# SUBSURFACE GEOLOGY OF BARBER COUNTY, KANSAS

by

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# INTRODUCTION

## Purpose of Investigation

The purpose of this investigation is to study the subsurface geology of Barber County, Kansas, and to determine how this is related to oil accumulation in the area.

## Location and Physiography

Barber County is an area covered by T. 30 to 35 S. and R. 10 to 15 W., and consists of 1,134 square miles. The county is bordered on the north by Pratt and Kingman counties; on the east by Harper County; on the south by Alfalfa and Woods counties, Oklahoma; and on the west by Comanche and Kiowa counties.

The county is drained by Elm Creek in the northern part, emptying into Medicine Lodge River just south of Medicine Lodge. Medicine Lodge River flows from the northwest part of the county to the southeast part of the county, draining that area. The southwest part of the county is drained by Salt Fork River. Medicine Lodge River drains into Salt Fork River in Alfalfa County, Oklahoma, and Salt Fork River, in turn, drains into Arkansas River in eastern Oklahoma.

The topography of eastern Barber County is rolling to flat, while the rugged Gypsum Hills, consisting of Permian redbeds with outcrops of gypsum and anhydrite, cover the western part of the county from north to south.

## Procedure

Six structural maps, two isopachous maps, and two cross-sections were drawn on the Arbuckle group, Simpson group, Viola limestone, Mississippian system, Lansing-Kansas City group, and Douglas group. A contour interval of 20 feet and a scale of one inch to the mile were used for the structural maps of the Mississippian system and Viola limestone. The remaining structural maps were contoured with an interval of 40 feet and a scale of one and one-tenths inches equaling six miles. Two isopachous maps were drawn to show the thickness of the Mississippian and Devonian systems and thickness of the Simpson group, and also to see if thickness contributed to production from these two zones. Isopachous maps of the Mississippian and Devonian systems were made by overlaying the Mississippian system structural map on the Viola limestone structural map. The Simpson group thickness map was made by overlaying the Simpson group structural map on the Arbuckle group structural map. The contour interval on the Mississippian and Devonian systems thickness maps is 20 feet, with a scale of one inch to the mile, and the contour interval of the Simpson thickness map is 40 feet, with a scale of one and one-tenth inches equaling six miles.

Two cross-sections were drawn to show facies change, pinchouts, and age of structure in the county, using as marker beds, the Heebner shale member, Douglas group, Lansing-Kansas City group, Cherokee group, Marmaton group, Mississippian system, Chattanooga shale, Viola limestone, Simpson group, and Arbuckle group. Herndon maps were the source for the data used in making the maps and cross-sections, supplemented by drillers logs, scout cards, electric logs, and, in one instance, samples.

## REVIEW OF LITERATURE

A report by Ver Wiebe (1938) described the stratigraphic units present in Barber County. Williams and Bayne (1946) published a ground water report on the Elm Creek Valley, covering the stratigraphy of outcropping rocks. Ver Wiebe (1948b) made an extensive study of the Viola limestone in the county. Since this time, no other reports have been published on Barber County.

The structural history of the Hugoton Embayment was discussed by Maher and Collins (1948), and Merriam (1955). The Central Kansas Uplift was described by Morgan (1932), and Koester (1935). Lee (1943) reported on the Forest City Basin and the Nemaha Anticline. The Nemaha Anticline was also discussed by Ley (1926). Jewett (1951) described briefly all of the major structures and many of the minor structures of Kansas. Wheeler (1947)(1950) has discussed the Anadarko Basin of Oklahoma.

Moore, et al (1951) described the stratigraphic units in Kansas. A very complete record of the development of oil in Kansas, by counties, has been maintained since 1927. Ver Wiebe and associates compiled this record from 1937 to 1954; from 1955 to the present, Goebel, et al, have continued the record. Before 1937, the record was maintained by Kestler (1928), Folger (1933), Hall (1933), Koester (1934), and Landes (1937).

## STRATIGRAPHY

### Pre-Cambrian Era

Rocks of pre-Cambrian age underlie all of Kansas. These rocks include granite, porphyry, gneiss, schist, quartzite, slate, and marble, according to reports from deep wells. Granite or gneiss probably is the most widespread (Moore, et al, 1951). In the deepest well drilled in Barber County, by Barbara Oil Company in 1928, the pre-Cambrian was described by geologist Frank Anderson as "hard sand", probably quartzite.

The grain of the continent in Kansas and Oklahoma, as indicated by the Nemaha Granite Ridge, Ozark Dome, and Hunton Arch of southeastern Oklahoma, is influenced by the northern to northwestern direction of the western leg of the pre-Cambrian trend line of the continent, and played a dominating role throughout Paleozoic deformation. The pre-Cambrian basement complex is part of the Laurentian continental nucleus (Ruedeman, 1935).

### Cambrian System

Waucoban and Albertan Series. Waucoban and Albertan series are absent in Barber County.

Croixian Series. The Croixian series consists of "granite wash", Reagan sandstone, Bonneterre dolomite, and Eminence dolomite. The "granite wash", Reagan sandstone, and Eminence dolomite are absent in Barber County.

Bonneterre dolomite is in contact with the pre-Cambrian system in Barber County. The Bonneterre dolomite is dense, coarsely crystalline, and glauconitic, locally brown in color, becoming coarser near the Reagan contact. Green dolocastic shale is common in the upper part (Keroher and Kerby, 1948).

The Bonneterre dolomite is correlated with the Honey Creek limestone of Oklahoma, and is conformable on the Reagan sandstone (Moore, et al, 1951). The formation varies in thickness from 25 feet in the SW¼ Sec. 29, T. 31 S., R. 10 W. to 140 feet in the NW¼ Sec. 19, T. 33 S., R. 12 W. in Barber County. Koester (1935) stated that McQueen found Ozarkian beds under Canadian beds and above the pre-Cambrian system in Barber County. Very little is known about this formation in Barber County, as only two wells have penetrated Cambrian rocks.

## Ordovician System

Canadian Series. The Canadian series is represented in Barber County by the Arbuckle group. The Roubidoux formation has a thickness of 150 to 200 feet in Kansas (Moore, et al, 1951). The formation is a white, very coarsely crystalline dolomite, containing fine bright angular sand, and is the most widely distributed formation of the Arbuckle group in Kansas. The Roubidoux formation lies unconformably on the Bonneterre dolomite in Barber County (Keroher and Kerby, 1948). The absence of glauconite and a change from coarse, rounded sand grains in the Roubidoux formation to fine-textured angular sand in the underlying Bonneterre dolomite differentiates the two formations. Very little change appears in the dolomite (Keroher and Kerby, 1948).

The uppermost recognized zones of the Arbuckle group are the Cotter and Jefferson City dolomites, consisting of dolomites of various textures and colors, characterized by a high percentage of chert. The Jefferson City and Cotter dolomites are correlated with Jefferson City and Cotter dolomites of Missouri, but are not differentiated in Kansas (Keroher and Kerby, 1948).

The Cotter-Jefferson City formation consists mainly of coarsely granular cherty dolomite, with oolitic brown chert, becoming white and decreasing in volume towards the base of the formation. As this occurs, white tripolitic chert becomes abundant (Moore, et al, 1951). The Cotter-Jefferson City formation is conformable with the underlying Roubidoux formation.

The Roubidoux and Jefferson City-Cotter formations are all Canadian in age, and compose the Arbuckle group in Barber County. The Arbuckle group in southern and eastern Kansas is a fine-grained brown dolomite, cherty in places, and is sometimes known as the "siliceous lime". McClellan (1930) says this name should be abolished, since the Arbuckle group is only locally siliceous and is dominantly dolomitic. The Arbuckle group varies from a thickness of 830 feet in the NW¼ Sec. 19, T. 33 S., R. 12 W., to 994 feet in the SW¼ Sec. 29, T. 31 S., R. 10 W. in Barber County.

Middle Ordovician. The St. Peter sandstone and underlying green Simpson shales and sandstones form the Simpson group of Barber County. The Platteville formation, overlying the St. Peter sandstone, is absent in Barber County because of post-St. Peter erosion. The Simpson group in Barber County is predominantly tan to brown, fine dolomitic sand, with rounded to frosted quartz grains, and grey to green shale, and, in part, correlates with the

Simpson group of Oklahoma. The Simpson group in Barber County is absent in T. 33 S., R. 12 W., but reaches a thickness of 260 feet in T. 35 S., R. 10 W. and T. 35 S., R. 11 W. (Appendix Fig. 4).

The Viola limestone is present throughout Barber County. Barwick (1926) called the Viola the " Urschel" limestone, but this name has never been generally accepted.

An important producing zone in Barber County is an argillaceous rock, sometimes referred to as Sylvan shale, lying above the coarse crystalline Viola limestone. In past years, there has been dissention among geologists as to whether this rock was Sylvan shale or Viola limestone. Ver Wiebe (1948b) states the argillaceous rock is merely a different zone in the Viola limestone. The Viola limestone in southern Kansas can be divided into six zones. All zones are present in Barber County except the top one, Zone I. The lowest zone (Zone VI) has been found in every well studied, and it probably occurs over the whole area of Barber County. The zones from top to bottom are (Ver Wiebe, 1948b):

" I - Cherty dolomite. Dolomite is brown chunky, finely crystalline. The chert is dull white or tripolitic. Average thickness 30 feet.

II - Limestone. White and grey with brown spots. Average thickness 20 feet.

III - Cherty dolomite. Dolomite is granular, buff, or finely crystalline, or chunky. The chert is usually white or tripolitic, rarely blue. Average thickness 50 feet.

IV - Same description as for Zone II. Locally crinoidal ls. Average thickness 30 feet.

V - Dolomitic and cherty argillite. Scattered dolomite rhombs set in white or dirty matrix. Or dolomite may be even granular and micro-rhombohedral. The chert is usually dark grey, smoky grey, or speckled. Rarely blue. Average thickness 70 feet.

VI - Limestone, coarsely crystalline, white with brown spots or splotches of grey or black - rarely pink or green. Locally some lithographic limestone. Sand-studded at base. Average thickness 20 feet."

Zone V is often called Sylvan shale by geologists and scouts, and with slight facies modifications, is the most distinctive unit in the entire Viola sequence (Ver Wiebe, 1948b).

Some of the wells on the Barber County Arch in the northwest part of the county show the Viola limestone eroded down to Zone IV and into the next lower zone (Ver Wiebe, 1948b).

Zone III is poorly represented in Barber County, because post-Ordovician erosion resulted in widespread solution of the calcareous material, leaving a thick mantle of detrital rubble. Nevertheless, some wells show the zone intact.

All zones from II to VI are preserved in T. 32 S., R. 14 W. (Ver Wiebe, 1948b).

Rocks of late Ordovician age, which include the Sylvan shale, are not present in Barber County. wrong - Maquoketa

Silurian System

Rocks of Silurian age are absent in Barber County.

## Devonian System

The only rock of Devonian age recognized in Barber County is the Chattanooga shale, often erroneously called the " Kinderhook shale" . The Misener sandstone member is located in the base of the Chattanooga shale, and has been recognized in some wells in Barber County, although pre-Chattanooga erosion removed most of this member from the area.

The silty and pyritiferous Chattanooga shale is above, below, and in the middle of grey dolomitic shale (McClellan, 1930). The shale contains round brownish spores Sporangites huronensis (McClellan, 1930). Chattanooga shale is present throughout the county, except over the Barber County Arch, where it was removed by pre-Mississippian erosion (Appendix Fig. 10 and 11).

## Mississippian System

The Mississippian system in Barber County is sometimes called the " Mississippi Chat" . The Mississippi Chat is absent in the northwest part of the county and has a thickness of 500 feet in T. 35 S., R. 14 W. (Appendix Fig. 7).

Kinderhookian Series. Rocks of Kinderhookian series are absent in Barber County.

Osagian Series. The St. Joe limestone is the only rock of Osagian age in Barber County. Greyish green and dark green shales are more abundant than red shales. The green shale is not sharply defined and may be 40 to 60 feet above the base of the St. Joe limestone. The rest of the St. Joe limestone is red crinoidal limestone, red and dark shales interstratified with cherty limestones (Lee, 1940).

Meramecian Series. The Meramecian series lies disconformably on deeply eroded beds of Osagian series. The Meramecian series contains Warsaw limestone and the Cowley formation in Barber County. The Cowley formation is predominantly dolomite, with dolomitic siltstone and variably large amounts of dark microfossiliferous chert. The Warsaw limestone is a semi-granular limestone interlaminated with sugary dolomite, and also contains large amounts of microfossiliferous chert (Moore, et al, 1951).

Chesterian Series. Rocks of Chesterian series are absent in Barber County.

## Pennsylvanian System

Morrowan and Atokan Series. Rocks of Morrowan and Atokan series are absent in Barber County.

Desmoinesian Series. The Desmoinesian series includes the Pennsylvanian basal conglomerate, Cherokee group, and Marmaton group in Barber County. The Pennsylvanian basal conglomerate was first called " Sooy Conglomerate" by Edson, the name originating from an early well drilled in Barton County. The name " Sooy Conglomerate" has not been very widely used. The conglomerate is usually coarse chert with minor amounts of sand, and is usually interstratified with red shale (Koester, 1935).

The Cherokee group is present in the southwestern part of Barber County (Appendix Fig. 10). The Cherokee group in Barber County is composed mostly of dark grey shales and sandy shales, with some limestone. The interpretation of the Cherokee group on radio active logs is similar to eroded Mississippian limestone and chert in Barber County.

The Marmaton group is the uppermost group in the Desmoinesian series. A big change occurs in paleontology and lithology of the formations between Missourian and Desmoinesian time (Moore, et al, 1951). The Marmaton group is sometimes distinguished in Barber County, and sometimes the interval between the base of the Kansas City group and Mississippian system is called " Basal Conglomerate" . The Marmaton group is composed of dark green to black shale, white to buff limestone, and some dense chert in Barber County.

Missourian Series. The Kansas City group is the lowermost group in the Missourian series in Barber County. The Lansing group and Kansas City group are considered as one unit in Barber County, as in no place can the two be separated, except in the very eastern part of the county (Appendix Fig. 11). The combined thickness of the Lansing-Kansas City group is about 400 to 500 feet. The Lansing-Kansas City group is white to buff, fine, dense, cherty limestone, with dark green hard splintery shale. Interbedded dark grey shales in the Lansing-Kansas City group reach a thickness of from five to ten feet (Rutledge and Bryant, 1937). These shales are clearly interpreted on electric logs (Appendix Fig. 10 and 11). Koester (1935) called the Lansing group the " Oswald limestone" in western Kansas, but the name has not been used by geologists and drillers in the Barber County area.

The Pedee group is absent in wells studied in Barber County.

<u>Virgilian Series</u>. The Douglas group is the lowermost group in the Virgilian series in Barber County, and unconformably overlies the Lansing-Kansas City group. The top of the Douglas group in Barber County is usually grey to dark green shale, and the Douglas sand is usually fine to medium grained sandstone. The lower 15 feet is composed of gray shales with some hard shelly limestones and an occasional massive water bearing sandstone (Ver Wiebe, 1938).

The average thickness of the Shawnee group is about 300 to 350 feet. The Topeka limestone marks the top of the Shawnee group. The Shawnee group is composed of massive limestones with thin bedded shales (Ver Wiebe, 1937). The Heebner shale is the most prominent bed in the formation, and is a black platy shale that is very distinctly interpreted on radioactive logs because of its high radioactive content, and is used as a marker bed in the area. Everything below the Heebner shale and above the Douglas group in Barber County is placed into one zone and called the " Toronto limestone" , although the Toronto limestone itself is located only in the bottom few feet of the zone. The Elgin sandstone is sometimes distinguished in Barber County. The Elgin sandstone is composed of sandy shale, red shale, and sandstone, and is located above the Heebner shale. Topeka limestone can be correlated with the upper part of the Pawhuska formation of Oklahoma (Moore, et al, 1951).

The Wabaunsee group is about 500 feet thick, except in places where the overlying unconformity cuts into the upper beds (Moore, et al, 1951). The Wabaunsee group is predominantly shale with thin limestones in Barber County.

## Permian System

Wolfcampian Series. The Wolfcampian series, formerly called the " Big Blue Series", contains the Chase, Council Grove, and Admire groups. The Admire group is predominantly shale with thin limestones and some coal (Moore, et al, 1951). The Admire group unconformably overlies Pennsylvanian rocks in Kansas.

The Council Grove group overlies the Admire group and is composed of alternating limestone and shale. The limestones are thinner and less massive than those in the overlying Chase group (Moore, et al, 1951). The Barneston limestone is the only formation in the Council Grove group of interest in Barber County. The Barneston limestone is called " Fort Riley limestone" by the drillers in the area, and is important as a marker, as it is the first hard, dense, massive limestone to be drilled.

The Chase group is the uppermost group of the Wolfcampian series, and is composed of red and green shales, and alternating escarpment making limestones. The only important formation in the group is the Herington limestone, which is a dolomitic limestone used in some areas as a subsurface marker bed (Moore, et al, 1951).

Leonardian Series. The Leonardian series was named from strata in the Glass Mountain area of west Texas, and is represented in Kansas by approximately 1900 feet of strata. The Leonardian series contains the Nippewalla and Sumner groups (Moore, et al, 1951). The Sumner group comprises approximately 1000 feet of strata. The only formations of importance in the Leonardian series in Barber County are the Wellington formation of lower Sumner and the Stone Corral dolomite of the upper Sumner group. The Stone corral dolomite is known as the "Cimarron anhydrite" in Oklahoma. The Wellington formation is chiefly shale, with a few hundred feet of salt in the middle (Moore, et al, 1951). The Stone Corral dolomite is a thin bed of dolomite, anhydrite, and gypsum, and is an excellent marker bed for electric logs, although it is more frequently used for seismic mapping than for electric logs in Barber County.

