# GEOLOGIC FACTORS OF THE GARFIELD FIELD AREA, PAWNEE COUNTY, KANSAS, IN RELATION TO PETROLEUM ACCUMULATION

by

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# INTRODUCTION

## Purpose of Investigation

The purpose of this investigation is the analysis of geologic factors associated with accumulation of petroleum in the Garfield Field Area, Pawnee County, Kansas.

## Physiography and Location of the Area

The Garfield Field is located in the vicinity of Garfield, Pawnee County, Kansas, 11 miles southwest of the City of Larned and 15 miles northeast of Kinsley (Plate 1).

The area of the field occupies 22 square miles and includes sections 31 through 36 of Township 22 South, Range 17 West and sections 1 through 10 and 15 through 20 of Township 23 South, Range 17 West.

The area lies in Central Kansas where the Arkansas River flows north in the "Great Bend", forming the Great Bend Lowland area of the Great Plains physiographic province (Plate I). The surface of the area is covered with alluvium and dune sand deposited during Pleistocene and Recent times.

The term "Great Bend Lowland" is applied to the immediate valley of the river. This "lowland" is not low with respect to the area surrounding it, but is a lowland only in the sense of being but little above the local base level of the Arkansas River, whereas streams in the surrounding area have carved deeper valleys (Fenneman, 1931). The river is not confined to a single channel but is characterized by a number of channels with

# EXPLANATION OF PLATE I

EXPLANATION

GREAT PLAINS PROVINCE

High Plains

Dissected High Plains

- Red Hills
- Smoky Hills
- Blue Hills

CENTRAL LOWLANDS

Arkansas River Lowland

- Great Bend Lowland
- Mc Pherson Lowland
- Wellington Lowland
- Finney Lowland

Dissected Till Plains

- Kansas Drift Plain
- Attenuated Drift Border

Osage Plains

- Cherokee Lowland
- Chautauqua Hills
- Osage Cuestas
- Flint Hills Upland

OZARK PLATEAU

- Springfield-Salem Plateau

Fig. 1. Map showing areal location of Garfield Field.

Fig. 2. Map showing physiographic provinces of Kansas in relation to area covered by this report.

PLATE I

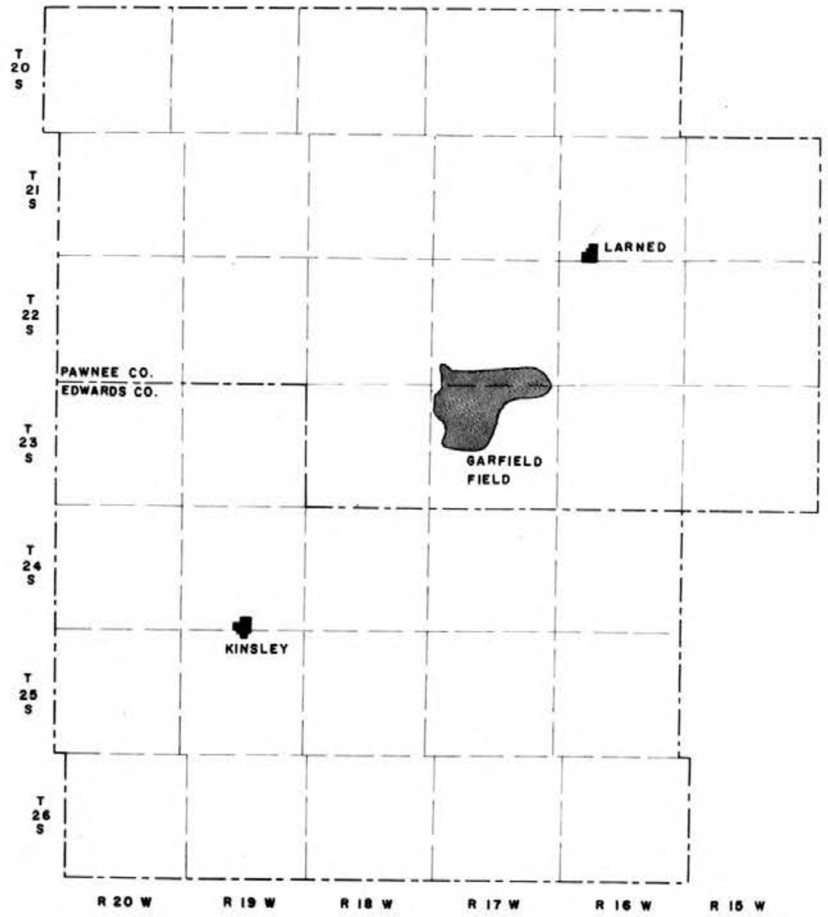



Fig. 1.

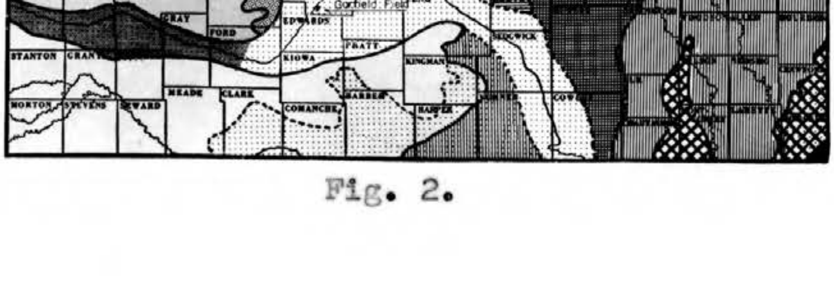



Fig. 2.

intervening islands, thereby producing a braided pattern indicative of an aggrading or depositing stream (Schoewe, 1949).

The Great Bend Lowland is from 1,060 to 2,200 feet above sea level and has a sub-humid climate. Abundance of subsurface water permits extensive practice of irrigation in the area. Agriculture and the production of oil and gas are the principal industries.

## Procedure

An appraisal of the extent of oil and gas reserves owned by Hilton Drilling Company, in Garfield Field, Pawnee County, Kansas, was completed May 1, 1955. Isopach maps of the "cherty conglomerate " (Pennsylvanian basal conglomerate), Mississippian and Misener sandstone net oil zones were constructed. These maps show total thickness of saturated zones within a formation at a given location. The datum were provided by Hilton Drilling Company for study and analysis.

Four subsurface structure maps, four isopach maps and two cross sections were constructed. These maps were compared with isopach maps of the net oil zones to determine geologic conditions within areas of petroleum accumulation.

Structural maps were drawn on the Pennsylvanian basal conglomerate, Mississippian limestones, Misener sandstone and Viola limestone. Isopach maps were constructed to determine thickness of the Pennsylvanian basal conglomerate, Mississippian limestones, Misener sandstone and combined reservoir rocks.

Two cross sections were constructed in a relatively straight line in order to avoid introduction of illusory structural features produced in a cross section that zigzags across an inclined surface. Cross section AA' is parallel with the regional dip of sedimentary rocks. Cross section BB' is approximately parallel to the axis of the Central Kansas Uplift and strike of sedimentary rocks.

The horizontal scale used on all maps is four inches equal one mile. The vertical scale on cross sections AA' and BB' is one inch equal 50 feet.

Two isopach maps, adapted from Dardenne (1956), showing location and accumulation of gas within the Garfield Field were constructed.

For the purpose of consistency, an acetate template was used to plot well locations. Well locations were obtained from Herndon maps and Kansas State Geological Survey scout cards.

## REVIEW OF LITERATURE

Numerous geological reports of areas in Central and Western Kansas were available to the writer. A report by Darton (1905) was one of the earliest publications describing the geology and underground water resources of the central great plains. Twenhofel (1920) described the geology of Comanchean and Dakota formations. McClellan (1930) described the distribution of pre-Mississippian rocks of Kansas. One of the first published geologic reports describing the stratigraphy of Pawnee County, Kansas, was by Ver Wiebe (1938). Lee (1940) submitted additional contributions to the description of subsurface Mississippian rocks.

Taylor (1946), Ver Wiebe (1947), Keroher and Kirby (1948), Lee, et al (1948), and Moore, et al (1951) contributed to the knowledge of regional stratigraphy in Central Kansas. Reports by McLaughlin (1949) and Fishel (1952) give the results of detailed investigations of the geology and ground-water resources of Pawnee and Edwards Counties and the Pawnee Valley. Fenneman (1931) and Schoewe (1949) described the physiography of the area. Recent publications are; descriptions of the producing zones of Kansas by Hilpman (1958), a description of the Precambrian rocks of Kansas by Farquhar (1957), and a subsurface correlation of Mesozoic rocks in Kansas by Merriam (1957).

A geological report by Darton (1918) described the structure of the central great plains. Barwick (1928) described the Salina Basin. The structural history of the Central Kansas Uplift was described by Morgan (1932). Koester (1935) summarized previous investigations and made additional contributions to the geology of the Central Kansas Uplift. Lee (1939) showed the relationship of thickness of Mississippian limestones in Central Kansas to oil and gas deposits. Walters (1946) described the structural history of buried Precambrian hills in northeastern Barton County, Kansas. Jewett (1951) presented a detailed study of structures in Kansas. The structural development of the Salina Basin area by Lee (1956) provided additional information of the geologic history.

Information relative to production in Garfield Field was obtained from Kansas Geological Survey bulletins. Garfield Engineering Committee reports described the Pennsylvanian basal conglomerate and initial fluid properties in the Garfield Field.

# STRATIGRAPHY

## Precambrian

The Precambrian rocks of Kansas are not exposed, but crystalline rocks of this age extend everywhere beneath later formations and are encountered by any well drilled to sufficient depth (Farquhar, 1957). The Precambrian rocks consist of granite and schists, and smaller quantities of igneous and metamorphic rocks such as slate, quartzite, marble and gneiss.

The Precambrian has not been encountered in the Garfield Field, however the nucleus of the Central Kansas Uplift and "ribs" or structurally higher parts of the Central Kansas Uplift are underlain by granite and quartzite (Dott, 1941).

Commercial quantities of oil are found in Precambrian arkose on the flanks of the Central Kansas Uplift. This is an exception and it is believed that oil was derived from geologically younger formations and has migrated into the arkose as a result of available pore space and structural conditions (Moore, 1940).

## Cambrian System

Rocks of Cambrian age have not been recognized in this area. Cambrian sediments were probably deposited in the Garfield Field Area but eroded away prior to deposition of the Roubidoux formation (Keroher and Kirby, 1948).

## Ordovician System

Lower Ordovician. The Arbuckle group lies unconformably below the Simpson group. The Arbuckle group consists of the Roubidoux dolomite and a basal Roubidoux sandstone in contact with the Precambrian surface, overlain by the Cotter and Jefferson City dolomites (Keroher and Kirby, 1948).

Ver Wiebe (1938) described the Arbuckle group in Pawnee county:

> The underlying Arbuckle is a dolomitic limestone of pale cream to pink in color. Its coarsely crystalline texture and the presence of oolitic chert make identification fairly definite.

A map showing structural contours on top of the Arbuckle group in Ellis, Russell, Barton, Rice and Ellsworth counties shows characteristics typical of karst topography. Ver Wiebe (1947) believes accumulation of oil in the Arbuckle group is related to its karst topography and not structure because high topographic features on the karst topography yield oil and low topographic features dry holes.

A structural contour map by Shapley (1956) indicates the Arbuckle group does not have characteristics typical of karst topography in the Garfield Field Area.

The Arbuckle is not a productive group in the Garfield Field, however wells in the Ryan and Pawnee Rock Fields encounter a thin oil zone with a thick gas cap in the Arbuckle dolomite (Cole and Koester, 1945).

In general, the Arbuckle may be expected to be rather thin in this area due to the proximity of the Central Kansas Uplift to the northeast (Ver Wiebe, 1939).

Middle Ordovician. The Simpson group lies conformably below the Viola and is represented by the St. Peter sandstone. The overlying Plattsville formation is absent because of post-St. Peter erosion.

The Simpson group consists of fine to medium, firmly cemented, subrounded sandstone and grades both laterally and vertically into a sandy shale and shale (Imbt, 1941).

The Simpson group is 50 to 80 feet thick and is not a reservoir for petroleum in the Garfield Field. Production from the Simpson group occurs in the Evers and Jay fields. The Evers and Jay fields are structurally up dip from the Garfield Field and between the Garfield Field and the Ryan and Pawnee Rock Fields where production is from the Arbuckle group.

The Viola limestone is a series of dolomites and cherty limestones. The thickness varies from a featheredge to 80 feet and probably represents only a portion of the original thickness because of pre-Chattanooga erosion (Ver Wiebe, 1938).

Late Ordovician. The Maquoketa (Sylvan) shale has been identified overlying the Viola limestone by Imbt (1941) in the Zenith Field to the southeast, but has not been recognized in the Garfield Field. Lee (1956) suggests the Maquoketa may become indistinguishable from the Viola because of increased proportions of carbonates in most of the western wells where Maquoketa is recognized.

## Silurian System

Rocks of Silurian age have not been encountered in the area. Silurian and Devonian rocks either were not deposited or deposited, then eroded prior to deposition of Misener sandstone (McLaughlin, 1949).

## Devonian System

The Misener sandstone, a member of the Chattanooga shale, overlies the Viola limestone in the southeast part of Garfield Field.

Lee (1956) describes the Chattanooga shale, often miscalled the "Kinderhook shale", in Pawnee and Edwards counties:

> The rocks between the Mississippian and the Viola differ from the Chattanooga shale in eastern Kansas areas. The rocks in these counties consist of greenish-gray and rusty-brown shale interstratified with sandy shale and streaks and beds of sandstone in the upper part as well as at the base. No black shale and no spores are reported. Dolomite, locally cherty, as much as 45 feet thick occurs in the middle of the formation in some wells on the flank of the Central Kansas Uplift.
>
> The lithology of these rocks is so strikingly different from the Chattanooga farther east as to suggest a Mississippian basal clastic deposit rather than Chattanooga . . . the Central Kansas Uplift had already begun before Mississippian time. The formations normally deposited . . . if they were ever present, were removed . . . During the hiatus it seems probable that the exposed surface was dissected. Loose debris, sand, shale, and, in protected areas, dolomite might accumulate as a Mississippian basal clastic . . . It is probable that these mixed clastics are a marginal facies of the Chattanooga or a local facies of the Boice shale . . .

The sequence between Mississippian limestones and Devonian limestones is characterized by many breaks in the neutron curve of radioactive logs, indicating porosity. The Misener is the lowest producing formation, stratigraphically, in the Garfield Field.

The Garfield Field is the only reported field in Pawnee county that has Misener production (Goebel, 1957). Misener production is also reported stratigraphically down dip from the Garfield Field in Embry and Kirk Fields, Edwards County, Kansas.

## Mississippian System

Kinderhookian Series. The Kinderhookian series is present in the southwestern part of the Garfield Field and is represented by the Gilmore City limestone. The Gilmore City limestone is a soft non-cherty, semigranular limestone, the lower part being oolitic (Lee, 1953).

Osagian Series. The Osagian Series is represented by the Reeds Spring formation, which consists of pink and white, non-cherty granular limestone at the top and varicolored agrillaceous limestone at the bottom (Lee, 1953). The Reeds Spring formation is unconformable on the underlying Kinderhookian Series or on older rocks.

The Osagian Series is sometimes called "Mississippian" or "Mississippian lime" by drillers (Koester, 1935).

The Keokuk and Burlington limestones were probably deposited, but later removed by post-Keokuk erosion and slight southerly tilting of the region (Moore, 1951).

Meremacean and Chesterian Series. Rocks of Meramecian and Chesterian age are absent in the Garfield Field. Moore (1951) believes Meramecian rocks may have originally extended throughout Kansas and later removed by pre-Pennsylvanian erosion.

## Pennsylvanian System

Morrowan and Atokan Series. The Pennsylvanian basal conglomerate rests on rocks of Mississippian age and represents the erosional remnant of rocks from the Cherokee group of the Pennsylvanian System to the Osagian Series of the Mississippian System.

A Garfield Field Engineering Committee Report (1956) describes the Pennsylvanian basal conglomerate, locally known as "cherty conglomerate" in the Garfield Field:

> The cherty conglomerate reservoir is of early Pennsylvanian age and is composed primarily of detrital materials with interfingering sand and shale lenses. The detrital material in the reservoir consists mostly of chert with some lime. The matrix within the detrital zones grades from sand to shale. The better productive areas in the reservoir are found where the matrix is composed of sand or predominantly sand. The reservoir exhibits a high degree of both vertical and horizontal fracturing throughout.

Desmoinesian Series. Above the Pennsylvanian basal conglomerate lies a shaly zone correlative with the Marmaton and possibly the Cherokee groups (Lee, 1953). The "shaly conglomerate" consists of a black shale overlying red and green shales. The lower part becomes increasingly cherty (Ver Wiebe, 1938). The "shale conglomerate" apparently provides an impermeable seal above the producing formations (Plate Box, Plate 15).

Missourian Series. The Pleasanton group, represented by a thin shale, lies disconformably on the underlying Marmaton group.

The Lansing and Kansas City groups constitute a sequence of deposits divided into dominantly white crystalline limestone formations with interbedded gray to dark gray shale (McGaha and Terry, 1952). The Lansing and Kansas City groups are sometimes called the "Oswald Lime". Because of the similarity of the two units, they cannot be easily distinguished as separate formations. It has become general practice to consider the interval as the Lansing-Kansas City zone. According to Lee (1956) subsurface correlation is further complicated by intercyclic erosion which has upset the orderly sequence of beds.

A cross section by Lee (1953) indicates the Kansas City group consists of the Bronson subgroup, the Linn subgroup and Zarah subgroup, and the Lansing group consists of the Plattsburg and Stanton limestones in ascending order.

The Pedee group, consisting of the Weston shale and the Iatan limestone member, overlies the Lansing group. The Iatan limestone, locally called the "Brown Lime", is brown in color with a very fine and dense texture and ranges between five and ten feet in thickness.

<u>Virgilian</u> <u>Series</u>. The Douglas group includes all strata above the Missourian-Virgilian unconformity and below the Oread limestone. The Douglas group consists of fine clastic, gray and red shales, and fine silty and calcareous sandstones (McGaha and Terry, 1952).

The Shawnee group, is a massive limestone section of white limestones with numerous shale horizons (McGaha and Terry, 1952). The Shawnee group contains the following formations in ascending order: Oread limestone, Kanwaka shale, Lecompton limestone, Tecumseh shale, Deer Creek limestone, Calhoun shale and Topeka limestone. The development of the uniformity of sequence and approximately constant thickness of Virgilian rock divisions are best expressed by the Shawnee and Wabaunsee groups (Moore, 1949). The Heebner shale, a member of the Oread limestone, is present throughout the area and provides an excellent lithologic marker.

The Wabunsee group includes all strata above the Topeka limestone and below the Pennsylvania-Permian contact. The Wabaunsee group consists of calcareous gray marine shale with interbedded white limestone. Much of the shale is sandy and grades laterally into sandstone beds (Moore, 1949). The thin limestone beds of this zone constitute a small part of the total thickness but radioactive logs reveal they are generally persistent throughout the subsurface.

## Permian System

Wolfcampian Series. The Admire group lies unconformably upon the Pennsylvanian and consists of an erratic sequence of thin impure limestones, red and gray shales and sandstones. The Admire group consists of the Houchin Creek limestone member, the Five Point limestone, the Falls City limestone, and Aspinwall limestone (Lee, 1953). Widespread post-Pennsylvanian erosion probably removed the Indian Cave sandstone.

The Council Grove group consists of predominantly limestone formations with intervening shales. The shales range in color from red to gray or varicolored (Lee, 1953). Thickness of the Council Grove group averages 300 feet.

The Chase group consists of gray dolomitic limestones with an occasional anhydrite streak and interbedded with numerous shale zones. The Florence Flint and Wreford formations are easily identified by the abundance of chert (McGaha and Terry, 1952).

Leonardian Series. The Sumner group consists of the Wellington formation, a predominantly gray shale associated with the Hutchinson salt member: The Ninnescah shale, a red shale containing impure limestone, and the Stone Corral dolomite, a variable sequence of evaporites and shales with locally interbedded dolomite (Lee, 1953). This is one of the most readily recognized "key beds" in the Kansas red bed section (Moore, 1951).

The Nipewalla group conformably overlies the Sumner group. The Nipewalla group consists of siltstones and very fine grained sandstones, with minor quantities of silty shale and gypsum. The predominant color is red. Formations present are the Harper sandstone, Salt Plain formation, Cedar Hills sandstone, Flowerpot shale, and Blaine formation. In well cuttings only the Blaine formations and Cedar Hills sandstone can be distinguished in the sequence of red silty shale and red sandstone that make up most of the Leonardian Series (Lee, 1953).

Guadalupian Series. The Quartermaster group consists of the lower part of the Whitehorse sandstone, a red and gray mottled sandstone, siltstone and silty shale, with an approximate thickness of 175 feet. The Day Creek dolomite and Tolga formation are missing.

## Triassic and Jurassic Systems

Triassic and Jurassic rocks are absent in the Garfield Field. During these periods of geologic time the area was being uplifted and eroded.

## Cretaceous System

Commanchean Series. The Cheyenne sandstone unconformably overlies the Whitehorse sandstone. The Cheyenne sandstone is a fine to medium-grained sandstone containing gray and gray-green shale and some siltstone (Fishel, 1952). Thickness of the formation averages 25 feet. The Cheyenne sandstone was deposited from exposed Permian rocks that were reworked by wave action of an eastwardly advancing sea (Lee, 1956).

The Kiowa shale overlies the Cheyenne sandstone and is a thinly laminated, dark calcareous shale, containing thin beds of sandstone, shell fragments and pyrite. A hard layer of shell limestone is encountered in the middle of the formation (Latta, 1948). Deposition of Kiowa shale represents a rapid change from non-marine to marine conditions as the sea advanced (Moore, 1951).

