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SUBSURFACE GEOLOGY OF CRAIG, MAYES AND EASTERN NOWATA AND ROGERS COUNTIES, OKLAHOMA

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CHAPTER I

INTRODUCTION

Location

The area encompassed by this investigation comprises approximately 1,870 square miles around the western flank of the Ozark uplift in northeastern Oklahoma. Specifically, the study includes Mayes County, Craig County, and the eastern township (T. 17 N.) of Rogers and Nowata Counties.

Purpose and Method of Investigation

This study was undertaken first, to establish a correlation of the rocks in the subsurface with those cropping out at the surface in the same area and in the subsurface of adjacent areas in Oklahoma and Kansas; and second, to prepare isopachous, structural contour, and paleogeologic maps of selected intervals from the

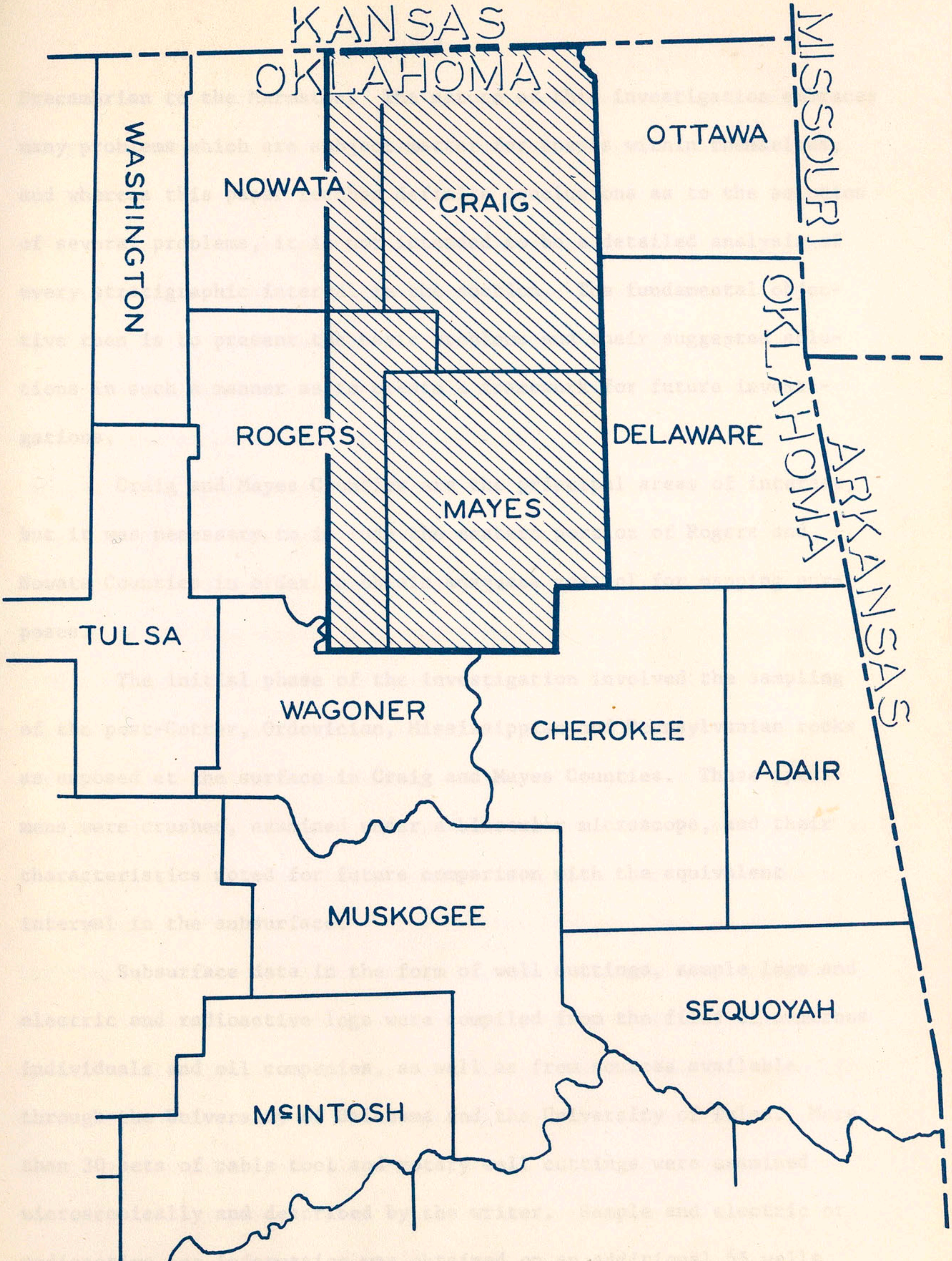

FIGURE I

INDEX MAP SHOWING LOCATION OF AREA.

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Precambrian to the Marmaton. The nature of this investigation embraces many problems which are subject matter for theses within themselves, and whereas this paper reaches definite conclusions as to the solution of several problems, it is not intended to be a detailed analysis of every stratigraphic interval in the section. The fundamental objective then is to present the basic problems and their suggested solutions in such a manner as to create a framework for future investigations.

Craig and Mayes Counties are the principal areas of interest, but it was necessary to include the eastern portion of Rogers and Nowata Counties in order to obtain adequate control for mapping purposes.

The initial phase of the investigation involved the sampling of the post-Cotter, Ordovician, Mississippian and Pennsylvanian rocks as exposed at the surface in Craig and Mayes Counties. These specimens were crushed, examined under a binocular microscope, and their characteristics noted for future comparison with the equivalent interval in the subsurface.

Subsurface data in the form of well cuttings, sample logs and electric and radioactive logs were compiled from the files of numerous individuals and oil companies, as well as from sources available through the University of Oklahoma and the University of Tulsa. More than 30 sets of cable tool and rotary well cuttings were examined microscopically and described by the writer. Sample and electric or radioactive log information was obtained on an additional 65 wells (Append. C and D). Sample logs from 32 wells, including five wells outside the area of interest, and six measured sections were used in the preparation of north-south and east-west stratigraphic cross sections.

The largest percentage of well information used in the construction of isopachous and structural contour maps was taken from driller's logs. More than 380 of these logs were selected from Corporation Commission records and other sources. The writer is well aware of the disadvantages of driller's logs, but in view of the limited quantity of more reliable subsurface information, it was necessary to make the best possible use of all data available. The wells plotted on the base map by no means represent all the wells drilled in the four-county area. The scale of the map and generalized nature of contouring, did not seem to justify the plotting of every reported well, particularly in Rogers and Nowata Counties. Most of the wells selected were drilled by cable tool rigs.

As previously mentioned, the use of driller's logs in a subsurface study has definite limitations, resulting primarily from the uncertain accuracy of the horizon "tops" on the logs and lack of detailed lithologic description. The writer has found the horizon-top accuracy to vary from driller to driller, but the lack of detailed description is universal. This failing precludes the use of the driller's log in subdividing a sequence of lithologically similar units such as is found in the Mississippian system. In many cases it is necessary to interpret even the basic rock types. A description of sandstone, for example, can mean anything from a siltstone to a fluid-bearing, coarsely crystalline limestone. A report of "limestone" is indicative of hard drilling. No distinction is generally made between limestone and dolomite. "Soft" drilling and a muddy bit denotes a "shale" interval. These principal rock types are commonly modified by the terms sandy, limy or shaly. Apparently a driller's description of a given interval depends as much on the manner in which it drills, as it does the nature of the rocks appearance in the cuttings.

Perhaps the most invalid aspect of driller's logs from a purely geological point of view is the misapplication of the terms "Wilcox sand", "top of the Mississippi lime" and "Burgess sand". These terms have a special significance to a driller but they cannot be taken as literal correlations. The "Wilcox sand" is a designation applied to any "sandy," fluid-bearing zone below the Chattanooga shale, whether it is the Simpson group or the upper part of the Arbuckle group. The "top of the Mississippi lime" cannot be interpreted always as the top of the Mississippian system because drillers usually log the Fayetteville shales with the Pennsylvanian and often describe the Hindsville limestone as the "Burgess sand." The term "Burgess sand" is applied to a porous or "sandy" zone above the hard "Mississippi lime". With few exceptions, the "Burgess" is the fluid-bearing upper portion of the Mississippian system, which is either the Hindsville or Warsaw limestones. Regardless of the limitations involved, total intervals such as the Arbuckle group, or the Mississippian system or the Morrowan series can be interpreted from a driller's log, if it is keyed to a sample log in the same area. Units which have distinct lithologic or stratigraphic characteristics, such as the Chattanooga shale and the Fort Scott limestone, can generally be distinguished from a driller's log without the aid of a comparable sample log.

The principal handicap to subsurface structural contour mapping in the area is the almost total absence of well elevations. Most of the surface elevations used in the preparation of the two structural contour maps included within this paper, were estimated from United States Geological Survey topographic sheets. The use of estimated elevations is unquestionably a limitation to these maps, but one which cannot be avoided if a structural study is to be undertaken in the Craig-Mayes County area.

History of Previous Investigations

A wealth of information has been published concerning the surface geology of this area of northeastern Oklahoma, but, with few exceptions, little detailed consideration has been given the subsurface stratigraphy.

Among the earlier publications to discuss the subsurface of northeastern Oklahoma were those by Aurin, Clark and Trager (1921) and Buchanan (1927). These papers dealt primarily with the distribution and correlation of the Mississippian system.

White (1926) established the erosional limits of the Tyner-Burgen sequence in southern Mayes and Rogers Counties. Recent well information within the area of interest has not altered appreciably this original interpretation.

A series of articles published in Bulletin 40 of the Oklahoma Geological Survey by Bloesch (1928), Woodruff and Cooper (1928), and Ireland (1930), summarized the surface and subsurface geology of the four counties included in this investigation. Cram (1930) as part of the same series, discussed the relationship of the subsurface "black lime" with the "Mayes" and "Boones" formations found at the surface in northeastern Oklahoma.

The subsurface distribution of the pre-Mississippian rocks of Kansas and Oklahoma was discussed by McLellan (1930). Wallace Lee (1940), in his classic study of the Mississippian rocks in the subsurface of Kansas, correlated the Cowley formation with a part of the Moorefield formation exposed at the surface in Mayes County.

Ireland (1944 and 1946) correlated the subsurface Lower Ordovician and Upper Cambrian rocks of southwestern Missouri with the pre-Simpson equivalents in northeastern Oklahoma. Thickness and distribution maps of this interval were prepared for an area which included parts of Oklahoma, Kansas, Missouri and Arkansas.

The problem of the subsurface "Mayes" or "black lime" has been revived and debated in separate papers published by Laudon and Selk in 1948.

Ireland (1955) published a comprehensive analysis of the Precambrian surface in northeastern Oklahoma and parts of adjacent states. This was followed by Dille' (1956) with his work on the "Paleotopography of the Precambrian surface of northeastern Oklahoma."

The most detailed examination of the subsurface yet undertaken within the area of interest was completed by Darnell in 1957. This study involved the subdivision and correlation of the Mississippian system in the Claremore-Wagoner area.

Since 1957, a number of published and unpublished papers have been completed which either include the area of this investigation as part of a regional survey, or as part of a regional subsurface discussion. Among the more important of these are works by Caplan (1957), Sartin (1958), Bercutt (1958), Merriam and Goebel (1959), Huffman (1959), and Jordan (1959).

CHAPTER II

STRATIGRAPHY

The Paleozoic rock column, as exposed at the surface in Craig and Mayes Counties, and those pre-Cotter Arbuckle formations which are not known to crop out within these counties, are represented in the subsurface of the area.

The oldest surface exposures are at Spavinaw in Mayes County where rocks of Precambrian age crop out. Progressively younger Mississippian and Pennsylvanian formations crop out in narrow, northeast-southwest striking bands, dipping gently to the west and northwest around the flanks of the Ozark uplift (Plate VII). The youngest surface rocks are Pennsylvanian (Upper Desmoinesian) in age, and are exposed in northwestern Craig County and northeastern Nowata County.

The rather unusual nature of the problem where within the same area nearly the entire subsurface rock column crops out at the surface, requires that a published outline of nomenclature and subdivision for the Paleozoic strata at the surface be accepted as a standard for subsurface correlation. Nomenclature applied to the pre-Mississippian and Mississippian units is based primarily on recent work by Huffman (1958). Subdivisions of the Pennsylvanian, as described by Branson (1954), are applied to equivalents in the subsurface. In the absence of faunal evidence, all correlations are based on the comparison of

SYSTEM	SERIES	GROUP and FORMATION	FEET	DESCRIPTION
PENNSYLVANIAN	DESMOINESIAN	MARMATON (Altamont, Bandera, Pawnee, Labette, Upper Fort Scott, Lower Fort Scott)	0–450	Gray shale, silty shale, sandstones and massive, dense limestones. Base of Fort Scott limestone makes an excellent surface and subsurface contour datum. Marmaton units at surface in northwestern corner of area. Thin southeastward to extinction in Craig County.
		CABANISS (Breezy Hill, Verdigris, Tiawah)	0–235	Well developed cyclic sequence of shales, sandstones, limestones and thin coals. Breezy Hill and Verdigris limestones are readily recognized in the subsurface. The basal Tiawah ("Pink") limestone is more commonly developed as a zone of interbedded black shales and clay ironstones. Sandstones grade laterally and vertically into siltstones and silty shales. Cabaniss units outcrop in western Craig and eastern Rogers Counties. Thins southeastward. Essentially absent in Mayes County.
		KREBS (Bluejacket, Warner)	0–570	Erratic sequence of dark gray and black shales, siltstones, sandstones, thin limestones and coals. Few persistent subsurface marker beds. Bluejacket and Warner sand zones fairly well developed, but commonly change laterally to siltstone and silty shale. Limestones generally thin and impure. Bedded clay ironstones and sideritic shales common in lower portion of interval. Rest unconformably on Mississippian limestones in northern part of area. Overlie Atokan sediments in southern Mayes and Rogers counties. Thins to extinction in eastern Mayes and southeastern Craig Counties.
	? ATOKAN	? ATOKA		Shales, sandstones and siltstones, occasionally conglomeritic at base. Difficult to distinguish from basal Krebs units. Truncated and overlapped northward.
	MORROWAN	MORROW	0–125	Fossiliferous, commonly glauconitic limestone with interbedded black shales. Lower interval typically a sandy limestone to calcareous sandstone. Truncated north and east of T. 23 N., R. 17 E.
MISSISSIPPIAN	CHESTERIAN	PITKIN	0–5	Gray, fossiliferous limestone. Absent north of T. 19 N.
		FAYETTEVILLE	0–130	Black, calcareous and non-calcareous shale with thin interbedded to massive, dark gray, dense, argillaceous limestone. Limited to central and southern Mayes County and southeastern Craig County.
		HINDSVILLE	0–64	Gray, crystalline to bioclastic, oolitic limestone. Sandy in northeastern Craig County. Absent to northwest in Craig County.
	MERAMECIAN	WARSAW / MOOREFIELD	0–165	Drab white, siliceous limestone and microfossiliferous chert. Base marked by glauconitic shale and limestone ("J" bed of Tri-State district). Meramec of Craig and eastern Nowata Counties. Moorefield silty, argillaceous limestone facies. Meramec of Mayes County.
	OSAGEAN	KEOKUK–REEDS SPRING	50-260	White tripolitic, white to tan, and blue-gray bedded chert and siliceous limestone. Smoky gray and gray mottled cherts interbedded with gray and tan limestone to base of interval.
		ST. JOE	0–100	White to gray, crystalline, crinoidal, noncherty limestone. Interbedded pale green shale.
	KINDERHOOKIAN	"KINDERHOOK SHALE"	0–35	Gray-green, dolomitic, _Tasmanites_-bearing shale in northern Craig County.
DEV.		CHATTANOOGA	0–84	Brownish-black, pyritic, _Tasmanites_-bearing shale. Thin Sylamore sandstone member at base.
ORDOVICIAN	CHAMPLAINIAN	TYNER / BURGEN	0–126	Sequence of green shales and dolomitic sandstones. White, fine-grained sandstone at base of interval. Characterized by numerous rounded, frosted sand grains. Essentially absent north of T. 19 N.
	CANADIAN	ARBUCKLE (Cotter)	37-1630	Series of brown and gray, massive, commonly cherty dolomites, sandy dolomites and white, dolomitic sandstones.
CAMB.	CROIXIAN	Bonneterre / LAMOTTE	0–100	Gray, conglomeritic sandstone. Angular to rounded quartz grains, fragments of feldspar and weathered granite.
PRECAMBRIAN		SPAVINAW	Unknown	Pink to red, coarse-grained, feldspathic granite. Basic igneous rocks are known to occur in parts of Craig County.

GENERALIZED COLUMNAR SECTION
For
CRAIG, MAYES, AND EASTERN NOWATA AND ROGERS COUNTIES, OKLAHOMA

FIGURE 2

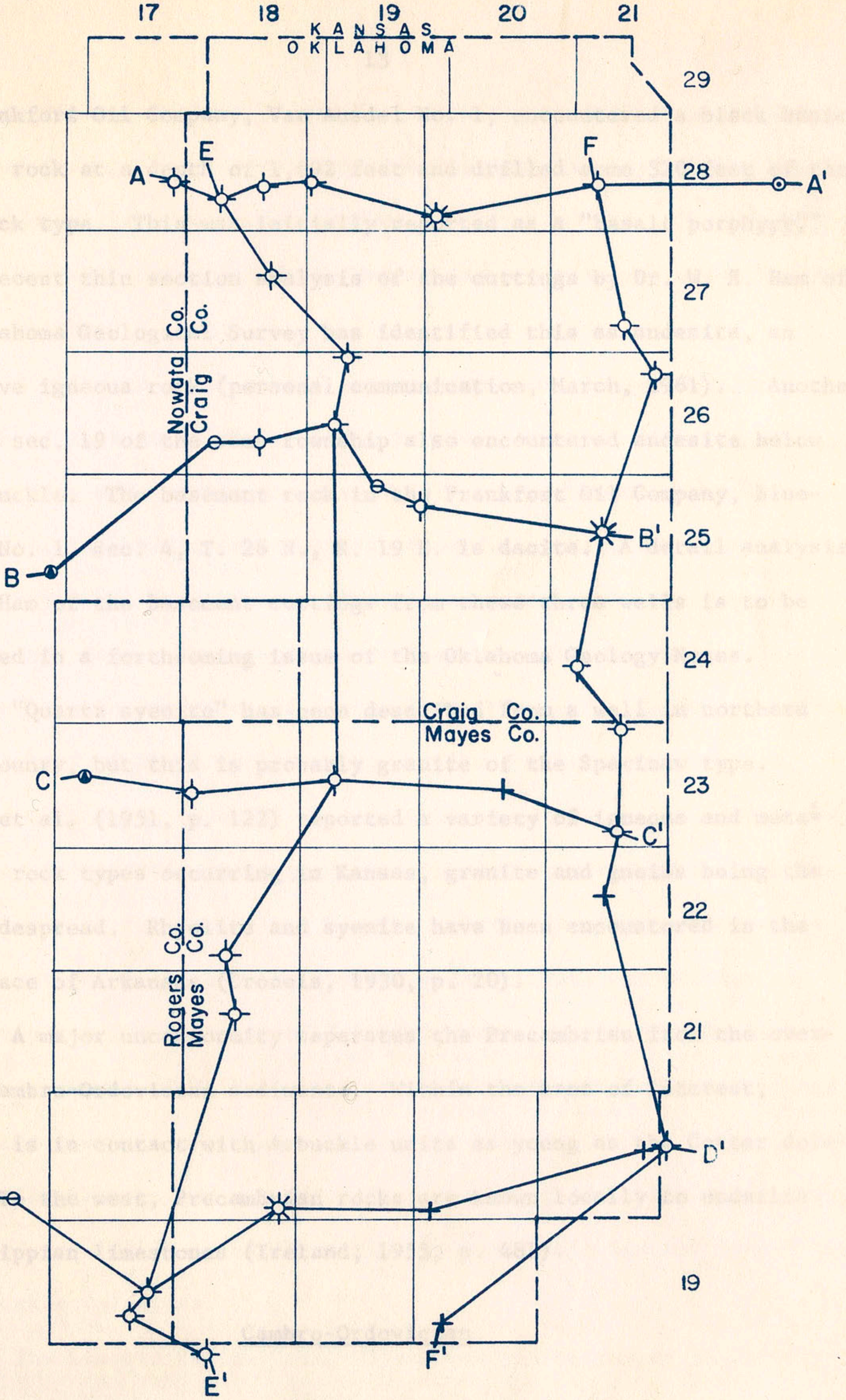
the subsurface lithologic characteristics of rock units, as determined from well samples, with formations described at the surface in northeastern Oklahoma and in the subsurface of adjoining areas. The relation of surface to subsurface stratigraphy is graphically presented by a series of north-south and east-west cross sections (Figure 3).

Precambrian

The rugged Precambrian surface in northeastern Oklahoma is indicative of the long period of erosion which preceded the deposition of Paleozoic sediments. Subsurface mapping of the basement topography by Dille' (1956) and by Ireland (1955) reveals a surface characterized by numerous steep-sided peaks, particularly in the area of the "Tulsa Mountains." The granite outcrop at Spavinaw in Mayes County is thought to represent an exhumed Precambrian peak (Ireland, 1930, p. 12-15 and 1955, p. 482), similar in nature to those mapped in the subsurface to the west.

Spavinaw granite at the outcrop is a red, coarse-grained granitoid rock consisting primarily of orthoclase feldspar, quartz and dark ferromagnesian minerals (Huffman, 1958, p. 15). Microscopic studies by Merritt (1960, p. 224-228) reveal the chief constituents to be orthoclase and microperthite, the latter intergrown with quartz to form a micropegmatite.

Basement rocks encountered in the subsurface of the area are, in most instances, of the pink to red, coarse-grained Spavinaw granite type, but at least three significant exceptions are noted in well cuttings from Craig County. In sec. 31, T. 28 N., R. 20 E., the



INDEX MAP TO CROSS SECTIONS

FIGURE 3

the Frankfort Oil Company, Van Ausdel No. 1, encountered a black basic igneous rock at a depth of 1,692 feet and drilled some 320 feet of the same rock type. This was initially reported as a "basalt porphyry," but a recent thin section analysis of the cuttings by Dr. W. E. Ham of the Oklahoma Geological Survey has identified this as andesite, an extrusive igneous rock (personal communication, March, 1961). Another well in sec. 19 of the same township also encountered andesite below the Arbuckle. The basement rock in the Frankfort Oil Company, Bluejacket No. 1, sec. 4, T. 26 N., R. 19 E. is dacite. A detail analysis by Dr. Ham of the basement cuttings from these three wells is to be published in a forthcoming issue of the Oklahoma Geology Notes.

"Quartz syenite" has been described from a well in northern Mayes county, but this is probably granite of the Spavinaw type. Moore, et al. (1951, p. 122) reported a variety of igneous and metamorphic rock types occurring in Kansas, granite and gneiss being the most widespread. Rhyolite and syenite have been encountered in the subsurface of Arkansas (Croneis, 1930, p. 20).

A major unconformity separates the Precambrian from the overlying Cambro-Ordovician sediments. Within the area of interest, granite is in contact with Arbuckle units as young as the Cotter dolomite. To the west, Precambrian rocks are known locally to underlie Mississippian limestones (Ireland, 1955, p. 481).

Cambro-Ordovician

Lamotte Sandstone

The Lamotte sandstone as defined by Dille' (1956, p. 15-20) is the partial equivalent of the Reagan sandstone, and like the Reagan is a time transgressing basal sandstone of Cambrian age resting unconformably upon the Precambrian surface.

Surface exposures of the Lamotte have not been found in northeastern Oklahoma.

A white to gray, poorly sorted sandstone, characteristically composed of fine-to coarse-grained, rounded, frosted, many regenerated quartz grains and varying amounts of feldspar and weathered fragments of granite, increasing in percentage toward the base, was found to overlie Precambrian rocks of a granitic composition in the Craig-Mayes County area. This sandstone and arkose interval is correlated with the Lamotte sandstone of southwestern Missouri. In areas where sandy members of the Arbuckle group overlie the Lamotte, the upper limit of this basal interval is difficult to establish. No definitive gamma-ray or electric response occurs consistently enough to be taken as representing the top of the Lamotte. Criteria used in the sample identification of the Lamotte sandstone is: first, the absence or relatively small percentage of dolomitic sand; second, the inclusion and larger amount of feldspar and weathered fragments of granite; and third, the presence of regenerated quartz grains.

The Lamotte was not identified in two of the wells previously described (p. 11-13) as having a fine-grained basic igneous rock below the Arbuckle dolomites.

The Lamotte in the Craig-Mayes County area ranges in thickness from zero to 100 feet, and averages between 40 and 60 feet.

Unconformities mark both the base and top of the formation.

As noted by Dille' (1956, p. 17), the Lamotte appears to transgress time lines. Wells encounter the sandstone at different stratigraphic intervals, i. e., below progressively younger Arbuckle units in the direction of regional Precambrian "highs."

Arbuckle Group

The Arbuckle Group of northeast Oklahoma includes the pre-Simpson post-Lamotte dolomite beds of late Cambrian and early Ordovician age. Aurin, Clark and Trager (1921) coined the term "Siliceous limestone" for the subsurface Arbuckle formations. This terminology persisted for many years but has been discarded in favor of the term "Arbuckle group" for dolomites of pre-Simpson age. Using insoluble residues, H. A. Ireland (1944) subdivided the Arbuckle group of northeastern Oklahoma into the following formations, in ascending order: the Bonneterre dolomite, Eminence dolomite, Gasconade dolomite and Van Buren formation (undifferentiated) with the Gunter sandstone member at the base, Roubidoux formation, Jefferson City dolomite, Cotter dolomite and the Powell dolomite. The Bonneterre and Eminence are considered Late Cambrian in age, and the succeeding formations are of Early Ordovician age. The Cotter formation is the only representative of the Arbuckle group to crop out in the Craig-Mayes County area. Ireland inferred that on the basis of rather scattered well information, the Cotter formation was the uppermost member of the Arbuckle group in the Craig-Mayes County area. Caplan (1957) mapped a wide band of Powell dolomite extending to the Oklahoma state line in the subsurface of northwestern Arkansas. It is possible that the Powell underlies

Simpson, and younger rocks to the east of or actually within the extreme southeast corner of this area.

No attempt was made to subdivide the Arbuckle group. Justifiable correlations require insoluble residue studies which are beyond the scope of this investigation.

In general, the Arbuckle is a brown to gray, massive, crystalline, commonly cherty dolomite with numerous zones of white, fine-grained, well-sorted dolomitic sandstone. The dolomites normally are porous, locally even vuggy. Included cherts are typically white and commonly oolitic. Sandstones and sandy dolomites in the lower portion of the Arbuckle are characterized by numerous large, rounded, frosted quartz grains.

An unusual sequence of post-Arbuckle and Arbuckle strata was encountered in the M & F Oil Company, Ransom No. 1 in sec. 18, T. 20 N., R. 22 E. (Cross Section D-D', Plate IV). The geologist at the well correlated a gray dolomite from 720 to 755 feet with the Powell dolomite of northwestern Arkansas. In evaluating the sample description, the author questioned correlations made below the Chattanooga shale; but without the samples, could only speculate as to the relationship of this interval to the Ordovician units found in wells to the west.

The Cotter dolomite is of particular interest within the area because it offers the most promising possibilities for oil and gas discovery. Characteristically, the Cotter is a buff to brown, crystalline dolomite containing white commonly oolitic, and white spotted brown oolitic chert. Sandy zones were noted throughout the interval. The base is normally marked by the "Swan Creek" sand zone. The upper portion of the Cotter is often reported as sandstone on driller's logs and referred to as the "Wilcox sand". As discussed in the introductory chapter, the term "Wilcox sand" is an invalid stratigraphic correlation in Craig and northern Mayes Counties, and when used by drillers can only mean a zone of porosity below the Chattanooga black shale. The Cotter normally contains varying amounts of sand and sandy dolomite in the upper portion, but what is described as a "sandstone" on driller's reports is actually a very finely ground crystalline dolomite with little or no included sand. The finely ground, sandy appearance of the sample normally is the result of water in the drill hole. A typical example of this condition was found in the Parker-Rich, Dunbar No. 1, sec. 27, T. 27 N., R. 21 E. (Cross Section F-F', Plate VI).

Oil shows have been reported in the upper part of the Cotter, but more often, water is encountered at the top or within a few feet of the top of the formation. Fresh water in the upper Cotter seems to be more prevalent in the extreme northeast and eastern portions of the area.

The Arbuckle group is present throughout the area, varying in thickness from 37 to 1,630 feet.

Lower Arbuckle formations rest unconformably on the Lamotte and in some instances directly overlie the Precambrian. Disconformities within the Arbuckle group appear to represent relatively short erosional intervals (Ireland, 1946). An unconformity of considerable magnitude separates the uppermost Arbuckle from the overlying beds of younger Ordovician and Devonian-Mississippian age. In southern Mayes County, Simpson sandstones overlie the Cotter dolomite. North of the

Simpson erosional limit, the Chattanooga formation rests unconformably upon the Cotter. Where the Chattanooga is locally absent, rocks of Mississippian age overlie the Arbuckle.

Ordovician System

Simpson Group

The Simpson group of the Craig-Mayes County area is composed of the Burgen sandstone and overlying Tyner formation.

At the outcrop in southeastern Mayes County the Burgen is a white to yellow-brown friable sandstone. The succeeding Tyner formation consists of bright green, waxy shale with interbedded brown, sandy dolomite (Huffman, 1958, p. 20-22).

In the subsurface the Burgen is characteristically a white, well-sorted, tightly bonded sandstone. The sand grains are fine to medium in size, rounded to subrounded in shape. Large, rounded and frosted grains are commonly found loose within the sample. The Burgen is succeeded conformably by the Tyner formation.

The Tyner consists of calcareous to dolomitic sandstones, sandy dolomites and interbedded green shales. The sandstones generally are fine-to medium-grained. Rounded, frosted sand grains are embedded in the green shale or free in the sand samples. Sandy portions of the Tyner are locally glauconitic. A typical Tyner-Burgen sequence is found in the Campbell, Ruppel No. 1, sec. 23, T. 19 N., R. 17 E. (Cross Section D-D', Plate IV).

Drillers commonly refer to the Simpson interval as the "Wilcox sand," and as previously discussed, this leads to considerable confusion when the term is applied to pre-Chattanooga "sandy" zones in areas north of the Simpson subcrop. As a general rule the true Simpson or Tyner-Burgen interval is described on driller's logs as a "sandstone" and "green shale," or "green sand."

The combined Tyner-Burgen interval has a maximum thickness of 126 feet along the southernmost margin of the area, but thins rapidly northward by truncation and is generally absent north of T. 19 N., Erosional remnants of the Simpson sands are believed to be present as far north as T. 21 N., (Plate X). A questionable thickness of 257 feet of dolomite, dark shale and green shale, sandy dolomite and sandstone found in the Ransom well (Cross Section D-D', Plate IV), Sec. 18, T. 20 N., R. 22 E., is tentatively assigned to the Simpson group. Previously this interval was correlated with the Everton of northwestern Arkansas. In view of lithologic affinities with the Simpson group of Mayes County, and the presence of beds dissimilar to the Everton of Arkansas (namely, thick dark and green shales) this interval is tentatively correlated with the Tyner-Burgen. The principal criticism to the Tyner-Burgen correlations is that the unusual thickness of this Tyner-Burgen lithology is in an area where these formations were previously thought to be thin or entirely absent.

The Simpson group rests unconformably upon the eroded surface of the Cotter formation and is overlain and truncated to the north by the Chattanooga formation of Devonian-Mississippian age.

Devonian-Mississippian

Chattanooga Formation

The Chattanooga formation, both at the outcrop and in the subsurface, consists of a basal sandstone member, the Sylamore, and an upper black shale member, the Noel (Huffman and Stark, 1960, p. 159-163).

In surface exposures, the Sylamore is a white, phosphatic sandstone conformable and gradational with the overlying black shale member (Huffman, 1958, p. 39). The thickness and distribution of the Sylamore is erratic. The unit at few places attains a thickness of more than a few feet and normally is entirely absent.

The black fissile, pyritic, (Noel) shale member is widely distributed throughout the area (Huffman, 1958, p. 39).

The subsurface character of the Chattanooga formation is virtually the same as found at the outcrop. The basal Sylamore sandstone is extremely erratic, locally absent, and normally is no more than a foot or two in thickness. A maximum thickness of 10 feet occurs in a northern Craig County well. The sand grains are generally fine to medium in size, subangular to rounded in shape, and poorly sorted. Large rounded, frosted, detrital sand grains are commonly found in the Sylamore interval, and in some wells they are the only evidence of a basal sand beneath the black shale member.

The overlying shale member is characteristically black to brownish-black, platy, pyritic and <u>Tasmanites</u>-bearing. The black organic nature of the shale records a distinctive maximum curve value on a gamma-ray log (Figure 4). Normally the Chattanooga is non-calcareous, but at least three wells in Craig County penetrated thin zones of impure carbonates and (or) calcareous shale within the Chattanooga interval. Approximately four feet of dark brown Tasmanites-bearing limestone or dolomitic limestone was logged in the upper portion of the Chattanooga shale in the Frankfort Oil Company, Bluejacket No. 1, sec. 4, T. 26 N., R. 19 E. (Cross Section E-E', Plate V). Lee (1940, p. 23) reports a similar local occurrence of impure dolomite within the black Chattanooga shale of southern Kansas.

The consistent lithology and widespread distribution of the Chattanooga shale make it an excellent subsurface datum.

The thickness ranges from zero to 84 feet, but generally an average of 50 to 60 feet is maintained in Mayes and southern Craig County. In northern Craig County, the Chattanooga thins to an average thickness of 30 to 40 feet. The apparent thinning in Craig County is due primarily to the northward thickening of the overlying "Kinderhook shale" (Figure 5).

The Chattanooga is absent either because of erosion and (or) of non-deposition in the extreme southwestern and northeastern corners of the area. No well data are available to justify assuming the absence of Chattanooga shale in northeastern Craig County, but adjoining areas to the north in Kansas (Lee, 1940, p. 25-26) and to the east in Ottawa County report the Chattanooga to be absent. Wells nearest the area display a general thinning of the Chattanooga to the northeast.

Lee (1940, p. 25) believed the absence of the Chattanooga in extreme southeastern Kansas was due to non-deposition. Darnell (1957,

p. 14), after a detailed study of the Mississippian system in the Claremore-Wagoner area, favored non-deposition of the Chattanooga as the reason for its absence over a large area in southwestern Mayes, southeastern Rogers and northern Wagoner Counties. In southwestern Mayes and southeastern Rogers Counties, the problem is complicated further by the questionable age assignment of the Mississippian rocks resting, in the absence of the Chattanooga, on Simpson sandstones. These units are tentatively considered Osagean in age, but should they prove to be Meramecian, there would be sound argument for pre-Meramec erosion having removed the Chattanooga.

