DEPOSITIONAL ENVIRONMENT, PETROLOGY, AND DIAGENESIS OF RED FORK SANDSTONE IN CENTRAL DEWEY COUNTY, OKLAHOMA

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CHAPTER I

ABSTRACT

The Red Fork sandstone in the area of study is believed to have been deposited in and near deltaic distributary channels. Two distinct phases of sand deposition are represented by the upper and lower units of the Red Fork sandstone. The upper and lower units are separated by a consistent marker bed. The marker bed is interpreted as being indicative of local disconformity. Based on the information from the strike and dip cross sections it is believed that the study area was part of the paleoshelf. Evidence for the present interpretation was gathered from the study of Red Fork sandstones in cores, thin sections, log signatures of the interval and the geometric relationships of stratigraphy.

The structural geology of the study area is that of gentle southwestward dip at about 1° per mile. Numerous anticlinal and synclinal features are present in the study area.

Sandstones of the lower Red Fork are sublithic to lithic arenites; the upper Red Fork is sublitharenite to litharenite. The dominant lithic fraction is shale and other rock fragments. The main diagenetic alterations of the upper and lower Red Fork sandstones consisted of destruction of primary porosity by compaction and cementation. Dissolution of shale clasts and feldspar grains, as well as matrix leaching, has generated secondary porosity. Illite and chlorite, both

detrital and authigenic,are the dominant clays in the Red Fork sandstone. Pore filling kaolinite occurs in minor amounts.

The Putnam Field is the major oil and gas field in the area of study. The upper Red Fork sandstone is the reservoir rock.

CHAPTER II

INTRODUCTION

The area of investigation consists of 12 townships, T.17N. and T.18N., and R.15W. through R.20W.; this covers the central part of the Dewey County, Oklahoma (Figure 1). The interval of interest, the Red Fork sandstone, is defined as the zone between the Pink (Tiawah) limestone and Inola limestones (Figure 2).

Objectives and Methods

The objectives of this study are: (1) to interpret the depositional environments of the Red Fork sandstones, (2) to determine oil and gas reservoir trends within the study area, and (3) to define the nature and sequence of diagenetic changes that have affected the Red Fork sandstones.

Trends, geometry and boundaries of the upper and lower Red Fork sandstones were determined through examination of gamma ray, induction, and compensated neutron-density logs of 400 wells. These data were used in the preparation of four stratigraphic cross sections, net-sand isopach maps of both upper and lower Red Fork sandstone trends, and an isopach of the entire Red Fork interval.

Ten cores of the Red Fork interval from the area of investigation were studied in detail. Of the ten cores, two consisted of the upper and lower Red Fork intervals. The remainder of the cores consisted of

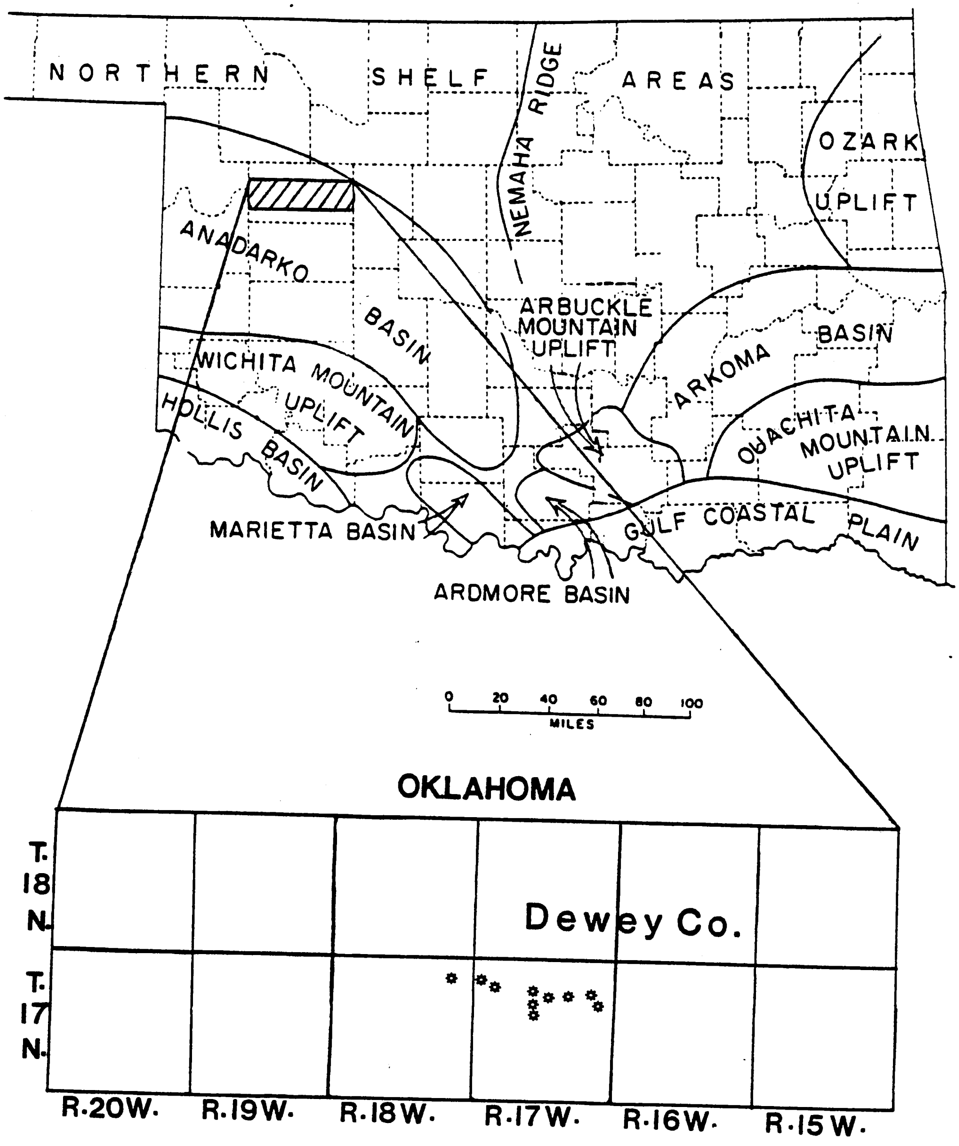

Figure 1. Map showing Location of the Study Area and Core Location (Oklahoma Geological Provinces map Publication of Oklahoma Geological Survey).

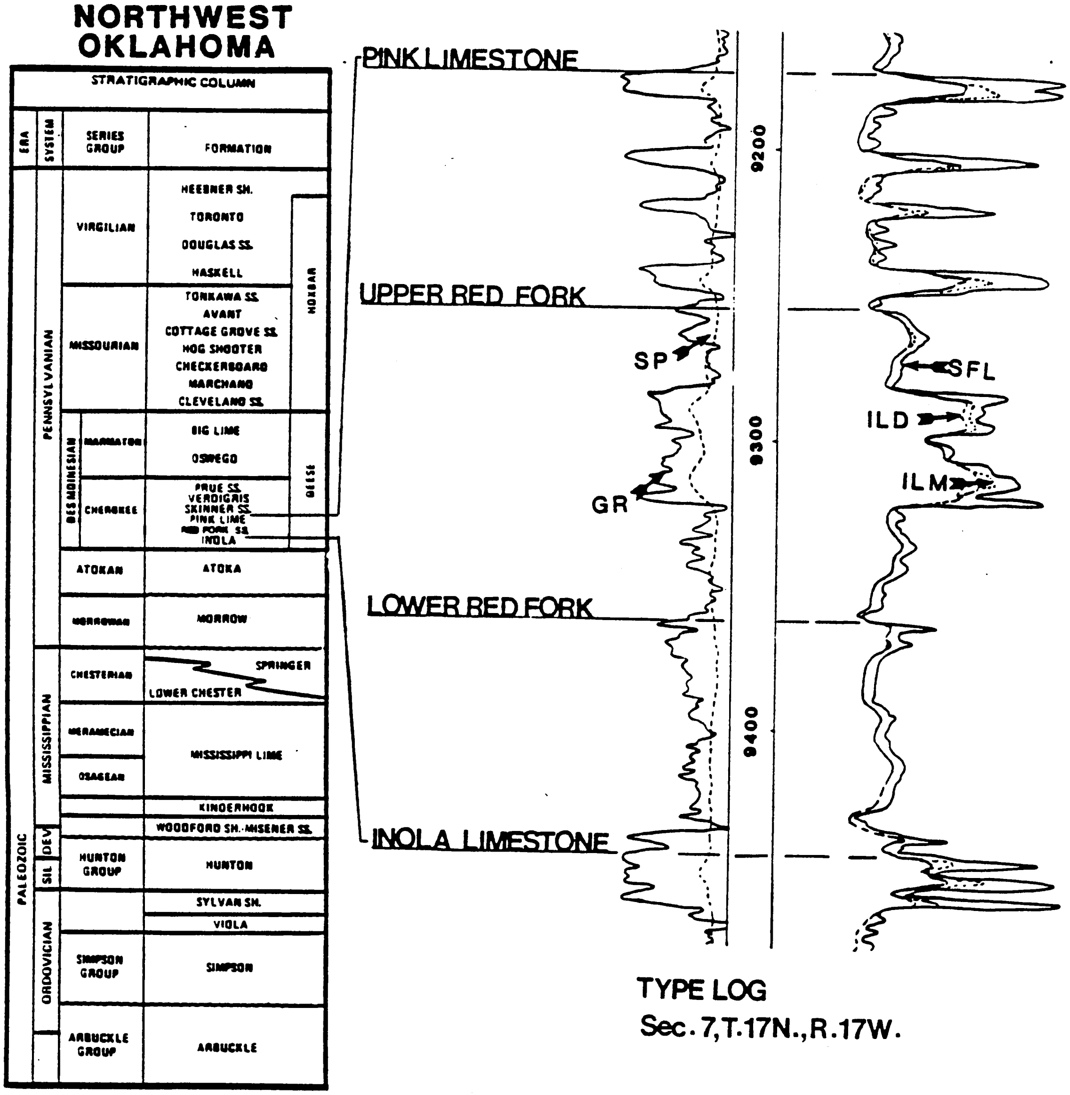

Figure 2. Type Log Showing Markers and Principal Subdivisions of the Interval Studied. General Stratigraphic Column after Johnson, 1984.

the upper Red Fork interval. Sedimentary structures, textures, mineralogical constituents and vertical sequences were described for these cores (Appendix A). Mineralogy and diagenetic alterations were investigated using petrographic methods (140 thin sections were examined), scanning electron microscopy, and energy dispersive x-ray analysis, and x-ray diffraction.

