THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

PALEOTOPOGRAPHY OF THE PRECAMBRIAN SURFACE OF NORTHEASTERN OKLAHOMA

A THESIS

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degree of

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BY

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CHAPTER I

INTRODUCTION

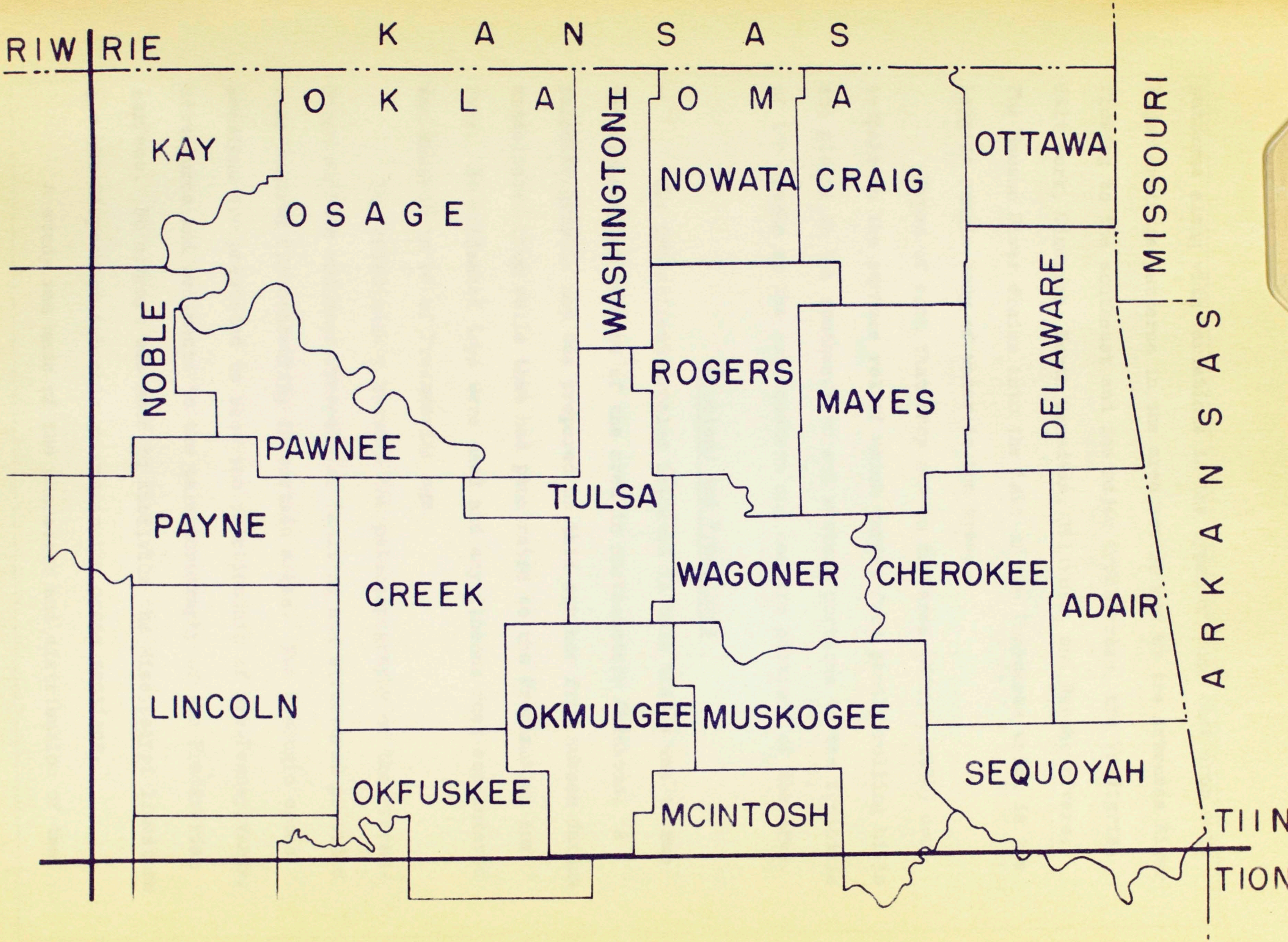
The Precambrian surface of northeastern Oklahoma represents a relatively untouched major geologic horizon with unlimited economic and academic possibilities for study. Today, many of the major oil companies are carrying out extensive research programs dealing with the investigation of this horizon. Petroleum reserve possibilities exist in the Arbuckle group, Reagan sandstone, and granite wash of northeastern Oklahoma. These potential horizons are all significantly influenced by the paleotopography of the Precambrian surface.

Location of the Area

The area covered by this study is located in northeastern Oklahoma and extends from the west line of Range 1 East, eastward to the Oklahoma-Arkansas state line, and from the north line of Township 10 North, northward to the Oklahoma-Kansas state line. The total area includes approximately 16,281 square miles of the state of Oklahoma (Fig. 1).

Geography

Surface features of the area are attributed to major drainage



LOCATION MAP

patterns along with variations in the types of rock that crop out. Major drainage patterns in the area are formed by the Arkansas River flowing to the southeast and its major tributaries, the Verdigris, Salt Fork, Cimarron, North Canadian, Illinois, and Neosho rivers. The Neosho River drains into the Lake of the Cherokees which is the largest single body of water in the area.

Types of rock that crop out in the area (Miser, 1954) contribute to the surface relief which varies from gently rolling hills and plains in the southwestern and western portions to the foothills of the Ozarks in the northeastern and eastern portions of the area.

Problems and Procedures

The pre-eminent problem involved in this thesis was to map the Precambrian surface of the area in northeastern Oklahoma. A paleotopographic map was prepared on this surface from subsea datums established from wells that had penetrated to the Precambrian surface. No estimated tops were used and any igneous rock encountered was assumed to be of Precambrian age.

The relationship between the paleotopography of the Precambrian surface and post-Precambrian faulting and structures provided some control for contouring in certain areas. Two geologic cross sections are presented to show the relationship of pre-Pennsylvanian structures and sediments to the paleotopography of the Precambrian surface. No attempt was made to subdivide the Mississippi limestone nor the Simpson or Arbuckle groups in the cross sections.

A study was made of the character and distribution of the

Reagan sandstone.

The data used in this study have been compiled by the writer and by men familiar with the area. The size of the area involved and the rarity of wells drilled to the Precambrian made the search for these data even more difficult. Much of the data were taken from Oklahoma Geological Survey bulletins dealing with counties in the area under study. Published lists of wells drilled to the Precambrian surface in Oklahoma added considerably to the amount of information. Well samples were available on some of the wells. Some sample logs were available along with a few electric logs of recent wells. The electric logs of scattered wells were of little value to the problem other than in determination of formation tops. The drillers logs of the Oklahoma State Corporation Commission were used also as a source of information.

The Precambrian outcrop near Spavinaw, Oklahoma, was visited to check field work done by others and to observe the outcrop of the surface under study (Fig. 6).

Since the thesis is a regional study with limited control, many features have not been shown; however, the regional interpretation is believed to be correct. Portions of the area were entirely without well control and through these areas the contouring was done mostly on a mechanical basis. Regional and local influences were taken into account in mapping these areas along with the attitude of the overlying beds.

CHAPTER II

REGIONAL STRATIGRAPHY

General Statement

The discussion of the stratigraphy includes the Mississippi limestone down to and including the Precambrian rocks. The descriptions of pre-Simpson beds are based primarily on the published work of Ireland (1944), supplemented by information obtained from this study and other sources as indicated.

PALEOZOIC ERA

MISSISSIPPIAN SYSTEM

Osagian Series

Mississippi Limestone

The Mississippi limestone is a series of limestones and cherts (Dott, 1941). At most localities the cherts are found in the upper part of the formation whereas toward the middle the formation darkens in color and becomes shaly. Coarse to finely crystalline limestones are found in the lower part of the formation.

The Mississippi limestone is composed predominantly of Osagian sediments; however, the Mississippi limestone may include younger sediments in parts of the thesis area. This formation is a rather uniform sequence throughout northeastern Oklahoma and, although the top is an erosional surface, many of its structures reveal the paleotopography of the Precambrian surface (Figs. 11, 12).

Kinderhookian Series

Chattanooga - Woodford Shale

Woodford shale is the subsurface equivalent of the Chattanooga shale. Subsurface terminology will be used for this interval in the thesis.

This formation is a black to brownish black, spore-bearing, hard shale. It has a characteristic brown streak, is slightly radioactive, and contains some pyrite. The thickness of the formation is rather consistent across northeastern Oklahoma (Figs. 11, 12).

Post-Hunton pre-Woodford time is represented by an unconformity at the base of the Woodford shale. In some areas the Misener sandstone is found below the Woodford shale; however, its occurrence is sporadic. The Woodford covers the entire area except where it is absent due to erosion or non-deposition (Fig. 2).

DEVONIAN-SILURIAN SYSTEMS

The Hunton limestone represents the Devonian-Silurian systems and is present in the southern and southwestern portions of the thesis area (Fig. 2). In the upper part the Hunton is a finely crystalline limestone whereas the middle is dolomitic and darker in color. At the base the limestone becomes more porous, sucrosic, and dolomitic. The Hunton conformably overlies the Sylvan shale, while the Misener sandstone or the Woodford shale unconformably overlies the Hunton.

ORDOVICIAN SYSTEM

Cincinnatian Series

Sylvan Shale

This is a light to dark green shale which is present in the area under study only in the southern and southwestern portions (Fig. 2).

Viola Limestone

The Viola limestone is a coarsely crystalline limestone in the upper portion grading downward into a gray, finely cyrstalline to sub-lithographic limestone in the lower part. The Viola is present in the area under study only in the southern and southwestern portions (Fig. 2).

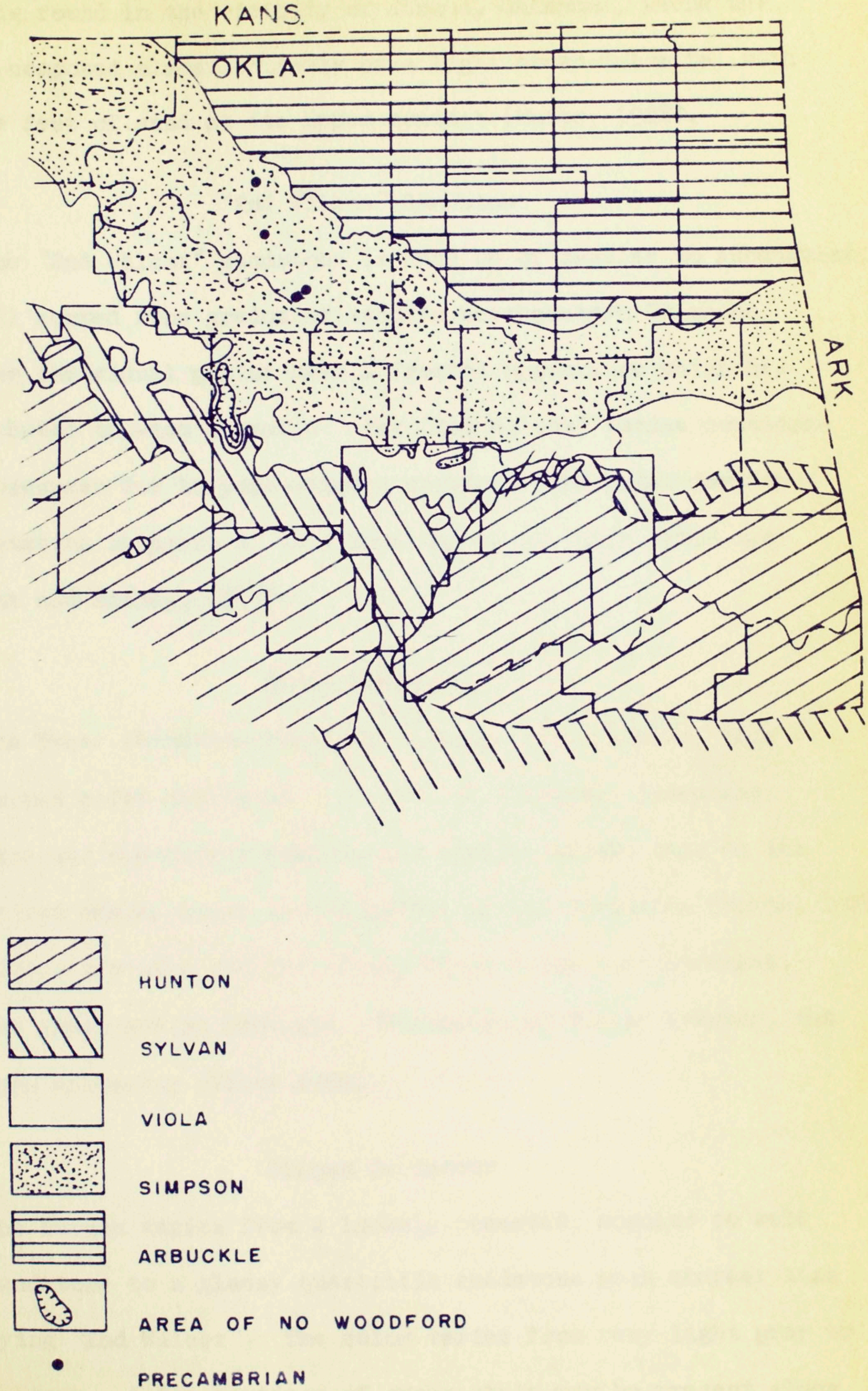
Champlainian Series

Simpson Group

The Simpson group of northeastern Oklahoma consists of, in descending order, the Simpson "Dense" limestone and Simpson dolomite, "2nd Wilcox" sandstone, Tyner formation, and the Burgen sandstone (Cronenwett and Disney, 1955).