Gulfian Series. The Dakota formation is of continental origin and consists of buff, yellow brown, and brown sandstone, varicolored and sandy clay, shale and some lignite and charcoal. Iron minerals such as limonite, siderite and pyrite occur in minor amounts (Lee, 1953).

The Graneros shale is a dark gray to black fissle shale (McLaughlin, 1949).

The Greenhorn limestone consists of alternating beds of gray calcareous shale and thin limestones. The lower limestone beds are crystalline. The upper beds are chalky and not readily separated lithologically from the overlying Carlile shale (Lee, 1956). The top of the Greenhorn limestone is marked by the Fence-post limestone, a prominant bed of relatively hard chalky limestone (McLaughlin, 1949).

The Carlile shale conformably overlies the Greenhorn limestone and comprises the Fairport chalky shale below and Blue Hills shale above. The Fairport chalky shale member is a gray shale with thin limestone stringers. The Blue Hills shale member is a non-calcareous gray shale.

The Codell sandstone zone at the top of the Blue Hills shale member is a gray to brown, fine grained, silty and calcareous sandstone (Lee, 1954).

### Tertiary Period

Pliocene Series. The Ogallala formation consists of sand, silt and gravel containing caliche (Fishel, 1952).

### Quaternary System

Pleistocene Series. The Meade formation consists predominantly of coarse sand and gravel containing beds of fine sand, silt and clay. In places, the sand and gravel is cemented with calcium carbonate, forming hard ledges known as "mortar beds", but the beds are generally poorly cemented (McLaughlin, 1949). The Meade is the most important water bearing formation in the area.

In the immediate vicinity of Garfield, the Meade formation consists of the Grand Island overlain by the Sappa member.

Overlying the Meade formation are terrace deposits of Wisconsin age. These deposits consist of light tan to brown clay and silt containing some caliche interbedded with fine to coarse sand and some gravel (McLaughlin, 1949).

Pleistocene and Recent Series. Overlying the Wisconsin deposits are the Peoria silt member and dune sand. Alluvium deposits of the Arkansas valley consist of sand, gravel, silt and clay. Thickness of the alluvium is irregular because of deposition in channels cut into Cretaceous, Tertiary, and Pleistocene sediments.

Recent Series. The Garfield Field Area is overlain by dune sand, consisting of uniform-grained, well rounded fragments of quartz and some silt and clay.

The dune sands consist of two phases: (1) the eolian or wind-blown phase during the time the dune is being built up, and (2) an eluvial or inactive phase where vegetation has prevented further weathering (Smith, 1940).

Thickness of the dune sand is variable and ranges from 0 to 50 feet. Dune sands are above the water table and yield no water (McLaughlin, 1949).

## GEOLOGIC HISTORY

### Precambrian History

Little is known about Precambrian geological history. Precambrian rocks are not exposed in Kansas, however wells have encountered Precambrian in about 75 percent of the Kansas counties at depths from 588 feet above sea level to 5,500 feet below sea level (Farquhar, 1957).

Enumerating the vertical movements experienced by a small area in northeastern Barton county, Walters (1946) refers to the Precambrian surface as "a peneplain eroded across a varied terrane of igneous and metamorphic rocks".

It is believed that intrusion by granitic igneous rocks caused metamorphism of the gneiss, schists and quartzites (Walters, 1946).

A long period of erosion resulted in an extensive peneplaned area during late Precambrian. Areas of resistant quartzite were left as low residual monadnocks rising above the average ground surface.

## Paleozoic Era

During the Waucoban and Albertan epochs the Garfield Field Area was relatively high and erosion continued. A gradual inundation of the area surrounding Garfield Field began during St. Croixan until the area was covered by a wide shallow sea. The surrounding area remained submerged until early Ordovician. The Regan (Lamotte) sand of upper Cambrian age is found in eastern Pawnee county but is not present in the Garfield Field Area (Shapley, 1956). The Garfield Field Area may have been a topographic high during early St. Croixan time, similar to the buried Precambrian hills in northeastern Barton county described by Walters (1946). The relatively thin section of Roubidoux underlain by Precambrian rocks support this assumption (Keroher and Kirby, 1948). The Central Kansas Uplift was not a structural feature (Lee, 1956).

During lower Ordovician the Garfield area was buried by transgressing seas, depositing the Roubidoux formation and the Jefferson City-Cotter dolomite sequence. The seas retreated from the Central Kansas area during the post-Beekmantown crustal movement. At this time the region was tilted along a line parallel to the northern margin of Kansas. The Jefferson City and Cotter dolomites and part of the Roubidoux deposits were eroded away.

At this time the area comprising the North Kansas Basin began a long period of differential subsidence. The Ozark Dome region of Missouri rose and the Chautauqua Arch and Central Kansas Uplift began their upward movement.

Encroaching seas from the south deposited beds equivalent to the upper part of the Simpson of Oklahoma on an Arbuckle surface of only minor topographic relief.

The Platteville formation was probably deposited but removed by post-Plattsville erosion, due to the fact outliers of residual Viola beds occur on the Central Kansas Uplift (Taylor, 1947).

Muddy upper Ordovician seas left shale deposits south of the Garfield Field Area. The Sylvan (Maquoketa) shale does not appear in the Garfield Field Area.

After deposition of Viola limestone the area was positive and rising. The area was either too high to receive sediments between Viola and late Devonian or the formations were deposited, raised and eroded.

Low arching of the Central Kansas Uplift had begun by late Devonian (Lee, 1956). During this erosional period, exposed formations were weathered. Loose debris accumulated as a Mississippian basal clastic.

Deposition of Siluro-Devonian (Hunton) strata may have covered the Garfield area, but were removed by Hunton, Pre-Kinderhook erosion.

The Misener sandstone member of the Chattanooga shale occurs in the southwestern part of the Garfield area. Taylor (1946) stated:

> . . . . . because of the thinness, fine grained texture, irregular distribution and superposition on various formations, above which is a black or gray shale, a long pre-chattanooga erosion interval during which near-by land was near base level occurred.

Beginning in late Devonian, extensive pre-Mississippian erosion truncated the Silurian and Devonian.

The Compton limestone and Sedalia dolomite were probably deposited but later removed by pre-Gilmore City deformation and erosion along the Nemaha Ridge and Central Kansas Uplift.

The Gilmore City limestone is found northeast and southwest of the Central Kansas Uplift in the Kansas subsurface. Lee (1940) suggested the Gilmore City limestone may have been deposited in an erosional basin because they are thick where they overlie the Chattanooga shale and thin where they overlie the Sedalia dolomite or Compton limestone. This Kinderhookian basin centered in Iowa and extended in a northeast-southwest direction across Kansas and Nebraska.

During the early part of Osagian, movements along the trend of the Nemaha anticline and slight elevation of the Central Kansas Uplift restricted the distribution of the Reeds Spring formation and St. Joe limestone to southeastern Kansas. Regional tilting toward the south during Osage time, created a south trending drainage. Kansas was the north part of an erosional basin in Oklahoma by the end of Osagian.

Rocks representing the Spergen and St. Louis limestones have been identified east of the Nemaha Ridge. Lee (1940) believes Meramecian rocks could have been deposited across the Central Kansas Uplift and subsequently eroded during pre-Pennsylvanian base leveling.

The peneplaned surface that resulted from erosion of warped and folded Mississippian rocks was subjected to renewed folding before Pennsylvanian seas reached Kansas. The folding followed the same pattern as folding at the end of Mississippian time (Lee, 1956).

Cherokee sediments are found west of the Garfield Area. A portion of the Pennsylvanian basal conglomerate may be Cherokee.

As the seas continued to advance, the Marmaton was deposited upon the eroded surface. The Marmaton sequence represents a progression from non-marine to marine deposition associated with oscillating seas (Moore, 1949). Upper Marmaton formations were removed by pre-Mississippian erosion.

Rocks of the Pleasanton group are missing in this area. During early Missourian time, Pleasanton deposits were formed from a encroaching sea from the west or southwest. The Garfield Field Area was probably an open sea where little deposition occurred. The Central Kansas Uplift continued to develop and in Hertha time a considerable part of its area was land (Lee, 1948). The Kansas City and Lansing groups were deposited in sequence above the Pleasanton group with only cyclical interruption.

Absence of the Weston shale of the Pedee group represents an probable recession of the seas prior to deposition of the Iatan limestone.

The hiatus that separated Missourian and Virgillian rocks was accompanied by low regional warping and regional subsidence toward the southeast (Lee, 1956). Seas advanced prior to deposition of the Virgilian Series. Arching of the Central Kansas Uplift had nearly ceased (Lee, 1948).

Uniformity of sequence and thickness of Virgilian rocks are well developed. Alternation of limestones and shale in vertical succession are a result of cyclic sedimentation.

Younger formations above the Dover limestone are probably absent (Lee, 1953). Narrow folding and some faulting again occurred during late Pennsylvanian and early Permian.

In Permian time a succession of seas covered Central Kansas and extended south and westward into Oklahoma, Texas and New Mexico (Taft, 1946).

The Wolfcampian sequence of Permian System represents cyclic sedimentation and is similar to upper Pennsylvanian rocks. The Permian sea in Kansas was cut off from the south by Permian mountains in present southern Oklahoma and Texas panhandle (Taft, 1946). Deposition of anhydrite, gypsum and salt beds occurred. The Hutchinson salt member of the Wellington shale formation is probably a result of restriction of marine circulation and an arid climate. A small advance of the sea or a short period of free circulation resulted in deposition of the Stone Corral dolomite (Hills, 1942). During deposition of the Salt Plain formation the land was probably low, covered with a brackish sea.

The Cedar Hills sandstone is believed to be the northern extension of Duncan and Chickasha sands and shales of Oklahoma. The Wichita and Ouachita ranges were being uplifted (Hills, 1942).

During lower Blaine rapidly advancing seas occurred. In late Permian there was general emergence that produced shallow basins and broad mud flats where red beds were deposited.

## Mesozoic Era

A major unconformity marks the base of Cretaceous rocks. During Triassic and Juriassic periods a broad syncline developed in southwestern Kansas and the area was raised above the surface of the sea (Lee, 1948).

The Cheyenne sandstone was deposited on eroded pre-Cretaceous rocks by an oscillating sea approaching from the south. The Cheyenne sandstone is believed to be either shallow sea or stream deposition. As the sea advanced, a marine environment developed, and deposition of Kiowa shale occurred. According to Twenhofel (1920), the Cheyenne and Kiowa were deposited during one general transgression of the sea, and the Dakota merely represents a halt in that advance rather than a complete retreat of the sea.

Following deposition of the Dakota formation, marine deposition of shale and limestone comprising the Gulfian series occurred. Part of the Niobrara formation and Pierre shale were probably deposited. Post-Dakota deformation tilted the syncline in Western Kansas toward the north and shifted the lowest part of the structural basin toward the east. During this time

Cretaceous deposits lying above the Blue Hill shale were probably eroded away. Merriam (1957) believes deposition of Blue Hill shale occurred at a time of shallow water and probably far from highlands because of absence of coarse clastic particles.

## Cenozoic Era

A considerable time interval elapsed from the end of Blue Hill deposition until deposition of the upper Tertiary Ogallala formation.

At the close of pre-Ogallala time, a widespread erosion surface extended from the Rocky Mountain front to Central Kansas. Smith (1940) described the Ogallala as a warped and dissected piedmont alluvial plain deposit. According to Smith (1940), the Ogallala should not be regarded as a fan deposit because its thickness increases away from the mountain front. Deposition of the Ogallala formation began with the change from stream degradation to stream aggradation.

The Pleistocene history has been complicated by a series of drainage changes that have resulted in abandoned and filled valleys of several ages (Frye, 1951). During Pleistocene through flowing streams from the Rocky Mountain area migrated northeastward, depositing gravel, sand and silt over Cretaceous bedrock. Some of the material may also be Pleistocene terrace deposits.

Existing surface features are the result of late Pleistocene and Recent deposition of alluvium and dune sand.

## STRUCTURE

### Major Pre-Mississippian Regional Structures

Ellis Arch. The Ellis Arch, (Fig. 1), considered to have been a part of the ancestral Barton Arch, was named by Moore and Jewett (1942) as being "southwest of the North Kansas Basin, in the region now defined as belonging to the Central Kansas Uplift". The Ellis Arch was called the Ancestral Kansas Uplift by Lee, et al. (1948).

During pre-Mississippian time the Ellis Arch extended eastward from Kansas to the Ozark dome as the Chautauqua Arch. This structure comprised part of the transcontinental arch of the central stable region that extended into Kansas and Missouri. These two pre-Mississippian structures separated the North Kansas Basin from the Southwest Kansas Basin. Local folds that developed were parallel with the major axis of the pre-Mississippian Ellis Arch trend which cut obliquely across the core of the post-Mississippian Central Kansas Uplift (Eardley, 1951).

North Kansas Basin. The North Kansas Basin, formed by post-St. Peter, pre-Mississippian subsidence of the Southeast Nebraska Arch, is north of the Chautauqua Arch and north and east of the Ellis Arch (Fig. 1). Before development of the Nemaha Uplift and other post-Mississippian major structural elements, the basin was regarded as one of the major structures that shaped the framework of Kansas (Jewett, 1951). The basin was named by Rich (1933).

Southwest Kansas Basin. The Southwest Kansas Basin, (Fig. 1) designated by Moore and Jewett (1942), was separated from the

North Kansas Basin by the Ellis-Chautauqua Arch (Jewett, 1951).

Chautauqua Arch. Barwick (1928) described the Chautauqua Arch (Fig. 1) as . . . "a name for the pre-Mississippian extension of the Ozark Uplift along the Kansas-Oklahoma line".

Minor Pre-Mississippian Regional Structures

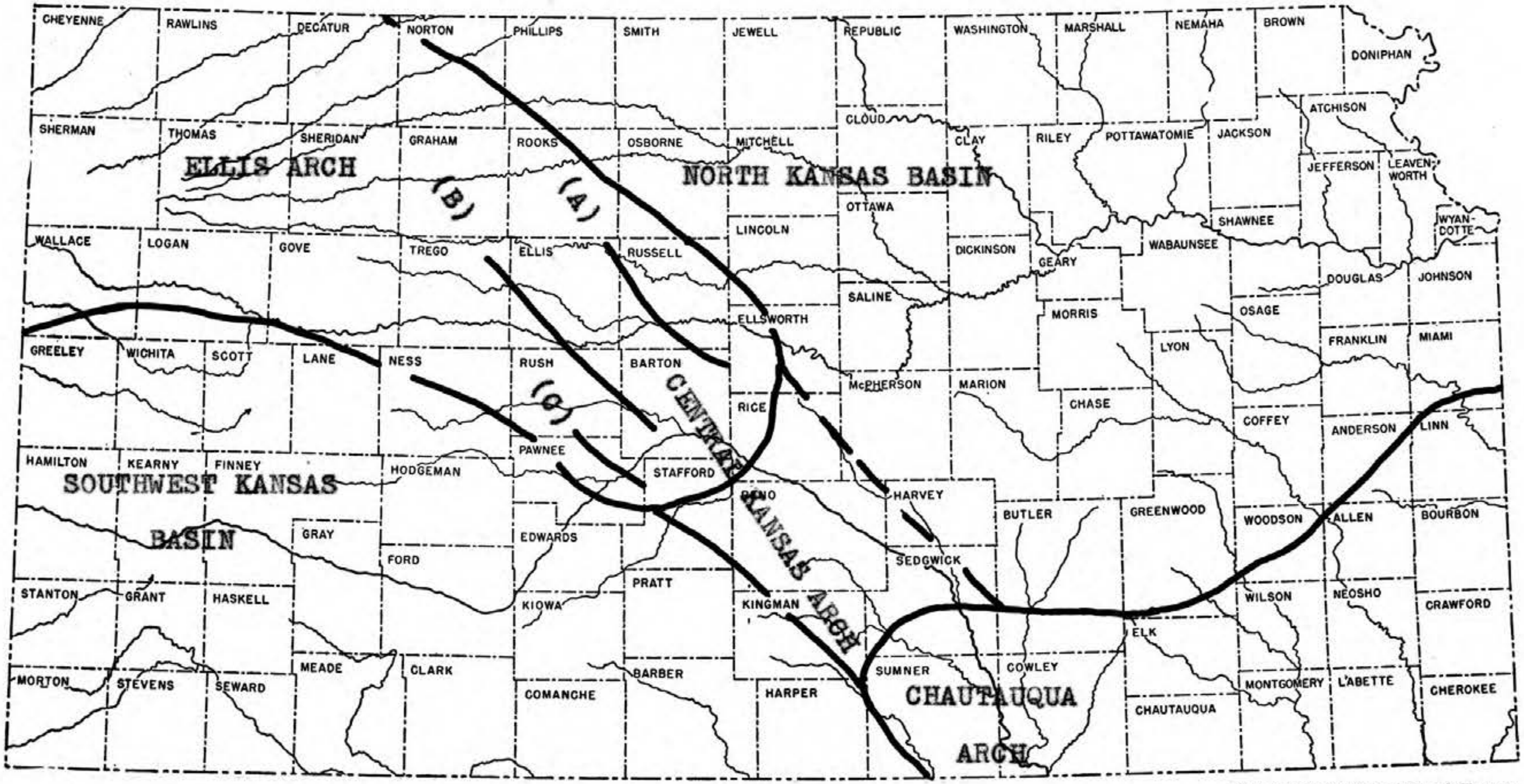
Russel Rib. The Russel Rib (Fig. 1) is a structural "high" reflected in pre-Ordovician and Ordovician rocks, as well as being a topographic monadnock (Koester, 1935). Moore and Jewett (1942) regarded the Russel Rib as part of the Ellis Arch. The Russel Rib extends from southwestern ellsworth county, across southern Russel county, thence northwestward across part of western Ellis county into Rooks county (Jewett, 1951).

Rush Rib. The Rush Rib is a term first used by Koester (1935) for a structural "high" reflected in Ordovician and older rocks trending northwest-southeast through parts of Graham, Trego, Ellis, Rush, Barton and Stafford counties (Jewett, 1951). The Rush Rib, (Fig. 1) as outlined by structure contour maps of the Precambrian surface, is probably a horst structure with both sides upfaulted parallel to the axis of the Central Kansas Uplift (Farquhar, 1957).

Pawnee Rib. Koester (1935) described the Pawnee Rib (Fig. 1):

> . . . the broad area in Pawnee County in which the 'siliceous lime' underlies the Pennsylvanian represents a third rib running approximatel parallel with the other two.

Jewett (1951) states the Pawnee Rib may be regarded as part of the Ellis Arch.




*State Geological Survey of Kansas*

Explanation: (A) Russell Rib (B) Rush Rib (C) Pawnee Rib

Fig. 1. Pre-Mississippian Regional Structures.

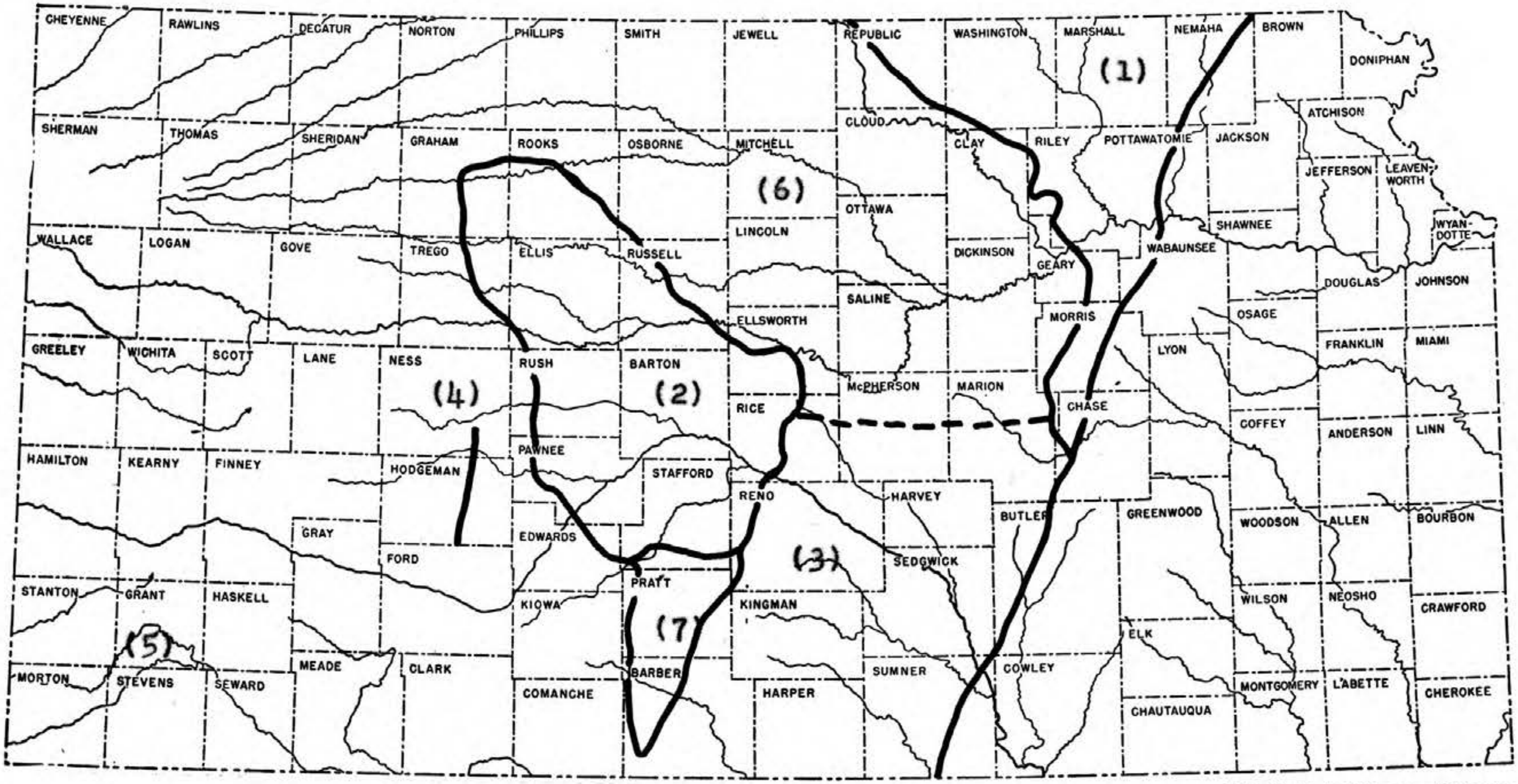
## Major Post-Mississippian Regional Structures

Central Kansas Uplift. The Central Kansas Uplift is a northwest-southeast trending structure superimposed at an oblique angle over the axis of the Ellis Arch (Eardly, 1951). The Central Kansas Uplift is the dominant structural feature of Central Kansas and separates the Salina Basin on the east from the Hugoton Embayment on the west (Fig. 2). Before formation of the Cherokee Basin the uplift continued to the southeast and connected with the axis of the Chautauqua Arch.

