

SUBSURFACE GEOLOGY RELATED TO PETROLEUM
ACCUMULATION IN RENO COUNTY, KANSAS

by

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INTRODUCTION

Purpose of Investigation

The purpose of this work is the analysis of the stratigraphy, structure, and the geologic history of Reno County, Kansas, and determination of the relationship of these geologic factors to petroleum accumulation.

Location and Topography

Reno County is in south-central Kansas (Appendix, Fig. 1), including Townships 22, 23, 24, 25 and 26S., and Ranges 5, 6, 7, 8, 9 and 10W. The county is bordered on the north by Rice and McPherson Counties, on the east by Harvey and Sedgwick Counties, on the south by Sedgwick and Kingman Counties, and on the west by Pratt and Stafford Counties. The county consists of 35 townships and has an area of about 1,255 square miles.

The area lies west of the "Flint Hills" and is in the Great Bend Prairie physiographic province (Moore, 1940). It is characterized by flatness of large areas and low topographic relief in parts of the county.

The area is drained by the Arkansas River and its tributaries.

The climate of this part of central Kansas is characterized by moderate precipitation, a wide range of temperature variations, moderately high average wind velocity and comparatively rapid evaporation.

Procedure

The Arbuckle dolomite of Cambro-Ordovician Age and the Mississippi "Chat" of Mississippian Age were chosen to be mapped because of their structural and stratigraphic significance.

The Arbuckle and overlying rocks to the top of the Mississippi have similar structural attitude; hence, structural deformation of the Arbuckle reflects structural conditions in the other rock units. Analysis of the Mississippi reveals many significant stratigraphic variations.

The Mississippian has the most oil and gas production in Reno County. The Arbuckle in Reno County has minimum production; however, in the adjacent county to the north, Rice, it is prolific.

All elevations available were used to plot the structure contours on these two horizons. These data were obtained from the Herndon Map Service and the Kansas State Geological Survey.

Figures 6A and 7A show the subsurface control points in Reno County used for contouring the Arbuckle and Mississippi.

Previous Investigations

Previous investigations in Reno County consisted of either individual studies of pools or studies of the county included within regional investigations.

Individual pool studies have been undertaken by Imbt (1941) and Kornfeld (1943) on the Zenith-Peace Creek pool. The State Geologic Survey of Kansas has published reports concerning oil and gas developments of Kansas which included Reno County.

Koester (1935), Lee (1939, 1948), Morgan (1932), and Taylor (1946, 1947) included Reno County in regional studies of Central Kansas.

GEOLOGY OF THE AREA

Geologic History

Pre-Cambrian Era. During Pre-Cambrian time the ancestral Central Kansas uplift was begun. Erosion laid bare the granite core of the uplift and produced the arkose and red clastics, the Lamotte, which accumulated in depressions to a thickness of a few hundred feet (Koester, 1935).

Paleozoic Era. Following the deposition of the Jefferson City and Cotter members of the thick Cambro-Ordovician Arbuckle dolomite, the Central Kansas uplift was slightly arched causing truncation of the Arbuckle due to erosion on the uplift. After a hiatus of long duration, characterized by base-levelling, the Early Ordovician seas invaded the area and deposited a series of sandstones (Simpson), dolomites, and shales on the periphery of the Central Kansas uplift. The Viola limestone was deposited with fairly regular succession over the Simpson formation. Major structural disturbance followed, causing

the erosion of the upper portion of the Viola limestone. The Maquoketa was then deposited, and was later removed by erosion except in the northeastern part of the county (Panel Diagram, Appendix, Fig. 5). Thin beds of Misener sands were laid down in contact with the Viola and Hunton formations over most of Reno County. Rapid submergence preceded the deposition of the Mississippian. This was followed by deposition of residual beds of Mississippian Osage ("Chat") age, principally detrital chert from higher elevation.

The next significant structural event was the erosion of the now-prominent Central Kansas uplift, allowing deposition of vari-colored cherty Pennsylvanian basal conglomerate over the now-eroded area (Kornfeld, 1943).

Following this erosional interval, the area was submerged again and about 3500 feet of Pennsylvanian and Permian rocks were deposited.

The land mass being elevated at this time caused a hiatus following the deposition of Permian rocks.

Mesozoic Era. The Mesozoic Era in Kansas is represented by rocks of the Triassic, Jurassic, and Cretaceous systems. Reno County was probably part of the land area during Triassic and Jurassic time and marine deposition was renewed during Cretaceous time. No Cretaceous rocks crop out, but these rocks are present only a few miles west in Stafford County and to north in Rice County. Probably a considerable thickness of Cretaceous rocks was deposited in Reno County and later removed

by erosion during early Tertiary time (Bayne).

Cenozoic Era. Reno County was probably subjected to erosion during most of Tertiary time. No Tertiary deposits have been found in the county, but deposits identified as the Ogallala formation have been identified in Rice County. Thin deposits of the Ogallala formation probably were deposited in Reno County and later removed by erosion. In late Tertiary time Reno County was an area of low relief, but renewed uplift in early Pleistocene time resulting in the erosion and the dissection of the land surface out deep valleys into the Permian beds. These valleys were later filled with alluvial deposits (Bayne).

Stratigraphy

Surface to the Missourian series of the Pennsylvanian system.

This section is discussed as one unit because it has no oil accumulation in Reno County and no data were available. This strata also lies above the section illustrated in the panel diagram (Appendix, Fig. 5).

The rocks that crop out in Reno County are sedimentary in origin and range in age from Permian to Pleistocene.

Cenozoic deposits of the Pleistocene series ranging in age from the Blanco formation of the Nebraskan glacial stage to recent alluvium unconformably overlies the Permian rocks over most of Reno County (Ver Wiebe, 1938). The alluvium of the Arkansas River between Hutchinson and Wichita attains a maximum thickness of 275 feet.

The oldest rocks that crop out in the county are a part of the Ninnescah shale of the Leonardian series, Permian system.

Dune sand, well-sorted, predominantly grey tan quartz, mantles the surface of much of the area south of the Arkansas River.

The three members of the Wellington formation, Sumner group, Leonardian series, are present in typical development. The upper one-third consists of grey soft shales and clays with red layers. The middle member is the Wellington salt, which here varies in thickness from about 150 to 300 feet. The greatest thickness has been found in wells drilled in the central and west-central parts of the county. Toward the southwest and the northeast of Reno County the thickness diminishes. As usual, much soft shale is interbedded with the pure salt. Below the salt lies an anhydrite zone which is commonly 125 feet thick in this part of the state and contains much soft gray clay in addition to the typical anhydrite (Ver Wiebe, 1938).

The first thin dolomitic limestone below the Wellington marks both the Herington and the top of a section of limestones and shales 600 feet thick which is correlated with the Big Blue series. A number of markers important in subsurface correlation appear within this series.

The succeeding 600 feet below the Big Blue series is characterized by the predominance of grayish, sometimes reddish and greenish, shale with thin limestones and sandy zones interbedded. This section is known as the Wabunsee group. The

Shawnee group averages 375 feet in Reno County. This group lies between the top of the Topeka limestone and the Oread limestone at the base. The Heebner black shale makes a convenient marker in Reno County (Ver Wiebe, 1938). The Douglas group averages 125 feet in thickness in Reno County and can be recognized in well cuttings by the appearance of shales, sandstones, and red rock.

Missourian Series. Pedee Group. The Pedee Group in Reno County is represented by the Iatan limestone. Drillers and geologists log this as the "Brown lime" (Nicholas, 1954). It is a light bluish-gray to nearly white limestone. The texture is very fine and dense, but there are numerous thin, irregular plates of clear calcite.

Lansing-Kansas City Group. The Lansing-Kansas City Groups were combined as one unit on the panel diagram (Appendix, Fig. 5). The Lansing-Kansas City is usually the first formation recorded by geologists in Reno County. This group ranges in thickness from 325 feet in the northwest to 535 feet in the southwest part of the county.

The Lansing-Kansas City show sub-cyclic sedimentation with its thick bedded limestones alternating with its thick shale beds. The variations in the thickness of the Lansing-Kansas City are due to differential structural movement and to the unconformity at the top of the Lansing. A 30 foot thick oolitic limestone lies 450 feet below the top of the Lansing in eastern Reno County. The oolitic limestone is a cross-bedded oolite made

up to 50 percent or more chert or flint, which is light pink and hence differs from other Pennsylvanian cherts. This limestone has been designated frequently as the "Kansas City Oolite" (Moore et al, 1951). In the Zenith-Peace Creek pool this oolitic zone occurs about 150 feet below the top of the Lansing. This zone has been cored in several wells with no production.

Pleasanton Group. The Pleasanton Group in Reno County is rather rare so it is not shown on the panel diagram (Appendix, Fig. 5). Also the top of the Pleasanton was not logged on the data used to present the panel diagram. The Pleasanton ranges in thickness from a featheredge on the Central Kansas uplift to 35 feet in northeastern McPherson County in the Salina Basin.

Desmoinesian Series. **Marmaton Group.** The Marmaton and Cherokee Groups are shown as one unit on the panel diagram (Appendix, Fig. 5). This unit ranges in thickness from 30 feet on the Central Kansas uplift to 300 feet to the south and southeast. It is comprised of red, green, and black shales with thin limestone beds at intervals.

Pennsylvanian Basal Conglomerate. A zone of variable thickness, known as the Pennsylvanian Basal Conglomerate, is found at the base of the Pennsylvanian system. It ranges from a featheredge thickness on the Central Kansas uplift to 75 feet adjacent to the uplift in the Zenith-Peace Creek field. In its most common development it is an impervious cherty conglomerate imbedded in a red and green shale matrix. Frequently thin lenses of medium to coarse sand occur, but these sands lack continuity (Imbt, 1941).

This conglomerate is the remnant of a transgressive sea which was encroaching upon the uplift. It overlies in an angular unconformity rocks from Ordovician to Mississippian age in the Zenith-Peace Creek pool.

Mississippian System. The Mississippian limestones were deposited on a level Chattanooga shale surface. After their deposition Mississippi and older rocks were gently folded and elevated and subsequent erosion reduced the surface in the pre-Pennsylvanian time to a peneplain surface. Rocks lowered below the plain of base leveling were preserved; those that had been raised above it were worn away. A close relationship exists between the thickness of the Mississippian limestones and folding that occurred during the time interval between the final deposition of the Chattanooga shale and the close of base leveling (Lee, 1939).

