SUBSURFACE GEOLOGY OF PHILLIPS COUNTY, KANSAS

by

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INTRODUCTION

Purpose of Investigation

The purpose of this investigation was to study the subsurface structure, stratigraphy and geologic history of Phillips County, Kansas, and relate them to accumulation of petroleum.

Location

Phillips County is located in northwestern Kansas adjacent to the Nebraska state line. The fifth county from the Colorado border, it lies within townships 1-5 south and ranges16-20 west. It is bordered on the east by Smith County, on the south by Osborne and Graham Counties and on the west by Norton County (Fig. 1, Appendix). The county is five townships square and covers approximately 880 square miles.

The county lies in the border section of the Great Plains physiographic province (Byrne, et. al., 1948). The surface is well dissected by streams, but has only moderate relief. The surface slopes regionally to the east.

The county is drained by two major rivers: the Republican River which flows eastward just north of Phillips County, and the North Fork of the Solomon River which also flows eastward in southern Phillips County.

Areal Geology

<u>Quaternary System</u>. Quaternary sediments, made up of the Sanborn formation, overlie all older rocks with an erosional

break. These sediments cap the uplands and blanket many of the slopes.

The Sanborn formation includes materials deposited by wind, stream and slope wash. It consists of silt, sand and gravel. The color is dirty gray to brown (Byrne, et. al., 1948).

Tertiary System. The Tertiary deposits of Phillips County are all of the Pliocene series and are made up of the Ogallala formation. The Ogallala formation was once a vast sheet of interbedded clays, silts, sands and gravels that were deposited by streams over the entire area of the county. The formation now occurs as scattered outcrops on the uplands (Byrne, et. al., 1948). Arkosic gravel, sand, silt, limestone, volcanic ash, chert and vari-colored bentonitic shale make up the formation (Moore, et. al., 1951).

Cretaceous System. Rocks of Cretaceous age are common outcrops in Phillips County. The Cretaceous outcrops are more widely distributed and numerous in the southern part of the county. Rocks of this system are common as outcrops along major valley walls. The outcropping rocks of Cretaceous age are broken into three formations.

The Pierre shale, youngest of the consolidated rocks in Phillips County, outcrops only in the northwestern part of the county. The Pierre shale is separated by an erosional break from the overlying Ogallala formation and overlies the Niobrara formation conformably. The Pierre shale is a black thin-bedded shale with streaks of bentonite and gypsum (Byrne, et. al., 1948).

The Niobrara formation has the largest area outcrop of any one of the Cretaceous rocks. Two members make up the formation. The upper member, the Smoky Hill chalk, is soft, blue-gray chalky shale interbedded with orange shaly chalks that weather into typical badland topography. The lower member, the Fort Hays limestone, consists of massive cream to buff limestones separated by thin gray shales. The Fort Hays limestone is exposed in only a few places in the southern portion of the county (Byrne, et. al., 1948).

The Carlile shale outcrops in one small area. The Carlile shale is a non-calcareous, thin-bedded, limonite stained shale underlain by a thin, fine-grained, rust-colored sandstone (Byrne, et. al., 1948).

Procedure

The stratigraphy and lithology of the rocks were obtained by reviewing literature.

Landes and Keroher (1942) have written a good article concerning the units that are recognizable in the well cuttings of Phillips County. Moore, et. al. (1951) reviewed the generalized stratigraphy of Kansas. Merriam (1955) studied the Jurassic rocks of the area. Koester (1935) has given a review of the stratigraphy of central Kansas in his article on the Central Kansas Uplift.

The Lansing-Kansas City group, Arbuckle group and Reagan sandstone are the oil producing formations in this area. The Lansing-Kansas City group and the Arbuckle group were mapped for this investigation. Very few wells, except in the southwest corner, penetrate the Reagan sandstone. The Reagan structure is reflected very closely in the Arbuckle structure which overlies it in the majority of the area of production and does not appear to be significant elsewhere.

Three west-east cross sections were constructed in an attempt to locate structural variation in the geologic section.

Evaluation of Data

For the most part, the formation tops used were taken from the Herndon maps. A few were taken from electric logs which were available and the remainder were taken from drillers logs. The majority of the tops used on the cross sections are electric log tops. The accuracy should be weighted according to their source.

Control on the Lansing-Kansas City group was fairly well distributed (Fig. 2, Appendix). The accuracy of some of the Lansing picks may be open to question. As was stated above, the majority of the tops were scout tops from the Herndon maps. Oil companies vary as to the placement of the Lansing top. A light bluish-gray to white limestone, probably the Iatan limestone, lies 17-24 feet above the more generally accepted Lansing (Stanton limestone) top and is picked by a few companies as their correalated top. Quite often the Iatan limestone is a white, dense limestone that looks typically Lansing in the samples. Therefore, it is possible that some tops may be in error by this interval. All electric log tops of this report were picked on the lower of the two limestones. The contour interval used on the Lansing was ten feet. This interval was chosen because it was believed there was sufficient control to merit so small an interval. The relief was not of great enough magnitude to make it an unusable interval.

The Arbuckle control was not as well dispersed as the Lansing (Fig. 3, Appendix). The Arbuckle does not produce as widely over the area, consequently, the top has not been penetrated nearly as often. The contour interval chosen for the Arbuckle was twenty feet. The control on the Arbuckle did not merit a smaller interval. Large and abrupt changes in structure are common making a small interval cumbersome and hard, if not impossible, to work.

The remainder of probable errors were strictly of the human realm. Errors of well location and incorrect tops due to clerical mistakes were only two of many possibilities. All possible precautions and care were taken in this work and it is believed that the errors were held to a minimum.

STRATIGRAPHY

Cretaceous System

Subsurface geologists recognize six subdivisions in the Cretaceous system. Listed from younger to older they are as follows: Pierre shale, Fort Hays limestone, Carlile shale, Greenhorn limestone, Graneros shale and the Dakota formation (Landes and Keroher, 1942).

The Pierre shale underlies the Ogallala formation which generally makes up the surface outcrop. The Pierre marine shale is thin-bedded and black to dark gray. It contains concretions and thin beds of bentonite (Moore, et. al., 1951).

The Fort Hays limestone is separated from the Pierre shale by the Smoky Hill chalk. The Fort Hays limestone, averaging about 40 feet in thickness, is a dark gray to white limestone (Landes and Keroher, 1942).

The Carlile shale occurs directly below the Fort Hays limestone. The Carlile shale is a dark gray shale with an average thickness of 260 feet (Landes and Keroher, 1942).

The Greenhorn limestone, underlying the Carlile shale, is a chalky limestone containing an abundance of the foraminifera Globigerina (Landes and Keroher, 1942).

The Graneros shale, averaging 75 feet in thickness, underlies the Greenhorn limestone. The Graneros is a dark gray shale with streaks of bentonite (Landes and Keroher, 1942).

The remainder of the Cretaceous section above the Permian top consists of sandstone and shale of continental origin. The interval is grouped under the Dakota formation.

Jurassic System

The Morrison formation of the Jurassic system unconformably overlies the Permian rocks, and is unconformably overlain by the Cretaceous rocks.

The Morrison formation of Phillips County is nearly 100 per cent clastic. White, fine-grained, subrounded, frosted, loosely-cemented quartz grains make up the bulk of the formation in this area. The remainder of the section is white to grayish-green siltstone.

The Morrison formation, believed to be of continental origin, is present on the western border of the county, along the northern border and in the eastern two townships along the eastern border. It varies in thickness from a featheredge to 100 feet (Merriam, 1955).

Permian System

The Permian system of this area is divided into an upper series (Leonardian) and a lower series (Wolfcampian) by the Kansas Geologic Survey. The Leonardian series is composed of shale beds, salt layers and layers of gypsum and anhydrite. The Wolfcampian series consists of alternating limestones and shales (Landes and Kercher, 1942).

<u>Leonardian Series</u>. Nippewalla Group. The youngest group of rocks of Permian age in Phillips County is the Nippewalla group. The Nippewalla group consists of red shale and red sand-

stone unconformably overlain by beds of Cretaceous and Jurassic ages. The Nippewalla group immediately overlies the Stone Corral dolomite (Landes and Keroher, 1942).

The next bed of importance to the subsurface geologist is the Stone Corral dolomite. Although the Stone Corral is relatively thin, its position between two thick shales makes it easy to pick on any type log. The Stone Corral is also very persistent over the western part of Kansas. It is a dolomite that contains much anhydrite (Landes and Keroher, 1942).

The Ninnescah shale, averaging about 200 feet in thickness, is the red shale immediately underlying the Stone Corral (Landes and Keroher, 1942).

The lowest formation of the Leonardian series in the county is the Wellington formation. The thickness of the Wellington formation varies from 200 to 300 feet and consists of anhydrite, red shale, and salt (Landes and Keroher, 1942).

