# THE RELATIONSHIP OF THE SUBSURFACE GEOLOGY TO THE PETROLEUM ACCUMULATION IN ELLSWORTH COUNTY, KANSAS

by

JAMES ROY HOWARD

B. S., University of Illinois, 1957

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A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology and Geography

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

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# INTRODUCTION AND REVIEW OF LITERATURE

## Purpose of Investigation

The purpose of this investigation is to give a clearer insight into the relationship of oil accumulation and production to stratigraphy and structure in Ellsworth County, Kansas.

## Location and Topography

Ellsworth County is located in central Kansas. The county includes Townships 14, 15, 16, and 17 South and Ranges 6, 7, 8, 9, and 10 West. The county contains 20 townships, comprising an area of 720 square miles in the Great Plains Province. The location of Ellsworth County in relation to adjoining counties is shown in the Appendix, Fig. 1.

Ellsworth County is divided into two nearly equal parts by the Smoky Hill River which enters from the west just south of the town of Wilson and flows southeastward past the city of Ellsworth, leaving the county near its southeastern corner. A narrow flood plain adjacent to the present channel is occupied by Quaternary sands and gravels. In the southwestern corner of the county, a small area is covered by similar material, occurring in flat lying terrace deposits which are remnants of the flood plain of an ancient river that flowed over Kansas in Pleistocene time.

## Previous Investigations

There is very little in Geologic literature concerning any detailed studies of the stratigraphy and structure of Ellsworth County. However, an extensive study of some of the adjoining counties has been conducted and this has helped considerably in preparing this thesis.

An individual pool study has been undertaken by Clark and others, (1948) of the Geneseo-Edwards pool of Rice and Ellsworth Counties. The major structural elements of the county are the Central Kansas uplift and the Salina basin. These structural elements have been studied and reports written by Koester (1935), Lee and others, (1948), Merriam (1955), Morgan (1932), and others. The minor structural elements of Ellsworth County have been touched upon by Koester (1934), Ver Wiebe (1938), and Clark and others, (1948).

## Procedure

The Arbuckle group of Cambro-Ordovician age (Appendix, Fig. 7) and the Lansing group of Pennsylvanian age (Appendix, Fig. 8) were chosen to be mapped because of their stratigraphic and structural significance in oil accumulation in Ellsworth County.

An isopachous map was also constructed of the interval between the top of the Lansing group and the top of the Arbuckle group to show the relationship of thickness to the subsurface structure (Appendix, Fig. 9). Two correlation charts were made to aid in the stratigraphic study of the area (Appendix, Figs. 10 and 11).

Abundant datum elevations for constructing the structure contour maps and correlation charts were obtained from the Herndon maps, Kansas Geologic Society driller logs, Scout tops, and a few electric logs.

# STRATIGRAPHY

## Pre-Cambrian System

The basement rocks in Kansas consist largely of granite, quartzite, gneiss, and schist. Generally, a coarse-grained, pink granite was encountered in several of the wells which penetrated the pre-Cambrian rocks in Ellsworth County.

## Cambrian System

Reagan Sandstone. The basal sandstone of the Kansas section is variously called Basal sand, Regan sandstone, or Lamotte sandstone. It has been drilled into at several points in Ellsworth County and completely penetrated in a few places. One well in section 34, T. 17 S., R. 8 W., encountered the basal sand from 3,823 to 3,880 feet, the total depth of the well. Another well, in section 29, T. 15 S., R. 8 W., found sand with dolomitic streaks and conglomerate from 3,102 to 3,204 feet. Subjacent to this conglomerate a mixture of materials consisting of quartz, feldspar, chlorite, muscovite and magnetite was found and indicates a very thick section of arkosic detritus above the pre-Cambrian rocks. The lithology of this stratigraphic unit has been described by Walters (1946).

Bonneterre Dolomite. The Bonneterre dolomite was originally deposited over the Central Kansas uplift, and it was subsequently removed by erosion before deposition of younger rocks. The Bonneterre dolomite includes a few thin, buff-colored sandstones or sandy dolomites. Although this unit has not proved productive in Ellsworth County, it has proved productive in nearby Barton County (Bonchonsky, 1957).

## Ordovician System

Arbuckle Group. The Arbuckle group consists of the Jefferson City dolomite and the Roubidoux dolomite. The age of the Arbuckle group is both Cambrian and Ordovician since deposition was transitional in Kansas between these two periods.

Its presence is often indicated by oolitic chert and other chert of various bright colors, either above or within it. One of the unique characteristics of the Arbuckle is the formation of a "Karst" topography upon its surface due to subaerial erosion. This can be seen from the structural contour map (Appendix, Fig. 7). A number of wells penetrated the Arbuckle and found it of greatly varying thickness. In a well in section 34, T. 17 S., R. 8 W., the top of the Arbuckle was found at 3,316 feet and the base at 3,823 feet, making a thickness of over 500 feet. Another well located in section 29, T.15 S., R. 8 W., found the Arbuckle high, with its top at 2,990 feet and its base at 3,100 feet, making a thickness of 110 feet. In a third well in T. 17 S., R. 10 W., a thickness of 218 feet was found. In Ellsworth County the thickness of the Arbuckle increases eastward away from the Central Kansas uplift and toward the Salina basin.

The Arbuckle group is the most prolific producer in Ellsworth County, perhaps because it offers the most structural control. Location of wells used to construct the structure contour map of this unit is shown in the Appendix, Fig. 2.

Simpson Group. The Simpson group rests with unconformable contact upon the underlying Arbuckle group. It is probably the most readily identifiable horizon found in well cuttings. Much green shale is interstratified with thin sands, and in a few wells this shale occupies most of the section. Conodonts and phosphatic nodules serve to distinguish this formation from others with which it might be confused (Taylor, 1947). The rounded, frosted grains (probably St. Peter) of sand which appear in some wells indicate that wind action had much to do with its formation. The thickness of the Simpson ranges from 30 feet in the western ranges to 90 feet and more in the extreme eastern ranges.

Viola. The Viola "lime" rests conformably upon the Simpson group and is predominately a coarse, crystalline, white to gray, slightly dolomitic unit. Its average thickness is 50 feet, but thins rapidly as it is traced up on the Central Kansas uplift. This thinning of the Viola and other early Paleozoic rocks can be seen by referring to the Appendix, Figs, 10 and 11.

Sylvan. The Sylvan shale appears beneath the Carboniferous rocks in Range 6 West and also in the three eastern ranges of Township 17 S. It is a greenish-gray, splintery shale which varies from a few feet to probably a maximum thickness of 90 feet (Taylor, 1947). Very often it is extremely difficult to distinguish between the Sylvan shale and the shales of the Kinderhookian series of Mississippian age.

## Silurian-Devonian Systems

"Hunton" Limestone. The "Hunton" of Silurian-Devonian age has been encountered in Range 6 West and Township 17 South and also in Range 6 West and Township 14 South. It is identified in well cuttings partly by its lithology and partly by its stratigraphic position (Taylor, 1946). The lithology has been exhaustively described by Johnson (1934). In Ellsworth County the "Hunton" unit is a pink limestone which may be sandy or crinoidal. It has been identified only from a limited number of wells in this county.

## Mississippian System

The Mississippian rocks consist essentially of two types, a limestone unit above the shale unit below. The limestone is usually eroded so that a much reduced thickness is found in Ellsworth County. In Range 6 West from 50 to 70 feet of limestone have been found in some wells. In Range 7 West the lime or its chert equivalent varies from zero to 300 feet. The most rapid variations are found in T. 16 S., and R. 7 W.

Thickness of Mississippian rocks is extremely variable, as a result of erosion subsequent to anticlinal folding. The Mississippian rocks underlie the Pennsylvanian sediments with angular unconformity (Lee, 1940).

Rocks of Mississippian age are primarily chert-bearing limestones and dolomitic limestones. Intensive weathering of these rocks removed many of the upper layers of the limestones and dolomites, leaving a relatively thick mantle of the more resistant chert. These weathered and eroded chert fragments are usually embeded in red and vari-colored clay and shale or cemented by quartz or chalcedony; occasionally they are unconsolidated. The weathered chert zone is often referred to as the Mississippian "Chat". This "Chat" zone is sometimes called the Basal Pennsylvanian conglomerate (Moore, 1926). No attempt has been made to divide these sediments, and they will be referred to in this report as the Mississippian "Chat".

Kinderhookian Series. The Kinderhookian series of rocks (lowermost Mississippian) are found only in the extreme eastern ranges of this county and consist mostly of shales. The Chattanooga shale is the basal unit of this series and is thought to be a transitional unit between the Devonian and Mississippian systems. The base of the Chattanooga shale rests with unconformable contact upon the subjacent "Hunton".

The Boice shale may be present in the eastern ranges and may occur as a thin interval above the Chattanooga. Lee and others (1948) believe that the Boice shale is derived from weathering and erosion of the top of the Chattanooga shale, giving rise to a marked disconformity between the two. In most instances the Boice shale is included with the Chattanooga shale. Overlying the Chattanooga shale there are two prominent formations which are named the Sedalia dolomite and the Gilmore City limestone.

Osage and Meramac Series. The Osage series overlie the Kinderhookian series and consist of four major limestone units. They are, in ascending order, the Reeds, Spring, Burlington, and Keokuk limestone formations.

The Meramac series overlie the Osage series of rocks and are present only in the extreme eastern ranges. This series has been divided into two major formational units which are, in ascending order, the "Warsaw" and Spergen limestones. The Meramac and possibly all of the Osage series are absent in the western half of the county, and the "Chat" represents eroded and weathered limestones of late Mississippian age.

## Pennsylvanian System

The average thickness of the Pennsylvanian rocks is 1900 feet, and they dip gently toward the west. This system is divisible into seven lithologic units which are, in ascending order, the Basal Pennsylvanian conglomerate, the Marmaton group, the Bronson-Kansas City-Lansing group, Pedee group, Douglas group, Shawnee group, and the Wabaunsee group. The Atoka and Morrowan series are absent in this area.

Desmoinesian Series. Pennsylvanian Basal Conglomerate. This zone of variable thickness at the base of the Pennsylvanian system consists of chert fragments imbedded in red and vari-colored clay and cemented by quartz and chalcedony. This unit is very often referred to as the Mississippian "Chat".

