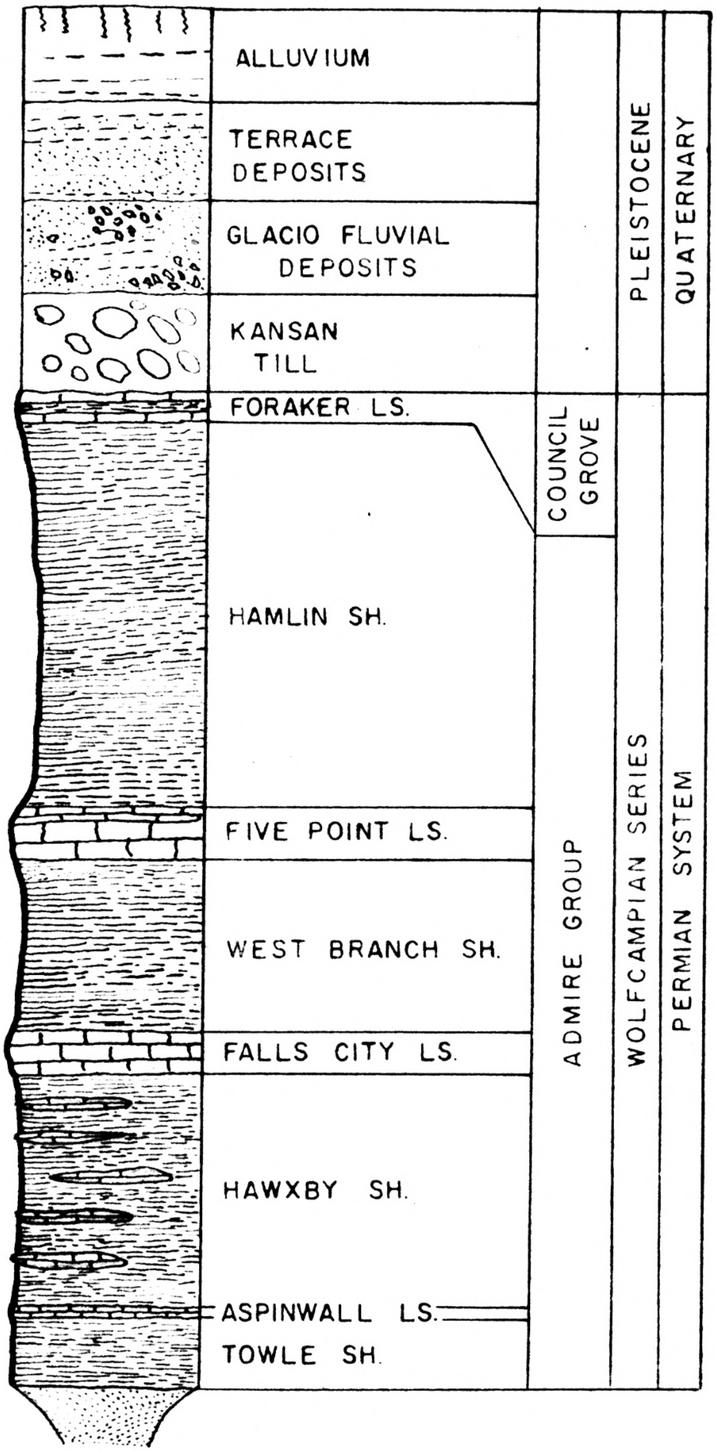
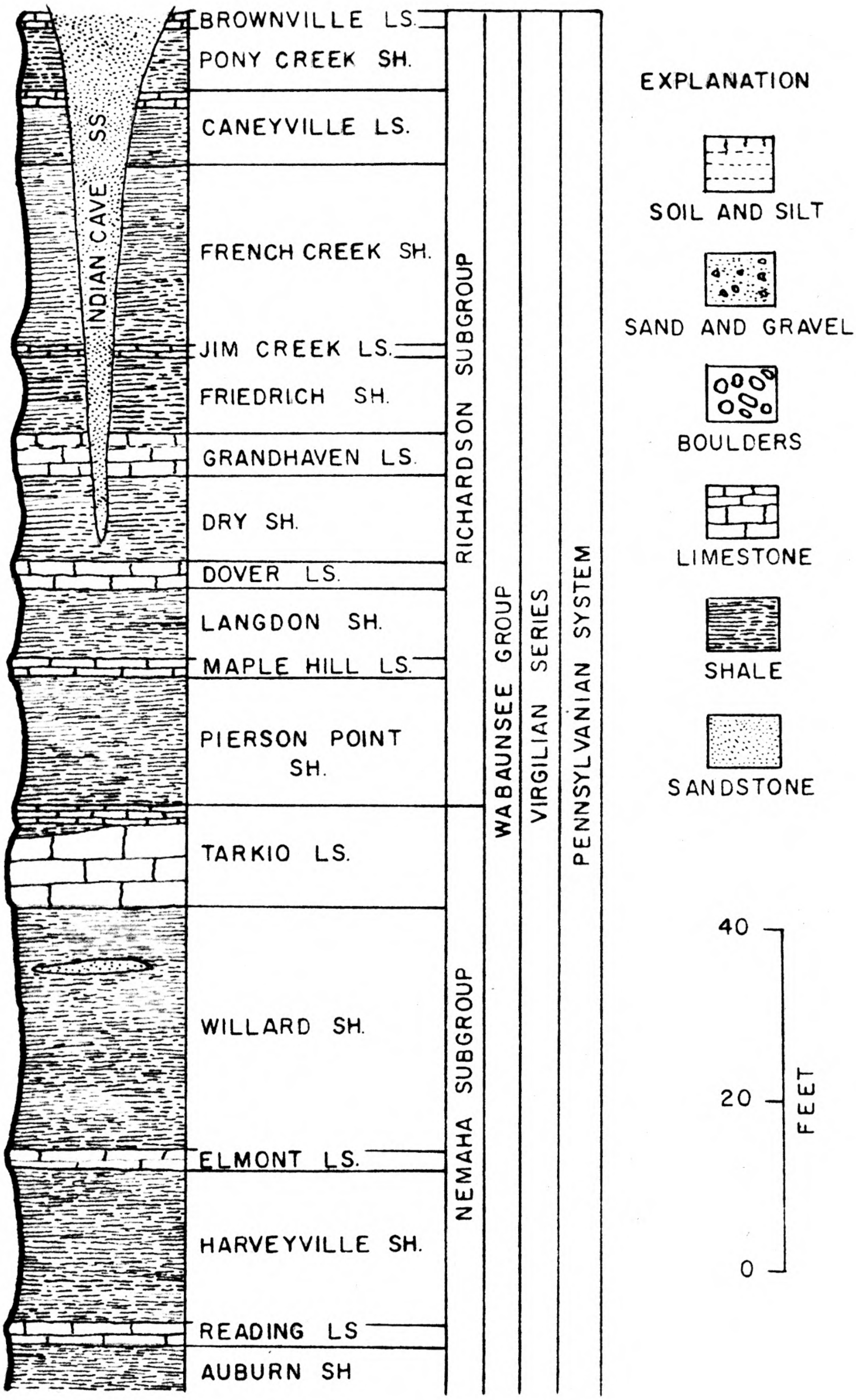

ALLUVIUM
TERRACE DEPOSITS
GLACIO FLUVIAL DEPOSITS
KANSAN TILL
FORAKER LS.
HAMLIN SH.
FIVE POINT LS.
WEST BRANCH SH.
FALLS CITY LS.
HAWXBY SH.
ASPINWALL LS.
TOWLE SH.
COUNCIL GROVE
ADMIRE GROUP
PLEISTOCENE
WOLFCAMPIAN SERIES
QUATERNARY
PERMIAN SYSTEM

PLATE II (cont.)



limestone and the base of the Burlingame limestone (Moore et al, 1951). Only that part of the Nemaha subgroup which lies above the Wakarusa limestone is exposed in this area.

Auburn Shale. The upper few feet of the Auburn shale are exposed along the south bank of Deep Creek near the Riley-Wabaunsee County line. In this area, it is a gray, non-fossiliferous shale and is recognized by its stratigraphic position below the Reading limestone.