Erosion of the uplifted area removed the entire sequence of Mississippian rocks and some older rocks before the beginning of Pennsylvanian deposition (Appendix, Fig. 5). Figure 6, (Appendix) structural contours on the Mississippi "Chat" and limestone, shows the pre-Pennsylvanian surface. Structural high areas are located in the northwest part of the county adjacent to the zero thickness of the Mississippian on the Central Kansas uplift and in the eastern part on the southern extremity of the plunging Voshell anticline. The northeast-southwest plunging syncline is the Conway syncline (Appendix, Fig. 2).

The Mississippian limestone ranges in thickness from a

featheredge on the uplift to 275 feet in the southeastern part of the county.

The producing zones in the Mississippian rocks appear to be independent of the vertical lithologic zones. Accumulation of petroleum is dependent on the porosity of the limestone. In some places where the ground-water level had been lowered by erosion, porous zones from leaching were present to a depth of over 100 feet below the surface of the Mississippian (Lee, 1939).

Chesterian Series. In the southwestern part of Kansas the Chesterian series attains a maximum thickness of 350 feet (Moore, et al, 1951). Rocks of Chester time probably covered Reno County, but post-Chesterian erosion took away any known Chesterian rocks and most rocks of Meramecian time.

Meramecian Series. The rocks of the Meramec age in Reno County are cherty white limestones and dolomites and are quite sparse due to post-Chesterian erosion.

Geologists and drillers designate the Meramecian limestone as the Mississippi "lime."

Osagian Series. The limestones of Osagian age in Reno County are referred to as the Mississippi "Chat" by the drillers. The Burrton pool, the largest in Reno County, obtains its oil and gas from "Chat" interval over the Voshell anticline.

The distinguishing feature of the "Chat" is the translucent and semitranslucent character of the chert. The color of the chert is variable, with shades of blue and bluish gray predominant.

In the Zenith-Peace Creek pool a thin section of Mississippi

limestone, which varied from a featheredge to 55 feet in thickness, is found in nearly all the producing sectors. It is essentially a chalky, residual chert, but elsewhere to the northwest it contains zones of tan to buff limestone and red chert at its base.

Basal Osagian rocks are separated from the underlying "Kinderhookian Shale" by a low angular unconformity.

Kinderhookian. Kinderhook rocks in Reno County range in thickness from a featheredge on the Central Kansas uplift to 200 feet in the southwestern part of the county (Appendix, Fig. 5). It varies to the east and southeast due to the presence of underlying Chattanooga and Hunton rocks.

The Kinderhook formation in the Zenith-Peace Creek areas includes a lower silty dolomite, and an upper shale bed comprised of green to red shale (Kornfeld, 1943).

Mississippian or Devonian (?) Chattanooga. The shale sequence between Mississippian and Devonian limestones is divided into two formations; in descending order, the Boice shale and the Chattanooga shale. They are separated by a marked disconformity. It is possible, although not proved, that the Boice shale is Mississippian age and the Chattanooga shale (often called "Kinderhook" shale) is Devonian age (Moore, et al, 1951).

The Boice shale is present in parts of Reno County as a thin interval over the Chattanooga shale.

The Chattanooga shale in Reno County ranges in thickness from a featheredge on the Central Kansas uplift to 50 feet and is composed of black fissile shale, slightly silty and finely

micaceous with perceptible amounts of pyrite.

The Chattanooga shales were not distributed over the entire county. This results from the post-Chattanooga erosion, as can be seen on the panel diagram (Appendix, Fig. 5) in wells number 6 and 11.

Misener. The term Misener sand is used to designate sandstone deposits at the base of the Chattanooga shale immediately above the pre-Chattanooga disconformity (Jewett, 1954). It ranges in thickness from a featheredge on the Central Kansas uplift to 20 feet adjacent to the uplift.

In the Zenith-Peace Creek pool this sand disconformably overlies the Viola formation. The Misener occurs irregularly as beach sands and off-shore sand bars in the lower Mississippian or Devonian (?). It is lithologically a fine to medium quartzose sandstone containing black chert (Kornfeld, 1943). The porosity and permeability of this sandstone are excellent and tend to make a fine reservoir for the accumulation of oil.

The Misener overlies various formations in Reno County due to erosion during post-Hunton and Maquoketa times. The Misener lies on Viola, Maquoketa, and Hunton beds.

Devonian-Silurian. Hunton. The limestones and dolomites lying between the Maquoketa shale and the Chattanooga shale are referred to as the Hunton formation or group by drillers and geologists in Reno County.

Several miles separate the Hunton limestone along the south edge of the Salina basin from the Hunton limestone section in

Reno County. Some geologists have considered the southern Kansas Hunton of Reno County an outlier of Salina basin beds; but the marked lithologic variations within a few miles in contrast with Salina basin Hunton beds which generally do not show much change over wide areas suggests that the two regions may never have been connected directly. An explanation may be that the limestones formed in two bays of the Hunton sea which filled the area at the northeast, and may have extended independently into central Kansas from the east (Taylor, 1946).

The Hunton limestone in Reno County has an average thickness of 40 feet. It is a light to medium brown crystalline limestone combined with tan chert. More calcium carbonate than magnesium carbonate is found in the upper parts of the section, and the opposite relation is found in the lower parts of the section. Sand grains are embedded in some limestone fragments from well cuttings, and sand is abundant in wells near the Hunton's edge.

Three similar chert zones appear in the thickest sections of Hunton. The cherts cannot be established beyond question by correlation over wide areas; but it is believed that as Hunton strata thin toward the southwest, the lowest cherty zone disappears as a result of geologic overlap (Appendix, Fig. 5); the highest cherty band is gone, perhaps through offlap and erosion; and the middle cherty zone is the most widespread of the three. These correlations are based on the chert lithologies. Some evidence of an erosional break in sedimentation above the middle

cherty zone is present. Little erosion took place because the land remained close to sea-level. If the Hunton in the Salina basin area is both Silurian and Devonian in age, this break may be the diastem between those two periods (Taylor, 1946).

The unconformity at the base of the Devonian is one of the most important in the geologic sequence of Kansas, for it represents local pre-Devonian erosion of Silurian and older rocks (Moore et al, 1951).

The Hunton limestone is a good producer in the Burrton pool.

Ordovician System. Maquoketa. The Maquoketa (Sylvan) shale is present on the panel diagram (Appendix, Fig. 5) in the northeastern corner of Reno County.

Over much of Reno County the Maquoketa section is a uniform gray and brown moderately dolomitic shale, which thins and disappears in Central Reno County (Taylor, 1947). It attains a thickness of 50 to 75 feet in Reno County.

Viola. The Viola limestone lies unconformably below the Maquoketa shale, Misener sandstone, and the Pennsylvanian Basal Conglomerate in Reno County. It ranges in thickness from a featheredge on the Central Kansas uplift to 100 feet to the south and 30 feet to the east in Reno County.

The Viola limestone of central Kansas is separable, on the basis of lithology, into six zones. These zones in descending order are: (1) upper limestone member, (2) upper cherty member, (3) middle limestone member, (4) middle cherty member, (5) lower limestone member, and (6) lower cherty or basal clastic member (Taylor, 1947).

Comparatively thin non-cherty limestones and dolomitic limestones form most of the Viola formations in Reno County. The dolomitized upper limestone member (zone 1) is missing in much of the area. In the southern part, dolomitic limestones are common, but they represent a gradational facies change from the limestones of zone 5 farther north, although a few feet at the top of some wells may be remnants of zone 1. The upper cherty member, upper limestone member, and middle cherty member (zones 2, 3, and 4) do not appear in this area. The lower limestone (zone 5) has a maximum thickness of about 50 to 100 feet and is the only member present over much of the county. The lower limestone is crystalline, gray or black splotched and calcitic in the north, browner and more dolomitic in the south. Bits of pyrite are disseminated through the limestone, and in some wells in the central and southern parts of the county a white or tan smooth chert forms as much as 10 percent of samples. The lower cherty or basal clastic member (zone 6) is poorly developed in Reno County. Some wells show thin sandy zones at the base of the limestone section, but the stippled chert is absent, and in many wells the change from limestone or dolomitic limestone to the underlying Simpson sand or shale is abrupt (Taylor, 1947).

The Viola formation was truncated by erosion in the northwestern Reno County due to the Central Kansas uplift. The formation thickens to the south-central through the Conway syncline and thins over the Voshell anticline in the southeast.

Oil in the Viola formation is quite prolific in Reno County.

The Viola limestone is the petroleum reservoir rock in the Albion North, Buhler, Hilger, Lerado-Southwest, Stankey, and Zenith-Peace Creek pools (Appendix, Fig. 3).

Simpson. The Simpson group lies unconformably below the Viola limestone in Reno County. The Simpson group consists of the Platteville formation of Middle Ordovician age, and the St. Peter sandstone, and slightly older rocks of Early Ordovician age. This group ranges in thickness from 75 to 100 feet.

The upper formation, the Platteville, consists of medium to dark green, splintery non-silty shale.

The St. Peter sand may be described as subrounded to rounded, fine to medium grained sand which grades both laterally and vertically into sandy shale and shale (Moore, et al, 1951).

The St. Peter is also called the "Wilcox" sand by drillers and geologists.

Cambro-Ordovician. Arbuckle Group. The Arbuckle group lies unconformably below the Simpson group.

The Arbuckle group consists of Early Ordovician and Late Cambrian deposits. Drillers and geologists refer to these rocks as the "siliceous lime."

The Arbuckle and the approximate equivalent Ellenburger formation of Oklahoma and north-central Texas form one of the most widespread and uniform stratigraphic units in the Mid-continent region.

The Arbuckle group consists of the following units from

top to bottom: (1) Cotter and Jefferson City dolomites, (2) Roubidoux formation and (3) Gasconade dolomite and Van Buren formation.

A few wells have penetrated 650 feet of the Arbuckle in Reno County. A zone of oolitic chert, and another zone of cherty dolomite, serve as correlation markers in this formation (Ver Wiebe, 1938).

