# STRUCTURE AND STRATIGRAPHY OF SUMNER COUNTY, KANSAS RELATED TO PETROLEUM ACCUMULATION

by

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petroleum production has been an important industry in Sumner County.

## Procedure

Two subsurface cross sections and three structural contour maps were constructed during the course of this investigation. The objective of the cross sections was to show the structure and stratigraphy of the area from the top of the Topeka limestone to the top of the Arbuckle group. Electric logs, radioactive logs and Kansas Sample Log Service logs were used in the construction of these cross sections.

Structural contours were drawn on top of the Simpson group, on top of the Mississippian limestone, and on top of the Stalnaker sandstone of the Douglas group. Well data used for the preparation of these maps was obtained from the Herndon maps and driller logs. The Simpson group and Mississippian limestone were selected for mapping as these horizons are the most persistent producers in the area. The Stalnaker sandstone was chosen as a mapping unit as it can be easily identified in the subsurface and also as significant production from this zone has been obtained in only two fields, yet it ranks first in total oil production of the county.

# STRATIGRAPHY

## Pre-Cambrian Rocks

Only five wells in Sumner County have been drilled to the "basement complex"; however, a large number of wells elsewhere in Kansas and northern Oklahoma have penetrated rocks of Pre-Cambrian age. The Pre-Cambrian rocks consist chiefly of granite and schist, but also include quartzite, quartz porphyry, diabase, gneiss, slate, marble and other rock types (Bass, 1929). A block diagram by Farquhar (1957) shows the "basement complex" of Sumner County to be composed mostly of schist, phyllite, and non-granitic gneiss while the roots of the Nemaha Range consists essentially of granite.

## Cambrian System

Waucoban and Albertan Series. Deposits of Waucoban and Albertan age are not recognized in the Sumner County area.

Croixian Series. The Lamotte (Reagan) sandstone, a wide-spread basal Paleozoic deposit, has not been identified in any of the five wells which penetrated to the Pre-Cambrian basement. The absence of the Lamotte in these wells is not sufficient evidence to assume that the deposit is missing from the sub-surface strata throughout the county as four of the granite tests were made in the Oxford and Churchill pools which are located on the Nemaha Range and one was drilled in sec. 9, T. 30 S. R. 1 W. However, a distribution map of the upper

Cambrian and lower Ordovician rocks by Keroher and Kirby (1948) indicates that Central Kansas was a granitic highland at the time of Lamotte deposition and since Sumner County lies within this area it is most likely that the Lamotte will not be found in the subsurface of the county. The glauconitic Bonneterre dolomite was deposited over the Lamotte sandstone without a break in sedimentation and spread beyond the margins of Lamotte deposition in some areas of Kansas and possibly on to the exposed Pre-Cambrian rocks of at least a portion of the Sumner County area. If the Bonneterre was deposited over the entire area, it was subsequently removed by erosion in the northern part of the county. The presence or absence of the Bonneterre dolomite in southern Sumner County is not known as wells have not penetrated to the possible depths of this formation. Pre-Eminence exposure of nearby Pre-Cambrian rocks is indicated by the basal member of the Eminence dolomite which contains a considerable amount of arkosic material in wells of Chautauqua, Labette, and Cherokee counties (Keroher and Kirby, 1948). Since the Eminence dolomite is also absent from subsurface strata in the area, and the basal arkosic member pinches out to the east of Sumner County, it is very probable that the Eminence seas did not transgress upon the Pre-Cambrian surface.

## Ordovician System

**Lower Ordovician.** The Arbuckle group in this area consists of the Van Buren-Gasconade sequence and the Roubidoux formation and the Jefferson City-Cotter sequence. The Gunter sandstone, which is the basal member of the Van Buren formation, rests unconformably on the Pre-Cambrian complex and is composed of coarse angular quartz fragments and quartz sand grains in contact with the weathered surface of the granite. Several feet above the granite, the sand grains are smaller, well sorted and highly rounded. The average thickness of the Gunter sandstone in Kansas is 10 feet, however, wells in the area have penetrated as much as 48 feet of this sandstone. Increased thicknesses of Gunter were noted in wells in which the Gunter sandstone rested on Pre-Cambrian granite (Kerohør and Kirby, 1948). The Van Buren formation and Gasconade dolomite are not clearly separable in the subsurface, therefore, the two formations are grouped as a unit. The Van Buren-Gasconade sequence consists mainly of a cherty, coarsely crystalline, white to gray dolomite. Thicknesses of slightly more than 200 feet have been reported in Sumner County.

The Roubidoux formation is a sandy dolomite which unconformably overlies the Van Buren-Gasconade sequence and ranges from 150 to 200 feet in thickness.

The Jefferson City dolomite probably is conformable on the Roubidoux formation in the area covered by this report. The Jefferson City and Cotter dolomites are classed together in the subsurface because they are not distinctly separable on lithologic criteria. This sequence consists of cherty, coarsely crystalline dolomite with thin beds of sand or dolomitic sandstone occurring in all parts of the unit. Wells in Sumner County have penetrated from 550 to 660 feet of the Jefferson City-Cotter deposits. The Arbuckle group, sometimes called the "Arbuckle lime" or "Siliceous lime" by drillers and geologists, ranges in thickness from 900 to 1100 feet from the northeast to the southwest in Sumner County. Due to the uneven surface of the basement complex over which the Arbuckle was deposited and the period of erosion which followed deposition, considerable variation in these thicknesses will occur in local areas.

Lower and Middle Ordovician. The Simpson group includes a unit of lower unnamed Simpson beds, the St. Peter sandstone and the Platteville formation. The lower Simpson beds, which rest unconformably on the Jefferson City and Cotter dolomites, consist of shale, sandy shale, and sandstone. The Simpson sands are commonly rather fine and quite angular, however, the typical rounded grains appear in many zones (Ver Wiebe, 1938). On well records the lower Simpson beds are often referred to as Wilcox sand #2 or Simpson sand #2 and the St. Peter sandstone as Wilcox sand #1 or Simpson sand #1. However, the name Simpson sand is usually applied which indicates either one or both of the units. According to Moore et al. (1951), the St. Peter sandstone and slightly older rocks of the Simpson group are lower Ordovician in age while the overlying Platteville formation is a middle Ordovician deposit. "The Platteville formation in Kansas consists of dolomite, limestone, sandstone and green shale in varied succession, and at the basal part is a persistent dolomite" (Moore, et al. 1951). As the result of pre-Viola erosion the basal dolomite is probably the only member of the Platteville formation present in the subsurface of Sumner County. In some wells the Simpson sand is found immediately below the Viola. Local thinning and absence of the Platteville, where overlain by the Viola, was due to the more extensive erosion of such areas during pre-Viola times. Thickness of the Simpson group ranges from 20 feet in the northeastern part of the county to 225 feet in the southwestern part.

The Viola, a cherty, coarsely crystalline, white limestone, rests unconformably on the Platteville and Simpson sands in southwestern Sumner. It is also found in isolated areas throughout the county which were probably topographic depressions during pre-Chattanooga erosion. Average thickness of the Viola, where present, is about 7 feet, however, well logs from the southwestern part of the county show that 20 to 25 feet of these deposits have been penetrated.

<u>Late Ordovician</u>. The Sylvan (Maquoketa) shale, which is an upper Ordovician shale, dolomitic limestone, and dolomite, was deposited over the entire county and extended from Oklahoma to the North Kansas Basin. As a result of pre-Devonian and pre-Chattanoogan erosion, the Sylvan was removed from all but

the extreme southwestern portion of the county where maximum thicknesses of about 10 feet exist.

Silurian System

Rocks of the Silurian system, including the Hunton limestone which is a Silurian and Devonian deposit, are found in the subsurface to the north, south, and west of Sumner County, but sedimentary rocks of this age are not recognized in the area.

Devonian or Mississippian System

The Misener sandstone, which is the basal member of the Chattanooga shale, consists of small lenses ranging in thickness from a thin streak of sandy shale to a clean sandstone 11 feet thick.

The black, fissle Chattanooga shale unconformably overlies the Sylvan, Viola, and Simpson strata in various parts of the county. The Chattanooga is characterized by a relatively uniform thickness of 70 feet over most of the area; however, as a result of pre-Cowley erosion, local thinning and absence of the deposit occurs in a small portion of eastern Sumner County. Cross sections of eastern Kansas and a thickness map of the Chattanooga shale by Lee (1940) indicates that a large erosional basin was formed in Cowley and Chautauqua counties during pre-Cowley time. Lee (1940) refers to the erosional feature as the Cowley basin. A small arm of the Cowley basin entered Sumner in the southeastern corner of the county, extended northward approximately 25 miles and was from 4 to 8 miles wide. In the area covered by this report, the Chattanooga was completely removed only in the deepest part of the Cowley basin extension. The Chattanooga shale is considered to be of Devonian age (Moore, et al. 1951). The Chattanooga was formerly classified as the basal portion of the Kinderhookian series (McClellan, 1930), and on most well records is still logged as the Kinderhook shale. However, since the Woodford shale (Devonian) of Oklahoma correlates with the Chattanooga (Melton, 1930), it is not unusual to find the name Woodford shale on well logs, particularly in the southern part of the county.

## Mississippian System

Kinderhookian Series. Rocks of the Kinderhookian age are not recognized in the Sumner County area.

Osagian Series. The Chattanooga was exposed until deposition of the Osage series, however, this area was probably too low to have undergone much erosion which is indicated by the uniform thickness of the Chattanooga. Osagian strata of the area include the St. Joe, Reeds Spring, and Burlington limestones which were deposited without a break in sedimentation. The St. Joe, lying unconformably on the Chattanooga, consists chiefly of a coarsely granular, noncherty, crinoidal limestone and a member of dark green argillaceous shale near the base. The limestone and shale member of the St. Joe range in thickness from 15 feet in the southern two-thirds of the county to 124 feet in the north.

Zones of dark bluish and brownish chert occur in the gray, granular Reeds Spring limestone distinguishing it from Burlington limestone which contains gray and bluish white chert (Lee, 1940). The Burlington limestone is also interstratified with thin beds of gray dolomite. Probably as the result of pre-Cowley erosion, the Reeds Spring and Burlington limestone are found only in the northern portion of the county. The combined thickness of these rock units range from a beveled edge at their southern most margin to approximately 145 feet at the Sedgwick-Sumner county line.

Meramecian Series. Meramecian rocks of the area consist of the Cowley formation and the overlying Warsaw limestone. Before the Cowley formation was deposited, the Osagian rocks of central and southern Sumner were subjected to severe erosion. The Cowley basin was formed and extended into the eastern portion of the Sumner County area exposing the Chattanooga shale and in the deepest part of the narrow basin, the Simpson group. At the base of the Cowley formation is a well-developed glauconitic zone averaging about 25 feet in thickness which is an excellent marker bed. The Cowley formation is characterized by relatively thick gray and dark colored silty, cherty, and dolomitic limestones. Overlap to the north suggests that the Warsaw, a gray-white fine textured non-silty limestone, was a transgressing deposit; therefore, the Warsaw limestone was probably deposited over the entire area but was removed from the southern portion of Sumner County by pre-Desmoinesian erosion. Thicknesses of the Meramecian rocks range from 350 feet in the central and southern part of the county to

110 feet in the north. The Cowley formation constitutes the greater part of the Mississippian rocks in this area. A zone of residual chert is often encountered in the uppermost 20 to 100 feet of the Cowley formation which is known to those of the oil industry as the Mississippi "chat". The "chat" serves as a reservoir for oil and gas in many localities, however, only the Wellington field produces oil from it in Sumner County.

Chesterian Series. Rocks of the Chesterian series are not recognized in Sumner County.

## Pennsylvanian System

Morrowan and Atokan Series. Rocks belonging to the Morrowan and Atokan series have not been identified in Sumner County.

Desmoinesian Series. The Pennsylvanian basal conglomerate, also known as the "Sooy" conglomerate, represents a transgressing deposit. According to Edson (1934) the "Sooy" conglomerate has no definite stratigraphic position, the deposit is underlain by beds ranging from Pre-Cambrian to upper Mississippian and is overlain by beds from Morrowan to upper Lansing in age. However, in the Sumner County area the "Sooy" was probably deposited by the advancing Cherokee seas. The "Sooy" is a coarse cherty and sandy deposits with thicknesses ranging from a thin veneer to 15 feet.

