COLE, Joseph Glenn, 1929-
STRATIGRAPHIC STUDY OF THE CHEROKEE AND MARMATON SEQUENCES, PENNSYLVANIAN (DESMOINESIAN), EAST FLANK OF THE NEMAHA RIDGE, NORTH-CENTRAL OKLAHOMA.

The University of Oklahoma, Ph.D., 1968
Geology

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

STRATIGRAPHIC STUDY OF THE CHEROKEE AND MARMATON SEQUENCES, PENNSYLVANIAN (DESMOINESIAN), EAST FLANK OF THE NEMAHA RIDGE, NORTH-CENTRAL OKLAHOMA

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

J. GLENN COLE

Norman, Oklahoma

1968

STRATIGRAPHIC STUDY OF THE CHEROKEE AND MARMATON SEQUENCES, PENNSYLVANIAN (DESMOINESIAN), EAST FLANK OF THE NEMAHA RIDGE, NORTH-CENTRAL OKLAHOMA

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ACKNOWLEDGMENTS

The writer wishes to extend his appreciation to Dr. George G. Huffman for his supervision of this dissertation and to the Dissertation Committee for their suggestions and criticisms.

Very special thanks are accorded to Roger Berg, whose companion study did much to further my interpretation, and to Gerald Nalewaik for his effort in devising a computer program utilized in this study.

A deep heartfelt acknowledgment is made to the late W. Reese Dillard of Tulsa, Oklahoma, for his encouragement and liberal use of data collected over the many years that he practiced geology in Oklahoma. The generous use of information from the files of Pan American Petroleum Corporation, Amerada Petroleum Corporation, Apache Corporation, and the Oil Information Center is greatly appreciated.

Drafting of the final maps was done by Leonard E. Olmstead.

To my wife, Kathryn, without whose support all this would not have been possible, I am eternally grateful and to my daughter, Jerre Lynne, who did much of the color work on the final maps, I am deeply thankful.

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INTRODUCTION

Purpose of Investigation

A wealth of information of stratigraphic nature lies at our finger tips in the form of mechanical well logs and samples. This information, when thoroughly evaluated and displayed, can shed much light on the geologic history of a region and its economic aspects. As Jewett (1941, p. 288) succinctly put it, "All stratigraphic information is of economic importance."

What is thoroughly evaluated? This is a hard question to answer and depends upon the nature of the inquiry and the nature of available data. For example, if one is interested in a stratigraphic unit that averages 100 feet in thickness over some given area and a four-inch core is taken through that interval every square mile only .0000012% of the total volume is obtained. If 16 wells per square mile (forty-acre spacing) are utilized the percentage is .000020 and if one well per township is cored only .00000003% of the total volume of rock is available for minute description. If only drill cuttings are available, depending on the quality of the cuttings, the percentage of total volume would fall off drastically. That worthwhile contributions have been made under these conditions will be granted by almost everyone.

With the advent of mechanical logging, recognition and tracing of stratigraphic units, many of them "marker defined," have become more precise than that which could have been determined from driller's logs and/or sample logs. As Busch observed (1961, p. 162), "Very precise correlations of many subsurface formations are now possible and geological phenomena such as unconformities and facies changes usually can be readily recognized from them [electric logs]." The fact that lithic character or type cannot be determined directly from the log is well known but it can be inferred from a study of the samples and the knowledge of electrical logging phenomena. Be that as it may, there are various "kicks" on the log that serve to define or isolate units which can be traced over wide areas and whose attributed can be depicted on maps. It is the purpose of this paper to analyze a succession of rocks in the light of these ideas, the establishment of marker-defined units (genetic sequences or increments of strata), their geographic distribution with attendant facies variations, inferences as to direction of transport and/or source, depositional strike, influence of positive areas, onlapping nature of strata, and the subcrop pattern of strata at any surfaces of unconformity.

The succession of rocks selected for analysis is bounded at the top by a persistent carbonate marker recognized by most workers as the Checkerboard Limestone and at the base by an unconformity, the surface of which shows truncated rocks from Arbuckle to Wapanucka. The succession, essentially, consists of the Cherokee and Marmaton Groups which are considered to be Desmoinesian in age with the very top and bottom portions being Missourian, and Atokan or Lampasan (Cheney, 1945, Moore, et al., 1944, and Moore, et al., 1951), respectively.

The size and location of the area investigated is largely arbitrary and was selected on the basis of convenient township and range boundaries. The area is still small when compared to modern analogues of sedimentary environments (Fig. 1) but when coupled with a companion study (Berg, 1968) the area becomes commensurate with that of some modern environments.

Location

The area of investigation comprises approximately 7,000 square miles in north-central Oklahoma. It is bounded on the west by the Principal Meridian (Indian Meridian), on the east by the east line of Range 10 East, on the south by the south line of Township 10 North, and on the north by the Kansas-Oklahoma State boundary which is the north line of Township 29 North. One hundred and ninety full townships and the partial townships 29 North are represented. As constituted this encompasses all of two counties and varying portions of twelve others including Pawnee, Lincoln, Osage, Kay, Noble, Payne, Creek, Okfuskee, Seminole, Pottawatomie, Logan, Oklahoma, Cleveland, and Tulsa, respectively (Fig. 2).

Tectonic Setting

The area of investigation is situated on the eastern flank of the Central Oklahoma Arch, a structure defined by Lowman (1933, p. 32) as, "a broadly regional positive feature which is well expressed from the Oklahoma City area on the south, northward along the line marked by such local uplifts as Crescent, Lovell, Garber, Thomas and others and

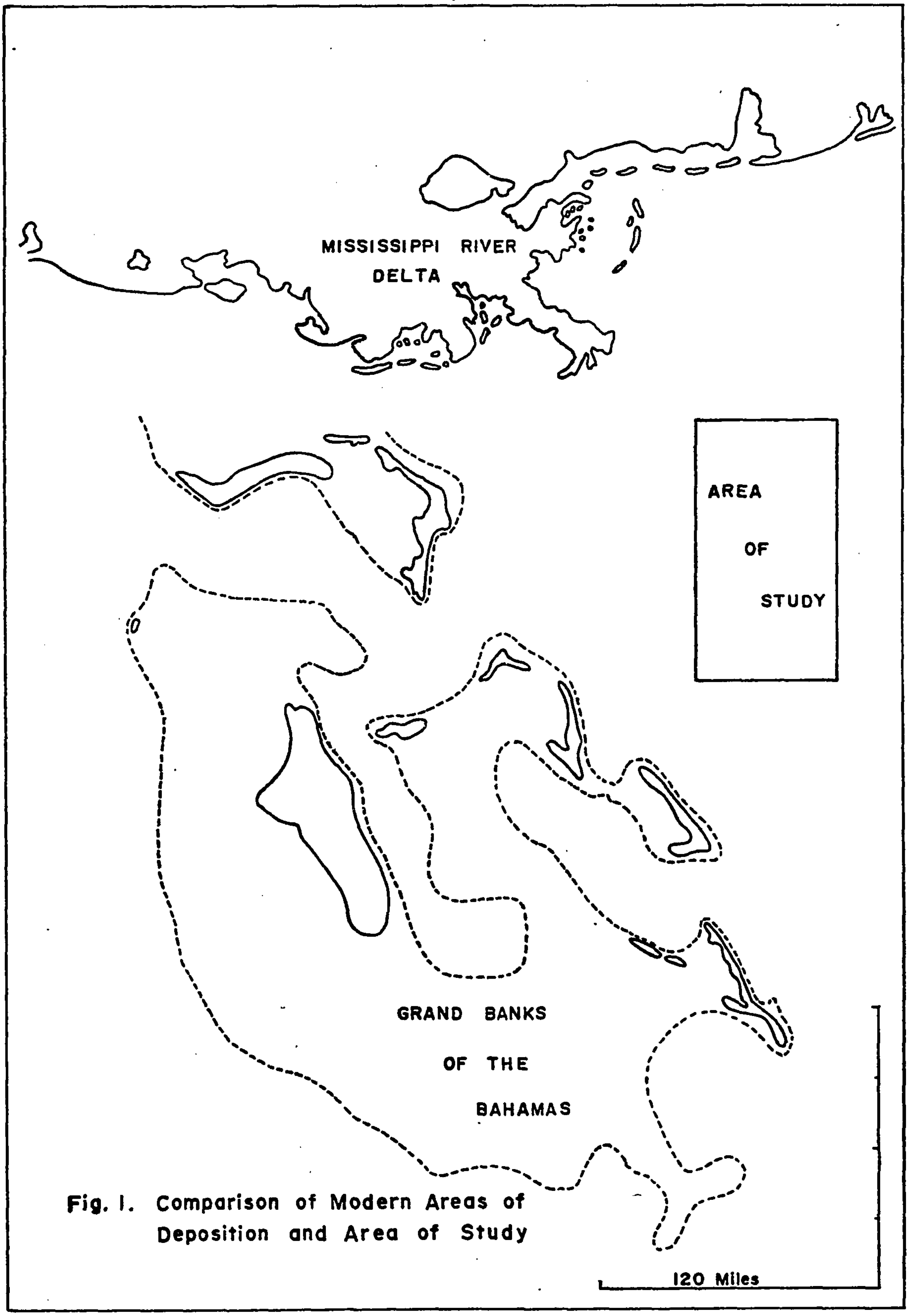

Fig. 1. Comparison of Modern Areas of Deposition and Area of Study

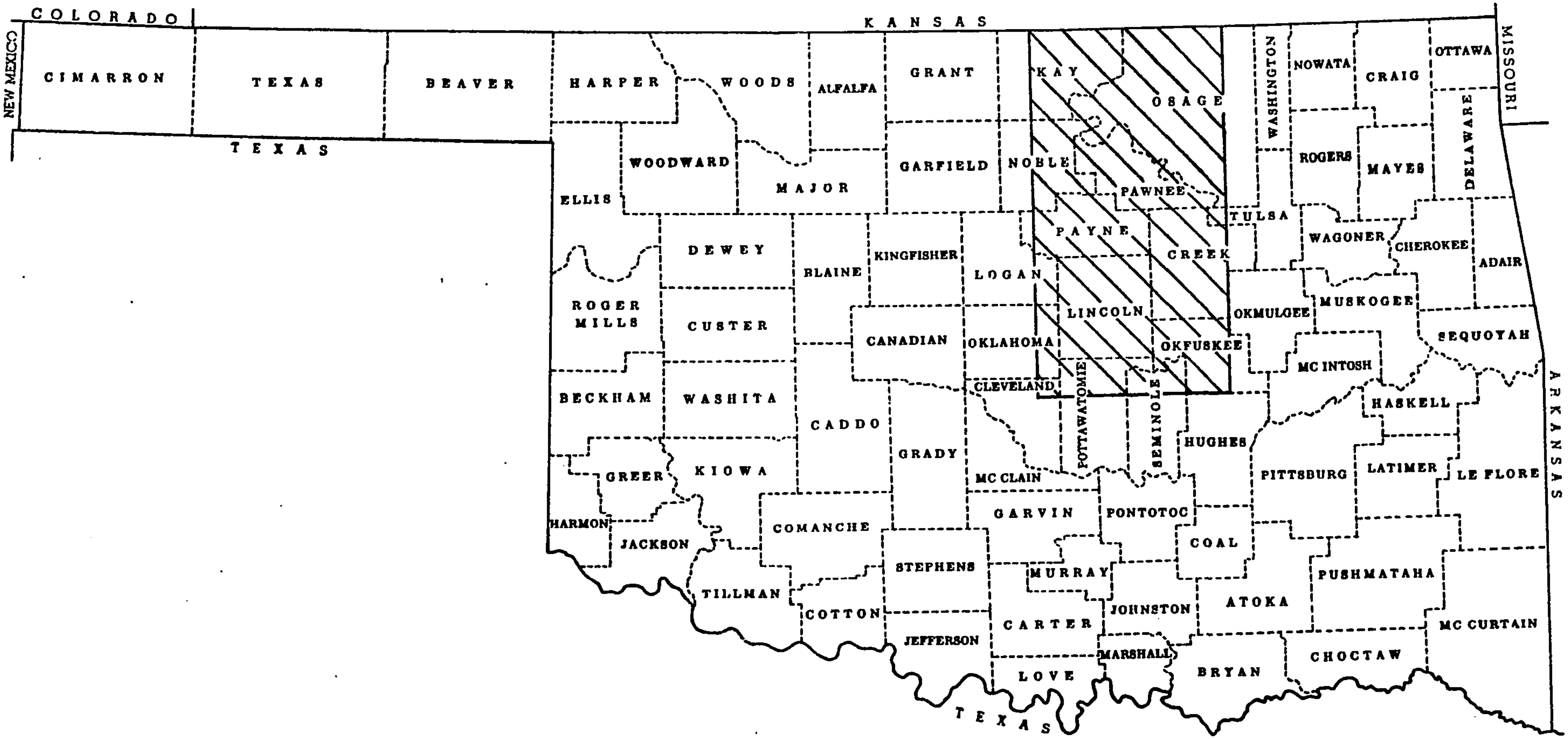

Fig. 2. Location Map of Area of Investigation

connecting with the Nemaha Mountains of Kansas." and depicted by Jordan and others (1962), and Jordan (1964, reprinted 1967). Most workers refer to this simply as the Nemaha Ridge, but it should be explicit that it is a broad feature. The area is also located on the western flank of the Pryor basin (Lowman, 1933, p. 31), ". . . a comparatively narrow, elongated basin in northeastern Oklahoma, . . ." which ". . . is continuous with, but separated by a saddle from the Kansas extension of the Forrest City basin in northwestern Missouri." The axis of this basin can best be seen on maps by Berger (1918, p. 619), Bass (1934, p. 1334), Bass (1936, Plate I), and Pierce and Courtier (1937, p. 36). Again, most workers would call this the Cherokee basin or the Northeast Oklahoma Platform. The northwest rim or "hinge line" of the McAlester or Arkoma basin crosses the southeastern corner of the area (rate of thickening almost doubles from 50 feet or less per mile to the northwest to 90 feet and more per mile to the southeast, Plate XII). Lowman (1933, p. 32) noted this rim or "hinge line" feature by saying that, "This was the flexure of the rim of the area of very rapid sedimentation in the McAlester [Arkoma] basin. This flexure can be traced in some detail from near the town of Ada, Oklahoma, northeastward through the Holdenville, Henryetta and Muskogee areas; thence eastward connecting with the northern side of the McAlester [Arkoma] basin in Arkansas where it has been called the Tahlequah flexure by Cheney." The Ozark uplift borders the Cherokee basin on the east and probably was comparable to the Central Oklahoma Arch as to tectonic response, as Melton (1931, p. 218) put it, ". . . the Ozark area was positive only with respect to its immediate surroundings, and was apparently part of a much larger area having negative tendencies." Other positive elements directly or indirectly related to the tectonic setting include the Ouachita complex to the southeast and the Arbuckle-Wichita trend to the southwest. Morgan (1924, p. 70) commented on the conglomerates in the McAlester formation (lower part of Cherokee sequence) saying that, "This conglomerate is largely composed of reworked fragments from the Caney and Woodford formations. . ." and also that ". . . later conglomerates in the McAlester carry fragments of Hunton limestone . . ." This would seem to indicate that the Arbuckles, at least in part served as a source area. Melton (1930) supported this and it would seem that nothing has been brought forth to counter this contention. Edwards (1959) supported the positive nature of the Wichita Mountains, indicating that vast quantities of arkosic debris were shed into the Anadarko basin during Pennsylvanian time. A generalized tectonic map was compiled to show the location of the area of investigation relative to the surrounding tectonic features (Fig. 3).

Previous Investigations

Inasmuch as all information is generally worthwhile, it is difficult to filter out that which is most pertinent. Therefore, the selection may not be that of someone else and will include only investigations within the studied area and its nearby environs.

Investigation of subsurface rocks has accompanied the petroleum development of Oklahoma, moving from the shallow producing pools in the northeastern part of the state westward and southward with increasing depths. Early studies dealt with the producing horizons which were extended from pool to pool or to potential prospecting areas based on amount of dip. As more and more wells were drilled, sandstones were traced from

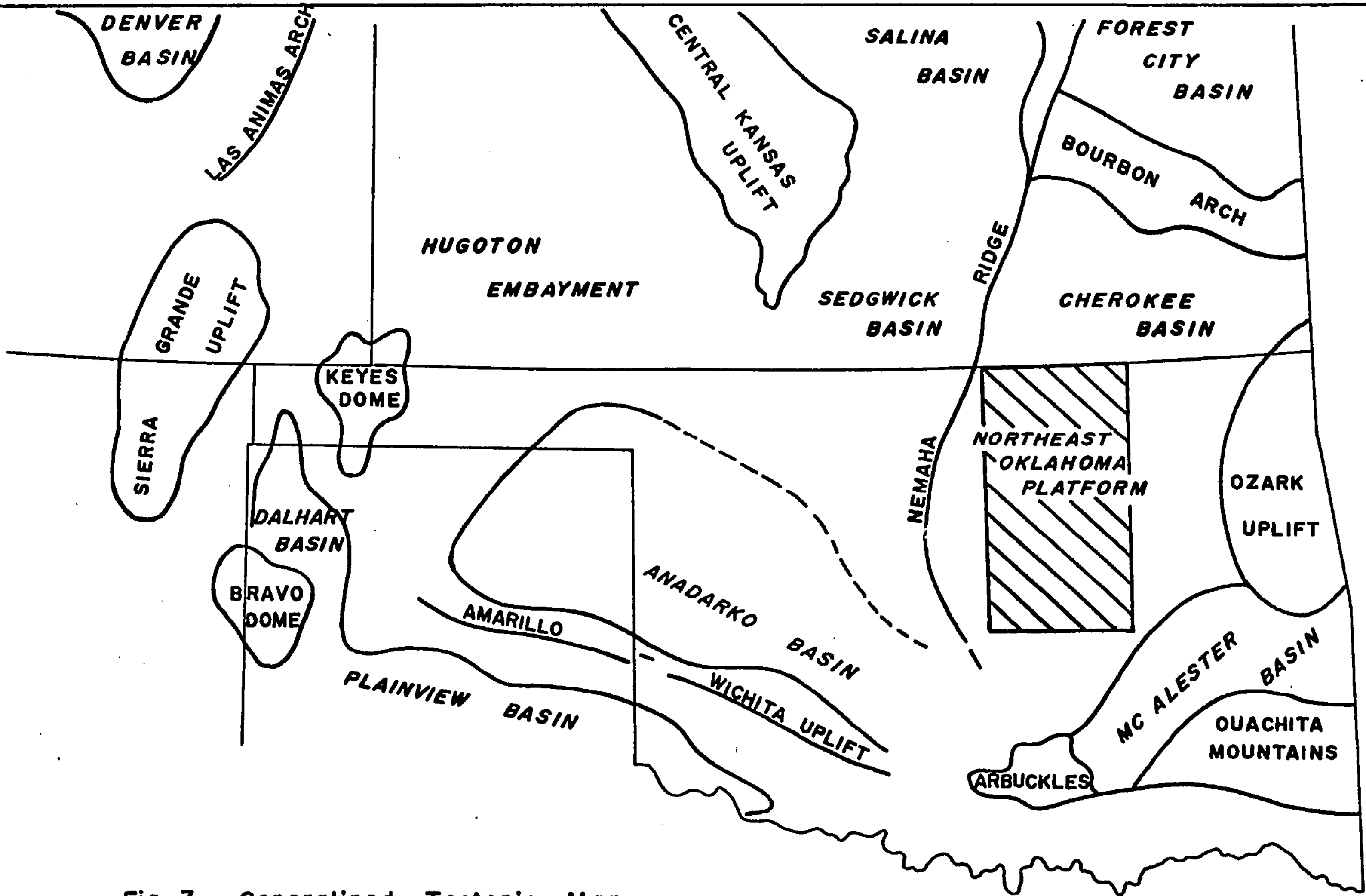

Fig. 3. Generalized Tectonic Map

well to well and certain marker beds were recognized ("Oswego" lime, for example) which enhanced the reliability of correlation. For the most part investigations have been confined to the correlation of various units and the structural nature of the rocks. More recently, emphasis has shifted to interpretations of a stratigraphic and environmental nature.

Hutchison (1911) discussed the stratigraphy of the Oklahoma Oil and Gas Field along with its history of development. Ohern and Garrett (1912) detailed the Ponca City Field, described the geology of the outcropping rocks and postulated the depths where sandstones producing farther east might be encountered. Wood (1913) described the drilling activity in north-central Oklahoma commenting on the wells drilled, where they stopped drilling, the sandstones that were encountered and their possible correlation with producing sandstones in pools to the east, and the potential of the area. Snider (1913) gave a thorough discussion of oil and gas development in Oklahoma which included maps of the various pools and a type log for each of the pools. Smith (1914) described the Glenn Oil and Gas Pool and presented a detailed discussion of the subsurface rocks with comparisons to the outcropping section to the east. Buttram (1914), in a classic paper on the Cushing Oil and Gas Field, gave a detailed description of the field and a resume of producing horizons with logs. Beal (1917) described Cushing again, more from an engineering point of view and included maps to show limits of production of each of the producing horizons (an isopotential map). Shannon (1917), in a major compilation, described the geology and petroleum potential of all the counties of Oklahoma, concluding with a section by Aurin on the correlation of oil sands. This appears elsewhere (Aurin, 1917) with a correlation chart arranged by pools. This publication would seem to be the forerunner of a much more comprehensive study which appeared approximately ten years later (Oklahoma Geological Survey, Bull. 40). Heald (1917) published a study on the Foraker Quadrangle relating to its oil and gas potential, in which he described the surface rocks, the possibility of producing sandstones in subsurface, location of anticlines, and a section on oil and gas accumulation. Heald (1918) described the geologic structure in the northwestern part of the Pawhuska Quadrangle from the same viewpoint as the previous article. White and others (1922) published a comprehensive study of the Osage Reservation, by townships. Emphasis was on the oil and gas potential and showed structure of surface rocks along with descriptions and discussions of the buried rocks, augmented by stratigraphic profiles. Fath (1925) completed a study of the Bristow Quadrangle, a portion of which had been published earlier (Fath, 1917). Emphasis was on the oil and gas potential and included a discussion of the subsurface rocks accompanied by three stratigraphic profiles. In the period 1926 to 1930, various workers published studies on the oil and gas in Oklahoma on a county by county basis; several included more than one county. These followed essentially the same outline; discussion of surface and subsurface rocks and structure of various pools and fields augmented by many stratigraphic profiles. These studies were reprinted as Vols. II and III of Oklahoma Geological Survey Bull. 40 covering Creek County (Merritt and McDonald, 1926), Kay, Grant, Garfield, and Noble Counties (Clark and Cooper, 1927), Cleveland County (Anderson, 1927), Payne County (Koschmann, 1928), Pawnee County (Greene, 1928), Osage

County (Beckwith, 1928), Seminole County (Levorsen, 1928), Logan County (Bale, 1928), Okfuskee County (Boyle, 1929), Pottawatomie County (Weirich, 1930), Lincoln County (Radler, 1930), Tulsa County (Cloud, 1930), and Oklahoma County (Travis, 1930). Bass (1929) published his investigations concerning the geology of Cowley County, Kansas, devoting attention to the occurrence of oil and gas. This may have led to his later studies on the origin of shoestring sands (1934, 1936). The American Association of Petroleum Geologists issued a series of stratigraphic profiles in 1930 revealing the lithologic correlation of formations across northeastern and central Oklahoma. During the 1930's Bass and others (1935, 1937) published the results of investigation in the Osage Reservation conducted by various workers and included in United States Geological Survey Bull. 900. Hoyle (1948) investigated the Shawnee Lake area of Pottawatomie County, showing the correlation of units by means of electric-log profiles. Jackson (1949, 1952) studied the subsurface distribution of the Lower and Middle Pensylvanian rocks in east-central Oklahoma and noted the nature and distribution of Atokan and Morrowan rocks with profiles and isopach maps. Lukert (1949) published a series of stratigraphic profiles dealing with Pennsylvanian rocks of north-central Oklahoma. Busch (1953) published a study dealing, in part, with the Booch sand of the Greater Seminole area.

During the middle and late 1950's and early 1960's several subsurface investigations were made by graduate students at the University of Oklahoma. For the most part these followed a standard plan consisting of several electric-log profiles depicting correlations of lithic units, a series of structural maps on various horizons, and where applicable, subcrop maps of the pre-Pennsylvanian and pre-Woodford surfaces. Much information is contained in these studies. Theses include those by Akmal (1953), Baker (1958), Berryhill (1961), Blakeley (1959), Blumenthal (1956), Bowman (1956), Cutolo (1966), Cole (1956), Dalton (1960), Ferguson (1964), Furlow (1956), Gearhart (1958), Graves (1955), Greer (1961), Kunz (1961), Kurash (1961), Page (1955), Querry (1958), Smith (1955), Stringer (1957), Talley (1955), and Ward (1956).

Investigations dealing primarily with Mississippian rocks and/or the nature of the pre-Pennsylvanian surface include those by Bellis (1961), Glenn (1963), Heinzelman (1957), Jones (1960), Jordan and others (1962), Krueger (1957), and Hyde (1957).

Recent studies of a more stratigraphic nature showing the delineation of various units by facies analysis, have been conducted by Berry (1965), Berg (1968), Bradshaw (1959), Clayton (1966), Clements (1961), Cole (1967), Cruz (1966), Duck (1959), Gamero (1965), Hanke (1967), Johnson (1958), McElroy (1961), Rascoe (1962), Shulman (1966), Ware (1955), and Weirick (1953).

Weaver (1954), in his study of Hughes County, Oklahoma, discussed the post-Senora subsurface rocks and tied them to the surface exposures by means of a north-west to south-east structural profile. Ries (1954), in his work on Okfuskee County, Oklahoma, accomplished the same. Tanner (1956) discussed the subsurface rocks in his study of Seminole County, Oklahoma, and depicted their correlation on several profiles. Kirk (1957), by means of electric-log profiles, traced subsurface units from southern Osage County to northwestern Okfuskee County and also to the surface exposures in western Tulsa County. Logan (1957) showed the subsurface rocks of the Okmulgee district by various profiles and prepared a map showing the distribution of the Booch sand. Greig (1959), in his work on Pawnee County, Oklahoma, discussed the subsurface sequence and depicted its relations on several profiles. Jordan (1959) discussed the oil and gas occurrences in Creek County, Oklahoma, and indicated the nature of subsurface rocks by means of stratigraphic profiles. Clare (1961) elaborated on subsurface knowledge of Pawnee County, Oklahoma, utilizing numerous profiles and maps.

Much information is available in the form of pool studies (not mentioned here) included in Stratigraphic Type Oil Fields and Structure of Typical American Oil Fields, Vols. I, II, & III (American Association of Petroleum Geologists). Geographic extent of previously mentioned works, where mapping is involved, can be seen in the Index to Geologic Mapping in Oklahoma by Branson and Jordan (1961, 1964).

Method of Study

The area of investigation includes approximately 200 townships, being 10 townships wide and 20 townships long. As originally conceived, the sampling grid was to include five wells per township with a sample log for each township, preferably for one of the five wells located in the grid. The wells were to be selected so as to be situated along north-south and east-west lines bisecting each township and spaced so that the distance between wells, along the line, would be two miles (Fig. 4). This was done so that stratigraphic profiles could be constructed across each township (east-west) and through each range (north-south) forming a correlation network or grid. The spacing of control points at about two-mile intervals was believed to be close enough to allow tracing of various units of

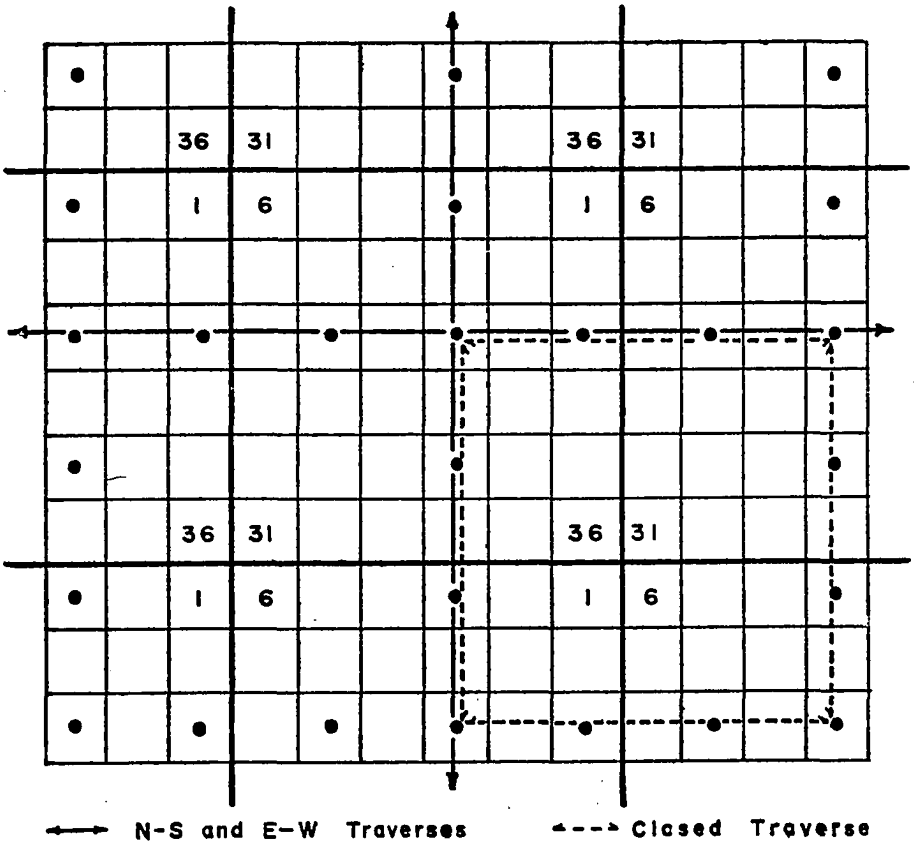

Fig. 4. Scheme of Well Location and Correlation Network

"marker beds" from well to well (lithologic correlation). Thus these markers could be traced north-south and east-west throughout the area (solid lines, Fig. 4). As the centrally located well in each township is included in both the north-south and the east-west profiles, the traced markers could be connected to form a closed traverse (dashed lines, Fig. 4).

Due to the vicissitudes of oil and gas exploration, this ideal spacing was not realized. Locations varied more or less from this pattern and in some cases information on a desired location was not available either because no well had been drilled there or a log was not available on an existing well. Even on this basis 98 per cent coverage of the 1,050 control points was realized. To expedite the study, only 77 sample logs were used; cuttings from 10 wells were examined by the writer and information on the remainder was obtained from various sources.

Key "marker beds" that seemed to be present throughout the area were recognized; certain horizons being traceable throughout the correlation network. These afforded a subdivision of the succession of rocks into numerous increments of strata, the aspects of which could be depicted on maps. These increments, as determined from the more detailed stratigraphic profiles, are shown by two stratigraphic profiles consisting of one well per township; one from the northwestern corner to the southeastern corner, and the other across T. 28 N. Additional profiles drawn on the individual maps illustrate the nature of the increment of strata shown. As each increment varies three dimensionally, a single profile cannot show all the details but does serve as a generalization.

The maps follow the same general method of depiction; the total increment of strata, which is for the most part shale, is isopached and isoliths of incorporated sandstone bodies are superimposed upon the isopach map. The technique is varied where dealing with carbonate units within the Marmaton sequence; the latter was further analyzed by using a multicomponent mapping system developed by Pelto (1954). A computer program was devised to handle the necessary computations.

The maps and profiles represent the writer's interpretations and conclusions and are believed to be relatively self-contained, therefore detailed description has been minimized.

Concept of Marker-defined Units

The status of marker-defined units is considered to be informal by the Stratigraphic Code (AAPG, 1961, p. 650). Krumbein and Sloss (1963, p. 333-338) discussed the distinction between formal and informal rock units and designated the latter as parastratigraphic units and relegated marker-defined units to this category. Chapter 12 of their text is devoted to the practicality of marker-defined units, essentially.

Forgotson (1957) discussed the nature of marker-defined units and proposed the term "format" for these (p. 2110). Moore (1958), in a timely article, subscribed to Forgotson's thesis, but would consider the marker-defined unit as a para-time-rock division. He called this unit a "lithizone" or "assise" preferring the more euphonious "lithozone" (p. 449). Krumbein and Sloss (1963, p. 338), on the other hand, preferred to call these marker-defined beds simply "operational units."

Moore (1958, p. 449) commented that "Cyclothems defined on the basis of attributes are often correlated by means of markers . . ." and asked the question ". . . what class of unit are they?" As the succession of rocks under investigation are considered to be cyclothemic (Abernathy, 1937 and Jewett, 1941) it seems that this question is pertinent. The Stratigraphic Code (AAPG, 1961, p. 649) excluded cyclothems from the category of formal rock units. Howe (1956), in a study of the Cherokee rocks of southeastern Kansas, divided the sequence into 17 formations. Each formation extended from the top of a coal bed to the base of the next higher coal bed, essentially. Are these not both marker-defined and cyclothemic? Branson (1954), on the other hand, would not formalize these and preferred the term "coal cycle" (p. 2.).

Branson (1956 and 1961) has further commended on these nomenclatural problems in Oklahoma.

Implicit in the writings of Busch (1953, 1959, 1961) is the concept of the "genetic sequence" about which he said (1959, p. 2841):

> It is extremely significant to take into account the genetic sequence in which each sand occurs. In other words, we are dealing with a preponderance of shale deposition interrupted by sand deposition, and where a stratigraphic interval can be defined which is devoid of any significant unconformities, that interval becomes a genetic sequence.

This idea was made explicit and amplified in his teachings, in which, according to Berg (1968, p. 11), Busch defined a "genetic increment of strata" as:

> An interval of strata representing one cycle of sedimentation in which each lithologic component is genetically related to all the others; the upper boundary must be a lithologic time marker and the lower boundary might be either a lithologic time marker or an unconformity. It frequently includes the sum total of all sedimentary deposition during one stage of cyclic subsidence.

In addition to this the "genetic sequence of strata" was defined as"

> An interval of strata consisting of two or more genetic increments of strata, representing continuous sedimentation; it must be devoid of any significant breaks.

The series of rocks under consideration seems to fall under this concept. The succession between the Checkerboard Limestone and the pre-Desmoinesian unconformity represents two genetic sequences of strata, essentially the Cherokee and Marmaton Groups. Exact correspondence to the ideal is not possible but is so close that, Busch's terms are used in this paper.

Geometry of Sandstone Bodies

Studies of the geographic distribution of ancient sandstone bodies are numerous in the literature but have probably received their maximum elucidation in studies conducted in the Illinois basin. For example, Waltersburg Sandstone (Swann, 1951), Anvil Rock Sandstone (Hopkins, 1958), Spar Mountain Sandstone (Whiting, 1959), Anvil Rock Sandstone (Potter and Simon, 1961), and Trivoli Sandstone (Andresen, 1961). Potter (1962a, 1962b, 1962c) summarized these investigations and extended them to the point where he recognized two main sandstone pattern types; elongate and sheet. The former were further subdivided into: wide belts, narrow dendroids, and small isolated lenses or pods (Fig. 5). He characterized these as follows:

> . . . the belt sand bodies have weakly meandering outlines. They consist of anastomosing, coalescing dendroid sand bodies that form fairly continuous belts up to 25 or 45 miles wide. Such belts nearly always contain "islands" of no permeable sand. Belts are considered to have resulted from either the lateral migration of dendroid sand bodies or their lateral coalescence.
>
> Dendroid sand bodies have patterns that are commonly sinuous and weakly to strongly meandering. Dendritic and anastomosing patterns are typical. Deltaic distributary patterns do occur, but are not common. In any part of the basin, both belt and dendroid sand bodies generally show a well defined, prevailing trend. Dendroid sand bodies may be as narrow as 25 feet or as wide as 2-3 miles. With increasing width, they grade into belts.

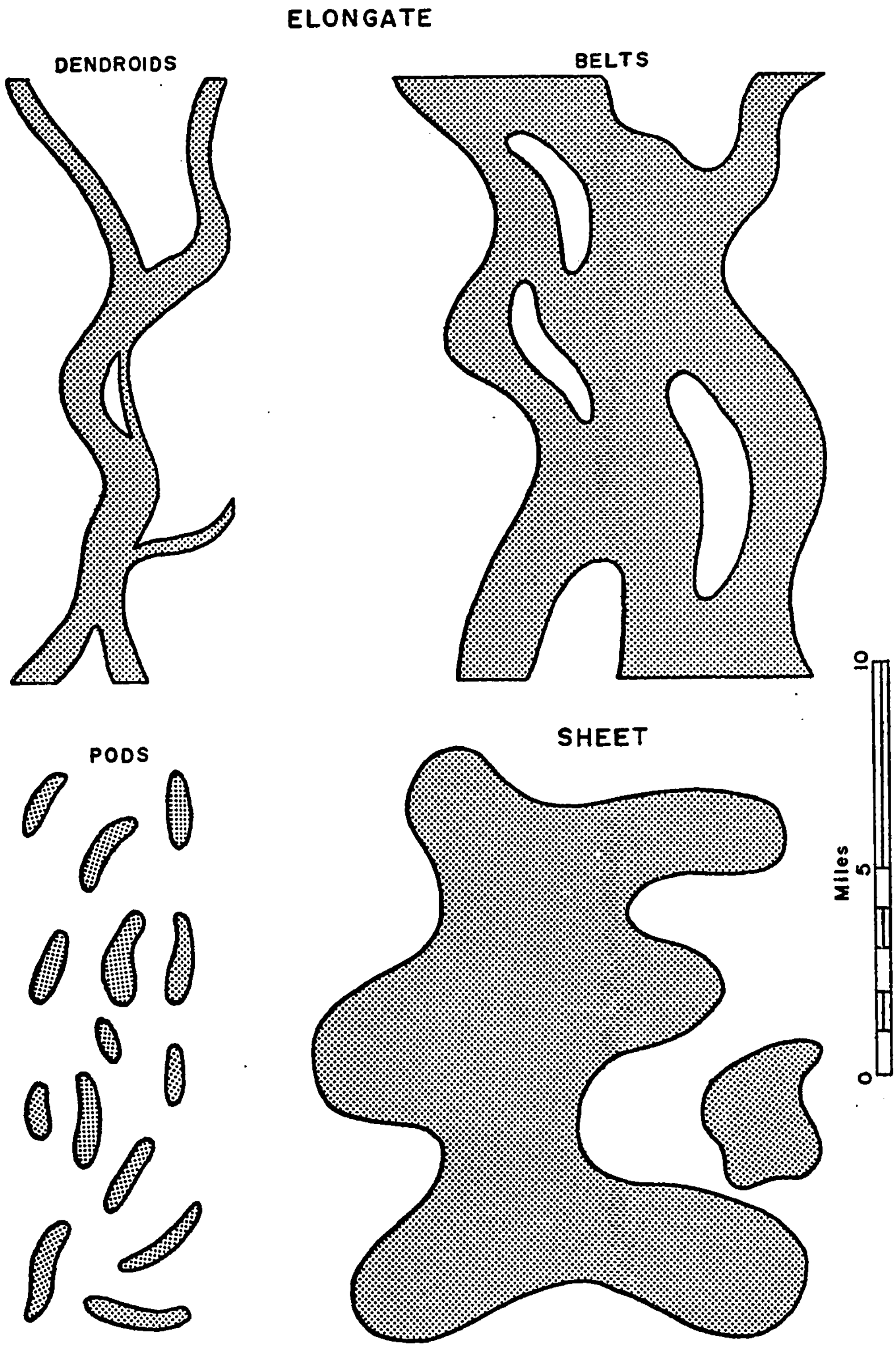

Fig. 5. Distribution Patterns of Pennsylvanian Sheet and Elongate Sand Bodies (Modified from Potter, 1962)

Sheets have somewhat less distinctive patterns. In subsurface the sheet sand body may be either very uniform over a wide area or it may be more patchy and consist of relatively small sand bodies of limited extent.

Potter (1967), in a review of sand bodies and environments, summarized the six major environments for sand accumulation. These are: (1) alluvial, which has been discussed above, but to which he has added the bar-finger sands of Fisk, (2) tidal, (3) turbidites, (4) barrier island, (5) shallow-water marine, and (6) desert eolian. As the current study deals primarily with the geometry of sandstone masses it might be worthwhile to give his characteristics as pertaining to size, shape, and orientation for each type, respectively:

(1) Alluvial sand bodies:

Commonly very elongate. Width ranges from a few tens of feet to composites of 30 miles. Dendritic as well as anastomosing and bifurcating patterns. Elongate downdip. Excellent correlation of internal directional structures and elongation.

(2) Tidal sand bodies:

A few tens of feet to more than 1,000 feet wide, mostly very elongate. Long axis at right angles to shoreline or parallel with estuarine axis. Straight to moderately meandering, dendritic patterns, the latter as tidal inlets. Also lunate bars in passes between barrier islands. Cross-bedding parallel with elongation; principal mode may point seaward as well as landward in estuaries.

(3) Turbidite sand bodies:

Elongate sandstone bodies up to several miles; fairly straight but dendritic and bifurcating possible. Extend downdip into basin. Excellent correlation of directional structure and shape. But sheet and blanket-like deposits probably predominate. Large Olistostromes not uncommon.

(4) Barrier-island sand bodies:

Widths from a few hundreds of feet to more than several miles. Thickness 20-60 feet. Very elongate, parallel with strand line. Sandstone bodies generally straight to cently curved. Grain fabrics and crossbedding can be variable, especially if eolian transport was important.

(5) Marine-shelf sand bodies:

Size and shape, highly variable, ranging from irregular, small pods through elongate ribbons to widespread sheets of many miles. Bifurcating and dendritic patterns absent. Elongate bodies have variable orientation with respect to depositional strike; parallel, perpendicular, and random. Relation of cross-bedding orientation to elongation not well known, but probably variable.

(6) Desert eolian sand bodies:

Most ancient eolianites consist of widespread thick sheets of cross-bedded sandstone. Conceivably, eolian sands may contain the largest of all contiguous sand bodies.

With the exception of the last type of sand body which Potter says (p. 357) ". . . systematic tabulations of the petrology, sedimentary structures, and geometry of individual sand bodies of eolian origin are scarce--scarce enough to tempt one not even to include their discussion." All the other sandstone bodies have their elongation parallel or in the direction of current flow. Thus maps depicting sandstone geometry would also be current maps. However, elongation alone would not give the direction but coupled with paleoslope and/or source areas it could be inferred.

STRATIGRAPHY

General Statement

The succession of rock strata between the Checkerboard Limestone and the pre-Desmoinesian unconformity consists largely of shale with subordinate amounts of sandstone and carbonate.

The shale is lithologically similar throughout the section, being essentially gray and greenish gray, finely micaceous, silty, with small specks to thin partings of carbonaceous material. Baker (1962) recognized two types of shale as the predominant lithic types, a greenish-gray shale, and a gray shale which he equated with a marine environment, the former being more oxygenated than the latter. These seem to be the same as those observed in cuttings. Light-green and maroon shales are not uncommon and seem to be more abundant in the section toward the southeast. Black, fissile, radioactive shale is a minor but persistent lithic type and is found in most cases in association with carbonate and coal units. This relationship does not seem to have been investigated to any great degree. Cassidy (1962, 1964), in a study of the Excello Shale, noted the gradational contact of this black fissile shale with the overlying and underlying carbonate beds, and the writer has observed a coaly bed overlain by a black, fissile shale which was in turn overlain by a carbonate bed within the Marmaton Group of northeastern Oklahoma. The shales associated with the Gilcrease sand zone are less silty and less micaceous than the heretofore mentioned shales and are somewhat darker in color and contain glauconite.

Three types of sandstones can be discerned from cuttings: the Gilcrease type which is a well-sorted, fine- to medium-grained, well cemented, glassy in appearance, and glauconitic sandstone; the Calvin and Wewoka type which is a fine-grained, fairly well-sorted, well-cemented, clean, and quartzose sandstone. The third type is characteristic of the Booch, Bartlesville, Red Fork, Skinner, Prue, and Cleveland and is very fine- to medium-grained, poor to well sorted, highly micaceous, argillaceous sandstone with numerous carbonaceous partings. The latter type would most probably be classed as a subgraywacke whereas the former two types would approach orthoquartzite. However, where the latter sandstone type is well developed it is cleaner and highly quartzose and could probably be classed as an orthoquartzite.

The carbonate units are almost everywhere fossiliferous, consisting of much shell debris, crinoid stems, with a rare recognizable fusulinid, and bryozoan fragments. As a rule the darker the color the more micritic, and the lighter the color the more calcisiltitic or calcarenitic the carbonate unit becomes. A connection exists between the SP values and the lithic nature; a light-colored, sparry, calcarenite is in most cases always reflected by a high SP whereas the darker-colored micritic units have a low SP value.

Delineation of Marker-defined Units

Two main subdivisions or genetic sequences can be established for the succession of rocks under study. The base of the lower sequence is marked by an angular unconformity where rocks from Simpson to Wapanucka are truncated and onlapped by Desmoinesian units. The top of the lower sequence and consequently the base of the upper sequence is the base of a carbonate unit widely known as the "Oswego lime." The top of the upper sequence is the base of a widespread carbonate unit known as the Checkerboard Limestone. As defined by these markers the two genetic sequences of strata correspond, essentially, to the long-recognized Cherokee and Marmaton Groups, respectively.

Six marker horizons are recognized in the Cherokee genetic sequence, seven if the unconformity is considered. The first persistent marker above the unconformity is a coal bed (Plate I, Marker "A"), which Jordan (1959, p. 90) considered to be the top of the Hartshorne. Traced eastward this appears to be what Koontz (1967, Plate IV) called Hartshorne. However, Busch (1961, Fig. 1) indicated this marker to be at the top of the lower Booch sand. The next marker horizon is believed to be one of the Brown limes (Plates I and II, Marker "B"). Several other markers (limestone and coal beds) have been observed both above and below but these converge and disappear when traced laterally to the northwest. Whether this carbonate unit corresponds to the Spaniard Limestone, basal member of the Savanna Formation, is not known. Jordan's cross-section (1959, Plate D) would seem to indicate such is not the case. Next in succession is a carbonate and/or black shale marker occurring at the horizon of the Inola Limestone (Plates I and II, Marker "C"). The next marker horizon is a carbonate and black shale unit known as the Pink lime which is considered to be the equivalent to the Tiawah Limestone (Plates I and II, Marker "D"). The fifth marker is the Verdigris Limestone (Plates I and II, Marker "E"), a carbonate unit with and underlying black shale bed and possibly a bed of coal which, when traced to the southeast to the outcrop, seems to be at the horizon of the Henryetta coal. A fairly persistent marker below this (Plates I and II) has been called "Henryetta" (Clayton, 1965, Shulman, 1966); but when traced to the outcrop it is below the Henryetta coal horizon. Cross-sections by Weaver (1954) and Ries (1954) showed the Verdigris marker as "Senora Limestone." However, Duck (1959) indicated this horizon to be the Henryetta, which would tend to support the writer's contention. The sixth horizon, and the top of the Cherokee genetic sequence, is the base of the Oswego lime (Plates I and II, Marker "F"). This carbonate unit is prominent over the northwestern three-fourths of the area but thins southeastward and becomes intercalated with the sandstone tongues of the Calvin Formation. Oakes (1963, p. 32) indicated that the Fort Scott and/or Breezy Hill Limestones are recognizable as far south, on the outcrop, as T. 15 N., R. 14 E. with black, fissile shale and phosphatic nodules extending somewhat farther south into T. 14 N. where they are a few inches below Calvin sandstone member number 5. This sandstone tongue can be recognized in the subsurface and would be the logical continuation for marker "F", however, it is not persistent enough to serve this purpose. Another sandstone tongue, that forms the top of the Calvin Formation is more persistent and has been used as the top of the Cherokee sequence where the Oswego lime is no longer distinguishable. Both on the outcrop (Oakes, 1963, Fig. 5) and in subsurface (Plate I), Calvin sandstone tongues pinch-out and the intervening shale units thin north and northwestward. Actually these sandstones could be considered with the overlying Marmaton genetic sequence, but a satisfactory solution was not found.

The genetic increments of strata defined by these markers are named for the sandstone bodies found therein. These are, in ascending order; Gilcrease, Booch, Bartlesville, Red Fork, Skinner, and Prue-Calvin. In the southeastern portion of the area the Calvin sandstones are included with the Prue but the writer feels that the former are above the Prue and the latter name should be confined to the shale interval in the upper shale member of the Senora Formation (Ries, 1954, Plate II).

The Marmaton genetic sequence of strata does not lend itself to the same type of incremental subdivision as does the Cherokee. In the northern portion of the area the sequence is characterized by thick carbonate development which gives way southward to a thick shale body which becomes intercalated with sandstone tongues in the southeastern portion (Plate I). These sandstone tongues are sheet-like masses that disappear northwestward, features that are shared with the underlying Calvin sandstones. Midway, in an east-west direction, is an elongate body of sandstone that is distinct from the tongues. No persistent markers are present between the base of the Oswego lime (marker "F") and the base of the Checkerboard Limestone. As a consequence the depiction of the Marmaton units varies from that of the Cherokee.

Within the carbonate succession, two main units can be distinguished; Oswego lime and Big lime (Plates I and II) which are, essentially, equivalent to the Fort Scott and Oologah Limestones on the outcrop. A third carbonate unit, the Lenapah Limestone (Plate II) is present in the northern portion of the area. The Labette Shale separates the Oswego and Oologah units (Plates I and II). In the extreme northern part of the area the Oologah can be separated into three units; Pawnee

Limestone, Bandera Shale, and Altamont Limestone (Plate II). The sandstones directly beneath the Checkerboard and the thicker body trending across the middle of the area are the Cleveland (Plate I). The sandstone tongues in the southeastern portion are, for the most part, the Wewoka Formation (Plate I). The uppermost tongues may be part of the Holdenville Shale, although this distinction is not herein made. The Checkerboard Limestone seems to be widespread and serves not only as a datum for the profiles (Plates I and II) but as the marker for the top of the Marmaton genetic sequence of strata. The Checkerboard loses its distinctiveness in the southeastern corner of the area where it disappears into sandstone. Ries (1954, p. 90) noted that the subsurface Checkerboard is not the same as the Checkerboard mapped on the surface in Okfuskee County but is equivalent to a sandy limestone in the basal part of the Seminole Formation. Wolfson (1963), in an investigation of the Checkerboard Limestone on the outcrop, felt that this carbonate unit graded southward into sandstone in the vicinity of Deep Fork River, northeastern Okfuskee and southwestern Okmulgee Counties. In the northern reaches of the area the Checkerboard is in close contact with a lower carbonate unit that is considered to be the Lenapah Limestone (Plates I and II).

Possible Unconformities in the Desmoinesian Section

Three unconformities have been postulated within this succession of strata; one at the top of Atoka, one within the Cherokee sequence (base Thurman Sandstone-top Boggy Formation), and one in the section just below the Checkerboard Limestone (base Seminole Formation). All three of these represent some series boundary; Lampasas-Atoka-Derry and Desmoinesian, Pottsville or Kanawha and Allegheny, Desmoinesian and Missourian (Moore, et al., 1944, Cheney, 1945, Moore and Thompson, 1949), respectively. The existence of these surfaces of discontinuity is explicit in the writings of Bloesch (1919), Clawson (1928), Lowman (1933), Oakes (1940, 1952, 1953, 1963, 1967), Jewett (1941, 1945), Oakes and Jewett (1942), Cheney (1945), Busch (1961), and Jewett, Emery, and Hatcher (1965).

The evidence for these unconformities in subsurface could not be substantiated inasmuch as none of the units is truncated and those that do disappear laterally are the result of onlap at the base of the sequence or gradation into shale within the sequence (Plates I and II). The shales and sandstones associated with the Gilcrease do differ from those higher in the section and Busch (1961, Fig. 1) indicated that this is a truncated series. A map by Busch (Dickey and Rohn, 1955, Fig. 4) would seem to support this contention. However, Blythe (1959) and Rowett (1963) indicated that the Atoka sandstones, at the outcrop, exhibited an onlapping relationship rather than one of truncation. The writer is inclined to go along with this and view these sandstones as being transgressive onto older truncated rocks, at least in the area of investigation.

Pre-Desmoinesian Rocks

Rocks older than Desmoinesian are truncated progressively from southeast to northwest. Easily definable units which can be delineated on electric logs and by samples in this older, truncated series, include: Wapanucka Shale, Cromwell sand, Springer Shale, Caney Shale, Mayes lime, "Osage," Woodford Shale, Hunton Limestone, Sylvan Shale, Viola Limestone, Simpson Formation, and Arbuckle Limestone. Rocks older than the Mississippian limestones subcrop beneath the unconformity surface along the axis of the Central Oklahoma Arch which lies largely west of the area

(Jordan, 1962) but crosses the extreme northwestern corner, the Cushing anticline, and a small structure north of Cushing (Plate III). Rocks referred to the Mississippian System dominate the subcrop map, with younger Pennsylvanian rocks being present only in the southeastern portion.

The so-called "Osage" series subcrops throughout the northern half of the area (Plate III), consisting of a massive sequence of light to dark-colored, fossiliferous, sparry to dense carbonates with blue-gray and white chert. Commonly present are zones of buff-colored tripoli. This zone is characterized by a large negative SP accompanied by very low resistivity, on electric logs, and occurs directly beneath the unconformity or at places deep within the carbonate section. This sequence gives way southward to black, argillaceous, arenaceous carbonates with intercalated black shales. Three subdivisions can be observed (Stratigraphic Profile CC', Plate III); a lower calcareous unit, a middle shale unit, and an upper calcareous unit. The lower unit is called "Mayes" by most geologists, the upper unit has been called "False Mayes" or combined with the middle shale unit and assigned to the Caney. Jordan (1959, Fig. 16, 17, and Plate D) considered the lower and middle units to be Meramecian and the upper unit Chesterian; they are so indicated on her map (Jordan, 1962).

The nature of the relationship between these Mississippian units is not within the scope of this study and certain units only were recognizable and mapped.

The Cromwell is a medium-grained, calcareous, glauconitic sandstone and, in this area, is overlain by a dark-grey shale termed

Wapanucka. These are considered to be Morrowan in age and are restricted to the southeastern and eastern portions of the area of study (Plate III and Stratigraphic Profile CC'). Beneath the Cromwell sand, in the extreme south and southeastern portions of the area, is a black fissile, soft, "greasy," shale unit called Springer (Stratigraphic Profile CC'). It subcrops in a small area in the northwestern corner of Seminole County (Plate III).

This map is in essential agreement with that of Jordan (1962) but extends and amplifies it by delineating the Seminole-Cushing ridge of Powers (1927, p. 1102, 1928, p. 1051) and its extension northward through the faulted White Tail area (Hayes, 1956, Fig. 1) of east-central Osage County, the area occupied by "Chat" facies, a large reentrant in the subcrop in northern Creek County indicative of a major stream channel (best shown by the isopach of the Gilcrease genetic increment, Plate IV), the subcrop of the middle shale unit within the Mississippian System (actually many markers are quite persistent within the so-called "Mayes" and Caney units and a much more detailed subcrop map is possible), and in addition the subcrop of the Cromwell and Wapanucka are depicted.

Truncation rates vary from place to place but average 10 feet per mile for the Wapanucka Shale in the southeastern corner of the area and about 20 feet per mile for the Caney-Mayes section west of the Seminole-Cushing ridge complex with direction of truncation westward or slightly northwestward. This would seem to indicate uplift along the Central Oklahoma Arch and/or regression toward the southeast prior to deposition of the overlying Desmoinesian rocks.

Cherokee Genetic Sequence of Strata

Gilcrease Genetic Increment of Strata

This succession of rocks is defined by the pre-Desmoinesian unconformity at the base and marker "A" at the top (Plate I, Stratigraphic Profile DD'). Marker "A" is at the horizon of the Hartshorne coal.

The Gilcrease increment of strata thickens to the southeast as a result of intrastratal thickening and onlap (Plate I, Stratigraphic Profiles CC' and DD'). The isopach map of this increment (Plate IV) shows the thickness ranging from zero in the west to more than 450 feet in the southeastern corner. Variations in thickening seem to follow certain linear trends that outline a dendritic pattern. Following Andresen (1962) and Martin (1966) it is felt that this phenomenon gives a good reflection, within the control used, of the pre-Desmoinesian drainage system developed upon the older series of rocks.

Two master channels are present, both trending southeastward. One trends southeastward across the northern half of Creek County, the other southeastward through the northern portion of Okfuskee County. The former seems to be the major channel. A marked downdip invagination is present along this major trend on the Subcrop Map (Plate III). Minor crenulations of the isopach limes are construed to represent tributaries of these master channels. Direction of flow would be to the southeastward off of the presumably emergent Central Oklahoma Arch.

Sandstone bodies fall into two categories; the northeast-southwest trending masses in the southeastern corner, and the smaller, thinner bodies in the western areas (Plate IV). The former are the

Gilcrease sands and the latter are referred to as "Burgess" or unconformity sands. Positive identification as to sandstone type appears to be impossible. However, due to their close proximity to the unconformity, their glauconitic nature and the alignment of the Gilcrease sand bodies normal to the postulated pre-Desmoinesian stream channels, it is felt that the concept of a neritic or littoral origin is most feasible. This general interpretation is shared by Jackson (1952) and Dickey and Rohn (1955) based on subsurface studies and also by Blythe (1959) and Rowett (1963) from their work on surface exposures.

The rate of onlap for the Gilcrease increment of strata varies from place to place but averages between 6 and 20 feet per mile in a westerly direction.

Booch Genetic Increment of Strata

This succession of rocks is defined as the strata between markers "A" and "B" or "B" and the pre-Desmoinesian unconformity where "A" is absent due to onlap (Plates I, II, Stratigraphic Profile EE'). Marker "A" is considered to be at the horizon of the Hartshorne coal and marker "B" is one of the Brown limes.

The Booch increment thickens to the southeast, both by interstratal thickening and onlap. Isopach map of this increment (Plate V) shows a thickening from zero along the western margin of the area to more than 300 feet in the southeastern corner. The portion of the Central Oklahoma Arch included by this map is almost completely covered by rocks of the Booch increment. Areas that were presumably emergent are located along the western margin of the map, the southwestern and northwestern corners of the map. These connect with a larger emergent region along the axis of the Central Oklahoma Arch beyond the western confines of the study (Berg, 1968, Plate V). Several isolated areas of emergence are present; two small ones along the Cushing anticline in northwestern Creek County, and a larger one in southeastern Kay and western Osage Counties. The latter occupies a portion of the region which Buchanan (1927, p. 1311 and Fig. 3) called "Osage Island." The increment is thin along the horst between the Wilzetta and Keokuk faults (Plate III), along an east-west trend through southern Payne and northern Lincoln Counties, and an irregular area of thinning is present northeast of the Cushing anticline in southeastern Osage County. The latter is the result of channeling of sandstones of the overlying Bartlesville increment. The east-west trend seems to reflect a drainage divide or interfluve between the two major channels previously described. The northern channel can be extended westward into Noble County and northward into Kay County and the southern channel, while somewhat subdued, can be extended westward into western Lincoln County. Numerous tributaries to these master channels are inferred by the crenulations of the isopach lines.

Sandstones of this increment consist of the thick accumulations of the Booch along the eastern and southeastern margins of the map and the small, thin bodies scattered along the trend of the northern master channel (Plate V). The Booch is a very fine- to fine-grained, subangular, micaceous, and carbonaceous sandstone that becomes quite thick along bifurcating trends. A classic study of the Booch, done by Busch (1953, 1954), suggests that it is of deltaic origin. Logan (1957, p. 5 and Map 5) is of a similar opinion. Scruton (1950), in a study of the Warner Sandstone (considered to be the Booch equivalent) in northeastern Oklahoma, favored a deltaic origin. This concept that the Booch is of a channel origin goes back at least as far as Reed (1923) who showed the thickness of this sand in the Henryetta area and postulated a deltaic origin. However, Tanner (1963) challenged this idea, postulating a "chenier-beach ridge-barrier island" mode of origin for both the Booch and Bartlesville sands. His interpretations are based on outcrop and subsurface studies and previous investigations (Tanner, 1959, Harvey, 1961).

The sandstones of the Cherokee genetic sequence of strata manifest similar characteristics, for the most part, and it is felt that speculations, as to type and origin, are best treated as a whole (Resumé of Cherokee sandstone bodies, p. 45) rather than individually.

Bartlesville Genetic Increment of Strata

The Bartlesville increment is defined at the base by marker "B" and at the top by marker "C", the Brown lime and Inola Limestone horizons, respectively (Plates I, II, Stratigraphic Profile FF'). Where the Brown lime onlaps, the Booch increment, the base of the Bartlesville increment is the pre-Desmoinesian unconformity.

Strata of this increment cover most of the Central Oklahoma Arch, within the confines of the investigated area, exceptions being three small localities; one on the Cushing anticline in northwestern Creek County, one in the extreme southwestern corner, and one in the northwestern corner of the map. The latter two are parts of larger areas to the west along the axis of the Central Oklahoma Arch or Nemaha Ridge (Berg, 1968, Plate VI). These patches where the Bartlesville increment is absent presumably represent areas that were emergent.

The increment thickens to the east and southeast, from zero to more than 350 feet (Plate V). Rate of thickening varies, but for the area west of the Seminole-Cushing ridge (Plate III) 5 feet per mile or less would be average whereas east of the ridge, rates greater than 5 feet per mile prevail. A slight thinning trend is discernible along the Seminole-Cushing ridge, being quite pronounced over the Cushing anticline itself in northwestern Creek County. Irregularities in the pattern of thickening are, for the most part, due to channeling and the presence of thick bodies of sandstone. However, some reflection of the ancient topography is indicated where the Bartlesville strata lie upon the unconformity surface, especially in eastern Logan County. Channeling is present at both the base and the top of the increment. The former has been discussed in the section dealing with the Booch increment. Channeling into the top of the increment is present in eastern Kay County, western Osage County, western Pawnee County, central Payne County, and northern Lincoln County. Thinning in these areas corresponds, essentially, to thick elongated sandstone trends in the overlying Red Fork increment (Plate VII).

In central Payne and northern Lincoln Counties an interesting situation exists where sandstones of both the Bartlesville and Red Fork increments are superimposed or stacked (Plates VI and VII). Potter (1963, p. 71) discussed this phenomenon and credited Feofilova with the name "multistory" sand bodies for such cases. This situation is not uncommon and leads not only to thick sandstone sequences but also to confusion as to what is happening. Linear thickening is present in the eastern portion of the area, corresponding to the thick elongated sandstone bodies

(Plate VI). This is understandable inasmuch as shale compacts more readily than sandstone. This phenomenon is prevalent northeast of Cushing anticline in southeastern Osage County where sandstone composes the entire increment but becomes less significant as the total increment thickens.

The bulk of the sandstone within the Bartlesville increment is situated in the eastern portion of the area, with the thickest parts having a southeast to northeast arcuate trend (Plate VI). Numerous digitations extend westward from the main mass for varying distances. The general pattern is one of elongated sandstone bodies, reaching thicknesses in excess of 160 feet, anastomosing and bifurcating, and in part dendritic. This would seem to qualify the Bartlesville sands as a belt type of deposit according to Potter's classification (1962), produced by the lateral migration and/or coalescing of dendroids. It seems that the direction of sand transport could only be in a direction parallel to the elongation, in this case either from north to south or vice versa, in the main. Could both directions be possible?

More study has been devoted to the sandstones of the Bartlesville and Red Fork increments than to all of the others. Prior to and during the 1930's all producing sandstones near the base of the Cherokee were called Bartlesville and much discussion centered around the nature of these sandstones. Berger (1921) discussed the Sallyards field of Kansas and favored a near-shore environment, presumably a bar although he did not actually call it a bar. Sands (1924) was of the opinion that the sandstone producing at Burbank pool, west-central Osage County, is deltaic and is separated from the Bartlesville sand, being at the same horizon but having sources to the west and east respectively. Cadman (1927), in a rather penetrating study, postulated a valley-flat environment for the sandstones of the Golden Lanes of Greenwood County, Kansas, pointing out that the sands seem to have been deposited in a scoured-out groove. Wilson (1927), in a discussion of the Glenn pool, eastern Creek County and east of the area of investigation, presented an isopach of the Bartlesville sand, apparently one of the first of this sandstone, and called for a southern or western source from which sand "was poured out on the sea bottom and distributed by wave action" (p. 238). Weirich (1932) distinguished the Burbank or Red Fork sand from the Bartlesville and propounded the off-shore bar origin. Bass (1934, 1936) and Bass, Leatherock, Dillard, and Kennedy (1937) favored a bar type of environment, amassing a tremendous amount of data supporting their interpretations. The work by Bass and coworkers seems to have been definitive and has been followed by later workers. However, Tarr (1934), in a discussion of Bass' 1934 paper, pointed out that a channel type of origin is not incompatible with the facts.

An interesting aspect concerned with observations made on the outcrop of the Bluejacket Sandstone (Bartlesville equivalent), west of the City of Pryor in northeastern Oklahoma, is that of disagreement on origin. Bass and co-workers interpreted the Bluejacket at this locality as being a beach deposit, a suggestion followed by Fischer (1961) and Visher (1965). However, in a detailed study of this outcrop, Berg (1963) concluded that the Bluejacket is best interpreted as a channel type sandstone. Which is the best hypothesis?

Red Fork Genetic Increment of Strata

The Red Fork increment comprises the strata between marker "C" at the base and marker "D" at the top (Plates I, II, Stratigraphic Profile GG'). The markers correspond to the Inola and Pink lime horizons, respectively.

Rocks of this increment cover the entire area except for a small portion in the extreme northwestern corner (Plate VII). Only a few areas along the Namaha axis remained emergent (Berg, 1968, Plate VII) at this time.

The increment thickens from zero in the northwestern corner to more than 500 feet in the southeastern corner (Plate VII). Rate of thickening varies from 5 feet per mile or less west of the Seminole-Cushing ridge to more than 10 feet per mile east of this feature. A general thinning trend is evident along the ridge and is paralleled by a band of thickening along its western margin which is on the downthrown side of the Wilzetta fault (Plate III). Apparently the Seminole-Cushing ridge had a tendency to be less negative than the surrounding environs. Other areas of thickening that differ from the grain of the regional picture reflect the enclosed sandstone bodies and the channeling at the base into the underlying Bartlesville increment, mentioned previously. The trend is, for the most part, in a direction parallel to elongation of the sandstone bodies.

Three zones of sandstone accumulation are recognized within the Red Fork increment, a lower, middle, and upper. All three are present in the southeastern part of the area, however, the lower and upper portions thin northwestward and the enclosed sandstone bodies are absent northwest of the 240 foot isopach line (Plate VII). The middle sandstone, on the other hand, is the most widespread of the three. Because of the limited occurrences of the upper and lower sandstones only the middle one is depicted (Plate VII). The middle sandstone presents a complex pattern of bifurcating, anastomosing dendroids forming a north-south trending belt. Thickness ranges from zero to more than 120 feet and locally approaches 200 feet in central Payne County where stacking occurs with the underlying Bartlesville sandstones (Plates VI and VII). A prominent, thick, elongated sandstone mass is present in the western part of the area, having a north-south trend and giving off numerous bifurcations both to the east and to the west. The westward extensions extend for varying distances into the western ranges, especially those of the so-called "Cherokee trend" (Berg, 1968, Plate VII). When viewed in the light of sediment transport it is apparent that a strong north-south component existed. The sandstone bodies in the southern half of the area give the appearance of having been spread from the south whereas just the opposite apply to those in the northern half. Is it possible that two opposite directions of transport are present? Mineralogical studies which might throw light on this are lacking. It appears that the only study of this nature was by Leatherock (1937) but she failed to denote distinguishable trends.

As mentioned under the Bartlesville increment, much study has been devoted to these sandstones and many workers have accepted the conclusions of Bass and co-workers and gone on from there. Others who have done studies of individual sandstone bodies have either rejected or affirmed these conclusions based on their studies. Neal (1951), in a paper on the Ceres pool, north-central Noble County, reaffirmed the bar theory and Clements (1961), in an interesting three component facies analysis of the Cherokee of Ceres and environs, also supported the bar theory. Clayton (1965), in a study of the Cherokee of western Payne County, was of the opinion that the Red Fork sand is a channel deposit. Cruz (1966), in a detailed study of the southeastern portion of the Burbank pool, favored a near-shore environment forming cheniers, beach ridges, barrier islands, and spits. An interesting fact can be gleaned from Cruz' profiles and this is that the Burbank sand channels into the underlying rocks. In two recent articles the origin of the Red Fork sand in the western ranges has been explored. Withrow (1967) in a study of the Wakita trend in northern Grant and Alfalfa Counties, has postulated an offshore bar mode of origin whereas Thalman (1967), in an investigation of the Oakdale field in southeastern Woods County, favored a channel type of environment for the Red Fork sand. Again one might ask which is the best interpretation or are they both applicable?

Skinner Genetic Increment of Strata

The Skinner increment comprises the strata between marker "D" and marker "E" (Plates I, II, and Stratigraphic Profiles HH', II', and JJ'), the Pink lime and Verdigris Limestone horizons, respectively.

Rocks of this increment cover the entire area and, in fact the whole Central Oklahoma Arch was buried except for a small area over the Oklahoma City uplift (Berg, 1968, Plate VIII).

Thickening of the Skinner increment takes place from northwest to southeast, essentially, being somewhat less than 40 feet thick in the northwestern corner and increasing to more than 480 feet in the southeastern corner (Plate VIII). The rate of thickening varies from place to place but, as in the previous instances, is less than 5 feet per mile west of the Seminole-Cushing ridge (Plate III) increasing to more than 5 feet per mile east of this feature but in few cases exceeding 10 feet per mile. This regional trend is interrupted by the Seminole-Cushing ridge, along which a general thinning is evident and by an east-west belt of thickening, essentially through the southern part of Lincoln County and the northern portion of Okfuskee County. The belt of thickening seems to be the result of thick, east-west trending sandstone bodies within the increment (Plates VIII, IX, and X). The thinning along the ridge follows the pattern already established, namely that the Seminole-Cushing ridge was less negative than the surrounding areas.

Three sandstone bodies are present within this increment and, unlike those of the underlying Red Fork, are widespread and worthy of individual mapping (Plates VIII, IX, and X). The lower sandstone (Plate VIII) exhibits the elongated, anastomosing, and bifurcating pattern of previous sandstone bodies but presents a rather complex trend orientation. However, the overall trend is north-south with a marked east-west component. The greatest thicknesses occur in the southern part of the area where the sandstone is in excess of 100 feet. Stacking is present along this east-west trend with the overlying middle Skinner sand (Plates VIII and IX). In the central and western portions of the area the dendroids present a pattern of fanning out from west to east. The middle sandstone (Plate IX) is confined to the eastern and southern parts of the area and presents a pattern of elongated, anastomosing, and bifurcating dendroids which seem to coalesce into a northeast-southwest trending belt. Thicknesses range from zero to in excess of 100 feet and stacking with the underlying sands (Plates VIII and IX) is common along the thickest trends. The upper sandstone (Plate X) exhibits a complex pattern of narrow, elongated, bifurcating, and slightly anastomosing dendroids having both an east-west and a north-south trend. Thicknesses range from zero to more than 100 feet with the greatest thickness of sandstone occurring in the southeastern part of the area (Plate X). Stacking with the underlying middle sandstone is not pronounced, occurring at only one control point (Plates IX and X).

According to Berg (1968, Plate VII) sandstones of this increment are present in the western ranges and form a north-south trending belt in the eastern half of his area. Comparison with the writer's maps is difficult because Berg shows the total sandstone within the Skinner increment, both lower and upper, the middle sandstone being absent. As the upper sandstone is only locally present in the western reaches of the writer's area it would seem that most of the sandstone shown by Berg is lower Skinner. Granting this it seems that the direction of transport for the lower sandstone could have been from south to north or from both directions while the middle and upper sandstones were spread from the south or southeast.

Investigations of geometry and origin of Skinner sand bodies are of a limited nature and are restricted largely to pool studies or, at most to several townships. Dillard (1941), in a study of the producing sandstone of the Olympic pool in southwestern Okfuskee and northwestern Hughes Counties, favored an "offshore bar" interpretation. Ware (1955), in a study of the Senora Formation on the outcrop and in the shallow subsurface of northeastern Oklahoma, implied a channel type of origin for the sandstones. Benoit (1957), in a study of the Desmoinesian of the Edmond area, postulated a stream or fluvial origin for the lower Skinner sands. Clayton (1965) interpreted the lower Skinner as a channel type of deposit in the Stillwater field. Shulman (1966), in a study of the Mount Vernon pools, postulated a channel origin for the lower Skinner sands. Hanke (1967) favored an interpretation of a channel nature for the Skinner sands of north-central Creek County.

Prue-Calvin Genetic Increment of Strata

The Prue-Calvin increment is defined by marker "E" at the base and marker "F" at the top (Plates I and II and Stratigraphic Profile KK'). Marker "E" is the horizon of the Verdigris Limestone and marker "F" is the base of the Oswego lime. However, as previously mentioned the Oswego thins southeastward and disappears into the Calvin Formation and for reasons of expediency the Calvin sands have been included with the Prue.

Strata of the Prue-Calvin increment cover the entire area and blanket the Central Oklahoma Arch (Berg, 1968, Plate IX). As is the case with the preceding increments, the Prue-Calvin thickens from northwest to southeast (Plate XI) but at an irregular rate from less than 40 feet to more than 500 feet. Two prominent trends of thinning are present; one running northeastward through eastern Kay County and central Osage County, the other slightly south of east across northern Lincoln County and southern Creek County. The former includes the "Osage Island" area but the latter, which persists into the western ranges (Berg, 1968, Plate IX), apparently had no antecedents. Two bands of thickening parallel this thin trend on the north and south sides. The southern band can be explained largely by the thick, elongated sandstone bodies therein but the northern belt is less clearly defined although elongated sandstone bodies are present (Plate XI). Southward from the 200 foot isopach line (Plate XI), the rate of thickening is more uniform being about 16 feet per mile. This 200 foot line is the approximate demarcation from base of Oswego to top of Calvin. The resulting rapid increase in thickness is caused by thickening of the Prue zone (upper Senora shale member) itself and thickening of the shale wedge separating the upper and lower Calvin sands.

Sandstone patterns of this increment vary considerably, forming two rather contrasting areas (Plate XI); a northern region where the sandstone bodies exhibit the familiar picture of elongation, anastomosing, and bifurcation, and a southern portion which is characterized by sheet-like wedges with thicker elongated trends. The general trend of elongation in the northern reaches is northwest-southeast which continues into the western ranges (Berg, 1968; Plate IX). A thick elongated sandstone body trends southeastward from Lincoln County into Pottawatomie and Seminole Counties where it becomes confounded with the sheet-like sandstones of the Calvin. Stacking occurs between the various sandstone bodies which makes separation unreliable and for this reason the total amount of sandstone is depicted. Part of the thickening trends is undoubtedly a reflection of the Prue zone. It is felt that a change in sedimentation has taken place where the dendroid type sandstone bodies give way to the sheet-like tongues of the Calvin and Wewoka Sandstones.

As far as the writer has been able to discern, no comprehensive investigation has been conducted on the Prue or Calvin. Busch (1953, p.

80, Figs. 5A and 5B), in a study of the Davenport pool in east-central Lincoln County, postulated a deltaic type of environment. McDade (1953), in a surface or outcrop study of the lower Calvin sands of Hughes County, favored a deltaic type of origin with a sourthern source. Ware (1955, p. 412 and Fig. VI) on the other hand, would seem to imply a bar type of origin from his work on the Senora Formation. Benoit (1957) favored a channel type of environment for the Prue sand of the Edmond area.

Resumé of Cherokee Sandstone Bodies

With the exception of the Gilcrease and Calvin sands, all the other units including the Booch, Bartlesville, Red Fork, Skinner, and Prue present a similar picture. They are present as widespread (meaning not sheet-like but occurring at various places over a large region), elongated, bifurcating, and anastomosing bodies. The patterns developed by these sandstones are similar to the belts and dendroids described by Potter (1962).

The general trend of these various sandstone bodies is not parallel to the direction of thickening but is at nearly right angles to it. This condition would seem to suggest sedimentation parallel to some shoreline. However, the area of study depicts only the western flank of the Cherokee basin which, based on maps of earlier workers already mentioned, has its axis some distance to the east and oriented in a north-south direction, essentially. This would place these sandstone belts in a position of being roughly parallel to the basin axis which seems to be very similar to the situation in the Illinois basin as set forth by

Potter (1962, 1963). It may be that most of these sandstone bodies represent part of fluvial dispersal systems that filled this basin.

The recurrence of similar sandstone patterns in the Cherokee succession would seem to indicate at least five major fluctuations or cycles and probably numerous minor ones if the Skinner increment is an indication. Much has been written on the possible causes of these cycles but one favored the most was propounded by Pike (1947), who explained transgressions and regressions by varying the rates of subsidence and sediment influx. In a similar vein Moore (1959) explained the cycles of the Lower Carboniferous of Britain by delta diversion or crevassing.

The general configuration of these sandstone bodies would tend to class them as alluvial sand bodies according to Potter (1967). However, tighter control and mapping throughout their geographic extent might show a complex of environments within any one increment similar to the situation postulated by Fisher and McGowen (1967) for the Wilcox Group of Texas.

The Gilcrease sands are probably best explained as marginal deposits of an encroaching sea upon the pre-Desmoinesian erosional surface. Individual sandstones are not persistent and do not seem to form dendroids and ones higher in the succession seem to extend farther westward and impinge upon the unconformity in an onlapping fashion. This situation might exist for the Bartlesville sands where they lie upon the unconformity in western Payne County.

The sheet-like tongues of the Calvin Formation present a difficult problem but could represent beach zone deposits that transgressed and regressed reflecting the change in the sedimentation picture where the

Central Oklahoma Arch became a domain of carbonate accumulation flanked by terrigenous sediments.

Cherokee Genetic Sequence of Strata and Lapout Relations

The Cherokee sequence is the sum total of the previous discussed six increments, having a surface of unconformity at its base and defined at the top by marker "F" which is the base of the Oswego lime in the northern reaches of the area and the top of the Calvin Sandstone in the southern part (Plates I and II).

The sequence thickens from less than 100 feet in the northwest corner to nearly 2700 feet in the southeastern corner (Plate XII). The Seminole-Cushing ridge complex (Plate III) interrupts the uniform southeastward thickening, manifesting itself by a northeast-southwest zone of thinning and separating the area into two portions characterized by differing rates of thickening. Northwest of the ridge rates of thickening are on the order of 20 feet per mile whereas southeast of the ridge the rate is 30 feet per mile or greater. It seems that subsidence varied throughout the region being somewhat greater on either side of the Seminole-Cushing ridge, especially to the southeast. It would seem to be quite possible that subsidence took place by movements along these faults, so-called growth faults. Several other faults can be postulated along the southeastern margins of the map where the isopach lines become closely spaced (Plate XII).

A paleodrainage system is discernable having a southeastern trend. A more detailed picture of this system is depicted by the increments that directly overlie the unconformity (Plates IV, V, and VI).

Increments of strata separated from the unconformity by other successions do not reflect this drainage net or do so only in a subdued manner. Studies of paleodrainage on this surface of unconformity have not been pursued in any degree of diligence. Berger (1918) seemed to be the first to indicate the presence of this ancient drainage system. This has been augmented in more recent times by Smith (1955), Clayton (1965), Shulman (1966), Cruz (1966), and Hanke (1967). All of these studies indicate drainage to the south or southeast away from the Central Oklahoma Arch. Work by Berg (1968) indicates a drainage system trending to the southwest in the western ranges. This would seem to imply that the Central Oklahoma Arch served as a major drainage divide between eastern and western Oklahoma with its axis along the Nemaha Ridge.

The Cherokee sequence is composed of a series of onlapping strata which gradually onlap and completely cover the Central Oklahoma Arch (Plate XII). With complete inundation, this arch, of which various portions were presumably emergent during deposition of the Cherokee sequence, became the realm of extensive carbonate deposition during deposition of the Marmaton sequence.

Summary of the Cherokee Genetic Sequence of Strata

Cherokee strata were deposited upon an eroded, stream-dissected surface formed on southeastward dipping older rocks ranging from Arbuckle Limestone to Wapanucka Shale. This older series has been folded and faulted to varying degrees. The major tectonic feature is the Seminole-Cushing ridge complex which bisects the area, essentially from northeast to southwest and which tended to be less negative than its environs, especially the eastern reaches which seem to have subsided along the bounding faults. Could these be so-called growth faults?

Rocks of the Cherokee sequence transgress the Central Oklahoma Arch in a cyclic manner. At least five major cycles are present, each containing an alluvial sandstone body or bodies. It is felt that these elongated sandstone bodies were part of a sediment dispersal system that contributed to the alluviation of the Cherokee basin and environs. If the trend of elongation of these sandstone bodies reflects current direction it seems reasonable to postulate several directions of transport, both from the north and from the south. However, the entire geographic extent of these sandstone bodies is not depicted and the interpretation might change if it were.

Channeling at the base of sandstone bodies is not exclusively limited to those of fluvial origin. Hoyt and Henry (1967), in a discussion of barrier island migration, indicated that the basal contact is erosional due to the channeling of tidal inlets. Even so it seems that an explanation which covers most of the features displayed by these sandstone bodies is a river system in its lower reaches where it is contributing to the filling of a basin or bay. Bar-finger sandstones of Fisk (1961) may be an accompanying phenomenon.

Marmaton Genetic Sequence of Strata

Oswego Lime Increment of Strata

The Oswego lime is a persistent and uniform carbonate unit over most of the area of investigation (Plates I, II, and Stratigraphic Profile

LL'). This carbonate succession is the lowest unit of the Marmaton genetic sequence of strata.

Five subdivisions can be recognized within the Oswego; three carbonate beds separated by two beds of black, fissile, radioactive shale. In a previous study (Cole, 1967) the writer traced this unit into the subsurface from the outcrop where the following names have been applied to the various subdivisions; Breezy Hill Limestone, Excello Shale, Blackjack Creek Limestone, Little Osage Shale, and Higginsville Limestone. The lowest two, Breezy Hill and Excello are considered to be part of the underlying Senora Formation at the outcrop whereas the other three units are termed the Fort Scott Formation (Jewett, 1941, Searight, et al., 1953). All of these are herein considered under the name Oswego, which, although preempted, is still much used.

The Oswego lime (Plate XIII) is fairly uniform in thickness throughout but variations exist where thicknesses in excess of ninety feet are present. Southward the unit thins and disappears into the sandstones of the Calvin Formation. An arbitrary cutoff has been established along the 10-foot isopach line (Plate XIII), south of which the Oswego loses its identity within the Calvin section and for all intent and purposes disappears. The lower carbonate member maintains a uniform thickness of only about 10 feet. This bed seems to pinch out in the northwestern corner of the area (where the Prue increment shows an increase in thickness Plate XI) and thins along the southern margin, pinching-out before the 10 foot isopach is reached. The upper carbonate bed is commonly the best developed, being about 30 to 40 feet thick throughout its extent. This unit pinches out along a line through southeastern Osage

County, southern Pawnee County, and through central Payne County where it passes out of the area (Plate XIII). This pinch-out is traceable to the outcrop (Cole, 1967, Plate II) to where the Higginsville Limestone grades into shale. The middle carbonate bed is relatively thin, 20 feet or less, but becomes better developed along a southwest-northeast trend across northern Lincoln County and northern Creek County. Thicknesses in excess of 80 feet are present in northwestern Lincoln County (Plate XIII). This trend, when extended into the western ranges, ties into a greatly thickened trend shown by Berg (1968, Plate XI).

None of the carbonate units develops any great buildups as they do in the western ranges (Berg, 1968, Plate XI, Richardson, 1965, Fig. 5A). Therefore, no attempt was made to follow Berg's method of depicting carbonate buildups. However, the general trend of thickening of the Oswego is northeast-southwest, parallel to the southern pinch-out which is also the general trend of thickening of the individual units.

The Oswego lime has been receiving considerable attention recently because of the discovery of hydrocarbons in this unit in the Putnam trend of Dewey County. Schell (1955) described the petrography of the Fort Scott on the outcrop in northeastern Oklahoma. Cassidy (1962, 1964) studied the Excello Shale, commented on reefing in the Breezy Hill Limestone and showed the extensive distribution of the radioactive black shales (Excello and Little Osage) by means of several profiles. In a previous study (Cole, 1967) the writer showed the geographic distribution and thickness variations within the Oswego in northeastern Oklahoma. Merriam (1963) discussed the Fort Scott in southeastern Kansas and postulated thickening due to carbonate bank development. Richardson (1965) indicated the geographic distribution of the Oswego lime in Oklahoma, postulating that "reef-like banks" developed along a narrow belt where shelf limestones give way to basin shales. Swanson (1967) followed this idea, essentially, in relating the bank development to the "hinge line" of the Anadarko basin.

Labette Shale Increment of Strata

The Labette Shale is a terrigenous wedge of rock that separates the Oswego lime from the so-called Big Lime or Oologah Limestone. This unit thickens to the northeast and thins southward becoming undefinable where the overlying carbonate unit pinches out (Plates I, II, and Stratigraphic Profile MM').

This shale increment thickens from less than 10 feet in eastern Logan and western Pawnee Counties to more than 120 feet in east-central Osage County (Plate XIV). Part of this decreasing thickness is due to the development of carbonate beds at the base of the overlying Oologah and thickening in the upper Oswego lime. Green (1918) noted this phenomenon and attributed it to the presence of limestone lenses in the Labette Shale. These are considered as part of the Oologah in this study, but Berg (1968, Plate XII) has isolated them as Labette. The increase in thickness continues to the east, exceeding 220 feet near the outcrop in northwestern Rogers County (Cole, 1967, Plate III).

Sandstones are present within this shale increment and present a picture of anastomosing, bifurcating, elongated dendroids, resembling the pattern shown by the sandstones of the Cherokee sequence (Plate XIV). A similar pattern has been demonstrated for the Labette sandstones to the east (Cole, 1967, Plate III). The general trend of these sandstone bodies is northeast-southwest.

Little attention has been devoted to the nature of the sandstones within the Labette Shale. Pierce and Courtier (1938, p. 45) discussed the Englevale Sandstone in the Labette Formation and Jewett (1941, p. 295, 1945, p. 26) indicated that the Englevale is essentially the same as the Warrensburg Channel Sandstone of Hinds and Greene (1915). In an earlier study (Cole, 1967) the writer postulated a channel type of origin based on the dendritic pattern of the Peru sand (subsurface equivalent of the Englevale Sandstone).

Oologah Limestone Increment of Strata

The Oologah is a succession of carbonates within the Marmaton sequence, which, when traced to the outcrop in northeastern Oklahoma, is divisible into three members; a lower carbonate unit called Pawnee, a middle shale termed Bandera, and an upper carbonate unit named Altamont. The Bandera thins westward and southward being replaced by carbonate members that develop at the base and top of the defining limestones. Thus, for mapping purposes, all three members are considered as a unit (Plates I, II, and Stratigraphic Profile NN').

The Oologah maintains an average thickness of 80 to 100 feet over the northern portion of the mapped area, but thickens in the northeastern corner and along a northeast-southwest belt through southeastern Osage County, central Pawnee County and northern Payne County. South of this belt the carbonate succession thins rapidly, disappearing into a shale sequence (Plate XV). The increase towards the northeast is the result of thickening of the Bandera Shale wedge to slightly over 80 feet

(Plate II and Stratigraphic Profile NN'). The Bandera seems to be present throughout the area (Plates I, II, and Stratigraphic Profiles LL', MM', NN', OO', and PP') but is difficult to trace where it becomes thin, 10 feet (plus or minus). Thickening along the belt is brought about by the thickening and coalescing of the carbonate members and the development of carbonate units at the base of the Oologah. These lower units extend farther to the south than the main mass of the Oologah and grade into shale along a northeast-southwest line through northern Creek County and across northern Lincoln County (Plate XV). Abrupt thinning occurs in northeastern Kay County where, in one well, the upper portion of the Oologah is occupied by what appears to be a calcareous shale.

As in the case of the Oswego, individual carbonate members of the Oologah were not delineated as was done by Berg (1968, Plate XIII) because of the difficulty of recognizing individual members due to coalescing and splitting into thinner units.

In a previous study (Cole, 1967) the writer depicted a similar situation existing at the outcrop and in the subsurface. It seems that the Oologah has received little study.

Cleveland Genetic Increment of Strata

This succession of strata has a well-defined top (base Checkerboard Limestone) and a poorly defined base. No persistent markers are present between the Checkerboard Limestone and the base of the Oswego lime, so the top of the next lower carbonate unit is utilized, excluding a carbonate unit believed to be Lenapah (Plates I, II, and Stratigraphic Profile OO').

The Cleveland increment thickens southeastward and southward from less than 100 feet in the northern portions to over 900 feet in the southern portion at the southern arbitrary terminus of the Oswego lime (Plate XVI). This is in part due to intrastratal thickening but, to a large degree is the result of the disappearance of carbonate units from north to south. First the main part of the Oologah gives way, approximately parallel to the 300 foot isopach, and lastly the Oswego, which is arbitrarily cut-off at its 10 foot isopach. A general trend of thinning is present from eastern Noble County into west central Osage County. Also a slight thinning trend is present along the Seminole-Cushing ridge. Presumably this is a reflection of the less negative tendencies of the Seminole-Cushing ridge complex and the larger Central Oklahoma Arch. A linear area of thickening trends across southeastern Osage County, through central Pawnee County, and northwestern Payne County. This trend is a reflection of a thick, east-west oriented, elongated sandstone body (Plate XVI).

North of T. 24 N., a carbonate unit is present below the Checkerboard Limestone marker (Plates II and XVI and Stratigraphic Profiles NN' and OO'). Along the northwestern margins these two units are almost in contact but eastward and southeastward they diverge and the lower unit pinches out. This lower carbonate unit, when traced to the outcrop, is recognized as the Lenapah Limestone. Where the Lenapah is present the underlying shale is called Nowata.

Much sandstone is present in this increment with a rather thick mass forming a belt across the middle portion of the area which is bordered, both north and south, by areas of less sandstone accumulation

(Plate XVI). These sandstone bodies which are generally referred to as Cleveland, are subdivided into a lower and upper Cleveland or Dillard and Jones sands, respectively. The upper sandstone directly underlies the Checkerboard and accounts for the widespread nature of the body in the southern portions of the area, whereas the lower sandstone is restricted to the middle and northern portions of the mapped area. The upper and lower sandstone bodies are stacked through the middle part of the area, producing elongated, bifurcating dendroids in excess of 100 feet in thickness. Along this thick trend through central Pawnee County the sandstone body appraoches 200 feet. Thicknesses of more than 100 feet have not been indicated by isopach lines. Channeling is present along this trend where the top of the Oologah has been cut into. The Cleveland sand presents, essentially, an east-west elongated, anastomosing pattern which continue into the western ranges where the sandstones pinch-out (Berg, 1968, Plate XIV).

It seems that little work has been done on the geometry and geographic distribution of these sandstone bodies. The writer, in an earlier study (Cole, 1967, Plate VI) showed the distribution of the sand-stones in the Nowata Shale of northeastern Oklahoma and postulated a channel type of environment for their origin. These sands were only mapped to the southern limit of the overlying Lenapah Limestone. Jewett (1941, p. 335) has called these sands the "Walter Johnson" on the outcrop and they are generally termed "Wayside" in the subsurface. When traced westward into the present area of investigation they seem to be equivalent to the lower Cleveland sand. The cleveland sands are considered to be the same as the Seminole Formation or at least the lower part by Ries

(1954, p. 90) and Jordan (1959, p. 97). The channel nature of these sandstone bodies is explicit in most of the studies conducted (see previous investigations) within the area, an idea which seems to be based solely on the nature of the contact of the Seminole Formation with the underlying rocks. Speculations as to the presence of an unconformity have already been discussed (see p. 27).

Wewoka Formation

As mentioned earlier the Marmaton sequence does not lend itself to nice, incremental subdivision like that of the Cherokee sequence. Three phases or types of sedimentary bodies are present within the predominantly shale section of the Marmaton sequence; a northerly carbonate domain, a southerly sandstone realm, and a medial east-west elongated sandstone belt (Plate I and Stratigraphic Profile PP'). The carbonate and channel sandstone realms have been depicted on other maps (Plates XIII through XVI). The southern sandstone realm consists of, essentially, four tongues of sandstone projecting northwestward for varying distances (Plate I and Stratigraphic Profile PP'). Ries (1954, p. 35 and Plate II) recognized four sandstone escarpments in the Wewoka Formation and depicted their northwestward gradation into the enclosing shale section. These sandstone bodies are variable in thickness but sheet-like in their distribution. These sandstones have been analyzed en masse, that is, the total amount of sandstone from the top of the Calvin (marker "F") to the base of the Checkerboard Limestone, excluding the Cleveland sands previously discussed. The Wewoka sands are discussed further in the next section and are depicted on Plate XVII.

Marmaton Sandstone-Carbonate Realms

To illustrate the nature of the units in the Marmaton genetic sequence of strata, two types of maps have been prepared; a carbonate-sandstone isolith, and a D-Function (Appendix I) map (Plates XVII and XVIII).

Appreciable limestone is present in the northern portions of the map area, approaching and exceeding 200 feet in thickness (Plate XVII) with the greatest thickness along a northeast-southwest trend through southeast Osage County, across south-central Pawnee County and through the northern part of Payne County. Southward from there the carbonate mass thins abruptly and finally to extinction along the 10 foot isopach line of the Oswego lime (Plate XIII).

Along this same line, sandstone tongues of the Wewoka enter the section from the southeast. Total sandstone thickness ranges from zero to more than 250 feet (Plate XVII). The pattern is quite different from that exhibited by the previous discussed sandstone bodies. However, this may be more apparent than real because four sandstone horizons are depicted, but these zones are more sheet-like and do not present the dendroid pattern of the previous sandstone bodies. By sheet-like it is meant that all wells have sandstone at the various horizons except as they pinch-out northwestward. This general pattern is reflected, in part by the Prue-Calvin increment (Plate XI) where the Calvin sandstones come into the section and become stacked with the channel-like Prue sands. As mentioned earlier it is felt that the Calvin sands belong to this sheet-like phase typified by the Wewoka. Also as noted with the Calvin, the separating shale units of the overlying Wewoka thin northwestward resulting in a convergence of higher sandstones with lower ones accompanied by progressive thickening of the succession between the Wewoka and Checkerboard (Stratigraphic Profile PP'). This phenomenon was noted by Berg (1968, p. 61 and Fig. 8) and seems to be implicit in Oakes' rendering of the Wewoka (1963, Figs. 5 and 6).

Much of the information that has been put forth here seems to be implicit in the many profiles, both surface and subsurface, that have been made in and around the area of investigation but no diagnostic studies have been made.

Marmaton D-Function Lithofacies Study

In a further attempt to depict the stratigraphy of the Marmaton genetic sequence of strata a facies mapping technique developed by Pelto (1954) was utilized. This technique divides a three component (or more) system into seven classes consisting of three sectors or one component, three sectors of two components, and one sector of three components as end members (Appendix I). The positioning of a point within any sector or class is a reflection of the proportions of the various end members.

This map (Plate XVIII) proved to be somewhat of a disappointment. The writer had hoped that the various realms would stand out, so to speak. However, the great thickness of the enclosing shales overshadows the carbonate and sandstone components, and only the progressive change from a terrigenous domain in the southeast to a carbonate one in the northwest is apparent.

The sandstones of the Cleveland have been included in this map and the trend of maximum development across the central portion of area is evident (Plate XVIII). Berg (1968, Plate X) indicated the same type of pattern for the western ranges.

McElroy (1962) investigated the Marmaton rocks using the facies mapping technique of Krumbein and Sloss but, inasmuch as his area is mostly within the carbonate domain, the contrast between realms is not evident except for a slight manifestation in the southeastern corner of his map. Rascoe (1962, Fig. 9) illustrated a facies map of Marmaton rocks west of the Nemaha Ridge which depicted carbonates giving way southward to terrigenous sediments.

Marmaton Isopachous Study

The Marmaton genetic sequence of strata thickens from less than 225 feet in the northwestern corner of the area to slightly over 1100 feet in the southeastern corner (Plate XIX), rates of thickening varying from 5 feet per mile to more than 25 feet per mile. The Seminole-Cushing ridge complex interrupts the progressive southeastward thickening. Along this trend a general thinning is present and it is interesting to note that this trend extends into the northeastern corner of the area. This corresponds with a down to the basin (Cherokee basin) fault indicated by Hayes (1965, p. 85, Fig. 1) and mentioned earlier. A band of thickening is present on the downthrown side of the Wilzetta fault (Plate III). A general thinning to the southwest seems to be developing along the southern margin of the area which may be a reflection of the Seminole uplift proper (Powers, 1927). It would appear that the Seminole-Cushing ridge complex was still exerting an influence on Marmaton sedimentation.

Convergence studies have usually been confined to the Cherokee sequence of rocks it seems, but in profiles by Levorsen (1927, Figs. 3B and 4B) and all subsequent profiles by workers in the area convergence is apparent in the Marmaton sequence as well as in younger rocks. Profiles by Lukert (1949, Plate II) and McElroy (1962, Plate IV) indicate convergence onto the Central Oklahoma Arch which would seem to indicate that the Arch too was less negative than its environs.

Resumé of Marmaton Sandstone Bodies

Sandstone bodies within the Marmaton sequence are essentially, of two types; the elongated sands of the Labette and Cleveland increments, and the sheet-like sands of the Wewoka Formation.

The sandstone bodies of the Labette and Cleveland increments exhibit a pattern similar to the Cherokee sands previously described. Again it seems that these sandstones could be classed as alluvial sand bodies, following Potter (1967). The general trend of elongation is from east to west, which would seem to indicate that the direction of transport was also in that direction.

The Wewoka sands present somewhat of a problem. They do not exhibit the anastomosing and bifurcating dendroid pattern, but are sheet-like, being present in each well in the southern portion of the area and pinching out into shale in a northwestward direction. Potter (1967) indicated that sheet-like sand bodies might be of shallow-water marine (marine-shelf) or of turbidite origin. No work has been done on the petrology or the sedimentary structures of these sands, to the writer's knowledge, but from sample study, the sands seem to be too quartzose and well-sorted to be classed as turbidites. On this basis these sheet-like sandstone bodies would have to be considered in the former category.

However, would it not be possible that these could be near-shore or beach deposits that transgressed and regressed due to variations in the rate of sediment supply from the south or in the rate of subsidence?

Resumé of Marmaton Carbonate Units

The carbonate units of the Marmaton sequence, Oswego, Oologah, and Lenapah, persist over the northern portions of the area and grade into shale in a south or southeastward direction. The constituent members of these units are fairly uniform, as to thickness, throughout their extent, except in the vicinity of their terminus, where individual members either thicken or coalesce with others to form a build-up that parallels this change from carbonate to shale. Each successive carbonate increment has a more restricted southern limit, that is the pinch-out of each unit is progressively farther northward than the preceding ones.

It is felt that this phenomenon is the result of the influx of terrigenous debris from the south, the greater the influx the more restricted the area of carbonate accumulation. Variations in the rates of subsidence would have the same effect. Along these lines it is interesting to note that this general idea was propounded by Hull (1862) to explain the relationships within the Carboniferous rocks of Britain.

Summary of Marmaton Genetic Sequence of Strata

The Marmaton genetic sequence represents a change from clastic sedimentation of the Cherokee to one characterized by carbonate development. The contrast is more marked by the fact that cyclical marker beds are not present to subdivide the sequence. Carbonate banks persist across the northern portions of the area; giving way southward, rather abruptly, to shale which becomes intercalated with sandstone tongues along the southern margins of the area, and northeastward becoming intercalated with thickening shale wedges.

After complete inundation of the less negative Central Oklahoma Arch, it is felt that this large feature became the locus of carbonate sedimentation and some kind of a balance was established between terrigenous influx and carbonate bank development. The reasons for this could be a more rapid subsidence of surrounding areas, lessening of clastic sedimentation, greater distances to source regions, or combinations of all three. That clastic sedimentation prevailed in the end is witnessed by the fact that each successive carbonate unit has its limits somewhat restricted from the ones below.

A multiple source direction seems to be evident from the fact that the Labette and Bandera shale units thicken northeastward and contain elongated sandstone bodies of that general trend, and the east-west alignment of the Cleveland sands would seem to indicate sediment transport from that direction. On the other hand, tongues of the Wewoka project into the area from the southeast and presumably had their origin from that direction.

On a larger scale it becomes quite apparent from maps by Sloss, Dapples and Krumbein (1960, Map 81) and Rascoe (1962, Fig. 9) that most of the Mid-Continent region was a domain of carbonate accumulation surrounded by a halo of terrigenous clastic sedimentation during the deposition of the Marmaton sequence.

CONCLUSIONS

Cherokee Genetic Sequence of Strata

Strata of the Cherokee sequence were deposited upon an eroded surface developed on southeasterly tilted older rocks. Folding and faulting along the Seminole-Cushing ridge complex and the Nemaha Ridge and erosion have exposed rocks as old as Arbuckle. The surface is stream dissected with the direction of drainage being dominantly southeastward.

Six genetic increments of strata were recognized: Gilcrease, Booch, Bartlesville, Red Fork, Skinner, and Prue-Calvin. Each of these seem to represent a major cycle of deposition. Minor cycles are probably present, at least in the Red Fork and Skinner increments, where several sandstone bodies are developed.

With the exception of the Gilcrease and Calvin sands, the others present patterns that are elongate and anastomosing and seem to be comparable to those sand bodies that Potter calls alluvial. These elongated sandstone bodies probably represent a part of the sediment dispersal system that contributed to the alluviation of the Cherokee basin and probably that of the McAlester (Arkoma) as well. Transportation of sediment could very well have been from both the north and south. The Gilcrease sands, lying as they do on an unconformable surface, represent the initial deposits of a transgressive sea.

The Cherokee sequence onlaps the Central Oklahoma Arch from the southeast, with each increment of strata extending farther westward until the Arch, at least in the area of investigation, was completely covered by rocks of the Prue-Calvin increment. It would seem that the Nemaha Ridge, the high or axial portion of the Arch, contributed little if any amount of debris. Most of the Cherokee is clastic while the rocks of the pre-Desmoinesian are largely carbonate, except for Simpson rocks. Not being able to demonstrate that the Ozark region or the Ouachita area served as a source for the sediment, one is left with postulating that the Wichita Mountain and Arbuckle complex furnished some of the debris from the south, and possibly southward flowing streams contributed sediment from more distant sources to the north.

The Calvin sandstones depart from the elongated type of sand body exhibited by the Prue and older ones; presenting a picture that is sheet-like, representing tongues that project into the area from the south and pinch-out into shale toward the north. Along with the change in sedimentation the Central Oklahoma Arch becomes a realm of carbonate accumulation.

Marmaton Genetic Sequence of Strata

Strata of the Marmaton genetic sequence could not be subdivided into genetic increments as was the underlying Cherokee. Thick carbonate units give way southeastward to a thick shale succession which becomes intercalated with northwestward projecting sandstone tongues and no markers are present to subdivide the sequence over the entire area. Sandstone tongues separated by thick shales comprise the Wewoka Formation;

carbonate units can be subdivided into the Oswego lime, Oologah Limestone, and Lenapah Limestone, with the latter being relatively thin and restricted to the northern portion of the area. Two terrigenous shale wedges, Labette and Bandera, separate the Oswego and Oologah and subdivide the Oologah, respectively. These thicken to the east and northeast and contain elongated sandstone bodies similar in pattern to those of the Cherokee.

Overlying the Oologah Limestone and beneath the Checkerboard Limestone is a shale succession that thickens southeastward, partially at the expense of the carbonate units that grade into shale in that direction. Across the northern portion of the area this succession of shale is split by a carbonate unit, the Lenapah Limestone, which closely underlies the Checkerboard but diverges from it to the south grading laterally into shale. Where the Lenapah is present the underlying shale could rightly be called Nowata. Also within this shale section are two sandstone bodies that are called Cleveland, which form a thick, east-west trending sand body similar also to those of the Cherokee. These sandstones seem to be distinct and of different origin than the northward projecting tongues of the Wewoka Formation.

It would seem, that whereas the Cherokee sequence represents an oscillatory inundating phase, the Marmaton sequence represents an inundated phase in which a majority of the area comprising the Central Oklahoma Arch became a site of large-scale carbonate accumulation, whose geographic limits flucuated to the dictates of terrigenous influx from both southerly and northerly or northeasterly sources.

As no apparent truncation or onlap of units was observed it seems that postulated unconformities within the Cherokee and Marmaton sequences could be explained by interruptions in an otherwise continuous depositional series due to channeling at the base of elongate sand bodies and by units grading into shale due to a change in depositional environments.

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APPENDIX I

CLASSIFYING FUNCTION MAPS

Pelto (1954) examined the problem of mapping sedimentary facies and proposed two contrasting methods of representation; a classifying-distance function, and an entropy-like function, both being applicable to systems of any number of components. The former method was utilized in this study and will be described briefly.

Besides Pelto's (1954) initial description, little use seems to have been made of this facies mapping technique. Forgotson (1960, in his resumé of quantitative mapping techniques, discussed the adequacy and drawbacks of the classifying function and could find no appreciable difference between the ratio-type lithofacies map (Krumbein and Sloss, 1963, p. 460) and the "D" function map, when applied to the Trinity Group of the Gulf Coast Cretaceous. Schramm (1964) utilized the "D" function to analyze the Simpson Group of Oklahoma with what seemed to be favorable results.

All three papers discussed the mathematical manipulations utilized in the computation of the classifying-distance function. For the purpose of this paper the outline given by Forgotson (1960, p. 88) will be utilized.

The function $D = 100(1- [(\Delta p)_m - (\Delta p)_{vm}])$ is used for mapping purposes (Pelto, 1954, p. 505). Where

$$\sum_{i=0}^{n} p_i = 1 \quad \text{and} \quad (\Delta p)_m$$

is the maximum of all positive differences of adjacent p's and $(\Delta p)_{vm}$ the next largest difference.

For a unit having the following lithological composition; non-clastics = 10%, shale = 40%, sand = 50%; $p_1 = 0.1$, $p_2 = 0.4$, $p_3 = 0.5$ and $\sum p_i = 1$. A null component, the proportion of which is always zero, is added to the three components and they are arranged in order of increasing magnitude from left to right.

$$0, \quad 0.1, \quad 0.4, \quad 0.5$$

$$\Delta p_1 = 0.1, \Delta p_2 = 0.3, \quad \Delta p_3 = 0.1$$

$$(\Delta p)_m = 0.3$$

$$(\Delta p)_{vm} = 0.1$$

$$D = 100[1 - (0.3 - 0.1)]$$

$$= 100(0.8) = 80$$

A point having the composition indicated above is at the intersection of the 10% non-clastic and 40% shale lines on the triangular plot. The point falls in the two-component end-member sector between sand and shale as shown on the facies triangle, and has the "D" value of 80 within this sector.

The classifying function method divides a three component system into seven classes each being bounded by 100, the maximum "D" value. Each class is represented by an end-member; Class I, one component, Class II, equal portions of two components, Class III, equal portions of three components. A further innovation was wrought on this basic scheme, where the classes were divided into subclasses to depict the general drift toward one or the other end-members and to identify the end-member being dealt with.

A computer program was devised to handle the numerous computations and print out the desired data.