Reading Limestone. The Reading limestone is exposed in the beds of tributaries to Deep Creek in the northeast part of this area and is recognized by its stratigraphic position below the Elmont limestone. It is a hard, gray, fossiliferous limestone about two feet thick.

Harveyville Shale. The Harveyville shale is a gray-green, non-fossiliferous, locally arenaceous shale about 18 feet thick. It is recognized by its stratigraphic position below the Elmont limestone and above the Reading limestone. The upper few feet are usually exposed wherever the Elmont limestone crops out.

Elmont Limestone. The Elmont limestone crops out extensively in the northeast part of this area. A good exposure is found in the bed of Deep Creek at Pillsbury Crossing (Plate III). This limestone is blue-gray, hard, and weathers to large, reddish-brown, rectangular blocks. The Elmont limestone is easily recognized by its massiveness, characteristic weathering, and stratigraphic position below the Tarkio limestone.

Tarkio Limestone. The Tarkio limestone crops out extensively

EXPLANATION OF PLATE III

Fig. 1. Photograph of the northwest bank of Deep Creek at Pillsbury Crossing (NE¼, NE¼, NW¼, Sec. 5, T. 11 S., R. 9E.) showing the outcrop of the Elmont limestone in the stream bed with the Willard shale and Tarkio limestone above.

Fig. 2. Closeup of the Tarkio limestone outcrop on the north side of a road cut in the SE¼, SE¼, SW¼, Sec. 36, T. 10 S., R. 9 E.

PLATE III

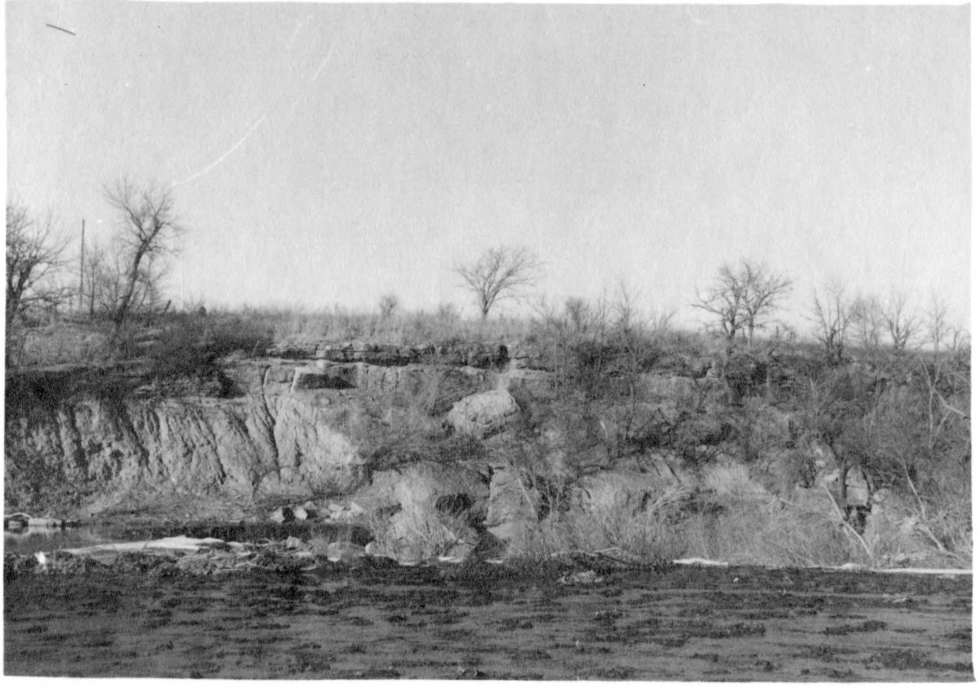


Fig. 1

Fig. 2

east of Deep Creek. One partial exposure is found in the west bank of Deep Creek in the SW¼, SW¼, NW¼, Sec. 5, T. 11 S., R. 9 E. about ½ mile southwest of Pillsbury Crossing (Plate VIII in appendix). One outcrop on the west bank of Deep Creek at Pillsbury Crossing (Plate VIII in appendix) can be traced north to a point (NE¼, NW¼, SE¼, Sec. 29, T. 10 S., R. 9 E.) ½ mile southwest of Zeandale. The Tarkio limestone is composed of two thick limestones sometimes separated by a shale. The lower limestone is gray-orange to gray-brown and weathers chocolate brown. It is hard and dense, and numerous orange limonite specks are evident on fresh surfaces. Except for a two to three foot thick massive zone at the top this limestone is abundantly fossiliferous. Large, light colored, fusulinids, more resistant than the limestone matrix, predominate and stand out in bold relief. This limestone unit forms the bench characteristic of the Tarkio limestone in the northeast part of this area.

The shale parting, when present, is tan to gray-green and contains calcareous nodules.

The upper limestone is gray, and weathers light gray. It is hard, weathers to irregular, rounded slabs, and contains abundant fusulinids. The fusulinids weather at about the same rate as the limestone matrix and tend to become sectioned so that their convolutions are evident. This limestone is exposed less conspicuously above the more resistant lower limestone. It is generally beveled back to a colluvial slope. In field mapping the highest limestone outcrop above the lower limestone and below the Pierson

Point shale, soil, or Quaternary cover has been interpreted as the top of the Tarkio limestone.

The Tarkio limestone is easily recognized by its relatively great, uniform thickness, abundance of fusulinids, and prominent bench. The average thickness in this area is about 13 feet.

Richardson Subgroup. The Richardson is the upper subgroup of the Wabaunsee group. It includes the strata between the top of the Tarkio limestone and the disconformity at the base of the Permian system.

Pierson Point Shale. The Pierson Point is a blue-gray to tan, non-fossiliferous shale about 15 feet thick, and is recognized by its stratigraphic position above the Tarkio limestone. It is usually exposed where the Tarkio limestone is found part way down a hill side.

Maple Hill Limestone. In this area the Maple Hill limestone is gray to brown, weathers brown, and contains fusulinids, crinoids, and fossil fragments in abundance. It is only about one foot thick and does not make a prominent outcrop. It is recognized in the NE$\frac{1}{4}$, SW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 9, T. 11 S., R. 9 E. by its stratigraphic position between the non-fossiliferous Pierson Point and Langdon shales.

Langdon Shale. The Langdon shale is generally covered in this area but it is exposed in a road cut in the SW$\frac{1}{4}$, SW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 27, T. 10 S., R. 9 E.. It is a gray-green, non-fossiliferous shale about nine feet thick and is recognized by its stratigraphic position below the Dover limestone.

Dover Limestone. The Dover limestone is found capping small knolls in Deep Creek valley in the Riley County portion of the area and in the extreme southeast corner of the Wabaunsee County portion. Where present it usually forms the first recognizable bench, or caps the hill, above the Tarkio limestone. The Dover limestone is gray, massive, contains numerous fusulinids, and is about three feet thick.

Dry Shale. The Dry shale is not well exposed in this area. It is a non-fossiliferous, gray, shale about 11 feet thick and is recognized by its stratigraphic position between the Grandhaven and Dover limestones.

Grandhaven Limestone. The Grandhaven limestone caps low hills in the south and west portion of this area and is recognized by its stratigraphic position above the Dover and Tarkio limestones. It is a light gray to brown limestone and generally weathers to a brown, irregular upper surface. An upper soft limestone and shale unit described in Measured Section 4 is usually weathered away in hill top exposures. Average outcrop thickness is about two feet.

Friedrich Shale. The Friedrich shale is not well exposed in this area. It is a green to yellow, non-fossiliferous shale about 10 feet thick and is recognized by its stratigraphic position above the Grandhaven limestone.

Jim Creek Limestone. Outcrop of the Jim Creek limestone is restricted to the southern portion of this area. It is a purplish-gray, hard, dense, fossiliferous limestone about one foot thick.

French Creek Shale. The French Creek shale does not crop out extensively in this area. It is a gray to tan, non-fossiliferous shale overlying the Jim Creek limestone. Thickness is about 20 feet.

