SUBSURFACE GEOLOGY OF ELLIS COUNTY, KANSAS

by

DONALD DEAN CARR

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

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

TABLE OF CONTENTS

INTRODUCTION

Purpose of Investigation

The purpose of this investigation is to study the geologic history, subsurface structure and stratigraphy of Ellis County, Kansas with intent to analyze and determine the relationship of these geological factors to the accumulation of petroleum.

Area Covered by the Report

Ellis County is in north-central Kansas (Fig. 1). It is bordered on the north by Rooks County, on the east by Russell County, on the south by Rush County, and on the west by Trego County. It consists of townships 11, 12, 13, 14, and 15 south, and ranges 16, 17, 18, 19, and 20 west. It contains 25 townships and has an area of approximately 900 square miles. It is located in the Great Plains physiographic province and comprises an area of relatively low topographic relief; however, in the subsurface, Ellis County is on the crest of the Central Kansas uplift (Fig. 3). The general stream drainage is to the east by the Smoky Hill and Saline Rivers and Big and Victoria Creeks.

Surface Geology

Ellis County is underlain by rock of Cretaceous age which outcrop on the surface and dip regionally to the north at a rate of ten feet to the mile. In addition, patches of Tertiary deposits overlying the Cretaceous rocks remain on parts of the upland and materials of Quaternary age have been deposited in the stream valleys. The primary Quaternary deposits consist of Pleistocene terraces that were laid down by the major streams. The position of the Pleistocene terraces in the stream valleys indicates that the streams flowed at a higher level during Pleistocene time than they do at the present time.

Procedure

The two major oil producing horizons in Ellis County belong to the Arbuckle group of Cambrian-Ordovician age and the Lansing-Kansas City groups of Pennsylvanian age. Structural maps were prepared of the top of the Arbuckle group and the top of the Lansing group. An isopach map was prepared between the top of the Arbuckle group and the top of the Lansing group. All elevations were taken from Herndon Maps and from driller's logs on file at Kansas State College. Cross sections were prepared from Herndon Maps and from radioactive well logs.

Previous Work

Previous subsurface work in Ellis County has seen limited publication; however, there are regional reports, surface studies, and annual publications of oil and gas development that include Ellis County. Limited subsurface studies have been made by Frye and Brazil (1943), Latta (1948), Koester (1935), and Farquhar (1957). Annual publications of oil and gas developments in the county have been made by Ver Weibe (1939), and Goebel et al.(1956).

History of Oil Production in Ellis County

Ellis County had its first oil production in commercial quantities in 1928 when Phillips Petroleum Company opened their No. 1 Shutts in the center N. E. $\frac{1}{4}$, sec. 5, T. 12 S., R. 17 W. at a depth of 3,569 to 3,575 feet. This became known as the North Ellis field. The finding of commercial quantities of oil was the impetus needed to probe the extent of the field and it encouraged a considerable amount of wildcat activity. By 1929 the North Ellis field became well established and another field, the Yocemento field, was opened by Phillips Petroleum Company. Both of these wells reached production in the Arbuckle group. The No. 1 Shutts well has the distinction of being the first well to find commercial production of oil in the Arbuckle group in western Kansas (Ver Weibe, 1939).

The largest pool in the county is the Bemis pool that was opened in October 1935. It covers approximately 3,200 acres. This pool has produced 85,422,605 barrels of oil to the end of the year 1956, or almost half of the total production of oil for the entire county.

At the end of 1956, Ellis County ranked 6th among counties in total cumulative production with 192,577,302 barrels. For the year 1956, Ellis County was second among counties for yearly production with 11,618,360 barrels and first among counties in the number of new pools discovered (Goebel et al., 1957).

STRATIGRAPHY

Quaternary System

The Quaternary sediments include deposits of Recent alluvium and Pleistocene sands and gravels. The alluvium deposits in the county are from 0-40 feet in thickness and consist of gravel, sand, silt, and clay underlying valley flats and along major streams. Pleistocene deposits are from 0-75 feet in thickness and consist of gravel, sand, silt, clay, and volcanic ash (Frye and Brazil, 1943). Most of the gravels consist of igneous and limestone pebbles with the exception of the Holdrege formation. This formation consists principally of pebbles of chalk believed to have been removed from the Niobrara formation (Frye and Leonard, 1952).

Tertiary System

The Tertiary system consists of the Ogallala formation in the uplands of Ellis County where it lies unconformably over Cretaceous rocks. It consists of gravels, sands, silts, and clay and is locally cemented with calcium carbonate. It has a thickness that ranges from 0-50 feet.

Cretaceous System

The rocks of the Cretaceous system overlie unconformably the Permian beds and are overlain unconformably by Tertiary sediments. Most of the Cretaceous sediments are believed to have been deposited in a marine type of environment. An exception is the Dakota formation that is believed to have been deposited in a continental environment (Moore, 1951).

Gulfian Series. Colorado Group. The Niobrara formation underlies much of the upland area of central and northern Ellis County. At no place in the area does the entire thickness of the formation occur, as the upper portion has been eroded away before deposition of Tertiary sediments. The maximum thickness of this formation is approximately 150 feet (Frye and Brazil, 1943).

Bass (1926) has described the two members of the Niobrara formation: the Smoky Hill chalk member (upper) and the Fort Hays limestone member (lower). The Smoky Hill chalk is a bluish-gray chalky shale containing thin beds of bentonite. The Fort Hays member is a massive cream-colored chalky limestone that is separated by thin layers of light gray to dark gray chalky clay shale. In contrasting the two members, the Fort Hays member appears slightly coarser in texture and somewhat harder.

The Carlile shale underlies all of the uplands of Ellis County and has a maximum thickness of approximately 300 feet. The upper two-thirds of the formation consists predominantly of gray-black fissle clay shale, and the lower one-third is a chalky shale with thin beds of chalky limestone. This upper portion is called the Blue Hill shale member and the lower member has been named the Fairport chalky shale member.

The Greenhorn limestone lies directly beneath the Carlile shale and ranges in thickness from 85-110 feet. It consists of interbedded shale and limestone. The shale is calcareous, tan to blue-gray; while the limestone is thin bedded, gray and fossiliferous. The formation is subdivided into the following members: Pfeifer shale, Jetmore chalk, Hartland shale, and Lincoln limestone.

The Graneros shale consists of dark gray to blue-gray shale and is directly beneath the Greenhorn limestone. The shale is fissle, noncalcareous, and is characterized by selenite crystals and pyrite. Locally there are thin beds of sandstone. The Graneros shale is approximately 25 feet in thickness in the northern part of Ellis County and thickens to approximately 40 feet in the southern part of Ellis County.

The Dakota formation directly underlies the Graneros shale and attains a maximum thickness of approximately 300 feet. It is a continental deposit and contains clay, shale, siltstone, and sandstone that are interbedded and varicolored. It contains abundant siderite, hematite, limonite,and some lignite. The formation is sub-divided into two members, the Janssen clay member (upper) and the Terra Cotta clay member (lower). The Dakota formation can be distinguished in well cuttings by the appearance of siderite, both in angular fragments with inclusions of fine sand and silt and in small globular concretions, and by the appearance of kaolin clay minerals (Plummer and Romary, 1942).

Comanchean Series. The Kiowa shale underlies the Dakota formation and consists of sediments with a maximum thickness of 100-125 feet. It is primarily a black shale containing thin beds of sandstone and siltstone, and crystals of gypsum and pyrite. It is a marine deposit and contains marine invertebrate fossils.

The Cheyenne sandstone varies in thickness from 0-200 feet and is composed of medium to fine grained particles. It consists dominantly of moderately well sorted quartz sand with a gray color. It has thin interbeds of shale and is thought to be a fluctuating non-marine, near-shore deposit. The deposit tends to thicken toward the western part of Ellis County (Plummer and Romary, 1942).

Jurassic System

There are no sediments of recognized Jurassic age in Ellis County.

Triassic System

There are no sediments of recognized Triassic age in Ellis County.

Permian System

The Permian beds of Ellis County are divided into an upper series (Leonardian) and a lower series (Wolfcampian) by the Kansas Geological Survey. The upper series (Leonardian) is composed primarily of red and gray shales, sandstones and thin beds of salt, gypsum, and anhydrite. The lower series (Wolfcampian) consists predominantly of limestones and dolomite rocks with alternating shale beds (Landes and Keroher, 1942). The Permian rocks are separated from the overlying Cretaceous by an angular unconformity.

Leonardian Series. Nippewalla Group. This group consists of alternating beds of red and gray sandstone, red siltstone, and shale. The Permian rocks are easily distinguished from the overlying Cretaceous beds in well cuttings by their brick-red color and fine textured sandstones (Frye and Brazil, 1943).

Sumner Group. This is the lower group of the Leonardian series and includes the Stone Corral dolomite, the Ninnescah shale, and the Wellington formation. The Stone Corral formation consists largely of white to light-gray crystalline anhydrite. It has a sugary texture and is locally dolomitic near the base. This formation is a good marker bed because of its ease of identification in well cuttings, radioactive logs, electric logs, and seismograph records. Below the Stone Corral dolomite is the Ninnescah shale. It consists primarily of red shales with sand and anhydrite. Below the Ninnescah shale is the Wellington formation which is chiefly a silty shale with some anhydrite and halite.

Wolfcampian Series. Chase Group. This group is composed chiefly of red and gray shales interbedded with limestone or dolomitic limestone. The limestones are usually cherty. It is these resistant chert beds that form the Flint Hills cuesta of eastern Kansas.

Council Grove Group. The Council Grove group consists of alternating beds of limestone and shale. The shales are usually medium to dark gray and red, and the limestones vary in color from white to brown. The limestones have a grannular texture and in places contain chert. The Cottonwood limestone member of the Beattie limestone formation in this group is a good marker bed because of its abundant fusulinids (Moore, et al., 1951). The Americus limestone member of the Foraker limestone is at the bottom of this group and is recognized because of its bluish-gray color and abundance of fusulinids and brachiopods. The approximate thickness of this group is 260 feet.

Admire Group. The Admire group is the lowermost section in the Permian system and lies unconformably over Pennsylvanian rocks. It consists of a basal sandstone, red and gray shales, and thin, finely crystalline limestone beds. The approximate thickness is 50 feet.

Pennsylvanian System

Virgilian Series. This series of rocks comprise the youngest Pennsylvanian rocks of the mid-continent region. They are separated from rocks above and below by unconformities. The series is divided into three groups on the basis of general differences in lithology and the nature of cyclic deposition (Moore, et al., 1951).

Wabaunsee Group. The Wabaunsee group is the uppermost group of rocks of the Pennsylvanian system and they lie unconformably below rocks of Permian age. The Wabaunsee group consists of the Richardson subgroup, the Nemaha subgroup, and the Sacfox subgroup. The group consists primarily of alternating beds of limestone and shale. The limestones are usually gray to blue-gray in color, massive, and quite abundant in fossils. The shales are also gray and quite often sandy. The approximate thickness is 550 feet.

Shawnee Group. The Shawnee group comprises alternating beds of limestone and shale. The uppermost formation is the Topeka limestone which is white to gray in color and with a finely crystalline texture. The shales are predominantly gray to blue-gray and often clayey and sandy. A distinctive formation in this group is the Heebner shale member of the Oread limestone. This is a black organic shale that is easily identified on radioactive logs because of its very strong gamma ray emanations. It has a thickness of approximately five feet. The basal member of the Oread limestone is the Toronto limestone member. It is easily picked in well cuttings due to its proximity to the Heebner shale. It is a brownish-gray limestone that is quite massive and contains flint. The total thickness of this group is approximately 200 feet.

Douglas Group. The Douglas group conformably underlies the Shawnee group, but is unconformable with the underlying Pedee group. This group is predominantly composed of sandstones and shales. The sandstones are tan to gray, and partly cross bedded. The shales are gray, calcareous and locally sandy. The thickness of this group is approximately 20 feet.

Missourian Series. Pedee Group. The Pedee group consists of the Iatan limestone and the Weston shale. The Iatan limestone is a white to a light bluish-gray limestone with a fine crystalline texture. The Weston shale is a dark bluish to bluish-gray clay shale that is nonfossiliferous.

Lansing Group. The Lansing group consists of alternating beds of limestone and shale. The limestones are recognized as being white to gray, finely crystalline and only slightly fossiliferous. They tend to be quite uniform in thickness throughout Ellis County. The shales are gray to black and also sparsely fossiliferous. The thickness of this group is approximately 90 feet.

