

SUBSURFACE GEOLOGY OF NORTON COUNTY, KANSAS

by

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INTRODUCTION

Purpose of Investigation

The purpose of this work is to study the geologic history, subsurface stratigraphy and structure of Norton County, Kansas, and to relate these geologic factors to petroleum accumulation. Special emphasis has been placed upon determining the zone of pinchout of the Arbuckle group and Reagan sandstone against the Cambridge arch.

Location and Physiography

Norton County is located in northwestern Kansas adjacent to the Nebraska State line and is bounded on the east by Phillips County, on the south by Graham County, and on the west by Decatur County. It lies in the northern tier of Kansas counties and is the fourth county from the Colorado State line. It contains an area five townships square, from T. 1 S. to T. 5 S., and from R. 21 W. to R. 25 W., which includes 885 square miles.

The county is located in the Plains Border section of the Great Plains physiographic province (Frye and Leonard, 1949). The surface slopes regionally to the east. For the most part the topography consists of gently undulating plains of moderate relief with extensive flat areas occurring along the terraces of the major valleys and on the upland divides. The area has been maturely dissected by streams and is drained by three eastwardly flowing permanent streams: the Sappa and Prairie Dog Creeks,

tributaries to the Republican River, and the North Fork Solomon River, tributary to the Smoky Hill River.

The climate of northwestern Kansas is subhumid, with an average precipitation of twenty inches per year.

Procedure

The Arbuckle and Lansing-Kansas City groups were chosen to be mapped because of their significance as oil producers in the county. The construction of these structural maps as well as an isopachous map of the interval between these two horizons supplies an indication of the Paleozoic structural and geologic history of the Cambridge arch.

The Arbuckle zone ranks first in importance as an oil producer in the county followed by the Reagan sandstone and the Lansing-Kansas City group.

The Cambridge arch has been one of the least known major structures in Kansas. However, in recent years, particularly since the discovery of the Norton field in 1953, increased drilling has provided additional information and a fairly accurate interpretation of the geologic history and structural development of the feature can now be made.

The information used in the construction of these maps was obtained from the Herndon Map Service and the State Geological Survey at Lawrence.

A contour interval of 20 feet was used on all four maps. It was found that the structural magnitude of the datum horizons and the amount of structural development in the stratigraphic

interval mapped were contiguous enough that an interval common to all maps could be used. This interval was appropriate for each map as it facilitates rapid and concise interpretation of the development of the Cambridge arch and adjacent areas.

A smaller interval might better depict small structures on the Lansing horizon, however, limited control would tend to eliminate the practicability of this.

The amount of control is extensive in the vicinity of the Cambridge arch but the information becomes limited farther away from this prominent feature. In these places the position of the contours may be altered somewhat with increased control, however, information is sufficient to depict a general picture of the subsurface geology of the county.

It should be pointed out that a purely mechanical method of contouring was not employed and the interpretation will often reflect the author's past experience and contouring methods.

Previous Work

Previous work in Norton County consists of surface studies of the county, a study of the Norton Pool, annual publications of oil and gas developments, and regional investigations that include Norton County.

Surface geological studies were made by Hay (1885), Frye and Leonard (1949), Byrne, et al., (1949), and Frye (1954). A detailed study of the recently discovered and developed Norton pool was made by Merriam and Goebel (1954). Annual publications of oil and gas developments in the county have been made by Ver

Weibe since 1941 (Ver Weibe, 1942, 1943, 1944, 1945, 1946, 1947; Ver Weibe and others, 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955). Regional reports including Norton County have been published by Lee and Merriam (1954), Merriam and Frye (1954), Merriam and Goebel (1954), Merriam and Atkinson (1955), and Merriam (1955).

STRATIGRAPHY

Quaternary System

The Quaternary sediments include deposits of alluvium, terraces, and the Sanborn formation. Alluvium deposits composed of gravel and sand with silt and some clay are found in the valley flats of tributary streams and underlie the flood plains of all the major valleys in the area. Broad smooth terrace surfaces trenched by relatively narrow channels compose the three major valleys. The terrace deposits of gravel, sand and silt overlie the Cretaceous bedrock surface at thicknesses of 40 to 80 feet (Frye and Leonard, 1949). The Sanborn formation (Pleistocene) constitutes the near-surface deposits of most of the area and consists of silt, soil, some sand and gravel, and overlies the Ogalalla formation.

Tertiary System

The Tertiary system is represented by the Ogalalla formation (Pliocene) and is composed of sand, gravel, silt, limestone, volcanic ash and silicified rock. The Ogalalla unconformably

overlies Cretaceous rocks and, except along the major valleys, underlies nearly the entire county. The elastic material is poorly sorted; where loosely cemented with calcium carbonate it is called "mortar beds". The "Algal limestone", where present, caps the formation (Merriam and Goebel, 1954).

Cretaceous System

Rocks of the Cretaceous System are unconformably overlain by Tertiary sediments and unconformably overlie Jurassic beds. Most of these sediments are marine with supposed continental deposits being represented by the Dakota formation.

The oldest outcropping rock unit in the county is the Smoky Hill chalk member of the Niobrara formation which underlies the entire area. This unit can be found exposed along the three major valleys.

Gulfian Series. The Pierre shale, basal member of the Montana group, outcrops just east of the Phillips County line but is absent in Norton County.

Colorado Group. The Colorado group is divided into the Niobrara formation, Carlile shale, Greenhorn limestone, Graneros shale, and the Dakota sandstone.

The Niobrara formation consists of two members: the Smoky Hill chalk at the top and the Fort Hays limestone below. The Smoky Hill chalk is a bluish gray chalky shale containing thin beds of bentonite. The Fort Hays limestone is a massive, gray to white, chalky limestone separated by thin beds of chalky clay shale and is about 50 feet thick in the area.

The Carlile shale directly underlies the Niobrara formation and is divided into two members: the upper, the Blue Hill shale member, and the lower, the Fairport chalky shale member. The Blue Hill shale is a dark gray, noncalcareous, pyritic shale, and is capped by the fine-grained Codell sandstone zone. The Fairport chalky shale is gray, mottled and calcareous with thin limestone stringers. The Carlile shale attains a thickness of 250 feet (Merriam and Goebel, 1954).

The Greenhorn limestone lies directly beneath the Carlile shale and contains 90 feet of interbedded chalky limestones and calcareous shales. The Fencepost limestone bed appears at the top of the formation.

The Graneros shale is dark gray, fissile, noncalcareous, and maintains a uniform thickness of about 75 feet in the area. The formation contains streaks of bentonite.

Directly underlying the Graneros is the Dakota formation which represents deposits of continental origin. The Dakota contains clay, shale and siltstone with lenticular sandstone beds. The formation, which is about 420 feet thick in the county, is characterized by considerable amounts of siderite pellets observed in well samples.

Jurassic System

Rocks of Jurassic age are represented by the Morrison formation which lies unconformably below Cretaceous sediments. The formation consists of varicolored green and red, calcareous and sandy shales with some limestone, anhydrite and chert. The lime-

stone is white to cream colored, slightly crystalline to chalky, soft to hard and pyritic. The chert is white to pinkish and translucent. White to pinkish crystalline anhydrite beds are also present (Merriam and Atkinson, 1955).

The distribution of characteristic lithologic units throughout the formation includes the predominantly green sandy shales at the top, a persistent zone of cherty shale near the center with anhydrite near the base. The thickness of Morrison sediments decreases eastwardly across the county, measuring about 160 feet in the vicinity of the Norton oil field (west central part of the county), and pinches out along the eastern boundary. An unconformity at the base of the Morrison formation marks the top of Permian strata.

Permian System

Permian rocks in this area are divided into an upper and lower series, these subdivisions being termed respectively the Leonardian and the Wolfcampian, as adopted by the Kansas Geological Survey. The Leonardian series is composed of red shales and some sandstones with some gray shales and thin beds of salt, gypsum and anhydrite. The Wolfcampian series consists predominantly of limestone and dolomite alternating with varicolored shales and some sandstone. Differentiation of many of the stratigraphic units of Permian age is particularly difficult in well samples because of the thinness of the beds which leads to ultimate contamination of the samples. Thus, the unconformity

marking the top of the Pennsylvanian is not easily recognized in samples. The Permian system is unconformably overlain by Jurassic sediments in all but the extreme eastern part of Norton County where an unconformity separates sediments of Permian age from those of Cretaceous.

Leonardian Series. Nippewalla Group. The red shales and sandstones of the lower part of the Nippewalla group represent the uppermost rocks of Permian age. These redbeds comprise alternating silty shale, very fine-grained sandstone and thin beds of anhydrite accumulating an average thickness of about 460 feet (Merriam and Goebel, 1954).

Sumner Group. This subdivision includes, in descending order, the Stone Corral formation, the Ninnescah shale and the Wellington formation. The uppermost unit, the Stone Corral formation, is particularly distinctive as a marker bed because of its ease of identification in well cuttings and on electric logs. Because of the sharp contrast in density it offers to the overlying and underlying shale beds, it produces prominent and continuous reflections on seismograph records, thus making it an important reflection horizon. The formation, ranging from 25 to 50 feet in thickness, consists largely of white to light-gray crystalline anhydrite sometimes called the Cimarron anhydrite. It has a sugary texture and is locally dolomitic near the base. Immediately below the Stone Corral is a thick bed of predominantly red shale with sand and anhydrite known as the Ninnescah shale (Landes and Kercher, 1942). The lowermost unit of the Sumner

group is the Wellington formation which consists chiefly of silty shale with some anhydrite and a layer of salt, called the Hutchinson salt member, near the middle. Salt is represented in well cuttings only by salt molds in the shale (Merriam and Goebel, 1954), because of its solubility. The entire thickness of the Sumner group is 375 feet in the county.

Wolfcampian Series. Chase Group. The Chase group is composed of red and green shales and interbedded limestone or dolomitic limestone. Chert or flintbearing limestones are characteristic of this division. The Flint Hills of eastern Kansas are largely composed of this group. The Herington limestone, a buff to gray dolomitic limestone, occurs at the top of the group and the Wreford limestone, a good example of the cherty limestone characteristic of this unit, occurs at the bottom of the group.

Council Grove Group. This unit consists of medium to dark gray and red shales and white to brownish, granular to finely crystalline limestone with some cherty limestone. The beds of this group are generally less massive with thinner limestone units than the overlying Chase group. The Cottonwood limestone member is a massive limestone of consistent thickness, about six feet. It contains abundant fusulinids in the upper part (Moore, et al., 1951) and is particularly distinctive as an excellent marker bed on electric logs. The base of the group is represented by the Americus member of the Foraker formation and is recognized as a persistent limestone overlying the shaly Admire group. The local thickness of the Council Grove group is 310 feet (Merriam and Goebel, 1954).

Admire Group. This division is composed of alternating impure limestones and red and gray shales. The limestone is white to light brown, finely crystalline and fossiliferous. The group is more clastic farther east in the state consisting predominantly of shales. Its entire thickness in this county is approximately 90 feet (Merriam and Goebel, 1954). This group, the lowermost of the Permian system, unconformably overlies Pennsylvanian rocks.