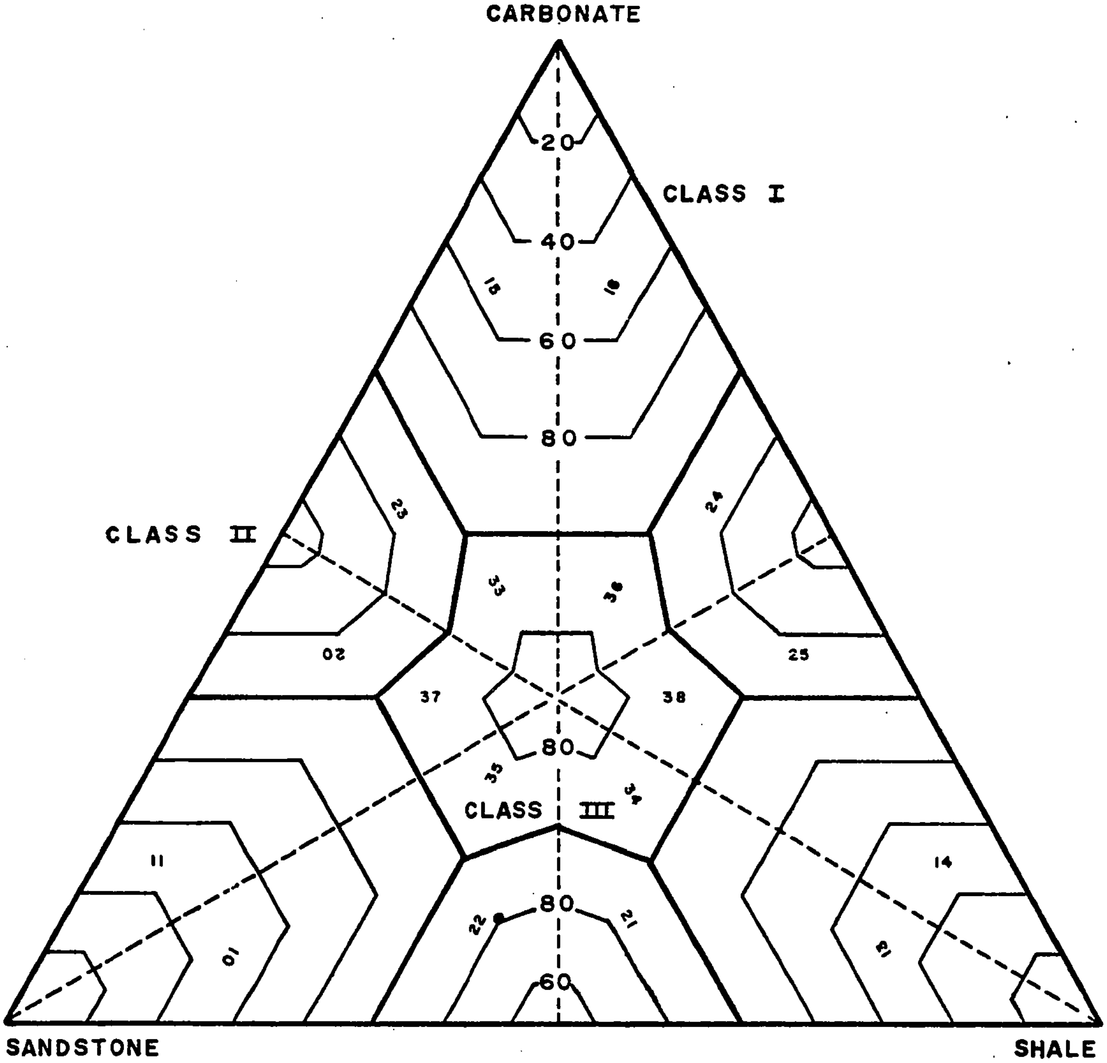


Fig. 6. Classifying Distance Function Triangle

APPENDIX II

LIST OF WELLS IN STRATIGRAPHIC PROFILES

Stratigraphic Profile A-A'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
1	Dave Morgan Oil Co., No. 1 Roach	SE SE	30	29N	1E
2	Jenkins-Musgrave & Tarpenning, No. 1 Snodgrass	SW NE	23	28N	1E
3	Randal R. Morton, No. 1 Spore	SW NE	21	27N	2E
4	Dave Morgan Oil Co., No. 1 Lew Wentz Estate	SE SE	13	26N	2E
5	Curt Brown, No. 1 Tapp	NW NE	5	25N	3E
6	Helmerich & Payne and Freeport Surphur Co., No. 1 Burt	NW SE	9	24N	3E
7	Porter Oil and Gas Co., No. 1A Perry	SE SE	21	23N	4E
8	Arthur B. Ramsey, No. 1 Walenciak	SW SW	14	22N	4E
9	Glenn Gillespie & Sons, No. 1 Wilbur Davis	NE NW	19	21N	5E
10	Clark & Cowden, No. 1 Rogers	NE NW	22	20N	5E
11	Warren Oil Corp. and Mul-Berry Oil Co., No. Lauderdale	SE SW	21	19N	6E
12	Foster Drilling Co., No. 1 Benton	NW NE	23	18N	6E
13	Thomas N. Berry & Co., No. 1 State Land	NE SW	33	17N	7E
14	Hubbell Drilling Co., No. 1 Busby-Canada	NE NE	23	16N	7E
15	E. S. Adkins, No. 1 Shannon	SE NW	20	15N	8E
16	Skelly Oil Co., No. 1 Exie Fife	NE SE	15	14N	8E
17	K. A. Ellison, No. 1 White	NW NW	20	13N	9E
18	British American Oil Prod. Co., No. 1 Admire	NW SW	24	12N	9E
19	Ashland Oil & Refining & W. C. McBride, Inc., No. 1 Palmer	NE SW	18	11N	10E
20	Amerada Petroleum Corp., No. 1 Roly Canard	SE NE	16	10N	10E

Stratigraphic Profile B-B'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
21	Anderson Prichard, No. 1 Fester	NW NE	20	28N	1E
22	John. W. Nichols Exploration Co., Ltd., No. 1 State-Voegele	NW SE	16	28N	2E
23	Ben J. Taylor, No. 1 Tipton	SW NE	21	28N	3E
24	Ada Oil Co., No. 1 Dora Goodson	SW NE	18	28N	4E
25	Service Drilling Co., No. 1 Boles	NE NE	28	28N	5E

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
26	Shamrock Oil & Gas Corp., No. 1 T. T. Holt	SE	18	28N	6E
27	White Star Oil Co., No. 1 Perryman	SE SE	17	28N	7E
28	L. B. Smith, No. 1 Robinson	SE NW	15	28N	8E
29	H. P. Forker, No. 1-A Earnest	SE SW	15	28N	9E
30	Globe Oil and Refining Co., No. 0-2 Osage	SW NW	21	28N	10E

Stratigraphic Profile C-C'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
31	B. C. Deardorf, No. 1 Anderson	SW NE	15	17N	3E
32	Blackwell Oil & Gas Co. and Foster Drilling Co., No. 1 Anderson	SW SW	18	16B	4E
33	Nadel & Gussman, No. 1 School Land	SW SE	16	15N	4E
34	Ketchum, Whan, Simon & Bassett, No. 1 Williams	SW NE	19	14N	6E
35	Mid-Continent Petr. Corp., No. 3 Leona Vinson	SW SE	4	13N	6E
36	Amerada Petr. Corp., No. 1 Mabel Leonard	SE SW	14	13N	7E
37	Deardorf Oil Corp., No. 1 Turner	NE SE	20	12N	8E
38	Wood Oil Co., No. 1 Ogden	SW NW	24	11N	9E

Stratigraphic Profile D-D'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
39	Mid-Continent Petr. Corp., No. 1 First National Bank of Grove	SE NW	34	13N	4E
40	Ashland Oil & Refining Co., No. 1 Katie Beel	NW NE	24	12N	5E
41	Falcon Seabord, No. 1 Gragg	SE NE	23	12N	6E
42	K & H Drilling Co., No. 1 Replogle	NW NE	27	12N	7E
43	J. A. Ligon, No. 1 Keyes	NW SE	16	11N	8E
44	Shell Oil Co., Inc., No. 4 Replogle	NE SE	35	11N	8E
45	Sunray Oil Corp., No. 1 Sam	NE SW	10	10N	9E
46	Amerada Petr. Corp., No. 1 Berryhill	SE NE	17	10N	10E

Stratigraphic Profile E-E'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
47	Clark & Cowden Prod. Co., No. 1 Cross	NE NE	32	16N	2E
48	C. A. McCann, No. 1 Nettie Lewis	SW SW	33	15N	3E
49	Eason Oil Co., No. 1 Mattheyer	NW NE	28	14N	4E
50	Hubbell & Webb, No. 3 James	SW SE	32	14N	6E
51	Mid-Continent Petr. Corp., No. 1 C. R. Diehl	NW NE	33	13N	7E
52	Halbert & Evans, No. 8-1 Replogle	NW SE	4	12N	8E
53	Robinson and Vierson & Cochran, No. 1 Gwaltney	NW SW	11	12N	9E
54	Wood Oil Co., No. 3 Tom Smith	SE NE	23	12N	10E

Stratigraphic Profile F-F'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
55	Seneca Oil Co., No. 1 Minnich	NE SW	33	18N	1E
56	Oklahoma Natural Gas Co., No. 1 Moore	NW SE	21	17N	2E
57	Scat Drilling Co., No. 1 State School Land	NW SE	16	16N	4E
58	Mid-Continent Petr. Corp., No. 1 Rueb	SW NE	23	15N	5E
59	Thompson & Lee, No. 1 Randle	NW NW	13	14N	7E
60	Clark C. Nye, No. 1 Replogle	NW SE	19	13N	8E
61	Clark C. Nye, No. 1 B. Manley	NW NW	20	12N	10E
62	Ashland Oil & Refining Co., No. 1 Burks	NE NW	20	11N	11E

Stratigraphic Profile G-G'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
63	Helmerich & Payne, No. 1 Hennessey	NE SE	23	16N	3E
64	H. F. Wilcox Oil & Gas Co., No. 1 Howell	SE SE	14	17N	3E
65	The Texas Co., No. 1 G. T. Norton	SE NW	15	18N	4E
66	Dirickson Lewis and Mercury Drilling Co., No. 1 Leka	SE NE	21	19N	5E
67	Falcon-Seaboard Drilling Co., No. 1 Demieville	NW NE	20	20N	6E
68	Kroy American Oils, Inc., No. 5 State	SW SE	16	20N	7E
69	Wilcox Oil Co., No. 1 Clark	SW SE	26	21N	8E
70	Elliott & Co., No. 24 Ruby Flick	SW NE	2	21N	9E

Stratigraphic Profile H-H'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
71	T. N. Berry & Co., No. 1 Earle White	SW NW	10	20N	2E
72	Fordee, Rhodes and Berry, No. 1 Mathews	NW SW	19	19N	2E
73	Ryan Oil Co., <u>et</u> <u>al</u>., No. 1 Madison	NW SW	34	17N	1E
74	Wilcox Oil Co., No. 1 Potter	SW SE	21	16N	3E
75	Williams Bros., No. 1 Chandler	NW SE	27	14N	3E
76	Delaney Drilling Co., <u>et</u> <u>al</u>., No. 1 Coe	SW SE	22	13N	5E
77	Smith Petr. Co., No. 1 Chew	NE SE	17	11N	6E
78	Johnson & Gill, No. 1 Black	NE NW	34	10N	6E

Stratigraphic Profile I-I'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
79	Don Jones, No. 1 Judge	NW NW	21	18N	2E
80	Atlantic Refining Co., No. 2 H. F. Jauch	SE NE	18	17N	4E
81	Sooner State Oil Co., Inc., No. 1 Gibson	NW SE	13	16N	5E
82	Amerada Petr. Corp., No. 1 Tipton	NW NW	13	14N	5E
83	Herdon Drilling Co., No. 1 Tucker	SE SE	19	13N	6E
84	J. E. Crosbie, Inc., No. 1 Sykora	NE SW	20	12N	7E
85	Kerlyn Oil Co., No. 1 Klabzuba	SW SE	18	11N	7E
86	Ryan Oil Co., No. 1 Norvell	SE NE	24	10N	7E

Stratigraphic Profile J-J'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
87	Kenneth Ellison, No. 1 Ross	SW SW	20	16N	2E
88	Davidor & Davidor, No. 1 Neill	SE NE	16	15N	3E
89	Deep Rock Oil Corp., No. 1 Rowan A	SE SE	9	15N	4E
90	L. S. Youngblood, No. 1 Sproles	SE NW	15	15N	5E
91	Sterling Oil of Oklahoma, Inc., No. 1 Secor	SW SE	23	14N	6E
92	Gulf Oil Corp., No. 1 Dakota	SE NW	24	13N	8E
93	The Texas Co., No. 1 Yahola	SE NW	18	12N	9E
94	Wilcox Oil Co., No. 1 Phillips	NW SE	4	11N	10E

Stratigraphic Profile K-K'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
95	Creekmore-Rooney, No. 1 Sudheimer	SW SE	18	14N	3E
96	Great Lakes Carbon Corp., No. 1 Lane	NE SE	23	14N	4E
97	Bishop Oil Co., No. 1 James	SW SW	35	13N	5E
98	Wilcox Oil Co., No. 1 Repa	NE NE	10	12N	6E
99	J. E. Crosbie Inc., No. 1 Crain	SW NE	19	12N	7E
100	Ashland, Kemrox, Arrow, No. 1 White	SW NW	24	11N	6E
101	Manahan Oil Co., No. 1 Hugh Stokes	SE NW	10	10N	7E
102	Schermerhorn Oil Co., No. 1 Tiger	SE NE	19	10N	7E

Stratigraphic Profile L-L'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
103	Signal Oil & Gas Co., No. 1 Endicott	NE NW	34	23N	5E
104	Westgate-Greenland, No. 1 Cooper	NE SE	19	20N	5E
105	Ambassador Oil Corp., No. 1 Hale	SW SW	18	19N	5E
106	C. J. Brown, No. 1 Thompson	SW SW	18	18N	5E
107	J. Tom Grimmett, No. 1 Anderson	SW NW	24	16N	4E
108	K. C. F. F. and Portable Drilling Co., No. 1 Adams	NW NW	3	14N	4E
109	Harry J. Schafer, No. 1 Peace	SW NE	9	13N	4E
110	Davidor & Davidor, No. 1 Necessary	SE NE	21	12N	4E

Stratigraphic Profile M-M'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
111	L. G. Smith, No. 1. Thompson	SE NW	15	24N	4E
112	B. A. Kaemmerer and R. L. Horn, No. 1 Joe Osage	SE NW	21	25N	5E
113	Kewanee Oil Co., No. 4 Lawrence	SW	22	26N	6E
114	Producers Pipe & Supply Co., No. 1 Anna Pitts	NW NW	19	27N	8E
115	Phillips Petr. Corp., No. A-2 Sarah	NE	18	27N	10E
116	Sunray Oil Corp., No. 1 Osage	SW SE	28	28N	10E
117	W. G. Rogers, No. 2-R Whiteman	SW SE	3	28N	10E
118	Toklan Oil Corp., "D" No. 1 N. W. Boulanger	SE NW	19	29N	10E

Stratigraphic Profile N-N'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
119	K. A. Ellison, No. 1 Big Heart	SW NE	25	26N	7E
120	Emby Kaye, No. 1 Butler	SW NE	33	24N	6E
121	Summit Drilling Corp., No. 1 Cadenhead	NW SW	33	23N	6E
122	Western Oil & Gas Co., No. 1 Wadlow	NW SE	10	21N	6E
123	Gambol Oil Co., No. 1 Cassidy	NE NE	31	21N	7E
124	Austin and K. D. Emrick, No. 1 Jones	SW NE	26	20N	7E
125	E. L. Oliver Co., No. 1 McCray	NW SW	9	19N	8E
126	Simon & Bassett, No. 1 Dill and Young	SE SE	18	18N	8E

Stratigraphic Profile O-O'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
127	Worley & Harrell, Inc., No. 1 Mathis	SE NE	30	25N	5E
128	A. D. Krow and Glenn Gillespie & Sons, No. 2 Quillen	SW NW	4	23N	5E
129	T. N. Berry & Co., No. 1 Deming	NW SW	2	21N	5E
130	Glenn Gillespie & Sons, No. 1 Summers	SW SW	34	21N	5E
131	Falcon Seaboard Drilling Co., No. 1 Demieville	NW NE	20	20N	6E
132	C. E. McCaughey, No. 1 Mock	SW NE	16	18N	7E
133	Delaney Drilling Co., No. 1 Beard	SE NE	21	18N	9E
134	C. H. Nicholson, No. 1 Dunbar	SW NW	21	17N	10E

Stratigraphic Profile P-P'

No.	Operator and Well Number	Loc.	Sec.	Twp.	Rge.
135	Clark & Cowden, No. 1 Rogers	NE NW	22	20N	5E
136	J. E. Crosbie, Inc., No. 1 L. D. Gaunt	NE SE	15	18N	5E
137	Kingery Drilling Co., No. 1 Haskin	NE SW	21	16N	5E
138	Bay Petroleum Corp. and Roy G. Woods, No. 1 Moody	NE NE	20	15N	6E
139	Huffman & Malloy, No. 1 Cowen	SE SW	33	14N	7E
140	Helmerich & Payne, No. 1 Crenshaw	SW NE	19	12N	8E
141	Illinois Exploration Co., No. 1 Frank	SE NW	10	11N	8E
142	Portable Drilling Co., No. 1 Key	SW SE	21	10N	8E

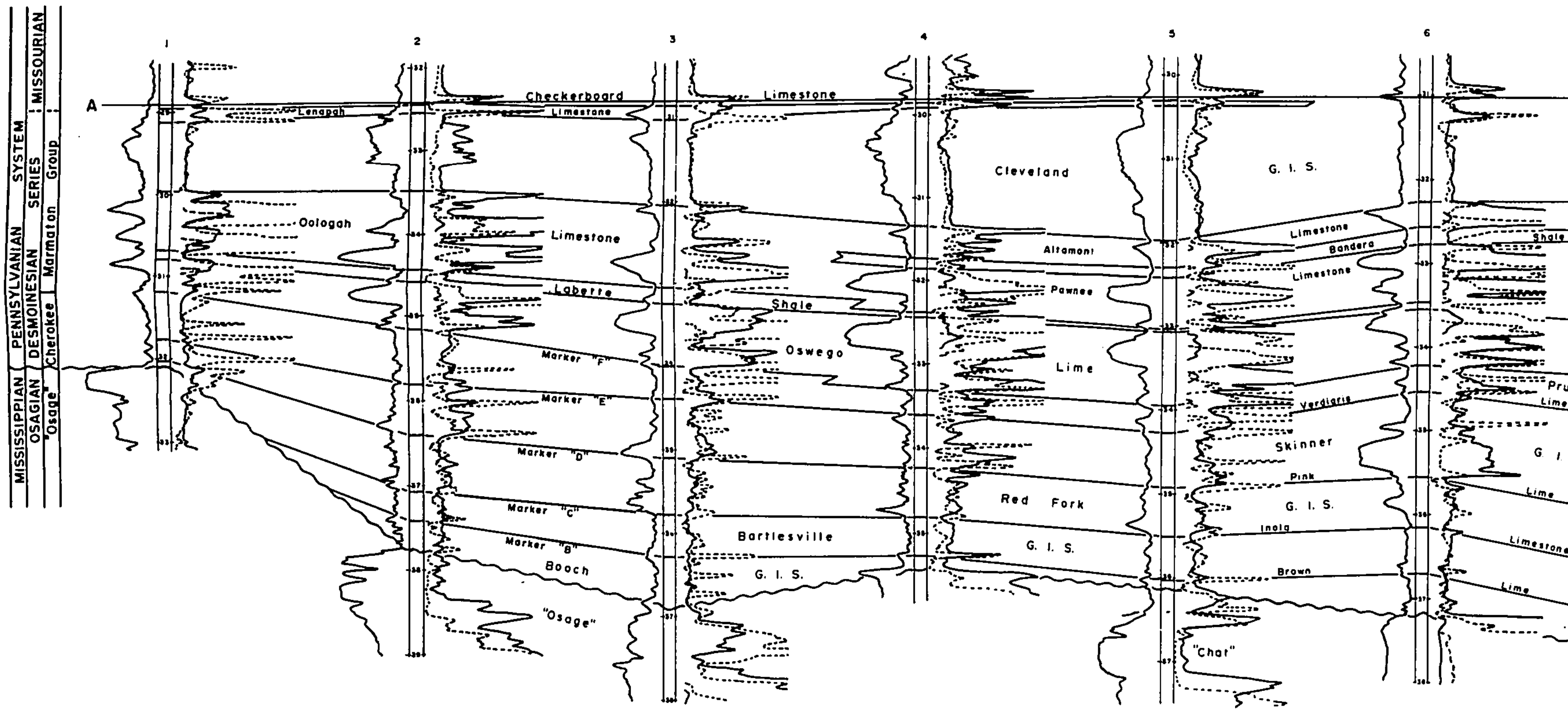


PLATE I

STRATIGRAPHIC PROFILE AA'

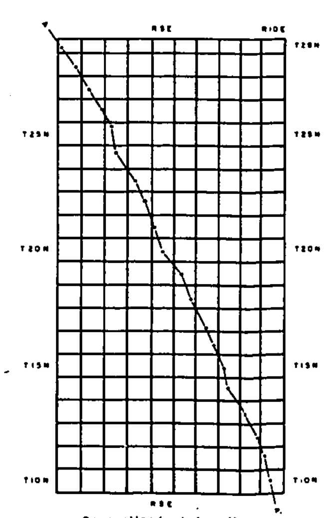
CORRELATIONS

CHEROKEE AND MARMATON

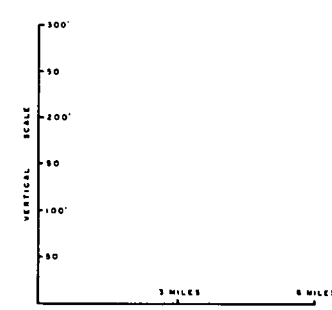
GENETIC SEQUENCES OF STRATA

by

J. Glenn Cole Ph. D. 1968



Generalized Index Map



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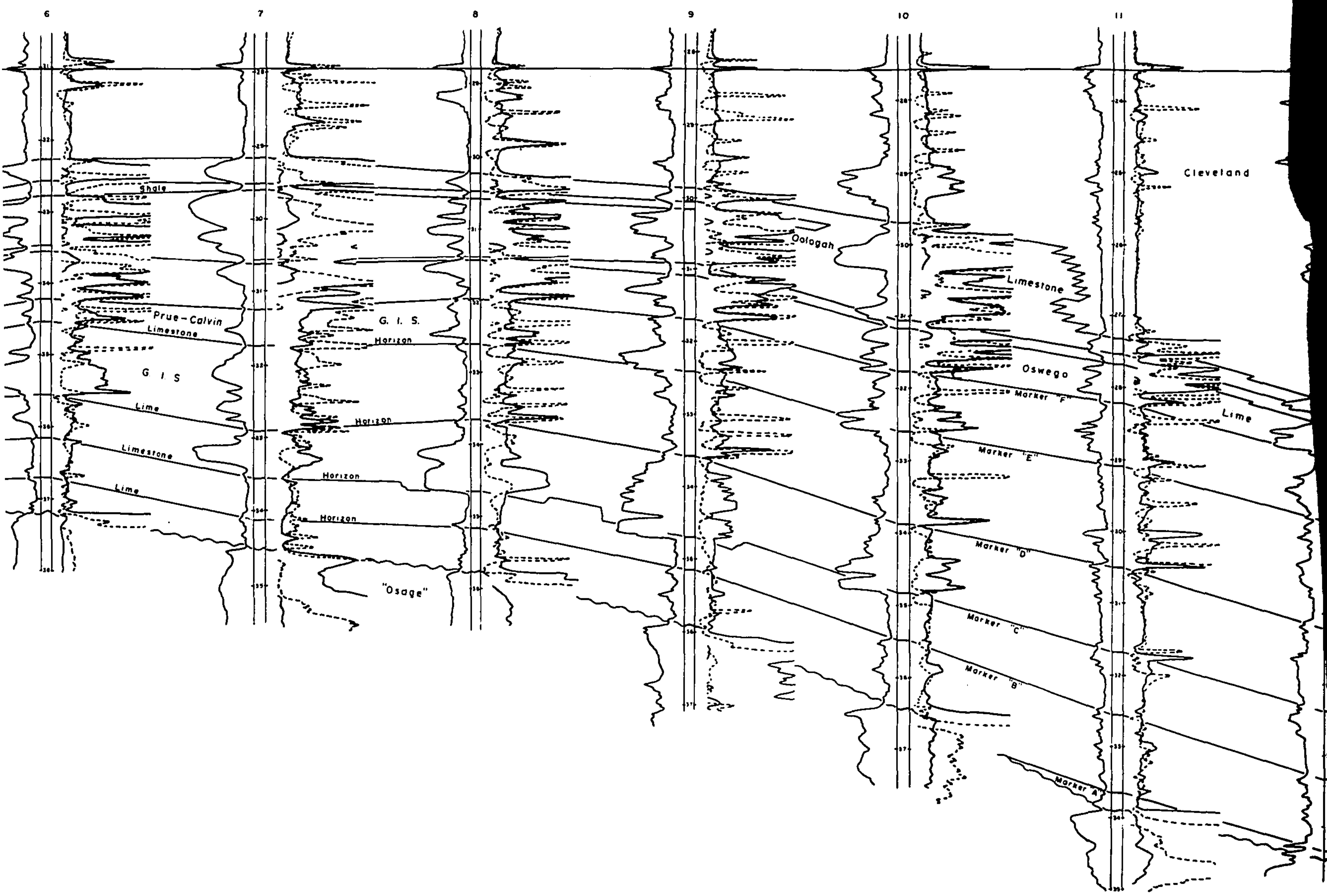

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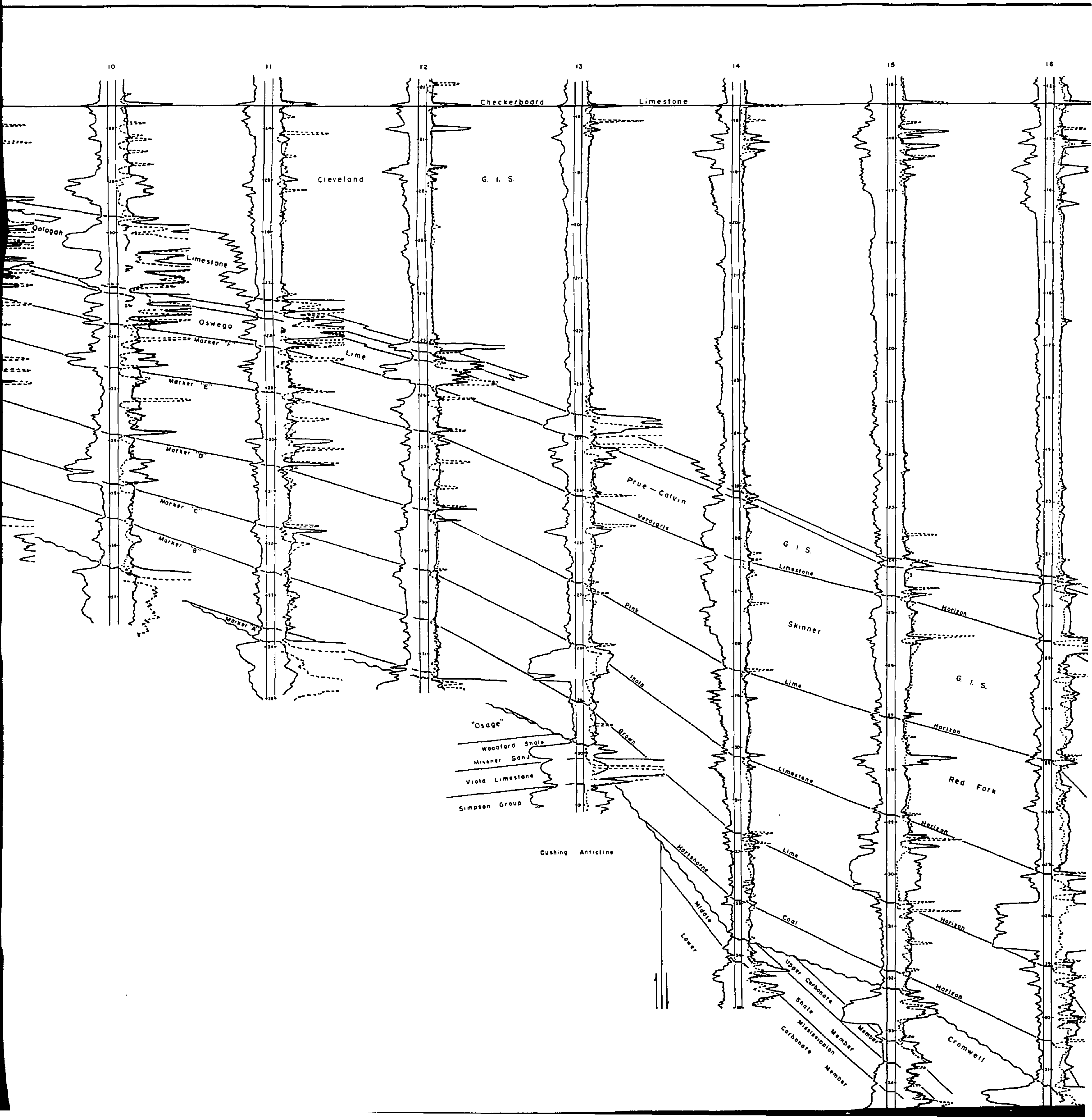
Scale


10
11
12
13
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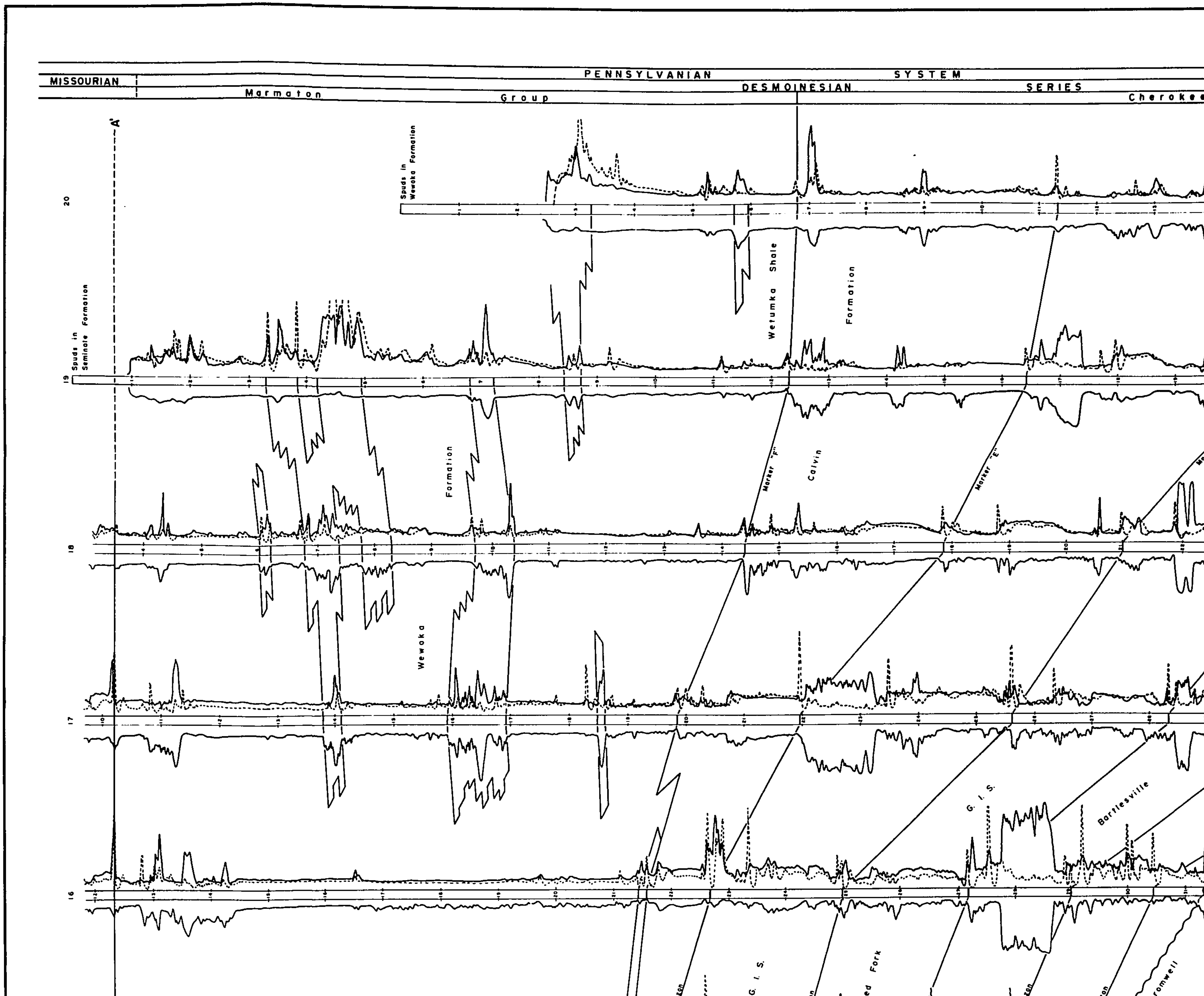
Checkerboard Limestone
Cleveland G. I. S.
Oologah Limestone
Oswego Lime
Marker "F"
Marker "E"
Marker "D"
Marker "C"
Marker "B"
Marker A
Prue – Calvin
Verdigris Limestone
G. I. S.
Skinner Lime
Pink Limestone
Inola Lime
Brown Coal
Horizon
Horizon
Horizon
Horizon
Horizon
G. I. S.
Red Fork
Cromwell
"Osage"
Woodford Shale
Misener Sand
Viola Limestone
Simpson Group
Cushing Anticline
Hartshorne
Middle
Lower
Upper Carbonate Member
Shale Member
Mississippian Carbonate Member



MISSOURIAN
PENNSYLVANIAN
SYSTEM
DESMOINESIAN
SERIES
Marmaton
Group
Cherokee
A'
20
Spuds in Wewoka Formation
19
Spuds in Seminole Formation
Wetumka Shale
Formation
Calvin
Marker "F"
Marker "E"
18
Formation
Wewoka
17
G. I. S.
Bartlesville
16
G. I. S.
Fork

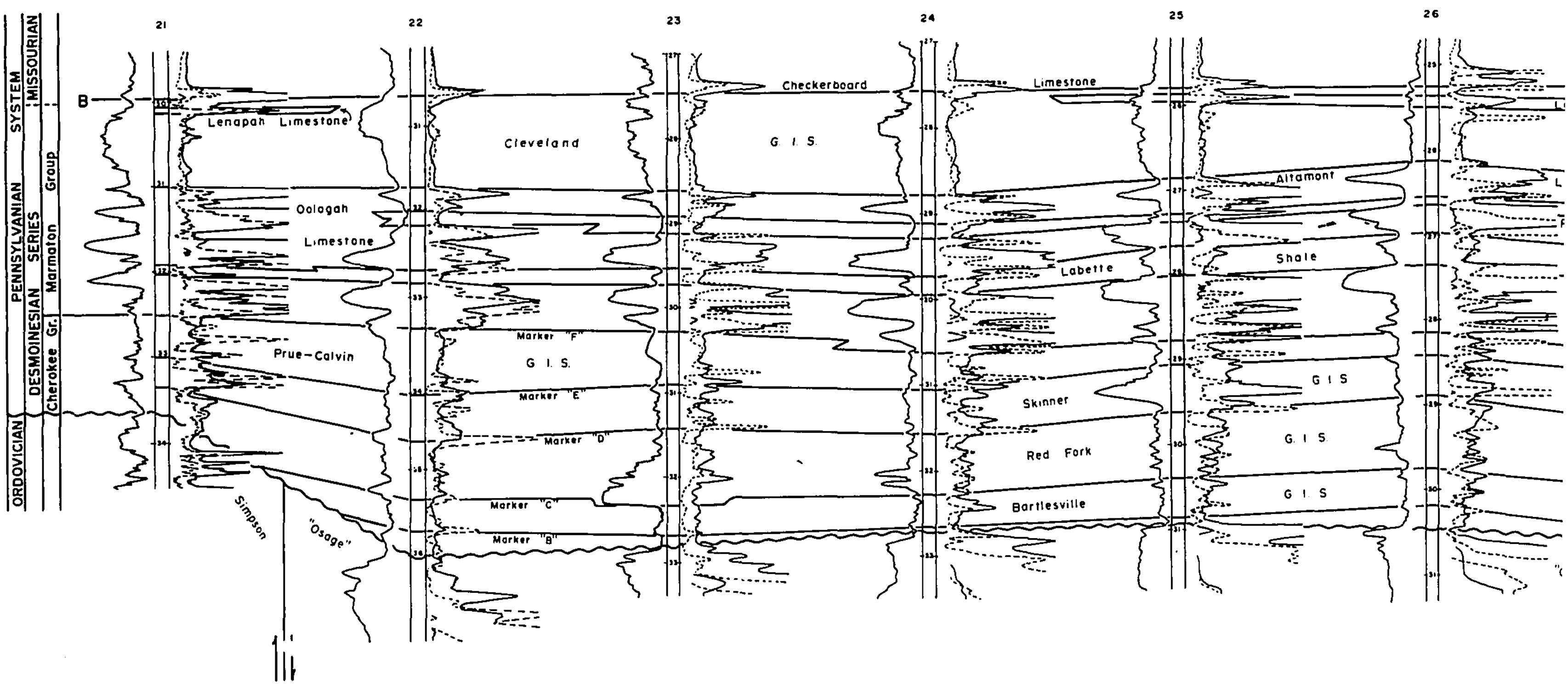


PLATE II

STRATIGRAPHIC PROFILE BB'

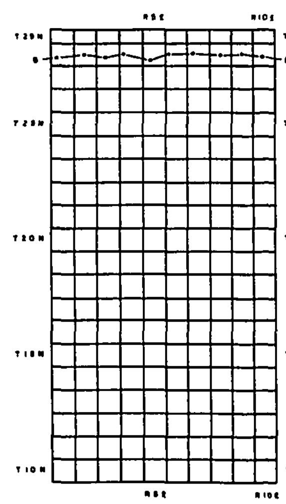
CORRELATIONS

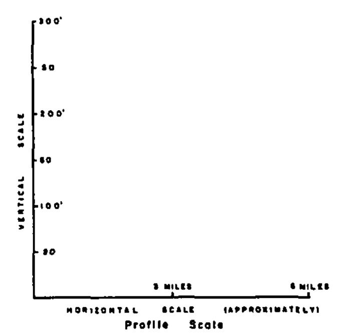
CHEROKEE AND MARMATON

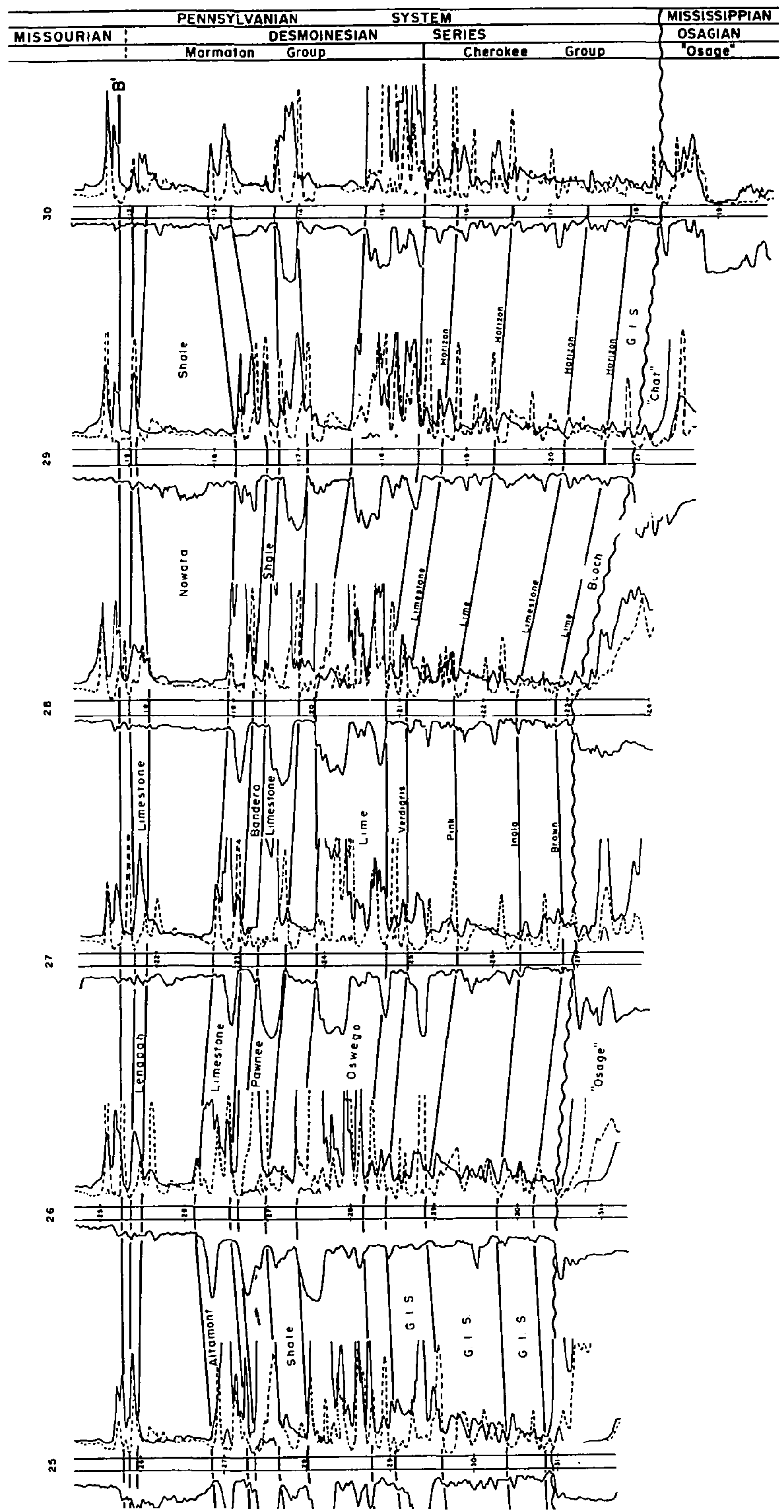
GENETIC SEQUENCES OF STRATA

by

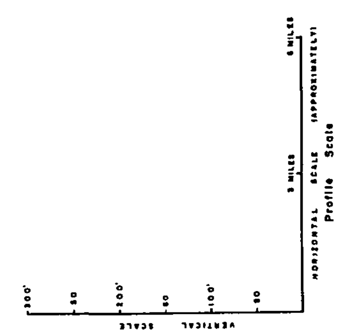
J. Glenn Cole Ph. D. 1968

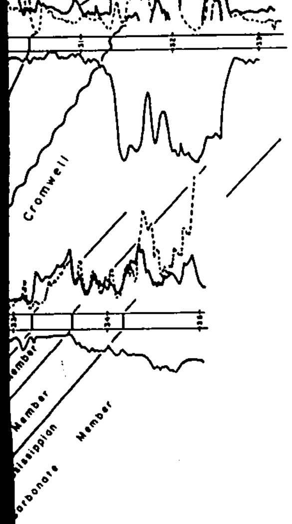




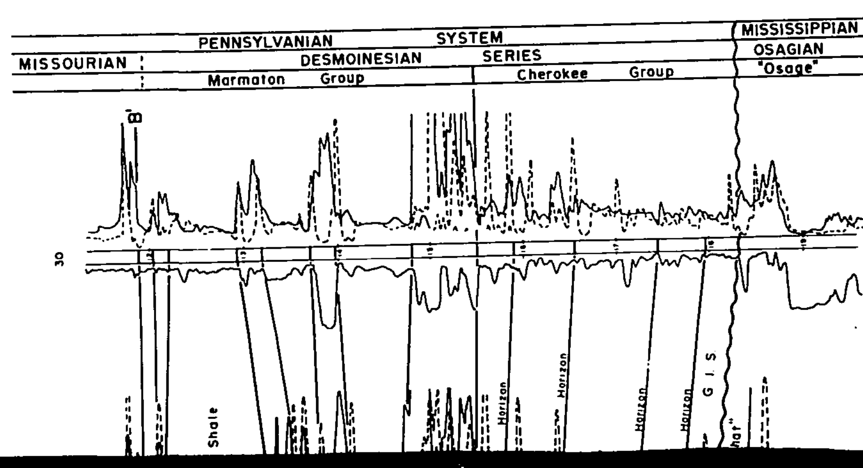

PENNSYLVANIAN SYSTEM
MISSISSIPPIAN
MISSOURIAN
DESMOINESIAN SERIES
OSAGIAN
Marmaton Group
Cherokee Group
"Osage"
B'
30
29
28
27
26
25
Shale
Horizon
Horizon
Horizon
Horizon
G I S
"Chat"
Nowata
Shale
Limestone
Lime
Limestone
Lime
Bloch
Limestone
Bandera
Limestone
Lime
Verdigris
Pink
Inola
Brown
Lenapah
Limestone
Pawnee
Oswego
"Osage"
Altamont
Shale
G I S
G I S
G I S


Profile Scale

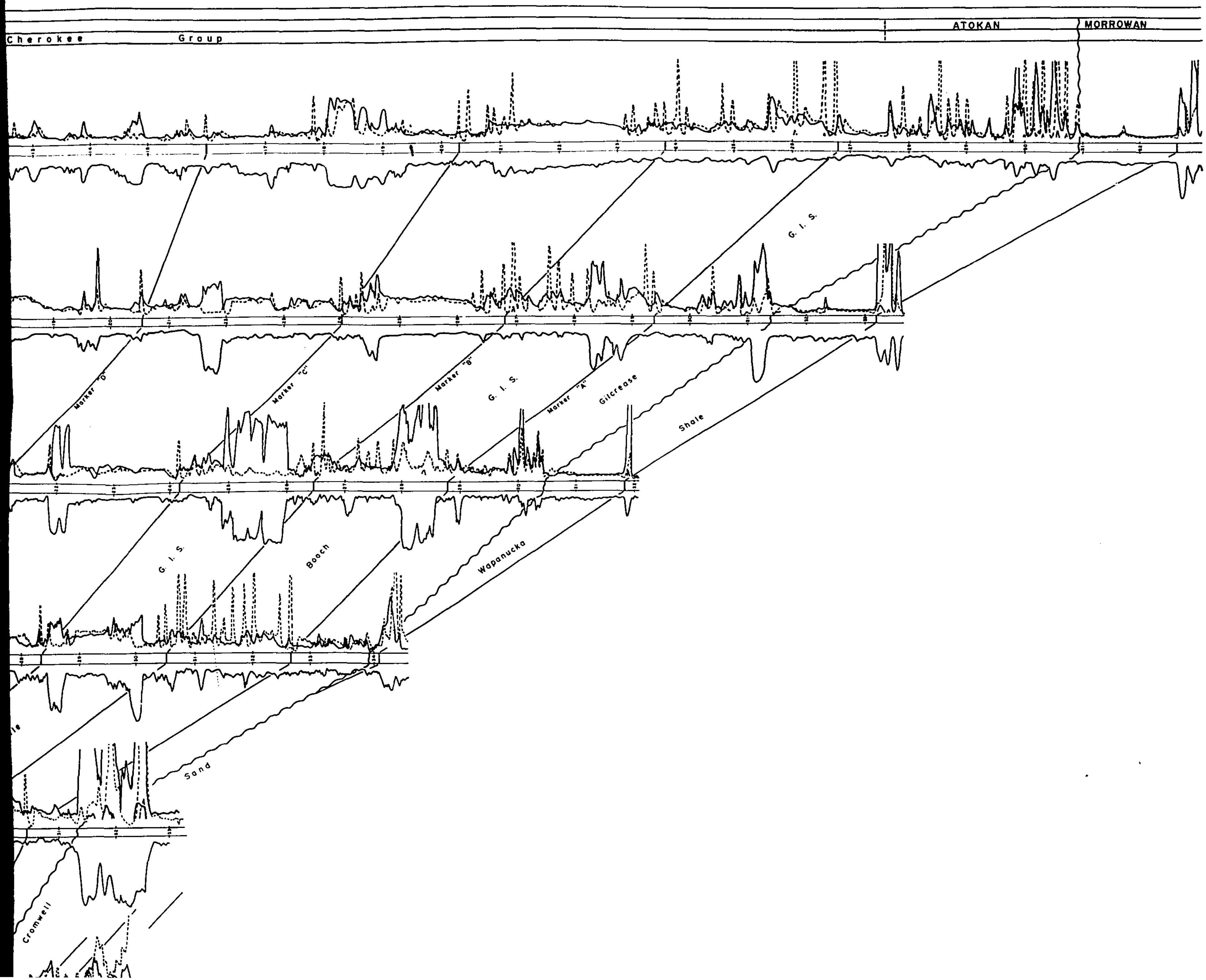

VERTICAL SCALE
300'
50
200'
50
100'
50
HORIZONTAL SCALE (APPROXIMATELY)
5 MILES
6 MILES
Profile Scale



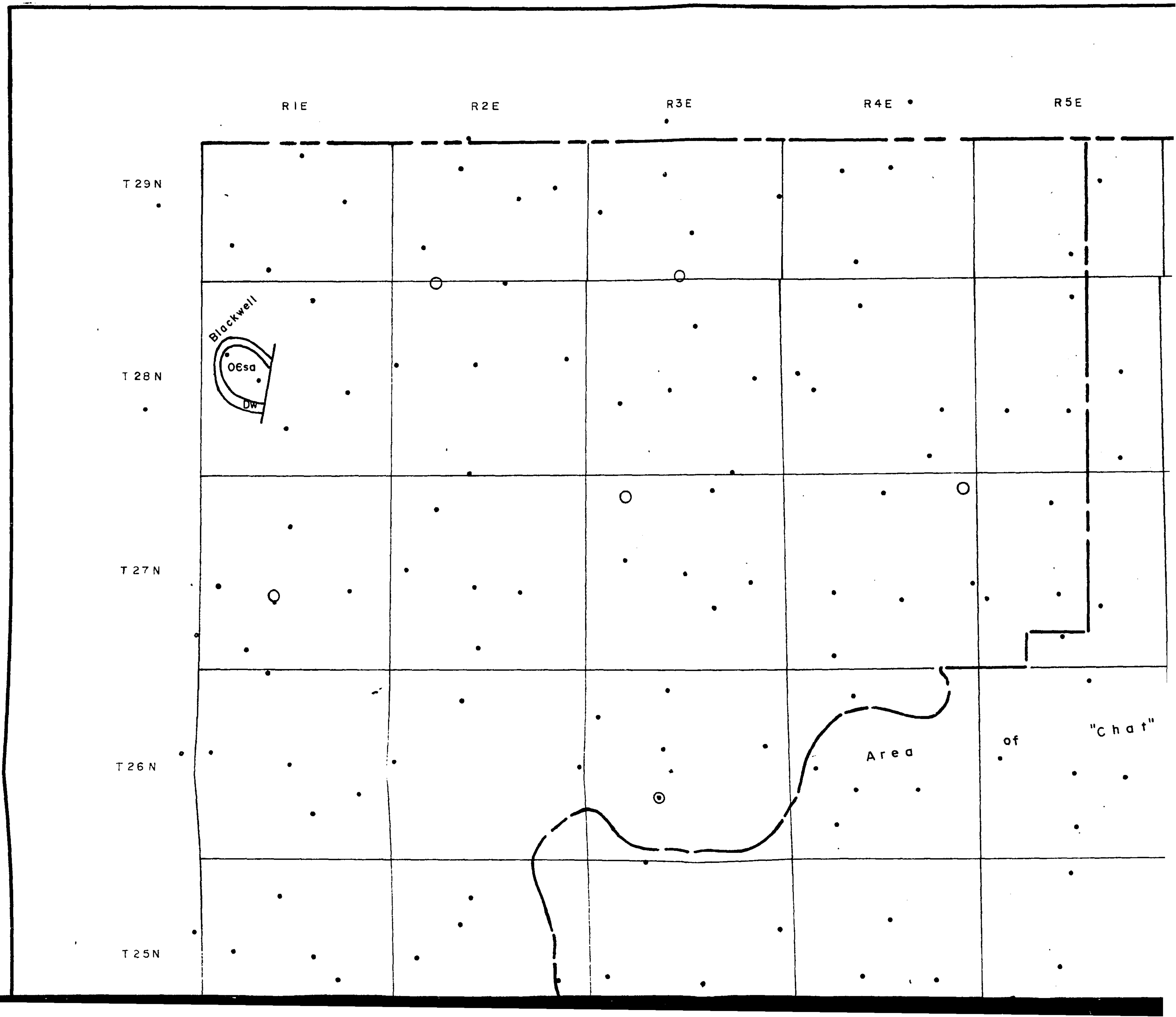
Cromwell
Member
Member



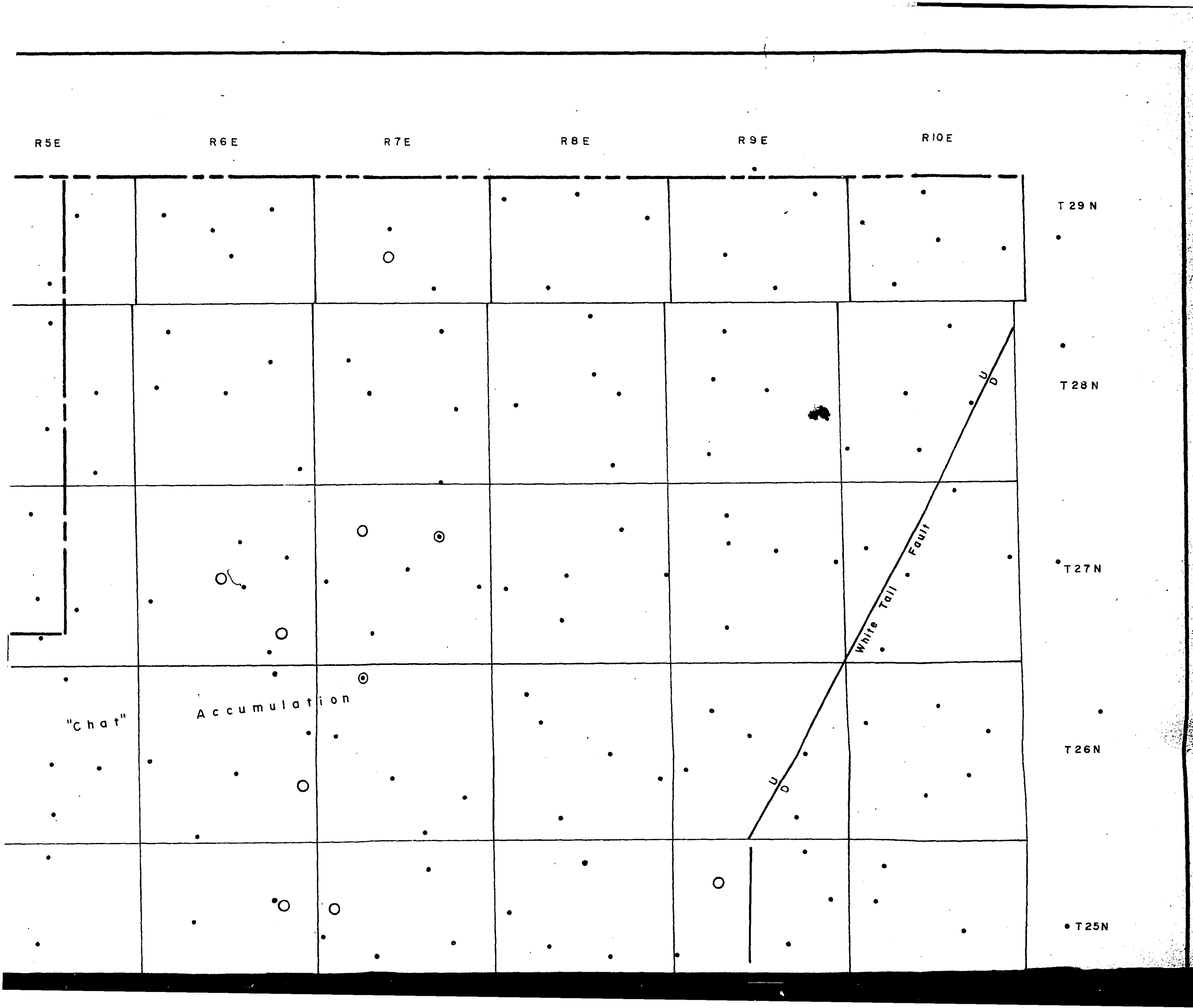
PENNSYLVANIAN SYSTEM
MISSISSIPPIAN
MISSOURIAN
DESMOINESIAN SERIES
OSAGIAN
Marmaton Group
Cherokee Group
"Osage"
B'
30
Shale
Horizon
Horizon
Horizon
Horizon
G I S



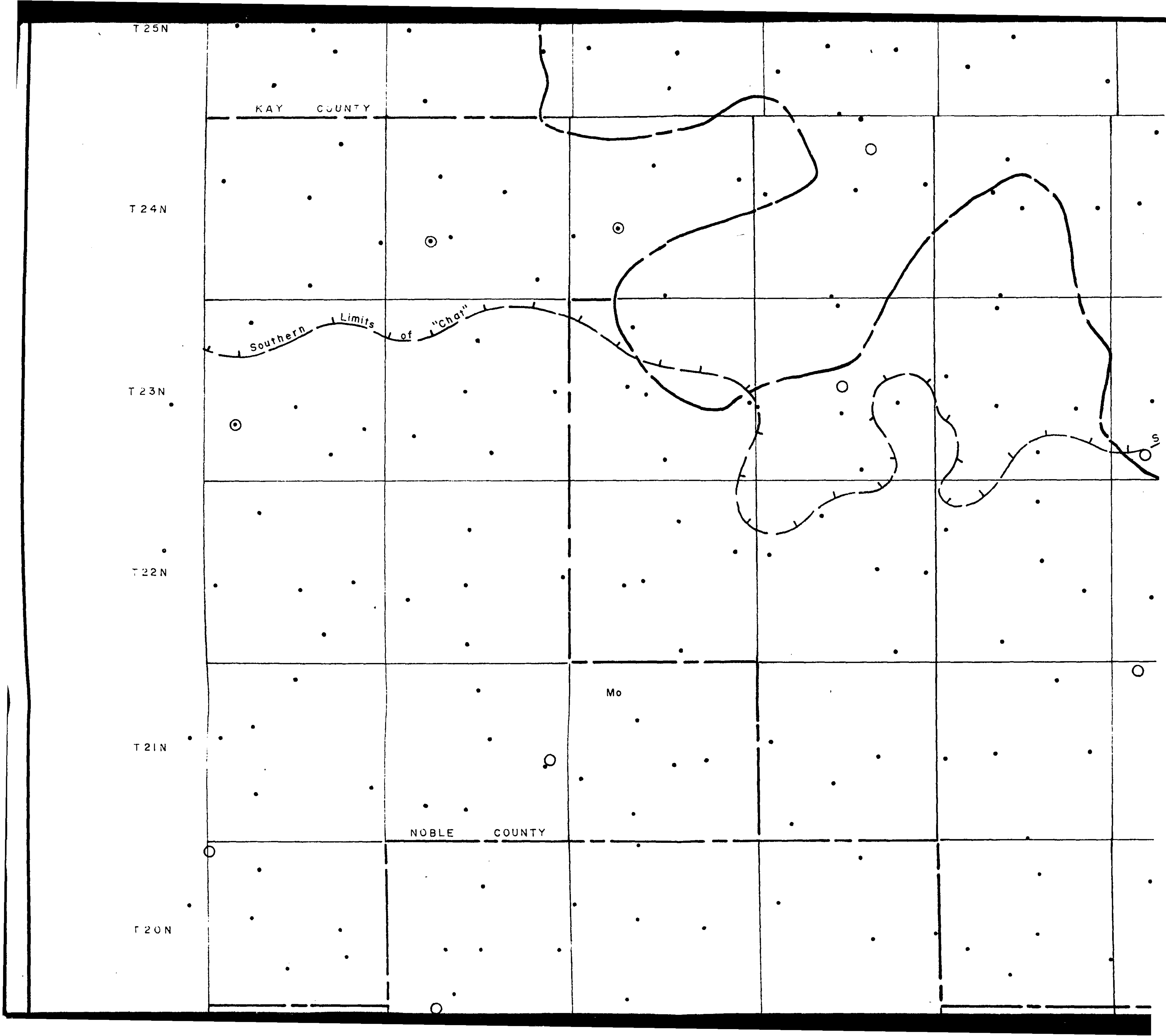
Cherokee Group
ATOKAN
MORROWAN
G. I. S.
Marker "D"
Marker "C"
Marker "B"
G. I. S.
Marker "A"
Gilcrease
Shale
G. I. S.
Booch
Wapanucka
Sand
Cromwell

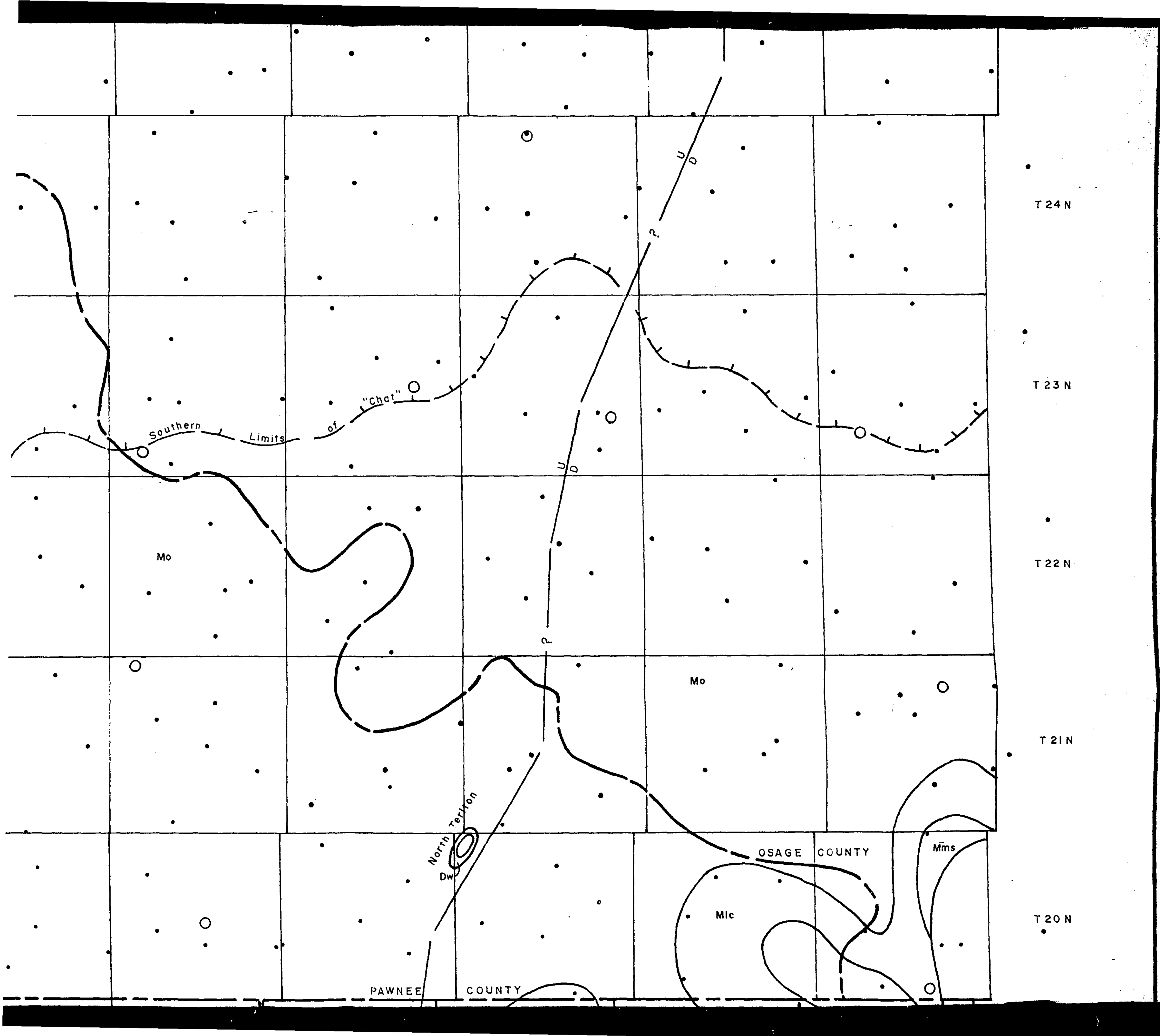


R1E
R2E
R3E
R4E
R5E
T29N
T28N
T27N
T26N
T25N
Blackwell
OЄsa
Dw
Area of "Chat"

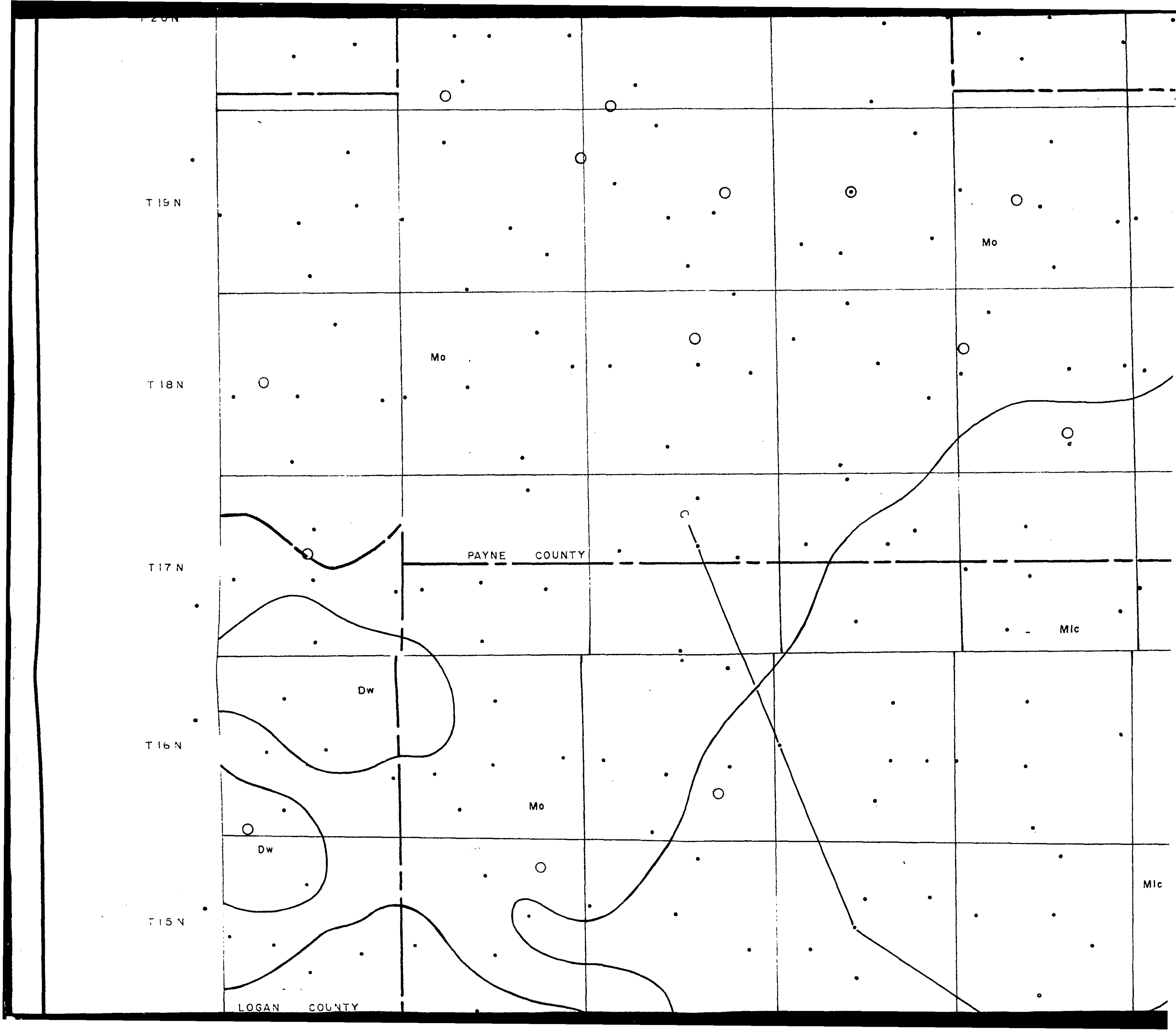


R5E
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
"Chat" Accumulation
White Tail Fault
U
D
U
D

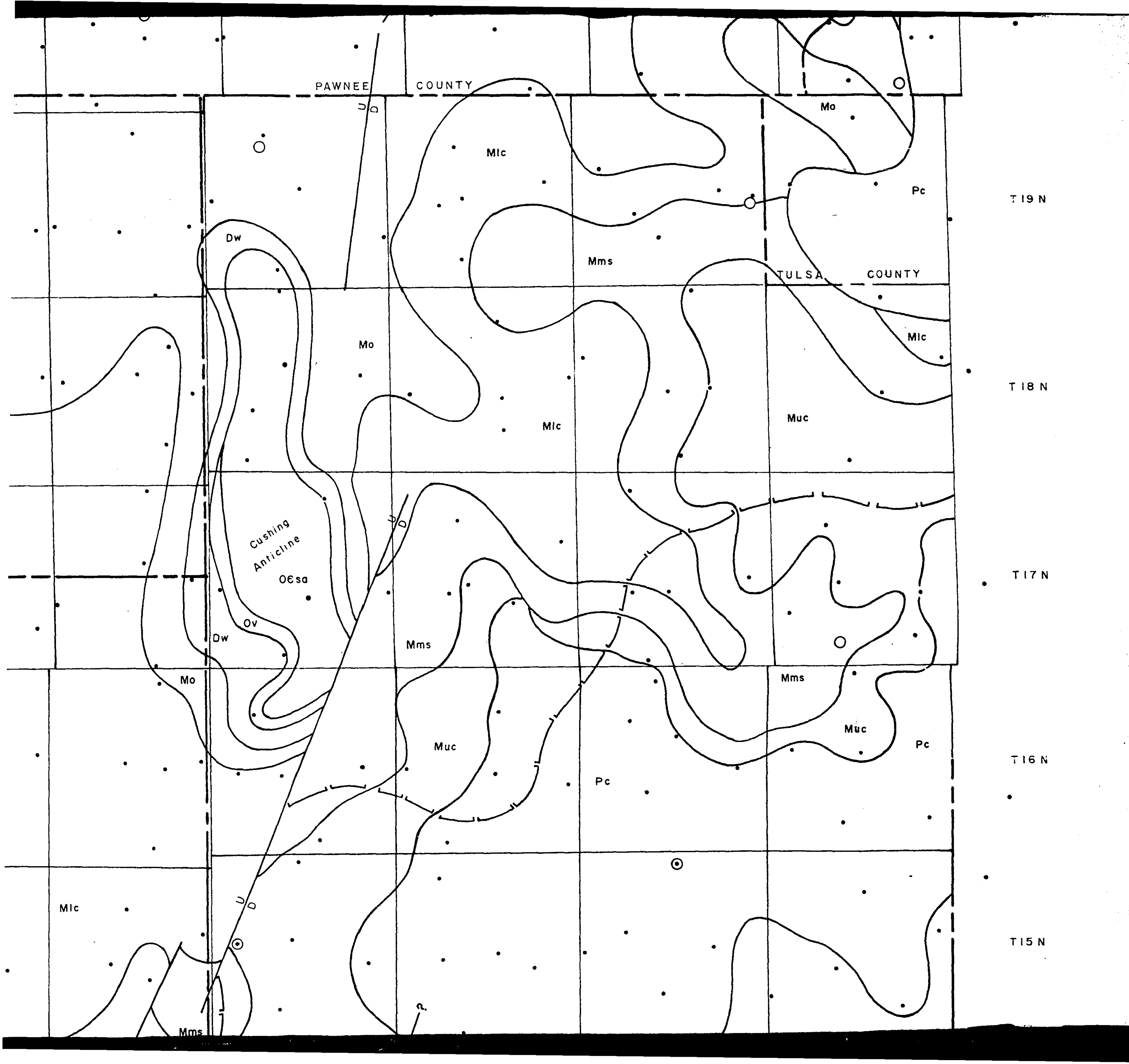

T 25 N
KAY COUNTY
T 24 N
Southern Limits of "Chat"
T 23 N
S
T 22 N
Mo
T 21 N
NOBLE COUNTY
T 20 N



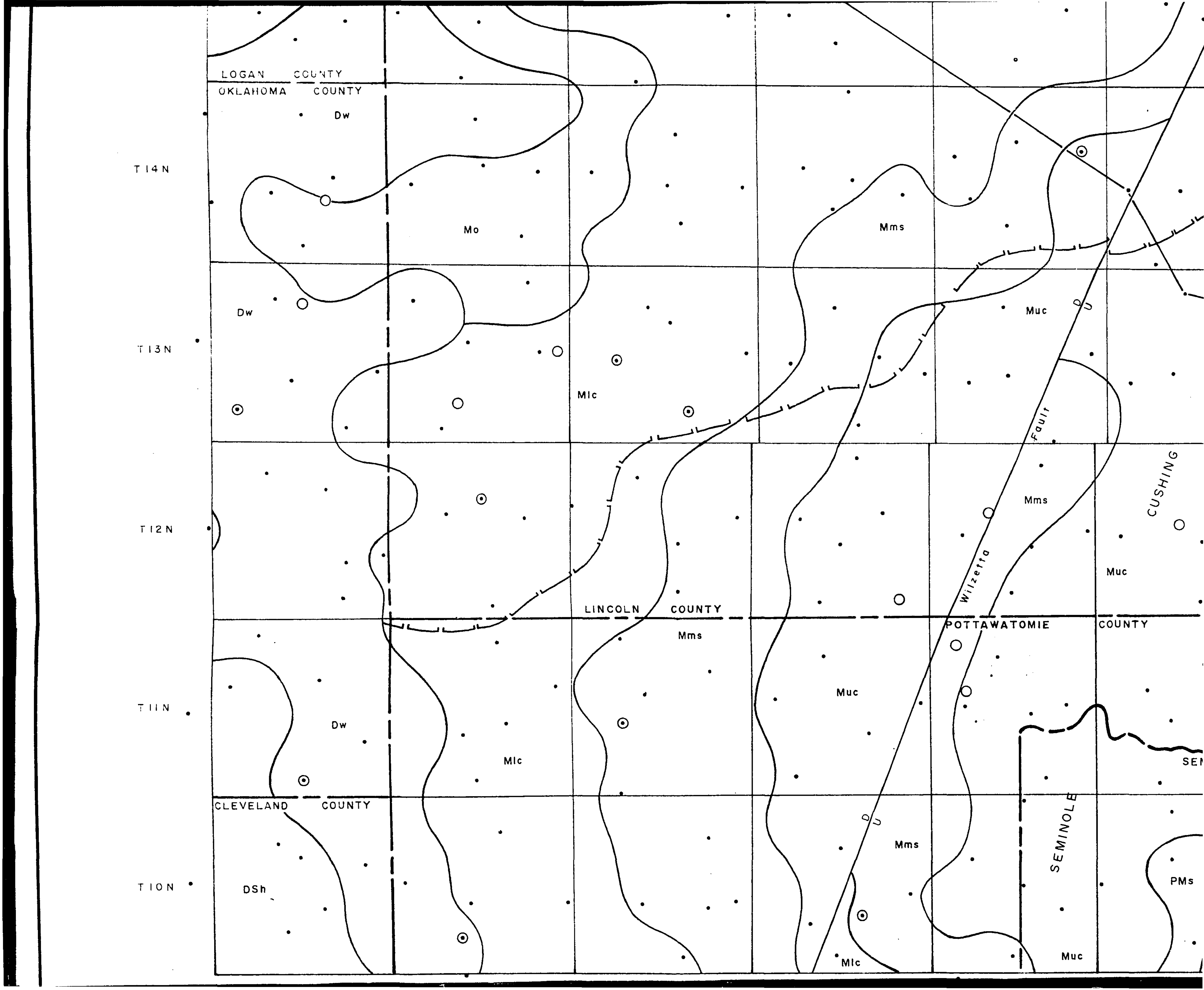
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
U
D
?
Southern Limits of "Chat"
Mo
Mo
North Terlton
Dw
OSAGE COUNTY
PAWNEE COUNTY
Mlc
Mms



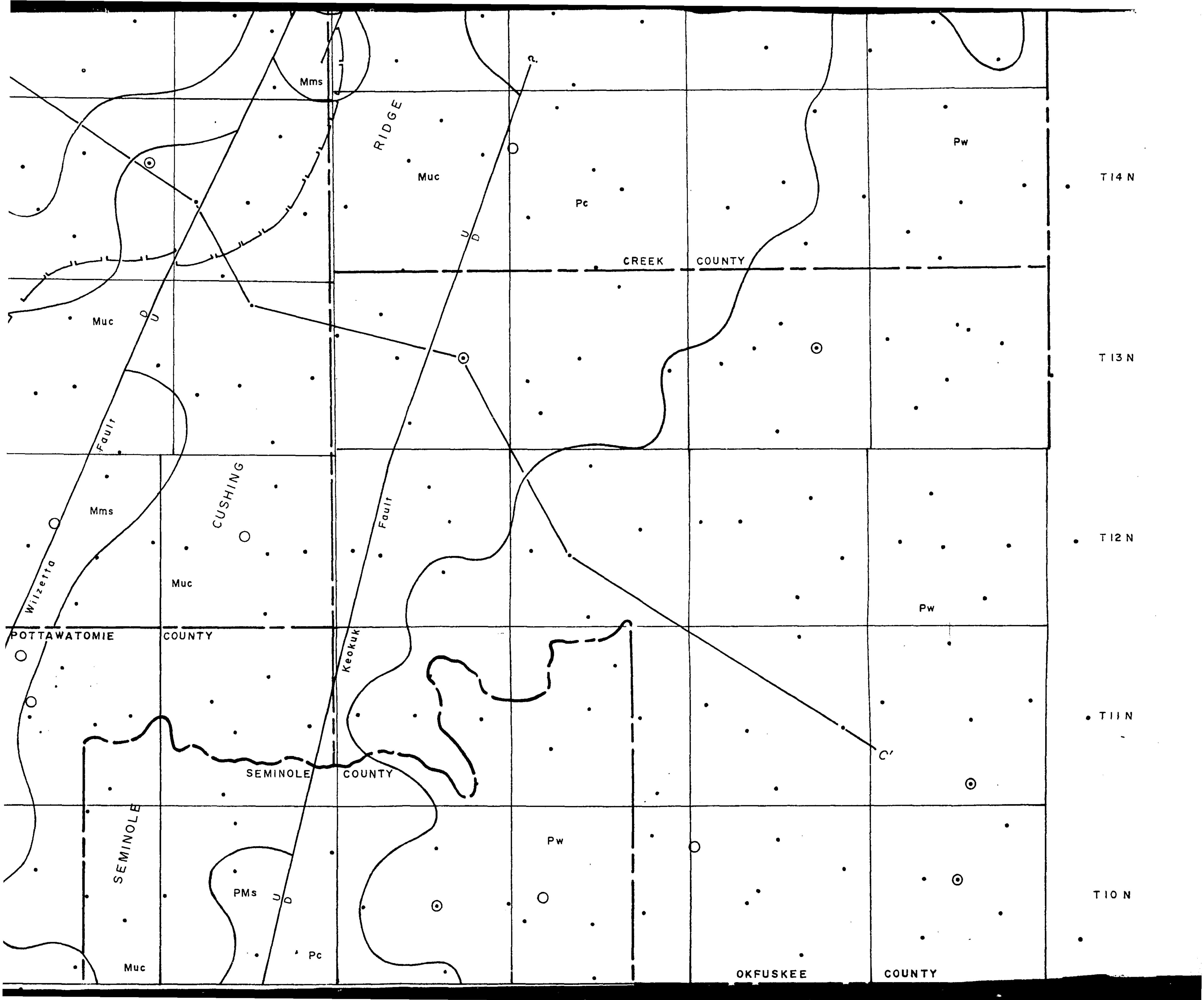
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
Mo
Mo
Mo
PAYNE COUNTY
Mlc
Mlc
Dw
Dw
LOGAN COUNTY

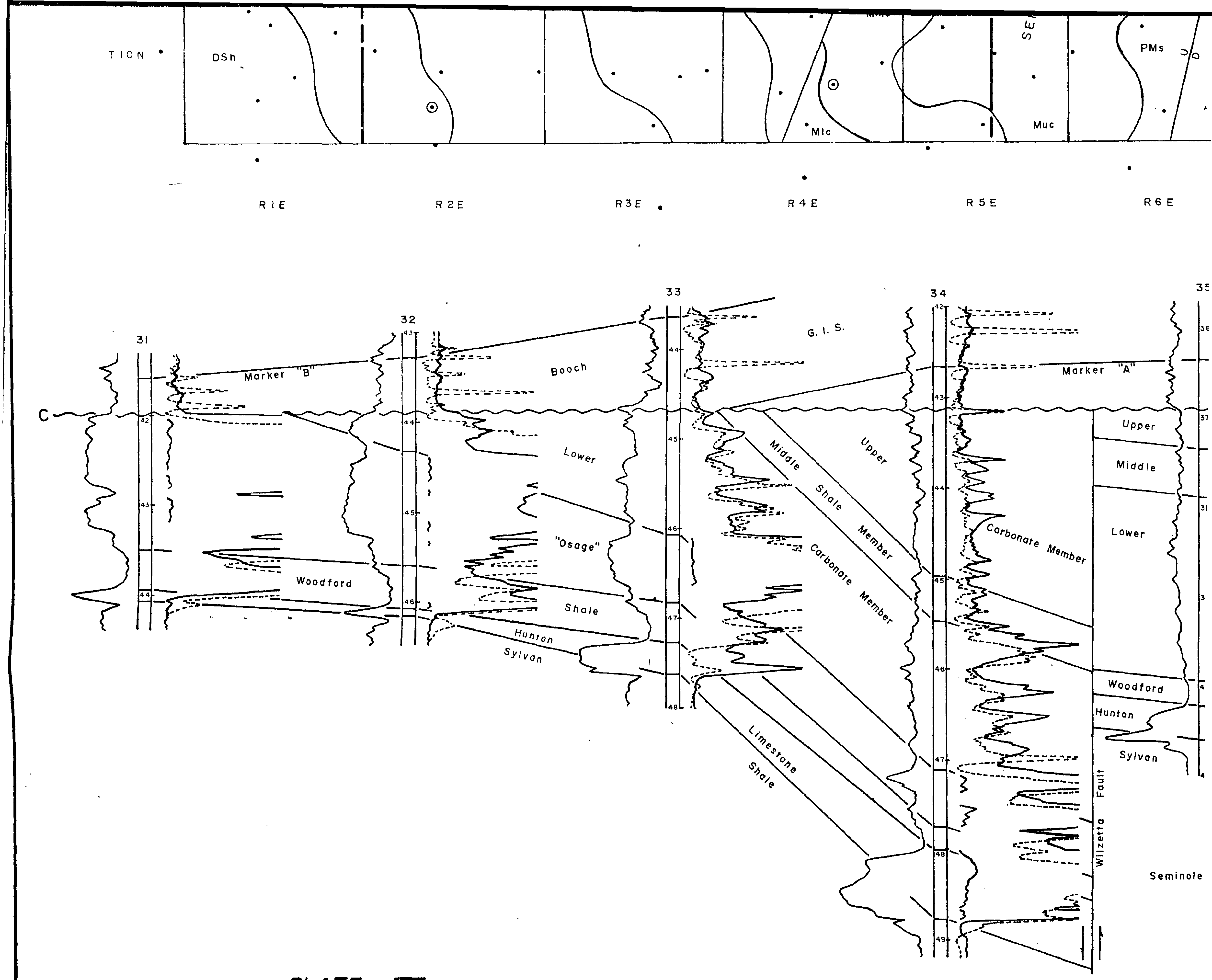


PAWNEE COUNTY
TULSA COUNTY
T19N
T18N
T17N
T16N
T15N
Cushing Anticline
OЄsa
Ov
Dw
Mo
Mlc
Mms
Muc
Pc
U
D

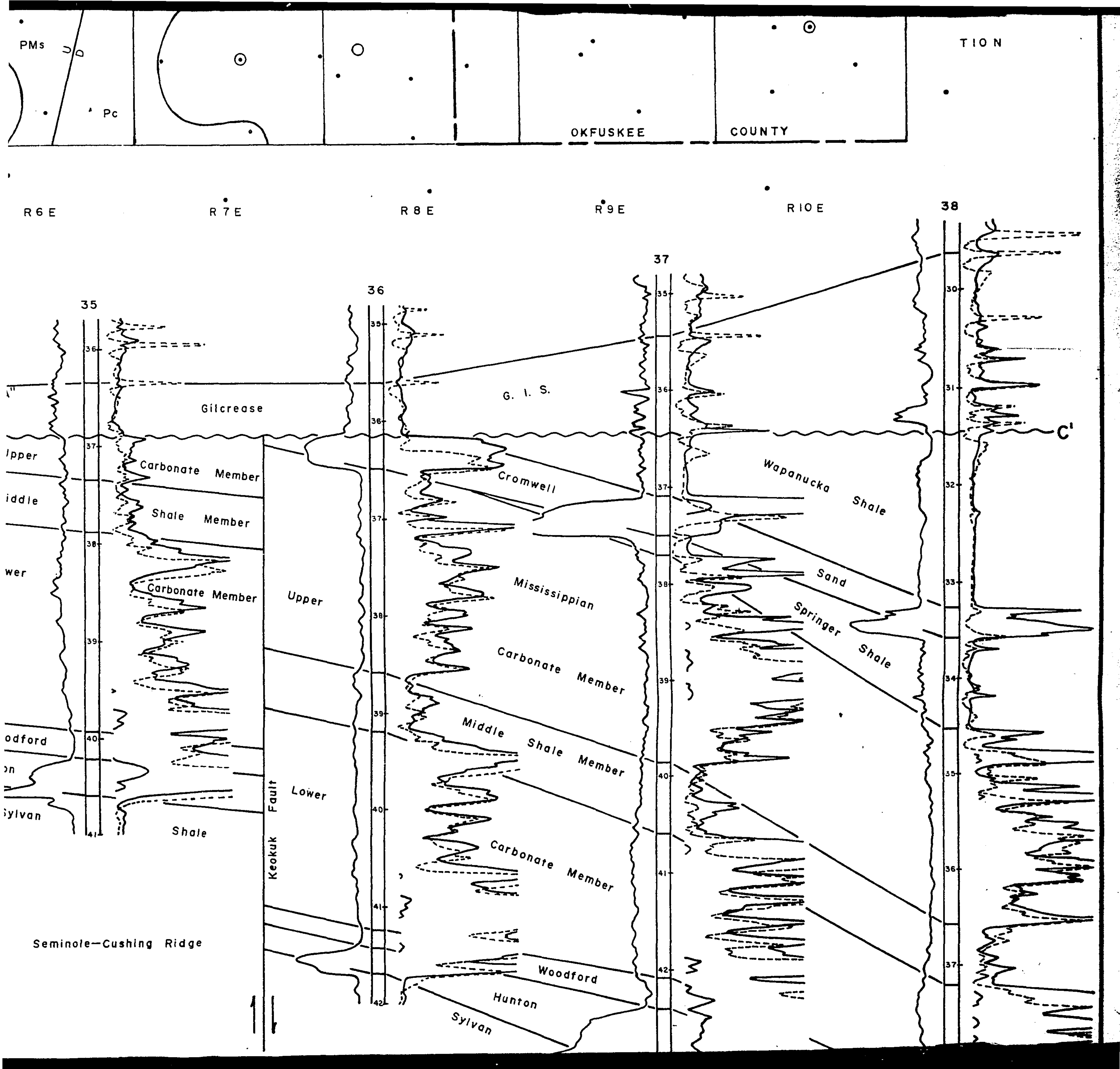


T14N
T13N
T12N
T11N
T10N
LOGAN COUNTY
OKLAHOMA COUNTY
Dw
Mo
Mms
Muc
D
U
Mlc
Dw
Mms
CUSHING
Wilzetta
Fault
LINCOLN COUNTY
POTTAWATOMIE COUNTY
Mms
Muc
Dw
Mlc
SEM
CLEVELAND COUNTY
SEMINOLE
Mms
PMs
DSh
Mlc
Muc


Mms
RIDGE
Muc
Pc
Pw
T14N
CREEK COUNTY
Muc
T13N
Wilzetta Fault
CUSHING
Mms
Keokuk Fault
T12N
Muc
Pw
POTTAWATOMIE COUNTY
T11N
C'
SEMINOLE COUNTY
SEMINOLE
Pw
PMs
T10N
Pc
Muc
OKFUSKEE COUNTY



TION
DSh
Mlc
Muc
PMs
SE
U
D
R1E
R2E
R3E
R4E
R5E
R6E
31
32
33
34
35
C
Marker "B"
Booch
G. I. S.
Marker "A"
Lower
"Osage"
Woodford
Shale
Hunton
Sylvan
Middle
Shale
Member
Upper
Carbonate Member
Carbonate Member
Limestone
Shale
Upper
Middle
Lower
Woodford
Hunton
Sylvan
Wilzetta Fault
Seminole



PMs
U
D
Pc
TION
OKFUSKEE
COUNTY
R6E
R7E
R8E
R9E
R10E
35
36
37
38
Gilcrease
G. I. S.
C'
Carbonate Member
Shale Member
Carbonate Member
Upper
Lower
Shale
Keokuk Fault
Cromwell
Mississippian
Carbonate Member
Middle Shale Member
Carbonate Member
Woodford
Hunton
Sylvan
Wapanucka Shale
Sand
Springer Shale
Seminole—Cushing Ridge

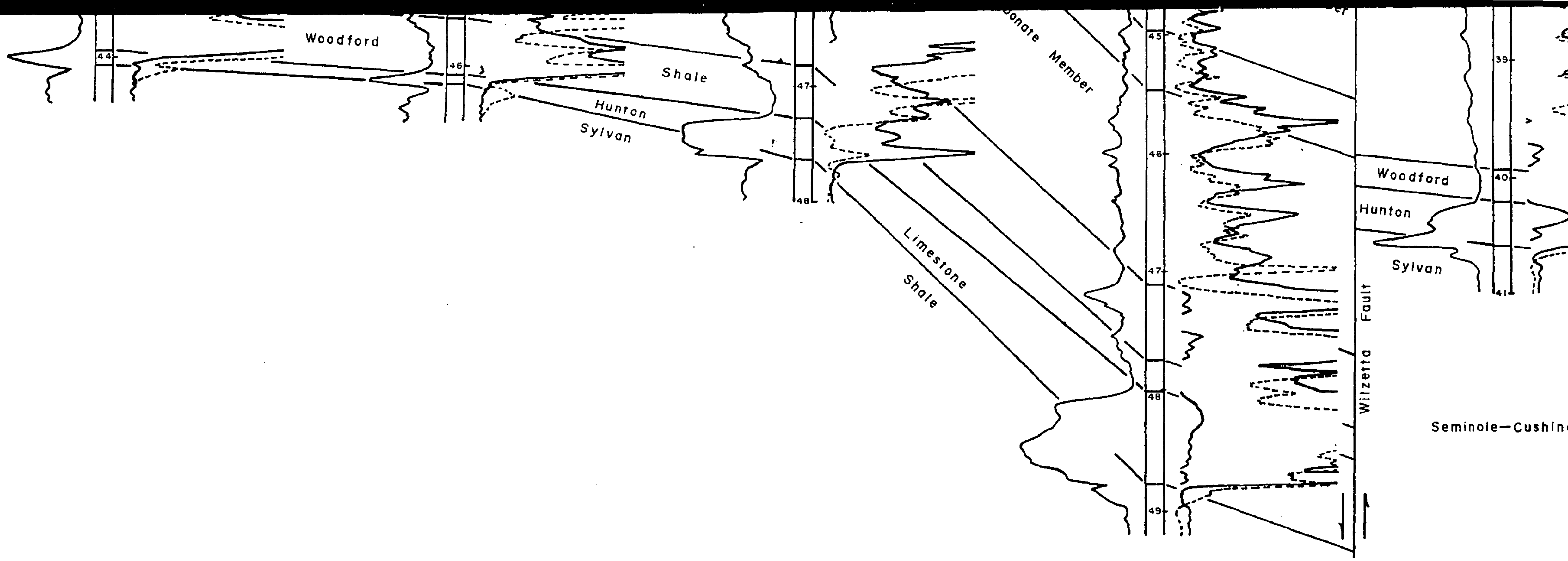


PLATE III

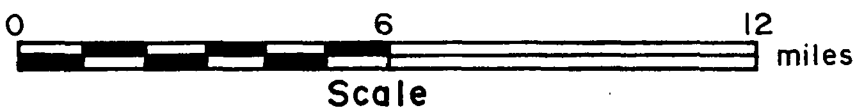
PRE-DESMOINESIAN SUBCROP MAP

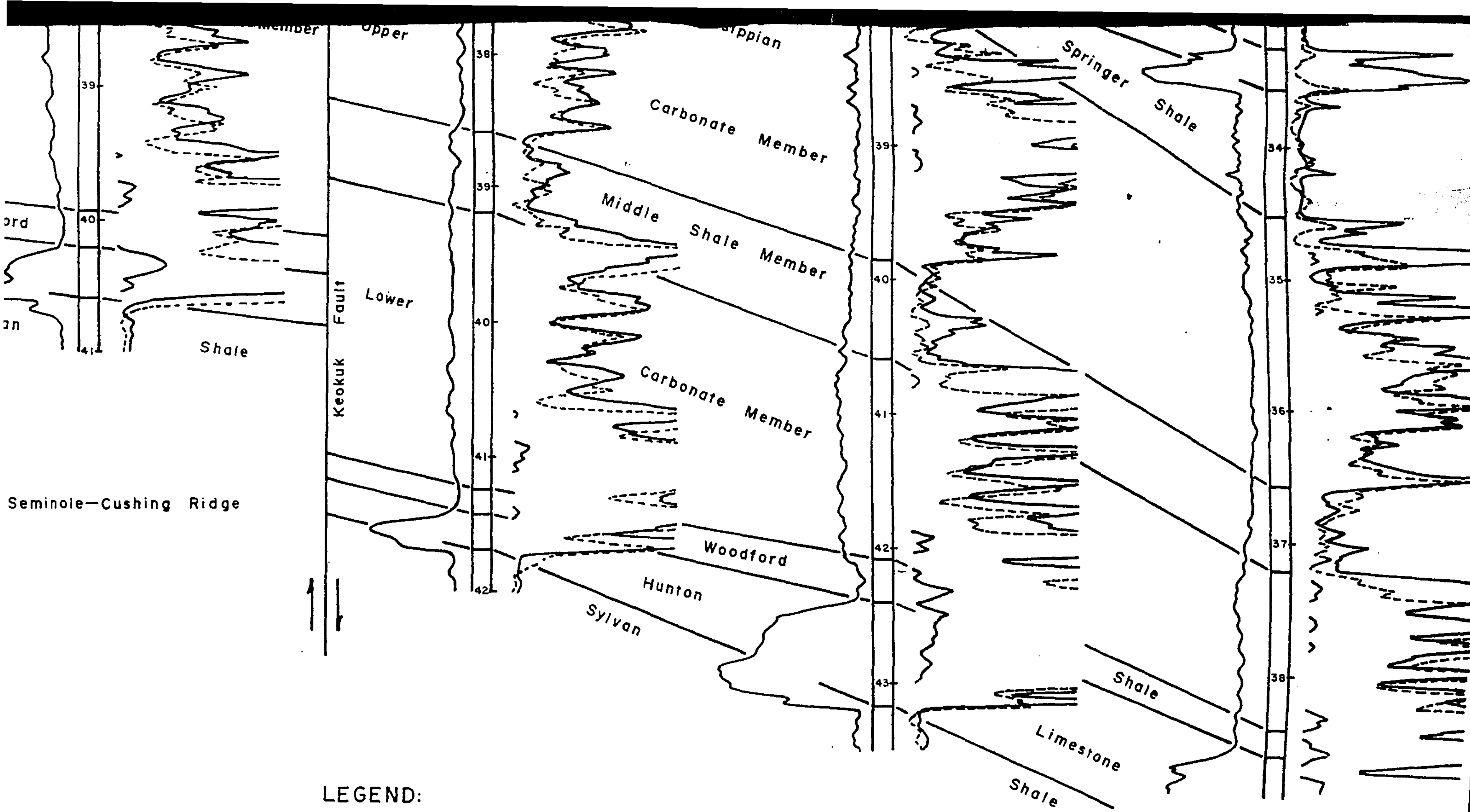
AND

STRATIGRAPHIC PROFILE CC'

by

J. Glenn Cole Ph. D. 1968





LEGEND:

- ● Control Well
- ○ Sample Control
- Southern Limits "Chat" Facies
- Southern Limits "Osage" Facies

Pennsylvanian

Pw	Wapanucka Shale
Pc	Cromwell Sand

Pennsylvanian–Mississippian

PMs	Springer Shale

Mississippian

Muc	Upper Carbonate Member
Mms	Middle Shale Member
Mlc	Lower Carbonate Member
Mo	"Osage" and "Chat"

Devonian

Dw	Woodford Shale

Devonian–Silurian

DSh	Hunton Limestone

Silurian

Ss	Sylvan Shale

Ordovician

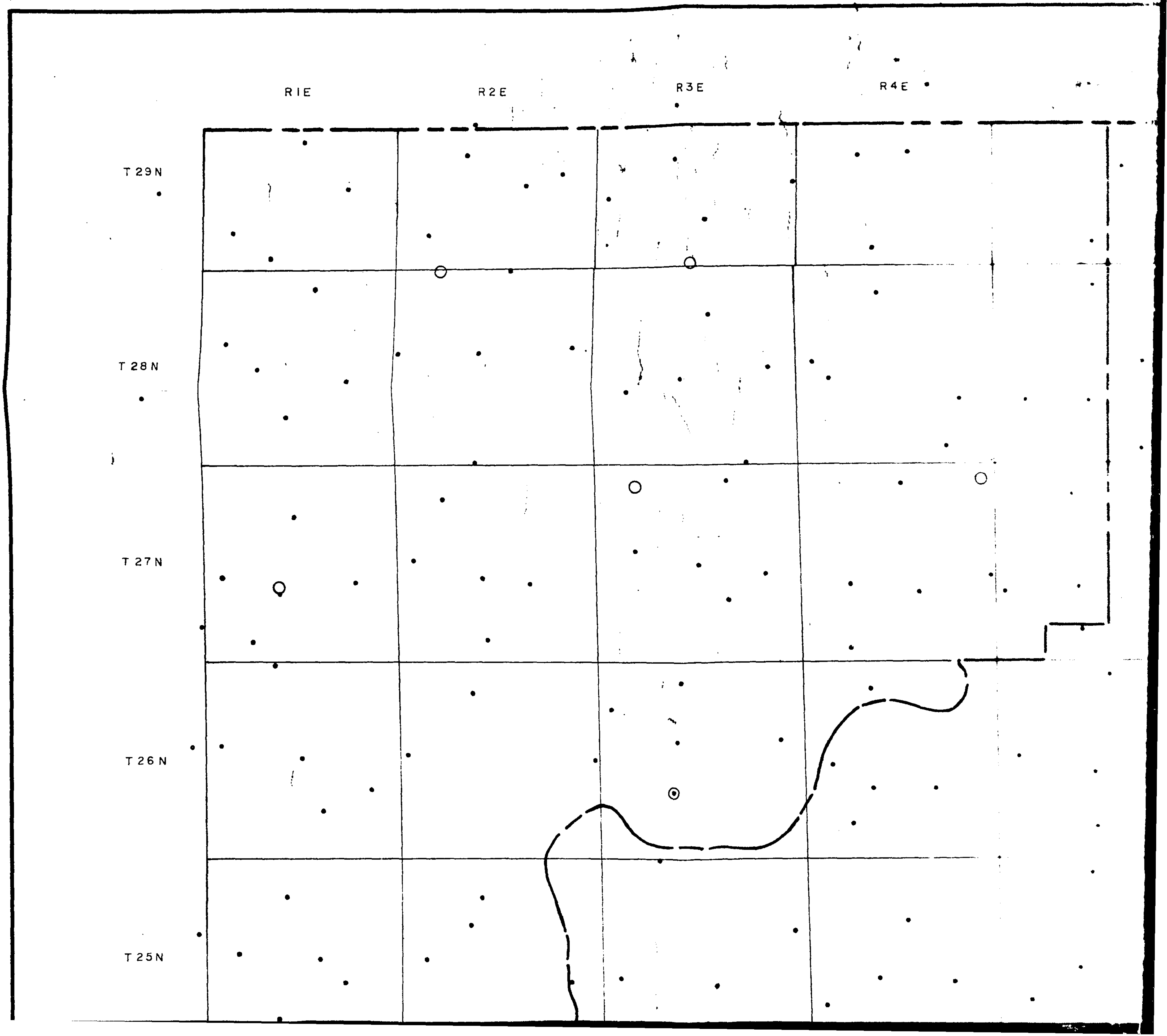
Ov	Viola Limestone

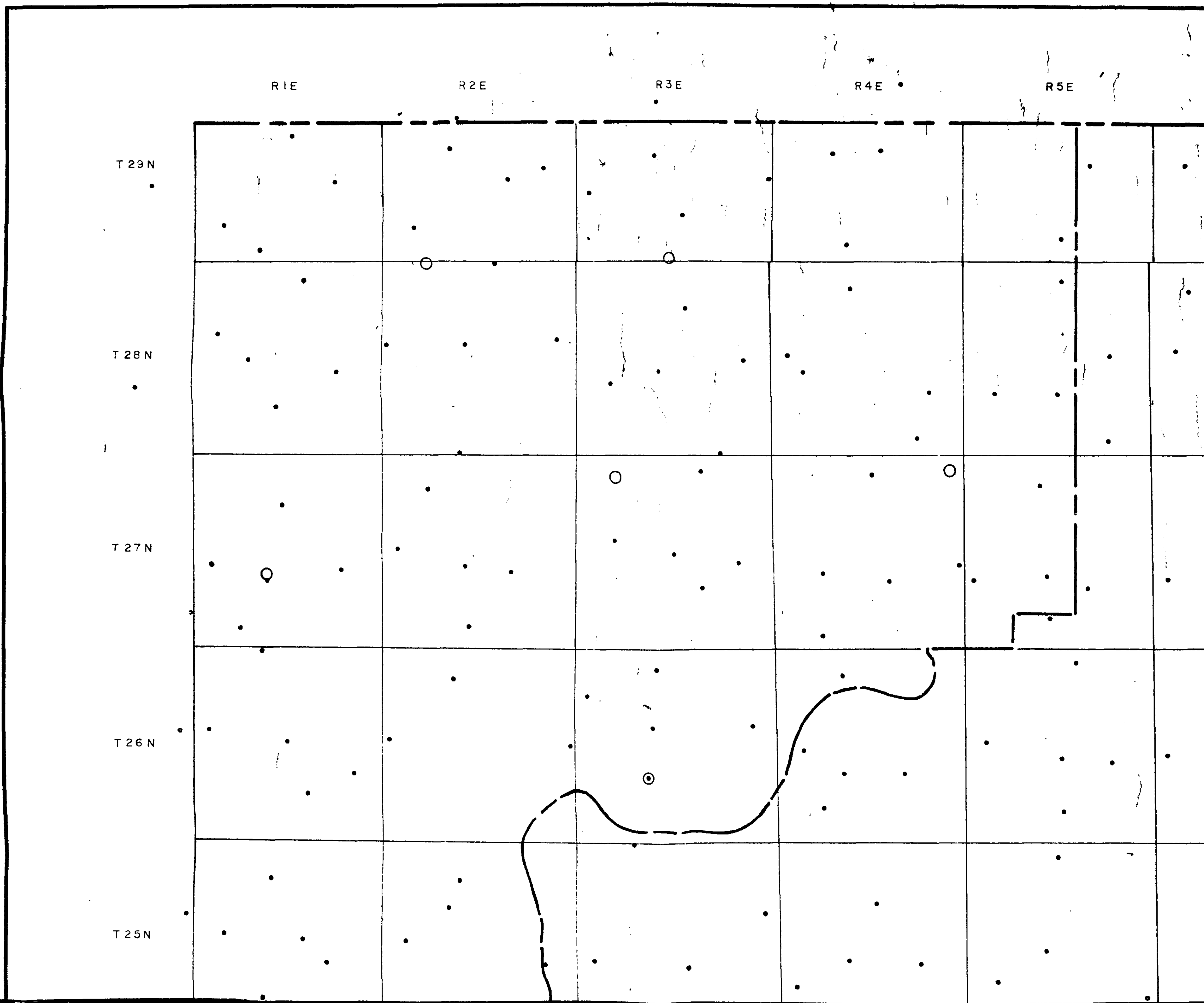
Ordovician – Cambrian

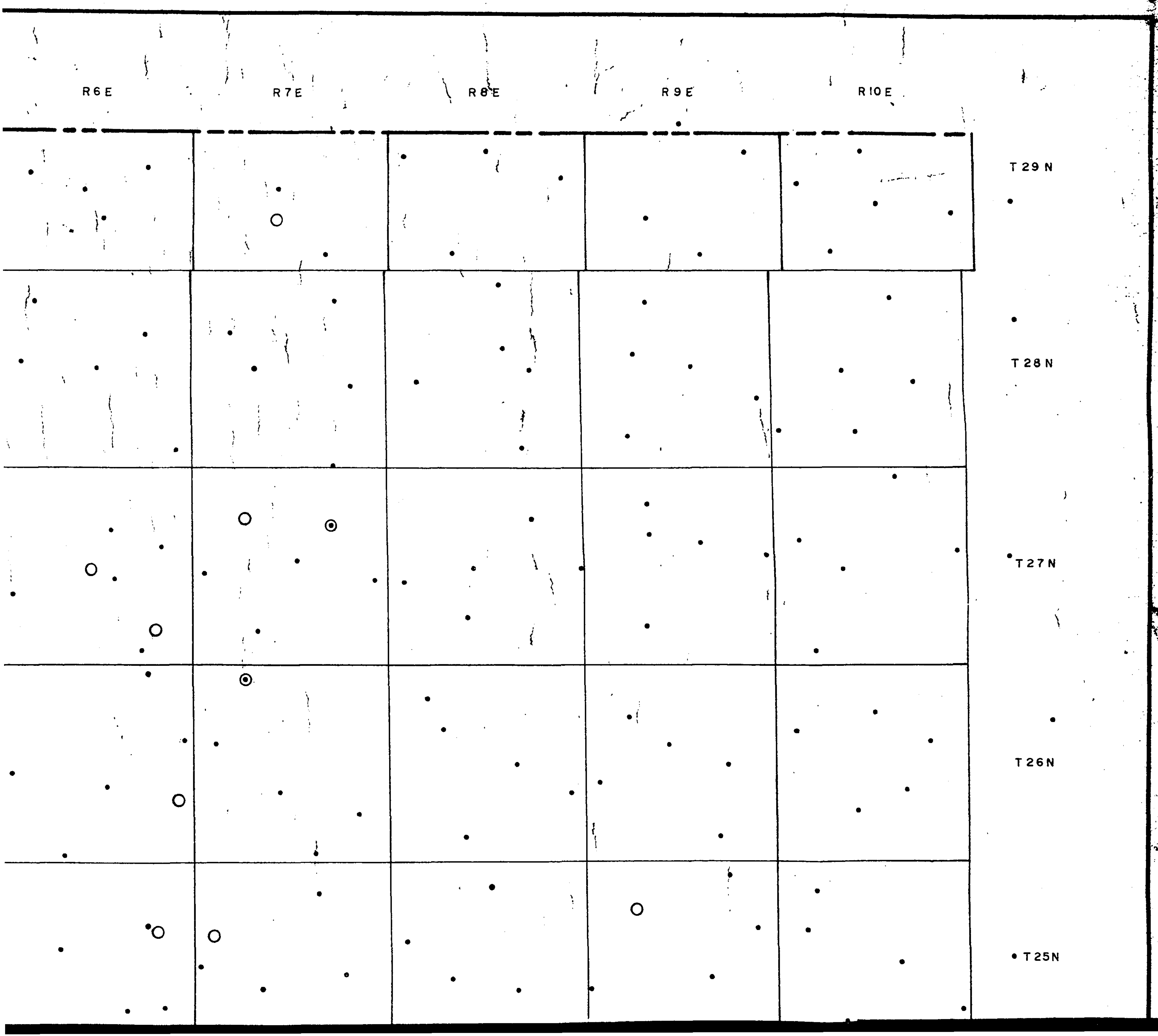
O€sa	Simpson – Arbuckle Groups

VERTICAL SCALE 100' 50'

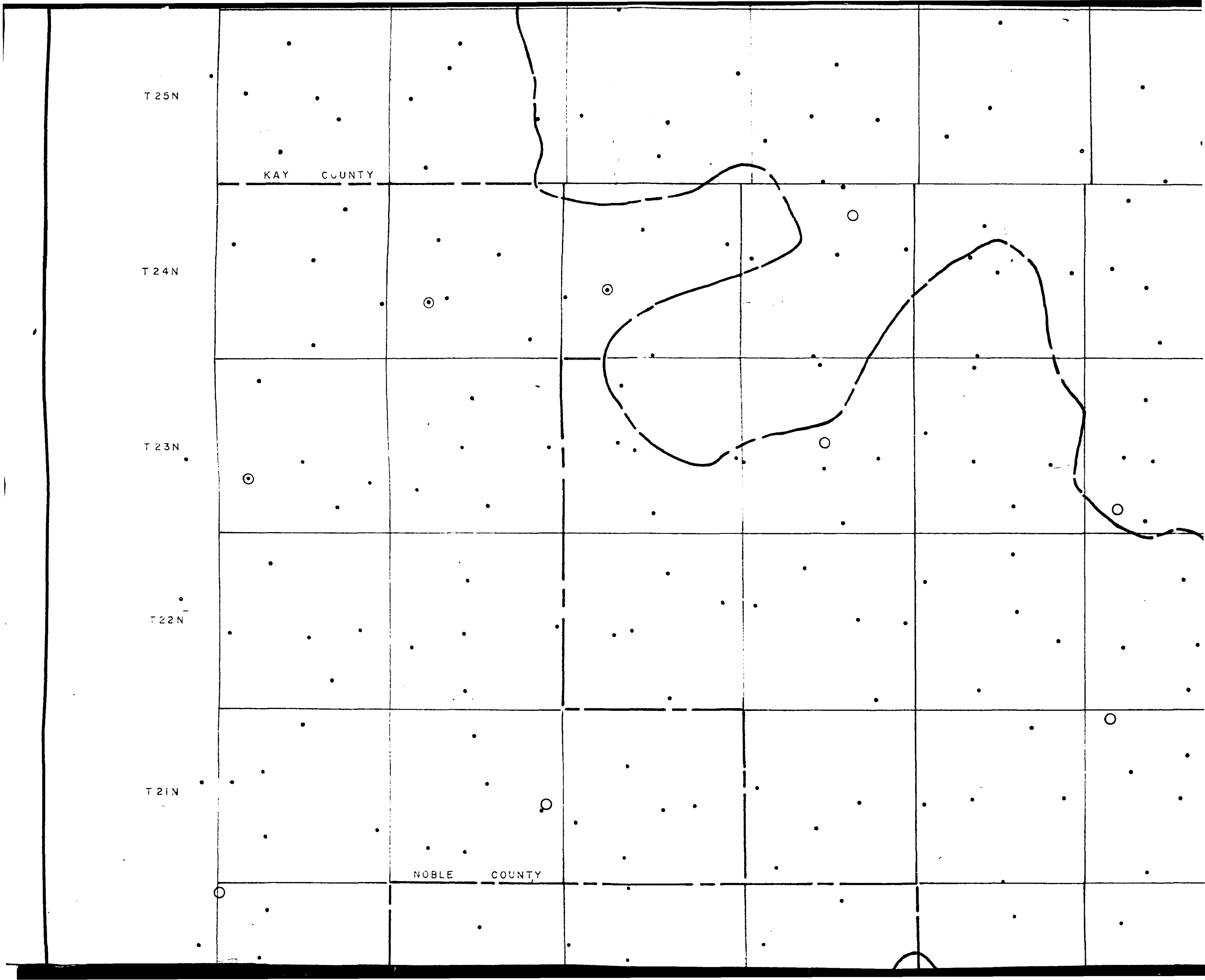
NO HORIZONTAL SCALE

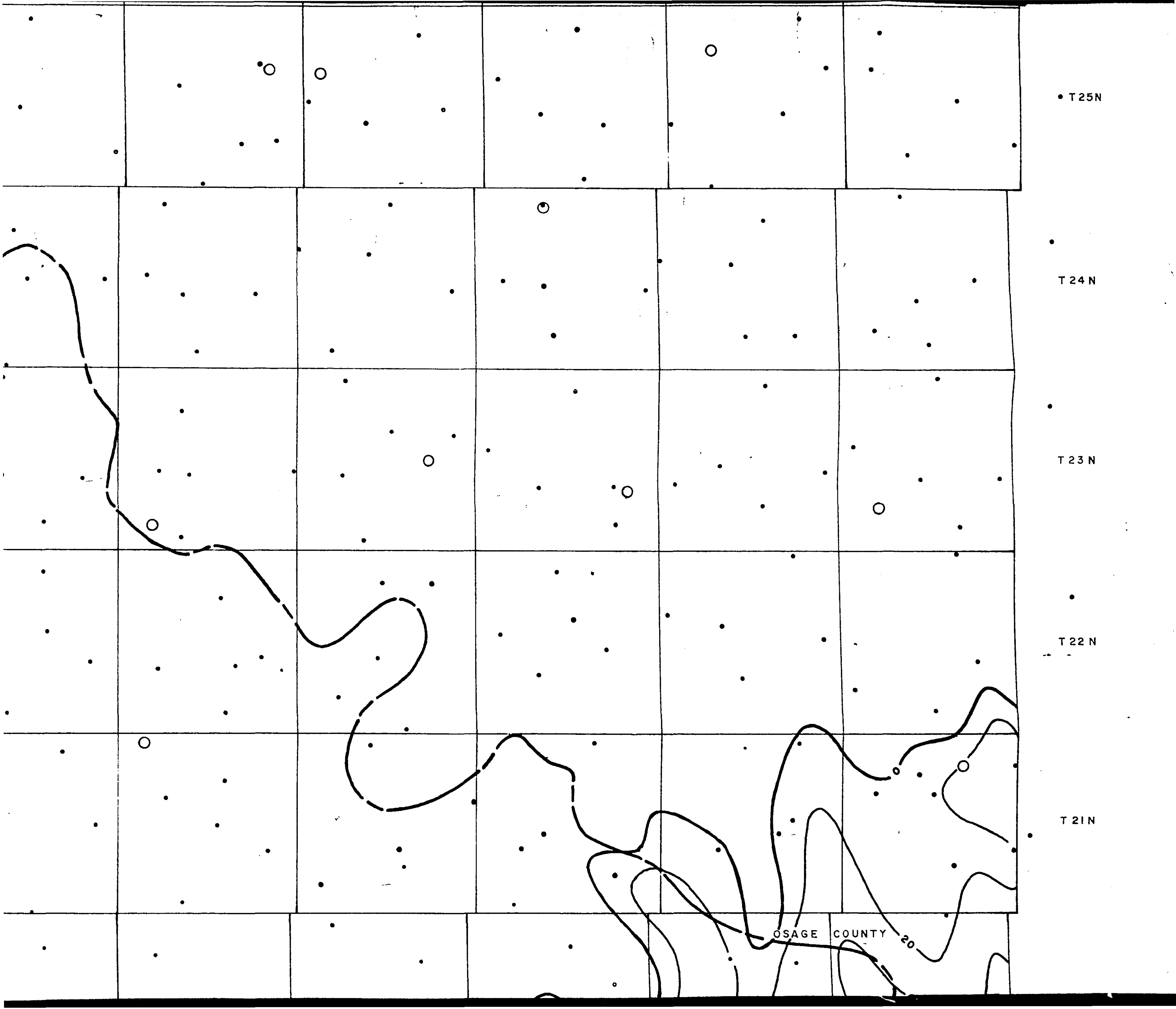

R1E
R2E
R3E
R4E
T29N
T28N
T27N
T26N
T25N


R1E
R2E
R3E
R4E
R5E
T29N
T28N
T27N
T26N
T25N

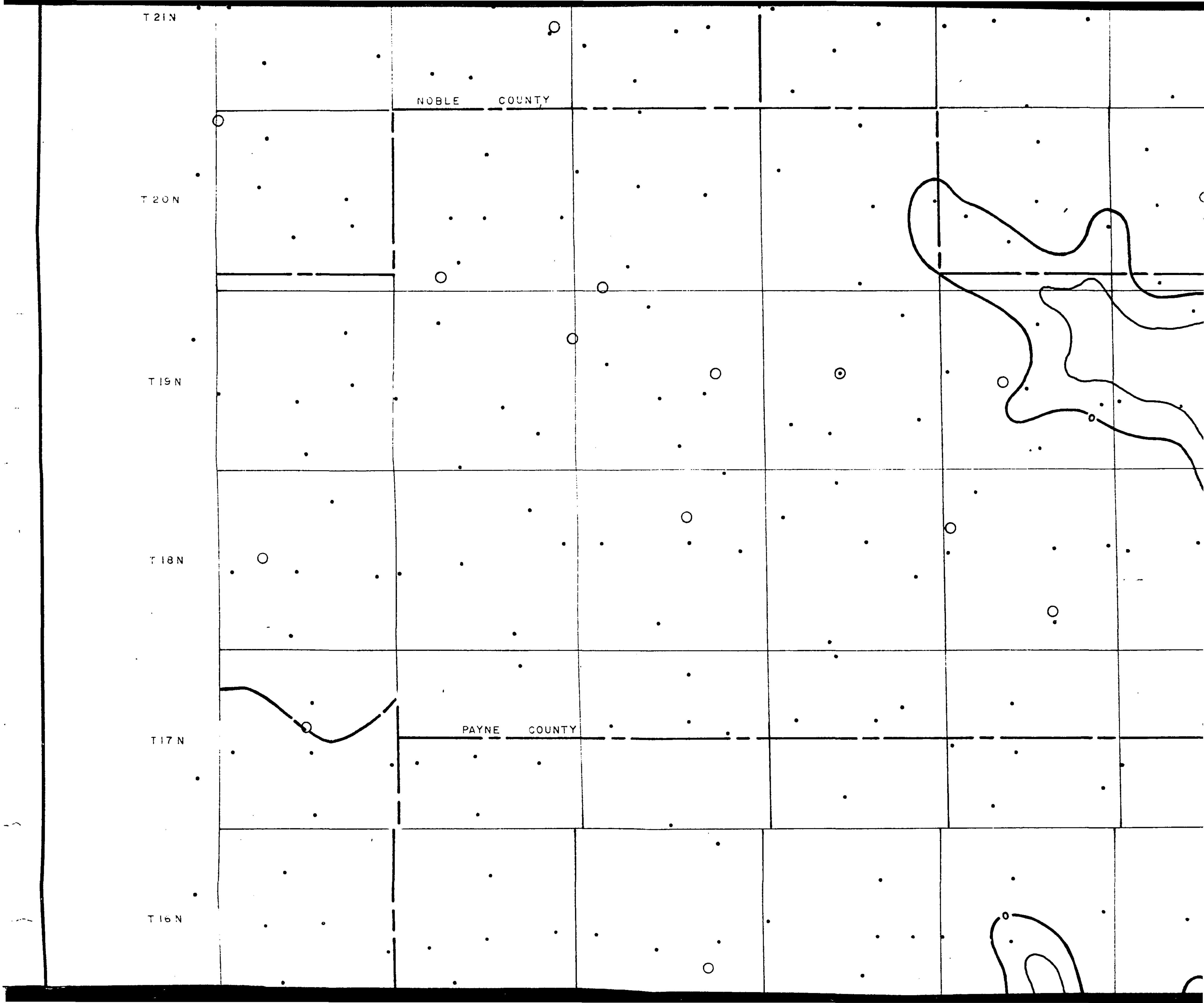


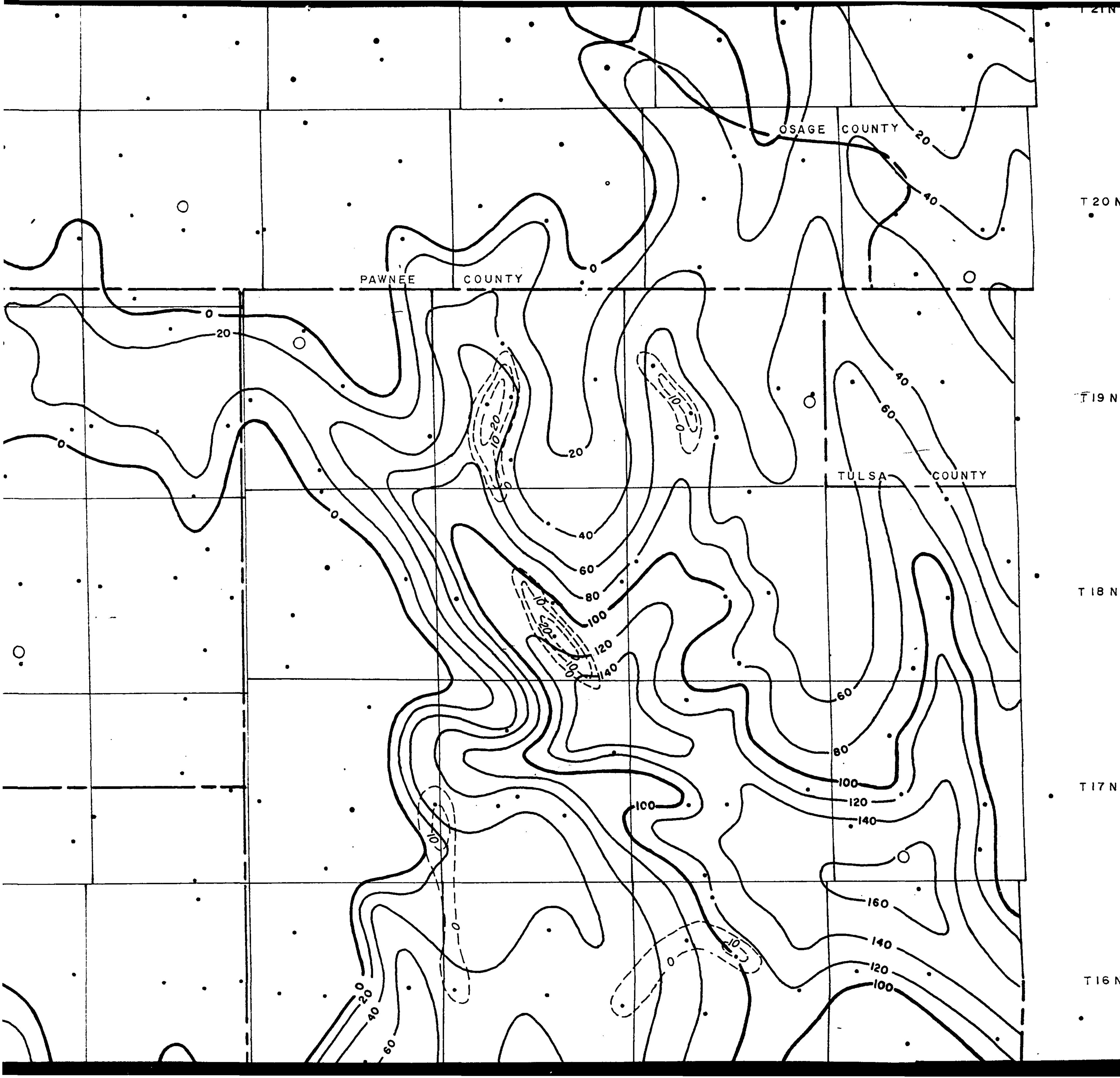
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N