The Arbuckle group on the panel diagram (Appendix, Fig. 5) was illustrated only to a depth of 100 feet.

The Arbuckle in the Zenith-Peace Creek pool lies unconformably upon the Lamotte ("Reagan") sandstone. The Arbuckle is generally fine to coarse crystalline dolomite, containing zones of oolitic chert within the dolomite in this area (Kornfeld, 1943).

Structural contours on the Arbuckle (Appendix, Fig. 7) reflect up to the Mississippi "Chat" and limestone. The top of the Arbuckle is structurally "high" in the northwest and northeast with a low area between the two "highs" (Conway syncline). This structure is apparent on the Mississippi Contour map (Appendix, Fig. 6).

Several structural "high" areas with closed contours appear on the Arbuckle surface. These areas are void of accumulation. These "highs" are found in formations overlying the Arbuckle and they provide satisfactory traps for oil accumulation. The anticline in T.22S., R.8W., the Sterling pool, has production in the Mississippi "Chat" but none in the Arbuckle.

The anticline in T.26S., R.9W., the Lerado pool, has production in the Viola but none in the Arbuckle. The only production in Reno County in the Arbuckle is in the Burrton pool.

Reno County has been rather disappointing to oil producers because of this lack of production in the Arbuckle. This is rather strange for only several miles north and northwest of Reno County the Arbuckle is a good producer. An answer may be that in the central Kansas pools that produce from the Arbuckle, beds of Lower Pennsylvanian age rest on deeply truncated Arbuckle. The Pennsylvanian deposits may be the source of the oil, and the Arbuckle dolomite the place of accumulation of the oil. In south-central Oklahoma, no commercial accumulation has yet been found in the Arbuckle in the following cases: (1) where the Arbuckle was overlain by a normal sequence of the Simpson formation which on structure contains producing oil sands, and (2) where the Arbuckle is in unconformable contact with Upper Pennsylvanian or Lower Permian beds even on major uplifts (Bartram, 1950).

Cambrian. The Cambrian system in Reno County is not an important oil reservoir rock, so it has been omitted from the panel diagram.

The Lamotte sandstone occurs in parts of Reno County. The sand grains composing the Lamotte are poorly sorted, rounded to angular, and coarse to fine. Arkose occurs in the lower part adjacent to Pre-Cambrian rocks. The Lamotte sandstone was deposited on a complex of Pre-Cambrian rocks which formed an uneven surface of very low relief.

In the Zenith-Peace Creek pool area the presence of 52 feet of Lamotte sandstone is indicated in a deep test drilled 11 miles northwest of the pool, where it lies on the Pre-Cambrian granite (Kornfeld, 1943).

Pre-Cambrian. The Pre-Cambrian rocks of Reno County consist of igneous and metamorphic rocks.

Major Structural Features

Central Kansas Uplift. The name Central Kansas uplift was first applied by Morgan to the major post-Mississippian uplift (Morgan, 1932).

The Ellis arch is referred to as the ancestral Central Kansas uplift of pre-Mississippian time by Moore and Jewett (Moore, et al, 1942).

The Central Kansas uplift occupies an area in central Kansas and probably part of south-central Nebraska, whose present northwestward trending structure has been developed by several periods of warping and erosion with subsequent truncation of sedimentary rock, the earliest of which dates back to pre-Cambrian time. Warping has occurred chiefly in post-Proterozoic (?), post-Canadian, post-Hunton, early Pennsylvanian, post-Missouri, and post-Cretaceous time. Depositional thinning toward the north and west has affected mainly Cambro-Ordovician and Pennsylvanian strata (Koester, 1935).

This sequence of events is illustrated in the panel diagram (Appendix, Fig. 5) by the angular unconformity in the

post-Mississippian and the disconformity in the post-Arbuckle of northwestern Reno County.

The uplift was evidently a land mass throughout a large part of early Paleozoic time, while the thicker dolomites, limestones, and sandstones of the Arbuckle group were forming in southern Oklahoma. Apparently the Central Kansas uplift is more closely related in geologic history to the Ozarks than to the areas north and south of the uplift.

The pre-Cambrian rocks of Kansas consist of igneous and metamorphic rocks with lighter granite occupying the nucleus of the uplift. In general, the schist along with arkoses and red clastics have been found on the flanks of the warped areas.

Possibly the forerunner of the uplift was a series of more or less parallel batholiths which were intruded into the schist in pre-Cambrian time.

The number of periods of uplift and erosion in pre-Cambrian time is unknown.

During Mississippian time the Central Kansas uplift was broadly elevated and folded along northeast-southwest trends. Simultaneously, the Nemaha Granite ridge was folded and faulted, and similar movement took place along the Voshell anticline (Appendix, Fig. 2), which lies between the uplift and the Nemaha anticline (Koester, 1935).

Chautauqua Arch. The Chautauqua Arch (Appendix, Fig. 2) is the name for the pre-Mississippian extension of the Ozark uplift along the Kansas-Oklahoma line (Barwick, 1928).

The Chautauqua Arch and the Ellis Arch in pre-Mississippian

time structurally divided northeastern Kansas from southwestern Kansas. This elongated arch passed through Reno County.

Sedgwick Basin. The Sedgwick basin, regarded as one of the major post-Mississippian structural provinces in Kansas, occupies an area in central Kansas southward from McPherson and Marion Counties (Appendix, Fig. 2). It is west of the Nemaha anticline and south of a low archlike structure that marks the southern boundary of the Salina basin (Appendix, Fig. 2), and east of a similar separation from Dodge City Basin or embayment (Jewett, 1954).

Salina Basin. The Salina basin occupies an area in north-central Kansas between the Nemaha anticline and the Central Kansas uplift (Appendix, Fig. 2). It is an area of depressed Mississippian and older rocks bounded on the south by the archlike structure between the Central Kansas uplift and Nemaha anticline separating it from the Sedgwick basin.

Interpretation of structural movements from thickness maps is based on the concept that if a sequence of rocks is deposited on a flat surface and then warped before a younger horizontal surface is developed, variations in the thickness of the rocks between the two surfaces reveal the amount and place of deformation (Lee, et al, 1948).

In the Salina basin five periods of folding are distinguished (1) Upper Cambrian and Lower Ordovician dolomites lying below the St. Peter sandstone were deformed before the deposition of the St. Peter sandstone. The structural movement resulted from

many minor movements that occurred at different times prior to the deposition of the St. Peter sandstone. The movements involved a subsidence of a deep basin in central Missouri in which more than 2,000 feet of dolomites were deposited. During the same epoch, a south-trending positive area, termed the Southeast Nebraska arch, was developed in southeastern Nebraska and northeastern Kansas. In central Kansas, a parallel north-south syncline was developed.

(2) Another period of folding extended from St. Peter time to the beginning of deposition of the Mississippian limestone and may have continued through Kinderhookian time. During this period the structural deformation was a complete reversal of that preceding St. Peter time. For now the Ozark uplift rose from the deepest part of the syncline in southern Missouri and a segment of the Southeast Nebraska arch became the site of a downwarped area called the North Kansas basin. Contemporaneous with these events were the development of the Chautauqua arch and the Central Kansas uplift (Appendix, Fig. 2) on the south and west.

(3) A third period of folding began at least as early as the beginning of Mississippian time, culminated after Mississippian deposition, and continued with diminished movement through Pennsylvanian into Permian time. The principal structural feature developed in Kansas was the Nemaha anticline (Appendix, Fig. 2), which was flanked by the Salina basin on the west and the Forest City basin on the east. The Salina basin was a

synclinal area which trended northwest and paralleled the northern flank of the Central Kansas uplift.

(4) A fourth period of deformation occurred after Permian time and before Cretaceous time. It involved the development of a broad synclinal basin in southeastern Kansas which gave the Permian and Pennsylvanian rocks of eastern Kansas a southwesterly dip.

(5) A fifth period of deformation occurred after the deposition of the Cretaceous rocks. As a result of this deformation these rocks were tilted toward the northeast in western Kansas and toward the north and northwest in central Kansas and were raised 1,500 to 2,000 feet above sea level in the Salina basin.

Each change in the pattern of structural movement altered the altitude of earlier anticlines as well as earlier regional structure. Changes in the direction of dip shifted the position of the crests of low anticlines in some cases and destroyed the closure in others. In consequence, the exposed crests of low anticlines in the younger rocks do not, in all cases, reveal accurately the position and configuration of those anticlines in older more steeply dipping rocks (Lee, et al, 1948).

Nemaha Anticline. The Nemaha anticline or ridge is an asymmetrical structural high in eastern Kansas that plunges to the southwest (Appendix, Fig. 2). It exhibits a remarkably straight northeast-southwest alignment and has a maximum relief of 3,200 feet on the steeper east flank. Its

configuration resembles a normal fault scarp (Rieb, 1954). The steep eastern flank is believed to be faulted in several places. The question then arises that the entire ridge is a normal fault causing the ridge's straight alignment.

The Nemaha anticline resulted from uplift in post-Mississippian times. The initial movements of the anticline began in Mississippian times and were followed by the major uplift at the close of Mississippian times.

Minor Structural Features

Voshell Anticline. The Voshell anticline (Appendix, Fig. 2) lies in Saline, McPherson, Harvey, and Reno Counties, approximately parallel to the Nemaha anticline which lies about 50 miles to the east. The Abilene anticline which is farther north in Kansas is approximately in line with the Voshell.

The Voshell was probably folded and faulted contemporaneously with the formation of the Nemaha anticline.

Conway Syncline. The Conway syncline (Appendix, Fig. 2), whose axis extends north and south across western Saline and McPherson Counties, turns and plunges southwest in Reno County toward the Dodge City basin. This can be seen on the structure contour maps (Appendix, Figs. 6, 7) of both the Arbuckle and the Mississippian.

Reno Fault Block. A pronounced structural high is in the NW 1/4, T.24S., R.8W.

Two wells have been drilled on this high indicating the following stratigraphic sequence.

- (1) Morton No. 1 - SW 1/4 SW 1/4 NE 1/4 Sec. 17, T.24S., R.8W.