The Cherokee group unconformably overlies the Meramecian rocks where the Pennsylvanian basal conglomerate is absent. The Cherokee is usually represented by dark to black shales; the amount of limestone present is very small. Sandstones in the

Cherokee rocks commonly occur in lenticular bodies but the lenses are arranged in definite stratigraphic zones (Moore, 1949). Long narrow channel fillings and bar deposits, often referred to as "shoestring" sands, are abundant in the extreme eastern portion of the county and many of them are important oil and gas reservoirs. The name "Bartlesville sand" has been applied to one and to several lenticular sands, some of which have been correlated with the Bluejacket sandstone. Other well known and important subsurface sands of the Cherokee group include the Red Fork, Skinner, and the Prue. The Prue sand, where present, is encountered at the top of the Cherokee section and is correlated with the Squirrel sand of eastern Kansas. Average thickness of the Cherokee in the area is about 200 feet.

The Marmaton group overlies the Cherokee group over the entire area covered by this report. Strata comprising the Marmaton group is made up of shale, sandy shale, sandstone and limestone. Radioactive logs indicate the presence of much more limestone in this group than in the underlying Cherokee deposits. The Marmaton group consists of seven formations, in ascending order, they are the Ft. Scott limestone, Labette shale, Pawnee limestone, Bandera shale, Altamont limestone, Nowata shale, and the Lenapah limestone. The Ft. Scott limestone provides an easy separation of the Marmaton and Cherokee deposits in most wells. In the subsurface the basal member of the Ft. Scott is the "Oswego lime", which corresponds to the Blackjack Creek limestone member on the outcrop. The "Peru sand", a producer in other localities, is a lenticular sandstone which occurs locally at the base of the Labette shale. The Cleveland sand correlates with the Wayside sand of eastern Kansas and is found near the top of the Nowata shale in the southern portion of the county. Although the average thickness of the Marmaton is 130 feet, the deposits range from 25 to 210 feet thick. Local thinning was probably due to the uneven surface upon which the beds were deposited as well as post-Marmaton erosion.

Missourian Series. A major unconformity separates the underlying Marmaton from the Pleasanton group. The Pleasanton strata is composed chiefly of a sandy shale; however, the Checkerboard limestone, an important marker bed, is encountered near the top of the group in all but the extreme northern portion of the area. The Checkerboard is a gray limestone approximately 5 feet thick and on electric logs it can be distinguished by a characteristic "kick" on both the normal and lateral curves. In the Nemaha Range area the Pleasanton beds become progressively thinner where thicknesses range from 20 to 40 feet on the higher domes, as compared with the 100 foot intervals associated with other parts of the county.

The Kansas City group consists of three subgroups, in upward order, called the Bronson, Linn, and Zarah subgroups. Although the subgroups are readily distinguishable at their outcrops in eastern Kansas, the alternating shales and limestones are not easily differentiated in the subsurface. However, the Hogshooter limestone, which corresponds to the Dennis limestone of the outcrop, marks the top of the Bronson and the Drum limestone represents a portion of the Linn subgroup. Distinguishing the Lansing-Kansas City contact becomes somewhat of a problem in Sumner County, as a result the Layton sand is misplaced on well logs. In the area covered by this investigation the Zarah subgroup and the upper portion of the Linn subgroup consists of a shale sequence ranging in thickness from approximately 70 to 170 feet. The Plattsburg limestone, which is the basal rock unit of the Lansing group, is missing from the subsurface strata south of sec. 35, T. 30 S., R. 2 W. in Sumner County (Winchell, 1957). Therefore, the Bonner Springs shale of the Zarah subgroup is overlain by the Vilas shale (Lansing) throughout most of Sumner County, and as both formations consist of gray to buff shale, sandy shale, and sandstone, they can not be differentiated in the subsurface. As a result, most geologists place the Lansing-Kansas City contact at the top of the Drum limestone which is underlain by thick sections of limestone interbedded with thin shale members comprising the remaining portion of the Linn subgroup and the Bronson subgroup. The well known Layton sand has been correlated with the Cottage Grove sandstone member of the Chanute shale in the Linn subgroup (Lukert, 1949) but as the formation is above the thick limestone section, the Layton is recorded as Lansing on all well records of the area. As the Lansing-Kansas City contact can not be determined throughout the largest part of the county, the subsurface cross sections (Appendix, Fig. 9) show the contact at the approximate stratigraphic interval. Where the Plattsburg is present and thicknesses of the Kansas City can be determined, the group ranges from 350 to 400 feet thick which is probable the case throughout most of the county.

The Lansing group rests unconformably on the underlying Kansas City beds and consists of three formations, the Plattsburg limestone, Vilas shale, and Stanton limestone, in ascending order. As previously mentioned, the Plattsburg limestone is absent from the Lansing strata in the largest portion of the county. Moore et al. (1951) state that the Plattsburg dissappears near the Oklahoma line but reappears farther south. "Slight regional warping of Kansas City and older rocks in the Chautauqua arch area, which does not affect the Lansing beds, is associated with absence of lower Lansing deposits" (Moore, 1949). Therefore, the absence of the Plattsburg in the area is probably the result of nondeposition rather than erosion. In most places in Summer County the Vilas shale is underlain by Kansas City rocks and overlain by the Stalnaker sandstone. The Stalnaker has been considered a facies of the Stanton limestone since the two beds are found at the same stratigraphic interval and consequently the Stalnaker is recorded as upper Lansing on well logs. By the use of electric and radioactive logs, Lukert (1949) found that the northern limit of the Stalnaker sand occurred in the same area that marks the southern limit of the Stanton limestone and concluded that the Stanton was removed by erosion prior to Stalnaker deposition and that the Stalnaker was Virgilian in age, in part equivalent to the Tonganoxie sandstone of the Douglas group. Recent work by Winchell (1957) has substantiated Lukert's conclusions and also defined the limits of Stalnaker deposition in south-central Kansas. Winchell (1957) has traced five buried stream channels from the north that led into the embayment area which probably carried the detritus material composing the Stalnaker sand. A structure contour map on top of the Stanton limestone by Winchell (1957) shows only three small outliers of the Stanton extending into north-central Sumner. As a result of the irregular surface due to post-Stanton erosion, the thickness of the Lansing group varies from possibly a few feet to 120 feet and consists essentially of the Vilas shale.

The Pedee group, consisting of the Weston shale and Iatan limestone, was probably deposited over the area but removed by erosion prior to Virgilian deposition.

<u>Virgilian Series</u>. The Stranger formation and the overlying Lawrence shale represents the Douglas group which rests unconformably on Lansing deposits in the area. The basal portion of the Stranger formation consists of the Stalnaker sand, a widespread marine deposit of south-central Kansas and northern Oklahoma. The Stalnaker is better known in Oklahoma as the Tonkawa sand which was named after the Tonkawa field. According to Hosterman (1924) the Tonkawa sand is one of the most persistent as well as productive sands of northern Oklahoma. In many areas of northern Oklahoma the first dependable correlation to be made is on the Tonkawa sand (Carpenter, 1930). Over 200 feet of the Stalnaker sand have been penetrated in parts of southern Sumner, however, the average thickness in the area is about 100 feet. The Haskell limestone is an excellent marker bed in the Stranger formation and is usually present just above the Stalnaker. The Douglas

group is composed of about 320 feet of shale with thin limestone layers and prominent sandstone bodies.

The overlying Shawnee group is made up of seven formations, in ascending order they are the Oread limestone, Kanwaka shale, Lecompton limestone, Tecumseh shale, Deer Creek limestone, Calhoun shale, and Topeka limestone. Well logs show that the limestones are much thicker than the interbedded shales. Many of the shales contain sand, some of which are reservoirs for oil and gas, such as the Hoover sands. The Heebner shale, a member of the basal Oread limestone, is a thin, black, platy shale which is very useful as a marker in the subsurface. The Shawnee beds are usually well over the 400 feet in thickness.

The Wabaunsee group is divided into the Sacfox, Nemaha, and Richardson subgroups, and consists of approximately 500 feet of alternating shale and limestone. As the individual limestone and shale beds are usually rather thin, it is impossible to correlate all of them with those of the outcrop. The Severy shale at the base of the group and the overlying Howard limestone have produced some gas and a small amount of oil, however, production was generally exhausted within a year.

## Permian System

<u>Wolfcampian Series</u>. The Wolfcampian series, formerly called the Big Blue series, consist of the Admire group, Council Grove group and the Chase group, in ascending order. The Admire beds rest unconformably on Pennsylvanian strata but because of their

similarity to the upper Pennsylvanian rocks the contact is difficult to determine in the subsurface. The Admire group is composed of shale with minor amounts of limestone and sandstone.

The Council Grove group comprises about 300 feet of alternating shales and limestones. The limestones are less massive and thinner in this group than those of the overlying Chase beds. The Americus limestone at the base of the Council Grove group is easily identified by the numerous fusulinids in the well samples.

The Chase group, composed chiefly of bright colored shales and thick cherty limestones, averages about 290 feet in thickness. At the base of the group lies the cherty Wreford limestone and the top is well marked by the Herington limestone. The Herington is the first prominent limestone found in wells of this area. Between 1920 and 1932, when much core drilling was carried on in Sumner County, the Herington was the rock unit usually sought to obtain information concerning the attitude of the underlying strata (Ver Wiebe, 1938). The Herington is found about 800 feet below the surface in the western part of the county.

Leonardian Series. The Sumner group, overlying the Chase deposits, consists of the Wellington formation and the Ninnescah shale in Sumner County. Wellington beds outcrop in the eastern two-thirds of the county where they are not covered by deposits of Quaternary age. The Wellington formation is primarily a gray silty shale but also contains evaporites and a few thin bedded limestones and dolomites. The middle part of the Wellington is made up of the Hutchinson salt member which is found in the subsurface of the western half of the county and attains a maximum thickness of 150 feet. The entire Wellington section has a thickness of 575 feet where it is protected by the Ninnescah shale. The Ninnescah shale is predominantly red, silty shale; however, some gray shale, impure limestone, and siltstone is present. This shale sequence is present only in the western one-third of Sumner County where it is either exposed to the surface or covered by Quaternary deposits. Thicknesses of the Ninnescah range from a beveled edge at their eastern margin to 200 feet along the western border of the county.

### Triassic, Jurassic, and Cretaceous Systems

Rocks of Triassic, Jurassic, and Cretaceous age are not represented in Sumner County.

### Tertiary System

Remnants of Tertiary river deposits, consisting of isolated pebbles of granite and chert, are found on the upland area in only a small portion of the extreme northwestern corner of Sumner County.

### Quaternary System

Pleistocene Series. The Gerlane terrace of the Sanborn formation, a Pleistocene river deposit, is composed of gravel, sand, silt, and clay which was derived from Permian and Tertiary formations (Ver Wiebe, 1938). It covers most of the area between the Chickaskia river and Bluff Creek as well as the southwestern corner of the county.

Recent Series. Alluvium along the Arkansas, Ninnescah, and Chickaskia rivers and Bluff Creek consists of gravel, sand, and silt which was deposited by these rivers while in flood stage during Recent time.

## STRUCTURE

### Pre-Mississippian Regional Structure

Southwest Kansas Basin. The name Southwest Kansas basin, coined by Moore and Jewett (1942), is applied to a major pre-Mississippian structural province southwest of the Ellis arch and west of the Chautauqua arch (Appendix, Fig. 2).

North Kansas Basin. Rich (1933) named a large pre-Mississippian basin north of the Chautauqua arch and north and east of the Ellis arch, the North Kansas basin (Appendix, Fig. 2).

Ellis and Chautauqua Arches. A major pre-Mississippian structural high trending northwest-southeast across Kansas separated the Southwestern Kansas basin from the North Kansas basin (Appendix, Fig. 2). The structural high was composed of two arches separated by a low saddle. Moore and Jewett (1942) applied the name Ellis arch to the structural high northwest of the saddle. The structure to the southeast of the saddle, a pre-Mississippian extension of the Ozark uplift, was named the Chautauqua arch by Barwick (1928). Rich (1933) coined the name Central Kansas arch to designate the entire pre-Mississippian structure, including the saddle. However, as this name may easily be confused with the post-Mississippian Central Kansas uplift, the terms Ellis arch and Chautauqua arch are most widely used in the literature, and the saddle between them is unnamed.

