GENESIS AND TREND OF THE LOWERMOST UNIT OF THE VAMOOSA FORMATION (GYPSY SANDSTONE) IN PARTS OF NORTHEASTERN AND CENTRAL OKLAHOMA

By

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PREFACE

The main objective of this thesis is to interpret the trend and genesis of the lowermost unit of the Vamoosa Formation in parts of northeastern and central Oklahoma. The following are included in the study: description of geometry and internal features, thickness map, correlation sections, measured sections, paleocurrent diagrams, map of maximum grain size, and map of general water quality.

The writer wishes to thank his thesis adviser, Dr. J. W. Shelton, who suggested the study and provided guidance both in the field, and in writing of the text. Advisory committee members, Dr. G. F. Stewart and Dr. J. D. Naff, made helpful suggestions, comments, and criticisms. The writer would like to thank his fellow graduate students for their encouragement and suggestions.

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Special gratitude is expressed to my wife, Susan, for her assistance, support, and many sacrifices. Finally, special appreciation to my parents, Doyle and Nina Ford, and sister, Kristin, for their encouragement and help.

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CHAPTER I

ABSTRACT

The Gypsy Sandstone Member is an informal stratigraphic unit used herein to designate sandstones and conglomerates in the lowermost unit of the Pennsylvania Vamoosa Formation. The base of the Gypsy Sandstone marks the currently mapped contact between the Missourian and Virgilian Series in Oklahoma. Trend and genesis of the Gypsy Sandstone is from both outcrop and subsurface data.

Channel sandstones with sharp erosional bases and sharp lateral contacts represent regressive, multistoried, multilateral alluvial sandstones with the Gypsy. In the study area, these sandstones occur in belts that are approximately 2 to 20 miles in width and from 60 to 140 feet in thickness. Individual channels were probably no more than 30 feet deep. An overall paleocurrent direction for the alluvial channel sandstones is between N25°W and N35°W. Because of distinct grain size differences, the alluvial sandstones are divided into piedmont-plain deposits (conglomeratic sandstones) and alluvial-plain deposits (coarse- to fine-grained sandstones). The piedmont-plain deposits are poorly- to moderately-sorted and are characterized by festoon medium-scale crossbedding, cut-out, initial dip, and vertical sequences of alternating grain size. Clasts in the conglomerates are predominantly cherts, quartzites, and breccias which appear to match descriptions given for rocks in the Ouachita uplift. Alluvial-plain sandstones

consist of well sorted, coarse- to fine-grained quartzarenites, and they are characterized by the following: medium-scale crossbedding, parting lineation, cut-out, high-angle initial dip, intraformational clasts, wood fragments, and an upward-fining sequence. A crevasse splay deposit which formed in the floodplain on the alluvial plain contains several upright Calamites stems with centroclinal cross strata developed adjacent to the stems.

Thin-bedded sandstones are very well sorted, very fine- to fine-grained quartzarenites. They contain medium- and small-scale crossbedding, parting lineation, initial dip, ripple marks, interstratification, burrows, and fossils. The thin-bedded sandstones with gradational lower and lateral contacts resulted from shallow marine and/or coastal deposition. The primary paleocurrent trend is N75°W; a secondary direction is S45°W.

The conglomeratic sandstones represent braided stream deposits on a piedmont plain that developed adjacent to the Ouachita uplift. As the regression continued, an alluvial plain built by numerous meander belts, progressed from the edge of the piedmont to beyond the western limits of the study area. Thin-bedded sandstones at the same stratigraphic position as channel sandstones apparently represent local areas where earlier deposited sediments were not eroded by the meandering channels. Deposition of the Gypsy Sandstone was terminated by a minor marine trangression which extended south and southeastward to the corresponding limits of the study area.

The boundary between fresh water and brackish water in the Gypsy Sandstone varies in depth from 150 feet in much of the northern part of the area to 1,400 feet in the southernmost part of the area of study.

CHAPTER II

INTRODUCTION

In the western part of northwestern and in east-central Oklahoma, the Upper Pennsylvanian Vamoosa Formation crops out. It consists of a complex of thin-bedded sandstones, massively bedded, lenticular sandstones, shales, and conglomerates. The Vamoosa has been divided into four units by use of three markers within the formation which represent minor trangressions. The lowermost unit of the Vamoosa is the subject of this study; it contains lenticular and thin-bedded sandstones, shales, and conglomerates. The base of this unit apparently marks the boundary between the Missourian and Virgilian Series (Oakes, 1950).

The eastern part of the area of study is the north-northeast-trending outcrop belt of Vamoosa Formation in the following counties, from south to north: Seminole, Okfuskee, Creek, Pawnee, and Osage. The study area, which is T10N-T25N, R5E-R10E, includes the Vamoosa in shallow subsurface west of the outcrop belt (Figure 1).

Objectives

The primary objective of this thesis is the determination of genesis and trend of sandstones in the study interval. A required corollary objective is establishing a correlation framework for the unit. A secondary objective is the description and interpretation of sandstone composition.

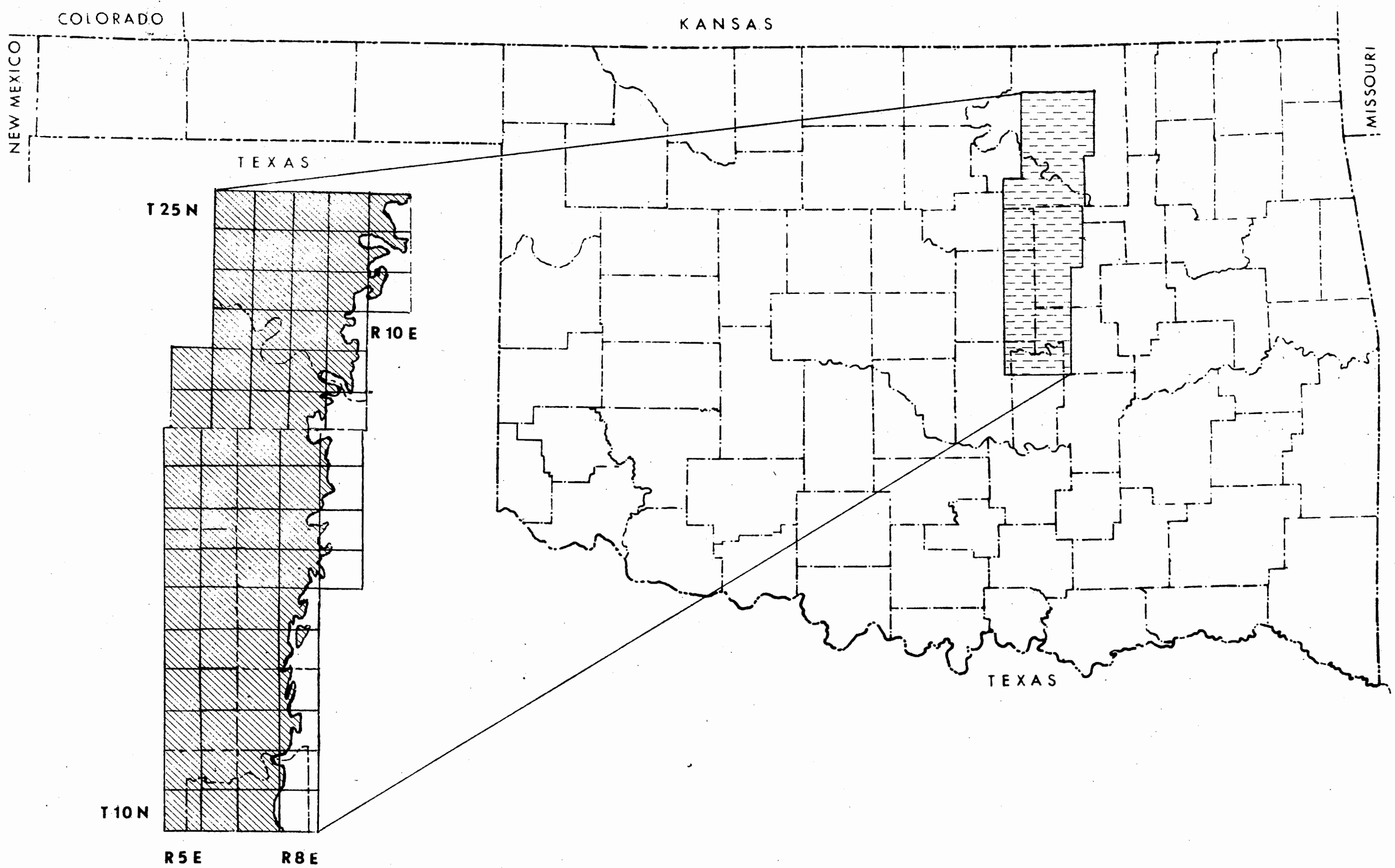

Figure 1. Location of area of study

Methods

Previous works by Tanner (1956a, 1956b), Ries (1954), Oakes (1959), Greig (1959), Carl (1957), and Gardner (1957) were used for correlation and definition of the Vamoosa Formation at the surface. Modifications were made where the lowermost unit of the Vamoosa, as mapped by earlier workers, does not correspond with the unit of this study, which is defined by an unconformity at the base and a transgressive marker at the top. Correlation was extended into the shallow subsurface by careful comparison of the surface sections to subsurface sections portrayed by electric logs.

Information concerning directional data, internal features, and sandstone geometry was obtained on outcrop from 19 measured sections. Source areas and transportation of sediments were interpreted from plots of paleocurrent indicators on azimuth diagrams. Thin-section analysis provided compositional data useful in interpreting provenance and diagenesis of sandstones. Net-sandstone thickness map (Plate 1) and a thickness map (Plate 2) of the unit were prepared from approximately 500 electric well logs of wells which penetrated this unit of the Vamoosa in the shallow subsurface.

Because this unit in the area of study contains important aquifers, an estimate was made of water quality. Electric-log characteristics, especially the recorded resistivities, were used to estimate areas of potable water.

CHAPTER III

STRATIGRAPHIC FRAMEWORK

The basal contact of the Vamoosa Formation in Oklahoma apparently marks the boundary between the Missourian Series and the Virgilian Series (Oakes, 1950). The base of the Virgilian Series from the Kansas-Oklahoma State line to the northern edge of the Arbuckle Mountains, was mapped by Oakes (1950), who regarded the lowermost conglomerate in the Vamoosa Formation in the latter area (Morgan, 1924) as the basal Virgilian unit. In Morgan's (1924) formal description of the Vamoosa, he included at its base about 30 feet of dark shale. Later, Ries (1954) restricted the base of the Vamoosa to the lowermost conglomerate. This study follows the correlations of Oakes (1950).

It should be noted that Heckel (1975) traced from Kansas into northeastern Oklahoma, the top of the South Bend Limestone Member of the Stanton Limestone as the redefined base of the Douglas Group, lowermost Virgilian group. He suggested that formations overlying the Birch Creek Limestone (in particular, the Tallant and Barnsdall) are Virgilian in age.

Just north of the Arbuckle Mountains, a gentle angular unconformity separates the Vamoosa Formation from the underlying Hilltop Formation (Tanner, 1956b); to the north the Vamoosa overlies the Tallant Formation with local disconformity. Overlying the Vamoosa is the Lecompton Limestone Member of the Pawhuska Formation. By using these formational boundaries and three thin shales, representing minor transgressions, four informal units can be distinguished in the Vamoosa. The upper two units have been described by Morganelli (1976) and Terrell (1974), respectively. This study deals with the lowermost units of the Vamoosa (Figure 2). Conglomeratic sandstone units have been mapped in the basal part of the Vamoosa by Tanner (1956b) in Seminole County, Ries (1954) in Okfuskee County, and Oakes (1959) in the southern part of Creek County. Equivalent sandstone units were mapped in Creek County by Oakes (1959), Pawnee County by Greig (1959), and Osage by Carl (1957), Gardner (1957), and Tanner (1956a).

Correlation of the lower part of the Vamoosa Formation in the subsurface west of the study area has been conjectural because the various studies related to this problem have not systematically correlated units on outcrop to the subsurface. Lukert (1949) in the area from Osage County to Garfield County defined the base of the Virgilian Series at the base of the Bigheart Sandstone, instead of the Vamoosa Formation. The lowermost unit of the Vamoosa, as defined in this study, corresponds to Lukert's (1949) Lovell sand and overlying Endicott sand (Figure 3). Sandstones equivalent to the lowermost unit of the Vamoosa may extend as far west as the Oklahoma Panhandle. However, unanimity does not exist concerning correlation of sandstone units into that area. Pate (1959) designates the Lovell sand in the Panhandle as the basal unit of the Virgilian Series, whereas Frezon and Dixon (1975) place the base of the series at the base of the Tonkawa sand in north-central and northwestern Oklahoma. The study interval is thought to be equivalent to the Douglas Group of Kansas, which contains the Tonganoxie Sandstone. Winchell (1957) indicates that the subsurface distribution of the

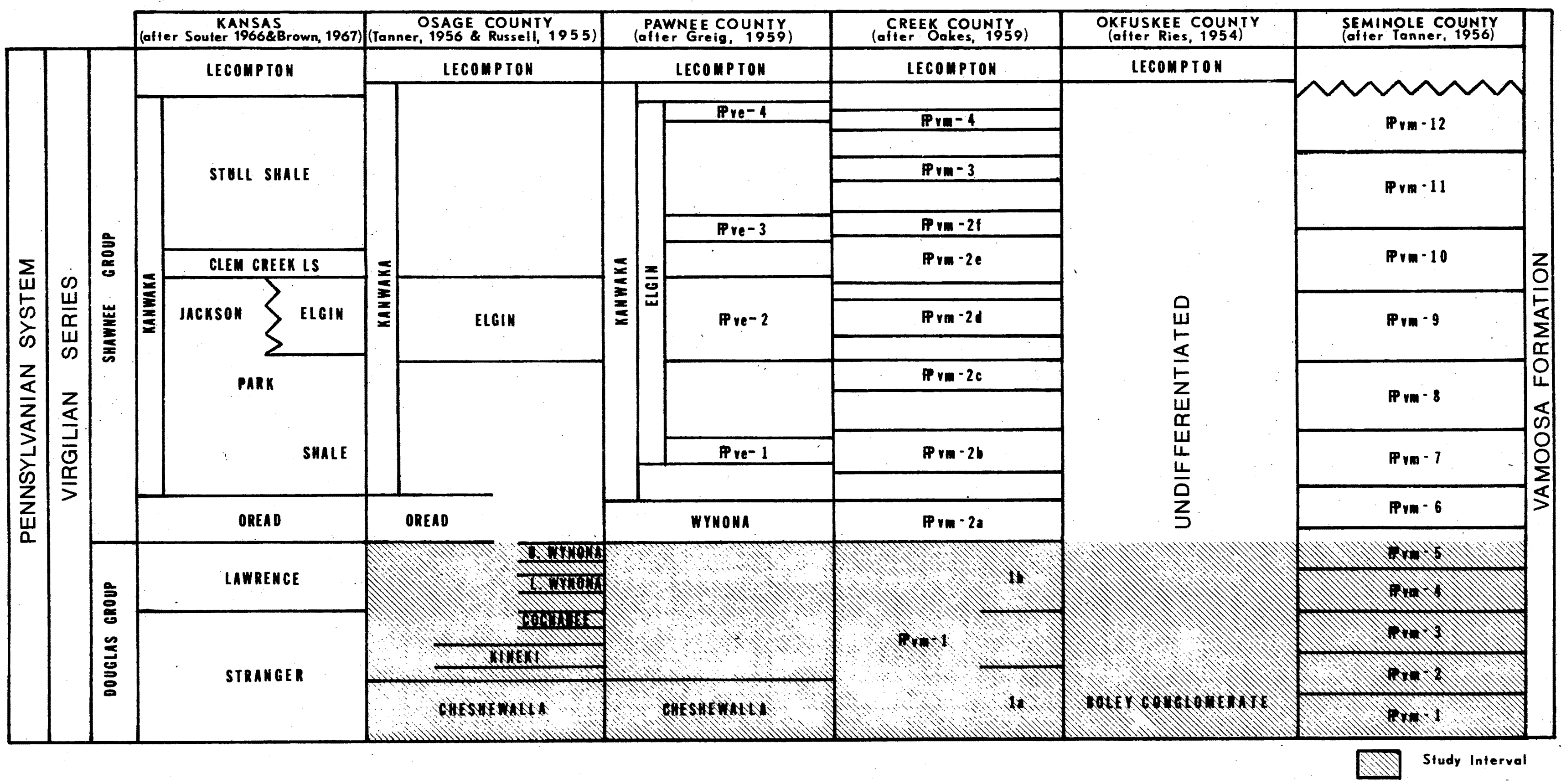

Figure 2. Stratigraphic correlation chart, showing position of Gypsy Sandstone, as the lowermost unit of the Vamoosa Formation

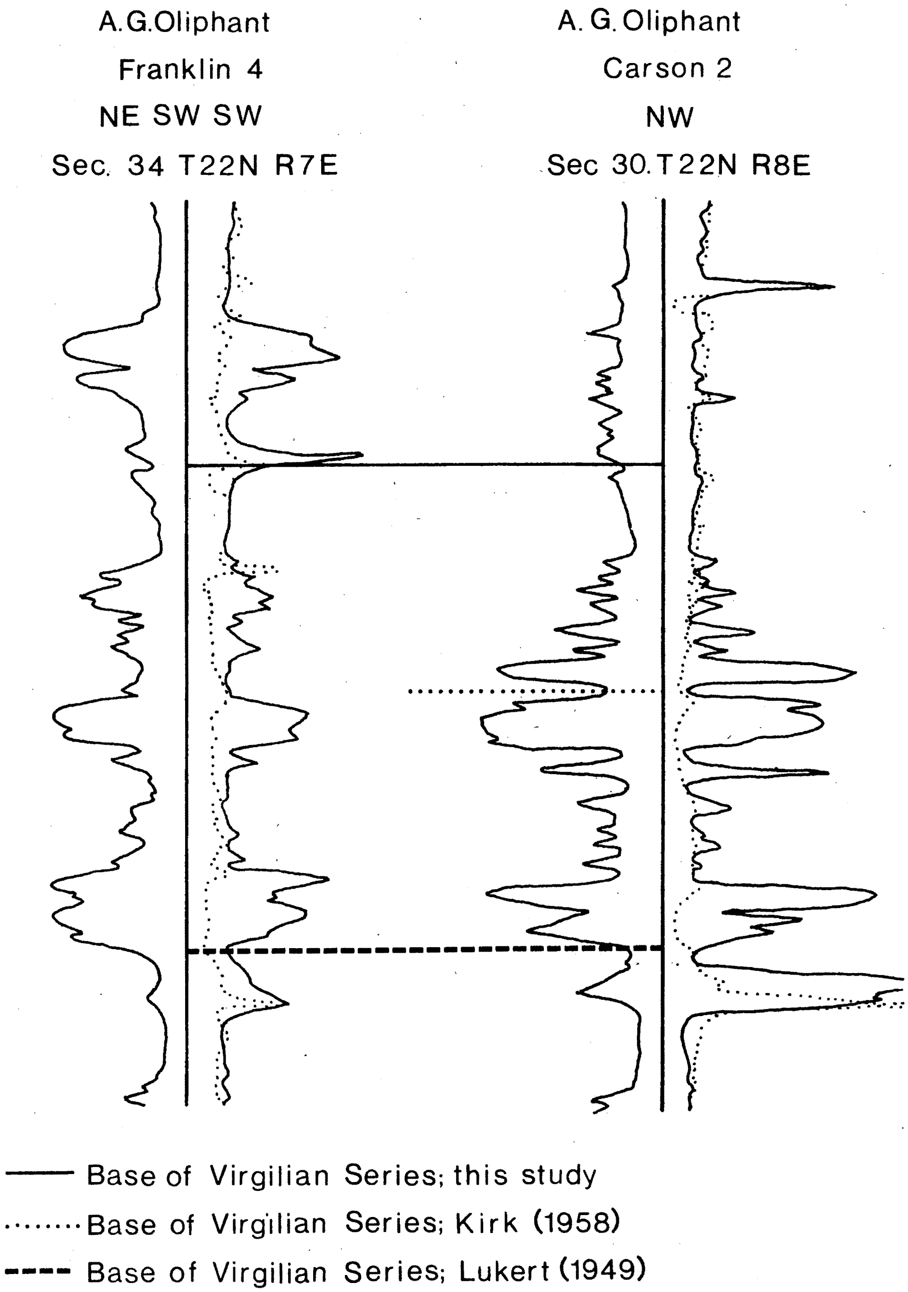

Figure 3. Differences in subsurface correlations of the base of the Virgilian Series

Tonganoxie is limited to south-central Kansas, but he may have included part of the underlying Missourian Series in his study of the Tonganoxie (Stewart, 1975).