Prior to the deposition of the Chattanooga formation, northeastern Oklahoma was tilted abruptly to the south, and units ranging from Ordovician to Devonian age were subjected to intensive erosion and peneplanation (Huffman, 1958, p. 106). Succeeding deposits of the shallow Chattanooga sea tended to fill the inequalities of a surface characterized by low relief. In southern Mayes County, the Chattanooga rests unconformably upon the Simpson group, and to the north is equally unconformable on the Cotter dolomite of the Arbuckle group. Throughout most of Mayes County and southern and eastern Craig County, the Chattanooga is succeeded unconformably by the St. Joe limestone of Mississippian age. In the northwestern portion of Craig County and adjacent areas of Nowata County, the Chattanooga is overlain by a sequence of gray and gray-green, dolomitic, Tasmanites-bearing shale ("Kinderhook shale"). The relationship of this interval to the underlying Chattanooga is not clearly understood.

The age of the Chattanooga formation has been a subject of considerable debate. Many geologists have restricted the formation to the Devonian system (Branson, 1959, p. 89 and Jordan, 1959, p. 125). Other authors, noting the angular unconformity at the base and the rather obscure disconformity separating the Chattanooga from the overlying Mississippian beds, have referred the entire sequence to the Kinderhookian series of the Mississipian system. Huffman (1958, p. 40) considered the Chattanooga of northeastern Oklahoma as Upper Devonian and Lower Mississippian in age. This age assignment is applied to the Chattanooga shale in the area of investigation.

The basal Sylamore sandstone is believed to be the equivalent of the Misener sand of the subsurface in other areas of Oklahoma and Kansas.

The overlying black shale (Noel) member is correlated with the Woodford of southern Oklahoma.

Mississippian System

The subsurface Mississippian strata of Craig and Mayes Counties are divided into four series, in ascending order: the Kinderhookian, Osagean, Meramecian, and Chesterian. These series further are subdivided by lithology, and in few areas by gamma-ray characteristics into units of formational rank. The thickness, distribution and lithology of individual units, as described in the following paragraphs, primarily are taken from sample logs. A detailed subdivision of the Mississippian system from driller's logs is almost impossible. In most instances the entire system is merely reported as "Mississippi lime."

Craig and Mayes Counties are characterized by two distinctively different sequences of Mississippian strata. In northern Craig County the Mississippian rocks closely resemble the post-Chattanooga formations, as found in the Tri-State mining district; whereas in southern Mayes County, the subsurface Mississippian is comparable to the surface exposures within that same county. The "type" Mississippian for Craig County is graphically presented in Figure 4 together with a typical gamma-ray correlation. The Mayes County "type" Mississippian is well developed in the Gardner, Gilbert No. 1, sec. 36, T. 20 N., R. 18 E. (Cross Section D-D', Plate IV).

Kinderhookian[1]

"Kinderhook shale"

The term "Kinderhook shale" is herein applied to a sequence of gray and greenish-gray, dolomitic, silty, Tasmanites-bearing shales, and local beds of thin impure dolomite, overlying the Chattanooga formation in northern Craig County (Figure 5). This unit is not found at the surface unless it is in part equivalent to a thin weathered zone of green shale at the base of the St. Joe group, and above the Chattanooga shale at the outcrop in Mayes County.

The Kinderhook shale is best developed in T. 28 N. (Cross Section A-A', Plate I) where it can be distinguished readily from the underlying Chattanooga shale both in well samples and on a gamma-ray log (Figure 4). This same unit on an electric log is difficult, if

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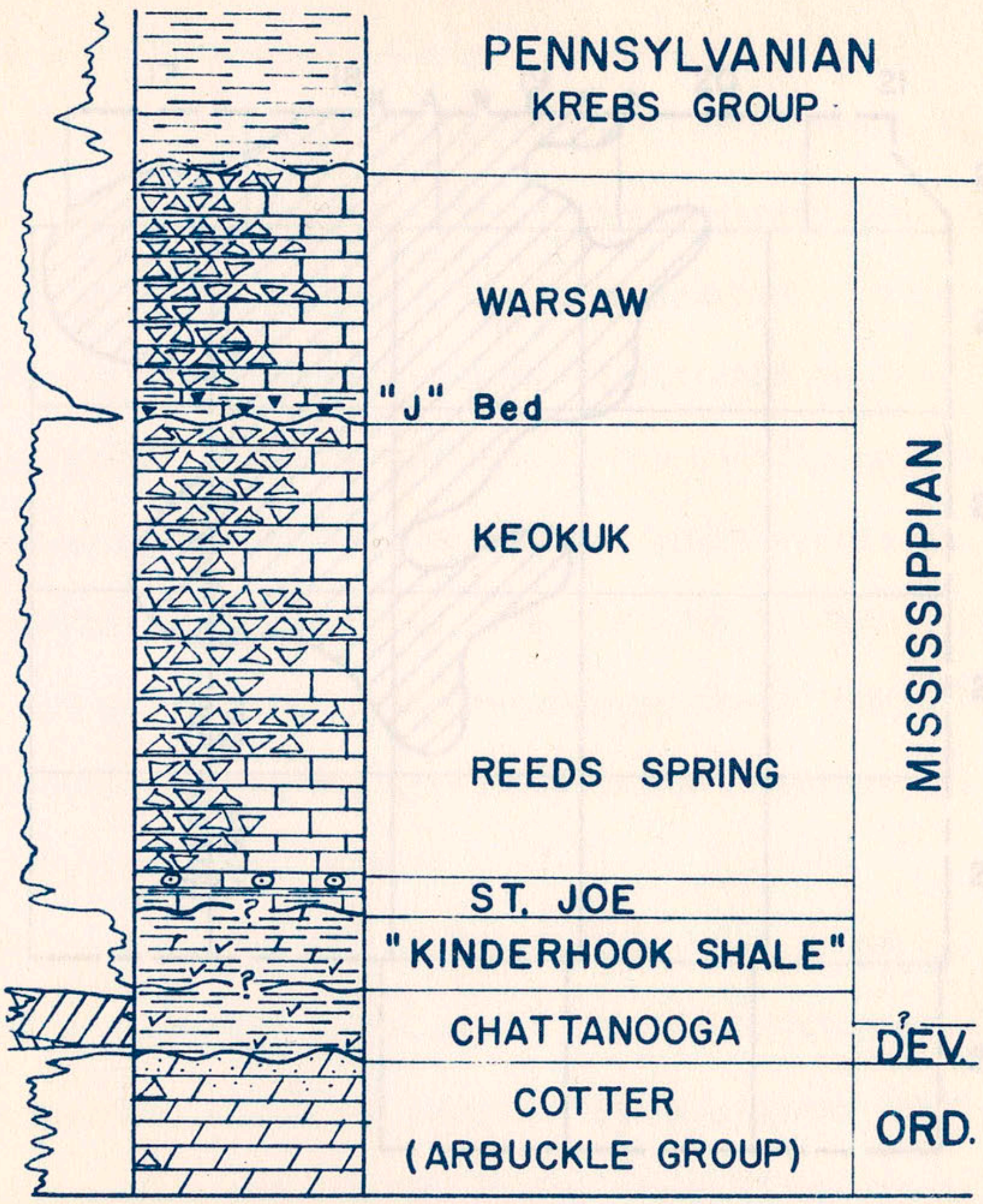
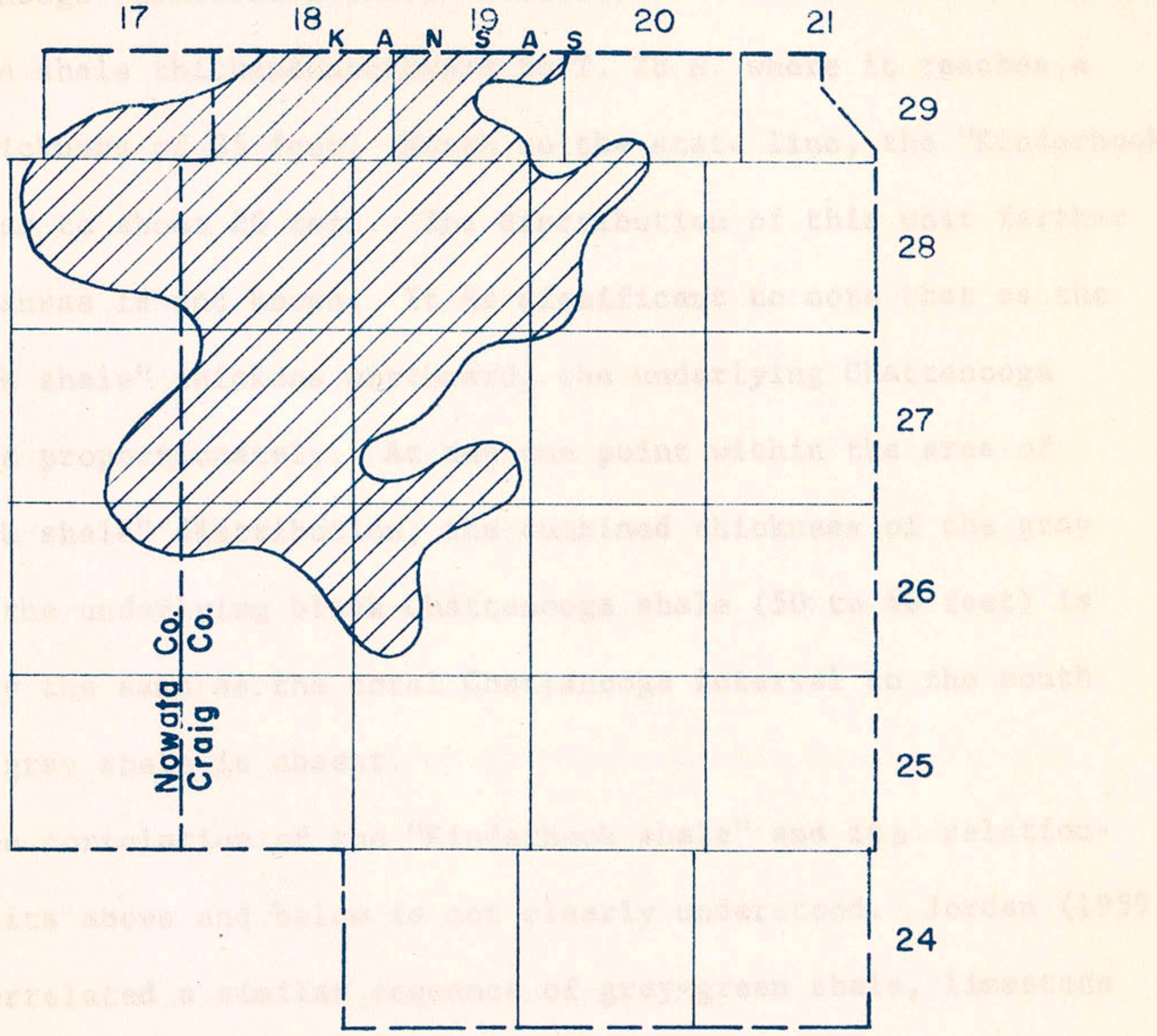
[1]The Chattanooga formation is included in the Kinderhookian series.



GAMMA-RAY CORRELATION OF PRE-PENNSYLVANIAN FORMATIONS IN NORTHERN CRAIG COUNTY

FIGURE 4



DISTRIBUTION OF "KINDERHOOK SHALE"

NOWATA AND CRAIG COUNTIES

FIGURE 5

not impossible, to separate from the underlying Chattanooga shale. Driller's logs normally note a color change in the shale below the "Mississippi lime" in this area which can generally be interpreted as the Chattanooga-"Kinderhook shale" contact.

The shale thickens northward to T. 28 N. where it reaches a maximum thickness of 35 feet. North to the state line, the "Kinderhook shale" thins to about 20 feet. The distribution of this unit farther north in Kansas is not known. It is significant to note that as the "Kinderhook shale" thickens northward, the underlying Chattanooga shale thins proportionately. At any one point within the area of "Kinderhook shale" distribution, the combined thickness of the gray shale and the underlying black Chattanooga shale (50 to 60 feet) is essentially the same as the total Chattanooga interval to the south where the gray shale is absent.

The correlation of the "Kinderhook shale" and its relationship to units above and below is not clearly understood. Jordan (1959, p. 128) correlated a similar sequence of gray-green shale, limestone and dolomite with a part of the St. Joe group (Kinderhookian and Osagean in age), as described by Huffman (1958, p. 42) at the surface in northeastern Oklahoma.

Wallace Lee (1940, p. 22) reported "sporaceous" gray shales in wells in southeastern Kansas, but considered them lateral variations of the Chattanooga. Moore, et al. (1951, p. 111) described a greenish-gray, "spore-bearing," silty or dolomitic shale resting unconformably on the Chattanooga in northeastern Kansas. This interval is called the Boice shale and is thought to be restricted to northeastern Kansas.

A satisfactory correlation of the "Kinderhook shale" awaits a broader regional study, but evidence gathered in Craig County substantiates some rather significant conclusions concerning the problem.

First, the "Kinderhook shale" as found in northern Craig County, is not equivalent to the Compton-Northview sequence of southeastern Kansas, nor the lower part of the St. Joe group (Compton-Northview equivalent) at the surface in Mayes County. This conclusion is based on the following factors: (a) the maximum thickness of the "Kinderhook shale" is almost twice the average combined thickness of the Compton limestone and Northview shale north of the state line in southeastern Kansas (Lee, 1940, plate 7); (b) a distinguishing characteristic of the Northview shale in southeastern Kansas is that it does not contain "spores" (Lee, 1940, p. 30), nor does Huffman (1958, p. 42) report Tasmanites in the middle shale member of the St. Joe group in Mayes County; (c) a typical sequence of Compton, Northview and Pierson (St. Joe group) commonly overlies the "Kinderhook shale" (Mesker Drilling Company, Miller No. 1, sec. 24, T. 28 N., R. 17 E., Cross Section A-A', Plate 1).

Second, the thickness of the Chattanooga interval remains essentially the same from areas of black shale to areas of black and gray shale deposition; therefore, the "Kinderhook shale" is possibly a lateral variation of the Chattanooga shale. In addition, the presence of Tasmanites in both shales may be indicative of a genetic relationship between the black and the gray shale. Such a correlation of the "Kinderhook shale" would imply a gradational contact with the underlying black shale and an unconformable contact with the overlying

St. Joe group.

Third, lithologically the "Kinderhook shale" is identical to the Boice shale of northeastern Kansas as described by Moore et al (1951, p. 111). The only exception is that the "Kinderhook shale" is not known to have basal beds of red shale or ferruginous oolite as does the Boice shale. The Boice is thought to rest disconformably upon eroded Chattanooga and to underlie conformably the Compton limestone. A discouraging factor in this correlation is that the Boice is believed to be restricted to northeastern Kansas (Moore, et al. 1951, p. 111), and specifically thought to be absent in the subsurface of southeastern Kansas (Merriam and Goebel, 1959, p. 138).

The relationship of the "Kinderhook shale" to units above and below depends upon the correlation accepted.

Kinderhookian-Osagean

St. Joe Group

Near Spavinaw, the St. Joe crops out as a three-fold lithic unit. The basal member consists of approximately ten feet of gray limestone. The middle member is composed of three to five feet of olive-green, soft, limy shale, and the upper member consists of a maximum of 25 feet of gray thick-bedded, finely crystalline limestone (Huffman, 1958, p. 42). Huffman has correlated these three members (in ascending order) with the Compton limestone, Northview shale and Pierson limestone of southwestern Missouri.

The Compton and Northview, classed as Kinderhookian in age, are separated from the overlying Pierson of Early Osagean, Fern Glen age (Moore, 1933, p. 203) by a relatively minor unconformity. The Pierson is considered to be equivalent to the basal non-cherty member of the "Boone" formation in the Ozark region. A slight disconformity between the upper St. Joe member (Pierson) and the overlying Reeds Spring formation, though not widely agreed upon, is recognized by Laudon (1939, p. 328) and Huffman (1958, p. 42).

Perhaps the most interesting feature of the St. Joe group is the local presence of biohermal reefs in the upper limestone member. Laudon (1939, p. 326) termed this the "reef phase," as opposed to the "non-reef phase" of the St. Joe. These massive lenticular cores, composed of coarse crinoidal material, were apparently reefs in a mariner's sense; that is, they stood as mounds of bioclastic material elevated above the floor of a shallow sea (Harbaugh, 1957, p. 2542). The thickness of these crinoidal "cores" ranges from 10 to 40 feet.

The St. Joe group in the subsurface of Craig and Mayes Counties maintains the same lithologic character and stratigraphic relations as those described for the St. Joe at the surface. The three member "group" is typified in the Mesker Drilling Company, Miller No. 1, sec. 24, T. 28 N., R. 17 E. (Cross Section A-A', Plate I).

The basal limestone is commonly cream to light gray in color, finely crystalline, pyritic, locally dolomitic and argillaceous, and fossiliferous. The middle shale member is pale-green in color, thin, pyritic and often calcareous or dolomitic. Glauconite, although rare, is reported in the lower members of the St. Joe in two wells in T. 23 N., R. 21 E. The upper limestone is the thickest and most persistent of the three members. Characteristically, it is a cream-colored, finely crystalline, non-cherty, crinoidal limestone. The contact with the overlying Reeds Spring formation is normally not difficult to recognize in well samples. Limestones associated with the gray cherts in the overlying Reeds Spring are dark, finely granular and often siliceous; whereas the upper St. Joe is a light colored, crystalline limestone. In logging well samples from the Craig-Mayes County area, a number of geologists have described varying amounts of chert in the St. Joe interval. The author's personal experience suggests that most, if not all of the chert seen in well cuttings from the St. Joe, is caving from the overlying Reeds Spring. The minor amount of chert that may occur in the St. Joe interval is well-masked by the abundance of gray chert caving from above. This is particularly true in rotary well cuttings.

At least six wells in Craig County encountered unusually thick, crinoidal, upper St. Joe limestones. These are thought to represent either the "reef phase" of the St. Joe or areas marginal to a biohermal development. A particularly good example of a "reef phase" in the upper St. Joe is found in the Mesker Drilling Company, Sheffield No. 1, sec. 21, T. 28 N., R. 21 E. (Cross Section A-A', Plate I). Approximately 87 feet of crinoidal limestone with pale-green calcareous shale partings was encountered below the Reeds Spring formation. In this well, as in others, a thickening of the upper St. Joe member results in a proportional decrease in thickness of the overlying Keokuk-Reeds Spring interval.

Whereas a distinctive three member sequence is typical of the subsurface St. Joe, such a grouping is not everywhere found. Often the interval is divisible only into an upper massive limestone and a lower greenish, argillaceous limestone.

The "non-reef" phase of the St. Joe group maintains a uniform thickness of 15 to 20 feet throughout the northern portion of the area. Wells encountering the "reef phase" report from 40 to 100 feet of St. Joe. Southward the St. Joe thins by loss of the lower members, as demonstrated in Cross Sections E-E', and F-F' (Plates V and VI). In the extreme southwestern corner of the area the St. Joe is absent.

The generally uniform thickness and wide-spread distribution of the St. Joe group is indicative of a relatively flat, featureless post-Chattanooga surface. Only a limited amount of erosion appears to have preceded the deposition of the St. Joe limestones and shales.

Throughout most of the southern and eastern part of the area, the St. Joe rests unconformably upon the Chattanooga black shale, but to the northwest in Craig and parts of Nowata Counties it overlies, with possible unconformity, the "Kinderhook shale." The upper St. Joe limestone (Pierson) is succeeded disconformably by the Reeds Spring formation.

Osagean

Keokuk-Reeds Spring

The Keokuk and Reeds Spring formations are exposed at the surface over much of the southeastern portion of the area. Farther to the northeast in Ottawa County, these units, less that portion of Keokuk above the Short Creek oolite, and the upper St. Joe limestones, are mapped as the lower "Boone" formation (Speer, 1951, fig. 1). No attempt was made to subdivide the Keokuk and Reeds Spring in the subsurface.

Huffman (1958, p. 43) described the Reeds Spring formation at the surface as a sequence of interbedded, fine-grained, limestones and dark gray to blue-gray cherts, resting with slight disconformity on the St. Joe and succeeded unconformably by the Keokuk formation. Much of the Reeds Spring chert is believed to be primary in origin.

The Keokuk at the outcrop consists of massive, white to buff chert and locally interbedded blue-gray limestone (Huffman, 1958, p. 44). Harbaugh (1957, p. 2540) reports two small crinoidal bioherms in the Keokuk in Mayes County. A bed of oolite, the Short Creek, occurs in the upper portion of the Keokuk in Ottawa County and marks the top of the lower "Boone" formation as mapped in that County (Speer, 1951, fig. 1). The Keokuk is separated from the overlying rocks of Meramecian age by a major unconformity. Buried hills of Keokuk chert, as seen in the field (Huffman, 1958, fig. 9), are indicative of a pre-Meramec erosion surface of considerable relief.

The Keokuk-Reeds Spring interval in the subsurface, with a few notable exceptions, is lithologically and stratigraphically consistent with its surface equivalent. The Reeds Spring consists of a series of interbedded tan to gray, finely granular, often siliceous limestones, and blue-gray, smoky gray to dark gray and brown vitreous cherts. Massive, chalk white, tripolitic, chert and (or) white, highly siliceous, finely granular limestone characterize the overlying Keokuk formation. This type of lithology is normally referred to as "cotton rock." In general, light colored cherts, i.e., tan, white-flecked brown, blue-gray and gray-mottled, predominate in the Keokuk formation, whereas dark gray cherts are characteristic of the Reeds Spring formation. Finely crystalline to dense, commonly siliceous limestone locally is interbedded with the massive cherts.

The exception to this described typical Keokuk-Reeds Spring unit is found in T. 19 N., R. 17 E. (Cross Section E-E', Plate V). In this area the Chattanooga and St. Joe formations are absent and Mississippian rocks directly overlie Simpson sandstones. These rocks[2] consist of dark and light colored chert, interbedded buff to dark gray-brown, finely granular limestone, and massive, brownish-black, argillaceous, limestone. The basal limestone is highly argillaceous and gradational to a dark gray to black calcareous shale. Traces of glauconite are found at the base of this unit ("Unit 1" of Darnell, 1957, p. 16-18). These cherts and dark limestones are questionably considered Osagean in age regardless of the fact that they are lithologically dissimilar to Osagean rocks at the surface or in the subsurface of areas to the north. As seen in Cross Sections D-D' and E-E', (Plates IV and V) wells to the west and south of the area encounter a similar sequence of "Osagean" rocks characteristically marked at the base by a zone of glauconite. Driller's logs describe portions of this interval as "black limestone"," and in truth, this area is marginal to the much debated problem of the subsurface "black lime" (Cram, 1930 p. 35-39 and Buchanan, 1927 p. 1315-1317).

The Keokuk-Reeds Spring interval is thickest in northern

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[2]See Reed, Koenig No. 1, Cross Section E-E' for a detail description of the Osagean in T. 19 N., R. 17 E.

and eastern Craig County where a maximum of 260 feet of cherty Osage is encountered in the subsurface. To the southwest and west, these units thin to approximately 50 feet. Cross Sections E-E' (Plate V) and B-B' (Plate II) best illustrate the general trend of Keokuk-Reeds Spring thinning. As noted in Cross Section E-E', the consistent decrease in thickness to the south is rather abruptly broken in T. 19 N., R. 17 E. where rocks questionably correlated with the Osagean series attain an average thickness of 150 feet.

The regional distribution of the Osagean series is significant to the problem of the subsurface "black lime" or "Mayes" formation, discussed later in the chapter.

The cherty Osagean interval overlies the St. Joe group in all but the extreme southwestern portion of the area where rocks of questionable Osagean age rest unconformably on sandstones of the Simpson group. The Keokuk formation is succeeded unconformably by Moorefield siltstones and argillaceous limestones in Mayes County, and by limestones and cherts of Warsaw age in Craig County.

The Reeds Spring formation is regarded generally as Fern Glen in age (Moore, 1933, p. 203 and Cline, 1934, p. 1146). The validity of assigning the overlying cherts and limestones to the Keokuk was questioned by Cline (1934, p. 1132) who considered them Burlington in age. Laudon (1939, p. 338) in correlating the post-Reeds Spring interval with the Keokuk, believed Burlington to be absent in northeastern Oklahoma. Huffman (1958, p. 46) followed Laudon's correlation of the upper Osagean.

Meramecian

Moorefield Formation

The Moorefield formation at the surface in northeast Oklahoma consists of four distinct facies of member rank (Huffman, 1958, p. 49). The lower, or Tahlequah member, is a massive, glauconitic limestone resting unconformably on Osagean chert. Huffman (1958, p. 50) suggested that the Tahlequah member is essentially equivalent to the "J" bed of Ottawa County. The succeeding Bayou Manard member is composed of blue-gray to black, argillaceous limestone which, in Mayes County, contains thin beds and nodules of black chert. Glauconite is found in the basal portions, particularly in those areas where the Bayou Manard rests upon eroded Keokuk. A gray, locally oolitic, chert-bearing calcarenite, the Lindsey Bridge member, conformably overlies the Bayou Manard. The Lindsey Bridge is succeeded conformably by the Ordnance Plant siltstone member. The upper portion of the siltstone is typically shaly, and the lower generally calcareous, at places grading into a lime sand. The Ordnance Plant member is overlain unconformably by the Hindsville limestone of Chester Age.

Faunally the Moorefield formation is characterized by the abundance of Leiorhynchus carboniferum, among other forms, which is recognized as a guide fossil to similar deposits of Meramecian age throughout the central, southwestern, northwestern United States and western Canada (Laudon, 1948, p. 301-302).

The Moorefield formation in the subsurface can be subdivided into four zones or members. In ascending order these are: a basal glauconitic zone, an argillaceous (commonly cherty) limestone, a calcarenitic limestone, and an upper calcareous siltstone member. These four units are well-developed in the McLennan, Trogdon No. 1, sec. 33, T. 22 N., R. 18 E. (Cross Section E-E', Plate V).

A basal zone of glauconitic, dark gray to black, calcareous, often silty shale or argillaceous limestone is, with few exceptions, present at the Osage-Meramec contact. The glauconite occurs as dark green pellets or nodules. This zone in Mayes County probably corresponds to the glauconitic basal portion of the argillaceous limestone member, rather than the Tahlequah member, in that the interval is not a definable unit nor is it always a limestone. A variation of the glauconitic zone, common to a few areas, is found in the Trogdon well. Therein, an upper glauconitic, cherty limestone and dark glauconitic shale sequence is separated from a basal calcareous, glauconitic shale by 12 feet of argillaceous limestone containing dark gray to black microfossiliferous chert. The glauconitic zone is of principal importance in correlating the Moorefield with other formations of Meramec age in Craig County and outside the area.

The argillaceous limestone member, together with the basal glauconite, is the most persistent and thickest member of the Moorefield formation. The limestone is normally gray to dark gray, dense to finely granular, argillaceous and occasionally dolomitic. Varying amounts of chert and siliceous limestone are also commonly included in the interval. A number of wells, as the Trogdon No. 1, have only minor amounts of brownish-black and black chert. In others, as exemplified by the Lee Milligan, Lee No. 1, sec. 17, T. 23 N., R. 19 E.

(Cross Section C-C', Plate III), the limestone contains a high percentage of dark gray, brownish-black, white-mottled brown chert, and gray to brownish-gray microfossiliferous chert. The Moorefield cherts are characterized by their dark color, and the presence of microfossiliferous chert. The gray and dark gray cherts of the Reeds Spring formation have a slight color resemblance to those in the Moorefield.

The calcarenitic limestone member is generally light gray to tan in color, finely crystalline, and at least one well reports the limestone to be highly siliceous and cherty. The unit is not readily discernible in well samples, unless the pseudo-"oolitic" character is well developed.

The upper siltstone member is second only to the argillaceous limestone member in distribution. Characteristically the siltstone is buff, gray or dark gray in color, platy, calcareous and shaly. All or part of the siltstone are commonly oil-stained. Toward the base, the calcareous siltstones grade to silty, occasionally fossiliferous limestones. This member is typically developed in the Gardner, Gilbert No. 1, sec. 36, T. 20 N., R. 18 E. (Cross Section D-D', Plate IV). Laterally, the siltstones grade to very fine-grained, calcareous sandstones. The sandy phase in the Milligan, Lee No. 1, sec. 17, T. 23 N., R. 19 E. (Cross section C-C', Plate III), is over 20 feet thick and consists of white calcareous sandstone and sandy to silty limestone.

In T. 19 N., R. 17 E., the siltstone member rests directly on argillaceous and cherty limestones, questionably considered Osagean in age. It is significant to note that, while glauconite is not uncommon in the lower portion of the siltstone, a basal glauconitic zone common in other parts of Mayes County, is not found at the presumed Osage-Meramec contact in this township. To the west and south of T. 19 N., R. 17 E. the most distinctive zone of glauconite occurs at the base of limestones and cherts, considered by many to be Osagean in age (Darnell, 1957, p. 17).

Lithologically the units below the siltstone member in T. 19 N., R. 17 E. closely resemble the lower Moorefield, but for reasons to be discussed later in the chapter, they are tentatively considered Osagean in age.

The subdivisions of the Moorefield in the subsurface are directly referable to the Bayou Manard, Lindsey Bridge and Ordnance Plant members at the surface. Only three of the subsurface zones, the basal glauconite, the argillaceous limestone member and the upper siltstone, are generally recognized in well cuttings. In northwestern Mayes and northeastern Rogers Counties the typical Moorefield subdivisions are not as apparent. Samples examined from the Moorefield interval in the Gulf Oil Company, Smith No. 1-S, sec. 17, T. 23 N., R. 17 E. (Cross Section C-C', Plate III), show 30 feet of tan to gray, very finely crystalline, limestone overlying approximately 70 feet of gray and dark gray to black, siliceous, dense limestone, containing minor amounts of gray microfossiliferous, white, gray-brown and black chert. The basal interval is highly argillaceous and rests directly on white Osagean cherts. Pellets of dark green glauconite are found in the chert samples at the Osage-Meramec contact. The lower 70 feet, if not the entire interval, is probably equivalent to the Bayou Manard, or argillaceous limestone, member of the Moorefield in southern Mayes County.

The thickness of the Moorefield formation ranges from zero to 165 feet, but generally averages between 110 to 150 feet. As is true in the surface, the thickness of the interval is controlled by the thickening and thinning of the underlying Osagean units, both locally and regionally. The maximum thickness of Moorefield sediments is encountered in sec. 17, T. 21 N., R. 18 E. where the underlying Keokuk-Reeds Spring interval thins to 50 feet. Over the thick, questionable Osagean interval in T. 19 N., R. 17 E. the Moorefield thins to 60 feet.

The surface and subsurface distribution of the Moorefield formation within the area is essentially restricted to Mayes and eastern Rogers Counties. The northernmost surface exposures of the Moorefield formation are found northeast of Pensacola in T. 23 N., R. 20 E. In the subsurface, a facies change occurs in the Meramec north of T. 23 N. South of the Craig County line the Moorefield formation occupies the Meramec interval. North of T. 24 N. the Warsaw limestone of Meramec age overlies the Osagean cherts. Unfortunately, little sample information is available from the area between these two distinctly different types of Meramec lithology.

The Moorefield formation of Mayes and eastern Rogers Counties rests with pronounced unconformity on the underlying Keokuk-Reeds Spring formations of Osagean age. The Hindsville limestone of Chester age unconformably succeeds the Moorefield formation in most areas of Mayes County. An exception to this occurs in T. 23 N., R. 17 E., where limestones and shales tentatively correlated with the Morrowan series rest unconformably on the Moorefield. A well in sec. 15, T. 21 N., R. 17 E., encountered sandstones of Morrowan age overlying a fine-grained, calcareous sandstone correlated with the upper siltstone member of the Moorefield formation. Apparently this is a local erosional feature, for in other wells in the same townships the Hindsville limestone overlies the Moorefield formation.

Wallace Lee (1940, p. 23) suggested that the lower dark to black limestone portion of the "Mayes" formation at the surface in Mayes County, is the "outcropping marginal part of the dark limestones of the Cowley formation". Translated into the terms used in this paper, Lee correlated those units below the siltstone member of the Moorefield with the Cowley formation. The siltstone and overlying Hindsville limestone were considered Chesterian in age. The writer concurs with Lee's interpretation as to the correlation of the Cowley with the lower Moorefield. The relationship of the upper siltstone member to the Cowley formation is not clearly understood. In light of surface evidence which now places the siltstone in the Moorefield formation (Huffman, 1958, p. 49), it is possible that this interval is also a Cowley equivalent.

The Moorefield formation of Mayes County is herein considered a basinward facies of the lower Warsaw, as found in the subsurface of Craig County and at the surface in Ottawa County. This conclusion is based on the following considerations: (1) the Moorefield and Warsaw formations, both Meramec in age, occupy the same stratigraphic position above, and rest unconformably on rocks of Osagean age; (2) both formations are marked at the base by a zone of glauconitic limestone ("J" bed of the Warsaw formation in Ottawa County) and (or) glauconitic shale, which is present at the Osage-Meramec contact throughout the area; (3) both the Moorefield and Warsaw formations are overlain unconformably by the Hindsville limestone of Chester age (Cross Sections A-A', Plate I, and D-D', Plate IV); (4) a well in sec. 25, T. 25 N., R. 16 E. (Cross Section B-B', Plate II) encountered 95 feet of typical Warsaw limestones and cherts overlying 52 feet of Moorefield type argillaceous limestone. The lower interval rests on light-colored limestones and cherts of Osagean age. This relationship suggests a transition from the north where only Warsaw is present above the Osagean to the south where the Moorefield occupies the Meramec interval; (5) a similar relationship exists between the Cowley formation (a Moorefield equivalent) and the Warsaw limestone in southern Kansas. Wallace Lee (1940, p. 66-81) does not specifically refer to the Cowley as a "facies" of the Warsaw, but does state that the Cowley is conformable and gradational with the overlying "Warsaw" limestone.

In an east-west cross section across the southern margin of Kansas, Lee (1940, plate 7) demonstrates a Cowley-Warsaw relationship which the writer considers nearly identical to that in the Craig-Mayes County area. The Warsaw in the extreme southeastern corner of Kansas has at its base the glauconitic "J" bed. Westward from the Tri-State district a wedge of Cowley sediments intervenes between the typical Warsaw facies and the basal glauconite bed. Farther to the west the Warsaw is missing and the Cowley formation thickens, and together with the basal glauconitic zone, occupies the entire Meramec interval.

The Warsaw formation is not known to overlie Moorefield sediments at the surface in Mayes County. Lee (1940, p. 93-94) suggested that the Moorefield of Mayes County originally was overlain by Warsaw limestones and cherts. According to this theory, pre-Chester erosion removed the Warsaw from the area of contact in Mayes County, and subsequent deposition of Chesterian limestones resulted in the separation of the Moorefield and Warsaw outcrop areas. There is no evidence, either at the surface or in the subsurface, to substantiate the presence of the typical Warsaw south of T. 23 N., but it is entirely possible that the Warsaw extended somewhat farther south than is presently known.

Cross Section E-E' (Plate V) graphically illustrates the writer's interpretation of the north to south expansion of the Moorefield facies. Unfortunately, no sample data other than from the well in T. 25 N., R. 16 E., were available to verify the exact nature of the facies change. Scattered well information in the "transitional zone" indicates that the area of principal change occurs roughly at the latitude of T. 24 N.