Simpson "Dense" Limestone and Simpson Dolomite (undifferentiated)

In northeastern Oklahoma this is a series of brown or gray sandy dolomitic limestones interstratified with some green shale and thin sandstone members (White, 1928). A near maximum thickness of



PRE-WOODFORD PALEOGEOLOGIC MAP

AFTER TARR

FIGURE 2

140 feet is found in the vicinity of Stroud, Oklahoma, where the series is composed almost entirely of a light brown dolomite, with about five feet of sand at its upper contact (White, 1928).

"2nd Wilcox" Sandstone

The "2nd Wilcox" sandstone is made up of angular to subangular, fairly well sorted fine grains of sand in northeastern Oklahoma. Many of the individual grains have a frosted appearance which has been attributed to wind abrasion. The "2nd Wilcox" varies considerably in thickness due to post-Simpson erosion. The basal portion of the formation in parts of this area may be of Tulip Creek age (Cronenwett and Disney, 1955).

Tyner Formation

The Tyner formation consists of sandy green shales, thin sandstones and a few scattered thin beds of dolomitic limestone. Both surface and subsurface samples are similar except that in the subsurface red shales occur in the middle of the formation (White, 1928). South of Tulsa the sand content of the Tyner formation increases, whereas the green shales decrease. Northwest of Tulsa; however, the base is more dolomitic (White 1928).

Burgen Sandstone

The Burgen varies from a loosely cemented, angular to well rounded sandstone to a glassy quartzitic sandstone much coarser than the overlying "2nd Wilcox". The color varies from very light gray to yellowish brown. A few partings of green shale may be present along with pyrite (White, 1928). The Burgen is believed to be basal Oil Creek in age (Cronenwett and Disney, 1955).

Canadian Series

Arbuckle Group

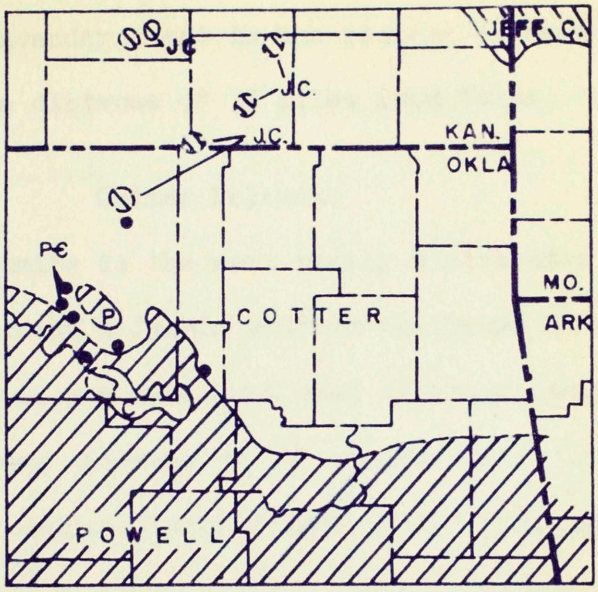
General Statement

The Arbuckle group includes those beds of dolomite that are of pre-Simpson post-Lamotte age. Unconformaties are present at both the top and bottom of the group and in addition, six unconformities occur within the group.

The Arbuckle group has been subdivided mainly on the basis of the dominant characteristics of the various formations and members. The percentage and type of insoluble residue, and sequence of beds have also been taken into consideration. The characteristics are not infallible however, and recognition of the residues is not always conclusive proof for the identification of the formations of the group. The nomenclature within the group is based on the Missouri type section (McQueen, 1931).

Powell Dolomite

Much of the Powell dolomite has been removed by post-Arbuckle pre-Simpson erosion (Fig. 3) in northeastern Oklahoma. This unconformity marks the top of the formation whereas the base is unconformable upon the underlying Cotter dolomite. Thickness of the formation ranges from zero to 220 feet and it is the youngest unit of the Arbuckle group.



POST-ARBUCKLE PRE-SIMPSON

PALEOGEOLOGY

AFTER IRELAND

FIGURE 3

COTTER DOLOMITE

JEFFERSON CITY DOLOMITE

POWELL DOLOMITE

PRECAMBRIAN

A dominant characteristic of the Powell dolomite is the presence of lavender chert in the insoluble residue. The chert is usually smooth, mottled, or oolitic; however, at times it is brown and greasy-looking. Lavender chert in the residue is especially characteristic within a distance of 35 miles from Tulsa, Oklahoma.

Cotter Dolomite

The Cotter dolomite is the most widely distributed unit of the Arbuckle group, maintaining a fairly uniform thickness of approximately 125 to 180 feet except in the area southwest of Craig County, Oklahoma, where the formation thickens to 240 to 270 feet. In certain areas the Cotter thins over structures especially where the Chattanooga shale rests upon the Cotter (Figs. 2, 3). This is probably due to the long period of post-Arbuckle erosion.

Characteristic residues of the Cotter dolomite are sandy, translucent, dull, white, oolitic, quartzose varieties of chert and fine varieties of dolocastic fragments, silt aggregates, and porous white, light green, or brown shale particles. The oolitic and quartzose varieites of chert are found chiefly in the lower half of the formation. Most of the oolites are either brown or white, set in a ground mass of a different color. A frosted appearance is due to the presence of minute quartz prisms over their outer surface. The Swan Creek zone occurs at the base of the Cotter dolomite in most places. It is a very fine sand of uniform grain size and is seldom over twenty feet in thickness. The Swan Creek zone unconformably overlies the Jefferson City dolomite.

Jefferson City Dolomite

The Jefferson City dolomite usually contains from 10 to 50 per cent chert that is brown or tan, smooth, sucrosic or finely crystalline. Sixty to 100 feet below the top of the formation is a consistent dark brown oolitic zone, below which are other minor oolitic zones. Northeast of Vinita, Oklahoma, the Jefferson City dolomite maintains a thickness of approximately 285 to 320 feet. Usually the Jefferson City dolomite is overlain unconformably by the Cotter dolomite, but in a few places post-Arbuckle beds overlie the Jefferson City dolomite (Fig. 3).

Roubidoux Formation

The Roubidoux formation contains from 20 to 40 per cent brown quartzose oolites occuring both in clusters and as individual grains. These oolites mark the top of the formation and occur in minor amounts throughout the formation. Sand zones occur at the top, in the middle, and at the base of the formation. These zones average 15 to 30 feet in thickness and contain as much as 80 per cent sand. The Roubidoux formation varies from approximately 170 feet thick near Vinita, Oklahoma, to 240 feet near Tulsa, Oklahoma. Unconformities occur at the top and bottom of the Roubidoux. The Roubidoux overlies the Gasconade dolomite.

Either the Roubidoux or upper Gasconade are the oldest beds of the Arbuckle group that are present over the highland areas on the Precambrian surface of northeastern Oklahoma.

Gasconade Dolomite and Van Buren Formation (undifferentiated)

This sequence, the top of which is marked by the sand at the base of the Roubidoux formation, is characterized by smooth porcelaneous chert with small dolocasts which are predominantly dark gray in color. A zone of cryptocrystalline chert often occurs approximately 50 feet below the top of this sequence and has been referred to as the top of the lower Gasconade by the Missouri Geological Survey (McQueen, 1931).

Southwest of Craig and Ottawa counties beds of middle Gasconade and older are not present over the high areas. However, in the deeper valleys and towards the southwest these older beds flank the highlands.

The Gunter member is found at the base of the Van Buren formation and is essentially a sandy dolomite which marks the base of the Ordovician system and rests unconformably upon the Eminence dolomite of Cambrian age.

CAMBRIAN SYSTEM

Croixian Series

Eminence Dolomite

The uppermost formation of the Cambrian system, the Eminence, is characterized by residues made up predominantly of pyrite with some finely crystalline chert, dolocastic chert, and oolites. The residue makes up less than one per cent of the total sample. Glauconite, which is a characteristic marker of the Cambrian portion of the Arbuckle group, is found in the Eminence dolomite but not in any abundance. The Eminence has been found in wells in Ottawa and Craig counties and from there it thickens into southwest Missouri. Unconformities mark the top and bottom of the formation, which rests upon the underlying Bonneterre dolomite in Oklahoma.

Potosi, Derby, Doerun, and Davis Formations

These formations, present in Missouri and equivalent to portions of the Arbuckle group, are not found in Oklahoma.

Bonneterre Dolomite

The Bonneterre dolomite is characterized by a residue made up predominantly of sand and silty, glauconitic shale particles. Upper portions of the Bonneterre contain less and finer amounts of residue. The clastics increase downward in the section resulting in a basal bed of sandstone ranging from 20 to 40 feet in thickness and grading into the Lamotte-Reagan sandstone below. This member of the Arbuckle group thins westward from the northeast corner of Oklahoma. The basal formation of the Arbuckle group, the Bonneterre has unconformable surfaces both at the top and bottom.

Reagan Sandstone

The type Reagan sandstone outcrop is in the Arbuckle Mountains of southern Oklahoma. Geologists who have worked in northeastern Oklahoma have applied the term Reagan sandstone to a "basal sandstone" overlying the Precambrian surface and believed to be of Cambrian age (Brant, 1953). Recent studies have shown that the

Reagan should now be identified as a "basal sandstone" in northeastern Oklahoma overlying the Precambrian surface and believed to be of Cambro-Ordovician age. This will be explained later.

In northeastern Oklahoma this formation is a fine, well sorted, greenish white, yellowish white, or white sandstone (Brant, 1953) containing minor amounts of glauconite and arkose. Some of the individual grains may have a frosted appearance. The Reagan rests with great unconformity upon the Precambrian surface and grades upward into sandy dolomitic limestones of the Arbuckle group.

The Reagan sandstone of northeastern Oklahoma is very likely a "basal sandstone" similar to the "basal sandstone" of Kansas described by E. A. Koester (Koester, 1935; Dott, 1941). A transgressive deposit of varying age, the "basal sandstone" of Kansas overlies the Precambrian surface and locally in southeastern Kansas is a direct equivalent to the Lamotte sandstone of Missouri of Croixian age. Farther west on the Central Kansas uplift this "basal sandstone" occurs higher in the section and is Canadian in age.