The location of Sumner County on the western flank of the Chautauqua arch is indicated by the thinning of the Simpson group and the absence of the Viola limestone and Sylvan shale in the northeastern portion of the county as shown by cross section B-B' in Fig. 9 (Appendix).

Sumner County is located on the pre-Mississippian saddle at the western margin of the Chautauqua arch and southeast of the Ellis arch. The Southwestern basin was to the west of the area and the North Kansas basin to the north. Subsidence of the Anadarko basin and structural movements of the Chautauqua arch were probably the controlling factors regarding the pre-Mississippian dip in the area which was to the southwest.

## Later Paleozoic Regional Structures

Central Kansas Uplift. The Central Kansas uplift is an important post-Mississippian element of different structural grain than that of the ancestral uplift of the same area, which is called Ellis arch (Appendix, Fig. 3). The post-Mississippian origin of the Central Kansas uplift is indicated by the tilted and truncated margins of Mississippian beds on its flanks which are separated from the overlying Pennsylvanian deposits by an angular unconformity and also by the absence of the Mississippian on higher parts of the uplift. The structure was originally named the Russell arch by Denison (1926) and later referred to as the Barton arch by Barwick (1928). The term Central Kansas uplift, coined by Morgan (1932), is the most widely used in literature.

Sedgwick Basin. The Sedgwick basin is a post-Mississippian feature which occupies the area north of the Northern basin shelf, west of the Nemaha Range, east of the Central Kansas uplift, and south of a low archlike structure which separates it from the Salina basin (Appendix, Fig. 3). The name Sedgwick basin was applied to this structure by Moore and Jewett (1942).

Anadarko Basin and the Dodge City Embayment. The Dodge City embayment is a large post-Mississippian structural province which occurs in the area south of the Central Kansas uplift and west of the Northern basin shelf (Appendix, Fig. 3). Clifton (1926) had previously regarded this area as an extension of the Anadarko basin; later, McClellan (1930) named the structure the Dodge City basin. As the number of wells drilled in western Kansas has greatly increased since 1930, it is known that this structure is not a true basin but merely an embayment of the northward extending Anadarko basin. The term Dodge City embayment was applied to the portion of the Anadarko basin extending into southwestern Kansas by Wheeler (1947). Maher and Collins (1948) proposed the name Hugoton embayment for the same structure because the city of Hugoton lies more nearly in the center of the embayment area. The terms Dodge City embayment and Hugoton embayment are both widely used in the literature.

Northern Basin Shelf. The Northern basin shelf occupies an area in south central Kansas extending west of the Nemaha Range, east of the Dodge City embayment and between the Anadarko basin and the Central Kansas uplift (Appendix, Fig. 3). According to Wheeler (1947) the Ordovician rocks rise northward into Kansas with only a gradual flattening, but the Mississippian and Pennsylvanian strata show an abrupt decrease in the rate of thinning, suggestive of a northern basin shelf.

Nemaha Range. The Nemaha Range is a prominent structure that extends southward from Nebraska, crossing Kansas from Nemaha County to Sumner County, and continues a short distance beyond Oklahoma City, Oklahoma (Appendix, Fig. 3). The eastern flank of the Nemaha Range is considerably steeper than the western flank throughout its entire length. It divided the pre-Mississippian North Kansas basin into two separate basins, the Salina basin on the west and the Forest City basin on the east. Deformation which resulted from the uplifting of the Nemaha Range in eastern Sumner County is revealed by the Simpson, Mississippian, and Stalnaker structure contour maps (Appendix, Fig. 6, 7, and 8) and the cross sections of the area (Appendix, Fig. 9). Many names appear in the literature referring to this structure, such as, the Nemaha mountains, granite ridge, Nemaha ridge, Nemaha anticline, Table Rock anticline (Nebraska) and Nebraska-Oklahoma anticline. Eardley (1951) states, "It resembles the Colorado Range of the Ancestral Rockies, and therefore the characterization of it as a range is more appropriate than as an arch, anticline, or ridge, as it has variously been called." It seems preferable to agree with Mr. Eardley and the name Nemaha Range will be used for the structure in this report.

Ozark Uplift. The Ozark uplift lies chiefly in southern Missouri and extends into southeastern Kansas. It is the result of several periods of uplifting and is responsible for the westward regional dip of Pennsylvanian and Permian beds which comprise the Prairie Plains monocline.

Cherokee Basin. The Cherokee basin in southeastern Kansas is regarded as an extension of the Ouachita basin of eastern Oklahoma. The Cherokee basin lies east of the Nemaha Range, south of the Bourbon arch, and west of the Ozark uplift (Appendix, Fig. 3).

## Minor Structures

Barwick (1928) named the anticlinal fold extending from Marion County across Butler, Harvey, Sedgwick, Sumner, and Harper counties the Bluff City anticlina (Appendix, Fig. 3). The northeasterly trend of the Bluff City anticline nearly parallels the axis of the Nemaha Range. In all probability the Bluff City anticline was formed contemporaneously with the Nemaha Range. In Sumner County the Bluff City anticline is represented by a plunging axis as indicated by the Simpson, Mississippian, and Stalnaker structure contour maps (Appendix, Fig. 6, 7, and 8), and cross section A-A', Fig. 9 (Appendix).

# GEOLOGIC HISTORY

## Pre-Cambrian Eras

"As in other regions, the Pre-Cambrian eras in Kansas may have been one of uplifts, accompanied by extensive folding and faulting and perhaps associated with considerable igneous activity" (Moore, 1918). Igneous activity is inferred from the metamorphosed rocks forming gneiss, schist, and quartzite that have been recognized from well cuttings. Before the beginning of Cambrian sedimentation, a period of widespread and extensive erosion probably reduced the basement rocks to nearly a level plain. A thickness map of the Bonneterre dolomite by Keroher and Kirby (1948) suggests that pre-Cambrian relief in Kansas seldom exceeded 150 feet prior to Cambrian deposition.

## Paleozoic Era

Strata of lower and middle Cambrian age are not found in Kansas, but the advancing Croixian seas, which deposited the Lamotte sandstone, Bonneterre and Eminence dolomites, covered much of the area. The Lamotte is absent from an extensive area in central Kansas, however, the overlying Bonneterre dolomite, which was deposited without a break in sedimentation, spread beyond the margins of Lamotte deposition onto Pre-Cambrian rocks, and probably covered the central part of the state (Keroher and Kirby, 1948). The Croixian seas then retreated, leaving the Bonneterre exposed and as a result of pre-Van Buren erosion the Bonneterre dolomite was removed from a large portion of the central Kansas "highland". Croixian seas re-entered the state and deposited the Eminence dolomite which is found in the extreme eastern and western parts of Kansas. Its absence in the area may be the result of post-Eminence removal by erosion but is probably the result of non-deposition over the central uplift area. Since Croixian deposits have not been recognized in the area covered by this report, it was probably a part of central Kansas "highland". Erosional debris from the Sumner County area was probably transported to the east and deposited in the subsiding Ozark basin.

The Arbuckle seas gradually transgressed northward, reworked the weathered Pre-Cambrian surface in the area and deposited the Gunter sandstone. Deposition of the Van Buren-Gasconade sequence was followed by a period of erosion which removed part of the Gasconade dolomite prior to the continuous sedimentation of the Roubidoux formation and Jefferson City-Cotter sequence. Prior to the invasion of the Simpson seas the region was uplifted. Arbuckle deposits were eroded from the crest of the Southeast Nebraska arch and reduced in thickness elsewhere in the area.

The Simpson sea, like the Arbuckle, transgressed gradually to the north. After the St. Peter sandstone was deposited the seas retreated, and due to periodic earth movements the Ellis arch, Chautauqua arch and Ozark dome began to rise contemporaneously with the downwarping of the North Kansas basin. The Simpson sea re-entered the area and the Platteville formation was deposited before the seas withdrew. The Platteville surface was attacked by erosion and in areas of higher elevation the St. Peter was exposed to the surface. The fluctuating Ordovician seas again advanced and before the close of the period the Viola limestone and Sylvan shale were deposited. With the exception of the southwestern corner of the county and perhaps a few isolated topographic depressions pre-Chattanooga beveling removed the Sylvan shale and reduced the thickness of the Viola limestone.

If the Hunton limestone of Silurian and Devonian age and older Silurian sediments were ever deposited in the area covered by this investigation, they were completely eroded during pre-Chattanooga times. Near the close of the Devonian and prior to Chattanoogan deposition, the Ellis and Chautauqua arches rose and were eroded so that the Arbuckle limestone was exposed over large portions of these structures. Uplifting of the Ozark dome was also rejuvenated at this time. Practically the entire region was again submerged and the Chattanooga shale was deposited on a nearly peneplained surface.

The Kinderhookian epoch of the Mississippian period was represented by minor erosion of the underlying Chattanooga in this area. It seems significant to note that all Kinderhookian formations present in the state thicken to the north, as does the Chattanooga; whereas the Osagian formations thicken southward. The thinning and overlap of Osagian deposits toward the north, as shown in cross sections by Lee (1940), indicate a southerly tilting of the whole region. Tilting is also shown by the similar overlap of younger Mississippian rocks. The distribution of the

Reeds Spring and Burlington limestones (Osagian) along the flanks of the Central Kansas uplift and the Nemaha Range strongly suggests that these two structures were gently deformed before or during the deposition of lower Osagian rocks (Lee, 1940). Therefore, crustal movement which was to later re-shape the entire region probably commenced during the Osage epoch. The retreating Osage seas left their deposits in the Sumner County area exposed to severe erosion. The region to the north was an upland area and to the south was a large erosional basin lying chiefly in Oklahoma. As a result, the majority of the Osagian sediments were eroded from the southern two-thirds of the county. The Simpson formation was exposed in the Cowley basin extension which entered the Sumner County area from the southeast and extended northward. The Cowley basin, an erosional feature, originated in Cowley and Chautauqua counties as a result of regional tilting to the south and pre-Cowley erosion. Meramecian seas advanced and eventually the Cowley formation filled the basin eroded in older rocks until its upper part and the conformable Warsaw limestone overlapped upon the upland. Upper Meramecian and Chesteran strata were probably deposited in the area, but like most of the Warsaw, were removed by pre-Desmoinesian erosion.

Regional movement of the earth's crust now commenced on a large scale. The Ozark dome was uplifted again in late Mississippian time and recurrences of uplift during the Pennsylvanian are apparent. Subsidence of the Chautauqua arch area resulted in the development of the Cherokee basin. Major deformation of the

Central Kansas uplift and Nemaha Range in late Mississippian and early Pennsylvanian times developed contemporaneously with downwarping of the Dodge City embayment, the Salina basin and the Forest City basin. The northeasterly trending Bluff City anticline and possibly other minor anticlinal structures paralleling the Nemaha Range appeared at this time. The Bourbon arch, a shallow platform between the Forest City basin on the north and the Cherokee basin on the south, came into existence during early Pennsylvanian time. The thickness of the Mississippian over the Nemaha Range in most of Sumner County indicates that deformation was not as severe as elsewhere in the region during late Mississippian and early Pennsylvanian time. In Sumner County the Arbuckle deposits were exposed only on the small anticlinal structure comprising the Churchill field (T. 31 S., R. 2 E.) during the uplifting of the Nemaha Range. Elsewhere in the county along the Nemaha Range the Mississippian beds vary in thickness from 150 feet on sharp domes and anticlines to 350 feet in surrounding areas. A regional thickness map of the Mississippian strata by Lee (1939) shows a thick section of Mississippian beds over the portion of the Bluff City anticline extending into Sumner County. It appears, therefore, that little deformation of the Bluff City anticline occurred in this area prior to Cherokee deposition. Cherty deposits, subsequently known as the Mississippi "chat", were derived from the weathering of the cherty Cowley formation and are found over most of the area. Local thinning and absence of the "chat" was probably the result of erosion during emergence and wave action during submergence from topographic highs.