Kansas City Group. The Kansas City group consists of alternate beds of limestone and shale. Because of its similarity to the above Lansing group it is often logged together as the Lansing-Kansas City groups. The limestones are massive, and characteristically oolitic. The thickness of this group is approximately 100 feet.

Pleasanton Group. The Pleasanton group of sediments is absent in Ellis County.

Desmoinesian Series. Marmaton Group. The oldest formation of the Pennsylvanian system is the Pennsylvanian basal conglomerate which is sometimes referred to as the Sooy conglomerate. It consists of chert and quartz in a matrix of varicolored clays and shales. Sandstone lenses have been found locally. In Ellis County the thickness varies from 10-100 feet.

Atokan Series. Rocks of this age are not present in Ellis County.

Morrowan Series. Rocks of this age are not present in Ellis County.

Mississippian System

There are no sediments of recognized Mississippian age in Ellis County. It is believed that the raising of the Central Kansas uplift during Mississippian time caused the erosion of these sediments from the crest before the deposition of Pennsylvanian sediments began.

Devonian System

There are no sediments of recognized Devonian age in Ellis County. It is believed that the raising of the Central Kansas uplift during Mississippian time caused the erosion of these sediments from the crest before the deposition of Pennsylvanian sediments began.

Silurian System

There are no sediments of recognized Silurian age in Ellis County. It is believed that the raising of the Central Kansas uplift during Mississippian time caused the erosion of these sediments from the crest before the deposition of Pennsylvanian sediments began.

Ordovician System

Viola Group. The Viola Group of rocks are found only in the northern portion of Ellis County. They consist primarily of limestones and dolomites intermixed with beds of chert. It is white to gray in color and varies in thickness from 0-50 feet.

Simpson Group. Rocks of the Simpson group are found in the northeastern portion of Ellis County. They overlie unconformably on the Viola group. The group consists of green shales, sandy clays, and glauconitic sandstones. The thickness varies from 0-63 feet.

Arbuckle Group. The Arbuckle group of rocks consists of sediments deposited during late Cambrian and early Ordovician. They are usually found in contact with the Pennsylvanian basal conglomerate throughout most of the county. The uppermost formation in this group is the undifferentiated Cotter and Jefferson City dolomites which underlie unconformably the Simpson Group. These dolomites are coarse, cherty, and often argillaceous. The color varies from white to a light gray. The thickness varies from a maximum of 157 feet in T. 13 S, R.17 W. to a feather edge in parts of southwestern Ellis County.

The Roubidoux formation consists mainly of a coarsely-crystalline, sandy dolomite and varies in color from a white to light pink. The maximum measured thickness is 200 feet in Ellis County.

The Gasconade dolomite and the Van Buren formation are missing in Ellis County.

Cambrian System

The Eminence dolomite is missing in Ellis County.

The Bonneterre dolomite lies unconformably below rocks of the Arbuckle group. It is a varicolored rock consisting of red, brown, and pink dolomite that is often glauconitic. It has a coarse crystalline texture and varies in thickness from 0-75 feet.

The Lamotte (Reagan) sandstone is the basal formation of the Cambrian system. It overlies the pre-Cambrian through most of the county and is conformable with the Bonneterre dolomite above. The sand grains are not well sorted, well rounded, and coarse to fine. It has been suggested that the sand was originally a wind blown deposit that was later rearranged by marine waters. A few wells in T. 14 S., Rs. 19 and 20 W. have found the Reagan sandstone in contact with the Pennsylvanian basal conglomerate.

Pre-Cambrian Rocks

The pre-Cambrian rocks in Ellis County consist primarily of metamorphic rocks of quartzite, granulite, schist, phyllite, and nongranitic gneiss (originally shales, mudstones, and clays). These metamorphic rocks are cut by igneous intrusions of granite, gabbro, and syenite. It is thought that regional metamorphism was moderately intense as indicated by the presence of garnet and silimanite in certain samples. Also, the quartzites bear evidence of tectonic strain (Farquhar, 1957).

GEOLOGIC STRUCTURES IN ELLIS COUNTY

There are several geologic structures that merit mention in this paper because of their influence on oil production in Ellis County.

Major Structures

Central Kansas Uplift. The Central Kansas uplift is a buried structural feature that trends northwest and southeast across west-central Kansas (Fig. 3). Ellis County rides on the crest of the axis of this anticlinal structure that extends from the Ozark Dome area in Missouri to the Black Hills uplift of South

Dakota. The Central Kansas uplift was previously named the Barton arch and both terms are in use today for the major post-Mississippian structural uplift.

Barwick (1928) was first to name the Barton arch as a pre-Pennsylvanian and probably pre-Mississippian high in Ellsworth, Rich, Barton, Russell and nearby counties. He suggested that it was in line with the Chautauqua arch to the south and separated from it by a gentle saddle.

The name Central Kansas uplift was first used by Morgan (1932), but it was not until 1935 when Koester published his "Geology of Central Kansas Uplift" that much detail of the structure was known. Koester (1935) suggests that the Central Kansas uplift existed as a series of parallel batholiths in pre-Cambrian time that persisted as a positive element throughout much of Paleozoic time. He continues to assert that broad upwarping occurred chiefly in post-Algonkian, post-Canadian, post-Hunton, early Pennsylvanian, post-Missouri, and post-Cretaceous times. Evidence for his conclusion is the depositional thinning toward the north and west of Cambro-Ordovician and Pennsylvanian sediments, and also the appearance of northeast-southwest folding in early Pennsylvanian and post-Cretaceous times. In the area near the southeastern end of the Central Kansas uplift and near the Nemaha anticline, the folds are sharper, although of less magnitude than the folds in the predominating northwest-southeast direction. These northeast-southwest fold trends which are parallel to the Nemaha anticline seem to have been formed from differential movements which may still be developing (Lee and Merriam, 1954).

The regional movement of the Central Kansas uplift appears to have ceased near the end of the Paleozoic era at the time of deposition of the Wellington formation. Afterward the region was differentially tilted toward the Hugoton embayment (Lee and Merriam, 1954). There have been several periods of local folding normal to the axis of the uplift during late Paleozoic and Mesozoic eras. These folds have been responsible to a large extent for the local accumulation of oil throughout the area (Koester, 1935).

Hugoton Embayment. The Anadarko basin in western Oklahoma and the Texas panhandle has a large synclinal shelf that extends into southwestern Kansas (Fig. 3). This southerly-plunging shelf was first named the Dodge City basin by McClellan in 1930 and renamed the Dodge City embayment by Wheeler in 1947. In 1948, Maher and Collins published a report in which they renamed the area the Hugoton embayment because of the close proximity of the town of Hugoton, Kansas to the axis of the embayment. Also the town of Hugoton appears to be directly over the thickest deposits of Pennsylvanian and Mississippian rocks; whereas, Dodge City is considerably northeast and on the thinning flanks of the embayment.

A series of epeirogenic downwarps occurring during pre-Cambrian, post-Arbuckle, post-Viola, post-Chesterian, post Morrowan, and post-Permian times provided the structural trough for the deposition of sediments. By the end of the Paleozoic era, the periodic downwarps had produced thick accumulations of sediments. Moderate tilting of the sediments to the northwest occurred in Mesozoic time and final tilting to the east in late Tertiary (Merriam, 1955).

Salina Basin. The Salina Basin is a zeugogeosynclinal basin located in north-central Kansas and extends into Nebraska (Fig. 3). It is bounded on the west by the Central Kansas uplift and on the east by the Nemaha anticline. Previous to the uplifting of the Nemaha anticline, a parageosyncline existed in the northern portion of Kansas and extended into the adjoining states of Nebraska, Iowa, and Missouri. It was given the name of the North Kansas basin by Rich in 1933. After the uplift of the Nemaha anticline in late Mississippian time, the North Kansas basin was divided into the Salina basin on the west and the Forest

City basin on the east.

Barwick in 1928 was first to use the name Salina Basin to describe the structural feature in its present day configuration. Lee (1954) utilized thickness maps and stratigraphic cross sections in studying the basin and he concluded that there were five principal periods of deformation in the development of the Salina Basin:

1. During pre-St. Peter time a broad synclinal basin was formed that extended from central Missouri westward to the approximate location of the present Central Kansas uplift.

2. Regional warping between St. Peter and Mississippian time produced the Ozark uplift and the North Kansas basin. The Chautauqua arch and the initial movements of the Central Kansas uplift and the Hugoton embayment were also developed.

3. The third period began in Mississippian and culminated in middle Permian time. This period produced the Nemaha anticline, and provided the maximum development of the Central Kansas uplift and the Hugoton embayment.

4. During upper Permian and Cretaceous periods the area of the Central Kansas uplift and the Salina basin experienced epeirogenic movements that tilted the area to the west. This greatly extended the northeast limb of the Hugoton embayment.

5. In post-Cretaceous time there was subsidence that tilted the region northward and northwestward toward the Denver basin (Lee and Merriam, 1954).

Ellis Arch. The Ellis arch is a pre-Mississippian anticlinal structure that is thought to have followed the trend of the present Central Kansas uplift (Fig. 2). It extended northwestward across north-central and central Kansas where it connected with the Chautauqua arch and on to the Ozark dome area.

Moore and Jewett were first to name the Ellis arch when they discovered that the anticlinal folds of the pre-Pennsylvanian rocks differed materially from the axis of the uplift of the Central Kansas uplift. They were of the opinion that the folds were pre-Mississippian in age (Jewett, 1951).

In 1948 Lee, Leatherock, and Botinelly renamed the Ellis arch the Ancestral Central Kansas uplift.

Minor Structures

<u>Fairport-Natoma Anticline</u>. The Fairport-Natoma anticline trends northeastward in the eastern portion of Ellis County and extends into the northwestern portion of Russell County (Fig. 3).

The discovery of the Fairport-Natoma anticline is credited to U. H. McNutt, whose structural mapping was responsible for the drilling of the M. H. Valerius Oil and Gas Company No. 1 Oswald well in SW cor. SE¼, sec. 8, T 12 S., R. 15 W. (Jewett, 1951). Rubey and Bass (1925) describe the Fairport-Natoma anticline as a structure in which the beds dip approximately 50-200 feet to the mile. East of the anticline they report that the beds dip 15-40 feet to the mile. They conclude that the Fairport-Natoma anticline was formed, not by movement along a buried fault, but chiefly by consolidation of sediments over a buried fault scarp.

<u>Pfeifer Anticline</u>. The Pfeifer anticline trends northeast-southwest across the eastern portion of Ellis County and appears to connect with the Fairport-Natoma anticline in northwest Russell County (Fig. 3). Bass (1926) was the first to describe this structure as it was visible in Cretaceous rocks which he mapped. The beds dip more steeply on the western flank of the anticline than they do on the eastern, which is congruent with the dip of the Fairport-Natoma

anticline.

<u>Rush Rib</u>. The Rush Rib was first described by Koester (1935) as a structural high in the Ordovician and pre-Ordovician rocks, as well as being topographic monadnocks of pre-Mississippian age (Fig. 2). It trends northwest-southeast across the southwestern portion of Ellis County with the axis extending into Trego County on the west and into Rush County on the south.

<u>Russell Rib</u>. Koester (1935) described the Russell Rib as extending only into northeastern part of Ellis County with the trend of the axis running northwest-southeast into Russell County on the east and into Rooks County on the north (Fig. 2). It appears to be a structural high in Ordovician and pre-Ordovician rocks.

<u>Stockton Anticline</u>. According to Jewett (1951), the Stockton anticline is a fold discernible in Cretaceous rocks of Ellis, Rooks and Phillips Counties (Fig. 3). Bass (1926) was first to name the structure which represents an axis of an extensive series of structural 'highs' extending from northwestern Ellis County into Rooks County.

GEOLOGIC HISTORY AND STRUCTURAL DEVELOPMENT

Pre-Cambrian Era

The pre-Cambrian rocks in Ellis County appear to be primarily intrusive granite and foliated metasediments, such as schist, gneiss, and quartzite (Farquhar, 1957). Koester (1935) considers the Central Kansas uplift area to be a series of parallel batholiths that were intruded into younger schists and quartzites in pre-Cambrian time. Erosion that followed laid bare the granite core which is found in the higher portions of the uplift, and left the metasediments along the flanks and in the synclinal troughs.

