SUBSURFACE GEOLOGY OF NORTHWESTERN KANSAS

by

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

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

1956

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INTRODUCTION AND REVIEW OF LITERATURE

Purpose of Investigation

The purpose of this work was to determine the relationship between structure, stratigraphy, geologic history, and petroleum accumulation in northwestern Kansas.

Location and Physiography

Northwestern Kansas includes nine counties in the northwest corner of the state (Fig. 1, Appendix). The area includes townships 1 through 15 south, and ranges 26 through 42 west. The area is bordered on the north by the state of Nebraska, on the west by the state of Colorado, on the south by Greeley, Wichita, Scott, Lane, and Ness counties, Kansas and on the east by Norton, Graham, and Trego counties, Kansas.

The area is characterized by gently undulating upland plains broken by shallow valleys, and deeply disected areas along the stream and river valleys along the north, east, and south flanks of northwestern Kansas (Moore and Landes, 1937). The area lies entirely within the area of the High Plains section of the Great Plains physiographic province. The northern half of the area is drained by streams flowing northeast into the Republican River. The southern half of the area is drained by streams flowing south and southeast into the Smokey Hill River. Many of the streams originate in Sherman, Thomas and Sheridan counties.

Procedure

The stratigraphy and lithology of the rock units in northwestern Kansas were reviewed by the binocular examination of well cuttings from Keller No. 1, Sec. 19, T. 9 S., R. 32 W., Thomas county and Wessel No. 1, Sec. 27, T. 6 S., R. 29 W., Sheridan county. Stratigraphic variation of the Paleozoic rocks was determined by the construction of cross sections from Cheyenne to Decatur county, from Decatur to Wallace county and from Decatur to Gove county. Electric logs were used to construct the cross sections.

The Lansing-Kansas City group and the Mississippian limestone were selected to be mapped because of their structural and stratigraphic significance. The tops of both rock units are easily recognized in well samples and on electric logs. The tops are usually reported by the Herndon Map Service, drillers' logs and scout tops. The Lansing and Mississippian surfaces were formerly flat due to the period of erosion which followed the deposition of each rock unit. Both rock units are widely distributed and are major producers in northwestern Kansas.

The structure maps on top of the Lansing-Kansas City group and the Mississippian limestone were contoured using an interval of 50 feet because of the limited subsurface control points. A structure map on top of the Lansing-Kansas City group was constructed of Decatur county and T. 6 S., Sheridan county using a contour interval of 20 feet. This map was constructed to show the relationship of petroleum accumulation to the structure along the southwest flank of the Cambridge arch. An isopachous map was constructed of northwestern Kansas to show the relationship of petroleum accumulation to the interval between the top of the Lansing-Kansas City group and the top of the Mississippian limestone. Information used in constructing the maps was obtained from the Herndon Map Service, State Geologic Survey of Kansas and the Kansas Sample Log Service. Figures 6, 7, and 8 (Appendix) show the subsurface control points used for contouring.

Previous Work

Darton (1905) reported on the geology and water resources of the central Great Plains which included northwestern Kansas. A more detailed report was published by Darton (1918) on the structure of parts of the central Great Plains. Bass (1926) discussed the structure of the Dakota sandstone of western Kansas. Reports on individual counties in northwestern Kansas were published by Elias (1931, 1937), Landes and Keroher (1939), Frye (1945), Prescott (1952, 1953) and Bayne (1956).

Work on structure and structural development in adjoining areas was done by Koster (1935), Collins (1947), Maher (1945, 1953), Maher and Collins (1953), Lee (1953), and Mc Coy (1953). Lee and Merriam (1954) published regional maps of western Kansas showing the structure of the upper Permian and Cretaceous rocks. The Cenozoic of western Kansas was discussed in a paper by Merriam and Frye (1954). The tectonic history of the Cambridge arch was covered by Merriam and Atkinson (1955). Merriam (1955) reviewed the structural development of the Hugoton embayment. Merriam and Goebel (1956) published a report on Kansas structural provinces.

STRATIGRAPHY

Tertiary and Quaternary Systems

Quarternary sediments consist of recent alluvium and terrace deposits along present or recently eroded valleys. Pleistocene sediments of gravel, sand, silt, and clay form the upland deposits. The Maximum thickness is 250 feet. The Ogallala formation which forms the greater part of the Tertiary rocks consists of sand, gravel, silt, volcanic ash, and limestone. The Algal limestone caps the Ogallala formation (Merriam and Frye, 1954). Tertiary sediments are generally less than 300 feet in thickness and lie unconformable on older rocks.

Cretaceous System

The Cretaceous rocks are calcareous shales, chalky limestones and sandstones. The Cretaceous system is divided into the Gulfian (upper) series and the Comanchean (lower) series. The average thickness of the Cretaceous rocks is 2,750 feet.

Gulfian Series. Montana Group. The Pierre shale is the basal formation of the Montana group. The Pierre formation consists of gray to black, laminated shale and averages 1200 feet in thickness. The Pierre shale crops out along the deeper stream valleys (Elias, 1931).

Colorado Group. The Colorado group is divided into the Niobrara formation, Carlile shale, Greenhorn limestone, Graneros shale, and the Dakota formation. The Niobrara formation is divided into two members: the Smokey Hill shalk (upper), a grayish white, chalky limestone and shale, and the Fort Hays limestone (lower), a light gray, chalky limestone. The Niobrara is exposed along the Smokey Hill River valley (Landes and Keroher, 1939). The Carlile shale is divided into an upper member, the Blue Hill shale, a dark gray calcareous shale and a lower member, the Fairport shale, a bluish black, non-calcareous shale. The Greenhorn limestone consists of chalky limestone and shale ranging in color from white to gray. The Fencepost limestone near the top of the formation gives the most characteristic electric log peak in the section. Its representation on electric logs is so distinctive that it can be recognized in Colorado, Nebraska, and Wyoming (Lee and Merriam, 1954). The Graneros shale is gray fissile, pyritic, and silty. The Graneros contact is not clearly recognized in well samples, but is clearly defined on electric logs. The Dakota formation is non-marine and consists mainly of clay and sandstone. Approximately three-fourths of the Dakota formation is clay at the outcrop area (Plummer and Romary, 1947). The sandstone is white, gray, or red in color and contains pyrite, siderite, limonite and other iron minerals. The well cuttings of the Dakota formation are predominantly sand and iron minerals as the clay was carried away with the drilling fluid.

<u>Comanchean Series</u>. The Comanchean series is divided into

the Kiowa shale, a gray, fissile shale, and the Cheyenne sandstone, a fine to coarse-grained, red or tan sandstone. This series is usually included with the Dakota formation because of the similar lithology.

Jurassic System

The Morrison formation of Jurassic age occurs only in the subsurface of northwestern Kansas (Lee and Merriam, 1954). The Morrison formation consists of varicolored shale with some limestone, anhydrite, and chert. The top is marked by sandy shales which are predominantly green in color. A persistent zone of cherty shales are present near the center of the formation. The chert is pink and translucent. An unconformity at the base of the Morrison formation marks the top of the Permian system.

Permian System

The upper part of the Permian section is composed of red shale, siltstone and sand with thin beds of anhydrite, gypsum, and salt. The lower part of the Permian section consists mainly of limestone and dolomite alternating with shale and sandstone. The finer texture and red color of the cementing material differentiate the Permian sands from the overlying formations. The system is represented by the Guadalupian, Leonardian and Wolfcampian series.

<u>Guadalupian Series</u>. Collins (1947) identified the Whitehorse sandstone in the southern part of Logan and Wallace counties.

The sandstone is red, fine grained, and contains thin beds of red shale and anhydrite.

Leonardian Series. Nippewalla Group. The Nippewalla group includes irregular beds of red shale and silty sandstone with lenses of evaporites. The Blaine formation consists of white, pink and red crystalline anhydrite interbedded with maroon shale.

Sumner Group. The Sumner group includes the Stone Corral formation, the Ninnescah shale and the Wellington formation. The Stone Corral formation consists of white to tan crystalline anhydrite. This formation marks the top of the Sumner group. Ease of identification in well cuttings and electric logs makes the Stone Corral formation a valuable subsurface marker bed. The Ninnescah shale consists of red and brown shale interbedded with sand and anhydrite. The upper part of the Wellington formation contains gray and red shale, sandstone, and anhydrite interbedded with dolomite. The lower part of the Wellington formation is predominantly red, fine-grained sandstone.

Wolfcampian Series. Chase Group. The Chase group contains beds of limestone and sandy dolomite alternating with red and green shale. These rocks lose their identity near the Kansas-Colorado state line where they grade into red shale, sandstone and thin beds of dolomite and limestone (Collins, 1947). The top of the Chase group is marked by the Herington limestone. The Herington limestone is a buff to gray dolomitic limestone, and its location directly below the Wellington formation makes it easily identified in well cuttings and electric logs. The Wreford limestone is a light gray, crystalline and cherty limestone. The base of the Wreford limestone marks the top of the underlying Council Grove group.

Council Grove Group. The Council Grove group included beds of light gray, fossiliferous limestones separated by beds of red and green shale. The Foraker limestone formation consists of gray to tan, fossiliferous limestones and gray shales. The base of the Foraker is recognized by gray chert and fusulinids. It marks the base of the Council Grove group.

Admire Group. The Admire group consists of gray to white, chalky, fossiliferous limestones and varicolored shales. The shales decrease in thickness and number near the Kansas-Colorado line (Edson, 1946). The Admire group lies unconformably on Pennsylvanian rocks.

Pennsylvanian System

The Pennsylvanian system is a marine sequence composed of alternating limestones and shales ranging in thickness from 1,000 to 1,500 feet. Rock units of the Virgilian, Missourian and Desmoinesian series are represented.

Virgilian Series. Wabaunsee Group. The Wabaunsee group consists of gray, crystalline, fossiliferous limestones separated by varicolored shales.

Shawnee Group. The Shawnee group consists of cherty, dolomitic limestones interbedded with dark colored shales. The Topeka limestone marks the top of the Shawnee group and is cream-colored, dolomitic and occasionally oolitic. The Heebner shale member near the base of the Oread formation is recognized as an excelent marker marker horizon for well samples and electric or radioactive logs. The Heebner is black, platy, and carbonaceous.

Douglas-Pedee Group. Either or both the Douglas group and the Pedee group may be present. This group of red and green shales and calcareous sandstones serves as an excellent indicator for determining the top of the Lansing group.

Missourian Series. Lansing-Kansas City Group. The Lansing group contains the Stanton and Plattsburg limestones; the underlying Kansas City group contains the Wyandotte, Iola, Drum, Westerville, Block, Dennis, Swope and Hertha limestones. Each of the limestones is separated by a shale formation that rarely exceeds 10 feet in thickness and generally less than 5 feet. The limestones of the Lansing-Kansas City group are oolitic and some of the beds contain pink chert or fine-grained sand. The base of the Kansas City group is easily recognized on electric logs by the characteristic peak of the Hertha limestone.

Pleasanton Group. Rocks between the Hertha limestone and the top of the Marmaton group are assigned to the Pleasanton group. The Pleasanton group is represented by shale and sandy shale from 5 to 40 feet thick. The Pleasanton is missing on the crest of the Cambridge arch probably from non-deposition.

Desmoinesian Series. Marmaton Group. The Marmaton group consists of thin gray shales and fine crystalline limestones containing gray to tan chert. Collins (1947) indicated the top of the Marmaton group at a thin bed of sandstone commonly present at the unconformable contact between the Missourian and Desmoinesian series in western Kansas and eastern Colorado. The lower boundary of the Marmaton group is placed at the base of the Fort Scott limestone which is gray to tan, crystalline, oolitic and fossiliferous. The Fort Scott limestone is not recognized north of Wallace, Logan and Gove counties.

Cherokee Group. The Cherokee group is composed of interbedded, dark-colored, finely crystalline, cherty limestones and black shales. The basal part of the Cherokee group is composed of detrital chert and quartz grains interbedded with varicolored shale. This detrital zone is generally referred to as the Pennsylvanian basal conglomerate. The Cherokee group lies unconformably on Mississippian rocks.

Mississippian System

The Mississippian system consists chiefly of limestones and dolomites, some of which are cherty or oolitic. A major angular unconformity separates the Mississippian rocks from the overlying Pennsylvanian rocks. Mississippian rocks vary in thickness from 0 to 350 feet. The distribution of Mississippian rocks are shown in Fig. 4 (Appendix). The Mississippian system is represented by rock units belonging to the Meramecian, Osagian, and Kinderhookian series.

Meramecian Series. The Ste. Genevieve limestone is light gray, oolitic or sandy and is the uppermost formation in the series. Collins (1947) identified the Ste. Genevieve limestone in Logan county. The St. Louis limestone is cream to tan, finely crystalline, dolomitic and oolitic. The base of the limestone contains chert, glauconite and sand. The Spergan and Warsaw limestones consist of gray, granular, dolomite and coarsely crystalline, oolitic limestone. Glauconite and chert are interbedded throughout the formation.

Osagian Series. The upper limestones of the Osagian series are the Keokuk-Burlington limestones which are referred to as a single formation. The limestones are tan to gray, granular, glauconitic, and very cherty. The chert is white to gray. Drusy quartz grains are also present.

Kinderhookian Series. The Gilmore City formation consists of light tan, crystalline, oolitic, and cherty limestone. The oolites are irregular in size and distribution and the cherts are gray to brown, fossiliferous and opaque. The greatest development of the Gilmore City limestone is in northwest Gove, southeast Thomas, and northeast Logan counties where the thickness is 156 feet (Clair, 1948). Merriam and Atkinson (1955) described a shale underlying the Gilmore City limestone as follows:

> The "Kinderhook" is a green to brown shale that is present locally and is placed in the Mississippian rather than the Devonian as a matter of convenience. It is

possible that this shale is Chattanooga or Boice or equivalent. The Chattanooga shale is thin on the western side of the Central Kansas Uplift and is known to be present farther south. This shale unconformably overlies the Viola limestone.