Wolfcampian Series. The youngest beds of the Wolfcampian series, the Hollenberg limestone, the Herington limestone and Winfield limestone, are difficult to identify positively from logs. They are recognized mainly according to their positions below the thick red and gray shale section and above the massive Fort Riley limestone (Landes and Keroher, 1942).

The Florence limestone, commonly called "Florence Flint", is recognized by a high percentage of gray to blue fossiliferous chert. The limestone is lighter in color than the gray chert. Locally, shale partings are common. The thick Matfield shale, underlying the Florence, makes it recognizable from similar lithologic units (Landes and Kerohor, 1942).

The Wreford limestone consists of two limestones separated by a gray calcareous shale (Moore, et. al., 1951). The Wreford limestone can be recognized by the presence of chert and its location below the thick Matfield shale and above the thick shales of the upper Council Grove group.

The Cottonwood limestone is a massive limestone of very consistent thickness, usually about six feet. It is recognized by its position below the thick shales of the upper Council Grove group and above the Eskridge red shale (Landes and Kerohor, 1942). The upper portion of the Cottonwood limestone contains abundant fusulines (Moore, et. al., 1951).

The Neva limestone member, several limestones separated by thin shales, is recognized by its position below the red Eskridge shale and above the gray, black, red and green shales of the lower Foraker and lower Grenola formations.

The Americus limestone is the oldest member of the Permian system which is recognizable in the subsurface. The Americus limestone can be recognized by its position between two thick shales (Landes and Kerohor, 1942).

The Admire group makes up the remainder of the Permian section and consists mainly of shale with a few thin limestone beds (Moore, et. al., 1951).

Pennsylvanian System

Rocks of the Pennsylvanian system unconformably underlie the rocks of the Permian system. Subsurface geologists commonly recognize the following zones in Phillips County: top of the Topeka limestone, base of the Oread limestone, top of the Lansing group, base of the Kansas City group and the top of the Sooy conglomerate (Landes and Keroher, 1942).

Virgilian Series. Wabaunsee Group. The Wabaunsee group, the youngest of the Pennsylvanian sediments, cannot be easily differentiated from the oldest Permian sediments in the subsurface. Subsurface geologists make no attempt to differentiate Pennsylvanian rocks and Permian rocks from samples. The Wabaunsee group of Phillips County consists mainly of alternating shales and thin limestones (Landes and Keroher, 1942).

Shawnee Group. Underlying the Wabaunsee group is found the Shawnee group. Rocks from the youngest member, the Topeka limestone, to the base of the Oread limestone remain essentially undifferentiated in the subsurface. Just above the base of the Oread limestone is the Heebner shale which is a remarkably consistent, black, platy shale. The Heebner shale is recognized in samples throughout the majority of western Kansas and is very easily picked on radioactive logs. The Shawnee group consists of limestone with thin layers of red or black shale (Landes and Keroher, 1942).

Douglas-Pedee Groups. The Douglas and Pedee groups occur undifferentiated between the base of the Oread limestone and the top of the Lansing-Kansas City group. They consist mainly of red and gray shales, sandstone and a few thin beds of limestone (Landes and Keroher, 1942).

Missourian Series. Lansing-Kansas City Group. The Lansing-Kansas City group, the youngest and most widely distributed producing section of the county, is the oldest group that has a consistent thickness over the entire county. This producing horizon is overlain by layers of younger rocks ranging from 3100 to 3500 feet in thickness. The production is from porous oolitic zones near the top of the group. The Lansing-Kansas City group consists mainly of gray to white limestone with thin shale partings. The thickness averages about 200 feet (Landes and Kerоher, 1942).

Des Moinesian Series. Marmaton Group. The rocks underlying the base of the Kansas City group and overlying the Sooy conglomerate are probably Marmaton in age. There is good evidence that an erosional break exists between the Missourian (Lansing-Kansas City) and the Des Moinesian (Marmaton) rocks (Moore, et. al., 1951). Due to the character of the Arbuckle surface, the thickness of this group of rocks is highly variable as is true also of the thickness of the underlying conglomerate. The rocks are shaly limestone, limestone and thin shales.

The Sooy conglomerate is believed to be a Pennsylvanian basal conglomerate formed by a transgressing sea. A thorough study of the Sooy conglomerate is not available; consequently, the thickness and areal extent are not known (Merriam and Goebel, 1954). The Sooy conglomerate contains chert and large sub-angular quartz grains that are found cemented together by a matrix of red, green or gray shale. The conglomerate overlies all older beds unconformably and parts of the formation can be shown to be of material derived from rock as young as lower Pennsylvanian (Landes and Keroher, 1942).

Mississippian System

No rocks of Mississippian age have been encountered by the bit in Phillips County. It is not impossible that with further drilling along the eastern border some Mississippian rocks may be encountered.

Ordovician System

Rocks of Ordovician age have not been encountered west of the Stockton anticline, but have been found only in the eastern part of the county (Fig. 4, Appendix). Only where they were far enough down the flank of the anticline to escape the erosional forces of the pre-Pennsylvanian unconformity are these rocks present. It is also possible that Ordovician sediments were deposited only in a synclinal area extending into the county from the east. They are represented by two formations: the Viola limestone and the Simpson formation.

The thickness of the Viola limestone varies from a featheredge to approximately 15 feet. The Viola limestone is a cherty, dolomitic limestone (Moore, et. al., 1951).

The Simpson formation is predominately green shale and coarse, well-rounded, frosted sand grains. Its thickness varies from a featheredge to approximately 30 feet (Landes and Keroher, 1942).

Cambro-Ordovician System

The Arbuckle group of Phillips County is a wedge shaped layer of coarse crystalline dolomite. The thickness varies from a featheredge in the southwest corner of the county to approximately 350 feet. The thickness of the Arbuckle is highly variable with local synclinal areas having considerably greater thickness and a general increase in thickness to the east. High up on the uplift, in the southwest corner, the Arbuckle group is missing and the Pennsylvanian rocks lie directly on Cambrian and Pre-Cambrian rocks (Landes and Kercher, 1942).

Cambrian System

A basal sand directly underlies the Arbuckle dolomite. Geologists of the area carry it on logs as the Reagan sandstone. The sand is fairly widespread, but locally the Arbuckle group may lie directly on the Pre-Cambrian surface. This occurs on structural highs in the Pre-Cambrian surface (Landes and Kercher, 1942). The Reagan sandstone is a coarse grained, ill sorted, subangular to rounded sandstone. Locally, close to the Pre-Cambrian granite, it may be arkosic (Moore, et. al., 1951).

Pre-Cambrian System

Pre-Cambrian rock underlies the whole of the area. Koester (1935) says, "The basement rocks of Kansas are granite, schist, quartzite, arkose and red clastics."

STRUCTURE

Major Structural Features

Central Kansas Uplift. The name, Central Kansas Uplift, first appeared in geologic literature on September 4, 1929, when L. C. Morgan used the term to describe an area in Central Kansas that contains an Ordovician-Pennsylvanian hiatus (Morgan, 1932).

Koester (1935) described the Central Kansas Uplift as:

> A buried, oft-rejuvenated structural feature trending northwest and southeast across west-central Kansas which has been revealed by drilling for oil and gas within the past 10 years. It originated in Pre-Cambrian time as a series of parallel batholiths and persisted as a positive element throughout much of Paleozoic time.

Studies show that the geologic history of the Central Kansas Uplift is more closely related to the Ozarks Uplift than to the areas immediately north or south. Like the Cambridge arch the uplift lies on an axis which is a broad arc-shaped structural trend that extends from the Black Hills on the north to the Chautauqua arch on the southeast (Fig. 5, Appendix).

The following periods of warping are recognized: post-Algonkian, post-Canadian, post-Hunton, early Pennsylvanian, post-Missourian and post-Cretaceous (Koester, 1935).

Cambridge Arch. The Cambridge arch, as it occurs in Kansas, is the southern end of a large northwest-southeast trending anticlinal structure of which the largest areal extent lies in Nebraska. The Cambridge arch lies on the northward extension of the same major axis as the Central Kansas Uplift (Fig. 5, Appendix) and is separated from the uplift by a low, flat, synclinal area. The Cambridge arch is flanked on the east and northeast by the Long Island syncline.

Several periods of structural movement are recognized as follows: 1. pre-Simpson; 2. pre-Kinderhookian; 3. post-Mississippian; 4. possible post-Permian and 5. post-Cretaceous (Merriam and Atkinson, 1955).

Salina Basin. The Salina Basin consists of a large area of basin-like sediments that is bordered on the west by the Cambridge arch and Central Kansas Uplift, on the east by the Nemaha anticline and on the south by a broad upwarp between the Nemaha anticline and the Central Kansas Uplift (Fig. 5, Appendix).