Elevation of formation top below datum

Lansing	1520 feet
Kinderhook	1997 "
Misener	2083 "
Viola	2088 "
Simpson	2138 "
Arbuckle	2216 "

- (2) Morton No. 1 "B" - NE 1/4 NW 1/4 SE 1/4 Sec. 17, T.24S., R.8W.

Elevation of formation top below datum

Lansing	1496 feet
Kinderhook	1971 "
Misener	2051 "
Viola	2061 "
Simpson	2139 "
Arbuckle	2217 "

Oil was produced from Morton No. 1 (Appendix, Table 1) from the Lansing-Kansas City.

The "high" is delineated on the structure contour map of the Mississippian erosional surface (Appendix, Fig. 6) with the Pennsylvanian Basal Conglomerate lying in contact with the Chattanooga shale.

Absence of the Osagian and the Meramecian series in this area indicates a fault in post-Kinderhookian-pre-Osagian or in

post-Mississippian time contemporaneous with the Voshell and Nemaha anticlinal folding. The Osagian and the Meramecian series were either not deposited due to this high land area or the series were eroded away during post-Mississippian uplift and erosion.

This "high" is probably a fault which occurred in post-Mississippian time and was then eroded.

The fault block may be triangular in shape with the southeast vertex being uplifted 350 feet and the northwest limb acting as a hinge line (Appendix, Fig. 7).

Seismic methods, in the "Sterling" pool area (Appendix, Fig. 3) 15 miles due north of this fault, indicate faulting in the subsurface (Allen). A cross-section of the fault block is shown on Figure 7B (Appendix) drawn to true scale; that is, the horizontal scale and the vertical scale are equal.

Peace Creek Fault. Kornfeld (1943) states that a normal fault in the Viola in the SW 1/4 of T.23S., R.10W., strikes north-northeast for a distance of 1 1/2 miles. He states that despite this structural feature, the predominating attitude of the accumulation of oil at Zenith-Peace Creek is a variation in stratigraphy wherein portions of the two upper members (upper limestone member and upper cherty member) of the Viola limestone formation have been removed by truncation and erosion.

The portion of this report that concerns structure has been limited to the contouring of the Arbuckle and Mississippian formations. This fault described by Kornfeld has not materialized

in the contouring of the Arbuckle or the Mississippi in this report. The fact that the fault is not evident on the structure contour maps of the Arbuckle and Mississippi may be due to interpretation and also to the fact that the fault may be confined only to the Viola limestone formation.

HISTORY OF DRILLING

The first pool to be discovered in Reno County was the Abbeyville pool in Sec. 24, T.24S., R.8W. (Appendix, Fig. 3). The discovery well was drilled on January 1, 1927, by Hartman and Shaer on the Smith farm with an initial production of 325 barrels of oil from a depth of 3,540 to 3,544 feet. (panel diagram, well No. 7, Fig. 5). Total production from the pool at the close of the 1927 drilling was 15,495 barrels (Kesler, 1928).

One of the largest pools in the county is the Burrton pool, in the eastern part of the county about 10 miles east of Hutchinson. The first well in this pool (1931) was the Empire Oil Company No. 1 Haury drilled in Sec. 1, T.23S., R.4W. Gas in the "Chat" was estimated to be 23 million cubic feet per day. The first oil well in the Burrton field was drilled by Lloyd, Frost, and Study on the Haury farm in the northwestern quarter of the same section about five months after gas was discovered. The oil was in the Mississippian "Chat" at a depth of 3,254 to 3,364 feet. The initial production was 327 barrels, with about 7 million cubic feet of gas higher in the producing

zone. After numerous wells had been drilled into the Mississippian, oil was also found in the Hunton and in the Arbuckle (Ver Wiebe, 1938).

The Burrton pool lies over the southern extent of the Voshell anticline (Appendix, Fig. 3). The outline of the pool can be seen from the structure contour maps on the Arbuckle dolomite and the Mississippi "Chat" and limestone (Appendix, Figs. 6, 7).

Many attempts to find the southern extension of the Burrton pool have failed. However, some oil was found in one small area, the Yoder pool. This pool was discovered in 1935 and lies three miles west of the south end of the Burrton pool.

The Hilger pool was opened in June, 1934, in Sec. 16, T.26, R.4W., (Appendix, Fig. 3). The Mississippian "Chat" is present in this area, but carries no oil or gas. The Hunton and Sylvan shale are missing. The Viola was encountered at 4,062 to 4,067 feet and produced almost 1,000 barrels per day in the initial potential test.

Another pool which obtains its production from the Viola is the Lerado pool in the southwestern part of the county (Appendix, Fig. 3). The first well was the Shell Petroleum Company No. 1 Reese, which was completed in October, 1935, in Sec. 11, T.26S., R.9W. The porous pay zone of the Viola was at 4,137 to 4,156 feet. The initial production was 878 barrels in 24 hours with 1 1/2 million cubic feet of gas (Ver Wiebe, 1938).

The Lerado pool is on a structural high as can be seen from the panel Diagram (Appendix, Fig. 5).

The Buhler pool was discovered in April, 1938 (Appendix, Fig. 3). The discovery well was drilled by the Amerada Petroleum Company on the Johns Ranch, in Sec. 25, T.22S., R.5W. Accumulation was in the "Wilcox sandstone" (Simpson formation) at a depth of 3,897 feet (Ver Wiebe, 1939).

The Zenith-Peace Creek pool was established in September, 1937, with the Zenith pool in Stafford County. This pool with its phenomenal production capacity gave impetus to extensive wildcat drilling in the western part of Reno County, and as a result, the Peace Creek pool was found.

The Peace Creek pool was opened in 1941, by the Simpson Oil Company on the completion of the first well on the Snowbarger Farm in the NE 1/4 Sec. 21, T.23S., R.10W. (Ver Wiebe, 1943).

Since the opening of the Peace Creek field, the Zenith and the Peace Creek merged into one field in 1943, covering 10,000 acres (Appendix, Fig. 3), making it one of the large pools, in area, of the state.

The Morton pool (Appendix, Fig. 3) was found during 1942. The discovery well was drilled by the Cities Service Oil Company in Sec. 17, T.24S., R.8W., on the Morton Farm. Oil was in the limestone of the Lansing-Kansas City sequence at several levels (Ver Wiebe, 1943).

In 1943 the Hilger North pool in Sec. 34, T.25S., R.10W., was discovered by the Phillips Petroleum Company.



A new producing zone, the Lansing-Kansas City was found in the Albion pool (Appendix, Fig. 3) late in 1948 when Helmerick and Payne, Inc., completed the No. 1 Waltner well in Sec. 23, T.26S., R.6W., which produced 33 barrels of oil per day (Ver Wiebe, 1952).

In 1951, in Rice County, the Flynn Oil Company drilled on the Mayer Farm in Sec. 4, T.22S., R.8W., and discovered a well which had an initial potential of 10 barrels of oil and 20 barrels of water per day. "Sterling" is the name thus far applied to the pool (Appendix, Fig. 3) (Ver Wiebe, et al, 1952).

Wells being drilled at present in Reno County are being drilled by rotary methods.

In the Zenith pool usually 250-280 feet of 10 3/4-inch surface casing is set. The oil string consists of 5 $\frac{1}{2}$ -to-7-inch casing which is usually set a foot or two below the top of the producing formation. Some operators make their entire penetration with rotary before setting casing, while others set casing after penetrating but a few feet of the producing formation, and move in cable tools for completion of the well, (Imbt, 1941).

CONCLUSIONS

All available points were used for the construction of the contour maps on the Arbuckle and Mississippi surfaces. If more data were available, these maps may be somewhat altered. Alteration might be due to better control with more points of the fact that the contouring on both maps was not always done

by mechanical methods; that is, measuring the distance between points and then measuring off the exact contour lines. The location of the subsurface control points used in this report are shown on Figs. 6A and 7A (Appendix).

This same idea of interpretation is also true when looking at the "Reno Fault." This fault may be interpreted in several ways. The interpretation depicted in Fig. 7 (Appendix) seems to be the best.

The future potentiality of Reno County is quite good. All possible structural highs and stratigraphic pinchouts on the flanks of synclines have not been drilled and all formations have not been drilled in known pools. Some production from the Arbuckle has been found in the Burrton pool, but the Arbuckle has not been drilled as much as the Mississippi and Hunton because oil is so prolific in these two formations.

The lateral extent of all the pools in Reno County has not been realized as yet. Nine new pools have been discovered since 1950, and the older pools have been expanded.

Secondary recovery has not been too pronounced in Reno County pools. Salt water injection has been used in the Abbyville and the Zenith-Peace Creek pools to produce only 2,060 barrels in 1952 (Ver Wiebe, 1954).

It is possible that oil companies will return to oil pools in Reno County to rework them by secondary recovery in the "tight" formations.

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APPENDIX

Table 1. Oil production in Reno County, Kansas to January 1, 1954.

