PETROLEUM GEOLOGY OF THE MISENER SANDSTONE

IN PARTS OF PAYNE AND LINCOLN

COUNTIES, OKLAHOMA

By

JAMES P. KOCHICK

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1976

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1978

PETROLEUM GEOLOGY OF THE MISENER SANDSTONE

IN PARTS OF PAYNE AND LINCOLN

COUNTIES, OKLAHOMA

Thesis Approved:

Gary F. Stewart
Thesis Adviser

John W. Shelton

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

Sincere appreciation and gratitude is extended to several individuals and groups who contributed to this study. Mr. Joe J. Newcomb of the Thomas E. Berry group suggested the problem, provided assistance throughout preparation and writing of the text, and contributed much in the form of experience, knowledge, and inspiration. Dr. Gary F. Stewart gave much time, effort, and advice throughout the author's educational career.

I am grateful to the late Thomas E. Berry, who was a sincere, dedicated oil finder and an inspiration to many in the oil industry. I thank him and his associates at Berry Operating Company for the use of data, for reproduction and drafting facilities, and for much of the funds that made this thesis possible.

Dr. R. Nowell Donovan helped the writer interpret the thin-sections described herein. Dr. John W. Shelton served on the writer's thesis committee and contributed valuable advice. Barney Harvey drafted many of the illustrations and maps. To these persons I express my appreciation.

Finally, I am sincerely grateful and indebted to my wife, Jo, for her help in editing of the text, and for constant support and encouragement. I am also grateful to my parents, Micheal and Myrtle Kochick, and to my wife's parents, Asa and Elaine Erwin, for their constant support and encouragement.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

In the area of investigation, T. 17 to 19 N., R. 4 and 5 E., the Misener sandstone is developed as two major northwest-trending belts. Areal distribution of the Misener sandstone was influenced by paleotopography of the pre-Woodford terrain. In turn, the paleotopography was influenced by the pre-Woodford subcrop and, to some extent, the pre-Woodford structural configuration.

The Misener sandstone generally was deposited in topographic "lows" of the pre-Woodford terrain. Its overall pattern includes dendritic and anastamosing networks of long, sinuous bodies of sandstone. The Misener is located mostly near or along the Sylvan Shale-Viola Limestone contact. In the study area, several paleostructural "lows" and "highs" show up as paleotopographic "lows" and "highs."

Several hypotheses concerning depositional environments of the Misener sandstone account for the facts compiled in this study. The writer favors the major hypothesis that the Misener sandstone was deposited as an alluvial sand.

Two basic kinds of hydrocarbon-trapping conditions can be described for the Misener: (1) pinchouts on flanks or crests of anticlines and domes, and (2) structural closure of the Misener sandstone where it is folded over anticlines and domes.

The risk-reward relationships of exploring for Misener sandstone oil and gas traps are sufficiently attractive for most investors.

INTRODUCTION

Location of the Study Area

The specific area studied covers approximately 216 sq. mi. in parts of Payne and Lincoln Counties, including T. 17 N. through T. 19 N., R. 4 E. and R. 5 E. (Fig. 1).

Statement of the Problem

The Misener sandstone is exceptionally productive of oil and gas in north-central Oklahoma. Its distribution, depositional environments, and trapping conditions have not been documented thoroughly in geologic publications. The problem addressed in this research can be expressed as a set of questions; answers to these questions can be integrated into a general overview of the petroleum geology of the Misener sandstone in the study area. The questions are:

1. What is the extent of the Misener sandstone within the thesis area?
2. Can paleotopography of the unconformity beneath the Misener sandstone and Woodford Shale be approximated closely? If so, how is paleotopography related to distribution of the Misener?
3. Can the subcrop pattern of the pre-Woodford unconformity surface be approximated closely? If so, how is it related to the distribution of the Misener sandstone?
4. Can relations be shown between paleostructural geology and

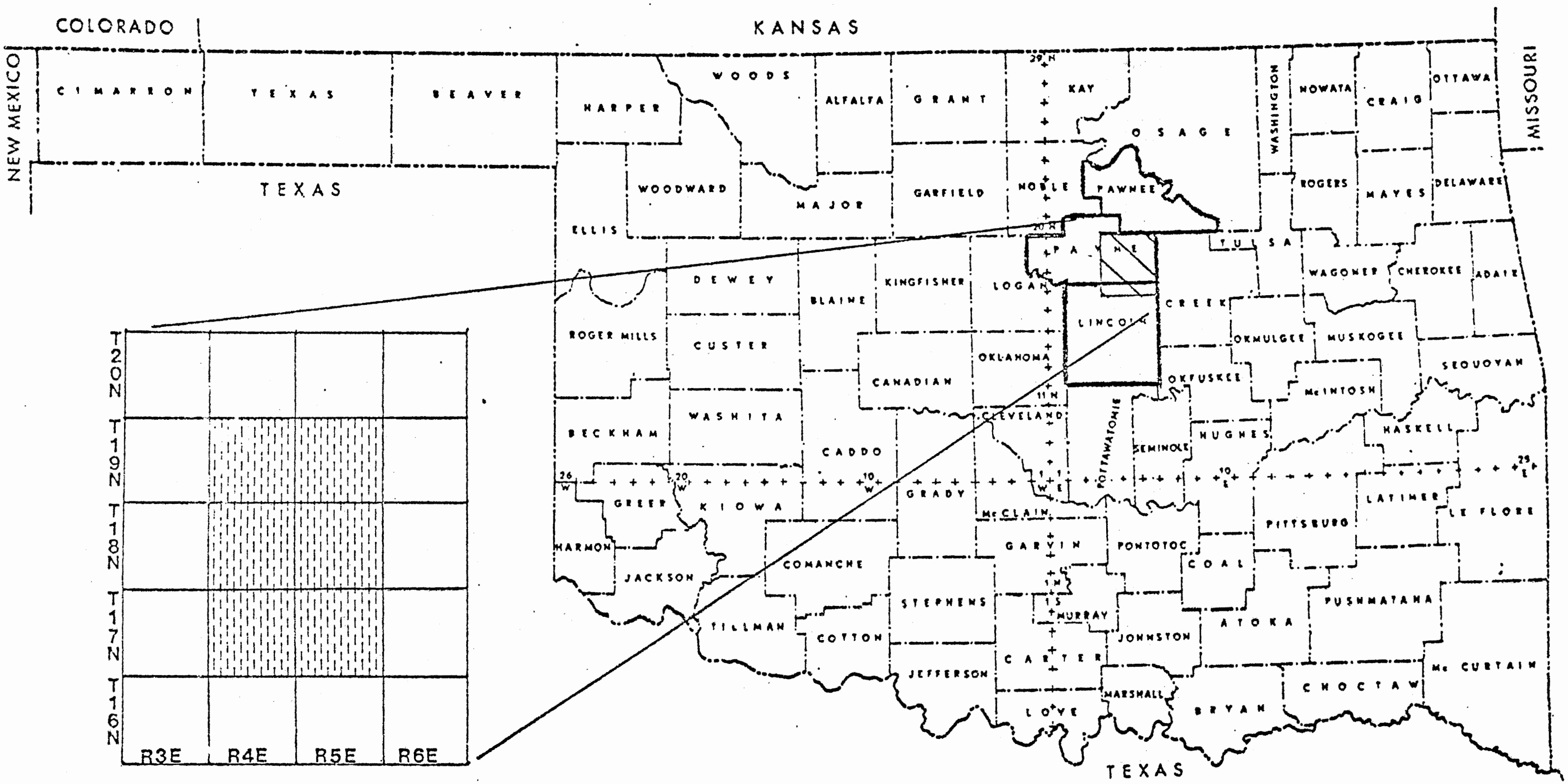


Figure 1.- Location of study area.

paleotopography of strata beneath the Misener and Woodford?

5. What were the depositional environments of the Misener sandstone?

6. What kinds of petroleum traps are developed in the Misener sandstone of the study area?

7. How productive of oil and gas are Misener oil fields?

8. What are the risk-reward relationships of exploring for traps in the Misener sandstone?

PREVIOUS INVESTIGATIONS

The Misener sandstone of late Middle to Late Devonian age was named after Fred D. Misener, a Tulsa, Oklahoma oil producer, for a sandstone penetrated at 3009-3054 feet in the No. 1 McWilliams well, Sec. 23, T. 15 N., R. 10 E., Creek County, Oklahoma (Amsden and Klapper, 1972). The surface equivalent of the Misener sandstone is considered to be the Sylamore Sandstone. The rock units are considered to be equivalent because, being within the Woodford Shale, of approximately the same age, they both overlie the pre-Woodford unconformity, and they are lithologically similar. The type area of the Sylamore is accepted as being along South Sylamore Creek in Stone County, Arkansas (Freman and Schumacker, 1969). These sandstones overlie the pre-Woodford unconformity, which in the study area truncates the Hunton Group, Sylvan Shale, Viola Limestone, and Simpson Group.

Studies of which the Misener was a primary subject of research were those of White (1926), Borden and Brant (1941) in the East Tuskegee Pool, Creek County, Oklahoma, Imbt (1941) in Stafford County, Kansas, Krumme (1969) in Creek County, Oklahoma, and Amsden and Klapper (1972) in parts of north-central Oklahoma. Explanations of origin of the Misener include aeolian deposits (White, 1926), alluvial deposits (Krumme, 1969), and near-shore marine deposits (Imbt, 1941; Borden and Brant, 1941; Amsden and Klapper, 1972).

Methods and Procedures

Data utilized in this study were obtained from approximately 590 electric logs, from scout tickets, from Vance Rowe production reports, from well samples, and from one well core.

An isopachous map of the Misener sandstone (Pl. 1) was used to estimate its thickness and areal distribution. A structural contour map on top of the Woodford Shale (Pl. 2) approximates configuration of the Misener sandstone. An isopachous map from the top of the Woodford Shale to the base of the "Viola dense" (Pl. 3) was used to estimate the general structural configuration of rocks on the pre-Woodford unconformity. An isopachous map from the top of the Woodford Shale to the base of the Woodford Shale or of the Misener sandstone (Pl. 4) was used to map paleotopography on the pre-Woodford unconformity. A subcrop map of the pre-Woodford unconformity was used in determination of paleotopography and Misener sandstone distribution. Several cross-sections aid in estimating geometry of the Misener sandstone.

Vance Rowe reports were the basis of cumulative production data on several Misener oil fields and of production curves. Bit cuttings from nine wells (including one core) were studied, and 30 thin sections were studied. These data were valuable in estimation of depositional environments.

REGIONAL GEOLOGY

In general, pre-Mississippian strata of Oklahoma record deposition in intracontinental basins. Moderately stable conditions seem to have existed from Late Cambrian time through much of the Devonian Period. Upper Cambrian and Lower Ordovician rocks (Fig. 2) record widespread deposition of carbonate sediments in shallow seas that extended across basin and platform areas of the southern Midcontinent region (Fig. 3) (Nicholas and Rozendal, 1975). Tectonic conditions described above existed through deposition of the Middle Ordovician Simpson Group, which records influx of terrigenous sediment and several transgressions and regressions. Strata of the Simpson thin upon flanks of the Ozark Uplift (Fig. 4), which began rising early during deposition of the Simpson (Ireland, 1966). The Viola Limestone, and uppermost Ordovician Sylvan Shale, and the Silurian-Devonian Hunton Group (Fig. 2) record deposition of carbonate and clayey sediments in fairly quiet, shallow seas.

During the Middle and Late Devonian, strata of the study area were tilted southward and southwestward and truncated by subaerial erosion. A hypothetical overview of the southern Midcontinent region in late Middle Devonian time shows the general tectonic conditions (Fig. 5). Following Late Devonian erosion and deposition of the Misener sandstone, marine conditions prevailed, and the former topography was buried by sediments of the Woodford Shale (Harvey, 1968).

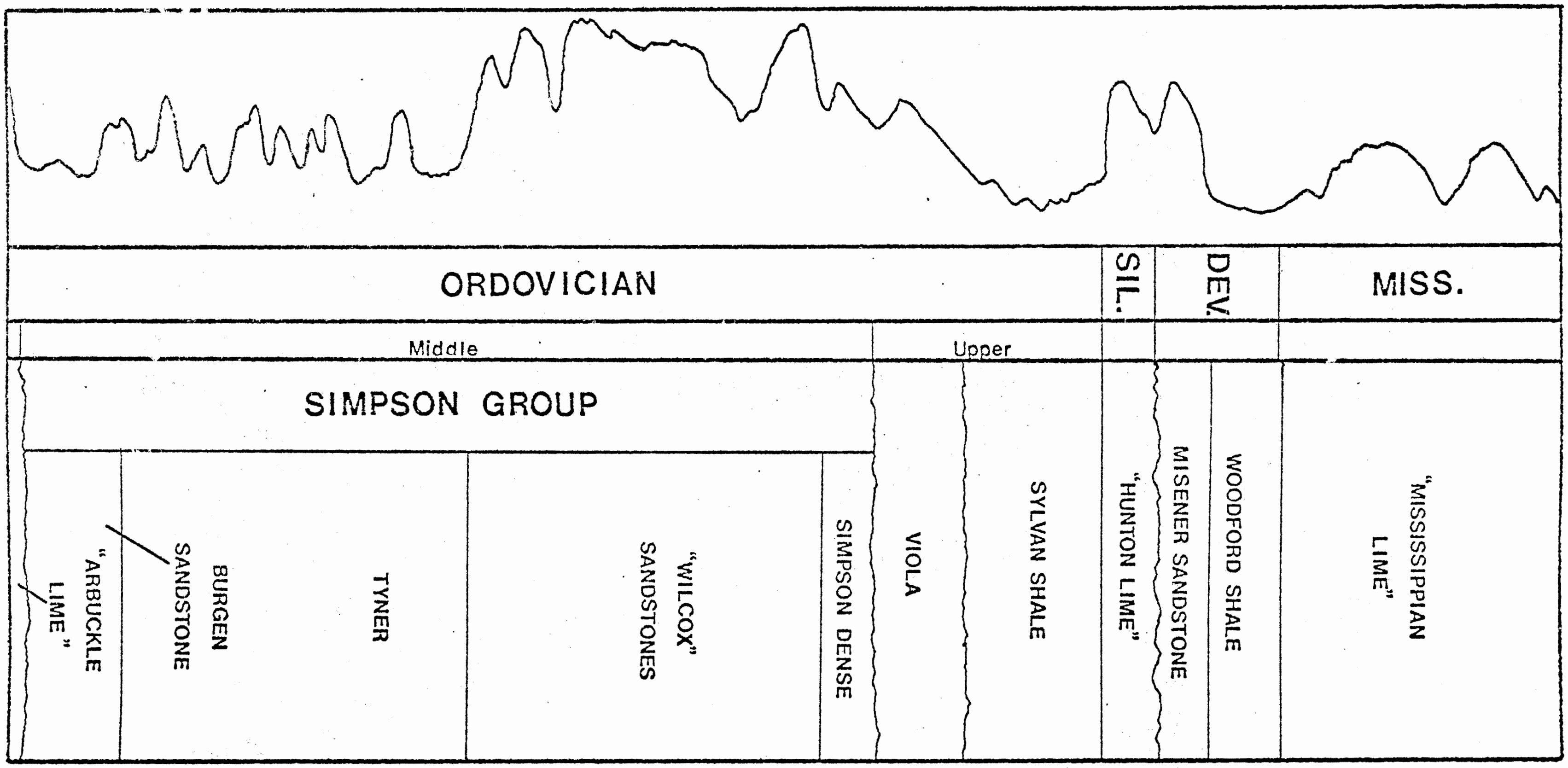


Figure 2.- Generalized stratigraphic chart showing Lower Ordovician to Lower Mississippian rocks of the study area.

