STRUCTURAL CONTOUR MAP OF OKLAHOMA ON THE PENNSYLVANIAN WAPANUCKA LIMESTONE, OSWEGO LIMESTONE, BASE OF THE HOXBAR GROUP, AND CHECKER-BOARD LIMESTONE

By

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PREFACE

The primary purpose of this study is the preparation of a regional Pennsylvanian structural map of Oklahoma after establishment of a correlation framework of potentially mappable horizons and other key beds. A secondary objective is a comparison of the Pennsylvanian structure with other geologic parameters of Oklahoma.

The author expresses his appreciation to his major adviser, Dr. John W. Shelton, for suggesting this problem for thesis study and for his guidance and assistance in the preparation of the map, cross sections, and manuscript. Appreciation is also expressed to Dr. G.F. Stewart and Dr. J.W. Trammell for their helpful suggestions and advice throughout the study.

A note of thanks is extended to fellow graduate students, especially Gary Ford and Jim Kochick, for their help and suggestions.

The writer is indebted to the Oklahoma Well Log Library and the Oklahoma City Well Log Library for supplying valuable well information and also to Darrell Haston and Shane Hembree for drafting the map and cross sections. Appreciation is also extended to JoAnn Jordan for typing the final manuscript.

Special gratitude is extended to my wife, Mary, for her work, encouragement and patience. Finally, special thanks are offered to my parents, Charles and Marilyn Fritz, and to the rest of my family for their help and encouragement.

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ABSTRACT

The general structural configuration of Pennsylvanian strata on the platform and in basinal areas of Oklahoma was determined through the recognition, correlation and mapping of key Pennsylvanian rock units. These are the Wapanucka Limestone, the Oswego Limestone, the base of the Hoxbar group (base of the "second Checkerboard Limestone") and the Checkerboard Limestone. Correlation across the Oklahoma platform indicates that two limestones are commonly regarded as the Oswego Limestone; the upper limestone is the Altamont Limestone Member of the Oologah Formation and the lower is the actual Oswego Limestone. Data were derived from previously reported well data, electric and radioactive well logs, correlation sections and previous works. Also involved in the study is the interpretation of structural origin and history. Mapping procedure involved preparation of local maps (1;63,360) and the reduction and compilation of these maps into a regional map (1:500,000).

Major trends are north-northeast on the platform and associated secondary trends are east-west. Drape folding over uplifts along these alignments may form structures. The Nemaha range is significantly more complex in the pre-Pennsylvanian sections than at the Oswego position. In the Anadarko and Arkoma basins structures are parallel or subparallel to the basinal axes and/or the associated uplifts. Most of the structures of Oklahoma formed during Late Pennsylvanian orogenic

activity; some activity represents rejuvenation of older structures during that period. Most of the larger structures are probably related to a component of dip-slip movement associated with major left-lateral strike-slip faulting. Some features formed as a result of differential compaction due to the irregularities of the Precambrian surface or due to lateral variation in lithology. Plate movement may have been the ultimate cause for major strike-slip movement within the study area and the bounding uplifts to the south. The structure of the Anadarko basin may be related to Early Paleozoic aulacogen formation.

Many of the larger Pennsylvanian structures are reflected by paleogeological and certain geophysical parameters.

CHAPTER I

INTRODUCTION

The area covered by this study extends westward from the outcrop of the Fort Scott Limestone (or the informally defined Oswego Limestone of the subsurface) in northeastern Oklahoma (T29N, R19E to T15N, R12E), and from the western part of the Arkoma basin (R12E), to the Texas state line (R26W), and southward from the Kansas state line (T29N) to the Wichita and Arbuckle uplifts in southern Oklahoma (T10N, R26W to T3S, R12E).

This area includes 50 of the 77 counties in Oklahoma and encompasses approximately 36,000 square miles (Fig. 1).

Purpose of Study

The purpose of this study is the preparation of a regional Pennsylvanian structural map of Oklahoma after establishment of a correlation framework of mapped horizons and other key beds (Figs. 2 and 3).

The main objective is to provide a meaningful map on a regional scale for delineation in some detail of significant structural features and trends portrayed by Pennsylvanian units in areas where deformation is not extreme.

Procedure

The procedure involves three parts: (a) selection of suitable

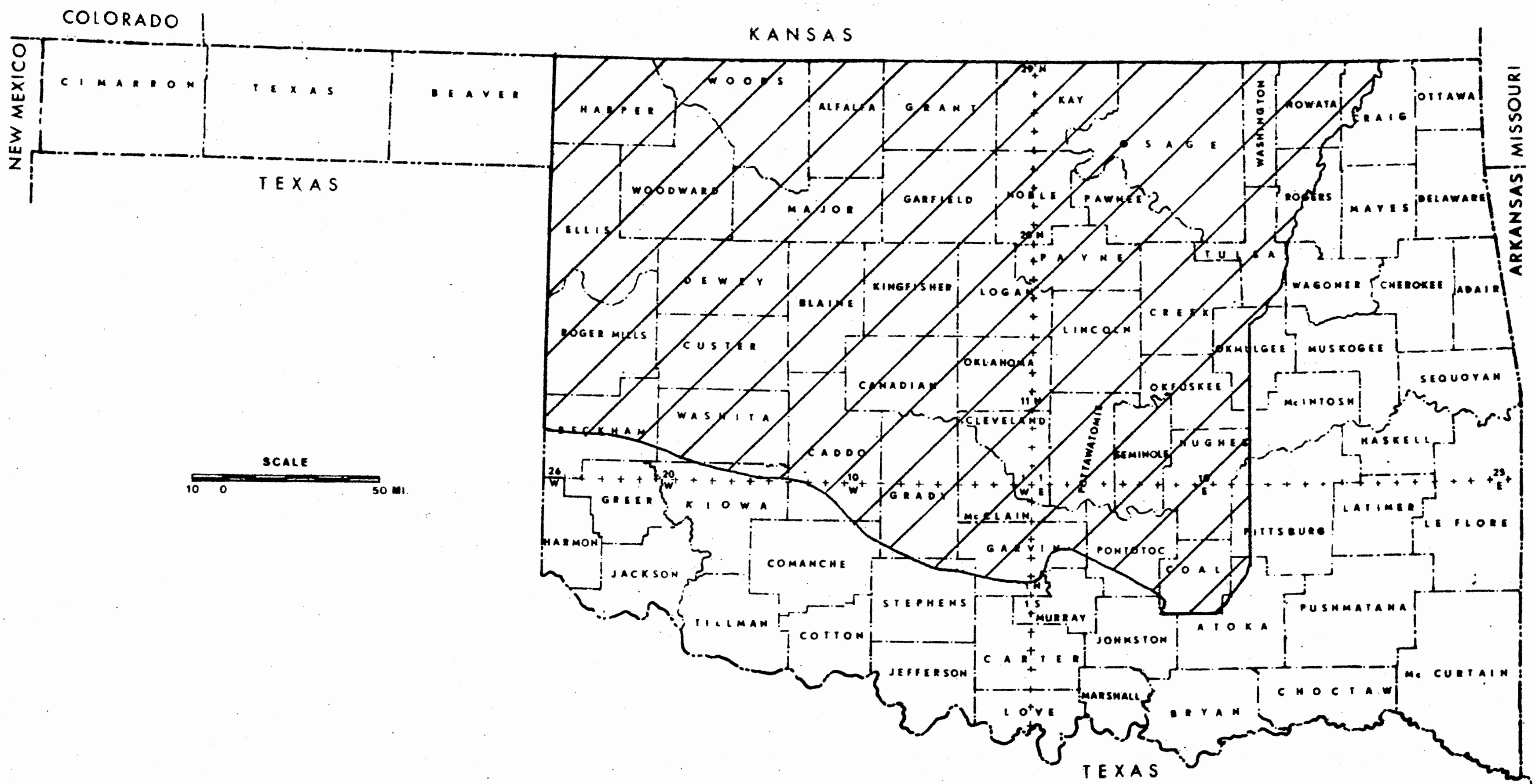

Fig. 1.-Index map of study area.