Two structural contour maps were prepared, one of the top of the Pink limestone and the other of the top of the Inola limestone.

Previous Investigations

The Red Fork is within the Cherokee "Group". Haworth and Kirk (1894) first used the name "Cherokee" for the sequence of black shale below the Pennsylvanian "Oswego" (Fort Scott) limestone and above the Mississippian in Cherokee County, Kansas (Withrow, 1968). The term was applied to the same stratigraphic interval in Oklahoma. Basic stratigraphic nomenclature was refined by the Oklahoma Geological Survey (Branson, 1954), with divisions of the Cherokee Group into "the Krebs" and "the Cabaniss" Groups (Withrow, 1968). In 1956, the term "Cherokee" was readopted for Kansas and Missouri with Krebs and Cabaniss being reduced to the rank of subgroups (Howe, 1956).

The Red Fork sandstone was named by Hutchinson (1911). The name described a shallow producing sandstone in the Red Fork field, near the town of Red Fork, southwest of Tulsa, Oklahoma (Red Fork was named for the color of a tributary of the Arkansas River).

The Red Fork sandstone is the subsurface stratigraphic equivalent of the Taft sandstone Member of the upper Boggy Formation. The subsurface equivalents include the Chicken Farm sandstone (also called

Chicken Ranch Sand) of Oklahoma County and the Earlsboro sand of Pottawatomie County (Jordan, 1957). The Burbank sandstone of Osage County originally was thought to be equivalent to the Red Fork; however, regional correlations suggest that it could be equivalent to the "lower part of the Boggy Formation or to both the Red Fork and Bartlesville" (Jordan, 1957, page 6).

Extensive investigations have contributed to a generally sound knowledge of the depositional environment of the Red Fork on the Northern Shelf area and on the Northeastern Oklahoma Platform (Figure 1).

McElroy (1961) made a regional study of the Red Fork in north central Oklahoma, across the Nemaha Ridge. He determined that fluvial deposition of the Red Fork was affected by the Nemaha Ridge. Thalman (1967) studied the productive Oakdale field in Woods and Major Counties, Oklahoma and concluded the existance of two genetic units of channel-fill sandstone deposition, namely upper and lower Red Fork. His interpretation, was that a "river bar" or a "bar finger" environment of deposition was the most likely. Withrow (1969) studied the Wakita trend (Alfalfa and Grant Counties, Oklahoma) and Oakdale fields (Woods County, Oklahoma) and proposed off-shore or barrier bar depositional environments. Berg (1968) agreed with Withrow's interpretation. Glass (1981) studied the same area and showed that a more probable interpretation is that of a dominantly fluvial system.

The Red Fork of Alfalfa, Major, and Woods Counties, Oklahoma, was described as fluvial (Lyon, 1971) and in Kingfisher County, Oklahoma as well defined fluvial systems (Zeliff, 1976). All of these authors described fine to very fine grained sandstone with medium to coarse grained sand located at the base of the Channels.

Whiting (1982) studied the Red Fork sandstone in part of the Anadarko Basin. He described the entire Red Fork interval as turbidites. Johnson's (1984) study area included T.12N. through T. 14N, R.11W. through R.16W. in Oklahoma. Johnson concluded that the lower Red Fork sandstone was deposited in a submarine canyon and submarine fan environment and the upper Red Fork sandstone was deposited by channels in a deltaic complex. This interpretation was based on study of six cores and numerous well logs.

CHAPTER III

STRUCTURAL FRAMEWORK

Regional Setting

The study area is located in the Anadarko basin region (Figure 1). The Nemaha ridge is located to the east of the study area.

The Anardako basin was described by Schatski (1946) as an example of an aulacogen: a long trough or furrow of anomalously thick sediments extending into the craton at a high angle to a major fold belt (the Ouachita System).

Using the concepts explained by Burke and Dewey (1973) and Hoffman, Dewey, and Burke (1974), genesis of an aulacogen can be divided into three stages: a rifting stage, a subsiding stage, and a deformation stage. The rifting stage is made evident by intrusive and extrusive rocks of Middle Cambrian Age. The subsident stage is reflected in Late Cambrian through Devonian sedimentary rocks. These predominantly are carbonate rocks and clean, well-sorted quartz sands. The deformation stage is recorded by Pennsylvanian siliceous clastic rocks. Basins and uplifts within the aulacogen probably are Pennsylvanian features produced during the deformation stage (Hoffman et al., 1974). However, the Wichita-Criner and Arbuckle uplifts apparently are due in large measure to left lateral strike-slip faulting associated with the Ouachita thrust.

The Nemaha Ridge (Figure 1) is thought to be a pre-Mississippian structural feature that extends from southeastern Nebraska to south central Oklahoma. A major unconformity separates eroded and tilted Mississippian and pre-Mississippian rocks from Desmoinesian strata (Hoffman, 1959).

The Amarillo-Wichita uplift which lies to the south of the Anadarko basin became active during late Morrowan time; however, it was not until Atokan time that the thick Granite Wash was shed from this uplift (Moore, 1979).

Local Structural Geology

Structural geologic maps were prepared using the top of the Pink limestone (Plate I), and the top of the Inola limestone (Plate II) as mapping surfaces.

Both structural maps show homoclinal dip of about S22°W. The dip on both the structural maps is 1° per mile. Numerous anticlinal and synclinal noses are present on the two structural maps. A major fold is shown in T.17N., R.18 W. (Pl. 1, II).

CHAPTER IV

STRATIGRAPHIC FRAMEWORK

The Red Fork sandstone is part of the Cherokee Group, Desmoinesian Series, Pennsylvanian System. The Cherokee Group includes rocks from the top of the Atokan Formation to the base of the Late Desmoinesian Oswego limestone and consists of interbedded sand and shale "packages" that are separated by limestone marker beds (Jordan, 1957).

In the study area the Red Fork is defined as the interval from the top of the Inola limestone to the base of the Pink limestone (Figure 2). Both the Pink limestone and the Inola limestone are present throughout the study area. The four finger-like log signatures (high gamma-ray and induction log response) are very characteristic of the Pink limestone in the study area (Figure 2).

The boundary between the upper and lower Red Fork was correlated and mapped after examination of many well logs within the study area (Plates I through IX). After the examination of two cores of both the upper and lower Red Fork and correlating the lithology to the well logs it was concluded that the boundary between the upper and lower Red Fork is a disconformity. It is used as a time-lithologic feature, as suggested by Busch (1971). The log signature in the form of a sharp "spike" was consistent at the top of the lower Red Fork interval. In some cases, where the sharp spike was absent from the logs, a sharp erosive base of the upper Red Fork was evident thus enabling the marking of the boundary between the upper and lower Red Fork.

The boundary of the upper Red Fork genetic increment of strata is the base of the Pink limestone. The Pink limestone is overlain by the Skinner genetic increment within the study area.

Correlations

To insure accurate correlation and to illustrate specific structural and stratigraphic, relationships two stratigraphic cross sections were constructed, one parallel to the strike (Plate VI), and the other parallel to the dip direction (Plate VII) of the marker beds. In both cross sections the thickness of the Red Fork interval is nearly consistent.

All well logs that were released by companies and available as of April, 1984 were used in this study. This included 400 well logs. Generally, the dual induction and neutron-density logs were necessary to make reliable correlations.

CHAPTER V

GEOMETRY OF THE RED FORK SANDSTONE

Isopach maps of the upper and the lower Red Fork were used to delineate and predict trends and distribution of sandstone (Plates III and IV). The spontaneous potential curve in the study area showed little or no response (Figure 2). So the criteria for the recognition of sandstone was based on the study of the gamma ray curve.

Clays, especially illite, in sandstone are made evident in the gamma ray curve by large API values. Petrographic studies indicate the presence of illite in significant ($\geq 4\%$) quantity in Red Fork sandstones. Due to the large average API value of gamma ray curves of the Red Fork section and because the variations around these averages are rather small, visual descrimination of sandstone and shale is generally inconclusive and therefore impractical. Based on the gamma ray readings of the Pink limestone and shale of the Red Fork interval a "clean" limestone line and a shale base line were established for the Red Fork section. The sandstone-shale cut-off line is defined by a line which is 70% of the distance from the "clean" limestone line to the shale base line.

Lower Red Fork

Trends and Widths

The lower Red Fork is a complex system of elongate sandstone bodies, generally one to two miles wide. Two major northeast-southwest trending sandstone bodies show evidence of multiple bifurcation within the study area (Plate IV).

Boundaries

The entire lower Red Fork is interpreted as consisting of one major genetic unit. This depositional unit has a sharp boundary with the lower Inola limestone and the overlying upper Red Fork sediments. The lateral boundary is thought to be sharp at the sandstone locations (Plates VIII and IX).

In the two cores of lower Red Fork that were studied (Appendices A and B) sandstones were found to grade into calcareous sandstone near the top. Thickness of the calcareous sandstone varies from two to three feet. Based on the study of well logs and the two cores, two to four feet of calcareous sandstone are generally present in the study area, where absent the sandstone was probably removed by erosion that preceeded the upper Red Fork deposition.

Thickness

Thickness of individual sandstone units of the lower Red Fork varies from zero to about 85 feet within the study area (Plate IV).

Upper Red Fork

Trends and Widths

The upper Red Fork sandstone system (Plate III) is more complex than that of the lower Red Fork and is better developed in the study area. Six major northeast-southwest to north-south trending sandstone bodies were mappable. Each trend varies in width from 1 to 3 miles and extends about 7 miles across the study area. Three of the major sand trends merge in T.17N. R.16W., R.17W. and R.18W (Plate III).