Originally called the Russel Arch by Denison (1926) and changed to Barton Arch by Barwick (1928), the name "Central Kansas Uplift" was first published by Morgan (1932) and Koester (1935) and is generally recognized as the accepted terminology at present (Jewett, 1951).

The Central Kansas Uplift contrasts strongly with the Nemaha Ridge in relief and symmetry. The Central Kansas Uplift is symmetrical and has gentle sloping sides, whereas the Nemaha Ridge has a very steep eastern front and gentle west slope. The Central Kansas Uplift originated in Precambrian time as a series of parallel batholiths and persisted as a positive element throughout much of Paleozoic time (Koester, 1935). The present structure has been developed by several periods of warping and truncation, but has not lost its anticlinal character (Lee, 1953).

Hugoton Embayment. The Hugoton Embayment is a northern shelflike extension of the Anadarko basin of Oklahoma (Fig. 2). The eastern edge of the structure is bounded by the Pratt




*State Geological Survey of Kansas*

Explanation:

(1) Nemaha Anticline
(3) Sedgwick Basin
(5) Hugoton Embayment
(7) Pratt Anticline
(2) Central Kansas Uplift
(4) Bazine Anticline
(6) Salina Basin

Fig. 2. Post-Mississippian Regional Structures.

Anticline, the Central Kansas Uplift and the Cambridge Arch. The western limit is formed by the Las Animas Arch. The Hugoton Embayment plunges gently to the south and the sedimentary rocks thicken in a southerly direction. The embayment is developed mainly in Paleozoic rocks and is not expressed in Mesozoic and Tertiary beds (Merriam and Goebel, 1956). The Hugoton Embayment is noted primarily for its production of gas.

Salina Basin. The Salina Basin, originally named by Barwick in 1928, occupies an area in north Central Kansas (Fig. 2). This basin is bounded on the east by the Nemaha Anticline, the west side by the Cambridge Arch, the southwest flank by the Central Kansas Uplift and on the south, by the saddle between the Chautauqua Arch and the Central Kansas Uplift. The axis of the basin trends northwest-southeast, digressing north toward the deeper part of the basin in Central Nebraska. The sediments decrease in thickness near the proximity of surrounding structures.

Nemaha Anticline. The Nemaha Anticline trends south approximately 14 degrees west from Cass County, Nebraska, through Nemaha County to Sumner County, Kansas, and south into Oklahoma to the vicinity of Oklahoma City (Fig. 2). This narrow anticline separates the Forest City and Cherokee Basins on the east from the Salina and Sedgwick Basins on the west.

The Precambrian core, or the granite ridge of the anticline, comes within about 400 feet of the surface near the Kansas-Nebraska line and plunges south. Near the Oklahoma-Kansas line it is about 4,000 feet below the surface. The Nemaha Anticline has a very steep eastern front and gentle back slope with 3,600 feet of relief (Eardly, 1951).

Sedgwick Basin. The Sedgwick Basin, named by Moore and Jewett (1942), is a northern shelflike extension of the Anadarko Basin in south Central Kansas (Fig. 2). This roughly symmetrical basin is bounded on the east by the Nemaha Ridge and on the west by the Central Kansas Uplift and the Pratt Anticline. The northern end is indistinct and no uparched area separates it from the Salina Basin. The Sedgwick Basin plunges southward and the strata increase in thickness from the shelf area into the deeper part of the Anadarko Basin (Merriam and Goebel, 1956).

## Minor Post-Mississippian Regional Structures

Bazine Anticline. The Bazine Anticline (Fig. 2) is an northeastward trending anticlinal fold, discernible in surface Cretaceous rocks, and situated in Ford, Hodgeman and Ness counties (Jewett, 1951).

Pratt Anticline. The Pratt Anticline is a large broad, southward-plunging nose that separates the Sedgwick Basin on the east from the Hugoton Embayment on the west (Fig. 2). Farther south in Oklahoma the Pratt Anticline dies out and the Sedgwick Basin and Hugoton Embayment apparently are not separated by this fold on the northeast flank of the Anadarko Basin (Merriam and Goebel, 1956).

## Areal Structure of Pawnee County, Kansas

The Garfield Field is situated on the southwestern flank of the Central Kansas Uplift in Pawnee County, Kansas. Structural maps of Pawnee County, Kansas, by Shapley (1956) indicate a southwest dip of 45 to 50 feet per mile for the Arbuckle Group, 20 to 25 feet per mile dip for Mississippian sediments, and 10 to 12 feet per mile dip for the Lansing Group. The dip of pre-Permian rocks increase near the proximity of the Central Kansas Uplift. The Central Kansas Uplift is obscured by a uniform cover of north and west dipping Permian and Cretaceous rocks.

### Structure within the Garfield Field Area

The Garfield Field Area structure map, Plate 4, contoured on the top of the Pennsylvanian basal conglomerate shows a comparatively large structural nose plunging southwest 20 to 25 feet to the mile from the major structural feature of the area, the Central Kansas Uplift. The structure is interrupted by very gentle folds and local terraces. The surface on which contours are drawn is an unconformity representing a post-Mississippian, pre-Desmoinesian erosion interval.

Cross section AA' (Plate Box, Plate 15), drawn parallel to regional dip and the structural nose shows progressive "pinching out" of pre-Desmoinesian, post-Cambrian sedimentary formations. Cross section BB' (Plate Box, Plate 15), drawn parallel to regional strike of sedimentary rocks, shows the configuration of the structural nose.

The structural nose is flanked by steeply dipping strata to the west and south and structural "highs" to the north and east.

A structural "low" northeast of the nose has apparently provided a trap for migration of petroleum. Combined thicknesses of the Pennsylvanian basal conglomerate, Mississippian limestones and Misener sandstone are similar to thicknesses over the structural nose, however Mississippian sedimentary rocks are locally absent and the Misener sandstone only 10 feet thick within the structurally "low" area. The Pennsylvanian basal conglomerate is abnormally thick within the basin area.

Plates 16, 6, and 9 are structure maps contoured on top of Viola, Misener, and Mississippian sedimentary rocks and show a series of parallel contour lines trending northeast-southwest through the N½ sec. 17, T. 23 S., R. 17 W., and S½ sec. 8, T. 23 S., R. 17 W. A possibility of faulting is apparent, however representatives of Colorado Oil and Gas, Sunray and Phillips Petroleum Company believe no faulting has occurred within the Garfield Area.

A detailed reflection seismograph survey, conducted by Geophysical Consultants, Incorporated of Delaware, Tulsa, Oklahoma, was completed September 2, 1953. The purpose of the survey was to determine if such a fault scarp or "bluff" could be located and defined by analysis of seismic records obtained in the area. The survey consisted of a line of shot points between dry holes located in NW¼ NW¼ NW¼ sec. 16, T. 23 S., R. 17 W., and SW¼ SW¼ NE¼ sec. 17, T. 23 S., R. 17 W. and continued west across an abandoned producer in SE¼ SE¼ NW¼ sec. 17, T. 23 S., R. 17 W. All efforts to find a sharp dip or break in the Viola proved unsuccessful. The area is adjacent to the Arkansas River, and the surface is covered by a thick layer of loose sand and gravel at various depths below the top of the ground. Such surface and shot hole conditions were not conducive to the production of good seismic records.

Plates 7 and 8 show how pre-Pennsylvanian sedimentary rocks "pinch out" in the northeast Garfield Area.

## HISTORY OF DRILLING AND PRODUCTION

The Garfield Field was one of four pools discovered in Pawnee County, Kansas, during 1947. The discovery well was drilled on the Hutchinson farm in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 17, T. 23 S., R. 17 W., by Gabbert and Lindas Drilling Company. The well, first thought to be a gas producer, was logged having an initial daily capacity of 44 barrels of oil. This single well comprised the Garfield Field until abandoned in early 1953 (Ver Wiebe, 1953). Figures 3 and 4 denote drilling activity and production from 1947 to 1957. Most interest for prospecting for oil was in the northeast part of Pawnee County between 1947 and 1953.

The Garfield Field was revived upon completion of the Hutchinson Estate "B" number 2 well in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 17, T. 23 S., R. 17 W., by Hilton Drilling Company, October 28, 1953. The well produced from Misener (Kinderhookian) sand of Mississippian age through perforations at a depth of 4,285 to 4,291 feet for a potential of 25 barrels of fluid a day (25 percent water). Subsequent development has proved the Pennsylvanian basal conglomerate and Mississippian "chat" also to be oil reservoirs (De Golyer and Mac Naughton, 1955).

An increase in exploration for oil in the Garfield Area during 1954 led to the discovery of three oil pools; Garfield

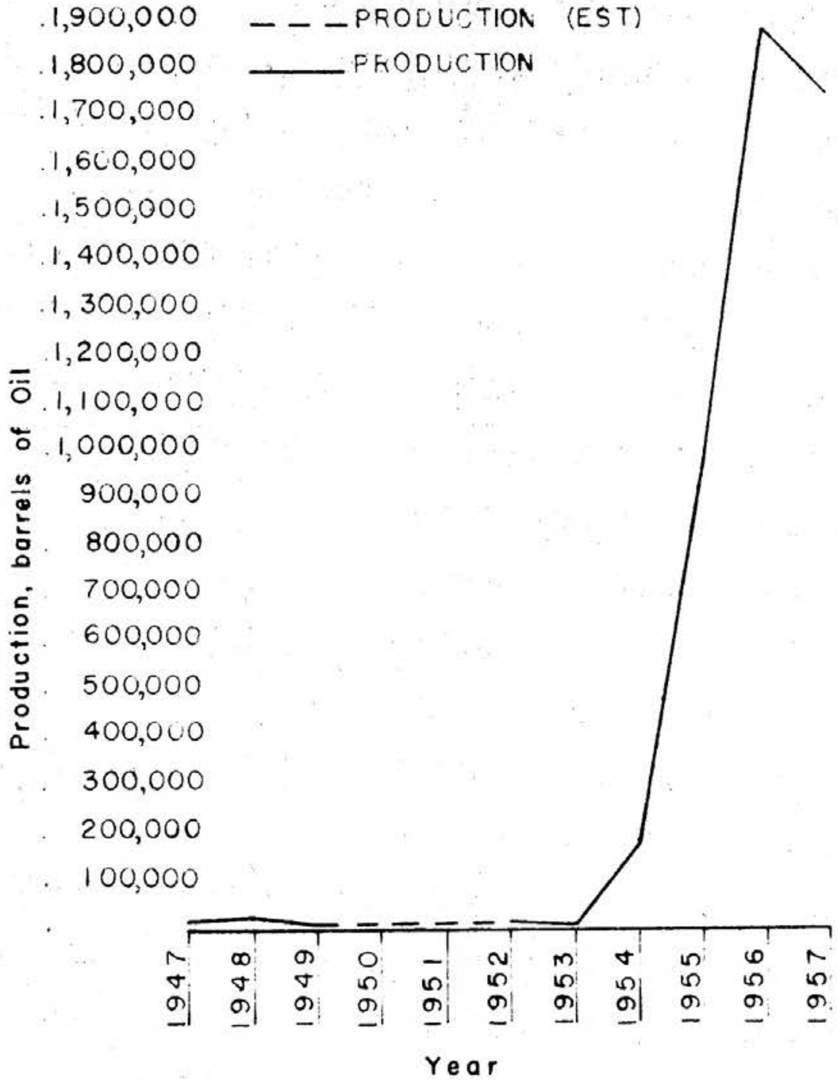



Fig. 3. Chart of petroleum production in Garfield Field Area.

Northeast, sec. 3, T. 23 S., R. 17 W., (Mississippian production), Garfield Southwest, sec. 30, T. 23 S., R. 17 W., (Mississippian and Misener production), and the Jab field, sec. 35, T. 23 S., R. 17 W., (Pennsylvanian basal conglomerate production). Thirty-six extension oil wells, one dry hole and one old well worked over and completed as an oil well were added to the Garfield Field during 1954 (Ver Wiebe, 1954).

An increase of about 57 percent of the total oil production in Pawnee County, Kansas, was almost entirely due to a successful development program in Garfield Field during 1955.

New fields discovered in Garfield Field Area during 1955 were; Garfield West, sec. 3, T. 23 S., R. 18 W., and Jab East, sec. 1, T. 23 S., R. 17 W. Three fields, Jab, Jab East and Garfield Northeast were declared to be producing from a common reservoir with Garfield and by action of the Nomenclature Committee were combined with that field during 1955. One hundred twenty-seven oil wells, three gas wells and 13 dry holes were completed in Garfield Field during 1955 (Ver Wiebe, 1955).

During 1956, 62 new oil wells, two gas wells, one reworked well, and 12 dry holes were drilled within the Garfield Field. Annual oil production increased nearly one million barrels during 1956 (Goebel, et al, 1956).

Garfield Southwest and Garfield West were abandoned during 1957, reflecting a sharp decrease in drilling activity. Oil production declined about seven percent and gas production 27 percent during 1957 (Goebel, et al, 1957).

Presently, 265 oil wells are producing in the Garfield Field.

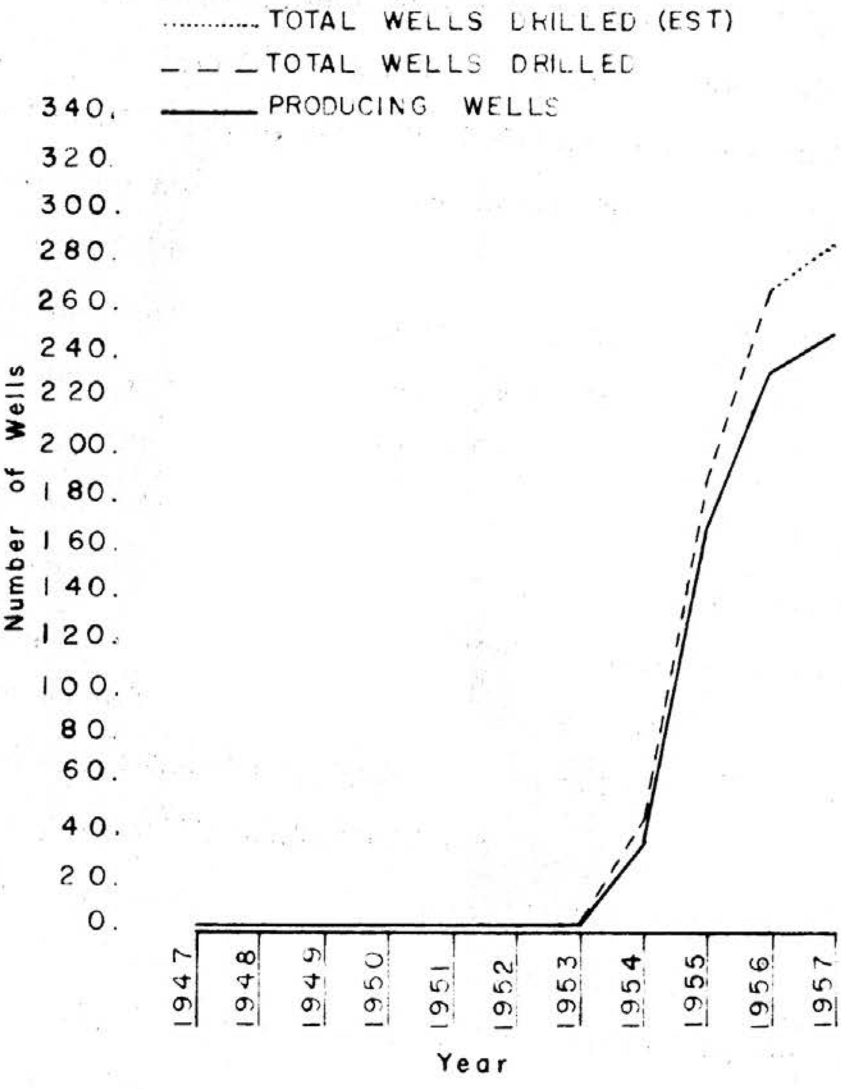



Fig. 4. Chart of drilling activity in Garfield Field Area.

## DRILLING, CASING AND COMPLETION METHODS

Drilling, casing and completion methods used in Garfield Field are described in a Garfield Field Engineering Committee Report (1957) as follows:

> All wells drilled in the field to date have been drilled with rotary rigs. The generally used casing program consists of setting 8 5/8" surface pipe at approximately 225' and cementing to surface, and the oil string is usually set through the intended completion interval and cemented with approximately 150-175 sacks. There have been isolated cases where pipe was set on top of the completion interval and an open hole completion made.
>
> In cases where open hole logs are run, the practice has been to run a salt mud survey or just a gamma ray-neutron survey. It is necessary to run one of the two above described surveys due to the salt content of the muds.
>
> Usually, after the long string is set, the rotary rig is moved off and a cable tool unit is moved on to do completion work. The completion is then made by perforating and treating. Treatments consist of a small mud acid cleanup treatment and then if necessary a formation fracture treatment usually of the sand-gelled crude oil variety is used.

## RESERVOIR AND INITIAL FLUID CHARACTERISTICS

A study to determine and recommend methods to be used to obtain maximum oil recovery from the Garfield Field reservoir was completed in 1957 by members of the Garfield Field Engineering Committee. Each operator of wells in Garfield Field submitted information (electric and radioactive logs, drill stem test results, core analysis, bottom hole pressures and completion data) on wells of his field to the engineering committee. The following data was obtained from this report:

Average porosity, 18.16 percent. Interstitial water, 43.40 percent. The formation permeability determined from core analysis ranges from 640 millidarcys (obtained in a clean chert section) to no permeability in the poorer productive areas. The average bottom hole temperature was 125 degrees Fahrenheit.

In the reservoir there are facies changes both laterally and vertically. There have been instances observed where within short distances laterally, the lithology of the formation changes from conglomerate with clean sand matrix to a very shaly chert or even pure shale. Changes of this type have in some cases been rather abrupt, sometimes occurring between offsetting wells 660' apart.

The reservoir drive is gas cap and solution gas drive. There is a possibility of some water drive acting from the west end of the field but it is not believed to be very strong.

An increase in temperature with increased depth below the earths' surface is a result of heat conduction from the earths' core to the surrounding atmosphere. It is said to average one degree Fahrenheit for each 60 feet of depth (Uren, 1953). Assuming an average surface temperature of 60 degrees Fahrenheit, an average bottom hole temperature of 125 degrees Fahrenheit is slightly lower than expected considering the total depth of most wells in Garfield Field is 4,250 to 4,350 feet. The geothermal gradient may be modified by chemical action, earth stresses resulting from diastrophism, proximity of intrusive rock masses or circulating ground water, and expansion of gasses. Studies of temperature gradient in a number of oil fields have indicated rates of temperature increase with depth ranging from one degree Fahrenheit for each 30 feet of depth to one degree Fahrenheit for each 70 feet (Uren, 1953).

Figure 5 is a fluid property curve taken by Big Chief

Drilling Company on J. A. Shoemake number one lease, NE/C sec. 19, T. 23 S., R. 17 W., and shows how viscosity increases as pressure decreases at a given temperature.

Samples from two cores obtained from Godfrey "A" well number four, NE¼ NE¼ SE¼ sec. 7, T. 23 S., R. 17 W., were analyzed by Houston Core Laboratory for Phillips Petroleum Company, August 23, 1955.

Procedure used in the core analysis was described by Houston Core Laboratory as follows:

> Samples number one through number nine and number 46 through number 58 were analyzed or merely described in the conventional manner. Samples number 10 through number 45 were conglomerate; therefore whole core porosities were run on the samples. The following method was used:
>
> The cores were thoroughly dried at 105 degrees Centigrade over night. They were then weighed. The samples were then placed in a vessel and a vacuum of one millimeter of mercury or better was maintained on them for several hours. The vessel was filled with kerosene while still under vacuum. When the vessel was filled with kerosene the pressure was run up to 3,500 psi and held over night. The samples were weighed again to determine the amount of kerosene forced into the pore space. The per cent porosity was then calculated from the pore space and bulk volume which was determined by mercury displacement.