Five periods of deformation are recognized in the Salina basin:

1. Deformation previous to the deposition of the Simpson St. Peter sandstone is shown by thickness maps. It was during this same period of time that the Southeast Nebraska arch began to develop along the Kansas border. Major movement was brought about by the subsidence of a deep basin in Missouri.

2. A second period of folding, extending from St. Peter time to lower Mississippian time, shows a complete reversal of the effects of the previous deformation. The Missouri basin was uplifted and the Southeast Nebraska arch became a gradually subsiding basin.

3. The main feature developed by the third period of deformation was the Nemaha anticline. The deformation began early in Mississippian time and continued at a diminishing rate through Pennsylvanian time into Permian time. During this time the

Salina basin was a syncline trending northwest-southeast along the positive Central Kansas Uplift. The Salina basin was a shallow sea conducive to cyclic deposition throughout the majority of Pennsylvanian and early Permian times.

4. The fourth period of deformation was characterized by the development of the Anadarko basin in southwestern Kansas giving the Pennsylvanian and Permian rocks southwesterly dip. The time was post-Permian and pre-Cretaceous.

5. The last period of deformation, post-Cretaceous, tilted the Cretaceous rocks toward the northeast in western Kansas and toward the north and northwest in central Kansas. The area was also elevated 1500 to 2000 feet above sea level (Lee, et. al., 1948).

Minor Structural Features

<u>Long Island Syncline.</u> The name Long Island syncline was first used by Merriam and Atkinson (1955) to describe a northeasterly plunging syncline located in eastern Norton and northwestern Phillips Counties. The structure was named for the town of Long Island which lies near the axis of the syncline.

The Long Island syncline vaguely shows on the Lansing structure map (Fig. 8, Appendix). The contours in the southwest portion of the westerly dip show a tendency to turn to the north. This tendency would be caused by the Cambridge arch which lies just west of the county. Although only one point is shown, the westerly dip shows a flattening and possibly would reverse if the area mapped were extended to the northwest. This would be in accordance with Merriam and Atkinson (1955).

The eastern portion of the Long Island syncline also shows on the Arbuckle structure. Although the control is poor, the dip is generally westward off the Stockton anticline. This would also agree with Merriam and Atkinson (1955).

Stockton Anticline. The name Stockton anticline has been used for a fold in the Cretaceous rock of this area. The name was first applied by Bass (1926) to a northeast-southwest trend of structural highs extending through Phillips County. Merriam and Atkinson (1955) prefer to call this trend the Stuttgart-Huffstutter anticline. Stockton anticline is used throughout this report (Fig. 5, Appendix).

The Stockton anticline shows plainly on both the Lansing and Arbuckle structure maps (Figs. 8 and 9, Appendix), as well as on the structural cross sections (Figs. 10, 11, and 12, Appendix). The anticline has been shown as faulted for the following reasons:

1. Severe local steepening of dip of this magnitude is not common in Kansas.

2. If the structure were not faulted, wells drilled near or on the steep dip should show an apparent thickening of the individual beds. A study of the well records does not indicate a thickening of beds in the area of the fault. This is shown by the cross sections (Figs. 10, 11 and 12, Appendix).

3. The rectilinear pattern of the trend of the fault was also taken into account (Fig. 8, Appendix). If the area were not faulted, a rectilinear pattern would not be conspicuous.

4. Although it would be possible to contour the area without showing a fault, a very severe crowding of the contours in the fault area would be apparent. At the scale and contour interval used, it would be almost impossible to contour the area as an anticline on the Lansing map. Due to the erosional character and the lack of control, the fault on the Arbuckle map cannot be as closely located; however, a trend of highs opposite lows does exist.

5. An inspection of Fig. 8 (Appendix) shows that the general trends of the anticlines are different on opposite sides of the fault line. West of the fault zone the trends are northeast-southwest while east of the fault the trends are northwest-southeast.

The throw of the fault is estimated to be approximately 130 feet. Cross sections I (Fig. 10, Appendix) and III (Fig. 12, Appendix) show this quite well. Cross section II (Fig. 11, Appendix) does not indicate the faulting as clearly. This is probably due to one of two reasons:

1. Locations of the wells on the structural trends. Well #6 is located some distance from the fault and is probably not at the low point east of the fault. Well #5 is located in a structural low west of the fault, thus giving a relatively small displacement of approximately 75 feet. If the displacement were projected from well #4 the throw would be about 210 feet; however, this would be an excessive figure. It is felt that an average would be closer to the correct figure. This is found to agree more closely with cross sections I and III (Figs.

10 and 12, Appendix).

2. Double faulting forming a keystone block. The area between well #5 and #7 may be a keystone block formed by two faults allowing a wedge shaped fault block to be dropped below the level of the other beds. The displacements in this case would not be expected to be nearly as large because the energy of formation would be taken up by two zones of shearing in place of the one zone of cross sections I and III. This block could be formed by tension due to the upwarping from below. When the upward force was released the block settled down into its present position.

An inspection of Fig. 8 (Appendix) reveals that, in order to contour the area in a logical fashion, the fault must be carried through this area. The offset of the contours is only slightly smaller than that shown at other places along the fault zone.

The cross sections show a dying out of the fault upward. This dying out is more pronounced to the north and the fault is shown as dying out also in the lower subsurface, near the Kansas-Nebraska border.

Three theories of origin can be advanced for the fault.

1. The fault may be a compaction fault formed by differential compaction of sediments over an escarpment formed by post-Mississippian faulting of the older rocks.

2. The faulting may have taken place during orogenic movement at the end of Cretaceous time. The force would have been deepseated with the throw dying out upward.

3. Koester (1935) suggested that differential movement occurred along zones of weakness in the basement rocks throughout Pennsylvanian and Permian times. The faulting may have been due to differential movement along a fault zone in the basement rock which caused the later sediments to be faulted continuously throughout Pennsylvanian and Permian times.

GEOLOGIC HISTORY

Pre-Cambrian Era

During Pre-Cambrian time a series of events occurred giving rise to the beginning of the Central Kansas Uplift, Cambridge arch and Stockton anticline. These events may have been the intrusion of a series of parallel batholiths (Koester, 1935). That intrusions took place is shown by the type sediments derived during erosion of the Pre-Cambrian surface during Cambrian time.

Merriam and Atkinson (1955) state:

> The distribution of the different rock types gives a vague suggestion that the biotite bearing granite was intruded into older pre-existing sediments, for, in general, the area of the granite is surrounded by meta-sediments--e.g., quartzite, schist, and gneiss. The schist which occurs on the crest of the arch could be interpretated as a roof pendant.

The number of periods of erosion and uplift during Pre-Cambrian time is unknown. Following the intrusions the area was subject to a period of uplift and erosion through part of Cambrian time (Koester, 1935).

Paleozoic Era

Cambrian Period. The transgressing sea of Cambrian time moved in working and reworking the older sediments giving rise to the Reagan sandstone. The Reagan sandstone directly overlies the Pre-Cambrian surface except where it has been removed over structural highs by post-Reagan erosion (Merriam and Atkinson, 1955).

Cambro-Ordovician Period. The sea moved in and a non-clastic environment was set up. The sediments deposited were those of the Arbuckle limestone group. Locally, where the Reagan sandstone has been eroded, the Arbuckle limestone lies directly on the Pre-Cambrian sediments. Following Cambro-Ordovician time the Central Kansas Uplift, Cambridge arch and the Stockton anticline were uplifted and subjected to severe erosion (Merriam and Atkinson, 1955). Parts of the structures remained positive until early Pennsylvanian time (Koester, 1935).

Ordovician Period. In Ordovician time the sea once more transgressed laying down the Simpson sediments. The sea probably covered the crest of the structure; however, the Simpson sediments have been removed from the crest of the structure during subsequent erosion (Koester, 1935).

A hiatus occurred in middle Ordovician period between the deposition of Simpson and Viola sediments (Koester, 1935). A non-clastic environment was evident during Viola time when the limestone was deposited.

Following Viola time the Central Kansas Uplift, Cambridge arch and related structures were uplifted and subjected to erosion. Viola sediments were removed from wide areas as were the Simpson sediments (Koester, 1935).

Mississippian Period. Devonian and Silurian rocks have been removed by post-Mississippian erosion if they were ever deposited. The Mississippian rocks lie not far to the east; thus, chances are very good that they were once present over the entire area. Following Mississippian time the area was subjected to its severest structural deformation. The structures were uplifted and extensively eroded. The pre-Pennsylvanian sediments were completely removed from parts of the Central Kansas Uplift, Cambridge arch and Stockton anticline; only where they were far enough from the crests of the structures do they still remain.