Ordovician System

The Ordovician system is separated from the Mississippian system by a major unconformity. This system contains two rock units; the Viola limestone and the Simpson group. The distribution of Ordovician rocks is shown in Fig. 4 (Appendix). The Viola limestone consists of gray to tan, fine to medium, crystalline limestone and dolomite. The chert present is white, smooth and subopaque. The thickness varies from 0 to 20 feet. The Simpson group, separated from the Viola limestone by an unconformity, consists of green shale and buff crystalline dolomite containing dense, gray chert. The thickness varies from 0 to 15 feet.

Cambro-Ordovician System

The Cambro-Ordovician system includes rocks which are either or both late Cambrian and early Ordovician in age. The distribution is shown in Fig. 4 (Appendix). Merriam and Atkinson (1955) stated as follows: "It is probable that most of the rocks reported as Arbuckle in western Kansas are or are equivalent to the Bonneterre dolomite, although the Bonneterre is not recognized as part of the Arbuckle group." The Arbuckle group consists of gray to buff, dense, vuggy limestone and dolomite. The chert contained in the limestone is light gray, subopaque and oolitic.

Cambrian System

The Cambrian system is represented by the Lamotte sandstone which marks the base of the Paleozoic rocks and lies unconformably on the Pre-Cambrian surface. The sandstone is composed of white to gray, medium to coarse-grained, angular to subrounded frosted quartz grains. Some of the angular quartz grains seem to be the result of secondary quartz enlargement, as shown by quartz crystal faces and terminations. Considerable arkosic material in the form of kaolinized pebbles of feldspar is present in the basal part of the formation (Keroher and Kirby, 1948). The sandstone may be dolomitic or pyritic and contain traces of glauconite.

Pre-Cambrian Rocks

The Pre-Cambrian rocks were described by Merriam and Atkinson (1955) as follows:

> The Pre-Cambrian is reported as granite, schist, gneiss, and quartzite. The granite is composed of quartz, pink feldspar, and biotite mica and thus could be considered a biotite-bearing granite. A majority of the wells which penetrate the Pre-Cambrian encounter this rock type on the Cambridge arch. Chloritic and micaceous schist were reported from some wells in the southeastern part of T. 3 S., R. 24 W. . . . . The fresh appearing granite or schist is usually overlain by a weathered arkosic zone of reqorked Pre-Cambrian material, referred to as "granite wash".

STRUCTURE

Major Structural Features

Major structural features are structural elements which influenced the geologic history and structural development of northwestern Kansas. Fig. 2 (Appendix) shows the geographic distribution of the major structures.

<u>Sierra Grande Uplift and Siouxian Uplift</u>. The Siouxian uplift and the Sierra Grande uplifts controlled deposition of the pre-Pennsylvanian sediments in eastern Colorado and western Kansas. Mc Coy (1953) constructed an isopachous map of the basal Paleozoic sandstone unit (Upper Cambrian) which includes the Ignacio sandstone of southwestern Colorado, the Sawatch sandstone in central Colorado, the Lodore sandstone in northwestern Colorado, the Deadwood sandstone in eastern Wyoming and southwestern South Dakota, and the Lamotte sandstone in western Kansas which are all lithologic equivalents. This basal sandstone unit varies in thickness from 0 to more than 100 feet in east central Colorado and western Kansas and from 0 to more than 400 feet in western Colorado. Mc Coy interpreted the isopaceous map as follows:

> It indicated the presence of the large positive element, Siouxian, extending across the southern half of South Dakota, western Nebraska, southeastern Wyoming and northeastern Colorado; it also indicated the presence of the large positive element, Sierra Grande, in northern New Mexico and south central Colorado.

<u>Las Animas Arch</u>. The Las Animas arch is an anticlinal feature trending northeast across eastern Colorado and northwestern Kansas. The Las Animas arch originated in post Mississippian

time by regional downwarping which affected the western part of the arch and created the earliest suggestion of an anticlinal structure. Subsidence formed a large basin including the western part of the arch in lower and middle Pennsylvanian time. The arch was clearly defined by the end of Desmoinesian time and the structural relief of the Ordovician beds was 200 feet. The arch was probably accentuated by minor structural adjustments throughout late Pennsylvanian and early Permian time. Erosion truncated the upper Permian beds after regional movement tilted the area eastward. The present structural attitude of the Cretaceous and older rocks indicated considerable movement since the beginning of Mesozoic sedimentation. Structural relief on Ordovician beds is now 750 feet (Maher, 1945).

The Las Animas arch is expressed in northwest Kansas in Cretaceous and older rock units (Fig. 10 and 11, Appendix). The surface of the Dakota formation displays an average northeasterly dip of 20 feet per mile from Hamilton county to northwestern Gove county. The north component of the dip is 16 feet per mile from western Hamilton county to the northwestern corner of Cheyenne county. The northeastern slope of the Dakota formation on the eastern flank of the Las Animas arch, in northwestern Kansas, is terminated by a well developed syncline that follows the margin of the arch (Lee and Merriam, 1954). The trend of the marginal syncline and the eastern edge of the Las Animas arch is shown in Fig. 3 (Appendix).

<u>Ellis Arch</u>. The Ellis arch is a pre- Pennsylvanian structure

trending northeast through northwestern and central Kansas (Jewett, 1951). At the close of the Devonian period the broad Ellis arch was uplifted and erosion exposed the lower Ordovician limestone. The Mississippian sediments covered the greater part of the Ellis arch. Post-Mississippian arching in a northerly direction uplifted the area and erosion removed the Mississippian rocks exposing the older rock units along the crest of the uplift. This uplift was called the Central Kansas uplift by Morgan (Jewett, 1951). The folds that developed parallel with the axis of the Ellis arch trend obliquely across the core of the Central Kansas uplift. The Ellis arch continued eastward as the Chautauqua arch to the Ozark dome during Devonian and Mississippian time and was considered by Eardly (1951) as one of the peninsular extensions of the Transcontinental arch which trended northeast-southwest through the central stable region of North America.

<u>Central Kansas Uplift</u>. The Central Kansas uplift is a northwest-southeast trending anticlinal structure located in central Kansas. The structure was developed by several periods of warping and truncation of the rock units. Warping occurred in post-Algokian, post-Canadian, post-Hunton, early-Pennsylvanian, post-Missourian, and post-Cretaceous time. Depositional thinning toward the north and west affected mainly Cambro-Ordovician and Pennsylvanian strata (Koster, 1935).

<u>Cambridge Arch</u>. The Cambridge arch is a large anticline trending northwest-southeast, located in south central Nebraska

and northwestern Kansas. Most of the structure occurs in Nebraska; however, the southern end of the arch extends into Decatur and Norton counties, Kansas. The arch lies on the same structural axis as the Chautauqua arch and the Central Kansas uplift of Kansas and the Chadron arch of Nebraska. The major periods of development were pre-Cambrian, post-Mississippian, and post-Cretaceous (Merriam and Atkinson, 1955). The Cambridge arch is reflected by contours on the Lansing-Kansas City group in Decatur county, Kansas (Fig. 9, Appendix). Several structural noses plunge southwest along the flanks of the arch. The arch is flanked on the west and southwest by the Selden syncline. The arch is separated from the Central Kansas uplift by a series of small closed synclinal basins located along a larger structural flat area in northern Graham county (Merriam and Atkinson, 1955).

Hugoton Embayment. The Hugoton embayment is located in western Kansas, southwestern Colorado and in the Panhandle of Oklahoma and Texas. The embayment is a northerly shelf-like extension of the Anadarko basin of Oklahoma. The Hugoton embayment is outlined structurally 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 embayment is developed mainly in Paleozoic rocks and is not expressed in Mesozoic and Tertiary beds. In Mesozoic time the Western Kansas basin developed in the area of the

Hugoton embayment. Post-Mesozoic development consisted of epeirogenic movements tilting the area eastward. The structural movements did not alter the shape of the embayment; however, facies and thickness changes occur southward from the shelf area to the geosynclinal conditions in the Anadarko basin. The development of the embayment was dependent on conditions that existed throughout the geologic history of the Anadarko basin (Merriam and Gobel, 1956).

Denver Basin. The Denver basin is a structural basin in eastern Colorado, southeastern Wyoming, western Nebraska, and northwestern Kansas. The basin is outlined structurally on the west by the Wet Mountain uplift and Front Range; on the northwest by the Laramie Range and the Hartville uplift; on the north by the southern flank of the Black Hills; on the east by the Chadron arch and the Las Animas arch; and on the south by the Apishapa arch.

The present structural configuration of the Denver basin is the result of a long series of tectonic adjustments and a regular and continuous succession of changing sedimentary basins from pre-Cambrian time to the present. The evolutionary picture of the Denver basin is one of gradual change from a Paleozoic positive area to a late Mesozoic sedimentary basin which presaged the post- Pierre shale orogenic movements and finally, the present post-Laramide restricted structural basin (Mc Coy, 1953).

Minor Structural Features

The minor structural features are structural elements which are present in northwestern Kansas. Fig. 3 (Appendix) shows the distribution of these features.

Oakley Anticline. The Oakley anticline is a pre-Dakota structure plunging south from Thomas to Finney county. The structural relief of the Oakley anticline was more than 200 feet in Dakota time (Lee and Merriam, 1954). The expression of the Oakley anticline at the horizon of the Stone Corral was cancelled by the post Dakota development of the marginal syncline in areas where the two structural features were in conflict. The marginal syncline was active during upper Cretaceous time. Lee and Merriam (1954) discussed the marginal syncline as follows:

> The marginal syncline has almost but not completely erased the structure of the Oakley anticline at the horizon of the Stone Corral without cancelling out the deeper structure at the tops of the Lansing and Mississippian. In view of the usual increment of structural relief on anticlines beveled at the end of Mississippian time, the Pre-Mississippian structure on the Oakley anticline, although modified was probably strong enough to have survived the interference of the post-Cretaceous marginal syncline although the position of the crest may have shifted . . . . under certain conditions of superposition a downward adjustment of the crest of an older anticline by a later syncline could have resulted in two parallel anticlines developed on each side of the syncline.

Figures 10 and 11 (Appendix) show the effect of the marginal syncline on the Mississippian and Lansing rocks.

Western Kansas Basin. The Western Kansas basin was developed in early Mesozoic time, and lies between the Las Animas arch and the Central Kansas uplift. It occupies the position of the Paleozoic Hugoton embayment. The Western Kansas basin is a broad syncline plunging north at the horizon of the Stone Corral formation. The Western Kansas basin is roughly 100 miles wide and 200 miles long and extends into Nebraska. Other elements of folding developed within the basin, all of which plunge in a northerly direction (Lee and Merriam, 1954).

Jennings Anticline. The Jennings anticline is defined as a north-south trending, southerly plunging structure, located in townships 3, 4, 5 and 6 south and ranges 26 and 27 west in eastern Decatur and northeastern Sheridan counties. The structure is named for the town of Jennings which is located on the crest of the anticline (Merriam and Atkinson, 1955). This anticline is revealed in considerable detail in Fig. 9 (Appendix) by the structural contours on top of the Lansing. The anticline trends north-south and plunges to the south in Decatur county, but the trend swings southeast in northern Sheridan county. There are several local areas of closure along the crest of the anticline. This feature probably outlines the western margin of the Cambridge arch. The oil fields on the Jennings anticline produce from the Lansing-Kansas City group.

Selden Syncline. The Selden syncline is located in southeastern Decatur and northwestern Sheridan counties and is named for the town of Selden, Sheridan County, Kansas. (Merriam and Atkinson, 1955). The Selden syncline is a northwest-southeast trending structure. The structure has several low areas which are closed located along the axis, but in general the plunge is southeast. A small structural saddle is located in T. 6 S., R. 28 W. separating two of the closed areas. The structural attitude of the syncline is shown at the Lansing-Kansas City horizon (Fig. 10, Appendix).

GEOLOGIC HISTORY

Pre-Cambrian Era

The pattern of the igneous rock types in the area of the Cambridge arch suggests the granite, which forms the core of the arch, was intruded into Pre-Cambrian sediments causing them to be metamorphosed. Merriam and Atkinson (1955) stated as follows:

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

Koster (1935) believed that small batholiths intruded in Pre-Cambrian time formed the meta-sediments identified on the Central Kansas uplift. Walters (1946) suggested that the granite intrusions were later than the metamorphic rocks since pegmatatic material, which is assumed to be present as intrusive dikes, is associated with the meta-sediments. Lugn (1934) implied that the Cambridge arch was formed by a granitic intrusion during the Killarney-Grand Canyon revolution. From the information available the emplacement of batholiths would account for the initial difference in elevation of the uparched and down-warped areas and the occurrence of metamorphic sediments which probably underlie the greater part of northwestern Kansas. The Pre-Cambrian surface was subjected to erosion and weathering during early and middle Cambrian time as the Cambrian seas were restricted to the Cordilleran geosyncline (Mc Coy, 1953).

Paleozoic Era

The late Cambrian seas advanced and deposited the Lamotte sandstone on the Pre-Cambrian surface. The Lamotte sandstone is generally an arkose or sandstone composed chiefly of coarse, subrounded quartz grains. The major source of the Lamotte sandstone was probably from the Pre-Cambrian rocks of the Siouxian uplift and the Sierra Grande uplift.

The Bonneterre dolomite overlies the Lamotte sandstone except locally where it is in contact with Pre-Cambrian rocks. Generally the Bonneterre dolomite is included with the Arbuckle group. Clastic material ceased to be the major factor influencing sedimentation and the non-clastic carbonates of the Arbuckle group were deposited. The Arbuckle group was more extensive than the older sediments and may have buried the Cambridge arch.

At the end of Arbuckle time the Cambridge arch was uplifted (Merriam and Atkinson, 1955). Extensive erosion removed the Arbuckle from the crest of the Cambridge arch, and a deeply weathered surface was produced throughout northwestern Kansas.