Boundaries

An easily correlated, 4 to 6 feet thick sandstone immediately below the Pink limestone is present throughout the study area (Figure 2). The sandstone units located below the above mentioned unit is laterally but not vertically consistent in position. Vertical location of the top of the upper Red Fork sandstone varies by about 100 to 150 feet below the Pink limestone in the study area. Generally two to three genetic units are recognizable in the well logs (Plates VIII and IX). A single blocky unit or a fining upward sequence forming one genetic unit are also common.

Sharp basal contacts and stacking of the channels are common features which can be identified in the well logs from the area of study (Figure 2). Stacked channel sandstone units were also found in the cores studied. Sandstone bodies generally are narrow, elongate belts, and crescent shaped pods (see Plate III T.17N., R.17W. and R.18W).

Thickness

Thickness of sandstone in the upper Red Fork interval ranges from zero to more than 80 feet. Individual sandstone units are commonly as thick as 40 feet. The thickness of the sandstone in the upper Red Fork interval is almost directly proportional to the number of depositional units contained within the interval (Plates VIII and IX).

CHAPTER VI

SEDIMENTARY STRUCTURES AND TEXTURES

Ten cores were examined in order to determine the character of internal features of the Red Fork sandstone within the study area. All the cores studied were from the Putnam Field (T.17N., R.17W. & R.18W.) Dewey County, Oklahoma. Of the ten cores studied, eight consisted of the upper Red Fork interval and two consisted of both the upper and lower Red Fork intervals (Appendices A and B).

Sedimentary Structures

Common sedimentary structures observed in the cores are inclined laminae, ripple laminae, channel lag features (rip up clasts), interstratification of sandstone and shale, small scale trough (Festoon) cross bedding, horizontal laminae, massive sandstone beds, flowage features and bioturbated rock. Although a detailed and consistent vertical sequence is not evident in the Red Fork cores, an overall general vertical sequence can be described as follows (in ascending order):

1. Sandstone showing channel lag features
2. "Massive" bedding
3. Trough cross bedded sandstone
4. Inclined laminated sandstone
5. Ripple laminated sandstone

6. Horizontally laminated to horizontally bedded and interstratified sandstone and shale.

Channel-lag Features

Rip-up clasts indicating channel lag are common in the cores examined. This feature is found near the shale sandstone interface (Figure 3).

"Massive" Bedding

Massively bedded sandstones were recorded in all the cores examined. Where shale underlies the massively bedded sandstones the contact between them is sharp (Figure 4).

Trough (Festoon) Cross Bedding

Small scale trough cross beds were observed in three of the cores logged. This sedimentary feature is especially associated with slightly rippled beds of sandstone. Trough cross bedding is detectable in the ARCO Presley No. 2 core. Trough cross bedding is present near the base of a sandstone interval, in the cores examined.

Inclined Lamination and Planar Cross Bedding

Inclined laminae are common in all the ten cores examined. Inclined laminae are more common in silty and interlaminated sandstone and shale intervals (Appendix B).

Small scale planar cross bedding (Figure 5) was observed in the Clark No. 2 and Presley No. 2 cores.

Figure 3. Channel lag features (rip-up clasts) in ARCO, A. M. Kunc No. 3 (Upper Red Fork). Depth, 9459 feet.

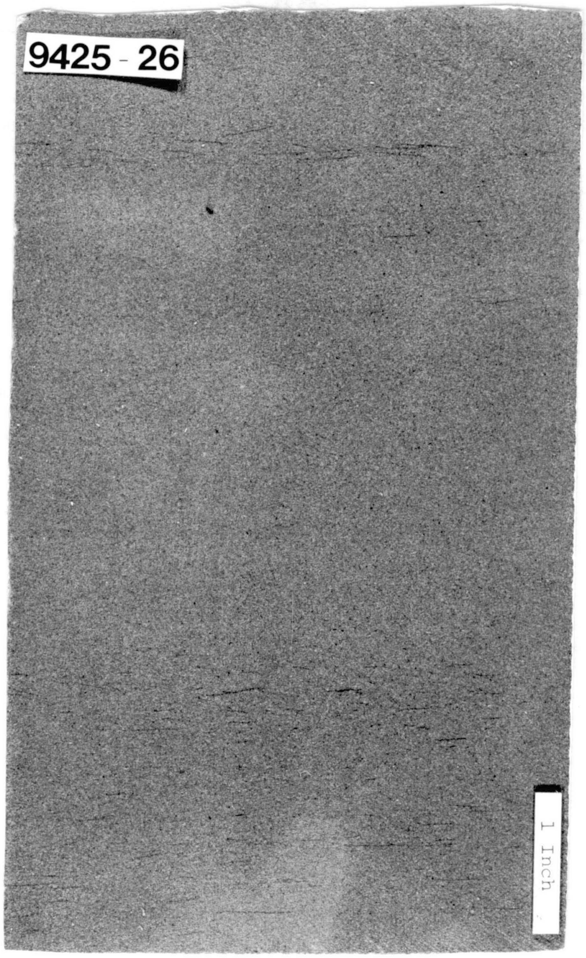

Figure 4. Massive bedded sandstone in ARCO, A. M. Kunc No. 3. Depth, 9425 feet (Upper Red Fork).

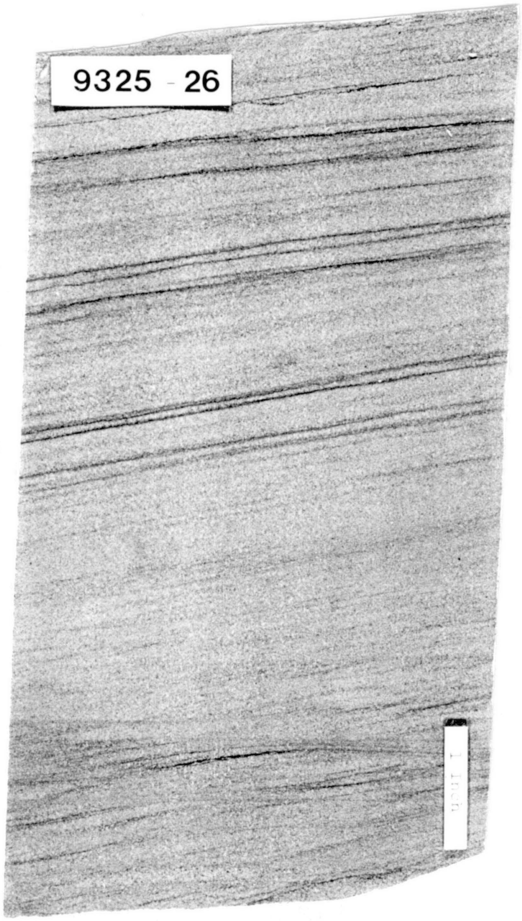

Figure 5. Planar Cross bedding, ARCO Presley No. 2. Depth, 9325 feet (upper Red Fork).

Ripple Lamination

Ripple laminae are one of the common sedimentary structures observed in the cores studied. They are identified as current ripples (Figure 6). Climbing ripples were also observed in the cores (Figure 7). Ripple laminae are generally present in the sandstone sections of the cores and at the locations where the sandstone beds grade into silty and shale beds. In the Clark No. 2 core randomly oriented wisps of organic matter are present in the sandstone (Figure 8). This is due to the rippling of the sandstone at the time of deposition.

Horizontal Lamination and Interstratified Sandstone and Shale

Horizontal laminae were observed in six out of ten cores studied. Horizontal lamination is more common in zones composed of silt and clay (Figure 9).

Interstratified sandstone and shale beds are present in eight of the cores studied. Interstratification is predominant in the more shaly intervals. Most interstratified beds and laminae are "horizontal" but in some instances low angle initial dip is discernible (Appendix B).

The contact between zones of interstratified sandstone and shale and massive sandstone and shale is both sharp and gradational. Interstratified sandstone and shale zones are generally found near the top of the sandstone interval in the cores examined.

Figure 6. Ripple laminae, Pearl Kunc A No. 2. Depth, 9449 feet (upper Red Fork).

Figure 7. Climbing ripples, ARCO, Presley No. 2. Depth, 9342 feet (upper Red Fork).

Figure 8. Rippled sandstone (disturbed bed), Wessely Clark No. 2. Depth, 9543 feet (upper Red Fork).

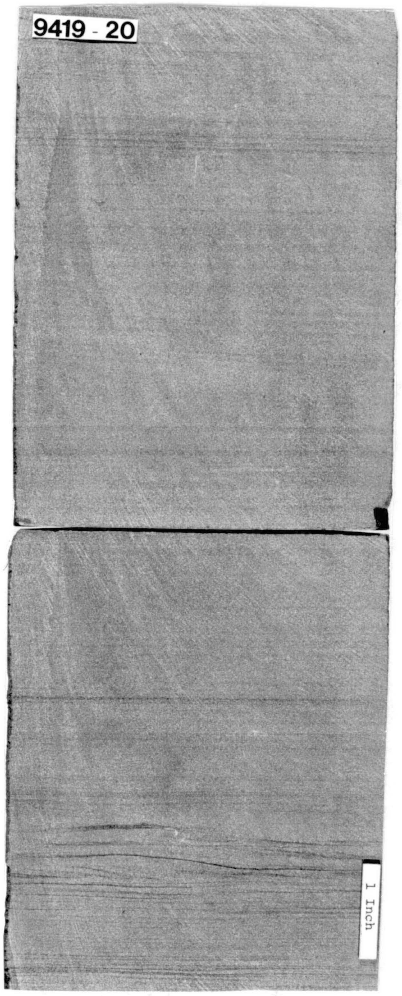

Figure 9. Horizontal laminae, ARCO, A. M. Kunc No. 3. Depth, 9419 feet (upper Red Fork).

Bioturbation

Bioturbated beds are not a common feature in the Red Fork cores studied. Bioturbation is best shown in the ARCO Pearl Kunc-A No. 2 core (Figure 10).

Slump Structure

Slump structure is rare in the cores and was only recorded in the ARCO Presley No. 2 core (Figure 11).

Texture

Red Fork sandstones within the study area show a vertical change in grain size. Apart from clay, grain size ranges from silt to medium-grained sand. Fining upward sequences were observed during the petrographic examination of the samples from the cores. In the W. C. Pickens Leslie No. 1 core this variation of grain size is very distinctive. Red Fork sandstone is moderately sorted with subangular to subrounded grains.

