DISTRIBUTION AND DEPOSITIONAL ENVIRONMENT OF THE PENNSYLVANIAN MARCHAND SANDSTONE, NORTHWEST CHICKASHA AND NORTHWEST NORGE FIELDS, OKLAHOMA

By

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PREFACE

The primary objective of this study is to determine the local depositional environment of the Upper Pennsylvanian Marchand Sandstone, basal unit of the Hoxbar Group of the Missourian Series. The depositional environment was determined by study of geometric characteristics through the construction of isopach maps, net and gross sandstone isopachs, structural contour maps, correlation sections, and distribution map and study of internal characteristics in cores of the Marchand Sandstone.

Sincere appreciation is extended to Professor John W. Shelton, who suggested the study and made helpful comments and criticisms. Assistance from advisory committee members, Professors Gary F. Stewart, John W. Trammell, and George E. Moore, Union Oil Company of California, are greatly appreciated. Gratitude is also extended to my fellow graduate students, especially Dale Shipley and Khalid Ngah, for their comments and suggestions. Subsurface information was made readily available to the writer from the Oklahoma City Geological Society Well Log Library, Oklahoma Geological Survey, Doug Hurlbut and Harold Reedy of Amarex, Inc. Tom Curlee, Phillips Petroleum Company, arranged for examination of a core. Jack Etter and Bill Tuttle of the Cities Service Company Research Laboratory, assisted in the micropaleontology of the Marchand. Appreciation is also extended to the personnel in the Midland, Texas district office of Cities Service Oil

Company, especially Bryan Pollard, Tom Klauss, and Dick Dawson, for their encouragement which aided in the final steps of completion of the study. Sincere gratitude is extended to my wife Carol, for her patience and dedication, and to our parents for their encouragement and support which made it possible for me to achieve my education.

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CHAPTER I

ABSTRACT

The Upper Pennsylvanian Marchand Sandstone, basal unit of the Hoxbar Group of the Missourian Series, is indicated by internal and geometric features to be a slope deposit similar to those in the middle-fan areas of modern deep-sea fans. Up to 200 feet of gross Marchand Sandstone, probably derived in large part from the Ouachita system, have been deposited dominantly by grain-flow mechanisms in water depths of at least 300 feet.

Geometric characteristics indicate a bifurcating pattern of channel deposits in each of two distinct depositional lobes which were deposited in the slope environment, perpendicular to the Marchand shelf-edge in the Anadarko basin. Large lenticular complexes of multistoried and multilateral channel deposits, exhibiting sharp lateral and basal contacts, compose the Marchand Sandstone. The dimensions of the sandstone in the Northwest Chickasha and Northwest Norge fields are more than 5 miles in an east-west direction and more than 7 miles in a north-south direction.

Internal features do not compose an idealized vertical sequence characteristic of well known depositional environments. Texture and sedimentary structures indicate that progradational, interstratified sequences of shale and siltstone-sandstone dominated deposition prior to channelization. Medium and small-scale crossbedding, flowage

features and massive bedding are the dominant sedimentary structures in the moderately well sorted, uniformly fine-grained channel sandstone. Shale interstratification and clay clasts are also common.

A gradual shift of the depocenter out of the area of study is indicated by an upper lenticular sequence of shale and siltstone-sandstone. The overlying "Hot Shale" reflects a further increase in distance from major dispersal centers and an increase in water depths accompanying lower rates of sedimentation.

CHAPTER II

INTRODUCTION

The area of investigation of the Marchand Sandstone includes 76 sections in T6-8N, R7-8W, Grady County, Oklahoma (Fig 1). Sub-sea depths to the top of the Marchand Sandstone range from 8800 feet in the northern part of the area to 9500 feet in the south. In the area of investigation the Marchand is oil and gas productive in Northwest Chickasha and the Northwest Norge fields due to stratigraphic entrapment. Cummulative production to July 1, 1976, is approximately 19,000,000 barrels of oil and an estimated 17,500,000,000 cubic feet of gas.

Objectives and Methods

The principal objective of this investigation is to determine the depositional environment of the Upper Pennsylvanian Marchand Sandstone, basal unit of the Hoxbar Group of the Missourian Series.

Determinations of local geometric features, such as trend, length, width, thickness, and boundaries, were made from data provided by gamma-ray, compensated formation density logs and induction electrologs from 130 wells by preparation and interpretation of 8 correlation sections, isopach maps of net and gross sandstone, and a map of sandstone trends. Internal features of the sandstone, including sedimentary structures, textures, and constituents, were analyzed from

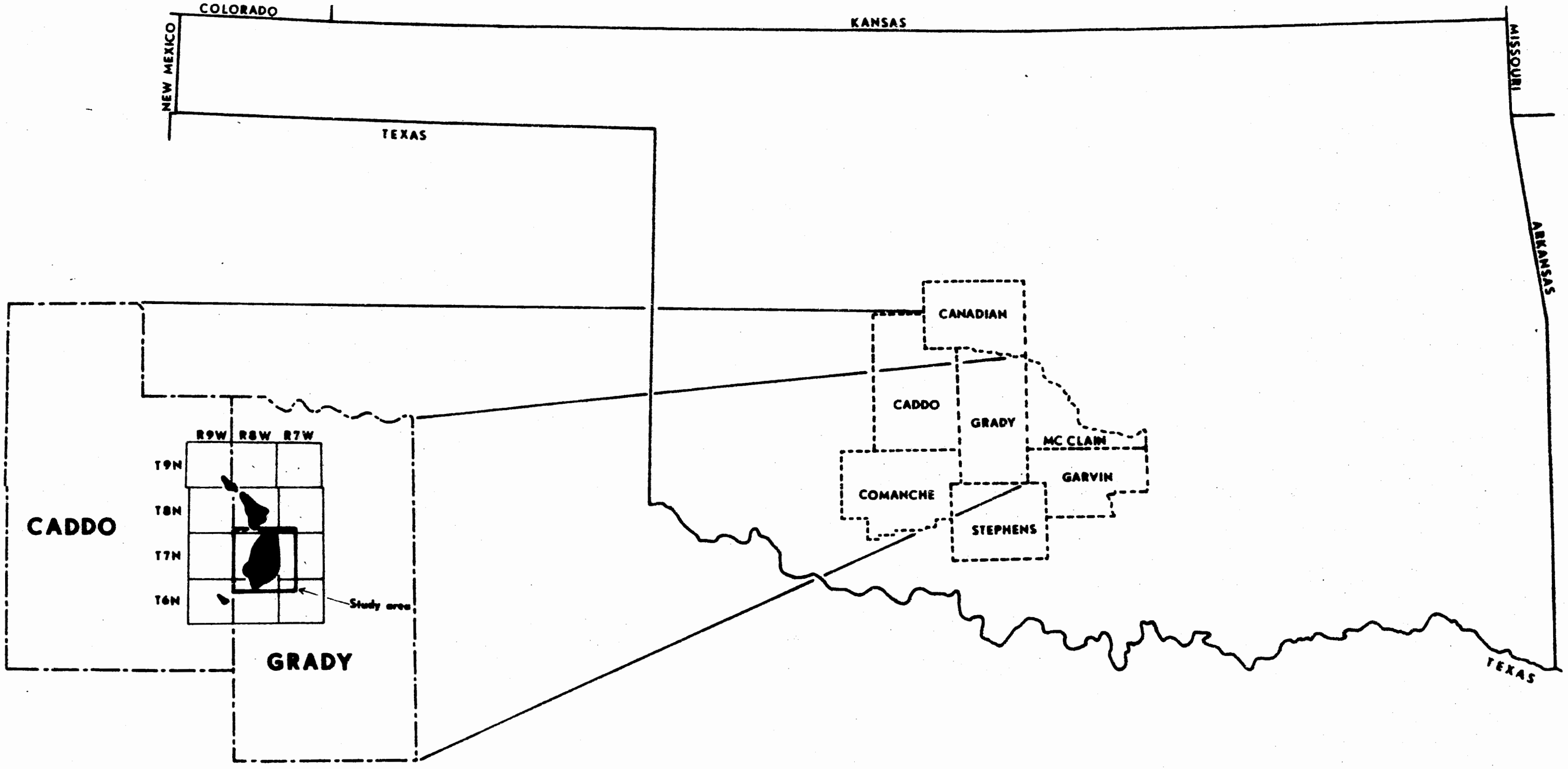


Fig. 1.-Location map of area of study, showing oil fields producing from Marchand Sandstones.

examination of 3 cores.

Structural maps, utilizing the base of the Hogshooter Limestone, the "Hot Shale" marker above the Marchand, and the top of the Huddleston Limestone below the sandstone as reference surfaces, were constructed to determine the present structural framework, including subregional dip and local anomalies.

Isopach maps were prepared of 3 intervals: the base of the Hogshooter Limestone to the "Hot Shale" marker, the "Hot Shale" marker to the top of the Huddleston Limestone, and the base of the Hogshooter Limestone to the top of Huddleston Limestone. These maps were used to determine local changes in thickness and estimating depositional topography.

Previous Investigations

Wheeler (1947) referred to the Marchand Sandstone as a prolific oil and gas producer in Cement field, Caddo County, Oklahoma, where the trap is dominantly structural due to Late Pennsylvanian folding and secondarily stratigraphic. The name is for the Marchand lease of Gordon Trust in NW¼ Sec. 2, T5N, R9W, of Cement field, Caddo County Oklahoma (Jordan, 1957).

Eisner (1955), from lithologic characteristics of the sandstone and associated conglomerate in the Cement area, concluded that the Marchand represents a stream deposit with a source area in the Wichita Mountains. Boeckman (1956) included a description of the Marchand in a study of Pennsylvanian stratigraphy, structure, sedimentation, and geologic history of that area. Harlton (1960) correlated the Marchand "zone" (interval containing Marchand Sandstone) to the Crinerville

Formation of the Ardmore basin and divided the Marchand into three units: an upper limestone, middle sandstone and conglomerate, and a lower oolitic limestone. Herrmann (1961) briefly described the Marchand lithologically in a study of the structure of the Cement-Chickasha area.

More recent investigations of the Marchand Sandstone include those made by Ash (1971), Graff (1971), and Sawyerr (1972). Ash (1971) in a study of the Northwest Verden field north of the study area concluded that the structure is monoclinal with local nosing, the trapping mechanism is stratigraphic, and the depositional environment was a northwest-trending offshore bar, with northeast-trending channels intersecting the bar. He suggested that an unconformity is present at the base of the "Hot Shale" directly overlying the sandstone. Graff (1971) postulated a deltaic origin for the Marchand, with a drainage basin to the northeast. He further concluded that a cover of shallow marine sediments was deposited during a subsequent transgression. Sawyerr's (1972) estimate of depositional environment is similar to that of Ash (1971). He suggested that it is a complex of northeast-trending offshore bars deposited by longshore currents and waves.

CHAPTER III

STRUCTURAL FRAMEWORK

Regionally the Marchand Sandstone is located on the northeast flank of the Anadarko basin. Subsidence in southern Oklahoma began during Cambrian with formation of the ancestral Oklahoma basin (Nicholas and Rozendal, 1975). Principal structural development in the Anadarko basin occurred in post-Morrowan Pennsylvanian time with uplift of the Amarillo-Wichita element (Rascoe, 1962). The present Anadarko basin represents a Late Paleozoic, asymmetric, west-northwest-trending, structural and depositional basin. It is characterized by a gently dipping, broad cratonal shelf on the north flank, and a narrow south flank bounded on the south by the steeply dipping, Frontal Wichita fault system (Harlton, 1972). The Cordell faulted, folded belt, representing the northern boundary of the Frontal Wichita system, is composed of west-northwest-trending normal faults and intersecting north-trending offset faults, which form a complex of horst and grabens (Nicholas and Rozendal, 1975).

Reference surfaces utilized in the structural portion of this study show no faults nor major structural irregularities in the study area. Overall homoclinal features are portrayed by all 3 reference surfaces; some variation exists in dip direction and magnitude.

Structure on Top of the Huddleston Limestone

The subregional structural trend at the position of the Huddleston Limestone is northwesterly to west-northwesterly; dip toward the southwest to south-southwest is approximately 100 feet per mile. Several broad gentle noses, separated by narrow saddles, characterize the slightly undulatory surface of the Huddleston (Fig. 2).

Structure on the "Hot Shale" Marker

The "Hot Shale" marker shows a subregional south-southwesterly to southerly homoclinal dip of approximately 80 feet per mile (Fig. 3). Although no structural closure is present within the area, undulations are more prominent than those expressed by the Hogshooter. The structural noses in Secs. 14 and 23, T7N, R8W, and Secs. 26 and 35 are a continuous feature. With bifurcation it extends to the southwest from Sec. 14 into Secs. 22 and 27, T7N, R8W. Another prominent nose is located in Secs. 20, 28, 29, 32, and 33, T8N, R8W, and Secs. 4, 9, 16, 21, and 28, T7N, R8W.

Structure on the Base of the Hogshooter Limestone

The subregional strike is essentially the same as that shown by the Huddleston. The dip averages 100 feet per mile in a southwesterly to south-southwesterly direction (Fig. 4). The surface is characterized by gentle undulations and small structural noses and saddles; no closed structures are located in the study area. The most prominent structural nose is located in Secs. 14 and 23, T7N, R8W. Two other minor noses are located in Secs. 21 and 28, and in Secs. 26 and 35, T7N, R8W.

CHAPTER IV

STRATIGRAPHIC FRAMEWORK

The Marchand Sandstone is present as a thick wedge of sediment on the northeast flank of the Anadarko basin, and it thins in a direction perpendicular to the northeast shelf-edge of the basin. Stratigraphically, the Marchand is in the basal portion of the Hoxbar Group of the Missourian Series. The Hoxbar Group includes the interval from the Upper Oolitic Limestone down to the base of the Huddleston, or Culp Melton, Limestone and ranges from 2300 to 4000 feet in thickness. Marine carbonate units, sandstones, and shales, exhibiting complex intertonguing relations, compose the Hoxbar Group (Jordan, 1957).

The interval of the Hoxbar Group studied comprises the section from the base of the Hogshooter Limestone to the top of the Huddleston Limestone. The Marchand Sandstone is present in the interval between the "Hot Shale" marker and the Huddleston Limestone (see correlation sections in the study area shown in Figs. 5-13).