Pennsylvanian Period. The Pennsylvanian sediments are the oldest sediments that have a consistent thickness over the entire area. As the sea moved in over the pre-Pennsylvanian surface the Soey conglomerate was deposited. The conglomerate overlies all formations from Pre-Cambrian to Mississippian unconformably. The Des Moinesian rocks are those characteristic of cyclic deposition in shallow seas (Lee, et. al., 1948).

Following Des Moinesian time the sea retreated and an erosional break exists below the Missourian rocks of the Lansing-Kansas City group. In Missourian time the sea invaded the area. Once more the environment was that of cyclic deposition of limestones and thin shales. The ending of Missourian time was marked by retreat of the sea prior to deposition of the overlying Douglas and Pedee groups (Moore, et. al., 1951).

During Douglas and Pedee time the environment of deposition was that of cyclic nature--e.g., alternating shales, sandstones, and limestones. This environment continued throughout Pennsylvanian time.

Permian Period. The Permian rocks are separated from the Pennsylvanian by an erosional break. The break is not of great magnitude and is very difficult to recognize. Structural movement of this time was confined to tilting and broad warping. The sediments are those of shallow seas and are cyclic in nature. Koester (1935) suggests that differential movement may have occurred from post-Mississippian throughout Permian time. At the close of Permian time the sea retreated and the surface was eroded during Triassic time.

Mesozoic Era

Jurassic Period. An unconformity separates Jurassic rocks from the underlying Permian rocks. The rocks show that they are fluvial and lacustrine in origin. Clastic ratio maps show the source of material to be to the southeast. The deposition was on an area of low relief from sluggish streams, thus accounting for the fineness (Merriam, 1955).

Cretaceous Period. Rocks of Cretaceous age unconformably overlie rocks of Jurassic and Permian ages. The basal section, Dakota group, is of continental origin. The remainder of the Cretaceous section is typically marine in nature.

Following Cretaceous time the area underwent a series of structural deformations and uplifts similar to those of post-Mississippian time. The structural movement of this time probably corresponded to the Laramide revolution of the Rocky Mountain region (Merriam and Atkinson, 1955).

Cenozoic Era

All rocks post-Cretaceous in age are continental in origin. The area remained uplifted after Cretaceous time and sediments of the Cenozoic probably came from eastern Colorado and the Rocky Mountain region. Structural movement of the era was westward tilting in early Cenozoic and eastward tilting in the later Cenozoic era (Merriam and Atkinson, 1955).

HISTORY OF PRODUCTION

Oil was first discovered in Phillips County, Kansas, in June 1939 when the Blue Stem Oil Company Donaldson #1 well in the south part of the county found oil in the Lansing-Kansas City group in what is now called the Bow Creek pool (Ver Wiebe, et. al., 1948).

Although 17 pools in Phillips County have been named by the Kansas Nomenclature committee, major production is from only seven of them. The remainder of the pools consist of five wells or less. A short discussion of the discovery pool and the six leading producers will be given. All cumulative production totals are through 1955.

Bow Creek Pool

The Bow Creek pool was discovered in 1939 by the Blue Stem Oil Company Donaldson #1 well in section 4 1S 18W (Ver Wiebe, et. al., 1948). The pool is located on a structural high in the Lansing-Kansas City formation (Figs. 6 and 8, Appendix) and consists of three wells with a cumulative production of 77,210 barrels from 53 feet of pay. Production in 1955 amounted to 4,194 barrels, a decrease of 1000 barrels from 1954 (Goebel, et. al., 1956).

Ray Pool

The Ray pool was discovered in 1940 when the Cities Service Oil Company #1 Ray well in section 32 5S 20W hit oil in the Reagan sandstone (Ver Wiebe, et. al., 1948). One well produced from the Lansing-Kansas City group on a structural high against the fault zone (Figs. 6 and 8, Appendix). The Arbuckle and Reagan production of this field was from a stratigraphic type trap with the formations and porosity pinching out on the Pre-Cambrian rocks below the Pennsylvanian unconformity (Fig. 4 and 7, Appendix). The Ray pool produced 1,274,789 barrels of petroleum from 148 wells in 1955 in Phillips County. Production from six wells located in Norton County was not included. The pay zone was 13 feet thick and cumulative production was 16,915,565 barrels (Goebel, et. al., 1956).

Huffstutter Pool

Discovery of oil in the B & R Drilling, Inc. #1 Huffstutter well in section 6 of 2S 18W in 1949 gave rise to the Huffstutter pool (Ver Wiebe, et. al., 1951). Production was from 36 feet of the Lansing-Kansas City group in 121 wells. The pool produced 278,506 barrels of oil in 1955. The oil was trapped on a structural high against the fault on the Stockton anticline (Figs. 6 and 8, Appendix). Cumulative production amounted to 3,281,649 barrels (Goebel, et. al., 1956).

Hansen Pool

Discovery of oil in 1943 by the Cities Service Oil Company #1 Hansen well in section 14 5S 20W gave rise to the Hansen pool which produces from the Lansing-Kansas City and Arbuckle groups (Ver Wiebe, 1944). Both traps are of a structural nature against the fault on the Stockton anticline (Figs. 6, 8 and 9, Appendix). The 1955 production was 201,128 barrels giving a cumulative production of 2,572,909 barrels from 36 wells (Goebel, et. al., 1956).

Dayton Pool

The Dayton pool, discovered in 1941 by the Carter Oil Company #1 Friebus well in section 36 2S 19W, produced from the Lansing-Kansas City group (Ver Wiebe, 1942). The trap was structural against the fault zone on the Stockton anticline (Figs. 6 and 8, Appendix). The 1955 production of the Dayton pool was 44,805 barrels from eight feet of pay. The cumulative total is 1,153,634 barrels from 17 wells (Goebel, et. al., 1956).

Logan Pool

The Logan pool was discovered in 1945 when the Helmerich and Payne and Tidewater Oil Company Bowman "A" #1 well in section 3 5S 20W found oil in the Lansing-Kansas City and Arbuckle groups (Ver Wiebe, 1946). The production, located on structural highs, (Figs. 6, 8 and 9, Appendix) amounted to 34,341 barrels in 1955 giving a cumulative total of 445,357 barrels from 12 wells (Goebel, et. al., 1956).

Stuttgart Pool

Discovery of oil in 1950 by the Imperial Petroleum Company Vogel #1 well in section 14 3S 19W gave rise to the Stuttgart pool (Ver Wiebe, et. al., 1951). The Stuttgart pool produces from a three foot section of the Lansing-Kansas City group. The production is from a structural high that is trapped against the fault on the Stockton anticline (Figs. 6 and 8, Appendix). The 1955 production was 36,299 barrels from 13 wells. The cumulative total was 264,618 barrels (Goebel, et. al., 1956).

The pool names and pertinent data for the remainder of the pools as adapted from Goebel, et. al. (1956) are summarized in Table 4 (Appendix). The traps for these pools are small structural highs or small closures on structural noses (Figs. 6, 8 and 9 Appendix).

A comparison of total oil production in the years 1954 and 1955 shows a decrease of 4 per cent during the latter year. No gas is produced in Phillips County (Goebel, et. al., 1956).

CONCLUSIONS

The major portion of the oil pools in Phillips County were formed by the concentration of oil into pools by trapping on structural highs. The most prolific pool, however, is a stratigraphic trap where the Reagan sandstone formation and the Arbuckle group pinch out over the Pre-Cambrian rocks against the overlying Pennsylvanian unconformity.

The larger pools lie on the Stockton anticline where the oil has been trapped by the fault. The major number of wells that were not located on the Stockton anticline were marginal wells economically.

Although Phillips County has been fairly well tested there will undoubtedly be other small pools located by drilling. Several highs are shown on Fig. 8 (Appendix) that have not been tested. This testing will probably be done by independents as the larger companies do not find the area economically attractive to explore and produce where the returns per well are relatively small.

ACKNOWLEDGMENT

The writer wishes to express his appreciation to Dr. J. R. Chelikowsky for his timely suggestions and helpful criticism in the preparation of this manuscript and to the remainder of the members of the staff of the Department of Geology for their sincere teachings and cooperation throughout his studies at Kansas State College.

Appreciation is also expressed to the Carter Oil Company and its employees in the Wichita district office for the use of their facilities and their helpful suggestions.

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APPENDIX

Table 1. The exact location of wells used on Cross Section I.