Marmaton Group. The Marmaton group consist of red and green shales. Due to the unconformity of the base this group varies in thickness, and in the western ranges it is absent.

Missourian Series. Bronson-Kansas City-Lansing Group. In this group there are five distinct oolitic zones. Most of the limestones in this group are white in color and rather crystalline in texture. The thickness of the unit varies from 200 to 300 feet. The top of this group is found at a depth of 2,700 feet in the eastern ranges, but in the western ranges it is somewhat deeper, about 3,100 feet (Appendix, Figs. 10 and 11).

Pedee Group. The only representative of the Pedee group is the Iatan limestone. Drillers and Geologists log this interval as the "Brown Lime". The Iatan unit is a bluish-gray to nearly white limestone. The average thickness is approximately 15 feet in Ellsworth County (Ver Wiebe, 1938).

Virgillian Series. Douglas Group. The Douglas group is characterized by red and green shales in which there are thin beds of limestones. This unit varies in thickness but is generally from 100 to 300 feet thick in the eastern ranges.

Shawnee Group. The Shawnee group is primarily made up of thick layers of limestone which are interstratified with dark shale and some sandstone. The Topeka limestone at the top of the Shawnee group is found at depths ranging from 3,000 feet in the west to 2,200 feet in the eastern part of the county. In the basal Oread, the Heebner black shale is especially prominent and persistent.

Wabaunsee Group. The Wabaunsee group is the uppermost group of rocks in the Pennsylvanian system. It contains mostly clastic material, among which red and green shales, micaceous sandstones, and a small amount of black shale near the middle are distinctive. This unit varies from 500 to 600 feet in thickness in Ellsworth County.

## Permian System

The Permian rocks of Kansas are divided into the following series listed in ascending order: Wolfcampina, Leonardian, and Guadalupian. Permian rocks overlie the Pennsylvanian rocks by a slightly angular unconformity and erosional surface. They are separated from the overlying Cretaceous rocks by an angular unconformity representing a long hiatus, during which hundreds of feet of Permian rocks were eroded.

The Permian system of Ellsworth County is restricted entirely to the subsurface with the exception of a small area in the southeastern townships. There are five main lithologic groups, which are, in ascending order, the Admire, Council Grove, Chase, Sumner and Nippewalla groups.

Wolfcampian Series. The sequence of rocks from the Herington (Chase group) to the base of the Americus (Council Grove group) limestone is probably the most distinctive of any group of subsurface rocks in the county. The Herington is easily picked in well cuttings, because it is the first dolomitic limestone of any consequence in the section. Below it is a thin zone of gypsiferous shale which is in return underlain by the Winfield limestone. Another shale, which is usually red, is underlain by the Ft. Riley limestone. This formation is important in that it serves as a correlation marker and is readily identified in well cuttings and in well logs of wildcat wells. Its position is determined by the cherty base which corresponds to the Florence member.

Another cherty limestone, the Wreford, lies about 75 feet lower in the section. In the following 300 feet there are thick limestones with thin shale streaks down to the base of the Americus, which can be identified by its abundance of fusilinids. The whole section is slightly over 600 feet thick. The Herington appears at a depth of 900 feet in the eastern ranges and at 1,500 feet in the western ranges of Ellsworth County.

Leonardian Series. The first important lithologic unit encountered while drilling in the Permian section is the red beds which are called the Cimarron series (Nippewalla group). In Range 6 West the thickness is about 450 feet, and in Range 10 West the thickness reaches 700 feet. Near the base of the Cimarron red beds is a zone of gypsum with dolomite (Stone Corral) below it, which is of great importance in subsurface studies because of its persistence. Core drill holes are usually bored to this bed for structural control. In Range 6 West the Stone Corral formation (Sumner group) appears at a depth of about 200 feet, but farther west it is reported at 750 feet in some wells. This variation is partly accounted for by difference in surface elevations.

Red siltstones and clays abruptly give way to gray shales at the top of the Wellington (Sumner group) formation of the Big Blue series. The Wellington formation is divisible into three members. The upper one is approximately 150 feet thick and contains a red zone similar to the Cimarron shales. The middle member is a salt deposit and is quite thick in this county. In Range 6 West it appears at a depth of about 850 feet and has a thickness of about 100 feet. In Range 8 West it is found from 1,150 feet to 1,400 feet in depth. The lower member is a uniform series of anhydrites and thin shales which average slightly over 100 feet in thickness.

# MAJOR STRUCTURAL FEATURES OF KANSAS

## Nemaha Anticline

The Nemaha anticline or ridge is an asymmetrical, structural high in eastern Kansas which plunges to the southwest (Appendix, Fig. 5). It has a maximum relief of 3,200 feet on its steeper (eastern side) flank and strikes northeast-southwest. According to Rieb (1954) the configuration of its eastern flank resembles a normal fault scarp, and it is believed to be faulted in several places. Perhaps the straight alignment of the anticline is due to faulting more than folding.

## Sedgwick Basin

The Sedgwick basin is regarded as one of the major post-Mississippian structural provinces in Kansas and occupies an area in central Kansas southward from McPherson and Marion Counties (Appendix, Fig. 5). It is located west of the Nemaha anticline and south of a low, arch-like structure that marks the southern boundary of the Salina basin and east of a similar separation from Dodge City basin (Jewett, 1954).

## Chautauqua Arch

The Chautauqua arch (Appendix, Fig. 5) is the name given for the pre-Mississippian extension of the Ozark uplift along the Kansas-Oklahoma line (Barwick, 1928).

The Chautauqua arch and the Ellis arch structurally separate northeastern Kansas from southwestern Kansas

## Forest City Basin

Most of the Forest City basin is located in the adjacent states of Iowa, Missouri, and Nebraska, and only the extreme southwestern corner lies in Kansas. This basin is bounded on the west by the Nemaha anticline and on the southwest by the Bourbon arch. The axis of the basin trends slightly east of north and is somewhat parallel to the Nemaha anticline. The western flank of the basin is steep and the eastern flank gentle, giving an asymmetrical profile analogous to the Salina basin. Mississippian and older strata are sharply upturned, truncated, and overstepped by Pennsylvanian sediments on the west side of the basin along the Nemaha anticline. The present basin has been one of deposition since post-Arbuckle time. The Forest City basin, as it is known today, did not form until post-Mississippian time. During early Pennsylvanian time the basin received sediments from the low, positive areas of the Nemaha granite ridge.

## Cherokee Basin

The Bourbon arch is a low, post-Mississippian structure separating the Forest City basin from the Cherokee basin. The northwestern part of the Cherokee basin occupies the extreme southeastern part of Kansas. It is a shallow basin which developed in early Pennsylvanian time upon the Chautauqua arch. Although a certain amount of downwarping took place in the basin as an accommodation to sedimentation, the basin is more depositional than structural in type (Jewett, 1951).

The axis of the Cherokee basin lies close to and parallel with the Nemaha anticline and it is asymmetrical in cross section as is the Forest City and Salina basin. In the Cherokee basin the Chattanooga shale (probably Upper Devonian) lies unconformably on the Arbuckle. On the western flank of the basin, as in the Forest City basin, the early Paleozoic rocks have been truncated and overstepped by younger Pennsylvanian rocks. During early Pennsylvanian time the Nemaha anticline served as a source of sediment to the basin.

## Salina Basin

Only the southern tip of the Salina basin extends into Kansas. By far the greater part of this structural unit lies in central Nebraska. The eastern edge of the basin is bounded by the Nemaha anticline; the western side is bordered by the Cambridge arch and the southwestern flank is outlined by the Central Kansas uplift (Morgan, 1932). The axis of the basin trends northwest-southeast and plunges north toward the deeper portion of the basin in central Nebraska. Pre-Pennsylvanian strata are upturned, truncated, and overstepped around part of the southern perimeter of the basin (Lee and others, 1948).

In the Salina basin there are five recognizable periods of folding (Appendix, Fig. 5). (1) Upper Cambrian and lower Ordovician dolomites below the St. Peter sandstones were deformed before the deposition of the St. Peter sandstone. This structural movement was the result of minor movements which took place at different intervals prior to the deposition of the St. Peter sandstone. During this epoch a south-trending positive area, the Southeast Nebraska arch, was developed in southeastern Nebraska and western Kansas. In central Kansas a parallel north-south sycline was developed (Lee and others, 1948).

(2) The second period of folding extended from St. Peter time to the beginning of deposition of the Mississippian limestones and probably continued throughout all Kinderhookian time. The Southeast Nebraska arch was down-warped into a low basin and has been called the North Kansas basin. Contemporaneous

with these events was the development of the Chautauqua arch and the Central Kansas uplift on the south and west.

(3) A third period of folding began at least as early as the beginning of Mississippian time, culminated after Mississippian time, and gradually diminished through Pennsylvanian and Permian time. During this period of folding the Nemaha anticline was formed with the Salina basin on the west and the Forest City basin on the east. The Salina basin was a synclinal area, trending northwest and paralleling the northern flank of the Central Kansas uplift.

(4) A fourth period of deformation occurred after Permian time and before Cretaceous time. It involved the development of a broad synclinal basin in southeastern Kansas which gave rise to the southwesterly dip of the Pennsylvanian and Permian rocks.

(5) A fifth period of warping took place after deposition of Cretaceous rocks. This deformation resulted in the tilting of these rocks toward the northeast in western Kansas and toward the north and northwest in Central Kansas.

## Central Kansas Uplift

The Central Kansas uplift occupies an area in central Kansas and part of south-central Nebraska, whose present northwestward trending structure has been developed by several periods of warping, followed by erosion and subsequent truncation of sedimentary rocks (Merriam, 1955). Warping has occurred chiefly in post-Proterozoic (?), post-Canadian, post-"Hunton", early Pennsylvanian, post-Missourian and post-Cretaceous time. Along the crest and flanks of the uplift there are several minor structures, which differ in trend from the uplift itself (Appendix, Fig. 6).

## MINOR STRUCTURAL FEATURES OF ELLSWORTH COUNTY

### Wilson-Burns Element

The name Wilson-Burns element has been suggested for a northwest trend of domelike structures in pre-Mississippian rocks that extend from the Burns dome in Marion and Butler Counties through Ellsworth County to Russell County (Jewett, 1951).