The Ordovician seas advanced and filled the shallow areas with Simpson sediments and retreated leaving an erosional break. The seas advanced and deposited the Viola limestone which covered and overlapped the Simpson sediments (Fig. 4, Appendix). Erosion and weathering beveled the Ordovician rocks until the advance of the Mississippian seas.

The Mississippian seas advanced depositing the "Kinderhook" shale (Chattanooga or Boice equivalent) on the eroded surface of the Viola and older rocks. The erosion which followed the deposition of the "Kinderhook" shale left only local patches of the shale (Merriam, 1955). The area was flooded, and limestones of the Kinderhookian series were deposited. The area of greatest thickness was in northwestern Gove, southeastern Thomas and northeastern Logan counties (Clair, 1948). The seas withdrew for a short period of time; then advanced and deposited limestones of the Osagian amd Meramecian series. The area was subjected to weathering and erosion during Chesterian time as indicated by the absence of sediments. Chesterian sediments are present in southwestern Kansas (Moore, et.al., 1951). The zero Mississippian line shown in Fig. 11 (Appendix) indicated the Cambridge arch was probably not covered by erosion. If covered, the sediments were removed by pre-Pennsylvanian erosion.

During the Mississippian period, the Siouxian uplift was the northwestern extension of a large positive area which was connected to the Canadian shield. This area known as the Transcontinental arch is believed to have been a major source for the Mississippian sediments (Eardly, 1951, p. 27). The Cambridge arch was uplifted at the end of Mississippian time. Mississippian rocks were eroded from the crest of the arch and the surface was extensively weathered. The residual chert at the top of the Mississippian sequence was formed by weathering of the limestones. The distribution of the Mississippian rocks is shown in Fig. 4 (Appendix).

The area was downwarped at the beginning of the Pennsylvanian period, with very rapid subsidence in southwest Kansas. The Morrowan and Atokan seas extended into southwest Kansas but did not reach northwest Kansas. At the end of Atokan time, the seas withdrew and erosion followed. Maher (1953) indicated that the source areas in Colorado were low until the end of Morrowan time when the uplift accompanied by faulting elevated the Sierre Grande uplift, the Wet Mountains and the Front Range. These areas provided coarse clastics for the remainder of the Pennsylvanian period. The clastic sediments of Colorado interfinger to the east with the marine limestones and shales deposited on the shelf area in western and northwestern Kansas.

The Desmoinesian seas covered northwestern Kansas with cyclic deposits of shales, limestones and sandstones. The seas retreated, and an erosional surface was developed. Missourian seas advanced and deposited cyclic sediments of limestones separated by shale breaks. The seas retreated, and an erosional surface was developed on top of the Lansing-Kansas City group. Desmoinesian and Missourian sediments extended across the Cambridge arch. Figure 13 (Appendix) well No. 1 shows Pennsylvanian sediments on the crest of the arch resting on Pre-Cambrian granite.

The Las Animas arch was uplifted during Missourian time and shifted the structural pattern from the deep trough present in southwestern Kansas in Morrowan, Atokan and Desmoinesian time to the northeast. After the retreat and advance of the sea at the end of Missourian time, sedimentation became more widespread and completely buried the Sierra Grande uplift and the Siouxian uplift. The Virgilian sediments deposited on the Missourian erosional surface consisted of predominantly shale, limestone and sandstone of the same characteristic cyclic deposits. This unit varies in thickness because of structural movements which were active contemporaneously with the deposition of sediments. The Mississippian seas retreated, and an erosional surface developed (Lee, 1954).

The Permian (Wolfcampian) seas advanced and deposited a sequence of limestones alternating with shales, on the Pennsylvanian erosional surface. The retreat of the Wolfcampian seas marked a change in the lithology of the sediments. The Leonardian rocks consisted of unfossiliferous, red sandstone, shale and evaporites suggesting deposition in shallow, oscillating seas. The upper Permian sediments are red shales, siltstones, sandstones and evaporites. The deposition was partly in shallow basins occupied by strongly saline water and partly by sluggish streams and action of the winds. The area of this sedimentary basin extended from western Oklahoma, through the northeastern corner of Colorado to the northwest corner of Nebraska. It was bounded on the west by North Park and the Uncompahgre region which furnished coarse, clastic material for the sediments in central Colorado (Mc Coy, 1953).

The eastern limit of the Hugoton embayment no longer existed as movement of the Cambridge arch and the Central Kansas uplift had ceased. The Las Animas arch was active at this time (Maher, 1946), and the Oakley anticline began its development (Lee and Merriam, 1954). By late Permian time the structural pattern which began to develop in late Pennsylvanian and early Permian time was accentuated, and the Oakley anticline obtained a structural relief of more than 300 feet. Downwarped basins were on both sides of the anticline forming the Syracuse syncline in Kearny and Wichita counties to the west, and the Cimmaron syncline in Lane and Finney counties to the east (Merriam, 1955). This structural pattern marked the end of the embayment which had persisted since Pre-Cambrian time. The seas withdrew completely at the close of the Paleozoic era, and the surface was eroded, uplifted and warped.

Mesozoic Era

The area of northwestern Kansas was high at the beginning of the Mesozoic era, and erosion occurred throughout the Triassic period is shown by the absence of Triassic sediments. Upper Jurassic seas encroached on eastern Colorado and western Kansas from the west and withdrew leaving fresh water lakes and swamps in which the varigated shales, marls, limestones and sandstones of the Morrison formation were deposited (Mc Coy, 1953). Northwestern Kansas was tilted into the Denver basin, as shown by the presence of Jurassic sediments (Lee and Merriam, 1954). The period was closed by the withdrawal of the seas and slight tilting to the south. An erosional surface was developed on the Jurassic surface by southerly flowing streams (Merriam, 1955).

The early Cretaceous seas advanced and deposited the Cheyenne sandstone which is inferred to have been deposited near or on the strand line of the advancing sea. The sediments are dominantly continental in character and locally they contain abundant plant remains (Plummer and Romary, 1942). The Kiowa shale was deposited after the advancing sea covered the land surface. The marine environment is suggested by the presence of marine fossils. The Dakota formation consisting of sandstone and clay represents sediments laid down in an environment at or near the shore line of a broad, relatively shallow sea (Plummer and Romary, 1942). The iron minerals found in the Dakota formation and at the base of the overlying Graneros shale were formed by the precipitation of iron caused by the mixing of brackish water with sea water (Plummer and Romary, 1942).

At the end of Dakota time the sea transgressed the area for the last time and the Graneros shale and overlying sediments were deposited. The area gradually subsided throughout upper Cretaceous time as indicated by the presence of more than 2,000 feet of fine-textured shallow water deposits. These strata consist of chalk and chalky limestone alternating with shale and calcareous shale.

The marginal syncline was developed during upper Cretaceous time, and regional tilting accentuated the northwesterly dip which began in post-Niobrara time. Orogenic movement accompanied the tilting during late Mesozoic and early Cenozoic time (Merriam and Frye, 1954). Subaerial erosion followed this structural orogeny which closed the Cretaceous period and the Mesozoic era.

Cenozoic Era

Northwestern Kansas was continually above sea level during early Tertiary time and was subjected to subaerial erosion until Pliocene time. Extensive uplift in the Rocky Mountains and streams flowing outward across the Great Plains deposited a complex sequence of lenticular and sheet-like bodies of gravel, sand, silt, and clay forming the Ogallala formation (Pliocene). The Ogallala formation was deposited on a plain with topography of low relief. The streams not only filled their shallow valleys but spread across the divides. Near the end of the Ogallala depositional period the Algal limestone was deposited on the flat bottom of a very large and shallow lake (Elias, 1931). Structural movement tilted the area to the east after the deposition of the Ogallala formation (Merriam and Frye, 1954). A long period of erosion followed the deposition of the Ogallala formation.

Deposits of the Pleistocene epoch in northwestern Kansas are fluviatile deposits which are generally associated with the present drainage system or with ancient drainage systems, whereas, the eolian deposits generally underlie the uplands. Minor and local structural movements probably took place during the Cenozoic era, but the Las Animas arch, the Cambridge arch, and the Western Kansas basin show no evidence of movement (Merriam and Frye, 1954).

DISCUSSION AND CONCLUSIONS

The first oil production in northwestern Kansas began in 1943 with the discovery of the Studley pool located in Sheridan county. Production was confined to Sheridan county until 1951 when pools were discovered in Gove, Decatur and Cheyenne counties. One pool was discovered in Thomas county in 1953. Table 1 (Appendix) shows that most of the pools were discovered during 1951 through 1953. Northwestern Kansas contained twenty-five named oil pools (Fig. 5, Appendix) by January, 1955 (Ver Wiebe, et al., 1955). Table 1 (Appendix) shows the Lansing-Kansas City group as the major oil producer. Minor production is obtained from the Marmaton and Wabaunsee groups, and the Mississippian limestone.

Lansing-Kansas City Production

Figure 9 (Appendix) shows the relationship of the Lansing-Kansas City oil pools to the structure in Decatur county and T. 6 S., Sheridan county. The Jennings, Feely, Hardesty, Adell, Adell Northwest and Hortonville pools are located on the crest of the Jennings anticline. The amount of closure on the Jennings anticline varies from less than 20 feet to more than 40 feet. Oil pools in Decatur county, not located on the Jennings anticline are associated with plunging anticlines or noses.

Figure 10 (Appendix) shows the relationship of all Lansing-Kansas City pools to structure in northwestern Kansas. Oil accumulation generally occurs on closed anticlinal structures in Decatur county. The oil pools in Gove and Sheridan counties occur on anticlines and anticlinal noses. The isopachous map (Fig. 12, Appendix) shows that the Lansing-Kansas City oil production occurs between the 500 and 650 foot thickness contour. Oil production from the Marmaton and Wabaunsee groups follow the same relationship to structure as the Lansing-Kansas City group.

Mississippian Production

Figure 11 (Appendix) shows the relationship of oil accumulation to the Mississippian structure. The Gove pool is located on an anticlinal nose separated from the Lungren and the Lungren South pools by a saddle. The Mingo pool is located near the end of a closed anticline which is on the same general trend as the Gove, Lungren, and Lungren South pools. This trend is the same as the Oakley anticline (Fig. 3, Appendix). The relationship of thickness to oil accumulation is shown in Fig. 12 (Appendix). The pools are located on or near the 600 foot thickness line.

The distribution of Mississippian rocks is shown in Fig. 4 (Appendix). In general, the older Kinderhookian and Osagian rocks are progressively overlain southward by the limestones of the Meramecian series. The zero Mississippian line trends through eastern Rawlins, southern Decatur, and northeast Sheridan counties. Cross sections A, B, and C (Fig. 13, Appendix) show the angular unconformity which truncated the Mississippian rocks. The Mississippian rocks are absent in T. 4 S., R. 35 W., Rawlings county. Well No. 3, cross section A (Fig. 13, Appendix) shows lower Pennsylvanian sediments resting on Pre-Cambrian granite. The writer believes that pre-Pennsylvanian erosion removed the Mississippian, Ordovician, and Cambrian sediments exposing the Pre-Cambrian granite. After erosion, lower Pennsylvanian sediments were deposited. Pre-Missourian and post-Mississippian folding produced the high areas in T. 4 S., R 35 W. which are reflected on the Lansing-Kansas City and the Mississippian structure maps (Figs. 10 and 11, Appendix). The suggestion of post-Mississippian folding came from the interpretation of the isopachous map (Fig. 12, Appendix) using the principles set forth by Lee (1954). The Mississippian surface was assumed to be originally flat. This flat surface was covered by younger sediments which were later folded and beveled by erosion. The erosional surface was developed on top of the Lansing-Kansas City rocks. The variation in thickness between the Lansing-Kansas City surface and the Mississippian surface reveals the place and amount of folding. The thin areas represent anticlines and the thick areas represent synclines. The thin area located in T. 4 S., R. 35 W., as shown by the isopachous map is directly above an anticlinal structure. The Mississippian oil accumulation is related to structure in northwestern Kansas along anticlinal trends. No production has been found in the truncated areas of the Mississippian rocks. However, no detailed exploration along the truncated area has been initiated as is shown by the location of wells penetrating the Mississippian rocks (Fig. 6, Appendix).

Arbuckle Production

In 1954 oil was discovered in Arbuckle rocks by W. L. Hartman, in Sec. 10, T. 19 S., R. 31 W., Scott county, Kansas. This discovery marked the first Arbuckle production west of the Central Kansas uplift and the Cambridge arch. The well was designated the Grigston pool. The discovery of this pool should completely re-evaluate the Arbuckle as a future producer in northwestern Kansas.

The Arbuckle fields in Norton and Phillips counties show little relationship to structure. An example is the Norton field, discovered in 1954, in Norton county. Merriam and Goebel (1954) showed that oil accumulation in the Norton field is limited to the Arbuckle and Lamotte rocks and that the trap is formed by a combination of truncation, overlap, change in the porosity of the reservoir rock, and structure. Structure plays a role secondary to the other conditions necessary for the accumulation of oil in the Arbuckle rocks in the vicinity of the Cambridge arch (Merriam and Atkinson, 1955). The Central Kansas uplift produces from the Arbuckle rocks where they are weathered and eroded along the flanks of the arch and covered by the Pennsylvanian rocks. Oil accumulation in the Arbuckle rocks in northwestern Kansas probably is not associated with structure, but could be associated with areas subjected to post-Arbuckle erosion and later covered by Pennsylvanian sediments.

Dakota Production

No Dakota production is reported in northwestern Kansas. A large percentage of petroleum produced in the Denver basin, in eastern Colorado and western Nebraska, is from zones of the Dakota formation. The Dakota production is usually found in sand lenses or stratigraphic traps (Donaldson, 1955). The Dakota formation underlies northwestern Kansas and should be considered for future production.