Warsaw Limestone

The Warsaw limestone comprises the uppermost part of the "Boone" formation in the Tri-State district. Speer (1951, fig. 1), in mapping Ottawa County, applied the term "Upper Boone" to the interval above the Short Creek oolite, which includes beds of both Keokuk and Warsaw age.

The Warsaw formation in the mining area is subdivided into a series of members to which are applied alphabetical designations (Moore, Fowler, and Lyden, 1939, p. 2-3). These members ("B" through "J") are in general, a series of gray to brown limestones and cherts, and some zones of white "cotton rock". The basal, or "J" bed, is described as a brownish to dark-gray, very glauconitic, shaly limestone. The "J" bed is normally about five feet thick, but reaches a maximum thickness of 50 feet. Moore, Fowler, and Lyden (1939, p. 3) place the Osage-Meramec unconformity at the base of the "J" bed. This boundary generally occurs some 30 to 40 feet above the Short Creek oolite. In places pre-Warsaw erosion has removed the intervening beds so that the "J" bed rests on the Short Creek oolite (Speer, 1951, p. 30).

The average thickness of the Warsaw in the Tri-State district is about 125 feet.

Some geologists, including Laudon (1939, p. 325) have questioned the presence of Warsaw in northeastern Oklahoma. Still others consider the Warsaw as Osagean in age. The lithologic and faunal similarity of the Warsaw to the underlying Keokuk formation, both at the type section and in the Tri-State area, is thought by some to justify such a conclusion.

Regardless of the age, the Warsaw limestone is a recognizable unit with distinctive lithologic characteristics. The most important is a basal zone of glauconite, which distinguishes it, both at the surface and in the subsurface, from the Keokuk formation. If the correlation of the "J" bed with the glauconitic zone at the Osage-Meramec contact in Mayes County is correct, then it seems logical to assume that the Warsaw is Meramecian in age. In addition to the basal zone of glauconite, the Warsaw limestone in the subsurface of Craig County is characterized by the presence of "cotton rock" in the upper portion of the formation, and the abundance of drab white and gray microfossiliferous chert throughout the entire interval.

The term "cotton rock" refers to a white, tripolitic, weathered chert or highly siliceous limestone. Samples of this rock type have a finely granular appearance and are generally quite porous. The porosity is developed from tubular molds from which unsilicified microfossils have been leached. The upper zone of "cotton rock" is commonly oil-stained or asphaltic. Drillers in the area often refer to this interval as the "chat."

The drab white and gray microfossiliferous cherts appear in various stages of replacement from the original limestone. In many instances they are better described as highly siliceous, microfossiliferous limestones. This incompletely altered appearance is equally characteristic of other varieties of Warsaw chert. Limestones associated with these cherts are generally tan to gray in color, finely granular to dense, and predominantly siliceous.

The "J" bed, or an equivalent zone of glauconite, consistantly occurs at the base of the Warsaw throughout Craig County. The zone is easily recognized in well cuttings, and interpreted from gamma-ray logs (Figure 4). Most commonly, the interval consists of brown, gray-green and dark brownish-black calcareous shale and some argillaceous limestone, containing abundant dark green nodules of glauconite. The thickness of this basal unit is variable, but generally averages less than ten feet. To the south the glauconitic zone can be traced into Mayes County where it marks the base of the Moorefield formation.

The Warsaw formation maintains a fairly uniform average thickness of about 120 feet throughout most of Craig County. Southward the Warsaw thins to zero near the Craig-Mayes County line.. As previously mentioned, Lee (1940, p. 93-94) expressed the opinion that the Warsaw had, prior to pre-Chester erosion, extended far south into Mayes County. Although agreeing that the limit of Warsaw deposition probably did exist farther to the south than is presently known, the writer believes the thinning and eventual absence of the Warsaw to be as much the result of the expanding Moorefield facies as it is of pre-Chester erosion.

The Warsaw formation is present in the subsurface throughout the northern half of the area. The southernmost occurrence of rocks correlated with the Warsaw limestone is in sec. 3, T. 23 N., R. 21 E. A log of a well drilled in that section reported a buff-weathered chert and cherty limestone from the surface to 30 feet. Below this interval the well encountered five feet of glauconitic, gray, argillaceous and sandy limestone overlying typical Keokuk limestones and cherts. The writer believes the upper 35 feet of this well to be the Warsaw limestone characteristically marked at the base by a zone of glauconite. The significance of this interpretation is two-fold. First, this is the only reported occurrence of the Warsaw formation at the surface in Mayes County. Previous to this investigation the surface rocks in this area were mapped as Keokuk-Reeds Spring (Huffman, 1958, plate I). The well is drilled on a topographic high; therefore, it is possible that this represents an isolated remnant of Warsaw limestone, Second, the well is located four miles northeast of known exposures of the Moorefield formation. This would indicate that the area of principal facies change, at least at this point, occurs within a relatively short distance.

The Warsaw formation is overlain unconformably by Pennsylvanian shales and sandstones in northwestern Craig and eastern Nowata Counties. To the southeast in Craig County, the Warsaw is succeeded unconformably by the Hindsville limestone. Throughout Craig County the Warsaw rests unconformably on Keokuk cherts and limestones.

Wallace Lee (1940, p. 69), in discussing the pre-Cowley (pre-Meramec) surface in southern Kansas, referred to the Tri-State region as an "upland" area during the deposition of Cowley sediments in the more deeply eroded areas to the west and southwest. In the direction of the "uplands" the silty and argillaceous Cowley sediments thin and grade upward into the Warsaw limestone. The "J" bed of the Warsaw, according to Lee, represents an "eastward continuation of the transgressing basal deposit of the Cowley." The transition from Cowley to Warsaw is believed to be an expression of the clearing of the seas.

Evidence gathered in the Craig-Mayes County area seems to favor the interpretation of a moderately dissected pre-Meramec "upland" area in most of Craig and Ottawa Counties.

The "clean" limestone lithology, uniform thickness, and gradational relationship of the upper Warsaw with the thin, basal, argillaceous and glauconitic Moorefield representative ("J" bed), is indicative of an environmental change from the dark, silty limestone basinward deposition found in Mayes County, which can logically be explained by postulating an "upland" area in these counties. This change, while not an answer to all the problems involved, particularly that of the close faunal relationship of the Warsaw to the Keokuk, is well-founded and worthy of consideration in any future regional investigation of the Mississippian problem.

Problems in the Regional Correlation of Subsurface Meramecian Units

The correlation of the subsurface "Mississippi lime," with surface exposures of Meramecian and Osagean rocks in northeastern Oklahoma, is perhaps the most controversial aspect of Mississippian stratigraphy in eastern Oklahoma and southern Kansas. Basically, the subsurface correlations made to date can be divided into two schools of thought. The first interprets the subsurface "Mayes" or "black limestone" to be Osagean in age and a facies of the Osage "Boone" formation. The second proposes a Meramec age for the same units, correlating them with the Moorefield formation at the surface in Mayes County. Before discussing the significance of new evidence presented in this paper, it is well to review briefly the most commonly cited published and unpublished investigations into the problem.

Aurin, Clark, and Trager (1921, p. 127) considered the middle black shaly and sandy limestone member of the Mississippi lime in the Okmulgee district, and elsewhere, "possibly" to be equivalent to the Mayes formation in Mayes County as described by Snider (1915, p. 27-31).

This correlation was in part established by faunal evidence. Fragments of fossils were found by the writers about 60 feet above the base of the "black lime," from a well drilled in sec. 19, T. 15 N., R. 11 E. One of the fossils was identified by Stuart Weller as Leiorhynchus carboniferum, a typical brachiopod of the Mayes group. The significance of this fact is completely ignored by later critics of their interpretations.

Buchanan (1927, p. 1316) in concurring with the above interpretation, correlated the "subsurface Mayes" with the Moorefield and Batesville formations of Arkansas and part of the Caney shale in the Arbuckle region. Buchanan further believed that no "Boone" deposition took place south of a line roughly parallel to the Arkansas River. At this point, the black Mississippi limestone was thought to overlap the margin of the "Boone" subcrop.

The first dissenting opinion was expressed by Cram (1930, p. 35-39) who considered the "black limestone" to be a lateral facies of the Osagean cherts. Cram fairly presented both Buchanan's and his own interpretations, admitting that, "A more thorough study of the outcrop must be made before either hypothesis can be proved." Succeeding writers, in agreement with Cram's interpretation, have referred to his investigation as being the ultimate reference on the subject.

Cline (1934, p. 1157 and Laudon 1948, p. 290-291) in support of Buchanan's interpretation, demonstrated the southward truncation and overlap of the Osagean by rocks of Meramec age. Both recognized the importance of the unconformity between the Osage and Meramec series. Laudon considered the Cowley formation to be younger than the Warsaw.

Wallace Lee (1940, p. 68-93) correlated the Cowley formation of southern Kansas with the lower portion of the "Mayes" at the surface and the "black limestone" in the subsurface in eastern Oklahoma.

Brant (1941, p. 41-42) and Selk (1948, p. 307) disagreed with Lee's correlation of the Cowley while following Cram's interpretation of the "black limestone". Selk considered both the subsurface "Mayes" and the Cowley formations to be Osagean in age.

The most recent surface investigation in northeastern Oklahoma (Huffman, 1958, fig. 4) has revealed the entire Osagean section to be truncated and overlapped from north to south by rocks of Meramec age. The southern margin of Osagean surface exposures (vicinity of Marble City, T. 13 N., R. 23 E.) very nearly corresponds to the Osagean depositional limits established by Buchanan.

Darnell (1957, p. 16-18, 30) in his paper on the subsurface Mississippian rocks in the Claremore-Wagoner area, placed a sequence of dark argillaceous, cherty limestones overlying rocks of Kinderhookian to Ordovician in age, in the Osagean series. The basal unit of this interval is marked by a zone of glauconite. Darnell concluded that on the basis of the abrupt change in lithology and the widespread occurrence of a basal zone of glauconite, a major unconformity occurs at the top of the Kinderhookian.

Subsurface studies of the Mississippian system in Oklahoma under the direction of Dr. Louise Jordan of the Oklahoma Geological Survey, show, by electric log and sample log cross sections, that the "Mayes" in the subsurface is not a facies of the Osage cherts and limestones, and that a regional unconformity exists between the Osagean and Meramecian series (Darnell, 1957, p. 12).

As is evident from a review of the literature, there is considerable disagreement as to the correlation of the subsurface Mississippian rocks with the surface exposures. New evidence gathered in this investigation is significant to the problem and justifies a number of conclusions and recommendations on the part of the author.

(1) The confused state of Mississippian stratigraphy partly results from the use of the terms "Mayes and "Boone"," especially when they are applied to the subsurface. As an example, the "Mayes" formation, or group, in Mayes County refers to rocks of both Chester and Meramec age. The "Mayes" as used in Ottawa County refers to the Hindsville-Batesville sequence of Chester age. When applied to the subsurface the usage of "Mayes" is even more perplexing. The "Boone" formation in Ottawa County consists of both Osagean and Meramecian rock units. The use of this combining term in surface mapping is apparently justified, in that the Warsaw, or Meramec portion of the "Boone"," is difficult to distinguish from the underlying Keokuk of Osagean age. When the term is applied to the subsurface, one is never sure whether the author is speaking of the Osage "Boone"," the combined Meramec-Osage "Boone"," or if the author even considers the "Boone" to have both Meramecian and an Osagean components. As suggested by other geologists (Brant, 1941, p. 1, and Laudon, 1948, p. 288), the author recommends that the combining terms "Mayes" and "Boone" not be applied to the subsurface.

(2) The major stratigraphic break within the Mississippian

system in the Craig-Mayes County area occurs between the rocks of Osagean age and those of Meramecian age. In some respects this unconformity eclipses even the pre-Pennsylvanian erosional interval. The magnitude of this unconformity has been recognized by many geologists (Cline, 1934, p. 1156-1158, Lee; 1940 p. 9 and Brant, 1941, p. 41). Laudon (1948, p. 288) referred to the Osage-Meramec unconformity as "...one of the most remarkable faunal breaks in the entire Paleozic era."

(3) The Osage-Meramec contact is persistently marked by a distinct zone of glauconite. This basal glauconite can be traced continuously from the base of the Warsaw formation in the Tri-State district southward into Mayes County where it marks the base of the Moorefield formation. To the west and southwest of Mayes County, the most prominent zone of glauconite occurs at the base of a sequence of chert and argillaceous limestones correlated with the Osagean series (Selk, 1948, p. 306; Darnell, 1957, p. 17, and Jordan, 1959, p. 128). In the writer's opinion this is more than coincidence. Within the area north and east of T. 19 N., R. 17 E. in only three wells is glauconite reported below unquestionable Osagean cherts. Two of the occurrences were reported from the St. Joe group of Kinderhookian-Osagean age. The third well encountered glauconitic zones both below the Moorefield formation and at the base of the Osagean. The implication here is that the basal zone of glauconite, both in the Craig-Mayes Counties area and southwest therefrom, represents the base of the Meramec and not the base of the Osage. Unfortunately, this interpretation has proven indefensible in southeastern Rogers County. As

previously discussed (page 34), a sequence of cherty, argillaceous limestones overlain by the Moorefield siltstone member rests unconformably on Simpson sandstones, in T. 19 N., R. 17 E. (Cross Section D-D', Plate IV and E-E', Plate V). This cherty unit overlain by the Moorefield, has been questionably placed in the Osagean series. To the south and west virtually the same sequence of rock, marked at the base by a zone of glauconite, is considered, by Darnell (1957, p. 16-25) to be Osagean in the lower and basal portions, and Meramecian in the upper portion. A Meramec age assignment for the entire lower Mississippian interval in T. 19 N., R. 17 E. and areas immediately to the west and south is defeated on three counts. First and most devastating, the limestone is extremely cherty, particularly at the top. The chert is partly light-colored, but generally ranges from gray to dark gray-brown and often black. Second, an interpretation which considers the Osagean to be absent by pre-Meramec erosion only eight miles west of well-developed surface exposures of Osagean cherts and limestones, is difficult to accept. This is true regardless of the fact that the interval in question has only a vague lithologic similarity to the Osagean formations at the outcrop. Third, the prevailing subsurface dictum is that a glauconitic zone marks the base of the Osagean, not Meramecian, in most every other area in eastern Oklahoma.

(4) Darnell (1957, p. 30) in correlating the lowermost cherty and argillaceous limestone interval in the Claremore-Wagoner area with the Osagean series, logically assumed that a major unconformity occurs at the top of the Kinderhookian. The concentration of glauconite,

abrupt change in lithology, and the fact that the supposed Osagean rocks rest unconformably on units from Kinderhook to Ordovician in age, would serve to support this conclusion. The writer, in dissenting from this opinion, found no evidence either at the surface or in the subsurface of the area, nor in southeastern Kansas, which points to a major unconformity at the end of Kinderhookian time. Most assuredly, the uniform thickness of the Northview-Compton (Kinderhookian) and regular contact with the overlying Pierson limestone (Osagean) are not indicative of a long period of erosion. The only erosional interval within the Mississippian system of sufficient magnitude to have produced such an unconformity was that which preceded the deposition of the Meramec in northeastern Oklahoma.

In summary, it is evident that the area most critical to regional correlations of Meramecian rocks at the surface and in the subsurface of the Craig-Mayes County area lies in T. 19 N., R. 17 E. To the north and east of this township the Osage-Meramec contact is quite distinct, and there is no doubt as to the lithologic criteria which serves to separate the two series. As unquestionable as this may be, a regional correlation of the Moorefield formation in Mayes County with the Mississippian rocks of areas to the west and southwest is inconsistent without a more satisfactory age assignment of the post-Simpson limestones and cherts in T. 19 N., R. 17 E. An Osagean age for these argillaceous limestones implies a facies relationship with the typical Keokuk-Reeds Spring cherts and limestones exposed at the surface. Such an interpretation, because this area is undoubtly related to the problem of the "black limestone," could only add support to the facies hypothesis as proposed by Cram (1930, p. 35-39), Brant (1941, p. 41 and fig. 6), and Selk(1948, p. 305-307).

If the inconsistencies of the area in question are ignored, then, on the basis of comparisons in Craig and Mayes Counties, the southward truncation of the Osagean at the surface (Huffman, 1958, fig. 4), and the faunal evidence of Aurin, Clark, and Trager (1921, p. 127), the writer believes the "black limestone" of the Okmulgee district to be the lateral equivalent of the Moorefield formation. If they are equivalent, the "black limestone" is Meramec, and not Osagean in age.

The writer, in recommending a re-evaluation of the subsurface Mississippian west and southwest of the outcrop, suggests that lines of cross section be initiated from the Tri-State district and extended basinward. Much of the confusion surrounding the Mississippian problem seems to result from the application of criteria established in the basin areas. Such an investigation should include thin section analysis and insoluble residue studies. Particular emphasis should be given to comparison of characteristic Meramecian and Osagean chert types and their importance in correlating questionable cherty intervals such as exist in T. 19 N., R. 17 E.

Chesterian

Hindsville Formation

The Hindsville limestone is the uppermost member of the "Mayes" formation of Snider (1915, p. 27) and equivalent to the Grand River (preoccupied) of Brant (1941, p. 31).

At the outcrop, the Hindsville generally consists of gray, medium-crystalline, oolitic and fossiliferous limestone (Huffman, 1958, p. 62). In some areas, as near Pensacola, the limestone is noticeably silty and contains interbeds of green shale (Harris, 1956, p. 236). The average thickness of the Hindsville at the surface is between 25 and 35 feet.

Surface exposures of the Hindsville limestone are widespread throughout eastern Mayes County, southeastern Craig County and extend northeastward into Ottawa County.

In the subsurface, the Hindsville is easily distinguished as a gray, fine to coarsely crystalline, oolitic and fossiliferous limestone. The limestone is commonly bioclastic, and locally contains an abundance of bryozoans. The upper portion is often dark gray and argillaceous. Gray and green shales are commonly interbedded with the limestone. Many driller's logs note the appearance of green shale within the upper limestone section of the Mississippian. The presence or absence of green shale generally has proved to be a useable criterion for determining the presence of the Hindsville formation when sample logs were not available. The Hindsville locally is silty, and in northeastern Craig County becomes quite sandy. Harris (1956, p. 253) suggested that the Hindsville has a facies relationship with the overlying Batesville sandstone in Ottawa County. It is entirely possible that the limestone-sandstone sequence in the upper portion of the Hindsville interval in the Mesker Drilling Company, Sheffield No. 1, sec. 21, T. 28 N., R. 21 E. (Cross Section A-A', Plate I), represents an interfingering of Hindsville-Batesville lithology. Drillers generally log most or all of the Hindsville as a "sandstone" or "sandy limestone," particularly where the formation is the uppermost Mississippian unit. Normally driller's descriptions refer to the ease of drilling and the fluid-bearing nature of the limestone rather than to its lithologic character.

The Hindsville is commonly petroliferous, accounting for much of the so-called "Burgess sand" production in Craig and northeastern Rogers Counties. Many of the oil seeps in Mayes County are believed to be from the Hindsville limestone.

The Hindsville subcrop strikes northeast-southwest across southeastern Craig County, western Mayes and eastern Rogers Counties (Plate XVII). To the northwest the Hindsville is truncated and overlapped by lower Desmoinesian shales of the Krebs group. The thickness ranges from zero to 64 feet, but generally averages less than 40 feet.

The Hindsville rests unconformably upon the Moorefield formation in southern Mayes and Rogers Counties, and on the Warsaw formation in eastern Craig County. At the surface, the Hindsville is known to overlie unconformably cherts and limestones of Osagean age. The Hindsville is succeeded conformably by the Fayetteville formation and unconformably by Pennsylvanian sediments ranging in age from Morrowan to Desmoinesian.

Fayetteville Formation

The Fayetteville limestones and shales are the upper portion of the Chesterian series over most of the Craig-Mayes County area. Surface exposures, representing the uppermost Mississippian rocks in all but the extreme southern portion of the area, can be traced from south of Mayes County, north to the vicinity of Vinita in Craig County, and from there, northeastward into Ottawa County.

Outcrops of the Fayetteville in southern Mayes County consist of two well-defined lithologic types (Huffman, 1958, p. 66). The lower is a gray to black, thin-to medium-bedded lithographic limestone, and the upper consists of soft, black, fissile shale. North of Strang, the lower portion of the Fayetteville passes into gray-green, calcareous shale with beds of dark, medium-crystalline, fossiliferous limestone. Pre-Hale erosion is thought to have removed most of the upper black shale facies (Huffman, 1958, p. 67).

The Fayetteville formation in the subsurface of southern Mayes County is readily distinguishable beneath the overlying Morrowan units. Characteristically, the formation consists of a lower limestone and an upper black shale. The limestone is generally dark gray, finely crystalline to dense, argillaceous and fossiliferous. In the Gardner, Gilbert No. 1, sec. 36, T. 20 N., R. 18 E. (Cross Section D-D', Plate IV), the lower limestone is 70 feet thick and occupies all but five feet of the total Fayetteville interval. The black shale facies normally is non-calcareous, but at least one well reports calcareous shales and thin, interbedded limestones in the upper Fayetteville. North of the Morrowan subcrop, the Fayetteville shale is extremely difficult to distinguish from the overlying lower Desmoinesian shales in well cuttings, and virtually impossible to interpret from driller's logs. Apparently, as in the surface, the dark Fayetteville argillaceous limestones pass northward to pale-green shale and thin-bedded limestones. A well in sec. 12, T. 25 N., R. 19 E., encountered this sequence above the Hindsville limestone. Driller's logs occasionally show a "Sylvan shale" atop the uppermost Mississippian limestones. The writer believes the shale is probably the gray-green Fayetteville shale.

As is evident from an examination of well cuttings from northern Mayes and southern Craig Counties, no diagnostic break occurs between the lower Pennsylvanian shales and the Mississippian Fayetteville shales. One would expect some evidence of the widespread regional emergence and erosion following the Mississippian period, but this is not true of the Fayetteville-Pennsylvanian. Lohman (1952, p. 8) in discussing the Mississippian contact at the surface in the Whiteoak area of Craig County stated that, "...there is no noticable topographic relief on the pre-Pennsylvanian surface and beds succeed each other across the boundary in apparent conformity."

The Fayetteville band of subcrop lies southeast of, and roughly parallel to that of the Hindsville limestone (Plate XVII). The formation is well developed in southern Mayes County where it reaches a maximum thickness of 130 feet. To the northwest, the Fayetteville is truncated and overlapped by Pennsylvanian shales and sandstones.

The Fayetteville lies conformably upon the Hindsville formation and near the Mayes-Wagoner County line grades upward into the Pitkin limestone. To the north the Fayetteville is succeeded unconformably by successively younger rocks of Pennsylvanian age.

Pitkin Limestone

The Pitkin limestone is absent by erosion north of the extreme southern portion of Mayes County, both at the surface and in the subsurface. The only known outcrops of the Pitkin in Mayes County occur just north of the Mayes-Wagoner County line (Huffman, 1958, plate II).

A well drilled in sec. 27, T. 19 N., R. 17 E., encountered three feet of gray, argillaceous, fossiliferous and crinoidal limestone above typical Fayetteville black shales. This may represent the Pitkin limestone. North of this point the Pitkin has not been found in subsurface. It is possible that wells to the south and east of sec. 27, T. 19 N., R. 17 E., encountered greater thickness of the Pitkin, but with only driller's logs available in these areas it is impossible to distinguish the Pitkin from the underlying Fayetteville formation.

The Pitkin limestone is conformable with the underlying Fayetteville formation, and succeeded unconformably by sandy limestones of the Morrowan series.

Pennsylvanian System

Morrowan Series

Surface exposures of the Morrowan series in northeastern Oklahoma are representative of two formations, the Hale and the overlying Bloyd (Huffman, 1958, p. 75-82). The Hale consists largely of calcareous sandstone which grades both laterally and vertically into sandy limestone. The upper portion is generally a gray or blue-gray, oolitic, crinoidal and fossiliferous limestone. A thin basal conglomerate marks the contact with the underlying Mississippian rocks. The Bloyd formation is composed of a sequence of alternating shales and limestones.

The shales are black, brown or greenish-gray to black, fine to coarsely crystalline, and massive-to thin-bedded.

The Hale formation is essentially absent at the surface north of T. 20 N. in Mayes County. Isolated exposures and small outliers occur as far north as T. 23 N., R. 21 E. The Bloyd is absent by truncation north of T. 19 N., R. 19 E.

The contact of the Hale with the succeeding Bloyd is conformable and gradational.

The Morrowan series in the subsurface of Mayes and eastern Rogers Counties can be traced almost continuously from the Mayes-Wagoner County line northward as far as T. 23 N., R. 17 E. (Plate XVII). Previous subsurface investigations (Bercutt, 1959, plate IX) have not recognized Morrowan equivalent this far north and east of their known surface distribution.

The subsurface Morrowan interval is best developed in southern Mayes County where it consists of a sequence of shaly limestones, shales, sandy limestones, and calcareous sandstones. The limestones normally are gray, tan to cream and brown in color, fine to coarsely crystalline, argillaceous to sandy, fossiliferous and crinoidal. One well in sec. 35, T. 20 N., R. 18 E., reports the Morrowan limestone to be oolitic. The sandstones are light-colored, calcareous and very fine-to medium-grained. Numerous, rounded, frosted sand grains are commonly associated with sandy portions of the Morrowan. The common occurrence of glauconite is a distinguishing subsurface characteristic of the Morrowan sandstones and limestones. Interbedded gray and black shales are found at variable intervals in the Morrowan of some areas.

Drillers variously refer to the sandy Morrowan as "Burgess," "Dutcher," and "Cromwell."

The Morrowan in subsurface can be subdivided into an upper limestone and shale, and a lower sandy limestone and sandstone, but these divisions are by no means consistent. In many wells almost the entire interval consists of sandstone and sandy limestone; whereas in others massive limestone and interbedded shales predominate. The sandy intervals resemble the Hale of the surface exposures, and it is possible that the limestone and shale sequence is equivalent to the Bloyd. No attempt was made to subdivide the two formations in the subsurface.

North of T. 20 N. a sequence of limestones and shales overlying the Hindsville formation, and in some areas the Moorefield formation, is correlated with the Morrowan series. This sequence is present in the McLennan, Trogdon No. 1, sec. 33, T. 22 N., R. 18 E. (Cross Section E-E', Plate V), and in the Gulf Oil Company, Smith No. 1-S, sec. 17, T. 23 N., R. 17 E. (Cross Section C-C', Plate III). The limestone is tan to dark gray in color, locally argillaceous, crystalline, crinoidal and fossiliferous. Individual limestone beds range in thickness from about 4 to 8 feet. The interbedded shales are characteristically black, calcareous to non-calcareous and commonly fossiliferous. The base of this limestone-shale interval is marked by a thick "detrital zone" consisting of fine to coarse, subangular to rounded, frosted sand grains embedded in a clay or shale matrix. The shale matrix locally is partly calcareous. Chert fragments and pyrite are common constituents. A thin, poorly sorted sandstone forms the base of the zone in the Smith well.

This sequence of rocks was assigned to the Morrowan series after a careful analysis of all possible correlations. The only other formations which even remotely qualify, both lithological and stratigraphically, as possible equivalents are: first, the Fayetteville formation; and second, the Atoka formation.

The Fayetteville formation, although closely resembling the rocks of this interval, is eliminated as a possible equivalent for three reasons. First, the limestones of the Fayetteville formation are most commonly dense to very finely crystalline. The limestones in question are generally medium crystalline in texture and only very locally are dense or lithographic. Second, the writer knows of no instance within the area of investigation where the Fayetteville limestones or shales are described as being glauconitic. Third, and most important, elsewhere in the area, the Fayetteville formation is conformable with the underlying Hindsville limestone. The presence of a thick "detrital zone" above the Hindsville in the Trogdon well and above the Moorefield formation in the Smith well, hardly implies a conformable relationship with the underlying limestones.

The second possibility is that this limestone and shale sequence is equivalent to part of the Atoka formation. This correlation is eliminated principally on the basis of the contrast in lithology between the Atoka and the limestone and shale sequence in question. The Atoka consists primarily of sandstones, siltstones and interbedded shales. Atokan limestones similar to those described for the interval in question, occur locally at the surface in T. 17 N.,

R. 19 E. (Huffman, 1958, p. 85), but are few or absent in other areas. In addition to these considerations, a sequence of shales and siltstones, marked at the base by a chert and sand conglomerate, believed to be Atokan in age, overlies the limestone and shale interval in the Trogdon well.

The elimination of these two formations as possible correlatives, and the lithologic and stratigraphic similarity of the limestones and shales to the Morrowan in areas to the south, seems to justify assignment of this interval to the Morrowan series. The distribution of the Morrowan, as proposed by the writer, is not inconceivable in that surface exposures of Morrowan equivalents are known as far north as T. 23 N., R. 21 E.

The thickness of the Morrowan is erratic, ranging from zero to 125 feet. South of the erosional limit the Morrowan is locally absent, but within a short distance thickens to as much as 120 feet.

Near the Mayes-Wagoner County line, Morrowan units rest unconformably upon the Pitkin limestone. Northward, the Pitkin is missing and the Morrowan overlies progressively older Mississippian strata. Atokan and lower Desmoinesian sediments truncate and overlap the eroded margin of the Morrowan to the north. Where the Morrowan is locally absent, such as in T. 20 N., R. 18 E., the Atoka rests directly on the Fayetteville formation. In T. 22 N., R. 18 E., Atokan or lower Desmoinesian units are believed to rest directly on the Hindsville limestone.

Southward tilting of the Ozark area and subsequent northward truncation of successively older Mississippian rocks preceded the advance of the Morrowan sea across the area (Huffman, 1958, p. 108). A period of emergence and extensive erosion in post-Morrowan time is indicated by the erratic thickness, distribution and northward truncation of the Morrowan.

Atokan Series

Atoka Formation

The Atoka formation is mapped at the surface over a large area in southern Mayes County. North of Adair (T. 23 N.) the Atoka is truncated and overlapped by lower Desmoinesian shales and sandstones (Huffman, 1958, p. 84).

At the outcrop in Mayes County the Atoka formation consists of sandstones, siltstones and interbedded shales (Huffman, 1958, p. 85). The sandstones are characteristically brown, massive, and iron-stained. The siltstones are thin-bedded, brown to gray, micaceous and iron-stained. The interbedded shales are typically brown to black, fissile, and iron-stained.

In well cuttings the Atoka lithology is extremely difficult to distinguish from that of the overlying shales and sandstones of the Krebs group. An interpretation from driller's logs is virtually impossible. The uncertainty of the upper limits, or for that matter, the presence of Atokan sediments, resulted in the interval being grouped with the Krebs for isopachous studies.

Two wells used in the preparation of the stratigraphic cross sections encountered sediments above the Moorowan which are tentatively assigned to the Atoka. A sequence of silty shales and gray-green siltstones marked at the base by a chert and sandstone conglomerate in the McLennan, Trogdon No. 1, sec. 33, T. 22 N., R. 18 E. (Cross Section E-E', Plate V), is believed to be equivalent to the Atoka. The Summers, Allen No. 1, sec. 16, T. 21 N., R. 18 E. (Cross Section E-E', Plate V) encountered a possible Atokan sequence consisting of gray silty and sandy shales and a basal sideritic and sandstone conglomerate.

Atokan sandstones and shales undoubtly are widely distributed in the subsurface of southern Mayes and eastern Rogers Counties, but the difficulty in establishing the contact with younger Pennsylvanian units precludes any statement as to the thickness or erosional limits of the formation. The stratigraphic relations of the Atoka are assumed to be the same as found at the surface. Where the Morrowan is thought to be locally absent in T. 22 N., R. 17 E. (Plate XVII) Atokan sediments, if present, may overlie the Hindsville limestone, a situation not reported at the surface.

Desmoinesian Series

Krebs Group

Oakes (1953, p. 1523) defined the Krebs group as the rocks between the top of the Atoka formation and the top of the Boggy formation. The Krebs group is subdivided into four formations recognized at the surface in northeastern Oklahoma. These are, in ascending order: the Hartshorne, McAlester, Savanna, and Boggy. The Krebs group together with the overlying Cabaniss group were formerly called the Cherokee group.

The Krebs consists of a cyclic sequence of shales, sandstones, thin limestones and coals. The dominant lithologic types, both at the outcrop and in the subsurface, are dark to gray shale and silty shale. The sandstones are generally silty, fine-to medium-grained, massive to cross-bedded and lenticular. The limestones are thin, impure and commonly developed as zones of interbedded clay ironstones and black shale. The principal marker beds at the surface are, in ascending order: the Warner or Little Cabin sandstone, the Spaniard, Sam Creek and Doneley limestone sequence ("brown limes" of the subsurface), the Bluejacket sandstone, the Inola limestone, and the Taft sandstone.

The subsurface character of the Krebs group is consistent with the lithology, as described at the surface. The lower portion of the Krebs interval consists primarily of dark gray to black shale with beds of sideritic siltstone, local sandstones, clay ironstones, impure limestones, and thin coals. In northern Craig County, gray-green, waxy, sideritic shales are characteristically interbedded with the gray and dark gray shales. The upper portion of the Krebs is composed of dark shales and massive sandstones which grade both laterally and vertically into siltstones and silty shales.

The erratic nature of the Krebs group makes a well to well correlation of individual members extremely difficult. The only horizons which are persistent enough to be considered marker beds are the Warner sandstone, the Bluejacket (Bartlesville) sandstone, and locally the Taft (Red Fork) sandstone.

The Warner, where well developed, is a fine-grained sandstone averaging about 10 feet in thickness. Normally, the Warner is 30 to

50 feet above the base of the Krebs group. Laterally, the sandstone grades to siltstone and silty shales.

The Bluejacket (Bartlesville) sand zone is generally recognizeable in well samples. The lithology ranges from a massive fine-grained sandstone, as much as 88 feet thick, to a series of alternating sandstones, silty sandstones and dark shales. Laterally and vertically, the Bluejacket grades to siltstones and silty shales.

The Taft (Red Fork) sandstone is generally described as a siltstone or silty shale. The interval is not commonly developed as a single sandstone body; rather, if distinguishable at all, it consists of a sequence of silty sandstones and shales.

The difficulty in correlating limestone units in the Krebs group is that normally they consist of a gradational sequence of thin clay ironstones. At places the "brown limes" are distinctive enough to serve as marker beds. Locally the Inola limestone is developed above the Bluejacket, but is not readily correlatable from well to well.

Driller's logs commonly describe the basal portion of the Pennsylvanian system as the "Burgess sand." This undoubtedly is the most misapplied subsurface term in the entire stratigraphic section. Jordan (1957, p. 31) defined the "Burgess sand" as a detrital sand and conglomerate at the base of the Desmoinesian series resting upon rocks of Mississippian age. In accordance with this definition, the usage of the term, while justified in some areas of eastern Oklahoma, is invalid as it is applied in the Craig-Mayes County area. This conclusion is based on a careful examination of well samples from the area. No evidence was found to substantiate the existence of the "Burgess sand" as a recognizable subsurface unit. A comparison of sample logs to driller's logs indicates that the term "Burgess" is applied to several stratigraphic intervals. In southern Mayes County, sandy zones of the Morrowan are called "Burgess." To the north the so-called "Burgess" oil and gas production is from the upper portions of the Mississippian system, which in some areas is the Hindsville limestone and in others the Warsaw limestone.