Undoubtedly there were several periods of uplift and erosion as is witnessed by the varying thickness of granite-wash; however, the exact number of periods of uplift have not been determined.

Paleozoic Era

In Cambrian time the advancing seas left a sandstone of well rounded, loosely cemented grains that has been named the Reagan sandstone. It appears to have been deposited over a moderately uneven surface which gives it an irregular thickness, thinning over the crests and thickening on the flanks (Koester, 1935). It has been suggested by McCoy (1953) that the source area of the Reagan could have been the Siouxia uplift in north-central Nebraska and the Sierra Grande uplift in northeastern New Mexico. Gradually the concentration of calcium carbonate in the sea increased producing a precipitate of sandy dolomite which is known as the Bonneterre dolomite and is conformable with the underlying Reagan sandstone. Uplift is believed to have followed, producing an unconformity between the Bonneterre dolomite and the next advancing sea deposit.

As the next sea came in during late Cambrian-early Ordovician, dolomitic conditions prevailed which favored the precipitation of dolomitic rock and chert. The Ellis arch began to rise at this time forcing the seas away and giving erosion a chance to produce a highly irregular surface on the Arbuckle group of sediments. In middle Ordovician time the seas again advanced and deposited the Simpson formation. This was followed by a break in deposition and great erosion of the Simpson. Then followed by the deposition of the Viola group with subsequent erosion.

No Silurian, Devonian, or Mississippian deposits have been found in Ellis County. The reason for the lack of these sediments has not been determined. Silurian, Devonian, and Mississippian sediments can be found in the Salina basin to the east; however, the high topographic relief of the Ellis arch may have prevented deposition in the Ellis County area.

Near the end of Mississippian time tectonic movements began which formed the great Central Kansas uplift and allowed erosional forces to eat away the sediments down to the Arbuckle group. Here again erosion produced a highly porous, and irregular surface that was later to become a highly important reservoir for the accumulation of oil.

The Pennsylvanian seas in their advance began depositing a conglomerate over the entire surface of Ellis County. This conglomerate has become known as the Sooy or Pennsylvanian basal conglomerate and represents the first stage in the process of Pennsylvanian deposition. The Pennsylvanian sea up until Kansas City time appears to have been shallow producing deposits of alternating thin shales and limestone. It is characteristic of cyclic deposition (Lee, 1956). An erosional break followed and then the advance of the sea during Missourian time produced more deposits of limestones and shales. A similar type of depositional environment existed for the rest of Pennsylvanian time and then uplift and erosion near the close of the period.

During Permian time seas again entered from the south and deposited limestones and shales in cyclic deposition. It is apparent from the presence of evaporites that the dying seas retreated to allow the deposition of halite, anhydrite, and gypsum. The most notable is the Hutchinson salt member of the Wellington formation that completely covers Ellis County (lee, 1956). Late in Permian time, uplift began which terminated Paleozoic sedimentation.

Mesozoic Era

During Triassic and Jurassic time widespread erosion was taking place across most of Kansas; however, the Central Kansas uplift region was undergoing tilting to the west. This tilting continued into Jurassic and it was not until Cretaceous time that the seas advanced into this area again. The Cretaceous rocks lie unconformably over Permian rocks. The basal member is the Cheyenne sandstone that represents the first phase of the incoming Cretaceous sea. It is probably a near shore or littoral deposit. As the sea transgressed inward the sediments became marine and it was then that the Kiowa shale was deposited. The seas retreated allowing for the deposition of about 300 feet of Dakota sediments. These sediments are composed primarily of sandstones, shales, siltstones and the presence of plant fossils, and fossil land vertebrates indicates a continental environment (Moore, 1951). The seas advanced again and the rest of the Mesozoic era was primarily a marine environment with deposits of limestones and shales. The seas retreated at the close of Cretaceous time and the region reflected structural movements that probably can be related to the Laramide revolution taking place in the Rocky Mountain region (Merriam and Atkinson, 1955).

Cenozoic Era

The Ellis County area remained above sea level through Cenozoic time and sedimentation was limited to continental environments. The Cascadian revolution in the Rocky Mountain region is thought to be responsible for the deposition of the Ogallala formation throughout much of western Kansas. This rejuvenation sent large quantities of coarse clastic material out in floodplains where they were deposited (Frye and Leonard, 1952). During Pleistocene time there is evidence that streams carried much larger quantities of water than at the present time. This is shown by stream terraces that are higher in the valleys than could be possible at the present time. Only moderate tilting of the sediments to the east was needed to give the area its present configuration.

DISCUSSIONS AND CONCLUSIONS

The presence of over 5,000 wells in Ellis County, or an average of approximately five wells per section might tend to discourage any future drilling in this county. However, it should be remembered that two-thirds of these wells are closely spaced along the major pools. There are still many acres of untested land that might be capable of economic oil production.

From a study of the structure contour maps and cross sections, it appears that anticlinal highs are primarily responsible for the accumulation of oil in the Arbuckle group (Fig. 5), while stratigraphic traps primarily control the accumulation of oil in the Lansing-Kansas City groups (Fig. 6). The major oil production appears to follow two northwest-southeast structural trends that parallel each other (Fig. 4). They occupy a position parallel to the axis of the Central Kansas uplift and are almost superimposed upon the Rush Rib and the Russell Rib. It seems probable that these two structures possessed some influence on the oil accumulation.

In the Bemis-Shutts pool, located in Ts. 11 and 12 S., Rs. 16, 17, and 18 W., it appears that the three producing zones, the Arbuckle group,the Pennsylvanian basal conglomerate, and the Lansing-Kansas City groups, are all controlled by anticlinal highs. It is possible that the northeastern limit of the Lansing-Kansas City production in this field may be controlled by stratigraphy.

In the other major pools of Ellis County, the Arbuckle group seems to be productive only upon anticlinal highs. The Arbuckle group having been subjected to several phases of erosion, broke down into a porous, weathered formation that became the perfect host for migrating oil. The permeable condition of the Arbuckle allowed oil to migrate freely, being subject only to structural conditions.

The Lansing-Kansas City oil accumulation appears to be controlled by a combination of structural highs and stratigraphic traps. Evidently the Lansing group was not subjected to as intensive erosion as the Arbuckle group. Consequently, the result is differential permeability of this group of sediments.

The structure mapped in sections 2, 3, 11, 12, and 13 of T. 11 S., R. 16 W. (fig. 5) is interpreted as a fault, with a displacement of approximately 250 feet and a strike of N47W-S47E. This is in alignment with the Rush Rib. According to Eastty (in preparation), the structure is a horst and is so interpreted in the southeastern corner of Rooks County. It seems possible that this fault was caused by differential vertical movements in the pre-Cambrian surface in pre-Mississippian time. There is no evidence of the fault in post-Mississippian sediments. This area has not been penetrated with intensive drilling to prove or disprove any oil possibilities. It seems possible that oil might be trapped along the fault scarp.

In the southwestern corner of Ellis County the beds have a monoclinal dip of approximately 50 feet to the mile to the southwest (Fig. 5). It is not believed that the dip is due to a drape effect over a buried pre-Cambrian fault. Probably it is only the result of sediments conforming to the basement complex during the raising of the Central Kansas uplift.

In 1956, more new pools were found in Ellis County than in any other county in the state. It seems reasonable to expect more new production from the Arbuckle and Lansing groups in the future. There is a possibility that production might be discovered in the Reagan sandstone in the southwestern portion of the county. In this area there is a good section of Reagan sandstone which might be productive in local structures near the Rush Rib.

ACKNOWLEDGMENTS

The writer would like to thank Dr. Charles P. Walters, Associate Professor of Geology, for his advice and helpful suggestions while this thesis was in process. Appreciation is also extended to Dr. J. R. Chelikowsky, Head of the Department of Geology, for his counseling that greatly speeded the progress of this report, and to Dr. Claude W. Shenkel Jr., Professor of Geology, for help in preparing the cross sections used in this thesis.

Thanks are also extended to the Herndon Map Service, Oklahoma City, Oklahoma, and to the Kansas Geological Survey, Lawrence, Kansas for supplying much of the material necessary for the preparation of this thesis.

REFERENCES

Bartram, J. G., W.C. Imbt, and E. F. Shea
Oil and gas in Arbuckle and Ellenburger formations, Mid-Continent region. Am. Assoc. Petrol. Geol. Bull., Vol. 34, 1950, 682-700 pp.

Barwick, John S.
The Salina basin of north-central Kansas. Am. Assoc. Petrol. Geol. Bull., Vol. 12, No. 2, 1928, 177-199 pp.

Bass, N.W.
Geologic structure of the Dakota sandstone of Western Kansas. Am. Assoc. Petrol. Geol. Bull., Vol. 9, No. 6, 1926, 1022-1023 pp.

Eardley, A. J.
Structural geology of North America. New York: Harper and Brothers, 1951.

Farquhar, O. C.
The pre-Cambrian rocks of Kansas. State Geol. Survey of Kansas, Bull. 127, pt. 3, 1957.

Frye, John C.
Origin of Kansas Great Plains depressions. State Geol. Survey of Kansas, Bull. 86, pt. 1, 1950

Frye, John C., and James J. Brazil
Ground water in the oil field areas of Ellis and Russell Counties, Kansas. State Geol. Survey of Kansas, Bull. 50, 1943, 104 pp.

Frye, John C., and A.R. Leonard
Pleistocene Geology of Kansas. State Geol. Survey of Kansas, Bull. 99, 1952, 230 pp.

Goebel, E. D., et al.
Oil and Gas Developments in Kansas during 1955. State Geol. Survey of Kansas, Bull. 122, 1956, 249 pp.

Goebel, E. D., et al.
Oil and Gas Developments in Kansas during 1956. State Geol. Survey of Kansas, Bull. 128, 1957.

Jewett, J. M.
Geologic structures in Kansas. State Geol. Survey of Kansas, Bull. 90, pt. 6, 1951, 172 pp.

Keroher, R. P. and J. J. Kirby
Upper Cambrian and Lower Ordovician rocks in Kansas. State Geol. Survey of Kansas, Bull. 72, 1948, 140 pp.

Koester, E. A.
Geology of Central Kansas Uplift. Am. Assoc. Petrol. Geol. Bull., Vol. 19, 1935, 1405-1426 pp.

Landis, K.K. and R. P. Keroher
Mineral Resources of Phillips County. State Geol. Survey of Kansas, Bull. 41, pt 8, 1942, 278-312 pp.

Latta, Bruce F.
Ground-water supplies at Hays, Victoria, Walker, Gorham, and Russell, Kansas. State Geol. Survey of Kansas, Bull. 76, pt. 6, 1948, 196 pp.

Lee, Wallace
Thickness maps as criteria for regional structural movement. State Geol. Survey of Kansas, Bull. 109, pt. 5, 1954, 65-80 pp.

Lee, Wallace
Stratigraphy and structural development of the Salina basin area. State Geol. Survey of Kansas, Bull. 121, 1956, 165 pp.

Lee, Wallace and D. F. Merriam
Preliminary study of the structure of western Kansas. State Geol. Survey of Kansas, Oil and Gas Investigations No. 11, Maps and Cross Sections, 1954, 23 pp.

Maher, J. C. and Jack B. Collins
Hugoton Embayment of Anadarko Basin in southwestern Kansas, southeastern Colorado, and Oklahoma panhandle. Am. Assoc. Petrol. Geol. Bull., Vol. 32, pt. 1, 1948, 813-816 pp.

McClellan, H. W.
Subsurface distribution of pre-Mississippian rocks of Kansas and Oklahoma. Am. Assoc. Petrol. Geol. Bull., Vol. 14, 1930, 1535-1556 pp.

McCoy, A. W.
Tectonic history of the Denver basin. Am. Assoc. Petrol. Geol. Bull., Vol. 37, 1953, 1873-1893 pp.

Merriam, D. F.
Stone Corral structure as an indicator of Pennsylvanian structure in central and western Kansas. State Geol. Survey of Kansas, Bull. 114, pt. 4, 1955, 133-152 pp.

Merriam, D. F. and W. R. Atkinson
Tectonic history of the Cambridge arch in Kansas. Kansas Geol. Survey Oil and Gas Invest. No. 13, Maps and Cross Sections, 1955, 28 pp.