Content of a letter from Mr. J. G. Firstenberger, Phillips Petroleum Company, Wichita, Kansas, dated May 26, 1959, proceeding a request for clarification of data describing gas content is as follows:

> We received an answer from our core laboratory in Houston today explaining the gas figures on the core analysis of the No. 4 Godfrey "A". Their explanation of these figures was made by describing how they obtained the data.
>
> The samples were shipped to the core laboratory in sealed tin cans. They pierced the cans with an

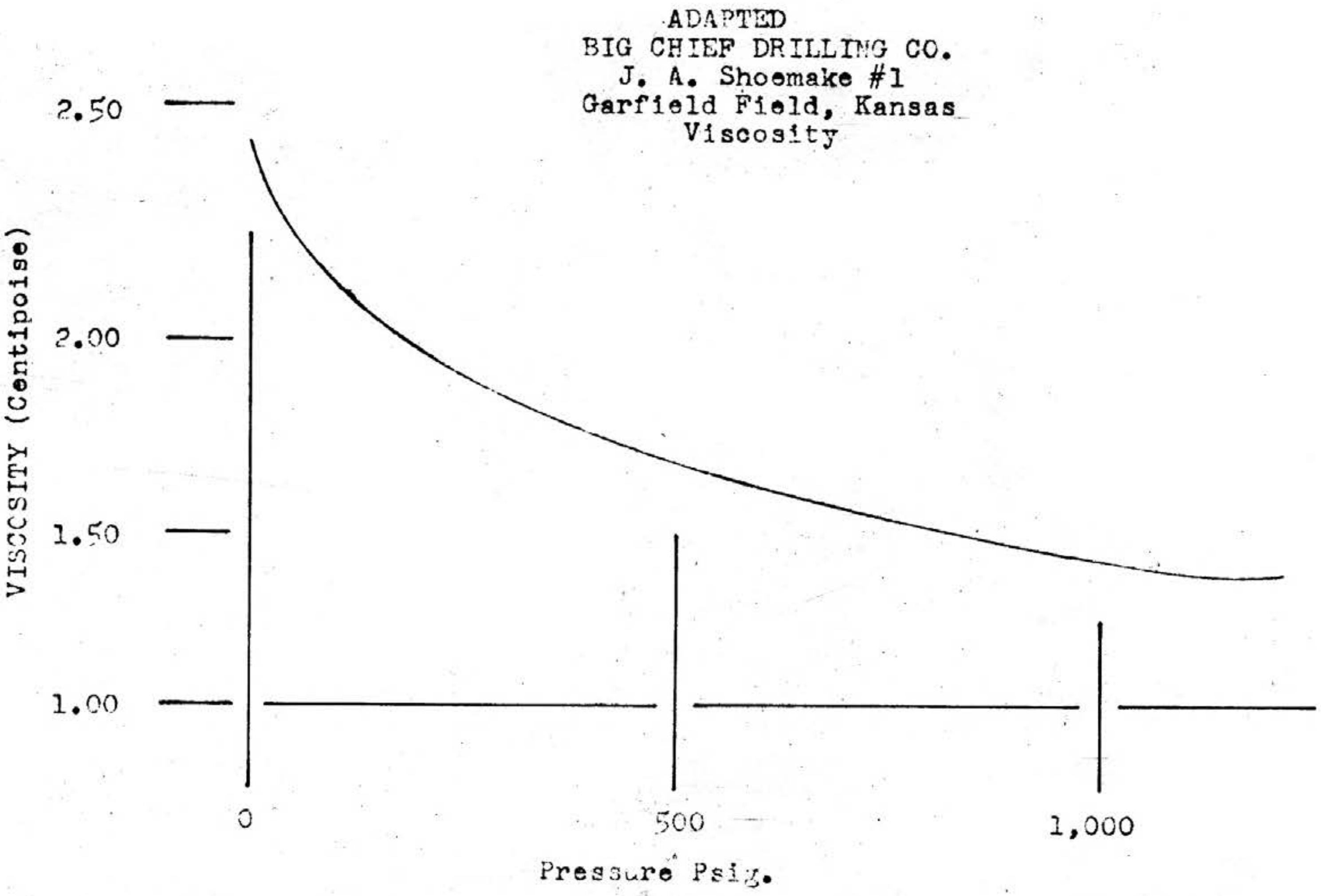



Fig. 5. **Fluid property curve (Adapted, Big Chief Drilling Co., 1956)**

ice pick and withdrew samples of gas from the cans with a hypodermic needle and syringe. They passed the gas across the element of a platinum wire (hot wire) gas detector.

Since the ignition temperatures for the various compounds in the hydrocarbon chain vary, they are able to ignite the gas at different temperatures by varying the temperature of the element, and thus they can determine approximately the comparative amounts of the different compounds by the imbalance of the Wheatstone bridge as it is recorded by the ammeter. In this way they will determine two things: first, the presence or absence of any combustible gas in the sample container, and second, a very rough and limited analysis of the gas that is present.

Tabulated core data for the Godfrey "A" well number four is illustrated in Table 1.

Samples number one through number three, taken from "shaley conglomerate", show lower permeability, slightly less porosity, and higher water content than producing formations. Low permeability and porosity of the "shaley conglomerate" provide a reservoir cap.

Samples number 48 through number 60 indicate greater permeability parallel to bedding planes. Water salinity within producing zones ranges from 93,000 to 143,600 parts per million parts water. This is comparatively high considering present-day sea water averages about 35,000 parts per million of dissolved salt (Uren, 1953).

An exact oil-water contact could not be determined from Kansas State Geological Survey scout cards, however it probably lies between -2,168 and -2,194 feet (subsealevel). Wells encountering an oil-water contact were in western and southwestern Garfield Field. Oil-water contacts were not reported for wells in northeastern Garfield Field.

Table 1. Tabulated core data of the Godfrey "A" well #4, NE$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$, sec. 7, T. 23 S., R. 17 W., Garfield Field, Pawnee County, Kansas (Courtesy Phillips Petroleum Company).

| Sample number | Depth | Permeability in millidarcys | | Porosity per cent | Residual Fluids | | Salinity ppmp Chlorine |
|---|---|---|---|---|---|---|---|
| | | Hor. | Vert. | | % oil | % water | |
| "shaley conglomerate" | | | | | | | |
| Red shale, slightly sandy. | | | | | | | |
| 1 | 4,199 | 1.1 | .5 | 12 | | | |
| 2 | 4,200 | 1.0 | 1.7 | 12 | | | |
| 3 | 4,201 | .7 | .7 | | | | |
| "cherty conglomerate" | | | | | | | |
| Chert-white, weathered, leached, tripolitic, crumbly, fractured, vuggy, bleeding gas and oil at fractures and vugs. | | | | | | | |
| 10 | 4,226 | | | 9 | | | |
| 11 | 4,227 | | | 16.5 | | | |
| 12 | 4,228 | | | 20.9 | | | |
| 13 | 4,229 | | | 21.5 | | | |
| 14 | 4,230 | | | 13.7 | | | |
| 15 | 4,231 | | | 22.0 | | | |
| 16 | 4,232 | | | 18.3 | | | |
| 17 | 4,233 | | | 6.9 | | | |
| 18 | 4,234 | | | 20.4 | | | |
| 19 | 4,235 | | | 20.6 | | | |
| 20 | 4,236 | | | 13.5 | | | |
| 21 | 4,237 | | | 16.8 | | | |
| 22 | 4,238 | | | 14.9 | | | |
| 23 | 4,239 | | | 14.2 | | | |
| 24 | 4,240 | | | 24.9 | | | |
| 25 | 4,241 | | | 19.1 | | | |
| 26 | 4,242 | | | 18.7 | | | |
| 27 | 4,243 | | | 19.1 | | | |
| 28 | 4,244 | | | 11.1 | Same as above with shale partings. | | |
| 29 | 4,245 | | | 21.1 | | | |
| 30 | 4,246 | | | 13.9 | | | |

Table 1. (cont.).

| Sample number | Depth | Permeability in millidarcys Hor. | Vert. | Porosity per cent | Residual Fluids % oil | % water | Salinity ppmp Chlorine |
|---|---|---|---|---|---|---|---|
| Show of oil and gas becomes poor. Chert-white, weathered, leached, tripolitic, crumbly, well fractured, vuggy, red shale matrix. Slight gas odor. | | | | | | | |
| 31 | 4,247 | | | 17.2 | | | |
| 32 | 4,248 | | | 16.8 | | | |
| 33 | 4,249 | | | 16.0 | | | |
| 34 | 4,250 | | | 16.0 | | | |
| 35 | 4,251 | | | 18.3 | | | |
| 36 | 4,252 | | | 17.8 | | | |
| 37 | 4,253 | | | 13.6 | | | |
| 38 | 4,254 | | | 16.2 | | | |
| 39 | 4,255 | | | 14.2 | | | |
| 40 | 4,256 | | | 16.9 | | | |
| 41 | 4,257 | | | 17.4 | | | |
| 42 | 4,258 | | | 15.9 | | | |
| 43 | 4,259 | | | 15.4 | | | |
| 44 | 4,260 | | | 16.8 | | | |
| 45 | 4,261 | | | 16.4 | | | |
| Shale - red, conglomeratic with lime and chert fragments. | | | | | | | |
| 46 | 4,262 | | | | | | |
| Sand - hard, firm, shaly, gray, stain and flouresence in sand. | | | | | | | |
| 48 | 4,268 | 64 | | 15.0 | 11.0 | 21.0 | 143,600 |
| 49 | 4,269 | 23 | 16 | 15.0 | 14.0 | 23.0 | 137,300 |
| 50 | 4,270 | 9 | 12 | 15.0 | 13.0 | 38.0 | 110,500 |
| 51 | 4,271 | 13 | 7 | 17.0 | 11.0 | 38.0 | 101,300 |
| 52 | 4,272 | 14 | 8 | 18.0 | 10.0 | 44.0 | 103,200 |
| 53 | 4,273 | 12 | 8 | 18.0 | 12.0 | 43.0 | 99,300 |
| 54 | 4,274 | 12 | 5 | 18.0 | 7.0 | 55.0 | 103,200 |
| 55 | 4,275 | 4 | 5 | 18.0 | 8.0 | 53.0 | 95,000 |
| 56 | 4,276 | 25 | 12 | 18.0 | 8.0 | 54.0 | 94,200 |

Table 1. (concl.).

| Sample number | Depth | Permeability in millidarcys Hor. | Permeability in millidarcys Vert. | Porosity per cent | Residual Fluids % oil | Residual Fluids % water | Salinity ppmp Chlorine |
|---|---|---|---|---|---|---|---|
| 57 | 4,277 | 32 | 8 | 17.0 | 10.0 | 38.0 | 108,800 |
| 58 | 4,278 | 17 | 15 | 23.0 | 9.0 | 43.0 | 93,000 |
| 59 | 4,279 | 25 | 13 | 18.0 | 9.0 | 39.0 | 114,200 |
| 60 | 4,280 | 8 | 6 | 17.0 | 8.0 | 56.0 | 103,800 |

| | Gas Content Methane | Gas Content Propane | Gas Content Butane |
|---|---|---|---|
| 48 | 51 | 28 | 37 |
| 49 | 55 | 59 | 64 |
| 50 | 54 | 64 | 62 |
| 51 | 18 | 25 | 28 |
| 52 | 42 | 44 | 39 |
| 53 | 50 | 47 | 60 |
| 54 | 42 | 18 | 19 |
| 55 | 34 | 38 | 40 |
| 56 | 58 | 62 | 64 |
| 57 | 30 | 33 | 43 |
| 58 | 44 | 46 | 54 |
| 59 | 65 | 88 | 98 |
| 60 | 40 | 36 | 41 |

Variance of oil-water contact depths within Garfield Field is probably due to variable reservoir rock porosities and permeabilities. Water may also appear at higher levels in some wells than in others because of facies changes, minor fracturing, irregular rates of production, leaking well casing, edge-water encroachment and water coning (Levorsen, 1956).

Four major gas caps occur in Garfield Field. Nomenclature and subsealevel gas-oil contact of each gas cap are: Northeast gas cap (-2,080), Northwest gas cap (-2,090), Central gas cap (-2,110) and, Southwest gas cap (-2,134). Plates 2 and 3 are adapted from gas cap isopach maps by Dardenne (1956).

## RELATIONSHIP OF PETROLEUM AND GAS ACCUMULATION TO STRUCTURE AND STRATIGRAPHY

### Gas Accumulation

Plates 1 and 2, adapted from Dardenne (1956), and 3 show relationships between gas accumulation and Pennsylvanian basal conglomerate structure and thickness.

The southwest gas cap, having a -2,134 foot gas-oil contact, is located in sections 16 and 17, T. 23 S., R. 17 W. The Southwest gas cap is situated on a structural "high" over the southeast extremity of a large southwest plunging anticlinal "fold". Pennsylvanian basal conglomerate thickness is 20 to 40 feet.

A -2,134 foot structural contour constructed above the anticlinal nose would close, however a -2,135 foot structural contour will not. Evidently the local "high" is completely gas filled. Additional gas coming out of solution under present hydrostatic pressure would probably migrate up dip.

The Central gas cap, sections 4, 5, 8, and 9, T. 23 S., R. 17 W., is situated on a south plunging anticlinal fold and bounded east, west and south by structures lower than -2,110 feet (gas-oil contact elevation). Plates 2 and 3, adapted from Dardenne (1956), indicate that the Northeast gas cap, having a -2,080 foot gas-oil contact, and Central gas cap, having a -2,110 foot gas-oil contact, overlap. The overlapping gas caps suggest either two levels of gas accumulation separated by a zone of impermeability or occurrence of a tilted gas-oil contact, however clarifying information was not obtained. If the gas-oil contact is tilted, this fact may suggest an unclosed gas reservoir.

Inadequate control points immediately north and east of Garfield Field prohibit showing actual relationship of the structural altitude of sediment rocks to gas accumulation, however presence of a structural "low" on the Pennsylvanian basal conglomerate structura contour map in northeast Garfield Field has apparently permitted gas to migrate farther up dip. Pennsylvanian basal conglomerate thickness is less than 10 feet where accumulation of gas is greatest. Some gas production is from Mississippian "chat" and Misener sandstone.

Presence of greatest gas accumulation in the northeast corner of Garfield Field may be an indication of lower permeability near the proximity of "pinching out" of reservoir rocks. Reservoir rocks may loose their effective permeability in an up dip direction as the result of finer rock texture, decrease in rock thickness, partial or complete filling of pore spaces and decrease in porosity.

The Northwest gas cap, situated on a small structural terrace in sec. 35, T. 22 S., R. 17 W. has a gas-oil contact at -2,090 feet. Plate 3 shows only five feet of gas accumulation.

Cross sections AA' and BB' show how gas accumulation is apparently governed by reservoir rock structure and configuration and presence of an impermeable shale conglomerate above. Small anticlinal "highs" occur on Pennsylvanian basal conglomerate structure over local flexures and a structural nose. Gas accumulation may also occur up dip near reservoir rock termination.

## Petroleum Accumulation

Plates 5, 6, and plate 7, adapted from De Golyer and Mac Naughton (1955), show relationships between structure, thickness, and petroleum accumulation of the Misener sandstone. Plate 16, contoured on top of the Viola limestone shows the underlying structural attitude of this rock unit in Garfield Field. Cross sections AA' and BB' show how structural features on the Viola limestone are reflected in overlying producing formations.

Plates 5, 6, and 7, show 10 feet of petroleum accumulation on a small plunging nose in the SW¼ sec. 5, T. 23 S., R. 17 W. between -2,180 and -2,130 feet. Misener thickness varies from 30 to 50 feet.

Plates 5, 6, and 7, indicate 30 feet of petroleum accumulation on a saddle between two structural "highs" in the SW¼ SW¼ SE¼ sec. 8, T. 23 S., R. 17 W., between -2,170 and -2,200 feet. "Lows" northwest and southeast of this saddle apparently limit petroleum accumulation. Misener thickness is 30 to 40 feet.

The W½ W½ sec. 16, T. 23 S., R. 17 W., has 10 feet of petroleum accumulation on a local terrace flanked by steeply dipping strata. Elevation of accumulation is between -2,190 and -2,200 feet. Misener thickness is 30 feet.

Ten feet of petroleum accumulation in the SE¼ SE¼ SE¼ sec. 18, T. 23 S., R. 17 W. occurs on the southern extremity of a large structural nose between -2,200 and -2,220 feet. Misener thickness is 30 to 50 feet.

An anticlinal "high" in the E½ sec. 7, T. 23 S., R. 17 W., does not show petroleum accumulation on Plate 7. Favorable conditions for oil accumulation are indicated on Plates 5 and 6. Plate 7, adapted from De Golyer and Mac Naughton (1955), was constructed prior to completion of wells in sec. 7.

Ten feet of petroleum accumulation in the W½ W½ sec. 9, T. 23 S., R. 17 W., appears anamalous. Plates 5 and 6 show 30 feet of Misener sandstone on a "low", bounded north and west by steeply dipping strata and a fairly level monocline to the east. Petroleum accumulation is between -2,200 and -2,220 feet. This "low" appears to be a topographical "low" due to pre-Mississippian erosion. Plate 16 shows a local monocline or decrease in rate of dip of Viola limestone. This particular "low" does not appear to be as abrupt or deep as neighboring "lows" of the area.

Petroleum accumulation in Misener sandstone is on a south-dipping structural nose. Greater petroleum accumulations occur between -2,170 and -2,230 feet on local structural "highs" and terraces relative to regional dip and where Misener thickness is between 30 and 50 feet. The Misener sandstone represents a subaerial surface of erosion. Petroleum accumulation in Misener sandstone probably occurs where zones of solution porosity serve as reservoirs. Radio-activity logs indicate a porosity decrease in the lower part of the Misener sandstone. Apparently post-Misener, pre-Mississippian weathering and ground water circulation were accompanied by cementation and recrystallization, thereby reducing effective porosity. Presence of some shale would also tend to decrease porosity.

Plates 8, 9, and Plate 10, adapted from De Golyer and Mac Naughton (1955), show relationships between structure, thickness and petroleum accumulation in Mississippian sedimentary rocks.

Twenty feet of petroleum accumulation in the S½ S½ sec. 3, T. 23 S., R. 17 W. occurs in 20 feet of Mississippian sedimentary rocks on the flank of a structural "high". Petroleum accumulation is between -2,150 and -2,080 feet.

Twenty feet of petroleum accumulation occurs on the flank of steeply dipping Mississippian sedimentary rocks in the W½ W½ sec. 3, T. 23 S., R. 17 W. Thickness of Mississippian rocks is 20 feet. Petroleum accumulation occurs between -2,130 and -2,150 feet Mississippian sedimentary rocks are underlain by Viola limestones in section 3 and appear to be entirely oil saturated.

Twenty feet of petroleum accumulation occurs in eastern and southwestern portions of sec. 4, T. 23 S., R. 17 W., on a small monocline. Petroleum accumulation occurs between -2,130 and -2,150 feet.

Twenty feet of petroleum accumulation occurs in the NW¼ SW¼

$SE\frac{1}{4}$ sec. 5, T. 23 S., R. 17 W., at the base of a structural nose. Mississippian thickness is 30 to 50 feet.

Thirty feet of Mississippian petroleum accumulation in the center of sec. 9, T. 23 S., R. 17 W., is on the flank of a structural nose. Petroleum accumulation is between -2,150 and -2,180 feet. Mississippian sedimentary rocks are absent in the $S\frac{1}{4}$ sec. 9, T. 23 S., R. 17 W.

A structural "high" in the $W\frac{1}{2}$ sec. 16, T. 23 S., R. 17 W., has 40 feet of petroleum accumulation between -2,140 and -2,170 feet. Mississippian thickness is 40 to 50 feet. An area slightly northeast is structurally higher and 60 to 70 feet thick. Petroleum accumulation is not indicated to be as prolific as over adjacent structural "highs". Producing wells in this area were apparently drilled after Plate 10, adapted from De Golyer and Mac Naughton (1955), was constructed.

Areas in the north central part and $SE\frac{1}{4}$ $SE\frac{1}{4}$ $SE\frac{1}{4}$ sec. 18, T. 23 S., R. 17 W. have 10 feet of petroleum accumulation in Mississippian sedimentary rocks. These areas are on a southwest dipping anticlinal "nose". Thickness of Mississippian rocks varies from 50 to 90 feet.

Petroleum accumulation in Mississippian sedimentary rocks is between -2,180 and -2,090 feet. Plate 10, adapted from De Golyer and Mac Naughton (1955), show Mississippian petroleum accumulation over the entire southwest dipping nose, however local petroleum accumulations are apparently not controlled by structural "highs". Lithologic characteristics of Mississippian sedimentary rocks and Pennsylvanian basal conglomerate are probably similar, especially in northeastern Garfield Field. Radioactivity logs show little or no porosity change between Pennsylvanian basal conglomerate and Mississippian rocks of individual wells. Petroleum accumulation is apparently controlled by lateral and vertical facies changes. Post-Mississippian, pre-Pennsylvanian erosion and ground-water circulation, accompanied by cementation, probably account for irregular distribution of permeability within the reservoir rock.

Thickness of Mississippian rocks within the producing reservoir are 20 to 110 feet. Locally, the entire Mississippian section appears to be saturated with oil. Apparently intercommunication occurs between the sedimentary reservoir rocks. Wherever petroleum accumulation occurs in Misener sandstone, petroleum accumulation occurs also in overlying Mississippian strata.

Plates 4, 11, and Plate 12, adapted from De Golyer and Mac Naughton (1955), show relationships between structure, thickness, and petroleum accumulation in Pennsylvanian basal conglomerate.

Thirty feet of petroleum accumulation occurs in sec. 7, 9, and 16, T. 23 S., R. 17 W., on local highs above a large southwest plunging structural "nose". Pennsylvanian basal conglomerate thickness varies from 30 to 40 feet, indicating the entire Pennsylvanian basal conglomerate is locally saturated. Plate 12, adapted from De Golyer and Mac Naughton (1955), and Plate 4, indicate some oil accumulation in the Pennsylvanian basal conglomerate in all places where it overlies a large structural nose.

Better productive areas in the reservoir are found where the sedimentary rock matrix is predominantly sand. Vertical and horizontal fracturing within the Pennsylvanian basal conglomerate may have been due to removal of overburden by erosion in the zone of weathering. Upper parts of Pennsylvanian basal conglomerate expanded, developing joints and fractures, as sediments were removed by erosion.

As intercommunication probably exists between producing formations of the Garfield Field, Plates 4, 13, and 14 were constructed showing relationships between structure, thickness and petroleum accumulation of combined reservoir rocks of Garfield Field.