The name Wilson-Burns was introduced as a structural term by Koester (1935) and his comments are as follows:

"Two high areas of 'Siliceous lime' cropped out in early Pennsylvanian time northeast of the nucleus of the uplift, one in central Ellsworth County near the town of Ellsworth, the other at Wilson on the Russel-Ellsworth County line. They represent a line of pre-Mississippian warping which can be traced northwestward from the Burns dome in northern Butler County through the Peabody, Ritz-Canton, and McPherson fields. While this tectonic feature, for which the name Wilson-Burns element is proposed, is closely related to the Central Kansas uplift, at least in part, in age and alignment, it does not seem to be a part of that structure".

According to Jewett (1951) the Wilson-Burns trend and pre-Mississippian structures in the Ellis arch are in accordance with the ancient grain of Kansas rocks. Attention is called to the Central Kansas uplift, as defined by Rich (1933) which is the combined Chautauqua and Ellis arches, and its axis is essentially parallel to the axis of the Wilson-Burns element as defined by Koester (1935).

## Geneseo-Edwards Uplift

The name Geneseo uplift is applied to the eastern part of the Barton arch in Rice, Ellsworth, and McPherson Counties.

The Geneseo uplift has been discussed in detail by Clark and others, (1948). These geologists believe the uplift occupies a triangular area including T. 17 S. and T. 18 S., the west half of R. 5 W. and all of R. 6, 7, and 8 W. It contains the Bornholdt, Edwards, Geneseo, Smyres, Welch, and Wherry oil pools.

Oil accumulations on or near this structure are located in stratigraphic traps with the exception of the Edwards pool which is in a closed structure. The dome that contains the Edwards pool, as measured on the eroded surface of the Arbuckle rocks, has about 125 feet of closure. Rocks ranging from early Ordovician (Arbuckle) to Mississippian age are truncated by post-Mississippian erosion and are overstepped by Pennsylvanian depostis.

## Ellsworth Anticline

A structure that underlies part of west-central Rice County is called the Ellsworth anticline. According to Koester, (1934), "This anticline runs through R. 8, 8, and 10 W. from the vicinity of Ellsworth to and beyond the southern limits of Rice County". In a later publication (Koester, 1935), Koester made this comment: "From the southwestern portion of Rice County to the vicinity of Ellsworth extends a relatively steep fold to which the name Ellsworth anticline has been given. Its position can be approximately found on the pre-Mississippian area made by the north-south Simpson bank of outcrop in this area". The Chase, Ploog, and Lorraine pools are on this axis. The axis of the Ellsworth anticline is nearly normal to the Wilson-Burns element and is thought to be an early Pennsylvanian structure.

## GEOLOGIC HISTORY

At least four major periods of folding have occurred in this particular area since pre-Cambrian time. These periods are, in chronological order: (1) pre-St. Peter, (2) post-Arbuckle to pre-Mississippian, (3) post-Mississippian to pre-Marmaton with diminished activity throughout Pennsylvanian and Permian time, and (4) post-Cretaceous.

The late Cambrian seas covered all of Ellsworth County and fluctuated from a relatively shallow sea in which the Lamotte sandstone may have been deposited to a deeper sea in which the Arbuckle sediments were deposited. The Arbuckle seas did not retreat until early Ordovician time, and sedimentation was continuous between the Cambrian and Ordovician systems. When the Arbuckle seas receeded, the area was uplifted and subjected to a period of subaerial erosion, forming a "Karst" topography on the surface of the Arbuckle.

The Arbuckle erosional period was followed by a three stage depositional environment. The clastic Simpson group was deposited in a shallow, fluctuating sea during the first stage. For the second stage of deposition there are two possible conditions for the deposition of the nonclastic Viola. The sea could have been deeper, or the land mass may have been very nearly leveled by erosion. Either of these conditions would make limestone sedimentation possible. A slight rise in the land mass, or perhaps a drop in sea level, contributed to the condition necessary for the deposition of the Sylvan shale during the third stage.

The "Hunton" limestone of Sil.-Dev. age was deposited conformably upon the Sylvan shale due to the continuation of this deep sea during Silurian and Devonian time.

Prior to Chattanooga deposition the area was slightly uplifted and subjected to another period of subaerial erosion. The Chattanooga shale is a transitional unit between the Devonian and Mississippian systems, and it is sometimes miscalled the "Kinderhook" shale or confused with the Sylvan shale. The Chattanooga shale was deposited unconformably upon the underlying "Hunton" limestone and other truncated, older formations.

Above the Chattanooga, there is a thick section of limestones interstratified with shales near its base. After the deposition of a thick Mississippian section, the area was uplifted once again and subjected to subaerial erosion. Uplift and erosion of the cherty, Mississippian limestones occurred in post-Mississippian and pre-Marmaton time and developed a thick zone of conglomerate. This zone of detritus is referred to as the Mississippian "Chat" or Basal Pennsylvanian conglomerate.

After Marmaton time the Pennsylvanian sediments were deposited upon the truncated Mississippian sediments with an angular unconformity. The Pennsylvanian system is characterized by a marine sedimentation environment in which fossiliferous limestones interbedded with shale and minor amounts of sandstones were deposited. Diminished structural movements during this period are represented by minor unconformities which appear at the close of each series.

The continuation of marine sedimentation into Permian time left deposits of interstratified limestones and shales until the end of Wolfcampian time when the seas retreated to the south.

## HISTORY OF DRILLING

The first commercial quantities of gas were found in 1904 in an anticlinal structure near the town of Ellsworth in T. 15 S. and R. 8 W. This discovery was incidental to a search for salt. The gas horizon was found at depths ranging from 950 to 1100 feet in the Winfield and Ft. Riley intervals. The wells were abandoned shortly afterwards, and drilling activity was stepped up when oil was discovered in the southwestern part of the county.

At the present time there are 16 major oil pools in Ellsworth County. Most of the oil fields are located in the southwestern townships on the Central Kansas uplift. Up to the end of 1955 they had accounted for a total of over eighty-one million barrels of oil (Appendix, Table I).

The first oil was discovered by Slick, Pryor, and Lockhart in 1930 when they completed the No. 1 Heiken well in Sec. 25, T. 17 S., R. 10 W. The well was started in June, 1930, and resulted in considerable excitement when gas was found in the Topeka formation and the Lansing limestone. The initial flow was six million cubic feet. The well was drilled down to the Arbuckle where oil was found at 3,222 feet. The cumulative production up to Jan. 1955 was 290,684 barrels of oil from eighty productive acres. Production comes from the Arbuckle and Kansas City-Lansing groups, but the Mississippian "Chat" is the most prolific pay zone in this pool (Appendix, Fig. 13).

The Stoltenberg pool is the largest pool in Ellsworth County, having a cumulative total of over thirty-seven million barrels of oil from 13,700 productive acres. The pool was first discovered in 1931 when Tom Palmer completed the first well on the Stoltenberg farm in sec. 21, T. 16 S., R. 10 W. The top fo the Arbuckle was reached at 3,333 feet. In 1937 there were 16 oil wells producing from this pool, but continued exploration extended the pool in a southeasterly direction. Now there are more than 350 producing wells in this field.

The Lorraine pool was opened when Twin Drilling Oil Company found production in the Arbuckle at 3,200 feet. The well was completed with an initial production of 526 barrels. Since then over ten million barrels of oil have been produced from 200 acres. Production is from the Kansas City-Lansing and the Arbuckle groups. The structure is anticlinal.

The Geneseo-Edwards pool was discovered in 1934 and is located in T. 17 S., and R. 8 W. It contains 3,680 productive acres, and production is from the Simpson and Arbuckle groups. This is one of the largest fields in Ellsworth County, having a cumulative production of some sixteen million barrels. The structure is anticlinal.

The Green Garden (1954) and Lorraine North (1953) were discovered N. E. of the Lorraine pool and approximately on strike with the Lorraine pool structure. Together they have a cumulative yield of over 35,000 barrels, and production is mostly from the Arbuckle. All three pools are probably on the same structure.

The Kraft-Prusa field was discovered in 1942 and the Kraft-Prusa East field was discovered in 1944 as a result of continued exploitation of the first pool. The Kraft-Prusa East field includes 40 productive acres and produces from the Arbuckle at 3,309 feet. The Kraft-Prusa field includes 800 productive acres (Appendix, Fig. 13) and produces from the Shawnee, Kansas City-Lansing groups, Arbuckle and the Reagan formations.

From 1942 to 1951 four more pools were found in the southwestern part of the county which are the: Wilkens Southeast, West, Vacek, Heiken North, and Palacky oil pools. Production in these fields comes entirely from the Arbuckle and, to a lesser degree, the Kansas City-Lansing groups. They are all located on the Central Kansas uplift.

## FUTURE POTENTIAL

The future potential for discovery of additional reserves of petroleum in Ellsworth County is fair. All known structural highs have been explored and for the most part drilled out.

The structure contour map of the Arbuckle (Appendix, Fig. 7) group, if the interpretation is correct, shows a few areas that may warrant further exploration. There is an anticlinal structure in the central part of the county adjacent to a northwest-southeast trending "syncline". This "syncline" trends from T. 17 S., R. 6 W. to T. 14 S., R. 10 W. and is asymmetrical in cross section, having its steeper side on the northeastern flank. The northeast-southwest cross section (Appendix, Fig. 11) gives evidence of Ordovician sediments pinching out against the anticlinal structure, and, perhaps there is a possibility of a stratigraphic play here.

Another area that might warrant further exploration is in T. 16 S., R. 7 W. There is an anticlinal "nose" in this area that might be found productive if drilling activity was stepped up in this township. This anticlinal "nose" is also reflected in the Kansas City-Lansing rocks (Appendix, Fig. 8) and has some closure. If oil is not found in a structural trap, there is still a possibility of obtaining production from Ordovician sediments which have been truncated and upturned on this structure.

The northeastern townships have not drilled extensively, and perhaps in the future new structures will be found. If new structures are not found in the northeastern part of the county, and if oil is not found in the areas mentioned above, the future outlook for Ellsworth County is not too bright. However, the chances of finding additional reserves seem favorable.

## CONCLUSIONS

Petroleum accumulation in Ellsworth County is a result of both structural and stratigraphic traps. The Edwards and Lorraine pools are on closed anticlines; whereas, the Stoltenberg pool, the largest field in the county, is located in a stratigraphic trap (Appendix, Fig. 7).