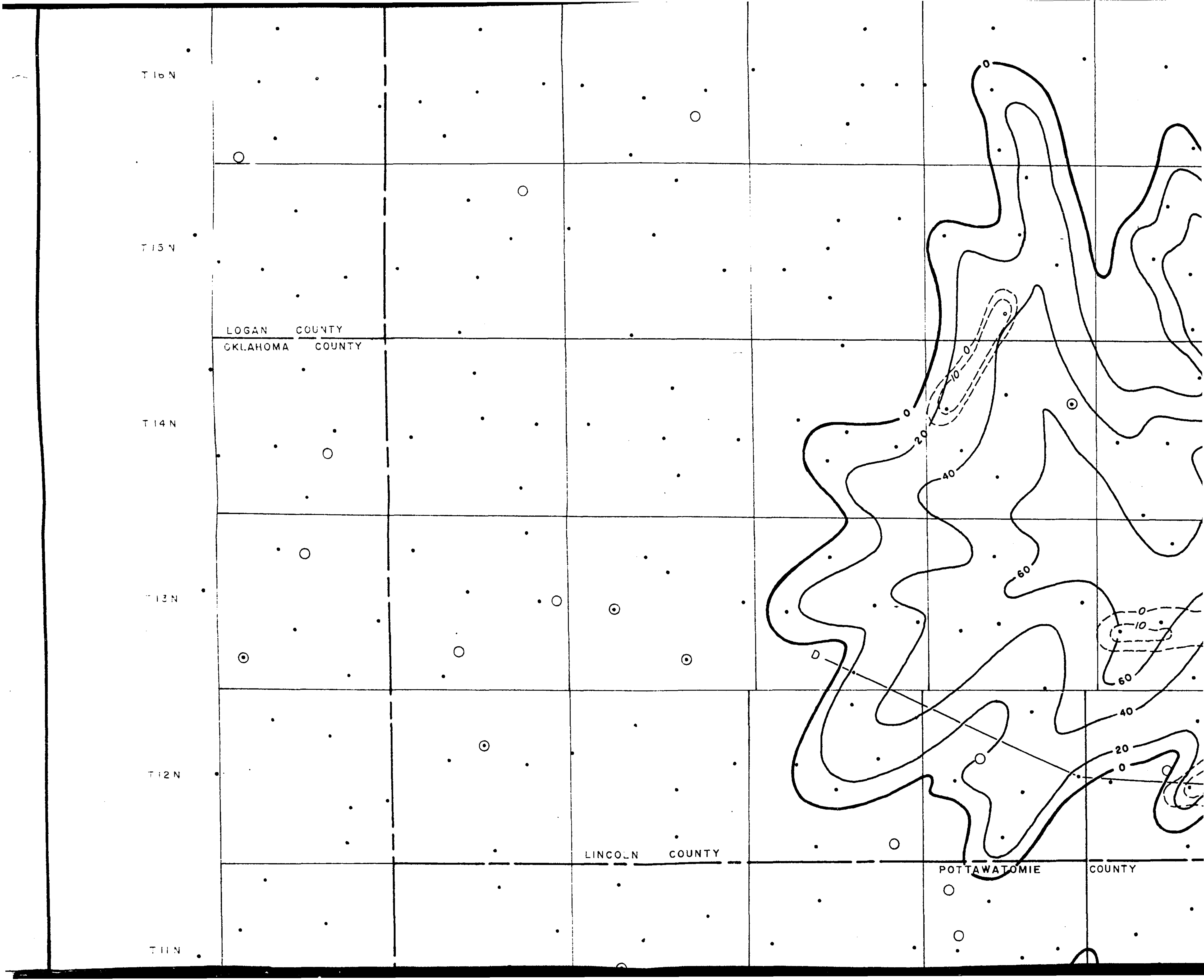

T 25N
KAY COUNTY
T 24N
T 23N
T 22N
T 21N
NOBLE COUNTY

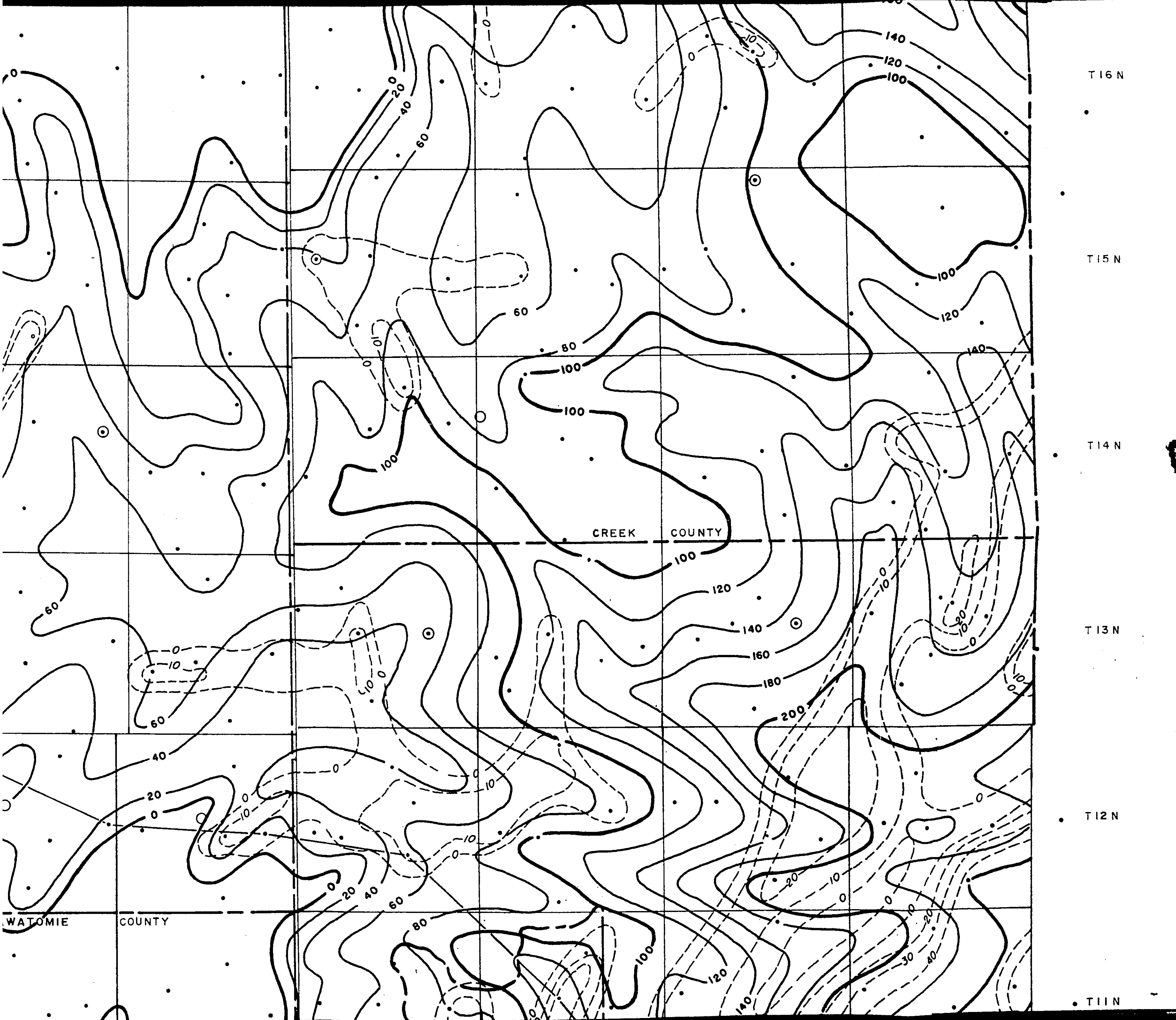


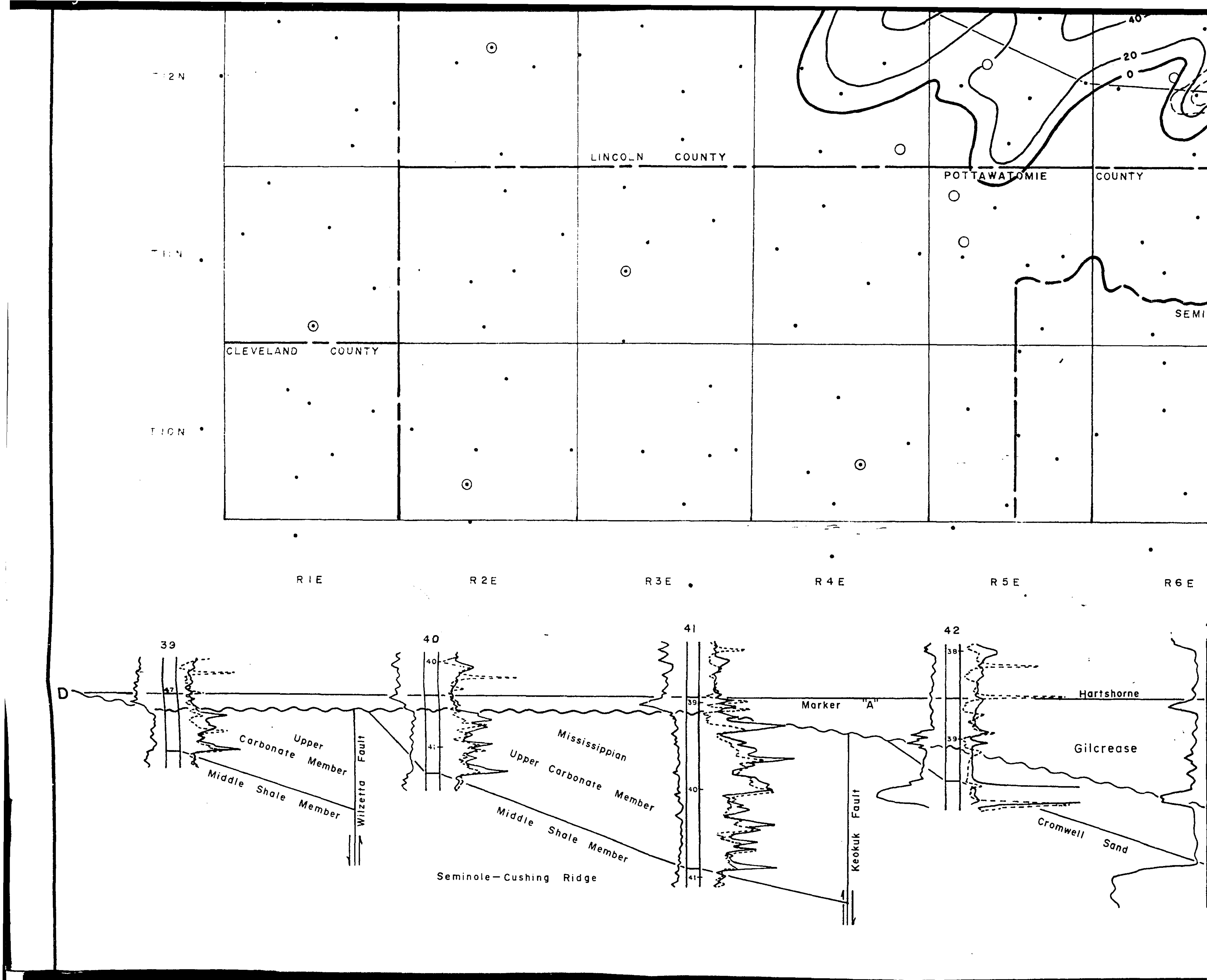
T25N
T24N
T23N
T22N
T21N
OSAGE COUNTY
20
0

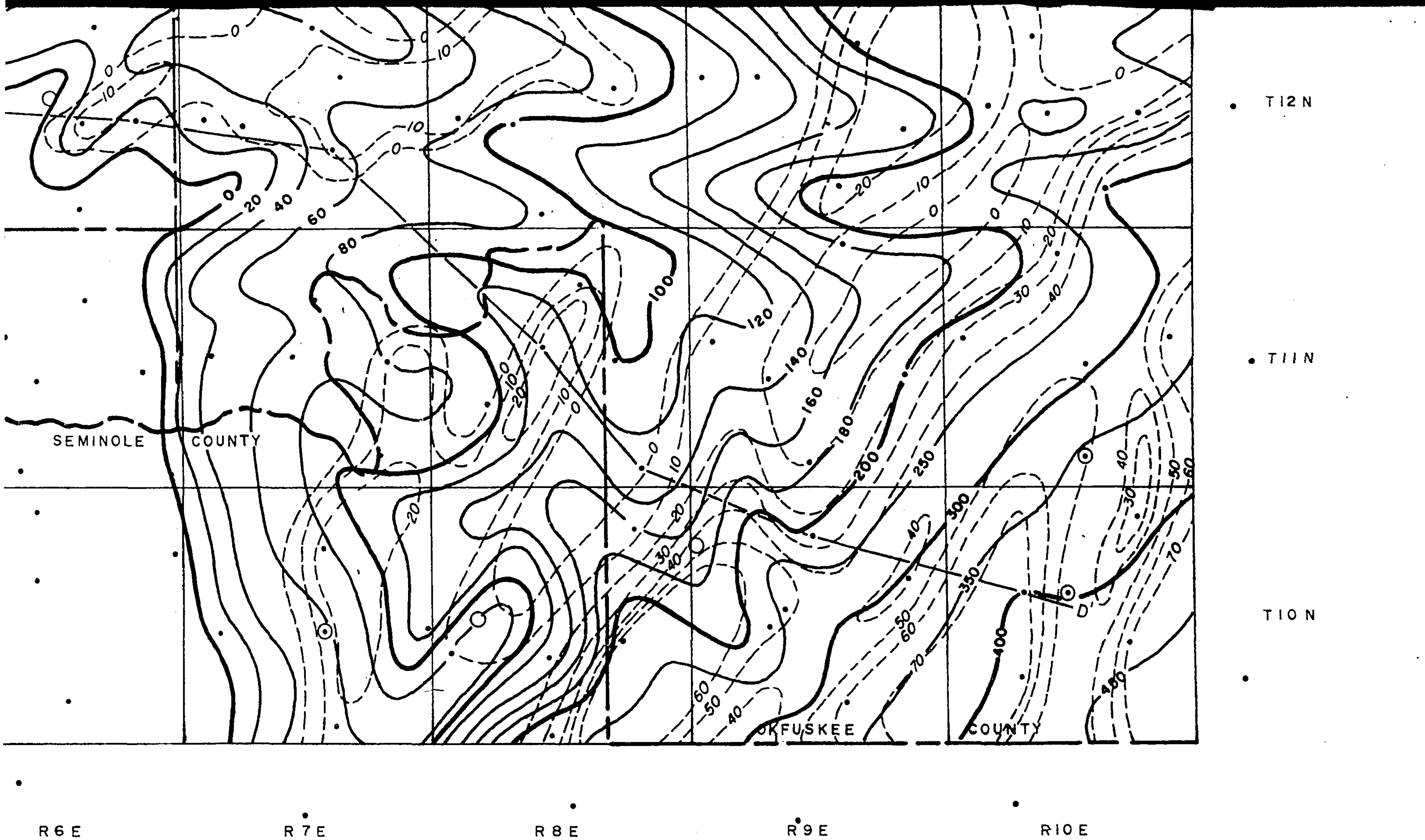

T 21 N
NOBLE COUNTY
T 20 N
T 19 N
T 18 N
PAYNE COUNTY
T 17 N
T 16 N

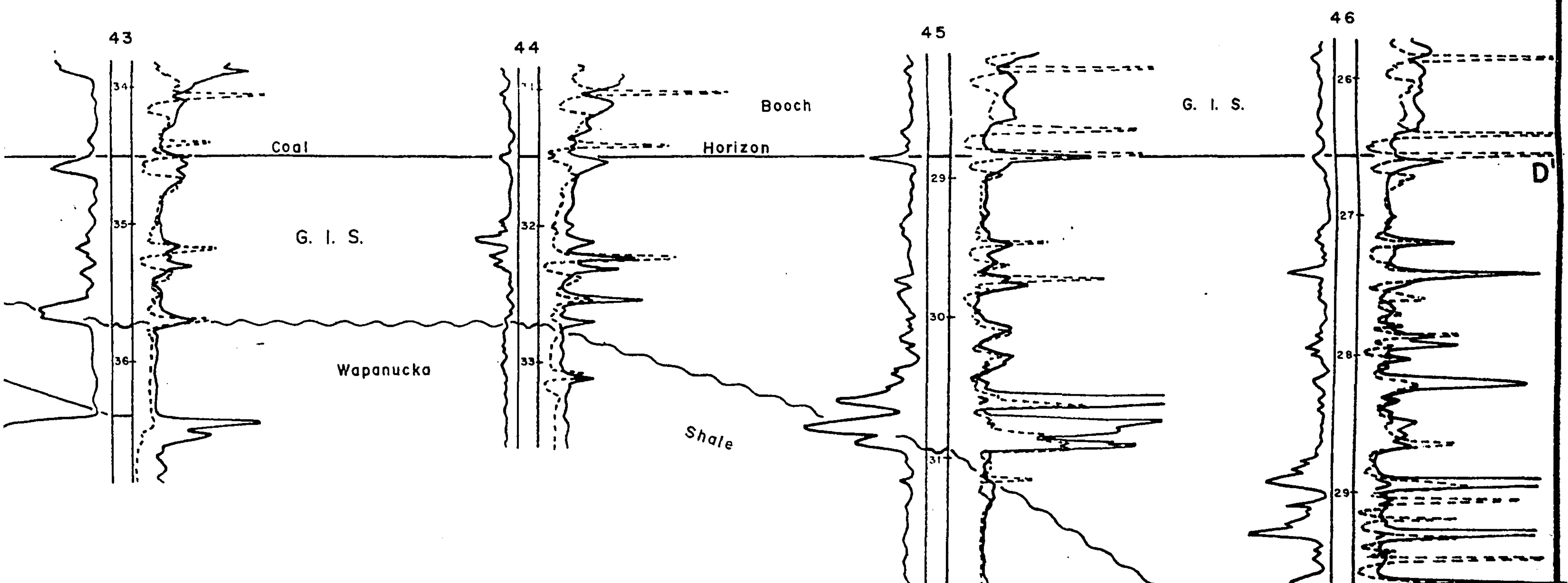

T 21 N
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
0
20
40
60
80
100
120
140
160
10


T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
D
0
10
20
40
60


T16N
T15N
T14N
T13N
T12N
T11N
CREEK COUNTY
WATOMIE COUNTY
140
120
100
80
60
40
20
0
10
160
180
200
30


T12N
T11N
T10N
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
SEMIN
40
20
0
R1E
R2E
R3E
R4E
R5E
R6E
39
40
41
42
D
Marker "A"
Hartshorne
Upper Carbonate Member
Middle Shale Member
Wilzetta Fault
Mississippian
Upper Carbonate Member
Middle Shale Member
Seminole—Cushing Ridge
Keokuk Fault
Gilcrease
Cromwell Sand


T12N
T11N
T10N
SEMINOLE COUNTY
OKFUSKEE COUNTY
D'
R6E
R7E
R8E
R9E
R10E


43
44
45
46
Booch
Coal
Horizon
G. I. S.
G. I. S.
Wapanucka
Shale
D'

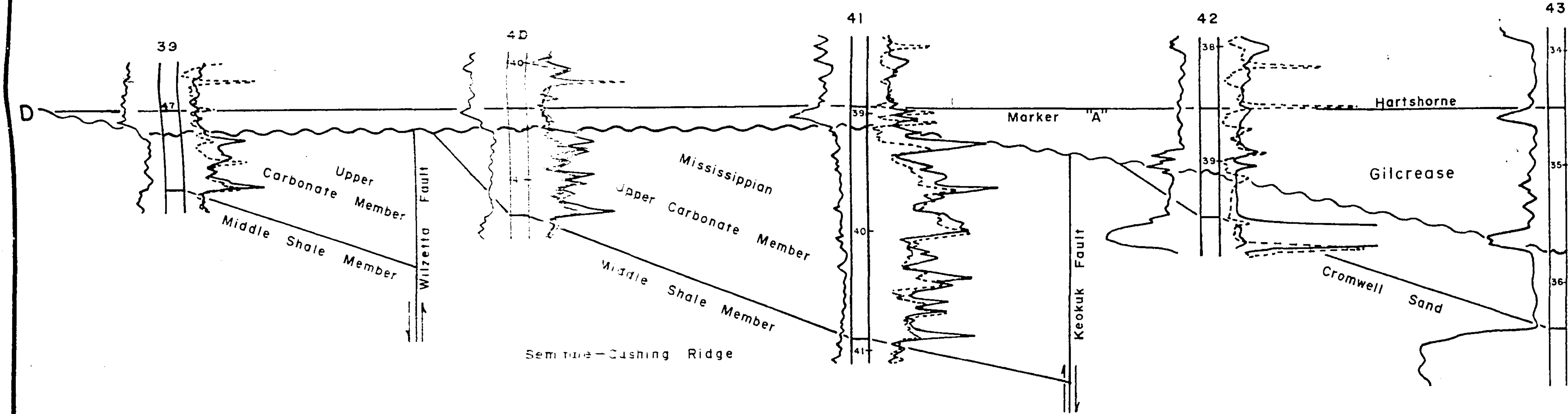
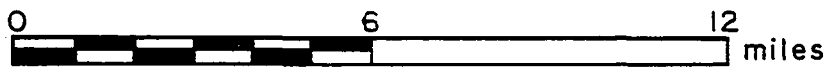


PLATE IV

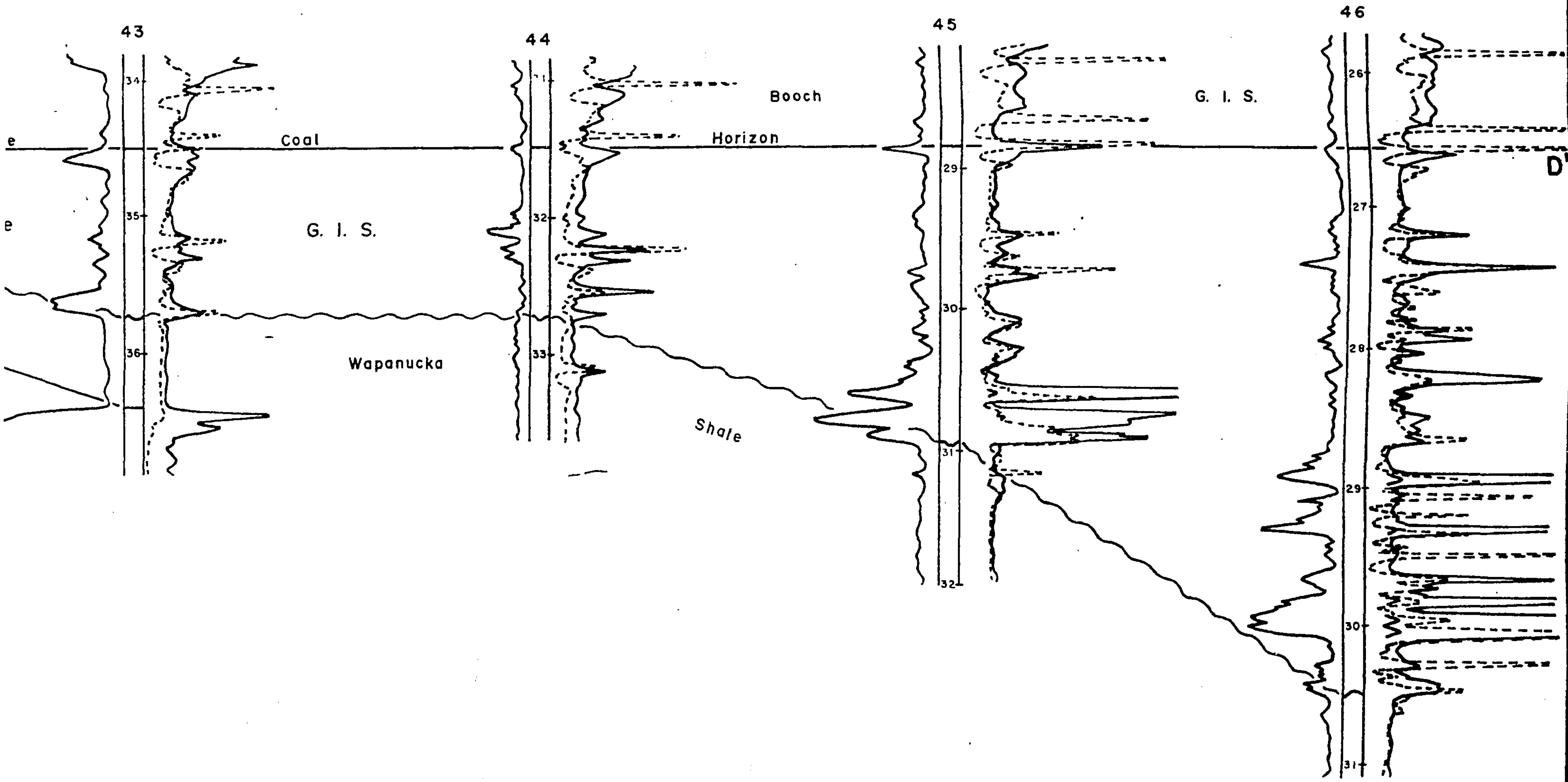
GILCREASE GENETIC INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP AND STRATIGRAPHIC PROFILE DD'

by

J. Glenn Cole Ph. D. 1968



Scale



LEGEND:

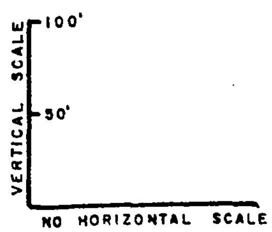
- ● Control Well
- O Sample Control
- C. I. Isopach 20'
- C. I. Isolith 10'
- —220—— Isopach Line
- ---*40*---- Isolith Line

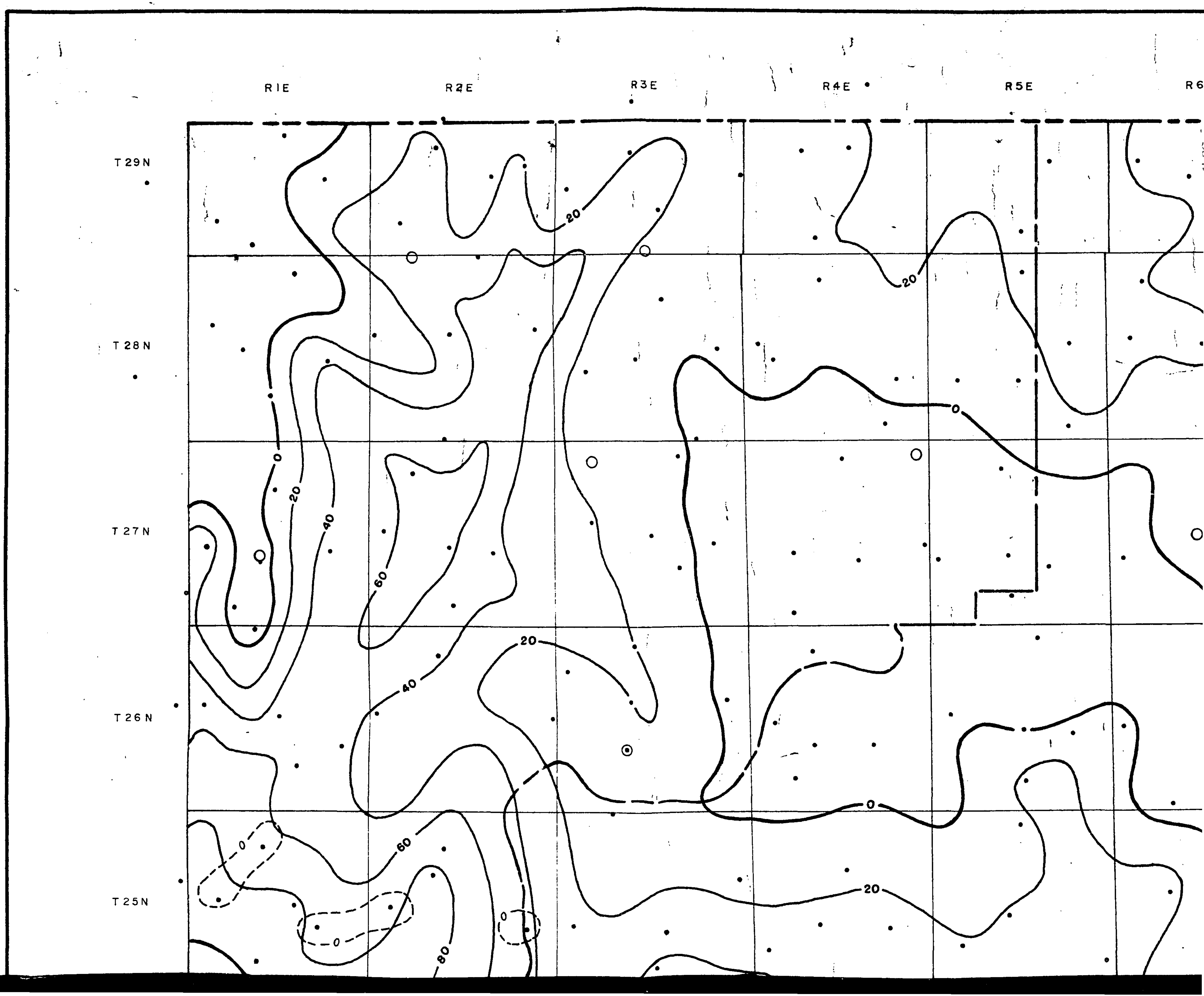
Sandstone Thickness

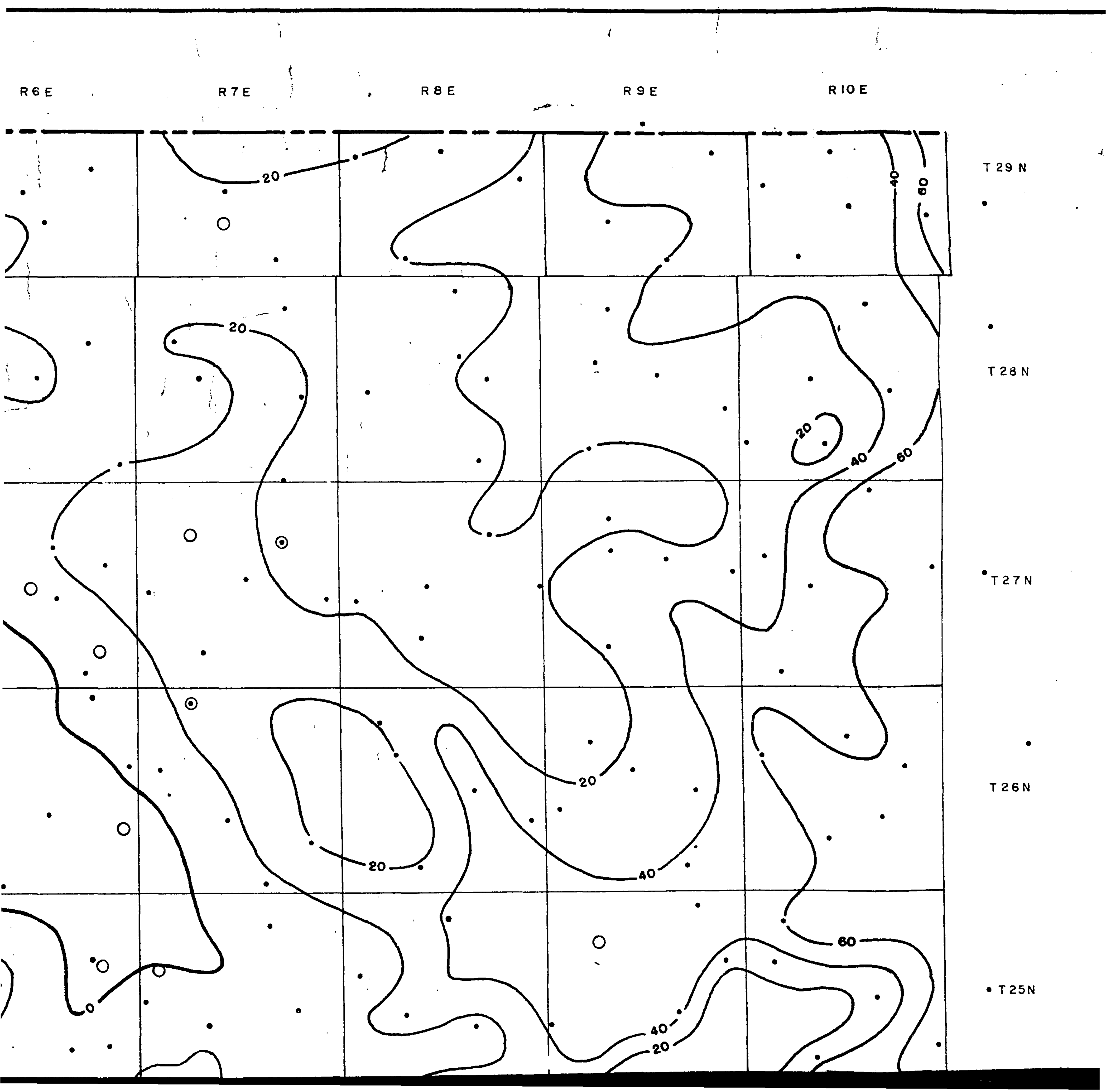
- ☐ 0-20'
- ☐ 20-40'
- ☐ 40-60'
- ☐ 60' +

Emergent Areas

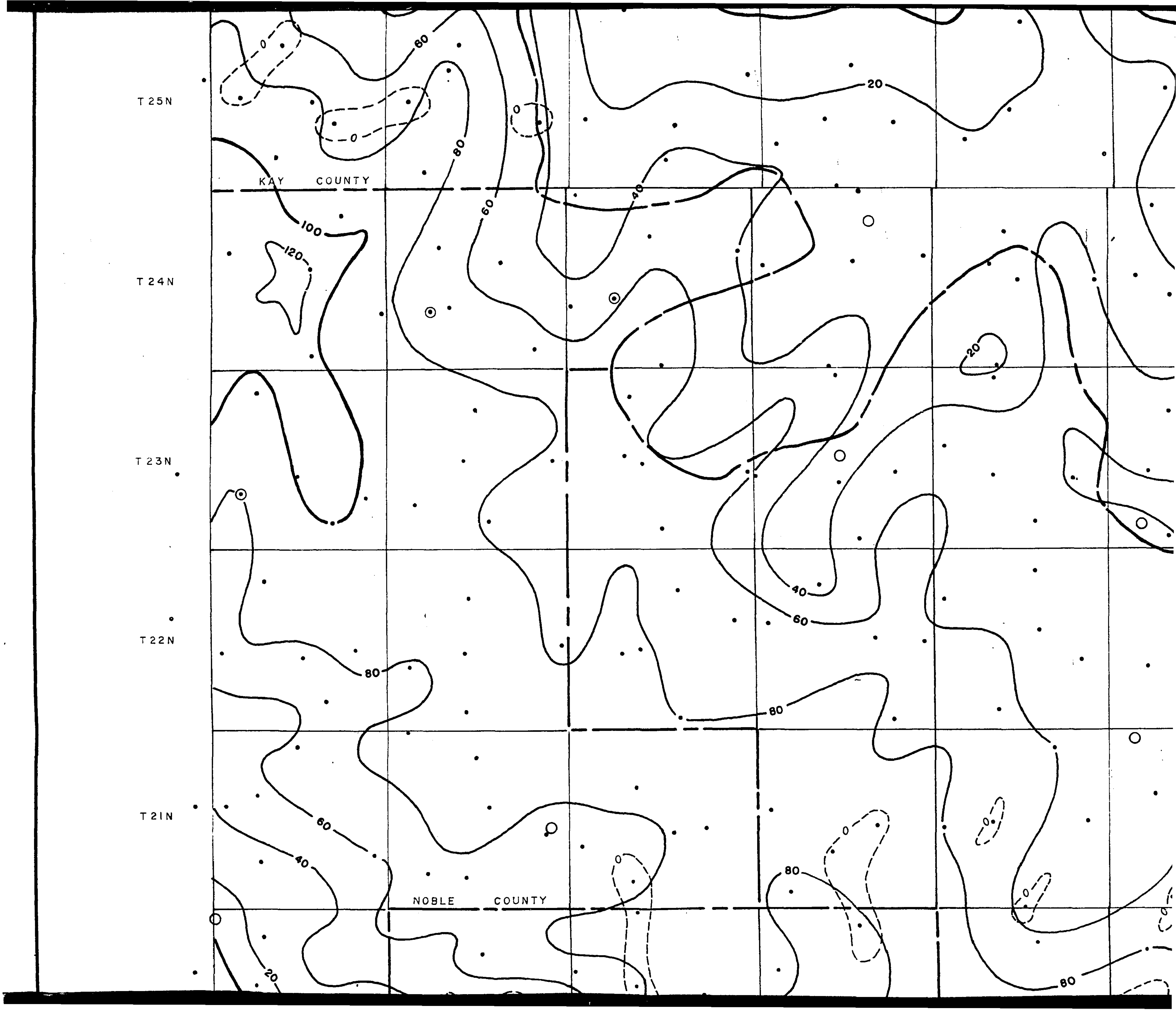
- ☐



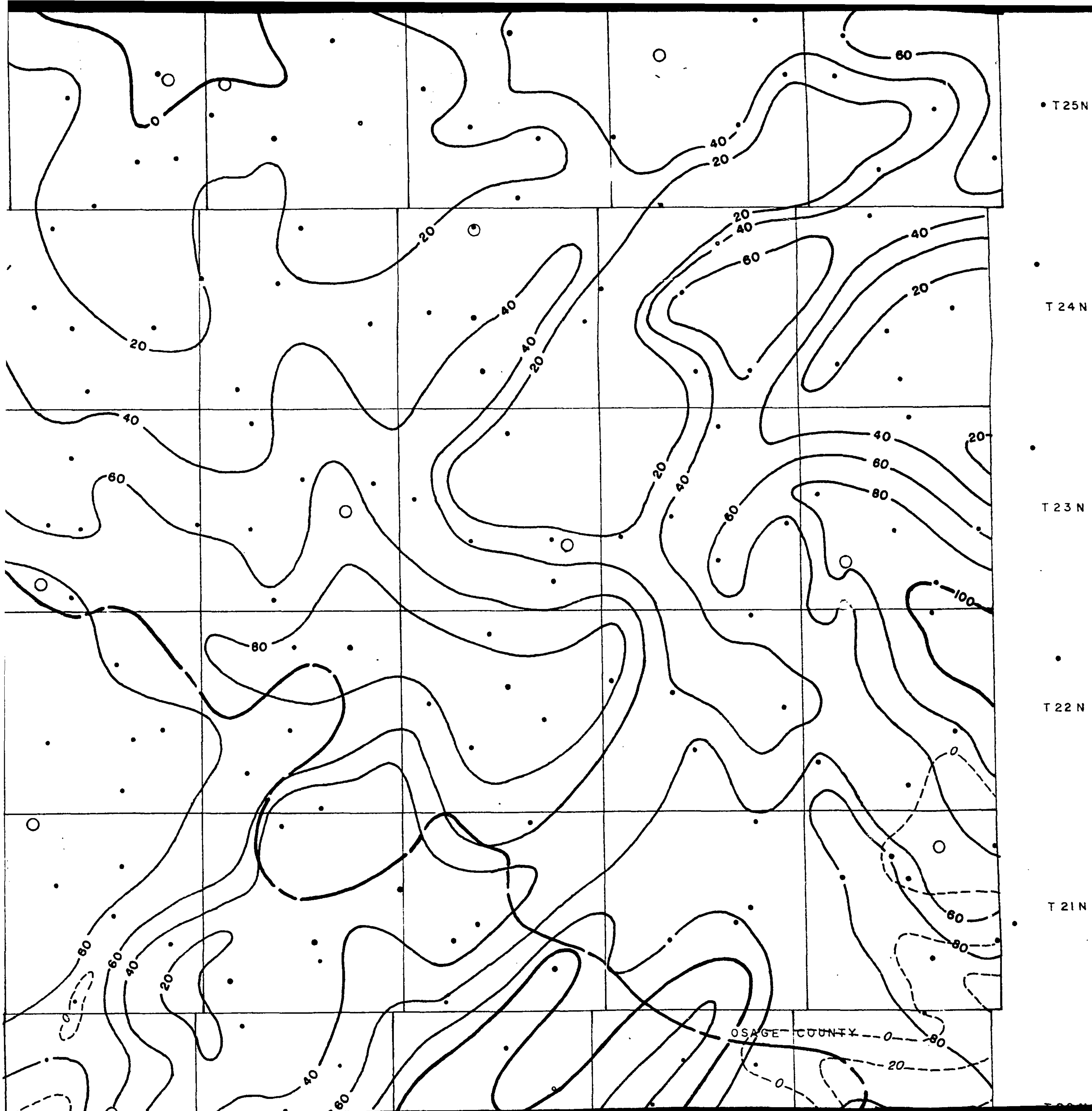

R1E
R2E
R3E
R4E
R5E
R6
T29N
T28N
T27N
T26N
T25N
20
20
0
0
20
40
60
20
40
0
60
0
0
0
20
80

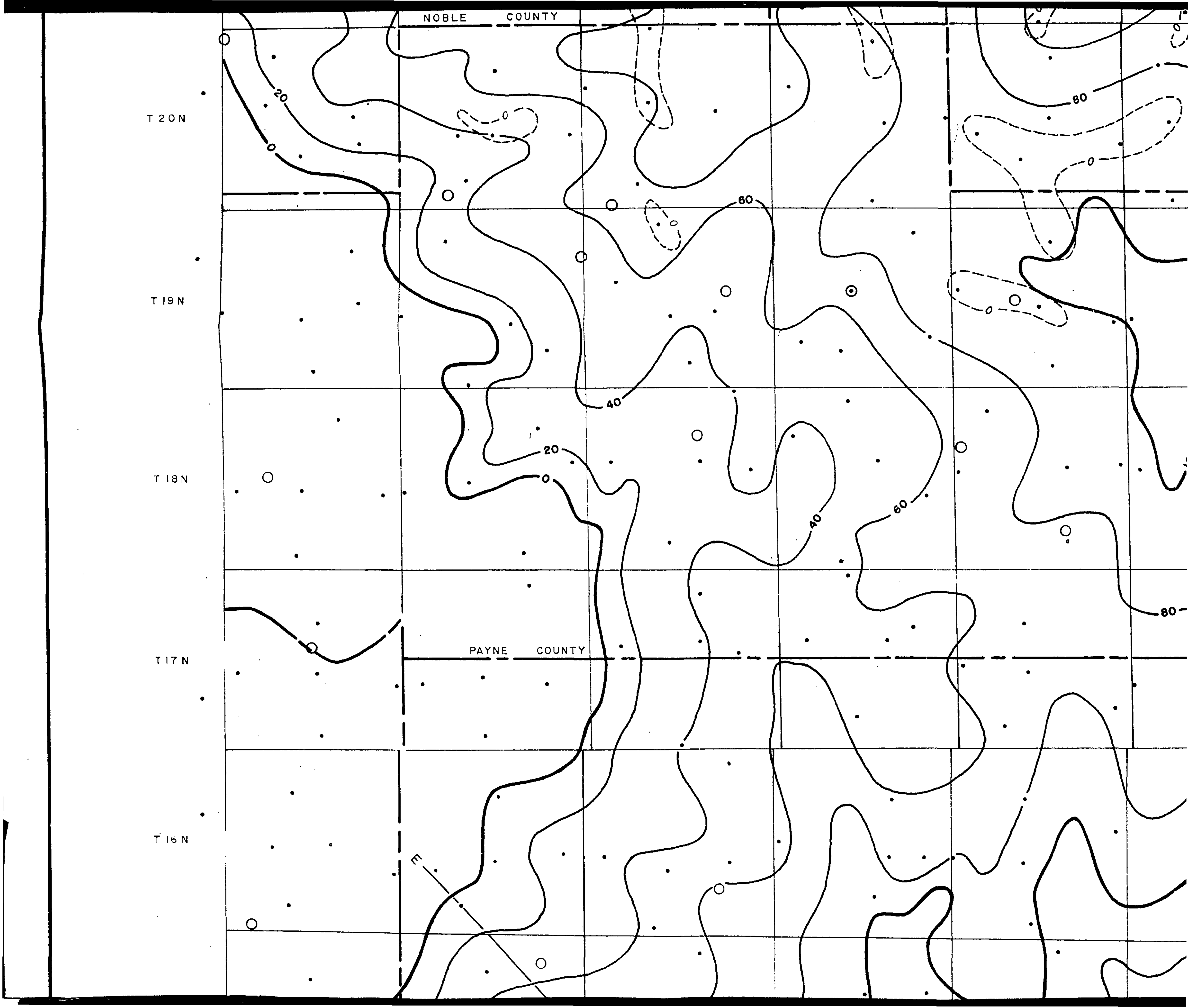


R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
20
40
60
0

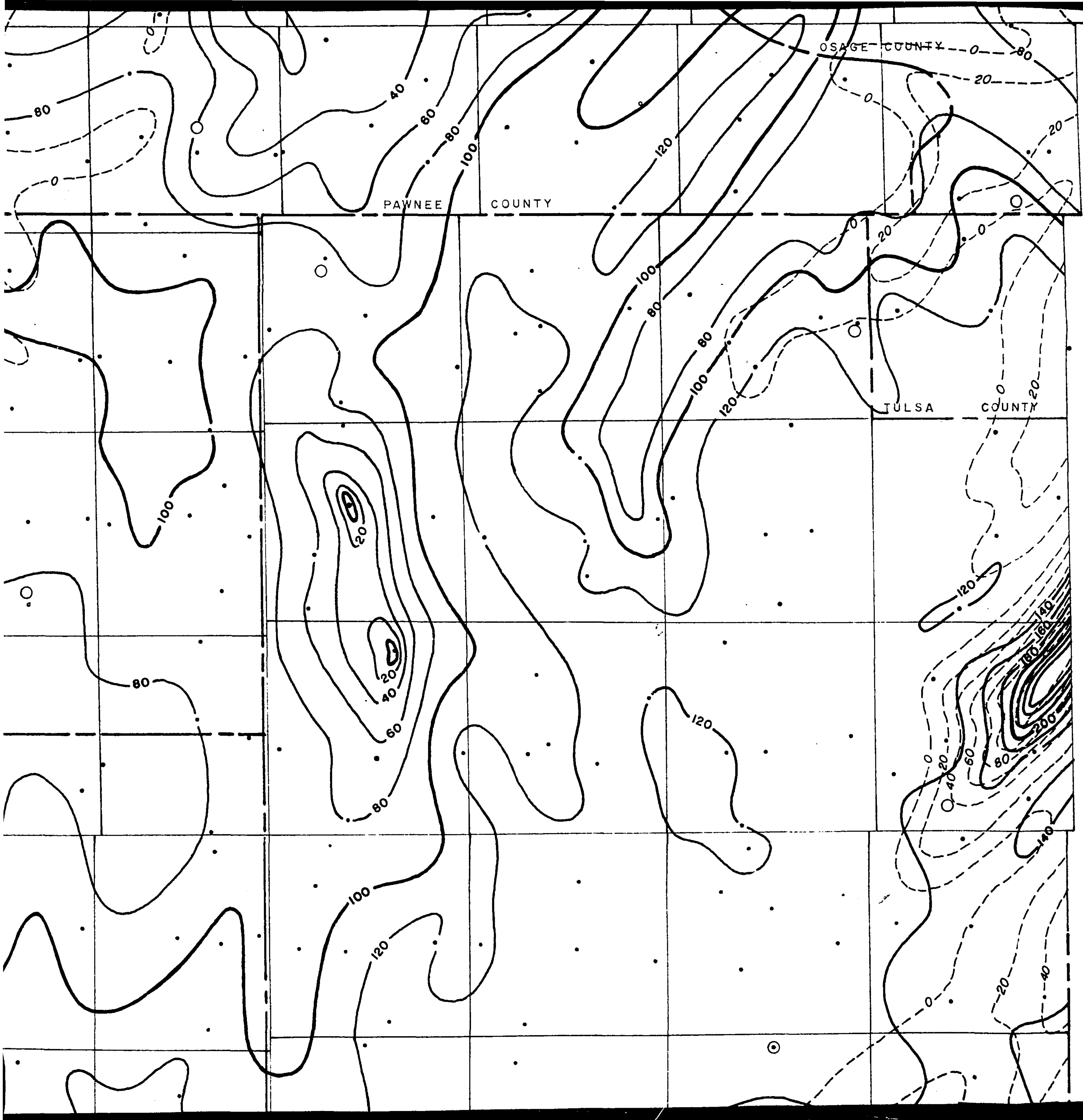


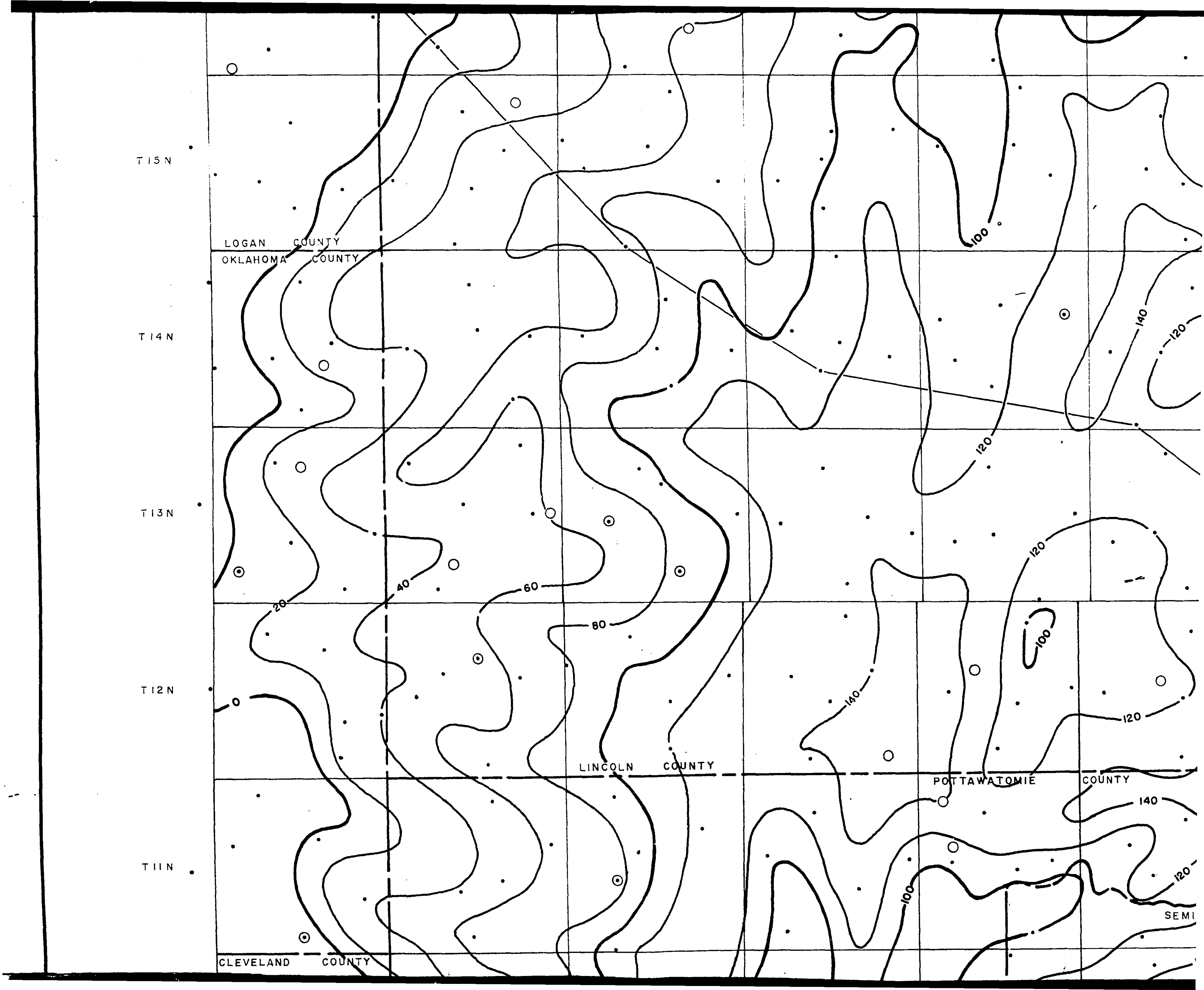
T 25N
T 24N
T 23N
T 22N
T 21N
KAY COUNTY
NOBLE COUNTY
0
20
40
60
80
100
120

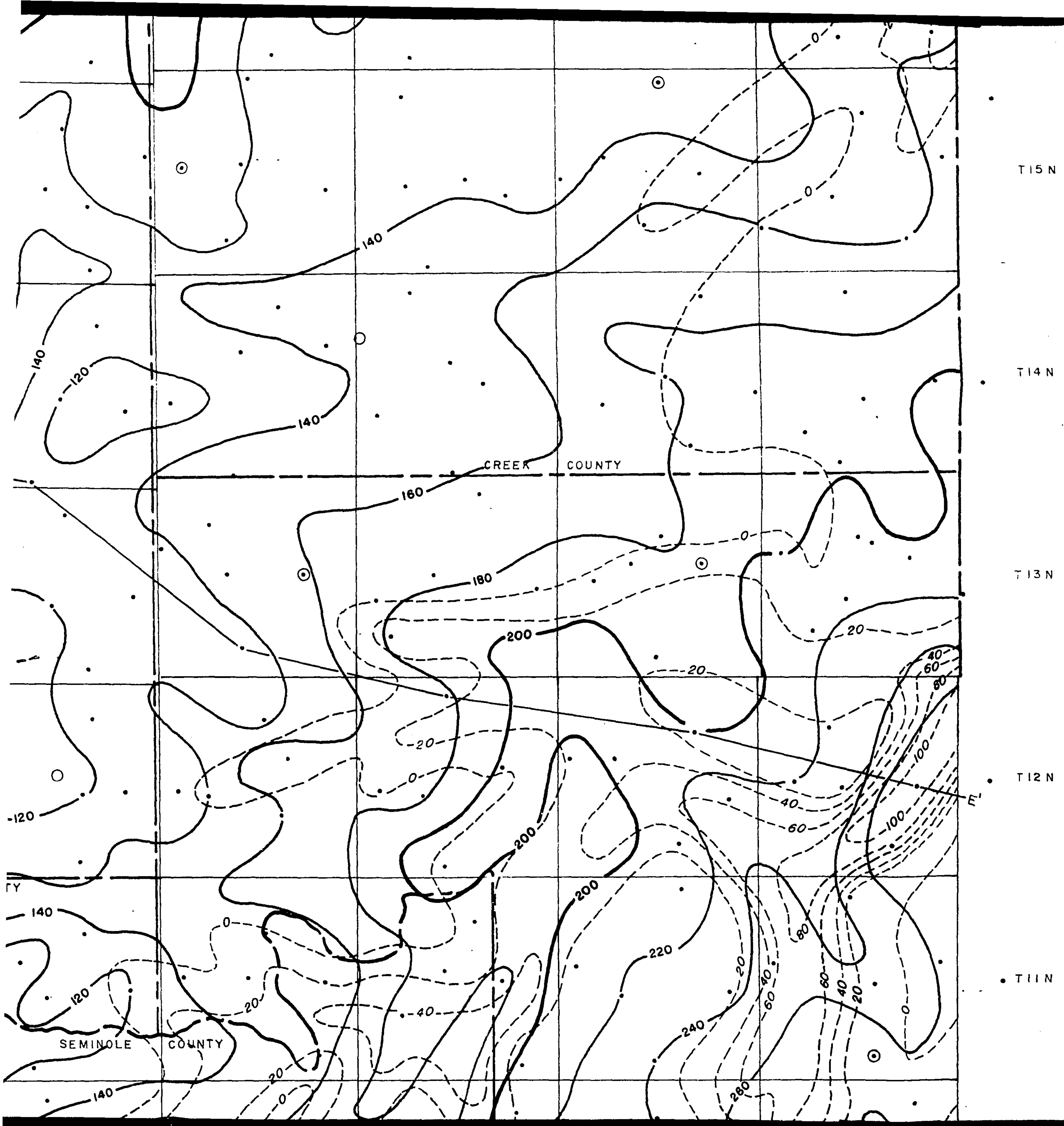

T25N
T24N
T23N
T22N
T21N
OSAGE COUNTY



NOBLE COUNTY
PAYNE COUNTY
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
0
20
40
60
80
E


OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
T20N
T19N
T18N
T17N
T16N
0
20
40
60
80
100
120
140
160
180
200


T15N
T14N
T13N
T12N
T11N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
SEMI
0
20
40
60
80
100
120
140



T15N
T14N
T13N
T12N
T11N
CREEK COUNTY
SEMINOLE COUNTY
140
120
160
180
200
220
240
280
0
20
40
60
80
100
E'

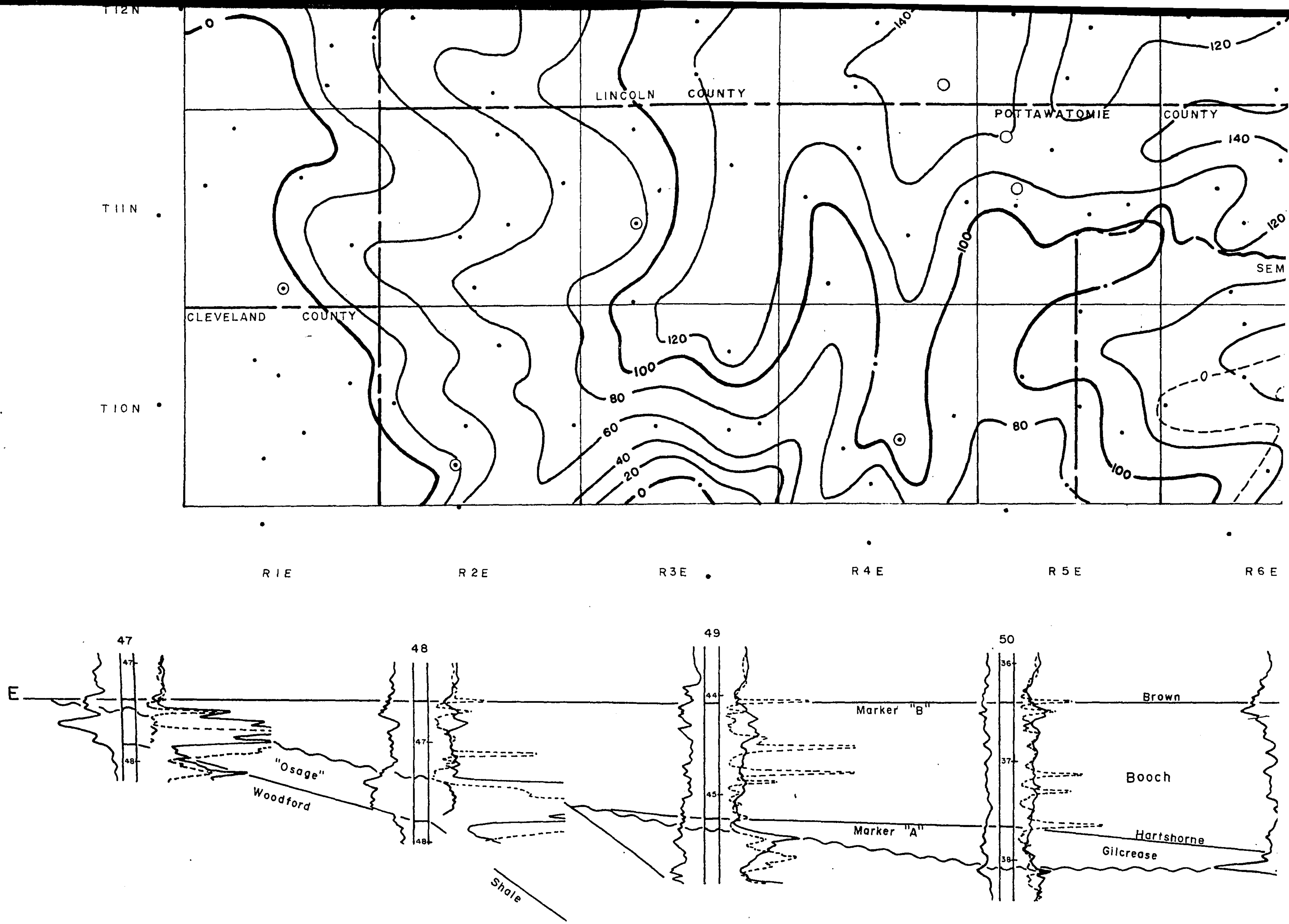
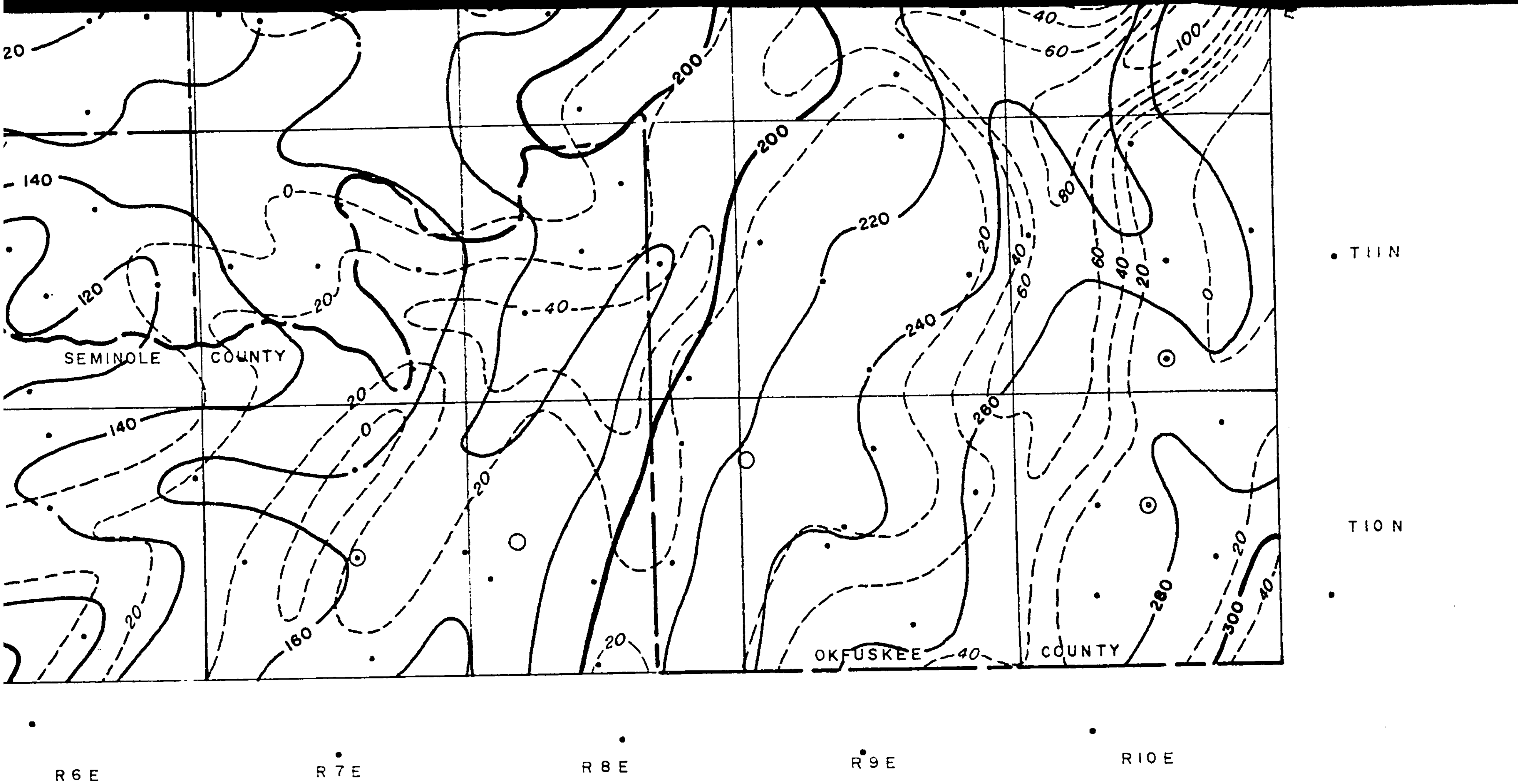


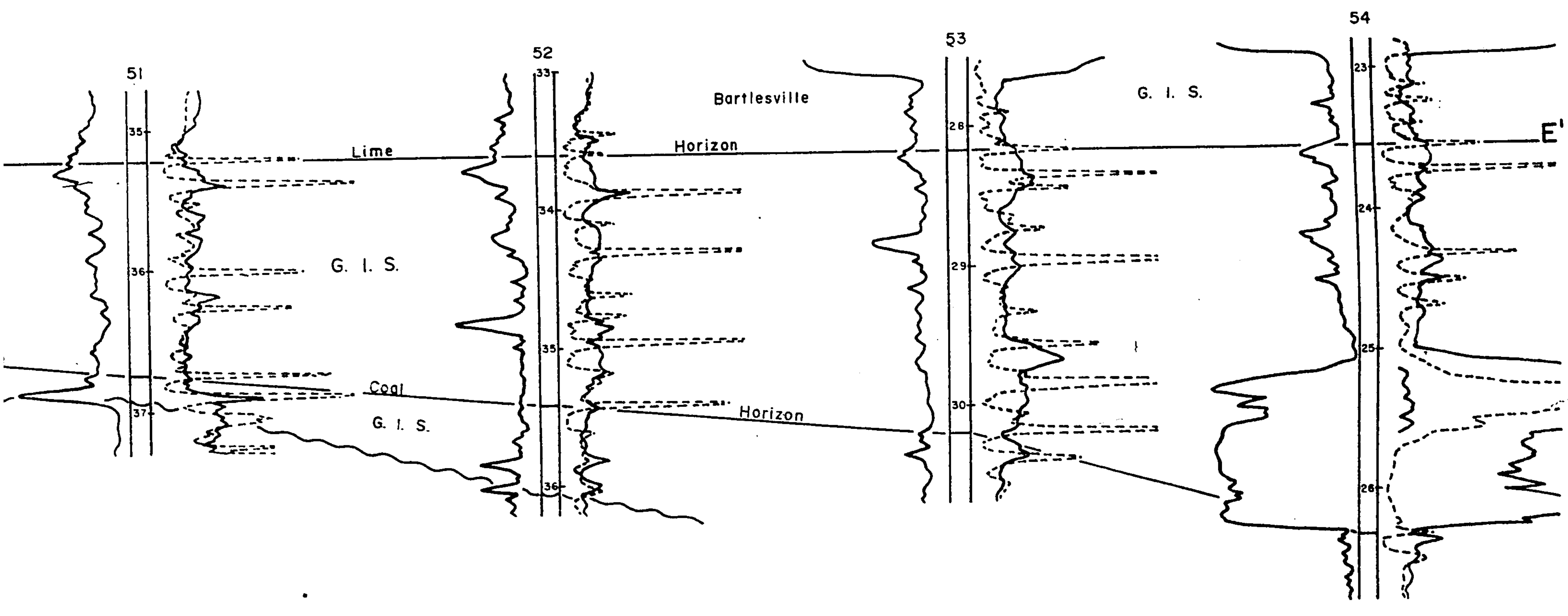
PLATE V

BOOCH GENETIC INCREMENT OF STRATA

ISOPACH AND SANDSTONE ISOLITH MAP



SEMINOLE COUNTY
OKFUSKEE COUNTY
T11N
T10N
R6E
R7E
R8E
R9E
R10E
140
120
160
200
220
240
260
280
300



51
52
53
54
Bartlesville
Lime Horizon
G. I. S.
Coal Horizon
G. I. S.
E'

LEGEND:

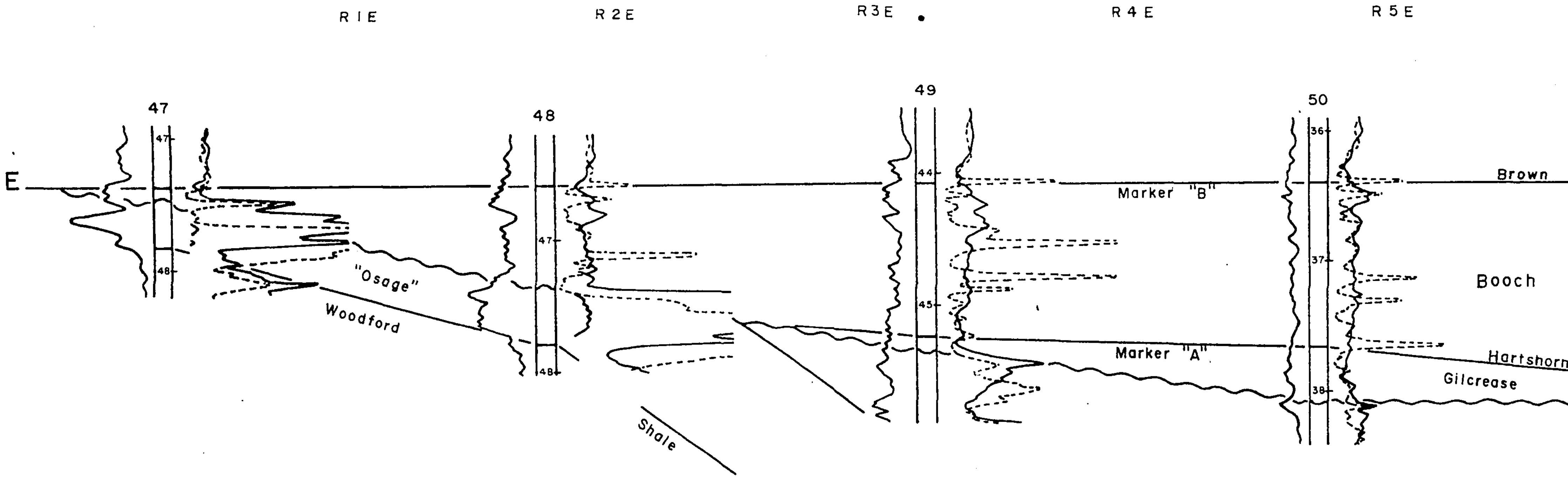
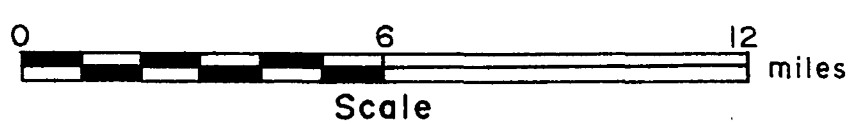


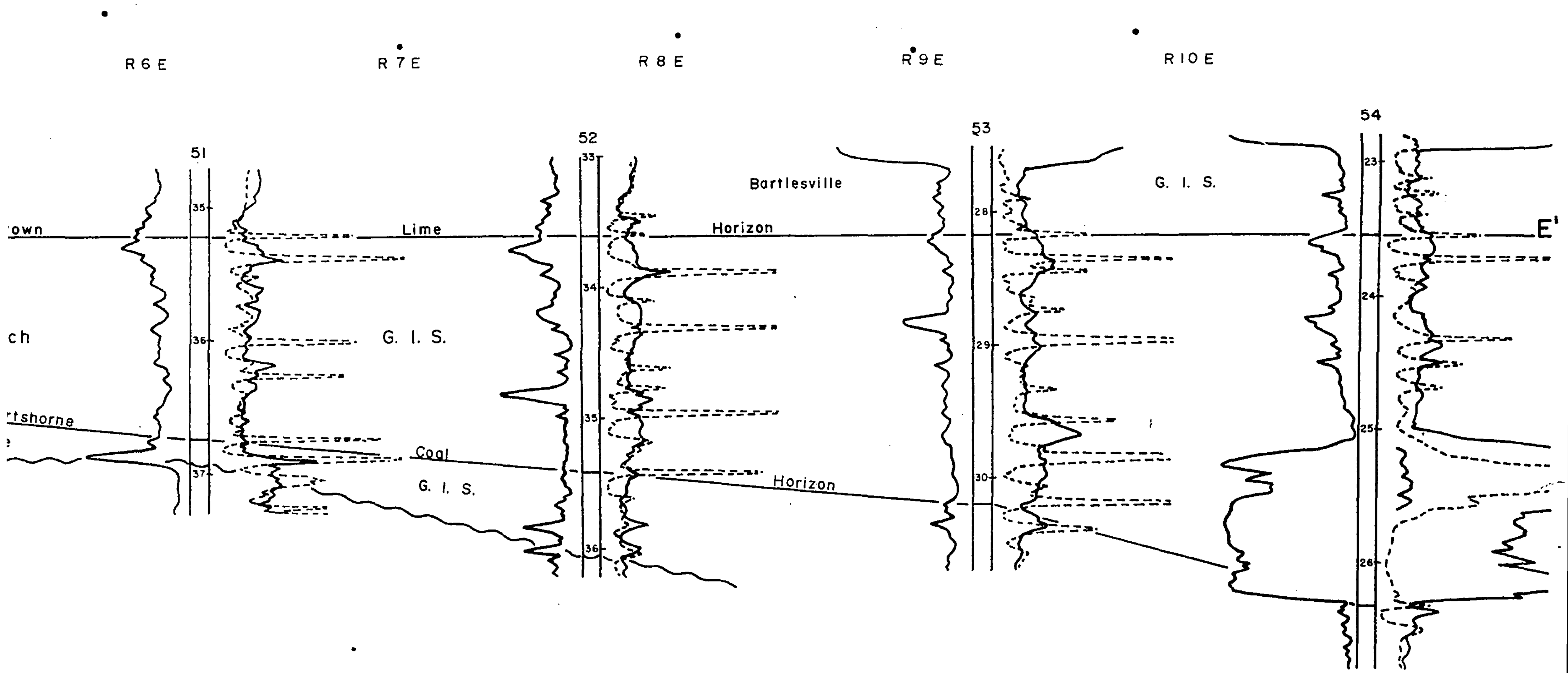
PLATE V

BOOCH GENETIC INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP AND STRATIGRAPHIC PROFILE EE'

by

J. Glenn Cole Ph. D. 1968



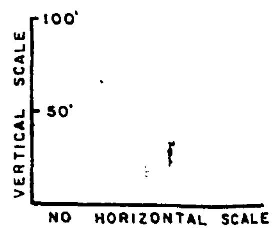


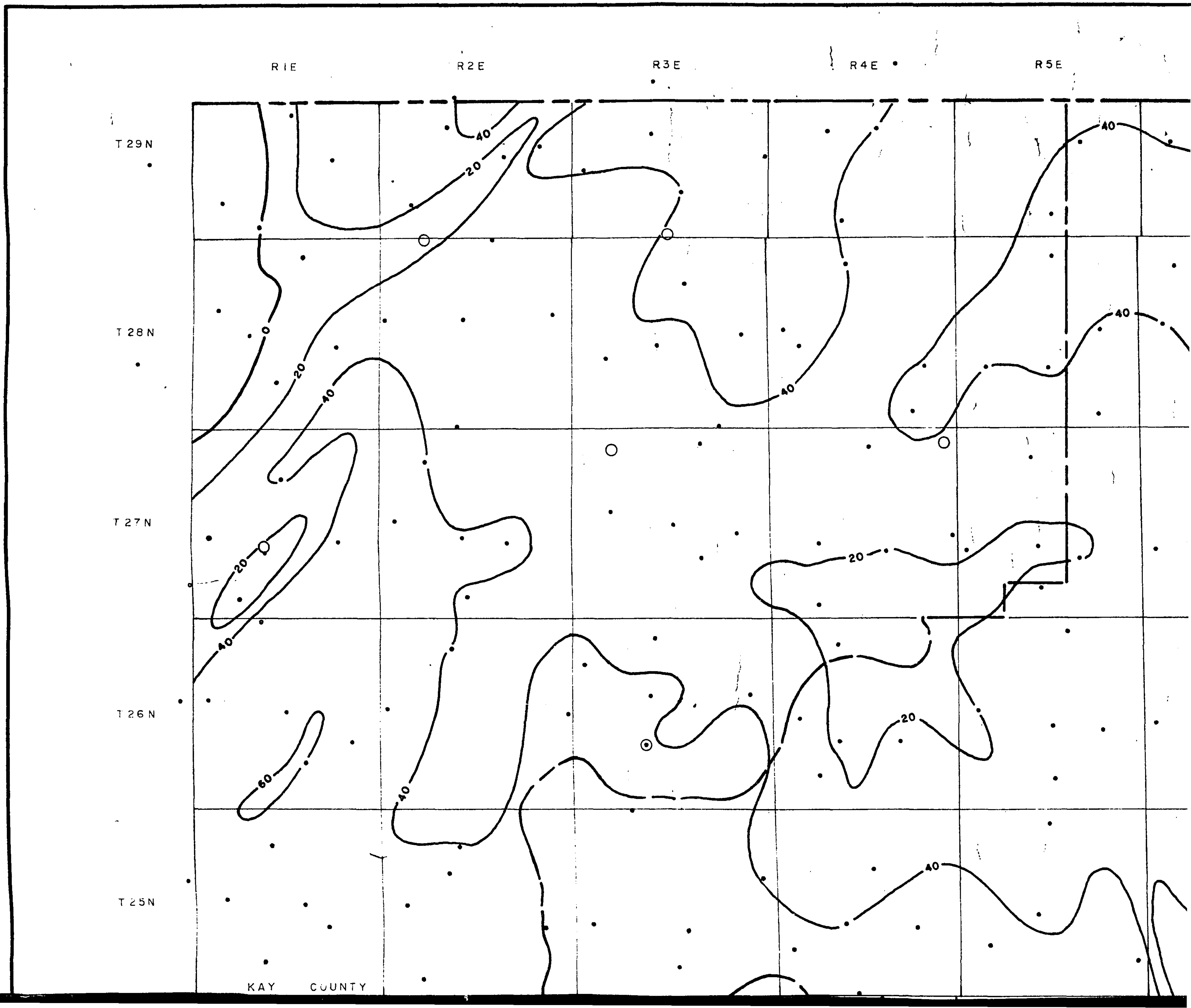
LEGEND:
- • Control Well
- ⊙ Sample Control
- C. I. Isopach 20'
- C. I. Isolith 20'
- ——180—— Isopach Line
- ---60----- Isolith Line

Sandstone Thickness

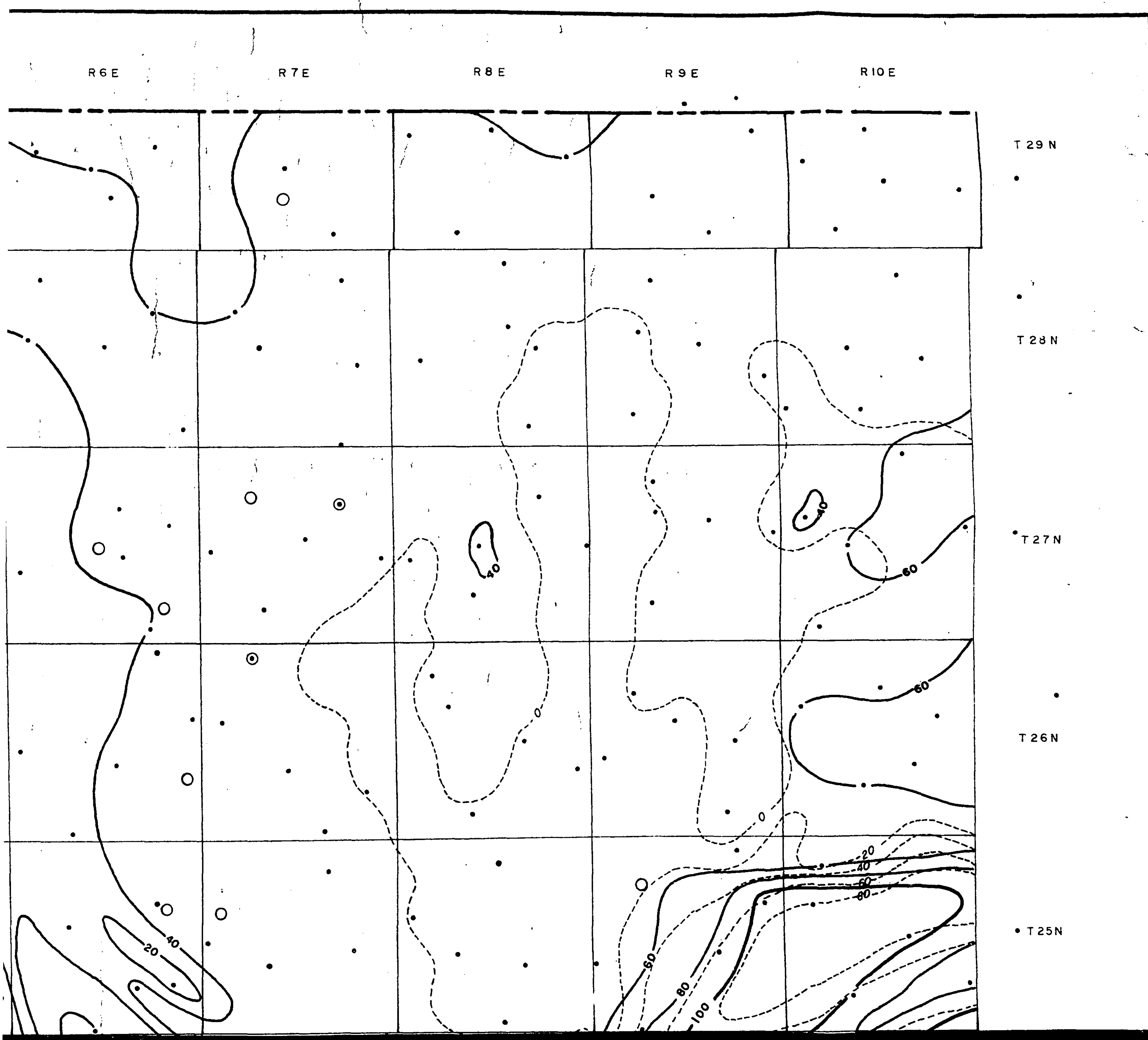
- 0-40'
- 40-80'
- 80-120'
- 120' +

Emergent Areas

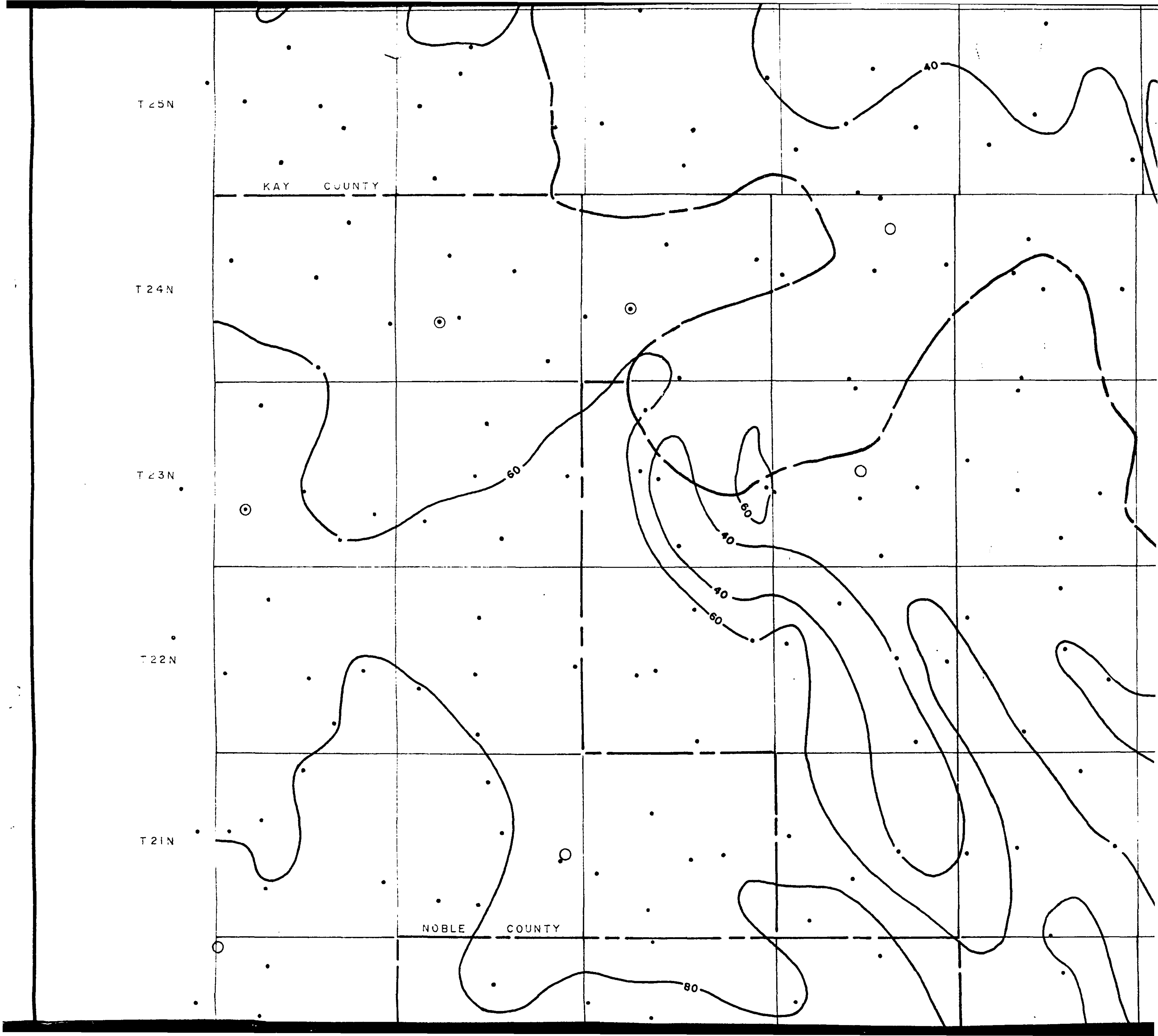




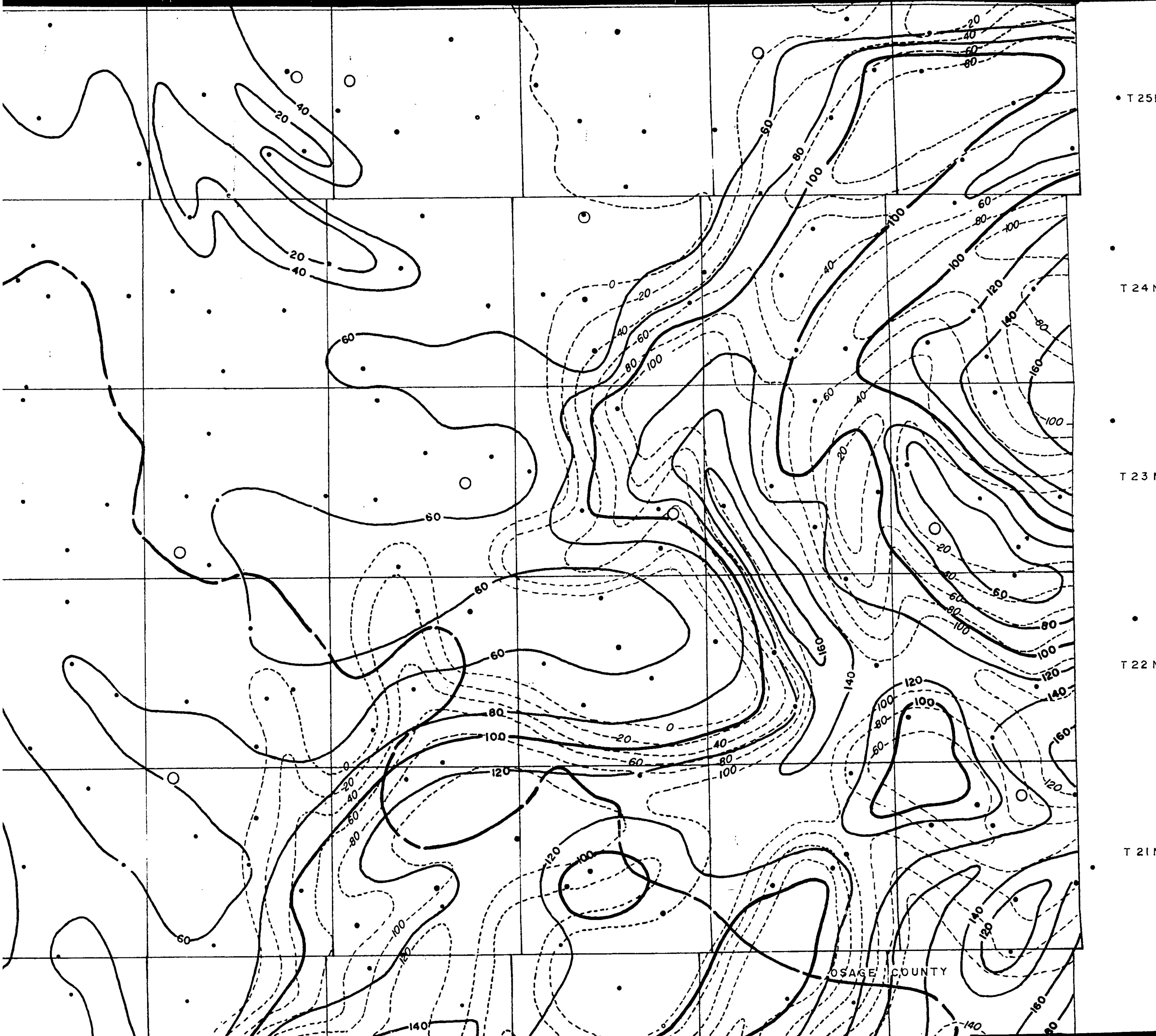
R1E
R2E
R3E
R4E
R5E
T29N
T28N
T27N
T26N
T25N
KAY COUNTY
40
20
0
60

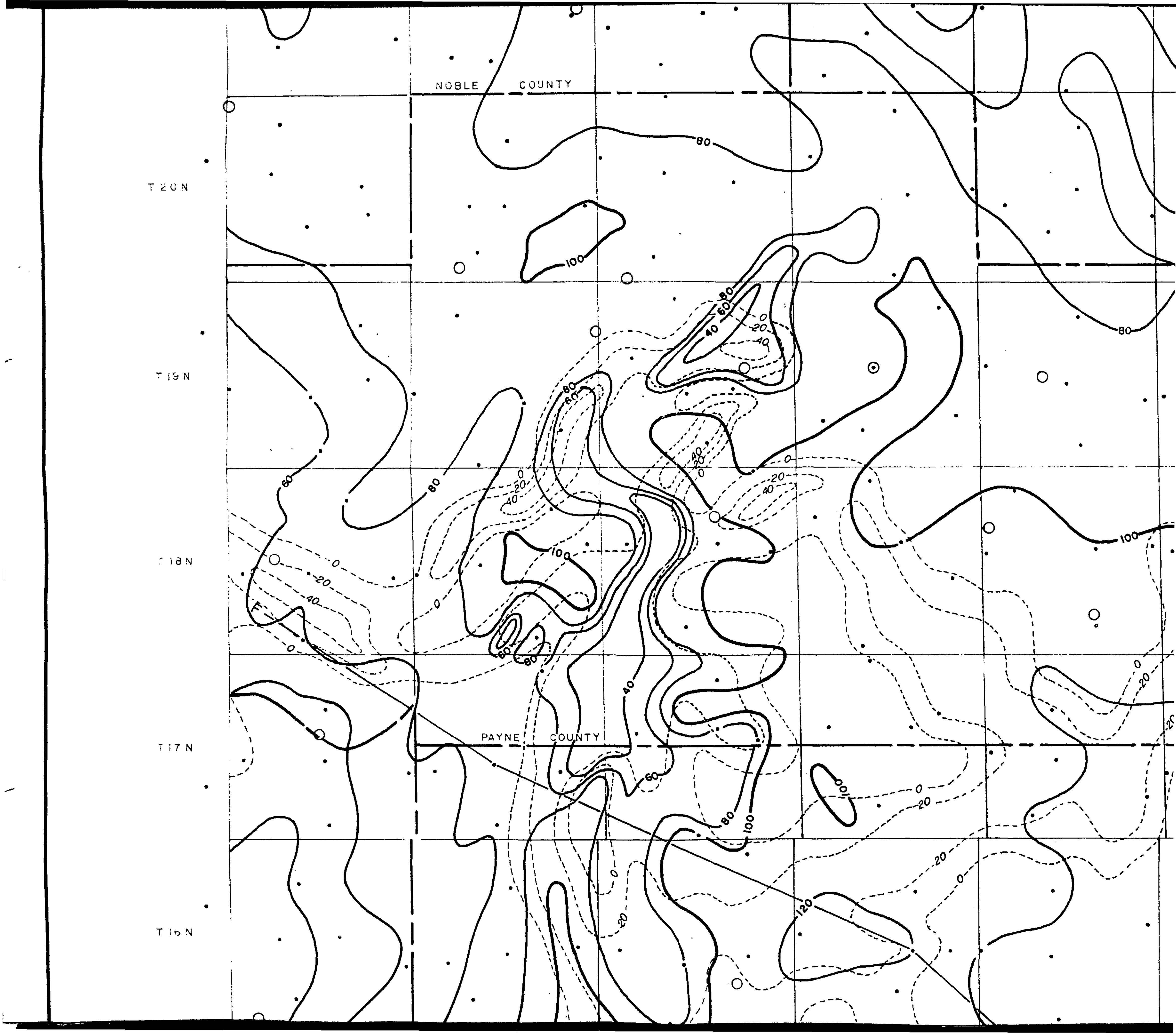


R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
0
20
40
60
80
100

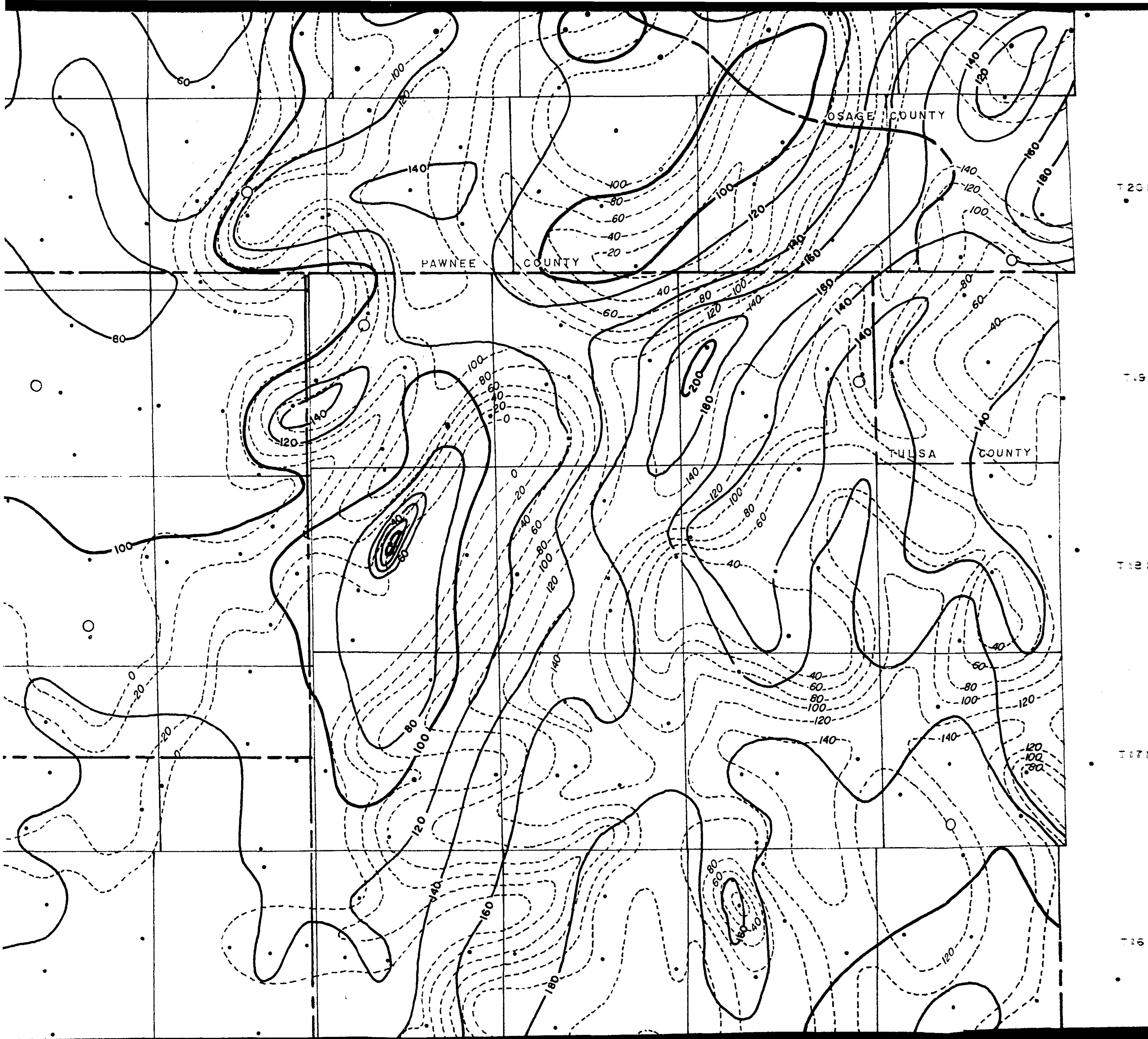


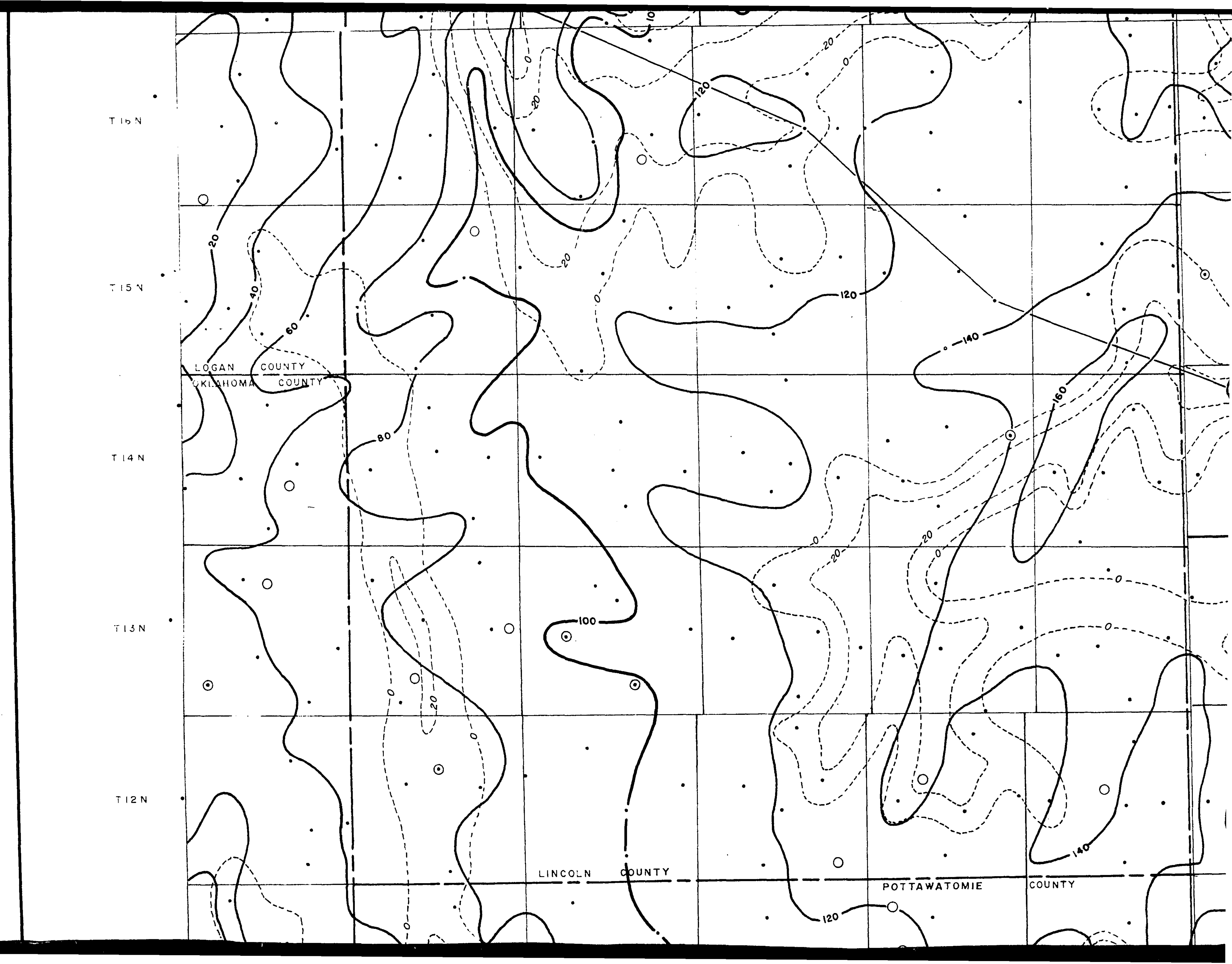
T 25N
T 24N
T 23N
T 22N
T 21N
KAY COUNTY
NOBLE COUNTY
40
60
80


T 25N
T 24N
T 23N
T 22N
T 21N
OSAGE COUNTY



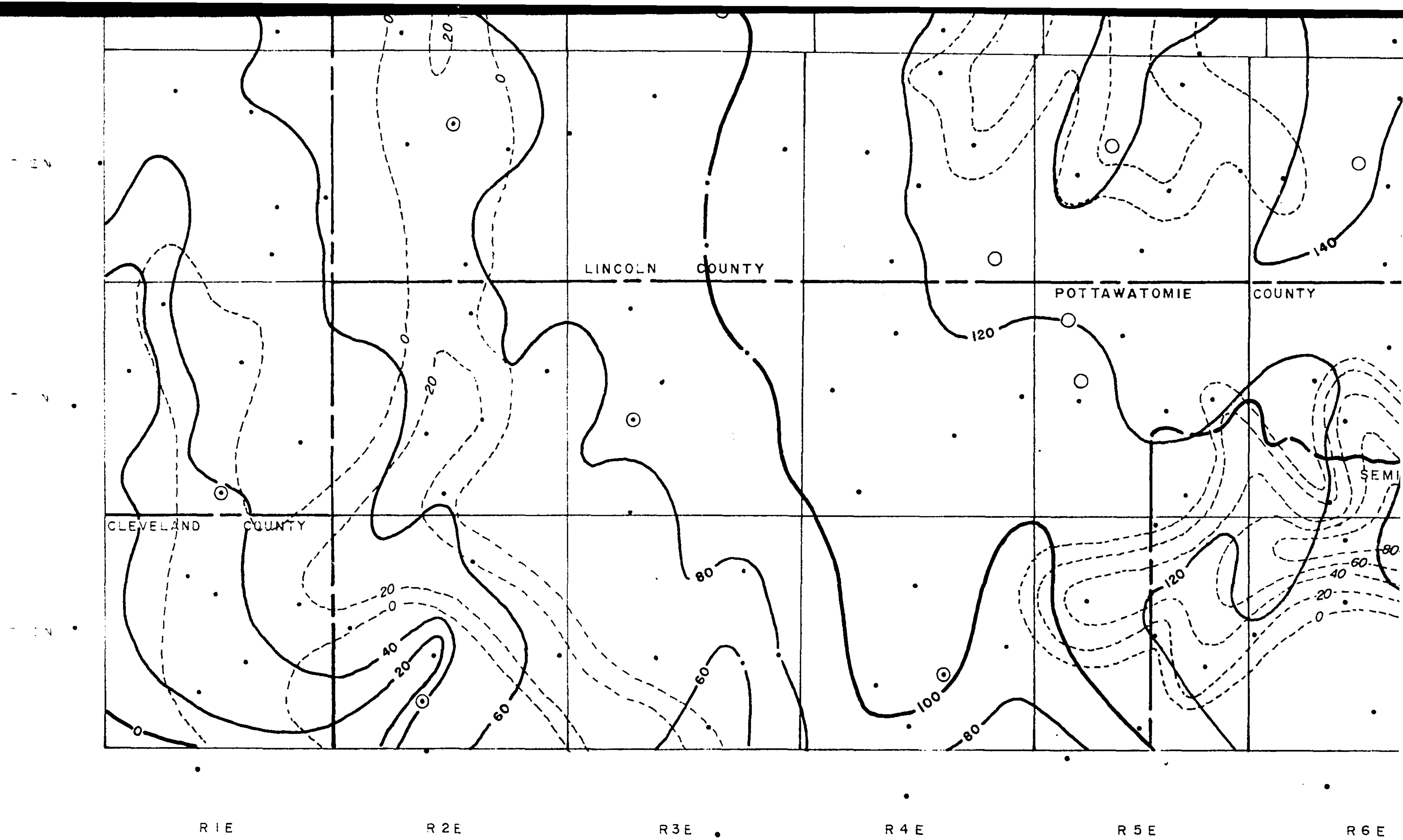
NOBLE COUNTY
PAYNE COUNTY
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
F
0
20
40
60
80
100
120

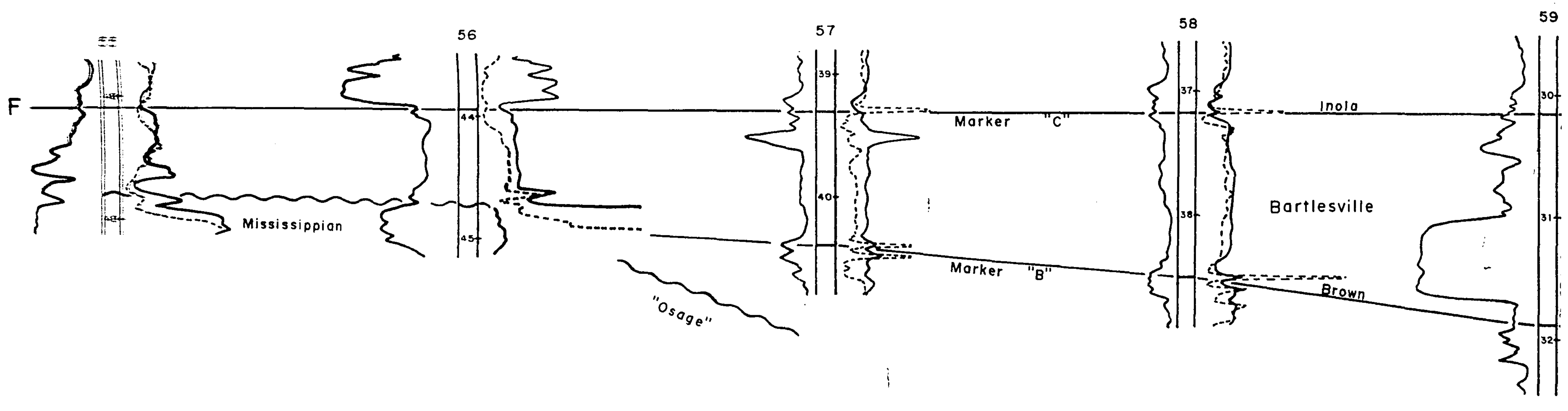

OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
T20N
T19N
T18N
T17N
T16N

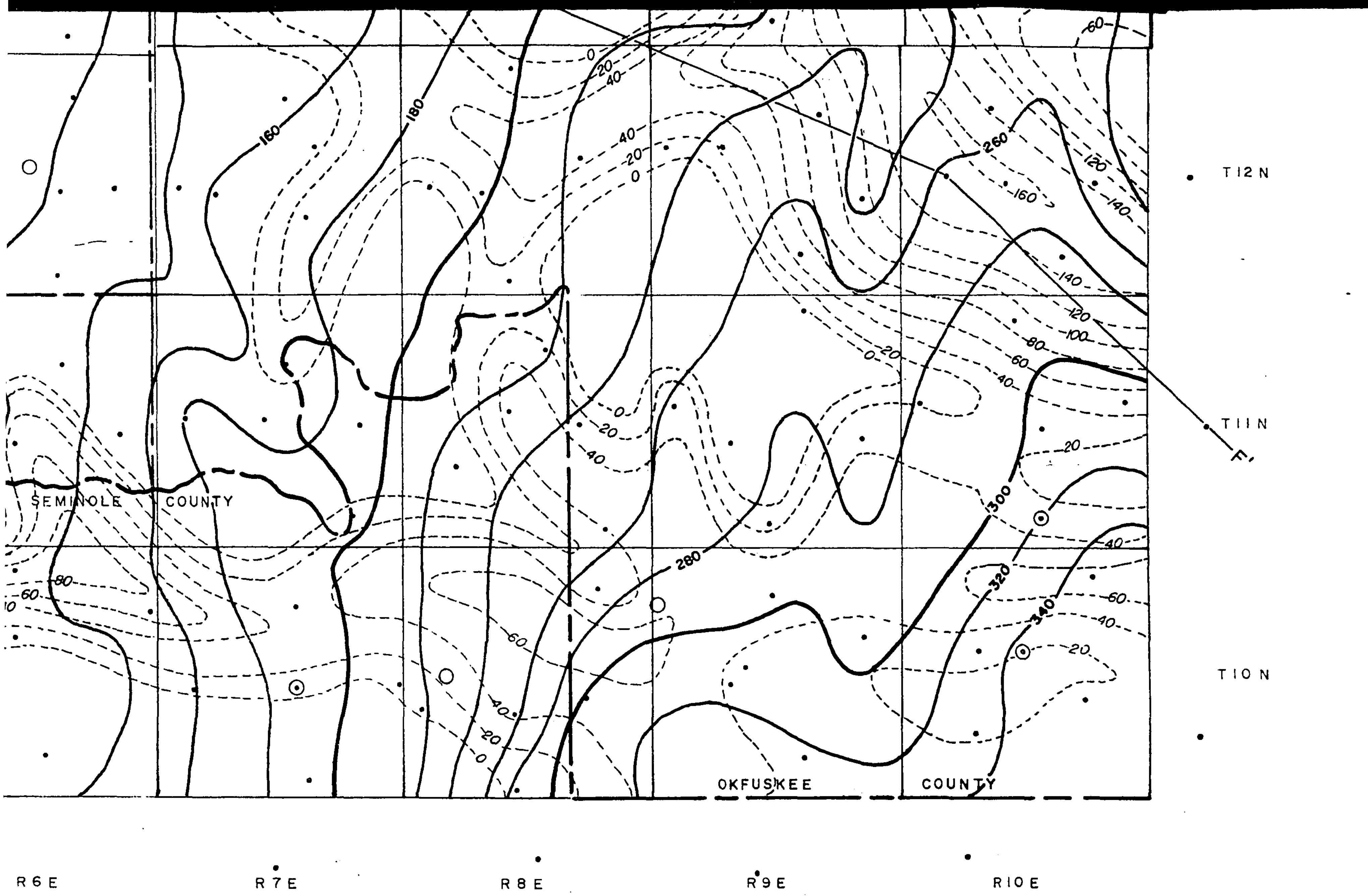


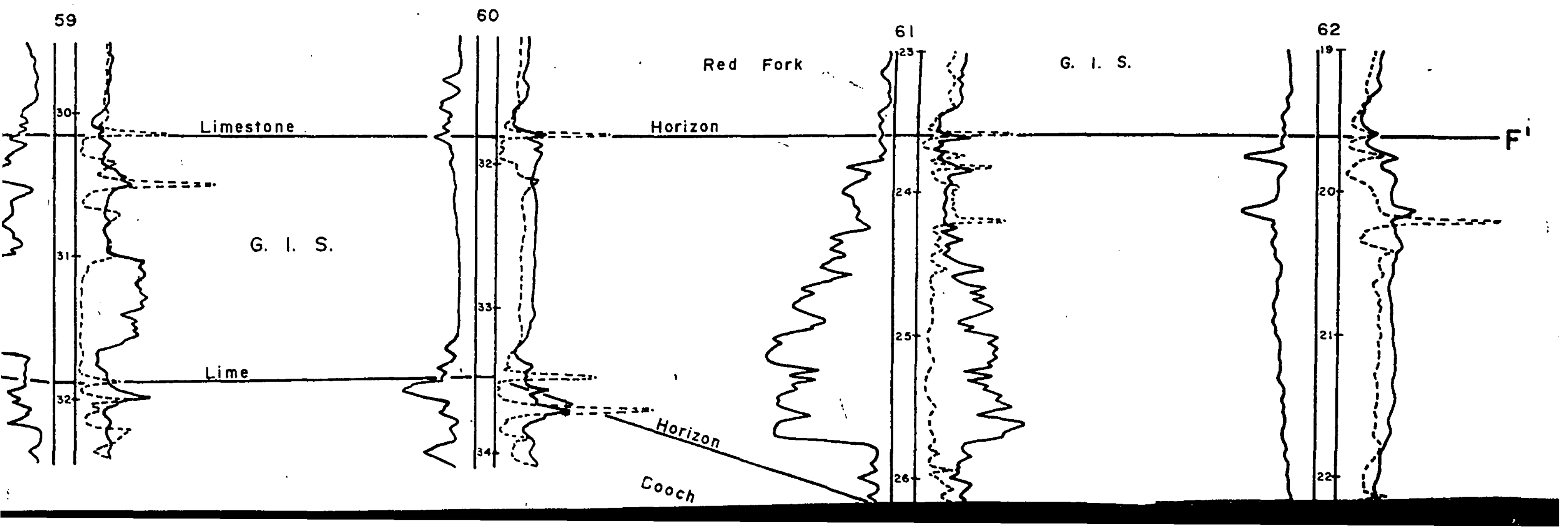
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
0
20
40
60
80
100
120
140
160

