SUBSURFACE STRATIGRAPHIC ANALYSIS OF THE SKIATOOK AND "CHEROKEE" GROUPS IN THE SOUTHWESTERN PART OF NOBLE COUNTY, NORTHERN PART OF LOGAN COUNTY, AND THE SOUTHEASTERN PART OF GARFIELD COUNTY, OKLAHOMA

By

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PREFACE

This study deals with the depositional environments of the Pennsylvanian "Cherokee" Groups in north-central Oklahoma. Evidence concerning environments of deposition was drawn from correlation cross-sections, isopach maps, structural contour maps, log maps, and sample logs.

Appreciation is extended to Professor Gary F. Stewart, thesis adviser, whose enthusiasm and constructive guidance throughout this study proved invaluable. Equal appreciation is extended to Dr. Donovan and Dr. John W. Shelton, who provided tangible and intangible support. Thanks are due to Peter G. Wilson and Beren-Berexeco Corporation for their valuable assistance in supplying materials and time for the thesis study. Appreciation is expressed to Walter Duncan Properties for allowing time to compile my thesis for final presentation and to the many helpful comments and criticisms by my fellow geologists at Walter Duncan Properties, including Mr. Louis M. Ford, Mr. John W. Erickson and Mr. Hubert H. Hunt. Special thanks are given to the invaluable aid from the drafting assistance received from Mr. Paul G. Reynolds, Mrs. Judy Phelps and Mr. David Hollingsworth. Thanks are given to Debra A. Hopp for her assistance in compiling the text and in the final typing. Gratitude is extended to the Oklahoma State Department of Geology for providing two years of financial assistance.

Finally, the writer would like to express special thanks to her parents and sisters for their continual encouragement and support which have made it finally possible to complete this study.

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CHAPTER I

INTRODUCTION

Location of the Study Area

The area of study covers approximately 216 sq. mi. in north-central Oklahoma, including T. 19 N., R. 2 W., R. 3 W. and R. 4 W. in northern Logan County, T. 20 N., R. 2 W. in southern Noble County, and T. 20 N., R. 3 W. and R. 4 W. in southern Garfield County (Figure 1).

Statement of the Problem

The principal objective of this investigation was to make the best reasonable judgments about environments of the Lower Layton and Cleveland stratigraphic intervals and about parts of the Middle Pennsylvanian "Cherokee" Group, and to estimate the influence of paleotopographic and paleostructural features upon deposition.

Previous Investigations

Although many investigations have been conducted about the Cherokee Group[1] since 1894, comparatively little work has been done on the

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[1] The Cherokee Group has been reduced to informal status or at least superseded in some subfields of applied geology, especially where areal geologic mapping is concerned (Oakes, 1953). The term is used here for the reason that in subsurface exploration, its meaning and importance have not been diminished seriously.

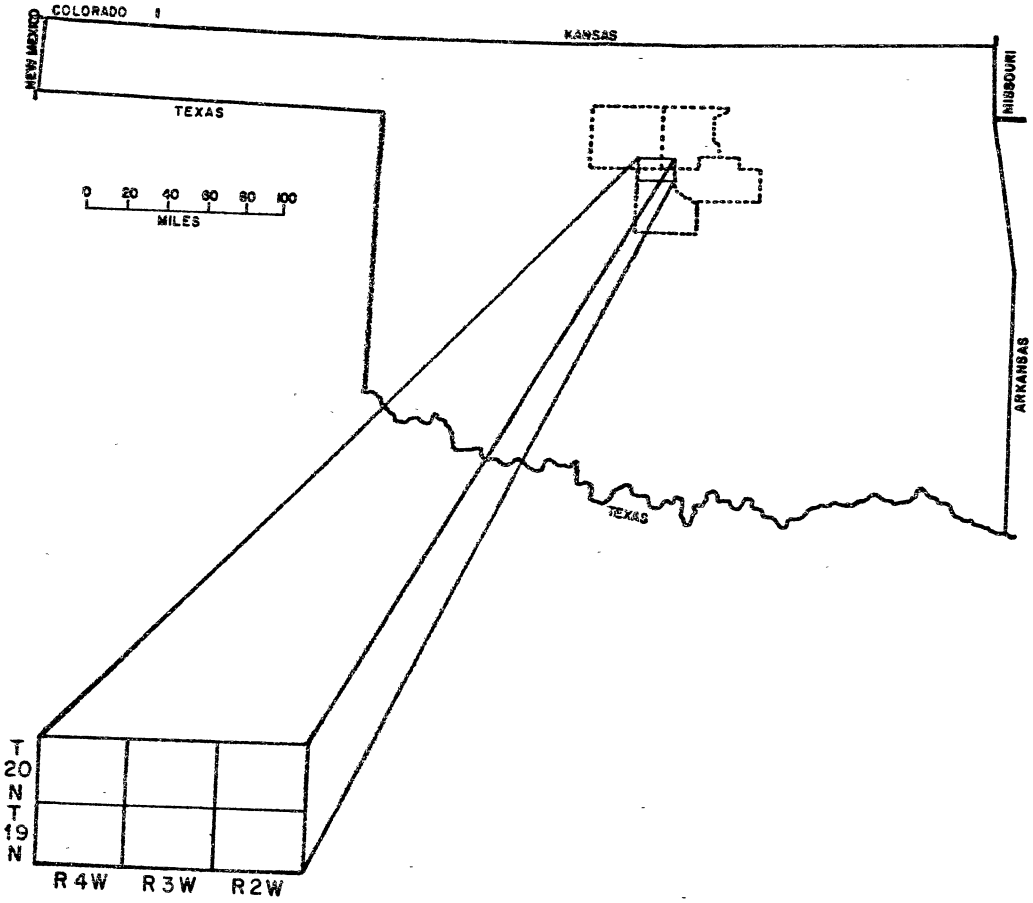

Figure 1. Location Map of Study Area

Skiatook Group. The Cherokee Group was described first as ashy shales about 500 ft. thick, with numerous beds of coal, sandstone and limestone (Hawthorne and Kirk, 1894). Since then many geologists have analyzed, described and classified this group, the most prominent general works being by Moore (1944, 1949, 1951), who worked out the correlation of many of the Pennsylvanian formations in the midcontinent, and Oakes (1953), who divided the original Cherokee Group into the Krebs and Cabaniss Groups. However, the names Krebs and Cabaniss commonly are not used in subsurface geology of northern Oklahoma.

Since the 1950s additional studies on the Cherokee Group have been conducted by Berg (1969), Clayton (1965), Shulman (1966), Dogan (1970), Lalla (1975), Shipley (1975), McElroy (1961), Valderrama (1976), Benoit (1957), Stringer (1957), Hawisa (1965), Scott (1970), Cole (1969) and Candler (1976). Although most of these studies are not related directly to the area encompassed in this particular study, many of the concepts and ideas involved were applicable in the research described here.

Whereas much has been written concerning the Cherokee Group, the Skiatook Group has been neglected for the most part. Only within the last decade have geologists concerned themselves closely about depositional environments of strata within this group. Certainly many geologists have worked with these rocks, but only a few have published papers. Lalla (1975) studied the Osage Layton sandstone, primarily concerning himself with Cottage Grove Formation and the so-called Upper Layton, and dealing briefly with the Lower Layton.[2] Fambrough (1963)

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[2] The writer acknowledges the fact that standard rules of stratigraphic nomenclature are not followed strictly in reference to units such as the Osage Layton sandstone.

discussed the Virgilian and Missourian Series of northeastern Oklahoma, which included the Skiatook. Bross (1960) discussed distribution of the Layton sandstone in Logan County, Oklahoma. Kausparis (1978) discussed sandstone-reservoir qualities of the Cleveland sandstone and Ekebafe (1973) analyzed the interval from the Hogshooter limestone to the Checkerboard limestone.