There is a rather complete Geologic column of rocks in eastern Ellsworth County, but most of the Ordovician and Mississippian rocks are absent in the western ranges. These rocks were removed after the Central Kansas uplift was formed.

The surface rocks of Ellsworth County are not regarded as very favorable toward delineating the subsurface structure. Therefore, in the past, oil companies have resorted to core drilling to outline areas favorable for exploration. Some of the prominent "highs" were originally located in this manner. Deep drilling was revealed a complicated pattern of buried structural elements and evidence seems to indicate two lines of deformation cross each other in this county.

One of these lines of deformation, the Wilson-Burns element, trends northwest-southeast parallel to the Central Kansas uplift. This deformation is clearly indicated by a series of "highs" from the northwestern corner of the county through Ellsworth townsite. The other line of deformation, the Ellsworth anticline, trends at almost right angles to the Wilson-Burns element and passes through the Lorraine pool northeastward to the town of Ellsworth.

The Geneseo-Edwards uplift is almost parallel with the Ellsworth anticline and normal to the Wilson-Burns element. Perhaps this structure constitutes a second structure in this county. At the present there is no information available in the literature about its structural significance in relation to the minor structures in Ellsworth County.

Since most of the known "highs" have been drilled out, it seems most likely that any new oil finds in this county will be in stratigraphic traps. There are several areas in the county that warrant further investigation in view of their stratigraphic significance, and these have been discussed in an earlier section of this thesis.

## ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. C. P. Walters for his valuable information and suggestions while preparing this thesis and the criticisms and suggestions while editing the thesis. Sincere thanks are also expressed to the Department of Geology and Geography for their help and consideration.

The writer is grateful to Grace Muilenburg of the State Geological Survey and the Herndon Map Service for furnishing a wealth of information.

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# APPENDIX

Table 1. Oil production in Ellsworth County, Kansas to January 1, 1955.

| Pool and location of discovery well | Oil Production | | | | | |
|---|---|---|---|---|---|---|
| | Discovery year | Number of wells | Area in acres | Depth in feet | Producing zone | Cumulative production in barrels |
| Andrews<br>4-17-8W | 1952 | 5 | 500 | 3,302 | Arbuckle | 62,118 |
| Bloomer<br>36-17-11W | 1936 | 96 | 2,900 | 3,044<br>3,257 | Lans.-K.C.<br>Arbuckle | 13,569,312 |
| Geneseo-Edwards<br>25-18-8W | 1934 | 143 | 3,680 | 3,157<br>3,278 | Simpson<br>Arbuckle | 16,453,262 |
| Green Garden<br>1-17-9W | 1954 | 1 | 40 | 3,046 | Lans.-K.C. | 4,667 |
| Heiken<br>25-17-10W | 1930 | 2<br>16<br>2 | 800 | 2,974<br>3,226<br>3,269 | Lans.-K.C.<br>Penn. congl.<br>Arbuckle | 290,684 |
| Heiken North<br>24-17-10W | 1942 | 2 | 80 | 3,212 | Arbuckle | 189,637 |
| Kraft-Prusa<br>10-17-11W | 1937 | 14 | 800 | 2,885<br>3,160<br>3,335<br>3,281<br>3,310 | Shawnee<br>Lans.-K.C.<br>Gorham<br>Arbuckle<br>Reagan | 1,078,644 |

Table 1. Oil production in Ellsworth County, Kansas to January 1, 1955, continued

| Pool and location of discovery well | Oil production | | | | | |
|---|---|---|---|---|---|---|
| | Discovery year | Number of wells | Area in acres | Depth in feet | Producing zone | Cumulative production in barrels |
| Kraft-Prusa East 18-17-10W | 1944 | 1 | 40 | 3,309 | Arbuckle | 13,723 |
| Lorraine 13-17-9W | 1934 | 34 | 2,000 | 3,060<br>3,200 | Lans.-K.C.<br>Arbuckle | 10,733,457 |
| Lorraine North 12-17-9W | 1953 | 2 | 80 | 3,066 | Lans.-K.C. | 33,851 |
| Maes 26-17-8W | 1952 | 21 | 760 | 3,341 | Arbuckle | 538,030 |
| Palasky 31-16-10W | 1949 | 2 | 80 | 3,148<br>3,390 | Lans.-K.C.<br>Arbuckle | 31,173 |
| Stoltenberg 22-16-10W | 1931 | 335 | 13,200 | 3,260<br>3,333 | Lans.-K.C.<br>Arbuckle | 37,248,702 |
| Vacek 32-15-10W | 1944 | 7 | 640 | 3,315 | Arbuckle | 299,846 |

Table 1. Oil production in Ellsworth County, Kansas to January 1, 1955, continued

| | | | Oil production | | | |
|---|---|---|---|---|---|---|
| Pool and location of discovery well | Discovery year | Number of wells | Area in acres | Depth in feet | Producing zone | Cumulative production in barrels |
| West<br>20-17-10W | 1951 | 2 | 80 | 3,287 | Arbuckle | 24,424 |
| Wilkens Southeast<br>32-17-9W | 1942 | 6 | 300 | 3,220 | Arbuckle | 453,525 |
| Total Ellsworth County | | 691 | 25,980 | | | 81,025,055 |

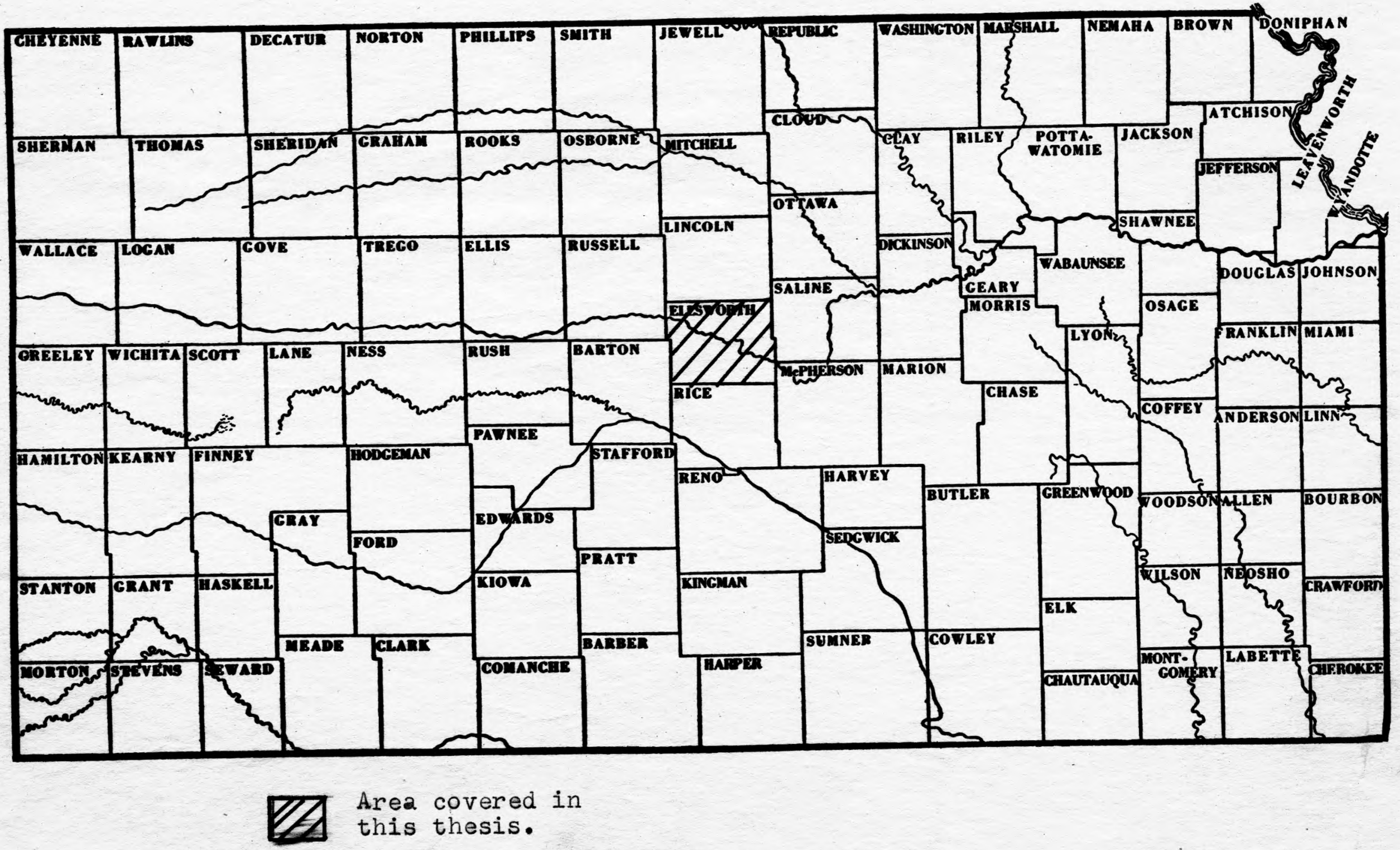



Fig. 1. Index Map, showing location of Ellsworth County, Kansas.

