

THE SUBSURFACE STRUCTURE AND STRATIGRAPHY RELATED TO  
PETROLEUM ACCUMULATION IN PAWNEE COUNTY, KANSAS

by

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## INTRODUCTION

### Purpose of Investigation

The purpose of this report is to analyze the geologic history, subsurface structure and stratigraphy of Pawnee County, Kansas, in order to determine the relationship of these geological factors to the accumulation of petroleum.

### Area Covered by the Report

Pawnee County is located in west central Kansas. (Fig. 1). It is bordered on the west by Hodgeman and Ness Counties, on the north by Rush County, on the east by Barton and Stafford Counties, and on the south by Edwards County. Pawnee County consists of Townships 20, 21, 22 south, Ranges 16, 17, 18, 19, 20 west; Township 23 south, Ranges 15, 16, 17, 18 west; Townships 21 and 22 south and Range 15 west. Pawnee County contains 21 Townships, comprising an area of about 756 square miles. The area is in the Great Plains province. The highest elevation in Pawnee County is along the northern border. From the north border the land slopes southeastward toward the Arkansas River which cuts diagonally across the eastern half of the county. The lowest land lies along the Arkansas River and is composed of alluvium deposited during the Pleistocene and Recent times. Another wide belt of alluvium lies in the valley of the Pawnee River, from Burdett to Larned. The Pawnee River drains the western part of Pawnee County and joins the Arkansas River at Larned. Southeast of the Arkansas River are broad areas covered with dune sand, which was

also laid down during Pleistocene and Recent times. The Arkansas River and Pawnee River, along with their tributaries, drain the area.

### Procedure

Previous reports from known pools in Pawnee County, show that several formations have an accumulation of oil. For this investigation only three formations were chosen to determine the structure and stratigraphy present in the Pawnee County area. The formations decided upon, because of known oil accumulation and the abundance of elevation tops available, were the top of the Arbuckle dolomite of Lower Ordovician age, the top of the Mississippian limestones, and the top of the Lansing group which is in the Missouri Series of Pennsylvanian rocks. The Pawnee Rock and Larned pools gain their production from the Arbuckle dolomite, while the Garfield pool produces oil from several zones in the Mississippian rocks. The main producing zone, however, is at the contact of Pennsylvanian and Mississippian rocks. Only a small amount of production is gained from the Lansing group. All available datum elevations on top of the Arbuckle dolomite, the Mississippian limestone, and the Lansing limestone, were used to construct the structural contour maps. Most points were obtained from the Herndon Maps and the Geological Survey of Kansas drillers logs and electric well logs.

## STRATIGRAPHY

## Quaternary Period

Recent Epoch. Dune Sand. The area south of the Arkansas River, where it makes its Great Bend in Pawnee County, is covered by dune sand. This dune sand contains well-sorted, moderately well-rounded fragments of quartz, as well as lesser amounts of silt and clay. This dune sand overlies the alluvium of the Arkansas River in some places, which is of Pleistocene age. (McLaughlin 1949).

Most of the sand dunes in Pawnee County are in the eluvial phase of the dune cycle, although a few dunes are in the eolian, or active phase. The thickness of the dune sand is variable and ranges from a featheredge to about 40 or 50 feet.

Pleistocene Epoch. Alluvium. The alluvium of the Pawnee and Arkansas Valleys consists of sand, gravel, silt, and clay. Alluvium underlies the bottomland of the Pawnee and Arkansas Valleys and of some of the larger tributaries to these valleys. The southern limit of the alluvium on the south side of the Arkansas River is not known because of the overlap of the dune sand. The thickness of the alluvium in the Pawnee Valley as determined in test holes, ranges from 65 to 138 feet with an average of 105 feet. In the Arkansas Valley the thickness, ranges from 18 to 135 feet and an average of 61 feet. (McLaughlin 1949).

The alluvium in the Pawnee and Arkansas Valleys has been deposited in channels cut into Cretaceous, Tertiary, and Pleistocene sediments. The age of the alluvium, therefore, probably is



late Pleistocene and in part Recent.

**Terrace Deposits.** The terrace deposits consist principally of light-tan to brown clay and silt containing some caliche and interbedded with fine to coarse sand and a little gravel. The silt and clay, which generally are brown or buff, may have a variety of colors ranging from white to bright green and blue. The sand and gravel is poorly sorted and generally occurs at the base of the formation. The sand may consist primarily of grains of quartz or may contain fragments of sandstone and limestone. The gravel pebbles consists principally of limestone, sandstone, and ironstone, which probably were derived from the Greenhorn limestone, Carlile shale, and the Dakota formation. Two and possibly three terraces have been observed in Pawnee County. The thickness of the terrace deposits in Pawnee County ranges from a feather-edge near the contact with the Cretaceous bedrock, to 145 feet just north of Larned in Ash Creek Valley. The average thickness of these deposits is slightly more than 60 feet. (McLaughlin 1949).

**Meade Formation.** This formation consists predominately of coarse sand and gravel containing beds of fine sand, silt, and clay. The beds generally are poorly consolidated, but in some places the sand and gravel is cemented with calcium carbonate to form hard ledges known as "mortar beds." (McLaughlin 1949).

In Pawnee County, the Meade formation underlies only the area south of the Arkansas Valley. The Meade formation in Pawnee County ranges in thickness from about 50 feet to more than 100 feet. In general, the formation thickens as you go south from

the Arkansas River into Edwards County. The Meade formation yields water to all wells in Pawnee County and is the most extensive and potentially the most important water-bearing formation.

### Tertiary Period

Pliocene Epoch. Ogallala formation. The Ogallala formation consists mainly of silt, sand, and gravel containing caliche. (McLaughlin 1949). It outcrops in a few scattered areas in Pawnee County. Many places in Pawnee County have thin patches of algal limestone overlying the Dakota formation, which probably are equivalent to the algal limestone that marks the top of the Ogallala formation in parts of western Kansas. The Ogallala is only a few feet thick in Pawnee County.

### Cretaceous Period

Gulfian Series. Carlile shale. The Carlile shale consists of the Codell sandstone member at the top, the Blue Hill shale member, and the Fairport chalky shale member at the base. The basal Fairport chalky shale member, which is the only part of the Carlile exposed in the Pawnee area, consists of thick beds of chalky shale containing flat concretions and a few beds of bentonite alternating with thin beds of chalky limestone. The Carlile shale outcrops only in the northern part of Pawnee County and has a maximum thickness of about 100 feet. (McLaughlin 1949).

Greenhorn Limestone. The Greenhorn limestone consists largely of a succession of thin chalky to crystalline limestones interstratified with thicker beds of gray calcareous shale. The



shales contain thin beds of bentonitic clay. The Greenhorn outcrops in the northwestern part of Pawnee County. The thickness of the Greenhorn is about 125 feet. (McLaughlin 1949).

Graneros Shale. The lithology of the Graneros shale is variable. In some places it consists entirely of dark-gray to black fissile argillaceous shale, whereas in other places it consists of shale, sandy shale, and sandstone. The formation is soft in most localities and forms a gentle slope between the Greenhorn limestone and the Dakota formation. The Graneros outcrops in northwestern Pawnee County and has a thickness of approximately 25 to 30 feet. (McLaughlin 1949).

Dakota Formation. This formation consists principally of buff, yellow-brown, and brown sandstone and varicolored clay and sandy clay. Where the formation is exposed, the sandstone may be thin-bedded to massive, but generally is strongly ripple-marked and cross-bedded. Where the Dakota is well cemented it forms steep cliffs. The Dakota underlies all of Pawnee County except perhaps local areas in the eastern part of the county. The Dakota attains a maximum thickness of about 275 feet. (McLaughlin 1949).

Comanchean Series. Kiowa Shale. This formation consists principally of light to dark-gray and black clay shale containing thin beds of sandstone. Thin layers of limestone are present in some localities. The Kiowa formation underlies all of Pawnee County. The thickness of the formation in Pawnee County ranges from about 133 to 222 feet. (McLaughlin 1949).

Cheyenne Sandstone. The Cheyenne sandstone consists chiefly of light-colored fine to medium-grained, friable, cross-bedded,

sandstone and lenses of sandy shale and conglomerate. (Latta 1946). Sandstone is the most dominant part of this formation. The Cheyenne sandstone probably underlies all or most of Pawnee County. The thickness of the formation in Pawnee County, as determined by drilling, ranges from about 19 feet to 40 feet. The average thickness is about 27 feet. (McLaughlin 1949).

### Jurassic and Triassic

No Jurassic or Triassic sediments were deposited in the Pawnee County area. This was a high land mass during the early and middle part of the Cenozoic Era.

### Permian

The Permian rocks in Kansas are divided into two series: the Leonard series and the Wolfcampian series. The Leonard series in Pawnee County is comprised of the Quartermaster group, the Nippewalla group, and the Sumner group. The Wolfcampian series consists of the Chase group, the Council Grove group, and the Admire group. The Leonard series is composed of red shales, gypsum (Blain formation), dolomite (Stone Corral), gray shales and members which make up the Wellington formation. (Lee 1953). The Wolfcampian series is comprised mainly of alternating fossiliferous limestones and shales. The base of the Permian beds contain no good identifying characteristics which make it nearly impossible to pick an exact contact with the underlying Pennsylvanian rocks. Permian rocks lie conformably on the Pennsylvanian rocks.

Leonard Series. Quartermaster Group. The Quartermaster group in Pawnee County is represented by the Whitehorse sandstone which is composed of redbeds of feldspathic sandstone, siltstone, shale and a minor amount of dolomite. The Quartermaster group has a thickness of approximately 150 feet in Pawnee County.

Nippewalla Group. The Nippewalla group consists mainly of sandstones, with a few beds of gypsum and shale. The formations present in the Pawnee County area are the Blaine formation consisting of gypsum and anhydrite beds; the Flowerpot shale which is soft red and gypsiferous; the Cedar Hills sandstone consisting of red sand and siltstone interstratified with silty shale; the Salt Plain formation, which consists mainly of red silty shale with interbedded sandstones; and the Harper sandstone, which is mainly red and gray sandstone with interbedded red shale. In Pawnee County, the thickness of the Nippewalla varies from about 600 feet in the north part of Pawnee County to 800 feet in the south part. In well cuttings, only the Blaine formation and the Cedar Hills sandstone can be distinguished in the log sequence of red, silty shale and soft red sandstone that make up the Nippewalla group. (Lee 1953).

Sumner Group. The Sumner group consists of the Stone Corral dolomite, the Ninnescah shale, the Wellington formation, and possibly the Hollenberg limestone. The Stone Corral consists of a variable sequence of evaporites and shales with locally interbedded dolomite. The Ninnescah shale underlying the Stone Corral dolomite is the lowest Permian formation that consists predominantly of redbeds. The upper part consists mainly of red clay



shale in part slightly silty. The lower part consists of mottled and laminated gray-green, red, and maroon clay shales with a few thin beds of red siltstone and fine sandstone. (Lee 1953). The Ninnescah ranges in thickness from about 200 feet in the north to 180 feet in the south part of Pawnee County. The Wellington formation is broken down into three members. The upper member contains red and gray shales with some gypsum; the middle member is the Hutchinson Salt member which contains some gypsum with an abundance of salt; and the lower member consists of gray shales with some gypsum intermingled in it. The formation is logged as the redbeds in some wells in Pawnee County. The thickness of the Wellington is somewhere between 500 to 600 feet.

Wolfcampian Series. Chase Group. The Chase group consists of alternating layers of limestones and calcareous shales. The limestones are usually cherty, although the chert is not readily identified in the subsurface cuttings from the wells. The shales range in color from gray to red or varicolored. Some of the limestones present are the Nolans, Winfield, Towanda, Barneston, and the Kinney. These formations constitute about 350 feet of sediments in Pawnee County.