For this study, the informal name "Gypsy Sandstone" is given to the lowermost unit of the Vamoosa Formation (Figure 4). The type of exposure is subject to the community of Gypsy located 4 miles west of Oklahoma Highway 48 at the intersection of sections 3,4,9,10 of T14N, R8E. The Gypsy Sandstone includes the Boley Conglomerate, Cheswalla Sandstone, Kiheki Sandstone, Cochahee Sandstone, and the upper and lower Wynona Sandstone (Figure 2). In Osage County, the Cheswalla Sandstone (basal Vamoosa) as mapped by Carl (1957) and Gardner (1957), does not correlate with that of this study (Figure 2). Greig (1959) noted that the Cheswalla Sandstone of his work corresponds to Carl's (1957) Kiheki Sandstone. Surface to subsurface correlations indicate the base of the Vamoosa is equivalent to the base of the Cochahee Sandstone of Carl (1957) and Gardner (1957).

The Gypsy Sandstone in the subsurface is from 40 to 150 feet thick. It contains conglomeratic sandstone, sandstone, and shale (Figure 4). On the outcrop, incomplete sections of the Gypsy are as much as 80 to 120 feet thick (Plate 3). The upper marker, regarded herein as representing a minor transgression, is characterized by a series of interbedded shale, siltstone, and sandstone as well as shales (Figure 5). At most locations, the upper marker is poorly exposed so only a few field observations were made. In the subsurface, the upper marker is not so well defined as the lower contact, but it is thought to be fairly reliable. The basal contact generally sharp as coarse-grained sandstone

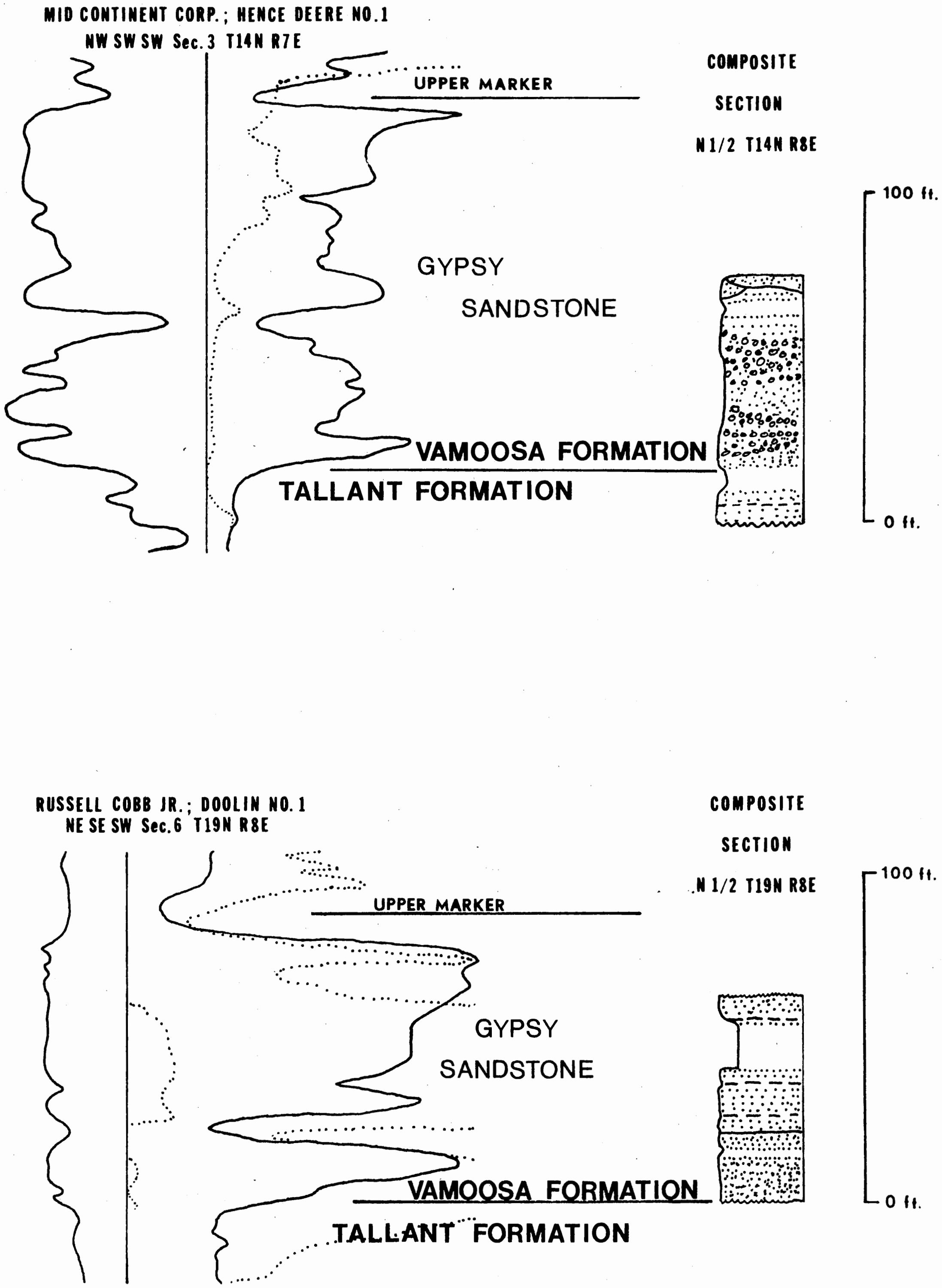

Figure 4. Stratigraphic interval of Gypsy Sandstone, outcrop to subsurface showing upper marker and lower contact

Figure 5. Upper marker on outcrop (Sec. 33, T20N, R8E) is a gray to maroon colored shale

with conglomerate overlies shales in the southern part, and coarse- to medium-grained sandstone overlies shale and/or fine-grained sandstone in the northern part (Figure 6).

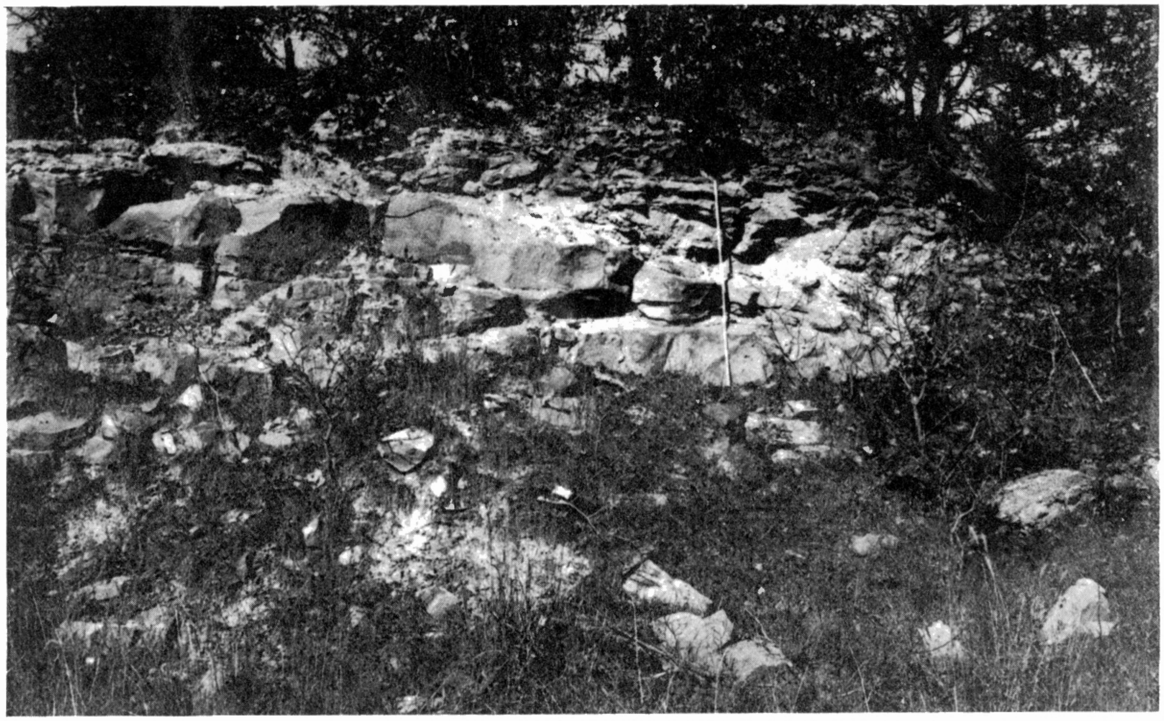

Figure 6. Lower contact on outcrop (Sec. 2, T14N, R8E) between Vamoosa and Tallant Formation

CHAPTER IV

GEOMETRY

Trend and Geographic Position

The Gypsy Sandstone and equivalent sandstone units extend beyond the area of study to the west and northwest (Pate, 1959 and Rascoe, 1962), north (Winchell, 1957), and south. Sandstone is best developed south of the Arkansas River. Trends in the non-conglomeratic sandstones are more commonly northwesterly, whereas those in the conglomeratic sandstones are quite variable (Plate 1). Thickness of the Gypsy Sandstone in the study area range from 40 to 160 feet; maximum thickness is present in Osage and Seminole Counties, where major sandstone development is present (Plates 1 and 2).

Width and Thickness

Based on outcrop data, genetic channel units are approximately 15 to 25 feet thick. Genetic widths, in general, are greater than the lengths of individual exposures, or 1/4 mile. Thin-bedded sandstones on outcrop are generally less than 10 feet thick. They also extend laterally beyond single exposures.

In the study area, south of the Arkansas River, multistoried and/or multilateral belts of channel sandstone range in width from 2 miles to approximately 20 miles. Sandstone in these belts commonly is from 60 to

140 feet thick. Isolated areas where sandstone is less than 20 feet thick are present throughout the study area (Plate 1).

Boundaries

Boundaries of channel sandstone units in the Gypsy Sandstone are generally sharp. The lower contact, an unconformity in most places, is well exposed on outcrop throughout the study area (Figure 7). Because of poor exposures, the upper boundary may be observed only at a few locations. It apparently is characterized by a gradation vertical change from sandstone to siltstone and shale. Vertical boundaries of genetic units are commonly obscured by the similar lithologies within the multilateral, multistoried units. Both lateral boundaries of a particular genetic unit are not observable, generally, because the width of the unit exceeds the length of the exposure. The thin-bedded sandstones are characterized by gradational lower and possibly lateral contacts (Figure 8).

Log characteristics suggest that major channel sandstone units in the subsurface have well defined boundaries: sharp base, abrupt upper boundary, and sharp lateral contacts (Plate 4). Locally, the base of the sandstone lies more than 20 feet below the top of the underlying Tallant Formation. In the subsurface of Seminole County, the upper marker of the interval is thought to be fairly reliable, although it is not so well defined there as it is in the northern part of the study area. Multilateral units are most prominent in T16N to T19N, whereas multistoried units are more commonly developed in the southern part of the study area. Gradational boundaries, both vertical and lateral, apparently characterize the thin-bedded sandstones in the subsurface (Plate 4).

Figure 7. Channel sandstone along the Cimarron Turnpike in Sec. 8, T20N, R9E, which cut 10 feet into the underlying Tallant Formation. Section exposed is approximately 30 feet thick. T = Tallant, V = Vamoosa, and arrows point out contact.

Figure 8. Thin-bedded sandstone in Sec. 7, T19N, R9E, exhibiting a gradational base. Section exposed is approximately 6 feet.

CHAPTER V

INTERNAL FEATURES

Sedimentary Structures

Notable types of sedimentary structures in channel sandstones of the Gypsy Sandstone include the following: medium- and small-scale crossbedding, parting lineation, high-angle initial dip, convolute bedding, cut-out, massive bedding, and horizontal bedding. The thin-bedded sandstones are characterized by medium- and small-scale cross-bedding, ripple marks, parting lineation, and low-angle initial dip. Burrows, casts of fossils, and concretions are present in a few of the thin-bedded sandstones. A common vertical sequence in channel sand-stones consists of massive or horizontal bedding, medium-scale cross-bedding, and small-scale crossbedding or horizontal bedding, in ascending order. Parting lineation is locally present near the top. Sedimentary structures in the conglomeratic sandstones consist of festoon medium-scale crossbedding, cut-out, convolute bedding, and initial dip. A good example of the vertical sequence developed in the channel sandstones is present on outcrop at the Cimarron Turnpike exposure of the Gypsy Sand-stone (Appendix A).

Two types of initial dip are present in the study area. High-angle initial dip occurs mainly in channel sandstone where it is thought to represent bank slope of channel deposits. Low-angle initial dip is present in the thin-bedded sandstones. The Cimarron Turnpike exposure exhibits two types of cut-outs: (1) between formations, at the contact between the Vamoosa and Tallant Formation, and (2) within the mapped unit.

A crevasse splay deposit contains several Calamites stems at the Cimarron Turnpike exposure of the Gypsy Sandstone (Figures 9 and 10). The stems are upright, 6 to 12 inches high and approximately 3 inches in diameter. The plants are in the upper part of the section, in a clay to silt layer and the overlying splay deposit. The bedding structures immediately adjacent to the stems are inclined toward the stems, whereas they are truncated by nearly horizontal strata 1 to 2 feet away from the stems (Figure 10). A modern analogy to this structure was formed in the floodplain in Palo Duro Canyon State Park in Texas after a flood in 1968. Underwood and Lambert (1974) described the structure as "centroclinal cross strata". This feature formed as scour holes developed by water flowing around the trees were filled by sediment as the water receded. Each scour hole apparently is elliptical in outline, with the center of the ellipse being downstream from the tree. In one exposure of a Calamites stem in the Gypsy Sandstone, the shape of the cross strata and orientation of the stem are paleocurrent indicators (Figure 10).

Paleocurrents

A total of 250 measurements was made of paleocurrent indicators, consisting of parting lineation, cut-out, medium-scale crossbedding, small-scale crossbedding, grain orientation, ripple marks, and grooves. Grain orientation measurements were made earlier by various workers,

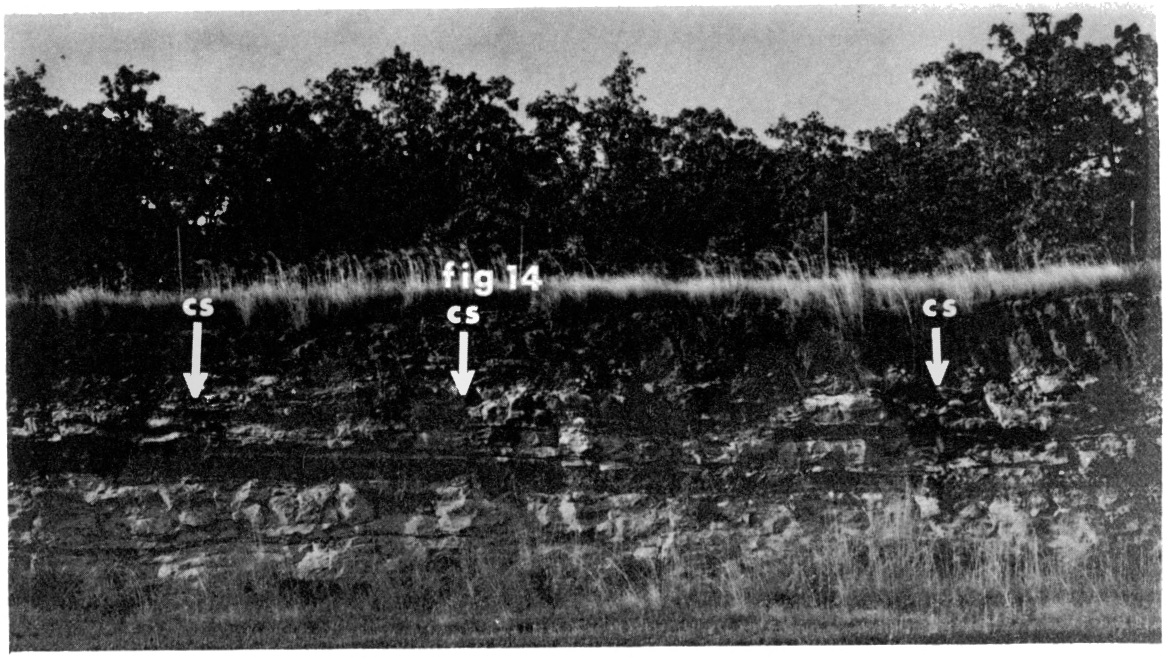

Figure 9. Crevasse splay deposit overlying major channel sandstone at the Cimarron Turnpike (Sec. 8, T20N, R9E) contains upright Calamites stems (cs). Section is approximately 12 feet high.

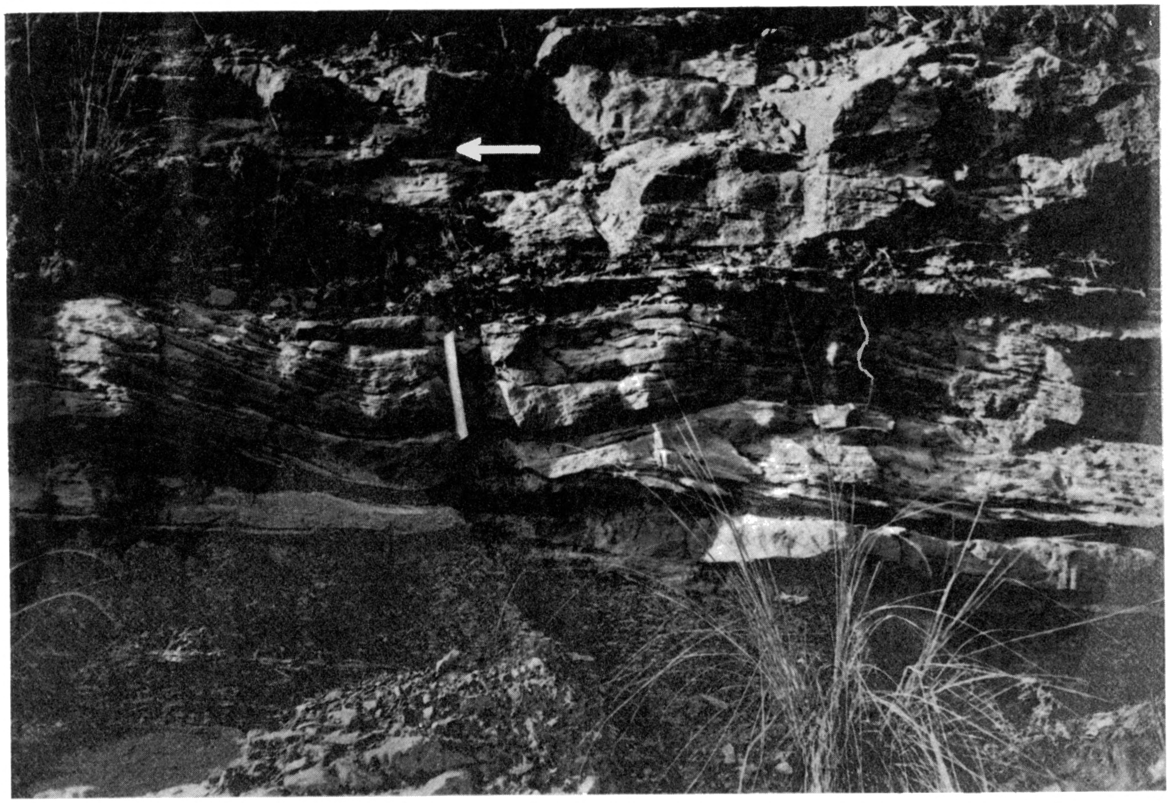

Figure 10. External mold of Calamites stem, inclined from vertical, and associated centroclinal cross strata. Arrow shows general current direction. Scale is 6 inches. For location see Figure 9.

using Shell's conductivity-anistropy instrument. The various measurements were divided into two groups according to sandstone type: channel sandstone or thin-bedded sandstone. The data, plotted on azimuth diagrams, were analyzed for each location (Plate 1). The paleocurrent indicators from all locations were grouped for a composite diagram for each type of sandstone (Figures 11 and 12). An additional composite diagram for channel sandstones was prepared by plotting weighted average paleocurrents at each location (Figure 13).

