A SUBSURFACE GEOLOGICAL AND GEOPHYSICAL INVESTIGATION IN BARTON COUNTY, KANSAS

by

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TABLE OF CONTENTS

INTRODUCTION

Purpose of Investigation

The purpose of this investigation was to analyze the subsurface structure and stratigraphy of Barton County, Kansas, in order to determine the relationship of geological and geophysical data.

Area Covered by the Investigation

Barton County is located in central Kansas. (Fig. 1 in Appendix.) The county includes Townships 16, 17, 18, 19, 20 South, and Ranges 11, 12, 13, 14, 15, West. The county contains 25 townships, comprising an area of 892 square miles. The location of Barton County with respect to adjoining counties is shown in Fig. 1 in the Appendix.

The area lies in the Plains Border section of the Great Plains province. The highest point, about three miles northwest of Pawnee Rock in southwestern Barton County, has an altitude of about 2,080 feet, and the lowest point, about seven miles southeast of Claflin in east-central Barton County, has an altitude of about 1,710 feet.

The upland in northern Barton County is the divide area between the Smoky Hill River to the north and the Arkansas River to the south. It is a well-drained area that has been dissected by many northward and southward-flowing tributaries. The Arkansas River enters the county near the southwest corner, flows across the southern part, and leaves near the southeast corner. Deposits of river alluvium border the northern banks of the river and extensive deposits of Quaternary dune sands mask the southern banks.

Previous Investigations

Previous investigations in Barton County consist of individual studies of oilpools, ground-water recources, and the general geology of the region.

Individual pool studies have been undertaken by Walters (1946) on the Kraft-Prusa oil field district. The State Geological Survey of Kansas has published reports concerning oil and gas developments of Kansas which include Barton County, also geology-ground water resources of Barton County by Latta (1950). Koester (1935), Lee (1956, 1954), McClellan (1930), Merriam (1955), and Morgan (1932), included Barton County in regional studies of central Kansas. Geophysical investigations by Glover (1953) covered the Central Kansas Uplift.

Procedure

Barton County ranks as the most prolific oil-producing county in Kansas. Abundant datum elevations for constructing structure contour maps were obtained from Herndon Maps, Kansas Geologic Society driller logs, Scout tops and electric logs. Detail structure contour maps were constructed on the Lansing and Arbucle groups because they are the major oil-producing units.

Geophysical reflection maps were constructed from seismic reflection times computed from seismograph records. Structure contour maps were made on the Stone Corral and Topeka formations because they are the most consistent and easily correlated. A cross section of Township 19 S., Range 12 W. was plotted to correlate reflection times with geologic depths. The isopach and isotime maps were constructed from the Stone Corral and Lansing interval. Using geologic tops and reflection times, velocity anomolies were computed and mapped.

Terminology

The meanings intended for certain descriptive geophysical terms used in this investigation are listed below.

Isotime Map - An isotime map is simply an isopach map between two easily identified geologic markers using reflection times from the tops of these beds.

Weathering Zone - The term "Weathered zone" as used by geophysicists refers to the layer or layers of unconsolidated and often heterogeneous material at the surface. Seismic reflection in the weathered zone usually have velocities less than 5,000 feet per second.

Shot-points - Shot points are shot holes drilled to depths from 30 to 300 feet depending on the surface geologic formations in the area.

Survey - A survey is often used to describe a geophysical exploration program.

Seismograph Record - A seismograph record or "seismogram" is a photographic paper on which seismic data has been recorded.

Seismic Velocity - A seismic velocity is the average speed of the seismic energy wave front traveling through different mediums.

Reflection Top - Reflection top has the same meaning as reflection time of a seismic wave. The reflection time of a seismic wave is a time interval between the instant artificial energy is propagated in the shot hole and the time it is recorded as a reflection on a seismogram at the surface.

STRATIGRAPHY

Pre-Cambrian System

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

Cambrian System

The Reagon (Lamotte) sandstone is generally found over the entire area. It consists of an aggregate of fairly well sorted, angular quartz, sand grains (Walters, 1946). The thickness is probably 40 feet on the average and absent on the buried pre-Cambrian hills in northeastern Barton County.

The Bonneterre dolomite was originally deposited over the

Central Kansas Uplift, and was subsequently removed by erosion before deposition of the Pennsylvanian rocks. The Bonneterre dolomite includes sandstone beds as well as buff, medium crystalline, sandy dolomite. This sandy dolomite when weathered to a residual sand by leaching of its carbonate content forms a good oil reservoir.

Ordovician System

Arbuckle Group. The Arbuckle group consists of the Jefferson City Cotter dolomite and the Roubidoux dolomite. The Arbuckle ranges from a few feet to 400 feet thick in wells drilled to granite. It is a red and pink, coarsely crystalline, porous dolomite, that contains some sand and white chert. The Arbuckle forms a "Karst" topography (Fig. 2, Appendix) and is absent on several pre-Cambrian buried hills. The Arbuckle group is the most prolific oil producer in Barton County. Location of wells used to construct the Arbuckle map is shown in Fig. 3 in the Appendix.

Simpson Group. The simpson group is found in several wells in the extreme southern part of Barton County. It consists of green shale and sandstone less than 50 feet thick.

Viola. The Viola is a series of limestones and dolomites, which is called the Viola lime. The Viola pinches out in the extreme southwestern part of Barton County (Lee, 1956).

Silurian, Devonian and Mississippian Systems

No known Silurian, Devonian, or Mississippian rocks are present in this area. Barton County lies on the crest of the Central Kansas Uplift and several long periods of erosion removed these formations or they were never deposited over this area.

Pennsylvanian System

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

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 varicolored clay and cemented by quartz or chalcedony. The conglomerate unconformably overlies the Arbuckle group and pre-Cambrian granite on buried hills.

Marmaton Group. This group consists of red and green shales. Due to the unconformity at the base, the Marmaton group varies considerably in thickness.

Missourian Series. Kansas City Group. The Kansas City group consists of cyclic deposition of limestones and shales, the latter being minor in total amount and occurring in thin breaks in the sequence. The combined thickness of the Lansing-Kansas City group is probably 275 feet in Barton County. The most characteristic feature of the Lansing-Kansas City group is the oolitic nature of many of its members (Lee, 1956).

Lansing Group. The top of the Lansing group is a good reference in well samples and radioactive logs. The Lansing consists of two limestone formations separated by a shale. The eroded top of the Lansing shows a topographic relief (Appendix, Fig. 4). Location of wells used to map the Lansing is shown in Figure 5 in the Appendix.

Pedee Group. The only representative of the Pedee group in Barton County is the Iaton limestone. Drillers and geologists log this as the "Brown Lime". The Iaton is a light bluish-gray to nearly white limestone. The average thickness is less than 15 feet.

Virgilian Series. Douglas Group. The Douglas group is rather thin, reaching a maximum of probably 80 feet. It is characterized by shale, sandy layers, and occasional thin limes.

Shawnee Group. The Shawnee group consists of limestones separated by shales. The Topeka limestone and the Heebner shale member of the Oread limestone are good bed markers. The average thickness of this group is about 280 feet.

Wabaunsee Group. The Wabaunsee group comprises a sequence of alternating limestones and shales. The average thickness in Barton County is about 600 feet.

Permian System

The Permian rocks of Kansas are divided into the following series listed in ascending order: Wolfcampian, Leonardian, and

Guadalupian. Permian rocks are separated from the Pennsylvanian by a slightly angular unconformity and an erosional surface. They are separated from overlying Cretaceous by an angular unconformity representing a long hiatus, during which hundreds of feet of Permian rocks were eroded.

<u>Wolfcampian Series</u>. The Wolfcampian series is divided into the following groups listed in ascending sequence: Chase, Council Grove, and Admire.

<u>Admire</u> Group. The Admire group, exclusive of the basal sandstone, consists predominantly of shale, some of which is sandy. The limestone beds although persistent, are thin and lack unique lithologic features that might identify them in the subsurface. Average thickness of this group is 134 feet.

Council Grove Group. The alteration of well-defined limestone and shales of the Council Grove group are in sharp contrast to that of thin limestones and dominant shales of the Ardmore group. The Council Grove group consists of equal proportions of shale, a large part of which is red, and of limestones, much of which are impure and shaley. The thickness of the Council Grove group averages about 390 feet on the Central Kansas Uplift, in T. 7 S., R. 20 W. (Lee, 1956.)

Chase Group. The Chase group consists of a sequence of alternating beds of thick limestones and shales. The limestones are usually cherty. The shales range in color from gray to red or varicolored. The Chase group thins toward the northwest and has an average thickness of 240 feet on the crest of the Central

Kansas Uplift. (Lee, 1956.)

Leonardian Series. The Leonardian series is divided into the Nippewalla Group and the Sumner Group.

Sumner Group. The following formations of the Sumner group, listed in descending order have been differentiated by the Kansas Geological Survey in outcrops in east-central Kansas (Moore and others, 1951): Stone Corral dolomite, Ninnescah shale, and Wellington formation which includes the Hutchinson salt member. The Sumner group comprises a sequence of beds of evaporite and shale containing a few local, more or less discontinuous, thin, limestone beds of variable character. The upper part consists mainly of shale, and the lower part in central Kansas consists chiefly of shale, anhydrite and salt.

Nippewalla Group. The Nippewalla group, the upper of two groups into which the Leonardian series of Kansas has been divided in outcrops, extends downward from the top of the Dog Creek shale to the top of the Stone Corral. It includes in descending order, the Dog Creek shale and the Blaine formation, consisting together of a sequence of relatively thin dolomite and gypsum or anhydrite beds interbedded with red shale; the lower Flowerport shale which is soft, red and gypsiferous; the Cedar Hills sandstone; the Salt Plain formation, which consists mainly of red, silty shale with interbedded sandstones; and the Harper sandstone, which is mainly red and gray sandstone, with interbedded red shale.

Triassic and Jurassic System

Rocks of Triassic and Jurassic age are absent in Barton County. They are present in northwestern Kansas.

Cretaceous System

Commanchean Series. The Cheyenne sandstone is absent in north central and northeastern Barton County because of non-deposition (Latta, 1950). Elsewhere, the Cheyenne overlies Permian rocks and is from a featheredge to more than 100 feet thick. The Cheyenne sandstone penetrated by test holes and oil wells in Barton was principally white to light-gray, light pale-green, light gray-green, and gray-green, friable to tightly cemented, very fine to medium-grained sandstone.

The Kiowa shale is the oldest formation exposed in Barton County. It is underlain by the Cheyenne sandstone everywhere but in the north central and northwestern parts of Barton where it overlaps the Cheyenne and rests unconformably on Permian rocks. The Kiowa shale is predominantly marine in origin and consists of light to dark gray, blue-gray, and black shale, sandstone lenses, and thin beds of limestone.

Gulfian Series. The Dakota formation lies conformably beneath the Granerous shale or unconformably beneath Quaternary silts, sands, and gravels in all but the southeastern part of Barton County, where it has been removed by erosion. The Dakota formation is 200 feet to 300 feet thick in the northern part of Barton County. It is composed of alternating beds of varicolored clay, shale, siltstone, and sandstone, in which siderite, hematite, and limonite are abundant.

The Granerous shale consists of 30 to 40 feet of light to dark gray, blue-gray, and brown non-calcareous shale overlying the Dakota formation and overlain by the Greenhorn limestone.

The Greenhorn limestone consists of chalky shale alternating with beds of hard chalk, and contains thin beds of hard, crystalline limestone in the lower part. It averages around 100 feet in thickness.

The Carlile shale, which conformably overlies the Greenhorn limestone, is divided into three members in other areas. A part of the lower Fairport chalky shale member is present over most of Barton County. It is about 50 feet thick and consists of alternating beds of hard chalk and chalky shale containing, in the lower part, thin beds of hard, crystalline limestone.

Tertiary System

The Ogallala formation is found in the western part of Barton County. It is a hard, grayish-white, arenaceous limestone marked with pinkish, irregular, concentric bands at the top. The Ogallala formation usually caps small hills at widely scattered localities. In some places, it is only a few inches thick and is broken into irregular blocks of different sizes (Latta, 1950).

Quaternary System

Pleistocene Series. Unconsolidated deposits composed of clay, silt, sand, and gravel of Pleistocene age overlie the eroded surface of Cretaceous in the southern half and east-central Barton County. These materials comprise undifferentiated early Pleistocene sediments, the Meade formation, and the Sanborn formation.

Pleistocene and Recent Series. Dune sand ranging in age from Pleistocene to Recent covers most of the area in eastern Barton County. The dune sand is composed predominantly of fine to medium-grained quartz and contains minor amounts of clay, silt, and coarse sand.

Cheyenne Bottoms is underlain by unconsolidated clay, silt, sand, and locally, gravels that range in age from Pleistocene to Recent. The thickness of these deposits ranges from less than 20 feet near the margins of the Bottoms to more than 100 feet in the deepest part of the old buried channel that trends northwest-southeast through the central part of the Bottoms.

Alluvium. The alluvium of the late Quaternary age consists of stream-laid deposits that range in texture from clay and silt to sand and very coarse gravel.

PRINCIPLE STRUCTURAL FEATURES OF KANSAS

Pre-Simpson Structure

The major structural features that were formed before the deposition of rocks of Simpson age are shown in Fig. 6 in the Appendix (Lee, 1956).

St. Peter and Early Mississippian Structures

The major structures formed between St. Peter time and early Mississippian time include the Chautauqua arch, the Central Kansas Uplift, and the North Kansas basin. (Appendix, Fig. 6.)

Post-Mississippian Structures

The most prominent of the regional structural features formed between the end of Mississippian time and Middle Permian time (Fig. 6, Appendix) are the Nemaha anti-cline, the Forest City basin, Bourbon arch, Cherokee basin, the Salina basin, and the enlarged Central Kansas uplift.

The Central Kansas Uplift. The Central Kansas uplift is the dominant structural feature of Central Kansas. The uplift separates the Salina basin on the northeast from the Hugoton embayment on the southwest. Before the formation of the Cherokee basin, the uplift continued to the southeast and connected with the axis of the old Chautauqua arch. Along the crest and flanks of the uplift are several minor structures, which differ in trend from the uplift itself. Pre-Cambrian rocks are overlain by Pennsylvanian sediments, and on the flanks pre-Pennsylvanian sediments are upturned, truncated, and overstepped by Pennsylvanian beds. (Merriam, Goebel, 1955)

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 east edge of the basin is bounded by the Nemaha anticline; the west side is limited by the

Cambridge arch; the southwest flank is outlined by the Central Kansas uplift. This is the second largest, synclinal basin in Kansas. The axis of the basin trends northwest-southeast and plunges north toward the deeper part of the basin in Central Nebraska. Pre-Pennsylvanian strata are upturned, truncated, and overstepped around part of the southern perimeter of the basin. Sediments increase in thickness toward the center of the basin.