Shale Rich in Organic Material

Shale rich in organic matter are common in all the cores examined. Carbonized plant matter is present in the shale beds in both the Pearl Kunc A No. 2 and Joe N. Champlin Stidham No. 1A cores. It is inferred that about 15 to 25 feet of dark shale rich in organic material is present. Twenty-five feet of shale is present near the bottom of the upper Red Fork interval in the Joe N. Champlin Stidham No. 1A core

Figure 10. Bioturbated silty claystone, ARCO, Pearl Kunc A. No. 2. Depth, 9452 feet (Upper Red Fork).

Figure 11. Slump structure, ARCO, Presley No. 2. Depth, 9351 feet (Upper Red Fork).

(Appendix B). The ARCO Pearl Kunc A No. 2 core (Appendix B) consist mostly of silty clay stone and shale rich in organic matter.

Fossils

Fossils were observed in the shale beds present near the top of the Red Fork interval as well as near the bottom of the upper Red Fork interval. In eight of the cores studied, brachiopods were observed in the shale bed present near the bottom of the upper Red Fork interval (Figure 12). The fossils (Figure 13) observed in the shale beds located near the top of the Red Fork interval were also identified as brachiopods.

Shallow marine fossils were observed in the calcareous sandstone bed (Figure 14) which serves as the marker between the lower Red Fork and the upper Red Fork intervals.

Figure 12. Calcareous shale with Brachiopods and carbonized plant matter, ARCO, A. M. Kunc No. 3. Depth, 9473 feet (Upper Red Fork).

Figure 13. Brachiopods in shale bed, ARCO, Presley No. 2. Depth, 9280 feet (Upper Red Fork).

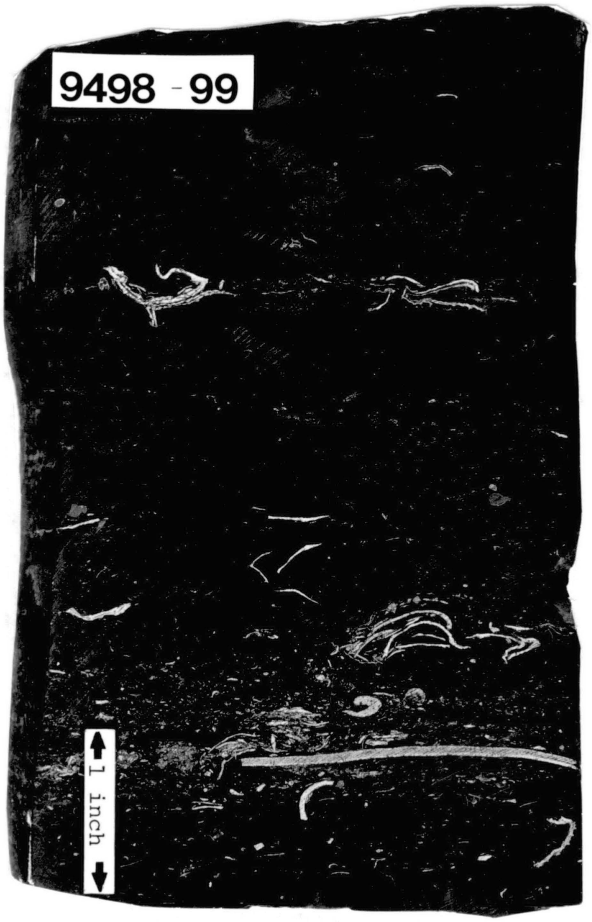

Figure 14. Brachiopods and Gastropods in Calcareous sandstone, Joe N. Champlin Stidham No. 1A. Depth, 9498 feet (Lower Red Fork).

CHAPTER VII

ENVIRONMENTS OF DEPOSITION

Introduction

Fluvial channel and distributary channel depositional environments have been proposed for the Red Fork sandstone in the northeastern shelf area (Berg, 1968; Glass, 1981; Lyon, 1971; Zeliff, 1975). A deltaic distributary channel environment is proposed as the depositional setting of the upper and the lower Red Fork sandstones in the study area.

A vast amount of published work outlines the properties of deltaic distributary channel environments. The most helpful publications are Brown (1969, 1973, 1979), Coleman (1981), Fisher (1969), Fisher et al. (1970), Shelton (1967, 1978), Coleman and Prior (1982) and Fisher et al. (1971).

The Red Fork has been divided into upper and lower units by other geologists (Glass, 1981; Johnson, 1983; Lyon, 1971) and this concept is considered to be critical for reliable interpretation of the depositional environment.

The marker bed that distinguishes the upper and the lower Red Fork is at the top of a persistent silty to fine grained sandstone. The marker was studied in the Joe N. Champlin No. 1A Stidham (Sec. 13-T. 17N.-R.17W.; Figure 11) and the Wessely A-1 Clark cores (Sec. 13-T. 17N.-R.17W., Figure 12).

Lower Red Fork

Basic Evidence from Analysis of Cores

The net-sandstone isolith map of the lower Red Fork stratigraphic interval (Plate IV) shows a pattern of bifurcated linear trends of thick sandstone. Rocks from the lower Red Fork interval were studied in cores from the Joe N. Champlin No. 1A Stidham, and the Wessley No. 1A Clark (Appendices A and B). Detailed descriptions of rocks in these cores are shown in Appendix A. Summary descriptions are in Table I.

Basic Evidence from Cross Sections

Cross sections A-A' through D-D' (Plates VI through IX) show these noteworthy features:

a. the Inola Limestone is present in all wells on cross sections.

b. the Inola is overlain by thick shale in all wells.

c. sections of sandstone are indicated by the blocky patterns of log signatures in most wells. The sandstone is not consistent in thickness or stratigraphic position.

Basic Evidence from Isopach Maps

The net-sandstone isolith map (Plate IV) shows a pattern of linear, thick sandstone bodies that bifurcate. Plate IV indicates that at the location of the Champlin No. 1A Stidham, the sandstone body is narrow and elongated. If present-day southwestward structural dip is interpreted as being generally consistent with dip during sedimentation of the Red Fork stratigraphic interval (a working assumption consistent

TABLE I. SUMMARY DESCRIPTION OF CORES

	WELLS	
	Stidham 1A	Clark 1A
Rock Type	Sandstone, fine grained; shale. Clasts in lower part.	Shale, overlain by argillaceious sandstone, Interbedded sandstone and shale, and fine grained sandstone; contact gradational.
Sedimentary Structures	Trough cross bedding, planar cross bedding inclined laminae, ripple laminae.	Ripple laminae, planar cross bedding, bedding slightly deformed by flowage and trough cross bedding.
Organic Content	Carbonized fragments of wood.	Carbonized plant material, macerated.
Accessory Rock Types	Sand-sized rock fragments.	Siderite in interbedded sandstone and shale. Sand sized rock fragments.
Calcareous Sandstone Marker Bed	One foot thick, silt size to very fine grained quartz grains, brachiopod, and echinoid fragments, and gastropod shells, and algae.	Two feet thick, silt size to very fine grained quartz grains, brachiopod and echinoid fragments, and gastropods.

with general knowledge of the Anadarko basin's history (see Berg, 1968; Johnson, 1984; and Zeliff, 1975), then the linear sandstone bodies are oriented at large angles to structural-depositional strike of the basin's northern flank. Source areas of clastic sediments seem to have been to the north or northeast (Berg, 1968; Johnson, 1984; Zeliff, 1975). On the basis of this general information, bifurcation of sandstone units seems to show evidence that during deposition, sand-filled channels bifurcated in a basinward direction.

Basic Evidence from Uppermost Marker Bed

Uppermost in the lower Red Fork stratigraphic interval is a widespread bed of calcareous sandstone, only a few feet thick (Figures 14, see also Plates VI through IX). This very fine-grained sandstone contains brachiopods, gastropods and echinoid fragments. Because of the thinness, extensiveness and comparative richness in marine fossils, this sandstone seems to be the record of a transgressive episode, during which influx of sediment was small, and sands were redistributed.

Interpretation of Depositional Environments

On the basis of the evidence shown above, a set of reasonable inferences about general depositional environments of the lower Red Fork sandstone would seem to include the following: (1) alluvial channels and alluvial plain, (2) deltaic distributaries and delta plain, and (3) submarine channels.

Elimination of an alluvial setting seems to be justified because of the tendency of sandstone bodies to be bifurcated basinward, and the apparent scarcity of rocks that would suggest terrestrial conditions (e.g. caliche-like nodular limestone, abundant wood, coarse clasts of rock that were lithified at deposition). Inference of a submarine-channel setting may be inconsistent with the data, because the study area seems to have been landward of the shelf-slope transition zone during deposition of the Red Fork (see Johnson, 1984, p. 42, Plate VI), and because of the apparent absence of lithic features regarded as being suggestive of deposition in submarine channels (e.g. marine fossils in sandstone).[1] A delta-plain environment would explain the bifurcated-basinward pattern of sandstone bodies, the clasts of fine-grained sand, and abundant rip-up clasts of shale, abundant macerated plant material, and the recorded sedimentary structures. Moreover, a deltaic origin of lower Red Fork sandstone would be consistent with the overall upward stratigraphic sequence of Inola limestone, thick shale, channel-like sandstone bodies and thin, widespread, fossiliferous sandstone. Altogether, these rocks could record a progression from transgressive marine limestone (Inola) to regressive prodeltaic shale, to distributary-channel-fill sandstone, to transgressive fossiliferous sandstone. The interpretation of a deltaic setting during deposition of lower Red Fork sandstone is favored. Deltaic distributary channel depositional environment of the lower Red Fork interval is illustrated in Figure 15.

Figure 16 shows the log signatures of the lower Red Fork interval at three locations. In Figure 16A log signature patterns indicate that the shale bed is overlain by sandstone. Based on the previously mentioned interpretation of depositional environments it is likely that

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[1] The fact is acknowledged that two cores must be regarded as a very small sample of lower Red Fork sandstone and that many critical lithic features absent from the rock inspected may be in lower Red Fork sandstone, in the study area.