Moore, R. C., et al.
The Kansas rock column. State Geol. Survey of Kansas, Bull. 89, 1951, 132 pp.

Morgan, L. C.
Central Kansas Uplift. Am. Assoc. of Petrol. Geol. Bull., Vol. 16, No. 5, 1932, 483-484 pp.

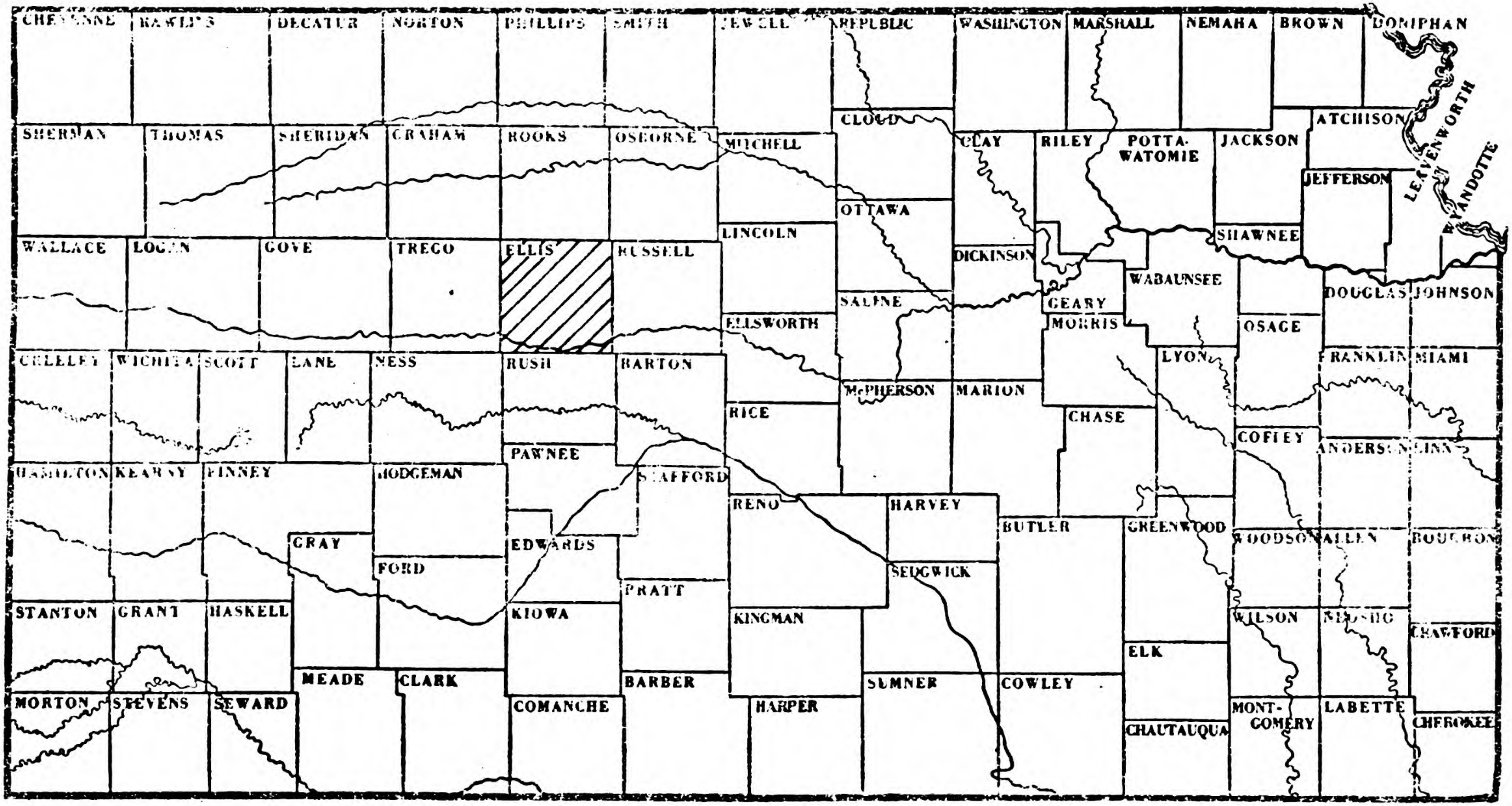
Plummer, N. V. and J. F. Romary
Kansas Clay, Dakota formation. State Geol. Survey of Kansas, Bull. 67, 1947, 241 pp.

Plummer, N. V. and J. F. Romary
Stratigraphy of the pre-Greenhorn Cretaceous beds of Kansas. State Geol. Survey of Kansas, Bull. 41, pt. 9, 1942, 36 pp.

Rubey, W. W., and N. W. Bass
The geology of Russell County, Kansas, with special reference to oil and gas resources. State Geol. Survey of Kansas, Bull. 10, pt. 1, 1925, 86 pp.

Ver Weibe, W. A.
Oil and gas developments in Kansas during 1938. Kansas State Geological Survey Mineral Resources Circular #13, 1939.

APPENDIX



Area covered by this report

Fig. 1. Map of Kansas showing location of Ellis County.

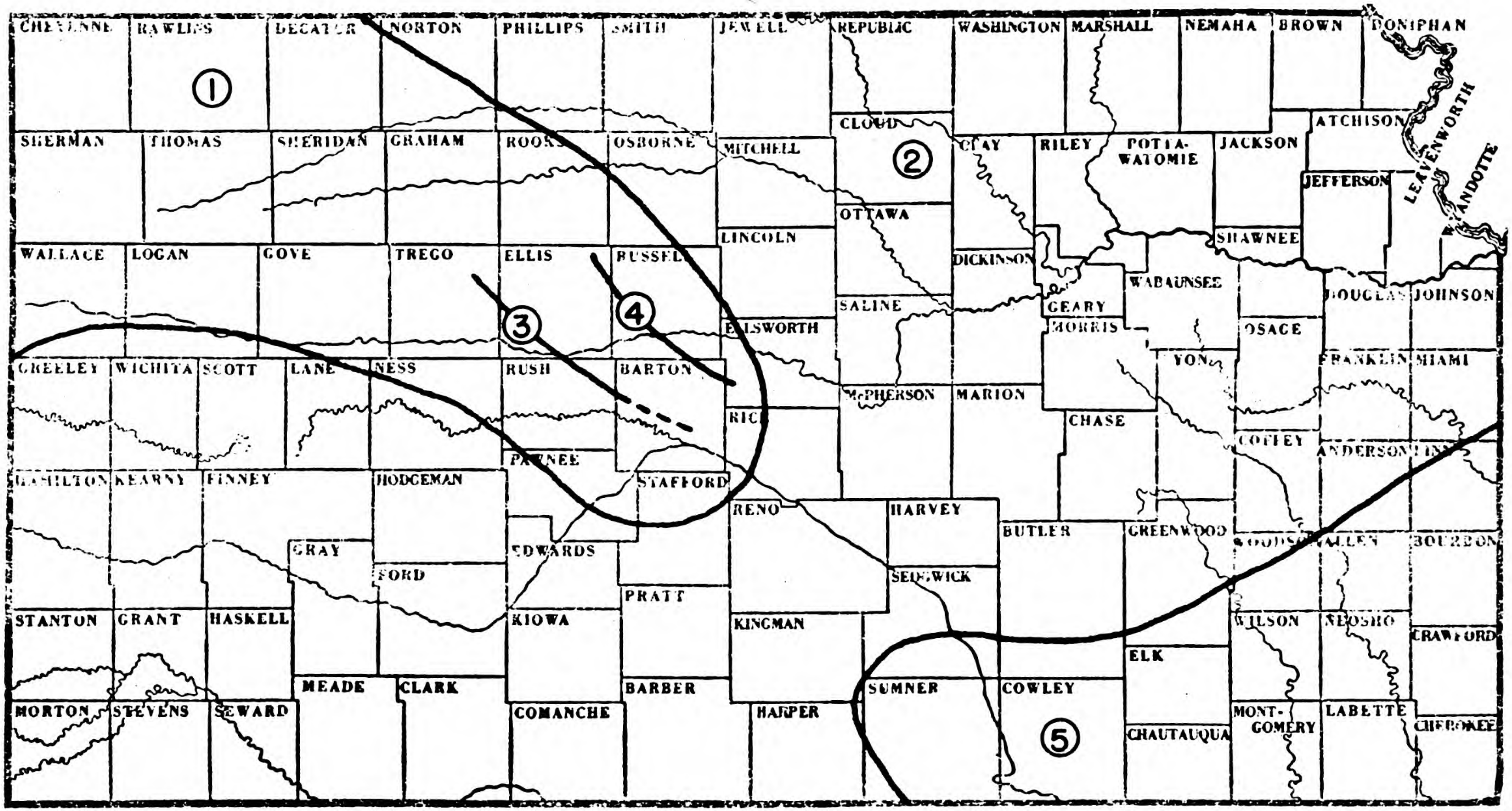


Fig. 2. Geographic distribution of major pre-Mississippian structural features.

① Ellis Arch

② North Kansas Basin

③ Rush Rib

④ Russell Rib

⑤ Chautauqua Arch

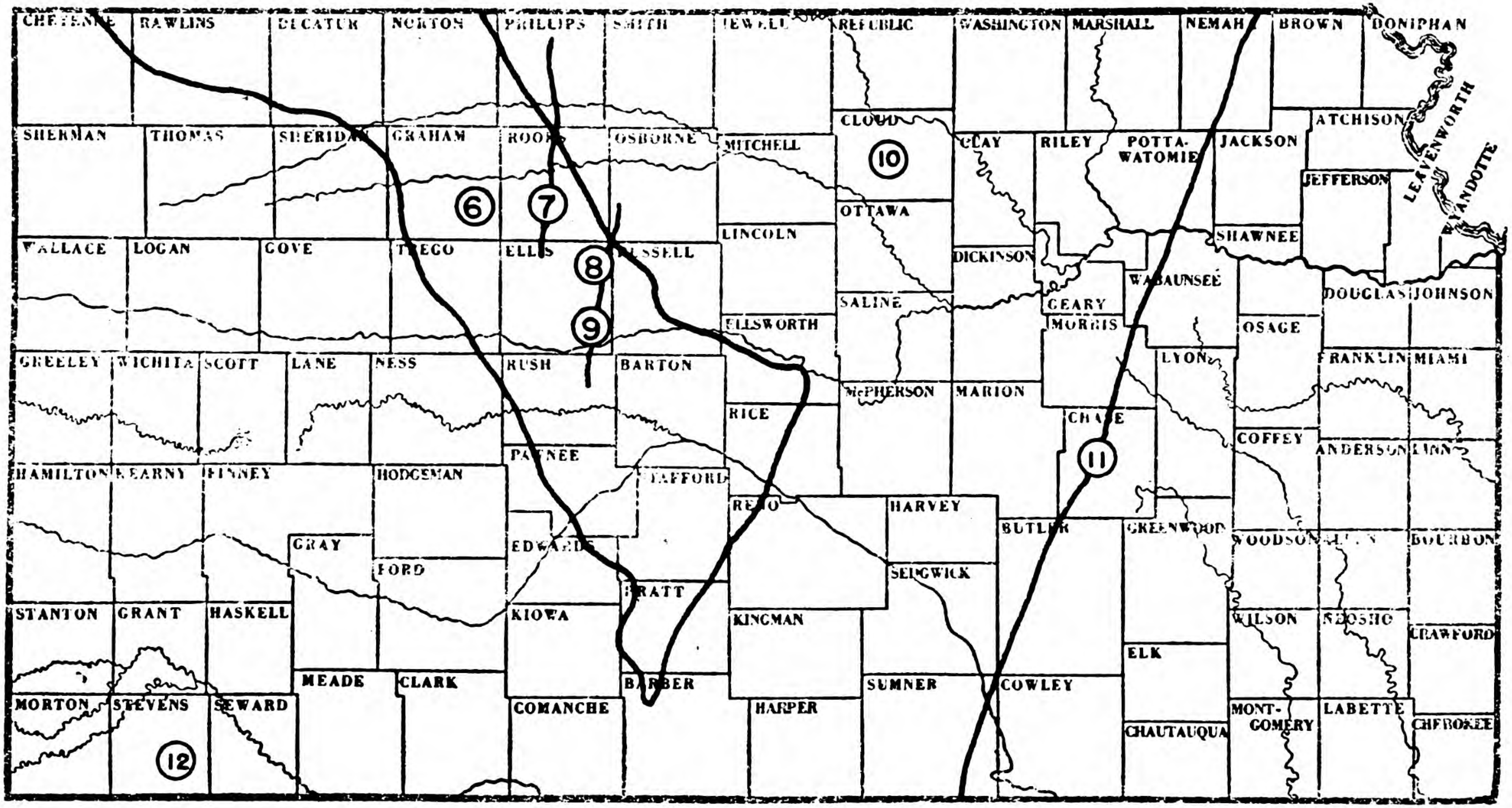


Fig. 3. Geographic distribution of major post-Mississippian structural features.