Nemaha Anticline. The Nemaha anticline trends northeast-southwest completely across Kansas. It continues north into Nebraska, where it is called the Table Rock anticline, and south into Oklahoma to the vicinity of Oklahoma City. The narrow anticline separates the Forest City and Cherokee basins on the east from the Salina and Sedgwick basins on the west. The pre-Cambrian core or the granite ridge of the anticline comes within about 700 feet of the surface near the Kansas-Nebraska line, but plunges south so that on the Oklahoma-Kansas line it is about 4,000 feet below the surface. The granite core of the anticline is characterized by a series of crystalline knobs along the crest of the structure. On both sides of the uparched area, pre- Pennsylvanian strata have been upturned, truncated, and overstepped.

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 low indistinct Bourbon arch. The axis of the basin trends slightly east of north and lies close to and paralleling the axis of the Nemaha anticline. The position of the basinal axis near the Nemaha gives the basin an asymmetrical profile, with a steep west flank and a gentle east flank. 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 a depositional area since post-Arbuckle time, first as part of the older North Kansas basin, then as a separate feature. It was not until after Mississippian time that the Forest City basin came into being as known today. During early Pennsylvanian time the basin derived sediments from the low chain of hills of the Nemaha granite ridge.

Cherokee Basin. Bourbon arch is a low post-Mississippian structure separating the Forest City and Cherokee basins. The northwest part of the Cherokee basin occupies extreme southeastern Kansas. It is a shallow basin, which in early Pennsylvanian time developed on top of the older Chautauqua arch. It is probably more a depositional than a structural basin, although a certain amount of down-warping took place as an accommodation to the sedimentation. The structural axis of the Cherokee basin lies near and parallel to the Nemaha anticline making the basin asymmetrical. Over a considerable portion of the basin, the Chattanooga shale is in contact with the Arbuckle group, the intervening rocks having been eroded away. On the west flank of the basin, there is truncation of the early Paleozoic beds as in the Forest City Basin. During early Pennsylvanian time, the

Nemaha ridge supplied sediments to the Cherokee basin.

MINOR STRUCTURES IN BARTON COUNTY, KANSAS

Rush Rib

The term Rush rib refers to a structural high in Ordovician and older rocks in the Barton and Ellis arch areas.

The term Rush rib was used by Koester (1935, p. 1419):

> Within the nucleus are two somewhat narrow bands, marked by the outcrop of pre-Cambrian rocks, which may be called the 'Russell rib' and the 'Rush rib'. These are true structural 'highs' in the Ordovician and pre-Ordovician rocks, as well as being topographic monadnocks. From southeastern Barton County, the Rush rib trends northwestward to the northwestern part of Rush County, whence it turns slightly northward through western Ellis County and eastern Trego County into Graham County. (Appendix, Fig. 2.)

Beaver Hill

The name Beaver Hill was given by Walters (1946, p. 671) to a buried hill of pre-Cambrian quartzite in the northwestern part of T. 16 S., R. 12 W., Barton County (Fig. 2 in Appendix). This hill underlies arched strata of Pennsylvanian and older rocks on their flanks.

Krier Hill

The name Krier hill was given by Walters (1946, p. 671) to a buried hill of pre-Cambrian quartzite in the southwestern part of T. 16 S., R. 11 W., and the southwestern part of T. 16 S., R. 12 W., Barton County (Fig. 2 in Appendix). Krier hill and the overlying arched Pennsylvanian beds with gently arched Cambro-Ordovician strata on their flanks are here regarded as geologic structures within the larger Kraft-Prusa structures of the Barton arch and Ellis arch area.

CORRELATING GEOLOGICAL AND GEOPHYSICAL DATA IN SOUTHERN BARTON COUNTY, KANSAS

Location, Maps, Source of Data

The area covered by this investigation is in Township 19 South, Range 12 West of southern Barton County, Kansas. It was surveyed by a contract seismograph crew in 1945 for the SOHIO Petroleum Corporation. The shot points plotted in Fig. 7 (Appendix) were obtained from the seismograph records donated by the SOHIO Petroleum Corporation. Up-to-date geologic information was obtained from the Herndon Map Service and from electric and drillers logs. Spot location of the wells are shown in Fig. 8 (Appendix). A Stone Corral reflection map was made from the geophysical data. A geologic map of the Stone Corral formation was constructed to show the relationship between geologic and seismic data. A Topeka reflection map was made to show the relationship of seismic structures to geologic structures of the Topeka. Location of wells used to construct the Topeka geologic map are shown in Fig. 9 in the Appendix. A cross-section (Fig. 10 in Appendix) was made to reveal the discrepancies that exist between the seismic structures and those as determined from geologic logs.

General Statement of the Problem

The problem was concerned with the use of up-to-date geologic information to check, evaluate, and help interpret the geophysical data. At the time the geophysical survey was made, little geologic information concerning the Stone Corral, Topeka and other geologic formations was available. The geology, interpreted from the geophysical data, did not fit the geologic facts as they are known today. A solution to the discrepancies was the object of the investigation.

Stone Corral, Discrepancies and Solutions

By superimposing the Stone Corral geologic-structure map (Fig. 11 in Appendix) over the Stone Corral seismic map (Fig. 12 in Appendix), it was noted that several of the highs and lows on the seismic map were non-existant on the geologic map. The crest of structures common to both seemed to be shifted in such a manner that on the seismic map they appeared displaced to the southwest. A truer seismic map could have been made if the following factors had been considered: (1) The surface formations in this area consist of alluvial deposits, wind deposits, out-cropping limestones, shales, and sandstones. These formations transmit seismic waves at various velocities that must be recognized and corrected before proper interpretation can be made. One velocity correction of 5,000 feet per second was applied indiscriminately to all seismic times of this survey. By applying the 5,000 feet per cecond correction factor to the Stone Corral, an erroneous interpretation was made. (2) The topographic relief of the area is about 100 feet. The seismic velocity through a given geologic unit varies with the amount of overburden. Hence, topographic relief is a factor controlling velocity. Variations in velocities caused by topography may be evaluated by making a study of local geology and topography. (3) When two or more geologic formations exist in the weathered zone near the surface, the seismic energy from the Stone Corral formation may be reflected several times after traveling along different paths. This will cause errors in picking true Stone Corral reflection tops.

Topeka Formation, Discrepancies and Solutions

By comparing the Topeka geologic map (Fig. 13 in Appendix) with the Topeka seismic map (Fig. 14 in Appendix), it was noted that the magnitude and location of the seismic structures did not correspond with the geologic structures. Several geologic factors may be responsible for this: (1) The Hutchinson salt member above the Topeka varies in thickness from about 200 to 350 feet (Fig. 15 in Appendix) because of the great velocity differential between the salt and the overlying formations, errors of 25 to 30 feet may result. (2) Velocities in the weathered zone near the surface vary throughout the area causing reflection time errors above the Topeka formation. (3) the cyclic sedimentation characteristic of Permian and Pennsylvanian sediments above the Topeka produce velocity variations due to density differences. (4) The total structural relief as shown on the Topeka structural map is less than 40 feet. The seismic method used at the time of this survey was probably not sensitive enough to record such low structural relief.

Cross Section, Discrepancies and Solutions

Stone Corral, Topeka and "Arbuckle" reflection tops were plotted to show how they tie in with the true geologic tops as picked from well logs (Fig. 10 in Appendix). The seismic shot points were spaced 1,320 feet apart and a total of twenty-four locations were used. The geologic formation tops were obtained from 14 dry holes, located less than 100 feet from the seismic locations.

Stone Corral reflection tops were computed using a 3,730 feet per second velocity (one way path) obtained from a well velocity survey 12 miles east of this area. The Stone Corral reflection tops as calculated from the data averages 20 feet higher than geologic tops. The seismic errors in depth were probably caused by the following geologic factors: (1) Lithologic variations in surface formations produce variable velocities. (2) Changes in surface elevations produce velocity differences. (3) Miscorrelation of the Stone Corral reflections due to facial changes may cause incorrect picks at this horizon.

The velocity used to compute the Topeka reflection times to depths was 5,200 feet per second (one way path). This average velocity was obtained from a well velocity survey located 12 miles east of this area. The average error in the Topeka reflection depth was 30 feet above the geologic top. The varying thickness of the Hutchinson salt above the Topeka will cause velocity errors. When the Topeka reflection passes through a varying weathered zone, variations in near surface velocities will result. Thinning of the Topeka limestone due to erosion will produce changes in its reflection characteristics.

It was noted in the cross-section that the "Arbuckle reflection" did not fit the true top of the Arbuckle formation. The velocity used to compute the "Arbuckle reflection" to depths was 5,550 feet per second (one way path). The "Arbuckle reflection" when computed to depth was usually about 80 feet below the Arbuckle top as obtained from well logs. The following geologic factors of the Arbuckle may be responsible for this: (1) It may be impossible for seismic energy to be reflected effectively from "Karst" topography present on the Arbuckle in this area. (2) The numerous solution cavities and porous zones in the surface of the Arbuckle cause poor reflections. (3) The Pennsylvanian conglomerate overlying the Arbuckle may prevent seismic energy to reflect from the Arbuckle top.

CORRELATING GEOLOGICAL AND GEOPHYSICAL THICKNESS MAPS IN SOUTHWESTERN BARTON COUNTY, KANSAS

Location, Maps, and Source of Data

A seismic isotime map was constructed from geophysical data in Township 19 S., Range 15 W., Township 20 S., Range 14 W., and

Township 20 S., Range 15 W. A geophysical survey was made in this area by the Pan American Petroleum Corporation in 1941, when little geologic information on the Lansing-Stone Corral formations was available. The seismograph records used in this investigation were donated by the Pan American Petroleum Corporation. Location of the seismic shot points used in the survey are shown in Fig. 16 (Appendix). Geologic information to construct an isopach map was obtained from the Herndon Map Service, electric and drillers logs. The location of the wells are shown in Fig. 17 (Appendix).

The Lansing-Stone Corral interval was used to construct an isotime map (Fig. 18 in the Appendix). The Stone Corral dolomite is a relatively thin bed and produces good seismic reflections throughout the area. The Stone Corral is relatively flat, thus, an isotime map could be made between the Lansing and Stone Corral with assurance that any variation in isotime was a true indication of the structure of the Lansing formation. The geologic isopach map (Fig. 19 in the Appendix) that was made on the Lansing-Stone Corral interval was used to check, evaluate, and help interpret the seismic isotime map.

A velocity anomaly map (Fig. 20 in the Appendix) between the Lansing-Stone Corral interval was computed by dividing the thickness as shown on the isopach map by the reflection time of the isotime map. The velocity anomaly map was made to show regional and local changes in seismic reflection velocities.

A cross-section (Fig. 21 in the Appendix) was made between the Topeka-Stone Corral interval and the Lansing-Stone Corral interval. True velocities of the reflection times were computed by dividing the geologic depths from neutron logs, by the reflection times from seismic records. This cross-section was made to show regional velocity variations in the area covered by this investigation.

General Statement of the Problem

The problem of this investigation was concerned with the use of up-to-date geologic data to check, evaluate and help interpret the geophysical data. The geologic structures as interpreted from the seismic isotime map did not correlate accurately with the geologic isopach map. A solution to the discrepancy was the object of this investigation.

Lansing-Stone Corral, Discrepancies and Solutions

By superimposing the isotime map over the isopach map, it was noted that several "thickening and thinning" structures on the isotime map were not present on the isopach map. Several geologic factors may be responsible for these erroneous structures on the isotime maps: (1) The variations in regional and local velocities as shown on the velocity anomaly map (Fig. 20 in the Appendix) will cause inaccurate computing of reflection times. (2) The Hutchinson salt member lies below the Stone Corral and varies in thickness from 250 to 350 feet (Fig. 22 in the Appendix). Since the Stone-Corral reflection paths of seismic energy must pass through this salt zone of higher velocity, down to the Lansing and back to the Stone Corral, it will cause false structures on the isotime map. By using time intervals between two reflections, both of which are emanating from below the base of the salt zone, the error in velocity due to varying salt thickness may be eliminated. It may be possible to use a lower Permian reflection top such as the Fort Riley as the upper bed for the isotime map, or if it is not present, the Topeka reflection top may be used. (3) Thickening and thinning of geologic units caused by cyclic sedimentation and differential compaction will affect reflection characteristics and cause an inaccurate correlation of the Lansing-Stone Corral. (4) The velocity anomaly map (Fig. 20 in the Appendix) shows an 800 feet per second regional velocity variation between the Lansing-Stone Corral interval. The Stone Corral formation is relatively flat and by applying true velocities from the velocity anomaly map, a more accurate picture of the geologic structures will result.

CONCLUSIONS

This investigation points up the need for an integration of geological and geophysical fundamentals to produce a more realistic picture of geological conditions as gleaned from seismic data.

It is necessary that the geologist and geophysicist understand the language of both professions. Translation of seismic data into a structural geologic map is a procedure which can only be properly performed by a thorough preliminary study of the local structural and stratigraphic features of the area, both surface and subsurface (logs).

Geologists and geophysicists should recognize that all geophysical anomalies are not related directly to geological structures, as we ordinarily use the term. They must be able to distinguish stratigraphic factors from those that are purely structural. A geophysicist should have a broader basic geologic imagination when relating geophysical anomalies to geologic structures.

The seismic method does not give geologic information directly. It gives only time-distance relationships which can be interpreted in terms of geology, providing certain conditions are fulfilled and certain data are available. Much of what passes for seismic interpretation is really computation with little reference to geologic data.

Perhaps the reason that we do not have enough true correlation at present is that we do not have enough men who have a thorough background in both geology and geophysics. This situation could be improved by giving young geologists and geophysicists more training in both fields.