Council Grove Group. The Council Grove group consists mainly of limestones with shale members between. The shales are predominantly red or varicolored although a few are gray to black. The limestones in descending order are the Funston, Crouse, Bader, Beattie, Grenola, Red Eagle, and the Foraker. The Eskridge shale, a member of the Council Grove group, is easily identified in subsurface cuttings, because of its brilliant red color. The

thickness of the Council Grove group ranges from 250 to 300 feet.

Admire Group. The Admire group consists of alternating sequences of thin impure limestones, red and gray shales, silty and sandy shales, and sandstone. The group is disconformable on the underlying Pennsylvanian rocks. The group includes the Houchen Creek, the Five Point, Falls City, and the Aspirwall limestones. (Lee 1953). The thickness ranges from 250 to 300 feet.

### Pennsylvanian

The Pennsylvanian rocks in Pawnee County consist of the Virgilian series, the Missourian series and the Desmoinesian series. The Atokan series and the Morrowan series are absent in the area.

Virgilian Series. Wabaunsee Group. The upper part of the Wabaunsee group is absent in Pawnee County. The Dover limestone is the first member present. This group consists mainly of shales with thin bedded limestones.

Shawnee Group. The Shawnee group is composed mainly of limestones. These limestones are the Topeka, Deer Creek, Lecompton, and the Oread. The Topeka is usually the first formation "logged" in wells drilled in Pawnee County. Although the Topeka may vary by several feet, the average thickness of the Topeka is 50 feet. The Heebner shale, a member of the Oread limestone is also logged. It is distinguished by its very black color. The Heebner is approximately five feet thick.

Douglas Group. The Douglas group is believed to be represented in the area by several feet of red and gray shale that is

sometimes quite sandy.

Missourian Series. Pedee Group. The Pedee group is believed to be represented in Pawnee County by the Iatan limestone which is usually called the "Brown lime" by the drillers. Nearly all the wells in Pawnee County log the "Brown lime" as being present. The "Brown lime" ranges between 5 and 10 feet in thickness.

Lansing-Kansas City Group. The Lansing group is composed mainly of limestones with thin shale partings. Electric well logs indicate that there are about two main limestones present in the Lansing group. These are separated by thin shale members. These limestones are probably the Stanton and the Plattsburg, as they correlate well with these formations both to the north and south of the Pawnee County area. The Kansas City group is also mainly limestone with thin shale partings. (Lee 1953) indicates on his cross-section that the Kansas City group includes the Wyandotte, Iola, Drum, Westerville, Block, Dennis, Swope, and the Hertha limestones. The Lansing-Kansas City group is the first oil bearing formation in the County. Several pools produce from the Lansing-Kansas City group. These pools are the Benson, Dunes, Southwest, Evers, Hearn, Lovett and the Shady Southwest.

Pleasanton Group. A thin shale bed, that ranges from 5 to 20 feet in thickness, is thought to represent the Pleasanton group in Pawnee County.

Desmoinesian Series. Marmaton Group. The Marmaton group, according to (Lee 1953), consists of cyclical deposits of limestone, shale, and sandstone. Four limestone formations, the Lenapah, the Altamont, the Pawnee, and the Fort Scott comprise

the Marmaton group in the county. The Marmaton group is between 90 and 100 feet in thickness. The Marmaton group lies on the Basal Pennsylvanian Conglomerate.

Cherokee, Atokan and Morrowan Groups. All of these groups were eroded away by post-Mississippian erosion. Much of the Mississippian rocks were also eroded at this time. The Mississippian rocks were eroded down to the Osagian group. The Basal Pennsylvanian Conglomerate was the erosional remnant of this period of erosion.

### Mississippian

Osagian Series. The Osagian series is represented by the Reeds Spring formation, which is present only on the flanks of the Central Kansas uplift located in the western part of the county. The Osagian series is sometimes called the Mississippian or the "Mississippian lime" by the drillers. According to (Koester 1935) this probably correlates with the Boone limestone of the Ozark region. The Mississippian is a white, gray, or buff, sucrose, cherty limestone or dolomitic limestone. The Reeds Spring formation represents the Osage series in Pawnee County. The Mississippian has become a large producer in the Garfield, Garfield Northeast, and the Garfield Southwest pools. By the end of 1955 there were approximately 200 wells drilled in the Garfield pool area.

Kinderhookian Series. The Kinderhookian is represented in Pawnee County only in the eastern part of the county. The Kinderhook ranges in thickness from a feather edge to approximately 15



feet. The Kinderhook is represented by the Gilmore City limestone. The Gilmore City consists of a soft, non-cherty, semi-granular limestone, the lower part of which is oolitic. (Lee 1953). The Garfield pool located in southwestern Pawnee County has a few wells that produce from the Kinderhook group.

### Silurian and Devonian

No known Silurian or Devonian rocks are present in the Pawnee area. These formations were probably never deposited in this area, as the Central Kansas uplift was a high area and erosion was taking place during these periods. The rocks of Mississippian age lie unconformably on rocks of Ordovician age.

### Ordovician

Viola. The Viola is a series of limestones, and dolomites, which is sometimes called the Viola lime. The Viola contains some chert. The Viola is very thin in the eastern part of the county near the Central Kansas uplift, but it thickens gradually to the west. It attains a thickness of about 80 feet in the western part of the county.

Simpson Group. The Simpson group lies conformably below the Viola. From information contained in electric well logs, the full Simpson group is present. The Simpson can be subdivided into the Platteville formation, which is a sandy shale, the St. Peter sandstone, and a lower sandy shale below the St. Peter sandstone. The Simpson group ranges in thickness from about 15 feet, to 25 or 30 feet. Two pools in Pawnee County produce from the

Simpson. The Evers pool has four Simpson producers and the Jay pool has two wells producing from the Simpson.

Arbuckle Group. Unconformably below the Simpson group lies the Arbuckle group. The Arbuckle underlies all of Pawnee County, and ranges from a few feet thick to 400 feet thick in the few wells that were drilled to the granite. Most of the wells were drilled only a few feet into the Arbuckle dolomite, which makes it very difficult to determine the thickness of the Arbuckle. The Arbuckle is a red and pink coarsely crystalline porous dolomite, that contains some sand and white chert. The drillers sometimes call the Arbuckle dolomite the "Siliceous lime", because of the siliceous material it contains. More petroleum is produced from the Arbuckle in Pawnee County than any other formation. Of the 262 producing wells in Pawnee County at the end of 1954, there were 161 wells producing from the Arbuckle. The Arbuckle wells produced about two-thirds of the total oil production in 1954. Some of the largest pools producing from the Arbuckle are the Dunes, Larned, and the Pawnee Rock.

#### Cambrian

Reagan sandstone or Lamotte sandstone. Some of the wells drilled in northeastern Pawnee County encountered sand below the Arbuckle, which seems to correlate with the Lamotte or Reagan sandstone as it is called in Pawnee County.

#### Pre-Cambrian

The basement rocks of Kansas consist of granite, schist,

quartzite, gneiss, slate, and marble, with gneiss and schist the most widespread.

## GEOLOGIC HISTORY

### Paleozoic Era

Records of deep drilling in Pawnee County show that approximately 3,500 to 5,000 feet of Paleozoic rocks exist above the pre-Cambrian surface. Rocks of pre-Cambrian age are found at depths ranging from 3,622 feet to 4,639 feet. Marine Cambrian and Ordovician rocks were deposited over this igneous and metamorphic floor of pre-Cambrian rocks. The land became submerged during Middle Cambrian time and remained submerged until the early part of Ordovician period. The Reagan sandstone of Upper Cambrian age is found in a few wells in eastern Pawnee County. Because of the limited number of wells that logged the Reagan, it is questionable whether this is really the Reagan sandstone. During the lower part of Ordovician time, the Arbuckle dolomite or "Siliceous lime", as it is sometimes called was deposited in Pawnee County. During Middle Ordovician time the Simpson group and the Viola limestone was deposited. The Simpson group lies above the Arbuckle dolomite and consists of a sandstone member between two sandy shale members. Above the Simpson group is the Viola limestone which consists of a series of limestones and dolomites with some chert.

Rocks of Silurian and Devonian age do not underlie Pawnee County. They either were not deposited in this area or were later removed by erosion subsequent to the deposition of the

overlying Mississippian strata. Deposits of marine dolomitic limestone and shale were laid down in this area during the early part of the Mississippian period. The sea withdrew during part of Mississippian time and again covered the area in the last part of the period.

A long period of erosion followed the deposition of the youngest Mississippian rocks and the oldest Pennsylvanian rocks that overlie them. Following this erosional period, the sea alternately advanced and retreated, causing the deposition of both marine and continental materials consisting of sandstone, shale, limestone, and coal. The alternating marine and continental deposition continued through early Permian time, but by late Permian time continental deposition became dominant. These deposits consist of redbeds containing gypsum, anhydrite, and salt, which suggests an arid climate.

### Mesozoic Era

The Cheyenne sandstone was deposited over all the Pawnee County area in early Cretaceous time. (McLaughlin 1949). During early Cretaceous time most of Kansas was covered by a shallow sea not over 1,000 feet in depth, which indicated the Cheyenne sandstone was deposited in a shallow sea environment. Following the deposition of the Cheyenne sandstone, the dark fossiliferous clay that formed the Kiowa shale was deposited. The sandstone and shale of the Dakota formation were laid down in late Cretaceous time under both fluviatile and near-shore marine conditions. Marine deposits of limestone and shale which were laid down in this



area after the deposition of the Dakota formation were composed of the Graneros shale, the Greenhorn limestone, and the Carlile shale. Younger Cretaceous deposits probably covered at least part of this area but these sediments have been removed by erosion.

### Cenozoic Era

Tertiary Period. The Laramide revolution, which began in late Cretaceous time and which continued into Tertiary time, probably caused the regional dip of the older beds in this area. (McLaughlin 1949). After this major deformation, which uplifted the Rocky Mountains, the Ogallala formation of Middle Pliocene age was deposited by streams that carried rock debris from the Rocky Mountains. These deposits mantled the bedrock in large areas in western Kansas. Most of these deposits have been removed by erosion, but the Ogallala formation may underlie a small area in southwest Pawnee County.

Quaternary Period. Pleistocene Epoch. The thick deposits of silt, sand, and gravel that overlie the Cretaceous bedrock south of the Arkansas River were laid down during the Pleistocene epoch and represent stream-laid debris from the Rocky Mountains. Part of the material south of the Arkansas River may be terrace deposits which were also laid down during the Pleistocene epoch. (McLaughlin 1949).

The ancestral Pawnee River and its tributaries deposited fine-grained materials over a large area in Pawnee County. These terrace deposits consist primarily of silt and clay, but contain lesser amounts of sand and gravel, and represent at least two

stages of deposition by the Pawnee River and its tributaries.

During late Pleistocene and Recent time the Arkansas and Pawnee Rivers and their tributaries deposited alluvium in their valleys. Part of the dune sand also may have been deposited in late Pleistocene time, but it is believed that most of the dune sand in the Pawnee area is Recent in age.

Recent Epoch. During Recent time most of the dune sand south of the Arkansas River was deposited, as is indicated by the presence of dune sand overlying alluvium. The present topography of Pawnee County was formed in part during the Recent Epoch. The principal valleys were eroded during the Pleistocene, but most of the existing surface features are the result of Recent erosion. (McLaughlin 1949).

## MAJOR STRUCTURES

### Central Kansas Uplift

The Central Kansas uplift, as it is known today, has been in existence since pre-Cambrian time. The Central Kansas uplift is flanked on the northeast by the Salina Basin and on the southwest by the Dodge City or Hugoton embayment as it is sometimes called. See Fig. 2 in the appendix for location. The term Central Kansas uplift is generally used for the post-Mississippian structures of Kansas, while several different terms have been used to describe the pre-Mississippian structure. Barwick (1928) named the pre-Mississippian uplifted area in southeastern Kansas, the Chautauqua arch. The Chautauqua arch was thought to be an extension of the Ozark uplift, located in Arkansas. Moore and Jewett (1942)

proposed the name Ellis arch for the pre-Mississippian structure located in central and north-central Kansas. Barwick (1928) also used the name Barton arch in the same sense that Moore and Jewett (1942) used the term Ellis arch.