Regionally, the Marchand is stratigraphically equivalent to the Crinerville Formation of the Ardmore basin, which has been divided into three parts: an upper limestone, middle sandstone and conglomerate, and a lower oolitic limestone (Tomlinson and McBee, 1959). The Marchand Sandstone is the approximate equivalent to coastal deposits of the subsurface Layton Sandstone and the Coffeyville Formation on

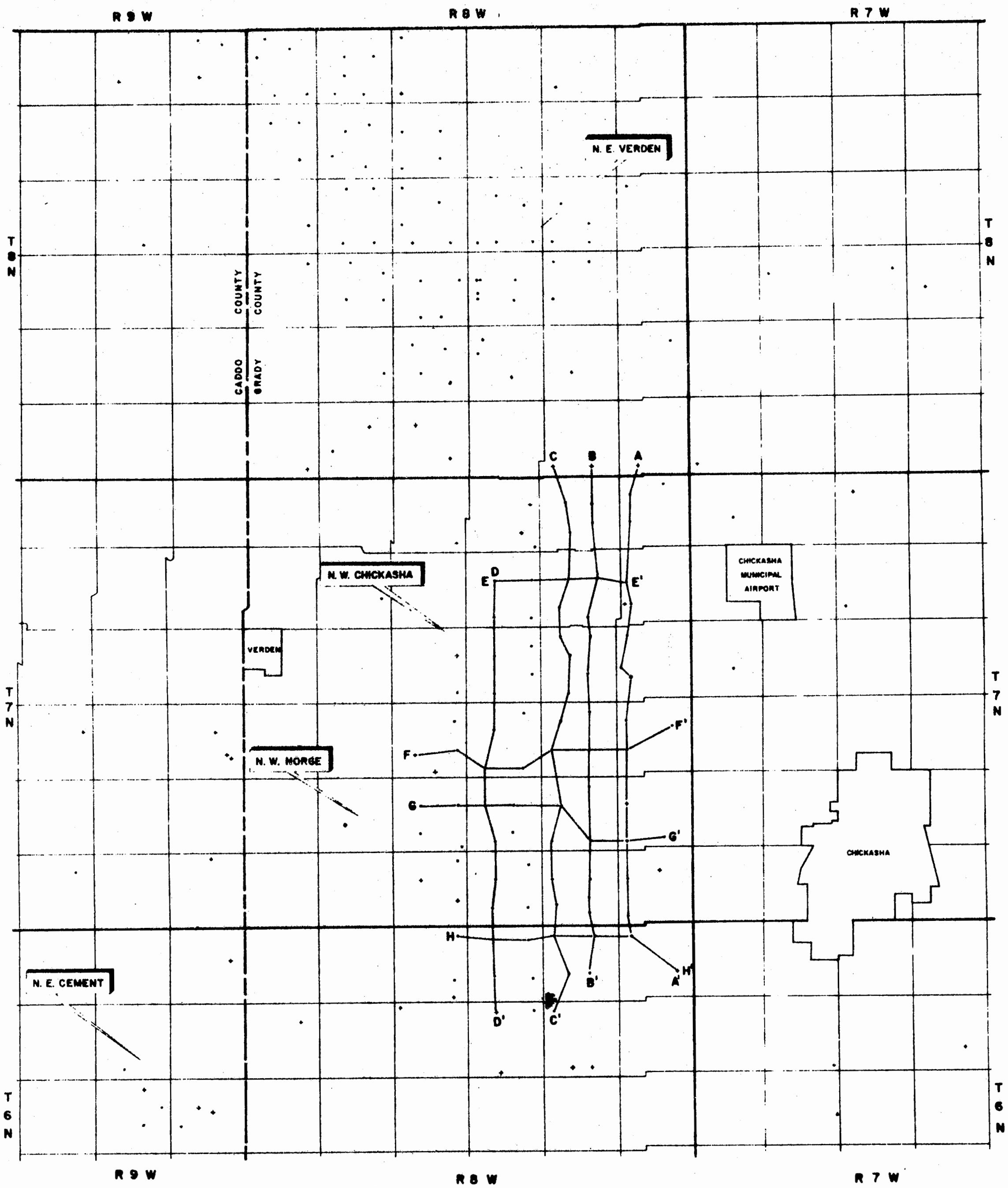


Fig. 5.-Index map of correlation sections.

outcrop studied by Visher et al. (1975). Marchand equivalents to the north, northwest, and west include limestone deposits of the lower part of the Kansas City Group.

Correlation

Correlation sections (Fig. 5) were prepared by utilizing the base of the Hogshooter Limestone, the "Hot Shale" marker, and the top of the Huddleston Limestone as reference surfaces (Figs. 6-13). Local correlatable markers M1, M2, and M3 were useful in determining the top of the Huddleston Limestone and interpreting Marchand Sandstone boundaries (Figs. 6-13). Marine units consisting of calcareous gray shales with interbeds of shaly sandstone are present within the Hogshooter Limestone-"Hot Shale" interval. The "Hot Shale" is thought to represent a transgressive, 10-foot interval of massive, black, silty, radioactive shale overlying the Marchand. The Huddleston and Hogshooter Limestones probably represents a local shelf-edge to slope limestone.

The 8 correlation sections (Fig. 5) prepared from gamma-ray and short normal resistivity curves are present to explain the stratigraphic relationships of the Marchand Sandstone. In north-south and west-east directions an apparent parallelism exists between the Hogshooter Limestone and the Huddleston Limestone, but the two do not parallel the "Hot Shale" (Figs. 6-13). Markers, M1, M2, and M3 also display apparent parallelism with the Hogshooter and Huddleston Limestone.

The "Hot Shale" was used as datum because the area of study is on or near the eastern shelf-edge, where depositonal slope was westerly toward the basinal trough. That westerly slope is portrayed by the two limestones when the "Hot Shale" is shown as a horizontal bed (Figs. 10-13). The "Hot Shale" itself may have formed on a westward-sloping surface, but that surface is thought to have been more gently sloping than those on which the limestones formed.

Thickness of the interval from the base of the Hogshooter Limestone to the top of the Huddleston Limestone ranges from 360 to 480 feet (Figs. 11 and 14). Increase in thickness is to the west-southwest at approximately 25 feet per mile. Local irregularities in thickness apparently reflect variations in Marchand Sandstone.

The "Hot Shale"-Huddleston Limestone interval is characterized by an increase in thickness from 40 to 340 feet in a westward direction (Fig. 15). Variations in thickness are minimal in a north-south direction. The interval thins to the east in a manner which represents a reciprocal relationship to the overlying interval. Where the interval is greater than 60 feet thick, it shows a westward thickening of approximately 60 feet per mile. Where the interval is less than 60 feet thick, it shows a westward thickening of 10 feet per mile; the easternmost portion of the mapped area, therefore, is characterized by relatively uniform thickness. Local irregularities within the interval reflect variations in thickness of the Marchand Sandstone. Deposition of Marchand Sandstone within the "Hot Shale"-Huddleston Limestone interval represents progradation and aggradation within the Anadarko basin. Deposition of the black, "Hot Shale" is thought to represent a transgression and a corresponding shift in sand deposition.

The abrupt increase in thickness of the interval from the "Hot Shale" marker to the top of the Huddleston Limestone probably defines the thinner shelf deposits on the east, and thicker sediments of the basinal area to the west.

The Hogshooter Limestone-"Hot Shale" interval displays a westward-thinning wedge from 140 to 320 feet within the study area (Figs. 10-13, 16). In a north-south direction variations in Hogshooter-"Hot Shale" thickness are minimal (Figs. 6-9). Where the interval is less than 220 feet thick, it shows an eastward thickening of approximately 20 to 30 feet per mile. Where the interval is between 220 and 300 feet thick, the rate of eastward thickening is about 50 feet per mile. From limited data the interval is essentially uniform in thickness in the easternmost part of the study area, which apparently corresponds to the eastern shelf. An approximation of the average Missourian shelf-edge in the Anadarko basin is presented in Figure 17.

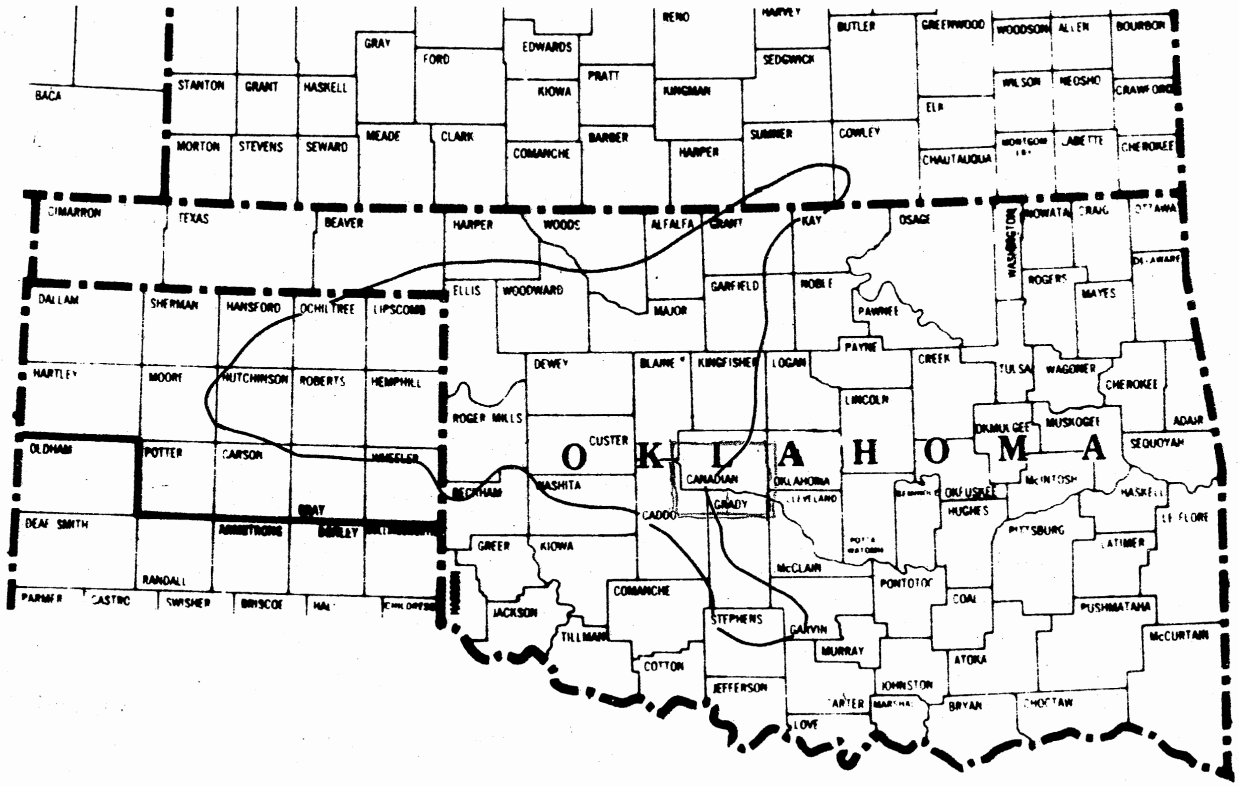


Fig. 17.-Regional map illustrating shelf margins of Anadarko basin during Missourian time.

CHAPTER V

GEOMETRY OF MARCHAND SANDSTONE

Length and Width

Neither the eastern nor the western terminations of the multistoried and multilateral Marchand Sandstone can be adequately defined from present subsurface control, which indicates an overall easterly dimension of more than 5 miles for the width of thick Marchand development (Figs. 18-20).

The Marchand "trend" extends for an overall distance of 15 miles in portions of Caddo and Grady Counties. The Marchand is recognized throughout the length of the area of study, which is approximately 7 miles in a north-south direction (Figs. 18-20). Sandstone is well developed in that direction for 5 miles. The lobate upper part of the Marchand trends southerly and extends throughout the study area (Fig. 18). The lower part of the Marchand, which is also lobate, is absent locally along an overall southerly trend (Fig. 18).

Thickness

Net Marchand Sandstone varies in thickness from 0 locally along portions of the updip eastern edge to more than 175 feet in central portions of the sandstone body (Fig. 19). Gross sandstone measurements reveal a similar pattern, with 3 local areas where sandstone is greater than 200 feet thick (Fig. 20).

Net sandstone is herein defined as units with deflections on the gamma-ray curve which are greater than 20 A.P.I. units from the shale base line. Gross sandstone is the interval from the base of the lowermost sandstone, based on deflections greater than 20 A.P.I. units, to the top of the uppermost sandstone.

Boundaries

Large lenticular complexes of multistoried and multilateral channel deposits, exhibiting sharp lateral and basal contacts, compose the Marchand Sandstone body (Figs. 6-13). Within the Marchand interval local lithologic markers M1, M2, and M3 were apparently eroded during deposition of the Marchand (Figs. 6-9, 11-13). In one place the Huddleston Limestone was locally eroded, and the stratigraphic position of it is occupied by a Marchand channel deposit (Fig. 6).

The sharp lower contact of the "Hot Shale" zone, displayed by gamma-ray curve, suggests abrupt changes in the depositional environment, whereas the interstratified sequence above the main part of the Marchand Sandstone body and below the "Hot Shale" suggests more gradational changes from dominant sand to shale deposition.