Future Potential

Many areas not yet drilled are located in northwestern Kansas which meet the criteria for possible production from the Lansing-Kansas City group and the Mississippian limestone (Figs. 10 and 11, Appendix). Figure 13 (Appendix) shows favorable conditions for the accumulations of oil within the area traversed by cross sections A, B, and C. This is suggested by the structure and stratigraphy between wells No. 1 and 2, wells No. 2 and 3, wells No. 3 and 4, wells No. 5 and 9, wells No. 1 and 5, and wells No. 5 and 6. The traps seem to have been formed by the truncation of Arbuckle rocks and Mississippian rocks and the subsequent sealing of the permeable beds of each rock unit by deposition of younger relative impermeable strata.

ACKNOWLEDGMENT

The writer is indebted to Dr. Claude W. Shenkel, Jr., Associate Professor of Geology, for his advice and suggestions while preparing this thesis, and to Dr. Joseph R. Chelikowsky, Head of the Department of Geology and Geography, for the criticisms and suggestions while editing the thesis.

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APPENDIX

Table 1. Oil production in northwestern Kansas to January 1, 1955.

Pool and Location of Discovery Well	Discovery Year	Area Acres	Depth Feet	Producing Zone	No. Wells	Production, bbl. 1954	Production, bbl. Cumulative
Cheyenne County							
Judy 26-1-39W	1951		4497	Marmaton		none	none
Decatur County							
Adell NW 34-5-27W	1952	640	3664	Lans-K.C.	13	115,897	334,220
Feely 2-5-27W	1952	200	3590	Lans-K.C.	5	31,721	76,019
Hardesty 22-5-27W	1952	560	3642	Lans-K.C.	6	43,593	103,353
Jennings 25-4-27W	1951	860	3478 3156	Lans-K.C. Wabaunsee	16	91,009	182,026
Monaghan 15-2-27W	1952	120	3514	Lans-K.C.	3	18,963	24,355
Pollnow 4-3-29W	1953	40	3734	Lans-K.C.	1	9,128	15,308
Pollnow NW 31-2-29W	1954		3772	Lans-K.C.		No report	none
Pollnow W 5-3-29W	1953	160	3744	Lans-K.C.	4	37,737	38,683
Total Decatur County		2,580			48	348,048	773,964

Table 1. (Cont'd.)

Pool and Location of Discovery Well	Discovery Year	Area Acres	Depth Feet	Producing Zone	No. Wells	Production, bbl. 1954	Production, bbl. Cumulative
				Gove County			
Beougher 8-13-30W	1952		4079	Lans-K.C.	1	no runs	652
Coberly 15-14-29W	1951	80	4287	Marmaton	2	14,434	53,655
Gove 26-13-30W	1951		4122 4547	Lans-K.C. Mississippian	2	no runs	3,977
Jasper 30-15-29W	1951		3670	Lans-K.C.		no report	740
Lundgren 30-14-29W	1952	80	4306	Mississippian	2	726	4,454
Lundgren S. 31-14-29W	1952	360	4277	Mississippian	4	12,689	41,587
Pyramids 9-15-31W	1952		4280	Marmaton	1	no runs	4,387
Total Gove County		520			12	27,849	109,452
				Thomas County			
Mingo 19-9-32W	1952	80	4414 4680	Marmaton Mississippian	2	4,575	7,130

Table 1. (Concl.)

Pool and Location of Discovery Well	Discovery Year	Area Acres	Depth Feet	Producing Zone	No. Wells	Production, bbl. 1954	Production, bbl. Cumulative
			Sheridan County				
Adell 11-6-27W	1944	1200	3755	Lans-K.C.	38	286,407	3,260,741
George 17-9-26W	1952	80	4023	Lans-K.C.	2	5,540	26,673
Hortonville 20-6-26W	1953	80	3789	Lans-K.C.	2	9,150	17,304
Moss 2-8-30W	1952	40	4033	Lans-K.C.	1	150	799
Studley 23-8-26W	1943	340	3810	Lans-K.C.	6	15,732	412,195
Studley SW 32-8-26W	1945	80	3758	Lans-K.C.	2	8,322	61,703
Wessel 27-6-29W	1953	540	3985	Lans-K.C.	9	42,220	64,140
Wessel N 16-6-29W	1953	200	4081	Lans-K.C.	5	14,281	14,782
Total Sheridan County		2,560			65	381,802	3,858,337

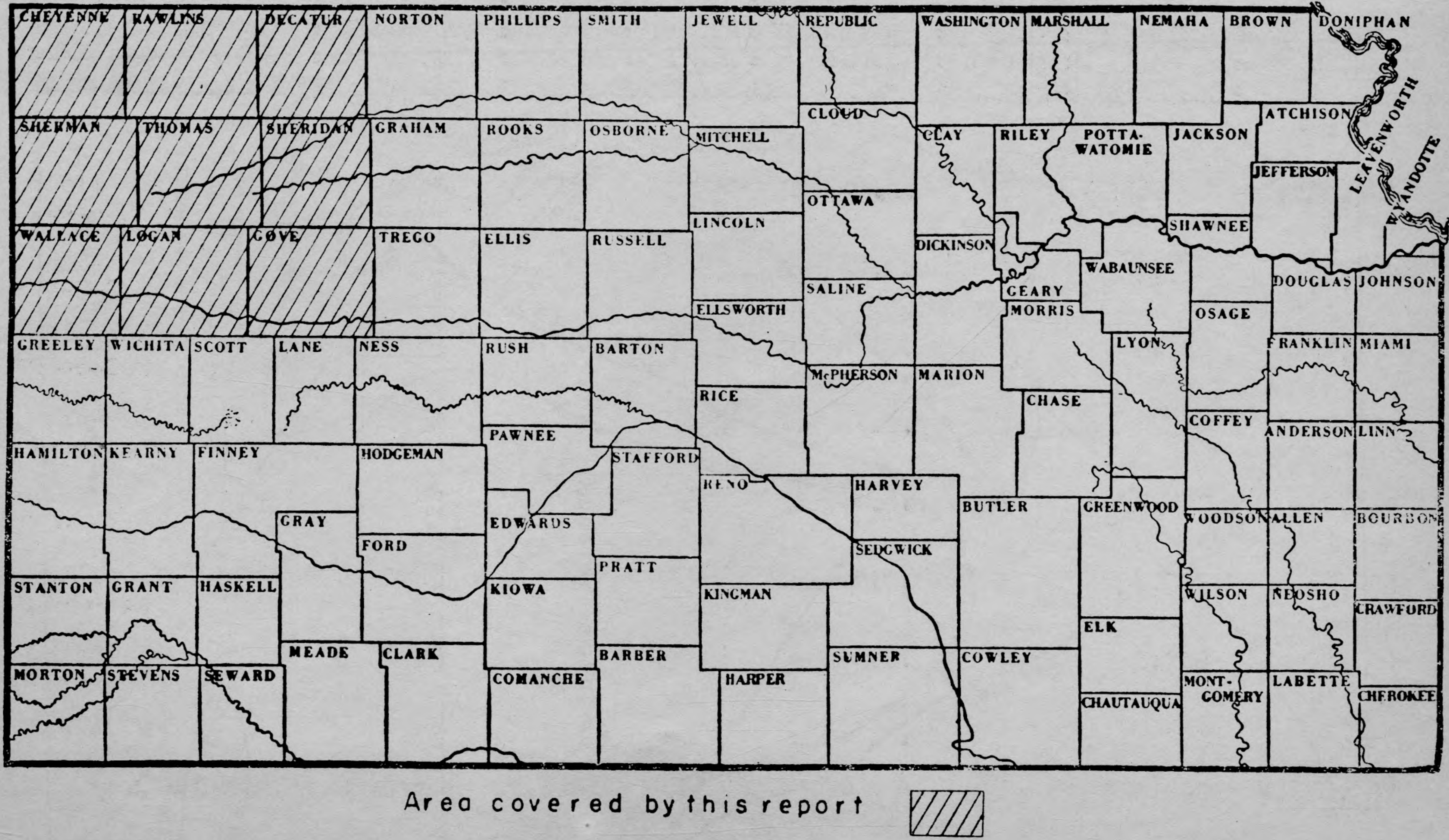


Fig. 1. Location of area covered by this report.

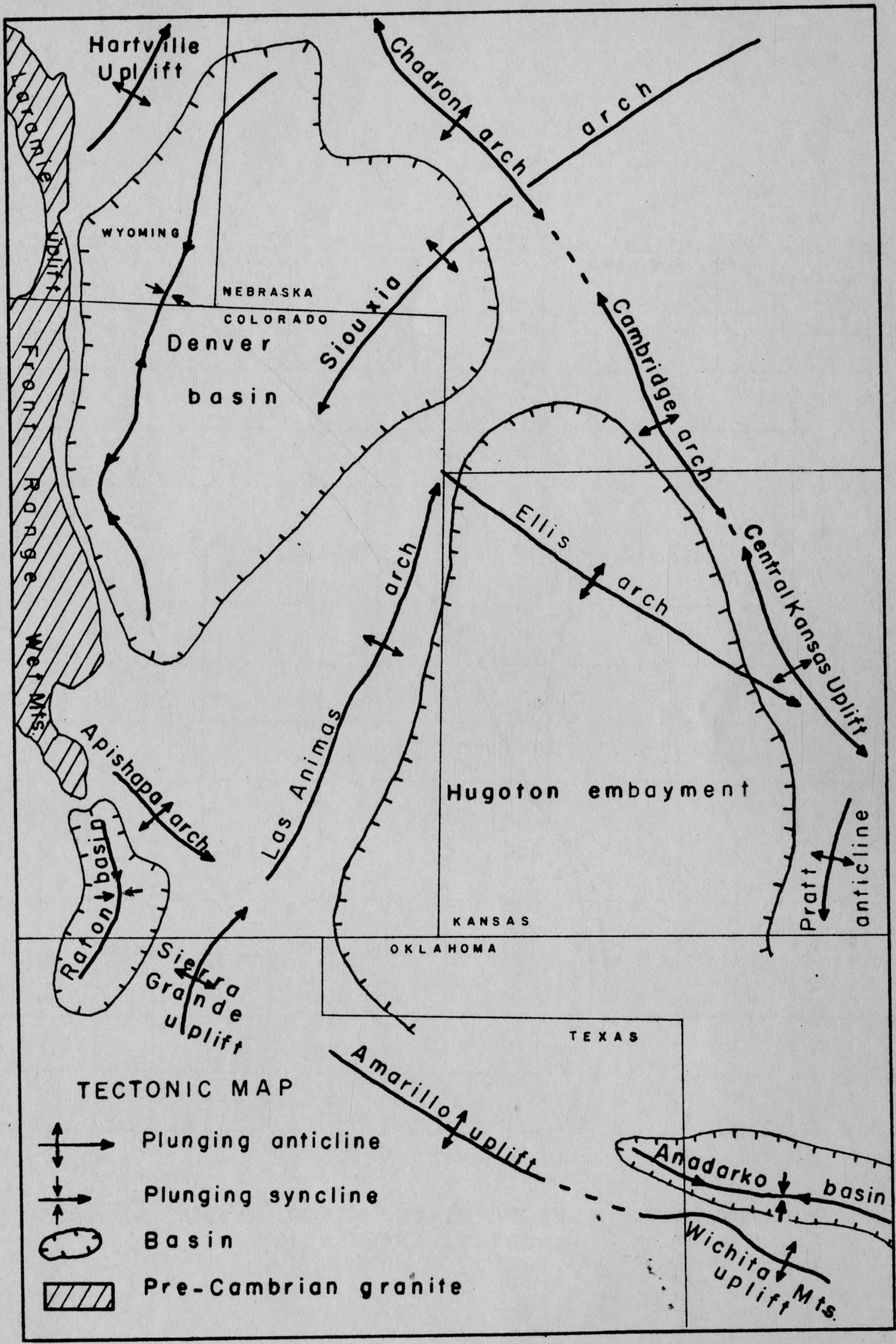


Fig. 2. Geographical distribution of major structures.

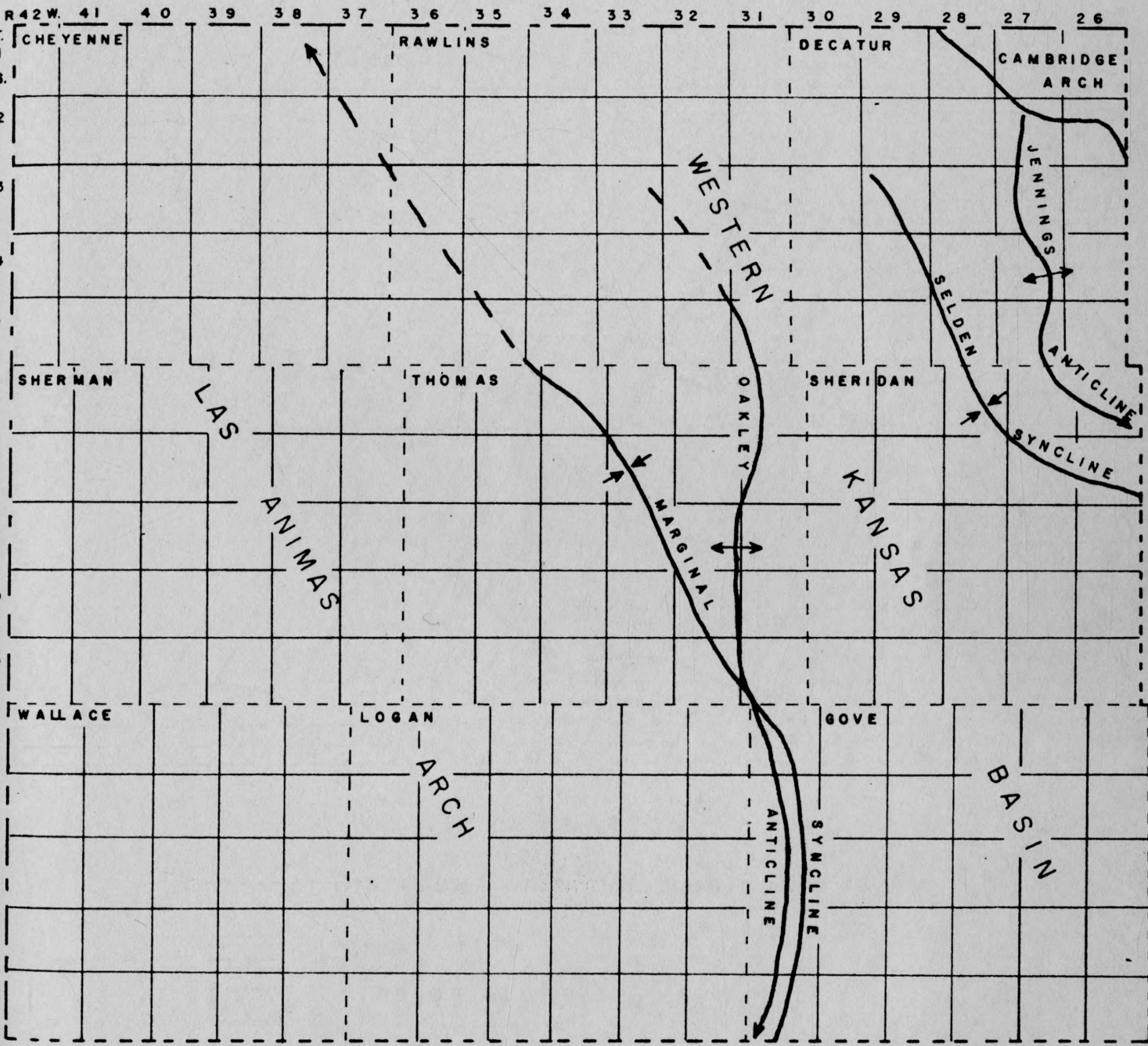


Fig. 3. Map of northwestern Kansas showing minor structural features.