The Barton arch is sometimes used to mean all the pre-Mississippian structure that was present in Kansas, which would include both the Ellis arch and the Chautauqua arch. Morgan (1932) was probably the first to use the term Central Kansas uplift for the major post-Mississippian structure of Central Kansas. Koester (1935) stated that the Central Kansas uplift occupies an area in central Kansas and probably part of south-central Nebraska, whose present north-westward trending structure has been developed by several periods of warping and truncation, the earliest of which dates back to pre-Cambrian time. Subsequent movements of variable magnitude, and covering different portions of the geographic area, have slightly altered the original size and shape of the uplift. Warping on a broad scale in the northwest and southeast direction, which has recurred throughout Paleozoic and Mesozoic time, has been modified by depositional thinning toward the northwest of some of the Paleozoic system and by folding in approximately northeast and southwest directions along old existing lines of weakness. Warping has occurred chiefly in post-Algonkian, post-Canadian, post-Hunton, early Pennsylvanian, post-Missouri, and post-Cretaceous time. Depositional thinning toward the north and west has affected mainly Cambro-Ordovician and Pennsylvanian strata. Most of the northwest-southwest folding occurred in early Pennsylvanian and post-Cretaceous time.



The Central Kansas uplift had several minor arches located on it. These arches were named the Pawnee Rib, the Rush Rib, and the Russell Rib. The Pawnee Rib will be discussed more fully under the heading "Minor Structures".

The edge of the Central Kansas uplift passes through the western part of Pawnee County. The Mississippian sediments are present in the western one-third of Pawnee County, but are absent in the eastern part of the county. This situation can be explained by one of two different ways. First, the sediments may not have been deposited on the uplifted area past the present zero line or, secondly, the Mississippian sediments may have been deposited on the Central Kansas uplift and post-Mississippian erosion removed the Mississippian sediments from the top of the Central Kansas uplift. Removal of the sediments by post-Mississippian erosion appears to be the most valid idea. The Central Kansas uplift is covered by sediments of Cambrian, Ordovician, Pennsylvanian, Permian, Cretaceous, and Quaternary age in the Pawnee County area.

#### Dodge City Embayment

The name Dodge City embayment commonly is applied to a large structural province of southwestern Kansas. It was classed as a major post-Mississippian structural province by Moore and Jewett (1942).

The name Dodge City basin was applied first by McClellan (1930), to the synclinal area of southwestern Kansas, into which rocks dip off the west flank of the Central Kansas uplift (Barton arch). Wheeler (1947), applied the term Dodge City embayment to

a portion of the Anadarko basin extending into parts of Stevens, Seward, Haskell, Meade, and Clark Counties, Kansas. Maher and Collins (1948), stated their belief that the "embayment" extends northward and westward including the area between the Sierra Grande uplift, the Las Animas arch, and the Central Kansas uplift, and they proposed the term Hugoton embayment as more suitable than Dodge City basin. Wheeler (1947) mentioned the gradual thinning of the Paleozoic section toward the granite core of the Central Kansas uplift. The Dodge City embayment has an asymmetric shape, with the deeper part or trough at the southwest.

The Dodge City embayment touches only the very western part of Pawnee County. The Dodge City embayment is believed to start at the edge of the Central Kansas uplift. The formations in the basin dip gently to the west in Pawnee County. The Dodge City basin has sediments present that are Cambrian, Ordovician, Mississippian, Pennsylvanian, Permian, Cretaceous, Quaternary, and possibly the Tertiary period in age.

#### MINOR STRUCTURES

##### Pawnee Rib

The Pawnee Rib is thought to be a pre-Mississippian structure in northeastern Pawnee County, which may be regarded as a part of the Ellis arch. Koester (1935) introduced the name Pawnee Rib for the broad area in Pawnee County in which the "Siliceous lime" underlies the Pennsylvanian. It is believed that Koester used the term "Siliceous lime" to mean the Arbuckle dolomite, or possibly the Viola limestone. From all available evidence today, the Pawnee

Rib was probably used in the same sense as the term Central Kansas uplift is used today. In the eastern part of Pawnee County the Pennsylvanian rocks lie directly on rocks of Ordovician age.

### HISTORY OF DRILLING IN PAWNEE COUNTY

The first oil pool in Pawnee County was discovered in September, 1936, by the Simpson and Noble No. 1 Gates well, which is located in Section 13, T 20 S, and R 16 W. (Fig. 3 in appendix). The well was completed in the Arbuckle dolomite at a depth of 3,841 feet. The porous zone of the Arbuckle was 9 feet thick and the initial production of the well was 187 barrels of oil and 4,000,000 cubic feet of gas a day. This pool was named the Pawnee Rock pool. For production see Table 1 and 2 in the appendix.

Interest was not too great in Pawnee County until 1941. Up to 1941 only 9 wells had been completed in the Pawnee Rock pool. By the end of 1941 the Pawnee Rock pool had 25 wells. In December 1941, Stanolind Oil and Gas Company started the Rosine Smith well in Section 16, T 23 S, R 16 W, and completed it on February 9, 1942. This was the discovery well for the Zook pool. Initial production was 6,000,000 cubic feet of gas and a few barrels of oil. (See Table 1 for total production).

During 1942 and 1943, only one new well was added in Pawnee County and it was located in the Zook pool.

During 1944, seven wells were drilled in Pawnee County. Six were dry holes. The other well discovered the Pawnee Rock South pool. This well was drilled by Nadel and Gussman-Aylward Producing Company in the center  $N\frac{1}{2}$  NE NW Section 25, T 20 S, R 16 W. The

well produced from the Arbuckle dolomite between the depths of 3,816 feet and 3,825 feet and had a daily initial production of 362 barrels. This pool was later combined with the Pawnee Rock. Production of the Pawnee Rock pool is shown in (Table 1 in the appendix).

During 1945, drilling became very active and four new pools were added. One new pool was named the Ryan Southeast and was found by W. F. Hildebrand in the NW NW Section 12, T 20 S, R 16 W.

The second new pool was named the Shady gas pool, which was discovered when J. M. Huber Corporation drilled a well in the NE NE Section 34, T 22 S, R 16 W, and completed it for 36½ million cubic feet of gas per day. (Production is shown in Table 2 in the appendix).

The third pool was named the Benson. The discovery well for this pool was drilled by the Stanolind Oil and Gas Company on the Benson lease in the NW NE NW Section 30, T 23 S, R 15 W. Gas was found in the Arbuckle, but was plugged back to the Kansas City-Lansing limestone. The porous zone was located between depths of 3,853 and 3,869 feet. The well had an initial production of 357 barrels a day. For production of the Benson pool see Table 1 in the appendix.

A fourth pool was discovered called the Ryan pool. This pool was located partly in Pawnee County and partly in Rush County. Ten producing wells were drilled in the Pawnee part of the pool. Production figures are shown in Table 1 in the appendix.

The Rutherford and Benson Southeast pools were discovered



during 1946. The discovery well for the Rutherford pool was drilled by Brack and Huber in the SW NE NW Section 8, T 20 S, R 16 W. Oil was found in the Arbuckle dolomite between 3,815 feet and 3,823 feet. Initial production of the well was 125 barrels of oil a day. The Benson Southeast pool was discovered by the Cities Service Company in the NE SE NW Section 32, T 23 S, R 15 W. Gas was discovered in the Arbuckle dolomite. Perforations were made between 4,048 feet and 4,138 feet. A flow of approximately 24 million cubic feet of gas was obtained. The Benson Southeast pool was combined with the Benson pool in 1953. (Table 2 in the appendix).

In 1947, drilling became widespread in the county and several new pools were found in the county. Main interest was centered about five or six miles northeast of Larned. Three new pools were discovered in this area: the Ash Creek South, the Ash Creek Southwest, and the Torrance. A fourth new pool, the Garfield, was discovered late in the year 12 miles southwest of Larned, near Garfield.

The Ash Creek South pool (combined with Ash Creek of Barton County in 1948) was found by the Bay Petroleum Corporation in Section 12, T 21 S, R 16 W. This discovery well was drilled on the Sara Smith farm. Oil was found at a depth of 3,766 feet to 3,788 feet in the Arbuckle dolomite. The initial flow of this well was 272 barrels of oil a day. (Table 1 in appendix).

The Ash Creek Southwest pool was discovered by the Mid-Continent Petroleum Corporation. The well is located in the SE SE NW Section 11, T 21 S, R 16 W, on the Bowman farm. Oil was found

in the Arbuckle dolomite between 3,779 feet and 3,789 feet. (Table 1 in the appendix).

The Torrance gas pool was discovered by the J. M. Huber Corporation in the SW corner of Section 19, T 21 S, R 15 W, on the Torrance farm. The Arbuckle dolomite produced gas at 3,846 feet. The well was rated at 35 to 53 million cubic feet of gas a day. Gas production is shown in Table 2 in the appendix.

The fourth pool, the Garfield, was discovered by the Gabbert and Lindas well on the Hutchinson farm in Section 17, T 23 S, R 17 W. This well had an initial production of 44 barrels a day. Production is shown in (Table 1).

During 1948, all the new wells discovered were extensions of pre-existing pools.

Drilling during 1949 produced two additional pools in Pawnee County. The Larned pool was discovered by the Sunray Oil Corporation in Section 28, T 21 S, R 16 W. Production was from the Arbuckle. The well's potential is 40 barrels of oil and  $4\frac{1}{2}$  million cubic feet per day. The second pool is the Pawnee Rock West drilled by the Jayhawk Oil Company and Vickers Petroleum Company, Inc. This well is located in Section 23, T 20 S, R 16 W. This is an Arbuckle dolomite producer. The Pawnee Rock West was combined with the Pawnee Rock pool in 1952. Production is shown in Table 1 in the appendix.

The Rutherford East pool was discovered in 1950 and combined with the Ryan pool in 1952. The discovery well was drilled by the Ben Brack Oil Company in Section 4, T 20 S, R 16 W. Gas was found in the top of the Arbuckle and the well tested 2,700,000

cubic feet per day. A few months later the Ben Brack Oil Company deepened the well about 40 feet into the Arbuckle dolomite and obtained oil production. The well had a rated potential of 280 barrels a day.

In 1951, the Evers pool was discovered by the Stanolind Oil and Gas Company in Section 1, T 22 S, R 16 W. Gas was discovered in the Arbuckle dolomite (3,000,000 cubic feet per day), and the Simpson sandstone (2,000,000 cubic feet per day). The well was plugged back to the Lansing limestone and perforated between the depths of 3,525 and 3,531 feet, where it yielded 58 barrels of oil a day. Production figures are shown in Table 1.

The Benson South pool was discovered in 1952 by the M. B. Armer Drilling Company in Section 30, T 23 S, R 15 W. The well produces from the Lansing-Kansas City formation. A potential of 401 barrels of oil a day was assigned. The Benson South pool was combined with the Benson pool in 1953. Production figures are shown in Table 1.

During 1953, drilling activity increased nearly three times over 1952. This increased drilling resulted in ten new pools being discovered. These pools are as follows: (1) the Conkling, (2) the Dunes, (3) the Dunes Southwest, (4) the Evers Northeast, (5) the Hearn, (6) the Oro, (7) the Oro West, (8) the Shady Southwest, (9) the Sweeney, and (10) the Sweeney Southwest. The Hearn, Sweeney Southwest, and Sweeney are gas pools. For production of these pools see Table 1 and Table 2 in the appendix.

The Conkling pool was discovered by the Morrison Drilling Company, Inc. in the NE SE Section 4, T 20 S, R 18 W. The Arbuckle



dolomite produces from a depth of 4,020 feet to 4,024 feet.