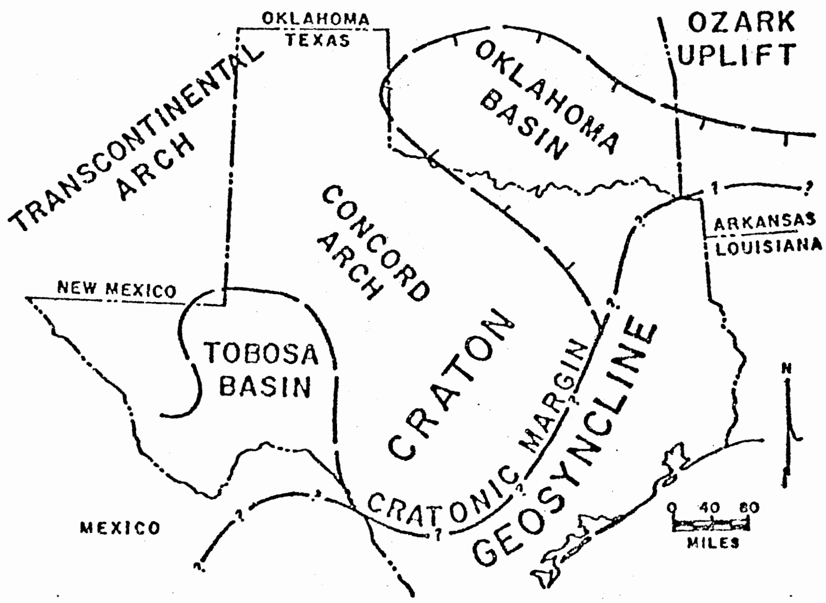


Figure 3.- Major uplifts and basins of the southern Midcontinent during Late Cambrian through Devonian time (after Nicholas and Rozendal, 1975).

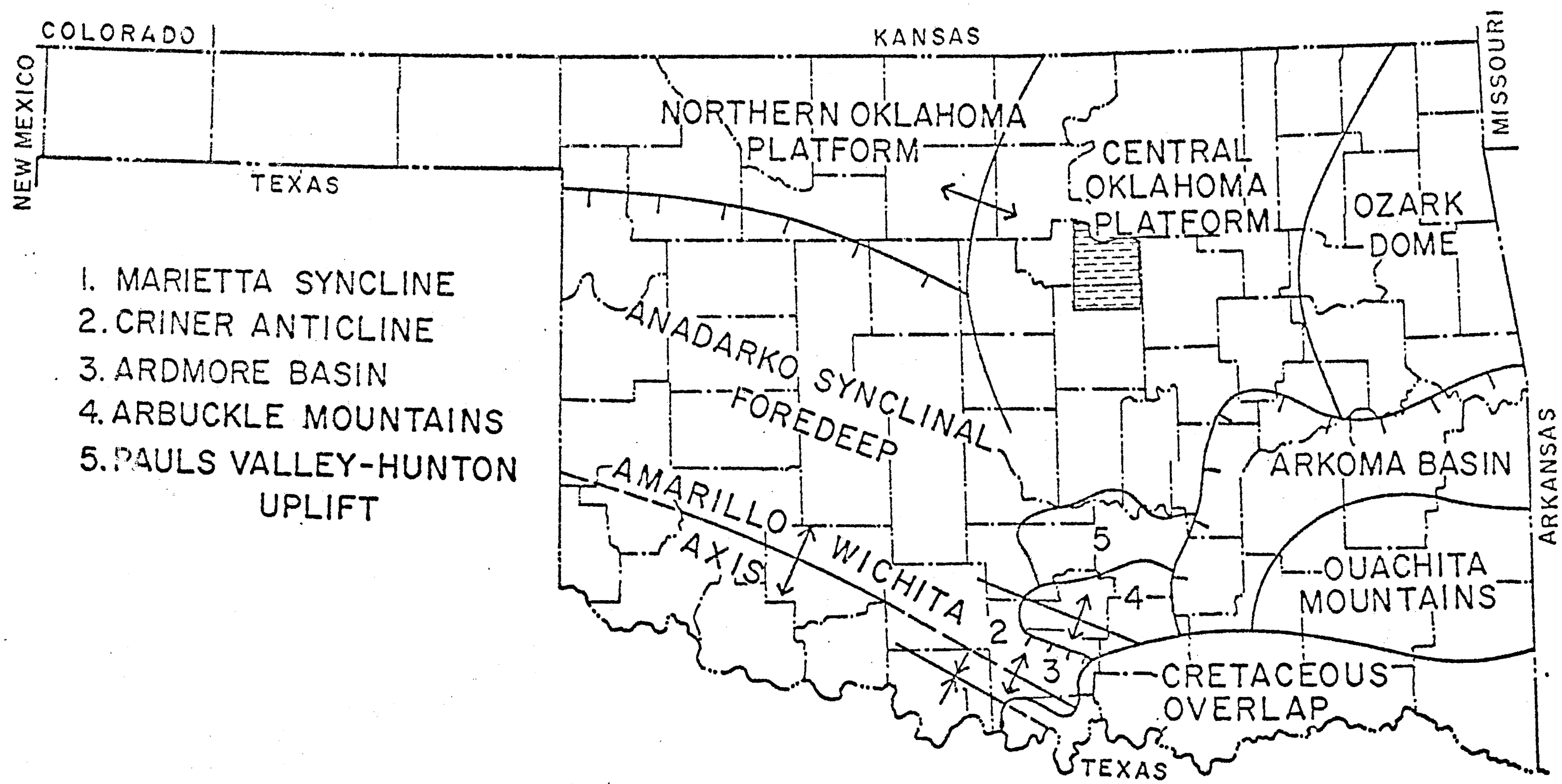


Figure 4.- Tectonic map of Oklahoma, also showing location of the study area. Numbered structural elements are as follows: (1) Nowata Ridge, (2) Pauls Valley-Hunton Uplift, (3) Arbuckle Mountains, (4) Criner Anticline, and (5) Ardmore Basin (after Arbenz, 1956).

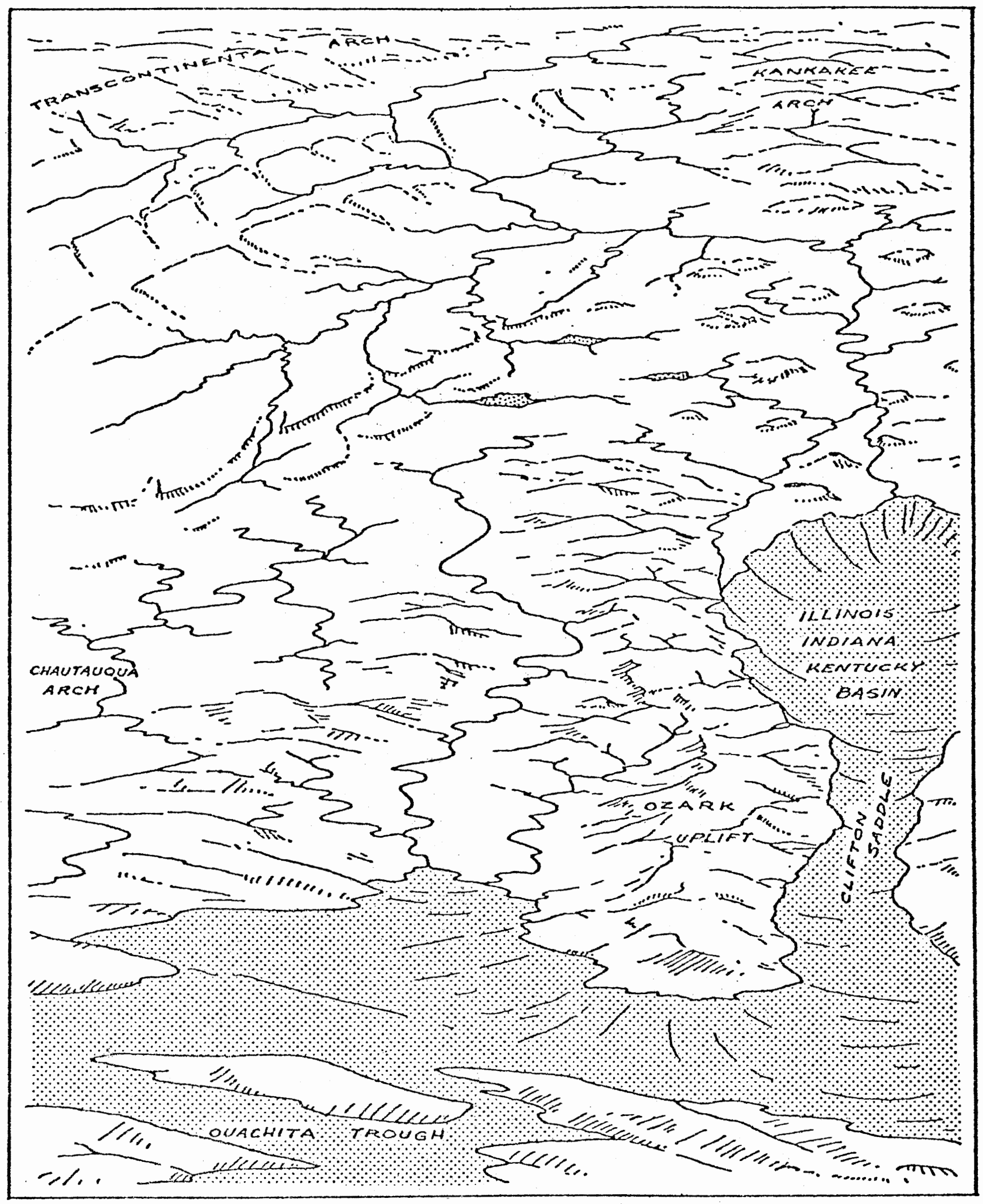


Figure 5.- Hypothetical overview of the Midcontinent region in late Middle Devonian time (adapted from Koenig, 1967).

STRATIGRAPHY

In the study area, the pre-Woodford unconformity extends across the truncated Simpson Group, Viola Limestone, Sylvan Shale, and the Hunton Group (Fig. 6). The Misener sandstone and Woodford Shale were deposited on this surface and are overlain by the Woodford Shale (Fig. 2).

In northeastern and north-central Oklahoma, the Simpson Group (Middle Ordovician) includes the Burgen Sandstone, the Tyner Formation, the "Wilcox" sandstones, and the "Simpson dense" (probably the Fite Limestone of the surface). The Simpson is unconformable upon the Lower Ordovician and the Cambrian-Arbuckle Group. Isopachous maps show northeastward thinning of the Simpson Group from almost 3000 ft. in the Ardmore Basin, to about 2300 ft. in the Arbuckle Mountains, to zero at the outcrop in southern Delaware and Mayes Counties, Oklahoma (Huffman, 1965) (see Fig. 1 for the locations of counties). Thinning of the Simpson is due to convergence of units, disconformities, and to pre-Woodford truncation (Huffman, 1965).

The Viola Limestone (Fernvale Limestone as exposed in the Tahlequah area, Cherokee County, eastern Oklahoma) overlies the Simpson Group unconformably. At the type locality in the Arbuckle Mountains, the Viola is thicker than 750 ft.; it thins northeastward, and wedges out in the study area (Fig. 6). In the type area, the Viola is bluish-gray to dark gray, thin- to medium-bedded, wavy- and

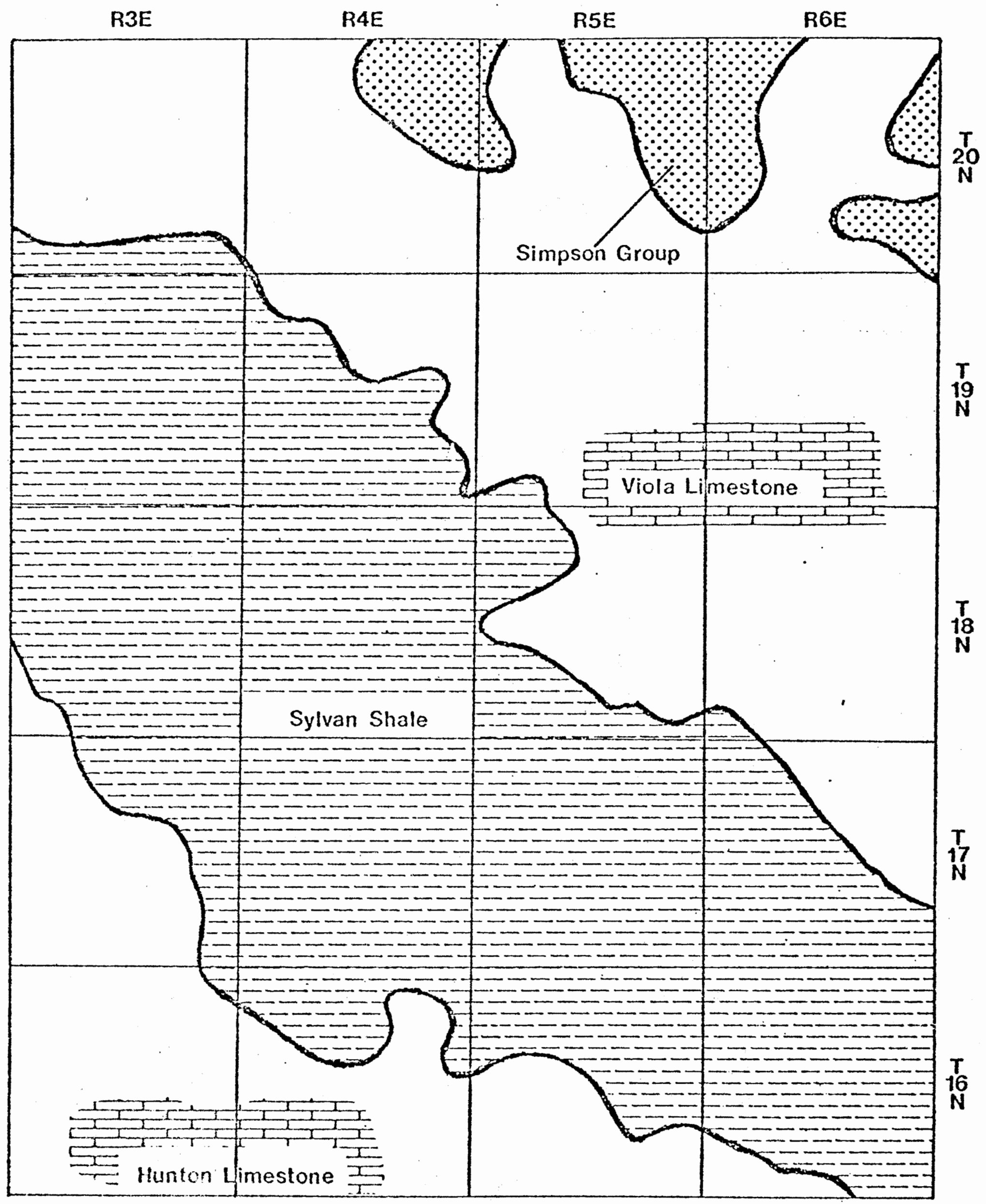


Figure 6.- General outcrop patterns of stratigraphic units beneath the Woodford Shale.

even-bedded limestone that contains some cherty strata (Ireland, 1965). In the study area the Viola is massive, coarsely crystalline, buff to white limestone; in bit cuttings the Viola is distinctive because of its color. The Sylvan-Viola contact (Fig. 2) was considered to be disconformable by Mairs (1966). The Sylvan Shale (Fig. 2) was named by Taff (1906) for exposures near the former village of Sylvan in Johnston County; it is the uppermost Ordovician rock unit of Oklahoma (Mairs, 1966). The Sylvan is distinguished on the electrical logs by the low values of both the resistivity and the self-potential curves. It is light green, splintery waxy shale in the upper one-half and brown, soft, granular, fissile shale in the lower one-half. The Sylvan thickens southwestward from the wedgeout in the study area (Fig. 6).

The Silurian-Devonian Hunton Group conformably overlies the Sylvan Shale (Fig. 2). In north-central Oklahoma the Hunton includes the Chimney Hill and Henryhouse Formations. The Chimney Hill is white to light tan, dense to finely crystalline limestone that contains many orange or pink fragments of crinoids (Hollrah, 1977). The Henryhouse is chalky or marly limestone; thin sections show the rock to be silty, dolomitic, and micritic (Hollrah, 1977). The Hunton thins northeastward to zero in the southern part of the study area (Fig. 6). In general, the Hunton Group records deposition of carbonate sediments in a fairly quiet, shallow sea.

As stated above, Misener sandstone lies on the pre-Misener unconformity and underlies the Woodford Shale. It is quite variable in extent, in some places thinning from 50 to 0 ft. in less than three-quarters of a mile. It is generally less than 10 ft. thick, but is thicker than 50 ft. at some places in the study area (Pl. 1). The

Misener generally is composed of fine- to coarse-grained, clean quartz sand. The rock is friable; commonly, in drilling samples, the sand occurs as individual quartz grains. In some wells, however, the Misener is very fine-grained to fine-grained, and tightly cemented. In some wells the sandstone is dolomitic. In some specimens, dolomite occurs interstitial to quartz, as replacement of quartz, or as interbeds.

The Woodford Shale is widely distributed within the Midcontinent. It ranges from 18 ft. thick in the northern part of the study area to more than 50 ft. in the southern part. The Woodford is dark gray to black shale.