(6) Central Kansas Uplift
(7) Stockton Anticline
(8) Fairport-Natoma Anticline
(9) Pfeifer Anticline
(10) Salina Basin
(11) Nemaha Anticline
(12) Hugoton Embayment

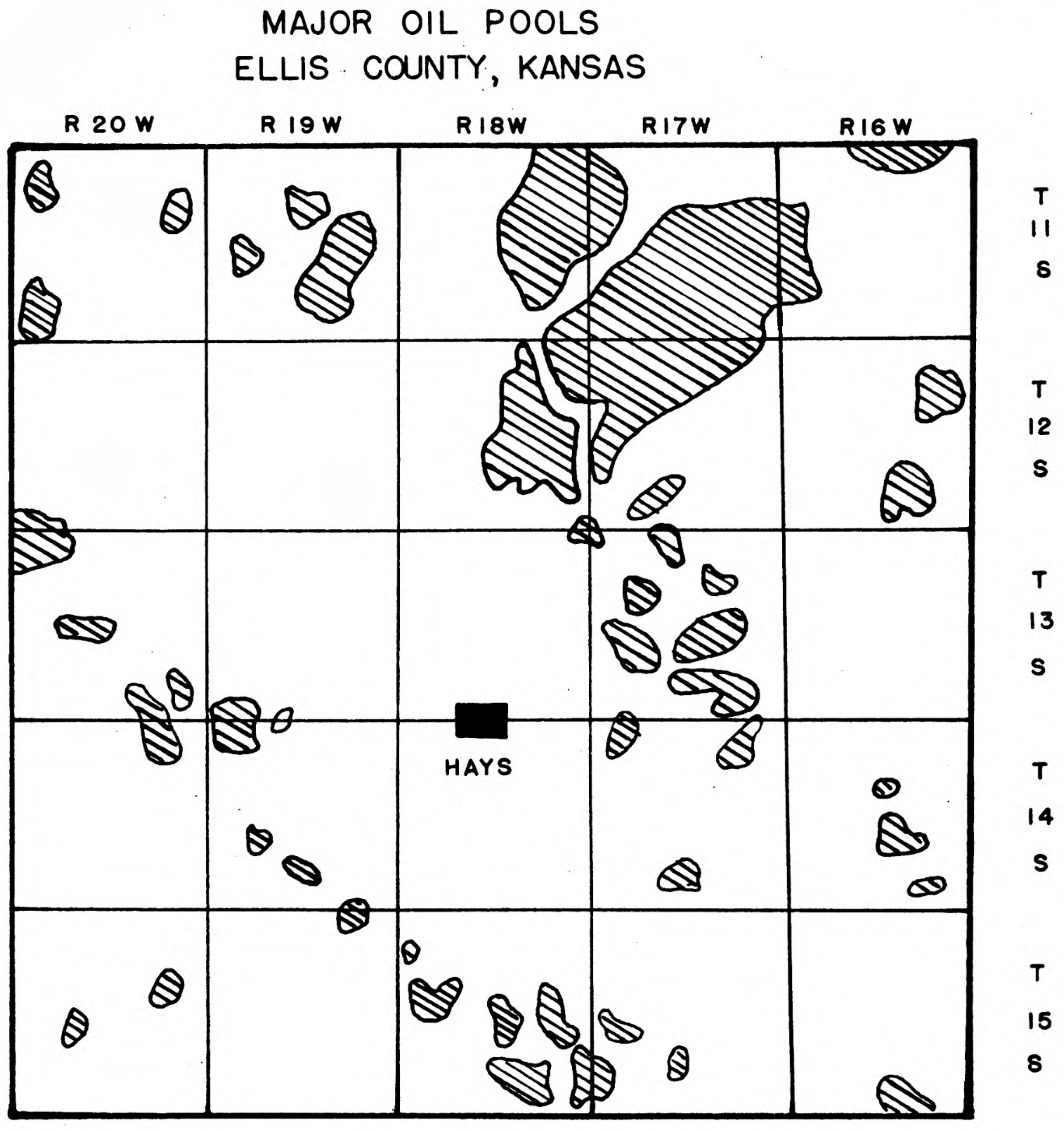
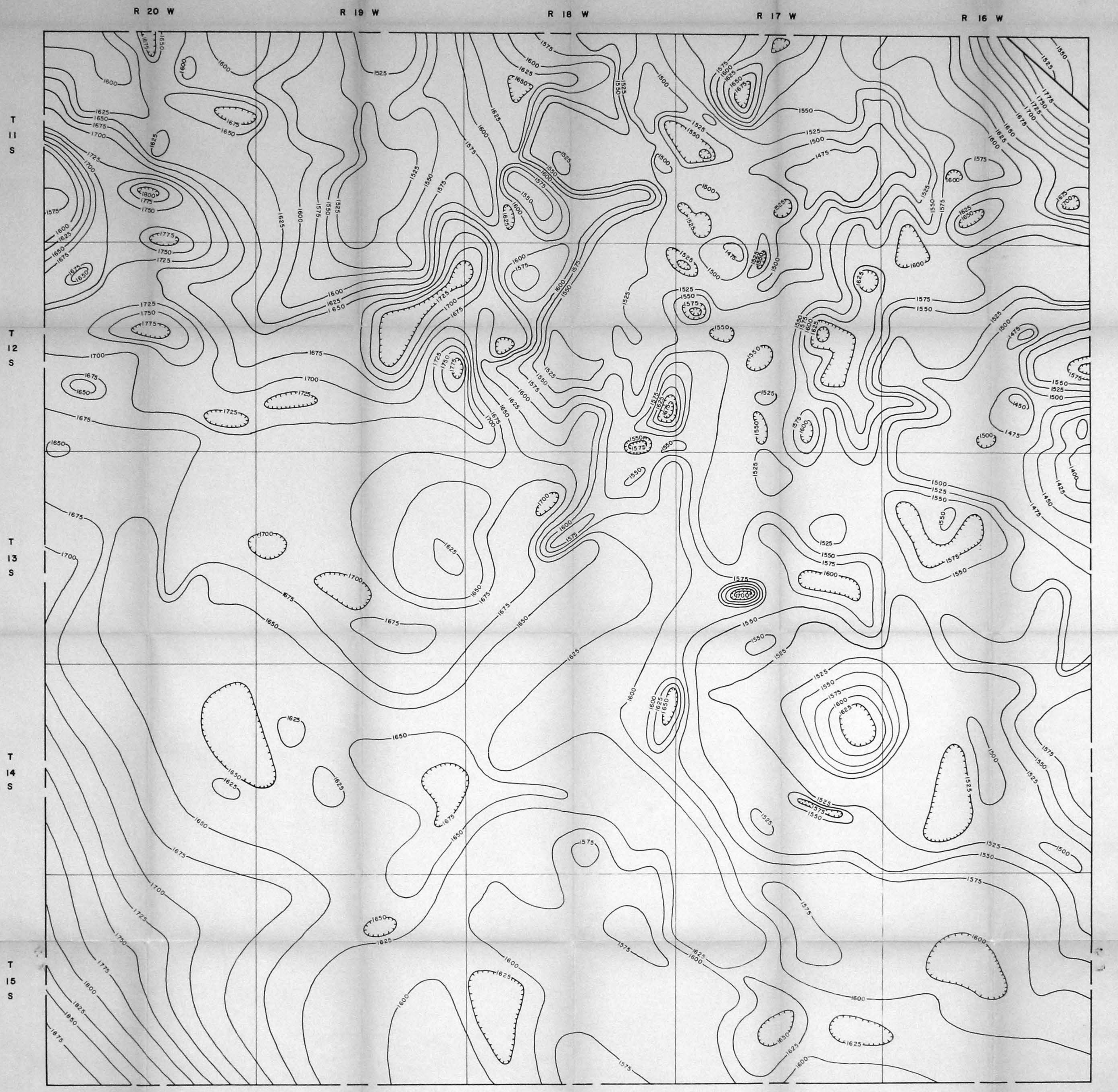


Fig. 4. Map of Ellis County showing the location of major oil pools.

Fig. 5 Structural contour map on top of the Arbuckle in Ellis County, Kansas
(in accompanying plate box)