Caneyville Limestone. Moore et al (1951) included the upper Grayhorse limestone member, a separating shale, and the lower Nebraska City limestone member in the Caneyville formation. In this area the members are not distinguished. The Caneyville consists of a limestone about two feet thick underlain by about seven feet of shale. The limestone is hard, tan, massive, and contains abundant fossil fragments. The shale is gray to tan and contains a few brachiopods. Total thickness of the Caneyville formation is about nine feet.

Pony Creek Shale. Only the lower few feet of the Pony Creek shale is exposed in this area. It is a tan shale about seven feet thick.

Brownville Limestone. The outcrop of the Brownville limestone is limited in this area and where present it is mostly covered and not prominent. The Brownville limestone is tan and weathers gray. It is fossiliferous and about two feet thick.

Permian System

The Permian system consists of, in descending order, the Guadalupian, the Leonardian, and the Wolfcampian series. The Wolfcampian series consists of, in descending order, the Chase, Council Grove, and Admire groups. Only the Admire group and the lowermost member of the Council Grove group are present in this area.

Admire Group. The Admire is the lower group of the Wolfcampian series and includes the strata overlying the disconformity at the base of the Permian system and underlying the Foraker limestone.

Towle Shale. In this area the Towle formation consists of an unnamed upper shale member and the lower Indian Cave sandstone member.

Indian Cave Sandstone. The Indian Cave sandstone is a channel deposit representing the disconformity at the base of the Permian system. In this area the Indian Cave sandstone has been found unconformably overlying the Grandhaven and Dover limestones. Its stratigraphic thickness range is 40 to 60 feet. The maximum exposed thickness is about 42 feet (Measured Section 6). The Indian Cave is a brown, poorly cemented, cross bedded, quartz-mica sandstone. It is recognized by its distinctive lithology and its nonconformable position in contact with older units.

Unnamed Shale. In the NW¼, NW¼, NW¼, NW¼, Sec. 31, T. 10 S., R. 9 E. the Indian Cave sandstone is not present and the rock between the Aspinwall limestone is a brown shale about seven feet thick. This shale is believed to represent the Towle formation.

Aspinwall Limestone. The Aspinwall limestone does not make a prominent outcrop in this area but is exposed near the northwest and south-central boundaries. It is a hard, gray, fossiliferous, limestone about two feet thick.

Hawxby Shale. The Hawxby shale is well exposed in the southeastern part of this area in road cuts along the southern boundary. It is a tan, non-fossiliferous shale with numerous thin, fossiliferous limestone lenses. The Hawxby shale is about 25 feet thick.

Falls City Limestone. The Falls City limestone does not make a distinctive outcrop in this area. It is present in the south-central and northwest portions of the area and is a tan, porous limestone about four feet thick. It is soft and weathers to gray, rounded pieces.

West Branch Shale. The outcrop of the West Branch shale is limited to the south-central and northwest portion of the area. It is gray to green, non-fossiliferous shale about 20 feet thick.

Five Point Limestone. The Five Point limestone usually forms the lowest recognizable bench in the Permian rocks in this area. The lower part is hard, gray, massive, and fossiliferous but the upper one to two feet is, in places, platy and argillaceous. The total thickness of this limestone is about five feet.

Hamlin Shale. The Hamlin shale is present near the top of Tabor Hill (SE$\frac{1}{4}$, SE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 9, T. 11 S., R. 9 E., Plate VIII) and in the northwest part of the area but it is mostly covered. The lower few feet are green shale. The total thickness, interpreted as the interval between the Americus limestone and the Five Point limestone, is about 40 feet.

Council Grove Group. The Council Grove is the middle group of the Wolfcampian series and includes the strata overlying the Hamlin shale and underlying the Threemile limestone.

Foraker Limestone. The Foraker limestone is the lowermost formation of the Council Grove group. It includes, in descending order, the Long Creek limestone, Hughes Creek shale, and Americus limestone members. The Americus limestone is the only member of the Foraker formation exposed in this area.

Americus Limestone. The Americus limestone caps Tabor Hill (Plate VIII in appendix) and is also found along the northwest boundary of this area. It is about three feet thick and consists of two blue-gray, hard, fossiliferous limestones separated by a shale. The upper limestone and shale is mostly weathered away in this area.

Quaternary System

Pleistocene Series. The Pleistocene series is represented in this area by alluvium, terrace deposits, glacio-fluvial material, and one deposit tentatively identified as glacial till.

Glacial Till. A concentration of large quartzite boulders indicates that a deposit of glacial till is present in the northeast corner of this area. This deposit is tentatively identified as Kansas till because the Kansas glacier is the only one reported to have penetrated this far south (Frye and Leonard, 1952). This till was so identified by Beck (1949).

Glacio-fluvial Material. Unconsolidated, sand, silt, and gravel carried by glacial melt-water streams has been extensively deposited in this area. Deposits may be found on most of the uplands.

Terrace Deposits. Terrace deposits are present along the valleys of Deep and Emmons creeks. They consist of stream deposited silt, sand, and gravel, and are recognized by prominent breaks in slope on the valley floors.

Alluvium. The valleys of Deep and Emmons creeks are generally deeply filled with recent alluvial deposits of sand, silt, and gravel.

GEOLOGIC HISTORY

Surface geology records only a brief portion of the geologic history of this area because the structural attitude of the rocks is nearly horizontal and topographic relief is low. Subsurface data is also limited. This description of the geologic history of the area investigated is based on the regional geologic history as interpreted by Lee (1956) and Farquhar (1957) supplemented by the available surface and subsurface data.

Paleozoic Era

The Paleozoic was an era of deposition, warping and folding, and erosion in this region. Several widespread periods of warping occured and each was followed by erosion to a relatively flat surface. The principal periods of warping and folding were, (1) during the deposition of the lower Ordovician Arbuckle group, (2) during the interval between the deposition of the middle Ordovician Simpson group and the Mississippian period, and (3) in the interval beginning in the Mississippian period and continuing into the Permian period.

Pre-Missourian post-Devonian uplift, associated with the formation of the Nemaha anticline, and subsequent erosion, caused granite to be exposed in the area covered by this investigation during part of Missourian time. Pennsylvanian seas encroached upon the Nemaha anticline and, by the end of Missourian time, this area was submerged and marine sediments covered the Precambrian granite. The frequent alternation of limestone and shale, and the gastropod fragments in drill cuttings reported in drillers records (Moore and Haynes, 1917) indicate that the depth of water was never very great in this area and minor fluctuations were common. Coal and "redrock" reported may indicate brief emergence of this area in Missourian or Virgilian time. As the Pennsylvanian sea retreated this area became part of an extensive land area. Valleys 60 feet or more deep were cut in the relatively flat surface left by the retreating sea. These valleys were filled with fluvial and littoral marine sands as the Permian sea advanced. By early Wolfcampian time the area was again submerged and probably remained covered by shallow water during most of the remaining part of the Paleozoic era.

Mesozoic Era

The Mesozoic was predominantly an era of erosion and regional tilting to the west. The Paleozoic seas had retreated and this area was exposed to erosion which removed most of the Permian sediments. Cretaceous tilting imparted a slight westward dip to the Paleozoic rocks.

Cenozoic Era

In this region the Cenozoic was primarily an era of erosion. All sedimentary rocks younger than Permian in the area covered by this investigation were stripped away by erosion during the Tertiary period. During the Pleistocene epoch of the Quaternary period two ice sheets extended into Kansas. A lobe of the Kansas glacier extended into the area of this investigation. Glacial till was deposited in the northeast corner and deposits by glacial melt-water streams and lakes covered the area. In recent times the post Kansan surface has been eroded by the Kansas River and its tributaries. Paleozoic bedrock has been exposed in many places and intermittent lowering of base level has caused Deep and Emmons creeks to erode topographic terraces in the alluvial filling of their valleys. At the present, alluvial material derived from weathered Paleozoic rock and Pleistocene deposits is accumulating in stream valleys in the area.

STRUCTURE

Regional Structures

Three regional structures, the Nemaha Anticline, the Salina

Basin, and the Forest City basin, are near this area.