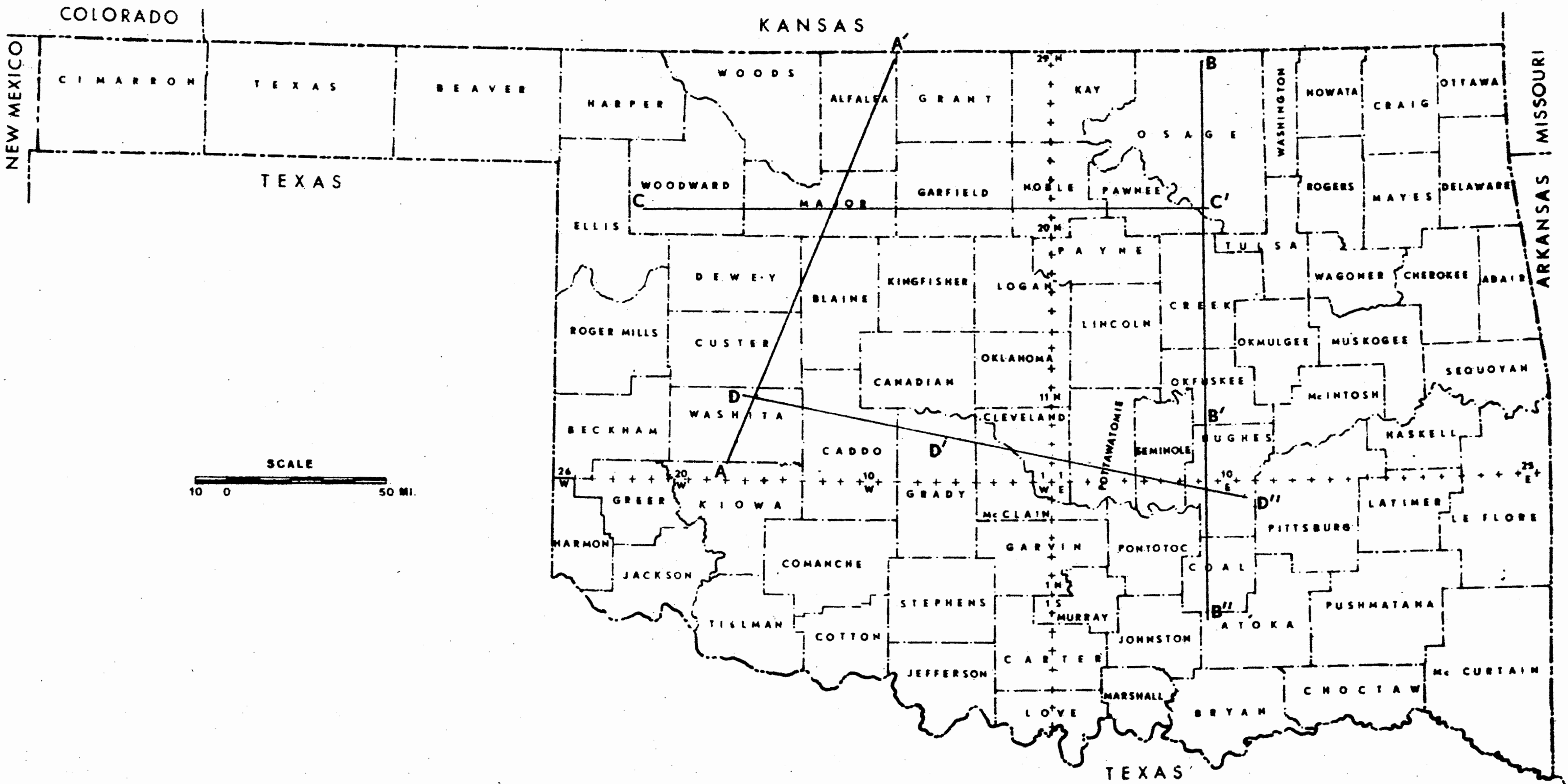

Fig. 2.-Location of correlation sections used in preparation of correlation framework.

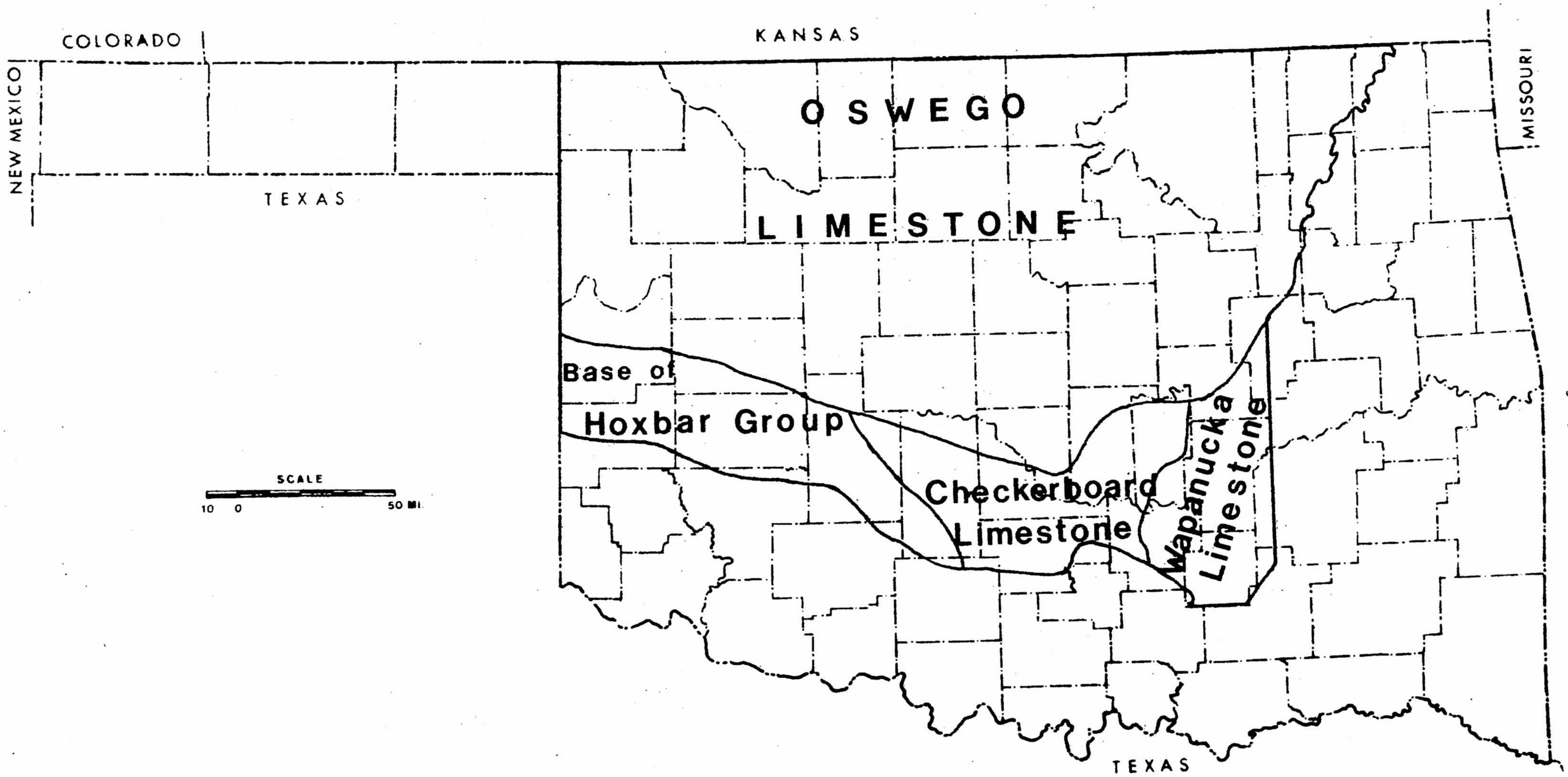

Fig. 3.-Index map showing areas for the different reference units or surfaces.

mappable horizons, (b) preparation of local maps, and (c) compilation of the regional map.

The horizons utilized were selected on the basis of the following criteria. These are: (1) traceable and mappable rock units with significant areal extent, (2) easy recognition on well logs, (3) common reference horizons or "markers" used and reported by previous workers, and (4) stratigraphic position in or near the middle part of the Pennsylvanian section in order to give a good representation of the structure of Pennsylvanian strata. These requirements generally restrict the available horizons to limestone markers.

Previous stratigraphic studies were examined in order to determine those horizons which had been utilized most widely in mapping. Samples of "scout data" were checked for the most commonly reported stratal horizons (or "tops").

The three limestone markers selected after this phase of the study are (1) the Oswego Limestone for central, western and northern Oklahoma, covering the known extent of the Oswego Limestone in Oklahoma, (2) the Checkerboard Limestone in south-central Oklahoma and (3) the Wapanucka Limestone in the southeastern part of the study area.

In the more negative part of the Anadarko basin, or southwestern part of the study area, no units completely meet the requirements because of the lateral changes in facies from limestone to sandstone-shale sequences. However, a fairly consistent marker is present near the base of the second Checkerboard Limestone, or base of the Hoxbar Group, marking the approximate top of the Desmoinesian series. This marker was used in the southwestern part of the study area because of the availability of data, maps, and cross sections. The writer recognizes that correlation of this marker is less reliable than the ideal features represented by the Oswego and Checkerboard.

The limits of these four horizons in mapping are shown in Figure 2. Their stratigraphic positions and log characteristics are shown on four regional correlation sections (Plates I-VI). Associated limestone marker beds are also shown on the sections to emphasize the positions of the mapping horizons.

Structural maps of these Pennsylvanian markers were made at a scale of one inch equal to one mile and a contour interval of 50 feet. In some of the Anadarko basin, however, a lower density of wells made a regional scale and a contour interval of 100, 250, or 500 feet more suitable in mapping.

The most commonly used data are scout information. Because the accuracy of these reported tops varies, an average of four electric logs per township was correlated with the correlation sections in order to examine the quality of the scout data.

Also, various publications and theses with structural maps and cross sections were used as guides and sources of data.

In areas where data on a particular marker were sparse or questionable in quality, available isopach maps and/or estimates of thicknesses were used along with structural maps on the associated horizons.

For mapping purposes minimal "throw" (vertical separation) along faults was established initially as 100 feet and minimal length was set at six miles; however, in order to show the desired detail in some areas, it was necessary to make exceptions.

After the small-scale maps were completed, the structurally anomalous areas, including those affected significantly by faulting, and areas of facies changes were further checked with additional well logs and published data. The maps were reduced photographically to a scale of 1:500,000, the scale of the Oklahoma Geologic Map. Contour intervals of the finished regional map are 100 feet for most of the area and 250, 500, or 1000 feet in the basinal areas.

Previous Investigations

Due to the emphasis of petroleum geology in Oklahoma, many local and regional structural studies have been made. Some of the earliest investigations were made by the United States Geological Survey and the Oklahoma Geological Survey. Various government publications used include bulletins, circulars, maps, and reports.

Other sources of published data are the American Association of Petroleum Geologists, Geological Society of America, Tulsa Geological Society, Oklahoma City Geological Society and trade magazines such as the Oil and Gas Journal and World Oil.

Many theses and dissertations of former students from the University of Oklahoma and Oklahoma State University and the University of Tulsa were used.

Publications that were especially helpful were those by Wheeler (1947), De Jong (1959), Huffman (1959), Bellis (1961), Gibbons (1962), Cole (1967), Berg (1969), Dogan (1970), and Krumme (1975).

CHAPTER II

STRUCTURAL FRAMEWORK

The area of study includes the Anadarko basin, the Hunton-Pauls Valley uplift, the western Arkoma basin, Northern and Central Oklahoma platforms and the southern Nemaha range. The area is limited on the south and southwest by the Amarillo-Wichita-Criner uplift, on the south by the Arbuckle uplift, on the southeast by the Ouachita uplift, and on the northeast by the Ozark uplift (Fig. 4).

Most of the structural features in Oklahoma formed either during three major orogenies, Early to Late Pennsylvanian in age, or by rejuvenation of older structures during that time (Arbenz, 1956; Jordan, 1967). Correlation of tectonic movements in Oklahoma according to age is shown in Figure 5.