Well No.	Well Location	Source	Elevation	Stone Corral	Heebner	Lansing	Base Kans. City	Congl.	Viola	Simpson	Arbuckle
1	19 2S 19W SESESE	Herndon Map	2235	362		-1256	-1490				-1615
2	20 2S 19W SESENW	Elec. Log	2166	386	-1200	-1240	-1457				-1586
3	15 2S 19W NWNWSE	Elec. Log	2199	419	-1141	-1191	-1403				-1527
4	13 2S 19W cNENW	Sample Log	2237	487		-1087	-1335	-1463			-1472
5	24 2S 19W cNWNE	Herndon Map	2166	435	-1055	-1115	-1250	-1475			-1503
6	18 2S 18W NWSWNE	Herndon Map	2181	362	-1250	-1261					
7	22 2S 18W SENENE	Elec. Log	2085	355	-1240	-1279	-1505	-1631		-1647	-1670
8	17 2S 17W SWSWSW	Elec. Log	2025	390	-1243	-1285	-1519	-1669		-1751	-1798

Table 2. The exact location of wells used on Cross Section II.

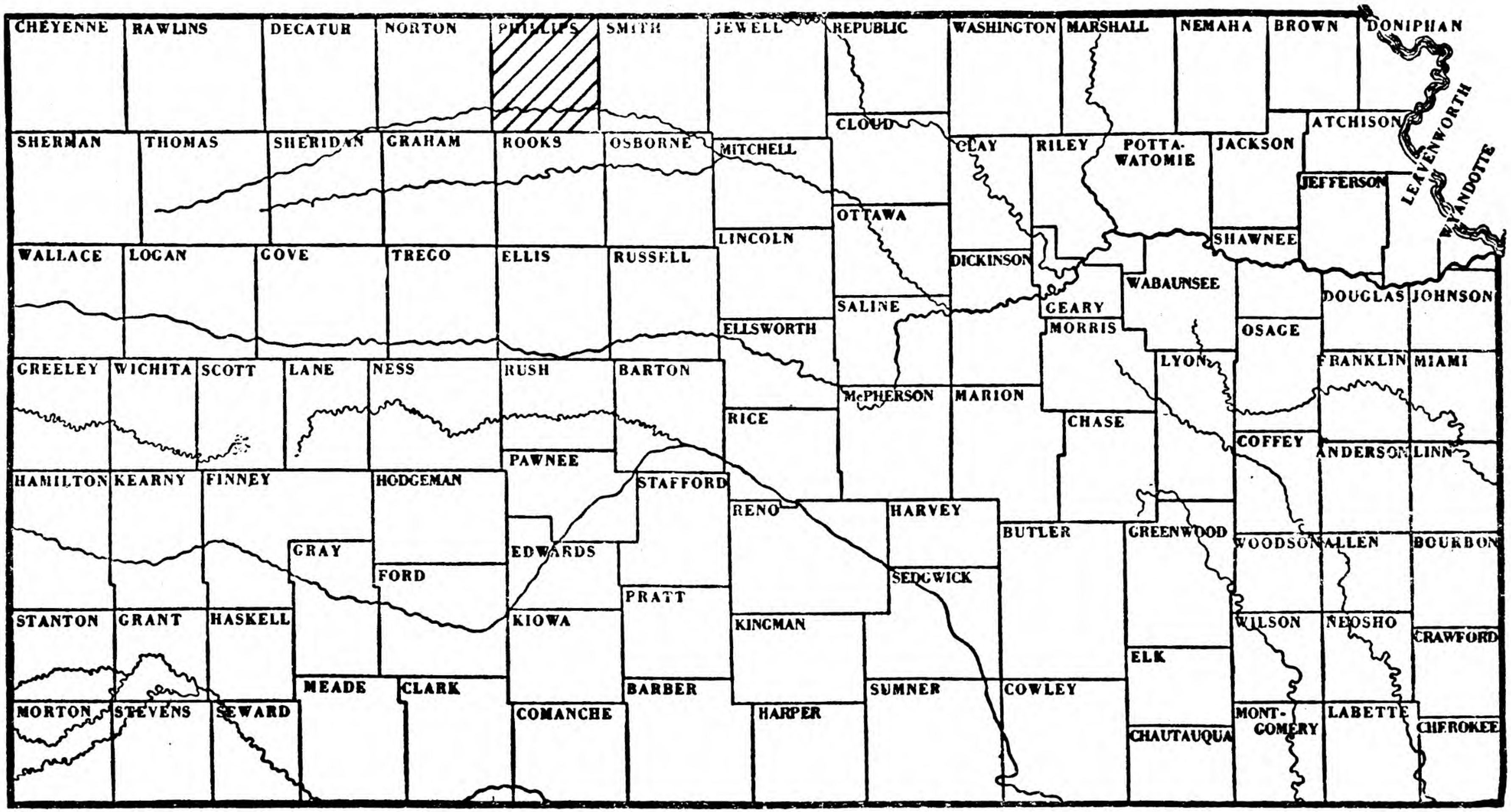
Well No.	Well Location	Source	Elevation	Stone Corral	Heebner	Lansing	Base Kans. City	Congl.	Viola	Simpson	Arbuckle
1	15 4S 20W NENENE	Herndon Map	2078	410		-1188	-1424	-1524			-1538
2	12 4S 20W SWSENW	Elec. Log	2069	422	-1173	-1217	-1427	-1536			-1548
3	8 4S 19W NEcNE	Elec. Log	2060	467	-1166	-1210	-1422	-1505			-1534
4	3 4S 19W SWSWSE	Elec. Log	2013	511	-1113	-1153	-1371	-1475			-1492
5	2 4S 19W NENWSW	Elec. Log	2026	483	-1156	-1194	-1420	-1526			-1568
6	2 4S 19W SEc	Elec. Log	1987	433	-1221	-1260	-1484	-1587			-1617
7	1 4S 19W SESESE	Elec. Log	2010	438	-1170	-1207	-1430	-1543			-1571
8	10 4S 18W NESWNW	Elec. Log	1894	439	-1214	-1258	-1484	-1616		-1662	-1682
9	6 4S 17W cE½SESE	Sample Log	1854	384		-1306	-1541	-1731		-1786	-1827
10	8 4S 16W NEc	Elec. Log	1801	463	-1245	-1295	-1564	-1811	-1845	-2005	-2047

Table 3. The exact location of wells used on Cross Section III.

Well No.	Well Location	Source	Elevation	Stone Corral	Heebner	Lansing	Base Kans. City	Congl	Viola	Simpson	Arbuckle
1	31 5S 20W NESESE	Elec. Log	2145	467	-1115	-1158	-1349	No Arbuckle or Reagan GW -1407			
2	29 5S 20W NENWSE	Elec. Log	2194	464	-1119	-1161	-1353				-1400
3	22 5S 20W SWSESW	Elec. Log	2188	557	-1098	-1140	-1338				-1390
4	23 5S 20W NWNWSW	Elec. Log	2140	512	-1067	-1109	-1308				-1374
5	23 5S 20W NWcSE	Elec. Log	2172	410	-1208	-1258	-1458				-1508
6	17 5S 20W SEc	Elec. Log	2108	384	-1220	-1262	-1460				-1542
7	27 5S 19W SESENE	Elec. Log	2033	423	-1198	-1237	-1440				-1539
8	26 5S 19W NENWNE	Elec. Log	2081	429	-1194	-1234	-1440				-1532
9	10 5S 18W NENENW	Elec. Log	1981	524	-1129	-1173	-1395				-1579
10	2 5S 18W SESESW	Elec. Log	1896	576	-1142	-1188	-1412				-1552
11	9 5S 17W SWSWSE	Elec. Log	1906	528	-1170	-1216	-1254			-1604	-1654

Table 4. Summary of minor oil pools in Phillips County.

Field name and year of discovery	Discovery well location	Oil Production, Barrels		Producing wells	Producing Zone	
		during 1955	to end, 1955		Name	Thickness, Ft.
Beckman ('51)	3-4-19W	1,945	9,464	1	Lans.-K.C.	4
Fredericksburg ('52)	4-1-18W	2,559	11,716	1	Lans.-K.C.	3
Glenwood ('51)	21-1-17W	3,839	20,026	1	Lans.-K.C.	21
Hansen West ('52)	15-5-20W	5,041	21,835	1	Arbuckle	11
Huffstutter Southwest ('51)	23-2-19W	21,295	118,787	5	Lans.-K.C.	4
Kent ('51)	22-1-18W	no report	1,472		Lans.-K.C.	
Mont-Sol ('54)	1-4-19W	36,919	67,765	5	Lans.-K.C.	10
Slinker ('51)	25-4-20W	21,469	106,520	5	Lans.-K.C.	8
Stuttgart South ('51)	23-3-19W	2,830	20,240	1	Lans.-K.C.	3
Wolf Creek ('54)	16-4-19W	3,189	3,644	1	Lans.-K.C.	2
Total Phillips County		99,086	381,469	21		