Branson, (1954, p. 11) noted a thin conglomerate at the base of the Krebs group overlying the Atoka in some areas and Mississippian rocks in other areas which he correlated with the "Burgess sand" of the subsurface. This seems more nearly to be the true representative of the "Burgess" in the Craig-Mayes County area. In well cuttings, such an interval might well be represented by a few pebble fragments or detrital sand grains. Locally, it is entirely possible that somewhat thicker "Burgess sand" bodies might be encountered, but most certainly they do not account for the "Burgess sand" oil and gas production, nor justify the widewpread application of the term. The "Burgess sand" is a term firmly entrenched in driller terminology and will likely remain as a standard description for a "soft" or fluid-bearing zone above the hard "Mississippi lime."

The Krebs group is present everywhere in the subsurface of the area west and north of the Mississippian outcrop. The combined thickness of the Atoka-Krebs interval ranges from zero to approximately 570 feet.

Shales and sandstones of the Krebs group rest unconformably on the Atoka in southern Mayes County, and on successively older Mississippian units to the north. The Krebs is succeeded unconformably by the Cabaniss group. Evidence of post-Taft pre-Tiawah orogenic movement, and a distinct paleontological break in post-Boggy time, are the principal criteria for placing an unconformity at the top of the Krebs (Lohman, 1952, p. 68).

Cabaniss Group

Oakes (1953, p. 1525) defined the Cabaniss group as including all the rocks above the Krebs group and below the base of the Marmaton group. At the type locality, the Cabaniss group comprises three formations: the Thurman sandstone, Stuart shale, and Senora formation. The Senora is the only formation of the Cabaniss group present in the Craig-Mayes County area.

The Senora formation consists of a well-developed cyclic sequence of shales, sandstones, limestones and thin coals. At the outcrop, the base of the Senora has been placed below the Tiawah limestone and the Tebo coal and above the Weir-Pittsburg coal; it may actually be below the Weir-Pittsburg coal according to recent paleobotanical information (Branson, personal communication, April 1961). In the subsurface, the base of the Tiawah ("Pink") limestone is generally used as the boundary between the Krebs and Cabaniss groups.

The principal marker horizons within the Senora formation are, in ascending order: the Tiawah limestone, Chelsea sandstone, Verdigris limestone, Lagonda sandstone, and the Breezy Hill limestone. These members are separated by variable thicknesses of dark to gray shale and silty shale.

The Senora formation in the subsurface is consistent with the surface descriptions. The limestones, with one notable exception, are excellent marker beds. The sandstones grade both laterally and vertically into siltstones and silty shales. In general, the shales are gray to black, and, compared to shales in the Krebs group, are not commonly sideritic.

The Tiawah, or "Pink" limestone, is the least distinguishable limestone member of the Senora. As noted at the surface (Claxton, 1952, p. 11) the Tiawah limestone in Craig County is commonly represented by a sequence of black shales and thin-bedded clay ironstones. As a result, the Tiawah interval is extremely difficult to distinguish in well cuttings, and impossible to interpret from a driller's log. In the absence of a recognizable limestone unit, it is necessary to establish a Tiawah "zone" based on the relative position of the Tiawah below the Verdigris, and in some cases, upon a correlative gamma-ray curve. The Tiawah is best developed as a massive limestone in northeastern Rogers County. In this area the Tiawah is easily recognized, both in the well cuttings and on driller's logs.

The Chelsea sandstone varies from a massive, reddish-brown silty sandstone more than 80 feet thick to a sequence of gray silty shales and siltstones. The erratic nature of the Chelsea is typical of other sandstone units in the Senora. The Chelsea is commonly referred to in the subsurface as the Skinner sand.

Approximately 40 to 50 feet below the Verdigris many wells encounter one or two dark gray, dense, massive to thick-bedded, argillaceous limestones and a thin coal. The writer is uncertain as to the surface equivalents of these limestones, but their position relative to the Verdigris is about the same as that of the McNabb limestone.

The Verdigris characteristically occurs as a dark gray, dense to finely crystalline limestone approximately 30 to 40 feet below the Breezy Hill. The average thickness of the Verdigris is about five to eight feet.

The Prue or "Squirrel" sandstone is erratic in occurrence. More commonly the interval is represented by siltstone or silty shale.

The Breezy Hill limestone is an exceptionally persistent subsurface marker bed. This gray, finely crystalline to dense limestone is separated from the lower Fort Scott limestone member of the Marmaton group by four to eight feet of black shale (Excello). The Breezy Hill is generally rather thin, averaging about four to six feet in thickness.

The surface and subsurface distribution of the Senora formation is confined to the western and northwestern part of the area. Southeastward the formation thins to extinction in central Craig and northeastern Rogers Counties. The thickness of the Senora ranges from zero to 235 feet, but beneath the outcropping margin of the Marmaton group the formation maintains a uniform average thickness of 175 to 200 feet.

The Senora formation unconformably overlies the Krebs group and is conformable beneath the Marmaton group (Oakes, 1953, p. 1525).

The depositional environment of the Senora formation, as indicated by its uniform thickness and the persistence of individual members, is in sharp contrast to that of the Krebs group. The erratic nature of the Krebs seems to indicate that the shelf was relatively unstable during its deposition. Beginning in post-Boggy time, the shelf progressively passed from unstable to relatively stable conditions which persisted throughout the remainder of the Desmoinesian epoch.

Marmaton Group

The Marmaton group includes the formations from the base of the Fort Scott limestone to the top of the Desmoinesian series.

The Marmaton group, as exposed in the extreme northwestern corner of the area (Plate VII), is comprised of the following formations: Fort Scott limestone, Labette shale, Pawnee limestone, Bandera shale, Altamont limestone, Nowata shale, and the Lenapah limestone. To the southwest in Tulsa County, the Holdenville shale overlies the Lenapah, and is the uppermost formation of the Marmaton group.

The limestones of the Marmaton group are excellent marker beds both at the surface and in subsurface, but few wells in the area are drilled far enough to the northwest to encounter units higher in the section than the Pawnee limestone. The only limestone with sufficient distribution in the area to be of value as a subsurface datum, is the Fort Scott.

The Mesker Drilling Company, Miller No. 1, sec. 24, T. 28 N., R. 17 E. (Cross Section A-A', Plate I), is the only well used in the stratigraphic cross sections which encountered Marmaton units higher than the Fort Scott limestone. The absence of additional sample data precluded a more detailed study of the Marmaton section, other than the Fort Scott limestone, but the section in the Miller well is believed to be fairly representative of the Marmaton group below the Altamont limestone.

The Fort Scott limestone, as developed in the subsurface of northern Craig County, consists of lower and upper members separated by black shale (Little Osage). These same units at the outcrop are termed the Blackjack Creek limestone and the Higginsville limestone. The lower, or Blackjack Creek member, is characteristically a tan to gray finely crystalline to dense, fossiliferous limestone. Fusulinids are particularly common in the lower member. The average thickness of the limestone is from 30 to 40 feet and is separated from the upper limestone by four to 10 feet of black shale. The upper, or Higginsville member, is typically a tan to gray, finely crystalline, fossiliferous limestone. The upper limestone is variable, but generally averages less than 40 feet in thickness.

The base of the lower Fort Scott limestone is an exceptionally good contour datum, and is commonly mapped both at the surface and in the subsurface (Plate XVI).

The Fort Scott limestone is equivalent to the Oswego limestone in the subsurface of other areas in eastern Oklahoma. To the south the Altamont and Pawnee limestones converge to become the Oologah limestone.

On the basis of scattered well information the total thickness of the Marmaton ranges from zero in eastern Craig County to a maximum of 450 feet in T. 28 N., R. 17 E.

The Marmaton group is conformable with the underlying Senora formation, and to the west of the area is succeeded disconformably by rocks of Missourian age.

The shales, sandstones and limestones of the Marmaton group are the youngest Paleozoic rocks in the area of investigation.

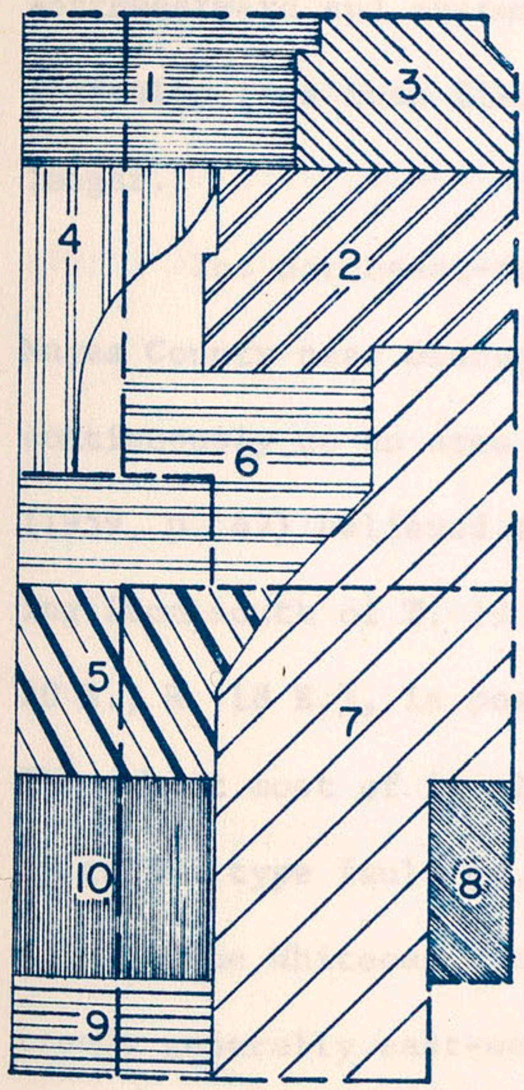
CHAPTER III

STRUCTURE

The area of investigation lies around the northwestern edge of the Ozark uplift and along the eastern margin of the Northeastern Oklahoma Platform. Successively younger formations strike in an arcuate pattern about the flanks of the Ozark uplift, and dip to the west and northwest at a regional rate of 25 to 50 feet per mile.

The subaerial and subsurface distribution of the post-Arbuckle formations in the area is directly related to the tectonic movements of the Ozark geanticline. Southward and southeastward tilting of the area in pre-Chattanooga, pre-Morrowan and pre-Atokan time resulted in the northward and northwestward truncation of older units and subsequent overlap by the younger. The principal structural deformation of the Ozark region, which initiated the present configuration of the area, occurred during Pennsylvanian time. Most of the faults and folds mapped at the surface in northeastern Oklahoma are post-Atoka and pre-Tiawah in age, indicating major tectonic movement during Desmoinesian time (Huffman, 1958, p. 109).

The Generalized Geologic Map (Plate VII) of the Craig-Mayes County area illustrates the relationship of the structural features in the area to the northeast-southwest trending extension of the Ozark uplift. This map is basically an enlargement from the Geologic Map of the State of Oklahoma by Miser (1954) with structural revisions



1 . . . Cade, C. M., III., M. S. Thesis, Univ. Okla.

2 . . . Chrisman, L. P., M. S. Thesis, Univ. Okla.

3 . . . Claxton, C. D., M. S. Thesis, Univ. Okla.

4 . . . Faucette, J. R., M. S. Thesis, Univ. Okla.

5 . . . Gruman, W. P., M. S. Thesis, Univ. Okla.

6 . . . Lohman, C., Jr., M. S. Thesis, Univ. Okla.

7 . . . Okla. Geol. Survey, Bull. 77

8 . . . Slocum, R. C., M. S. Thesis, Univ. Okla.

9 . . . Stringer, R. S., M. S. Thesis, Univ. Okla.

10 . . Tillman, J. L., M. S. Thesis, Univ. Okla.

INDEX MAP TO AREAS
MAPPED IN DETAIL ON THE SURFACE

FIGURE 6

as noted by Huffman (1958) and others.

The area is characterized by a series of northeast trending normal faults roughly paralleling the axis of the Ozark uplift. A number of faults, however, depart from this general trend, striking northwestward and eastward. Most of the faults in the area are generally less than five miles in length, but three are considerably longer.

The northeast-southwest trending Seneca fault zone enters Mayes County near Disney (T. 23 N., R. 21 E.) and is mapped almost continuously to an area south of Pryor (T. 21 N., R. 19 E.). Stringer (1959, p. 47) believed that the long northeast trending fault, extending from south of T. 19 N., R. 17 E. to an area west of Chouteau (T. 20 N., R. 18 E.), is possibly a continuation of the Seneca fault zone. Throughout most of its length the Seneca fault zone is characterized by graben type faulting, typically produced by tensional forces.

The Whiteoak Creek fault (T. 24 N., R. 20 E. and R. 21 E.) trends generally east-west, but turns sharply to the northeast in T. 24 N., R. 21 E. The fault is normal and downthrown to the north. The Locust Grove fault (T. 19 N., R. 20 E.) strikes north-northeast from the Mayes-Cherokee County line to the vicinity of Locust Grove in Mayes County. The eastern side is the upthrown side of this normal type fault.

The principal folds in the area are the Miami syncline (T. 26 N., R. 21 E.) and the Horse Creek anticline (T. 24 N., R. 21 E.). Both features trend generally northeast-southwest.

By far the most severely deformed portion of the area of investigation is in T. 19 N., Rs. 17 and 18 E. This area in the subsurface as well as at the surface, seems to be near the apex, or focal point, of structual activity in northeastern Oklahoma. According to Stringer (1959, p. 47) most of the faulting occurred in post-Boggy, pre-Senora time. It is interesting to note that the most questionable area of Mississippian geology occurs within these same townships (page 34). The relationship of the structure to the Mississippian stratigraphy in this area and to the south is not clearly understood, but it is a factor which should be taken into consideration in any future analysis of Mississippian stratigraphic problems.

Structural contour maps were prepared on two horizons in the subsurface of the area of interest; specifically, the top of the Arbuckle group and the base of the Fort Scott limestone.

Structural Contour Map on Top of the Arbuckle Group

(Plate IX)

The basic structure of the Arbuckle surface in this area is that of a westward dipping homocline. The average regional dip of between 30 and 40 feet per mile is interrupted in southern Mayes County by a series of moderately steep-sided structural and topographic high areas. In Craig County the uniform westward dip is broken occasionally by west and northwest plunging structural noses.

Two faults were mapped on the Arbuckle surface, both of which are reflected in the isopach map of the overlying Chattanooga formation. Southeast of Chouteau (T. 20 N., R. 18 E.) a northeast-southwest trending fault apparently is the trapping mechanism for a small "Arbuckle" gas field located on the downthrown side of the fault. The difference in elevation between the high well on the upthrown, or southeastern side of the fault, and those on the downthrown is about 220 feet in a distance of approximately one-half mile. This faulted area is the most persistent feature of the pre-Chattanooga surface. Its presence is reflected in the succeeding Chattanooga and Mississippian isopach maps, and at the surface.

North of Disney in T. 23 N., R. 21 E. a pre-Chattanooga fault trends northwest-southeast. The difference in elevation across the fault is only 80 feet in a distance of less than one-half mile; but the northern or upthrown well reported 40 feet of Chattanooga shale, while the well on the downthrown side encountered 84 feet of Chattanooga. This abrupt change in thickness seems to justify the existence of a fault between the wells.

Other faults may cut the Arbuckle surface, particularly in southern Mayes County, but the scattered control, and size of the contour interval do not justify arbitrarily placing faults in an area when the same area can be contoured without them.

Most of the folding mapped on the Arbuckle surface apparently originated during a post-Mississippian or later period of crustal movement. This conclusion is based on the fact that folding is not reflected in either the Chattanooga or Mississippian isopachs. Among the most prominent of these fold-structures are the north-south trending anticline north of Chouteau (T. 20 N., R. 18 E.); the strongly developed northeast-southwest trending anticlinal fold in the vicinity of Ketchum; and the two areas of synclinal folding near Pensacola

(T. 23 N., R. 21 E.) and Locust Grove (T. 20 N., R. 20 E.). Most of the small westward plunging noses are also the result of post-Mississippian or later structural activity.

One of the particularly important features of the Arbuckle surface which did affect the deposition of succeeding formations from Simpson through Mississippian time, is located in the southeastern corner of T. 20 N., R. 17 E. In this area, Arbuckle units thin across a Precambrian granite peak (Plate VIII). A pre-Simpson high at this same location was apparently the result of differential compaction of Arbuckle sediments around the flanks of this granite "island." Later crustal movement in the area may have accentuated further the elevation of this area above the Arbuckle surface.

Structural Contour Map on the Base of the Fort Scott Limestone

(Plate XVI)

The Fort Scott limestone is stripped from all but the northwestern corner of the area of investigation. The base of the Fort Scott marks the base of the Marmaton Group. This map, therefore, represents the structural configuration of the upper surface of the Cabaniss group (top of the "Cherokee") resulting from late Pennsylvanian orogenic movements.

The predominant structural feature illustrated by this horizon is a westward dipping homocline marked by a series of west and northwest plunging anticlinal noses. The average rate of dip is about 45 feet per mile. Locally, about the limbs of a structural nose, the dip is as much as 150 feet per mile.

CHAPTER IV

DISCUSSION OF ISOPACHOUS AND PALEOGEOLOGIC MAPS

An isopachous map ideally indicates not only the varying thickness of a designated stratigraphic interval, but also the nature of the predepositional surface; and when compared to intervals above and below, provides clues to the structural history of a particular area.

Within the area of investigation, basically two factors served to limit or to obscure the "ideal" in isopachous studies. The first, and most readily observed on many of the included maps, is the effect of recent erosion. Obviously, this only influences those formations or systems which have a broad subaerial distribution; specifically, the Mississippian system and the lower Desmoinesian Krebs and Cabaniss groups. Isopach contours across areas exposed to erosion can only represent a thickness in place, and cannot be interpreted as revealing the structure or topography that lies beneath. A true isopach of units partially exposed at the surface, begins at the point where they dip beneath a younger formation. Undoubtedly, the original thickness of nearly every major sequence in the section, whether presently exposed at the surface or not, has been reduced to a lesser or greater degree by post-depositional erosion in past geologic time. This is a limitation common to all isopachous studies and does not render valueless interpretations as to the pre-and post-depositional history of a particular formation.

The second limiting factor involves isopaching as a single interval, a sequence of formations separated by a major unconformity. A broad regional isopach of this type reveals the major structural features of an area; locally the presence of a major unconformity within the interval tends to obscure the details of the underlying depositional surface and the nature of any related structural activity. The isopach map of the Mississippian system (Plate XII), for example, indicates the total thickness of the system at any one point, but is not necessarily a true reflection of the pre-Mississippian surface, nor of the structures which grew contemporaneous with, or followed the Mississippian period.

One paleogeologic map showing the pre-Atoka erosion surface (Plate XVII) is included in the following discussion.

Isopach Map of the "Arbuckle" Group

(Plate VIII)

The isopach map of the "Arbuckle" group includes the pre-Simpson rocks from the base of the Lamotte sandstone to the top of the Cotter dolomite. The variation in the thickness of the "Arbuckle" reveals, in general, the paleotopography of the Precambrian surface within the area of investigation. The scattered well control permits only a generalized interpretation of the "Arbuckle" interval. The basic regional trends generally coincide with those established by Ireland (1946) and Dille' (1956, plate I).

The most prominent features of the Precambrian surface as reflected in the "Arbuckle" thickness map are the two granite peaks located in Mayes County. These positive areas, as exposed at the surface near Spavinaw and in the subsurface west of Chouteau, apparently remained as islands in an Ordovician sea until late Canadian time. Upper Arbuckle dolomites thin to as little as 37 feet across the crest of one of these granite knobs.

A consideration which should not be overlooked in any future mapping of the basement surface is that succeeding granite tests never fail to prove these Precambrian peaks to be steeper sided than originally postulated. A well drilled north of the Spavinaw granite outcrop in sec. 34, T. 23 N. R. 21 E. encountered 1,426 feet of "Arbuckle" rocks above the basement surface. This is a difference in elevation of over 1,500 feet between the outcrop and the well, a distance of approximately three miles.

To the north, a deep trough of "Arbuckle" sediments separates the Spavinaw peak from a broad, high area near Welch. The thinning of the "Arbuckle" to the north is as much a regional trend as it is a local development. The overall regional slope of the Precambrian surface is generally from northeast to southwest. A maximum thickness of 1,686 feet of "Arbuckle" is encountered in the extreme southwestern corner of the area. Along the Kansas-Oklahoma border the "Arbuckle" thins to between 900 and 1,000 feet. It is interesting to note that, in general, the isopach maps of succeeding horizons, as well as the structural map of the Arbuckle surface (Plate IX), display the same characteristic of rugged topography in Mayes County, and a comparatively gently sloping terrain to the north in Craig

County. It would appear that basic patterns established on the Precambrian surface, to some degree, control the succeeding depositional environments.

Isopach Map of the Simpson Group

(Plate X)

The subsurface distribution of the Simpson group (Tyner- Burgen formations) is limited to the southernmost portion of Mayes and Rogers Counties. Simpson equivalents north of this area were removed by pre-Chattanooga erosion. In general, the local variations in thickness of the Simpson sandstone and shales corresponds with the topography of the underlying Arbuckle surface (Plate IX). To the east of T. 19 N., R. 18 E. there is no well control to substantiate the thickness or even the presence of the Simpson group, but in sec. 12, T. 19 N., R. 20 E., the Burgen sandstone and the Tyner formation are exposed at the surface.

The Simpson group thickens from zero in T. 19 N., and T. 20 N. to 126 feet along the Rogers-Wagoner County line. South of the area the Simpson thickens to as much as 700 feet near the Choctaw fault (Bercutt, 1949, p. 15). North of the erosional limit three wells encountered Simpson sandstones ranging from 12 to 26 feet in thickness. These have been contoured as a single outlier, but could as well represent three isolated remnants of Simpson equivalents. A well marginal to the area in sec. 18, T. 20 N., R. 22 E., drilled more than 250 feet of rocks tentatively assigned to the Simpson group. Although this is an unusually thick Simpson section for this area, it could possibly represent a depression in the Arbuckle surface similar to those mapped in the subsurface of Cherokee and Muskogee Counties (Bercutt, 1959, plate II).

Isopach Map of the Chattanooga Formation

(Plate XI)

The Chattanooga formation maintains an average thickness of between 50 and 60 feet throughout most of Mayes and southern Craig Counties. To the north, the apparent thinning of the black shale is primarily the result of the presence and northward thickening of the gray-green, Tasmanites-bearing "Kinderhook shale." The combined thickness of the "Kinderhook shale" and the black Chattanooga shale is roughly the same as the total Chattanooga interval to the south. This observation has been advanced in support of the theory that the "Kinderhook shale" is a lateral variation of the Chattanooga formation.

In the extreme northeastern and southwestern corners of the area, the Chattanooga is absent by erosion and (or) non-deposition. A number of geologists favor non-deposition, but it is significant to note that (at least in the southwestern portion of the area) there is some evidence to support the erosion hypothesis. In sec. 35, T. 20 N., R. 17 E., a well which marks the crest of a pre-Chattanooga Arbuckle high (late IX) reports 35 feet of Chattanooga shale, while a well less than one-half mile to the south (sec. 2, T. 19 N., R. 17 E.) and on the flank of the Arbuckle structure reports only 18 feet of Chattanooga shale. If the Chattanooga were thinning to the southwest as the result of non-deposition then it would logically be extremely thin or absent across the Arbuckle positive areas, but instead, the structurally high well reported the greater thickness. This situation implies that erosion did effect the removal of a part of the Chattanooga at this locality, and that erosion is at least partially responsible for the total absence of the unit to the southwest.

Variations in the thickness of the Chattanooga formation reflect several of the pre-Chattanooga structural features (Plate IX), but, as indicated by the uniform thickness of the black shale interval across known Arbuckle highs, many of the underlying folds were the result of a later period of crustal movement, probably post-Mississippian. The Chattanooga isopach seems to justify the two faults mapped on the Arbuckle surface (Plate IX). Southeast of Chouteau, the closely spaced contour lines are indicative of a northeast-southwest trending "Arbuckle" fault. North of Disney another "Arbuckle" fault, trending northwest apparently accounts for the abrupt change in thickness of the Chattanooga in two adjacent wells in sec. 2, T. 23 N., R. 21 E. The thickest reported Chattanooga interval (84 feet) was encountered on the downthrown side of this fault.

Isopach Map of the Mississippian System (post-Chattanooga)

(Plate XII)

The post-Chattanooga, Mississippian system includes all the formations from the base of the "Kinderhook shale" to the top of the Pitkin limestone.

The isopach map of this interval is affected by both factors previously discussed as limiting the value of interpretations made from a thickness study. Over a large area in eastern Mayes County and southeastern Craig County the thickness of the Mississippian system was markedly reduced by recent erosion. In addition to this, the interval includes a major unconformity (Osagean-Meramecian). To some extent the affect of this unconformity is offset by the remarkably uniform total thickness of the Mississippian system in the subsurface. With these reservations in mind, a number of general observations based on the comparison of this map with the preceding maps, seem justified.

The isopach map of the Mississippian system illustrates the characteristic paleotopography of the area of investigation. The uniform thickness of the Mississippian in Craig County is indicative of the gentle low relief which characterized this portion of the area throughout the Paleozoic era. In southern Mayes and Rogers Counties the terrain is typically irregular, undoubtedly a result of the close proximity of this area to the focal point of structural activity in the southern Ozarks.

The thickness of the Mississippian ranges from 67 to 455 feet, but generally averages between 250 and 350 feet. While the overall thickness of the Mississippian is fairly uniform west and north of the outcrop, there is a moderate regional thinning of the interval from northeastern Craig County to the west and southwest into Nowata and Rogers Counties. The local thinning of the Mississippian system across areas immediately to the west (sec. 25, T. 20 N., R. 17 E.) and southeast (sec. 31, T. 20 N., R. 19 E.) of Chouteau is undoubtedly a reflection of pre-existent Arbuckle structural features (Plate IX). These two particular anomalous areas are the most persistant elements of the pre-Chattanooga erosional surface in southern Mayes County.

The exposure of rocks older than the Mississippian around Spavinaw and areas to the south, and the related thinning of the system eastward across the area of outcrop, is the result of Middle Pennsylvanian uplift and erosion.

<u>Isopach Map of the Morrowan Series</u>

(Plate XIII)

The principal limitation to the Morrowan isopachous map is the highly interpretive nature of the data used in its preparation. The Morrowan is readily distinguishable on a sample log, based on criteria established in the previous chapter (page 62), but sample logs are too few in number to justify contouring on their data alone. It was, therefore, necessary to interpret the Morrowan sequence from driller's logs. In all cases the driller's log had to be compared with a sample log in the same vicinity to establish effectively the boundaries of the series. This is not particularly difficult in southern Mayes County, but is extremely interpretive along the northern margin of Morrowan distribution. The erosional limit is only approximate, and may vary from what is presently shown.

The thickness of the Morrowan series is notably erratic, a characteristic resulting from an intensive period of post-Morrowan erosion. The interval thickens from zero south of Chelsea to 125 feet near the Rogers-Wagoner County line. Locally in T. 21 N.,

R. 17 E. the series thickens to 120 feet only a short distance south of an area where it is thought to be entirely absent.

To the north the Morrowan is truncated and overlapped by younger Pennsylvanian sediments. Eastward the Morrowan is absent, except for a few scattered outliers, primarily as the result of uplift and subsequent erosion during Middle Pennsylvanian time.

Subsurface Distribution of Pre-Atokan Formations

(Plate XVII)

This map represents the paleogeology of the pre-Atokan surface. The Warsaw limestone of Mississippian age is the oldest formation beneath the post-Morrowan Pennsylvanian sediments. To the southeast, successively younger northeast striking bands of strata form the uppermost portion of the Mississippian system. The northwestern truncation of these younger Mississippian formations is indicative of the southeastward tilting of the area in post-Mississippian time.

In the vicinity of T. 24 N., R. 17 E. a facies change occurs in the Meramecian series; therefore, it is possible that in parts of that township the uppermost Mississippian unit is the Moorefield formation rather than the Warsaw, as indicated on the map. Unfortunately, there is no well sample information available within this area to substantiate either conclusion.

To the south in Rogers and Mayes Counties, the Mississippian formations are overlain unconformably by the Morrowan series of Pennsulvanian age. The distribution of the Morrowan is based on the writer's interpretation of a sequence of limestones and shales found in the subsurface as far north as T. 23 N., R. 17 E. (page 2). The inliers of Hindsville and Fayetteville south of the Morrowan erosional limits may indicate the presence of minor anticlinal folds.

Isopach Map Base of Atoka Formation to Base of Tiawah Limestone (Atoka-Krebs) (Plate XIV)

This map represents the combined thickness of the Atoka formation and the lower Desmoinesian Krebs group. North of Adair in Mayes County, the Atoka is essentially absent and the Krebs group rests directly on Mississippian rocks (Huffman, 1958, p. 84). The average thickness of the Atoka in the subsurface of southern Mayes County is not known, but it probably occupies only a small percentage of the total Atoka-Krebs interval.

The northeast-southwest striking band of rapid thinning noted on the isopach is indicative of the rapid eastward truncation of the beds as the result of surface erosion, i.e., erosion from the top. The isopachs in this area represent only a thickness in place and are not a reflection of the pre-Atokan topography. This band of thinning as well as the distribution of the Atoka-Krebs sequence serves to outline the margin of the Ozark uplift. The true isopach of the Atoka-Krebs interval begins west of the dot and dash line which represents the approximate base of the overlying Cabaniss group.

The combined thickness of the Atoka-Krebs sequence ranges from zero to 570 feet. The interval thins northward from an average thickness of about 500 feet in Mayes County to a thickness of 350 feet or less in northern Craig County. In the southeastern corner of T. 26 N., R. 21 E. the presence of the Miami syncline is indicated by the distribution of the Krebs group and the thickening of the interval along the axis of the syncline.

Isopach Map Base of Tiawah Limestone to Base of Fort Scott Limestone (Cabaniss Group)

(Plate XV)

The interval mapped is the Senora formation of the Cabaniss group. As on the Atoka-Krebs isopach map, the narrow northeast striking band of rapid thinning is the result of recent erosion and is not a reflection of the pre-Senora depositional surface. Northwest of the dash and dot line the Senora is overlain by the Fort Scott limestone of the Marmaton group; in this area, the isopach lines are representative of the true thickness of the Senora.

The total thickness of the formation ranges from zero to 235 feet, but in areas not exposed to erosion the Senora maintains a uniform thickness of between 175 and 200 feet. A general thinning of the Senora occurs to the northwest of the vicinity of Centralia. In comparison with the somewhat erratic thickness of the Atoka-Krebs interval, the general uniformity of the Senora formation seems to indicate that more stable conditions prevailed during its deposition.

CHAPTER V

ECONOMIC GEOLOGY

The Craig-Mayes County area abounds with legends and rumors of mineral deposits ranging from uranium to gold. Exploration of one type or another has persisted from the early days of the Cherokee Nation, but to date only some rather unromantic deposits of coal have been uncovered in the area.

The search for oil and gas in Craig and Mayes Counties, although somewhat more rewarding, has failed to discover a major producing area. The neighboring counties to the east, though, have produced considerable quantities of oil and gas since the late 1800's.

Oil and Gas Development

According to James M. Carselowery (personal communication), and substantiated by publications of the Oklahoma Historical Society, Mayes County had a flowing oil well in 1859, the same year of Drake's discovery in Pennsylvania. Lewis Ross, a prominent Cherokee Indian, drilled the discovery well in sec. 23, T. 21 N., R. 20 E., which was then the Salina District of the Cherokee Nation, Indian Territory. Ross originally drilled the well for the purpose of recovering salt, and the discovery of oil was quite by accident. The well is said to have flowed at the rate of ten barrels a day for about a year, and believed by some to have continued to flow for several years thereafter.

The first well drilled in Oklahoma, for the specific purpose of exploring for oil, was commenced in the year 1889, west of the town of Chelsea, in sec. 5, T. 23 N., R. 17 E. (Woodruff and Cooper, 1928, p. 18). The discovery of a small quantity of oil opened the Chelsea field. Drilling continued in the area and by 1910 most of the oil pools in eastern Rogers and Nowata Counties had been discovered. These areas are still producing primarily as the result of secondary recovery projects.

Methods of drilling and exploration, particularly in Craig and Mayes Counties, have not changed appreciably in the last thirty years. The principal drilling unit is still the cable tool rig, and not without reason. The cable tool is more economical to operate than a rotary unit in shallow, hard rock areas, and from the viewpoint of a geologist, the sampling is more accurate and the cuttings less difficult to interpret. While geological methods have been employed in many cases, the most prevalent tendency in exploration is to offset old producing areas, wells that reported good oil shows, active seeps, or water wells that encountered shows of oil or gas. In addition to these more conventional methods of locating a well site, the use of "doodlebug" or "witching" devices to establish well locations is not uncommon. The writer was told of one unusual instrument, purported to be of some scientific merit, which was capable of producing a picture of the subsurface. Taken at proper angles, the pictures would accurately locate a body of entrapped oil. To the best of the writer's knowledge, the device met with little success in the area.

The following outline of the oil and gas producing areas (Plate

XVIII) in Craig, Mayes and eastern Nowata and Rogers Counties is summarized in part from data compiled by Bess Mills-Bullard (1928). Note that the term "Burgess" sand is commonly used to describe the lowermost producing horizon in these areas. As previously discussed, the term "Burgess" is misapplied, and almost without exception the oil and gas production attributed to that horizon is actually from the upper Mississippian limestones and siltstones. In the southern portion of the area the term "Burgess" has been applied to Morrowan sandstones and sandy limestones.

Many of the wells plotted on the base map as producing oil or gas may now be abandoned, but no records exist to substantiate whether or not they have been plugged.

Rogers and Nowata Counties

The eastern margin of these two counties contains the major oil and gas pools within the area of interest. The principal producing horizon is the Bartlesville sandstone. Production from this lenticular sand body is controlled as much by the thickness and permeability of the unit as by the local structure (Sartin, 1958, p. 53).

In the vicinity of Chelsea and Alluwe the Bartlesville produces from a depth of about 400 to 450 feet. To the north in the Coody's Bluff district the pay sand is generally encountered between 500 and 700 feet below the surface. Depending upon the locality, "Burgess" production is found at depths ranging from 400 to 1,000 feet. The ensuing paragraphs briefly summarize the production and producing horizon, or horizons, of the principal oil and gas pools within eastern Rogers and Nowata Counties.

The East Claremore field (T. 21 N., R. 17 E.) is part of the larger Claremore field which was opened in 1904. Oil is produced primarily from the "Burgess" sand. The initial production from this horizon ranged from 10 to 50 barrels per day. Wells in the "Tucker" sand produced from one to seven million cubic feet of gas per day. The production described from the "Burgess" and "Tucker" sands is believed to be from the upper Mississippian Moorefield and Hindsville formations and from the overlying Morrowan series.

Several small areas in the vicinity of Foyil (sec. 32, T. 23 N., R. 17 E.) produce oil and gas from the Bartlesville and so-called "Burgess" sand.