The most reliable indicators for the channel sandstones are medium-scale crossbedding, parting lineation, cut-out, and grain orientation, while the most reliable for the thin-bedded sandstones are parting lineation and grain orientation. An overall current direction for the channel sandstones is from N25°W to N35°W (Figures 11 and 13). This is in accordance with the major sandstone trends in the study area (Plate 1). Thin-bedded sandstones exhibit a primary trend of N75°W and a secondary direction of S45°W (Figure 12).

In previous work (Terrell, 1974), paleocurrent data obtained from the Elgin Sandstone Member of the Vamoosa show geographical differences; that is, data north of the Cimarron River indicate a westerly direction and those south of the river indicate a north-northwest direction. Geographic variation was not observed in this study.

Texture

Based on grain size, channel sandstones are separated into sandstone units and conglomeratic units. The sandstone units commonly show an overall upward decrease in grain size. In this type of sequence, coarse- to medium-grained sandstones occur at the base with fine- to

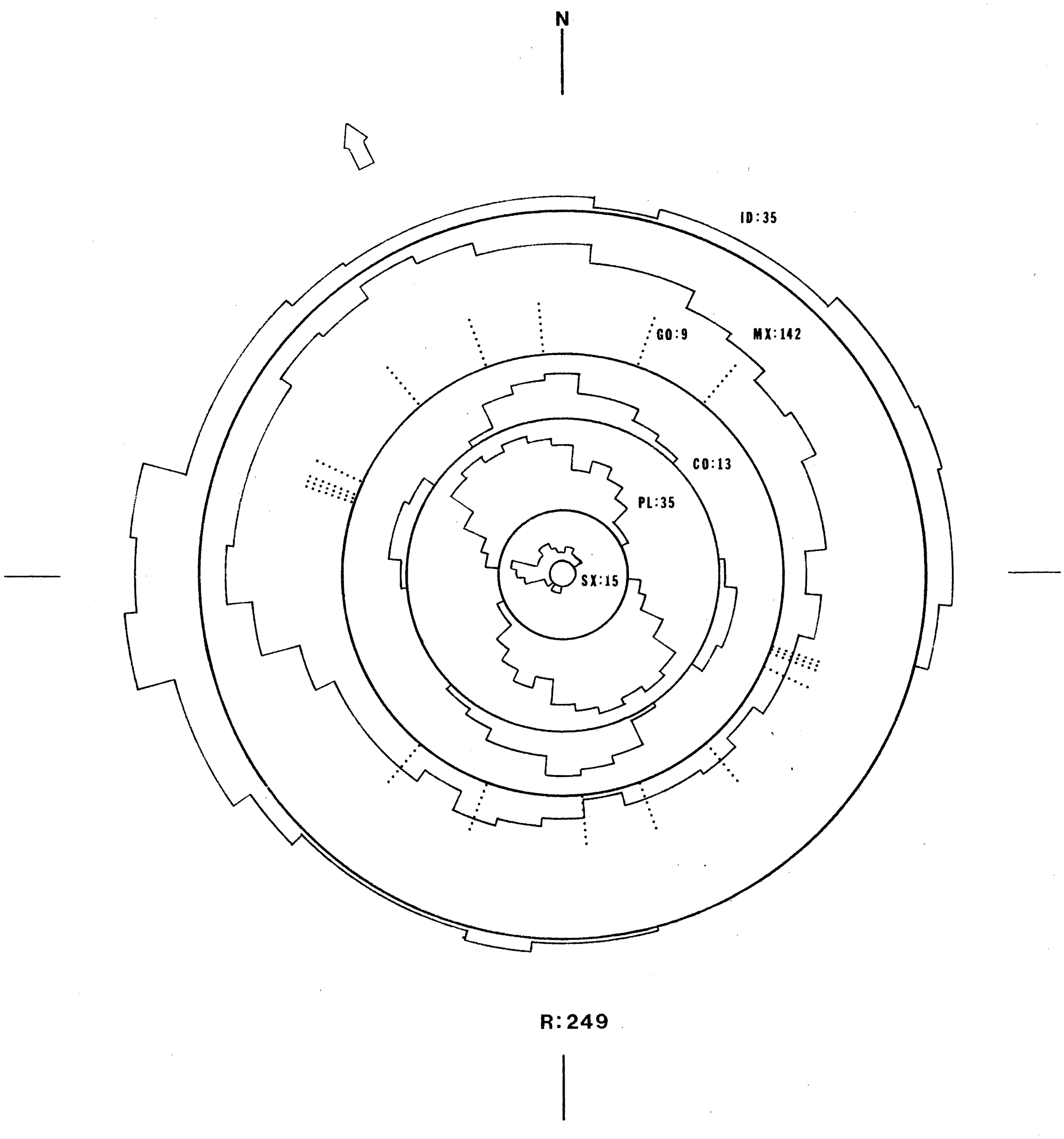

Figure 11. Paleocurrent diagram of channel sandstones, indicating an overall direction of N25°W. ID = initial dip, MX = medium-scale crossbedding, CO = cut-out trend, PL = parting lineation trend, SX = small-scale crossbedding, GO = grain orientation trend (dotted lines), and R = total number of readings. A 30°-sliding average was used in preparation of diagram.

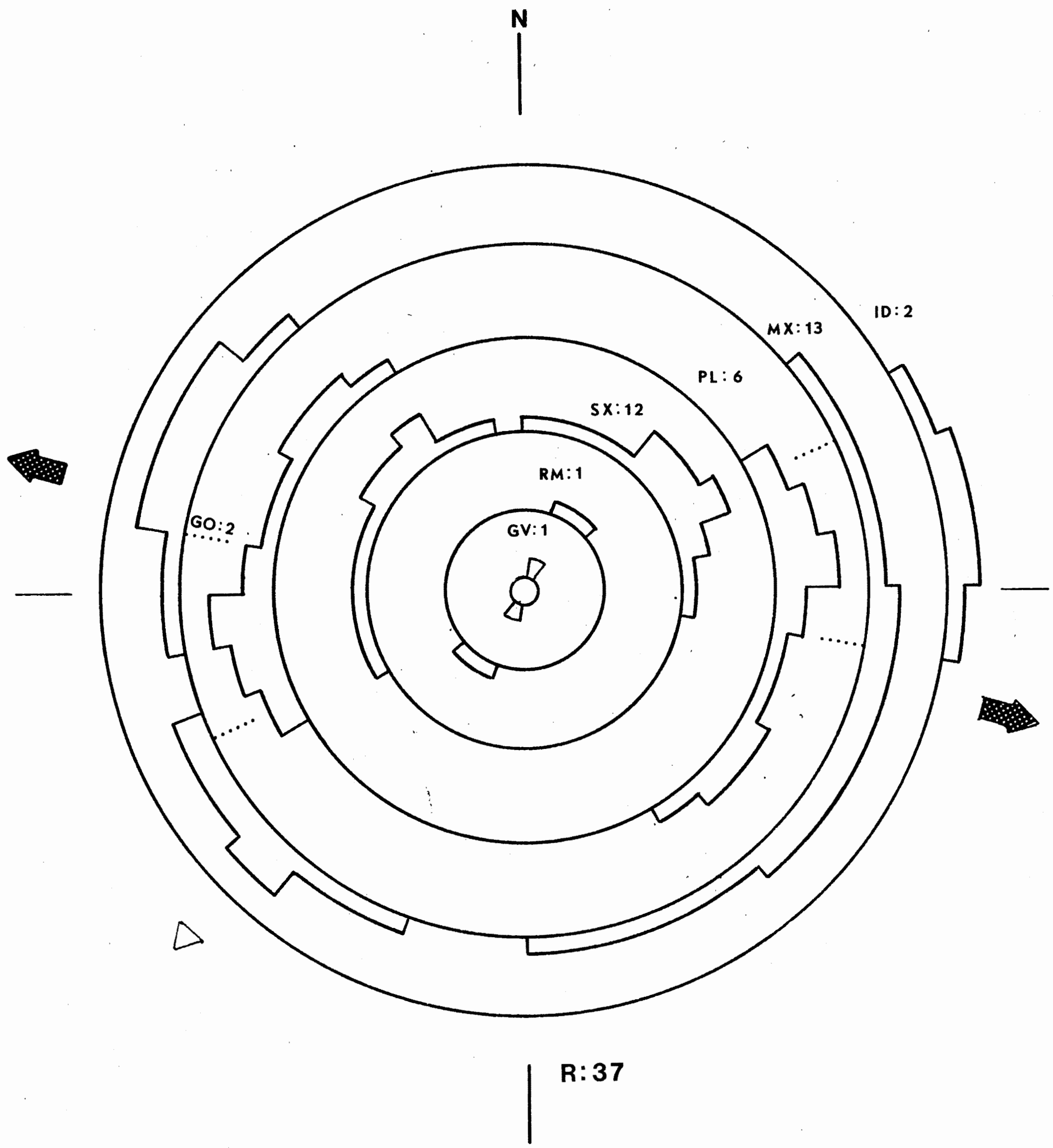

Figure 12. Paleocurrent diagram of thin-bedded sandstones indicating a primary trend of N75°W, and a secondary direction of S45°W. ID = initial dip, MX = medium-scale crossbedding, PL = parting lineation trend, SX = small-scale crossbedding, RM = ripple marks, GV = grooves, GO = grain orientation trend (dotted lines), and R = total number of readings.

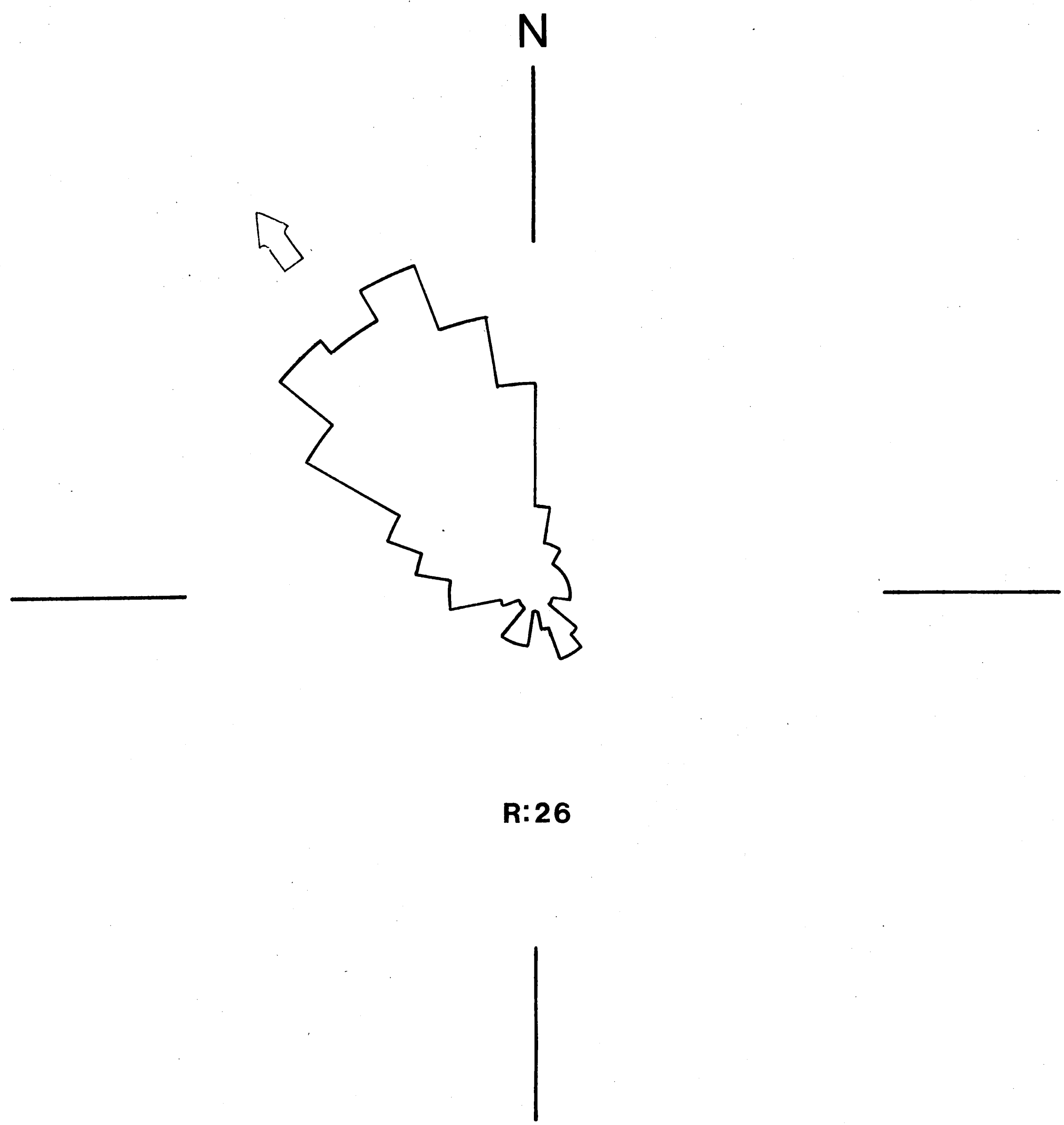

Figure 13. Composite paleocurrent diagram of channel sandstones from local average directions. Overall current direction is N35°W. R = total number of readings. A 30°-sliding average was used in preparation of diagram.

very fine-grained sandstones near the top. Conglomeratic units also show an overall upward decrease in grain size, but the important aspect of this is alternating layers of cobble- to pebble-sized clasts with coarse-grained sandstones which are overlain by coarse- to fine-grained sandstones (Appendix A).

The transition from a conglomerate to a sandstone in T14N is abrupt (Plate 5). To the south in T13N, R8E, coarse-grained sandstones define a "finger-like" distribution of conglomerates. The largest clast size, 150 mm in diameter, is present in Sec. 28, T12N, R8E (Plate 5).

Sandstone units in the channel sandstones are well- to very well-sorted compared to the poorly- to moderately-sorted conglomeratic units. Sand grains in the sandstone units are subangular whereas cobbles and pebbles in the conglomerates are rounded to subrounded. Most grain contacts in the sandstones are long and convex-concave contacts; suture contacts are also present.

The thin-bedded sandstones are fine- to very fine-grained. They are well sorted, and the grains are mainly subangular. The thin-bedded sandstones also are characterized by long and convex-concave grain contacts.

Constituents

Petrographic study of 18 thin-sections indicates that the Gypsy Sandstone is quartz-rich. The channel sandstones are quartzarenites, with small percentages of feldspar (Figure 14). One sample (Sec. 11, T15N, R8E) is a quartz-rich subarkose with 6% feldspar. North of T14N, R8E, the maximum chert content is 2%. Some sandstone units in the south

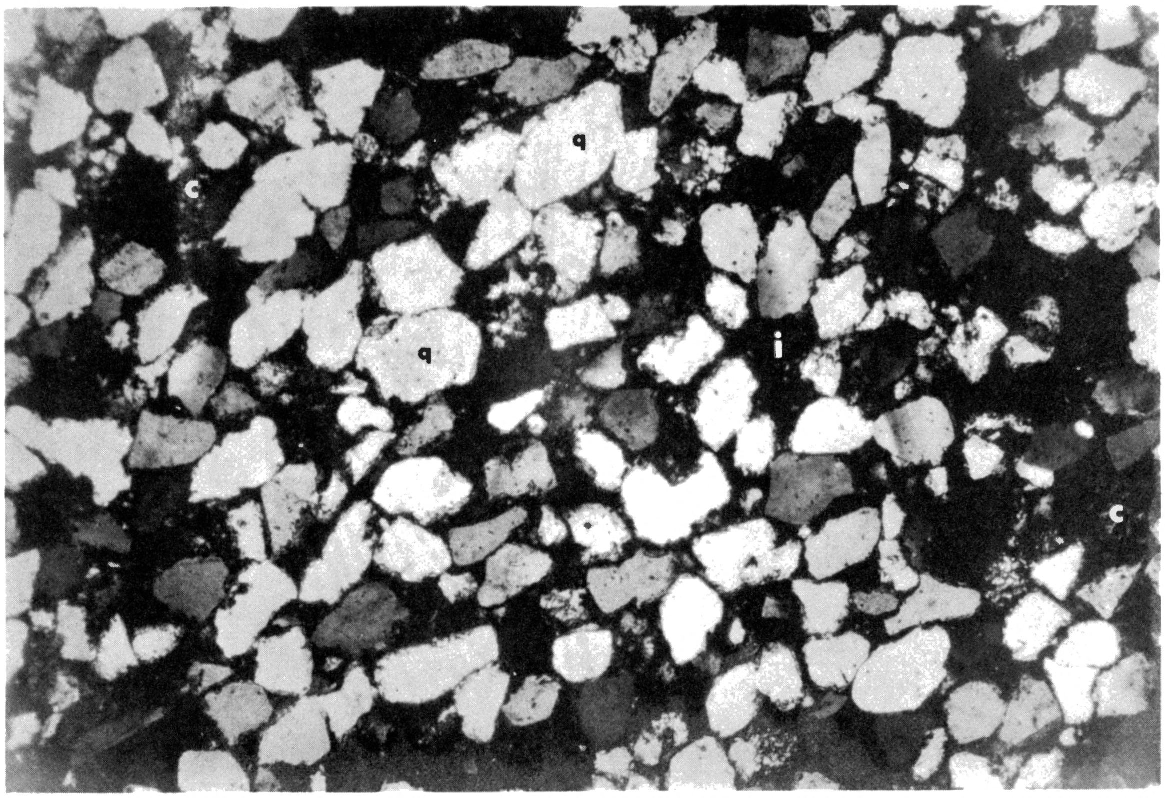

Figure 14. Quartzarenite in channel sandstone in Creek County (Sec. 7, T19N, R9E) contains subangular, well sorted, fine-grained, quartz (q) and chert (c) grains with illite and/or iron-rich clay lining pore spaces (i). Crossed nicols, field of view 1.66 x 2.5 mm.

contain 20% chert. Traces of zircon, tourmaline, and muscovite are present in the channel sandstones.

Pore spaces in some of the channel sandstones are lined by illite and/or an iron-rich clay (Figure 15). In some samples, the pores are filled by one or a combination of the following: illite, quartz overgrowths, hematite, iron-rich clay, and possibly kaolinite. Chalcedony was present in one sample as pore filling. Many grains are coated by the iron-rich clay and/or hematite. The basal parts of the channel sandstones contain locally derived clay clasts, pelecypod and brachiopod fragments (Sec. 17, T24N, R9E), and plant fragments.

All thin-bedded sandstones examined are quartzarenites, with a maximum chert content of 2% (Figure 16). This type of sandstone contains the same accessory minerals as those of the channel sandstones. Pore spaces are lined and/or filled with the following: illite, hematite, iron-rich clay, quartz overgrowths, and possibly kaolinite (Figure 16). Burrows, pelecypods, and brachiopods are preserved in a few thin-bedded sandstones. A zone of sideritic concretions in shale is present within the Gypsy Member on outcrop near Mill Creek in Osage County (Appendix A).