The Lamotte sandstone of Cambrian age in Missouri extends into northeastern Oklahoma as a "basal sandstone" overlying the Precambrian surface. This formation contains considerable arkosic material in the form of pink, gray, green, and black feldspar fragments in the basal part. These fragments are sometimes found in the form of kaolinized pebbles. This zone varies in thickness from 5 to 50 feet and grades into a white sandstone above. Grain size is medium to coarse and irregular due to secondary growth and the individual grains have a frosted appearance. Upward in the section the Lamotte becomes finer and grades into the basal sandstones of the overlying Bonneterre dolomite.

If the Reagan sandstone of northeastern Oklahoma is a time-transgressing unit that rests upon the Precambrian surface, then, like the "basal sandstone" of Kansas, it should be a direct equivalent to the Lamotte or to parts of it, especially to the basal sediments in the northeast portions of the thesis area. If this is the case, then the Reagan of the northeast portion of the thesis area should be younger than the Reagan reported to the southwest.

Evidence that the Reagan transgresses time units is shown in the stratigraphic diagram (Fig. 4). Five wells located in a general northeast-southwest direction across northeast Oklahoma encounter the Reagan sandstone at different stratigraphic intervals. In the southwest part of the thesis area in T. 17 N., R. 10 E. the Reagan lies below the Roubidoux formation. Toward the northeast the Reagan occurs lower in the section and in T. 20 N., R. 13 E. it is found underlying sediments of probable Eminence age. From T. 20 N., R. 13 E. the Reagan occurs higher in the section, and in T. 22 N., R. 15 E. it lies beneath the Jefferson City dolomite of Ordovician age. From T. 22 N., R. 15 E. the Reagan must be in contact with Roubidoux, Gasconade-Van Buren, Eminence, and Bonneterre sediments toward a well in T. 25 N , R. 20 E. that encountered Bonneterre dolomite on Lamotte sandstone, which is thought to be a unit equivalent to the Reagan in this area, especially to the basal part. This would date the Reagan in this well as Cambrian, whereas in the other wells it is Ordovician or possibly Cambrian in age, being either pre-

STRATIGRAPHIC DIAGRAM
SHOWING TIME TRANSGRESSION
OF THE REAGAN SANDSTONE IN
NORTHEASTERN OKLAHOMA

DATUM: TOP OF JEFFERSON CITY DOLOMITE

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FIGURE 4

ACFD

Jefferson City, pre-Roubidoux, or pre-Eminence. The Reagan occurs higher in the section from T. 25 N., R. 20 E. until in T. 28 N., R. 22 E. it again underlies the Roubidoux.

Ireland (1944) refers to the Reagan sandstone in each of the wells as igneous detrital and did not attempt to correlate it as a rock unit. It is believed that the Reagan sandstone can be correlated as a rock unit which transgresses time lines as shown by the diagram and explained above.

Reagan sandstone is a characteristic bed found below many of the beds of the Arbuckle group. The source of the Reagan was the progressive disintegration of the Precambrian igneous rocks. As the Cambro-Ordovician seas advanced, streams with loads of sediments deposited them at the edge of the sea, there to be reworked and redeposited by wave and current action on the Precambrian erosional surface.

The Reagan sandstone has been identified overlying the Precambrian surface in the Cities Service Oil Company No. 5 Farley, SW NE NW, sec. 19, T. 11 N., R. 2 W. at Oklahoma City (Moore, Carl A., personal communication, 1955). The Reagan in this well was described as a clear, glassy, light gray, conglomeratic sandstone containing quartz grain aggregates and cemented with silica. Near the top of the Reagan, glauconite and calcite were logged. Eight feet into the formation, a clear, glassy, porous sandstone was logged that contained some rounded and frosted, largely disaggregated sand grains. This sample contained profuse glauconite which very likely would date the Reagan in this area as Cambrian. Towards the base of the Reagan the sandstone is almost entirely disaggregated with increasing amounts of arkosic material.

It is possible that the Reagan may eventually be correlated as a unit of the basal portions of the type Reagan of southern Oklahoma.

PRECAMBRIAN

The Precambrian of northeastern Oklahoma was exposed to erosion for an unknown interval of geologic time. This interval is represented by a major unconformity over the Precambrian surface. Igneous pebbles that have been partially kaolinized (Fig. 8) from exposure are encountered near the Precambrian surface in the overlying sediments. These indicate the unconformable contact with the overlying paleozoic sediments.

Rocks of Precambrian age are not all granite in northeastern Oklahoma. Quartzite, schist, and gneiss have been identified in well cuttings. Haworth (1915) and Landes (1927) both report from their petrographic examinations that metamorphic rocks are more common in southern Kansas. Croneis (1930) reported rhyolite and syenite from wells in Arkansas.

The granite that is encountered in the well cuttings in northeastern Oklahoma is,in most instances,a pink, coarse grained igneous rock consisting mostly of orthoclase feldspar, quartz, and black flecks of hornblende. It is very similar to the Spavinaw granite, near Spavinaw, Oklahoma (Ireland, 1930). Occasionally black varieties of "granite" are reported in well cuttings.

The Spavinaw granite is probably typical of the Precambrian surface below northeastern Oklahoma. This granite appears to be a coarse grained igneous rock consisting predominantly of orthoclase feldspar with black flakes of magnetite and hornblende scattered through it. Megascopically the quartz constituents that place the rock in the classification of a granite cannot be seen, therefore, upon first observation the rock appears to be a syenite. Some portions of the granite are green in color, especially in the vicinity of exposure number three (Fig. 7).

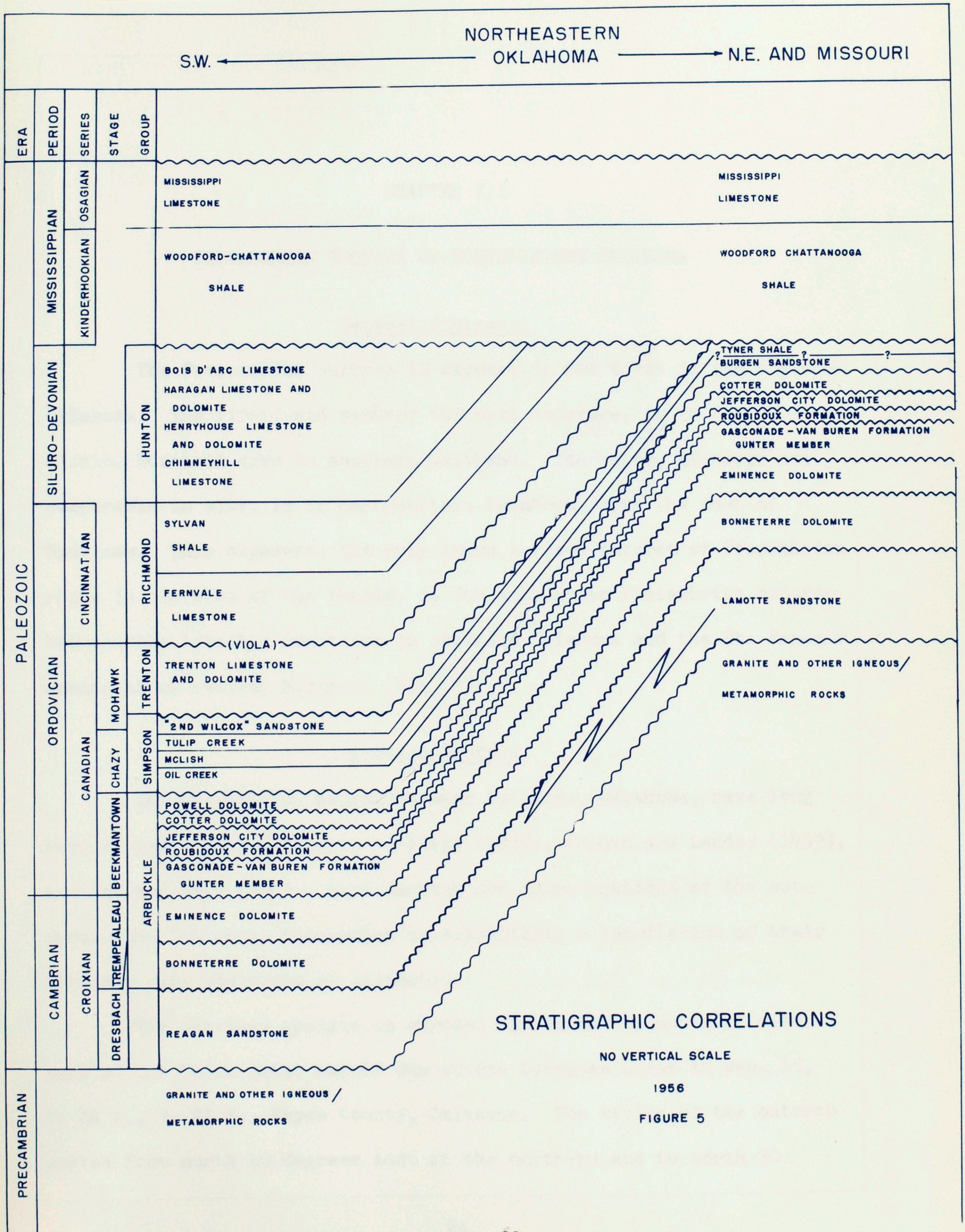
Microscopically (Ireland, 1930), the predominant minerals making up the Spavinaw granite are orthoclase and plagioclase feldspars, quartz, chlorite and magnetite. Hornblende and epidote occur in minor amounts. The structure is of a granophyric and micropegmatitic nature. An intergrowth of quartz exists throughout most of the feldspar crystals in a radiating or alternating manner in each individual crystal. The included quartz plates or prisms show a similar orientation. Quartz does not occur often in the larger crystals and it seldom shows its outline.

Orthoclase is the predominant feldspar and anhedral phenocrysts of feldspar are abundant. A reddish color and fine granular appearance is characteristic of the feldspars. Small opaque masses of magnetite occur in groupings giving a blended appearance to the crystals. Many of the masses of magnetite show crystal outlines. Greenish bands of chlorite are common along with spherular aggregates and minute particles of chlorite . Epidote is rather common.

Chemical Analysis of Spavinaw Granite (Dr. N. F. Drake, 1898)

	per cent
Silica (SiO_2)	71.10
Ferric oxide and alumina (Fe_2O_3)	20.60
Calcium oxide (CaO)	2.53
Magnesium oxide (MgO)	.99
Sodium and Potassium oxides (Na_2O,K_2O)	3.76
Loss on ignition	1.11
Total	100.09

A petrographic analysis of the Spavinaw granite by Roth (Ireland, 1930), shows it is between an "alkali granite" and a syenite. Quartz is abundant in the thin section. This accounts for the large per cent of silica in the chemical analysis above. Soda feldspars are predominant and are altered to kaolinite-like material. Ferromagnesium silicates are, for the most part, an arfvedsonite variety of hornblende along with augite. The hornblende gives blue and green tones. These femics are quite well altered. The characteristics seem to be homogeneous throughout. The texture of the rock is hypidiomorphic which is indicative of deep seated consolidated rocks. The basic secretions separating out from this "acid syenite" are composed largely of hornblende and some augite. White mica is present along the twinning plains of the feldspar.



STRATIGRAPHIC CORRELATIONS

NO VERTICAL SCALE

1956

FIGURE 5

CHAPTER III

PRECAMBRIAN SURFACE OF NORTHEASTERN OKLAHOMA

General Statement

The Precambrian surface is exposed in two areas in the state of Oklahoma. The first, and perhaps the best exposure, is in the Arbuckle-Wichita Mountain area in southern Oklahoma. The other, although not comparable in size, is in northeastern Oklahoma, near the town of Spavinaw. This exposure, the only known surface outcrop of Precambrian rocks in the area of the thesis, is the only known Precambrian outcrop between the Arbuckle mountains in southern Oklahoma and the St. Francis mountains of central Missouri (Fig. 9).

Exposed Surface

The Precambrian exposures near Spavinaw, Oklahoma, have long been of geological interest. Ireland (1930), Tolman and Landes (1939), and Ham and Dott (1943), have carried out investigations of the outcrop. The following discussion is essentially a compilation of their findings plus additions as indicated.