CHAPTER VI

INTERNAL FEATURES

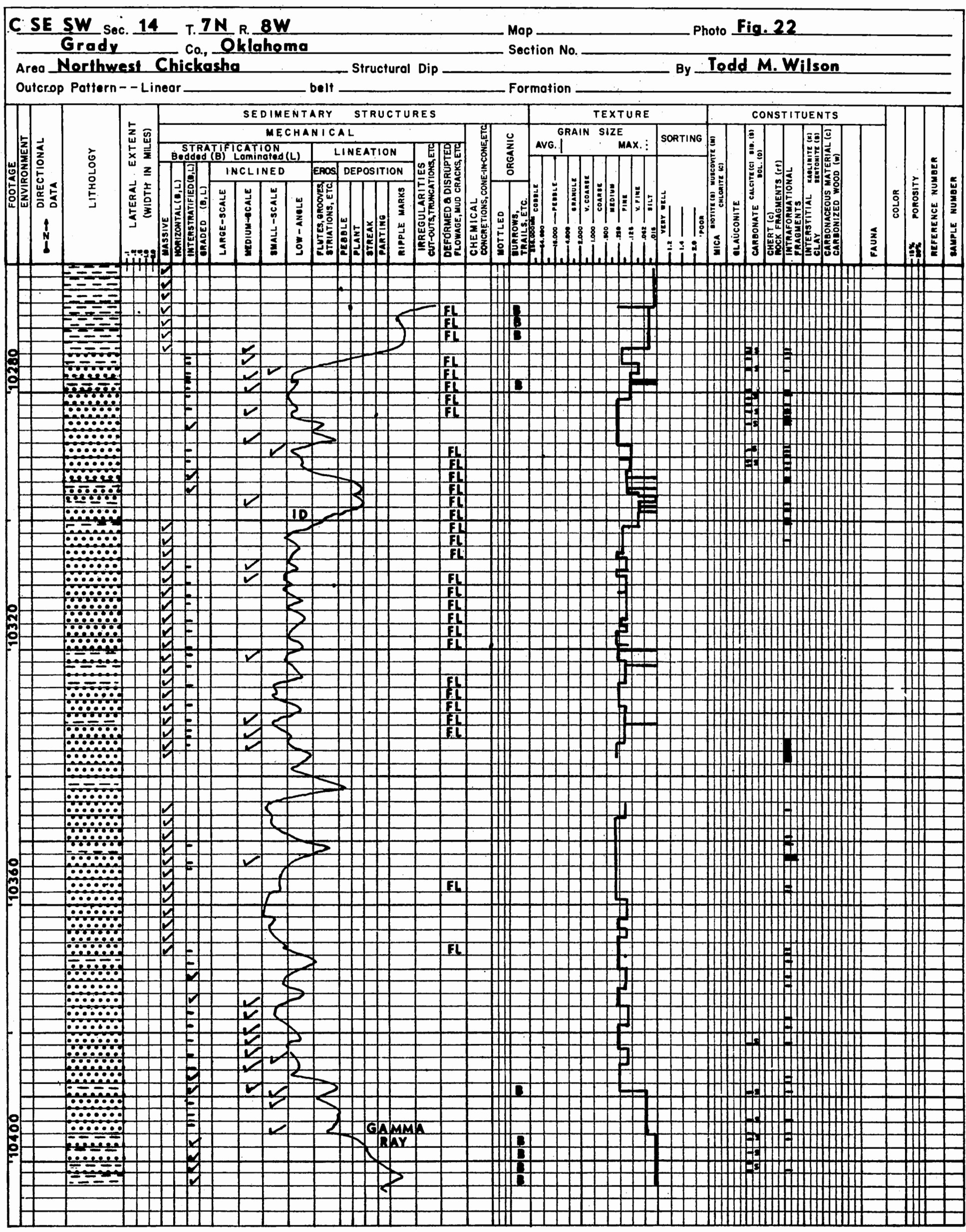
Sedimentary Structures

The environmental interpretation of clastic deposits is appreciably strengthened by establishing a vertical sequence of sedimentary structures. The vertical sequences in the 3 cores studied are diverse in nature, and they are not similar to the idealized, well-documented sequences of various depositional environments, such as point bars, barrier islands, and deep-marine turbidity currents.

Common sedimentary structures in the cores include massive, interstratified, and horizontal bedding, medium- and small-scale cross-bedding, low-angle initial dip, flowage and bioturbated features, and several types of vertical and horizontal burrows (Figs. 21-26). Although no well developed, systematic sequence of these various sedimentary structures were observed, an overall vertical sequence is represented by a lower interstratified shale and siltstone-sandstone, the thick Marchand Sandstone, and an upper interstratified sequence.

Massive-Bedding

All 3 cores of the Marchand contain massive bedding. Part of the "Hot Shale," which overlies the Marchand is massively bedded whereas other parts are laminated (Fig. 27). Large portions of the Marchand



C SE SW Sec. 14 T. 7N R. 8W Map Photo Fig. 22
Grady Co., Oklahoma Section No.
Area Northwest Chickasha Structural Dip By Todd M. Wilson
Outcrop Pattern--Linear belt Formation

Fig. 21.-Core description of Marchand Sandstone, Phillips Petroleum Company, Walters "J" No. 1.

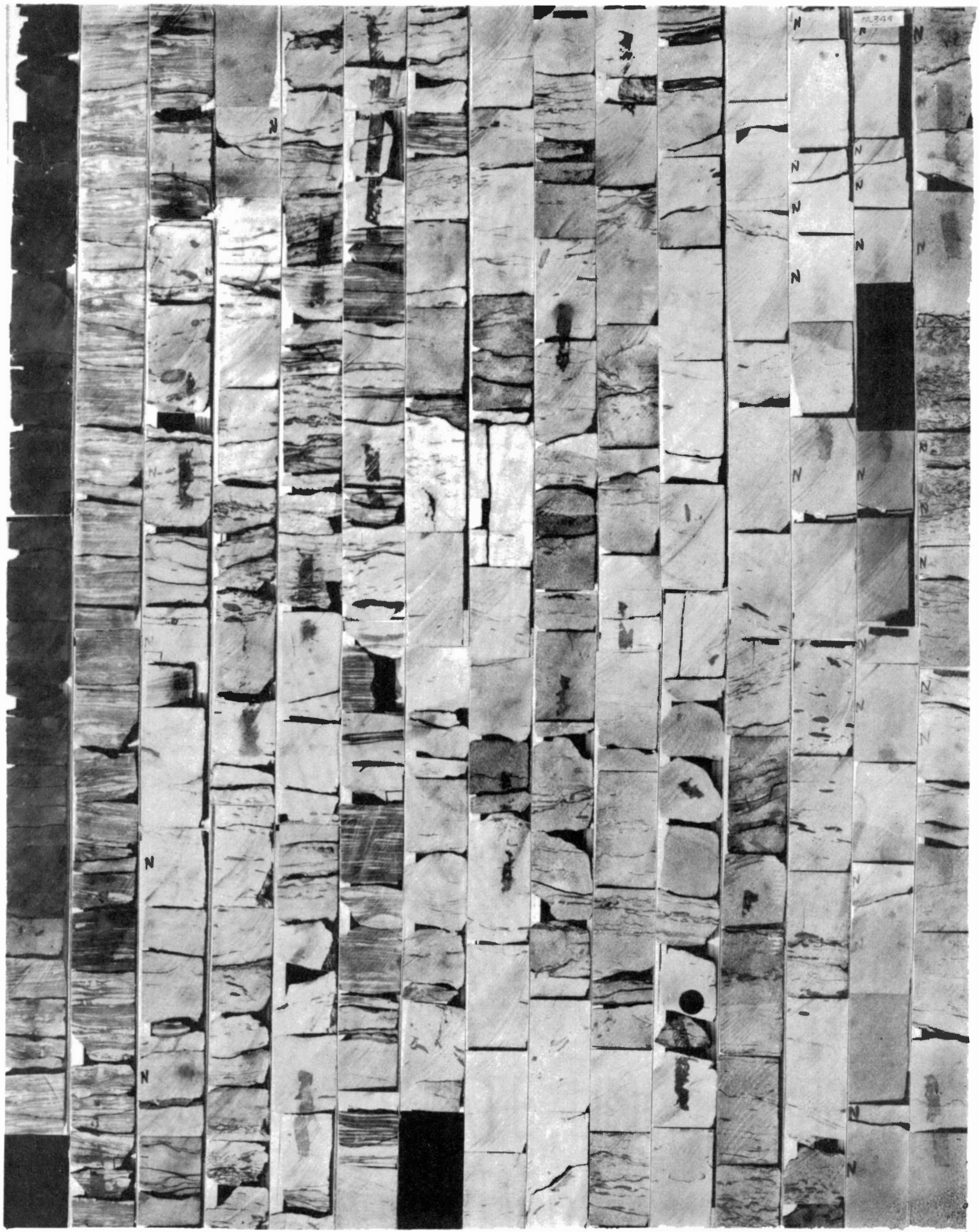


Fig. 22.-Photographs of Marchand Sandstone, Phillips Petroleum Company, Walters "J" No. 1. Length of each column is 6 feet; top of core, upper left.

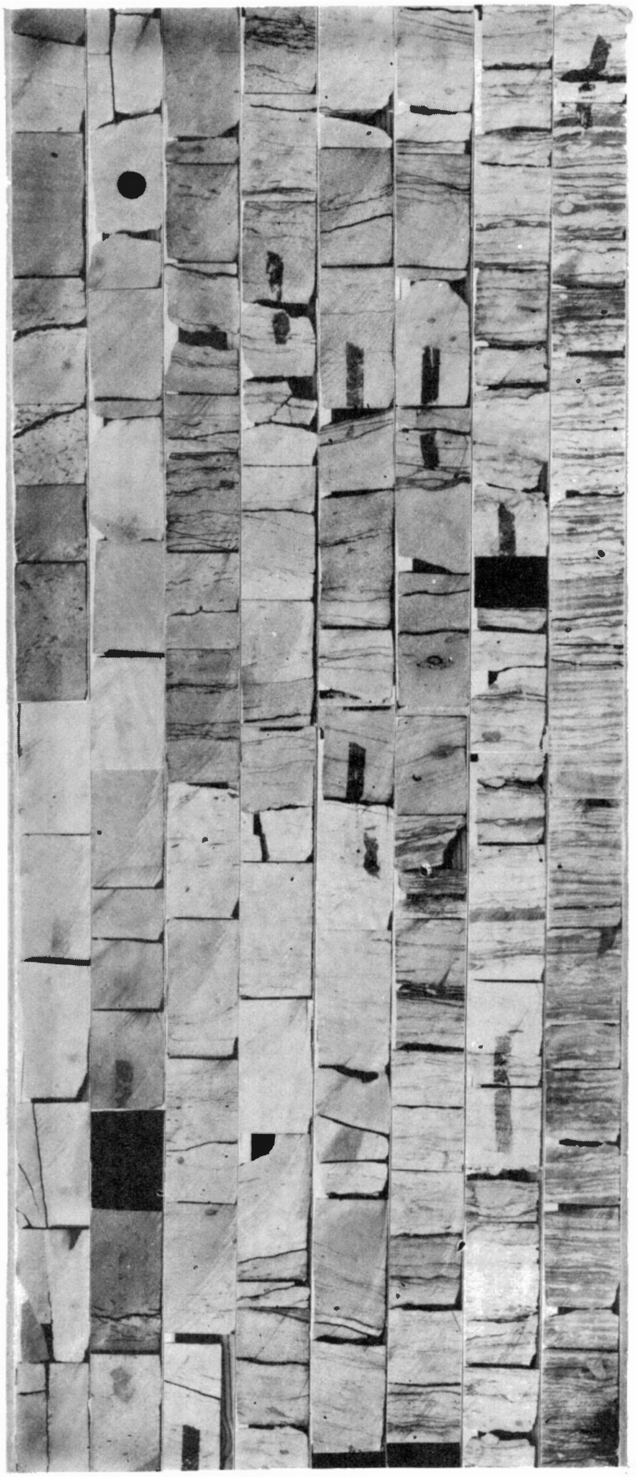
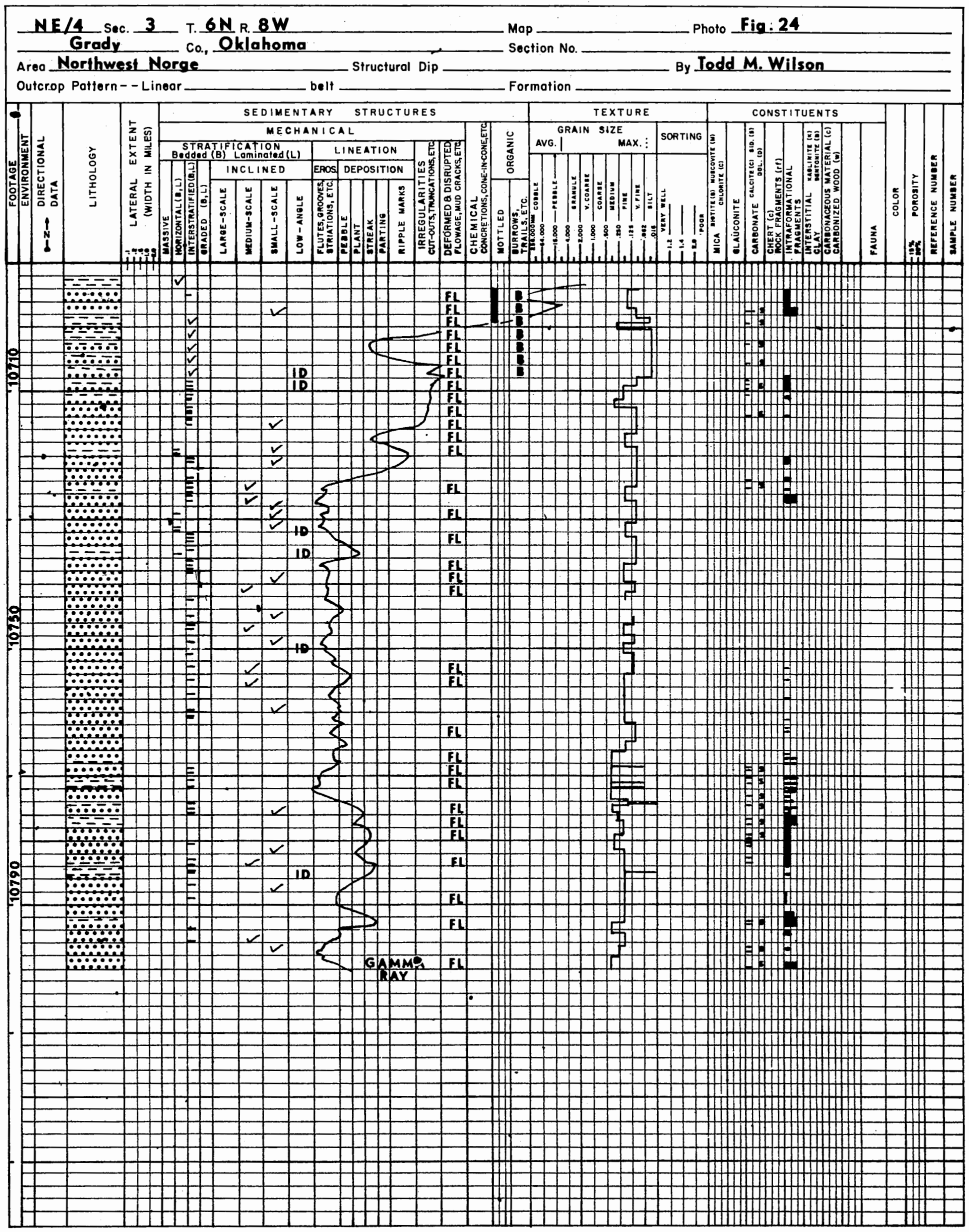


Fig. 22.-(Continued)



NE/4 Sec. 3 T. 6N R. 8W Map Photo Fig. 24

Grady Co., Oklahoma Section No.