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APPENDIX

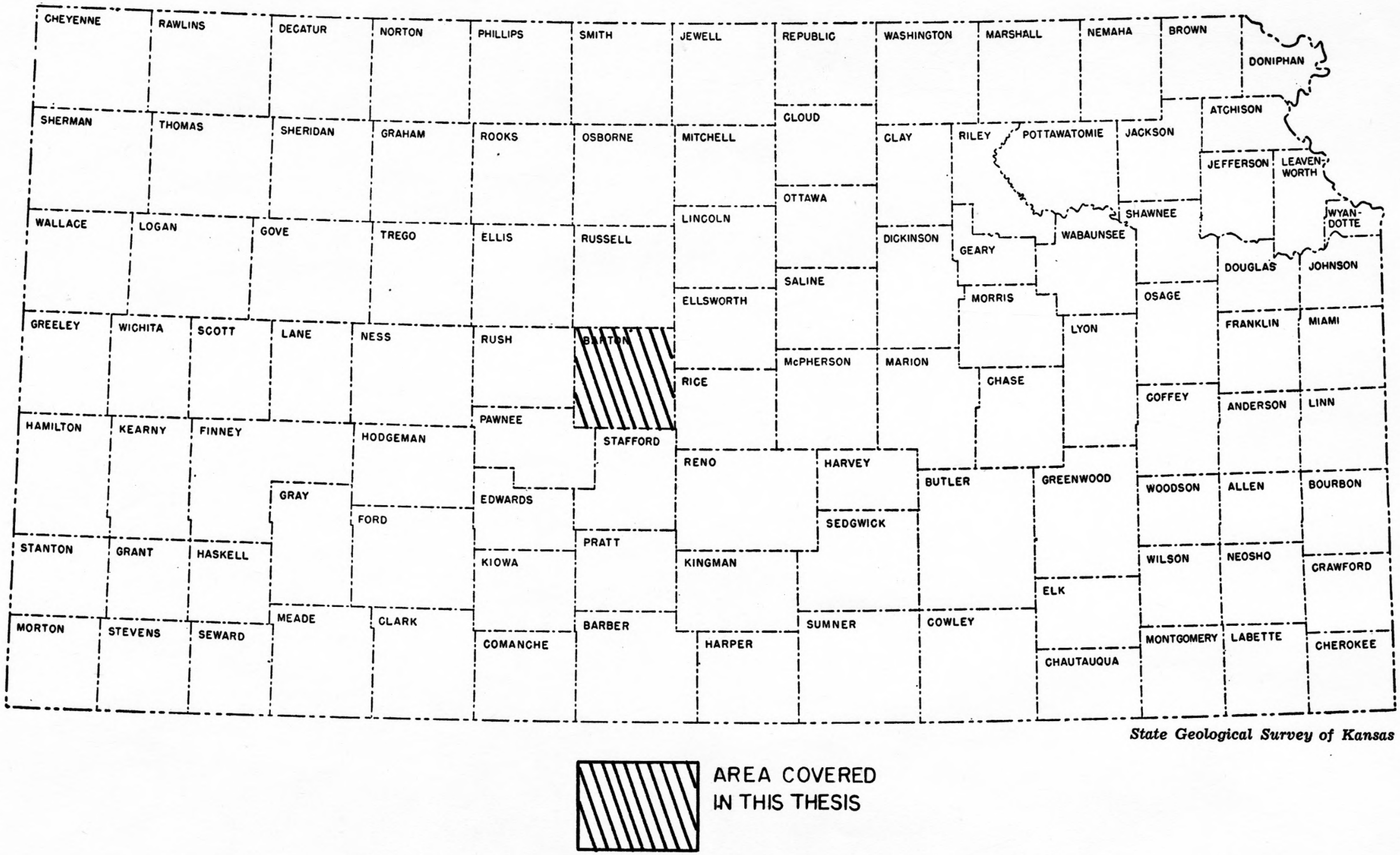
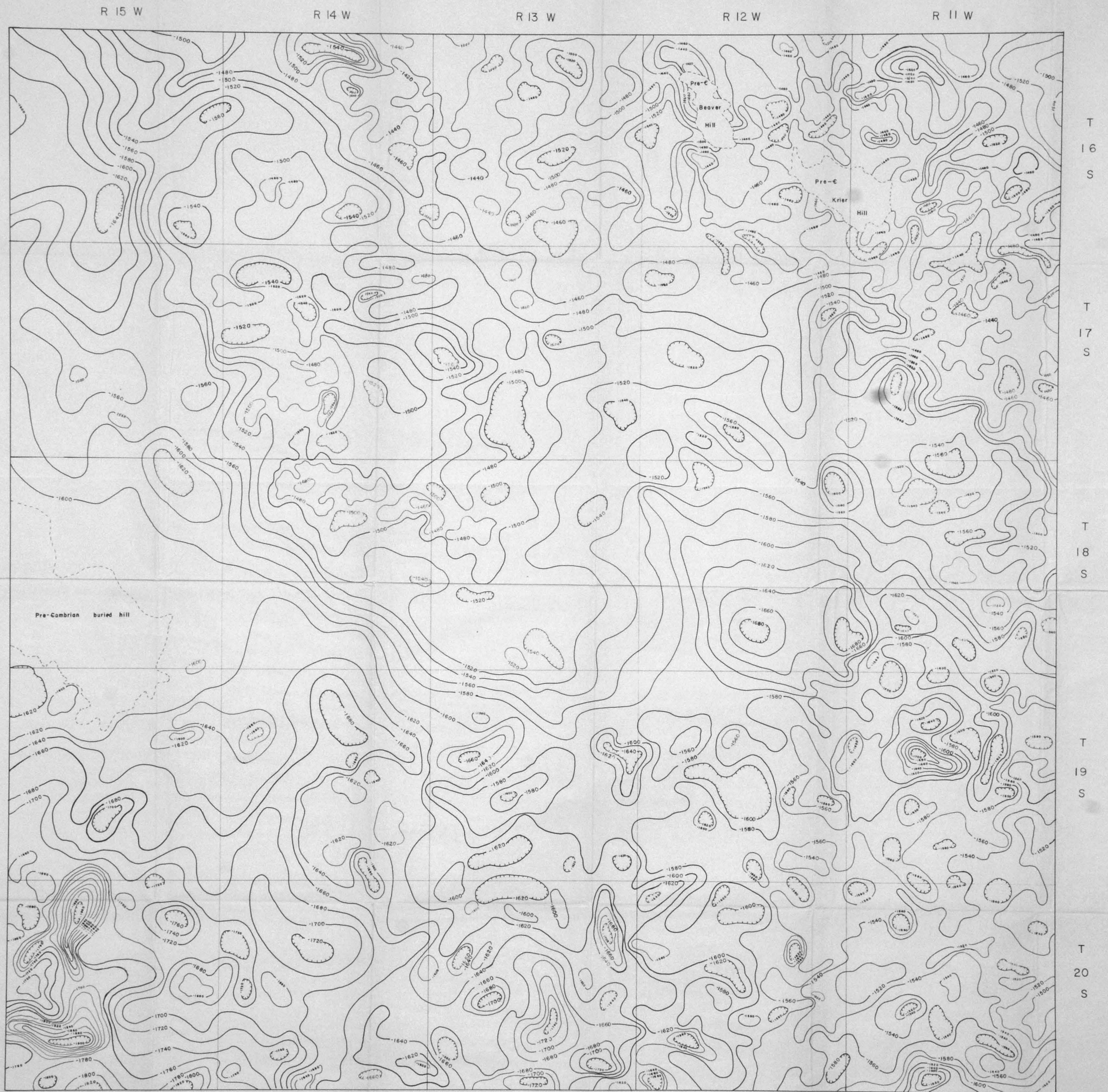


FIG. 1 INDEX MAP, SHOWING LOCATION OF BARTON COUNTY, KANSAS.

Fig. 2. Structural contour map on top of the Arbuckle in Barton County.

(In accompanying plate box.)



Contour line — Township line — Contour line — C.I. = 20'

Pre-Cambrian buried hills

Scale 1" = 1 mile

0 1/2 1 2 3 miles

SCALE

N

FIG. 2. STRUCTURAL CONTOUR MAP ON THE TOP OF THE ARBUCKLE IN BARTON COUNTY, KANSAS.

1957

Andrew P. Bonchonsky

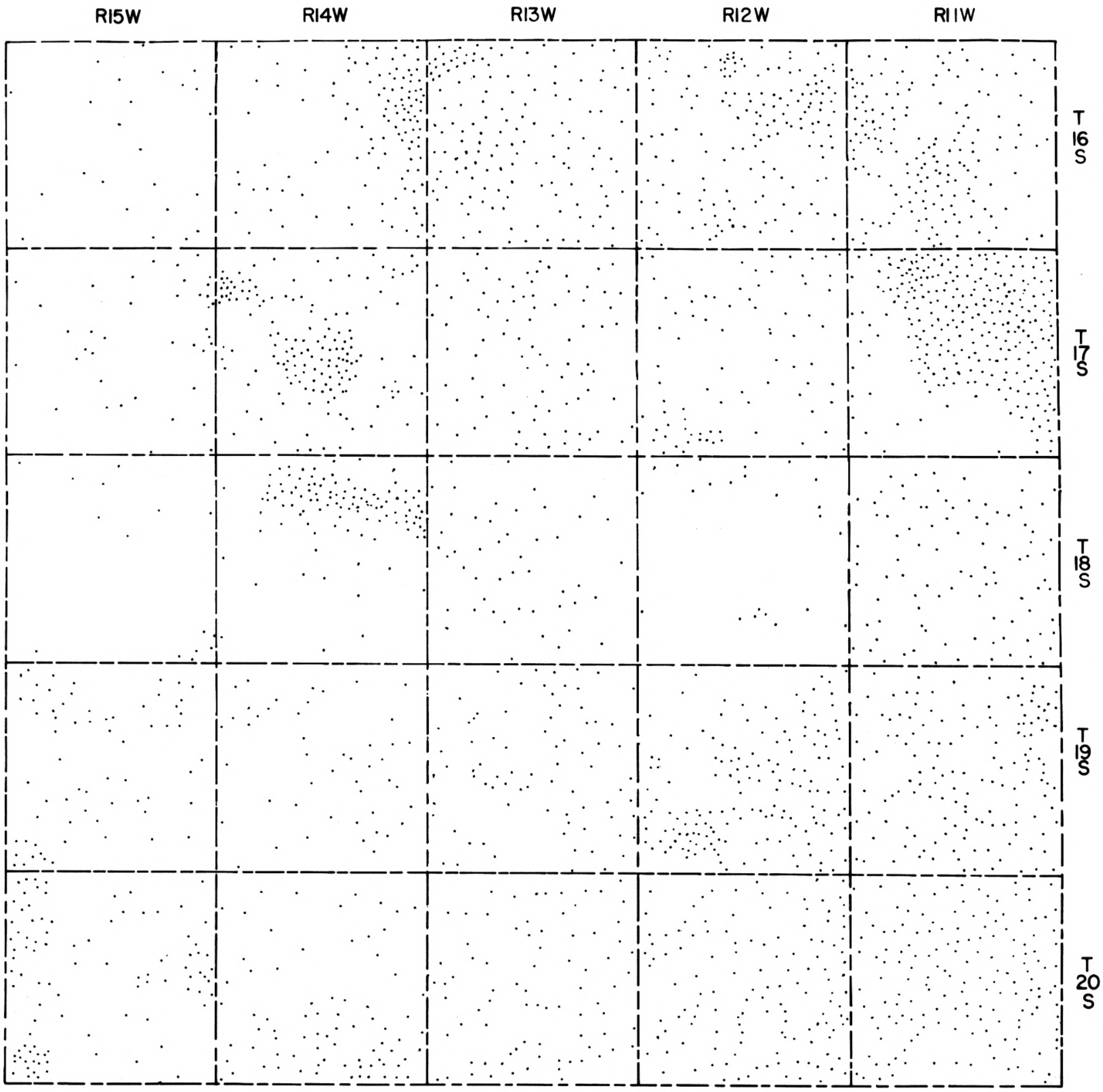


FIG. 3 MAP OF BARTON COUNTY, SHOWING THE LOCATION OF WELLS USED TO CONSTRUCT THE ARBUCKLE GROUP CONTOUR MAP.

Fig. 4. Structural contour map on top of the Lansing in Barton County.

(In accompanying plate box.)

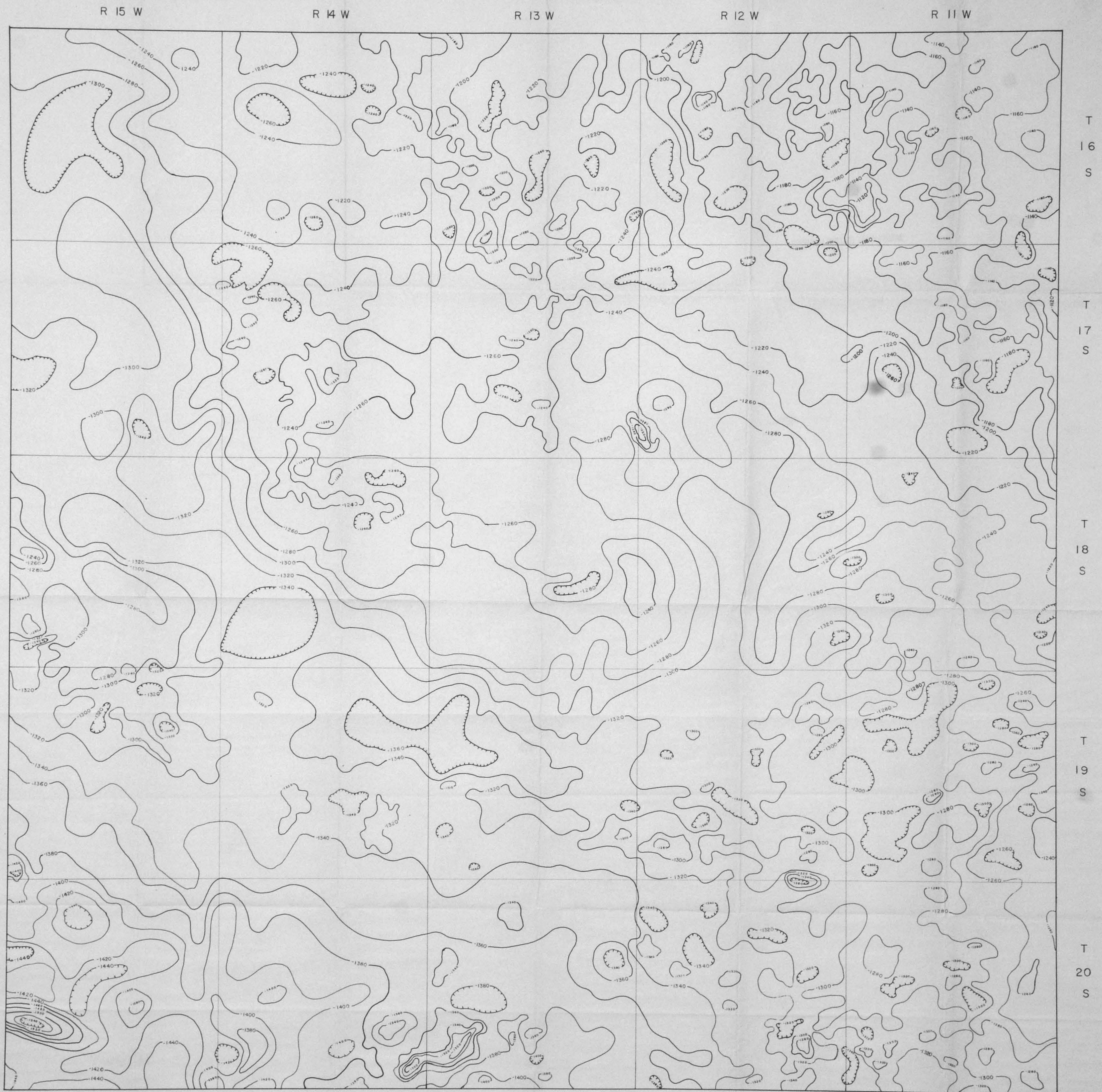


FIG. 4. STRUCTURAL CONTOUR MAP ON THE TOP OF THE LANSING IN BARTON COUNTY, KANSAS.