Methods and Procedures

Data utilized in this study were obtained from approximately 500 electric well logs, from scout tickets, sample logs and core analyses. Subsea elevations were computed from the drilling data and log data of each well.

Six regional cross-sections were prepared to insure accurate correlation of the stratigraphic sections across the six-township area (Plates 1 through 7). Several local correlation sections were prepared for accurate interpretation of faulting and of sand trends. An isopach map (Plate 8) was used to estimate configuration of the surface of pre-Pennsylvanian rocks during deposition of the Cherokee Group.

The base of the Oswego limestone (Figure 2) was used as one of the main structural datums for this study (Plate 9). Although any of the several limestone marker beds within the Cherokee Group could have been used, the base of the Oswego was chosen because it is an extensive, easily recognizable marker, and it is the first evidence of the major transgression that terminated depositional conditions characteristic of the Cherokee Group.

The structural contour map of the base of the Oswego limestone (Plate 9) was used to estimate configuration of the study area after

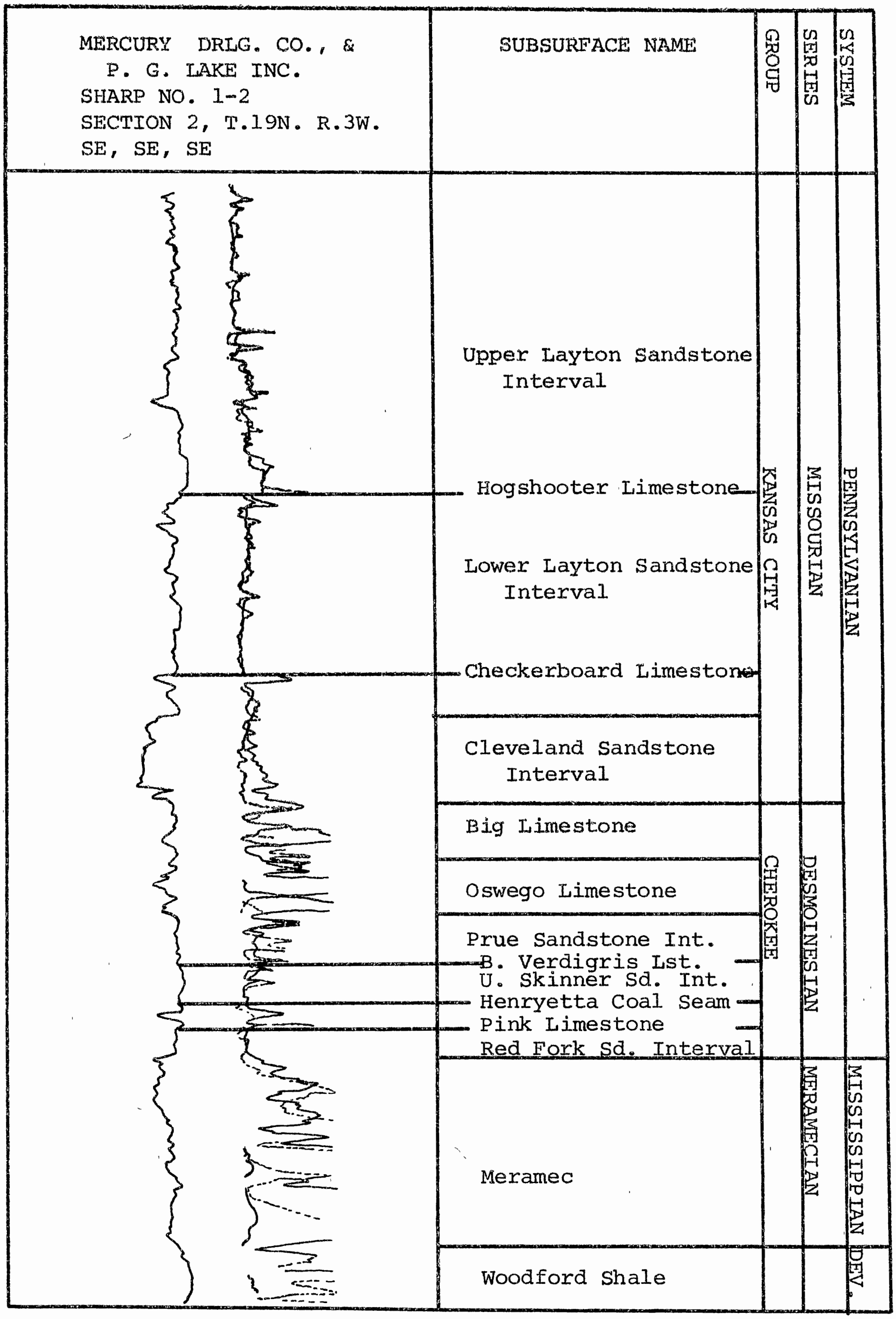

Figure 2. Type Electric and Sample Log

deposition of the Cherokee Group and to compare this configuration to basic shape of the pre-Pennsylvanian unconformity surface. Thereby one can estimate structural deformation that occurred in the increment of time between first deposition of Pennsylvanian strata and deposition of the Oswego.

The Checkerboard Limestone (Figure 2) was used as a main datum above the base of the Oswego limestone. Other markers in the Missourian section could have been used of course, but the more probable facies changes within these limestone marker beds could have caused problems in correlation, and ultimately could have caused errors in calculation of subsea elevations. The Checkerboard is an extensive and distinguishable marker bed; it was the first extensive limestone to be deposited in Missourian time.

Values of gross-sandstone thicknesses were recorded, and isopachous maps were made of each of the sandstone units of primary concern (Plates 11 through 15). Representative log maps of each of the sandstone units were made to illustrate the different "log characters" from place to place within the sandstone units (Plates 17 through 19).

Sample logs encompassing the Lower Layton sandstone, Cleveland sandstone and Lower Skinner sandstone (Figure 2) were studied to help in estimation of depositional environments.

CHAPTER II

GENERAL GEOLOGY

Regional Geology

Cherokee and Skiatook seas covered most of northeastern Oklahoma. The Cherokee sea advanced from a southerly direction, and in the early stages of transgression was bounded to the west by the Nemaha Ridge and to the east by the Ozark Uplift. However, the Skiatook sea apparently advanced from the west and southwest. The Cherokee and Skiatook Groups show evidence of "cyclic" deposition, with some strata clearly having been deposited during transgressions[1] and extensive regressions. The Cherokee consists mostly of shales separated by thin, persistent, presumably "time-parallel" limestone beds. The Pink and Verdigris limestones (Figure 2) extend throughout the study area. These units indicate relatively stable intervals of shallow-marine deposition. In the study area, general regression is indicated by the Skinner sandstone.