The Nemaha anticline extends northeast across Kansas through Nemaha and Sumner counties, and extends into Nebraska and Oklahoma. It is a broad arch, steeper on the east limb, and somewhat narrower on its southern extension. The Burns Dome, Elmdale Anticline, Diamond Creek Province, Cottonwood Province, and the Zeandale Dome are local anticlinal structures along the axis of the larger Nemaha anticline. The crest of the Zeandale Dome is the highest point on the axis of the Nemaha anticline in the area covered by this investigation.

The Forest City basin, on the east, and the Salina basin, on the west, were formed by the division of the older North Kansas Basin by the uplift of the Nemaha anticline. Numerous northeast trending anticlinal structures were formed in the basins during post Mississippian deformation. The two major anticlines near this area are the Abilene Anticline in the Salina basin, about 35 miles northwest, and the Alma Anticline in the Forest City basin, about 20 miles southeast.

Local Structure

Seven normal faults located one to five miles southwest of this area have been mapped by Mudge (1949) and Bruton (1958). These faults strike northeast and maximum displacement is 25 feet. A fault within the area of this investigation was mentioned by Mudge (1949).

> ....a small overthrust fault, discovered by Neff (1949), affecting the Tarkio limestone as it is exposed in a stream cut in the SE¼, SW¼, NW¼, Sec. 5, T. 11 S., R. 9 E..

Neff (1949) stated,

> ....one fault was found in the Elmont shale, SW¼, Sec. 6, T. 11 S., R. 9 E. and is located on the west bank of Deep Creek.

An extensive search of the above locations was made but no positive evidence of displacement was found there or elsewhere within the area.

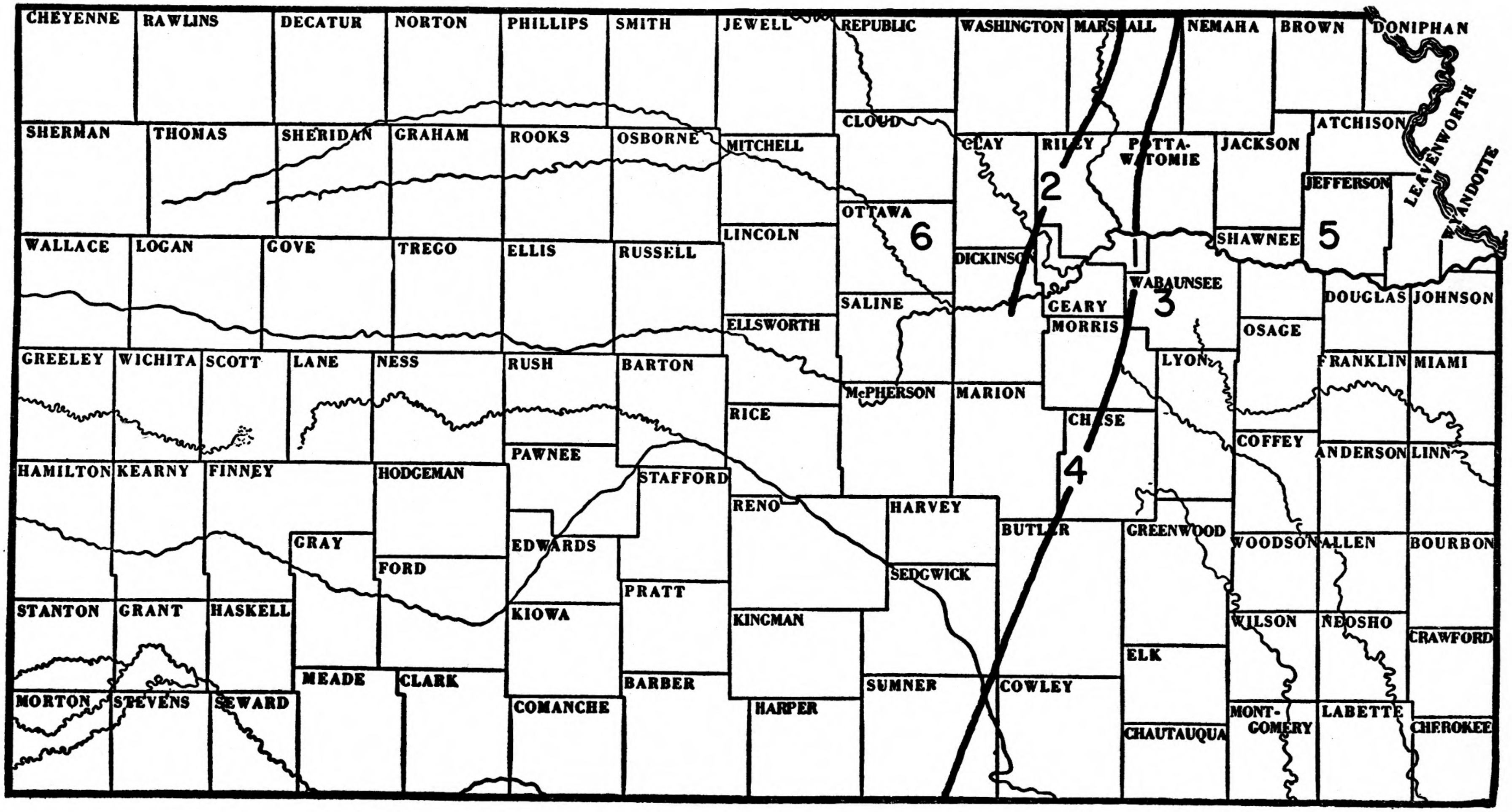
The surface crest of the Zeandale dome is near the center of the area covered by this investigation in the south half of Sec. 34, T. 10 S., R. 9 E., (Plate VIII in appendix). The area mapped covers only the structurally higher portion of the dome. Pronounced elongation is not apparent in this area but the west flank is noticeably steeper than the east. Within the area mapped the Zeandale dome is nearly symmetrical along a north-south axis but slightly asymmetrical along its east-west axis. Plate VII and plates IX and X (in appendix) show the asymmetrical nature of the dome. Closure in the area covered by this investigation is about 40 feet, but maximum closure on the Zeandale dome is probably somewhat greater. Dip of the Tarkio limestone from the crest of the dome to the borders of the area averages 45 feet per mile to the west, 20 feet per mile to the east, and 25 feet per mile to the north and south. The steepest dip in the area is 140 to 160 feet per mile on the southwest flank of the dome in Sec. 6, T. 11 S., R. 9 E..

EXPLANATION OF PLATE IV

Regional and local structures.

1. Zeandale Dome
2. Abilene Anticline
3. Alma Anticline
4. Nemaha Anticline
5. Forest City Basin
6. Salina Basin

PLATE IV


CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTA-
WATOMIE
JACKSON
ATCHISON
LEAVENWORTH
WYANDOTTE
JEFFERSON
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
LINCOLN
OTTAWA
DICKINSON
GEARY
WABAUNSEE
SHAWNEE
DOUGLAS
JOHNSON
SALINE
ELLSWORTH
MORRIS
OSAGE
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
RICE
McPHERSON
MARION
LYON
FRANKLIN
MIAMI
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
MONT-
GOMERY
LABETTE
CHAUTAUQUA
CHEROKEE
1
2
3
4
5
6

Drainage of the area is partially controlled by the structure of the Zeandale dome. Deep and Emmons creeks circumfluent the dome except on the south flank and are generally at about the same level in relation to the Tarkio limestone. Both Deep and Emmons creeks flow updip on the dome in the south part of the area. Most of their major tributaries flow down dip on the dome and one branch of Emmons creek in Sec. 35, T. 10 S., R. 9 E. flows down a large structural trough in the east flank of the dome. Other large structural troughs in the north and east flanks of the dome are not conformable with topography.

The Zeandale dome is primarily responsible for the relatively low altitude of the area compared with the surrounding bluffs. The resistant middle Wolfcampian cherty limestones were eroded first from the apex of the dome and subsequent erosion proceeded at a more rapid rate in the less resistant limestones and thick shales of the lower Wolfcampian and upper Virgilian series. A temporary reduction in the pace of erosion was probably produced by the uncovering of the Tarkio limestone, the uppermost thick resistant limestone of the rocks outcropping in the area. A nickpoint was developed in Deep creek at Pillsbury Crossing (Plate VIII in appendix) where it flows over the resistant Elmont limestone and from there to a point about 1½ miles upstream the stream is aggrading rather than degrading.