The Nippewalla group outcrops in Barber County and has a total thickness of 900 feet. The hills of Barber County are composed chiefly of Cedar Hills sandstone, Flowerpot shale, Blaine formation, and Dog Creek shale. Cedar Hills sandstone crops out in Elm Creek Valley and includes a prominent white sandstone at the base and top. Softer, more shaly red siltstones separate the more massive sandy beds (Williams and Bayne, 1946). The Flowerpot shale was differentiated by Cregin, who named it from Flowerpot Mound, southwest of Medicine Lodge at the divide between East and West Cedar Creeks. Flowerpot shale consists of dark red-brown to reddish-purple shale, containing many thin and a few thick sandstones. The Blaine formation was named by Gould, and takes its name from Blaine County, Oklahoma (Latta, 1948). The Blaine formation is divided into four members, from top to bottom: Haskew gypsum member, Shimer gypsum member, Nescatunga gypsum member, and Medicine Lodge gypsum member. The Medicine Lodge gypsum member is the thickest gypsum bed in Kansas, reaching a thickness of 30 feet (Moore, et al, 1951). The Medicine Lodge gypsum member is the only remaining member of the Blaine formation in the Medicine Lodge River drainage basin of Barber and Kiowa counties (Latta, 1948). The Medicine Lodge gypsum member is of economic importance in Barber County, where it is mined southwest of Sun City by the National Gypsum Company.

Dog Creek shale was named by Cregin from exposures on Dog Creek, south of Lake City, in Barber County. According to Knight, Dog Creek shale contains several thin beds of impure granular dolomite, but in places in the northwestern part of the county, the dolomites are absent, and at about the same stratigraphic position, thin beds of gypsum bearing sandstones occur (Latta, 1948).

Guadalupian Series. Rocks of Guadalupian series are absent in Barber County.

## Triassic System

Rocks of Triassic age are absent in Barber County.

## Jurassic System

Rocks of Jurassic age are absent in Barber County.

## Cretaceous System

Comanchean Series. The Cheyenne sandstone is the only rock of Cretaceous age in Barber County, and was named in 1889 from Cheyenne Rock, a mass of sandstone forming a prominent ledge on the north side of Medicine Lodge Valley, about three-fourths of a mile west of Belvidere, in Comanche

County. Cheyenne sandstone crops out in an irregular narrow band around the headwaters of Medicine Lodge River, Mule Creek, and other streams in Barber, Kiowa, and Comanche counties. Cheyenne sandstone consists of light colored, fine to medium grained, friable cross-bedded sandstone and lenses of sandy shale and conglomerate, and is 55 feet thick in Barber County (Latta, 1948).

## Tertiary System

Pliocene Series. The only rock of Pliocene series recognized in Barber County is the Ogallala formation, consisting chiefly of calcareous silt, sand, and gravel. Ogallala sedimentation probably started in the lowland areas and expanded over the highlands as the lowlands filled (Latta, 1948).

## Quaternary System

The Quaternary system in Barber County is represented by the Pleistocene series. Gravelly Pleistocene deposits crop out in the steep valleyside walls at heads of pediments cut in Permian shales and siltstones.

Aftonian and Nebraskan Stages. An exposure of Blanco formation occurs along road cuts in the SW¼ Sec. 35, T. 31 S., R. 10 W. in northeastern Barber County. Here, partly cemented fine sands, silts, and sandy silts, grey and grey-green in color, occur on the Permian surface, below the level of extensive Grand Island gravels to the north (Frye and Leonard, 1952).

The Blanco formation is predominantly gravel, sand, silt, and clay, derived from continental and mountain outwash (Moore, et al, 1951). Eroded remnants of Afton soil have been observed at localities in Kingman, Meade, Harper, and northern Barber counties (Frye and Leonard, 1952).

Yarmouthian and Kansan Stages. The Meade formation is predominantly gravel, sand, silt, and clay derived from continental and mountain glacial outwash (Moore, et al, 1951). The Meade formation contains the Pearlette volcanic ash beds to the north and east. The Meade formation occurs in the eastern part of Barber County.

Sangamonian and Illinoian, Wisconsinan, and Recent Stages. The Sanborn formation is predominantly massive silt, soil, sand, and gravel (Moore, et al, 1951). The Sanborn formation includes the following members: (1) Crete sand and gravel member, (2) Loveland silt member, (3) Unnamed early Wisconsinan alluvial deposits, (4) Peoria silt member, (5) Unnamed late Wisconsinan alluvial deposits, and (6) Bignell silt member (Frye and Leonard, 1952). South of the Arkansas River Valley in extreme south central Kansas, late Wisconsinan alluvium occurs in many of the valleys under a distinct terrace surface at a level lower than the adjacent early Wisconsinan terrace. The red rock floor below also shows this distinct effect in level. The change in level is shown by exposures in the cut bank of Medicine Lodge River in the NE$\frac{1}{4}$SW$\frac{1}{4}$ Sec. 20, T. 33 S., R. 11 W. in Barber County. The town of Gerlane is on the surface of the second terrace. The terrace deposits consist of sand and gravel, resting on Permian shale and siltstone three or four feet above normal water level of the Medicine Lodge River. Late Wisconsinan terrace terminates the Gerlane terrace, and its bedrock floor is at an unknown depth below channel level. The Wisconsinan terrace is predominantly sandy silt and clayey silt, and contains a buried soil about four feet below the terrace surface. A post-Bradyan molluscan fauna was collected from below the base of the buried soil profile (Frye and Leonard, 1952). The terraces were named " Gerlane formation" from the town of Gerlane (Latta, 1948). Knight says the Gerlane formation is of alluvial origin, being derived from remains of Tertiary formations of the area (Williams and Bayne, 1946). The Gerlane formation is at least part Sanborn formation, and is Illinoian-Wisconsinan in age (Frye and Leonard, 1952). Alluvium in the valley of Elm Creek and in places along the Medicine Lodge River Valley is of Recent age and consists of unconsolidated stream deposited material (Williams and Bayne, 1946).

## STRUCTURE

### Major Pre-Mississippian Structures in Kansas

Southwest Kansas Basin. The name " Southwest Kansas Basin" was given to a major pre-Mississippian structural province in southern Kansas by Moore and Jewett in 1942 (Appendix Fig. 12). The Southwest Kansas Basin is one of two major pre-Mississippian basins in Kansas, and was separated from the other basin, the North Kansas Basin, by the Central Kansas Arch, or Ellis-Chautauqua Axis. Devonian and Silurian rocks (Hunton) are absent in southwestern Kansas, and Mississippian beds overlie, at least locally, the Viola limestone (Jewett, 1951).

North Kansas Basin. The name " North Kansas Basin" was proposed by

Rich in 1933 for the large pre-Mississippian basin north of the Chautauqua Arch and north and east of the Ellis Arch (Appendix Fig. 12). The North Kansas Basin was one of the major structures of Kansas before the development of the Nemaha Uplift and other post-Mississippian major structures. The North Kansas Basin formed after Simpson time, when the Nebraska Arch subsided. The Nebraska Arch was a positive area until the end of Simpson time. The Ozark region of Missouri rose and the Chautauqua Arch and Central Kansas Uplift began their upward movement at the time the North Kansas Basin formed (Jewett, 1951).

Ellis Arch. The "Ellis Arch" was named by Moore and Jewett (Moore and Jewett, 1942). The Ellis Arch is part of the ancestral Barton Arch, or what is now known as the Central Kansas Uplift (Appendix Fig. 12). The Ellis Arch is a major pre-Mississippian structure in central and northwestern Kansas. Mississippian rocks are absent over this area (Jewett, 1951).

Chautauqua Arch. The name "Chautauqua Arch" is applied to a major pre-Mississippian structural element in Kansas and Oklahoma, and is part of the ancestral Ozark Uplift (Appendix Fig. 12). The Chautauqua Arch was named by Barwick (1928). Dipping pre-Mississippian beds on the north flanks of the Chautauqua Arch comprise a structure known as the Ozark Monocline (Jewett, 1951). The Ellis Arch and Chautauqua Arch comprise part of the Transcontinental Arch extending into Kansas and Missouri (Eardley, 1951).

## Major Post-Mississippian Structures

Anadarko Basin. The Anadarko Basin occupies an area of approximately

35,000 square miles in western Oklahoma, the Texas Panhandle, and southwestern Kansas. The Anadarko Basin is bounded by the Wichita Mountains and the Amarillo Uplift on the south, the Hugoton Embayment on the west, the Central Kansas Uplift on the north, and the Nemaha-Oklahoma City Uplift on the east (Ball, 1951).

The Anadarko Basin came into existence as a subdivision of a larger southern Oklahoma exogeosyncline, and was further modified during Pennsylvanian and Permian times to create additional combination of structure and stratigraphy. The Anadarko Basin was shown to extend into Kansas by Clifton in 1926, when he published a map showing the deepest part of the Kansas portion being in Comanche County (Jewett, 1951). Clifton's theory was later disproved by Collins in 1948, when he found the deepest part of the basin to lie further to the west, near the town of Hugoton, Kansas (Jewett, 1951).

Wheeler (1950) says development of the Anadarko Basin can be broken down into four major orogenic movements:

(1) Appearance and rejuvenated arching of the Central Kansas and Ozark Uplifts. Deposits of Cambrian to pre-Mississippian age converged on the uplifts.

(2) Regional tilting and broad gentle warping, bevelling off northward, the Hunton limestone to Arbuckle group sequence.

(3) A full scale orogeny in early Pennsylvanian time developed the Amarillo, Wichita, Arbuckle, and Ouachita Uplifts. Deformation decreased from east to west. The northern flanks of the Amarillo, Wichita, Arbuckle, and

Ouachita Uplifts formed the Anadarko Basin.

(4) Rejuvenated faulting, warping, and overthrusting, culminating in late Pennsylvanian and early Permian time, re-elevated the above features.

The Anadarko Basin may be divided into five structural provinces, according to Wheeler (1947):

(1) Anadarko Trough. The Anadarko Trough is located along the northern flank of the Amarillo-Wichita Uplift, and is characterized by large isolated northwest trending structures, related to the Wichita Mountains.

(2) The Southeastern Embayment. The Southeastern Embayment lies between the Nemaha-Oklahoma City Uplift and the Western Arbuckles, and is bordered on the southeast by the Pauls Valley Uplift. The area is highly faulted and folded.

(3) The Central Basin Flank. The Central Basin Flank is located in the center of the Anadarko Basin, north of the Anadarko Trough, and is relatively undisturbed, except locally.

(4) The Northern Basin Shelf. The Northern Basin Shelf is located on the northwestern flank of the Anadarko Basin, extending from Oklahoma to Clark, Comanche, and Barber counties in Kansas (Appendix Fig. 13). The area was named by Wheeler (1947)(Jewett, 1951). The Mississippian and Pennsylvanian rocks undergo an abrupt change in their rate of thinning, and undergo a facies change from basal sands to platform limestones suggestive of a north basin platform. The facies change makes the Northern Basin Shelf an important oil province.

(5) The Dodge City "Hugoton" Embayment. The Dodge City, or "Hugoton" Embayment is a northern extension of the Anadarko Basin extending into southwestern Kansas. The embayment extends down into the panhandles of Oklahoma and Texas and out into southeastern Colorado, and has an asymetrical shape, with the deepest part to the southwest. The embayment is approximately 150 miles wide and is over 150 miles long, and lies between the Sierra Grande Uplift to the west and the Central Kansas Uplift to the east (Appendix Fig. 13).

The term "Dodge City Basin" was applied by McClellan (1930) to the area. Later, the term "Hugoton Embayment" was applied to the area by Maher and Collins (1948), who gave three reasons "Hugoton" should be used rather than "Dodge City":

(1) Axis of the trough extends northwest across Kansas near the town of Hugoton, 85 miles from Dodge City.

(2) The thickest deposits of Pennsylvanian and Mississippian rocks lie considerably southwest of Dodge City.

(3) Lower Pennsylvanian and upper Mississippian rocks are located only in the deepest part of the basin, and the town of Hugoton lies near the center of the area (Maher and Collins, 1948).

Jewett (1951) says "Dodge City" should be used, because of its long usage. The priority and usage of a name should not have precedence, if due to further investigation, a name of an area if found to be incorrect (Muehlhauser, 1958).

The Hugoton Embayment underwent several periods of deformation during the Paleozoic era, causing marginal areas to be uplifted. The uplifted areas supplied sediments for the Hugoton Embayment. The deformation can be divided into five major periods: (1) At the close of Arbuckle time, (2) at the close of Viola time, (3) at the close of Chesterian time, (4) at the close of Morrowan time, and (5) at the close of Permian time. The Hugoton Embayment was divided into two basins during Permian time by the Oakley Anticline, and the basins were called Syracuse to the west and Cimarron to the east. The Oakley Anticline was almost destroyed during the Cretaceous period when a marginal syncline developed (Merriam, 1956).

A depression forms near the borderland in many asymmetric basins. The borderland of the Anadarko Basin is the Wichita Mountains. Stagnant conditions are developed in the depressions, where rapid deposition tends to bury quickly organic material susceptible of being formed into petroleum. Such an area may become the source area for the evolution of petroleum. Petroleum may move upward and outward until it is stopped by a structural or stratigraphic trap (Moore, 1951).

Central Kansas Uplift. The Central Kansas Uplift occupies a position in central Kansas and south central Nebraska (Appendix Fig. 13). The term "Russell Arch" was first used by Denison in 1926, and the term "Barton Arch" was used by Barwick in 1928 for the Central Kansas Uplift (Koester, 1935). Neither term has had wide acceptance since Morgan, in 1932, introduced the term "Central Kansas Uplift". The term "Central Kansas Uplift" had been in use among Kansan geologists before Morgan published a paper on the subject. Since the paper was published, "Central Kansas Uplift" has been the most widely used structural term (Koester, 1935).

The Central Kansas Uplift originated in pre-Cambrian time as a series of parallel batholiths, and remained a positive element throughout most of the Paleozoic folding. The folding occurred chiefly in post-Algonkian, post-Canadian, post-Hunton, early Pennsylvanian, post-Missourian, and post-Cretaceous times. Folding normal to the axis of the uplift occurred during the last two phases, and has been an important factor in local accumulation of petroleum. At the time the Central Kansas Uplift was broadly warped during early Pennsylvanian time, the Nemaha Anticline and other structures in Kansas underwent movement. Most folds produced during the Pennsylvanian and post-Cretaceous movements were merely a resurrection of earlier folding (Koester, 1935).

Salina Basin. The Salina Basin is located in north central Kansas. The Salina Basin is bordered on the west by the Central Kansas Uplift and Cambridge Arch, and on the east by the Nemaha Anticline. The Salina Basin is separated from the Sedgwick Basin to the south by a broad gentle uplift, running between the Central Kansas Uplift and the Nemaha Anticline (Appendix Fig. 13). The Salina Basin was named by Barwick in 1928 (Jewett, 1951).

Lee divided the structural development of the Salina Basin into five phases by use of thickness maps:

(1) Arbuckle dolomites were uplifted and eroded before the deposition of St. Peter sandstone. A broad syncline developing at this time was later to become the Central Kansas Uplift.

(2) The Ozark Basin was transformed into the Ozark Uplift, and the North Kansas Basin was formed from the Southeast Nebraska Arch from St. Peter to Mississippian time.

(3) From Mississippian to Permian time, the Nemaha Anticline was formed, dividing the North Kansas Basin into the Forest City Basin on the east, and the Salina Basin on the west side of the anticline.

(4) From post-Permian to post-Cretaceous time, gentle tilting toward the Hugoton Embayment took place.

(5) Post-Cretaceous tilting again shifted the dip of the Salina Basin rocks. The tilt was in the direction of the Denver-Julesburg Basin (Lee, 1956). Changes in dip have destroyed the closure and changed the axis in many low anticlines, making the search for petroleum difficult in this area.

Nemaha Anticline. The Nemaha Anticline is a northeast-southwest anticlinal fold pitching south. The Nemaha Anticline extends from Nebraska to Oklahoma, where it joins the Oklahoma City Uplift (Appendix Fig. 13). The Nemaha Anticline was first recognized as an uplift of great length by Moore and Haynes in 1917, and they called it the " Nemaha Buried Mountains" , although they were not the first to recognize structure in this area. In 1904, Prasser and Beide named some minor structures later recognized as part of the anticline (Jewett, 1951). The Nemaha Anticline has had many names applied to it since its discovery.

## Minor Pre-Mississippian Structure

Pratt Anticline. The Pratt Anticline has a northeast-southwest trend, and plunges to the south, terminating in Barber County (Appendix Fig. 13). The anticline separates the Hugoton Embayment from the Sedgwick Basin in Kansas. Part of the Pratt Anticline extends into Barber County, and is sometimes referred to as the Barber County Arch. The Pratt Anticline is probably an extension of the Ellsworth Anticline, to the north. Viola limestone is present throughout Pratt County, but the Mississippian system is absent in parts of T. 29 S., R. 14 and 15 W. (Muehlhauser, 1958). Viola limestone is also present throughout Barber County, but the Mississippian system is absent in parts of T. 30 S., R. 14 and 15 W. (Appendix Fig. 6). The Pratt Anticline does not show in the structural map of the Lansing-Kansas City group, indicating the anticline formed after Viola limestone deposition and before the beginning of Lansing-Kansas City time (Appendix Fig. 8).

Almost all oil and gas found in pre-Mississippian rocks in Barber County is in structures associated with the Pratt Anticline.

The Barber County Earthquake of 1956, centered in western Barber County, did not affect the Pratt Anticline in any way, except by sending vibratory waves through the overlying formations (Dellweg, 1956).

## Minor Post-Mississippian Structure

Deerhead Fault. The Deerhead Fault is an east northeast-west southwest trending fault through T. 32 S., R. 14 and 15 W. The fault occurred during early Pennsylvanian time, as the Lansing group is not affected. However, the base of the Kansas City group shows about 100 feet of throw (Appendix Fig. 10). The name "Deerhead Fault" is proposed for the following reasons:

(1) The fault was first recognized and mapped by Virgil M. Tucker in 1955, whose map of the Deerhead oil pool showed the fault located in Deerhead Township.

(2) The fault is located about two miles south of the town of Deerhead.

McAdoo Fault. The McAdoo Fault is a north northeast-south southwest trending fault through T. 30 S., R. 14 W. in Barber County and T. 29 S., R. 14 W. in Pratt County. The McAdoo Fault was located by geophysical methods, and this information was obtained by personal contact with John Frank Ricke, who is engaged in geophysical work in Dallas, Texas. His information was derived from a map based on the top of the Arbuckle group. The name "McAdoo" has been used here because the fault runs through McAdoo Township and was first discovered in McAdoo Township.