The Big Lime-Oswego sequence (Figure 2) was deposited in shallow-marine environments, and deposition was interrupted by minor regressions. The succeeding Cleveland format (Figure 2) was dominated by less stable environments, under which were deposited lenticular sandstones

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[1] Use of the terms "transgression" and "regression" is not intended to convey the impression that each such event was regional in extent and related to eustatic fluctuations. For example, the fact a local evidence of "regression" and "transgression" can be generated simply by progradation and destruction of deltaic lobes was clearly in mind.

with no obvious control by local structural geology. Deposition of the Checkerboard occurred in a transgressive phase of regional extent. For the most part, relatively stable conditions existed with intermittent episodes of high-standing sea level.

In places where sandstone units are well developed and where they trend across anticlinal structures, they generally are commercially productive of oil and gas, as in the case of the Lower Layton and the Cleveland. Production from the Lower Skinner seems not to be closely related to anticlinal structures, in some instances.

Classification, Description and Distribution of Rock-stratigraphic Units

Figure 2 illustrates the lower portion of the Pennsylvanian section by a type electric log and sample description. Generalized but accurate descriptions of the rock-stratigraphic units encountered were compiled from published literature, electric logs, sample logs, and Oklahoma Corporation Commission Forms 1002A. Regional correlation sections (Plates 1 through 7) were used to determine the distribution and character of rock-stratigraphic units.

Mississippian System

In general, within the study area the Cherokee Group unconformably overlies Mississippian rocks. However, in the northwestern part of the thesis area the Cherokee unconformably overlies the Woodford Shale, and in some places the Viola Limestone (Ordovician). Because in most of the area Pennsylvanian rocks are underlain by the Mississippian, a brief discussion of correlations is appropriate.

Before deposition of the Cherokee Group, cherty residual deposits accumulated by weathering and erosion of Mississippian rocks. These chert deposits probably were reworked by processes attendant to deposition of Cherokee sediments. The reworked chert, "Mississippian Chat," although not recognizable in all the electric logs, is difficult to distinguish from chert weathered in place. For the purposes of this thesis it is assumed that residual and reworked chert should show lower resistivity on electric logs than do unweathered Mississippian rocks. Therefore, the top of the Mississippian System was recorded at the uppermost highly resistant section recorded. By this method some Mississippian rocks may have been mapped as Pennsylvanian, but this error is considered to be preferred to errors inherent in distinguishing residual chert from reworked chert.

Pennsylvanian System, Desmoinesian Series,
Cherokee Group

Red Fork Sandstone. Throughout most of the area the Red Fork interval (Figure 2) is gray or dark gray to greenish gray micaceous shale containing little or no sandstone. The sandstone is "colorless" to light brown, fine-grained to very fine-grained, moderately porous, micaceous, and as thick as 30 feet. The Red Fork sandstone commonly lies 10 to 20 ft. below the Pink limestone (Figure 2), but is not consistent in stratigraphic position.

Pink Limestone. The Pink limestone is extensive, only 5 to 10 ft. thick, light brown to light gray and siliceous. In the study area, the Pink is 30 to 60 ft. above the pre-Pennsylvanian unconformity.

Lower Skinner Sandstone. The Lower Skinner (Figure 2) is light gray to white, fine-grained to very fine-grained, micaceous and generally "tight," but is porous and permeable in some wells. Shales of the Lower Skinner interval are dark gray, micaceous and slightly calcareous, with thin beds of green shale and coal. Sandstone in the Lower Skinner interval generally is a single unit about 20 ft. thick. The sandstone commonly is 50 to 70 ft. below the Verdigris Limestone (Figure 2) and is a few feet above the Pink limestone; in some instances the sandstone lies directly upon the Pink limestone.

Henryetta Coal. In north-central Oklahoma the Henryetta coal (Figure 2) is a consistent, reliable marker that separates the Upper and Lower Skinner intervals. The Henryetta Coal is distinguishable by exceptionally large resistivity, as shown by short-normal, lateral or laterolog curves on well logs.

Upper Skinner Sandstone. The Upper Skinner interval (Figure 2) consists of gray to dark gray or black micaceous shale with thin beds of coal. Although the Upper Skinner sandstone is present in wells to the east of the study area, Upper Skinner sandstone was penetrated in none of the wells examined in the study area.

Verdigris Limestone. The Verdigris limestone is the uppermost persistent limestone marker bed of the Cherokee Group. It is approximately 80 to 110 ft. above the Pink limestone and 40 to 60 ft. below the Oswego limestone (Figure 2). The Verdigris is buff to light brown, finely crystalline to granular, generally 8 to 10 ft. thick, and it extends throughout the study area.

Prue Sandstone. The Prue sandstone interval (Figure 2) comprises gray to dark gray shale interbedded with thin beds of coal, siltstone, and discontinuous beds of sandstone. The sandstone is white, fine-grained, micaceous, calcareous, and tightly cemented. The few lenticular sandstones that are present within the study area generally are less than 20 ft. thick. The beds of sandstone are at various stratigraphic positions within the interval, but normally are 10 to 20 ft. below the base of the Oswego limestone.

Pennsylvanian System, Desmoinesian Series, Marmaton Group

The Marmaton Group (Figure 2) consists of limestones interbedded with shales. The group ranges from about 180 ft. to about 200 ft. thick. At some localities the group shows only a few shale "breaks." Lowermost beds of this group record the end of the repetitive Cherokee clastic depositional environments, and the beginning of predominantly marine carbonate-sediment depositional environments.

Oswego Limestone. The Oswego limestone is the basal unit of the Marmaton Group (Figure 2). The Oswego is composed of buff to gray, mottled, compact, finely crystalline limestone. It is sucrosic, argillaceous, dolomitic, and fossiliferous; oolitic and cherty strata are near the base. The Oswego contains evidence of weathered zones. Porosities of some beds within the Oswego range from 8 to 20 percent. The high porosities are mainly in oolitic strata, but in some cases are in weathered beds. Interbedded with limestone are thin, dark gray to black, micaceous shales. The Oswego extends throughout the thesis area; it ranges in thickness from 90 to 130 ft.

"Big Lime". The "Big Lime" interval (Figure 2) is separated from the Oswego by a shale approximately 10 to 20 ft. thick. The Big Lime is buff to gray, micritic to coarsely crystalline limestone. In some places, it is chalky, oolitic, slightly fossiliferous, and porous; locally it contains secondary dolomite. Within the study area, the Big Lime consists of two limestone units separated by a shale approximately 10 to 15 ft. thick. The entire interval is approximately 40 ft. thick.

The shale that lies between the Big Lime and the Oswego is dark gray to black, micaceous, and contains some green to mottled strata.

Pennsylvanian System, Missourian Series, Skiatook Group

Cleveland Sandstone. The Cleveland sandstone (Figure 2) is in the lower part of the Missourian Series. Sandstones of the Cleveland interval mostly are white to buff, and medium-grained. They are micaceous, argillaceous, calcareous to dolomitic, and range from tightly cemented to having moderately high porosity. Locally, thickness of the overall interval is approximately 150 ft., with the thickness of the sandstone ranging from 0 to approximately 70 feet.

The Peru[2] sandstone is next above the Big Lime (Figure 2). White to buff and fine- to medium-grained, the sandstone normally is micaceous, argillaceous, and calcareous to dolomitic.