STRUCTURAL GEOLOGY

The study area is in the west-central portion of the Northeastern Oklahoma Platform. Other regional tectonic provinces that border the Northeastern Oklahoma Platform include the Ozark Uplift and Chautauqua Arch, the Nemaha Range, Pauls Valley-Hunton Uplift, and the Arkoma Basin (Fig. 4).

As shown by a structural contour map of the top of the Woodford Shale (Pl. 2), regional strike is north-northwest and dip is west-southwest, except where modified locally by folds or faults. Regionally dip varies from about 50 to about 70 ft./mi.; locally, dip is on the order of 300 ft./mi.

Within the study area two major trends are detectable. Figure 7 shows an east-west set of aligned structural axes and a north-northeast-trending set that forms a general en-echelon pattern. Figure 8 shows evidence that the eastward trend was prominent before deposition of Mississippian carbonate rocks.

The most prominent east-west trend is the Ripley-Cushing syncline (Fig. 7). This trend may be associated with the Coyle fault, a basement fault mapped by Lyons (1950) west of the study area (Fig. 9). This synclinal trend is also the most prominent feature inferred on the pre-Woodford paleostructural contour map (Pl. 3). Several other east-trending synclinal and anticlinal trends are in the study area. South of the Ripley-Cushing synclinal trend are the Cushing anticlinal

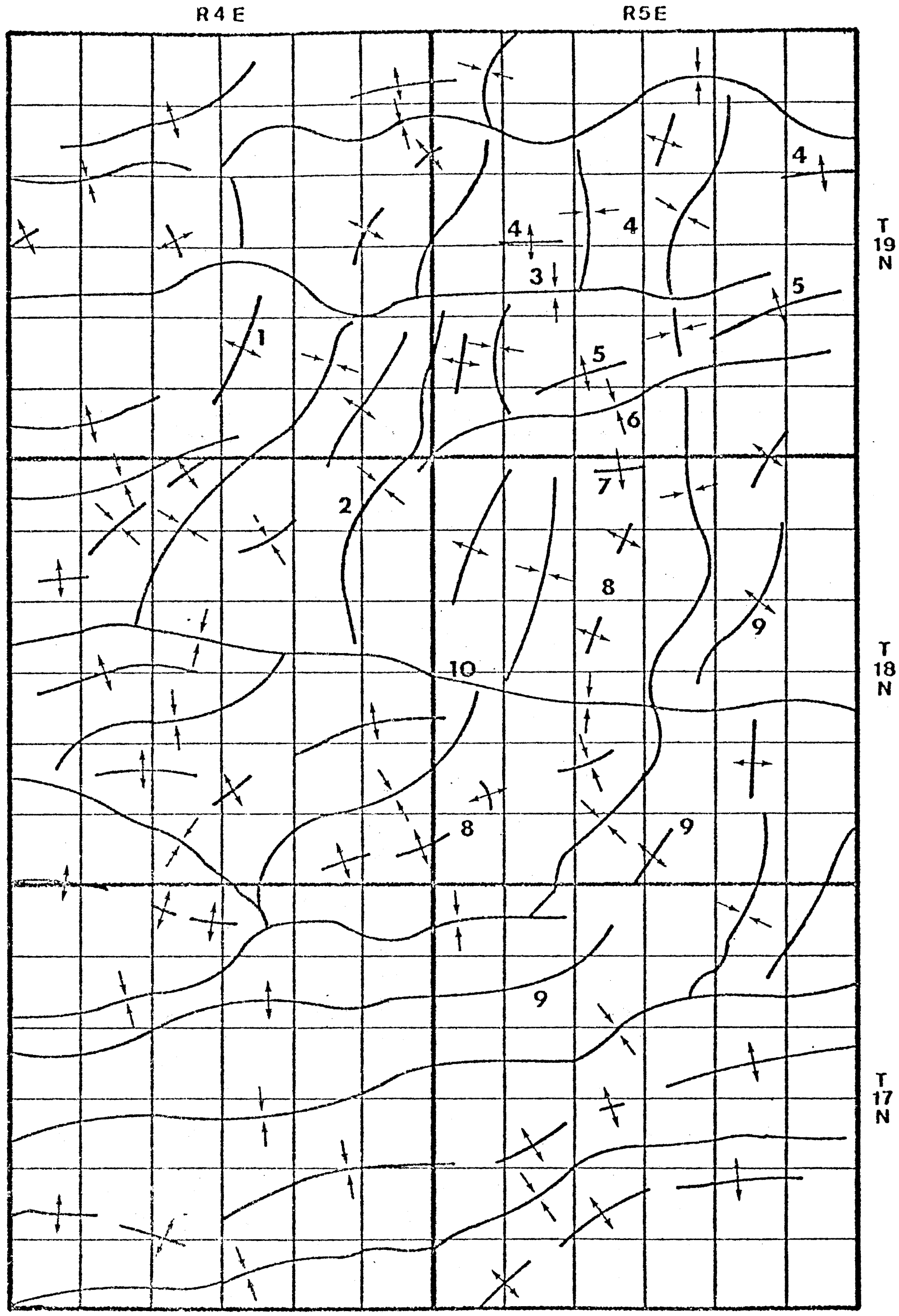


Figure 7.- Structural trend map, top of Woodford Shale. 1-Ingalls Anticline; 2-East Ingalls Syncline; 3-North Ingalls Syncline; 4-North Ingalls Anticlinal Trend; 5- Pratt Anticlinal Trend; 6-Pratt Syncline; 7-Pratt Dome; 8-West Cushing Anticlinal Trend; 9-Cushing Anticlinal Trend; 10-Ripley-Cushing Syncline; 11-North Lincoln County Anticline.

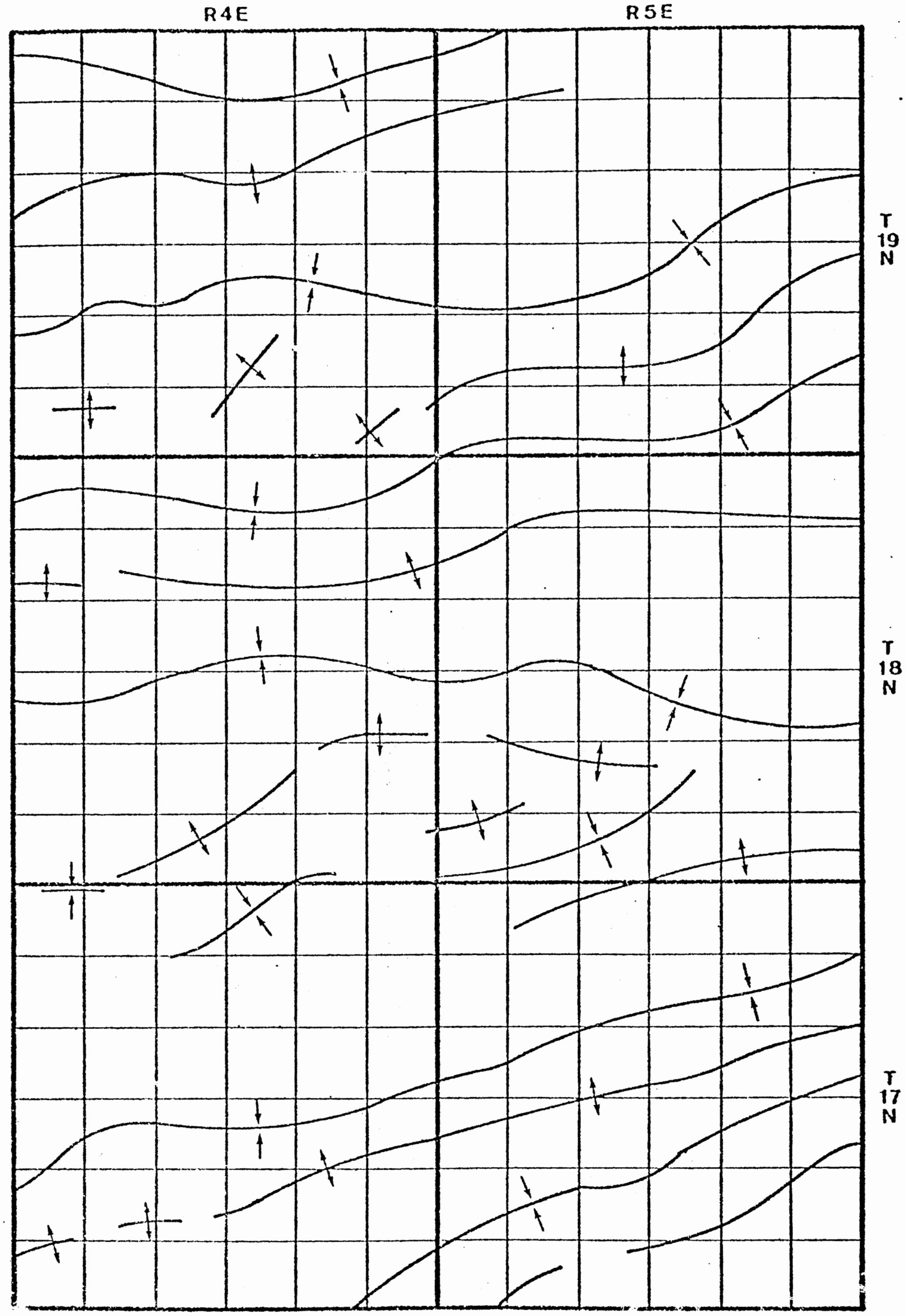


Figure 8.- Trend map, structure of pre-Woodford surface (based on Pl. 3).

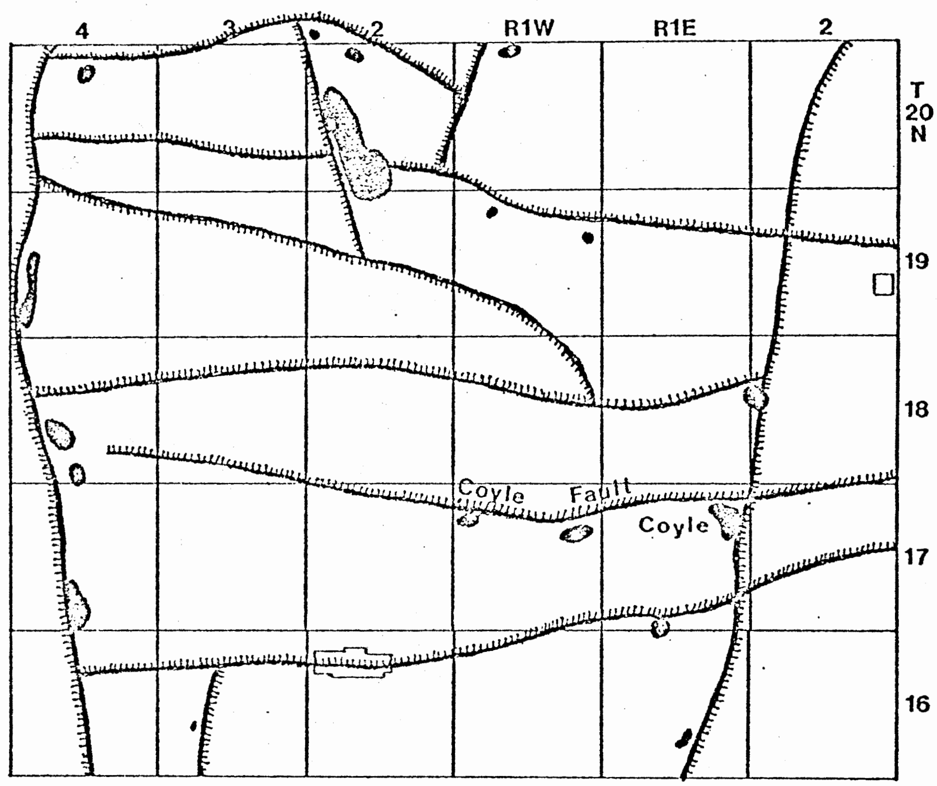


Figure 9.- General locations of major basement faults (hachured lines) and the major structurally controlled oil fields (black patches), north-central Oklahoma.

trend and the northern Lincoln County anticlinal trend (Fig. 7). North of the Ripley-Cushing synclinal trend are the prominent Pratt and North Ingalls anticlinal trends (Fig. 7).

The major northeast-trending set of folds includes the Ingalls and east Ingalls anticlinal trends, and the west Cushing and Cushing anticlinal trends (Fig. 7). East-trending folds seem to cut across and, in some instances, to offset the northeast-trending set, suggesting either (a) movement of the east-trending folds after establishment of the northeastern set, or (b) folding of the northeast-trending set of structures in response to movement along the east-west trend. Most of the folds that have closure of as much as 200 ft. are aligned with or make up the northeast-trending set.

The Ingalls anticline and the Pratt anticline (Fig. 7) are noteworthy. Ireland (1955) suggested that these folds are associated with paleotopographic "highs" on the pre-Cambrian erosional surface. The Ingalls anticline is quite complex. The Tyner Formation of the Simpson Group (Fig. 2) underlies the Woodford Shale on the crest of the structure and Hunton strata underlie Woodford Shale in the synclinal area to the east, far removed from the main body of Hunton strata (Fig. 10). Moreover, faulting has produced repeated sections in some wells on the western side of the structure. The Pratt anticline is faulted on the northeast side, and the fault shows approximately 150 ft. of displacement.

In my opinion, most faulting and folding in Paleozoic strata of the project area are related to recurrent movement of the basement rock. Chief evidence for this conclusion is twofold, as stated by Hollrah (1977): (1) length and throw of faults generally increase with

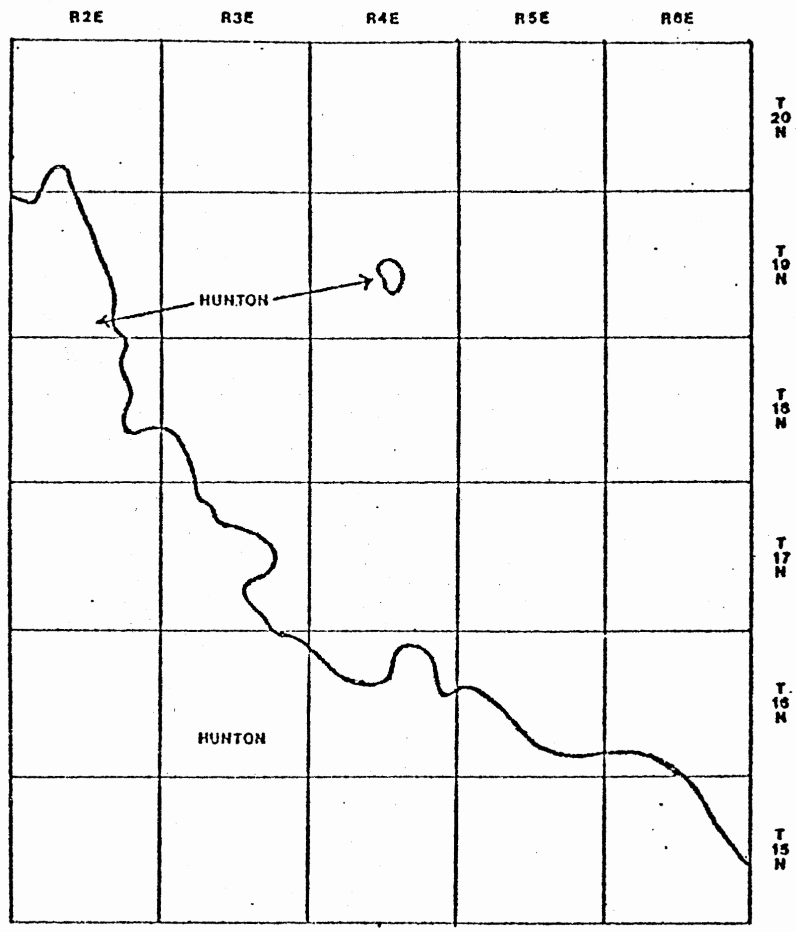


Figure 10.- Location of an outlier of Hunton rocks east of the Ingalls anticline, T. 19 N., R. 4E., in relation to the main body of Hunton strata.

depth, and show marked differences above and below major unconformities; and (2) limbs of folds generally show steeper dip and more closure below the post-Mississippian unconformity than above. Gentle folds in Pennsylvanian beds seem to be due to rejuvenation of more complex folds and faults that existed before Mississippian time. The similarity of structural fabric in shallow and deep strata, and increased complexity of folds and faults with depth suggest that the basic structural make-up of the study area originated in basement rocks.