## GEOLOGIC HISTORY

### Pre-Cambrian Era

Regional metamorphism occurred in Kansas during pre-Cambrian time and changed the sandstones and shales into quartzites and shists. An earlier granite was intruded and both types of rock assumed the same foliation pattern. When the earlier granite intruded, pre-existing sediments and original magma were brought into close relationship, resulting in a degree of mixing, and the resulting rocks approach migmatic texture (Farquhar, 1957).

Granite showing no foliation and clearly cutting across the older rocks was intruded after the regional metamorphism and was called "Later" granite. The "Later" granite was of batholithic proportions and was intruded in several igneous phases. The time from the end of regional metamorphism to the end of pre-Cambrian time was of long duration (Farquhar, 1957).

The pre-Cambrian system was peneplained except for a few low hills before Cambrian sediments were deposited. Between the interval of pre-Cambrian and late Cambrian, when sediments were deposited on the pre-Cambrian surface, a weathered layer developed (Farquhar, 1957).

The pre-Cambrian surface has been subjected to at least four major periods of structural deformation (Farquhar, 1957):

(1) During deposition of the Arbuckle group of lower Ordovician time.

(2) During the interval from Simpson to Mississippian time. The Chautauqua Arch was uplifted and then subdivided into the Cherokee Basin Syncline.

(3) At the end of Mississippian time and during early Pennsylvanian time, when many post-Mississippian structures in Kansas were developed.

(4) During and after Cretaceous time, tilting the Central Kansas Uplift northwestward.

## Paleozoic Era

The sea first advanced over Barber County in Croixian time, depositing the Bonneterre dolomite. The major source of sediments was probably the Sierra Grande and Siouxian uplifts in Colorado. Eminence dolomite is not present in Barber County, although it may have been deposited and then eroded off, or may represent a period of no deposition. The sea again advanced, depositing the Roubidoux formation of lower Ordovician, and the Jefferson City-Cotter formation. The sea retreated and a period of erosion took place, occurring from north to south, so the Cotter formation is present only in the very southern part of the state, but the Jefferson City and Roubidoux formations are present throughout the state.

The sea again covered Barber County and the sediments forming the Simpson group were deposited. The sea retreated and the Platteville formation of the Simpson group was probably eroded away during post-Simpson, pre-Viola erosion (Lee, 1956). The erosion left the St. Peter sandstone and underlying Simpson shales and sandstones in Barber County.

The sea again covered the county in middle Ordovician time, depositing the Viola limestone. After the Viola limestone was deposited, the sea retreated and did not cover Barber County again until Devonian time, when the Chattanooga shale was deposited. A period of erosion after Chattanooga time removed most Chattanooga shale from the area (Appendix Fig. 10 and 11).

The sea advanced over Barber County in Osagian time, depositing the St. Joe limestone. A period of erosion occurred after St. Joe time, before the Cowley and Warsaw formations of Meramecian series were deposited. The sea retreated and a long period of post-Mississippian erosion occurred. The Nemaha Anticline was uplifted, forming the Salina and Forest City basins, and the Central Kansas Uplift was re-elevated and regional warping took place. The Pratt Anticline finished forming and Mississippian system and Chattanooga shale were eroded from it in northwestern Barber and southwestern Pratt counties. The unconformity between the Mississippian and Pennsylvanian systems is the major unconformity in Kansas.

The sea advanced and retreated repeatedly during early Pennsylvanian time, as shown by alternating shales and limestones of the Cherokee and Marmaton groups. The Cherokee group is present only in the southwestern part of the county, but the Marmaton group is present throughout the area (Appendix Fig. 10 and 11). Kansas was not completely covered by Pennsylvanian sediments until Kansas City time, during the Missourian epoch (Moore, et al, 1951).

The absence of the Pedee group in Barber County indicates a period of erosion before rocks of Virgilian series were deposited, because the Douglas group unconformably overlies the Lansing-Kansas City group. Deposition was continuous through Shawnee time. A period of erosion occurred between the Virgilian series of Pennsylvanian time and the Wolfcampian series of lower Permian time (Moore, et al, 1951). Deposition in lower Permian time was similar to late Pennsylvanian time, as each was a cyclic type deposition.

The sea retreated into the Permian Basin of West Texas during Leonardian time, where it deposited salt beds. The Nippewalla group was the last Permian beds deposited in Barber County. The Nippewalla group consists of thick red shales, thin sandstones, and a few interbedded gypsums and anhydrites.

## Mesozoic Era

Barber County was a positive area during Triassic and Jurassic times. The Hugoton Embayment was destroyed by northwestward tilting of the rocks into the Denver-Julesburg Basin, during Triassic time. Before Cretaceous sediments were deposited, the area was again tilted to the south (Merriam, 1955).

The only rock of Cretaceous age to be deposited in Barber County was the Cheyenne sandstone. The Cheyenne sandstone was deposited at or near the shore line of the transgressing sea. The Cretaceous sea covered only the northwestern part of Barber County (Latta, 1948). After deposition of the Cheyenne sandstone, the sea again retreated.

During the Cretaceous period, the Hugoton Embayment was again tilted northwestward into the Denver-Julesburg Basin and the area folded (Merriam, 1957).

## Cenozoic Era

Stream deposits occurred in Barber County during the Tertiary period, depositing the Ogallala formation of Pliocene time. The sedimentation probably started in the lowlands and expanded over the highlands as the lowlands filled (Latta, 1948).

The Blanco formation and Meade formation were deposited in northeastern and eastern Barber County during Pleistocene time. The Meade formation contains the Pearlette volcanic ash beds to the north and east, although volcanic ash has not been found in Barber County. The Blanco and Meade formations are a result of continental and mountain outwash (Moore, et al, 1951). Because of the Meade formation being a thick gravel suggestive of a major stream in eastern Kiowa County, it has been suggested that the ancestral Arkansas River followed approximately the same path as the present Medicine Lodge River (Latta, 1948).

The Sanborn formation was deposited after a period of erosion, following deposition of the Meade formation.

The Gerlane formation and other recent deposits in Medicine Lodge River Valley and Elm Creek Valley are stream deposits.

## DRILLING HISTORY OF BARBER COUNTY, KANSAS

Shaffer Oil and Gas Company opened the petroleum industry in Barber County in January, 1927, with their No. 1-13 Alexander well in the SE¼ Sec. 13, T. 33 S., R. 15 W. The well produced gas, estimated at four to six million cubic feet, from Mississippian reservoirs. The well was the discovery well of the Medicine Lodge Pool and is still producing gas at the present time.

The deepest well in Barber County was drilled in 1928, and at the time it was drilled, was the deepest well in Kansas. The well, No. 1 Boggs, was drilled in the SW$\frac{1}{4}$ Sec. 19, T. 33 S., R. 12 W., and topped the pre-Cambrian system at 6,185 feet.

Exploration and drilling in Barber County continued at a slow but steady pace from 1927 to 1950.

Barber County became a focal point for drilling in Kansas in the early 'fifties. A total of 885 wells were drilled from 1950 to 1957, resulting in 250 oil wells, 246 gas wells, 11 combination gas and oil wells, and 378 dry holes. Drilling reached an all-time high in Barber County in 1956, when 217 wells were drilled, 126 of which were producers. Ten new Mississippian reservoirs were discovered in 1956.

Statistics show at the end of 1957, Barber County had a total of 52 producing oil, gas, or combination oil and gas, pools. Thirty-six of the pools produced from reservoirs in the Mississippian system, making the Mississippian system the most important producing zone in Barber County. The largest oil pool in Barber County is the Rhodes Pool, in T. 33, R. 11 W., and the largest gas pool is the Medicine Lodge-Boggs Pool, in T. 33 S., R. 12 and 13 W.

## THE RELATIONSHIP OF THE SUBSURFACE GEOLOGY TO PETROLEUM ACCUMULATION

### Production From Arbuckle Reservoirs

The Arbuckle group has never been very productive in Barber County. The Lake City Pool, in T. 31 S., R. 13 W. is the only Arbuckle oil pool in Barber County (Appendix Fig. 14). A well drilled in 1959 in T. 31 S., R. 14

W., one and a half miles northeast of the Little Bear Creek Pool, had 2,900 feet of pure oil in an Arbuckle drill-stem test, with 1,600 pounds of bottom hole pressure, and could possibly open up some new production from the Arbuckle reservoirs in Barber County. The Clara Pool, in T. 30 S., R. 14 W., is the only Arbuckle reservoir producing gas in the county (Appendix Fig. 14). Arbuckle reservoir production is associated with local closures on top of the Pratt Anticline in western Barber County. Production depends upon porosity and permeability of the reservoir rock. Production from Arbuckle reservoirs in Barber County is found down in the Arbuckle group rather than at the top of the group, because the cap rock is a tight dolomitic limestone at the top of the Arbuckle group.

## Production From Simpson Reservoirs

The Bloom, Clara, Lake City, Medicine Lodge-Boggs, Skinner, Stumph, and Turkey Creek pools all produce from Simpson reservoirs (Appendix Fig. 14). The Medicine Lodge-Boggs and Bloom pools are located on anticlinal noses, and the remaining pools are associated with local closures on the Pratt Anticline (Appendix Fig. 3). Simpson reservoir production has not been found in eastern Barber County. The St. Peter sandstone of the Simpson group makes a very good reservoir rock where it is clean. The thickness of the producing zone varies from three to seven feet. Cap rock for petroleum trapped in the Simpson group is an impermeable shale located in the Simpson group.

## Production From Viola Reservoirs

Viola reservoir production is found in western Barber County, and two isolated pools, the Gudeman and Rhodes, are located in eastern Barber County. Pools located in western Barber County are the Lake City, Little Bear Creek, Skinner, Turkey Creek East, Clara, Aetna, DeGeer, and Deerhead (Appendix Fig. 14). The Rhodes and Gudeman pools are combination stratigraphic and structural traps, whereas the pools in western Barber County are associated with isolated closures on the Pratt Anticline, except for the DeGeer and Deerhead pools, located on the south end of the Pratt Anticline. The DeGeer and Deerhead pools are trapped against the Deerhead Fault, formed when the Pratt Anticline was developing (Appendix Fig. 5). The porosity and permeability in the top of the Viola limestone in Barber County is the result of pre-Mississippian erosion, and cap rock for the traps is an impermeable shale above the Viola limestone. Thickness of the producing reservoirs is nine to thirty-eight feet.

## Production From Chattanooga Reservoirs

Chattanooga reservoir production is located in the Misener sandstone member at the bottom of the Chattanooga shale, with the Chattanooga shale forming the cap rock. Oil is found only in the Misener sandstone lenses in combination stratigraphic and structural traps. The only pool in Barber County to produce from a Misener reservoir is the Medicine Lodge-Boggs (Appendix Fig. 14).

## Production From Mississippian Reservoirs

The Mississippian system contains the most important producing reservoirs in Barber County. Thirty-six pools produce from Mississippian reservoirs. The pools are the Aetna, Aetna Northeast, Blunk, Blunk South, Canema, Cedar, DeGeer, Elsea, Forsyth, Highway North, McGuire, Nippewalla, Roundup South, Traffas, Amber Creek, Bloom, Boggs Southwest, Brooks-Younger, Donald, Farley, Gudeman, Hardtner, Landis, Medicine Lodge-Boggs, Medicine Lodge North, Medicine Lodge Southwest, Rhodes, Rhodes South, Salt Fork, Sharon, Sharon Northwest, Stumph, Wells, Whelan, and Whelan Southwest (Appendix Fig. 14). The producing zone varies from five to thirty feet thick (Goebel, 1958). Production occurs in reservoirs in the weathered porous limestone and chert at the top of the Mississippian system, and depends on the thickness of the chert. Cap rock for Mississippian traps is an impermeable shale in the basal Pennsylvanian system, unconformably overlying the Mississippian system in Kansas.

Mississippian reservoir wells in Barber County are almost always improved with a fracturing, because fracturing increases the permeability of the formation. Increases of 20 times the production shown on the drill-stem test have been made in some instances where wells were fractured. Mississippian reservoirs produce a high yield with very little water.

Mississippian rocks are absent in the northern part of T. 30 S., R. 15 W., and T. 30 S., R. 14 W. Oil accumulation in the Mississippian system does not seem to be associated with the pinchout, and Muehlhauser (1958) says no oil accumulation is associated with the Mississippian system pinchout in Pratt County, to the north.

## Production From Pennsylvanian Basal Conglomerate Reservoirs

The Turkey Creek North Pool is the only pool in Barber County producing from Basal Conglomerate reservoirs (Appendix Fig. 14). The producing reservoir is 12 feet thick. The Moffett Pool, abandoned in 1957, also produced from the Pennsylvanian Basal Conglomerate. The pool was located approximately two miles north of the Turkey Creek North Pool. The cap rock is impermeable Marmaton shale. Production in the area may be associated with the pinchout of the Mississippian system, as T. 30 S., R. 15 W. is the only Pennsylvanian Basal Conglomerate production in Barber County. Production may be associated to a thickening of the Pennsylvanian Basal Conglomerate in this area.

## Production From Cherokee Reservoirs

Pools producing from Cherokee reservoirs are the Wolgamott and Hardtner (Appendix Fig. 14). The Platt Pool, abandoned in 1957, also produced from a Cherokee reservoir. The producing zone is four feet thick, and production is associated with the Cherokee pinchout in southwestern Barber County (Appendix Fig. 10). Cap rock for the Cherokee traps is impermeable limestone in the base of the Kansas City group, and an impermeable shale in the Cherokee group.

## Production From Marmaton Reservoirs

Pools producing from the Marmaton group are the Stumph, Skinner, Salt Fork, Clara, and Medicine Lodge-Boggs (Appendix Fig. 14). Average thickness of the producing reservoirs is 18 feet. Production is trapped in combination stratigraphic and structural traps. The cap rock for the traps is dense limestone in the base of the Kansas City group. Marmaton reservoirs have never been found in eastern Barber County.

## Production From Lansing-Kansas City Reservoirs

Pools producing from Lansing-Kansas City reservoirs are the Skinner, Sun City, and Turkey Creek (Appendix Fig. 14). Lansing-Kansas City reservoirs are not found anywhere except in the northwestern part of the county. Production from the Lansing-Kansas City group is from combination stratigraphic and structural traps, and the reservoirs are approximately 26 feet thick (Appendix Fig. 8). Cap rock for the Lansing-Kansas City reservoirs is lack of porosity in the upper Lansing group, and an impermeable shale.

## Production From Douglas Reservoirs

Pools producing from Douglas reservoirs are the Highway, Little Bear Creek, Nippewalla, Whelan East, Boggs, Nurse, Rhodes, Whelan, and Skinner (Appendix Fig. 14). Petroleum is trapped in combination stratigraphic and structural sandstone lenses (Appendix Fig. 9). The cap rock is impermeable Douglas shales. The thickness of the reservoirs in Barber

County is approximately 16 feet (Goebel, 1958). Douglas reservoir wells in Barber County have a high initial production, but fall off rapidly and usually go to water as the pressure falls.

## Production From Elgin Reservoirs

One pool in Barber County produces from Elgin reservoirs, and it is the Elwood Pool, in T. 34 S., R. 13 W. (Appendix Fig. 14). The Elwood Pool seems to be a stratigraphic trap, with the cap rock being impermeable Elgin shales. The Elwood Pool was not discovered until 1956, therefore it has not produced long enough to prove the source as yet.

# CONCLUSIONS

The major portion of pre-Mississippian production in Barber County is associated with the Pratt Anticline. Production is either along the flanks or in isolated closures on the anticline. Traps in Barber County are either structural or a combination of structure and stratigraphy, and combination traps are by far the most important. Some of the pre-Mississippian traps associated with the Pratt Anticline are purely structural traps, and the remainder are a combination of structure and stratigraphy. Post-Mississippian traps are a combination of structure and stratigraphy. Purely stratigraphic traps probably do not exist in Barber County, because the regional dip helps account for petroleum migration and accumulation in the area.

The major structures in the county are the south end of the Pratt Anticline, Deerhead Fault, and McAdoo Fault. These faults are associated with the formation of the Pratt Anticline. The Deerhead Fault is known to have occurred during early Pennsylvanian time. Field work in the area of the McAdoo Fault has shown the fault does not occur in the surface, and it is assumed this faulting also occurred during early Pennsylvanian time, possibly at the same time as the Deerhead Fault. The names " Deerhead" and " McAdoo" have been suggested for these Barber County faults.

The Stone Corral dolomite, or " Cimarron Anhydrite" as it is known in Oklahoma, is the highest correlated unit in subsurface. This unit is used by geophysicists for the upper bed in seismograph correlation. Sedimentation in Permian rocks as low as Basal Leonardian is predominantly of Continental origin, and the beds below the Leonardian series are chiefly marine deposits.

The Mississippian system may be differentiated into the Osagian and Meramecian series. Mississippian reservoir production in Barber County seems to be associated with the reef-like thickening of the chert section in the county. Wherever this thickening is found, there is almost always production. A great change in thickness occurs from one well location to another in the same section.

A major portion of the petroleum in Barber County probably was formed from organic compounds during pre-Mississippian time when the Anadarko Basin was a part of a much larger southern Oklahoma geosyncline. The remainder of the petroleum probably formed from Pennsylvanian source beds in the area.

Petroleum from the Anadarko Basin started migrating into the traps of Barber County when the basin formed during Pennsylvanian time. The migration from the basin into the flanks continued until after Permian time, as gas is found along the flanks of the Anadarko Basin in the Hugoton gas field, to the west. The gas is found in the Fort Riley limestone, of Permian age. Diastrophism occurring later than Permian time seems to have had little effect on petroleum accumulation in Barber County. As the Anadarko Basin subsided, gentle marine onlap occurred, and as this onlap continued, pressure became greater in the center of the basin and less towards the flanks, therefore the porosity was decreased in the center, forcing the petroleum to migrate updip towards the flanks of the basin. Petroleum in Barber County evidently accumulated during Pennsylvanian time, as no petroleum has been located above the Elgin sandstones. no longer true As this lateral migration occurred, there was some vertical migration, which could account for the greater production in the Mississippian and Viola limestones. Lack of production in the Pennsylvanian system ? is due to the dense limestones and impermeable shales of the basal Pennsylvanian and due to lack of suitable traps. Petroleum migrating up from the Anadarko Basin probably could not migrate into the Pennsylvanian rocks due to these dense limestones and impermeable shales. Therefore, most of the petroleum found in the Pennsylvanian rocks of Barber County formed in the Pennsylvanian rocks of the area. Most of this petroleum is trapped near where it was formed.