The Dunes pool was discovered by Westgate-Greenland in the SE SW Section 22, T 22 S, R 15 W. The Arbuckle dolomite produces from 3,956 feet to 3,980 feet. The initial production was 2,822 barrels of oil a day.

The Dunes Southwest pool was discovered by Westgate-Greenland in the Ne NW Section 33, T 22 S, R 15 W. This well was a Lansing-Kansas City producer. Oil was found from 3,728 feet to 3,736 feet. Initial production was 141 barrels a day.

Petroleum Inc. found the Evers Northeast pool with their well in the SE NE Section 31, T 21 S, R 15 W. This was an Arbuckle producer at a depth of 3,915 feet to 3,918 feet. Initial production was 48 barrels a day.

The Hearn pool, located in the SW NE Section 35, T 23 S, R 15 W, was discovered by the Natural Gas and Oil Corporation and Sinclair Oil and Gas. The Lansing-Kansas City produced from 3,833 feet to 3,837 feet. The well had a flow of 4,000,000 cubic feet of gas a day.

The Oro pool, located in the SE NE Section 9, T 20 S, R 19 W, was discovered by M. B. Armer. This well produced from the Pennsylvanian Basal Conglomerate at a depth of 4,204 feet to 4,209 feet. Initial production was 651 barrels of oil a day.

The Oro West pool, located in the NE SW Section 8, T 20 S, R 19 W, was discovered by the Carl Todd Drilling Company. Production was from the Pennsylvanian Basal Conglomerate at a depth of 4,124 feet to 4,136 feet. Initial production was 281 barrels of oil a day.

The Shady Southwest pool, located in the SE NW Section 3, T 23 S, R 16 W, was discovered by the Graham-Messman-Rinehart Oil Company. Production was from the Lansing-Kansas City between the depths of 3,705 feet and 3,710 feet. Initial production was 1,458 barrels of oil a day.

The Sweeney pool, located in the NW NE Section 8, T 21 S, R 15 W, was discovered by Vickers Exploration, Ltd. Production was from the Arbuckle dolomite between the depths of 3,792 feet and 3,818 feet. The initial production was 6,160,000 cubic feet of gas a day.

The Sweeney Southwest pool, located in the SE SE Section 7, T 21 S, R 15 W, was discovered by the Graham-Messman-Rinehart Oil Company. Production was from the Arbuckle dolomite between the depths of 3,808 feet and 3,822 feet. Initial production was 5,000,000 cubic feet of gas per day. (This pool was combined with the Sweeney pool during 1954).

Drilling activity continued at a high level again in 1954. Eight new pools were discovered in the county during 1954. The names of the pools are as follows: (1) the Garfield Northeast, (2) the Garfield Southwest, (3) the Jab, (4) the Jay, (5) the Lovett, (6) the Shiley, (7) the Shiley East, and (8) the Sweeney West. (Table 1 shows the production figures).

The Garfield Southwest pool, located in the SE NW Section 30, T 23 S, R 17 W, was discovered by the Coppinger Drilling, Inc. This was thought to be a Misener sand producer, but later was found to be a dry hole and was abandoned. No additional wells have been drilled in this area, so it is questionable whether the

Garfield Southwest pool name should be retained. No production has been gained from this pool.

The Derby Oil Company and Honaker Drilling Company discovered the Jab pool located in the SE SE Section 35, T 22 S, R 17 W. This was a gas well with a potential of 3,500,000 cubic feet of gas per day. The producing zone was the Basal Pennsylvanian Conglomerate.

Atlantic Refining Company discovered the Jay pool in the NW SW Section 3, T 23 S, R 15 W. Production was from the Simpson sand with a rating of 146 barrels of oil per day.

The Lovett pool, located in the NW NW Section 35, T 22 S, R 15 W, was discovered by the R. W. Rine Drilling Company. This was a Lansing-Kansas City producer for 54 barrels of oil per day.

Cities Service Oil Co. discovered the Shiley pool located in the NE NE Section 14, T 20 S, R 20 W. This well produces from the Basal Pennsylvanian Conglomerate and had an initial production of 506 barrels of oil per day.

The Shiley East pool was discovered by the National Cooperative Refining Association in the NW NW Section 18, T 20 S, R 19 W. Production came from the Pennsylvanian basal sand (Cherokee) and had an initial production of 91 barrels a day.

The Sweeney West pool, located in the SE SE Section 6, T 21 S, R 15 W, was discovered by the Graham-Messman-Rinehart Oil Co. This well was a gas and oil producer from the Arbuckle. It had an initial production of 5,000,000 cubic feet of gas and 168 barrels of oil per day. The Sweeney West pool was later combined with the Sweeney pool.

## RELATIONSHIP OF ACCUMULATION OF PETROLEUM TO STRUCTURE AND STRATIGRAPHY

The Central Kansas uplift has several small structural "highs" associated with it in eastern Pawnee County. All of the known oil and gas pools in Pawnee County prior to 1953, except the Garfield pool, occur on these structural "highs".

The Arbuckle structural contour map (Fig. 6A in the appendix) and the Lansing structural contour map (Fig. 4A) reflect very similar structure. The reflection of this structure is extremely well defined over the Central Kansas uplift. The Arbuckle contour map shows that a structurally "high" area trends north and south in the eastern part of Pawnee County in Ranges 15 and 16 West. The following pools are located on this structural "high": (1) the Larned, (2) the Sweeney, (3) the Ash Creek, (4) the Ash Creek Southwest, (5) the Pawnee Rock, (6) the Ryan, (7) the Ryan Southeast, and (8) the Rutherford. Most of the pools are located on "plunging anticlinal folds", with very small closure. Numerous low areas or "sink holes" are located on both sides of this structural "high". A stratigraphic cross-section (Fig. 7 appendix) shows the position of the Central Kansas uplift in Pawnee County. The Arbuckle dolomite shows gradual west dip off of the Central Kansas uplift into the Dodge City basin (Fig. 2 appendix), which extends to the western edge of Pawnee County.

The Lansing-Kansas City group is the reservoir rock for five pools in Pawnee County. These five pools are as follows: (1) the Lovett, (2) the Dunes Southwest, (3) the Shady Southwest, (4) the Hearn, and (5) the Benson. The Lansing structural contour map



(Fig. 4A in appendix), shows the location of these pools and their associated "highs". Of the five pools, the Benson pool has the most closure and is located on the most pronounced Lansing structure.

The Mississippian structural contour map (Fig. 5A in appendix) depicts the zero line of Mississippian sedimentary rocks that "pinch-out" on the flanks of the Central Kansas uplift. The Garfield pool is due mainly to a stratigraphic trap. Very little structure is present. The stratigraphic cross-section of Pawnee County (Fig. 7 in appendix) shows the Mississippian "pinching out" and overlain by the Pennsylvanian Basal Conglomerate which has a shale member at the base that forms the impervious layer needed to produce a stratigraphic trap.

Several other formations besides the Lansing-Kansas City, the Mississippian limestones, and the Arbuckle dolomite are oil and gas reservoir rocks. These formations include the Pennsylvanian Basal Conglomerate, the Simpson sands, and the Cherokee group.

#### FUTURE POTENTIAL

The future potential for oil and gas production in Pawnee County is good. Eight new pools were discovered during 1954, which gives an indication of the drilling activity in Pawnee County. Most of the larger structural "highs" on the Central Kansas uplift have been drilled, but a few areas still seem to have good possibilities.

The lateral extent of known pools have not been reached in several instances. Examples of this are shown by the Garfield,

Larned, and Benson pools, in which a total of 47 extension wells were drilled in 1954. The Garfield pool was the leader with 36 new wells.

Another good possibility for oil production is in the Mississippian limestones which form reservoir rocks where they are "Wedged-out" on the flanks of the Central Kansas uplift. A good possibility exists that other pools similar to the Garfield may be found in western Pawnee County. Mississippian production has increased greatly with the discovery of the Garfield pool. The Garfield pool will probably be one of the largest pools in Pawnee County when it has been completely drilled out.

Many wells have had a show of oil, but were not of economic value. As improved methods are devised for fracturing and acidizing, some of these wells may become producers.

Secondary recovery has not been used in Pawnee County. In the future this could be one method of increasing or prolonging production from a field as it is becoming dry.

### CONCLUSIONS

The possibility of finding oil and gas in Pawnee County is very good. Drilling was first started in 1936 with the discovery of the Pawnee Rock pool. The drilling activity was never very great in Pawnee County until after 1948. Since 1948 the drilling has increased at a rapid pace. Only 7 pools were discovered prior to 1948. Since 1948, 21 new pools have been discovered. During 1954, eight new pools were discovered. At the close of 1954 there were 28 pools in Pawnee County that produced 1,512,658

barrels of oil and 3,834,660 thousand cubic feet of gas during 1954.

Several of the pools have great possibilities for expansion as they have not been drilled to their lateral extent.

One of the best possible places for future exploration lies on the flank of the Central Kansas uplift where the Mississippian formation "wedge-out".

Another possibility lies on the Central Kansas uplift. A very close study of the structure and stratigraphy may result in the finding of small structures and stratigraphic traps in this area.

The structural contour maps on the Arbuckle (Fig. 6A in appendix) and the Lansing (Fig. 4A in appendix) reflect very similar structure, especially over the Central Kansas uplift.

The accumulation of petroleum in Pawnee County is the result of both structural "highs" and stratigraphic traps.

The accumulation of oil in the Arbuckle dolomites and the Lansing group is due to structure. The structures have very small closure and trend north and south in Ranges 15 and 16 West in the eastern Pawnee County. Most of the pools are located on "plunging anticlinal folds".

The Garfield pool is a good example of a pool formed in a stratigraphic trap with very little structure associated with it. The Mississippian structural contour map (Fig. 5A in appendix) depicts the zero line of the Mississippian sedimentary rocks in Pawnee County.

Wells that are now abandoned with a show of oil may be made

into producers as new completion methods are discovered.



## ACKNOWLEDGMENTS

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## REFERENCES

- Barwick, J. S.  
Salina Basin of north-central Kansas, Am. Assoc. Petroleum Geologists Bull., Vol. 12, No. 2, 1928, pp. 77-199.
- Fishel, V. C.  
Ground-Water Resources of Pawnee Valley, Kansas, State Geol. Survey of Kansas, Bull. 94, 1952, 144 pp.
- Jewett, J. M.  
Geologic Structures in Kansas, State Geol. Survey of Kansas, Bull. 90, Part 6, 1951, pp. 105-177.
- Koester, E. A.  
Geology of the Central Kansas Uplift, Am. Assoc. Petroleum Geologists Bull., Vol. 19, No. 10, 1935, pp. 1405-1426.
- Latta, B. F.  
Cretaceous Stratigraphy of the Belvidere area, Kiowa County, Kansas, State Geol. Survey of Kansas, Bull. 64, Pt. 6, 1946, pp. 217-260.
- Lee, Wallace  
Subsurface Geologic Cross Section from Meade County to Smith County, Kansas, Oil and Gas Investigation No. 9, State Geol. Survey of Kansas, 1953.
- Maher, J. C., and Collins, J. B.  
Hugoton Embayment of Anadarko Basin in southwestern Kansas, southeastern Colorado, and Oklahoma panhandle, Am. Assoc. Petroleum Geologists Bull., Vol. 32, No. 5, 1948, pp. 813-819.
- McClellan, H. W.  
Subsurface Distribution of pre-Mississippian rocks of Kansas and Oklahoma, Am. Assoc. Petroleum Geologists Bull., Vol. 14, No. 12, 1930, pp. 1535-1556.
- McLaughlin, Thad G.  
Geology and Ground-Water Resources of Pawnee and Edwards Counties, Kansas, State Geol. Survey of Kansas, Bull. 80, 1949, 189 pp.
- Moore, Raymond C., and others  
The Kansas Rock Column, State Geol. Survey of Kansas, Bull. 89, 1951, 132 pp.
- Moore, R. C., and Jewett, J. M.  
Oil and Gas Fields of Kansas, Mines Mag., Vol. 32, No. 10, 1942, pp. 481-488.