The Amarillo-Wichita-Criner uplift extends for more than 300 miles from the Texas Panhandle to southern Oklahoma. The Wichita uplift includes the Wichita Mountains of southern Oklahoma, where igneous and metamorphic rocks are exposed (Ham et al., 1964), and continues westward into the subsurface Amarillo uplift. This system of uplifts divides the Anadarko basin on the north from the Palo Duro-Hollis-Hardeman basins on the south. The Criner uplift, a faulted anticline which is represented at depth by a basement horst, separates the Ardmore basin on the north from the Marietta basin on the south. The Marietta basin is bounded on the south by the Muenster-Waurika arch which is a

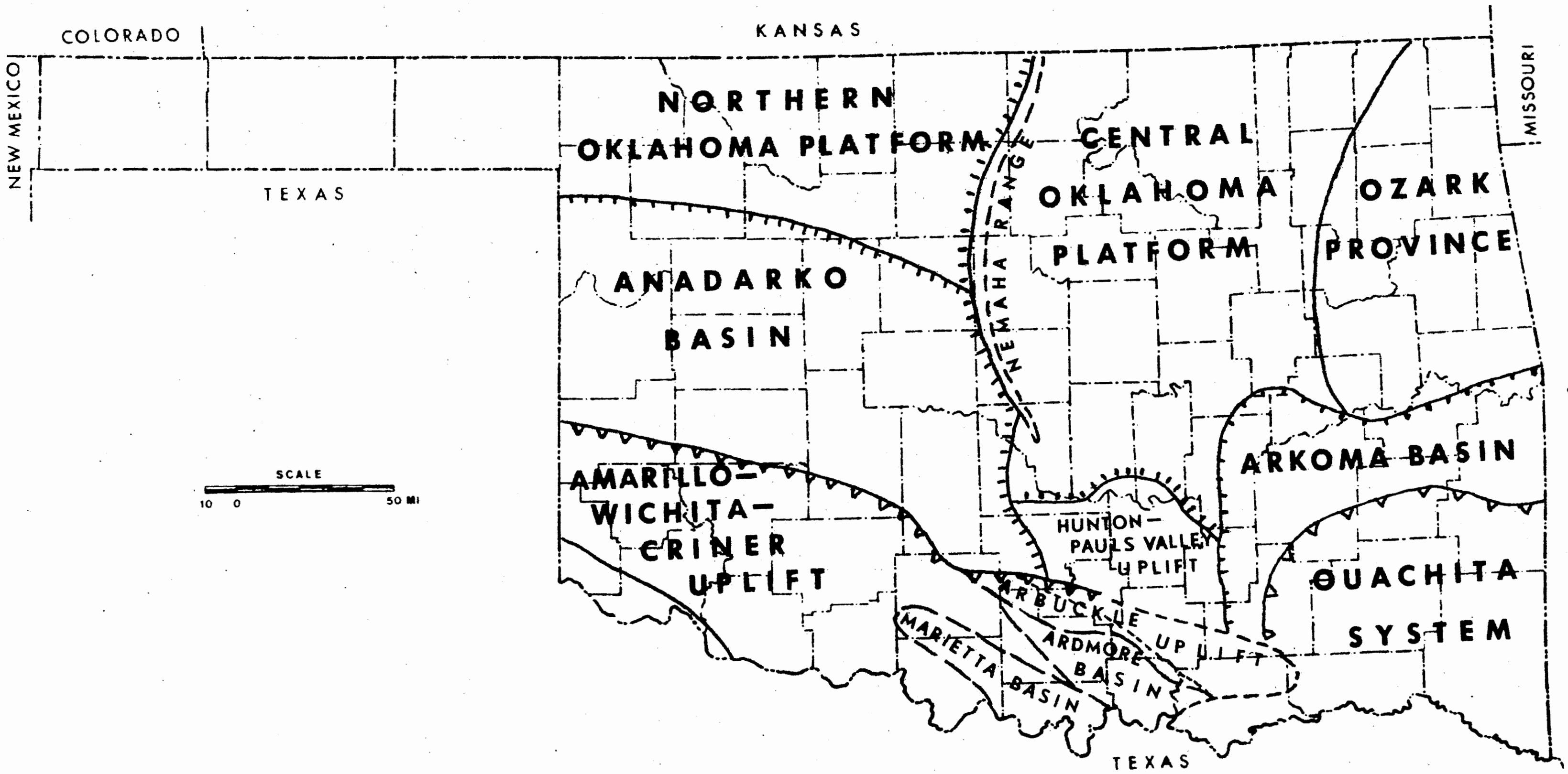

Fig. 4.-Tectonic framework of Oklahoma (after Arbenz, 1956).

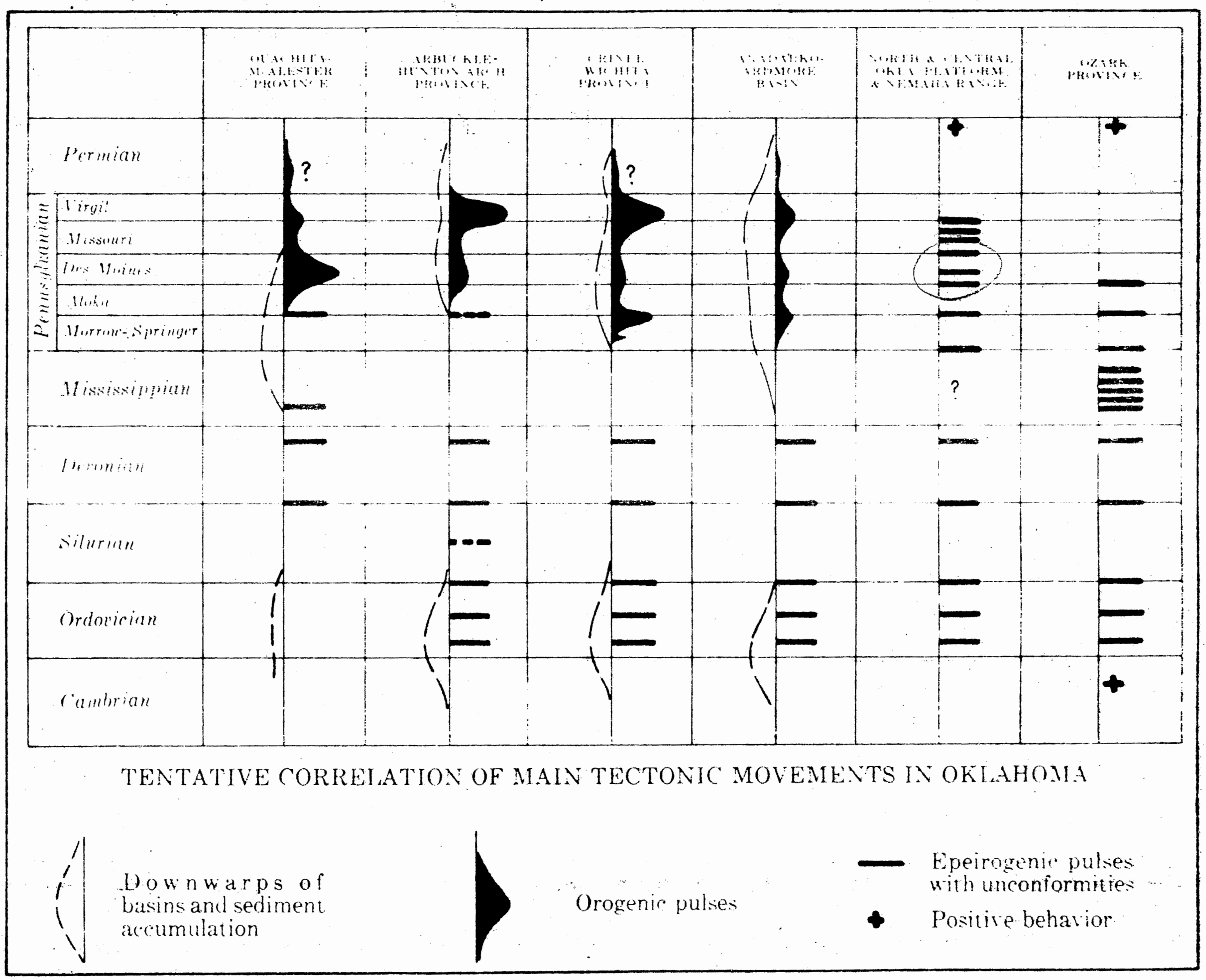

Fig. 5.-Tectonic movements in Oklahoma (after Arbenz, 1956).

bifurcation of the Wichita uplift. The Amarillo-Wichita-Criner uplift was formed by two major orogenic pulses in Early and Late Pennsylvanian; parts of the uplift were tectonically active during Middle Pennsylvanian.

Parts of the Arbuckle uplift include Precambrian basement rocks at the surface. The Arbuckle uplift and the associated Hunton-Pauls Valley uplift separate the western Arkoma basin on the northeast from the Ardmore basin on the southwest. The uplift is onlapped on the south by Cretaceous rocks; the southeast part of the uplift lies below the allochthonous Ouachita uplift. The first period of uplift began in Early Pennsylvanian and the culminating pulse was in Late Pennsylvanian when complex folding and faulting modified original Wichita and Ouachita structures.

The Ouachita uplift in southeastern Oklahoma lies south of the Arkoma basin and east of the Arbuckle and Hunton-Pauls Valley uplifts. It is onlapped on the south by Cretaceous units. The uplift is part of a major tectonic system which includes the Appalachian and Marathon uplifts. The Middle Pennsylvanian Ouachita orogeny was represented by overthrusting of geosynclinal sediments of Cambrian to Early Pennsylvanian age. These overthrusts extend into the Arkoma basin, a "foreland-foredeep" basin.

The Ozark uplift in northeastern Oklahoma is bounded on the south by the Arkoma basin and on the west by the Central Oklahoma platform. It is a gentle, stable geanticline which was submergent and emergent a number of times during the Paleozoic.

The Nemaha range is a series of fault-bounded, narrow uplifts which extend from Nebraska into Oklahoma, where it joins the Hunton-Pauls Valley uplift and separates the Northern Oklahoma platform and the adjoining Anadarko basin on the west from the Central Oklahoma platform and the adjoining Arkoma basin on the east. The Nemaha range was uplifted during Late Mississippian and Early Pennsylvanian; individual fault blocks were generally tilted toward the west.

Paleogeology

Prior to the Pennsylvanian orogenies, a major erosional surface was formed in Oklahoma. It is one of the major unconformities in the southern Midcontinent. The pre-Pennsylvanian rocks are Mississippian in age in most of the Northern and Central platform areas; however, in southern parts of the Anadarko and Arkoma basins and in the Ouachita system, the Pennsylvanian-Mississippian contact is conformable. In parts of these areas a prominent unconformity is present within the Lower Pennsylvanian section.

