DEPOSITIONAL SETTING, FACIES, AND PETROLOGY OF CABANISS (UPPER "CHEROKEE") GROUP IN BECKHAM, DEWEY, CUSTER, ELLIS, ROGER MILLS, AND WASHITA COUNTIES, OKLAHOMA

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DEDICATION

This thesis is dedicated to the memory of Mr. J Lynn Stratton who was my teacher and friend. His charm and wit are sorely missed, but the pleasant memories of J will be cherished forever by the many geologists who had the opportunity to share his company and to work under his guidance.

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Reserved for last is a special "thank you" for my family for encouraging me and tolerating the long hours of my absence from home while working on this thesis. The love and support of my wife Jennifer and understanding of my son Andrew have been essential to completion of this study. Finally, I would like thank my parents who kindled within my brothers and me an early interest in the natural sciences and welcomed the specimens and treasures that filled our home.

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CHAPTER I

INTRODUCTION

The area of this study encompasses 56 townships covering a portion of the Anadarko Basin in T.11N. through T.17N. and R.16W. through R.23W. This area includes parts of Beckham, Dewey, Custer, Ellis, Roger Mills, and Washita Counties, Oklahoma (Figure 1). The stratigraphic interval studied is part of the Desmoinesian Series of the Pennsylvanian System. This interval, which is referred to by the petroleum industry as "Upper Cherokee," is equivalent to the Senora Formation of the Cabaniss Group, which crops out in east-central Oklahoma. Included in the "Upper Cherokee" in ascending order are the Pink Limestone, Lower and Upper Skinner Sandstones, Verdigris Limestone, Prue Sandstone, and "Cherokee hot shale" (Figure 2).

Sandstones in the upper part of this sequence are significant hydrocarbon-bearing reservoirs in the study area and are commonly called the "Upper Skinner" or "Prue" sandstone.

Objectives

The primary objectives of this study are as follows: 1) Establish an acceptable correlation of rock-stratigraphic units comprising the Cabaniss Group in the

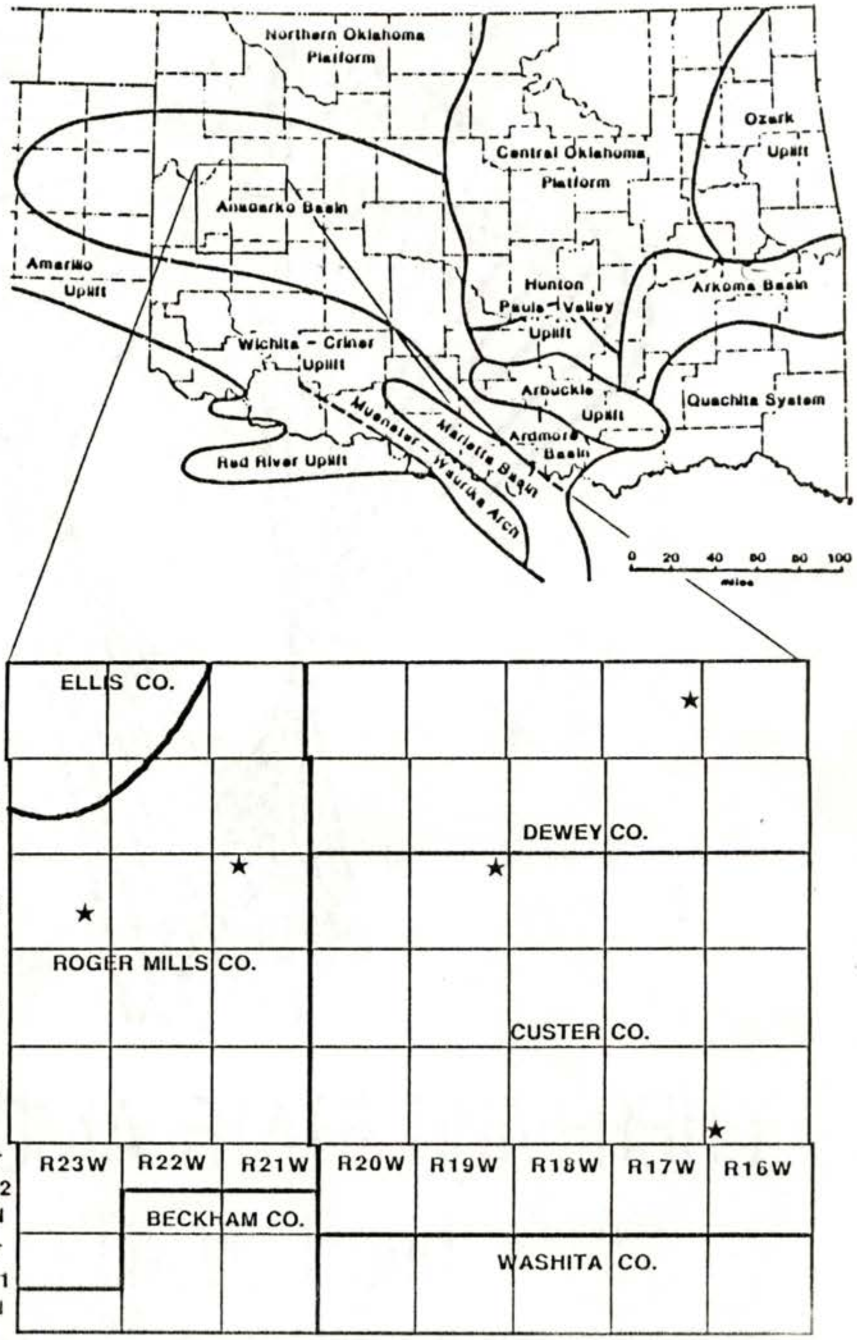


Figure 1. Map showing locations of the study area and cores examined (after Al-Shaieb and Shelton, 1977; Arbenz, 1956).

SYSTEM	SERIES	GROUP		FORMAL NAME (FORMATIONS)	FORMAL NAME (MEMBERS OR MARKER BEDS)	SUBSURFACE NAME (PLATFORM)	SUBSURFACE NAME (STUDY AREA)
PENNSYLVANIAN	DESMOINESIAN	MAR-MATON		OOLOGAH LS	OOLOGAH LS	BIG LIME	OSWEGO LM
				LABETTE SH			
				FT. SCOTT LS	FT. SCOTT LS	OSWEGO LM.	
		UPPER "CHEROKEE"	CABANISS	SENORA FM.	EXCELLO SH BREEZY HILL LS		'CHEROKEE' HOT SH
					LAGONDA SD	PRUE SD.	PRUE SD
					VERDIGRIS LM	VERDIGRIS LM	VERDIGRIS LM
						U. SKINNER SD	U. SKINNER SD
					CROWEBURG COAL	HENRYETTA COAL	
					CHELSEA SD	L. SKINNER SD	L. SKINNER SD
					TIAWAH LM	PINK LM	PINK LM
		LOWER "CHEROKEE"	KREBS	BOGGY FM.	TAFT SD	RED FORK SD	RED FORK SD
					INOLA LM	INOLA LM	INOLA LM

Figure 2. Generalized stratigraphic nomenclature of Cabaniss (Upper "Cherokee") Group (after Lojek, 1983).

Anadarko Basin.

2) Decipher the depositional facies, petrology and depositional environments.

3) Examine the effects of cyclicity on the depositional scenario.

4) Determine the geometry of hydrocarbon-bearing reservoirs.

5) Describe the diagenetic features of hydrocarbon-producing reservoirs and establish a paragenetic sequence of diagenetic events.

Methods of Investigation

The following methodology was used in this study to correlate the Cabaniss Group, and to formulate a systematic process of establishing and presenting evidence necessary to interpret the depositional and diagenetic history of the Cabaniss Group.

1) A literature search was conducted regarding the "Cherokee," Krebs, and Cabaniss Groups and the rock units that compose these groups.

2) Stratigraphic cross-sections were constructed to show correlation of rock-stratigraphic units within the study area to accepted correlations of the Cabaniss Group on the Central Oklahoma Platform.

3) The geometric features, widths, thicknesses, and boundaries of facies that compose units of the Cabaniss Group were determined through examination of various types of geophysical and lithologic data.

4) Thickness and structural geologic maps of the Cabaniss Group were constructed to interpret depositional settings and predict facies geometry.

5) Internal features of the hydrocarbon-bearing reservoirs, including sedimentary structures, textures, and constituents, were analyzed from the examination of cores, thin sections, and rock cuttings from several wells.

6) A paragenetic sequence of diagenetic events was established based on cross-cutting textural relationships seen in thin sections.

CHAPTER II

GEOLOGIC SETTING

Tectonic Features

The area of study is located in the central part of the Anadarko Basin, which is between the stable Northern Oklahoma Platform and the Wichita Mountain Uplift (Figure 1). The Anadarko Basin is bounded to the north by the Central Kansas Uplift, to the east by the Nemaha Ridge, and to the south by the Wichita-Amarillo Uplift (Arbenz, 1956).

Structural evolution of the Anadarko Basin is believed to have been related closely to the development of the southern Oklahoma aulacogen. Late Paleozoic orogenic pulses were initiated during the late Morrowan and continued into the early Virgilian; they were responsible for the present configuration of the basin as a northwest-trending asymmetrical syncline.

The northern flank of the Anadarko Basin is a broad, gently dipping cratonal shelf; the narrow, steeply dipping southern flank is bounded by the Wichita-Amarillo frontal-faults system. Fault patterns indicate a significant strike-slip component (Hansen, 1978).

Local Structural Geology

Structural contour maps were constructed using the base of the Cherokee "hot shale" marker (Excello Shale) (Plate II) and the base of the Cabaniss Group (Plate I) as mapping surfaces. Both maps showed similar homoclinal dip to the south and southwest of approximately one degree, or 100 feet per mile. Several anticlinal folds are in the northern part of the study area, but no significant faulting is observable northward of the frontal faults of the Wichita-Amarillo Uplift. The structure of the base of the Cabaniss Group is shown in Figure 3.

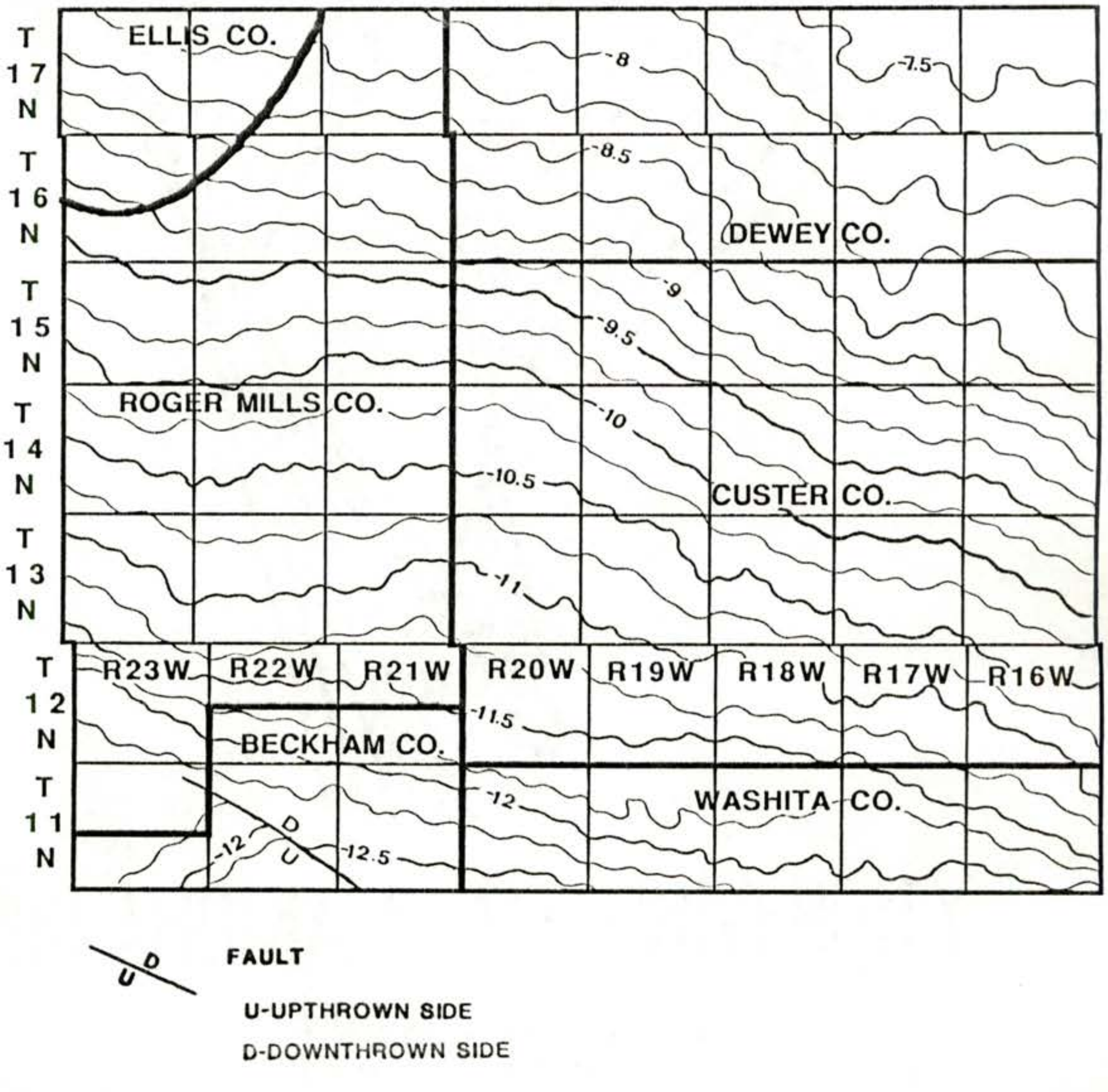


Figure 3. Structural contour map of the base of the Cabaniss Group. Contour interval is 250 feet. Index-numbers of countour lines should be multiplied by 1000.

CHAPTER III

PREVIOUS INVESTIGATIONS

Scores of studies have concentrated on the "Cherokee Group" in central and eastern Oklahoma and on the Northern Oklahoma Platform. These include work by Albano (1975), Ahmedduddin (1968), Berg (1969), Candler (1977), Lyon (1971), Pulling (1979), Shipley (1977), Shulman (1966), and Zeliff (1976). Lojek (1983) conducted a comprehensive study of the Skinner sandstones in north central and northeastern Oklahoma. She indicated that the source of the Skinner sandstone was to the northeast and that the Skinner was deposited in upper deltaic plain, lower deltaic plain, marginal marine, and pro-delta environments. To date, no published studies are available on the "Upper Cherokee" or Cabaniss Group in either the unstable-shelf or the slope regions of the Anadarko Basin. Previous investigations show the extent of the Cabaniss Group on the Northern Oklahoma Platform, along the Nemaha Ridge, and on the Central Oklahoma Platform. The Cabaniss Group stratigraphic framework used in these studies was correlated and extended into the study area (Figure 4). Stratigraphic cross-sections were constructed from the areas of previous investigations in central Oklahoma and extended to the Wichita Mountain Uplift.

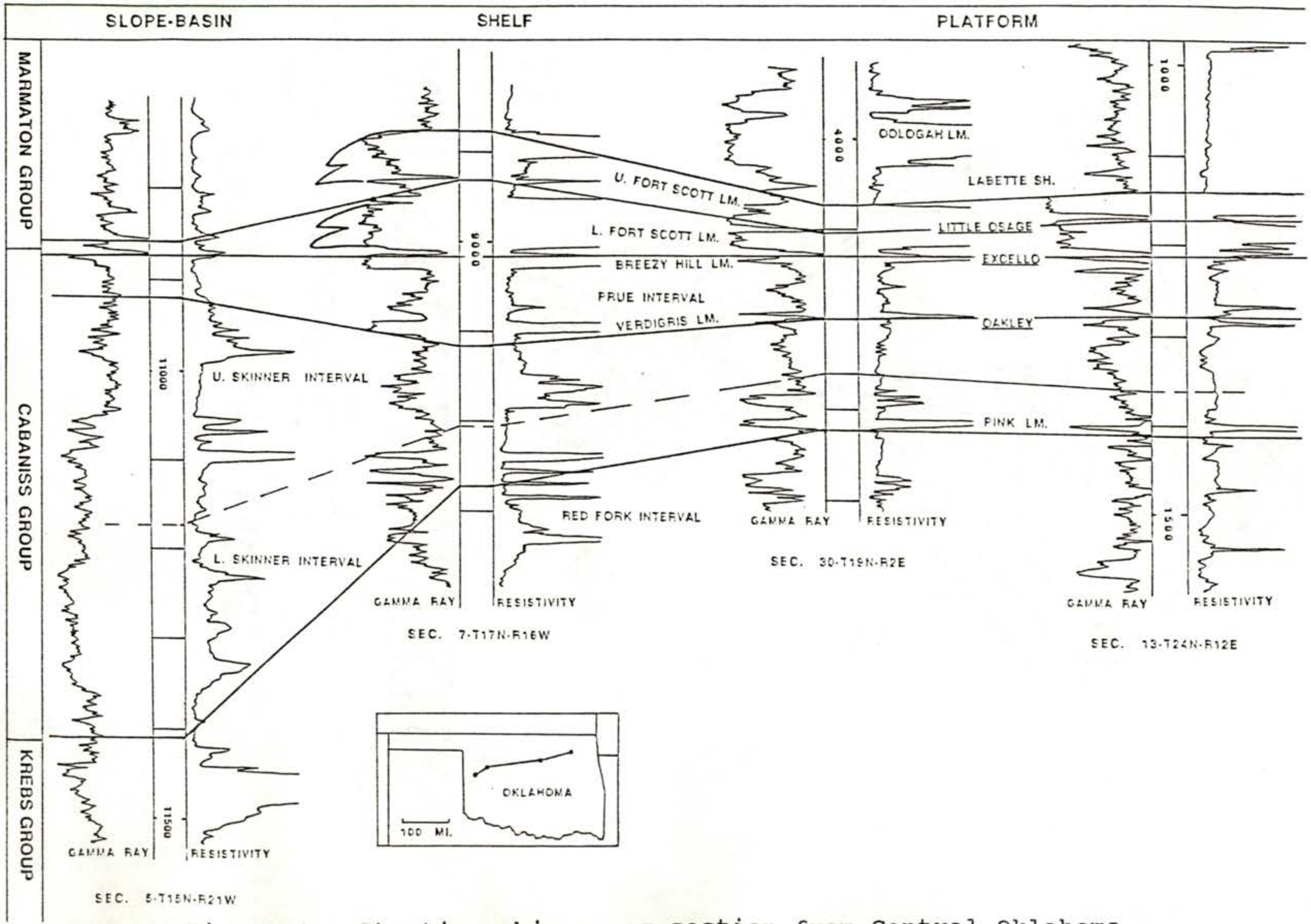


Figure 4. Stratigraphic cross section from Central Oklahoma Platform to Anadarko basin.

CHAPTER IV

STRATIGRAPHIC FRAMEWORK

The Cabaniss Group or "Upper Cherokee" is part of the Desmoinesian Series, Pennsylvanian System (Oakes, 1953). On the northern and western fringes of the Arkoma Basin, the Cabaniss Group (Figure 2) is separated from the underlying Krebs Group by an unconformity at the top of the Boggy Formation. Correlation of the Cabaniss and Krebs Groups between the Anadarko Basin and the Arkoma Basin indicates that Cabaniss rocks deposited in the Anadarko Basin are equivalent only to the Senora Formation. The unconformity between the Cabaniss and Krebs Groups is not recognizable in the Anadarko Basin.

The top of the Cabaniss Group is easily identified on wire-line logs by signatures of the radioactive shales that are equivalent to the Excello Shale of the Senora Formation and Little Osage Shale of the Fort Scott Formation (Figure 4) (Michlik, 1980). The conformable boundary between the Marmaton and Cabaniss Groups is recognized as the top of the Excello Shale, the lowermost of the Cherokee ("hot") radioactive shales. However, bases of these shales are better defined on logs (Figure 4) and are used for correlation and mapping in the study area. These shales are recognizable on wire-line logs throughout most of the study area; they are lithologic-time markers (Busch, 1971 and 1985). The Excello Shale is traceable from northeastern Oklahoma to the frontal zone of the Wichita-Amarillo Uplift, where this marker is not distinguishable in the proximal fan-delta facies of the Desmoinesian Granite Wash arkoses (Plate V).

In the study area, the Verdigris and Pink Limestones are not widespread carbonate marker beds and are not easily recognized on wire-line logs (Figure 4). However, the persistent radioactive-shale marker below the Verdigris Limestone can be used to define the boundary between the Skinner and Prue rock-stratigraphic intervals. This radioactive black shale records deposition in oxygen-deficient water associated with widespread marine transgression over the Upper Skinner deltaic plain. Because the Henryetta Coal is absent, the Skinner format was divided using a (marine) shale to define the base of the Upper Skinner (Figure 4). This marker is not as reliable as other lithologic-time markers used, but appears to fit the criteria of a lithologic-time marker as defined by Busch (1971, 1985). Basinward absence of the Pink Limestone and thickening of the equivalent fossiliferous black shale and muddy carbonate facies complicate recognition of the lower boundary of the Skinner format (Figure 4). This shale and other black shales in the Cabaniss Group are believed to have been deposited in relatively deep water conditions during transgression over the underlying Red Fork interval. This transgression or relative sea level rise may have resulted from basin subsidence and/or eustacy.

CHAPTER V

RECONSTRUCTION OF PALEOBASIN CONFIGURATION

Depositional Setting

Johnson (1984) documented a hingeline or shelf edge for the Lower Red Fork format that extended northwest-southeast subparallel to paleostrike. Figure 5 (Plate III) indicates that increases in thickness of the Cabaniss Group are gradual; this leads to inference of absence of a steep shelf edge during deposition of the Group. An increase in contour density is evident along the western fringe of the study area in R.23W., where a possible shelf-to-slope break or shelf steepening may have existed. A second slight increase in thickness extends from T.13N., R.16W. northwestward to T.17N., R.21W. This thickening does not appear to affect the Cabaniss sandstone facies but it does correspond to a shelf-to-slope facies change in both the Pink and Verdigris limestone intervals. Another area of thickening is along the southern boundary of the study area in T.11N., R.19W. through R.21W. This thickening is believed to have been part of the shelf-to-slope break or steepening mapped in R.23W. Therefore, it is likely that the sandstone intervals of the Cabaniss Group were deposited on a relatively stable shelf over most of the

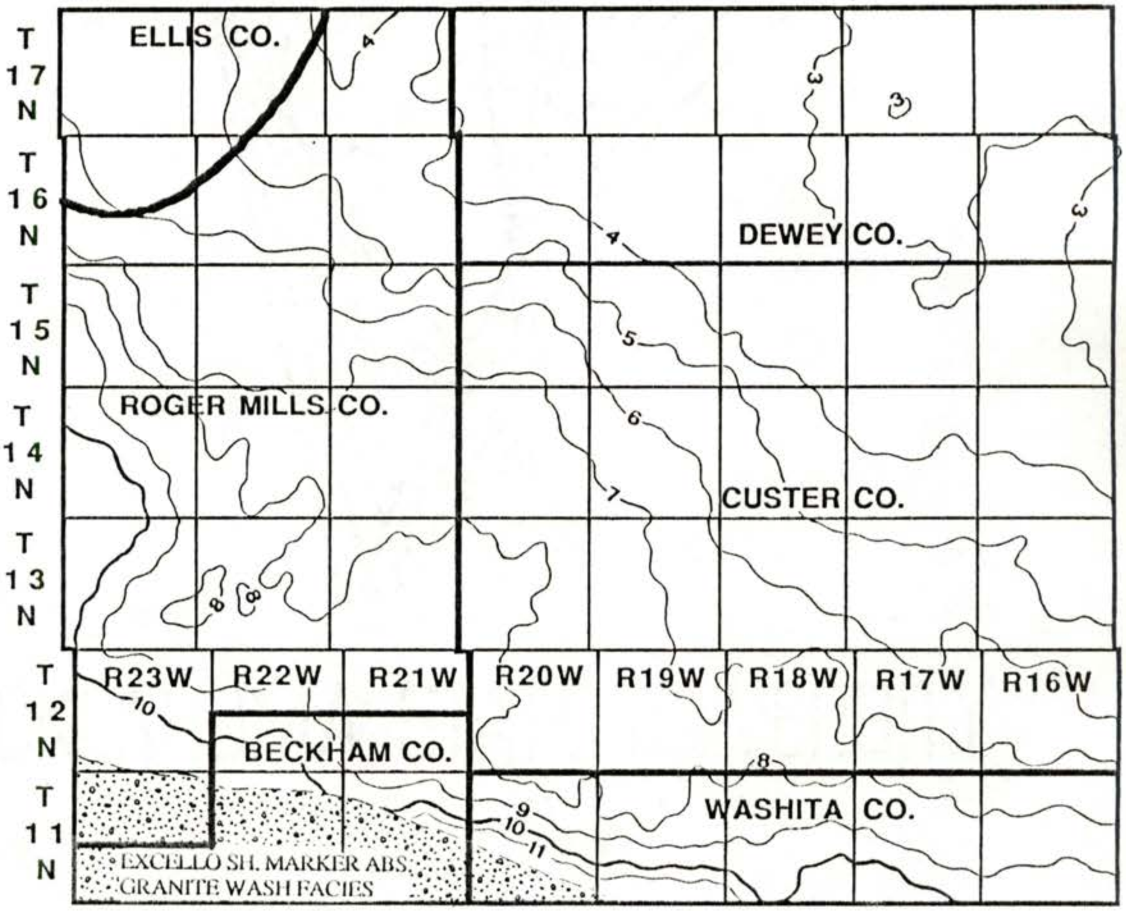


Figure 5. Thickness map of Cabaniss (Upper "Cherokee") Group. Contour interval is 100 feet; index numbers on contour lines should be multiplied by 100.

study area, where fluvio-deltaic and shallow marine conditions were prevalent. The change of the Pink and Verdigris light-colored, clean shelf carbonate facies to darker fossiliferous shale and muddy carbonate strata basinward suggests possible deepening conditions. Change from shallowing to deepening conditions during deposition of the Cabaniss Group is indicated by the alternating carbonate and clastic sediments. These alternating facies suggest that an overriding cyclic mechanism existed during deposition of the Cabaniss Group.

CHAPTER VI

DEPOSITIONAL FACIES

Introduction

Recognition of carbonate and sandstone log facies is imperative in a study where lithologic data is limited. Recognition of carbonate rock was based on the following wire-line log criteria, with clean carbonate defined as having (1) gamma ray deflection of 30-45 A.P.I. units leftward from the shale base line, (2) short-investigation resistivity curves corresponding with an increase to 30-50 ohm-m resistivity, and (3) density, sonic, or neutron-density curves indicating low porosity which is commonly associated with carbonate strata. Recognition of sandstone was based on the following wire-line log criteria: (1) leftward gamma ray deflection of greater than 30 A.P.I. units from the shale base line, (2) short-investigation resistivity curves corresponding to an increase of 20 ohm-m over shale base line resistivity, and (3) density, sonic, or neutron-density porosity curves indicating a corresponding increase in porosity.

Well sample cuttings and cores were necessary to distinguish tightly cemented sandstones from low-porosity carbonates. The reliability of the criteria described above was checked against reported results of completion production tests and drill stem tests, and against cores and sample cuttings.

Geometry of Sandstones and Carbonates

The thickness map of the Cabaniss Group (Figure 5) (Plate III) was used to predict trends of sandstones within the Prue and Skinner intervals. Sandstone is sparse in the Lower Skinner interval, abundant in the Upper Skinner interval, and absent in the Prue interval.

Depositional settings inferred from the Cabaniss Group thickness map were useful in predicting carbonate facies. Carbonate facies of the Pink and Verdigris intervals can be divided into a "clean" shelf facies and a "dirty" or "muddy" basinward facies. The boundary between these facies coincides with a thickening of the Cabaniss Group that extends from T.13N., R.16W. to T.17N., R.21W. (Figure 5). Carbonate facies of the Skinner interval appear to coincide with the increase in thickening and possible shelf edge along the western border of the study area in T.12N. through T15N., R.23W. (Figure 5) (Plate III).

Pink Limestone

The Pink limestone carbonate-and-shale sequence overlies the Red Fork sandstone interval of the Krebs Group. Pink carbonate log facies is traceable from the Northeast Oklahoma Platform and shelf into the Anadarko basin (Figure 4). This facies shows little change in wire-line log signature from the platform to the shelf. However, in the area of transition between the deep-water unstable shelf and the basin's slope, log signatures and lithofacies change considerably.

Lithofacies and Log Facies

Two cores were studied that contained the Pink limestone interval in the study area (Figure 6). The Wessely, Clark No. 1-A core in Sec. 13, T.17N., R.17W., Dewey County, Oklahoma, encountered the Pink Limestone in a relatively stable shelf setting. This core contains silt- and sand-rich microspar and sparry calcite (Figure 7) that cleans and coarsens upward to biosparite (Figure 8)(Folk, 1970) or wackestone (Dunham, 1970). The log signature across this interval shows relatively low gamma ray readings and high resistivity that are characteristic of the Pink Limestone "clean" carbonate log facies (Figure 9). The second core studied was the Woods, Switzer "C" No. 1 in Sec. 5, T.15N., R.21W., Roger Mills County. Cored are very dark biomicrite (Figure 10) and black calcareous and siliceous shales (Figure 11). This interval has a radioactive (shale-like) gamma-ray signature and corresponding low resistivity readings across the Pink interval (Figure 9). Whole-core photographs of these facies are in Appendix B.

Distribution and Environments of Deposition

Positions of these two cores relative to the

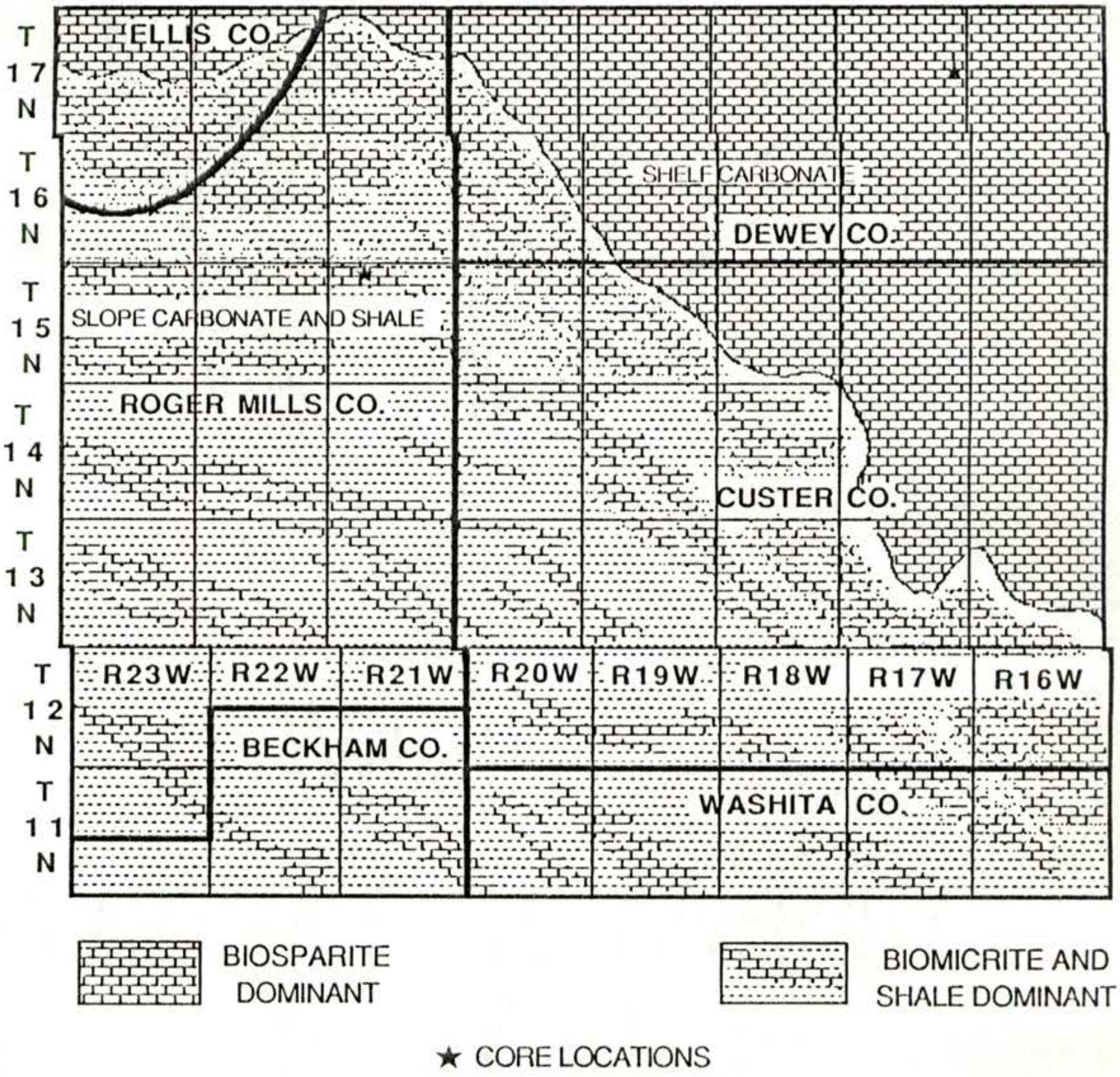


Figure 6. Pink Limestone facies distribution and locations of cores examined.

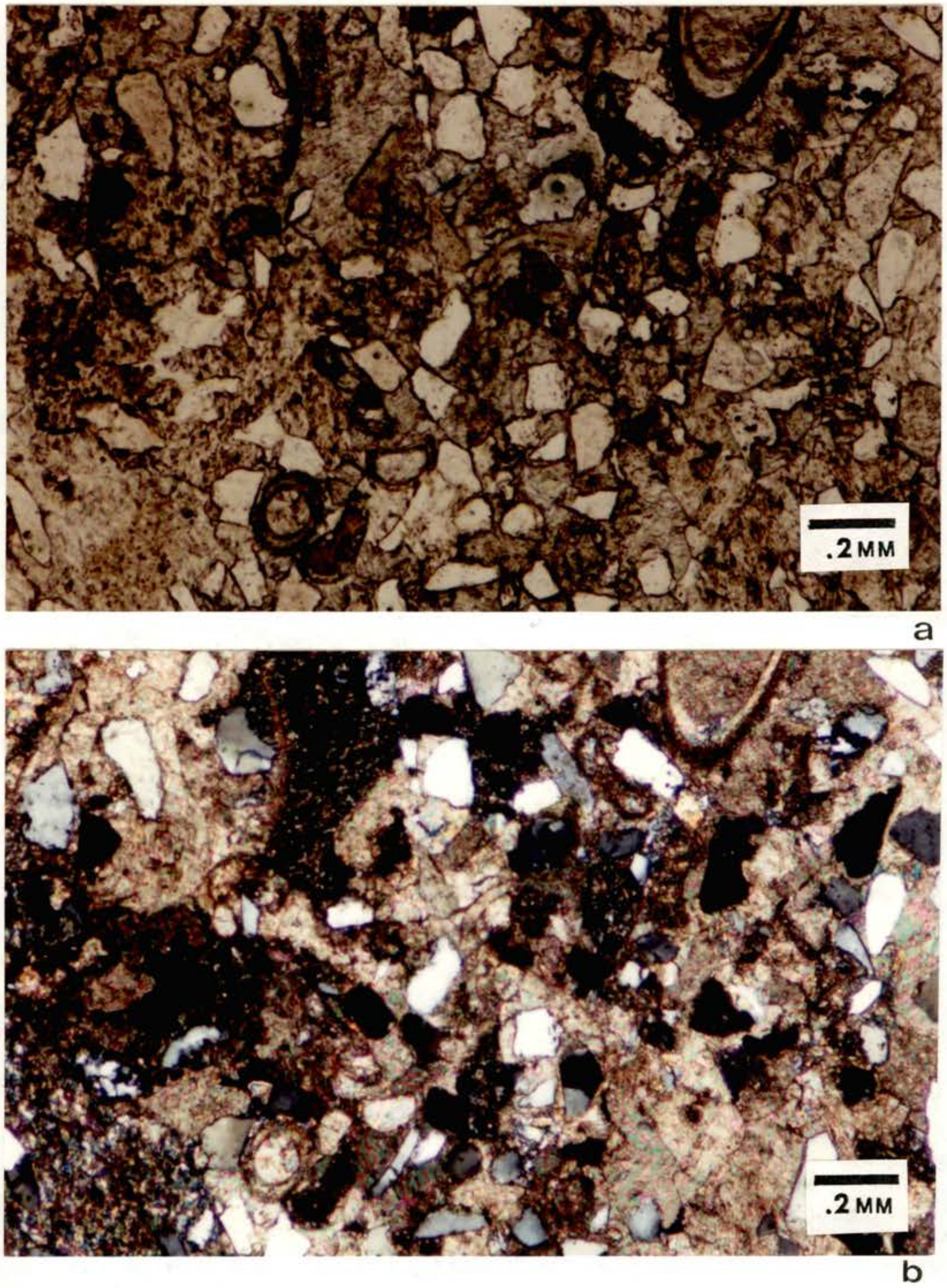


Figure 7. Pink limestone shelf-carbonate facies. Very fine to fine sand grains, silt, and microspar with echinoid fragments. Wessely, Clark No. 1-A. Depth 9496 feet. a) (ppl) b) (cpl)

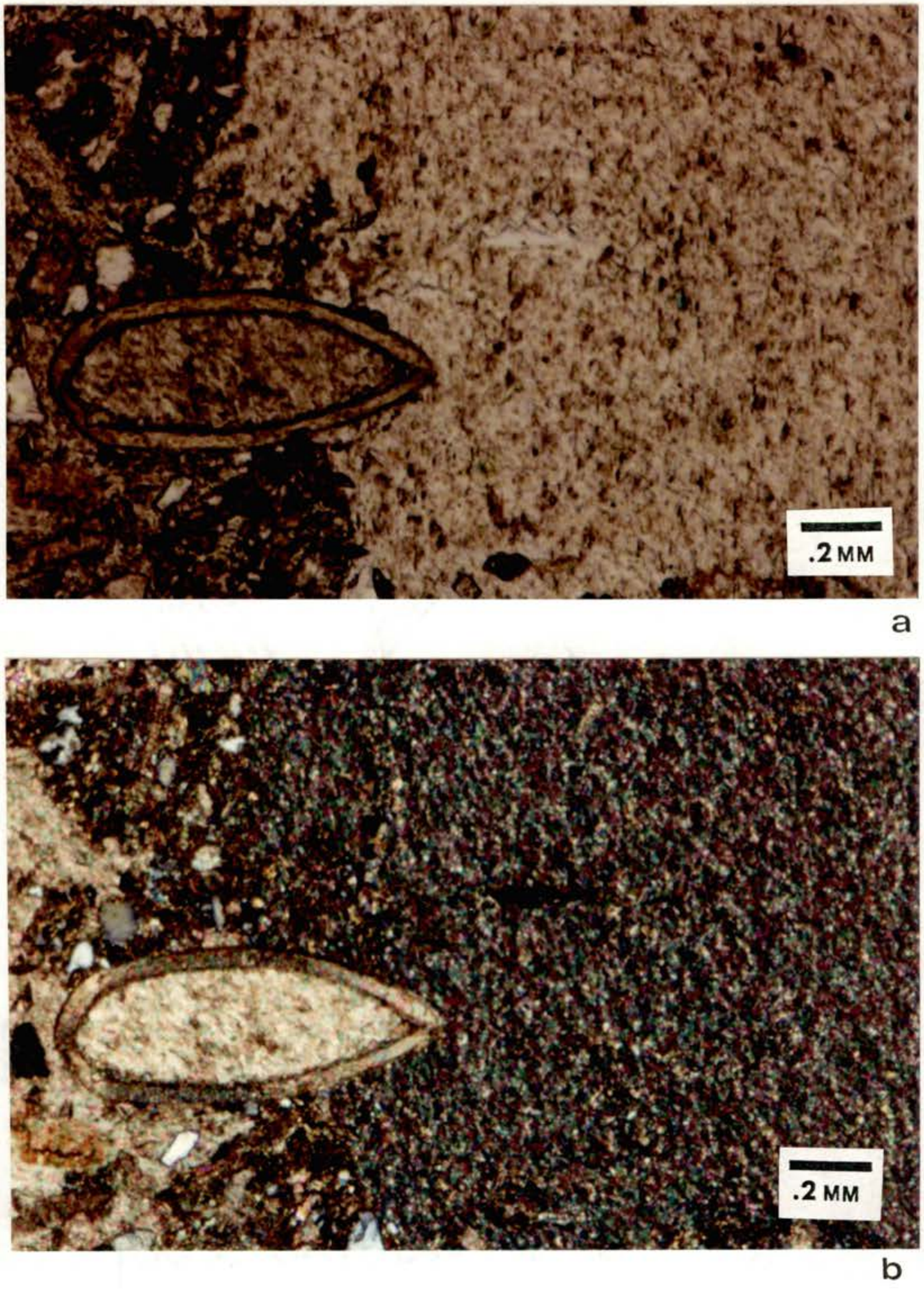


Figure 8. Pink limestone shelf-carbonate facies. Ostracode fragment and coarsely crystalline sparry calcite. Wessely, Clark No. 1-A. Depth 9498 feet. a) (ppl) b) (cpl)

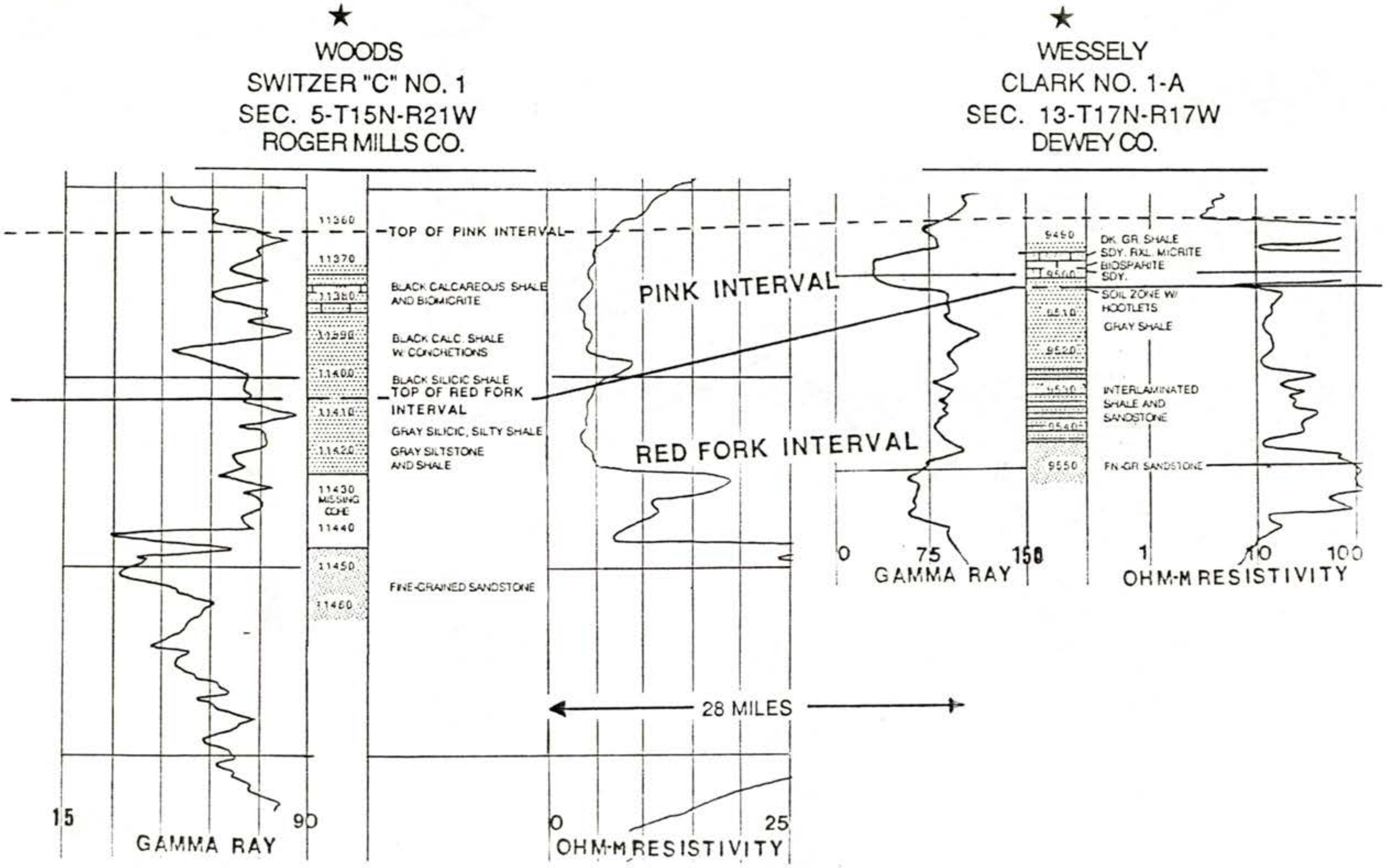


Figure 9. Pink limestone log facies and lithofacies changes in the transition from shelf to slope setting.