In the upper part of the Cleveland sandstone format (Figure 2) is the Cleveland sandstone proper. The sandstone is as thick as 30 ft. at

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[2] Original use of the subsurface stratigraphic name "Peru" was in reference to sands within the Labette Shale, which is bounded below by the Oswego limestone and above by the Big Lime. However, in north-central Oklahoma, the name Peru commonly is applied to sands in the Lower Cleveland interval (Figure 3).

some places, where it shows log characteristics of a channel-like unit. It is buff to gray, and fine- to medium-grained. The sandstone also generally is micaceous, argillaceous, and calcareous to dolomitic.

Checkerboard Limestone. The Checkerboard limestone (Figure 2) generally is about 80 ft. above the Cleveland sandstone. The marker bed is approximately 10 to 20 ft. thick, and it comprises buff to mottled gray, fine-grained, dense, sucrosic, and slightly fossiliferous limestone. Due to the extensiveness of this unit and its relatively uniform stratigraphic position across the study area, it is an extremely good marker bed for structural contouring. However, at some localities within the study area, a limestone unit that is approximately 150 ft. above the Checkerboard limestone proper occasionally is also referred to as the Checkerboard limestone; this marker usually is distinguished by the term "Oklahoma City Checkerboard limestone." Because it is approximately 200 to 250 ft. above the Cleveland sandstone interval and is discontinuous across the study area, confusion of terminology generally is not problematic.

Lower Layton Sandstone. Stratigraphically above the "Oklahoma City Checkerboard limestone" and below the Hogshooter limestone (Figure 2), the Lower Layton sandstone is brown to light gray, fine-grained to very fine-grained, micaceous, carbonaceous, calcareous and shaly. In some wells the sandstone is glauconitic.

Hogshooter Limestone. The Hogshooter limestone is tan, compact, crystalline limestone. Its typical electric-log signature is that of a low spontaneous-potential signature and high resistivity. Although the Hogshooter generally is distinctive (Figure 2), it is discontinuous across part of the study area and therefore is an unreliable marker.

Paleotopography and Paleostructural Geology

Paleotopography

Isopachous maps were constructed as a means to evaluate the extent to which paleotopography of the Mississippian rocks and subsequent structural movement affected deposition of the Cherokee Group (Plates 8, 20, 21).

Paleotopography developed on Mississippian limestone can be approximated by contouring the thickness of the interval between the top of the Mississippian and a limestone marker bed a short distance above this unconformity. This method is based on these assumptions: (a) the Cherokee marker bed was deposited in an essentially horizontal position; (b) rocks below the marker bed should have thinned depositionally above the paleotopographic "highs" and thickened into paleotopographic "lows" and, therefore, (c) an isopachous map of rocks of such an interval should indicate paleotopography.

In the study area, the Pink limestone (Figure 2) is the most consistent marker bed nearest Mississippian rocks. The Mississippian paleotopographic surface was approximated by mapping the thickness of the interval between the base of the Pink and the top of the Mississippian (Plate 8)[3] or the top of older rocks that underlie the Pennsylvanian. Thickness of the interval ranges from 20 ft. in the western part of the study area to more than 120 ft. in the eastern part. The greatest

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[3] On Plate 8, index numbers of contour lines are shown with negative notation. These numbers indicate the distances of Mississippian rocks below the base of the Pink lime.

variation in thickness is near the northeastern corner of the study area (Plate 8).

Evidence shown on Plate 8 suggests that a southwest-trending drainage system developed on the Mississippian surface, and that one major stream crossed the southeasterly part of the study area. This stream apparently entered the eastern part of the study area near the boundary between T. 20 N., R. 2 W. and T. 20 N., R 1 W. and flowed southwesterly.

Paleostructural Geology

Possible paleostructural movement can be inferred by mapping the thickness of a stratigraphic interval between two thin, extensive marker beds. An isopachous map of the interval between the base of the Oswego limestone and the base of the Pink limestone was constructed as a means of estimating the extent to which structural movement may have influenced thickness of this part of the Cherokee Group (Plate 20). Structural factors include differential compaction, folding due to differential movement of rocks older than those of the interval mapped, or some combination of the two. Differential compaction of sediments on existing topographic or structural highs should result in an accentuation of these features; for example, thick deposits of mud in paleotopographically low areas compact more (in terms of feet) than do thinner deposits over paleotopographically high areas.

The "paleostructural map" (Plate 20) shows only two obviously anomalous areas. The interval mapped ranges from less than 100 ft. thick in the far western part of the thesis area to more than 160 ft. in the northeastern quadrant (Plate 20). Anomalously thin rocks trend northerly in Sections 4-6, 7-9, 18-16, 19-21, 26-30, and 31-33, T. 19

N., R. 4 W., and Sections 10-12, 14-15, 21-23, 26-29, and 32-33, T. 20 N., R. 4 W (Plate 20). Several broad areas of thin sequences are present within the thesis area, but these are not as pronounced as the trend in T. 19 N., R. 4 W., and T. 20 N., R. 4 W. Areas where the rocks are exceptionally thick include virtually all of T. 20 N., R. 2 W., and Sections 3, 4, and 10, T. 19 N., R. 2 W (Plate 20). Regionally the rocks tend to thicken southward in the thesis area and near the northwestern boundary of the thesis area (Plate 20).

Plates 22 and 23 indicate locations of negative paleostructural features and paleotopographic "lows" and positive paleostructural features and paleotopographic "highs", respectively.

Interpretation of these maps is based on Candler's (1976) work, which indicated that similar orientations of paleotopographic and paleostructural trends tend to show effects of (a) structural movement due to deformation of rocks older than the mapped interval, (b) variations caused by differential compaction of sediments within the interval, or (c) combination of (a) and (b). Testing of Candler's (1976) hypothesis within the study area does seem to generate support. Plate 22 shows that trends 1 and 1a are prominent negative features based on a thick section of rocks between the Oswego limestone and the Pink lime (cf. Plate 20). This thickness is suggestive of subsidence of these areas during deposition or of minimal compaction of sediments, relative to nearby areas. Trend 2 is a smaller, elongated negative feature, suggestive of a thickened section in a paleotopographic low (cf. Plate 8). Trend 3 is an elongate east-west negative feature, which has very small ellipsoidal "thicks" situated along its flanks, which suggest effects of differential compaction and some structural movement. Trends 4, 5, and

6 are elongate negative trends which have associated negative paleotopographic thicks. These are indicative of thickening into paleostructurally low areas (cf. Plates 8 and 20).

On Plate 23, Trend 1 shows evidence of thinning of stratigraphic sections that may be associated with paleostructurally high areas over which thinning by differential compaction may have occurred. Trend 2 is a broad east-west feature with some indication of associated paleotopographic thinning, suggestive of slight structural movement. Trends 3, 3a and 4 are broad features, associated perhaps with high-standing paleostructure or paleotopography. Trends 5 and 5a are suggestive of positive structural movement during deposition.

CHAPTER III

STRUCTURAL GEOLOGY

The study area is located in the west-central portion of the Northeastern Oklahoma Platform, and is bounded on the western edge by the Nemaha Ridge (Figure 3). Additional regional tectonic provinces that border the Northeastern Oklahoma Platform include the Ozark Uplift to the northeast, the Arkoma Basin to the southeast, and the Hunton Arch to the south (Figure 3).

Structural geology of the base of the Oswego Limestone (Plate 9) shows that regional strike is northwestward; dip is westward and southwestward, interrupted locally by folds and faults. Dip varies from as much as about 150 ft. per mile to as little as about 20 to 40 ft. per mile across the study area.