In the northern part of the Nemaha range, Pennsylvanian sediments were deposited on basement rocks, whereas along the uplift to the south, pre-Pennsylvanian subcrops are Ordovician, Silurian, and/or Devonian in age.

A major angular unconformity separates Pennsylvanian beds from Cambrian through Mississippian units on the Amarillo-Wichita-Criner uplift, the Arbuckle uplift and the Hunton-Pauls Valley uplift.

Plate Tectonics

It has been hypothesized that the west-northwest trend of basins and uplifts in southern Oklahoma is related to continental rifting, spreading and collision. This area has been referred to as the Southern Oklahoma aulacogen by Hoffman et al. (1974).

As shown in Figure 6, the aulacogen developed as a rift valley in Cambrian time. It was later eroded and filled with Paleozoic marine sediments. Although it is believed that the tectonic development in the Pennsylvanian may not be genetically related to the aulacogen formation, Pennsylvanian deformation may have formed along the same zone of weakness (Pruatt, 1975).

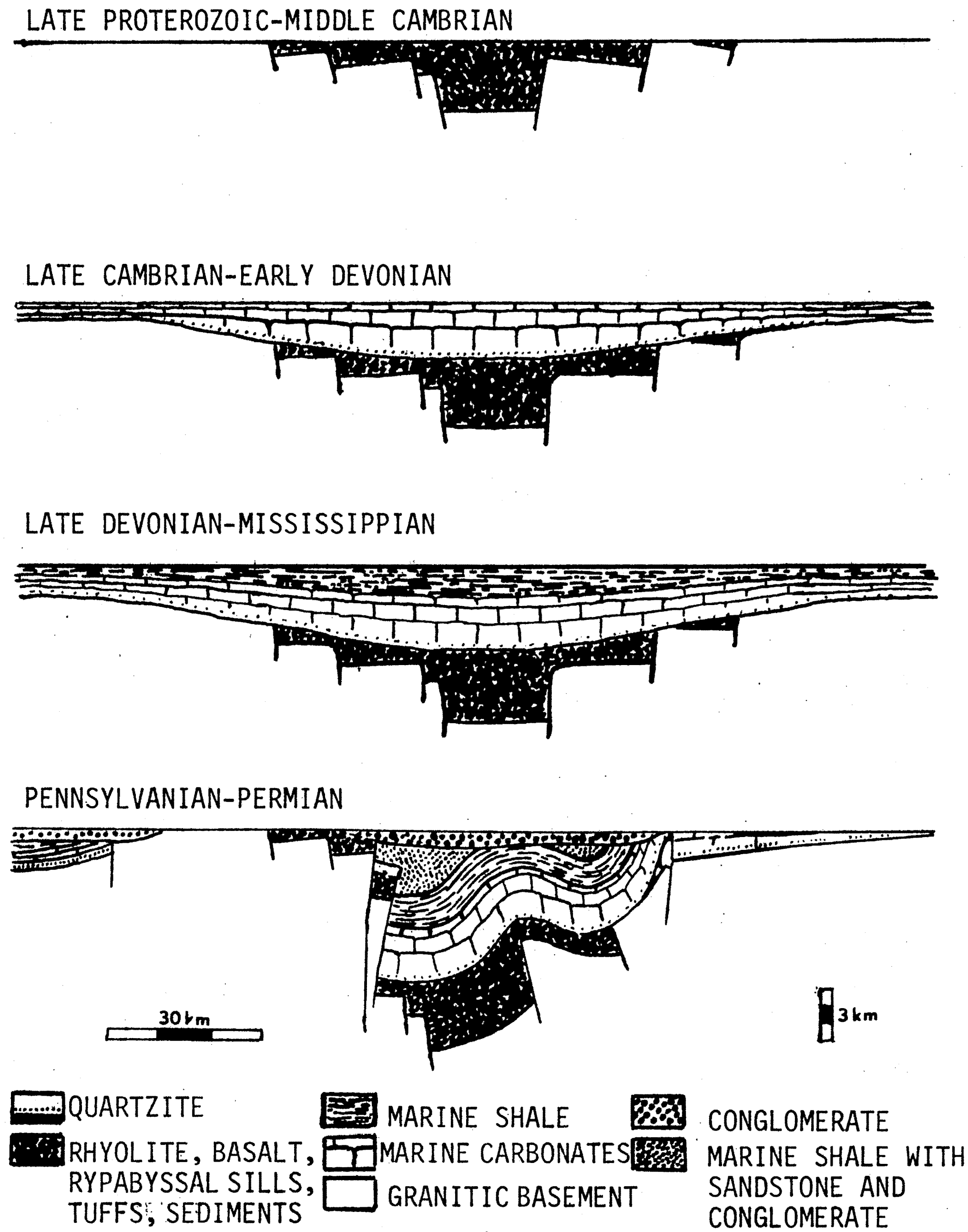

Fig. 6.-Schematic cross sections showing evolution of Southern Oklahoma aulacogen. Aulacogen begins with graben stage of block faulting and volcanism, evolves into broad unfaulted downwarp, and ends with a stage of folding, faulting, and fanglomerate sedimentation. (after Hoffman et al., 1974)

CHAPTER III

STRATIGRAPHIC FRAMEWORK

The end of Mississippian time was marked by a major regression which restricted marine environments in Oklahoma to the basinal areas. The associated unconformity at the base of the Pennsylvanian is one of the most prominent erosional surfaces in stratigraphic sections outside the basins. The Pennsylvanian System essentially represents many cyclic episodes of transgression and regression.

The Pennsylvanian is generally divided in ascending order into the Morrowan (Springer-Morrowan), Atokan, Desmoinesian, Missourian and Virgilian series (Fig. 7). Both the Mississippian-Pennsylvanian and the Pennsylvanian-Permian boundaries are disputed where the contacts are conformable. The base of the Pennsylvanian apparently lies within the Springer Group; however, in some cases for convenience the entire Springer is considered Pennsylvanian in age.

Morrowan (Springer-Morrowan) Series

The Morrowan includes, in ascending order, the upper part of the Springer Group and the Golf Course Formation of the lower part of the Dornick Hills Group in the area around the Arbuckle Mountains and in the Ardmore basin; the upper part of the Springer Group, the Union Valley Formation, and the Wapanucka Formation in the area north of the Arbuckle Mountains and in the Arkoma basin; and the Morrow Group in the

	Ouachita Mountains	Arbuckle Mountains and Ardmore basin	North of Arbuckle Mts. / Arkoma basin	Northeastern Oklahoma	Anadarko basin
VIRGILIAN		Vanoss Formation Collings Ranch Conglomerate	Vanoss Fm. Ada Fm. Lecompton Ls. Vamoosa Formation		Wabaunsee Group Shawnee Group Douglas Group
MISSOURIAN		Hoxbar Formation	Ochelata Group Skiatook Group	Ochelata Group Skiatook Group	Lansing Group Kansas City Group Pleasanton Group
DESMOINESIAN		Deese Formation	Marmaton Group Cabaniss Group Krebs Group	Marmaton Group Cherokee Group	Marmaton Group Cherokee Group
ATOKAN	Atoka Formation	Lake Murray Formation Dornick Hills Formation	Atoka Formation	Atoka Formation	Atoka Formation
MORROWAN	Johns Valley Shale Jackfork Group	Golf Course Formation Dornick Hills Formation Springer Group	Wapanucka Formation Springer Group	Bloyd Formation Hale Formation	Morrow

Fig. 7.-Correlation chart of Pennsylvanian strata.

Anadarko basin. The upper Morrowan representatives in northeastern Oklahoma are the Hale and Bloyd formations.

The Morrowan is as much as 1,500 feet thick in the Arkoma basin, 7,000 feet thick in the Anadarko basin (Cline, 1968) and 10,000 feet thick in the Ardmore basin.

The Wapanucka Limestone of the Wapanucka Formation is used as the mapping horizon in the southeastern part of the study area. The Wapanucka Formation includes, in ascending order, a thin basal sandstone, the Wapanucka Shale, the Wapanucka Limestone and the Barnett Hill Shale (Jordan, 1957) or "Post-Wapanucka Shale" (Jackson, 1949). The Wapanucka Limestone was used in mapping because it is the youngest widespread limestone in the Arkoma basin.

The limestone which is as much as 250 feet thick is generally light gray and oolitic (Jordan, 1957). Along the northern and western edges of the area where the limestone has been used, it is partially truncated by Atokan units, and in these areas the mapped horizon is essentially the pre-Atokan unconformity surface.

Atokan Series

The Atokan Formation essentially comprises the Atokan Series, except in the Arbuckle Mountains and Ardmore basin where the equivalent is the Lake Murray Formation of the upper part of the Dornick Hills Group. The Atokan lies unconformably on the Wapanucka Formation or its equivalent, the Bloyd Formation. In some places where the top of the Atokan is defined by the base of the Hartshorne Formation, the contact is conformable and the base of the McAlester Formation where the contact is unconformable.

Original thickness of the Atokan in the most active part of the Arkoma basin was as much as 10,000 ft. Maximum thickness exceeds 3,000 feet in the Anadarko basin (Wheeler, 1947) and 2,400 feet in the Ardmore basin (Tomlinson and McRee, 1959). The Atokan consists of alternating beds of white to gray, fine to medium-grained sandstones and gray to black, silty shales. Limestone and coal are developed locally. Sediments of the Atokan and Morrowan Series are more closely related lithologically to each other than to post-Atokan Pennsylvanian units.

Desmoinesian Series

The Desmoinesian is represented, in ascending order, by the informally named Cherokee Group and the Marmaton Group in most of Oklahoma. In the area of the Northern Oklahoma and Central Oklahoma platforms, the Arkoma basin, and the greater part of the Anadarko basin, the Cherokee Group is divided into the Krebs Group and the Cabaniss Group. In the area of the Arbuckle Mountains, Ardmore basin and southeastern part of the Anadarko basin the Lower Desmoinesian is the Big Branch Formation, the upper unit of the Dornick Hills Group, and the greater part of the Desmoinesian is represented by the Deese Formation.

Generally in the Arkoma basin the basal unit is the Hartshorne Formation. The Desmoinesian is approximately 4,000-5,000 feet thick in parts of the Anadarko and Arkoma basins; most units within the series thin or wedge-out northward.