T16N
T15N
T14N
T13N
T12N
CREEK COUNTY
TAWATOMIE COUNTY


LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
SEMI
0
20
40
60
80
100
120
140
R 1 E
R 2 E
R 3 E
R 4 E
R 5 E
R 6 E


F
56
57
58
59
Marker "C"
Inola
Mississippian
Bartlesville
Marker "B"
Brown
"Osage"


T12N
T11N
T10N
SEMINOLE COUNTY
OKFUSKEE COUNTY
F'
R6E
R7E
R8E
R9E
R10E


59
60
61
62
Red Fork
G. I. S.
Limestone
Horizon
F'
G. I. S.
Lime
Horizon
Cooch

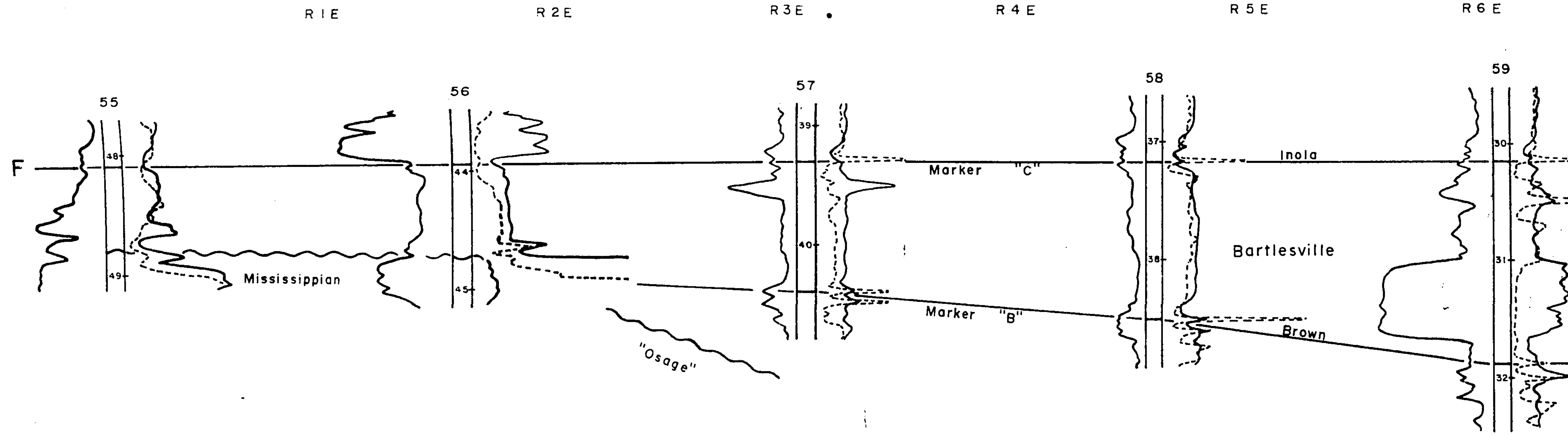


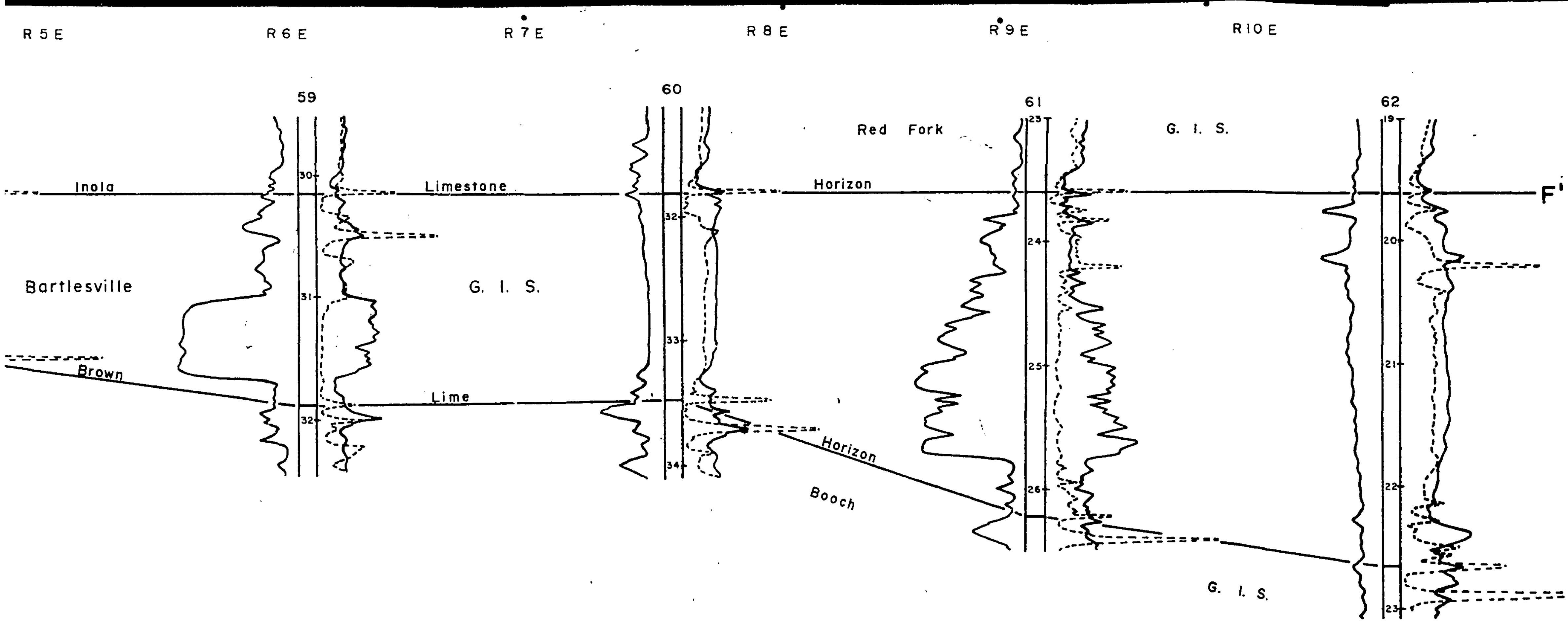
PLATE VI

BARTLESVILLE GENETIC INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP AND STRATIGRAPHIC PROFILE FF'

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles
Scale



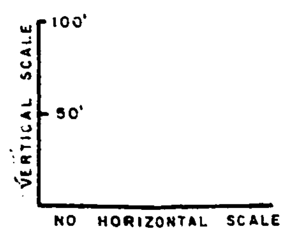
LEGEND:

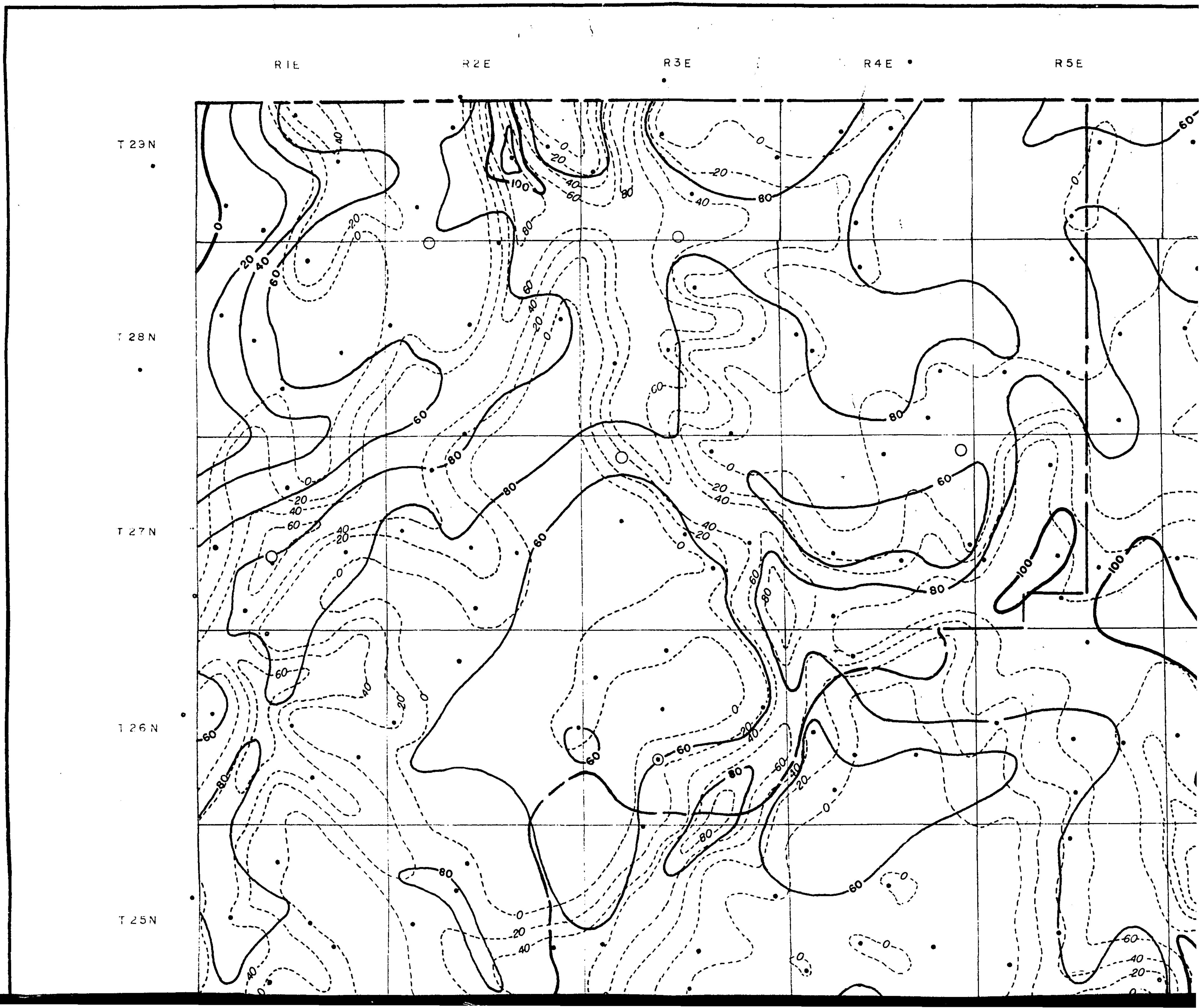
- • Control Well
- ⊙ Sample Control
- C. I. Isopach 20'
- C. I. Isolith 20'
- —220— Isopach Line
- ---80---- Isolith Line

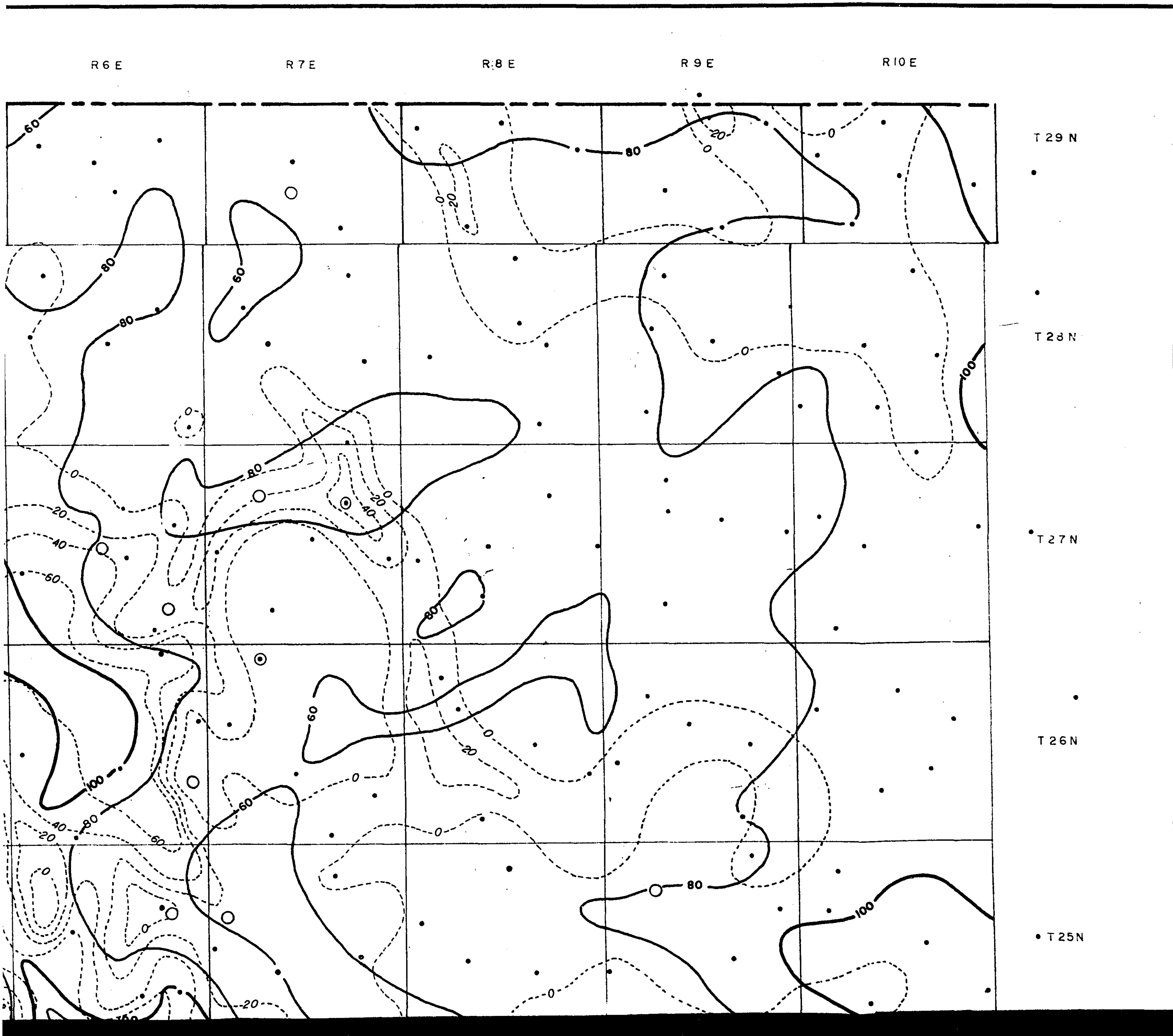
Sandstone Thickness

- 0-40'
- 40-80'
- 80-120'
- 120' +

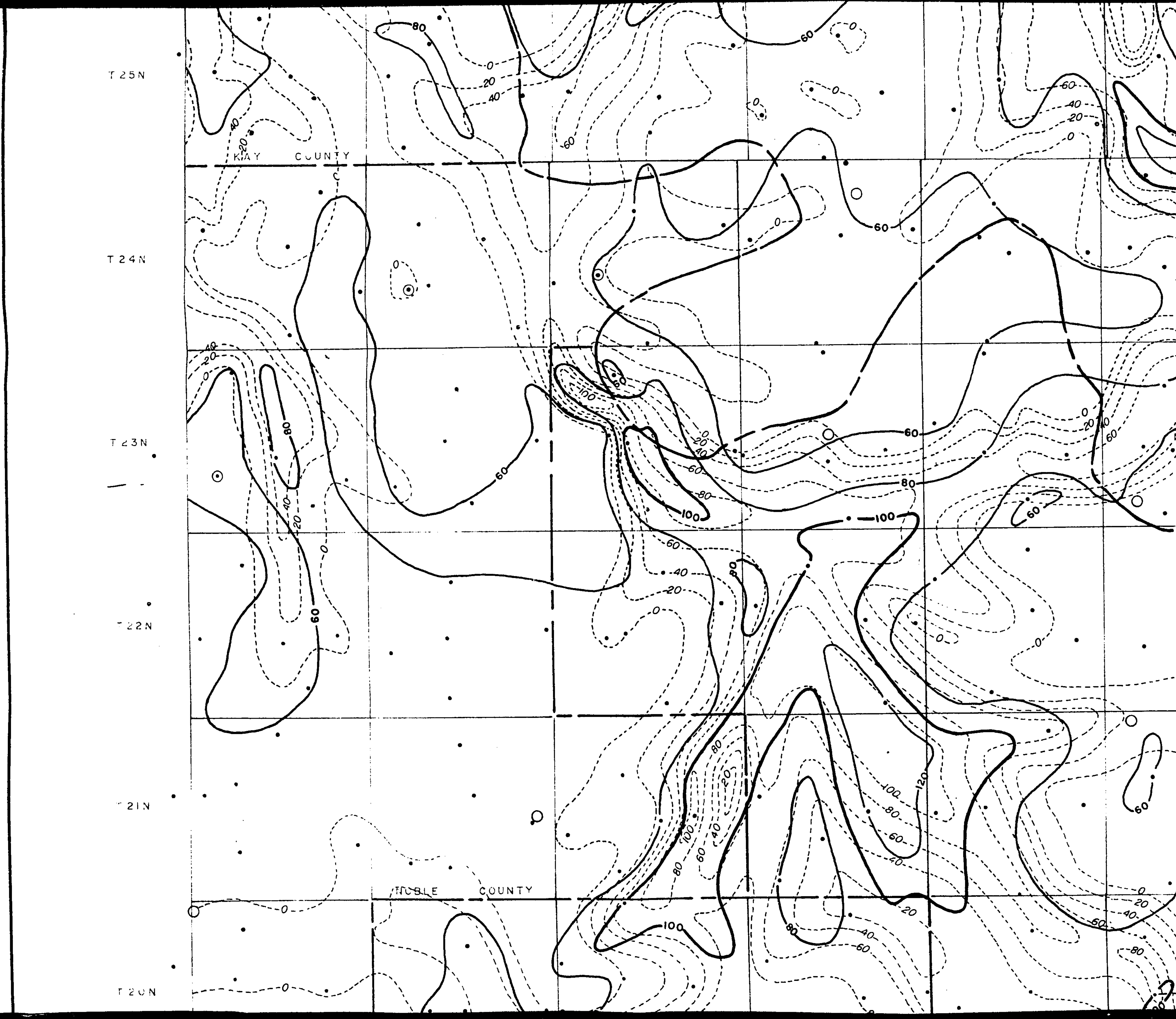
Emergent Areas

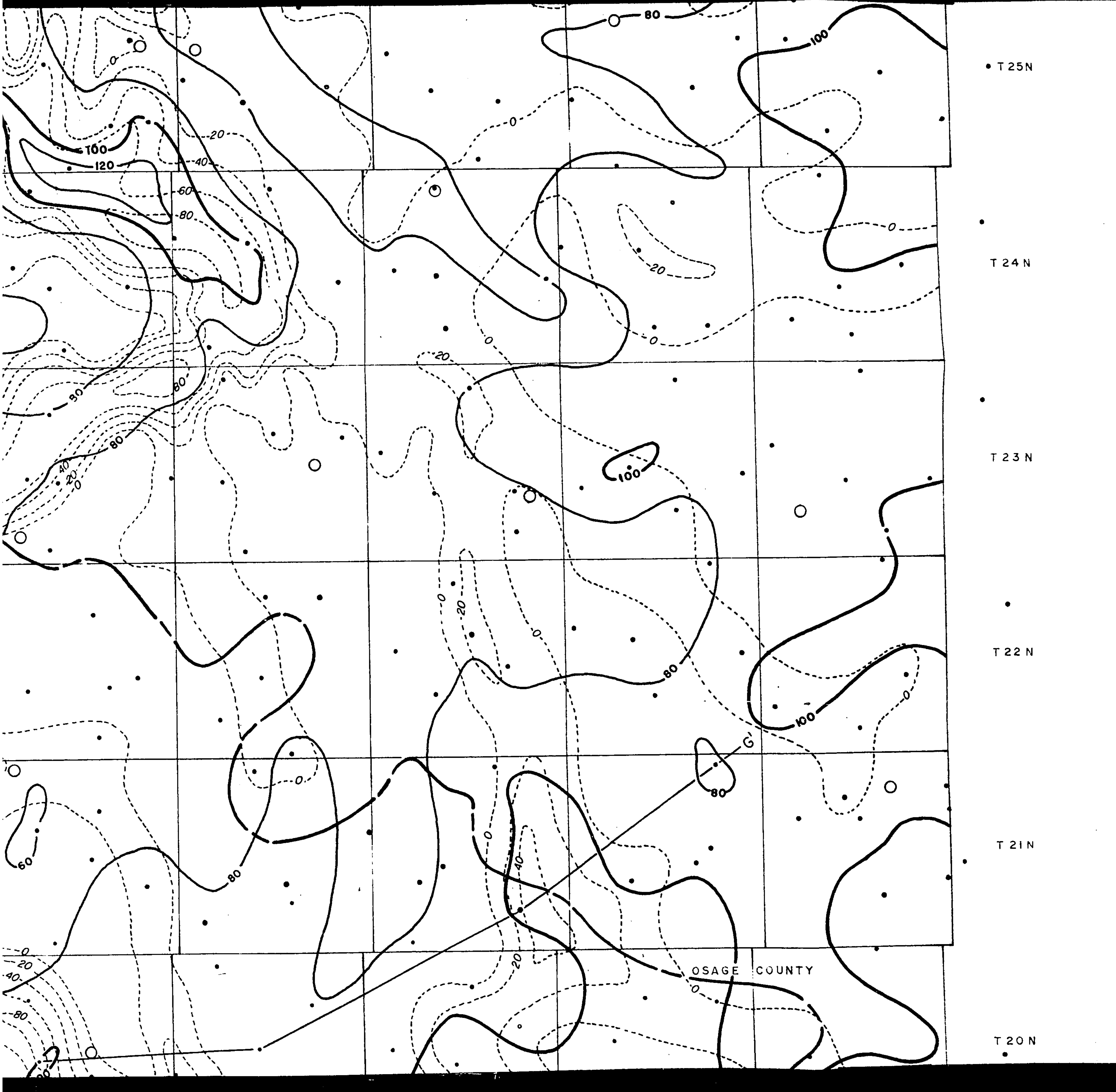



R1E
R2E
R3E
R4E
R5E
T 29N
T 28N
T 27N
T 26N
T 25N

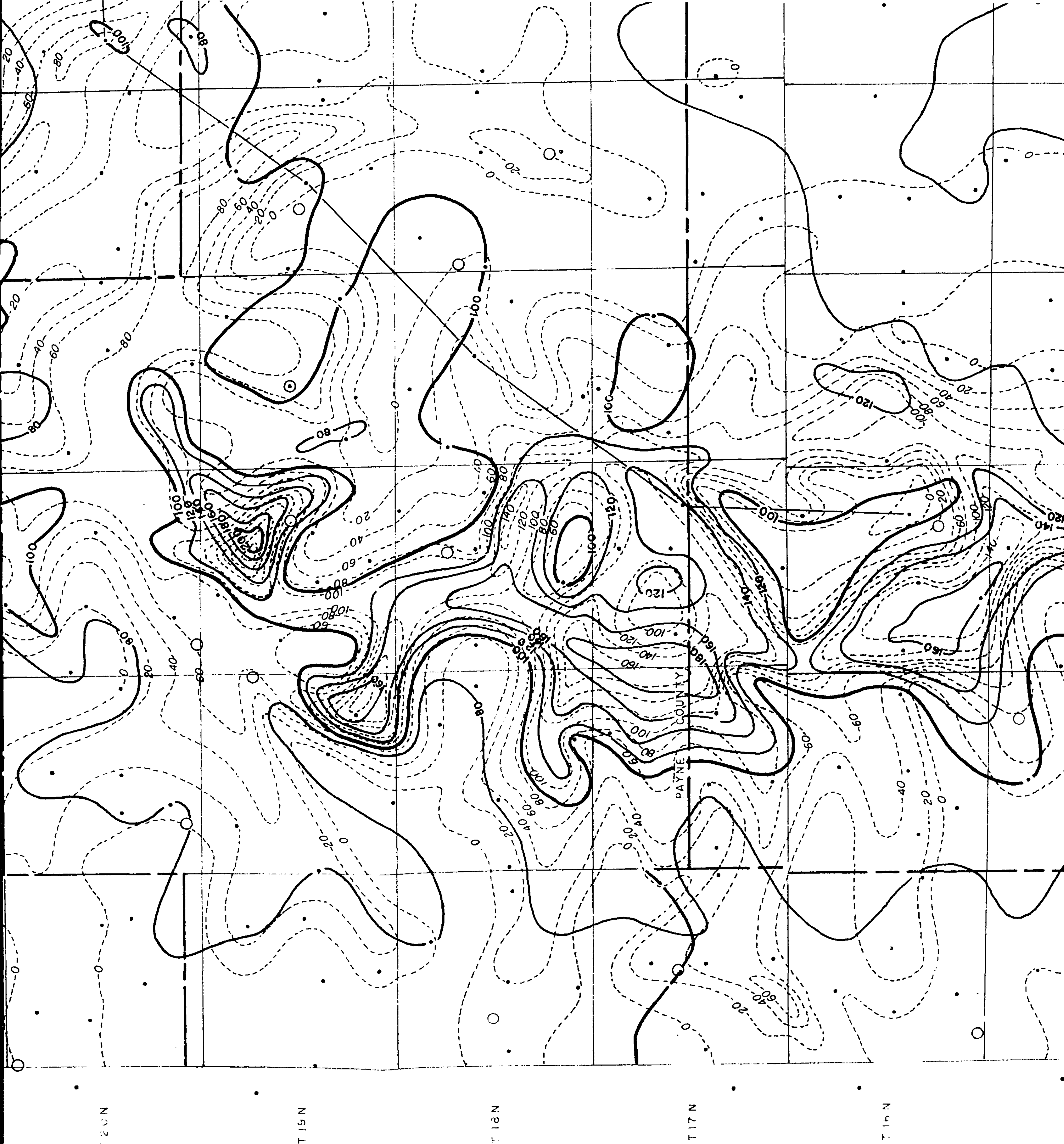


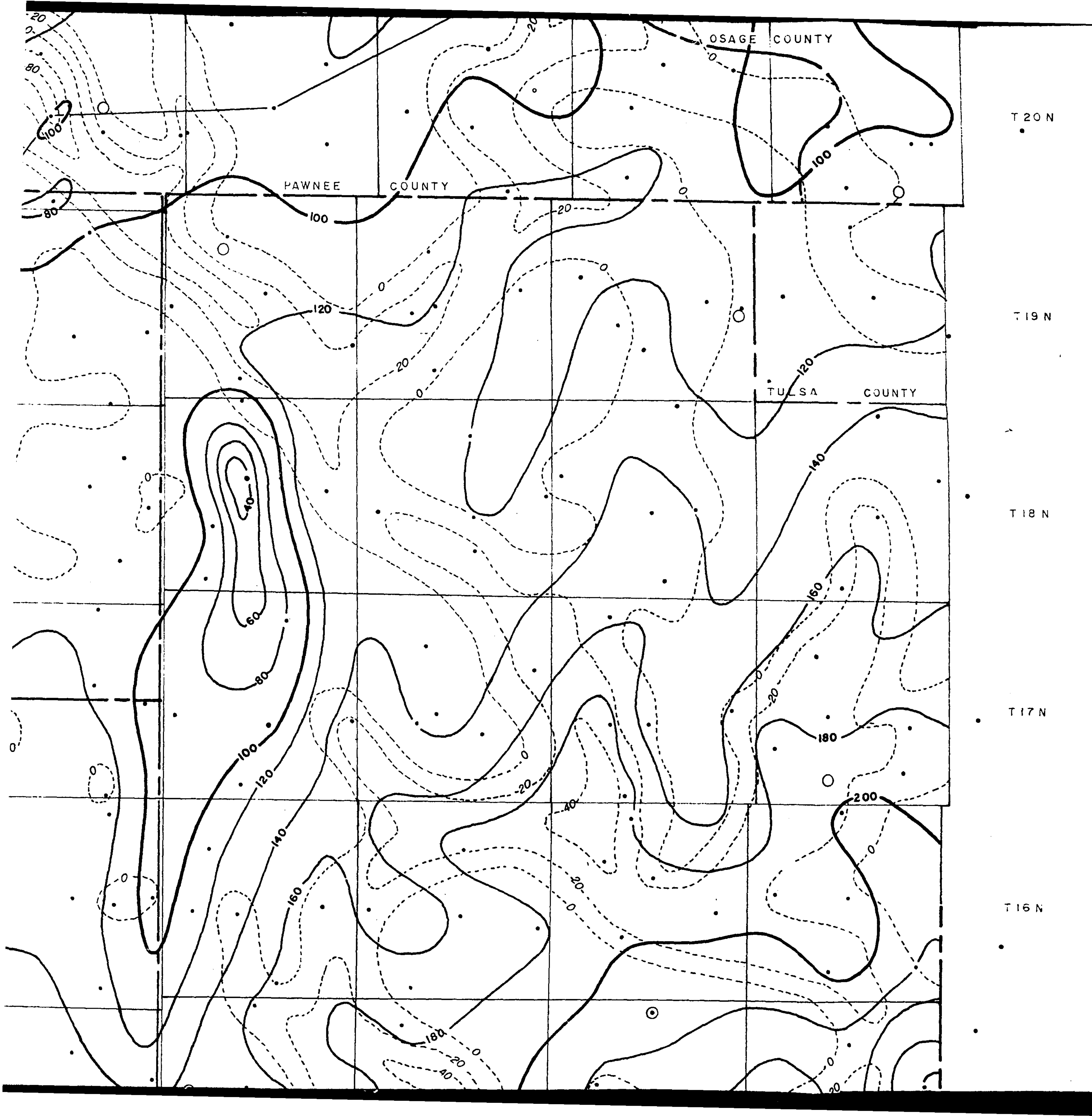
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
60
80
100
0
20
40

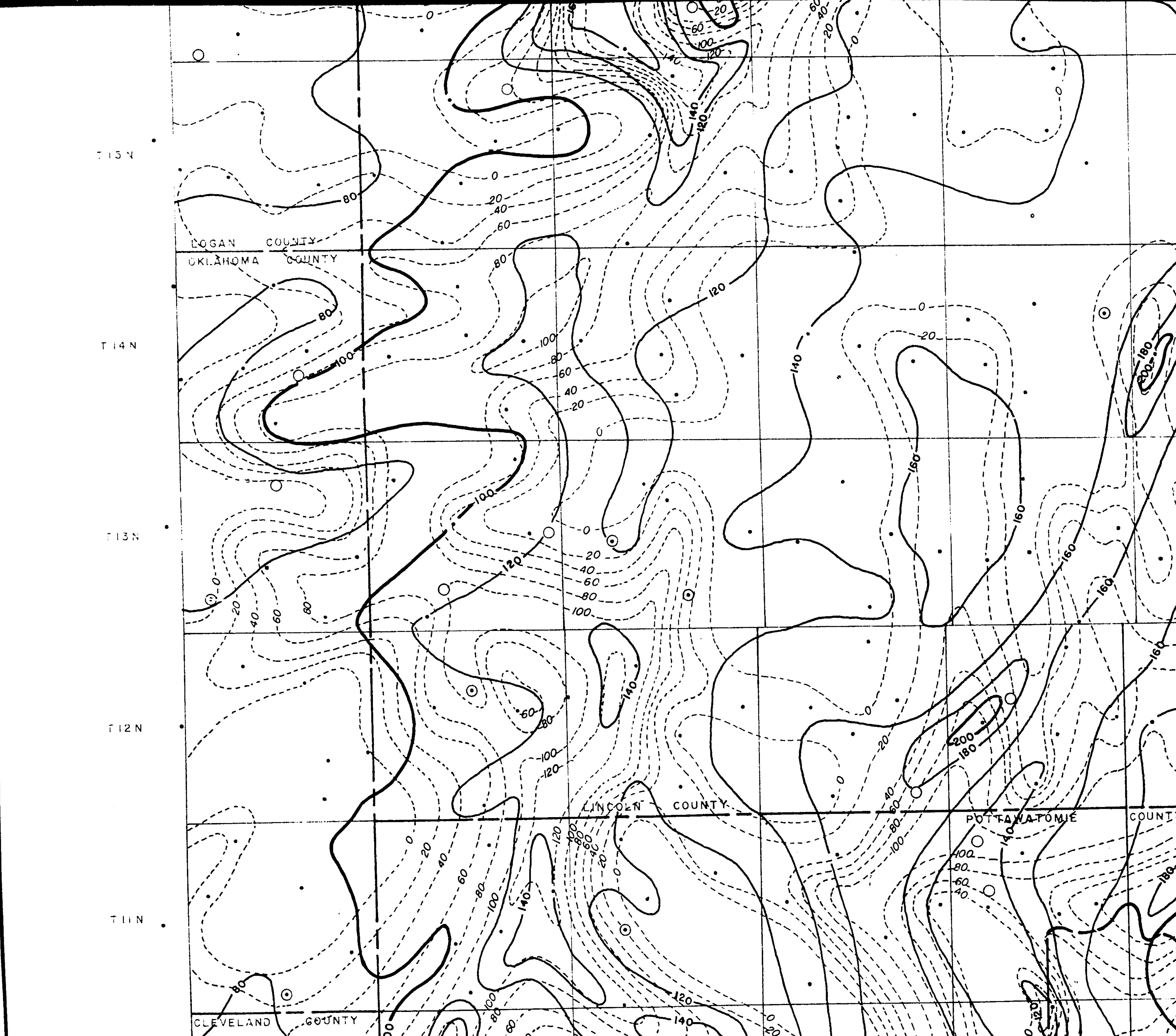

T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
KAY COUNTY
NOBLE COUNTY



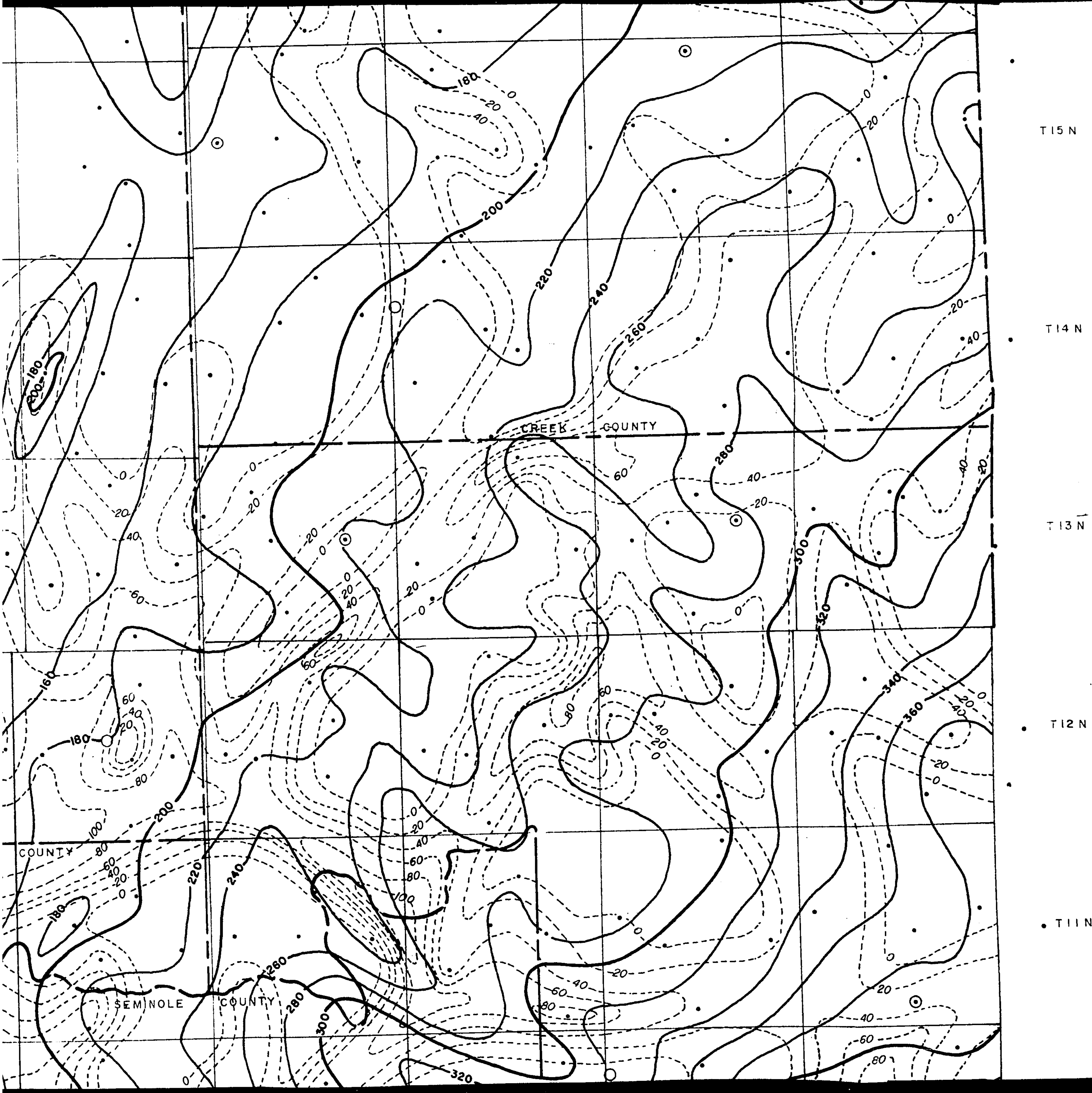
T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
OSAGE COUNTY
G'
80
100
120
0
20
40
60


PAYNE COUNTY
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N


OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
0
20
40
60
80
100
120
140
160
180
200



T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY



T15 N
T14 N
T13 N
T12 N
T11 N
CREEK COUNTY
SEMINOLE COUNTY
COUNTY

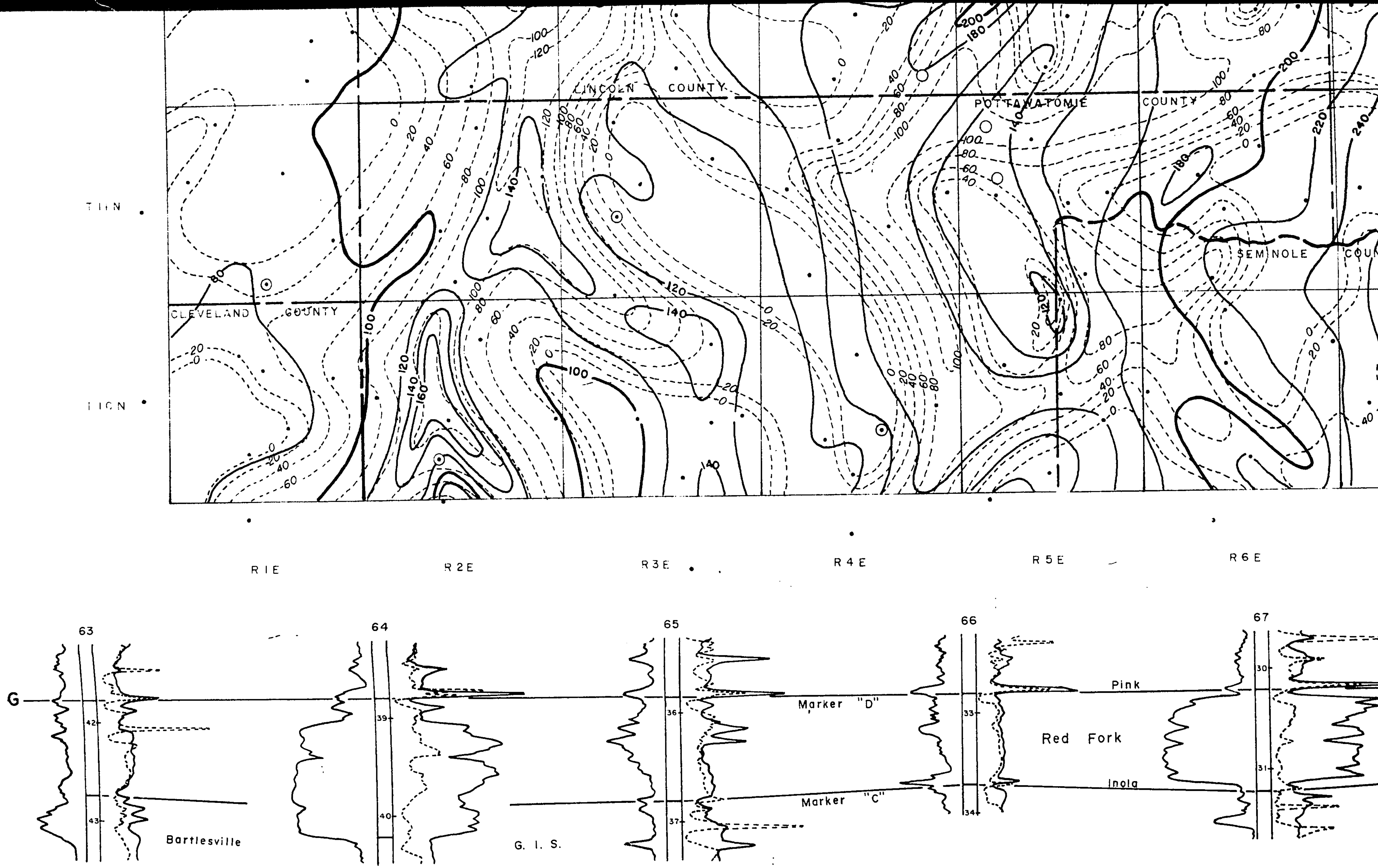
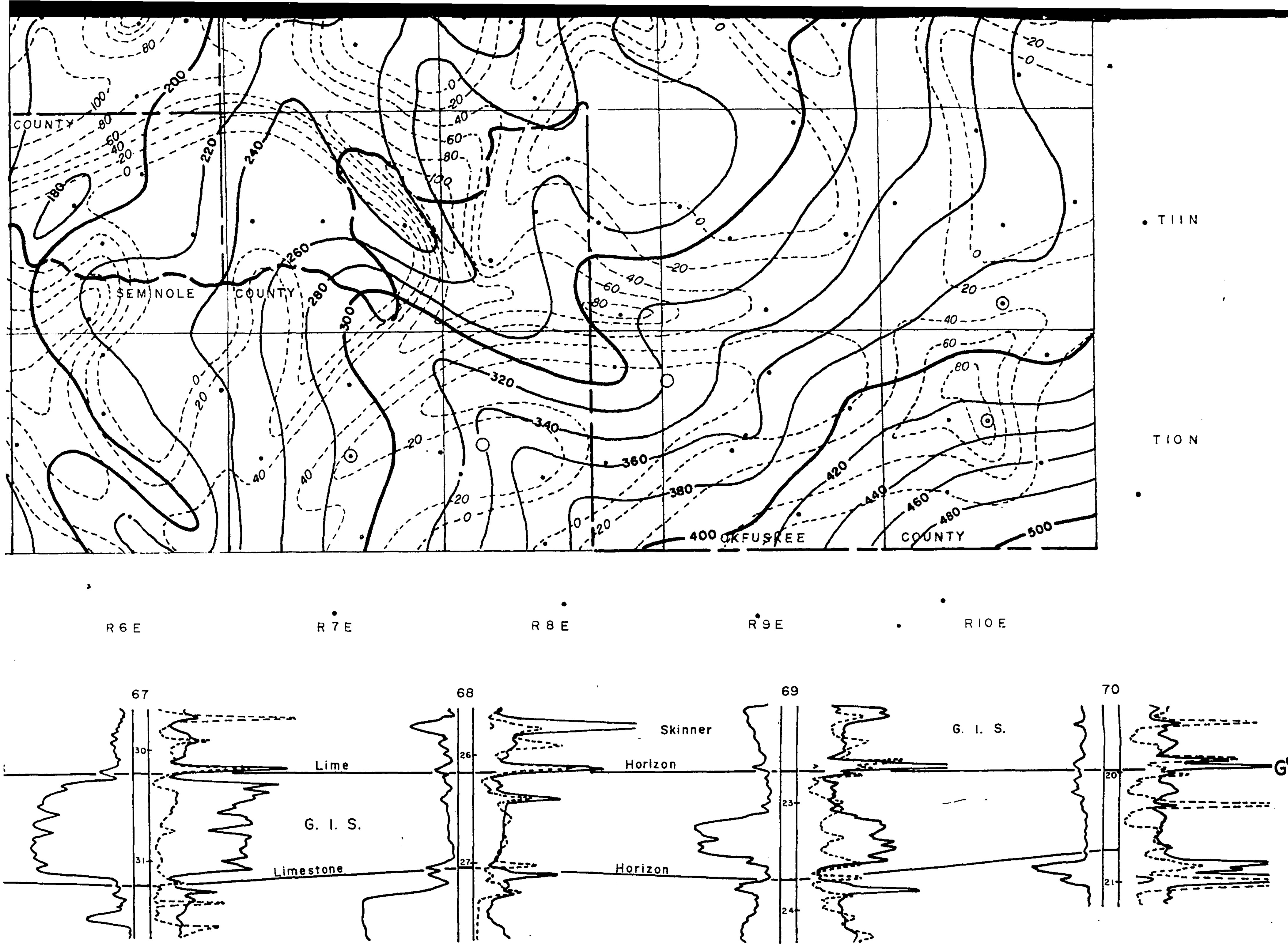


PLATE VII

RED FORK GENETIC INCREMENT OF STRATA



SEMINOLE COUNTY
COUNTY
OKFUSKEE COUNTY
T11N
T10N
R6E
R7E
R8E
R9E
R10E
67
68
69
70
Skinner
Lime
Horizon
G. I. S.
Limestone
Horizon
G'

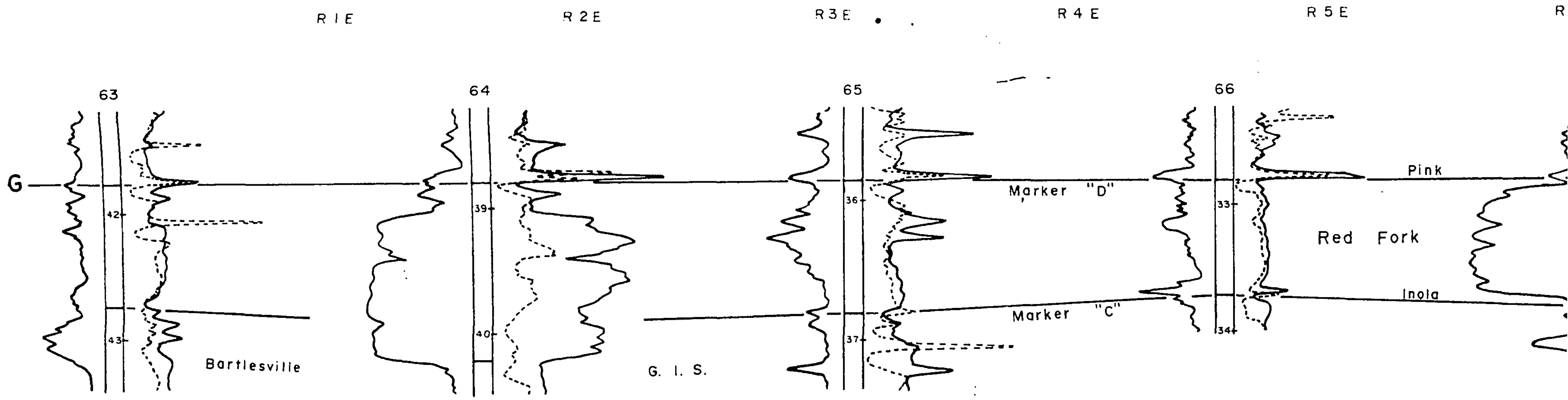
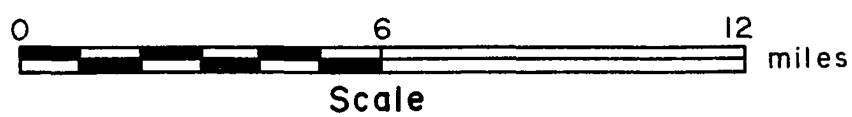


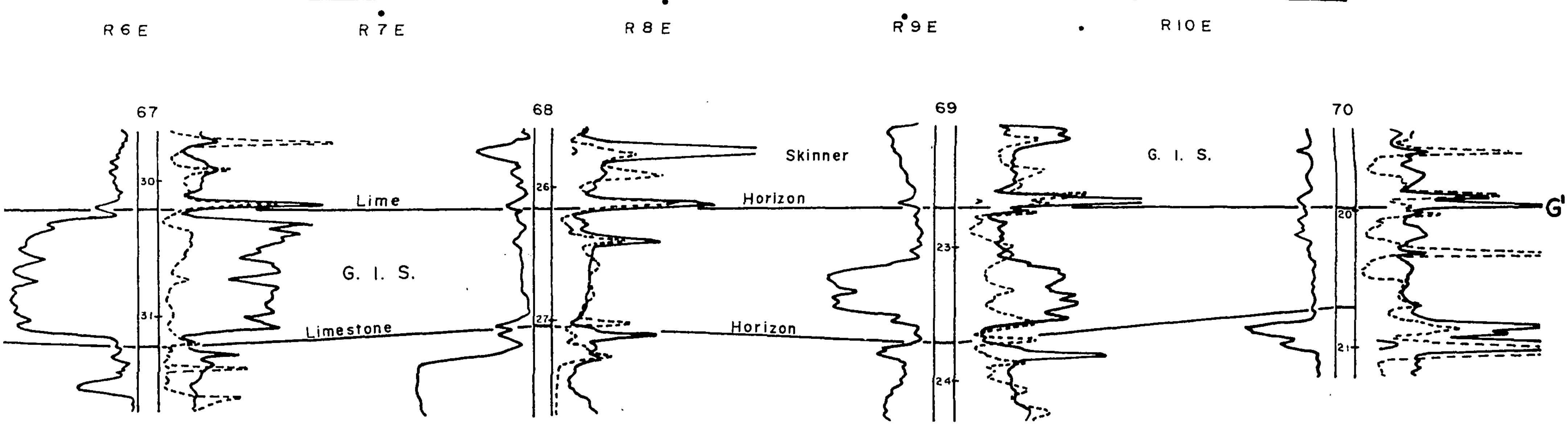
PLATE VII

RED FORK GENETIC INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP AND STRATIGRAPHIC PROFILE GG'

by

J. Glenn Cole Ph. D. 1968





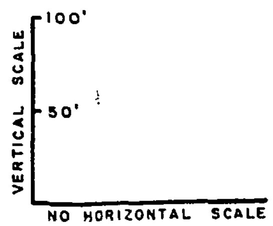
LEGEND:

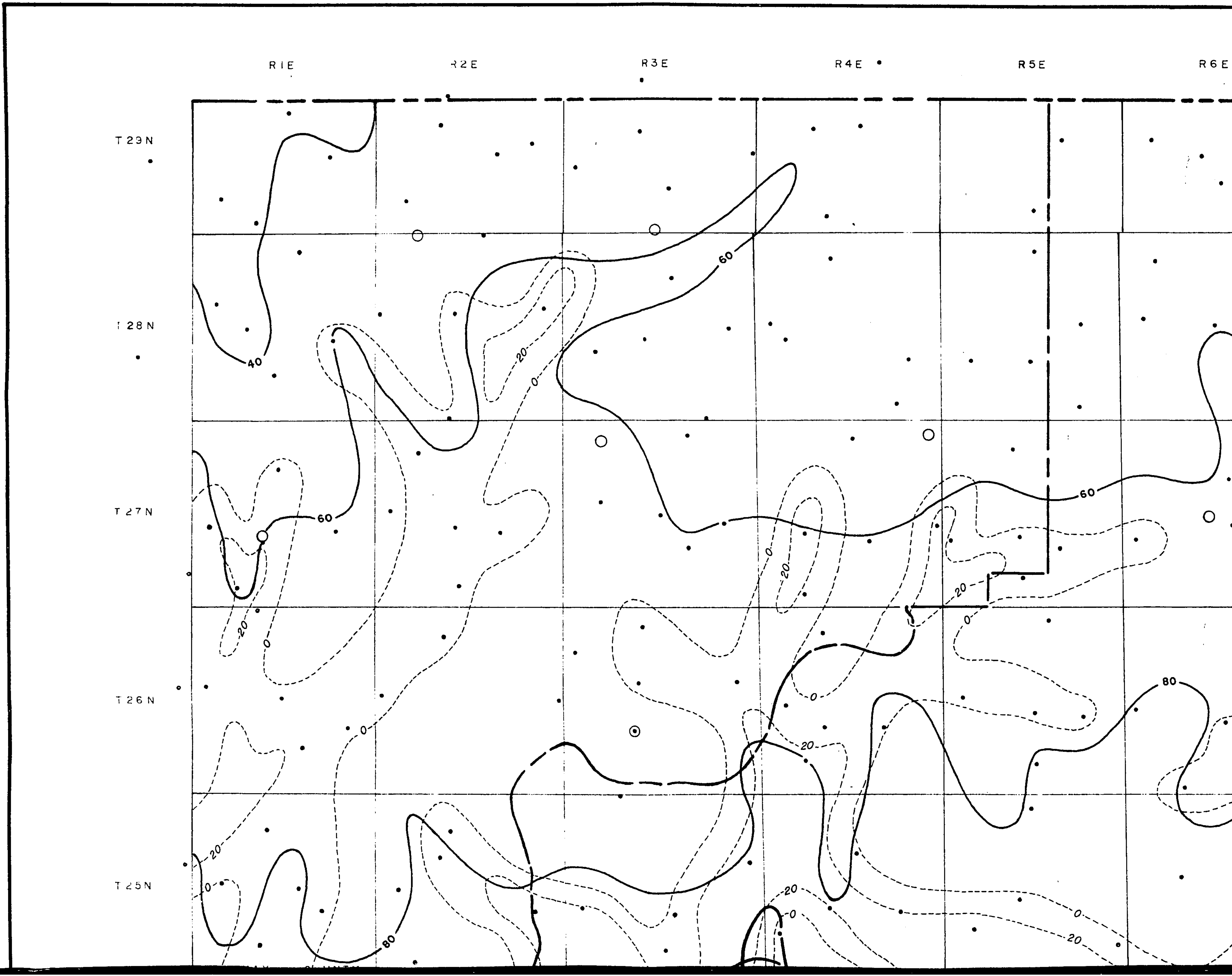
- ● Control Well
- ○ Sample Control
- C. I. Isopach 20'
- C. I. Isolith 20'
- —200—— Isopach Line
- ---*40*---- Isolith Line

Sandstone Thickness

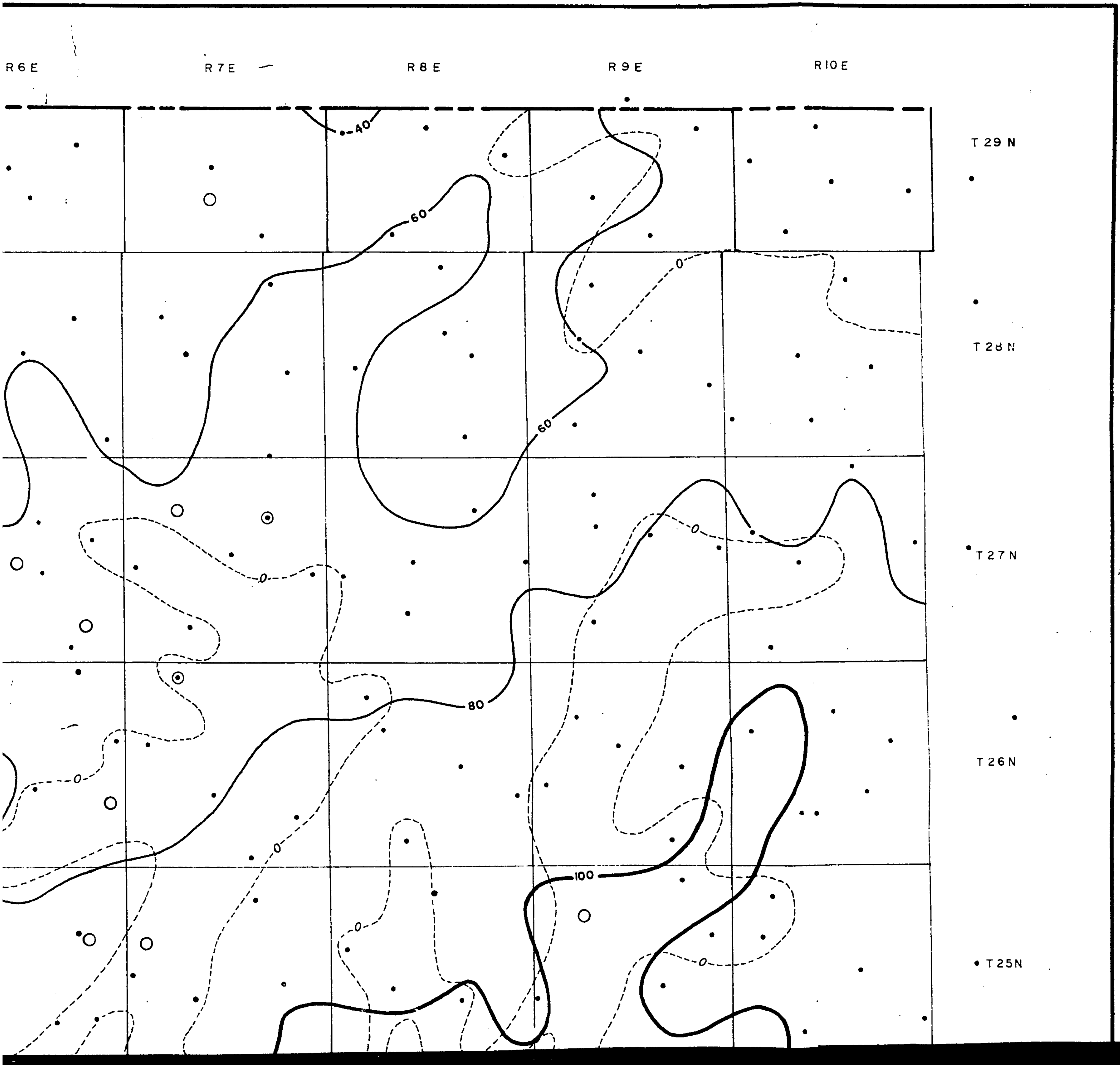
- 0-40'
- 40-80'
- 80'-120'
- 120' +

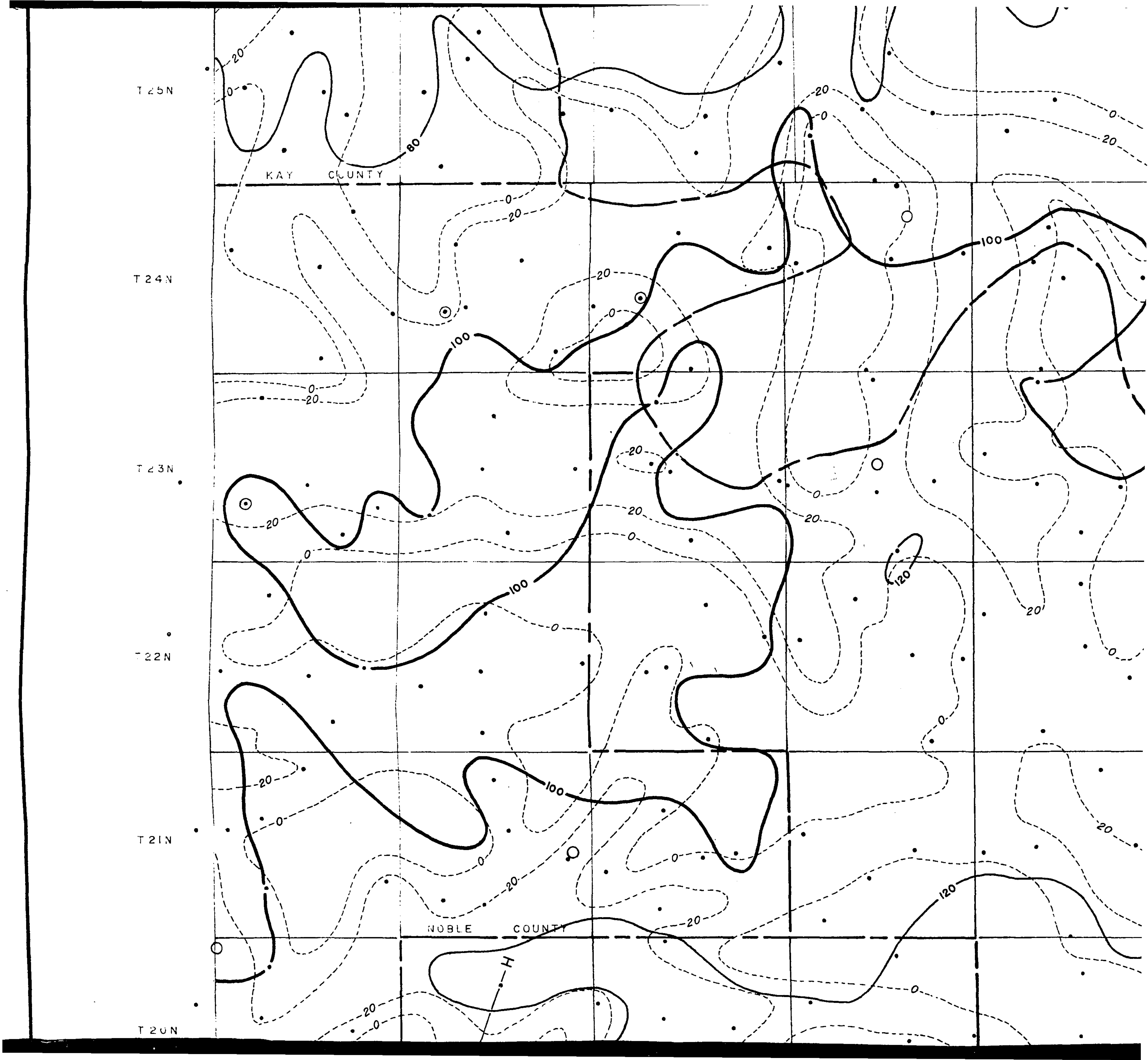
Emergent Areas

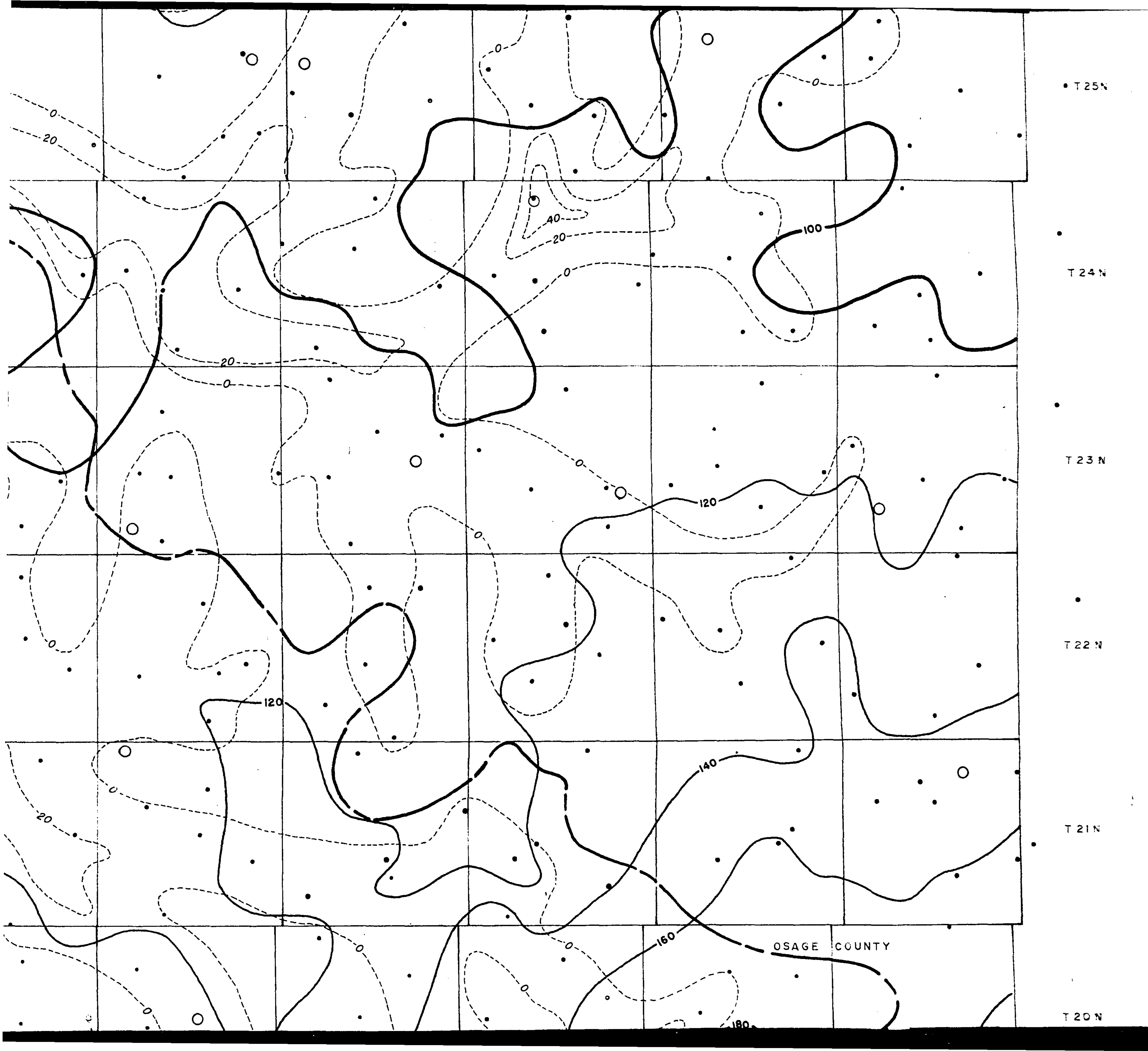


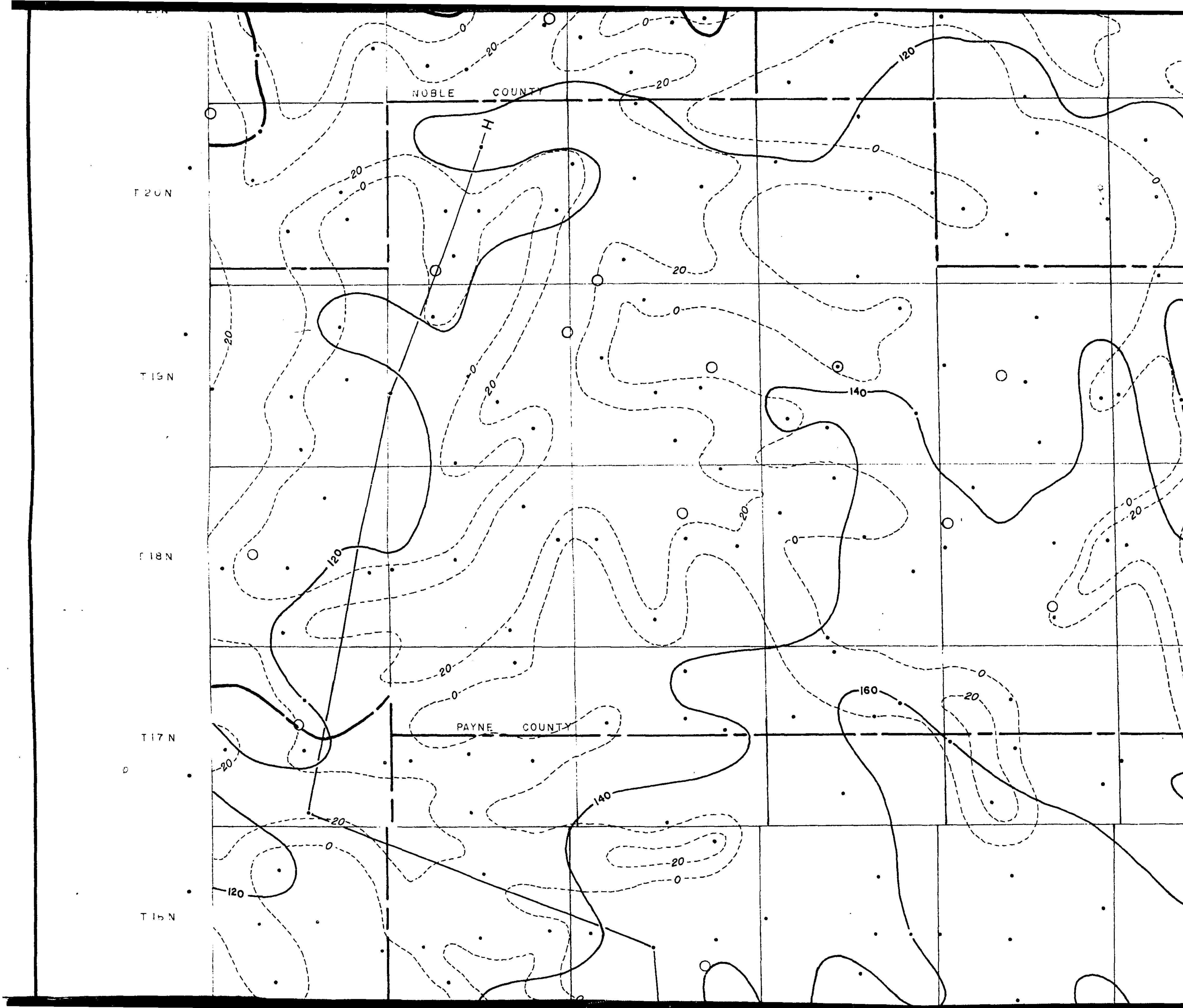


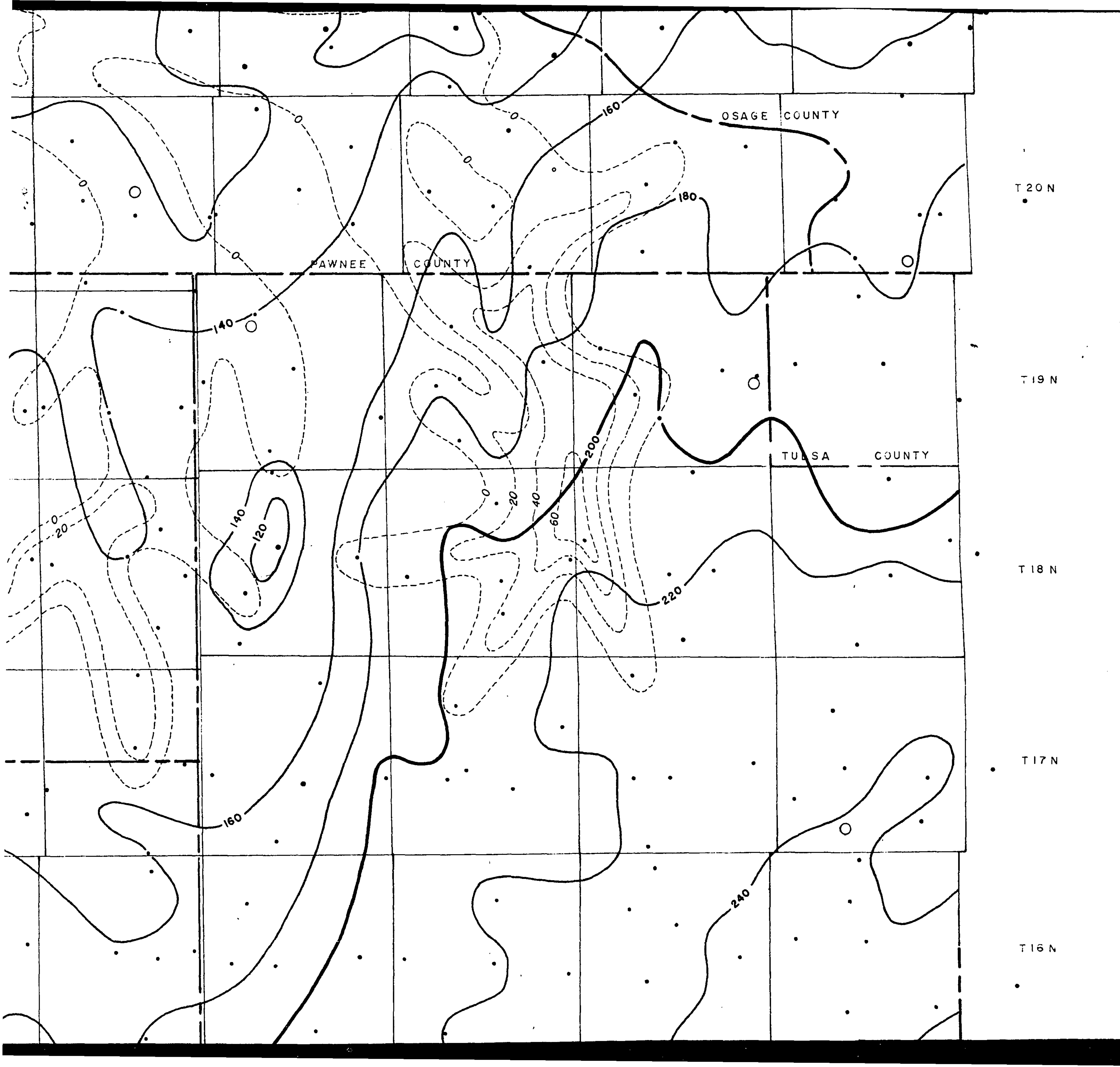
R1E
R2E
R3E
R4E
R5E
R6E
T29N
T28N
T27N
T26N
T25N
40
60
80
20
0

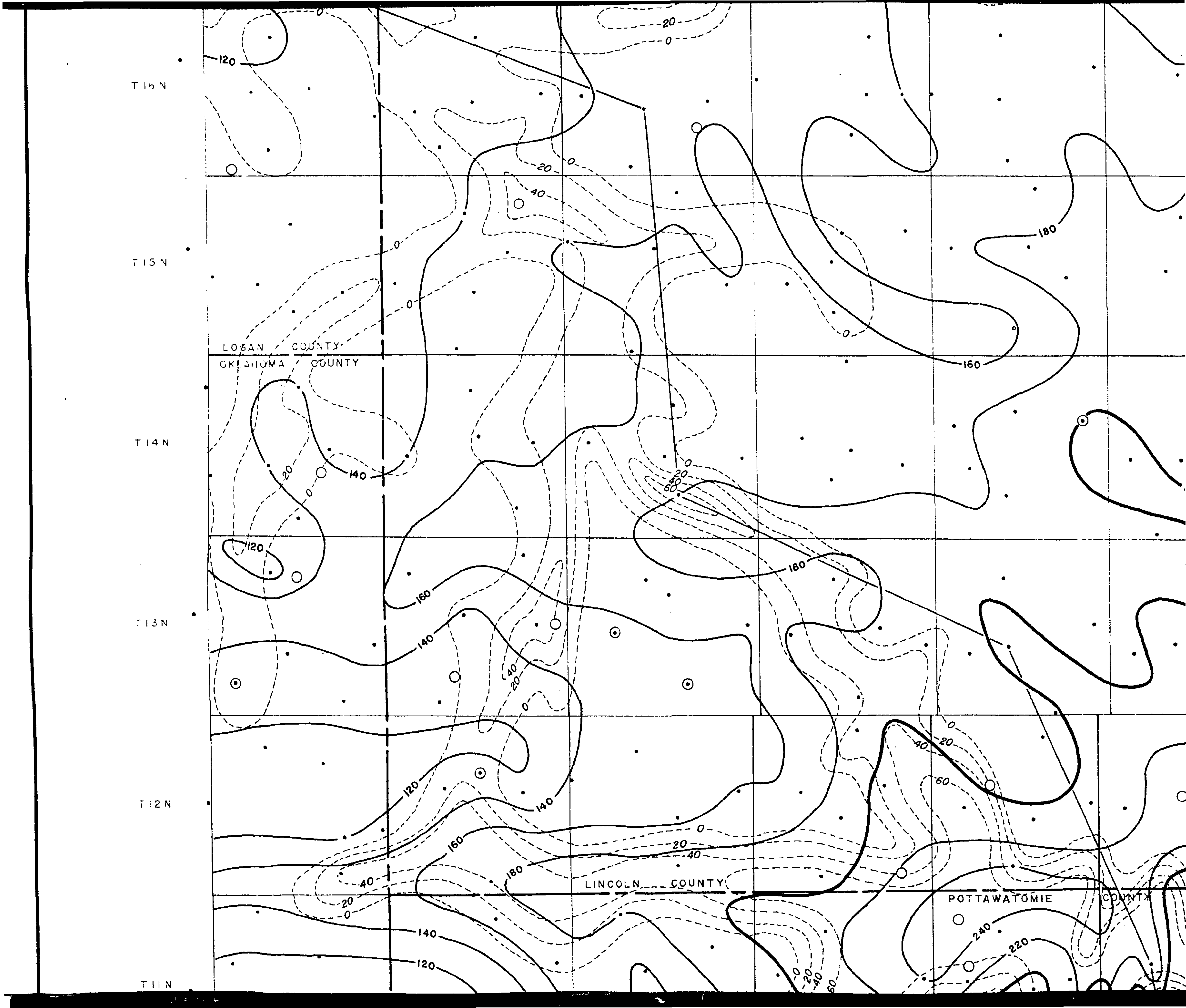

R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
40
60
60
80
100
0
0
0
0
0
0
0
0

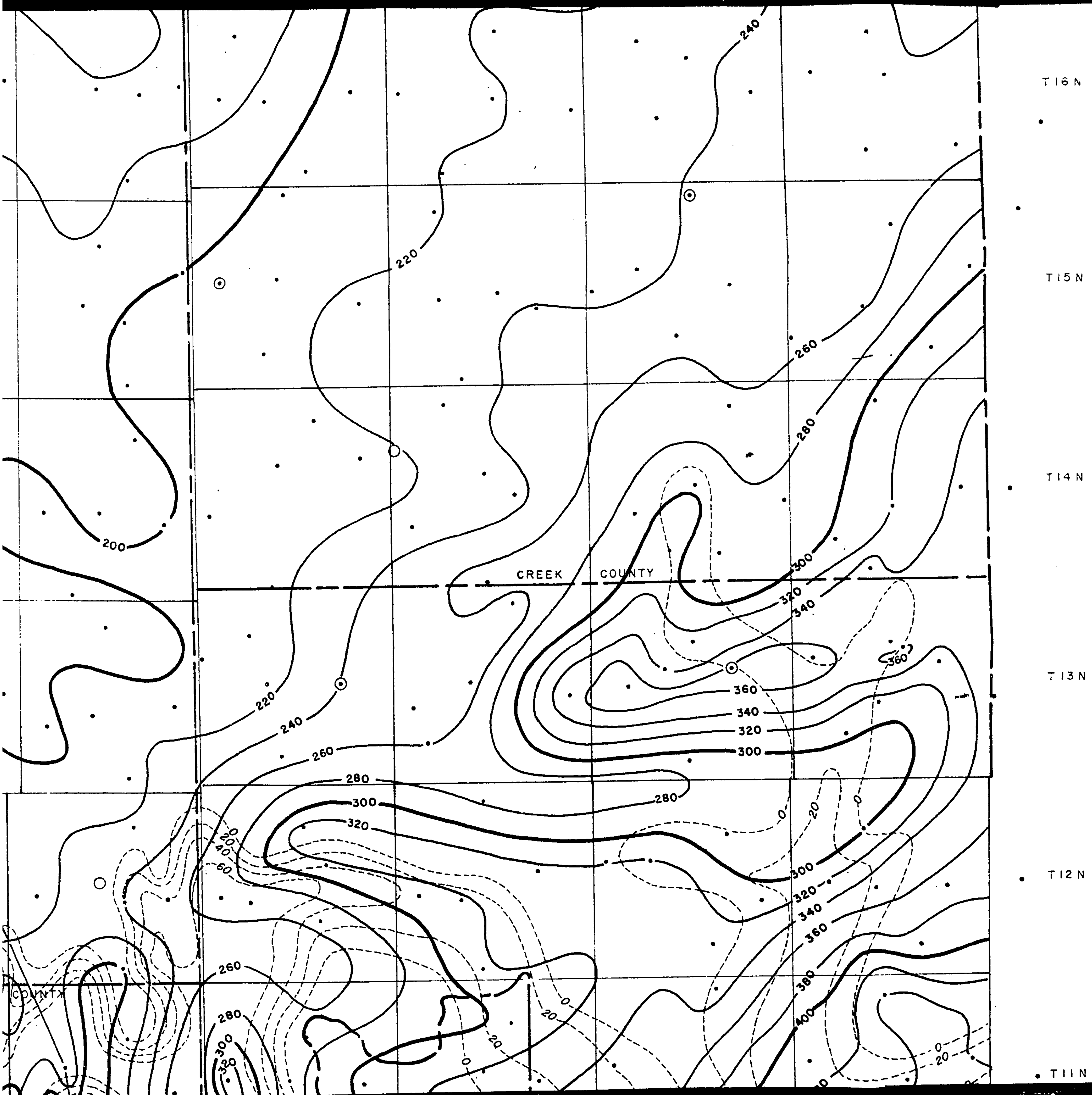

T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
KAY COUNTY
NOBLE COUNTY
80
100
120
20
0
H


T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
OSAGE COUNTY
0
20
40
100
120
140
160
180

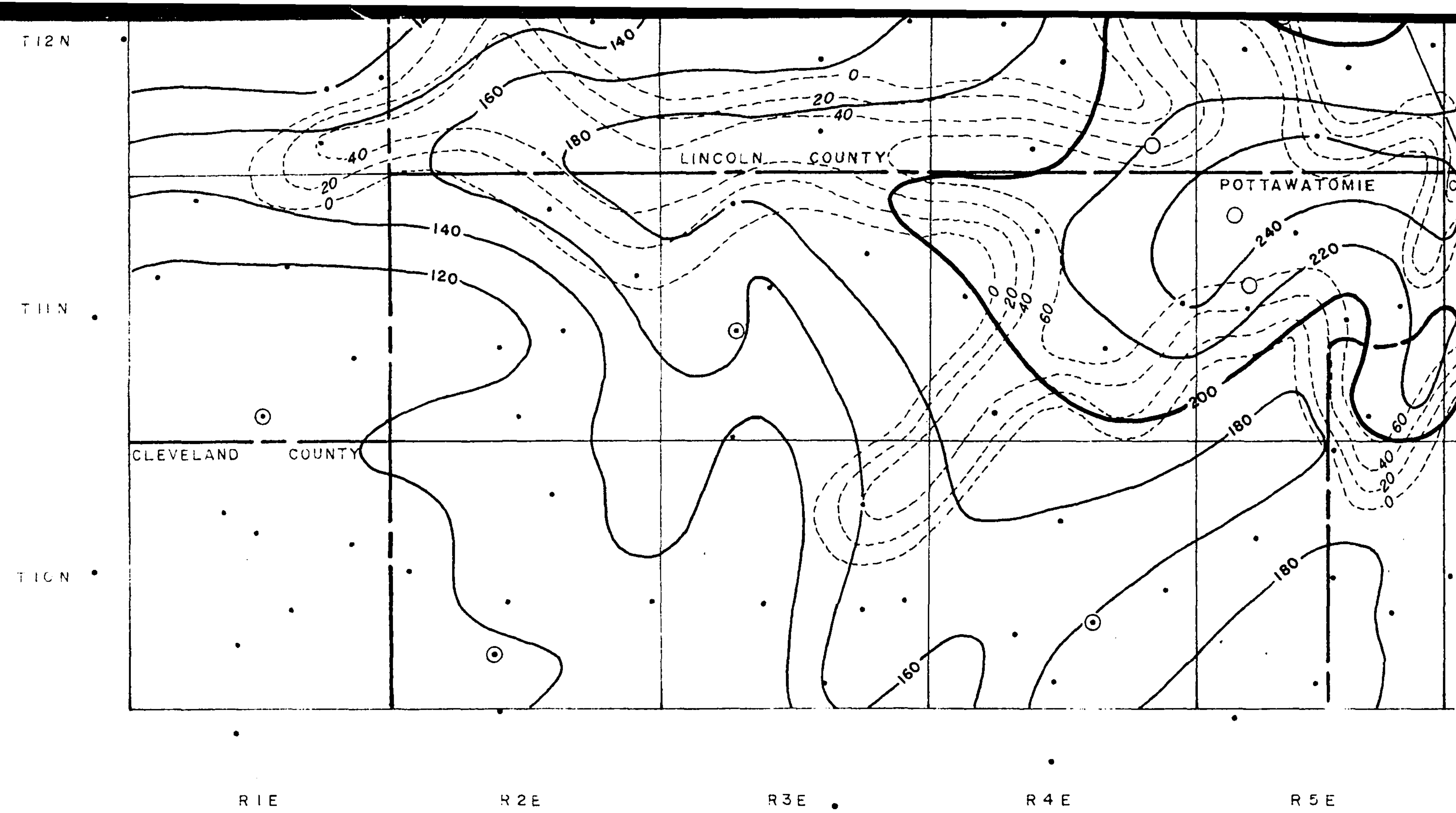

T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
NOBLE COUNTY
PAYNE COUNTY
H
0
20
120
140
160

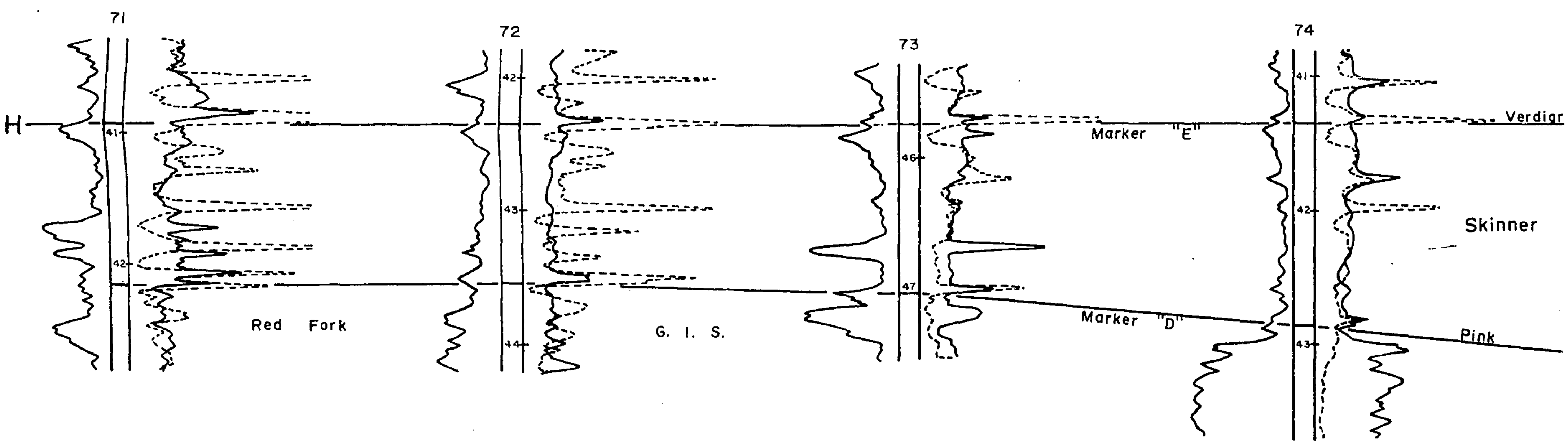

OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
T20N
T19N
T18N
T17N
T16N
0
20
40
60
120
140
160
180
200
220
240

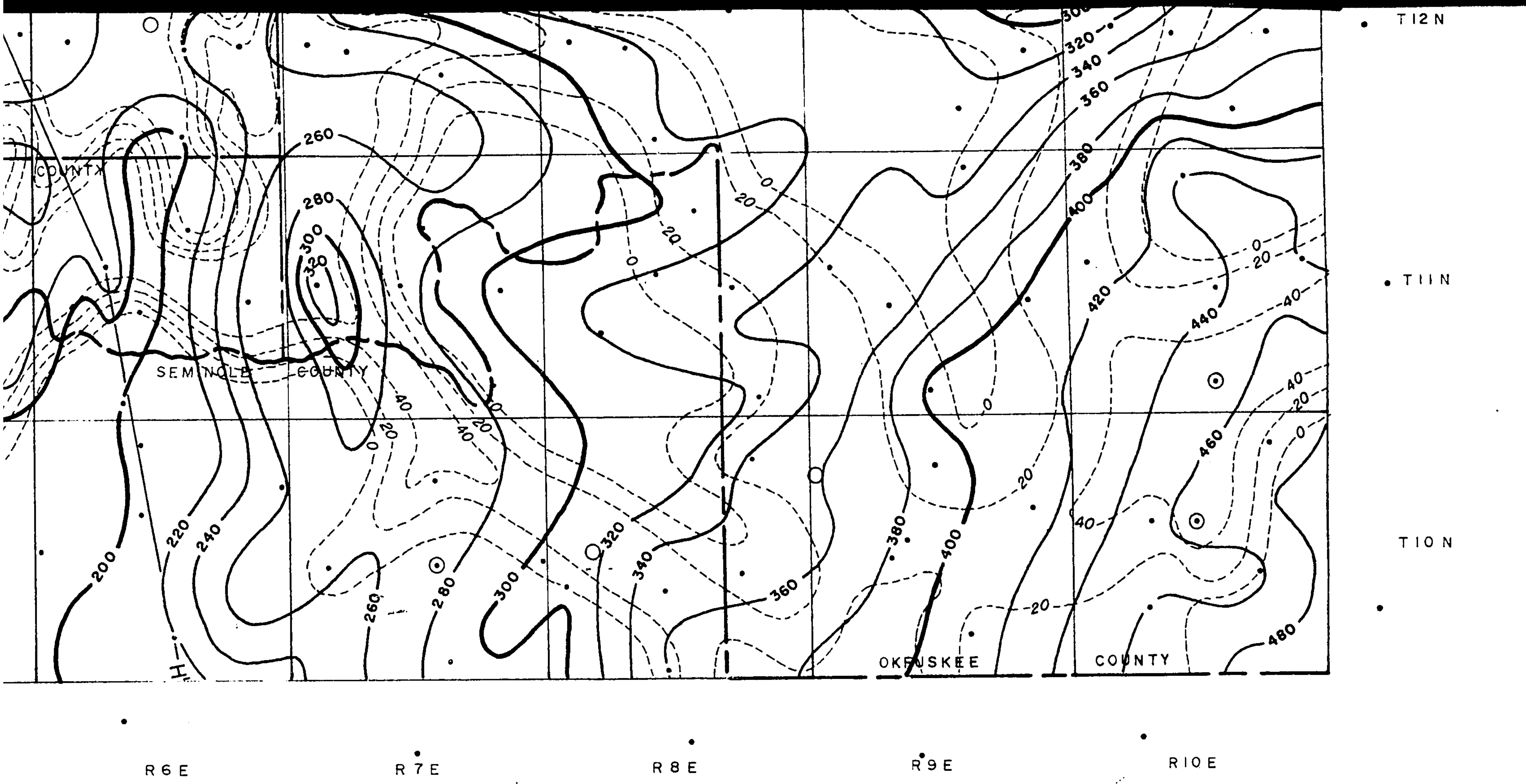

T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
0
20
40
60
120
140
160
180
220
240



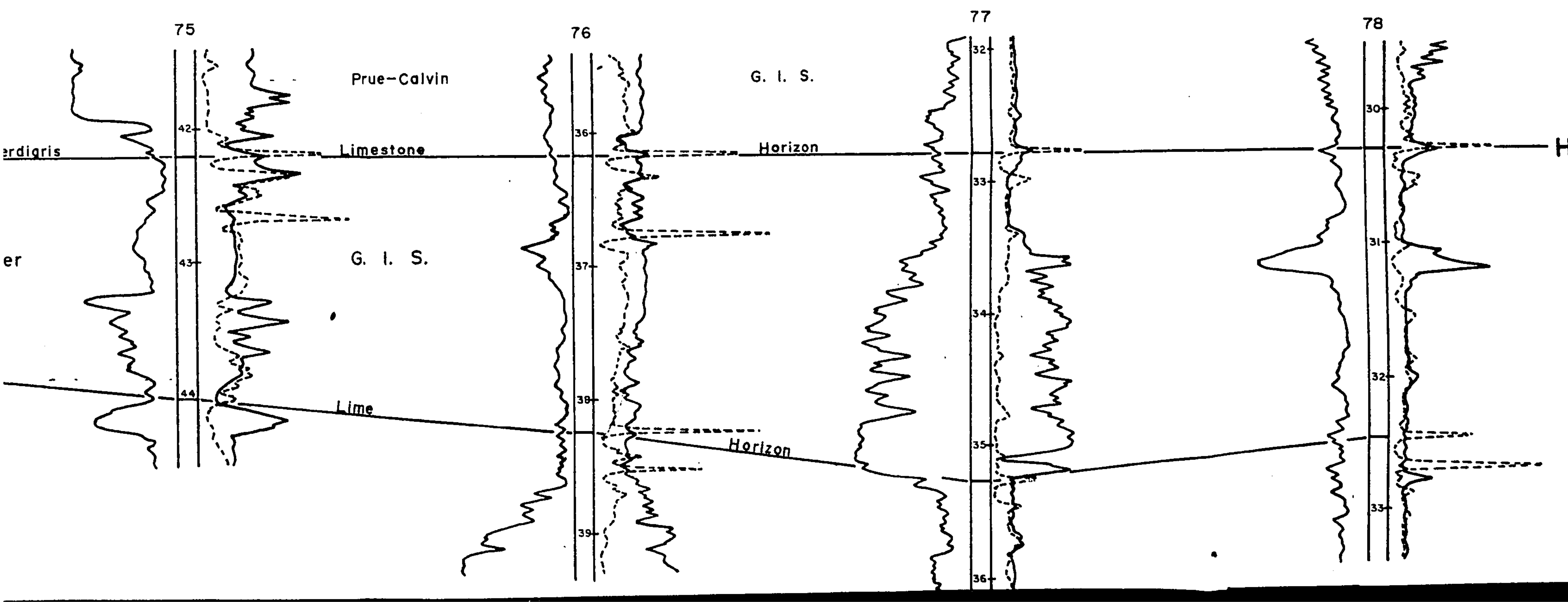
T16N
T15N
T14N
T13N
T12N
T11N
CREEK COUNTY
COUNTY
200
220
240
260
280
300
320
340
360
380
400
0
20
40
60


T12N
T11N
T10N
LINCOLN COUNTY
POTTAWATOMIE
CLEVELAND COUNTY
R1E
R2E
R3E
R4E
R5E
140
160
180
120
0
20
40
60
200
220
240


71
72
73
74
H
Verdigr
Marker "E"
Skinner
Red Fork
G. I. S.
Marker "D"
Pink



T12N
T11N
T10N
SEMINOLE COUNTY
OKFUSKEE COUNTY
COUNTY
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
0
20
40
-20
R6E
R7E
R8E
R9E
R10E



75
76
77
78
Prue-Calvin
G. I. S.
Limestone
Horizon
G. I. S.
Lime
Horizon
H'

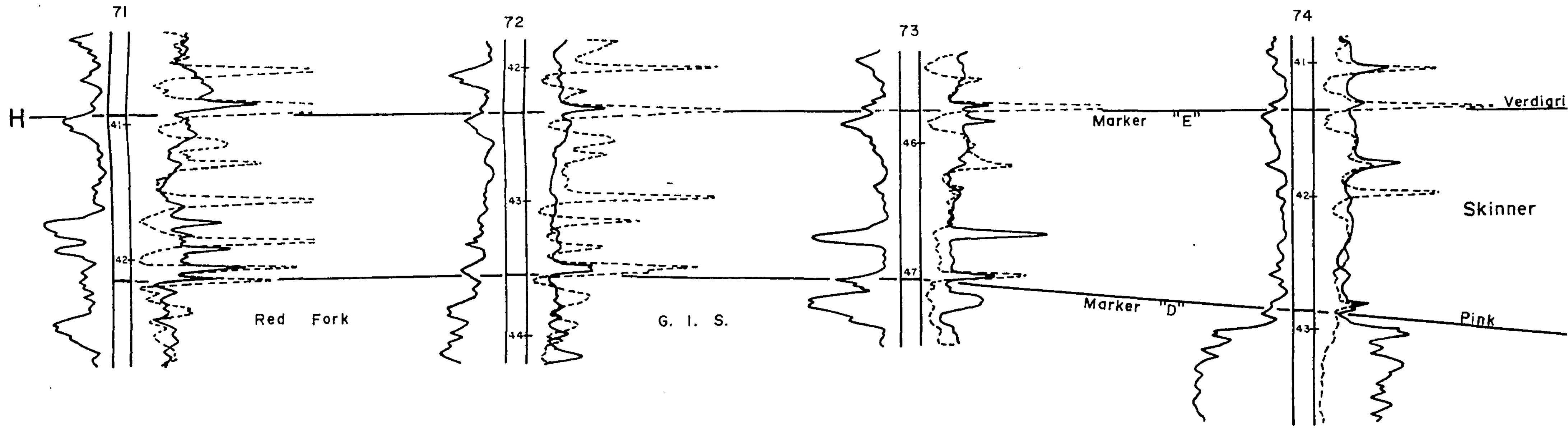


PLATE VIII

SKINNER GENETIC INCREMENT OF STRATA

ISOPACH AND SANDSTONE ISOLITH MAP

(LOWER SANDSTONE)

AND

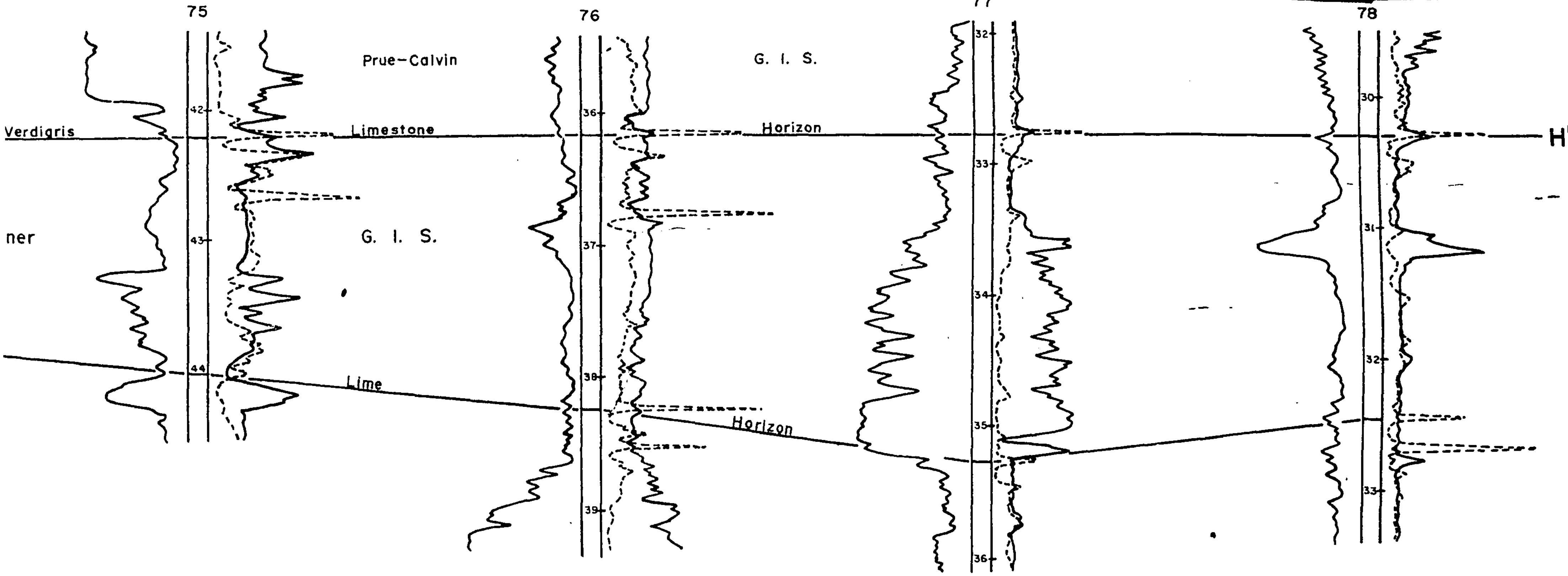
STRATIGRAPHIC PROFILE HH'

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles

Scale



LEGEND:

- • Control Well
- O Sample Control

C. I. Isopach 20'

C. I. Isolith 20'

—260— Isopach Line

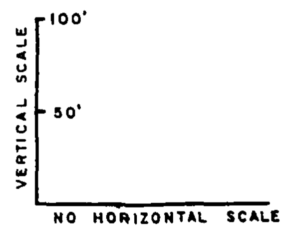
---40---- Isolith Line

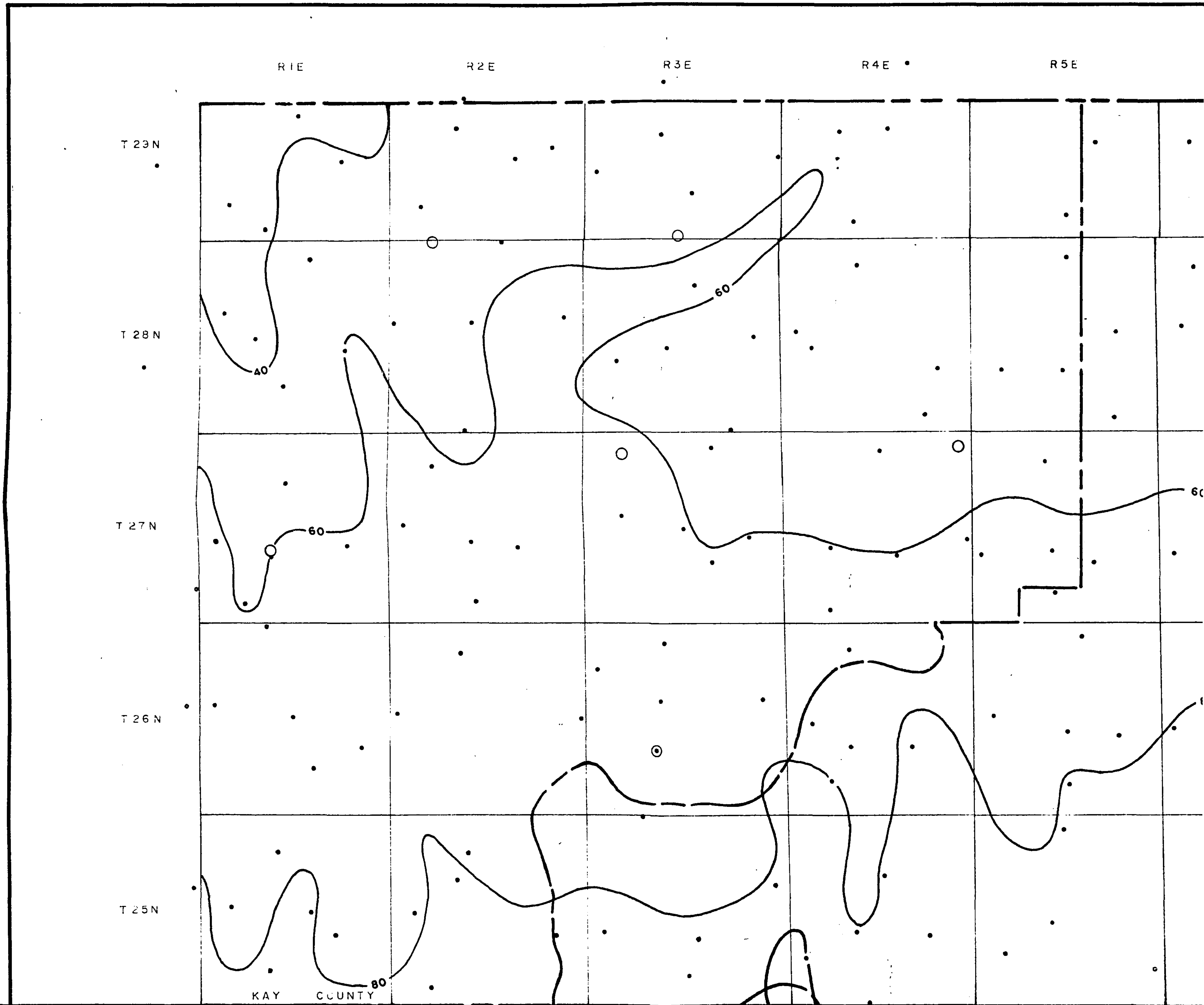
Sandstone Thickness

☐	0-20'
☐	20-40'
☐	40-60'
☐	60' +

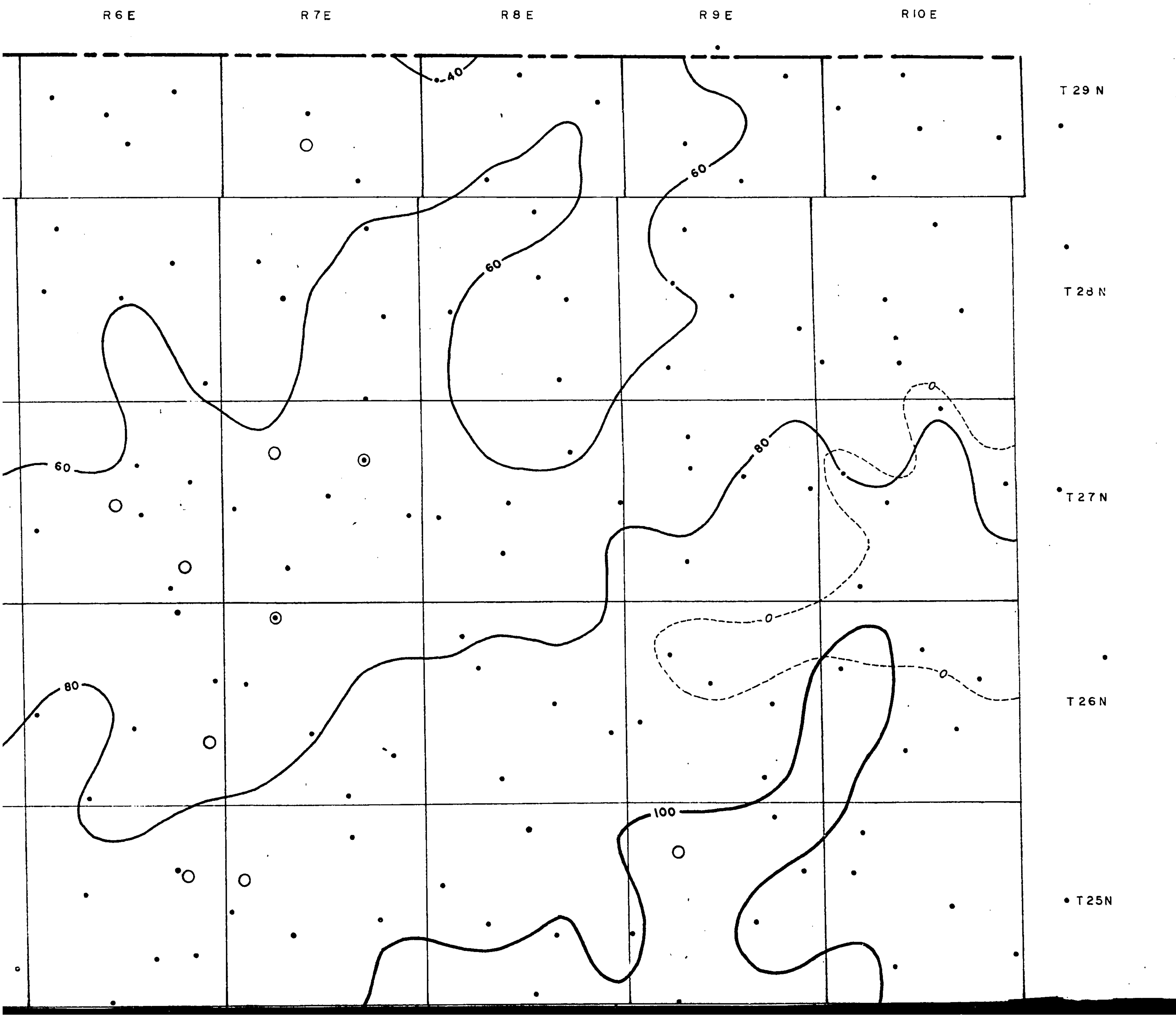
Emergent Areas

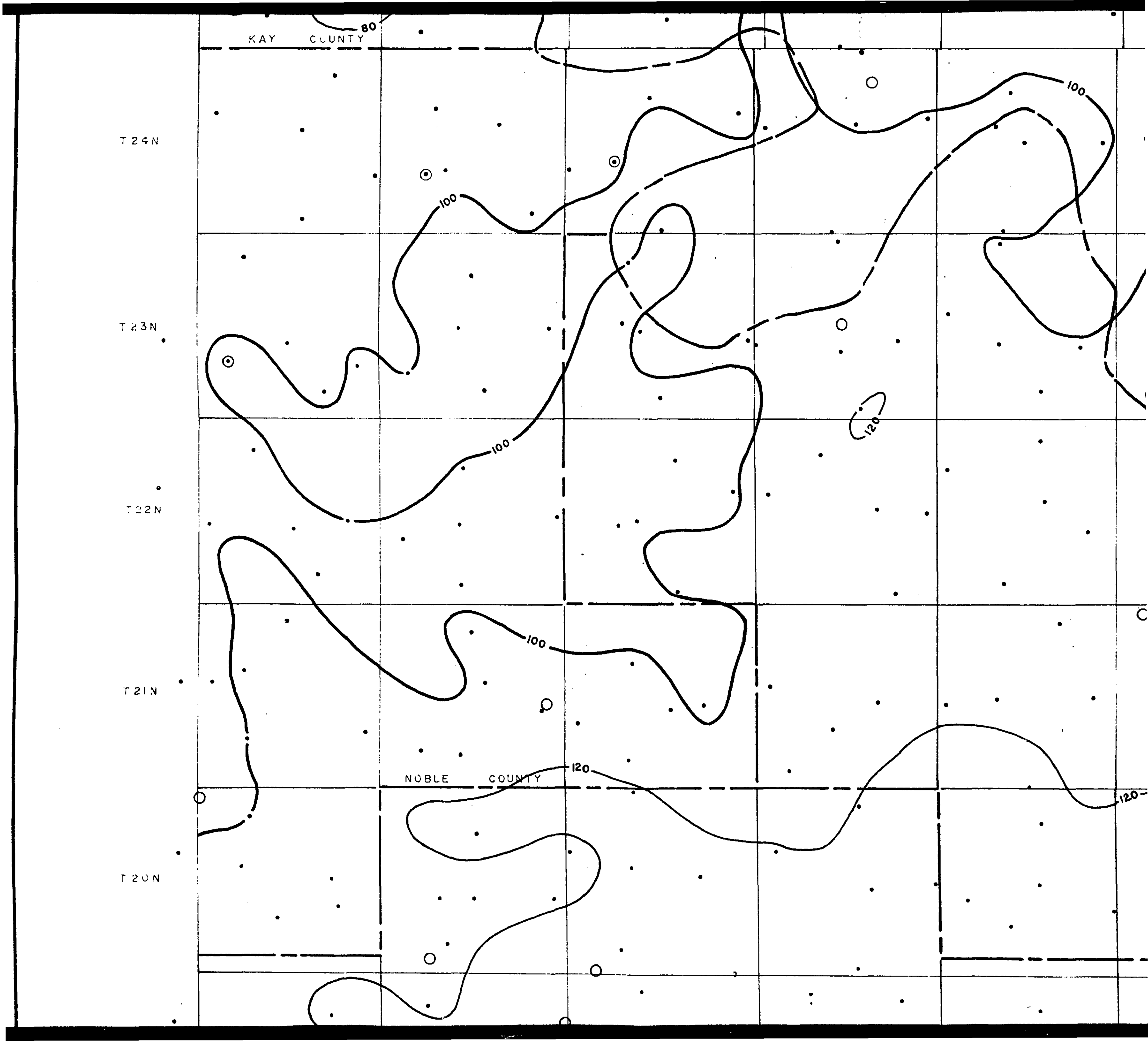
☐



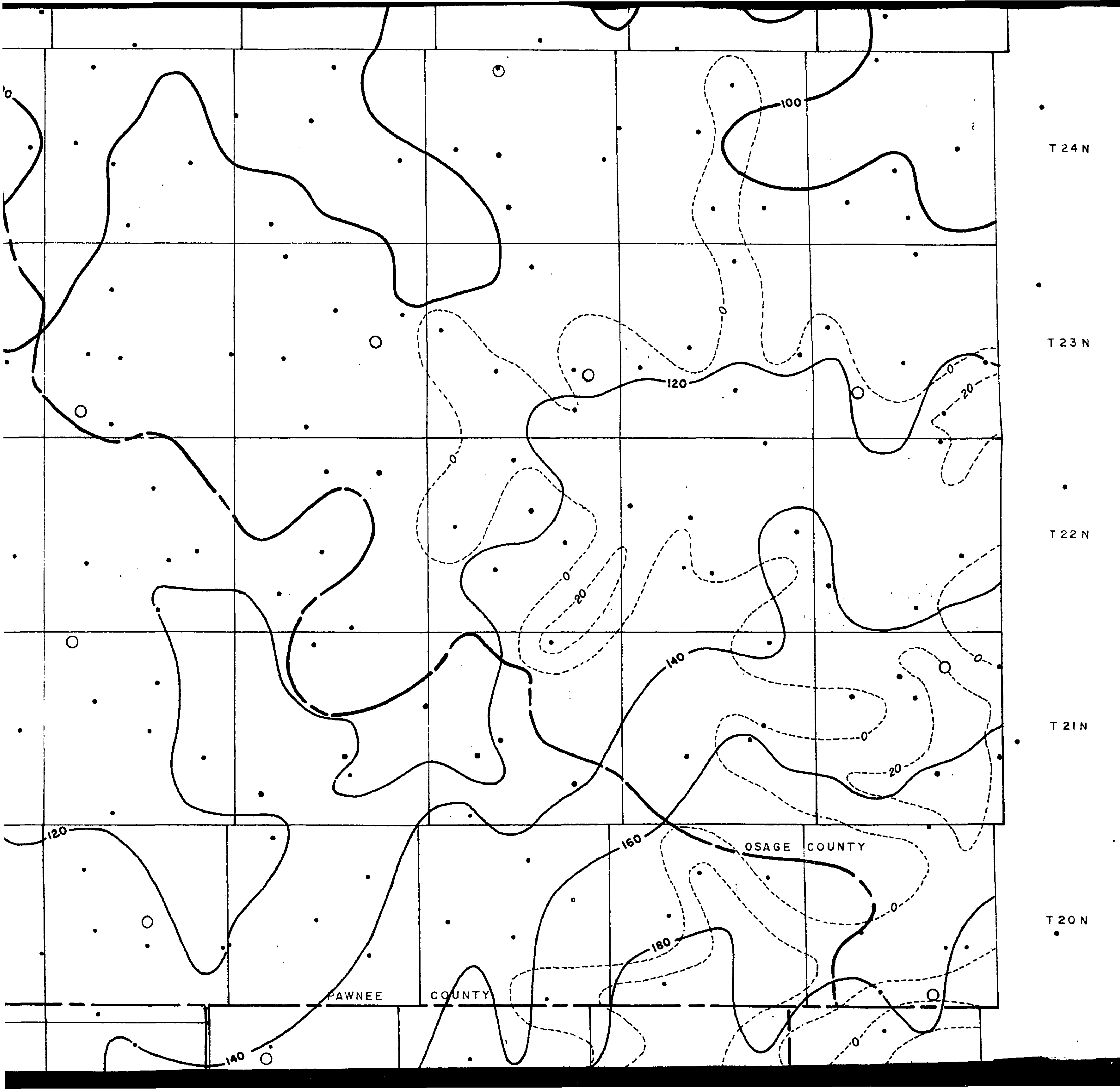


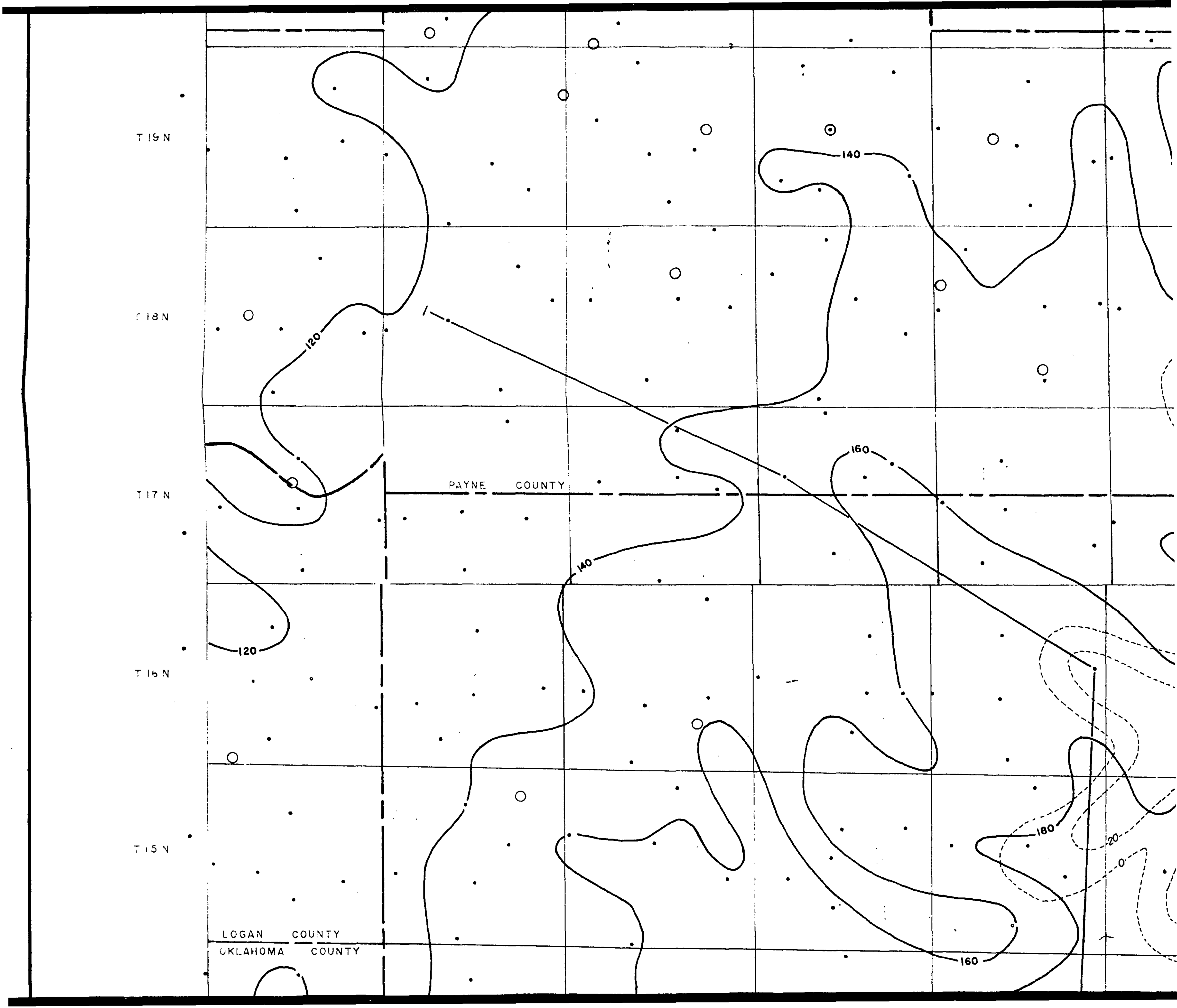
R1E
R2E
R3E
R4E
R5E
T 29 N
T 28 N
T 27 N
T 26 N
T 25 N
40
60
60
60
80
KAY COUNTY