Area Northwest Norge Structural Dip By Todd M. Wilson

Outcrop Pattern--Linear belt Formation

Fig. 23.-Core description of Marchand Sandstone, Midwest Oil Company, Scott No. 1.

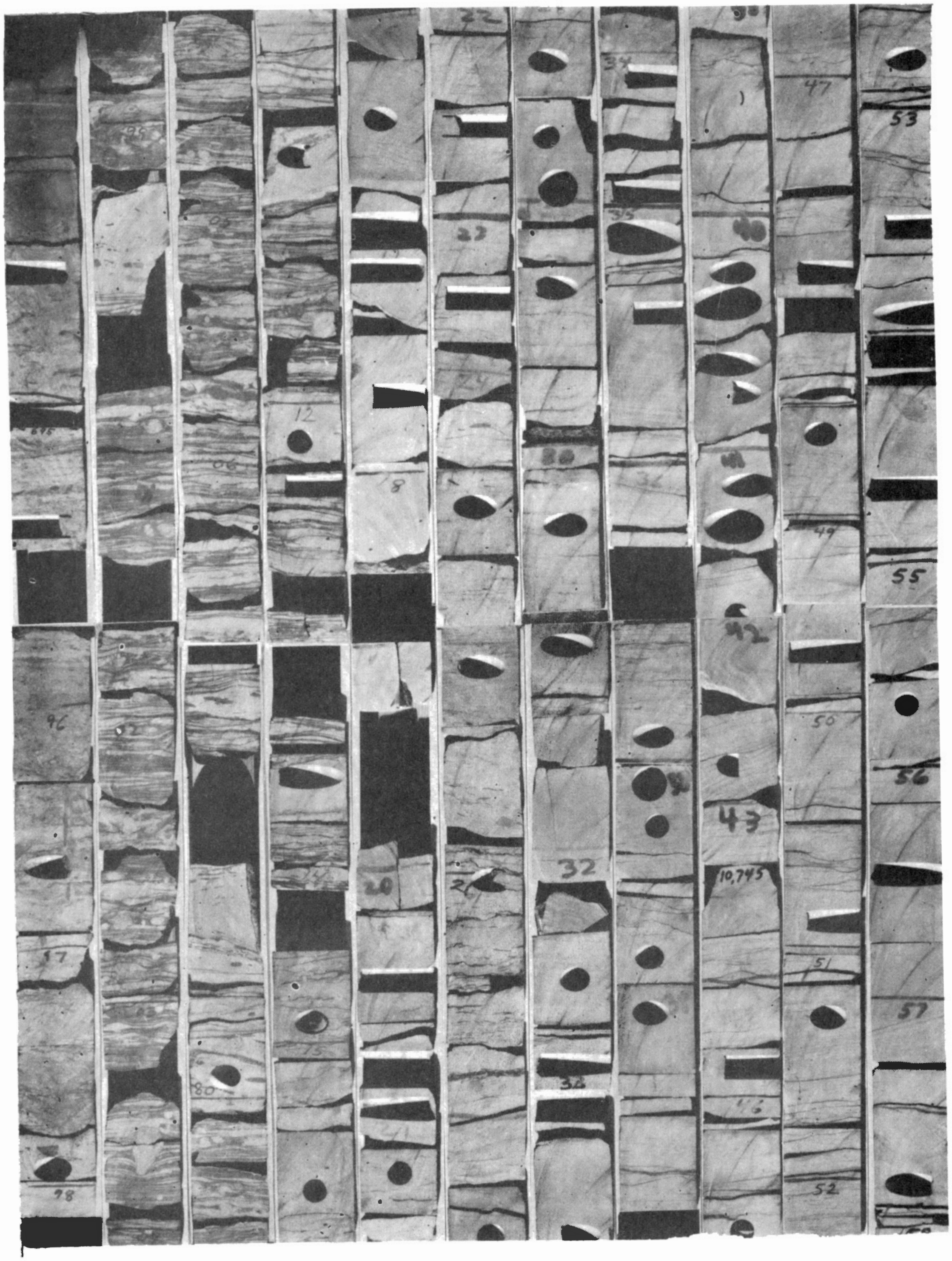


Fig. 24.-Photographs of Marchand Sandstone, Midwest Oil Company, Scott No. 1. Length of each column is 6 feet; top of core, upper left.

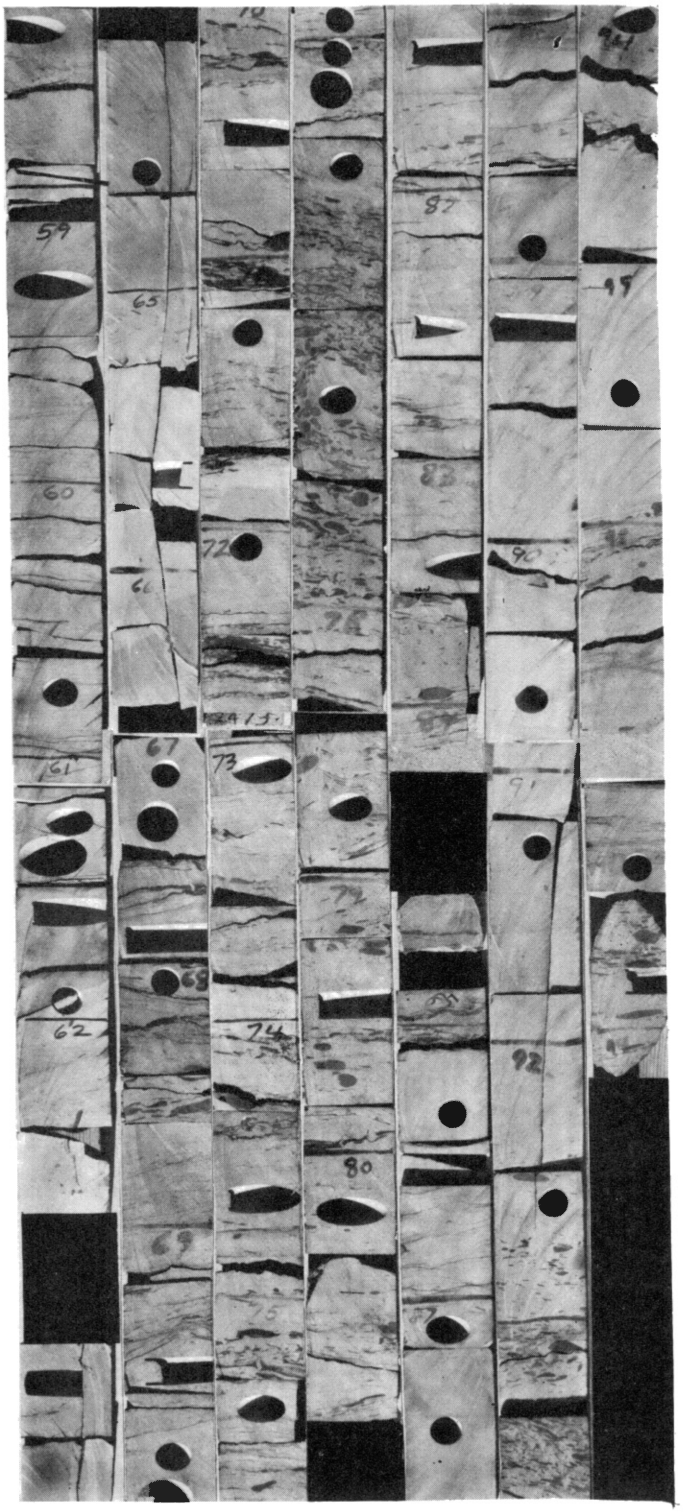


Fig. 24.-(Continued)

C NW NW Sec. 11 T. 6N R. 8W Map Photo Fig. 26

Grady Co., Oklahoma Section No.

Area Northwest Norge Structural Dip By Todd M. Wilson

Outcrop Pattern--Linear belt Formation

1 Abundant shale interbeds of flaser-like features

Fig. 25.-Core description of Marchand Sandstone, Ramsey Engineering, Scott No. 1.

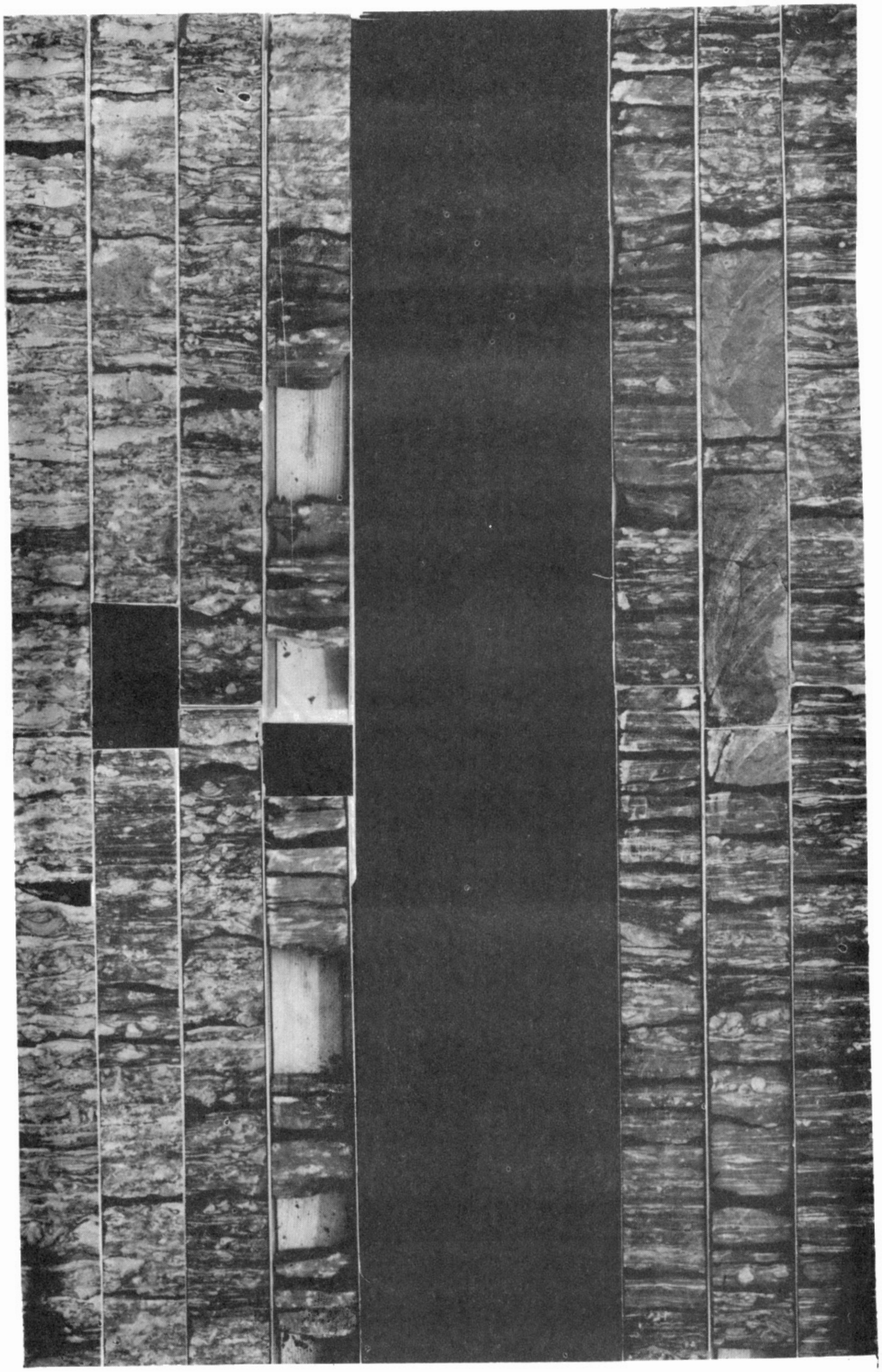
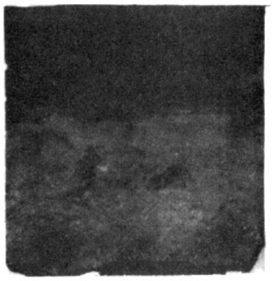
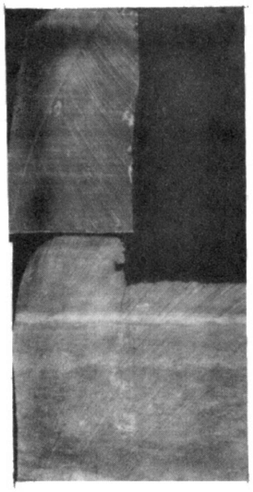


Fig. 26.-Photograph of Marchand Sandstone, Ramsey Engineering, Scott No. 1. Length of each column is 6 feet; top of core, upper left.



a) Massive bedding in the "Hot Shale." Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,266 feet.



b) Lamination in "Hot Shale." Midwest Oil Company, Scott No. 1, from depth of 10,693 feet.

Fig. 27.-Massive bedding and lamination in the "Hot Shale," a black, silty, radioactive shale which overlies the Marchand Sandstone. Core width is 3½ inches.

in the Phillips Petroleum Company, Walters "J" No. 1 are massively bedded (Fig. 22).

The Marchand section in the Ramsey Engineering, Scott No. 1 contains some massive bedding, which probably resulted from bioturbation (Fig. 26).

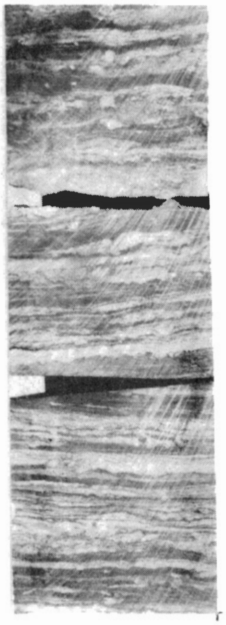
Interstratification

Interstratified sequences are most common in upper and lower portions of the Marchand Sandstone interval (Figs. 21-24).

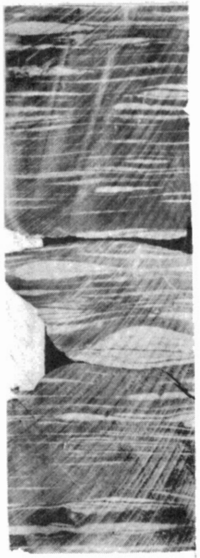
The most common type is the interstratification of sand in dominant shale sections both above and below the main part of the Marchand Sandstone. Both parallel and lenticular interstratification is present within these sequences (Fig. 28). Parallel interstratification is dominant in the lower sequence whereas lenticular interstratification is more common in the upper interstratified sequence (Figs. 21 and 22). Some of the lenticular interstratified zones in the Ramsey Engineering, Scott No. 1 core contain abundant flaser-like features (Fig. 29). Parallel interstratification of shale within sandstone is another type of interstratification in the Marchand interval. The shale contains sharp upper and lower contacts (Fig. 30).