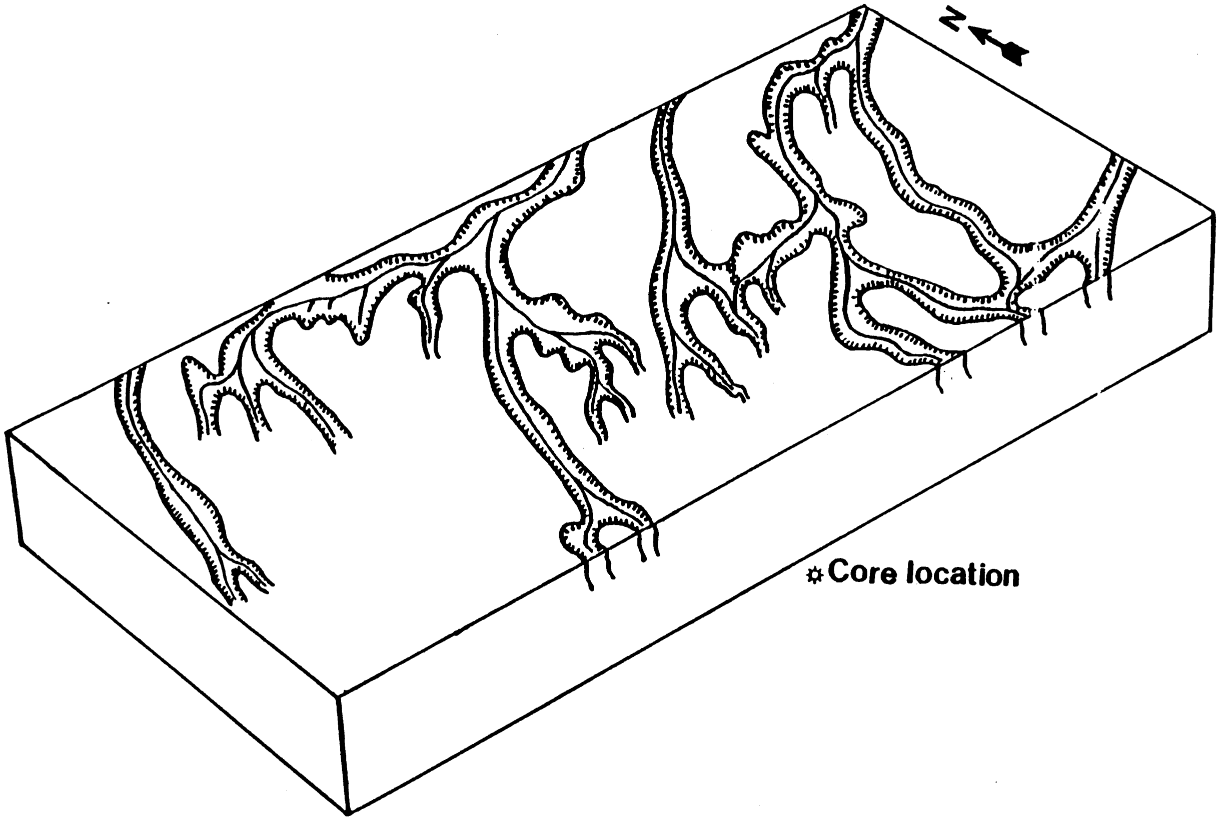

Figure 15. Conceptual Model of Depositional Environment of the lower Red Fork Sandstone-Deltaic Distributary Channels.

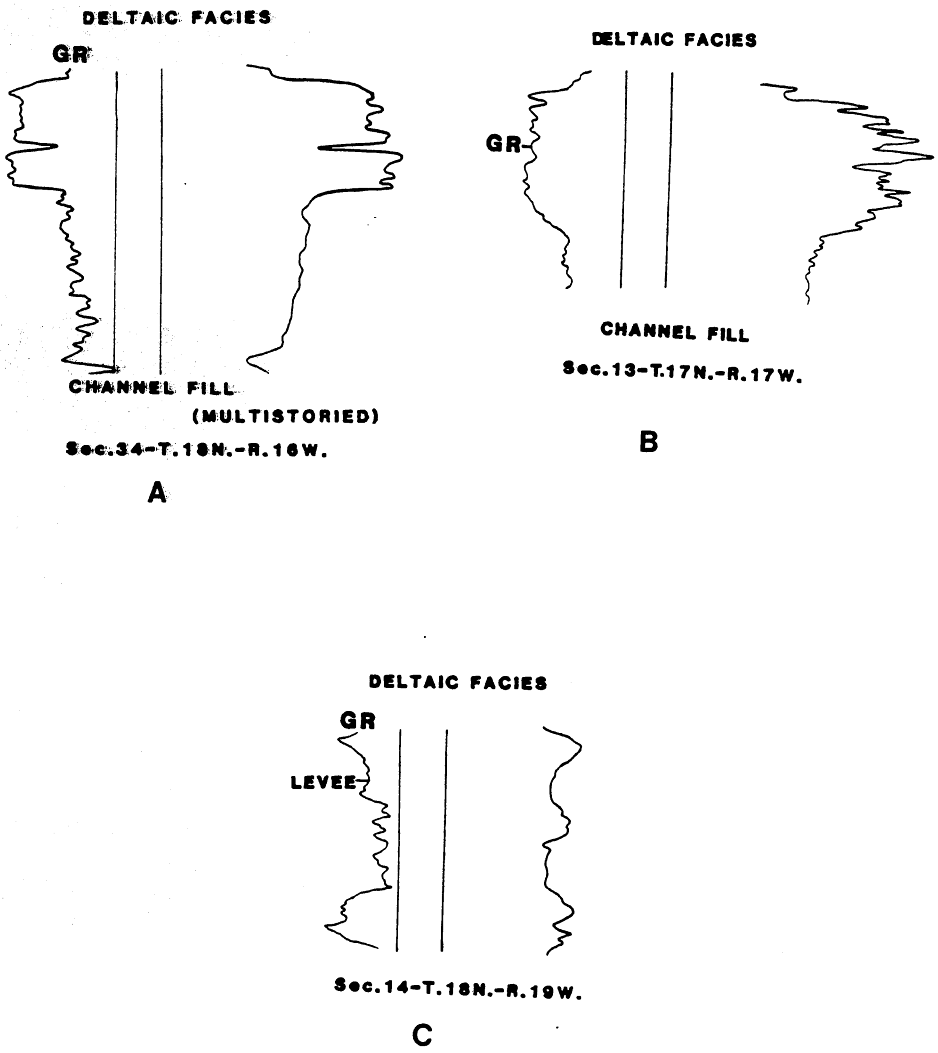

Figure 16. Characteristic gamma ray signature of Deltaic Facies in the lower Red Fork.

pro-delta shale is overlain by channel fill sandstone. Blocky sections of the log signature indicates the location of the sandstone. Sandstone sections are likely to consist of two units separated by a thin shaly interval. This is suggestive of stacking of the sandstones. Figure 16B is the log signature of the Stidham No. 1A well. Lower Red Fork interval in the Stidham No. 1A core consists mostly of fine grained sandstone (Appendices A and B, Table I). Based on the evidence from the core study it is concluded that channel fill sandstone is present at this location. The net sandstone isolith map (Plate IV) at Figure 16A and 16B well locations shows the presence of elongate channel fill sandstones. The pattern of log signature in Figure 16C is believed to indicate the presence of sandstone, shale, and siltstone beds in ascending order. The net sandstone isolith map (Plate IV) shows the location of this well near the channel margin. Based on this information the presence of a levee deposit is favored at this location.

Upper Red Fork

Basic Evidence from Analysis of Cores

Rocks from the upper Red Fork interval were studied in ten cores. The cores are located in T.17N., R.17W. and R.18W. Detailed descriptions and photographs of the cores are given in Appendices A and B. Summary descriptions are in Table II.

The lower most unit in the cores is dark shale rich in carbonaceous plant matter. Brachiopods are present in the shale bed. In the A. M. Kunc No. 3 core, the lower most shale bed is calcareous. Dark shale beds are overlain by sandstones. Channel lag features (rip-up clasts of

TABLE II. SUMMARY DESCRIPTION OF CORES

Rock Type	Shale bed, very fine to fine grained sandstone (medium grain present in some cores near the bottom of the sandstone section), interbedded sandstone, shale and siltstone. Shale clasts in the lower part of the sandstone bed and at many locations in the sandstone. Sandstones have a sharp contact with the shale below and gradational contact above.
Sedimentary Structures	Ripple laminae, Trough cross bedding, planar cross bedding, horizontal bedding, climbing ripples, bioturbation, slump features, slightly deformed beds due to flowage.
Organic Content	Carbonized plant matter. Brachiopod fossils in the shale bed present above and below the sandstone section.
Accessory Rock Type	Sand sized rock fragments. Siderite in shale beds

shale) are present in the sandstones indicating a sharp erosive contact with the shale bed below. Sandstones with basal lag features are overlain by massive bedded and trough cross bedded sandstone. These beds are overlain by ripple laminated sandstone. Planar cross bedded sandstone is present above the ripple laminated sandstone. Near the upper part of the core the sandstone grades into interbedded to interlaminated sandstone, siltstone and shale. Overlying the interbedded sandstone, siltstone and shale sequence is dark shale bed rich in carbonaceous plant matter. Interbedded sandstone and shale sequences are slightly deformed due to flowage. In some cores (see Appendix A) several zones of channel lag features are present which is indicative of the multistoried (stacking) nature of the sandstone.

Figures 17 and 18 show the vertical sequences of structure and texture of the channel fill sandstones (Brown 1973, 1979). The vertical sequences of structure and texture observed in A. M. K. No. 3 and Presley No. 2 (see Appendices A and B) are similar to the sequence described in Figure 17. The Pearl Kunc A No. 2 (Appendices A and B) core consists of shale rich in carbonaceous plant matter, silty claystone and interbedded sandstone and shale. Silty claystones are bioturbated. Minute fragments of carbonized plant matter are present in most of the core. The Wessely Steers unit No. 1 core consists of shale, silty claystone, sandstone and siltstone in ascending order (Appendix A).

Basic Evidence from Cross Sections

Cross sections A-A' through D-D' (Plates VI through IX) show the following features:

a. shale bed above the lower Red Fork interval.