The Cherokee Group may be divided into many cyclothemic sequences which are composed mostly of sandstone and shale with some thin coal and thin, widespread limestones. These limestones are used widely as stratigraphic markers, especially in mapping transgressive-regressive couplets. The upper three most prominent limestones in the Cherokee Group--the Inola Limestone, the Pink Limestone and the Verdigris Limestone, in ascending order, are present over most of the Northern Oklahoma and Central Oklahoma platforms; they were used as stratigraphic guides in this study.

The Marmaton Group includes, in ascending order, the Oswego Limestone, the Labette Shale, which includes the Peru Sandstone and the Oologah Formation. The last is divided into the lower Altamont Limestone Member, the Bandera Shale Member, and the upper Pawnee Limestone Member.

The Oswego Limestone, which is the main mapping horizon in this study, is present in most of northern and central Oklahoma. The surface equivalent of the Oswego is the Fort Scott Limestone, which is divided, in ascending order, into the Blackjack Creek Limestone Member, the Little Osage Shale Member, and the Higginsville Limestone Member. Maximum thickness of the Oswego is approximately 200 feet (Cole, 1967; 1970). Two Oswego markers are present (Plates I, II, and IV) the lower marker is the "true" Oswego and the upper datum is the "First Oswego" of early workers.

This "First Oswego" is approximately 50 feet above the "true" Oswego and is approximately equivalent to the Altamont Limestone Member of the Oologah Formation. In the area where the upper limestone has been reported as Oswego by well operators, it was mapped instead of the "true" Oswego in order to use all data available (Fig. 8). Because the stratigraphic interval between the two limestones is generally less than 100 feet, error produced by the change in datum is negligible on a

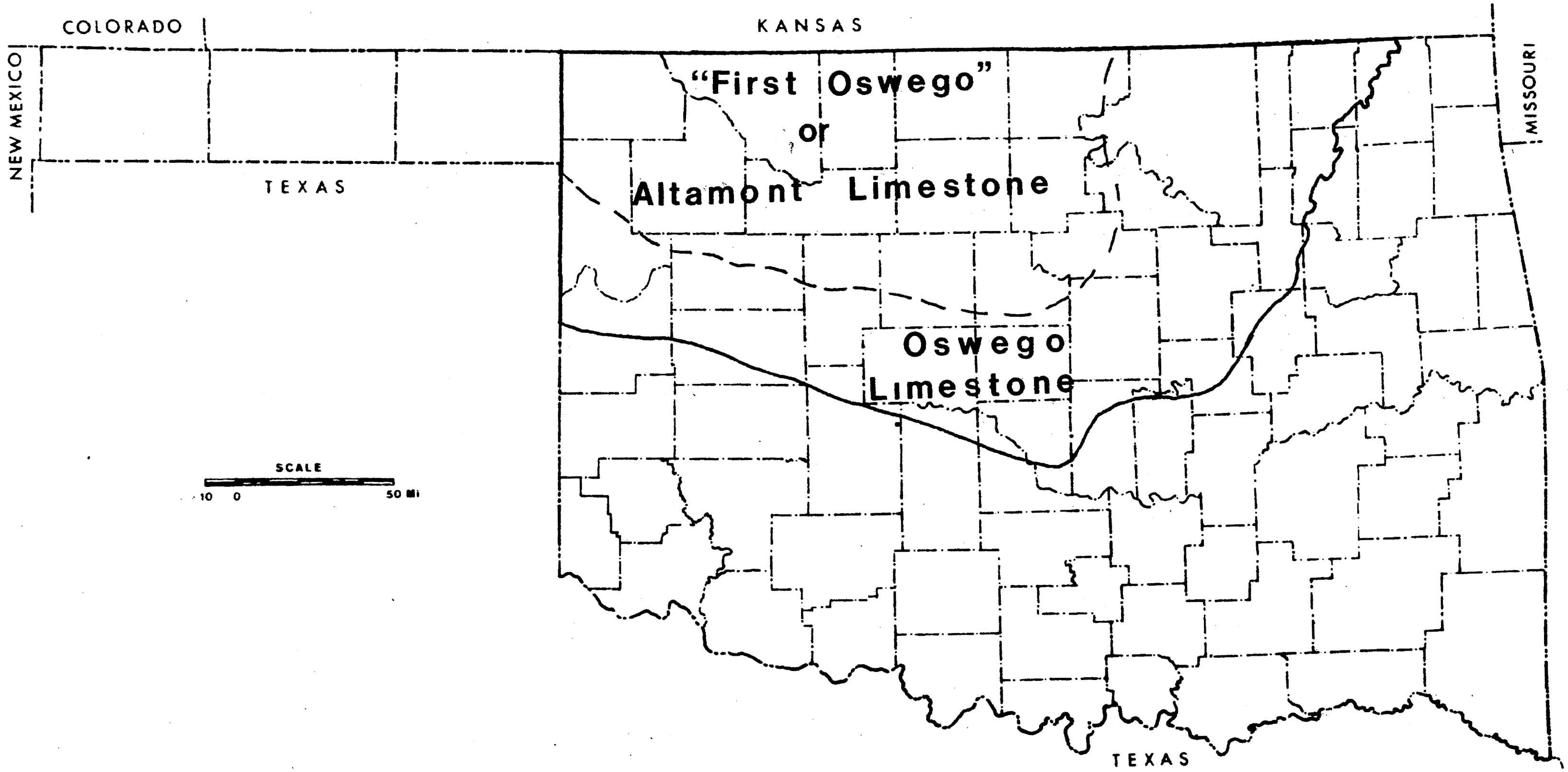

Fig. 8.-Areas in which Oswego and Altamont limestones are mapping horizons.

regional scale.

Southward into the Arkoma basin the Oswego thins abruptly along a line from T10N, R9E, to T12N, R12E, into interbedded sandstones and shales of the Wewoka Formation (Krumme, 1975). In this area the Oswego equivalent was correlated and mapped to provide map continuity between the area of the Oswego development to the north and the area of Wapanucka development and preservation to the south.

In the Anadarko basin the Oswego thins gradually and interfingers with interbedded sandstones and shales of the Deese Group. Because an interval equivalent to the Oswego cannot be correlated across the basin, the mapping horizon there is the approximate top of the Desmoinesian--or the contact between the Deese and Hoxbar Groups. The horizon is the base of a sequence of oolitic limestone in the "Checkerboard Limestone Group" of Wheeler (1947), the top of which is equivalent to the top of the Checkerboard Limestone on the platform.

Missourian Series

The Missourian Series includes, in ascending order, the Skiatook Group and Ochelata Group in the Northern Oklahoma and Central Oklahoma platforms and the Pleasanton Group, Kansas City Group and the Lansing Group in the Anadarko basin. The Missourian is comprised of the Hoxbar Group around the Arbuckle Mountains, Ardmore basin and the southeastern part of the Anadarko basin. It is as thick as 3,000 to 3,500 feet in the Ardmore and Anadarko basins. It is dominantly a clastic sequence in the southern part of the state. In the northern part, however, it consists of a thick carbonate sequence.

The Checkerboard Limestone is a carbonate unit near the middle of the Skiatook Group. It is a thin, widespread limestone, which has been used extensively as a stratigraphic guide. Although the limestone is present over most of the state, in this study it was mapped only in the south-central part of the state--north of the Arbuckle Mountains--and in the southeastern part of the Anadarko basin.

The Hogshooter Limestone above the Checkerboard is a prominent limestone which was used as a stratigraphic guide to correlations in this study.

Virgilian Series

In the Ardmore basin and the Arbuckle Mountains, the lower and middle Virgilian is composed of the Collings Ranch Conglomerate and in the Central Oklahoma and Northern Oklahoma platforms it is composed, in ascending order, of the Vamoosa Formation, the Lecompton Limestone, the Ada Formation and Vanoss Formation. In the Anadarko basin, it is composed of the Douglas Group, the Shawnee Group, and the Wabaunsee Group. Generally, the Vanoss Formation on outcrop in south-central Oklahoma has been regarded as the uppermost unit of the Virgilian and approximately equivalent to the Wabaunsee Group. However, the Oklahoma Geological Survey has recently adjusted the top of the Virgilian upward to correspond to the top of the Lower Permian Chase Group. The Virgilian is approximately 3,500 feet thick in the Anadarko basin and 1,600 feet thick in the area north of the Arbuckle Mountains.

CHAPTER IV

INTERPRETATION OF STRUCTURAL MAP

Tectonic Provinces

Major trends on the Pennsylvanian structural map (Plate VII) and their genetic relationships are herein discussed according to the six major tectonic provinces in the area mapped. These are the Central Oklahoma platform, the Arkoma basin, the Hunton-Pauls Valley uplift, the Nemaha range, the Northern Oklahoma platform, and the Anadarko basin (Fig. 3).

Central Oklahoma Platform

Pennsylvanian strata of this area have a strike ranging from N30°E to N30°W and a dip ranging from 25 feet per mile to 100 feet per mile to the west. This general westerly dip, formed by uplift of the Ozark geanticline, is interrupted by numerous noses, saddles, anticlines and faults, which are generally regarded as steeply dipping normal faults. The top of the Oswego Limestone, the reference horizon in this area, reflects most of the structure because much of the tectonic activity occurred after Oswego deposition.

The dominant structural trend on the Central Oklahoma platform is a north-to-northeast alignment of folds and faults. A secondary east-west trend is present in the central and northern parts of the platform.

The larger structural features have a north-to-northeast alignment, such as the Cushing uplift (T16-19N, R7E), the Mervine-Ponca City trend (T28N, R4E to T25N, R2E), and the Domes-Pond Creek-Pawhuska trend (T29N, R10E to T25N, R9E). Belts of en echelon faults extend south-southwest from Osage County into Seminole and Hughes Counties (T6N, R5-9E to T27N, R8-12E) (Miser, 1954).

The smaller structural features are more nearly randomly oriented; however, several east-west trends are indicated on the map, such as the west-plunging nose at Stillwater (T19N, R1-3E), the west-plunging nose north of Cushing (T18N, R3-6E), and the Glenpool trend (T17-18N, R11-12E).

Most theories regarding the origin of these structures involve, in some manner, Precambrian basement. Two of the most important theories are (a) strike-slip movement along zones of weakness in the basement and (b) differential compaction due to the irregularity of the Precambrian surface or due to lateral variations in lithology.