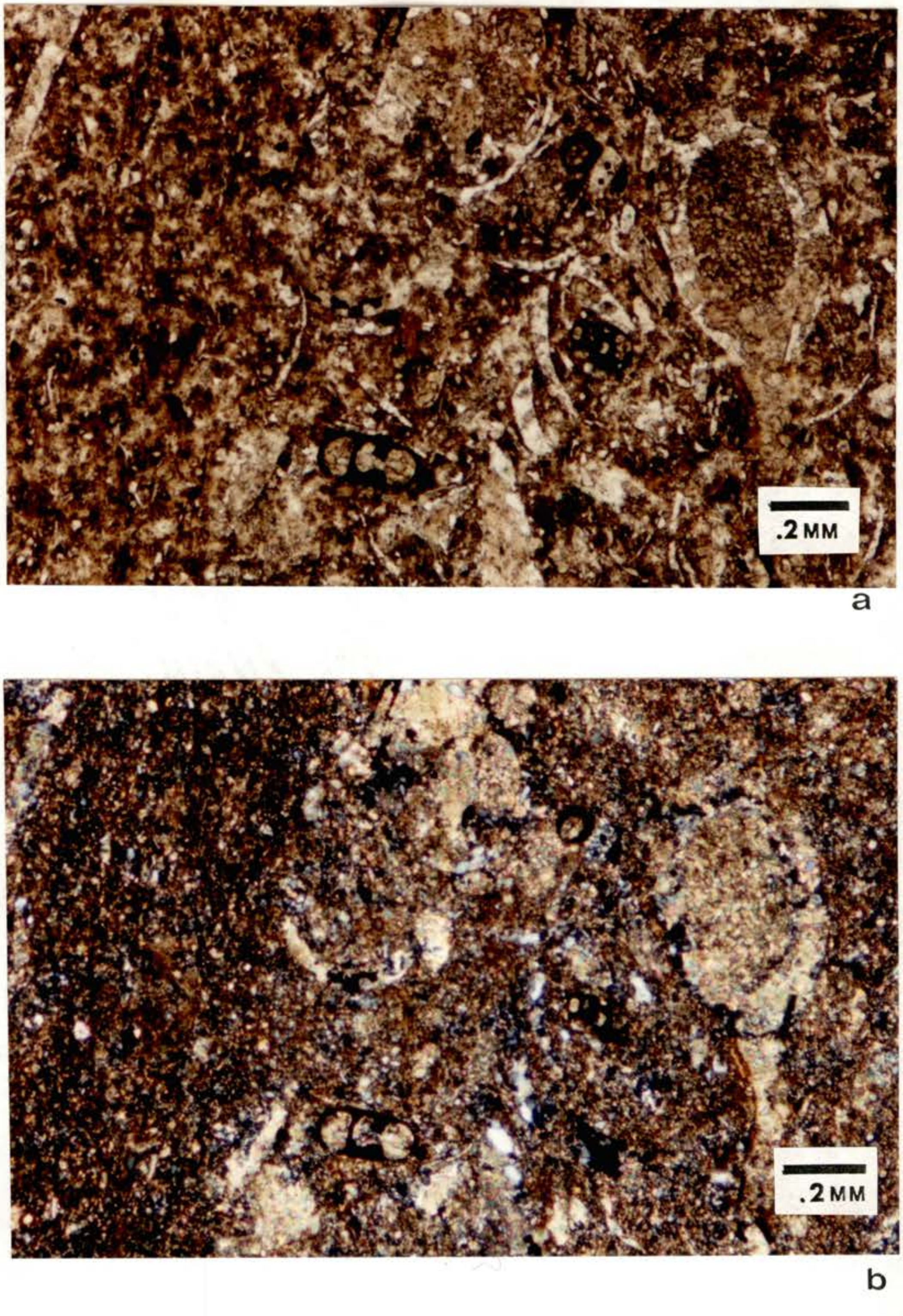


Figure 10. Pink limestone slope-carbonate facies. Trilobite and gastropod fragments in siliceous micrite matrix. Woods, Switzer "C" No. 1. Depth 11378 feet. a) (ppl) b) (cpl)

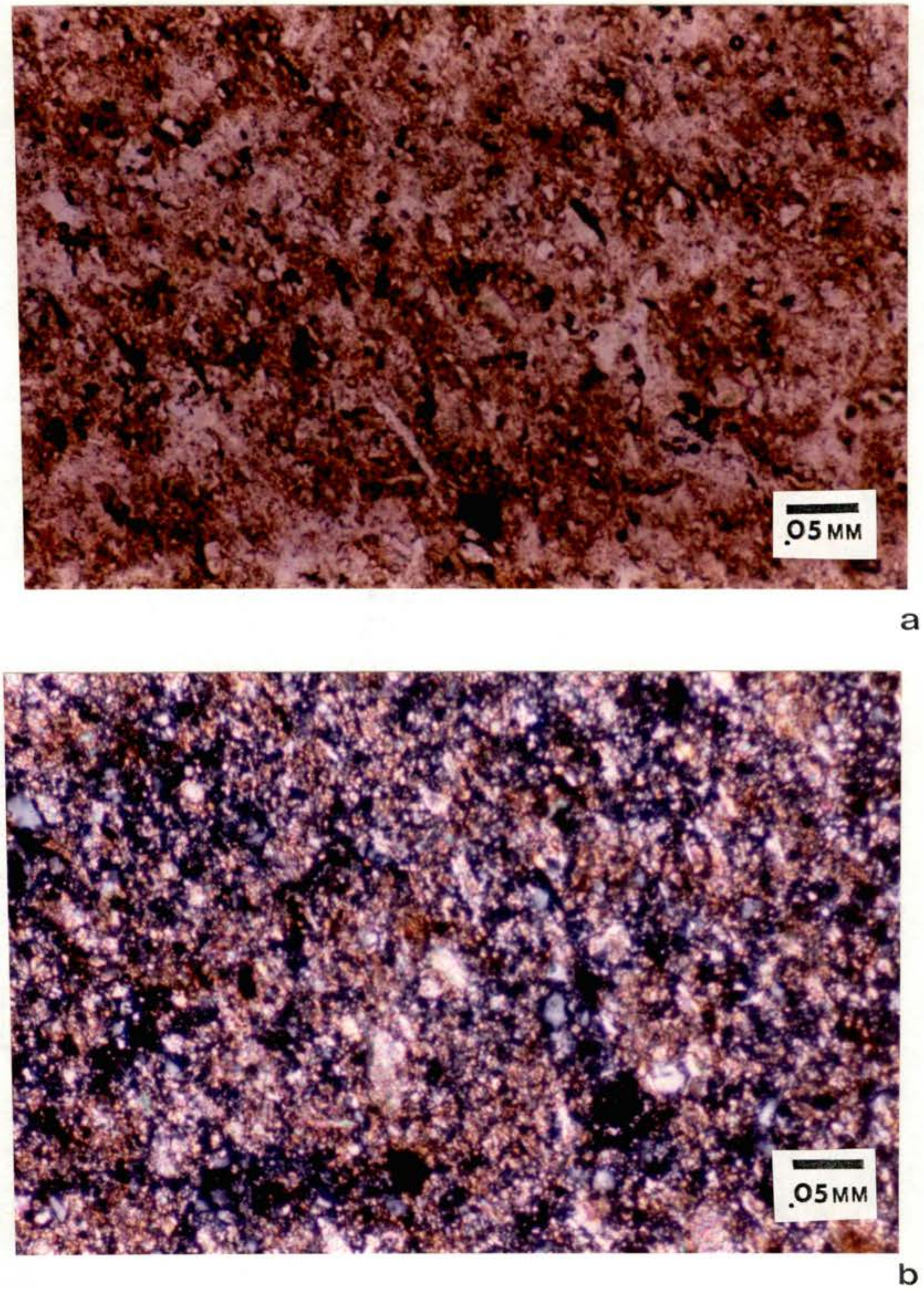


Figure 11. Pink limestone slope-carbonate facies. Muddy micrite or calcareous mudstone. Woods, Switzer "C" No. 1. Depth 11385 feet. a) (ppl) b) (cpl)

distribution of mapped facies and interpreted depositional setting are shown in Figures 6 and 7. The Pink limestone interval in the Wessely 1-A Clark core is from the general carbonate-producing zone (Figure 12). The Pink limestone interval represented in the Woods, Switzer "C" No. 1 core is from the lower limit of the carbonate producing zone and near the base of the effective photic zone (Figure 12). Black shale associated with this deeper water facies indicates a sufficient increase in water depth to create anoxic conditions and preserve organic material.

Lower Skinner

Lower Skinner Sandstone

The sparseness of sandstone prevented mapping of trends in the Lower Skinner interval. Wire-line logs of Lower Skinner sandstones exhibit several characteristic profiles including (1) fining-upward sequences, (2) coarsening-upward sequences, and (3) sandstone-shale sequences with no discernible trend. Widths of these sandstone units are believed to be less than one mile. Extensive deposits of Lower Skinner interval Granite Wash arkose are in T.11N., R.22W. and R.23W. and T.12N., R.22W. and R.23W.

Lower Skinner Carbonate

Lithofacies and Log Facies.

The Skinner interval in the northwestern portion of the

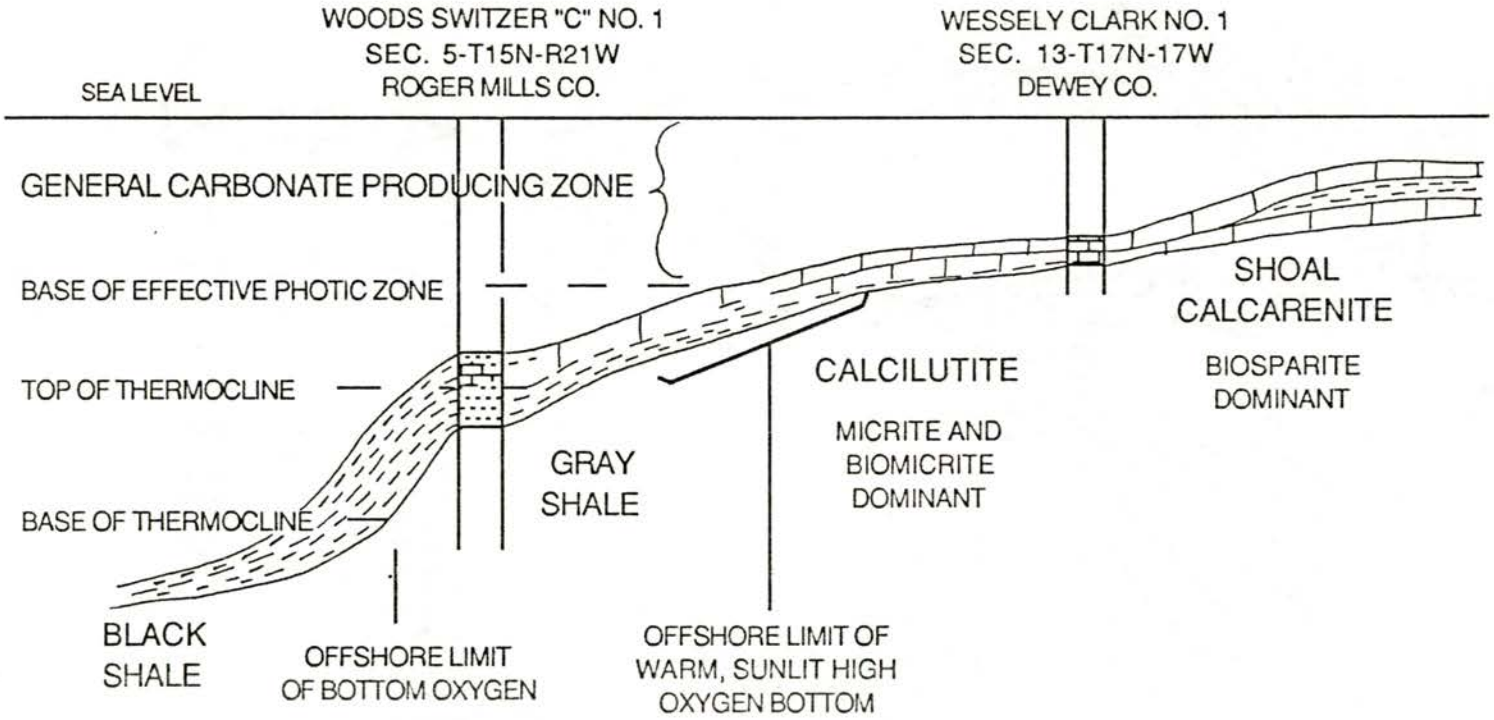


Figure 12. Schematic of Pink carbonate deposition on a sloping shelf (after Heckel, 1986).

study area is dominated by micrite and biomicrite (Folk, 1962) or mudstone (Dunham, 1962) lithologies. These sequences often indicate a general coarsening-upward log character (Figure 13). Sparry calcite cemented fossiliferous wackestone to packstone occur in the upper part representing a typical peritidal shoaling-upward sequence. Gamma ray deflection of 30 A.P.I. units from the shale base line was used to distinguish carbonate from shale, while well sample cuttings were used to distinguish carbonate from sandstone.

Distribution.

Skinner mudstone facies sequences (Figure 14) trend north-south to northeast-southwest and have a length of 18 to 24 miles. The width of these sequences is 5 to 12 miles. They are best developed in T.15N., R.22W. and T.15N., R.23W. where a maximum aggregate thickness of carbonate interval is observed. Individual mudstone sequences range from 20 to 75 feet in thickness, while total aggregate thickness reaches 350 feet. The uppermost sequence is distinctly thicker than the middle and lower carbonate sequences (Figure 14).

These sequences generally exhibit very gradational basal and lateral contacts, and sharp upper contacts (Figure 13).

Environments of Deposition.

Paucity of data makes interpretation of depositional environment for the Skinner carbonate sequences tenuous at

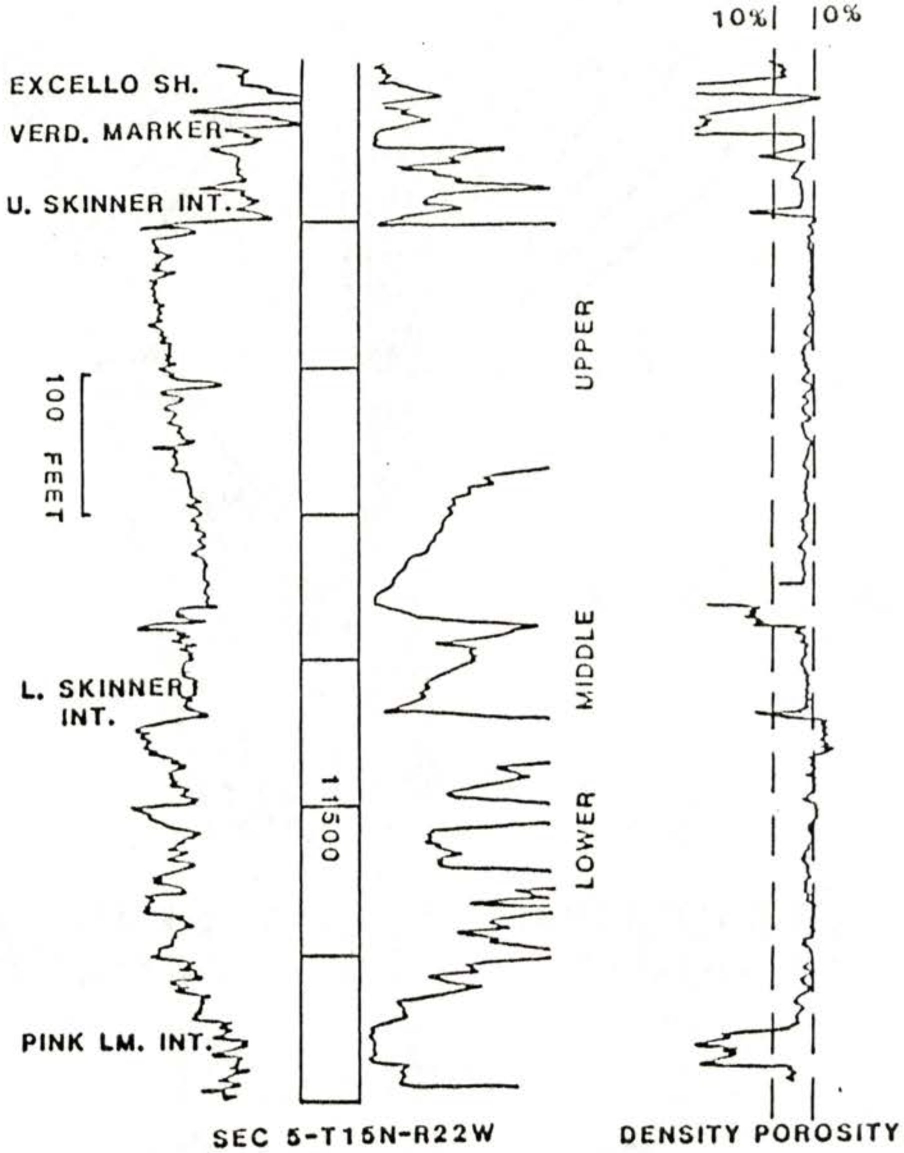


Figure 13. Gamma-ray, resistivity, and porosity log character of Skinner carbonate sequence.

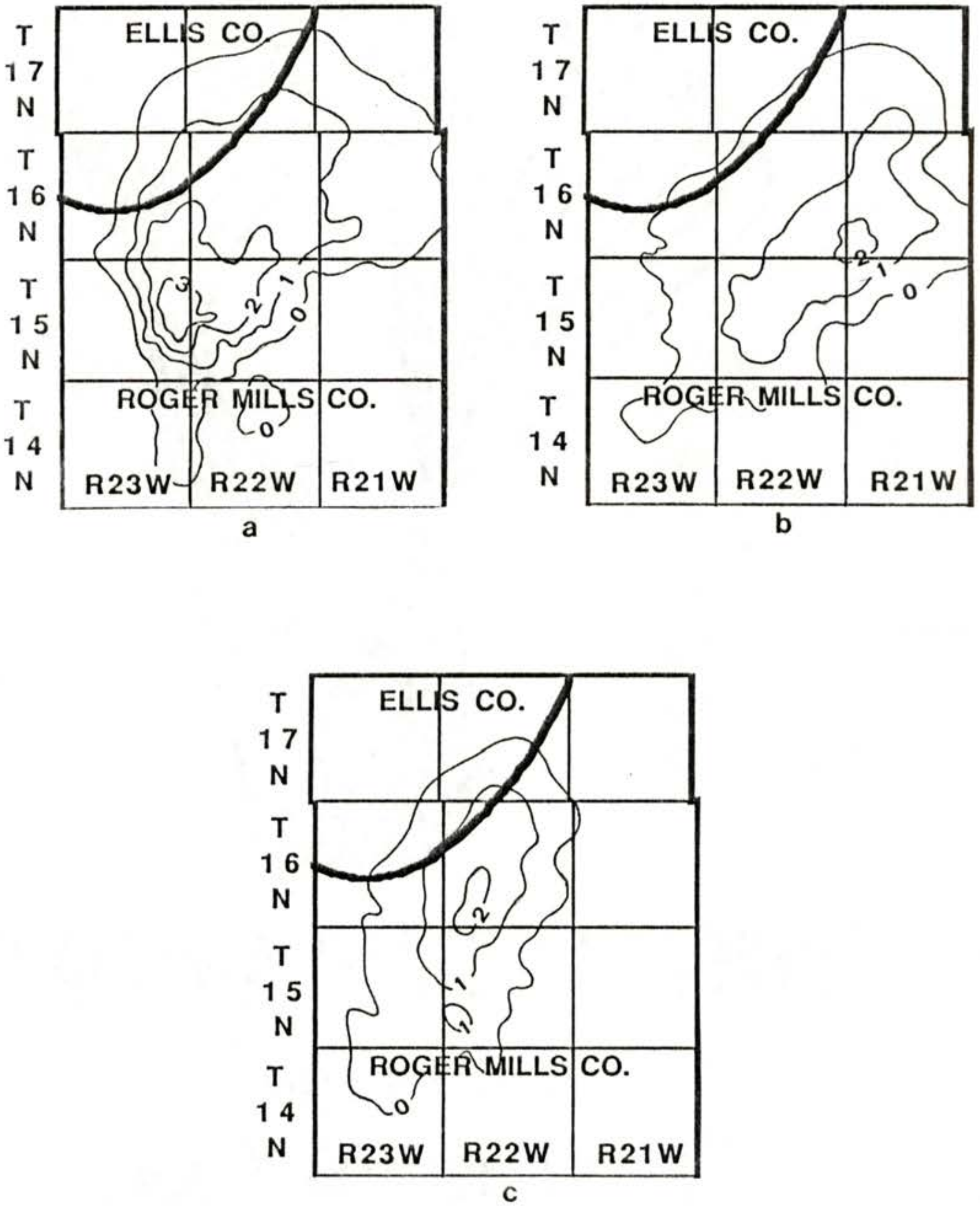


Figure 14. Distribution and thickness of principal Skinner carbonate sequences. Contour interval is 100 feet. Index numbers on contour lines should be multiplied by 100. a) upper b) middle c) lower

best. However, the log character combined with lithological data suggest deposition on a ramp for these carbonates. They are basically peritidal shoaling-upward sequences which may have been deposited along the possible shelf to slope break indicated by thickening of the Cabaniss interval.

Upper Skinner Sandstone

Introduction

Three dominant types of sandstone and interbedded sandstone-shale sequences are recognized in the Upper Skinner interval. These three types are (1) fining-upward sandstone sequences, (2) interbedded sandstone-shale sequences showing upward fining due to increase in shale content, and (3) interbedded sandstone-shale sequences showing coarsening upward due to an increase in sand size grains. The first two types of sandstones typically exhibit sharper basal contacts, while the third type exhibits a sharp upper contact. Type logs of gamma ray-porosity-resistivity for these three sequences are shown in Figure 15. Plate IV shows the total thickness of the sequences.

Fining-Upward Upper Skinner Sandstones

Geometry and Distribution.

Sandstones with overall fining-upward units have a primary northwest-southeast to east-west trend, and secondary northeast-southwest trends. The primary trend

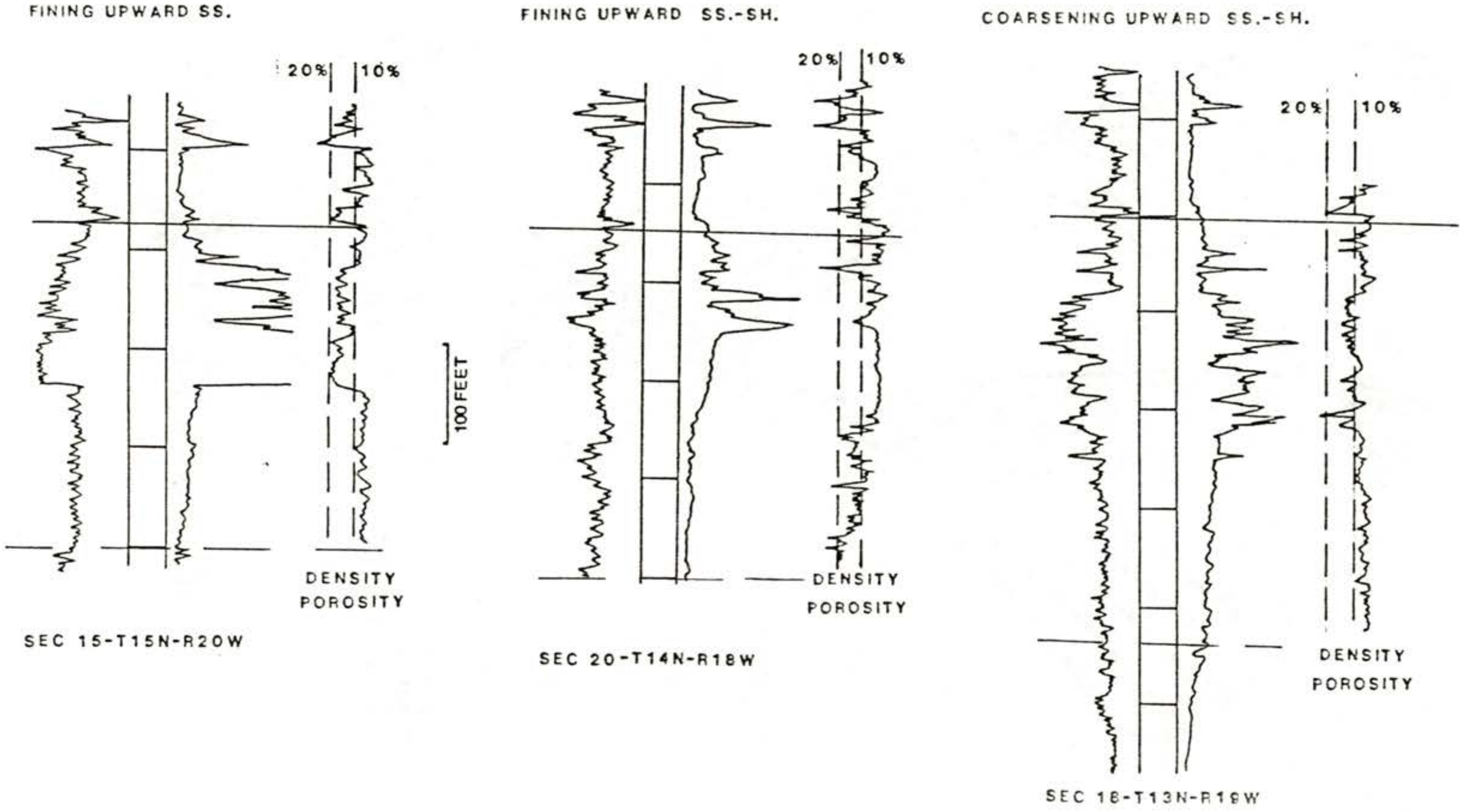


Figure 15. Gamma-ray, resistivity, and porosity log character of principal Upper Skinner sandstone and sandstone-shale sequences.

extends northwest-southeast some 25 miles across the study area from T.13N., R.16W. to T.15N., R.20W., and east-west another 20 miles from T.15N., R.20W. to T.15N., R.23W. (Figure 16). The width of the sandstone units ranges from a minimum .75 mile to a maximum of 2.0 miles.

Upper Skinner fining-upward sandstones are best developed in the Moorewood Field area in T.15N, R.20W. where net (reservoir) thickness of Upper Skinner sandstone ranges from 0 to 110 feet, and total sandstone thickness of 150 feet is attained. Net (reservoir) sandstone is defined as units with gamma ray deflections greater than 45 A.P.I. units and neutron-density porosity greater than 10%. Single unit thicknesses range from 10 to 30 feet, while "stacked" multistoried sandstones can reach a thickness of 150 feet.

These sandstones are elongate, lenticular units exhibiting sharp basal and sharp to gradational lateral contacts. The upper contacts are almost all gradational. Locally correlatable markers are absent in wells with thick fining-upward sandstones, inferring downcutting prior to deposition of the sandstone.

Fining-Upward Interbedded Sandstone-Shale Sequences

Geometry and Distribution.

These sandstone-shale sequences trend northwest-southeast, east-west, and northeast-southwest. Dominant trends are northwest-southeast and east-west, closely

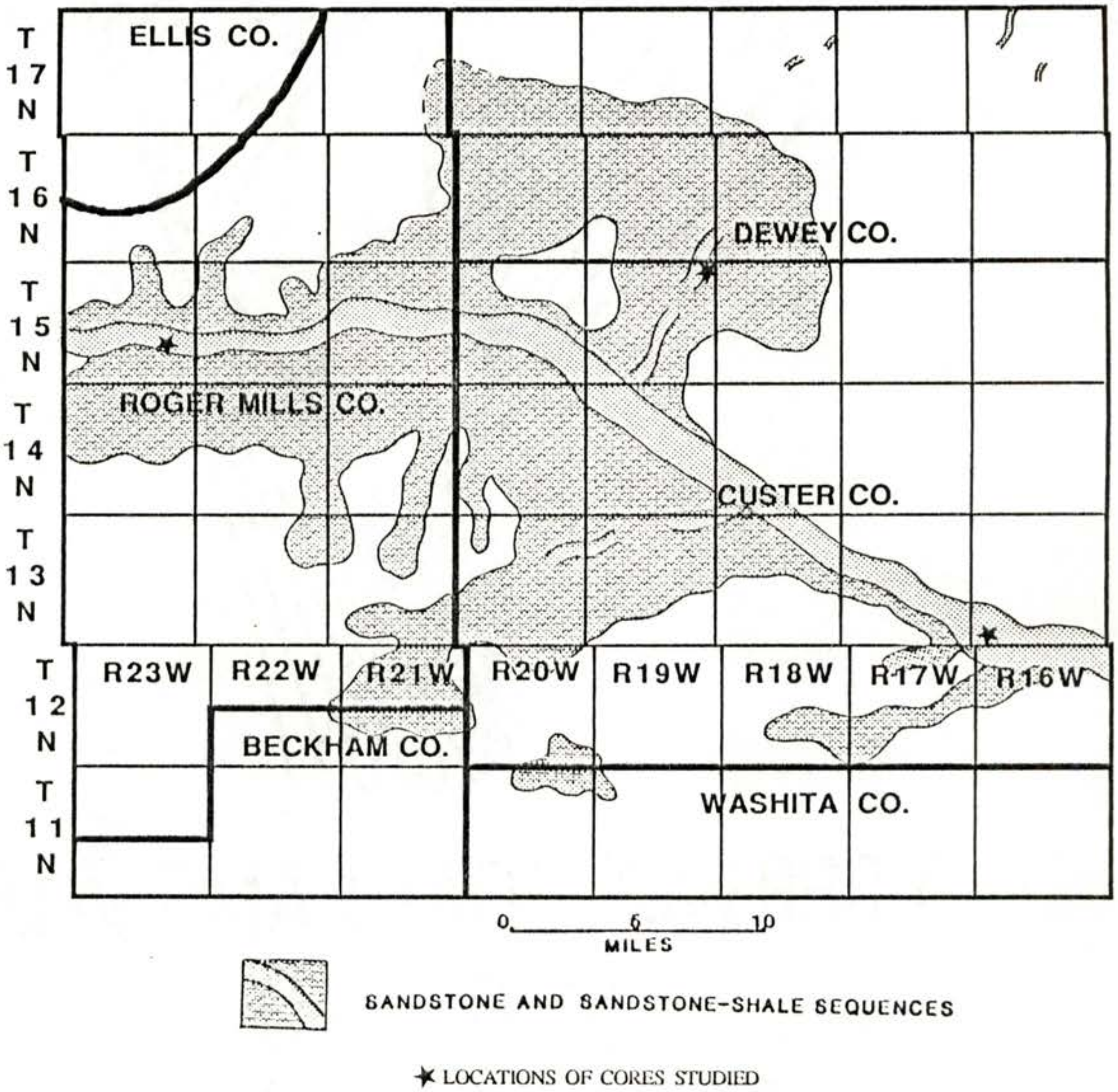


Figure 16. Distribution of Upper Skinner fining-upward sandstone and sandstone-shale sequences.

resembling the pattern of the Upper Skinner fining-upward sandstones. The dominant northwest-southeast trend extends 45 miles across the study area subparallel to the primary fining-upward sandstone trend. The width of these interbedded sandstone-shale sequences ranges from a minimum of .75 mile to a maximum of approximately 12 miles (Figure 16).

Fining-upward sandstone-shale sequences are 50 to 150 feet thick with a general increase in thickness to the south and west. They are defined on logs as having gamma ray deflections greater than 15 A.P.I. units from the shale base line. Corresponding to the gamma ray deflection is an increase in resistivity greater than 10 ohm-m over the resistivity of the shale base line.

Fining-upward sequences are elongated, somewhat lenticular bodies exhibiting sharp to slightly gradational basal contacts, with sharp and gradational lateral contacts. Upper contacts tend to be very gradational.

Coarsening-Upward Interbedded Sandstone-Shale Sequences

Geometry and Distribution.

These sequences display dominant northeast-southwest trends with significant east-west and southeast-northwest secondary trends. The dominant trends are approximately 14 to 20 miles in length while the secondary trends are 6 to 10 miles. The width of both trends ranges from 2 to a maximum of 5 miles (Figure 17).

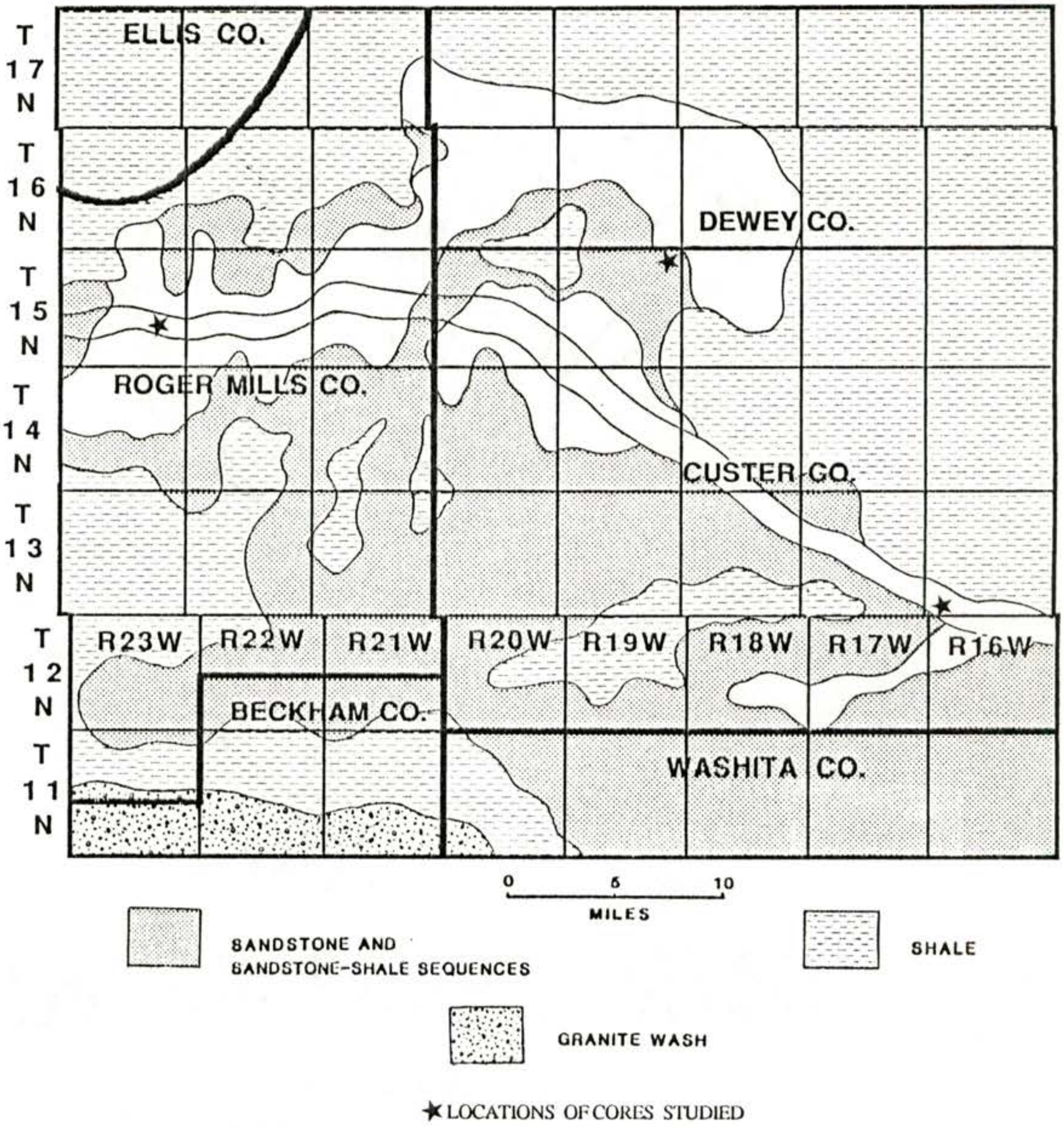


Figure 17. Distribution of Upper Skinner coarsening-upward sandstone, sandstone-shale sequences, shale, and Granite Wash.

Coarsening-upward sandstone-shale sequences are best developed in T.13N., R.19W. and T.13N., R.20W., with extensive development of "clean" sandstone. Total thickness of these sequences ranges from 0 to 250 feet with a general increase in thickness toward the southwest. Coarsening-upward sequences are defined by gamma ray deflection of 15 A.P.I. units from the shale base line and corresponding increases in resistivity.

These sequences were deposited as elongate to lobate bodies. They have very gradational lateral and basal contacts. Upper contacts are usually sharp and often occur along another sandstone type observed in the study area.

Arkosic Granite Wash Facies

Geometry and Distribution.

Granite Wash fan-delta complexes were deposited along the southern boundary of the study area (Figure 17). These fan-delta complexes are composed of detritus shed from the rising Wichita Mountain Uplift. Though some Granite Wash arkose sequences were apparently deposited contemporaneously with the Upper Skinner sandstones and shales of the study area, they are not genetically related. The Granite Wash log facies identified on wire-line logs represents the proximal fan-delta facies. Distal fan-delta facies are not recognized on wire-line logs and likely extend miles beyond the mappable Granite Wash log facies. The influence of Granite Wash deposition on the composition of the Upper Skinner Sandstone within the study area will be discussed in Chapter VIII titled "Petrology and Diagenesis of Reservoir Rocks."