Prior to Cherokee deposition the area was eroded to a relatively smooth surface and regional tilting to the southeast toward the Ouachita basin occurred. The Forest City and Cherokee basins became an arm of the Ouachita basin that extended northward from southeastern Oklahoma. The fluctuating Cherokee sea invaded Sumner County from the southeast, reworking the weathered surface and depositing the Pennsylvanian basal conglomerate and the lenticular Bartlesville sand in parts of the area. The Bartlesville sand is developed best in the southeast and eastern part of the county over portions of the Nemaha Range which indicates previous peneplanation and southeastward tilting of the area. As the seas advanced, the Marmaton group was deposited on the underlying Cherokee sediments. At the close of the Desmoinesian epoch the Marmaton beds became an erosion surface which existed until deposition of Pleasanton group in Missourian time. Thinning of the Pleasanton beds over the Nemaha Range in the northeastern portion of Sumner County, as shown on cross section B-B' in Fig. 9 (Appendix) and a cross section by Lee and Merriam (1954) using the base of the Kansas City strata as the datum plane, indicates that increased uplifting occurred during Pleasanton time. Slight regional warping occurred after the deposition of the Kansas City group, therefore, the lowermost Lansing beds found elsewhere in the region are not present in the Sumner County area. Before the Missourian seas retreated, the Pedee group was probably deposited in the area but subsequently removed prior to Virgilian deposition. According to Roth (1930), the most pronounced unconformity of the Pennsylvanian system occurred near the end of Missourian time and previous to most of the Douglas deposition. The transgressing Virgilian seas covered the area and the Douglas and Shawnee groups were deposited. A period of erosion followed which removed a portion of the Topeka limestone, upper-most formation of the Shawnee strata, before sedimentation of the Wabaunsee group. Judging from the relief shown on the structure contour map of the Stalnaker sandstone (Appendix, Fig. 8) and the relative uniform thickness of the Pennsylvanian deposits, it appears that gentle uplifting of the Nemaha Range in the Sumner County area extended into late Pennsylvanian and early Permian time.

Invasion of the Permian sea during the Wolfcampian epoch resulted in a thick sequence of alternating limestones and shales of the Admire, Council Grove and Chase groups which were probably deposited under normal marine conditions. Leonardian deposits however, represent a marked change in conditions. The silty shale and evaporites of the Sumner group were deposited during an arid climate and in shallow restricted seas which probably were connected to the open sea at various times. Younger Leonardian beds and possibly Guadalupian sediments were deposited over the area and were subsequently removed by erosion.

## Mesozoic Era

During the Triassic and Jurassic periods the seas probably did not extend into eastern and south-central Kansas. Deposits of

Triassic and Jurassic age are found only in the western one-fifth of Kansas and attain a maximum thickness of more than 325 feet (Moore, 1951). Permian beds in the area probably contributed sediments to the westward lying seas until early Cretaceous time. Spreading northward from the Gulf of Mexico, the Cretaceous seas submerged the entire state which resulted in the deposition of the Comanchean and Gulfian series. As the seas retreated for the last time, regional tilting toward the northwest occurred and the area was again subjected to erosion.

### Cenozoic Era

Removal of the Cretaceous and probably much of the upper Permian strata occurred in the area throughout the greater part of the Tertiary period. During the Quaternary period a portion of the eroded Permian surface was covered by stream deposits of both Pleistocene and Recent age.

## OIL AND GAS PRODUCTION IN SUMNER COUNTY

Active drilling in Sumner County did not begin until 1914. During June of the following year the Empire Gas and Fuel Company completed the first commercial gas well in what was later to become the North Vernon field. Production was obtained from a sand lense in the Severy shale of the Wabaunsee group.

Ten years later, on May 14, 1925, the first oil was discovered in the county by Prairie Oil and Gas Company in the Padgett gas field. This well, producing from the Mississippian "lime", had an initial production of 315 barrels of oil and averaged better than a 1,000 barrels per month for the next four years. The Rainbow Bend field was extended into Sumner during December when the Phillips Petroleum Company completed a 185 barrel producing well. At the close of 1925 Sumner County had produced 3,436 barrels of oil for the year, only 0.01 percent of the state's gross production.

The discovery of the Churchill field in 1926 and the Oxford field in 1927, the two most productive fields in the county, resulted from core drilling exploration. The Churchill field was the most important discovery of oil in Kansas during 1926 and resulted in the first prolific production on the Nemaha Range south of Butler County. The 100 to 150 foot sequence of Stalnaker sand and interbedded shale was by far the most important producing horizon in both the Churchill and Oxford pools. The discovery well in the Douglas field was completed on July 26, 1927, in the Wilcox sand which resulted in the first Wilcox production in central and western Kansas. Four other fields were discovered during this two-year period, however, they were all relatively small producers. At the end of 1927 the nine oil fields produced 15.98 percent of the state's total production. Sumner was now the third ranking county in Kansas oil production, a position it held until 1929.

The important discoveries during 1929 were the Caldwell and Wellington fields, also discovered by core drilling exploration. The Gypsy Oil Company completed the Caldwell discovery well in the

Wilcox sand with an initial production of 1,400 barrels of oil. Only one well was completed in the Wellington field during 1929, however, later development proved it to be the third top producer in the county. The twelve pools produced 11.25 percent of the Kansas oil during 1929 and Sumner became the fourth leading county in oil production.

Due to the depression and overproduction of oil in Kansas, Oklahoma, and Texas, the price of crude began to drop early in 1930 and by July of 1931 producers were receiving twenty-two cents a barrel for crude oil. As a result, drilling activity in Sumner County slumped sharply to a total of five completions in 1931 and six in 1932. In the following years development was restricted primarily to extending proven fields.

It was not until 1945 that operators began to show a revival of interest in Sumner County. A total of 37 tests were made and three new fields were discovered. Drilling activity continued to increase until 1956 and resulted in the discovery of twenty-five new fields. The peak in drilling activity was reached in 1955, when 222 tests were drilled and 130 producing oil wells and 1 gas well were discovered. Drilling activity has declined appreciably since 1955. Developments during 1957 consist of 124 tests which resulted in 59 oil wells, 1 gas well, 64 dry holes and the discovery of six new fields. Sumner County was eleventh in total oil production for counties in Kansas in 1957. Oil and gas fields of Sumner County as of 1957 are listed in Table 1 and 2 (Appendix).

# THE RELATIONSHIP OF STRUCTURE AND STRATIGRAPHY TO PETROLEUM ACCUMULATION

## Arbuckle Production

Arbuckle production in Sumner County has been confined to nine anticlinal structures located on the Nemaha Range (Appendix, Fig. 5). The Simpson structure contour map (Appendix, Fig. 6) shows that six of the pools are prominent anticlinal structures while the Metz pool (Sec. 7, T. 32 S., R. 2 E.) appears to be located on a structural nose. Contouring on top of the Arbuckle however indicates that the Metz pool is located on the axis of the Oxford West anticline. In general, the structures responsible for Arbuckle accumulation appear to be rather well developed anticlines containing 100 feet or more of closure. High initial production and rapid potential recovery indicates that good permeability and porosity usually exists. The formation of solution cavities during the prolonged period of erosion and weathering to which the Arbuckle surface was exposed prior to Simpson deposition and the apparent fracturing and faulting that occurred later while the structures were being formed would account for sufficient porosity in the upper Arbuckle zone. Although the accumulation of oil is definitely related to structure, other important factors appear to be involved. Numerous Arbuckle tests on favorable structures of the Nemaha Range and elsewhere in the county have resulted in a "hole full" of water. From a study of Arbuckle accumulations in the central Kansas fields, Walters (1958) has given convincing evidence to support his theory that the oil and gas migrated from the Anadarko basin in Oklahoma northward through Arbuckle rocks during middle Pennsylvanian times. Considering the above, many favorable anticlinal structures with good closures developed in Sumner County prior to Arbuckle migration in middle Pennsylvanian times. Local and regional dips were never sufficient to allow total remigration from the various structural highs in the area if accumulations once existed in these structures. It seems probable, therefore, that a large percentage of the available oil may have migrated to porous zones in the overlying Simpson sand and accumulated in the Arbuckle only when the Simpson sand immediately above the contact was not porous enough to allow vertical migration.

## Simpson Production

Although the Simpson sand is not the most prolific producing zone in the county, it has been reported productive in more fields than any other horizon. The Simpson produces from nearly half of the Sumner pools and is the most persistent producing zone in the area (Appendix, Fig. 5). Eighteen pools have obtained production solely from the Simpson, however, many of them are one and two well producers. The Anness is a typical example of these small pools, although now abandoned, the producing well was surrounded by four dry holes, yet 154,772 barrels of oil were produced. Since the Anness pool has only thirteen feet of closure, the structure is not apparent on the Simpson structure contour map (Appendix, Fig.6). Although the majority of the pools are located on anticlines and structures with extremely small closures, many result from permeability and porosity pinchouts as the pools have no established up dip closure. The Simpson sands vary from a tight quartzitic type to the loosely cemented, well-rounded, practically pure quartz sand. Simpson accumulations appear to be dependent to a large extent upon porosity related to sand development since a number of anticlinal structures consisting of good closures are devoid of oil in this zone. Undoubtedly the small closure in some pools and the sand development in others has been responsible for so many one and two well pools.

## Mississippian Production

Only the Stalnaker of the Douglas group has exceeded the Mississippi "chat" and "lime" in total production in Sumner County. Porous zones in the Mississippian rocks developed as a result of detrital and residual chert accumulations, granular texture of the limestone, and solution cavities which were probably formed by ground-water action. Electric and radioactive logs indicate the presence of possible porous zones at depths of 150 feet below the top of the Mississippian in some wells, however, petroleum accumulations are seldom found below the upper 100 feet. A "hole full" of water usually results from tests in the lower horizons. In the Wellington field approximately 50 feet of the Mississippian strata is penetrated for well completion. Seventeen pools have obtained production from the Mississippian, however, production has been discontinued from this horizon in five of the pools. Pools producing from Mississippian rocks not concentrated in the Nemaha Range area are the Wellington, Wellington Northeast, Anson, Latta, Kerschen, and Caldwell pools (Appendix, Fig. 5). As indicated by the Mississippian structure contour map (Appendix, Fig. 7), the Wellington, Caldwell, and Anson pools possess a very small amount of closure while the Wellington Northeast, Latta, and Kerschen show no apparent up dip closure. The same situation appears in pools located on the Nemaha Range, accumulations often occur in both large and small structures containing very little closure or on the flanks of steep anticlines while at the crest the Mississippian zone may be devoid of oil and gas. Therefore, porosity in the upper zone, coupled with either or both up dip porosity pinchouts and anticlinal closures were apparently the chief factors which controlled Mississippian accumulation.

## Cherokee Production

Cherokee production in Sumner County results from accumulation in lenticular, elongated sand bodies logged as the Bartlesville sand. Petroleum accumulation in the Bartlesville sand is confined to Townships 32, 33, 34, and 35 south of Range 2 east (Appendix, Fig. 5). Distribution of the sand bodies were probably controlled by the pattern of the Cherokee sea at the time of deposition. Cherokee accumulation in the area may be dependent to some extent, upon structure, however, porosity resulting from sand development and the lenticular nature of the sand bodies were probably the dominate factors regarding accumulation.

## Marmaton Production

Only a minor amount of oil and gas has been produced from Marmaton strata in Sumner County. Petroleum accumulations occur in the Cleveland sand, a thin sheet deposit at the top of the Marmaton group. The four pools which obtain commercial quantities of petroleum from the Cleveland sand are located in the extreme southeastern portion of Sumner County (Appendix, Fig. 5). The limits of Cleveland production in these pools extend well down the flanks of the anticlines shown by the Mississippian and Stalnaker structure contour maps (Appendix, Fig. 7 and 8). Apparently Cleveland accumulations were largely controlled by differential porosity and perhaps, in a broad way, by structure. Limited accumulations in the area result from a facies change from sand to sandy shale throughout most of the county.

## Kansas City Production

A considerable amount of oil and gas has been produced from the Kansas City group in Sumner County. Petroleum accumulations from porous oolitic limestone intervals and the Layton sand have made this group the fourth most important zone in the area.

Kansas City "lime" production has been reported from six pools, all of which are located in the northwestern one-fourth of the county. It appears that a possible relationship may exist between Kansas City "lime" and Mississippian production.