PALEOTOPOGRAPHY

General topography that existed on the pre-Woodford unconformity was approximated by an isopachous map of the interval from the top of the Woodford Shale to the base of the Misener sandstone or of the Woodford Shale. The logic of this method is based on the following two assumptions: (1) For all practical purposes, the uppermost part of the Woodford Shale was deposited horizontally. (2) Rocks below the top of the Woodford Shale should be thinner above paleotopographic "highs" and thicker above paleotopographic "lows." Therefore, an isopachous map of the Woodford and Misener should indicate paleotopography.

Because of differential compaction of the Woodford Shale, an accentuated version of the true pre-Woodford topography might be shown by an isopachous map from the top of the Woodford Shale to the unconformity, but interpretation of the general and larger features should be dependable, nevertheless (Isom, 1973). Another modifying factor could be growth of folds or faults contemporaneous with deposition of the Woodford Shale. Such movements could accentuate or subdue paleotopographic "highs" and "lows," and more, or less, topographic variation could be interpreted than exists. Appendix A, this paper, shows evidence of exceedingly small general variation in thickness of the Woodford Shale, a fact that in itself suggests minimal contemporaneous growth of folds. However, the Woodford thins uncommonly above the

Ingalls oil field, thereby suggesting that some of the folds were enlarged a small amount during deposition of the Woodford.

Figure 11 is a diagrammatic map of the study area showing the terrain as it generally might have been prior to deposition of the Woodford Shale. Two major factors seem to have influenced paleotopography in the study area: (a) the pre-Woodford subcrop pattern and (b) paleostructure.

If one observes areas of modern topography where the terrain is made up of strata of limestone and shale in contact at the surface, generally these areas show relief due to differential erosion. Terrain of shale bedrock should be low-standing, gently rolling, and show greater density of drainage than terrain underlain by limestone. Based on Figure 6 and Plate 4, the area of the most variation is the subcrop of the Sylvan Shale; within this area the most variation generally is near the Viola Limestone-Sylvan Shale contact. In my opinion, during deposition of the Misener sandstone, terrain of the study area was underlain by belts of limestone of the Viola and Hunton, separated by the outcrop of Sylvan Shale. Through the Sylvan outcrop, streams flowed southeastward, predominantly in strike-valley systems.

In considering the relation between paleostructure and paleotopography, one should consider the effects that folding and faulting should have on topography. With folding, one might expect that synclinal and anticlinal features would be expressed as topographic lows and highs, respectively. As is well known, however, in some instances topography can be "inverted," as where rock is exposed in the central parts of domes or anticlines. With faulting, seemingly one would expect similar relationships, where downthrown sides of faults would correspond to

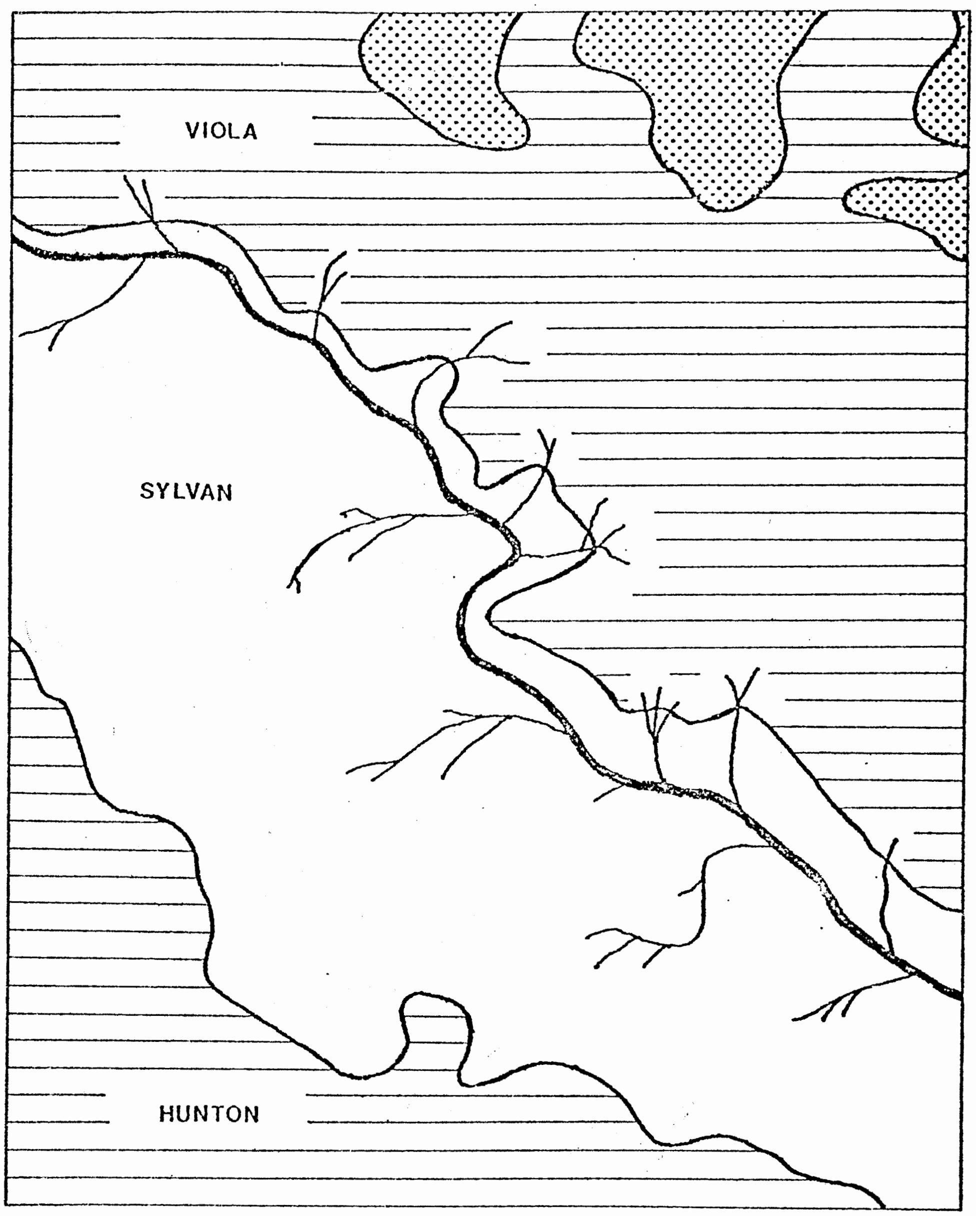


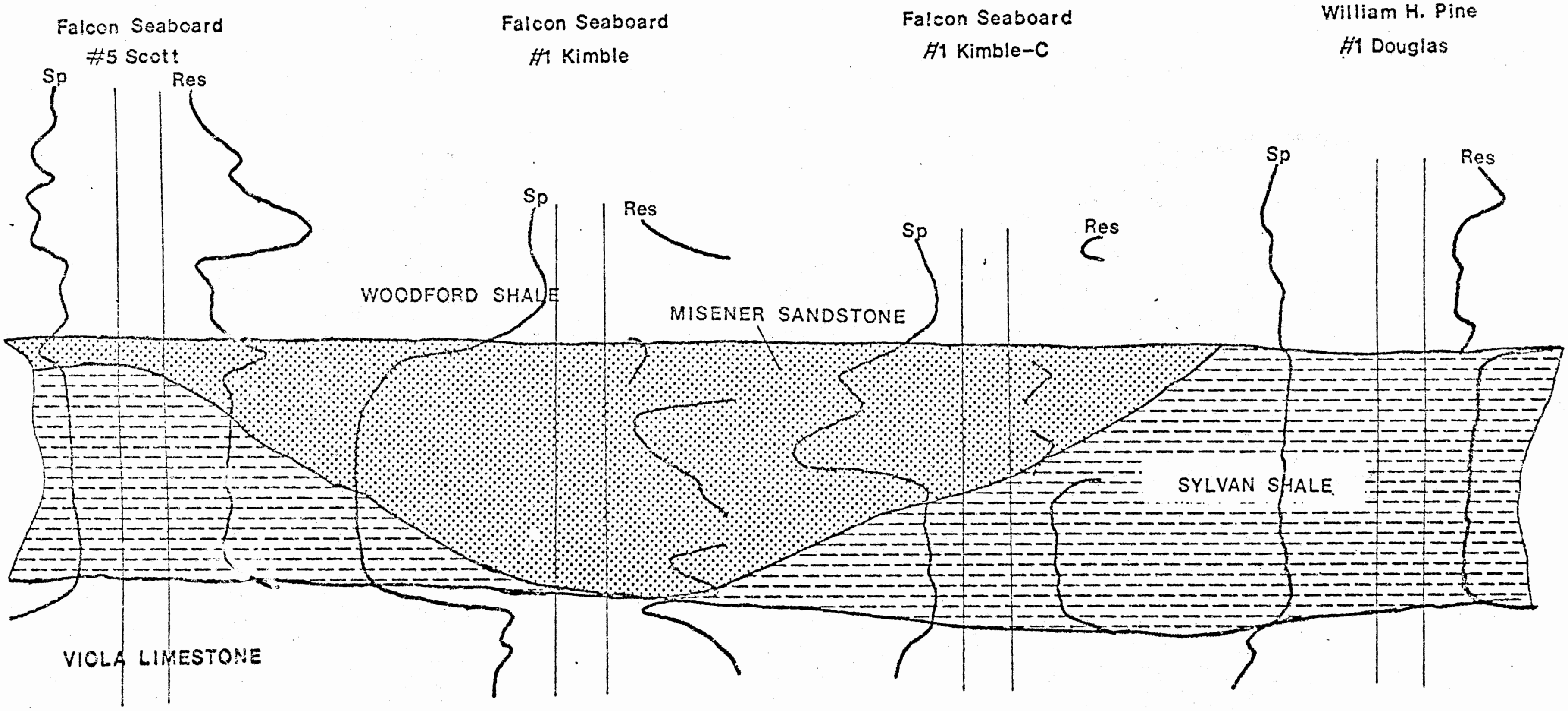
Figure 11.- Diagrammatic terrain map of the study area.

topographic lows and upthrown sides would corresponded to topographic highs. The exceptional case would be where a graben is capped by uncommonly resistant rock, leading to topographic inversion. These relationships exist in modern topography, with the amount of structural relief being an important factor in the degree to which topography is controlled by structure. I believe that in the study area, paleostructure influenced paleotopography to a detectable extent. Plate 3 and Plate 4 show some of the more prominent areas where this relationship can be seen: (1) A paleotopographically low area in T. 18 N., R. 4 E. and R. 5 E. seems to be associated quite closely with the Ripley-Cushing synclinal area shown on Plate 3. (2) Paleotopographic lows seem to be related to the north Ingalls syncline and to the east Ingalls and Pratt synclines.

GEOLOGY OF THE MISENER SANDSTONE

The depositional environment of the Misener sandstone has been reported as aeolian (White, 1926), alluvial (Krumme, 1969), and near-shore marine (Bordon and Brant, 1941; Imbt, 1941; and Amsden and Klapper, 1972).

White (1926) observed that the Misener is generally subcircular in the outline of subcrop, is extremely lenticular, and is not elongate, as are the "shoestring" sands of Kansas. He believed that the Misener sandstone deposits were composed of a few well developed dunes and a thin "veil" of windblown sand scattered over the pre-Woodford unconformity. Krumme (1969) recorded some of the major characteristics of the Misener in Creek County, Oklahoma (Fig. 1). In this area, the Misener is clean sand, has sharp contacts with strata above and below, and has no contemporaneous or adjacent deposits. Its electric-log character indicates that the sand fills channels cut into the underlying units (Fig. 12). Krumme (1969) stated that tectonic conditions of the Midcontinent during the deposition of the Misener, absence of contemporaneous deposits, and channel-fill sands inferred from electric log cross-sections are strongly suggestive of alluvial deposition. Amsden and Klapper (1972) studied the Misener in north-central Oklahoma and stated the following observations: (1) The Misener is primarily a quartzose sandstone with crystalline dolomite grading crystalline dolomite with scattered quartz grains. (They believed that the



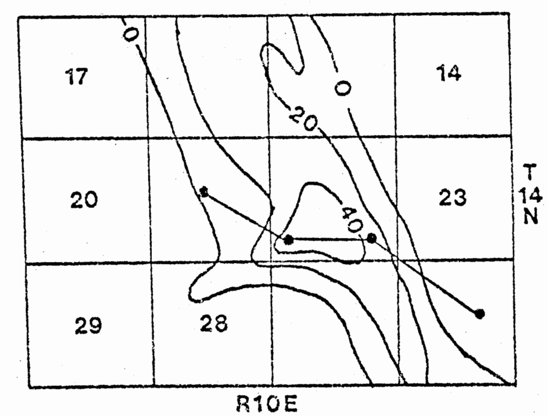


Figure 12.- Cross-section, Misener sandstone channel fill (after Krumme, 1969).

dolomite is a primary carbonate.) (2) The sandstone is cross-bedded. (3) Conodonts of late Middle to Late Devonian age and some linguloid brachiopods are within the unit. (4) The Misener is distributed erratically; it commonly is thinner than 20 ft., and the areas where it is thicker are aligned roughly northwestward. They believe that the Misener is substantially a marine sandstone, deposited near an old shoreline (Amsden and Klapper, 1972). The interpretation of marine deposition of the Misener by Borden and Brant (1941) was based on examination of well samples from which they described conodonts, spores, "coprolites," and "gastroliths" (Borden and Brant, 1941). They also stated that the Misener grades upward into the Woodford Shale.

In the study area, the Misener is developed as two major northwest-trending belts. The overall pattern includes dendritic and anastomosing networks of long, sinuous bodies of sandstone (Pl. 1). Lengths of the major trends are as much as 14 mi.; minor trends are 1 to 2 mi. long. Widths of sand bodies vary from less than one-quarter mile, in branches of the main trends, to more than 3 mi. in the major trends (Pl. 1). Widths of the major trends vary considerably. Thickness ranges from zero to more than 50 ft. (Pl. 1). Where the Misener is thick, underlying units are thin (Pl. 4; Figs. 13-17). Thickness is also quite variable; in some instances the Misener thins from 50 ft. to zero in less than one-half mile. The lower and lateral contacts of the sandstone with other strata are generally abrupt. At some places, the upper boundary of the Misener with Woodford is gradational. Predominately the Misener is a single unit of sand; at several localities, however, the sand contains interbedded shale.

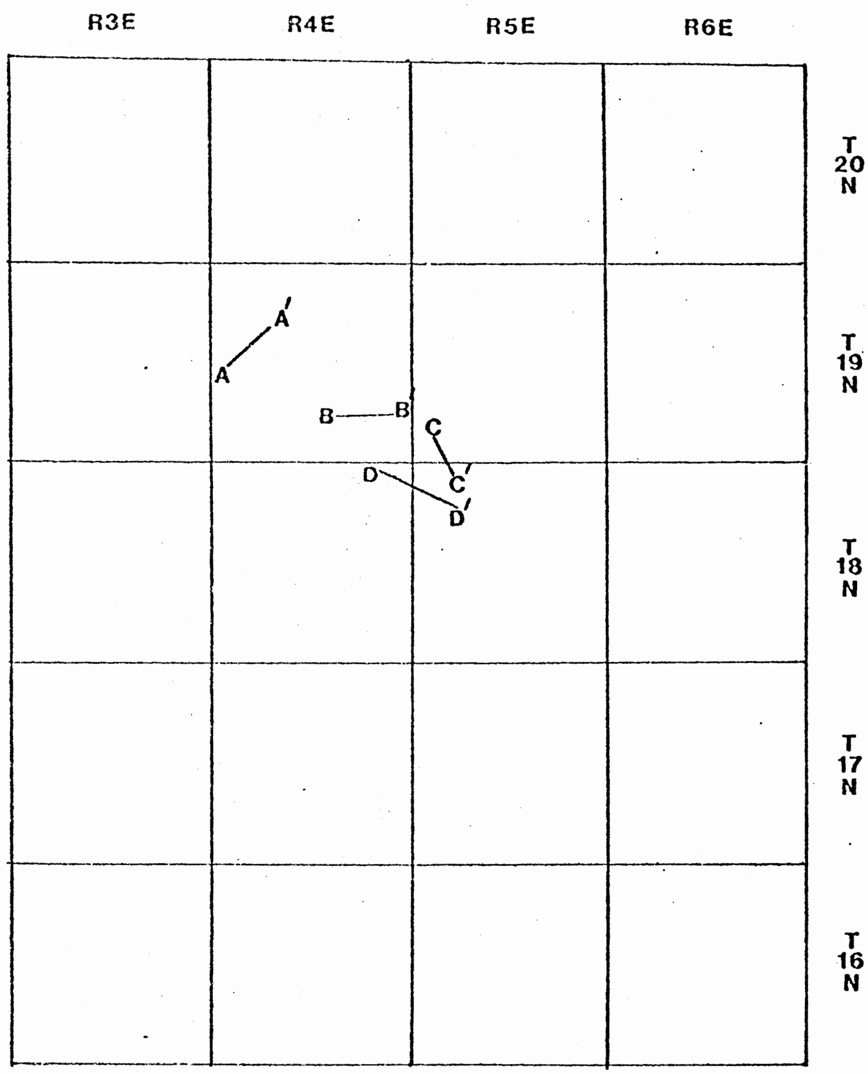


Figure 13.- Locations of correlation sections shown in Figures 14 through 17.