Locations of Cores

Three cores of Upper Skinner sandstone intervals were examined to determine the lithology types, constituents, grain size, and sedimentary structures. Analysis of bed contacts and vertical features characteristic of sequences were essential in interpretation of the depositional environments. In addition, close correlation of cores and respective logs has provided sufficient information to identify various lithofacies in the Upper Skinner Sandstones. The cores are the Harper, Merrick No. 1-23 in Section 23 T.15N., R.23W., Santa Fe, Williams No. 1-31 in Section 31 T.13N., R.16W., and Barnes, Walker "B" No. 1 in Section 1 T.15N., R.19W. The locations of these cores are represented by stars on Figures 16 and 17.

Sedimentary Structures of Sandstones

The more common sedimentary structures observed in the Upper Skinner Sandstone are listed in approximate order of abundance. These are (1) medium scale trough and planar cross bedding, (2) ripple laminae, (3) channel lag features (rip-up clasts), (4) massive bedding, (5) interstratified sandstone and shale, (6) soft sediment deformation including slumping and faulting, (7) horizontal lamination, and (8) burrowing. Calcareous nodules were observed at the top of one sandstone interval.

A typical sequence through an Upper Skinner fining-upward sandstone unit is shown in Figure 18. The sequence consists of lower dark gray shale in sharp contact with massive to cross-bedded sandstone with channel lag features. It grades upward into ripple-laminated muddy sandstone and horizontal laminated interstratified sandstone and shale. Burrows, flowage, slumping, and soft sediment deformation features occur in the upper zone. Photographs of some of these features are shown in Figures 19, 20, 21, and 22. Calcareous nodules were observed at the top of the sandstone sequence in the Harper, Merrick No. 1-23. This zone is adjacent to interbedded sandstone and shale and only 1 foot above the uppermost sandstone in the sequence. These nodules appear to have formed in situ and represent a calcrete or caliche zone (Figure 23).

Fossils

Carbonaceous plant fragments were the only fossils observed within the Upper Skinner sandstone interval. The shale associated with the calcareous nodule zone in the Harper, Merrick No. 1-23 contains echinoderm fragments, while the dark gray shale above this interval contains crinoid and brachiopod fragments, indicating marine origin. However, the latter shale is likely a part of the sequence associated with the Verdigris Limestone interval transgression. The dark gray shale beneath the Upper Skinner Sandstone in the Santa Fe, Williams No. 1-31, and

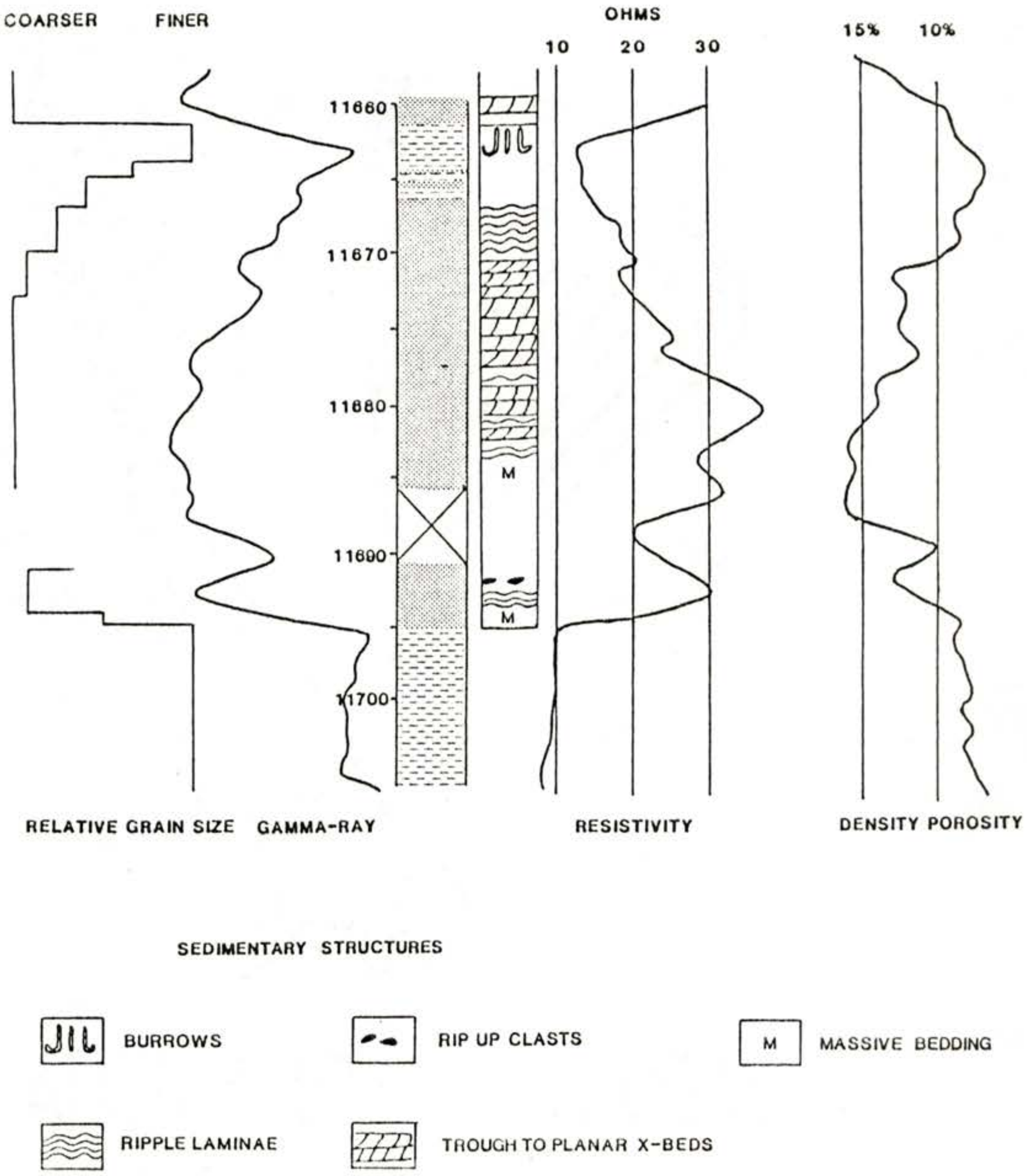


Figure 18. Fining-upward Upper Skinner sandstone unit from Santa Fe, Williams No. 1-31.

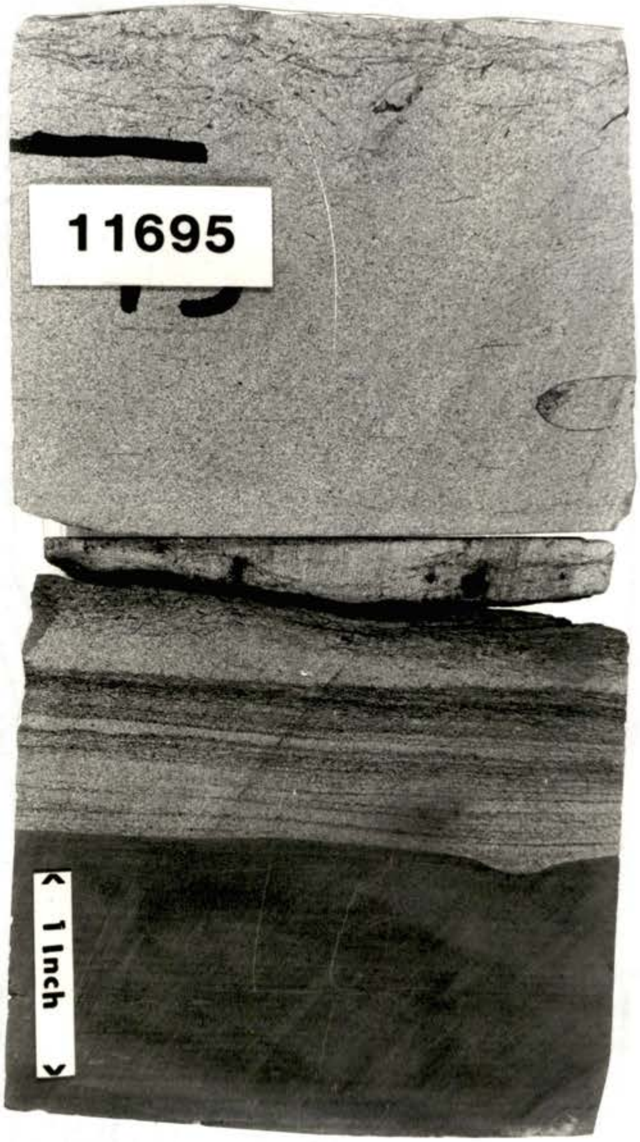


Figure 19. Sharp basal contact between sandstone and shale. Santa Fe, Williams No. 1-31.

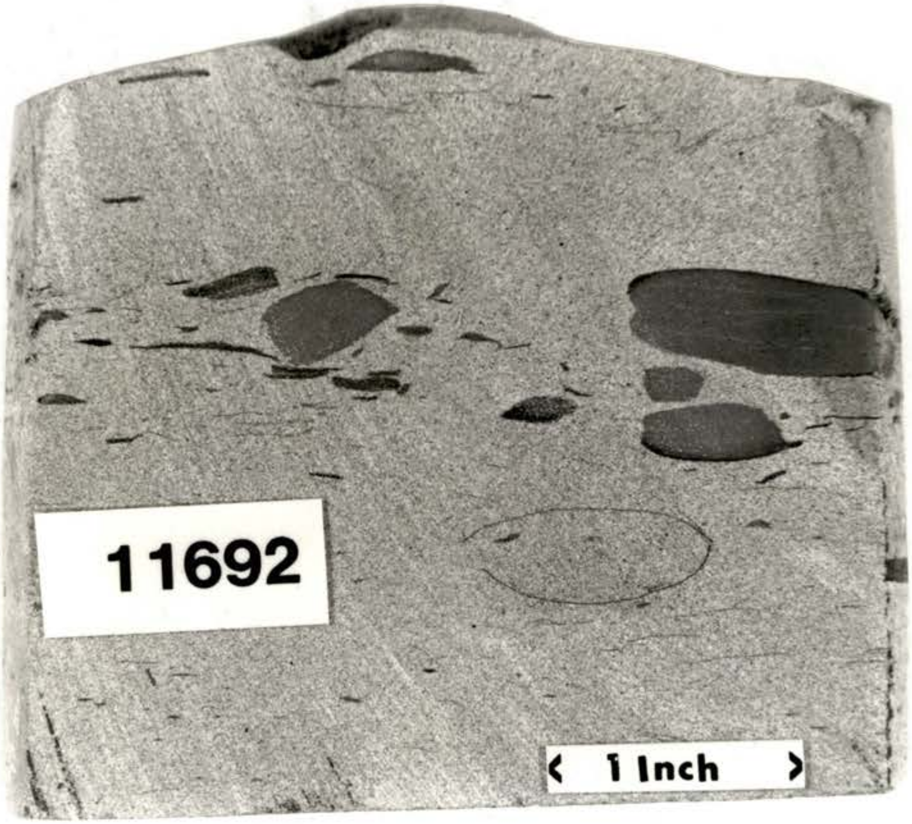


Figure 20. Channel lag features (rip-up clasts) in sandstone. Santa Fe, Williams No. 1-31.

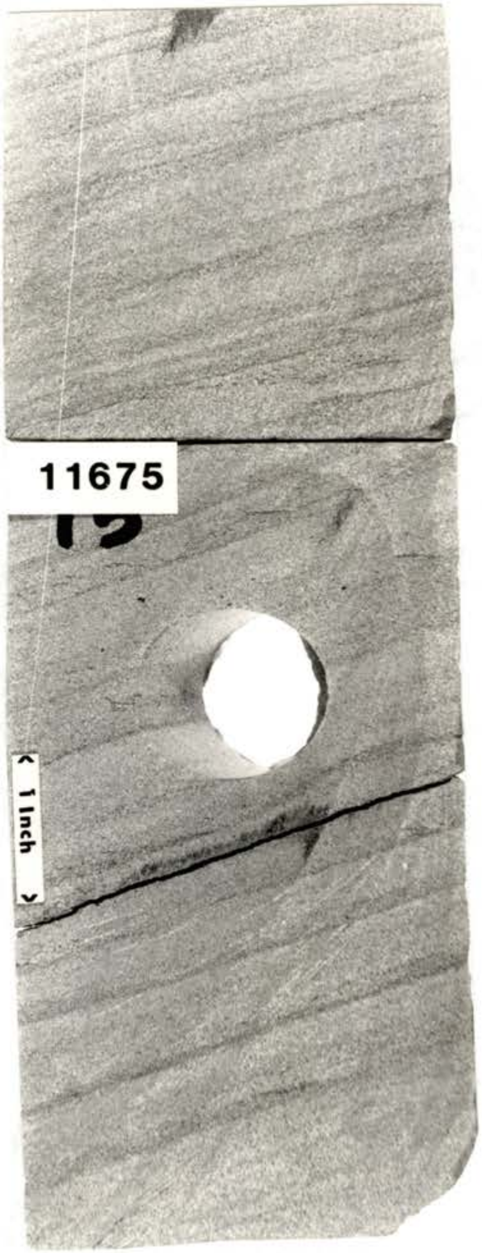


Figure 21. Medium-scale tabular cross-beds. Santa Fe, Williams No. 1-31.

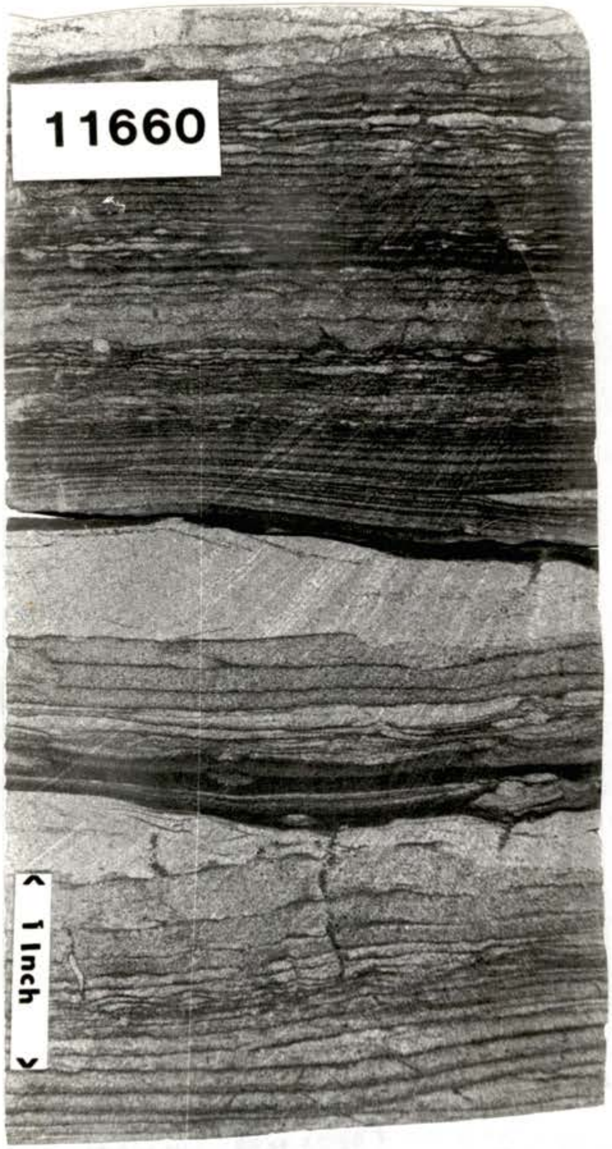


Figure 22. Interstratified shale, siltstone and sandstone (burrowed). Santa Fe, Williams No. 1-31.

the interbedded and shale intervals above and below the sandstone in the Barnes, Walker "B" No. 1, are apparently void of fossils.

Environments of Deposition

Fluvio-deltaic and shallow marine environments have been proposed as depositional models for the Skinner sandstones in the Northern Oklahoma Platform, Nemaha Ridge and Central Oklahoma Platform areas (Ahmedduddin, 1963; Berg, 1969; Zeliff, 1976; Pulling, 1979; and Lojek, 1983). Core and log evidence from the study area indicates that the Upper Skinner Sandstone was deposited in a lower delta plain and shallow marine setting. One interpretation is that the Upper Skinner Sandstone is representative of syndepositionally deposited primary distributary channel sandstone and associated splay, interdistributary bay, and delta fringe facies. An alternate interpretation is that the Upper Skinner is represented by syndepositional deltaic and shallow marine sedimentation, but the primary channel trend resulted from channel-fill of a later river that incised the existing sediments.

The net-sandstone thickness map (Figure 24) shows a primary linear trend that extends northwest-southeast and then east-west. A secondary trend that extends southwest-northeast in T.13N., R.19W. may be a bifurcation of the primary channel trend. It also may be an unrelated trend of a different age. The dominant northwest-southeast sandstone trend is subparallel to structural-depositional

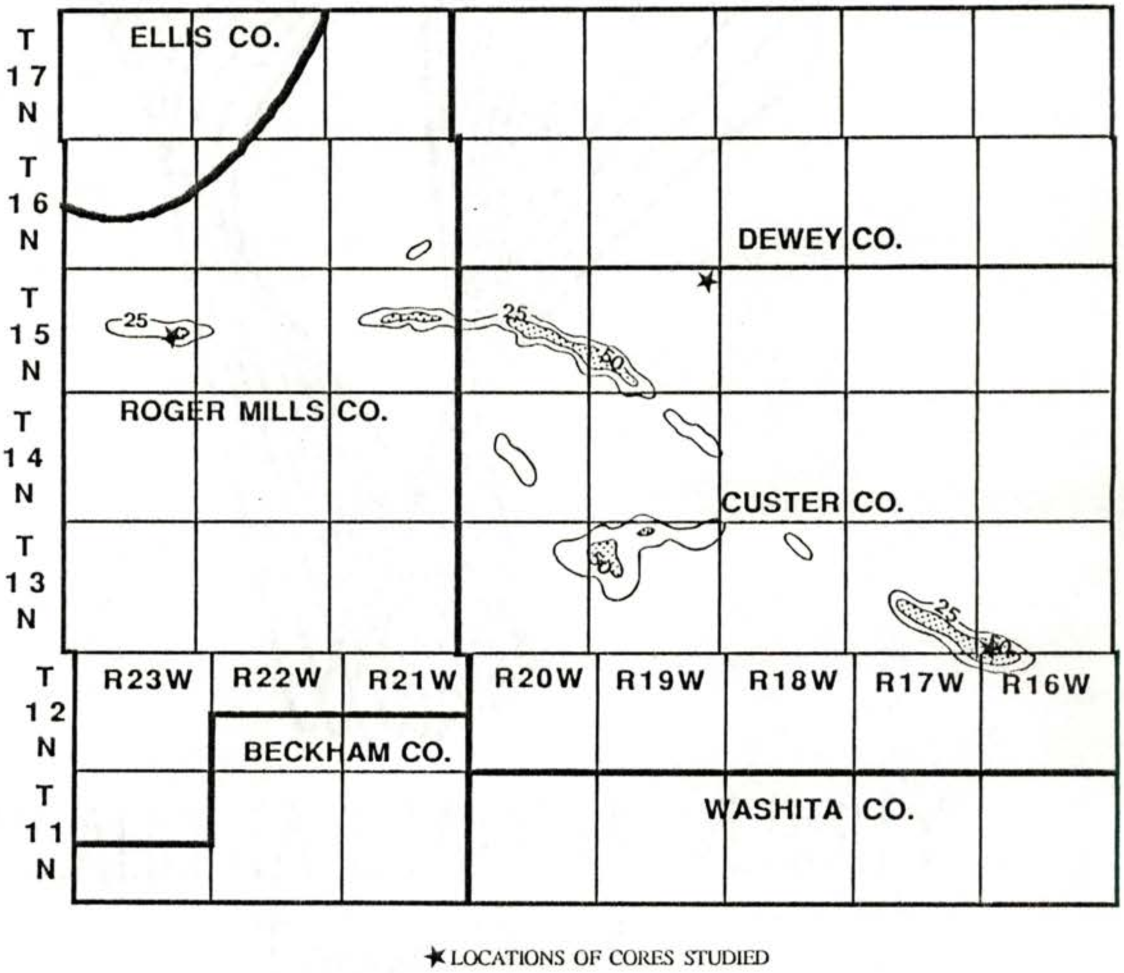


Figure 24. Upper Skinner Sandstone net-thickness map. Contour interval is 25 feet.

paleostrike. It then turns westward and becomes geometrically normal to the paleostrike (Figure 5). The secondary trend in T.13N., R.19W. is at a high angle to perceived paleostrike as would be expected for a distributary channel. Upper Skinner sandstone cores in Section 31, T.13N., R.16W. and Section 23, T.15N. R.23W. are located in the primary sandstone trend (Figure 24). The wire-line log signatures of the cored interval have blocky to bell-shaped fining-upward log character. A third core in Section 1, T.15N., R.19W. is outside the primary trend and contains a subtle coarsening-upward sandstone-shale sequence followed by a fining-upward sandstone-shale sequence.

The Santa Fe, Williams No. 1-31 core in Section 31, T.13N., R.16W. exhibits fining-upward character and contains both underlying and overlying shale intervals. The Harper, Merrick No. 1-23 in Section 23, T.15N., R.23W. has similar log character to the lower portion of the Santa Fe, Williams No. 1-31. These two sandstones are believed to be very similar though the basal contact of the sandstone in the Harper, Merrick No. 1-23 was not cored.

The lowermost lithology observed in the Santa Fe, Williams No. 1-31 core is dark shale that is apparently void of fossils. The contact between the dark shale and the lowermost sandstone is sharp (Figure 19). Rip-up clasts (Figure 20) occur in the lower sandstone units in both the Harper, Merrick No. 1-23 and Santa Fe, Williams No. 1-31 cores. The basal sandstone is overlain by massive and predominantly planar and trough cross-bedded sandstone (Figure 21). The overlying ripple-bedded sandstones grade into interbedded sandstones and shales and interlaminated sandstone, siltstone, and shale intervals (Figure 22).

The top of the multistoried sequence in the Harper, Merrick No. 1-23 core is a fossiliferous shale with a calcrete zone. This calcrete or caliche indicates the the top of this interval experienced subaerial exposure prior to the Verdigris transgression. In the Santa Fe, Williams No. 1-31 core, interbedded and interlaminated zones extend another 30 to 40 feet.

The core from the Barnes, Walker "B" No. 1 in Section 1, T.15N., R.19W. is very different from the other two Upper Skinner cores. It is dominated by interbedded and interlaminated sandstone, siltstone, and shale with minor thin sandstone units. This interval is burrowed and contains many soft-sediment deformational features. The basal contact is very gradational with underlying dark gray shale, while the upper contact of the interval is not well defined. The lower part of this core is very similar to delta-margin or distal-delta front facies (Brown, Cleaves, and Erxleben 1975).

Based on sedimentary structures, texture, and geometry, the sandstone in the Santa Fe, Williams No. 1-31, is believed to represent a multistoried channel-fill sandstone. The lower lithologies (dark shales) of the cored intervals in the Barnes, Walker "B" 1 and Santa Fe, Williams No. 1-31 were interpreted to be interdistributary bay or distal delta front deposits. The overlying sandstone and burrowed, interbedded sequences in the Barnes, Walker "B" No. 1 core may represent crevasse splay deposits. The proximity of the Barnes, Walker "B" No.1 to an apparent minor channel trend (Figure 16), favors splay deposition for the upper part of this core. The Harper, Merrick No. 1-23 can be interpreted as a distributary channel-fill or incised valley-fill sandstone. The fossiliferous shale containing calcrete at the top of the Upper Skinner Sandstone interval indicates minor inundation and subaerial exposure occurred following sandstone deposition. This caliche zone may have formed as the result of a minor rise and subsequent extended drop in sea level following channel fill. Long periods of subaerial exposure prior to the Verdigris Limestone interval transgression created conditions favorable for caliche formation.

Verdigris Limestone Interval

The Verdigris Limestone interval includes the Verdigris "hot" shale and the Verdigris Limestone (Figure 4). The Verdigris "hot" shale, which appears to correlate to the Oakley "core" shale (Heckel, 1987) (Ross and Ross, 1987), is traceable from the Central Oklahoma Platform to the frontal zone of the Wichita Mountains where arkosic facies of the Granite Wash fan deltas are encountered.

Lithofacies and Log Facies

The only part of the Verdigris interval that was cored and available for study was a few feet of the shale immediately above the Upper Skinner caliche zone in the Harper, Merrick No. 1-23 well. This zone consisted of dark grey marine shale with abundant brachiopod and enchinoderm fragments. Examination of well cuttings from the Verdigris interval indicates the dominant lithofacies are dark-grey to black shale and mudstone (Folk, 1970) or micrite (Dunham, 1970). Verdigris interval arkosic facies were not examined.

Distribution and Environments of Deposition

The mappable ranges of the Verdigris Limestone "clean" and "muddy" log facies are shown in Figure 25. Based on the stratal relationship of the Verdigris Limestone and underlying "hot" shale, logfacies distribution, and limited lithofacies data, it is believed that the Verdigris Limestone was deposited in a similar basinal setting as the Pink Limestone. The distribution of the "clean" shelf carbonate and "muddy" slope-basin shale facies bears a strong resemblance to the Pink Limestone facies distribution (Figure 6). A change in basin configuration is indicated as the boundary separating the Verdigris Limestone "clean" shelf carbonate and slope-basin shale (and likely "muddy" carbonate) has moved shelfward (updip) approximately 6 miles from the location of the boundary

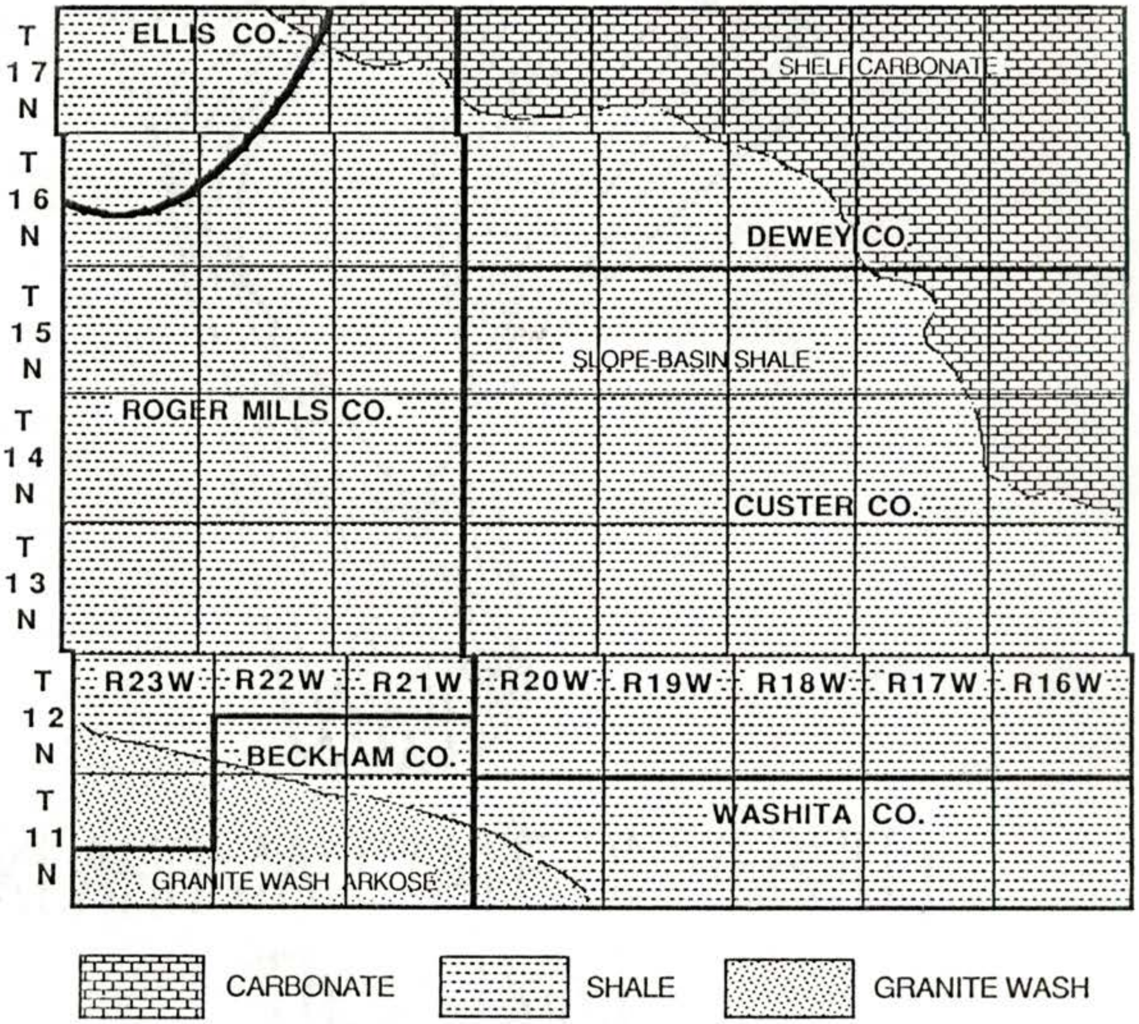


Figure 25. Log facies distribution of Verdigris Limestone and Granite Wash.

between similar Pink Limestone facies. The shelf-slope break represented by the change in Pink lithofacies and Verdigris log facies corresponds to a thickening of the Cabaniss Group format (Figure 5). This thickening infers that deeper water conditions caused by tectonics (slowing of the Wichita Orogeny) and/or eustacy are responsible for the thickening and facies changes observed in the Cabaniss Group sequence.

Prue

The Prue (Lagonda) Sandstone interval immediately overlies the Verdigris Limestone interval. In the study area, the Prue interval contains shale facies only. The Prue interval thins westward, indicating sediment-starved conditions and nondeposition (Figure 4) (Plate VI). On the Central Oklahoma Platform, the Prue interval is overlain by the Breezy Hill Limestone. This carbonate is believed to represent a transgressive limestone that signaled the initiation of the maximal transgression that deposited the Excello Shale. Within the study area, the Breezy Hill or its equivalents cannot be differentiated by log data, and the Cherokee "hot" (Excello) shale appears to conformably overlie shales of the Prue interval.

Excello (Cherokee "Hot") Shale

The Excello Shale conformably overlies the Breezy Hill Limestone on the Central Oklahoma Platform. Within the Anadarko Basin, the Excello Shale is commonly called the

Cherokee "hot" shale. The correlation of the Cherokee "hot" shale of the basin to the Excello "Core" Shale on the platform is shown in Figure 4. This cross section includes the Fort Scott (Oswego) Limestone interval and shows the basinward absence of carbonate facies beyond the Lower Fort Scott (Oswego) shelf-slope break in Dewey County. In basinal areas where the Fort Scott Limestone is absent, the entire Fort Scott interval may be represented by "core" shales. The Excello "Core" Shale of the Cabaniss Group and the Little Osage "Core" Shale of the Marmaton Group appear to combine to form a condensed section that is called the Cherokee "hot" shale. This condensed section would contain age-equivalent strata to the Cabaniss Excello Shale, and the Blackjack Creek Limestone (Lower Fort Scott), Little Osage Shale, and Higgensville Limestone (Upper Fort Scott) members of the Marmaton Fort Scott Limestone (Figure 4).

The Excello Shale is a marker unit on wire-line logs throughout the study area. The gamma ray log signature of the Excello Shale can be correlated from the outcrop in eastern Oklahoma to near the Wichita Mountain Uplift (Figure 26) (Plate V). Excello Shale logged within the Granite Wash interval indicates that some proximal fan-delta complexes were inundated by the Excello Sea (Fritz, 1989). The lack of extensive Excello Shale deposition within the Granite Wash log facies may indicate that the proximal fans were not fully inundated by the Excello Sea. It is also possible Excello Shale deposited within proximal fan deltas may have been eroded by subsequent fan channels.

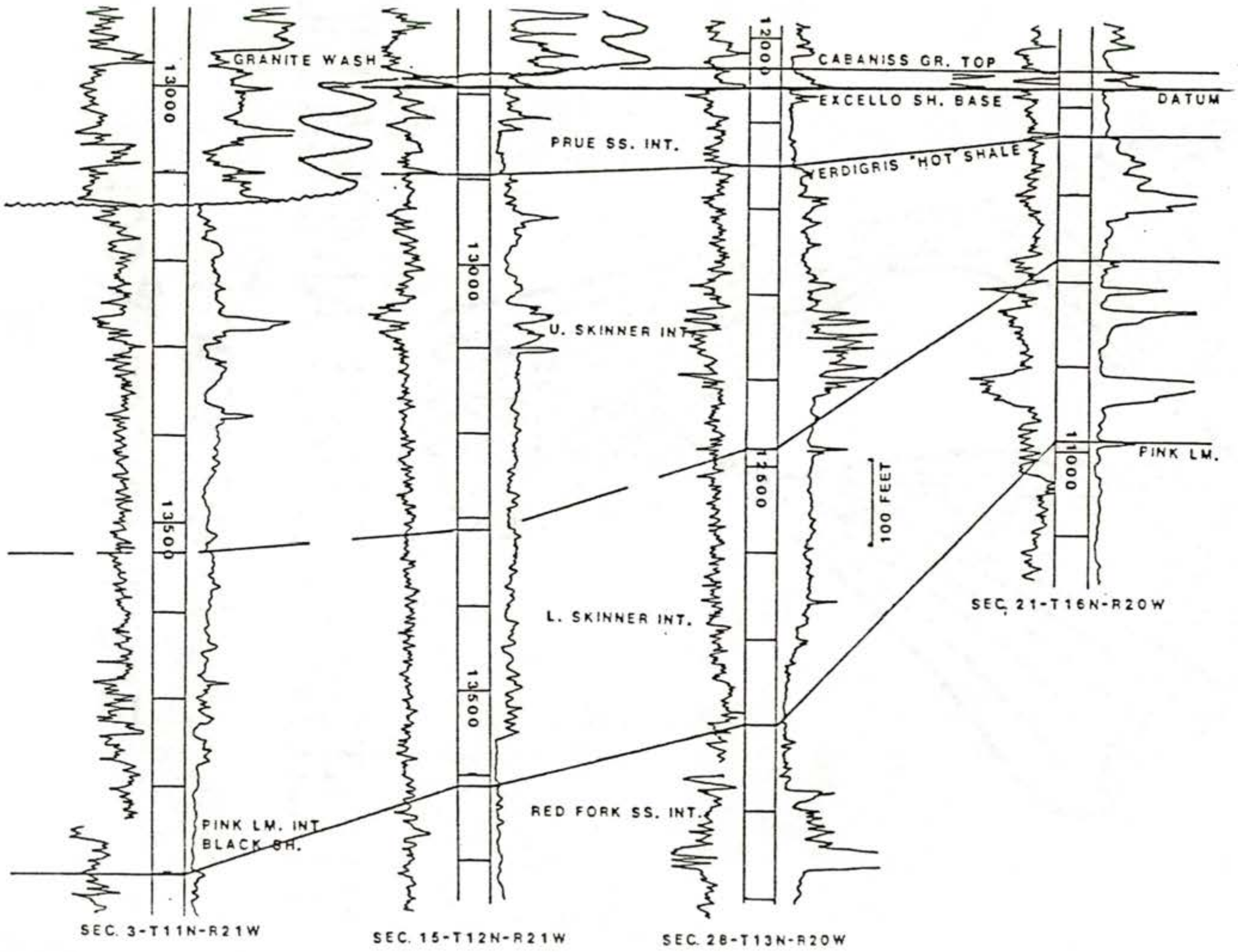


Figure 26. Stratigraphic cross section showing correlation of Cabaniss Group units and Granite Wash arkoses.

CHAPTER VII

CYCLICITY AND DEPOSITIONAL SCENARIO

Introduction

Sedimentary depositional cycles of alternating limestones, shales, and sandstones dominate the Upper Pennsylvanian stratal record along the Midcontinent outcrop belt in Oklahoma, Kansas, Missouri, Nebraska, and Iowa. These cycles were named cyclothems by Wanless and Weller (1932) for repeating rock types in the Illinois basin. Genesis of cyclothems or cyclic deposition has been related to changes of sea level caused by periods of tectonism (Weller, 1930) and glaciation (Wanless and Shepard, 1936) (Heckel, 1980) (Ross and Ross, 1985).

Classic "Kansas" Cyclothem and Cycles

Heckel (1977, 1985, and 1987) defines cyclothems as marine transgressive-regressive sequences, centered on thin euxinic black phosphatic "core" shales. Heckel (1987) described the "Kansas" cyclothem (Figure 27) that resulted from a major rise and fall of sea level over the northern Midcontinent shelf. This cyclothem contains in ascending order the following: (1) transgressive limestone, (2) offshore "core" shale, (3) regressive limestone, and (4)

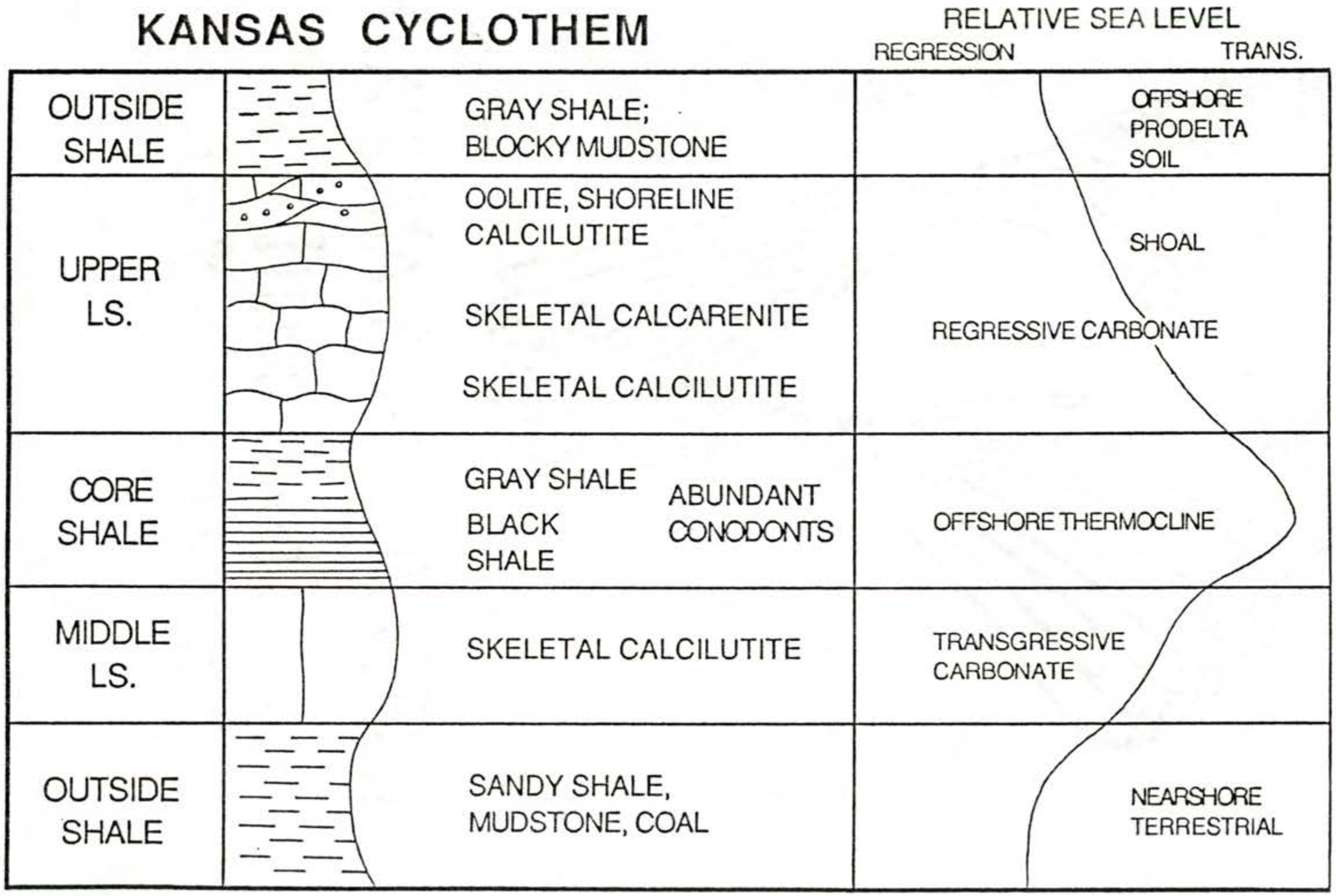


Figure 27. "Kansas" cyclothem of Heckel, 1986.

nearshore "outside" shale. Often only parts of the classic cyclothem formed because inundation and withdrawal of seas were too fast or incomplete, or excessive detrital influx prevented formation of carbonate sequences (Heckel, 1987). Partial cyclothems, or cyclothems missing some of the components, are called cycles. The prominent Middle and Upper Pennsylvanian cycles and eustatic curves are shown in Figure 28 (Ross and Ross, 1987).