The Chelsea field (T. 24 N., R. 17 E.) opened in 1889, is the oldest oil producing area in Oklahoma. The Bartlesville sand is the principal producing horizon. Wells in the Bartlesville initially produced upwards of 100 barrels per day. By 1928, the average production per well had declined to an average of one-half barrel to 20 barrels per day (Woodruff and Cooper, 1928, p. 21). The area is now under a water flood recovery program. Some oil was produced originally from the "Burgess" and "stray" sands.

The Catale District (T. 24 N., R. 18 E.) produces some oil and gas from the "Burgess" (probably the Hindsville formation). The field was opened in 1910. Initial oil production ranged from three to 10 barrels per day.

The Alluwe field (Twps. 24 and 25 N., R. 17 E.) opened in 1904, is a northward extension of the Chelsea field. The Bartlesville is the principal producing horizon. Initial production from a number of Bartlesville wells ranged as high as 500 barrels per day. Some oil and gas is obtained from the "Burgess." In this area the "Burgess" or "chat" production is primarly from the Warsaw limestone. The use of the term "chat" is indicative of the cherty nature of the Warsaw. Northwest of the Hindsville subcrop there is a marked increase in the usage of this term on driller's logs.

The Coody's Bluff field (Twps. 25 and 26 N., R. 17 E.) is the northern portion of the Chelsea-Alluwe-Coody's Bluff district. The pool was opened to exploration in 1904. As in the areas to the south, the Bartlesville sand is the principal producer of oil. Initial production from the Bartlesville ranged from 25 to 125 barrels per day. This area, as most others in Nowata and Rogers Counties, is now producing under secondary recovery programs. Wells in the "Burgess" sand initially produced as much as 16 million cubic feet of gas per day. "Burgess" production in the Coody's Bluff area is believed to be from the upper portion of the Warsaw limestone.

The southeastern end of the Delaware-Childers field extends into the area of interest just north of the Coody's Bluff field in T. 26 N., R. 17 E. The first production from the field was obtained in 1907. The Bartlesville sandstone is the major oil producing horizon.

Mayes County

There are no major oil or gas producing pools in Mayes County, but a number of isolated areas have produced small quantities of oil and, more commonly, gas. Noncommerical quantities of oil are often reported from the Hindsville limestone and from the upper siltstone member of the Moorefield formation, but rarely from the Osagean cherts and limestones. Below the Mississippian system gas has been found in the Simpson group and in the top of the Arbuckle group.

The following resume' of the oil and gas producing areas in Mayes County was compiled by the author from material obtained through a research of the literature, Corporation Commission records, and other sources of well information.

The now depleted Mazie gas field (secs. 26 and 27, T. 19 N., R. 18 E.) initially produced between 50,000 and 2,000,000 cubic feet of gas from the Simpson group at a depth of 475 to 525 feet. One well reported oil production at the rate of 175 barrels per day. The principal drilling activity took place between 1919 and 1925.

Four wells in sec. 36, T. 20 N., R. 18 E., drilled in the late 1930's and early 1940's, produced gas from the top of the Arbuckle. All are aligned on the downthrown side of a northeast-southwest trending fault (Plate IX). The initial production ranged between 100,000 and 1,000,000 cubic feet of gas per day from an average depth of about 460 feet. One well on the upthrown side of the fault (sec. 31, T. 19 N., R. 19 E.) yielded a small quantity of gas.

A well drilled in sec. 22, T. 20 N., R. 19 E. reported an unknown quantity of gas in the lower portion of the Osagean series. This is one of the few reports of oil or gas in the Osagean portion of the Mississippian system.

Two wells drilled in sec. 27 and in sec. 34, T. 21 N., R. 18 E. yielded between 80,000 and 400,000 cubic feet of gas per day from the top of the Arbuckle and the Chattanooga shale. Both horizons were encountered at a depth of approximately 400 feet. These wells were drilled in 1930.

Small quantities of oil, five barrels per day or less, were produced from the uppermost Mississippian limestones in sec. 31, T. 22 N., R. 19 E. and sec. 4, T. 23 N., R. 18 E. These wells produced from an average depth of less than 100 feet.

Other unrecorded areas of oil or gas production probably exist, but it is doubtful that they are of greater importance than those listed above.

One of the most interesting, and probably most deceiving, features of oil exploration in Mayes County is the wide spread occurrence of oil and gas seeps. The presence of surface seeps was known to Indian settlers from the early days of the Territory, and provided the stimulus for oil exploration in Mayes and adjacent Rogers Counties. The discovery well in the Chelsea field was drilled to test a seep known and used by the Cherokee Indians (Woodruff and Cooper, 1928, p. 18). Most of these seeps appear to be from the Hindsville limestone, but at least one is thought to originate from the cherty Osagean limestones. Six typical occurrences of oil and gas seeps are listed below and keyed by number to their location as spotted on Plate XVIII: location (1) sec. 1, T. 23 N., R. 19 E., an active gas seep in a silo trench, gas coming from a vertical fracture in beds of shale; location (2) sec. 24, T. 23 N., R. 19 E., excellent example of an oil seep in the Hindsville limestone, exposed in a quarry northeast of Adair; location (3) sec. 25, T. 23 N., R. 20 E., an oil seep with active gas action in a lead and zinc exploratory shaft drilled in "Boone" chert; location (4) sec. 3, T. 22 N., R. 19 E., oil and gas seeping from the bottom of a 70 foot water well; location (5) sec. 21, T. 22 N., R. 19 E., an oil seep with active gas action in a lead and zinc prospecting shaft; location (6) sec. 28, T. 22 N., R. 19 E., oil and gas seeping from around the plug of an old lead and zinc exploratory shaft. In addition to these, gas seeps have been noted along Chouteau Creek in sec. 32, T. 20 N., R. 19 E., and an oil seep is found in a Hindsville quarry in sec. 30, T. 23 N., R. 20 E. (Huffman, 1958, p. 101).

Craig County

Northwest of the Ozark uplift the section thickens, generally improving conditions favorable to the discovery of oil. For this reason Craig County has proved to be a somewhat more productive area of oil exploration. Several small oil and gas fields producing primarily from the so-called "Burgess" sand, have been discovered north of Vinita and east and southeast of Centralia. "Burgess" or "chat" production in Craig County, as in other areas, can be interpreted as production from the Hindsville or Warsaw limestones. Upper Mississippian production is encountered at the depths ranging from 160 to 730 feet below the surface. The deeper wells are drilled in the northwestern corner of Craig County, and the shallow production is found nearest the flanks of the Ozark uplift. Other horizons producing minor amounts of oil and gas include the top of the Arbuckle dolomite, the Bartlesville sand, and in the extreme northwestern corner of the county, wells report gas from the Fort Scott limestone (Oswego). The shallow depth and limited distribution of both the Bartlesville (Bluejacket) and the Fort Scott severly limits their value as producing horizons. The Arbuckle, however, is relatively untested, and is the only horizon which offers promise as a possible area of major discovery.

The following production information was compiled primarily from Corporation Commission records, and data reported in the Oklahoma Geological Survey, Bulletin 40.

The East Catale field (T. 24 N., R. 19 E.) was known in the early literature as the Vinita pool (Mills-Bullard, 1928, p. 260). The area was opened in about 1910 and produced oil and gas from the "Burgess" (probably the Hindsville limestone) at a depth of about 400 feet. The initial production ranged from three to 10 barrels of oil, and one to two million cubic feet of gas per day.

In the vicinity of Booker School, (secs. 28 and 32, T. 25 N., R. 18 E.), a number of wells are reported to have produced a small quantity of oil from the "Burgess" sand (Bloesch, 1928, p. 29).

Northeast of Vinita in T. 25 N., Rs. 19 and 20 E., a small field produced gas and some oil from the Hindsville and Warsaw limestones at depths of 160 to 240 feet. Initial gas production ranged as high as six million cubic feet per day, but the wells generally averaged less than one million cubic feet per day. These wells were drilled in the middle and late 1930's. In areas, as the above, where the Hindsville overlies the Warsaw, the oil is believed to be from the Hindsville and the gas from the Warsaw. Northwest of the Hindsville subcrop, the Warsaw produces primarily gas.

Two areas east of Vinita in sec. 24, T. 25 N., R. 20 E. and sec. 16, T. 25 N., R. 21 E. produced gas from the top of the Arbuckle at depths of 380 and 360 feet. The initial production averaged about one million cubic feet of gas per day.

In sec. 20, T. 26 N., R. 18 E. a pool, opened in 1916, produced a small quantity of oil from the Bartlesville sand, and according to Bloesch (1928, p. 29), from the "Burgess" sand.

The "Vinita" field (T. 26 N., R. 20 E.) produces oil from the "Burgess" (probably the Hindsville) and gas from the "chat" (Warsaw). These horizons are generally found between 210 and 270 feet below the surface. The initial production ranged from one-half to 25 barrels of oil per day, but usually averaged less than five barrels per day. Gas yields of over one million cubic feet per day have been reported. Most of the wells were drilled in the 1930's, but as recently as February, 1961, oil wells were being completed in the "Vinita" field.

Southeast of Centralia in T. 26 N., R. 19 E. a small field produces gas from the upper portion of the Warsaw limestone at a depth of 460 to 490 feet. The interval on driller's logs is described as the "Burgess" or "chat". Most of the wells were drilled in the late 1930's and early 1940's. Initial production was rather small, rarely exceeding one million cubic feet of gas per day.

Commercial maps plot an oil field, the East Centralia pool, in T. 27 N., R. 19 E. The writer was unable to locate any information as to the history or nature of the production. Two wells located in the vicinity of the area reported "shows" of oil and gas from the top of the Arbuckle, the Mississippian "chat," and from the Bartlesville sand.

Several wells in sec. 1, T. 27 N., R. 18 E. produce small quantities of oil and gas from a Pennsylvanian sand. A well in sec. 25 of that same township reports three million cubic feet of gas at a depth of 574 feet. This is believed to be in the upper Mississippian.

Recent activity in sec. 4, T. 26 N., R. 21 E. and sec. 32, T. 27 N., R. 21 E. has proven a limited amount of oil production from the upper Mississippian (probably Hindsville) limestones at a depth of 105 to 120 feet.

Several isolated areas in T. 28 N., R. 18 E. and T. 29 N., R. 18 E. report minor amounts of "chat" gas from the Warsaw limestone at depths of 645 to 760 feet. Lesser quantities of gas are reported from the Fort Scott limestone and from Pennsylvanian sands. In sec. 21, T. 29 N., R. 18 E., four wells encountered oil in the top of the Arbuckle. One of these wells is reported to have yielded 50 barrels per day (Bloesch, 1928, p. 29).

Prospects for Future Oil and Gas Discovery

There are basically only three horizons, the Arbuckle group, the upper Mississippian, and the Bartlesville sandstone which have produced, or have the capability of producing, commercial quantities of oil and gas. The term "commercial quantities" is rather difficult to define in the Craig-Mayes County area in that it is not uncommon for a two or three barrel well to be put on a pump and economically produced. In times of great demand, such properties would undoubtedly increase in value, and perhaps, warrant further development; in the following discussion the author is restricting the definition of "commercial quantities" to discoveries at least comparable to the initial production obtained in eastern Rogers and Nowata Counties.

The Bartlesville sand has been a producer of oil since before the turn of the century, but it is doubtful that it will be the source of any large future discovery. Frequent testing beyond the boundaries of oil fields has not been particularly successful in extending the limits of Bartlesville production. In Craig and Mayes Counties, the Bartlesville is either missing by erosion, or is found at too shallow a depth below the surface, hence it is virtually eliminated as a goal for future exploration.

The upper Mississippian Warsaw, Moorefield and Hindsville formations may be found to produce small quantities of oil in areas not now known, but it is unlikely that a major discovery will be made from these horizons. The shallow depth of the Mississippian surface in the Craig-Mayes County area does not favor the accumulation of large quantities of oil or gas.

If a major discovery is to be made in the area, then it apparently must come from the Arbuckle group. In comparison to the other oil producing horizons, the Arbuckle is an interval essentially untouched by oil exploration. A number of wells have tested the top of the Arbuckle but less than 25 are known to have drilled the entire sequence from the Cotter to the Precambrian. A more active program of drilling has been discouraged primarily by the disappointing results of the previous granite tests. Almost without exception, these wells reported "shows" of oil and gas within the Arbuckle, but none have encountered commercial quantities. The top of the Arbuckle, however, has produced gas (near Chouteau) and small amounts of oil, particularly in Craig County. The persistent occurrence of large quantities of water at the top of the Arbuckle or within a few feet of the upper contact has not served to encourage deeper drilling. Not only is the presence of water effective in preventing deeper exploration, but if the drilling of the upper surface of the Arbuckle is not properly handled, it can ruin any potential production from that zone. Once water is encountered, drillers have found it almost impossible to complete the well.

The most impressive characteristic of the Arbuckle group from an examination of the samples is the excellent reservoir potential possessed by the dolomites. The sandstones on the other hand, are generally fine-grained, well-sorted and often non-porous. If a major oil discovery is forthcoming from the Arbuckle it will likely be from the dolomites and not the sandstones. The least promising aspect of the over-all Arbuckle sequence, is the lack of an evident source rock, principally shale. Admittedly, shales are not considered the only source of petroleum, but they are by far the most common. None of the Arbuckle wells examined by the author contained more than a few scattered, thin-bedded shales, and several were almost entirely free of shale.

On the basis of the few wells drilled to the Precambrian, it is difficult to evaluate accurately the prospects for a discovery within the pre-Cotter portion of the Arbuckle except to say that the

Arbuckle dolomites are excellent reservoir rocks; but to date, suitable source rocks have not been found within the sequence.

A number of granite wells in the area have been drilled to test the Lamotte sandstone. The Lamotte is unquestionably an adequate reservoir rock, but no production and very few oil or gas "shows" have been reported from that interval.

The most promising horizon for oil and gas exploration in the immediate future, is the uppermost part of the Arbuckle group rather than from within the Arbuckle or from the Lamotte sandstone. This conclusion is based on the fact that oil and gas have been produced from the top of the Arbuckle in this area as well as in adjacent areas of northeastern Oklahoma and southeastern Kansas; while the remainder of the Arbuckle group, as well as the Lamotte sandstone, has not as yet yielded commercial quantities of hydrocarbons. In addition, the upper portion of the Arbuckle qualifies as a reservoir rock and is directly overlain by a potential source rock, the Chattanooga shale. As previously discussed, the writer is not convinced that an adequate source rock exists below the Cotter dolomite.

Several promising and, presumably, untested structures, mapped on the Arbuckle surface (Plate IX) in Craig and eastern Rogers and Nowata Counties, are of particular interest as prospects for future exploration.

Coal and Other Products

A number of coals in the lower Desmoinesian of the area in the past, have been extensively stripped for commercial or domestic use.

At present only a few pits in Craig and Rogers Counties are active. The principal commercial coals include the Weir-Pittsburg in northern Craig County and the "Pawpaw," Broken Arrow, Bluejacket, and Iron Post coals, all mined in the vicinity of Whiteoak and Estella. In addition to the commercial operations, the Mineral, Drywood, and Rowe coals locally have been mined for domestic purposes.

Prospects for future development of the area's coal resources are not encouraging. The coal industry in northeastern Oklahoma has been on the decline for many years, and it is difficult to visualize an economic situation which would stimulate further exploration and development in the forseeable future.

Efforts to uncover deposits of lead and zinc, particularly in northeastern Craig County, have not been successful. The Eagle-Picher Company still examines samples from deep tests in the northern and eastern portion of the area, but no active program of exploratory drilling has been undertaken since the early 1940's.

Locally some of the Pennsylvanian sandstones have been used for building, but are apparently of little commercial value. A number of the Desmoinesian shales, such as those below the Fort Scott limestone (Excello), as well as local deposits of terrace gravels, are commonly used to surface the county roads.

Water

The abundance of surface water, as well as the presence of proven and potential subsurface aquifers, may be northeastern Oklahoma's most priceless natural resource. The growing need for water, both domestic and industrial, feasibly could stimulate large scale exploration for sources of ground water. The existence of proven aquifers in the subsurface of many areas in northeastern Oklahoma would then be attractive to industries now outside the state, particularly if a market outlet, such as the proposed Arkansas Valley Waterway, is in close proximity.

At present, the principal industrial utilization of ground water in northeastern Oklahoma is found in Ottawa County (Schoff, et al., 1955, p. 122-124). Water from the Arbuckle group in the Tri-State district is used in the milling process as well as for sanitary and drinking facilities. The B. F. Goodrich Company, located near Miami, has six Arbuckle wells which supply cooling water for a large tire plant. In addition to the industrial users, all the public water supplies in Ottawa County, as well as in some areas in northeastern Craig County, come from the Arbuckle group.

The two best sources of ground water in northeastern Oklahoma have been the Roubidoux formation of the Arbuckle group and the Mississippian "Boone" chert. Other members of the Arbuckle are capable of producing varying quantities of water, but the Roubidoux is the principal aquifer. The upper portion of the Cotter dolomite is also a source of fresh water in many areas including the eastern margin of Craig County. To the west, the percentage of dissolved solids increases and renders the water unfit for drinking.

A detailed analysis of the water producing characteristics of the Arbuckle group and other horizons in Ottawa County is published in Bulletin 72 of the Oklahoma Geological Survey by Schoff, Reed and Branson (1955, p. 36-72).

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APPENDIX

A. DESCRIPTION OF MEASURED SECTIONS

ADAPTED FROM:

OKLAHOMA GEOLOGICAL SURVEY, BULLETIN 77, <u>GEOLOGY OF THE FLANKS OF THE OZARK UPLIFT</u> by GEORGE G. HUFFMAN, et al.

No. 138 HILLSIDE 100 YARDS SOUTHWEST LONE STAR SCHOOL

Near North Line of Section 32, T. 19 N., R. 20 E.

Formational Description	Thickness in Feet Of Unit	To Base of Fmtn.
Atoka:		
Sandstone, buff-brown, medium-grained.	16.5	16.5
Hale:		
Covered.	11.0	57.3
Covered, float is gray-brown limestone	5.5	46.3
Limestone, blue-gray, finely crystalline, massive, hard.	5.5	40.8
Limestone, gray-brown, finely crystalline to dense, fossiliferous, weathers fluted. . . .	5.5	35.3
Covered.	5.5	29.8
Limestone, blue-gray to brown, finely crystalline, fossiliferous, hard	11.0	24.3
Limestone, orange, extremely sandy	0.8	13.3
Limestone, rust-colored, fossiliferous	1.0	12.5

Continued: No. 138

Sandstone, greenish-brown, in thin irregular beds	4.0	11.5
Covered (probably sandstone)	5.5	7.5
Conglomerate, red, calcareous sandstone matrix with limestone pebbles.	2.0	2.0
Fayetteville:		
Silt, greenish-yellow.	0.5	63.0
Shale, black	35.0	62.5
Shale, black, contains dense black limestone concretions.	5.5	27.5
Shale, black, well exposed	11.0	22.0
Covered, probably black shale	11.0	11.0
Hindsville:		
Covered.	5.5	35.5
Limestone gray, coarse, platy.	5.5	30.0
Covered, float is dense limestone full of <u>Diaphragmus</u> and "<u>Linoproductus</u>".	11.0	24.5
Limestone, gray, coarsely crystalline calcite, oolitic, crinoidal.	11.0	13.5
Covered.	2.5	2.5
Moorefield:		
Ordnance Plant member:		
Covered.	2.5	13.5
Siltstone, brown, poorly exposed	5.5	11.0
Covered, float is brown, limy siltstone, . .	5.5	5.5

Continued: No. 138

Lindsey Bridge member:		
Limestone, gray, fine, hard, few fossils . .	1.8	4.3
Limestone, conglomerate, buff, chert-pebbles.	2.5	2.5
Bayou Manard member:		
Limestone, brown-gray, finely-textured, glauconitic.	3.0	3.0
Keokuk:		
Chert, white, mottled; to base of exposure .	5.0	5.0

No. 143 SECTION ON WEST SIDE OF HILL
S.E.¼ of Section 31, T. 20 N., R. 20 E.

Formational Description	Thickness in Feet Of Unit	To Base of Fmtn.
Hale:		
Sandstone, calcareous, medium-grained.	18.0	18.0
Fayetteville:		
Shale, non-calcareous, black, platy, containing occasional black limestone concretions . . .	39.7	90.2
Limestone, lithographic, gray, massive-bedded, fossiliferous.	2.0	50.5
Limestone, sublithographic, gray with alternating thin beds of shale, weathers cuboidal	48.5	48.5
Hindsville:		
Limestone, coarsely crystalline, massive-		

Continued: No. 143

bedded, fossiliferous.	28.3	28.3
Moorefield:		
Ordnance Plant member:		
Shale, cream-brown.	1.5	1.5
Base of exposure:		

No. 159 SECTION IN RAVINE TO SOUTH OF SPAVINAW CREEK BRIDGE
East Side of Section 16, T. 22 N., R. 21 E.

Formational Description	Thickness Of Unit	in Feet To Base of Fmtn.
Keokuk formation:		
Chert, white, yellowish to reddish-brown tripolitic at top, massive-jointed and fractured, fossils common as molds and casts.	64.0	64.0
Reeds Spring formation:		
Limestone and chert, gray, blue to buff (darker near base), interbedded, medium hard.	132.0	132.0
St. Joe "group":		
Limestone, bluish-gray, dense to finely crystalline, massive, hard, crinoid stems small and abundant	6.0	25.3
Limestone, light gray, dense, cherty and shaly, nodular and laminated on weathered surface.	4.0	19.3

Continued: No. 159

Limestone, bluish to buff yellow, dense to finely crystalline, massive to thin-bedded, shaly and soft, upper massive limestone parted by soft, shaly limestone, crinoid stems.	11.0	15.3
Limestone, gray, dense to finely crystalline, massive, hard, crinoid stems	3.0	4.3
Shale, green, laminated, calcareous, mainly covered.	1.3	1.3
Chattanooga formation:		
Shale, black slightly iron-stained, platy and fissile, pyritic, cone-in-cone black limestone near center, jointed and fractured .	65.3	65.3
Cotter formation:		
Dolomite, white to buff, finely crystalline, hard, massive, some beds appear cherty . .	25.4	85.1
Dolomitic conglomerate; pebbles and cobbles, gray, dense to semi-crystalline, hard, cherty, and dolomitic, elongated parallel to bedding; matrix, white to light gray, slightly sandy, very oolitic, well-cemented, hard, massive.	3.4	59.7
Dolomite, white to light gray, lithographic to crystalline, limy, hard, massive, medium-to thin-bedded, nodular weathering surface. .	30.2	56.3

Continued: No. 159

Dolomite, white to buff, finely crystalline, sandy, hard, massive	12.8	26.1
Dolomite, white, buff to vitreous gray, finely crystalline, sandy with some laminations of yellow chert near base, hard, massive to laminated, basal beds unexposed	13.3	13.3

No. 165 SECTION ALONG ROAD AND IN STREAM

East-line of Section 22, T. 23 N., R. 20 E.

Formational Description	Thickness in Feet Of Unit	To Base of Fmtn.
Hindsville:		
Covered, occasional buff siltstone float . . .	12.0	18.6
Siltstone, buff, calcareous, flaggy to massive, laminated, uneven bedding, color has gray cast near top.	5.3	6.6
Limestone, gray, medium to coarse, fossiliferous, some clastic chert, shale nodules.	1.3	1.3
Moorefield:		
Ordnance Plant member:		
Siltstone, gray, massive to flaggy, banded coloring, rests on middle member in creek	12.0	12.0
Lindsey Bridge member:		
Limestone, gray, fine to medium, calcarenitic, fossiliferous, clastic chert, medium and rounded sand grains, interbedded		

Continued: No. 165

siltstone.	7.7	14.7
Covered.	2.0	7.0
Bayou Manard member:		
Limestone, gray, flaggy, medium-bedded, nodular chert.	5.0	5.0
"Boone":		
Limestone, gray, chertified, iron-stained. . . .	6.0	6.0

No. 167 SECTION IN QUARRY
S.E.¼ of Section 16, T. 25 N., R. 21 E.

Formational Description	Thickness in Feet Of Unit	To Base of Fmtn.
Hindsville:		
Limestone, gray, medium to coarse, calcarenitic, thin shale interbedded, irregular bedding.	2.0	22.7
Shale, green, weathered, nodules of dense limestone.	0.7	20.7
Limestone, dark gray, calcarenitic, medium, abundant <u>Agassizocrinus</u>.	1.0	20.0
Limestone, gray, medium, calcarenitic, thin shale interbedded.	1.6	19.0
Limestone, gray, medium, calcarenitic.	0.5	17.4
Limestone, gray, medium, calcarenitic, thin shale interbedded.	0.9	16.9
Limestone, gray, medium, flaggy and irregular bedding abundant <u>Agassizocrinus</u>.	1.0	16.0

Continued: No. 167

Siltstone gray, high calcareous content, massive, cross-bedded, zones of calcarenite, fossiliferous.	3.0	15.0
Limestone, gray to white, medium to coarse, calcarenitic, interbedded fine limestone, nodules of shale and limestone, "conglomerate" development near top, black chert near base.	10.6	12.0
Limestone, gray, even textured, medium, chert fragments are microscopic, interbedded green shale laminae.	1.4	1.4
"Boone":		
Limestone, blue-gray, cherty, massive, saccharoidal	8.0	8.0

ADAPTED FROM:

OKLAHOMA GEOLOGICAL SURVEY, CIRCULAR NUMBER 35, POST-BOONE OUTLIERS OF NORTHEASTERN OKLAHOMA by R. C. SLOCUM

RCS No. 1 SECTION ALONG NORTH BANK OF SNAKE CREEK
S.W.¼ of Section 13, T. 20 N., R. 21 E.

Formational Description	Thickness Of Unit	in Feet To Base of Fmtn.
Covered		
Hindsville limestone:		
Gray, crystalline, hard, glauconitic, bituminous, weathers dark gray, Agassizocrinus, crinoid fragments.	1.0	1.0
Moorefield:		
Covered, may be upper silty limestone (Ordnance Plant) member of Moorefield.	6.0	6.0
Gray cherty limestone (Lindsey Bridge) member:		
Limestone, gray, silty, hard, thin-bedded, cherty, Spirifer increbescens zone, weathers gray, bituminous odor	0.8	10.4
Covered.	1.0	9.6
Siltstone, brownish-gray, platy, thin-bedded, smooth surface, calcareous, limonitic, upper 8" extremely fossiliferous with abundant Moorefieldella eurekensis, cross-bedded	2.8	8.6
Covered.	4.6	5.8

Continued: <u>RCS No. 1</u>

Limestone, gray, hard, argillaceous, chert layer 4" thick at base, dense, limonitic, weathers dark gray.	1.2	1.2
Lower Argillaceous limestone (Bayou Manard) member:		
Limestone, gray, weathers platy to thin-bedded, finely crystalline to silty, bituminous, limonitic, *Spirifer increbescens*	8.8	10.3
Covered.	1.5	1.5
"Boone":		
Chert, brown to gray to white, massive, irregular.	1.0	1.0

B. SAMPLE DESCRIPTION[1]
of
WELLS USED IN CROSS SECTIONS

CROSS SECTION A-A'

Mesker Drilling Company
Miller No. 1
Sec. 24, T. 28 N., R. 17 E.
SE SE NW Elev. 900±
DTD 1332 D & A

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Marmaton Group		
Altamont limestone		
Limestone, tan to dark gray, dense, trace chert fragments.	Surface	12'
Bandera shale and sandstone		
Shale, gray to dark gray, silty, in part carbonaceous.	12	28'
Sandstone, buff, very fine-grained, subrounded, in part argillaceous, micaceous, porous, oil stained.	40	10'
Shale, gray, silty, carbonaceous, micaceous to black platy, carbonaceous at base.	50	94'
Pawnee limestone		
Limestone, tan to light gray, dense, argillaceous at top, trace white chert fragments; thin shale, dark gray to black, carbonaceous, in upper part	144	29'
Shale, black, platy, carbonaceous.	173	8'
Limestone, light gray, dense	181	3'
Labette shale with "Peru sand"		
Shale, black, platy, carbonaceous, to gray, platy.	184	19'

[1]Sample depths corrected to gamma-ray or electric-log depth if available.

Miller No. 1	Depth	Thickness
Limestone, tan, dense.	203	7'
Shale, gray, platy, silty, carbonaceous, micaceous.	210	6'
Sandstone, gray, very fine-grained, argillaceous, micaceous to siltstone, gray, platy, carbonaceous	216	46'
Shale, gray, carbonaceous, micaceous, in part silty.	262	53'
Shale, dark gray to black.	315	2'
Fort Scott Limestone		
Limestone, tan to gray, finely crystalline to dense.	317	26'
Shale, black, platy.	343	5'
Limestone, gray, finely crystalline to dense, in part argillaceous, trace white chert fragments, fusulinids, crinoids.	348	30'
Cabaniss Group		
Excello shale		
Shale, black, platy.	378	8'
Breezy Hill limestone		
Limestone, light gray, dense, earthy	386	5'
Shale, black, platy, carbonaceous to gray to greenish-gray, platy, silty, micaceous, carbonaceous; thin coal.	391	38'
Verdigris limestone		
Limestone, gray, finely crystalline to dense . . .	429	5'
Shale, dark gray to gray, platy, micaceous, carbonaceous, in part silty, thin coal	434	59'
Limestone, dark gray, dense, carbonaceous-flecked, thin coal at base	493	4'
Shale, green waxy to gray, platy, micaceous, carbonaceous, in part silty.	497	31'
Limestone, buff to dark gray, dense, carbonaceous-flecked	528	3'

Miller No. 1	Depth	Thickness
Shale, thin, black, carbonaceous to gray, platy, micaceous, in part silty.	531	18'
Tiawah ("Pink") Zone[2]		
Shale, black, platy.	549	3'
Krebs Group		
Shale, gray to dark gray to black, platy, micaceous; thin coal at base	552	36'
Sandstone, gray, very fine-grained, micaceous, carbonaceous, porous	588	5'
Shale, gray, platy, micaceous, silty	593	19'
Sandstone, gray, very fine-grained to silty, argillaceous, sideritic, porous.	612	4'
Shale, dark gray to black platy shale.	616	4'
Sandstone, gray, silty, argillaceous, porous . .	620	5'
Shale, dark gray to black, platy	625	48'
Siltstone, gray, platy, carbonaceous, in part sandy, sideritic	673	9'
Shale, dark gray to black, platy	682	23'
Siltstone, gray, highly sideritic.	705	8'
Shale, dark gray to black, platy, interbedded sideritic siltstones, thin coal at base. . . .	713	89'
Shale, gray-green, waxy, carbonaceous, sideritic, pyritic at top, alternating with dark gray to black, platy, in part silty shale.	802	88'
Shale, dark gray to black, platy	890	17'

[2] In the absence of a limestone or sequence of clay ironstones the Tiawah ("Pink") zone was picked on the basis of a correlative high gamma-ray curve value which appears at the approximate Tiawah interval as estimated from surface exposures.

Miller No. 1

MISSISSIPPIAN

Meramecian

	Depth	Thickness
Warsaw limestone		
Limestone, white to drab white, finely granular, highly siliceous, tripolitic, porous, flecked with black asphaltic stain, no smooth chert. . .	907	24'
Limestone, same with some white to gray chert, in part faintly mottled; no stain.	931	22'
Limestone, drab white to light gray, finely granular, highly siliceous; abundant drab white to gray microfossiliferous chert, incompletely to entirely altered from original limestone	953	39'
"J" bed (Gamma-ray top at 993)		
No sample.	992	5'
Shale, dark gray-green, to brownish, highly calcareous, glauconitic, in part pyritic, some argillaceous limestone.	997	13'

Osagean

	Depth	Thickness
Keokuk-Reeds Spring		
Chert, white and gray; some interbedded finely granular, siliceous limestone.	1010	13'
Limestone, white to tan, finely granular, siliceous, trace white and gray chert.	1023	88'
Limestone, light gray to tan, finely granular, siliceous, gray, white and tan chert	1111	30'
Chert, light gray, some white; same siliceous limestone.	1141	11'
Chert, gray, trace siliceous limestone	1152	28'
Limestone, tan to gray, finely crystalline, siliceous, gray chert.	1180	10'

<u>Miller No. 1</u> — Kinderhookian-Osagean

	Depth	Thickness
St. Joe Group		
Limestone, cream, finely crystalline, trace pyrite	1190	14'
Shale, light gray-green, waxy, carbonaceous streaked	1204	2'
Limestone, cream, finely crystalline, trace pyrite	1206	5'
Kinderhookian		
"Kinderhook shale"		
Shale, dark gray-green, gritty, calcareous towards base, <u>Tasmanites</u>	1211	36'
Chattanooga formation (Devonian-Mississippian)		
Shale black, platy, pyritic, <u>Tasmanites</u>. . . .	1247	24'
Sylamore sand member		
Sandstone, gray, fine-grained, subrounded to rounded, medium-sorted, in part calcareous; numerous large detrital quartz grains. . . .	1271	10'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter Dolomite		
Dolomite, brown, sucrosic, to crystalline, sandy to dolomite sandstone, fine-grained, medium sorted, subangular to rounded.	1281	19'
Dolomite, gray, sucrosic, white, gray and oolitic chert.	1300	18'
Dolomite, gray, sucrosic, in part sandy, trace blue-gray chert.	1318	14'
DTD	1332	

Z. W. Dean
Tritthart No. 1
Sec. 29, T. 28 N., R. 18 E.
NE SE NE   Elev. 740±
DTD 1096   D & A

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Marmaton Group		
No Sample.	Surface	20'
Shale, black	20	9'
Fort Scott limestone		
Upper limestone member	29	26'
Shale, black	55	4'
Lower limestone member	59	32'
Cabaniss Group		
Excello shale.	91	9'
Breezy Hill limestone.	100	6'
Shale and siltstone.	106	37'
Verdigris limestone.	143	6'
Shale, siltstone, thin limestones and thin coals.	149	113'
Tiawah ("Pink") Zone (no sample, depth determined from gamma-ray log[3])	262	6'
Krebs Group		
Shale and siltstone.	268	68'
Siltstone and sandstone, thin shale beds . . .	336	64'
Shale, dark gray to black.	400	56'
Siltstone and sandstone, thin shale beds . . .	456	44'

[3]See footnote, page 128.