In an early study of the structural development of the Central Oklahoma platform, Fath (1920) suggested that a combination of vertical and horizontal shearing of the basement produced the structural features of the platform. It is suggested here that basement blocks moved along left lateral faults; this interpretation is supported by the en echelon fault system which does not generally persist at depth. Fault-block movement on the platform may have been related to the more significant activity of the Wichita, Arbuckle, and/or Ouachita uplifts.

In association with north-south fault trends on the platform, Lyons (1950) has mapped a system of east-west basement faults; some structures may be related to drape folding over corners of uplifted basement blocks.

Differential compaction over buried Precambrian ridges or pinnacles is responsible, at least in part, for some of the noses, domes, and synclines in Osage, Washington, Tulsa, and Creek Counties. In a map of the Precambrian surface of northeastern Oklahoma, Ireland (1955) described a granite highland which he named the "Tulsa Mountains." Several of these Precambrian "highs" are overlain by anticlinal structures. For example, the Bartlesville dome (T26N, R13E) overlies one of these pinnacles, and in northeastern Osage County a basement ridge formed by Precambrian volcanics is approximately overlain by the Domes-Pond Creek-Pawhuska structure (Muehlberger et al., 1967).

Many small structures are related to differential compaction of sediment due to lateral facies changes in sandstone or limestone. Compactional structures are generally characterized by regional nosing and long, narrow anticlines and synclines.

Western Arkoma Basin

The Wapanucka Limestone, the reference horizon in this area, has an overall structural trend which is approximately parallel to the frontal part of the Ouachita uplift. The Wapanucka dips southeastward approximately 80 feet per mile near the hingeline of the basin (T7N, R8E to T10N, R12E in the mapped area) and 500 feet per mile near the Ouachita Mountains. North-to-northeast trends and secondary east-west trends are present also in this area, and most faults associated with these trends are high-angle normal faults. Growth faults are related to the hingeline of the basin, especially east of the study area where the Atoka Formation thickens appreciably. Several subparallel anticlinal and synclinal structures are present near the front of the Ouachita uplift.

A dominant southwest-plunging nose located near the northwestern edge of the basin (T13N, R12E to T8N, R10E), is masked to the south by a normal fault (T5-8N, R9-10E). A synclinal feature is normal to the above mentioned fault in T6N, R9-10E. To the west is a parallel fault (T6-8N, R7-8E) with a major syncline on the downthrown side (T7-8N, R6E). Several major basement trends are present in or around Coal County; these include the west-plunging synclinal nose at Gerty (T4N, R9-10E), the west plunging Ashland anticline, or nose, and associated syncline (T3N, R11-12E), the Wardville-Kiowa synclinal nose (T2N, R10-13E), the Coalgate anticine (T1N, R10E to T2N, R13E), and the Lehigh syncline (T1S-T1N, R11E). Three faulted domal structures with as much as 1,000 feet of closure are located in western Coal County (T1-3N, R9E), in the area common to both the Arkoma basin and Hunton-Pauls Valley uplift.

Most of the structures are related to activity of the Ouachita and/or Arbuckle uplifts. The parallel fold system in the southeasternmost part of the study area was formed during the thrusting of the Ouachita uplift. Disharmonic folds are present in this area due to ductility of Lower Pennsylvanian-Mississippian shale during deformation.

Hunton-Pauls Valley Uplift

The major feature of this area is a complex of graben and horst structures and associated anticlines and synclines. The dominant feature at or near the surface is the Hunton-Tishomingo arch, which apparently is a separate structural unit from the Arbuckle uplift

(Dott, 1934). It plunges west-northwest from southern Pontotoc County and is known as the Pauls Valley arch in the subsurface.

In the southeastern part of the uplift the generally southeast dip of the Wapanucka Limestone is interrrupted by numerous folds and high-angle reverse and normal faults. In the area where the Wapanucka Limestone crops out on the eastern part of the uplift, several graben and horst structures are present. These are the Franks graben (T2N, R6-8E), the Clarita horst (T1S, R8-9E), the Wapanucka graben (T2S, R8E) and in T3N, R6E, a graben associated with the Ahloso fault zone.

In the central and western parts of the uplift the Checkerboard Limestone is the mapping horizon which expresses most of the general structure of the area; however, many of the major basement faults do not intersect the Checkerboard surface. Strike of the limestone is generally to the north or northeast, and dip is westerly or northwesterly at 110 to 170 feet per mile. Most faults in this area are downthrown to the north, with the exception of the fault southeast of Pauls Valley (T3N, R2E). Displacement at the Checkerboard position ranges from 50 to 100 feet. The Golden trend is dominated by north-striking faults in T3-4N, R3W. A west-plunging anticlinal nose is present north of Corbett (T6N, R1E).

Most of the major structures of the Pauls Valley area possibly formed as vertical components of northwest-trending, dominantly left-lateral strike-slip movement within the Hunton-Pauls Valley uplift and/or the Arbuckle uplift (Walper, 1970). Minor structures apparently formed by differential compaction associated with paleotopographic expressions of older structural features.

Nemaha Range

The Nemaha range is a relatively narrow belt in which the gentle westerly to southwesterly dip of platform strata is disturbed. Within the range are many dip reversals due to major anticlines, domes, synclines, noses and faults. The dominant faults extend from T10N, R2W, to T19N, R4W and to T29N, R1W. Most of the fold structures are related to north-trending, high-angle, normal or, less commonly, reverse faults which generally are downthrown on the east. Local structures increase in size, number per unit area, and complexity as the range is approached. In Oklahoma, compared to Kansas and Nebraska, the central part of the uplift is lower and less continuous--with similar, shorter uplifts on each side (King, 1951).

Many of the larger structures in Oklahoma are associated with the Nemaha range; these include the Oklahoma City uplift (T11-13N, R3W), the Crescent-Lovell trend (T17-18N, R4W), the Marshall field (T19N, R4W), the Garber field (T21-23N, R3-4W), the Deer Creek field (T27N, R3W), the Blackwell field (T27N, R1W), the Sumpter field (T28N, R1W), and the Dilworth field (T28-29N, R1E). Related structural trends include the Billings-Tonkawa feature trend (T23N, R2W to T24N, R1W), and the Lucien-Polo structures (T20-22N, R2W). Some structures, such as the Billings field, are associated with east-west faults.

Formation of the Nemaha range was originally thought to be the result of basement uplift (Fath, 1920). However, now it is considered generally that the uplift is probably the vertical component of left-lateral strike-slip faulting. Movement along associated east-west basement faults may have been dominantly strike-slip also. These fault segments resemble the more subdued structural setting on the Central

Oklahoma platform.

Northern Oklahoma Platform

The Oswego Limestone on the platform dips to the south-to-southwest toward the Anadarko basin at approximately 20 to 60 feet per mile. The southwesterly dip is fairly uniform, with anomalies less common in this area than on the platform to the east. However, many major trends exist. The structural noses are generally broader and less steep, and faulting is not as prominent as it is to the east.

Major trends include the southwest-plunging nose associated with the Lovedale field, (T27N, R21W), the south-plunging nose associated with the Gage fields (T23N, R23-24W), the south-plunging nose of the Cedardale trend (T22N, R16E), and the southwest-plunging synclinal nose south of Ames (T20N, R9-10W).

After deposition of the Oswego Limestone, the basement was not very active and much of the structure is related to basinal subsidence. If the area was part of the aulacogen in Early Paleozoic, rift boundary faults might be expected in the basement along the northern edge of the basin. At the Oswego position, differential compaction does not appear to be a dominant factor in formation of structural anomalies.

Anadarko Basin

The greater part of western Oklahoma is dominanted by the asymmetric Anadarko basin. South-to-southwest dip of Middle Pennsylvanian strata is relatively gentle on the northern basinal flank; dip ranges from 100 to 300 feet per mile. Steep northern dip, as much as 1,000 feet per mile, characterizes the south flank of the basin at the position of the mapping horizon. The axis of the basin trends northwest-to-west-northwest. Basinal fill is thickest in northern Beckham, southern Roger Mills, Washita, Caddo, and western Grady Counties, where the elevation of the mapping horizon is estimated to be between 11,000 and 12,000 feet below sea level.

The south flank of the basin is characterized by large, faulted, northwest-to-west-northwest trending structures; the north flank is characterized by fewer, smaller, less complex structures with the same general trend as those on the south flank.

Some of the major structural features are an anticlinal nose across Caddo County (T11N, R14W to T7N, R11W), the Elk City anticline (T10N, R20-21W), the Cordell structure (T8N, R16W to T9N, R18W), the Cement structure (T5-6N, R9-11W), the north-northwest-trending Chickasha structure (T4-5N, R8W), and the Chitwood-Pleasant View-Knox trend (T2-5N, R5-6W).

Structures of the basin are related to activities of the Wichita uplift. Reverse faults characterize most of the major faulting. These faults are located in the southern part of the basin. Dip-slip components of left-lateral strike-slip movements are probably the primary reason for the vertical uplift of the Wichita element as well as vertical displacements within the basin.

Structure of Major Oil Fields

Oklahoma City Field

This structure, located in central Oklahoma at the southern end of the Nemaha range (T11-13N, R3W), is a north-northwest-trending anticline which is faulted on its eastern flank at the Oswego position.

It is 12 miles long and four and one-half miles wide and has 400 to 600 feet of closure. Folding, faulting, and associated truncation began as early as the Cambrian, and structural activity continued intermittently through the Pennsylvanian. On the crest Middle Pennsylvanian units directly overlie Ordovician units.

Cushing Field

Cushing field, in Creek County, resembles the Oklahoma City structure in that it is also a north-trending anticline which is faulted on the east flank; however, the Oswego Limestone is not faulted. The structure lies along a basement-fault trend which extends from T10N, R4E to T18N, R7E. Approximately 200-300 feet of closure is present at the Oswego level. Beds as old as Ordovician subcrop out below the Pennsylvanian.

Glenpool Field

This field is on a west-plunging nose which is located in northeastern Creek County (T17-18N, R12E). Although the structure is a fairly prominent anticlinal nose, the accumulation at Glenpool is dominantly stratigraphic in entrapment.

Mervine-Ponca City Fields

These fields form a north-northeast trend in Kay County (T25N, R2E to T28N, R3E). Oil production from both these fields is associated with well-defined anticlines and domes. Early workers suggested that the folds involved with these fields were formed in relation to buried granite ridges (Clark and Daniels, 1929). However, formation of these structures is probably associated with basement faulting which may be related to the Tonkawa-Billings structures to the southwest (T23N, R2W to T25N, R1W).