Oil production						
Pool and location : of discovery well :	Discovery : year	Number : of wells	Area in : acres	Depth in : feet	Producing : zone	Cumulative production : in barrels
Abbyville 24-24S-8W	1927	5	1,040	3540	Lansing- Kansas City	852,575
Albion 14-26S-6W	1948	3	100	3654	"Chat"	25,492
Albion North 14-26S-6W	1950	1	40	3997	Viola	767
Bacon 36-23S-5W	1953	1	40	3382	Mississippi	2,141
Buhler 25-22S-5W	1938	7	1,000	3890	Viola	1,007,706
Burrton 1-23S-4W	1931	326	11,000	3266 3583	Mississippi "Hunton"	48,168,687
Haven 9-25S-4W	1951	2	80	3977	Simpson	13,742
Hilger 16-26S-4W	1934	15	900	4062	Viola	4,704,110
Lerado Southwest 21-26S-9W	1944	1	40	4177	Viola	130,509
Morton 17-24S-8W	1942	1	40	3180	Lansing- Kansas City	42,689
Morton Southeast 16-24S-8W	1951	1	40	3423	Lansing- Kansas City	7,030
Nicklaus 3-26S-4W	1952	2	80	3249	Lansing- Kansas City	21,689
Stankey 22-22S-10W	1951	2	80	3187	Lansing- Kansas City	22,064

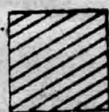
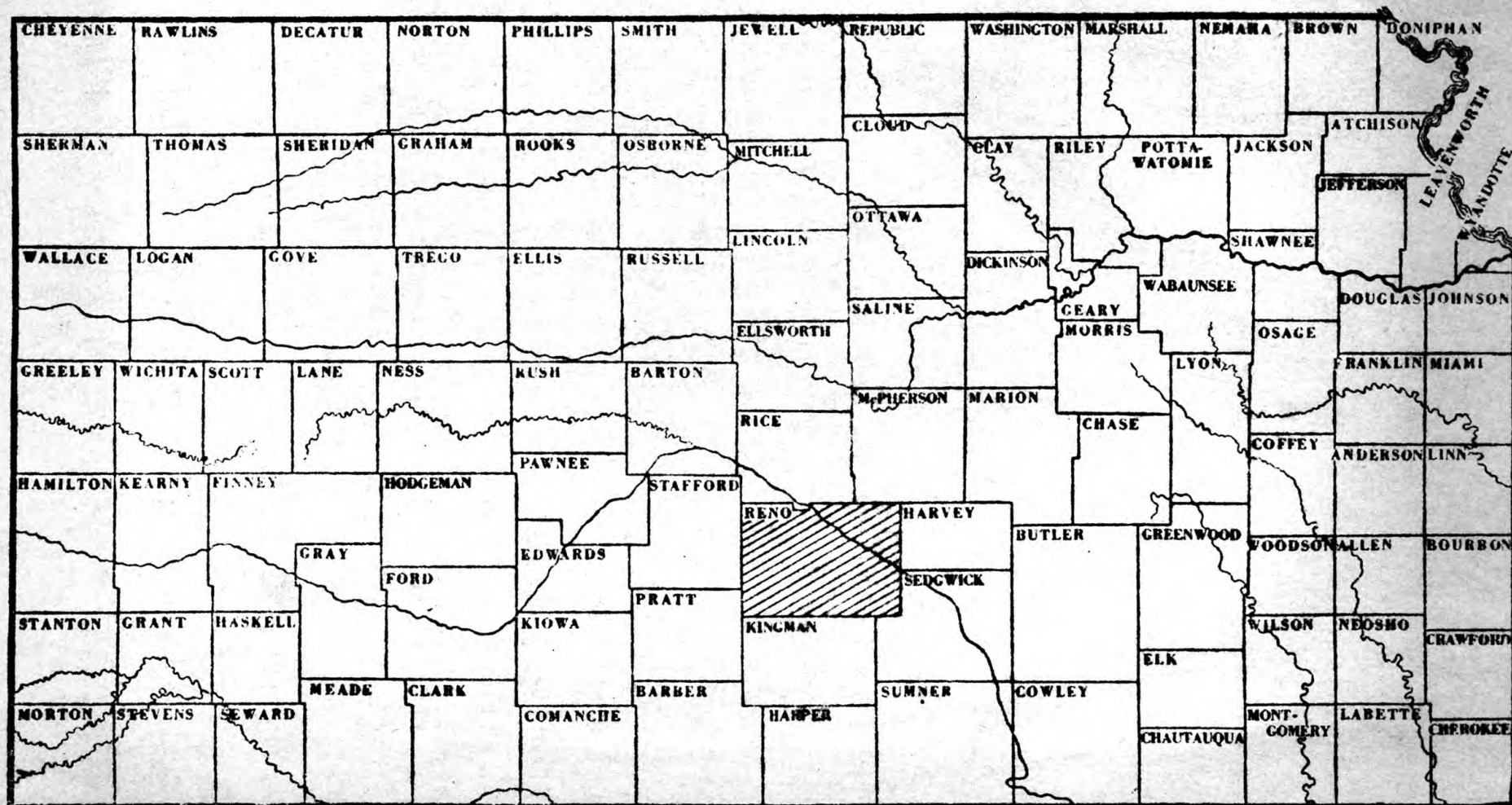
Table 1. (cont.)

Oil production						
Pool and location : of discovery well :	Discovery : year	Number : of wells	Area in : acres	Depth in : feet	Producing : zone	Cumulative production : in barrels
Stankey Southwest 21-22-10W	1952	1	40	3548	Viola	7,451
Sterling 4-22-8W	1951				Mississippi	none
Yoder 34-24S-5W	1935	3	120	3402	"Chat"	93,285
Zenith-Peace Creek	1941	117	8,500	3773	Viola	17,860,339
County Total						72,859,276

Table 2. Gas production in Reno County, Kansas to January 1, 1954.

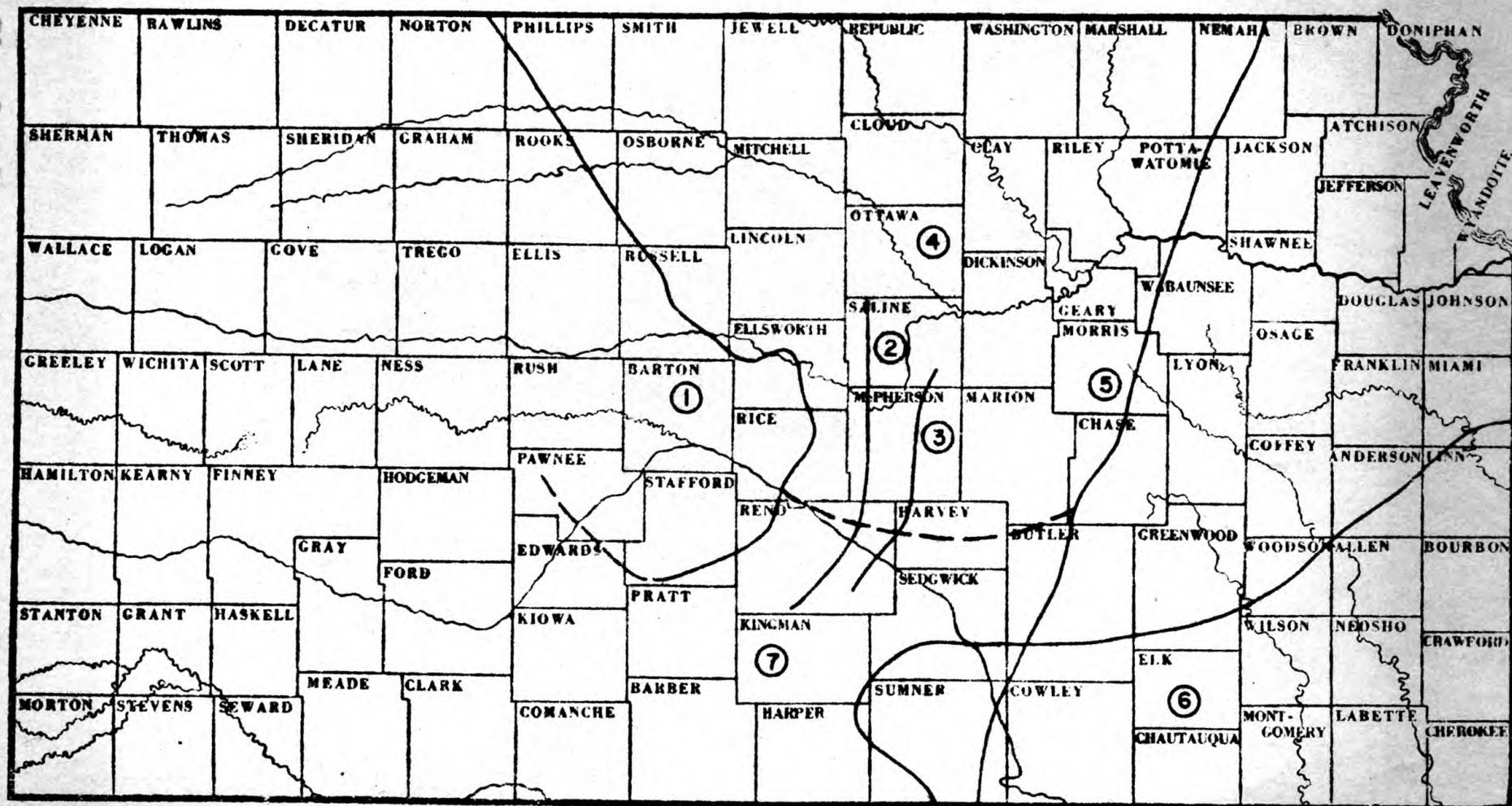
Gas production						
Pool and location : of discovery well :	Discovery : year	Number : of wells	Area in : acres	Depth in : feet	Producing : zone	Cumulative production : millions of cubic feet
Burrton 23-23S-4W	1930	13	800	3298	Mississippi	385,065 - Included with Harvey County
Lorado 10-26S-9W	1937	4	200			1,634,569
Yoder 34-24S-5W	1935	1	100	3402	"Chat"	123,149
Zenith-Peace Creek 23-24S-11W	1937			3860	Viola	No Report
County Total						2,142,893

Fig. 1. Area covered by this report



Area covered by this report

Fig. 2. Structural features in Central Kansas



- | | |
|-------------------------|--------------------|
| ① CENTRAL KANSAS UPLIFT | ⑤ NEMAHA ANTICLINE |
| ② CONWAY SYNCLINE | ⑥ CHAUTAUQUA ARCH |
| ③ VOSHELL ANTICLINE | ⑦ SEDGWICK BASIN |
| ④ SALINA BASIN | |