Pennsylvanian System

An unconformity exists between Pennsylvanian and Permian rocks but because of the difficulty in recognizing this interzonal phenomenon in well samples most subsurface geologists do not attempt to draw a definite line between the two. Pennsylvanian deposits consist chiefly of marine limestones, some cherty and others oolitic, alternating with shale and thin beds of sandstone. Several black shales serve as good marker horizons, especially on electric logs. The Heebner shale member of the Oread limestone formation is distinctive, particularly on radioactivity records because of its strong gamma ray emanations (Moore, et al., 1951). The base of the Kansas City group is used as a datum plane for structural mapping since it too, is easily recognized on electric logs. The stratigraphic intervals in the Pennsylvanian are fairly consistent above the base of the Kansas City group; however, older beds of this period are not consistent because of the irregularity of the pre-Pennsylvanian surface, particularly where they unconformably overlie rocks of pre-Cambrian, Cambrian (Reagan), and

Cambro-Ordovician (Arbuckle) ages. Pre-Cambrian rocks are unconformably overlain by Pennsylvanian beds along the crest of the Cambridge arch and the northeastern end of the Central Kansas uplift, which appears in the extreme southeastern part of the county. Cambrian rocks are contiguous with those of the Pennsylvanian where a thin band of the Reagan sandstone occurs on the edges of the pre-Cambrian structural features. The Arbuckle group of Cambro-Ordovician age unconformably underlies Pennsylvanian strata in all the remaining area of the county not described above (Merriam and Goebel, 1954). The entire thickness of rocks of the Pennsylvanian system in the area is about 800 to 900 feet (Landes and Kercher, 1942). Rock units of the Virgilian, Missourian and Desmoinesian series are represented.

Virgilian Series. Wabaunsee Group. This group is composed of limestone with interbedded red and gray shale and some sandstone. The limestone is gray, cream and buff, finely crystalline and fossiliferous. Some of the layers are cherty and dolomitic. The thickness of the group in the area is about 225 feet (Merriam and Goebel, 1954).

Shawnee Group. Thick white to gray, dense to finely crystalline, fossiliferous limestone and dark colored shale comprise the Shawnee group. The Topeka limestone marks the top of the group and is cream colored, dolomitic and sometimes oolitic. The previously mentioned Heebner shale appears near the base of the formation and is recognized in samples as a predominantly black, platy and fossiliferous shale.

Douglas-Pedee Groups. These groups are often treated as an undifferentiated unit between the base of the Oread formation and the top of the Lansing group. The beds consist of red and gray shale, sandstone and some bluish-gray to white limestone (Landes and Kercher, 1942).

Missourian Series. Lansing-Kansas City Group. This group is represented predominantly by limestone with some interbedded gray and red shale. The limestone is cream, white and gray, dense to finely crystalline and fossiliferous. Some of the limestone layers are cherty, oolitic and dolomitic (Merriam and Goebel, 1954). Several different limestones, particularly oolitic zones near the top of the division, and especially in the Lansing, have shows of oil with some Lansing-Kansas City production being reported. This division marks the oldest Pennsylvanian beds that are continuous throughout the area (Landes and Kercher, 1942). Variations in the thickness, as thinning over the Cambridge arch and the Central Kansas uplift, are caused by differential structural movement and to some extent by an unconformity at the top of the Lansing group.

Rocks occurring at the bottom of the Pennsylvanian division are probably either Pleasanton (Missourian series) or Marmaton (Desmoinesian series). These layers contain red and gray sandy shale with interbedded cream to light gray, dense to finely crystalline, sandy limestone (Merriam and Goebel, 1954). The presence of the Basal Pennsylvanian conglomerate is noted in some wells but not frequent enough to indicate any degree of continuity. However, the occurrence of the conglomerate and its composition

indicates deposits undoubtedly derived from Arbuckle beds located higher on the flanks of the uplifted areas, the Cambridge arch and the Central Kansas uplift. The conglomerate is composed of smooth, white chert of weathered nature and some sand grains, cemented in a matrix of red and green shale.

Mississippian System

Rocks of Mississippian age are absent in the county, however, considerable thicknesses of these rocks are found in adjacent counties to the south and west.

Ordovician System

Except for the Cambro-Ordovician division, there are no rocks of Ordovician age represented in the county and only small amounts occur locally to the south in Graham County.

Cambro-Ordovician System

Arbuckle Group. The Arbuckle group includes rocks of both Ordovician and Cambrian ages, the larger part of the division representing Ordovician sediments. The thickness in the county ranges from a featheredge to several hundred feet as it thickens sharply away from the Cambridge arch. The composition of the Arbuckle group includes gray or buff to brown, dense or porous and vuggy, medium to coarsely crystalline, sandy, glauconitic porous dolomite and limestone. The group is the most important oil producing zone in the county. The porosity and permeability in the Arbuckle is a result of erosion that took place after the

Arbuckle was deposited until the Pennsylvanian beds were unconformably laid down over them. This period of erosion lasted for a relatively long interval of time. Porosity and permeability were particularly well developed along the flanks of the uplifted Cambridge arch, and similarly the Central Kansas uplift, and these porous zones have become important petroleum reservoirs. Except when the Reagan sandstone is present, the Arbuckle lies directly on pre-Cambrian rocks.

According to Merriam and Atkinson (1955), many of the rocks in the area designated as Arbuckle are really the Bonneterre dolomite or are equivalent to it, and since this formation is Cambrian in age they should not be included under the Cambro-Ordovician system.

Cambrian System

The oldest sedimentary rock unit in the area is represented by the Reagan sandstone, a basal sand composed of white to gray, fine to coarse grained, angular to subrounded, poorly sorted grains. The grains are predominantly frosted quartz and often contain arkosic material with them in the lower part of the unit. The Reagan, equivalent to the Reagan sandstone of Oklahoma and the Lamotte sandstone of Missouri, unconformably overlies the pre-Cambrian surface and appears as a discontinuous band along the flanks of the uplifted pre-Cambrian areas including the Cambridge arch, the Central Kansas uplift and the Jennings anticline. The latter is a relatively small structural feature located in the adjacent county to the west. The Reagan sandstone

occurs in only a few wells in the area which suggests it is limited in extent. It was assumed by Merriam and Atkinson (1955) that it was a sheet deposit that was later removed in many places by post-Reagan erosion.

Pre-Cambrian Rocks

The majority of the wells drilled in the county penetrate pre-Cambrian rocks only along the crest of the Cambridge arch and the Central Kansas uplift as the Arbuckle thickens sharply away from these positive features. Most of the wells reaching pre-Cambrian rocks penetrate only a weathered arkosic zone called "granite wash" (Merriam and Geobel, 1954). Where fresh pre-Cambrian rocks are encountered the samples contain biotite-bearing granite with fewer reports showing chloritic and micaceous schist. Merriam and Atkinson (1955), suggest that from the distribution of the different pre-Cambrian rocks types a biotite-bearing granite intruded pre-existing sediments since the granite is surrounded by such metasediments as schist, gneiss, and quartzite. In this case, the presence of schist on the crest of the Cambridge arch is explained as being possibly a roof pendant (Merriam and Atkinson, 1955) p. 3.

STRUCTURE

Regional Structural Features

Central Kansas Uplift. The Central Kansas uplift is a low, broad, northerly plunging anticlinal structure trending northwest

southeast. It is situated on a broad arcuate anticlinal area which is convex to the southwest. This positive trend extends from the Ozark dome of Missouri to the Black Hills uplift of South Dakota with the Central Kansas uplift situated between the previously formed Chautauqua arch on the southeast and the Cambridge arch to the northwest. The latter suffered movement after the Central Kansas uplift became quiescent. There is no evidence of regional arching on the surface to suggest the existence of this buried feature although several minor northerly to northwesterly plunging anticlines and synclines are present in the area (Lee and Merriam, 1954).

The Central Kansas uplift originated in pre-Cambrian times as a series of parallel batholiths and existed throughout the Paleozoic as a positive element. Koester (1935) suggested recurring broad scale warpings took place during the following periods: post-Algonkian, post-Canadian, post-Hunton, early Pennsylvanian, post-Missourian and post-Cretaceous. These structural movements were modified by early Paleozoic depositional thinning toward the northwest and by folding along pre-existing lines of weakness in northeasterly and southwesterly directions (Koester, 1935). Some of these northeast southwest structures, particularly in the area between the southeastern end of the Central Kansas uplift and the Nemaha anticline, are sharper, although of less magnitude than those in the predominating northwest southeast direction. It has been suggested by Lee and Merriam (1954) that these northeast southwest structures, which are parallel to the Nemaha anticline, were produced by remotely

originating differential movements and may still be developing. On the northern margin of the Central Kansas uplift as far northwest as the southeastern corner of Norton County, oil producing anticlines trending parallel to the Nemaha structure indicate an earlier development by increased structural relief with depth.

Regional movement of the Central Kansas uplift ceased at the end of the Paleozoic at the time of deposition of the Wellington formation after which the area was differentially tilted toward the Hugoton embayment, however, local folding in the area took place even after Dakota time (Lee and Merriam, 1954).

The name, Central Kansas uplift, was first published by Morgan in 1932 when he defined the uplifted area as being formed by Caledonian folding parallel to the pre-Cambrian grain followed by Appalachian folding normal to the grain. This same structure has been called the Barton arch, as suggested by Barwick in 1928, and some geologists still prefer to use this term which preceded Morgan's publication, however, the name Central Kansas uplift more accurately describes this feature.

Salina Basin. The Salina basin is a structural feature located in northern east-central Kansas and extends for an undetermined distance into Nebraska. It is bounded on the southwest and west by the Central Kansas uplift and the Cambridge arch, on the east by the Nemaha anticline, and on the south by a broad upwarp between the Nemaha anticline and the Central Kansas uplift. The Salina basin lies on the margin of an earlier structural basin called the North Kansas basin that was divided by

the uplifting of the Nemaha anticline forming the Salina basin on the west and the Forest City basin to the east (Lee, 1956).

The Salina basin was first named in a publication by Barwick in 1928 and the term has since been used.

Lee (1954) recognized five principal periods of deformation in the development of the Salina basin:

1. A broad synclinal basin extending from central Missouri as far west as the area later represented by the Central Kansas uplift existed in pre-St. Peter time.

2. Regional warping between St. Peter and Mississippian time produced the Ozark uplift and the North Kansas basin. At the same time the Chautauqua arch was developed, and the Central Kansas uplift and Hugoton embayment were initiated.

3. A third period of development extending through the Mississippian up to middle Permian time resulted in the uplifting of the Nemaha anticline which divided the North Kansas basin. Within this span of time the Central Kansas uplift and the Hugoton embayment reached the zenith of their development.

4. During the upper Permian and Cretaceous periods, the area of the Central Kansas uplift and western Salina basin were tilted toward the Hugoton embayment greatly extending its northeastern limb. Erosion has obliterated significant formations to the degree that the structural development in eastern Kansas cannot be determined.