Garber Field

This field, in T22N, R3-4W, Garfield County, is a domal structure along the Nemaha range. Like many of the structures associated with the Nemaha range, it is faulted along its eastern margin, and rocks as old as Ordovician subcrop out below the Pennsylvanian unconformity (Gish and Carr, 1927). Deep-seated faulting, probably strike-slip in nature, occurred repetitiously throughout the Pennsylvanian and part of the Permian, based on the thin Pennsylvanian and Permian section over the structure.

West Edmond Field

West Edmond field, more than five miles wide and 20 miles long, is located in T12N, R4W to T15N, R4-5W. The structure, however, is little more than a westward-dipping homocline in which the major trapping mechanism is stratigraphic.

Elk City Field

Elk City field, in T10N, R20-22W, Washita and Beckham Counties, is a west-northwest-trending anticline, near the axis of the Anadarko basin, which lies parallel to the north front of the Wichita Mountains. Closure on the structure at the Desmoinesian mapping horizon is approximately 1,250 feet. The structure is faulted at depth along its northern flank and is along the same trend as the Cordell structure to the east-southeast. The structure was active during Late Pennsylvanian.

Cement Field

The Cement structure is a west-northwest-trending faulted anticline in T5-6N, R9-11W. Complex reverse faults dominate the structure which was formed in association with movements of the Wichita uplift. Structural development continued until Late Pennsylvanian.

Golden Trend

This broad trend, in northwestern Garvin County, is on the western part of the Hunton-Pauls Valley uplift east of the Anadarko basin. Structure is dominantly a westward-dipping homocline which is broken by several faults, the most prominent of which trends northward.

CHAPTER V

COMPARISON OF STRUCTURAL MAP TO OTHER GEOLOGIC FEATURES

The general trends of the Middle Pennsylvanian strata in much of the subsurface are expressed on the surface by outcrops of Pennsylvanian and Permian units (Misner, 1954). The en echelon fault system of the Central Oklahoma platform is not regionally expressed on the structural map; however, several local structures coincide with en echelon fault trends; for example, the structural nose (T27N, R9-10E to T21N, R8E) and Cushing field (T16-19N, R6-7E). The mapped anticlinal and synclinal structures near the frontal Ouachita Mountains (T3N, R11-12E to T1S, R10-11E) are expressed on the surface. The Oklahoma City structure is expressed by the outcrop pattern of Permian rocks. Graben and horst structures mapped at the level of the Wapanucka horizon in the Hunton-Pauls Valley uplift are expressed at the surface in T3N, R5-7E to T1S, R8-9E. The general configuration of the Anadarko basin is expressed by the outcrop pattern of Permian strata.

The extension of the Nemaha range from north-central Oklahoma to the Hunton-Pauls Valley uplift and the Arbuckle uplift is the dominant feature in the central part of the pre-Pennsylvanian geologic map (Jordan, 1962) which is related to the structural map. Many structures, such as the Oklahoma City structure (T11-13N, R2-3W), the Garber structure (T21-23N, R3-4W), and the Cushing structure (T16-19N, R6-7E), are expressed on the pre-Pennsylvanian surface by Ordovician through Mississippian subcrops. Both the Anadarko and the Arkoma basins are defined by the subcrop of pre-Pennsylvanian strata, and in both basins the most deeply buried areas, from the structural map, are within the area in which the Mississippian-Pennsylvanian contact is conformable.

Many of the structures located on the Central Oklahoma platform are expressed on the pre-Woodford geologic map (Tarr et al., 1965) by Ordovician or Precambrian subcrops. For example, the structural noses along the eastern edge of T25N, R12E and near the southeastern edge of T24N, R12E are underlain by outliers of Ordovician-age Simpson units.

Many of the Cambrian pinnacles in Osage County which subcrop below the pre-Woodford surface are overlain by Pennsylvanian structures; for example, the noses located near the southeastern edge of T23N, R8E and in the north-central part of T21N, R9E. Other structures which are expressed on the pre-Woodford surface include the Oklahoma City, Cushing, Garber, Billings, and Tonkawa fields.

A prominent nose which is expressed at the Wapanucka Limestone position in T13N, R12E to T8N, R10E is reflected by the subcrop pattern of the Ordovician Sylvan Shale.

The dip expressed by the structural map generally agrees in direction and magnitude with the dip at the surface on the tectonic map (Arbenz, 1956). Also, positions of major faults, anticlines and synclines agree with those of the structural map, as does the axis of the Anadarko basin.

Locations of many major oil and/or gas fields (Oil and gas map of Oklahoma, 1966) are associated with major structures shown on the structural map. However, because many oil and gas fields in Oklahoma are associated with stratigraphic entrapment, locations of fields of that type do not show positive relationships with the structural map.

Regional trends of oil and/or gas fields are correlated with the general structural grain; for example, the elongation of production along the Nemaha range and northward trend of fields on the Central Oklahoma platform. Other examples are major alignments of fields parallel to the basinal axes of the Anadarko and Arkoma basins.

Along the southern boundary of the mapped area the Wichita and Arbuckle uplifts are expressed as gravity maxima (Lyons, 1964). The central part of the Anadarko basin is expressed as two regional gravity minima, separated by a north-trending maximum. The trend of the Arkoma basin and that of the gravity field are parallel. The Nemaha range is not directly expressed by regional gravity data; the range is between an elongate gravity minimum and a maximum on the east and two gravity maxima on the west.

On the Central Oklahoma platform the majority of the gravity maxima and minima are not expressed by major Pennsylvanian structures. Cushing field is reflected by a local gravity anomaly. The large gravity maximum in Osage County is probably related to the Precambrian "Tulsa Mountains" of Ireland (1955) or to variations within the basement. The northern part of the structural alignment from T8N, R4E to the Cushing field in T17N, R5E is expressed by the trend of the gravity field. Several major gavity anomalies on the north flank of the Anadarko basin are not expressed by the Pennsylvanian structure.

The Wichita and Arbuckle uplifts are expressed as maxima on the magnetic map. The Anadarko basin is depicted in a general way by the magnetic data. The positive anomalies in Cleveland, McClain, Pontotoc and Pottawatomie Counties may be related to the Hunton-Pauls Valley uplift. More detailed mapping of positive features in Osage County may show correlation with some Pennsylvanian structures related to Precambrian hills. Several major structures, such as the Oklahoma City and Cushing fields, are in the general area of magnetic anomalies. However, the majority of the magnetic maxima and minima on the platform and northern flanks of the Anadarko and Arkoma basins do not correspond to the Pennsylvanian structures.

Geothermal maxima (DeFord, Khele et al., 1976) in the study area are probably related to the Precambrian in Osage and Tulsa Counties, the Arkoma basin, and the Hunton-Pauls Valley uplift. A small geothermal high corresponds to the Nemaha range in northern Oklahoma. The structural configuration of the Anadarko corresponds to a geothermal minimum.

The structural framework of Oklahoma is generally expressed by the salinity map of Oklahoma (Buckner, 1972). On the Central Oklahoma platform several north-northeast structural alignments such as the en echelon fault system are subparallel to north-trending salinity gradient anomalies. The Nemaha range is expressed by several salinity gradient highs, particularly in the Oklahoma City and Garber fields. The Cushing field corresponds approximately to a salinity gradient minimum. The southwest-plunging nose just west of Henryetta is strongly expressed by a salinity gradient maximum.

CHAPTER VI

CONCLUSIONS

Conclusions based on these findings and evaluation of pertinent literature are as follows:

1. Correlation of Desmoinesian and Missourian strata across the Northern and Central Oklahoma platforms indicate that two limestones approximately 50 feet apart are commonly regarded as the Oswego Limestone. The upper limestone is actually equivalent to the Altamont member of the Oologah Formation, and the lower limestone is the actual Oswego Limestone.

2. Most structural features in Oklahoma formed either during an orogeny initiated during the Late Pennsylvanian, or by rejuvenation of older structures during that time.

3. Much of the Pennsylvanian structure is expressed by subcrop and fault patterns on the pre-Pennsylvanian and pre-Woodford surfaces.

4. Due to the number of oil fields in Oklahoma which are formed by stratigraphic mechanisms, oil and/or gas fields cannot always be related to Pennsylvanian structures; however, Pennsylvanian structures are commonly traps for oil and/or gas accumulations.

5. Several of the major Pennsylvanian structural features are expressed by gravity, magnetic, geothermal and salinity anomalies.

6. The dominant structural trend on the Central Oklahoma platform is a north-to-northeast alignment of folds and faults along with

secondary east-west alignments.

7. The en echelon fault system on the Central Oklahoma platform was produced by left-lateral strike-slip faulting, possibly related to movements which affected the Wichita, Arbuckle and Ouachita uplifts.

8. In central and north-central Oklahoma, local structures are larger and more complicated near the midline of the Nemaha range.

9. Tectonic activity was not prominent on the Northern Oklahoma platform and the northern flank of the Anadarko basin.

10. Pennsylvanian structure in the Anadarko basin may be related to an Early Paleozoic aulacogen. In that case, rift boundary faults might be expected in the basement along the northern edge of that basin, and they may have affected Pennsylvanian strata.

11. Two of the most important interpretations regarding the origin of Pennsylvanian structures are (a) strike-slip movement along zones of weakness in the basement and (b) differential compaction due to the irregularity of the Precambrian surface or due to lateral variations in lithology.

12. The structure of the Pennsylvanian strata reflects most of the present structural configurations of sedimentary strata in the area of study.