- Morgan, L. C.  
Central Kansas Uplift, Am. Assoc. Petroleum Geologist Bull.,  
Vol. 16, No. 5, 1932, pp. 483-484.
- Ver Wiebe, Walter A.  
Mineral Resources Circular no. 10, Oil and Gas Resources  
of Western Kansas, State Geol. Survey of Kansas, 1938, 179 pp.
- Ver Wiebe, Walter A., and others  
Oil and Gas Developments in Kansas during 1947, State Geol.  
Survey of Kansas. Bull. 75, 1948, 230 pp.
- Ver Wiebe, Walter A., and others  
Oil and Gas Developments in Kansas during 1948, State Geol.  
Survey of Kansas, Bull. 78, 1949, 186 pp.
- Ver Wiebe, Walter A., and others  
Oil and Gas Developments in Kansas during 1949, State Geol.  
Survey of Kansas, Bull. 87, 1950, 176 pp.
- Ver Wiebe, Walter A., and others  
Oil and Gas Developments in Kansas during 1950, State Geol.  
Survey of Kansas Bull. 92, 1951, 187 pp.
- Ver Wiebe, Walter A., and others  
Oil and Gas Developments in Kansas during 1951, State Geol.  
Survey of Kansas, Bull. 97, 1952, 188 pp.
- Ver Wiebe, Walter A., and others  
Oil and Gas Developments in Kansas during 1953, State Geol.  
Survey of Kansas, Bull. 107, 1954, 204 pp.
- Ver Wiebe, Walter A., and others  
Oil and Gas Developments in Kansas during 1954, State Geol.  
Survey of Kansas, Bull 112, 1955, 215 pp.
- Wheeler, R. R.  
Anadarko Basin, Geology and Oil Possibilities, World Oil,  
Vol. 127, No. 4, 1947, pp. 38-42.

**APPENDIX**



Table 1. Production of Oil Pools in Pawnee County, Kansas.

Pool name and year of discovery	1954 produc- tion, bbls.	Cumulative production : to end 1954, bbls.	No. of produc- : ing wells	Producing zone
Ash Creek (1947)	No runs	240,495	1	Arbuckle
Ash Creek Southwest (1947)	4,478	107,321	1	Arbuckle
Benson (1945)	153,834	527,349	24	Lans-K.C.
Conkling (1953)	No report	none		Arbuckle
Dunes (1953)	75,292	125,185	8	Arbuckle
Evers (1951)	16,396	169,385		
	29,401		2	Penn. Congl.
	25,907		4	Simpson
Evers Northeast (1953)	3,240	6,626	3	Arbuckle
Garfield (1947)	157,641	165,453	2	Arbuckle
			43	Penn.-Miss. contact
				Kinderhook
Garfield Northeast (1954)	3,942	3,942		Mississippian
Garfield Southeast (1954)	No report	none	Unknown	Mississippian
Hearn (1953)	3,592	3,592	1	Misener
Jay (1954)	4,181	4,181	2	Lans-K.C.
Larned (1949)	548,917	945,175	55	Simpson
Lovett (1954)	1,650	1,650	1	Arbuckle
Oro (1953)	48,337	87,523	1	Lans-K.C.
Oro West (1953)	1,767	3,891	8	Penn. Congl.
Pawnee Rock (1936)	301,316	3,657,275	1	Penn. Congl.
Rutherford (1946)	16,900	282,935	60	Arbuckle
Ryan (1945)	29,166	513,844	6	Arbuckle
Ryan Southwest (1945)	14,265	316,750	8	Arbuckle
Shady (1948)	No runs	6,038	9	Arbuckle
Shady Southwest (1953)	24,989	26,047	2	Arbuckle
Shiley (1954)	28,591	28,591	3	Lans-K.C.
			5	Penn. Congl.

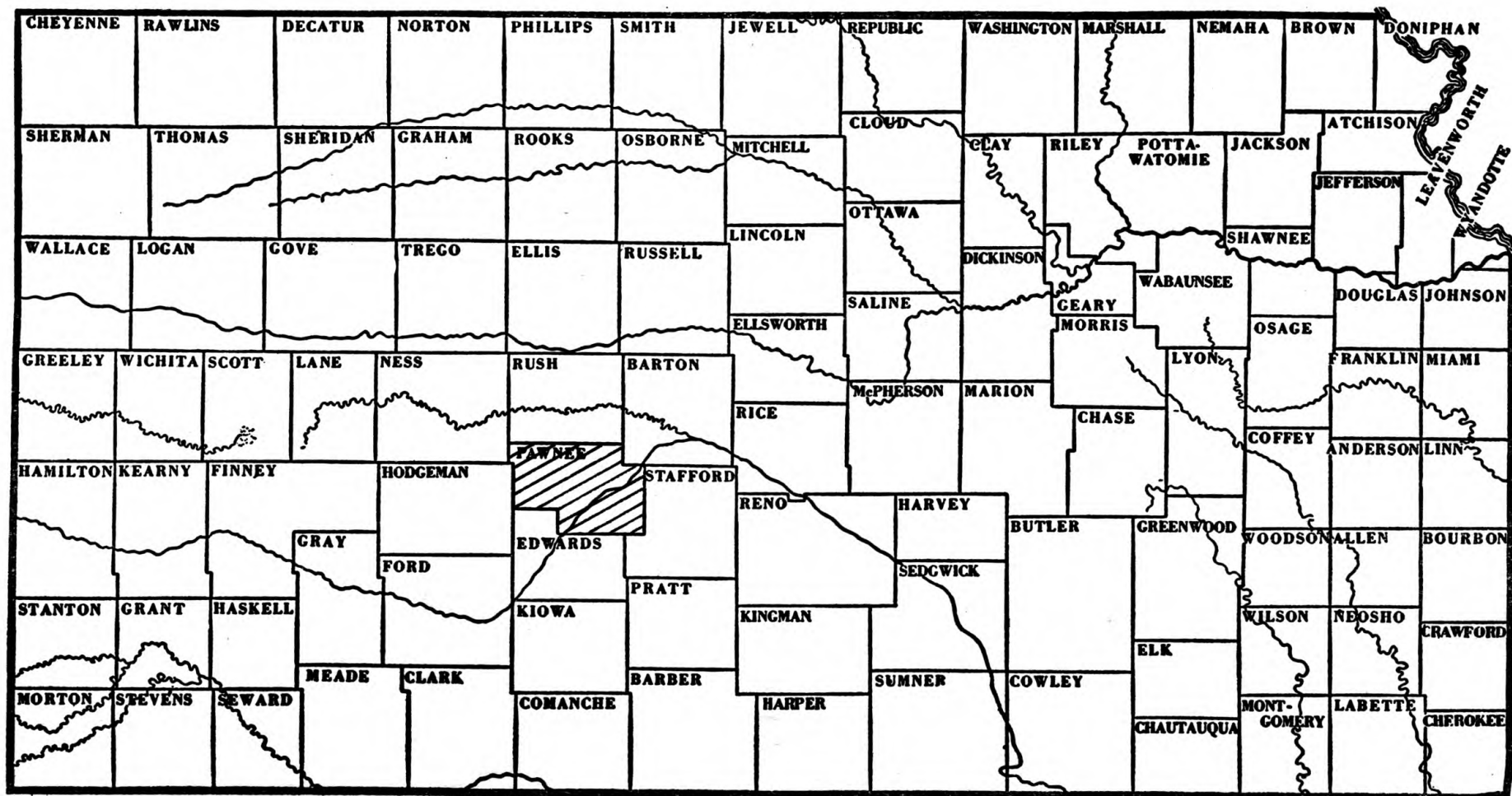


Table 1. (Continued).

Pool name and year of discovery	: 1954 produc- tion, bbls.	: Cumulative production : to end 1954, bbls.	: No. of produc- : ing wells	: Producing zone
Shiley East (1954)	3,021	3,021	2	Cherokee
Sweeney (1953)	6,772	6,772	6	Arbuckle
Sweeney West (1954) (Combined with Sweeney)				
Totals	1,512,658	7,255,325	262	

Table 2. Production of Gas Pools in Pawnee County, Kansas.

Pool name and year of discovery	: 1954 production : Million of Cu. Ft.	: Cumulative production : to end 1954, Millions : of Cu. Ft.	: No. of produc- : ing wells	: Producing : zone
Ash Creek (1948)	No report	No report		Arbuckle
Benson (1945) (includes Zook)	1,834,354	No report	15	Arbuckle
Evers (1951)	2,689	850,468	1	Arbuckle
Hearn (1953)	No report	none		Lans-K.C. Simpson
Jab (1954)	No report	none		Penn. Congl.
Larned (1954)	No report			Arbuckle
Pawnee Rock (1936)	1,578,000 est.		16	Arbuckle
Ryan (1954)	90,000 est.		2	Arbuckle
Shady (1945)	58,791	3,992,596	1	Arbuckle
Sweeney (1953)	370,896		4	Arbuckle
Sweeney Southwest (1953)		Combined with Sweeney		
Sweeney West (1954)		Combined with Sweeney		
Torrance (1947)		Combined with Sweeney		
Zook (1942)		Included with Benson		
Totals	3,934,660		39	



Area covered by this report

Fig. 1. Index map of Kansas showing location of Pawnee County.

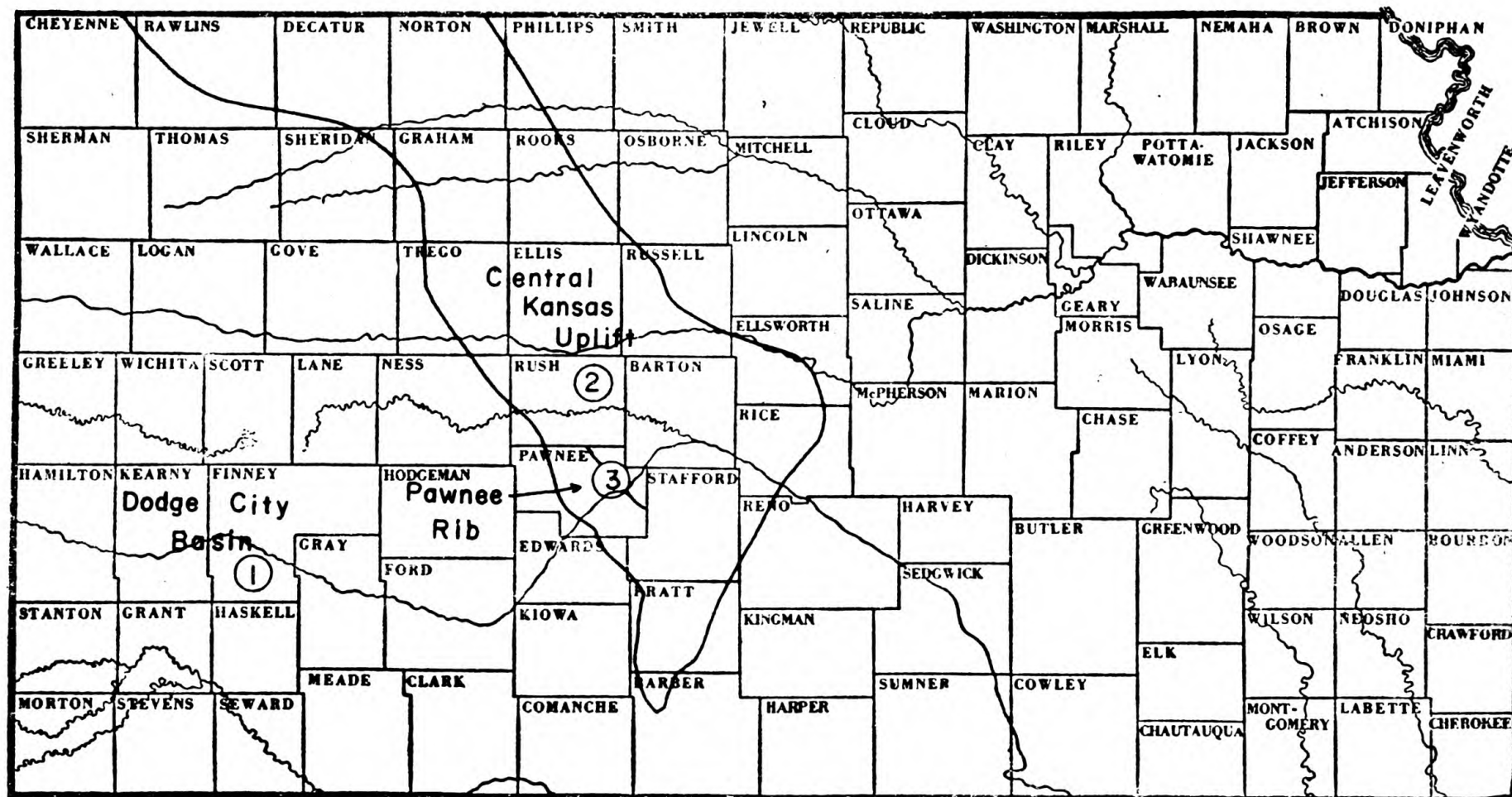


Fig. 2. Structural features covered by this report.