County line

Township line

Contour line

C.I. = 20'

Scale 1" = 1 mile

0 1/2 1 2 3 miles

SCALE

N

1957

Andrew P. Bonchonsky

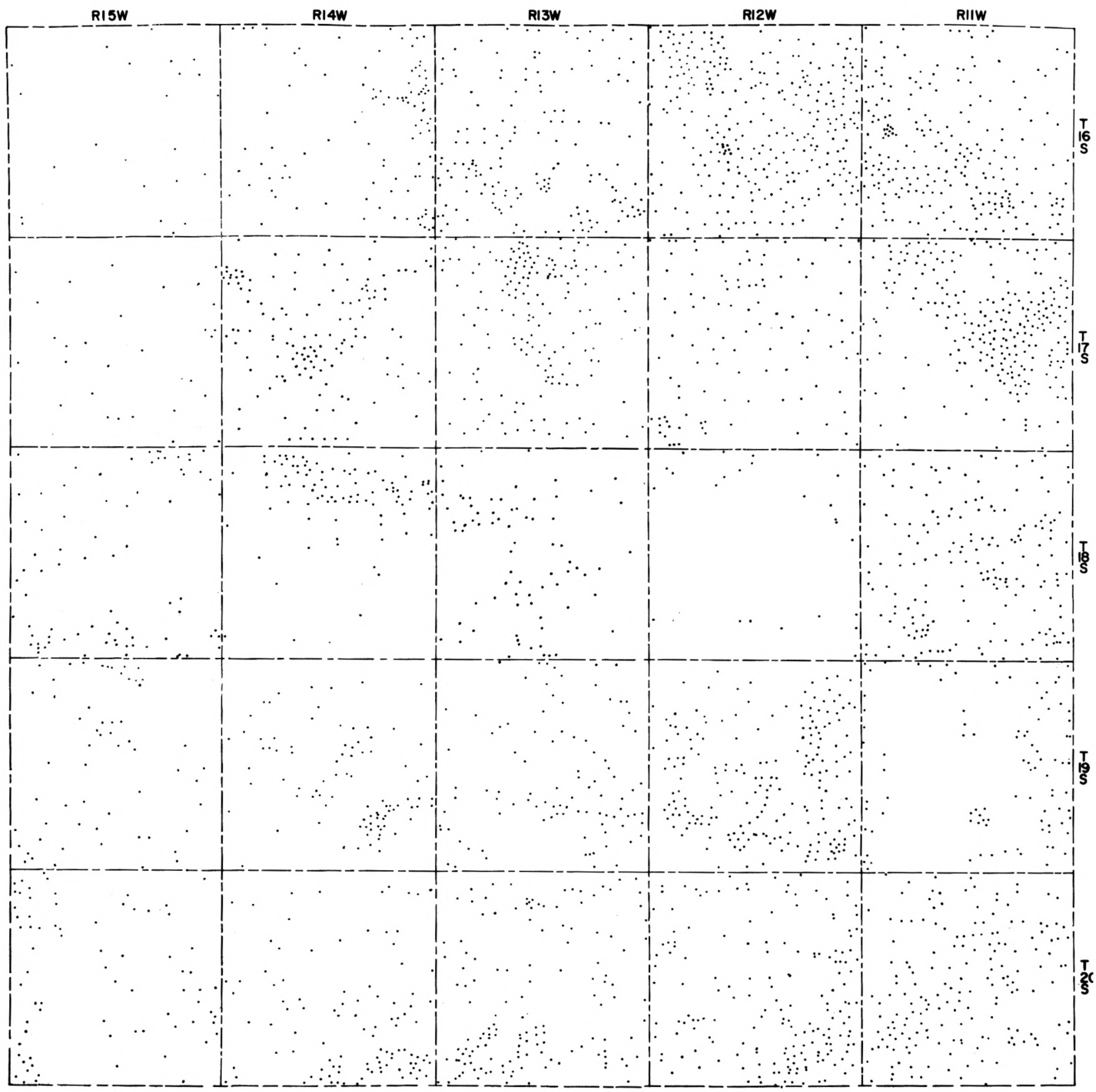


Fig. 5. Map of Barton County showing the location of wells used to construct the Lansing group contour map.

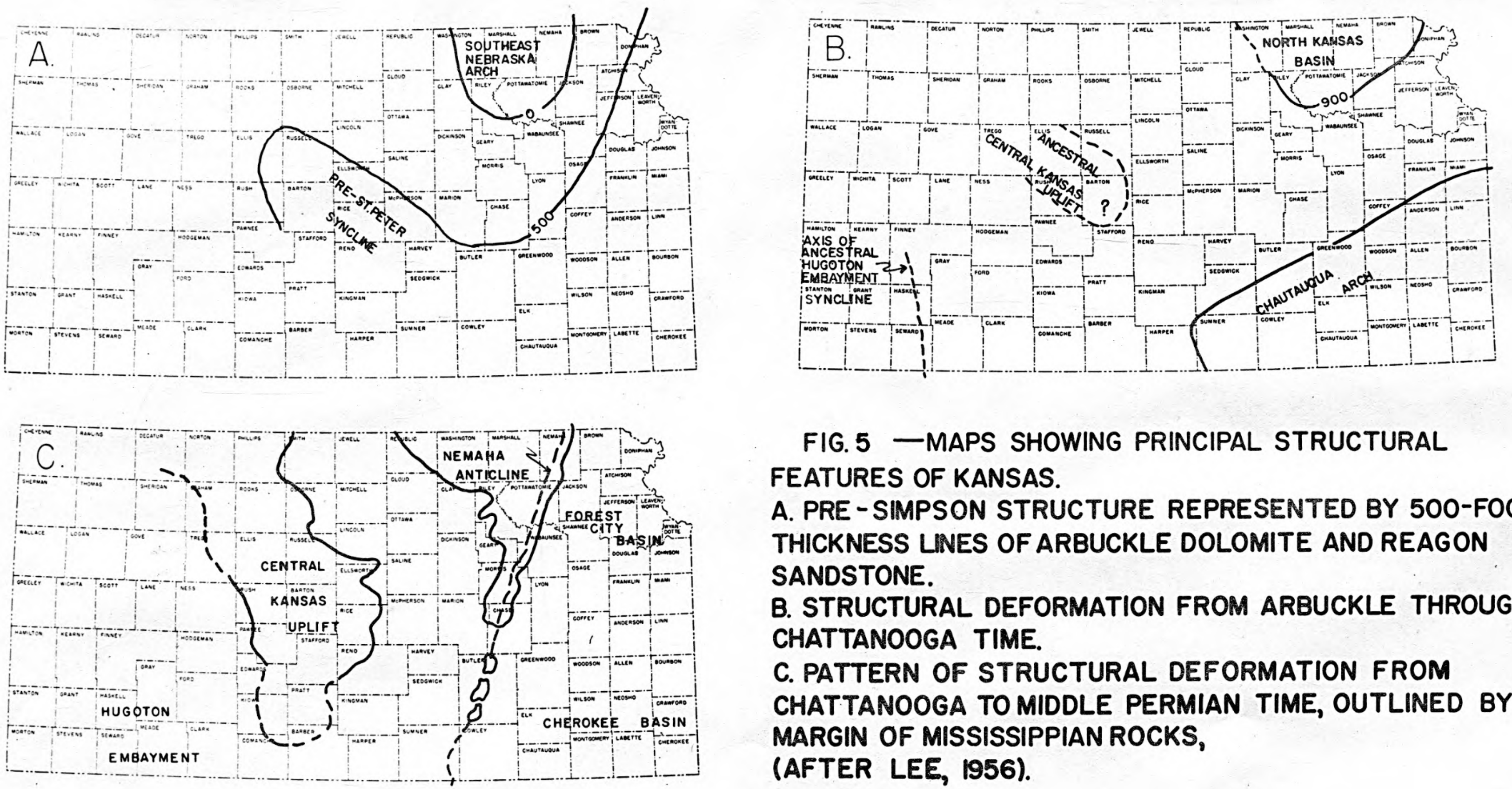


FIG. 5 —MAPS SHOWING PRINCIPAL STRUCTURAL FEATURES OF KANSAS.

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).

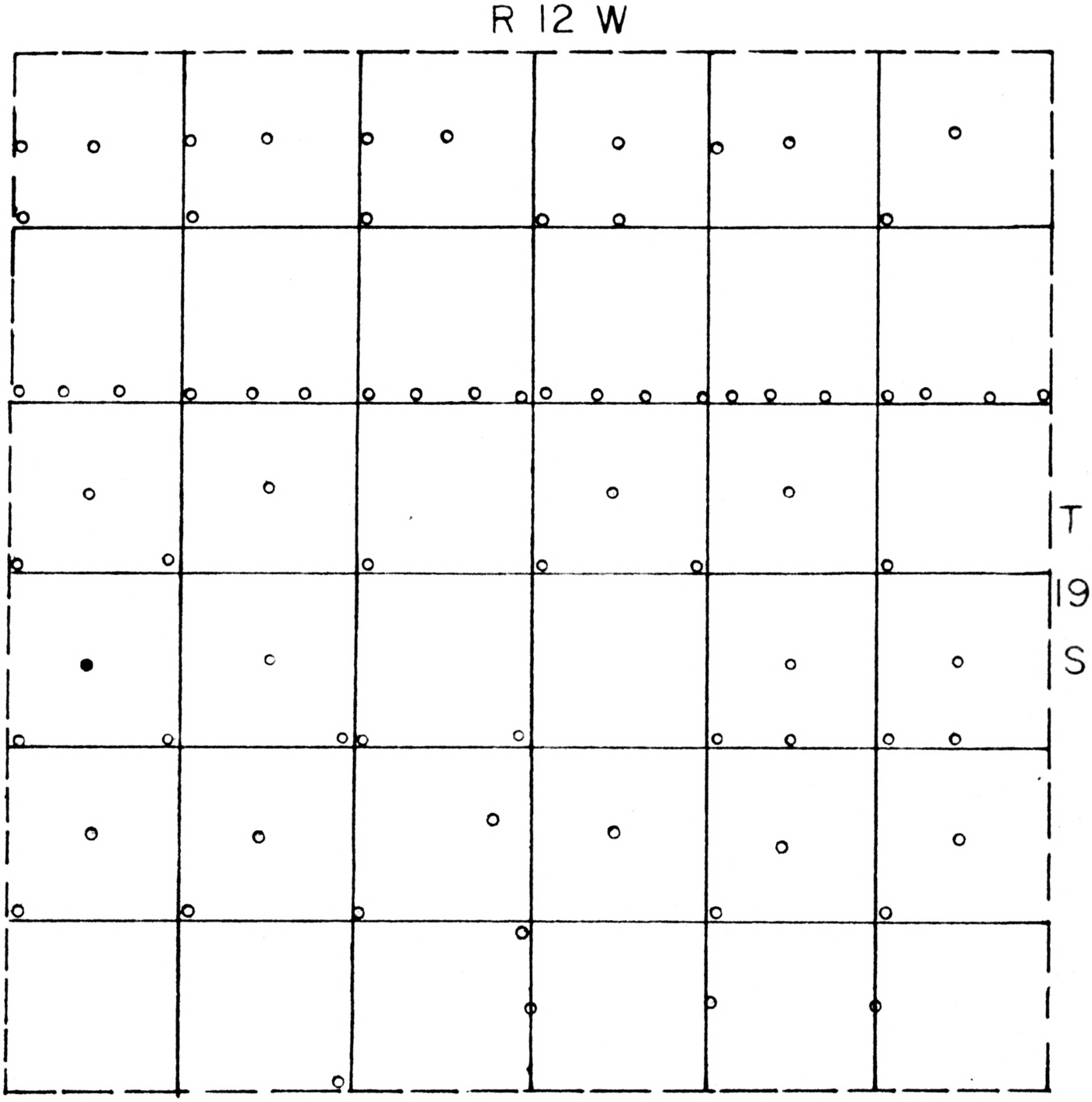


Fig. 7. Location of seismic shot points used to construct geophysical maps in southern Barton County, Kansas.