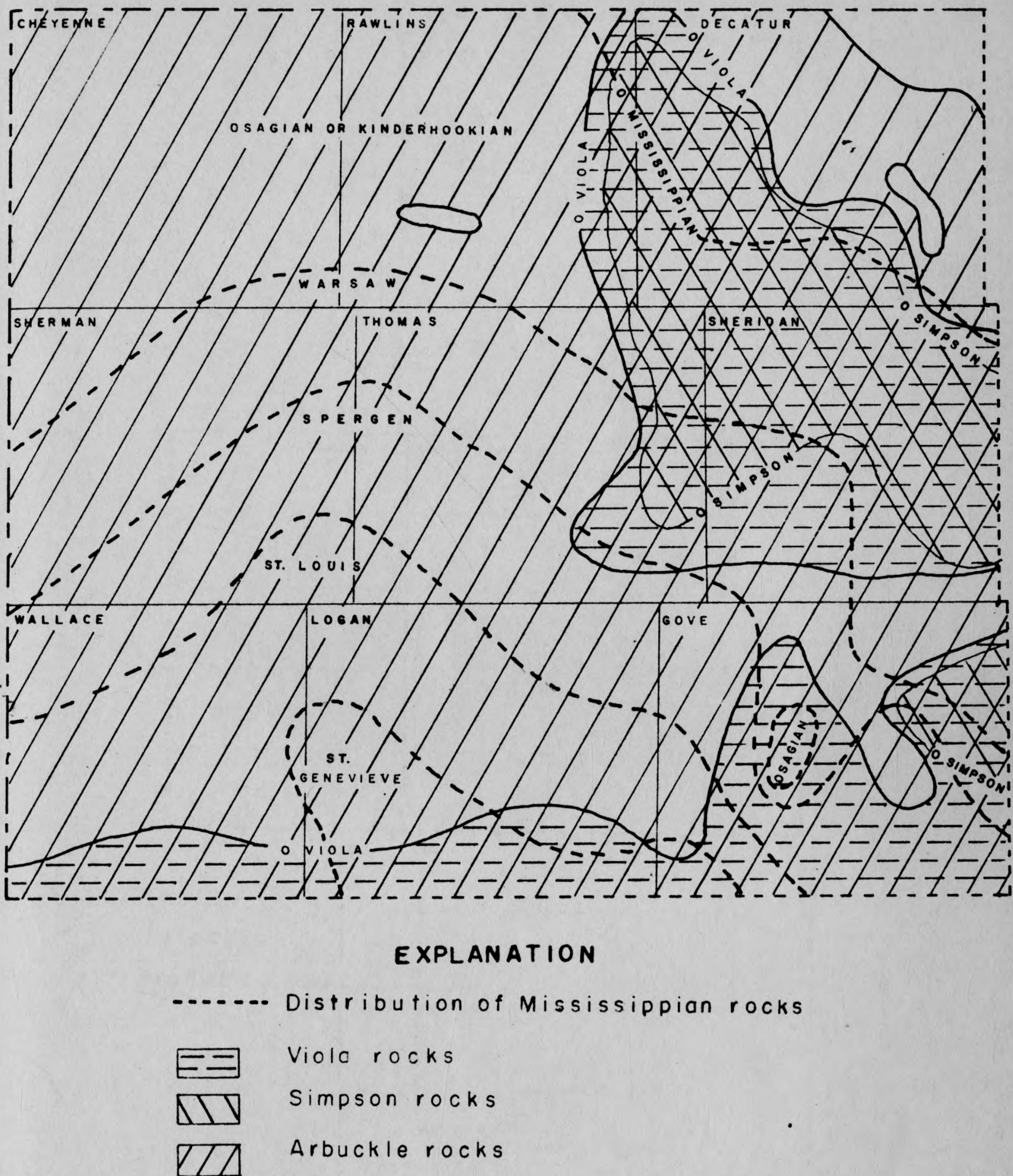


Fig. 4. Map of northwestern Kansas showing distribution of Mississippian and older rocks.

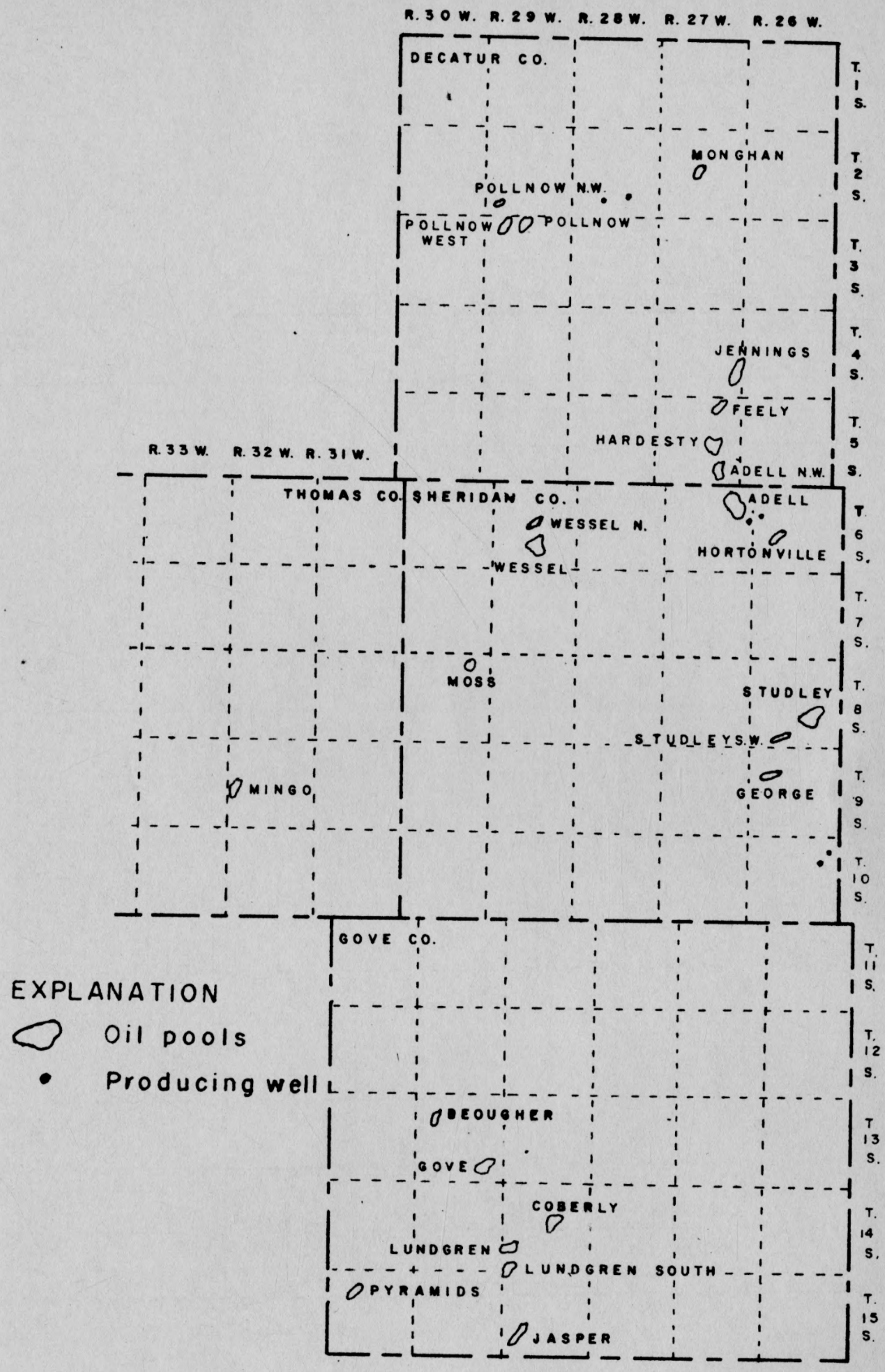


Fig. 5. Map showing oil pools of northwestern Kansas.

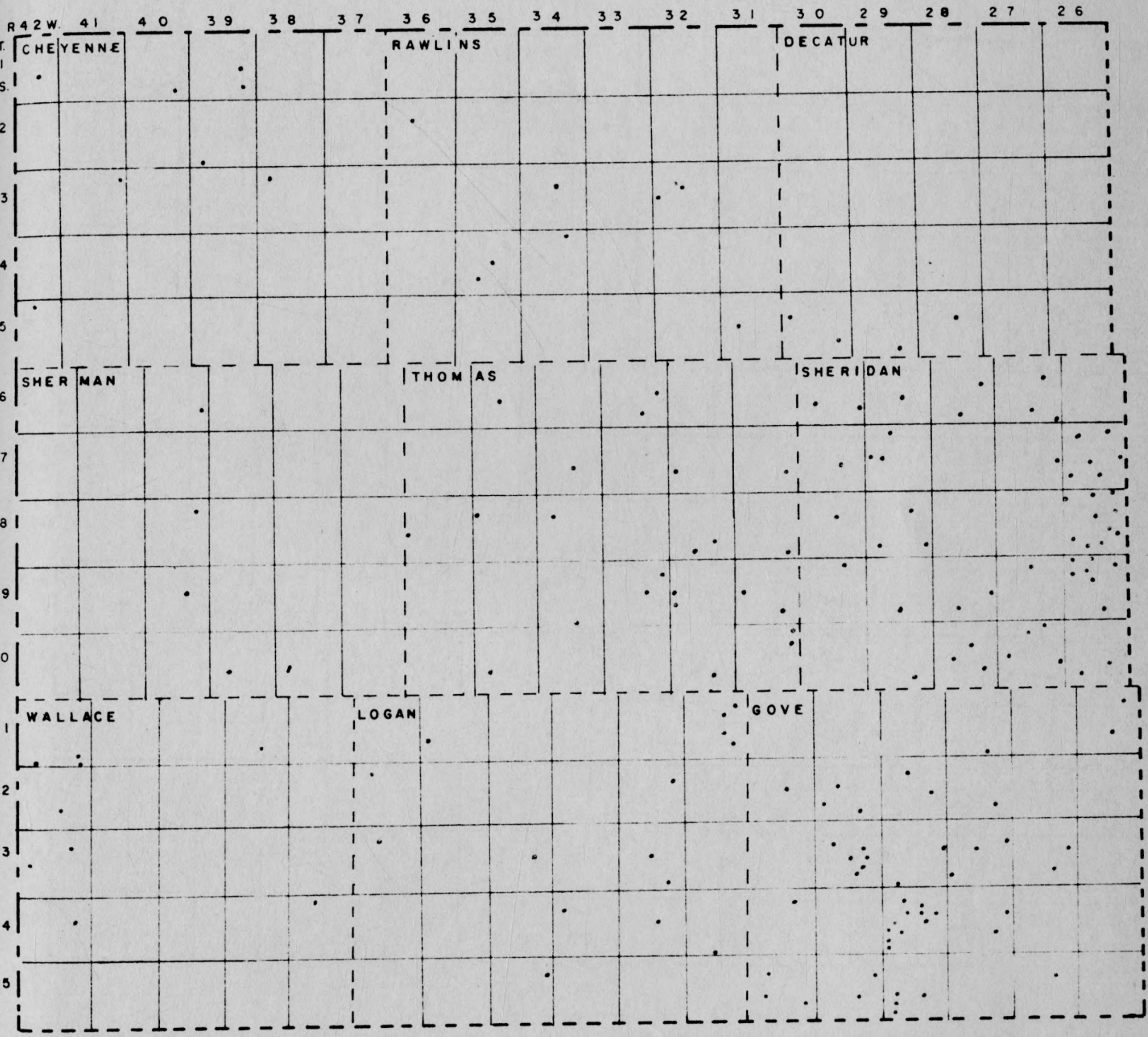


Fig. 6. Map of northwestern Kansas showing subsurface control points used for contouring structure on the Mississippian limestone.