The latest statistics available, through 1957, show that Barber County ranks 21st in oil production in Kansas, with a total of 18,236,761 barrels of oil produced through 1957. The oil was taken from an accumulative area of 40,220 acres. The largest oil pool in the county is the Rhodes, followed by the Medicine Lodge-Boggs and the Whelan. The largest gas field in the county is the Medicine Lodge-Boggs, followed by the Hardtner and Skinner fields. The Medicine Lodge-Boggs field alone produced about fifty percent of the gas produced in the county.

Future possibilities of large oil and gas pools being discovered are not very encouraging. There will undoubtedly be more oil found in isolated closures on and around the Pratt Anticline in the western part of the county. Also, many combination stratigraphic and structural traps in the Mississippian and younger rocks will be discovered, and there will probably be more wells drilled in the old fields.

In mapping the county, a large terrace was found in T. 30 S., R. 13 W. and T. 30 S., R. 14 W., which has been relatively undeveloped. Seismic maps of the area show four small highs on the Arbuckle group have not been drilled. Three of these highs are associated with the McAdoo Fault. There is a chance for a small oil pool or two to be developed in the area.

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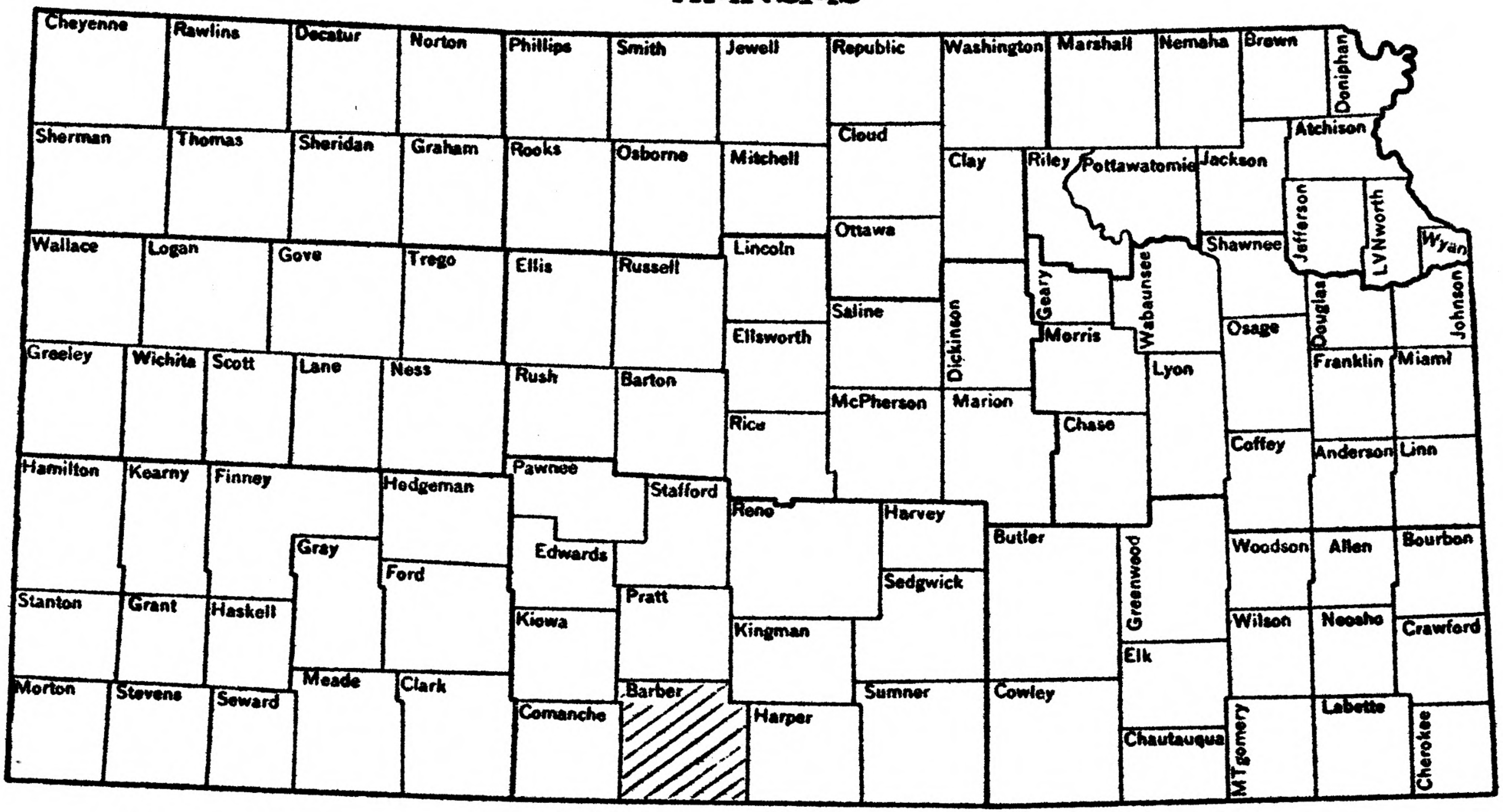
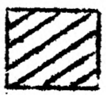
# APPENDIX

# KANSAS



Area covered by this thesis.

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

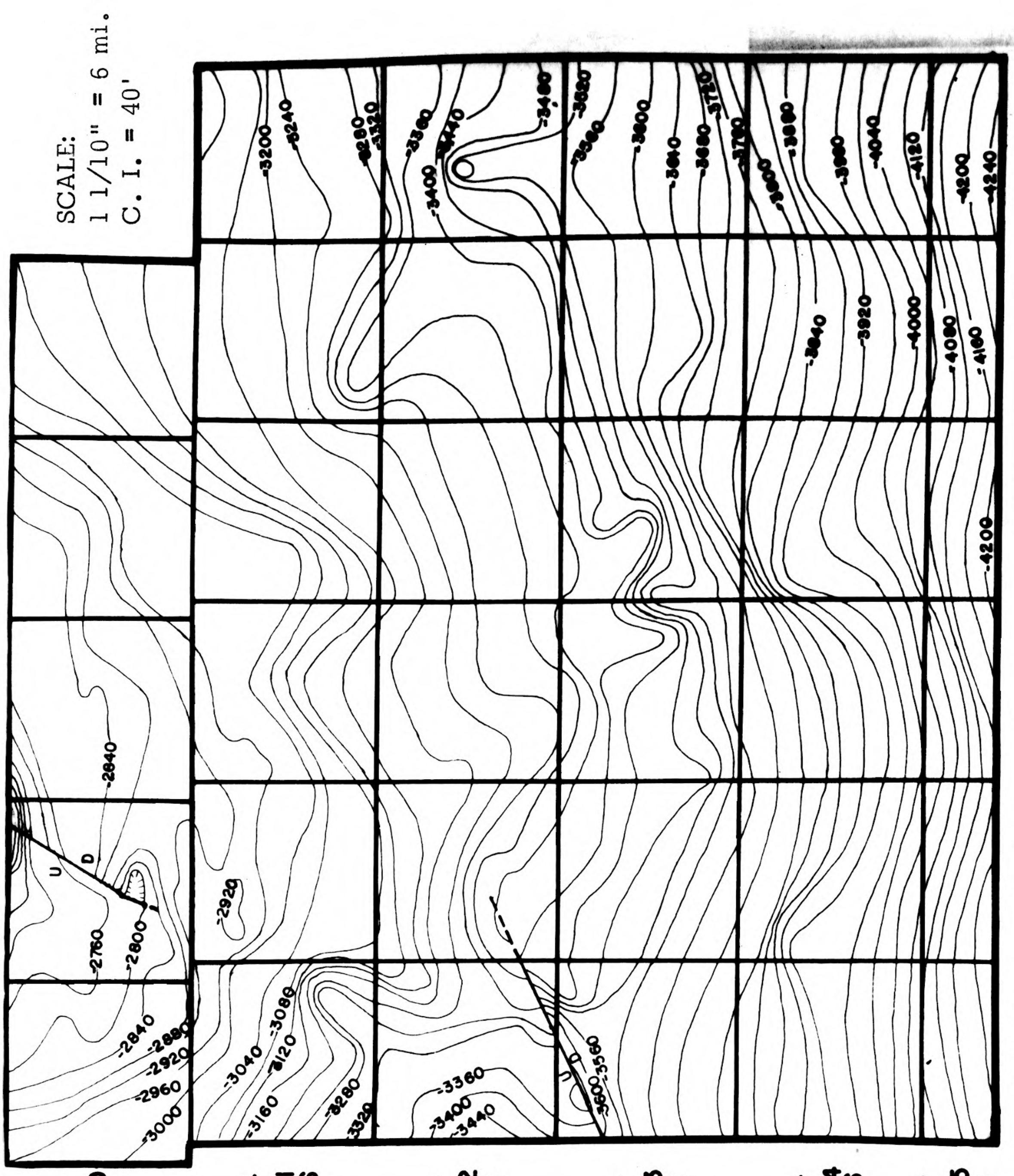



Fig. 2. Structure contours drawn on top of the Arbuckle group, Barber County, Kansas.

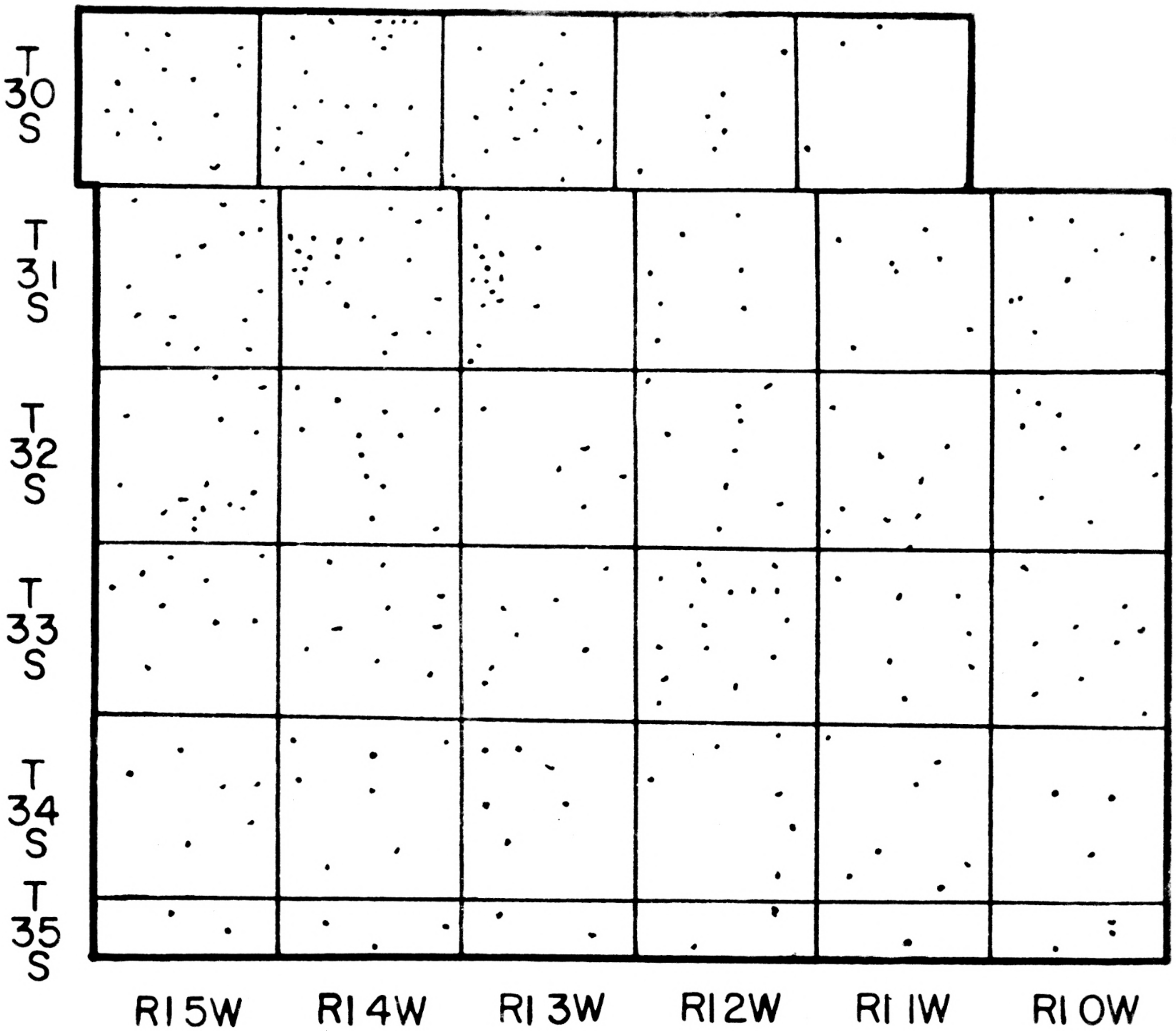
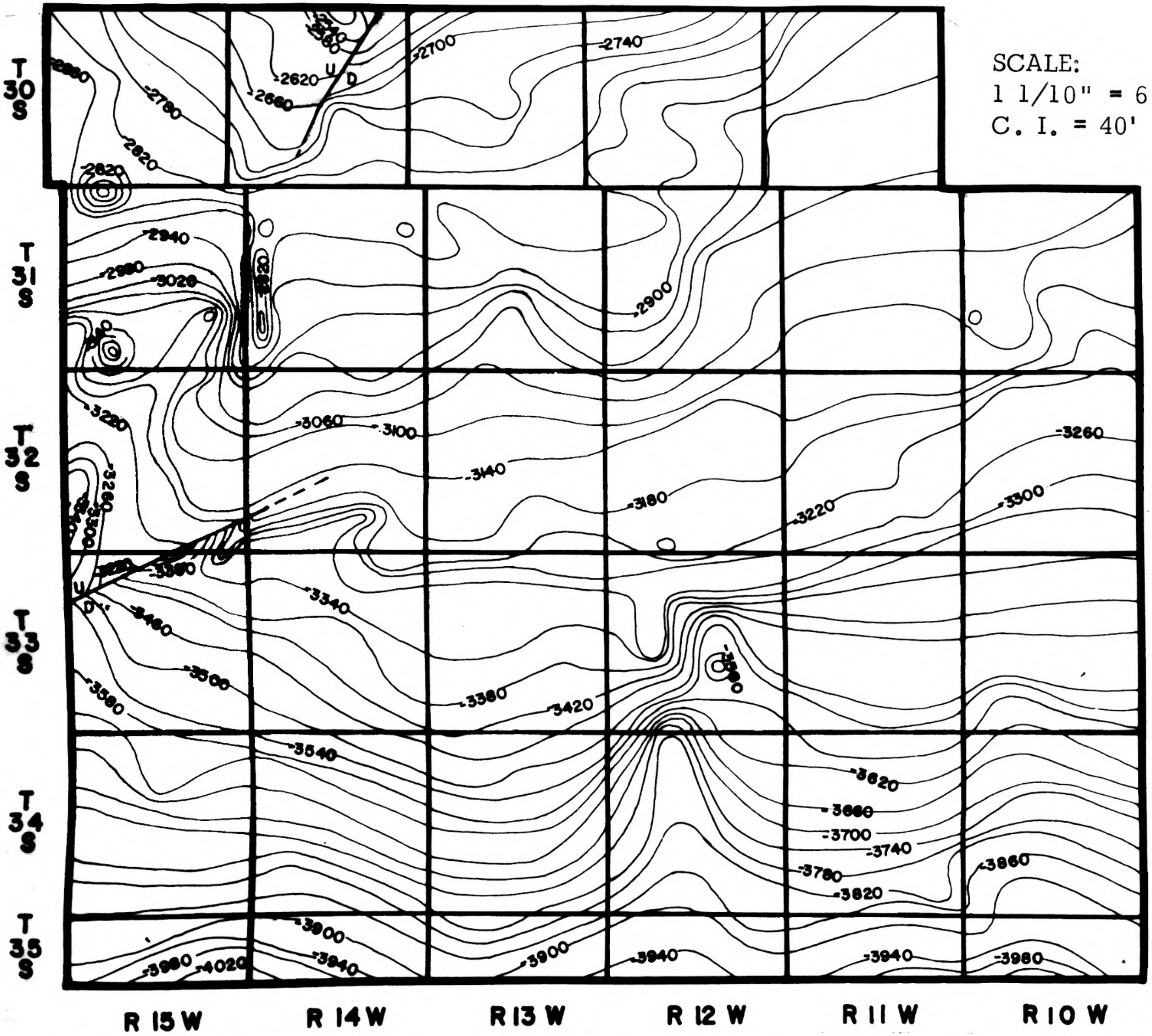



Fig. 2A. Map of Barber County, showing the locations of control points used for drawing the structure contours on the Arbuckle group.




SCALE:
1 1/10" = 6 mi.
C. I. = 40'

Fig. 3. Structure contours drawn on top of the Simpson group, Barber County, Kansas.