Cobbles and pebbles in the southern exposure of the Gypsy Sandstone may be grouped into three main types: cherts, quartzites, and breccias. The cherts vary in color from buff to dark green. Relict textures such as sponge spicules and fossil fragments appear in a few of the cherts (Figure 17). Optical properties divide the cherts into "isotropic" silica and cryptocrystalline cherts (Goldstein and Hendricks, 1953). The quartzites contain abundant quartz overgrowths and well rounded grains (Figure 18). Several specimens are composed of quartzite, cryptocrystalline chert, and "isotropic" silica (Figure 19). The

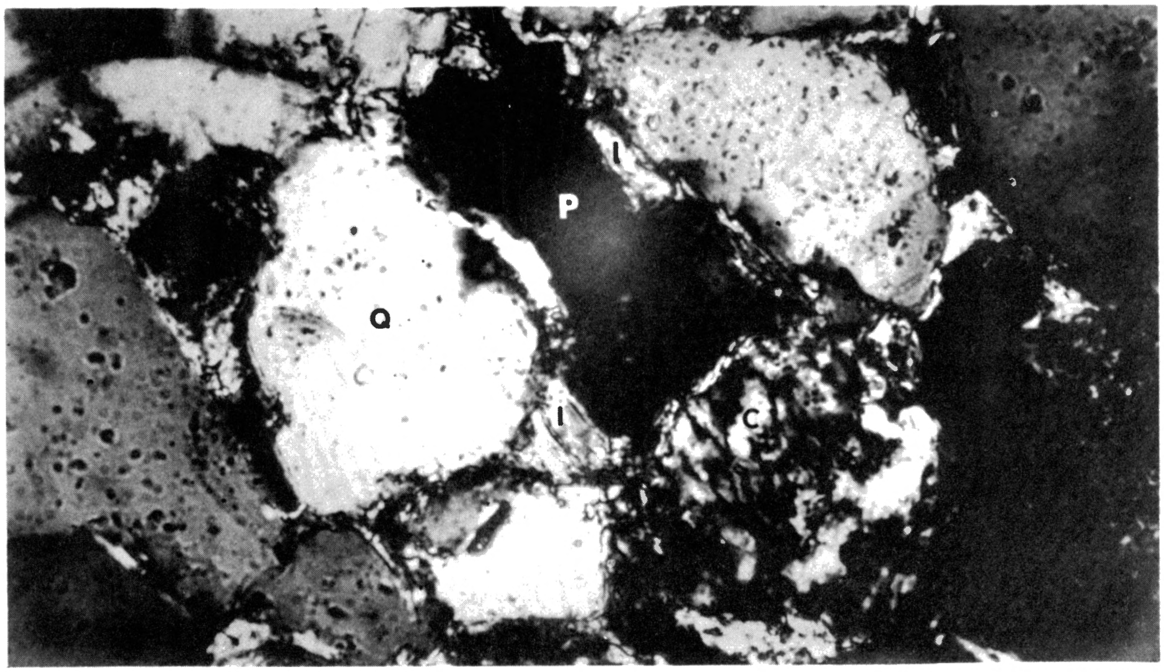

Figure 15. Quartzarenite in Creek County (Sec. 2, T14N, R8E) contains subangular, well sorted, medium-grained quartz (Q), chert (C), and illite (I) lining pores (P). Crossed nicols, field of view 0.45 x 0.66 mm.

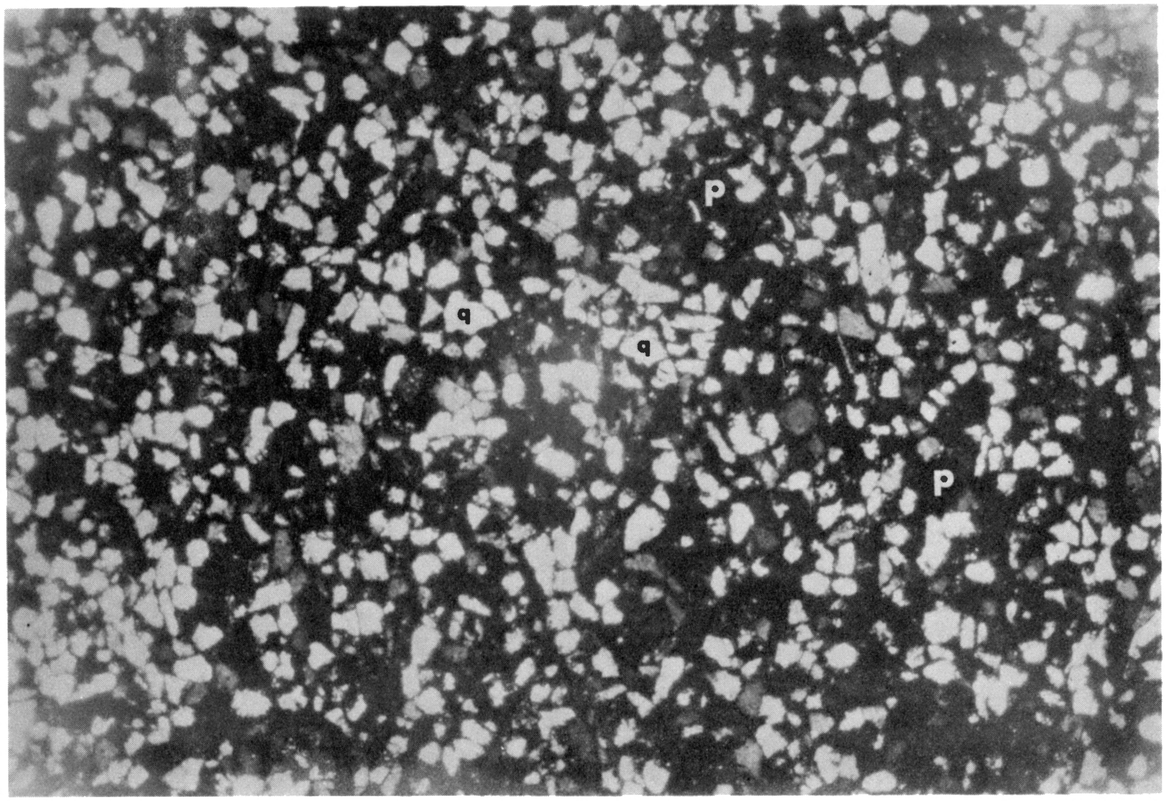

Figure 17. Quartzarenite in thin-bedded sandstone in Creek County (Sec. 7, T19N, R9E) contains subangular, well sorted, quartz (q) grains and iron-rich clay filling pores (p). Crossed nicols, field of view 1.66 x 2.5 mm.

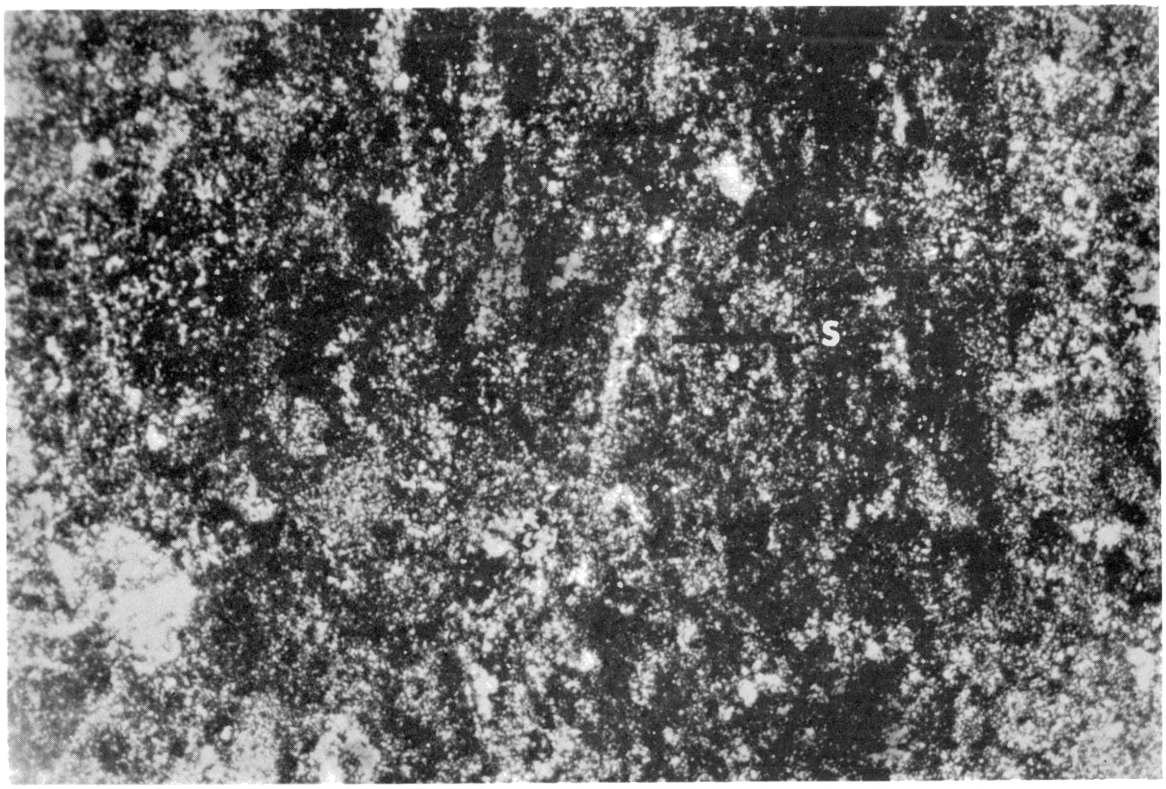

Figure 17. Chert cobble in conglomeratic sandstone in Seminole County (Sec. 12, T10N, R7E) contains possible relict structures of sponge spicules (s). Crossed nicols, field of view 1.66 x 2.5 mm.

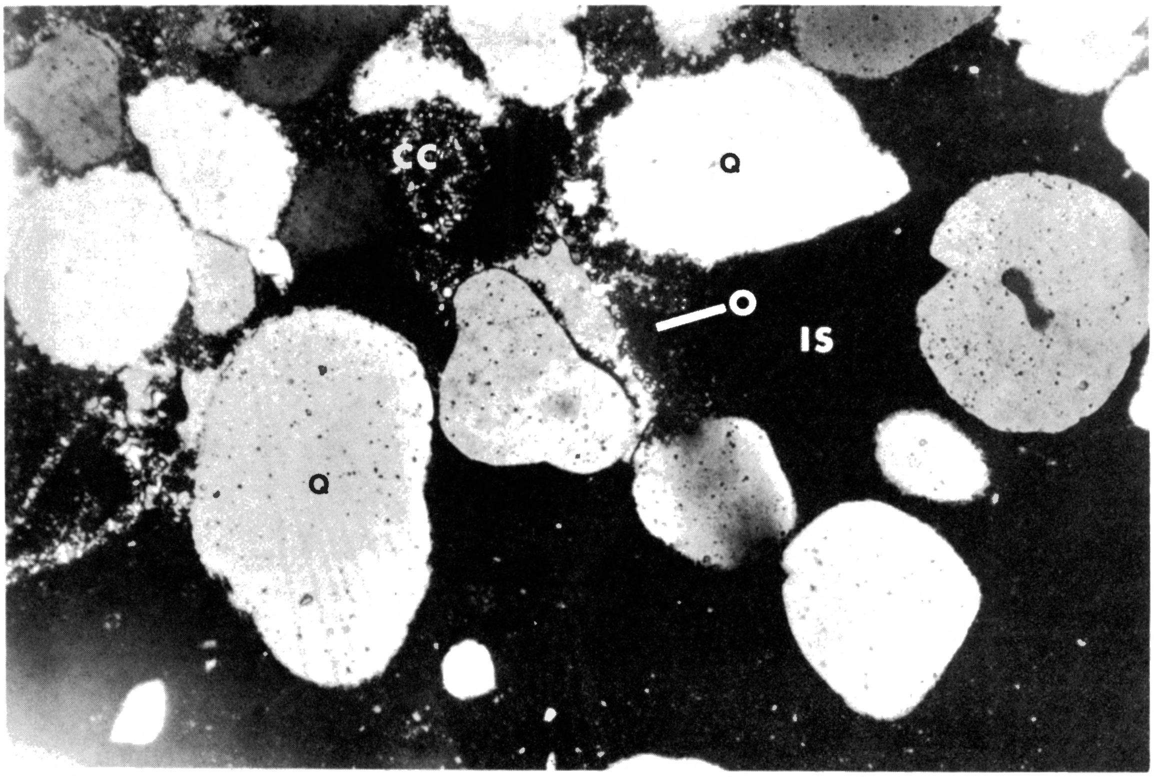

Figure 18. Quartzite-chert cobble in conglomeratic sandstone in Okfuskee County (Sec. 3, T12N, R8E) contains well rounded, well sorted, medium- to coarse-grained quartz (Q), "isotropic" silica (IS), and cryptocrystalline chert (CC). Overgrowth (O) is present at center. Crossed nicols, field of view 1.66 x 2.5 mm.

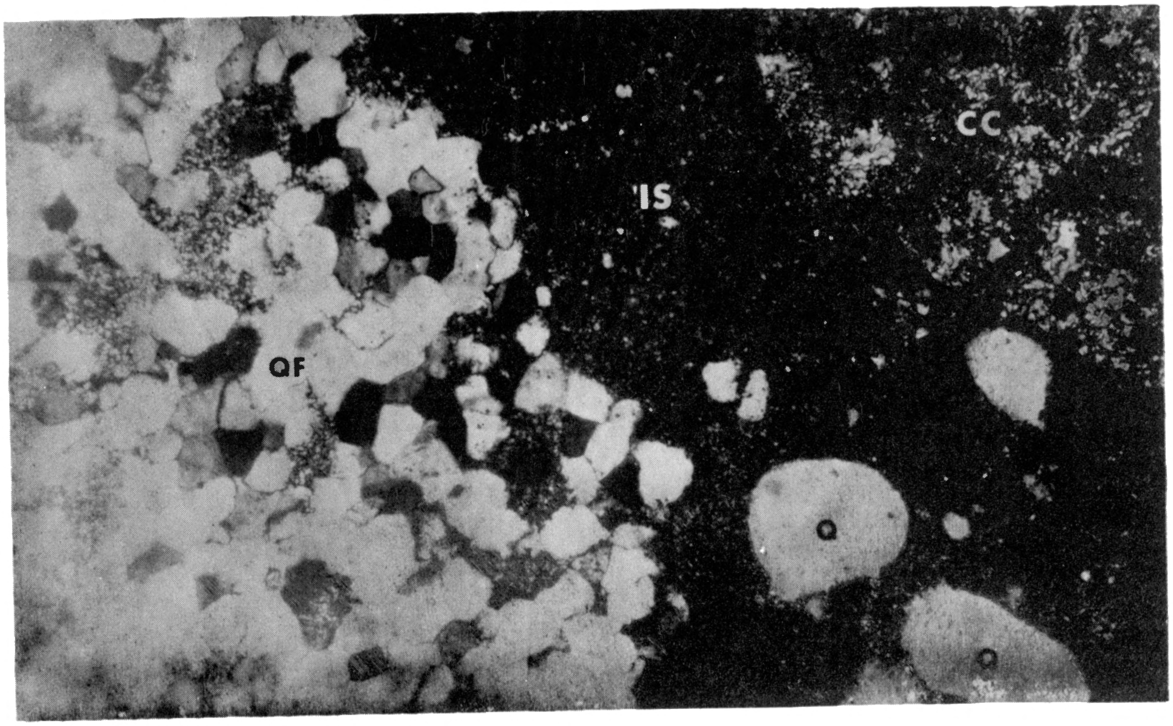

Figure 19. Quartzite-chert cobble in conglomeratic sandstone in Okfuskee County (Sec. 3, T12N, R8E) contains well rounded, fine-grained quartz (Q), very fine-grained quartzite fragment (QF), "isotropic" silica (IS), and cryptocrystalline chert (CC). Crossed nicols, field of view 1.66 x 2.5 mm.

breccia consists of cryptocrystalline chert, "isotropic" silica, and quartzite clasts cemented in a chert and "isotropic" silica matrix.

Water Quality

The boundary between fresh water and brackish water in the Gypsy Sandstone (Plate 1) was determined from visual inspection of electric logs. Water resistivities greater than 50 ohm m^2/m with zero to positive spontaneous potential deflection from the shale base line were used to delineate fresh water. The depth to the boundary varies in depth from 150 feet in the northern part of the study area to 1,400 feet in the extreme southern part. This variation is in accordance with the major sandstone development in the south.

CHAPTER VI

DEPOSITIONAL ENVIRONMENT AND SOURCE AREA

Major sandstone development in the Gypsy Sandstone interval represents multistoried and/or multilateral alluvial deposits. These sandstones formed in channels on an alluvial piedmont plain and an alluvial plain. Based on thickness of genetic units, depths of Gypsy piedmont plain and alluvial plain channels were 20 to 30 feet, respectively. Gypsy stream width, which cannot be determined directly, may have been approximately 10 times the depth. Alluvial sandstones and conglomerates in the Gypsy Sandstone have sharp erosional bases and sharp lateral contacts. The main difference between the alluvial-plain channel deposits and piedmont-plain deposits is grain size. The piedmont deposits are coarse-grained to conglomeratic; the alluvial-plain sandstones are coarse- to fine-grained. Alluvial-plain deposits are developed more widely than the piedmont-plain deposits, which show better multistoried development than the former. The piedmont-plain deposits are poorly to moderately sorted and are characterized by festoon medium-scale crossbedding, cut-out, and initial dip. The alluvial-plain deposits are better sorted, and they contain medium-scale crossbedding, parting lineation, cut-out, and initial dip.

The thin-bedded sandstones are thought to have been deposited by shallow marine and/or coastal processes. They are characterized by: (1) gradational lower contacts, and perhaps gradational lateral contacts,

(2) ripple marks, small-scale crossbedding, low-angle initial dip, interstratification, and wide ranges in paleoccurent directions, (3) very fine grain size and good sorting, and (4) fossils, burrows, and bioturbated bedding.

Earlier workers (Terrell, 1974; Morganelli, 1976) recognized transgressive-regressive couplets developed in the upper part of the Vamoosa Formation. The Gypsy Sandstone in the study area does not represent a transgressive-regressive couplet because the base corresponds to an unconformity. Correspondingly, the Gypsy Sandstone is a tectonosedimentologic unit.

Conglomerates of the Gypsy Sandstone, which represent piedmont-plain deposits, formed after parts of southern Oklahoma and northeast Texas were uplifted during Middle and Late Pennsylvanian tectonic events. Coarse clastics eroded in the source areas were deposited by braided streams which built a piedmont plain. As regressive conditions continued, alluvial-plain streams to the northwest eroded earlier deposited shallow marine and/or coastal sediments. Meander belts are thought to have been prominent on the alluvial plain because of the lateral extent of alluvial-plain sandstones. During maximum regression, the alluvial plain extended north and northwestward from the piedmont plain over the entire study area (Figure 20). Busch (1971) describes a deltaic sequence in the Endicott Sandstone in Harper County, in western Oklahoma, which might be associated with the maximum regression of the Gypsy Sandstone.