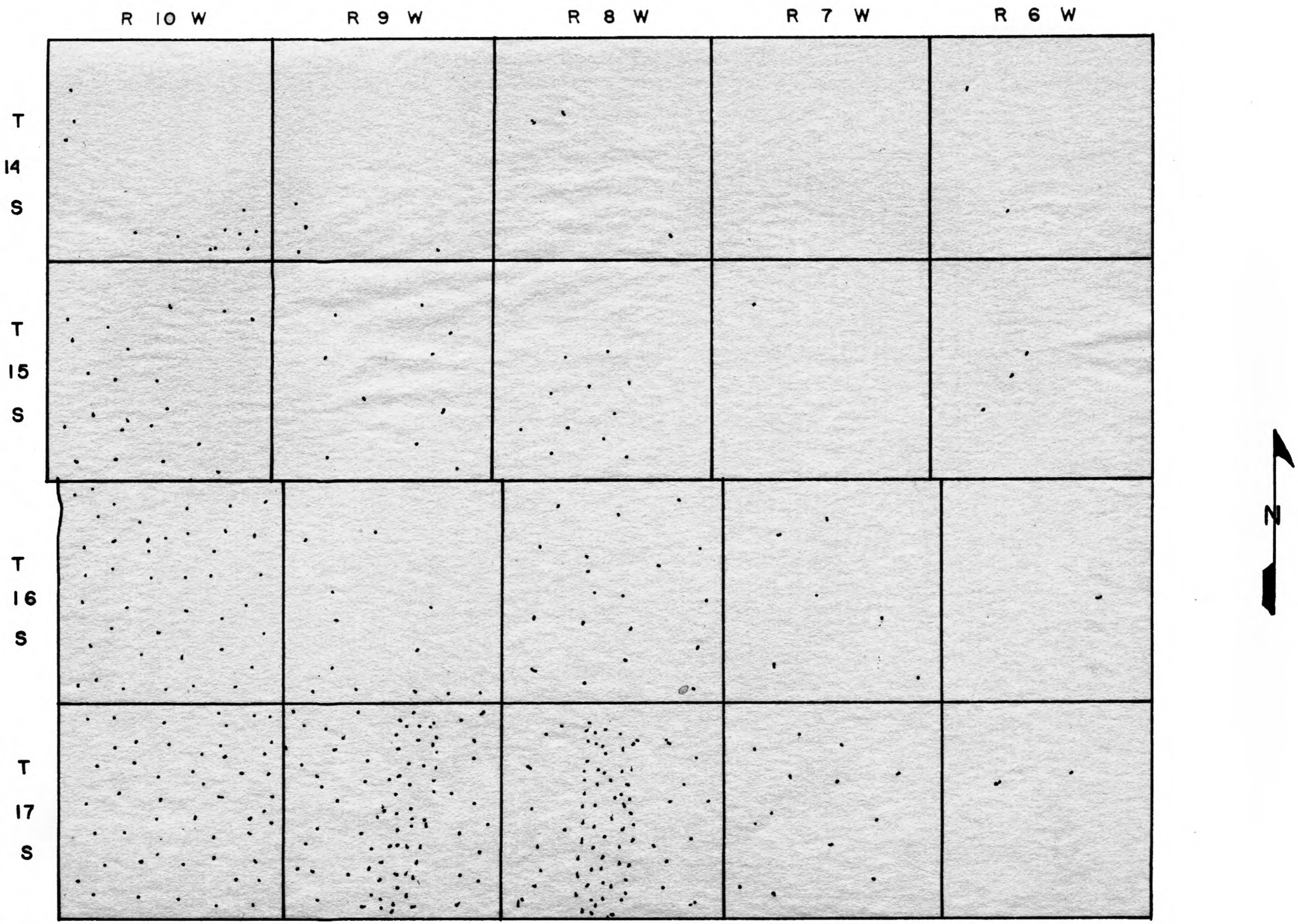



Fig. 2. Location of wells in Ellsworth Co., Kansas used to contour structure on the Arbuckle.

SCALE
3 0 3 MILES

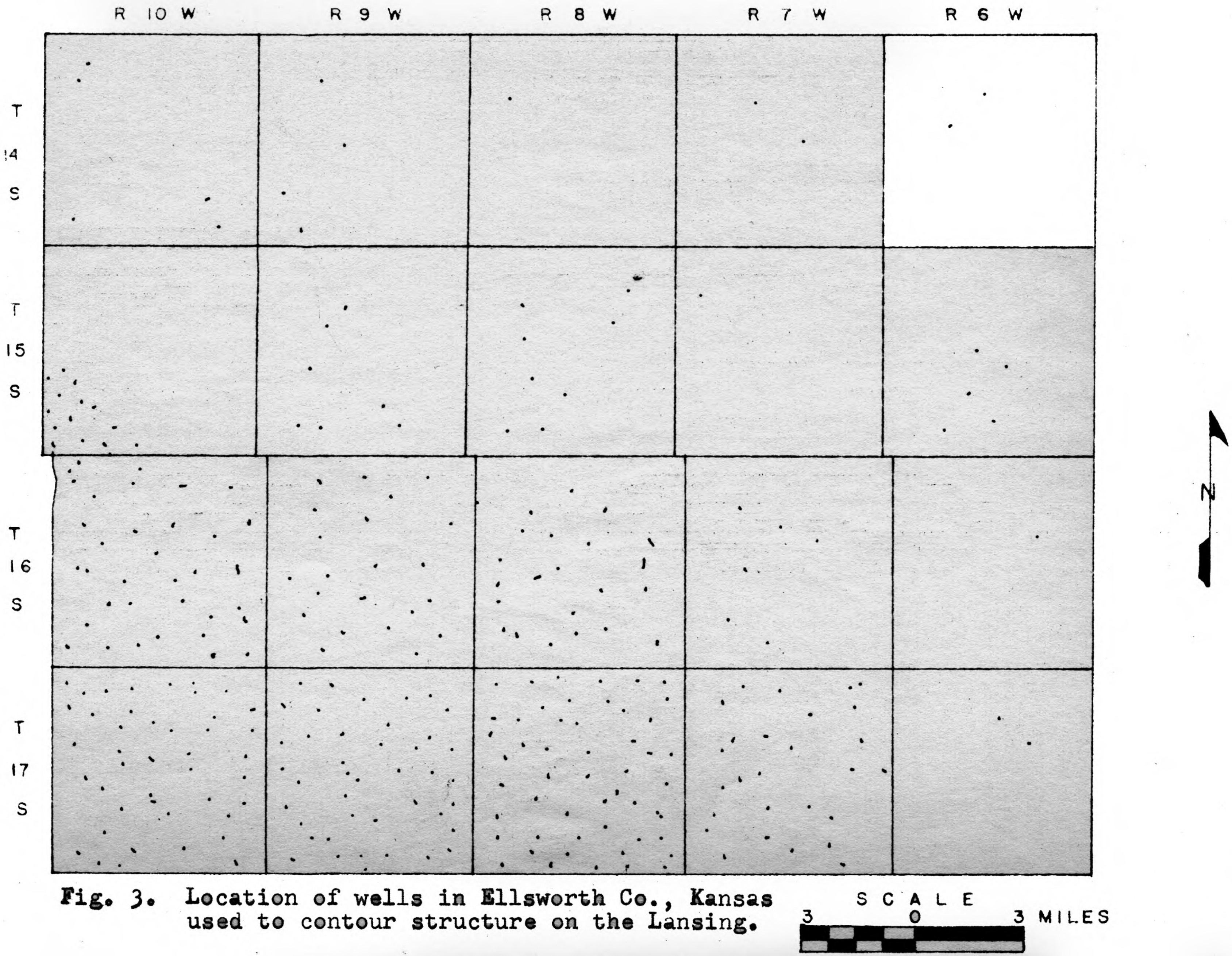



**Fig. 3.** Location of wells in Ellsworth Co., Kansas used to contour structure on the Lansing.

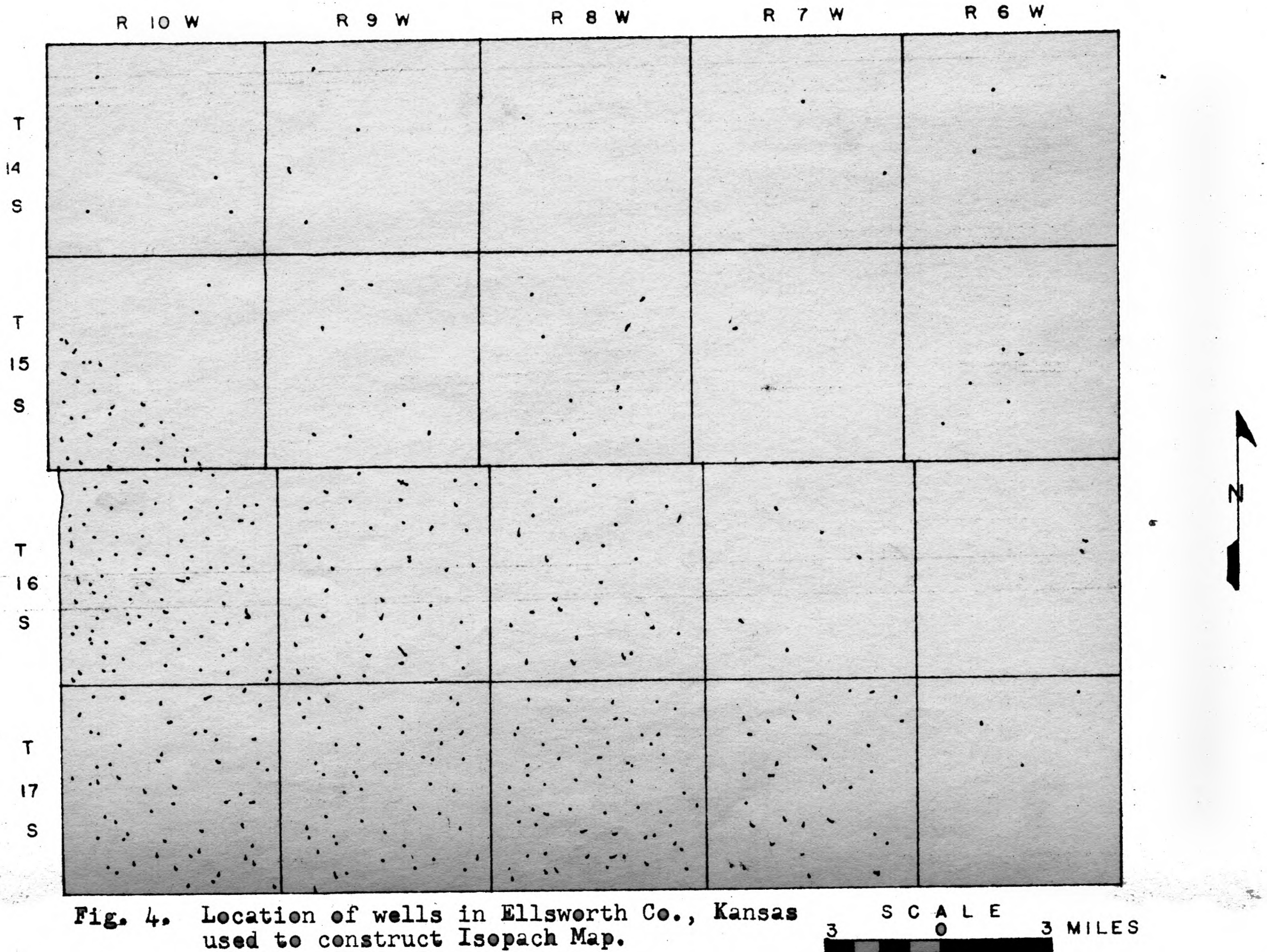
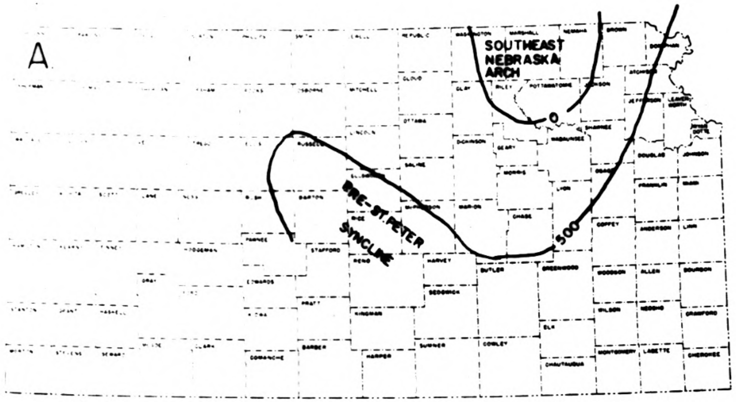
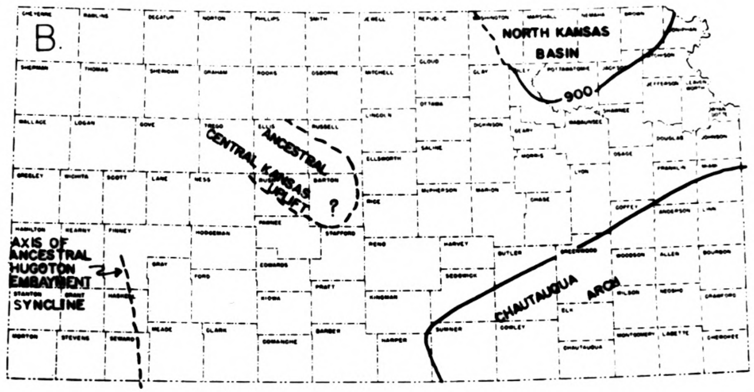