STRUCTURAL CONTOUR MAP ON THE TOP OF THE ARBUCKLE
IN ELLIS COUNTY, KANSAS

COUNTY LINES

TOWNSHIP LINES

1 0 1 2 miles
SCALE

N

CONTOUR INTERVAL : 25 feet
DATUM PLANE : SEA LEVEL
ALL ELEVATIONS BELOW DATUM

DONALD D. CARR

1958

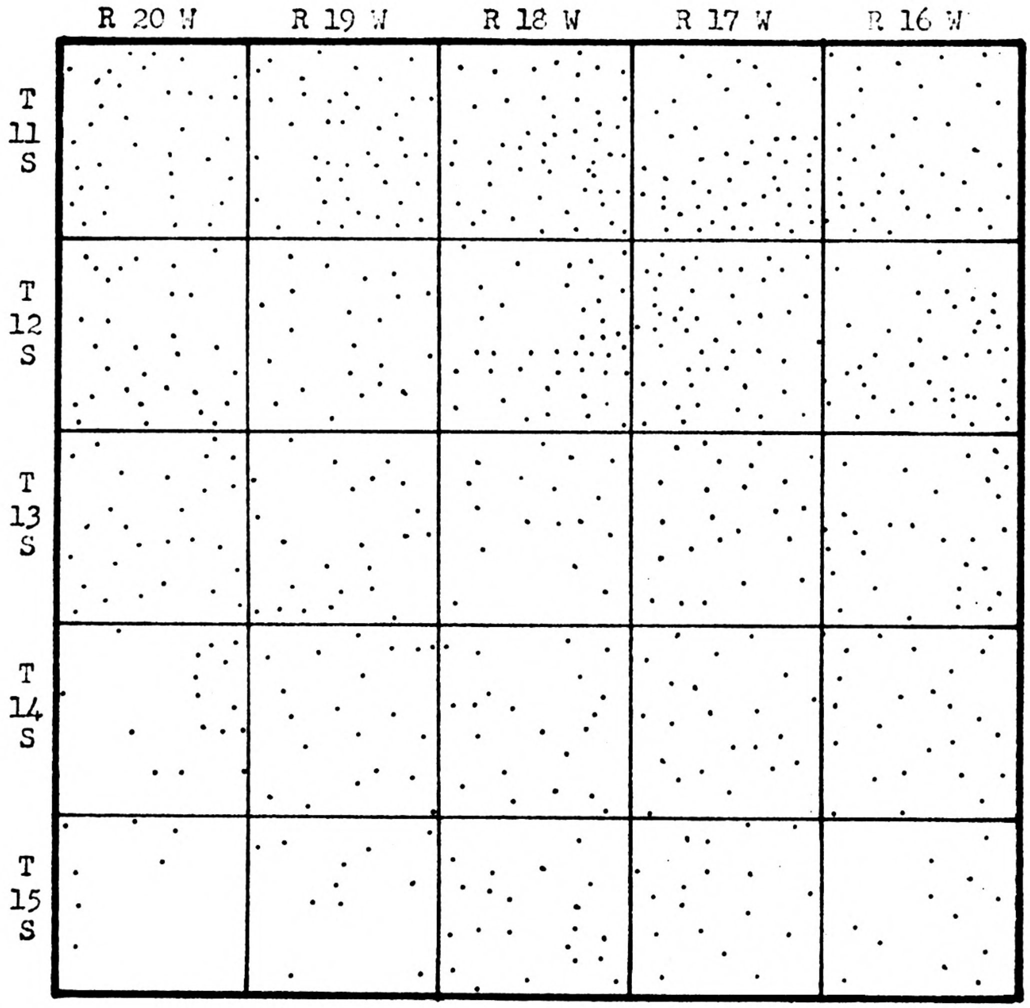
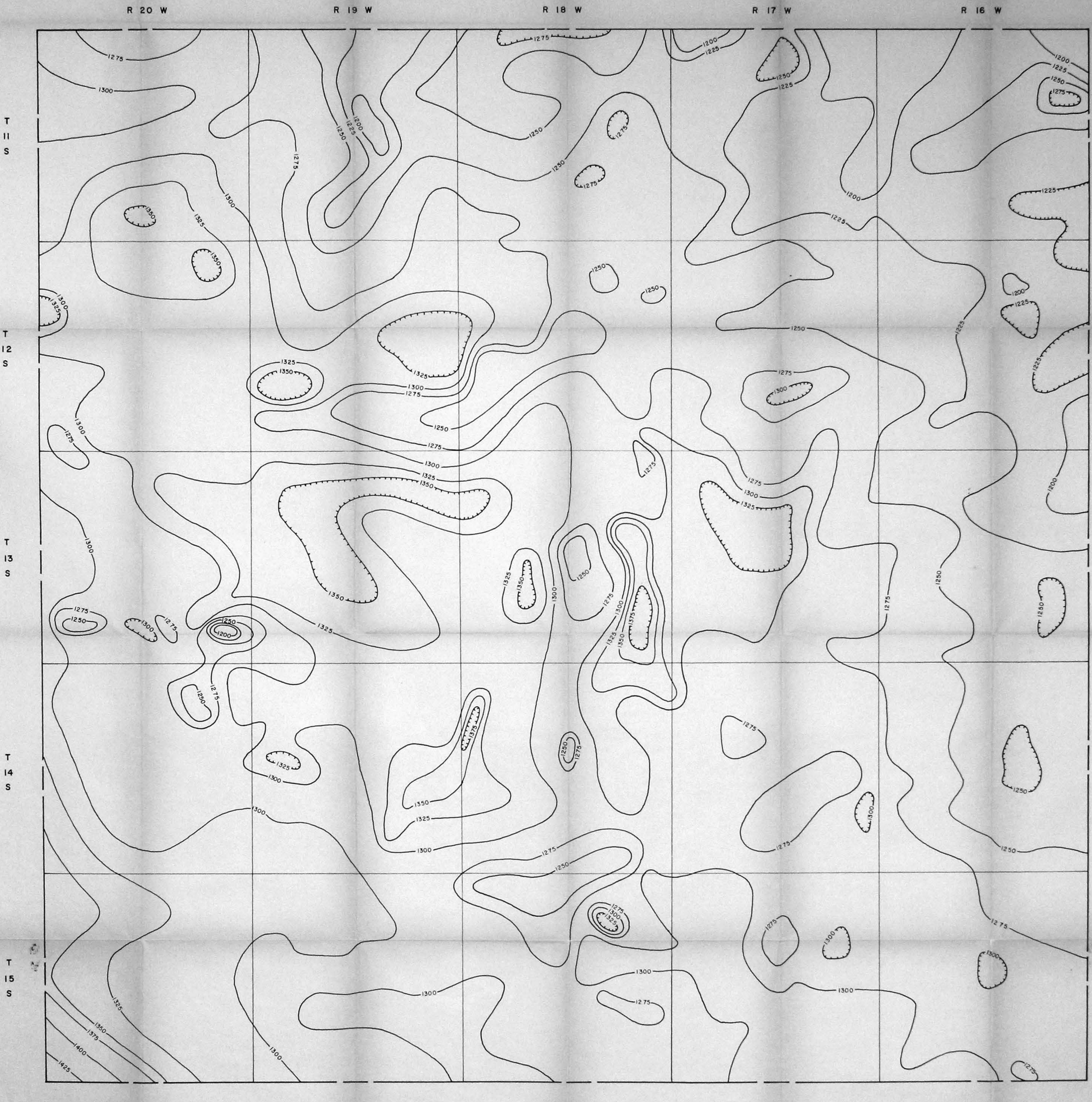


Fig. 5A. Map of Ellis County showing the location of subsurface control points used to construct the Arbuckle structural map.

Fig. 6 Structural contour map on top of the Lansing in Ellis County, Kansas. (in accompanying plate box)



STRUCTURAL CONTOUR MAP ON THE TOP OF THE LANSING IN ELLIS COUNTY, KANSAS

COUNTY LINES

TOWNSHIP LINES

1 0 1 2 miles
SCALE

N

CONTOUR INTERVAL: 25 feet
DATUM PLANE: SEA LEVEL
ALL ELEVATIONS BELOW DATUM

DONALD D. CARR

1958

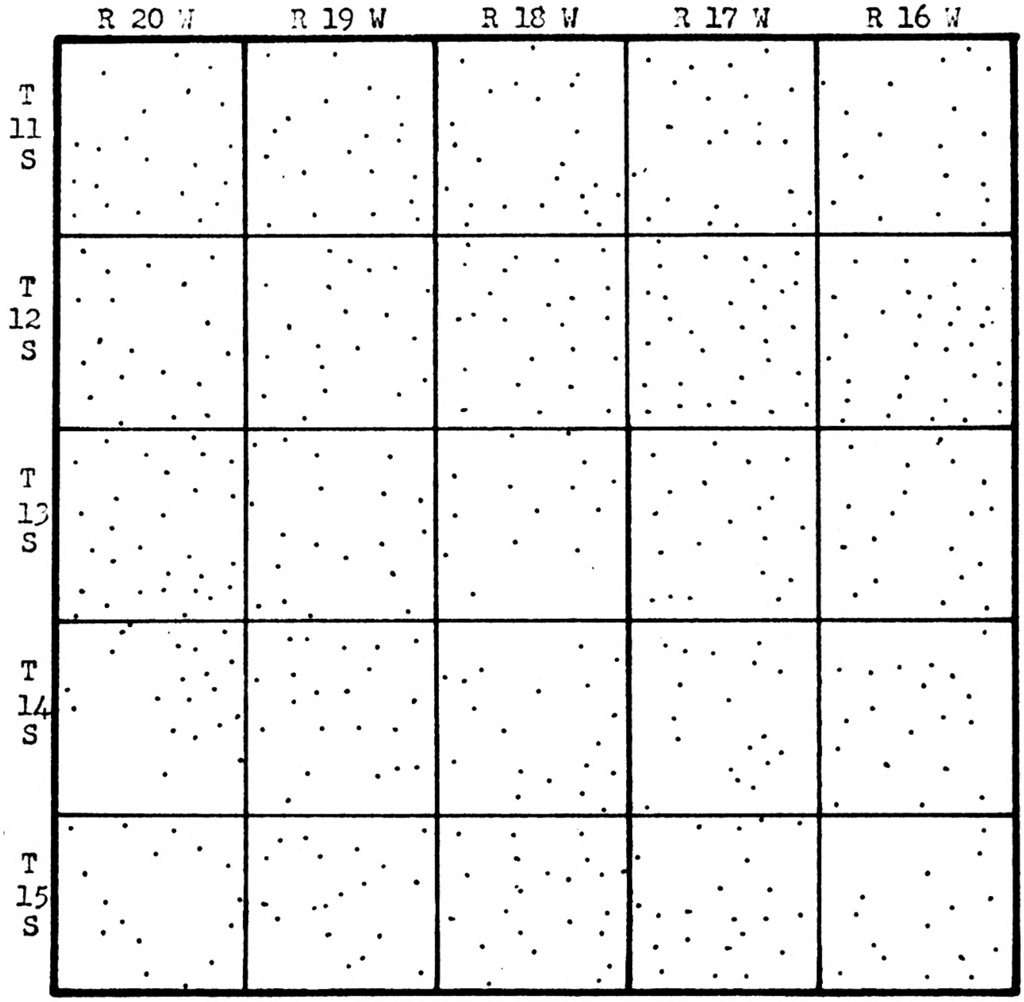
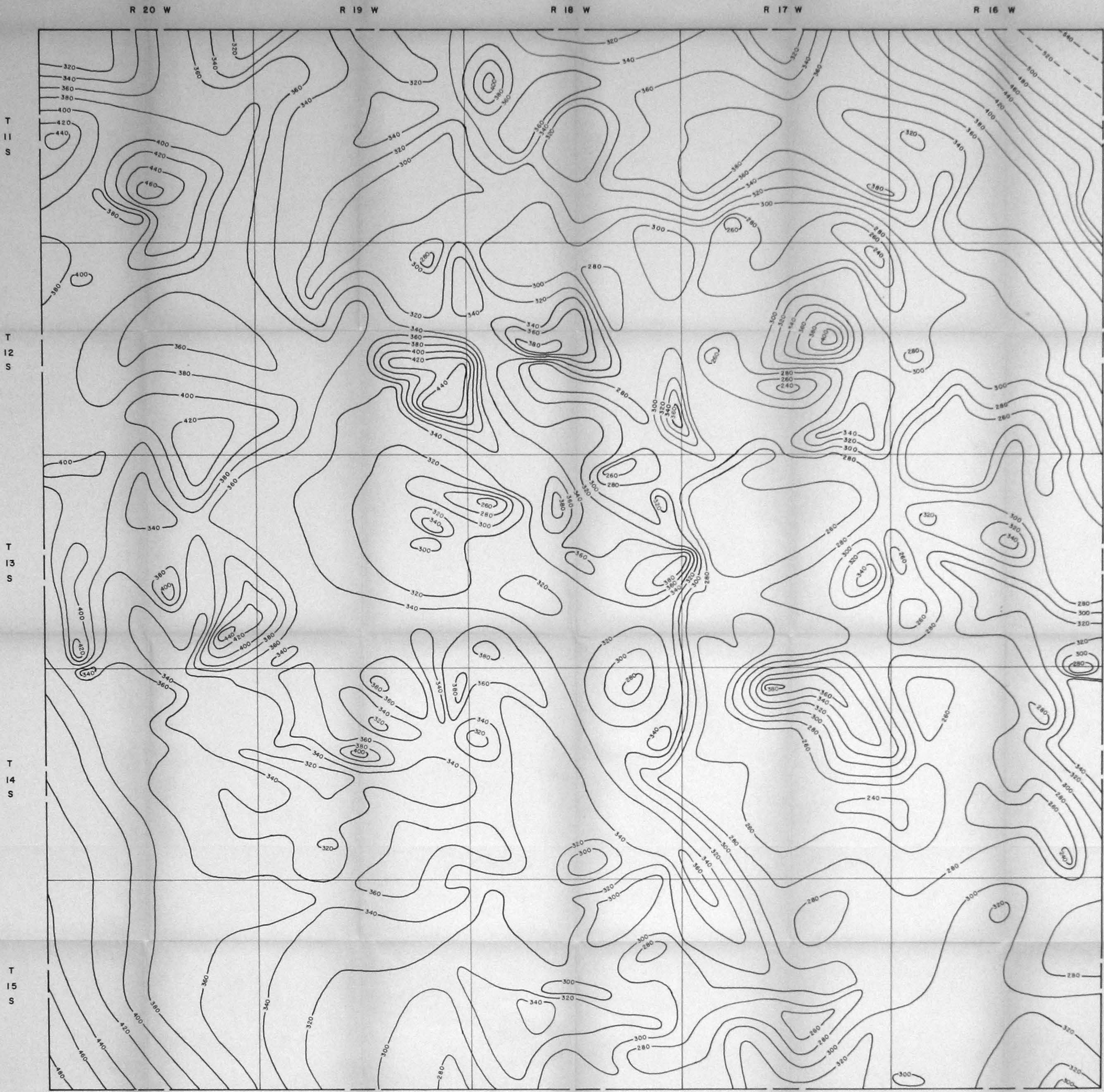


Fig. 6A. Map of Ellis County showing the location of subsurface control points used to construct the Lansing structural map.