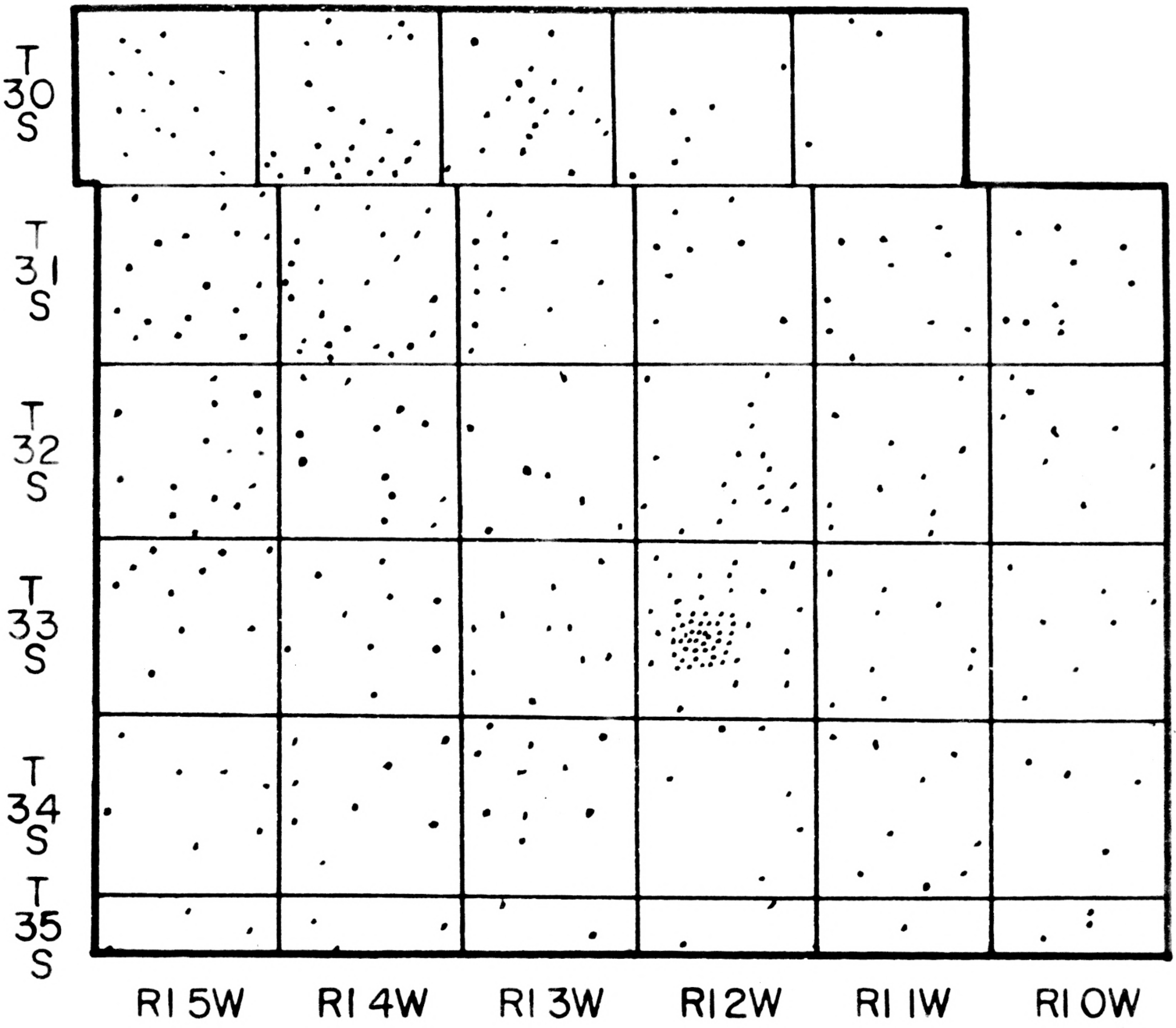



Fig. 3A. Map of Barber County, showing the locations of control points used for drawing the structure contours on the Simpson group.

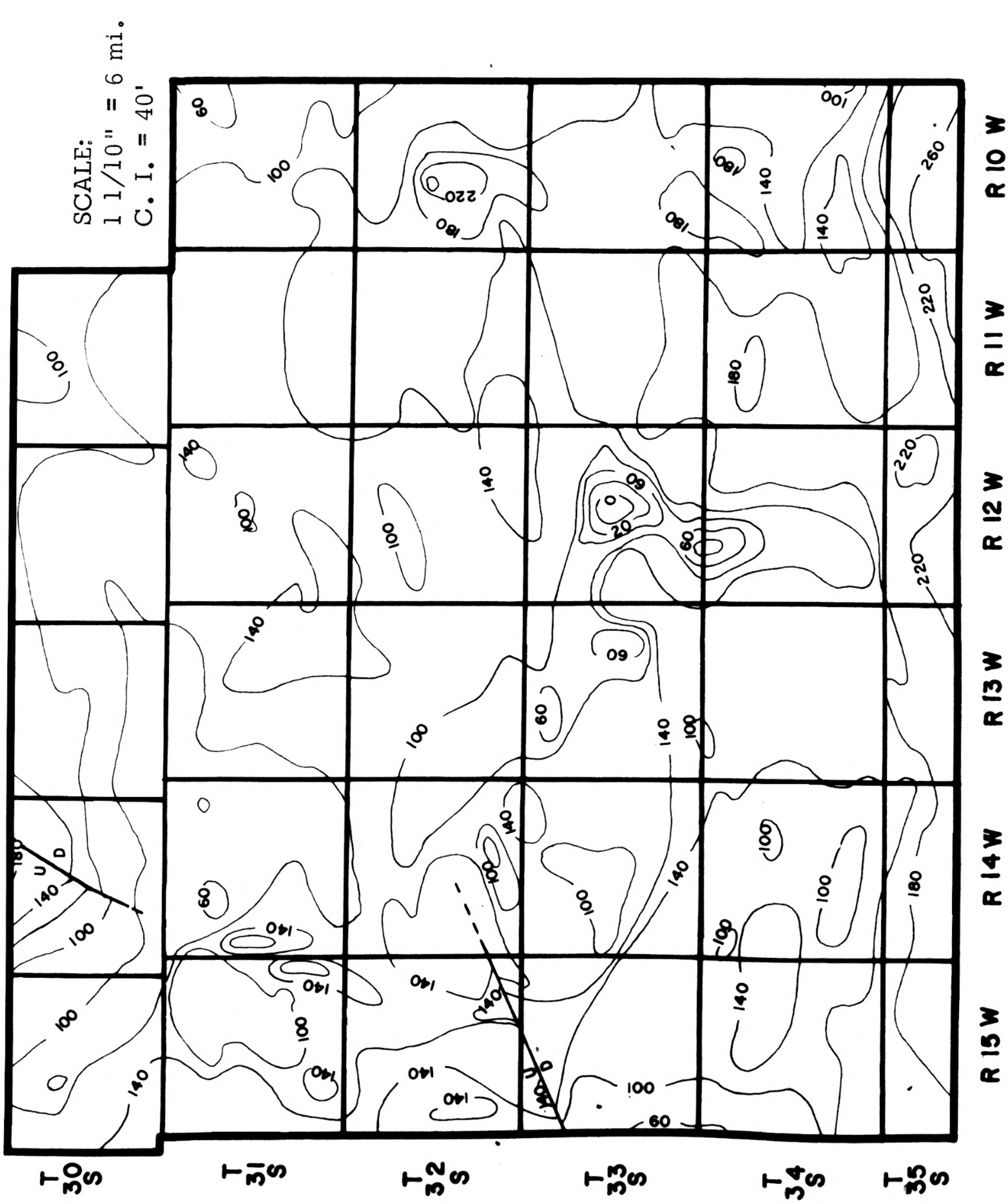



Fig. 4. Isopachous lines (thickness) representing the interval between the top of the Simpson and the top of the Arbuckle, Barber County, Kansas.

Fig. 5. Structure contours drawn on top of the Viola limestone, Barber County, Kansas.

(In accompanying plate box)

# STRUCTURE CONTOURS ON TOP OF THE VIOLA LIMESTONE

BARBER COUNTY, KANSAS

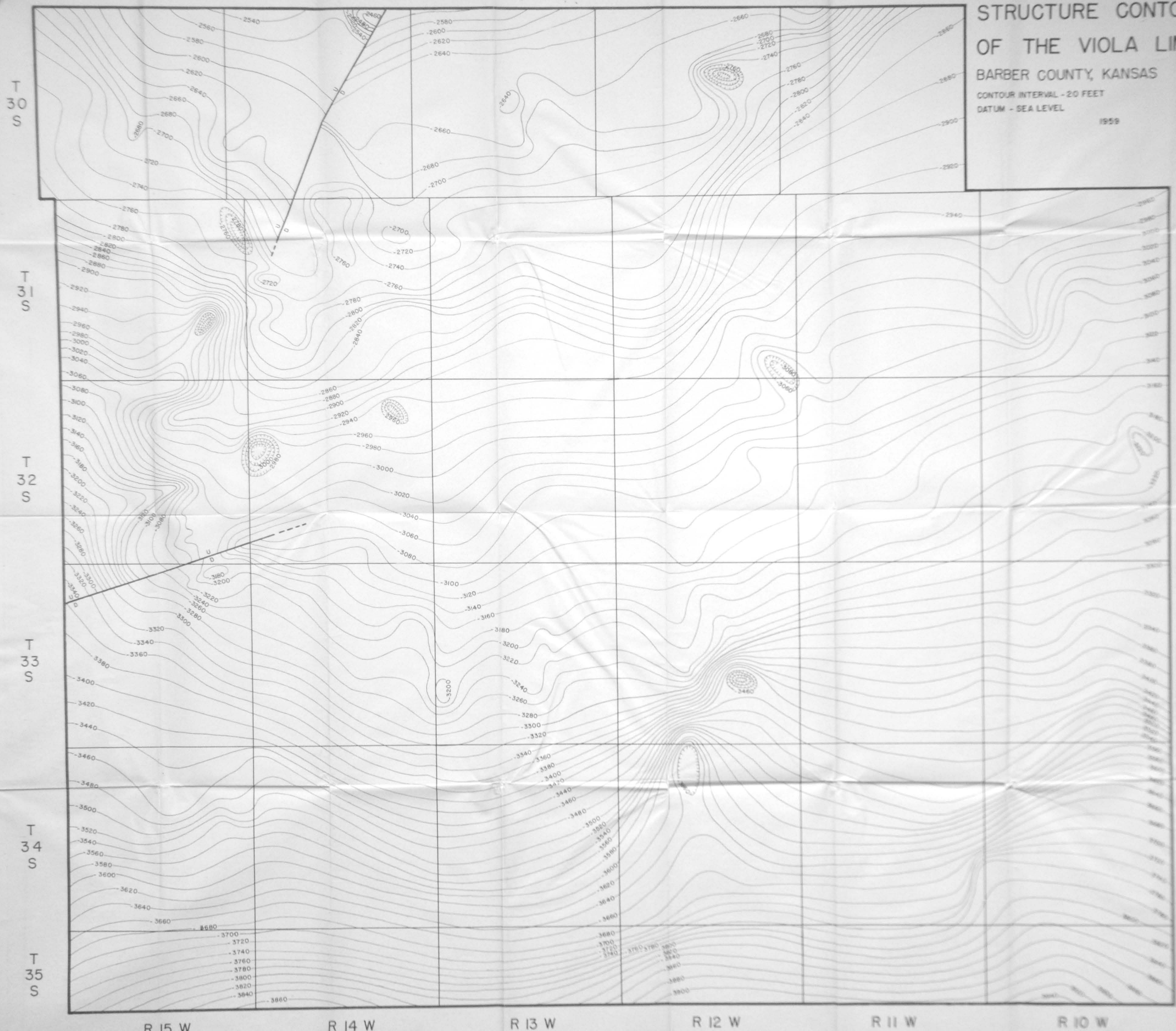
CONTOUR INTERVAL - 20 FEET

DATUM - SEA LEVEL

1959

SCALE

RICH STRONG



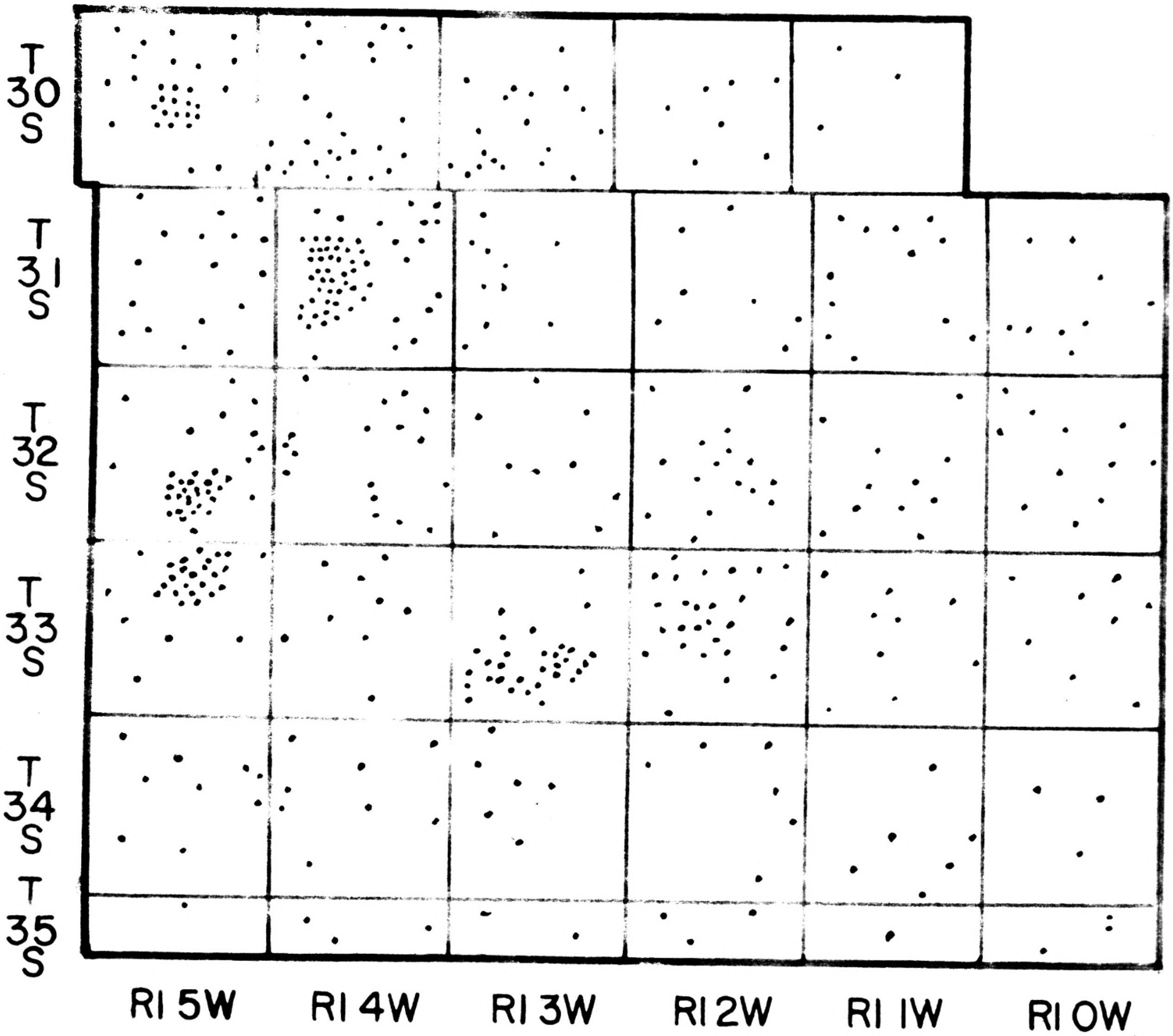



Fig. 5A. Map of Barber County, showing the locations of control points used for drawing the structure contours on the Viola limestone.

Fig. 6. Structure contours drawn on top of the Mississippian rocks, Barber County, Kansas.

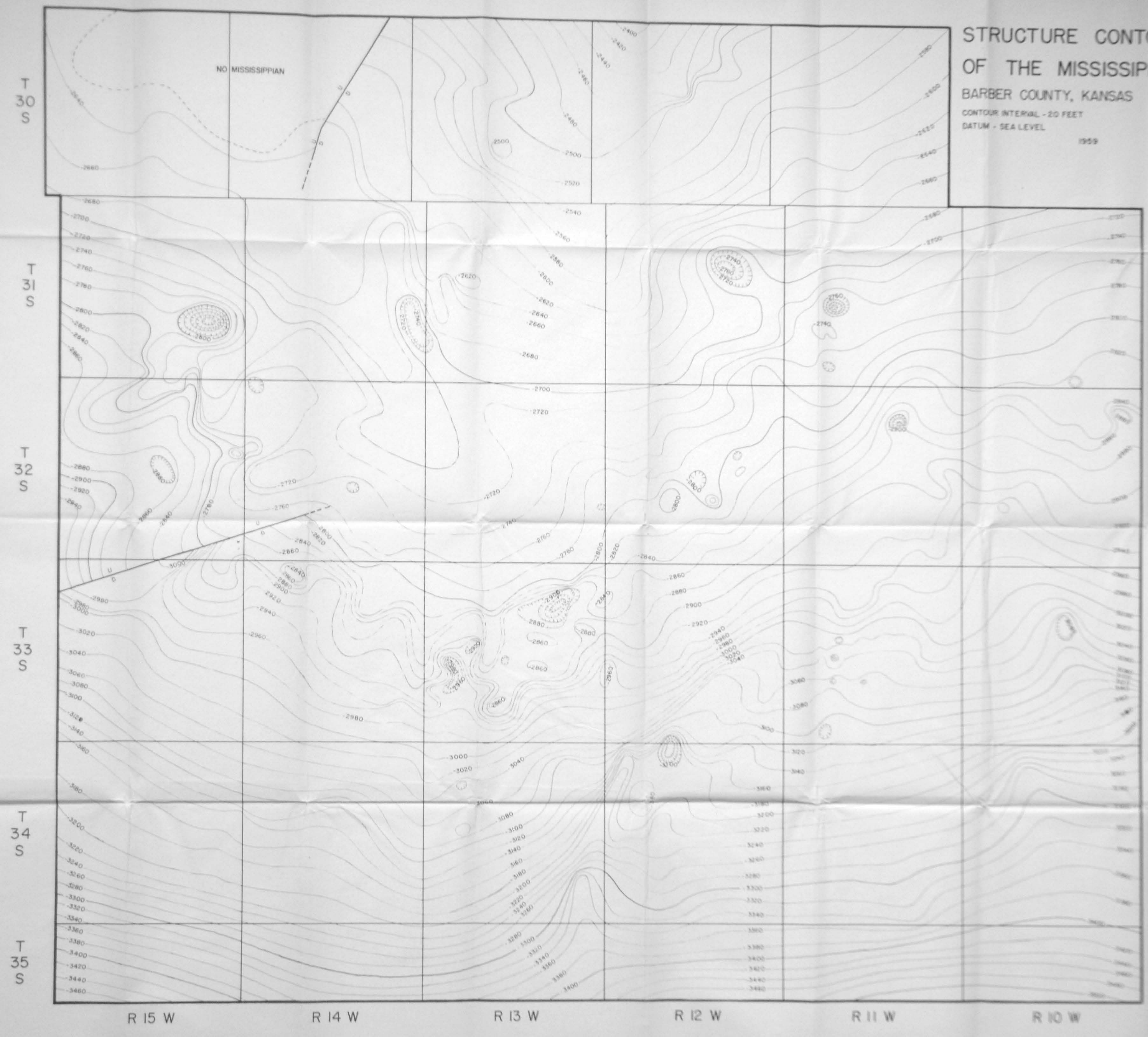
(In accompanying plate box)