Several positive structural features interrupt the overall regional grain of the study area. A prominent faulted block extends across T. 20 N., R. 2 W. and the northern part of T. 19 N., R. 2 W (Plate 9). Structural closure against faults is as much as about 100 ft. at some places (Plate 9). The faults probably are en-echelon to some extent; they trend generally northward in T. 20 N., R. 2 W. Short east-trending faults intersect with the north-trending set in Sec. 5, T. 19 N., R. 2 W. (Plate 9). The Lucien Field is on the prominent upthrown block, in T. 20 N., R. 2 W. The data suggest that at the base of the Oswego limestone, strata are displaced as much as 300 ft. in some locations along the faults.

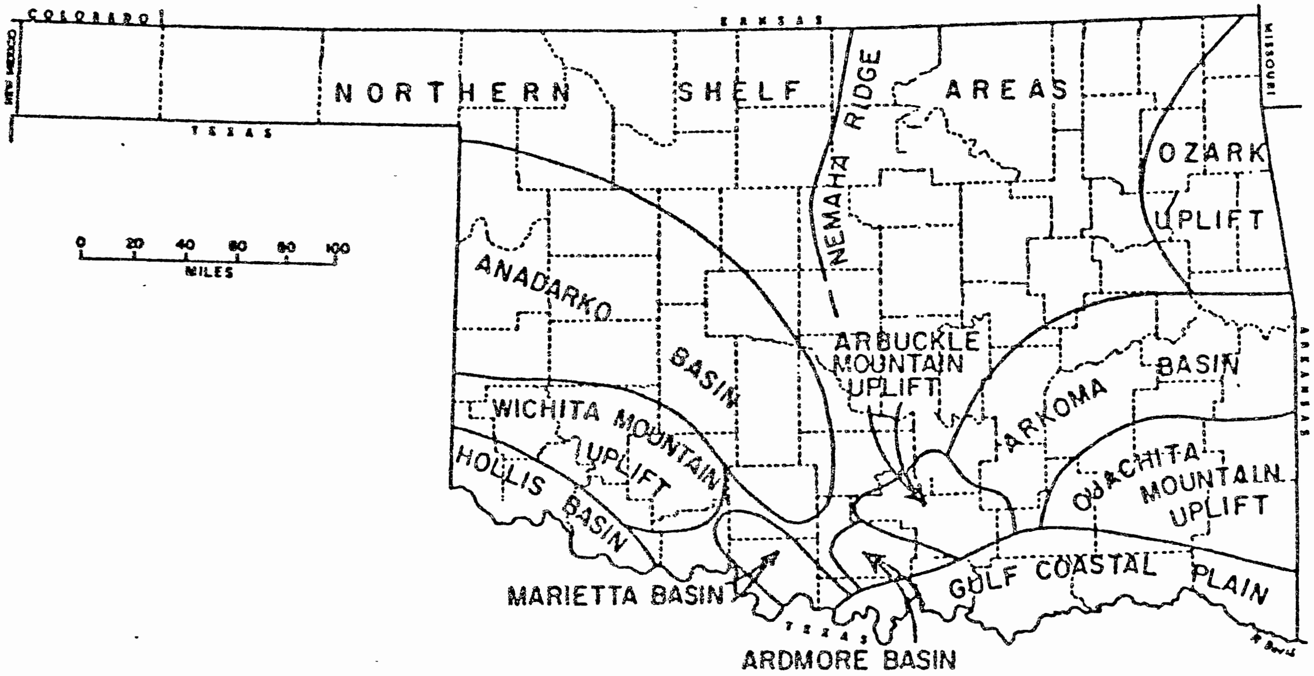

Figure 3. Geologic Provinces of Oklahoma

Structural geology of the central one-third of the study area basically is consistent with regional dip, but in this area are several pronounced anticlinal and synclinal noses.

An anticline in Sections 33 to 36, T. 20 N., R. 3 W. and Sections 4 through 6, 7 through 9, 16, and 18 of T. 19 N., R. 3 W. is bounded by a syncline in Sections 2 and 3, 10 and 11, 15 and 16, 21 and 22 T. 19 N., R. 3 W. (Plate 9).

In the western one-third of the study area, several moderately long normal faults show evidence of short splay faulting (Plate 9). This faulting is part of a larger system of faults located to the west and southwest of the study area, along the Nemaha Ridge. Several small anticlines appear to be related genetically to the faulting. Examples are in Sections 30 and 31, T. 19 N., R. 4 w., Sections 17 and 18, 19 and 20 of T. 19 N., R. 4 W., Section 31, T. 20 N., R. 4 W., and Section 6 of T. 19 N., R. 4 W. (Plate 9). Although the southwestern part of the study are is extensively faulted, the faults seem to die out northward in Sections 31 and 33, T. 20 N., R. 4 W. The northwestern part of the study area shows mostly regional dip, interrupted by a fault and several small folds within T. 20 N., R. 4 W. A normal fault extends from Sections 4 and 5 to Sections 8 and 17 of T. 20 N., R. 4 W (Plate 9). Although this fault appears to terminate in Section 17, it may extend to the fault in Section 31, T. 20 N., R. 4 W. Two small, prominent anticlines within T. 20 N., R. 4 W. are in Sections 9 and 10, and in Section 12. In general, structural trends mapped at the base of the Oswego are representative of structural trends at the base of Pennsylvanian rocks, and larger pre-Pennsylvanian anticlinal features also are expressed (cf. Plates 9, 24, 25).

A structural contour map of the base of the Checkerboard limestone (Plate 10) indicates that flexure and faulting at the Oswego level and deeper are shown at Checkerboard level, but that axes are offset slightly.[4]

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[4] Faults shown on Plate 10 are inferred largely from Plate 9. The writer recognizes that faulting may be less extensive than is shown, but evidence compiled in the course of this study suggests that some of the deeper faults extend as high in the section as the Checkerboard limestone.

CHAPTER IV

INFERRED DEPOSITIONAL ENVIRONMENTS AND TRENDS OF SANDSTONE UNITS

Depositional environments and trends of the Lower Layton, Cleveland and Cherokee sandstone units were inferred from data already discussed, log maps, and isopach maps of gross sandstone.

As a general assumption, shapes of spontaneous-potential curves of well logs are regarded as being indicative of the vertical sequence of textures and lithologies of depositional units (Visher and others, 1971; Shelton, 1973). Each pattern is suggestive of a particular environment or subenvironment. In construction of a regional log map, the grouping of similar log shapes leads to the outlining of presumed different paleodepositional environments (Plates 16-19).

Cherokee Group

The Cherokee Group extends throughout the thesis area as a sandstone-and-shale sequence. The Redfork and Prue sandstones (Figure 2) are developed in only a few isolated areas. Because of the lack of data, depositional environments of the Redfork and Prue will not be dealt with as a primary topic. However, the general depositional setting of both sandstones probably is deltaic. The Lower Skinner Sand is the only well-developed, extensive Cherokee unit.

Lower Skinner Sandstone

The Lower Skinner sandstone, located mainly in the northwestern quadrant of the study area (Plate 16) extends mainly across T. 20 N., R. 2 W., and the eastern edge of T. 20 N., R. 3 W.

Thickness of the Lower Skinner sandstone is about 20 ft., on the average. Shapes of spontaneous-potential curves of the Lower Skinner sandstone (Plate 16) suggest the general occurrence of gradational lower contacts and locally, abrupt erosive basal contacts. Regional setting of the study area is deltaic-shallow marine (Shipley, 1975; Candler, 1976; Astarita, 1975).