R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
40
60
60
60
60
80
80
100
0
0
0

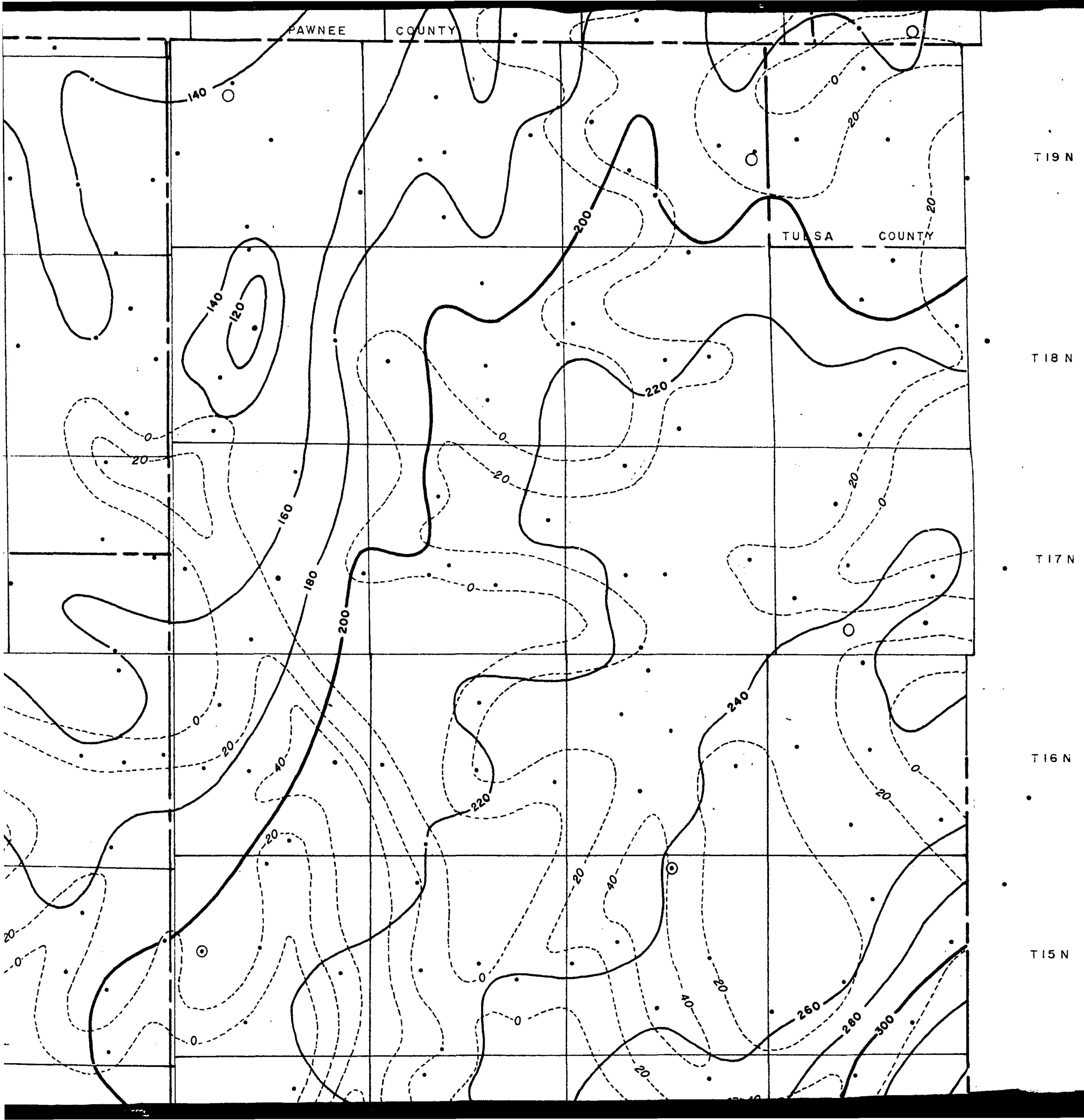


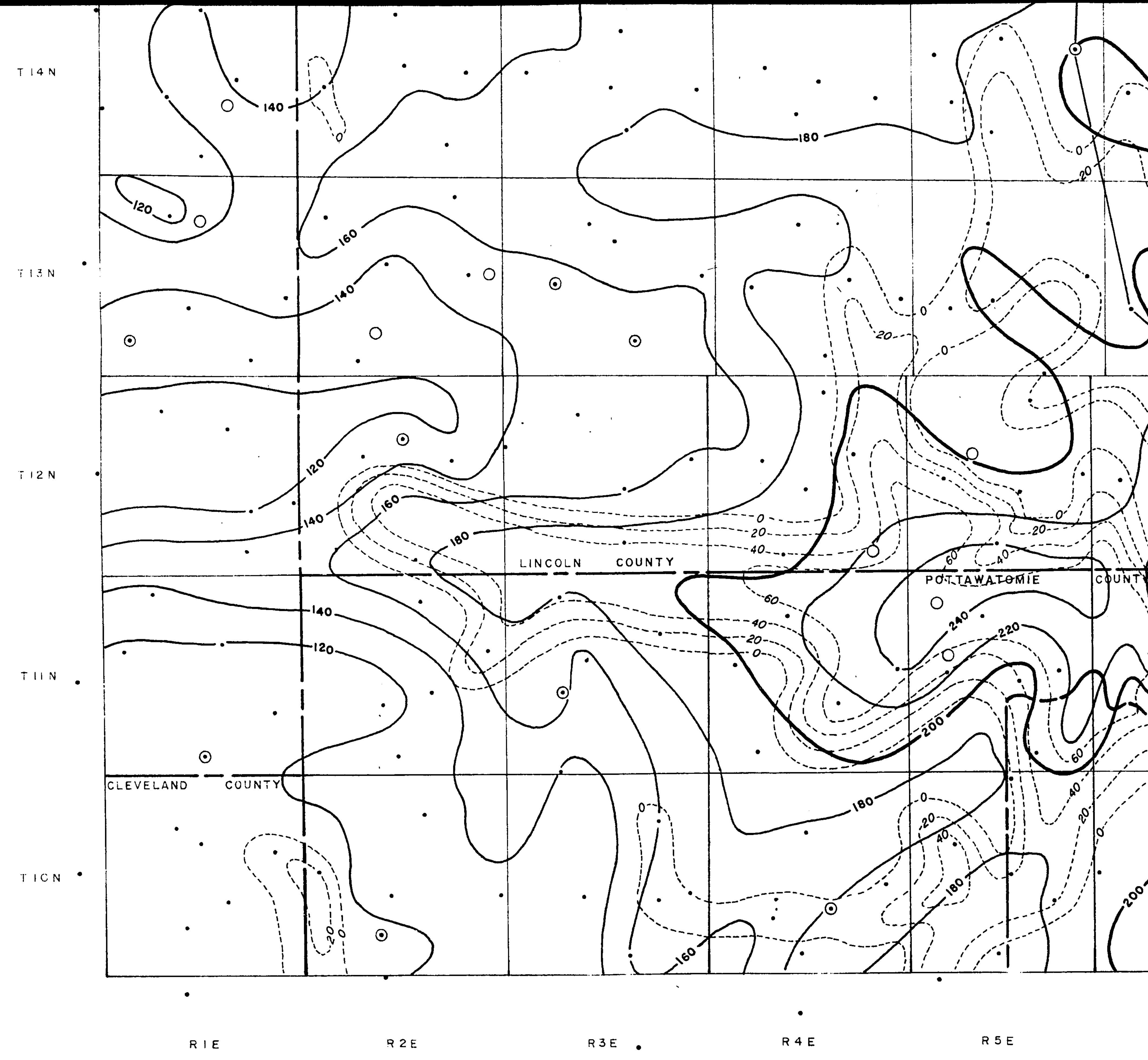
KAY COUNTY
80
100
120
T24N
T23N
T22N
T21N
T20N
NOBLE COUNTY

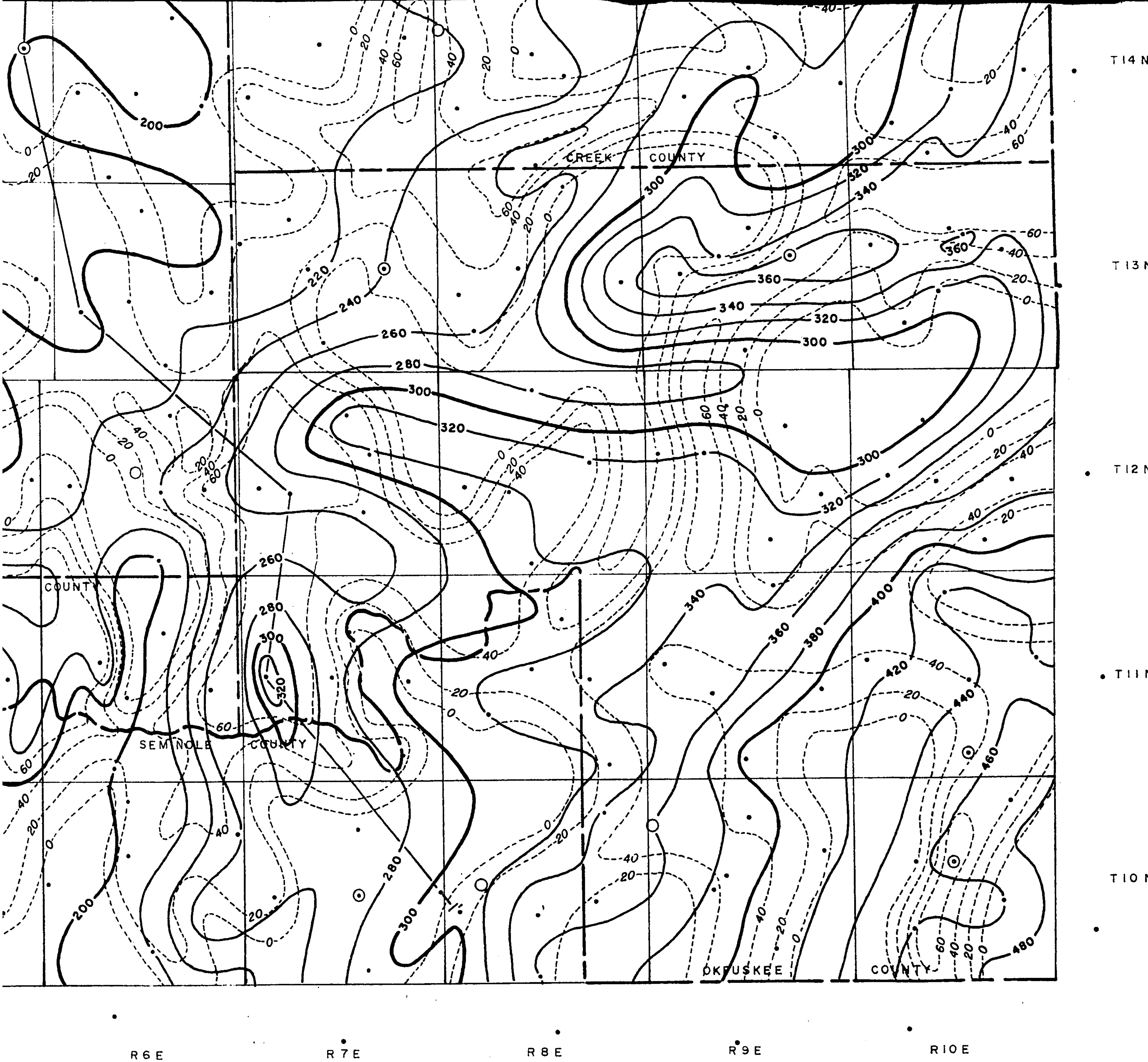

T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
100
120
140
160
180
0
20
OSAGE COUNTY
PAWNEE COUNTY



T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
140
120
160
180
20
0
PAYNE COUNTY
LOGAN COUNTY
OKLAHOMA COUNTY


PAWNEE COUNTY
TULSA COUNTY
T19N
T18N
T17N
T16N
T15N
140
120
160
180
200
220
240
260
280
300
0
20
40


T14N
T13N
T12N
T11N
T10N
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
R1E
R2E
R3E
R4E
R5E



T14N
T13N
T12N
T11N
T10N
CREEK COUNTY
SEMINOLE COUNTY
OKFUSKEE COUNTY
R6E
R7E
R8E
R9E
R10E

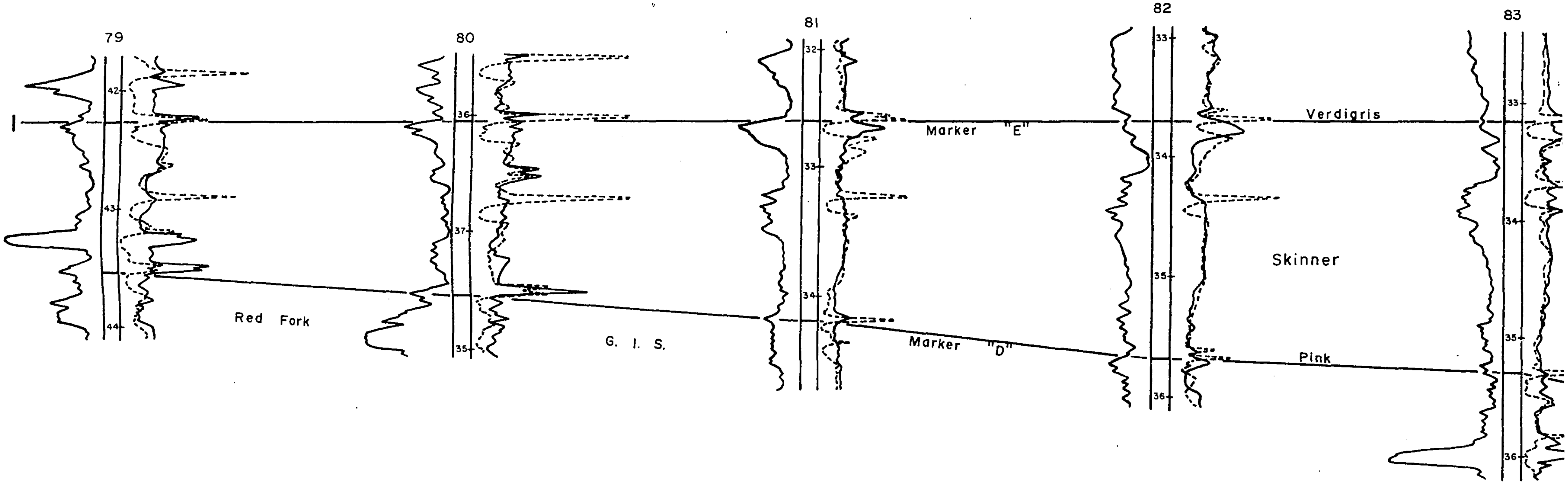


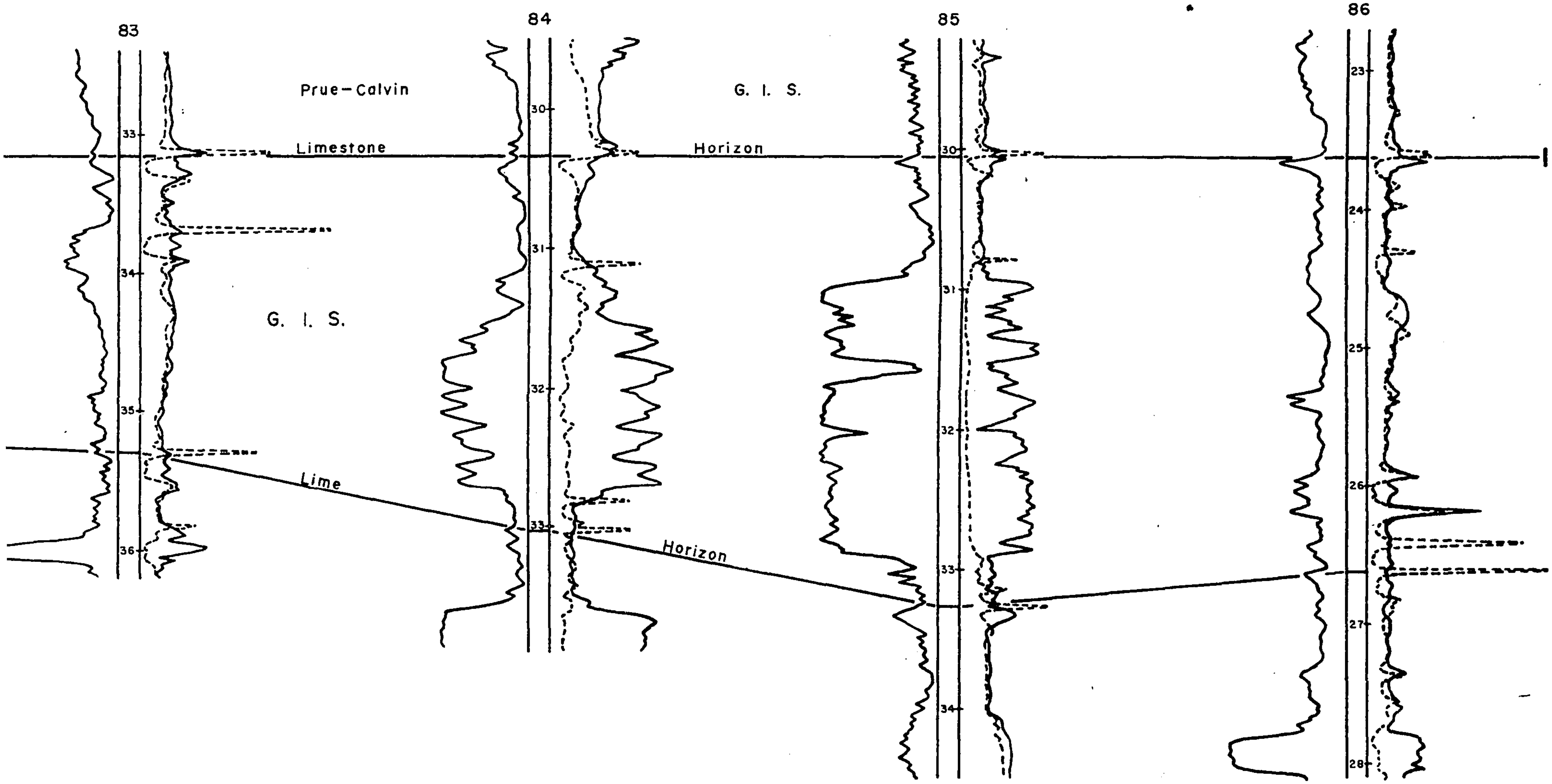
PLATE IX

SKINNER GENETIC INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP (MIDDLE SANDSTONE) AND STRATIGRAPHIC PROFILE II'

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles
Scale



LEGEND:

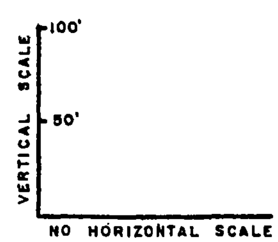
- • Control Well
- ⊙ Sample Control

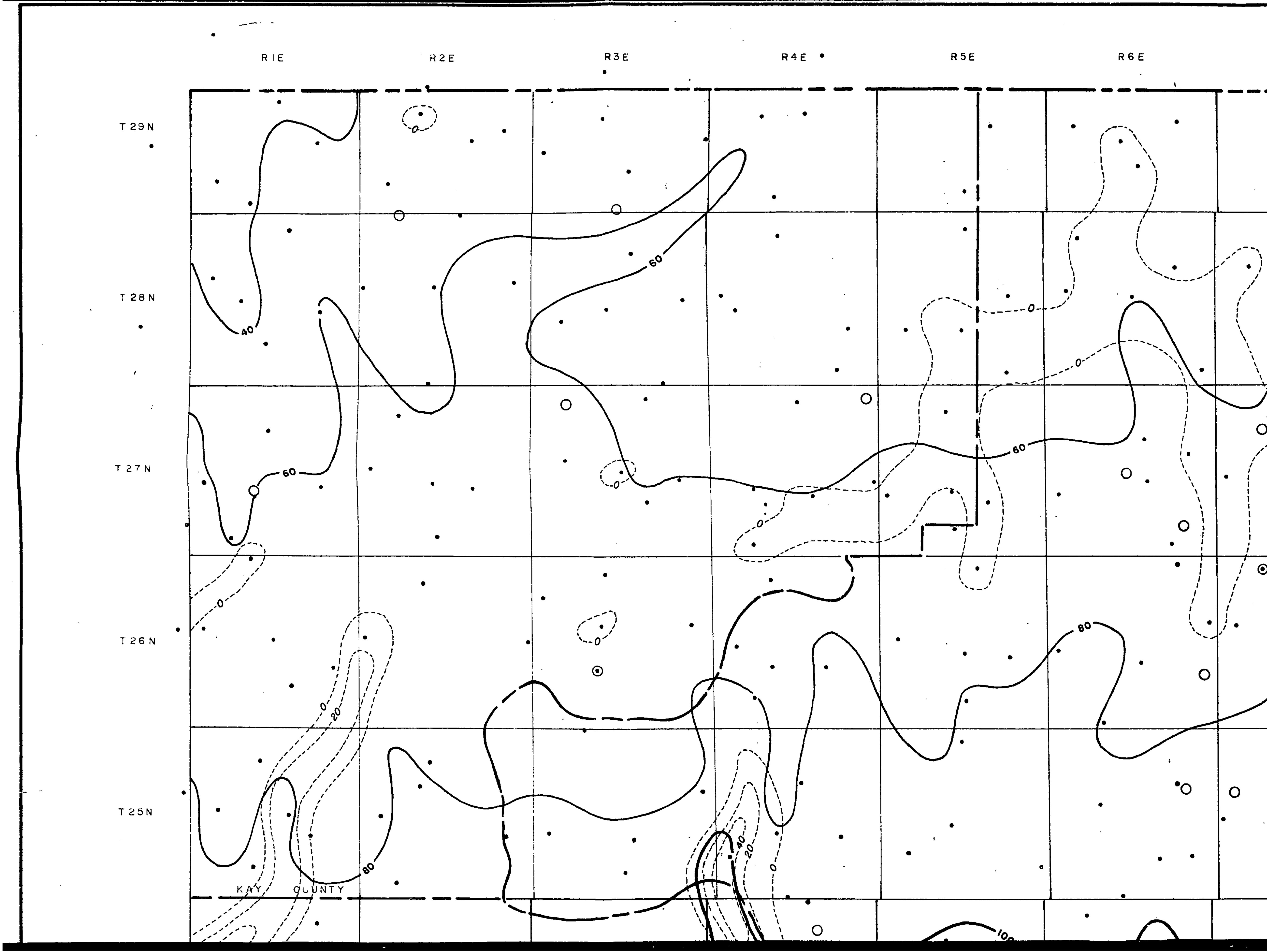
C. I. Isopach 20'
C. I. Isolith 20'
—320—— Isopach Line
---*60*---- Isolith Line

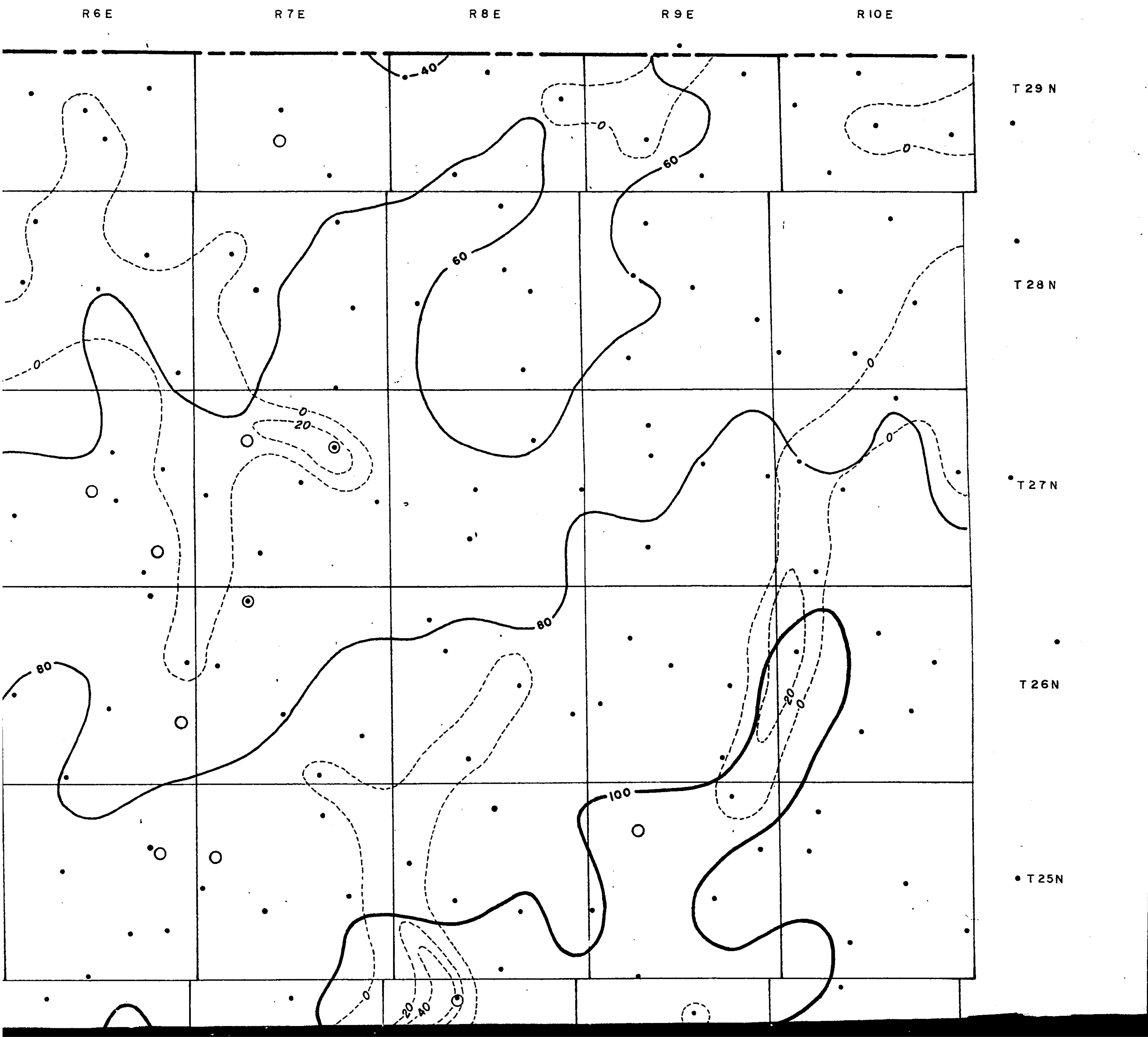
Sandstone Thickness

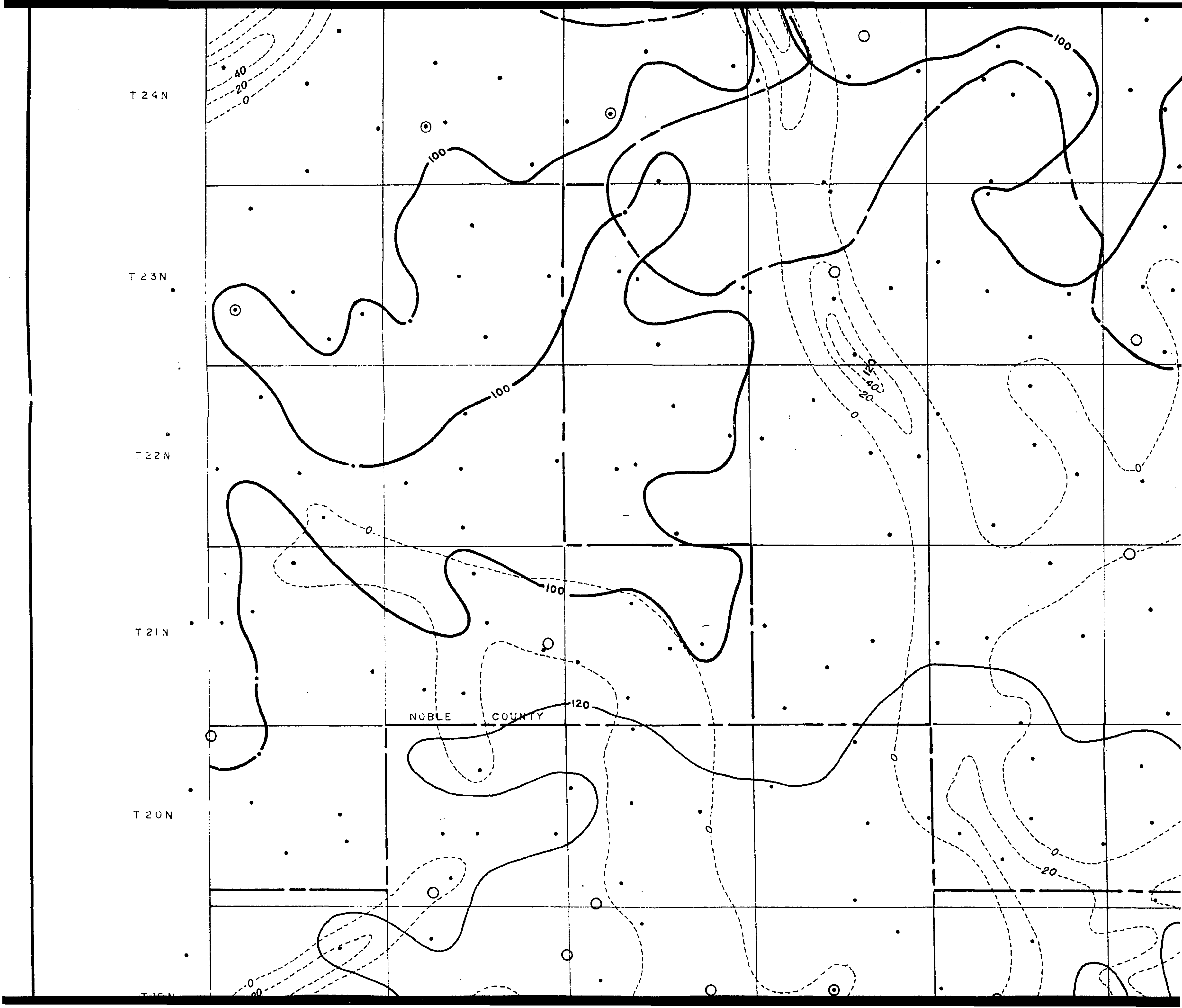
- 0-20'
- 20-40'
- 40-60'
- 60' +

Emergent Areas

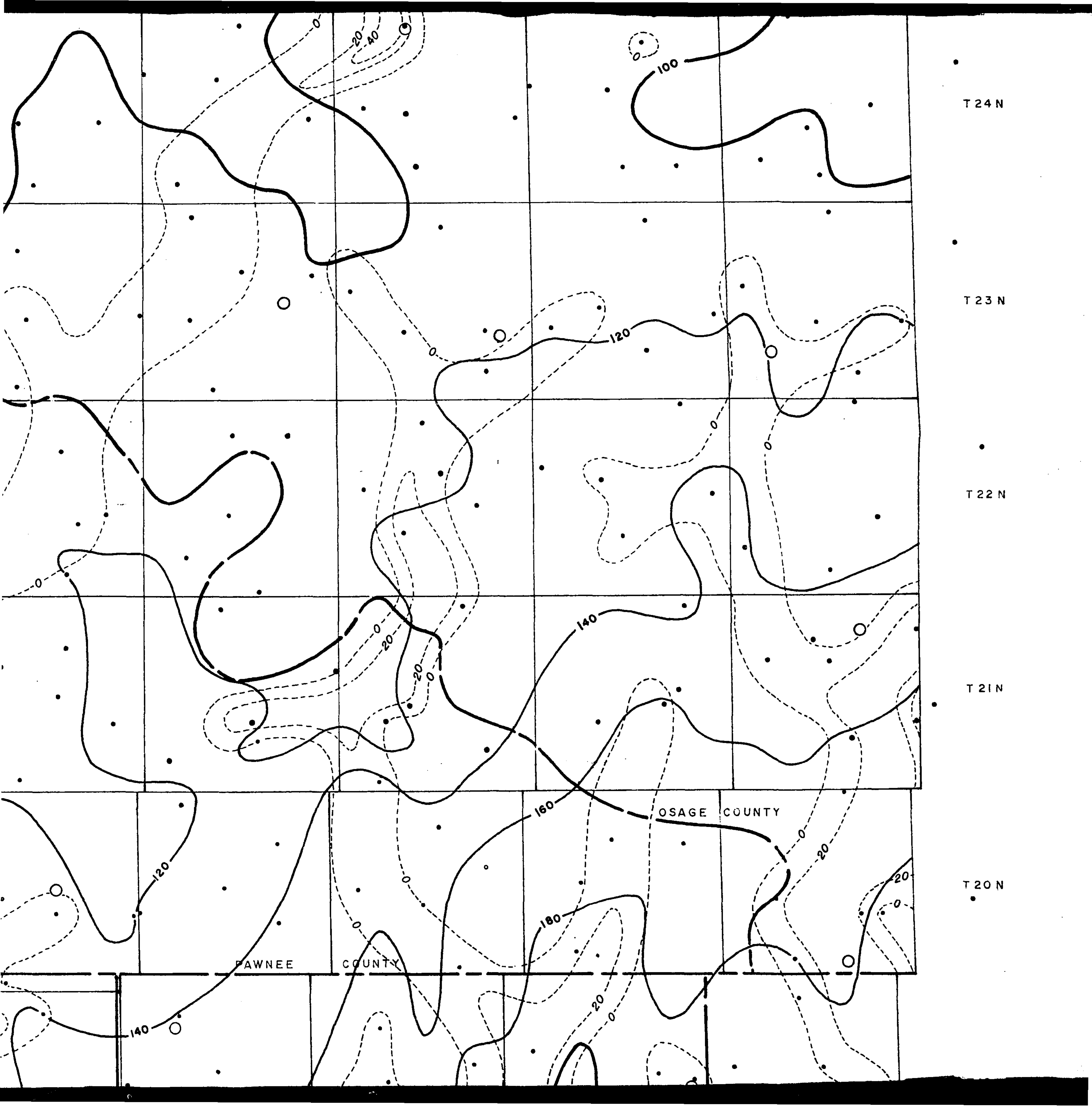


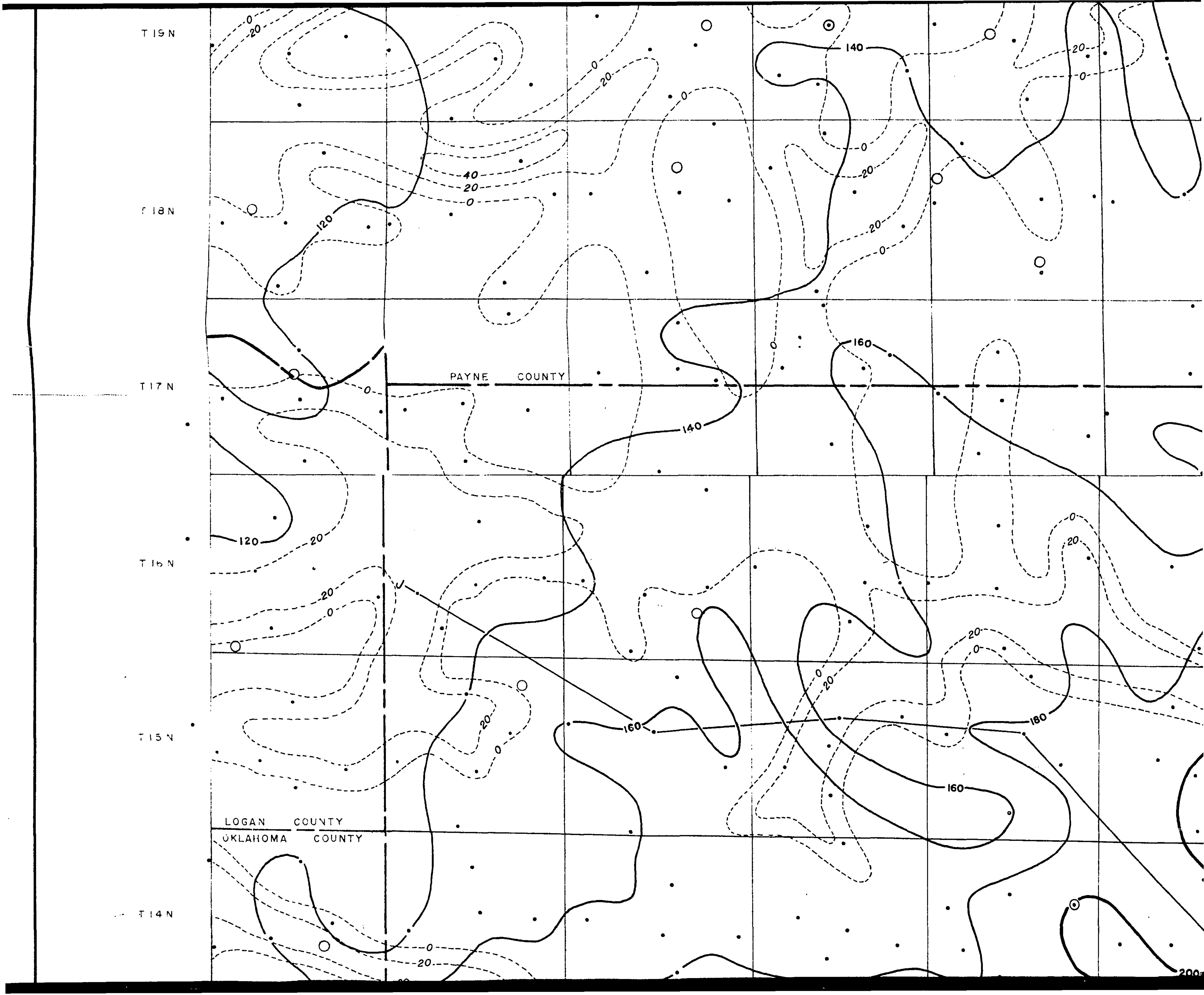

R1E
R2E
R3E
R4E
R5E
R6E
T29N
T28N
T27N
T26N
T25N
KAY COUNTY
0
20
40
60
80
100

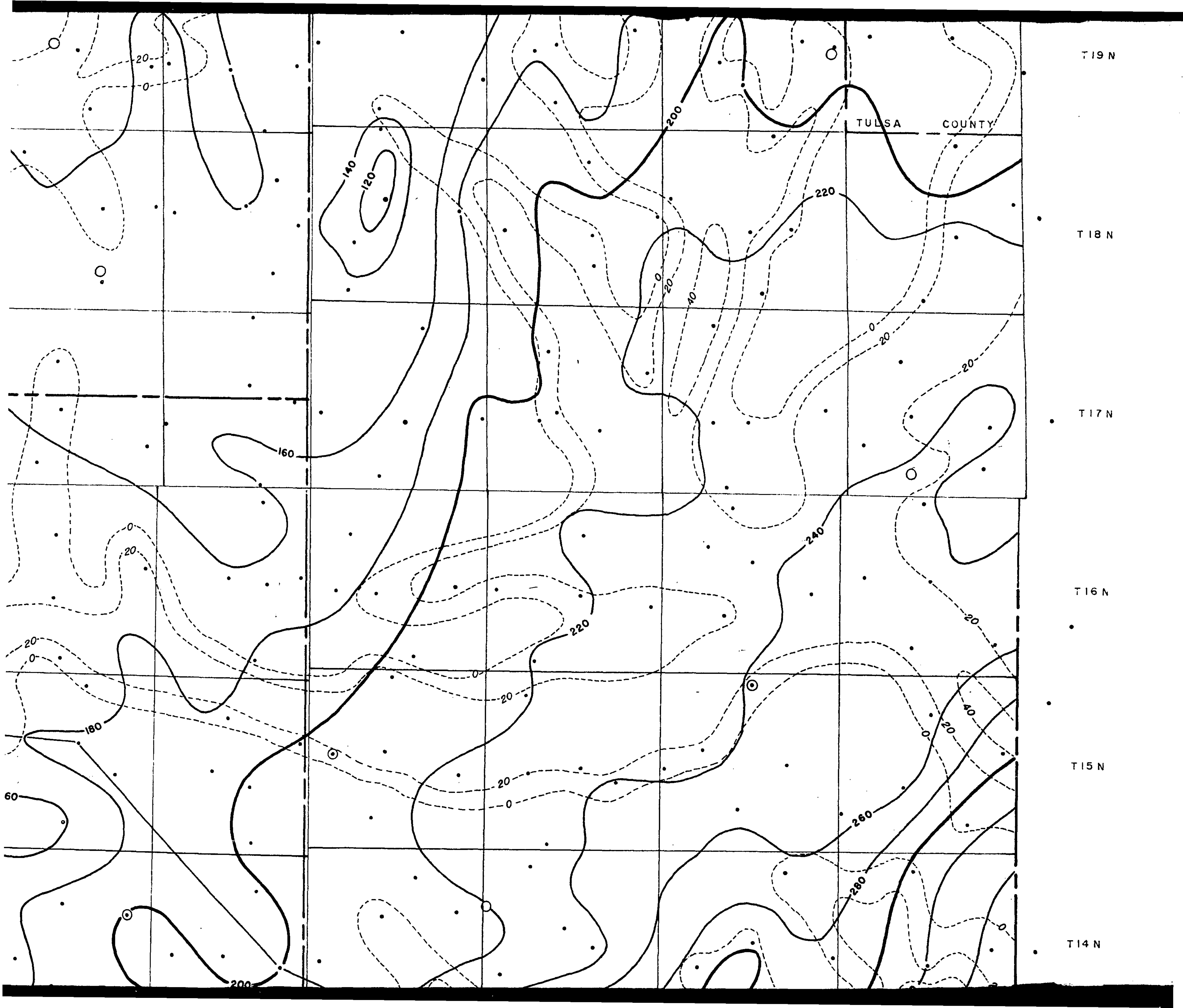

R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
40
60
60
0
0
0
0
0
20
0
80
80
100
20
0
0
20
40



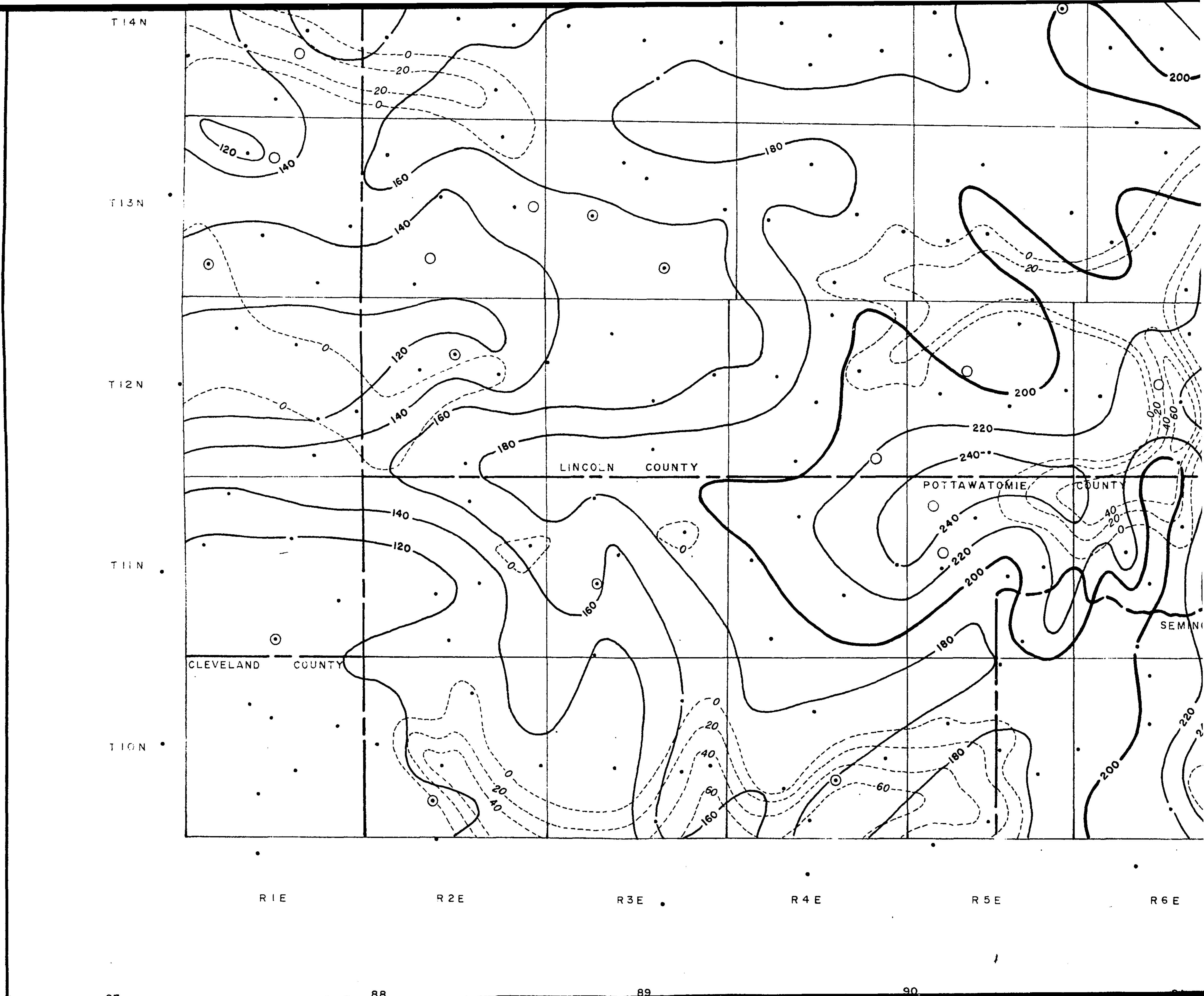
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
NOBLE COUNTY
100
120
40
20
0

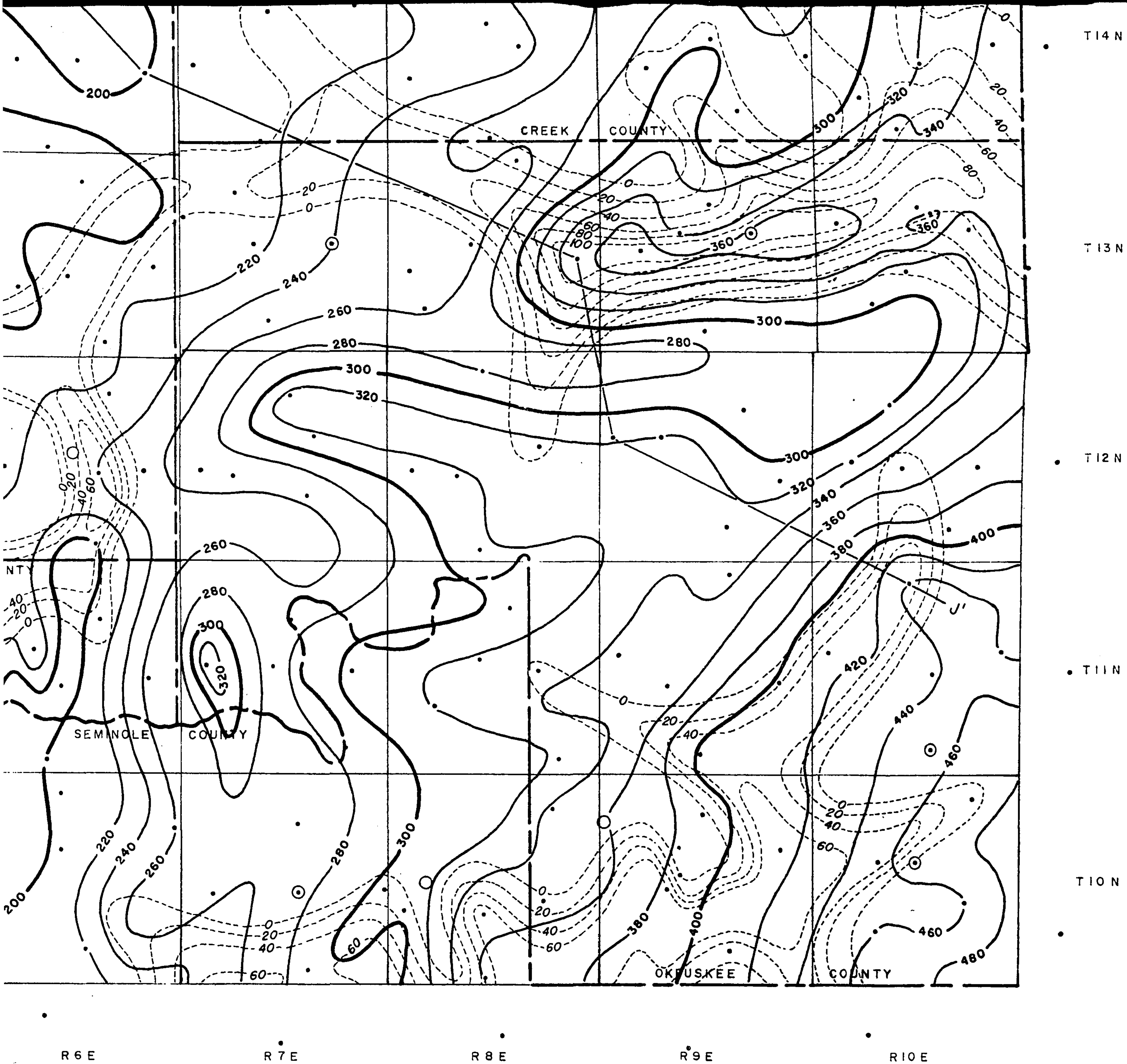

T24N
T23N
T22N
T21N
T20N
OSAGE COUNTY
PAWNEE COUNTY
100
120
140
160
180
0
20
40


T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
PAYNE COUNTY
LOGAN COUNTY
OKLAHOMA COUNTY
J
120
140
160
180
200
0
20
40



T19N
T18N
T17N
T16N
T15N
T14N
TULSA COUNTY
120
140
160
180
200
220
240
260
280
0
20
40


T14N
T13N
T12N
T11N
T10N
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
R1E
R2E
R3E
R4E
R5E
R6E


CREEK COUNTY
SEMINOLE COUNTY
OKFUSKEE COUNTY
T14N
T13N
T12N
T11N
T10N
R6E
R7E
R8E
R9E
R10E
J'
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
0
20
40
60
80
100

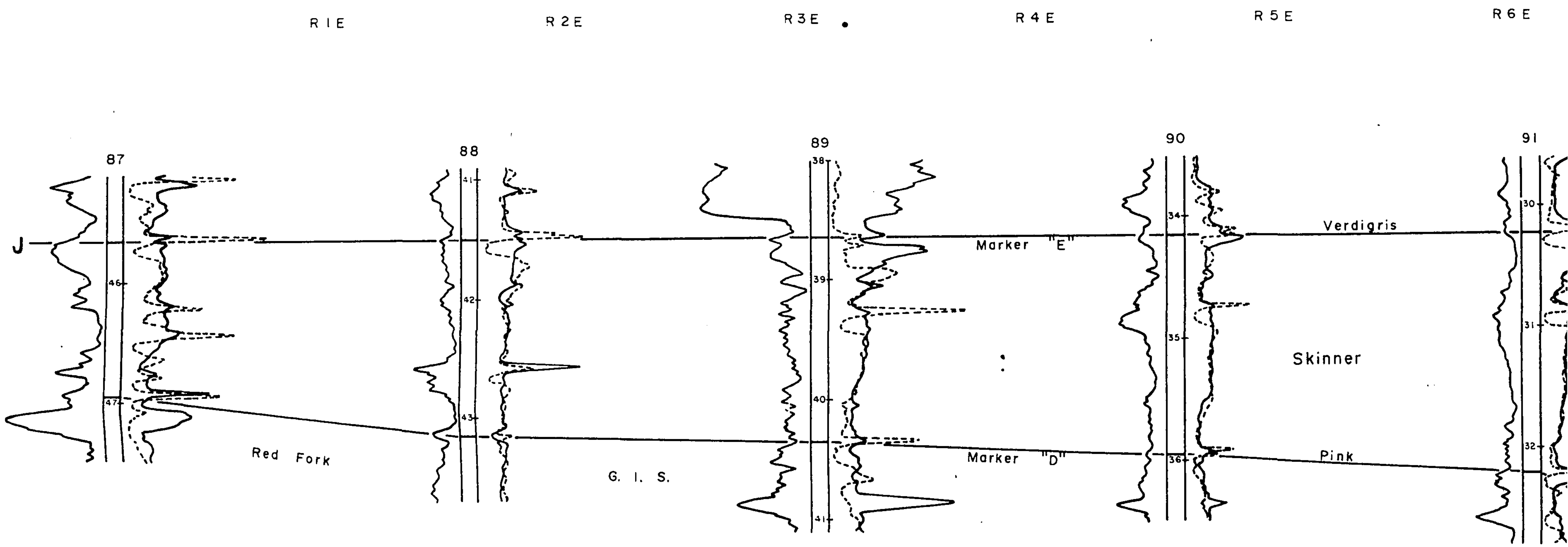
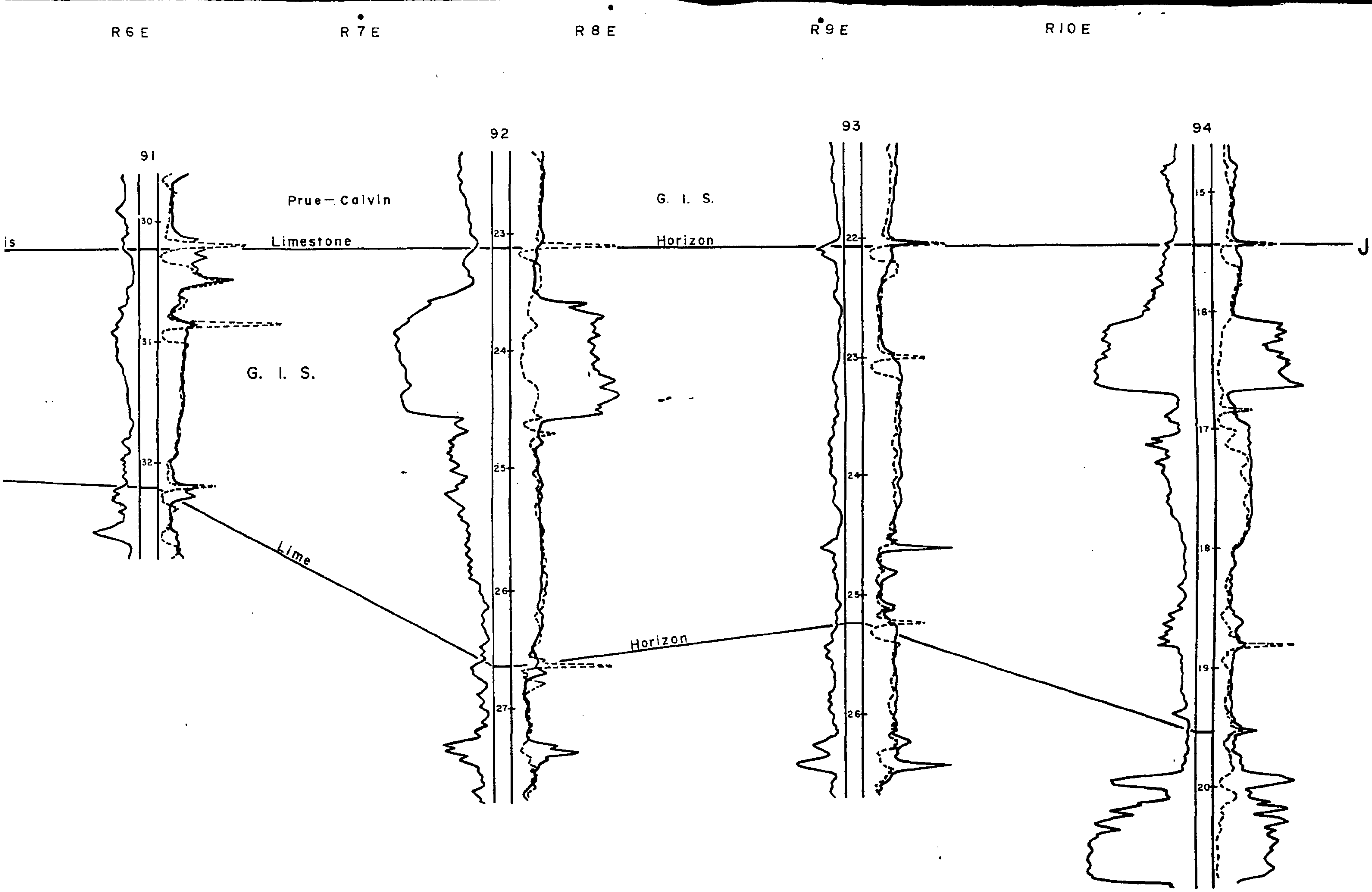


PLATE X

SKINNER GENETIC INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP (UPPER SANDSTONE) AND STRATIGRAPHIC PROFILE JJ'

by

J. Glenn Cole Ph. D. 1968



LEGEND:

- ● Control Well
- ○ Sample Control
- C. I. Isopach 20'
- C. I. Isolith 20'
- —240—— Isopach Line
- ---*20*---- Isolith Line

Sandstone Thickness

- ▭ 0–20'
- ▭ 20–40'
- ▭ 40–60'

SCALE 100'

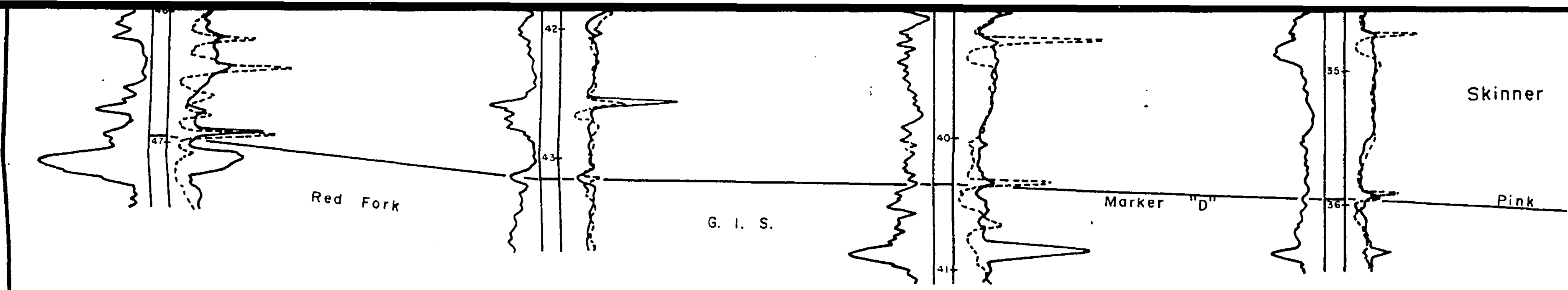
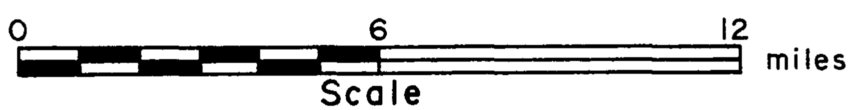


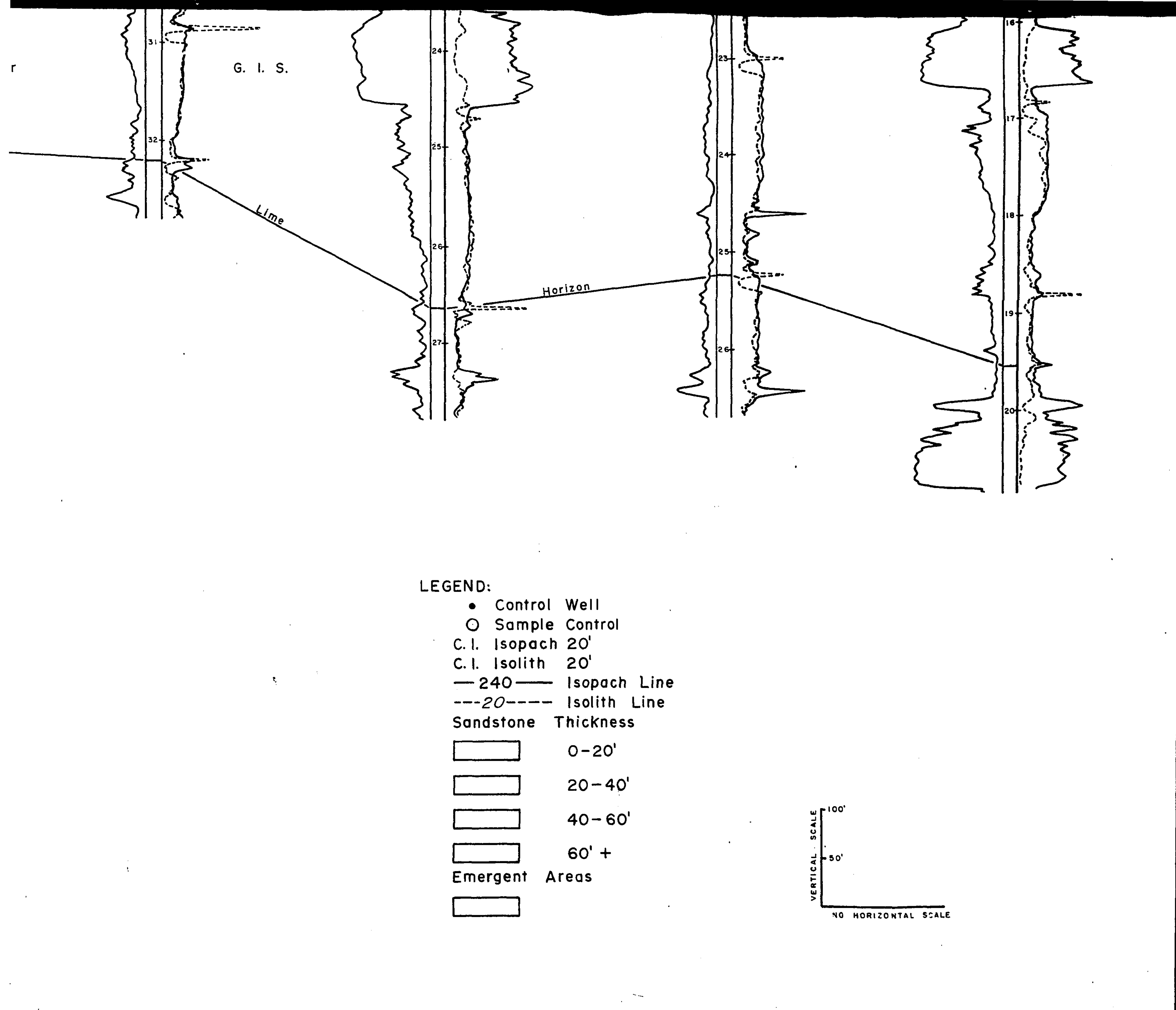
PLATE X

SKINNER GENETIC INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP (UPPER SANDSTONE) AND STRATIGRAPHIC PROFILE JJ'

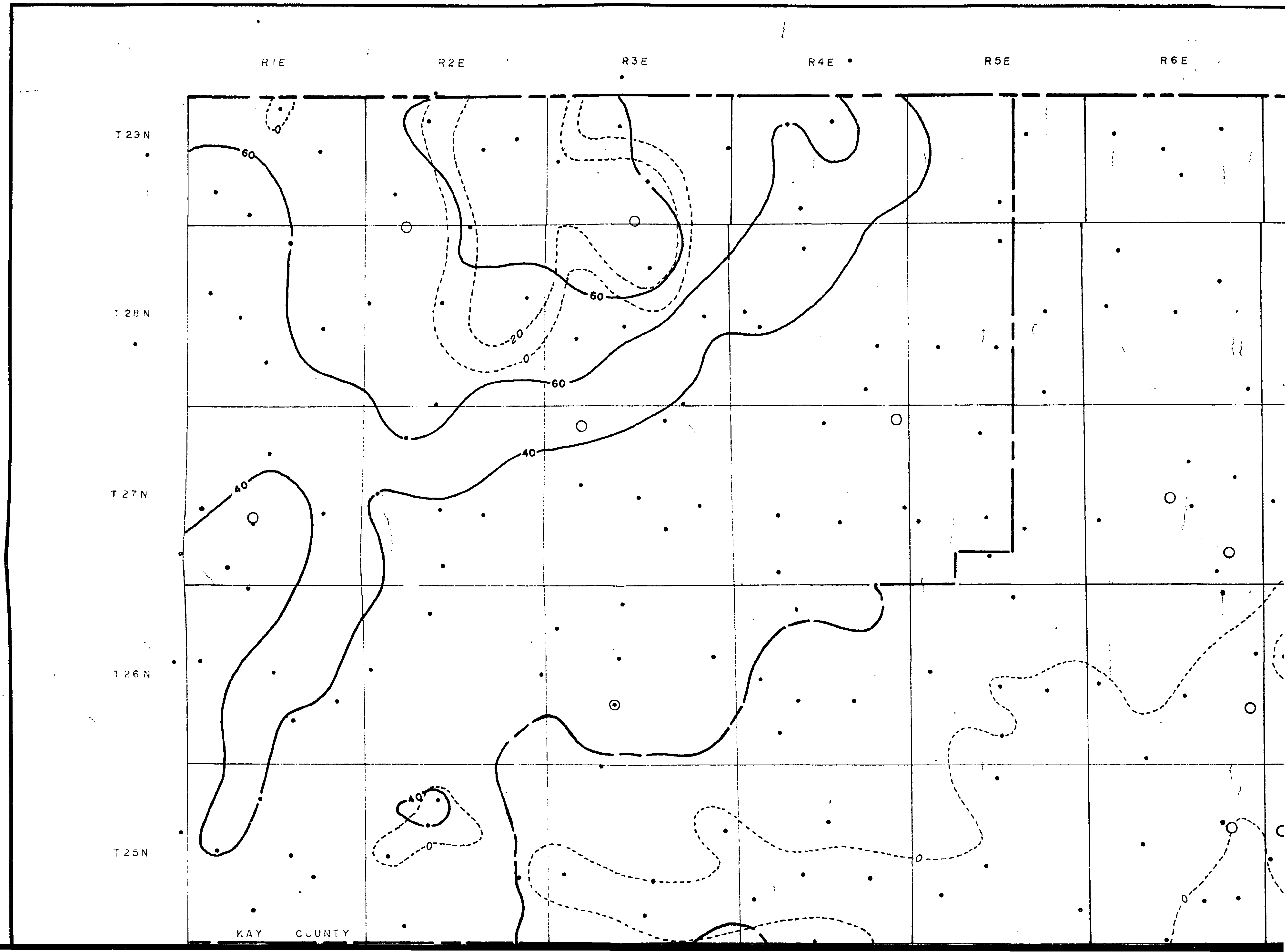
by

J. Glenn Cole Ph. D. 1968

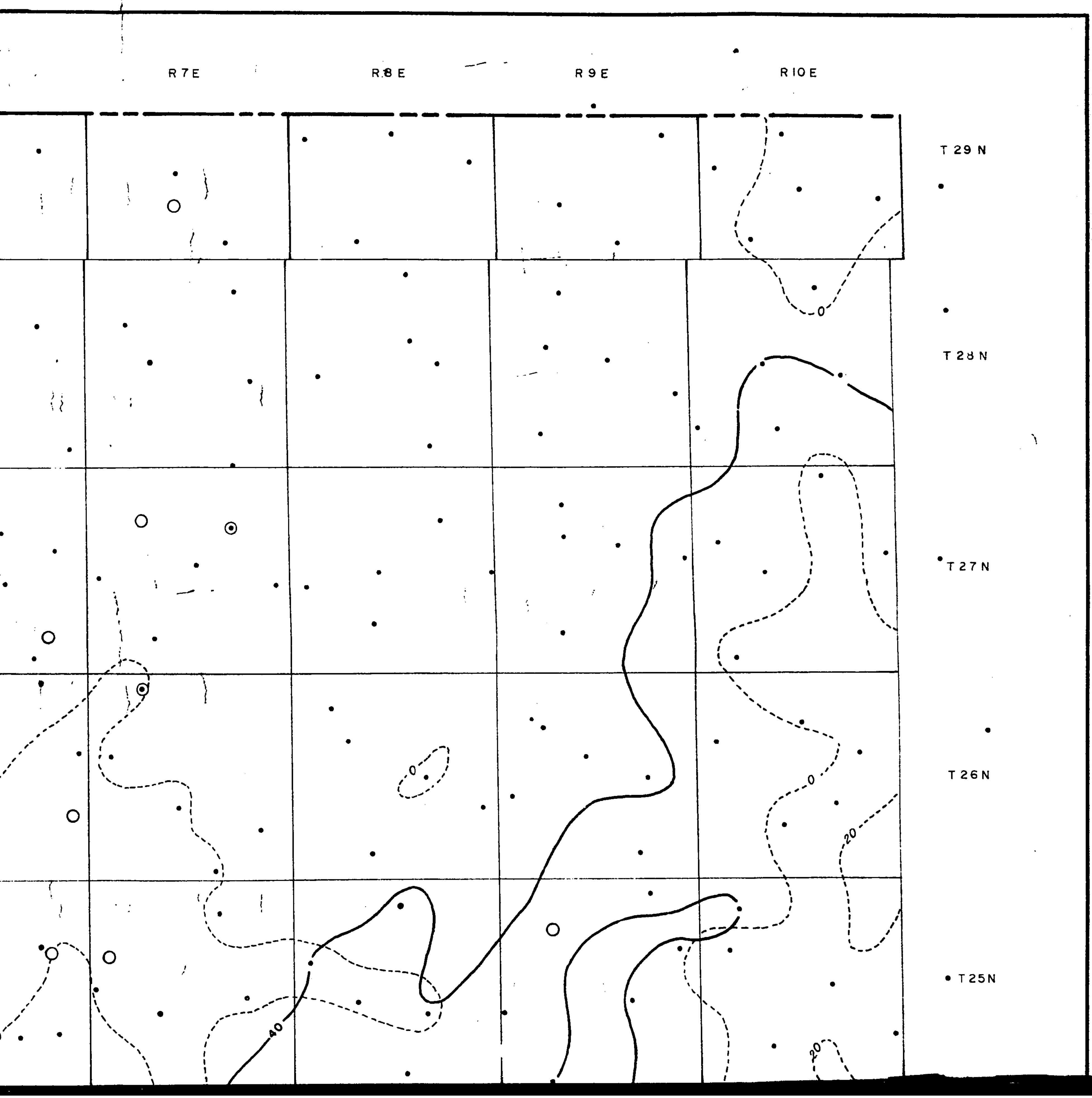


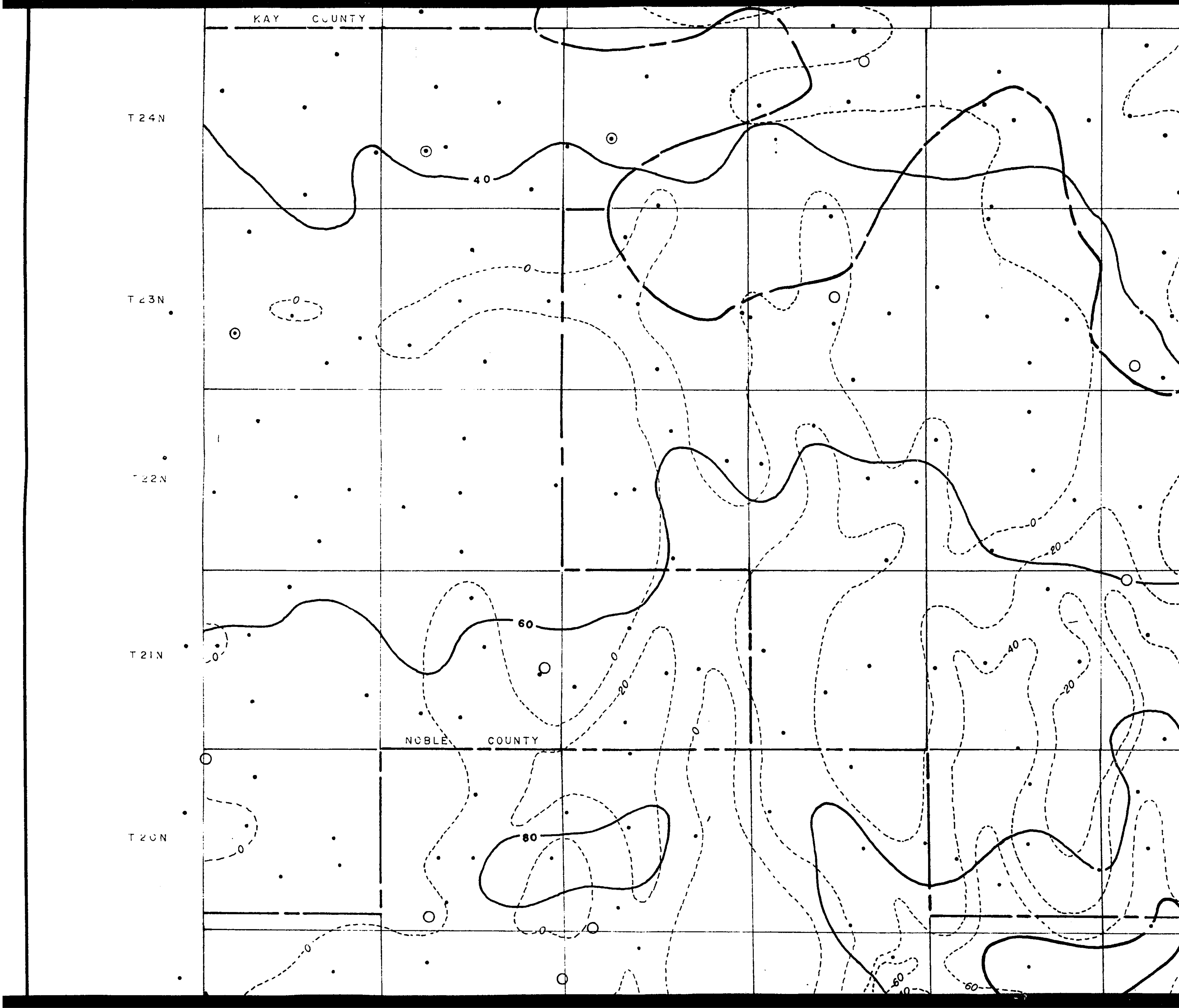


r
G. I. S.
31
32
24
25
26
27
23
24
25
26
16
17
18
19
20
Lime
Horizon
LEGEND:
• Control Well
○ Sample Control
C. I. Isopach 20'
C. I. Isolith 20'
—240—— Isopach Line
---20---- Isolith Line
Sandstone Thickness
0-20'
20-40'
40-60'
60' +
Emergent Areas
VERTICAL SCALE
100'
50'
NO HORIZONTAL SCALE

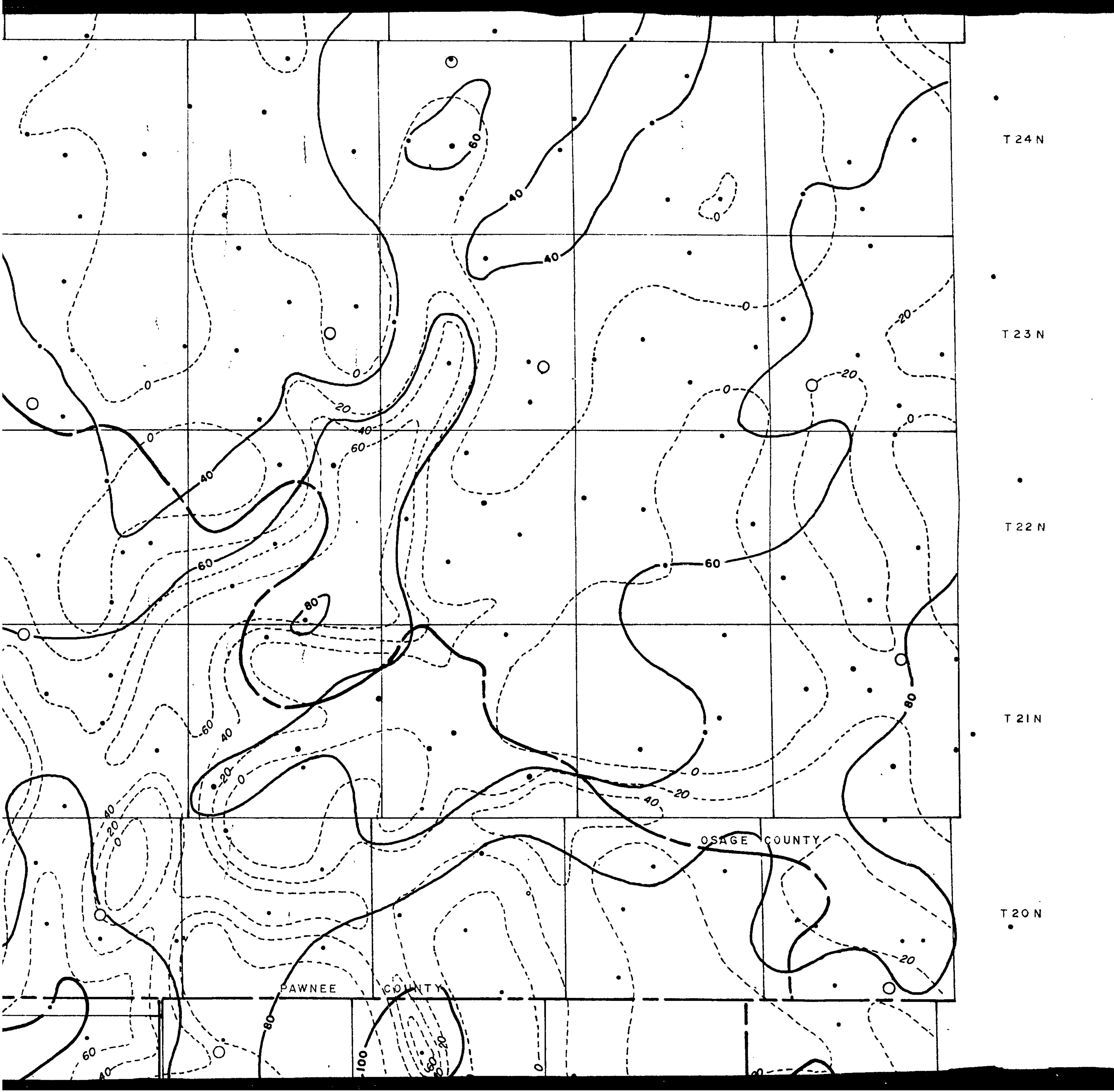


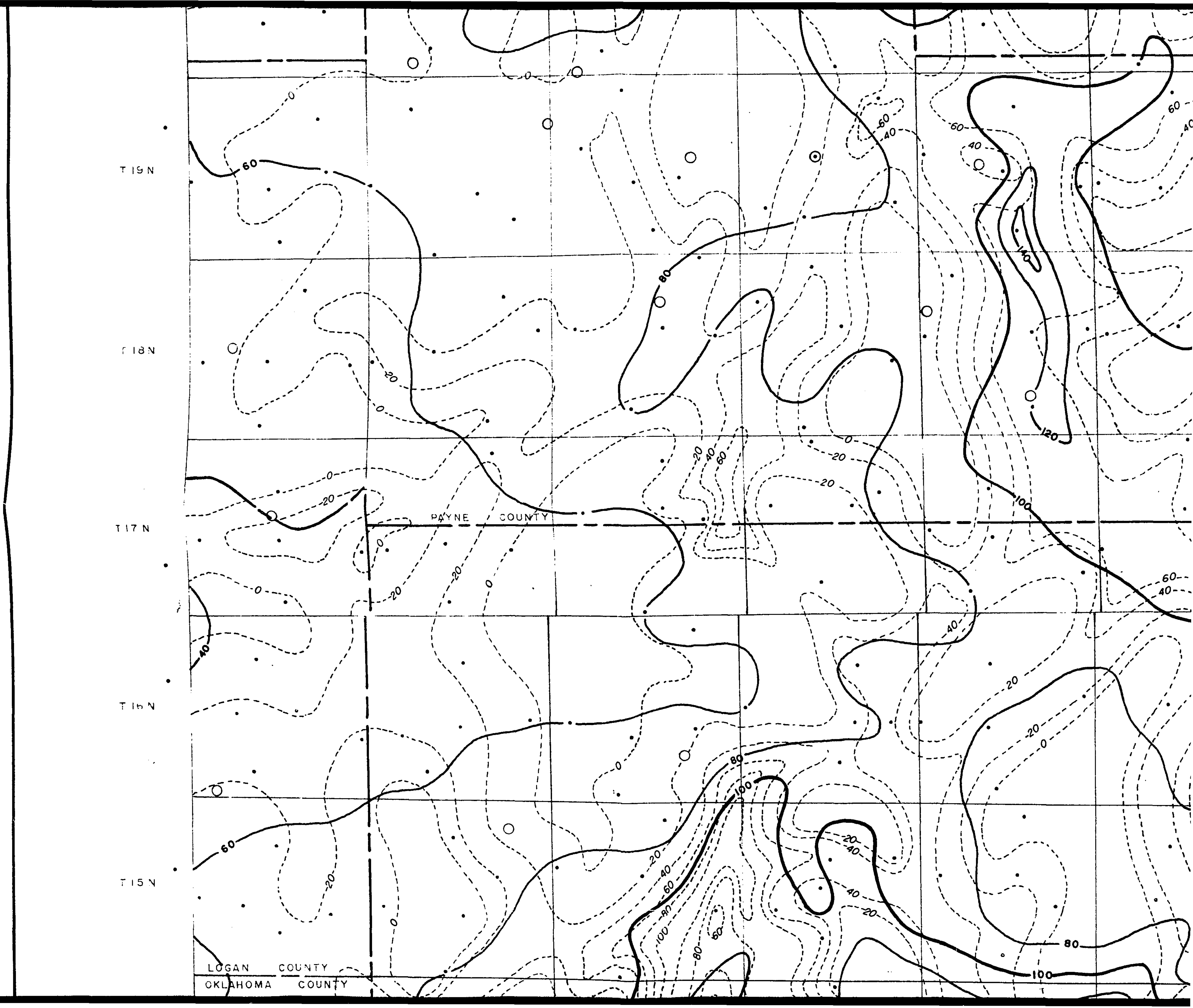
R1E
R2E
R3E
R4E
R5E
R6E
T 29 N
T 28 N
T 27 N
T 26 N
T 25 N
60
20
0
40
KAY COUNTY

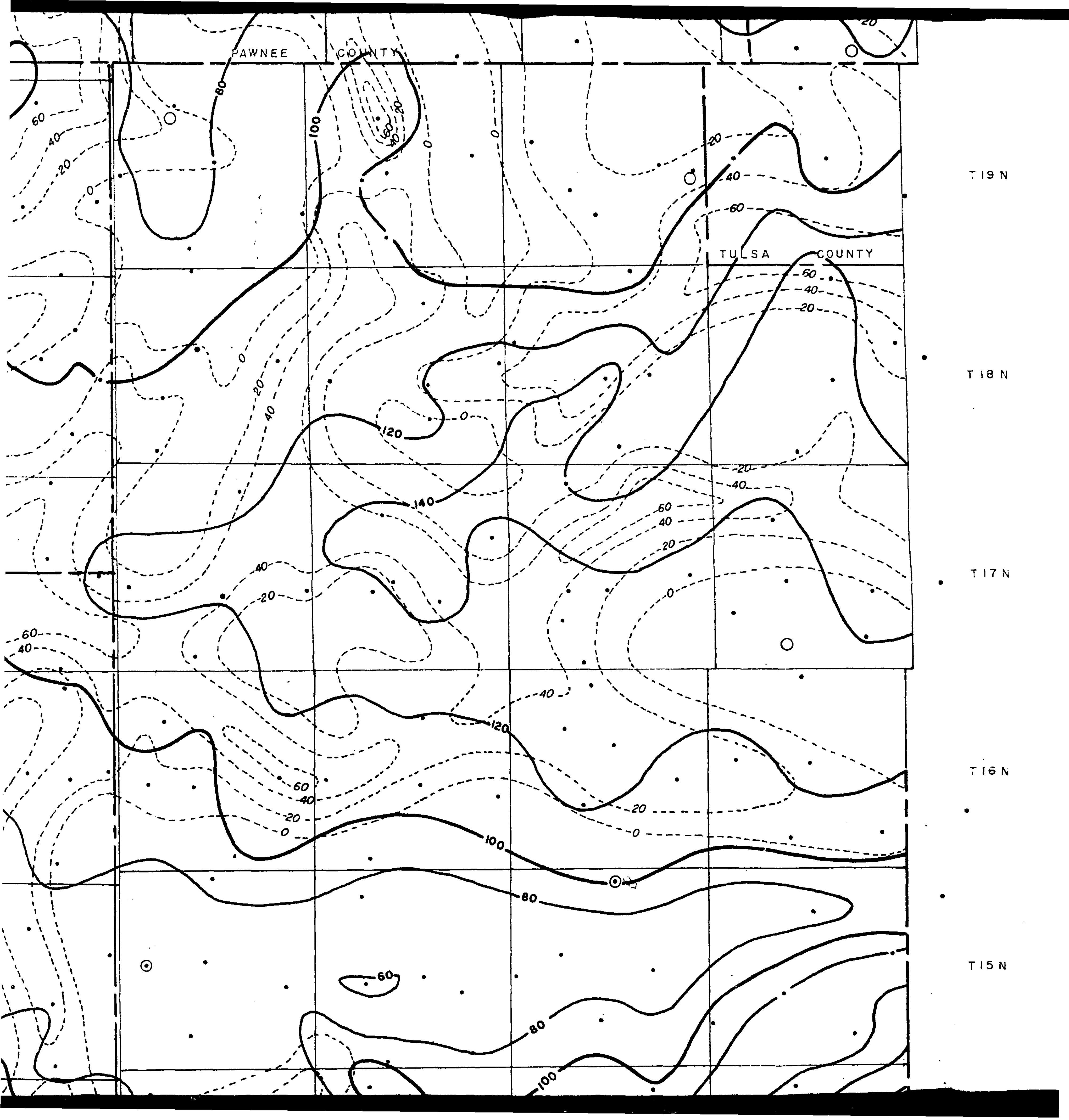

R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
0
0
0
20
20
40
20

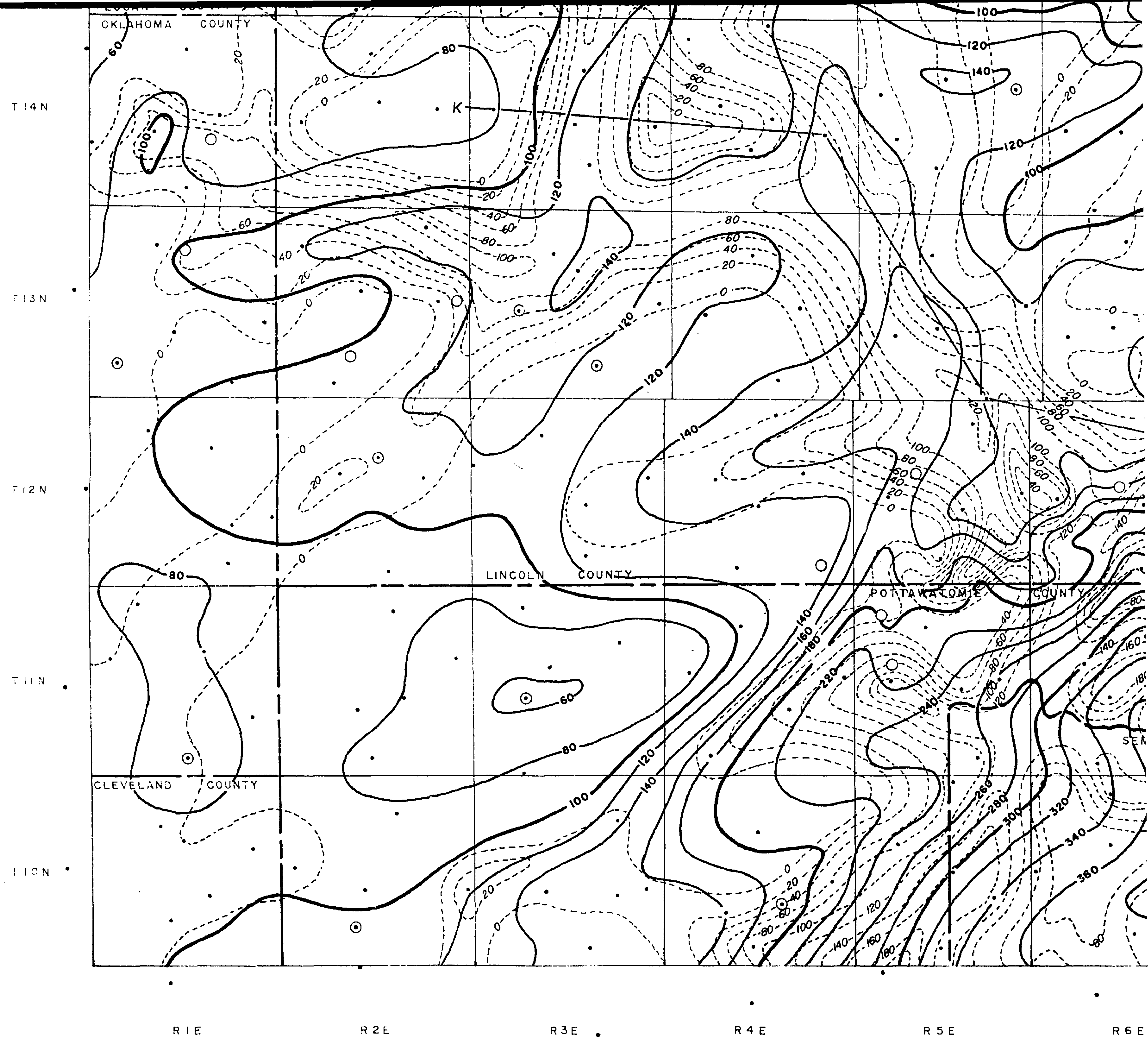


KAY COUNTY
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
NOBLE COUNTY
40
60
80
0
20
40
60

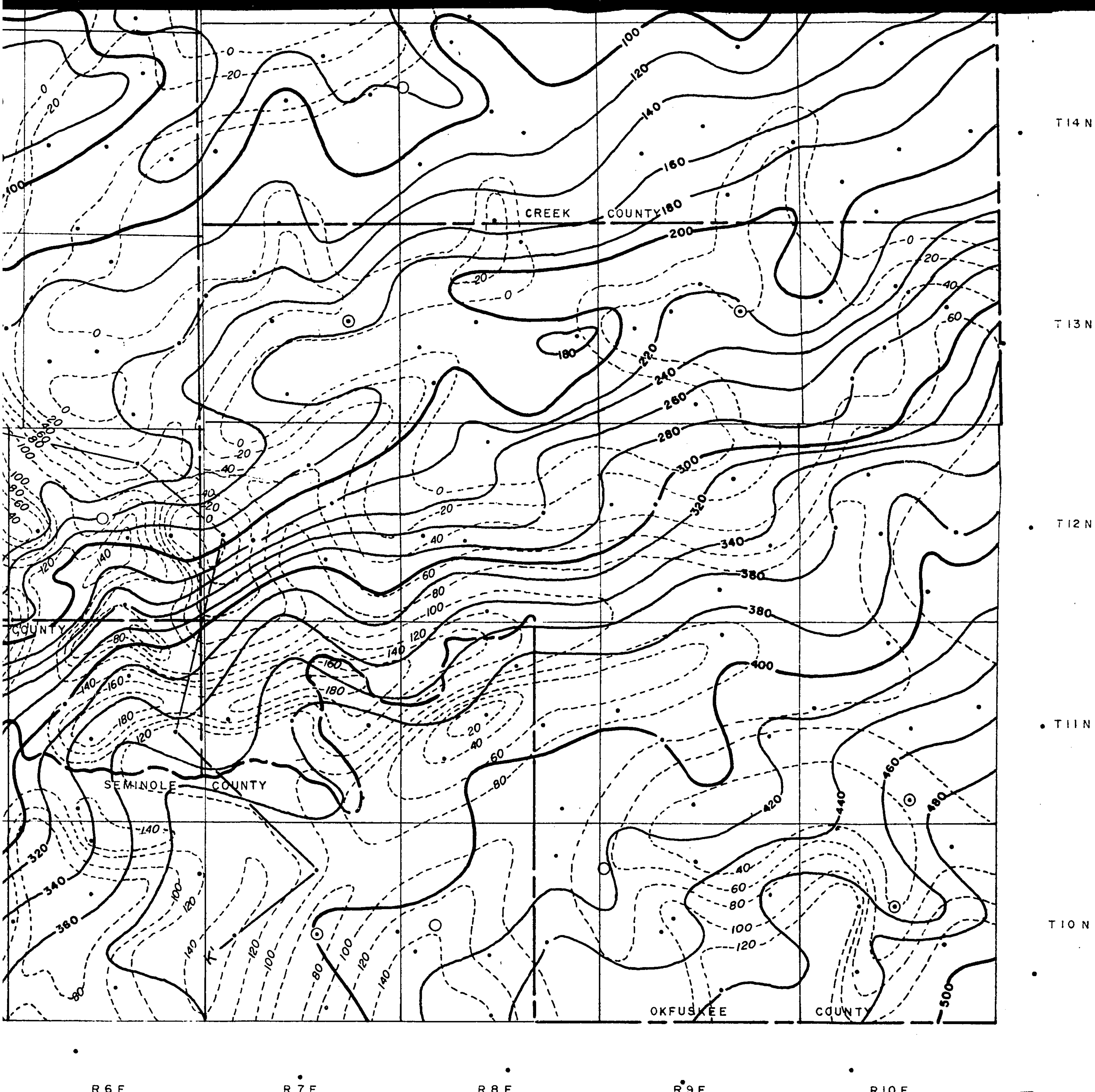

T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
OSAGE COUNTY
PAWNEE COUNTY
0
20
40
60
80
100


T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
PAYNE COUNTY
LOGAN COUNTY
OKLAHOMA COUNTY
0
20
40
60
80
100
120
140


PAWNEE COUNTY
TULSA COUNTY
T19N
T18N
T17N
T16N
T15N
80
100
120
140
60
40
20
0



OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
T14N
T13N
T12N
T11N
T10N
R1E
R2E
R3E
R4E
R5E
R6E
K


CREEK COUNTY
SEMINOLE COUNTY
OKFUSKEE COUNTY
T14N
T13N
T12N
T11N
T10N
R6E
R7E
R8E
R9E
R10E

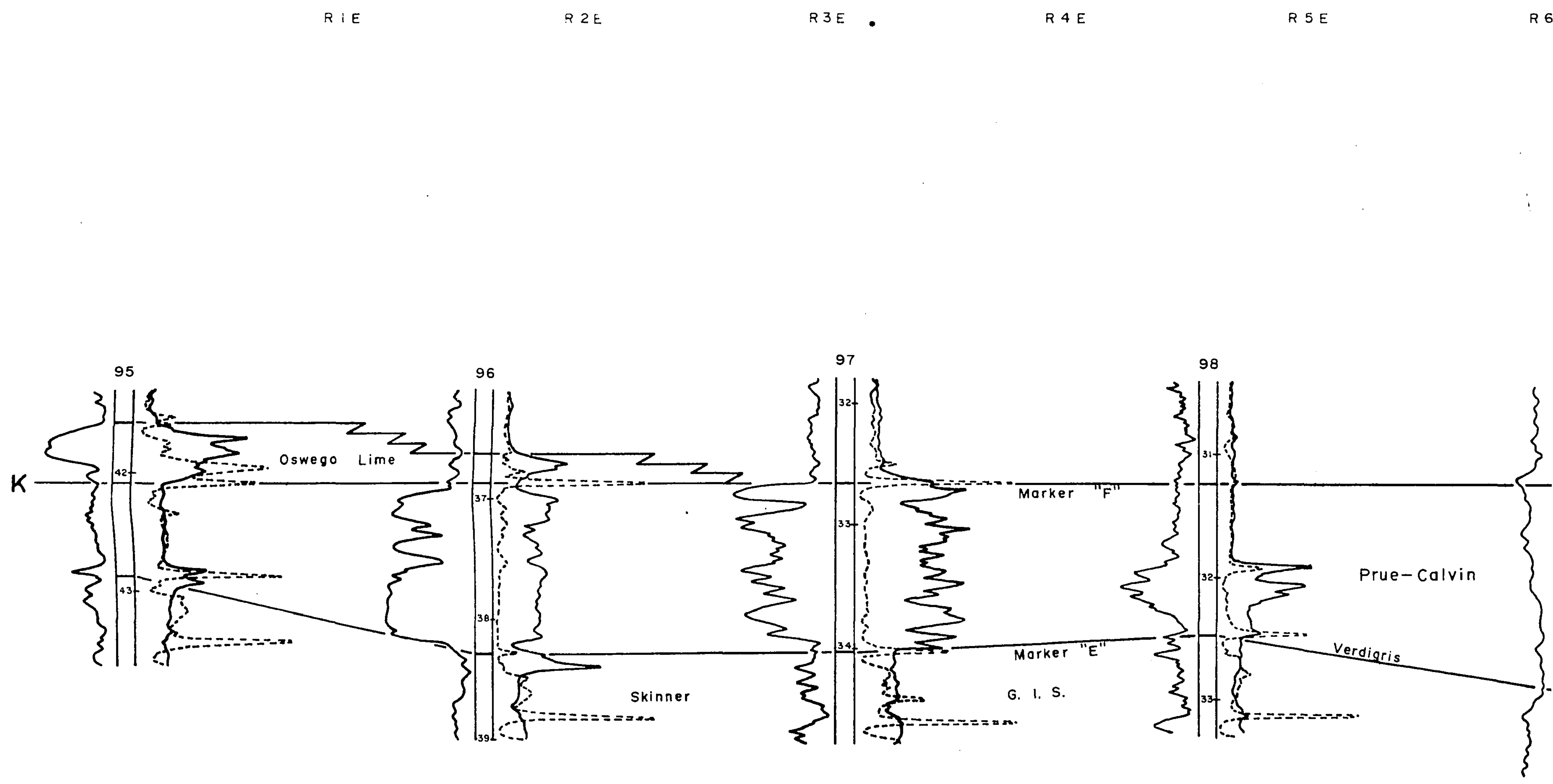


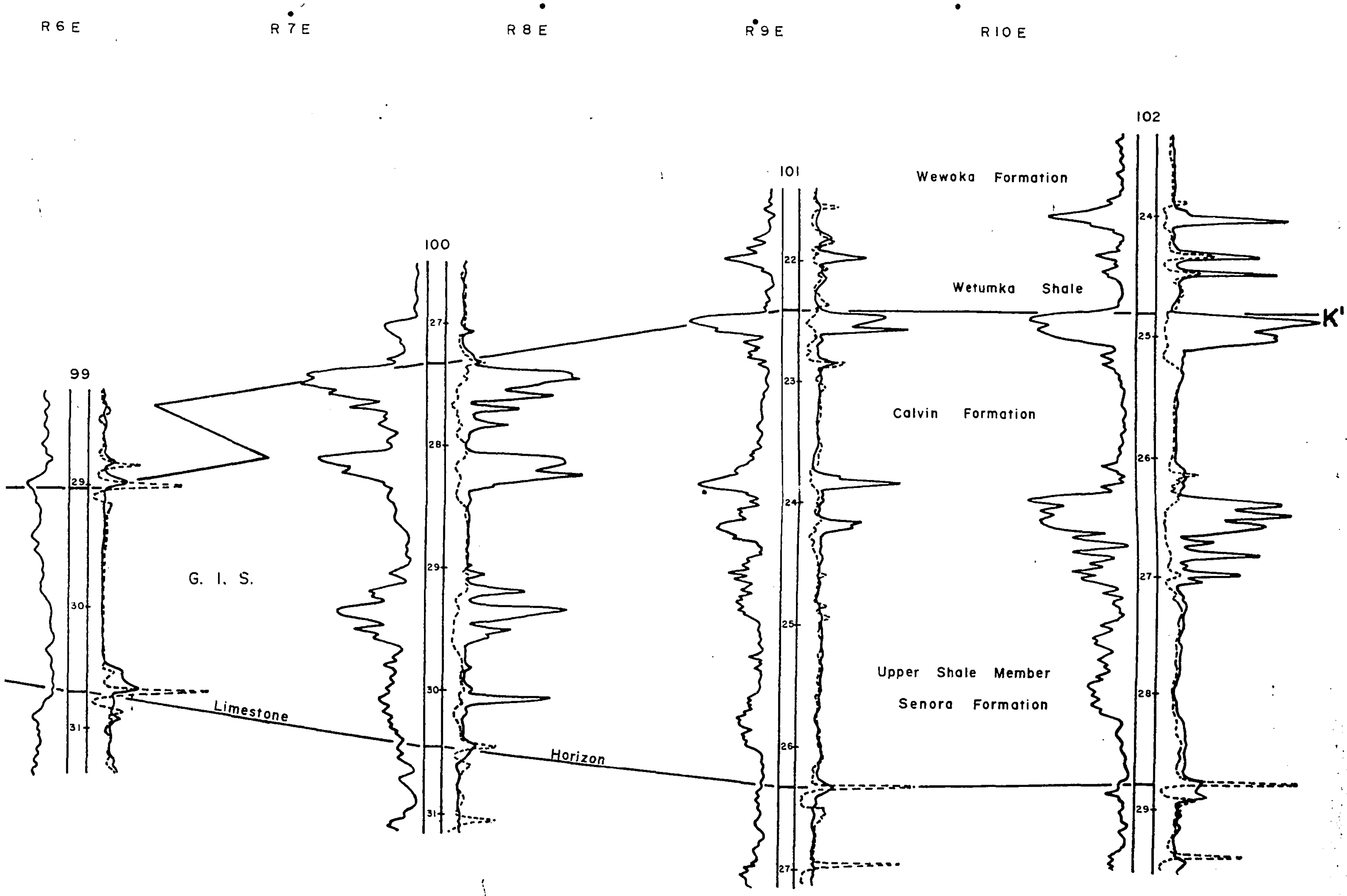
PLATE XI

PRUE–CALVIN GENETIC INCREMENT OF STRATA

ISOPACH AND SANDSTONE ISOLITH MAP

AND

STRATIGRAPHIC PROFILE KK'



LEGEND:
• Control Well
○ Sample Control
C. I. Isopach 20'
C. I. Isolith 20'
——160—— Isopach Line
---100---- Isolith Line
Sandstone Thickness

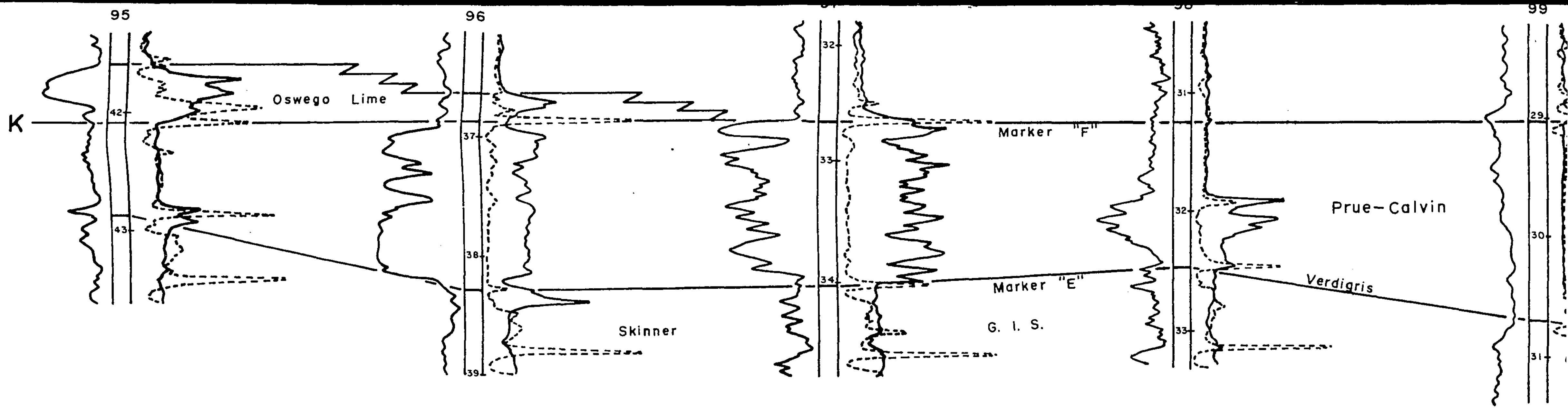


PLATE XI

PRUE—CALVIN GENETIC INCREMENT OF STRATA

ISOPACH AND SANDSTONE ISOLITH MAP

AND

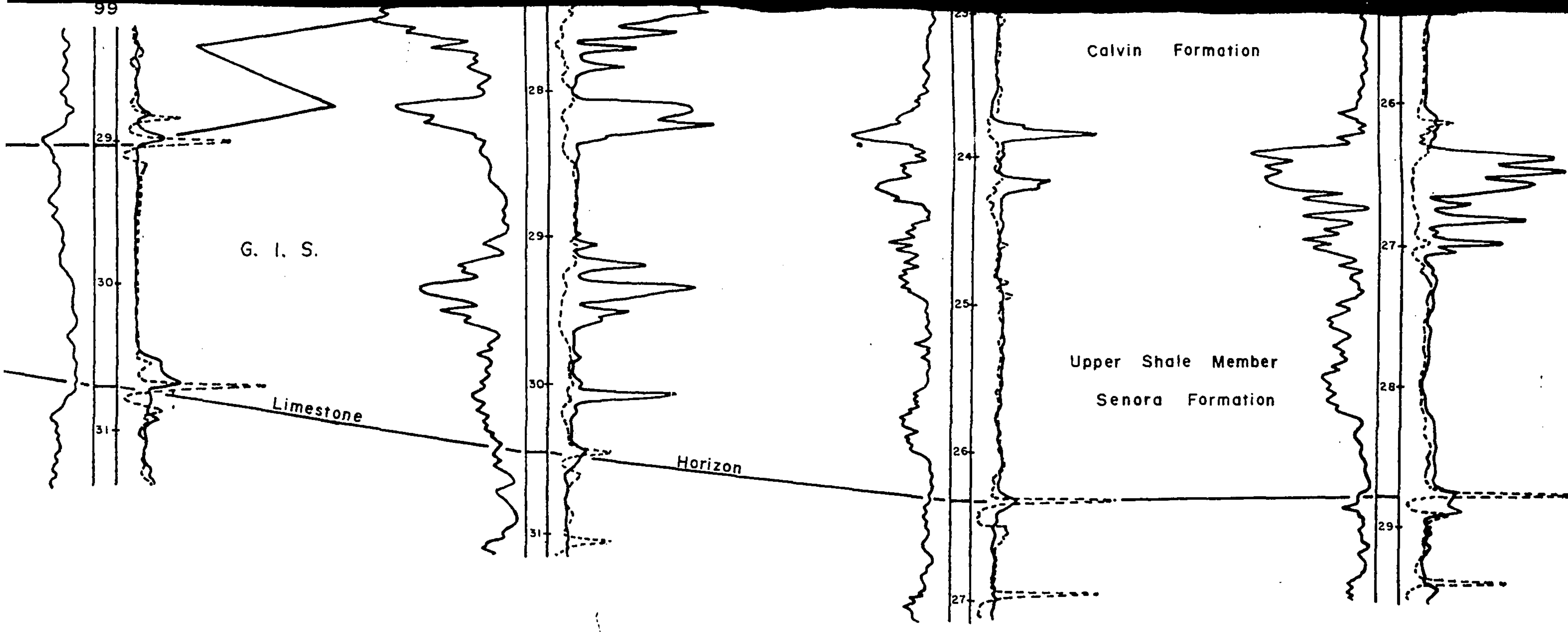
STRATIGRAPHIC PROFILE KK'