Fig. 4. Location of wells in Ellsworth Co., Kansas used to construct Isopach Map.



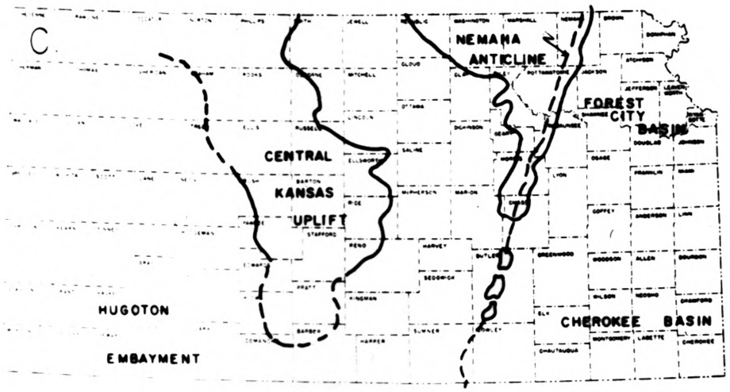




FIG. 5 —MAPS SHOWING PRINCIPAL STRUCTURAL FEATURES OF KANSAS.

A. PRE-SIMPSON STRUCTURE REPRESENTED BY 500-FOOT THICKNESS LINES OF ARBUCKLE DOLOMITE AND REAGON SANDSTONE.

B. STRUCTURAL DEFORMATION FROM ARBUCKLE THROUGH CHATTANOOGA TIME.

C. PATTERN OF STRUCTURAL DEFORMATION FROM CHATTANOOGA TO MIDDLE PERMIAN TIME, OUTLINED BY MARGIN OF MISSISSIPPIAN ROCKS,

(AFTER LEE, 1956).

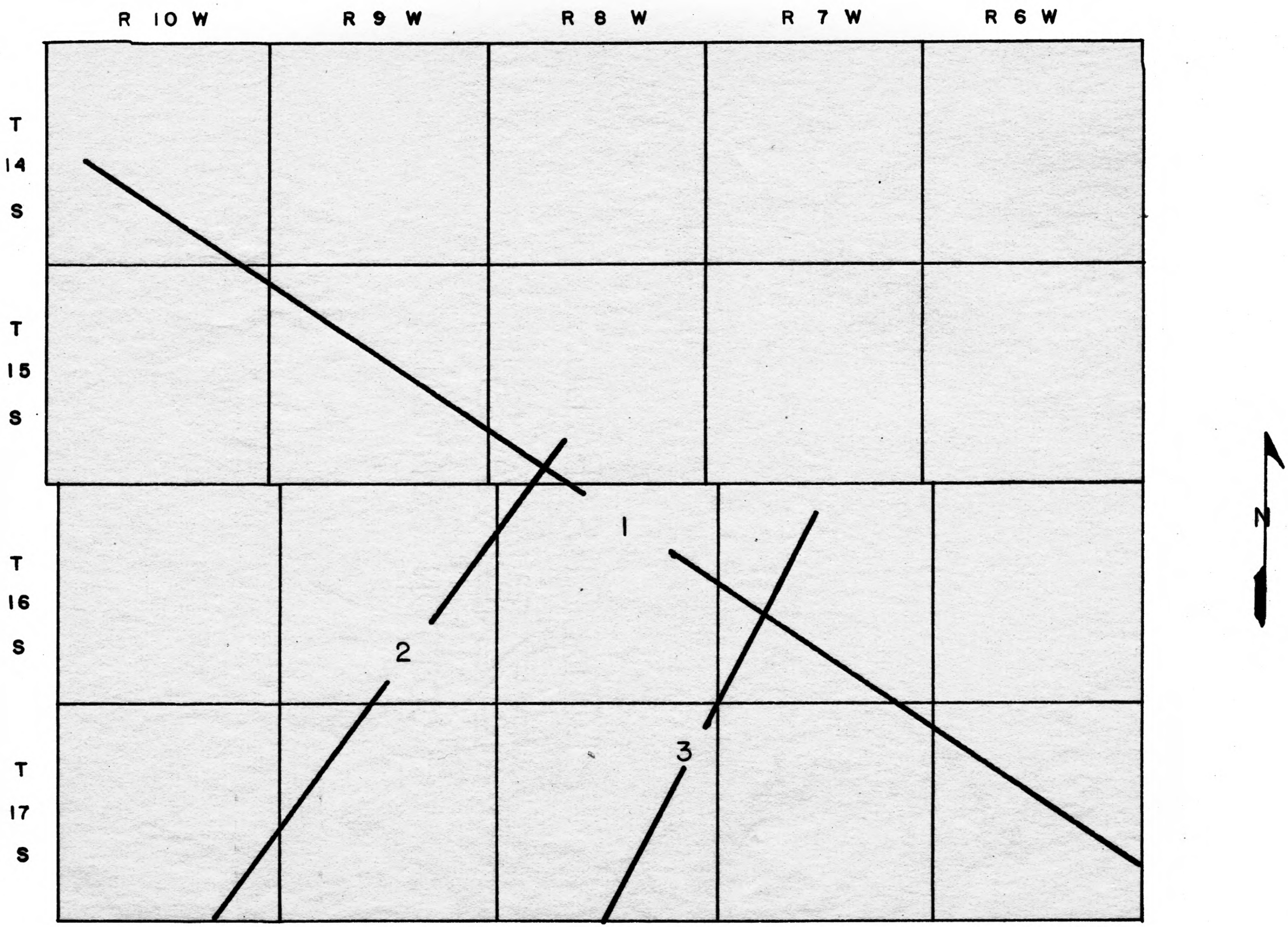
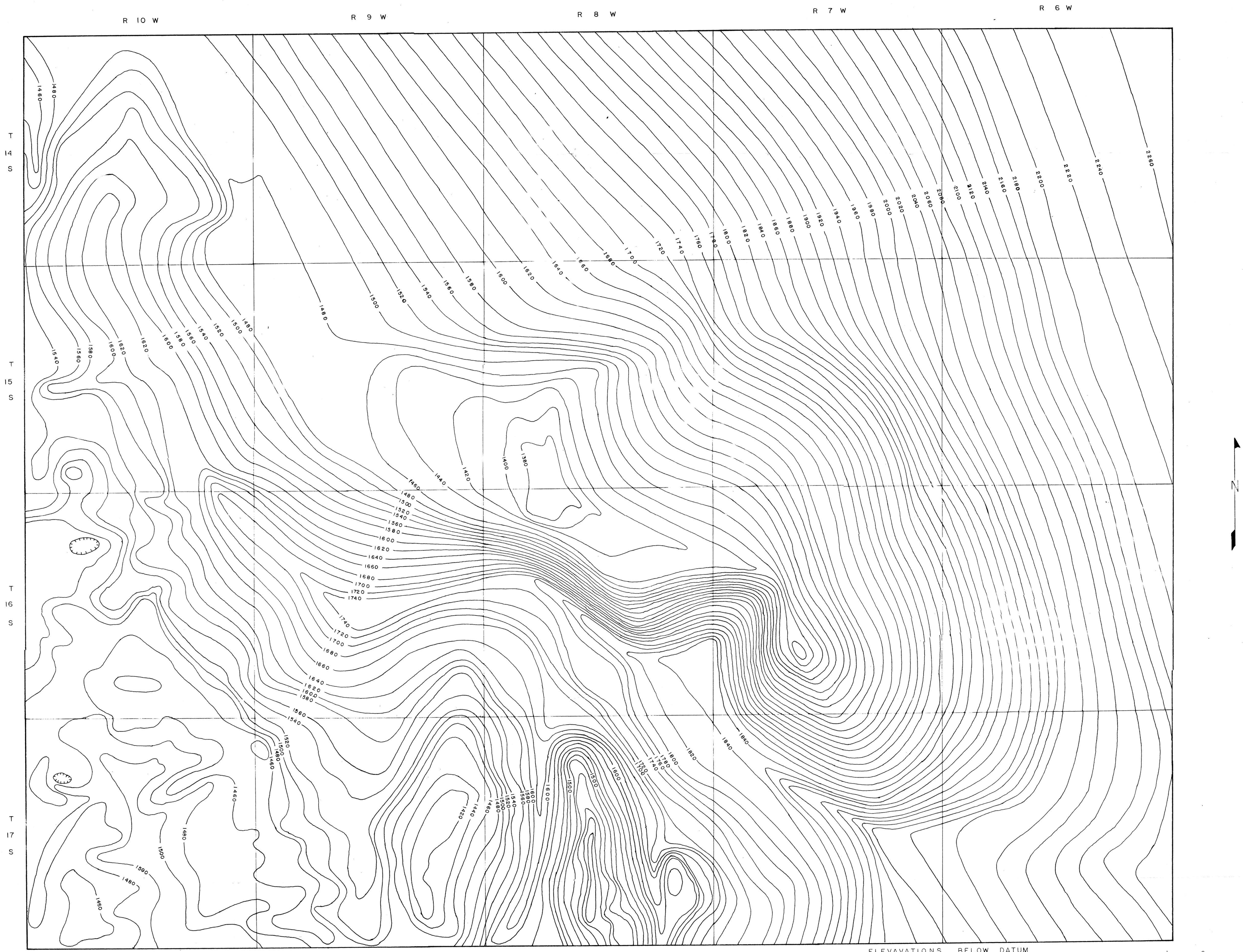



Fig. 6. Minor Structural Features of Ellsworth Co., Kansas.
1. Wilson-Burns Element
2. Ellsworth Anticline

SCALE
3 0 3 MILES

Fig. 7. A geologic structure contour map of the Arbuckle group, Ellsworth County, Kansas.