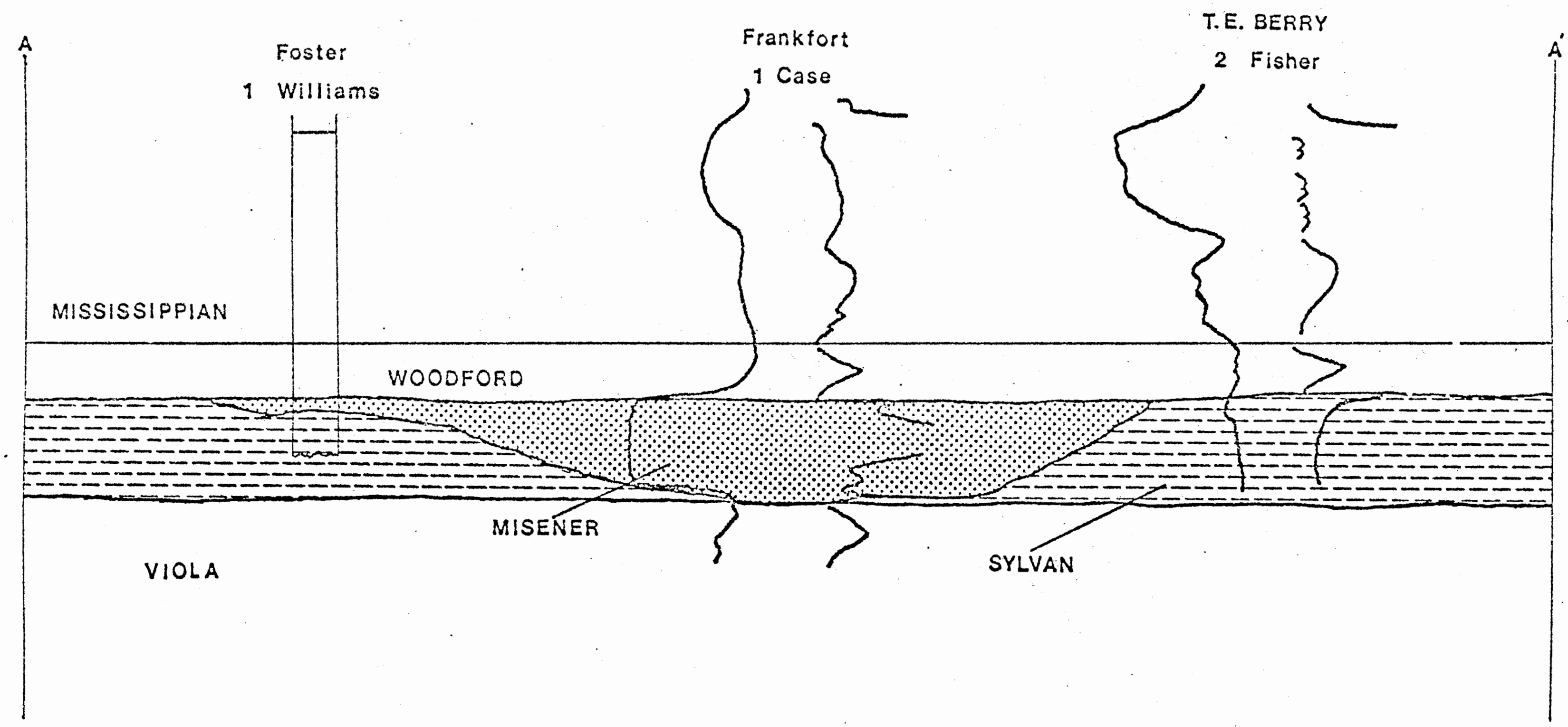


Figure 14.- Correlation section A-A'. Locations of wells are shown in Figure 13 and Appendix C.

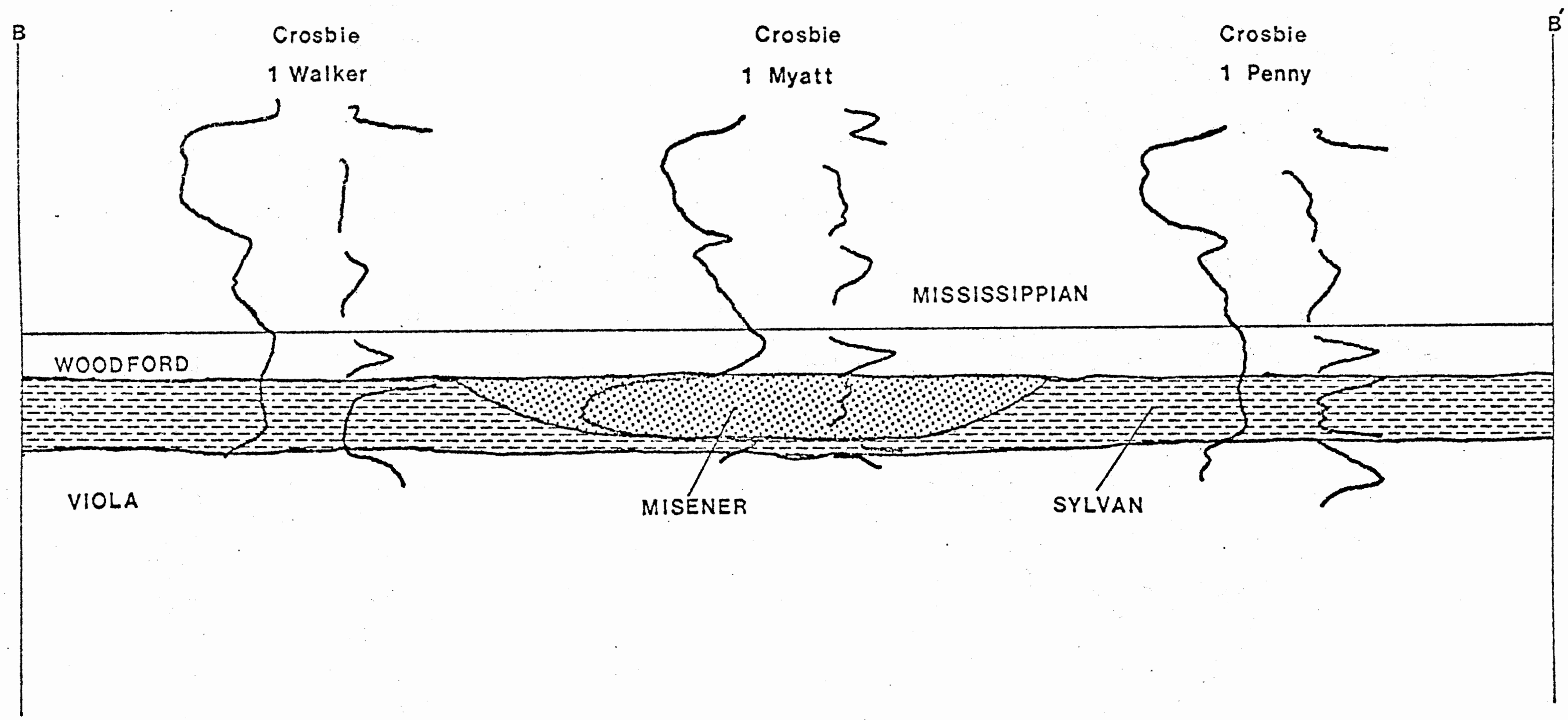


Figure 15.- Correlation cross-section B-B'. Locations of wells are shown in Figure 13 and Appendix C.

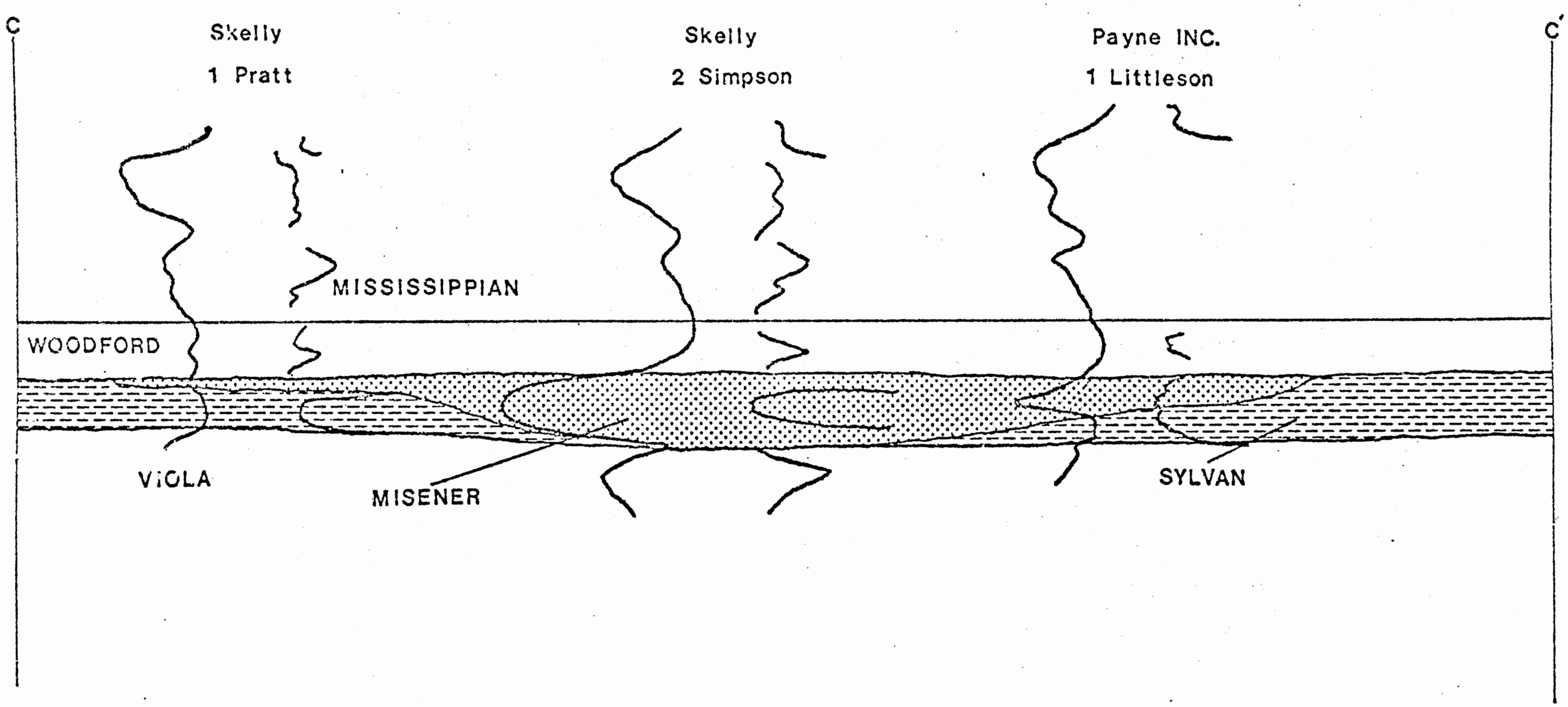


Figure 16.- Correlation cross-section C-C'. Locations of wells shown in Figure 13 and Appendix C.

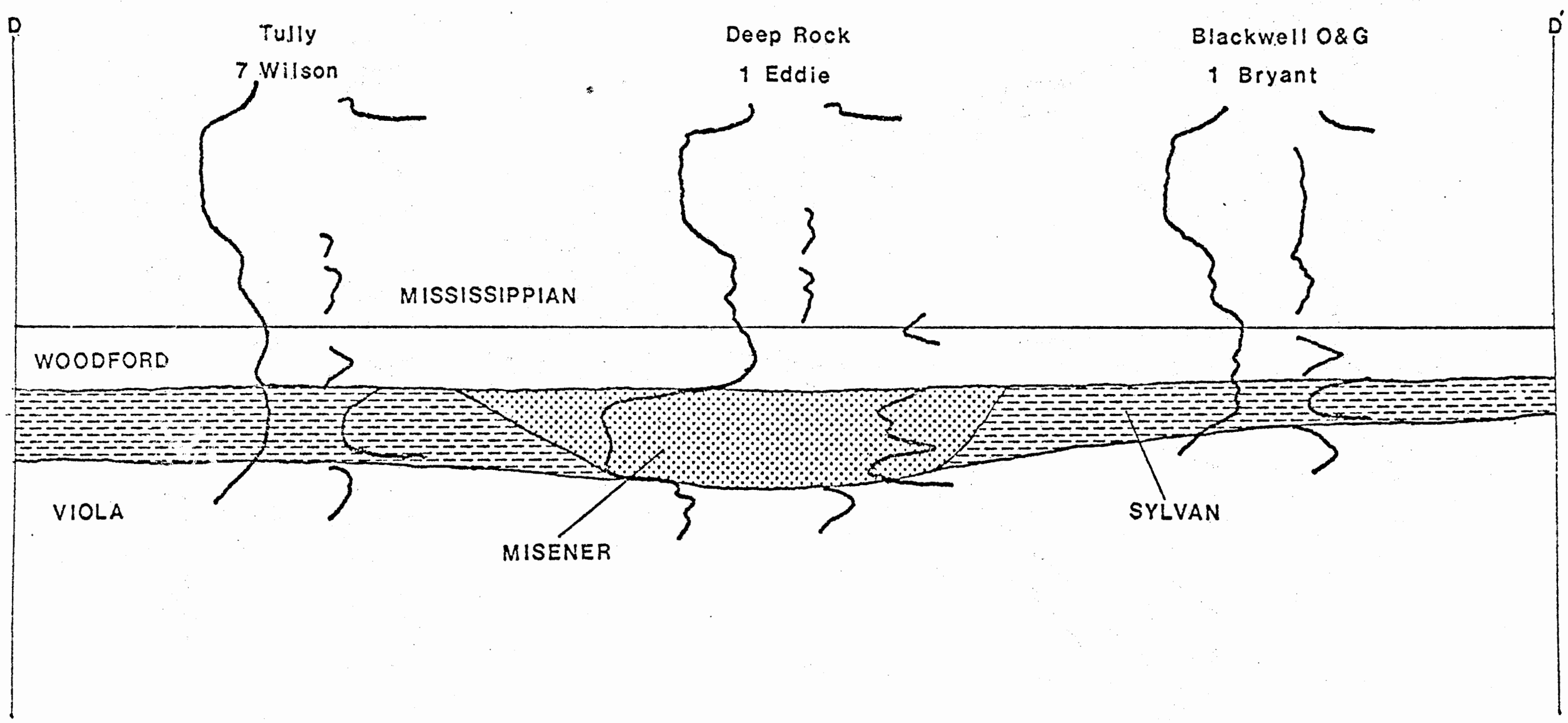


Figure 17.- Correlation cross-section D-D'. Locations of wells shown in Figure 13 and Appendix C.

Internal features of the Misener are not well studied, because of the lack of complete cores. Most petrologic data are derived from bit cuttings or core chips. No sedimentary structures were observed, due mostly to the absence of cores in the area of investigation. Within this region, the Misener is very fine to coarse grained; it is poorly to moderately sorted, and for the most part is well rounded. Some grains appear at first glance to be quite angular, but quartz overgrowths, sutured contacts, and brecciated texture mask the original well rounded grains. The Misener has both siliceous and carbonate cement. Some glauconite and phosphate pellets were found in the sand.

Paleotopography of the study area seems to have had a strong effect on distribution and quantity of the Misener sandstone. As mentioned previously, the Misener is thickest in paleotopographic "lows." Thickness of the total Woodford section and thickness of Misener sandstone are positively correlated (Fig. 18 and Appendix A).