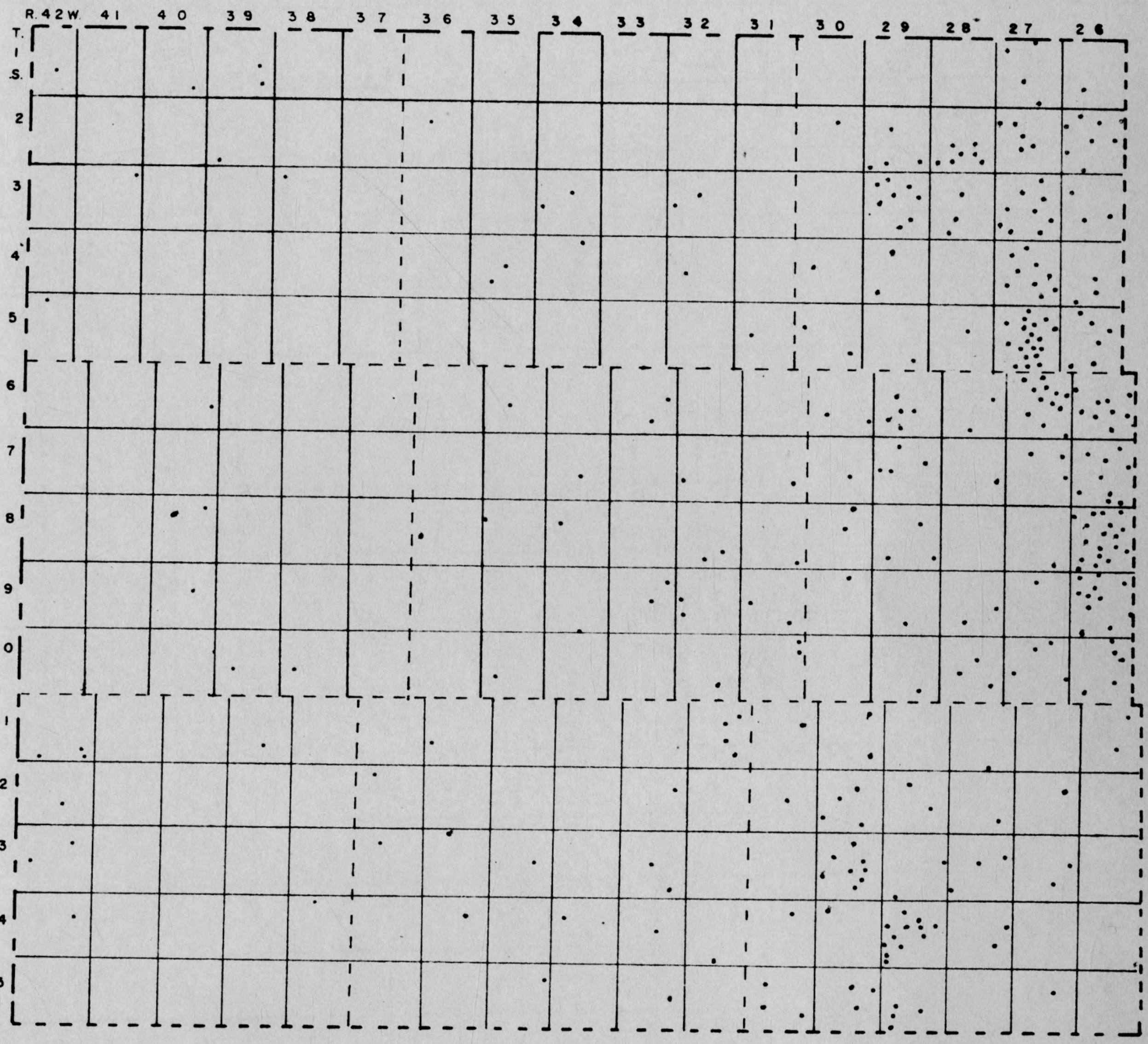


Fig. 7. Map of northwestern Kansas showing subsurface control points used for contouring structure on the Lansing-Kansas City group.

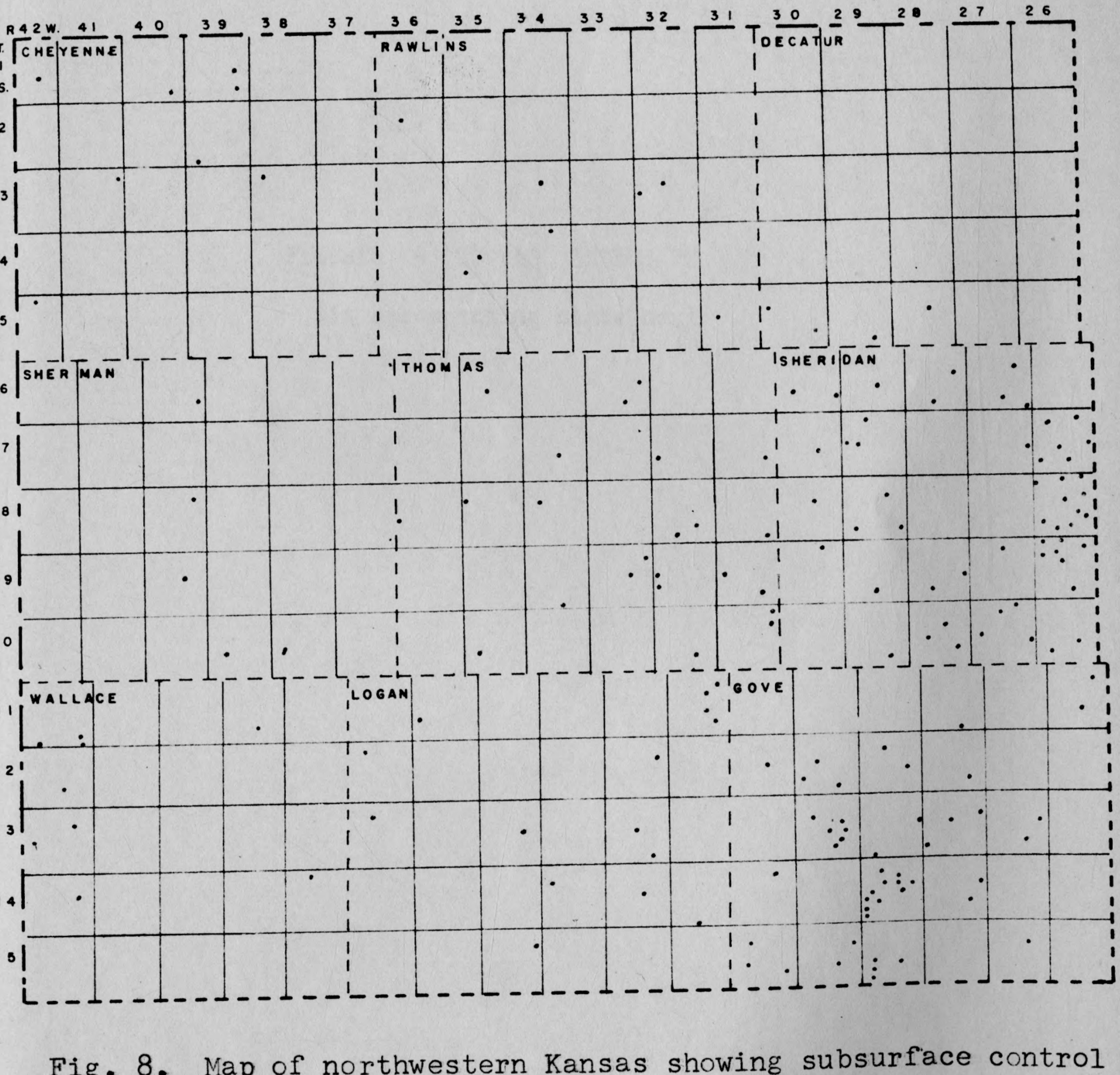


Fig. 8. Map of northwestern Kansas showing subsurface control points used for contouring the isopachous map.

FIGURES 9 TO 13 INCLUSIVE

(in accompanying plate box)

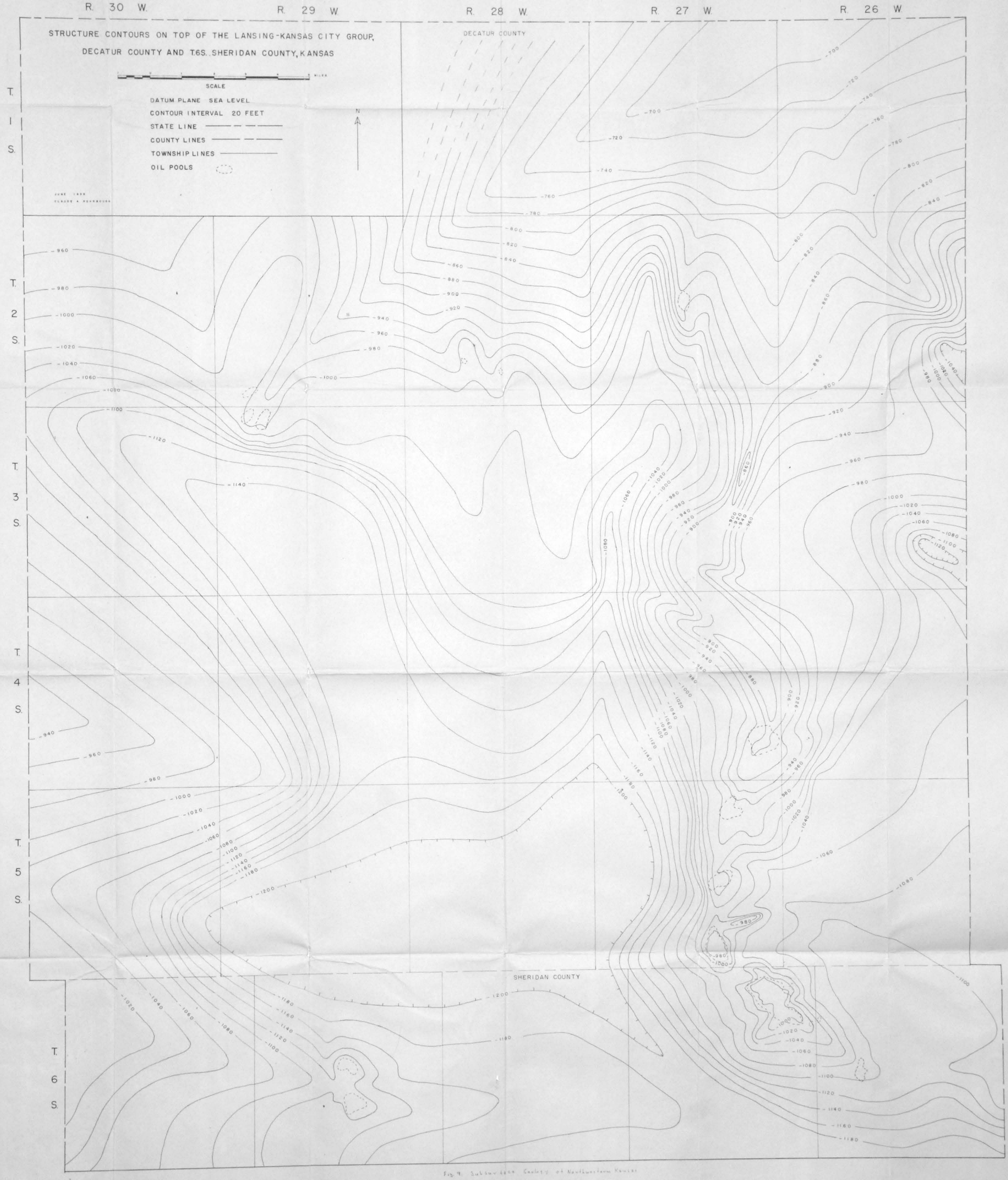
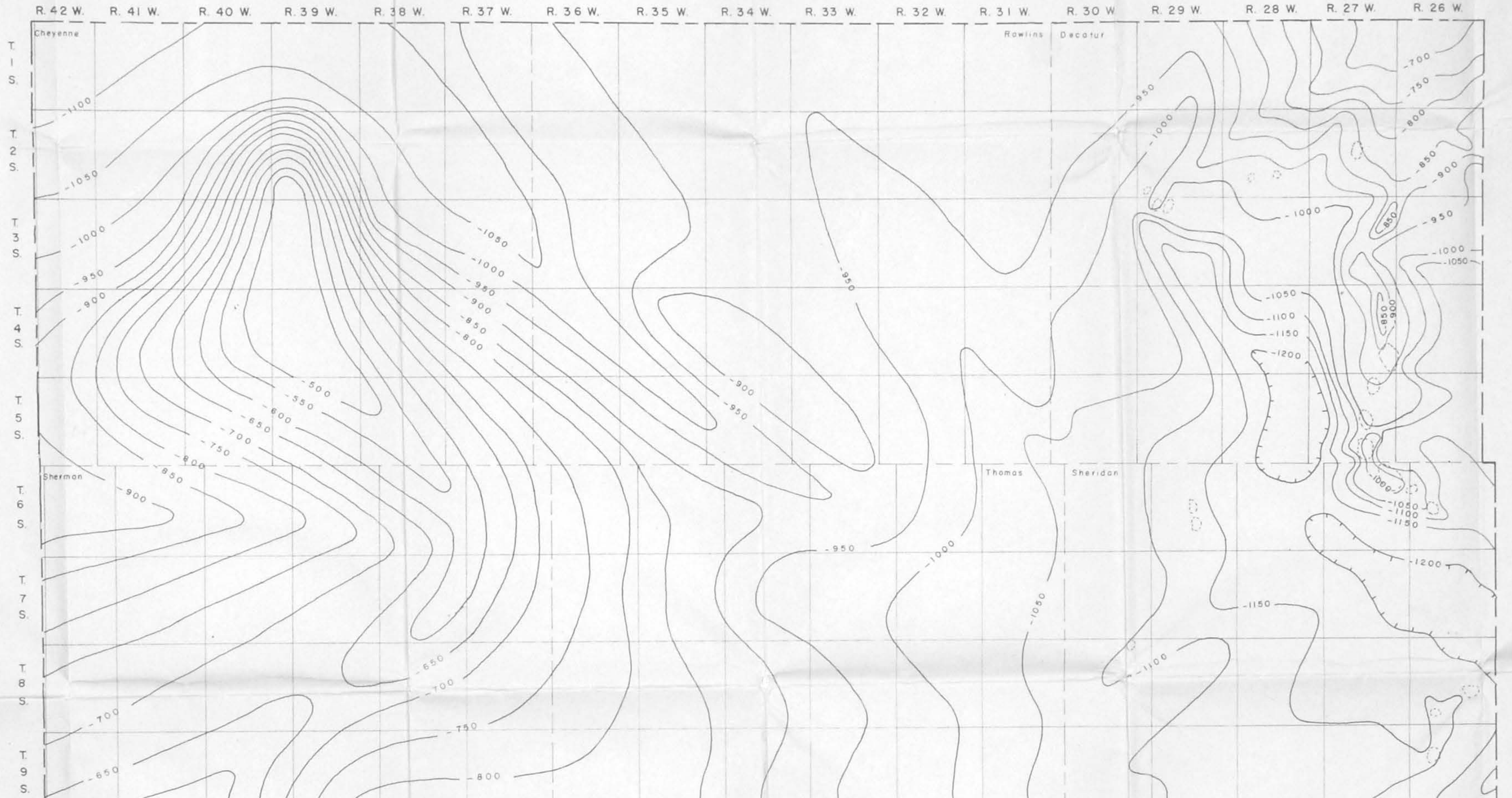