Tritthart No. 1

	Depth	Thickness
Shale, dark gray to gray-green sideritic, thin limestone and thin coals	500	130'
MISSISSIPPIAN		
Meramecian		
Warsaw limestone		
Limestone, buff white, granular, highly siliceous, tripolitic, minor amounts of white chert in upper part; abundant gray microfossiliferous chert, incompletely to entirely altered from original limestone, towards base, upper half of interval asphaltic-stained.	630	117'
"J" bed		
Shale, dark gray-black, calcareous, glauconitic.	747	4'
Keokuk-Reeds Spring		
Chert, blue-gray, drab white, gray mottled to predominately smoky gray in lower one third; white tripolitic siliceous limestone associated with cherts in upper section; gray finely crystalline limestones interbedded with smoky gray cherts in lower one third. . .	751	209'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, cream, crystalline, crinoid, pyrite, with an interbed of gray dolomitic shale, crinoid	960	13'
Kinderhookian		
"Kinderhook shale"		
Shale, gray-green, platy, gritty, slightly dolomitic, pyritic, Tasmanites; thin gray-green argillaceous dolomite at base.	973	35'
Chattanooga formation (Devonian-Mississippian)		
Shale, brownish-black, platy, pyritic, abundant Tasmanites.	1008	27'

Tritthart No. 1

	Depth	Thickness
Sylamore sand member		
Sandstone, gray, very fine-to fine-grained, subangular to subrounded, medium-to poorly sorted, trace large, rounded, frosted, quartz grains.	1035	3'

ORDOVICIAN

Canadian

Arbuckle Group		
Cotter dolomite		
Dolomitic sandstone, gray to brown, very fine to fine-grained, well-sorted, at top of interval to brown, finely ground, sucrosic to crystalline sandy dolomite, some snow white dolomitic sandstone; dolomite, gray-brown, sucrosic, trace light gray and white chert at total depth.	1038	58'
DTD	1096	

Mesker Drilling Company
Huggins No. 1
Sec. 22, T. 28 N., R. 18 E.
SE NE SE Elev. 820
DTD 1088 D & A

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Marmaton Group		
Fort Scott limestone		
Upper limestone member	Surface	16'
Shale, black	16	10'
Lower limestone member	26	31'
Cabaniss Group		
Excello shale.	57	8'

Huggins No. 1	Depth	Thickness
Breezy Hill limestone.	65	4'
Shale and siltstone.	69	41'
Verdigris limestone.	110	6'
Shale, siltstone, silty sandstone, highly argillaceous limestone and thin coal	116	121'
Tiawah ("Pink") zone[4]		
Shale, black, carbonaceous	237	2'
Krebs Group		
Shale and siltstone, thin coal	239	121'
Shale, dark gray to black.	360	23'
Siltstone and shale, thin coal at base	383	42'
Shale, dark gray, alternating with highly sideritic siltstones and thin-bedded ironstones	425	132'
Sandstone, very fine-grained, argillaceous . .	557	15'
Shale and thin coal.	572	21'
MISSISSIPPIAN		
Meramecian		
Warsaw limestone		
Limestone, oil stained, at top of interval, gray-white to tan below stain, granular, highly siliceous, in part tripolitic, pyritic at top, porous; drab white to gray microfossiliferous chert incompletely to entirely altered from original limestone; white and blue-gray chert.	593	108'
"J" bed		
Shale, brown to dark brownish-black, calcareous, pyritic, abundant glauconite	701	5'

[4]See footnote page 128.

Huggins No. 1	Depth	Thickness
Osagean		
Keokuk - Reeds Spring		
Limestone, tan, finely crystalline, siliceous to chalky white, tripolitic, trace dark green glauconite nodules along Osagean-Meramecian contact; white and blue-gray mottled chert; lower portion of interval almost entirely smoky gray chert and interbedded gray, finely crystalline, siliceous, limestone.	706	220'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, light gray, finely crystalline, trace pyrite, crinoid; gray-green calcareous shale to argillaceous limestone at base.	926	15'
Kinderhookian		
"Kinderhook shale"		
Shale, gray to dark gray-green, slightly dolomitic, gritty, finely pyritic, becomes increasingly dolomitic towards base, _Tasmanites_	941	31'
Chattanooga formation (Devonian-Mississippian)		
Shale, black, platy, pyritic, _Tasmanites_ . . .	972	24'
Sylamore sand member		
Sandstone, gray, fine-grained, subangular fairly well sorted	996	2'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, brown to gray, sucrosic to medium crystalline, in part finely ground and sandy; oolitic white and brown chert, gray chert. .	998	90'
DTD	1088	

Mesker Drilling Company
Beaty No. 1
Sec. 19, T. 28 N., R. 19 E.
NW NW SW Elev. 875
DTD 1146 D & A

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Marmaton Group		
Shale and thin coal.	Surface	48'
Fort Scott limestone		
Upper limestone member	48	31'
Shale, black	79	5'
Lower limestone member	84	35'
Cabaniss Group		
Excello shale.	119	8'
Breezy Hill limestone.	127	6'
Shale and thin limestone	133*	10'
Prue sandstone	143*	21'
Siltstone and shale.	164*	20'
Verdigris limestone.	184*	7'
Shale, thin sideritic siltstones and thin coal .	191	116'
Tiawah ("Pink") zone[5].	307	2'
Krebs Group		
Siltstone, sideritic; shale and thin coals . .	309	58'

*Poor sampling, missing short intervals; errors corrected to gamma-ray data.

[5]See footnote, page 128.

Beaty No. 1

	Depth	Thickness
Shale, black, highly bituminous; coal.	367	5'
No sample.	372	13'
Shale and siltstone.	385	35'
Shale, dark gray to black to gray-green sideritic; sideritic siltstones, thin coal near base.	420	247'

MISSISSIPPIAN

Meramecian

Warsaw limestone		
Limestone, asphaltic stained, medium crystalline, pyritic, to siliceous, granular at top; below unconformity limestone, drab white, dense to finely granular, highly siliceous, in part tripolitic, porous, and asphaltic stained with drab white microfossiliferous chert and incompletely replaced microfossiliferous limestone; basal limestone light brown, finely crystalline to dense siliceous with gray to brown partially to completely altered microfossiliferous chert	667	108'
"J" bed		
Limestone, dark gray-brown, argillaceous, to light brown, calcareous, glauconitic shale .	775	7'

Osagean

Keokuk - Reeds Spring		
Limestone, white to drab white, dense, highly siliceous, in part tripolitic, minor amounts of chert in upper section; cherts drab white, gray and gray-mottled; lower portion of interval entirely smoky gray chert and interbedded gray to tan, finely crystalline limestone. . .	782	215'

Beaty No. 1

	Depth	Thickness
Kinderhookian-Osagean		
St. Joe Group		
Limestone, cream to gray, finely crystalline, in part gray-green, argillaceous, pyritic, crinoidal, trace green shale partings. . . .	997	18'
Kinderhookian		
"Kinderhook shale"		
Shale, dark gray-green, slightly calcareous, to dolomitic, finely pyritic, becomes increasingly calcareous towards base, <u>Tasmanites</u>.	1015	25'
Chattanooga formation (Devonian-Mississippian)		
Shale, brownish-black, pyritic, <u>Tasmanites</u>; thin basal sandstone member, gray, fine-to medium-grained, subangular to subrounded, poorly sorted.	1040	22'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, brown, sucrosic to medium crystalline, massive to finely ground and sandy, several thin zones of predominately white, fine-grained, well-sorted sand; drab white oolitic cherts associated with dolomite in lower half of interval.	1062	84'
DTD	1146	

Frankfort Oil Company
Van Ausdel No. 1
Sec. 31, T. 28 N., R. 20 E.
SE NE NW Elev. 848.9
DTD 2014 Gas

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Cabaniss Group		
No sample.	Surface	100'
(Base Tiawah "Pink" zone estimated at 40')		
Krebs Group (No sample at top)		
Shale and silty shale.	100	16'
Bluejacket sandstone	116	88'
Shale, dark gray to black, in part sideritic, thin limestones and ironstones, thin coal. .	204	167'
Shale, silty, calcareous; thin limestone . . .	371	13'
Sandstone, calcareous.	384	9'
Shale and thin ironstone	393	37'

MISSISSIPPIAN

Meramecian

Warsaw limestone		
Limestone, oil stained, crystalline, clastic, pyritic, at top of formation with drab white, siliceous limestone and tripolitic white and gray-mottled chert; limestone, tan to gray finely crystalline, in part siliceous, associated with tan, drab white to gray microfossiliferous cherts displaying varies stages of alteration from original limestone; limestone, gray finely crystalline at base, no chert.	430	107'

Van Ausdel No. 1	Depth	Thickness
"J" bed		
Limestone, dark gray, argillaceous to dark gray calcareous shale; abundant nodules of glauconite	537	13'
Osagean		
Keokuk - Reeds Spring		
Limestone, bleached white ("cotton rock") to tan flecked, dense to tripolitic, highly siliceous, minor amounts of white, tan-flecked and gray-mottled cherts in upper portion of interval; lower interval predominately gray-mottled and smoky gray cherts interbedded with tan to gray finely crystalline limestone, in part siliceous . .	550	205'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, cream to gray, fine to medium crystalline, fossiliferous, interbed of greenish-gray, calcareous, finely pyritic shale . . .	755	15'
Kinderhookian		
"Kinderhook shale"		
Shale, greenish-gray, slightly dolomitic, gritty, pyritic.	770	5'
Chattanooga formation (Devonian-Mississippian)		
Shale, black, platy, <u>Tasmanites</u>.	775	29'
CAMBRO-ORDOVICIAN		
Arbuckle Group[6]		
Cotter dolomite		
Dolomite, brown, sucrosic to medium crystalline, in part sandy, trace shale, gray, dolomitic; chert white and white and brown oolitic (no sample 805-850).	804	187'
"Swan Creek" sandstone, white, fine-to medium fine-grained, subangular, medium well-sorted,		

[6]The author made no attempt to subdivide by formational names, the Arbuckle units below the Cotter dolomite.

Van Ausdel No. 1	Depth	Thickness
slightly porous, in part dolomite-cemented . .	991	13'
Jefferson City - Precambrian		
Dolomite, brown, dark brown to gray, sucrosic to coarsely crystalline, slightly porous to vuggy, in part oolitic and sandy; cherts chalky white, white, gray, brown and white oolitic.	1004	688'

Notably sandy zones within the above interval as follows:

1346 - 1370 .....Sandstone, white, fine to medium-grained, subangular to subrounded, poorly sorted, some coarse, rounded frosted grains, loose to dolomite-cemented, porous.

1406 - 1445 .....Sandstone, light brown, fine to medium-grained, subrounded to rounded, poorly sorted, numerous rounded, frosted grains, dolomite-cemented to sandy dolomite, porous. . . . .

1614 - 1630 .....Sandstone, white, fine to medium-grained, subangular to rounded, poorly sorted, loose to dolomite-cemented, porous, numerous large rounded, frosted quartz grains in sample.

PRECAMBRIAN

	Depth	Thickness
Andesite, black basic extrusive igneous rock (W.E. Ham, personal communication, April, 1961).	1692	322'
DTD	2014	

Mesker Drilling Company
Sheffield No. 1
Sec. 21, T. 28 N., R. 21 E.
SW NW SE Elev. 855
DTD 683 D & A

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample.	Surface	40'
Shale, dark gray to black, platy, thin coals .	40	130'
Shale, gray-green, waxy to silty, sideritic,	170	20'
Shale, black, platy, ironstones.	190	23'

MISSISSIPPIAN

Chesterian

	Depth	Thickness
Hindsville limestone		
Limestone, light gray, coarsely bioclastic, oolitic, pyritic, crinoidal, very fossiliferous	213	5'
Sandstone, buff, oil stained, fine to medium-fine-grained, subangular to subrounded, medium sorted, loose to clustered.	218	5'
Limestone, light gray, crystalline, finely sandy to limy sand, oolitic, fossiliferous; thin shale light green, silty, slightly calcareous	223	20'
Limestone, tan, crystalline, oolitic, fossiliferous, crinoidal	243	10'
Siltstone, light greenish-gray, calcareous to silty limestone, trace gray and gray-mottled chert fragments, large rounded, frosted sand grains.	253	10'
Limestone, tan to cream, finely crystalline,		

Sheffield No. 1

	Depth	Thickness
fossiliferous, trace gray-mottled chert, large rounded, frosted sand grains	263	14'
Meramecian		
Warsaw limestone		
Limestone, light gray to tan, crystalline, oil stained, in part dense to granular, highly siliceous, flecked with black asphaltic stain; chert, drab white faintly micro-fossiliferous.	277	17'
Limestone, tan to cream, finely granular, siliceous, in part asphaltic stained; chert drab white, gray and gray-mottled. . .	294	22'
Chert, drab white; same limestone.	316	5'
Limestone, tan, fine to medium crystalline, gray chert.	321	10'
Limestone, chalky white, finely granular, siliceous; chert white, gray-and gray-mottled.	331	20'
Limestone, drab white, finely granular, siliceous,little or no smooth chert.	351	5'
Limestone, same with white-mottled tan, white, gray and gray-mottled chert.	356	18'
"J" bed		
Limestone, light brown to dark gray-brown, highly argillaceous, glauconitic, dark gray chert	374	9'
Osagean		
Keokuk - Reeds Spring		
Limestone, chalky white, finely granular, siliceous, tripolitic; abundant chert drab white to light gray.	383	4'
Chert, drab white, gray and gray-mottled; same siliceous limestone	387	44'

Sheffield No. 1

	Depth	Thickness
Chert, light to dark gray and gray-mottled; limestone drab white, in part tripolitic, to dark gray-brown, finely granular, siliceous.	431	39'
Chert, light gray and gray-mottled; limestone, chalky white, finely granular, siliceous . . .	470	15'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, cream, medium crystalline, crinoidal ("reef phase"); pale-green, calcareous shale partings	485	87'
Shale, gray-green, dolomitic, silty to dolomitic siltstone, finely pyritic.	572	5'
Dolomite, white to drab white, sucrosic to finely crystalline, in part slightly argillaceous	577	7'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, brownish-black, platy, pyritic.	584	7'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, light brown to dark gray, sucrosic to finely crystalline, massive, trace white chert.	591	21'
Sandstone, gray, very fine-grained, dolomitic, non-porous	612	5'
Dolomite, brown, sucrosic to medium crystalline, minor amounts of white, gray and white oolitic chert.	617	43'

Sheffield No. 1

	Depth	Thickness
Dolomite, same, finely ground to sand size, trace white chert.	660	7'
Shale, black, hard, siliceous(?), in part dolomitic to shaly dolomite.	667	7'
Dolomite, tan, medium crystalline, large rounded, frosted sand grains in sample . .	674	9'
DTD	683	

City of Miami
Goodrich Rubber No. 3
Sec. 24, T. 28 N., R. 22 E.
SW NE SW   Elev. 798
DTD   1055   Water well

Description in Brief
Sinclair Oil Company
sample log

	Depth	Thickness
No sample.	Surface	23'

MISSISSIPPIAN

Chesterian

Hindsville limestone

	Depth	Thickness
Limestone, light gray to white, finely crystalline, pisolitic; thin calcareous sandstone; limestone, finely crystalline, oolitic, slightly glauconitic and oil-stained, some gray dense to porous- weathered chert.	23	37'

Meramecian

Warsaw limestone

	Depth	Thickness
Limestone, white, fine, tripolitic, porous, "dead" oil stain, white chert; limestone, buff finely crystalline to light gray, dense, siliceous; chert bluish-gray. . . .	60	100'

Goodrich Rubber No. 3

	Depth	Thickness
"J" bed		
Shale, dark gray, calcareous; limestone, gray, fine, slightly argillaceous, sparsely oolitic, abundant glauconite.	160	10'
Osagean		
Keokuk - Reeds Spring		
Limestone gray to white, siliceous, oolitic zone (Short Creek) at Keokuk - Warsaw contact; limestone, white, coarsely crystalline, in part buff, oolitic; limestone white, siliceous to tripolitic, some chert; chert dark gray at base.	170	240'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, white to gray, medium to coarsely crystalline, in part dolomitic, interbed of pale green, granular, calcareous, pyritic, argillite; limestone white, coarsely crystalline, crinoidal at base	410	25'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, platy.	435	10'
ORDOVICIAN		
Canadian		
Arbuckle Group[7]		
Cotter Dolomite		
Dolomite, gray to buff, sucrosic to medium crystalline, in part sandy; chert, white, gray and brown oolitic and gray translucent; sandstone, white, fine-grained, angular, nonporous at base	445	133'

[7] Sample tops as determined by W.D. McEachin, Sinclair Oil Company.

Goodrich Rubber No. 3

	Depth	Thickness
Jefferson City dolomite		
Dolomite, brown, dark gray to white, sucrosic to coarsely crystalline, in part siliceous, oolitic, abundant pyrite at 720 to 740, sandy at base; chert, gray, white and oolitic white, brown and gray.	578	307'
Roubidoux formation		
Sandstone, white, coarse-grained, angular, porous	885	15'
Dolomite, white to gray, coarsely crystalline, in part sandy, some oolitic chert.	900	38'
Sandstone, white, coarse-grained, angular to subangular, some subrounded, clear to frosted grains	938	19'
Dolomite, white to gray, fine to coarsely crystalline; thin-bedded white, fine-grained sandstone.	957	38'
Sandstone, white, coarse-grained, non-porous to porous	995	17'
Dolomite, white to dark gray at base, fine to coarsely crystalline, in part sandy, some white chert, in part weathered, nodular; dolomite becomes glauconitic, pyritic towards base, intermixed with red, weathered granite fragments at unconformity . .	1012	33'
PRECAMBRIAN		
Spavinaw granite		
Granite, bright red, highly feldspathic. . . .	1045	10'
DTD	1055	

CROSS SECTION B-B'

Shell Oil Company
M. Parris No. 1-W
Sec. 25, T. 25 N., R. 16 E.
SW Elev. 622
DTD 1152 Water supply well

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Marmaton Group		
No sample.	Surface	26'
Fort Scott limestone(lower limestone member)		
Limestone, tan to gray, very finely crystalline to dense, fossiliferous, glauconitic in argillaceous zone above an interbed of black, fossiliferous, slightly calcareous shale	26	27'
Cabaniss Group		
Excello shale		
Shale, black, platy.	53	7'
Breezy Hill limestone		
Limestone, gray, finely crystalline, fossiliferous, fusulinid, thin coal at base.	60	6'
Shale, gray, platy, silty, micaceous	66	24'
Prue sandstone		
Sandstone, light gray, fine-grained, subangular, well-sorted, micaceous, in part argillaceous, porous	90	10'
Shale, dark gray to black, in part calcareous.	100	3'
Verdigris limestone		
Limestone, tan, very finely crystalline, fossiliferous.	103	6'
Shale, black, bituminous to gray, platy, micaceous, in part silty, ironstones	109	39'

Parris No. 1-W

	Depth	Thickness
Sandstone, white, coarse silt to very fine-grained, calcareous.	148	12'
Shale, dark gray to brown, platy, sideritic, in part silty; thin brown, calcareous claystone to argillaceous limestone at top of interval.	160	88'
Shale, black, platy.	248	2'
Tiawah ("Pink") limestone		
Limestone, buff, sandy, fossiliferous, trace of coal at base.	250	8'
Krebs Group		
Shale, black, bituminous	258	7'
Siltstone, gray-green, highly calcareous, micaceous.	265	5'
Shale, black, bituminous to gray platy	270	13'
Limestone, chalk white, finely granular, marly.	283	3'
Shale, dark gray and gray-green sideritic. . .	286	9'
Sandstone, light gray, coarse silt to very fine-grained, micaceous, calcareous to argillaceous	295	13'
Shale, gray, platy, in part silty sideritic. .	308	12'
Sandstone, gray, coarse silt to very fine-grained, highly argillaceous, micaceous, carbonaceous, trace oil stain.	320	18'
Shale, dark gray, platy, micaceous, in part silty, abundant ironstone.	338	42'
Sandstone, light gray to buff, silty to very fine-grained, argillaceous, micaceous, sideritic, slightly oil stained brown waxy shale partings.	380	37'
Shale, dark gray to black.	417	6'
Sandstone, brown to buff, coarse silt to very fine-grained, argillaceous, micaceous, trace oil stain.	423	35'

Parris No. 1-W

	Depth	Thickness
Shale, dark gray to black; limestone, thin, brown to drab white, marly	458	16'
Limestone, brown, finely crystalline, fossiliferous.	474	2'
Sandstone, brown, silty to fine-grained, argillaceous, in part calcareous, porous, oil stained, large rounded quartz grains at base.	476	55'
Shale, dark gray to black, alternating with thin, brown, very finely crystalline, fossiliferous, argillaceous limestone	531	33'
Clay ironstone, brick red to bright orange, hard dense, siliceous, thick-bedded, alternating with dark gray to brown shale, and thin brown, dense, fossiliferous, impure limestone; abundant fine-to medium-grained, rounded to subrounded quartz grains loose in sample towards base of interval	564	66'
Shale, dark gray, black and dark brown, platy, in part sideritic, in part slightly calcareous, interbedded thin, impure limestone and ironstone, large rounded, frosted quartz grains at base.	630	168'

MISSISSIPPIAN

Meramecian

Warsaw limestone

Limestone, tan to gray, finely granular, highly siliceous, in part tripolitic, porous, flecked with black asphaltic stain, trace buff oil stain; some drab white and gray chert.	798	37'
Limestone, tan to gray, very finely crystalline, gray and glassy-gray chert	835	10'
Limestone, tan, very finely crystalline, slightly siliceous; no smooth chert	845	10'
Limestone, same with gray to dark gray micro-fossiliferous chert.	855	38'

Parris No. 1-W

	Depth	Thickness
Moorefield facies		
Limestone, dark gray to brown, argillaceous, black calcareous shale, dark gray microfossiliferous chert.	893	20'
Limestone, dark gray to black, highly argillaceous to limy shale, little or no dark gray microfossiliferous chert, trace glauconite at base	913	32'
Osagean		
Keokuk - Reeds Spring		
Limestone, tan to gray, dense to very finely crystalline, siliceous; chert, drab white, gray, gray-mottled and blue-gray	945	32'
Limestone, same, chert predominantly light and dark gray.	977	45'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, tan to gray, finely crystalline, interbeds of pale green, calcareous shale. .	1022	19'
Chattanooga formation (Devonian-Mississippian)		
Shale, brownish-black, platy, pyritic, *Tasmanites*	1041	55'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, brown, sucrosic; finely-ground, sandy, porous at top; trace glassy white chert.	1096	56'
DTD	1152	

H. L. Leak
Cox No. 1-A
Sec. 29, T. 26 N., R. 18 E.
Location unknown Elev. 800±
DTD 622 Production unknown

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Cabaniss Group		
Shale, gray, silty	Surface	16'
Verdigris limestone.	16	9'
Shale, dark gray to black.	25	5'
Sandstone, gray, argillaceous.	30	5'
Shale, gray to brown, silty, bedded ironstone.	35	25'
Limestone, gray, sandy	60	10'
Shale and siltstone, ironstone	70	67'
Limestone, brown, argillaceous, thin coal at base.	137	3'
Shale, thin impure limestones and calcareous, sideritic siltstones, trace coal	140	50'
Tiawah ("Pink") zone		
Shale, dark gray, bedded clay ironstone. . . .	190	6'
Krebs Group		
Shale, gray to black, in part silty, sideritic.	196	29'
Siltstone to very fine-grained, argillaceous, sandstone.	225	10'
Shale, gray, silty, in part highly sideritic .	235	45'
Shale, gray, alternating with thin calcareous siltstones and fine-grained sandstones; ironstones	280	69'
Sandstone, gray, very fine-grained, highly calcareous to a sandy limestone.	349	5'
Shale, gray to dark gray and brown, highly		

Cox No. 1-A

	Depth	Thickness
sideritic, in part silty, abundant ironstone, thin coal.	354	201'
Sandstone, gray, very fine-grained, calcareous.	555	5'
Shale, gray to dark gray, brown and black bituminous, sideritic, in part calcareous and silty	560	37'
Shale, dark gray to black platy.	597	3'

MISSISSIPPIAN

Meramecian

	Depth	Thickness
Warsaw limestone		
Limestone, drab white to oil stained, granular, highly siliceous, tripolitic, porous, faintly microfossiliferous, trace light gray chert .	600	22'
DTD	622	

Major Oil Company
Condry No. 1
Sec. 27, T. 26 N., R. 18 E.
SW NE Elev. 904
DTD 1013 D & A

Description in brief
Major Oil Company
sample log

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Marmaton Group		
Fort Scott limestone		
Lower limestone member	Surface	8'
Cabaniss Group		
Excello shale.	8	5'
Breezy Hill limestone.	13	5'
Shale.	18	22'

Condry No. 1

	Depth	Thickness
Verdigris limestone	40	5'
Shale	45	28'
Limestone	73	3'
Shale	76	12'
Limestone	88	3'
Shale	91	69'
Sandstone, in part argillaceous	160	30'
Shale, black	190	9'
Sandstone	199	6'
Shale, in part calcareous	205	19'
Tiawah ("Pink") limestone	224	6'
Krebs Group		
Shale	230	6'
Sandstone, and thin coal	236	29'
Shale, dark gray, in part calcareous	265	25'
Limestone	290	2'
Shale	292	8'
Sandstone, white	300	12'
Shale	312	18'
Sandstone, broken by thin streaks of light colored shale, trace of coal	330	25'
Sandstone, white, silty to fine-grained	355	14'
Shale	369	6'
Sandstone, white, black shale laminae	375	9'
Shale, black	384	6'

Condry No. 1

	Depth	Thickness
Limestone.	390	2'
Shale, black	392	14'
Sandstone, white, sideritic.	406	10'
Shale, gray to black	416	27'
Limestone, crinoidal	443	2'
Shale, black	445	79'
Shale, sandy, sideritic.	524	7'
Shale.	531	56'
Sandstone, poorly sorted, pyritic.	587	6'
Shale, black, silty.	593	23'
Shale, thin conglomeritic sand at base, chert fragments.	616	15'

MISSISSIPPIAN

Meramecian

Warsaw limestone

	Depth	Thickness
Limestone, brown, asphaltic-stained, crystalline to granular, siliceous, in part tripolitic, porous, minor amounts of blue-gray opaque chert in upper portion of interval; limestone, gray to brown, finely granular, siliceous, associated chert, white, gray, blue-gray, and brown-mottled; basal limestone, gray, crystalline to granular and siliceous, glauconitic, smoky gray chert	631	149'

Osagean

Keokuk - Reeds Spring

Limestone, milky white, finely granular, highly siliceous, minor amounts of blue-gray vitreous chert in upper portion of interval; lower

Condry No. 1

	Depth	Thickness
half of interval, limestone, gray, white and brown, finely crystalline to siliceous and finely granular, moderate to predominant amounts of blue-gray, smoky gray to dark gray and brown vitreous chert.	780	150'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, white to gray, finely crystalline, in part argillaceous and gritty; shale, light gray, calcareous, finely pyritic; basal limestone, chalk white, crystalline, finely pyritic.	930	23'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, pyritic (log reports dolomitic shale, dark gray to brown gritty, six feet below top of black shale)	953	55'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, oil-stained, granular, porous to white, dense with vitreous opaque chert. . .	1008	5'
DTD	1013	

Mesker Drilling Company
Beisley No. 1
Sec. 20, T. 26 N., R. 19 E.
NE NE SW Elev. 767
DTD 890 D & A

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Cabaniss Group		
No sample.	Surface	40'
(Base Tiawah ("Pink") zone estimated at 30')[8]		
Krebs Group		
Shale, gray to green, in part sideritic. . . .	40	50'
No sample.	90	10'
Siltstone, sideritic	100	10'
Shale, gray.	110	47'
Siltstone to very fine-grained sandstone, abundant siderite nodules.	157	13'
No sample.	170	12'
Shale, dark gray to black, calcareous, thin coal	182	3'
Shale, dark gray	185	28'
Siltstone, sideritic	213	10'
Shale, gray-green, thin coal	223	27'
Shale, dark gray to black.	250	58'
Shale, gray-green, waxy, sideritic and dark gray to black, platy, thin sideritic siltstones, thin to medium-bedded coal . . .	308	119'
No sample.	427	6'

[8] See footnote, page 128.

Beisley No. 1

	Depth	Thickness
MISSISSIPPIAN		
Meramecian		
Warsaw limestone		
Limestone, chalky white to oil-stained, very finely granular, siliceous, soft, weathered appearing, trace of blue-gray chert; limestone, drab white to tan, in part oil-stained and asphaltic flecked, highly siliceous, microfossiliferous, incompletely to entirely altered to white, tan, and light gray microfossiliferous chert, minor amounts of gray chert; limestone, tan to light gray, finely crystalline, glauconitic, pyritic, trace chert; shale, greenish-black, calcareous, highly glauconitic at base of interval . . .	433	122'
Osagean		
Keokuk - Reeds Spring		
Limestone, chalky white, finely granular, siliceous, tripolitic to light gray, highly siliceous, minor amounts of white chert; limestone, light gray, finely crystalline, in part siliceous, associated with moderate to predominate amounts of smoky gray and gray-and white-mottled cherts.	555	183'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, light gray to cream, crystalline, crinoidal, interbedded shale, gray-green, calcareous, crinoidal, finely pyritic. . . .	738	40'
Kinderhookian		
"Kinderhook shale"		
Shale, dark greenish-gray, gritty, dolomitic, pyritic, *Tasmanites*.	778	14'
Chattanooga formation (Devonian-Mississippian)		
Shale, black, platy, pyritic, *Tasmanites* . . .	792	42'

Beisley No. 1

	Depth	Thickness
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, gray to brown, sucrosic to crystalline, slightly sandy and pyritic, in part oolitic, sandy and pyritic at top; chert, brown and white oolitic and gray translucent	834	56'
DTD	890	

W. D. Flourney
Harper No. 1
Sec. 3, T. 25 N., R. 19 E. — Description in brief
Location unknown Elev. 725±
DTD 795 Production unknown

	Depth	Thickness
PENNSYLVANIAN		
Desmoinesian		
Krebs Group		
No sample.	Surface	310'
Shale, gray to black bituminous, in part silty, abundant siderite pellets	310	20'
MISSISSIPPIAN		
Chesterian		
Fayetteville formation		
Limestone, dark gray, dense; highly argillaceous to limy shale.	330	3'
Hindsville formation		
Limestone, light gray to tan, crystalline, bioclastic, crinoidal, moderately pisolitic.	333	7'
No sample.	340	7'

Harper No. 1

	Depth	Thickness
Meramecian		
Warsaw limestone		
Limestone, oil-stained, asphaltic speckled to drab white, granular, highly siliceous, faintly microfossiliferous, tripolitic, little or no vitreous chert; limestone, tan to gray, finely crystalline to siliceous, dense, associated chert, light blue-gray, microfossiliferous, white, gray-mottled and gray-mottled and flecked-brown; shale at base, dark reddish-brown to brown, highly calcareous, abundant glauconite pellets. . .	347	148'
Osagean		
Keokuk - Reeds Spring		
Limestone, white to gray, dense to finely granular, highly siliceous, minor amounts of white and light gray chert; limestone, tan to gray, very finely crystalline, interbedded with blue-gray and smoky gray chert	495	110'
No sample.	605	165'
(Missing interval would include the remainder of the Keokuk - Reeds Spring, the St. Joe Group and the upper portion of the Chattanooga shale).		
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, platy, pyritic, <u>Tasmanites</u>; thin Sylamore sandstone member at base . . .	770	5'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, brown to gray, sucrosic to crystalline, pyritic at top, trace white chert. . .	775	20'
DTD	795	

Hyer
Applegate No. 1-A
Sec. 12, T. 25 N., R 19 E.
SW SE NE Elev. 710±
DTD 607 Production unknown

Description in brief
Sinclair Oil Co.
sample log

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
Shale, gray, silty and sandy at top.	Surface	34'
Siltstone, greenish-gray	34	6'
Shale, gray.	40	24'
Limestone, argillaceous, fossiliferous	64	6'
Siltstone to fine-grained sand alternating with shale	70	18'
Shale, black, fissile.	88	16'
No sample.	104	6'
Sandstone, conglomeratic, siderite nodules, ironstone, glauconite, pale green shale. . .	110	10'
Limestone, brown to black finely crystalline, in part dolomitic, argillaceous, glauconite, black shale partings	120	11'
Sandstone, gray, calcareous, silty, sideritic, shale partings	131	12'
Shale, black, fissile, coal at base.	143	28'

Atokan

	Depth	Thickness
Sandstone, tan, fine-grained, calcareous, glauconitic.	171	9'

Applegate No. 1-A

	Depth	Thickness
MISSISSIPPIAN		
Chesterian		
Fayetteville formation		
Shale, pale green, thin-bedded; limestone, semi-dense	180	10'
Hindsville formation		
Limestone, gray, highly fossiliferous, oolitic, porous, oil-stained	190	15'
No sample.	205	5'
Meramecian		
Warsaw limestone		
Limestone, oil-stained and flecked with asphaltic stain, granular, spongy, tripolitic, highly siliceous, in part chalky, little or no smooth chert; limestone, tan, granular, siliceous, glauconitic at base	210	100'
Osagean		
Keokuk - Reeds Spring		
Chert, chalky white, granular, de-vitrified; limestone and brown to blue-gray mottled, chert in lower portion of interval	310	170'
(Sinclair log has no description below 400 feet. Sample description of units to total depth taken from log by R. A. Brant).		
Kinderhookian-Osagean		
St. Joe Group		
Limestone, gray, coarsely crystalline, crinoidal, green shale partings, pyritic	480	58'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, pyritic, Tasmanites.	538	48'

Applegate No. 1-A

	Depth	Thickness
Sylamore sandstone member.	586	4'

ORDOVICIAN

Canadian

Arbuckle Group		
Cotter dolomite		
Dolomite (no description).	590	17'
DTD	607	

J. Charles
Tucker No. 1
Sec. 16, T. 25 N., R. 21 E.
SE SW SE Elev. 745
DTD 368 Gas

Description in brief
Sinclair Oil Co.
Sample log[9]

MISSISSIPPIAN

Chesterian

	Depth	Thickness
Hindsville limestone[10]		
Limestone, gray, coarsely crystalline, some oolites, chert fragments	Surface	Estimated 10'

Meramecian

Warsaw limestone		
Limestone, cream, tan to gray, siliceous, blue-gray chert; basal limestone, cream to tan, medium crystalline, siliceous, glauconitic .	110±	75'

[9]Samples inadequately described.

[10]See measured section No. 167 for detail description of Hindsville at surface.