5. Post-Cretaceous subsidence of the Denver basin to the west and northwest probably accounts for the tilting of western Kansas region in that direction (Lee and Merriam, 1954).

Hugoton Embayment. The Anadarko basin in western Oklahoma and the Texas panhandle, which is well defined on the west by the parallel alignment of the Wichita Mountain system and on the east by the southern end of the Nemaha anticline, extends as a large synclinal shelf into the southwestern Kansas area. This southerly-plunging synclinal shelf or embayment of the Anadarko basin was first named the Dodge City basin by McClellan in 1930, but was replaced by the term Hugoton embayment, by Maher and Collins in 1948, so named for the town of Hugoton, Kansas, which is located near the axis of the embayment and overlying the thickest rock section. Tectonically the feature is bounded on the southwest by the Amarillo uplift, on the west by the Sierra Grande uplift, on the northwest by the Las Animas arch, on the northeast by the Cambridge arch and the Central Kansas uplift and on the east by the Pratt anticline. The major positive areas flanking the embayment served as source areas as well as restricting the extent of advancement of the Paleozoic seas. The structural development of the Hugoton embayment consisted of a series of epeirogenic warpings occurring during pre-Cambrian, post-Arbuckle, post-Viola, post-Chesterian, post-Morrowan and post-Permian times. By the end of the Paleozoic thick sediments had accumulated as periodic downwarpings paved the way for the thick deposits. In Mesozoic and Tertiary time the structure of the Hugoton embayment was modified somewhat with northwesterly tilting in the Jurassic period and finally tilting to the east in late Tertiary time (Merriam, 1955).

Denver Basin. The Denver basin is a structural depression located in northeastern Colorado, southeastern Wyoming, western Nebraska and extreme northwestern Kansas. Its position is defined by the following positive elements: on the west by the Front Range and Wet Mountain uplift in Colorado and the Laramie Range and the Hartville uplift in Wyoming; on the north by the southern flank of the Black Hills in Nebraska; on the northeast by the Chadron arch and Cambridge arch in west central and southern Nebraska and northwestern Kansas; on the southeast by the Las Animas arch in eastern Colorado; and on the south by the Apishapa arch in southeastern Colorado. The basin is asymmetrical with its eastern flank dipping gently westward from the Chadron, Cambridge and Las Animas arches, while its western flank rises abruptly adjacent to the mountain front. The structural development of the Denver basin represents several periods of orogenic and epeirogenic movements. According to McCoy (1953) the basin area was an early Paleozoic positive area that gave way to orogenic movement causing downwarping and subsidence of the area in late Mesozoic time probably due to Laramide movement. After deposition of Tertiary sediments the basin was tilted to the east as a result of sagging under its load of sediments, the greater volume resting on the gently dipping eastern flank, and assumed its present structural configuration.

Las Animas Arch. The Las Animas arch is an anticlinal feature trending along the eastern border of Colorado and extends into northwestern Kansas. Although the feature was probably initiated in pre-Cambrian time, the principal structural relief,

which reached from 3,000 to 4,000 feet by the end of the Permian, resulted chiefly from differential subsidence of the beds over the arch and along its flanks (Eardley, 1951). The arch had little effect on the structures of western Kansas prior to Cretaceous time except as it represented the western limb of the Hugoton embayment. The northeasterly slope of the Dakota formation on the flank of the Las Animas arch in western Kansas is terminated by a well developed northerly trending marginal syncline that became more sharply defined after Cretaceous time (Lee and Merriam, 1954).

Ellis Arch. The Ellis arch is an anticlinal structure trending northwesterly across northwestern and central Kansas and continues east southeastward as the Chautauqua arch to the Ozark dome. The Ellis arch is a pre-Mississippian structure with anticlinal folds striking northwesterly represented in pre-Cambrian, Cambrian and Ordovician rocks (Jewett, 1951). Eardley (1951) suggested that the Ellis arch was eroded at the end of the Devonian exposing the Arbuckle group and locally pre-Cambrian rocks in the core. Mississippian sediments were deposited over the area and post-Mississippian arching in a more northerly direction resulted in the development of the Central Kansas uplift which was superposed upon part of the Ellis arch. The Ellis arch was so named by Moore and Jewett in 1942. Lee, Leatherock and Botinelly called the same structure the Ancestral Central Kansas uplift in a 1948 publication.

Cambridge Arch. The Cambridge arch is a large anticlinal feature located in south-central Nebraska and northwestern Kansas.

The larger part of the structure occurs in Nebraska and derives its name from the town of Cambridge in Furnas County, Nebraska, located near the anticline. Condra and Reed applied the name in a 1943 Nebraska Geological Survey publication. The southeastern end of the arch extends into Kansas in northeastern Decatur County and trends diagonally across the central part of Norton County to the southeastern corner where a structural saddle separates the arch from the northwestern end of the Central Kansas uplift. The Cambridge arch is situated on a broad arcuate anticlinal axis extending across the mid-continent region in a northwest-southeast direction from the Ozark dome of Missouri to the Black Hills uplift of South Dakota and is one of several major structural features. This axis, which is convex to the southwest, contains the following features: the Chautauqua arch, the Central Kansas uplift, the Cambridge arch, the Chadron arch and the Black Hills uplift. Each feature is separate from the other with those on the northwestern end of the trend displaying later movement. For example, the Chautauqua arch became quiescent by the end of Mississippian time; adjacent on the west is the Central Kansas uplift that suffered major movement until Permian time; the next feature to the northwest, the Cambridge arch, shows post-Cretaceous structural movement, etc. The Cambridge arch is flanked by major synclines that represent a part of larger structural basins. The Long Island syncline to the east plunges to the northeast into the Salina basin, and the Seldon syncline, located on the southwestern flank of the arch, plunges northwestwardly into the larger Western Kansas basin.

Tectonically the Cambridge arch represents several periods of uplifts and tiltings. Study of the structural development of the arch indicates that the area was tectonically active several times during the early Paleozoic. At the end of the Mississippian period strong major structural movement occurred in the area of the Cambridge arch and the Central Kansas uplift. Unrest prevailed with tilting progressing until the end of the Paleozoic when there was orogenic movement. During Mesozoic time, differential movement and tilting continued to the end of the era when orogenic folding occurred, possibly associated with the Laramide revolution in the Rocky Mountain region (Merriam and Atkinson, 1955).

Minor local epirogenic structural movements may have taken place during the Tertiary, however, no evidence of movement is indicated on the Cambridge arch and the Tertiary sediments show no relation to the underlying structure. At the end of Cretaceous time the Mesozoic sediments were dipping northwestward into the Denver basin, but the present regional dip of the Cretaceous rocks is to the north. Since the present configuration of the "Algal limestone" is monoclinial eastward dip the area was no doubt tilted to the east after the deposition of the "Algal limestone" (Merriam and Frye, 1954).

Increased drilling in the area of the arch in recent years has defined the existence of two converging re-entrants of the pinchout zone of the Arbuckle (and Reagan sandstone) against the arch. The possibility exists that the zone crosses the arch

completely displaying a structural saddle on the crest of the arch similar to the low saddle separating the Cambridge arch from the Central Kansas uplift in Southeastern Norton County.

Major Structural Features

Long Island Syncline. The Long Island syncline is a broad northeast-southwest trending structure plunging northeastward and is located in eastern Norton and northwestern Phillips Counties. The feature, although discernible, has only a small amount of structural relief that decreases slightly in younger beds. The structure was named by Merriam and Atkinson in 1955 for the town of Long Island which is located near the axis of the syncline in Phillips County. Tectonically the Long Island syncline is a western extension of the Salina basin. The structural attitude of the feature is depicted on the Arbuckle and Lansing-Kansas City structural maps (Figs. 6 and 7, Appendix).

Seldon Syncline. This northwest-southeast trending structural feature flanks the Cambridge arch on the southwest and is located in southeastern Decatur and northeastern Sheridan Counties. The syncline has several closed lows separated by small, low saddles, but the feature plunges generally to northwest into the Western Kansas basin of which it is a part. It first received recognition in a State Geological Survey bulletin by Merriam and Atkinson (1955), the name being derived from the town of Seldon, located geographically near the axis of the syncline.

Jennings Anticline. The Jennings anticline is a north-south trending southerly plunging structure located principally in

southeastern Decatur County. The structure is no doubt associated with the Cambridge arch and, although the Reagan sandstone and Arbuckle rocks are present on its flanks as on the Cambridge, production is from several closed highs in the Lansing-Kansas City horizon situated on the crest of the anticline. The Jennings anticline was named for the town of Jennings located on the crest of the uplift in a publication by Merriam and Atkinson (1955).

Western Kansas Basin. The Western Kansas basin is a synclinal structure in Mesozoic rocks and represents in altered form the northern part of the Hugoton embayment on which it was superposed in post-Paleozoic time. It is a broad syncline as was its predecessor, lying between the Las Animas arch on the west and the Cambridge arch and the Central Kansas uplift on the east. Unlike the Hugoton embayment, however, it dips northwesterly into and represents an arm of the Denver basin as a result of post-Permian northerly tilting of the area (Lee and Merriam, 1954).

GEOLOGIC HISTORY AND STRUCTURAL DEVELOPMENT

Pre-Cambrian Era

The distribution of the different pre-Cambrian rock types in the area of the Cambridge arch where wells penetrate the pre-Cambrian rocks generally indicate biotite-bearing granites with some wells recording schists on the crest of the arch. Wells encountering pre-Cambrian rocks on the flanks of the arch and farther out into the flanking synclinal areas report chiefly meta-sediments--e.g., schist, gneiss, and quartzite. Merriam and

Atkinson (1955) suggest that the granite that forms the core of the arch was intruded into pre-existing sediments, the emplacement causing metamorphism of the surrounding rocks and that the schist on the crest of the arch could be a roof pendant. Similarly, in the area of the Central Kansas uplift, Koester (1935) believed that the intrusion of small batholiths explained the presence of the meta-sediments in that area.

The configuration of the pre-Cambrian surface of Norton County is represented in Fig. 5, Appendix. The southerly plunging northwest-southeast trending Cambridge arch is the principle structure depicted. A saddle in the southeastern part of the county separates the arch from the Central Kansas uplift, the northwestern end appearing in the extreme southeastern corner of the county. Extensive post-pre-Cambrian erosion took place as evidenced by numerous minor irregularities on the surface and by the presence of variable thicknesses of "granite wash".

Paleozoic Era

Lower Paleozoic rocks are present on the flanks of the Cambridge arch in a wedge-shaped mass that thickens away from the crest of the arch rather sharply. Pennsylvanian deposits lie directly upon pre-Cambrian rocks on the crest of the arch indicating that if pre-Pennsylvanian sediments accumulated on the arch they have since been removed by erosion.