A minor transgression terminated deposition of the Gypsy Sandstone. The shallow marine and/or coastal units associated with the upper marker

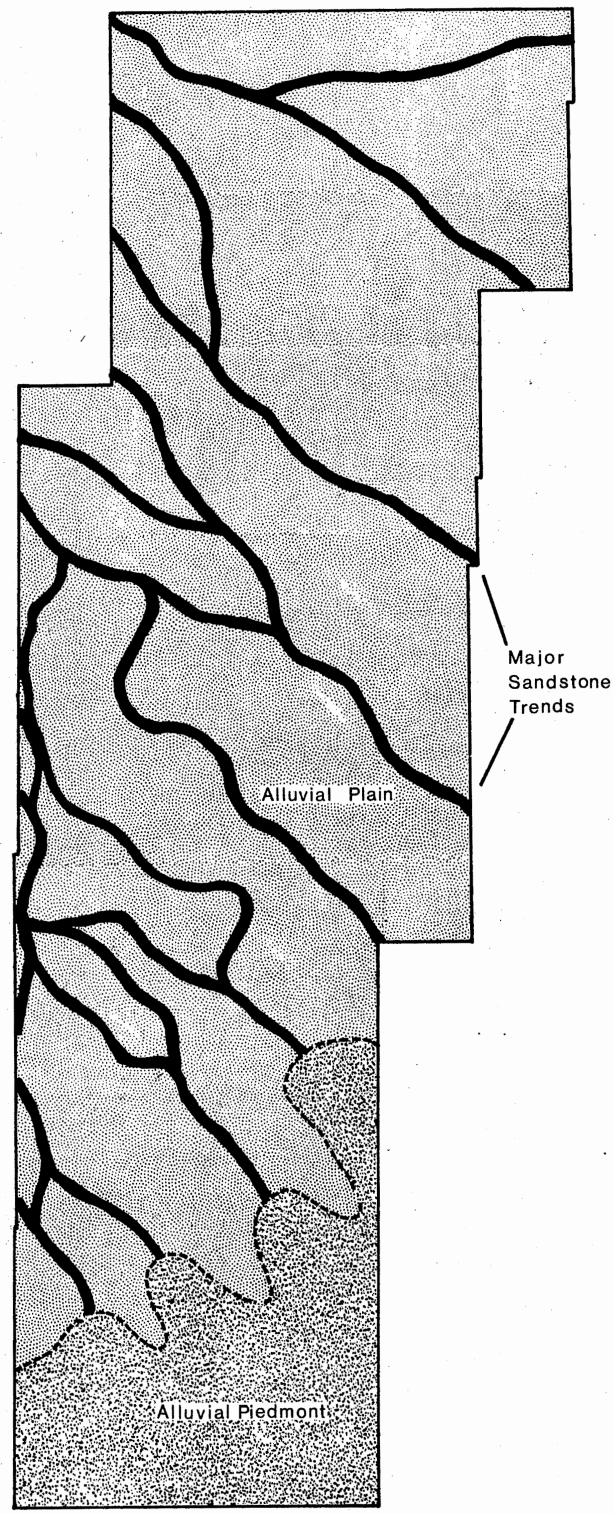

Figure 20. Paleogeographic map of study area during maximum regression associated with deposition of Gypsy Sandstone.

depict this transgression, which represents only a brief interruption in the overall Vamoosa regression.

The dominant source area for the Gypsy Sandstone was the Ouachita system (Oakes, 1948 and Chenoweth, 1959); the Arbuckle uplift apparently was a minor source area. The following are criteria used in evaluation of the source area: (1) paleocurrents and sandstone trends, (2) plot of maximum grain size, and (3) composition of clasts in the conglomeratic units. The northwesterly paleocurrent directions and sandstones trends point to a southeasterly source area. Maximum grain size (Plate 5) exhibits two distinct features: a gradation from conglomerate to sandstones in a northwesterly direction, and abrupt changes in grain size in northward direction, suggesting a non-Arbuckle source. Tanner (1956b) considered the chert pebbles in the Vamoosa to have been derived from Ordovician, Siluro-Devonian, and Pennsylvanian rocks in the Arbuckle Mountains. Although recognition of novaculite by scanning electron microscopy (Keller et al., 1977) was beyond the scope of this study, chert and breccia clasts are thought to be similar to the Bigfork Chert and Arkansas Novaculite of the Ouachita system (Goldstein and Hendricks, 1953). The quartzite pebbles that contain well rounded quartz grains with abundant overgrowths are thought to be similar to quartzites in the Blakely Sandstone (Honess, 1923).

CHAPTER VII

SUMMARY

The principal conclusions of this study are as follows:

1. The Gypsy Sandstone in the study area is predominantly an alluvial deposit. During deposition of the Gypsy Sandstones, an alluvial plain extended northwestward from a piedmont plain which developed in the southern part of the study area. Analysis of paleocurrent data, regional sandstone trends, distribution of maximum grain size, and composition of conglomerates suggest the Ouachita system as the primary source area and the Arbuckle uplift as a possible secondary source area. Deposition of the Gypsy Sandstone was terminated by a minor transgression.

2. Major sandstone development represents multistoried and/or multilateral units which formed belts ranging in width from 2 miles to approximately 20 miles. Sandstone in the belts is from 60 to 140 feet in thickness. Individual Gypsy Sandstone channels were 20 to 30 feet deep for piedmont-plain and alluvial-plain deposits respectively. Apparently, braided streams were prominent on the piedmont, whereas meandering streams were the dominant channel type on the alluvial plain. Sandstone belts are best developed south of the Arkansas River.

3. Alluvial-plain and piedmont-plain sandstones have sharp erosional lower contacts and sharp lateral boundaries. The piedmont-plain deposits are thicker than the former.

4. Piedmont-plain sandstones are characterized by festoon medium-scale crossbedding, cut-out, and initial dip. The alluvial plain sandstones exhibit medium-scale crossbedding, parting lineation, cut-out, and high-angle initial dip. A crevasse splay deposit associated with a meandering stream contains upright Calamites stems with centroclinal cross strata developed adjacent to the stems. The overall paleocurrent direction for both types of channel sandstones is northwest.

5. The piedmont-plain sandstones are coarser-grained than the alluvial-plain sandstones. Fining-upward sequences characterize the alluvial-plain sediments; abrupt vertical changes in grain size are typical of the piedmont deposits. Alluvial-plain sandstones are better sorted than the piedmont-plain sandstones. Sandstones are predominantly quartzarenites, with up to 2% chert.

6. Thin-bedded sandstones represent shallow marine and/or coastal deposits. These sandstones have gradational lower contacts, and possibly lateral contacts. The thin-bedded sandstones are best developed in the northern part of the study area.

7. The thin-bedded sandstones contain small-scale and medium-scale crossbedding, parting lineation, ripple marks, fossils, and burrows. Local paleocurrent directions range widely, but they indicate an overall average of N75°W and a secondary direction of S45°W.

8. Thin-bedded sandstones are fine- to very fine-grained, subangular, well sorted quartzarenites.

9. The boundary between fresh and brackish water in the Gypsy Sandstone varies in depth from 150 to 1,400 feet.

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APPENDIXES

APPENDIX A

KEY MEASURED SECTIONS

NESWSE Sec. 17 T. 24N R. 10E Map ______ Photo ______

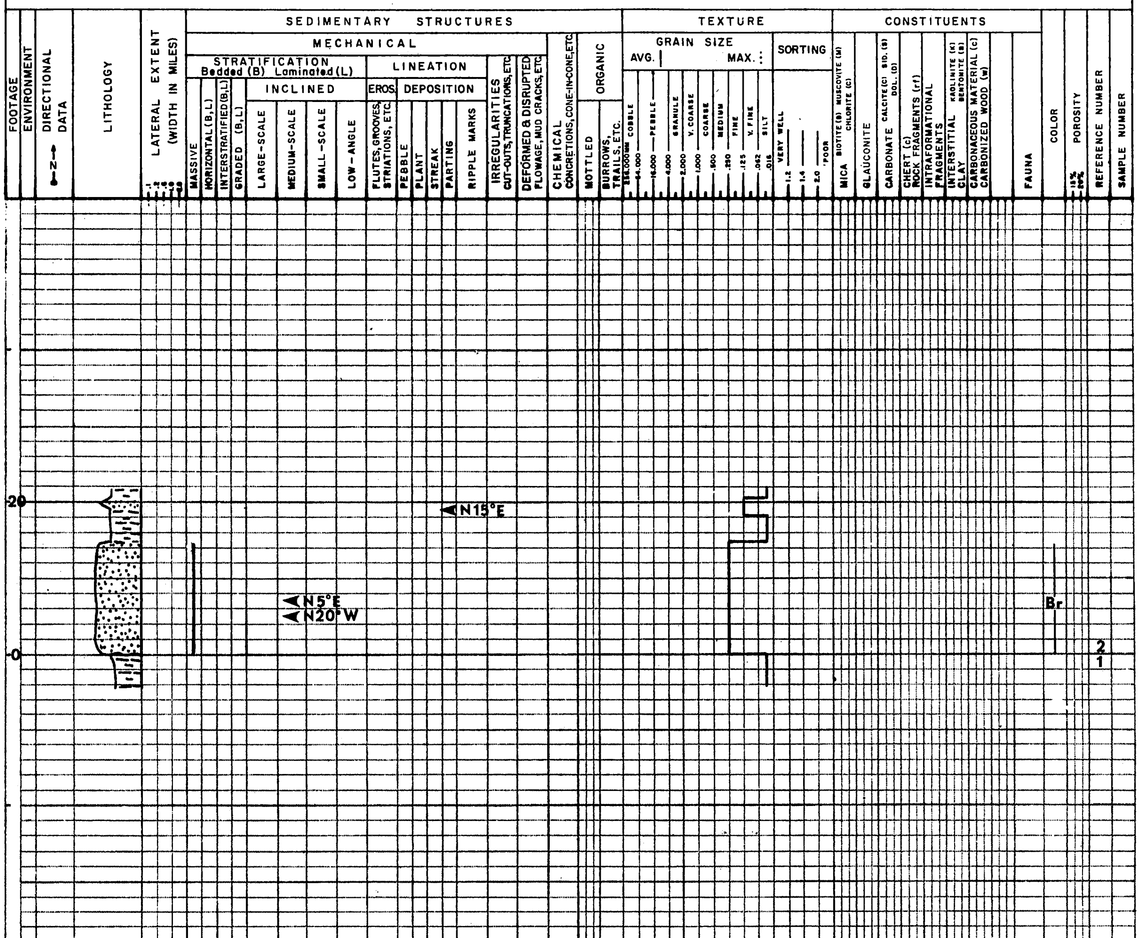
OSAGE Co., OKLAHOMA Section No. 1

Area along paved road from Wynona to Barnsdall By G.W. Ford

Outcrop Pattern - - Linear ______ belt ______ Formation Vamoosa

1. Tallant Formation
2. Vamoosa Formation
3. Brachipod and Pelecypod casts

SESENE
SWSWNW Sec. 7/8 T. 23N R. 10E Map ____ Photo ____
OSAGE Co., OKLAHOMA Section No. 2
Area along N-S section line road By G.W. Ford
Outcrop Pattern - - Linear ____ belt ____ Formation Vamoosa



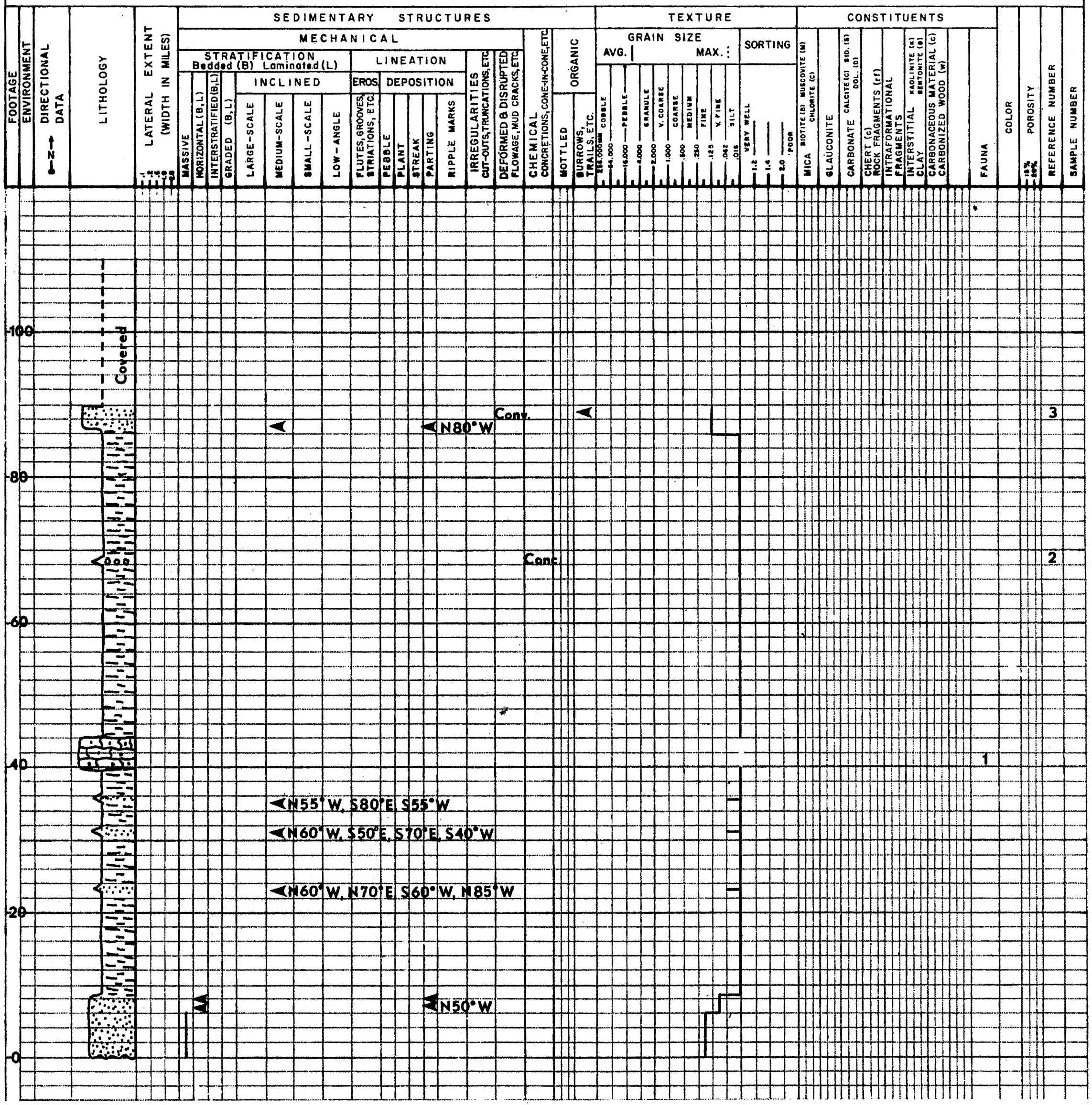
1. Tallant Formation
2. Vamoosa Formation

SW Sec. 20 T. 21N R. 9E Map ______ Photo ______

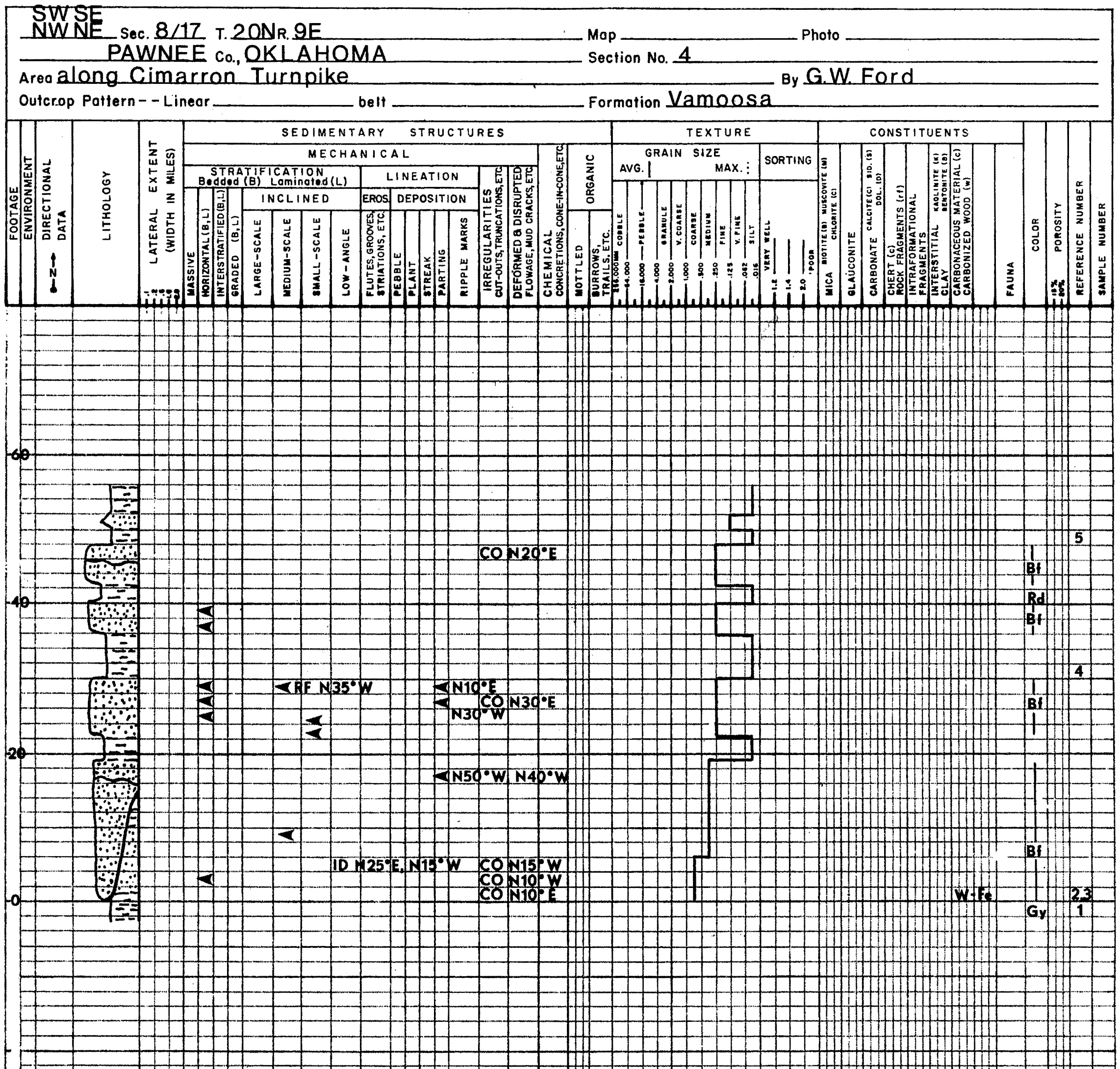
OSAGE Co., OKLAHOMA Section No. 3

Area from Mill Creek east along road to crest of hill By J.W. Shelton & G.W. Ford

Outcrop Pattern--Linear ______ belt ______ Formation Vamoosa



1. Pelecypod molds
2. Sideritic nodules
3. Conv.--convolute bedding



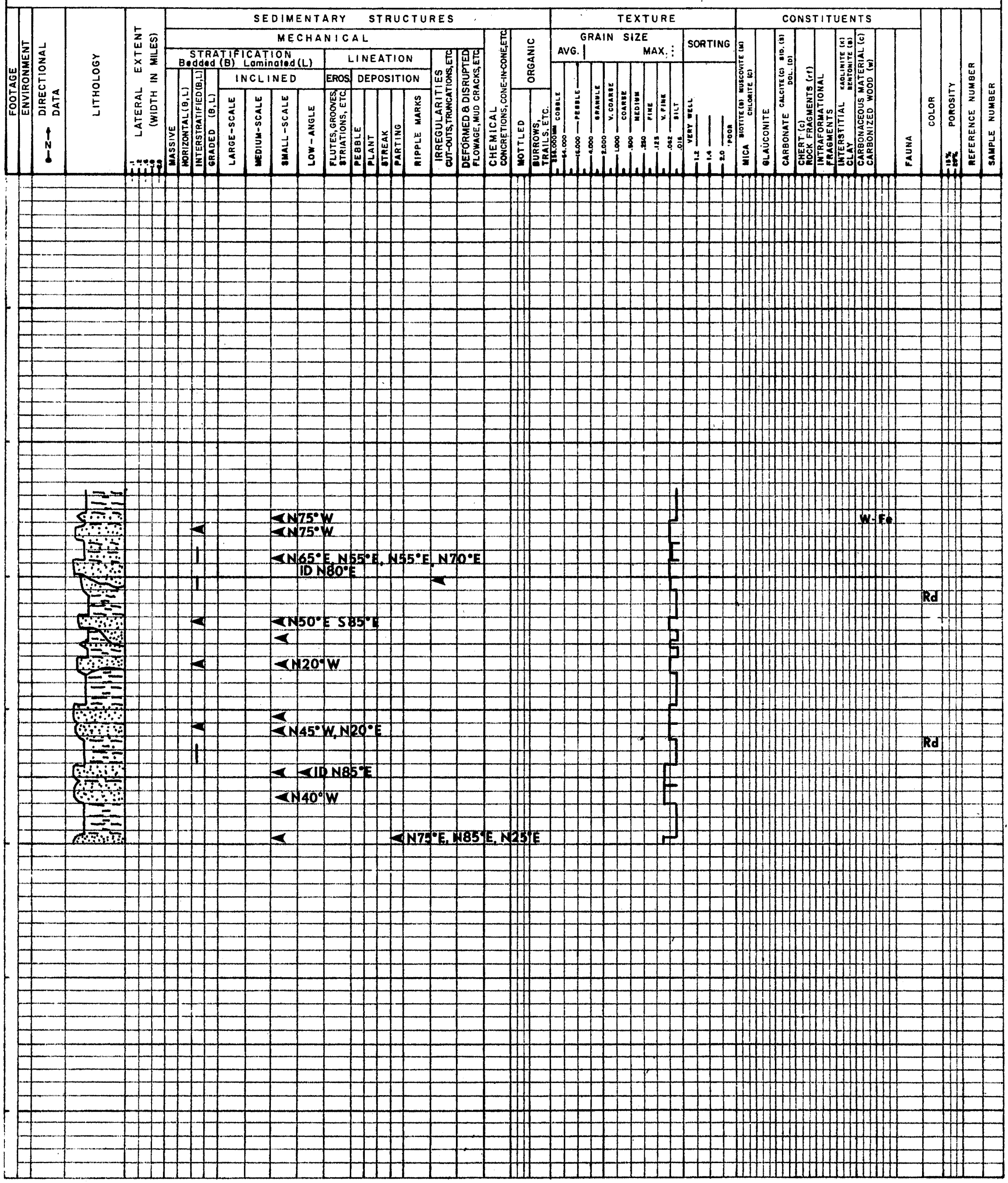
1. Tallant Formation
2. Vamoosa Formation
3. Plant fragments
4. Level of service road
5. Uprite Calamites stems in a splay deposit