In consideration of the data, one could form the following hypotheses as to depositional environments of the Misener sandstone:

H_1: The Misener was deposited as an alluvial sand; it was reworked entirely at some places by the Woodford sea.

H_2: The Misener was a near-shore marine sand that was deposited selectively in low areas.

H_3: The Misener was deposited originally as an alluvial sand in some localities and as a shallow marine sand elsewhere.

H_4: The Misener was deposited as an alluvial sand. The upper part was reworked by marine processes, so that at one locality the lower part may be alluvial and the upper part marine.

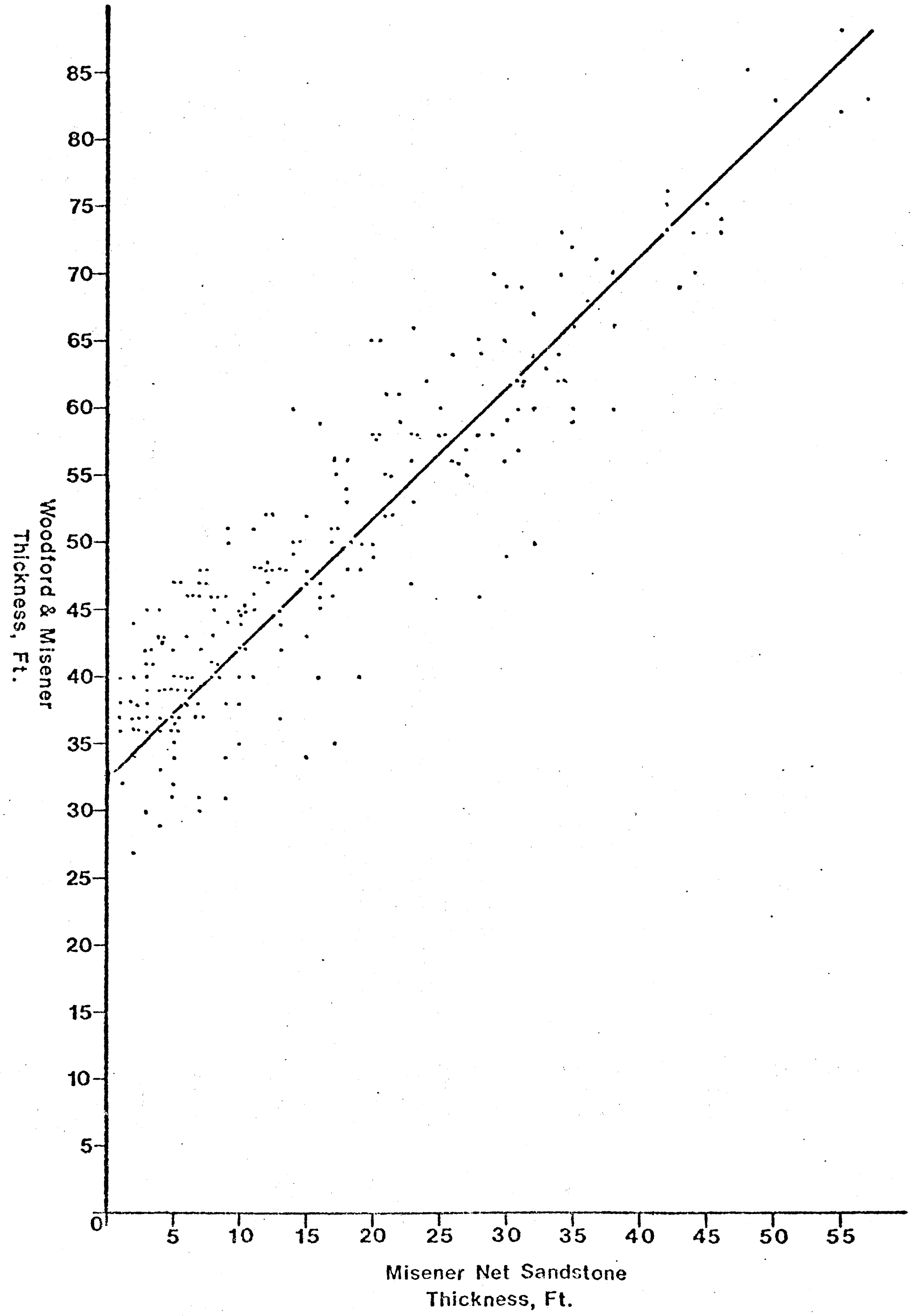


Figure 18.- Correlation of total thickness, Woodford and Misener section with thickness of Misener sandstone. Mean thickness, Woodford and Misener, 50 ft.; mean thickness, Misener, 17 ft. Correlation coefficient, 0.92. Sample size, 223.

The following data support hypothesis 1: (1) Areal distribution, extent, and geometry seem to resemble an alluvial system moreso than marine bodies. (2) Breaching of the Sylvan and contact with the Viola at some places where the sandstone is quite thick are indicative of channeling. (3) The sharp basal and lateral contacts are indicative of channeling. (4) The width-thickness ratio is smaller than expectable for a shallow-marine bar deposit (see Shelton, 1973). Glauconite, contained in some samples of the Misener, is taken to be diagnostic of marine conditions (Selley, 1976).

Hypothesis 2 is supported by presence of glauconite. Hypotheses 3 and 4, being combinations of 1 and 2, are each supported to some degree by data compiled in the course of this study.

In my opinion, in the study area hypothesis 4 explains the observed facts better than hypotheses 2, 3, or 4. The data available indicate that hypothesis 2 is the weakest of the set. I believe that the Misener was deposited as a system of alluvial channels on the pre-Woodford unconformity surface, and was partly reworked by the advancing Woodford sea. In the study area the Misener appears to be mostly an alluvial deposit, but northwest of the study area, in Sec. 15, T. 22 N., R. 1 W., a core contains extensive bioturbation, much glauconite, and dolomite layers. These properties indicate a predominately marine environment; therefore for the whole of north-central Oklahoma, hypothesis 3 would explain the data best.

PETROLEUM GEOLOGY

General Statement

In the study area fourteen fields produce oil and gas from the Misener sandstone (Fig. 19). Northeast Ingalls and East Ingalls fields are the most prolific, with cumulative production of more than 3 million barrels of oil as of May, 1977; a minor amount of the production from these fields was from other formations. Ingalls field probably has produced the most oil from the Misener, but because of the nature of the records, the exact amount cannot be determined. Production is commingled with that from the Hunton. A recent producing well in the Misener of the study area is the Thomas E. Berry, No. 5 Brookshire, NE NE SW, Sec. 28, T. 18 N., R. 5 E. This well, drilled in February, 1977, and an offset well had produced 36,613 barrels of oil and 13 million cubic feet of gas as of May, 1977.

Table 1 shows field names, numbers of producing wells in fields, discovery dates, cumulative-production values of oil and gas (as of May, 1977, if available), and present status of fields in the area of investigation that have Misener production. (Some cumulative production values are estimated on the basis of dependable data; all data are from standard production reports published by Petroleum, Inc.)

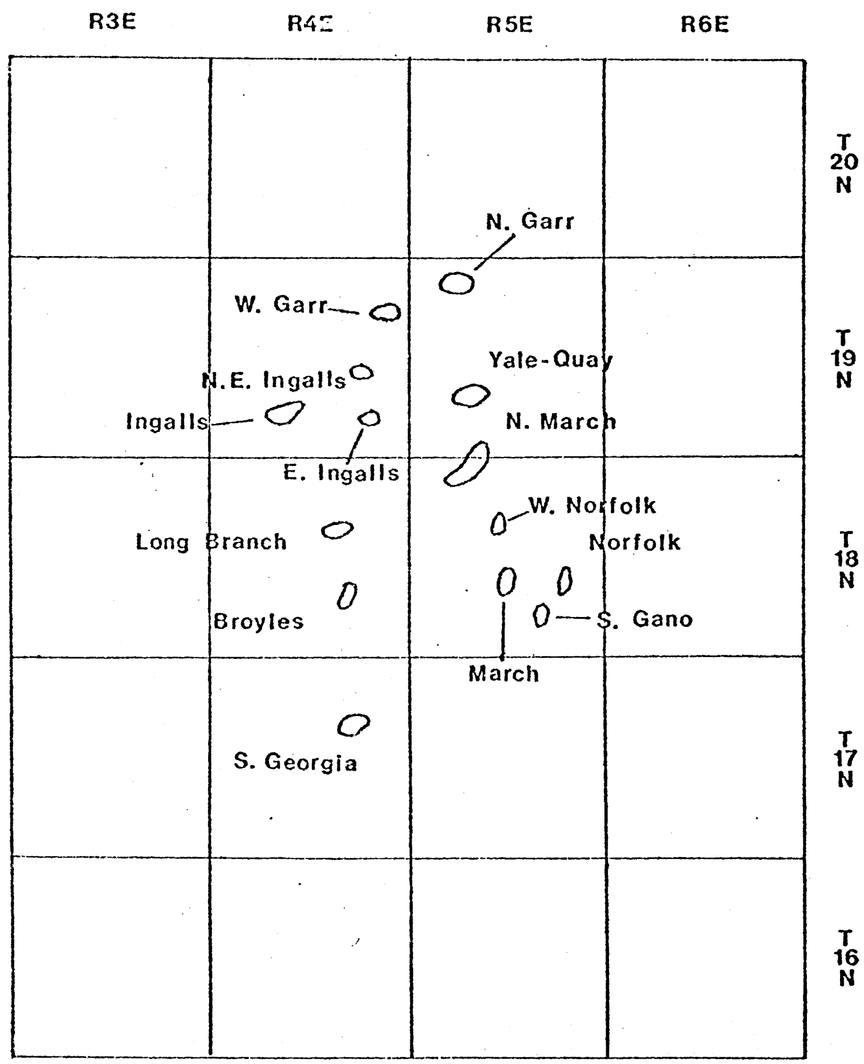


Figure 19.- Locations of oil and gas fields that produce from the Misener sandstone.

TABLE 1

DATA OF FIELDS PRODUCING FROM MISENER SANDSTONE

Field Name	No. of Wells	Year Discovered	Cummulative Production (9/78) *	Status of Misener Production
Broyles	5	1945	250,000bbls.+Gas (est.)	Abandoned
S. Gano	2	1952	51,347 MCFG	Abandoned
N. Garr	5	1937	350,000bbls.(est.)	Producing
W. Garr	2	1939	155,000bbls.(est.)	Abandoned
Ingalls	60	1920	4,800,239 (commingled)	Abandoned
E. Ingalls	3	1943	550,000bbls.(est.)	Abandoned
N.E. Ingalls	9	1926	600,000bbls. (est.)	Abandoned
Long Branch	2	1952	Not Available	Abandoned
March	4	1945	356,071 bbls. + Gas	Producing
N. March	2	1963	Gas	Abandoned
Norfolk	3	1946	250,827 bbls.	Producing
W. Norfolk	1	1966	36,594 bbls.	Producing
N. Soonerville	3	1951	37,757bbls.+65.2MMCFG	Abandoned
Yale-Quay	3	1936	1,250,000MCFG (est.)	Abandoned

*Cumulative production rounded in some instances.

Traps for Misener Production

Most of the oil and gas produced from the Misener in the study area is from traps controlled by (1) sandstone pinchouts on flanks of domal structures, (2) sandstone pinchouts on anticlinal noses, and (3) Misener sandstone folded entirely over domal structures.

Misener production at March, North March, Broyles, and Yale-Quay fields is from sandstone pinchouts on flanks of domes. South Georgia and North Garr fields are examples of traps where hydrocarbons are trapped by pinchouts on anticlinal noses. The South Georgia field is on a structural nose associated with the Cushing anticlinal trend. Ingalls, Northeast Ingalls, East Ingalls, West Garr, South Gano, Norfolk, West Norfolk, and Long Branch fields are fields in which the trap is formed by structural closure of the Misener over domes. This kind of trap is by far the type in which the greatest amount of production has been realized in the study area.

A type of trap that is not exemplified in the study area is one in which a salient of the Misener sandstone pinches out up-dip, where the structure is homoclinal. In view of the Misener as shown on Plate 1, it is highly probable that this kind of trap does exist in the study area and should have much potential for production.

Economic Analysis of Exploration for Misener Sandstone

An important part of the petroleum geology of the Misener sandstone is its value as an exploration target. Some of the more important factors to consider in such an analysis are (1) production histories of wells, shows by production curves, (2) amounts of time required to recover total reserves, (3) depth ranges of wells and costs of drilling, and (4) profit-to-investment ratios. Table 2 shows data on four wells used to evaluate the historical and future production performance of Misener wells in the study area. Values are based on drilling and completion costs of $60,000, price per barrel for oil of $11.12, and operating costs of $2,400 per year.

Production curves of the Crosbie 1 Myatt, and the T. N. Berry 1 Olinghouse (Figs. 20, 21) basically are "typical"; curves show marked decline during or after the first few years of production, with the decline becoming gradual thereafter. The production curve of the Home Gas 1 Annie Perry is uncommon, because after the initial drop in production the well recovered to some degree and its production has remained almost uniform for more than 20 years. Building up of the curve probably was a result of the well's being changed from a flowing well to a pumping well; the long-lived production may be indicative of large reserves and a water-drive reservoir (J. J. Newcomb, personal communication, 1977).

The amount of time required to produce the total recoverable reserve for the wells studied varied from 8 years (Silberman 1 Morley) to 21 years (Crosbie 1 Myatt). The exceptional Home Gas 1 Annie Perry has produced for 31 years, and still produces almost 600 bbl. per month. Ideally, an investor wants the largest amount of oil in the least amount of time. Thus, the Crosbie 1 Myatt would be the favored type of production because in the first 12 years after discovery it produced more than twice as much oil as the No. 1 Annie Perry or the No. 1 Olinghouse.

TABLE 2

ECONOMIC EVALUATION, FOUR MISENER WELLS IN THE STUDY AREA

Operater & Well	Production or Future Prod.		Gross Income (at $12.33/bbl.) Dollars	Operating ($2400/year) Expense	Net Income Dollars	Present Worth Dollars at 10% Discount	Profit-Invest. Ratio	Payout Period (Months)
	Gross	Net						
Home Gas 1 Annie Perry	221,590	193,891	2,390,676	179,200	2,211,476	Not available	22.1	1.5
Crosbie 1 Myatt	195,743	171,275	2,111,820	131,200	1,980,620	1,701,210	19.8	1
Berry 1 Olinghouse	84,632	74,053	913,073	124,000	789,073	589,910	7.9	2
Silberman 1 Morley	27,884	24,399	300,839	119,200	181,639	121,256	1.8	20

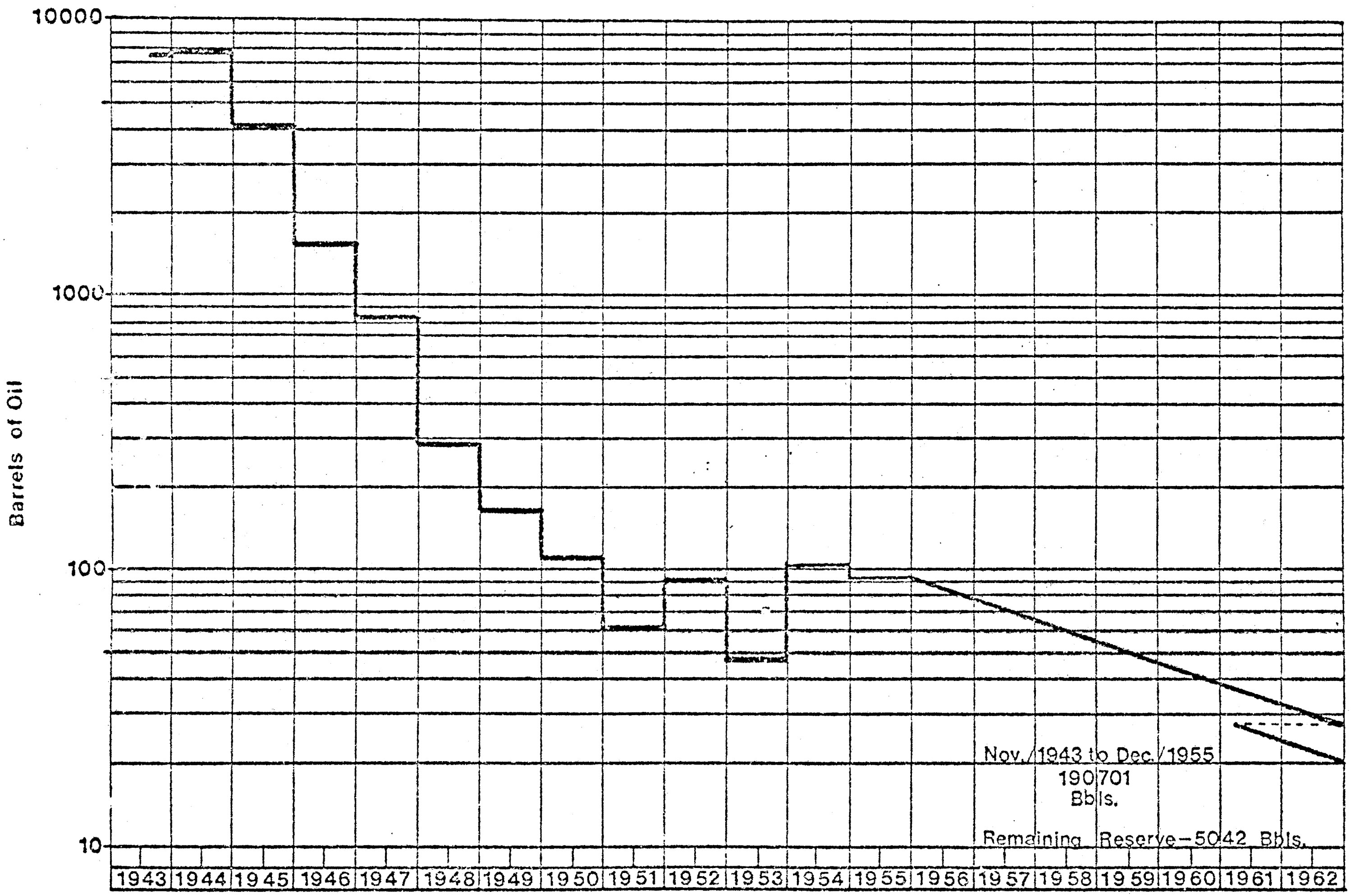


Figure 20.- Production curve, Crosbie No. 1 Myatt

Figure 21.- Production curve, T.N. Berry No. 1 Olinghouse

Depth of the Misener in the study area ranges from about 3,700 ft. in Sec. 7, T. 19 N., R. 5 E., to about 4,200 ft. in Sec. 6, T. 19 N., R. 4 E. Average cost of drilling and completing Misener wells was approximately $60,000 as of May, 1977.