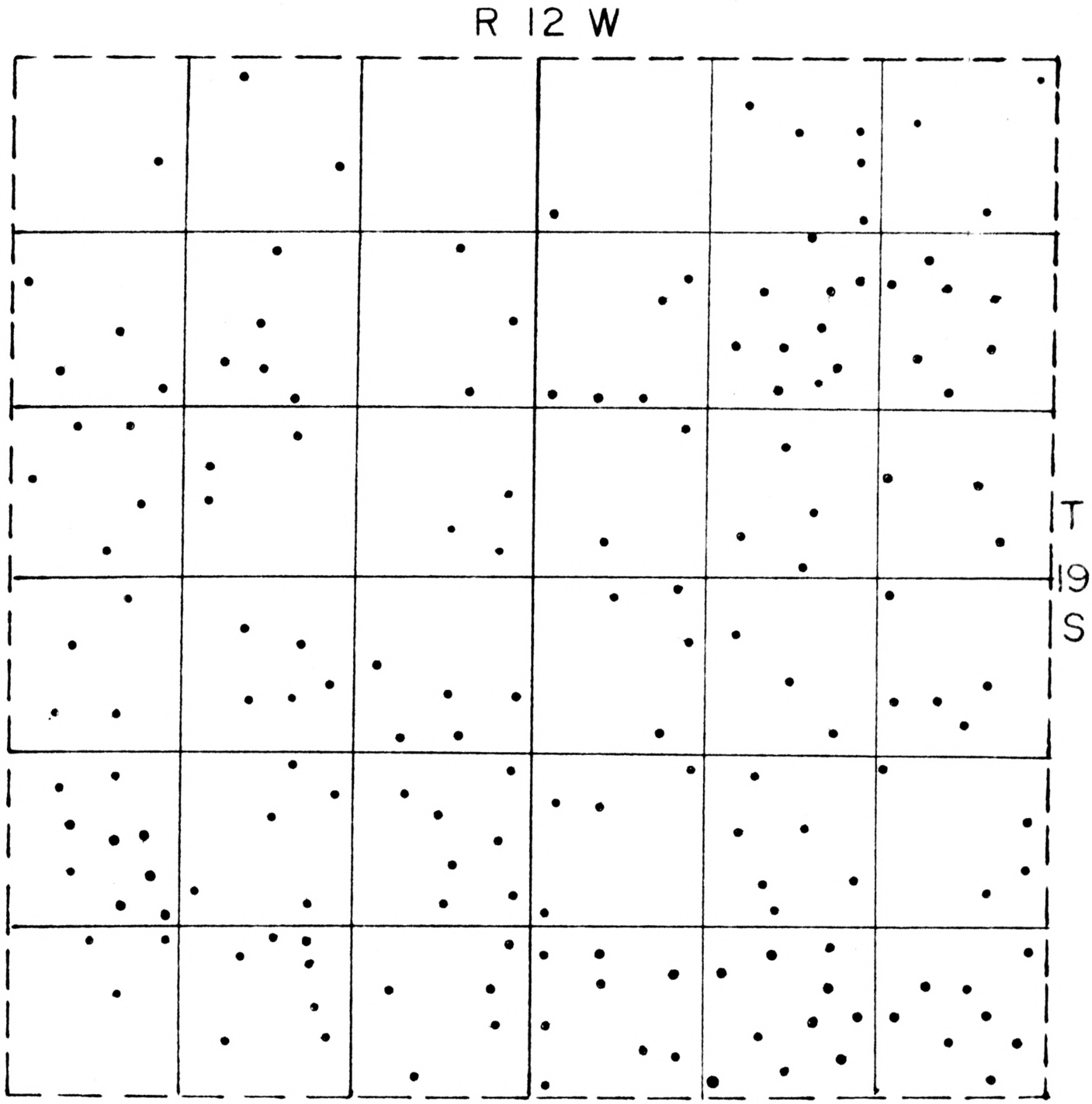


Fig. 8. Locations of wells used to construct a Stone Corral geologic map in southern Barton County, Kansas.

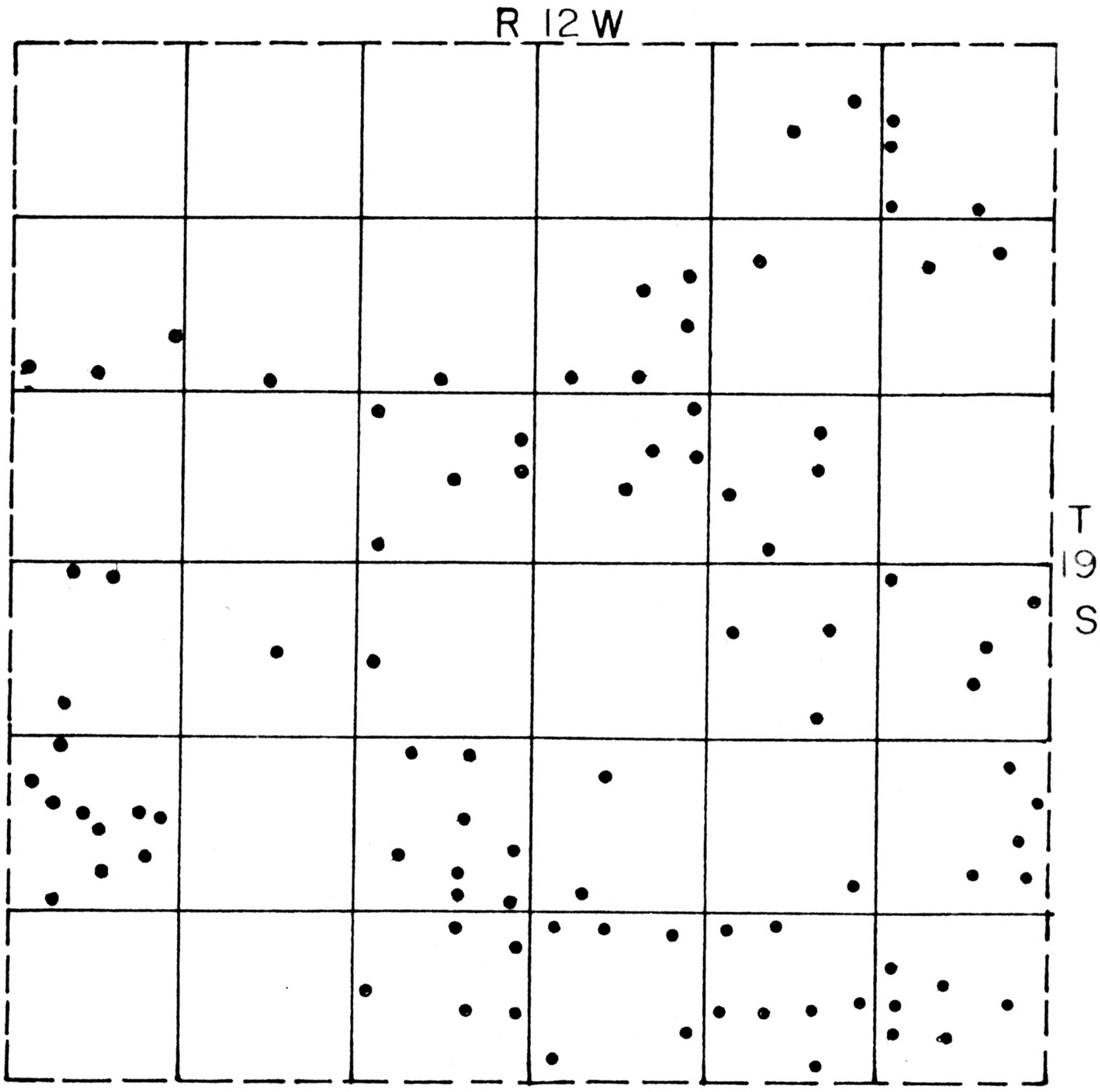


Fig. 9. Location of wells used to construct a geologic map on the Topeka in southern Barton County, Kansas.

Fig. 10. A seismic-geologic, time-depth, cross-section in southern Barton County, Kansas.

(In accompanying plate box.)

FIG. 10. TIME-DEPTH CROSS SECTION A-B of SOUTHERN BARTON COUNTY, KANSAS.

Fig. 11. A geologic structure contour map of the Stone Corral in southern Barton County, Kansas.

(In accompanying plate box.)

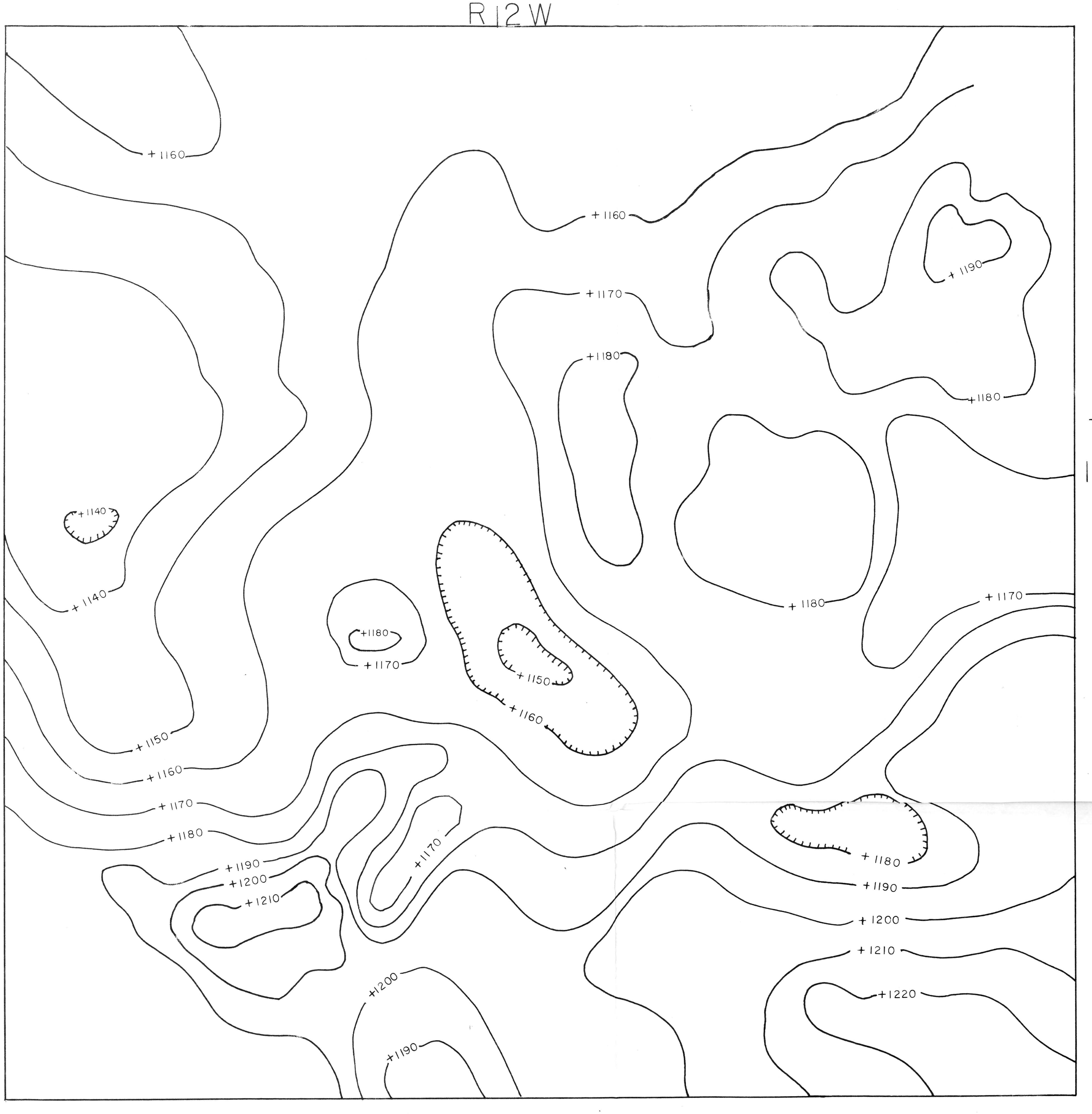


FIG. 11. GEOLOGIC STRUCTURE CONTOUR MAP ON THE TOP OF THE STONE CORRAL FORMATION IN SOUTHERN BARTON COUNTY, KANSAS. CONTOUR INTERVAL = 10' SCALE: 0' 2000' 4000' 1" = 2000'

Fig. 12. A seismic reflection time map to the top of the Stone Corral in southern Barton County, Kansas.

(In accompanying plate box.)

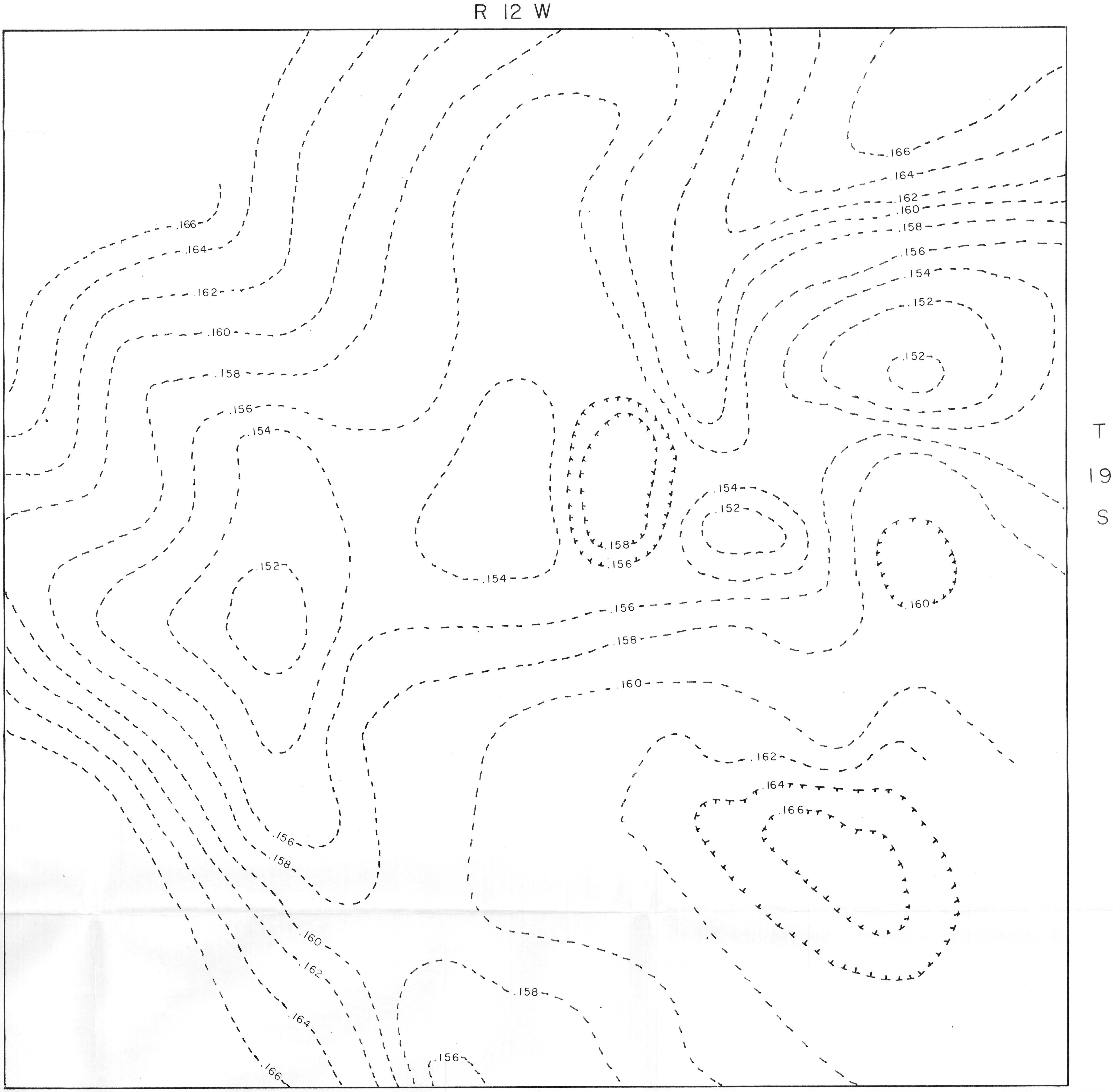


FIG. 12. SEISMIC REFLECTION TIME MAP TO THE TOP OF THE STONE CORRAL FORMATION IN SOUTHERN BARTON COUNTY, KANSAS. CONTOUR INTERVAL = .002 MILLISECONDS.