All pools producing from the Kansas City "lime", except the Chicaskia, either obtain production from the Mississippian rocks or they are closely associated structurally with Mississippian pools. Kansas City "lime" pools appear to be located along the trend of the Bluff City and Wellington anticlines shown on the Mississippian structure contour map (Appendix, Fig. 7). Contour maps on top of the Kansas City limestone reveals that pools producing from the Kansas City "lime" contain from 5 to 18 feet of closure. Petroleum accumulations in this horizon probably result as a combination of porous oolitic limestone intervals and structural highs. Although the Simpson produces throughout the area, production from the Simpson has not been obtained in any of the structures responsible for Kansas City "lime" accumulations. The possibility exists, therefore, that the Kansas City "lime" accumulations may result from topographic rather than structural highs. If this should be the case, any relationship between Mississippian production, where obtained from up dip porosity pinchouts, and Kansas City "lime" production would only be a coincidence.

Although the Layton sands do not constitute a sheetlike deposit, they are widespread in the eastern and southern most tier of townships in Sumner County and often attain thicknesses of 200 feet. Current production from this zone has been confined to nine anticlinal structures shown on the Stalnaker structure contour map (Appendix, Fig. 8), all of which are located on the Nemaha Range. The lenticular nature of the sand within the shales associated with structural highs were probably the dominate factors regarding petroleum accumulations within this horizon.

## Douglas Production

The Stalnaker sand comprises the sole producing zone of the Douglas group in Sumner County. Although the Stalnaker underlies the entire area and averages more than 100 feet in thickness, only four oil fields and one gas field have established production from this zone (Appendix, Fig. 5). The Douglas group ranks first in total production of petroleum in Sumner County as a result of enormous quantities of oil obtained from the Stalnaker in the Churchill and Oxford fields. Oil accumulations in the Stalnaker are restricted to structural highs on the Nemaha Range, as shown on the Stalnaker structure contour map (Appendix, Fig. 8) while the recently discovered gas production is derived from the anticlinal structure comprising the Chicaskia field in sec. 5, T. 33 S., R. 3 W. Electric logs reveal that the Stalnaker contains an abundance of salt water in many wells of the area which indicates good porosity prevails. Therefore, petroleum accumulation in this horizon was probably dependent primarily upon favorable structure rather than sand development.

## Shawnee Production

Current production from the Shawnee group is restricted to the Oxford field which produces a very limited amount of petroleum from the "lower" Hoover sand. Approximately 416 million cubic feet of gas from the Hunnewell field is the only other recorded production from this horizon in Sumner County. The "lower" Hoover occurs locally in the area and consists of sand lenses in the Kanwaka shale. Since the Oxford and Hunnewell fields are anticlinal, Hoover accumulations probably resulted from a combination of sand development and structural highs.

Porous intervals within the Topeka limestone produced 478 million cubic feet of gas in the Latta field before production from this zone was discontinued in 1929. Porous zones within the limestone coupled with a small anticlinal closure was responsible for gas accumulation in this particular field.

## Wabaunsee Production

The Severy shale and Howard limestone have been oil and gas reservoirs in Sumner County fields but production from these formations has been discontinued for some time. Production from lenticular sand deposits in the Severy shale has been obtained from the Oxford, Pagett, North Vernon, and Anson fields. Porous limestones in the Howard formation have been productive in the Oxford and Anson fields. All of the above named fields are located on structural highs shown on the Stalnaker structure contour map (Appendix, Fig. 8). Therefore, anticlinal closures associated with differential porosity of the sand bodies in the Severy shale and porous intervals within the Howard limestone probably were the controlling factors regarding oil and gas accumulations within these two formations.

# CONCLUSIONS

As indicated in the foregoing pages, the present attitude of the strata in Sumner County has developed as a result of various structural movements during different intervals of geologic time. The regional tilting and structural deformation which occurred at the various stages of the geologic past must have influenced the migration and accumulation of petroleum to a considerable extent. Apparently the most significant structural deformation resulting in petroleum accumulation was the development of the Nemaha Range and the numerous small structures throughout the area during late Mississippian and Pennsylvanian times. Of equal importance were the periods of exposure and erosion of some stratigraphic units and the lithology of others which eventually became the carrier beds and reservoirs for oil and gas. Porosity development in the Arbuckle and Mississippian strata resulted chiefly from solution and erosion as a result of exposure to the elements. The oolitic nature of the Kansas City limestone was responsible for porous intervals in this horizon. Porosity resulting from sand development in the Simpson and Stalnaker and a combination of sand development and lenticular distribution of the Bartlesville, Cleveland, Layton, and Hoover sands was dependent upon the pattern of the seas and conditions at the time of deposition. Most of the oil and gas accumulation in Sumner County occur on structural highs with varying amounts of closure, although a few of the anticlinal structures produce little or no petroleum. Some very productive pools appear to be largely independent of structural conditions and are controlled by porosity pinchouts and the extent of the reservoir bodies. As the Nemaha Range area and other prominent structures in Sumner County have been extensively drilled, exploration will be largely confined to the discovery of small structural and stratigraphic traps in the future. Future drilling activity in Sumner County will probably increase with the development of new drilling techniques, methods of production, and a greater demand for crude oil.

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# APPENDIX

Table 1. Oil fields and oil production in Sumner County, Kansas

| Field and Year of Discovery | Location Discovery Well | Oil Production bbls. 1957 | Cumulative | Producing Horizon |
|---|---|---|---|---|
| Alton ('49) | 10-35-2W | Abandoned during 1957 | | Simpson |
| Anness ('37) | 2-30-4W | Abandoned during 1957 | | Simpson |
| Anson ('48) | 35-30-2W | 160,262 | 357,655 | Kansas City |
| | | | | Mississippian |
| Anson South ('57) | 2-31-2W | Combined with Anson | | |
| Ashton ('54) | 19-34-2E | 5,364 | 38,064 | Cleveland |
| Beatie ('56) | 21-31-2W | 10,422 | 16,138 | Simpson |
| Bellman ('45) | 15-30-1E | 5,779 | 320,060 | Simpson |
| Bellman West ('57) | 16-30-1E | 6,319 | 6,319 | Simpson |
| Bitter Creek ('53) | 1-35-1E | 49,670 | 203,328 | "Stalnaker" |
| | | | | Mississippian |
| Caldwell ('29) | 17-35-3W | 23,464 | 1,638,063 | Mississippian |
| | | | | Simpson |
| Caldwell Northwest ('52) | 8-35-3W | 2,424 | 58,798 | Simpson |
| Chicaskia ('54) | 5-33-3W | no report | 6,118 | "Stalnaker" |
| | | | | Kansas City |
| Churchill ('26) | 25-31-2E | 62,488 | 19,862,778 | "Stalnaker" |
| | | | | Arbuckle |
| Corbin ('48) | 23-24-2W | no report | 37,286 | Simpson |
| Fall Creek ('50) | 3-35-3W | 256,174 | 2,133,482 | Simpson |
| Gerberding ('54) | 6-34-4W | 22,303 | 67,898 | Simpson |
| Guelph ('51) | 6-35-1E | 65,575 | 1,279,406 | Kansas City |
| | | 119,711 | | Simpson |
| | | 3,490 | | Arbuckle |
| Kerschen ('55) | 17-31-3W | 145,935 | 244,330 | Kansas City |
| | | 5,718 | | Mississippian |
| Latta ('27) | 9-30-2W | 36,201 | 1,462,792 | Kansas City |
| | | | | Mississippian |
| Latta Northwest ('56) | 5-30-2W | 9,286 | 16,554 | Kansas City |
| Lee ('51) | 33-32-2E | 9,224 | 101,551 | Mississippian |
| Margaret ('46) | 36-32-2E | no report | 108,423 | Arbuckle |
| Mayfield ('57) | 19-32-2W | 7,636 | 7,636 | Simpson |
| Meek ('56) | 10-35-1E | no report | none | Cleveland |

Table 1. (Concl.)

| Field and Year of Discovery | Location Discovery Well | Oil Production bbls. 1957 | Cumulative | Producing Horizon |
|---|---|---|---|---|
| Metz ('51) | 7-32-2E | 1,349 | 55,925 | Simpson<br>Arbuckle |
| Murphy* ('33) | 7-35-3E | 463,323 | 1,910,432 | "Layton"<br>"Bartlesville" |
| Norris ('55) | 3-34-2E | 3,203 | 8,769 | "Layton" |
| O'Hara ('55) | 18-32-1W | 38,402 | 70,225 | Kansas City |
| Oxford ('27) | 14-32-2E | 69,513 | 16,558,879 | "Hoover"<br>"Stalnaker"<br>"Layton"<br>Arbuckle |
| Oxford West ('26) | 17-32-2E | 25,619 | 829,707 | Simpson |
| Padgett ('25) | 12-34-2E | 151,249 | 3,079,709 | Cleveland<br>Marmaton<br>"Bartlesville"<br>Mississippian<br>Simpson |
| Padgett West ('54) | 21-34-2E | no runs | 9,584 | "Layton"<br>Mississippian |
| Perth ('45) | 12-33-2W | 61,125 | 1,085,094 | Simpson |
| Portland ('50) | 16-34-1E | 33,264<br>46,814 | 497,184 | "Layton"<br>Simpson |
| Portland South ('56) | 28-34-1E | 8,735 | 12,146 | "Layton" |
| Priddy ('57) | 35-33-1W | 4,905 | 4,905 | Simpson |
| Rainbow Bend* ('25) | 24-33-2E | no report | 453,000 | Arbuckle |
| Rutter ('26) | 21-33-2E | 33,951 | 171,235 | "Bartlesville"<br>Mississippian<br>Arbuckle |
| Rutter Southwest ('57) | 29-33-2E | 1,787 | 1,787 | Arbuckle |
| Slate Creek ('52) | 9-33-2E | 3,842 | 38,766 | "Layton" |
| Slick-Carson* ('24) | 19-33-3E | 20,799 | 7,713,033 | "Bartlesville" |
| South Haven ('54) | 2-35-1W | 59,292 | 194,015 | Simpson |
| State Line ('53) | 14-35-2E | 306,318 | 2,218,003 | Cleveland<br>Mississippian |
| Subera ('57) | 22-34-3W | 32,554 | 32,554 | Simpson |

Table 1. (Concl.)

| Field and Year of Discovery | Location Discovery Well | Oil Production bbls. 1957 | Cumulative | Producing Horizon |
|---|---|---|---|---|
| Tate ('50) | 31-32-2E | no report | 3,171 | Simpson |
| Val Verde ('45) | 23-33-2E | 361 | 8,524 | "Bartlesville" |
| Wellington ('29) | 33-31-1W | 372,199 | 9,374,129 | "Chat" |
| Wellington Northeast ('55) | 27-31-1W | 106,792 | 272,364 | Mississippian |
| Zoglmann ('51) | 8-31-1W | Abandoned during 1957 | | Simpson |
| Zyba ('37) | 7-30-1E | 27,640 | 514,202 | Simpson |
| Zyba Southwest ('44) | 22-30-1W | 119,580 | 1,385,924 | Simpson |
| Pools or fields abandoned | | | 312,979 | |
| Total Sumner County | | 2,979,322 | 67,069,889 | |

*Fields extending into Cowley County

**Table 2.** Gas fields and gas production in Sumner County, Kansas

| Field and Year of Discovery | Location Discovery Well | Gas Production. M cu. ft.** during 1957 | to end. 1957 | Producing Zone |
|---|---|---|---|---|
| Bitter Creek ('53) | 1-35-1E | no report | none | "Stalnaker" |
| Chicaskia ('57) | | no report | none | "Stalnaker" |
| Fall Creek ('50) | 3-35-3W | no report | | Simpson |
| Padgett ('24) | 23-34-2E | no report | | "Miss. Lime"<br>Marmaton |
| State Line ('53) | 15-35-2E | no report | none | "Bartlesville" |
| Wellington ('29) | 33-31-1W | No longer productive; used for gas storage only | | "Chat" |
| Miscellaneous | | 33,163 | | |