The Spavinaw granite is exposed approximately one-half mile west of the Tulsa water supply dam across Spavinaw Creek in sec. 15, T. 22 N., R. 21 E., Mayes County, Oklahoma. The strike of the outcrop varies from north 40 degrees east at the northern end to north 30 degrees east at the southern end.

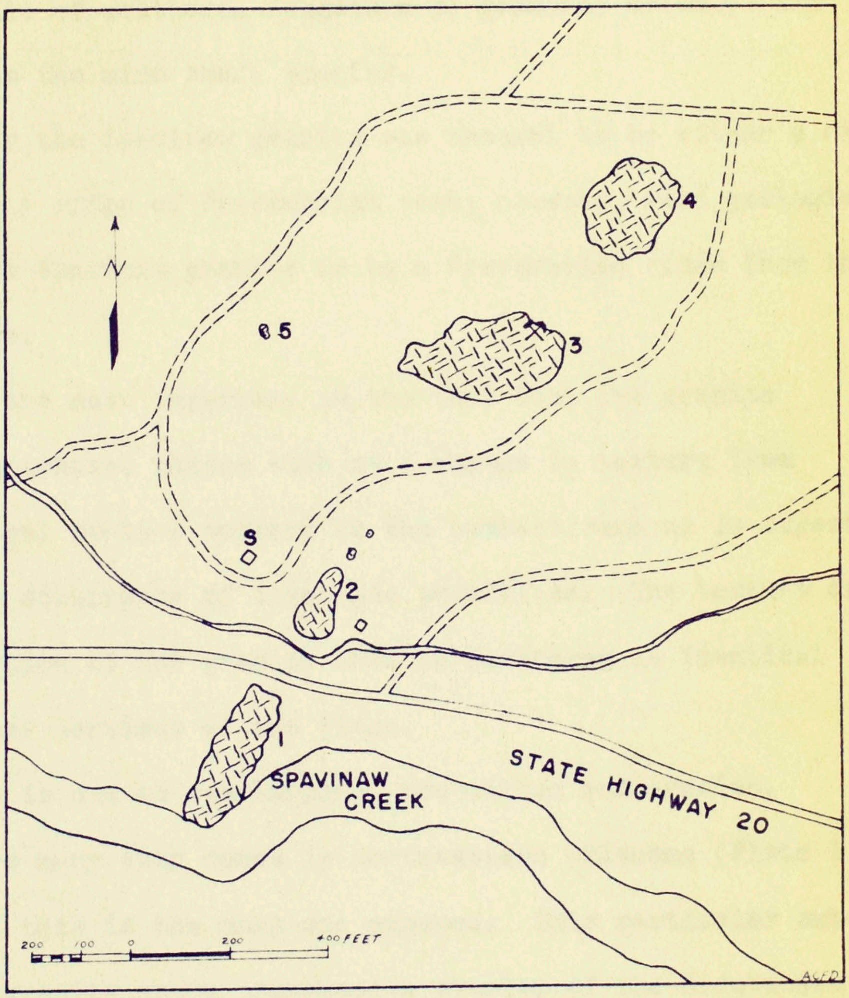
A series of five exposures constitute the Spavinaw outcrop (Fig. 7).

Fig. 6. - Spavinaw Granite Exposure No. 1.

The entire outcrop is a narrow ridge extending 1600 feet in a northeast-southwest direction. There is a zone of intense silicification from ground waters in the overlying Cotter dolomite on both flanks of the ridge and which decreases away from the granite.

Wells drilled in the vicinity of the ridge indicate its position. A well drilled on the east flank near the south end 100 feet away from the outcrop struck granite at a depth of 50 feet. Near the north end on the east flank, weathered granite was encountered in a well at 74 feet. Two-hundred yards east of the outcrop a well was drilled to a depth of 95 feet without encountering granite, whereas a well a few hundred feet west of the granite outcrop failed to reach the granite at a depth of 112 feet.

A government mine shaft was sunk immediately west of exposure



GRANITE OUTCROPS ALONG SPAVINAW CREEK, OKLAHOMA

FIGURE 7

AFTER IRELAND

number two, extending 87 feet to a 9 foot zone of pyrite to be used in the manufacture of sulphuric acid for use in war supplies. Today the shaft is filled with water and an accumulation of trash. There is a small tailings pile of weathered fragments of granite, dolomite and pyrite adjacent to the mine shaft opening.

Originally the Spavinaw granite was thought to be either a dike-intrusion or else a ridge of Precambrian rock; however, most geologists today consider the Spavinaw granite to be a Precambrian ridge from the following evidence.

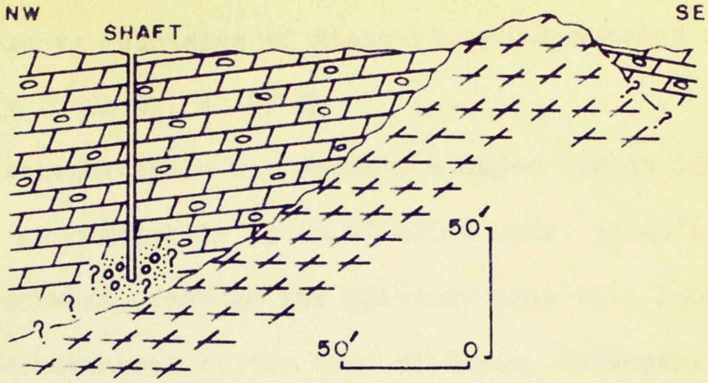
1. Perhaps the most important is the fact that the granite shows no contact phases such as a change in texture from the central portion outward to the contact zone as is expected with the occurrence of dikes and pegmatites. The texture of that portion of the granite that is weathered is identical with other portions of the ridge.
2. Exposure is due to overlapping, truncation and erosion. There are many such domes in northeastern Oklahoma (Plate I); however, this is the only one exposed. This particular outcrop of granite shows progressive overlap of the Ordovician sediments over the high and on to the northeast.
3. A strand line, as would be expected with a Precambrian high, is indicated by an abundance of well preserved fossils near the contact of the granite with the overlying Ordovician dolomite. The abundance of the fossils decreases upward in the stratigraphic column as would be expected.

4. There is no evidence of the common features of an igneous intrusion such as associated sills, dikes, and contact metamorphism. The conglomerates and the quartzites adjacent to the granite are unmetamorphosed. Neither is there evidence of the pneumatolytic action of the hydrothermal gases emanating from the igneous mass. Grahamite and marcasite are abundant next to the granite which is not indicative of temperature that would form in this contact region adjacent to a dike intrusion.
5. Brecciation in the top of the overlying Cotter dolomite appears to be mostly debris along the unconformable contact with the overlying Ordovician green shale instead of broken fragments resulting from igneous intrusions.
6. The presence of detrital feldspar, quartz, and well-rounded pebbles of gray, decomposed granite in the dolomite adjacent to the granite within the mine shaft and also upon the tailings pile (Fig. 8) (Ham and Dott, 1943; Tolman and Landes, 1939).

Paleotopography (Plate I)

The paleotopography of the Precambrian surface of northeastern Oklahoma is largely the result of a long interval of erosion prior to the deposition of Cambrian sediments. Figures 11 and 12 reveal the ruggedness of this surface as the Cambrian seas transgressed over it.

In the physiographic region of the Prairie Plains homocline (Fig. 9) this Precambrian surface has a regional westward slope that



GEOLOGIC CROSS SECTION,
SHOWING RELATION OF
COTTER DOLOMITE TO
SPAVINAW GRANITE

AFTER HAM AND DOTT

COTTER DOLOMITE (CHERTY)

DETRITAL ZONE (CONTAINING GRANITE BOULDERS, ARKOSE LAYERS, AND FROSTED SAND GRAINS)

SPAVINAW GRANITE

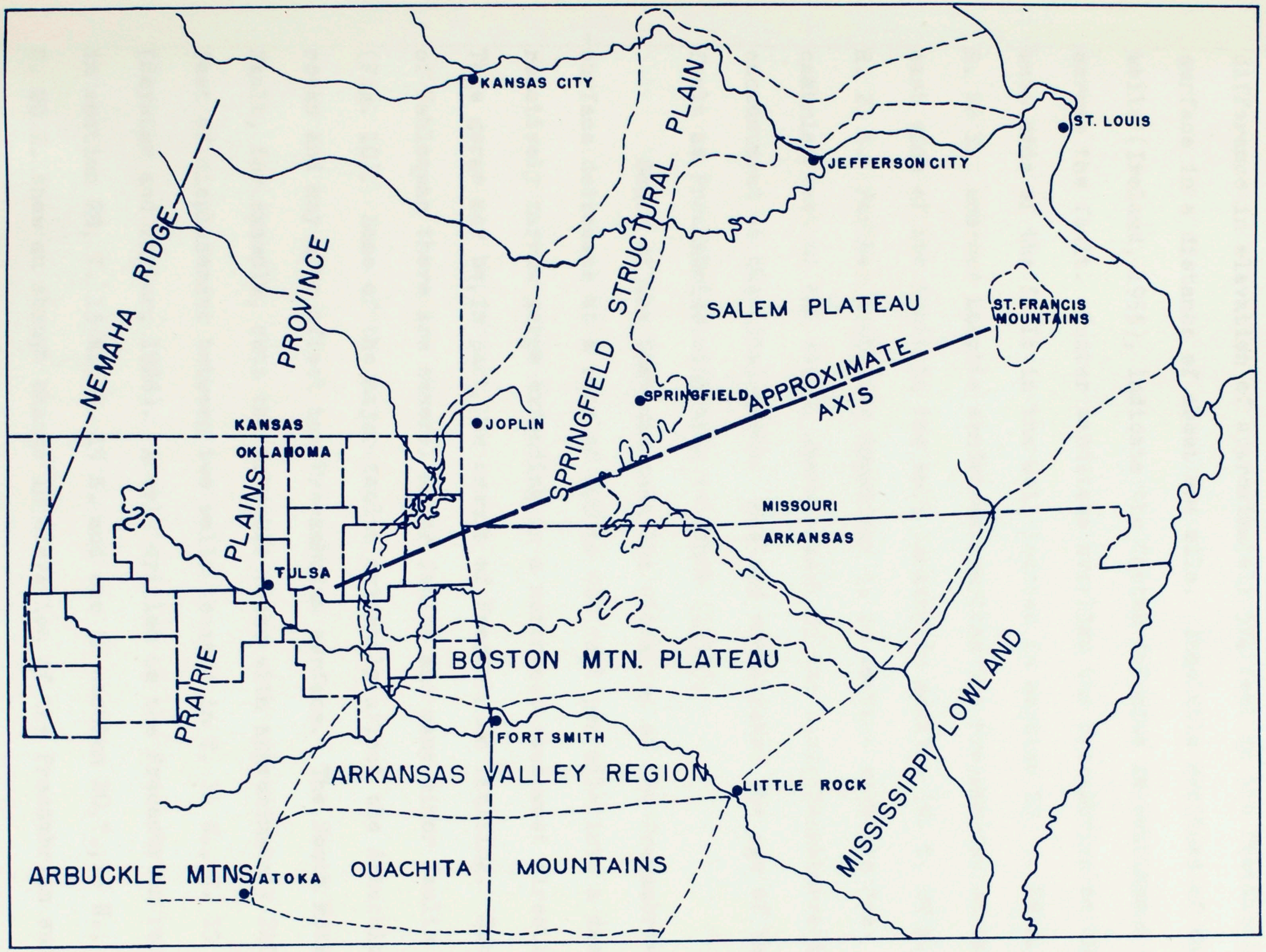
FIGURE 8

is probably a result of an Ozark uplift. The major axis of the Ozark uplift as shown by Taff, Fenneman, and others (Huffman, 1951), extends from the St. Francis Mountains of Missouri, southwestward into Oklahoma at approximately T. 24 N., R. 25 E.