NE NE Sec. 33 T.20N R.8E Map ______ Photo ______

PAWNEE Co., OKLAHOMA Section No. 5

Area along east road, north of bridge By J. W. Shelton

Outcrop Pattern -- Linear ______ belt ______ Formation Vamoosa

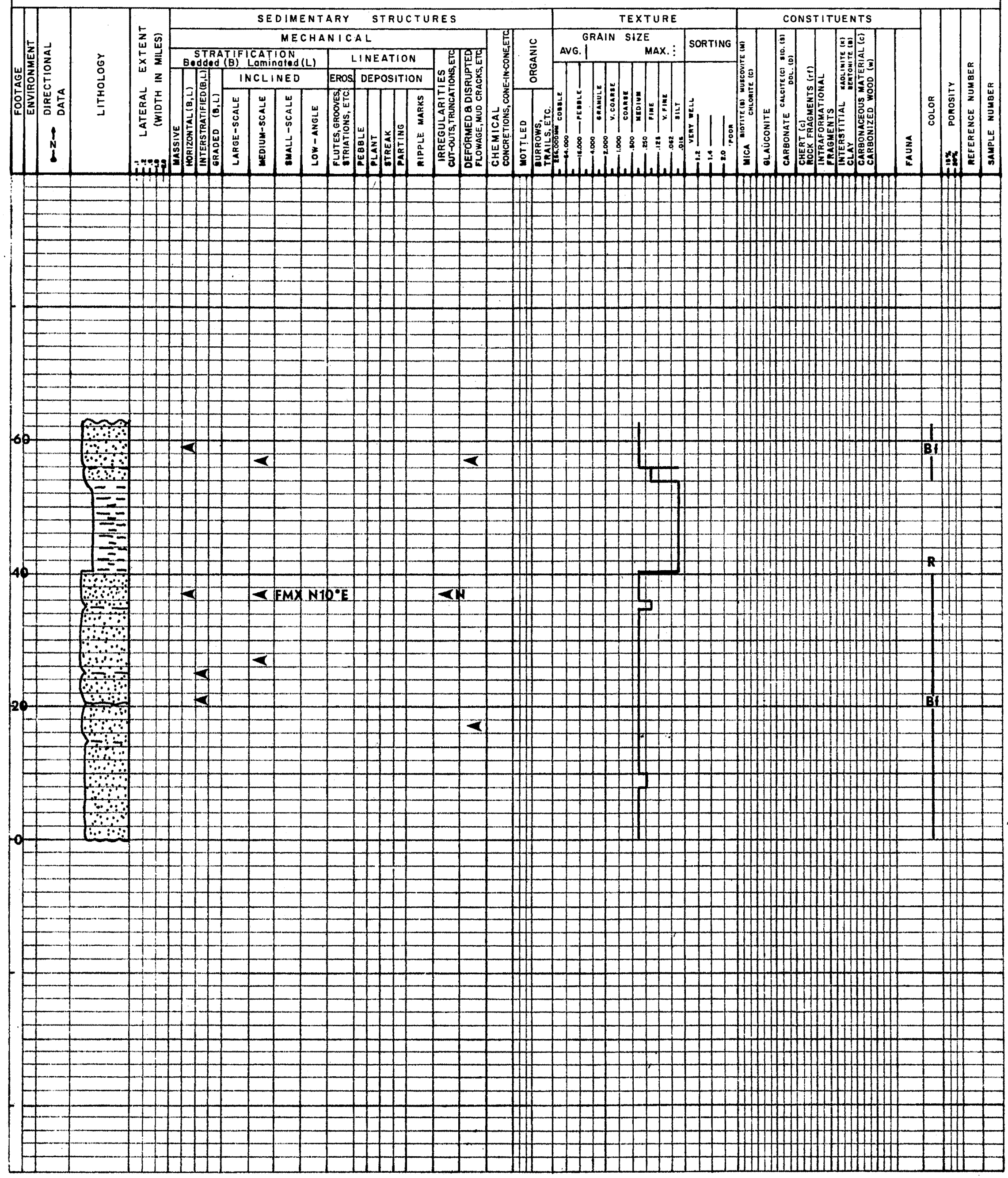


SWNW Sec. 7 T. 19N R. 9E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 6

Area east of river, west of cemetery By J.W. Shelton

Outcrop Pattern - - Linear ______ belt ______ Formation Vamoosa

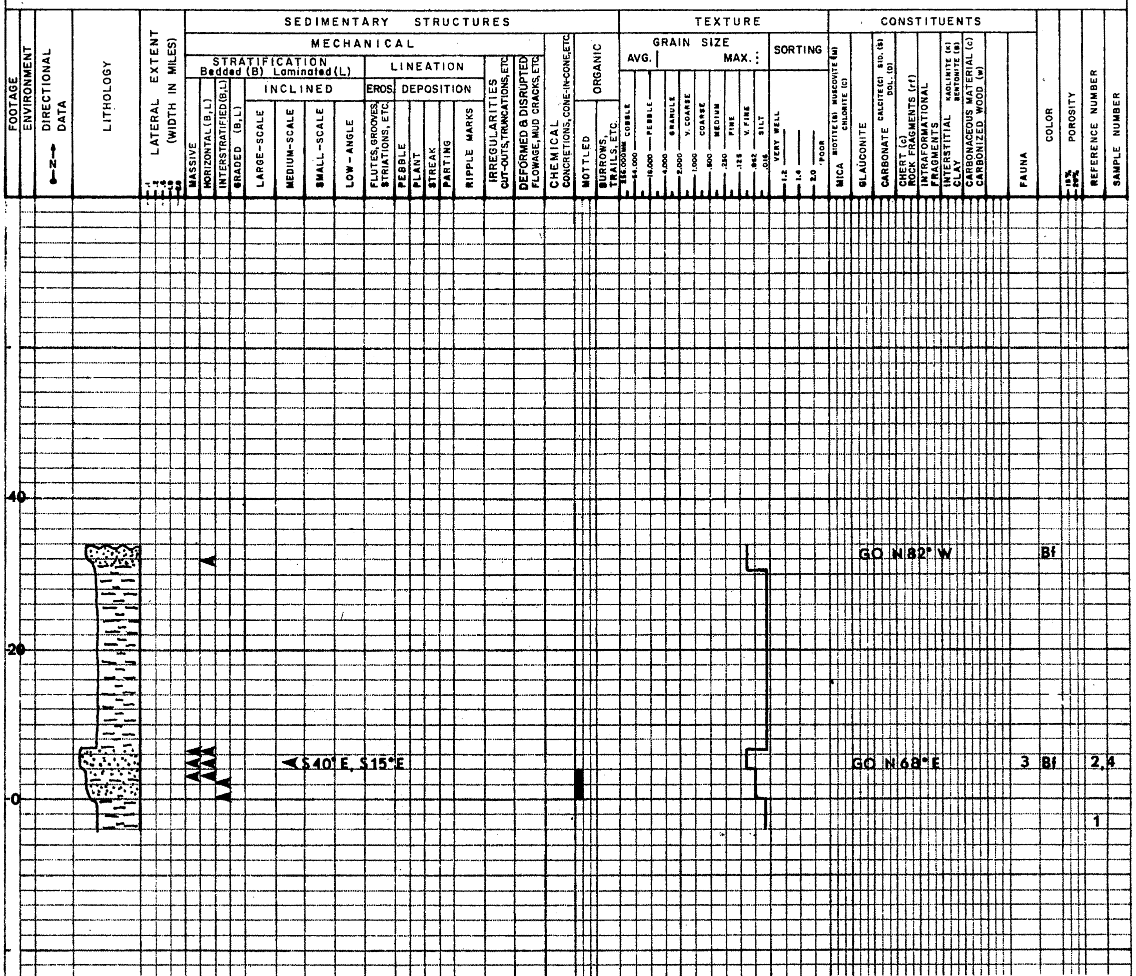


SWSE Sec. 7 T. 19N R. 9E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 7

Area along old highway 51-64 cut off; railroad cut just N By J.W. Shelton

Outcrop Pattern -- Linear ______ belt ______ Formation Vamoosa



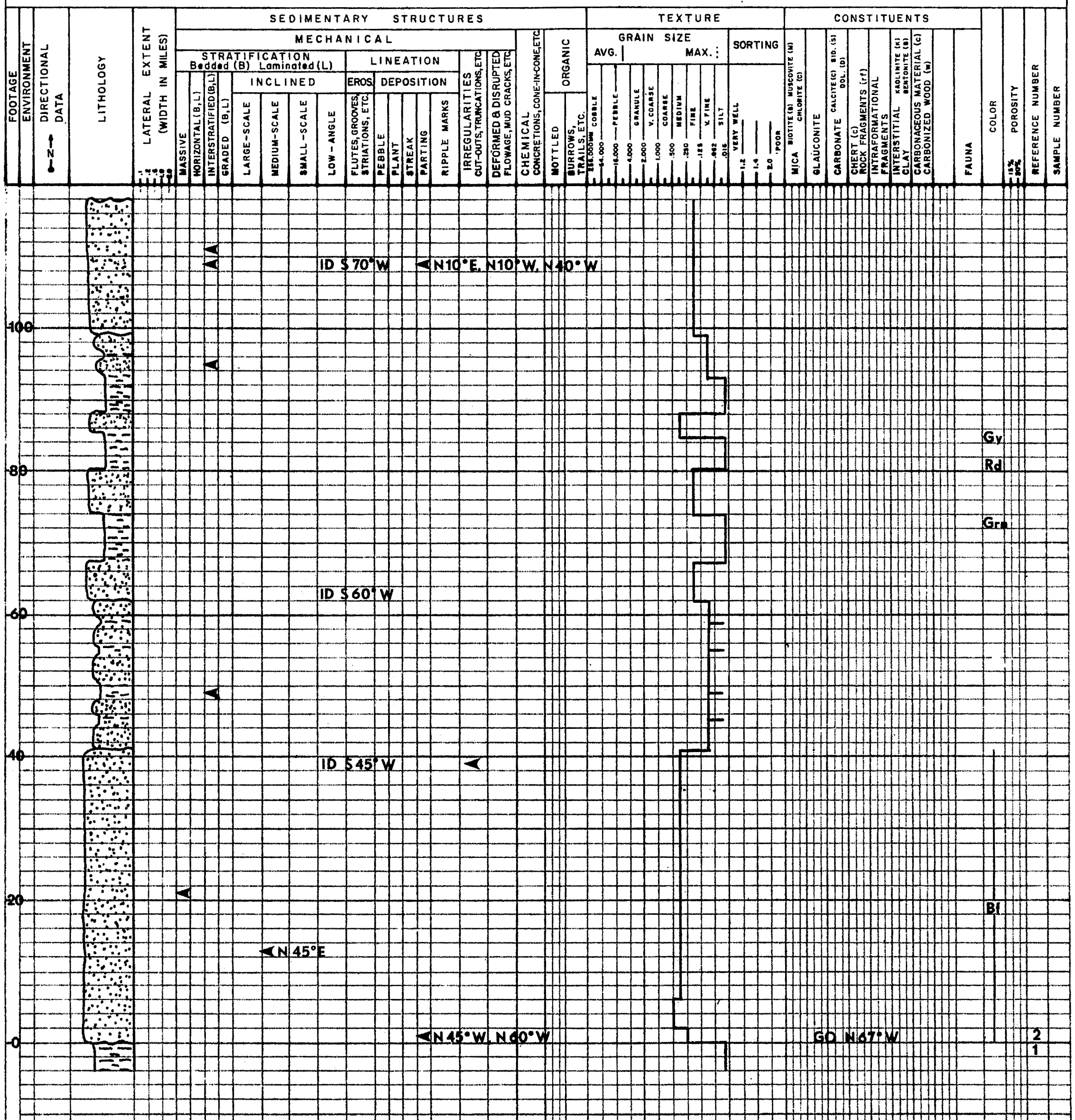
1. Tallant Formation
2. Vamoosa Formation
3. Brachipod and Pelecypod casts
4. Section south of R.R. cut in hill with MX sandstone at comparable position to west and north of R.R. cut

Sec. 7/18 T. 18N R. 9E Map Photo

CREEK Co., OKLAHOMA Section No. 8

Area along road By J. W. Shelton

Outcrop Pattern - - Linear belt Formation Vamoosa



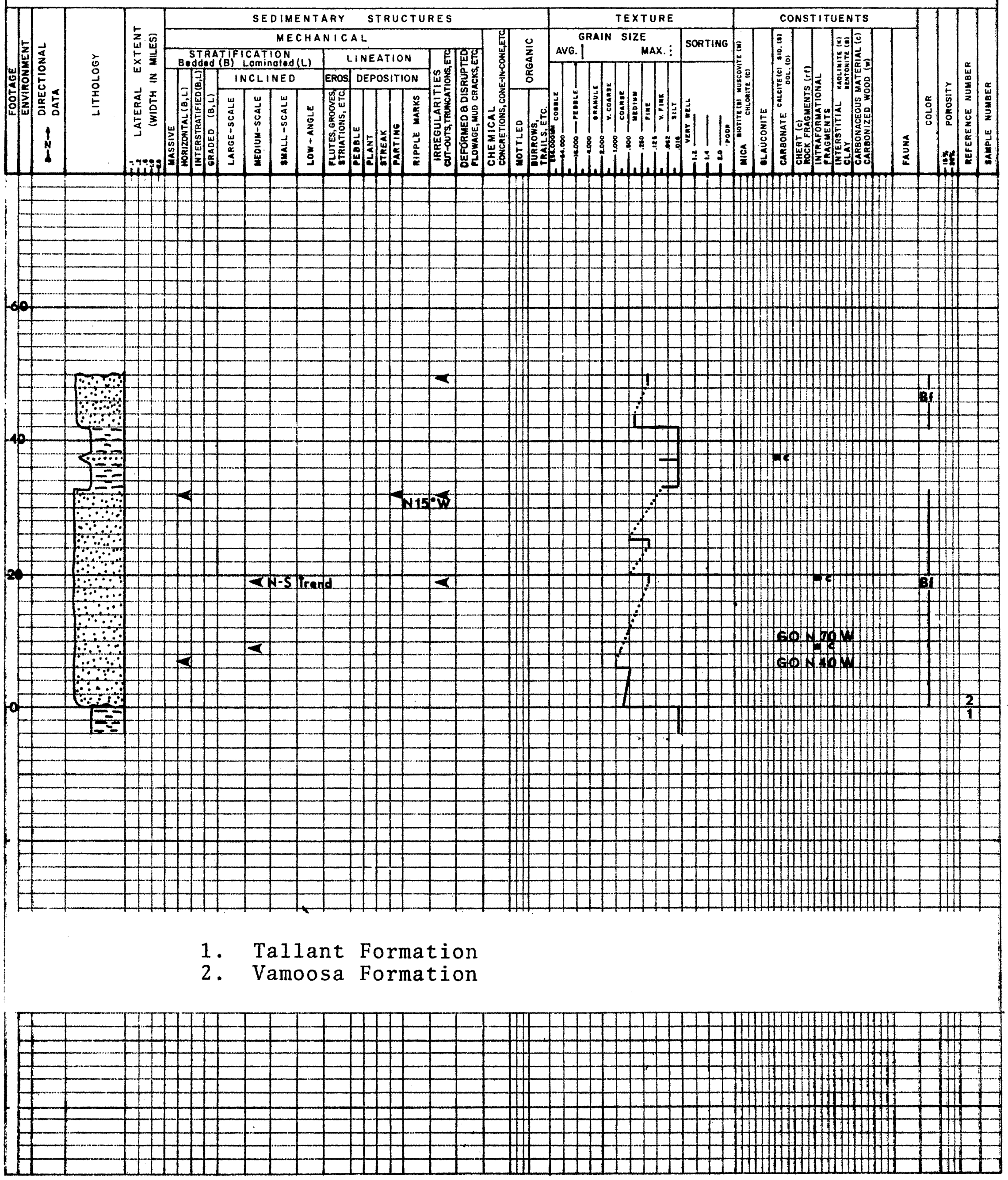
1. Tallant Formation
2. Vamoosa Formation

SW NW Sec. 31 T. 18N R. 9E Map Photo

CREEK Co., OKLAHOMA Section No. 9

Area 4 miles E of Happy Corner along road (substation) By J. W. Shelton

Outcrop Pattern -- Linear belt Formation Vamoosa



SE 36 17N 8E
SW Sec. 31 T. 17N R. 9E Map Photo
CREEK Co., OKLAHOMA Section No. 10
Area along road around curve to y By J. W. Shelton
Outcrop Pattern--Linear belt Formation Vamoosa

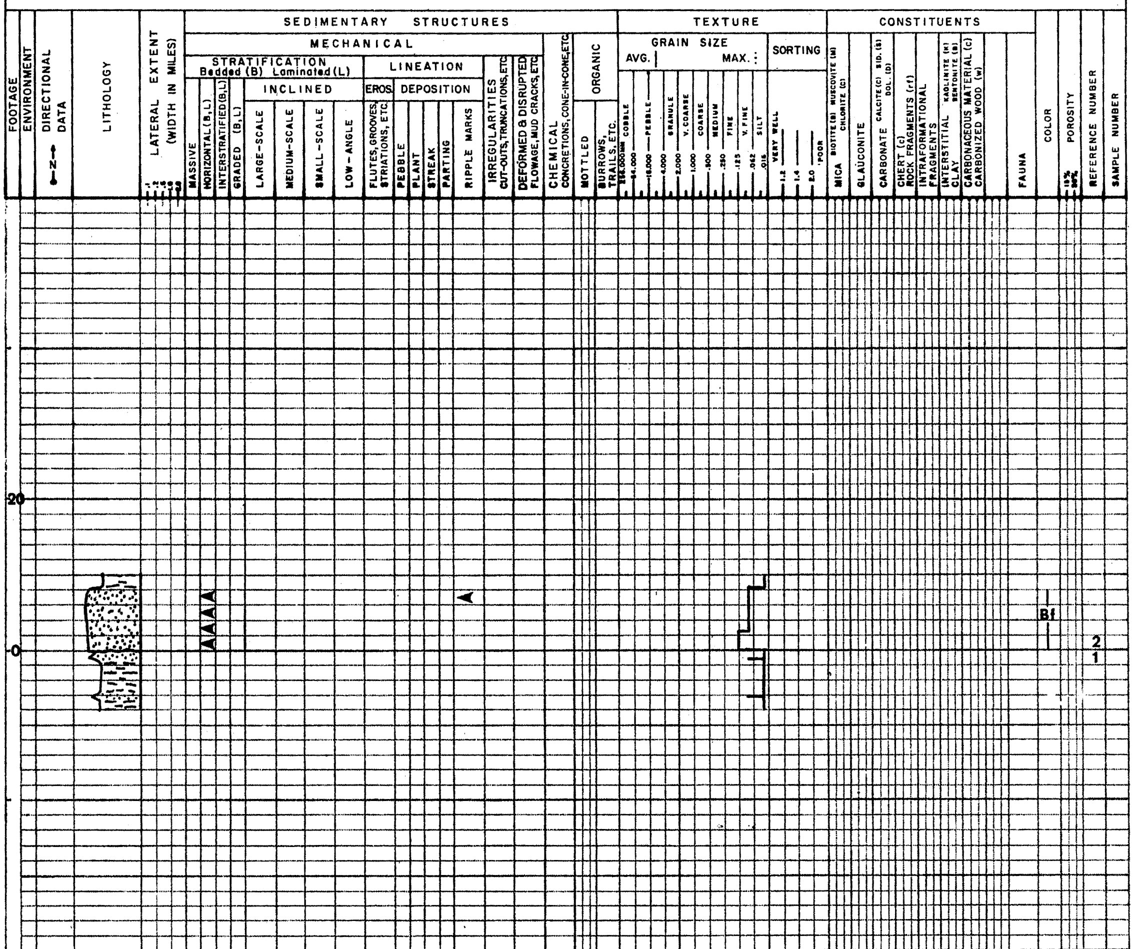
1. Tallant Formation
2. Vamoosa Formation