In late Cambrian time seas advanced and the Reagan sandstone was deposited over an uneven pre-Cambrian surface of low relief. McCoy (1953) suggested that the source for this basal Paleozoic

sandstone unit was two positive areas: the Siouxi uplift to the northwest and the Sierra Grande uplift to the southwest. The Reagan, which was unconformably overlain by the Arbuckle, is encountered by many wells only on the flanks of the Cambridge arch and since no wells penetrate through the thick Arbuckle section in the synclinal areas surrounding the arch it is not known if the Reagan is present there. Where the Reagan is not present beneath the Arbuckle on the flanks of the arch it probably was removed by post-Reagan erosion. Merriam and Atkinson (1955) stated that the Reagan probably accumulated as a sheet deposit but since only limited wells encounter the Reagan this can only be assumed.

Existing evidence tends to indicate that the Cambridge arch was not high during the deposition of the Arbuckle and that the Arbuckle was deposited over it and was subsequently removed from the crest of the arch by erosion. On the Arbuckle structural map, Fig. 6, Appendix, the strike of the contours as they abutt into the area along the crest of the arch where the Arbuckle is absent, generally parallel this area where the arch is wider and to the southeast they would seem to connect forming southeasterly convex arcs showing the beds dipping southeastward. Also, the non-clastic content of the Arbuckle sediments indicates that there was no immediately adjacent high area to furnish clastic deposits. The Cambridge arch as well as the Central Kansas uplift were subsequently uplifted and the Arbuckle subjected to erosion resulting in its removal from the crest of the Cambridge arch.

In middle Ordovician time seas again advanced and deposited the Simpson formation. On the flanks of the Cambridge arch in the adjacent counties to the south, southwest and west, the overlying Viola formation oversteps the Simpson and lies directly upon the Arbuckle indicating that the Simpson was eroded prior to the deposition of the Viola (Merriam and Atkinson, 1955). Furthermore, the Cambridge arch was probably uplifted subsequent to the deposition of the Simpson and erosion followed. The seas moved in again and the Viola was deposited. By the same reasoning, the Mississippian sediments overstep the Viola toward the arch suggesting post-Viola uplift and erosion followed by advancing Mississippian seas. The "Kinderhook" shale and younger Mississippian sediments were deposited. At the end of Mississippian time the greatest single major structural movement in the area caused the Cambridge arch and Central Kansas uplift to be elevated and extensive erosion followed, removing all Mississippian sediments from Norton County and any pre-Pennsylvanian sediments that may have remained topographically high on the Cambridge arch (Merriam and Atkinson, 1955). There are no sediments in the county younger than Arbuckle and older than Pennsylvanian, however, Mississippian and Ordovician sediments pinch out farther out on the flanks of the Cambridge arch and the Central Kansas uplift in the areas to the south and west of the county. The Arbuckle surface was exposed to erosion several times as is represented by the high degree of porosity which lent itself locally as a reservoir for petroleum accumulation.

The Cambridge arch and the Central Kansas uplift remained high after post-Mississippian uplift and with the Sierra Grande and Siouzia uplifts, served as source areas as the Hugoton embayment to the southwest continued to downwarp while the Morrowan seas served as a medium of deposition. Source areas in Colorado remained low until the end of Morrowan time when regional movement caused the Sierra Grande uplift, the Wet Mountains and the Front Range to be implaced (Merriam, 1955) and served as source areas for the remainder of Pennsylvanian time. The seas remained through the Atokan period as sediments were added to the southwest in the area of the Hugoton embayment. The Atokan seas withdrew and a period of erosion took place. The Desmoinesian sea then transgressed and inundated the Cambridge arch and the Central Kansas uplift depositing the basal Pennsylvanian conglomerate in its wake. That these positive areas were topographically high is evidenced by early Desmoinesian sediments abutting against the uplifted areas.

Missourian seas then appeared and the Lansing-Kansas City group was deposited representing cyclic deposits resulting from a fluctuating sea level causing repetitious advance and withdrawals of the sea. By the end of Missourian time the Cambridge arch and Central Kansas uplift were completely blanketed by a veneer of sediments and no longer served as source areas while only the crests of the Sierra Grande and Siouzia uplifts remained exposed and subject to erosion (Merriam, 1955). Missourian seas retreated and Lansing-Kansas City rocks were subjected to erosion.

Virgilian seas invaded the area and cyclic deposition took place for the remainder of Pennsylvanian time. By the end of Virgilian time the Sierra Grande and Siouxia uplifts were completely buried. The Hugoton embayment which had been downwarped and receiving deposits during the Paleozoic, accumulated locally 3,600 feet of sediments by the close of the Pennsylvanian period which marked the climax of its development (Merriam, 1955).

During early Permian time, conditions remained much the same as in late Pennsylvanian with the seas again advancing depositing chiefly marine alternating fossiliferous limestones and shales. By the middle of the Permian, the Wichita mountain system began to restrict the advancement of the Permian seas from west Texas and the environment became more and more saline. By Leonardian time the shallow seas and sluggish streams in Kansas were depositing evaporites and nonfossiliferous clastics (Moore, et al., 1951). The Permian period closed with retreating seas followed by a period of erosion during which structural movement occurred.

Mesozoic Era

The dawn of the Mesozoic era saw widespread subaerial erosion across most of Kansas during the Triassic while continental deposits comprising the Dockum group were accumulating locally in the southwestern Kansas area. During Jurassic time, western Kansas was tilted northwestward into the Denver basin and within this period the Morrison formation was deposited. The Cambridge arch was topographically high at the beginning of the Jurassic period but became buried by late Morrison deposits as the

sediments, which extend from a featheredge in Phillips County, thicken to the west as a result of westerly tilting (Merriam and Atkinson, 1955). These non-marine deposits originated from the east and southeast and were deposited by sluggish streams and shallow lakes.

A period of extensive erosion took place between Jurassic and Cretaceous time and the area was tilted southward. Shallow Cretaceous seas advanced and deposition took place. The Dakota formation was suggested by Plummer and Romary (1947) as being a shallow sea shoreline deposit. The seas advanced further and marine limestone and shales were deposited.

Some minor structural movement took place on the southeastern end of the Cambridge arch during Cretaceous time although it is possible that differential compaction of Cretaceous rocks is the cause for the irregularities. Post-Cretaceous orogenic folding is thought to correspond with the Laramide revolution in the Rocky Mountain region.

Cenozoic Era

After the close of Oligocene time the Rocky Mountains were re-elevated during the Cascadian revolution and rejuvenated streams flowed out across the great plains resulting in the deposition of the Ogallala formation in eastern Colorado and western Kansas during the Pliocene epoch. That the mountain area was uplifted considerably is evidenced by the coarse clastic material comprising the Ogallala deposits. The remainder of the Cenozoic deposits were also continental in origin being deposited by streams and

wind. After deposition of the "Algal limestone" which caps the Ogallala formation the area was tilted toward the east and the area assumed its present configuration of gentle monoclinal dip.

HISTORY OF DRILLING IN NORTON COUNTY

In June, 1939, the first area to be officially designated an oil pool in Norton County was a well completed with shows of oil at two depths in the Lansing-Kansas City zone on the Van Patton farm in sec. 26, T. 4 S., R. 21 W (Ver Weibe, 1942). Although this pool never produced commercial quantities of oil and was later abandoned, it nevertheless served as a stimulus to increased drilling interest in the area. During 1941, eleven test holes were drilled and the Hewitt pool, located in sec. 11, T. 4 S., R. 21 W, was discovered. The well was rated at 272 barrels per day of oil and produced from a depth of 3394 to 3401 feet in the Lansing-Kansas City zone. However, the well produced for only a few years and finally was abandoned in 1950 with its cumulative production standing at 32,054 barrels (Ver Weibe, et al., 1951).

Although the Ray pool was discovered in Phillips county in 1940, increased drilling extended its boundary into southeastern Norton County in secs. 24 and 35, T. 5 S, R. 21 W. This important discovery produces from three separate horizons: the Lansing-Kansas City, the Arbuckle and the Reagan. The Ray West pool was discovered in 1945 in sec. 25, T. 5 S., R. 21 W, and produces from the Arbuckle group.

Drilling continued at a slow rate for the next few years with no important discoveries being made except new wells being

completed in the Ray and Ray West pools spasmodically. By the end of 1952, the combined total of producing wells for the county from two pools was ten. With 1953 came the discovery of two new oil pools, one a very important discovery, named the Norton pool. The field was initiated in May by Jones, Shelburne and Farmer on the Lawson farm in sec. 36, T. 3 S, R. 24 W and produced with an assigned initial potential of 200 barrels per day from the Arbuckle zone at a depth from 3778 to 3790 feet. By the end of the year, 30 wells were pumping with all production being taken from the Arbuckle in an area of 1500 acres with 41,694 barrels being recorded. That same year the Ray Northwest pool was discovered in sec. 22, T. 5 S, R. 21 W and produced from a thin zone in the Arbuckle. In 1954 production for the county was more than seven times that of the previous year with 76 new wells being completed in the Norton pool extending its proved acreage to around 1750 acres. During the year oil was found to exist in the Reagan sandstone and it became an important reservoir. Drilling interest in the county was greatly augmented as attested by 44 dry holes being drilled, 33 of which were wildcats. The Ray North pool was initiated also that year but was abandoned later in the year because of lack of commercial production.

The drilling pace slacked off in 1955 with 12 new wells being opened in the Norton field and 22 wildcats being reported although the county reached its highest production mark with a record of over a million barrels for the year. Production as well as drilling activity declined the following year with a

cumulative production figure for the county standing at 3,196,518 barrels from five fields, 2,544,353 barrels or about 80% of the total being represented by the Norton pool.

So far in 1957, one pool discovery has been made. The Densmore pool was located in sec. 12, T. 5 S., R. 22 W., on the Archer farm near Densmore. At present two wells are producing from the Reagan sandstone. No production figures have been obtained on this recent field.

Recent increased drilling activity is occurring in the southeastern tip of the county associated with the Ray and Ray West pools as additional Arbuckle and Reagan discoveries are extending these fields farther to the west.

RELATION OF PRODUCTION TO STRUCTURE AND STRATIGRAPHY

Lansing-Kansas City Production

The relation of Lansing-Kansas City production to structure is depicted in Fig. 7, Appendix. All Lansing-Kansas City production in Norton County is or was from small anticlinal or nosing structures of less than 20 feet closure in the southeastern part of the county. The Ray pool is the only field in the county currently producing from this zone and is situated as a structural high associated with the Central Kansas uplift. The abandoned Van Patton and Hewitt pools produced from small structural uplifts as described above that were probably formed by differential compaction of the Pennsylvanian and overlying Permian strata. Although the configuration of the contours depicting the Lansing

surface indicates the presence of the Cambridge arch structurally in Norton County by regional southeastward dip there are no closed anticlinal structures indicated on the arch at this horizon.