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles

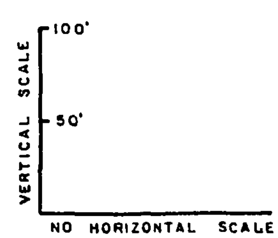
Scale

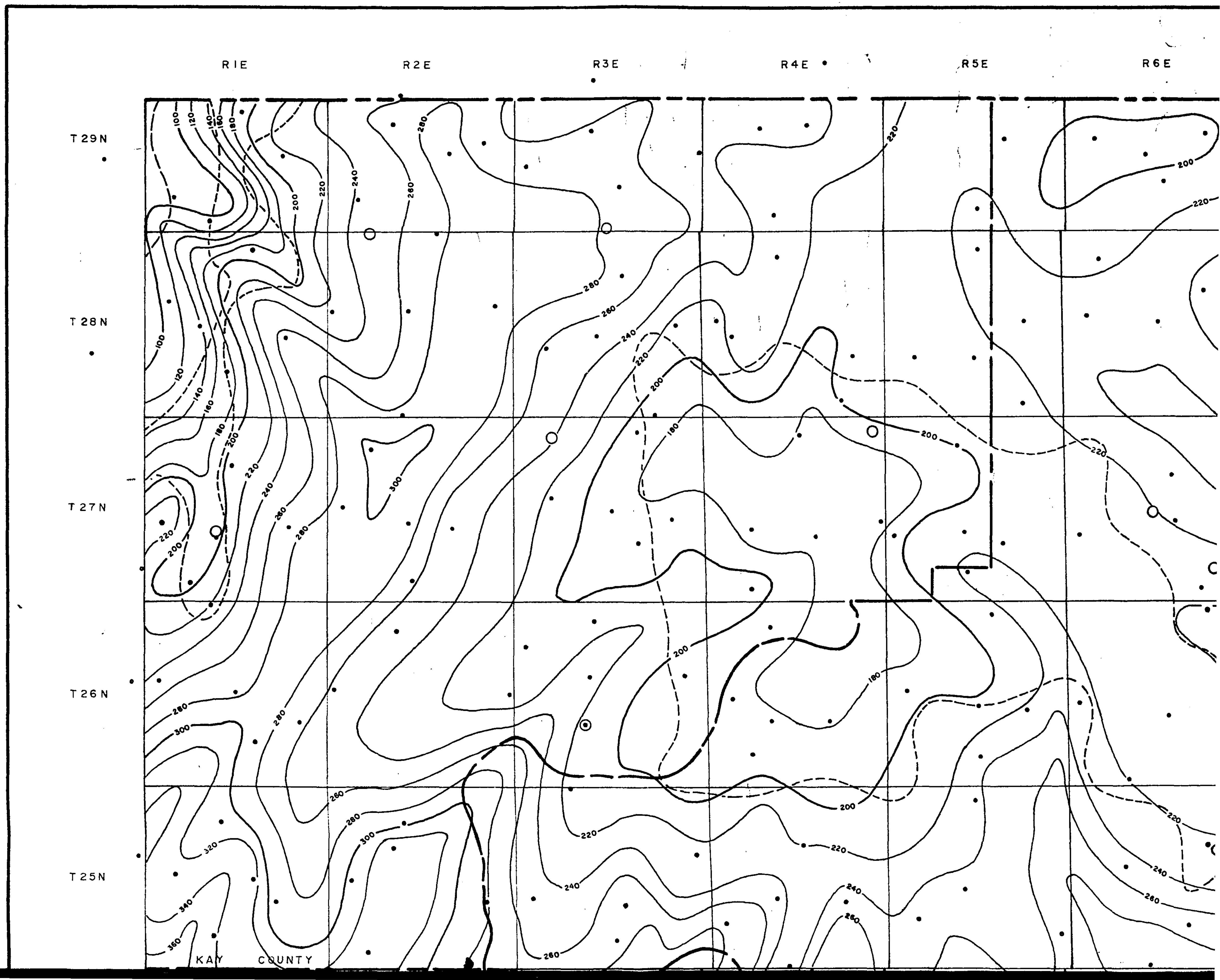


LEGEND:
- • Control Well
- O Sample Control
- C. I. Isopach 20'
- C. I. Isolith 20'
- —160—— Isopach Line
- ---*100*---- Isolith Line

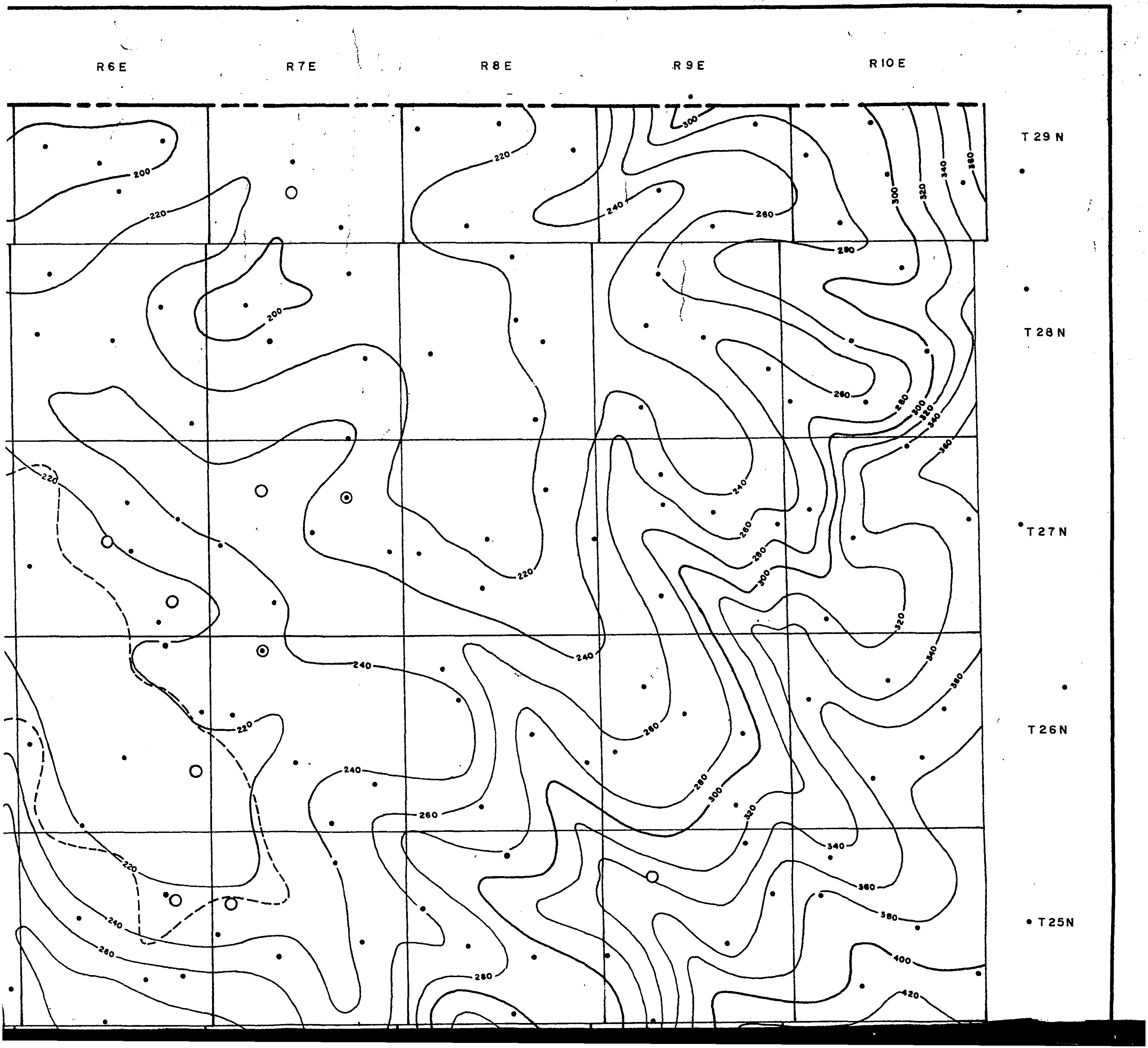
Sandstone Thickness

☐	0-40'
☐	40-80'
☐	80-120'
☐	120-160'
☐	160' +

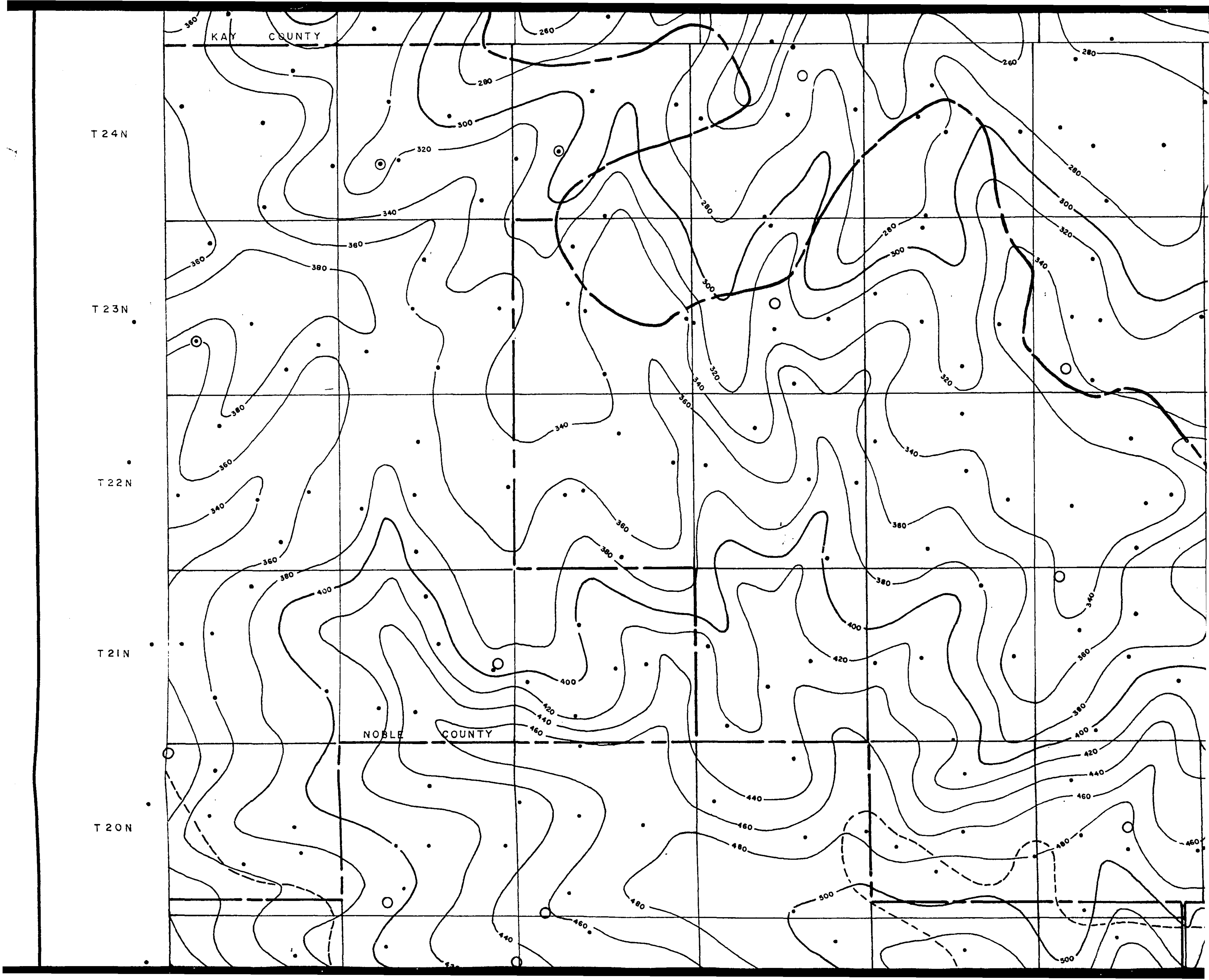




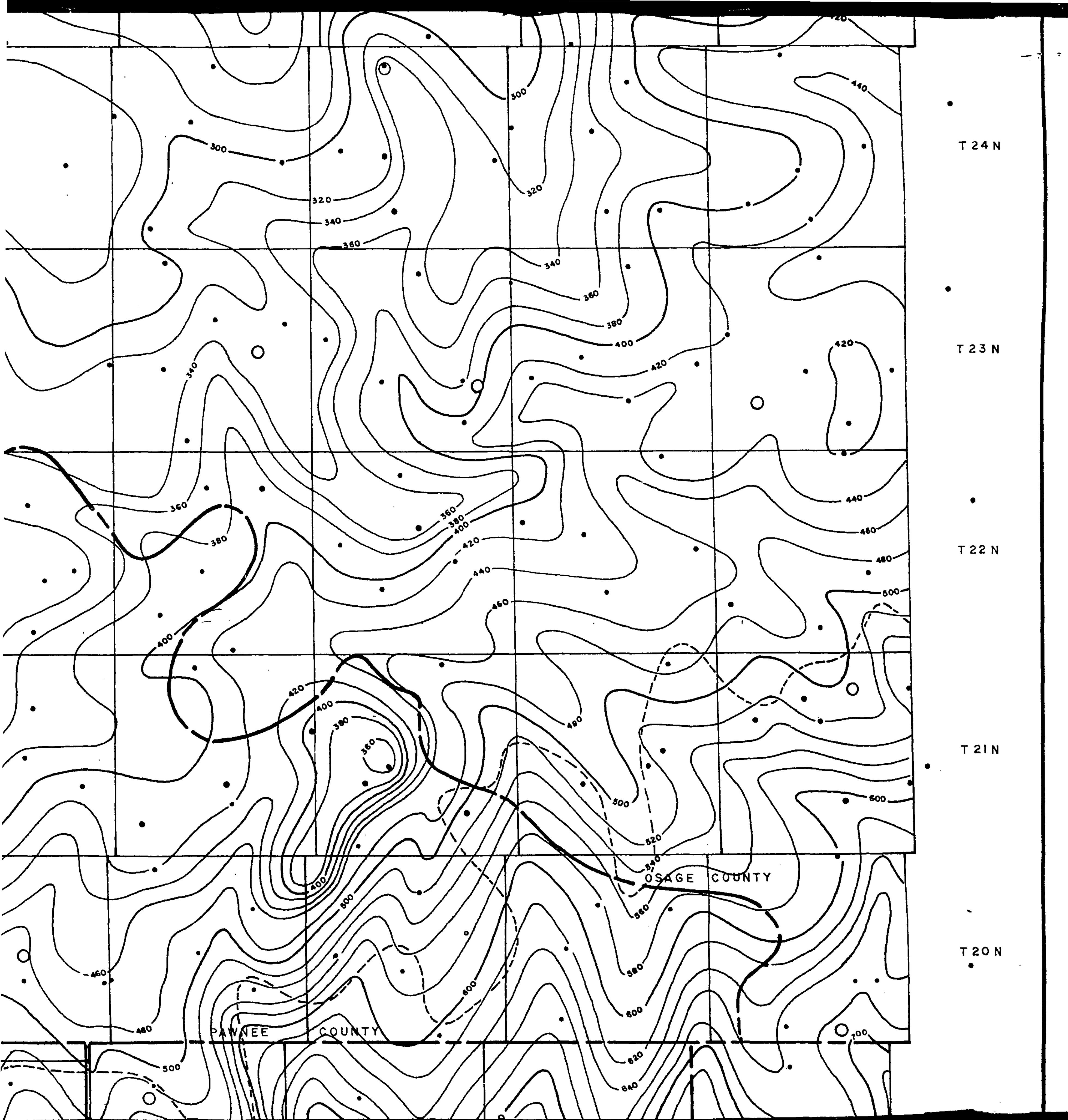
R1E
R2E
R3E
R4E
R5E
R6E
T29N
T28N
T27N
T26N
T25N
KAY COUNTY

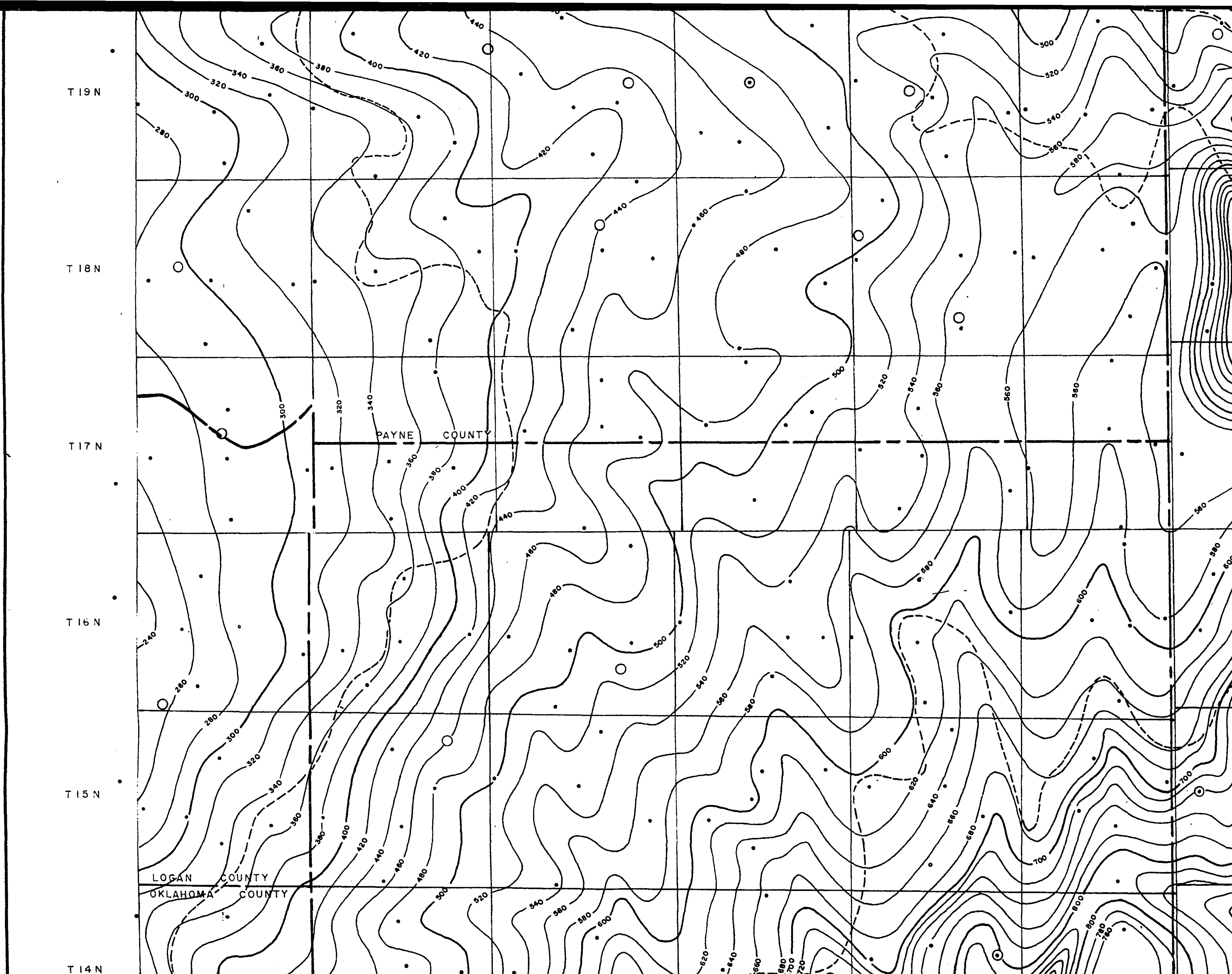


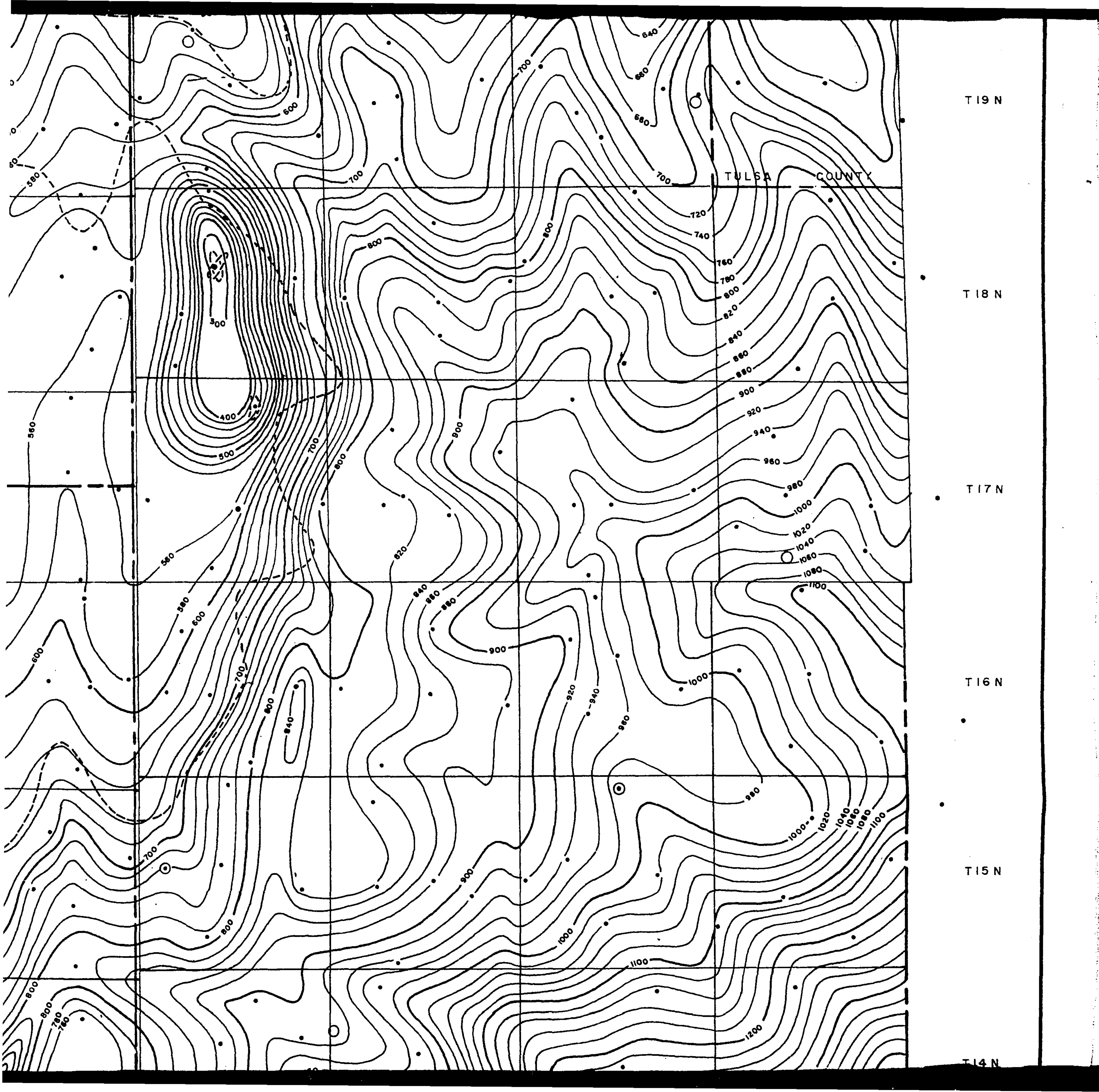
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
200
220
240
260
280
300
320
340
360
380
400
420

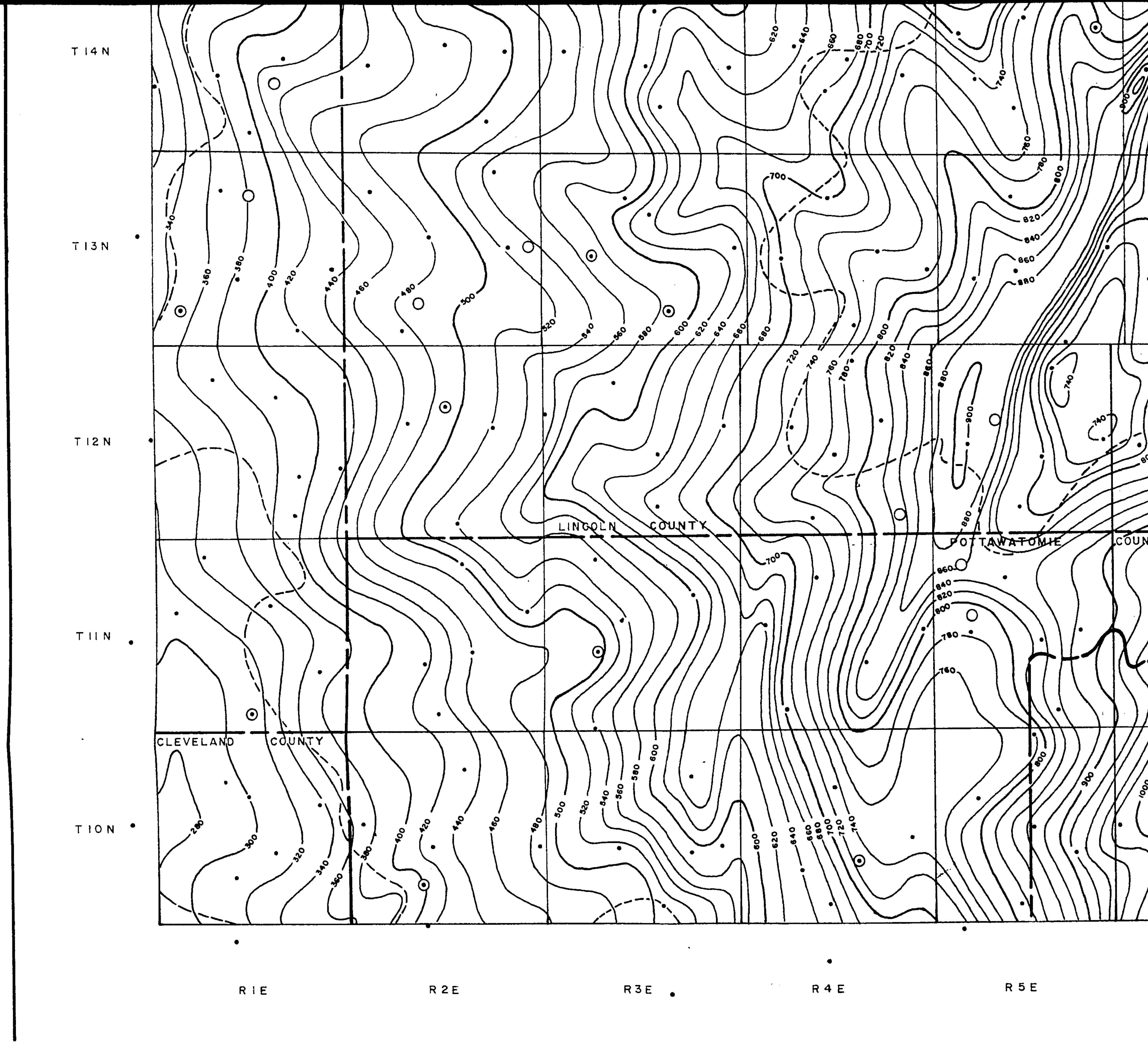


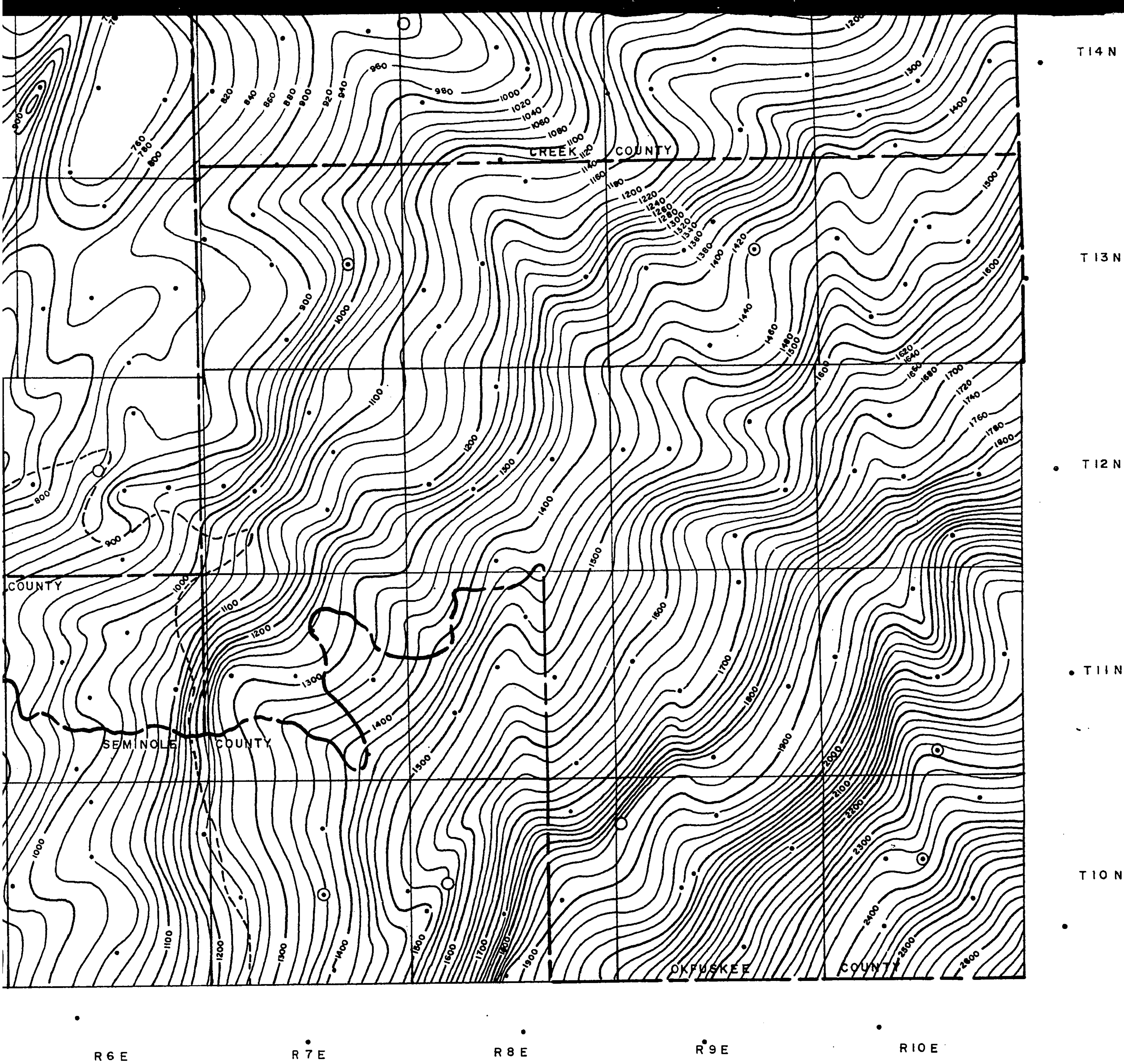
KAY COUNTY
NOBLE COUNTY
T24N
T23N
T22N
T21N
T20N
260
280
300
320
340
360
380
400
420
440
460
480
500


T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
OSAGE COUNTY
PAWNEE COUNTY
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
700


T19N
T18N
T17N
T16N
T15N
T14N
PAYNE COUNTY
LOGAN COUNTY
OKLAHOMA COUNTY


T19N
T18N
T17N
T16N
T15N
T14N
TULSA COUNTY


T14N
T13N
T12N
T11N
T10N
LINCOLN COUNTY
POTTAWATOMIE
COUN
CLEVELAND COUNTY
R1E
R2E
R3E
R4E
R5E



CREEK COUNTY
COUNTY
SEMINOLE COUNTY
OKFUSKEE COUNTY
T14N
T13N
T12N
T11N
T10N
R6E
R7E
R8E
R9E
R10E
760
780
800
820
840
860
880
900
920
940
960
980
1000
1020
1040
1060
1080
1100
1120
1140
1160
1180
1200
1220
1240
1260
1280
1300
1320
1340
1380
1400
1420
1440
1460
1480
1500
1600
1620
1640
1660
1680
1700
1720
1740
1760
1780
1800
1900
2000
2100
2200
2300
2400
2500
2600

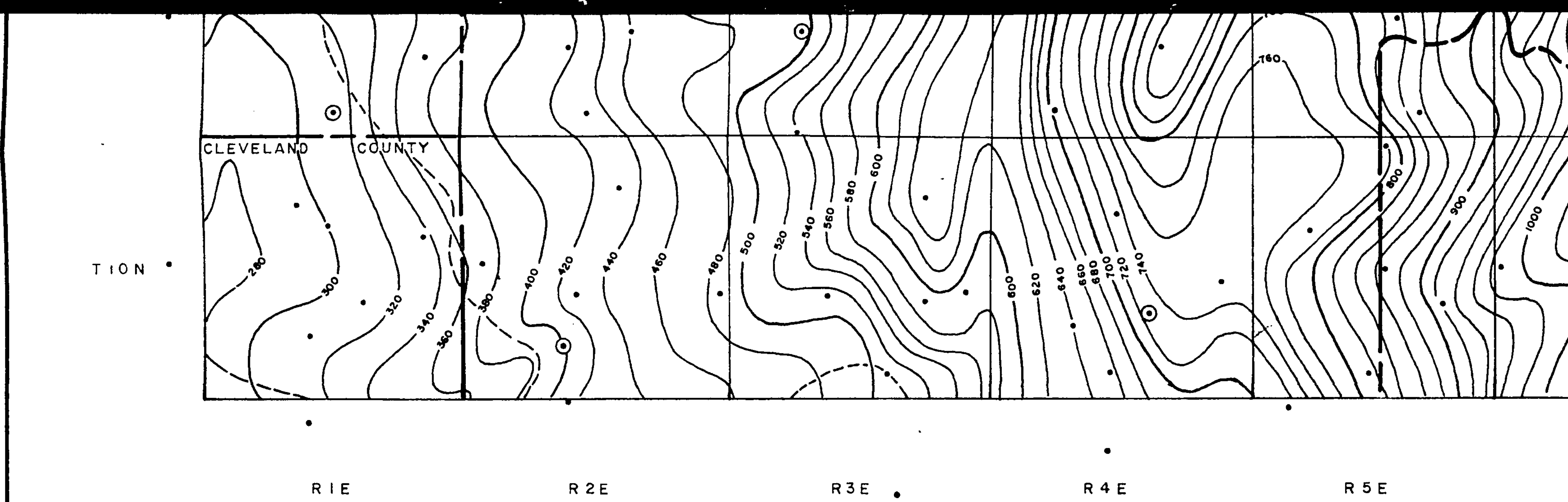


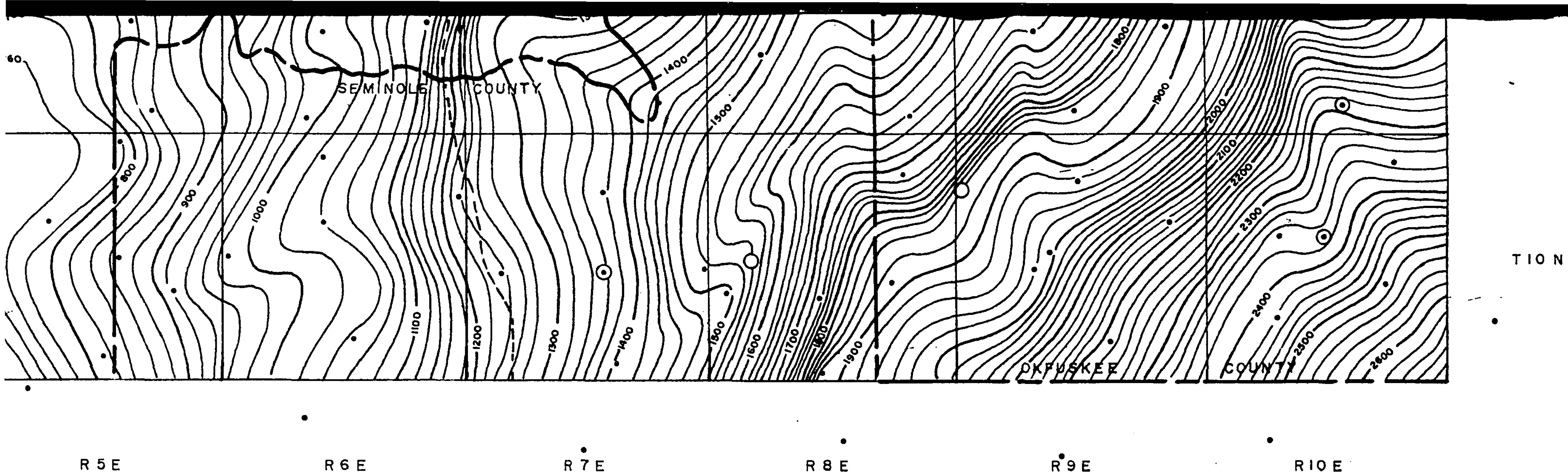
PLATE XII

CHEROKEE GENETIC SEQUENCE OF STRATA ISOPACH AND LAPOUT MAP

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles
Scale



LEGEND:

- • Control Well
- O Sample Control

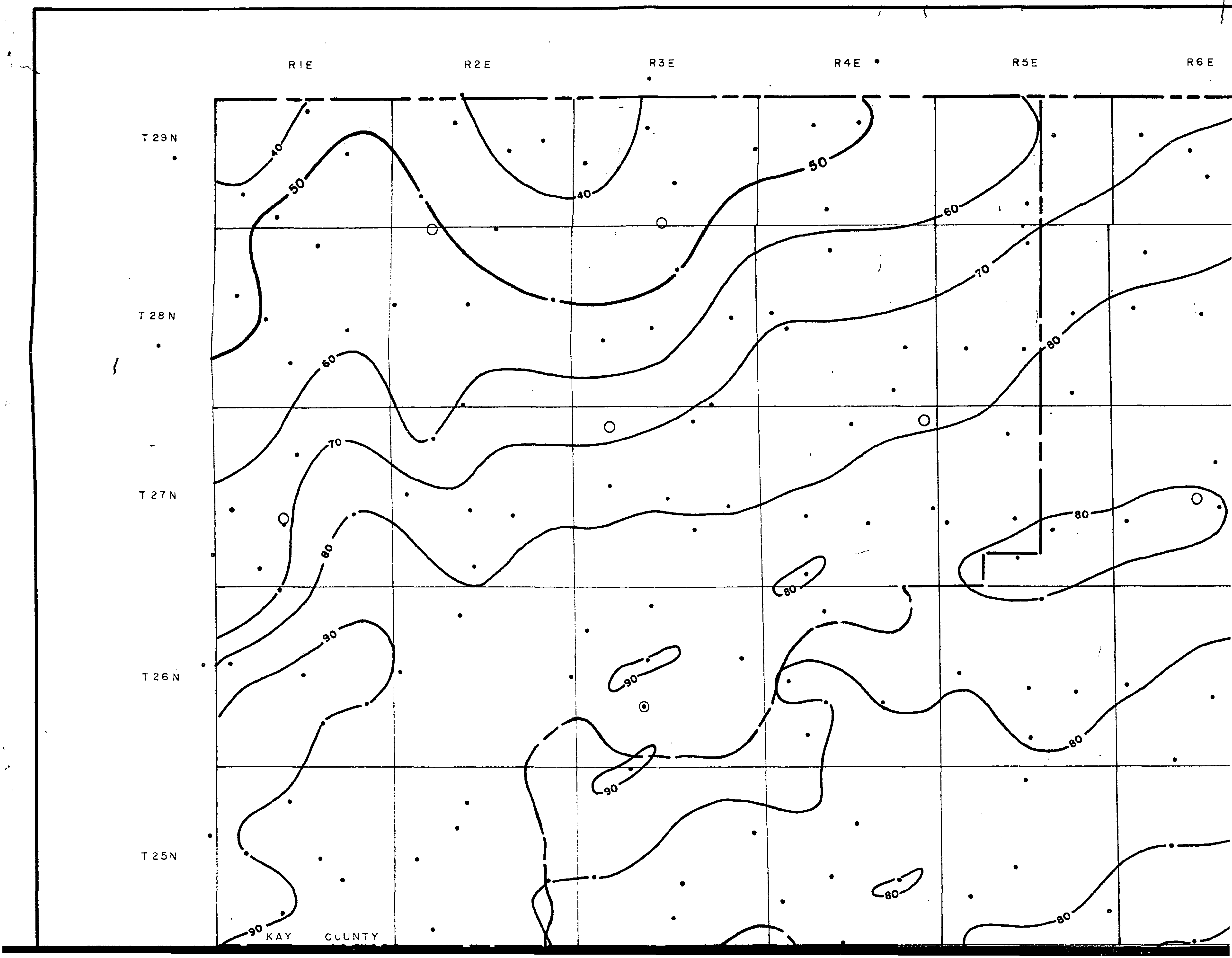
C. I. Isopach 20'

—900— Isopach Line

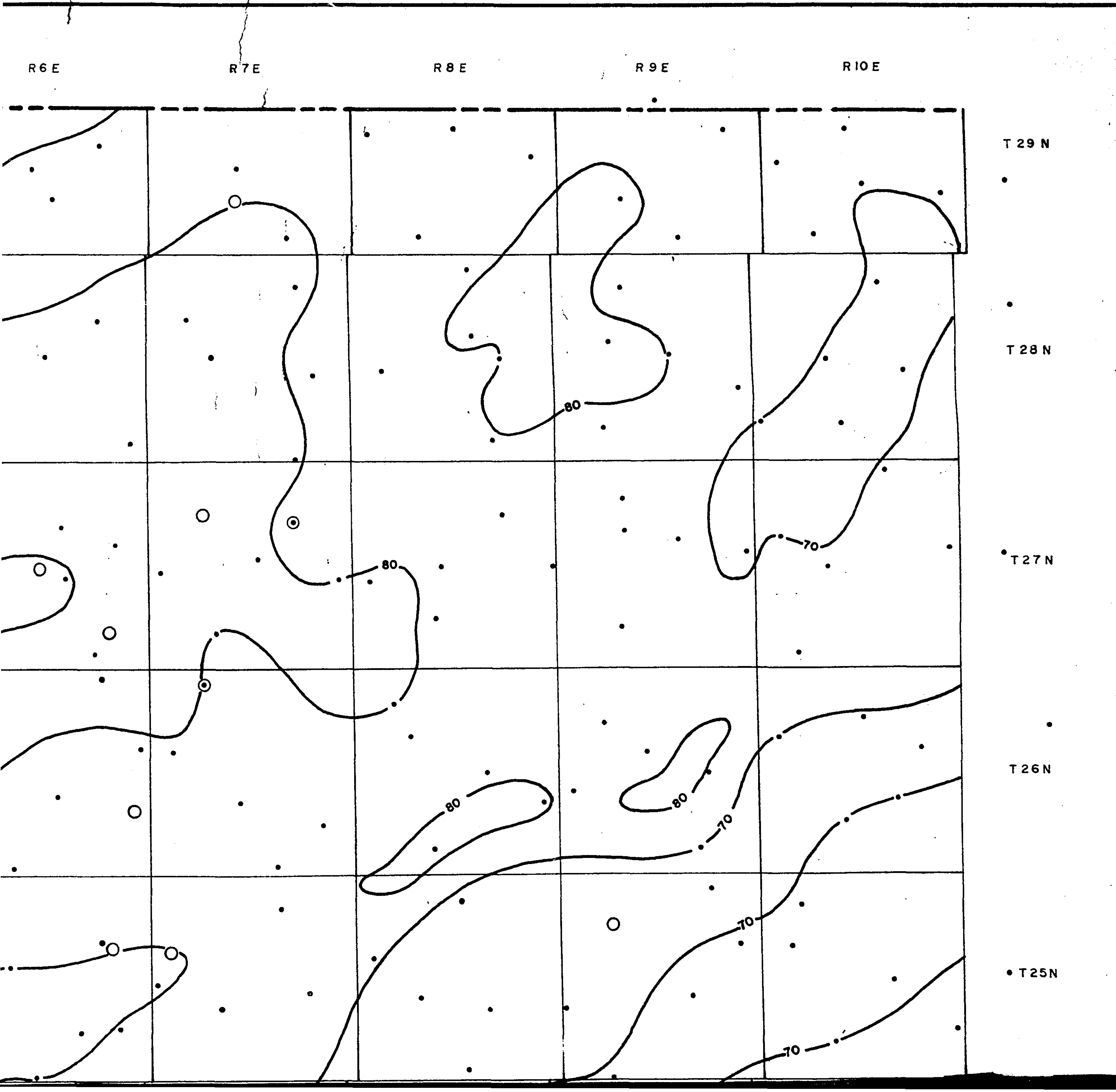
– – – – – – Limits of G. I. S.

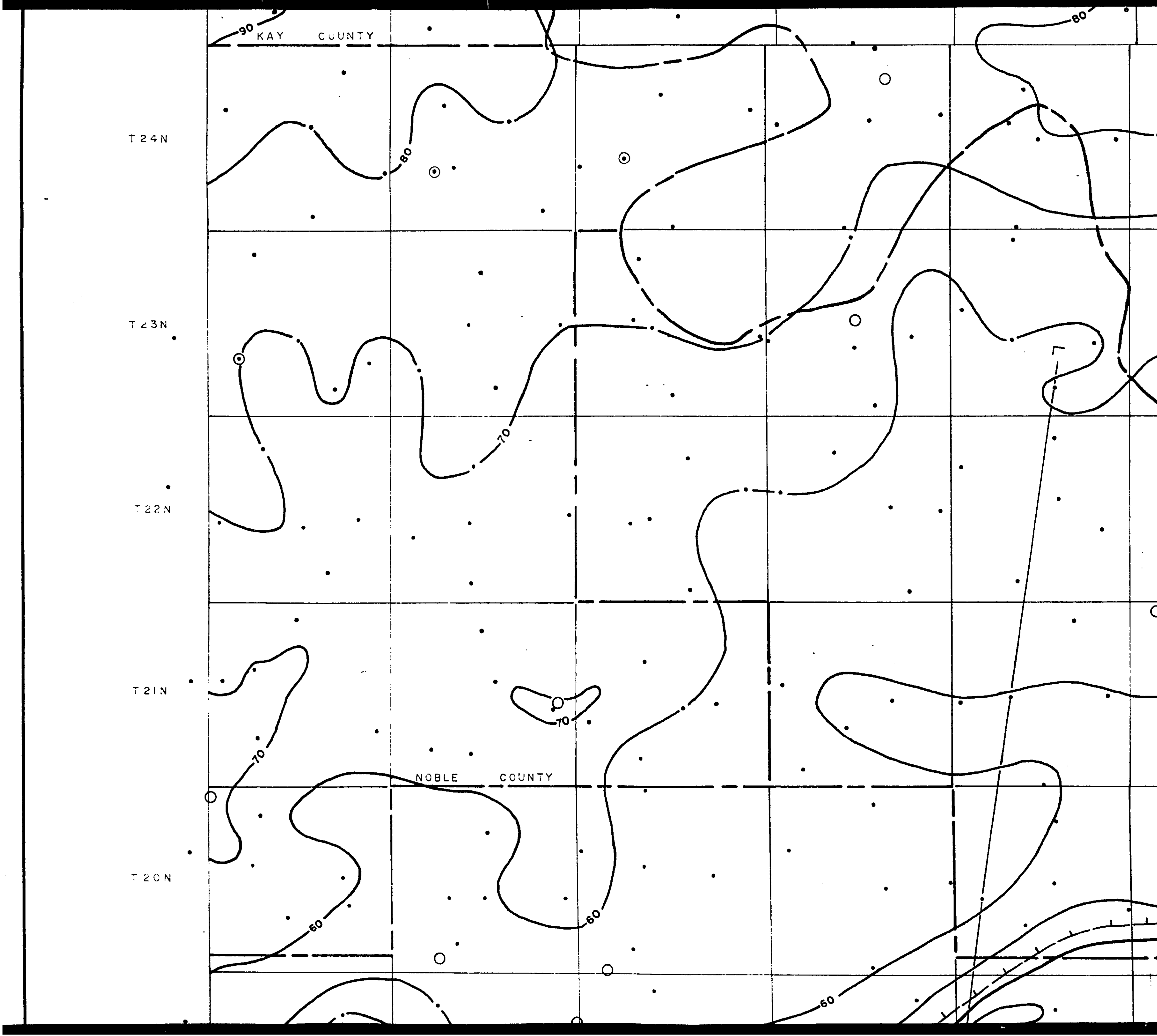
Genetic Increments of Strata

- ☐ Skinner G. I. S.
- ☐ Red Fork G. I. S.
- ☐ Bartlesville G. I. S.
- ☐ Booch G. I. S.
- ☐ Gilcrease G. I. S.

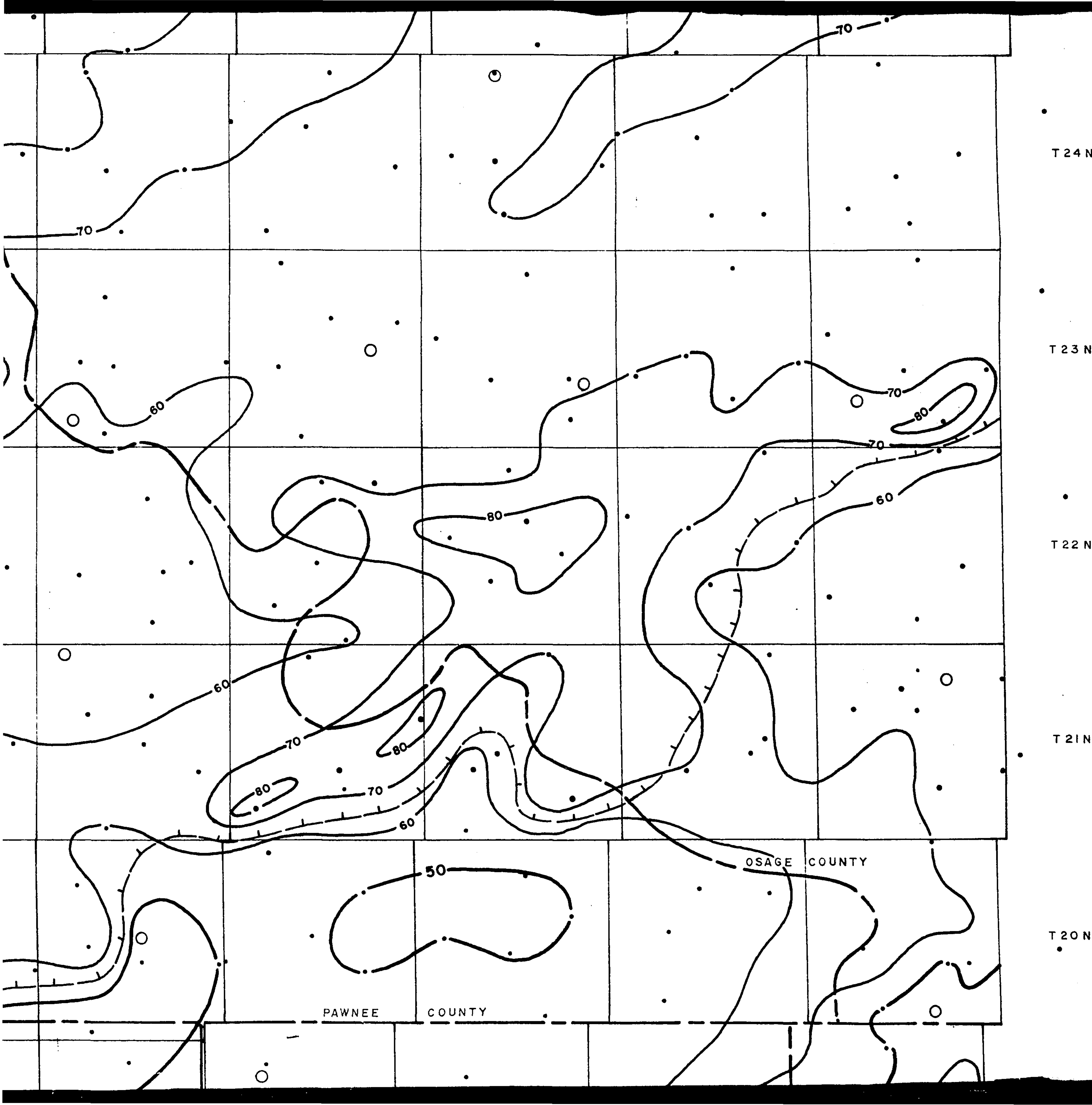


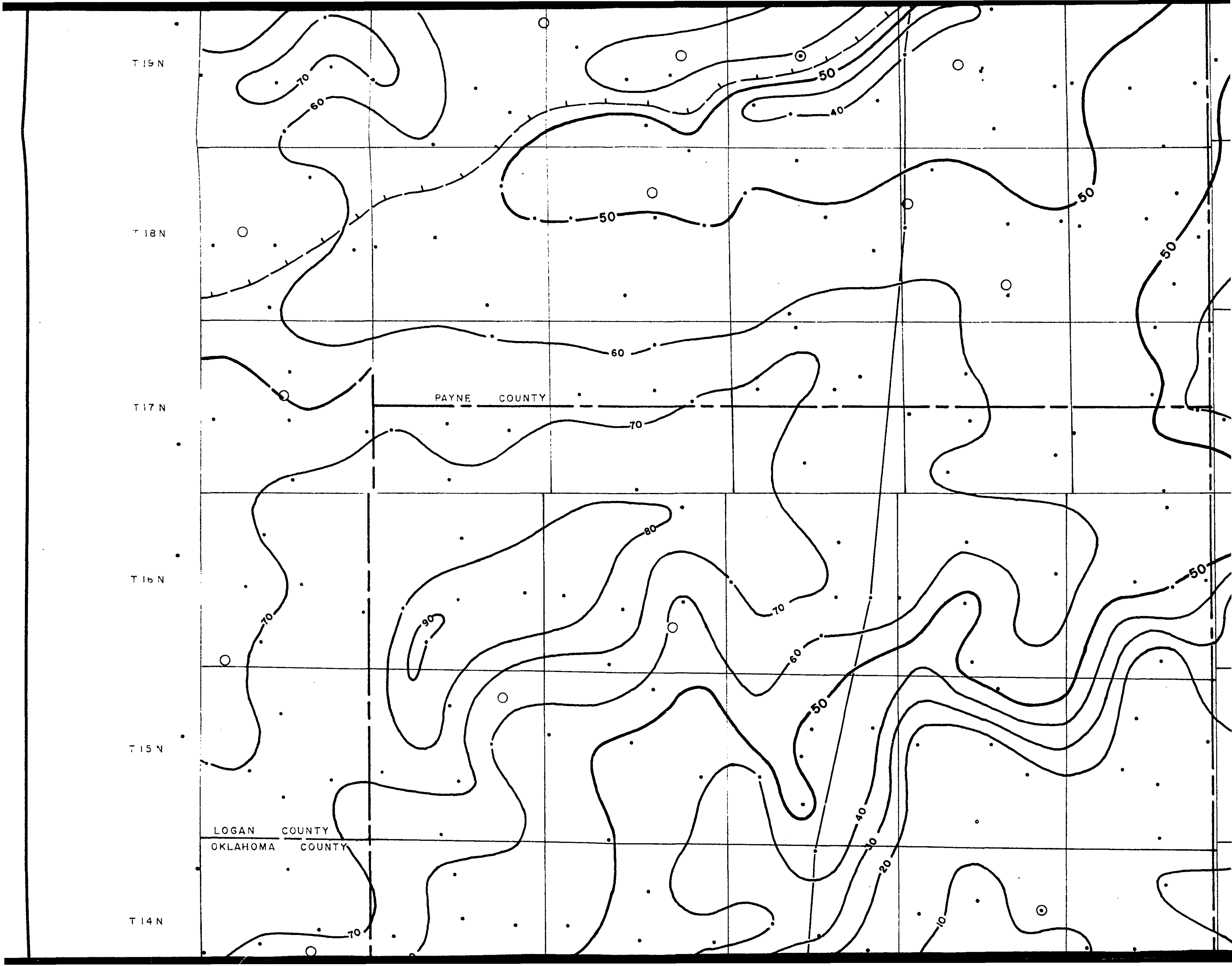
R1E
R2E
R3E
R4E
R5E
R6E
T29N
T28N
T27N
T26N
T25N
40
50
60
70
80
90
KAY COUNTY


R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
80
80
80
80
70
70
70
70

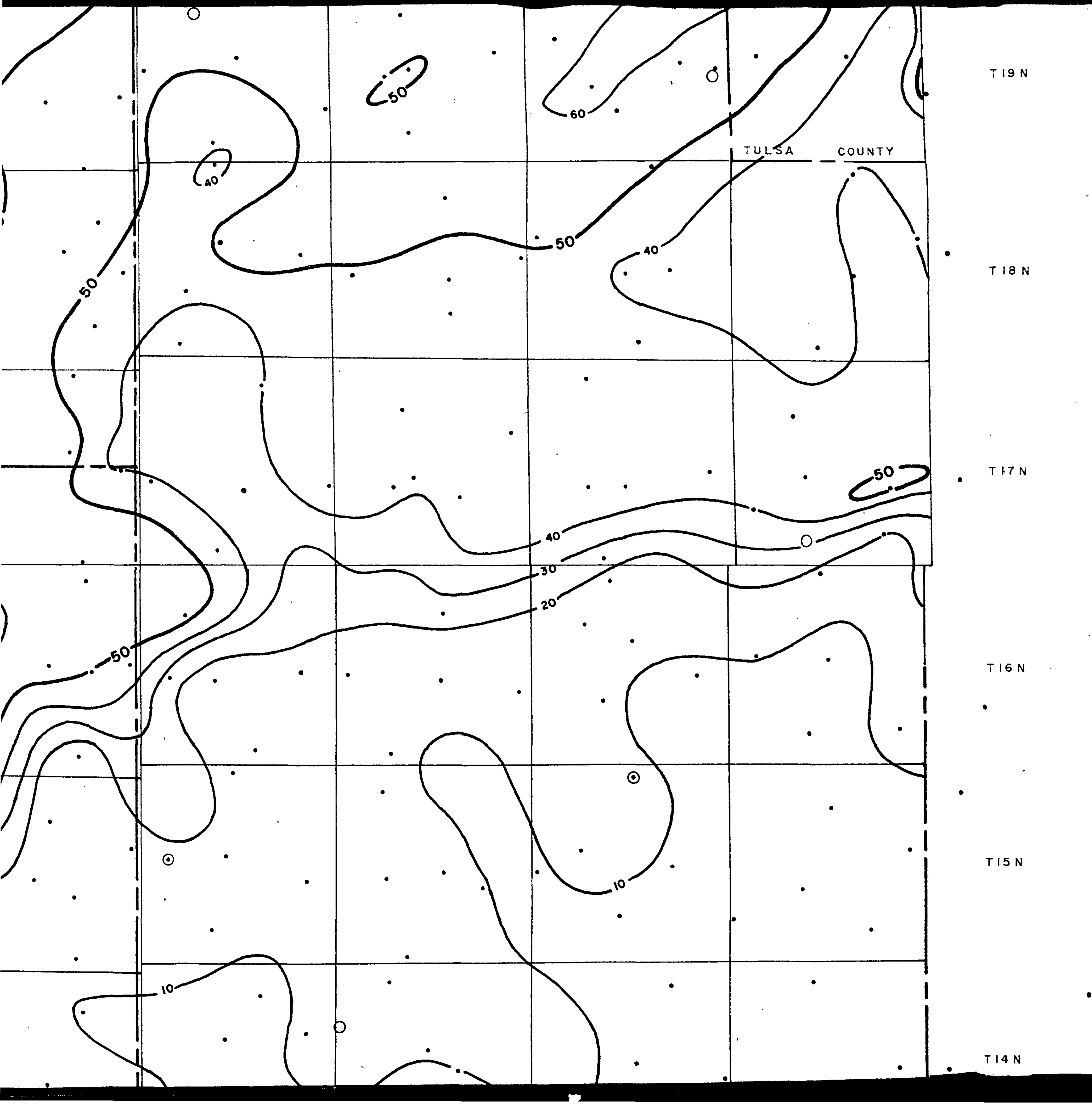


T24N
T23N
T22N
T21N
T20N
KAY COUNTY
NOBLE COUNTY
90
80
80
70
70
70
60
60
60

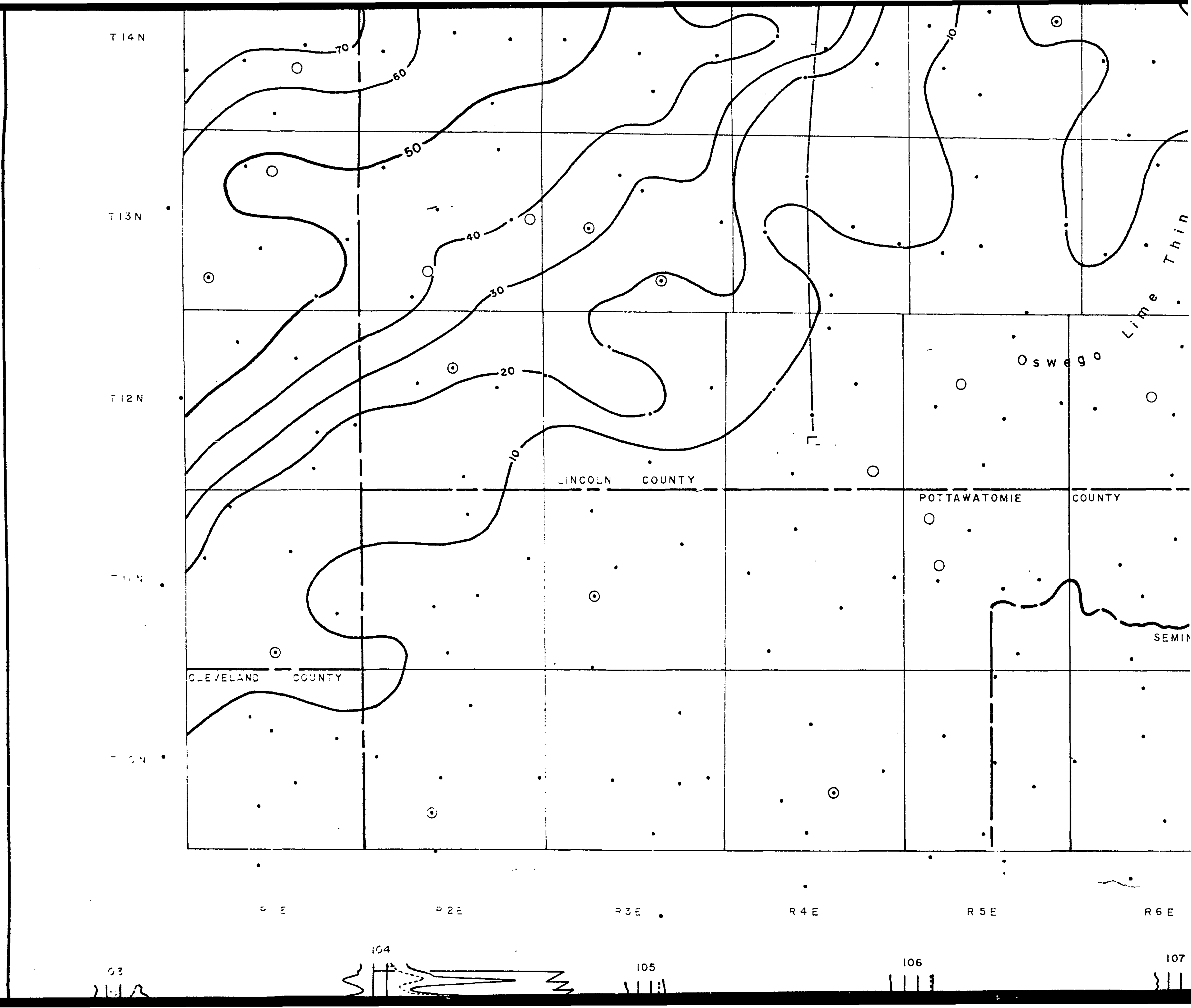

70
70
70
60
70
80
70
60
80
60
70
80
80
70
60
50
OSAGE COUNTY
PAWNEE COUNTY
T24N
T23N
T22N
T21N
T20N



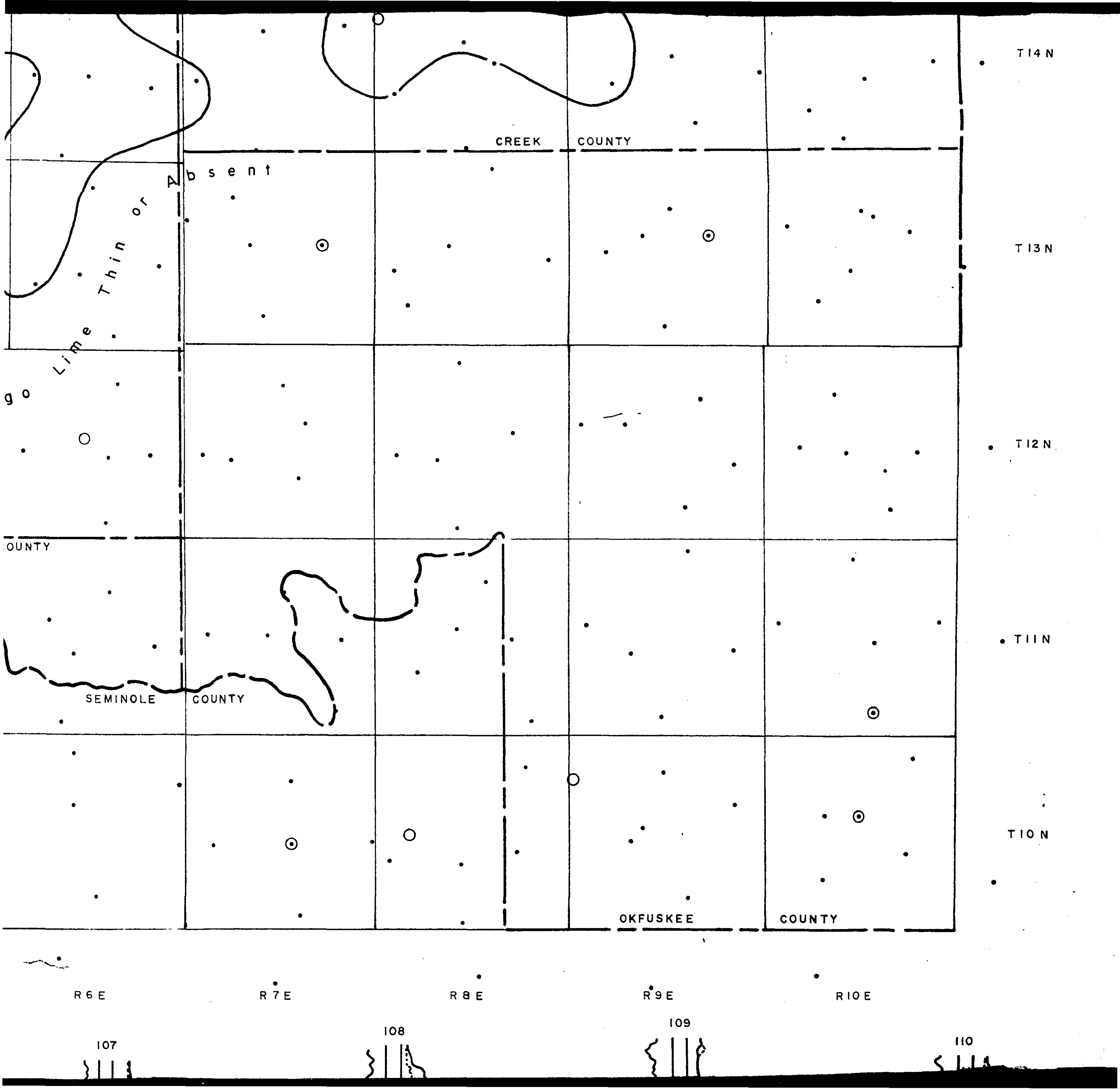
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
PAYNE COUNTY
LOGAN COUNTY
OKLAHOMA COUNTY
90
80
70
60
50
40
30
20
10



T19N
T18N
T17N
T16N
T15N
T14N
TULSA COUNTY
60
50
50
50
50
50
40
40
40
30
20
10
10



T14N
T13N
T12N
70
60
50
40
30
20
10
10
Oswego Lime Thin
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
R2E
R3E
R4E
R5E
R6E
104
105
106
107


T14N
T13N
T12N
T11N
T10N
CREEK COUNTY
go Lime Thin or Absent
OUNTY
SEMINOLE COUNTY
OKFUSKEE COUNTY
R6E
R7E
R8E
R9E
R10E
107
108
109
110

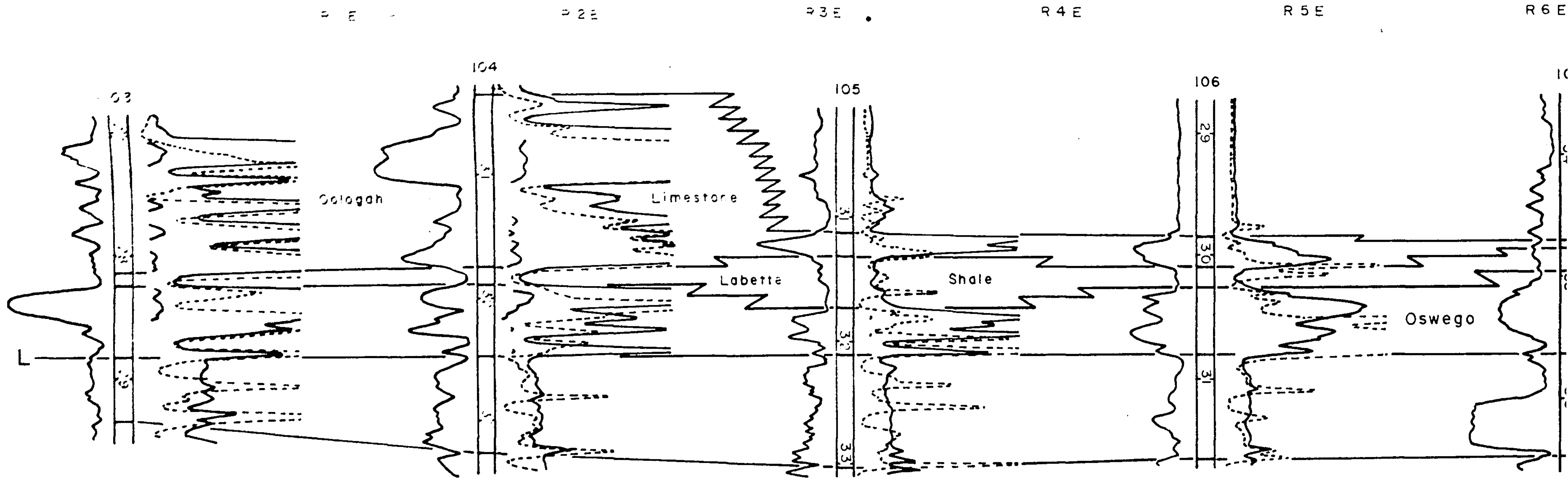


PLATE XIII

OSWEGO LIME INCREMENT OF STRATA

ISOPACH MAP

AND

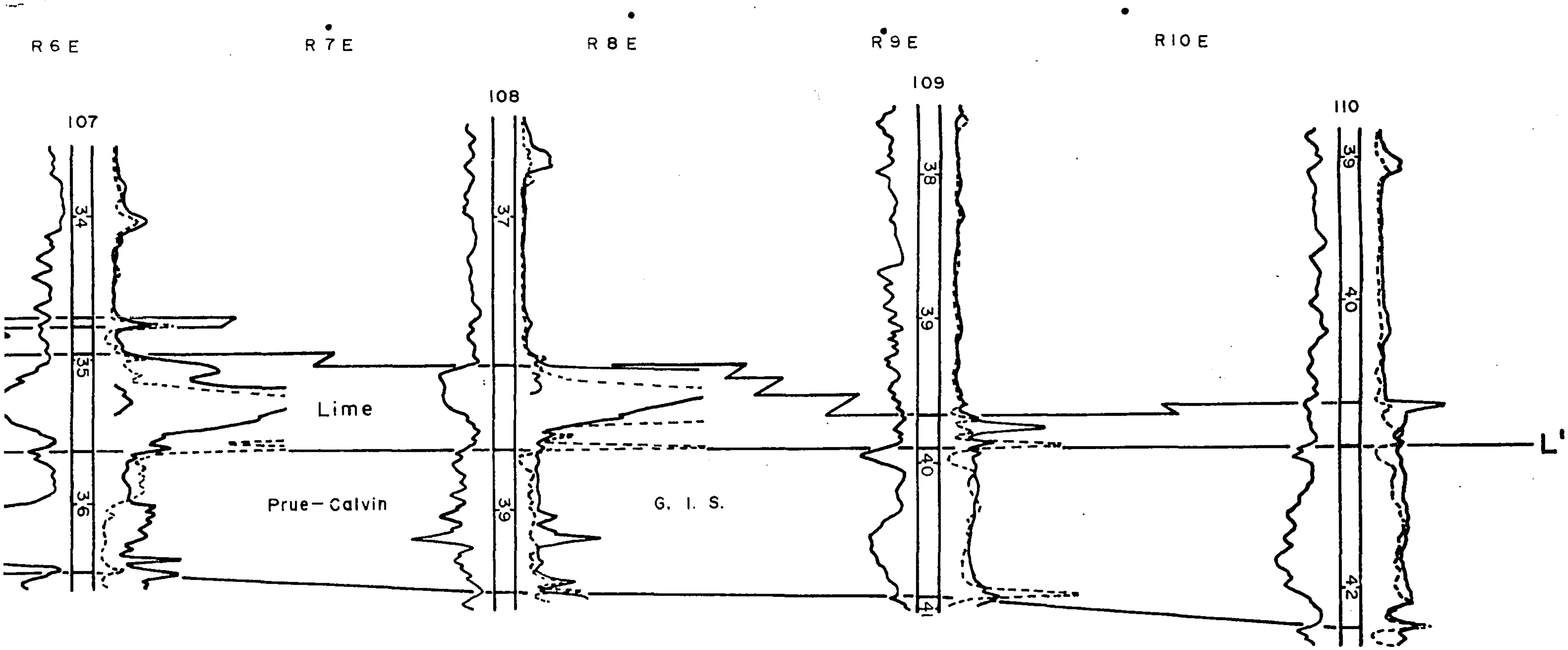
STRATIGRAPHIC PROFILE LL'

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles

Scale



LEGEND:

∘ Control Well

⊙ Sample Control

C. I. Isopach 10'

——50—— Isopach Line

—┴— —┴— Southern Limit Higginsville Limestone

Limestone Thickness

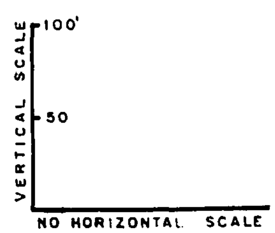
▭ 10-20'

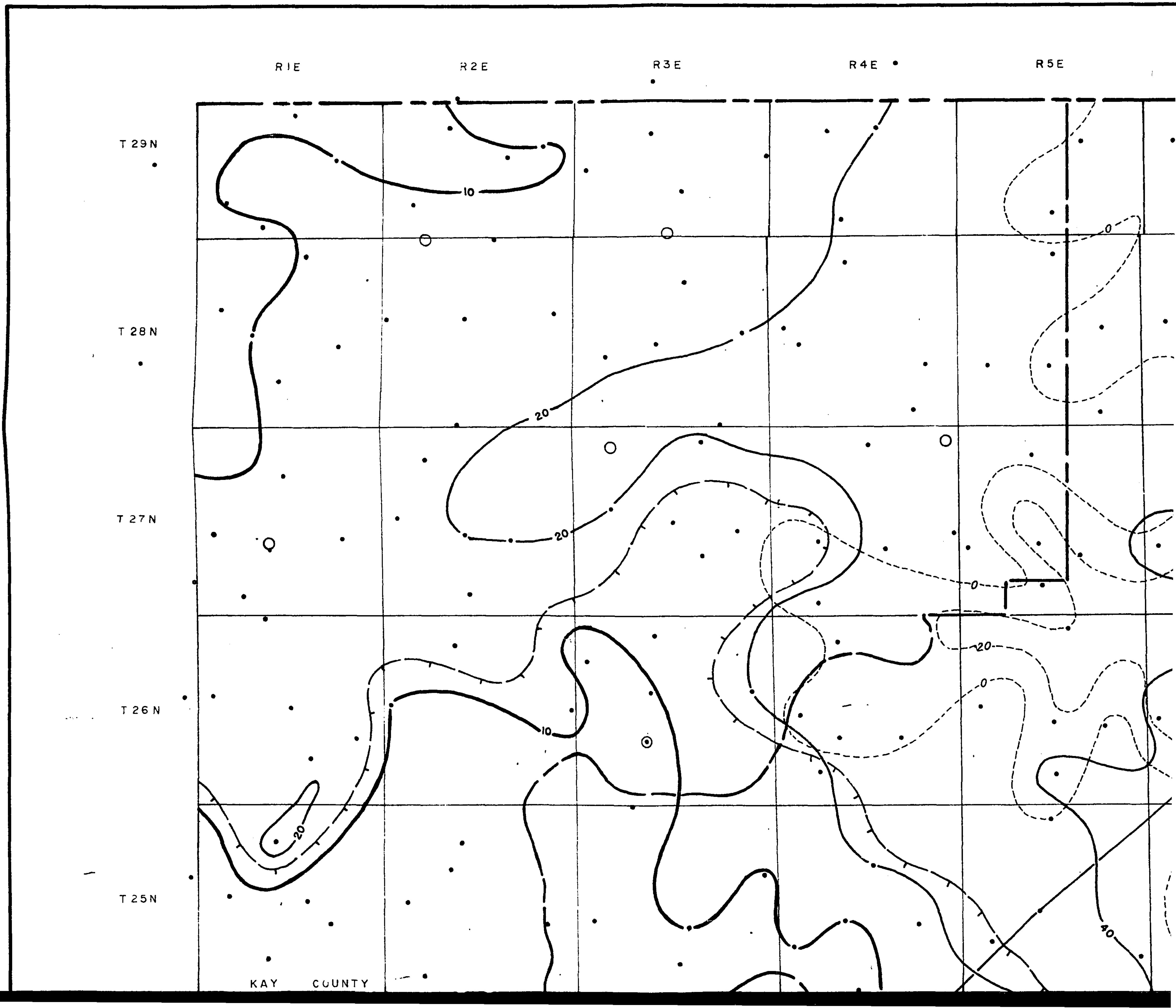
▭ 20-40'

▭ 40-60'

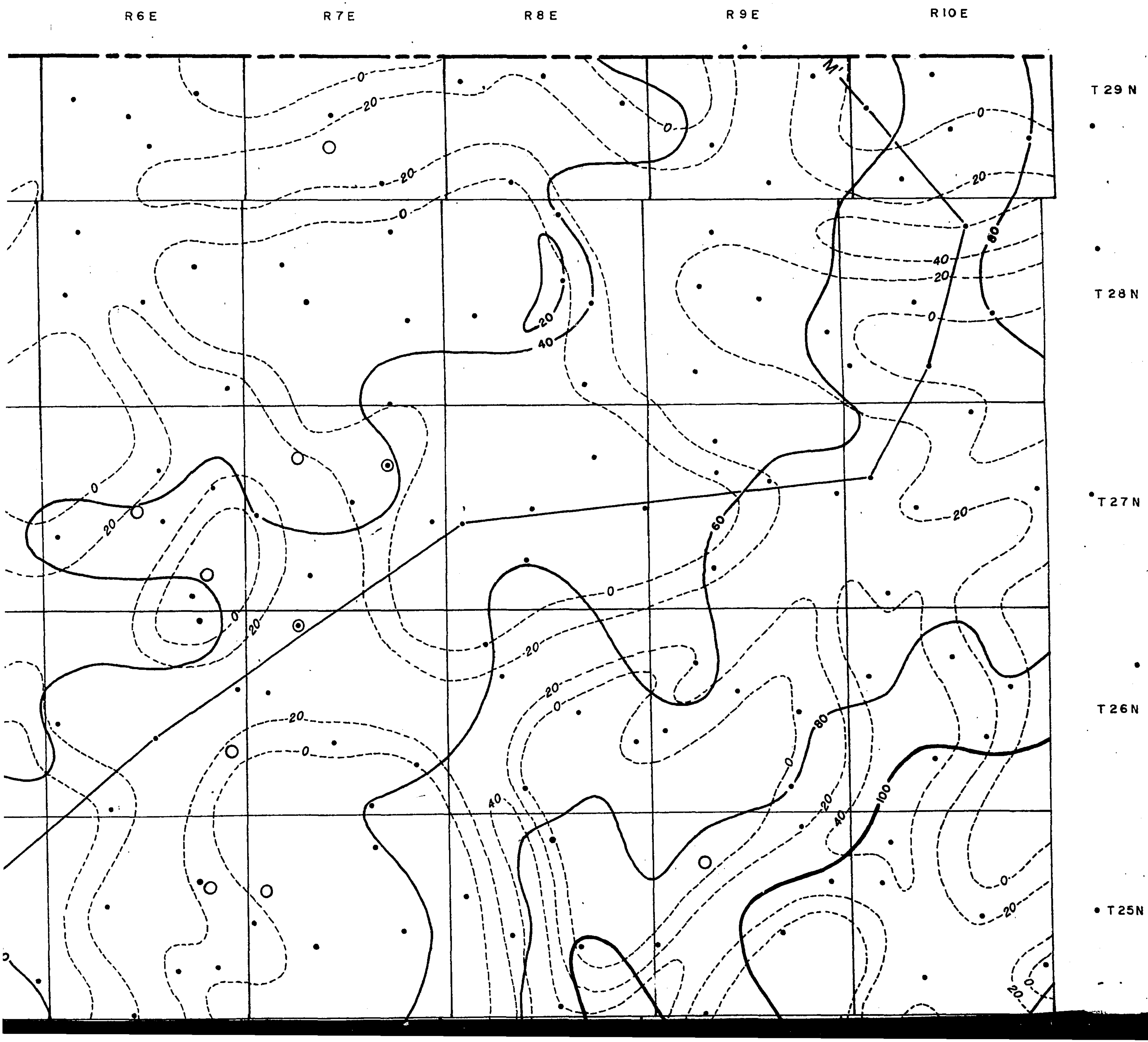
▭ 60-80'

▭ 80' +

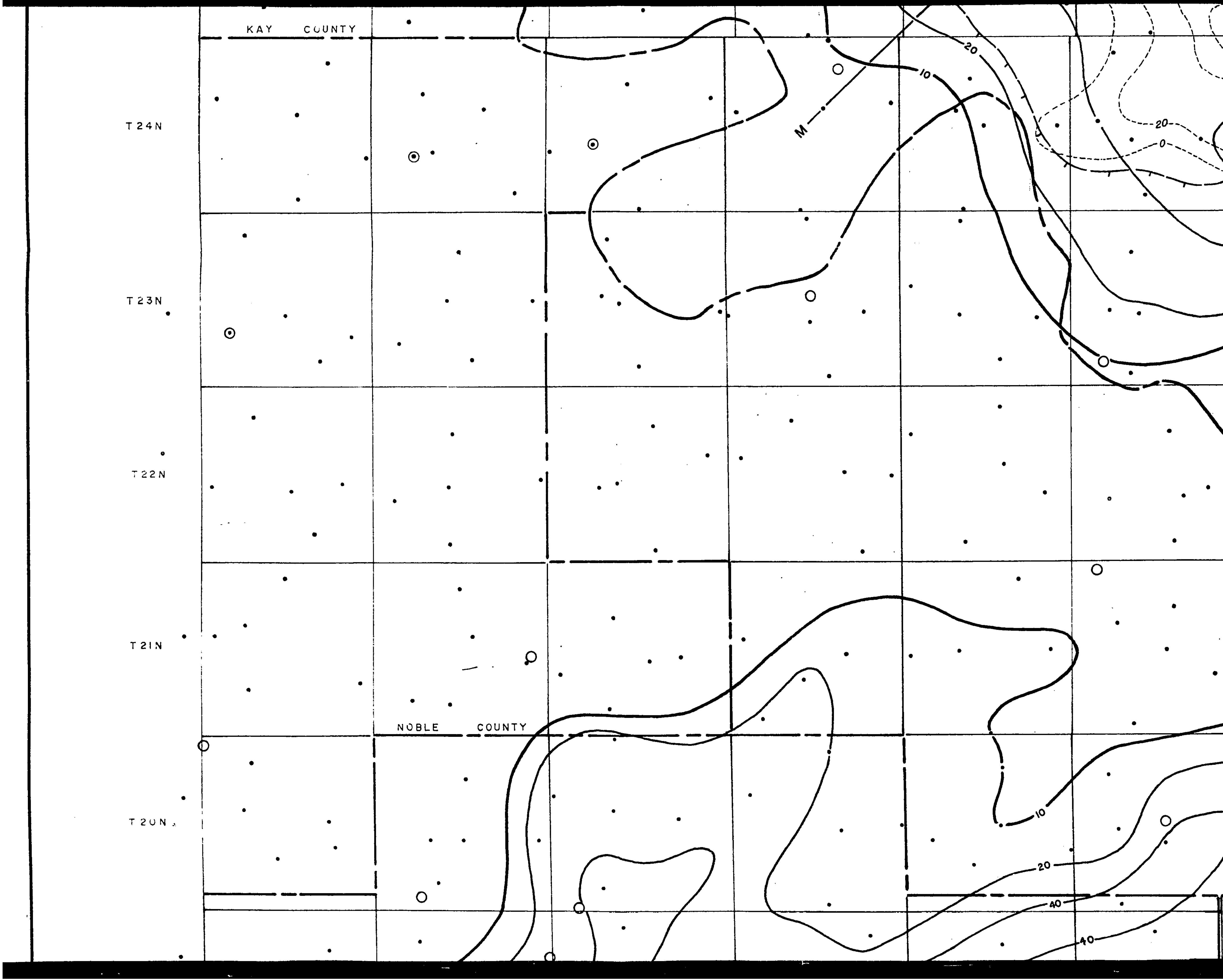




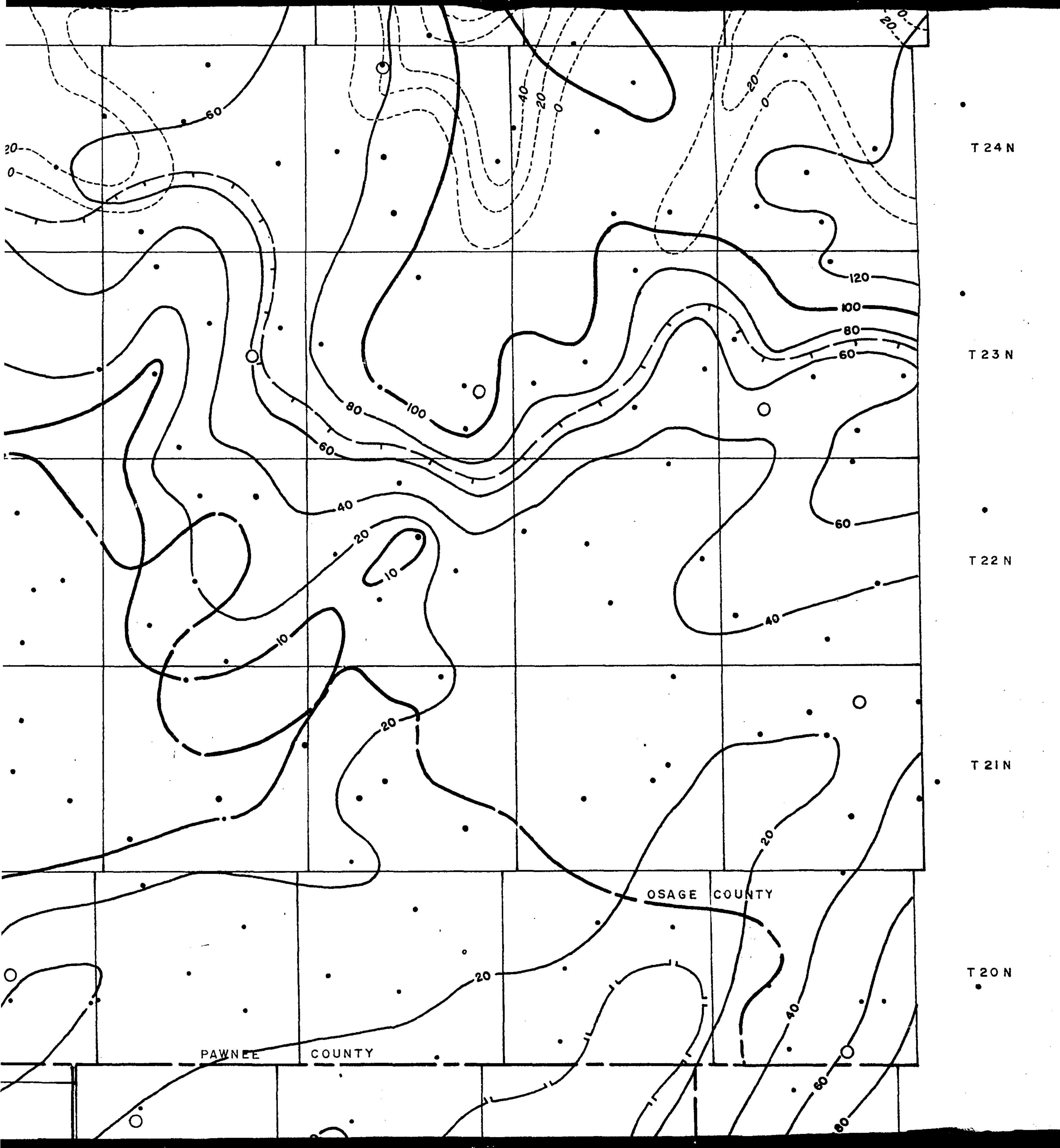
R1E
R2E
R3E
R4E
R5E
T 29N
T 28N
T 27N
T 26N
T 25N
10
20
20
10
20
0
20
0
40
KAY COUNTY



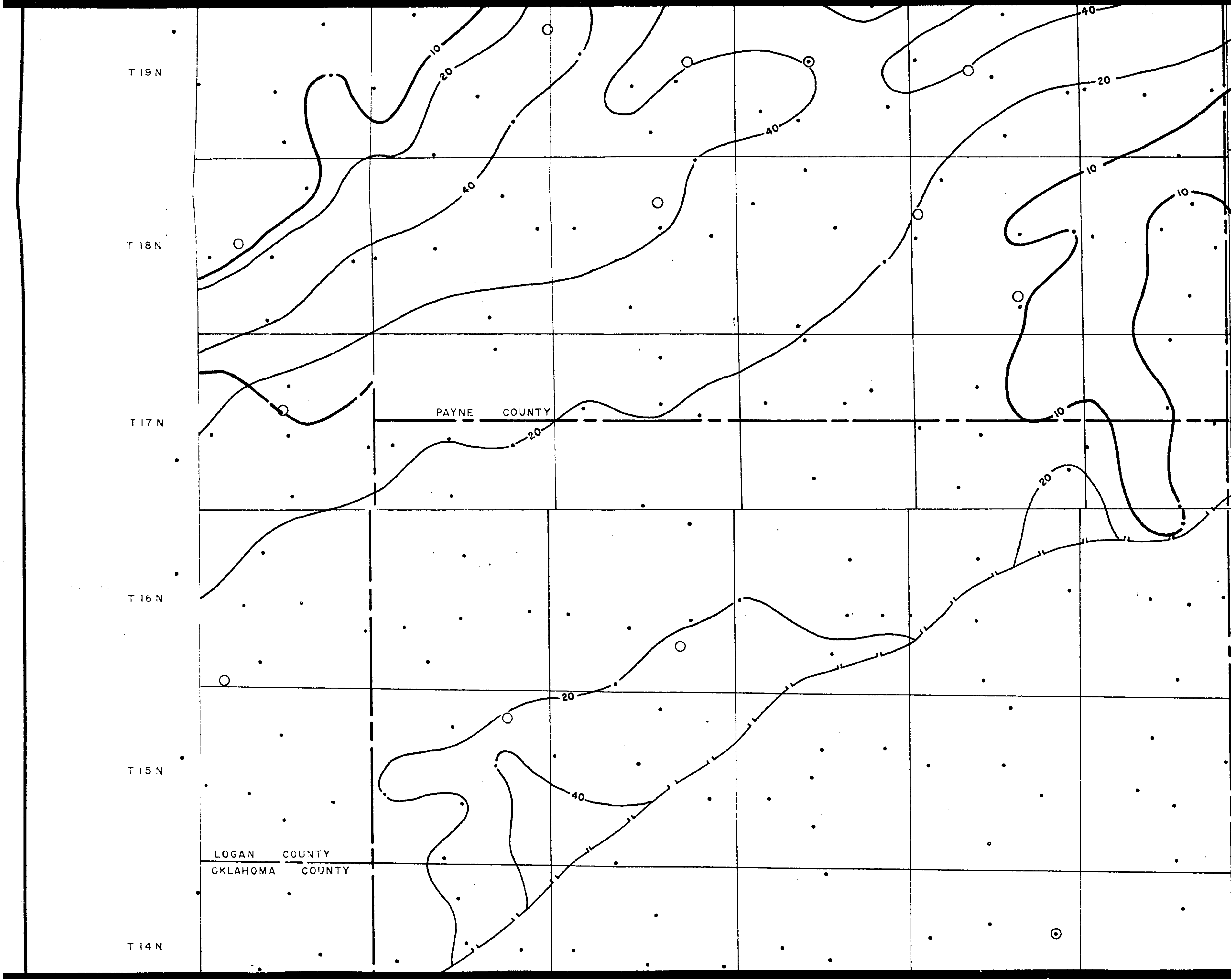
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
M'
0
20
40
60
80
100



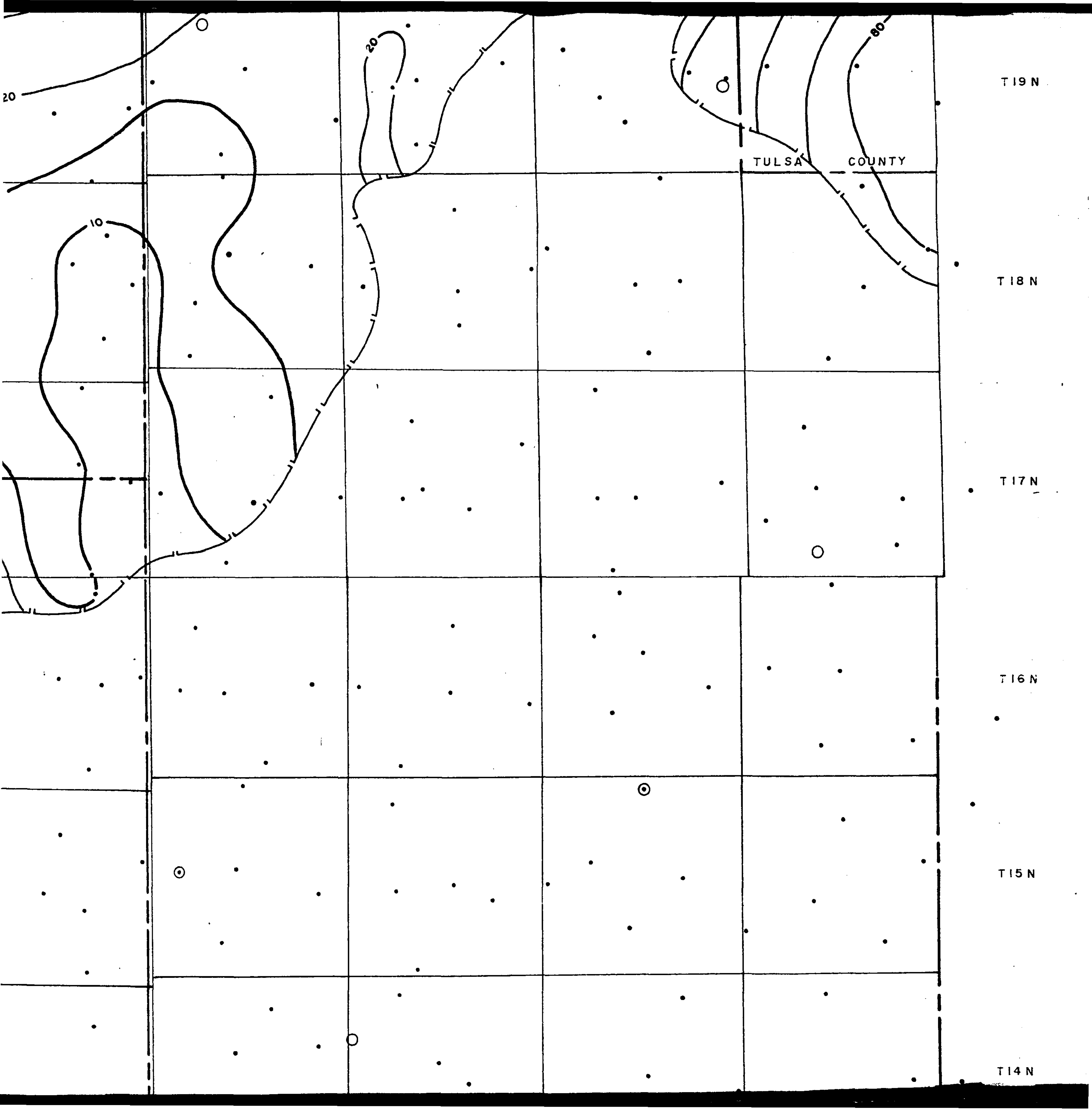
KAY COUNTY
T24N
T23N
T22N
T21N
T20N
NOBLE COUNTY
M
10
20
0
40

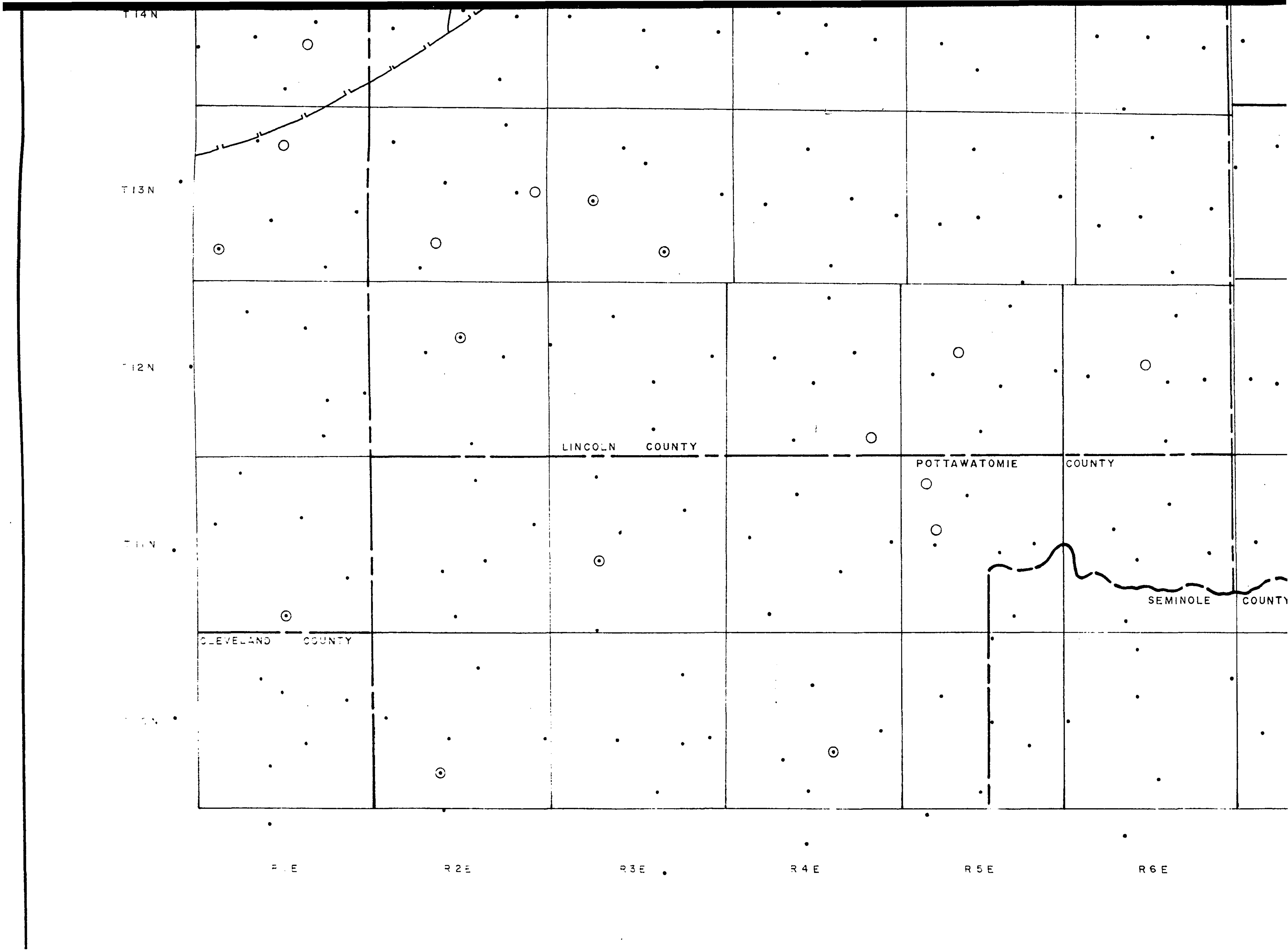


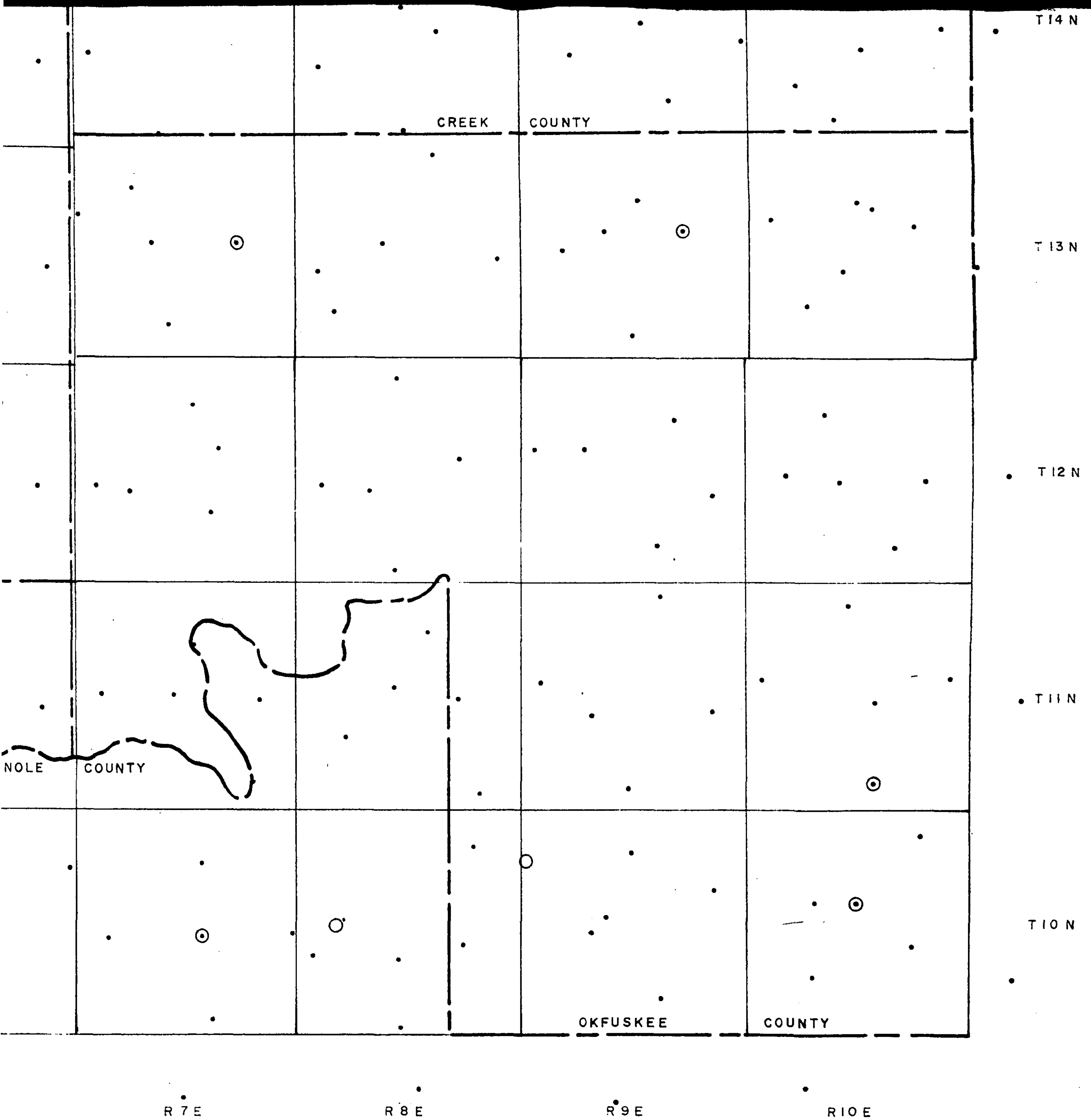
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
OSAGE COUNTY
PAWNEE COUNTY
120
100
80
60
40
20
10
0



T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
PAYNE COUNTY
LOGAN COUNTY
OKLAHOMA COUNTY
10
20
40


20
20
10
80
TULSA COUNTY
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N


T14N
T13N
T12N
LINCOLN COUNTY
POTTAWATOMIE COUNTY
SEMINOLE COUNTY
CLEVELAND COUNTY
R2E
R3E
R4E
R5E
R6E


T14N
CREEK COUNTY
T13N
T12N
T11N
NOLE COUNTY
T10N
OKFUSKEE COUNTY
R7E
R8E
R9E
R10E

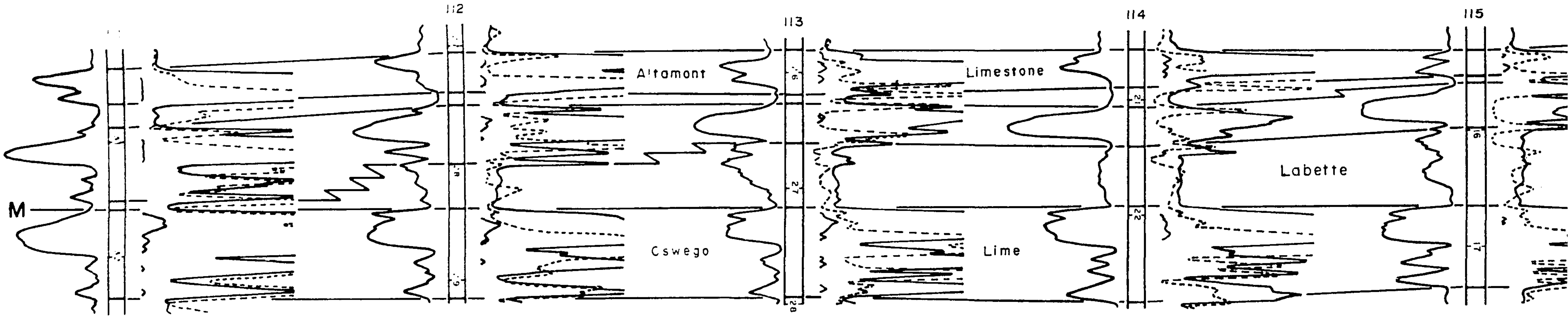


PLATE XIV

LABETTE SHALE INCREMENT OF STRATA ISOPACH AND SANDSTONE ISOLITH MAP

AND

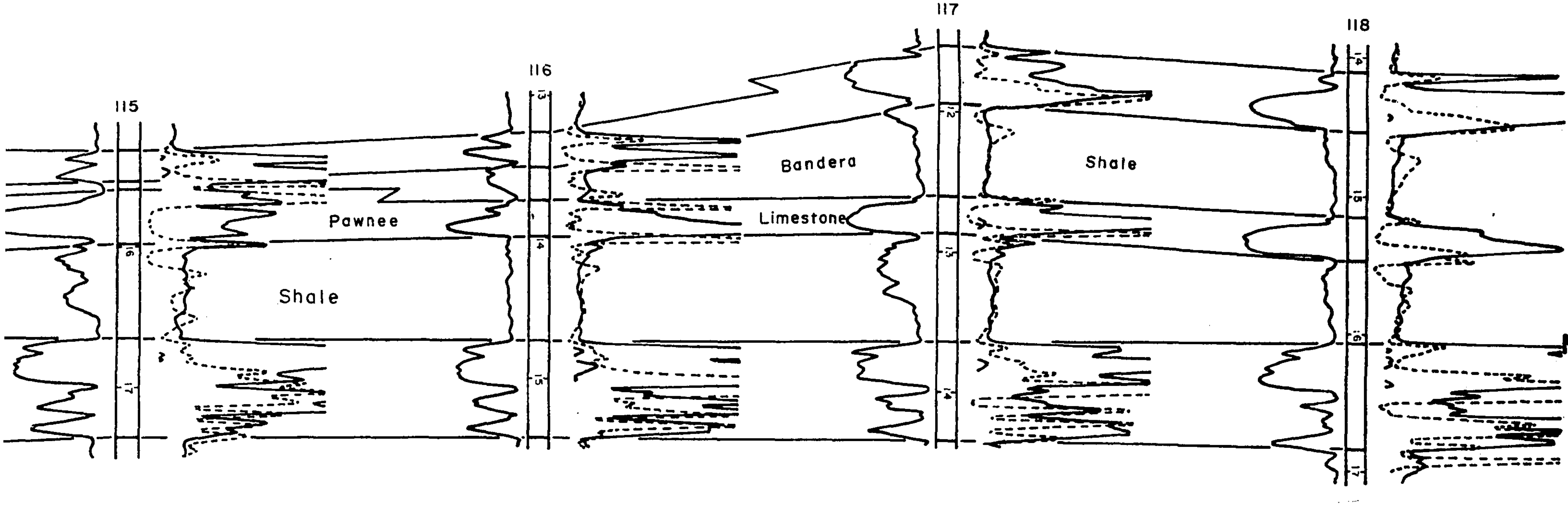
STRATIGRAPHIC PROFILE MM'

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles

Scale

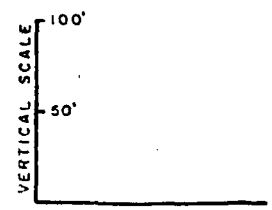


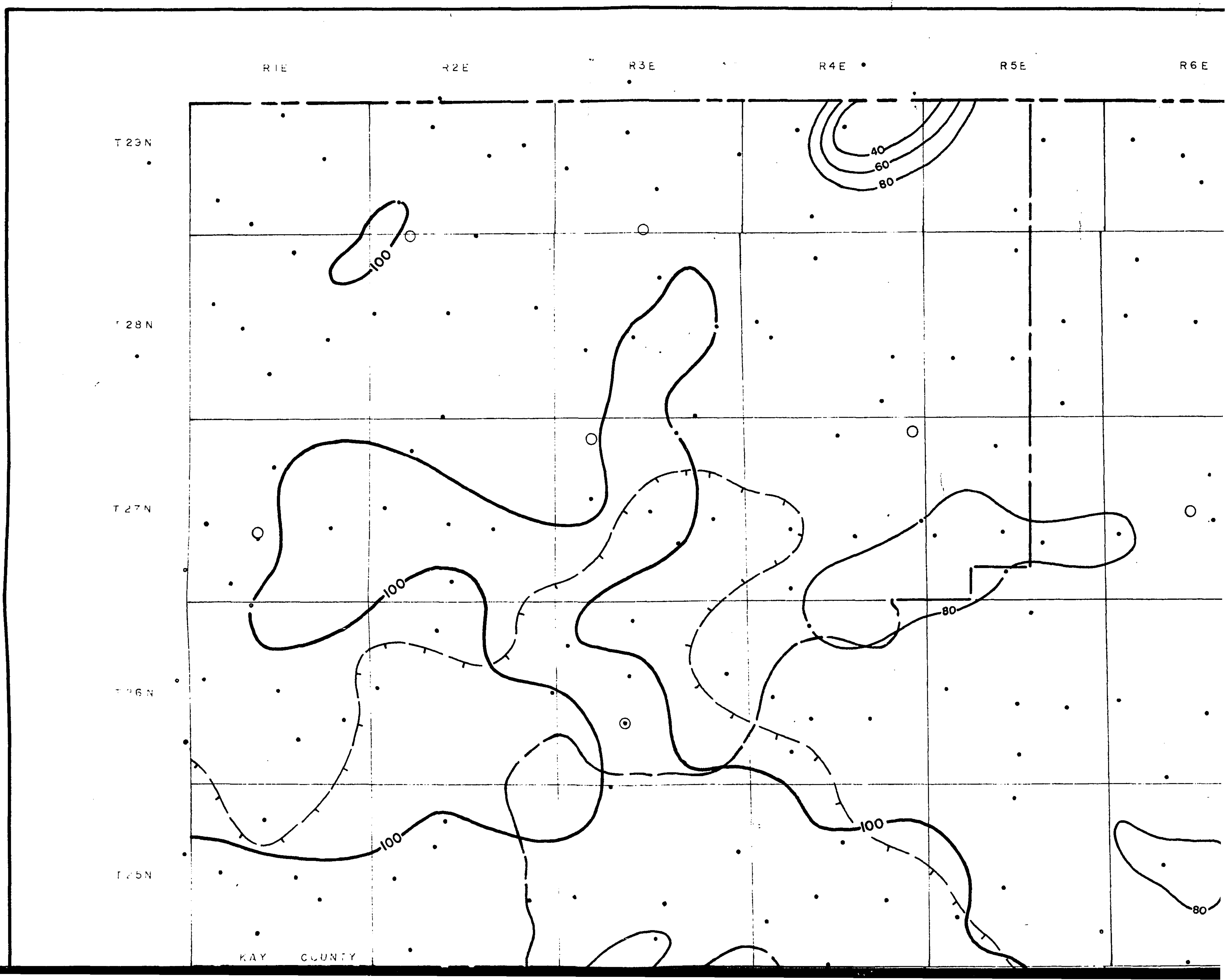
LEGEND:

- • Control Well
- ⊙ Sample Con
- C. I. Isopach 10' & 20'
- C. I. Isolith 20'
- —— 80 —— Isopach Line
- - - - *20* - - - Isolith Line
- Southern Limits Oologah Limestone
- Northern Limits Limestone in Lower Oologah