Outcrop and Basinal Cycles

Wire-line logs and lithologic data from samples and cores can be used to correlate components of the recognized cycles of the Midcontinent outcrop belt with their basinal equivalents within the study area. Correlating cycle components of the Cherokee Group basinward from the outcrop shows remarkable lateral continuity for some components.

Three prominant cycles can be identified for the Cabaniss Group within the study area (Figure 29). The first cycle was initiated with deposition of the transgressive Pink Limestone interval and ended with deposition of the Upper Skinner Sandstone. The second cycle was initiated with a rapid transgression and deposition of the Verdigris "hot" (Oakley "core") shale and was completed with the deposition of the Prue (Lagonda) "outside" shale sequence. A third cycle began with deposition of the Cherokee "hot" (Excello) shale interval and ended with deposition of the Blackjack Creek member of the Fort Scott (Oswego) Limestone of the Marmaton Group. None of these cycles contains all

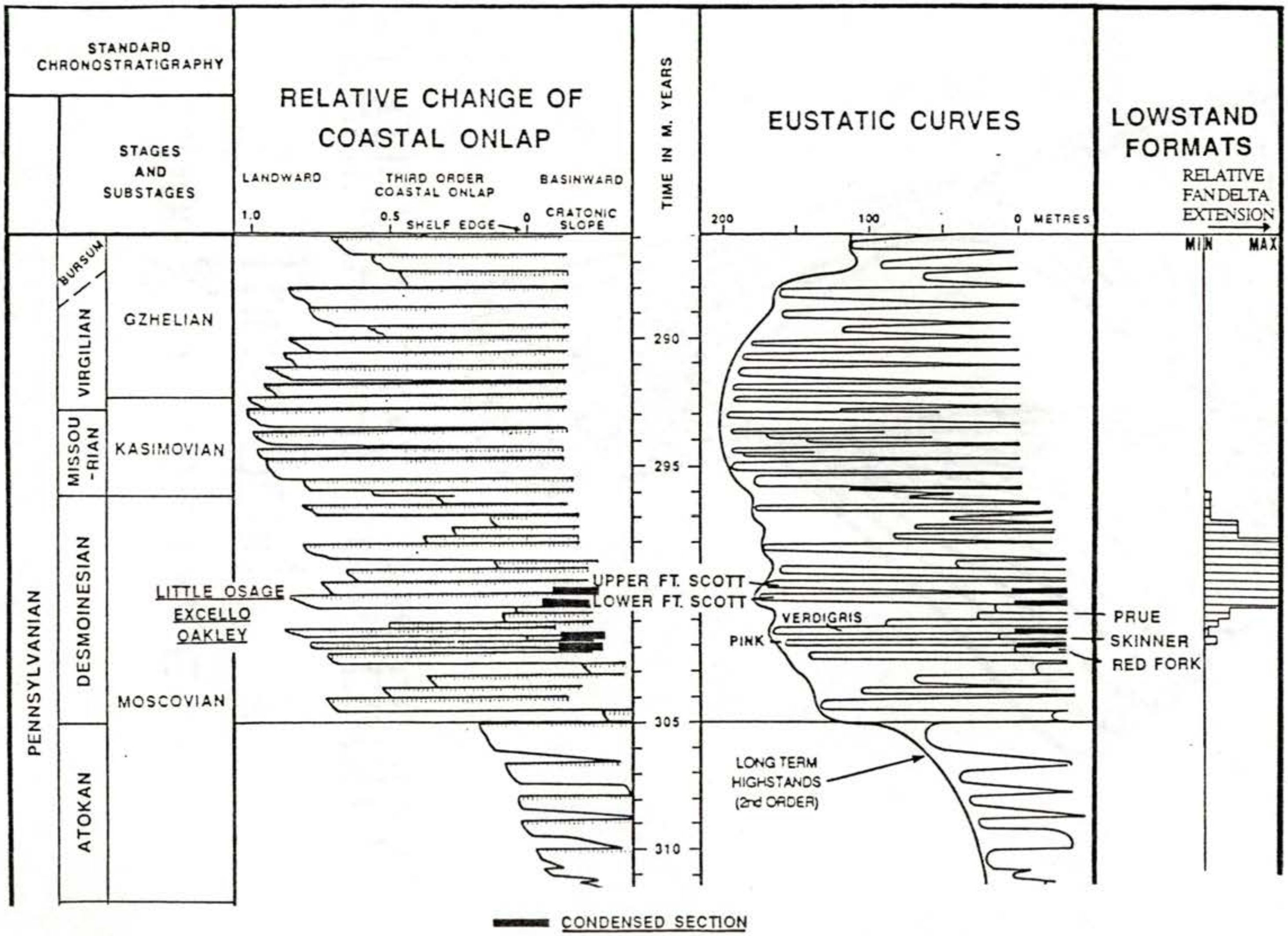


Figure 28. Major Pennsylvanian sea-level cycles and fan delta extension (After Ross and Ross, 1987).

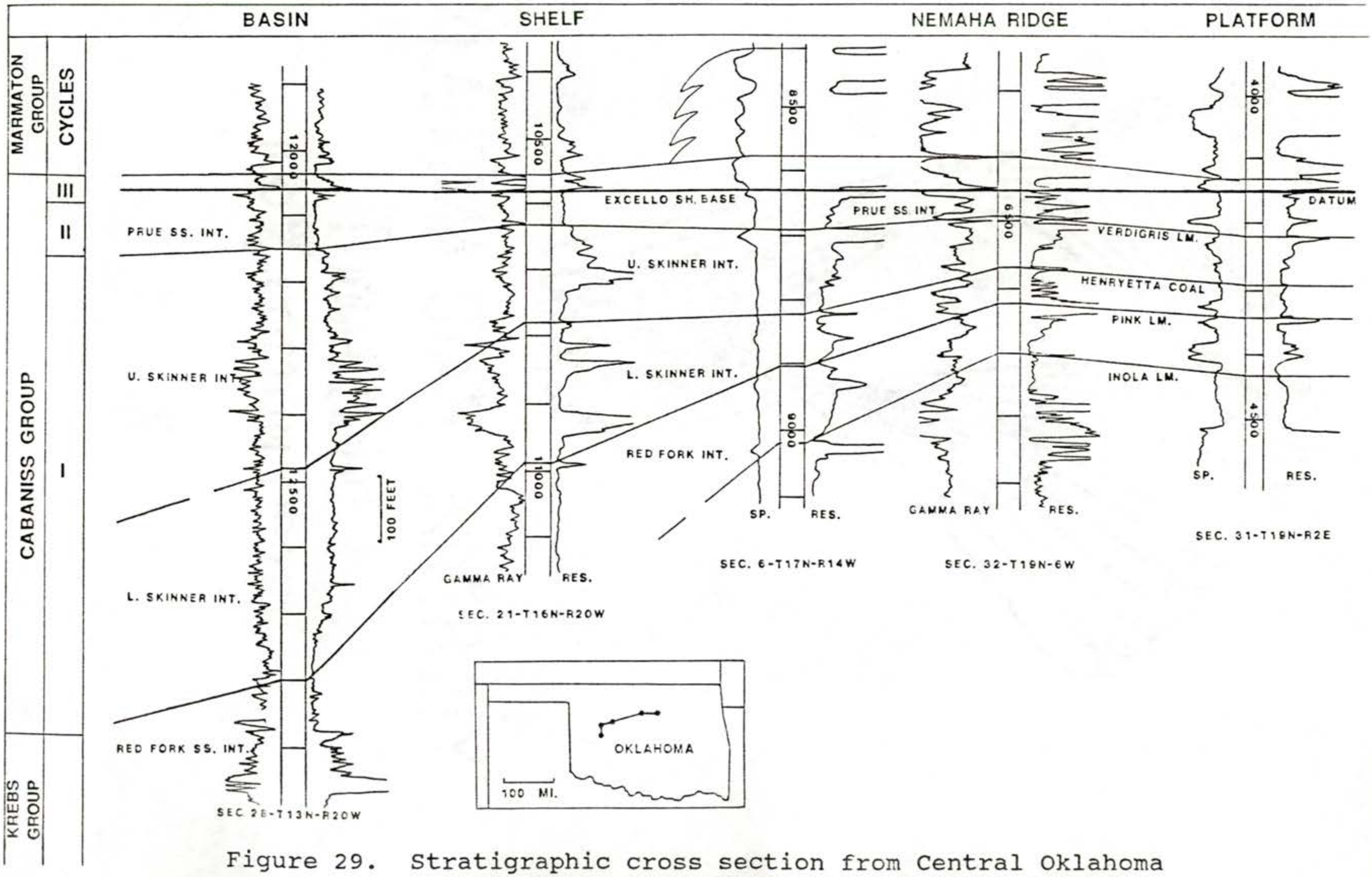


Figure 29. Stratigraphic cross section from Central Oklahoma Platform to Anadarko basin with major Cabaniss Group sea-level cycles.

four components of the classic "Kansas" cyclothem of Heckel (1985). These cycles are also represented by much thicker sedimentary sequences than their platform and outcrop equivalents.

Facies and Sea Level Fluctuation

Introduction

Understanding cyclic sedimentation is important in interpreting the depositional history of the Cabaniss Group in the Anadarko basin. The integration of lithologic, tectonic, and sea level data provides the best means of interpreting depositonal processes observed within the study area. Using this integrated data, a depositional scenario can be constructed for the Cabaniss Group in the Anadarko Basin. Changes in sea level during Cabaniss Group deposition are probably related to both eustacy and tectonics. The alignment of the Pink and Verdigris Limestone shelf-slope breaks with the thickening of the Cabaniss Group implies tectonics may have influenced deposition of thick siliclastic sequences in the Cabaniss Group. Periods of uplift of the Wichita-Amarillo Mountains would cause a relative basin floor and sea level drop in the adjacent basin. Uplift episodes are represented by the extension of Granite Wash fan delta complexes into the basin. Prominent fan delta extensions are recognized in the Lower Skinner, Veridgris, Prue, Excello and Marmaton intervals (Figure 28). Periods of tectonic inactivity would contribute to basin stability and sea level highstand conditions. Inactive episodes are expected to be represented by relative limited fan delta development.

The stratal record of Cabaniss and Marmaton Group deposition indicates that highstand conditions often coincide with extensive fan delta development. Conversely, lowstand conditions appear to coincide with times of limited fan delta development. These observations (Figure 28) indicate that both eustacy and tectonics have influenced Upper Desmoinesian deposition in the Anadarko Basin.

Krebs-Cabaniss Boundary

Following deposition of the Upper Red Fork sandstone interval of the Krebs Group, there was extended emergent terrane on the stable shelf prior to the Pink transgression. In this area, a soil horizon formed on the subaerially exposed Upper Red Fork interdistributary shale (Udayashankar, 1985) prior to deposition of the Pink limestone. Basinward, the evidence of an extensive emergent terrane is not observed. Here the Pink transgression resulted in deposition of deeper-marine muddy carbonate and shale facies over shallow-marine delta-fringe sandstones and shales of the Red Fork interval. This lowstand-highstand (regressive-transgressive) relationship between the Red Fork and Pink intervals is important in establishing the boundary between the Krebs and Cabaniss Groups in the study area. A conceptual model of the late

Upper Red Fork Sandstone lowstand is shown in Figure 30. The conceptual model for the Pink Limestone sea level highstand is shown by Figure 31.

Skinner Lowstand or Regression

The relative sea level lowstand of the Lower Skinner Sandstone interval followed the Pink Limestone interval transgression (Figure 28). Within the study area this decline in sea level is represented by prodelta-delta front shales, limited channel sandstones, and coarsening-upward (cleaning upward) carbonate sequences. A minor sea level rise likely followed Lower Skinner deposition, but cannot be verified without lithologic data.

The Upper Skinner Sandstone interval represents an extended relative drop in sea level that culminated with the incising of the primary elongate channel trend. Following the erosional phase of this channel, the channel may have filled during a minor transgression that deposited the thin fossiliferous shale over the channel sequence. Following this event, the calcareous nodule zone or caliche formed indicating extended emergent terrane (Figure 23). The conceptual depositional model of the Upper Skinner Sandstone interval lowstand terrane is shown in Figure 32.

Verdigris Highstand or Transgression

The Verdigris Limestone interval "hot" shale (Oakley "Core" Shale) records a significant rise of sea level following Upper Skinner sandstone deposition (Figure 28).

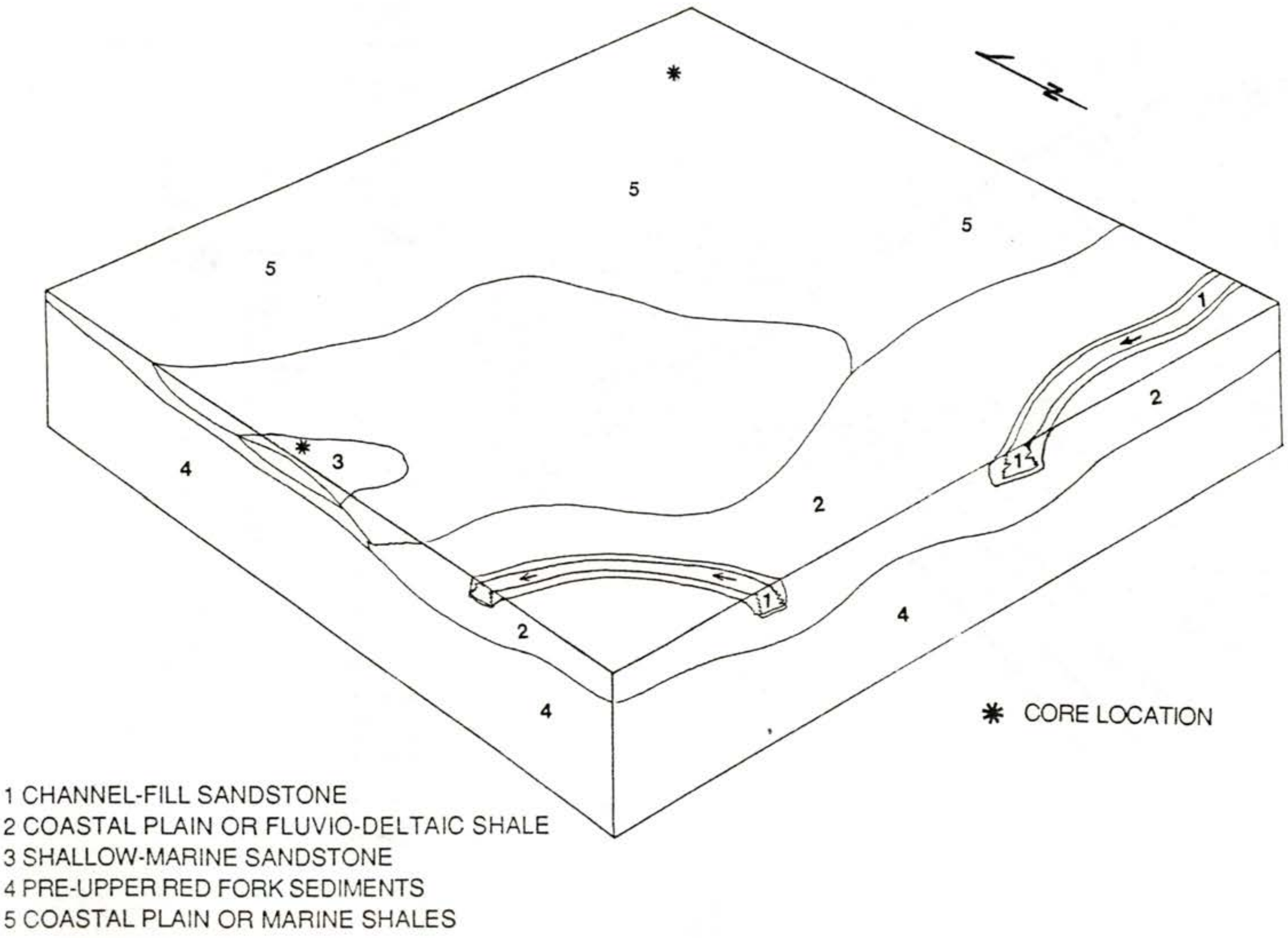


Figure 30. Conceptual model of depositional environment of Upper Red Fork channel and shallow-marine sandstones.

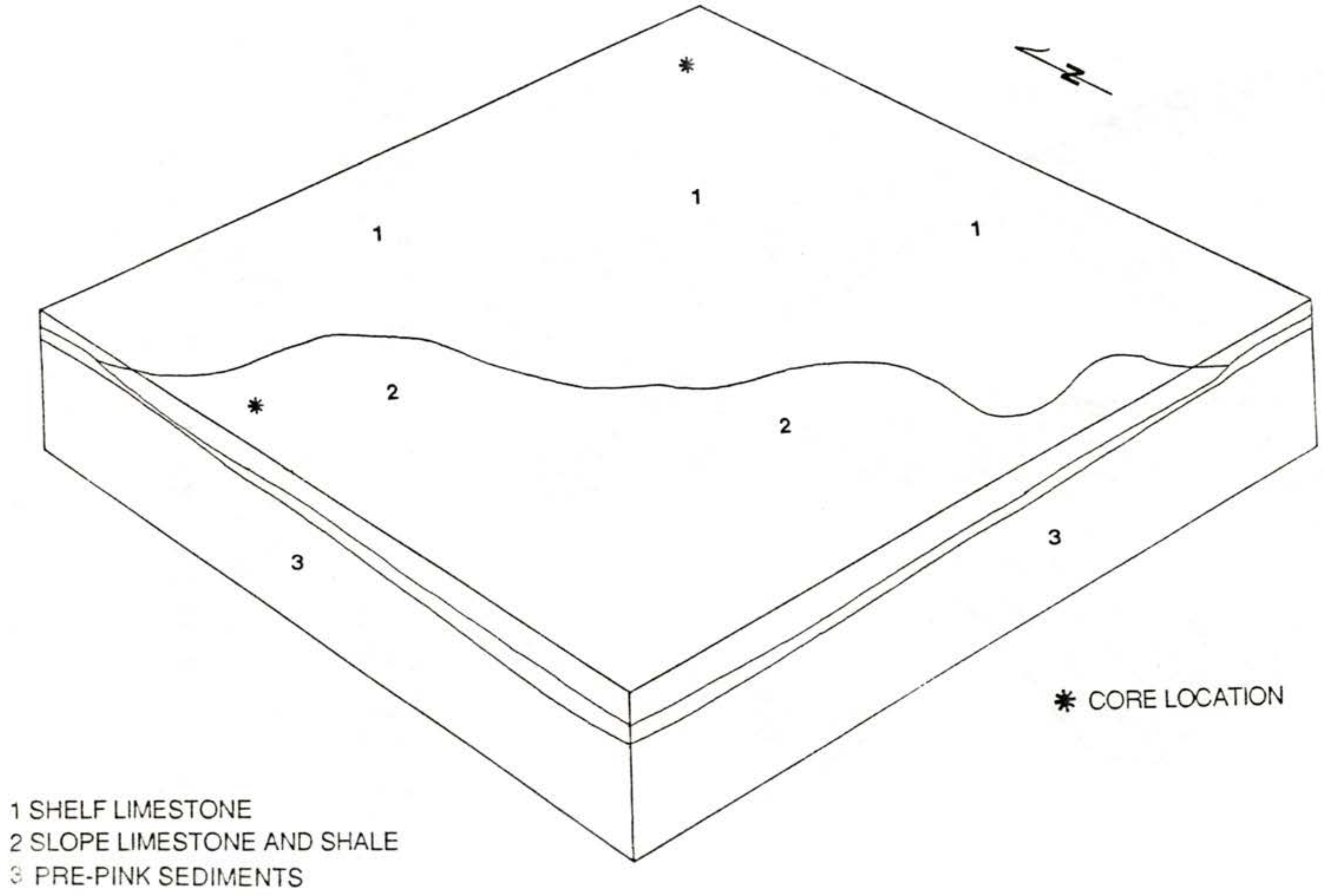


Figure 31. Conceptual model of depositional environment of Pink limestone and shale facies.

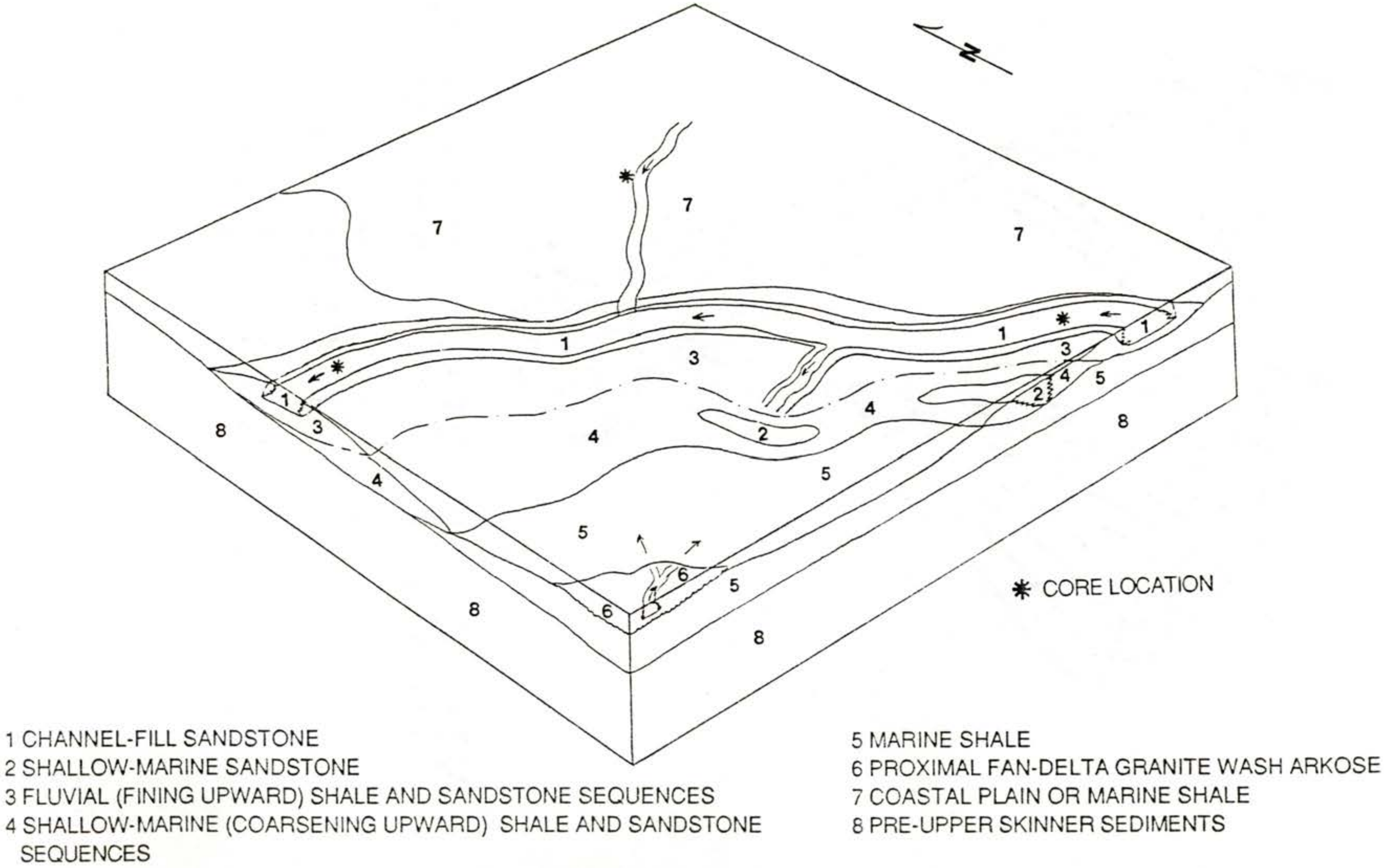


Figure 32. Conceptual model of depositional environment of Upper Skinner channel-fill and shallow marine sandstones, shales, and fan-delta arkose.

The relationship of the Verdigris Limestone to the underlying "hot" shale supports interpretation of the Verdigris carbonate as a regressive limestone formed during shallowing of water following the maximal transgression of the Oakley "Core" Shale. Basinward, a "muddy" carbonate facies of the Verdigris Limestone is expected but has not been cored. The conceptual model of the depositional setting of the Verdigris Limestone interval is shown in Figure 33.

Prue Lowstand or Regression

A fall in sea level continued following deposition of the Verdigris Limestone as shales of the Prue interval were deposited (Figure 28). This shale sequence may represent the "outside" shale that culminates the Verdigris cycle.

Excello Shale Highstand or Transgression

Following Prue deposition, an extensive marine transgression deposited the Breezy Hill Limestone and the Excello Shale. The rise in sea level was sufficient to cause deposition of the euxinic Excello "core" shale (Figures 28 and 29) over a large area of the Midcontinent.

Regressive conditions returned with deposition of the Blackjack Creek member of the Fort Scott Limestone during Marmaton time. The Little Osage ("core") Shale member of the Fort Scott Limestone represents another extensive sea level highstand and transgression following deposition of the Blackjack Creek (Lower Fort Scott) Limestone. Basinward

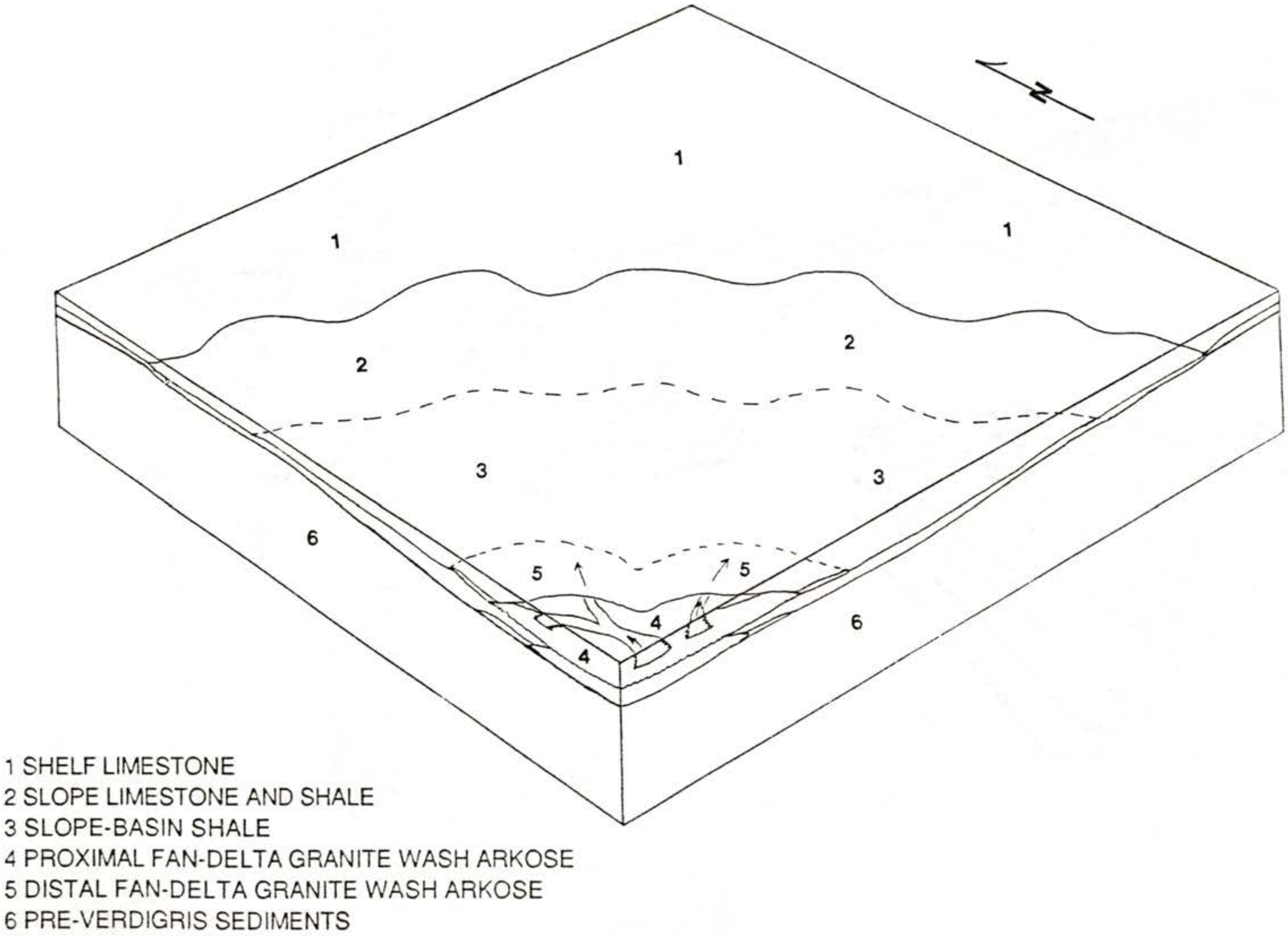


Figure 33. Conceptual model of depositional environment of Verdigris limestone and shale facies and Granite Wash arkose.

of the Fort Scott Limestone "clean" carbonate facies, the Little Osage Shale and Excello Shale may combine to represent the primary "hot" units of the Cherokee "hot" shale (Figure 29). Though the boundary between the Cabaniss and Marmaton groups is recognized as being between the Excello Shale and Blackjack Creek Limestone, it appears both belong in the same cycle or partial cyclothem. Within much of the study area, the Breezy Hill, Excello, Lower Fort Scott, Little Osage, and Upper Fort Scott units may all be contained in a condensed section called the Cherokee "hot" shale.

CHAPTER VIII

PETROLOGY AND DIAGENESIS OF RESERVOIR ROCKS

Introduction

Petrographic analysis of the Cabaniss Group was designed to determine the (1) mineralogical composition, (2) textural relationship, and (3) diagenetic history of sandstone reservoirs with emphasis on porosity enhancement and occlusion. A minor southerly source for the Upper Skinner Sandstone is proposed because of the presence of granophyric rock fragments and microperthite in the sandstones. The petrology of the Upper Skinner Sandstone within the study area was compared with that of the Prue and Skinner Sandstones from the Central Oklahoma Platform. Further comparative analysis of petrology and texture was achieved by examination of thin sections of Upper Skinner Sandstone and Granite Wash arkoses from cores within the study area.

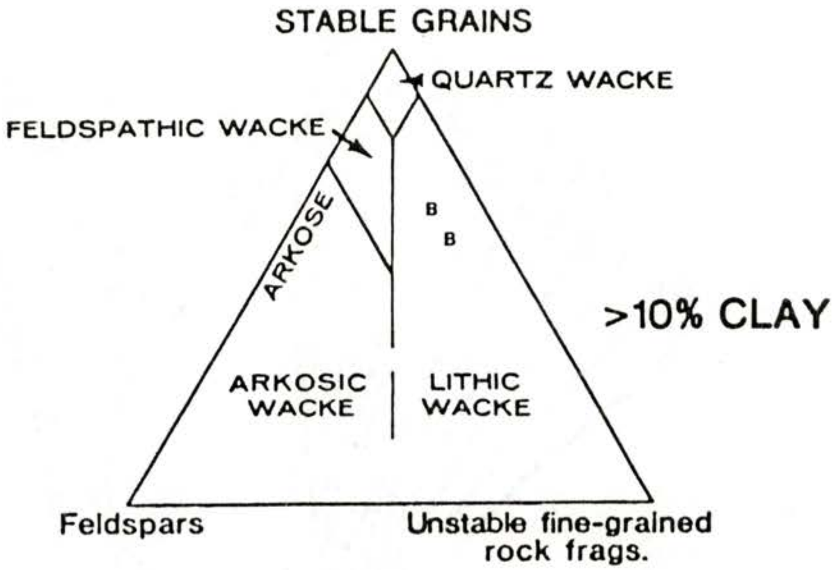
Diagenetic modifications have drastically affected the Upper Skinner Sandstone reservoirs. Dissolution of metastable rock constituents is a very important process in the development of secondary porosity. On the other hand, diagenetic cements, such as quartz, calcite, and clay minerals, have significantly reduced porosity. Initial mineralogical composition and texture also influenced diagenetic pathways and affected porosity and permeability development.

Detrital Constituents and Texture

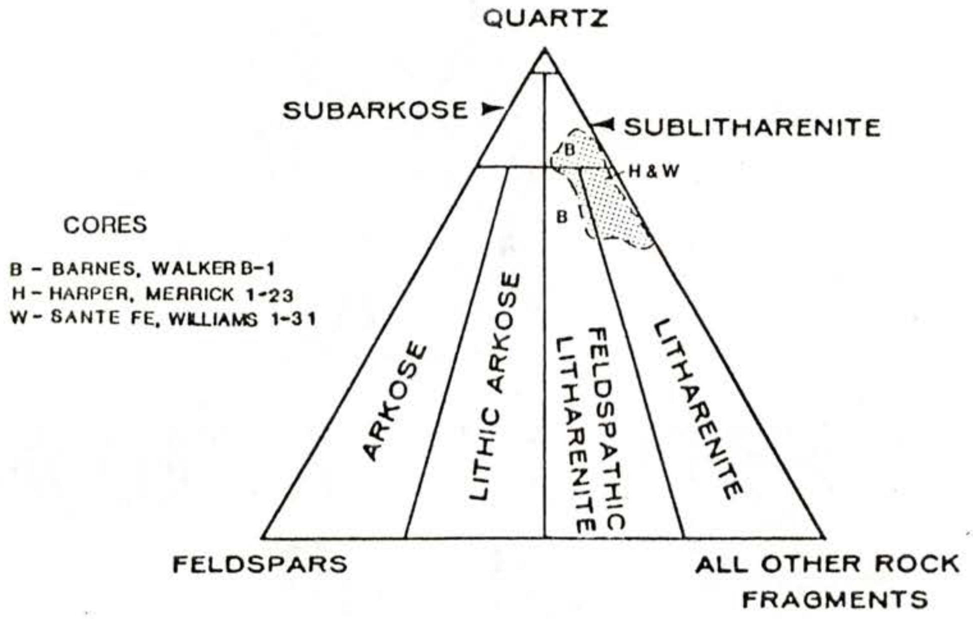
Quantitative detrital mineral composition was plotted on proper ternary diagrams. Arenite dominant (<10% matrix) rocks were plotted on a quartz, rock-fragment, and feldspar (QRF) diagram (Folk, 1974), while matrix rich (>10%) rocks were plotted on stable grains, unstable grains, and feldspars diagram (Williams, etal, 1954). Compositions of Upper Skinner Sandstones are shown in Figure 34. The Upper Skinner Sandstones in the Harper, Merrick No. 1-23 and Santa Fe, Williams No. 1-31 cores are primarily litharenites and sublitharenites. Matrix rich sandstones sampled from the Barnes, Walker "B" No. 1 are lithicwackes.

The Upper Skinner Sandstones are primarily very fine to medium grained. The primary detrital constituent is monocrystalline quartz (Figures 35a and 35b), which comprises 55 to 80% of the detrital fraction. Trace amounts of polycrystalline quartz were recognized. Feldspars were relatively abundant in some samples and sparse in others, comprising 5 to 12% of detrital constituents. Twinned plagioclase (Figure 36), microcline, microperthite (Figure 37), and untwinned potassic feldspars were the more frequently identified feldspars.

Rock fragments are abundant in the Upper Skinner Sandstone. Low-grade metamorphics (Figures 38a and 38b),



(AFTER WILLIAMS, TURNER, AND GILBERT, 1954)



(AFTER FOLK, 1974)

Figure 34. Detrital composition of Upper Skinner Sandstones.