Fig. 3. Map of Reno County, Kansas, showing oil and gas pools

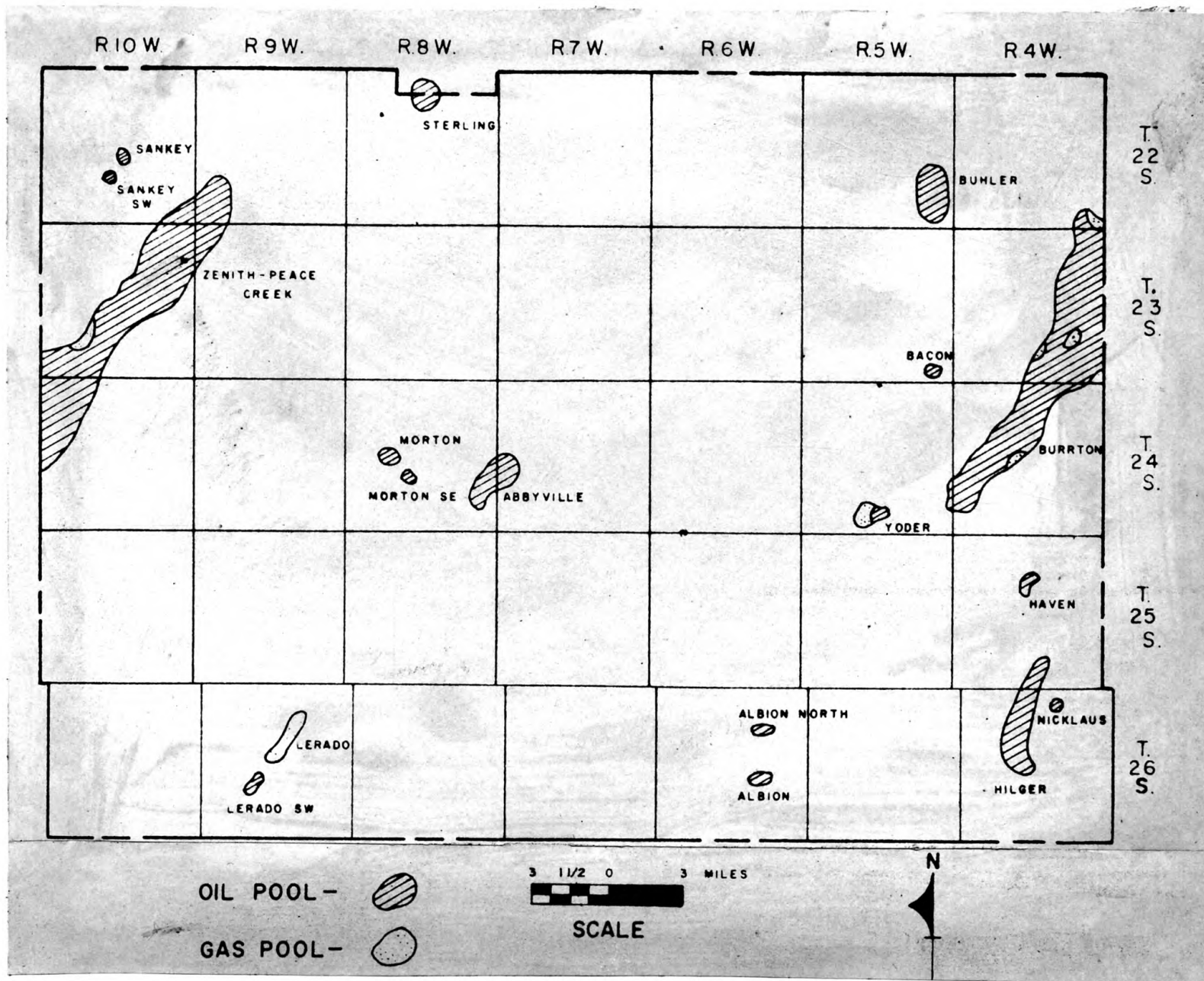
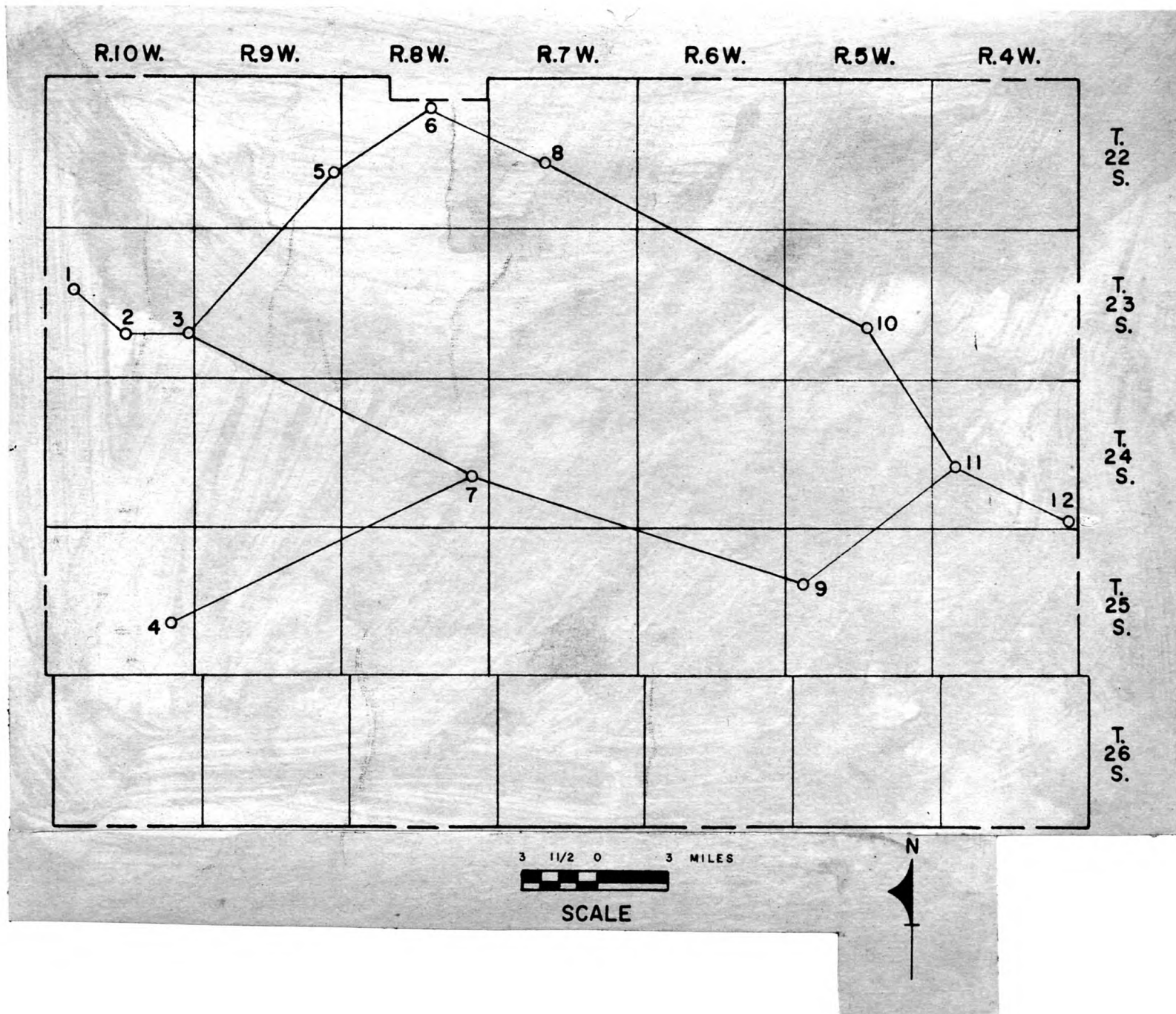


FIG. 4. Map of Reno County, Kansas, showing well locations of panel diagram



- LIMESTONE

DOLOMITIC LIMESTONE

OLOLITIC LIMESTONE

CHERTY LIMESTONE

SANDY LIMESTONE

DOLOMITE

OLOLITIC DOLOMITE

CHERTY DOLOMITE

SANDY DOLOMITE

SANDSTONE

SHALE
- SILTSTONE

BLACK SHALE

DOLOMITIC SHALE

CONGLOMERATE

PROMINENT UNCONFORMITY

FORMATIONS WEDGING OUT

APPROXIMATE CORRELATION

INCOMPLETE FORMATION

WELL LOCATION

TOWNSHIP LINES

COUNTY LINE

PANEL DIAGRAM THROUGH RENO COUNTY, KANSAS

Vertical

Horizontal

Top of section of points 1 through 12 is taken at top of Lansing-Kansas City

Datum: Sea level

Data obtained from Herndon Map Service and Kansas State Geological Survey

Armando T. Ricci, Jr. May, 1955

FORMATION OR MEMBER	GROUP	SERIES	SYSTEM	ERA			
	Lansing	Missourian	Pennsylvanian	PALEOZOIC			
	Kansas City						
	Marmaton	Desmoinesian					
Basal Conglomerate	-----		Mississippian		PALEOZOIC		
"Lime"	-----						
"Chert"	-----						
		Meramecian	Mississippian			PALEOZOIC	
		Osagian					
		Kinderhookian					
Chattanooga			Mississippian or Devonian				PALEOZOIC
Misener			Devonian				
"Hunton"			Silurian				
Maquoketa			Ordovician	PALEOZOIC			
Viola							
	Simpson						
	Arbuckle						