Fig. 7 Isopach map of the interval between the top of the Lansing and the top of the Arbuckle in Ellis County, Kansas.
(in accompanying plate box)



ISOPACH MAP: TOP OF LANSING TO THE TOP OF THE ARBUCKLE IN ELLIS COUNTY, KANSAS

COUNTY LINES

TOWNSHIP LINES

1 0 1 2 miles

SCALE

N

CONTOUR INTERVAL: 20 feet

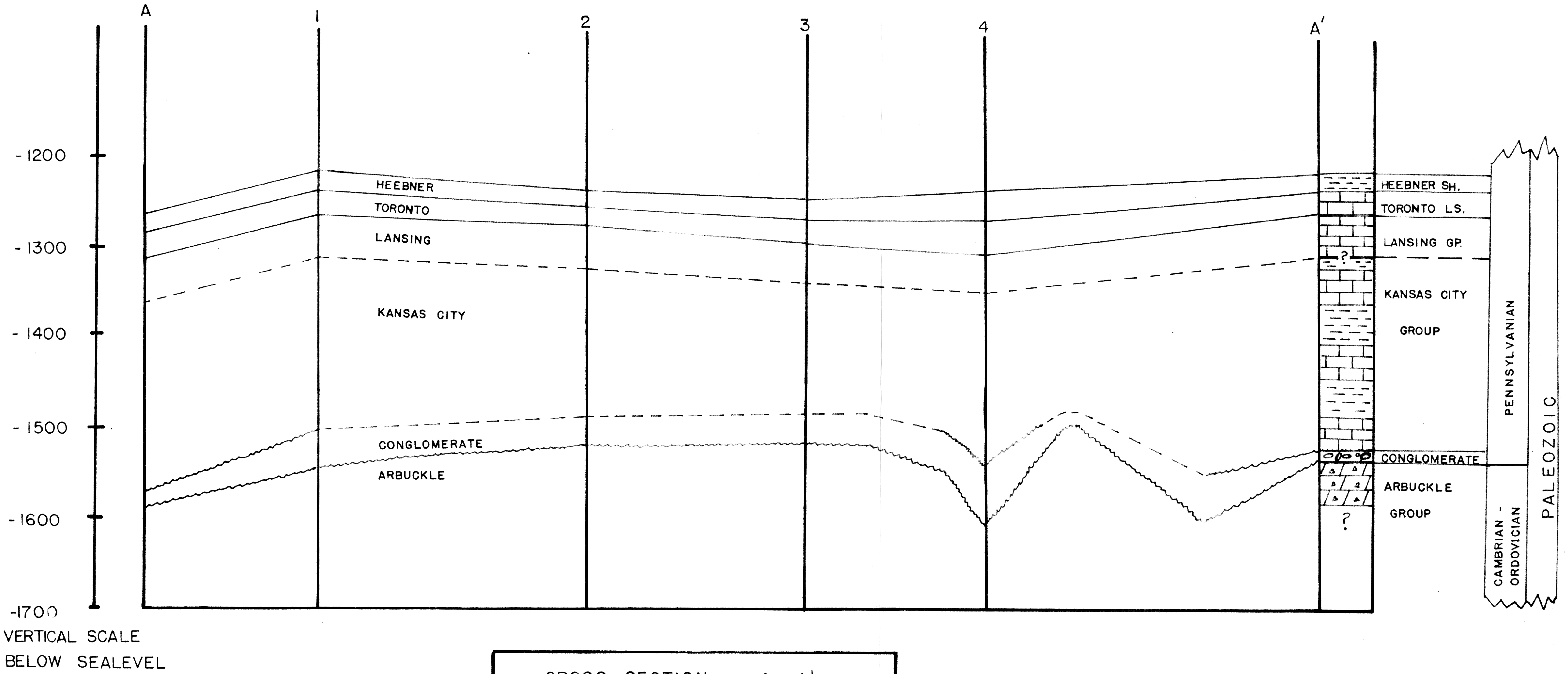
DATUM PLANE: SEA LEVEL

ALL ELEVATIONS BELOW DATUM

DONALD D. CARR

1958

Fig. 8 Cross Sections: Ellis County, Kansas.
(in accompanying plate box)

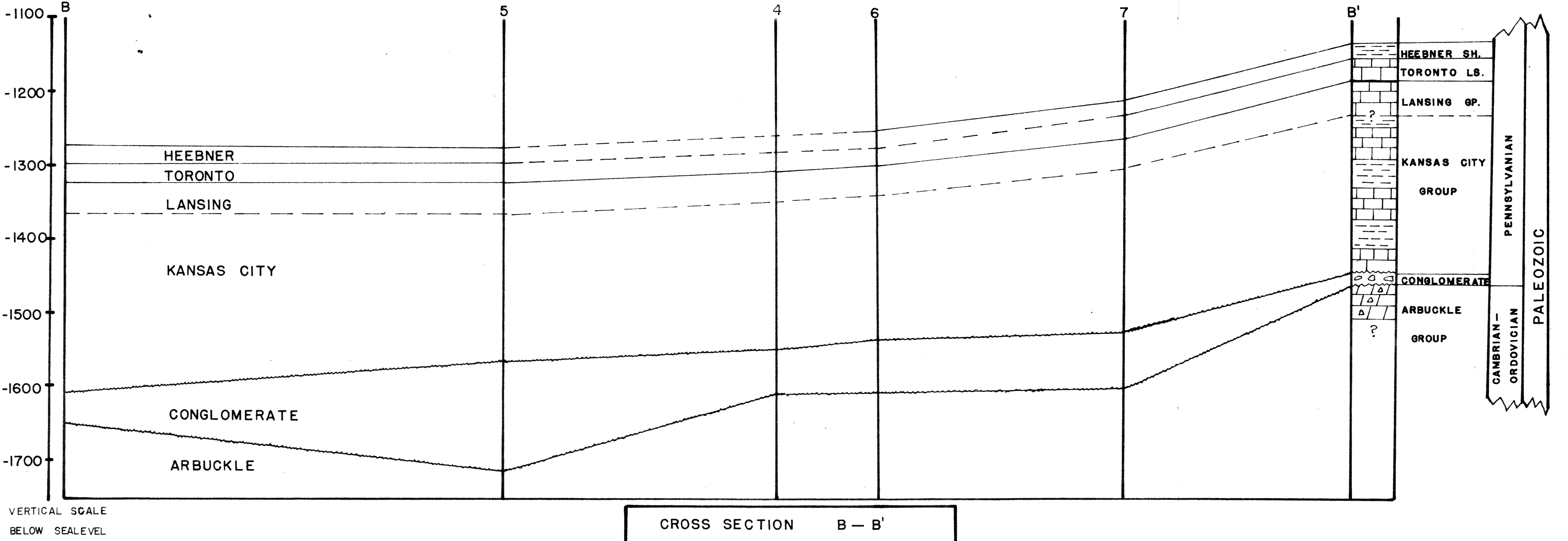


CROSS SECTION A— A'

0 1 2

HORIZONTAL SCALE
IN MILES

1958 D. D. CARR

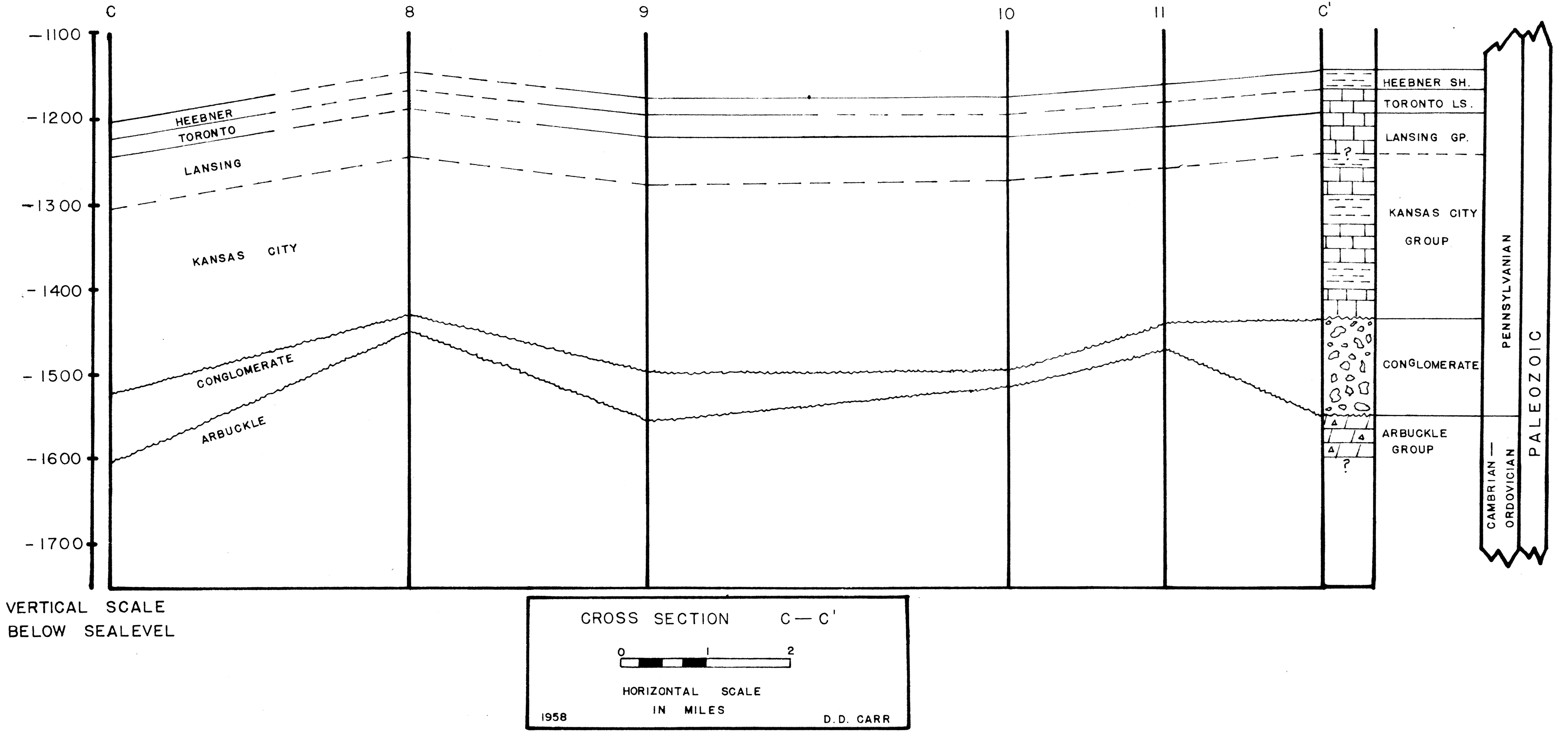


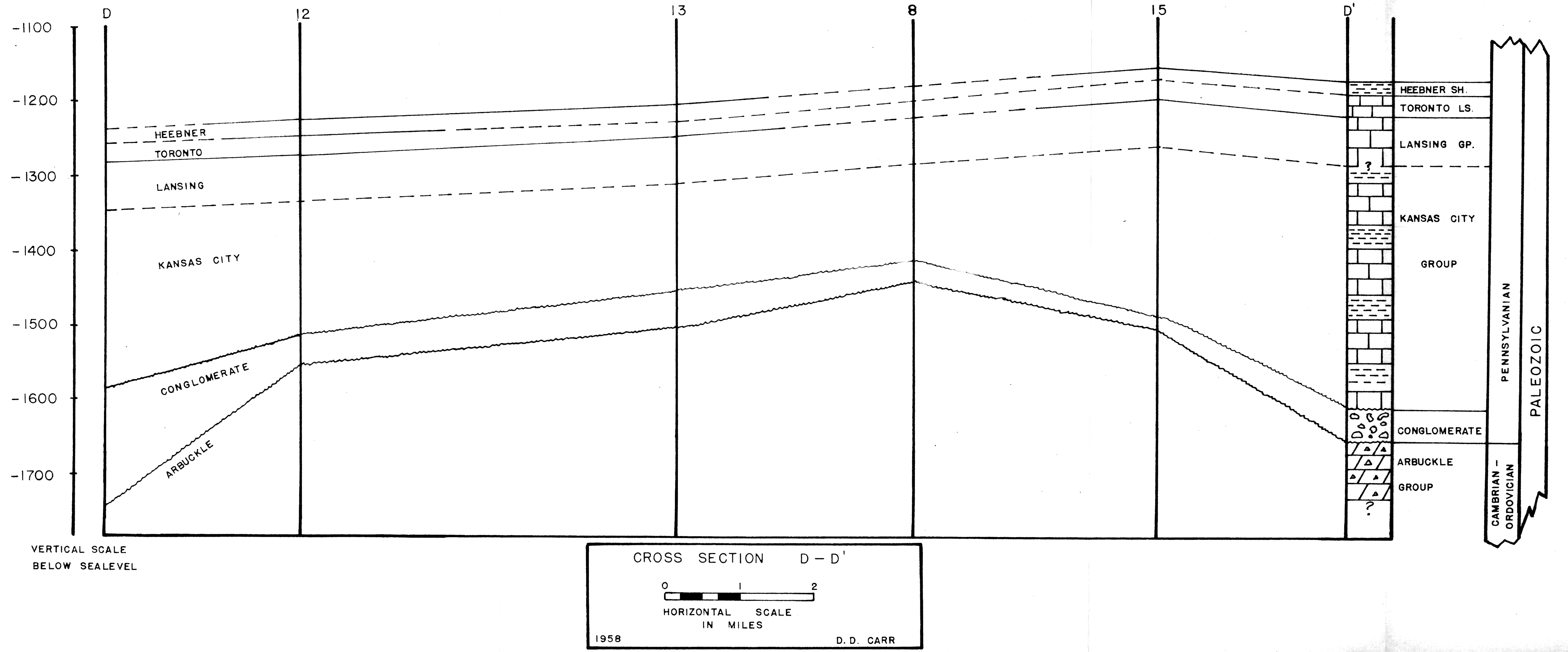
CROSS SECTION B — B'