In accompanying plate box)




ELEVAVATIONS BELOW DATUM

DATUM PLANE MEAN SEA LEVEL

SCALE 1 IN 1 MILE

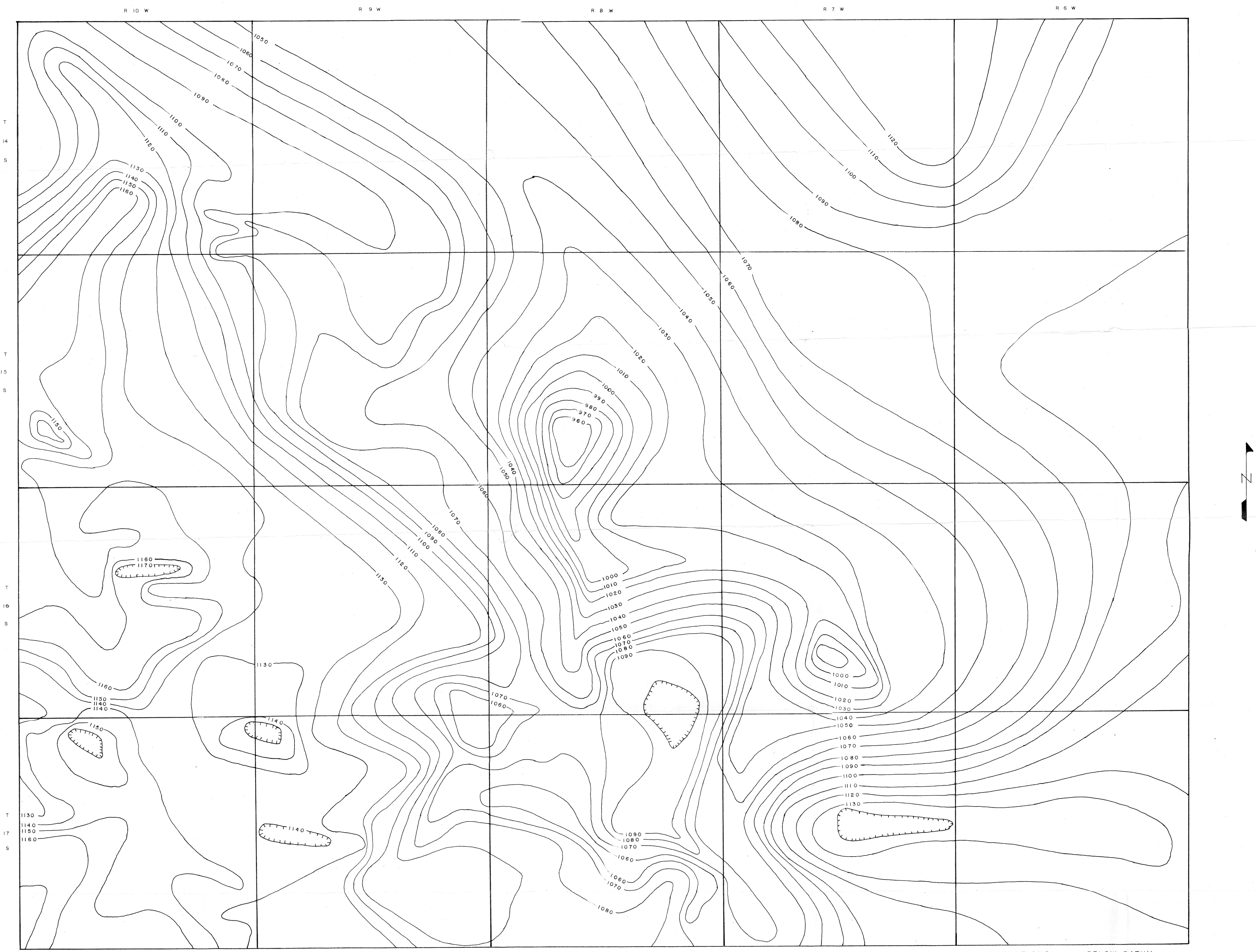
0 1 2 3 4 5

CONTOUR INTERVAL 20 FEET

A STRUCTURE CONTOUR MAP OF THE ARBUCKLE GROUP

Fig. 8. A geologic structure contour map of the Lansing group, Ellsworth County, Kansas

(In accompanying plate box)



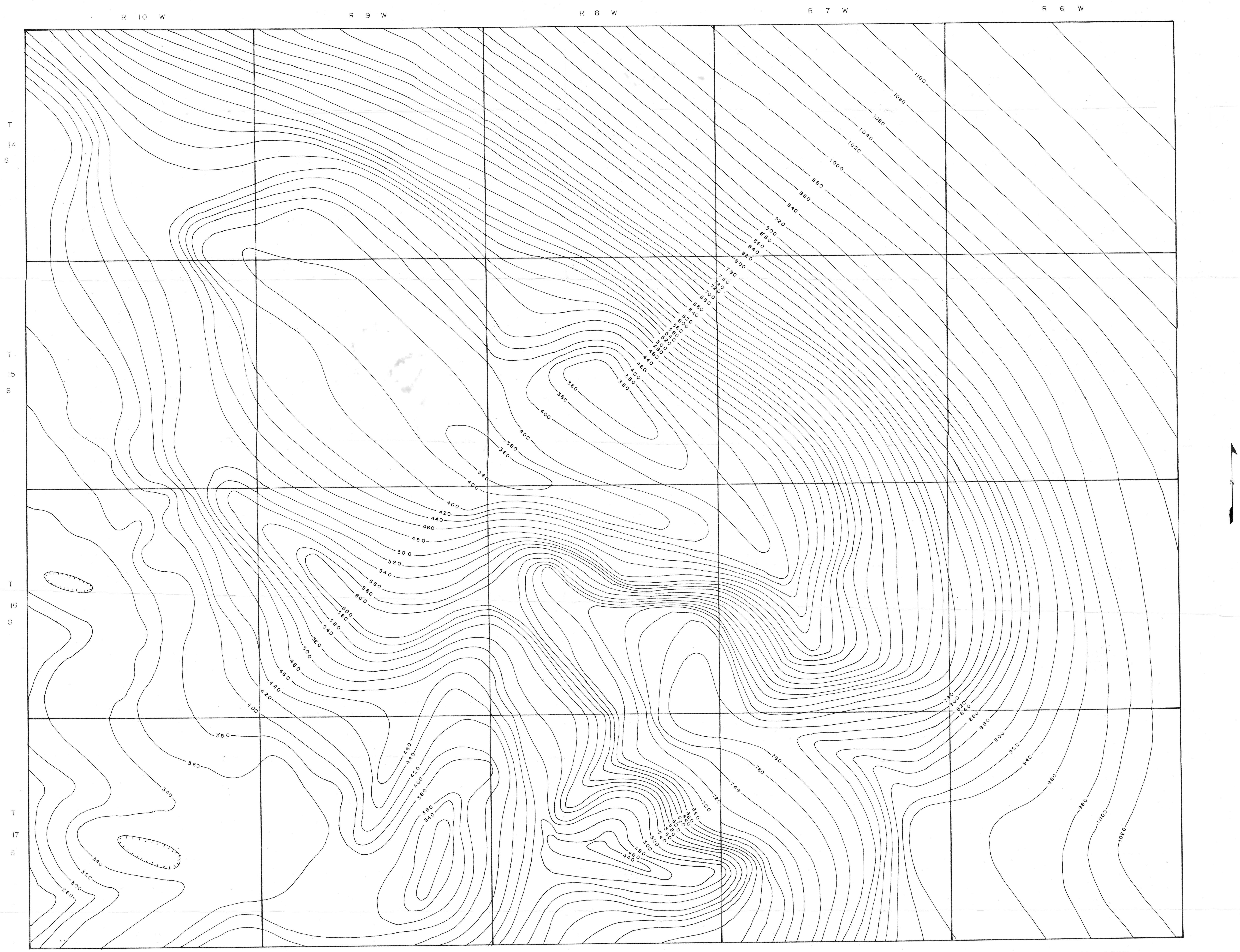

ELEVATIONS BELOW DATUM
DATUM PLANE MEAN SEA LEVEL
SCALE 1 IN 1 MILE
CONTOUR INTERVAL 10 FEET

A STRUCTURAL CONTOUR MAP OF THE LANSING FORMATION

HOWARD

Fig. 9. A geologic ispach between the top of Arbuckle and top of the Lansing groups in Ellsworth County, Kansas.

(In accompanying plate box)




AN ISOPACH MAP OF THE INTERVAL BETWEEN THE TOPS OF THE ARBUCKLE AND LANSING GROUPS

DATUM PLANE MEAN SEA LEVEL

SCALE 1 INCH = 1 MILE

0 1 2 3 4 5

ISOPACH INTERVAL = 10 FEET

HOWARD

Fig. 10. An East-West cross section of Ellsworth County, Kansas.

(In accopanying plate box)


AN EAST WEST CROSS SECTION OF ELLSWORTH CO., KANSAS

Fig. 11. A SW-NE cross section of Ellsworth County, Kansas.