Greatest petroleum accumulations (40 to 60 feet) occur in sections 7, 8, 9, 15, 16, and 17, T. 23 S., R. 17 W. on local anticlinal "highs" and terraces of a southwest dipping anticlinal "nose", between -2,110 and -2,130 feet. Reservoir thickness of areas having greatest petroleum accumulation varies from 70 to 150 feet, indicating petroleum accumulation in Garfield Field is related to porosity, permeability, and structure rather than thickness only.

Termination of petroleum accumulation appears to be along a line parallel to the 90 foot isopachous line, north of Garfield Field. The reservoir rock probably loses its effective permeability near the proximity of the "pinch out" as the result of finer texture, decrease in thickness and partial or complete filling of pore spaces.

## FUTURE POSSIBILITIES

Future possibilities for discovery of additional petroleum reserves in the Garfield Field Area are limited, however a few new wells may be discovered along margins of proven areas.

Figure 6 shows locations of dry wells drilled in the Garfield Field area which delimit areas of petroleum accumulation.

Garfield Engineering Committee Members have decided against the use of water flooding as a means of secondary recovery (personnel communication, Mr. Eugene Hilton). To satisfy requirements for a successful water-flood operation, the following conditions would have to be fulfilled: (1) an adequate source of water, (2) possibility of achieving cooperation or a unitization agreement among various operators and lessors in Garfield Field, (3) the reservoir must contain substantial amounts of recoverable oil and be amenable to water flooding, and (4) income resulting from expected oil recovery must be sufficient to yield a satisfactory profit after cost of development and expense of operation (Kepplinger and Wanenmacher, 1954).

Conditions such as: (1) non-uniformity of permeability, (2) presence of natural crevices and fractures, (3) vugular type porosity, and (4) repeated fracture treatments of many of the wells, would probably prohibit satisfactory results from water flooding in Garfield Field. Gas-caps may also make flooding difficult, because water could pass through the gas sands more readily than oil sands.

Pressure restoration, pressure maintenance or gas drive would probably be a better means of secondary recovery. Levorsen (1956) states:

Interstitial water may occupy from a few percent

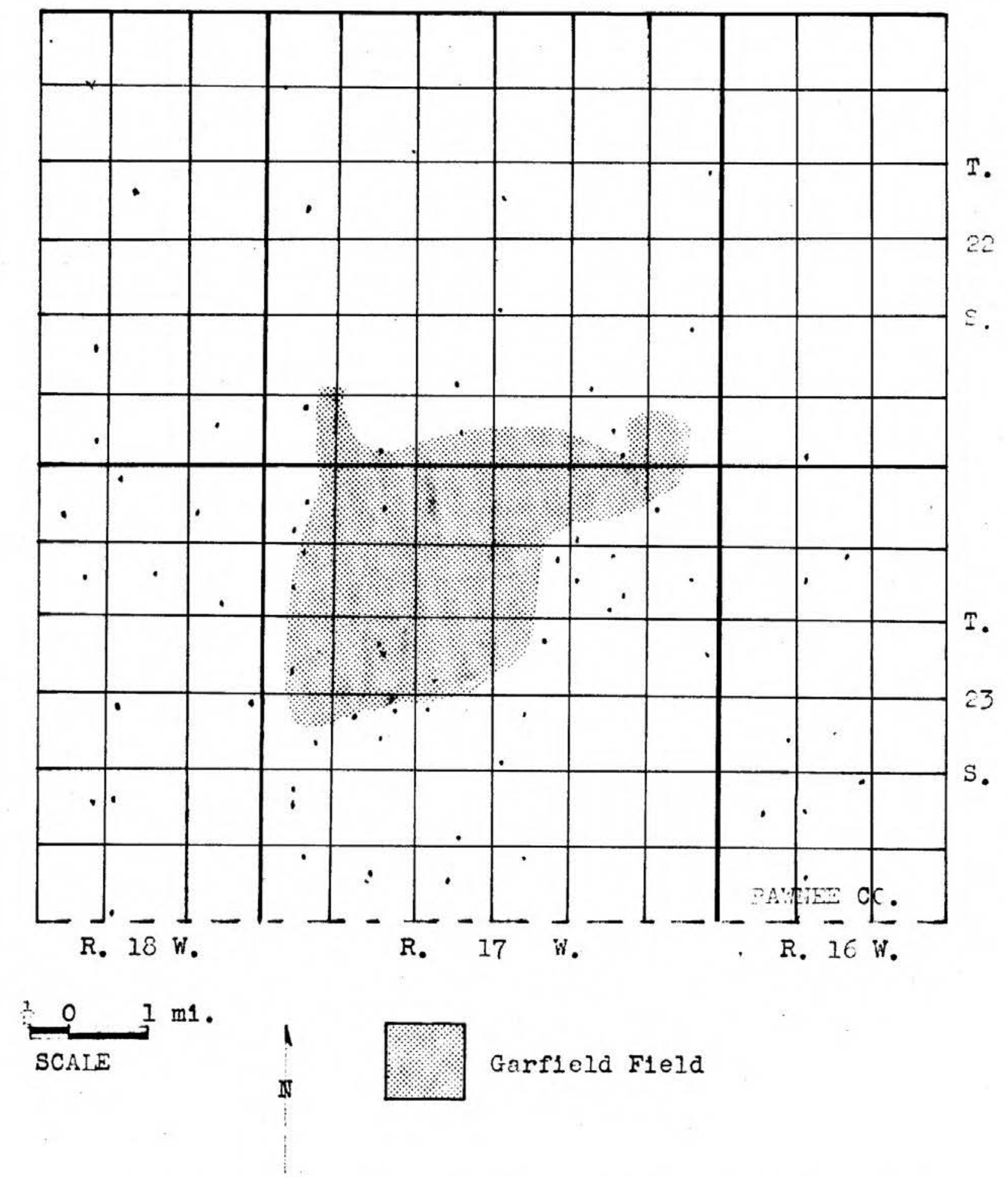



Fig. 6. Map showing dry wells drilled in the Garfield Field Area.

> up to 50 percent, but generally between 10 and 30 percent, of the pore space . . . A gas drive has generally been found to be more effective in a reservoir with a high interstitial water saturation, whereas a water flood is more effective in a reservoir with a high oil saturation and a low water saturation.

A detailed study of information including production records, well logs, radio-active and electric logs, and core data would be required before justification of the use of any means of secondary recovery.

## CONCLUSIONS

Petroleum accumulation in the Garfield Field Area is associated with the following structural and stratigraphic features: (1) a large anticlinal "nose" plunging southwest from the major structural feature of the area, the Central Kansas Uplift, (2) truncation of Misener and Mississippian formations in the northeast Garfield Field Area, (3) presence of an impermeable seal above all producing formations, (4) lateral changes in effective porosity and permeability, (5) local structural "highs" and terraces superimposed on a structural nose, (6) permeable bedding and unconformity planes, (7) anticlinal "highs" north and east of Garfield Field, and (8) a porosity "pinch out" northeast of Garfield Field.

Gas accumulation may be found in Garfield Field in folds which are associated with structural closure at the surface of a disconformity, where the irregular Pennsylvanian basal conglomerate erosional surface is overlain by impervious "shaly" conglomerate.

## ACKNOWLEDGMENTS

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# APPENDIX

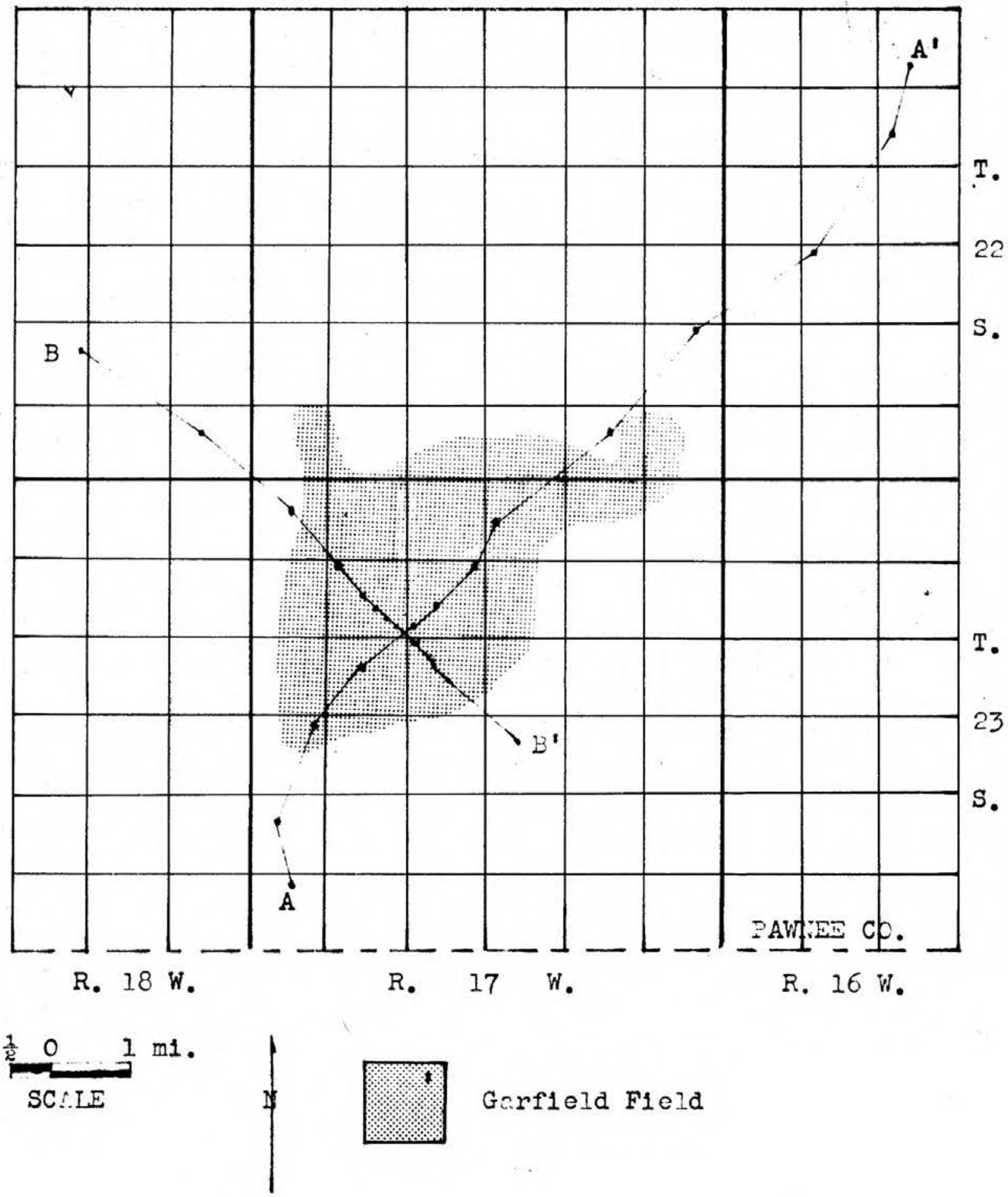



Fig. 7. Map of Garfield Field Area, showing points used for construction of cross sections.

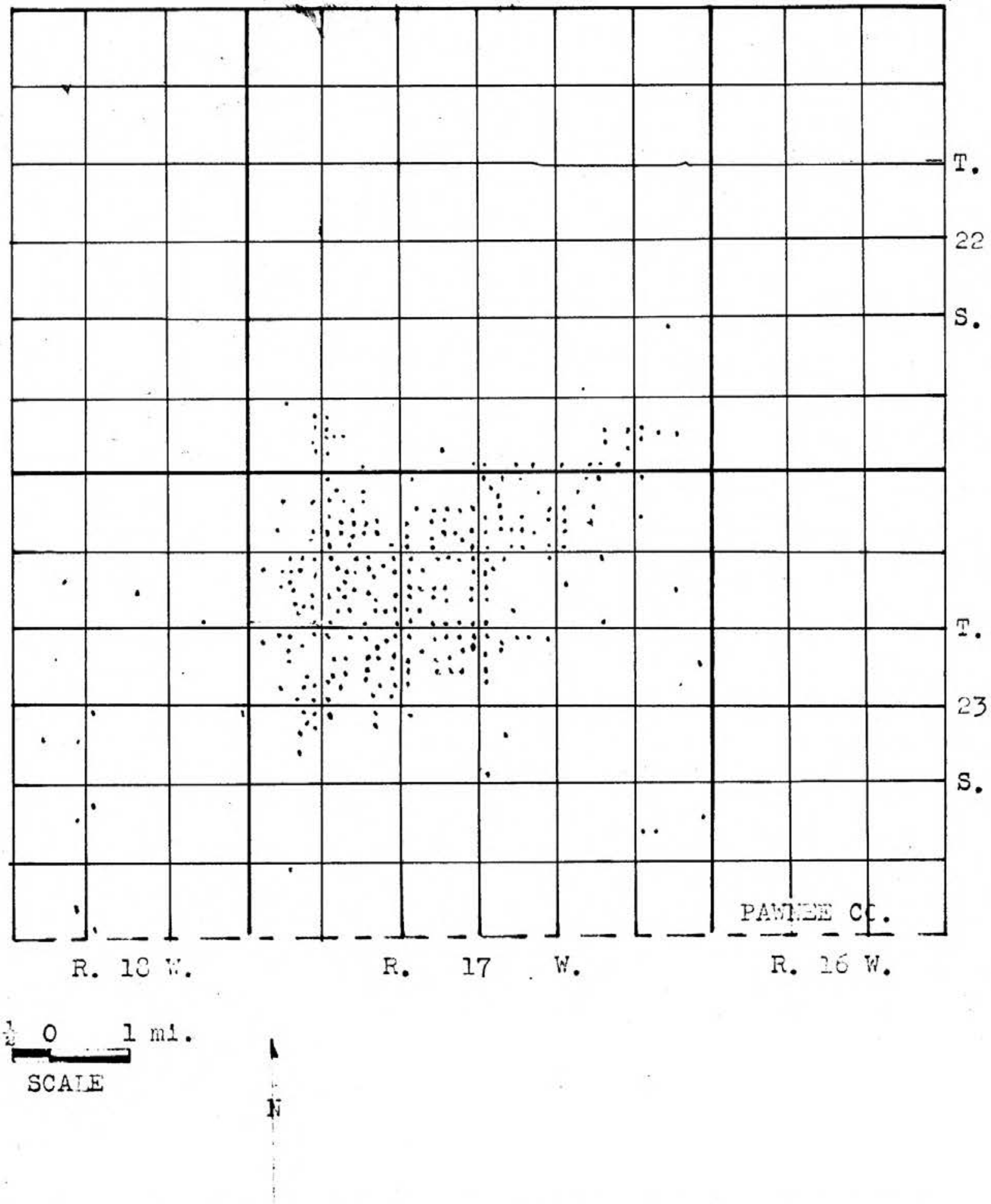



Fig. 8. Map of the Garfield Field Area, showing locations of control points used for drawing structural contours on the Pennsylvanian basal conglomerate.

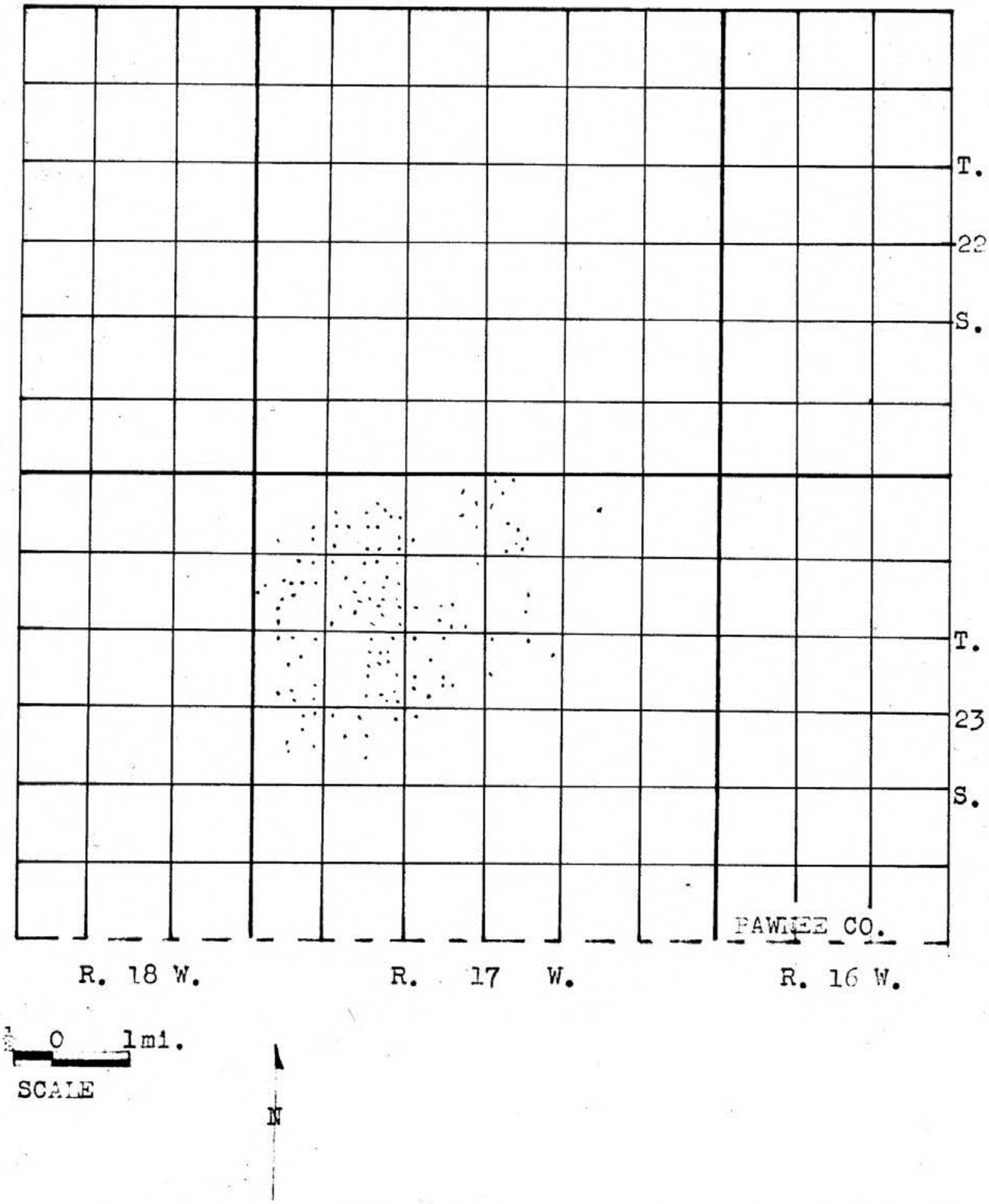



Fig. 9. Map of the Garfield Field Area, showing locations of control points used for drawing structural contours on the Mississippian limestones.

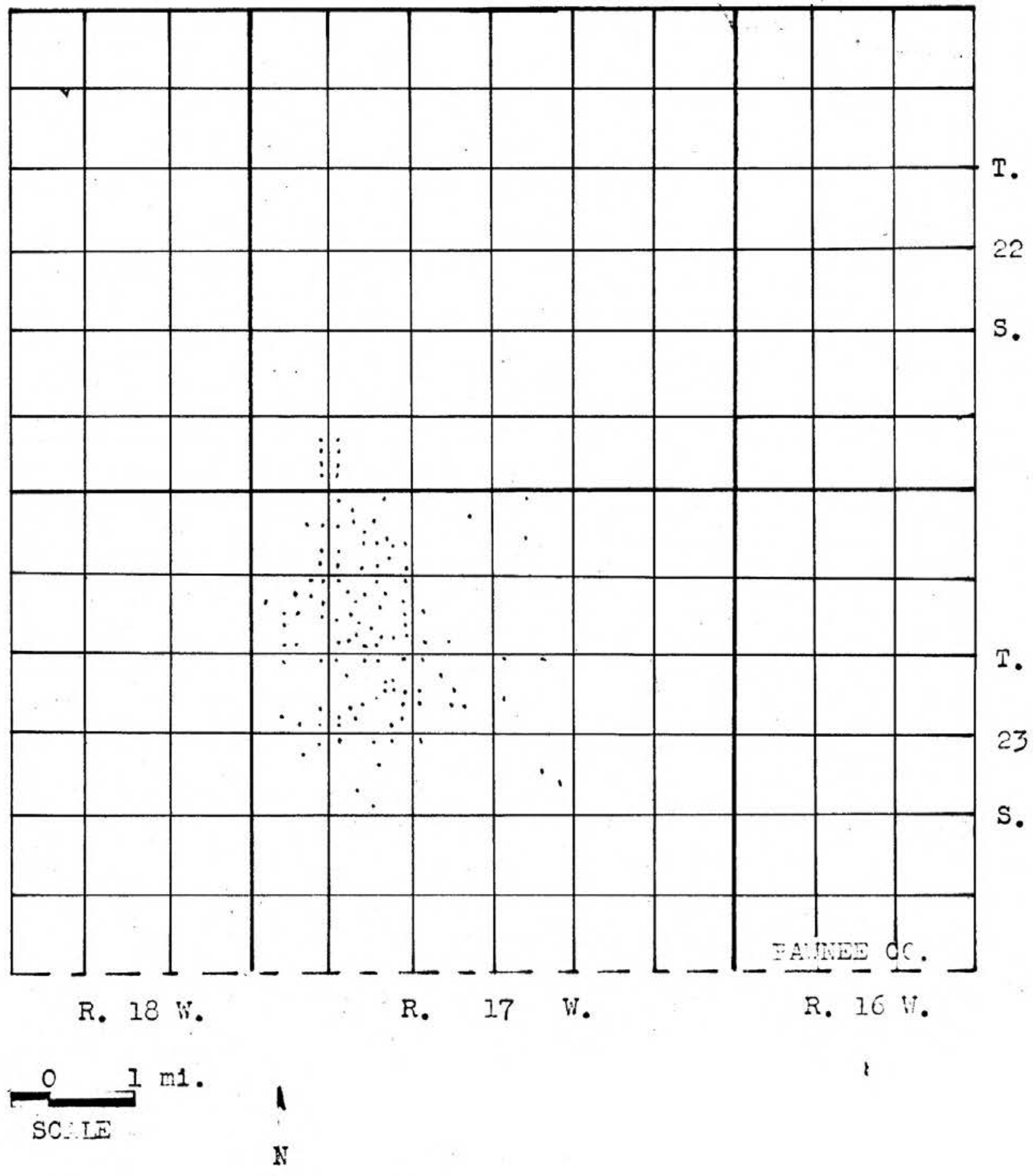



Fig. 10. Map of the Garfield Field Area, showing locations of control points used for drawing structural contours on the Misoner sandstone.