# STRUCTURE CONTOURS ON TOP OF THE MISSISSIPPIAN ROCKS

## BARBER COUNTY, KANSAS

CONTOUR INTERVAL - 20 FEET
DATUM - SEA LEVEL
1959

SCALE
RICH STRONG



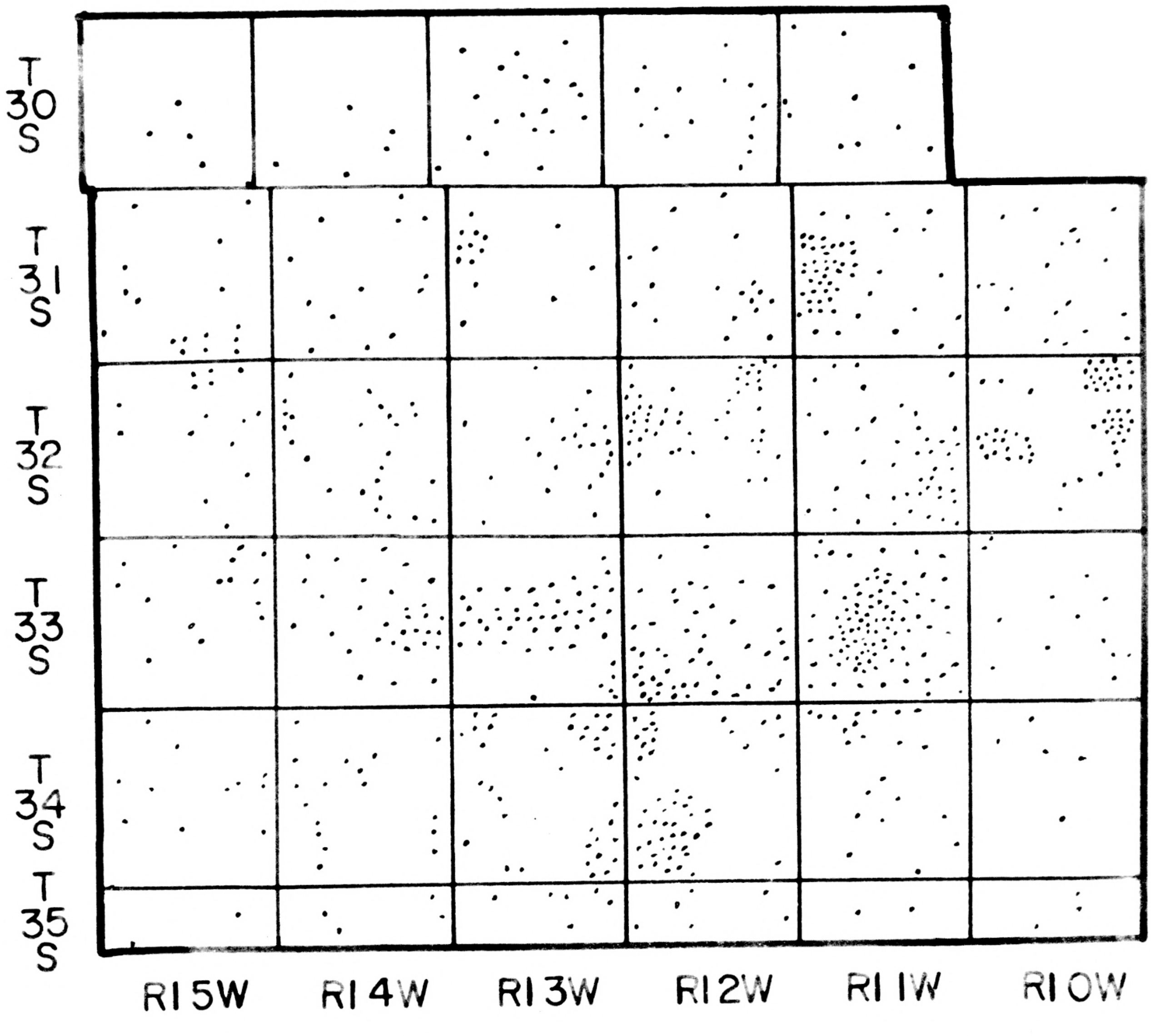



Fig. 6A. Map of Barber County, showing the locations of control points used for drawing the structure contours on the Mississippian rocks.

Fig. 7. Isopachous (thickness) map representing the interval between the top of the Mississippian rocks, and the top of the Viola limestone, Barber County, Kansas.

(In accompanying plate box)

# ISOPACHOUS MAP SHOWING THE THICKNESS OF THE MISSISSIPPIAN ROCKS AND CHATTANOOGA SHALE

BARBER COUNTY, KANSAS

CONTOUR INTERVAL - 20 FEET

RICH STRONG

SCALE

1959

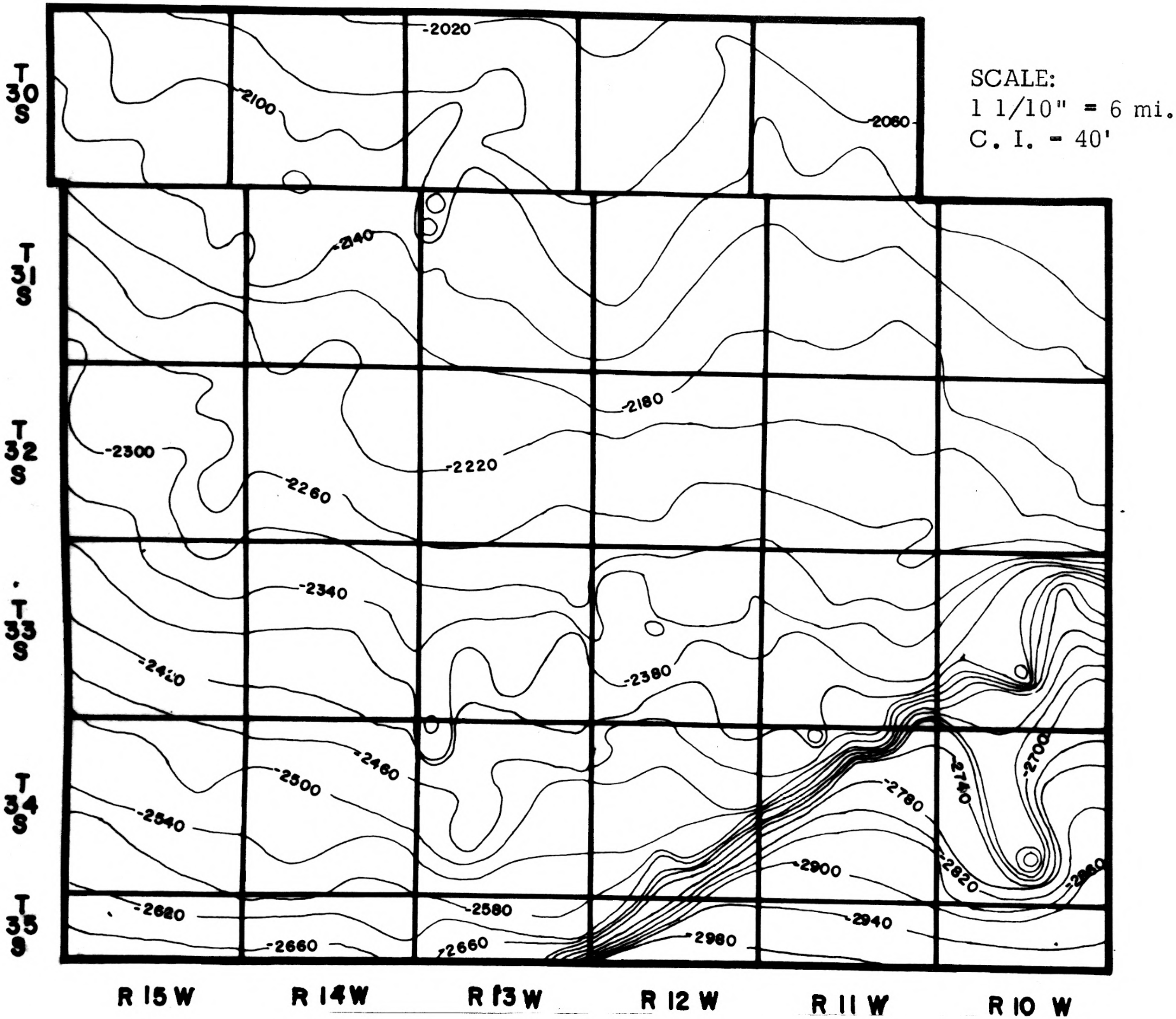



Fig. 8. Structure contours drawn on top of the Lansing-Kansas City group, Barber County, Kansas.

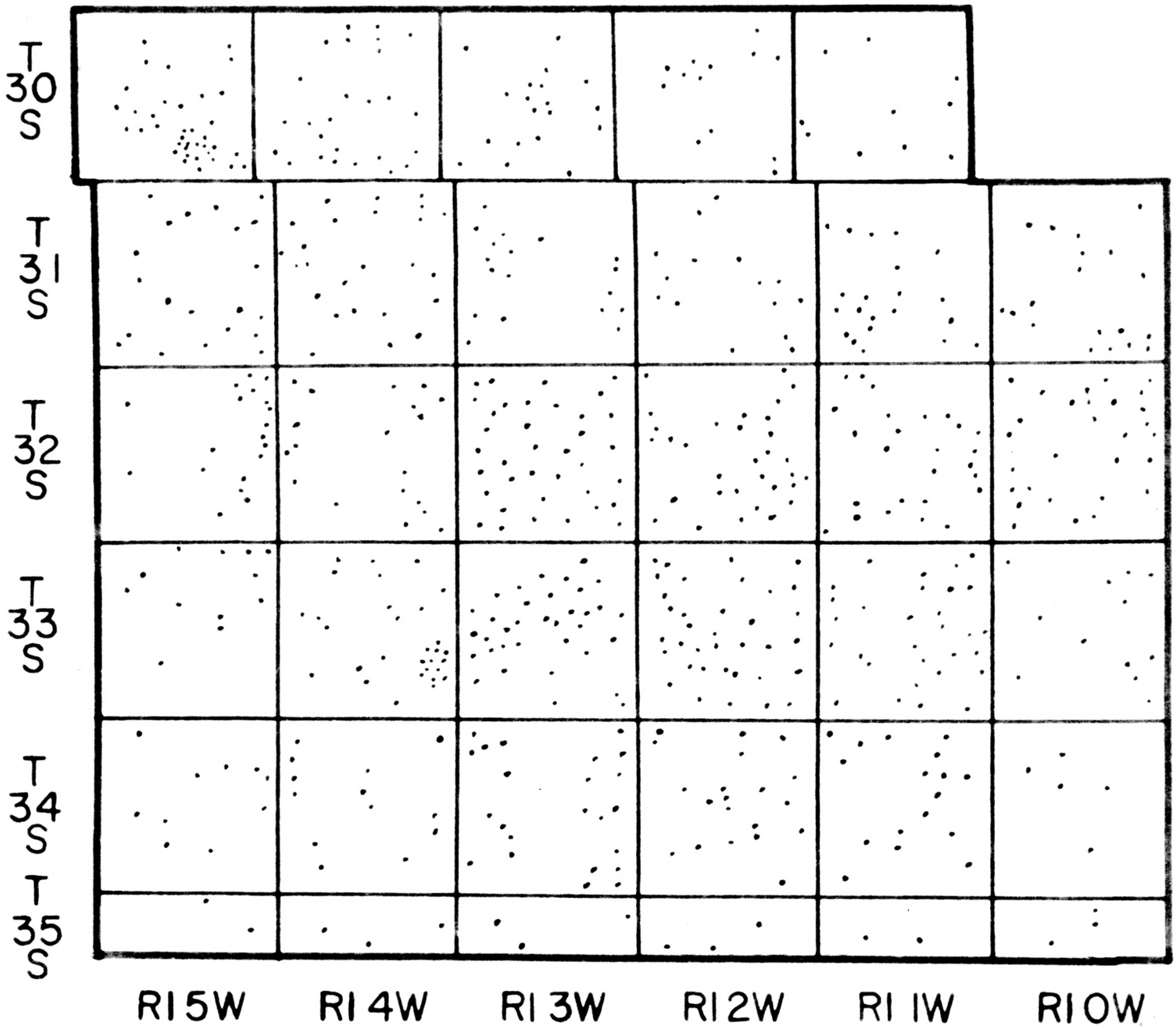



Fig. 8A. Map of Barber County, showing the locations of control points used for drawing the structure contours on the Lansing-Kansas City group.

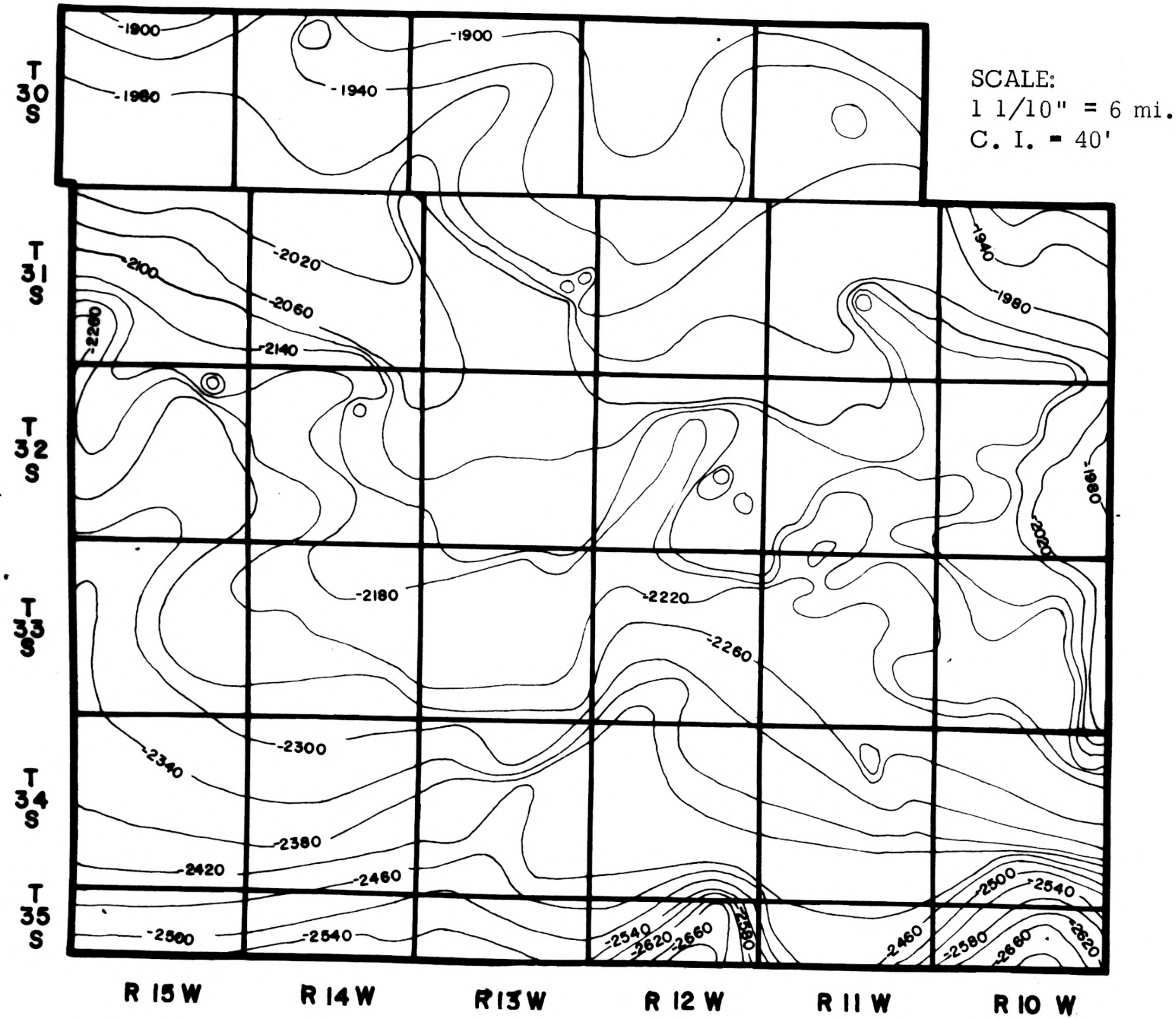



Fig. 9. Structure contours drawn on top of the Douglas group, Barber County, Kansas.