Fig. 9. Subsurface Geology of Northwestern Kansas



STRUCTURE CONTOURS ON TOP OF THE LANSING-KANSAS CITY GROUP, NORTHWESTERN KANSAS

DATUM PLANE SEA LEVEL

SCALE IN MILES

CONTOUR INTERVAL 50 FEET

STATE LINE

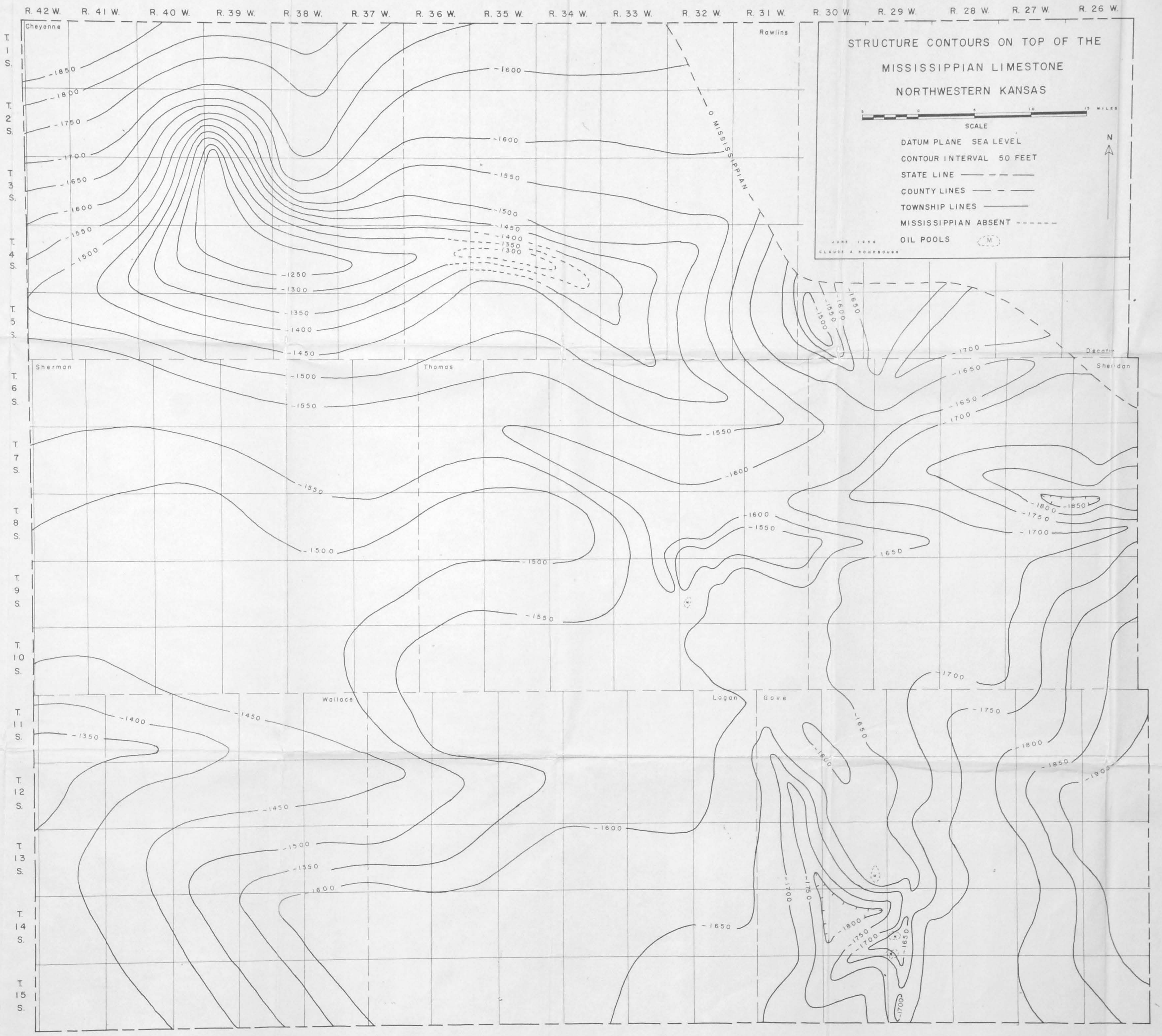
COUNTY LINES

TOWNSHIP LINES

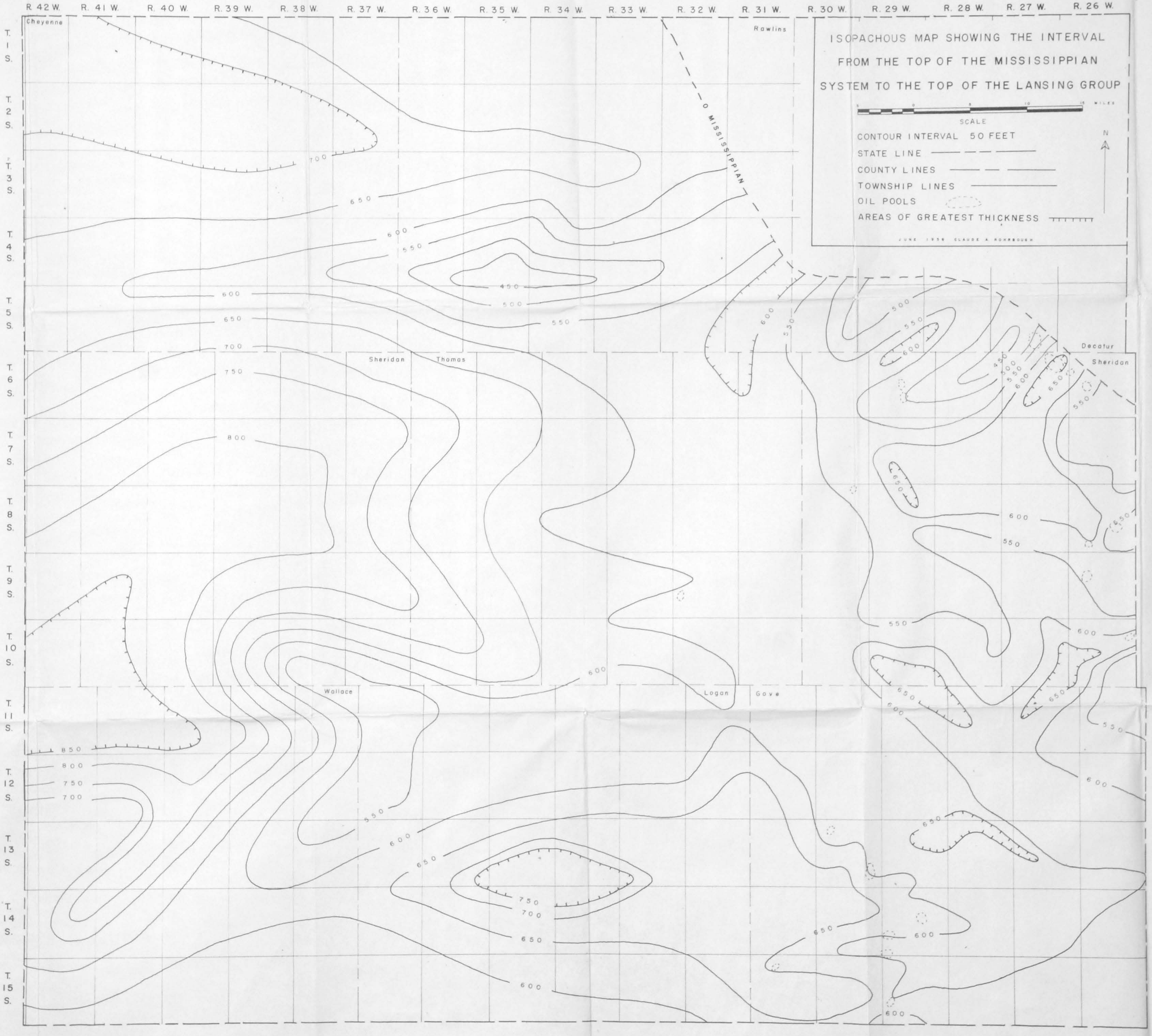
OIL POOLS

N

JUNE 1958 CLAUDE A. ROHRBOUGH



STRUCTURE CONTOURS ON TOP OF THE
MISSISSIPPIAN LIMESTONE
NORTHWESTERN KANSAS
SCALE
DATUM PLANE SEA LEVEL
CONTOUR INTERVAL 50 FEET
STATE LINE
COUNTY LINES
TOWNSHIP LINES
MISSISSIPPIAN ABSENT
OIL POOLS
N
R. 42 W. R. 41 W. R. 40 W. R. 39 W. R. 38 W. R. 37 W. R. 36 W. R. 35 W. R. 34 W. R. 33 W. R. 32 W. R. 31 W. R. 30 W. R. 29 W. R. 28 W. R. 27 W. R. 26 W.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8 S.
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
T. 14 S.
T. 15 S.
Cheyenne
Rawlins
Sherman
Thomas
Decatur
Sheridan
Wallace
Logan
Gove
0 MISSISSIPPIAN