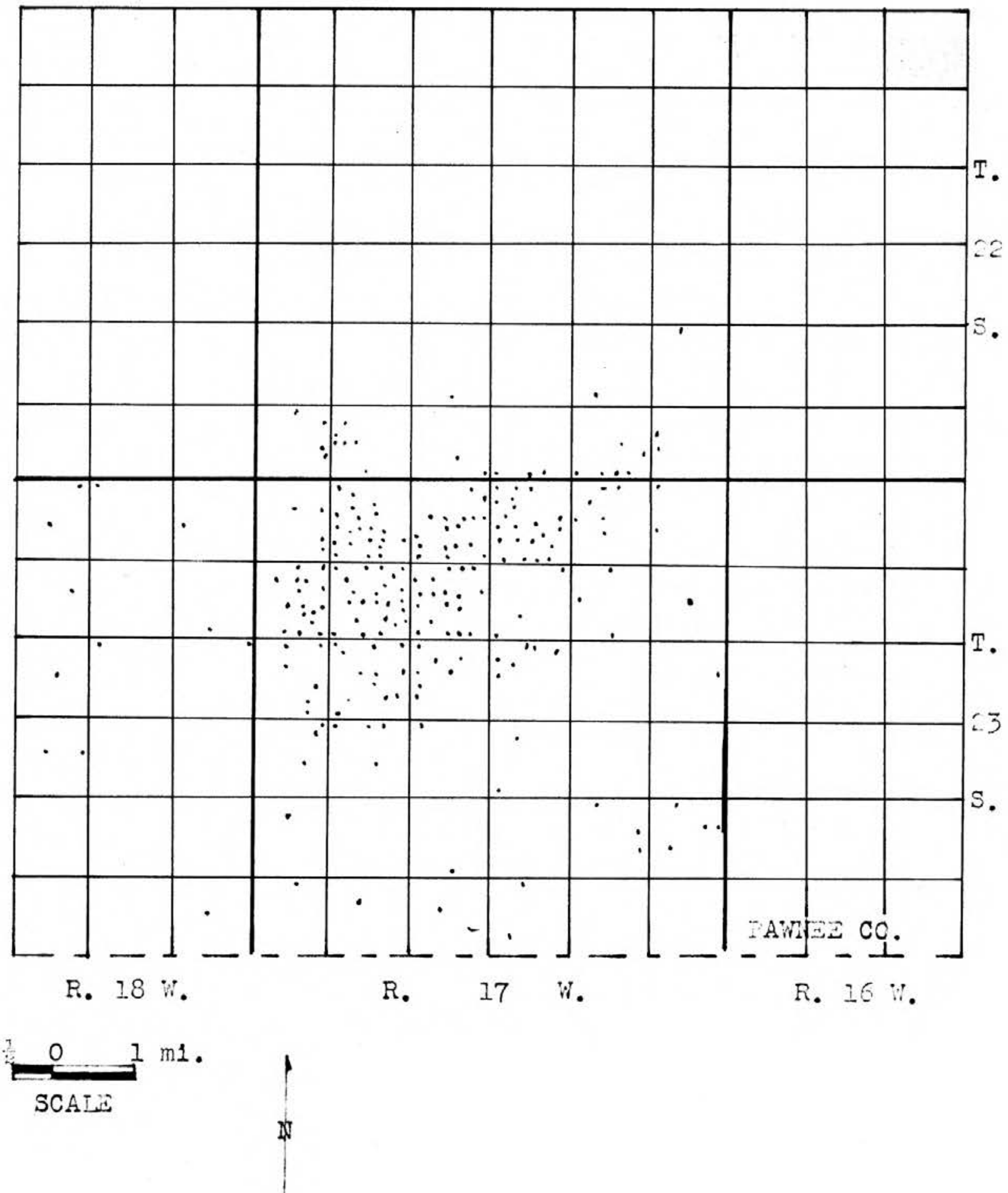



Fig. 11. Map of the Garfield Field Area, showing locations of control points used for drawing structural contours on the Viola limestones.

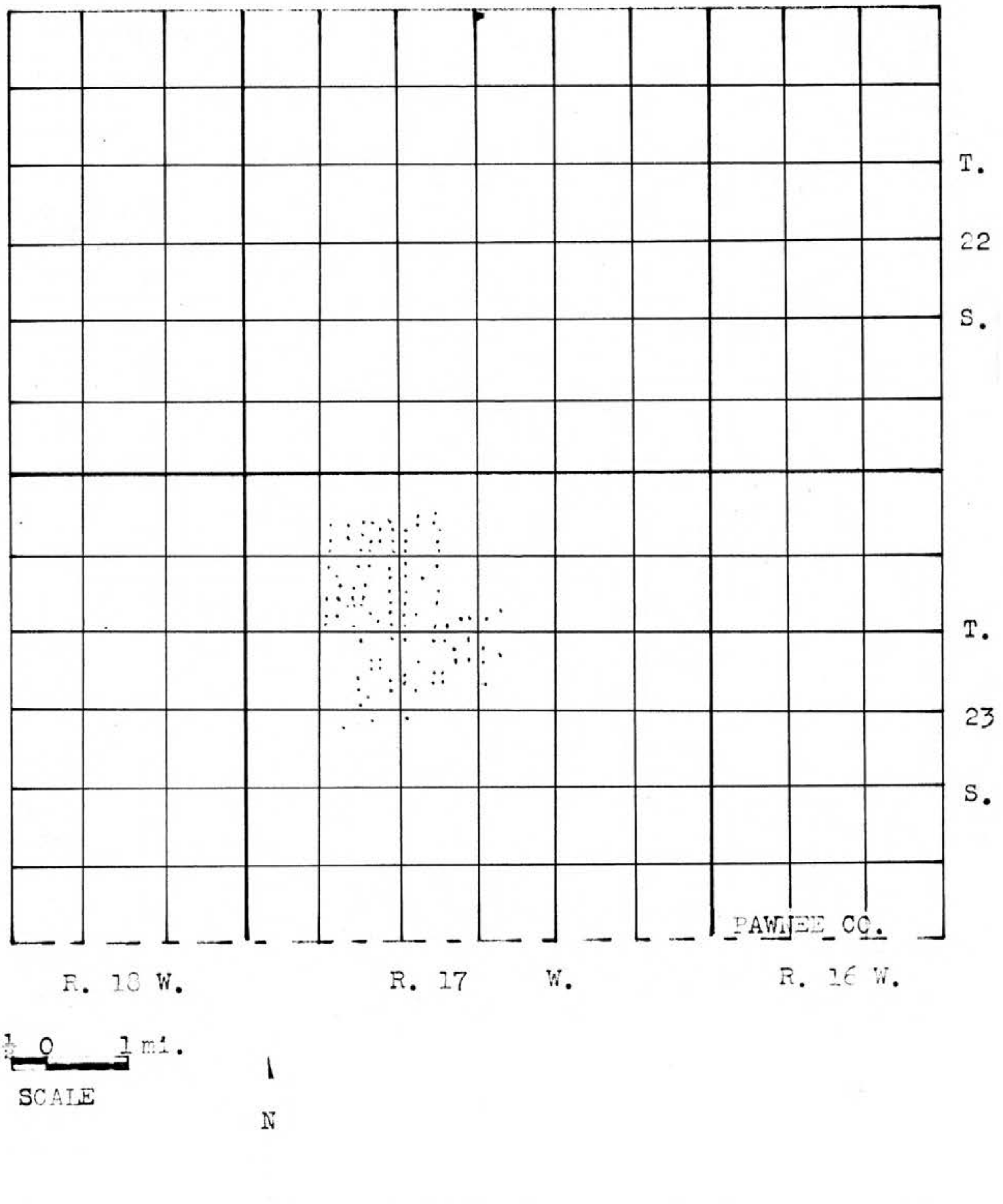



Fig. 12. Map of the Garfield Field Area, showing the locations of control points used for drawing the Central and Southwest gas cap isopachous map.

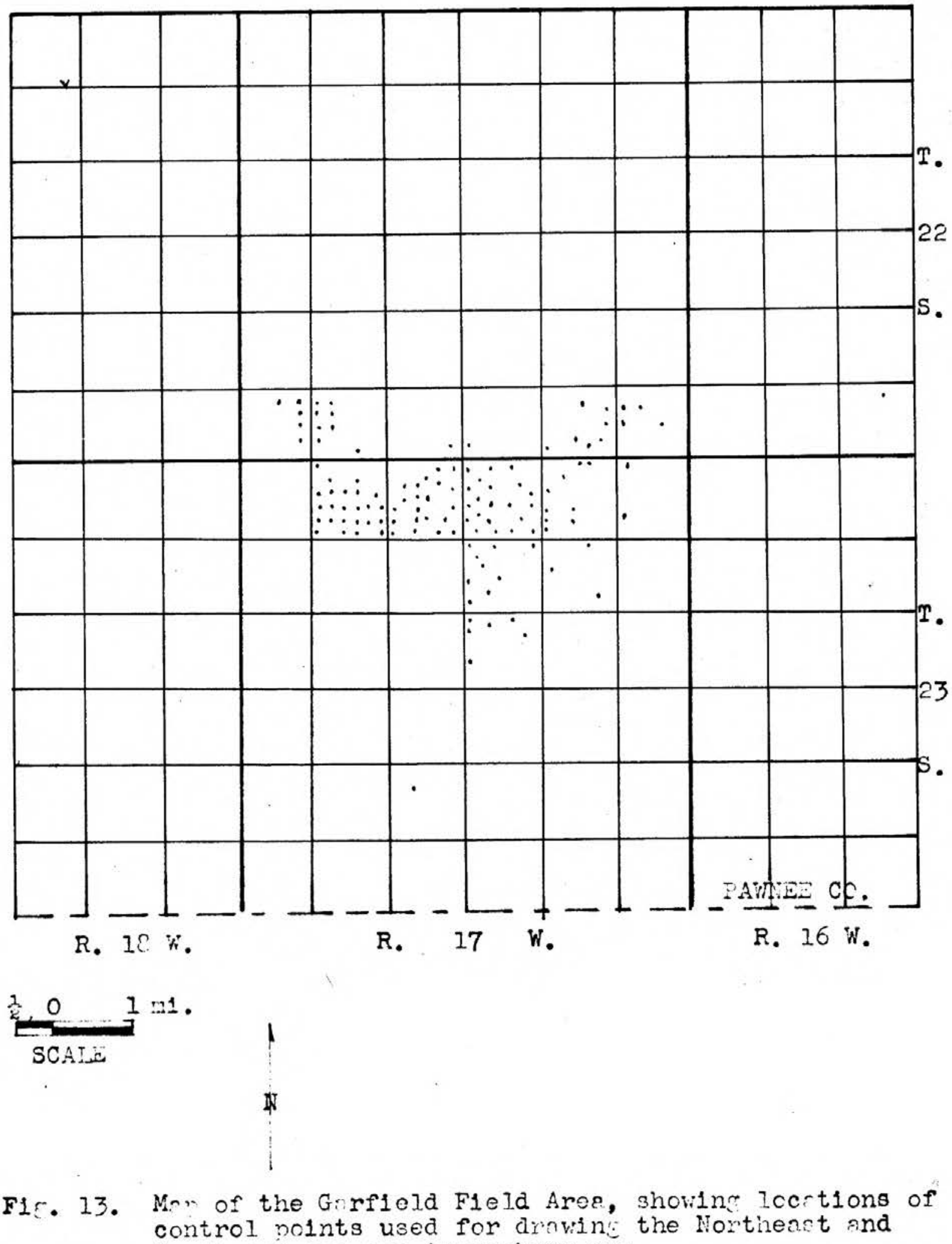



Fig. 13. Map of the Garfield Field Area, showing locations of control points used for drawing the Northeast and Northwest gas cap isopachous map.

# CENTRAL & SOUTHWEST GAS CAPS ISOPACHOUS
## GARFIELD FIELD
## PAWNEE COUNTY, KANSAS

# NORTHEAST & NORTHWEST GAS CAPS ISOPACHOUS
## GARFIELD FIELD
## PAWNEE COUNTY, KANSAS

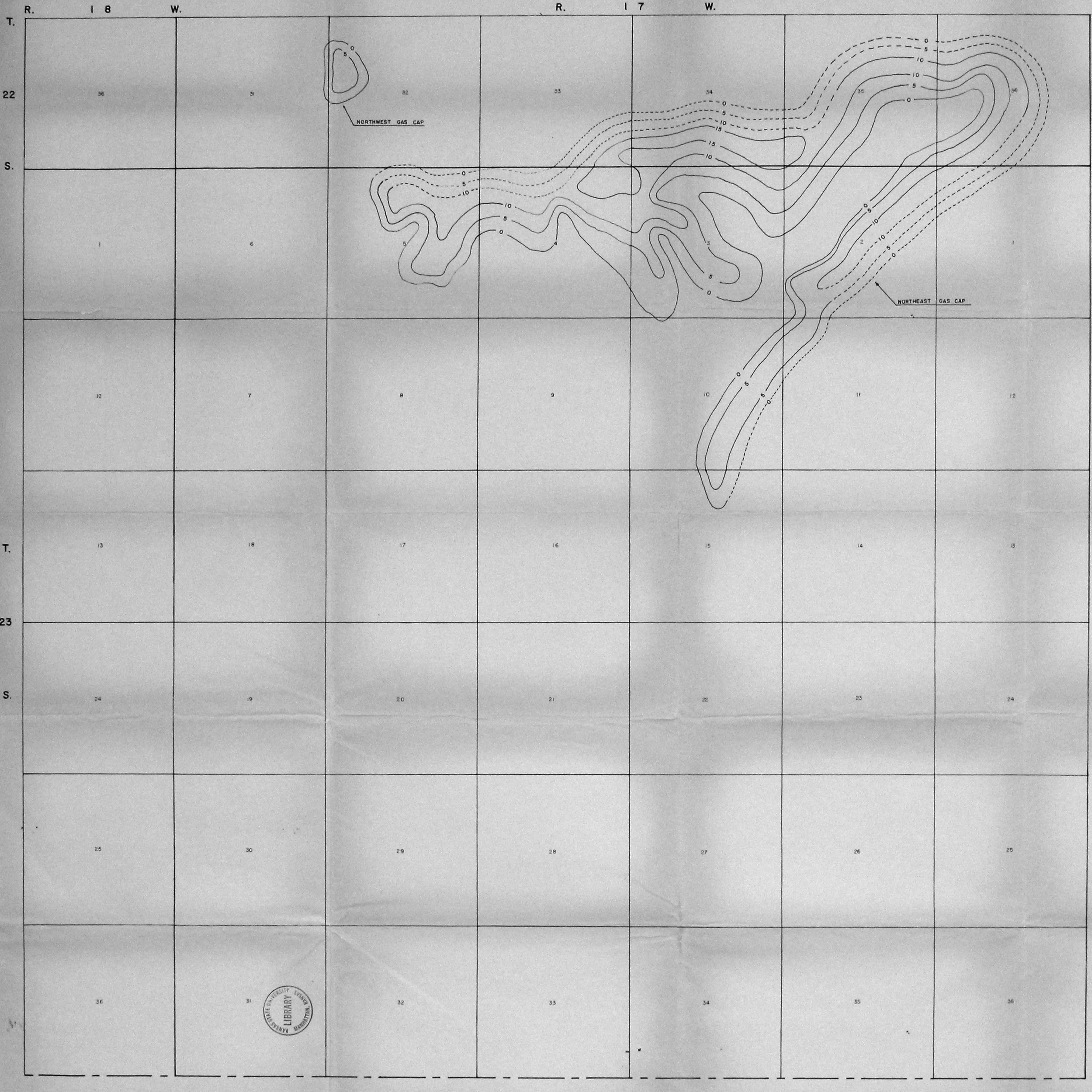





PLATE 3

EXPLANATION

| | |
|---|---|
| Section line | |
| Township line | |
| County line | |
| Section number | 10 |
| Contour line | |
| Contour line (estimated) | |
| Contour interval | 5 feet |