Tucker No. 1

	Depth	Thickness
Osagean		
Keokuk - Reeds Spring		
Limestone, chalky white to tan, finely granular, siliceous, stained streak, moderate amounts of gray and tan chert; chert, gray and gray-brown, interbedded siliceous limestone.	85	197'
Kinderhookian-Osagean		
St. Joe Group		
Dolomite, greenish-gray, finely crystalline, argillaceous to dolomitic shale; basal limestone, cream, coarsely crystalline . . .	282	23'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, fissile, thin sandy zone at Chattanooga-St. Joe contact.	305	51'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, gray to tan, medium crystalline, slight oil stain, white chert.	356	12'
DTD	368	

CROSS SECTION C-C'

Gulf Oil Company
W. M. Smith, No. 1-S
Sec. 17, T. 23 N., R. 17 E.
NE SW NW Elev. 771
DTD 1140 Water supply well

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Cabaniss Group		
Shale, gray, platy, micaceous.	Surface	3'
Chelsea sandstone		
Sandstone, reddish-brown to gray, coarse silty to fine-grained, well-sorted, micaceous, in part argillaceous, porous, becomes platy, silty towards base	3	86'
Shale, black, platy.	89	2'
Limestone, gray.	91	2'
Shale, black, platy.	93	6'
Tiawah ("Pink") limestone		
Limestone, dense to very finely crystalline, sparsely fossiliferous	99	7'
Krebs Group		
Shale, dark gray to black bituminous, platy. .	106	33'
Limestone, gray, dense, thin coal at base. . .	139	6'
Shale, gray, silty to sideritic siltstone. . .	145	55'
Shale, black, bituminous, thin dense limestone	200	5'
Shale, gray, platy, silty.	205	9'
Limestone, brown, dense.	214	3'
Shale, dark gray, trace gray-green, sideritic shale.	217	63'
Sandstone, buff to brown, very fine to fine-grained, porous, clustered, calcareous-cemented	280	10'

W. M. Smith No. 1-S

	Depth	Thickness
Shale, dark gray to black platy.	290	11'
No sample.	301	49'
(Bartlesville sand interval 308 to 324, as interpreted from electric log)		
Limestone, tan, compact.	350	1'
Shale, dark gray to black, platy, trace gray-green sideritic shale.	351	44'
Limestone, brown, dense, thin coal at base . .	395	1'
Shale, gray, dark gray and brown	396	88'
Limestone, dark gray to brown, dense	484	1'
Shale, black, bituminous	485	9'
Limestone, brown, dense to finely crystalline, sparsely fossiliferous	494	5'
Shale, dark gray, black and brown, in part sideritic, ironstones, thin coal	499	95'
Limestone, brownish-black, finely crystalline.	594	3'
Shale, dark gray to black.	597	8'
No sample.	605	10'
Shale, dark gray to black.	615	7'
Morrowan		
Limestone, dark gray, medium crystalline, fossiliferous, crinoidal, trace glauconite (?)	622	8'
Shale, black, in part slightly calcareous, crinoids	630	6'
Limestone, dark gray, crystalline, argillaceous, fossiliferous.	636	4'

W. M. Smith No. 1-S

	Depth	Thickness
Shale, gray and black.	640	13'
Limestone, tan to dark gray, medium crystalline, fossiliferous, crinoidal	653	2'
Shale, black platy, medium-grained, subrounded, detrital quartz grains in sample	655	5'
Detrital zone, medium to coarse-grained, subrounded, frosted quartz grains and brown and white chert fragments embedded in shale matrix, abundant pyrite; predominantly shale at top of interval, thin, poorly sorted sand at base.	660	10'

MISSISSIPPIAN

Meramecian

Moorefield formation

Limestone, tan to gray, very finely crystalline, residue slightly silty, trace crinoids . . .	670	30'
Questionable sample.	700	5'
Limestone, gray to dark gray, very finely crystalline, slightly silty, trace gray-flecked brown chert and gray translucent chert.	705	10'
Limestone, dark gray, dense, highly siliceous.	715	5'
Limestone, dark gray, very finely crystalline, trace gray-flecked brown chert	720	10'
Limestone, dark gray to black, highly siliceous, to calcareous chert, minor amounts of vitreous white, gray microfossiliferous and black chert	730	35'
Limestone, dark gray to black, highly argillaceous, some blue-gray chert	765	6'

Osagean

Keokuk - Reeds Spring

Chert, "dead" white, bluish-white, gray and gray-

W. M. Smith No. 1-S

	Depth	Thickness
mottled, trace glauconite pellets on chert at Osagean-Meramecian contact.	771	4'
Questionable sample.	775	5'
Chert, predominantly white, some white-flecked brown, gray and gray-mottled chert; limestone very finely crystalline, in part siliceous, dense.	780	20'
Chert, gray and smoky gray, minor amounts of light colored chert, and interbedded limestone.	800	10'
Samples mixed, Osagean cherts and Moorefield argillaceous limestone	810	20'
Chert, gray, interbedded tan to gray limestone	830	31'

Kinderhookian-Osagean

	Depth	Thickness
St. Joe Group		
Limestone, cream to light gray, fine to medium crystalline; basal portion gray-green argillaceous, crinoidal.	861	10'

Kinderhookian

	Depth	Thickness
Chattanooga formation (Devonian-Mississippian)		
Shale, black to brownish black, platy.	871	54'

ORDOVICIAN

Canadian

	Depth	Thickness
Arbuckle Group		
Cotter dolomite		
Dolomite, light brown, sucrosic to medium crystalline, white chert and light brown oolitic chert.	925	135'
Dolomite, light brown, medium crystalline, upper five feet oil-stained; chert, white oolitic, white, brown-mottled.	1060	30'

W. M. Smith No. 1-S

	Depth	Thickness
Dolomite, same, dark gray shale partings . . .	1090	10'
Dolomite, sandy, fine-to medium-grained, rounded, frosted quartz grains	1100	5'
Jefferson City (?) dolomite		
Dolomite, light brown, finely crystalline, upper five feet oil-stained, green shale partings, white oolitic chert, abundant pyrite at total depth	1105	35'
DTD	1140	

Service Drilling Company
Clifton No. 1
Sec. 19, T. 23 N., R. 18 E.
SW SW NE Elev. 710±
DTD 699 D & A

Description in brief
Service Drilling Co.
sample log

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample.	Surface	38'
Limestone, gray to tan	38	5'
Shale, sandy to silty sandstone.	43	7'
Sandstone, gray, fine to medium-grained, porous, stained at base.	50	49'
Shale, dark gray to black.	99	20'
Shale, gray to black, in part sandy.	119	51'
Shale, dark gray to black.	170	50'
Shale, dark gray to black, micaceous, alternating with thin, brown, crystalline limestones	220	70'
No sample.	290	10'

Clifton No. 1

	Depth	Thickness
Shale, dark gray to black, micaceous.	300	7'
Morrowan		
Limestone, brown, coarsely crystalline, glauconitic; shale, dark gray to black	307	10'
Shale, dark gray to black, micaceous	317	23'
Limestone, black, dense.	340	6'
Limestone, gray to brown, crystalline, glauconitic.	346	7'
Shale, black, abundant pyrtie.	353	5'
MISSISSIPPIAN		
Chesterian		
Hindsville formation		
Limestone, gray, brown, cream to tan, fine to coarsely crystalline, in part oolitic, trace of light green shale	358	47'
Meramecian		
Moorefield formation		
No sample.	405	10'
Limestone, white, sucrosic to crystalline, in part oolitic, some black asphaltic stain at base	415	15'
Limestone, gray to tan, dense to finely crystalline, some gray calcareous, and light green shale.	430	42'
Limestone, dark brown to black, dense to coarsely crystalline, in part silty.	472	44'
Limestone, gray to buff, dense, cherty; black chert associated with limestone at base. . .	516	36'

Clifton No. 1

	Depth	Thickness
Osagean		
Keokuk - Reeds Spring		
Limestone, white, chalky at top of interval to tan to gray, dense, cherty.	552	28'
Chert, dark gray to gray, opaque to translucent; limestone, tan to gray, dense to finely crystalline.	580	37'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, white to buff, crystalline, pyritic at base, with an interbed of greenish-gray, dolomitic, pyritic shale	617	18'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, pyritic.	635	57'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, gray to tan, finely crystalline to crystalline, cherty, pyritic, few scattered sand grains, in part vuggy porosity.	692	7'
DTD	699	

Lee Milligan
Lee No. 1
Sec. 17, T. 23 N., R. 19 E.
SE SE SE Elev. 700±
DTD 1957 D & A

Description in brief
Sample description of Arbuckle Group taken from Shell Oil Co. log

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample. (Driller's log reports shale and lime 0-187)	Surface	225'

MISSISSIPPIAN

Chesterian

Fayetteville formation(?)
(No sample) Driller's log reports:
limestone 187-189
shale 189-225
This interval interpreted as Fayetteville in that a similar sequence of limestone and shale designated as the Fayetteville formation is found at the surface between this well and Measured Section No. 165.

	Depth	Thickness
Shale, gray.	225	1'
Hindsville formation		
Limestone, dark gray, argillaceous, crinoidal, at top of interval to gray, bioclastic, oolitic, crinoidal, abundant bryozoa; some very finely crystalline limestone with black shale partings	226	32'

Meramecian

	Depth	Thickness
Moorefield formation		
Limestone, tan, silty to white, sandy limestone and calcareous sandstone	258	22'
Limestone, cream, bioclastic, gritty, detrital sand grains.	280	22'
Limestone, light gray, crystalline, in part highly siliceous to calcareous, cherty, pseudoolitic	302	14'

Lee No. 1

	Depth	Thickness
Chert, tan-mottled brown, gray; limestone, very finely granular.	316	14'
Limestone, tan to gray, very finely granular, gray and dark gray chert	330	18'
Limestone, same, in part siliceous; chert, white-mottled brown, brownish-black and gray to brownish-gray microfossiliferous	348	24'
Limestone, dark gray, argillaceous to a calcareous gritty shale, abundant glauconite.	372	10'
Osagean		
Keokuk - Reeds Spring		
Chert, white to tanish-white faintly mottled .	382	23'
Chert, light gray, blue-gray, gray-mottled, some white; chert increasingly darker gray toward base of interval; limestone, gray, very finely crystalline.	405	35'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, cream to gray, crystalline, crinoidal, in part pyritic ("reef phase"), trace blue-gray chert fragments.	440	62'
Shale, gray-green, calcareous, pyritic to limestone, argillaceous, pyritic	502	9'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, brownish-black, pyritic, some calcite veining, Tasmanites.	511	57'
CAMBRO-ORDOVICIAN		
Arbuckle Group		
Cotter dolomite		
Dolomite, cream to brown, sucrosic to medium		

Lee No. 1

	Depth	Thickness
crystalline, sandy at top; chert, white, opaque and white, translucent, oolitic; thin, white, fine-grained, dolomitic, semi-to non-porous sandstone at base	568	187'
Jefferson City - Lamotte[11]		
Dolomite, cream to brown and gray, sucrosic to coarsely crystalline, in part oolitic, notably sandy at 948 to 952; chert, white opaque, gray to tan opaque, blue-gray translucent, translucent oolitic, brown oolitic and white oolitic.	755	1086'
Lamotte sandstone		
Sandstone, gray, fine to very coarse-grained, subrounded, some secondary quartz growth, minor amounts of feldspar and igneous rock fragments.	1841	56'
Questionable interval.	1897	36'
(Sample top of Precambrian logged at 1897 while electric log shows characteristic granite curve at 1933. The interval 1897-1933 shows an increase in resistivity over the sand zone and may possibly be a "granite" wash).		
PRECAMBRIAN		
Quartz syenite, pink feldspar, very little quartz, minor amounts of dark minerals.	1933	24'
DTD	1957	

[11] See footnote, page 140.

L. Miller
Knight No. 1
Sec. 34, T. 23 N., R 21 E.
NE SW NE Elev. 651
DTD 1622 D & A

Description in brief
Luther Miller sample log

MISSISSIPPIAN

Osagean

	Depth	Thickness
Keokuk - Reeds Spring		
Chert, white, weathered.	Surface	35'
Limestone, blue-gray, gray and light brown, very fine to finely crystalline, cherty.	35	40'

Kinderhookian-Osagean

	Depth	Thickness
St. Joe Group		
Limestone, white to gray, coarsely crystalline, fossiliferous with an interbed of pale-green shale, trace of glauconite and pyrite in basal limestone	75	37'

Kinderhookian

	Depth	Thickness
Chattanooga formation (Devonian-Mississippian)		
Shale, black, hard	112	62'

CAMBRO-ORDOVICIAN

	Depth	Thickness
Arbuckle Group		
Cotter dolomite		
Dolomite, brown, white to gray, sucrosic to coarsely crystalline, in part oolitic, in part sandy; chert, milky white and smoky, in part oolitic; at base, sandstone, thin, medium to coarse-grained, poorly sorted, slightly porous	174	148'

Jefferson City - Lamotte[12]
Dolomite, white to gray, brown to dark brown, some gray and green sucrosic to coarsely

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[12] See footnote, page 140.

Knight No. 1

	Depth	Thickness
crystalline, in part oolitic, shale, in part sandy, basal portion of interval argillaceous, pyritic, abundant glauconite at 1450; chert, varicolored, predominantly white, white oolitic, light brown and smoky, some weathered chert.	322	1236'

Notable sand zones in the above interval as follows:

500-510. . .Sandstone, medium to coarse-grained, rounded, frosted, poorly sorted, dolomitic to sandy dolomite.

697-700. . .Sandstone, white, coarse-grained, rounded to subrounded, dolomitic, porous.

945-948. . .Sandstone, white, coarse-grained, chert fragments, conglomeritic.

992-1010. . .Sandstone, white, coarse-grained, rounded to subrounded, poorly sorted, dolomitic, weathered chert fragments, porous.

1065-1083. . .Sandstone, glassy, coarse-grained, rounded, poorly sorted, dolomitic.

1520-1558. . .Sandstone, glassy, coarse-grained, dolomitic, pyritic.

	Depth	Thickness
Lamotte sandstone		
Sandstone, white, glassy, coarse-grained, conglomeritic, pyritic, increasing amounts of feldspar and granite fragments towards base.	1558	42'

PRECAMBRIAN

	Depth	Thickness
Spavinaw granite		
Granite, orthoclase feldspar, quartz, hornblende	1600	22'
DTD	1622	

CROSS SECTION D-D'

Young and Carter
State Life No. 1
Sec. 35, T. 20 N., R. 16 E.
NW NW NW Elev. 600±
DTD 979 Production unknown

Description in brief
Post-Mississippian
description from
Sinclair Oil Co.
sample log

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample	Surface	90'
Limestone, brown	90	3'
Bartlesville sandstone	93	37'
Shale, black	130	30'
Shale, gray and green alternating with thin, brown, sideritic limestone	160	70'
Shale, black	230	20'
Sandstone, gray	250	30'
Shale, black	280	43'
Warner sandstone	323	47'
Shale, black	370	60'
No sample	430	30'

Atokan

(Top possibly in missing interval)

	Depth	Thickness
Shale, dark gray	460	6'
Sandstone, gray	466	4'
Shale, black	470	10'
Shale, sandy	480	20'

State Life No. 1

	Depth	Thickness
Morrowan		
Limestone, white to tan, coarsely crystalline, crinoidal, glauconitic	500	4'
Argillite, dark, calcareous, glauconitic . . .	504	13'
Sandstone, white	517	5'
Shale, brownish-black, sandy at top, in part glauconitic.	522	28'
Missing samples. . . . . (Two samples representing short intervals show sandstone; white sandstone at base)	550	22'
MISSISSIPPIAN		
Chesterian		
Fayetteville formation		
Shale, light gray, calcareous, in part crinoidal, interbedded argillaceous limestone	572	106'
Hindsville formation		
Limestone, tan to gray, bioclastic, oolitic. .	678	24'
Meramecian		
Moorefield formation		
Siltstone to very fine-grained sandstone, buff to dark gray, calcareous; shale at top of interval, dark gray to black, silty, calcareous.	702	46'
Limestone, buff to gray, crystalline, fossiliferous, silty	748	14'
Osagean		
Keokuk - Reeds Spring		
Chert, translucent gray and white-speckled and mottled brown, trace gray-mottled black, minor amounts brownish-gray highly siliceous limestone.	762	12'

State Life No. 1

	Depth	Thickness
No sample.	774	16'
Limestone, dark gray to gray-brown, dense to finely granular, in part highly siliceous, becomes argillaceous towards base, some buff, finely crystalline limestone; chert, gray to dark gray, blue-black mottled, abundant at top of interval, diminishing in amount towards base	790	56'
Limestone, buff, crystalline, some white-speckled tan, tripolitic chert.	846	18'
Limestone, dark brownish-gray, dense to finely granular, argillaceous; black, calcareous, glauconitic shale at base.	864	16'

Kinderhookian-Osagean

St. Joe Group

Limestone, tan, dense, some pale green shale at base.	880	4'

Kinderhookian

Chattanooga formation (Devonian-Mississippian)

Shale, black, pyritic, <u>Tasmanites</u>; thin, coarse-grained, poorly sorted, Sylamore sandstone member at base	884	51'

ORDOVICIAN

Champlainian

Simpson Group

Tyner-Burgen

Sandstone, white, coarse-grained, poorly sorted, rounded, frosted to angular unfrosted, in part dolomite-cemented; thin green shale at top	935	44'
DTD	979	

A. T. Campbell
Ruppel No. 1
Sec. 23, T 19 N., R. 17 E.
Location unknown Elev. 610±
DTD 672 D & A

Description in brief
Post-Mississippian and Simpson description taken from a Sinclair Oil Company sample log

PENNSYLVANIAN

Desmoinesian-Atokan

	Depth	Thickness
Krebs-Atoka		
No sample	Surface	110'
Morrowan		
Sandstone, tan, calcareous, glauconitic, pyritic	110	6'
Limestone, tan, coarsely crystalline, fossiliferous; shale at base, gray, gritty, calcareous	116	29'
Sandstone, calcareous, argillaceous, glauconitic	145	27'
Sandstone, brown, medium-grained, glauconitic	172	18'
MISSISSIPPIAN		
Chesterian		
Fayetteville formation		
Shale, dark gray to black, finely micaceous, non-calcareous	190	52'
Limestone, dark gray to brown, dense, in part argillaceous, slightly silty at base	242	53'
Hindsville formation		
Limestone, buff to gray, bioclastic, oolitic, crinoidal, streaks of black and green calcareous shale	295	25'

Ruppel No. 1

	Depth	Thickness
Meramecian		
Moorefield formation		
Siltstone to a very fine-grained sandstone, gray to dark gray, calcareous, shaly, glauconitic at base; dark brownish-gray, silty shale at top of interval.	320	39'
Limestone, tan, finely granular, silty, gradational with a brownish-gray highly calcareous siltstone at base, trace of glauconite . . .	359	16'
Osagean		
Keokuk - Reeds Spring		
Limestone, buff to dark brownish-gray, very finely granular, siliceous, some brown, dense, smooth, highly siliceous limestone; dark gray to black, slightly siliceous, argillaceous limestone at base	375	15'
Chert, translucent gray and white-speckled brown, dark gray, dark blue-gray, interbedded light brown, very finely granular, slightly siliceous limestone; limestone, dark gray, highly argillaceous grading to black, calcareous shale at base	390	45'
Limestone, buff to brown, very finely crystalline, in part siliceous, moderate amounts of gray and tan translucent chert, some light and dark, brownish-gray, dense, highly siliceous limestone.	435	65'
Limestone, dark gray to black, highly argillaceous grading to black, calcareous shale	500	34'
ORDOVICIAN		
Champlainian		
Simpson Group		
Tyner-Burgen		
Shale, green, arenaceous, pyritic, with rounded, frosted sand grains and interbedded sandstone	534	21'

Ruppel No. 1

	Depth	Thickness
Sandstone, fine-grained, angular, calcareous, in part argillaceous, pyritic, glauconitic, abundant rounded, frosted sand grains toward base	555	55'
Sandstone, white, fine-grained, subrounded to rounded, well-sorted, some rounded, frosted sand grains.	610	24'

Canadian

Arbuckle Group
Cotter dolomite

Dolomite, tan, crystalline, white and oolitic chert.	634	38'
DTD	672	

Gardner
Gilbert No. 1
Sec. 36, T. 20 N., R. 18 E.
NW NW SE Elev. 660±
DTD 463 Gas

PENNSYLVANIAN

Atokan-Morrowan
(Top of Morrowan in missing interval)

	Depth	Thickness
No sample.	Surface	15'
Limestone, cream, coarsely crystalline, sandy, crinoidal, bryozoa; sandstone at base, medium-grained, angular, calcareous, porous	15	40'

MISSISSIPPIAN

Chesterian

Fayetteville formation

Shale, black, platy, non-calcareous.	55	5'

Gilbert No. 1

	Depth	Thickness
Limestone, gray, finely crystalline, argillaceous, fossiliferous, brachiopods	60	70'
Hindsville formation		
Limestone, gray to cream, medium to coarsely crystalline, oolitic to pisolitic, fossiliferous, in part dark gray, finely crystalline, trace of gray shale partings	130	40'
Meramecian		
Moorefield formation		
Siltstone, gray, platy, calcareous, to a dark gray silty, argillaceous, limestone, in part fossiliferous	170	55'
Limestone, gray to dark gray, very finely crystalline, argillaceous, dark gray to black chert, abundant glauconite pellets in a black, calcareous shale at base	225	55'
Osagean		
Keokuk - Reeds Spring		
Chert, white, white tripolitic, tan, blue-gray and gray-mottled, interbedded tan to gray, finely granular limestone, in part siliceous	280	20'
Chert, smoky gray and gray-mottled, interbedded gray to tan, dense to finely crystalline limestone	300	55'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, cream to light gray, very finely granular to finely crystalline, in part crinoidal, fossiliferous, interbed of gray-green, highly argillaceous, finely pyritic limestone	355	22'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		

Gilbert No. 1

	Depth	Thickness
Shale, black, platy, Tasmanites.	377	63'
Sylamore sandstone member		
Sandstone, medium to coarse-grained, subrounded to rounded, poorly sorted, frosted, grains loose in sample.	440	2.5'
No sample.	442.5	2.5'

ORDOVICIAN

Canadian

	Depth	Thickness
Arbuckle Group		
Cotter dolomite		
Dolomite, brown to gray, sucrosic to medium crystalline, in part oolitic to pisolitic; chert predominantly white, some brownish-white.	445	18'
DTD	463	

M & F Oil Company
Ransom No. 1
Sec. 18, T. 20 N., R 22 E.
SW NW SW Elev. 1010±
DTD 2215 D & A

Description in brief
M & F Oil Co.
sample log

MISSISSIPPIAN

Osagean

	Depth	Thickness
Keokuk - Reeds Spring		
Chert, weathered	Surface	44'
Chert, white and white-weathered; limestone, gray, dense, siliceous	44	106'
Limestone, gray, dense, cherty	150	90'

Kinderhookian-Osagean

	Depth	Thickness
St. Joe Group		
Limestone, pink to gray, finely crystalline. . .	240	13'

Ransom No. 1

	Depth	Thickness
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, carbonaceous	253	31'
Sylamore sandstone member (?)		
Sandstone, medium to coarse-grained, angular to rounded, porous	284	19'
ORDOVICIAN		
Champlianian		
Simpson Group(?)[13]		
Tyner-Burgen(?)		
Dolomite, medium crystalline, greenish glauconite staining.	303	14'
Dolomite, white to gray, finely granular to finely crystalline, in part slightly sandy, white chert.	317	65'
Shale, dark, calcareous.	382	58'
Shale, green, waxy	440	33'
Dolomite, gray, finely granular to sandy dolomite	473	37'
Sandstone, medium-grained, light silica-cemented	510	15'
Dolomite, sandy.	525	15'
Sandstone, medium to coarse-grained, dolomitic, non-porous	540	20'

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[13]The sequence of formations below the Chattanooga shale in the Ransom well is unique within the thesis area. Without samples the author could only speculate as to their correlation with units encountered to the west. See page 19 for a discussion of this well.

Ransom No. 1

		Depth	Thickness

CAMBRO-ORDOVICIAN

Arbuckle Group[14]

Cotter (?) - Lamotte

	Depth	Thickness
Dolomite, white, gray to dark gray, dense to coarsely crystalline, in part sandy, in part oolitic; chert, white, light blue, blue-gray and tan.	560	1622'

Notable sand zones within the above interval as follows:

600- 624 ... Sandstone, fine-grained, rounded, non-porous.

885- 905 ... Sandstone, light gray, dolomitic

1085-1120 ... Dolomite, sandy and cherty, streaks of quartzite.

1286-1320 ... Dolomite, sandy, cherty, streaks of quartzite.

Lamotte (?)

	Depth	Thickness
Arkose conglomerate, fine-grained sand, fragments of dolomite and red orthoclase feldspar	2182	2'

PRECAMBRIAN

	Depth	Thickness
Syenite porphyry, red orthoclase feldspar, some green ferromagnesian minerals.	2184	31'
DTD	2215	

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[14] See footnote, page 140.

CROSS SECTION E-E'

Z. W. Dean
Tritthart No. 1
Sec. 29, T. 28 N., R. 18 E.

(See CROSS SECTION A-A', P. 131)

Carter Oil Company
Wilkerson No. 1
Sec. 14, T. 27 N., R 18 E.
NW NE NW Elev. 813
DTD 498 D & A

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Marmaton Group		
Fort Scott limestone		
Upper limestone member	Surface	11'
Shale, black	11	4'
Lower limestone member	15	42'
Krebs Group		
Excello shale	57	6'
Breezy Hill limestone	63	5'
Shale, black and coal	68	9'
Shale, gray, in part silty	77	37'
Verdigris limestone	114	7'
Shale, black to gray, in part sandy	121	32'
Shale, dark gray to black	153	40'
Limestone, dark gray, fossiliferous	193	10'
Shale, dark gray to black, ironstones, thin coal	203	44'
Siltstone, gray, calcareous	247	8'
Shale, gray and gray-green, ironstones	255	17'
Tiawah ("Pink") limestone	272	4'

Wilkerson No. 1

	Depth	Thickness
Cabaniss Group		
Shale, gray silty, dark gray to black.	276	77'
Limestone, tan, thin coal at base.	353	4'
Shale, dark gray to black (low gamma-ray curve value 417-422, typical limestone curve but no evidence of limestone in samples at that interval)	357	65'
Shale, gray-green, sideritic, in part silty .	422	22'
Shale, dark gray to black, thin siltstone. . .	444	54'
DTD	498	

Frankfort Oil Company
Bluejacket No. 1
Sec. 4, T. 26 N., R. 19 E.
NW NW NW Elev. 835±
DTD 2128 D & A

Description in brief

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Cabaniss Group		
No sample.	Surface	100'
Siltstone and gray shale	100	14'
Tiawah ("Pink") zone		
Limestone, dark brown, impure; clay ironstone.	114	2'
Krebs Group		
Shale, gray, black and brown	116	25'
Sandstone, silty to very fine-grained.	141	29'
Shale, gray, dark gray to black, bituminous, in part sideritic, thin coal	170	80'
Siltstone to silty shale, thin-bedded clay ironstone.	250	29'

Bluejacket No. 1

	Depth	Thickness
Limestone, argillaceous, fossiliferous	279	1'
Shale, black, bituminous to gray, sideritic. .	280	37'
Siltstone, calcareous.	317	5'
Shale, dark gray to black, thin coal	322	96'
Shale, black to gray, sideritic, alternating with thin-bedded, dolomitic clay ironstones.	418	62'
Siltstone, calcareous	480	3'
Shale, gray.	483	12'

MISSISSIPPIAN

Meramecian

Warsaw limestone

Limestone, white to buff and oil-stained, highly siliceous, tripolitic, in part altered to white and white microfossiliferous chert; chert, light blue-gray flecked brown, white-mottled brown and light gray micro-fossiliferous, interbedded tan to gray, dense to very finely crystalline, in part siliceous limestone; shale at base, dark brown to black, highly calcareous to an argillaceous limestone, abundant dark green glauconite nodules . . .	495	144'

Osagean

Keokuk - Reeds Spring

Chert, white, chalky, tripolitic, predominantly de-vitrified; limestone, tan to gray, very finely crystalline to dense, in part siliceous, interbedded with smoky gray and gray-mottled chert towards base	639	163'

Kinderhookian-Osagean

St. Joe Group

Limestone, cream to tan, very finely crystalline to crystalline, in part fossiliferous and crinoidal.	802	50'

Bluejacket No. 1

	Depth	Thickness
Kinderhookian		
"Kinderhook shale"		
Shale, gray-green.	852	6'
Chattanooga formation (Devonian-Mississippian)		
Shale, dark brown to brownish-black, abundant _Tasmanites_; limestone near top of interval, dark gray-brown, medium crystalline, thick-bedded, argillaceous, fossiliferous, _Tasmanites_; thin Sylamore sandstone member at base, fine to medium-grained, poorly sorted, oil-stained.	858	46'
CAMBRO-ORDOVICIAN		
Arbuckle Group		
Cotter - Lamotte[15]		
Dolomite, brown to cream and gray, sucrosic to coarsely crystalline, in part sandy, in part oolitic, slightly oil-stained (intervals noted on Cross Section E-E', Plate V); chert, predominantly white and white oolitic, some light gray translucent and chalky white tripolitic	904	1136'

Notable sand zones within the above interval as follows:

988-1004 ... Sandstone, glassy-white, fine-to medium-grained, subangular to subrounded, poorly sorted, dolomitic.

1584-1612 ... Sandstone, glassy-white, fine-to medium-grained, subangular, poorly sorted, porous, dolomite-cemented.

2003-2040 ... Dolomite, brown, crystalline with shale partings, becomes increasingly sandy towards base.

	Depth	Thickness
Lamotte sandstone		
Sandstone, gray, fine-to coarse-grained, subangular to rounded, frosted, poorly sorted, dolomitic, coarse, rounded, frosted grains loose in sample, feldspar fragments at base.	2040	64'

[15]See footnote, page 140.

Bluejacket No. 1

	Depth	Thickness
PRECAMBRIAN		
Dacite, light colored extrusive igneous rock (W. E. Ham, personal communication).	2104	24'
DTD	2128	

Mesker Drilling Company
Beisley No. 1 (See CROSS SECTION B-B, p.156)
Sec. 20, T. 26 N., R. 19 E.

Lee Milligan
Lee No. 1 (See CROSS SECTION C-C', p. 171)
Sec. 17, T. 23 N., R. 19 E.

E. K. McLennan
Trogdon No. 1
Sec. 33, T. 22 N., R. 18 E.
NW SW NW Elev. 675±
Sample T.D. 600 D & A

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample.	Surface	15'
Shale, gray (from driller's log)	15	65'
Shale, gray to dark gray, platy, abundant ironstone.	80	6'
Shale, gray-to gray-green, platy, sideritic. .	86	22'
Shale, dark gray to black, platy	108	36'
Limestone, dark gray, very finely crystalline.	144	1'
Shale, gray, silty, micaceous.	145	10'
Shale, dark gray to black, slightly calcareous, finely micaceous	155	20'

Trogdon No. 1

	Depth	Thickness
Atokan (?)		
Shale, gray-green, silty, in part slightly calcareous	175	5'
Siltstone, gray-green.	180	5'
Chert conglomerate ("chat"), drab white, dark blue-gray, and dark reddish-brown, vitreous chert, tripolitic chert with trace glauconite; sandstone, tan to gray, very fine to medium sand grains embedded in a silicified matrix, coarse, subrounded to rounded sand grains loose in sample	185	5'
Morrowan		
Limestone, tan to gray, crystalline, bioclastic, glauconitic, crinoidal, bryozoa, interbedded shale, black, calcareous, fossiliferous.	190	20'
Detrital zone, fine to coarse-grained, subangular to rounded and frosted quartz grains, loose in sample to embedded in an argillaceous to calcareous matrix, in part a poorly sorted sandstone, pyritic at base	210	12'
MISSISSIPPIAN		
Chesterian		
Hindsville formation		
Limestone, tan to gray, dense to crystalline, in part argillaceous, and silty, oolitic, fossiliferous, crinoidal, bryozoan	222	20'
Meramecian		
Moorefield		
Siltstone, gray, highly calcareous, to a silty limestone, oil-stained	242	51'
Limestone, tan, finely crystalline, calcarenitic, moderately fossiliferous	293	4'

Trogdon No. 1

	Depth	Thickness
Limestone, gray, very finely granular, argillaceous, trace green shale.	297	23'
Limestone, same with brownish-gray and black chert.	320	8'
Limestone, dark gray, argillaceous	328	49'
Limestone, tan, finely crystalline, glauconitic; limestone, dark gray-brown, siliceous with white and gray-mottled brown chert; shale, dark gray-brown, highly calcareous, glauconitic.	377	5'
Limestone, tan to gray, very finely crystalline, argillaceous, gray and dark gray to black microfossiliferous chert	382	12'
Shale, dark gray, calcareous, abundant glauconite pellets	394	2'

Osagean

Keokuk - Reeds Spring

	Depth	Thickness
Chert, white to tan; limestone, tan to gray finely granular, siliceous	396	12'
Chert, predominantly gray, interbedded limestone, tan to gray, finely granular, in part siliceous	408	39'
Questionable sample.	447	6'
No sample.	453	86'

(Missing interval includes the St. Joe Group and Chattanooga formation. Driller estimates top of Chattanooga black shale at 489)

ORDOVICIAN

Canadian

Arbuckle Group
Cotter dolomite
Dolomite, light brown, sucrosic, in part very

Trogdon No. 1

	Depth	Thickness
finely ground and sandy, abundant white and glassy gray chert at top	539	61'
Sample T.D.	600	

A. E. Summers
J. D. Allen No. 1
Sec. 16, T. 21 N., R. 18 E.
NE NE Elev. 650±
DTD 482 D & A

Description in brief
Sinclair Oil Co.
sample log

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample.	Surface	50'
Shale, gray to black	50	22'

Atokan(?)

	Depth	Thickness
Shale, gray, in part silty to sandy, sideritic nodules.	72	23'
Siderite conglomerate, abundant coarse, rounded to subrounded detrital quartz grains, some sandstone, clustered, very fine-grained. . .	95	5'

Morrowan

	Depth	Thickness
Limestone, gray, crystalline, crinoidal, in part argillaceous, interbedded shale, dark gray, in part calcareous and sandy at base.	100	40'

MISSISSIPPIAN

Chesterian

Hindsville formation
Limestone, gray, dense to crystalline, oolitic to

J. D. Allen No. 1

		Depth	Thickness
	pisolitic, sandy and glauconitic at base, fossiliferous, bryozoan, crinoidal	140	30'
	Meramecian		
Moorefield formation			
	Siltstone to an argillaceous sandstone, gray to brown, in part highly calcareous to a sandy limestone.	170	70'
	Limestone, brown, finely crystalline to dense, in part siliceous, with brownish-black chert, argillaceous toward base, interbedded dark gray and green shale, glauconite at base . .	240	58'
	Limestone, dark gray, dense to very finely crystalline, argillaceous, dark gray microfossiliferous chert, shale partings, abundant glauconite at base	298	22'
	Osagean		
Keokuk - Reeds Spring			
	Chert, bleached white, tripolitic, tan-flecked and blue-gray, trace glauconite on chert at Osage-Meramec contact; chert, predominantly gray, to base of interval interbedded tan finely granular limestone.	320	77'
	Kinderhookian-Osagean		
St. Joe Group			
	Limestone, cream, coarsely crystalline at top of interval, finely crystalline at base, pyritic, interbed of pale green, argillaceous, pyritic, fossiliferous limestone.	397	20'
	Kinderhookian		
Chattanooga formation (Devonian-Mississippian)			
	Shale, black, carbonaceous, *Tasmanites*-bearing; thin poorly sorted sandstone at base (Sylamore)	417	53'

J. D. Allen No. 1

	Depth	Thickness
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, drab, finely crystalline, cherty . .	470	12'
DTD	482	

A. T. Campbell
Ruppel No. 1 (See CROSS SECTION D-D', p. 179)
Sec. 23, T. 19 N., R 17 E.

Reed
Koenig No. 1
Sec. 27, T. 19 N., R. 17 E.
NW SE SE Elev. 575±
DTD 1758 D & A
DTD 2415 (Koenig 1-A)

Description in brief
Arbuckle description
from Shell Oil Co.
sample log

PENNSYLVANIAN

Desmoinesian-Atokan

	Depth	Thickness
Krebs - Atoka[16]		
No sample.	Surface	7'
Shale, dark gray, calcareous	7	8'
Siltstone to a very fine-grained, calcareous sandstone.	15	15'
Shale, dark gray to black, in part silty . . .	30	32'
Shale, gray-green, sideritic, ironstone. . . .	62	8'
Limestone, brown, finely crystalline, dolomitic.	70	1'

[16] No distinctive Atoka sandstones or siltstones found in this interval. Shales below 70 feet may be Atokan in age.