Area Covered by this report

Fig. 1. Map showing location of Phillips County

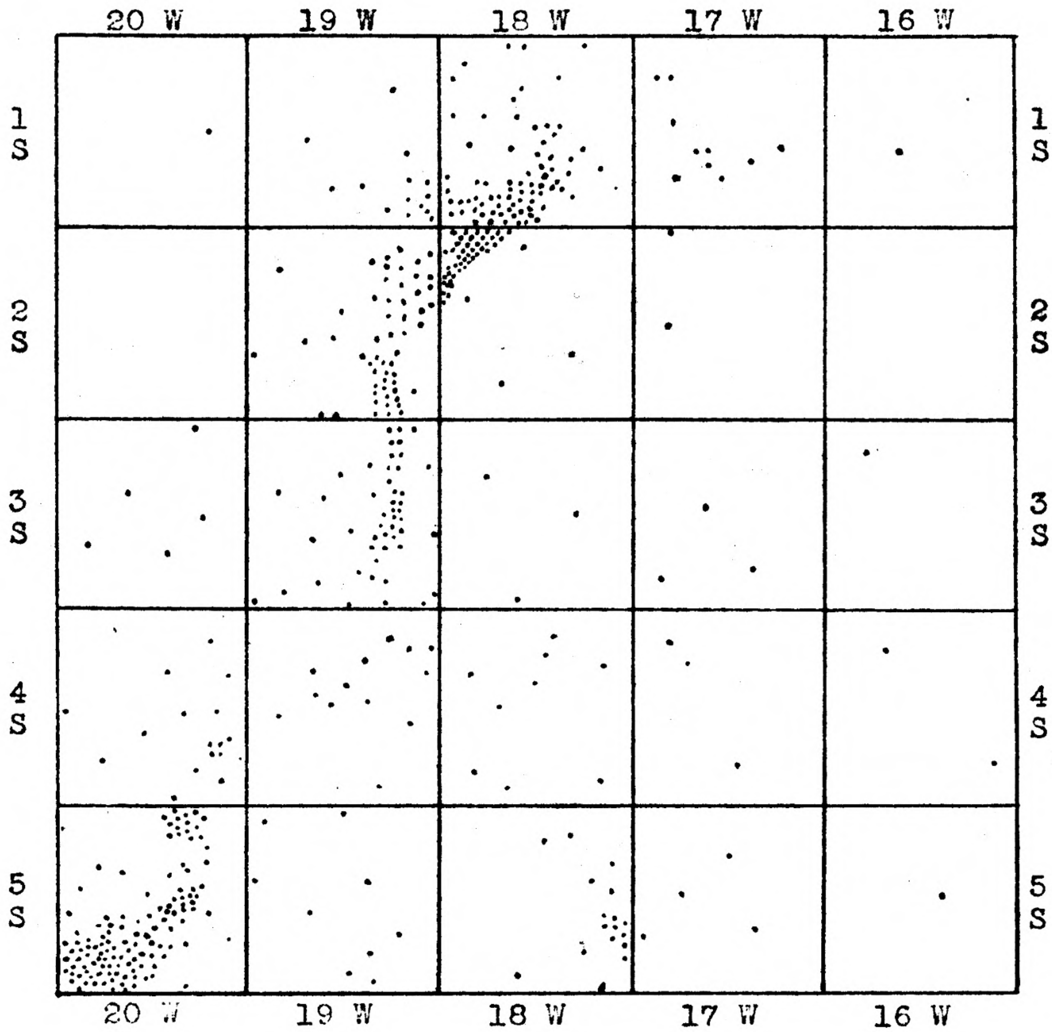


Fig. 2. Map of Phillips County showing the location of subsurface control points used for contouring the Lansing-Kansas City structure map.

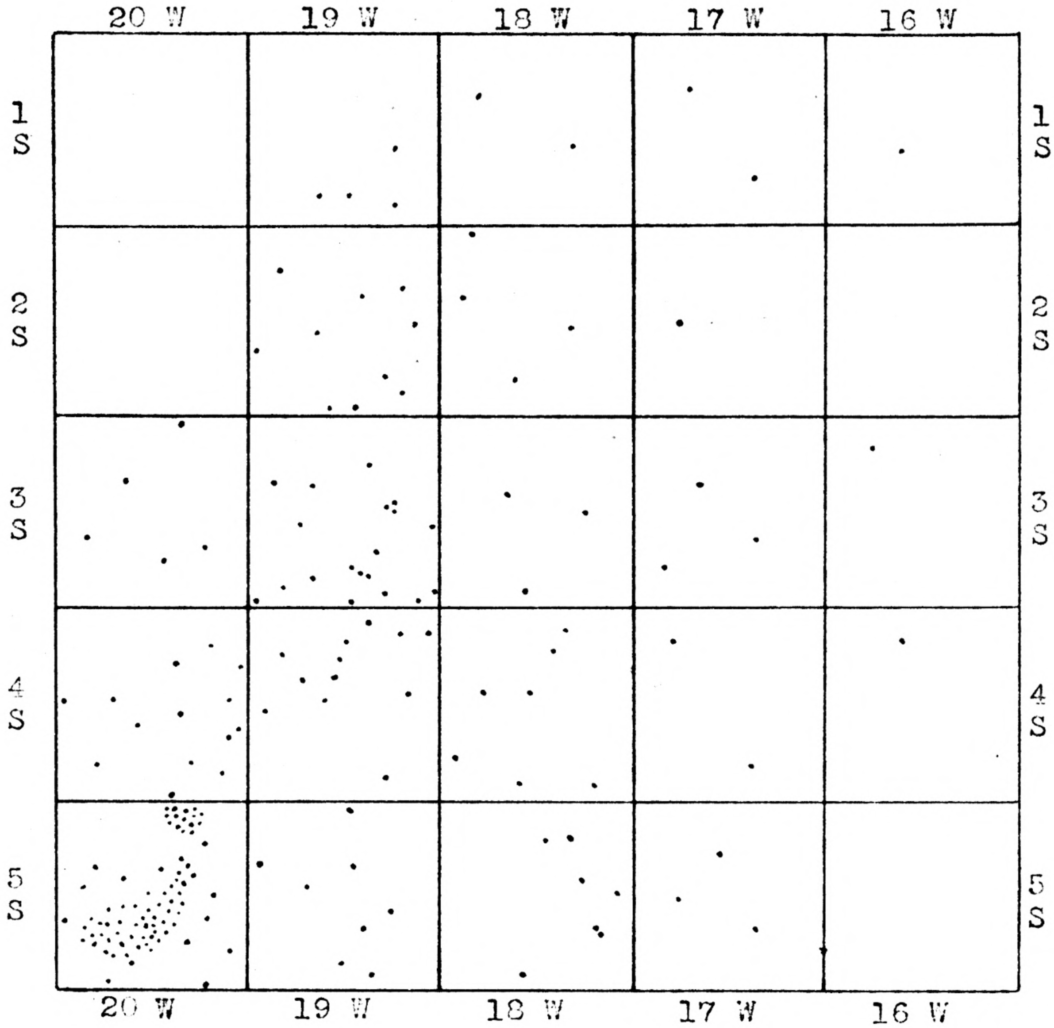


Fig. 3. Map of Phillips County showing the location of subsurface control points used for contouring the Arbuckle structure map.