** All figures at base of 14.65 psia.

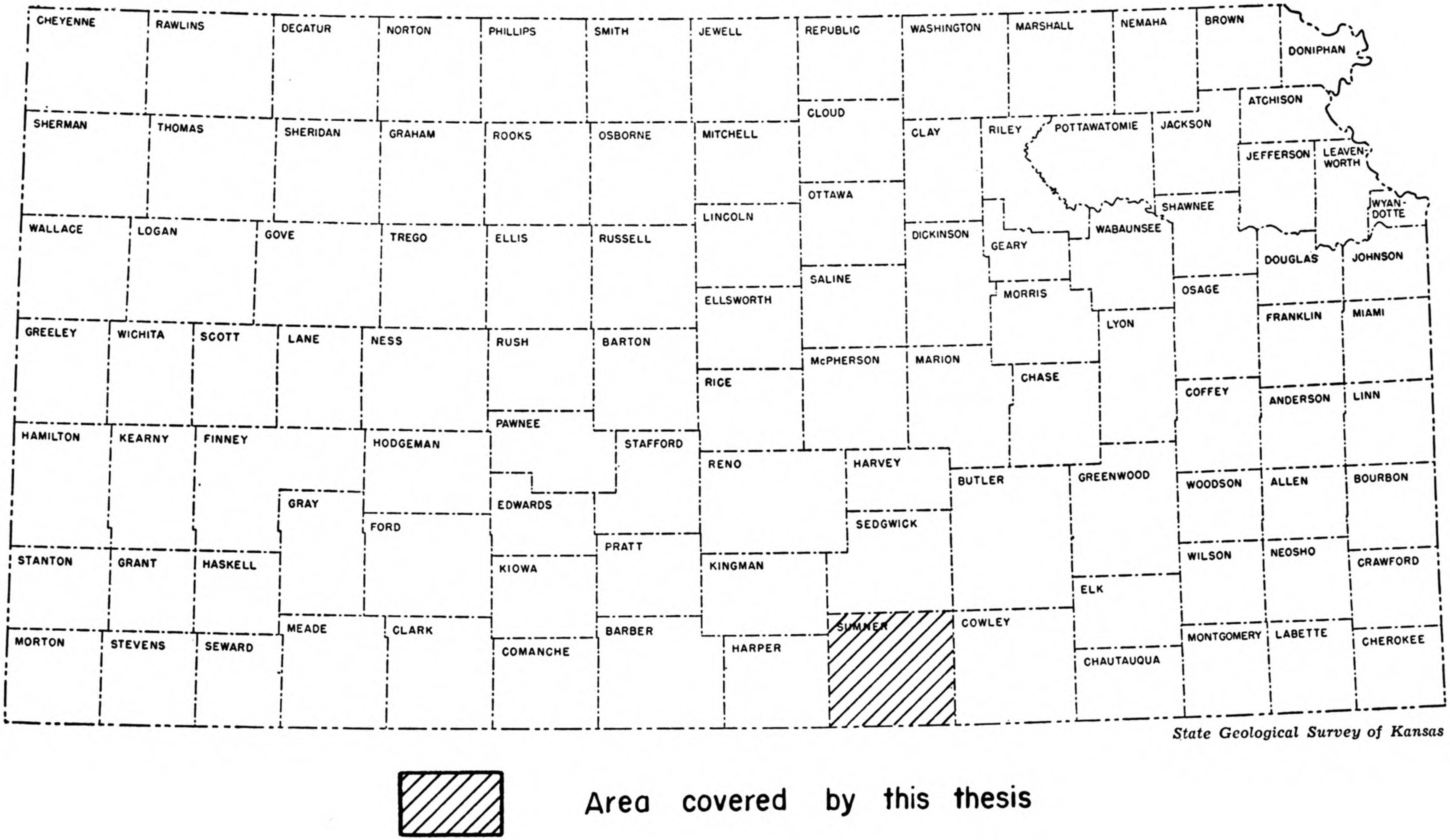
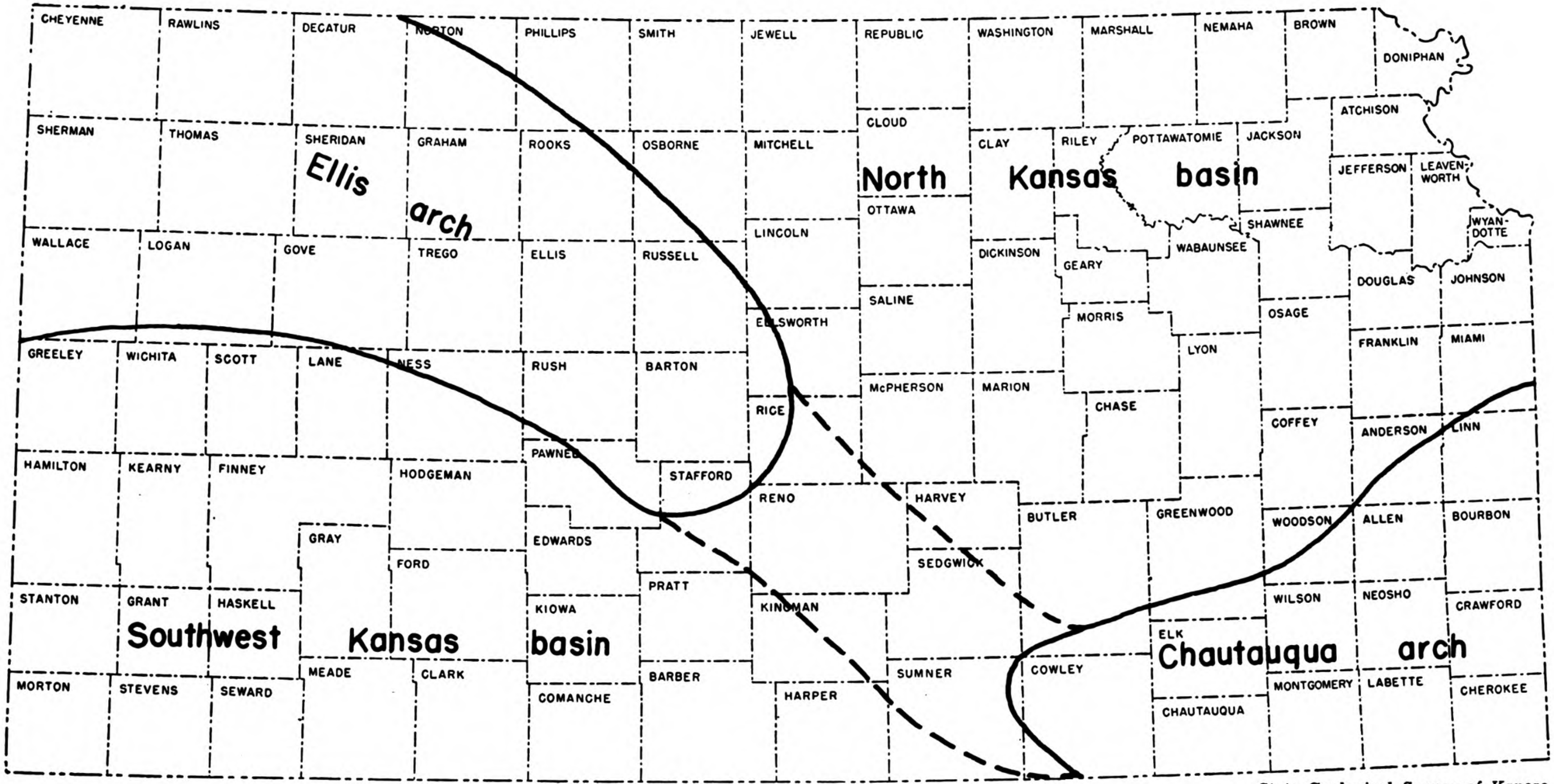