SE SW Sec. 19 T.16N R.9E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 11

Area NNE of Bristow on State Highway 16 & Turner Turnpike By J. W. Shelton

Outcrop Pattern--Linear ______ belt ______ Formation Vamoosa



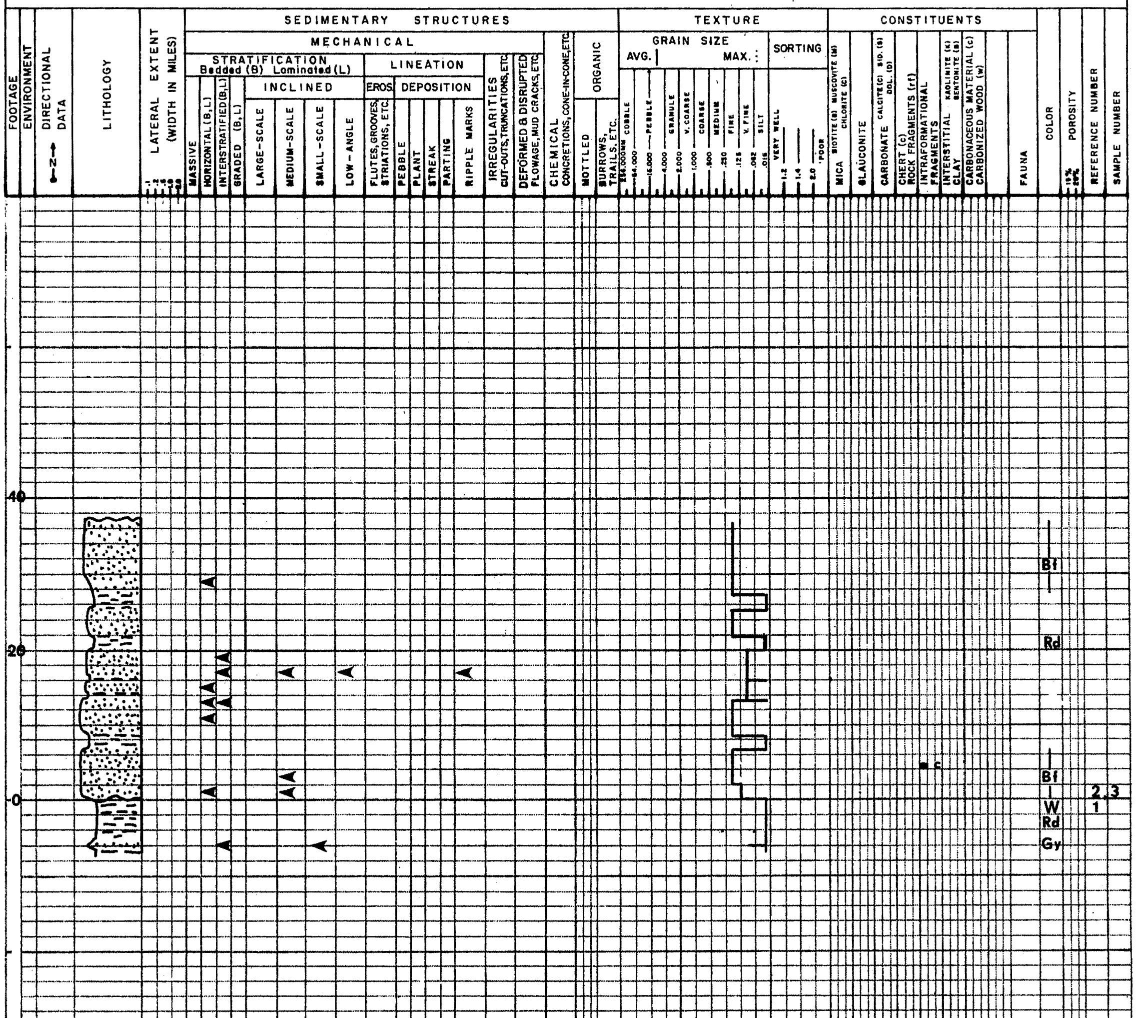
1. Tallant Formation
2. Vamoosa Formation

SE SE 16
NE NE Sec. 21 T. 15N R. 8E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 12

Area G Bar Ranch, Wamarkee Lease (Am. Oil Co.) By J.W. Shelton

Outcrop Pattern - - Linear ______ belt ______ Formation Vamoosa



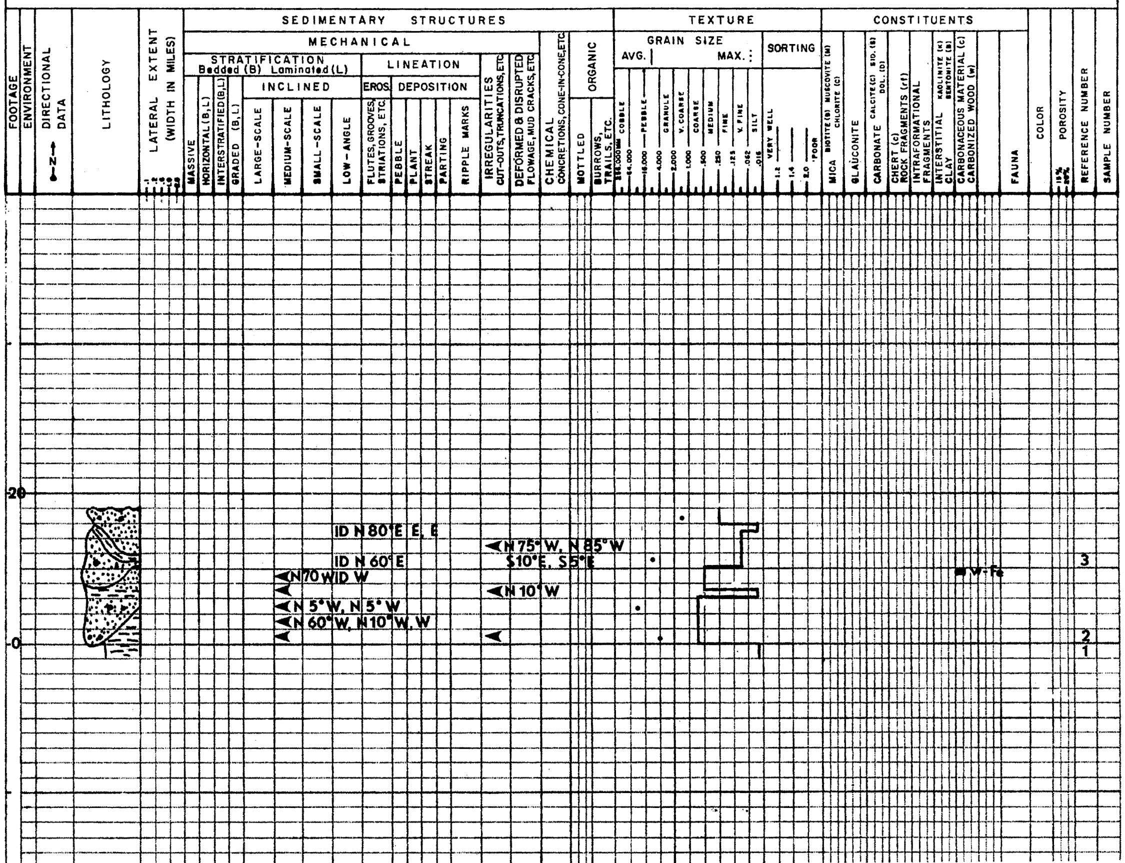
1. Tallant Formation
2. Vamoosa Formation
3. Lower surface with ID

SE SE SE Sec. 5 T. 14 N R. 8E Map Photo

CREEK Co., OKLAHOMA Section No. 13

Area along E-W section line road By J. W. Shelton

Outcrop Pattern - - Linear belt Formation Vamoosa



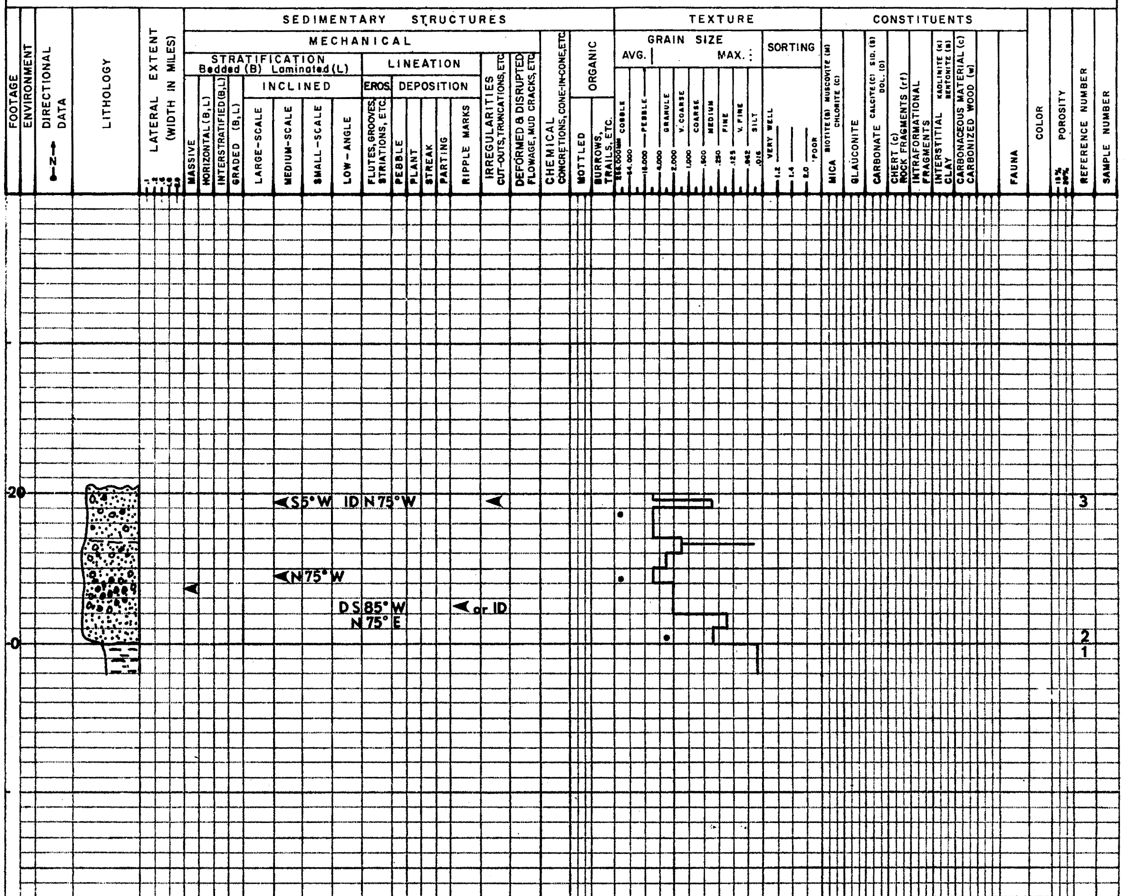
1. Tallant Formation
2. Vamoosa Formation
3. Very fine-to fine-grained lens with ID of W, and SX of N70°W; it is cut by a clay channel

SE SE Sec. 2 T. 14 N R. 8 E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 14

Area road cut on N side of road By J.W. Shelton

Outcrop Pattern-- Linear ______ belt ______ Formation Vamoosa



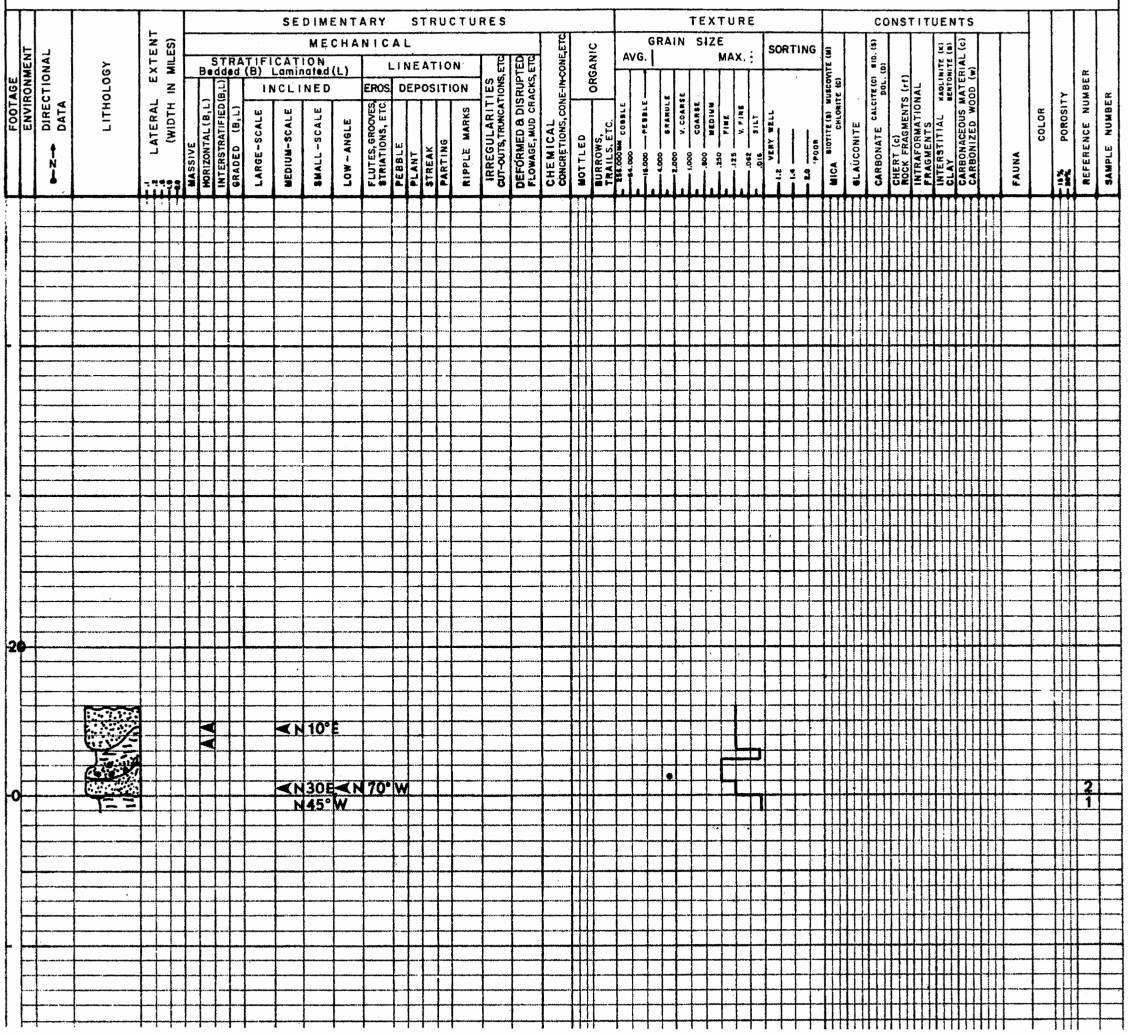
1. Tallant Formation
2. Vamoosa Formation
3. FMX in conglomerate

NE NE Sec. 17 T. 13 N R. 8E Map ______ Photo ______

OKFUSKEE Co., OKLAHOMA Section No. 15

Area ______ By J. W. Shelton

Outcrop Pattern -- Linear ______ belt ______ Formation Vamoosa



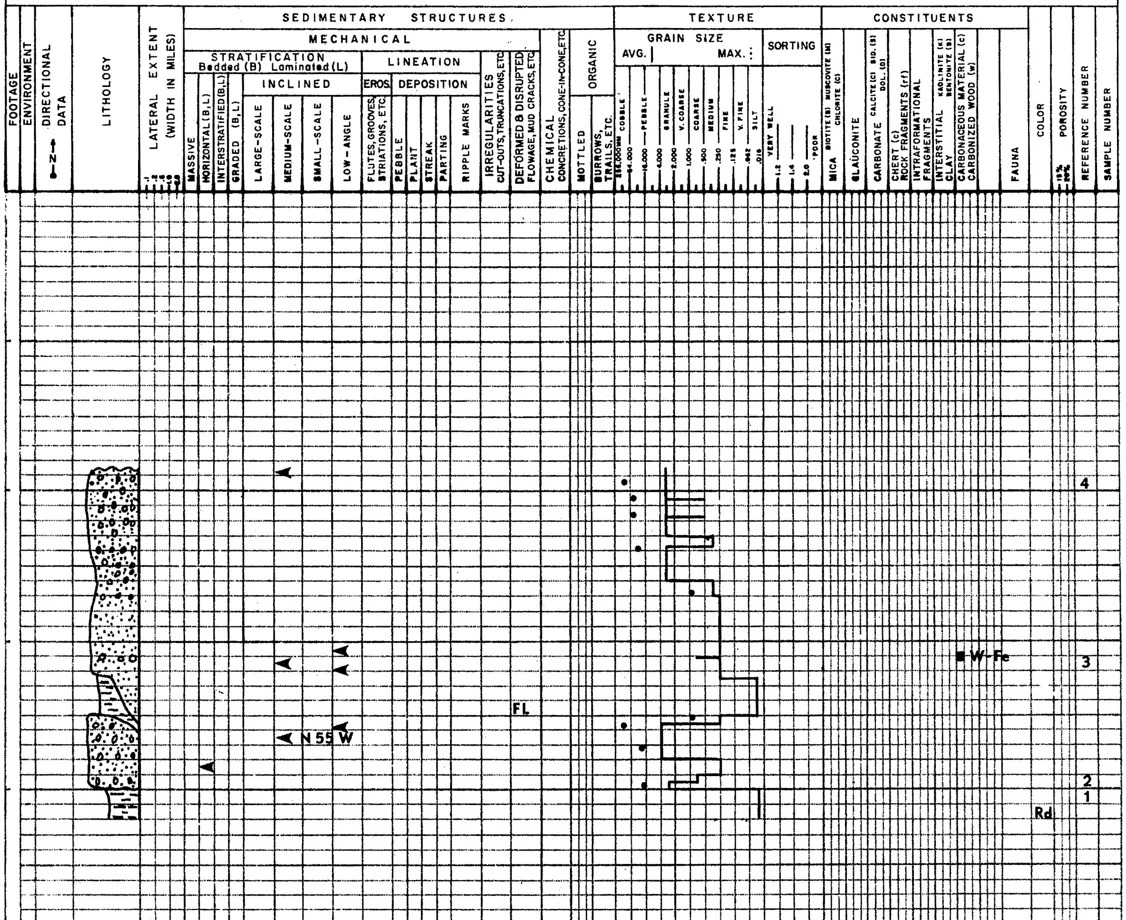
1. Tallant Formation
2. Vamoosa Formation