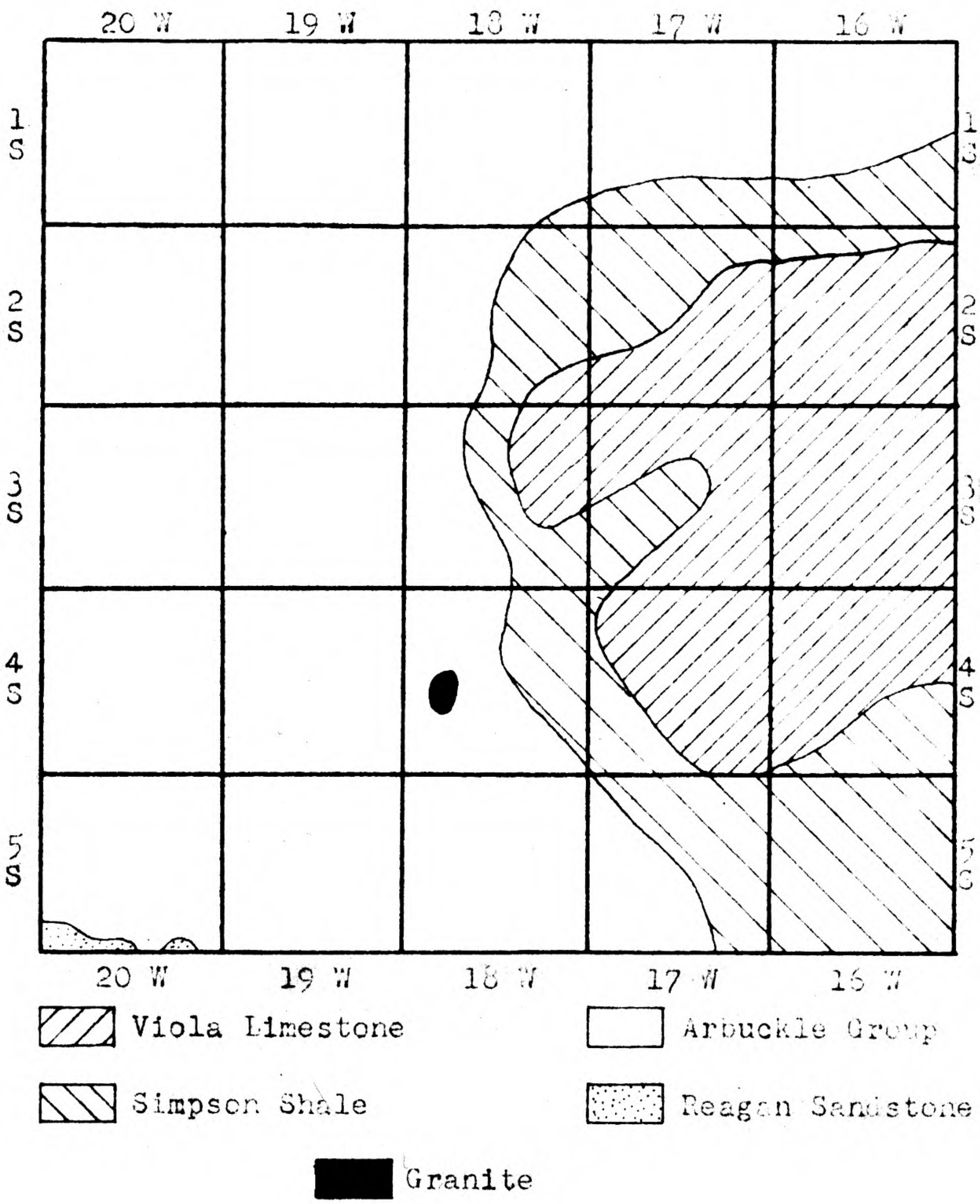
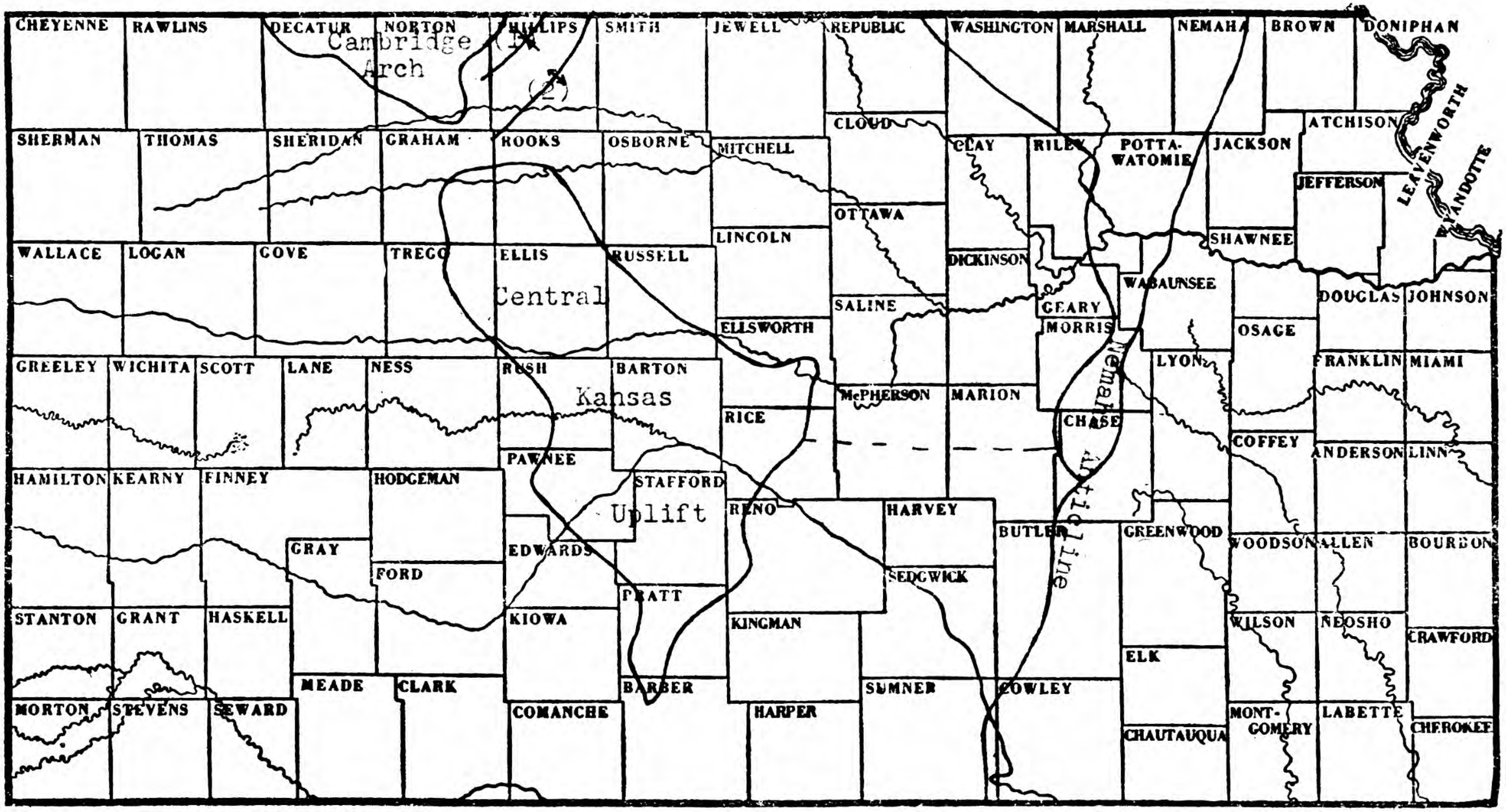


Fig. 4. Paleogeologic map of pre-Pennsylvanian sediments of Phillips County.



(1) Long Island Syncline

(2) Stockton Anticline

Fig. 5. Geographical distribution of structures.