The Zeandale dome is responsible for the outcrop of Pennsylvanian rocks bordered by Permian rocks on the south, east and

EXPLANATION OF PLATE V

A panoramic view of inclined strata on the west flank of the Zeandale Dome taken from the NW corner, Sec. 30, T. 10 S., R. 9 E., looking south.

PLATE V

west. Outcrop distribution of the Tarkio limestone is partly related to the dome. A nearly continuous, prominent escarpment formed by the Tarkio limestone borders the dome on the north, east and west. The relatively steep dip on the west flank of the dome causes the Tarkio limestone to dip under the Deep Creek alluvial blanket in a relatively short distance. On the gently dipping east flank the Tarkio limestone contains Emmons Creek between two escarpments. The Tarkio limestone outcrop band is about one mile wide on the west flank of the dome and about two miles wide on the east.

DISCUSSION

Other geologic features which might be expected in a surface domal structure were considered in an attempt to interpret the origin and history of the Zeandale Dome.

Thinning of formations over the apex of the dome might give some clue as to the geologic time of its origin. Unfortunately no sedimentary rocks outcrop close to the inferred crest of the dome. Thickness of the Willard shale was measured in several locations on the north, east and west flanks but no uniform thickening or thinning trend was noted. The thickness of the Willard shale amounts to only three tenths of one per cent (0.003) of the total thickness of the sediments overlying the granite dome. If thinning over the crest of the dome were distributed evenly throughout the 1000 feet of sediments overlying the granite a total thinning of over 300 feet would be required to produce one foot of thinning in the Willard shale.

The channels developed on the Pennsylvanian surface in the area might have been structurally controlled. Outcrops of the Indian Cave sandstone, which now fills these channels, are limited and discontinuous and the channels could not be mapped. It was noted that, at its structurally and topographically highest outcrop in the NE$\frac{1}{4}$, NE$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 28, T. 10 S., R. 9 E., the Indian Cave sandstone overlies the Dover limestone. In its structurally and topographically lowest outcrop in the SE$\frac{1}{4}$, NE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 30, T. 10 S., R. 9 E., the Indian Cave sandstone overlies the Grandhaven limestone. The Grandhaven limestone is about 20 feet stratigraphically higher than the Dover limestone. If these channels are assumed to have been about at base level at the time of their filling by the Indian Cave sandstone the fact that younger formations underlie the Indian Cave sandstone on the west than on the east indicates dip to the west at the beginning of Permian time. Westward dip in one location does not indicate the presence of a dome and might equally well be the result of westward dip on the west limb of the Nemaha anticline. Exposures of the Indian Cave sandstone on the east, north and south flanks of the dome which might indicate pre Permian dip in those directions could not be found.

The structural attitude of the Tarkio limestone east of the area mapped in detail was determined with a Paulin altimeter from the few outcrops available. The east dip away from the crest of the Zeandale dome is probably continuous down the east limb of the

Nemaha anticline. Relatively steep dip observed affecting lower Permian sediments east of the area mapped in the center of Sec. 33, T. 10 S., R. 10 E. is assumed to represent the sharp increase in dip normally found on the east limb of the Nemaha anticline.

North and south of the area covered by this investigation previous surface investigations were consulted. Harned and Chelikowsky (1945) mapped the structural attitude of the base of the Tarkio limestone along a two mile east-west line about three miles northeast of this area. They found the Tarkio limestone forming a low anticlinal ridge with three feet of closure on its crest at elevation 1073. A syncline trending northwest-southeast and plunging northwest between this area and Harned and Chelikowsky's line is suggested. The Kansas River flows southeast, updip, in this supposed syncline.

Bruton (1958) mapped the structural attitude of the Cottonwood limestone in a 15 square mile area southwest of this one. Bruton noted dip of 200 feet per mile to the south on the Cottonwood limestone in the SW$\frac{1}{4}$, Sec. 18, T. 11 S., R. 9 E.. This probably represents the southern flank of the Zeandale dome.

Table 1 contains a summary of the data published on the five wells that have been drilled in the area covered by this investigation. It may be inferred from this data that the wells drilled in the area have penetrated about 1000 feet of alternating limestones and shales before penetrating granite. The maximum difference in elevation of the granite in the area covered by this investigation has been reported by Koons (1955) and Rieb (1950) as 183 feet. All of the wells have been drilled on the flanks of the surface expression of the dome.

If it is assumed that about 1000 feet of pre Tarkio sedimentary rocks overlie a granite dome in this area, the closure in the structure of the Tarkio limestone could be attributed to differential compaction of sediments. Twenty per cent compaction of the overlying sediments would produce a surface dome with 40 feet of closure 1000 feet above a granite dome with 200 feet of closure. Plate VI shows the degree of compaction necessary for other granite closure values. Blackwelder (1920) showed that in a Permian section, such as that at Eldorado, Kansas, 35 per cent compaction during lithification is possible.

The structure observed in the surface rocks might also have been produced by vertical uplift subsequent to deposition. Farquhar (1957) stated,

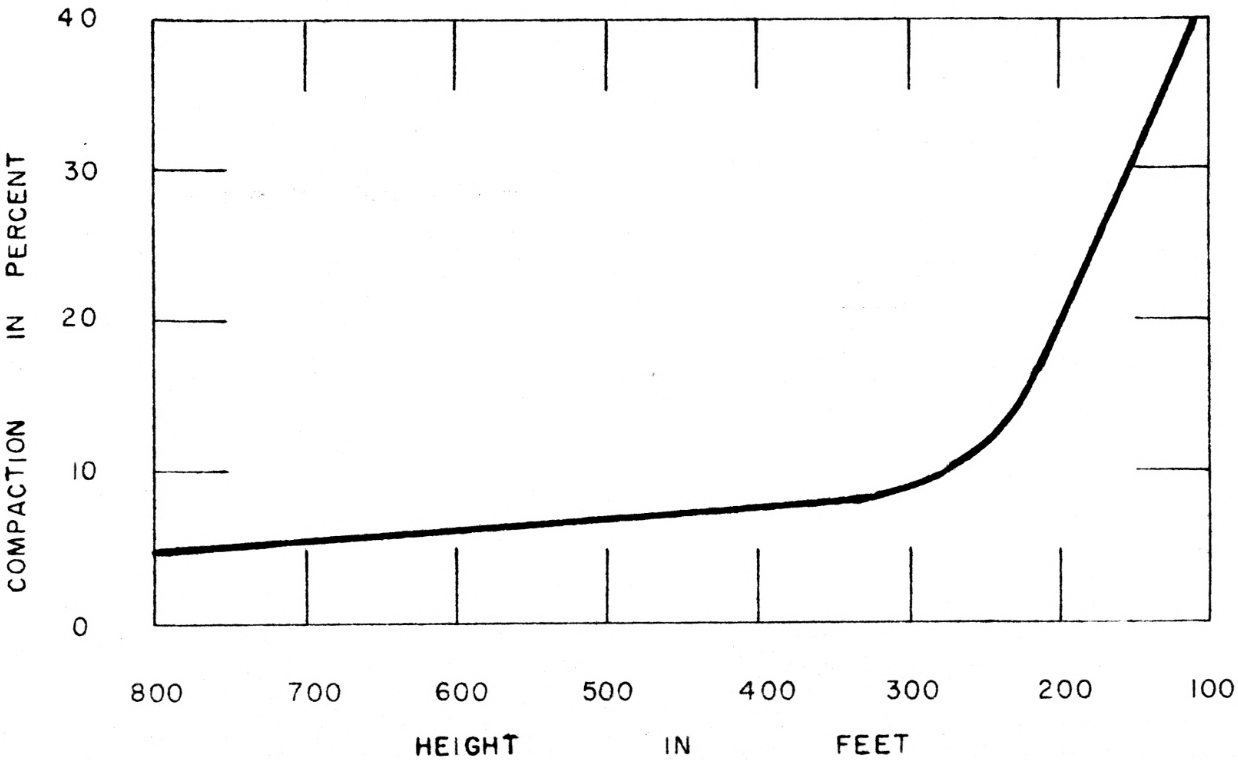
> ....On the Nemaha anticline the Precambrian rocks and overlying sediments were uplifted, exposed, and eroded at the end of Mississippian time. The surface that resulted was marked by knobs and saddles. Parts remained concealed by Pennsylvanian and later rocks. The anticline is still tectonically active, and uplift evidently has not been completed.