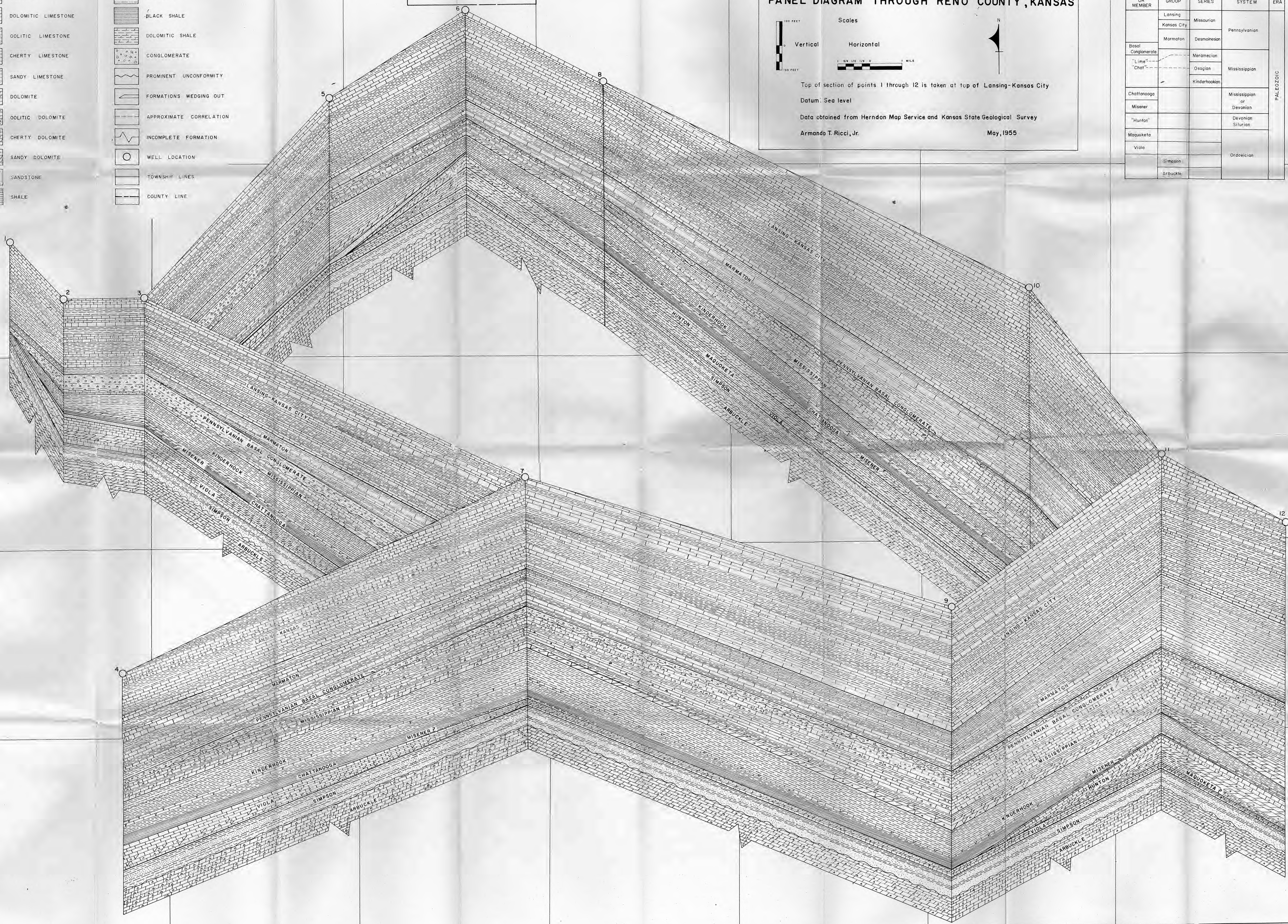


Table 3. Exact location of wells used in Fig. 5.

Well number :	Location	:	Section :	Township :	Range :	Elevation of Lansing top below datum
1	SW 1/4, SW 1/4, NE 1/4	:	17	23S	10W	1478 feet
2	Center NW 1/4	:	27	23S	10W	1540 "
3	SW 1/4, NE 1/4, NE 1/4	:	25	23S	10W	1515 "
4	SW 1/4, SW 1/4, SW 1/4	:	24	25S	10W	1689 "
5	Center SE 1/4	:	24	22S	9W	1431 "
6	Center NE 1/4	:	10	22S	8W	1388 "
7	SW 1/4, SW 1/4, SE 1/4	:	24	24S	8W	1558 "
8	SW 1/4, SW 1/4, NW 1/4	:	21	22S	7W	1361 "
9	NE 1/4, NE 1/4, NE 1/4	:	18	25S	5W	1242 "
10	SE 1/4, SE 1/4, SW 1/4	:	22	23S	5W	1194 "
11	NW 1/4, SW 1/4, NE 1/4	:	20	24S	4W	1037 "
12	NW 1/4, NW 1/4, SE 1/4	:	36	24S	4W	1248 "

R.4 W.

COUNTOUT INTERVAL 25 FEET
COUNTY LINES
TOWNSHIP LINES
KNOWN OIL POOLS

ARMANDO T. RICCI, JR. MAY, 1955

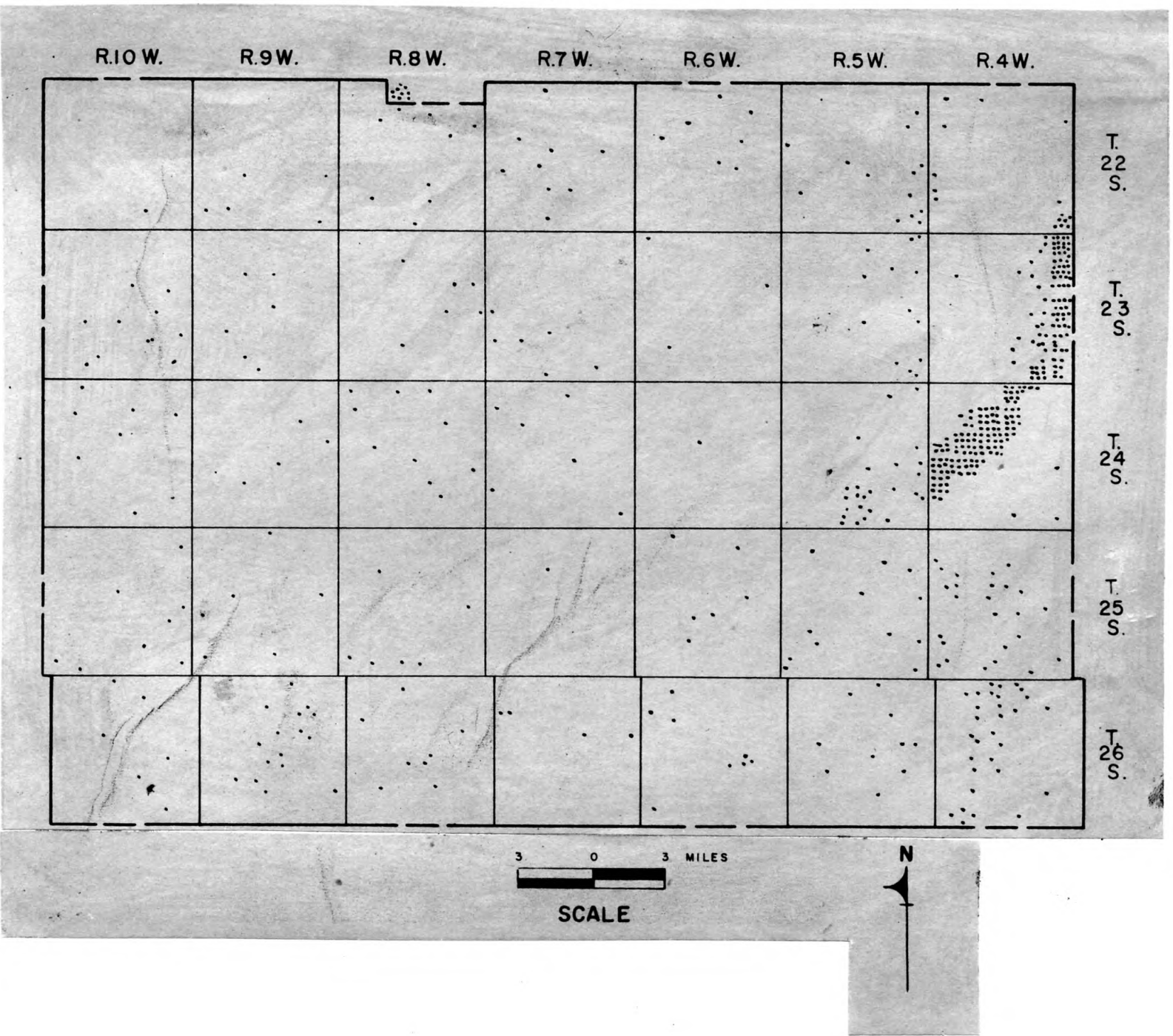


Fig. 6A. Map of Reno County showing 545 subsurface control points used for contouring structure on Mississippi "Chat" and limestone