Based on combination of evidence from the regional setting, variations in patterns of thickness, and shapes of log curves, these two inferences seem to be warranted: (a) in the eastern part of the study area, sandstone probably was deposited in small distributary channels and in delta-fringe areas. (For example, the former type of sandstone is in Sec. 2, T. 20 N., R. 2 W., Sec. 35, T. 20 N., R. 2 W., and Sec. 25, T. 20 N., R. 3 W.) Sheetlike sandstone is evident in numerous other log profiles. Source areas probably were to the north and east.

The log map and isopach map (Plates 16 and 11) show definite patterns in presence and absence of Lower Skinner sand, the patterns being suggestive of some type of distributary system.

Cleveland Sandstone Interval

In the Cleveland sandstone interval (Figure 2) sandstone is distributed widely in the study area. The thickest sandstone unit trends westerly subparallel to the Garfield - Logan county line and the Logan - Noble county line (Plate 12). Thin deposits bound this thick sandstone unit on the north and south.

At some localities, stratigraphy of the Cleveland interval is that of a lower sandstone unit commonly locally referred to as the "Peru" and an upper unit referred to as the "Jones". Where the entire interval is composed predominantly of sandstone, then the sandstone is referred to as the "Cleveland" sandstone.

"Peru" Sandstone. The Peru sandstone, in the lower part of the Cleveland interval, mostly is in the southern two-thirds of the study area. Plate 17 indicates that the Peru is a short distance above the Big Lime, and that locally the Peru is disconformable upon the Big Lime (for example, in the southern part of T. 20 N., R. 2 W.). Thickness of the Peru generally ranges from 30 to 60 ft. (Plate 17), but because of the general stratigraphy of the Cleveland interval, the Peru is not clearly distinguished at some places.

The spontaneous-potential curve of the Peru generally is slightly bell-shaped, implying sharp basal contacts and gradational upper contacts of sandstone units. Probably the general depositional setting was one of distributary channels and delta-front terrain. An alternate explanation could be terrain comprising distributary channels and interdistributary bays. Either of these hypotheses would be consistent with local patterns, such as is shown on Plate 17, but the initial explanation is considered to be the more probable one.

Several wells that show log shapes judged perhaps to be indicative of delta-fringe environments are located in Section 22, T. 19 N., R. 4 W., and Section 27, T. 19 N., R. 3 W.

"Jones" Sandstone. The Jones sandstone is present throughout the study area as a thin, extensive upper Cleveland sandstone unit (Plate 17). Log maps of the Cleveland interval (Plates 17, 18) show that the stratigraphic position of the Jones sandstone generally is a short distance below the Checkerboard limestone (the uppermost marker on the log map). The Jones interval is about 30 feet thick, on the average but at some places it is as thick as 60 feet.

The spontaneous-potential curve within this interval is a serrate "funnel-shaped" curve. Generally the interval is interbedded sandstone and shale; sandstones seem to have gradational bases and rather abrupt upper contacts. The uppermost part of the sequence may be extraordinarily calcareous or siliceous, a property suggested by the generally high resistivity. The Jones sandstone probably was deposited in delta-fringe environments.

Several wells that show characteristic log shapes of this unit are in Section 1, T. 20 N., R. 2 W., Section 14, T. 19 N., R. 2 W., and Section 5, T. 20 N., R. 4 W.

"Lower Cleveland" Sandstone. The undifferentiated "Lower Cleveland" sandstone is thick and fine-grained to very fine-grained. At some places in the study area, this unit is at least 120 ft. thick (Plate 12). The unit trends westerly in a belt as wide as 2 mi. at some localities (Plate 12). The spontaneous-potential curve generally is slightly serrate to smoothly cylindrical or bell-shaped (Plate 18). The restricted width of this thick belt, its overall linear extent, and shapes of the spontaneous-potential curve all suggest distributary-channel or perhaps fluvial deposition.

Several wells that tend to show evidence suggestive of distributary-channel fill are in Sections 26 and 35, T. 20 N., R. 2 W., Section 5, T. 19 N., R. 2 W., and Section 1, T. 19N., R. 4 W. (Plate 18).

Regional Trends

The overall sequence of deposition within the Cleveland stratigraphic interval perhaps was: (1) Sand deposited probably as delta-fringe sand and sand in minor distributary channels. (2) Transgression and deposition of clayey sediments. (3) Regression and extension of delta-fringe sands, the Jones unit. (4) Extension of a distributary channel across delta-fringe terrain in a westerly direction, with cutting-out of the Jones and Peru units and deposition of thick, multistoried Cleveland sandstone. A noteworthy fact is that the Checkerboard-to-Big Lime isopach map (Plate 21) shows strongly the trend of channel-fill sandstone in the Cleveland interval.

Lower Layton Sandstone Interval. Within the study area, the Lower Layton interval comprises interbedded sandstone and shale. Lower Layton sandstone is distributed widely in the eastern one-half of the study area; therefore, the isopach and log maps pertain only to that area where data are sufficient for meaningful mapping.

The Lower Layton interval generally is bounded above by the Hogshooter Limestone (Figure 2) and the "Oklahoma City Checkerboard Limestone," which is a short distance below the Hogshooter. However, the Oklahoma City Checkerboard marker-unit is absent at some localities in the study area. Therefore, the mapped interval comprises all strata between the Hogshooter Limestone and the Checkerboard Limestone. Because of the exceptional variability of sandstone within the Layton interval (Plate 19), the information shown on isopach maps (Plates 14,

15) is limited to sandstone developed closely beneath the Hogshooter Limestone (for example, compare the northeastern part of T. 20 N., R. 2 W. on Plates 14 and 20).

The isopach map of the Lower Layton (Plate 14) suggests anastomosing thick sandstone units that are coalescent at some localities. (For example, in Sections 4 and 5, T. 19 N., R. 2 W., Sections 1-3, T. 19 N., R. 3 W., and Sections 34-36, T. 20 N., R. 3 W.) Widths of the thick sandstone units are as much as 2 to 2 1/2 mi., and thicknesses are more than 80 ft. at some localities.

CHAPTER V

PETROLEUM GEOLOGY

Study of the larger oil fields in the thesis area (Plate 26), of productive stratigraphic units (Table I), and of cumulative production (Tables II-IV) is necessary to evaluate the economic potential of sandstone units discussed above. Many of the oil fields produce from more than one reservoir. The general conclusion reached from evaluation of statistics on production is that exploration for Cherokee, Cleveland, and Lower Layton reservoirs can be quite profitable. In the study area, depths of oil- and gas-productive rocks range from 2400 ft. to 5600 ft.

First production was established in 1926 in the Crescent Lovell Pool (Plate 26). The production within this field is from several stratigraphic intervals (Plate 27; Table III). Although about 190 wells still produce within the field, many wells previously abandoned now are under secondary recovery procedures. Because the Crescent Lovell Field is quite old, total production is not known. However, this field still produces at least 360,000 barrels of crude per year. Also, it is impossible to tabulate production from individual reservoirs, and thus the overall performances of the Cleveland and Lower Layton sandstones are not known.

Lucien Field (Plate 26) has produced since 1932. It includes more than 200 wells. Numerous rock units are productive and to date, more than 53,700,000 barrels of oil have been produced.