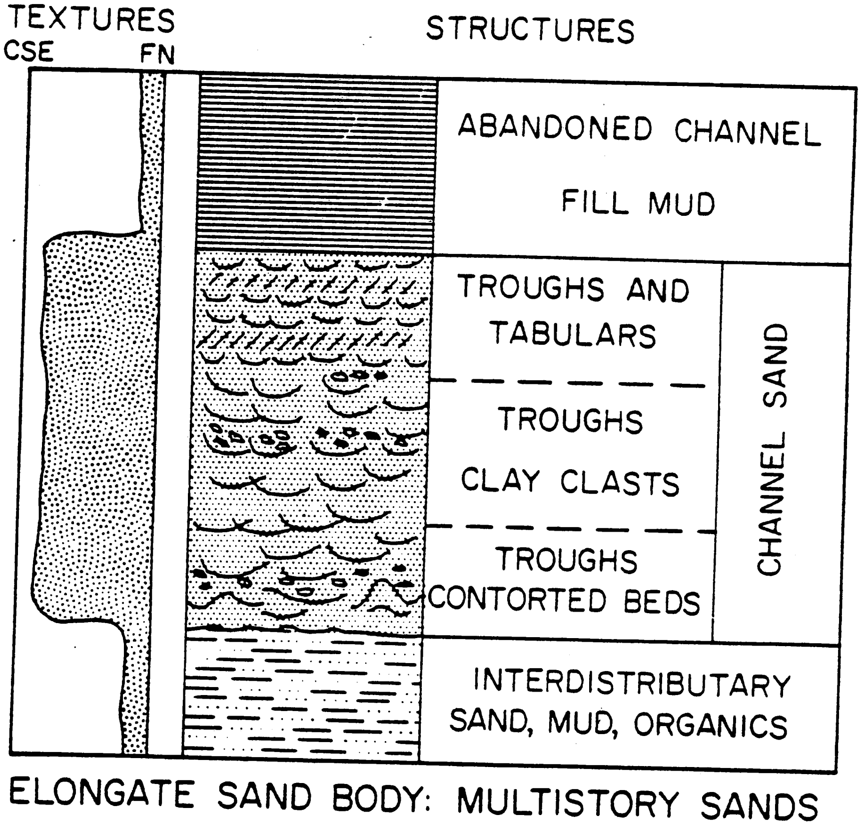

Figure 17. Idealized vertical sequences of distributary Channel fill sandstones in intercratonic basins (after Brown et al., 1973).

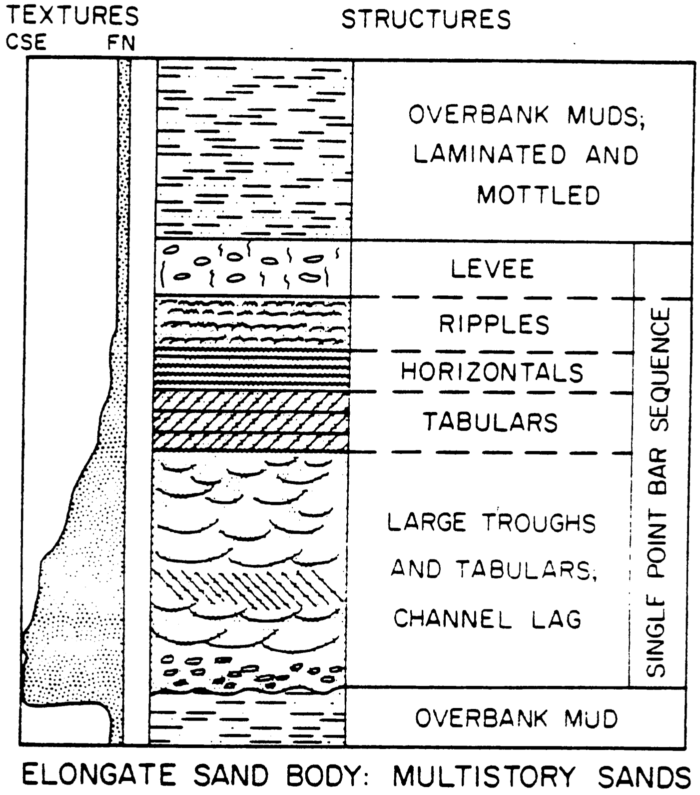

Figure 18. Idealized vertical sequence of point bar sandstones in intercratonic basins (after Brown et al., 1973).

b. a thin sandstone to siltstone bed overlying the shale bed (well 4 in cross sections C-C' and D-D').

c. sections of thick sandstone are indicated by "blocky" or "inverted Christmas tree" pattern of the log signature in most wells.

d. shale bed overlying the sandstone near the top in most wells.

Basic Evidence from Isopach Maps

The net sandstone isolith map (Plate III) shows thick, bifurcated, linear sandstone bodies. Plate III indicates that at the core locations sandstone bodies are narrow and elongate. The present-day southwestward dip (Plates I and II) is interpreted as being generally consistent with the dip during sedimentation of the Red Fork stratigraphic interval (a working assumption consistent with the general knowledge of the Anadarko basin's history (see Berg, 1968; Johnson, 1984; and Zeliff, 1975)). The linear sandstone bodies are oriented at large angles to structural-depositional strike of the basin's northern flank. Source areas of clastic sediments seem to have been to the north or northeast (Berg, 1968; Johnson, 1984; Zeliff, 1975). On the basis of this general information, bifurcation of sandstone units seems to show evidence that during deposition, sand filled channels bifurcated in a basinward direction.

Interpretation of Depositional Environment

On the basis of evidence shown above, a set of reasonable inferences about general depositional environments of the upper Red Fork sandstone would seem to include the following:

a. alluvial channels and alluvial plain
b. deltaic distributaries and delta plain
c. distributary mouth bar
d. submarine channels.

Elimination of an alluvial setting seems to be justified because of the tendency of the sandstone bodies to be bifurcated basinward, and the apparent scarcity of constituents that would suggest terrestrial conditions (e.g. calich-like nodular limestone, abundant wood, coarse clasts of rock that were lithified at deposition). A distributary mouth bar deposit seems to be unlikely for the reason that sandstones are oriented parallel to the structural dip which is also considered as the depositional dip. In the cores examined, the upper Red Fork sandstones do not show any evidence of reworking by marine wave action. The original sedimentary structures and textures are preserved in the sandstones, and the composition of the sandstone (presence of large amount of rock fragments and shale clasts) indicate otherwise. Inference of a submarine-channel setting may be inconsistent with the data, because the study area seems to have been landward of the shelf-slope transition zone during deposition of the Red Fork (see Plate VII, and Johnson, 1984, p. 53) and because of absence of graded bedding and marine fossils in sandstone which are regarded as being suggestive of deposition in submarine channels.[2]

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[2] The fact is acknowledged that ten cores must be regarded as a small fraction of the upper Red Fork sandstone in the study area and they are more or less from the same location. Many critical lithic features absent from the rocks inspected may be in the upper Red Fork, in the study area.

A delta-plain environment would explain the bifurcated-basinward pattern of sandstone bodies, abundant rip-up clasts of shale, abundant macerated, carbonized plant material and the recorded sedimentary structures. Moreover, a deltaic origin of the upper Red Fork sandstone would be consistent with the overall upward stratigraphic sequence of thin, widespread fossiliferous sandstone (of lower Red Fork interval), thick shale, thin sandstones, channel like sandstone bodies, thin shale bed and the Pink limestone. Altogether, these rocks could record a regressive prodeltaic shale to delta front sandstone, to distributary channel fill sandstone, to interdistributary bay shales. The interpretation of a deltaic setting during deposition of upper Red Fork sandstone is favored. Figure 19 is the block diagram illustrating the deltaic distributary channel depositional setting of the upper Red Fork sandstone.

In the cores studied delta front sandstone is not present. It is interpreted that the delta front sandstones were probably removed by the erosive downcutting of the pro-grading channels.

A narrow, elongate sandstone body having an east-west trend is present in T.17N., R.17W. and R.18W. (Plate III). The net sandstone isolith map (Plate III) shows the merging pattern of the elongate sandstone bodies at this location. The pattern of the sandstone bodies suggests that three distributary channels had originated here and had flowed in a southerly direction. The ten cores studied are from the east-west trending sandstone body. Channel lag features, trough cross bedding, ripple laminae, and planar cross bedding (see Chapter VI) are the common sedimentary structures present. In some cores (Appendix A) several zones of channel lag features are present indicating the multi-storied nature of the sandstones. Based on these facts it is inferred