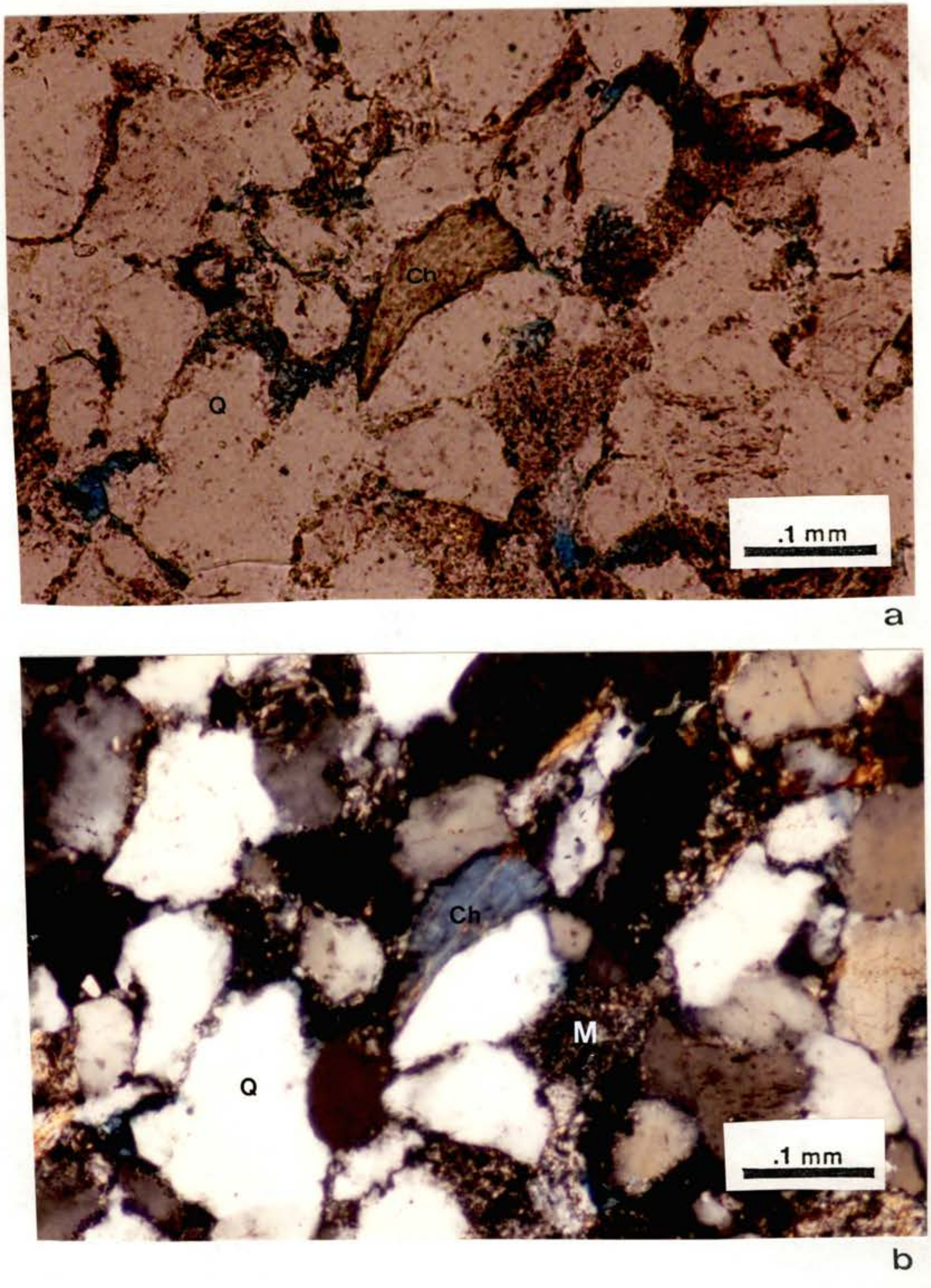


Figure 35. Monocrystalline quartz (Q), metamorphic rock fragments (M), and accessory grains (detrital chlorite) (Ch). Santa Fe, Williams No. 1-31. Depth 11680 feet. a) (ppl) b) (cpl)

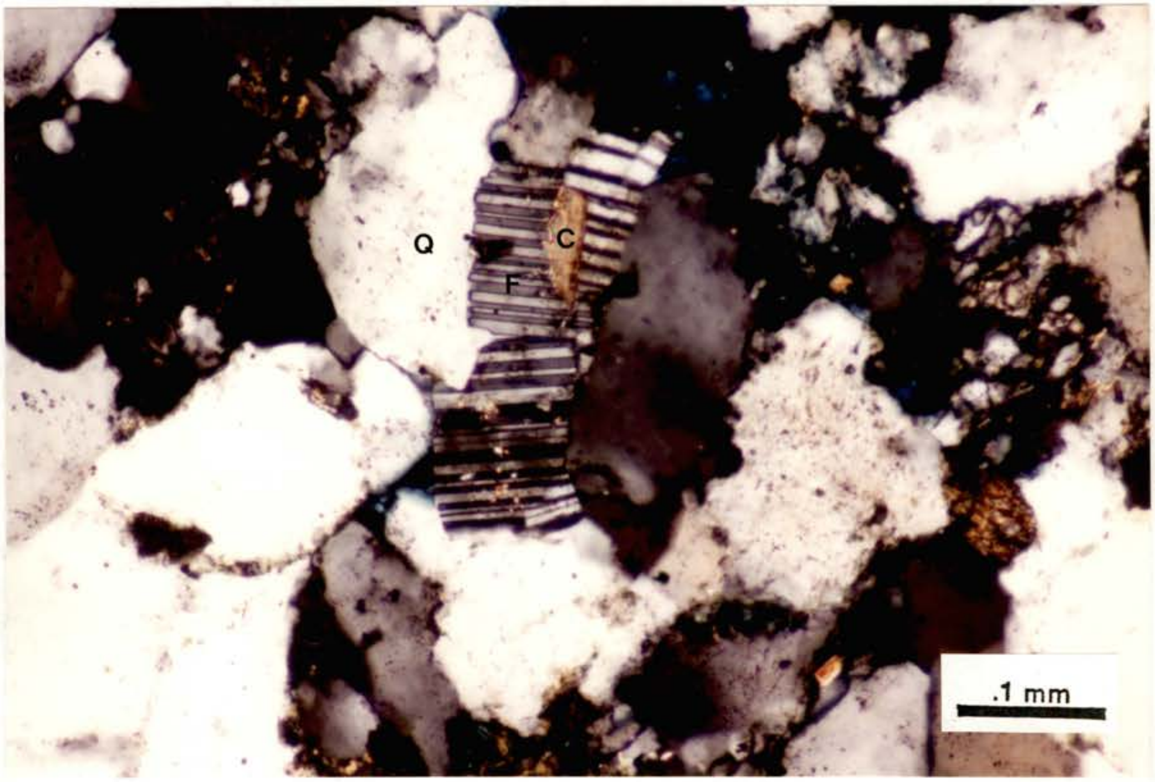


Figure 36. Plagioclase feldspar (F), monocrystalline quartz (Q), carbonate (C), and metamorphic rock fragments (M). Harper, Merrick No. 1-23. Depth 11263 feet. (cpl)

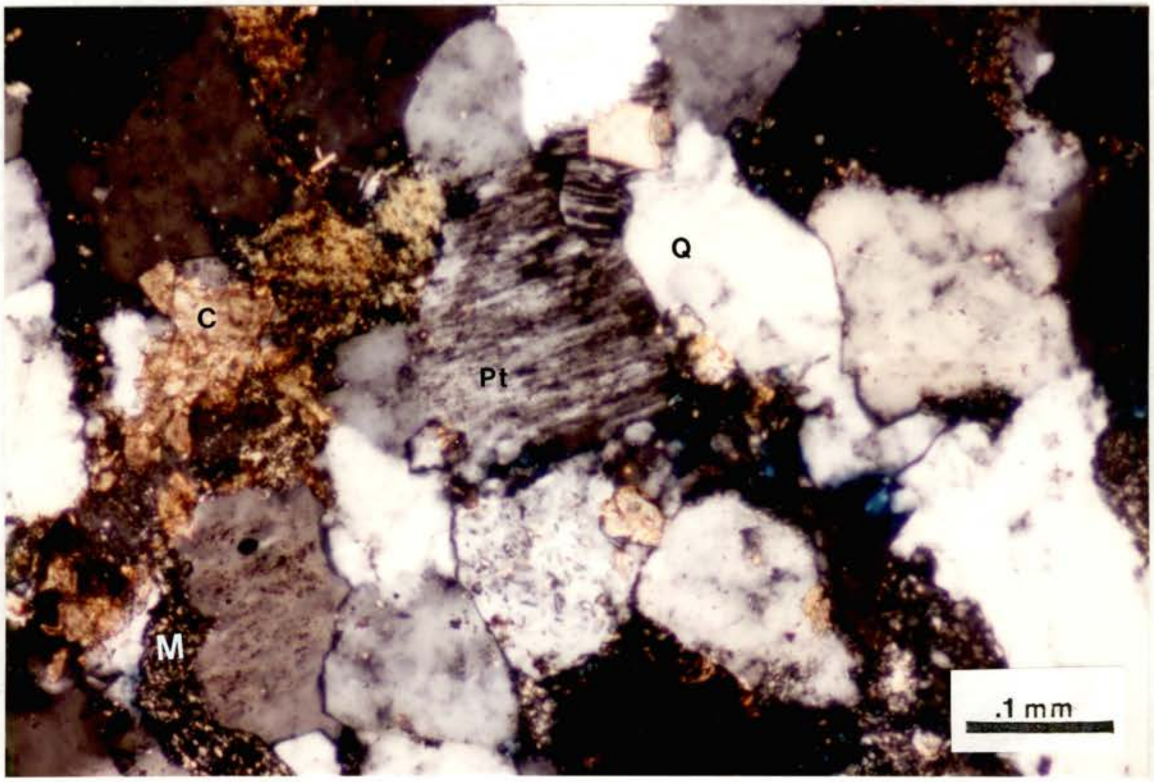


Figure 37. Microperthite (Pt), quartz (Q), carbonate cement (C), and metamorphic rock fragments (M). Santa Fe, Williams 1-31. Depth 11616 feet. (cpl)

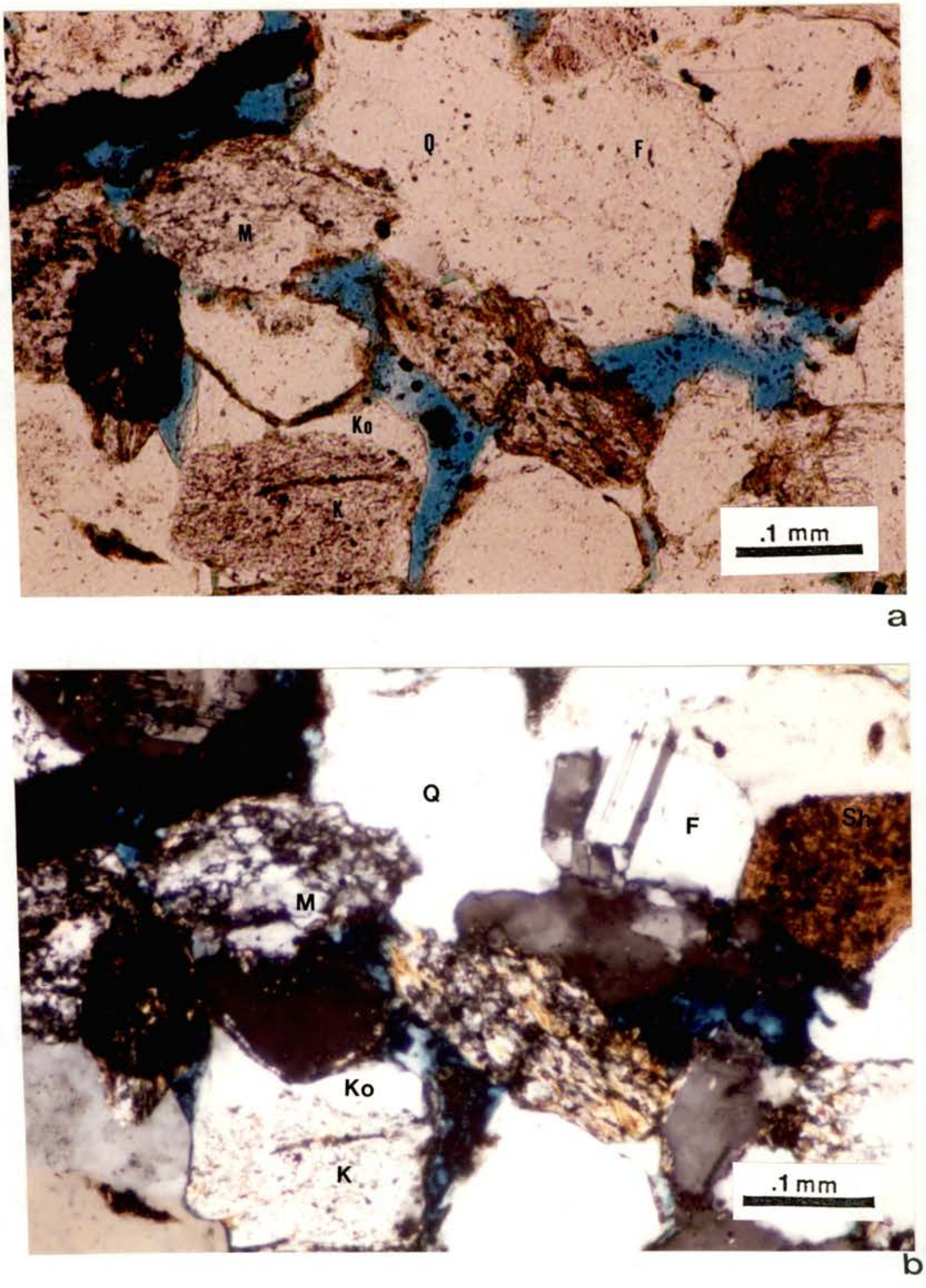


Figure 38. Low-grade metamorphic rock fragments (M), quartz (Q), plagioclase feldspar (F), potassic feldspar (K) with overgrowths (Ko), and illitic shale clast (Sh). Harper, Merrick No. 1-23. Depth 11264 feet. a) (ppl) b) (cpl)

including schists, phyllites, and quartzose rock types, are common and compose 13 to 33% of the detrital constituents. Granophyre (Figure 39a and 39b), illitic shale clasts, siltstone, and chert were also observed. Ductile deformation of shale clasts and low-grade metamorphic rock fragments resulted in the formation of siliceous pseudomatrix (Figures 40a and 40b) that comprises up to 8% of the rock composition. Minor amounts (<1%) of glauconite, phosphate, and accessory heavy minerals, including zircon, sphene, tourmaline, and garnet, were also observed. Pyrite, chlorite, chloritized biotite, muscovite, and carbonaceous material occur as accessory constituents.

Diagenetic Constituents

Diagenetic constituents documented in the Upper Skinner Sandstone were silica, clays, carbonates, and sulfate cements.

Authigenic silica occurs primarily as syntaxial quartz overgrowths and minor feldspar overgrowths. Chlorite is present as pore lining and grain coating, illite as grain coating, pore lining and bridging, and kaolinite as pore filling. Figures 41 and 42 show authigenic illite and chlorite in the Upper Skinner sandstone. Authigenic clays recognized in thin section were confirmed by X-ray analysis (Figure 43). Diagenetic carbonate cements recognized in the Upper Skinner Sandstone are calcite and dolomite. Dolomite (probably after calcite) often replaces feldspar,

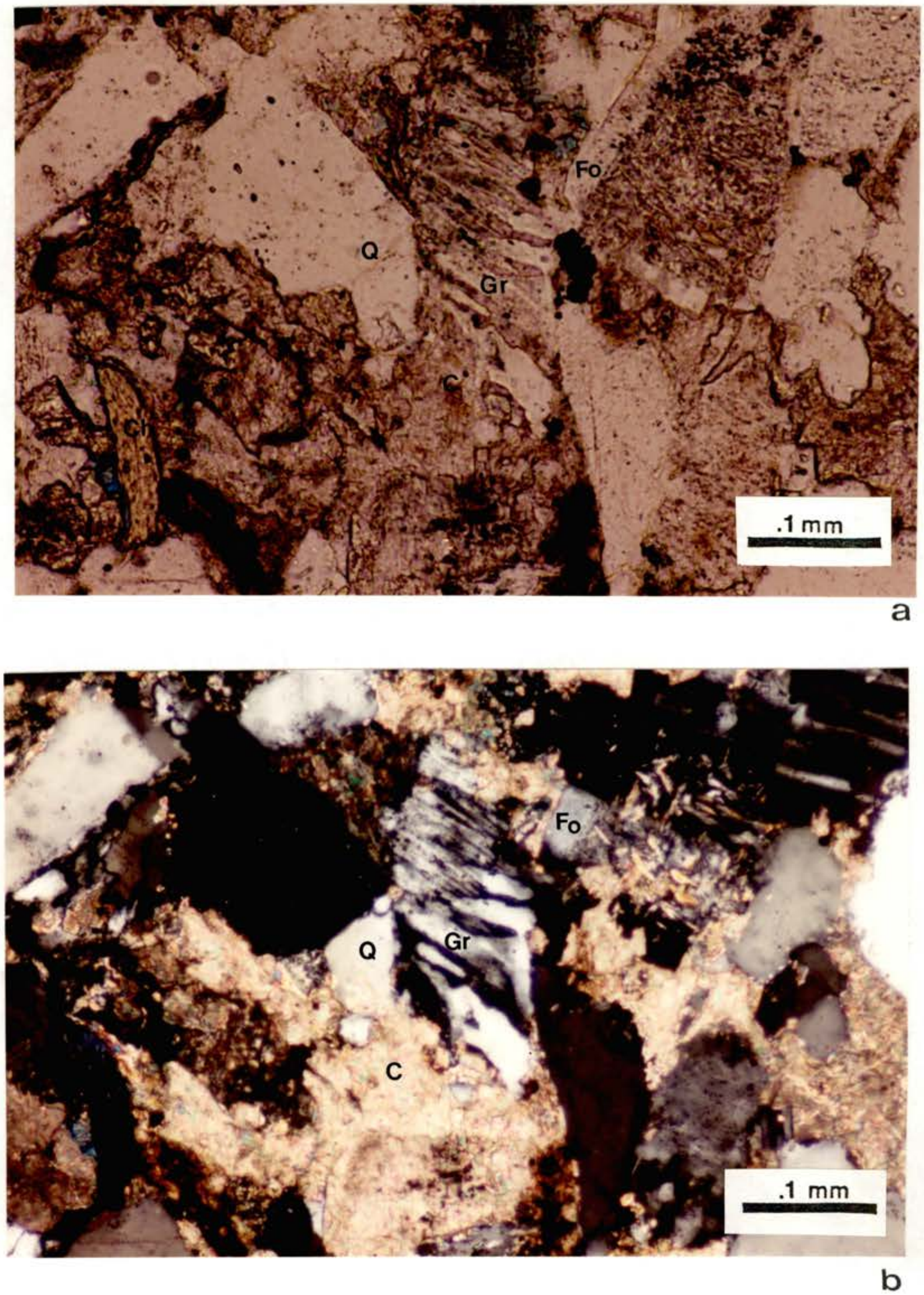


Figure 39. Granophyre (Gr), quartz (Q), feldspars with overgrowths (Fo), detrital chlorite (Ch), and carbonate cement (C). Harper, Merrick No. 1-23. Depth 11241 feet. a) (ppl) b) (cpl)

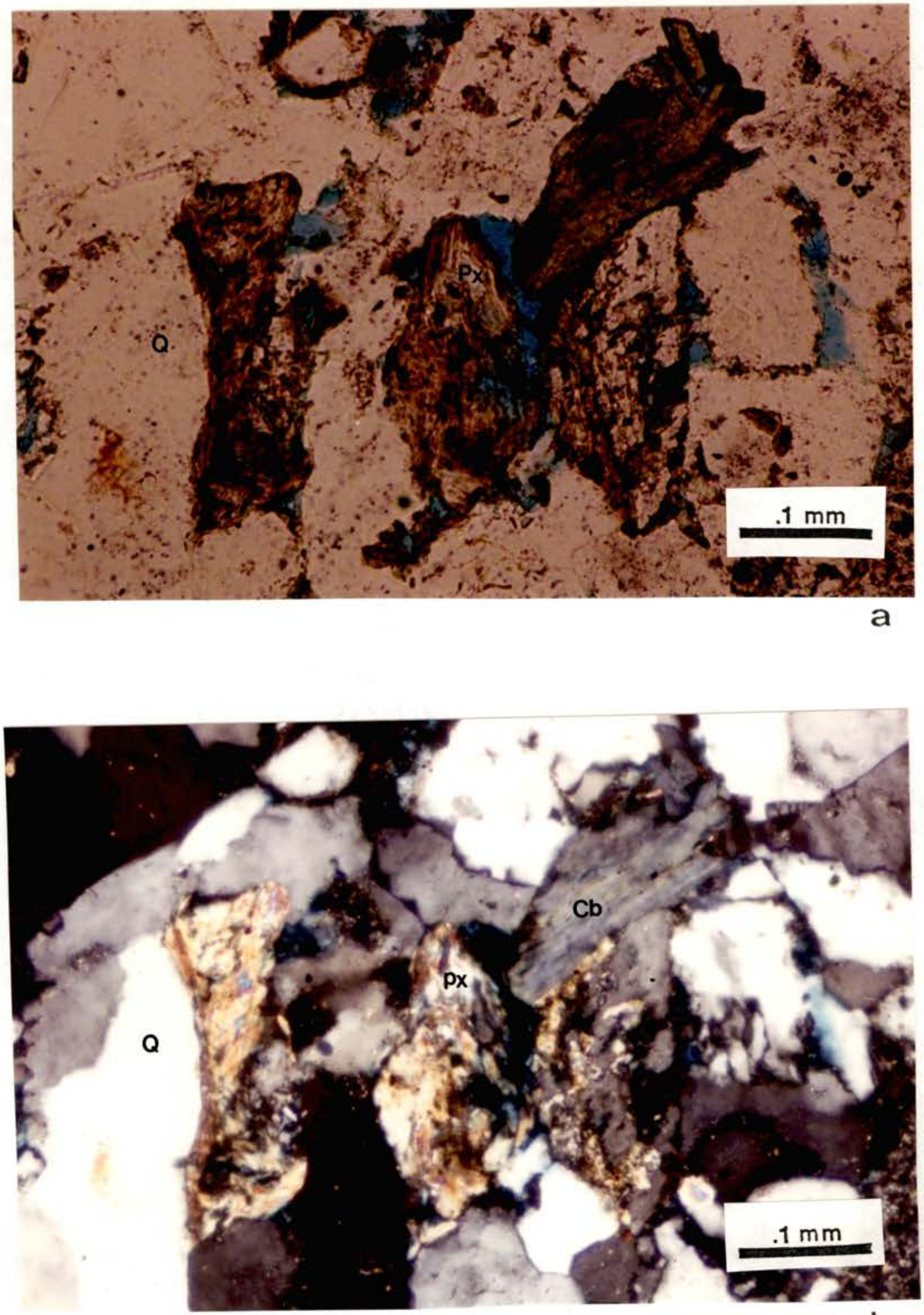


Figure 40. Pseudomatrix (Px), quartz (Q), and chloritized biotite (Cb). Harper, Merrick No. 1-23. Depth 11263 feet. a) (ppl) b) (cpl)

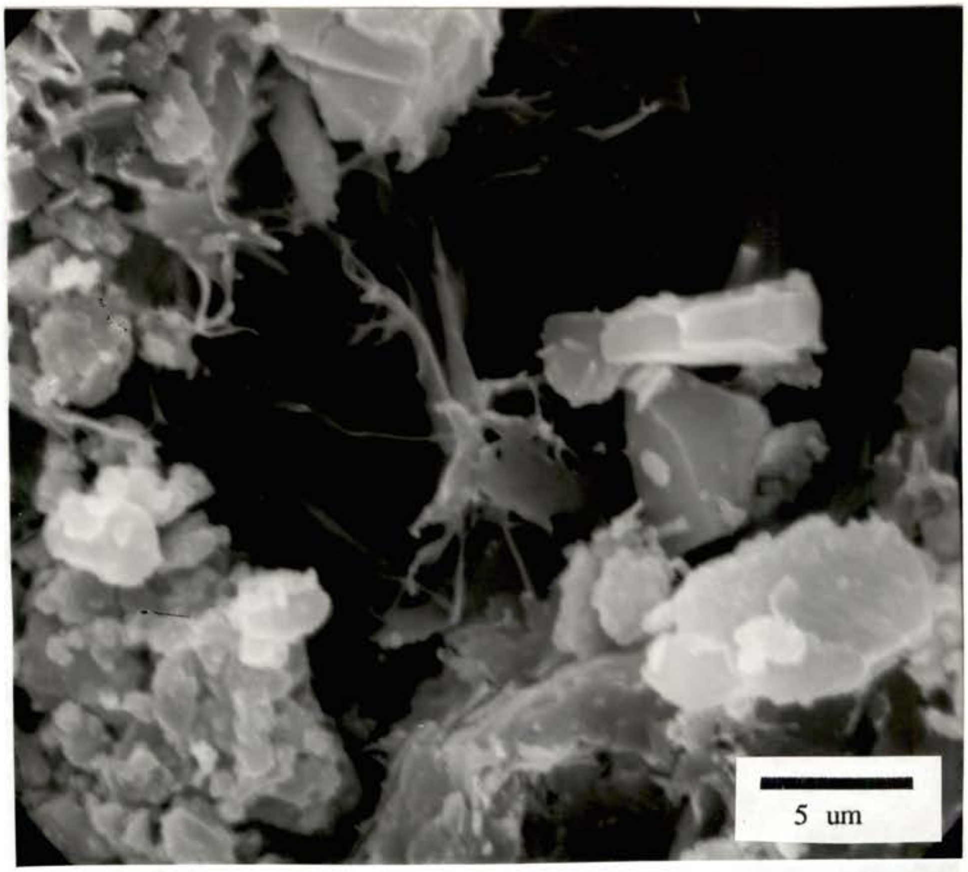


Figure 41. Authigenic pore-bridging illite in the Upper Skinner Sandstone. Santa Fe, Williams No. 1-31. Depth 11591 feet. Magnification 3900X.

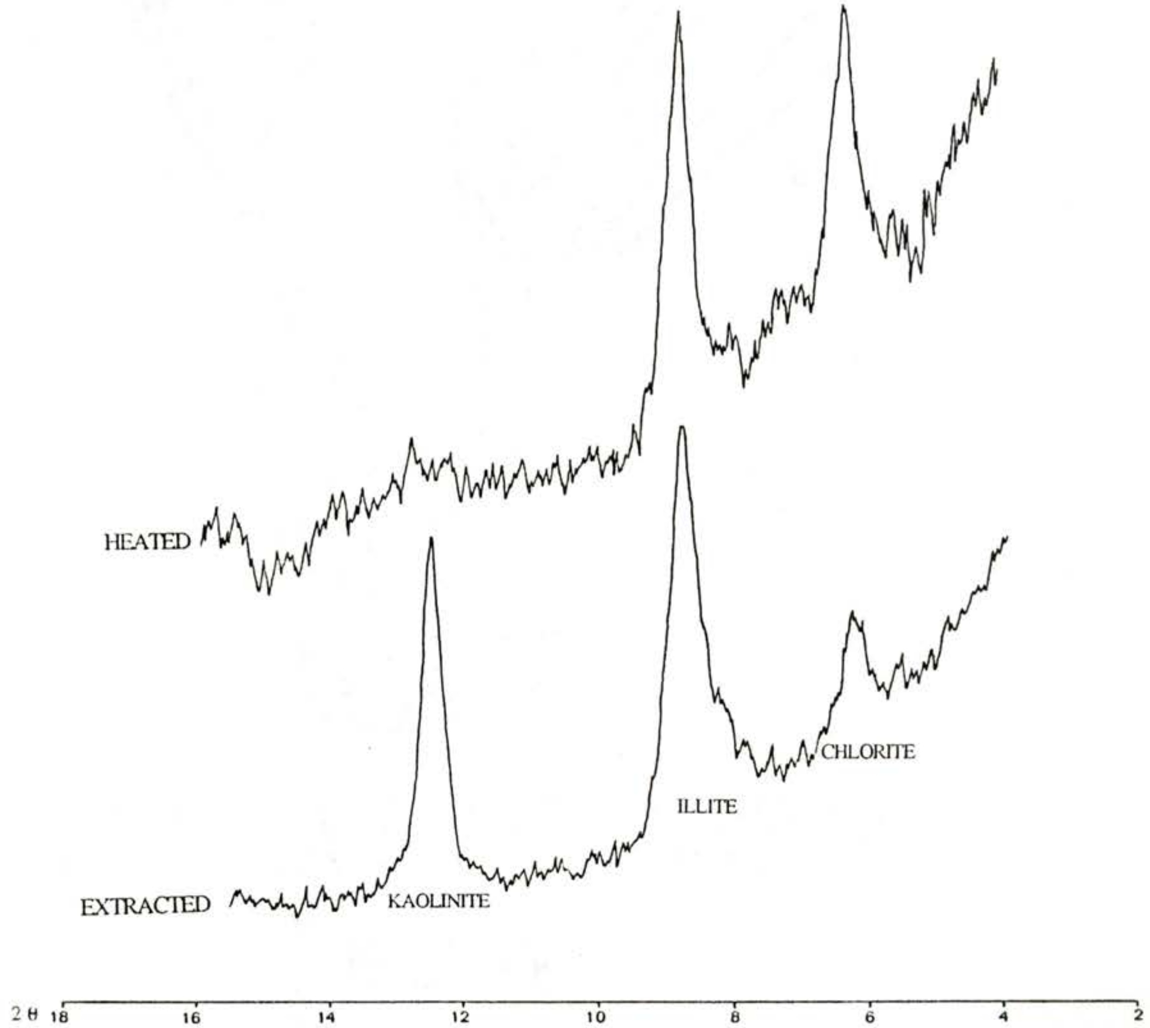


Figure 43. X-ray diffractogram of authigenic clay fractions from the Upper Skinner Sandstone

quartz and other rock constituents. Poikilotopic texture (Figure 44) is common where carbonate cement is abundant. Gypsum and carbonate cement occur together as fracture-filling material (Figure 45).

Porosity

Primary porosity accounts for less than 3% of the total rock porosity. In relatively "cleaner" sandstones, syntaxial quartz overgrowths have significantly reduced primary porosity (Figure 46). In relatively "dirtier" sandstones with higher percentages of matrix and low grade metamorphic rock fragments, deformation of ductile constituents material has reduced primary porosity to negligible amounts. Rocks with higher total porosity show the presence of both primary and secondary porosity. This indicates that primary porosity may have provided the pathways for fluid movement which resulted in the development of secondary porosity.

Secondary porosity is the dominant porosity type observed. It resulted from dissolution of rock constituents, especially feldspars, metamorphic rock fragments, and pseudomatrix (Figures 47 and 48). Secondary porosity, as determined from thin sections, ranges from 0% to 12% and appears to increase with increasing grain size. Original coarser-grained sandstones with appropriate metastable fragments may have had a better chance of preserving primary porosity and generating secondary porosity.

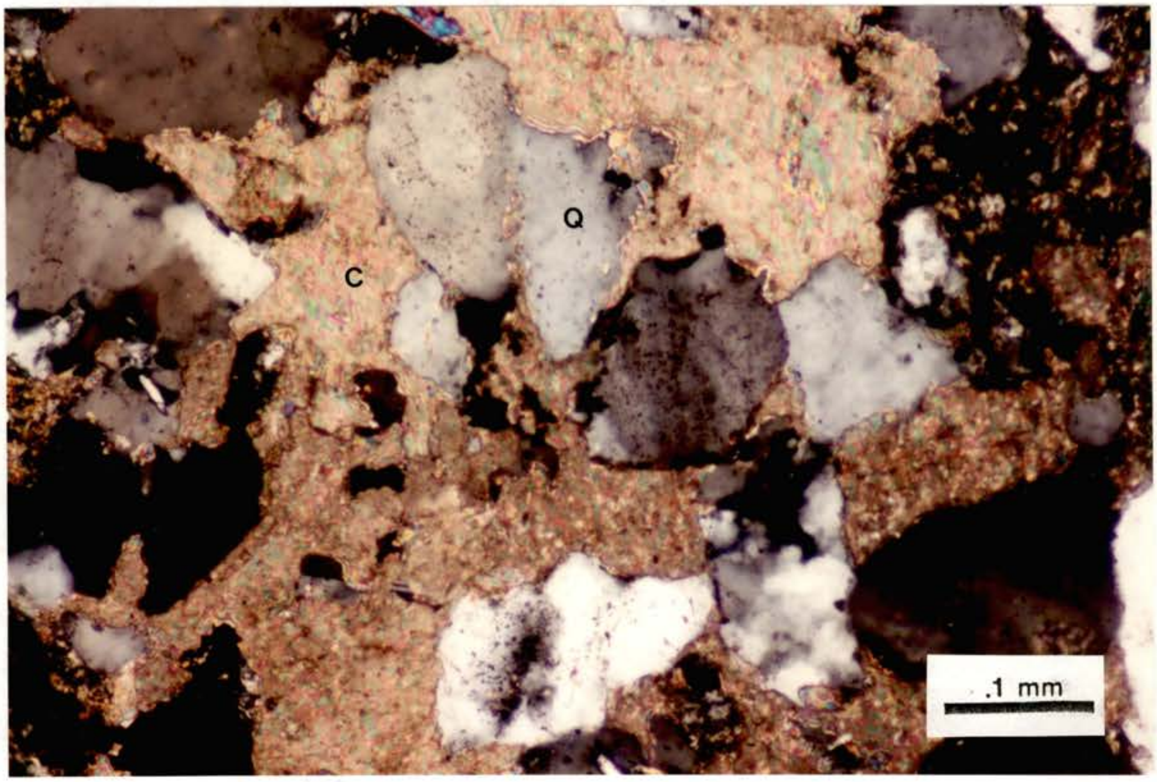


Figure 44. Extensive carbonate cement (C) and "floating" corroded quartz (Q) grains of poikilotopic texture. Harper, Merrick No. 1-23. Depth 11241 feet. (cpl)

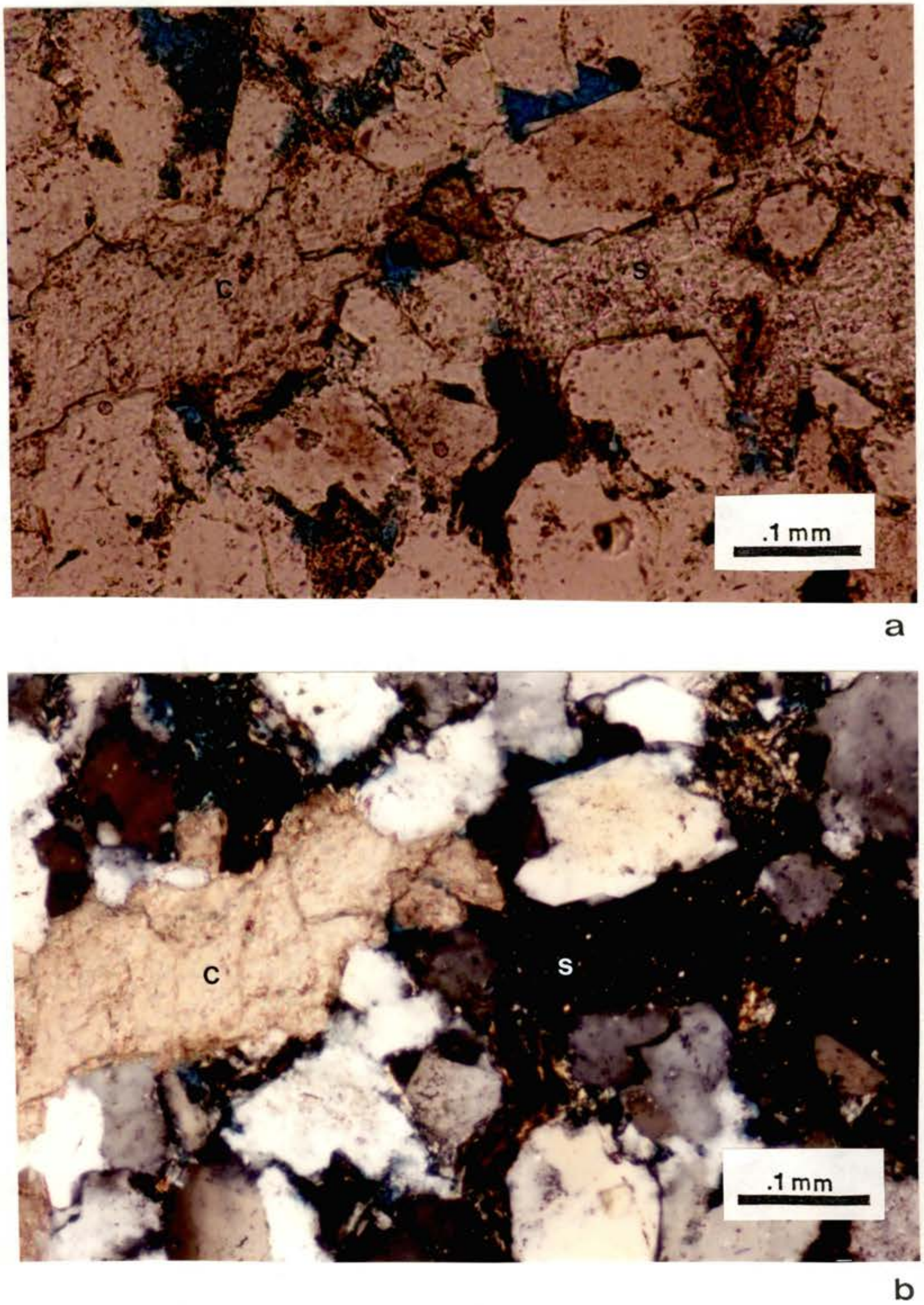


Figure 45. Fracture-filling carbonate (C) and sulfate (S) cement. Santa Fe, Williams No. 1-31. Depth 11677.5 feet. a) (ppl) b) (cpl)

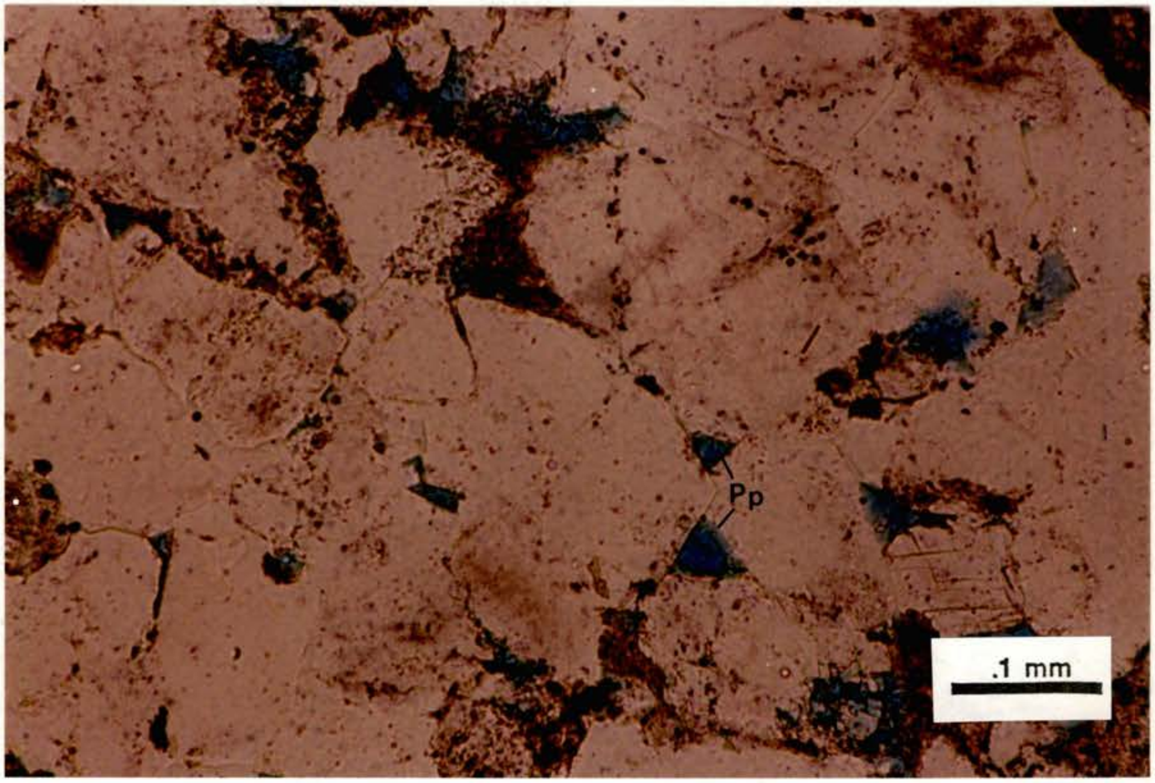


Figure 46. Primary porosity (Pp) in silica-cemented sandstone. Harper, Merrick No. 1-23. Depth 11267 feet. (ppl)

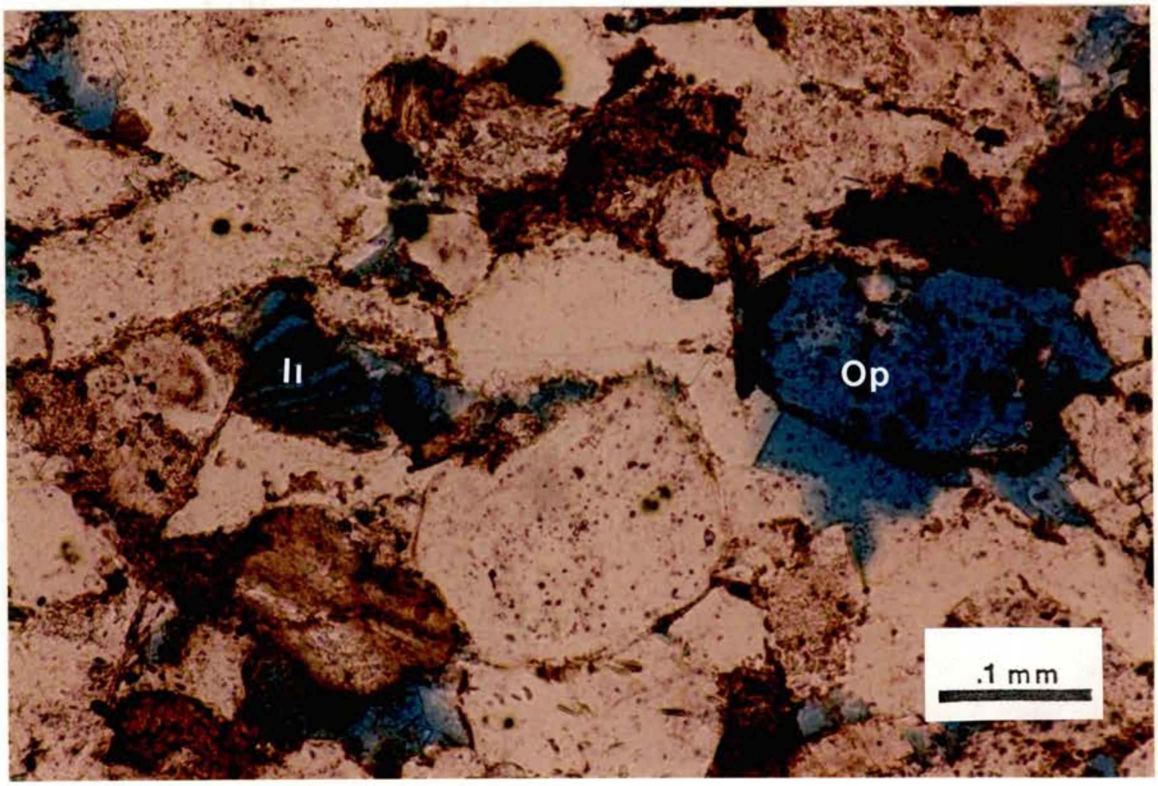


Figure 47. Secondary porosity (blue) formed from dissolution of detrital grains. Note illite bars after feldspar (Il) and oversized secondary pore (Op). Harper, Merrick No. 1-23. Depth 11264 feet. (ppl)

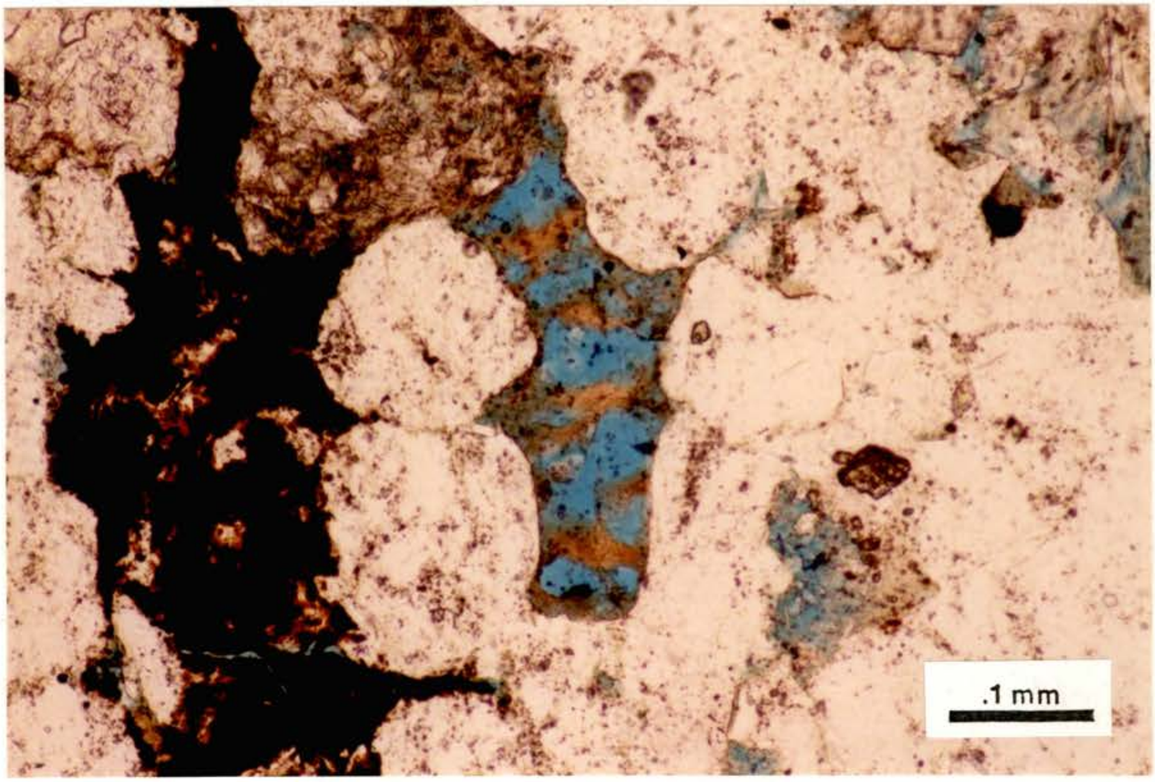


Figure 48. Secondary porosity (blue) formed from dissolution of pseudomatrix. Note the original round morphology of sand grains. Santa Fe, Williams No. 1-31. Depth 11616 feet. (ppl)

Pressure solution of quartz in styolites and corrosion of authigenic and detrital quartz creates secondary porosity. However, the contribution of quartz dissolution to total porosity is minimal.