Profit-to-investment ratio is based on net income and initial cost of drilling and completion. Ratios for the No. 1 Annie Perry (about 33:1) and the No. 1 Myatt (30:1) should be extremely attractive to investors. Although the No. 1 Morley has a profit to investment ratio of only 3.2, some independent oil operators would consider it to be a worthy investment.

CONCLUSIONS

Principal conclusions of this study are as follows:

1. Paleotopography beneath the Misener sandstone and the Woodford Shale can be approximated by interpretations of an isopachous map of the section from the top of the Woodford Shale to the base of the Woodford Shale or to the base of the Misener Sandstone.

2. In the study area, the Misener sandstone generally is in topographic "lows" of the pre-Woodford terrain.

3. A subcrop map of the pre-Woodford unconformity surface in the study area shows that the Misener sandstone is located more commonly near or along the Sylvan Shale-Viola Limestone contact than in other parts of the study area.

4. In the study area, paleostructure and paleotopography of the pre-Woodford unconformity seems to be associated; several paleostructural "lows" and "highs" show up as paleotopographical "lows" and "highs."

5. Each of several hypotheses concerning depositional environments of the Misener sandstone would account for facts compiled in this study. The writer favors the hypothesis that the Misener sandstone was deposited as an alluvial sand, and that the upper part was reworked during transgression and submergence by the Woodford sea.

6. Two basic kinds of traps have been defined that account for production from the Misener: (1) pinchouts on the flanks or crests of

anticlines and domes, and (2) structural closure of Misener sandstone where it is folded over anticlines and domes. Moreover, the traps generally are on post-Mississippian folds, or folds that show evidence of growth in post-Mississippian time.

7. Production has been established from Misener sandstone in at least 14 oil fields in the study area.

8. The risk-reward relationships of exploring for traps in the Misener are sufficiently attractive for most investors.

SELECTED REFERENCES

Amsden, T. W., and Klapper, Gilbert, 1972, Misener sandstone (Middle-Upper Devonian), north-central Oklahoma: Am. Assoc. Petroleum Geologists Bull., v. 56, p. 2323-2334.

Arbenz, J. K., 1956, Tectonic map of Oklahoma: Okla. Geol. Survey Map GM-3.

Borden, J. L., and Brant, R. A., 1941, East Tuskegee Pool, Creek County, Oklahoma: Am. Assoc. Petroleum Geologists Stratigraphic Type Oil Fields, p. 436.

Freman, T., and Schumacher, D., 1969, Qualitative Pre-Sylamore (Devonian-Mississippian) physiography delineated by onlapping conodont zones, northern Arkansas: Geol. Soc. of Amer. Bull., v. 80, p. 2327-2334.

Harvey, Ralph, 1968, The west Campbell field--key to unlock the Hunton: Shale Shaker, v. 18, p. 183-195.

Hollrah, T. L., 1977, Subsurface lithostratigraphy of the Hunton Group, in parts of Payne, Lincoln, and Logan Counties, Oklahoma: Unpublished M.S. thesis, Oklahoma State Univ.

Hopkins, T. C., 1890, The St. Clair marble: Arkansas Geol. Survey Ann. Report, 1890, v. 4, p. 212-222.

Huffman, G. G., 1965, Simpson Group in northeastern Oklahoma: Tulsa Geol. Soc. Digest, v. 33, p. 109.

Imbt, W. C., 1941, Zenith Pool, Stafford County, Kansas - An example of stratigraphic trap accumulation: Am. Assoc. Petroleum Geologists Stratigraphic Type Oil Fields, p. 139.

Ireland, H. A., 1955, Pre-Cambrian surface in northeastern Oklahoma and parts of adjacent states: Am. Assoc. Petroleum Geologists Bull., v. 39, p. 468-483.

________, 1965, Regional depositional basin and correlations of Simpson Group: Tulsa Geol. Soc. Digest, v. 33, p. 74.

________, Resumé and setting of Middle and Upper Ordovician stratigraphy, Midcontinent and adjacent regions: Tulsa Geol. Soc. Digest, v. 34, p. 26.

Isom, J. W., 1973, Subsurface stratigraphic analysis, Late Ordovician to Early Mississippian, Oakdale-Campbell trend, Woods, Major, and Woodward Counties, Oklahoma: Shale Shaker, v. 24, p. 32-42, 52-57.

Keller, G. R., and Cebull, S. E., 1973, Plate tectonics and the Ouachita System in Texas, Oklahoma, and Arkansas: Geol. Soc. of Amer. Bull., v. 84, p. 1659-1666.

Koenig, J. W., 1967, The Ozark Uplift and Midcontinent Silurian and Devonian stratigraphy: Tulsa Geol. Soc. Digest, v. 35, p. 119-147.

Krumme, G. W., 1969, The geomorphology of the pre-Woodford unconformity surface in the Midcontinent and its relation to oil production: Unpub. paper.

Lyons, P. L., 1950, A gravity map of the United States: Tulsa Geol. Soc. Digest, v. 18, p. 33-43.

Mairs, Tom, 1966, A subsurface study of the Fernvale and Viola Formations in the Oklahoma portion of the Arkoma Basin: Tulsa Geol. Soc. Digest, v. 34, p. 60.

Nichols, R. L., and Rozendal, R. A., 1975, Subsurface positive elements within Ouachita foldbelt in Texas ans their relation to Paleozoic cratonic margin: Am. Assoc. Petroleum Geologists Bull., v. 59, p. 193-216.

Shelton, J. W., 1973, Models of sand and sandstone deposits: A methodology for determining sand genesis and trend: Okla. Geol. Survey, Bull. 118.

White, L. H., 1926, Subsurface distribution and correlation of the Pre-Chattanooga ("Wilcox" Sand) series of northeastern Oklahoma: Okla. Geol. Survey, Bull. 40, p. 22.

APPENDIX A

ASSOCIATION OF THICKNESSES, WOODFORD SHALE AND MISENER SANDSTONE

ASSOCIATION OF THICKNESSES, WOODFORD SHALE AND MISENER SANDSTONE

G. F. Stewart and J. P. Kochick

In the course of tabulating and plotting data for the thickness map of the Woodford Shale, an association of Woodford thickness and Misener thickness became noticeable. To test the hypothesis of strong association of these variables the scatter diagram shown in Figure A-1 was constructed. From this decidedly elliptical pattern a trend of increased thickness of Misener sandstone with increased thickness of Woodford Shale is obvious.

In the study area, on the average, the Woodford-Misener section is 50 ft thick and the Misener sandstone is 17 ft thick (numbers rounded). Clearly, as the Woodford section thins toward 30 ft, thickness of the Misener converges on zero. As the Woodford thickens to about 85 ft, the Misener thickens to about 50 to 55 ft. This relation indicates that in general, increase in thickness of the total Woodford section above 30 ft is due almost entirely to addition of the Misener sandstone; the shale itself varies in thickness only a small amount.

The relation described here is useful as a prediction device, because in a few parts of the study area, wells have penetrated more than 40 ft of Woodford section, but drilled no sandstone. Figure A-1 shows clearly that in such places the weight of probability justifies the geologists' interpretation of nearby sandstone. For example, in the northern part of T19N, R5E, centered along the south lines of Secs. 3 through 6 (Pl. 4), is a belt of Woodford Shale thicker than 40 ft, but which contained no Misener sandstone in wells that established the contour line of 40-ft thickness. Figure A-1 shows that where the Woodford section is about 45 ft thick, the Misener generally is 2 to 16 ft thick. This empirically established relationship and the probability that it implies justify mapping an eastward-extending tongue of Misener along the south lines of Secs. 3 through 6 (Pl. 1). Of course, the tongue of Misener could have been mapped on a more common basis, namely that because of similarity of Woodford and Misener patterns elsewhere in the area, the 40-ft Woodford line tends to "pull" the Misener thickness lines into a similar pattern. This rationale and that based on Figure A-1 are essentially the same; the advantage of using both is that the two sources of information--although somewhat redundant--are convergent, and they fortify mapping a Misener pinchout as a working hypothesis.

The point should be made here that the variables under discussion can be treated more vigorously under standard statistical analysis, and that probabilities of sand thickness can be specified accordingly.

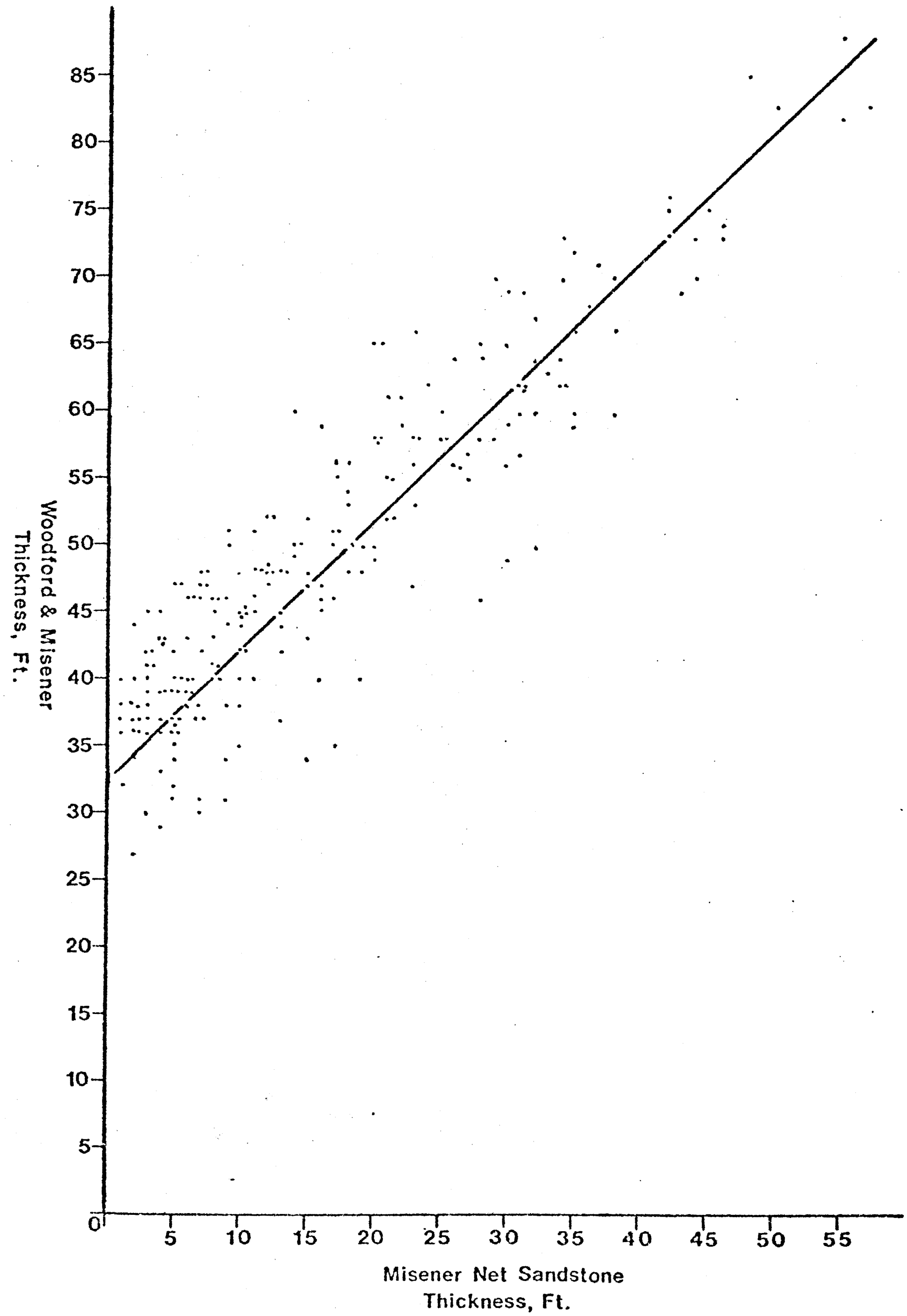


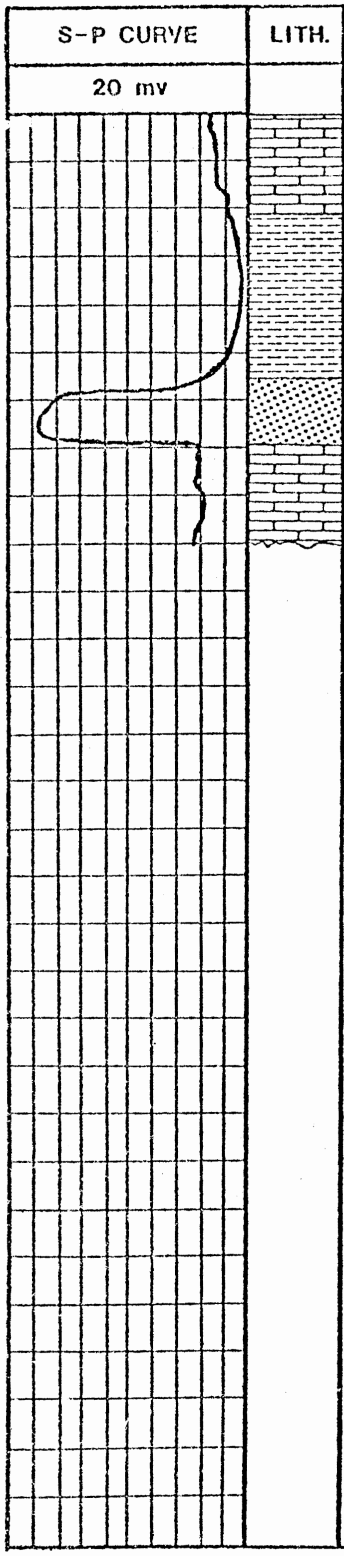
Figure A-1.- Correlation of total thickness, Woodford and Misener section with thickness of Misener sandstone. Mean thickness, Woodford and Misener, 50 ft.; mean thickness, Misener, 17 ft. Correlation coefficient, 0.92. Sample size, 223.

APPENDIX B

SAMPLE LOG CHARTS OF SELECTED

WELLS IN THE STUDY AREA

Crosbie No. 1 Wilson
NW NE NE Sec. 28, T. 19 N., R. 5 E.