1" = 2000'
SCALE: 0' 2000' 4000'

Fig. 13. A geologic structure contour map of the Topeka in southern Barton County, Kansas.

(In accompanying plate box.)

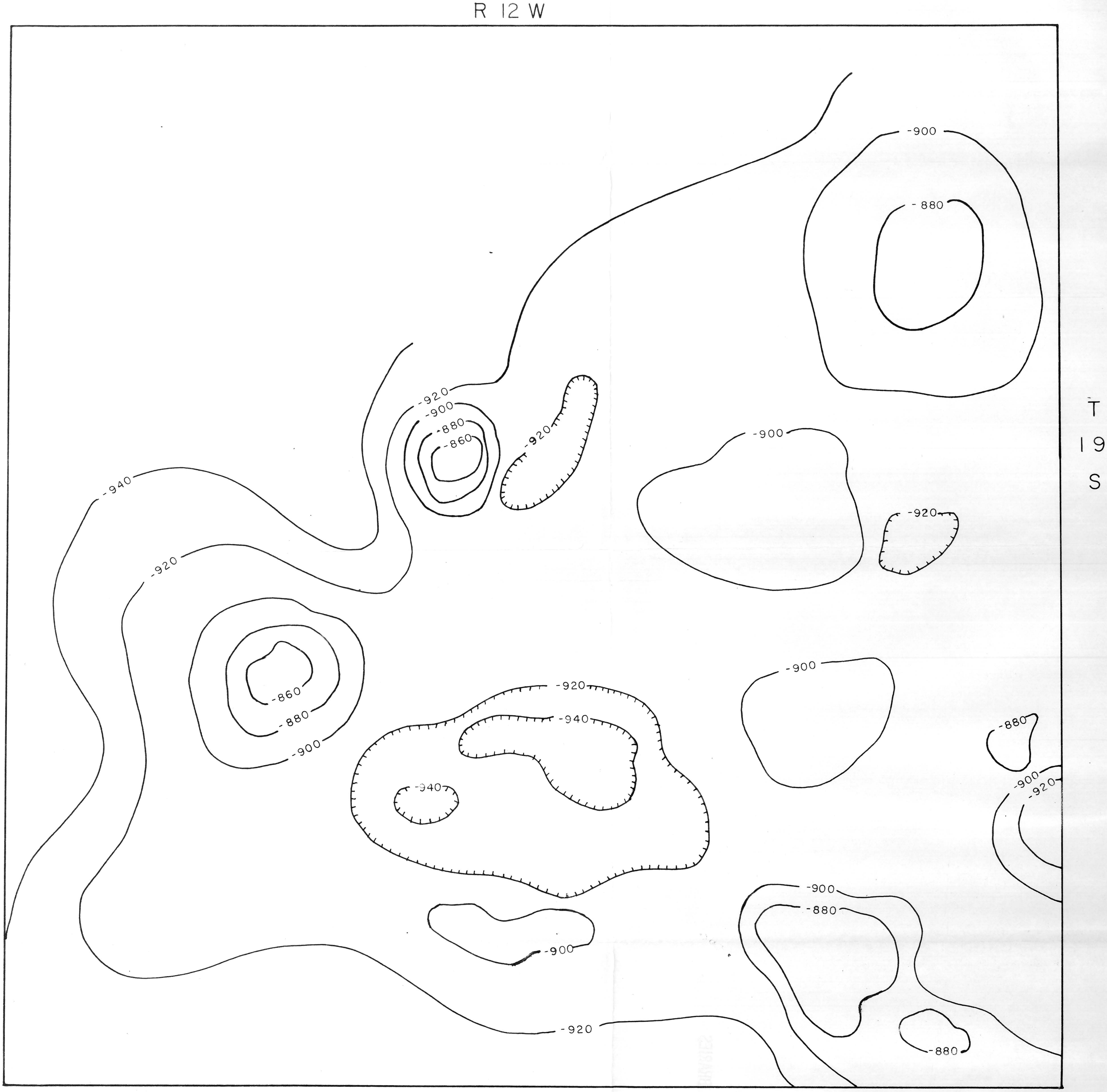


FIG. 13. GEOLOGIC STRUCTURE CONTOUR MAP ON THE TOP OF THE TOPEKA FORMATION IN SOUTHERN BARTON COUNTY, KANSAS. CONTOUR INTERVAL = 20'

1" = 2000'

SCALE: 0' 2000' 4000'

Fig. 14. A seismic reflection time map to the top of the Topeka in southern Barton County, Kansas.

(In accompanying plate box.)

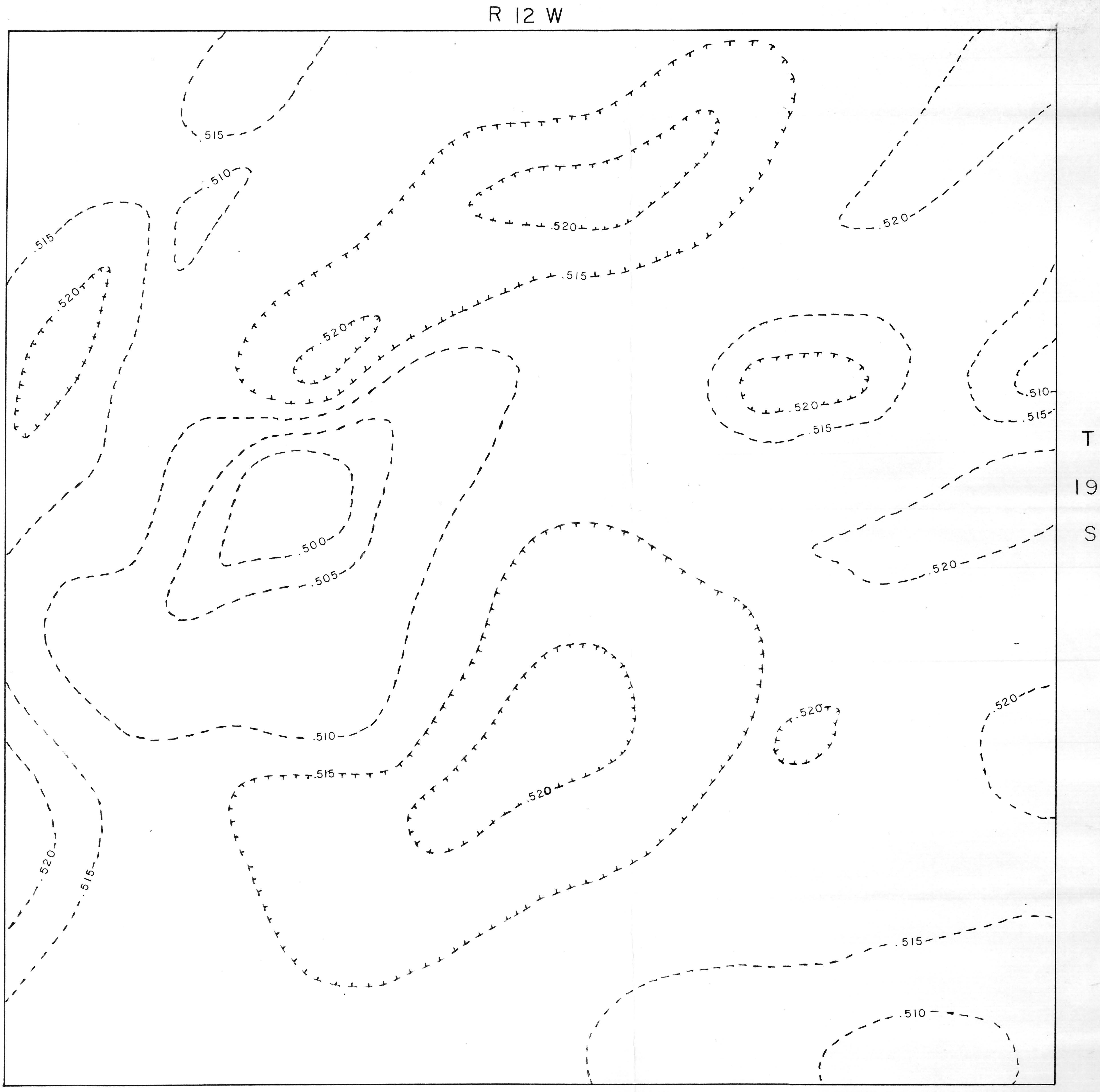


FIG. 14. SEISMIC REFLECTION TIME MAP TO THE TOP OF THE TOPEKA FORMATION IN SOUTHERN BARTON COUNTY, KANSAS. CONTOUR INTERVAL=.005 MILLISECONDS. SCALE: 0' 2000' 4000' 1" =2000'

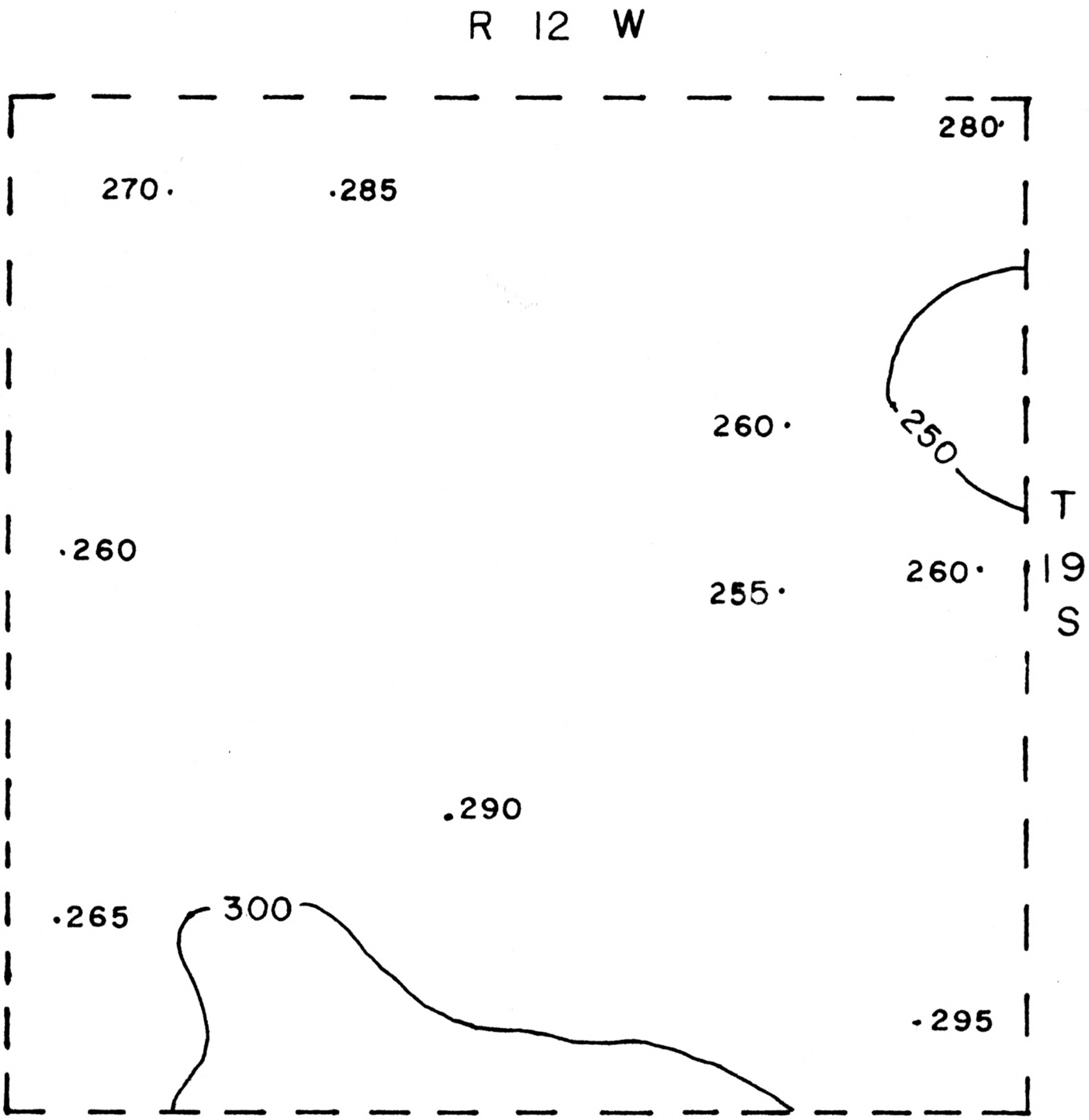


Fig. 15. Isopach map of the Hutchinson Salt Member in southern Barton County, Kansas.