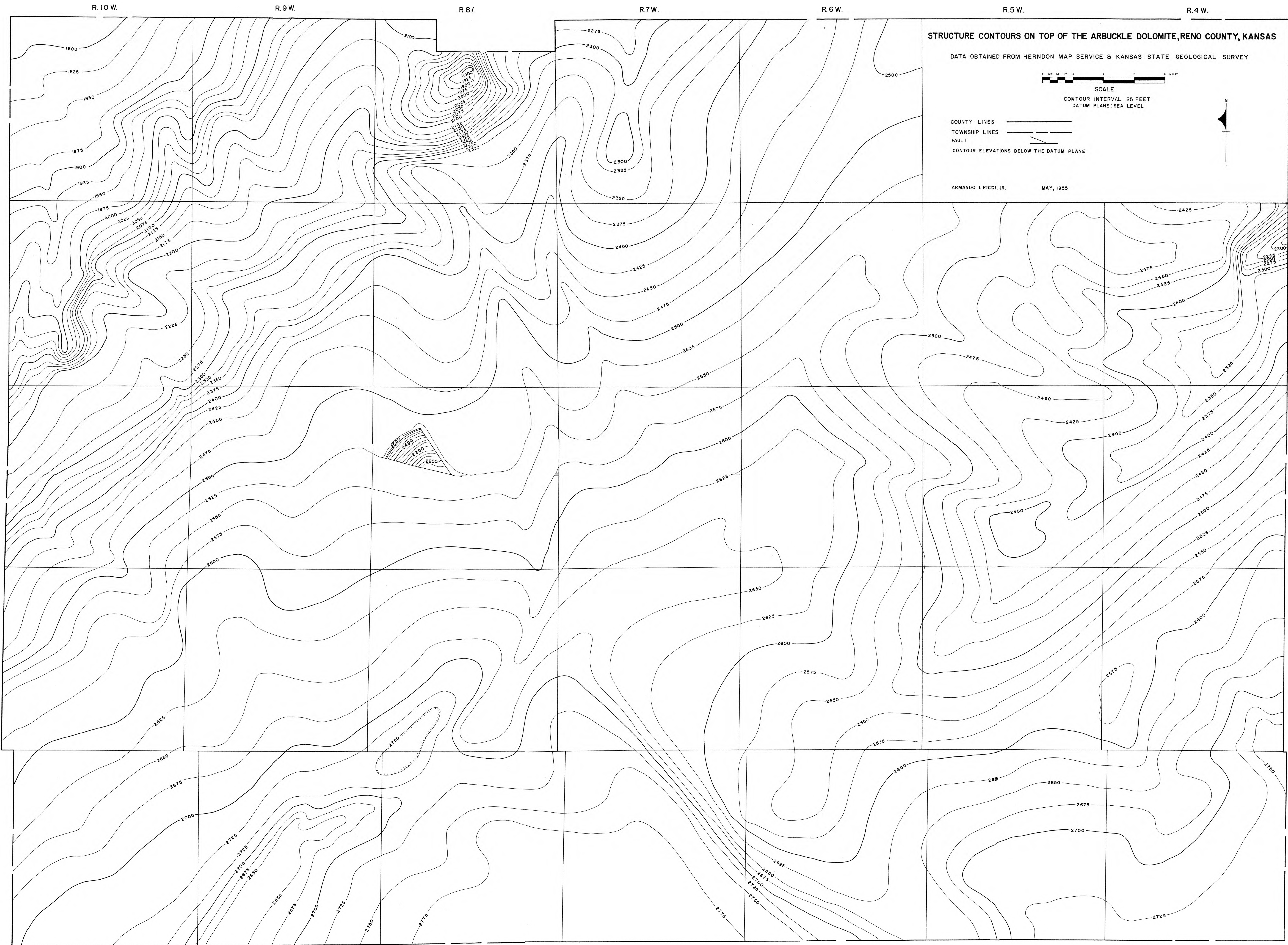
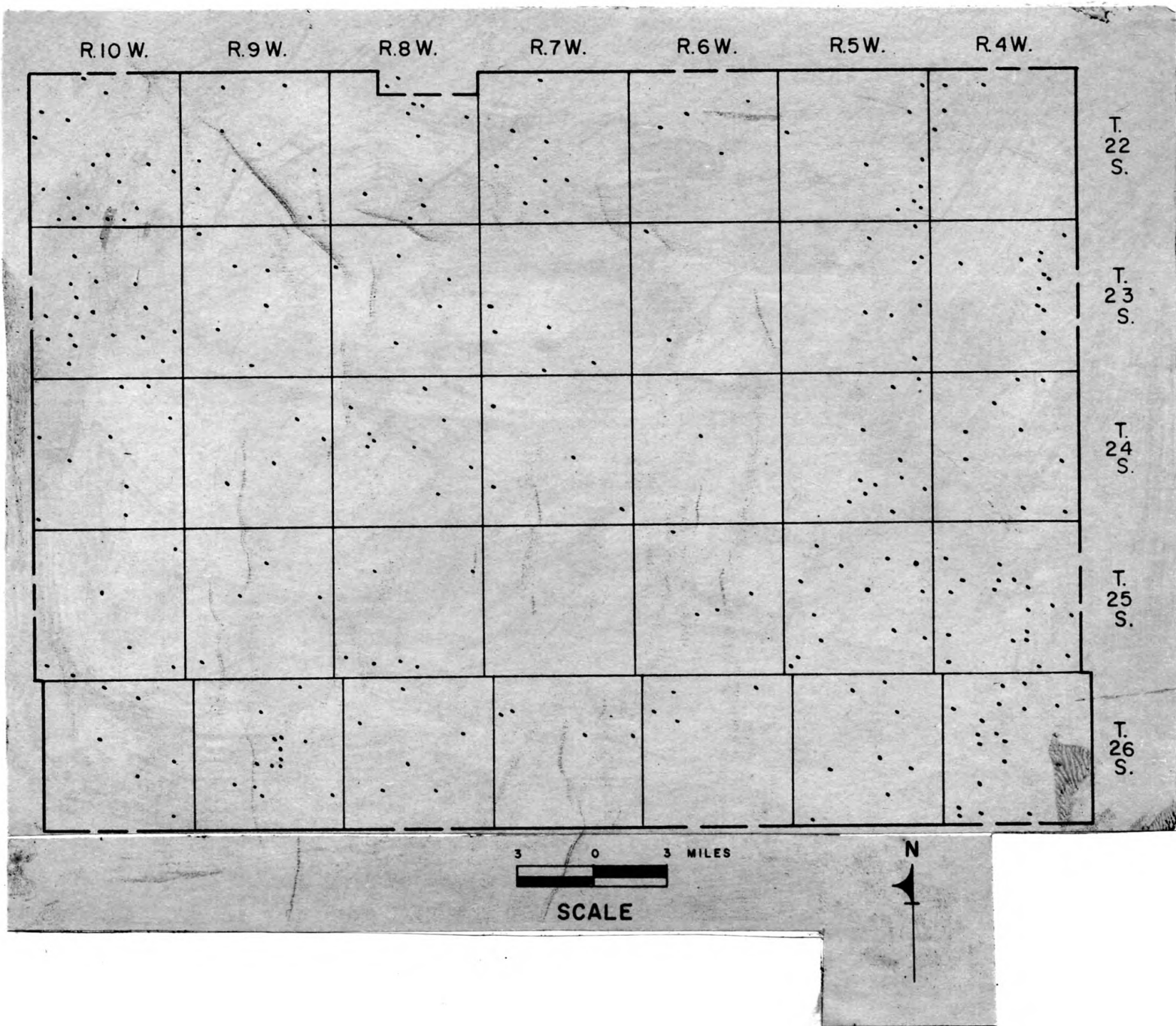


FIG. 7A. Map of Reno County showing 277 subsurface control points used for contouring structure on Arbuckle Dolomite



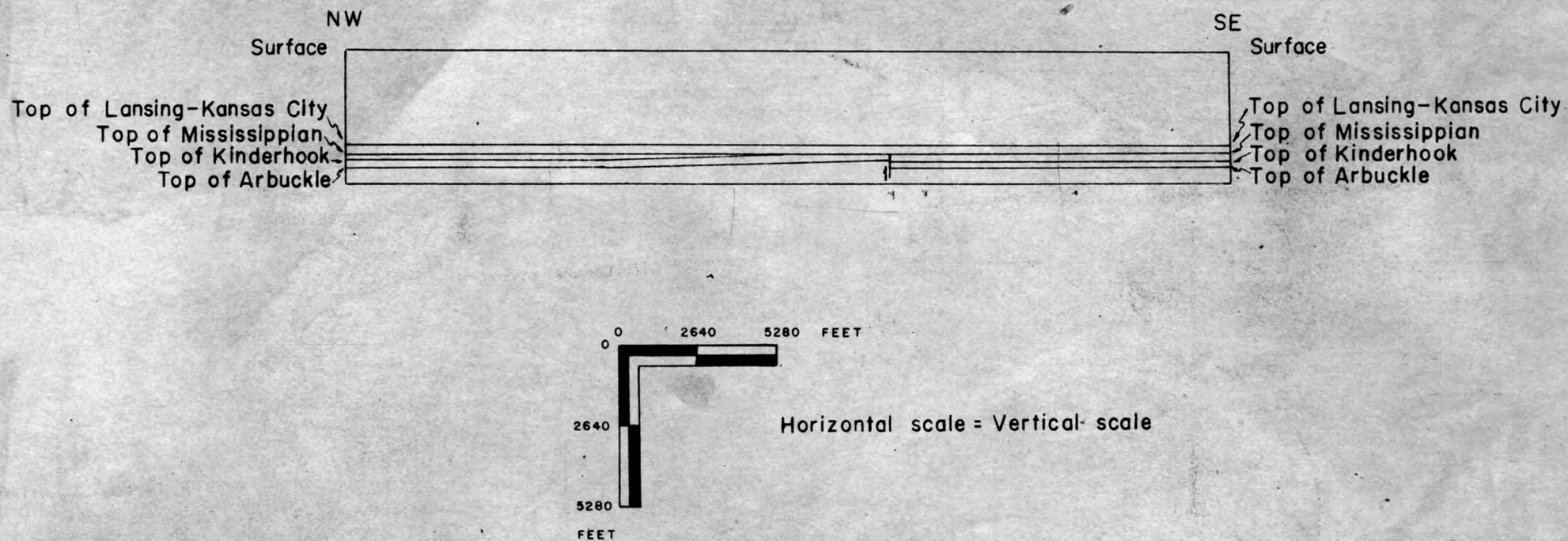


Fig. 7B. Cross section of Reno Fault Block T.24S., R.8W.

SUBSURFACE GEOLOGY RELATED TO PETROLEUM
ACCUMULATION IN RENO COUNTY, KANSAS

by

ARMANDO TUNON RICCI, JR.

B. S., Trinity College, 1951

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1955

ABSTRACT

Reno County, an area of 1,255 square miles, consists of 35 townships in south-central Kansas. This investigation is an analysis of the relationships between stratigraphy, structure, and geologic history to petroleum accumulation.

A panel diagram and structure contour maps depict structural and stratigraphic features of the county. Data used to construct these maps were obtained from numerous well logs within the county.

Oil accumulation occurs in the subsurface of Reno County in the following formations: The Lansing-Kansas City Group of Pennsylvanian Age, the Mississippi "Chat" of Mississippian Age, the Hunton of Devonian-Silurian Age, the Viola and Simpson of Ordovician Age and the Arbuckle of Cambro-Ordovician Age. The Mississippi "Chat" has the largest accumulation in Reno County.

Several major and minor structural features are evident in Reno County. Part of the Central Kansas uplift is in northwestern Reno County. This structure has been developed by several periods of warping and erosion with subsequent truncation of sedimentary rock. Warping has occurred chiefly in post-Proterozoic (?), post-Canadian, post-Hunton, early Pennsylvanian, post-Missouri, and post-Cretaceous time.

The Sedgwick basin occupies an area in central Kansas southward from McPherson and Marion Counties. It is west of the Nemaha anticline and south of a low archlike structure that marks the southern boundary of the Salina basin, and east of

the Dodge City basin or embayment.

The southern extremity of the Voshell Anticline lies in Reno County, approximately parallel to the Nemaha Anticline which is about 50 miles east of the Voshell Anticline. Oil accumulation occurs in the Mississippi "Chat" on this anticline.

The Conway syncline bounded on the east by the Voshell Anticline and on the west by the Central Kansas uplift plunges southwest toward the Dodge City basin.

The Reno Fault Block in NW 1/4, T.24S., R.8W. produces oil from the Lansing-Kansas City Group. The fault occurred in post-Mississippi time and was later eroded.

The future potentiality for oil in Reno County is good. All possible structural highs and flanks of synclines for stratigraphic traps and pinchouts have not been drilled in known pools. The lateral extent of all the pools in Reno County has not been realized as yet. Nine new pools have been discovered since 1950, and older pools have been expanded.