Microporosity is often developed in partially leached feldspars, rock fragments (Figure 49), and within authigenic clay constituents.

Fracture porosity was also observed in a particular field and may contribute to productivity of the sandstone reservoirs (Figure 50).

Paragenesis

The Upper Skinner Sandstone has experienced a complex diagenetic history. Textural relationships suggest the presence of several diagenetic episodes which are related to compaction, cementation, and dissolution. Diagenetic events within the Upper Skinner Sandstone's paragenetic sequence can be divided into two general diagenetic stages. These are the eodiagenetic (diagenetic regime near the surface) and mesodiagenetic (diagenesis after effective burial) stages. The telediagenetic stage that results from burial and heating of the rocks to cause metamorphism was not experienced by the Cabaniss Group in the study area.

With burial, the Upper Skinner sediments were compacted and eodiagenetic processes were initiated. Compaction deformed various rock fragments (primarily low-grade metamorphics) to form pseudomatrix. Formation of pseudomatrix was very early in the diagenetic history of

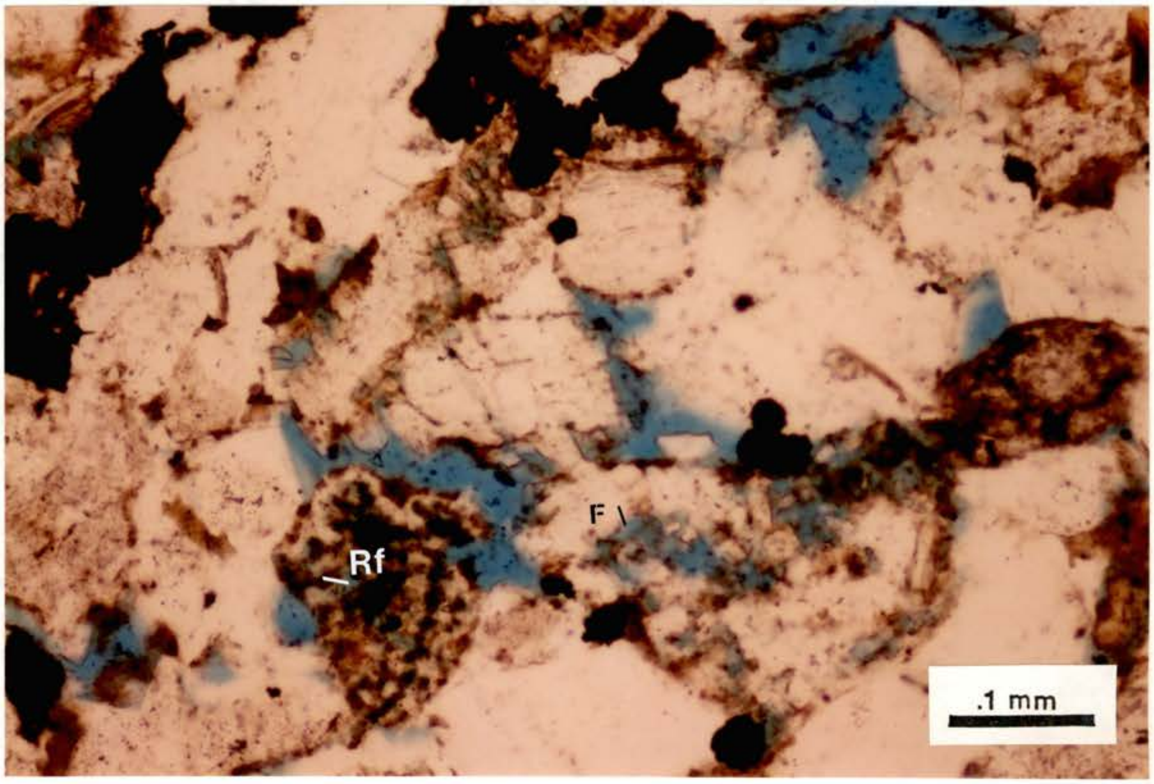


Figure 49. Secondary microporosity (arrow) developed within partially-leached feldspar (F) and rock fragment (Rf) detrital grains. Harper, Merrick No. 1-23. Depth 11264 feet. (ppl)

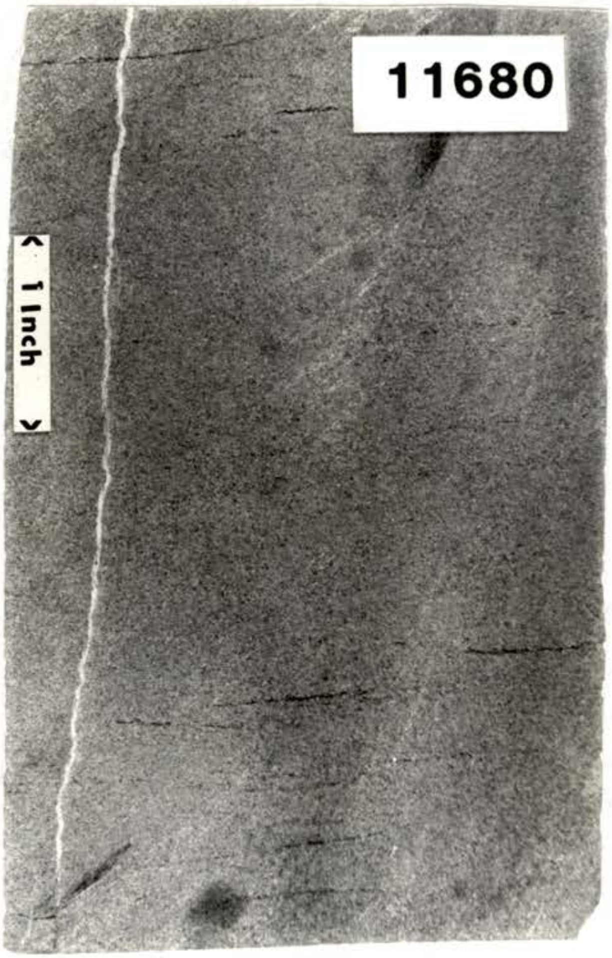


Figure 50. Carbonate-cemented fracture in Upper Skinner Sandstone. Santa Fe, Williams No. 1-31.

the rock since quartz grains enveloped in pseudomatrix retain their original grain morphology (Figure 48) and are not extensively silica cemented. As burial depths increased and overburden pressure increased, quartz pressure solution along grain contacts were initiated. The liberated silica from this dissolution was precipitated in lower pressure areas (pores) as quartz cement in the form of syntaxial quartz overgrowths. Feldspar overgrowths also occurred at this time under similar circumstances. Primary porosity was nearly totally occluded by these cementation processes.

Mesodiagenetic processes observed in the Upper Skinner Sandstone are dissolution of detrital constituents to form secondary porosity, growth of authigenic clays, and carbonate and sulfate cementation. Generation of secondary porosity was caused by the dissolution of feldspars, rock fragments, and pseudomatrix. Minor dissolution of quartz also occurred at this stage.

Most authigenic clays observed in the Upper Skinner Sandstone are believed to have formed during the late mesodiagenetic stage. This timing is inferred from the X-ray analysis and thin section petrology as both tools indicate highly crystalline clays are present in these sandstones.

Patchy carbonate cement in the sandstones fills pores and appears to engulf corroded quartz and feldspar detrital grains. Fracture filling sulfate cement is probably a product of chemical processes involving H_2S associated with hydrocarbon migration. Hydrocarbons were generated during the late mesodiagenetic stage by thermal maturation of the organic-rich Cabaniss Group shales.

Figure 51 depicts the paragenetic sequence of diagenetic events.

Provenance of Detrital Constituents

Petrographic analysis of Upper Skinner Sandstones indicates that sandstones within the study area have similar mineralogical constituents as the Prue and Skinner Sandstones of the Central Oklahoma Platform. Plagioclase, monocrystalline quartz, and metamorphic rock fragments are the primary detrital components of Cabaniss Group sandstones in the study area and on the Central Oklahoma Platform. This similar detrital composition suggests common northerly and/or easterly sources for the primary framework grains of these sandstones. However, minor amounts (<1 %) of microperthite and granophyre were identified in Upper Skinner Sandstones from the study area. Petrographic analysis of the Desmoinesian Granite Wash arkoses indicates that microperthite and granophyre are common constituents of sediments shed from the Wichita Mountains to the south. Microperthite and granophyre grains were transported to the north as fan deltas prograded northward during the Upper Desmoinesian (Al-Shaieb, 1977; Hansen, 1978). It is probable these grains mixed with Upper Skinner deltaic facies and were incorporated into the channel-fill sandstone after the

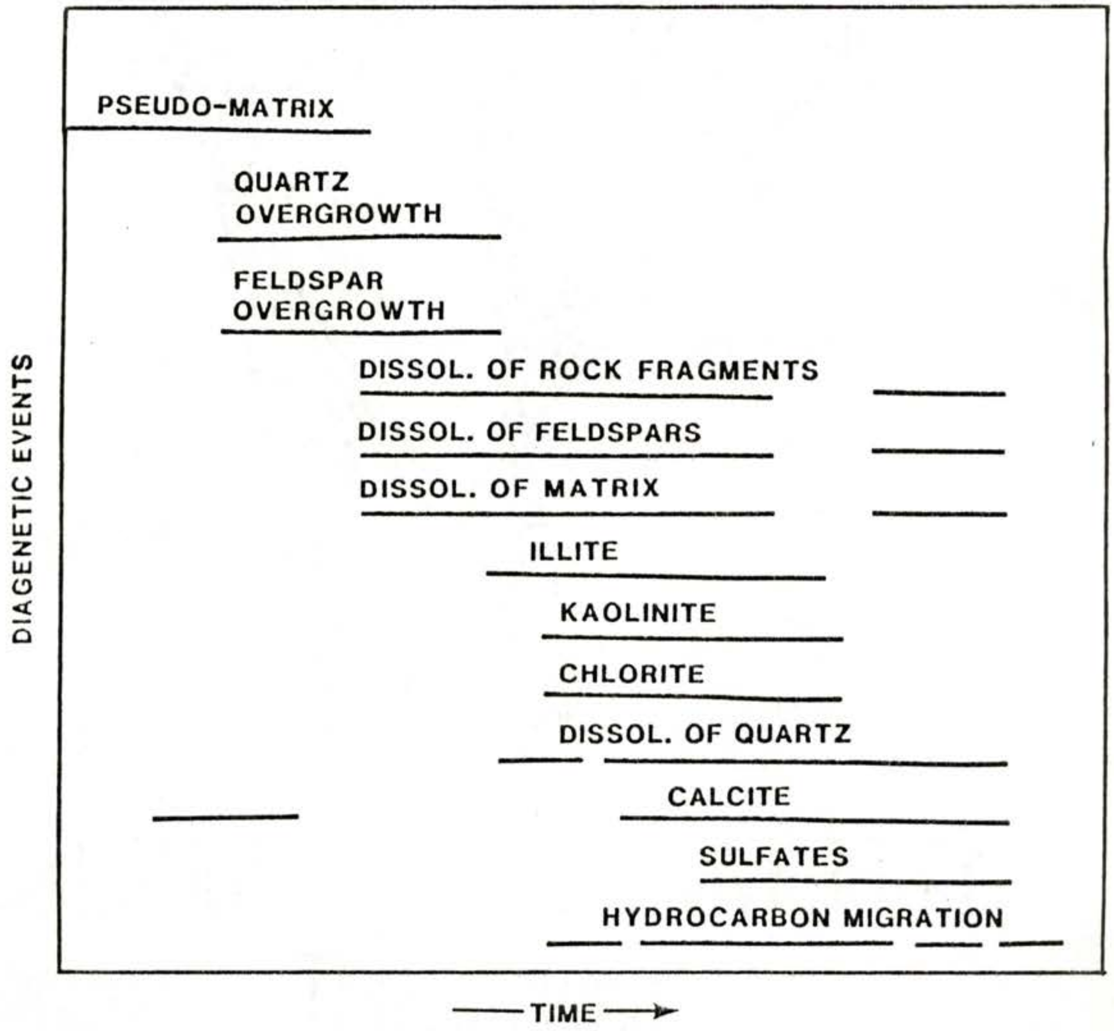


Figure 51. Paragenetic sequence of diagenetic events of the Upper Skinner Sandstone.

channel incised the older deltaic sediments.

Petroleum Geology

The majority of wells producing oil and gas from the Upper Skinner Sandstone are located along the primary channel-fill sandstone trend. Oil and gas fields along this trend include: Northeast Moorewood, Strong City District, Arapaho, and Indianapolis. Fields producing form the shallow marine sandstone facies are Butler-Custer and Stafford. These fields are identified and outlined on Figure 52.

Oil and gas produced from the Upper Skinner Sandstone within the study area is stratigraphically trapped. Channel-fill sandstone reservoirs within the channel trend are separated by clay- and silt-facies plugs. The entire channel sequence is then encased in shale or relatively non-permeable interbedded sandstone-shale facies, creating isolated stratigraphic traps along the trend. Shallow marine sandstone reservoirs are encased in shale and relatively non-permeable interbedded sandstone-shale facies.

The source for hydrocarbons in the Pennsylvanian sandstones has been suggested to be the enclosing Pennsylvanian shales (Hatch and Leventhall, 1982). Cabaniss Group shales observed in cores and samples appear rich in organic matter and are a likely source for hydrocarbons recovered from Upper Skinner sandstone reservoirs.

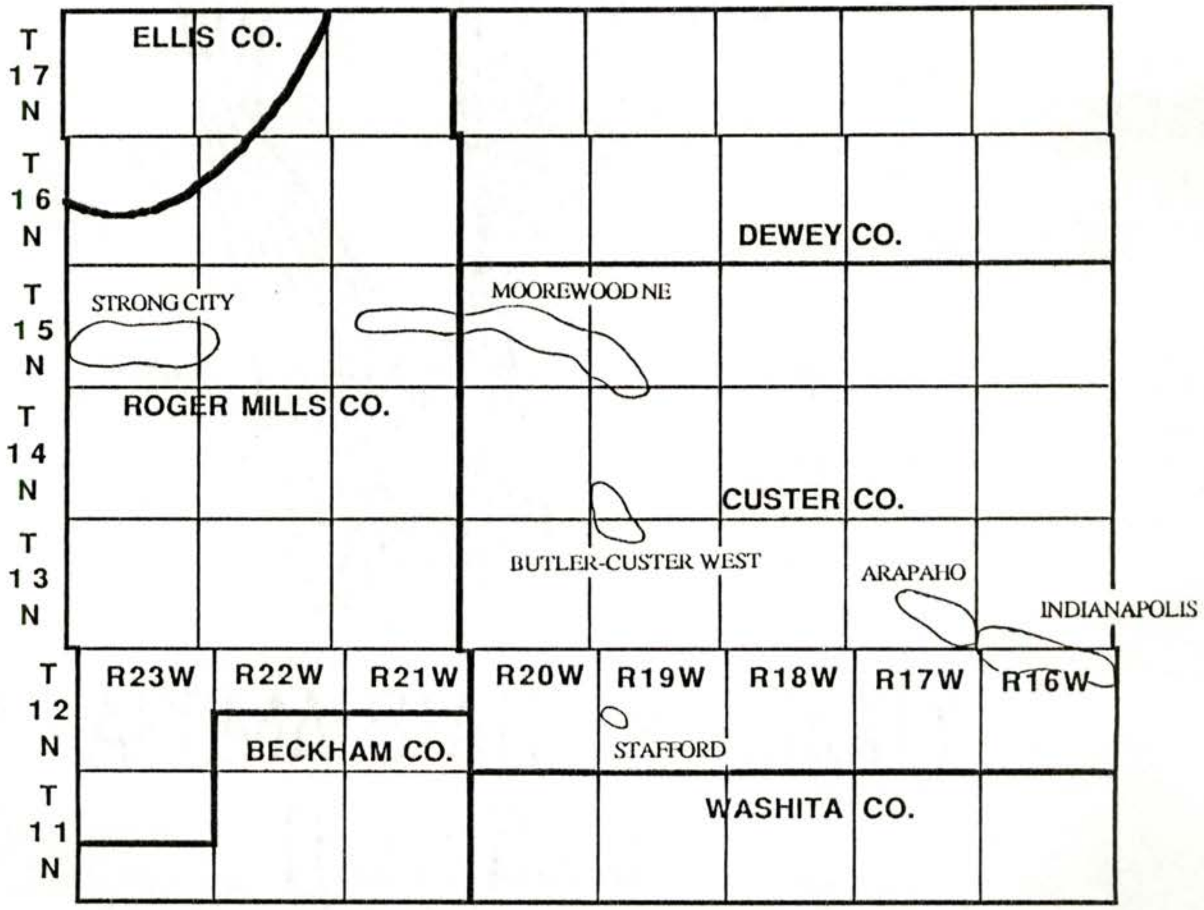


Figure 52. Map showing locations and names of oil and gas fields producing from the Upper Skinner Sandstone.

Most exploration and development drilling has occurred along the primary Upper Skinner Sandstone channel trend. These thicker channel-fill sandstones offer the best exploratory target due to their thickness and better reservoir quality. Reservoir quality is related to texture and rock constituents, with channel-fill sandstones being coarser grained than the flanking deltaic facies. These coarser channel-fill sandstones are more conducive to primary porosity preservation and subsequent secondary porosity development. Deltaic interbedded sandstone and shale facies are less likely to develop extensive secondary porosity because their higher clay and silt content and smaller grain size are not conducive to preserving primary porosity.

CHAPTER IX

CONCLUSIONS

The principal conclusions of this study are as follow:

1. The change from shallow water facies to deeper water facies for carbonate marker beds has created difficulties in correlating stratigraphic units within the study area.

2. The Cabaniss Group was deposited primarily in a relatively stable shelf setting where cyclic sea level changes stongly affected depositional facies.

3. The Cabaniss-Krebs Group boundary can be identified by changes in lithofacies and sedimentary structures across the boundary.

4. Pink and Verdigris facies distributions indicate similar depositional settings and migration of the shelf edge updip by Verdigris time.

5. Skinner shallow-marine sequences are finely crystalline carbonate that typically clean or coarsen upward and may have been deposited along the shelf-to-slope break.

6. Sandstone is sparse in the Lower Skinner interval, abundant in the Upper Skinner interval, and absent in the Prue interval.

7. The Upper Skinner sandstones were deposited in a

fluvio-deltaic setting. They may represent distributary channel fill, crevasse splay, and delta fringe deposition.

8. The primary Upper Skinner channel-fill reservoir trend may represent a sea-level lowstand incised valley that was filled during a minor sea-level rise.

9. Calcrete at the top of the Harper, Merrick No. 1-23 core indicates extensive subaerial exposure and sea level lowstand prior to deposition of the transgressive Verdigris interval.

10. The Cherokee "hot" shale marker bed may be a condensed section containing the deeper water facies equivalents to the Breezy Hill Limestone, Excello Shale, Blackjack Creek Limestone, Little Osage Shale, and the Higgensville Limestone.

11. Upper Skinner Sandstone is the primary "Upper Cherokee" or Cabaniss Group producing reservoir in the study area.

12. Upper Skinner sandstones underwent compaction and silica precipitation that occluded most primary porosity in the rock.

13. Dissolution of detrital grains, especially feldspar and metamorphic rock fragments, created most of the porosity observed in the sandstones.

14. Detrital constituents in the sandstones indicate a northeasterly source and a minor southern source for Upper Skinner sediments.

15. Upper Skinner channel-fill sandstones are important Cabaniss Group hydrocarbon-producing reservoirs.

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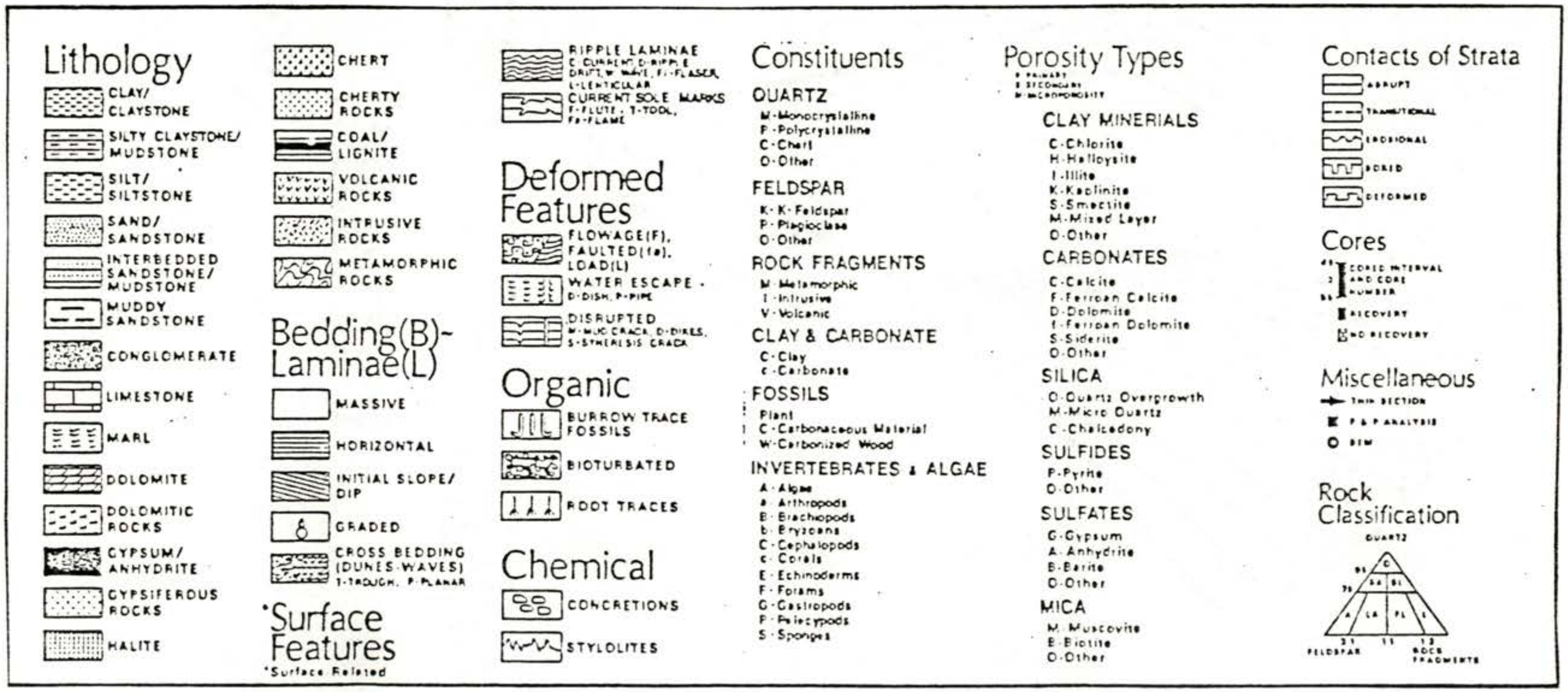
APPENDIX A

CORE DESCRIPTIONS


Lithology
CLAY/ CLAYSTONE
SILTY CLAYSTONE/ MUDSTONE
SILT/ SILTSTONE
SAND/ SANDSTONE
INTERBEDDED SANDSTONE/ MUDSTONE
MUDDY SANDSTONE
CONGLOMERATE
LIMESTONE
MARL
DOLOMITE
DOLOMITIC ROCKS
GYPSUM/ ANHYDRITE
GYPSIFEROUS ROCKS
HALITE
CHERT
CHERTY ROCKS
COAL/ LIGNITE
VOLCANIC ROCKS
INTRUSIVE ROCKS
METAMORPHIC ROCKS
Bedding(B)-Laminae(L)
MASSIVE
HORIZONTAL
INITIAL SLOPE/ DIP
GRADED
CROSS BEDDING (DUNES-WAVES) T-TROUGH, P-PLANAR
*Surface Features
*Surface Related
RIPPLE LAMINAE C-CURRENT, D-RIPPLE DRIFT, W-WAVE, F-FLASER, L-LENTICULAR
CURRENT SOLE MARKS F-FLUTE, T-TOOL, Fa-FLAME
Deformed Features
FLOWAGE(F), FAULTED(fa), LOAD(L)
WATER ESCAPE - D-DISH, P-PIPE
DISRUPTED M-MUD CRACK, D-DIKES, S-SYNERESIS CRACK
Organic
BURROW TRACE FOSSILS
BIOTURBATED
ROOT TRACES
Chemical
CONCRETIONS
STYLOLITES
Constituents
QUARTZ
M-Monocrystalline
P-Polycrystalline
C-Chert
O-Other
FELDSPAR
K-K-Feldspar
P-Plagioclase
O-Other
ROCK FRAGMENTS
M-Metamorphic
I-Intrusive
V-Volcanic
CLAY & CARBONATE
C-Clay
c-Carbonate
FOSSILS
Plant
C-Carbonaceous Material
W-Carbonized Wood
INVERTEBRATES & ALGAE
A-Algae
a-Arthropods
B-Brachiopods
b-Bryzoans
C-Cephalopods
c-Corals
E-Echinoderms
F-Forams
G-Gastropods
P-Pelecypods
S-Sponges
Porosity Types
P PRIMARY
S SECONDARY
M MICROPOROSITY
CLAY MINERALS
C-Chlorite
H-Halloysite
I-Illite
K-Kaolinite
S-Smectite
M-Mixed Layer
O-Other
CARBONATES
C-Calcite
F-Ferroan Calcite
D-Dolomite
f-Ferroan Dolomite
S-Siderite
O-Other
SILICA
O-Quartz Overgrowth
M-Micro Quartz
C-Chalcedony
SULFIDES
P-Pyrite
O-Other
SULFATES
G-Gypsum
A-Anhydrite
B-Barite
O-Other
MICA
M-Muscovite
B-Biotite
O-Other
Contacts of Strata
ABRUPT
TRANSITIONAL
EROSIONAL
BORED
DEFORMED
Cores
CORED INTERVAL AND CORE NUMBER
RECOVERY
NO RECOVERY
Miscellaneous
THIN SECTION
P & P ANALYSIS
SEM
Rock Classification
QUARTZ
95
75
Q
SA
SL
A
LA
FL
L
3:1
1:1
1:3
FELDSPAR
ROCK FRAGMENTS

SANTA FE MIN., WILLIAMS NO. 1-31

SE SEC. 31, T.13N., R.16W.

CUSTER CO., OKLA.

Petrologic Log

Lithology

- CLAY/ CLAYSTONE
- SILTY CLAYSTONE/ MUDSTONE
- SILT/ SILTSTONE
- SAND/ SANDSTONE
- INTERBEDDED SANDSTONE/ MUDSTONE
- MUDDY SANDSTONE
- CONGLOMERATE
- LIMESTONE
- MARL
- DOLOMITE
- DOLOMITIC ROCKS
- GYPSUM/ ANHYDRITE
- GYPSIFEROUS ROCKS
- HALITE
- CHERT
- CHERTY ROCKS
- COAL/ LIGNITE
- VOLCANIC ROCKS
- INTRUSIVE ROCKS
- METAMORPHIC ROCKS

Bedding(B)- Laminae(L)

- MASSIVE
- HORIZONTAL
- INITIAL SLOPE/ DIP
- GRADED
- CROSS BEDDING (DUNES WAVES)
- RIPPLE LAMINAE
- CURRENT SOLE MARKS

*Surface Features

*Surface Related

Deformed Features

- FLOWAGE(F), FAULTED(FA), LOAD(L)
- WATER ESCAPE
- DISRUPTED

Organic

- BURROW TRACE FOSSILS
- BIOTURBATED
- ROOT TRACES

Chemical

- CONCRETIONS
- STYLOLITES

Constituents

QUARTZ

- M-Monocrystalline
- P-Polycrystalline
- C-Chert
- O-Other

FELDSPAR

- K-K Feldspar
- P-Plagioclase
- O-Other

ROCK FRAGMENTS

- M-Metamorphic
- I-Intrusive
- V-Volcanic

CLAY & CARBONATE

- C-Clay
- L-Carbonate

FOSSILS

- Plant
- C-Carbonaceous Material
- W-Carbonized Wood

INVERTEBRATES & ALGAE

- A-Algae
- A-Arthropods
- B-Brachiopods
- B-Bryozoans
- C-Cephalopods
- C-Corals
- E-Echinoderms
- F-Forams
- G-Gastropods
- P-Pelecypods
- S-Sponges

Porosity Types

CLAY MINERALS

- C-Chlorite
- H-Halloysite
- I-Illite
- K-Kaolinite
- S-Smectite
- M-Mixed Layer
- O-Other

CARBONATES

- C-Calcite
- F-Ferroan Calcite
- D-Dolomite
- F-Ferroan Dolomite
- S-Siderite
- O-Other

SILICA

- Q-Quartz Overgrowth
- M-Micro Quartz
- C-Chalcedony

SULFIDES

- P-Pyrite
- O-Other

SULFATES

- G-Gypsum
- A-Anhydrite
- B-Barite
- O-Other

MICA

- M-Muscovite
- B-Biotite
- O-Other

Contacts of Strata

- ABRUPT
- TRANSITIONAL
- EROSIONAL
- SOLED
- DEFORMED

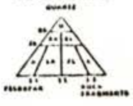
Cores

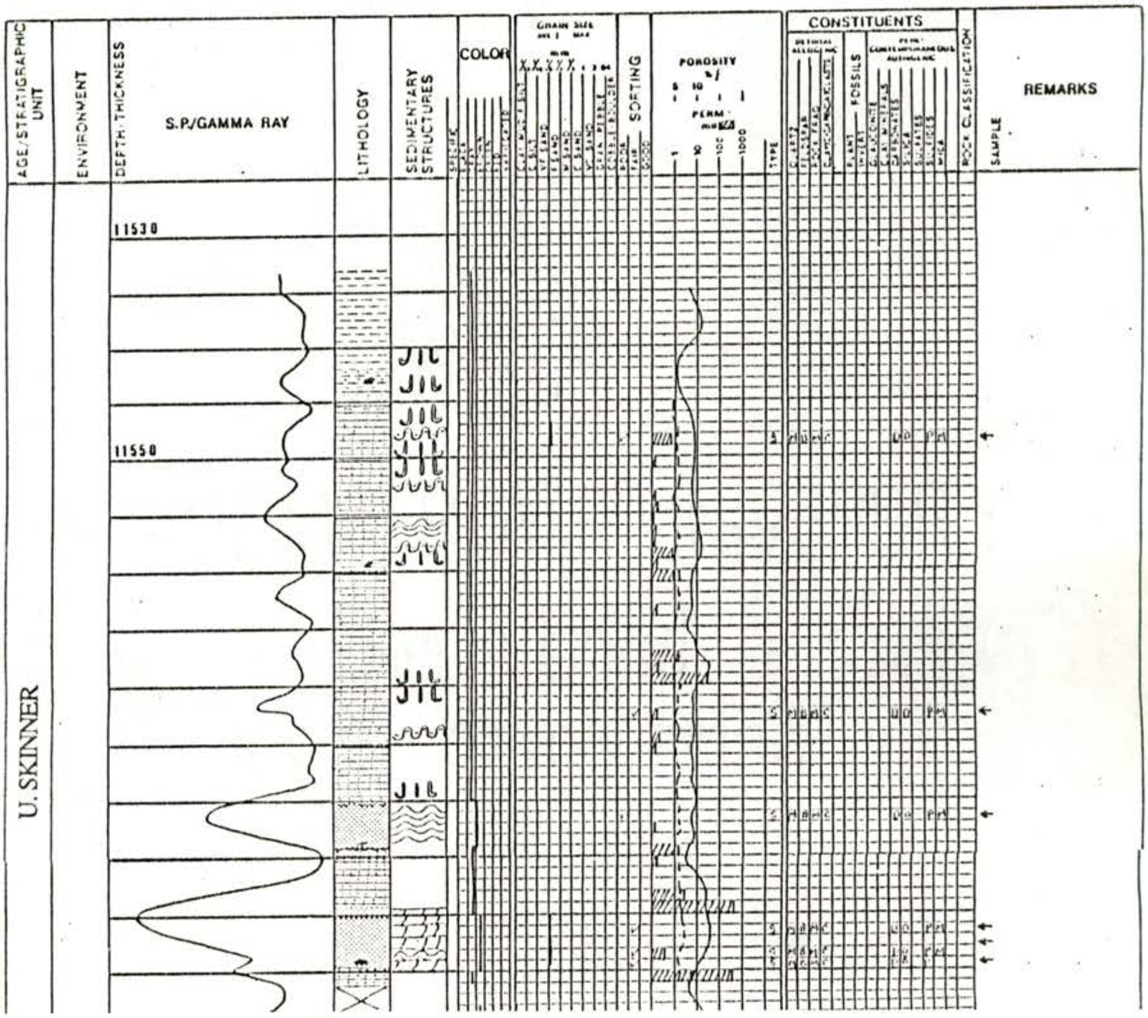
- CORED INTERVAL AND CORE NUMBER
- RECOVERY
- NO RECOVERY

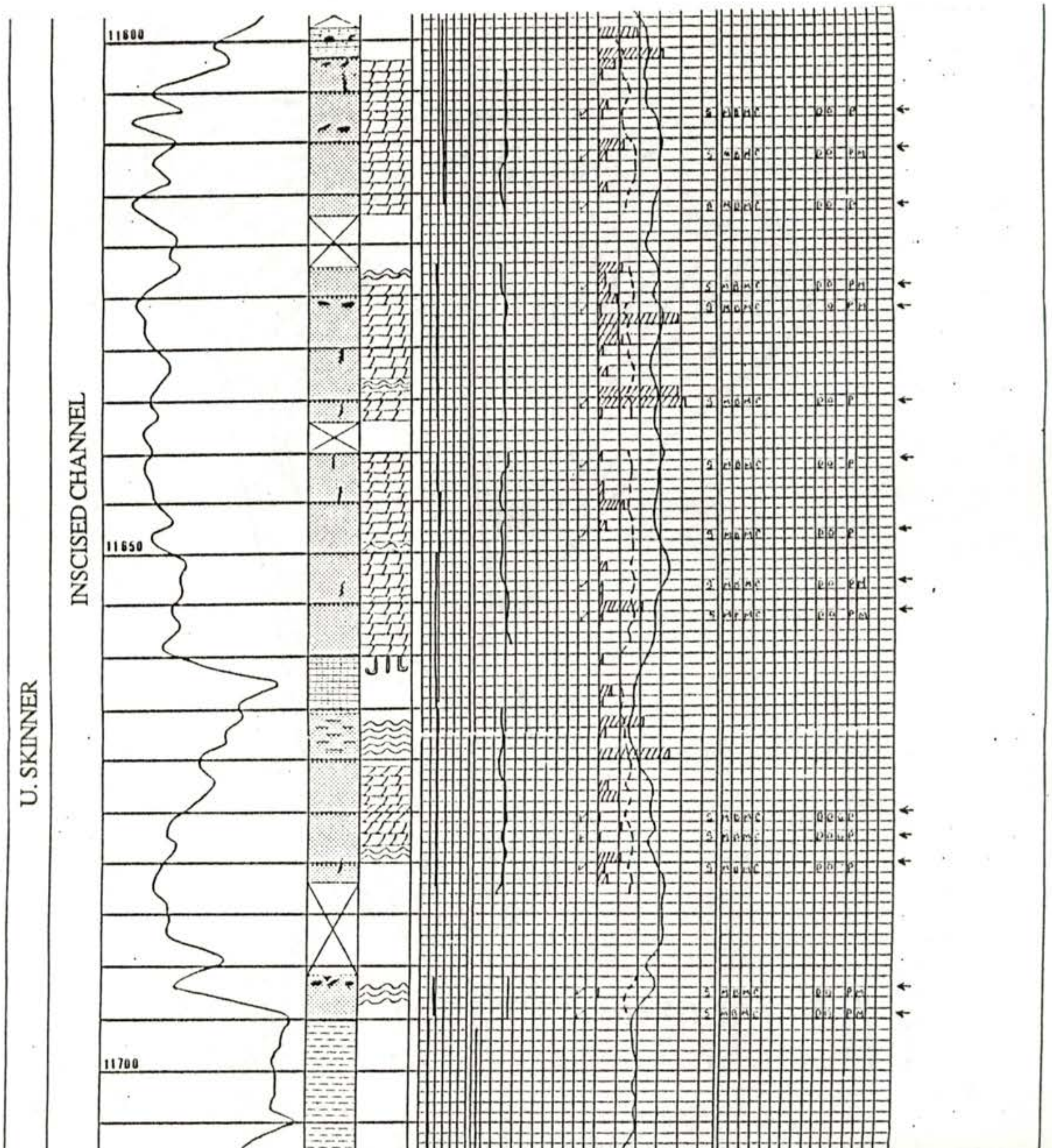
Miscellaneous

- THIN SECTION
- SEM

Rock Classification






U. SKINNER
INSCISED CHANNEL
11600
11650
11700
11740

Well: Santa Fe Minerals, Williams No. 1-31

Location: SE Sec. 31, T.13N., R.16W., Custer County, Oklahoma

Depth: 11533'-11739'

Stratigraphic Interval: Upper Skinner

The cored sequence is composed of dark shale, sandstone, and interbedded sandstone, siltstone, and shale. The lowest interval (11739'-11695') is a dark gray shale that is interpreted as pro-deltaic in origin.

A sharp erosive base separates the overlying fine-grained sandstone unit (11695'-11666') from the underlying shale unit (11739'-11695'). The sedimentary structures of the sandstone unit include channel-lag features (rip-up clasts), medium-scale tabular cross beds, and ripple laminae. The sandstone unit exhibits a fining-upward texture and upward increase in shale content. Carbonized plant material, carbonate cement, and both open and cemented fractures were observed in this unit.

An interval (11666'-11659') of burrowed interbedded sandstone and shale separates the lowest sandstone unit (11695'-11666') from the next sandstone unit. The interbedded interval (11666'-11659') has a gradational contact with the underlying sandstone unit and a sharp erosive contact with the overlying sandstone unit.

The next sandstone unit (11659'-11602') has similar sedimentological structures as the lowest sandstone unit at 11666' to 11659'. Channel-lag features (rip-up clasts), medium-scale tabular cross beds, and ripple laminae are the sedimentological features observed in this unit. Fracturing and carbonate cement are also observed in this unit.

The next interval (11602'-11594') is an interbedded shale and sandstone zone similar to the zone at 11665'-11659'. The interbedded interval at 11602' to 11594' contains a thin, black, highly carbonaceous shale bed at 11602'. The interbedded interval has a gradational contact with the underlying sandstone (11659' -11602') and a sharp contact with the overlying sandstone (11595'-11589'). The sandstone interval from 11595' to 11589' contains channel-lag features, ripple laminae, and tabular to trough cross beds as sedimentological features.

The next interbedded interval (11589'-11584') is in gradational contact with the underlying sandstone unit (11595'-11589'). This interbedded interval is wavy bedded sandstone and shale that is burrowed.

The uppermost sandstone unit (11584'-11580.5') is in sharp erosive contact with the underlying interbedded interval (11589'-11584'). This sandstone has channel-lag features (rip-up clasts) and ripple laminae.

The next interval (11580.5'-11541') is a lenticular and wavy-bedded sandstone-shale sequence that grades upward into shale with thin siltstone and sandstone laminae.

The lithology of the remaining cored interval is dark gray shale with siltstone and sandstone laminae (11541'-11533'). The uppermost intervals are burrowed and contain soft-sediment deformation features.

The sandstone and interbedded intervals of this core (11695'-11580.5') are interpreted as a multistoried channel-fill sequence that rests on pro-delta shale (11739'-11695'). Sandstones represent higher-energy deposition in channels that eroded during sea level lowstands. As sea level increased, energy within the stream decreased and sands were deposited in the channels. The interbedded sequences are ripple-dominated reflecting tidal influence in the inundated channel. The upward increase in shale content in the interbedded sequences reflects deeper-water settings and quiet-water (quiescent) conditions. Increases in sandstone in the interbedded sequences reflect higher energy (flood or storm) conditions.