- ① Dodge City Basin
- ② Central Kansas Uplift
- ③ Pawnee Rib



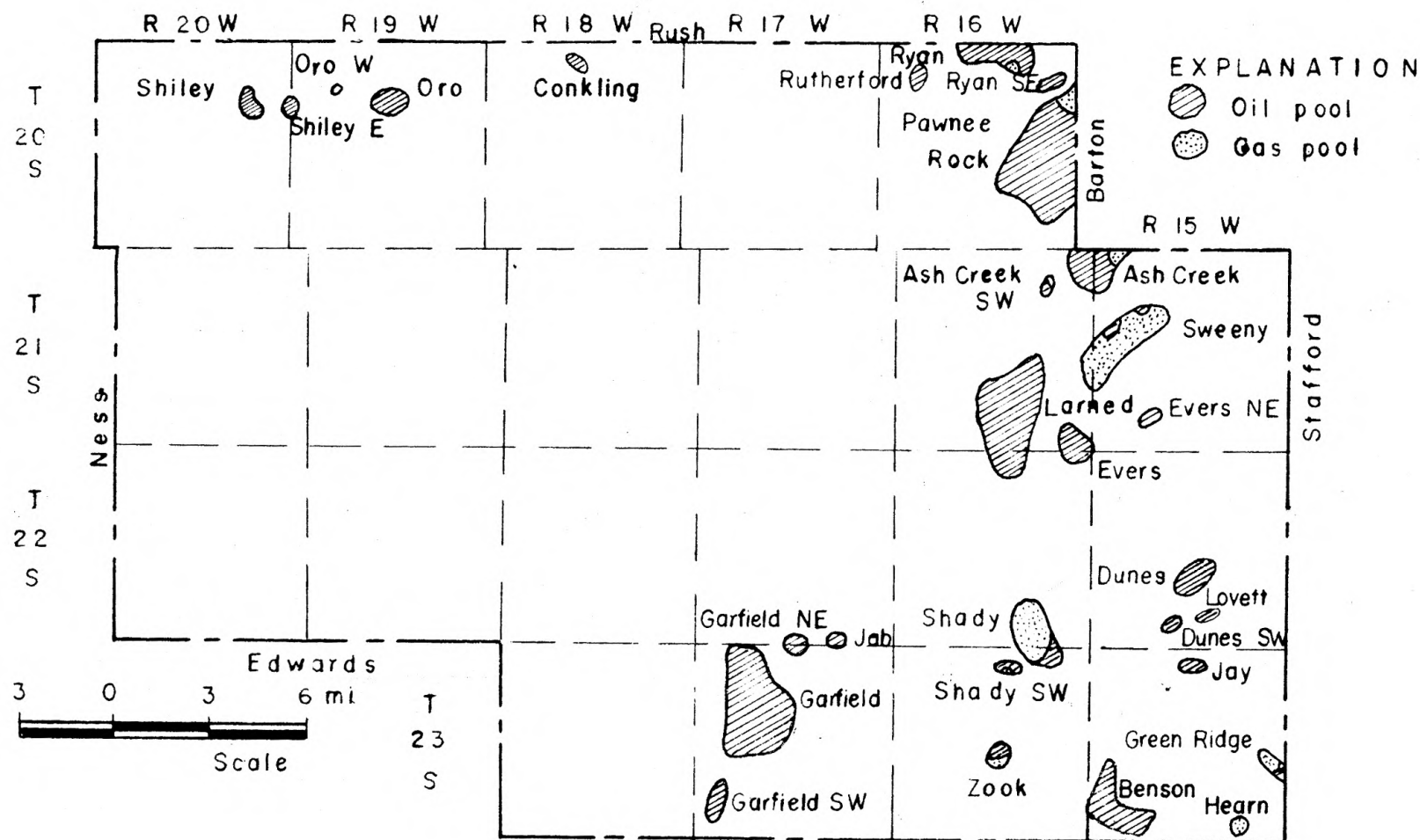


Fig. 3. Map of Pawnee County showing oil and gas pools.

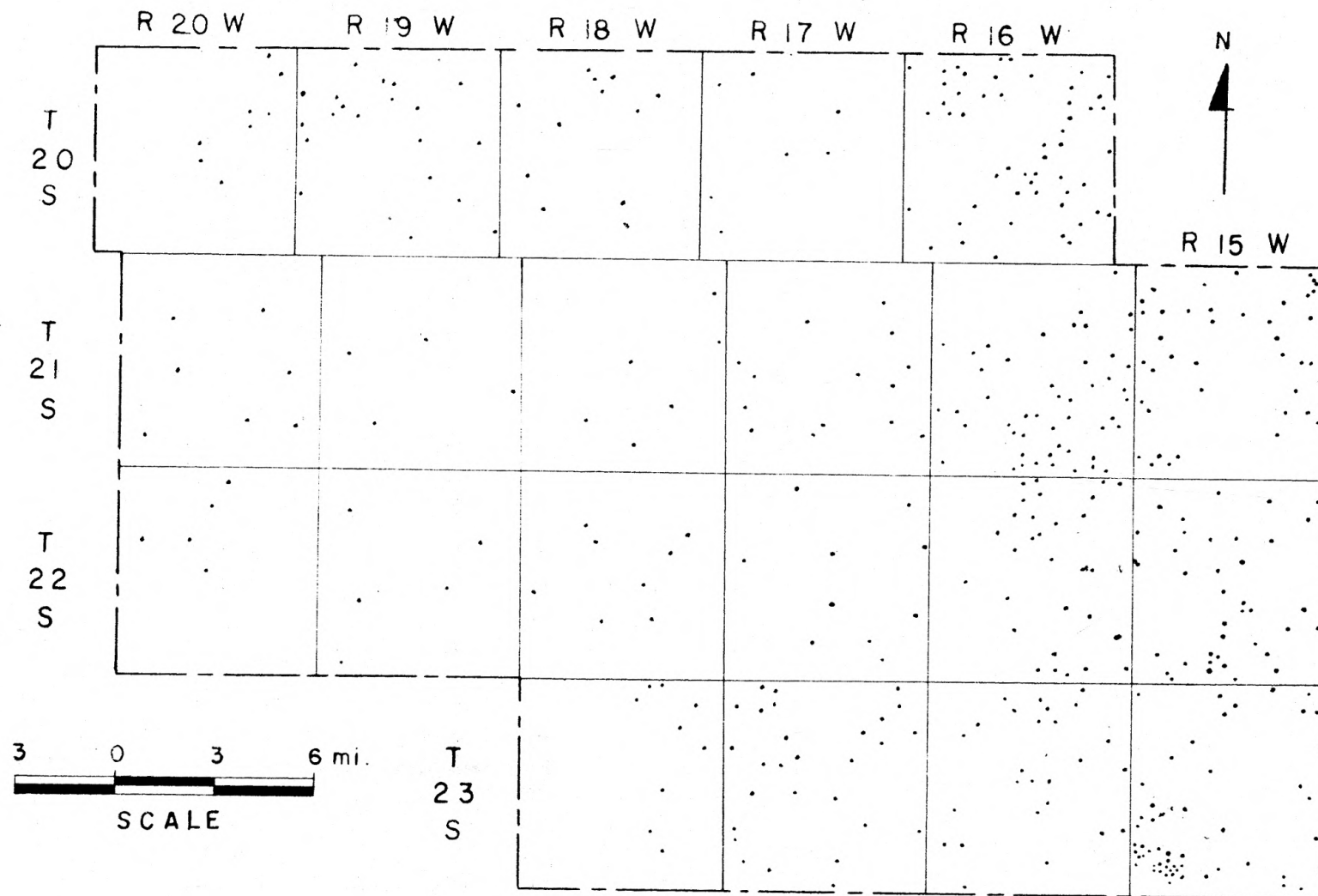
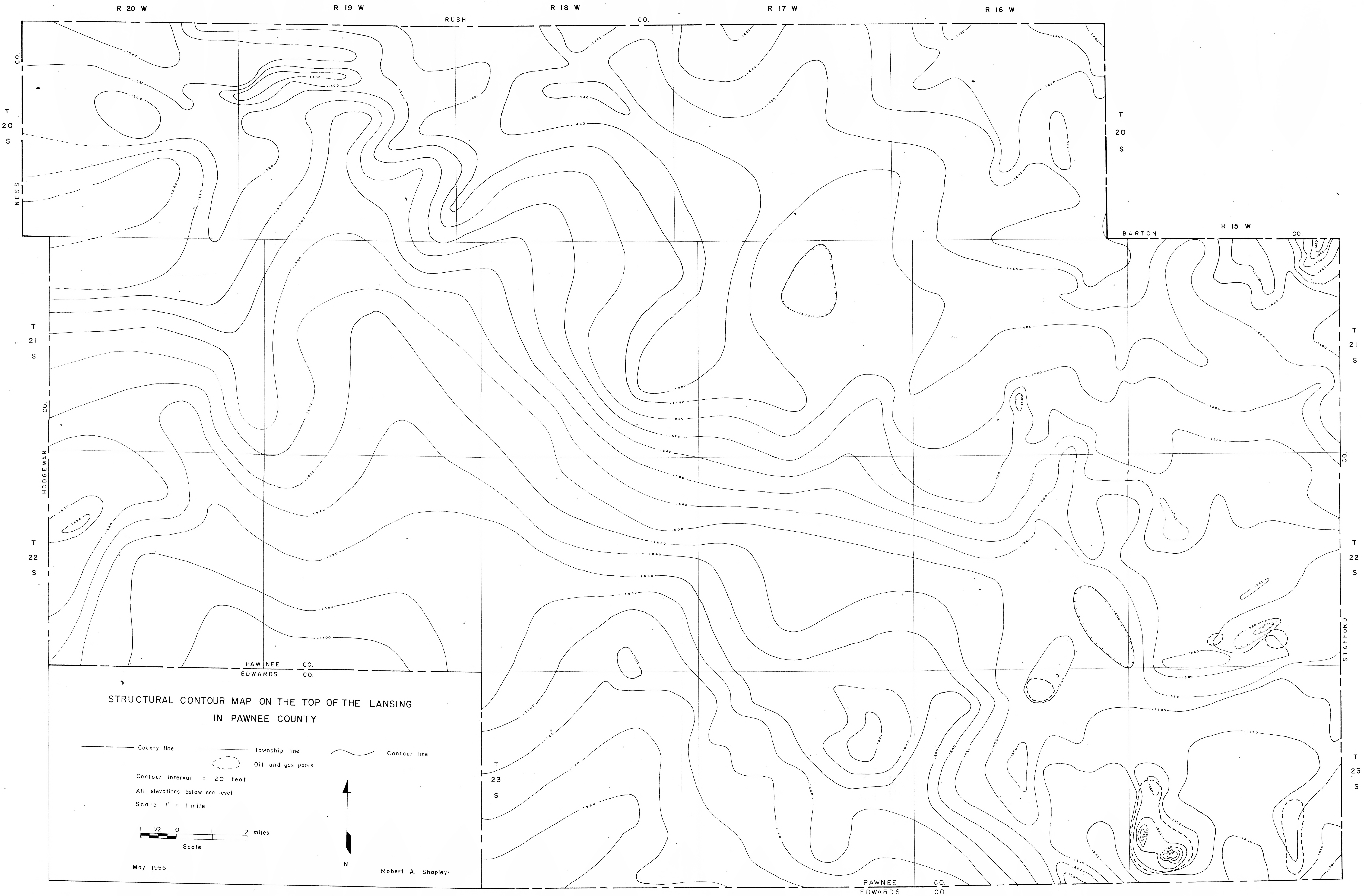


Fig. 4. Map of Pawnee County showing the location of wells used to construct the Lansing countour map.