NW NW Sec. 28 T. 12N R. 8E Map Photo

OKFUSKEE Co., OKLAHOMA Section No. 17

Area 1.1 miles E of Boley on U.S. Highway 62 By J. W. Shelton

Outcrop Pattern - - Linear belt Formation Vamoosa



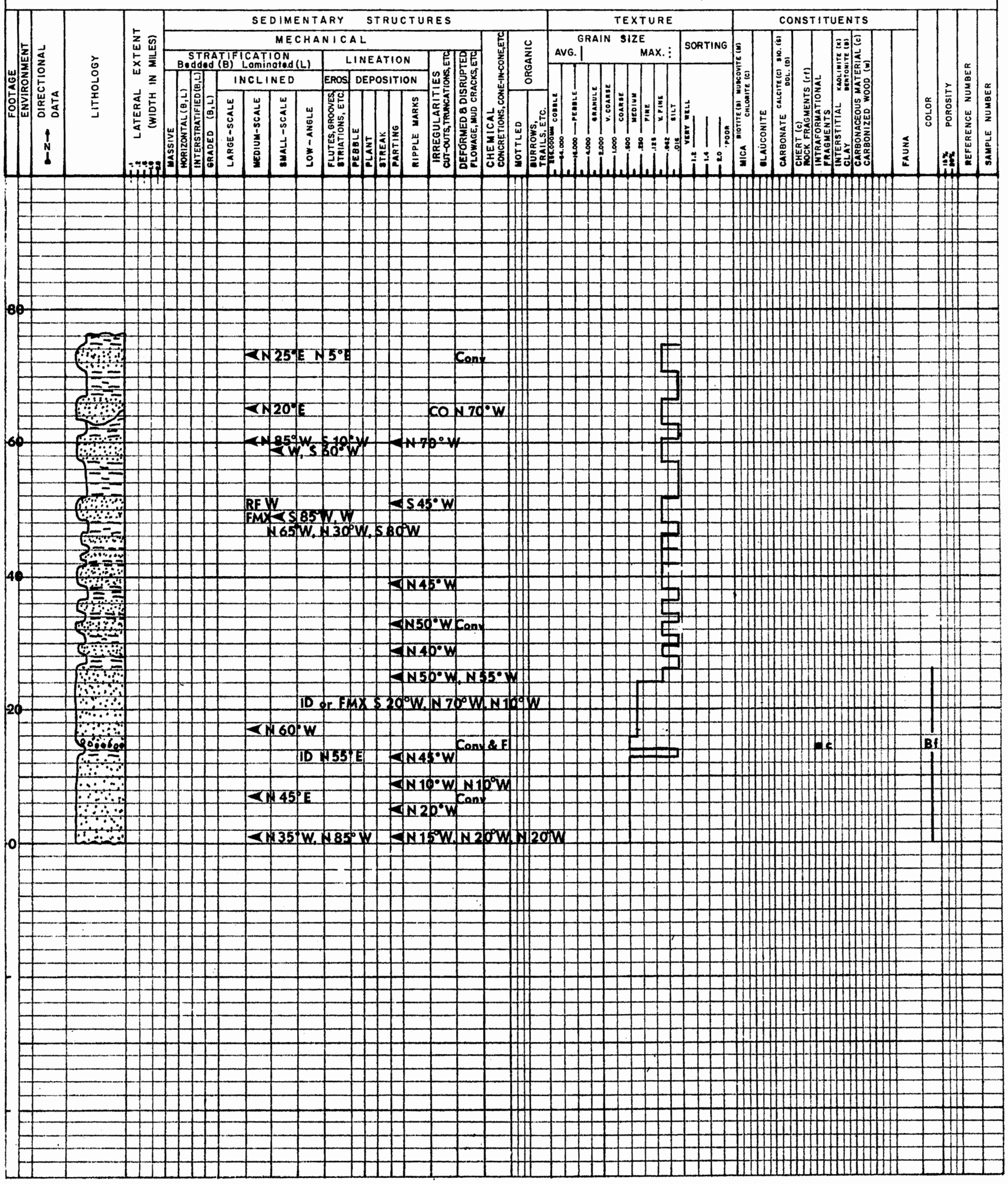
1. Tallant Formation
2. Vamoosa Formation
3. FMX in conglomerate: S40°E, S10°E, N70°E, N55°E, N30°W, S85°W, N40°E, N40°W, S75°E, S30°E, N50°W, N85°E, S50°W, N70°E, S75°E, S55°W, N80°E, S60°W, N30°E, N20°E, N45°W, N5°W
4. Gravel pit atop hill

SE NE Sec. 8/17 T. 12N R. 8E Map ______ Photo ______

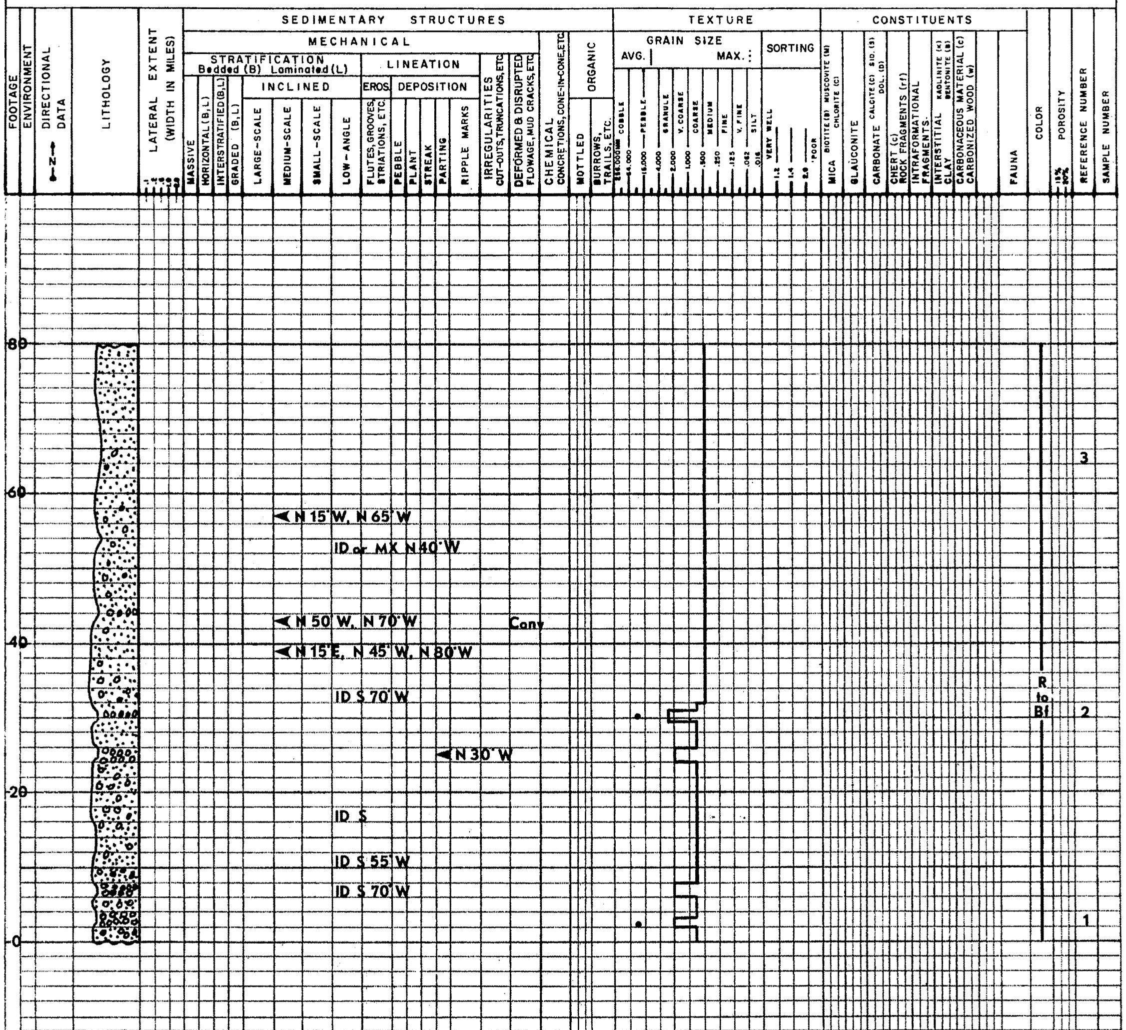
OKFUSKEE Co., OKLAHOMA Section No. 16

Area along paved road NE of Boley By J. W. Shelton & G. W. Ford

Outcrop Pattern--Linear ______ belt ______ Formation Vamoosa



SW Sec. 11 T. 10 N R. 7E Map ______ Photo ______
SEMINOLE Co., OKLAHOMA Section No. 18
Area from creek E along State Highway 99A By J. W. Shelton & G. W. Ford
Outcrop Pattern--Linear ______ belt ______ Formation Vamoosa



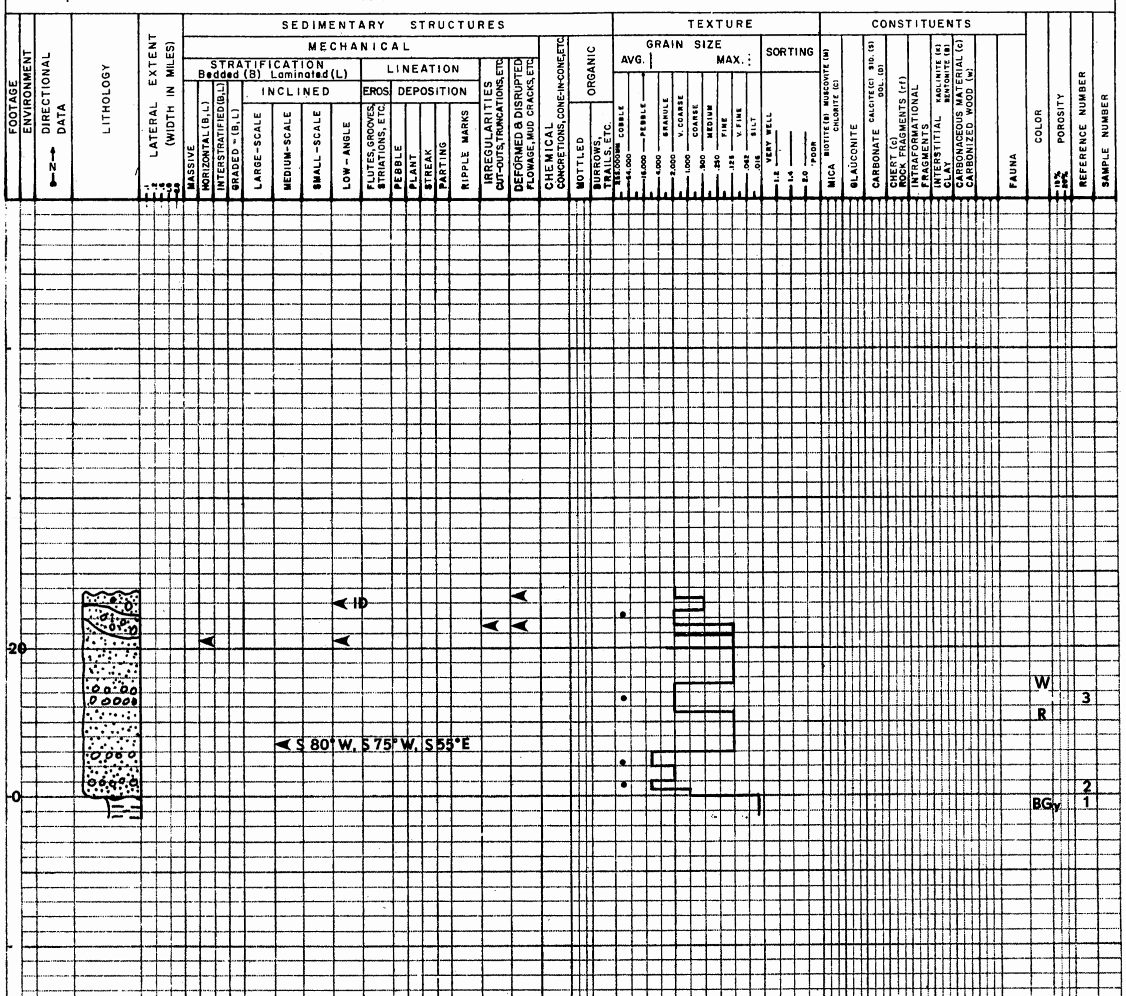
1. Clast 20 mm in diameter
2. Clast 25 mm in diameter
3. Smaller clast size than below

S Line Sec. 12 T. 10 N R. 7E Map Photo

SEMINOLE Co., OKLAHOMA Section No. 19

Area 3 miles west of Cromwell on State Highway 99A By J W Shelton

Outcrop Pattern -- Linear belt Formation Vamoosa



1. Hilltop Formation
2. Vamoosa Formation
3. Clast 127mm in diameter

APPENDIX B

LOCATION OF ELECTRIC LOGS USED IN PREPARATION OF CORRELATION SECTIONS

No.	Operator and Well Number	Location
1.	Davon Oil and Gas Co., Harjo #1	SE NW SE Sec. 34-10N-6E
2.	Ashland-Kemrow-Arrow, White #1	SW NW Sec. 24-11N-6E
3.	Flynn Oil Co., Terry #1	SW SW SE Sec. 14-12N-6E
4.	J. E. Crosbie, Inc., Heinzig #1	Lot 7 Sec. 24-13N-6E
5.	Skaggs Oil Co. of Texas, V. V. Harris #1	SE SW NE Sec. 30-14N-7E
6.	J. J. Deaner, Shannon #1	NE SE NW Sec. 33-15N-7E
7.	Wilcox Oil Co., Fixico #1	SW SE NW Sec. 21-16N-7E
8.	Mid-Continent Petr. Co., A. Sawyer #14	SW SW NE Sec. 27-17N-7E
9.	Orville H. Parker, Richner #1	NW NE NE Sec. 22-18N-7E
10.	Graybol Contracting Co., Oller #1	SE NE SE Sec. 11-19N-7E
11.	Russell Cobb, Jr., Scenold #1	NW SW SE Sec. 11-20N-7E
12.	Johnny Mitchell, Cook #1	SE SW SE Sec. 24-21N-7E
13.	A. G. Oliphant, Carson #2	NW Sec. 30-22N-8E
14.	National Assoc. Petr. Co., Pettit Dome #3	SW Sec. 21-23N-8E
15.	Sooner Oil Co., Sturat #1-A	NE NE NW Sec. 16-24N-8E
16.	National Assoc. Petr. Co., N. Cold Spring #4-1	SE SE SW Sec. 21-25N-8E
17.	Transcontinental-Empire Drlg. Co., Osage #1	SE SE SE Sec. 11-25N-8E
18.	A. G. Oliphant, Osage #1	SE SW SW Sec. 7-25N-6E
19.	Kewanee Oil Co., Kern #5	SE Sec. 23-25N-6E
20.	J. M. Graves, Osage #2	NE NE SW Sec. 17-25N-7E
21.	J. M. Graves, Osage #1-A	SW SW SW Sec. 15-25N-7E
22.	Mary F. Ramsey, Alred #1	SW SW NE Sec. 23-25N-7E
23.	George F. Martin, Higgins #1	SW SW NE Sec. 19-25N-8E
24.	Osage Prod. Co., Osage #1	SE SW SW Sec. 19-25N-9E
25.	E. J. McCurdy, Jr., Osage #1	NE NW NE Sec. 21-25N-9E
26.	T. C. Hudson, Gardner #1	SE NE SE Sec. 31-22N-6E
27.	R. G. Woods, Pasley #1	NW SW NE Sec. 34-22N-6E
28.	Robert C. Davis, School Land #1	SW SW SE Sec. 36-22N-6E
29.	Esperanza Oil, Helland #1	NW SE SE Sec. 31-22N-7E
30.	A. G. Oliphant, Franklin #4	NE SW SW Sec. 34-22N-7E
31.	Oakleaf Drlg. Co., Pitts #6	SW SE NW Sec. 27-22N-8E
32.	Tesoro Petr. Corp., Nave #30-1A	SE NE SW Sec. 30-22N-9E
33.	Midwestern Constrs. Inc., Wetzel #1	NE NE NW Sec. 18-19N-5E
34.	Joe S. Anderson, Kirby #2	SE NE NE Sec. 16-19N-5E
35.	Robert L. Parker, Hampton #2	SE SE SW Sec. 14-19N-5E
36.	Carl Crites and Assoc., Merritt #1	SE NW SW Sec. 19-19N-6E
37.	Anchor Petr. Co. and Manhatton Constr. Co., City Park #1	NW SW SE Sec. 17-19N-6E
38.	Falcon Seaboard Drlg. Co., Reynolds #1	SE SE SW Sec. 2-19N-6E
39.	Jay Simmons, Anthis #1	NW SE SE Sec. 7-19N-7E
40.	E. L. Oliver Co., Ruscoe #1	NE NE NE Sec. 19-19N-8E
41.	C-G Drlg. Co., Grimes #2	SW NE NW Sec. 21-19N-8E
42.	Austin-Dunham, Reeder #1	SE SE SE Sec. 19-16N-5E
43.	Blackwell Oil Co., Hoskin #1	NE NE SW Sec. 21-16N-5E
44.	E. F. Moran Inc., Herman #1	SE NW SE Sec. 24-16N-5E
45.	Harper-Turner, Homer #1	SE NE SW Sec. 20-16N-6E
46.	Inland Producing Co., Murphy #1	NE NE NW Sec. 26-16N-6E
47.	Mid-Continent Petr. Co., Estates Land Co., #1	NE SE NE Sec. 19-16N-7E

No.	Operator and Well Number	Location
48.	T. O. Lilystrand, Jr., Lucas #1	SE SE SW Sec. 23-16N-7E
49.	The Texas Co., Julia Wickham #1	NW SE SW Sec. 19-16N-8E
50.	Anchor Petr. Co., Fredman #1	SW SE SW Sec. 18-13N-5E
51.	Delaney Drlg. Co., State-Snider #1	NW NW SE Sec. 16-13N-5E
52.	Anderson-Prichard, Elsine Marshall #1	NE NE SE Sec. 14-13N-5E
53.	Thomas C. Davis, Jr., School Land #3	NE NE SE Sec. 16-13N-6E
54.	Olson Drlg. Co., Munson #1	C SE SE Sec. 16-13N-7E
55.	Phillips Petr. Co., Seran #1	NW NE Sec. 14-13N-7E
56.	Newton Barrett, Flowers #A-1	SE SE NW Sec. 12-13N-7E
57.	Nail Drlg. Co., Hale Estate #1	SW NW NE Sec. 31-10N-5E
58.	F. P. Shonwald, Varnum #1	SW NE NE Sec. 34-10N-5E
59.	Dunham Prod. Co., Cox #1	NW NE SE Sec. 31-10N-6E
60.	Deardorf Oil Corp., Doris #1	SE SE SW Sec. 31-10N-7E
61.	J. E. Hall, Austin #1	SE SE SW Sec. 33-10N-7E

VITA

Gary Wayne Ford

Candidate for the Degree of

Master of Science

Thesis: GENESIS AND TREND OF THE LOWERMOST UNIT OF THE VAMOOSA FORMATION (GYPSY SANDSTONE) IN PARTS OF NORTHEASTERN AND CENTRAL OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, July 21, 1953, the son of Mr. and Mrs. Bernard Doyle Ford.

Education: Graduated from Putnam City High School, Warr Acres, Oklahoma, in May, 1971; received Bachelor of Science degree in Geology from Oklahoma State University, Stillwater, Oklahoma, in May, 1975; completed the requirements for the Master of Science degree at Oklahoma State University in May, 1978, with a major in Geology.

Professional Experience: Junior member of the American Association of Petroleum Geologists; Roustabout, Getty Oil Company, 1972; Exploration Geologist, Getty Oil Company, 1975; Research Assistant, Department of Geology, Oklahoma State University, 1976; Exploration Geologist, Getty Oil Company, 1976; Teaching Assistant, Department of Geology, Oklahoma State University, 1975-1977.