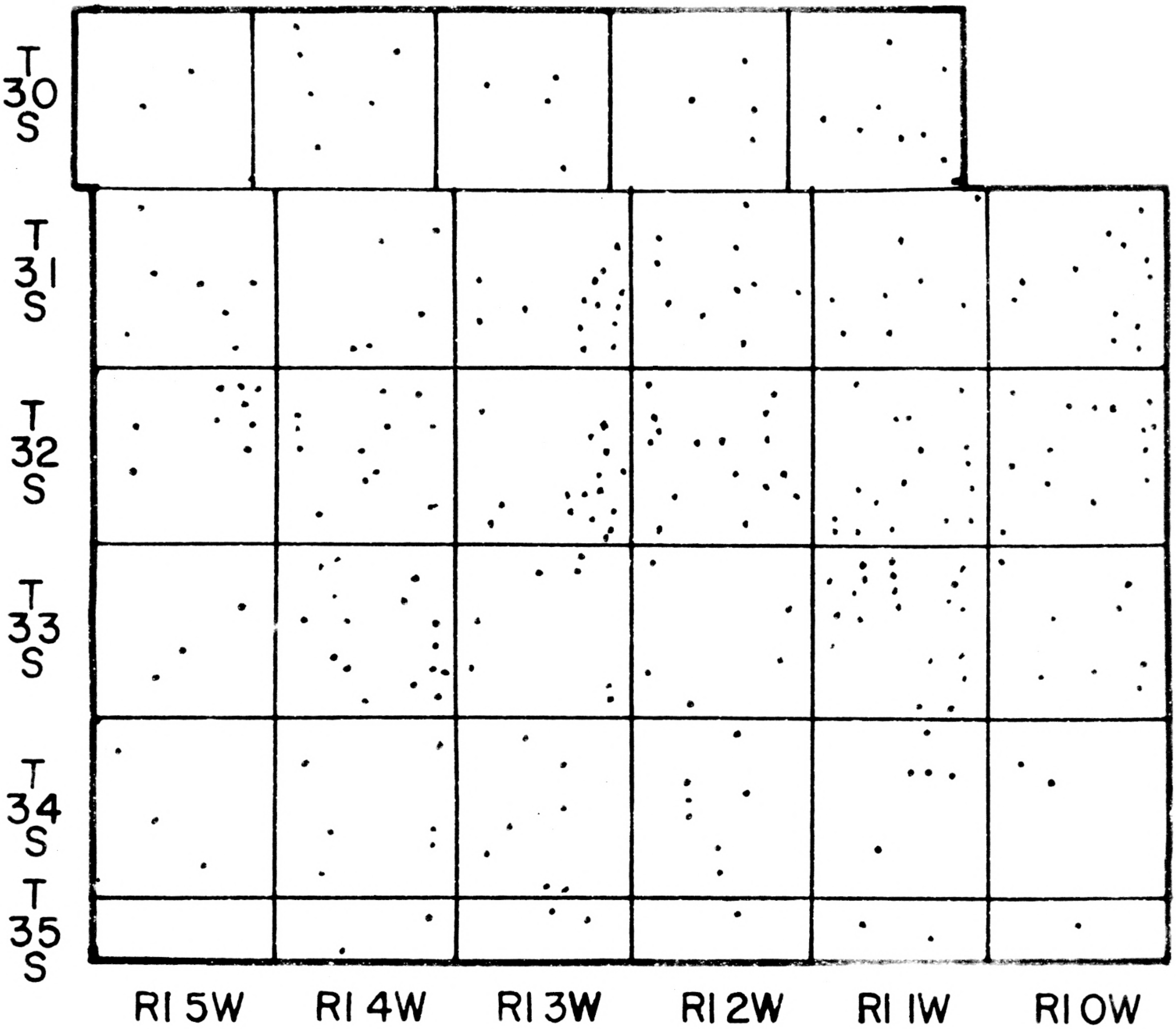
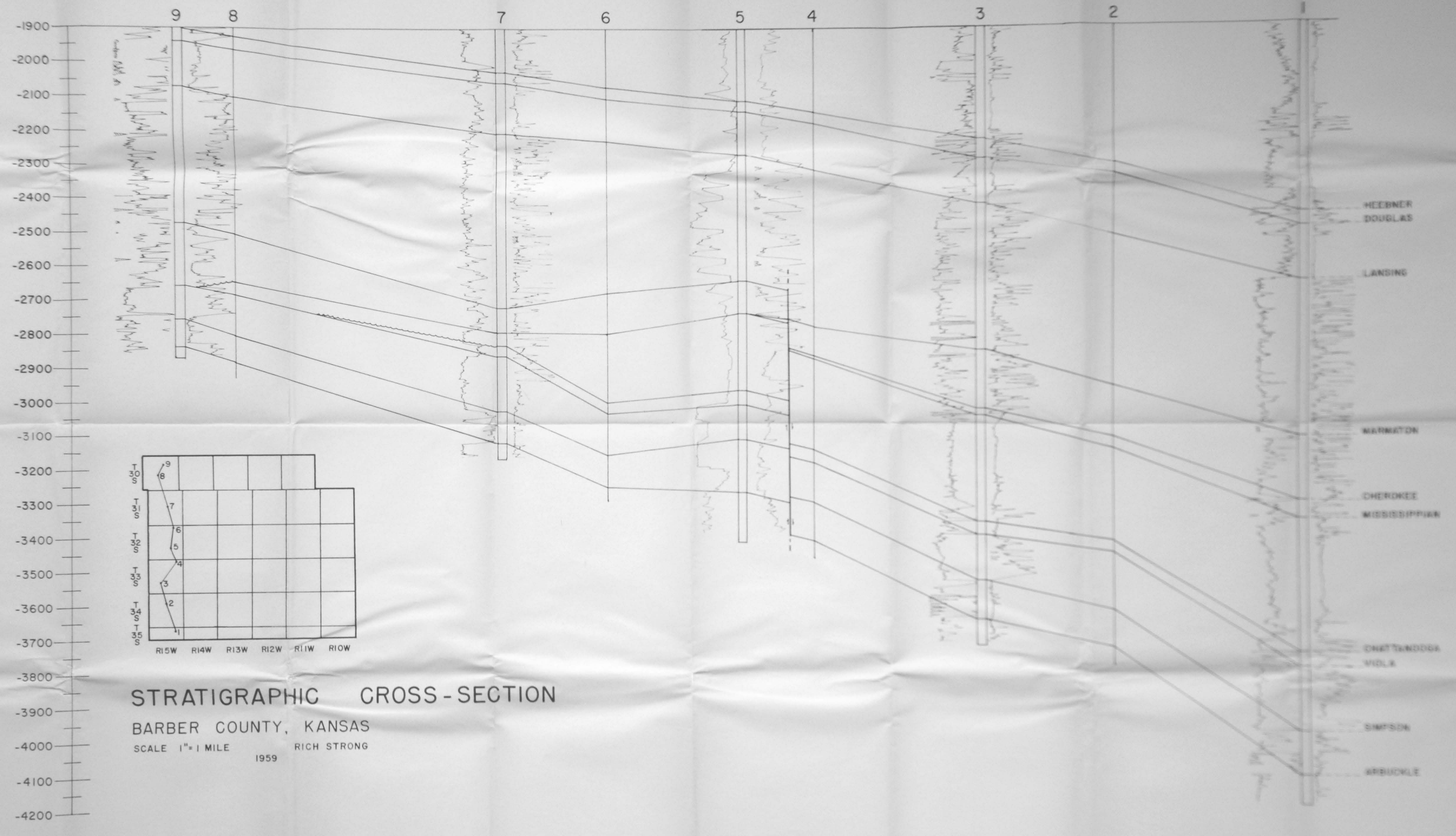



Fig. 9A. Map of Barber County, showing the locations of control points used for drawing the structure contours on the Douglas group.

Fig. 10. Stratigraphic cross section No. 1, running North-South across western Barber County, Kansas.

(In accompanying plate box)




STRATIGRAPHIC CROSS-SECTION

BARBER COUNTY, KANSAS

SCALE 1" = 1 MILE 1959 RICH STRONG

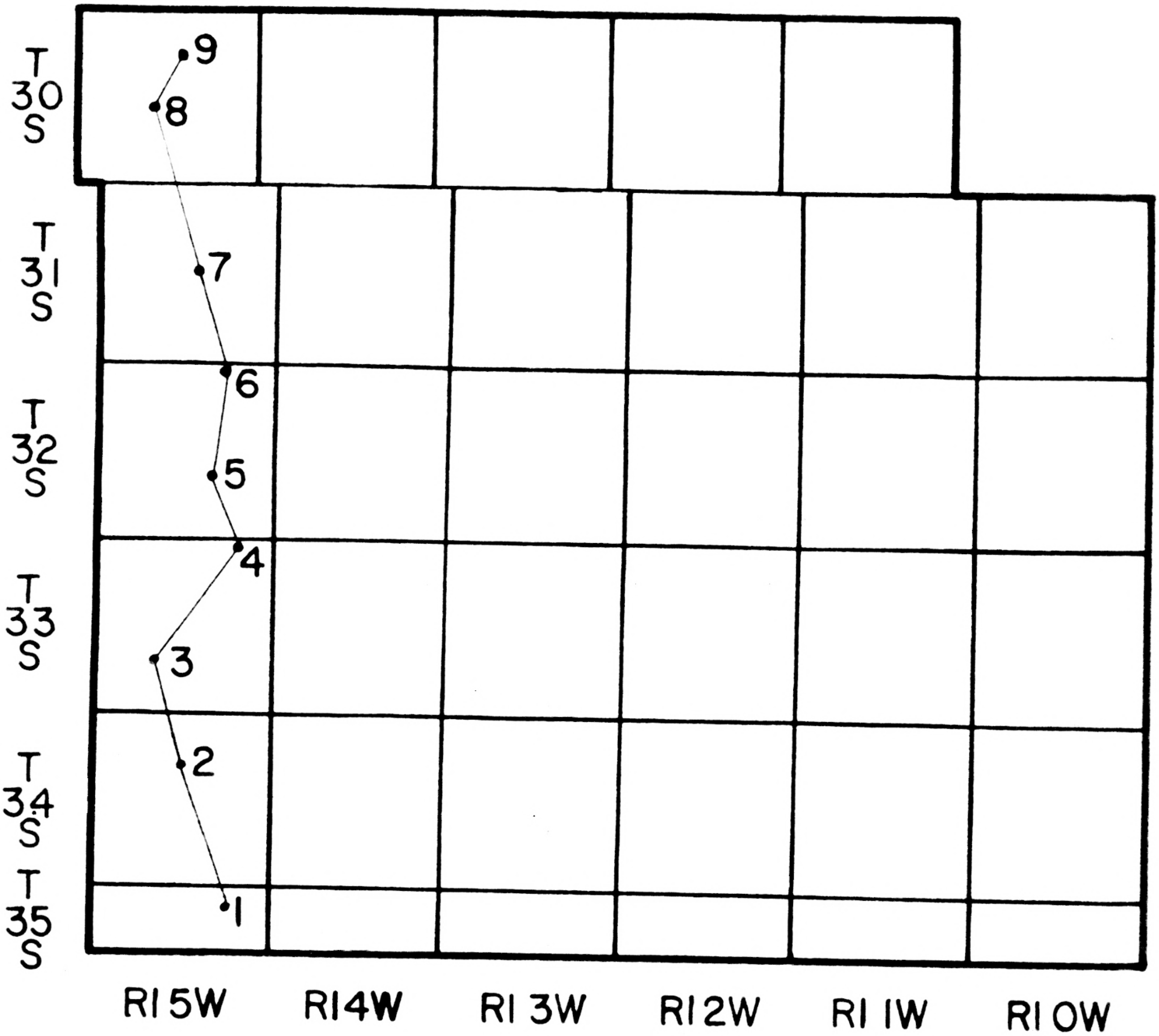



Fig. 10A. Map of Barber County, showing general locations of wells used in North-South cross section.

| | | | |
|---|---|---|---|
| WELL NUMBER: | 1 | 2 | 3 |
| Well location | 11-35-15 CNENE | 9-34-15 CSESE | 28-33-15 CNWNW |
| Source | Electric Log | Electric Log | Electric Log |
| Elevation | 1609 | 1601 | 1759 |
| Heebner | -2456 | -2299 | -2235 |
| Douglas | -2496 | -2321 | -2285 |
| Lansing | -2655 | -2511 | -2431 |
| Marmaton | -3113 | -2954 | -2851 |
| Cherokee | -3301 | -3119 | -3036 |
| Mississippi | -3357 | -3146 | -3045 |
| Chattanooga | -3749 | -3411 | -3330 |
| Viola | -3789 | -3447 | -3368 |
| Simpson | -3981 | -3619 | -3507 |
| Arbuckle | -4107 | -3729 | -3649 |
| WELL NUMBER: | 4 | 5 | 6 |
| Well location | 1-33-15 NWNWNW | 26-32-15 CE½NENW | 2-32-15 NWNWNE |
| Source | Electric Log | Electric Log | Electric Log |
| Elevation | 1991 | 1911 | 1927 |
| Heebner | -2147 | -2109 | -2070 |
| Douglas | -2177 | -2140 | -2103 |
| Lansing | -2321 | -2267 | -2228 |
| Marmaton | -2785 | -2646 | -2683 |
| Cherokee | -2868 | ----- | ----- |
| Mississippi | -2879 | -2735 | -2803 |
| Chattanooga | -3147 | -2969 | -3005 |
| Viola | -3185 | -3012 | -3039 |
| Simpson | -3303 | -3114 | -3161 |
| Arbuckle | -3415 | -3271 | -3255 |
| WELL NUMBER: | 7 | 8 | 9 |
| Well location | 23-31-15 NENENE | 21-30-15 NENENE | 10-30-15 SESENW |
| Source | Electric Log | Electric Log | Electric Log |
| Elevation | 1752 | 1842 | 1951 |
| Heebner | -2026 | -1923 | -1900 |
| Douglas | -2055 | -1963 | -1939 |
| Lansing | -2203 | -2101 | -2016 |
| Marmaton | -2723 | -2506 | -2471 |
| Cherokee | ----- | ----- | ----- |
| Mississippi | -2745 | -2647 | ----- |
| Chattanooga | -2836 | ----- | ----- |
| Viola | -2866 | -2682 | -2655 |
| Simpson | -3028 | -2801 | -2753 |
| Arbuckle | -3122 | -2880 | -2835 |

Table 1. The exact location and correct tops used on the North-South cross section.

Fig. 11. Stratigraphic cross section No. 2, running Northwest-Southeast across Barber County, Kansas.

(In accompanying plate box)


STRATIGRAPHIC CROSS-SECTION
BARBER COUNTY, KANSAS
SCALE 1"=1 MILE
RICH STRONG
1959
-1900
-2000
-2100
-2200
-2300
-2400
-2500
-2600
-2700
-2800
-2900
-3000
-3100
-3200
-3300
-3400
-3500
-3600
-3700
-3800
-3900
-4000
9
6
5
4
3
2
1
HEEBNER
DOUGLAS
LANSING
KANSAS CITY
MARMATON
MISSISSIPPIAN
CHATTANOOGA
VIOLA
SIMPSON
ARBUCKLE
T 30 S
T 31 S
T 32 S
T 33 S
T 34 S
T 35 S
R15W
R14W
R13W
R12W
R11W
R10W

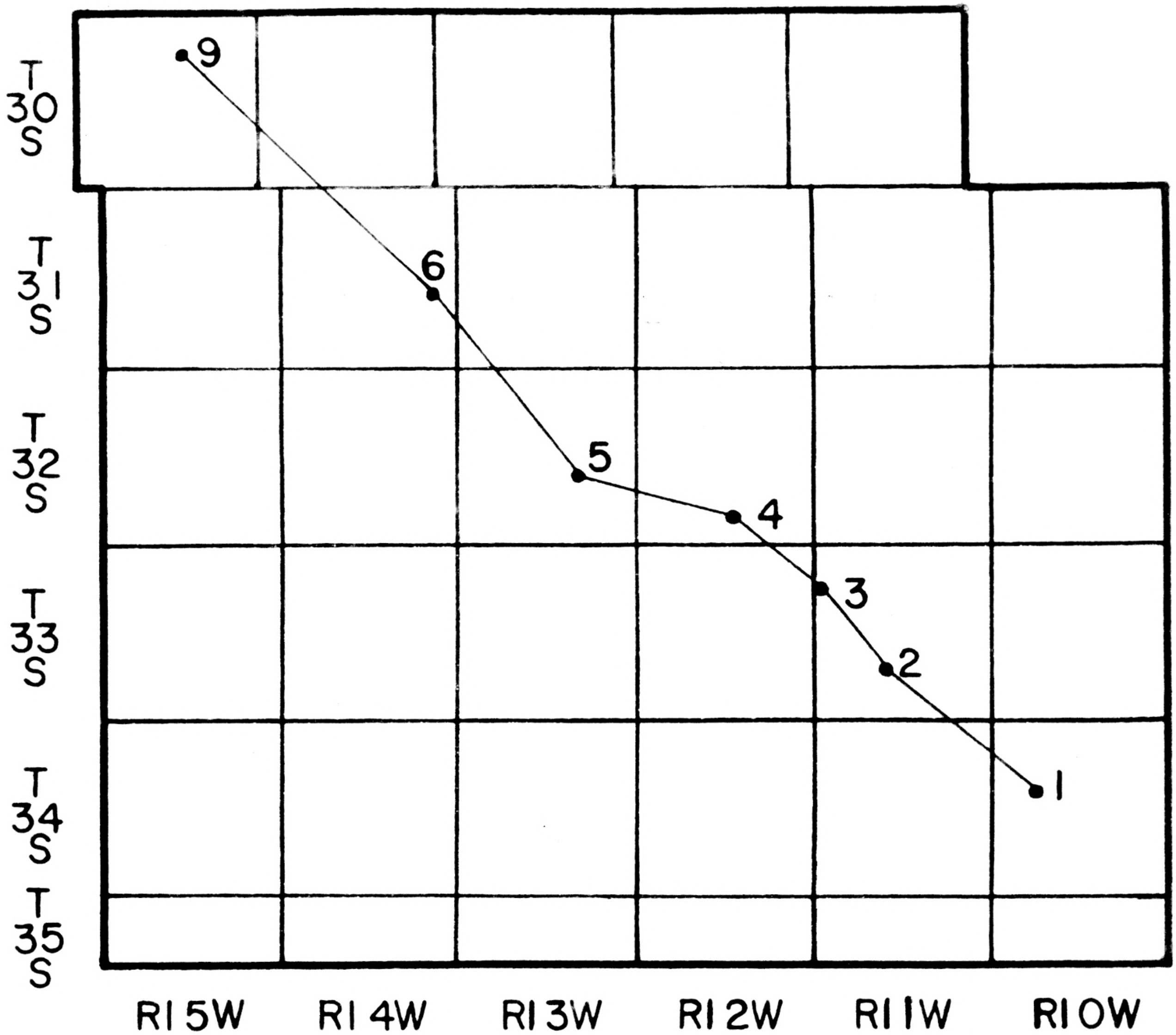



Fig. 11A. Map of Barber County, showing general locations of wells used in Northwest-Southeast cross section.

| WELL NUMBER: | 1 | 2 | 3 |
|---|---|---|---|
| Well location | 17-34-10 NENENE | 28-33-11 SWNWNE | 6-33-11 SWSWSW |
| Source | Electric Log | Electric Log | Electric Log |
| Elevation | 1392 | 1372 | 1408 |
| Heebner | -2230 | -2164 | -2116 |
| Douglas | -2276 | -2262 | -2218 |
| Lansing | -2638 | -2371 | -2308 |
| Kansas City | -2795 | ----- | ----- |
| Marmaton | -3115 | -2886 | -2786 |
| Mississippi | -3290 | -3058 | -2939 |
| Chattanooga | -3584 | -3259 | -3102 |
| Viola | -3655 | -3378 | -3216 |
| Simpson | -3749 | -3478 | -3298 |
| Arbuckle | -3912 | -3618 | -3446 |

| WELL NUMBER: | 4 | 5 | 6 |
|---|---|---|---|
| Well location | 34-32-12 NWNENW | 23-32-13 SWNWNW | 24-31-14 SESENW |
| Source | Electric Log | Electric Log | Electric Log |
| Elevation | 1523 | 1662 | 1624 |
| Heebner | -2089 | -2052 | -1989 |
| Douglas | -2181 | -2093 | -2025 |
| Lansing | -2283 | -2236 | -2157 |
| Kansas City | ----- | ----- | ----- |
| Marmaton | -2715 | -2646 | -2503 |
| Mississippi | -2833 | -2726 | -2682 |
| Chattanooga | -3019 | -2986 | -2781 |
| Viola | -3123 | -3082 | -2841 |
| Simpson | -3219 | -3184 | -2905 |
| Arbuckle | -3329 | -3294 | -2973 |

| WELL NUMBER: | 9 |
|---|---|
| Well location | 10-30-15 SESENW |
| Source | Electric Log |
| Elevation | 1951 |
| Heebner | -1900 |
| Douglas | -1939 |
| Lansing | -2016 |
| Kansas City | ----- |
| Marmaton | -2471 |
| Mississippi | ----- |
| Chattanooga | ----- |
| Viola | -2655 |
| Simpson | -2753 |
| Arbuckle | -2835 |

Table 2. The exact location and correct tops used on the Northwest-Southeast cross section.