This area was uplifted as part of the Nemaha anticline but some differential uplift is required to produce a tectonic dome in the area. Differential vertical uplift affecting limited areas along the axis of the Nemaha anticline probably occured as a part

EXPLANATION OF PLATE VI

A graph showing variation in compaction per cent and granite relief necessary to produce a surface dome with 40 feet of closure 1000 feet above the granite floor.

PLATE VI



COMPACTION IN PERCENT
40
30
20
10
0
800
700
600
500
400
300
200
100
HEIGHT IN FEET

of the uplift that produced the Nemaha anticline. Uplift of a major structure such as the Nemaha anticline could be the combined result of numerous small uplifts over a long period of time rather than a single diastrophic movement. Upper Permian and younger sedimentary rocks are not present in this area but upper Wolfcampian rocks are exposed nearby and are arched up on the dome (Plate V). Supposed movement resulting in the doming of the overlying rocks is probably in part post Wolfcampian.

Some clue as to when possible deformation had been completed may be gained by considering the present expression of the dome with reference to the Mesozoic history of the region. During and after, and possibly before, Cretaceous time this region was tilted to the northwest. At present the average regional dip of the Permian rocks in Riley County is about 14 feet per mile to the northwest. The Zeandale dome is slightly steeper on the northwest than on the southeast. If Cretaceous tilting is assumed to have been 14 feet per mile to the northwest, a symmetrical dome in this area would have been tilted into about the present attitude of the dome on a northwest-southeast cross section. Plate VII shows the effect of tilting a northwest-southeast profile across the dome 14 feet per mile to the southeast, thus eliminating the influence of Cretaceous tilting. A more symmetrical appearance results. The present structure is steepest on the southwest flank. A post Pennsylvanian pre Cretaceous (?) age might be suggested for possible uplift creating a slightly asymmetrical dome in this area.

The Zeandale dome is probably the result of differential

EXPLANATION OF PLATE VII

Fig. 1. A diagrammatic northwest-southeast structural profile across the Zeandale dome on the top of the Tarkio limestone.

Fig. 2. The same profile as Fig. 1 tilted 14 feet per mile to the southeast showing the pre-Cretaceous more symmetrical appearance of the dome.

PLATE VII

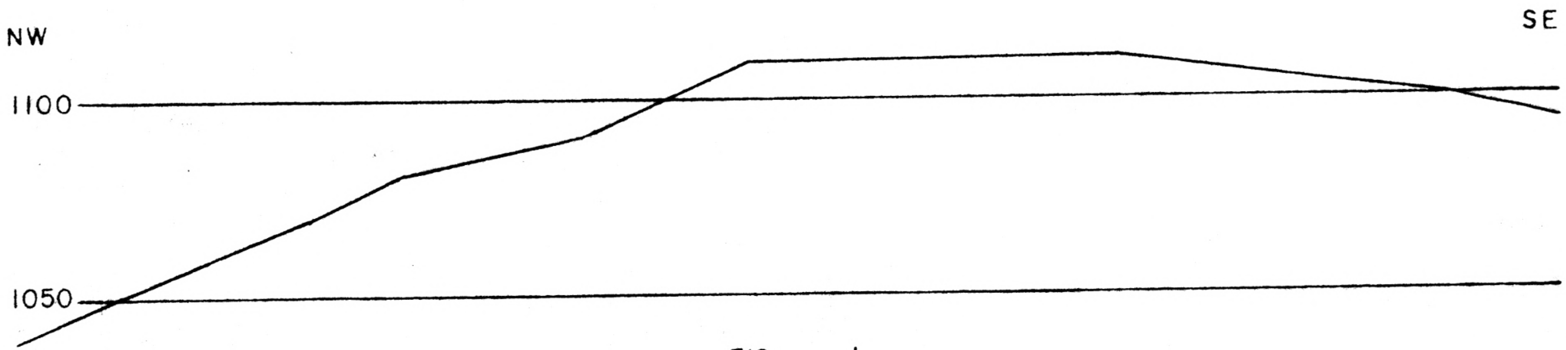


FIG. 1

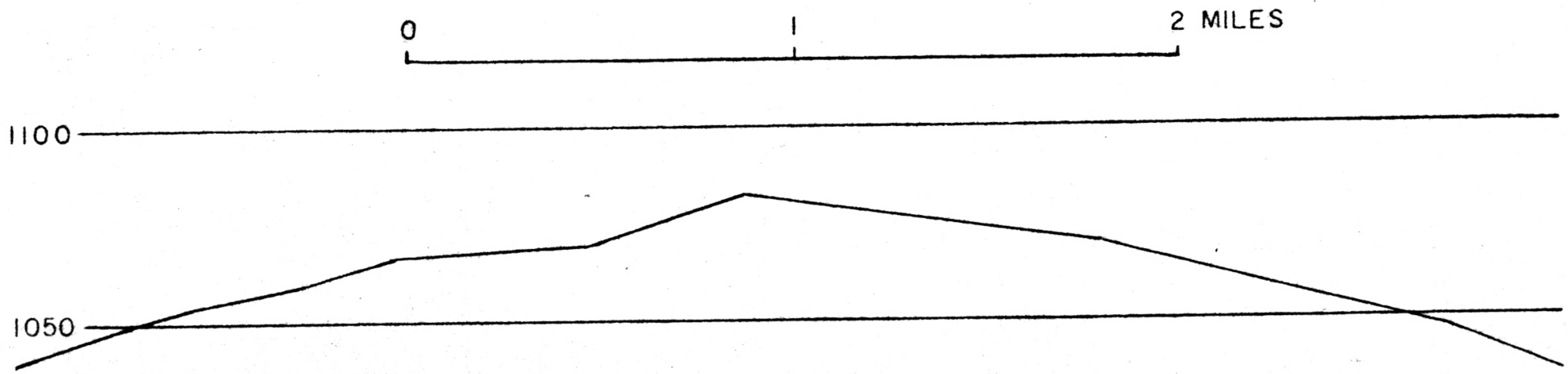


FIG. 2

compaction of sediments over a granite dome emphasized by uplift contemporaneous with deposition, and post depositional deformation and uplift. If a granite hill were present in this area as a result of the erosion of the Mississippian surface following the major uplift of the Nemaha anticline, any further regional or local uplift would promote the formation of a sedimentary dome over the granite hill. Local differential uplift would, (1) arch sediments deposited previous to the uplift, (2) cause thinning over the crest of the dome in sediments deposited contemporaneously with the uplift, and (3) increase the effect of differential compaction on sediments deposited after the uplift. Regional uplift of the Nemaha anticline in the Pennsylvanian period would cause thinning of the Pennsylvanian sediments over the crest of the dome. If regional uplift were intermittent or proceeded at a slower rate than deposition, the effect of the granite hill on the thickness of the overlying sediments would be progressively less as it became more deeply buried. The absence of thinning in the Willard shale over the crest of the dome should not be interpreted as meaning that all uplift was post Pennsylvanian.

CONCLUSION

A part of the Zeandale dome has been mapped in the area covered by this investigation. The crest of the dome is believed to lie near the center of the area in the south half of Sec. 34, T. 10 S., R. 9 E.. Thirty to forty feet of surface closure has been mapped around the apex of the dome but it is believed that somewhat greater closure is present on the entire structure.

The Zeandale Dome is a local "high" on the axis of the regional Nemaha anticline.

Surface data has not revealed the precise age and origin of the Zeandale Dome. It is believed to be the result of differential compaction of sediments over an anomaly in the granite surface emphasized by post Mississippian pre Cretaceous (?) uplift associated with the Nemaha anticline.