Arbuckle and Reagan Production

Generally Arbuckle producing fields have shown little relation to structure (Fig. 6, Appendix). The Cambridge arch has a structural relief of about 100 feet and is well defined on the pre-Cambrian and Arbuckle maps as they display local structural noses and re-entrants on the flanks of the arch. (Figs. 5 and 6, Appendix). The Norton pool, located on the western flank of the Cambridge arch, shows that the producing horizons, the Arbuckle and the Reagan, are situated as a wedge between the underlying pre-Cambrian crystalline rocks and the capping Pennsylvanian beds, and the trap was formed by a combination of truncation and overlap, change in porosity of the reservoir beds, and structure (Merriam and Goebel, 1954). The deeply eroded Arbuckle fields in the Central Kansas uplift area are similar to the Norton field as might be expected from the parallel development of the two positive structures. The Reagan sandstone probably occurred as a sheet deposit and is generally present beneath the Arbuckle on the flanks of the Cambridge arch and also occurs higher on the flanks of the arch generally than does the Arbuckle. The Densmore pool produces from the Reagan on the flank of the northwestern end of the Central Kansas uplift as it wedges out against the pre-Cambrian granite and is capped by the Pennsylvanian sediments.

DISCUSSION AND CONCLUSIONS

Locally many small Lansing-Kansas City pools occur on small anticlinal structures and the possibility of new discoveries in this capacity are very likely. More important is the possibility of Arbuckle and Reagan pools occurring along the pinch-out zone on the flanks of the Cambridge arch and the northwestern end of the Central Kansas uplift in southeastern Norton County. Although the Reagan does not appear continuously its pattern nevertheless has a marked degree of continuity as to occurrence along the flanks of the uplifted areas as is testified by production from this zone in the recently discovered Norton pool and more recently, the Densmore pool. As shows of oil have been reported in wells along the flanks of the Cambridge arch, particularly the eastern flank, it is the writer's opinion that the possibility of petroleum accumulation is ever present in traps of the nature of the Norton pool which is located in a re-entrant of the flank of the uplifted zone of the arch. Drilling has not been prolific enough to predict the exact position of this pinchout zone where petroleum accumulation is expected. A particular area of good potentiality is the exact location of the re-entrant on the eastern flank of the arch in the area of Townships 1 and 2 S., Ranges 24 and 25 W (Figs. 5 and 6, Appendix) where the two re-entrants of the pinchout zone of the Arbuckle converge. In this area, there is the possibility that a structural saddle exists across the crest of the arch.

Norton County is still a relatively virgin area from the standpoint of petroleum exploration. Production is chiefly from

stratigraphic trapping of oil in the pinchout zone of the Arbuckle and the Reagan over the pre-Cambrian rocks of the Cambridge arch and the Central Kansas uplift and is capped by the Pennsylvanian unconformity. The Norton pool produces from this type of reservoir. It is the only major oil field within the county and its areal extent was quickly realized as the field was developed very rapidly. Minor petroleum accumulation occurs in Lansing-Kansas City rocks in small anticlinal structures of low relief in the southeastern part of the county. There is no production from anticlinal structures on the crest of the Cambridge arch in Norton County as contrasted with production of this type from the Central Kansas uplift and the Jennings anticline, the latter located in the adjacent county to the west. At present, exploration is taking place at a moderate pace in the county and is affected directly by local discoveries. As the overall potentiality of the area is good, although the chance of discovering large pools has been diminished, predominantly the smaller companies and local independent concerns will no doubt continue exploration while some major oil companies will probably retain checkerboard leases until areas are proven barren.

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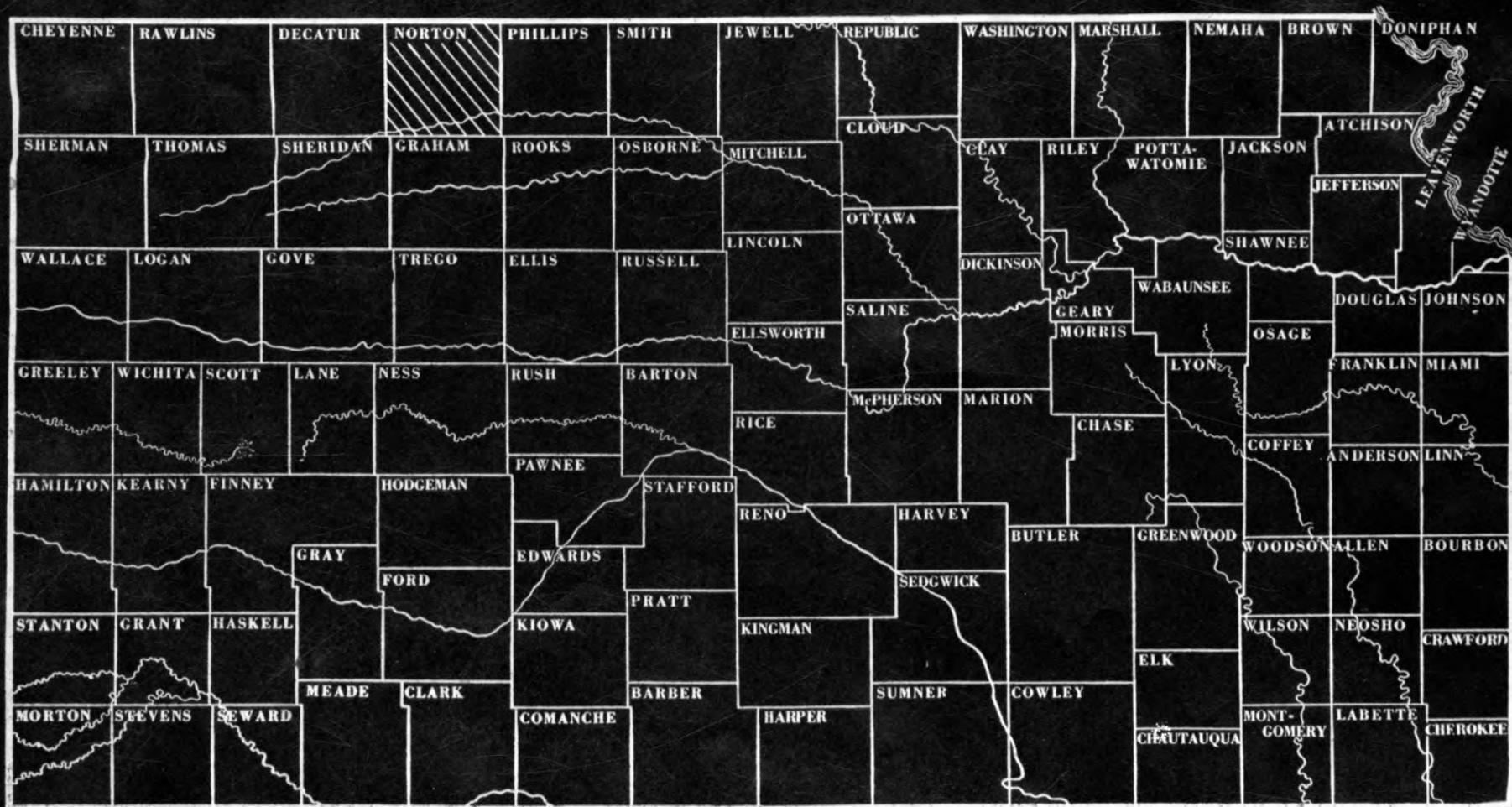
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APPENDIX

Table 1. Oil Production in Norton County, Kansas, to January 1, 1956.

Pool and location of Discovery Well	Discovery Year	Area :Acres	Depth :Feet	Producing : Zone	No. :Wells	Production. bbl.	
						1956	Cumulative
Norton 36-3-24W	1953	2,180	3,778	Arbuckle Reagan	117	853,816	2,549,353
Ray* 32-5-20W	1940	340	3,297 3,575 3,540	Lans.-K.C. Arbuckle Reagan	5	34,907	391,050
Ray North 13-5-21W	1954		3,544	Arbuckle		no report	none
Ray Northwest 22-5-21W	1953	80	3,605	Arbuckle	2	6,775	21,254
Ray West 26-5-21W	1945	200	3,650	Arbuckle	7	24,209	202,807
Hewitt (abandoned) 11-4-21W	1941	40	3,404	Lans.-K.C.	1	none	32,054
Van Patten (abandoned)	1939		3,475 3,487	Lans.-K.C. " "		none	none
Densmore 12-5-22W	1957	80	3,543	Reagan	2	no report yet	

*Also located in adjacent county or counties.



Area covered by this report

Fig. 1. Map of Kansas showing the location of Norton County.

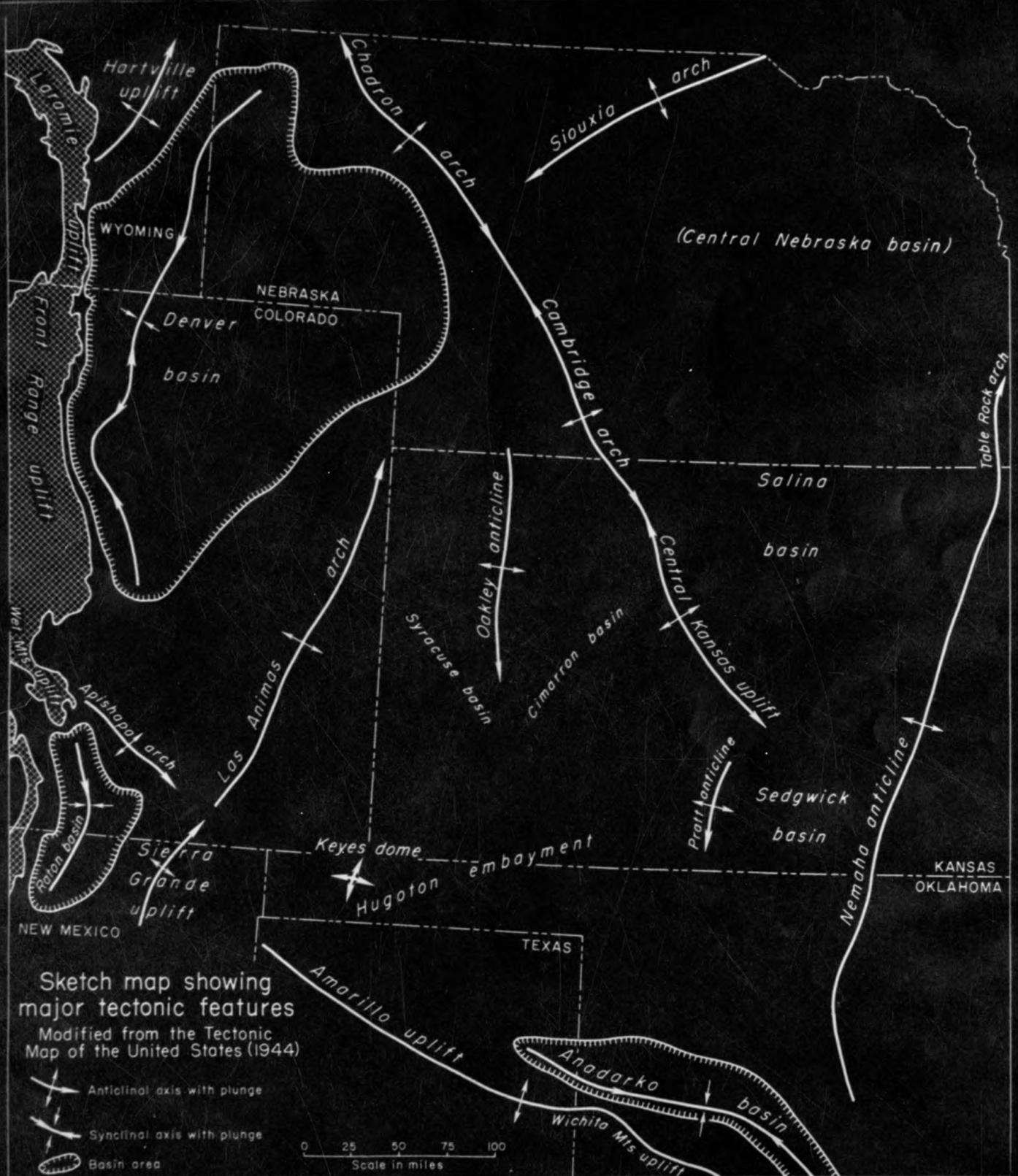


Fig. 2. Regional geographic distribution of major tectonic features.