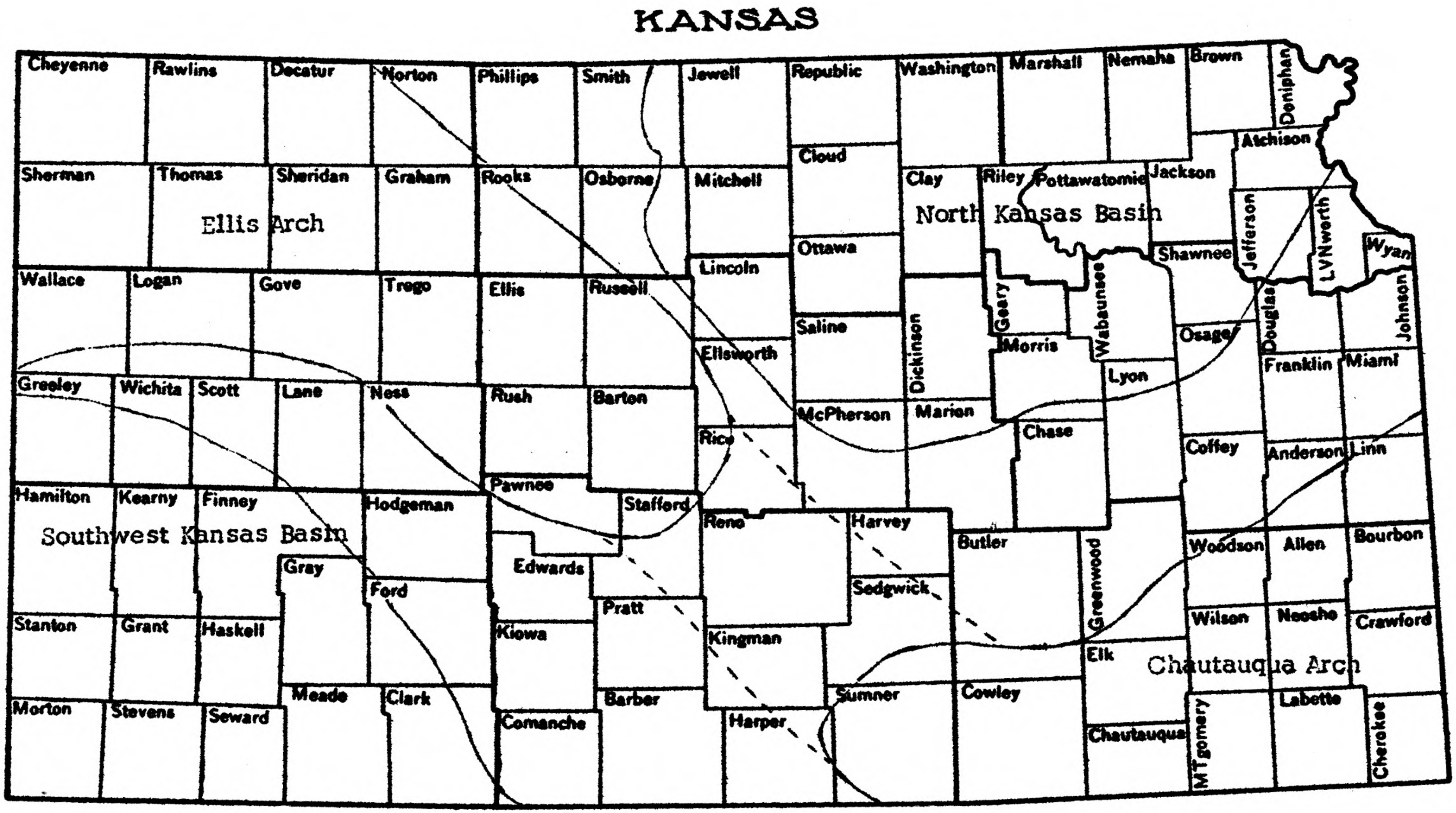
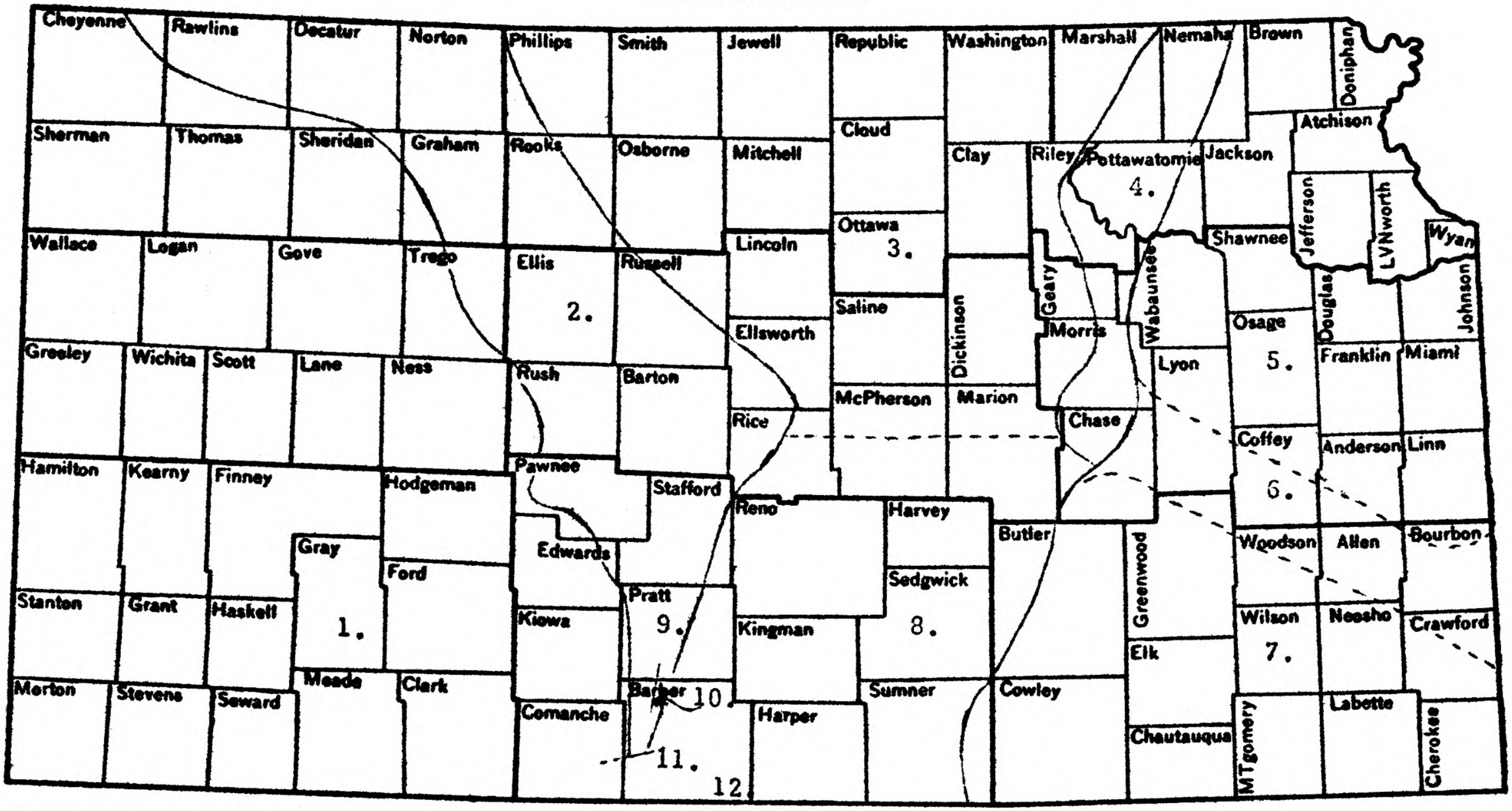



Fig. 12. Geographical location of major pre-Mississippian structures in Kansas.

KANSAS




Explanation: 1. Hugoton Embayment 2. Central Kansas Uplift 3. Salina Basin 4. Nemaha Anticline 5. Forest City Basin 6. Bourbon Arch 7. Cherokee Basin 8. Sedgwick Basin 9. Pratt Anticline 10. McAdoo Fault 11. Deerhead Fault 12. Northern Basin Shelf.

Fig. 13. Geographic location of major and minor post-Mississippian structures in Kansas.

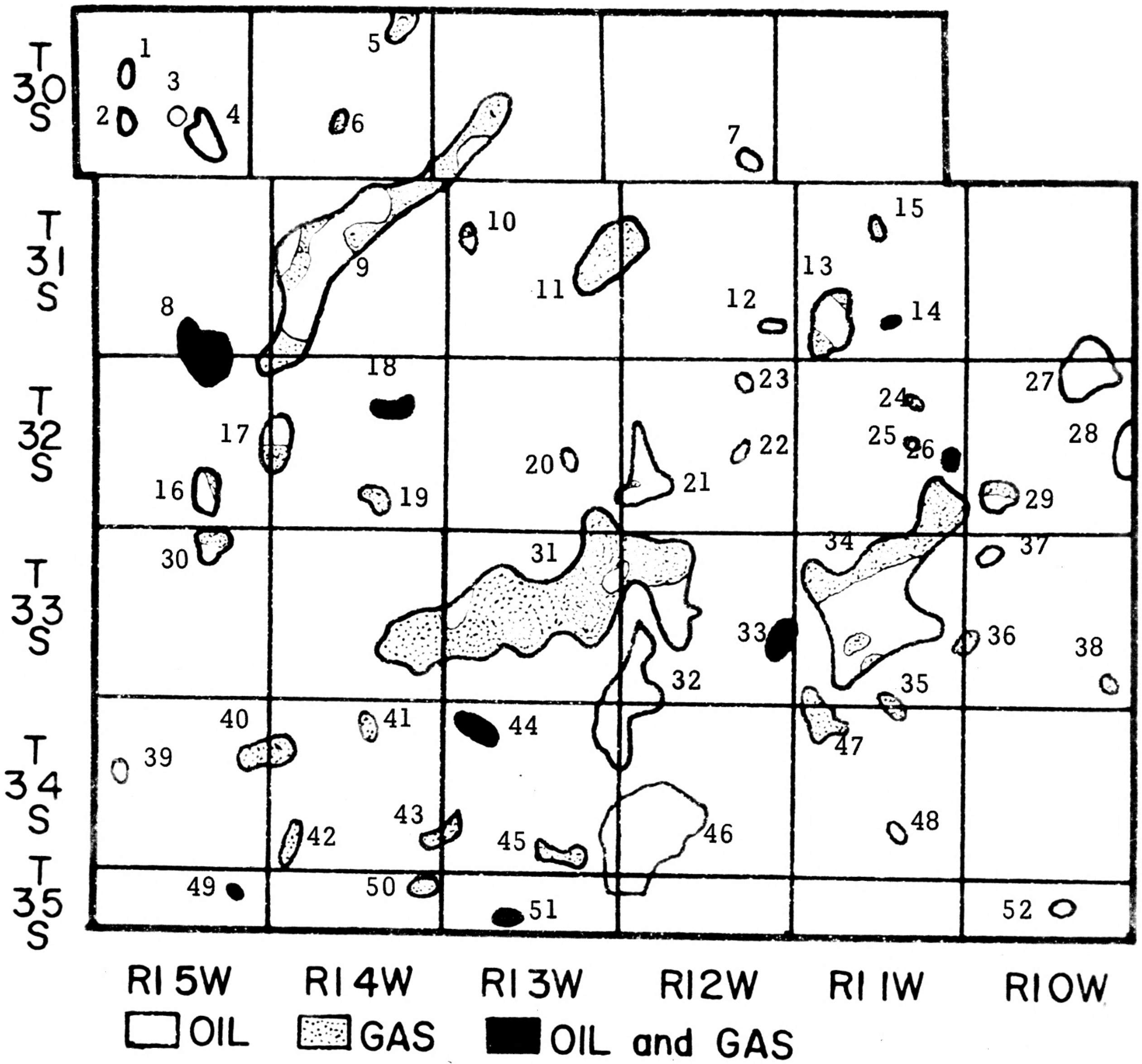



Fig. 14. Map of Barber County showing the location of producing oil and gas pools.

1. Turkey Creek North
2. Turkey Creek
3. Turkey Creek East
4. Sun City
5. Clara
6. Cottonwood Creek
7. Amber Creek
8. Donald
9. Skinner
10. Lake City
11. Nurse
12. Whelan West
13. Whelan
14. Whelan East
15. Ils
16. Deerhead
17. Stumph
18. Little Bear Creek
19. Elsea
20. Brooks-Younger
21. Medicine Lodge North
22. Bloom
23. Whelan Southwest
24. Highway North
25. Highway
26. McGuire
27. Sharon Northwest
28. Sharon
29. Goemann
30. DeGeer
31. Medicine Lodge-Boggs
32. Boggs Southwest
33. Nippewalla
34. Rhodes
35. Roundup South
36. Canema
37. Traffas
38. Cedar
39. Wells
40. Aetna
41. Aetna Northeast
42. Farley
43. Blunk
44. Medicine Lodge Southwest
45. Elwood
46. Hardtner
47. Rhodes South
48. Landis
49. Salt Fork
50. Blunk South
51. Wolgamott
52. Gudeman

Fig. 14A. Index of Barber County oil and gas pools.

# SUBSURFACE GEOLOGY OF BARBER COUNTY, KANSAS

by

Richard Melvin Strong

B. S., Kansas State University of
Agriculture and Applied Science, 1958

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AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE UNIVERSITY OF
AGRICULTURE AND APPLIED SCIENCE

1960

The purpose of this investigation is to study the subsurface geology and to determine how this is related to oil accumulation in Barber County.

Barber County is located on the Kansas-Oklahoma border in south central Kansas and has an area of 1,134 square miles.

Six structure maps, two isopachous maps, and two cross-sections were drawn. The maps show that major pre-Mississippian production is related to anticlinal noses and structural highs, and the majority of post-Mississippian production is in combination structural and stratigraphic traps. The cross-sections show faulting and pinchouts in the county.

Structures in Barber County are the Pratt Anticline, the Deerhead Fault, and the McAdoo Fault. The Pratt Anticline is sometimes known as the Barber County Arch in Barber County. The Deerhead and McAdoo faults are associated with the formation of the Pratt Anticline. The majority of pre-Mississippian production is associated with these structures.

The geologic history of the county indicates the following periods of erosion: Post-Arbuckle time, post-Simpson time, post-Viola time, post-Chattanooga time, post-Mississippian time, post-Missouri time, and post-Pennsylvanian time.

Petroleum traps in Barber County are either structural or a combination of structure and stratigraphy, with combination traps being most important.

The Stone Corral dolomite is the highest correlated unit in the subsurface of Barber County.

Mississippian production in the county seems to be associated with the reef-like thickening of the chert section. Wherever this thickening is found, there is almost always production.

A major portion of the petroleum in Barber County probably formed from organic compounds during pre-Mississippian time from a large southern Oklahoma geosyncline, and the remainder of the petroleum probably formed from Pennsylvanian source beds in the area.

Petroleum from the Anadarko Basin started migrating into the traps of Barber County during Pennsylvanian time and continued until after Permian time. As the Anadarko Basin subsided, gentle marine onlap occurred, forcing the petroleum to migrate towards the flanks of the basin. As this lateral migration occurred, there was some vertical migration, which accounts for the greater production in the Mississippian system and Viola limestone. Lack of production in the Pennsylvanian system is due to the dense limestones, impermeable shales, and lack of suitable traps. Therefore, most of the production found in the Pennsylvanian system probably formed in the area.

Latest statistics through 1957 show that Barber County ranks 21st in oil production and 5th in gas production in Kansas.

Future possibilities of large oil and gas fields are not very encouraging, but many small pools are yet to be discovered in the county. In mapping the county, a large terrace was found which has been relatively undeveloped. Seismic maps of the area show that four small highs on the Arbuckle group have not been drilled. Three of these highs are associated with the McAdoo Fault.