The paleotopographic map reveals a major divide 1000 to 1500 feet in height, approximately 15 to 20 miles wide, extending from this point to the southwest, through the Spavinaw peak to a locality approximately 12 miles southwest of the town of Pryor, Oklahoma. The divide branches here, one branch extending almost directly south, upon which two known Precambrian peaks occur, and the other relatively smaller extending to the northwest. This major divide is probably a southwestern extension of the Precambrian core of the major axis (Fig. 9) of the Ozark uplift. It may be that the south branch of this divide is part of the major axis also, since it appears to be of comparable size; however, the abrupt change of trend to the south does not conform to the general trend of the Ozark axis.

North of this major Precambrian divide is a broad east-west valley, approximately 70 miles long extending from T. 26 N., R. 25 E. to the vicinity of T. 24 N., R. 14 E. There was probably a major westward drainage system down this valley on the Precambrian surface. The valley floor at the present time has an approximate westward slope of 25 to 50 feet per mile. North of this valley the surface rises on a broad westward plunging ridge upon which are two known isolated highs located respectively in T. 27 N., R. 16 E. and T. 28 N., R. 20 E.

A northeast-southwest striking Precambrian fault is indicated in the area north of Miami, Oklahoma, where a well in section 13,



SKETCH MAP OF OZARK UPLIFT AND ADJOINING PHYSIOGRAPHIC PROVINCES

(AFTER TAFF, FENNEMAN, OTHERS WITH MODIFICATIONS BY THE AUTHOR)

FIGURE 9

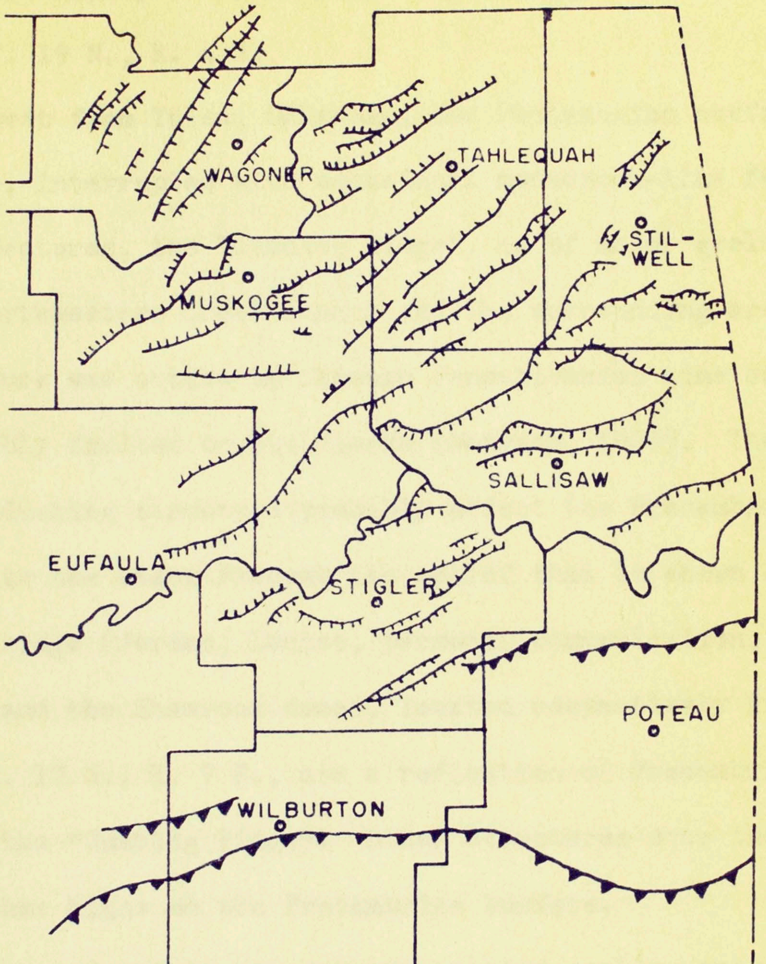
T. 29 N., R. 22 E. and one in section 19, T. 29 N., R. 23 E. show a difference in elevation of approximately 574 feet on the Precambrian surface in a distance of about one mile. Insoluble residues of these wells (Ireland, 1955), indicate the Cotter dolomite is continuous across the fault. Gunter sandstone overlies the Precambrian on the west side of the fault in the well located in section 13, T. 29 N., R. 22 E., whereas Lamotte sandstone overlies the Precambrian on the east side of the fault in the well located in section 19, T. 29 N., R. 23 E. Farther south the Roubidoux is in contact with the Precambrian west of the fault, whereas east of the fault Bonneterre is encountered at the total depth. Ireland established the age of the fault as Precambrian with this evidence (1955).

South of the Spavinaw peak the elevation of the Precambrian surface decreases at a rate of 600 to 900 feet per mile into a deep, relatively narrow gorge extending in a northeast-southwest direction. This gorge may be, in part, the result of Precambrian faulting. South of Tahlequah there are several major faults and many minor faults (Fig. 10). Some of the major faults evidently affect the Arbuckle rocks and may also affect the Precambrian surface. The South Muskogee fault, for example, cuts the Arbuckle rocks with approximately 240 feet of displacement between two wells located in T. 14 N., R. 19 E. (Soyster and Taylor, 1928). A well drilled to the Precambrian rocks in section 28, T. 15 N., R. 19 E. and one in section 20, T., 15 N., R. 20 E. show an abrupt change in elevation of the Precambrian surface of 1543 feet in approximately 5 miles. The surface strike of the south Muskogee fault extends between these wells. It is therefore assumed that the South Muskogee fault has affected the Precambrian surface and, in part, may have attributed to the gorge previously mentioned.

Northwest of Tulsa in Osage County and in parts of Washington, Pawnee, and Creek counties, a high Precambrian area has been severely dissected by post-Precambrian erosion. This ancient range of mountains that existed during Precambrian time has been named the "Tulsa Mountains" by Ireland (1955). Today the remnants of these mountains exist as a number of relatively small oval peaks and domes that are scattered over the area in a north-south and northwest-southeast alignment. Several of these ancient peaks are reflected in surface beds whereas others affect the older sediments. The Oswego limestone, for example, structurally reflects a large number of these Precambrian peaks in Osage County. The Precambrian surface of the "Tulsa Mountains" probably has a much more rugged surface than is possible to show on the paleotopographic map because of the lack of control.

The heights of the peaks in Osage County varies from 500 to 1100 feet and the majority of these are encountered by drilling at a depth of approximately 1300 feet below sea level near the southeast corner of Osage County, to 3600 feet below sea level in the Morrison Field in western Pawnee County. Some of the peaks in Osage County may be related to faulting in the Precambrian rocks, for example, the east flank of the Delaware anticline and the Bald Hill dome in Twps. 20 and 21 N., Rngs. 11 and 12 E., may involve faults rather than the steep relief that is shown.

Beginning in western Osage County, the Precambrian surface relief is a gradual westward slope of 30 to 50 feet per mile. This



TECTONIC MAP OF NORTHEASTERN OKLAHOMA

FAULTS (NORMAL AND REVERSE)

THRUST FAULT

AFTER JOHN M. WHITE JR.

M.S. 1955

FIGURE 10

slope is interrupted at intervals by isolated highs, for example, the Morrison and Ripley domes located respectively in T. 23 N., R. 3 E., and T. 19 N., R. 4 E.

Southwest from Tulsa, Oklahoma, the Precambrian surface becomes deeper, interrupted with occasional monadnock-like features. One of these features, the "Cushing Ridge", is of major geologic importance in northwestern Creek County and the surrounding area. The Cushing structure was active up through Pennsylvanian time and has been considerably faulted on its flanks (Weirich, 1929). The major faults of the Cushing structure probably affect the Precambrian surface and attribute to the steep Precambrian relief that is shown on the flanks of the ridge (Jordan, Louise, personal communication, 1955). The Dropright and the Shamrock domes, located respectively in T. 18 N., R. 7 E., and T. 17 N., R. 7 E., are a reflection of Precambrian highs that occur on the "Cushing Ridge". Other structures over the ridge may reflect other highs on the Precambrian surface.

Only the major features and outstanding smaller ones have been discussed. There are undoubtably hundreds of small features overlooked due to the lack of control. The highest known point upon the Precambrian surface in this area of study is the Spavinaw peak at approximately 650 feet above sea level whereas the lowest point is in T. 11 N., R. 21 E. where the igneous basement rocks were encountered at 4138 feet below sea level. The maximum known difference in elevation on the Precambrian surface then is approximately 4788 feet.

CHAPTER IV

RELATIONSHIP OF PRECAMBRIAN PALEOTOPOGRAPHY TO SOME POST-PRECAMBRIAN FORMATIONS AND STRUCTURES

Granite Wash

Granite wash is recorded immediately above the Precambrian surface in 14 wells in northeastern Oklahoma. All but 3 of these wells were located over Precambrian highs. Seven of these wells located in Osage County encountered an average of 18 feet of granite wash above the Precambrian surface. Five of these wells are located in the area of the "Tulsa Mountains". A maximum of 46 feet of granite wash was reported to the State Corporation Commission in a well located in T. 24 N., R. 8 E.

The information concerning the occurrence of granite wash in northeastern Oklahoma is meager and some of the records are rather doubtful. The reported occurrence of granite wash over Precambrian highs might be explained as follows. As the Cambro-Ordovician seas transgressed into northeastern Oklahom streams eroded the highlands. The stream gradients were reduced and the water could no longer carry away the granite fragments resulting from the weathering of the exposed surfaces. These fragments lay in place more or less as lag deposits to be reworked and redeposited by encroaching seas.

Reagan Sandstone (Plate II)

Reagan sandstone occurs in the major valleys on the Precambrian surface of northeastern Oklahoma as a flanking, sheet-like sandstone that pinches out over the prominent highs of the region.

The Reagan sandstone occurs in two principle areas in northeastern Oklahoma. The first is in the broad, east-west Precambrian valley located north of the southwestern extension of the major axis of the Precambrian core of the Ozark uplift (p. 30), where the Reagan sandstone reaches a maximum known thickness of nearly 100 feet. This maximum accumulation lies along the axis of the valley and extends to the west into a low area on the east flank of the "Tulsa Mountains". North and south of this east-west valley the Reagan pinches out or thins considerably over the adjacent highs. A zero thickness line was impossible to predict due to the lack of well control; however, it is likely that the Reagan does not go over the major divide to the south because the few Precambrian wells drilled over the divide did not record the presence of a "basal sandstone".

A second area of Reagan sandstone accumulation is in the trough southeast of the "Cushing Ridge" and to the southwest, south, and southeast of Tulsa, Oklahoma. In these valleys the Reagan sandstone flanks the surrounding highs and reaches a maximum known thickness of approximately 88 feet. The Reagan probably extends across the "Cushing Ridge". An attempt has been made to establish an approximate zero thickness line of the Reagan sandstone encircling the high directly south of Tulsa, Oklahoma. Reagan sandstone has not been reported in wells in the area of the "Tulsa Mountains".

A well in northwestern Osage County drilled through approximately 66 feet of Reagan sandstone in a broad, relatively shallow valley sloping to the north. West of Osage County and out of the thesis area only a few wells have been drilled deep enough to reach the Reagan.

Geologic Cross Sections of Pre-Pennsylvanian Sediments (Figures 11, 12)

Two geologic cross sections were prepared to show the relationship of the Precambrian surface to some pre-Pennsylvanian sediments. Seventy-six wells were used, most of which were drilled into the Arbuckle sediments, whereas 32 of the wells were drilled to the Precambrian surface. Wells used in these cross sections are listed in the appendix.

These cross sections illustrate seven major points:

1. The Mississippi limestone reflects some of the Precambrian highs. It remains a rather consistently thick rock unit even over these highs.
2. The Arbuckle limestone reflects the Precambrian peaks and valleys in most instances, by thinning over the peaks and thickening in the valleys as would be expected with such transgressive sediments.
3. Parts of northeastern Oklahoma were deeply dissected by post-Precambrian erosion. The Cambro-Ordovician seas transgressed over this rugged surface.
4. The Reagan sandstone of the thesis area has the greatest

GEOLOGIC CROSS SECTION OF PRE-PENNSYLVANIAN SEDIMENTS

DATUM: MEAN SEA LEVEL FIGURE 11 M.S. THESIS 1956 A.C.F. DILLE

LIST OF WELLS IN APPENDIX

FIGURE 12

LIST OF WELLS IN APPENDIX

accumulation in the lows on the Precambrian surface in the area southwest of Tulsa, Oklahoma.