Smaller fields (Plate 26) include North Lucien, which was discovered in 1936. This field produces from 18 wells; cumulative production is more than 3,500,000 barrels of oil, from several stratigraphic units (Plate 27), including the Skinner and Layton sands.

Tables I, II, III, and IV show that in most fields, a few to several formations are productive. Therefore, to calculate per-well, per-stratigraphic unit production is almost impossible.[1]

The most productive fields in the thesis area are structural traps. Entrapment of oil in the Cleveland and Layton sandstones also is strongly influenced by structural geology (Plates 13, 15). The Skinner sandstone seems to be the only producing sand in which entrapment is primarily stratigraphic.

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[1] Statistics on production discussed above and shown in Tables I-IV were obtained from Petroleum Information Corporation (1982) and from some private sources.

TABLE I

ABBREVIATED STRATIGRAPHIC SECTION COMMON NAMES OF PRODUCING INTERVALS

Subsurface	Nomenclature	Abbreviations
Pennsylvanian	Hoover Sand	Hovr
	Endicott Sand	
	Tonkawa Sand	Tnks
	Perry Gas Sand	Prry
	Avant Limestone	
	Layton Sand	
	Cleveland Sand	Clvd
	Peru Sand	
	Big Lime-Oswego Lime	
	Skinner Sand	Sknr
	Red Fork Sand	Rd Fk
	Burgess Sand	Brgs
Mississippian	Mississippi Chat	Chat
	Mississippi Lime	Miss
Devonian	Misener Sand	Msnr
	Hunton Lime	H
Ordovician	Viola Lime	V
	Wilcox Sand	Wlcx
Cambrian	Arbuckle Lime	Arb

TABLE II

DATA ON FIELDS PRODUCING FROM THE CHEROKEE INTERVAL

Field	Producing Formations	Date Disc.	No. Wells Producing	Bbls., 1982	Cum. Production (Bbls.)
Asp N. W.	Skinner	5-74	1	1,719	51,019
Brown E.	Osw., Sknr. Wlcx.	8-45	4	2,047	437,569
Elkhorn N. E.	Carm., Hovr., Sknr., Miss., Msnr.	1-53	22	15,857	1,042,507
Gansel E	Skinner	10-57	19	27,549	967,117
Lucien N.	Ltn., Osw. Sknr., Miss. Msnr., V. Wlcx.	12-36	18	17,832	3,569,410
Lucien N. E.	Osw., Sknr. Msnr., V. Wlcx.	6-42	6	3,552	1,293,570
Lucien S.	Clvd., Sknr. Miss.	6-55	3	31,641	211,799
Mitchell	Sknr., Miss.	5-65	3	4,035	12,127
Orlando S.	Clvd., Sknr.	2-55	6	13,792	195,133

TABLE III

DATA ON FIELDS PRODUCING FROM THE CLEVELAND-PERU INTERVALS

Field	Producing Formations	Date Disc.	No. Wells Producing	Bbls., 1982	Cum. Production (Bbls.)
Crescent-Lovell	End., Carm. Clvd., Ltn. Miss., V., Wlcx.	5-26	192	189,915	Unknown
Elkhorn N.	Vertz Clvd.	12-74	13	8,317	122,435
Lucien S.	Clvd., Sknr.	6-55	3	31,641	211,799
Marshall E.	Clvd., Miss.	6-66	18	71,794	246,810
Marshall N.	Clvd., Ltn. Peru, Miss. Wlcx.	7-50	14	10,224	669,193
Marshall S. E.	Clvd., Miss.	6-76	1	333	1,236
Orlando S.	Clvd., Sknr.	2-55	6	13,792	195,133

TABLE IV

DATA ON FIELDS PRODUCING FROM THE LOWER LAYTON INTERVAL

Field	Producing Formations	Date Disc.	No. Wells Producing	Bbls., 1982	Cum. Production (Bbls.)
Brown	Ltn., Osw. Miss., V. Wlcx., Arb.	5-30	8	4,978	2,316,130
Crescent-Lovell	End., Carm. Clvd., Ltn. Miss., V., Wlcx.	5-26	192	189,915	Unknown
Douglas S. E.	Ltn.	6-67	11	11,767	312,072
Elkhorn N. W.	Avt., Ltn., Miss.	3-55	25	74,464	256,464
Elkhorn S.	Miss., Ltn.	9-68	33	24,486	304,393
Hull N.	Ltn., Miss.	3-77	15	9,264	155,692
Lucien	Multi-zone	9-32	216	119,875	53,742,480
Lucien N.	Ltn., Osw., Sknr., Miss. V., Wlcx.	12-36	18	17,832	3,569,410
Lucien W.	Sknr., Ltn., Miss.	5-75	21	7,389	421,457
Marshall N.	Clvd., Ltn. Peru, Miss. Wlcx.	7-50	14	10,224	669,193

CHAPTER VI

CONCLUSIONS

Principal conclusions of this study are:

1. The Cherokee Group unconformably overlies the Mississippian limestone.

2. The Cherokee rocks thin west and north of the study area indicating transgressive onlap of the Cherokee Group onto the eroded Mississippian System.

3. The Red Fork, Skinner, and Prue sandstones intervals primarily are shale, with local lenticular sandstones.

4. The Skinner sandstone is believed to be deltaic in origin. Inferred depositional environments would be distributary channels and delta-fringe terrain.

5. Source area of the Cherokee sediments is believed to have been east and northeast of study area.

6. Sandstone deposits mainly are in the eastern and northeastern parts of the study area.

7. The structural contour map of the base of the Oswego limestone indicates essentially homoclinal structure in the central part of the study area, superimposed on which is a large anticlinal nose. The northeastern one-quarter and the southwestern one-quarter of the study area are terrain of faulted anticlinal structure.

8. Sediments of the Cherokee Group were influenced by

paleotopography of the surface of Mississippian rocks. The Cherokee sediments also were influenced locally by paleostructure, including differential compaction and structural movement.

9. The Skinner is the only producing interval within the Cherokee Group that is commercially productive of hydrocarbons within the study area.

10. The Skinner production is not closely related to structural geology.

11. Lower Cleveland (Peru) sandstone is disconformable upon the Big Lime at some localities.

12. Cleveland rocks thin to the north of the study area.

13. The Cleveland stratigraphic interval is thought to be deltaic in origin. Inferred depositional environments include deltaic distributaries and delta-fringe sandstones.

14. Source area of Cleveland sediments is believed to have been east and northeast of the study area.

15. Sandstone in the Cleveland interval is thin and widely distributed over the study area; one thick Cleveland sandstone extends westward across the study area.

16. Sediments deposited in the Cleveland interval seem not to have been influenced significantly by pre-Pennsylvanian paleotopography or by paleostructural geology of the Mississippian limestone and older rocks.

17. Parts of the Cleveland interval are commercially productive of oil and gas within the thesis area.

18. Production from the Cleveland is due to combination of structural geology and stratigraphic entrapment.

19. The Lower Layton interval is thought to be deltaic in origin.

Inferred depositional environments suggest a mix of delta-fringe terrain and deltaic distributaries.

20. Depositional geometry of the Lower Layton seems to have been influenced slightly or not at all by pre-existent structural geology.