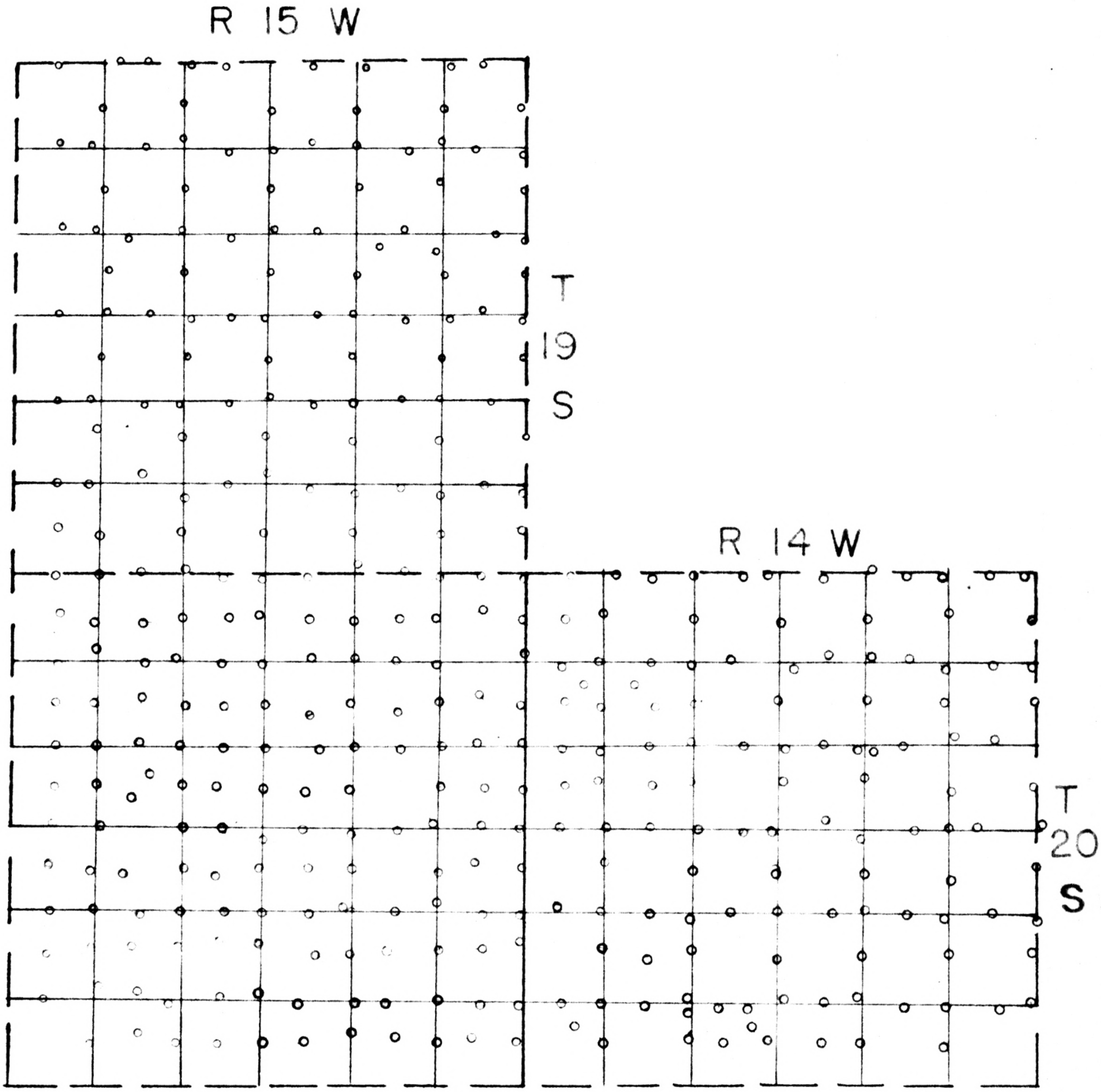


Fig. 16. Location of shot points used to construct geophysical isotime maps in southwestern Barton County, Kansas.

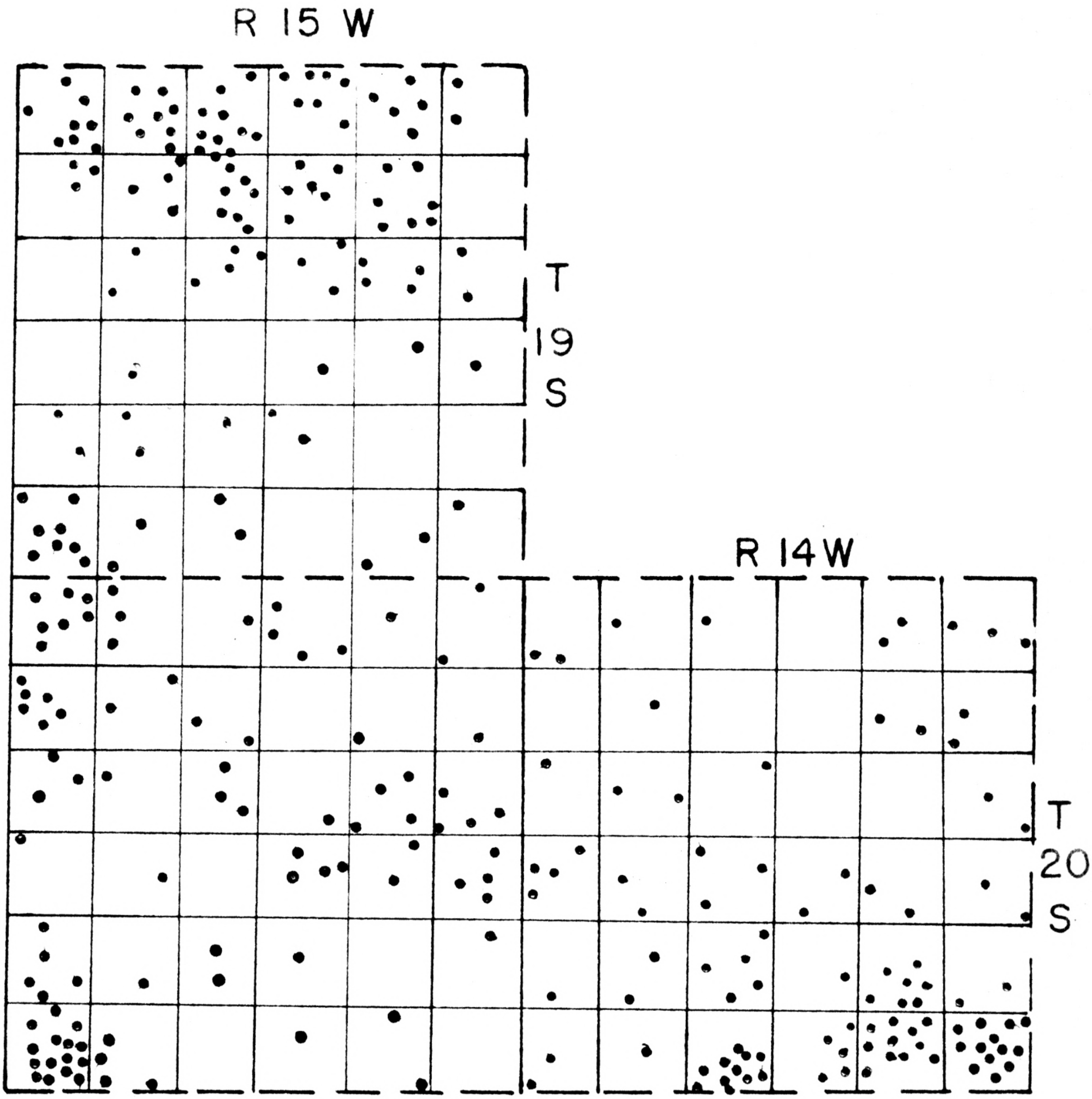


Fig. 17. Location of wells used to construct a geologic isopach map in southwestern Barton County, Kansas.

Fig. 18. Seismic isotime map using a time interval between Lansing-Stone Corral in southerwestern Barton County, Kansas.

(In accompanying plate box.)

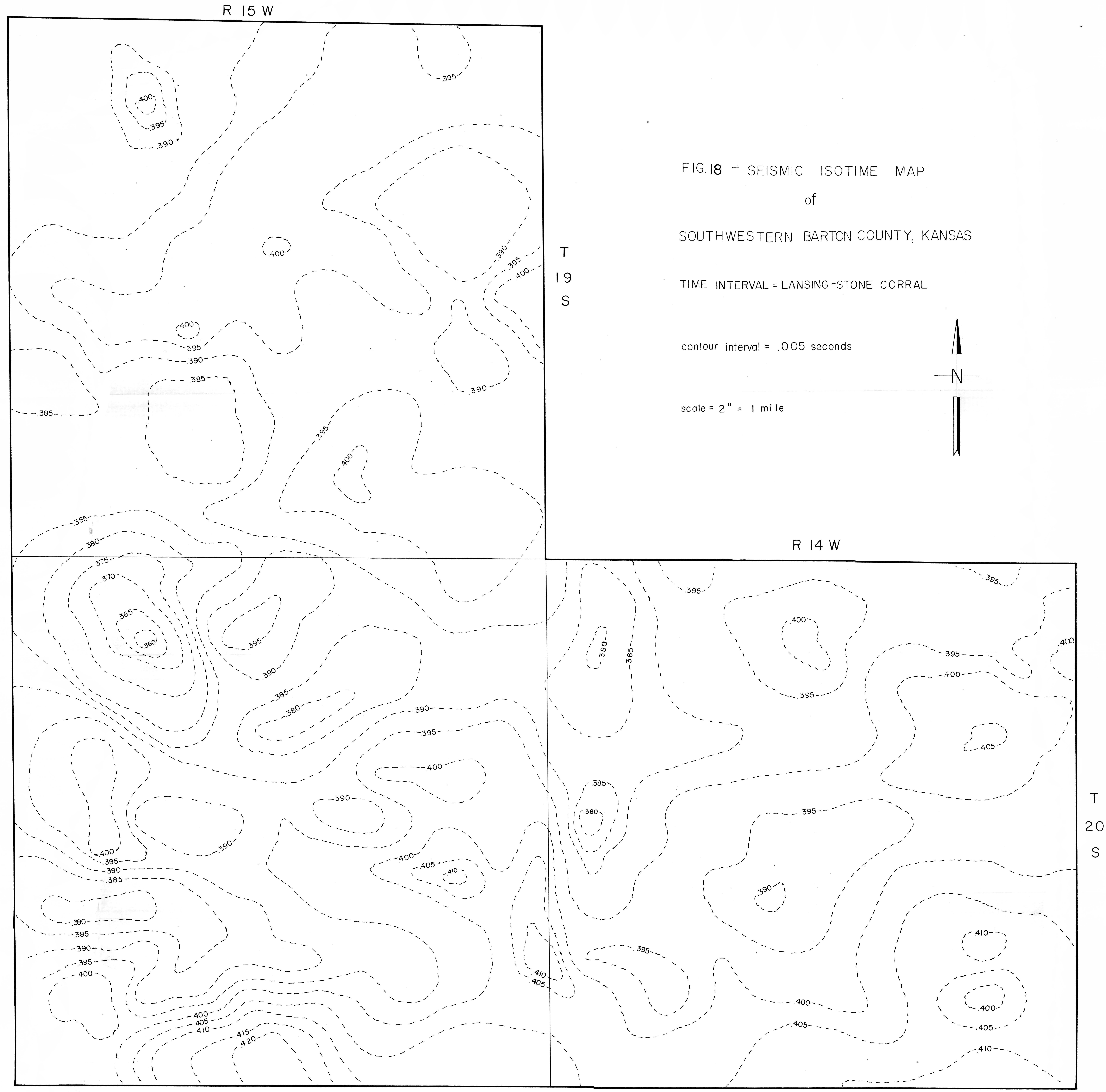


FIG. 18 – SEISMIC ISOTIME MAP of SOUTHWESTERN BARTON COUNTY, KANSAS

TIME INTERVAL = LANSING-STONE CORRAL

contour interval = .005 seconds

scale = 2" = 1 mile

Fig. 19. Geologic isopach map between the Lansing-Stone Corral in southwestern Barton County, Kansas.

(In accompanying plate box.)

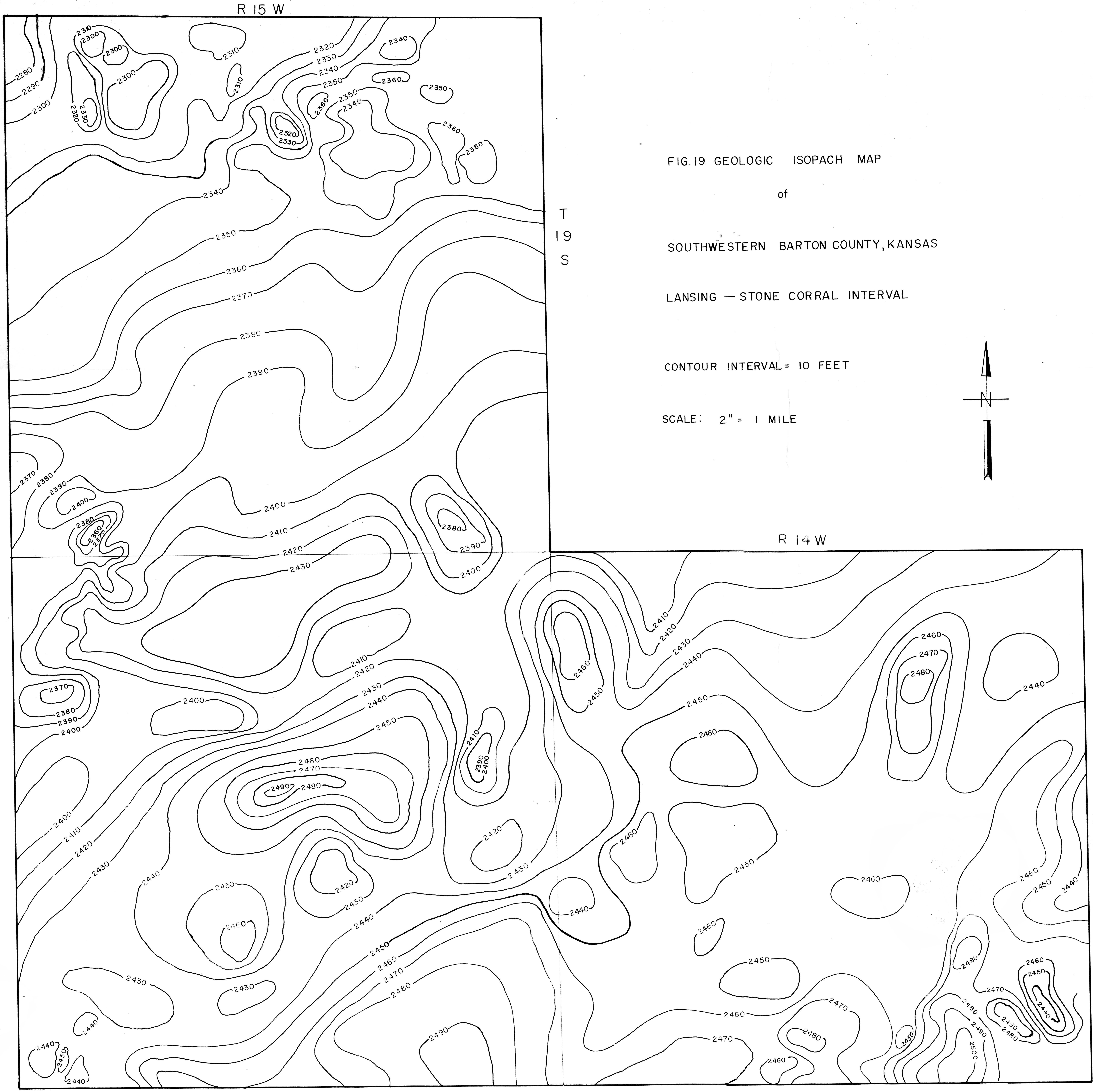


FIG. 19. GEOLOGIC ISOPACH MAP

of

SOUTHWESTERN BARTON COUNTY, KANSAS

LANSING — STONE CORRAL INTERVAL

CONTOUR INTERVAL = 10 FEET

SCALE: 2" = 1 MILE

Fig. 20. Velocity anomaly map computed from the isotime map (Fig. 17) and the isopach map (Fig. 18) in southwestern Barton County, Kansas.