0 1 2

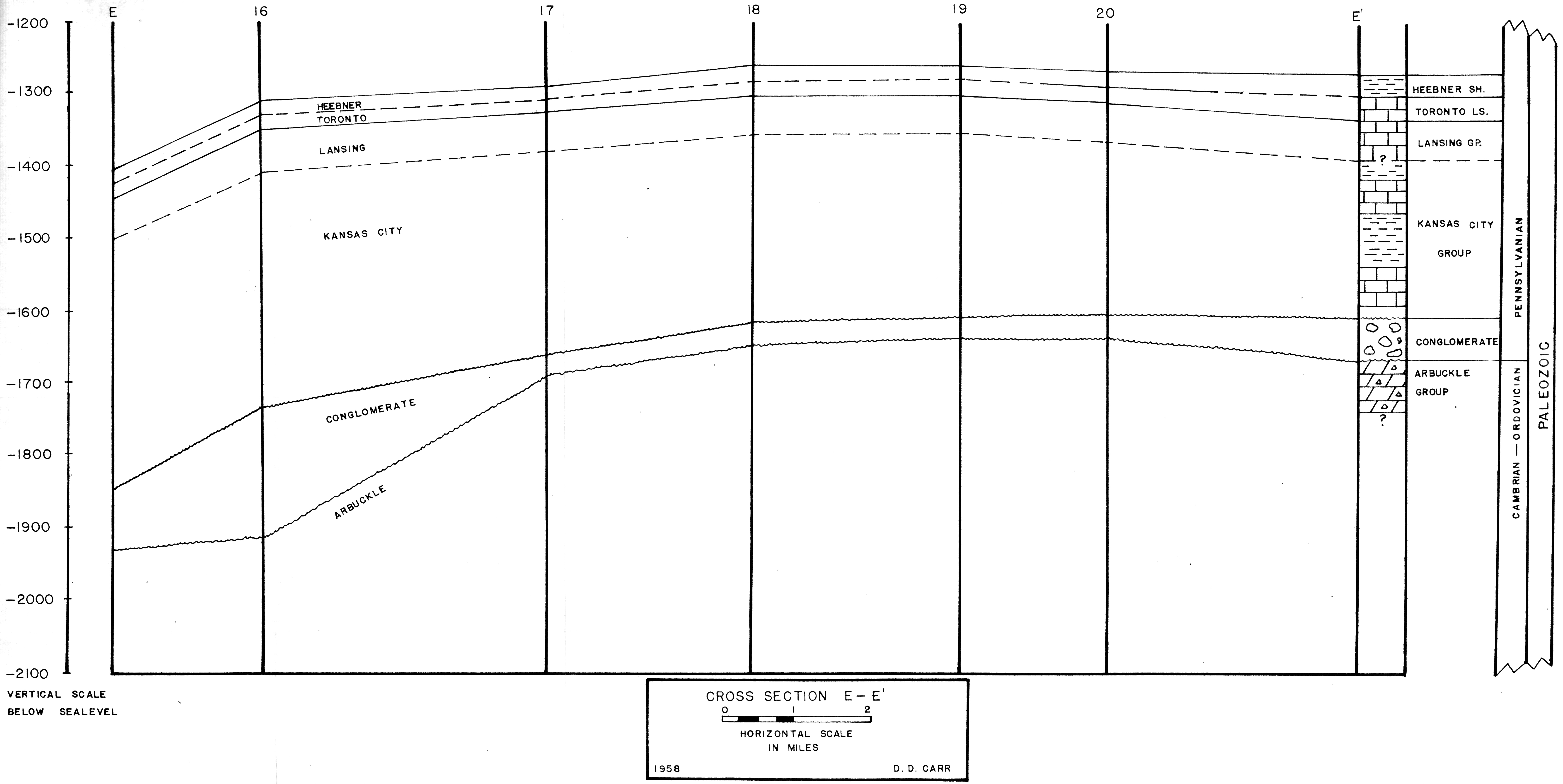
HORIZONTAL SCALE IN MILES

1958 D. D. CARR


C
8
9
10
11
C'
-1100
-1200
-1300
-1400
-1500
-1600
-1700
HEEBNER
TORONTO
LANSING
KANSAS CITY
CONGLOMERATE
ARBUCKLE
HEEBNER SH.
TORONTO LS.
LANSING GP.
KANSAS CITY GROUP
CONGLOMERATE
ARBUCKLE GROUP
PENNSYLVANIAN
CAMBRIAN — ORDOVICIAN
PALEOZOIC
VERTICAL SCALE
BELOW SEALEVEL
CROSS SECTION C — C'
0
1
2
HORIZONTAL SCALE
IN MILES
1958
D.D. CARR



D
12
13
8
15
D'
-1100
-1200
-1300
-1400
-1500
-1600
-1700
HEEBNER
TORONTO
LANSING
KANSAS CITY
CONGLOMERATE
ARBUCKLE
HEEBNER SH.
TORONTO LS.
LANSING GP.
KANSAS CITY
GROUP
CONGLOMERATE
ARBUCKLE
GROUP
PENNSYLVANIAN
CAMBRIAN - ORDOVICIAN
PALEOZOIC
VERTICAL SCALE
BELOW SEALEVEL
CROSS SECTION D - D'
0
1
2
HORIZONTAL SCALE
IN MILES
1958
D. D. CARR


E
16
17
18
19
20
E'
-1200
-1300
-1400
-1500
-1600
-1700
-1800
-1900
-2000
-2100
VERTICAL SCALE
BELOW SEALEVEL
HEEBNER
TORONTO
LANSING
KANSAS CITY
CONGLOMERATE
ARBUCKLE
HEEBNER SH.
TORONTO LS.
LANSING GP.
KANSAS CITY
GROUP
CONGLOMERATE
ARBUCKLE
GROUP
PENNSYLVANIAN
CAMBRIAN — ORDOVICIAN
PALEOZOIC
CROSS SECTION E – E'
0
1
2
HORIZONTAL SCALE
IN MILES
1958
D. D. CARR

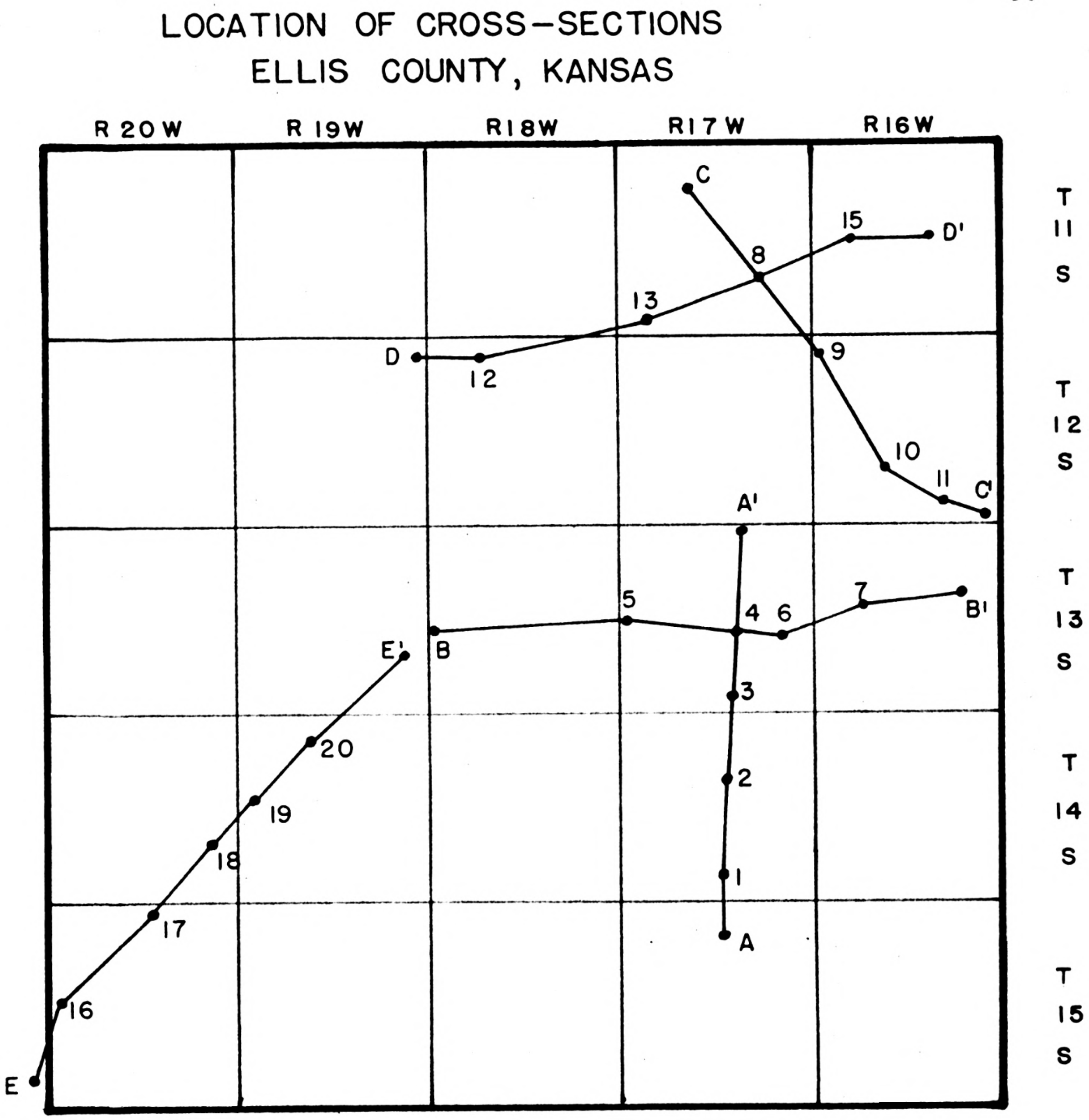


Fig. 8A. Map of Ellis County showing location of cross sections.

SUBSURFACE GEOLOGY OF ELLIS COUNTY, KANSAS

by

DONALD DEAN CARR

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

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

Ellis County is located in north-central Kansas in the Great Plains physiographic province. It consists of 25 townships with an area of approximately 900 square miles. The purpose of this investigation was to study the relationship of subsurface structure to petroleum production. Structural contour maps, an isopach map, and cross sections were utilized to accomplish the objective.

Ellis County rides the crest of the Central Kansas uplift. Other major features include the Salina basin on the east, the Hugoton embayment to the southwest, and the Cambridge arch to the north. Important smaller structural features in the county are the Russell Rib and Rush Rib. It is possible that both of these structures may represent faulting of the pre-Cambrian surface. In this report only the Russell Rib is interpreted as a fault.

The geologic history indicates that the area of Ellis County was subjected to major erosion in post pre-Cambrian, post-Arbuckle, post-Mississippian, post-Permian, and post-Quaternary times. Rock units are present from pre-Cambrian to Quaternary with the exception of Silurian, Devonian, Mississippian, Triassic, and Jurassic periods.

In 1956 Ellis County ranked first among counties in Kansas in opening new pools, and second among counties for yearly production. The two major producing horizons are the Arbuckle and Lansing-Kansas City groups. It appears that production from these two horizons is influenced by stratigraphic traps and by their position along anticlinal highs.