SAMPLE DESCRIPTION

Mississippian limestone

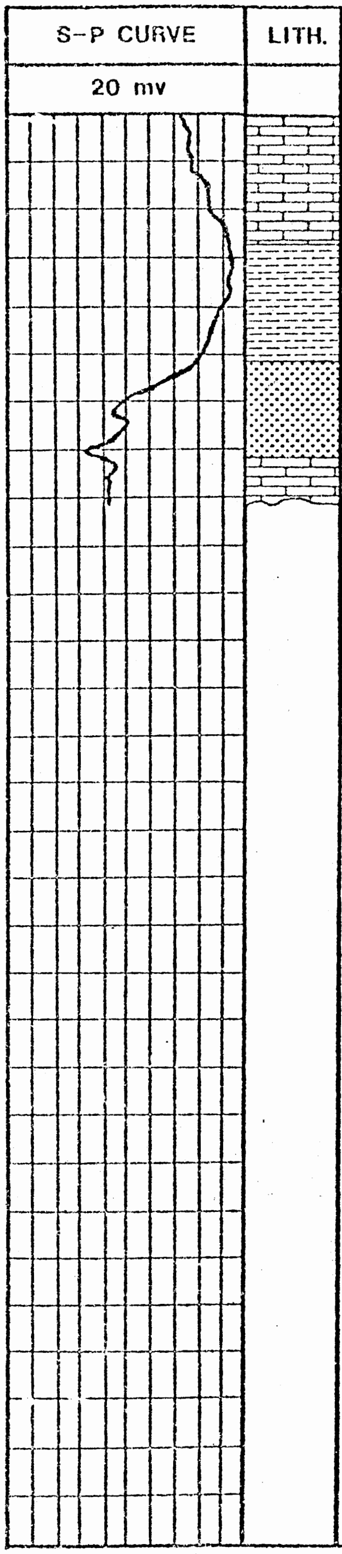
Woodford Shale

Misener sandstone*

Viola Limestone

*Misener sandstone - fine- to medium-grained, moderately sorted, well rounded; phosphatic grains, glauconite, extensively altered. Slight increase in grain size downward in the section. Section predominately quartz grains with siliceous cement; only a moderate amount of carbonate material, which fills pores.

T. E. Berry No. 1 Fee
NE SE SE Sec. 12, T. 19 N., R. 4 E.



SAMPLE DESCRIPTION

Mississippian limestone

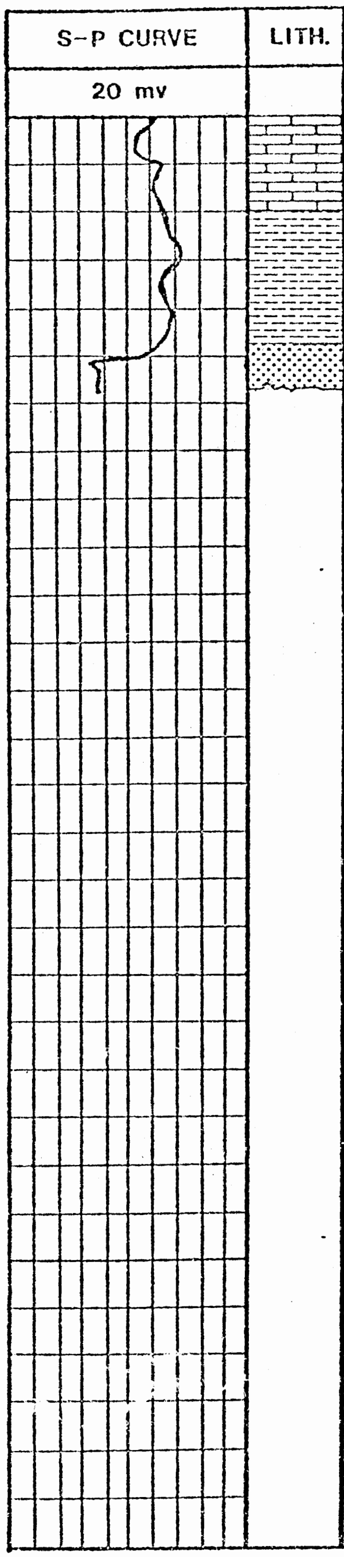
Woodford Shale

Misener sandstone*

Viola Limestone

*Misener sandstone - fine-grained, moderately sorted, rounded to subrounded, with phosphatic grains; extensive alteration. Sand contains interbedded carbonate layers; sand grains "floating" in carbonate matrix. Layers of carbonate material are graditional into sand.

Skelly Oil Co. No. 4 Berry
NW SW SE Sec. 22, T. 19 N., R. 4 E.



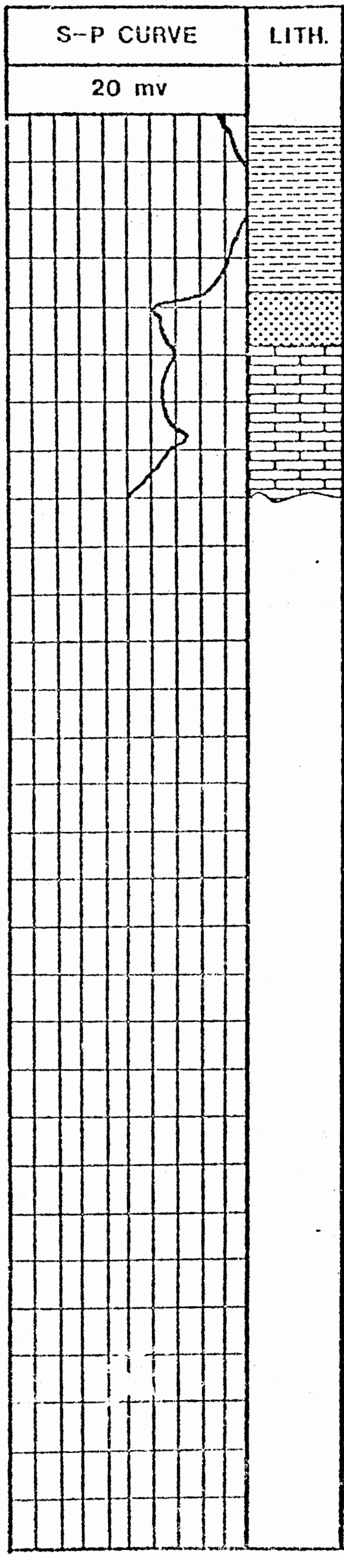
SAMPLE DESCRIPTION

Mississippian limestone

Woodford Shale

Misener sandstone - fine- to medium-grained sand, moderately sorted, rounded to subrounded with phosphatic grains.

Skelly Oil Co. No. 1 Reed
SE SE NW Sec. 27, T. 19 N., R. 5 E.



SAMPLE DESCRIPTION

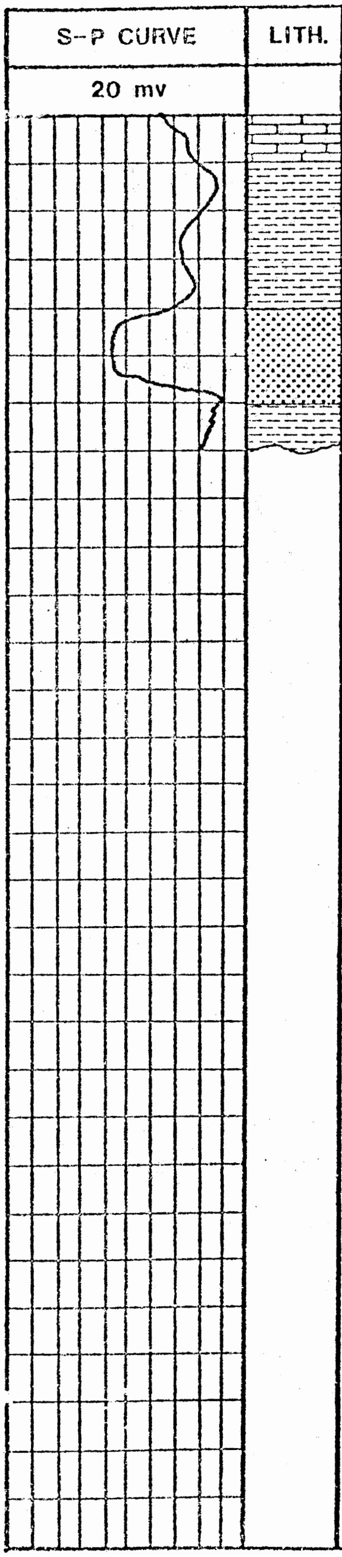
Woodford Shale

Misener sandstone*

Viola Limestone

*Misener sandstone - very fine-grained to medium-grained, moderately sorted, well rounded. Contains phosphatic grains, glauconite, and shows extensive alteration. Contains interbeds of carbonate material, in which sand grains "float." Carbonate material gradational with sand. "Ghost" grains suggest replacement of silica by carbonate.

Clay Moore No. 1 Fisher
NW SW NW Sec. 21, T. 19 N., R. 4 E.



SAMPLE DESCRIPTION

Mississippian limestone

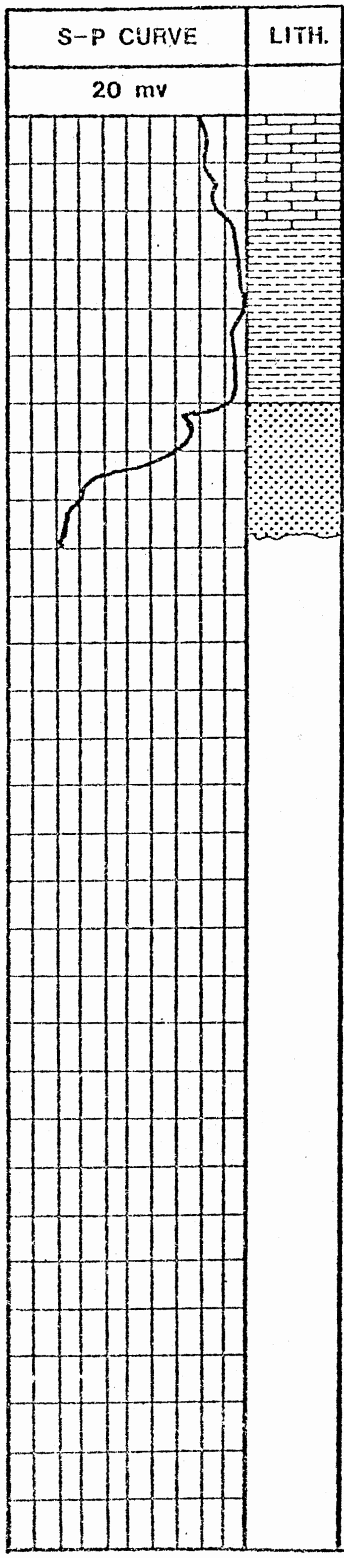
Woodford Shale

Misener sandstone*

Sylvan Shale

*Misener sandstone - fine- to coarse-grained sand, moderately sorted and well rounded. Contains phosphatic grains, and glauconite. Shows extensive secondary alteration. Grain size shows slight increase upward. Carbonate layers are contained, in which sand grains "float"; carbonate and sand layers are gradational.

Chalmette Petroleum No. 1 Thompson
NW SE NE Sec. 26, T. 18 N., R. 5 E.



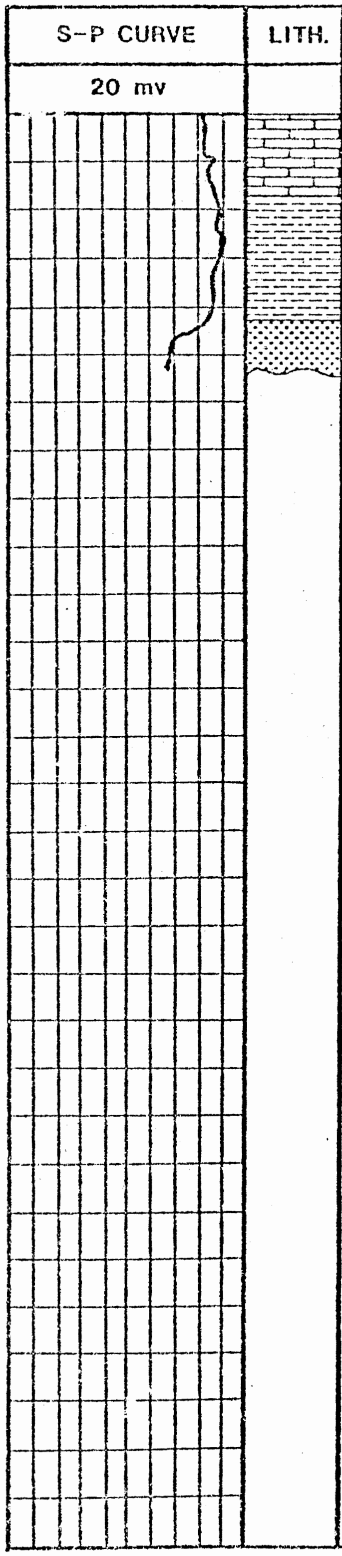
SAMPLE DESCRIPTION

Mississippian limestone

Woodford Shale

Misener sandstone - fine- to medium-grained, moderately sorted, and well rounded. Contains phosphatic grains, glauconite, and shows evidence of secondary alteration. Carbonate cement fills many of the pore spaces.

Magnolia Petroleum No. 12 W. H. Grove
NW NE NW Sec. 27, T. 19 N., R. 4 E.



SAMPLE DESCRIPTION

Mississippian limestone

Woodford Shale

Misener sandstone - very fine- to coarse-grained, moderately sorted and well rounded. Contains phosphatic grains, much glauconite, and shows extensive alteration. Grain size increases upward. Sand layers grade into carbonate beds, in which sand grains "float."

APPENDIX C

LOCATIONS OF KEY WELLS

LOCATIONS OF KEY WELLS

1. Falcon Seaboard 5 Scott
   SE SE NW Sec. 21, T14N, R10E

2. Falcon Seaboard 1 Kimble
   NW SW SW Sec. 22, T14N, R10E

3. Falcon Seaboard 1 Kimble-C
   NW SE SE Sec. 22, T14N, R10E

4. William H. Pine 1 Douglass
   SE SW NE Sec. 26, T14N, R10E

5. H. A. Tully 7 Wilson
   NW NE NW Sec. 1, T18N, R4E

6. Deep Rock Oil 1 Eddie
   NW SE NE Sec. 1, T18N, R4E

7. Blackwell Oil & Gas 1 Bryant
   NW SW SE Sec. 6, T18N, R5E

8. Foster Drilling Company 1 Williams
   NW NW SE Sec. 20, T19N, R4E

9. Frankfort Oil Company 1 Case
   NE NE SE Sec. 20, T19N, R4E

10. Thomas E. Berry 2 Fisher
    NE NW NW Sec. 21, T19N, R4E

11. J. E. Crosbie Inc. 1 Wyatt
    C NE SW Sec. 25, T19N, R4E

12. J. E. Crosbie Inc. 1 Perry
    NW NE SE Sec. 25, T19N, R4E

13. J. E. Crosbie Inc. 1 Walker
    SE NE SE Sec. 26, T19N, R4E

14. Skelly Oil Company 1 Pratt
    SW SW NE Sec. 30, T19N, R5E

15. Skelly Oil Company 2 Simpson
    SW NW SE Sec. 30, T19N, R5E

16. Payne Inc. 1 Littlesun
    C NW NW Sec. 32, T19N, R5E

VITA

James P. Kochick

Candidate for the Degree of

Master of Science

Thesis: PETROLEUM GEOLOGY OF THE MISENER SANDSTONE IN PARTS OF PAYNE AND LINCOLN COUNTIES, OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Shawnee, Oklahoma, January 1, 1953, the son of Mr. and Mrs. Michael S. Kochick.

Education: Graduated from Tecumseh High School, Tecumseh, Oklahoma, in May, 1971; received Bachelor of Science degree in geology from Oklahoma State University, Stillwater, Oklahoma, in July, 1976; completed requirements for the Master of Science degree at Oklahoma State University in May, 1978, with a major in geology.

Professional Experience: Exploration Geologist, Thomas E. Berry and associates, September, 1974, to June, 1977; Consulting Geologist, Southern States, December, 1975; Consulting Geologist, ERICO INC., in the North Sea area, December, 1976, through January, 1977; Associate Geologist, Sun Oil Company, June, 1977, to November, 1977; Exploitation Geologist, Cleary Petroleum Corporation, December, 1977, to present; Junior member, American Association of Petroleum Geologists; member Oklahoma City Geological Society, member Society of Economic Paleontologists and Mineralogists.