21. Source area of the Lower Layton sediments is believed to have been east and northeast of the study area.

22. Parts of the Lower Layton are commercially productive of oil and gas.

23. Commercial production from the Lower Layton is due to combination of structural geology and stratigraphy.

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LOCATIONS OF LOGS SHOWN ON CORRELATION SECTIONS

Correlation Section A-A'

1. Gibralter Oil No. 1-4 Meier
   NE NW NW Sec. 4, T. 20 N., R. 4 W.

2. Rodman Corp. No. 1-4 Bentz
   C SE SE Sec. 4, T. 20 N., R. 4 W.

3. B. R. Polk & May Pet. No. 2 Johnson "A" (Also D-D')
   SW NE SW Sec. 15, T. 20 N., R. 4 W.

4. Schermerhorn Oil No. 1-4 Thomson (Also E-E')
   NE NW SW Sec. 4, T. 19 N., R. 4 W.

5. F. C. D. LTD. No. 1 Reim "A"
   C SE NW Sec. 16, T. 19 N., R. 4 W.

6. B. R. Polk Inc. No. 1-21 Warden/Wehling
   C W/2 NW Sec. 21, T. 19 N., R. 4 W.

7. Midstates Oil No. 1-32 Abrams (Also F-F')
   NW NW SW Sec. 32, T. 19 N., R. 4 W.

Correlation Section B-B'

8. Cities Service Oil Co. No. 1-1 Haber
   NW SE NW Sec. 1, T. 20 N., R. 3 W.

9. Aggie Oil Co. No. 1-10 Redding (Also D-D')
   C SE SE Sec. 10, T. 20 N., R. 3 W.

10. Earth Energy Res. No. 2-27 Caudle.
    SE SE SE Sec. 27, T. 20 N., R. 3 W.

11. Sun Oil No. 1-3 Zondler
    SE NE NE Sec. 3, T. 19 N., R. 3 W.

12. Jet Oil No. 1-4 Crews (Also E-E')
    SE SE SE Sec. 11, T. 19 N., R. 3 W.

13. Shell Oil No. 1-16 Oldenburg
    C SW NW Sec. 16, T. 19 N., R. 3 W.

14. Sidwell Oil & Gas No. 1-27 Oldenburg
    C SE SW Sec. 27, T. 19 N., R. 3 W.

15. Fears & Buck No. 1-33 Acton (Also F-F')
    C SE SE Sec. 33, T. 19 N., R. 3 W.

Correlation Section C-C'

16. T. N. Berry & Co., No. 1-4 Reppert
NW NW NW Sec. 4, T. 20 N., R. 2 W.

17. Wm. A. Jenkins, Delaware, Inc. No. 1-16 Jerome (Also D-D')
SE NW SW Sec. 16, T. 20 N., R. 2 W.

18. Max Pray No. 1-28 Kolb.
NE NE SW Sec. 28, T. 20 N., R. 2 W.

19. Bonray Oil & Blaik Oil Co., No. 1-28 Kolb
SW SE SW Sec. 28, T. 20 N., R. 2 W.

20. Continental Oil No. 1-4 Grininger (Also E-E')
NE NW SE Sec. 4, T. 19 N., R. 2 W.

21. Brooks Hall Corp., No. 1-16 Frey
NE SW Sec. 16, T. 19 N., R. 2 W.

22. Appleton Oil Corp. No. 1-28 Henke
NE SW Sec. 28, T. 19 N., R. 2 W.

23. Harper Oil No. 1-33 Howard
E 1/2 W 1/2 NE NW Sec. 33, T. 19 N., R. 2 W.

24. Hillshafer Duncan Co. (R. D. McAnich) No. 1-22 Wepant (Also F-F')
SW SW SW Sec. 33, T. 19 N., R. 2 W.

Correlation Section D-D'

25. Arco Oil & Gas Co., No. 1-18 Frank Burton
NE NW Sec. 18, T. 20 N., R. 4 W.

3. B. R. Polk & May Pet. No. 2 Johnson "A" (Also A-A')
SW NE SW Sec. 15, T. 20 N., R. 4 W.

26. Wm. A. Jenkins, Inc. No. 1-7 Pauline
C SE NW Sec. 7, T. 20 N., R. 3 W.

9. Aggie Oil Co., No. 1-10 Redding (Also B-B')
C SE SE Sec. 10, T. 20 N., R. 3 W.

17. Wm. A. Jenkins, Delaware, Inc. No. 1-16 Jerome. (Also C-C')
SE NW SW Sec. 16, T. 20 N., R. 2 W.

27. Berry Operating Co., No. 2-11 Sams
SE NE SW Sec. 11, T. 20 N., R. 2 W.

28. Bentley & Laing No. 1-13 Mulch
NW NE NE Sec. 13, T. 20 N., R. 2 W.

Correlation Section E-E'

29. Texas Co. No. 1-16 Cromer
NW SW SE Sec. 6, T. 19 N., R. 4 W.

4. Schermerhorn Oil No. 1-4 Thompson (Also A-A')
NE NW SW Sec. 4, T. 19 N., R. 4 W.

30. Wheatland Oil Co. No. 1-11 Cassady
C NW NW Sec. 11, T. 19 N., R. 4 W.

31. Hungerford Oil & Gas No. 1-6 Jordon
SW NW SW SE Sec. 6, T. 19 N., R. 3 W.

12. Jet Oil No. 1-4 Crews (Also B-B')
SE SE SE Sec. 11, T. 19 N., R. 2 W.

32. Nadel & Gussman No. 1-8 Bulling
NW NW NE Sec. 8, T. 19 N., R. 2 W.

20. Continental Oil No. 1-4 Grininger (Also C-C')
NE NW SE Sec. 4, T. 19 N., R. 2 W.

32. Woods Oil & Gas No. 1-10 Brase
SE SE NE Sec. 10, T. 19 N., R. 2 W.

34. Tenn. Gas Trans. No. 1-12 J. W. Powers
SE SW NW Sec. 12, T. 19 N., R. 2 W.

Correlation Section F-F'

7. Midstates Oil No. 1-32 Abrams (Also A-A')
NW NW SW Sec. 32, T. 19 N., R. 4 W.

35. B. R. Polk, Inc. No. 1-34 Griffy-York
NW NE Sec. 34, T. 19 N., R. 4 W.

36. Vancol Oil Company, Inc. No. 1-31 Post
NW NW Sec. 31, T. 19 N., R. 3 W.

15. Fears & Buck No. 1-33 Acton (Also B-B')
C SE SE Sec. 33, T. 19 N., R. 3 W.

37. Joe L. Thompson No. 1-35 Cothern
NW NE SE Sec. 35, T. 19 N., R. 3 W.

24. Hillshafer Duncan Co. (R. D. McAninch) No. 1-22 Wepant (Also C-C')
SW SW SW Sec. 33, T. 19 N., R. 2 W.

38. Peninsula Exploration Co., No. 1-35 Pfeiffer
SE SW Sec. 35, T. 19 N., R. 2 W.

39. Wilshire Oil Company of Texas No. 1-25 Bircket
50 ft. W of CNE SW Sec. 25, T. 19 N., R. 2 W.

VITA 2

Nancy E. Campbell

Candidate for the Degree

Master of Science

Thesis: SUBSURFACE STRATIGRAPHIC ANALYSIS OF THE SKIATOOK AND "CHEROKEE" GROUPS IN THE SOUTHWESTERN PART OF NOBLE COUNTY, NORTHERN PART OF LOGAN COUNTY, AND THE SOUTHEASTERN PART OF GARFIELD COUNTY, OKLAHOMA

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