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APPENDIX

MEASURED SECTIONS

(1) SW$\frac{1}{4}$, NW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 27, T. 10 S., R. 9 E.

Maple Hill limestone	
1 foot	limestone, hard; gray-brown, weathers tan; massive; crinoid columnals, fusulinids, brachiopods.
Pierson Point shale	
14.8 feet	shale, calcareous; tan to gray. weathers orange; non-fossiliferous.
Tarkio limestone	
6.0 feet	limestone, hard; brown, weathers light brown; massive; fusulinids and fossil fragments; not a prominent bench.
6.0 feet	limestone, hard; tan, weathers brown; weathers in large irregular blocks and slabs; fusulinids large and stand out prominently in lower part, upper three feet non-fossiliferous; makes a prominent bench.
Willard shale	
28 feet	shale, non-calcareous; light green, weathers yellow green; non-fossiliferous.
Elmont limestone	
2 feet	limestone, hard; blue-gray, weathers buff to reddish-brown; fusulinids and fossil fragments abundant, fucoidal markings.
Harveyville shale	
18 feet	shale; gray-green; mostly covered.
Reading limestone	
2 feet	limestone, hard; blue-gray, weathers gray; fossil fragments abundant.

Auburn shale

4 feet	shale; dark gray, weathers gray; base covered.

(2) SE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 5, T. 11 S., R. 9 E.

Grandhaven limestone

3 feet	limestone, soft; gray, weathers brown; weathers flaggy; crinoids and fusulinids abundant.
41 feet	covered interval.

Tarkio limestone

3 feet	limestone, hard; light gray, weathers brown; massive; white fusulinids weather level with matrix.

(3) NW$\frac{1}{4}$, NE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 32, T. 10 S., R. 9 E.

Dover limestone

3 feet	limestone, basal part hard, grades upward into soft shaly limestone; gray, weathers light gray; fusulinids, brachiopods, and fossil fragments abundant.

Langdon shale

8.5 feet	shale, calcareous; gray-green, weathers light green; non-fossiliferous.

Maple Hill limestone

1.8 feet	limestone, hard; gray-brown, weathers tan; weathers to irregular upper surface; fusulinids and fossil fragments common.

Pierson Point shale

13.0 feet	shale, calcareous; light gray, weathers tan; non-fossiliferous.

(4) NE$\frac{1}{4}$, SW$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 28, T. 10 S., R. 9 E.

Grandhaven limestone

.7 feet	limestone, soft; light gray; massive; weathers smooth; chonetes, fusulinids, crinoids.
2.1 feet	shale, non-calcareous; gray, weathers light gray-green; non-fossiliferous.
1.9 feet	limestone, hard; brown, weathers light brown; weathers to irregular sharp pieces; crinoids, brachiopods.

(5) SW$\frac{1}{4}$, SW$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 5, T. 11 S., R. 9 E.

Grandhaven limestone (incomplete)

1.5 feet	limestone, hard; gray, weathers tan; massive; weathers in blocks and slabs; chonetes, fusulinids and crinoids abundant.

Dry shale

10.5 feet	shale, calcareous; gray; non-fossiliferous; grades into underlying Dover limestone.

(6) SE$\frac{1}{4}$, NE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 30, T. 10 S., R. 9 E.

Five Point limestone

2 feet	limestone, hard; gray; thin bedded; weathers platy.
3 feet	limestone, hard; gray; massive; weathers blocky, forms bench, large blocks slumped down slope.

West Branch shale

20 feet	covered interval.

Falls City limestone

3 feet	limestone, soft, porous; gray; very poor exposure, mostly loose pieces.
40 feet	covered interval.

Indian Cave sandstone

41.5 feet	sandstone, loosely cemented; brown; thin bedded and cross bedded; fine grained quartz, micaceous flecks.
17 feet	covered interval.

Grandhaven limestone (incomplete)

1.0 feet	limestone, hard; brown; massive; weathers to irregular knobs; fusulinids and fossil fragments.

(7) NW¼, NW¼, NE¼, Sec. 9, T. 11 S., R. 9 E.

Jim Creek limestone

1.1 feet	limestone, hard; blue-gray, weathers gray-brown; brachiopods.

Friedrich shale

8 feet	shale, non-calcareous; gray-green, weathers tan; non-fossiliferous.
4 feet	covered interval.

Grandhaven limestone (incomplete)

2 feet	limestone, hard; gray, weathers brown; massive; weathers to irregular slabs; fusulinids and fossil fragments.

(8) NW¼, NW¼, NW¼, Sec. 31, T. 10 S., R. 9 E.

Aspinwall limestone

1.1 feet	limestone, hard; gray; massive, weathers blocky; argillaceous lenses; crinoids and fossil fragments.

Towle shale

7 feet	shale, calcareous; brown, weathers tan.

Brownville limestone

2 feet	limestone, soft; tan; weathers gray; chonetes and other brachiopods abundant.

Pony Creek shale

7 feet	shale; tan; mostly covered.

Caneyville limestone

1.5 feet	limestone, hard; tan, weathers light brown; massive; fossil fragments abundant.
7 feet	shale, calcareous; gray, weathers tan; fossiliferous; partly covered.

French Creek shale (incomplete)

21 feet	shale, non-calcareous; gray, weathers tan; non-fossiliferous; partly covered.

(9) SW$\frac{1}{4}$, SE$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 9, T. 11 S., R. 9 E.

Falls City limestone

4.0 feet	limestone with thin shaly partings, soft; tan; porous; brachiopods.

Hawxby shale

24.4 feet	shale, calcareous; blue-gray to brown, weathers tan; numerous thin fossiliferous limestone lenses; shale non-fossiliferous.

(10) SE$\frac{1}{4}$, NW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 30, T. 10 S., R. 9 E.

Americus limestone (incomplete)

1.0 feet	limestone, hard; blue-gray, weathers gray; crinoid columnals and fossil fragments abundant.

Hamlin shale

35.0 feet	covered interval.
5.0 feet	shale, calcareous; gray-green, weathers light green; non-fossiliferous.

Five Point limestone

2.0 feet	limestone, hard; gray; thin bedded; weathers in slabs.
3.0 feet	limestone, hard; gray; massive; weathers blocky; brachiopods; makes bench.

West Branch shale (incomplete)

11 feet	shale, calcareous; gray, weathers tan; non-fossiliferous; base covered.

PLATE VIII

Geologic map of an area
in southeast Riley County
and northwest Wabaunsee
County, Kansas (In Pocket)

GEOLOGIC MAP OF AN AREA IN

SOUTHEAST RILEY COUNTY AND NORTHWEST WABAUNSEE COUNTY, KANSAS

PLATE IX

Structural contour map of
an area in southeast Riley
County and northwest Wabaunsee
County, Kansas. (In Pocket)