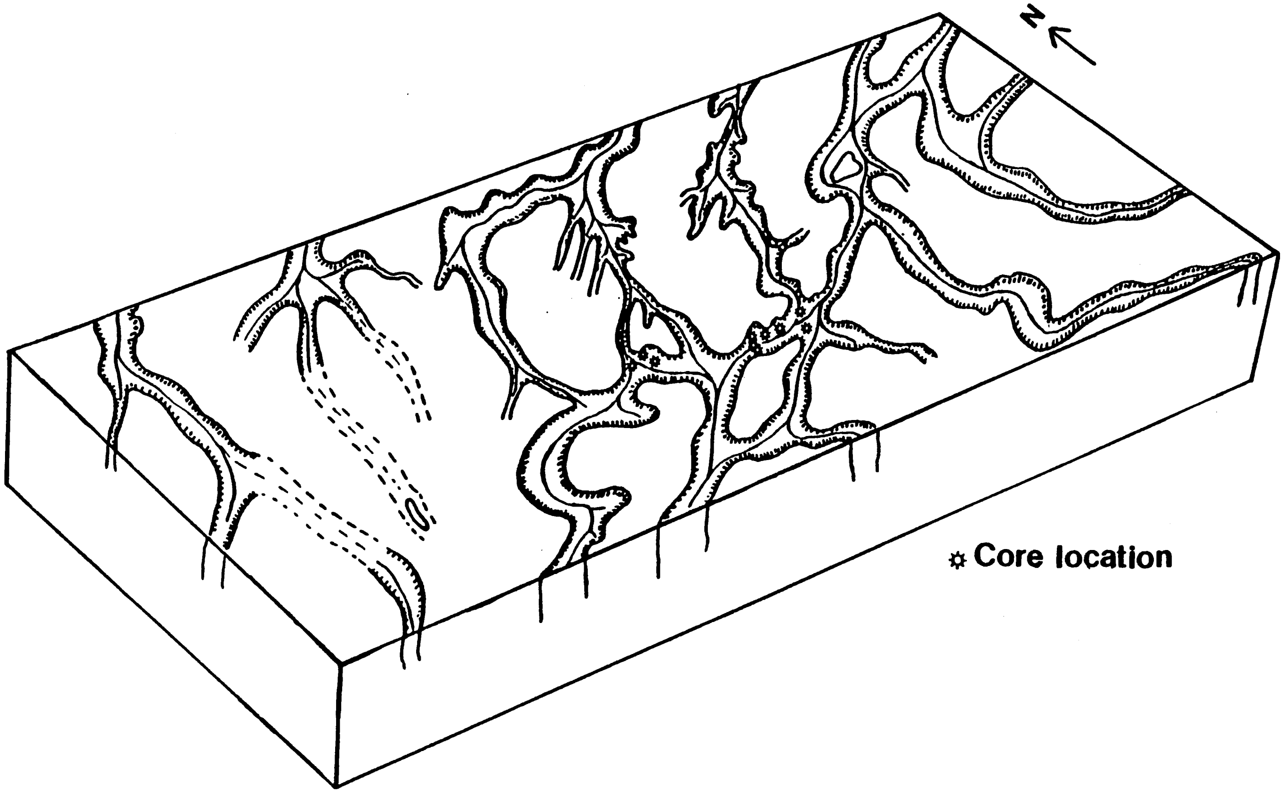

Figure 19. Conceptual Model of Depositional Environment of the upper Red Fork Sandstone-Deltaic Distributary Channels.

that three different channels deposited sand and shale during different periods of time. This resulted in the stacking of the sands. It is possible that during periods of higher flow regime, these channel cut into other previously deposited sediments, thus depositing sediments across the region. Paleotopography also seems to have played a role in influencing the channel course. These processes probably have resulted in the deposition of the east west trending sandstone body in T.17N., R.17W. and R. 18W.

The log signatures and the related depositional interpretation of the upper Red Fork sandstone at certain locations are given in Figure 20. Figure 20A is the log signature of the A. M. Kunc No. 3 well. Core from this well was studied (Appendix A and B). Based on the sedimentary structure, texture, and composition it is concluded that the core is a multistoried channel fill sandstone. Figure 20B is the log signature of the Pearl Kunc A No. 2 well. Core from this well consists of shale rich in carbonaceous plant matter, silty claystone and interbedded sandstone and shale. Silty claystones are commonly bioturbated (Appendix A). Carbonized plant matter is present in most part of the core. It is interpreted that the shale and silty claystones were deposited in an interdistributary bay environment. On the net sandstone isolith map (Plate III) interdistributary bay regions are indicated by "thin" areas. Analysis of the log signature shown in Figure 20C suggests the presence of about 3 feet of sandstone above a thick shale bed. Sandstone seems to be overlain by siltstone. The net sandstone isolith map (Plate III) shows a minor channel pattern of the sandstone at this well location. This information favors the presence of a crevasse splay deposit. The pattern of the log signature shown in Figure 20D suggests the presence

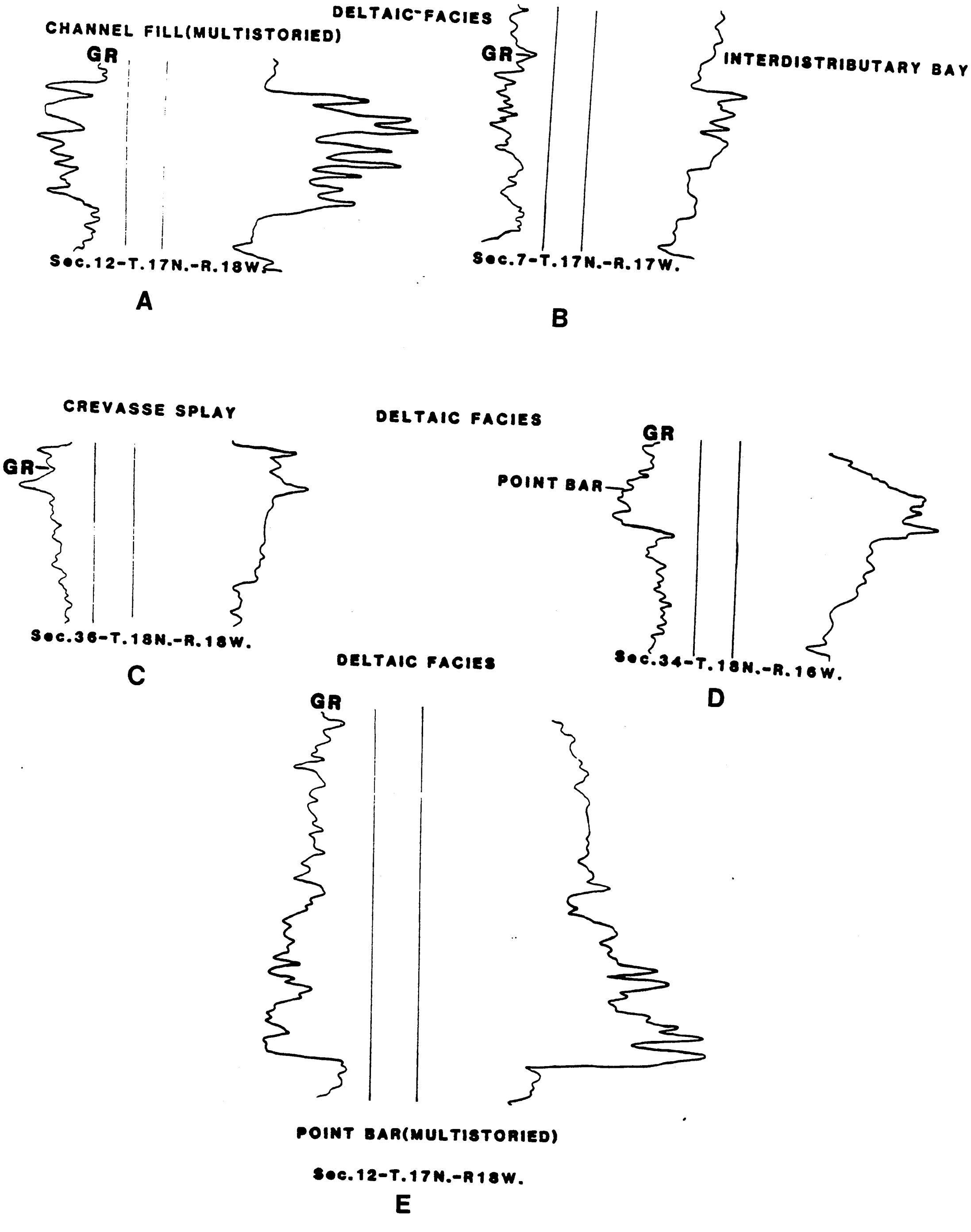

Figure 20. Characteristic gamma ray signature of Deltaic Facies in the upper Red Fork.

of sandstone above shale. The log signature also indicates the fining upward nature of the grain size in the sandstone section. The net sandstone isolith map (Plate III) shows the presence of a crescent shaped sandstone body here. This information suggests point bar deposition.

The log signature of the ARCO, Seal well (Figure 20E) is similar to the log signature shown in Figure 20D, except that at the Seal well location most of the upper Red Fork unit consists of sandstone. Log signatures indicate the fining upward nature of the grain size in the sandstone. The net sandstone isolith map (Plate III) shows the meandering pattern of the sandstone body at this well location. Based on the width of the sandstone (Plate III) at the Seal well location it is interpreted that the channel was nearly 1.5 miles wide. Larger channel width at this location and the removal of shale due to erosion seems to have resulted in the deposition of thick sands at this well location.

CHAPTER VIII

PETROLOGY AND DIAGENESIS

Introduction

Petrographic analysis of the Red Fork sandstones includes the examination of 140 thin sections from ten cores located in the study area (Appendix). Bulk and extracted x-ray diffraction (Kittrick and Hope, 1963) analysis of clays was performed on selected samples from the cores studied. Scanning electron microscopy along with energy dispersive x-ray analysis were utilized to illustrate textural relationships and identify the authigenic clay minerals.

The purpose of the petrographic analysis of the Red Fork were: (1) to determine textural and mineralogical compositions, (2) to confirm the environment of deposition and facies interpretation by relating the grain size variation to the gamma ray signature pattern in the well logs, and (3) to describe the diagenetic changes and its implications on porosity and permeability within the sandstone.

It is interpreted that the porosity and permeability development in the upper and the lower Red Fork sandstone is dependent on mineralogic composition and sorting which in turn is dependent on the environment of deposition. A major factor is the relative amounts of quartz, and rock fragments present. Diagenetic alterations and dissolution processes have played a significant role in the generation of secondary porosity.

Lower Red Fork

Texture

The petrographic study of twelve thin sections from the lower Red Fork interval in the Joe N. Champlin Stidham No. 1A and the Wessely Clark 1A cores (Appendix A) indicates that the grain size varies from fine at the bottom of the interval to siltsized grains near the top. Sand grains are moderately sorted and are submature.

Detrital Constituents

The major detrital constituent is quartz, which ranges from 55% to 59% of the rock composition. Only trace amounts of polycrystalline quartz were recorded. Feldspars are not very abundant, and range from 1% to 3% in thin sections. Twinned plagioclase was most easily identified. Untwinned potassic feldspars can be recognized by their turbid appearance, caused by their alteration to sericite. Microcline feldspar is recognized by their cross-hatched twinning.

Rock fragments are more abundant than feldspars and compose 10% to 13% of the lower Red Fork sandstones. Illitic shale clasts, siltstones, chert and fragments of low grade metamorphic rocks were documented in the thin section study. Fragments of low grade metamorphic rocks include schists, phyllites and quartzites (Figure 21). Illite and chlorite, are the detrital clays observed in the thin sections (Figure 22). Trace amounts (< 1%) of glauconite was found in the study. Ductile deformations of shale clasts has resulted in the formation of pseudomatrix which forms about 5% to 8% of the rock composition. Mica flakes and zircon were also documented in accessory amounts.