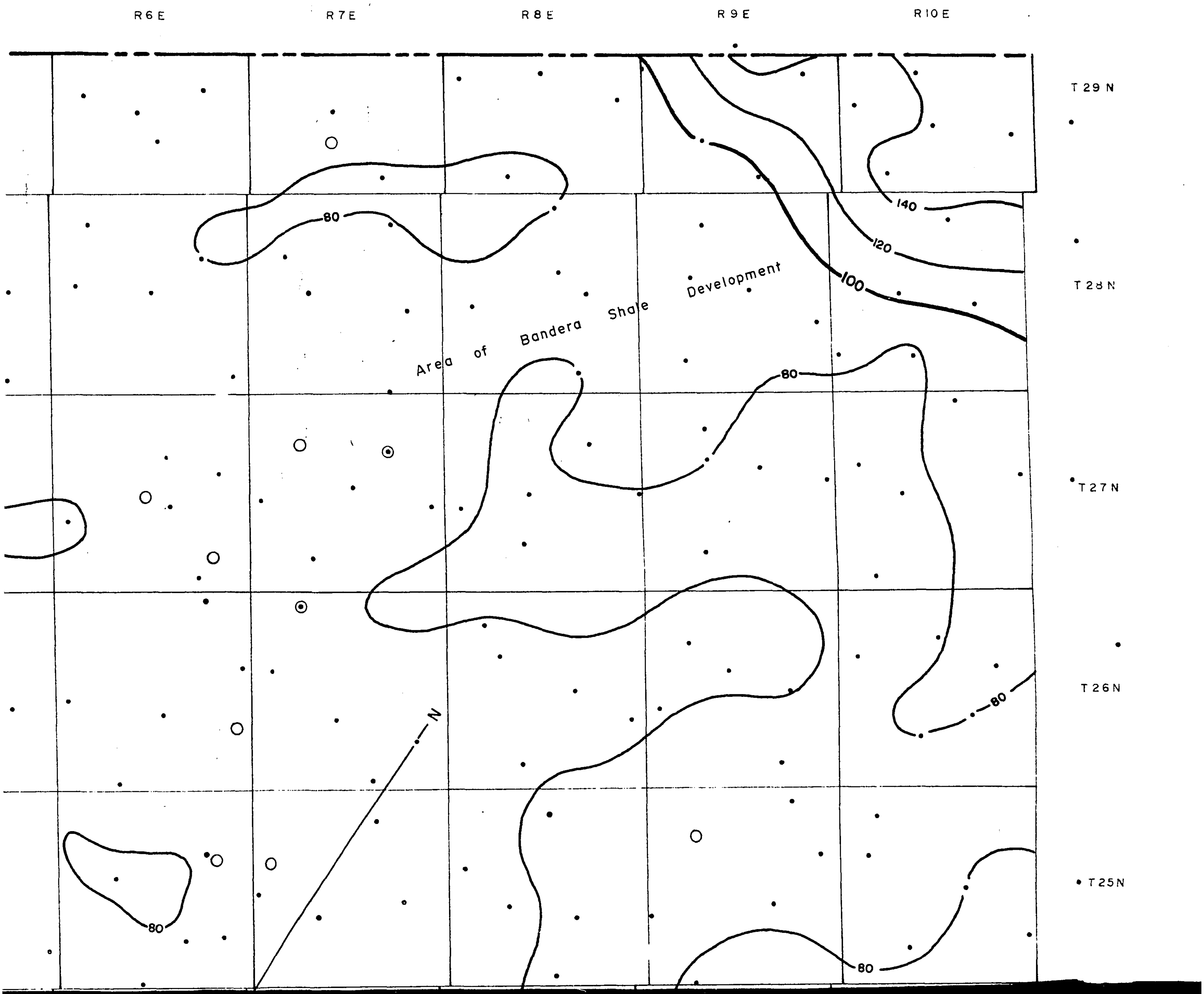
Sandstone Thickness

- 0–20'
- 20–40'
- 40' +

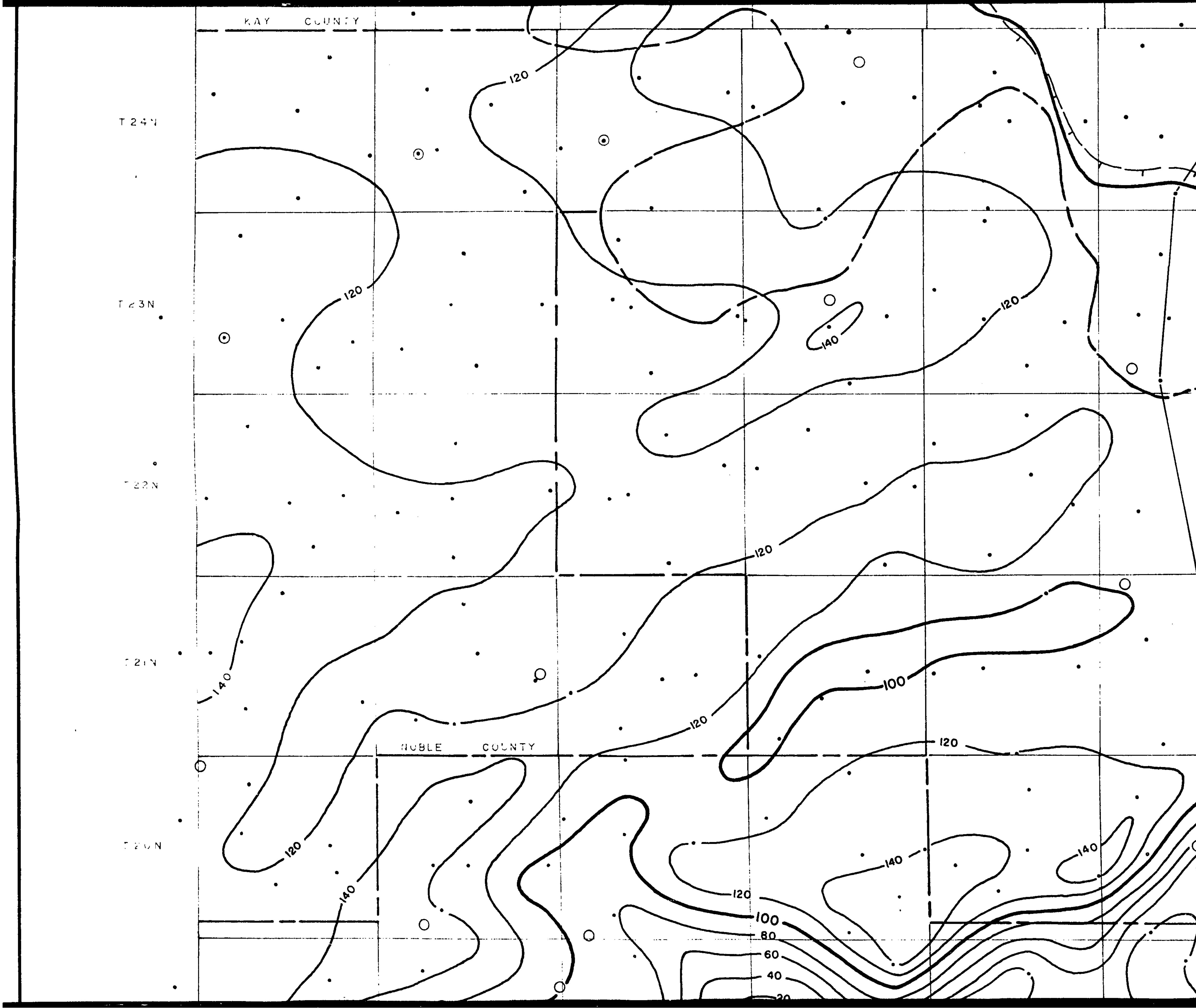




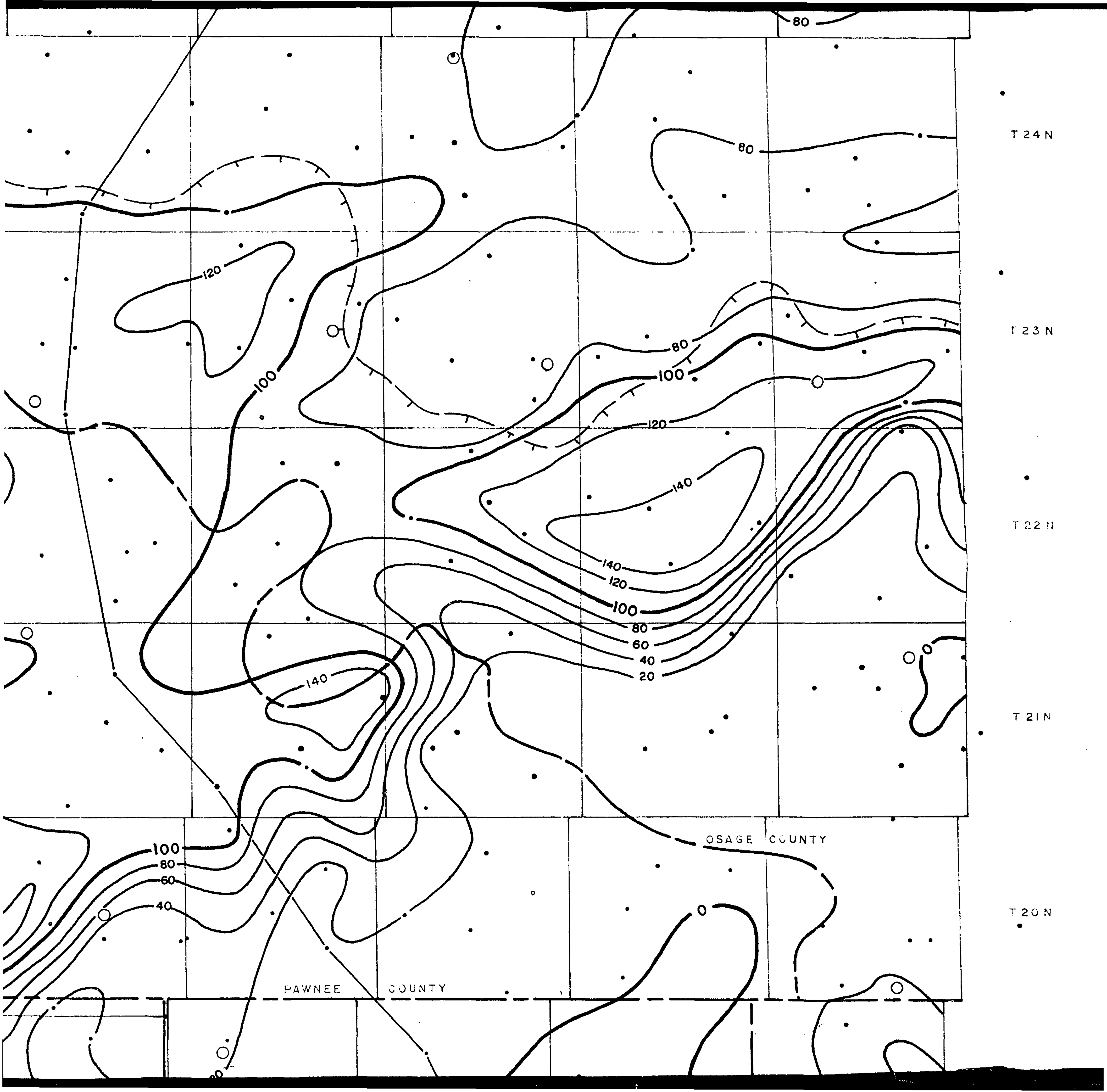
R1E
R2E
R3E
R4E
R5E
R6E
T28N
T27N
T25N
40
60
80
100
KAY COUNTY



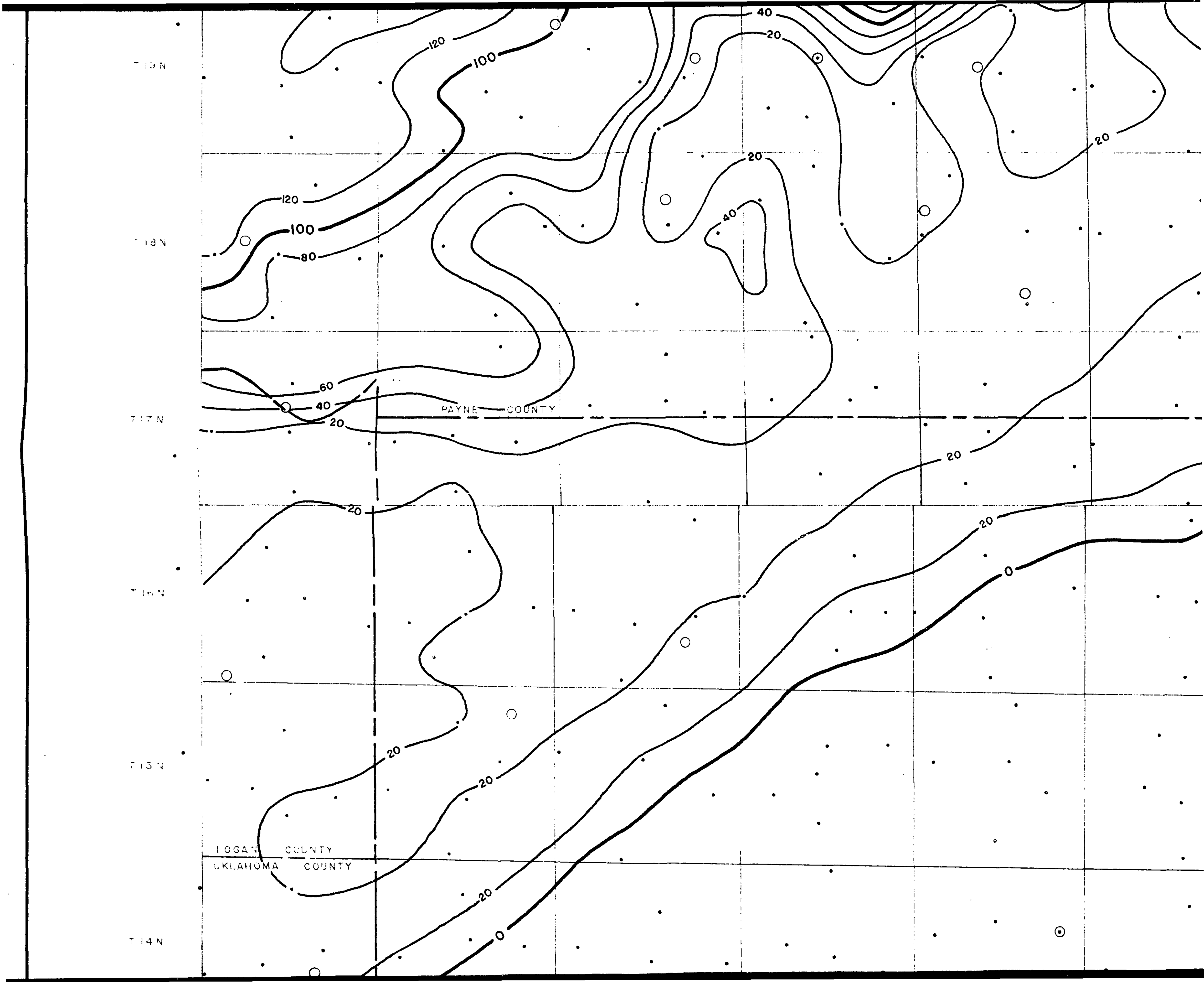
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
Area of Bandera Shale Development
80
100
120
140
N



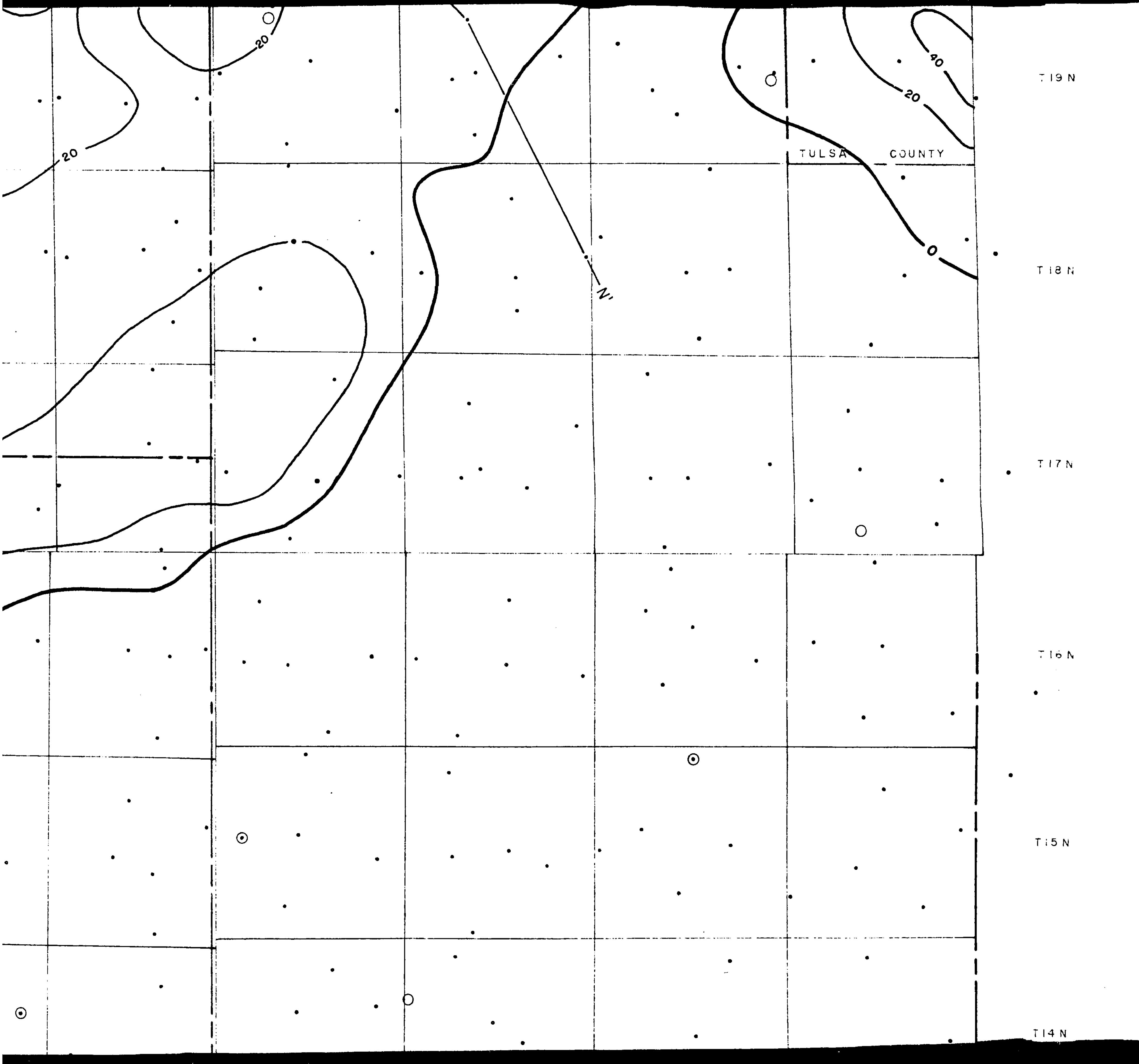
KAY COUNTY
NOBLE COUNTY
T24N
T23N
T22N
T21N
T20N
120
140
100
80
60
40
20



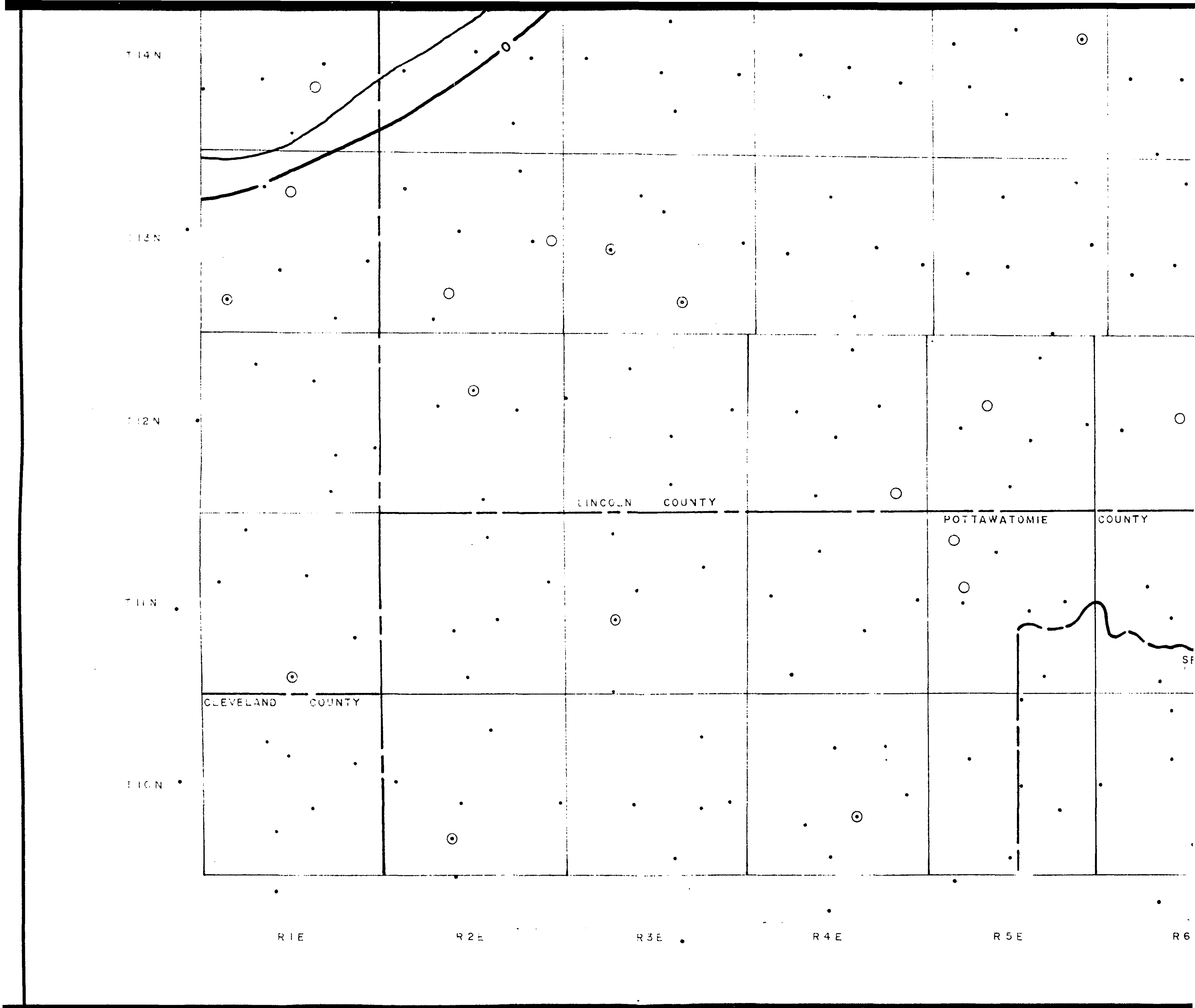
80
T 24 N
80
120
100
T 23 N
80
100
120
140
T 22 N
140
120
100
80
60
40
20
140
T 21 N
0
100
80
60
40
OSAGE COUNTY
0
T 20 N
PAWNEE COUNTY



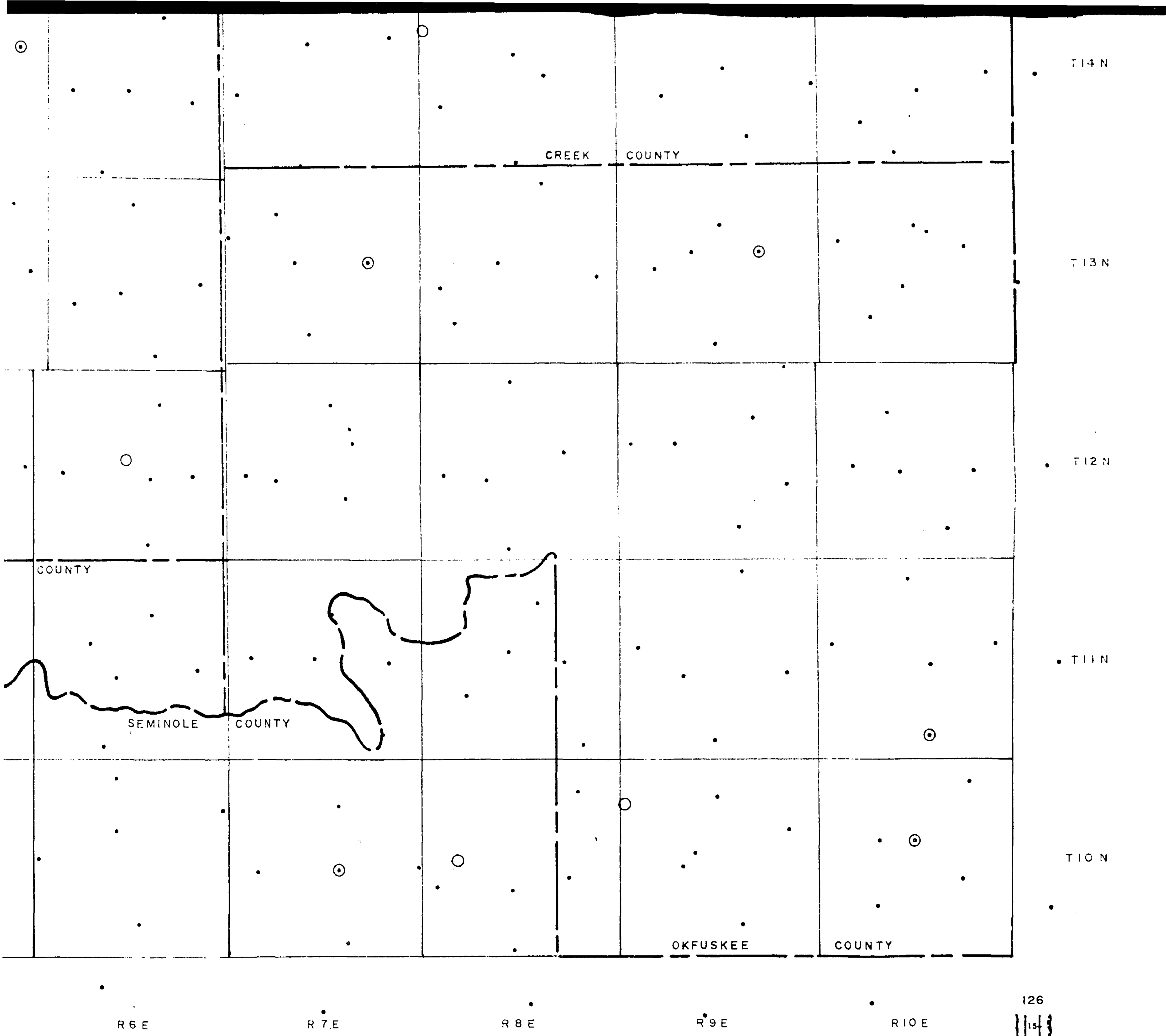
120
100
80
60
40
20
0
T18N
T17N
T14N
PAYNE COUNTY
LOGAN COUNTY
OKLAHOMA COUNTY



20
20
40
20
TULSA COUNTY
0
N'
T19N
T18N
T17N
T16N
T15N
T14N



T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
R 1 E
R 2 E
R 3 E
R 4 E
R 5 E



T14N
T13N
T12N
T11N
T10N
CREEK COUNTY
COUNTY
SEMINOLE COUNTY
OKFUSKEE COUNTY
R6E
R7E
R8E
R9E
R10E

126

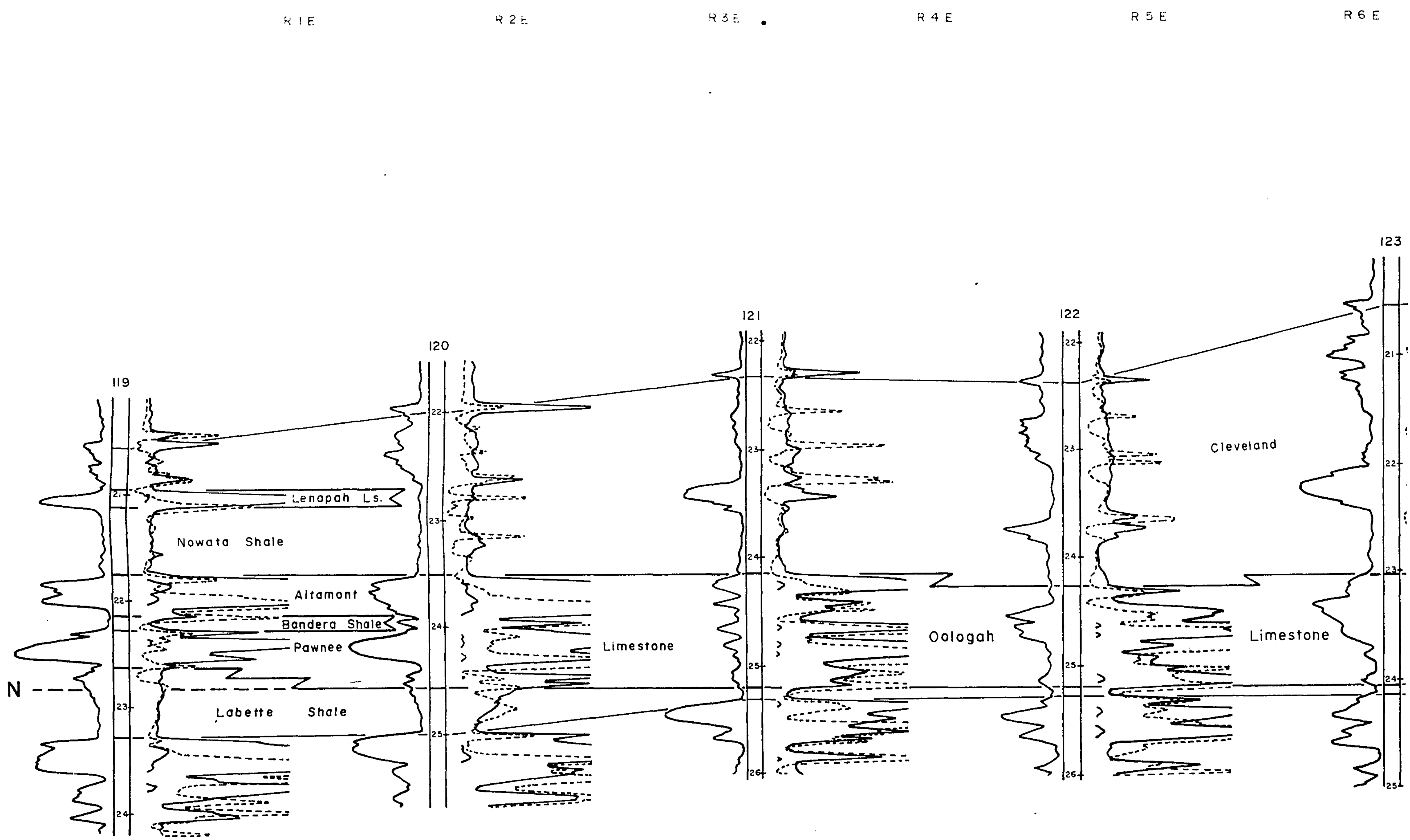
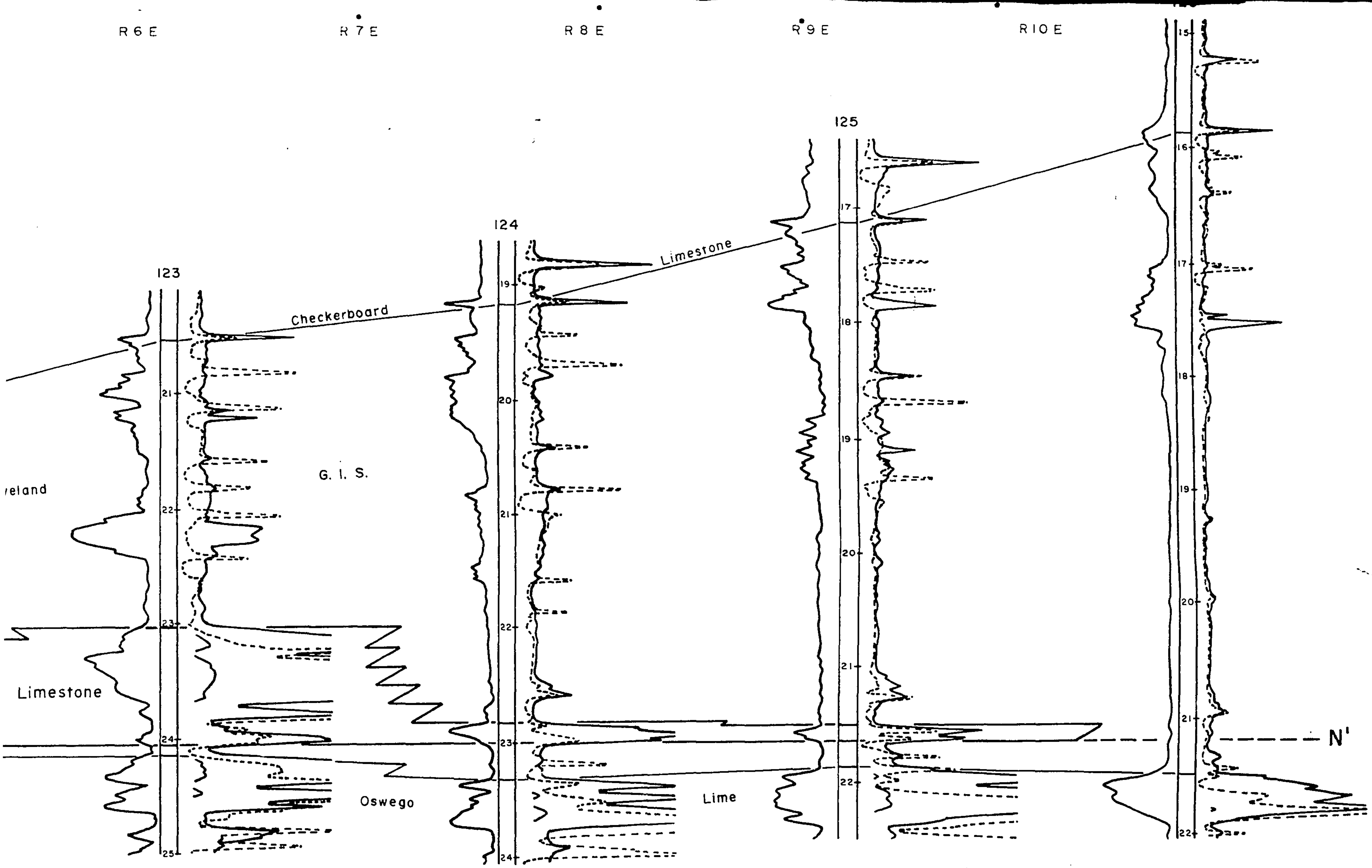


PLATE XV

OOLOGAH LIMESTONE INCREMENT OF STRATA

ISOPACH MAP

AND



LEGEND:

- Control Well
- Sample Control

C. I. Isopach 20'

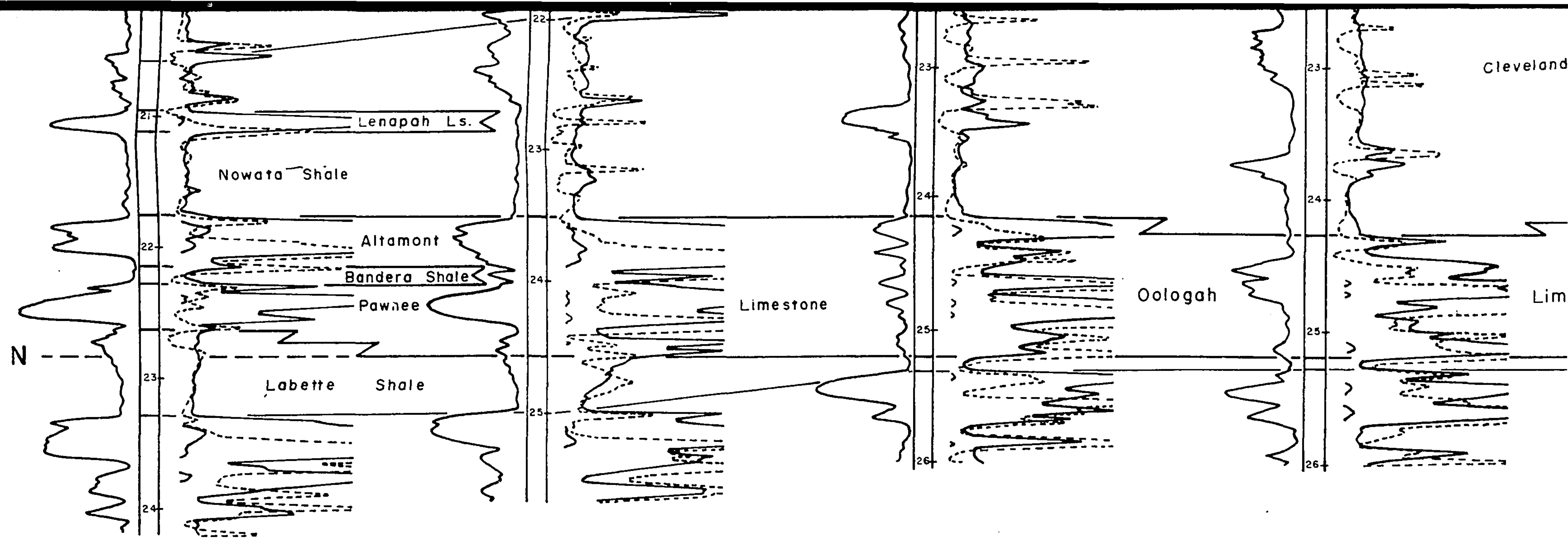
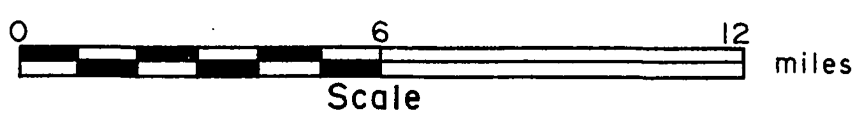


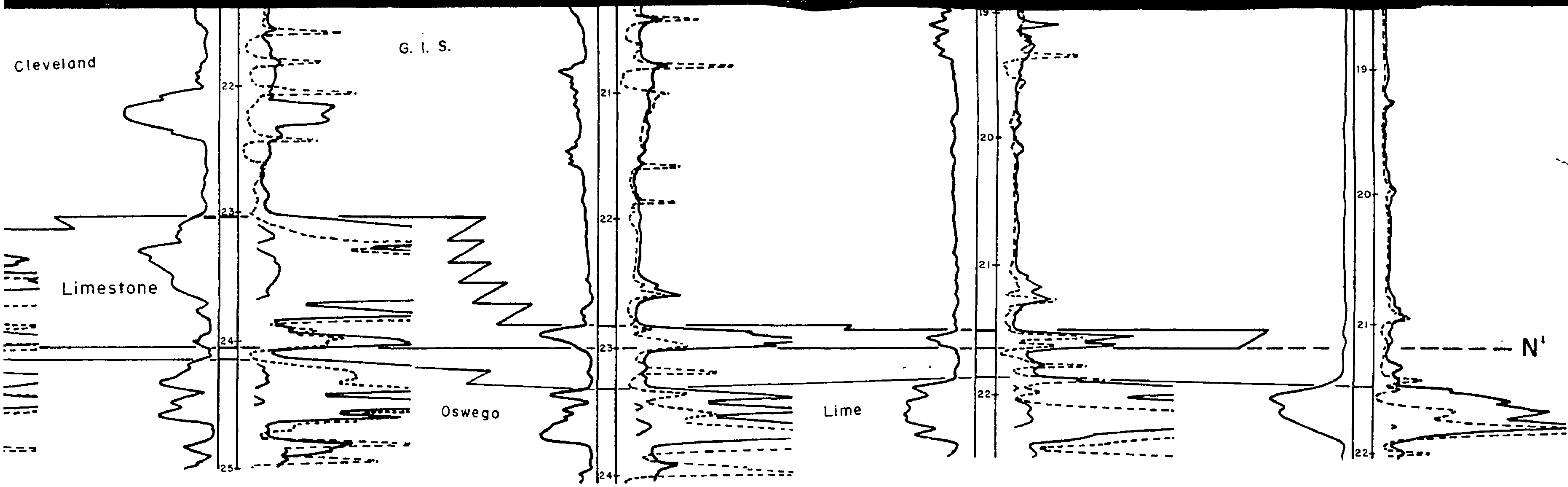
PLATE XV

OOLOGAH LIMESTONE INCREMENT OF STRATA ISOPACH MAP AND STRATIGRAPHIC PROFILE NN'

by

J. Glenn Cole Ph. D. 1968





LEGEND:

- ● Control Well
- ⊙ Sample Control

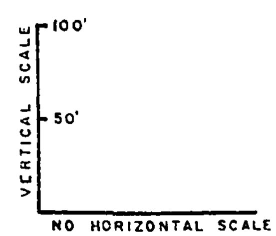
C. I. Isopach 20'

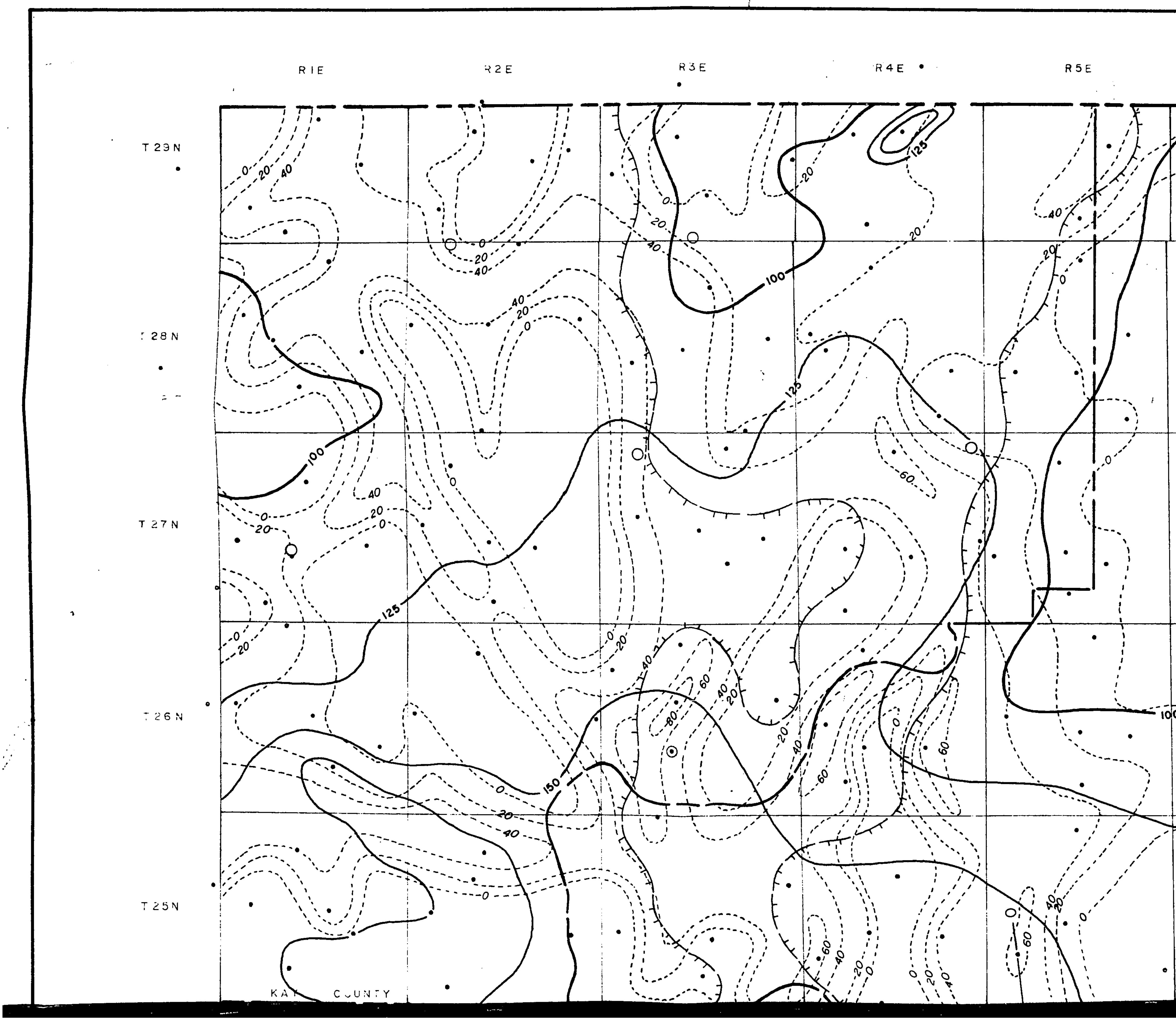
—140— Isopach Line

—┬— —┬— Northern Limit Limestones in Lower Oologah

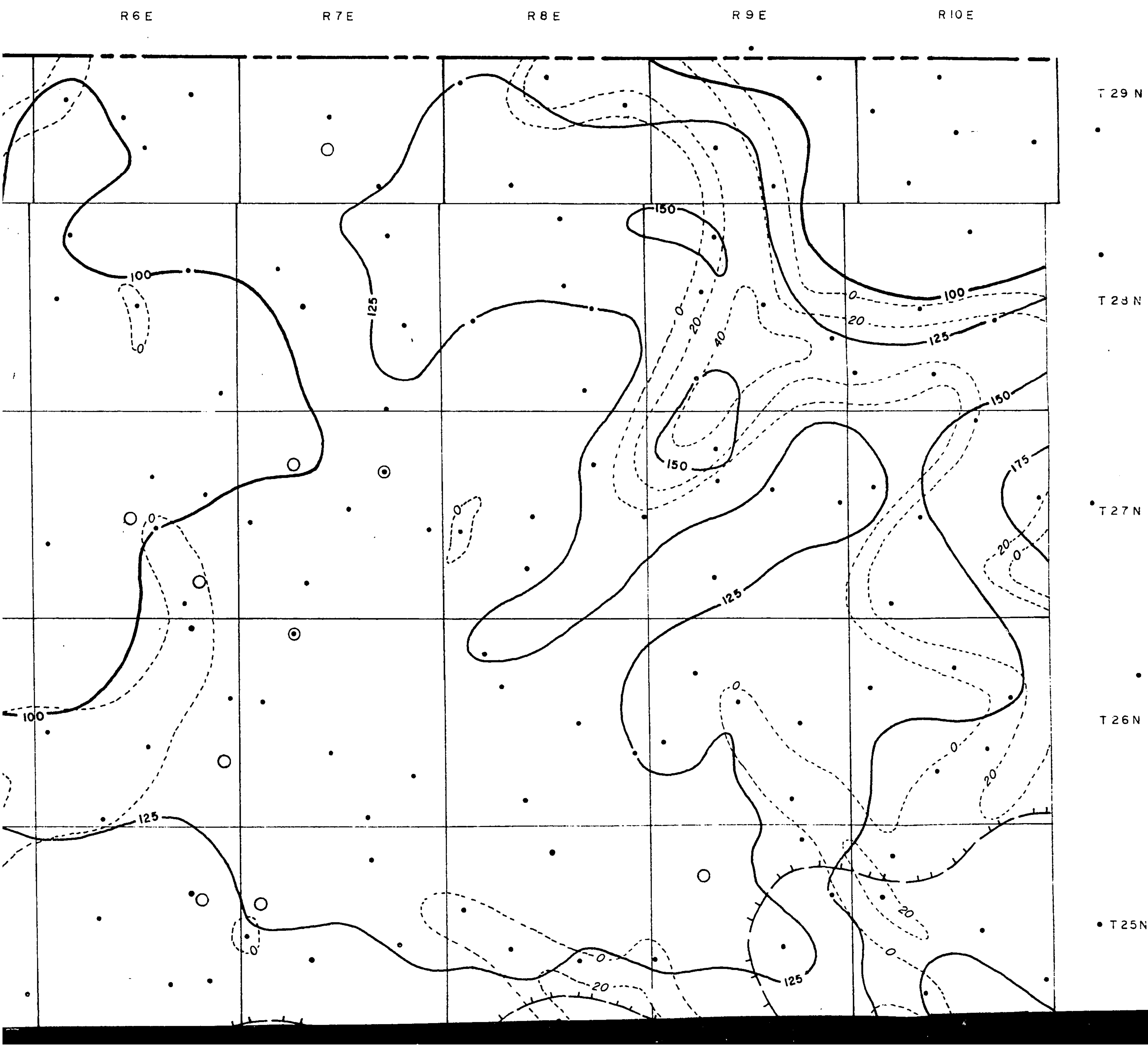
Limstone Thickness

▭	0-20'
▭	20-60'
▭	60-12
▭	100-140'
▭	140' +

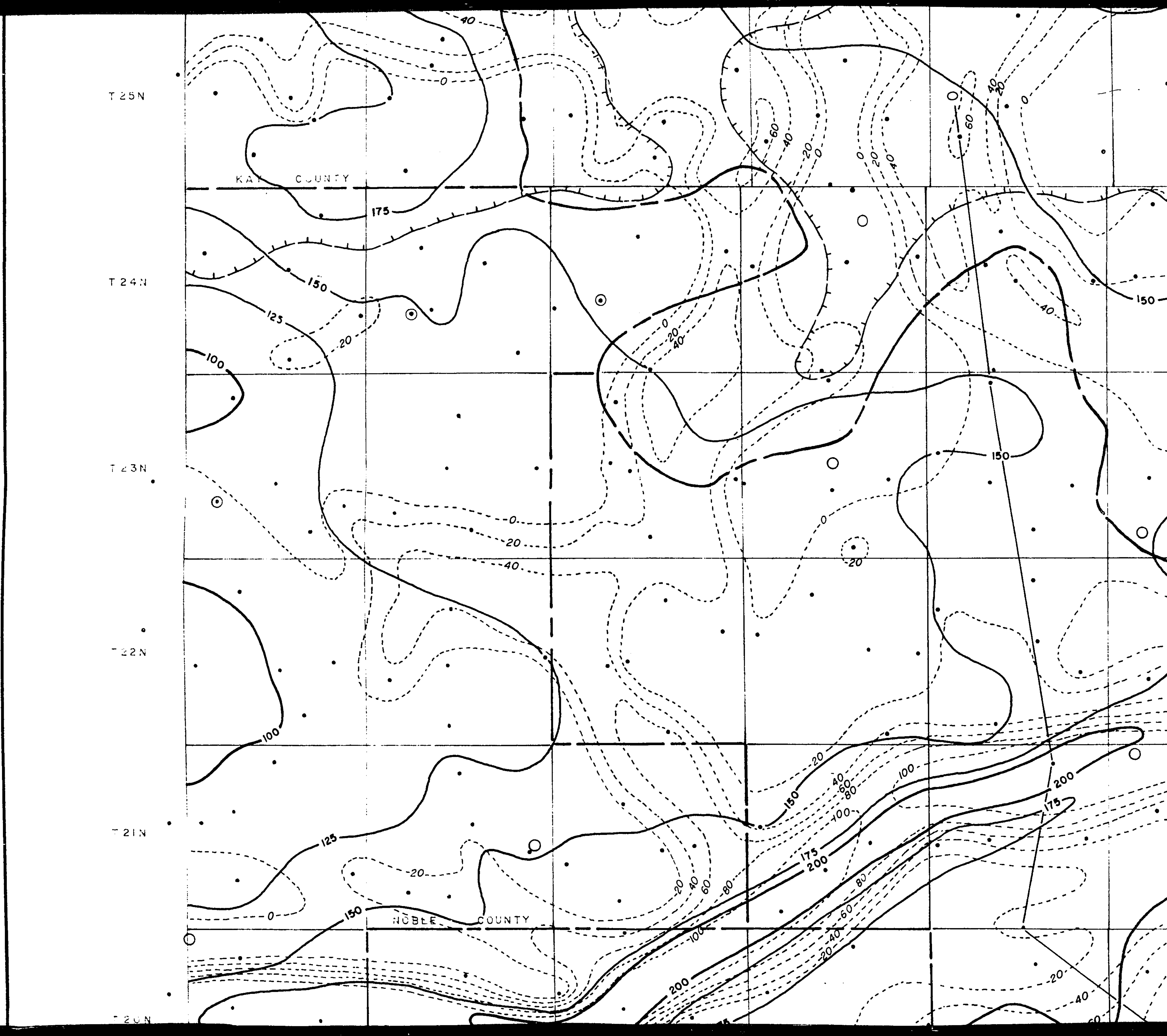




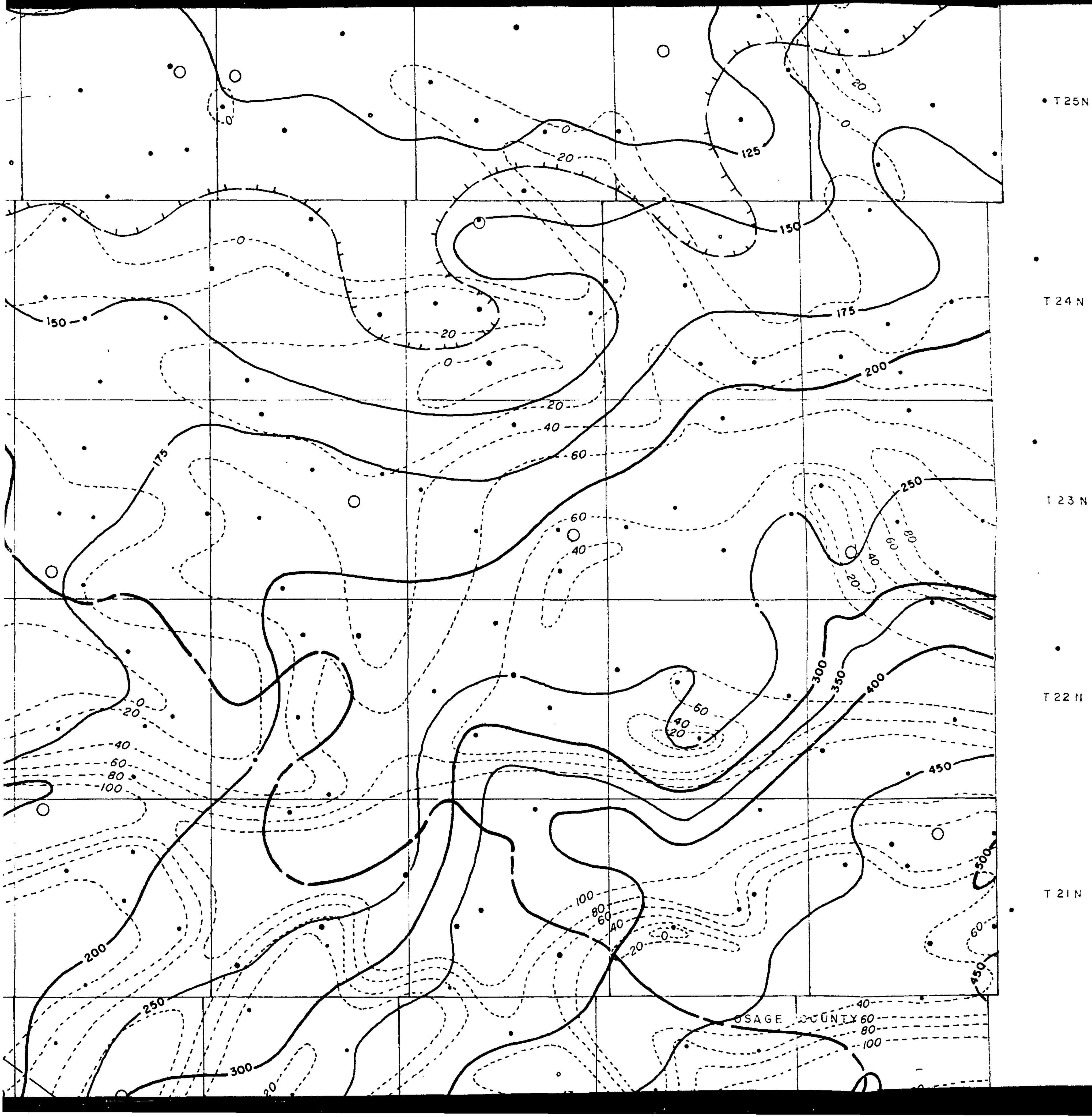
R1E
R2E
R3E
R4E
R5E
T29N
T28N
T27N
T26N
T25N
KAY COUNTY
100
125
150
0
20
40
60
80

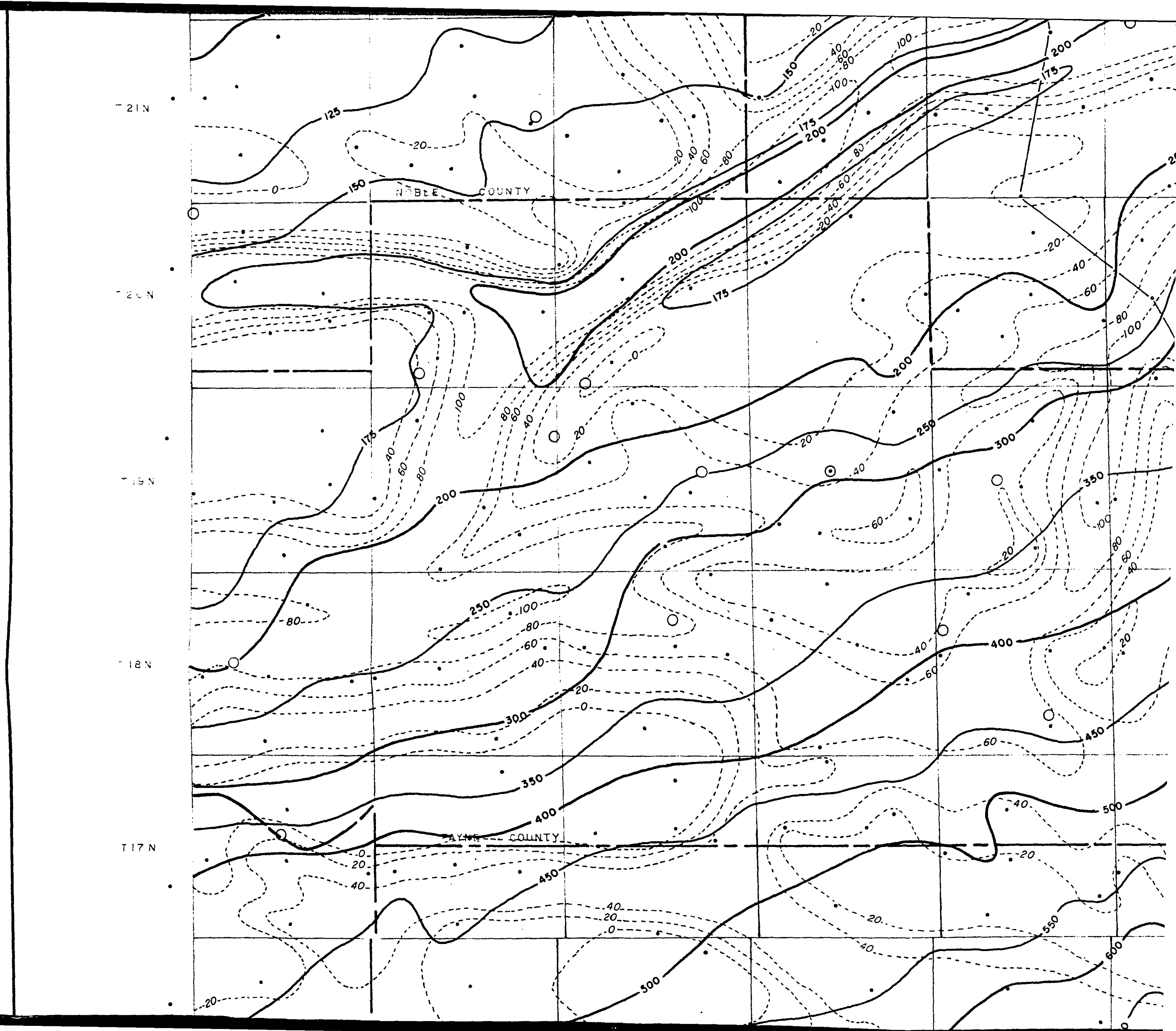


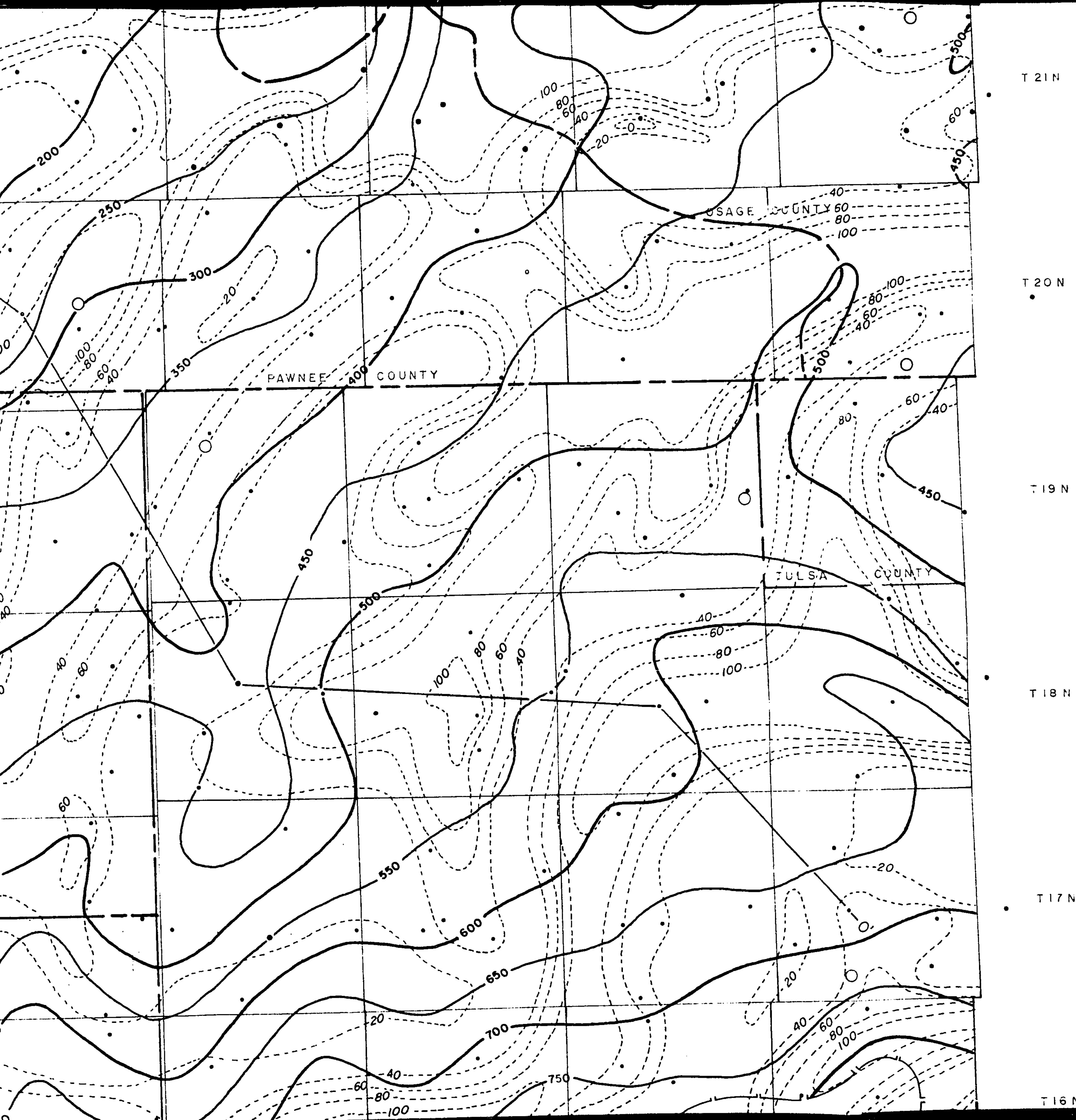
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
100
125
150
175
0
20
40



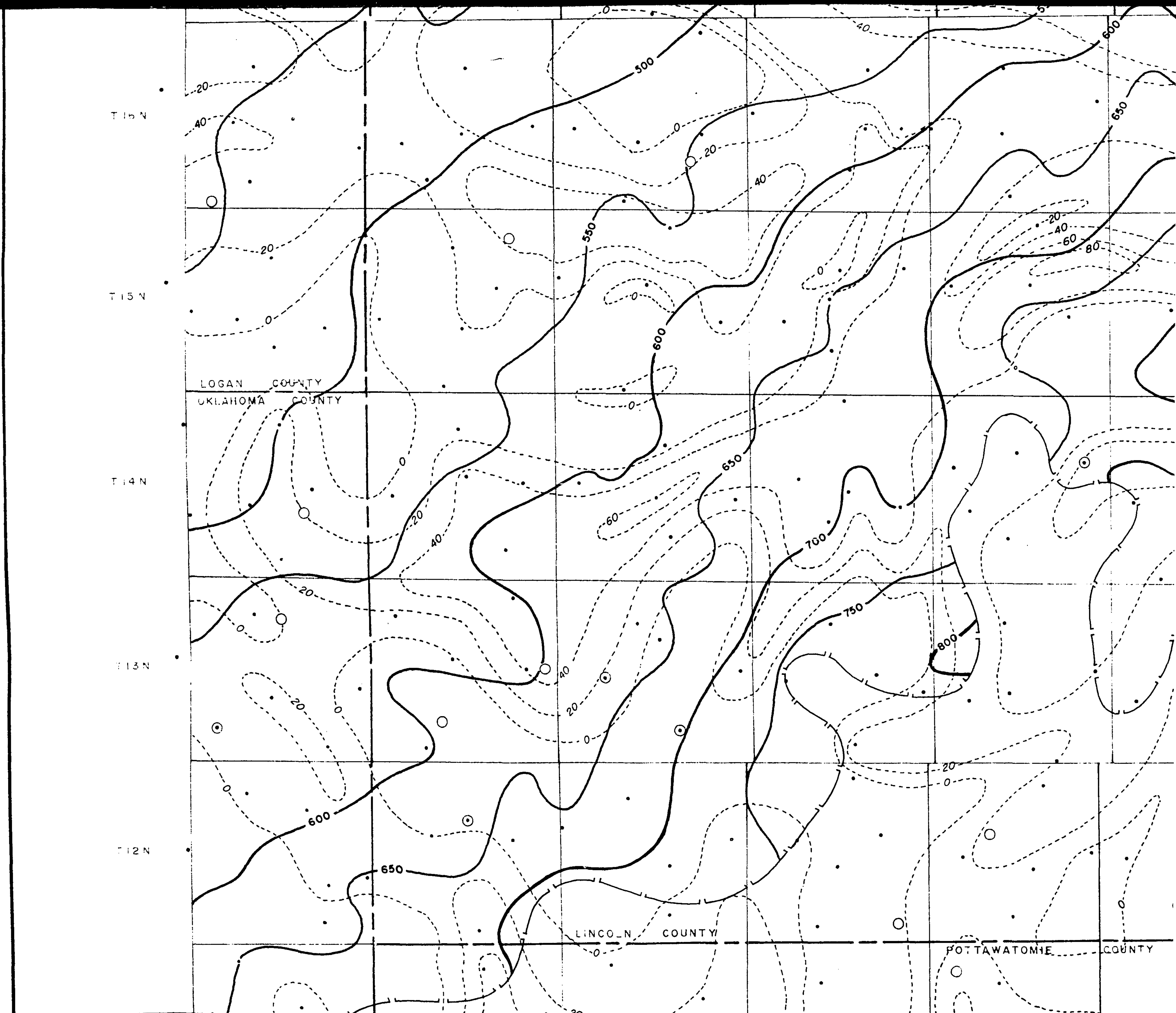
T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
KAY COUNTY
NOBLE COUNTY
175
150
125
100
200


T25N
T24N
T23N
T22N
T21N
OSAGE COUNTY

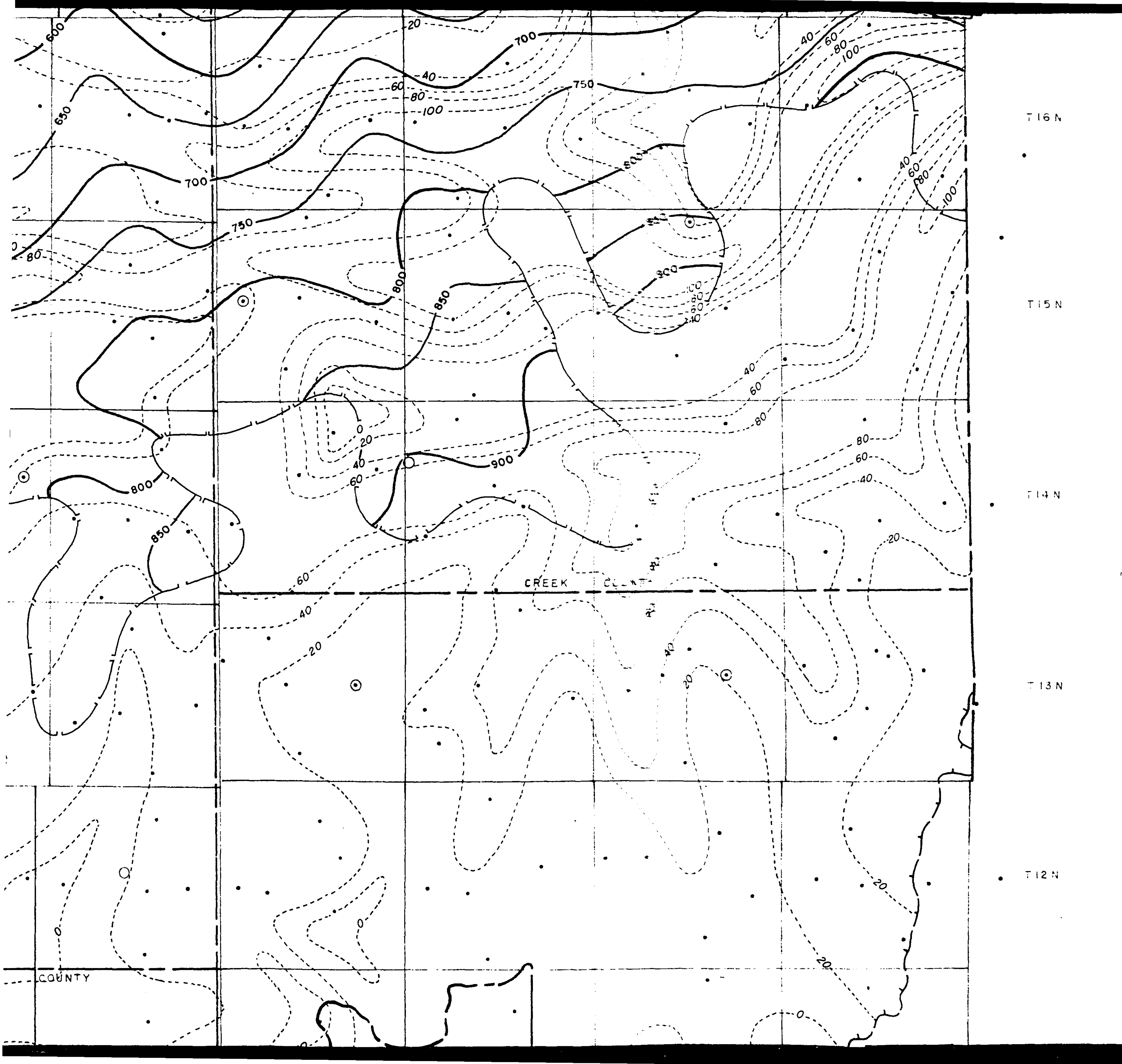

T21N
T20N
T19N
T18N
T17N
NOBLE COUNTY
PAYNE COUNTY



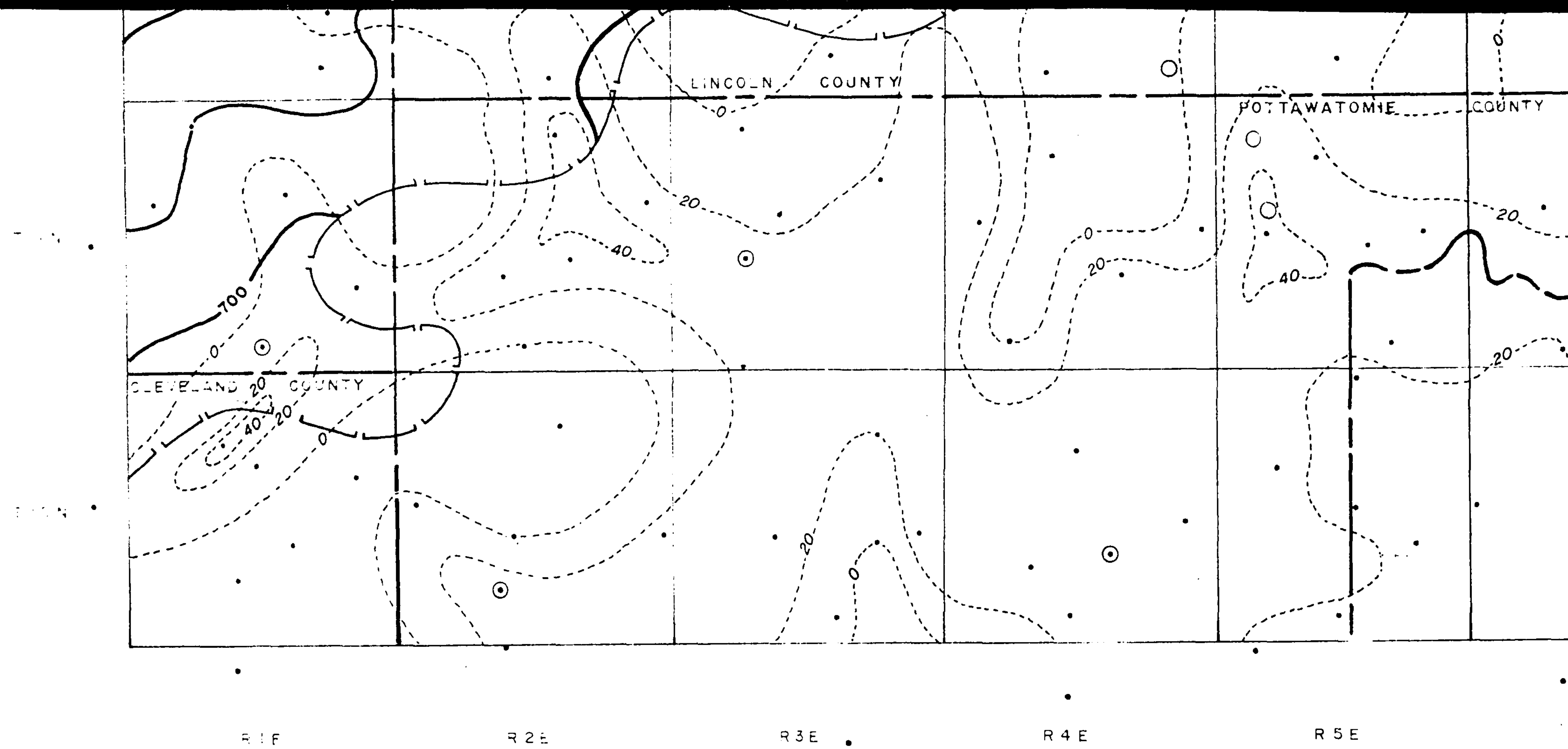
T21N
T20N
T19N
T18N
T17N
T16N
OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
200
250
300
350
400
450
500
550
600
650
700
750

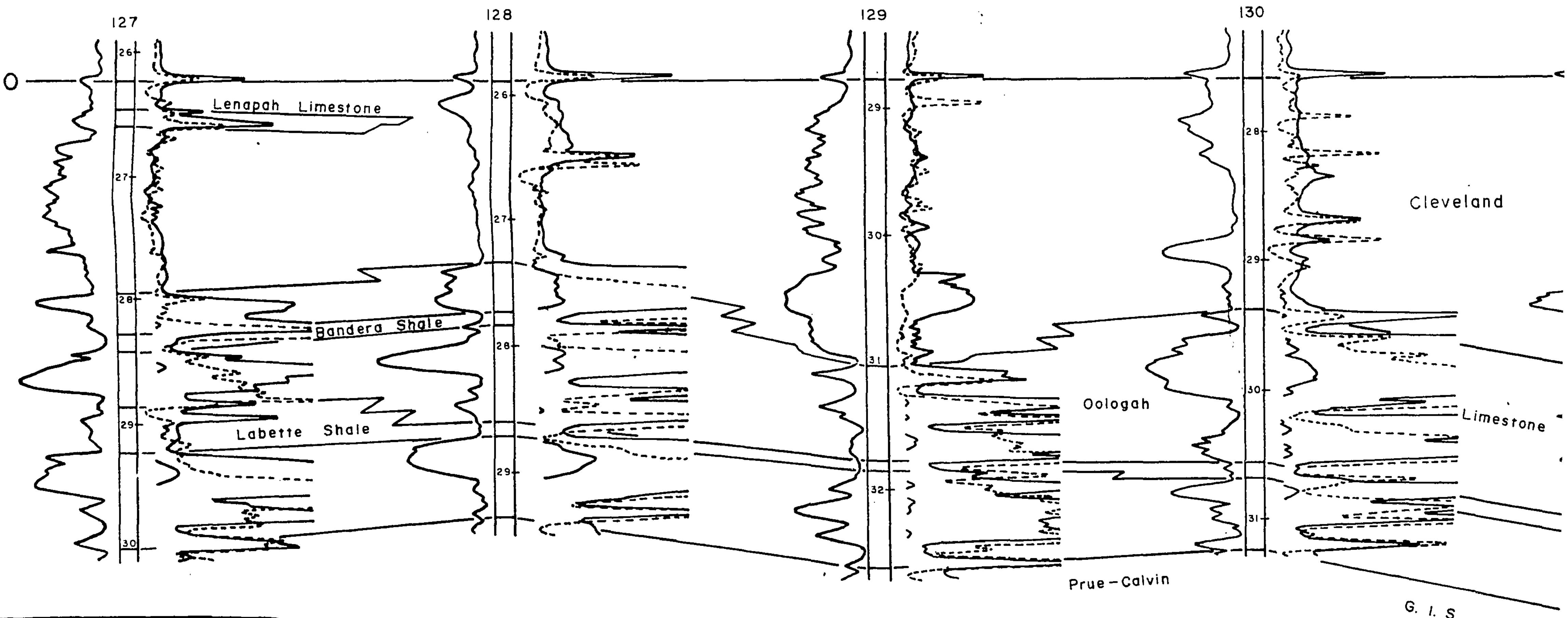


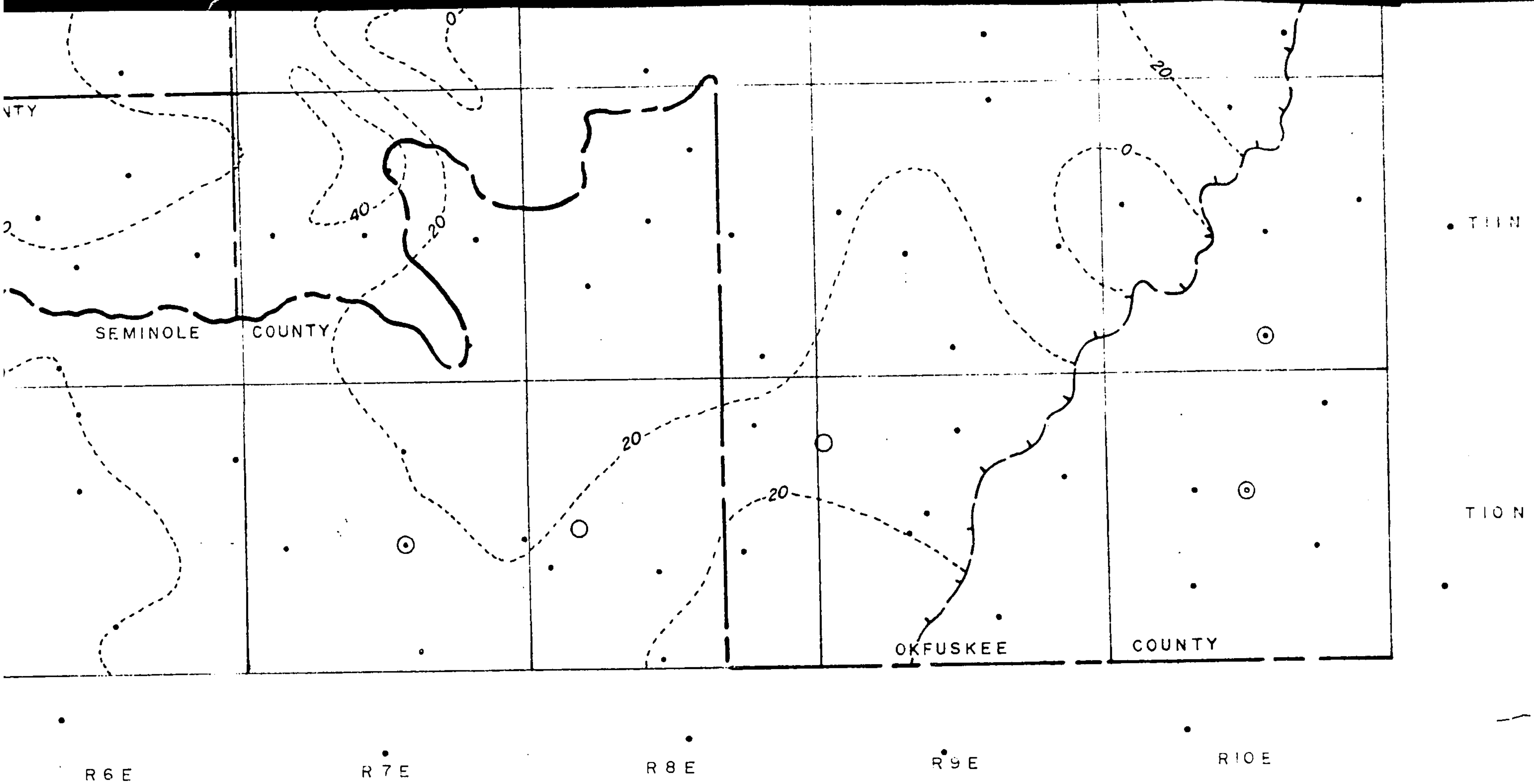
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
500
550
600
650
700
750
800
0
20
40
60
80



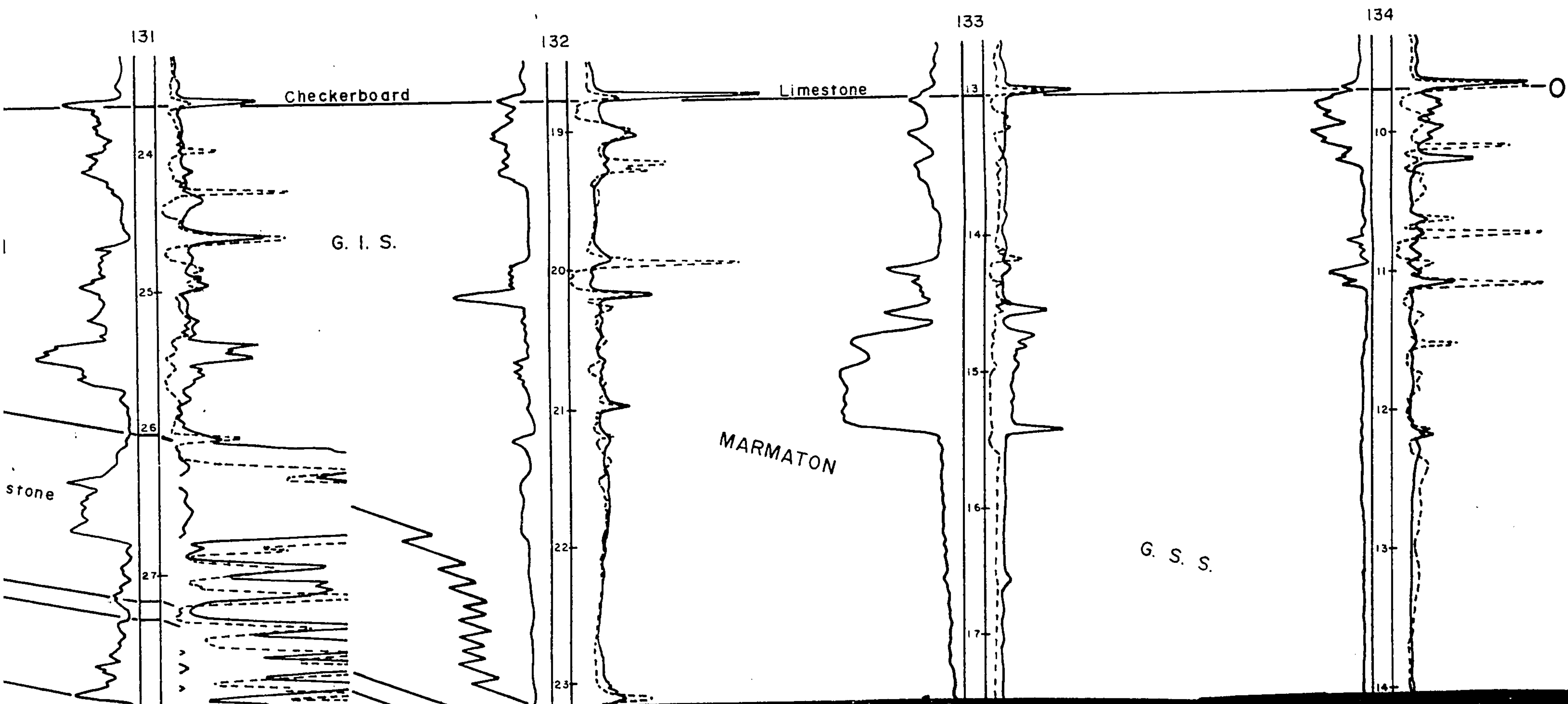
T16N
T15N
T14N
T13N
T12N
CREEK COUNTY
COUNTY
600
650
700
750
800
850
900
20
40
60
80
100
0


LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
700
20
40
R 2 E
R 3 E
R 4 E
R 5 E


127
128
129
130
0
Lenapah Limestone
Bandera Shale
Labette Shale
Oologah
Cleveland
Limestone
Prue-Calvin
G. I. S.



SEMINOLE COUNTY
OKFUSKEE COUNTY
T11N
T10N
R6E
R7E
R8E
R9E
R10E



131
132
133
134
Checkerboard
Limestone
0'
G. I. S.
MARMATON
G. S. S.
stone

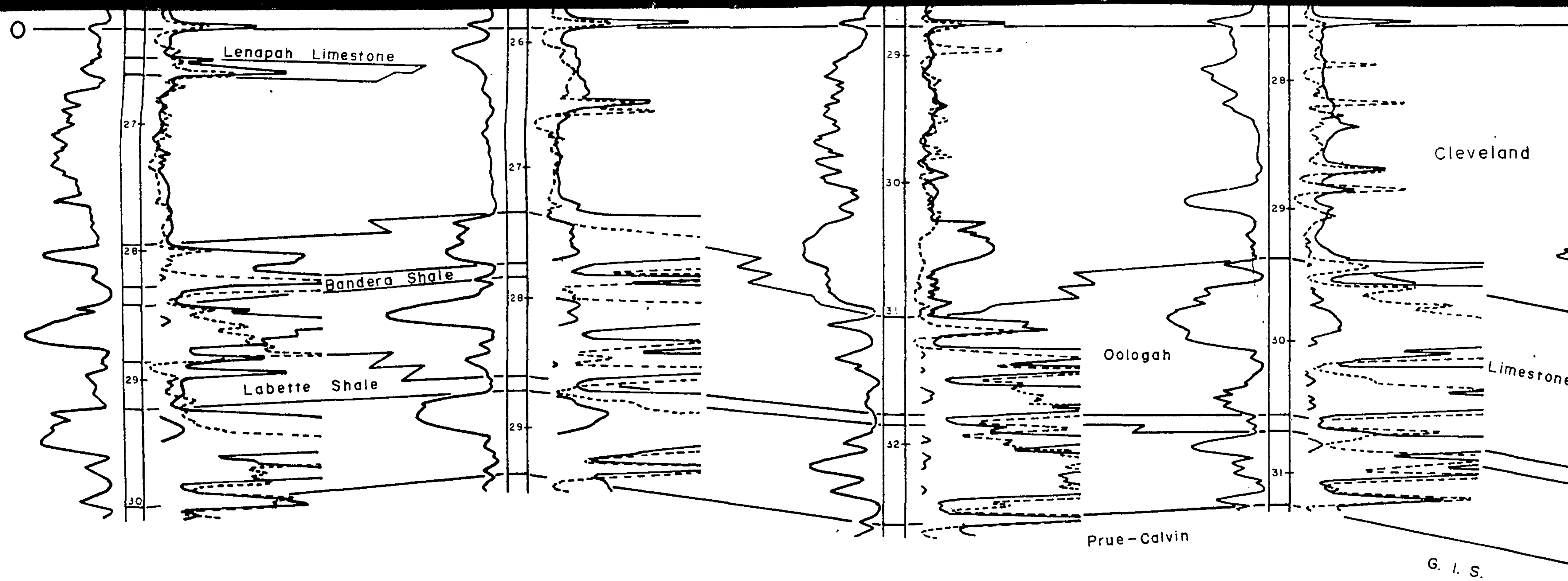


PLATE XVI

CLEVELAND GENETIC INCREMENT OF STRATA

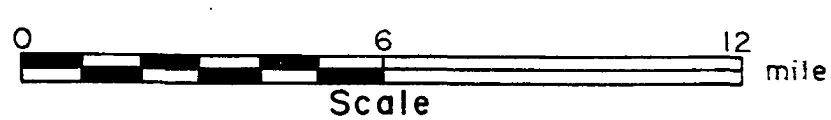
ISOPACH AND SANDSTONE ISOLITH MAP

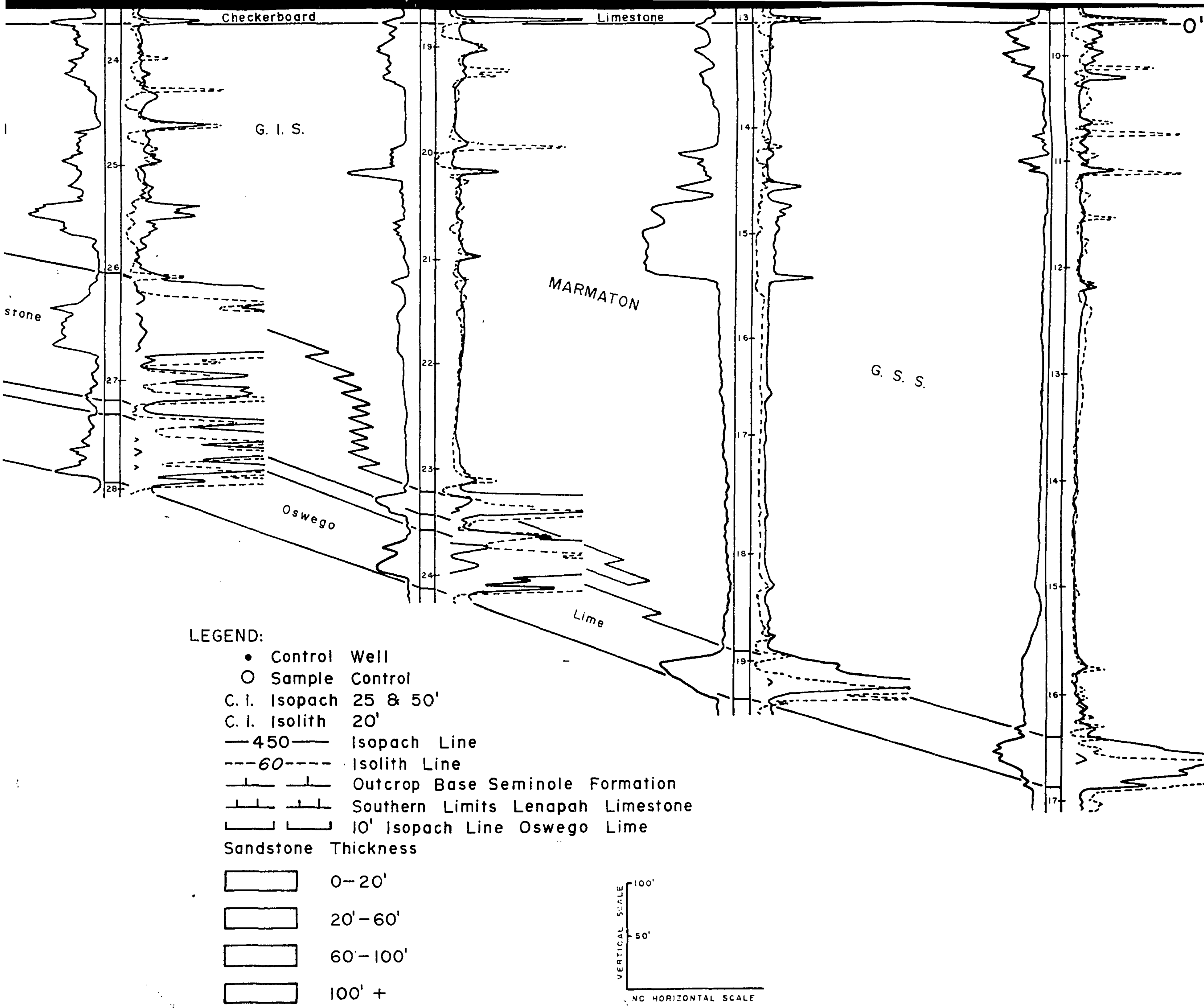
AND

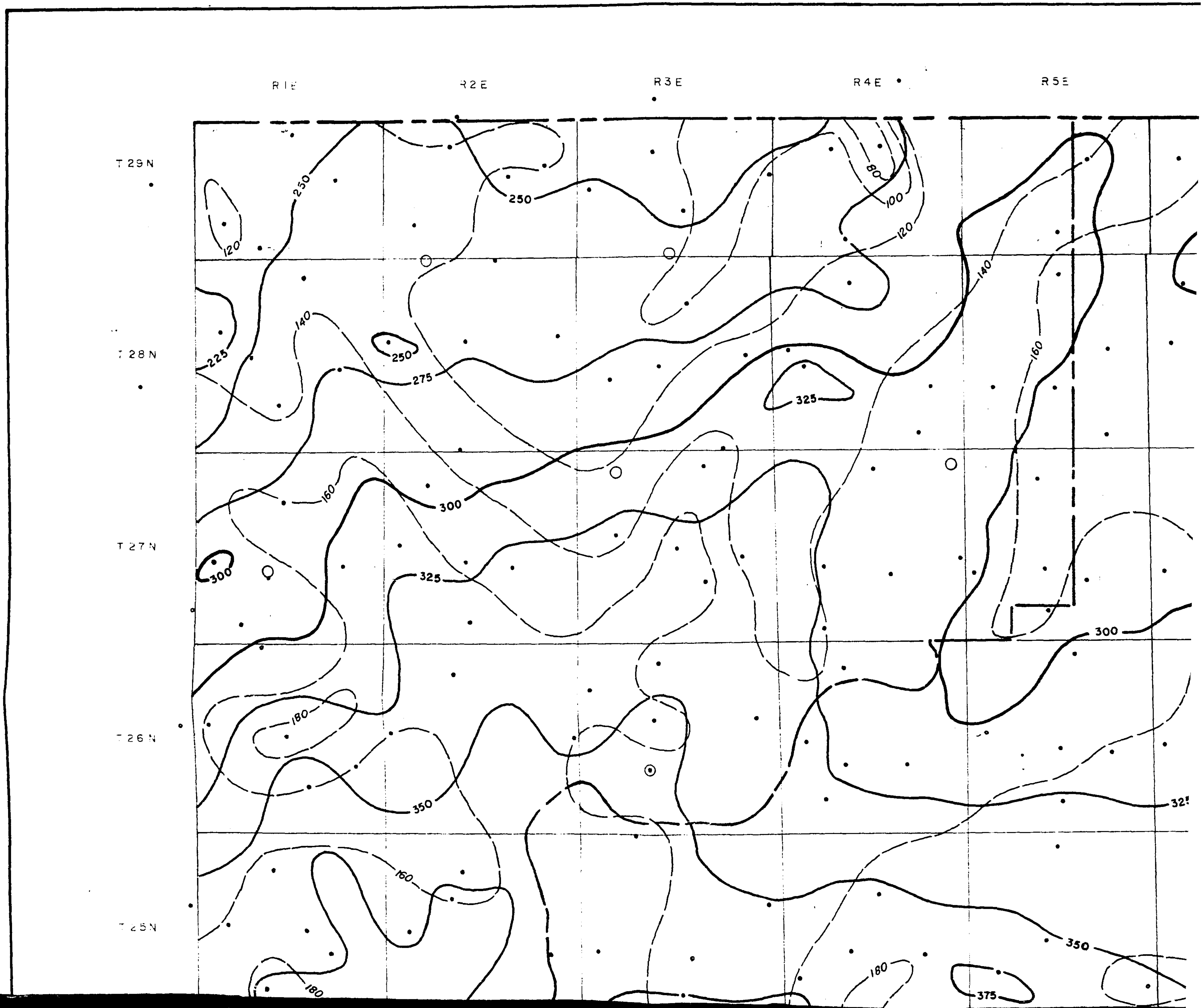
STRATIGRAPHIC PROFILE OO'

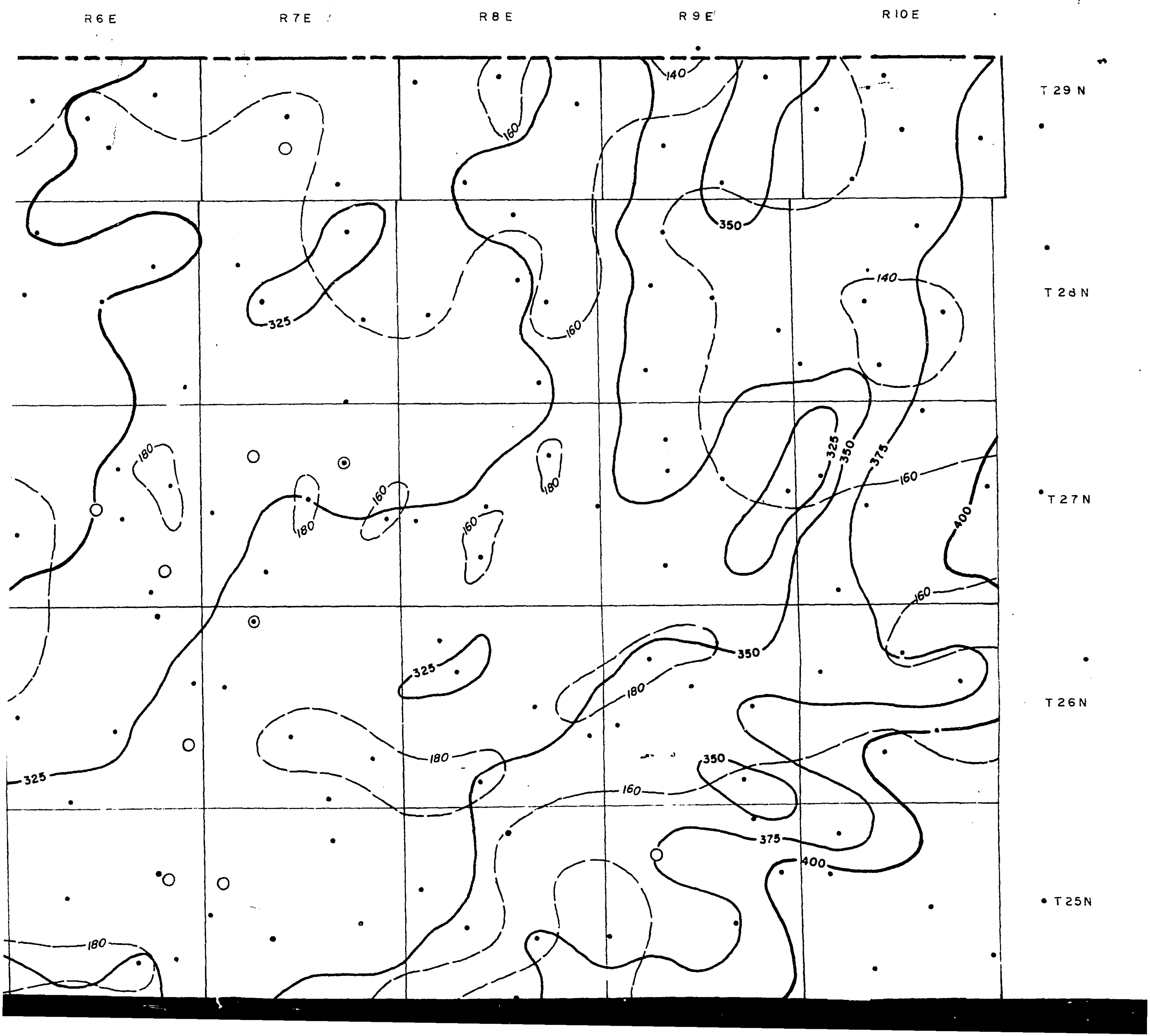
by

J. Glenn Cole Ph. D. 1968

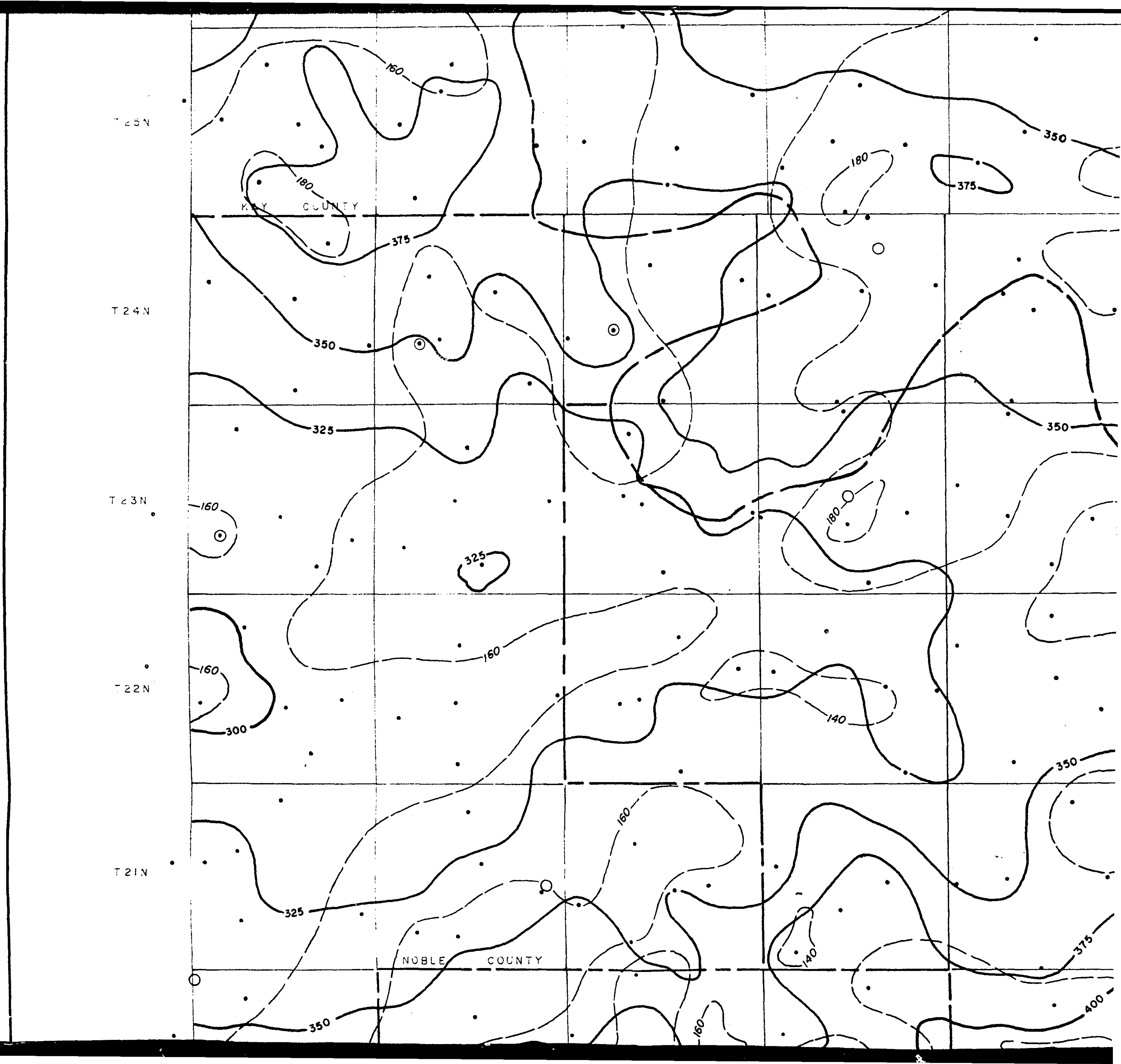



Checkerboard
Limestone
0'
G. I. S.
MARMATON
G. S. S.
stone
Oswego
Lime
LEGEND:
Control Well
Sample Control
C. I. Isopach 25 & 50'
C. I. Isolith 20'
450 Isopach Line
60 Isolith Line
Outcrop Base Seminole Formation
Southern Limits Lenapah Limestone
10' Isopach Line Oswego Lime
Sandstone Thickness
0–20'
20'–60'
60'–100'
100' +
VERTICAL SCALE
100'
50'
NO HORIZONTAL SCALE

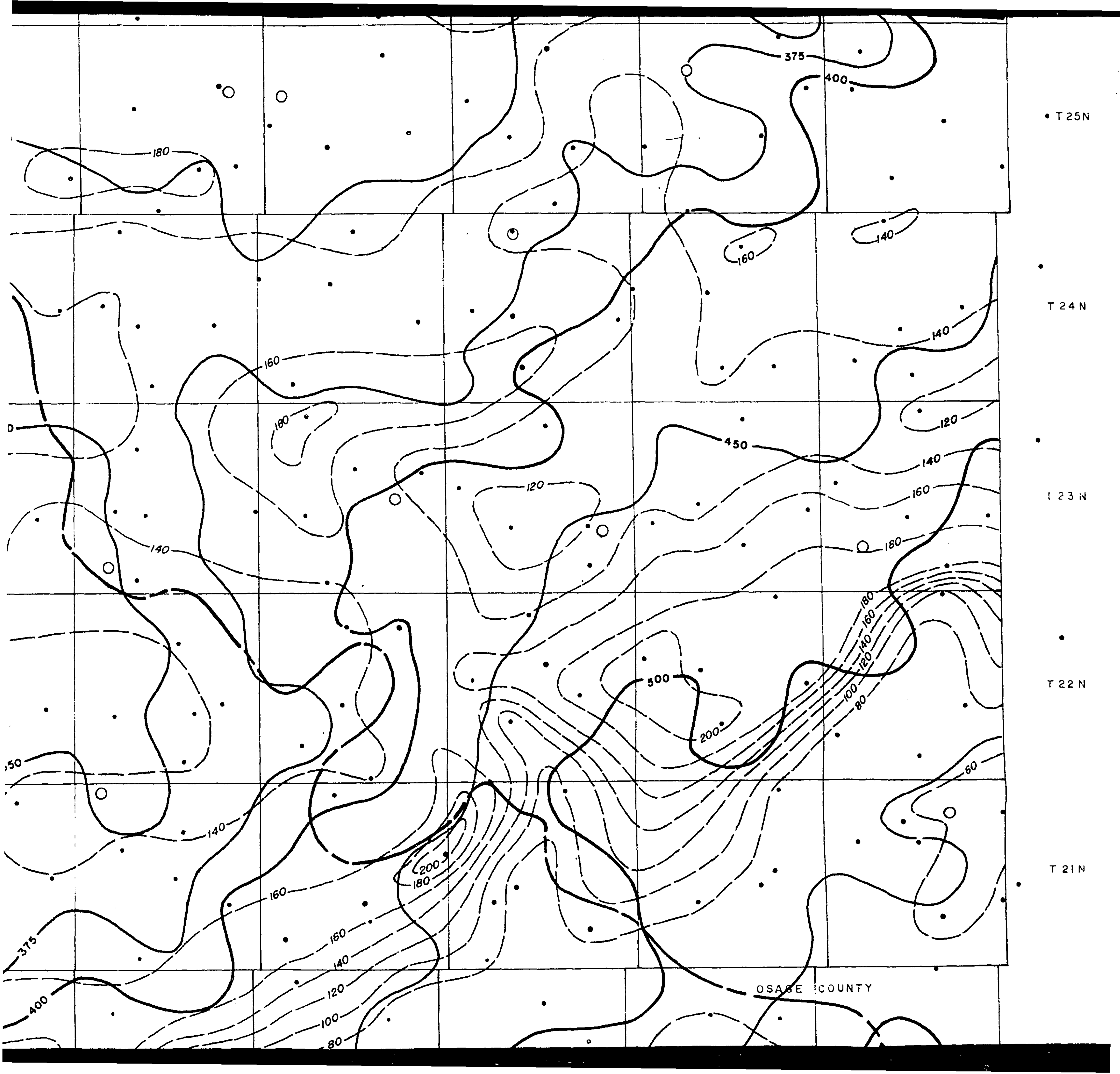

R1E
R2E
R3E
R4E
R5E
T29N
T28N
T27N
T26N
T25N
80
100
120
140
160
180
225
250
275
300
325
350
375

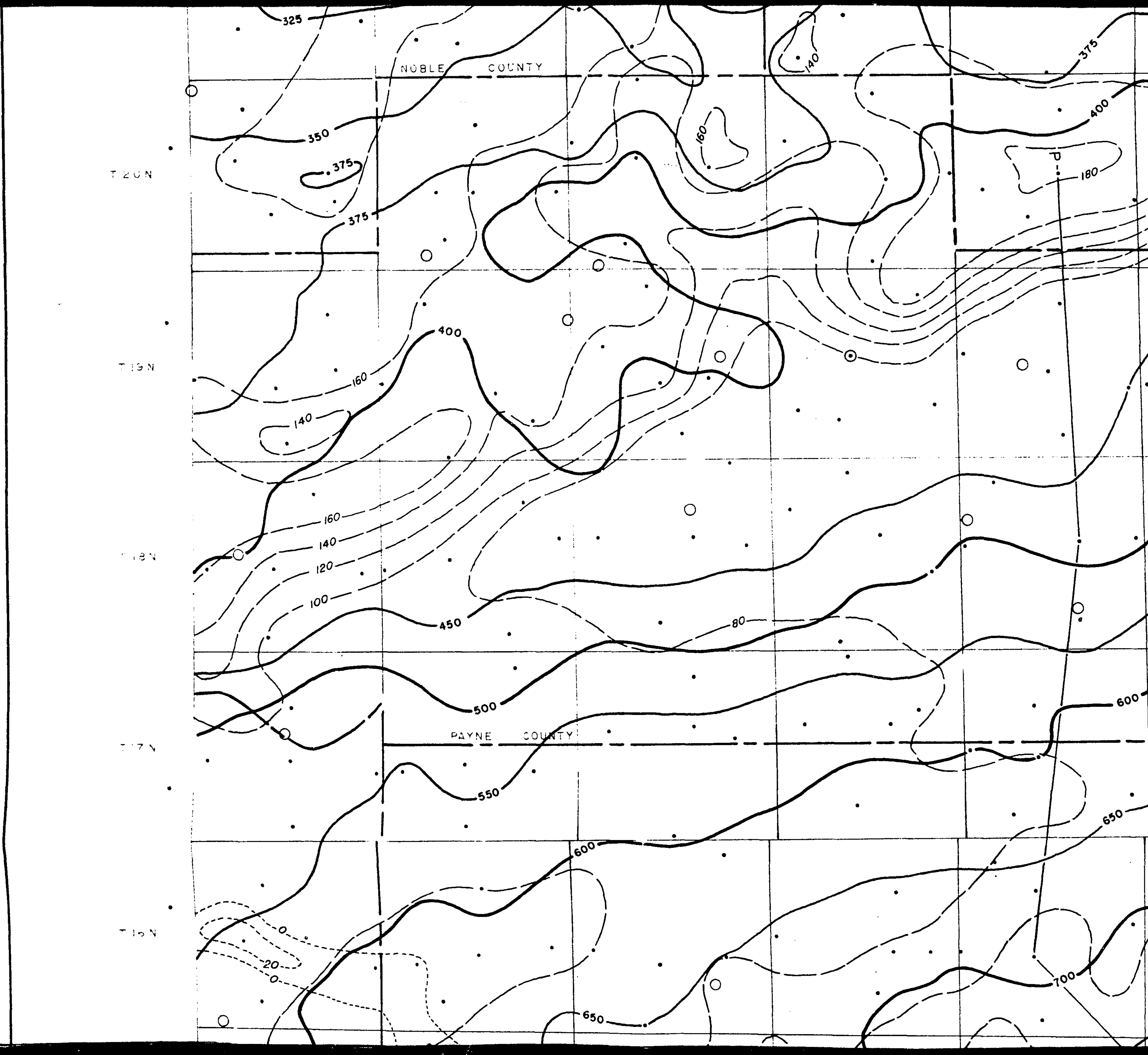


R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
140
160
325
350
160
140
160
180
180
160
180
160
325
350
375
160
400
160
350
325
180
180
325
350
160
375
400
180