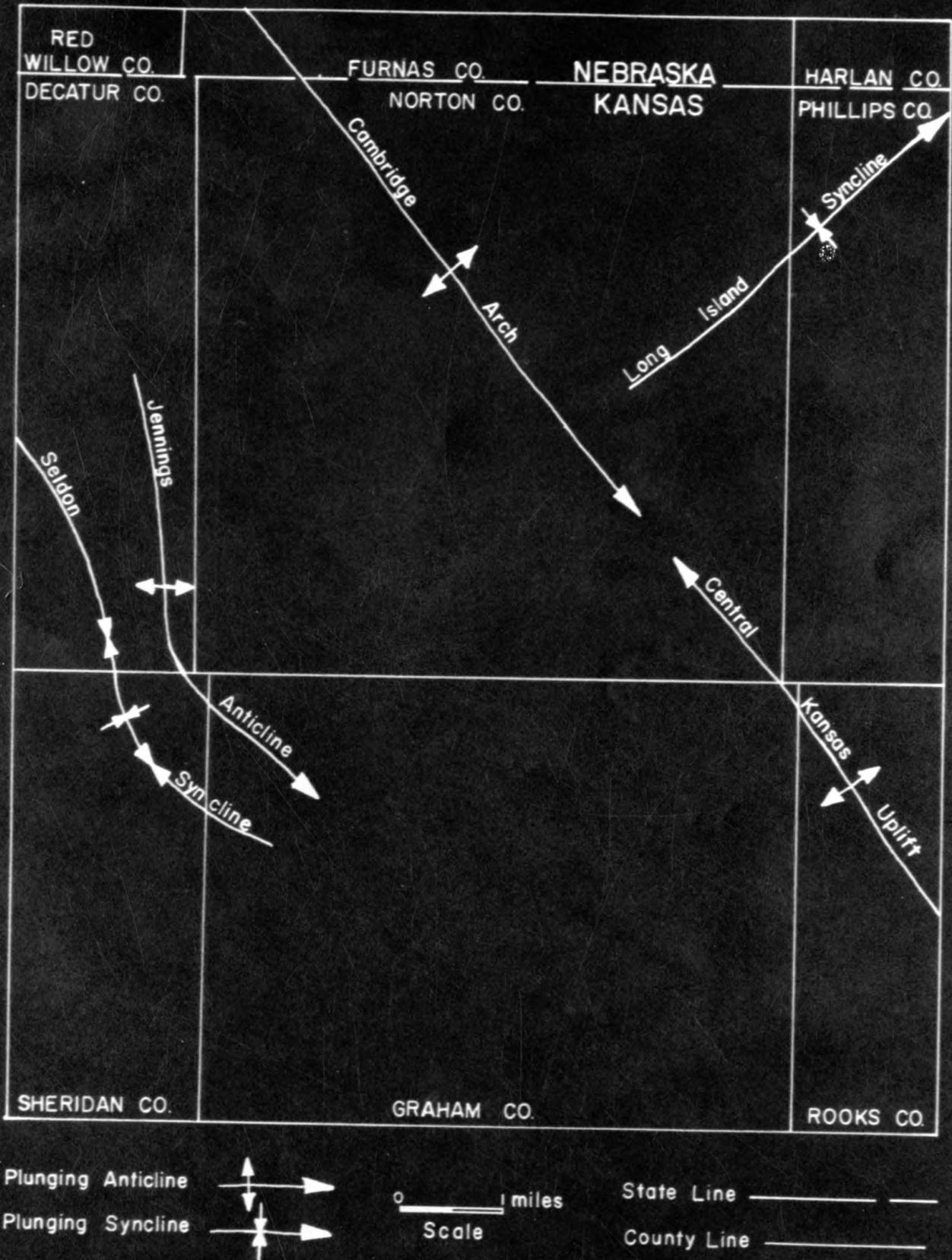
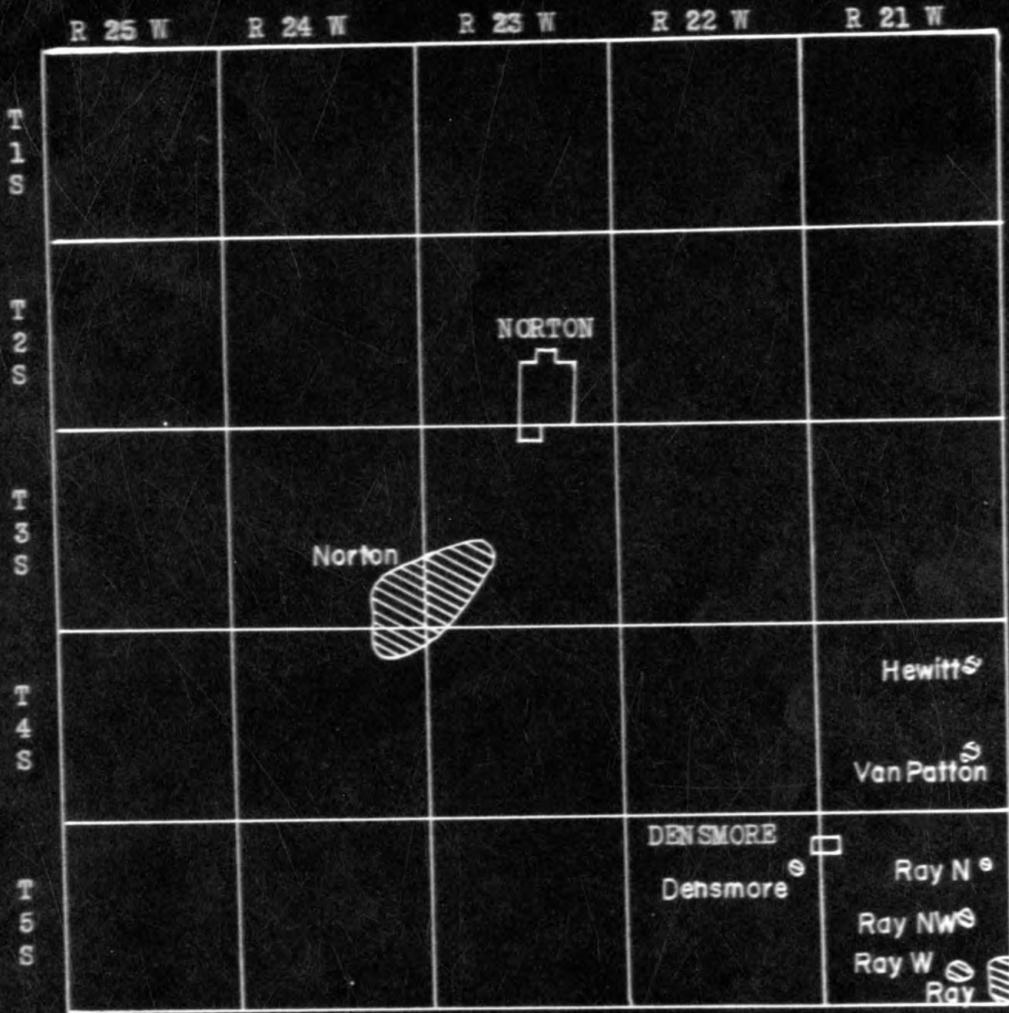


Fig. 3. Map of Norton County and adjacent areas showing local major structural features.



EXPLANATION

Oil field

Abandoned oil field



0 6 Miles

Scale

Fig. 4. Map of Norton County showing the location of oil pools.

Fig. 5. Structural contour map on top of the
pre-Cambrian in Norton County.

(in accompanying plate box)