Fig. 1. Location of the area covered by this investigation




*State Geological Survey of Kansas*

Fig. 2. Geographical location of pre-Mississippian structures

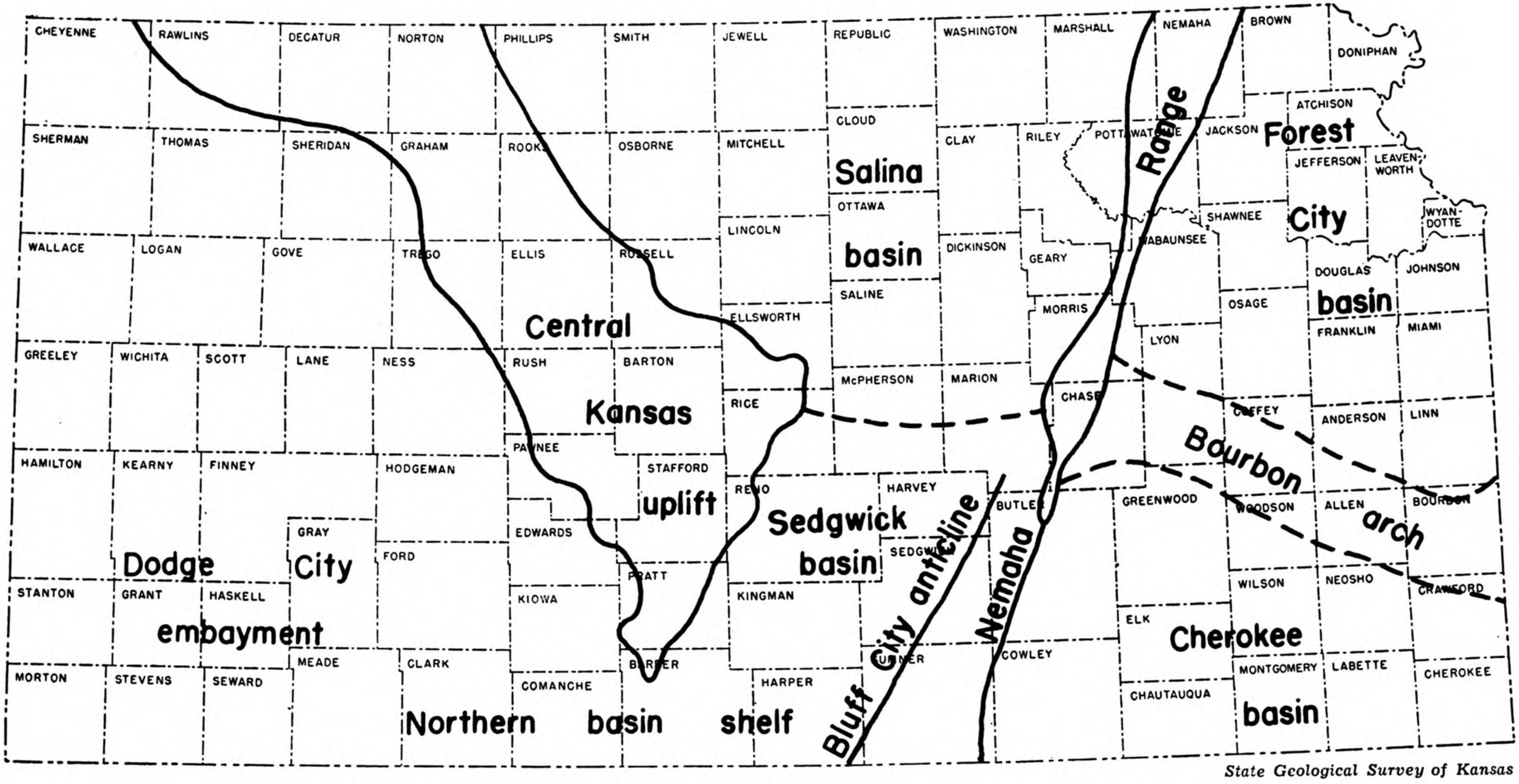



Fig. 3. Geographical location of post-Mississippian structures

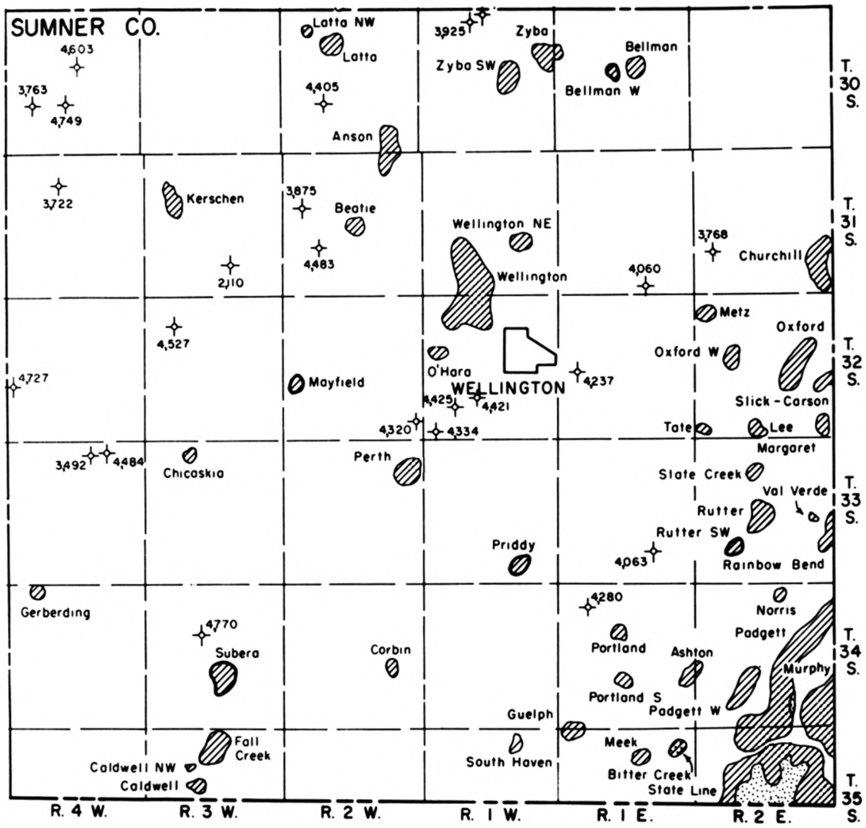



Fig. 4. Map showing oil and gas pools in Sumner County, Kansas

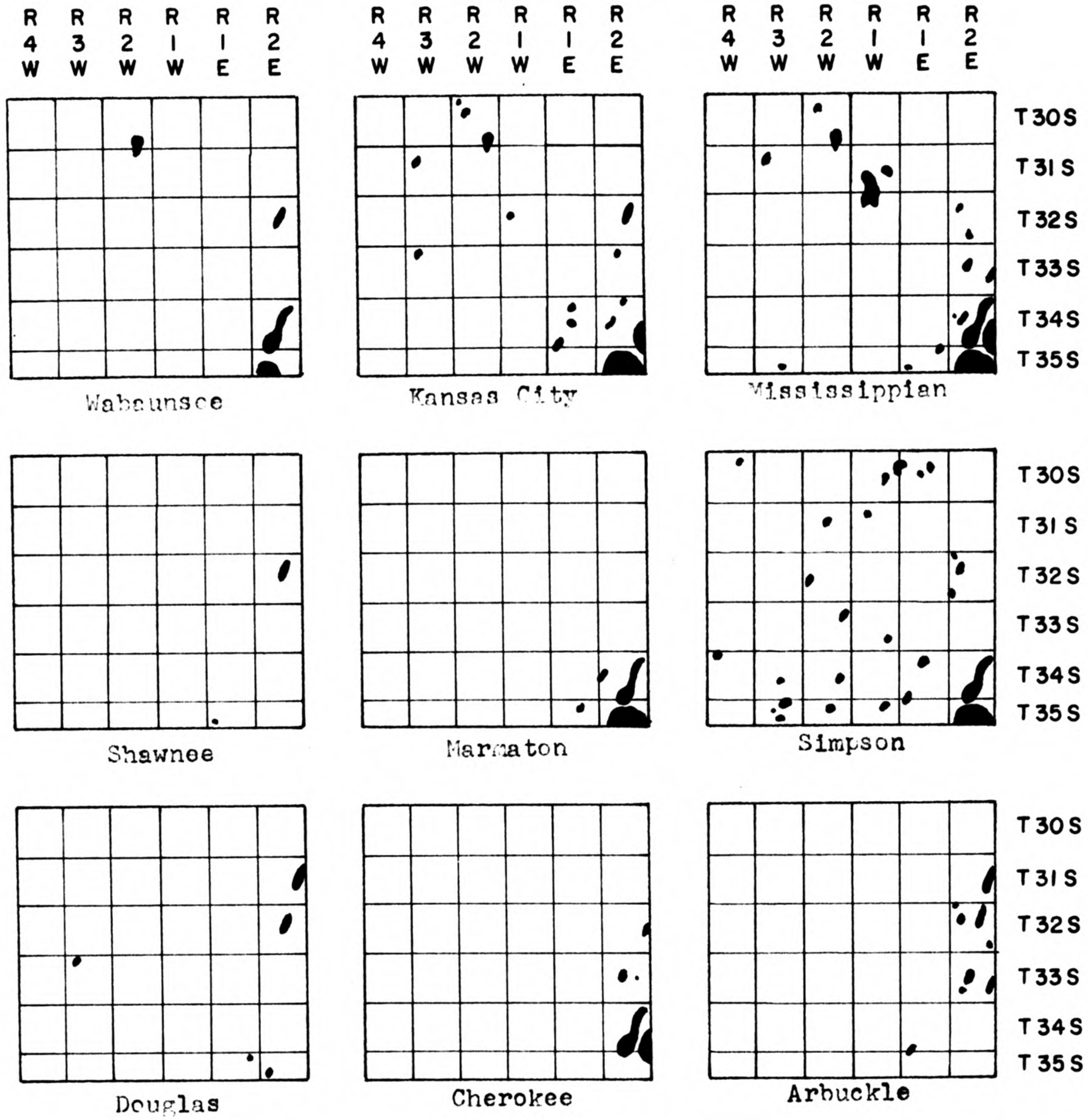



Fig. 5. Maps showing the areal distribution of producing fields by zones in Sumner County

Fig. 6. Structure contours drawn on the Simpson group, Sumner County, Kansas
(in accompanying plate box)


Fig. 6

STRUCTURAL CONTOUR MAP
ON THE TOP OF THE SIMPSON
SUMNER COUNTY, KANSAS

County line

Township line

Contour line

Contour interval = 20 feet

Scale 1" = 1 mile

1 1/2 0 1 2

Scale

N

1959

Charles H. Soucek

Fig. 7. Structure contours drawn on the Mississippian limestone, Sumner County, Kansas
(in accompanying plate box)

Fig. 7

**STRUCTURAL CONTOUR MAP ON THE TOP OF THE MISSISSIPPIAN SUMNER COUNTY, KANSAS**

County line

Township line

Contour line

Contour interval = 20 feet

Scale 1" = 1 mile

1 1/2 0 1 2

Scale

N

1959

Charles H. Soucek

Fig. 8. Structure contours drawn on the Stalnaker sandstone, Sumner County, Kansas
(in accompanying plate box)

Fig. 8

**STRUCTURAL CONTOUR MAP**
**ON THE TOP OF THE STALNAKER**
**SUMNER COUNTY, KANSAS**

County line

Township line

Contour line

Contour interval = 20 feet

Scale 1" = 1 mile

1 1/2 0 1 2

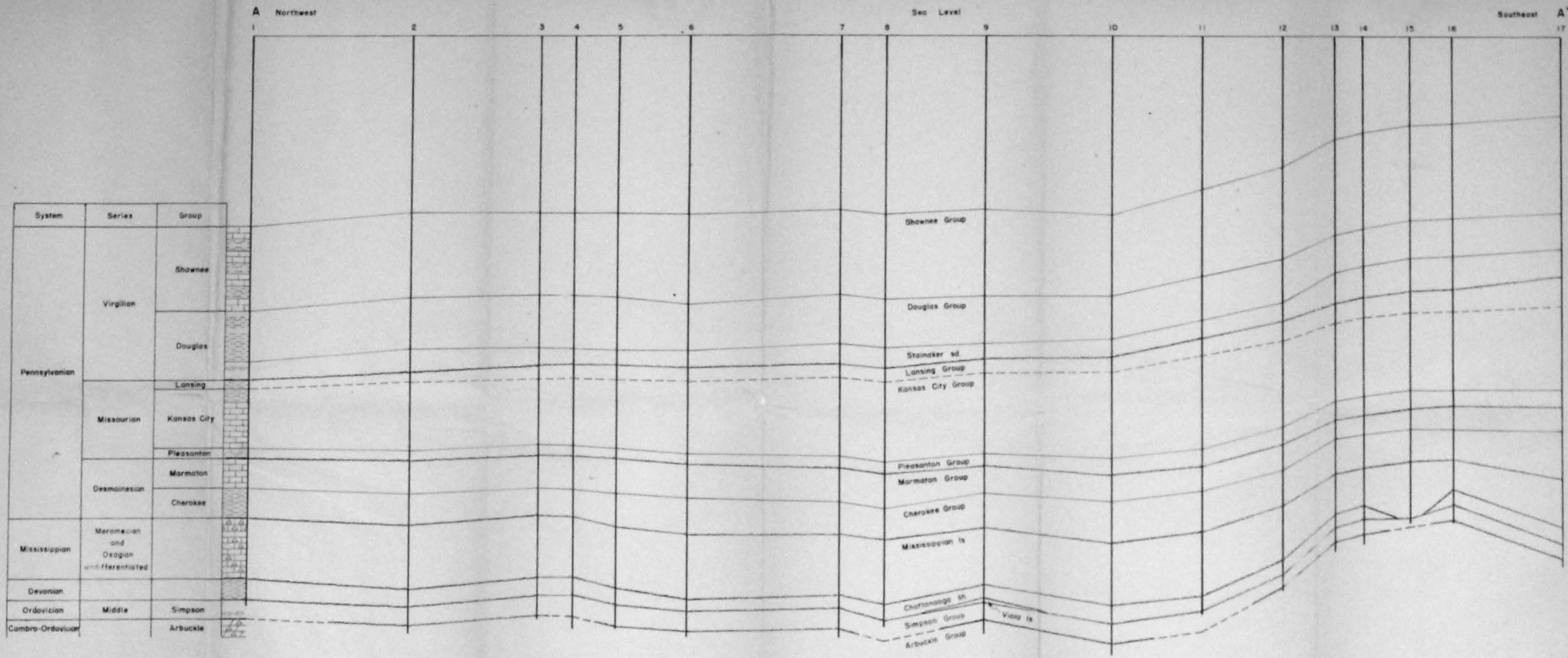
Scale

N

1959

Charles H. Soucek

Fig. 9. Cross sections of Sumner County, Kansas
(in accompanying plate box)