(In accompanying plate box.)

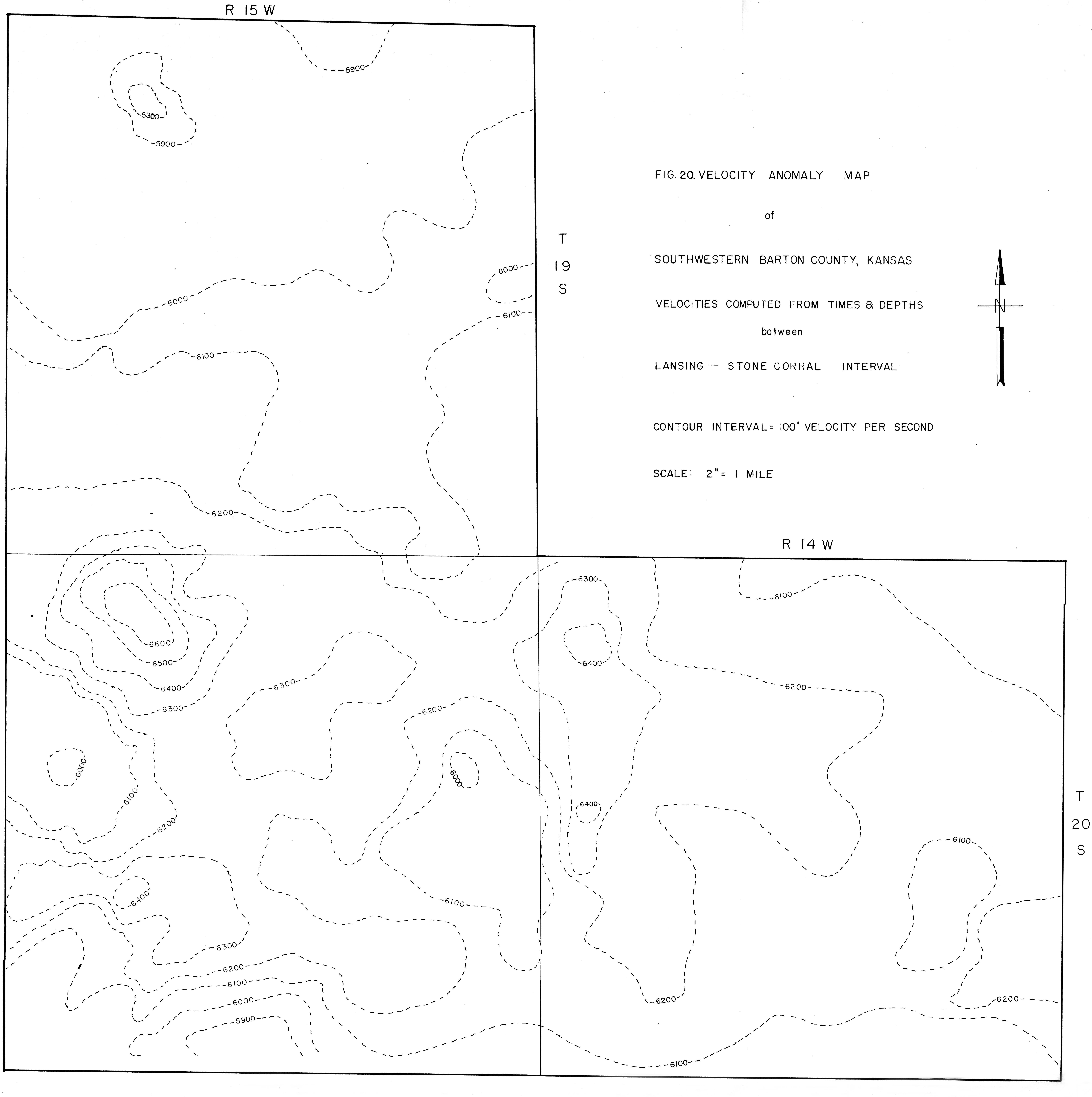


FIG. 20. VELOCITY ANOMALY MAP

of

SOUTHWESTERN BARTON COUNTY, KANSAS

VELOCITIES COMPUTED FROM TIMES & DEPTHS

between

LANSING — STONE CORRAL INTERVAL

CONTOUR INTERVAL = 100' VELOCITY PER SECOND

SCALE: 2" = 1 MILE

Fig. 21. Cross-section showing seismic interval velocities, two-way path times and geologic tops from neutron logs in southwestern Barton County, Kansas.

(In accompanying plate box.)

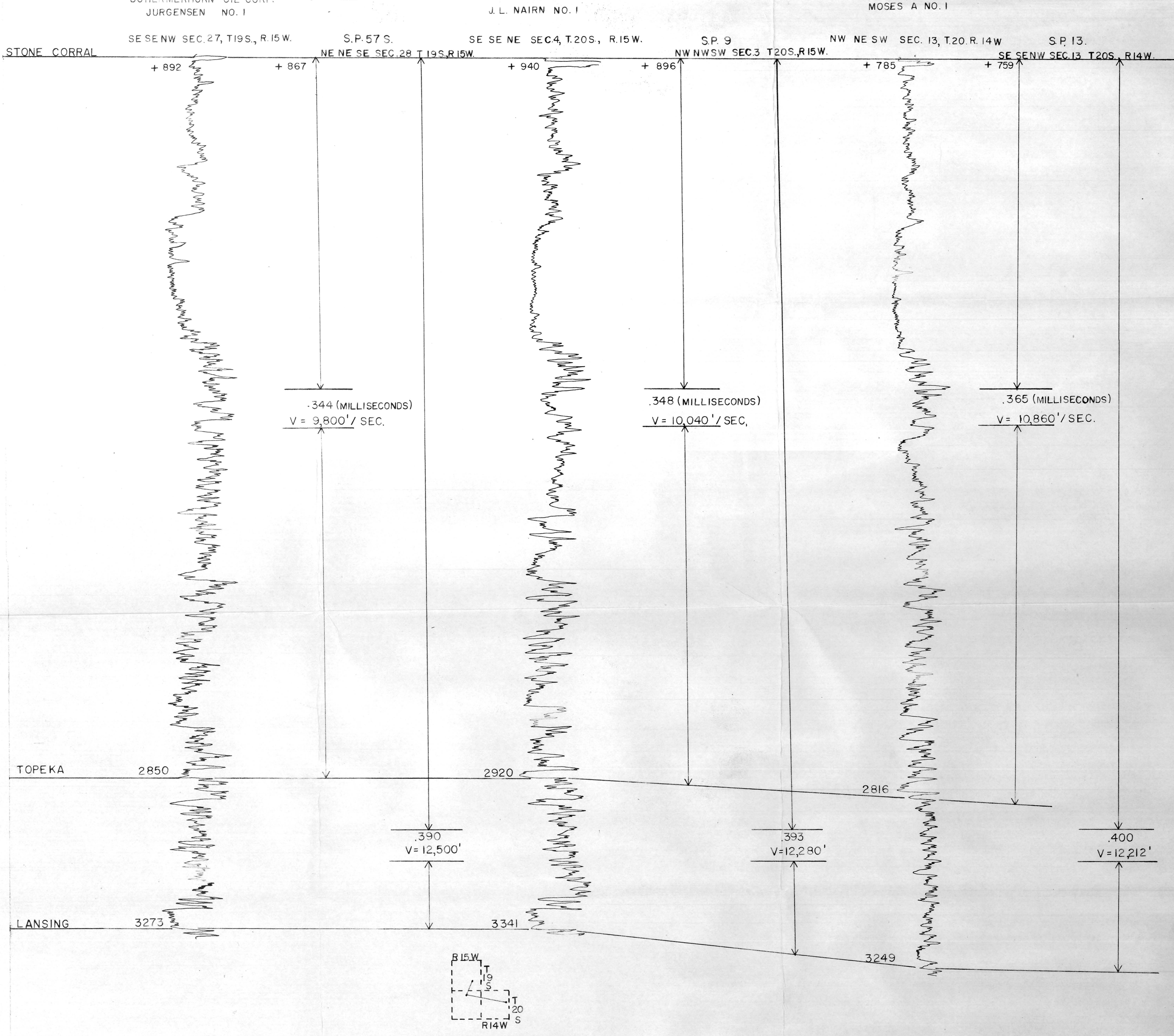


FIG. - NEUTRON LOGS, SEISMIC INTERVAL VELOCITIES, AND TWO WAY TRAVEL TIMES IN SOUTHWESTERN BARTON COUNTY, KANSAS.

Fig. 22. Isopach map of the Hutchinson Salt Member in southwestern Barton County, Kansas.

(In accompanying plate box.)

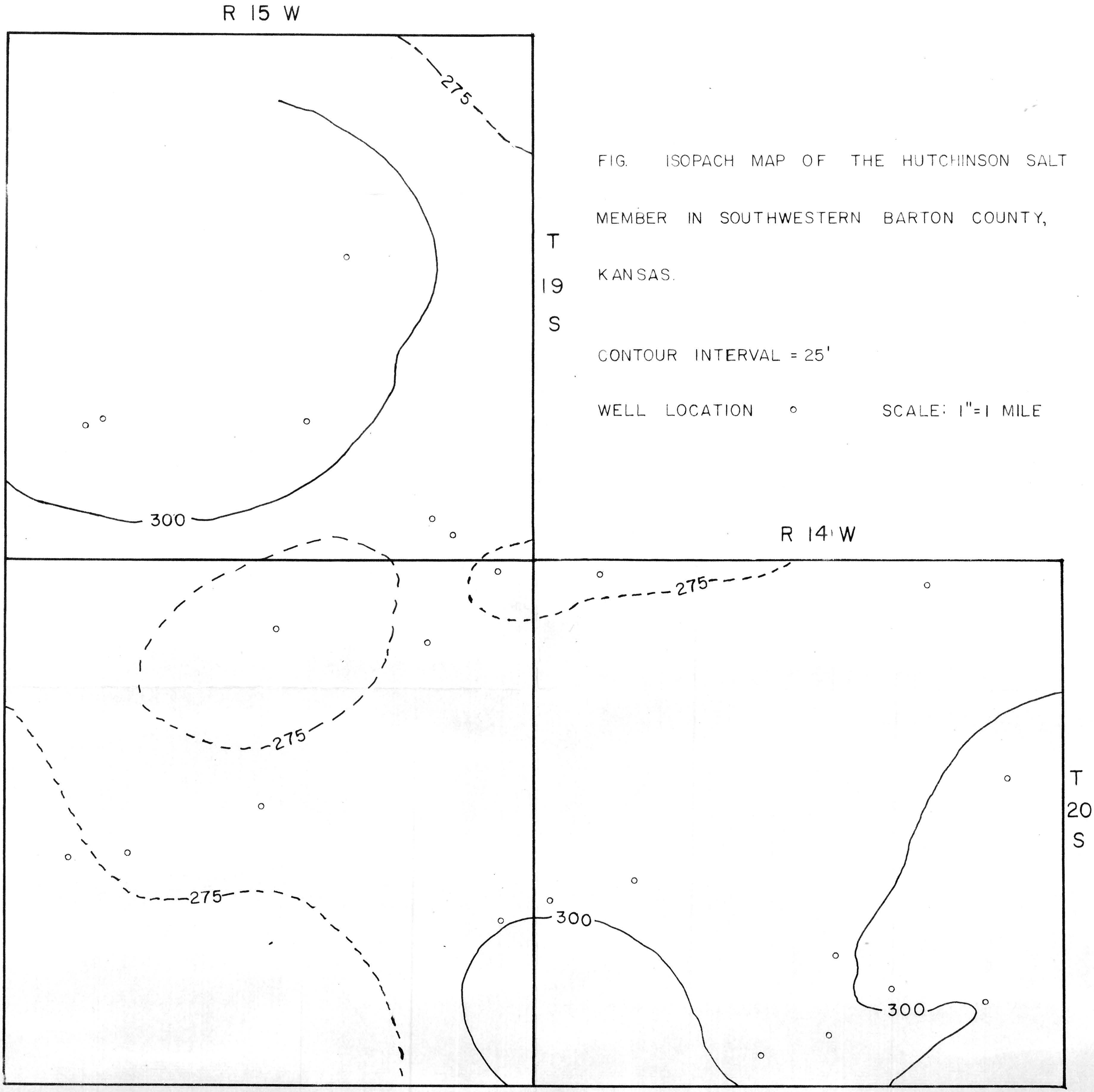


FIG. ISOPACH MAP OF THE HUTCHINSON SALT MEMBER IN SOUTHWESTERN BARTON COUNTY, KANSAS.

CONTOUR INTERVAL = 25'

WELL LOCATION ○ SCALE: 1" = 1 MILE

A SUBSURFACE GEOLOGICAL AND GEOPHYSICAL INVESTIGATION IN BARTON COUNTY, KANSAS

by

ANDREW PAUL BONCHONSKY

B. S., Kansas State College
of Agriculture and Applied Science, 1954

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

1957

The purpose of this investigation was to analyze the subsurface structure and stratigraphy of Barton County, Kansas, in order to determine the relationship of geological and geophysical data.

The data for the construction of a detail Lansing and Arbuckle structural map were taken from the Herndon maps, Scout-tops, electric and drillers logs. The Arbuckle structural map revealed a "Karst" topography and the Lansing map reflected underlying topographic forms in a subdued manner.

Geophysical data obtained from the Sohio Petroleum Corporation was computed from seismograms in southern Barton County. Seismic reflection-time maps were constructed on the Stone Corral and Topeka formations and a cross-section was made from dry hole information to tie geophysical data to geological data. Geologic structure contour maps were constructed on the Stone Corral and Topeka formations to check, evaluate, and help interpret the seismic maps.

In southwestern Barton County an isotime map was made from geophysical data obtained from the Pan American Petroleum Corporation. Using up-to-date geologic information, an isopach map was made to check, evaluate, and help interpret the isotime map.

By superimposing the geological maps over the seismic maps, it was noted that all seismic anomalies are not related directly to geologic structures as they are known today. Translation of seismic data into structural geologic maps is a procedure which can only be properly performed by considering geologic factors of the area. Some of the geologic factors that were considered are: depth of weathering, topographic relief, presence of salt beds, cyclic sedimentation, facial changes, and thickening and thinning of stratigraphic units.

Perhaps the reason that we do not have enough true correlation at the present is that we do not have enough men who have a thorough background in both geology and geophysics. This situation could be improved by giving young geologists and geophysicists more training in both fields.