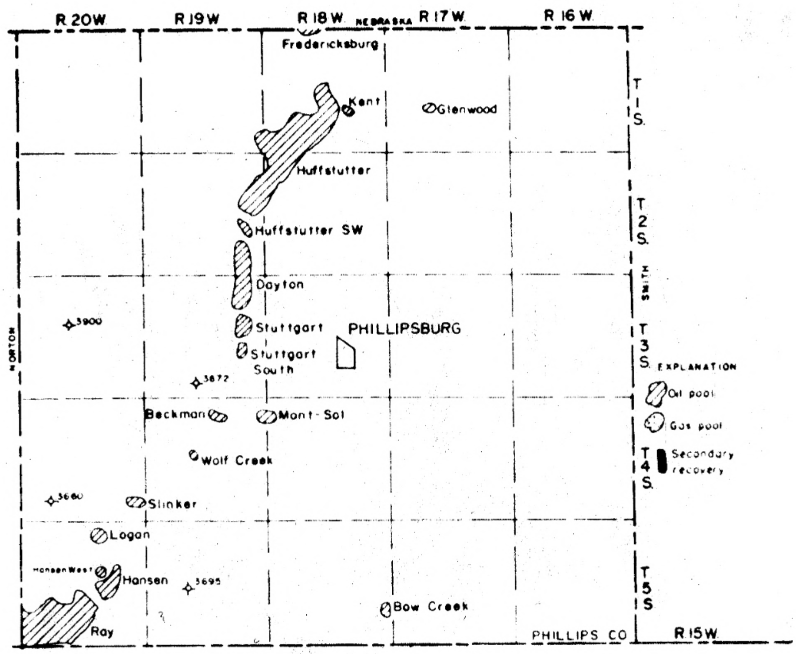
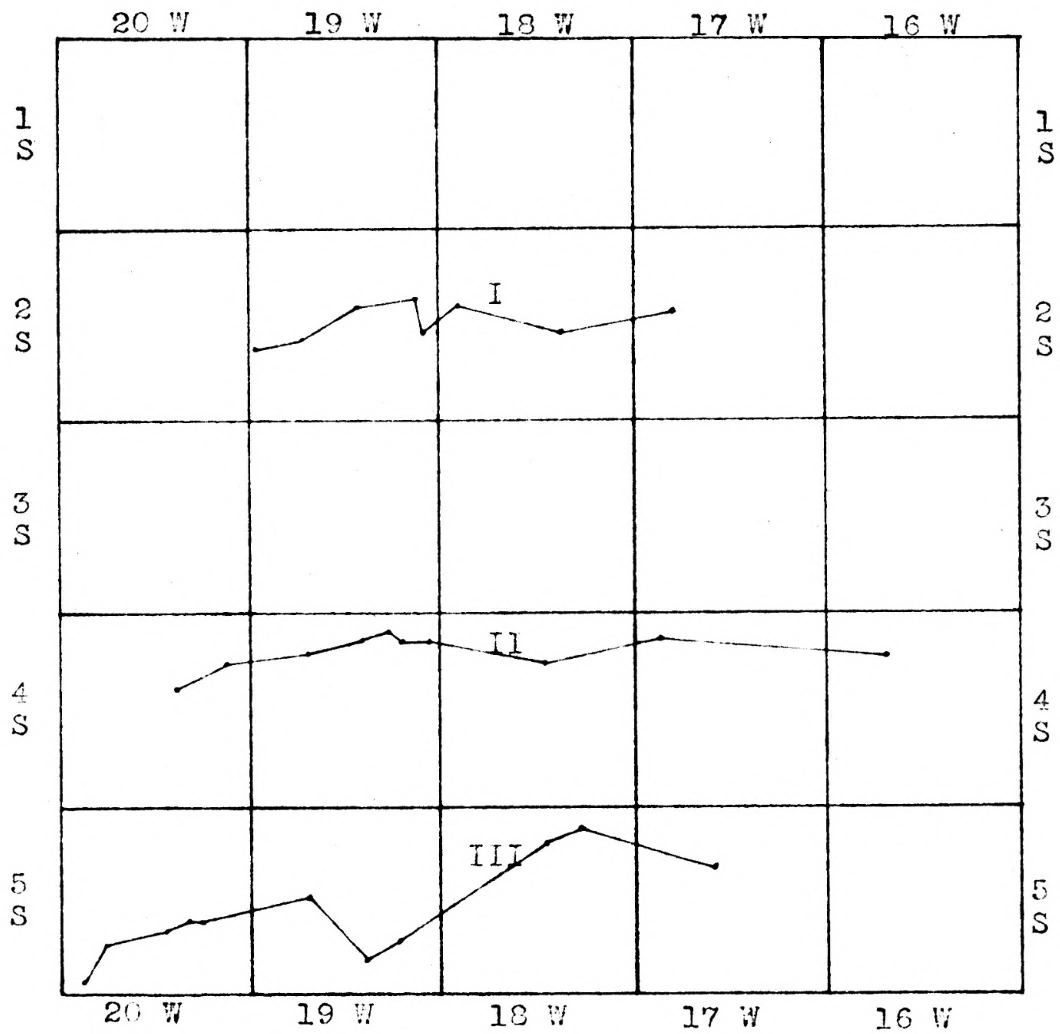


Fig. 6. Map of Phillips County showing locations of producing oil pools.



I. Cross Section I

II. Cross Section II

III. Cross Section III

Fig. 7. Map of Phillips County showing general locations of cross sections.

Figures 8 to 12 inclusive

(in accompanying plate box)

Fig. 10 Cross section number I

Fig II Cross section II

Fig 12 Cross section number III

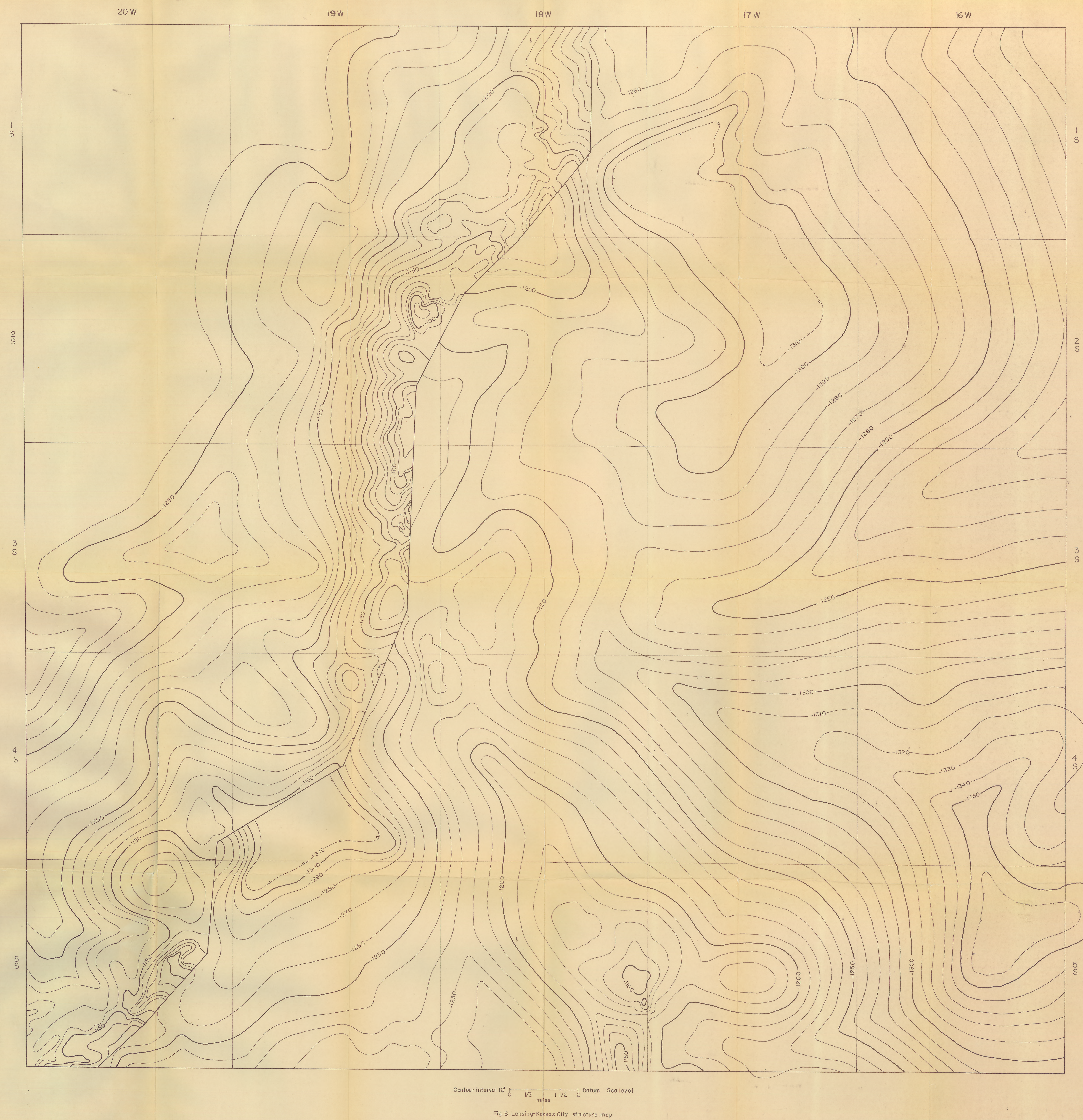


Fig. 8 Lansing-Kansas City structure map

Contour interval 20' | Datum Sea level

0 1/2 1 1 1/2 2
miles

Fig. 9 Arbuckle structure map

SUBSURFACE GEOLOGY OF PHILLIPS COUNTY, KANSAS

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1953

AN ABSTRACT OF A THESIS

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Phillips County is located in the first tier of counties south of the Nebraska border and five counties from the Colorado line. The area of the county is twenty-five townships. The purpose of the investigation was to study the structure, stratigraphy and geologic history of the county and relate them to petroleum production. Rocks of Phillips County range in age from Pre-Cambrian to Quaternary with the Devonian, Silurian, Mississippian and Triassic rocks missing.

Structurally the area is bordered on the west by the Cambridge arch, on the southwest by the Central Kansas Uplift and lies on the western edge of the Salina basin. The Nemaha anticline, a large north-south trending, faulted anticline, borders the Salina basin on the east. Two smaller structural features of importance to Phillips County are the northeast-southwest trending Stockton anticline and the corresponding Long Island syncline. The Stockton anticline has been shown as faulted in this report because the area can be more logically and simply contoured if a fault is shown as present.

The geologic history shows major erosion in post-Pre-Cambrian, post-Arbuckle, post-Mississippian and post-Quaternary times. The erosional periods of post-Pre-Cambrian and post-Arbuckle resulted in making these horizons potential oil reservoirs.

Investigation of the drilling and producing histories show the Reagan sandstone, Arbuckle group and Lansing-Kansas City group are the oil bearing strata of the area. The Reagan sandstone and Arbuckle group produce from stratigraphic type pools while concentration of oil in the Lansing-Kansas City group was brought about by structural type traps.

The yearly oil production from the seventeen pools of Phillips County showed a decrease in 1955.