1/2 1/4 1 mile

Scale 4" = 1 mile

Adapted, Dardenne, C. R., 1956

N

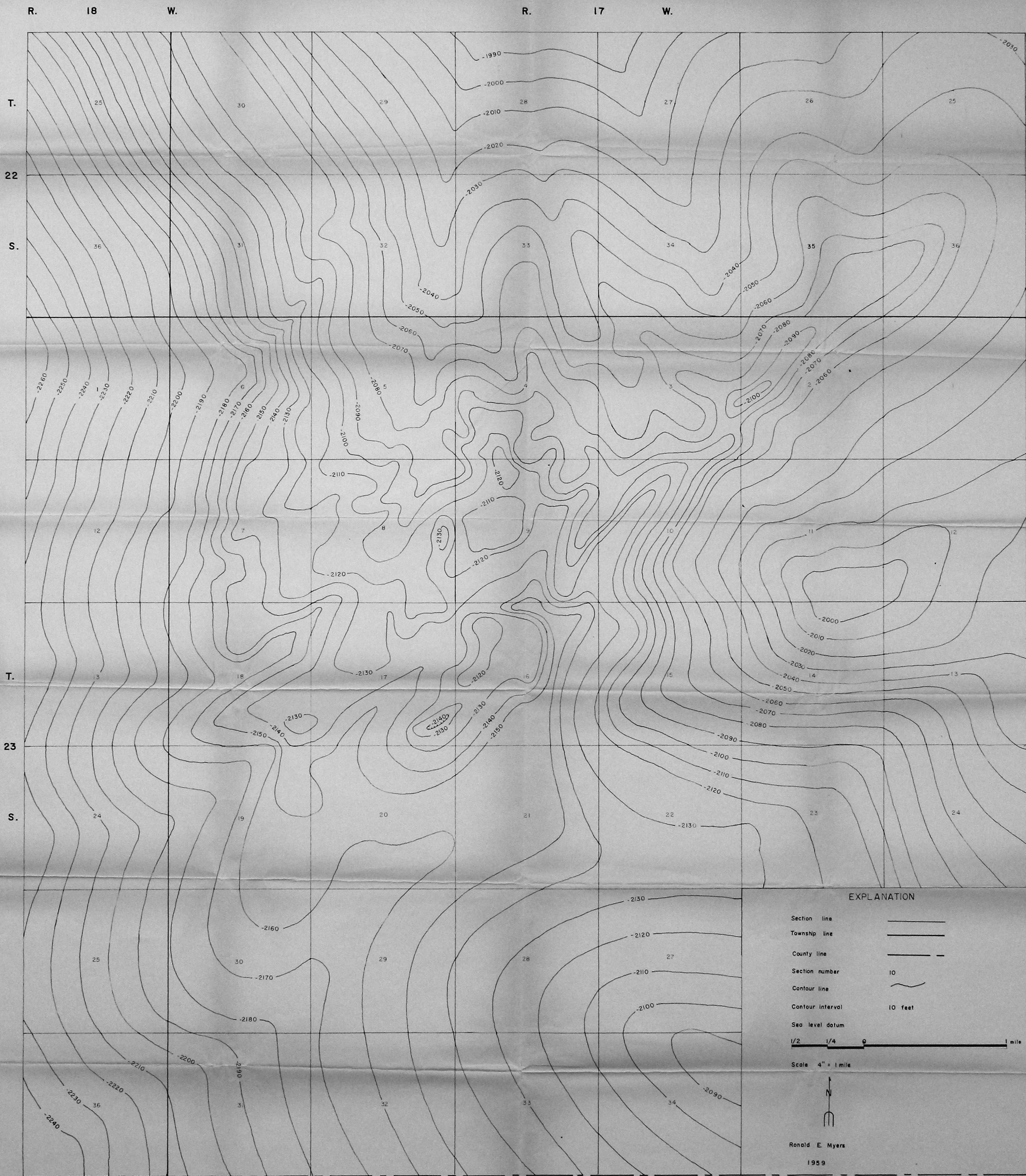
Ronald E. Myers

1959

# Structure Contour Map on the top of the Chert Conglomerate,

# Garfield field area, Pawnee County, Kansas

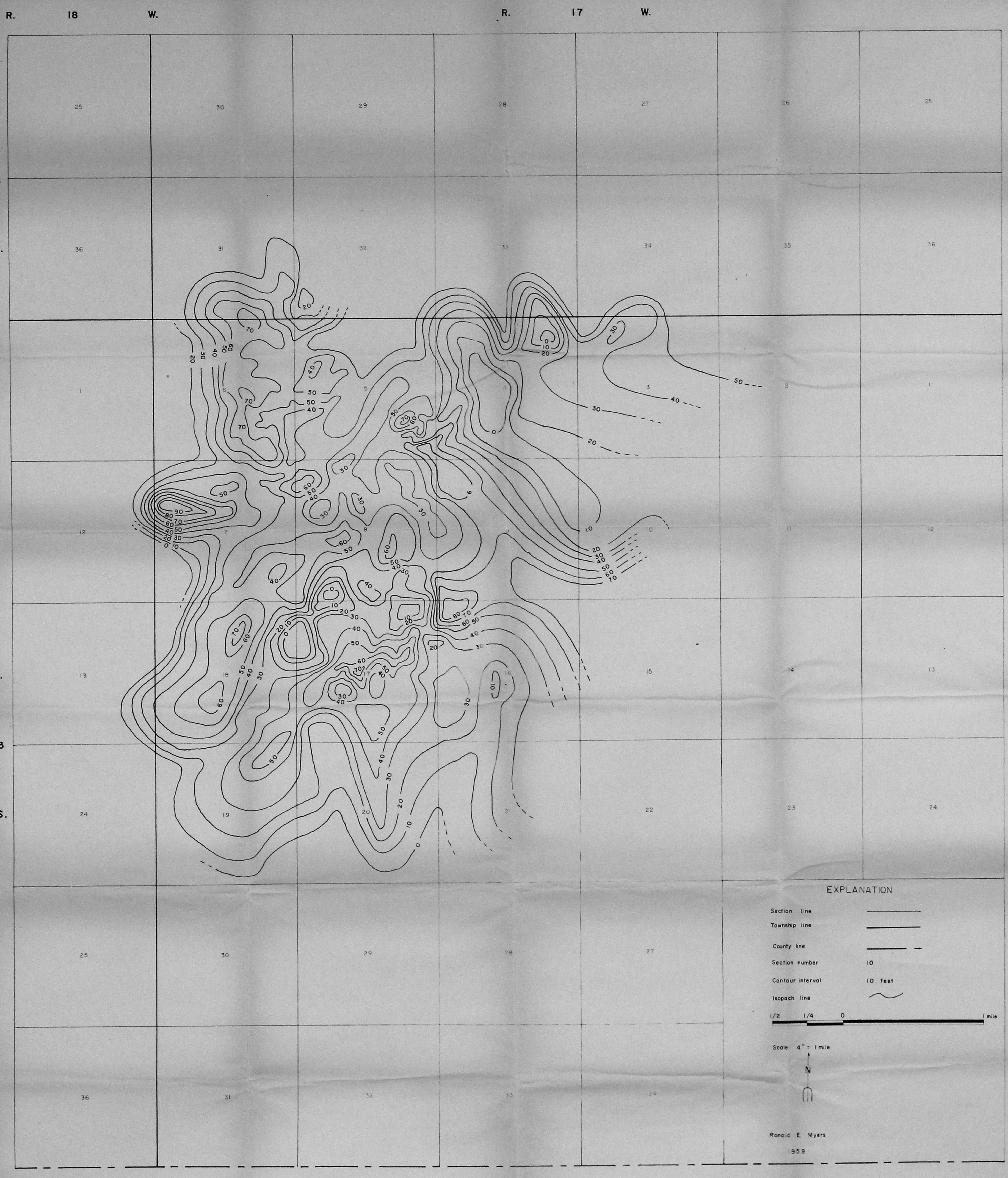
PLATE 4



## Isopachous Map of the Misener sand,

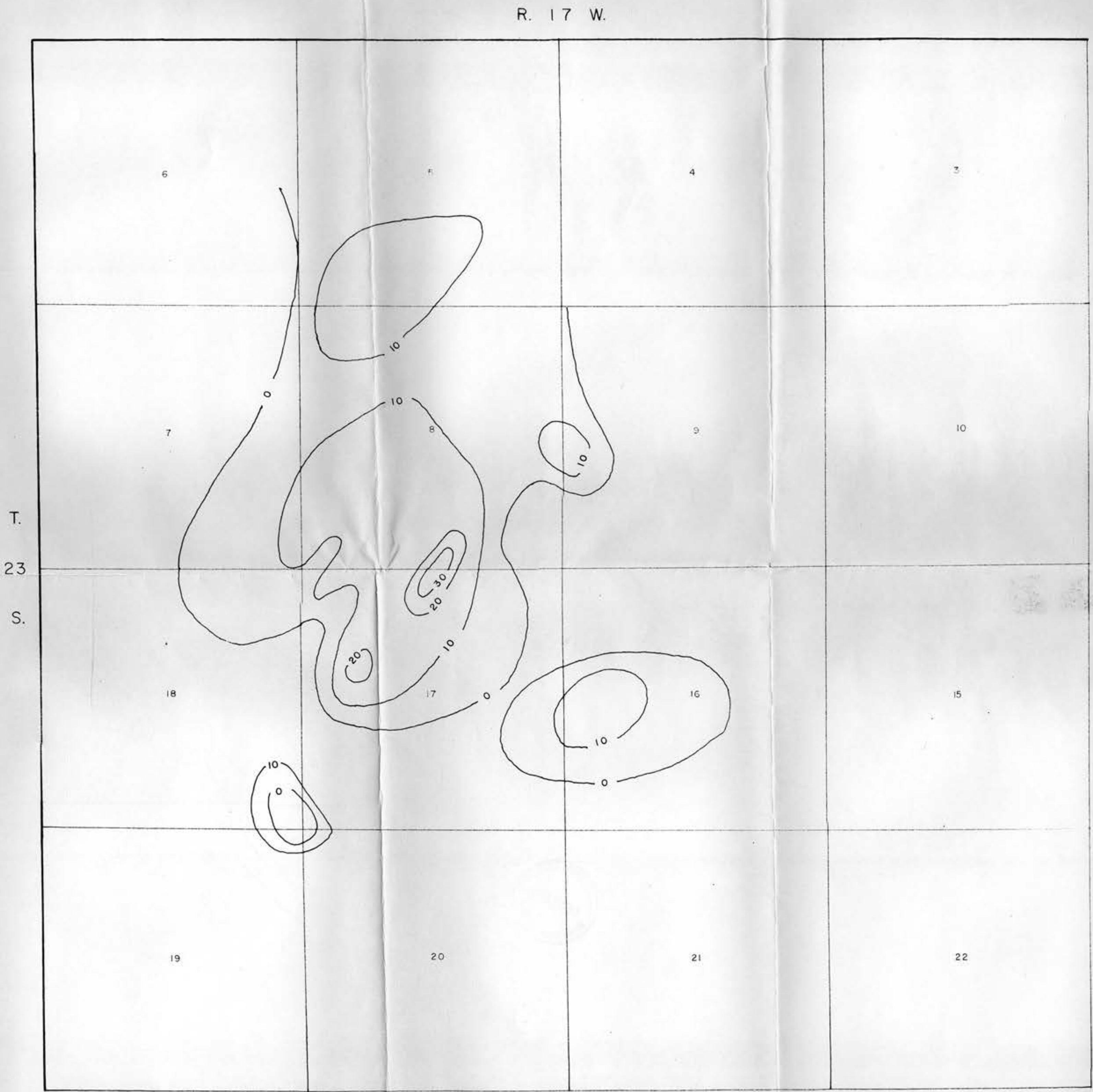
## Garfield field area, Pawnee County, Kansas

PLATE 5



# Structure Contour Map on the top of the Misener sand, Garfield field area, Pawnee County, Kansas

PLATE 6




ISOPACHOUS MAP
OF
MISENER (KINDERHOOKIAN)
NET OIL ZONE
GARFIELD FIELD
PAWNEE COUNTY, KANSAS

PLATE 7

EXPLANATION

| | |
|---|---|
| Township lines | |
| Section lines | |
| Section numbers | 10 |
| Contour lines | |
| Contour numbers | 20 |
| Contour interval | 10 feet |

1/2 1/4 0 1mi.

Scale 4" = 1 mile

Adapted, De Golyer & Mac Naughton 1955

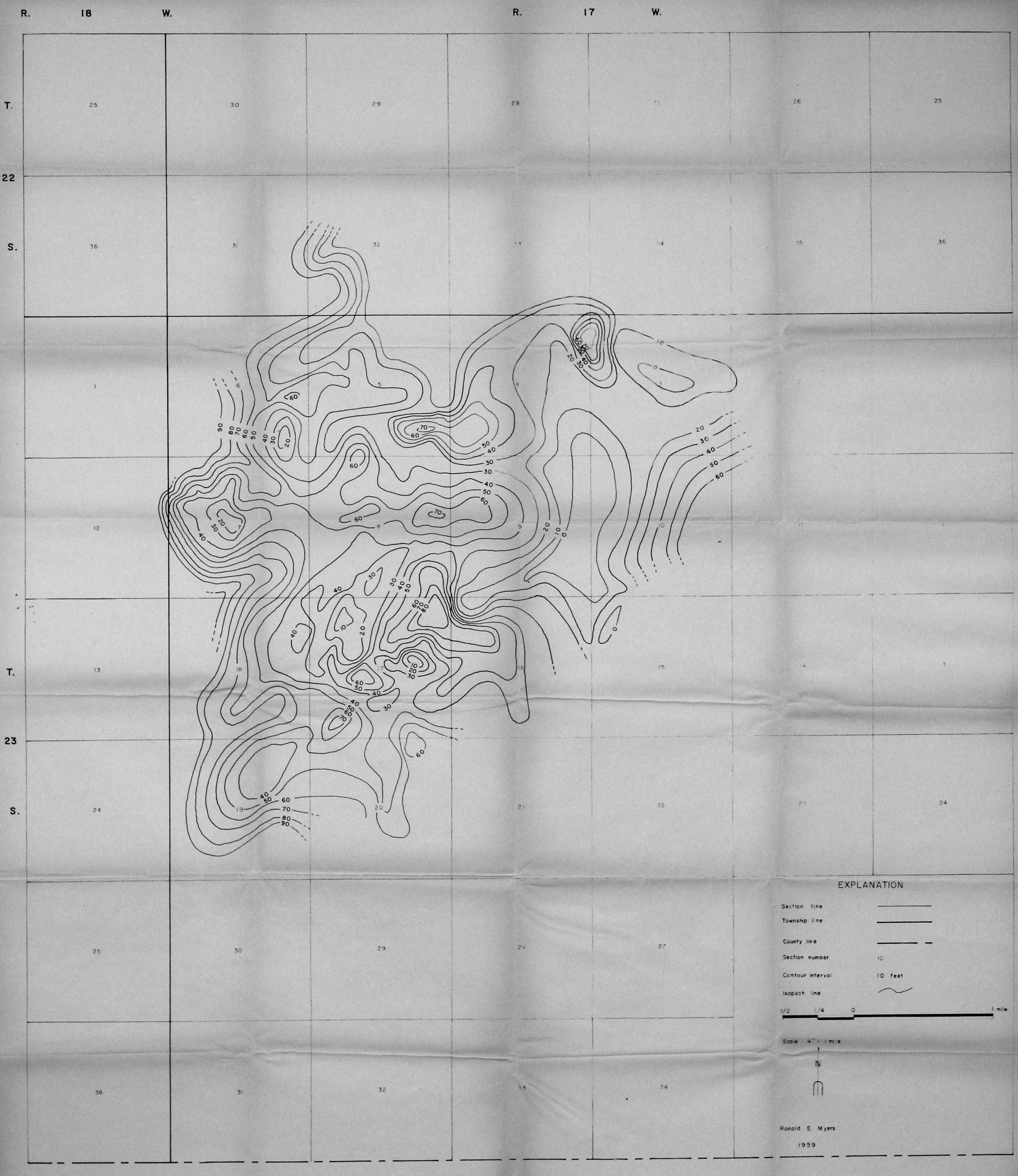
N

Ronald E. Myers
1959

Isopachous Map of the Mississippian limestones,

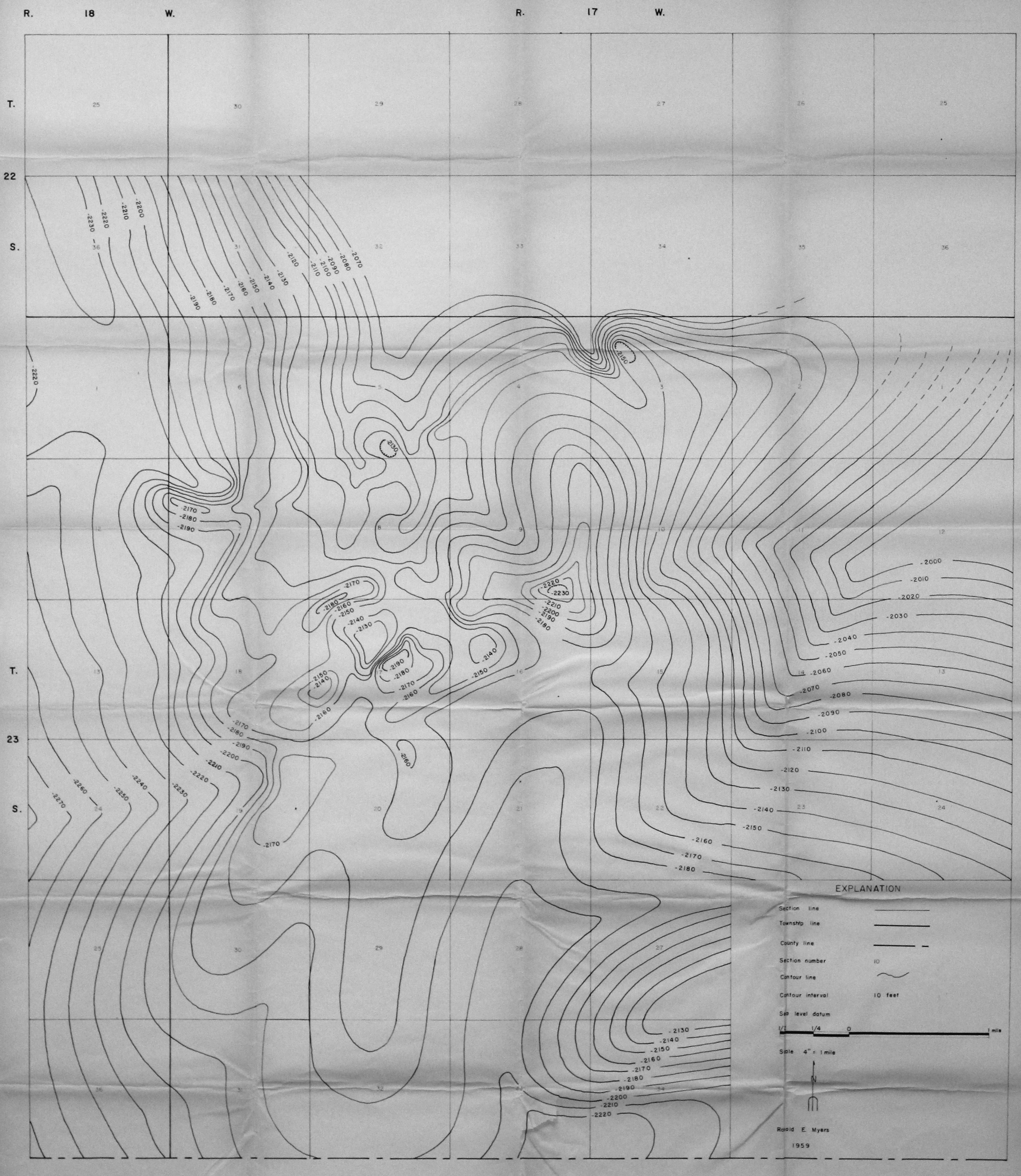
Garfield field area, Pawnee County, Kansas

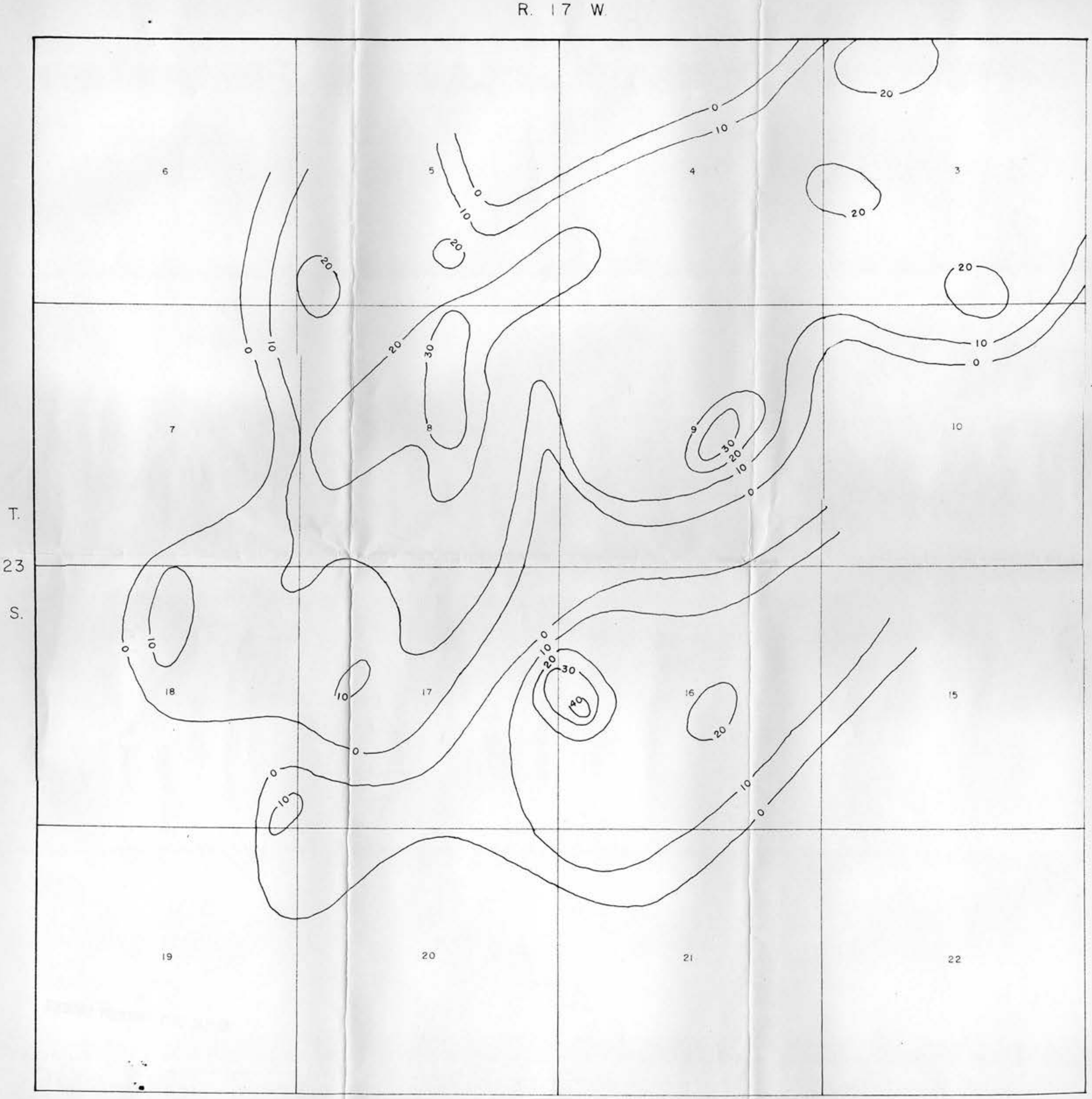
PLATE 8



# Structure Contour Map on top of the Mississippian limestones, Garfield field area, Pawnee County, Kansas

PLATE 9






ISOPACHOUS MAP
OF
MISSISSIPPIAN
NET OIL ZONE
GARFIELD FIELD
PAWNEE COUNTY, KANSAS

PLATE 10

EXPLANATION

Township lines

Section lines

Section numbers 10

Contour lines

Contour numbers 20

Contour interval 10 feet

1/2 1/4 0 1 mi.