Fig. 4A. Structural contour map on top of the Lansing in Pawnee County  
(in accompanying plate box)





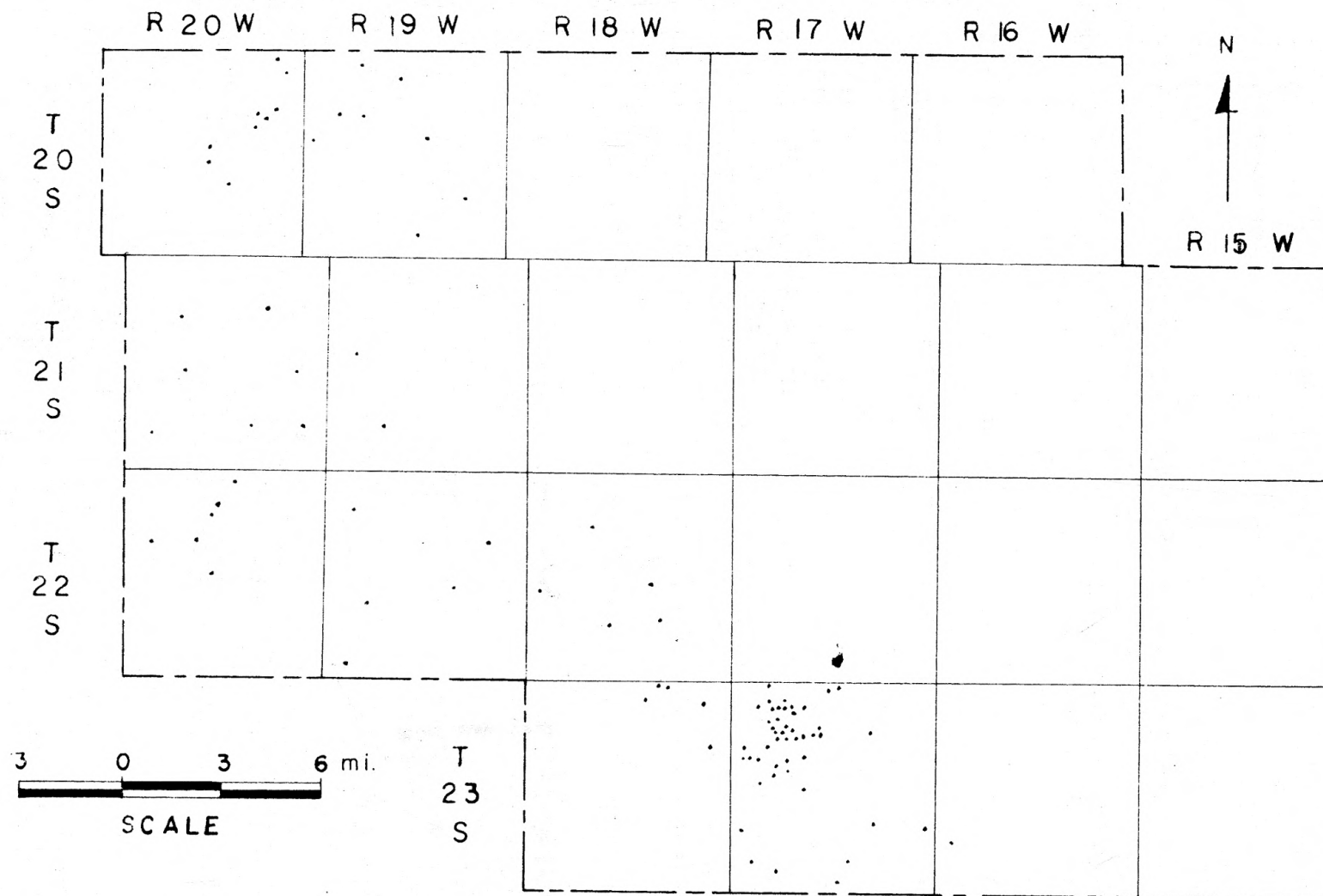
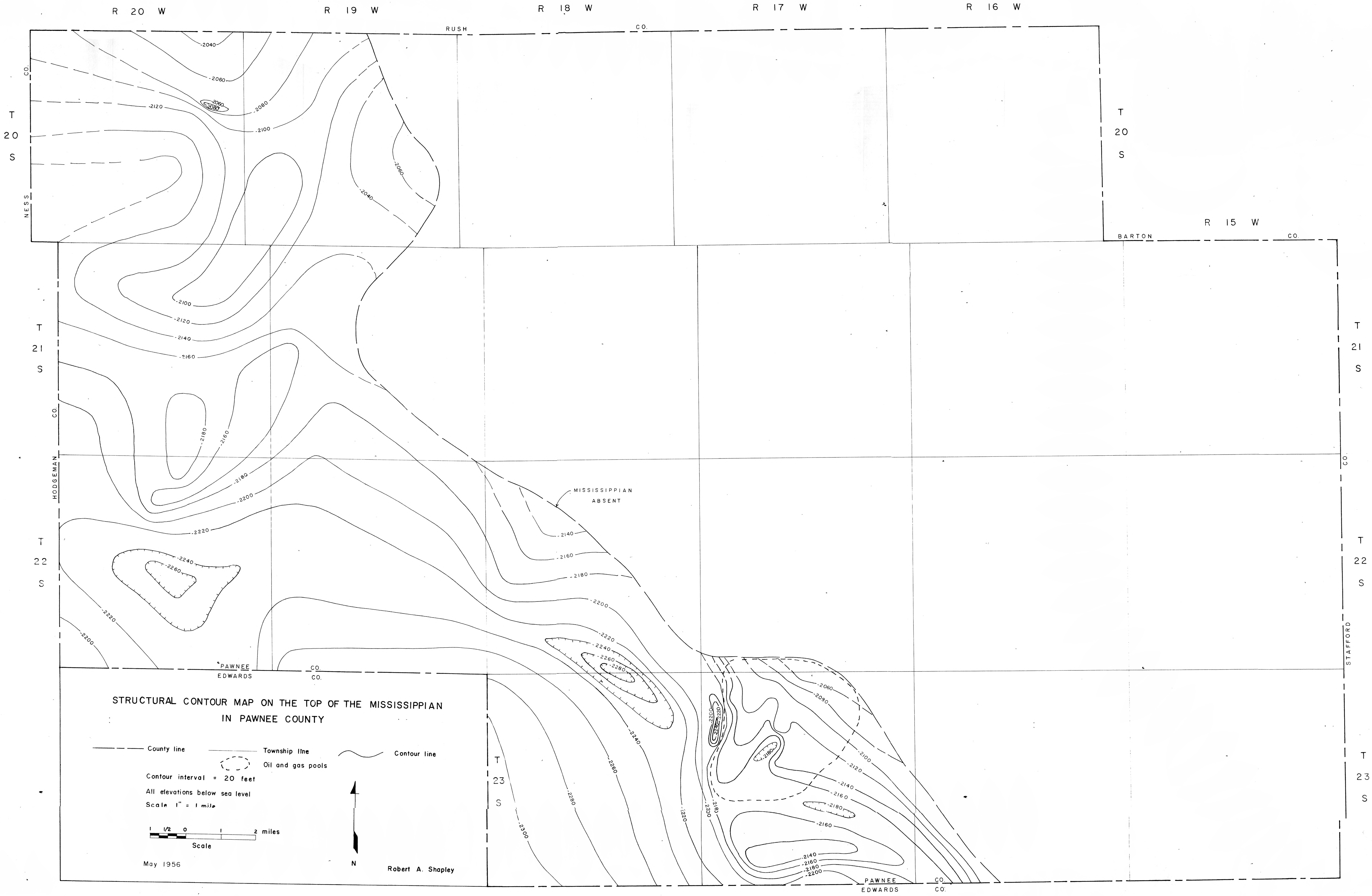


Fig. 5. Map of Pawnee County showing the location of wells used to construct the Mississippian contour map.

Fig. 5A. Structural contour map on top of the Mississippian in Pawnee County.  
(in accompanying plate box)