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APPENDIX

LOCATIONS OF ELECTRIC LOGS USED IN PREPARATION OF CORRELATION SECTIONS

North-South Correlation of Section A-A'

No.	Operator and Well Number	Location
1.	Cities Service Oil Co., Knie "A" #1	NW SE Sec. 26- 9N-17W
2.	Gulf Oil Corp., B.W. Fletcher #1	SW NW Sec. 34-11N-16W
3.	J.M. Huber Corp., Wagner #1	NE SW Sec. 10-12N-16W
4.	Gulf Oil Corp., Burgtorf #1	SE NW Sec. 6-13N-15W
5.	Tidewater Oil Co., Ashby Unit #1	C SW NE Sec. 36-14N-15W
6.	Tidewater Oil Co., L. Sweeney Unit #1	NW SE Sec. 28-15N-14W
7.	Pan Am Petroleum Co., Johnston Unit "B" #1	NE NE SE Sec. 7-15N-14W
8.	Northern Oil Co., Seibald #1	NW SE Sec. 34-16N-14W
9.	Texas Co., C.A. Boyd #1	NE NE SE Sec. 14-16N-14W
10.	Apache Corp., Owings Unit #1	SW NE Sec. 16-17N-13W
11.	Miles, Jackson Drilling Co., Haigler #1	SW SE Sec. 26-18N-13W
12.	Pam Am Petroleum Co., Johnston Unit "B" #1	SW NE Sec. 13-19N-13W
13.	Gulf Oil Corp., R.E. Perkins #1	C NW NW Sec. 11-21N-12W
14.	Amerada Petroleum Corp., W.L. Rex Roat #1	SE NE Sec. 14-23N-11W
15.	California Time Petroleum Co., Hartman #1	C SE NW Sec. 33-25N-10W
16.	Ashland & Davon, Loree Smith #1	C NW SW Sec. 19-26N-10W
17.	Davon Drilling Co. et al., Bill Ginder #1	C SW NW Sec. 22-27N-10W
18.	Texas Co., A.A. Bula #1	NE NW SE Sec. 24-29N- 9W

North-South Correlation Section B-B', B'-B"

No.	Operator and Well Number	Location
1.	National Associated Petroleum Co. Rattlesnake Spring #3-3	E½ E½ Sec. 31-28N-10E
2.	National Associated Petroleum Co. N. Cedar Creek Well #2-2	NW NW SW Sec. 18-27N-10E
3.	D.H. Lovelace Drilling Co. #2 Osage Nation	SW SW SW Sec. 30-26N-10E
4.	Shamrock Oil & Gas Co. Miller Kennedy #1	SW¼ Sec. 29-25N- 9E
5.	Carter Drilling Co. Lanton #1-A	SW SW SE Sec. 13-24N- 9E
6.	White Star Oil Drummond #1	SW SW NE Sec. 24-23N- 9E
7.	BBR Oil Corp. Bone #1	SE¼ Sec. 14-22N- 9E
8.	Wilcox Oil Co. Sutherland #1	SW SE SW Sec. 14-21N- 9E
9.	Wilcox Oil Co. Mary Brown #1	NE NE SE Sec. 11-20N- 9E
10.	Activated Chemical Co. Stone #1	SE SW NW Sec. 33-18N- 9E
11.	Pringle, Novak and Tarr Miracle #1	NE SW NW Sec. 24-17N- 9E
12.	Tenneco Oil Co. Tiger Dutcher Sand Unit #1	NE SE SE Sec. 12-16N- 9E
13.	Waggoner Drilling Co. Blosh B-1	NW SW SE Sec. 11-15N- 9E
14.	Illinois Exploration Co. J. Long #1	SW NE SE Sec. 2-14N- 9E
15.	H.R. Forker Mill #1	NE NE SE Sec. 24-14N- 9E
16.	Plateau Development Co. Repologle #1	NW SW SW Sec. 10-13N- 9E
17.	John B. Quinn Haydon #1	NE NW NW Sec. 24-13N- 9E
18.	Ambassador Oil Corp. Fixico #1-A	NW SW SE Sec. 32-12N- 9E
19.	Merle C. Kelce Tinkler #1	NW NW SE Sec. 25-10N- 9E
20.	W.R. Yinger & R.C. Johnston Palmer #1	SW NE NW Sec. 23-10N- 9E
21.	Carter OilCo. Jackson #1	SW SE Sec. 24- 8N- 9E
22.	Seaboard Oil Co. Estate #1	NW NW SW Sec. 18- 6N- 9E
23.	Midwest Oil Corp. Dexter Clenney #1	NE SE NE Sec. 1- 5N- 9E
24.	Apache Corp. Hudson #1	SE SE Sec. 6- 4N- 9E

No.	Operator and Well Number	Location
25.	Stanolind Oil & Gas Co. O.J. Hamilton #1	C NW SW Sec. 33- 4N- 9E
26.	Atlantic Refining Co. A.D. Cody #1	C NE NE Sec. 25- 3N- 9E
27.	Carter Oil Co. Centrahoma #1	NE SE SW Sec. 27- 2N- 9E
28.	Tenneco Oil Co. Mayer Jr. #1	S½ SW NE Sec. 1- 1N- 9E
29.	Cities Service Oil Co. Whiteley #1	SE NW Sec. 27- 1N- 9E
30.	Gibson and Holliman M.M. Thomas #1	C SW NE Sec. 10- 1S- 9E
31.	F.M. Porter Hudson #1	C SE NW Sec. 28- 1S- 9E
32.	R.J. Turner Coe #1	NE NW SE Sec. 7- 2S- 9E

East-West Correlation Section C-C'

1.	Global Oils Inc. Schikendanz #1	NE NW SE Sec. 10-21N-22W
2.	Pan Am Petroleum Corp. H.E. Dean #1	C SW NE Sec. 3-21N-21W
3.	Carter Oil Co. Phillips #1	NW SE NW Sec. 17-21N-20W
4.	Clarcen Petroleum Co. Sears #1	NE SW Sec. 11-21N-18W
5.	Amarex Drilling Co. Sears #1	C SE Sec. 5-21N-17W
6.	Apache Corp. Hutchinson #1	SW NE SW Sec. 3-21N-15W
7.	Tenneco Oil Co. Jordan #A-1	SW NE Sec. 3-21N-14W
8.	Gulf Oil Corp. R.E. Perkins #1	SW NW SE Sec. 11-21N-12W
9.	Julius C. Livingston Coppock #C-1	NE NE NE Sec. 8-21N-11W
10.	Gulf Oil Corp. Turner #1	C SW SE Sec. 2-21N- 9W
11.	Sinclair Oil and Gas Co. Winston Long Unit	C NW SE Sec. 11-21N- 8W
12.	Tidewater Associated Oil Co. Winchester #1	NE SE NE Sec. 12-21N- 7W
13.	Shell Oil Co. Hunter #1-11	SE SW SE Sec. 11-21N- 6W
14.	Gene Goff Loesch #1	C NE SE Sec. 10-21N- 5W
15.	Pure Oil Co. Narth #1	SW SE SW Sec. 33-21N- 4W

No.	Operator and Well Number	Location
16.	T.N. Berry Donahue #1	SE SE NE Sec. 32-21N- 2W
17.	Hanlon-Boyle Inc. Jaunita Allen #1	SW SW NE Sec. 1-21N- 1E
18.	W.H. Marigan Mace #1	NE NE SW Sec. 15-21N- 2E
19.	Bell Oil and Gas Co. Tyler #1	SW SW SW Sec. 9-21N- 3E
20.	T.N. Berry and Co. Rodgers #1	SW SW SW Sec. 2-21N- 5E
21.	Roy McAninch Martin #1	NW NW SW Sec. 12-21N- 6E
22.	Glenn Gillespie and Sons Armstrong #1	NE NE SE Sec. 35-21N- 7E
23.	Gulf Oil Corp. Purcell #14W	S½ SW NE Sec. 34-21N- 8E
24.	Wilcox Oil Co. Sutherland #1	SW SE SW Sec. 14-21N- 9E

East-West Correlation Section D-D', D'-D"

1.	Gulf Oil Corp. B.W. Fletcher	SW NW Sec. 34-11N-16W
2.	Continental Oil Co. North Corn Unit #1	NE SW Sec. 19-11N-14W
3.	Phillips Petroleum Co. Luekenga "A" #1	NE NW SE Sec. 25-11N-14W
4.	Davis Oil Co. Reynolds #1	C SW Sec. 5-11N-13W
5.	Magnolia Petroleum Co. H. Troy Smith	C SW NW Sec. 12-11N-11W
6.	Jerry Chambers Oil Crain Unit #1-7	SW¼ Sec. 7-10N-10W
7.	Helmerich and Payne Inc. Marti Unit #1	C NW SE Sec. 24-10N-10W
8.	Trigg Drilling Black #1	SW SW Sec. 25-10N- 9W
9.	Sunray DX Oil Archer Cullen #1	NW SW Sec. 34-10N- 7W
10.	MacKeller Inc. Engelle #1	C SW NE Sec. 3- 9N- 5W
11.	Pure Oil Co. O.U. Tract "C" #1	NE SE NE Sec. 23- 9N- 3W
12.	Ashland Oil and Refining Co. Joe Martin #1	C NE SE Sec. 36- 9N- 2W
13.	Herman and George Brown Wilcox #1	SW SE SW Sec. 35- 9N- 2W
14.	Anderson Prichard Oil Co. Bell #1	C NW NE Sec. 12- 8N- 1W

No.	Operator and Well Number	Location
15.	Johnson & Gill & Morton Drilling Steil #1	SE NW SE Sec. 14- 8N- 1E
16.	E.F. McDonald Jr. Buford Jones #1	SW SE SW Sec. 14- 8N- 3E
17.	J.F. Smith Drouch #1	NW NW NE Sec. 5- 7N- 4E
18.	A.W. Hembree Hembree #1	SE SW SE Sec. 19- 7N- 5E
19.	Mapco Inc. Ruetz #1	NW SW SW Sec. 20- 7N- 6E
20.	Arthur C. Hill Co. E.M. Whitney #1	SE SW NW Sec. 24- 5N- 6E
21.	Stanolind Oil and Gas Co. Arbuckle Operation Unit #1	SW NW SE Sec. 31- 7N- 8E
22.	Seaboard Oil Co. Estate #1	NW NW SW Sec. 18- 6N- 9E
23.	Stephens Petroleum Crop. Turner #1	SE SE NW Sec. 7- 6N-10E
24.	Deep Rock Oil Co. Troup Moore #1	NW NW SE Sec. 11- 6N-10E
25.	Ideal Cement Co. Ross #1	NE NE NE Sec. 31- 6N-11E

VITA

RICHARD DALE FRITZ

Candidate for the Degree of

Master of Science

Thesis: STRUCTURAL CONTOUR MAP OF OKLAHOMA ON THE PENNSYLVANIAN WAPANUCKA LIMESTONE, OSWEGO LIMESTONE, BASE OF THE HOXBAR GROUP, AND CHECKERBOARD LIMESTONE

Major Field: Geology

Biographical:

Personal Data: Born in Tulsa, Oklahoma, August 4, 1952, the son of Mr. and Mrs. Charles Burton Fritz.

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