STRUCTURE CONTOUR MAP OF AN AREA IN

SOUTHEAST RILEY COUNTY AND NORTHWEST WABAUNSEE COUNTY, KANSAS

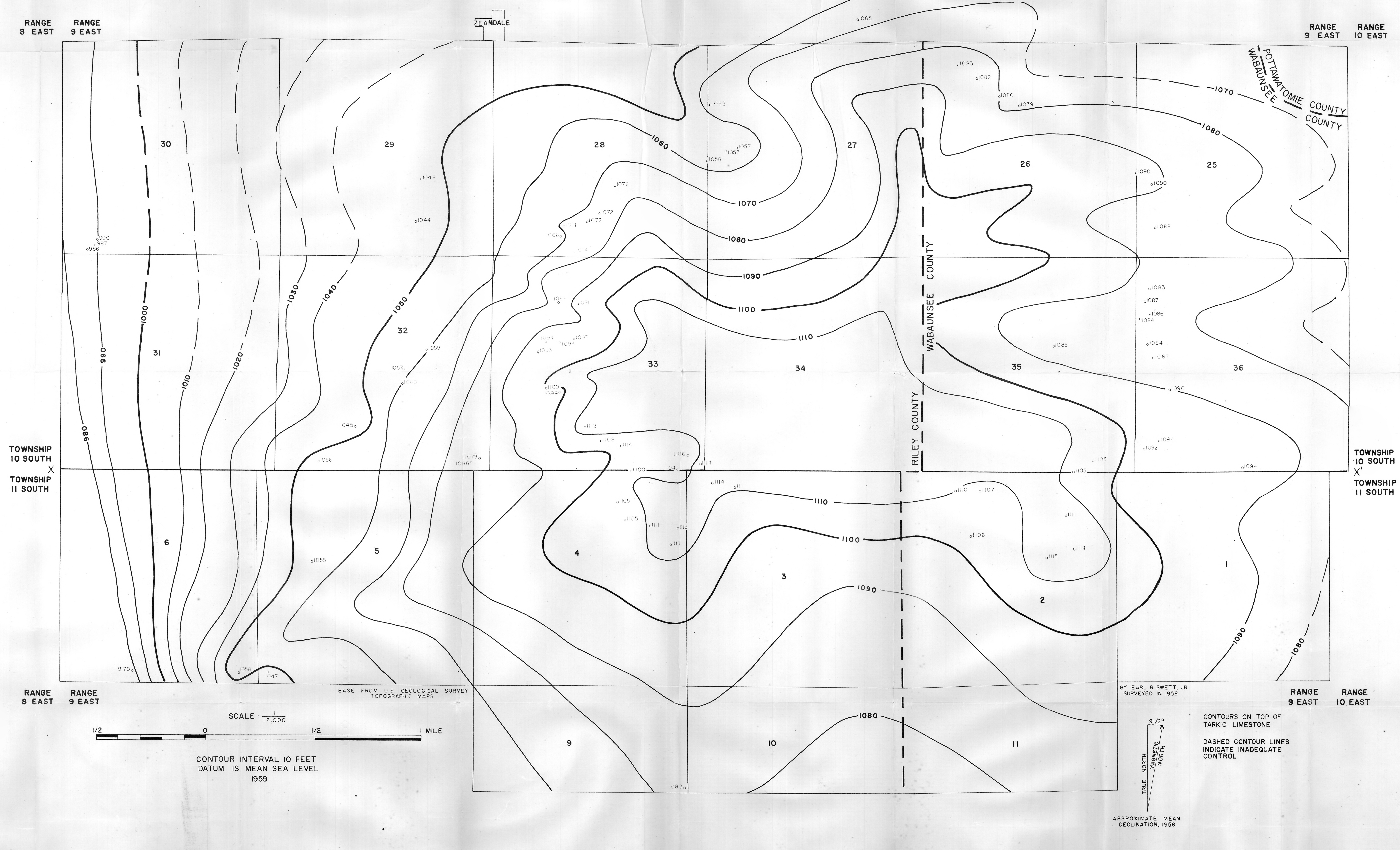
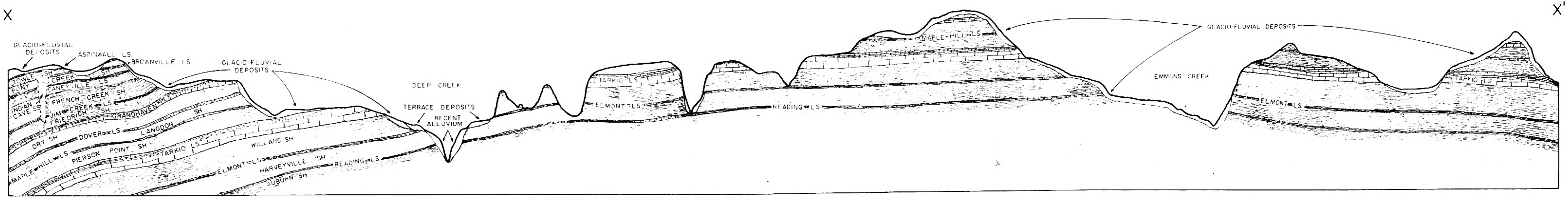
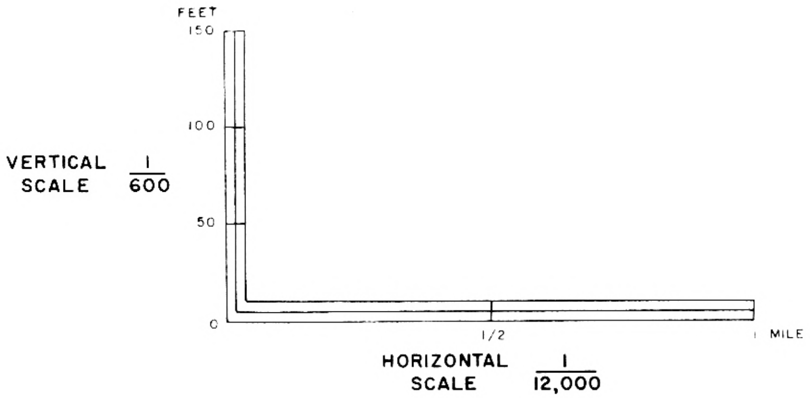


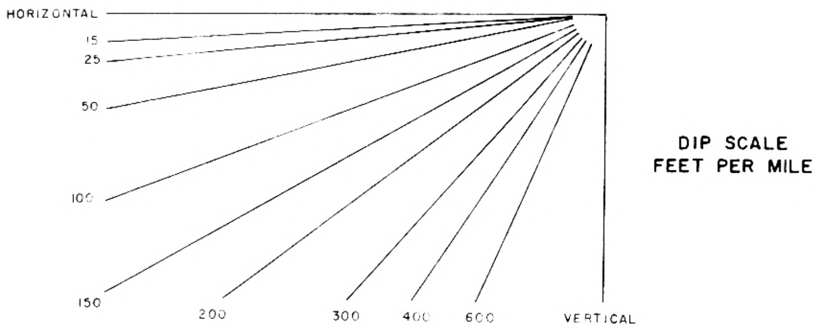
PLATE X

Cross section (In Pocket)

CROSS SECTION







EARL R. SWETT, JR.
1959

THE SURFACE EXPRESSION
OF THE ZEANDALE DOME

by

EARL RUDOLPH SWETT, JR.

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AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

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Department of Geology and Geography

KANSAS STATE COLLEGE
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This investigation covers an area of about 20 square miles in southeast Riley County and northwest Wabaunsee County, Kansas. The apex of the Zeandale dome, an uplift on the Nemaha anticline, is thought to be near the center of this area. The subsurface expression of the Zeandale dome has been mapped by numerous geologists. The purpose of this investigation is to map and describe the surface expression of the Zeandale dome.

A general reconnaissance was made of an area of about 40 square miles centered on the supposed crest of the Zeandale dome. Relatively steeply tilted Permian strata west of the area mapped in detail is believed to lie on the west flank of the dome. Seven normal faults trending northeast one to five miles southwest of the area are believed to be parallel to the southwest flank of the Zeandale dome and related to it in origin. The Zeandale dome is responsible for the Pennsylvanian outcrops in Riley County and northwest Wabaunsee County, and may exert some control on the drainage patterns of the area. General reconnaissance with a Paulin altimeter revealed a probable continuation of the east dip of the Zeandale dome on the east limb of the Nemaha anticline.

In the area investigated in detail sedimentary outcrops were identified and measured and their elevations relative to sea level were determined with a plane table and alidade. A structural contour map on the top of the Tarkio limestone, a geologic map, and a geologic cross section were prepared from the data thus obtained.

Although this area does not cover the entire surface expression of the Zeandale dome about 40 feet of closure was mapped on the dome. The part of the Zeandale dome revealed by this investigation is asymmetrical, slightly steeper on the west and southwest flanks, irregular in outline, and shows no pronounced elongation. Sedimentary rocks covering the dome show no evidence of thinning over the crest and no faults were found in the area mapped. The Zeandale dome is apparently a local "high" superimposed on the axis of the Nemaha anticline.

The surface expression of the Zeandale dome is believed to have been formed by combined differential compaction of Pennsylvanian sediments over a granite hill, and local and regional post Mississippian uplift, followed by Cretaceous westward tilting.