ISOPACHOUS MAP SHOWING THE INTERVAL
FROM THE TOP OF THE MISSISSIPPIAN
SYSTEM TO THE TOP OF THE LANSING GROUP
SCALE
MILES
CONTOUR INTERVAL 50 FEET
STATE LINE
COUNTY LINES
TOWNSHIP LINES
OIL POOLS
AREAS OF GREATEST THICKNESS
N
R. 42 W.
R. 41 W.
R. 40 W.
R. 39 W.
R. 38 W.
R. 37 W.
R. 36 W.
R. 35 W.
R. 34 W.
R. 33 W.
R. 32 W.
R. 31 W.
R. 30 W.
R. 29 W.
R. 28 W.
R. 27 W.
R. 26 W.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8 S.
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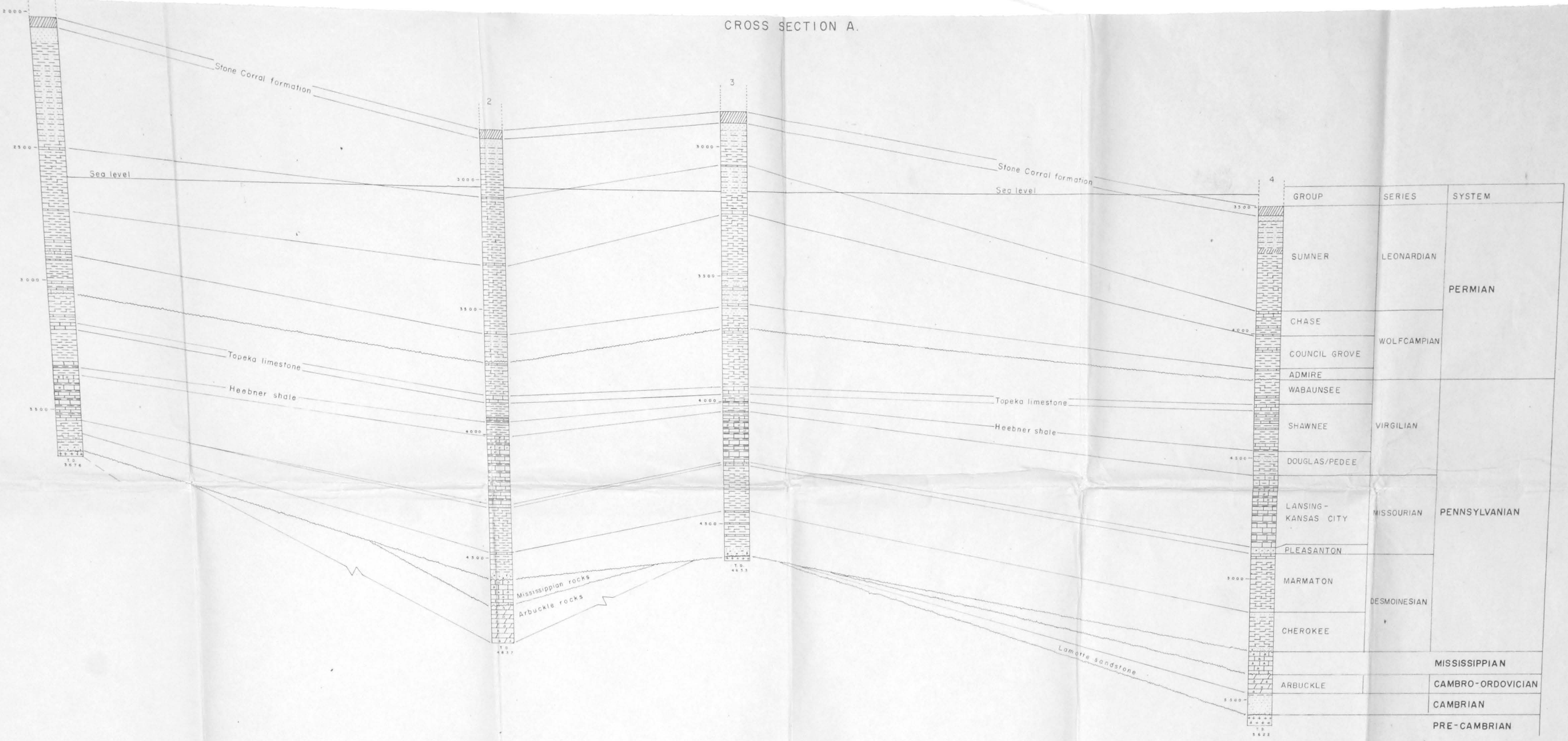
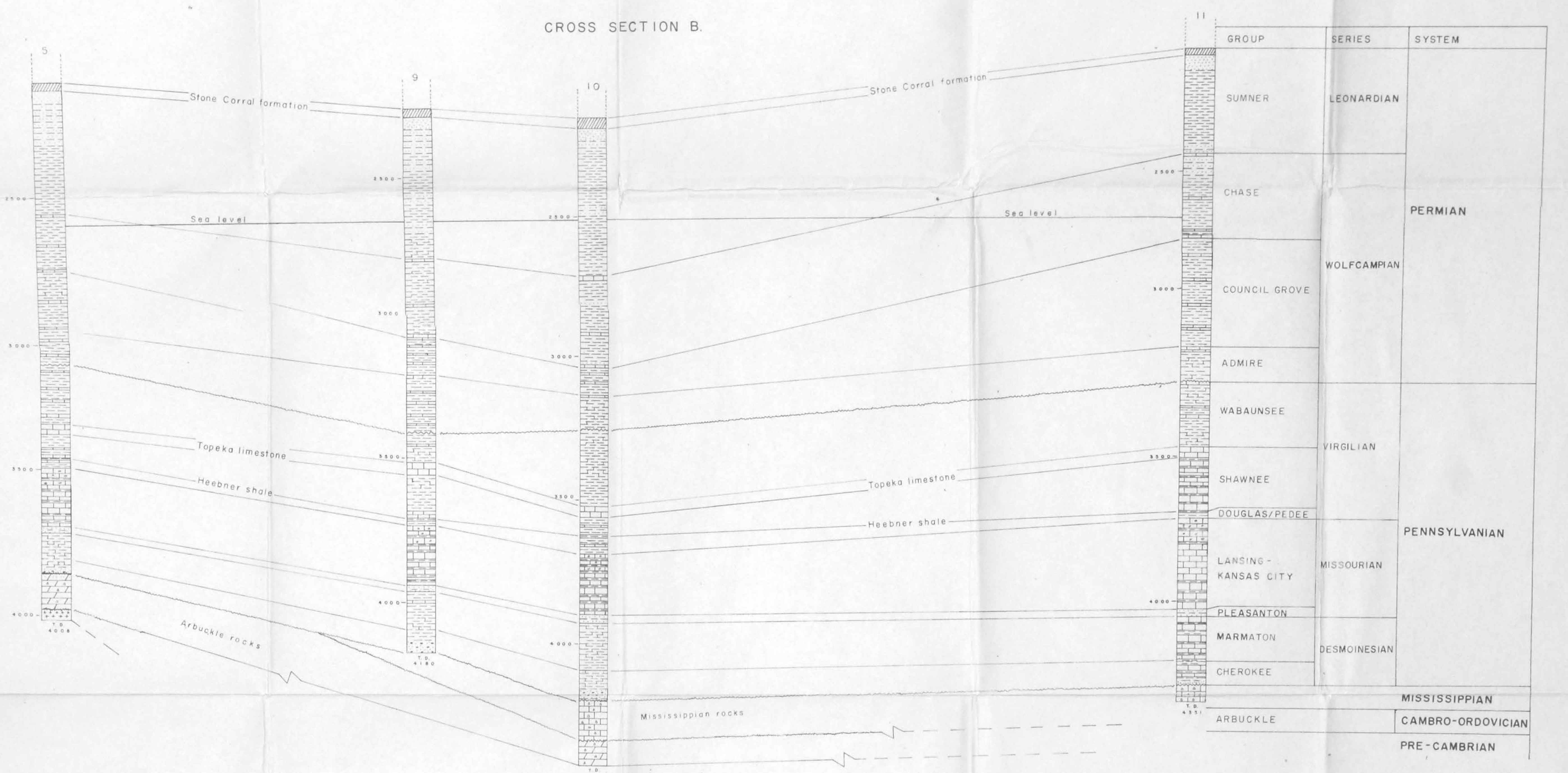
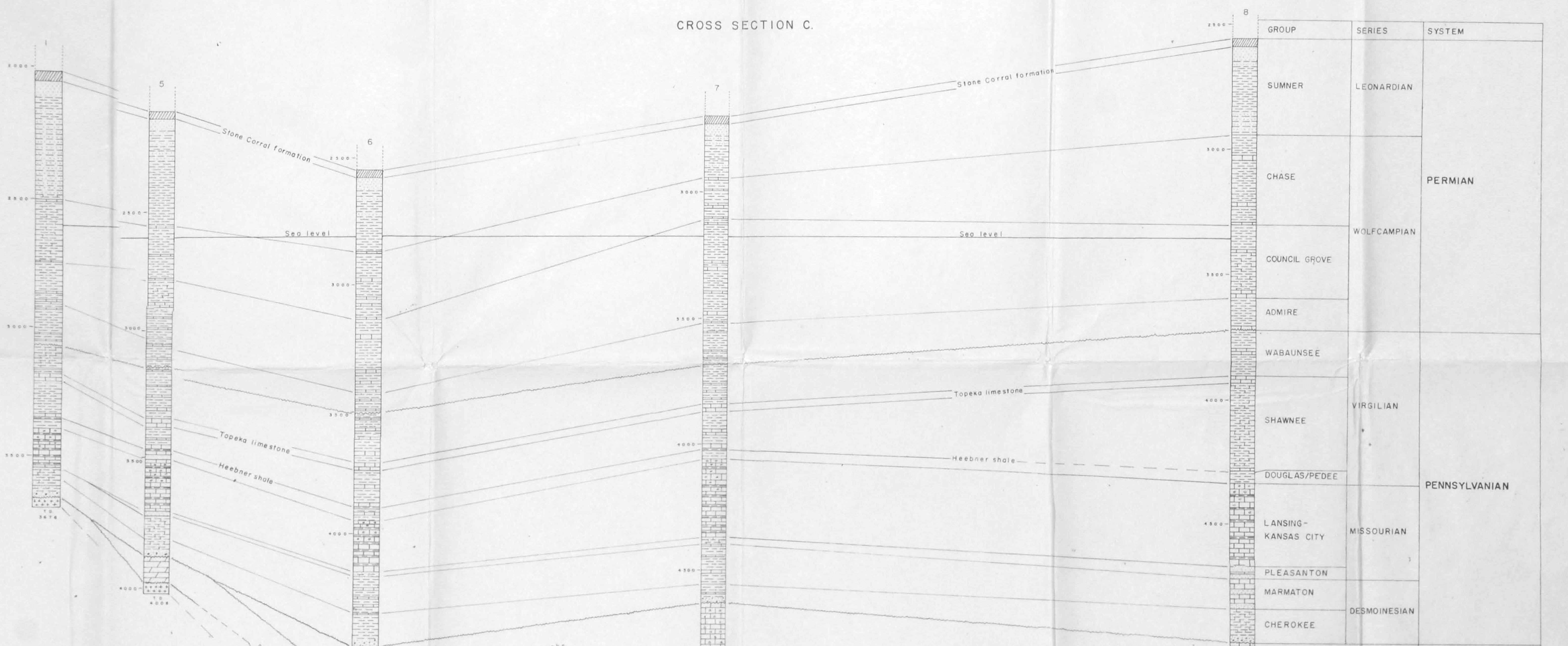
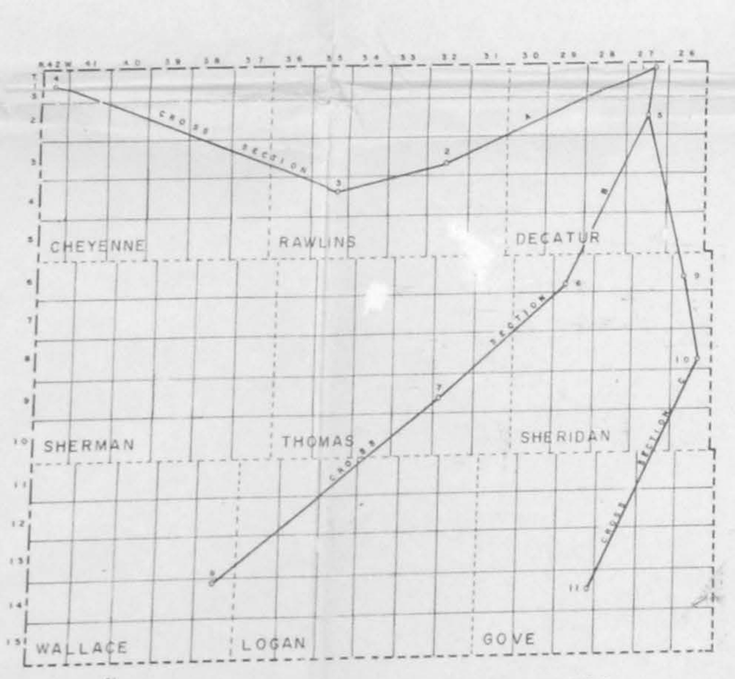
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
T. 14 S.
T. 15 S.
Cheyenne
Rawlins
Decatur
Sheridan
Thomas
Wallace
Logan
Gove
0 MISSISSIPPIAN









List of Wells

Well No.	Company	Farm name	Fee No.	Location	Elevation in feet above sea level
1.	Helmerich & Payne Inc.	Sauvage	1	Sec. 3, T 1 S., R 27 W., Decatur Co.	2612
2.	National Gas & Oil	Lewis	1	Sec. 21, T 3 S., R 32 W., Rawlings Co.	3018
3.	Stanolind Oil & Gas	Mullen	1	Sec. 14, T 4 S., R 35 W., Rawlings Co.	3174
4.	Deep Rock Oil Corp.	Clark	1	Sec. 23, T 1 S., R 42 W., Cheyenne Co.	3456
5.	E.K. Carey Drilling Co.	Monaghan	1	Sec. 15, T 2 S., R 27 W., Decatur Co.	2601
6.	Westpan Hydrocarbon Co.	E. Wessel	1	Sec. 27, T 6 S., R 29 W., Sheridan Co.	2815
7.	Trans-Tex. Drlg.	Keller	1	Sec. 19, T 9 S., R 32 W., Thomas Co.	3183
8.	Flynn Oil Co.	C. Pierce	1	Sec. 4, T 14 S., R 38 W., Wallace Co.	3349
9.	Natl. Coop. Ref. Assoc.	Hardesty	1	Sec. 20, T 6 S., R 26 W., Sheridan Co.	2657
10.	Union Oil of California	Pratt	1	Sec. 23, T 8 S., R 26 W., Sheridan Co.	2510
11.	Wycoff & Williams	R.L. Lundgren	2	Sec. 31, T 14 S., R 29 W., Gove Co.	2663

EXPLANATION

- Limestone
- Oolitic limestone
- Cherty limestone
- Sandy limestone
- Dolomite
- Cherty dolomite
- Sandy Dolomite
- Anhydrite
- Shale
- Shale and limestone
- Sandstone
- Conglomerate
- Granite wash and granite
- Prominent unconformity
- Doubtful correlation
- Incomplete formation

Simpson rocks are included with the Arbuckle group.

SUBSURFACE GEOLOGY OF NORTHWESTERN KANSAS

by

CLAUDE ALVIN ROHRBOUGH

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

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

1956

Northwestern Kansas includes nine counties in the north and west corners of the state. This investigation was to determine the relationship of stratigraphy, structure, geologic history and petroleum accumulation. Structure maps and cross sections were constructed to show the relationship of petroleum accumulation to the structure and stratigraphy of the Paleozoic rocks. Subsurface data was obtained from Herndon Map service, electric logs and drillers logs. Rock units present in northwestern Kansas range in age from Pre-Cambrian to Quaternary, but Silurian, Devonian and Triassic rocks are absent.

Structurally, northwestern Kansas is the northern end of the Hugoton embayment, which is a southerly plunging synclinal area, of the larger Anadarko basin in Oklahoma. The Hugoton embayment exists only in Paleozoic rocks. Post-Paleozoic movement tilted the area into the Denver basin giving Mesozoic sediments a northerly dip. Cenozoic rocks assumed a different structural pattern and generally dip east. Structural features in northwestern Kansas are the Las Animas arch, Cambridge arch, Ellis arch, Jennings anticline, Selden syncline, Oakley anticline, Western Kansas basin, and a marginal syncline along the eastern edge of the Las Animas arch.

Geologic history shows erosional zones developed by weathering in post-Ordovician, post-Mississippian, and post-Missourian time are potential oil reservoirs. Major oil production is obtained from the Lansing-Kansas City group (Pennsylvanian) and the Mississippian limestone. Potential producing zones are the

Arbuckle group (Ordovician), the Lamotte sandstone (Cambrian) and the Dakota formation (Cretaceous).

Lansing-Kansas City production is obtained from closed anticlinal structures in Decatur county and on noses in Sheridan and Gove counties. Mississippian production in Gove and Thomas counties is associated with noses which follow the trend of the Oakley anticline. Arbuckle production in bordering counties is from stratigraphic traps, generally independent from structure. Dakota production in the Denver basin is from lenticular sand bodies and stratigraphic traps. Many areas not yet drilled are located in northwestern Kansas which meet the criteria for possible production from the Lansing-Kansas City group and the Mississippian limestone. Stratigraphic traps developed by truncation of the Arbuckle rocks and the Mississippian rocks are undeveloped in Rawlins and Decatur counties.