Horizontal Bedding

Horizontal bedding in the sandstone is present only in the Midwest Oil Company, Scott No. 1 (Figs. 23 and 24). In the Scott No. 1, this sedimentary structure characterizes a significant part of the interstratified section.



a) Parallel interstratification of sandstone and shale. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,402-403 feet.



b) Lenticular interstratification of sandstone in shale. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,296 feet.

Fig. 28.-Parallel and lenticular interstratification of very fine grained sandstone and shale in the Marchand section. Core width is 3½ inches.

Fig. 29.-Flaser-like interstratification in the Ramsey Engineering Company, Scott No. 1, from depth of 10,849 feet. Core width is 3½ inches.

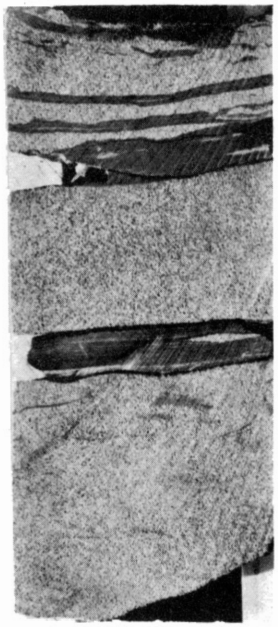


Fig. 30.-Parallel interstratification of shale in sandstone with abrupt upper and lower contacts. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,322 feet. Core width is 3½ inches.

Medium- and Small-Scale Crossbedding

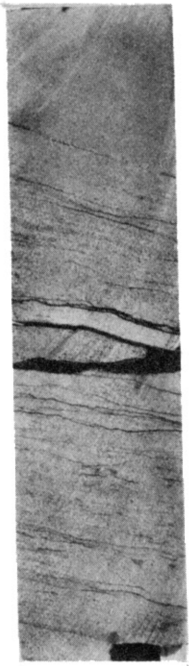
Abundant medium- and small-scale crossbedding are present in the Phillips Petroleum Company and the Midwest Oil Company cores (Figs. 21-24). Sparsity of crossbedding in the Ramsey Engineering core is attributed to the small percentage of sand-size material present (Figs. 25 and 26). In general, small-scale crossbedding is in the finer grained portions of the sandstone, and it overlies medium-scale crossbedding in some sequences. Small-scale crossbedding is more common in the Midwest Oil Company core where the overall grain size is finer than that of the Phillips Petroleum Company core (Figs. 21, 23). Correspondingly, medium-scale crossbedding is more common in the Phillips Petroleum Company Core (Figs. 21, 31-33). Small-scale crossbedding is commonly associated with burrows and flowage structure.

Initial Dip

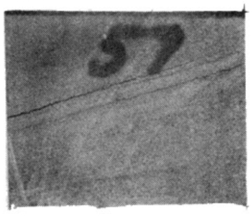
Low-angle initial dip is most common in the Midwest Oil Company core and is absent in the Ramsey Engineering Core (Figs. 23-26). It is present only in one part of the Marchand in the Phillips Petroleum Company core (Figs. 21, 22, and 34).

Flowage

The most dominant sedimentary structure in the Marchand Sandstone interval is flowage. In most cases slightly rounded to angular, flattened clay clasts define the deformational structure (Figs. 35 and 36). Clay clasts also outline small-scale folding (Fig. 36). Another type of deformation is the load features developed primarily in the

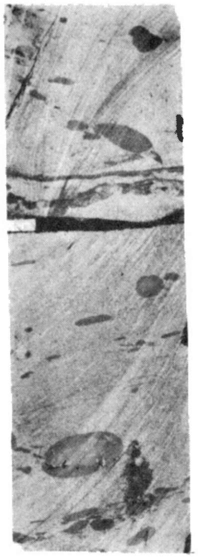


a) Medium-scale crossbedding outlined by clay interstratifications. Phillips Petroleum Company, Walters "J" No.1, from depth of 10,385 feet.

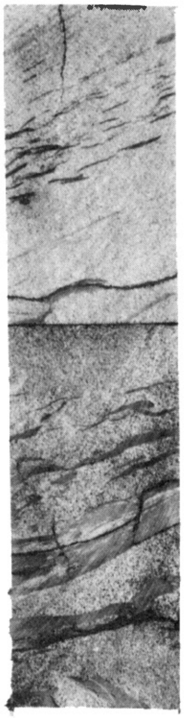


b) Medium-scale crossbedding with uniform foresets outlined by clay interstratifications. Midwest Oil Company, Scott No. 1, from depth of 10,757 feet.

Fig. 31.-Medium-scale crossbedding. Core width is 3½ inches.



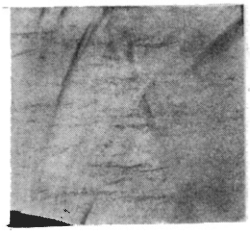
a) Medium-scale crossbedding outlined by directionally oriented siderite pebbles. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,274 feet.



b) Medium-scale crossbedding outlined by irregular clay clasts. Phillips Petroleum Company, Walter "J" No. 1, from depth of 10,331 feet.

Fig. 32.-Medium-scale crossbedding. Core width is 3½ inches.

a) Small-scale crossbedding and vertical burrows in very fine-grained sandstone. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,390-391 feet.



b) Small-scale crossbedding in very fine-grained sandstone. Midwest Oil Company, Scott No. 1, from depth of 10,722 feet.

Fig. 33.-Small-scale crossbedding in very fine-grained sandstone. Core width is 3½ inches.

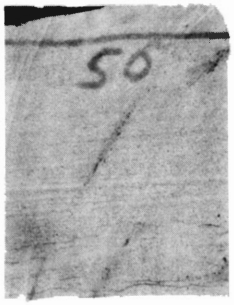


Fig. 34.-Low-angle initial dip in Marchand Sandstone. Midwest Oil Company, Scott No. 1, from depth of 10,750 feet.

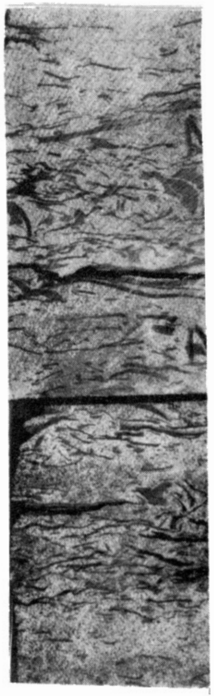
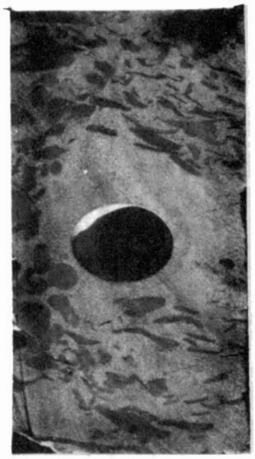


Fig. 35.-Flowage within Marchand Sandstone, defined by flattened, angular clay clasts. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,325 feet.

a) Flowage structure in upper sample is characterized by randomly oriented clay clasts; the lower sample contains oriented clay clasts outlining a small-scale overturned fold. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,347-358 feet.



b) Outline of small-scale fold by clay clasts. Midwest Oil Company, Scott No. 1, from depth of 10,777 feet.

Fig. 36.-Small-scale folding due to mass flowage of the Marchand Sandstone. Core width is 3½ inches.

interstratified sequences. The load casts are commonly associated with burrows and in some cases they cannot be clearly distinguished.

Bioturbation and Vertical and Horizontal Burrows

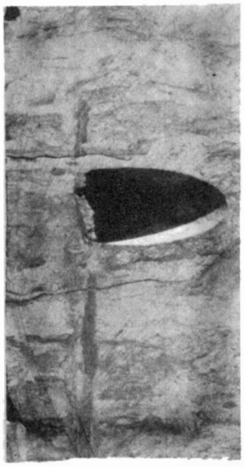
Bioturbation and vertical and horizontal burrows are present in the upper and lower interstratified sequences of the Marchand interval (Figs. 21-26). Bioturbation and burrows are present throughout that part of the Marchand section in the Ramsey Engineering core (Figs. 37 and 38). The absence of burrows in well developed Marchand Sandstone suggests rather rapid deposition.

Texture

Rock types in the Marchand interval include sandstone and interstratified shale and sandstone. One 3-foot interval of sandy fossiliferous limestone is present in the Ramsey Engineering, Scott No. 1 core (Figs. 25 and 26). Locally derived clay clasts are abundant throughout the Marchand Sandstone. Siderite pebbles are concentrated in upper and lower interstratified sections.

Excluding clay-size minerals, the range in average grain size of the Marchand Sandstone is from silt (0.16 mm) to medium sand (.375 mm) (Figs. 21, 23, and 25). The majority of the Marchand Sandstone is moderately well sorted, with minor amounts of interstitial silt and clay. The average grain size in sandstone sections is relatively uniform. Interstratified and intraformational clasts represent the only significant variations in grain size. Interstratification and overall uniform grain size are reflected in the gamma-ray curves by

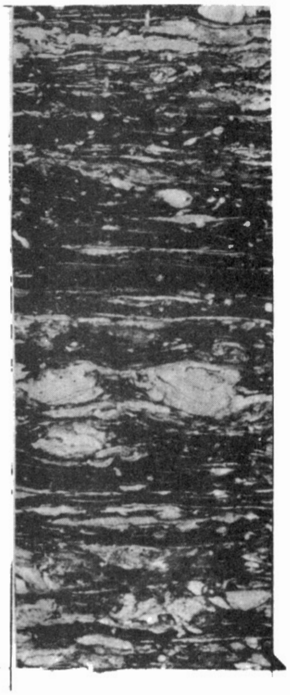
a) Disruption of bedding by bioturbation. Ramsey Engineering Company, Scott No. 1, from depth of 10,822 feet.



b) Prominent clay filled burrow in very fine-grained, bioturbated sandstone. Midwest Oil Company, Scott No. 1, from depth of 10,796 feet.

Fig. 37.-Bioturbation and disruption of bedding by extreme burrowing in the Marchand Sandstone. Core width is 3½ inches.

a) Horizontal burrows and disrupted sandstone lenses, due in part to flowage. Ramsey Engineering Company, Scott No. 1, from depth of 10,836 feet.



b) Small horizontal burrows, disrupted sandstone lenses, and dikes. Ramsey Engineering Company, Scott No. 1, from depth of 10,830 feet.

Fig. 38.-Horizontal burrows and disrupted sandstone lenses in the Marchand Sandstone. Core width is 3½ inches.

blocky, serrated shapes in the Phillips Petroleum Company and Midwest Oil Company cores.

Constituents

Five major framework constituents, based on examination of 10 thin sections prepared from the Phillips Petroleum Company and Midwest Oil Company core samples, are quartz, potassium feldspars, plagioclase, chert, and carbonate grains. Quartz is the dominant framework mineral, with percentages varying from 57 to 86. Quartz overgrowths and partial replacement of quartz by carbonate are common (Fig. 39).

Calcite is the carbonate framework mineral; it averages 3-7 percent in all thin sections, except for one in which calcite composes 25 percent (Fig. 40). A small portion of the carbonate is oolites, which contain relatively large quartz grains as nuclei (Fig. 41). Fossil fragments, which are rather common in several thin sections, are another type of carbonate grain (Figs. 42 and 43).

Chert, composing 5 to 15 percent of the framework, is present as Chalcedonic and recrystallized chert (Fig. 44).

Plagioclase is present in amounts varying from 1-10 percent. Grains of the potassium feldspars are generally less abundant--from 1-5 percent (Figs. 45-47).

Accessory minerals include tourmaline, zircon, sphene, muscovite, glauconite, and pyrite. Rutile and apatite inclusions are present in some quartz grains. Other framework grains in the Marchand include intraformational fragments of clay and siderite. Subrounded siderite nodules, ranging in size from 1 to 3 centimeters, are present in both the upper and lower interstratified intervals (Figs. 21-26). The

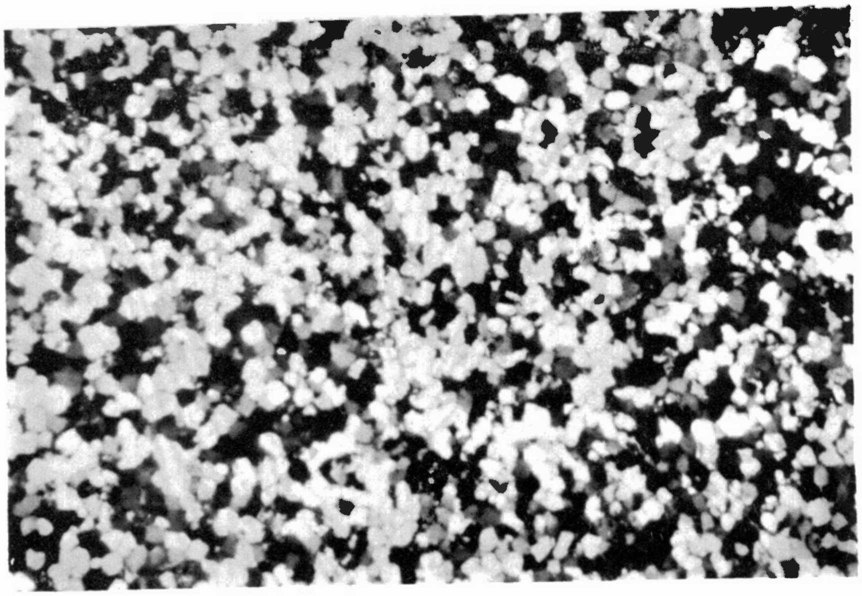


Fig. 39.-Siliceous overgrowths in tightly packed and cemented sandstone containing subordinate carbonate matrix. Sandstone is horizontally bedded. Midwest Oil Company, Scott No. 1, from depth of 10,729 feet. Crossed nicols X20.