5. The Woodford shale structurally reflects the paleotopography of the Precambrian surface in many instances and seems to be a unit of rather consistant thickness except where it has been truncated by erosion.

6. The area of the "Tulsa Mountains" has a much more rugged Precambrian surface than the rest of northeastern Oklahoma.

7. Accumulations of granite wash are not common on the Precambrian surface in northeastern Oklahoma.

Structures Overlying Known Precambrian Highs

The following structures may be controlled, in part, by the Precambrian paleotopography. In each case the location of the structure is that of the well that encountered the peak at the shallowest depth, in other words, the highest known point on the Precambrian surface below the structure.

Structure	Location		
	Section	Township North	Range East
Osage County			
Wildhorse anticline	32	22	10
South Brown anticline	9	22	11
"West Fox dome"	36	23	10
Hardy dome	7	23	11
"Southwest Hominy dome"	14	22	8
Manion anticline	25	23	8
Unnamed anticline	9	23	8
Wheeler dome	16	24	8
Cold Spring anticline	19	25	8
Birch Creek dome	30	24	11

Structure	Location		
	Section	Township North	Range East
Osage County (contd.)			
Red Eagle anticline	12	24	10
Backius anticline	31	27	12
Bald hill dome	8	20	12
"Northwest Delaware anticline"	30	21	12
Unnamed anticline	19	21	9
Unnamed anticline	9	21	9
Tulsa County			
Owasso dome	26	21	13
Washington County			
Bartlesville anticline	17	26	13
Ochelata anticline	25	25	12
Creek County			
Dropright dome	4	18	7
Shamrock dome	22	17	7
Payne County			
Ripley anticline	34	19	4
Unnamed anticline	4	18	5
Pawnee County			
Morrison dome	33	23	3
Kay County			
"Northeast Newkirk dome"	18	28	3

TABLE I

Post-Arbuckle Exposures of the Precambrian Surface*

Name of well	Location	Formation resting on Precambrian
Deep Rock Oil Co., No. 3 Little Chief	NE NW NE Sec. 4, T. 18 N., R. 5 E.	Tyner
Lewis Oil Co. No. 1 McCune	SW SW SW Sec. 3, T. 21 N., R. 9 E.	Woodford
Ohio, Osage, and Moore No. 24 Osage	CN½ SW SW Sec. 9, T. 21 N., R. 9 E.	Woodford
Superior Oil Co. No. 1 Blakemore	SW NW SW Sec. 26, T. 21 N., R. 13 E.	Woodford
Tidal Osage Oil Co. No. 20 Wildhorse	SW SE NE Sec. 32, T. 22 N., R. 10 E.	Tyner
Tidal Osage Oil Co. No. 18 Wildhorse	C NE NE Sec. 32, T. 22 N., R. 10 E.	Burgen
Pure-Sinclair Oil Co. No. 171 Osage	C SE SW, Sec. 9, T. 23 N., R. 8 E.	Burgen
J. R. Higgins No. 16 Osage	CN½ SW SE Sec. 25, T. 23 N., R. 8 E.	Mississippi limestone
Buell and Markey No. 14 Osage	NE SW SE Sec. 25, T. 23 N., R. 8 E.	Mississippi limestone
Prairie Oil and Gas Co. No. 12 Osage	SW NE SE Sec. 25, T. 23 N., R. 8 E.	Mississippi limestone
E. M. Pinney No. 41-296	NW SW NW Sec. 15, T. 24 N., R. 8 E.	Woodford
Pure-Sinclair Oil Co. No. 16 Osage	NE SW SW Sec. 9, T. 23 N., R. 8 E.	Simpson

*Twelve wells have encountered post-Arbuckle sediments of Simpson, Woodford, or Mississippi limestone age resting on the Precambrian surface. These wells were drilled on Precambrian peaks that protrude through the Arbuckle sediments. The peaks covered by the Mississippi limestone were probably exposed until post-Woodford time. Either the Arbuckle did not cover the remaining peaks or they were exposed by post-Arbuckle or post-Hunton erosion.

CHAPTER V

REGIONAL GEOLOGIC HISTORY

It was not until upper Cambrian time that sediments were deposited upon the Precambrian surface. Upper Cambrian time brought an advancing sea over this rugged surface of northeastern Oklahoma. Isolated Precambrian highs remained as positive areas until, as the sea continued to advance, many were progressively overlapped. As this upper Cambrian sea advanced to the north across the Precambrian surface of the Mid-Continent region, basal sandstones were progressively deposited along with the overlying sandy dolomitic Arbuckle limestone. Local fluctuations of the sea during the deposition of the Arbuckle sediments produced unconformities within this thick sequence of sediments.

The end of Cambrian time resulted in major land masses in the Ozarks of Missouri and the "Tulsa Mountains" of Oklahoma along with isolated Precambrian peaks exposed as islands in a Cambrian sea.

Hundreds of feet of dolomite and sandstone represent the early Ordovician of Oklahoma. The Ordovician sea continued to overlap the Precambrian surface of the Mid-Continent region. Cotter time saw the overlapping of the Spavinaw Precambrian peak. Eventually the entire Mid-Continent region was covered by Ordovician sediments.

Post-Arbuckle and pre-Simpson time resulted in a minor uplift in northeastern Oklahoma and the Ozark Mountains. The effect was a slight tilting of the Arbuckle rocks to the southwest and erosion of upper Arbuckle sediments. Arbuckle sediments were eroded to the lowest levels in northern Oklahoma exposing several Precambrian peaks (Fig. 3).

Simpson time brought a gradually encroaching sea over an Ordovician land mass in the area of the Ozarks. The Simpson, Viola, and Hunton deposition was followed by a period of tilting and erosion. Movements uplifted the Ozark Mountains and formed the Chautauqua arch to the north (Fitts, 1951). Approximately at this time the Hunton arch to the southwest was uplifted (Moore, Carl A., personal communication, 1956). Northeastern Oklahoma was tilted to the south and southwest and the Viola, Sylvan, and Hunton formations were removed by erosion. The remaining Simpson and Arbuckle sediments were peneplaned with a few isolated Precambrian peaks exposed (Fig. 2).

A widespread shallow sea brought the deposition of the Woodford shale over the entire Mid-Continent region with a few local exceptions (Fig. 2). This was followed by the deposition of younger Mississippian rocks.

During post-Mississippian pre-Pennsylvanian time more movements took place in the Ozark region which resulted in a tilting to the south and southeast in northeastern Oklahoma. These movements were followed by a long period of erosion.

Lower Pennsylvanian seas did not extend over the high area of north central Oklahoma (Fitts, 1951) but instead deposited sediments along the flanks on the south and east. The greatest amounts of deformation took place in the Ozark region beginning with the middle Pennsylvanian (Huffman, 1951). The Ozark high began to rise again while to the south the Ouachita Mountains began to form. A regional tilting to the southwest was the effect of these movements on northeastern Oklahoma. This culminated the major movements affecting northeastern Oklahoma leaving the region much the same as it is today.

CHAPTER VI

Oil and Gas Reservoirs in Relation to Paleotopography of the Precambrian Surface

The oil and gas prospects concerned with this thesis involve the Arbuckle sediments, Reagan sandstone, and granite wash.

Arbuckle Limestone

Engineers give ultimate recoveries of 60,000 to 100,000 barrels of oil per well to many Arbuckle wells today (Tuttle, 1955). There are 196 oil and gas pools that have produced from the Arbuckle in northeastern Oklahoma (Tuttle, 1955) most of which are located in Osage County (Ireland and Warren, 1946). The Arbuckle pools in northeastern Oklahoma show a high average ultimate recovery of as much as 100,000 barrels per well as compared with 45,000 barrels per well in most Pennsylvanian sands (Tuttle, 1955). Some of the most prolific wells in northeastern Oklahoma produce from the Arbuckle with initial potentials ranging as high as 8000 barrels per day (Tuttle, 1955).

A high percentage of the subsurface highs in Osage County reflect the paleotopography of the Precambrian surface. Many of these highs have never had a test to the Precambrian surface. Twenty of these highs have less than 300 feet of Arbuckle over them (Tuttle, 1955). Oil or gas may be trapped on their flanks or in the sediments over them. Four unconformities which are possible oil traps exist within the Arbuckle above the upper Gasconade which is probably the oldest Arbuckle formation in the area of Osage County. Porous zones in the sands, cherts, dolomites, and limestones may afford excellent reservoirs also.

With the large percentage of the wells drilled to the Precambrian surface in Osage County, the rest of northeastern Oklahoma is relatively untouched by deep penetrations below the top of the Arbuckle. The majority of the deep penetrations were drilled in the early days when tests were seldom taken below the base of the Mississippi limestone or Simpson sandstones. Often a well would miss a structure in these horizons and the result would be a dry hole. Occasionally, these off structure dry holes were carried on down to deeper horizons only to result in a dry and abandoned well still off the structure. The result has been that relatively few Precambrian peaks have deep tests within their overlying closures that exist below the upper beds of the Arbuckle group. Structural shift with depth was seldom taken into account in the early days of exploration. Today it is recognized and taken into account in much of the drilling in northeastern Oklahoma. This would be another factor to consider as to why these early day tests did not drill within the deeper closures.

The Powell and Cotter dolomites offer good possibilities when found within a certain stratigraphic sequence (Table II). The Roubidoux formation is a likely oil and gas reservoir within the Arbuckle group (Ireland, 1955), in northeastern Oklahoma. It contains three sand zones from 15 to 30 feet thick that contain as much as 80 per cent sand.

TABLE II

Oil and Gas Pools in the Arbuckle Group
(after H. A. Ireland)

Producing Structures	Pools in the Powell Dolomite		Pools in the Cotter Dolomite		Pools in the Jefferson City Dolomite	
	Oil	Gas	Oil	Gas	Oil	Gas
Northeastern Oklahoma						
Where Simpson group overlies the Arbuckle	32	8	4	1	0	0
Where Woodford shale overlies the Arbuckle	0	0	1	14	0	4
Where Mississippi lime overlies the Arbuckle	0	0	3	18	0	0
Southeastern Kansas						
Where Woodford shale overlies the Arbuckle	0	0	22	9	0	0
Total	32	8	30	42	0	4

From a study of Table II, one might conclude that production is found only in the top of the Arbuckle group; however, few deep tests have been made. Several of the wells drilled deep into the Arbuckle recorded oil shows far below the top but were untested.[1]

Reagan Sandstone

This "basal sandstone" upon the Precambrian surface is a potential oil and gas reservoir in northeastern Oklahoma. One well, the Jones Oil Co. No. 9 Furst, Sec. 16, T. 2 S., R. 8 W., in southern Oklahoma has produced from the Reagan sandstone, while other wells in southern Oklahoma have encountered water in the Reagan. The Hickory sandstone of Texas, a "basal sandstone" resting upon the Precambrian surface, is a prolific producing horizon, and the "basal sandstone" of Kansas has also been known to produce. These previous statements should warrant an investigation of the Reagan over the entire state when at all practical.

Reagan sandstone, being a typical sheet sand that pinches out over the highs with best accumulations in the lows, should have good possibilities for flank production against Precambrian highs. The most likely area for Reagan production would be on the flanks of the highs adjacent to the deep valleys to the south, southeast and southwest of Tulsa, Oklahoma. Another prospective area would be the flanks of the

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[1] Although removed from the thesis area, a recent discovery in southern Oklahoma indicated that production can be found deep in the Arbuckle. The Frankfort Oil Company's No. 2 Williams, sec. 12, T. 5 S., R. 2 W. made a discovery of 4928 feet of free oil on a nine hour drill stem test 4500 feet below the top of the Arbuckle.

highs adjacent to the broad east-west Precambrian valley to the north of the southwest extension of the axis of the Ozark uplift. The east flank of the "Tulsa Mountains" north of Tulsa, Oklahoma, might have possibilities also.