R 25 W

R 24 W

R 23 W

R 22 W

R 21 W

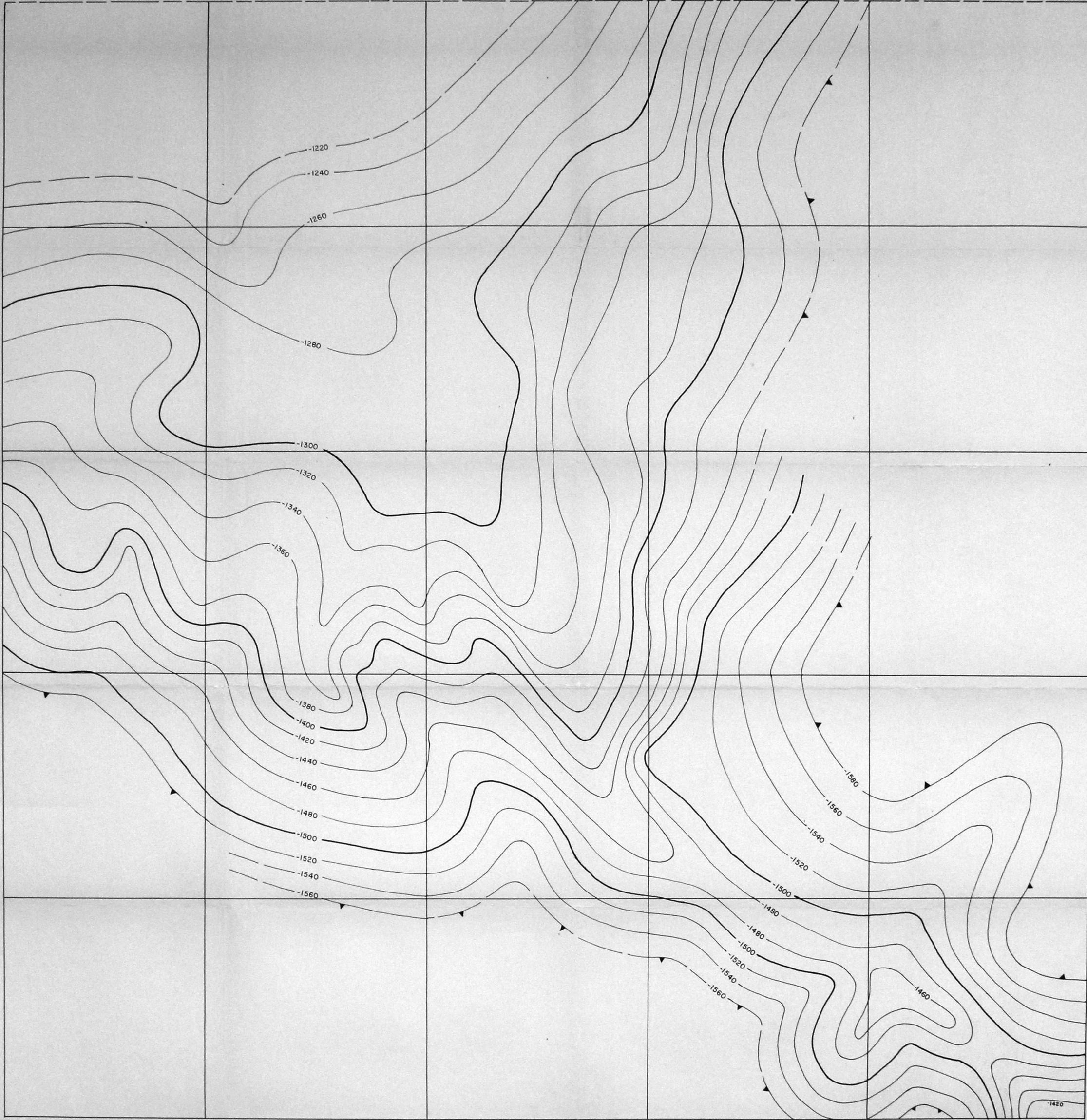
T 1 S

T 2 S

T 3 S

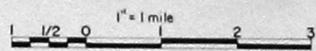
T 4 S

T 5 S



STRUCTURAL CONTOUR MAP ON TOP OF PRE-CAMBRIAN, NORTON COUNTY, KANSAS

STATE LINE ———
 COUNTY LINE ———
 TOWNSHIP LINE ———



Scale in Miles
 January 1958
 Benton L. Tibbetts

CONTOUR INTERVAL = 20 FEET
 DATUM PLANE = SEA LEVEL
 CONTOUR LINE ———

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Fig 5

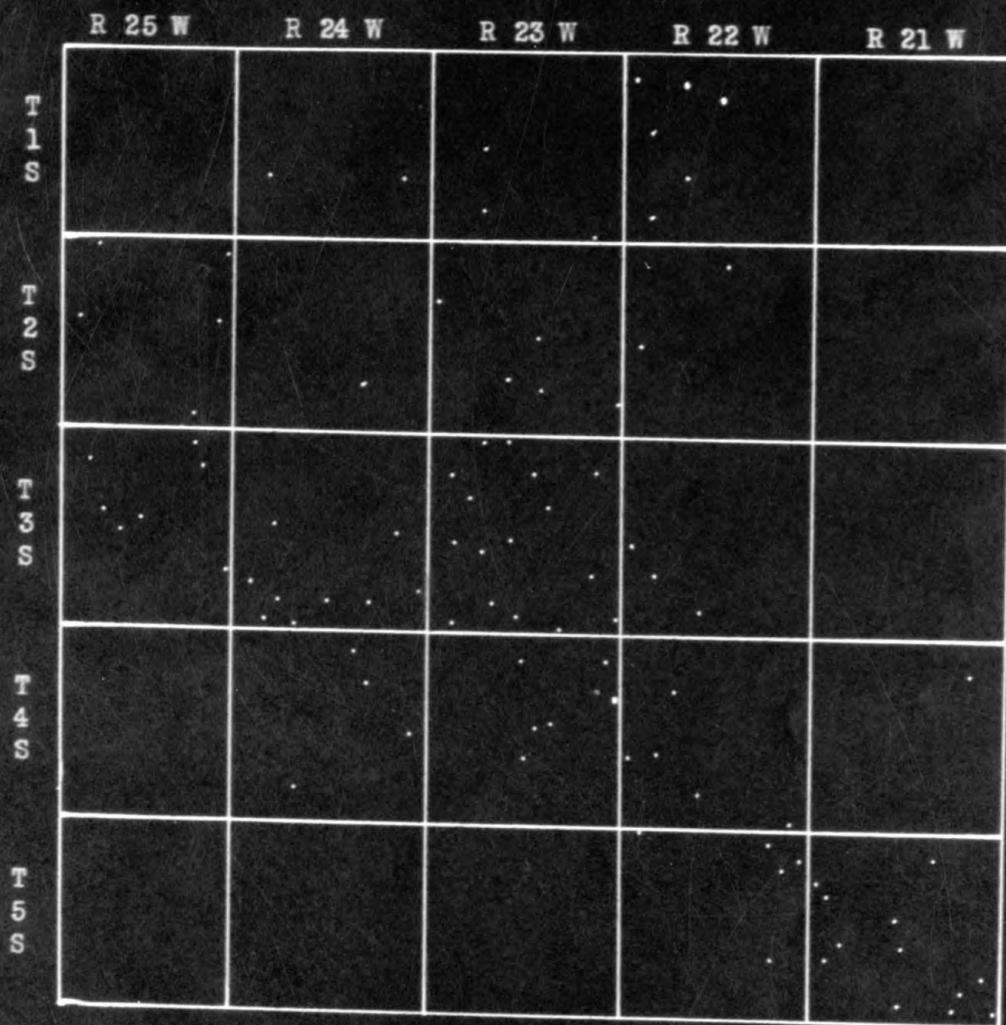


Fig. 5A. Map of Norton County showing the location of subsurface control points used to construct the pre-Cambrian structural map.

Fig. 6. Structural contour map on top of the
Arbuckle in Norton County.

(in accompanying plate box)

R 25 W

R 24 W

R 23 W

R 22 W

R 21 W

T 1 S

C A M B R I D G E

T 2 S

T 3 S

T 4 S

T 5 S

A R C H

CENTRAL

KANSAS

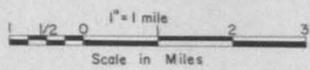
UPLIFT

STRUCTURAL CONTOUR MAP ON TOP OF ARBUCKLE, NORTON COUNTY, KANSAS

STATE LINE 

COUNTY LINE 

TOWNSHIP LINE 



January 1958

Benton L. Tibbetts

CONTOUR INTERVAL = 20 FEET

DATUM PLANE = SEA LEVEL

CONTOUR LINE 

Fig 6

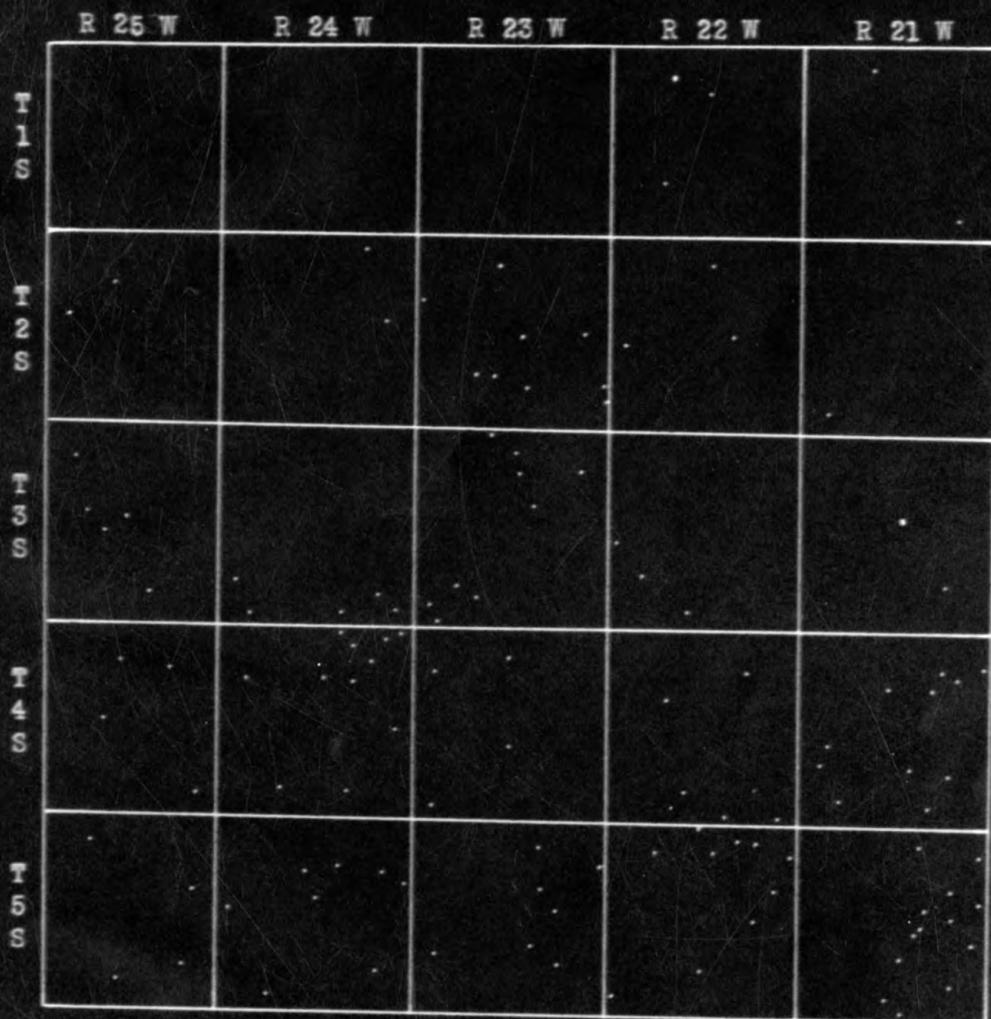


Fig. 6A. Map of Norton County showing the location of subsurface control points used to construct the Arbuckle structural map.