(In accompanying plate box)


A SW-NE CROSS SECTION OF ELLSWORTH CO., KANSAS

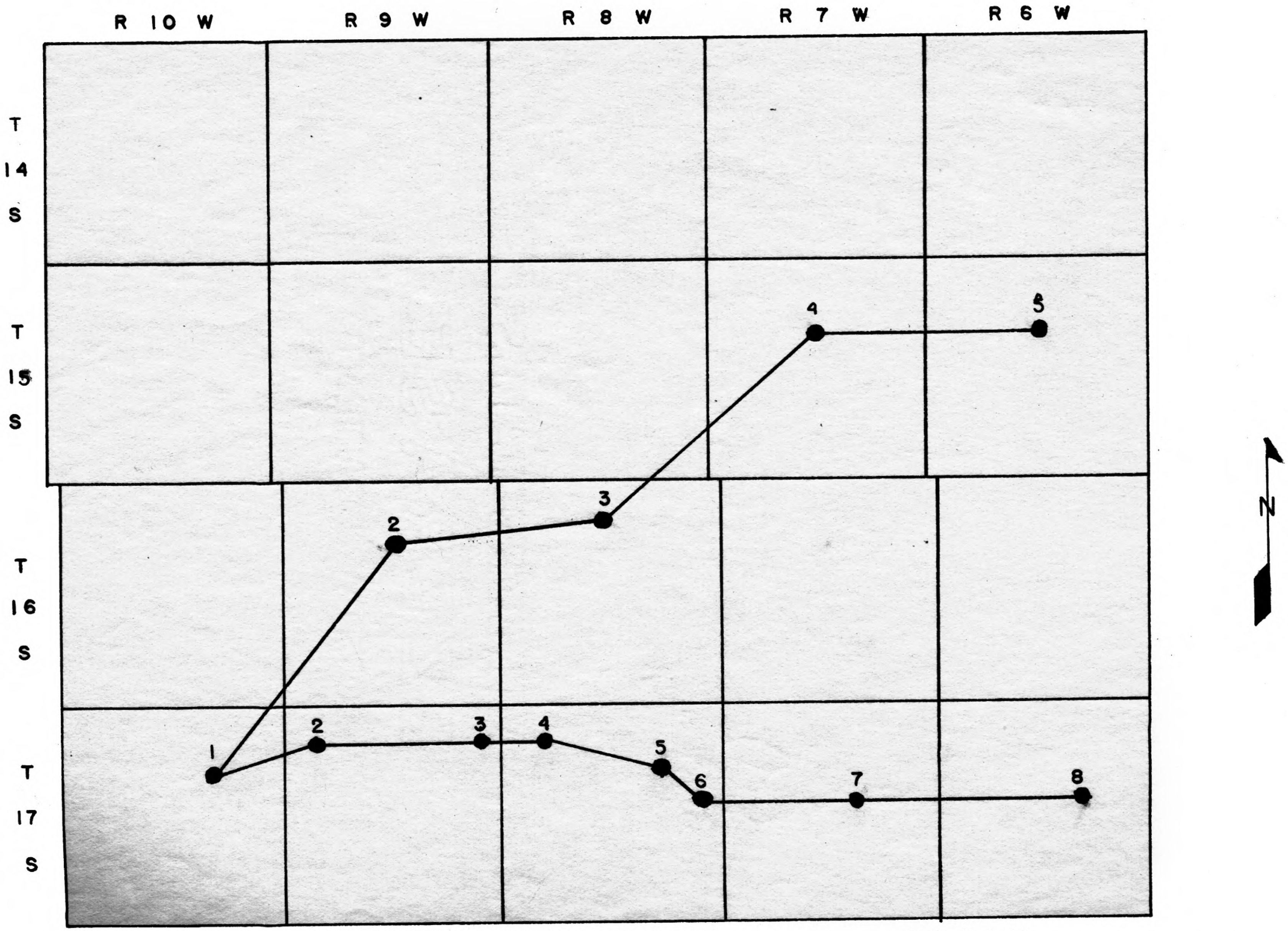



Fig. 12. Location of wells used to construct cross sections in Ellsworth Co., Kansas.

SCALE
3 0 3 MILES

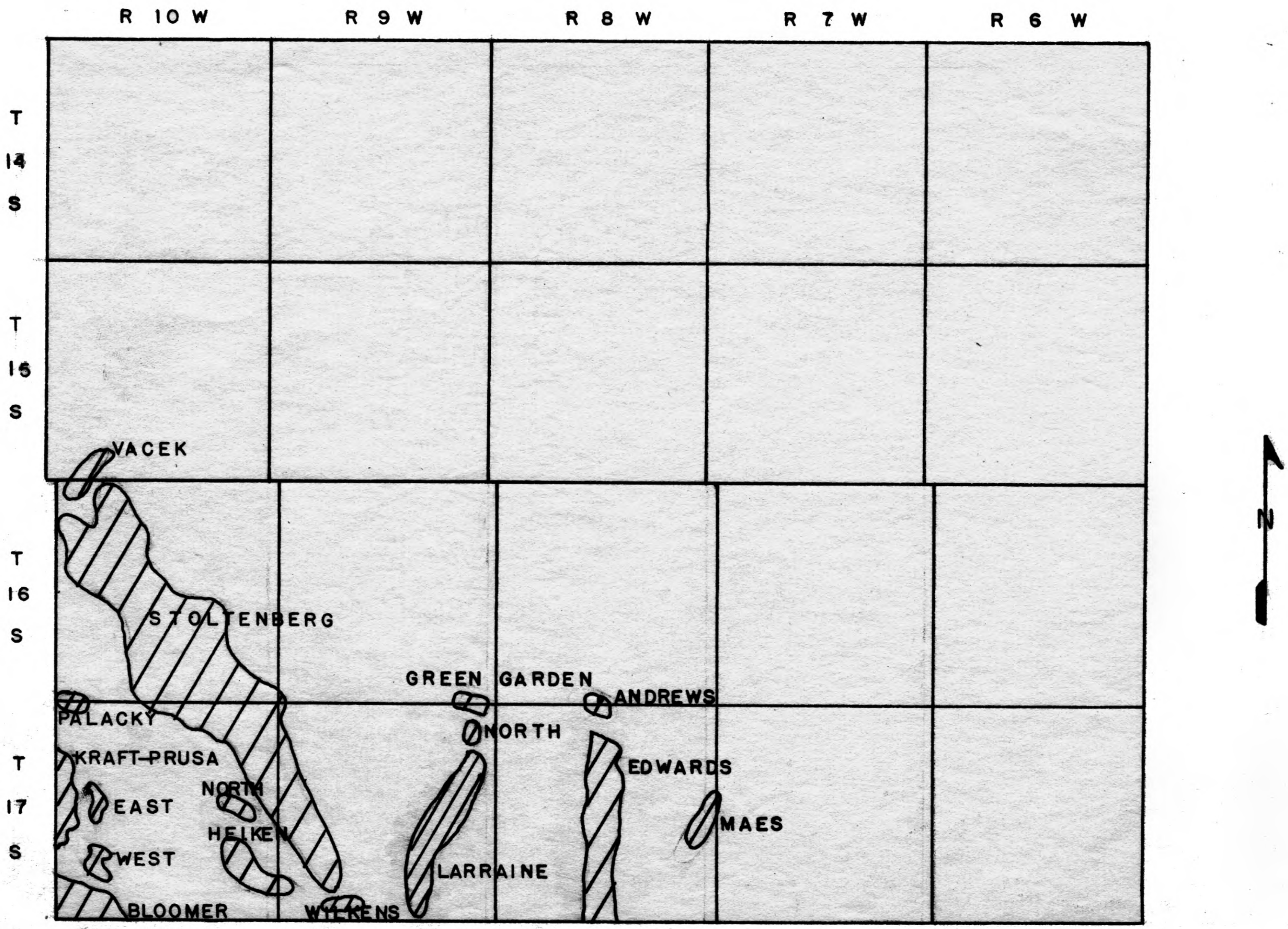



Fig. 13. Map of Ellsworth Co., Kansas showing location of oil pools.

THE RELATIONSHIP OF THE SUBSURFACE GEOLOGY TO THE
PETROLEUM ACCUMULATION IN ELLSWORTH COUNTY, KANSAS

by

JAMES ROY HOWARD

B. S., University of Illinois, 1957

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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 and Geography

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

The purpose of this investigation was to give a clearer insight into the relationship between the subsurface geology and petroleum accumulation in Ellsworth County, Kansas.

Ellsworth County is located in central Kansas in the Great Plains Province, astride the Central Kansas uplift, and adjacent to the Salina basin. The county covers an area of approximately 270 square miles and includes 20 townships.

The data for the construction of a detailed Lansing and Arbuckle structure contour map and an isopach map was taken from the Herndon maps, Scout tops, electric logs, and drillers logs. The Arbuckle structure contour map reveals a structural attitude which is reflected in the Lansing rocks. The isopach map shows the relationship of thickness to structure.

Two cross sections of Ellsworth County were constructed to point out the relationship of stratigraphy to structure. Part of the stratigraphic column is missing over all of the major folds in this county.

Oil accumulation occurs in the subsurface of Ellsworth County in the Reagan, Arbuckle, Simpson, Viola, Mississippian "Chat", and the Kansas City-Lansing formations. However, the most prolific producers are the Arbuckle and Lansing formations.

The structure of Ellsworth County has been developed by several periods of warping and erosion followed by truncation of thick sections of sedimentary rocks. The two major structural features of the county are the Central Kansas uplift and the Salina basin. Rocks older than Pennsylvanian dip gently off the uplift into the basin. The Pennsylvanian sediments overstep the older rocks and dip gently toward the southwest.

The minor structural features of Ellsworth County are the Wilson-Burns element, the Ellsworth anticline, and the Geneseo-Edwards uplift. The Wilson-Burns element is essentially parallel to the Central Kansas uplift, but the other two structures are at nearly right angles to it.

There are sixteen oil fields in Ellsworth County. Three of them produce from structural traps; whereas, the other thirteen are either stratigraphic traps or a combination of stratigraphic and structural traps.

The future potential for discovery of additional reserves of petroleum in this county is fair. Although all known structural "highs" have been explored and for the most part drilled out, there are a few areas that warrant further exploration.