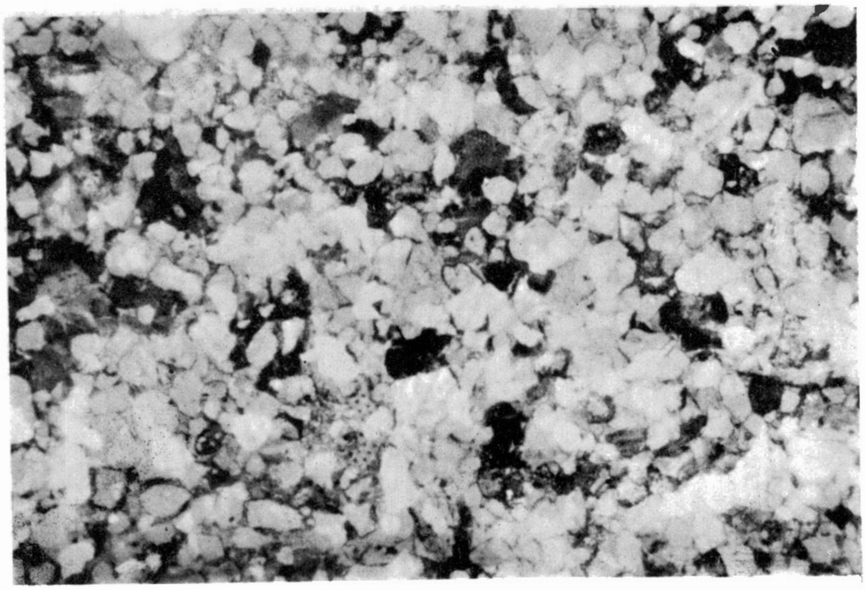


Fig. 40.-Sandstone containing 25 percent carbonate; matrix is dominantly calcium carbonate with some sericite. Sandstone is extensively burrowed. Midwest Oil Company, Scott No. 1, from depth of 10,696 feet. Plane polarized light X20.

Fig. 41.-Tightly packed and cemented sandstone containing oolites with large quartz nuclei. Some quartz grains have corroded rims; others show overgrowths. Sandstone is massively bedded. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,317 feet. Crossed nicols X50.

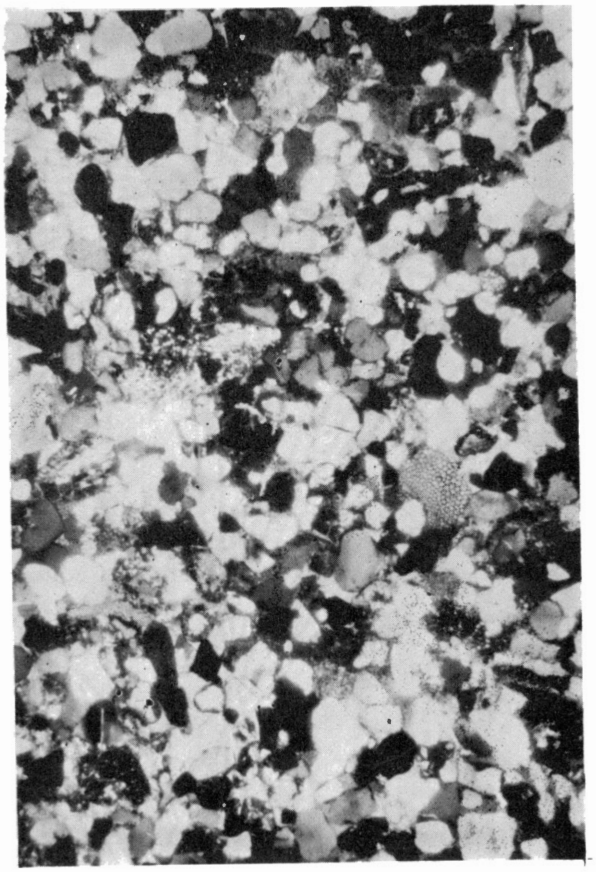


Fig. 42.-Bryozoan and unidentified fossil fragments as part of the framework in the Marchand. Sandstone is extensively burrowed. Midwest Oil Company, Scott No. 1, from depth of 10,696 feet. Crossed nicols X20.

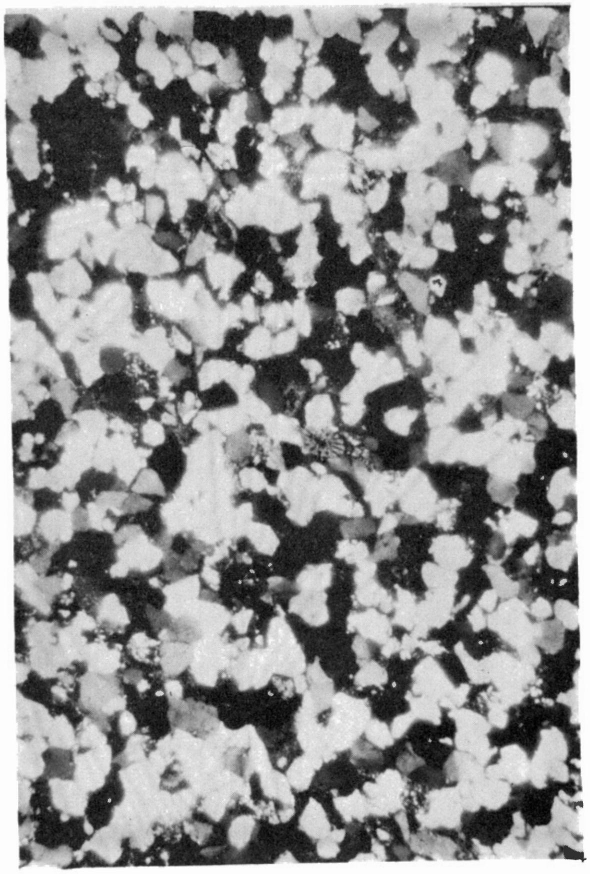


Fig. 43.-Portion of a crinoid stem (center of photograph) in sandstone with a matrix dominated by sericite. Quartz overgrowths are common, along with partial replacement of quartz grains by carbonate and sericite. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,266 feet. Crossed nicols X20.

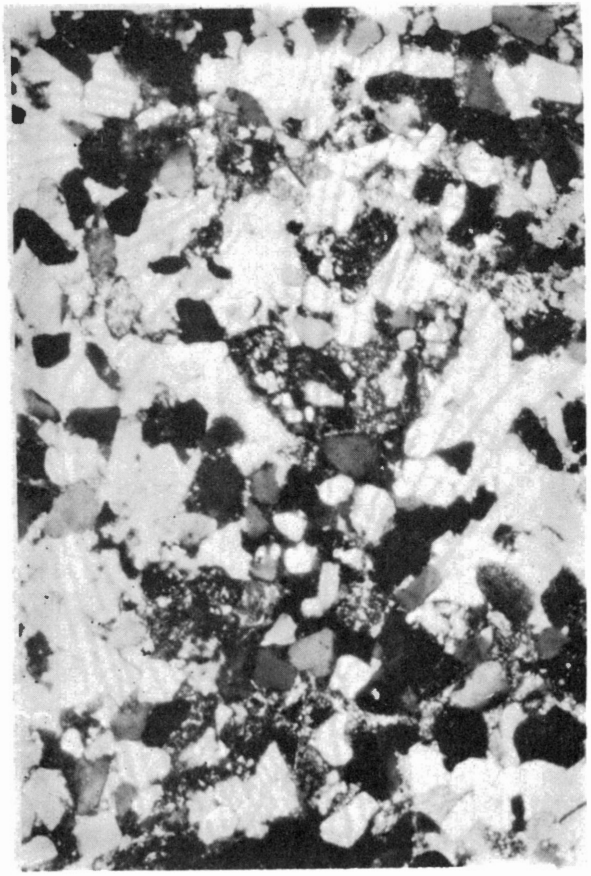


Fig. 44.-Quartz overgrowths, calcite partially replacing quartz, and dominant calcite matrix. Sandstone is characterized by small-scale crossbedding. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,391 feet. Crossed nicols X20.

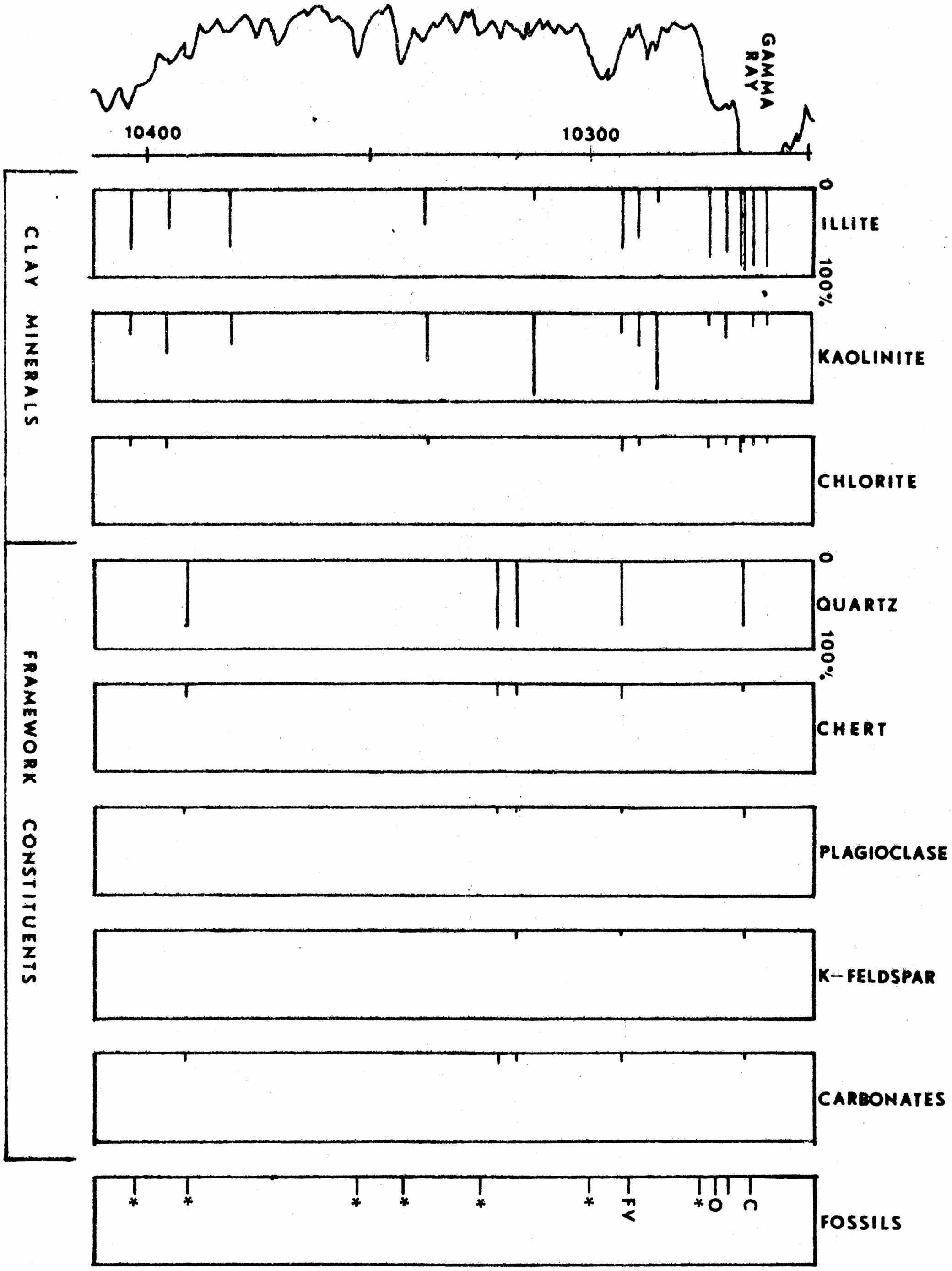


Fig. 45.-Constituents in Marchand Sandstone in Phillips Petroleum Company, Walters "J" No. 1 core. (C-conodont, O-ostracod, FV-fish vertebrae, *-unfossiliferous sample).

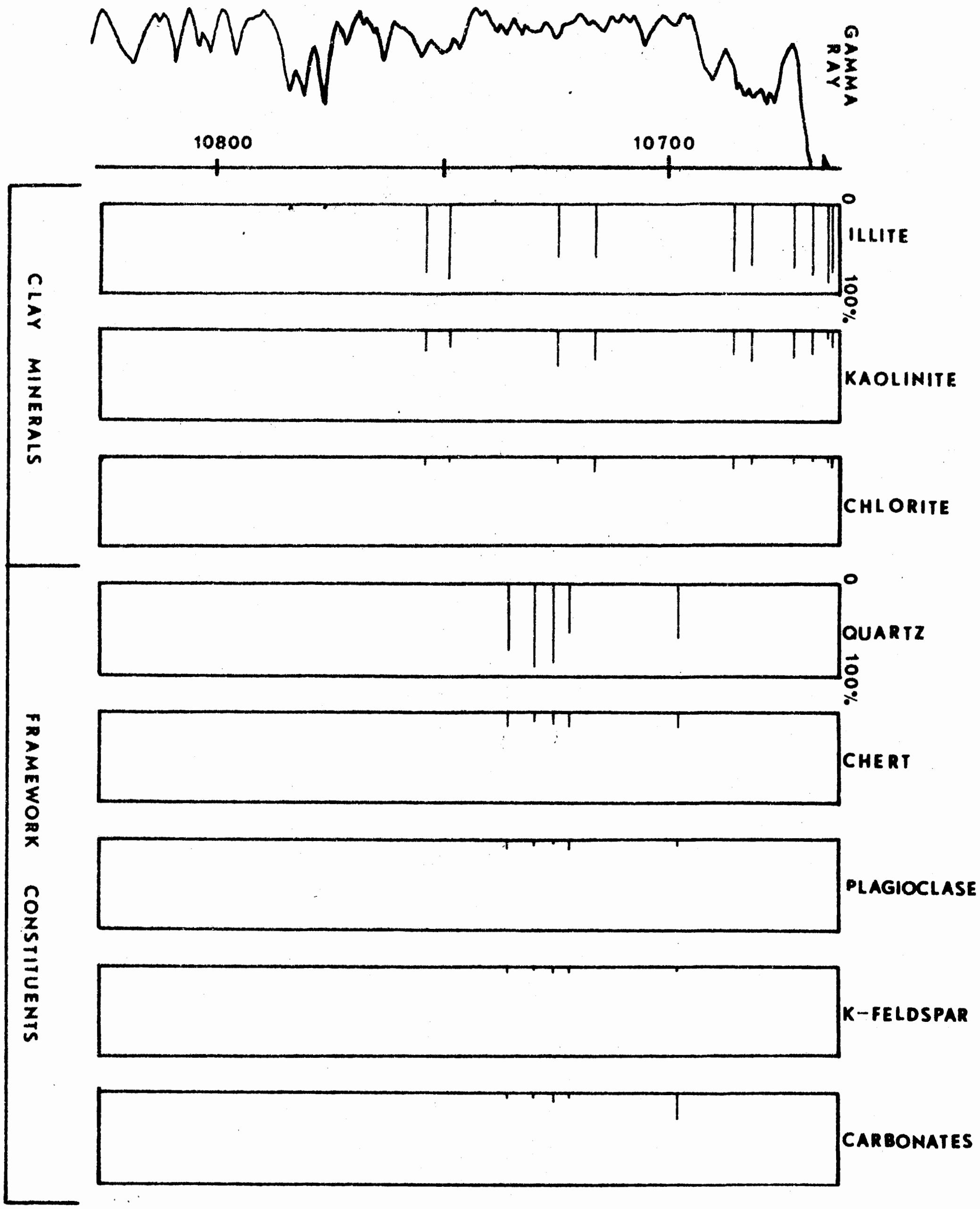


Fig. 46.-Clay-minerals and framework constituents in the Midwest Oil Company, Scott No. 1 core.