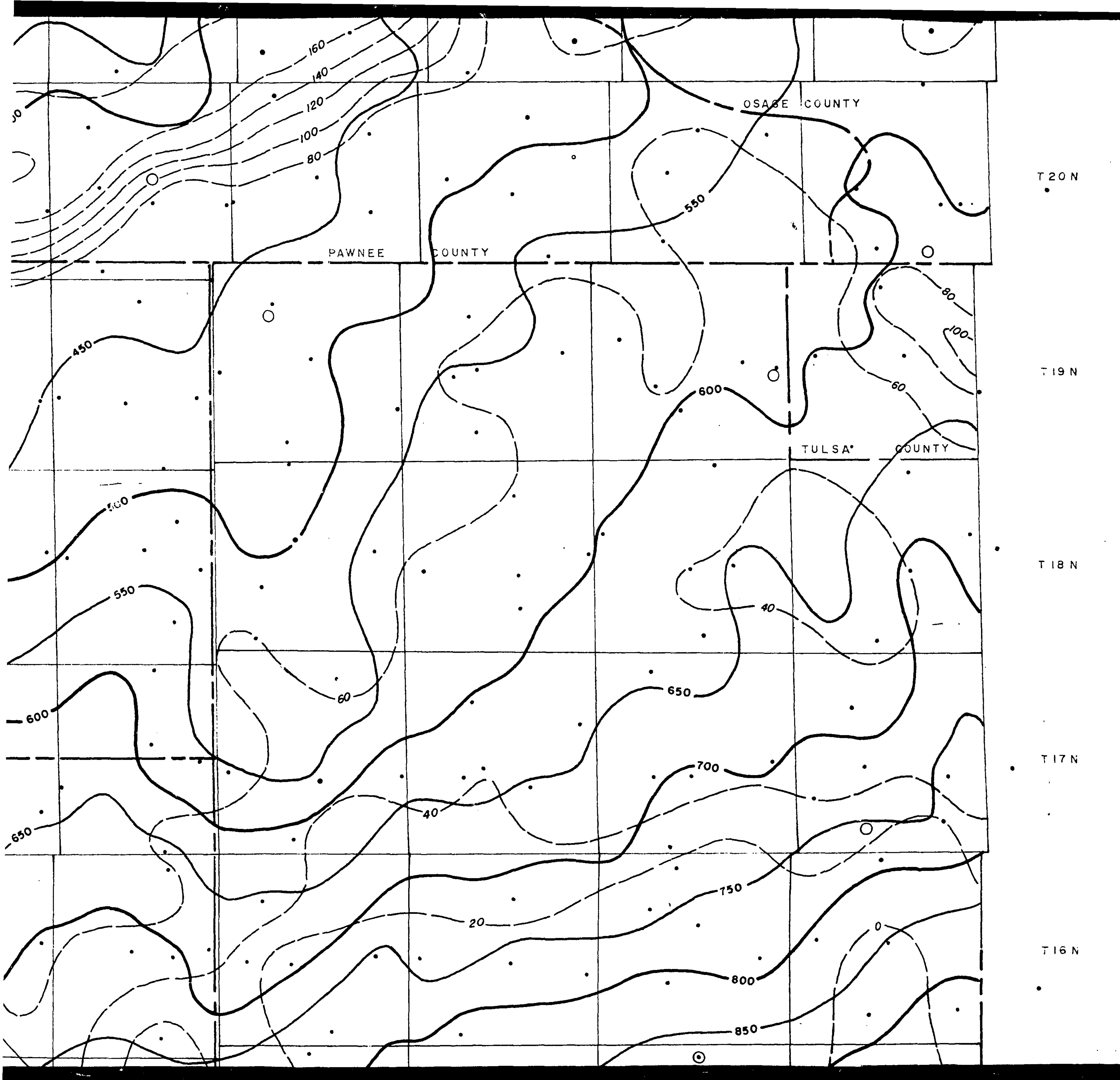


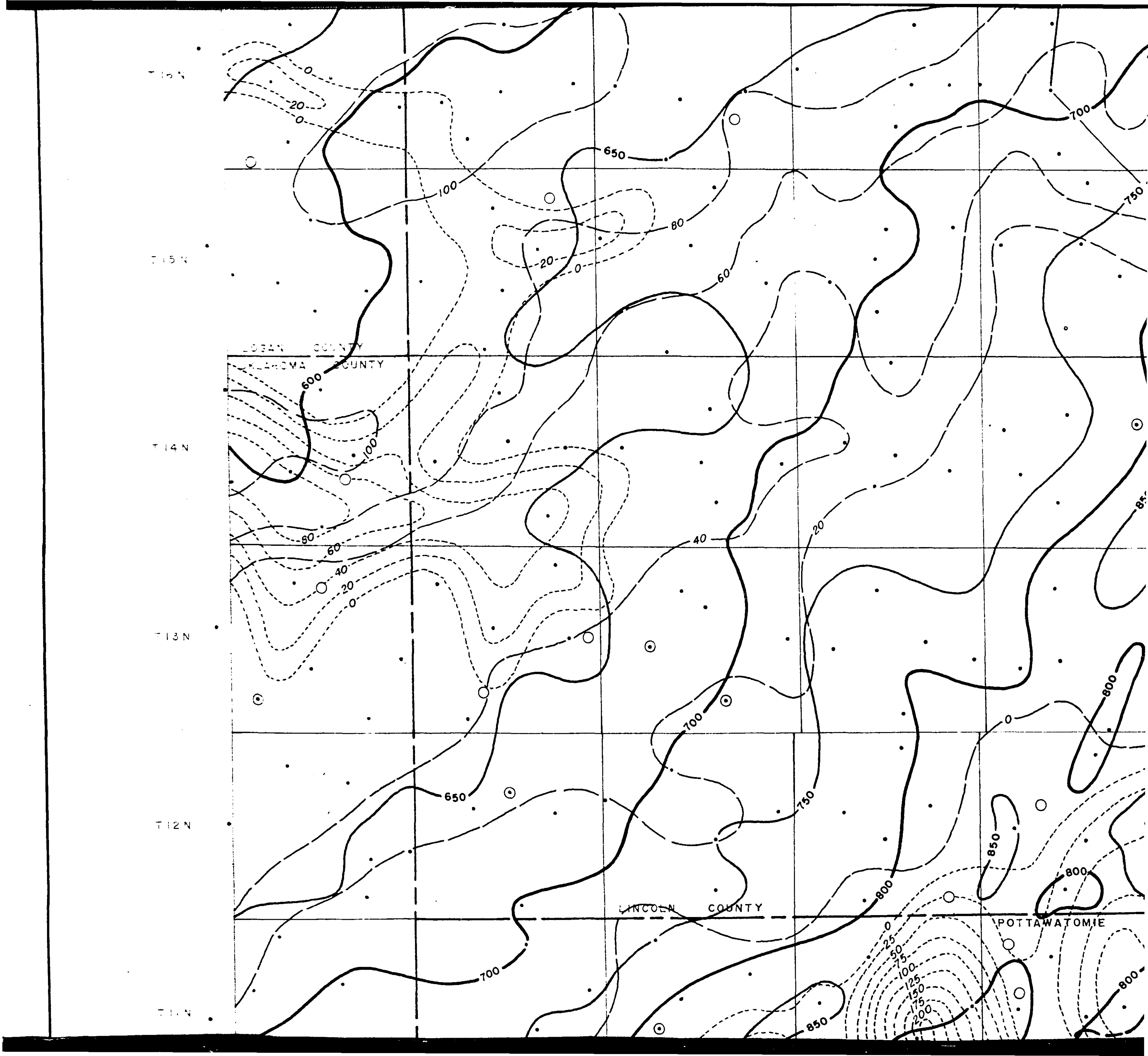
T25N
T24N
T23N
T22N
T21N
KAY COUNTY
NOBLE COUNTY
160
180
375
350
325
300
140
400


T 25 N
T 24 N
I 23 N
T 22 N
T 21 N
375
400
450
500
180
160
140
120
200
100
80
60
OSAGE COUNTY

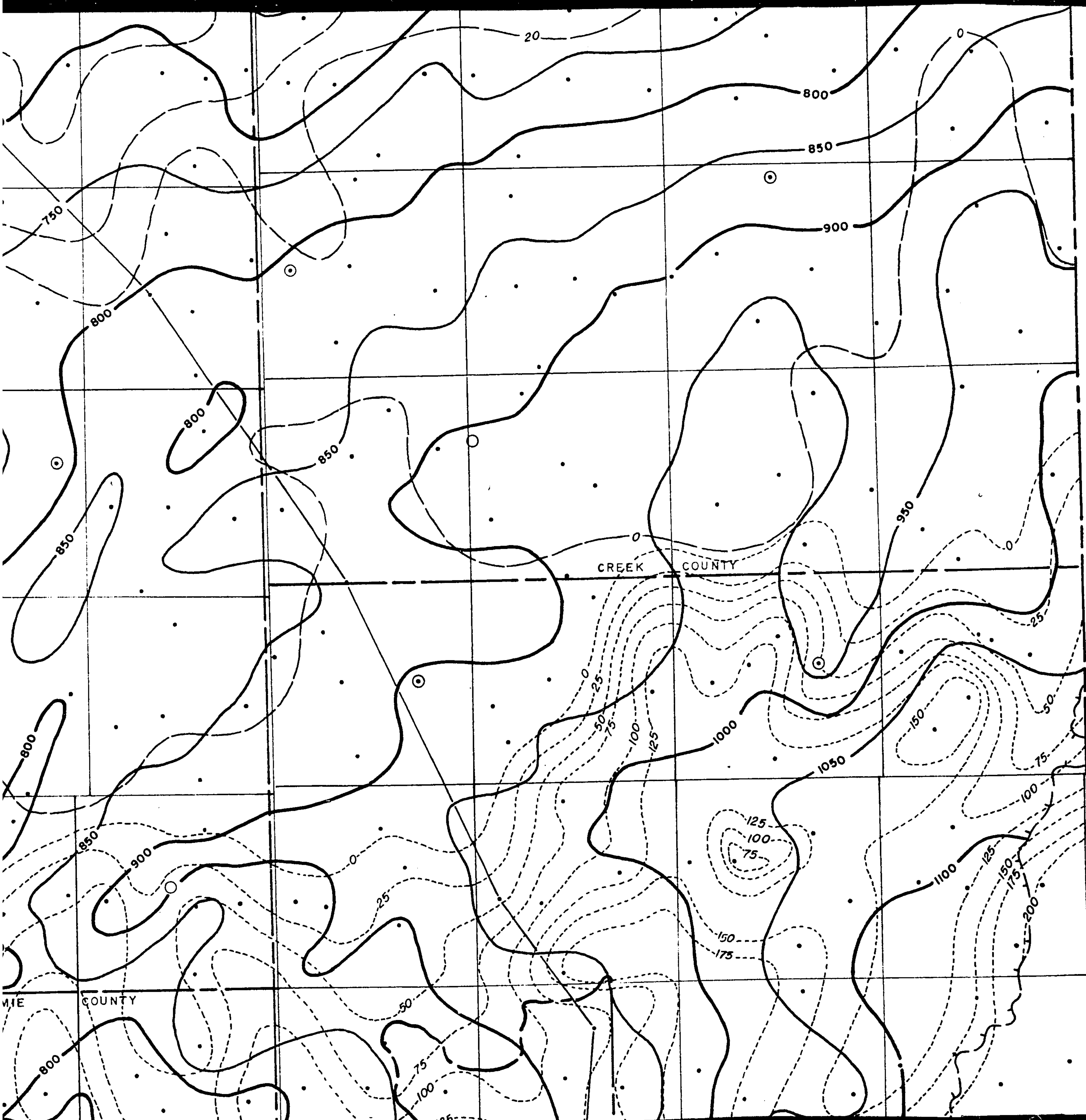


NOBLE COUNTY
PAYNE COUNTY
T 20 N
T 19 N
325
350
375
375
375
400
400
450
500
550
600
600
650
650
700
140
140
160
160
160
140
120
100
80
180
0
20
0

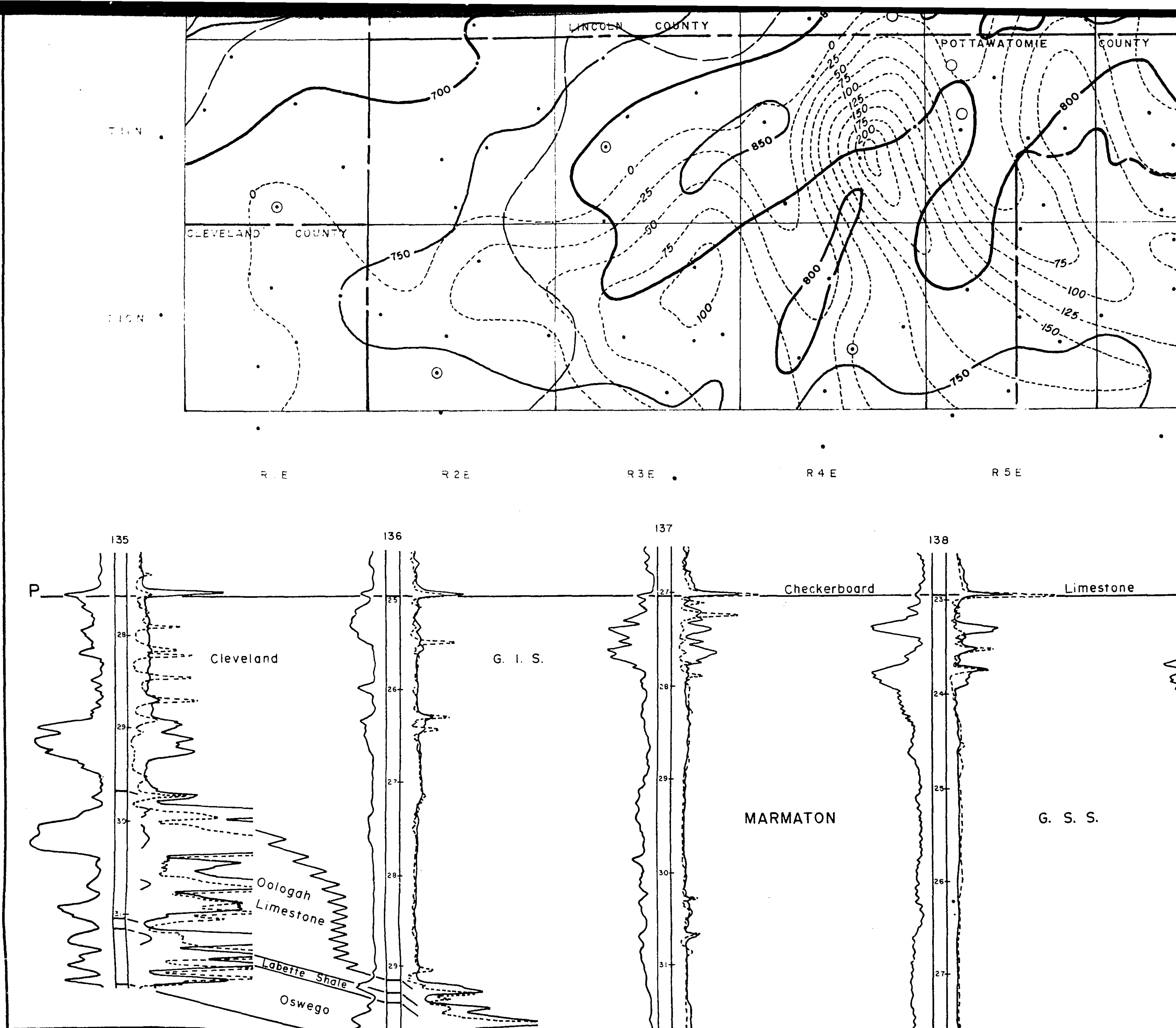

OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
T20N
T19N
T18N
T17N
T16N
160
140
120
100
80
550
450
80
100
60
600
500
550
40
60
600
650
650
700
40
750
20
0
800
850



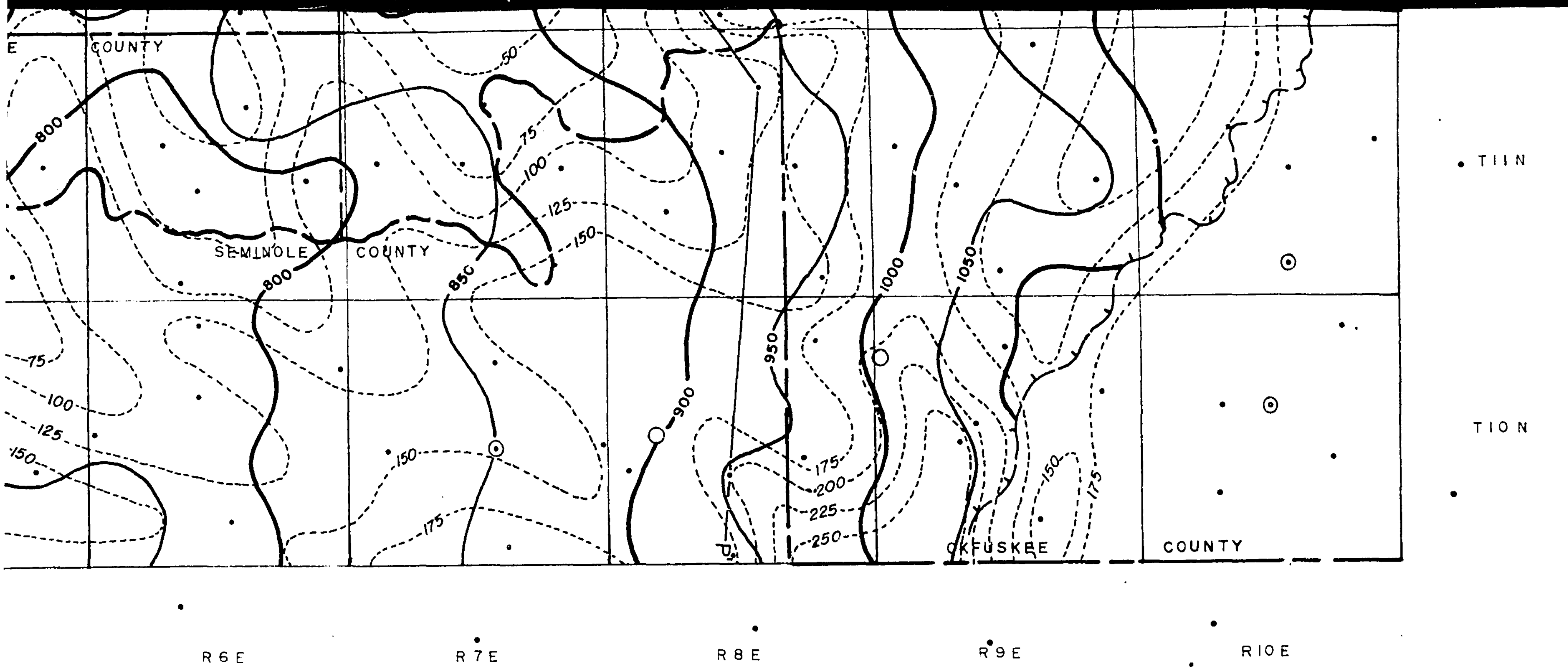
T15N
T14N
T13N
T12N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE
600
650
700
750
800
850
0
20
40
60
80
100
25
50
75
125
150
175
200

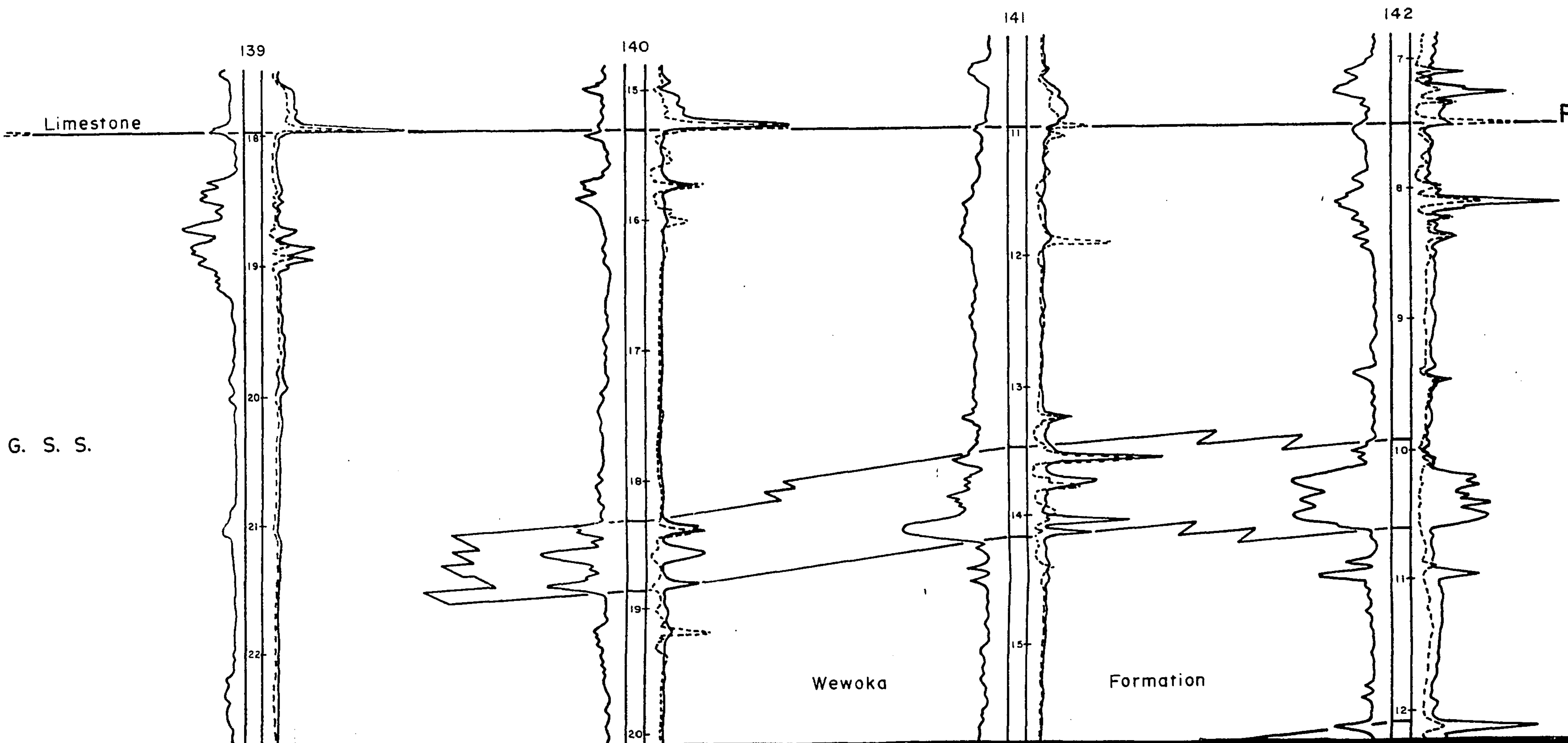


T16N
T15N
T14N
T13N
T12N
T11N
CREEK COUNTY
MIE COUNTY
20
750
800
850
900
950
1000
1050
1100
0
25
50
75
100
125
150
175
200



LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
700
750
800
850
0
25
50
75
100
125
150
175
200
R 2 E
R 3 E
R 4 E
R 5 E
135
136
137
138
P
Checkerboard
Limestone
Cleveland
G. I. S.
MARMATON
G. S. S.
Oologah
Limestone
Labette Shale
Oswego


COUNTY
SEMINOLE COUNTY
OKFUSKEE COUNTY
T11N
T10N
R6E
R7E
R8E
R9E
R10E
800
850
900
950
1000
1050
50
75
100
125
150
175
200
225
250
P


139
140
141
142
Limestone
P'
G. S. S.
Wewoka Formation

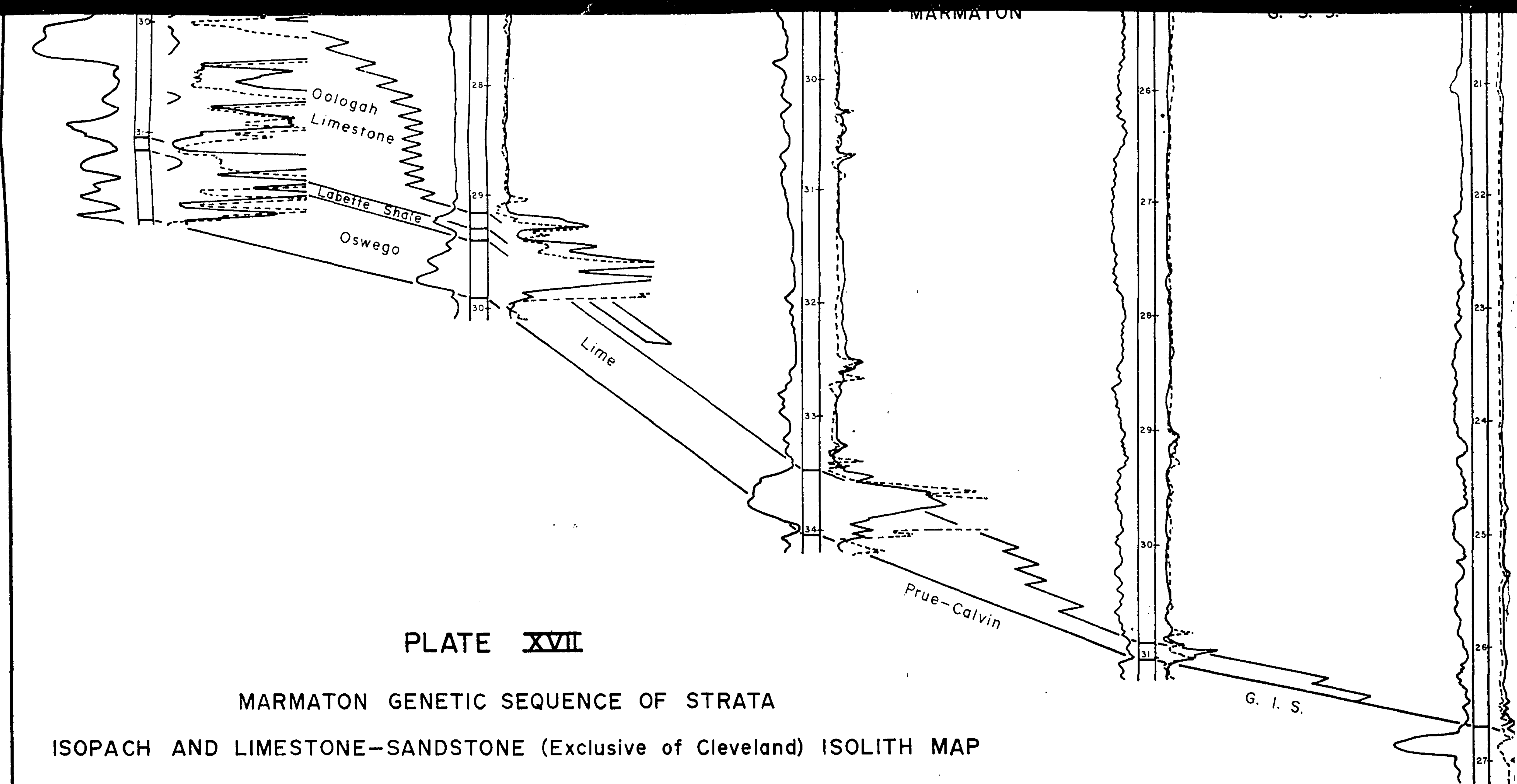


PLATE XVII

MARMATON GENETIC SEQUENCE OF STRATA

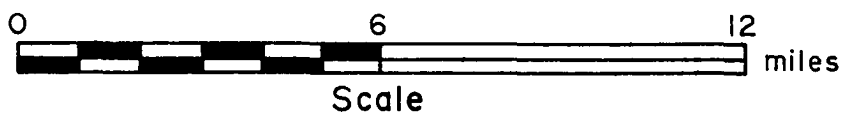
ISOPACH AND LIMESTONE–SANDSTONE (Exclusive of Cleveland) ISOLITH MAP

AND

STRATIGRAPHIC PROFILE PP'

by

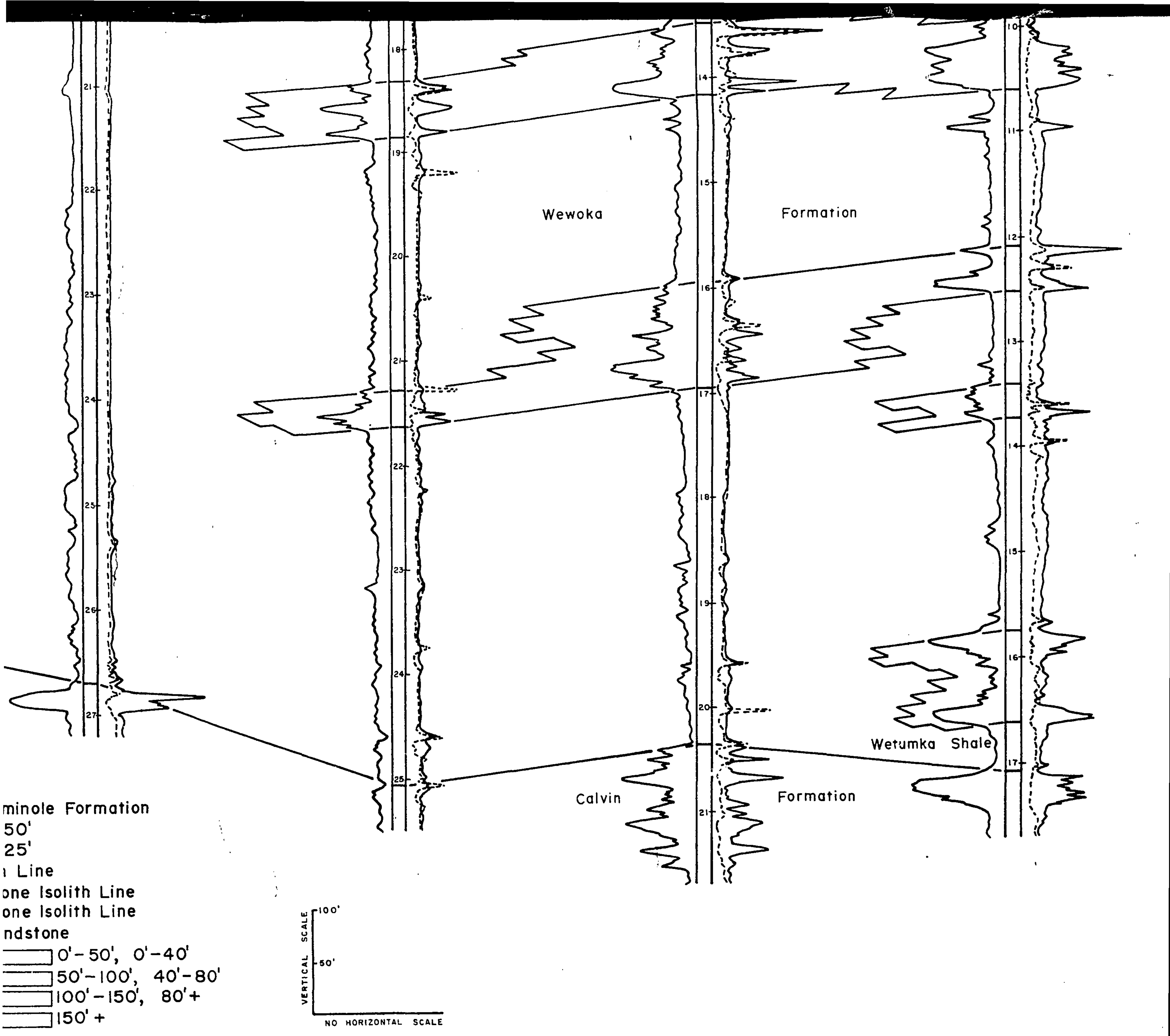
J. Glenn Cole Ph. D. 1968

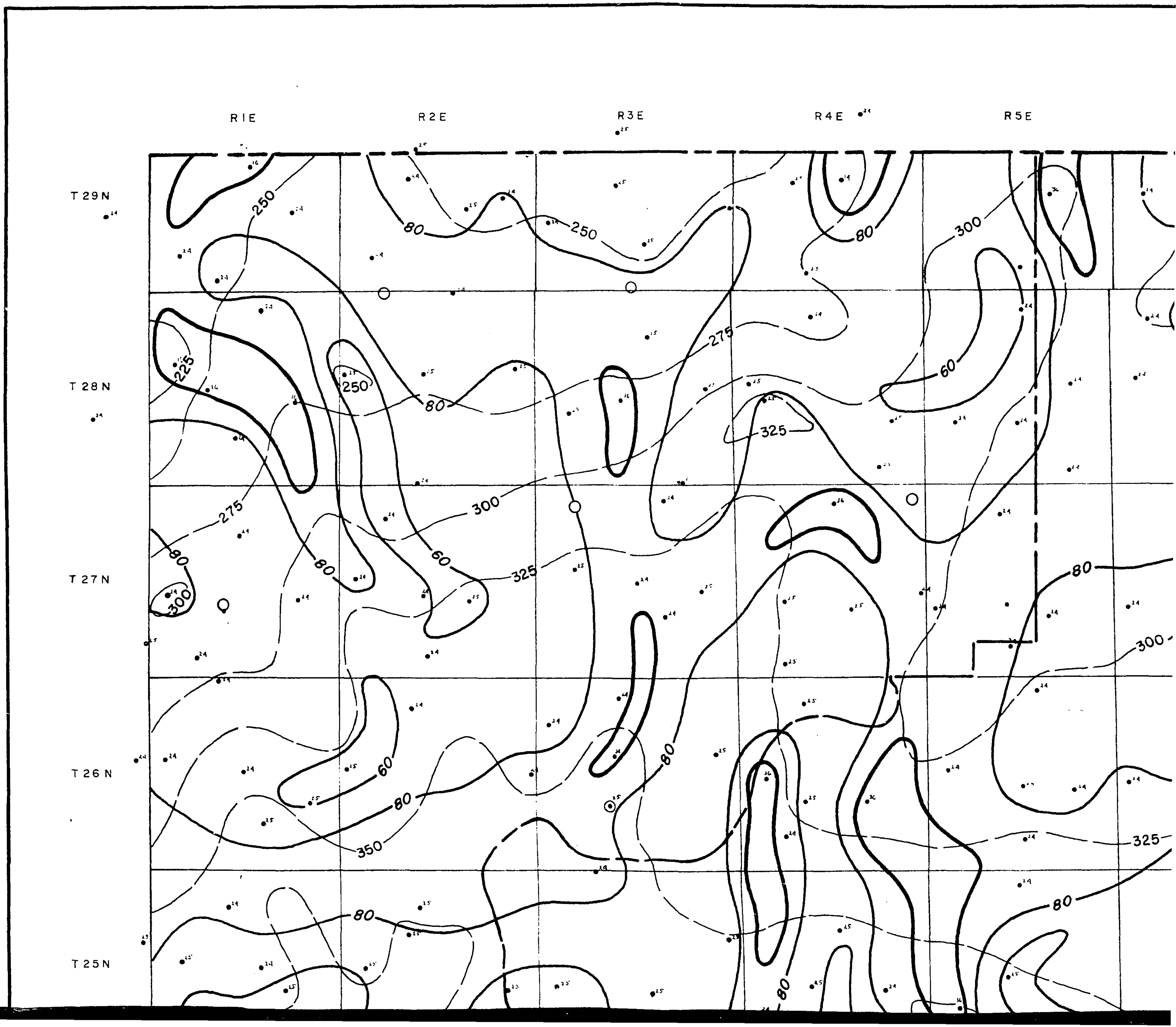


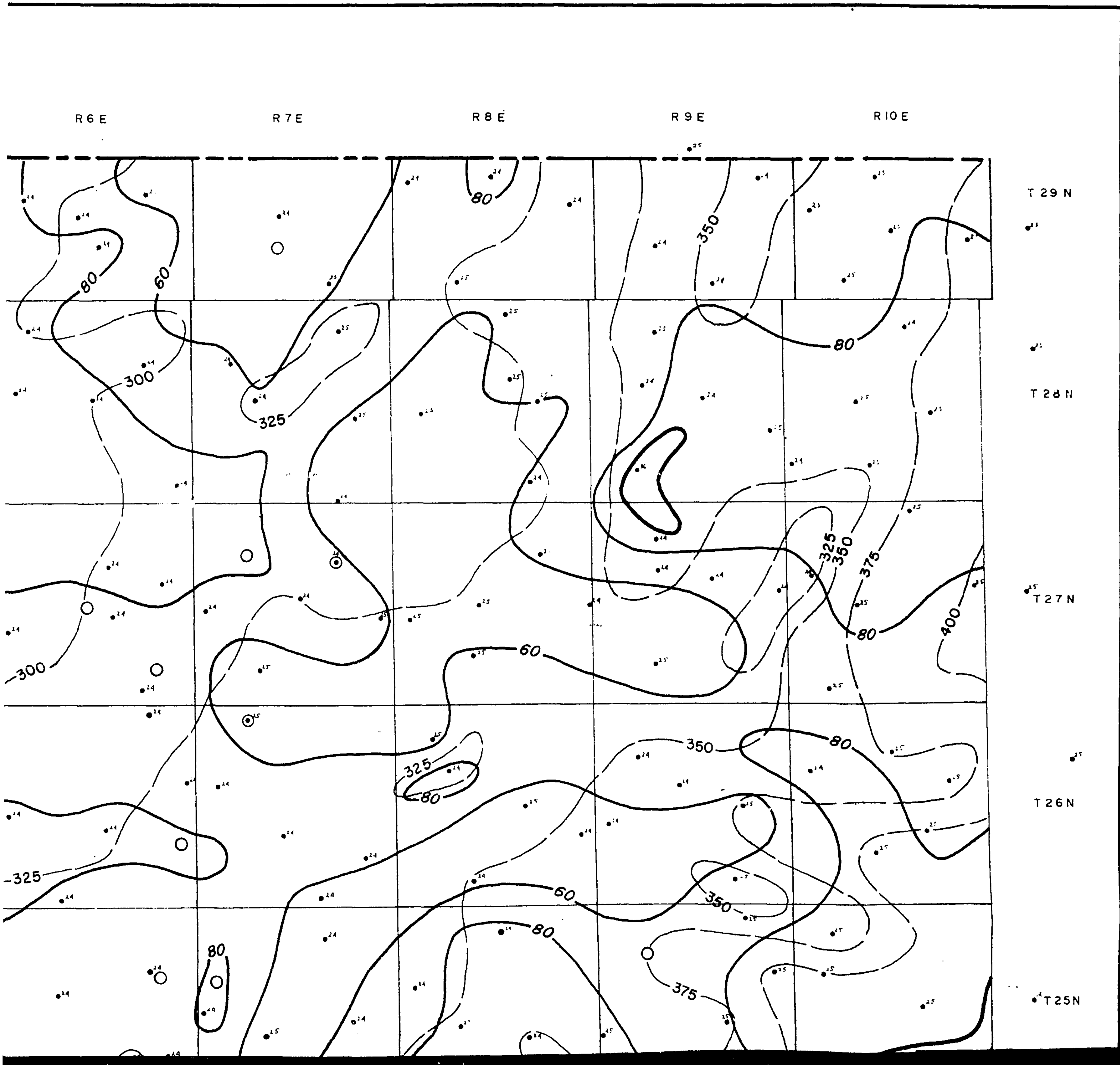
LEGEND:

- • Control Well
- ⊙ Sample Control
- Outcrop Base Seminole Format
- C. I. Isopach 25' & 50'
- C. I. Isolith 20' & 25'
- —325— Isopach Line
- – –100– – Limestone Isolith Lir
- ----100---- Sandstone Isolith Lir

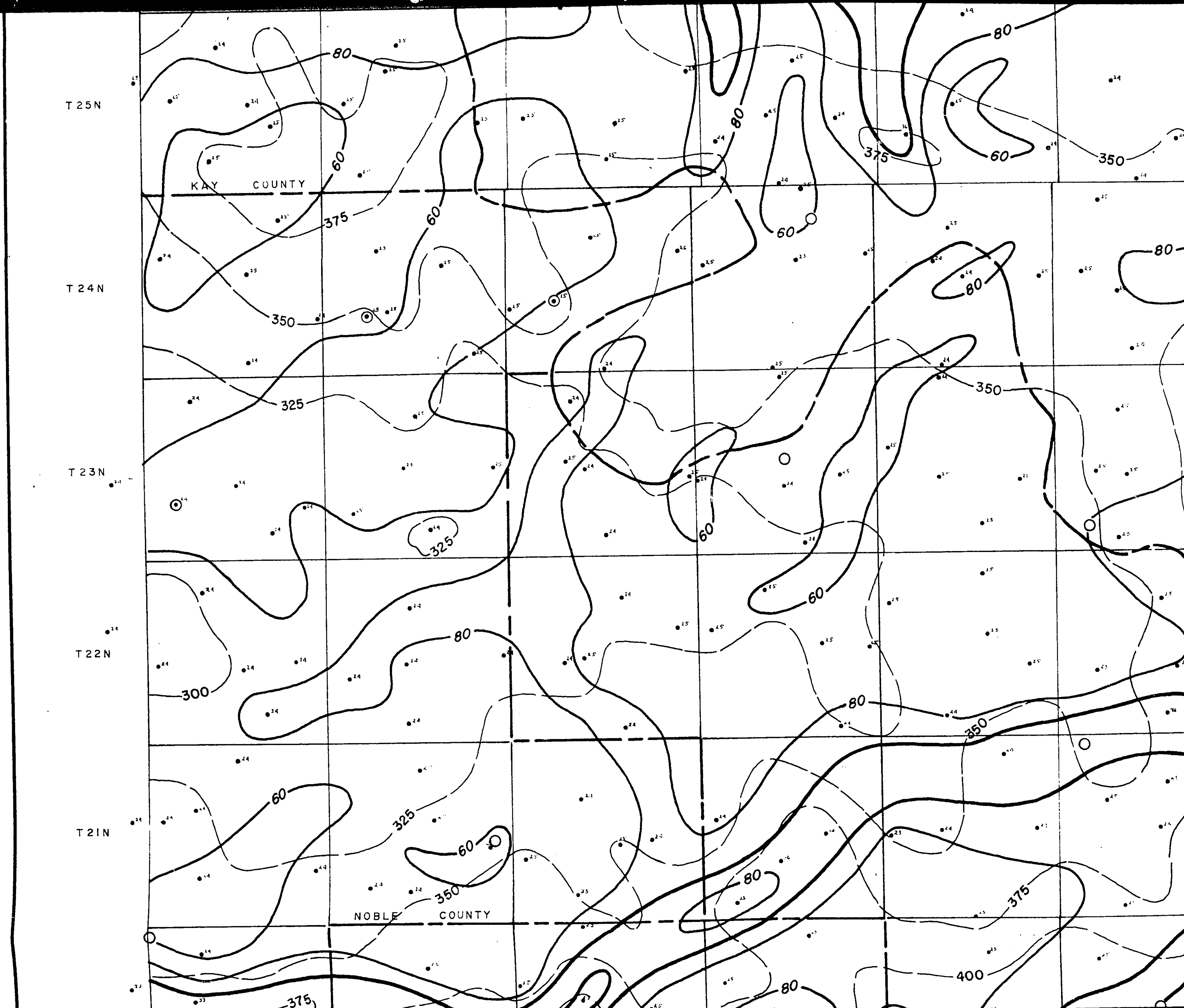
Limestone	Sandstone
0'-60'	0'-50',
60'-120'	50'-10(
120'-180'	100'-15
180' +	150' +


Wewoka
Formation
Wetumka Shale
Calvin
Formation
minole Formation
50'
25'
Line
one Isolith Line
one Isolith Line
ndstone
0'-50', 0'-40'
50'-100', 40'-80'
100'-150', 80'+
150' +
VERTICAL SCALE
100'
50'
NO HORIZONTAL SCALE

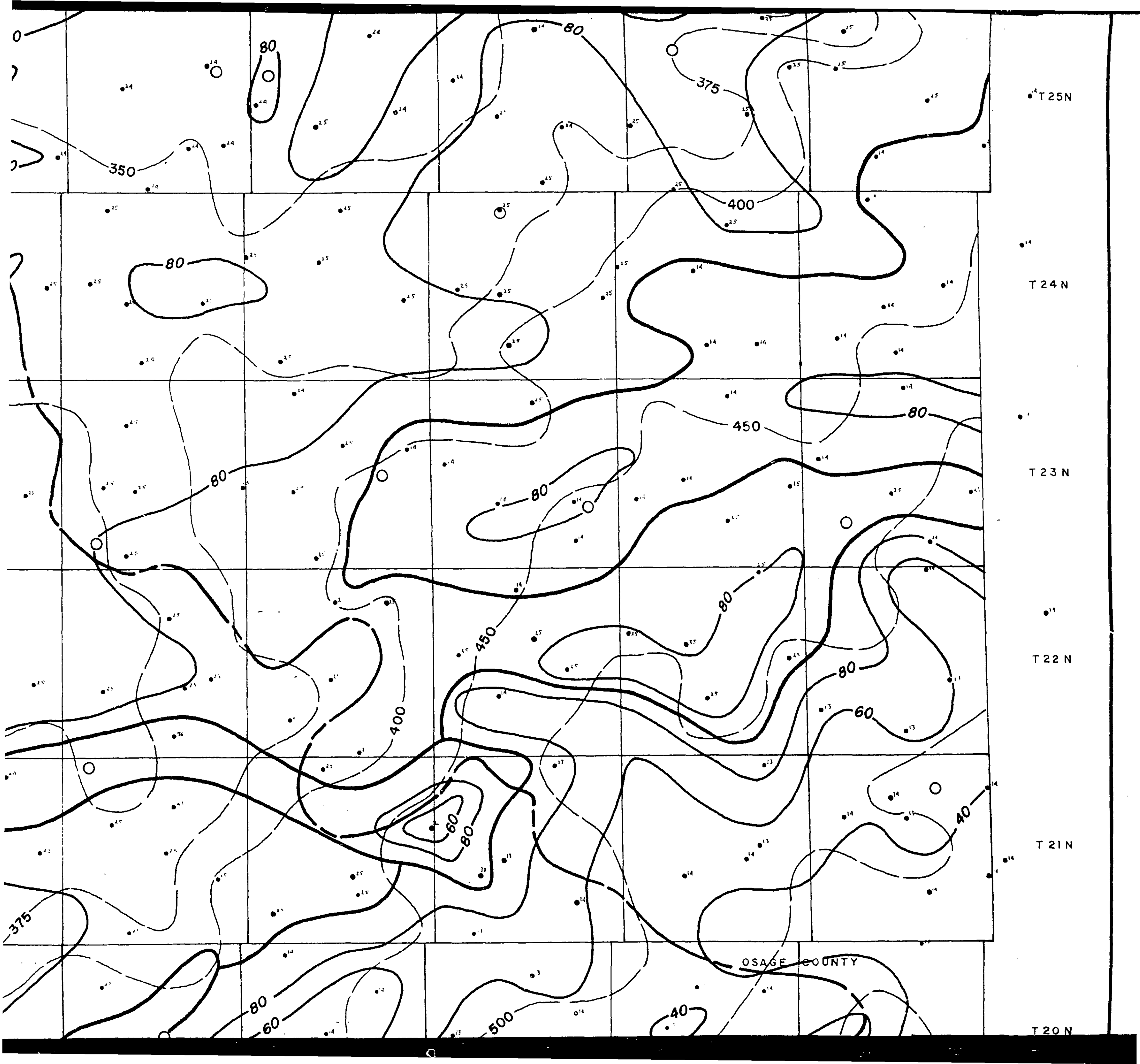

R1E
R2E
R3E
R4E
R5E
T29N
T28N
T27N
T26N
T25N
250
80
250
80
300
225
250
80
275
325
60
275
300
80
60
325
300
80
300
60
80
80
350
325
80
80
80



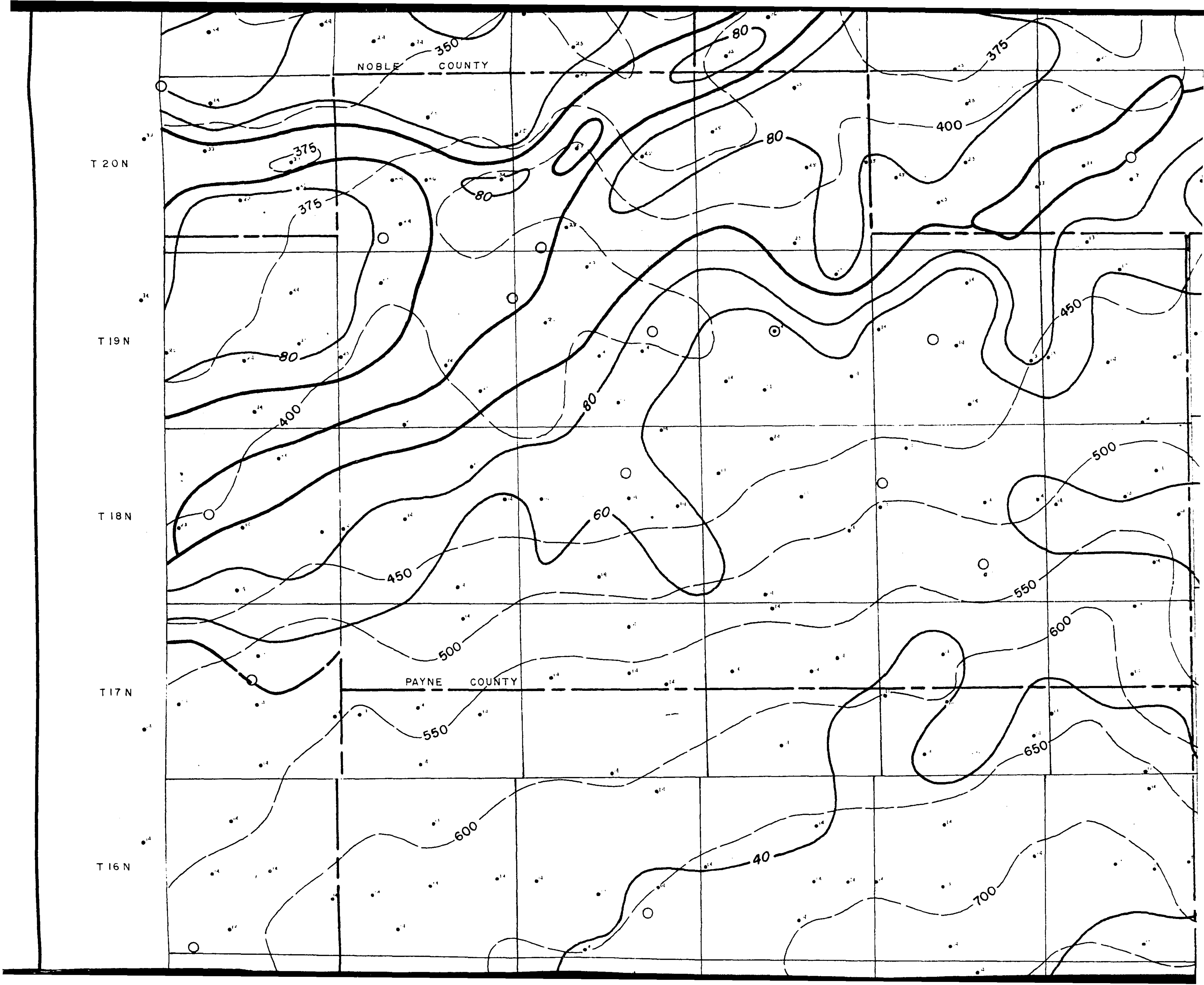
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
80
60
300
325
350
375
400



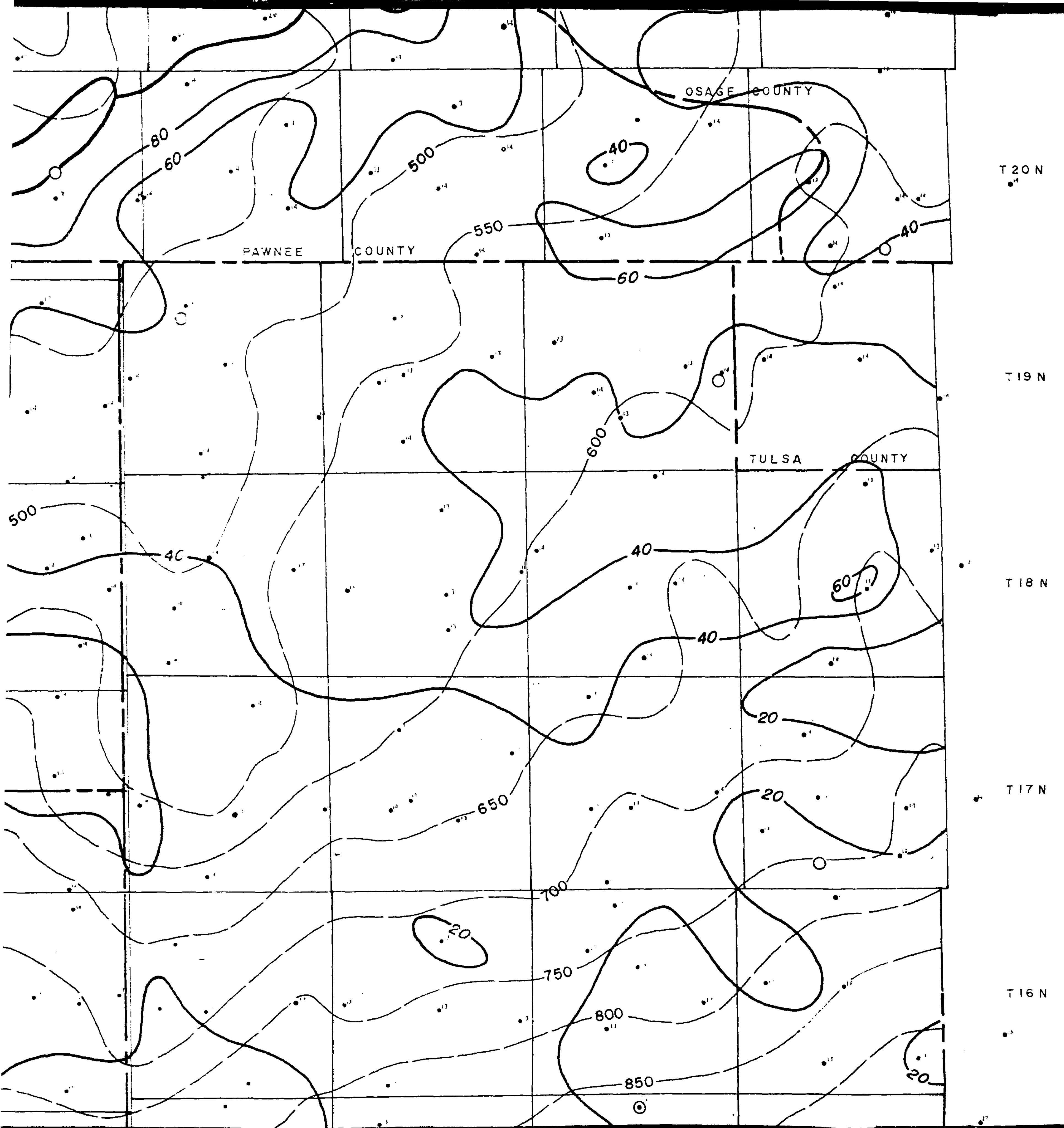
T25N
T24N
T23N
T22N
T21N
KAY COUNTY
NOBLE COUNTY
80
60
375
350
325
300
400



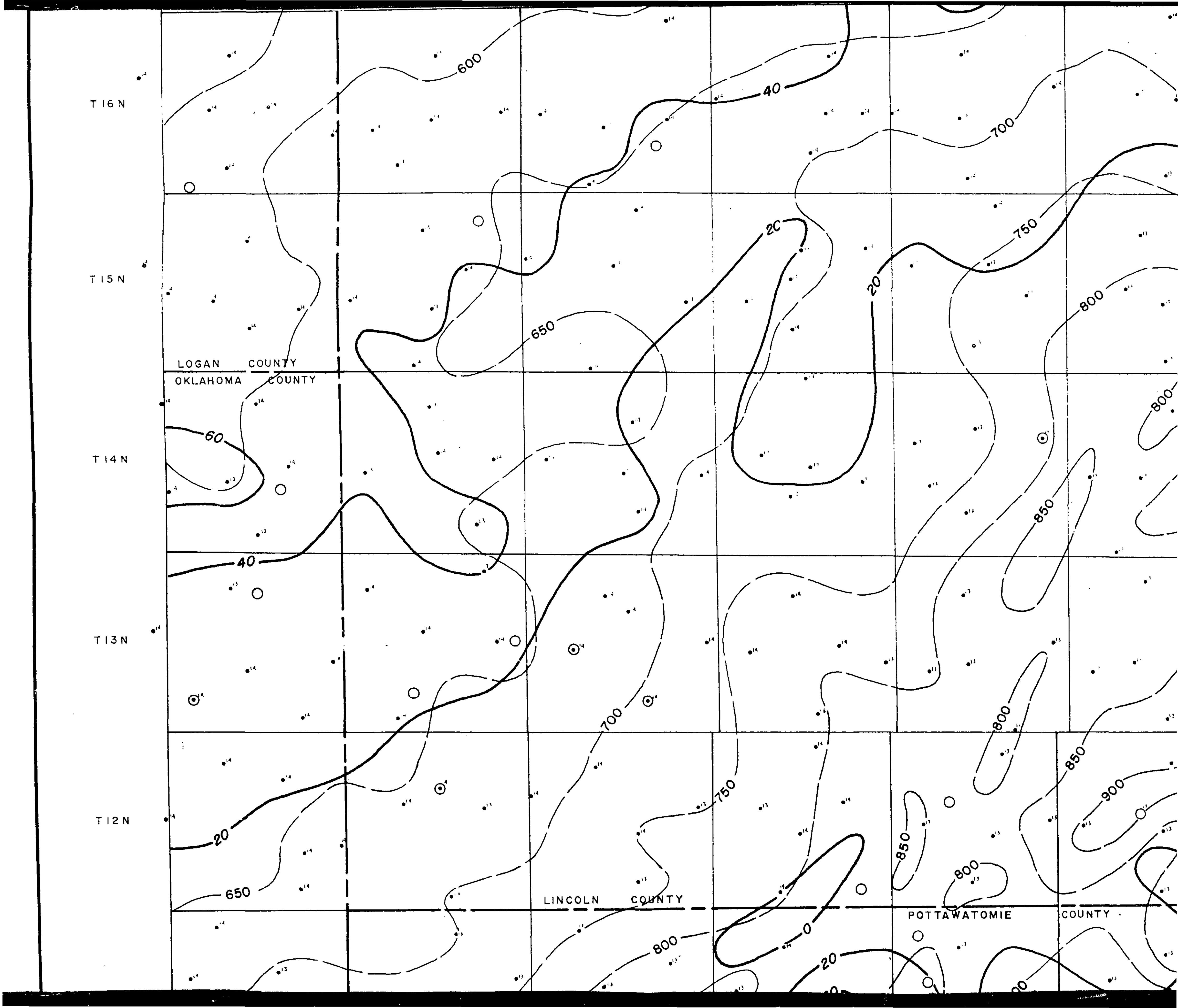
T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
OSAGE COUNTY
350
375
400
450
500
80
60
40



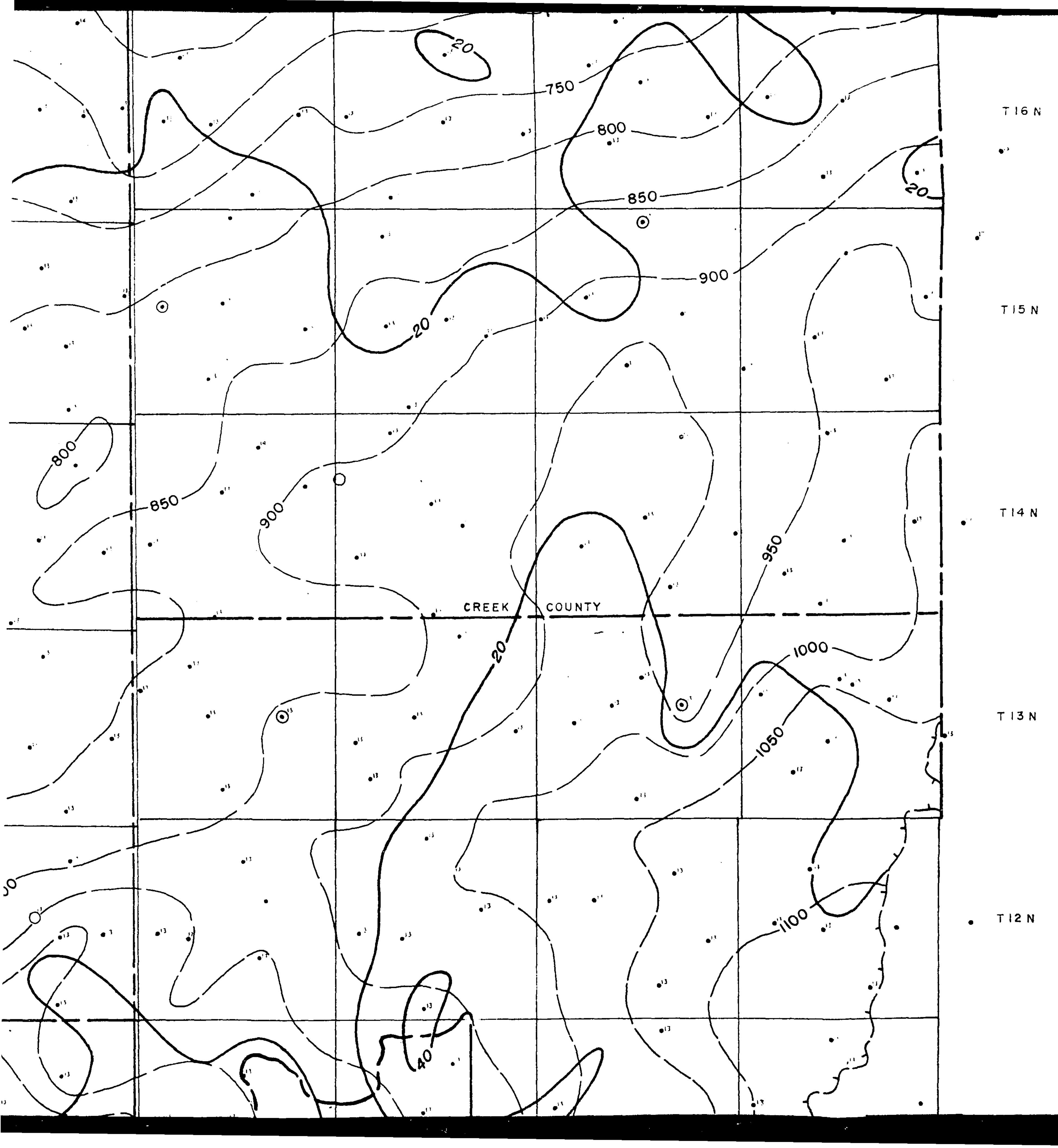
NOBLE COUNTY
PAYNE COUNTY
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
350
375
375
375
400
400
450
450
500
500
550
550
600
600
650
700
80
80
80
80
80
60
40



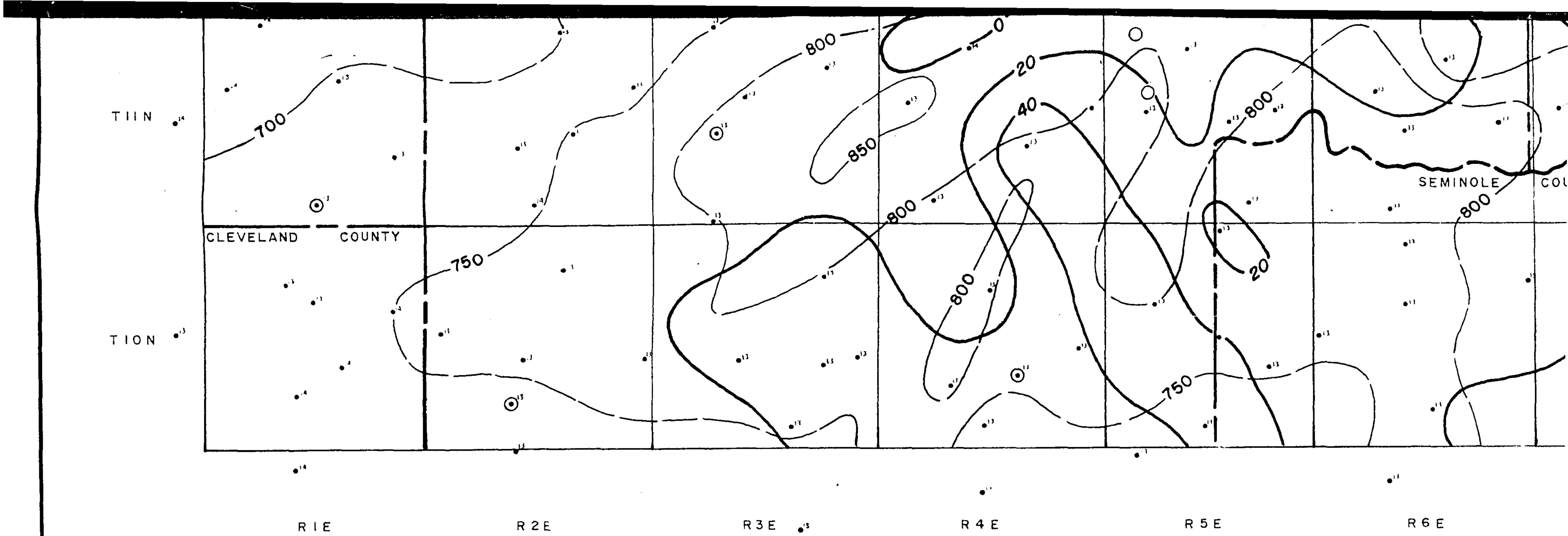
OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
T20N
T19N
T18N
T17N
T16N
80
60
500
550
40
60
40
600
500
40
40
40
60
20
20
650
700
20
750
800
850
20



T16N
T15N
T14N
T13N
T12N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
600
650
700
750
800
850
900
0
20
40
60



20
750
800
850
900
950
1000
1050
1100
40
CREEK COUNTY
T16N
T15N
T14N
T13N
T12N



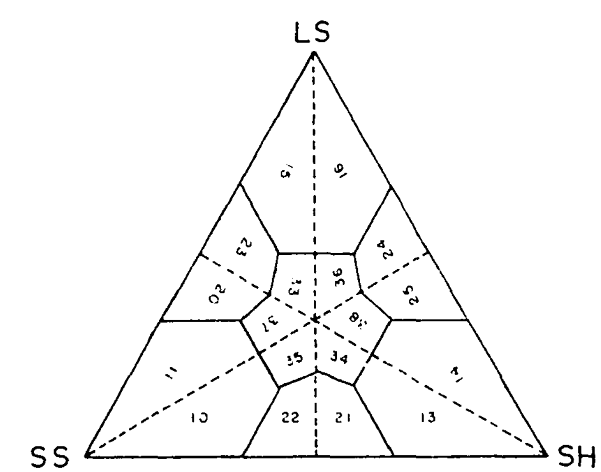


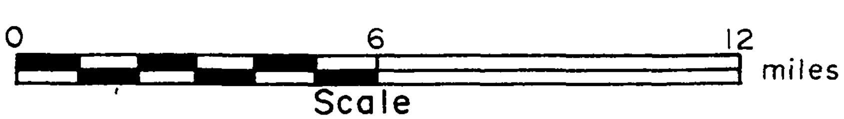
PLATE XVIII

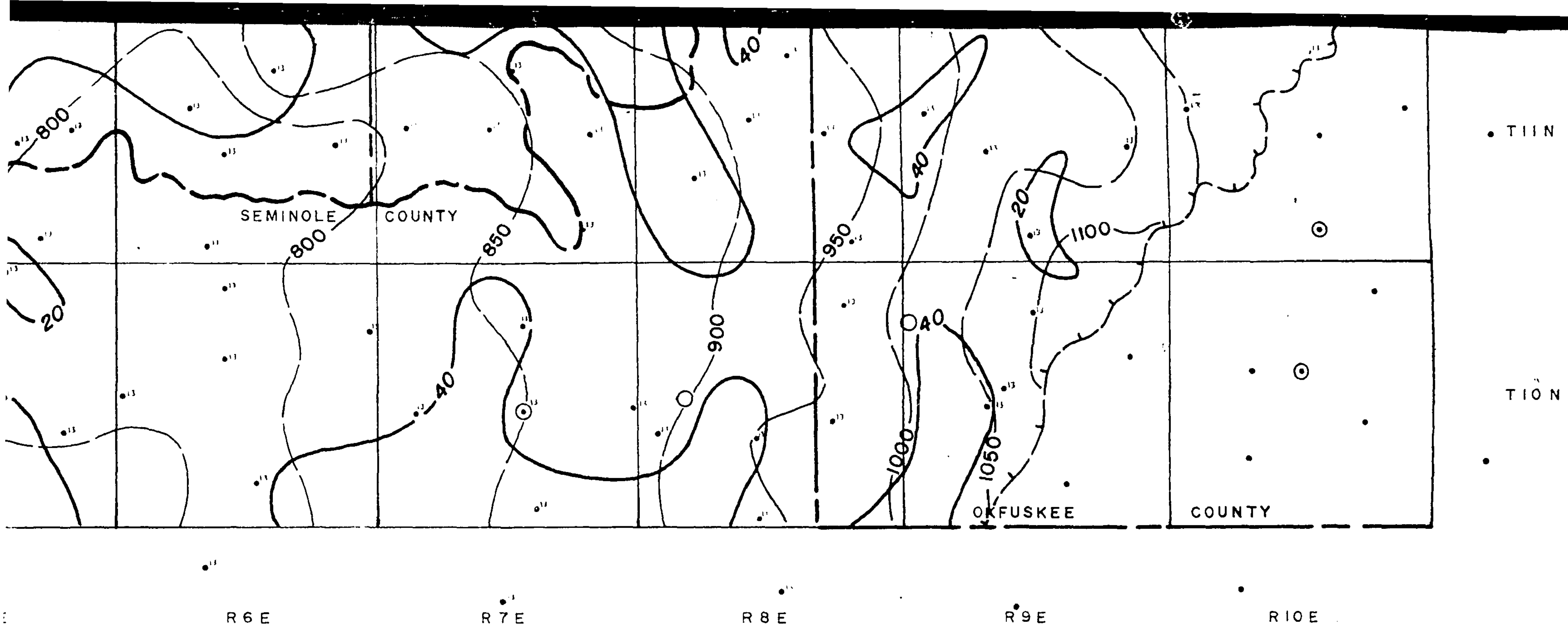
MARMATON GENETIC SEQUENCE OF STRATA

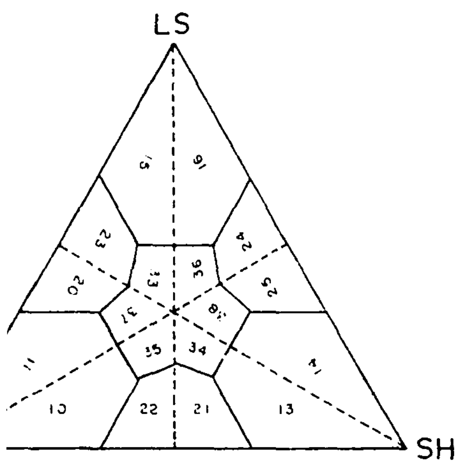
D-FUNCTION LITHOFACIES AND ISOPACH MAP

by

J. Glenn Cole Ph. D. 1968

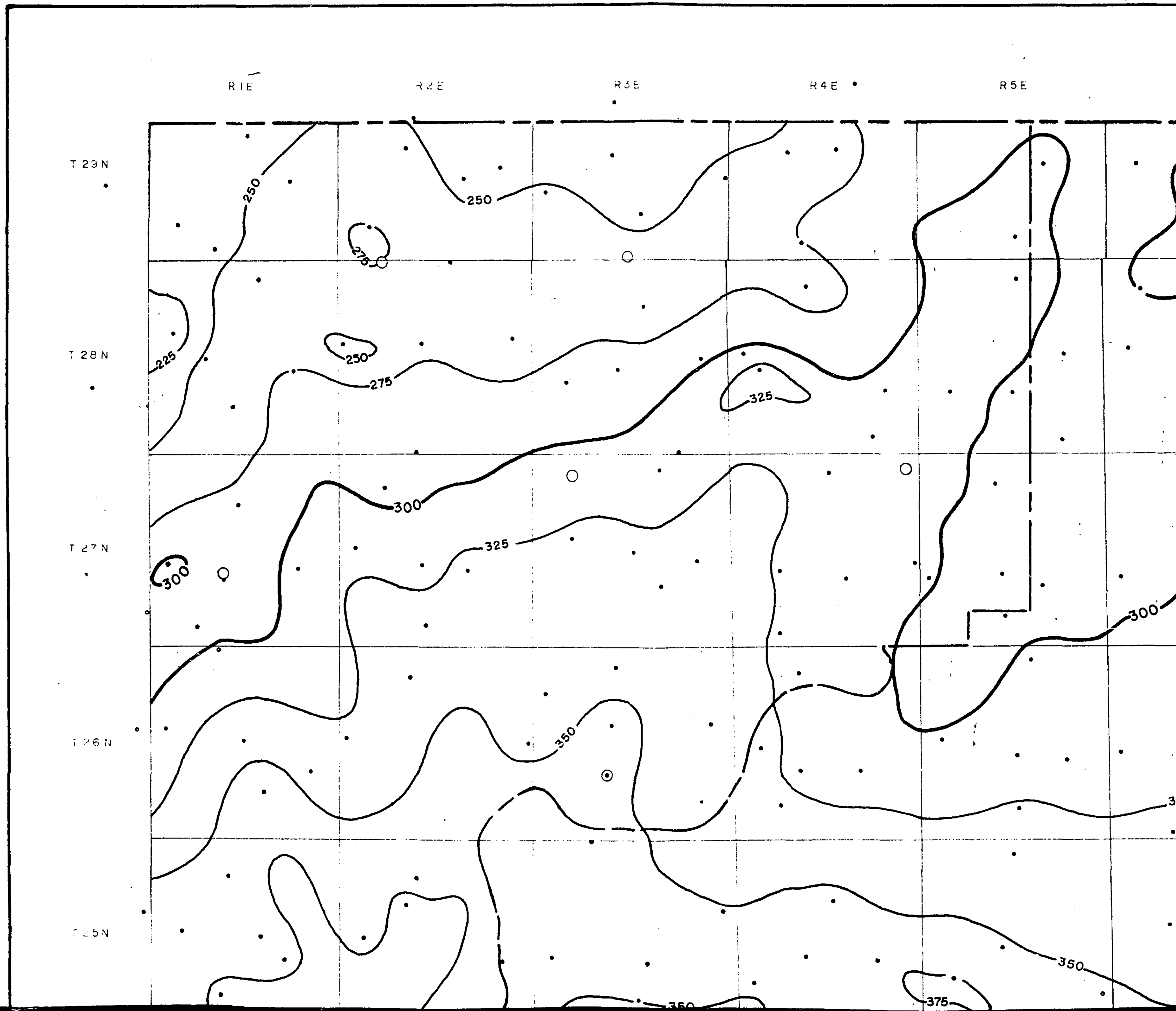




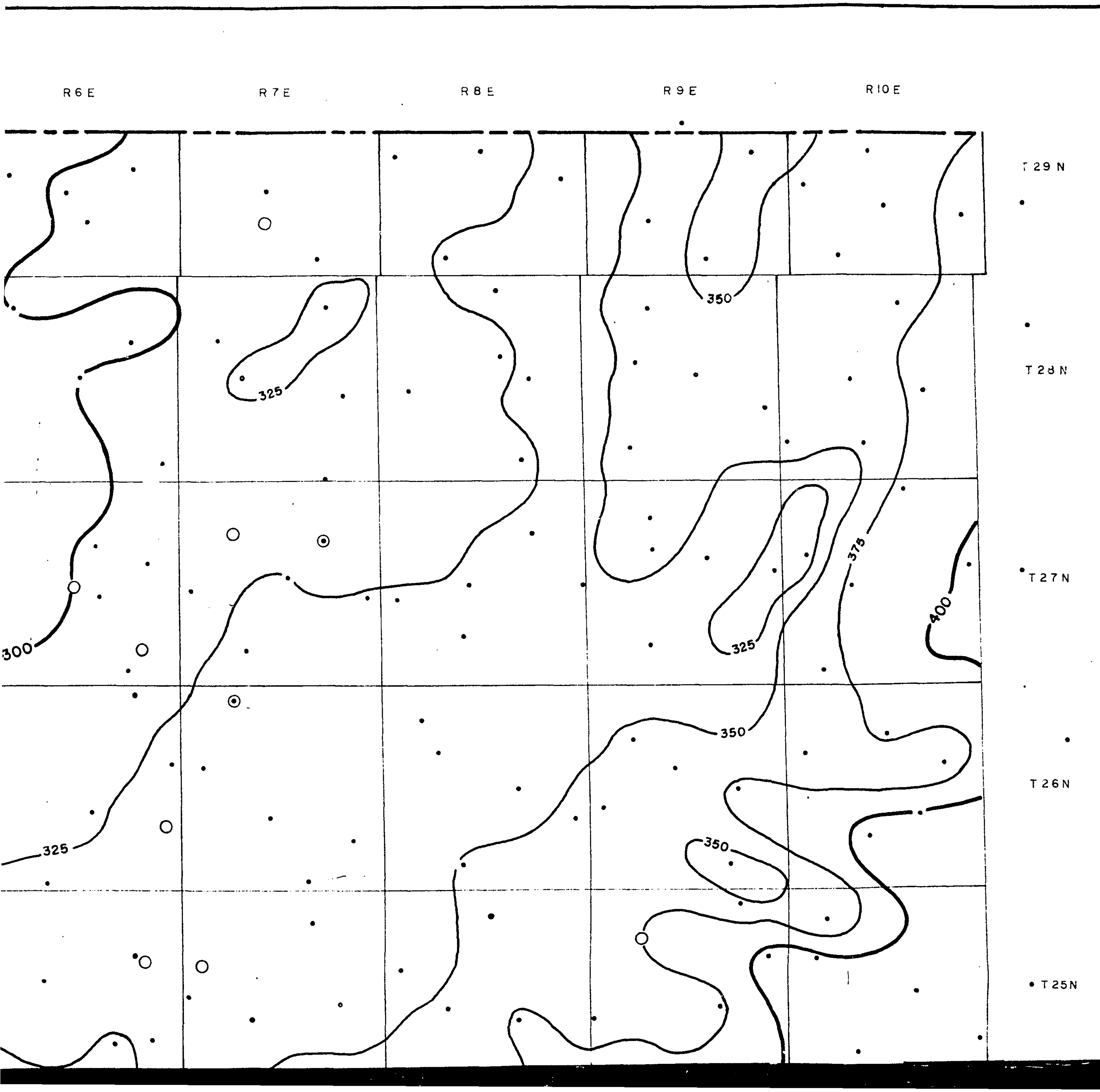


LEGEND:

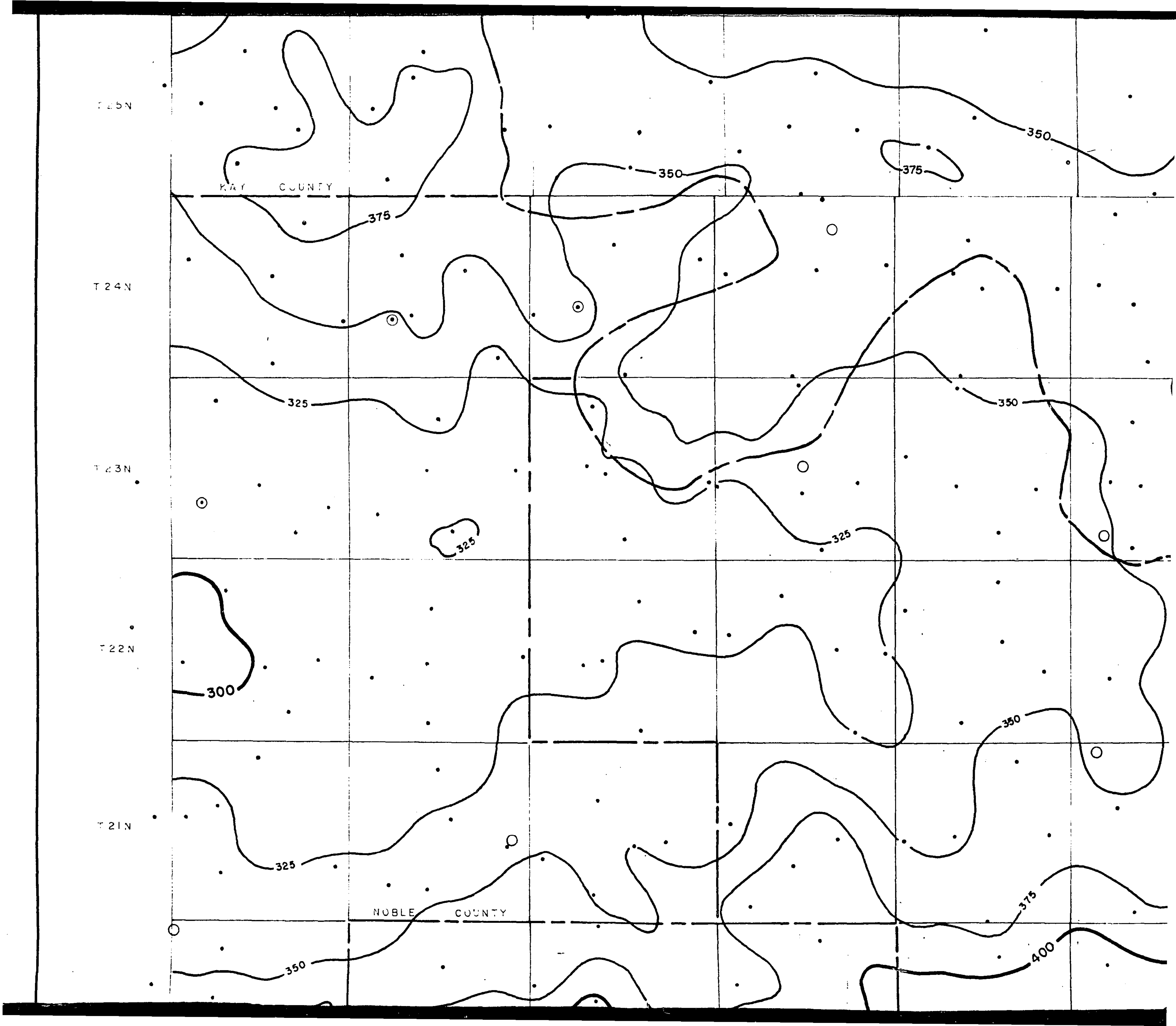
- • Control Well
- O Sample Control
- Outcrop Base Seminole Formation
- C. I. Isopach 25' & 50'
- C. I. D-Function 20
- --500-- -- Isopach Line
- ——80—— D-Function
- —— Class Boundary
- •[14] Subclass



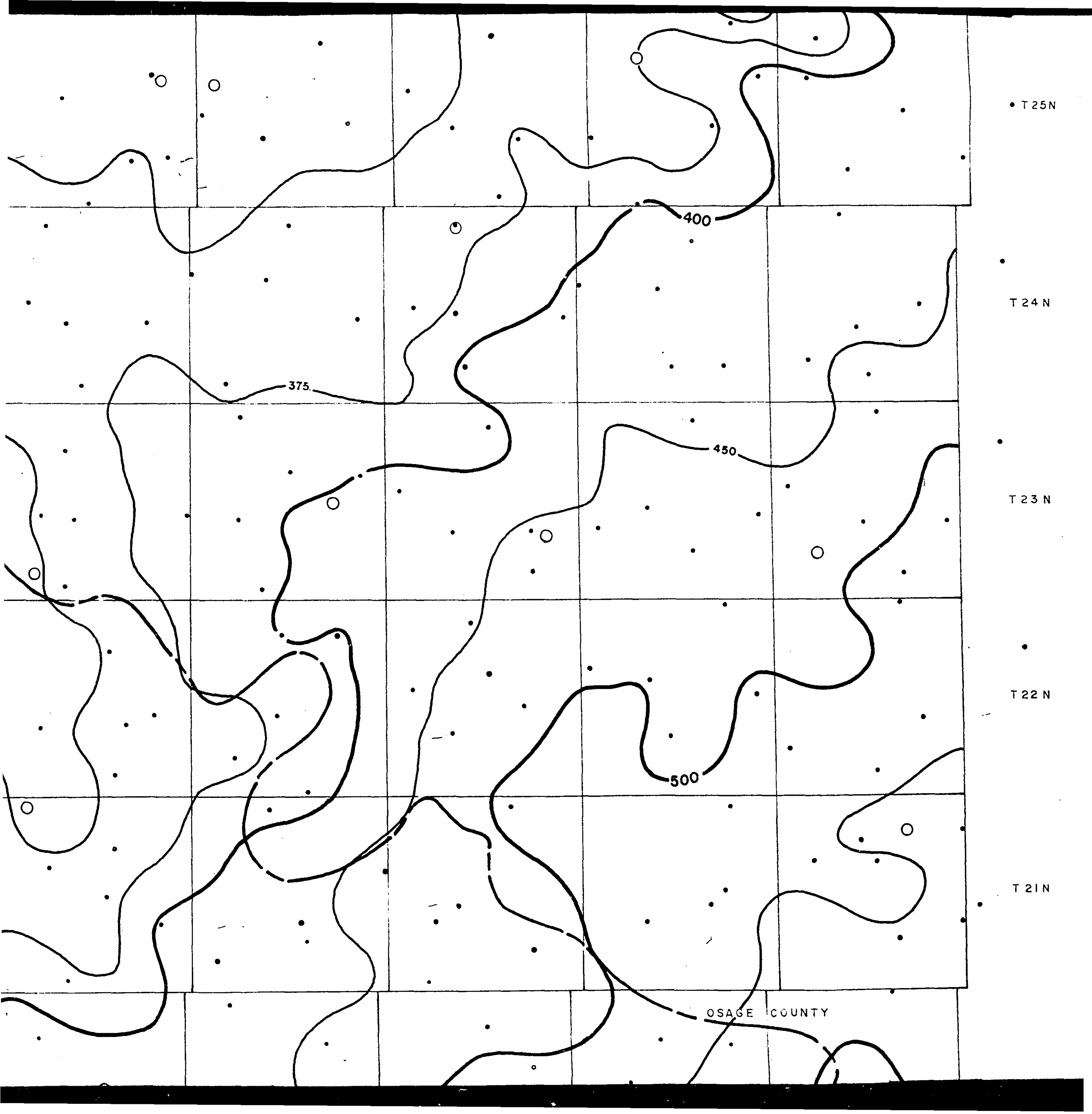
R1E
R2E
R3E
R4E
R5E
T 29 N
T 28 N
T 27 N
T 26 N
T 25 N
225
250
275
300
325
350
375



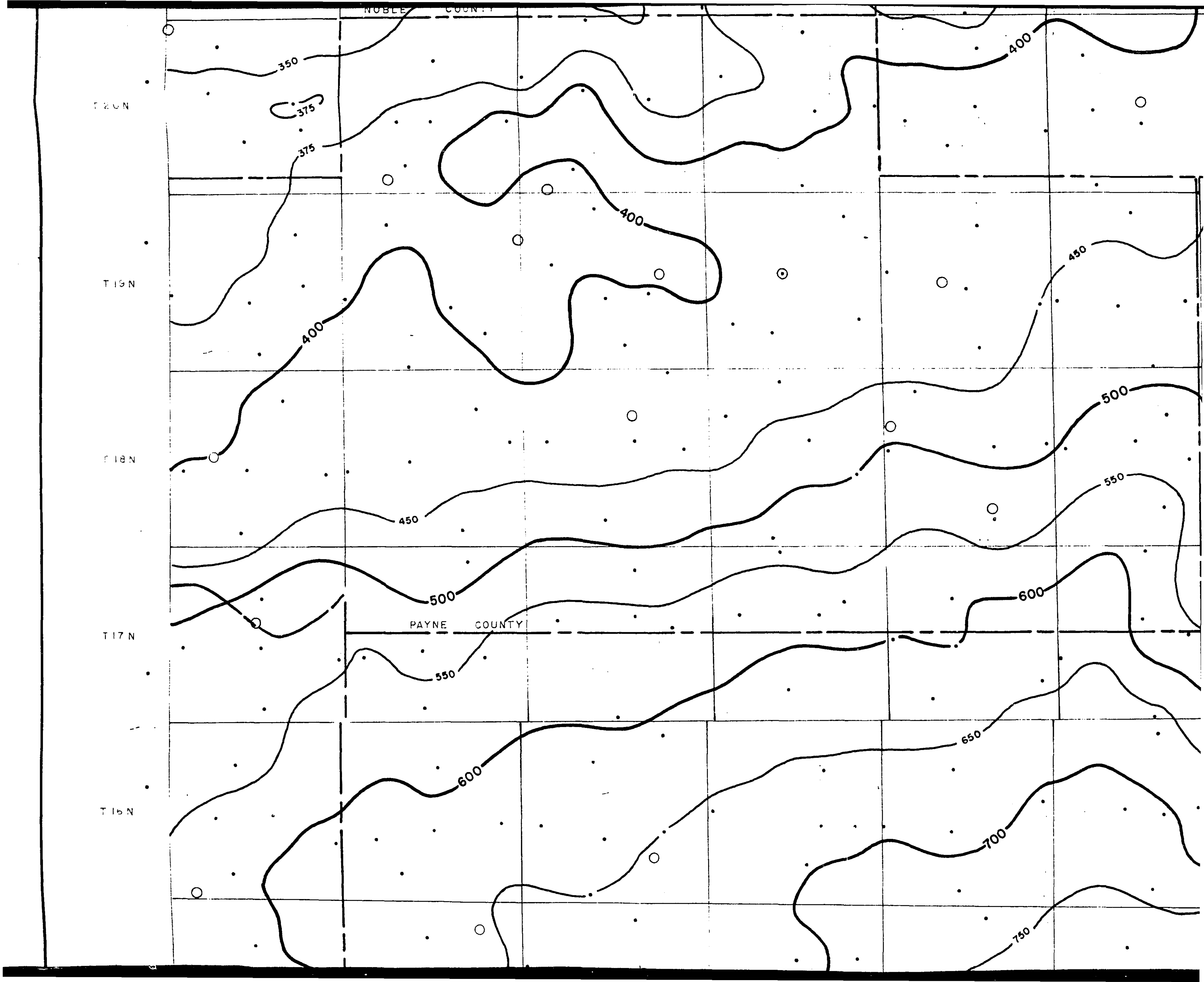
R6E
R7E
R8E
R9E
R10E
T29N
T28N
T27N
T26N
T25N
300
325
325
350
325
375
400
350
350
325



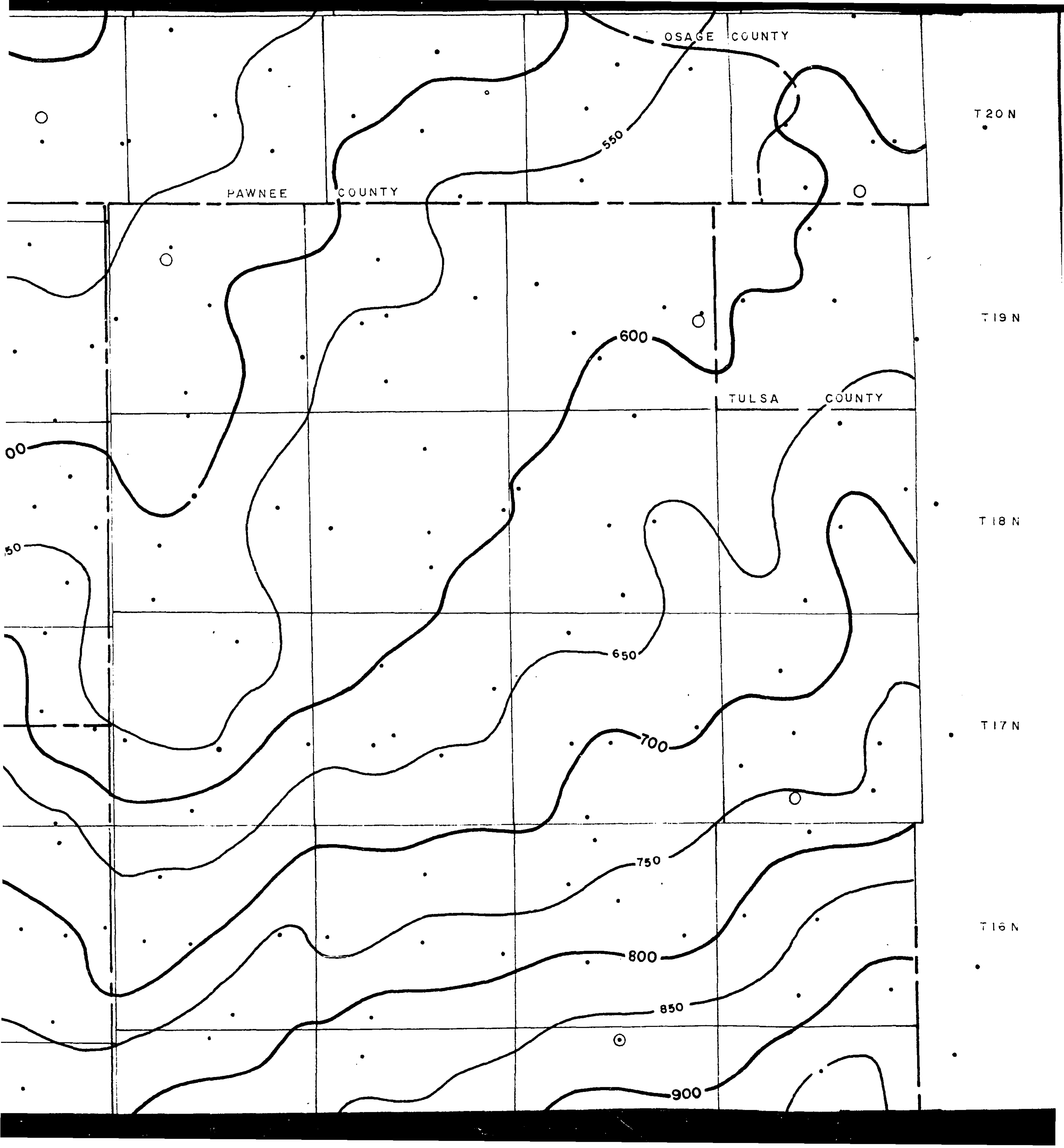
T25N
T24N
T23N
T22N
T21N
KAY COUNTY
NOBLE COUNTY
375
350
350
375
325
350
325
325
300
350
325
375
350
400



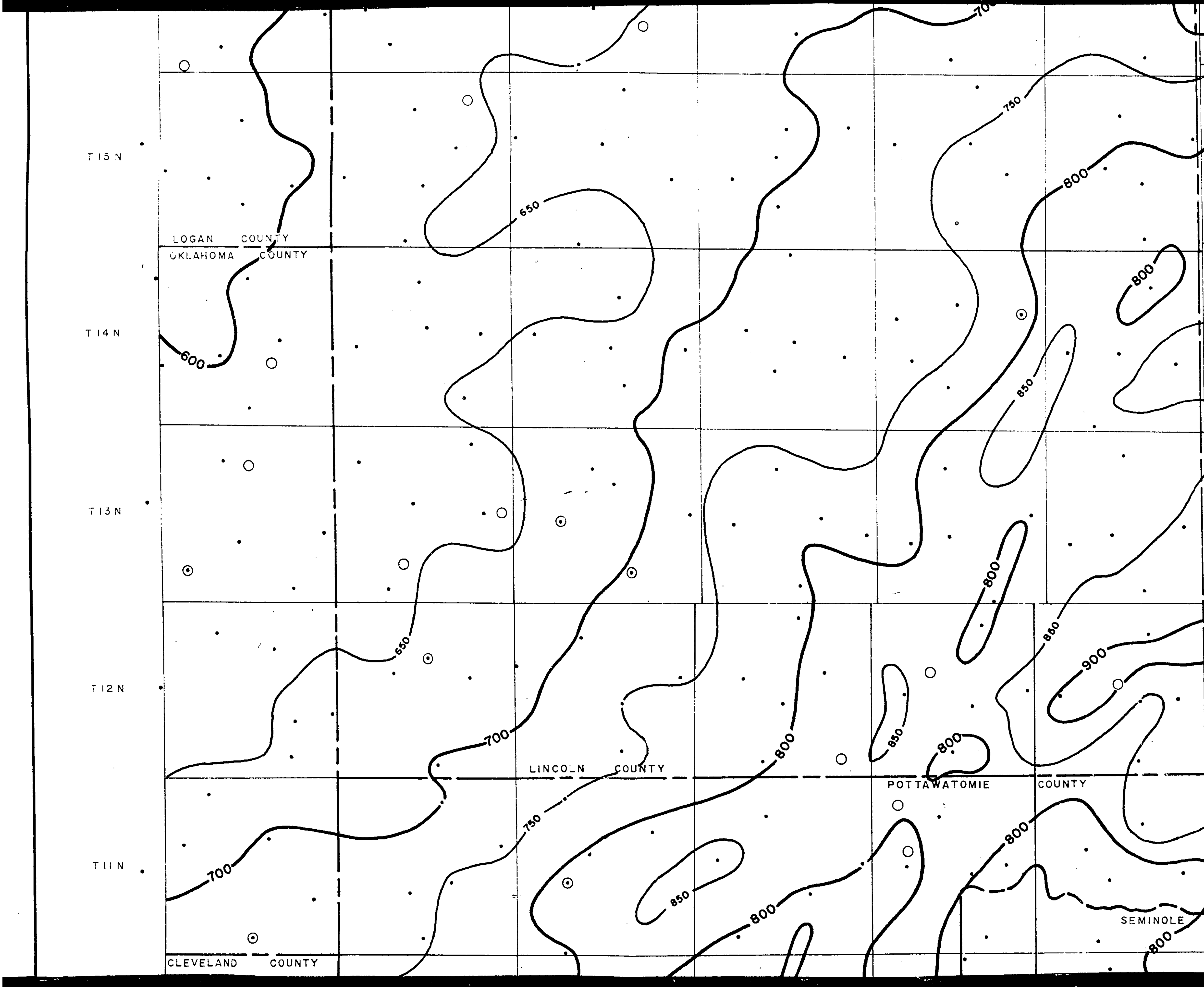
400
375
450
500
OSAGE COUNTY
T 25 N
T 24 N
T 23 N
T 22 N
T 21 N

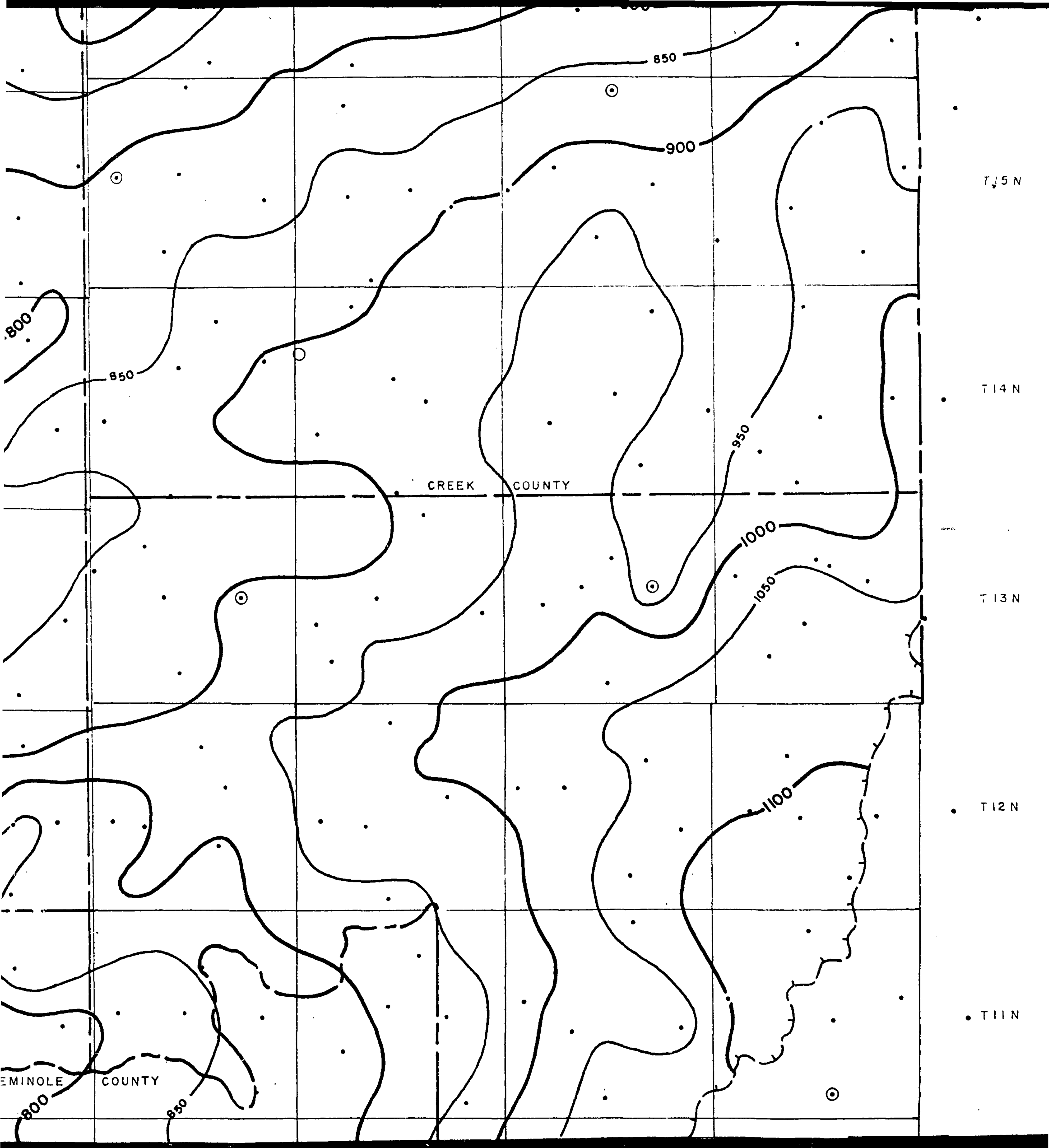


NOBLE COUNTY
350
375
375
400
400
400
450
450
500
500
550
550
600
600
650
700
750
PAYNE COUNTY
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N



OSAGE COUNTY
PAWNEE COUNTY
TULSA COUNTY
T20N
T19N
T18N
T17N
T16N
550
600
650
700
750
800
850
900


T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
LOGAN COUNTY
OKLAHOMA COUNTY
LINCOLN COUNTY
POTTAWATOMIE COUNTY
CLEVELAND COUNTY
SEMINOLE
600
650
650
700
700
700
750
750
800
800
800
800
800
800
800
800
850
850
850
850
850
900


850
900
800
850
950
CREEK COUNTY
1000
1050
1100
EMINOLE COUNTY
800
850
T15N
T14N
T13N
T12N
T11N

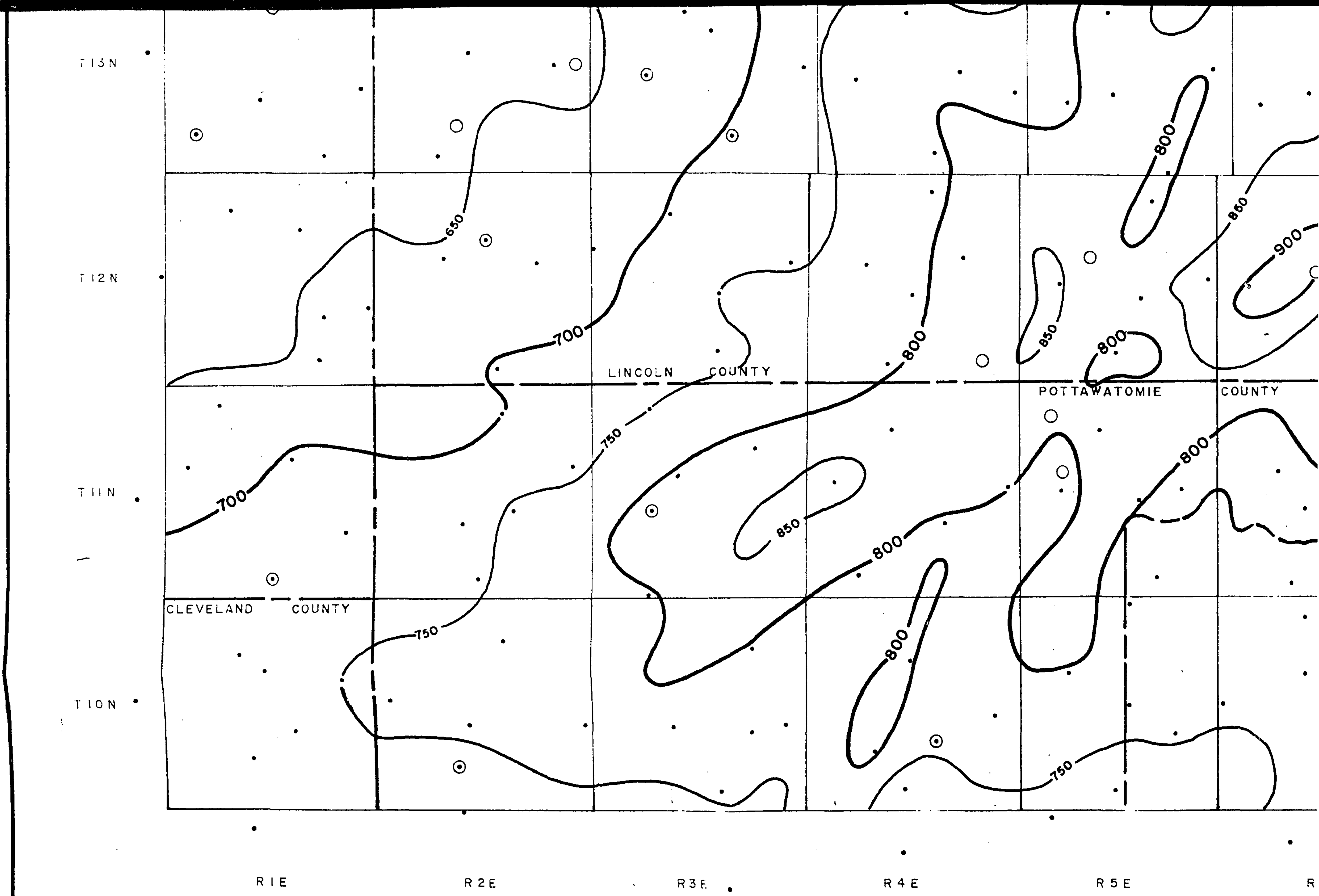
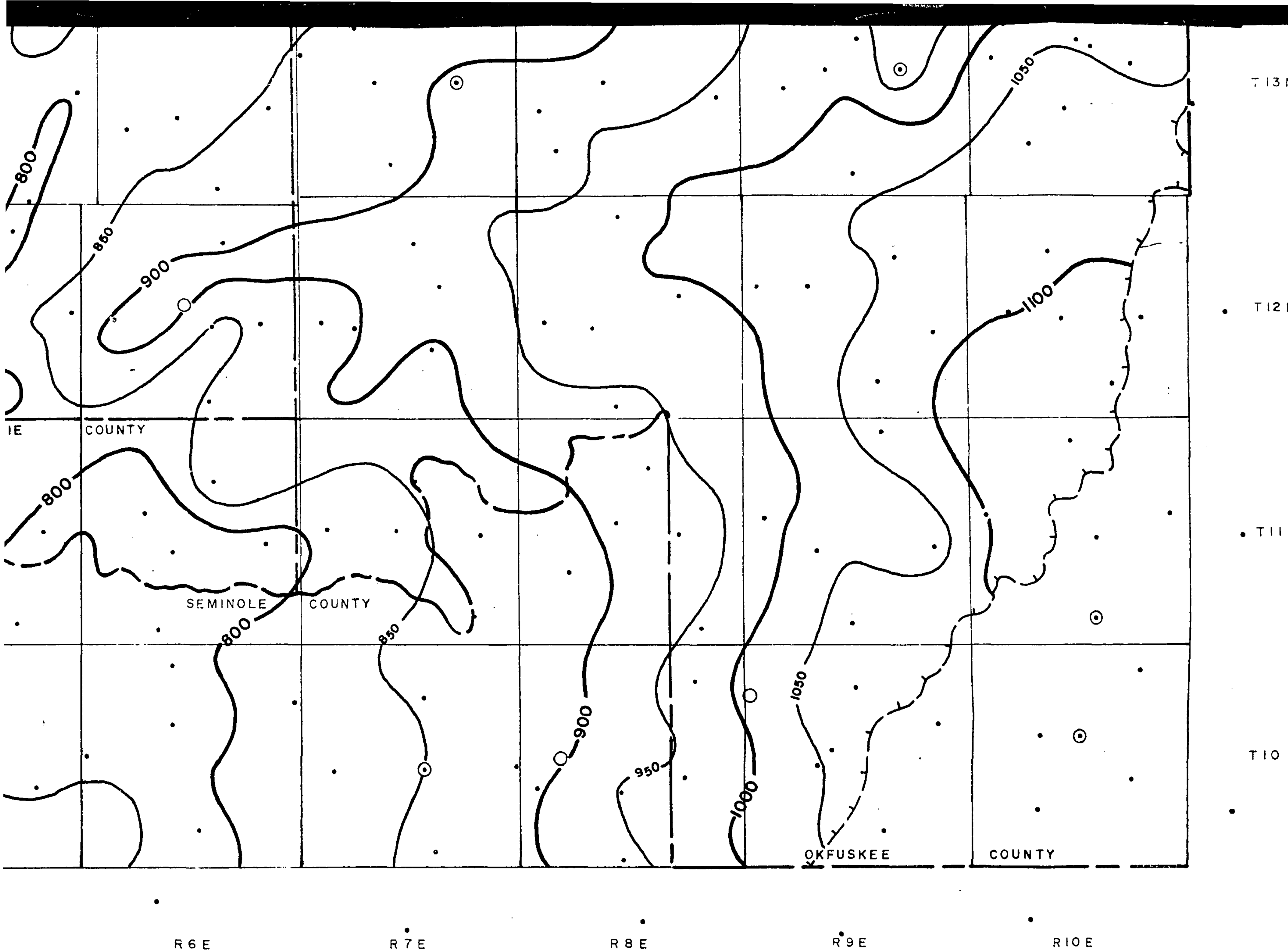


PLATE XIX

MARMATON GENETIC SEQUENCE OF STRATA



T13N
T12N
T11N
T10N
800
850
900
1050
1100
IE COUNTY
800
SEMINOLE COUNTY
800
850
900
950
1000
1050
OKFUSKEE COUNTY
R6E
R7E
R8E
R9E
R10E

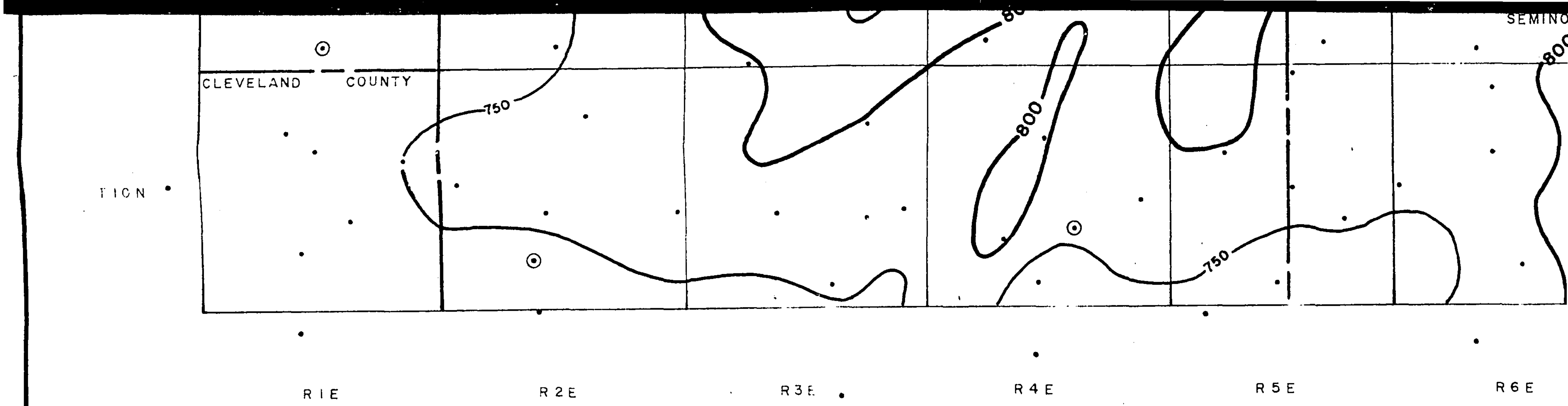


PLATE XIX

MARMATON GENETIC SEQUENCE OF STRATA

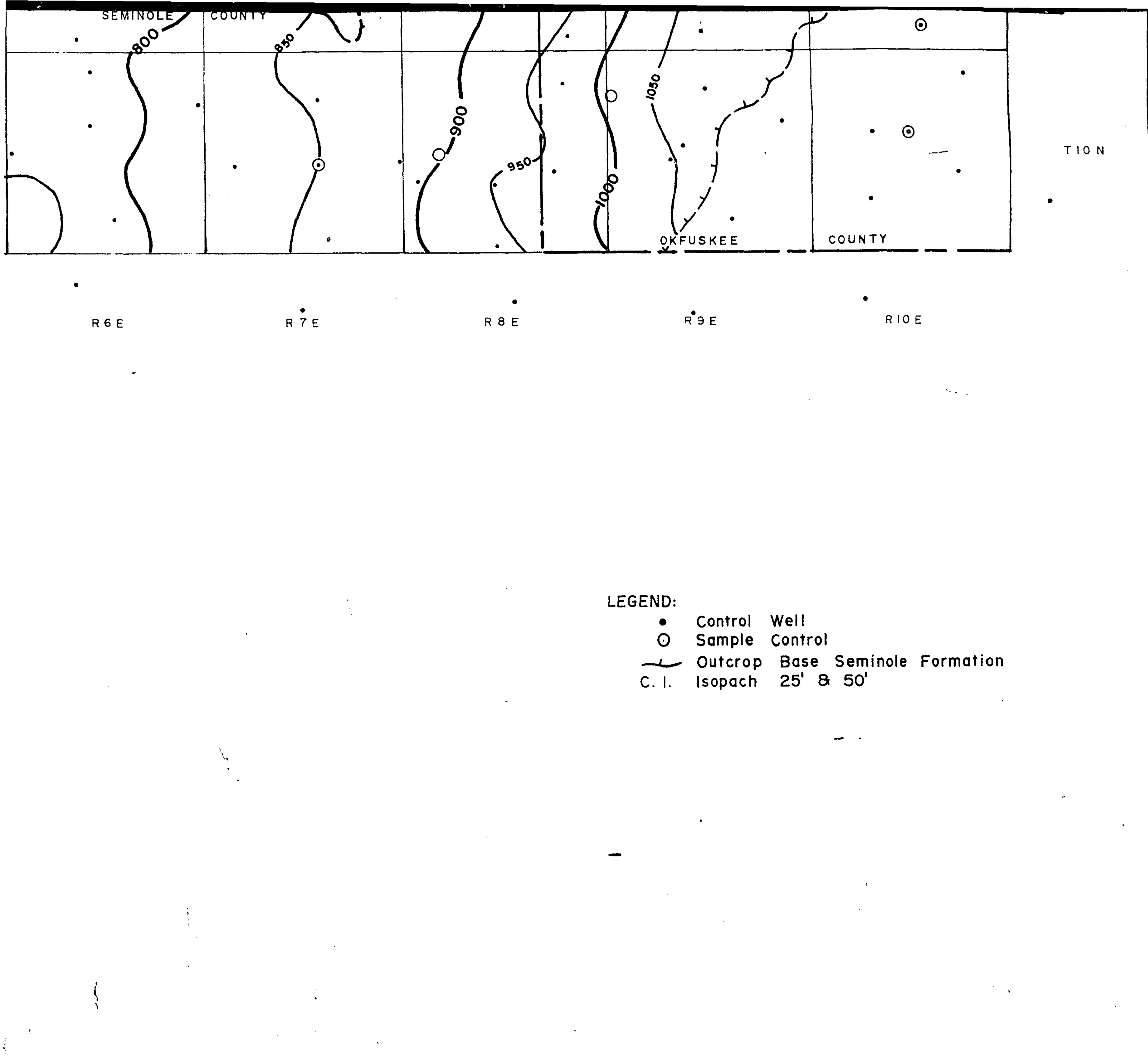
ISOPACH MAP

by

J. Glenn Cole Ph. D. 1968

0 6 12 miles

Scale


SEMINOLE COUNTY
800
850
900
950
1000
1050
OKFUSKEE COUNTY
TION
R6E
R7E
R8E
R9E
R10E
LEGEND:
Control Well
Sample Control
Outcrop Base Seminole Formation
C. I. Isopach 25' & 50'