Scale 4" = 1 mile

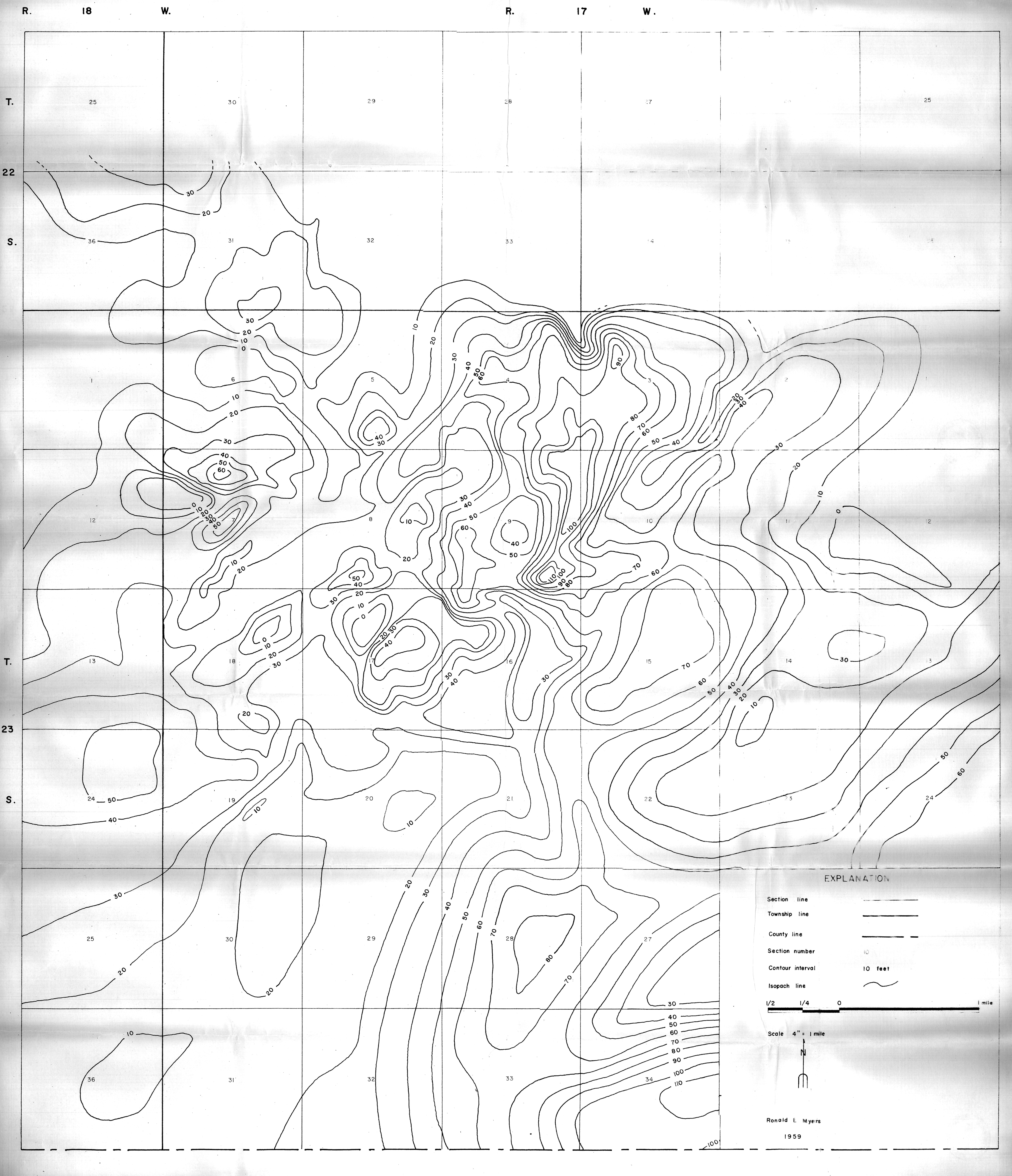
Adapted, De Golyer & Mac Naughton, 1955

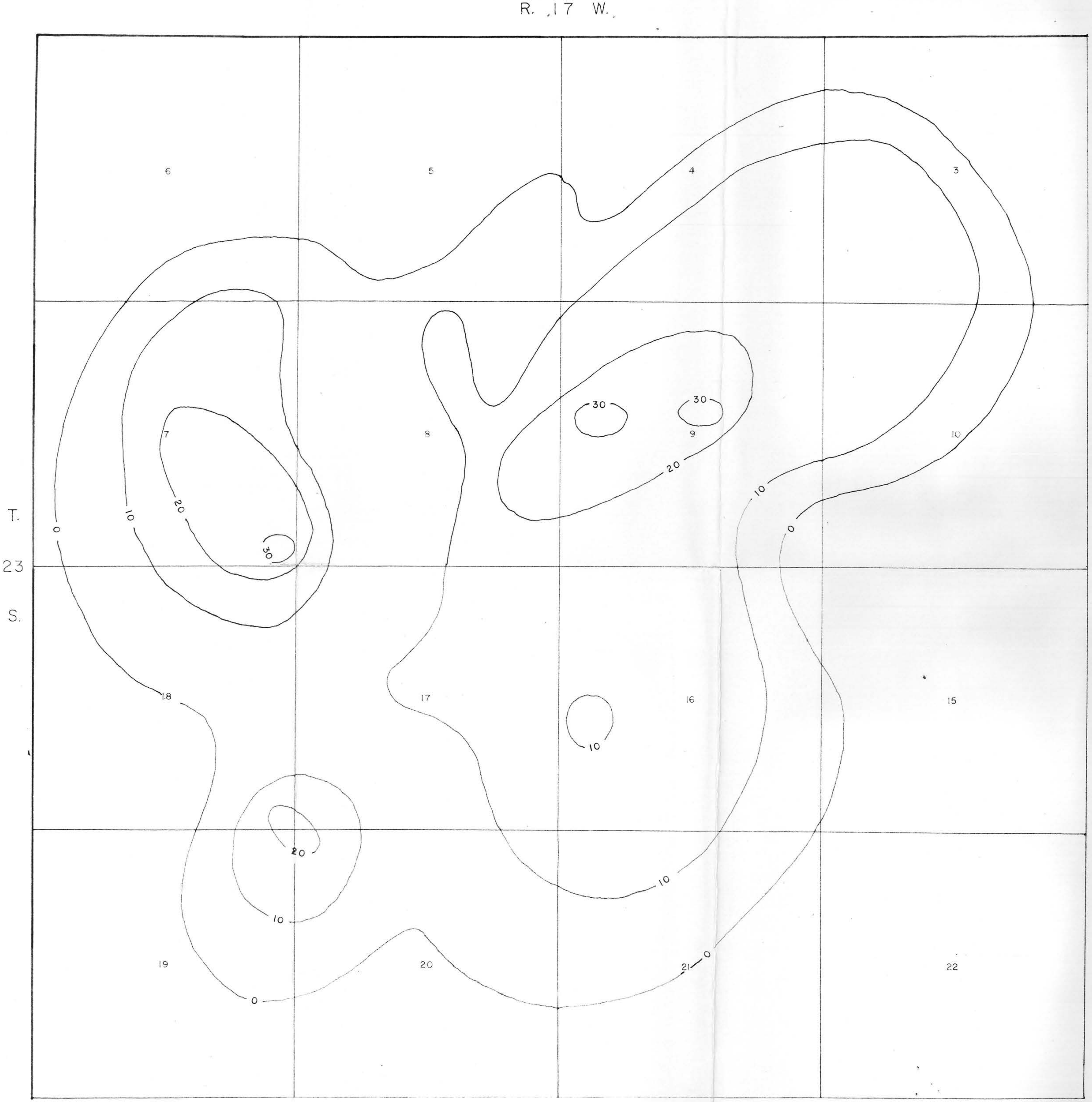
N

Ronald E. Myers
1959

# Isopachous Map of the Chert Conglomerate, Garfield field area, Pawnee County, Kansas

PLATE II






# ISOPACHOUS MAP OF CONGLOMERATE NET OIL ZONE GARFIELD FIELD PAWNEE COUNTY, KANSAS

PLATE 12

EXPLANATION

| | |
|---|---|
| Township lines | |
| Section lines | |
| Section numbers | 10 |
| Contour lines | |
| Contour numbers | 20 |
| Contour interval | 10 feet |

1/2 1/4 0 1m

Scale 4" = 1 mile

Adapted, De Golyer & Mac Naughton, 1955

N

Ronald E. Myers
1959


# ISOPACHOUS MAP OF RESERVOIR NET OIL ZONE GARFIELD FIELD PAWNEE COUNTY, KANSAS

**PLATE 13**

## EXPLANATION

| | |
|---|---|
| Township lines | |
| Section lines | |
| Section numbers | 10 |
| Contour lines | |
| Contour numbers | 20 |
| Contour interval | 10 feet |

1/2 1/4 0 1 mi.

Scale 4" = 1 mile

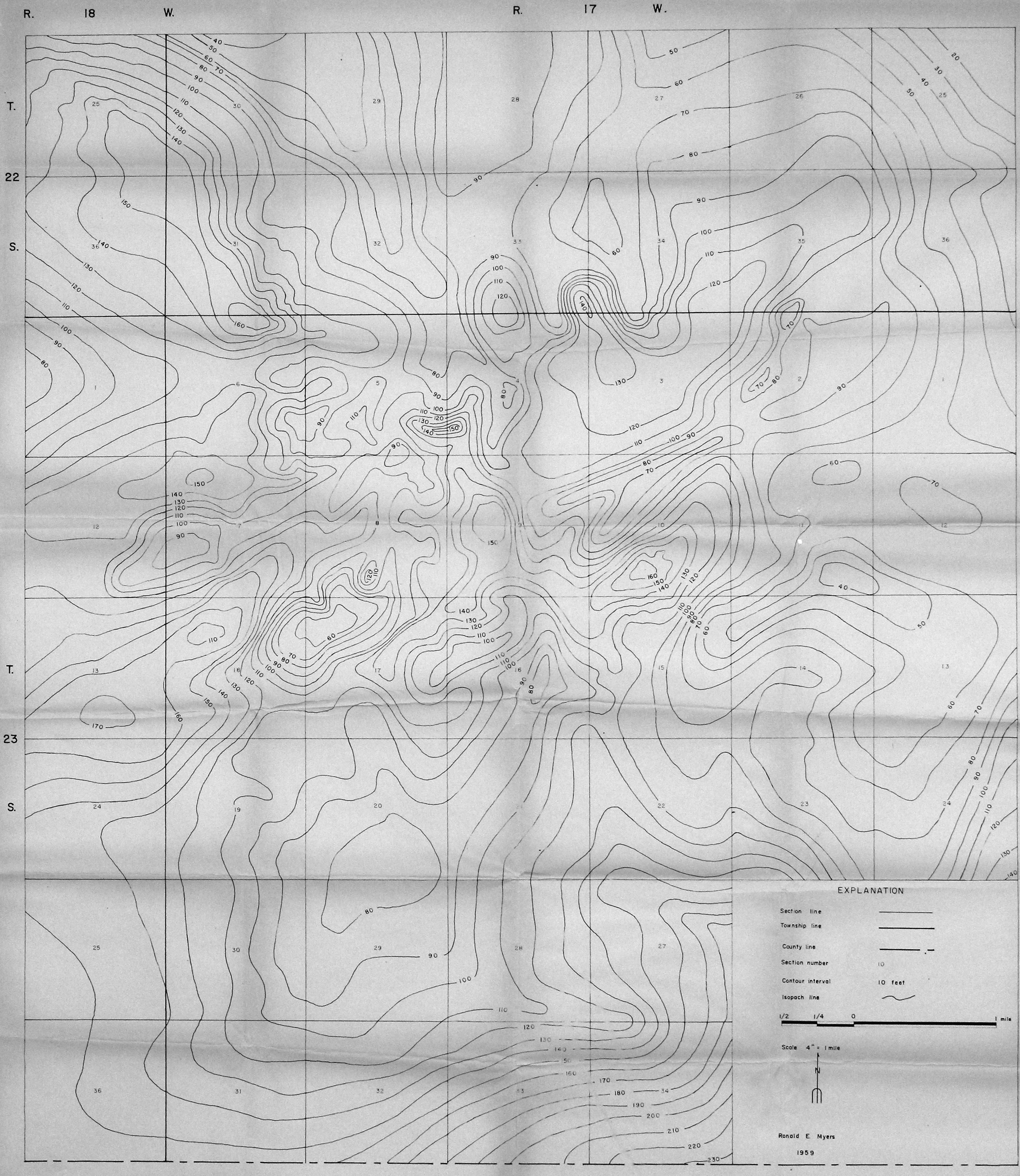
N

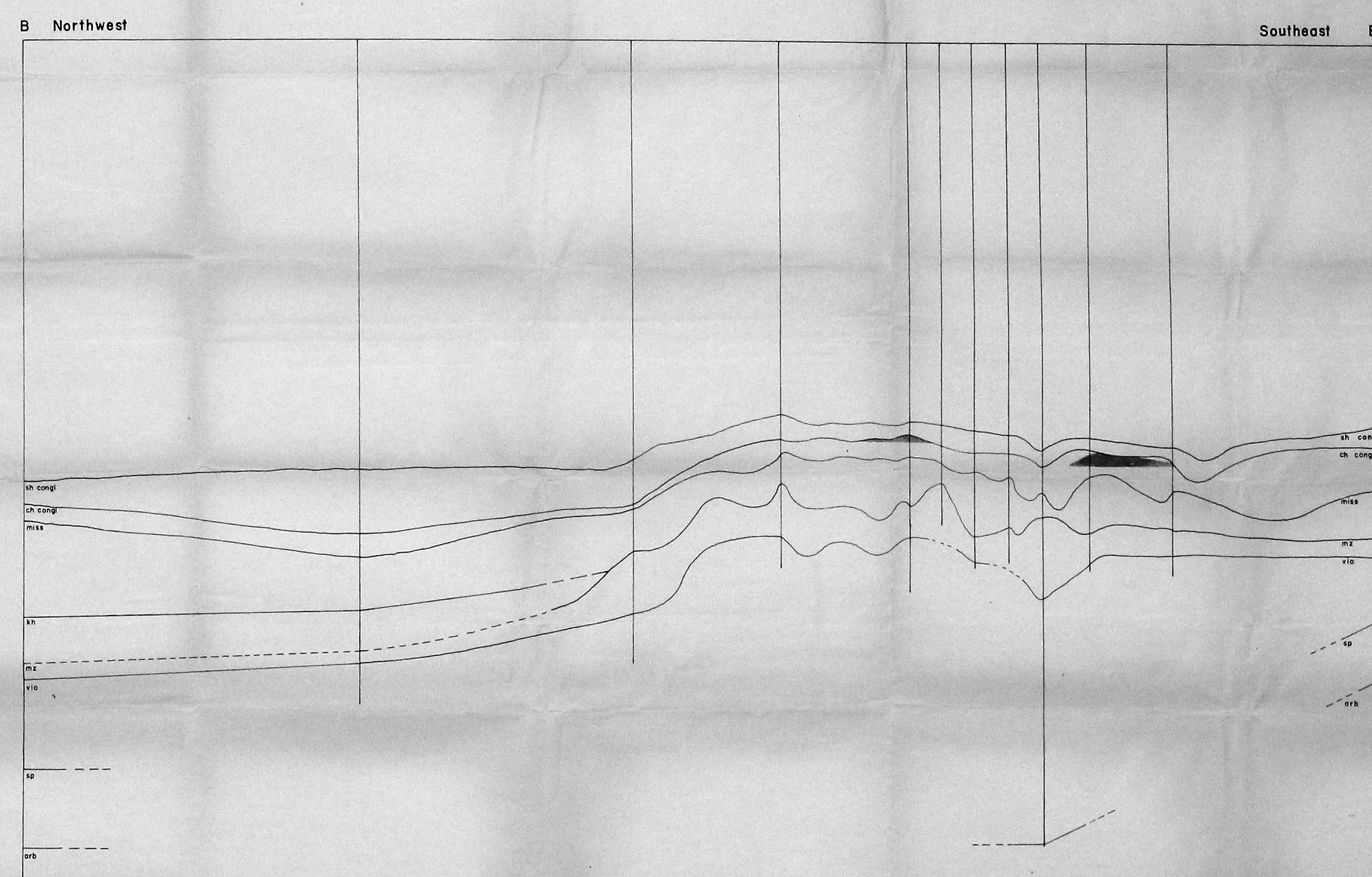

Ronald E. Myers
1959

# Isopachous Map of the Reservoir Rocks,

# Garfield field area, Pawnee County, Kansas

PLATE 14




# Cross sections of the Garfield field area, Pawnee County, Kansas

PLATE 15

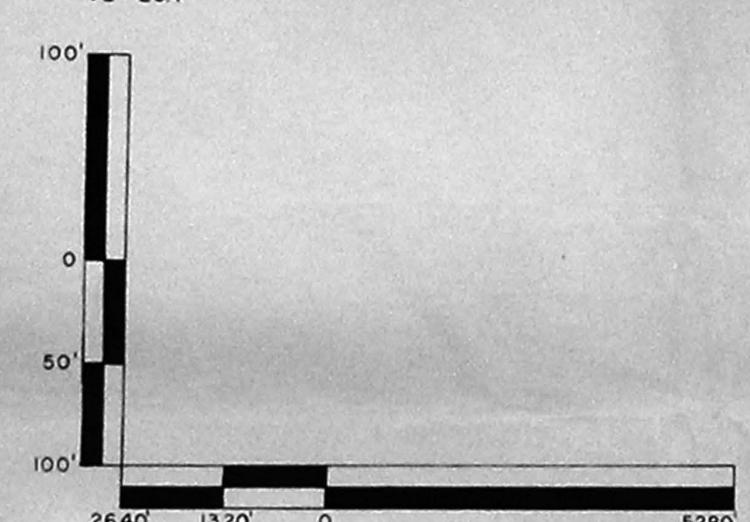
EXPLANATION

| Symbol | Formation |
|---|---|
| sh congl | shale conglomerate |
| ch congl | chert conglomerate |
| miss | Mississippian |
| kh | Kinderhook shale |
| mz | Misener sand |
| vio | Viola limestone |
| sp | Simpson group |
| arb | Arbuckle group |

Gas Accumulation

Datum sea level

VE = 26.4




Scale

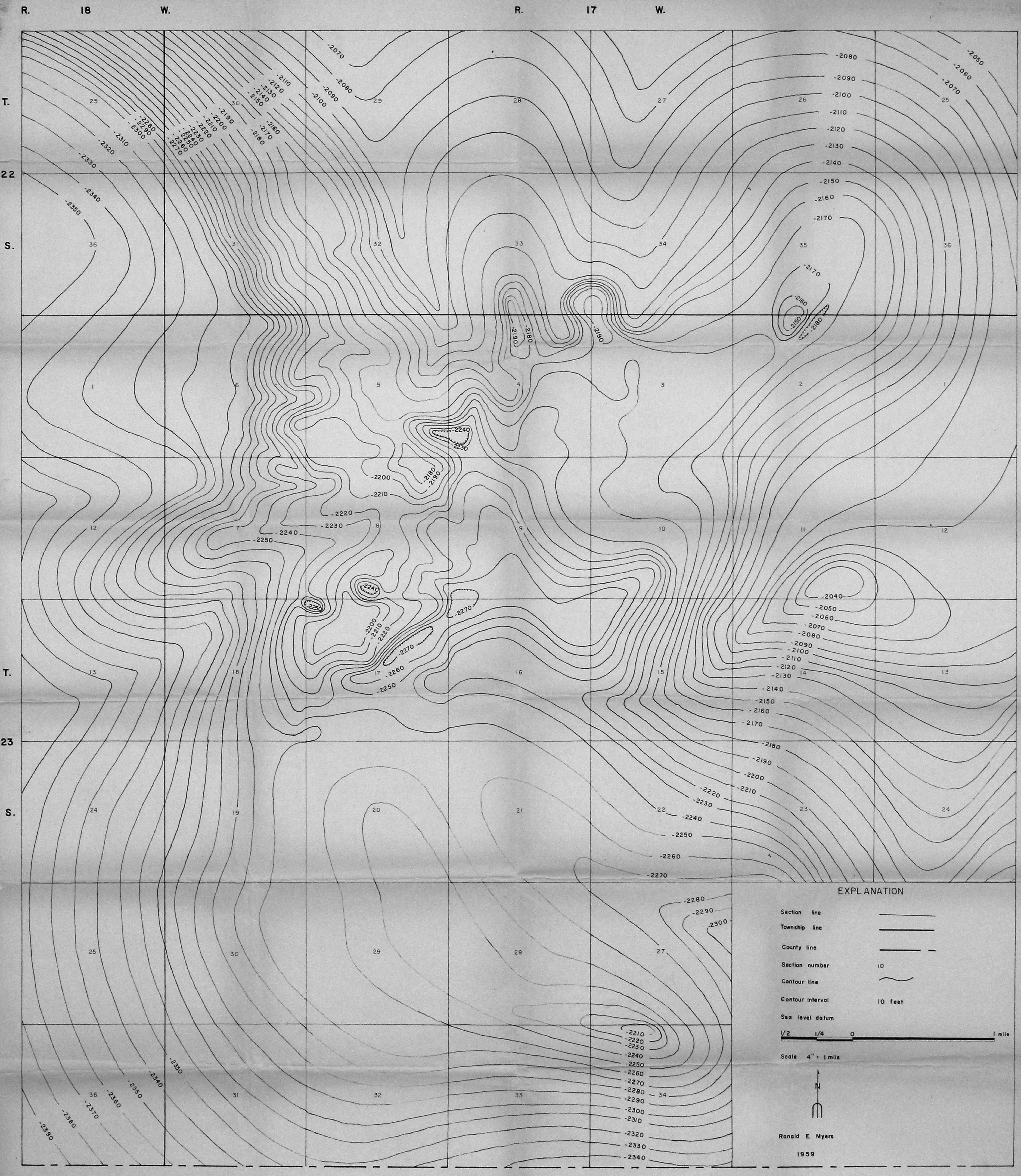
Ronald E. Myers

1959

# Structure Contour Map on the top of the Viola limestone,

# Garfield field area, Pawnee County, Kansas

PLATE 16



# GEOLOGIC FACTORS OF THE GARFIELD FIELD AREA, PAWNEE COUNTY, KANSAS, IN RELATION TO PETROLEUM ACCUMULATION

by

RONALD EUGENE MYERS

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

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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

1959

This study is an analysis of geologic factors associated with accumulation of petroleum in the Garfield Field Area, Pawnee County, Kansas. Garfield Field occupies an area of approximately 22 square miles in the vicinity of Garfield, Pawnee County, Kansas, 11 miles southwest of the City of Larned and 15 miles northeast of Kinsley. Garfield Field lies within the Great Bend Lowland area of the Great Plains physiographic province.

Four subsurface structure maps, four isopach maps and two cross sections were constructed. These maps were compared with isopach maps of the net oil zones of Pennsylvanian basal conglomerate, Mississippian limestones and Misener sandstones and isopach maps of gas accumulation to determine geologic conditions within areas of petroleum accumulation.

The discovery well of the Garfield Field Area was drilled in 1947. This single well comprised Garfield Field until abandoned in early 1953. Garfield Field was revived upon completion of the Hutchinson Estate "B" number 2 well in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 17, T. 23 S., R. 17 W., October 28, 1953. Production was from Misener sand of Mississippian age. Subsequent development has proved the Pennsylvanian basal conglomerate and Mississippian "chat" also to be oil reservoirs. By 1957 cumulative production exceeded 1,900,000 barrels. Presently, 265 oil wells are producing in Garfield Field.

Accumulation of petroleum in the Garfield Field Area is associated with the following structural and stratigraphic features: (1) a large anticlinal nose plunging southwest from the major structural feature of the area, the Central Kansas Uplift, (2) truncation of Misener and Mississippian formations in the northeast Garfield Field Area, (3) presence of an impermeable seal above all producing formations, (4) lateral changes in effective porosity and permeability, (5) local anticlinal "highs" and terraces superimposed on a structural nose, (6) permeable bedding and unconformity planes, (7) structural "highs" north and east of Garfield Field, and (8) a porosity "pinchout" northeast of Garfield Field.

Gas accumulation may be found in Garfield Field in folds which are associated with structural closure at the surface of a disconformity, where the irregular Pennsylvanian basal conglomerate erosional surface is overlain by impervious "shaly" conglomerate.

Possibilities for discovery of additional petroleum reserves in the Garfield Field Area are limited. A detailed study of reservoir characteristics would be required before secondary recovery methods could be used.