Reagan sandstone probably extends across many subsurface Precambrian highs, and in these cases it might produce on closure. It may be that the Reagan has better production possibilities to the southwest beyond the thesis area since it has indications of thickening in that direction.

Reports of oil and gas shows in the Reagan are few and only somewhat reliable, nevertheless, they cannot be overlooked. A well in sec. 8, T. 20 N., R. 12 E., Osage County, was reported as having an oil show in the first 14 feet above the Precambrian surface. A well in the same section had an 11 foot porous zone above the Precambrian surface. This zone may have been weathered granite.

The Oklahoma State Corporation Commission reported a well in sec. 27, T. 24 N., R. 13 E. as having a show of oil in a 2 foot zone of Reagan above the Precambrian surface.

Granite Wash

Reports of the occurrence of granite wash are rather scattered and all are located over Precambrian highs.

Two reports of oil and gas in granite wash are known. The Oklahoma State Corporation Commission reported a 42 foot layer of weathered granite lying upon a 4 foot hard gray sandstone, which had a 2 foot zone of oil saturation, overlying a Precambrian surface of un-

unweathered granite. This well was located in sec. 16, T. 24 N., R. 8 E. Another well in sec. 4, T. 15 N., R. 18 E. had a reported show of gas in a 5 foot zone of granite wash.

CHAPTER VII

CONCLUSIONS

1. The paleotopography of the Precambrian surface of northeastern Oklahoma is largely the result of a long interval of erosion that occurred before the deposition of Cambrian sediments.

2. Cambrian seas transgressed over a rugged Precambrian surface.

3. The Precambrian surface of northeastern Oklahoma has a regional westward slope that is the result of movements in the Ozark Mountains.

4. A major divide exists upon the Precambrian surface that may be a southwestern extension of the Precambrian core of the major axis of the Ozark uplift.

5. A major westward drainage system probably existed upon the Precambrian surface across the northern parts of Rogers, Mayes, and Delaware counties.

6. A Precambrian fault probably exists north of the town of Miami, Oklahoma.

7. South of the town of Tahlequah, Oklahoma, are several major surface faults that probably in turn affect the Precambrian surface, for example, the South Muskogee fault.

8. Northwest of Tulsa, Oklahoma, in Osage County and parts of

Washington, Pawnee, and Creek counties, a high Precambrian area exists that has been severely dissected by post-Precambrian erosion.

9. Many of the Precambrian domes of Osage County are reflected upon the surface and in younger beds in the subsurface.

10. The Cushing structure is represented by a north-south trending Precambrian ridge.

11. The Reagan sandstone is a "basal sandstone" upon the Precambrian surface in northeastern Oklahoma that varies in age as it transgresses time lines and whose source was the progressive disintegration of the Precambrian igneous rocks.

12. The Reagan sandstone is equivalent to the Lamotte of Missouri in parts of northeastern Oklahoma.

13. The Reagan sandstone being a transgressive unit of varying age, is a characteristic bed found below many of the beds of the Arbuckle group.

14. It is possible that the Reagan sandstone of northeastern Oklahoma may eventually be correlated with the basal portions of the type Reagan of southern Oklahoma.

15. The Reagan sandstone occurs in the major valleys on the Precambrian surface of northeastern Oklahoma as a flanking, sheet-like sandstone that pinches out over the prominent highs of the region.

16. Granite wash seems to occur mostly over Precambrian highs.

17. The Arbuckle sediments and the Reagan sandstone are possible oil and gas reservoirs in northeastern Oklahoma.

18. The Mississippi limestone is a rather uniform sequence throughout northeastern Oklahoma and, although the top is an erosional

surface, many of its structures reveal the paleotopography of the Precambrian surface.

19. The Woodford shale is a rather uniform unit throughout most of northeastern Oklahoma which in turn reflects some of the paleotopography of the Precambrian surface.

20. The Reagan sandstone in the vicinity of Oklahoma City, Oklahoma, is probably Cambrian in age due to the presence of profuse glauconite in the interval.

BIBLIOGRAPHY

Aurin, F. L., Clark, G. C., and Trager, E. A., 1921, "Notes on subsurface Pre-Pennsylvanian stratigraphy in north Mid-Continent fields", Bull. Amer. Assoc. Petroleum Geologists, Vol. 5, pp. 117-53.

Bass, N.W., 1942, "Subsurface geology and oil and gas resources of Osage County, Oklahoma," U.S. Geol. Survey Bull. 900 A-K (1938-1942).

Beckwith, H. T., 1930, "Oil and gas in Oklahoma", Okla. Geol. Survey Bull. 40, Vol. III, pp. 241-42.

Bloesch, Edward, 1930, "Oil and gas in Oklahoma", Okla. Geol. Survey Bull., 40, Vol. III, 363-73.

Brant, R. A., 1953, "Sedimentation as studied under the microscope", Compilation of Lecture Notes and Experience of Ralph A. Brant, 1925-1953, University of Tulsa Sedimentation Class, unpublished lecture notes.

________, 1954, "A sketch of the geologic history of northeastern Oklahoma", Tulsa Geol. Soc. Guidebook, p. 17.

Carpenter, Everett, 1930, "Oil and gas in Oklahoma", Okla. Geol. Survey Bull. 40, Vol. III, pp. 136-37.

Cram, Ira, 1930, "Oil and gas in Oklahoma", Okla. Geol. Survey Bull. pp. 585-86.

Croneis, Carey G., 1930, "Geology of the Arkansas Paleozoic area", Arkansas Geol. Survey Bull. 3.

Disney, R. W., and Cronenwett, C. E., 1955, "Simpson group along the east flank of the Anadarko basin", Proceedings of the Fourth Symposium on Subsurface Geology, Extension Division of Oklahoma University, Norman, Oklahoma, pp. 107-15.

Dott, R. H., 1941, "Regional stratigraphy of Mid-Continent", Bull Amer. Assoc. Petroleum Geologists, Vol. 25, pp. 1619-1705.

Dott, R. H., and Ham, W. E, 1943, "New evidence concerning age of Spavinaw granite, Oklahoma", Bull. Amer. Assoc. Petroleum Geologists, Vol. 27, No. 12, pp. 1626-31.

Drake, N. F., 1898, "A geological reconnaissence of the coal fields of the Indian Territory", Proceedings of the American Philosophical Society, Vol. xxxvi, No. 156,341.

Fath, A. E., 1920, "The origin of faults, anticlines, and buried granite ridge of northern part of the Mid-Continent oil and gas fields", U.S. Geol. Survey Prof. Paper 128 C.

Fitts, L. E., 1951, "North central Oklahoma shelf area", Shale Shaker, Vol. 2, No. 3, part II, p. 4.

Greene, Frank, 1925a, "Various types of granite form largest group in Mid-Continent", Oil and Gas Jour., Vol. 24, No. 22 (October 22), p. 69.

________, 1925b, "Granite wells in the northern Mid-Continent region", Bull. Amer. Assoc. Petroleum Geologists, Vol. 9, pp. 351-54.

________, 1930, "Oil and gas in Oklahoma", Okla. Geol. Survey Bull. 40, Vol. III, p. 170.

Haworth, Erasmus, 1915, "On crystalline rocks of Kansas", Kansas Univ. Geol. Survey Bull. 2, pp. 7-13.

Huffman, George G., 1951, "Geology of the Ozark uplift, northeastern Oklahoma", Shale Shaker, Vol. 2, No. 3, pp. 5-14.

________, 1951, "Recent investigations of the Pre-Atokan rocks in northeastern Oklahoma", Tulsa Geol. Soc. Digest, Vol. XIX, pp. 112-18.

Ireland, H. A., 1930, "Oil and gas in Oklahoma", Okla. Geol. Survey Bull. 40 Vol. III, pp. 473-81.

________, 1936, "Use of insoluble residues in Oklahoma", Bull. Amer. Assoc. Petroleum Geologists, Vol. 20, p. 1086.

________, 1944, "Correlation and subdivision of subsurface lower Ordovician and upper Cambrian rocks in northeastern Oklahoma", U. S. Geol. Survey Prelim. Chart 5, Oil and Gas Inv. Ser. (with text).

________, 1946, "Maps of northeastern Oklahoma and parts of adjacent states showing the thickness and subsurface distribution of lower Ordovician and upper Cambrian rocks below the Simpson Group", U. S. Geol. Survey Prelim. Map 52 (with text).

________1955, "Precambrian surface in northeastern Oklahoma and parts of adjacent states", Bull. Amer. Assoc. Petroleum Geologists, Vol. 39, No. 4, pp. 468-83.

Keroher, R. P., and Kirby, J. J , 1948, "Upper Cambrian and lower

Ordovician rocks in Kansas", State Geol. Survey Kansas Bull. 72, pp. 82-112.

Koester, E. A., 1935, "Geology of Central Kansas Uplift", Bull. Amer. Assoc. Petroleum Geologists, Vol. 19, No. 10, pt. 2, pp. 1405-26.

Landes, K. K, 1927, "A petrographic study of the pre-Cambrian of Kansas", Bull. Amer. Assoc. Petroleum Geologists, Vol. 11, pp. 821-24.

Landes, Kenneth K., and Tolman, Carl, 1939, "Contributions to a knowledge of the lead and zinc deposits of the Mississippi Valley region", Geol. Soc. of Amer., Spec. Paper, No. 24, Chapter III, pp. 76-81.

McQueen, H. S., 1931, "Insoluble residues as a guide in stratigraphic studies", Missouri Bureau Geology and Mines 56th Bien. Rept., pp. 102-131, pls. 3-14.

Merritt, J. W., and McDonald, O. G., 1930, "Oil and gas in Oklahoma", Okla. Geol. Survey Bull. 40, Vol. III, pp. 7-32.

Miser, H. D., 1954, "Geologic map of Oklahoma", Okla. Geol. Survey and U. S. Geol. Survey.

Moore, R. C., 1918, "Geologic history of the crystalline rocks of Kansas", Bull. Amer. Assoc. Petroleum Geologists, Vol. 2, pp. 98-113.

Powers, Sidney, 1917, "Granite in Kansas", Amer. Jour. Sci., 4th Ser., Vol. 44, pp. 146-50.

________, 1922, "Reflected buried hills and their importance in petroleum geology", Econ. Geol., Vol. 17, pp. 223-59.

________, 1925, "Structural geology of Mid-Continent region", Bull. Geol. Soc. America, Vol. 36, pp. 379-92.

Snider, L. C., 1915, "The geology of a portion of northeastern Oklahoma", Okla. Geol. Survey Bull. 24, p. 51.

Soyster, H. B. and Taylor, T. G., 1928, "Oil and gas of Muskogee County", Okla. Geol. Survey Bull. 40-FF, September, pp. 1-28.

Stephenson, C. D., 1929, "An oil field in T. 25 N., R. 8 E., Osage County, Oklahoma", Structure of Typical American Oil Fields, Vol. 2, p. 382, Amer. Assoc. Petroleum Geologists.

Taylor, C. H., 1917, "Granites of Kansas", Bull. Southwestern Assoc. Petroleum Geologists, Vol. 1, pp. 9-12.

Tuttle, R. C., 1955, "Deeper zones offer promise in northeastern Oklahoma", Oil and Gas Journal, June 20, pp. 152-53.

Weidman, S., 1932, "The Miami-Picher lead-zinc district", Okla. Geol. Survey Bull. 56.

Weirich, T. E. 1929, "The Cushing oil and gas field, Creek County, Oklahoma", Structure Typ. Amer. Oil Fields, Vol. 2, pp. 396-406.

White, David, 1922, "Structure and oil and gas resources of the Osage Indian Reservation of Oklahoma", U. S. Geol. Survey Bull. 686.

White, Luther, 1924, "Four horizons below Mississippi lime", Oil and Gas Journal, Vol. 24, No. 15 (March 13), p. 42.