Koenig No. 1

	Depth	Thickness
Shale, black, calcareous	71	11'
Shale, gray-green, sideritic, ironstone. . . .	82	8'
Shale, dark gray to black, thin coal	90	16'
Shale, black to brownish-black, dolomitic, sideritic.	106	14'
No sample.	120	5'
Morrowan		
Limestone, gray to brown, fine to coarsely crystalline, sandy, fossiliferous, in part argillaceous, glauconitic, numerous rounded, frosted, quartz grains loose in sample.	125	35'
Shale, gray, platy	160	4'
Sandstone, buff, very fine-grained, argillaceous	164	22'
Limestone, buff, medium crystalline, sandy, fossiliferous, crinoidal, large, rounded, frosted sand grains; calcareous sandstone at base.	186	36'
Shale, dark gray to black.	222	6'
Limestone, buff, finely crystalline, sandy, fossiliferous, crinoidal	228	6'
MISSISSIPPIAN		
Chesterian		
Pitkin limestone		
Limestone, gray, crystalline, argillaceous, pyritic, fossiliferous, crinoidal.	234	3'
Fayetteville formation		
Shale, dark gray to black, calcareous, thin interbedded argillaceous limestone	237	30'
Shale, black, non-calcareous	267	44'

Koenig No. 1

	Depth	Thickness
Limestone, dark gray, dense, argillaceous, in part fossiliferous; shale, black, calcareous	311	22'
Limestone, gray, very finely crystalline, argillaceous, silty at base.	333	13'
Hindsville formation		
Limestone, buff to gray, crystalline, oolitic to pisolitic, fossiliferous, crinoidal, in part argillaceous.	346	23'
Meramecian		
Moorefield formation		
Siltstone, gray to buff, calcareous, highly argillaceous at top of interval, trace of glauconite	369	61'
Osagean		
Keokuk - Reeds Spring		
Chert, gray to dark gray-brown mottled and flecked, gray microfossiliferous, dark gray to black, blue-gray, some white with moderate to predominant amounts of limestone, buff to dark gray-brown, dense to finely granular, in part siliceous; shale, a thin interbed, dark gray to black, calcareous.	430	43'
Limestone, dark brownish-black, argillaceous, in part slightly siliceous, to a hard calcareous shale.	473	24'
Limestone, buff to dark gray, finely granular, siliceous; chert, dark gray to brown, tan-flecked brown, white, gray-flecked brown, gray microfossiliferous.	497	53'
Chert, predominantly white tripolitic; limestone, highly siliceous, trace of glauconite. . . .	550	6'
Limestone, dark gray, highly argillaceous to a dark gray to black calcareous shale, in part streaks brown, trace glauconite at base. . .	556	30'

Koenig No. 1

	Depth	Thickness
ORDOVICIAN		
Champlainian		
Simpson Group		
Tyner-Burgen		
Sandstone, white to tan, very fine to medium-grained, subrounded to rounded, medium to poorly sorted, in part dolomitic to a sandy dolomite, abundant coarse, rounded, frosted grains, interbedded bright green shale, in part sandy and pyritic; basal sandstone, snow-white and well-sorted	586	126'
CAMBRO-ORDOVICIAN		
Arbuckle Group[17]		
Cotter-Lamotte[18]		
Dolomite, cream to gray, buff to brown, dense to coarsely crystalline, in part sandy, scattered oolitic zones; chert, predominantly white and white oolitic, some white tripolitic and gray translucent.	712	1628'
Notable sand zones within the above interval as follows:		
1933-1936 ... Sandstone, medium to coarse-grained, rounded, dolomitic.		
2142-2200 ... Sandstone, fine to coarse-grained, dolomitic to a sandy dolomite.		
2298-2340 ... Siltstone to a very fine to medium-grained, subangular, argillaceous, slightly dolomitic sandstone.		
Lamotte sandstone		
Sandstone, conglomeritic, fine to very coarse-grained, angular to subrounded, fragments of feldspar and chlorite, grades to a weathered granite at base.	2340	58'

[17] Sample description below 1758 taken from log of Koenig No. 1-A (Koenig No. 1 abandoned, new location in same quarter section).

[18] See footnote, page 140.

Koenig No. 1

		Depth	Thickness

PRECAMBRIAN

Granite, quartz, pink to red orthoclase feldspar, minor amounts of ferromagnesian minerals		2398	17'
	DTD	2415	

A. T. Campbell
John Weldon No. 1
Sec. 5, T. 18 N., R. 18 E.
SW SW NE Elev. 608
DTD 925 D & A

Description in brief
Sinclair Oil Co.
sample log

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample.	Surface	10'
Limestone, brown, sideritic, thin coal at base	10	6'
Sandstone to sandy shale	16	10'
Limestone, brown, sideritic, fossiliferous . .	26	7'
Shale, black, in part sandy.	33	21'
Sandstone, brown, slight oil stain	54	16'
Shale, black, platy.	70	28'

Atokan(?)

	Depth	Thickness
Sandstone, gray, fine-grained, calcareous, glauconitic.	98	2'
Shale, black and light gray sideritic.	100	36'

John Weldon No. 1

	Depth	Thickness
Morrowan		
Sandstone, gray, argillaceous, glauconitic and gray sideritic shale	136	14'
Limestone, tan to white, coarsely crystalline, highly glauconitic, interbedded black shale.	150	28'
Sandstone, gray, medium to coarse-grained, angular to rounded; limestone, coarsely crystalline, sandy, bryozoans, crinoids	178	42'
MISSISSIPPIAN		
Chesterian		
Pitkin limestone		
Limestone, gray, coarsely crystalline, fossiliferous.	220	6'
Fayetteville formation		
Shale, dark gray to black, interbedded, gray to brownish-gray, dense limestone.	226	37'
Shale, dark gray, in part fossiliferous, pyritic, calcareous at base	263	85'
Hindsville formation		
Limestone, gray, coarsely crystalline, oolitic, fossiliferous.	348	26'
Meramecian		
Moorefield formation		
Siltstone to a very fine-grained sandstone, white, gray to dark gray, argillaceous, calcareous to a silty limestone; black shale at top of interval	374	64'
Limestone, gray, finely crystalline, argillaceous	438	8'

John Weldon No. 1

Description	Depth	Thickness
Osagean		
Keokuk - Reeds Spring		
Chert, white, buff, gray; limestone, black, finely crystalline, argillaceous, in part siliceous.	446	44'
Limestone, black, highly argillaceous; chert, black at top of interval	490	28'
Limestone, light gray, granular to medium crystalline, in part argillaceous, some white, siliceous limestone; chert predominantly gray.	518	52'
Limestone, dark gray, granular; shale, dark gray to black, calcareous, gritty, glauconitic and pyritic at base.	570	28'
ORDOVICIAN		
Champlainian		
Simpson Group		
Tyner-Burgen		
Sandstone, white to buff, gray, fine to medium-grained, angular to rounded, poorly sorted, numerous coarse, rounded, frosted sand grains, dolomitic, glauconitic and pyritic in upper portion of interval; sandstone at base, white, coarse, subangular to rounded, well sorted; thin interbeds of pale green and gray shale.	598	95'
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, dark gray, white to buff, finely sucrosic to coarsely crystalline, in part finely ground and sandy, gray, white and white oolitic chert	693	232'
DTD	925	

CROSS SECTION F-F'

Mesker Drilling Company
Sheffield No. 1 (See CROSS SECTION A-A', p.142)
Sec. 21, T. 28 N., R. 21 E.

Parker-Rich
Dunbar No. 1
Sec. 27, T. 27 N., R. 21 E. Description in brief
SE SE SE Elev. 750±
DTD 533 D & A

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
No sample (driller reports "shale" for this interval)	Surface	108'
MISSISSIPPIAN		
Chesterian		
Hindsville formation		
Limestone, tan to gray, fine to coarsely crystalline, silty, in part oil-stained, crinoidal, fossiliferous, bryozoans, gray-green calcareous shale at base	108	27'
Warsaw formation		
Limestone, white to tan, gray, dense, granular to medium crystalline, carbonaceous flecked at top, in part highly siliceous, displaying various stages of alteration to chert; moderate to predominate amounts of chert, smooth white to white de-vitrified and tripolitic, white-mottled brown, gray-mottled and speckled, light brown.	135	100'
Limestone, dark gray-brown, finely granular, argillaceous, siliceous, abundant dark gray to black chert, trace pyrite	235	11'

Dunbar No. 1

	Depth	Thickness
Osagean		
Keokuk - Reeds Spring		
Limestone, white to tan, gray to dark gray, crystalline to predominantly dense to finely granular, highly siliceous, associated with moderate amounts of white-speckled black, white tripolitic, light tan, light gray and gray-mottled chert, trace of white fossiliferous chert; chert, smoky gray and gray-mottled interbedded with gray to tan finely crystalline limestone in lower portion of interval.	246	230'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, tan, finely crystalline, crinoidal with an interbed of gray-green, argillaceous, pyritic limestone.	476	13'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale, black, pyritic, <u>Tasmanites</u>.	489	35'
Sylamore sandstone member		
Sandstone, fine to medium-grained, subangular to rounded, poorly sorted, numerous loose, rounded, frosted, coarse grains.	524	1'
ORDOVICIAN		
Canadian		
Arbuckle Group		
Cotter dolomite		
Dolomite, brown, sucrosic, very finely ground, trace white chert.	525	8'
DTD	533	

3-B Oil Company
Helmick No. 1
Sec. 12, T. 26 N., R. 21 E.
NW NW Elev. 750±
DTD 1944 D & A

Description in brief
Eagle-Picher Co.
driller's log and
sample log[19]

PENNSYLVANIAN

Desmoinesian

	Depth	Thickness
Krebs Group		
Shale, gray.	Surface	90'
MISSISSIPPIAN		
Chesterian		
Hindsville formation		
Limestone, gray.	90	55'
Meramecian		
Warsaw limestone		
Limestone and flint, light brown flint at base	145	115'
Osagean		
Keokuk - Reeds Spring		
Limestone, light to dark, sandy[20]; flint . . .	260	182'
Kinderhookian-Osagean		
St. Joe Group		
Limestone, gray, interbedded green shale . . .	442	24'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian)		
Shale.	466	36'

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[19]Driller's log from surface to 1095. Sample log from 1095-1944. Interpretation of post Arbuckle units made on the basis of gamma-ray and driller's log data.

[20]The term "sandy" as used in the Osagean interval probably refers to the nature of drilling and(or)the granularity of the limestone rather than the lithology of the sample.

Helmick No. 1

	Depth	Thickness

CAMBRO-ORDOVICIAN

Arbuckle Group
Cotter - Lamotte[21]

Dolomite (driller's log has "limestone") brown to gray, dense to coarsely crystalline, in part sandy, thin gray and green shales; chert, white, white oolitic, light gray to dark gray.	502	1188'

Sample tops and notable sand zones within the above interval as follows:

768- 773 ... "Swan Creek" sandstone (driller's log)

810- 820 ... Sandstone, white ("Roubidoux" on driller's log - questionable call)

920- 945 ... Sandstone, very fine-grained (base of "Roubidoux" on driller's log - questionable call)

1205-1220 ... Gunter sandstone

1220-1350 ....Emminence dolomite

1350-1690 ... Bonneterre dolomite and sandstone

Lamotte sandstone

Sandstone, gray to dark gray, fragments of weathered reddish-brown orthoclase feldspar, increasing in number towards base, marcasite, thin gray-green shale; driller reports slight oil and gas show at 1759	1690	79'

PRECAMBRIAN

Granite, essential brick red orthoclase feldspar with traces of quartz and marcasite	1769	175'
DTD	1944	

[21]See footnote, page 140. Sample tops below 1095 taken from Eagle-Picher log.

J. Charles
Tucker No. 1
Sec. 16, T. 25 N., R. 21 E.

(See CROSS SECTION B-B', p.163)

Dye-Henry
Frank Ross No. 1
Sec. 20, T. 24 N., R 21 E.
NW SW NE   Elev. 856
DTD 1764   D & A

Description in brief
Sample log from
J. W. Dye

MISSISSIPPIAN

	Depth	Thickness
No sample.	Surface	99'
Osagean		
Keokuk - Reeds Spring Chert, milky white, blue-white, tan, associated limestone, tan, in part dense and siliceous; blue-gray and gray cherts interbedded with tan, siliceous limestone in lower portion of interval.	99	108'
Kinderhookian-Osagean		
St. Joe Group Limestone, tan to white, crystalline, interbedded green calcareous shale.	207	26'
Kinderhookian		
Chattanooga formation (Devonian-Mississippian) Shale, black, pyritic, thin, gritty, calcareous zone below top of interval	233	66'

CAMBRO-ORDOVICIAN

Arbuckle Group
Cotter - Lamotte[22]
Dolomite, brown, white, gray to dark gray, dense to coarsely crystalline, in part sandy, oolitic zones, thin green, black

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[22]See footnote, page 140.

Frank Ross No. 1

	Depth	Thickness
and gray, shales; chert predominantly white, white oolitic and blue-gray	299	1403'

Notable sand zones within the above interval as follows:

732- 742 ... Sandstone, white, fine-grained, dolomitic.

970-1128 ... Dolomite, sandy, sand fine to medium-grained, abundant rounded, frosted, coarse quartz grains free in samples.

1164-1190 ... Dolomite, sandy to dolomitic sandstone, medium to coarse sand grains, subrounded, in part frosted.

1629-1702 ... Sandstone, fine to very coarse-grained, in part dolomitic, pyritic, some interbedded dark shales.

	Depth	Thickness
Lamotte sandstone		
Sandstone, poorly sorted, in part frosted, fragments of orthoclase feldspar and angular quartz crystals, trace dark green minerals .	1702	53'

PRECAMBRIAN

	Depth	Thickness
Granite, pink orthoclase feldspar, quartz, trace dark green mineral	1755	9'
DTD	1764	

W. W. Peck
Sloan No. 1
Sec. 3, T. 23 N., R. 21 E.
NE NW NE Elev. 810±
DTD 343 D & A

Description in brief
Sinclair Oil Co.
sample log

MISSISSIPPIAN

Meramecian

	Depth	Thickness
Warsaw limestone Chert, buff, weathered and gray to white, interbedded siliceous limestone; limestone, gray, finely crystalline, argillaceous, slightly sandy, pyritic, glauconitic at base	Surface	35'

Osagean

Keokuk - Reeds Spring Limestone, highly siliceous, tripolitic, some brown, porous, slightly oil-stained at top of interval, white chert; limestone, gray, siliceous, some white chert; chert, dark gray and blue-gray to base of interval . . .	35	203'

Kinderhookian-Osagean

St. Joe Group Limestone, white, coarsely crystalline, interbedded greenish-gray shale, abundant glauconite in shale and basal limestone member .	238	15'

Kinderhookian

Chattanooga formation (Devonian-Mississippian) Shale, brownish-black, pyritic	253	61'

ORDOVICIAN

Canadian

Arbuckle Group
Cotter dolomite
Dolomite, gray, finely crystalline, oil-stained

Sloan No. 1

	Depth	Thickness
at top, transluscent chert	314	29'
DTD	343	

L. Miller
Knight No. 1
Sec. 34, T. 23 N., R. 21 E.

(See CROSS SECTION C-C, p. 175)

M & F Oil Company
Ransom No. 1
Sec. 18, T. 20 N., R. 22 E.

(See CROSS SECTION D-D, p.184)

C. WELL SAMPLES AND SAMPLE LOG DATA AVAILABLE WITHIN THE THESIS AREA[1]

	Sec.	Location[2]	Well	Production	DTD	Elev.[3]	Type Info.	Source[4]
T. 19 N., R. 17 E. (Rogers)								
	* 13	NW NW NE	Harry Culver Inc. Lincoln National Life Ins. Co. No.?	D & A	671	620±	Sample log	SOC
	* 21	SE NE NE	Big Bear Courtney No. 1	D & A?	2390	610±	Sample log	Gulf
	* 23	Unknown (center of section)	A.T. Campbell Ruppel No. 1	D & A?	672?	610±	Samples 112-665	SOC
	* 27	SW NW SE SE	Reed Koenig No. 1	D & A	1758	575±	Samples 7-1758	Shell
	27	N/2 S/2 SE	C.L. Reed & Sons Koenig No. 1A	D & A	2415	575±	Samples 700-2415	OSL

[1]Key control wells listed from Rogers and Nowata Counties.

[2]Footage plotted where a discrepancy exists between spot and footage.

[3]Elevation at ground level. (±) elevations estimated from U.S.G.S. topographic maps of the area.

[4]Key to abbreviations on page.

*Wells plotted on base map.

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 19 N., R. 18 E. (Mayes)								
	* 2	SE NE NW SW	J. Mast Stamper No. 1	D & A	497	600±	Sample log	CRT
	20	Unknown	Mullins, et al ? No. 1	Unknown	350?	675±	Samples 89-350	OSL
	20	Unknown	K. G. Hunt No. 1	Unknown	745?	675±	Samples 690-745	OSL
	* 21	NW NW NW	L.F. Ice, et al ? No. ?	D & A?	904	635±	Samples 631-904	OSL
	* 27	SW SE SE 250' NSL 250' EWL ¼ sec.	A.B. Chase Bone Cutter No.1	D & A	610	625±	Sample log	ARC
	31	Unknown	Campbell Brown No. 1	Unknown	245?	610±	Samples 40-245	SOC
	31	Unknown	G.W. Thompson & Campbell G.W.P.Brown No.1	Unknown	205?	610±	Samples 0-205	SOC
	* 34	SE NW	A. B. Chase Slifer No.1	Unknown	480	590±	Sample log	ARC
T. 20 N., R. 17 E. (Rogers)								
	* 35	SW Cor SE NW	? ? No. ?	Unknown	520?	650±	Sample tops	Bull. 40

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 20 N., R. 18 E. (Mayes)								
	* 16	SW NW NE	W.H. Strickler G.B. Lindsey No.1	D & A	441	600±	Samples 12-441	TU
	* 35	SW SE SE	Leo Ekstrom ? No. 1	Unknown	650	630±	Samples 0-650	TU
	* 36	NW NW SE	Gardner, et al Gilbert No. 1	Gas	463	660±	Samples 15-463	TU
	36	NE SW NE	Gardner, et al Gilbert No. 2	Gas	450	663	Samples 135-450	SOC
T. 21 N., R. 17 E. (Rogers)								
	* 4	C S½	J. B. Ross Mullens No. 1	D & A	1015	810±	Samples 708-1014	Shell
	* 10	NE SW SE	Barton & Qualls ? No. 1	Unknown	568	660±	Sample log	SOC
	15	Unknown	Barton ? No. 1	Unknown	585	660±	Sample log	SOC
T. 21 N., R. 18 E. (Mayes)								
	* 16	C NE NE	A. E. Summers J.D. Allen No. 1	D & A	482	650±	Samples 53-482	SOC
	* 17	SE NE NE	A. E. Summers Lee Price No. 1	D & A	484	662	Samples 125-484	OU

Township	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 21 N., R. 18 E. (Mayes)								
	* 17	NW NE NE	J.W. Merritt Price No. 1	D & A	615	713	Sample log	SOC
T. 21 N., R. 19 E. (Mayes)								
	* 12	NW NE SW	McCullough & Warner Hadden No. 1	Unknown	442	660±	Samples 30-430	TU
	30	Unknown	Phillips Johnston No. 10	Unknown	338?	580±	Samples 30-338	OSL
	* 33	SW NW NE	Deere & Co. J. Deere No. 1	Chemical Disposal	815	600±	Samples 200-815	Shell
T. 22 N., R. 17 E. (Rogers)								
	* 16	SW NW NE	Wise & Smith Green No. 1	D & A?	634	711	Samples 77-634	OU
T. 22 N., R. 18 E. (Mayes)								
	* 33	NW SW NW	E.K. McLennan Trogdon No. 1	D & A	600?	675±	Samples 80-600	BL
T. 22 N., R. 19 E. (Mayes)	* 31	NW NE	Tec. Prod. Boyd No. 1	D & A	150	608	Sample log	CRT

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 22 N., R. 20 E. (Mayes)								
	* 29	SE SW SW	O.A. Garr, et al Thomas Hale No. 1	Asphalt test hole	27½	650±	Samples 0-27½	TU
T. 23 N., R. 17 E. (Rogers)								
	* 17	NE SW NW	Gulf Oil Corp. W.M. Smith No. 1-S	Water supply	1140	771	Samples 0-1073	OSL
T. 23 N., R. 18 E. (Mayes)								
	* 19	SW SW NE	Service Drilling Co. Clifton No. 1	D & A	699	710±	Sample log	SDC
T. 23 N., R. 19 E. (Mayes)								
	* 17	SE SE SE	Lee Milligan Lee No. 1	D & A	1957	700±	Samples 225-1928	Shell
T. 23 N., R. 20 E. (Mayes)								
	* 10	NE NW NW	Allen & Teal J. McKee No. 1	D & A	458	694	Sample log	ARC
	* 26	Unknown (center of section)	Kelly Brothers M. Brown No. 1	Unknown	500	610±	Sample log	ARC
T. 23 N., R. 21 E. (Mayes)								
	* 3	NE NW NE	W.W. Peck L. O. Sloan No. 1	D & A	343	810±	Samples 0-335	SOC

Township	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 23 N., R. 21 E. (Mayes)								
	* 34	NE SW NE	Davis & Miller Knight No. 1	D & A	1622	651	Sample log	MLM
T. 24 N., R. 19 E. (Craig)								
	6	SE SE SW	William Bros. Rogers No. 2	Unknown	392½	860±	Samples 119-392½ (Missing 156-361½)	OU
T. 24 N., R. 19 E. (Craig)								
	* 28	CSL SW SE	Earl Vaught Pitts No. 1	Unknown	468	740±	Sample log	EP
	28	SE SE	? Wayne Trundle No. 1	Unknown	465	710±	Sample log	EP
T. 24 N., R. 20 E. (Craig)								
	* 26	SE NE SW	Wiljohn Oil Co. White No. 1	D & A	1203	665±	Sample log	ARC
T. 24 N., R. 21 E. (Craig)								
	* 14	C SW NE	Wilkinson Kaufman No. 1	D & A	485	950±	Samples 0-485	OU
	* 20	NW SW NE	J.W Dye & M.O. Henry Frank Ross No. 1	D & A	1764	856	Sample log	JWD

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 24 N., R. 21 E. (Craig)								
	25	Unknown	Andrew Morgan Trundle No. ?	Unknown	565?	800±	Samples 183-565	OSL
	* 25	NE NE SW	Barnett-Stark, et al Stark No. ?	D & A	400	780±	Samples 245-400 (Most of set missing)	OU
	26	SE SE	Cotton Martin No. 1	Unknown	255?	770±	Samples 26-255	OSL
	26	Unknown	O.N. West Gregory No. 1	Unknown	275?	750±	Samples 262-275	SOC
	* 26	Unknown (center of section)	Millard Sloan No. 1	Unknown	283	773±	Samples 215-283	SOC
T. 25 N., R. 19 E. (Craig)								
	* 3	Unknown (center of section)	W.D. Flourney Harper No. 1	Unknown	795	725±	Samples 310-795 (Missing 605-770)	OU
	* 12	SW SE NE	F.R. Hyer Applegate No. 1-A	D & A	607	710±	Samples 0-402	SOC
T. 25 N., R. 21 E. (Craig)								
	* 16	SE SW SE	John B. Charles Tucker No. 1	Gas	368	745	Sample log	SOC

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 25 N., R. 21 E. (Craig)	12	Unknown	Charles Bond No. 1	Unknown	130?	760±	Samples 15-130	Shell
	16	CS½ SE SE	John B. Charles Tucker No. 2	D & A	410	753	Samples 0-400	Shell
T. 26 N., R. 18 E. (Craig)								
	* 27	CEL SW NE	Major Oil Co. Milburn Condry No.1	D & A	661	904	Sample log	MOC
	* 27	CWL SE SW 660' NSL 860' EWL ¼ sec.	Major Oil Co. Milburn Condry No.2	D & A	710	891	Sample log	MOC
	* 29	Unknown (center of section)	H.L. Leak Cox No. 1-A	Unknown	622	800±	Samples 0-622	OU
T. 26 N., R. 19 E. (Craig)								
	* 4	NW NW NW	Frankfort Oil Co. Bluejacket No. 1	D & A	2128	835±	Samples 100-2128	OSL
	* 20	NE NE SW	Mesker Drilling Co. Beisley No. 1	D & A	890	767	Samples 40-890	CD
T. 26 N., R. 21 E. (Craig)								
	* 12	NW NW	3-B Oil Co. Helmick No. 1	D & A	1944	750±	Samples 1095-1944	OGS

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 27 N., R. 18 E. (Craig)								
	* 14	NW NE NW	Carter Wilkerson No. 1	D & A	498	813	Samples 0-498	CD
T. 27 N., R. 19 E. (Craig)								
	* 26	NE	Prentice, et al Vandever No. 1	D & A?	801	761±	Sample log	MOC
T. 27 N., R. 21 E. (Craig)								
	* 27	SE SE SE	Earl Rich Dunbar No. 1	D & A	533	750±	Samples 105-531	PF
T. 28 N., R. 17 E. (Nowata)								
	* 24	SE SE NW	Mesker Drilling Co. Miller No. 1	D & A	1332	900±	Samples 0-1332	CD
T. 28 N., R. 18 E. (Craig)								
	* 22	SE NE SE	Mesker Drilling Co. Huggins No. 1	D & A	1088	820	Samples 0-1088	CD
	* 29	NE SE NE	Z.W. Dean Tritthart No. 1	D & A	1096	740±	Samples 20-1096	CD
	36	SW SE NE SE	Cameo Oil Co. Neil No. 1	D & A	330	781	Sample log	COC

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 28 N., R. 19 E. (Craig)								
	* 19	NW NW SW	Mesker Drilling Co. Beaty No. 1	D & A	1146	875	Samples 0-1146	CD
T. 28 N., R. 19 E. (Craig)								
	* 31	SE SW NE SW	Cameo Oil Co. Neil No. 1	D & A	330	796	Sample log	COC
	31	SE SW NW SW	Cameo Oil Co. Neil No. 2	D & A	345	787	Sample log	COC
T. 28 N., R. 20 E. (Craig)								
	* 9	NW NW NW	Wackerle Unitization No. 1	Unknown	966	950±	Sample log	EP
	* 19	SE SW SE	Wackerle (Neofuels) Hood No. 4	D & A	1590	838	Sample log	EP
	* 31	SE NE NW	Frankfort Oil Co. Van Ausdel No. 1	Gas	2014	848.9	Samples 100-2014	OSL
T. 28 N., R. 21 E. (Craig)								
	* 21	SW NW SE	Mesker Drilling Co. Sheffield No. 1	D & A	683	855	Samples 40-683	CD
	* 29	SE NW	City of Welch Well No. 2	Water	1230	858±	Sample log	EP

	Sec.	Location	Well	Production	DTD	Elev.	Type Info.	Source
T. 29 N., R. 18 E. (Craig)								
	* 20	SE NW SE	Carter Rexwinkle No.1	D & A	718	962	Samples 0-598	CD
T. 29 N., R. 18 E. (Craig)								
	21	CSL SW SE NW	? Rexwinkle No. 2	D & A	1150	870	Sample log	MOC
	* 21	SE SW NW	Stroyick, et al Rexwinkle No. 1	Abandoned oil	1108	882	Sample log	MOC
	* 26	NW SW SE	Carter Lotz No. 1	D & A D & A	559	905	Samples 0-559	CD
T. 29 N., R. 19 E. (Craig)								
	* 27	NE SE NW	Carter Hively No. 1	D & A	419	925	Samples 0-418	CD

D. RADIOACTIVE AND ELECTRIC LOG DATA AVAILABLE WITHIN THE THESIS AREA[1]

	Sec.	Location	Well	Production	DTD	Elev.[2]	Type Log	Source[3]
T. 23 N., R. 17 E. (Rogers)								
	* 7	NE NW NW	J.B. King and Geo. Beecroft McSpadden No. 1	D & A	793	810±	Radioactive 0-793	RR
	* 17	NE SW NW	Gulf Oil Corp W.M.Smith No.1-S	Water Supply	1140	771	Elec.** Micro. 77-1076	RR
T. 23 N., R. 19 E. (Mayes)								
	* 17	SE SE SE	Lee Milligan Lee No. 1	D & A	1957	700±	Elec.** 500-1966	LM
T. 23 N., R. 21 E. (Mayes)								
	* 34	NE SW NE	Davis & Miller Knight No. 1	D & A	1622	651	Elec.** Micro. 76-1614	MLM

[1] Key control wells listed from Rogers and Nowata Counties.

[2] Elevation at ground level. (±) elevations estimated from U.S.G.S. topographic maps of the area.

[3] Key to abbreviations on page 227.

*Wells plotted on base map.

**Samples or sample log also available. See pages 211-221.

	Sec.	Location	Well	Production	DTD	Elev.	Type Log	Source
T. 24 N., R. 18 E. (Rogers)	* 1	NE SE NE	K.L. Scott Scott No. 1	D & A	863	890±	Elec. Micro. 151-862	RR
T. 24 N., R. 21 E. (Craig)	* 20	NW SW NE	J.W. Dye & M.O. Henry Frank Ross No. 1	D & A	1764	856	Radioactive** 10-1765	RR
T. 25 N., R. 17 E. (Nowata)	18	Unknown	N.Y.K. Oil Co. Carry No. S-35	Oil	750	645±	Radioactive 10-739	RR
		(Incorrectly listed in T. 27 N.)						
T. 26 N., R. 17 E. (Nowata)	* 9	NW SW NW	Western Hills Oil Inc. Maddox No. 1	D & A	582	660±	Elec. 250-577	RR
T. 26 N., R. 19 E. (Craig)	* 4	NW NW NW	Frankfort Oil Co. Bluejacket No. 1	D & A	2128	835±	Elec.** Micro. 100-2128	RR
	* 20	NE NE SW	Mesker Drilling Co. Beisley No. 1	D & A	890	767	Radioactive** 0-886.5	RR

	Sec.	Location	Well	Production	DTD	Elev.	Type Log	Source
T. 26 N., R. 21 E. (Craig)								
	* 12	NW NW	3-B Oil Co. Helmick No. 1	D & A	1944	750±	Radioactive** 0-1868	OGS
T. 27 N., R. 18 E. (Craig)								
	* 14	NW NE NW	Carter Wilkerson No. 1	D & A	495	813	Radioactive** 0-495	CD
T. 28 N., R. 17 E. (Nowata)								
	* 24	SE SE NW	Mesker Drilling Co. Miller No. 1	D & A	1332	900±	Radioactive** 0-1329.5	RR
T. 28 N., R. 18 E. (Craig)								
	* 16	SE SW NE	Roche Oil Co. Freeman No. 1	D & A	716	840±	Radioactive 100-716	ROC
	* 22	SE NE SE	Mesker Drilling Co. Huggins No. 1	D & A	1088	820	Radioactive** 0-1071	CD
	23	NE SE NE (approx.)	Roche Oil Co. Maxson No. 2	D & A	457	872	Radioactive 250-455	CD
	* 29	NE SE NE	Z.W. Dean Tritthart No. 1	D & A	1096	740±	Radioactive** 0-1092.5	CD
T. 28 N., R. 19 E. (Craig)								
	* 19	NW NW SW	Mesker Drilling Co. Beaty No. 1	D & A	1146	875	Radioactive** 0-1144	CD

	Sec.	Location	Well	Production	DTD	Elev.	Type Log	Source
T. 28 N., R. 19 E. (Craig)								
	20	SW 990' SL, 330' WL	Tex-ota Oil Co. Spears No. 1	Unknown	380	860±	Elec. 0-380	CD
	20	SW 1570' SL 330' WL	Douglas Corp. Spears No. 1	D & A	400	860±	Elec. Micro. 50-396	RR
	* 20	SW 1320' SL 330' WL	Dietz & Campbell Spears No. 1	Unknown	390	878	Elec. 0-390	CD
	* 29	NW 990' NL 1650' WL	Tex-ota Oil Co. Walter Spears No. 7	Unknown	394	861	Elec. 0-394	CD
T. 28 N., R. 20 E. (Craig)								
	* 19	SE SW SE	Wackerle (Neofuels) Hood No. 4	D & A	1590	838±	Elec. 1492-1532	APC
	* 31	SE NE NW	Frankfort Oil Co. Van Ausdel No. 1	Gas	2014	848.9	Elec.** Micro. 61-2012	RR
T. 28 N., R. 21 E. (Craig)								
	* 21	SW NW SE	Mesker Drilling Co. Sheffield No. 1	D & A	683	855	Radioactive** 0-680	CD

	Sec.	Location	Well	Production	DTD	Elev.	Type Log	Source
T. 29 N., R. 18 E. (Craig)								
	* 13	Unknown (center of section)	Hamco Oil & Drlg. Co. Stine No. 1	D & A?	499	925±	Elec. 10-496	CD
	* 14	NE SW NE	J.A.Ervin Petrol. Maxon No. 1	D & A	2143	905±	Gamma-ray Tops	COC
	* 14	C NE NE	Hamco Oil & Drlg. Co. Maxon No. 3	D & A?	476	910±	Elec. 6-476	CD
	* 20	SE NW SE	Carter Rexwinkle No. 1	D & A	718	962	Radioactive** 0-717	CD
	* 23	C NE	Hamco Oil & Drlg. Co. Maxson No. 1	D & A?	476	883±	Elec. 48-476	CD
	* 26	NW SW SE	Carter Lotz No. 1	D & A?	559	905	Elec. ** Radioactive 0-558	CD
T. 29 N., R. 19 E. (Craig)								
	* 27	NE SE NW	Carter Hively No. 1	D & A	419	925	Elec. ** Radioactive 32-419	CD

LIST OF ABBREVIATIONS

APC	Amerada Petroleum Corporation	Tulsa, Okla.
ARC	Atlantic Refining Company	Dallas, Texas
BL	Mr. Bill Lee	Vinita, Okla.
Bull.40...	Publication Okla. Geol. Survey	Norman, Okla.
CD	Carter Division Humble Oil & Refining Co.	Ft. Smith, Ark.
COC	Cameo Oil Company	Okla. City, Okla.
CRT	Mr. C. R. Tooker	Norman, Okla.
EP	The Eagle-Picher Company	Miami, Okla.
Gulf	Gulf Oil Company	Okla. City, Okla.
JWD	Mr. J W. Dye	Okla. City, Okla.
LM	Mr. Lee Milligan	Amarillo, Tex.
MLM	Mr. Luther Miller	Okla. City, Okla.
MOC	Major Oil Company	Tulsa, Okla.
OGS	Oklahoma Geological Survey	Norman, Okla.
OSL	Oklahoma Sample Library	Shawnee, Okla.
OU	University of Oklahoma	Norman, Okla.
PF	Personal File	Tulsa, Okla.
ROC	Roche Oil Company	Austin, Tex.
RR	Riley's Reproduction	Okla. City, Okla.
SDC	Service Drilling Company	Tulsa, Okla.
Shell	Shell Oil Company	Okla. City, Okla.
SOC	Sinclair Oil Company	Tulsa, Okla.
TU	University of Tulsa	Tulsa, Okla.

[redacted]