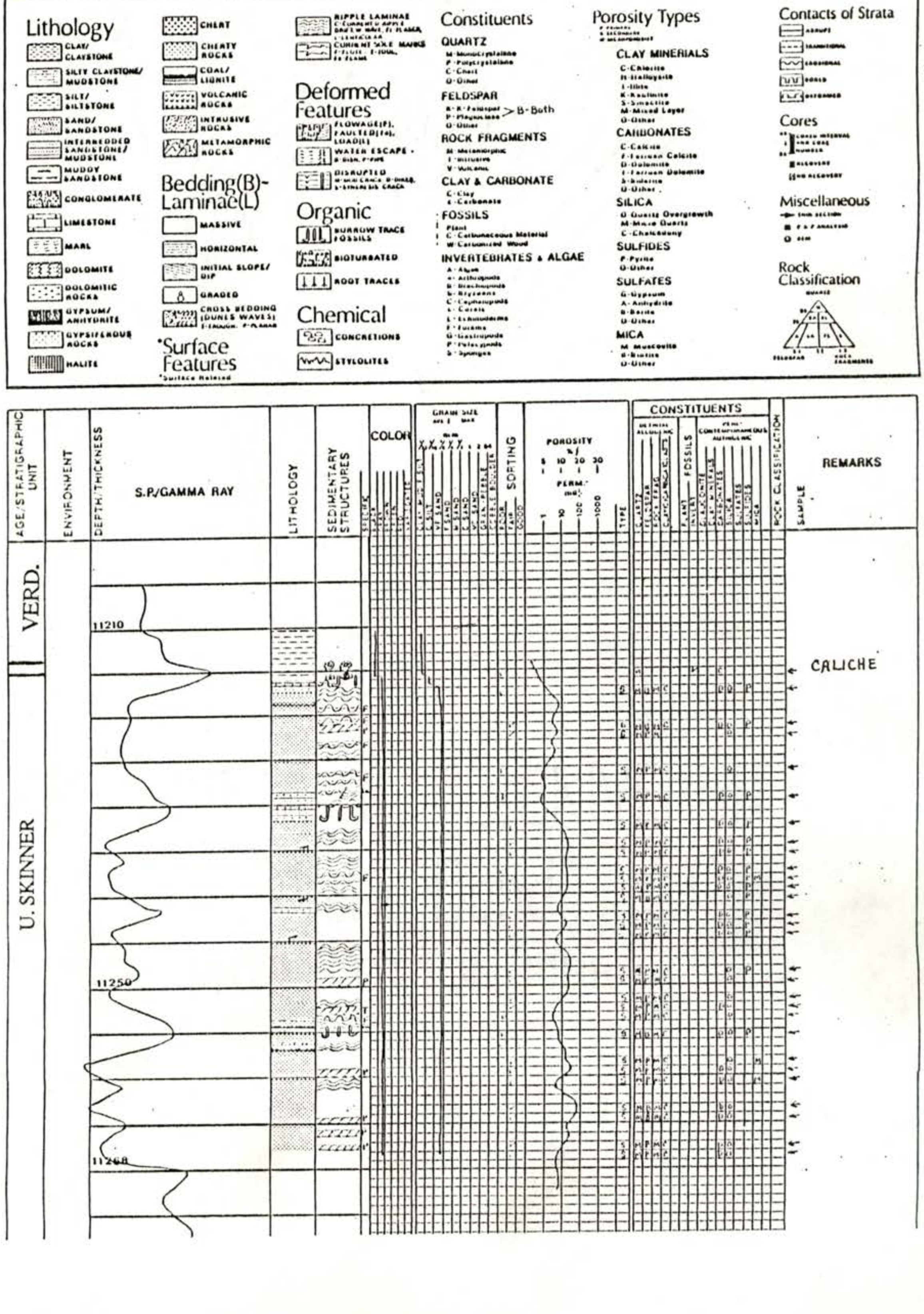
The upper part of the cored interval (11580.5'-11535') reflects a general sea-level rise and flooding of the channel tract. The upward decrease in sandstone and burrows suggest deepening water conditions. This interbedded, shale-rich interval may have been deposited in an estuary formed over the flooded channel tract.

HARPER OIL, MERRICK NO. 1-23

SE SEC. 23, T.15N., R.23W.

ROGER MILLS CO., OKLA.

Petrologic Log



]

Well: Harper Oil, Merrick No. 1-23

Location: W/2 SE Sec. 23, T.15N., R.23W., Roger Mills County, Oklahoma

Depth: 11210'-11268'

Stratigraphic Interval: Upper Skinner

The cored interval consists of sandstone and shale of the Upper Skinner interval. The interval from 11268'-11217' contains four sandstone units separated by thin shale-rich interbedded sandstone-shale zones. These sandstone units have sedimentary features with channel-lag characteristics (rip-up clasts), medium-scale planar and trough cross-bedding, and ripple laminae. The contact between the lowermost sandstone unit 11268'-11257' is sharp (log-inferred) with the underlying shale. The shale-rich intervals separating the sandstone units are burrowed and contain flowage features and soft-sediment faults. The sandstone unit from 11241' to 11232' contains flowage features. This sandstone unit is also massively bedded in part and contains ripple laminae.

The interval from 11232' to 11229.5' is interbedded sandstone, shale, and muddy sandstone. This interval exhibits wavy bedding and is burrowed. Overlying this interval is a sandstone unit from 11229.5' to 11217'. This sandstone is massively bedded in part and contains ripple laminae and flowage features.

The interval from 11217'- 11216' is interbedded sandstone, siltstone, and shale that is burrowed. This interval is in sharp contact with the underlying sandstone. Overlying the interbedded zone is a carbonate-rich, fossiliferous dark shale with calcareous nodules (caliche). This carbonate-rich shale zone (11216'-11214.5') is in gradational contact with the underlying interbedded unit.

The final interval (11214.5'-11210') in this core is dark-gray fossiliferous shale. This dark shale is in sharp contact with the underlying caliche zone.

The sandstone and shale sequence of the cored interval (11268'-11217') contains four sandstone units separated by interbedded sandstone-shale zones. The channel-fill characteristics of the sandstone units are indicative of a multistoried sandstone body. Channel-fill is probably related to sea level rise and decreased energy in the channel. The burrowed interbedded zones reflect complete inundation of the channel fill and relatively quiet water conditions.

The decrease in planar and trough cross-beds toward the top of the sequence reflects increased marine and less fluvial (current) influence on deposition. Increased flowage in the upper units suggests subaqueous suspension and less current influence. Complete inundation of the channel-fill is inferred by the interbedded zones and fossiliferous shale zone (11217'-11215') at the top of the channel sequence.

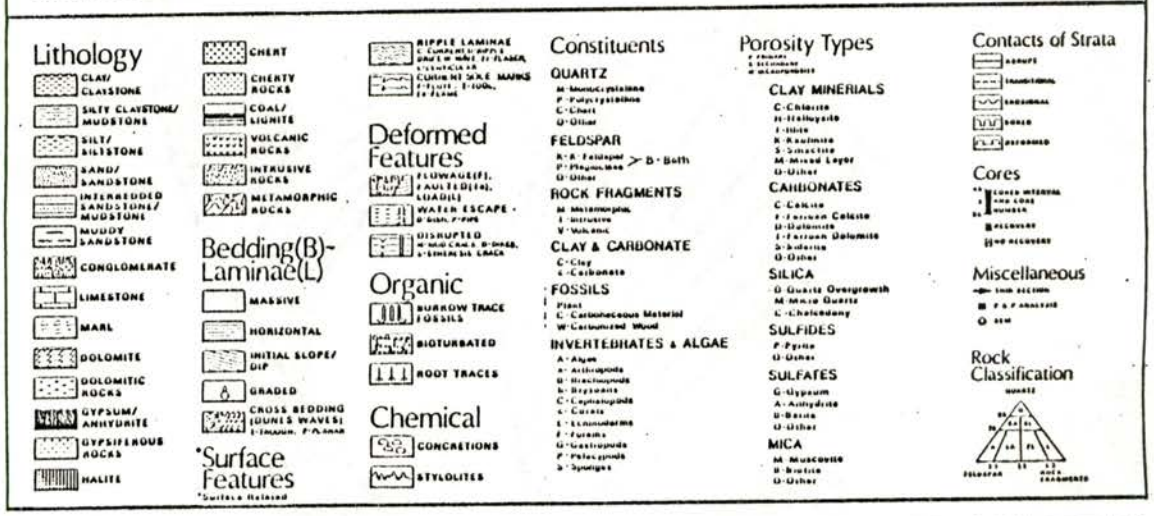
Extensive subaerial exposure formed the caliche zone from 11215' to 11214.5'. Subsequent flooding of the emergent Upper Skinner rocks by the Oakley Shale transgression deposited the dark shale from 11214.5' to 11210'.

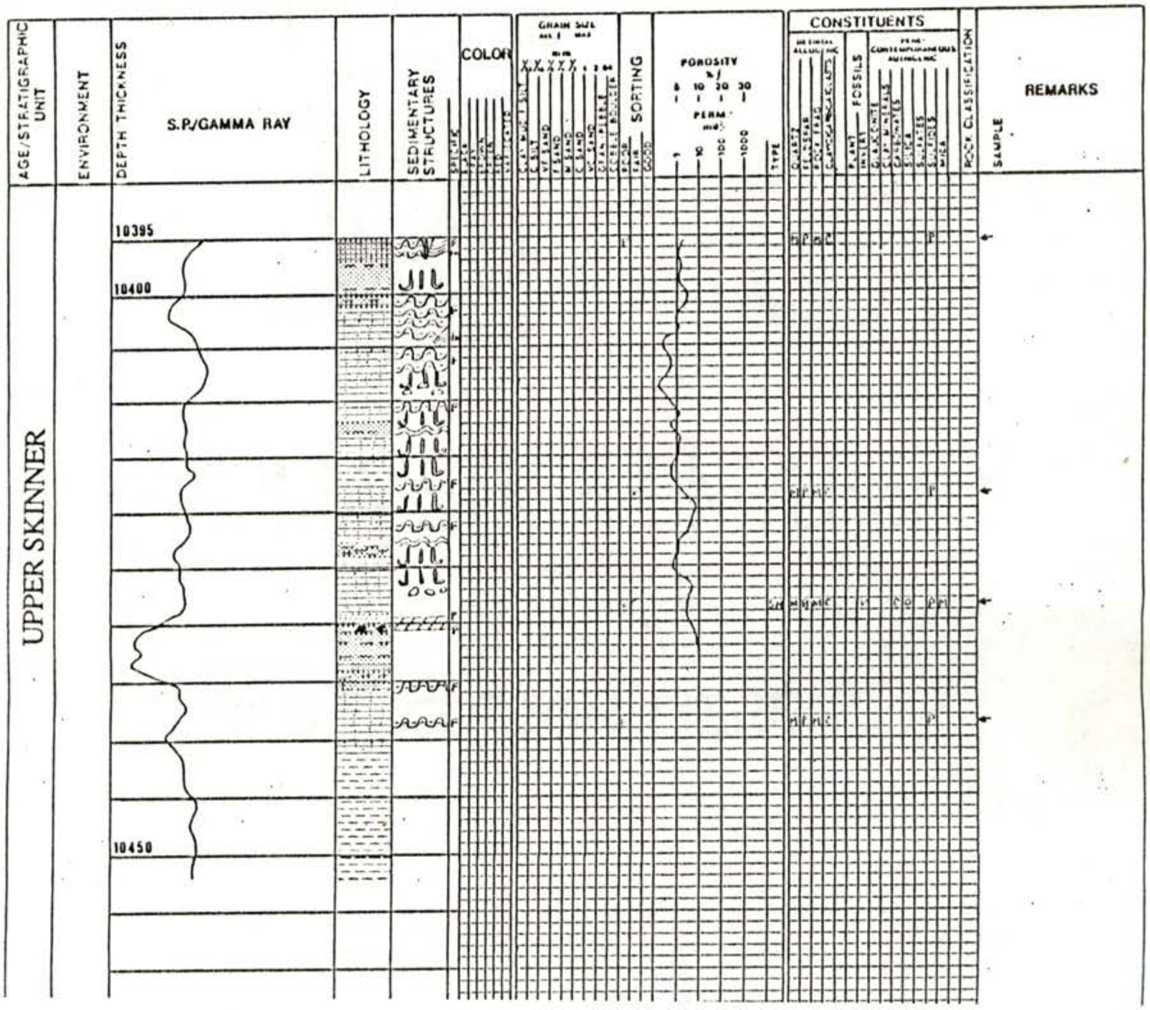
BARNES, WALKER "B" NO. 1

NE SEC. 1, T.15N., R.19W.

CUSTER CO., OKLA.

Petrologic Log





Well: Barnes, Walker "B" No. 1

Location: NE Sec. 1, T.15N., R.19W., Custer Co., Oklahoma

Depth: 10395'-10452'

Stratigraphic Interval: Upper Skinner

The cored interval contains dark shale, interbedded-interlaminated sandstone, siltstone, and shale, and thin sandstone beds. The interval from 10452' to 10443.5' is primarily dark shale with thin sandstone laminae. These relatively flat-lying beds show an apparent increase in inclination upward. This interval is sparsely burrowed and apparently devoid of fossils.

The interval from 10443.5' to 10440.5' is dominated by dark gray shale. However, this interval shows a significant increase in sandstone content in the form of wavy bedding. This interval is only sparsely burrowed and in gradational contact with the underlying sand-starved interval.

The interval from 10440.5' to 10436' is dominated by wavy to flaser-bedded shale and sandstone. This interval is in gradational contact with the underlying shale-dominated interval.

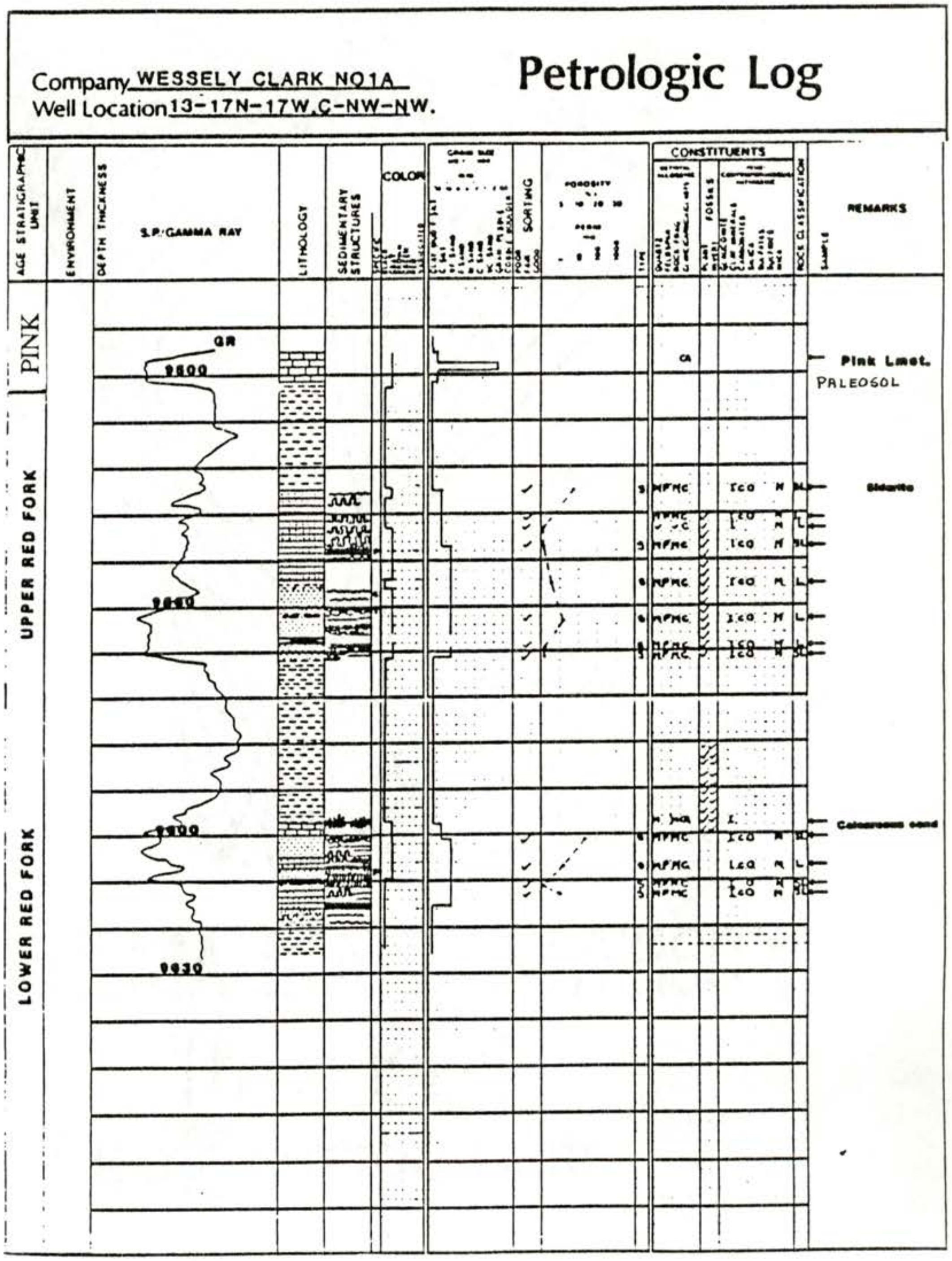
The muddy sandstone from 10436' to 10429' is in gradational contact with the underlying unit. The sandstone exhibits channel-lag features (rip-up clasts) and tabular cross beds. This sandstone is overlain by an interbedded zone from 10429' to 10424'. This zone contains a few thicker (.5'-.75') muddy sandstone beds, but is dominated by wavy to thin flaser-bedded sandstone-shale intervals. This zone is heavily burrowed and contains siderite concretions.

A thin sandstone unit is found from 10424' to 10423'. This sandstone contains carbonaceous material and ripple laminae. The interval from 10423' to 10413' consists of shale-dominated, interbedded sandstone-shale sequences that range from shale to muddy sandstone. This zone is burrowed and displays many flowage features.

A muddy sandstone with ripple laminae is found from 10413' to 10412'. Overlying this muddy sandstone is another interval (10412'-10401') of interbedded sandstone and shale that is burrowed and has flowage features. This zone contains siderite concretions.

The interval 10401' to 10395' is a muddy sandstone-dominated zone with shale laminae. This zone shows evidence of soft-sediment deformation and is burrowed. Shale laminae and burrowing increase toward the top of this zone as flowage features decrease.

The cored sequence in this well can be interpreted as interdistributary marsh and bay and/or estuarine deposits. The muddy sandstone and shale with flowage features represent deposition during higher flow regimes when water overflowed channel banks or storms churned bay muds and sands. The thin flat-lying shale-dominated laminae represent deposition during relatively low-energy water conditions. Wavy-bedded zones in this core represent tidal or storm influence in the estuary or interdistributary marsh or bay. The highly burrowed zones may reflect low-energy shallow-water conditions following sediment influx from storms or high stream-flow periods.



(AFTER UDAYASHANKAR, 1985)

Well: Wessely, Clark No. 1-A

Location: NW NW Sec. 13, T.17N., R.17W., Dewey Co., Okla.

Depth: 9495'-9520'

Stratigraphic Interval: Red Fork and Pink

This core contains parts of the Red Fork Sandstone and Pink Limestone intervals. The lower cored interval (9520'-9503.5') in the Upper Red Fork consists of interbedded to interlaminated sandstone, siltstone, and shale. This zone directly overlies a channel-fill sandstone that was interpreted as a deltaic distributary channel (Udayashankar, 1985). These interbedded to interlaminated sandstones, siltstones, and shales are believed to be of interdistributary bay or estuarine origin.

The interbedded-interlaminated zone is overlain by a clay-rich "punky" shale zone with carbonized rootlets. This zone is from 9503.5' to 9502' and represents a paleosol formed on emergent Upper Red Fork interdistributary or estuarine shales. This soil zone may represent the disconformity between the Krebs and Cabaniss Groups.

Immediately above the paleosol is a silty, muddy carbonate and calcareous silty shale zone from 9502' to 9499.5'. This silty carbonate is the basal part of the Pink Limestone interval. Carbonate in the basal Pink interval increases toward the top of the zone at 9499.5'. The Pink carbonate is in sharp contact with the underlying paleosol zone.

The middle interval (9899.5'-9498.7') of the Pink Limestone is a biosparite containing abundant brachiopod and echinoid fragments. This is the "cleanest" (silt-free) carbonate in the Pink interval. The biosparite is in sharp contact with the underlying silty carbonate.

The upper part of the Pink Limestone interval (9498.7'-9495') is very similar to the basal part of the Pink interval. This upper interval is silty and sandy microspar that becomes more silty and shale-rich upward toward the top of the carbonate interval at 9495.5'. This upper carbonate zone is in sharp contact with the underlying biosparite.

The remaining .5 feet of this core is dark gray shale. This shale is in sharp contact with the underlying Pink carbonate interval.

The Upper Red Fork interval in this core is interpreted to be of deltaic origin (Udayashankar, 1985). The interbedded-interlaminated sandstone, siltstone, and shale of this interval are interpreted as interdistributary bay or estuarine deposits.

The "punky" shale zone with rootlets is interpreted as a paleosol developed on the emergent Upper Red Fork deltaic or coastal plain. This plain was subsequently flooded during the Pink transgression.

The basal part of the Pink Limestone interval includes siliclastic material derived from the underlying

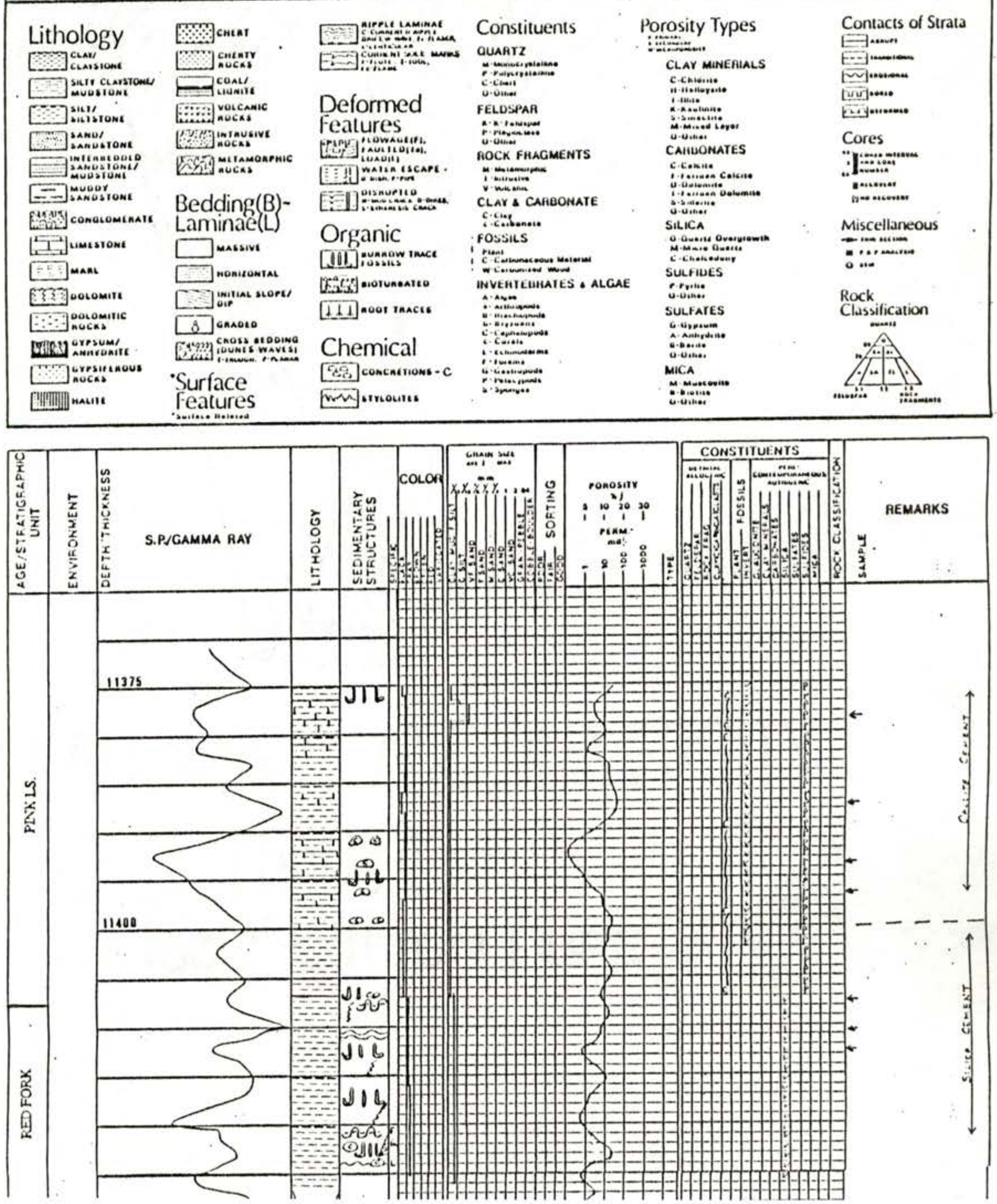
Upper Red Fork sediments. The middle "cleaner" biosparite interval represents deposition during relatively stable conditions that encouraged a vigorous biota. The upper Pink interval reflects less-stable conditions and increasing siliclastic influence on Pink deposition. An upward increase in shale in this interval infers deeper-water conditions. The dark gray shale overlying the Pink carbonate reflects deeper-water sedimentation.

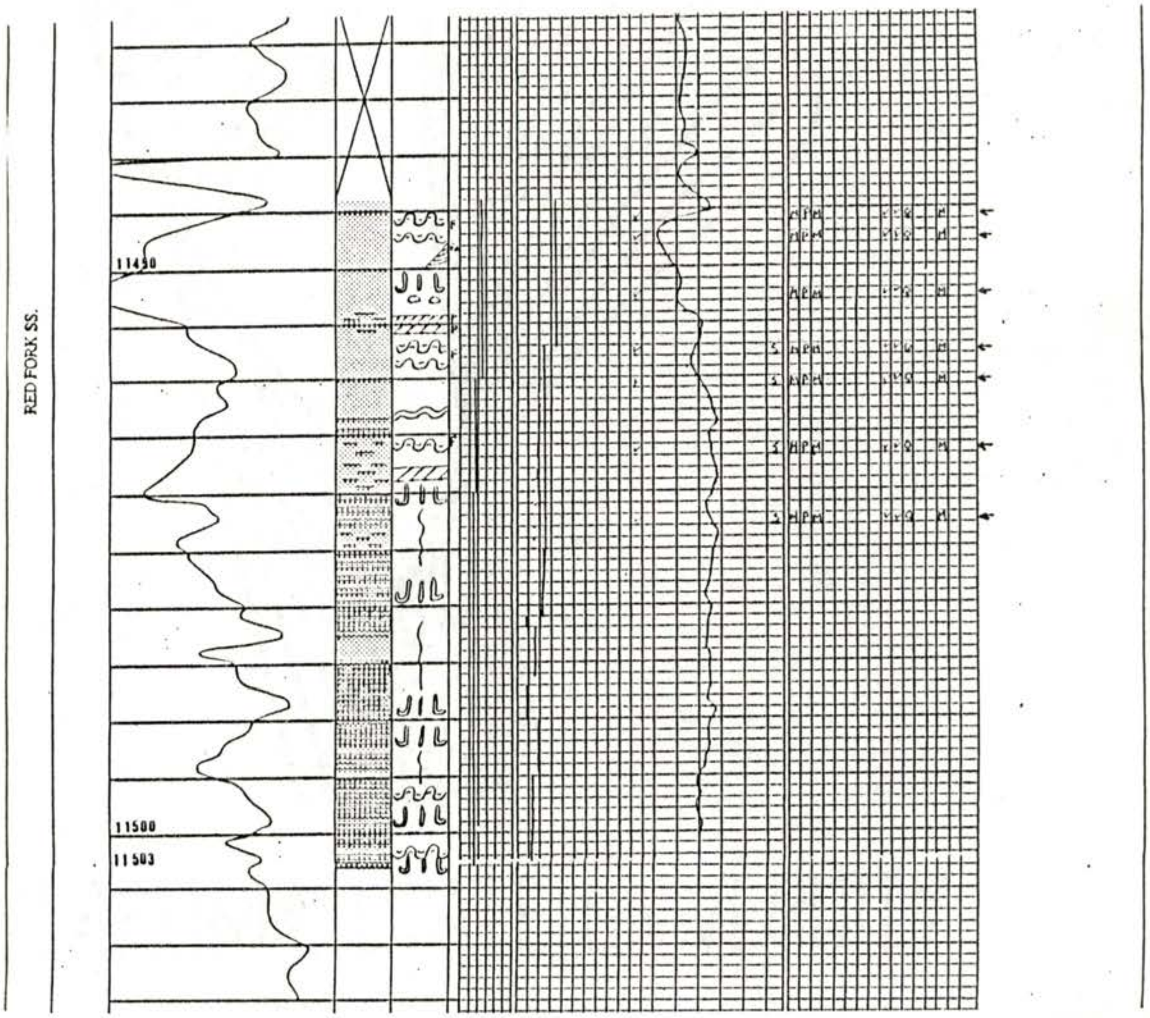
WOODS, SWITZER "C" NO. 1

NE SEC. 5, T.15N., R.21W.

ROGER MILLS CO., OKLA.

Petrologic Log




RED FORK SS.
11450
11500
11503
HPM
S
M

Well: Woods Petroleum, Switzer "C" No.1

Location: NE Sec. 5, T.15N., R.21W., Roger Mills County, Oklahoma

Depth: 11375'-11427' and 11444'-11503'

Stratigraphic Interval: Upper Red Fork and Pink

This core contains two intervals separated by approximately 16 feet of missing core. The lower cored interval 11503'-11444' is interbedded sandstone, siltstone, and shale. The basal part of this interval (11503'- 11470') is shale-rich and exhibits an increase in sandstone content upward. This interbedded sequence has apparent initial dip, lenticular, wavy, and flaser bedding, ripple laminae, burrows and bioturbation, and flowage features.

The interval from 11470' to 11467' is muddy sandstone with shale beds and laminae. This interval has burrows, flowage features, ripple laminae, and planar cross beds. Overlying this sequence is sandstone from 11467' to 11444'. This Upper Red Fork sandstone interval exhibits extremely contorted bedding due to flowage, soft-sediment faulting, ripple laminae, planar small-scale cross beds, and flame structures. This sandstone displays general coarsening upward texture and appears to be in sharp contact (based on log signature) with the overlying Upper Red Fork siltstone and shale interval. Bedding contacts within the Upper Red Fork interval are sharp, but the overall Red Fork sandstone interval is a coarsening-upward sequence.

The upper cored interval from 11427' to 11375' contains the Upper Red Fork (Krebs Group)-Pink (Cabaniss Group) boundary. The lower part of this core (11427'-11407') is silica-cemented gray siltstone and shale. This interval contains abundant pyrite at 11407', burrows, concretions, flowage, and soft sediment faulting. Fracturing and some small-scale planar cross beds are also evident in this interval.

The next interval (11407'-11375') is dark gray to black calcareous shale and muddy micrite. The lower part of this zone from 11407' to 11400' is pyrite-rich and silica cemented. Pyrite occurs as thin partings, replacement after fossils and organic material in burrows, and as concretions. The upper part of the zone from 11400' to 11375' is calcite-cemented shale and muddy silicified carbonate. Pyrite is abundant in this interval as replacement of fossils and organic material in burrows, concretions, veinlets, and thin partings in the finely laminated shale. Several zones of carbonate concretions and fossil debris are evident in the interval from 11398' to 11378'. Sparse burrowing and horizontal bedding are the other sedimentary features observed in the Pink interval.

The Upper Red Fork Sandstone interval from 11503' to 11407' represents deposition in an interdistributary or delta-fringe environment. The lower shale interval represents pro-delta mud on which the shallow-marine sandstone was deposited. The lenticular- to flaser-bedded interval between the pro-delta shale and clean sandstone has an upward-increase in sandstone content. The upward-increase in sandstone reflects higher energy depositional conditions and decreased water depth.

The disconformable boundary between the Cabaniss and Krebs Groups is picked as 11407 feet. This is the depth of the contact between the dark shale of the Pink interval and the lighter gray shale and siltstone of the underlying Upper Red Fork interval. The dark calcareous shale of the lower Pink interval represents a deeper-marine slope setting. This deep-water facies rests directly on the Red Fork shallow-marine interdistributary siltstone-shale facies. Carbonate-rich zones within the Pink interval suggest shallowing water or storm-generated carbonate influx from the shelf. The upper part of the Pink interval 11377'-11375' is black finely laminated shale. This shale may suggest a return to relative deeper-water conditions.

APPENDIX B

CORE PHOTOGRAPHS

Figure 53. Upper Skinner, Santa Fe, Williams No. 1-31.

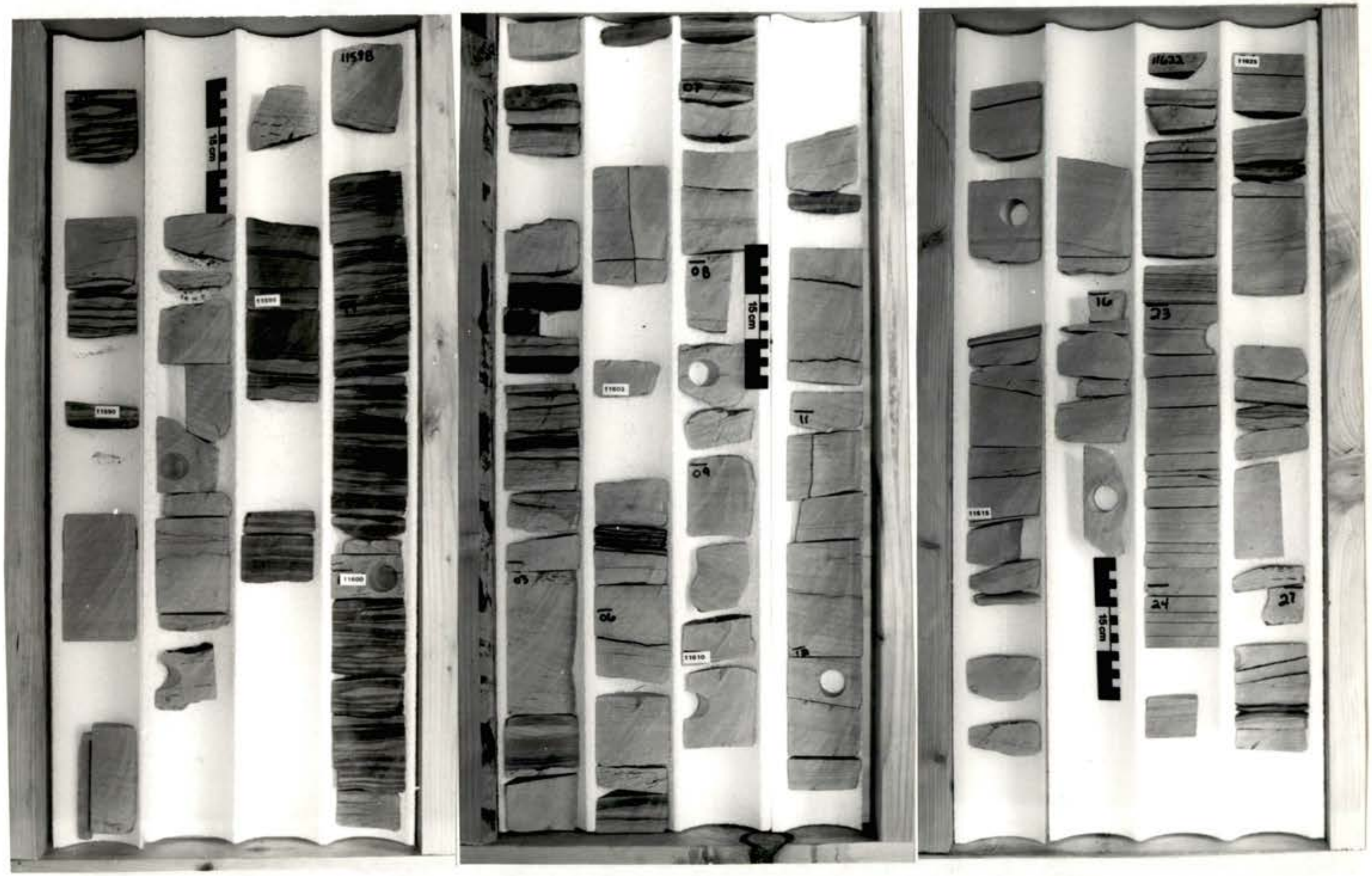


Figure 53. Continued

Figure 53. Continued

Figure 53. Continued

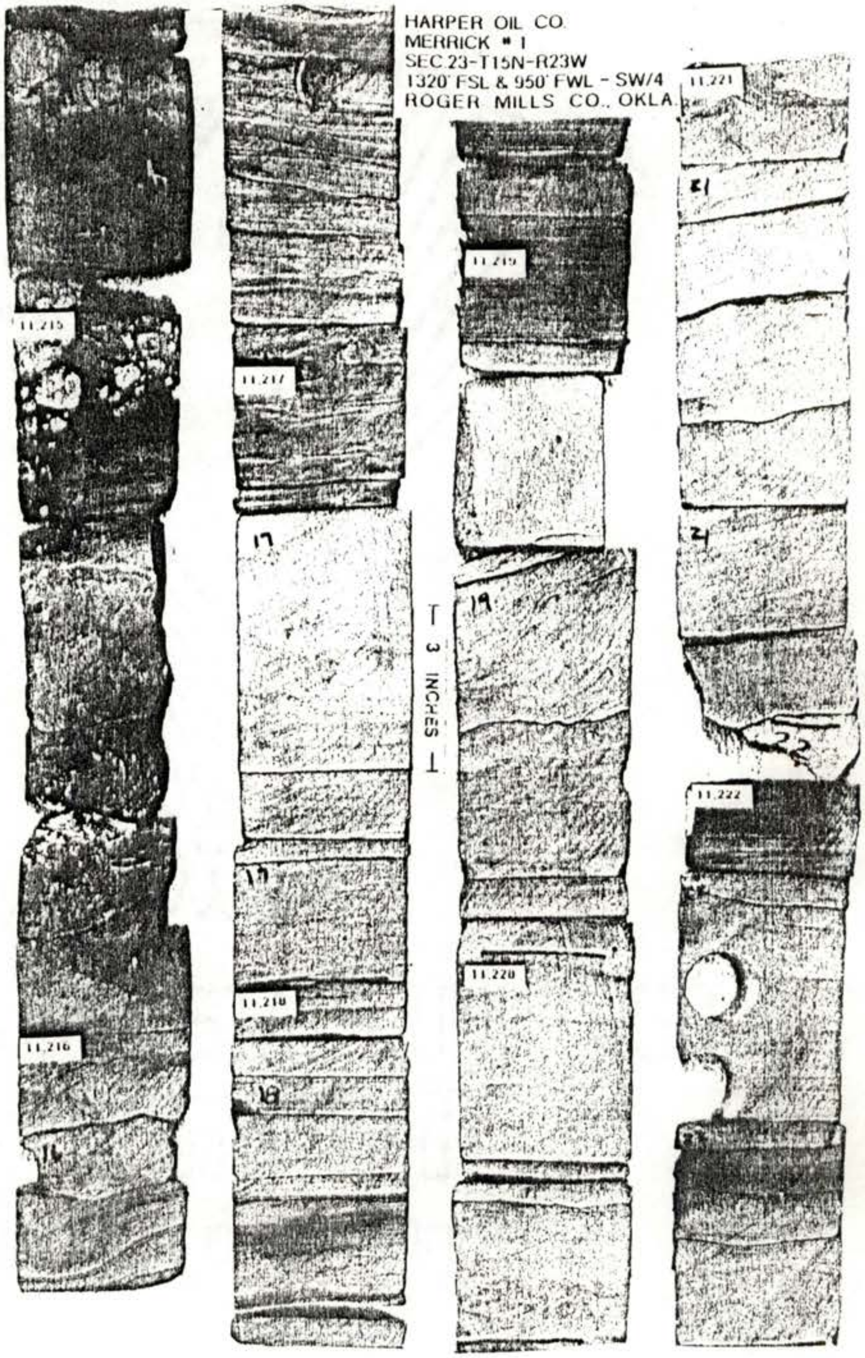


Figure 54. Upper Skinner, Harper, Merrick No. 1-23.