_______, 1926, "Oklahoma's deep horizons correlated", Oil and Gas Journal. No. 45 (April 1), p. 60.

________, 1928, "Subsurface distribution and correlation of the pre-Chattanooga (Wilcox Sand) series of northeastern Oklahoma", Okla. Geol. Survey Bull. 40, Vol. 1, p. 25.

Wright, Park, 1917, "Granites in Kansas Wells", Trans. Amer. Inst. Min. Eng. Vol. 57, pp. 906-13.

APPENDIX

List of wells used in Northeast-Southwest Cross Section A-A' (Figure 11)

Well No.	Name and Location	Elevation
1	City of Miami No. 3 Goodrich, SE NE SW, Sec. 24, T. 28 N., R. 22 E.	798, T.D. 1055
2	City of Miami No. 2 Goodrich, NW NW SW, Sec. 24, T. 28 N., R. 22 E.	765, T.D. 1200
3	City of Welch, SW NW SW, Sec. 29, T. 28 N., R. 21 E.	850, T.D. 1566
4	Frankfort Oil Co. No. 1 Van Ausdel, SE NE NW, Sec. 31, T. 28 N., R. 20 E.	849, T.D. ? 2014
5	Frankfort Oil Co. No. 1 Bluejacket, NW NW NW, Sec. 4, T. 26 N., R. 19 E.	835, T.D. 2128
6	Flourney No. 1 Harker, ? Sec. 3, T. 25 N., R. 19 E.	725, T.D. 795
7	Dekoma Devonian Company No. 1, NW NW NW, Sec. 29, T. 25 N., R. 19 E.	830, T.D. 904
8	E. A. North No. 1 Harris, NW NE NW, Sec. 15, T. 24 N., R. 19 E.	750, T.D. 1957
9	Everitt and Prewitt No. 1 Freeman, NW NE SE, Sec. 17, T. 24 N. R. 19 E.	900, T.D. 1047
10	Union Oil and Mining No. 1 Dannenberg, SW NE NE, Sec. 12, T. 23 N., R. 16 E.	820, T.D. 1140
11	Kanola Oil and Refining Co. No. 1 Bell, SE NW SE, Sec. 9, T. 22 N., R. 15 E.	650, T.D. 1665
12	New England Oil and Pipeline Co. No. 1 Murphy, SW NE SW, Sec. 16, T. 22 N., R. 15 E.	650, T.D. 1390
13	Duquesne Oil and Gas No. 1 Doublehead, NE NE SE, Sec. 31, T. 22 N., R. 15 E.	784, T.D. 2765
14	Sequoyah Oil and Refining Co. No. 1 Allen, SE SE SW, Sec. 3, T. 21 N., R. 14 E.	718, T.D. 1550
15	Moore, Dickson, and Louvier No. 2 Smith, NE NW SW, Sec. 28, T. 21 N., R. 14 E.	700, T.D. 1460

(Figure 11 contd.)

Well No.	Name and Location	Elevation
16	Superior Oil Co. No. 2 Blakemore, NE SW SE, Sec. 26, T. 21 N., R. 13 E.	660, T.D. 1586
17	Superior Oil Co. No. 1 Blakemore, SW NW SW, Sec. 26, T. 21 N., R. 13 E.	654, T.D. 1462
18	(Operator unknown) No. 2, Swimmer, NE NW SW, Sec. 3, T. 20 N., R. 13 E.	580, T.D. 1742
19	Little Fay Oil Co. No. 1 Crosbie, SE NW NE, Sec. 30, T. 20 N., R. 13 E.	667, T.D. 2608
20	Dowell Incorporated No. 1 Fee, SW SE NW, Sec. 31, T. 20 N., R. 13 E.	721, T.D. 3310
21	Texas Refinery No. 5, SW SE NW, Sec. 23, T. 19 N., R. 12 E.	632, T.D. 3460
22	G.W. Sander, et al No. 1 Breash, SW NW SE, Sec. 27, T. 19 N., R. 12 E.	722, T.D. 2303
23	G. B. Suppes No. 1 Randolph, SW SW SE, Sec. 34, T. 19 N., R. 12 E.	825, T.D. 2200
24	Frank Baker No. 5 Fee, CSL SW SE, Sec. 3, T. 18 N., R. 12 E.	750, T.D. 3015
25	D. W. Franchot Co. No. 1 Standwaite, NE SW NE, Sec. 16, T. 18 N., R. 12 E.	750, T.D. 2380
26	Prairie Oil and Gas Co. No. 14 Alexander, SE SE SW, Sec. 33, T. 18 N., R. 12 E.	750, T.D. 2460
27	Gulf Oil Corp. No. 1 Berryhill C NW NE, Sec. 8, T. 17 N., R. 12 E.	718, T.D. 3929
28	Gypsy No. 37 Pittman, NE NE SE, Sec. 7, T. 17 N., R. 12 E.	717, T.D. 2563
29	Inlan and Shinlan No. ? McComb, SE SW NE, Sec. 10, T. 17 N., R. 11 E.	810, T.D. 2880
30	Deep Rock Oil Co. No. 8 Wacoche, SW NE NE, Sec. 17, T. 17 N., R. 11 E.	876, T.D. 2985

(Figure 11 contd.)

Well No.	Name and Location	Description
31	Central Commercial No. 3 Hay, SW NW SW, Sec. 10, T. 17 N., R. 10 E.	793, T.D. 4282
32	Transcontinental No. ? Charcotena McCauley, NW NE SE, Sec. 9, T. 17 N., R. 10 E.	797, T.D. 3260
33	Texas No. ? Kay, SE SE SW, Sec. 18, T. 17 N., R. 10 E.	747, T.D. 3486
34	Prairie Oil and Gas Co. No. 3 Letts, SE SW SE, Sec. 23, T. 17 N., R. 9 E.	832, T.D. 4344

List of wells used in North-South Cross Section B-B' (Figure 12)

Well No.	Name and Location	Elevation
1	Gypsy Oil Co. No. 8 Eythl Bryant, NE SE SE, Sec. 18, T. 27 N., R. 8 E.	1069, T.D. 3444
2	Seamans Oil Co. No. 1 Seamans, SE SE NW, Sec. 29, T. 27 N., R. 8 E.	1042, T.D. 2802
3	Seamans Depository No. 1 Osage, NW NW SW, Sec. 8, T. 26 N., R. 8 E.	985, T.D. 2785
4	New England Public Light Co. No. 1, SW NW SE, Sec. 31, T. 26 N., R. 8 E.	1033, T.D.2973
5	Johnson Oil Refinery No. 1 Tract 44, SW NE SW, Sec. 7, T. 25 N., R. 8 E.	1000, T.D. 2964
6	Atlantic Refining Co. No. 9-V569, WL NE SW, Sec. 19, T. 25 N., R. 8 E.	1089, T.D. 2838
7	Atlantic Refining Co. No. 4-V569, SW NE SW, Sec. 19, T. 25 N., R. 8 E.	1094, T.D. 2874
8	R. J. Barrett et al No. 1, N½ N½ SW, Sec. 4, T. 24 N., R. 8 E.	976, T.D. 2862
9	Gled Oil Co. No. 3 Kohpay, SE NE NE, Sec. 16, T. 24 N., R. 8 E.	997, T.D. 2720
10	F. M. Pinney No. ? NW SW NW, Sec. 15, T. 24 N., R. 8 E.	1017, T.D. 2563
11	Marland and Gled Oil Co. No. 2 Kohpay, SE SE NE, Sec. 16, T. 24 N., R. 8 E.	1029, T.D. 2570
12	McCullough Oil Co. No. 2 Roach, SW SW SE, Sec. 21, T. 24 N., R. 8 E.	1063, T.D. 2810
13	Norbla Oil Co. No. 1-A, NE SW SW, Sec. 28, T. 24 N., R. 8 E.	833, T.D. 2558
14	Mutual Oil Co. No. 22-A, NW NW NW, Sec. 33, T. 24 N., R. 8 E.	825, T.D. 2858
15	Sinclair-Prairie Oil Co. No. 128, SW SW SW, Sec. 4, T. 23 N., R. 8 E.	960, T.D. 2754

(Figure 12 contd.)

Well No.	Name and Location	Elevation
16	Prairie-Prairie and Pure Oil Co. No. 16, NE SW SW, Sec. 9, T. 23 N., R. 8 E.	971, T.D. 2615
17	Pure Oil Co. No. 171, NW SE SW, Sec. 9, T. 23 N., R. 8 E.	970, T.D. 2678
18	Quinlan et al No. 1, SW SW SE, Sec. 14, T. 23 N., R. 8 E.	875, T.D. 2795
19	Prairie Oil and Gas No. 12, C NE SE, Sec. 25, T. 23 N., R. 8 E.	876, T.D. 3037
20	J. G. Buell and Markey No. 14, NE SW SE, Sec. 25, T. 23 N., R. 8 E.	860, T.D. 2390
21	J.R. Higgins No. 16, N½ SW SE, Sec. 25, T. 23 N., R. 8 E.	843, T.D. 2480
22	Carter No. 2, N½ NE NE, Sec. 36, T. 23 N., R. 8 E.	831, T.D. 2615
23	Red Bank Oil Co. No. 2 Little, CSL NW, Sec. 14, T. 22 N., R. 8 E.	861, T.D. 3429
24	Red Bank Oil Co. No. 1 Little, SW SW NW, Sec. 14, T. 22 N., R. 8 E.	954, T.D. 2940
25	Foster and Norwood No. 1, NE NE NW, Sec. 24, T. 22 N., R. 8 E.	871, T.D. 2972
26	Norbla and Peters No. 1, NW NE SW, Sec. 30, T. 22 N., R. 9 E.	888, T.D. 2768
27	Moore No. 1 Rush, NW SW NE, Sec. 32, T. 22 N., R. 9 E.	830, T.D. 2760
28	Lewis Oil Company No. 1 McCune, SW SW SW, Sec. 3, T. 21 N., R. 9 E.	915, T.D. 2845
29	Forester and Norwood No. 1, NW NW SE, Sec. 9, T. 21 N., R. 9 E.	1016, T.D. 2952
30	Moore Oil Co. and Ohio Oil Co., No. 2 Osage, SW SW SW, Sec, 9, T. 21 N., R. 9 E.	915, T.D. 2667

(Figure 12 contd.)

Well No.	Name and Location	Elevation
31	Finance Oil Co. and Foster-Davis No. 34, SE SW SE, Sec. 19, T. 21 N., R. 9 E.	884, T.D. 3202
32	Tidal No. 2 Sewell, WL SW NE, Sec. 35, T. 21 N., R. 8 E.	883, T.D. 3124
33	Gypsy No. 1 Widener, SE SE SE, Sec. 34, T. 21 N., R. 8 E.	809, T.D. 2950
34	Tidal Osage No. 8 Arnold, NE SE SW, Sec. 3, T. 20 N., R. 8 E.	901, T.D. 3217
35	Flight-Beacon No. 1 Yowell, NW NW NE, Sec. 9, T. 20 N., R. 8 E.	1028, T.D. 3262
36	Major No. B-1 Baker, NE NE NW, Sec. 9, T. 20 N., R. 8 W.	1010, T.D. 2995
37	Minnehoma No. 1 Richards, NE NW NW, Sec. 9, T. 20 N., R. 8 E.	1019, T.D. 3072
38	Wood Oil Co. No. 1 Schooland, C NW NE, Sec. 36, T. 20 N., R. 7 E.	860, T.D. 3655
39	J. H. Markham No. 1 Schooland, SE SE NW, Sec. 36, T. 20 N., R. 7 E.	880, T.D. 3602
40	Sand Springs Home No. 13 Atkins, CEL SW NW, Sec. 4, T. 18 N., R. 7 E.	825, T.D. 3840
41	Riverside No. 2 Yarhola, NW SW SE, Sec. 8, T. 18 N., R. 7 E.	748, T.D. 3810
42	Cosden Oil and Gas Co. No. 17 Barnett, NE NW SE, Sec. 22, T. 17 N., R. 7 E.	1012, T.D. 3704