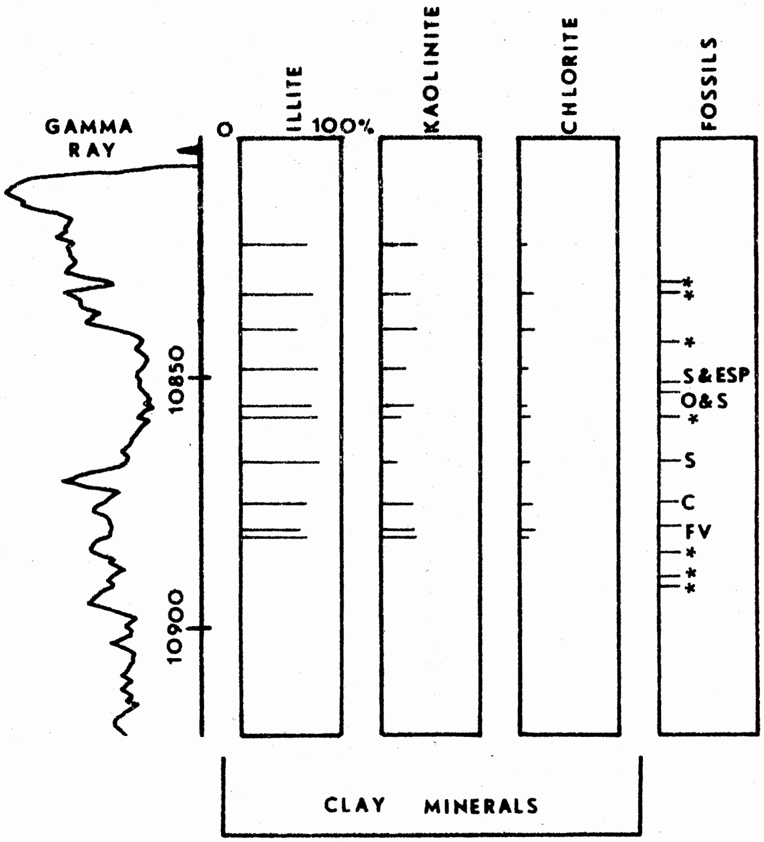


Fig. 47.-Clay minerals and fossil fragments in the Ramsey Engineering, Scott No. 1 core. (C-conodonts, S-spores, ESP-echinoid spine and plate, *-unfossiliferous sample).

roundness of the siderite nodules possibly suggests a greater distance of transportation than that of the clay clasts.

Carbonate and clay minerals, in varying proportions, compose the matrix of the Marchand Sandstone. Calcite is the dominant matrix mineral, with sericite being common in several thin sections (Figs. 48 and 49). Siderite, occurring as partial replacement of calcite and quartz grains, is a minor matrix constituent. Siliceous cement, dominantly as quartz overgrowths, is present in particularly "tight" portions of the Marchand Sandstone (Fig. 39).

X-ray diffraction techniques indicate that only 3 clay minerals are present in the 34 core samples analyzed. They are, in order of decreasing abundance, illite, kaolinite, and chlorite. Illite ranges from 15 to 92 percent; kaolinite varies from 0 to 95 percent; and chlorite is present in percentages of 0 to 16 (Figs. 45-47). Clay minerals were analyzed in 3 different lithologies--a black, carbonaceous shale ("Hot Shale"), sandstone, and interstratified sandstone and shale both above and below the main sandstone. Subsurface depths of the samples ranges from 10,261 to 10,881 feet.

The "Hot Shale" is characterized by a high illite content, ranging from 75 to 92 percent. Kaolinite varies from 0 to 17 percent; chlorite, from 3 to 8 percent. Illite and kaolinite are well crystallized, whereas chlorite is not highly crystallized.

In the interstratified intervals of the Phillips Petroleum Company core, illite is the dominant clay mineral, with kaolinite and chlorite being more common than in the "Hot Shale."

The relative percentages of the different clay minerals are quite variable in the sandstone. Illite and kaolinite show the greatest

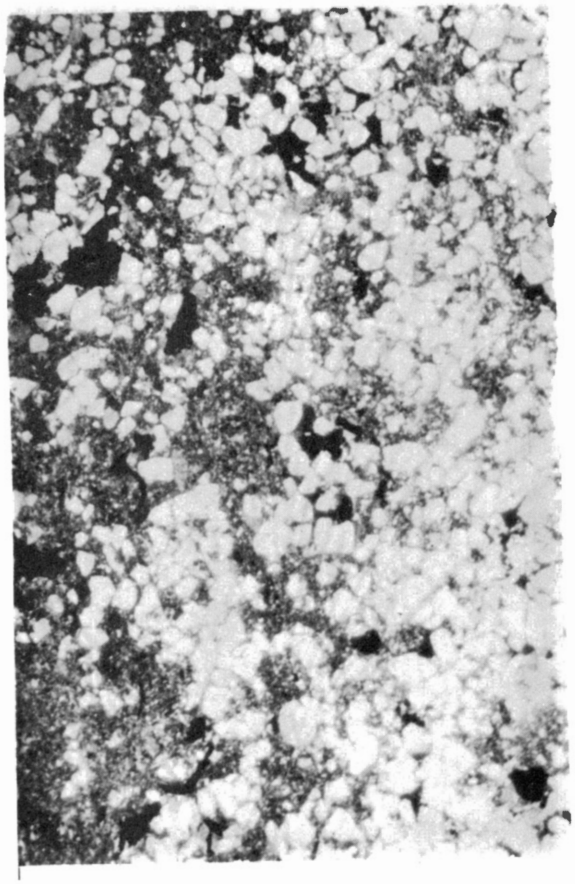


Fig. 48.-Abundant sericite clay as matrix around quartz grains. Quartz overgrowths among the quartz grains decrease as the sericite increases. Sandstone is massively bedded. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,266 feet. Crossed nicols X20.

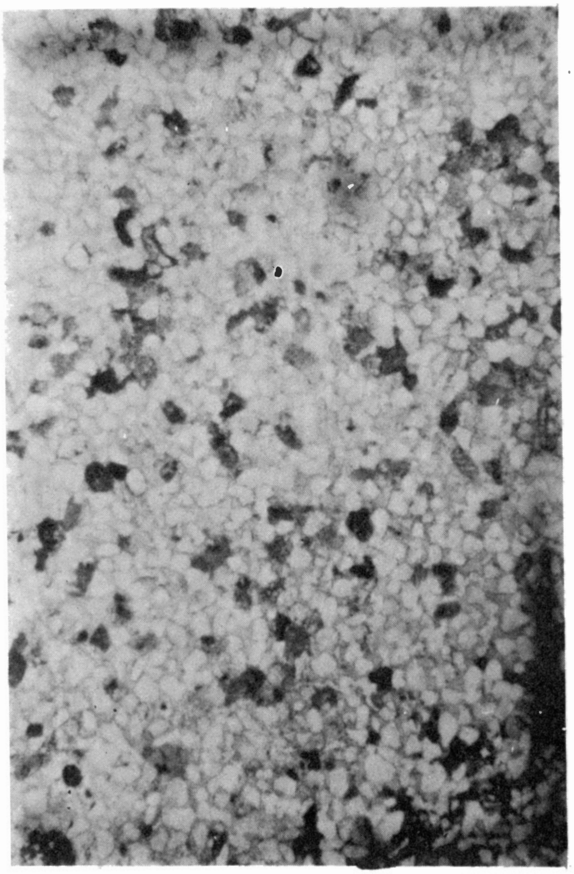


Fig. 49.-High concentration of calcite cement and framework with loose packing. Quartz overgrowths decrease as the calcite cement increases. Megascopically the sandstone contains flowage features. Phillips Petroleum Company, Walters "J" No. 1, from depth of 10,293 feet. Plane polarized light X20.

variation in abundance.

Fossils

Selected samples of shale interbeds in the Marchand Sandstone in the Phillips Petroleum Company, Walters "J" No. 1 and the Ramsey Engineering, Scott No. 1 were studied for microfossils for purposes of environmental interpretation. Of 23 samples analyzed, microfossils are present in only 8. The forms include triaxial spores, brackish water ostracods, echinoid spine and plate, conodonts, and fish vertebrae (Figs. 45-47). Fragments of bryozoans and crinoid stems are recognizable fossils in thin sections of the Marchand Sandstone (Figs. 42 and 43).

CHAPTER VII

DEPOSITIONAL ENVIRONMENT

Because the Marchand Sandstone can be divided in a general way into 2 major units over much of the study area, it is considered to be a multistoried deposit. The sharp lateral boundaries coupled with rather wide sandstone distribution are suggestive of a multilateral unit. The distribution pattern of each part of the Marchand indicates that the sandstone body is a composite of 2 distinct depositional lobes, each of which may compose a genetic unit formed in the same environment. Each of the 2 units is elongate or lobate, and distribution maps and thickness maps are similar in configuration to delta-front sands of highly constructive, elongate deltas. Sharp lateral and lower boundaries and absence locally of markers M1, M2, M3, and the upper part of the Huddleston Limestone are evidence of channel deposits.

Significant depositional slope is suggested by the wedges of strata formed by the "Hot Shale" and the Hogshooter and Huddleston Limestones, which are essentially parallel to one another. Because the Marchand section is markedly thinner in the eastern part of the study area, toward the shelf, it is thought that the depositional slope during Marchand deposition is approximately portrayed by the isopach map of the "Hot Shale"-to-Huddleston Limestone interval, but the "Hot Shale" probably was deposited on a westward slope. The eastward thickening wedge of the interval between the Hogshooter Limestone and the "Hot Shale" may reflect a westward increase in water depths due to partial infilling at the basin.

Although the gamma-ray curves of the well developed Marchand Sandstone suggest repetitive vertical sequences, results of examining the cores do not support the log character. The serrated shape of the gamma-ray log apparently reflects clay interbeds and abundant clasts. Although most structures are present at a number of positions within the sandstone, a diagnostic vertical sequence of sedimentary structures and textures are apparently absent. In the Phillips Petroleum Company core the basal bed of the well developed sandstone, containing a sharp lower contact, is crossbedded (medium-scale). Several other beds, with similar characteristics, are present in the lower part of the Marchand in that well.

The abundance of flowage features is evidence of the persistence of an unstable depositional slope. The parallel interstratification is another characteristic structure which probably is environmentally significant. Although it resembles flaser-bedding in some respects, the poor development of cross-lamination in the siltstone-sandstone contrasts rather sharply with the delicately cross-laminated units in typical flaser bedding.

The relatively uniform grain size is not particularly definitive in estimating depositional environment. The moderate to good sorting may also characterize a number of depositional processes.

The largely detrital constituents are better indicators of source area than environment of deposition. The calcite grains including fossil fragments in the sandstone and shale interbeds and siderite pebbles probably suggest no more than general marine conditions.

Together the fossil fragments and fine-grained, moderately-to-well sorted sandstone suggest a marine depositional environment a significant distance from any elevated source area. Because the Marchand is not feldspar-rich, the Wichita uplift was probably not the source area for the Marchand. The extensive shelf carbonates in Kansas suggest that the cratonic source areas were contributing minor amounts of coarse clastics. Consequently, the Ouachita system, with possible contributions from the Arbuckle and even the Appalachian area, probably supplied the sand-size material to form the Marchand in the study area.

The deformed structures in the sandstone, with shale interbeds, suggest deposition of the sand-size material by mass-flow during pulses. The introduction of sand to the depositional site apparently interrupted deposition of clay by normal marine currents.

The abnormally thick section of sandstone, compared to the eastern equivalents, Layton Sandstone and Coffeyville Formation, and the wedge of sharply bounded sandstone, are suggestive of a marine slope deposit off the shelf of the Anadarko basin.

Minimum water depths in the western part of the area can be estimated from variation in thickness of the "Hot Shale"-Huddleston Limestone interval. Thickness is 40 feet in the east and 340 feet in the west. If the Huddleston in the easternmost part of the area formed at sea level, if the area during deposition at the interval did not subside, and if sea level were stationary, water depths at the beginning of Marchand deposition in the west was at least 300 feet.

Although the actual mechanism, or mechanisms, by which the Marchand was deposited is not clearly known, it is suggested that much of the sandstone formed by grain-flow, with flow down the slope toward the west initially and then northward and southward parallel to the slope. Stauffer (1967) proposed the term "grain-flow deposit" for sandstone characterized by thick, ungraded beds with uniform average grain size, moderate to good sorting, and relatively minor matrix. The grain-flow sandstones contain sharp lateral and lower boundaries, outsized clasts or inclusions, interstratification, dish structures, and mass-flowage structures. Grain-flow is described by Middleton (1973) as a mass-flow mechanism dependent on the dispersive pressures of grain collisions in currents with high suspension loads. Stauffer (1967) suggested that grain-flow formed by gravational slides on steep slopes. The characteristics described by Stauffer (1967) are quite similar to the internal features of the Marchand. Dish structures apparently are not present in the Marchand.

In comparison to the Pennsylvanian shelf sandstones of Oklahoma, the Marchand is thicker, and initial dips of associated markers were apparently steeper. Flowage structures, shale interbeds with sharp contacts, and marine fossil fragments are dissimilar to the deltaic sandstones, which are generally characterized by abundant medium-scale crossbedding, changes in grain size, and flaser-bedding in associated interbeds.