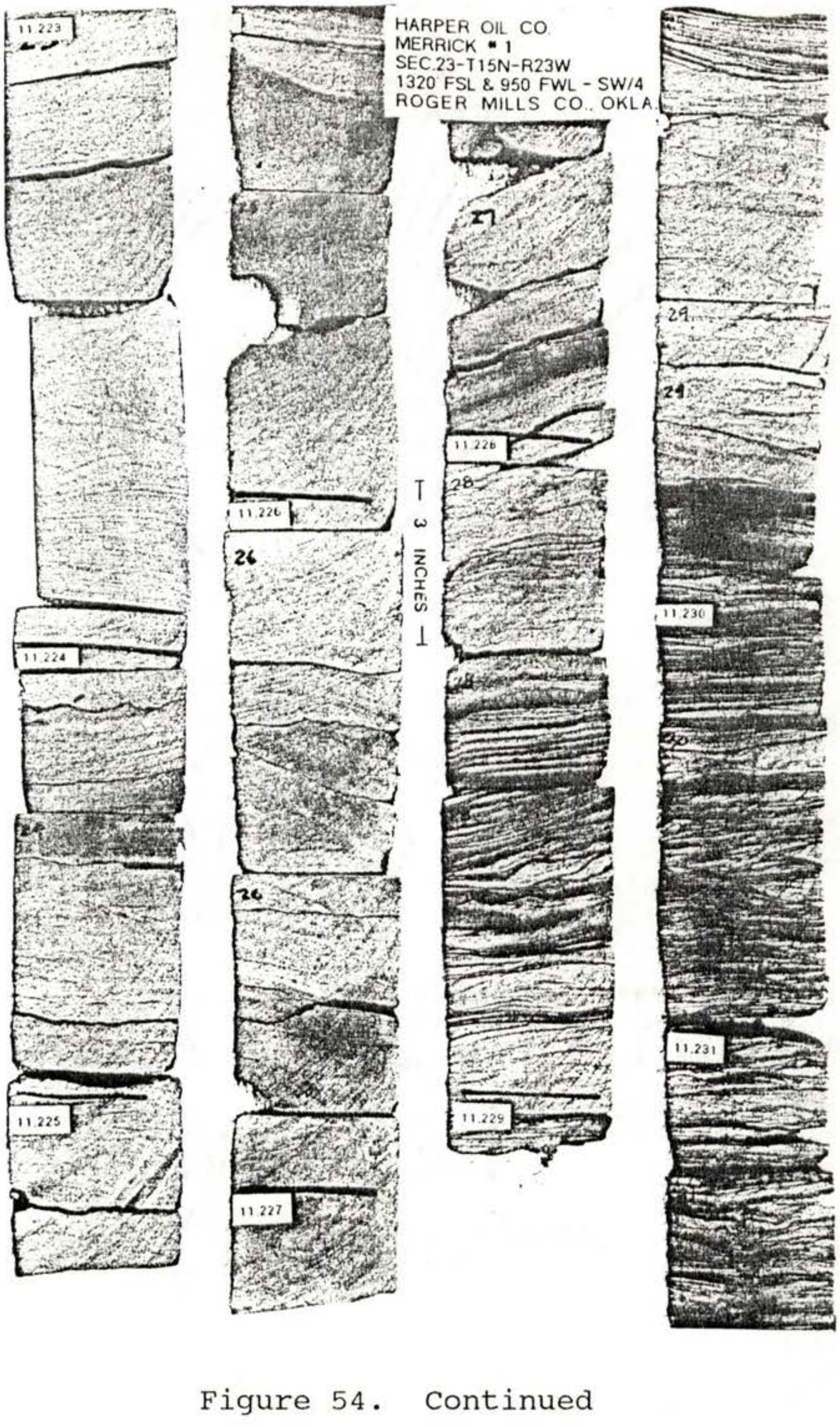


Figure 54. Continued

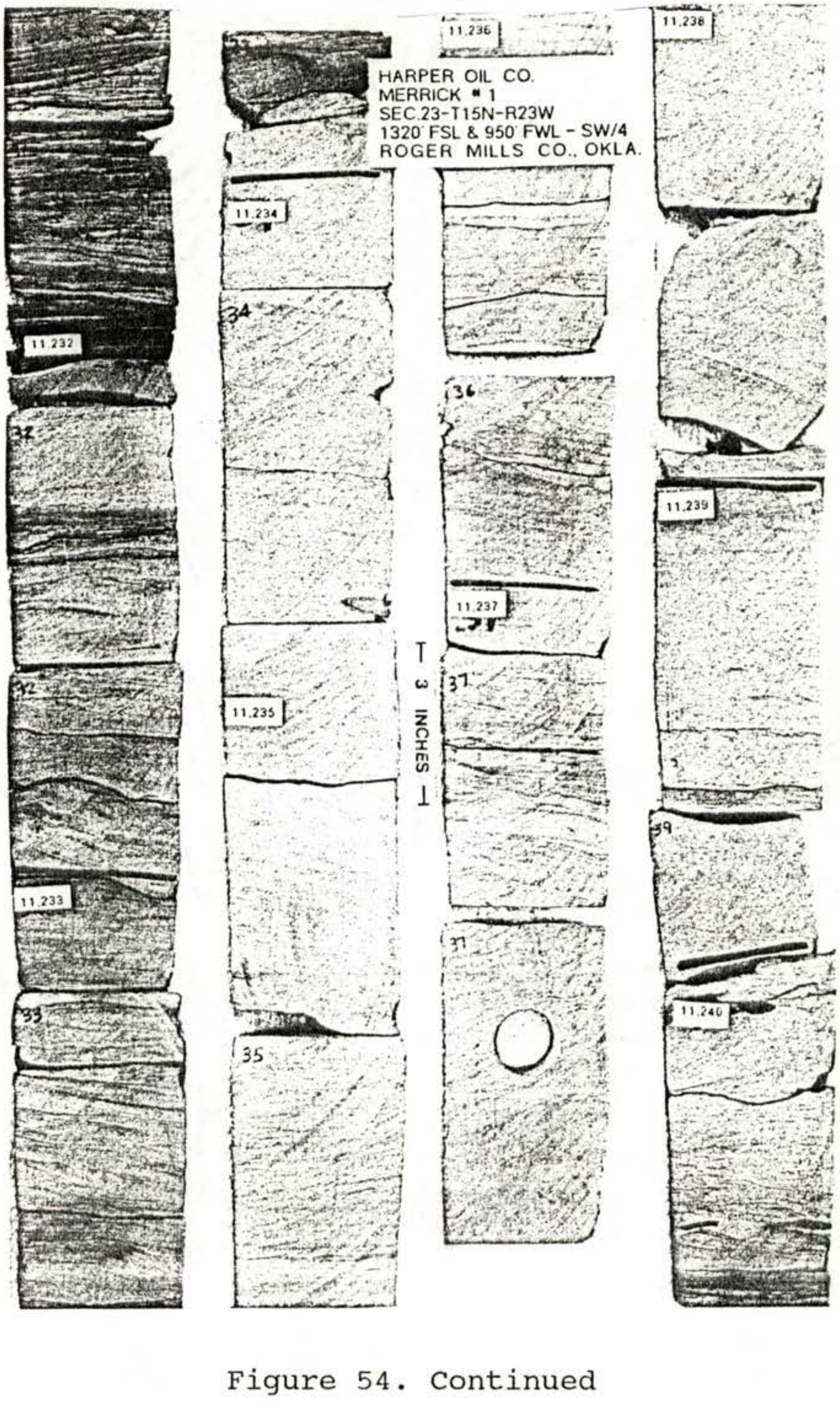


Figure 54. Continued

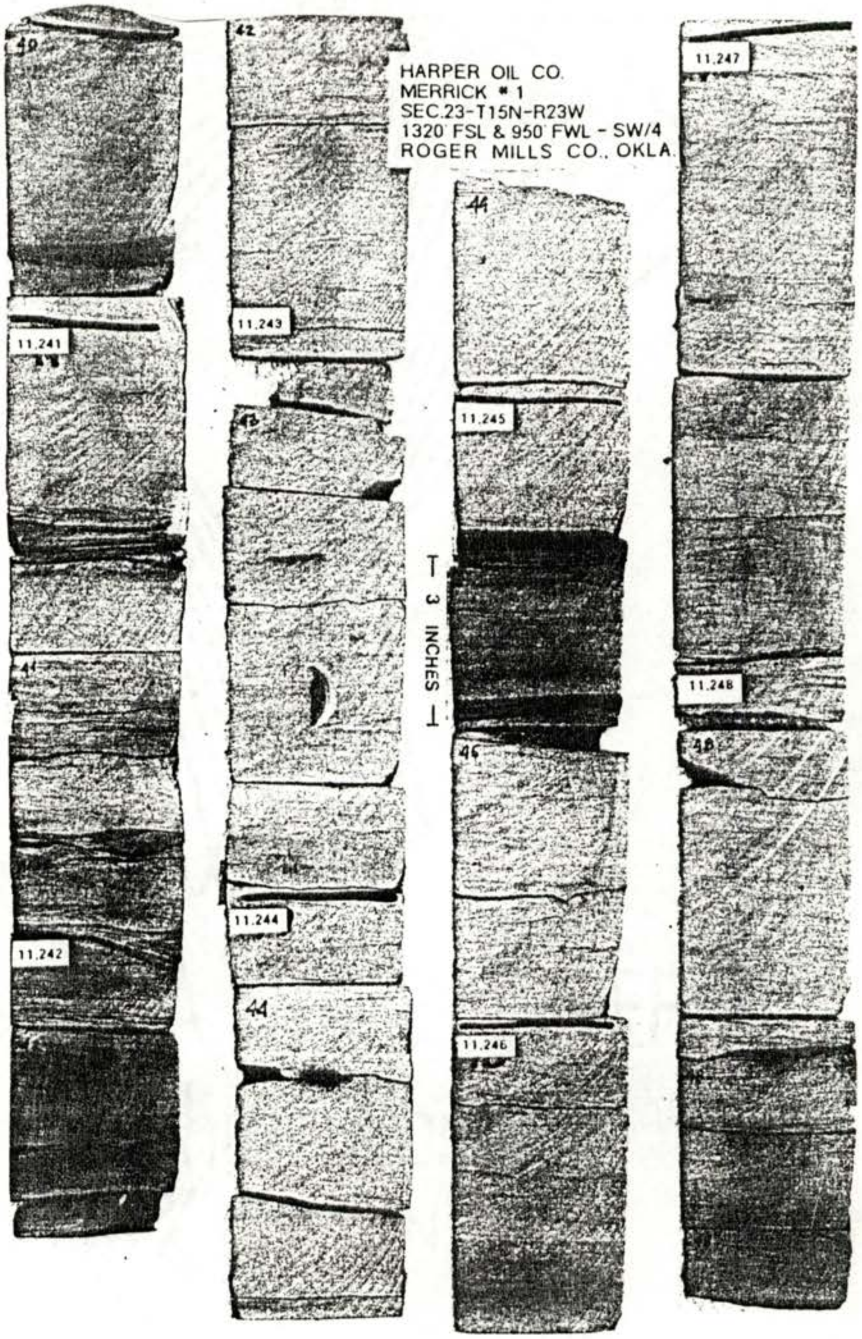


Figure 54. Continued

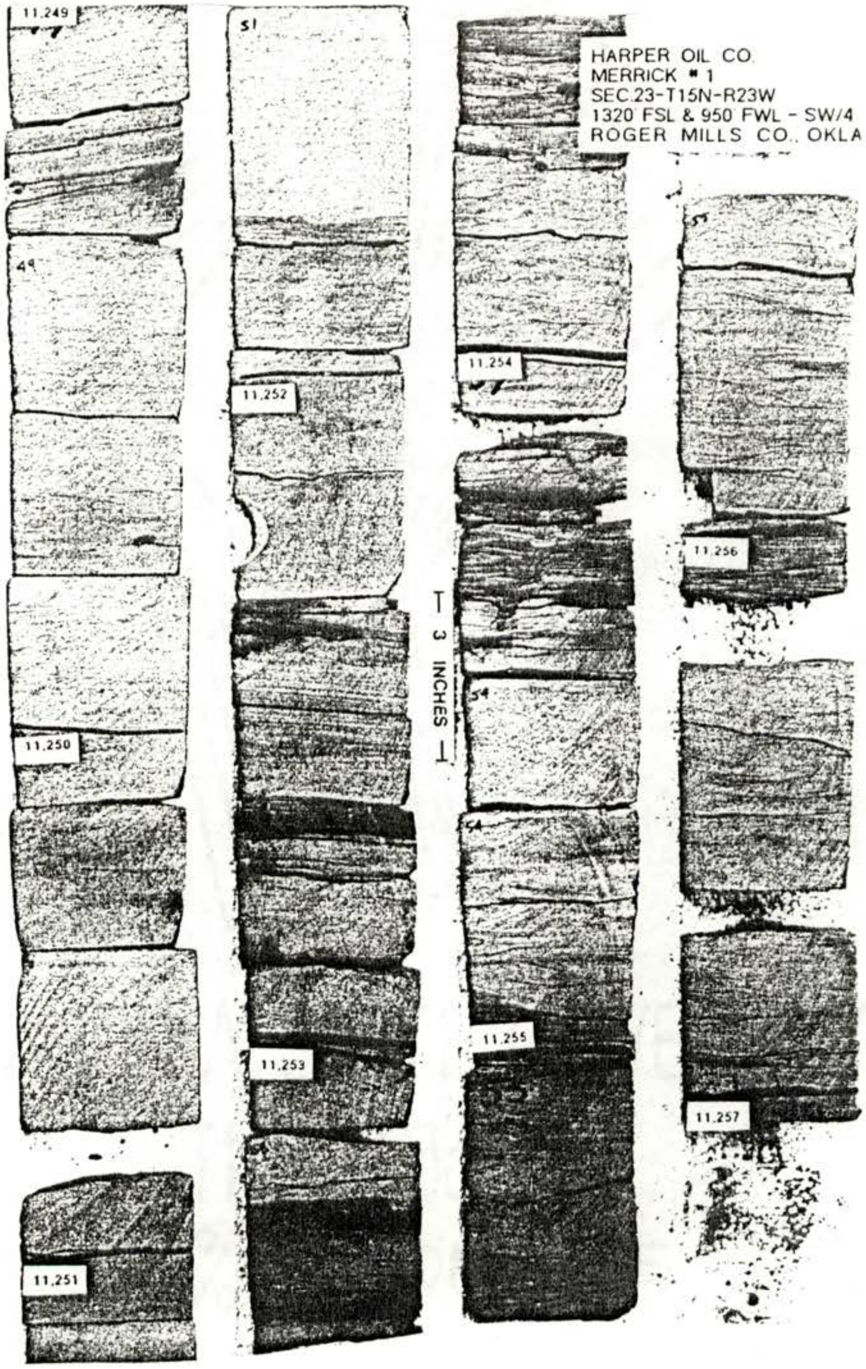


Figure 54. Continued

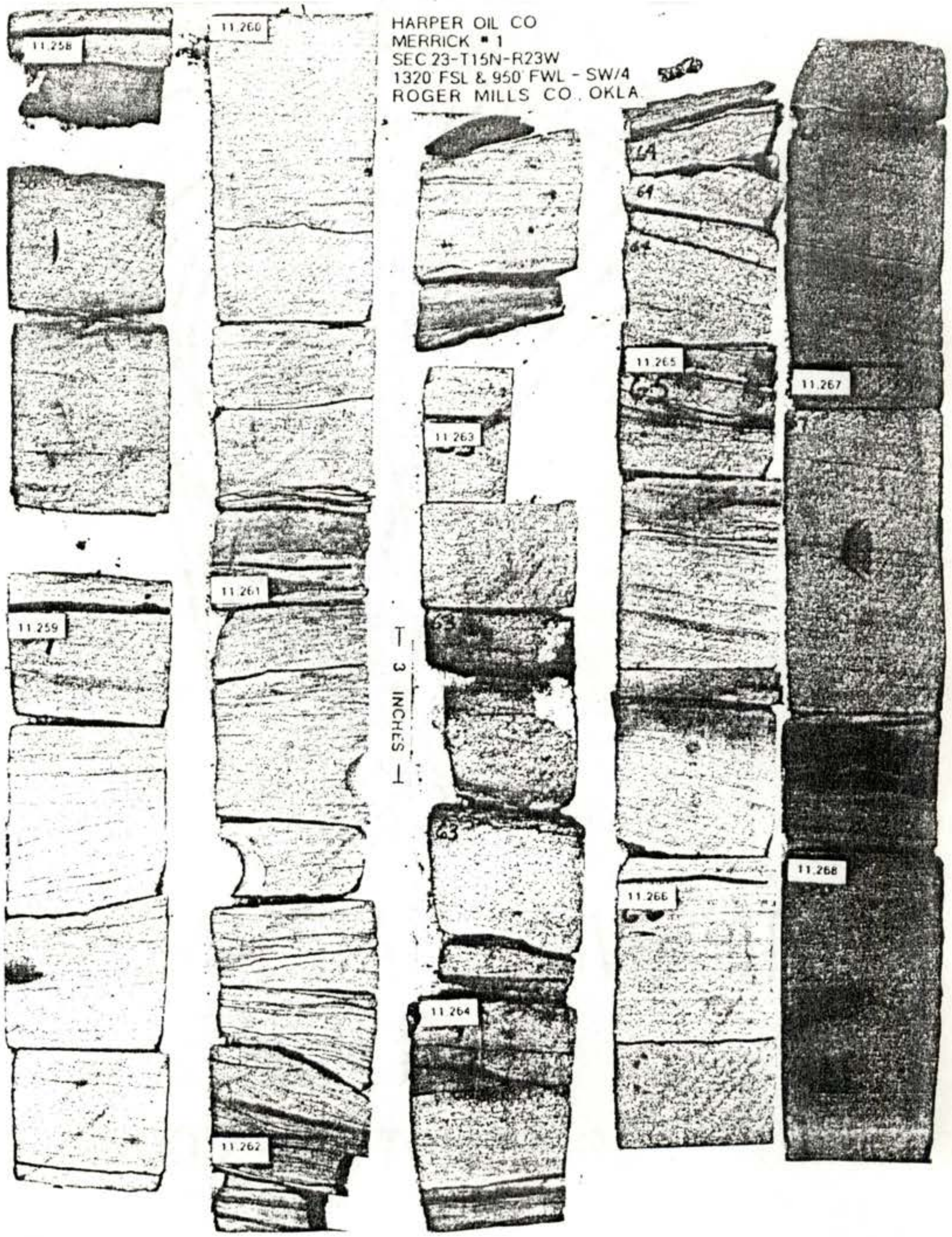


Figure 54. Continued

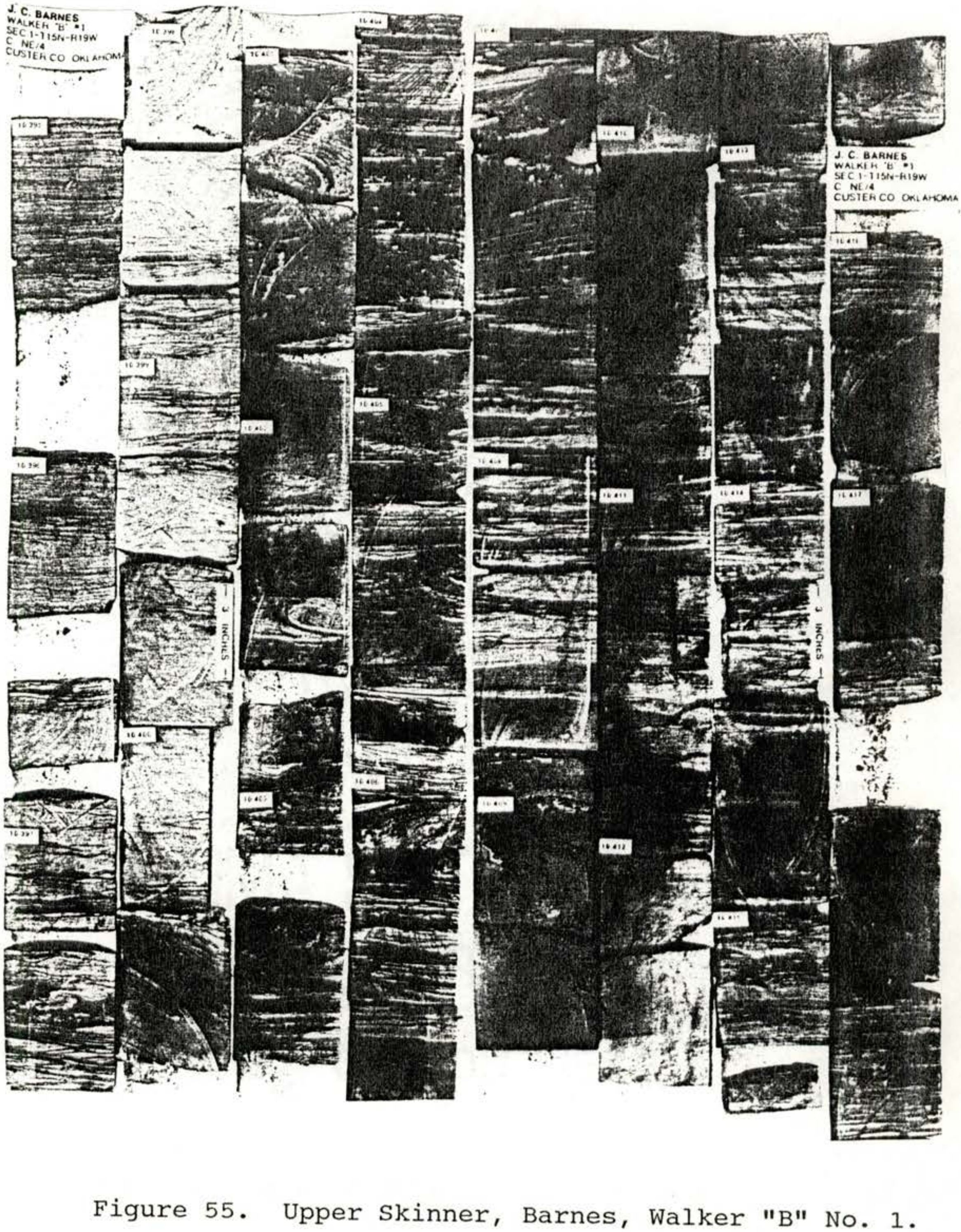


Figure 55. Upper Skinner, Barnes, Walker "B" No. 1.

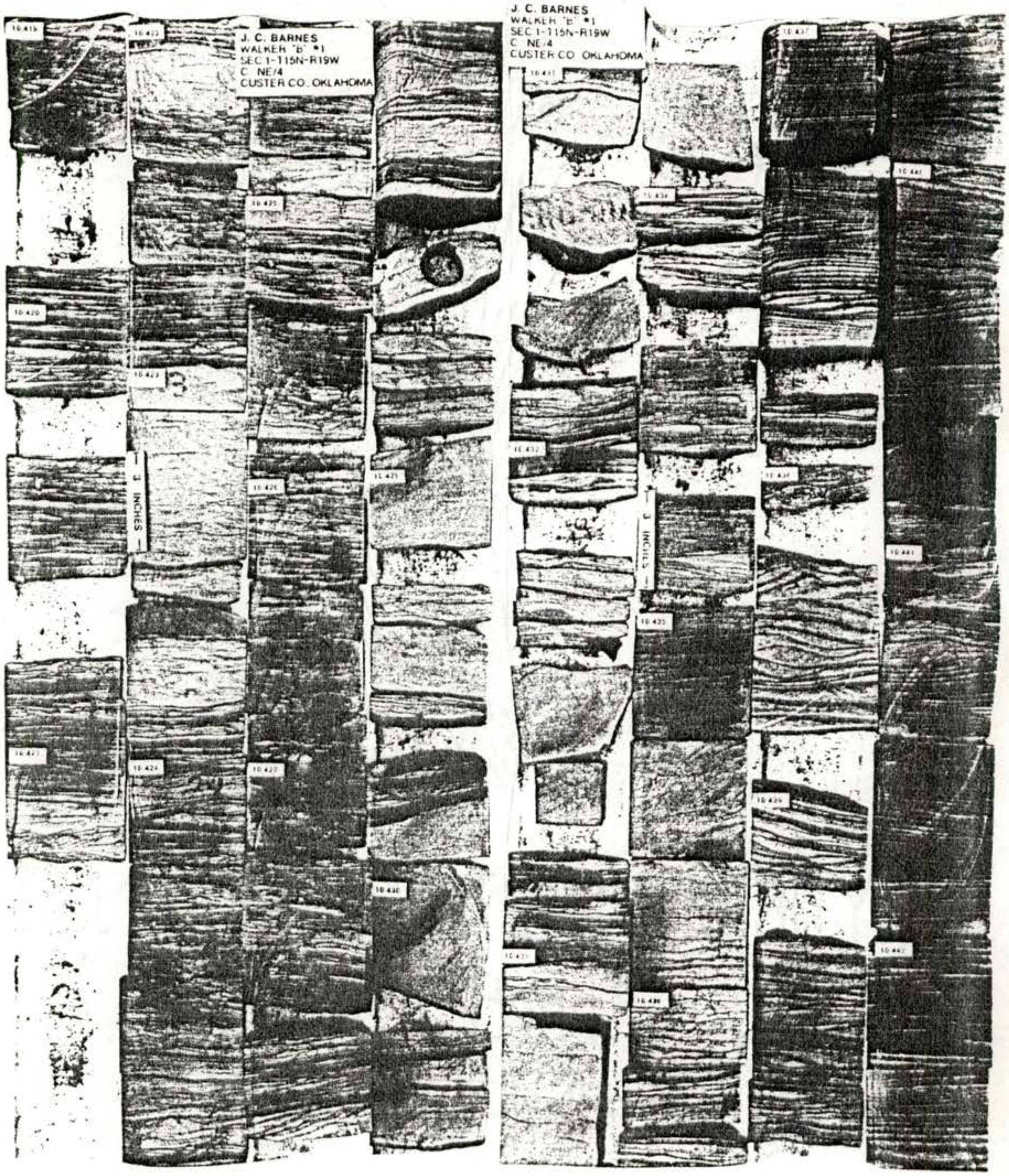


Figure 55. Continued

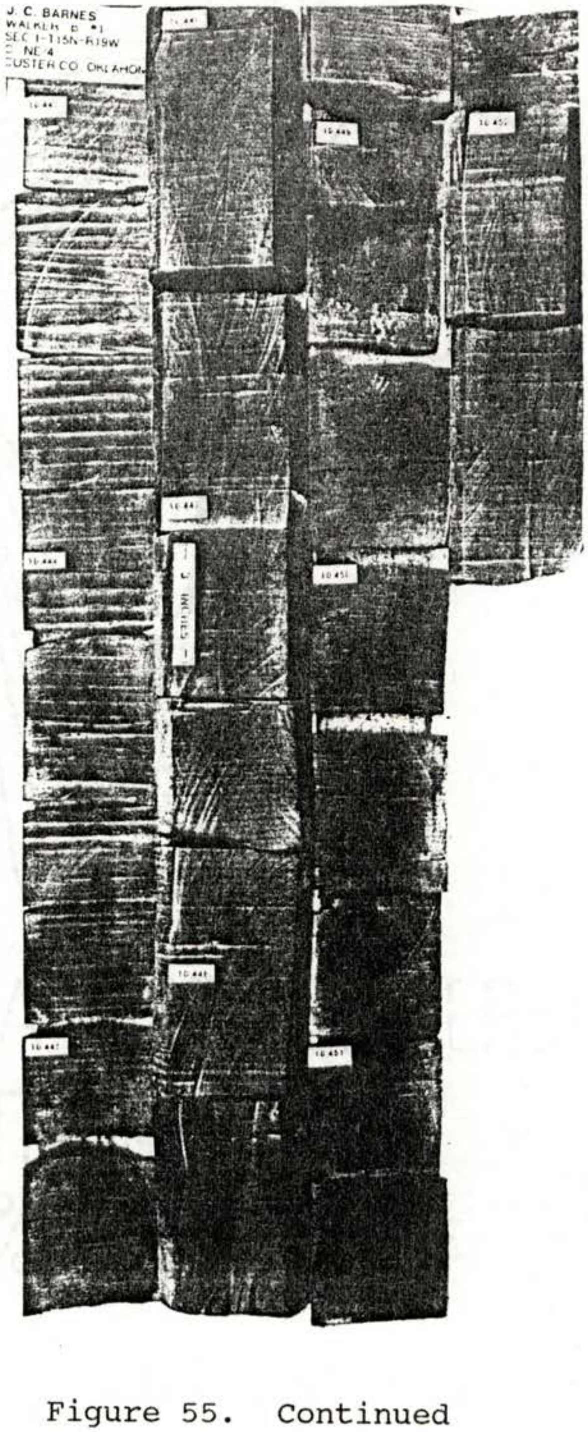


Figure 55. Continued

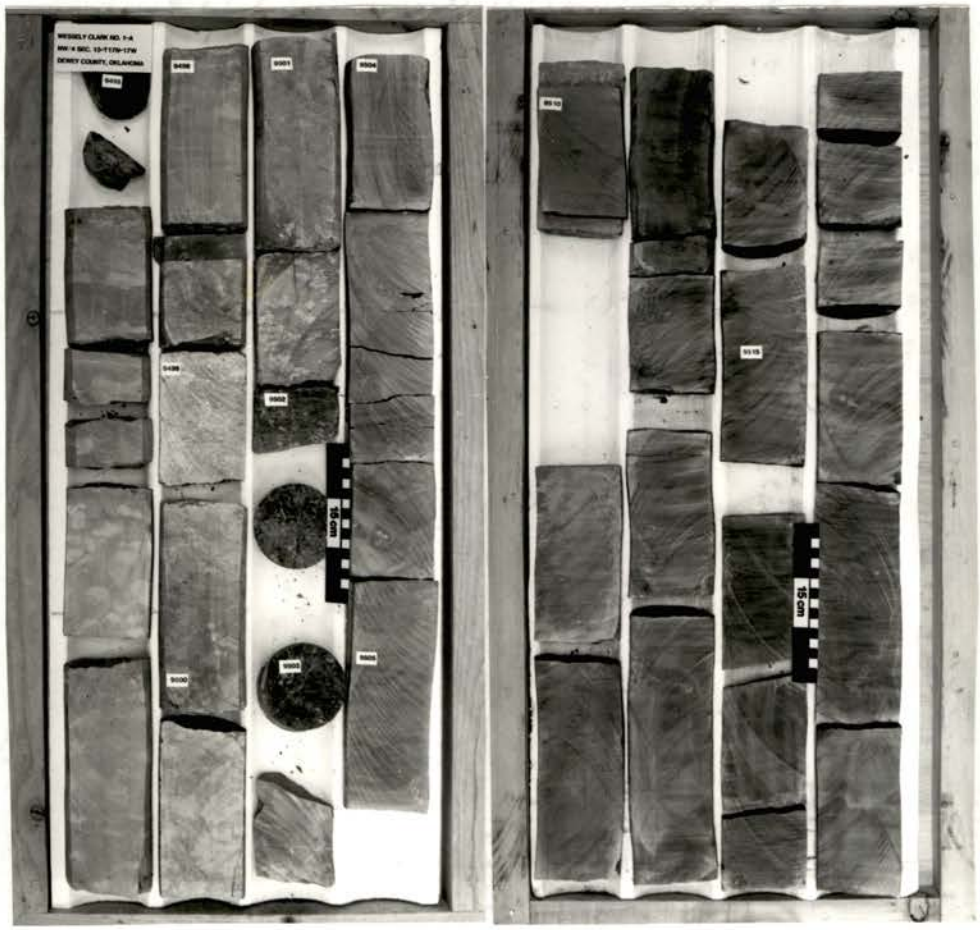


Figure 56. Pink Limestone, Wessely, Clark No. 1-A.

Figure 57. Pink "clean"
shelf facies.
Wessely, Clark
No. 1-A.

Figure 58. Woods, Switzer "C" No. 1 core slabs.
a) Pink slope ("muddy") facies.
b) Red Fork siltstone and shale.

VITA

James O. Puckette

Master of Science

Thesis: DEPOSITIONAL SETTING, FACIES, AND PETROLOGY OF CABANISS (UPPER "CHEROKEE") GROUP IN BECKHAM, DEWEY, CUSTER, ELLIS, ROGER MILLS, AND WASHITA COUNTIES, OKLAHOMA

Major Field: Geology

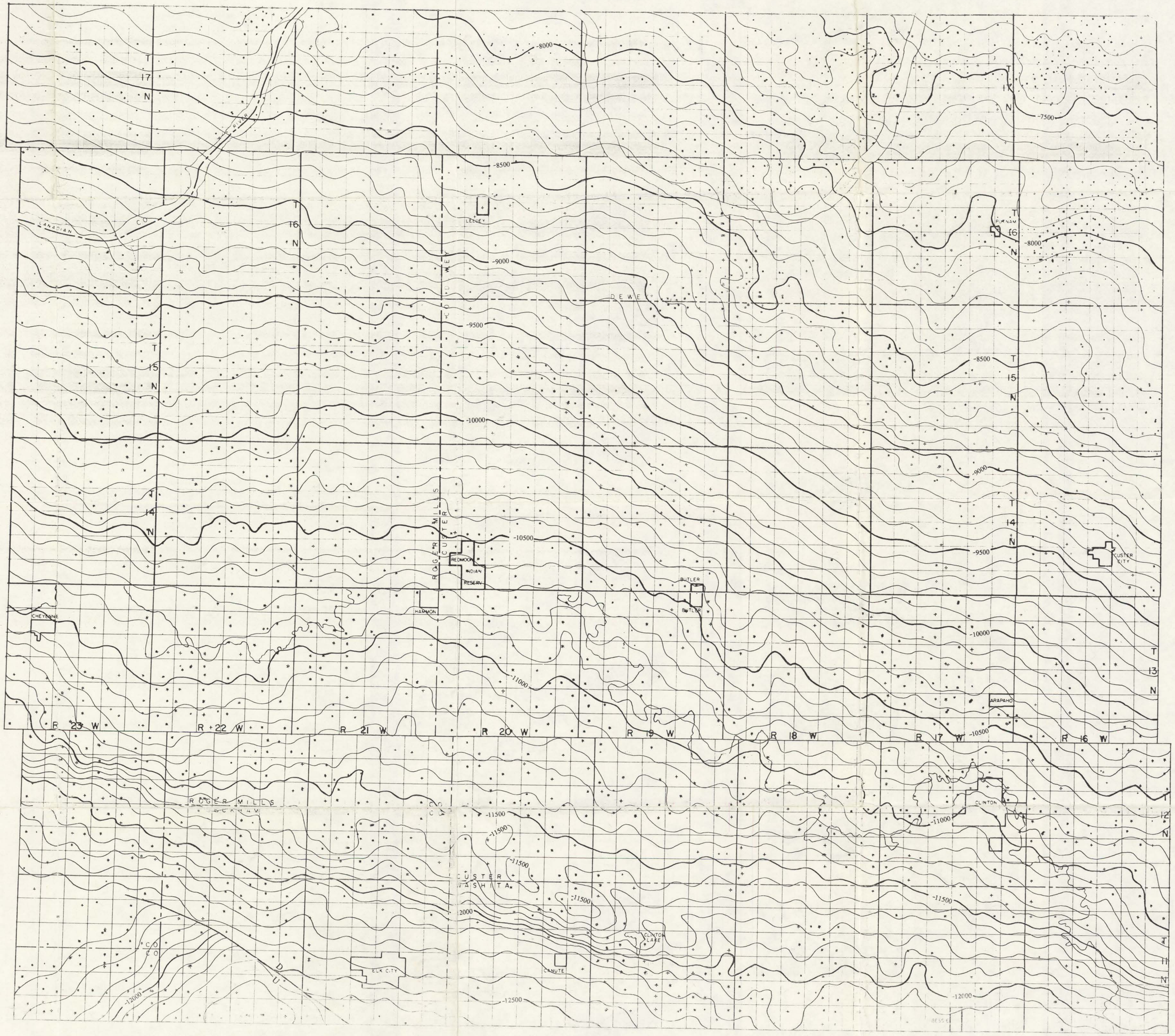
Biographical:

Personal Data: Born in Poteau, Oklahoma, August 2, 1954, the son of Charles P. and Oneta Puckette.

Education: Graduated from Jay Senior High School, Jay, Oklahoma, in May 1972; received Bachelor of Science Degrees in Geology and Secondary Education from Oklahoma State University at Stillwater in May 1976; completed requirements for the Master of Science degree at Oklahoma State University in July, 1990.

Professional Experience: Chief Geologist, Rocky Mountain Production Co. and O.R.M. Exploration Co., Stillwater, Oklahoma, 1982 to 1987. Research Assistant, Oklahoma State University, 1987 to June, 1990. Research Associate, Oklahoma State University, June, 1990 to Present.

Professional Affiliations: American Association of Petroleum Geologists and Oklahoma City Geological Society



FAULT

U-UPTHROWN SIDE
D-DOWNTHROWN SIDE

NORTH

SCALE: 1 INCH = 2 MILES

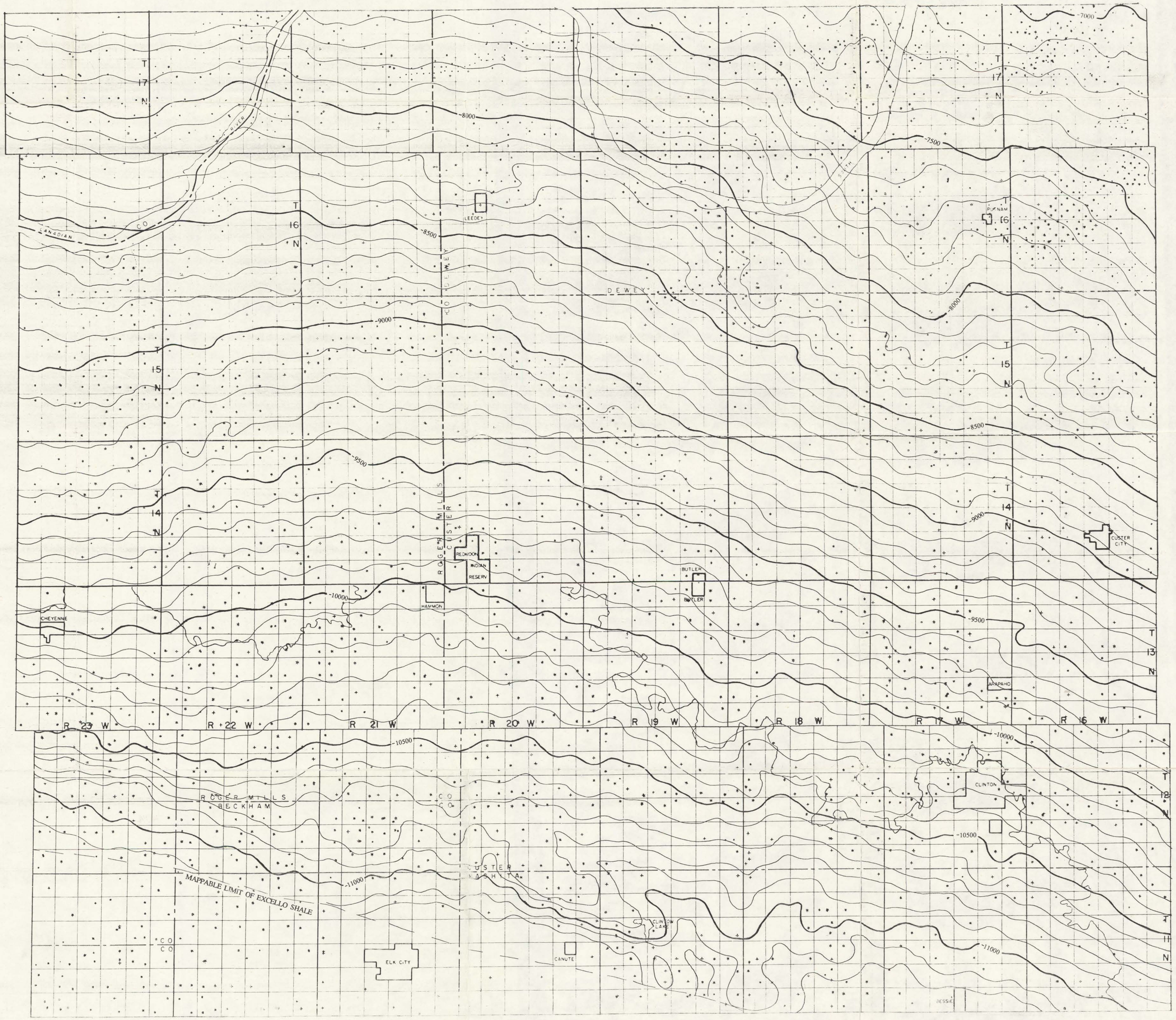
PLATE I

STRUCTURAL CONTOUR MAP OF BASE OF CABANISS GROUP

C. I. = 100 FEET

(DATUM: SEA LEVEL)

J. PUCKETTE, 1990



NORTH

SCALE: 1 INCH = 2 MILES

PLATE II

STRUCTURAL CONTOUR MAP OF BASE OF THE EXCELLO SHALE

C. I. = 100 FEET

(DATUM: SEAL LEVEL)

J. PUCKETTE, 1990

NORTH

SCALE: 1 INCH = 2 MILES

PLATE III

THICKNESS MAP OF CABANISS GROUP

C. I. = 50 FEET

J. PUCKETTE, 1990

NORTH

SCALE: 1 INCH = 2 MILES

PLATE IV

THICKNESS MAP OF UPPER SKINNER SANDSTONE AND SANDSTONE-SHALE SEQUENCES

C. I. = 100 FEET

(DATUM: SEA LEVEL)

J. PUCKETTE, 1990

VERTICAL SCALE: 1 INCH = 100 FEET

HORIZONTAL SCALE: NONE

CROSS SECTION LOCATION MAP

PLATE V

STRATIGRAPHIC CROSS-SECTION A - A'

(DIP ORIENTED)

DATUM: EXCELLO (CHEROKEE "HOT") SHALE BASE

J. PUCKETTE, 1990

VERTICAL SCALE: 1 INCH = 100 FEET

HORIZONTAL SCALE: NONE

CROSS SECTION LOCATION MAP

PLATE VI

STRATIGRAPHIC CROSS-SECTION B - B'

(OBLIQUELY ORIENTED)

DATUM: EXCELLO (CHEROKEE "HOT") SHALE BASE

J. PUCKETTE, 1990

Hilly
713-520-8300