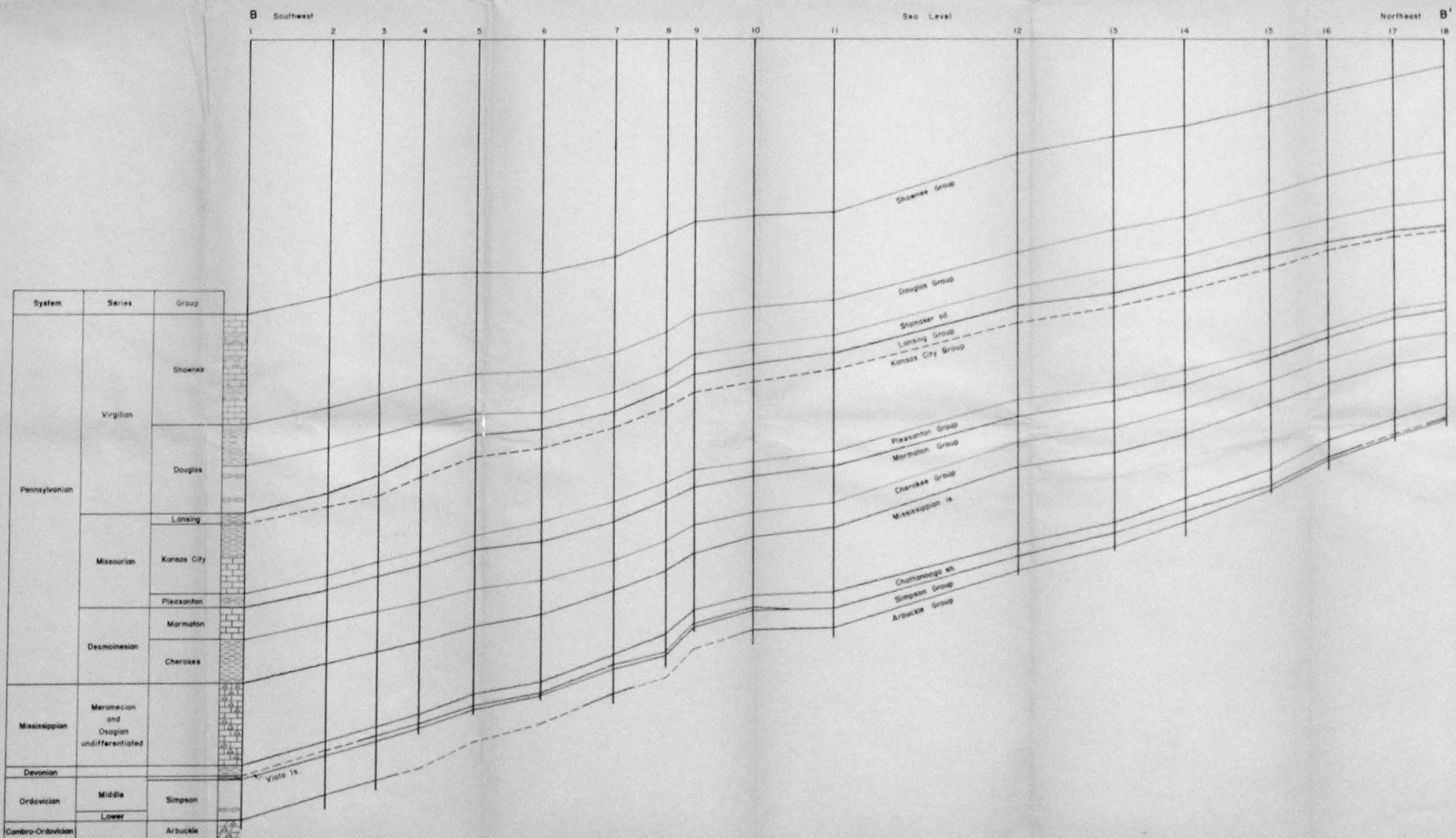




Fig. 9

# CROSS SECTIONS OF SUMNER COUNTY, KANSAS

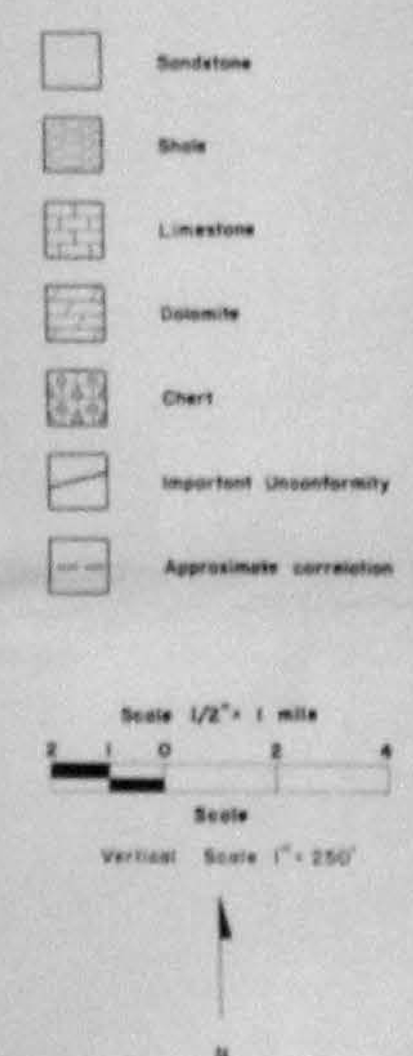
## CROSS SECTION A-A'

| Well No. | Company | Location |
|---|---|---|
| 1 | Anschutz Drlg. Co. | Sec 27, T 29 S, R 5 W |
| 2 | National Cooperative Refinery Ass'n | Sec 15, T 30 S, R 4 W |
| 3 | Aylward & Aurora Gas | Sec 6, T 31 S, R 3 W |
| 4 | Consolidated Gas Utilities Corp. | Sec 8, T 31 S, R 3 W |
| 5 | Gulf Oil Corp. | Sec 21, T 31 S, R 3 W |
| 6 | Tennessee Gas Transmission | Sec 34, T 31 S, R 3 W |
| 7 | Aurora Gas, Farmer, Jones & Shelburne | Sec 30, T 32 S, R 2 W |
| 8 | South Texas Development | Sec 33, T 32 S, R 2 W |
| 9 | Carter Oil | Sec 12, T 33 S, R 2 W |
| 10 | Stanolind Oil & Gas | Sec 26, T 33 S, R 1 W |
| 11 | K & E Drlg. Co. | Sec 5, T 34 S, R 1 E |
| 12 | Osage | Sec 15, T 34 S, R 1 E |
| 13 | Flynn | Sec 24, T 34 S, R 1 E |
| 14 | Natural Gas & Oil | Sec 30, T 34 S, R 2 E |
| 15 | Criswell Drlg. Co. | Sec 4, T 35 S, R 2 E |
| 16 | Crow Drlg. Co. | Sec 3, T 35 S, R 2 E |
| 17 | San Diego | Sec 17, T 35 S, R 3 E |

## CROSS SECTION B-B'

| Well No. | Company | Location |
|---|---|---|
| 1 | Falcon Seaboard | Sec 17, T 29 N, R 5 W |
| 2 | Texas Company | Sec 13, T 35 S, R 4 W |
| 3 | Mid-Continent | Sec 5, T 35 S, R 3 W |
| 4 | Texas Company | Sec 33, T 34 S, R 3 W |
| 5 | Petroleum Inc. | Sec 22, T 34 S, R 3 W |
| 6 | Time Petroleum | Sec 12, T 34 S, R 3 W |
| 7 | Herndon Drlg. Co. | Sec 30, T 33 S, R 2 W |
| 8 | Herndon Drlg. Co. | Sec 27, T 33 S, R 2 W |
| 9 | Adair | Sec 22, T 33 S, R 2 W |
| 10 | Carter Oil | Sec 12, T 33 S, R 2 W |
| 11 | Maytor Mineral Inc. | Sec 29, T 32 S, R 1 W |
| 12 | National Cooperative Refinery Ass'n | Sec 32, T 31 S, R 1 E |
| 13 | Getty | Sec 14, T 31 S, R 1 E |
| 14 | Smitherman | Sec 6, T 31 S, R 2 E |
| 15 | Wixson et al | Sec 21, T 30 S, R 2 E |
| 16 | Aurora & Leben | Sec 14, T 30 S, R 2 E |
| 17 | Perkins & McKinna | Sec 5, T 30 S, R 3 E |
| 18 | Vickers | Sec 3, T 30 S, R 3 E |

EXPLANATION

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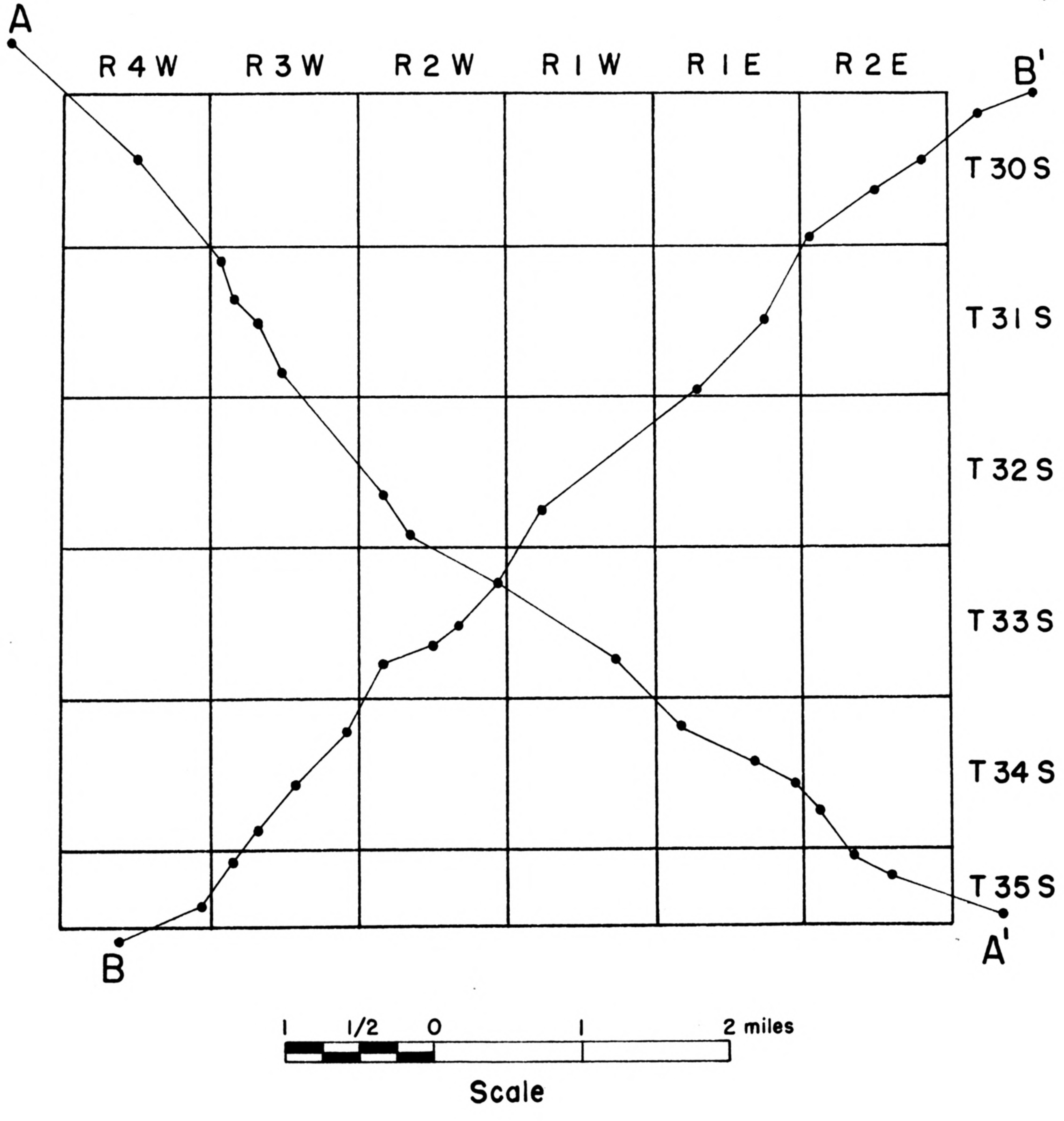


Fig. 8A. Map of Sumner County, Kansas showing points used for construction of cross sections

STRUCTURE AND STRATIGRAPHY OF SUMNER COUNTY, KANSAS RELATED TO PETROLEUM ACCUMULATION

by

Charles H. Soucek

B. S. Oklahoma Agricultural and Mechanical College, 1957

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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

1959

The purpose of this investigation was to delineate the subsurface structure, stratigraphy, and geologic history of Sumner County, Kansas, and the relationship of these factors to petroleum accumulation.

Two subsurface cross sections and three structural contour maps were constructed as a means of determining the relationship of petroleum accumulation to the structure and stratigraphy of the area. Data used for the preparation of the cross sections and contour maps consisted of the Herndon maps, electric logs, radioactive logs, drillers logs and Kansas Sample Log Service logs.

Rocks of Sumner County range in age from Pre-Cambrian to Quaternary, however, as a result of numerous hiatuses, the complete stratigraphic section is not represented in the area. The most important erosional periods concerning petroleum accumulations existed at the close of Arbuckle and Mississippian times, as solution from ground-water activity resulted in the development of porous intervals within the limestone and dolomites. The oolitic nature of the Kansas City limestone contributed to the permeability and porosity necessary for suitable oil and gas reservoirs in this horizon. Variable porous zones in the Simpson and Stalnaker sand resulted from decreased cementation and the degree of rounding and sorting of the sand. The lenticular development of the Bartlesville, Cleveland, Layton, and Hoover sands within the associated shales was responsible for the permeability and porosity essential for oil and gas reservoirs in these horizons.

Various phases of regional tilting and structural deformation occurred during different intervals of geologic time. The sites of the most significant structural deformation regarding petroleum accumulation were the Nemaha Range, Bluff City anticline and numerous small north-east trending structures throughout the area which developed during late Mississippian and Pennsylvanian times. Most of the petroleum accumulations in Sumner County occurs in anticlinal structures, however, some accumulations of petroleum appear to be independent of structural conditions and result from porosity pinchouts.

The peak in drilling activity for Sumner County was reached in 1955 but has declined appreciably since that time. Sumner County was rated eleventh in total oil production for counties in Kansas during 1957. Future exploration will probably be confined largely to the discovery of small structural and stratigraphic traps as the Nemaha Range area and other prominent structures in Sumner County have been extensively drilled.