The bifurcating pattern of the Marchand is similar to the California La Jolla fan (Normark, 1970). These lower and middle fan deposits are similar in many respects to delta-front and distributary sand deposits of highly constructive, elongate deltas. This similarity is undoubtedly the reason for some errors in interpreting depositional environments. Modern California fans are composed of upper, or proximal, fan deposits dominated by a single entrenched, leveed valley, middle-fan deposits of distributary, braided, or meandering channels, and lower, or distal fan deposits of braided distributary channels that are sand-poor (Normark, 1970 and Haner, 1971). Those modern fans are much larger in extent and thickness than the Marchand. The geometry of the Marchand Sandstone suggests that it primarily represents middle fan, or suprafan, deposits. The proximal and distal portions do not appear to have been well developed in the Marchand complex, which appears telescopic in extent compared to modern fans on continental margins.

The type of channel system developed in submarine fans depends on the amount and size of sediment being supplied to the fan (Normark and Piper, 1969, 1971). The La Jolla fan-valley is dominated texturally by fine sand and relatively slow rates of deposition, which apparently resulted in a bifurcating distributary system on the middle fan (Normark, 1970). The Redondo and Astoria deep-sea fans, on the other hand, are characterized by meandering channels on the middle fan with braided channel systems in the lower or distal fan (Haner, 1971).

Other sandstones similar to the Marchand in having formed as slope deposits in cratonic basins include the Bell Canyon and Cherry Canyon Formations in the upper part of the Delaware Mountain Group in the Delaware basin of West Texas and Southeast New Mexico as described by Beck (1967), Jacka et al. (1968), Harms (1974), and Payne (1976), and Upper Pennsylvanian sediments of North-Central

Texas (Galloway and Brown, 1972). Rascoe (1976) considers the Virgilian (Pennsylvanian) clastics in portions of the Anadarko basin also to be delta-shaped submarine fans.

CHAPTER VIII

SUMMARY

The principal conclusions of this study are as follows:

1. The Marchand Sandstone, a thick wedge of coarse clastics on the northeast flank of the Anadarko basin, forms a stratigraphic trap for hydrocarbon accumulations.

2. Reference surfaces utilized display unfaulted, homoclinal features, with only minor irregularities.

3. A reciprocal relationship exists between the thickness of the Hogshooter Limestone-"Hot Shale" interval and the "Hot Shale"-Huddleston Limestone interval.

4. The Missourian shelf-edge, defined by abrupt increases in thickness, separates the thinner shelf deposits from the thicker sediments of the slope and basinal areas where the Marchand Sandstone was deposited.

5. Trends of net and gross thicknesses of sandstone are dominantly parallel to the eastern shelf-edge of the Anadarko basin during the Missourian; minor trends are perpendicular to the shelf-edge.

6. Distribution patterns of the Marchand indicate that the sandstone body is a composite of two distinct depositional lobes, representing bifurcating channels.

7. Multistoried and multilateral channel deposits, exhibiting sharp lateral and basal contacts, compose the Marchand Sandstone.

8. The channel-forming processes locally eroded lithologic markers and part of the Huddleston Limestone.

9. Sedimentary structures in the Marchand Sandstone are not arranged in vertical sequences characteristic of well known depositional environments.

10. Parallel interstratified sandstone and shale sequences below the main body of the Marchand Sandstone dominated the depositional area prior to channel development.

11. Medium and small-scale crossbedding, flowage, and massively bedded sandstone, with shale interstratification and clay clasts, are dominant internal features.

12. Shale with lenticular interlaminations of sandstone characterize the uppermost part of the Marchand.

13. Transgression and abandonment of the depositional center is indicated by the "Hot Shale."

14. Constituents in the Marchand are not indicative of a specific source area, but the rather low percentage of feldspar suggests that the Wichita uplift was not a major contributor of sediments and that the Ouachita uplift probably was.

15. Grain flow is thought to have been the primary depositional mechanism for formation of the Marchand Sandstone.

16. Water depths when the well developed sandstone began to be deposited were probably at least 300 feet.

17. The Marchand Sandstone is a clastic wedge deposited in the marine-slope environment of the Anadarko basin.

18. The Marchand possesses geometric characteristics similar to middle-fan deposits of modern California deep-sea fans.

19. The stratigraphic-structural setting, geometry, and internal features of the Marchand Sandstone are similar to marine-slope sandstones in the Delaware basin of West Texas and Southeast New Mexico, Upper Pennsylvanian sandstones of the Midland basin, Texas, and Upper Pennsylvanian sandstones in the northern part of the Anadarko basin.

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APPENDIX

LOCATION OF GAMMA-RAY, COMPENSATED FORMATION DENSITY AND INDUCTION ELECTRIC LOGS USED IN PREPARATION OF CORRELATION SECTIONS

North-South Correlation Section A-A'

No.	Operator and Well Number	Location
1.	Gulf Oil Co., Morse #1	W/2 W/2 SE SW Sec. 36-8N-8W
2.	Sun Oil Co., Benda #1	W/2 NW Sec. 1-7N-8W
3.	Mack Oil, Royse Unit #1	C NW SW Sec. 1-7N-8W
4.	Phillips Petroleum Co., Bingham "A" #2	SW SW NW Sec. 12-7N-8W
5.	Gulf Oil Co., Schlechet #1	S/2 S/2 NW SW Sec. 12-7N-8W
6.	Phillips Petroleum Co., Dietrich "A" #2	W/2 E/2 NW NW Sec. 13-7N-8W
7.	Phillips Petroleum Co., Dietrich "A" #3	NW NW SW Sec. 13-7N-8W
8.	Big Chief Drilling, Dietrich #1	N/2 SE NW SW Sec. 13-7N-8W
9.	Phillips Petroleum Co., Hanson "A" #1	S/2 S/2 NW NW Sec. 24-7N-8W
10.	Resources Exploration, Inc., Wheeler #1	C NW SW Sec. 24-7N-8W
11.	Big Chief Drilling, Wheeler Unit #1	C SW NW Sec. 25-7N-8W
12.	Rodman Corp. & Basin Petroleum, Wheeler "25" #1	SW SW Sec. 25-7N-8W
13.	Chieftain Petroleum Inc., State #2	C SW NW Sec. 36-7N-8W
14.	Big Chief Drilling, State #2	C SW SW Sec. 36-7N-8W
15.	Chieftain Petroleum Inc., Lowe #1	NW SE NW NW Sec. 1-6N-8W
16.	Big Chief Drilling, Smith Unit #1	NW SW NE SE Sec. 1-6N-8W

North-South Correlation Section B-B'

No.	Operator and Well Number	Location
1.	Amerada Hess Corp., Smedley #1	C SW SE Sec. 35-8N-8W
2.	Apache Corp., Erwin Unit #1	C SW NE Sec. 2-7N-8W
3.	Phillips Petroleum Co., Alexander "E" #1	C NW SE Sec. 2-7N-8W
4.	Apache Corp., Nightingale Unit #3	S/2 N/2 S/2 NE Sec. 11-7N-8W
5.	Apache Corp., Nightingale Unit #2	SW NE SW SE Sec. 11-7N-8W
6.	Sun Oil Co., Mainka "A" #1	W/2 E/2 NW NE Sec. 14-7N-8W
7.	Phillips Petroleum Co., Wheeler "S" #1	C NW SE Sec. 14-7N-8W
8.	Sun Oil Co., Wheeler #1	C NW NE Sec. 23-7N-8W
9.	Sun Oil Co., Wheeler "A" #1	C NW SE Sec. 23-7N-8W
10.	Sun Oil Co., Mecoy #1	C NW NE Sec. 26-7N-8W
11.	Walter Duncan, Davidson #1	C SW SE Sec. 26-7N-8W
12.	Walter Duncan, Cole #1	C SW NE Sec. 35-7N-8W
13.	Phillips Petroleum Co., Reiss "A" #2	C NW SE Sec. 25-7N-8W
14.	Phillips Petroleum Co., Reiss "A" #1	S/2 N/2 SE SE Sec. 35-7N-8W
15.	Midwest Oil Co., Lowe #1	W/2 E/2 NW NE Sec. 2-6N-8W
16.	Sun Oil Co., Salter #1	NE SW NW SE Sec. 2-6N-8W

North-South Correlation Section C-C'

1.	Trigg Drilling Co., Smedley #1	C SW SW Sec. 35-8N-8W
2.	Apache Corp., Frey Unit #1	SE NW SE NW Sec. 2-7N-8W
3.	Apache Corp., Alexander Unit #1	E/2 SW Sec. 2-7N-8W
4.	Apache Corp., Nightingale Unit #1	C SE NW Sec. 11-7N-8W
5.	Apache Corp., Nightingale Unit #1	C SW Sec. 11-7N-8W
6.	Sun Oil Co., Mainka #1	C N/2 NW Sec. 14-7N-8W

No.	Operator and Well Number	Location
7.	An-Son Corp., Wheeler #1	C SW NW Sec. 14-7N-8W
8.	Phillips Petroleum Co., Walters "J" #2	C SE SW Sec. 14-7N-8W
9.	Sun Oil Co., Patterson #1	C NW Sec. 23-7N-8W
10.	Phillips Petroleum Co., Wheeler "H" #1	C NW SW Sec. 23-7N-8W
11.	Tenneco Oil Co., Sims #1-26	C S/2 NW Sec. 26-7N-8W
12.	Sun Oil Co., Looney #1	C SW SW Sec. 26-7N-8W
13.	Sun Oil Co., Schenk #1	C SW NW Sec. 35-7N-8W
14.	Amarex, Inc., Metcalf #1	S/2 SE NW SW Sec. 35-7N-8W
15.	Midwest Oil Co., Nightingale #1	C NW NW Sec. 2-6N-8W
16.	Midwest Oil Co., Hall #1	NE SW NE SW Sec. 2-6N-8W
17.	Ramsey Engineering, Scott #1	C NW NW Sec. 11-6N-8W

North-South Correlation Section D-D'

1.	Walter Duncan, Keahtigh #1	C SE NW Sec. 10-7N-8W
2.	Phillips Petroleum Co., Weeds "H" #1	C SE SW Sec. 10-7N-8W
3.	Sun Oil Co., Boothe #1	C SE NW Sec. 15-7N-8W
4.	Sun Oil Co., Methvin #1	C SE SW Sec. 15-7N-8W
5.	Chieftain Petroleum Inc., Chahkeah #1	S/2 N/2 SE NW Sec. 22-7N-8W
6.	Phillips Petroleum Co., Powell "C" #1	C S/2 SW Sec. 22-7N-8W
7.	Sun Oil Co., Evelyn Schenk #1	E/2 E/2 SW NW Sec. 27-7N-8W
8.	Sun Oil Co., Roy Schenk #1	C SE SW Sec. 27-7N-8W
9.	Phillips Petroleum Co., Jantz "A" #1	C SE NW Sec. 34-7N-8W
10.	Eason Oil Co., Nightingale #1	E/2 W/2 E/2 SW Sec. 34-7N-8W
11.	Eason Oil Co., Metcalf Estate #1	NE SW NE NW Sec. 3-6N-8W
12.	Eason Oil Co., Priddle #1	NE SW NE SW Sec. 3-6N-8W

No.	Operator and Well Number	Location
13.	Midwest Oil Co., Mollett #1	C NE NW Sec. 10-6N-8W

West-East Correlation Section E-E'

No.	Operator and Well Number	Location
1.	Walter Duncan, Keahtigh #1	C SE NW Sec. 10-7N-8W
2.	Phillips Petroleum Co., Briscoe "B" #1	C SE NE Sec. 10-7N-8W
3.	Apache Corp., Nightingale Unit #4	C SE NE Sec. 11-7N-8W
4.	Apache Corp., Nightingale Unit #3	S/2 N/2 S/2 NE Sec. 11-7N-8W
5.	Phillips Petroleum Co., Bingham "A" #1	SW SW NW Sec. 12-7N-8W

West-East Correlation Section F-F'

No.	Operator and Well Number	Location
1.	Phillips Petroleum Co., Jantz "B" #1	C SE NW Sec. 28-7N-8W
2.	Sun Oil Co., Smith #1	C SE NE Sec. 28-7N-8W
3.	Sun Oil Co., Evelyn Schenk #1	E/2 E/2 SW NW Sec. 27-7N-8W
4.	Eason Oil Co., Schmidt #1	C SW NE Sec. 27-7N-8W
5.	Tenneco Oil Co., Sims #1	C S/2 NW Sec. 26-7N-8W
6.	Walter Duncan, Davidson #1	C SW SE Sec. 26-7N-8W
7.	Rodman Corp. & Basin Petroleum, Wheeler "25" #1	C SW SW Sec. 25-7N-8W
8.	Rodman Corp. & Basin Petroleum, Lawrence "25" #1	C SW SE Sec. 25-7N-8W

West-East Correlation Section G-G'

No.	Operator and Well Number	Location
1.	Phillips Petroleum Co., Koehn "A" #1	SW NE SW Sec. 21-7N-8W
2.	Phillips Petroleum Co., Koehn "B" #1	C NE SE Sec. 21-7N-8W
3.	Phillips Petroleum Co., Powell "C" #1	C S/2 SW Sec. 22-7N-8W
4.	Chieftain Petroleum Co., Satonka Unit #1	E/2 E/2 SW SE Sec. 22-7N-8W

No.	Operator and Well Number	Location
5.	Phillips Petroleum Co., Wheeler "H" #1	C NW SW Sec. 23-7N-8W
6.	Sun Oil Co., Wheeler "A" #1	C NW SE Sec. 23-7N-8W
7.	Resources Exploration Inc., Wheeler #1	C NW SW Sec. 24-7N-8W
8.	Phillips Petroleum Co., Melton "B" #1	C S/2 NE Sec. 24-7N-8W

West-East Correlation Section H-H'

1.	Apache Corp., Waldrup #1	C NE NE Sec. 4-6N-8W
2.	Eason Oil Co., Metcalf Estate #1	NE SW NE NW Sec. 3-6N-8W
3.	Midwest Oil Co., Scott #1	NE SW NE NE Sec. 3-6N-8W
4.	Midwest Oil Co., Nightingale #1	C NW NW Sec. 2-6N-8W
5.	Midwest Oil Co., Lowe #1	W/2 E/2 NW NE Sec. 2-6N-8W
6.	Chieftain Petroleum Inc., Lowe #1	NW SE NW NW Sec. 1-6N-8W
7.	Big Chief Drilling, Smith Unit #1	NW SW NE SE Sec. 1-6N-8W

VITA

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Master of Science

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