**Fig. 7. Structural contour map on top of Lansing
in Norton County.**

(in accompanying plate box)

R 25 W

R 24 W

R 23 W

R 22 W

R 21 W

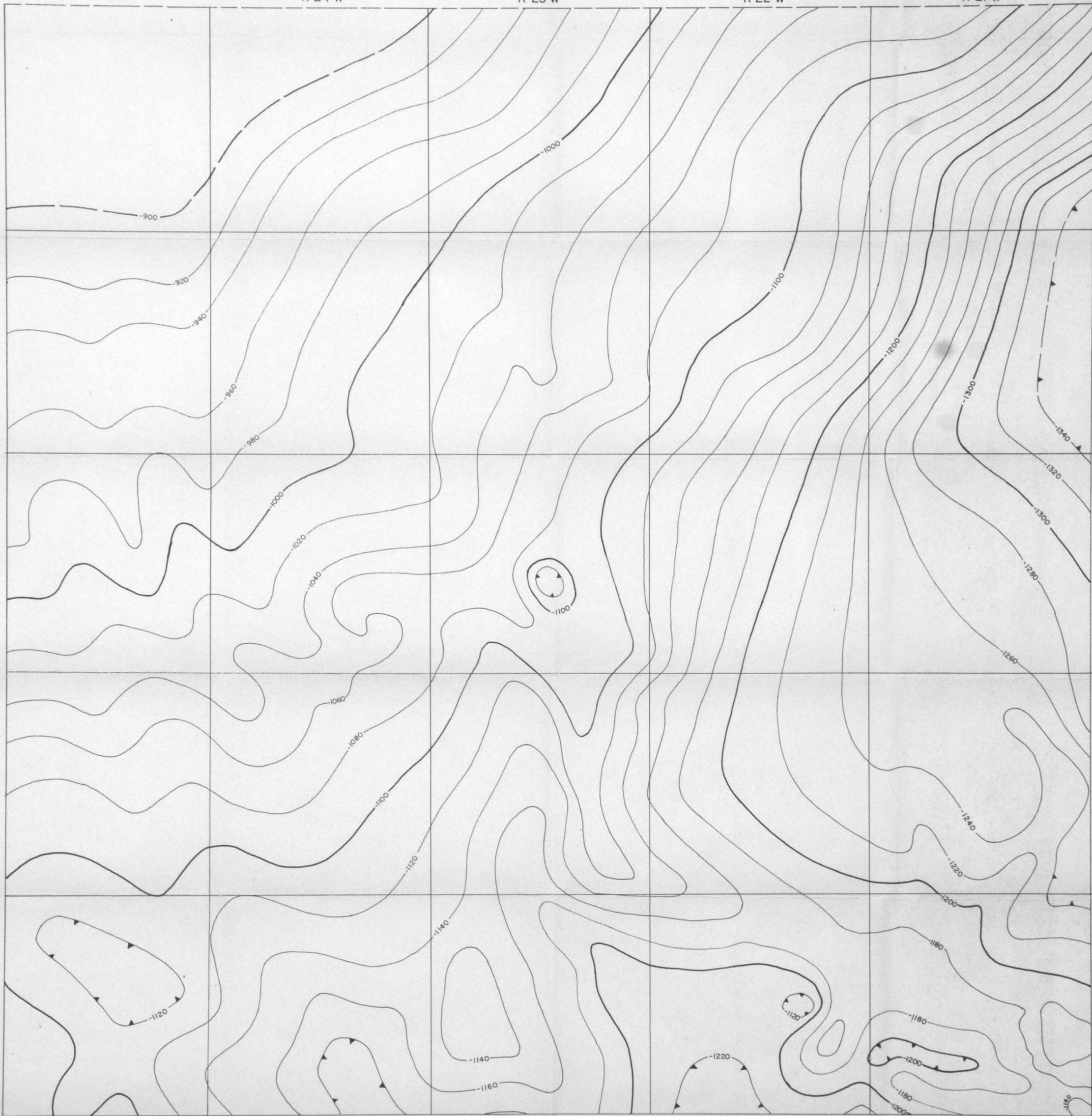
T 1 S

T 2 S

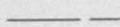
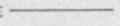
T 3 S

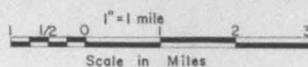
T 4 S

T 5 S



STRUCTURAL CONTOUR MAP ON TOP OF LANSING, NORTON COUNTY, KANSAS

STATE LINE 
 COUNTY LINE 
 TOWNSHIP LINE 



January 1958
 Benton L. Tibbetts

CONTOUR INTERVAL = 20 FEET
 DATUM PLANE = SEA LEVEL
 CONTOUR LINE 

Fig 7

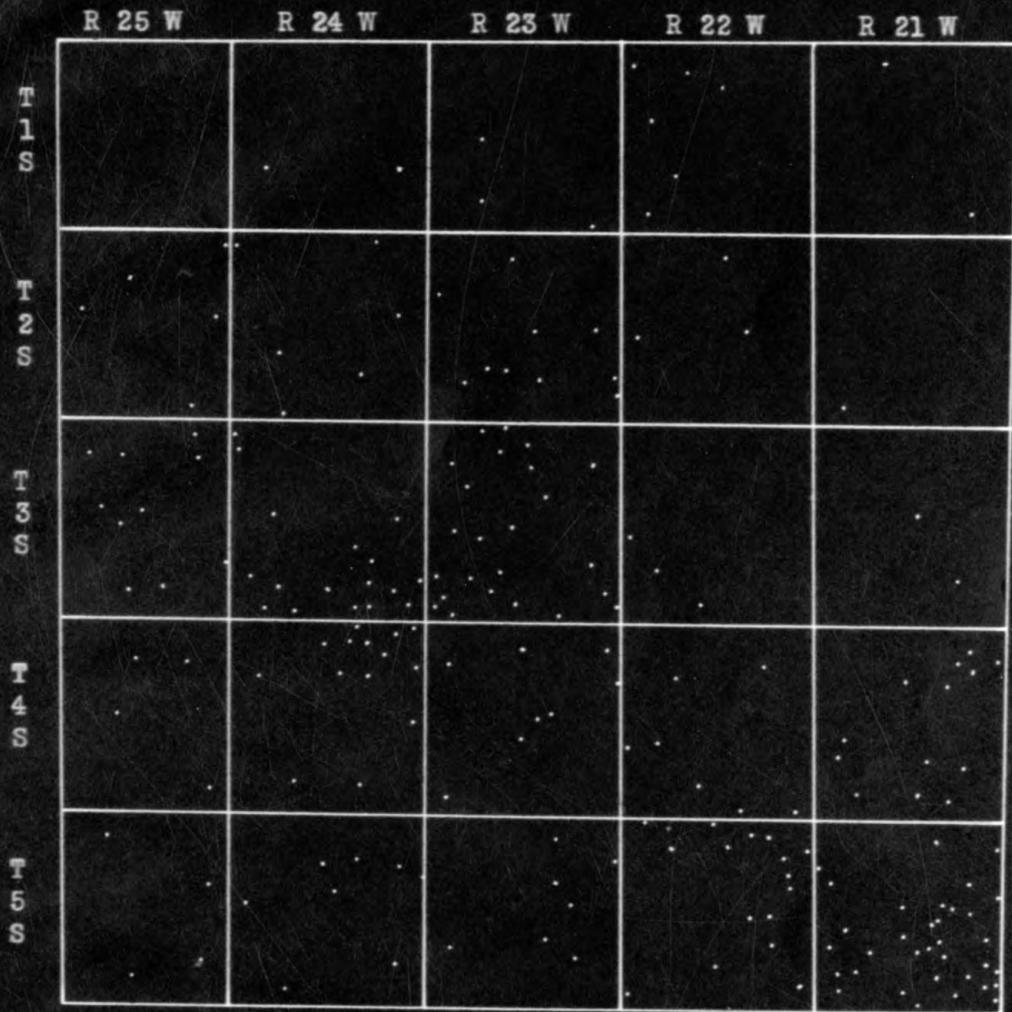


Fig. 7A. Map of Norton County showing the location of subsurface control points used to construct the Lansing structural map.

Fig. 8. Isopachous map of the interval between the top of the Lansing and the top of the Arbuckle in Norton County.

(in accompanying plate box)

R 25 W

R 24 W

R 23 W

R 22 W

R 21 W

T 1 S

T 2 S

T 3 S

T 4 S

T 5 S

C A M B R I D G E

A R C H

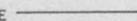
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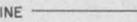
KANSAS

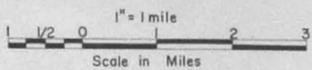
UPLIFT

ISOPACHUS MAP FROM THE LANSING TO THE ARBUCKLE, NORTON COUNTY, KANSAS

STATE LINE 

COUNTY LINE 

TOWNSHIP LINE 



January 1958

Benton L. Tibbetts

CONTOUR INTERVAL = 20 FEET

DATUM PLANE = SEA LEVEL

CONTOUR LINE 

*Fig 8
Tibbetts*

Fig 8

SUBSURFACE GEOLOGY OF NORTON COUNTY, KANSAS

by

BENTON LAWRENCE TIBBETTS

B. S., Kansas State College
of Agriculture and Applied Science, 1955

AN ABSTRACT OF A THESIS

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1958

Norton County is located in northwestern Kansas adjacent to the Nebraska State line four counties from the Colorado State line. In this study, it was the writer's purpose to attempt to relate the stratigraphy, structure and geologic history to petroleum accumulation with particular emphasis placed on studying the area of the zone of pinchout of the Arbuckle group and Reagan sandstone against the Cambridge arch. Structural maps and an isopachus map were constructed to depict the structural and stratigraphic distribution of the rocks in the county and to relate them to petroleum accumulation. Although subsurface control was a limiting factor the relationship of the units mapped was best shown using a contour interval common to all maps to facilitate rapid and concise interpretation.

A thin veneer of sediments blanket the pre-Cambrian surface in the county. Test wells have been drilled to depths of, from 3,600 to 4,000 feet, however, the exact thickness of the Arbuckle in the basin areas flanking the locally prominent Cambridge arch is unknown as the beds thicken relatively sharply off the arch and no wells have penetrated the entire thickness in these areas. Rock units are present from the pre-Cambrian to the Quaternary with the exception of Silurian, Devonian, Mississippian and Triassic sequences.

Structurally, Norton County is located on the southeastern terminus of the Cambridge arch and the northwestern terminus of the Central Kansas uplift. A low structural saddle separates these positive elements in the southeastern part of the county.

Three local major structures lie partially within or adjacent to Norton County and represent segments of larger tectonic features: the Long Island syncline, located in eastern Norton County plunges northeastwardly into the Salina basin; the Seldon syncline, located in the southwestern extremity of the county, plunges to the northwest into the West Kansas basin which in turn represents an arm of the Denver basin to the west; and the Jennings anticline, located in the adjacent county to the west, is no doubt related structurally to the Cambridge arch.

The principle producing horizon is the Arbuckle group but the Reagan sandstone is rapidly gaining stature in this capacity. Petroleum accumulation from these two zones occurs in traps formed where the zones wedge out against the Cambridge arch and the Central Kansas uplift and are capped by Pennsylvanian sediments. Erosional zones developed in these horizons principally in post-Ordovician and post-Mississippian time. Minor amounts of oil are being produced from the Lansing-Kansas City zone where accumulation occurs in small anticlinal or noseing structures probably formed by differential compaction of Pennsylvanian and overlying Permian sediments.

The first production recorded in the county was from the Lansing-Kansas City group in 1941 but commercial amounts of production were soon depleted. Exploration increased in the area of the Cambridge arch and the county saw its zenith of drilling activity in 1954. Most of this activity was centered around the Norton pool which was responsible for the county recording its maximum production figure of over a million barrels the following

year. However, 1956 production and new test well figures both showed a decline as a direct result of the rapid development of the Norton pool. Despite this decline, the future potential of the county is very good, particularly in the zone of pinchout of the Arbuckle and Reagan against the Cambridge arch.