STRUCTURAL CONTOUR MAP ON THE TOP OF THE MISSISSIPPIAN  
IN PAWNEE COUNTY

County line      Township line      Contour line

Oil and gas pools

Contour interval = 20 feet

All elevations below sea level

Scale 1" = 1 mile

1 1/2 0 1 2 miles

Scale

May 1956

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Robert A. Shapley

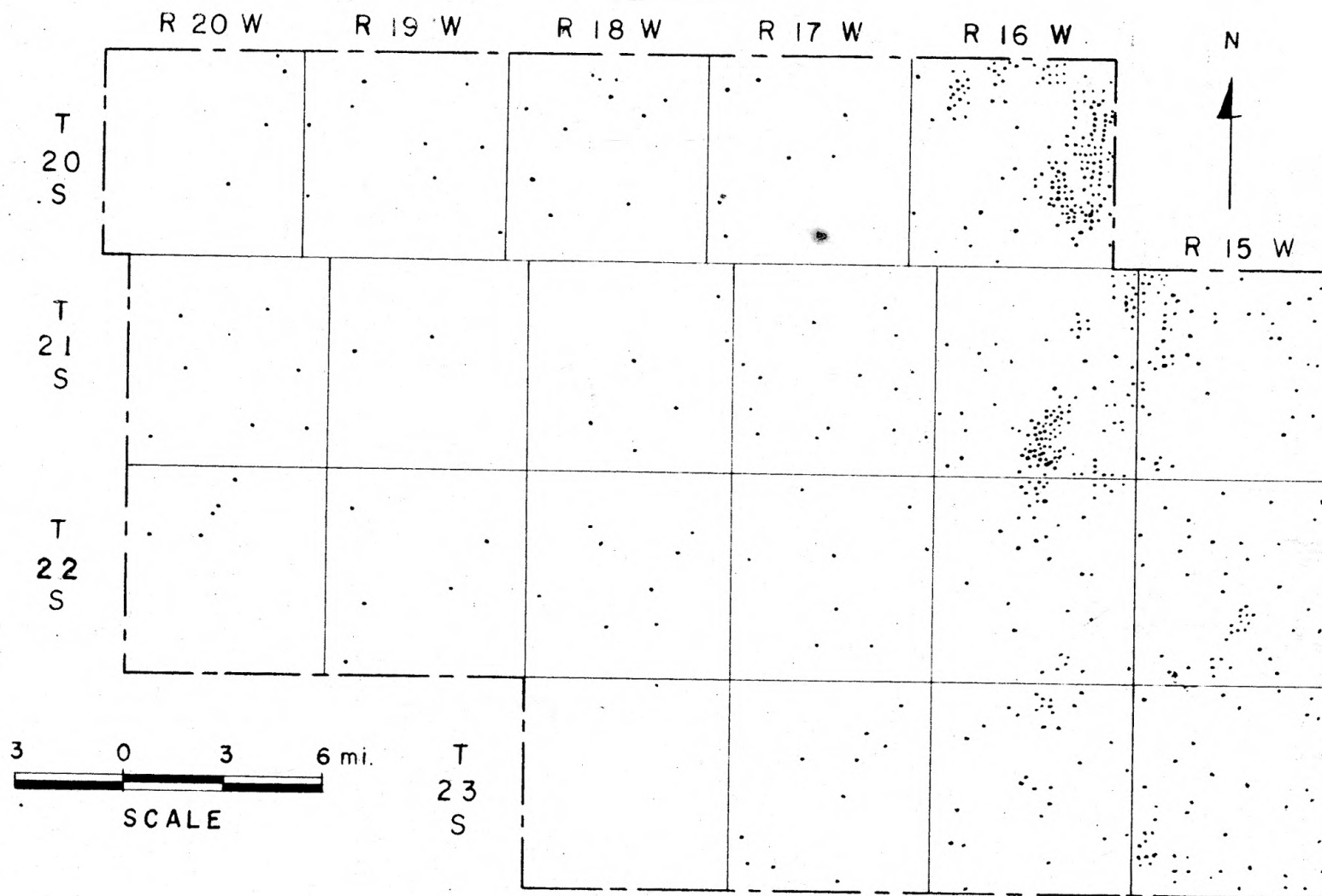
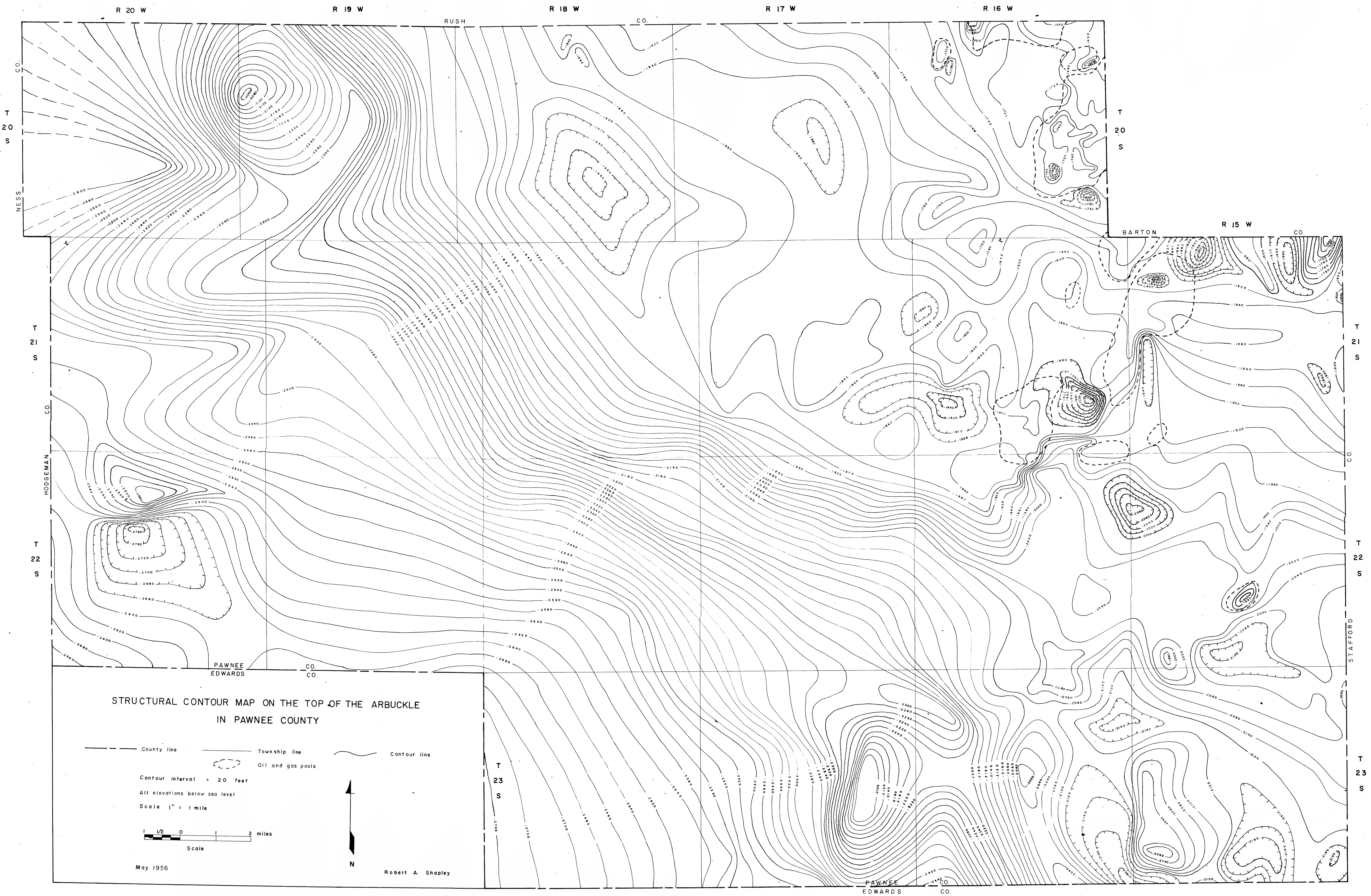


Fig. 6. Map of Pawnee County showing the location of wells used to construct the Arbuckle contour map.



Fig. 6A. Structural contour map on top of the Arbuckle in Pawnee County.  
(in accompanying plate box)





STRUCTURAL CONTOUR MAP ON THE TOP OF THE ARBUCKLE  
IN PAWNEE COUNTY

--- County line      --- Township line      --- Contour line

--- Oil and gas pools

Contour interval = 20 feet

All elevations below sea level

Scale 1" = 1 mile

1 1/2 0 2 miles

Scale

May 1956



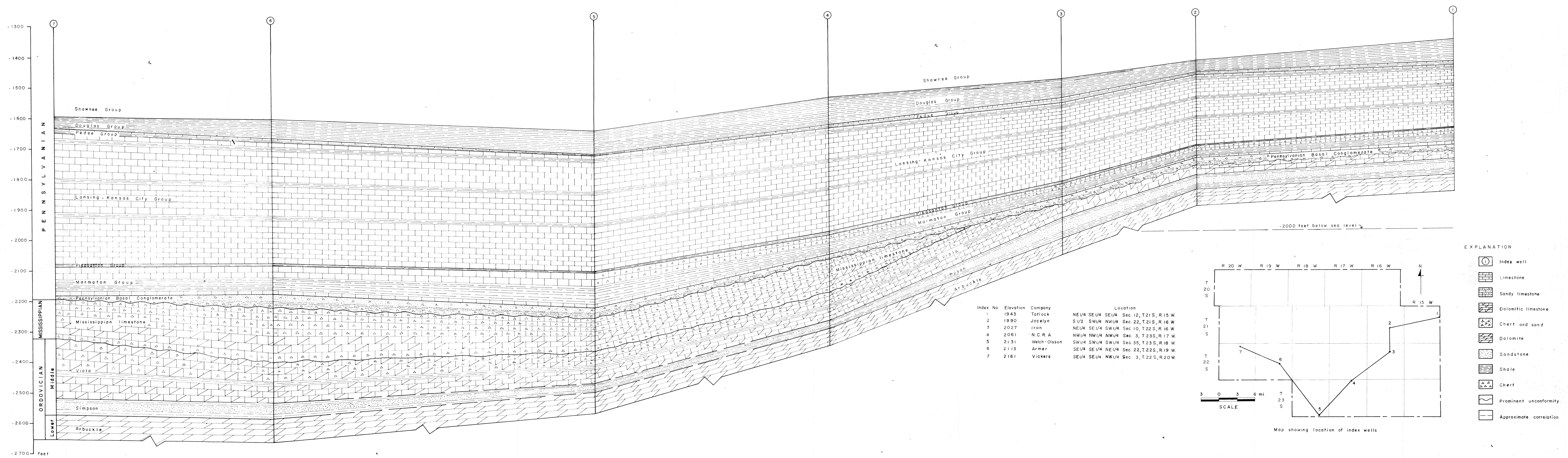
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Fig. 7. Stratigraphic cross-section of Pawnee County.

(in accompanying plate box)





STRATIGRAPHIC CROSS-SECTION OF PAWNEE COUNTY, KANSAS

By Robert A. Shapley - May 1956



THE SUBSURFACE STRUCTURE AND STRATIGRAPHY RELATED TO  
PETROLEUM ACCUMULATION IN PAWNEE COUNTY, KANSAS

by

ROBERT ALLEN SHAPLEY

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

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AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

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MASTER OF SCIENCE

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1956

This study is an analysis of the geological factors associated with the accumulation of petroleum in Pawnee County, Kansas. Pawnee County is located in west central Kansas. It is bordered on the west by Hodgeman and Ness Counties, on the north by Rush County, on the east by Barton and Stafford Counties and on the south by Edwards County. Pawnee County contains 21 Townships, comprising an area of about 756 square miles. The area is a part of the Great Plains province.

Three structural contour maps were prepared. These maps were contoured on the tops of the Arbuckle dolomite, the Mississippian limestones, and the Lansing group. A stratigraphic cross-section through Pawnee County was also prepared. The stratigraphic cross-section and the structural contour maps depict stratigraphic and structural conditions within the areas where petroleum accumulation occurs.

Three formations in Pawnee County have an accumulation of oil and gas. These formations are the Arbuckle dolomite, the Mississippian limestones, and the Lansing-Kansas City group. The Arbuckle dolomite is the greatest producer of the three. Minor oil accumulation occurs in the Pennsylvanian Basal Conglomerate, the Simpson group, and the Cherokee group.

Three structural features are delineated in Pawnee County. These structural features are as follows: (1) the Central Kansas uplift, (2) the Dodge City basin, and (3) the Pawnee Rib. The Central Kansas uplift is a high structural feature that covers the eastern one-half of the county. It was warped and truncated during several periods, the earliest of which dated back to

pre-Cambrian time. Warping has occurred chiefly in post-Algonkian (?), post-Canadian, post-Hunton, early Pennsylvanian, post-Missourian, and post-Cretaceous time.

The Dodge City basin is located in the western half of Pawnee County just off the flanks of the Central Kansas uplift. The rock formations in the Dodge City basin have a gentle dip to the west. The Garfield pool is located on the edge of the Dodge City basin and the flanks of the Central Kansas uplift. The term Pawnee Rib was introduced by Koester (1935) for a structurally "high" area in the northeastern part of the county. The Pawnee Rib is a structural "high" that occurs on the Central Kansas uplift. This structural "high" trends north and south in the eastern part of Pawnee County in Ranges 15 and 16 West. Most of the oil pools of Pawnee County are located on this structurally "high" area.

It was found that the Arbuckle structural contour map and the Lansing structural contour map reflect very similar structure, especially over the Central Kansas uplift. Most of the known pools of Pawnee County prior to 1954, were located on structures that were associated with the Central Kansas uplift.

The stratigraphic cross-section of Pawnee County, shows the Mississippian rocks as they "wedge-out" on the Central Kansas uplift.

The future for oil and gas production in Pawnee County is very good. Two sources of future production are as follows: (1) the structures on the Central Kansas uplift, and (2) the Mississippian limestones that "pinch-out" on the flanks of the Central

Kansas uplift. A very close study of the relationship of structure and stratigraphy will have to be made in order to find future structures and stratigraphic traps.

Production of petroleum has been on the increase in Pawnee County since 1948. Pawnee County produced 1,512,658 barrels of oil and 3,934,660 thousand cubic feet of gas during 1954.