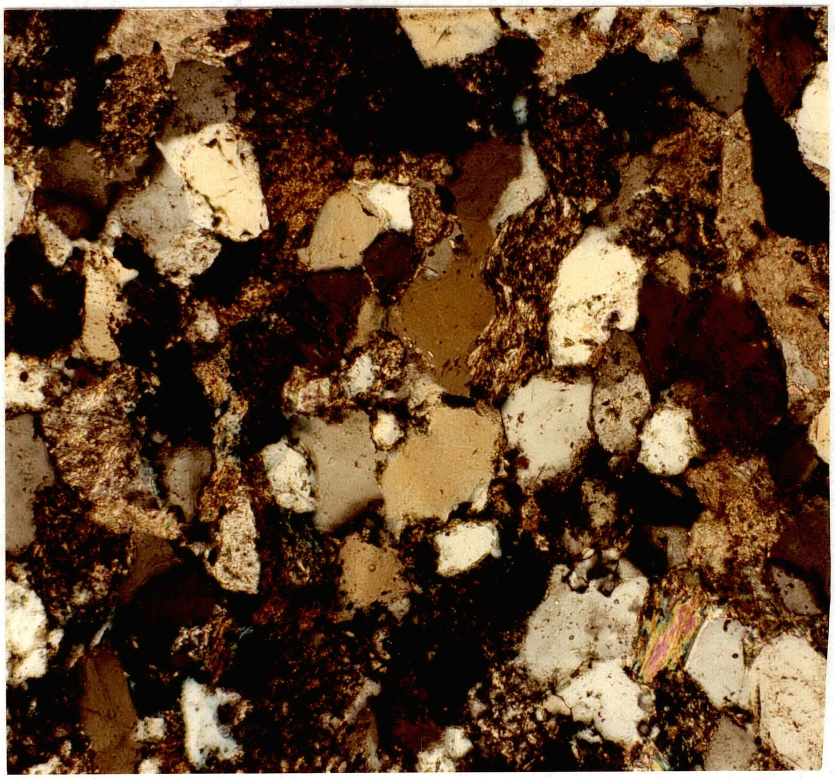

Figure 21. Phyllite fragments in lower Red Fork sandstone. Joe N. Champlin Stidham No. 1A. Depth 9502 feet (Crossed Nicols) (X100).

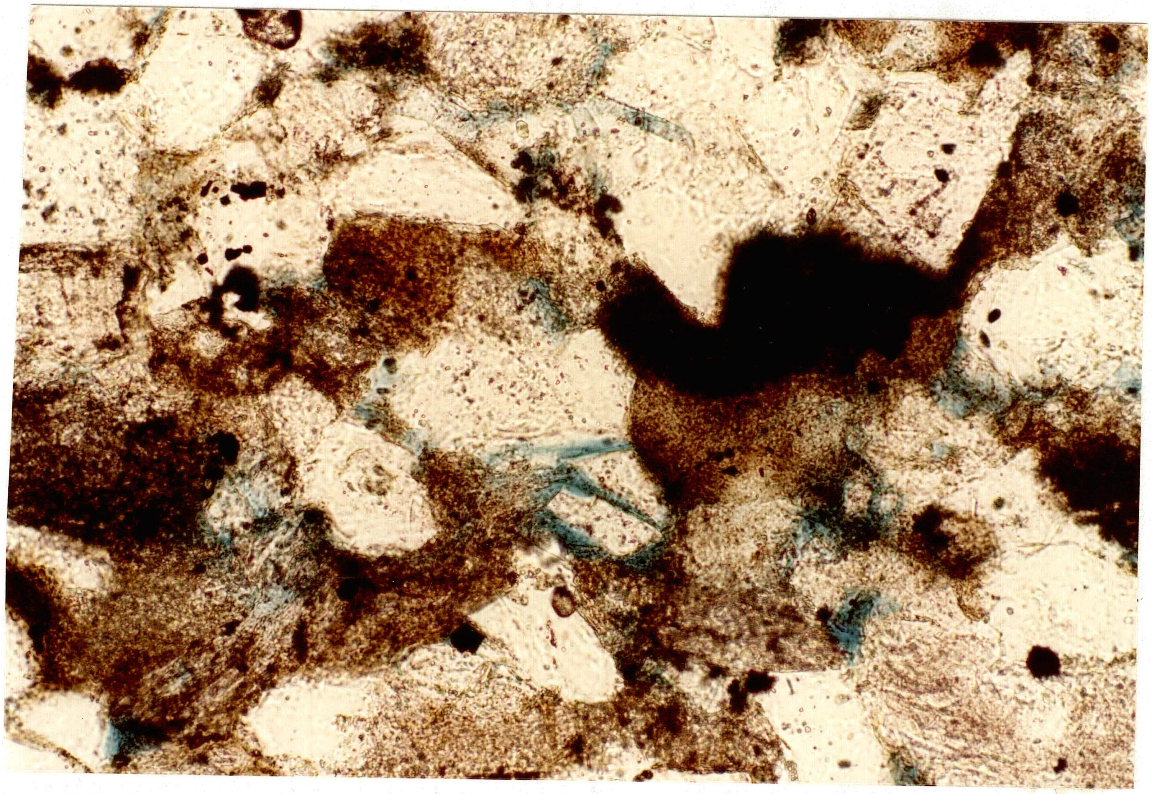

Figure 22. Detrital clays, Illite and Chlorite in lower Red Fork sandstone, Wessely Clark 1A. Depth 9607 feet (plane polarized) (X200).

Figure 23 depicts the QRF diagram (Folk, 1968) for the lower Red Fork sandstones samples. Most samples are plotted as sublitharenite which are indicative of the presence of considerable rock fragments in the sandstone composition. A few samples from the Wessley Clark IA core were plotted as litharenites. The lower Red Fork interval in this core consists of interlaminated sandstone and shale. Petrographic study indicates the presence of abundant rock fragments, and shale clasts.

Diagenetic Constituents

The diagenetic constituents documented in the lower Red Fork sample study include authigenic clays, authigenic silica, and diagenetic carbonate cement. Authigenic clays and silica are the dominant cements. Illite, chlorite and kaolinite are the authigenic clays observed in thin sections. Chlorite is found as pore lining and grain coating whereas illite occurs as grain coating (Figure 24). Kaolinite books were found filling the pore space but kaolinite is not common. Figure 25 illustrates the x-ray analysis results. Scanning electron microscopy and EDAX analysis results are illustrated in Figures 26, 27 and 28. In Figure 28 a partially dissolved and altered feldspar grain is shown. Dissolution of feldspar has created secondary pore space in the sandstone. Figure 28 shows illite laths growing from the feldspar grain. This indicates that diagenetic alteration of feldspar has resulted in the formation of illite. The projection of illite laths into the pore space would reduce the pore aperture which will result in the reduction of permeability.

Authigenic silica cement observed in thin sections occurs in the form of syntaxial quartz overgrowths (Figure 29). Calcite cement is

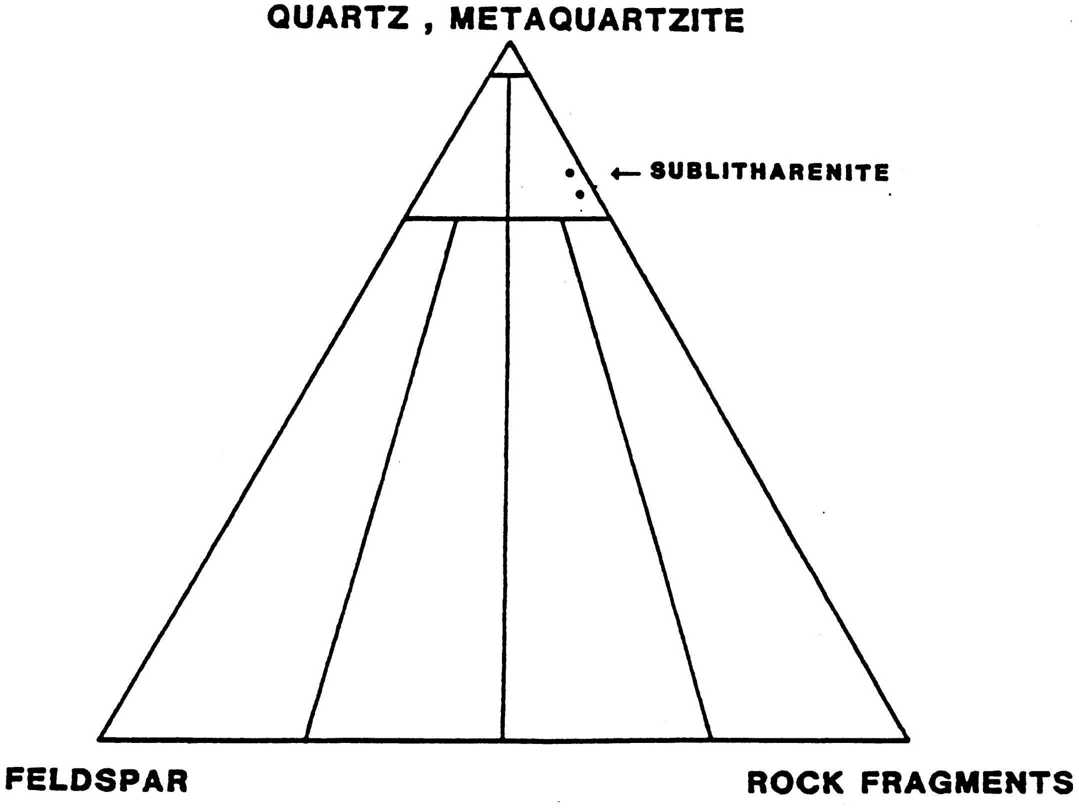

Figure 23. Ternary diagram (QRF) depicting the mineralogic composition of the lower Red Fork sandstone in J. N. C. Stidham No. 1A and Wessely Clark IA cores (Classification of Folk, 1968).

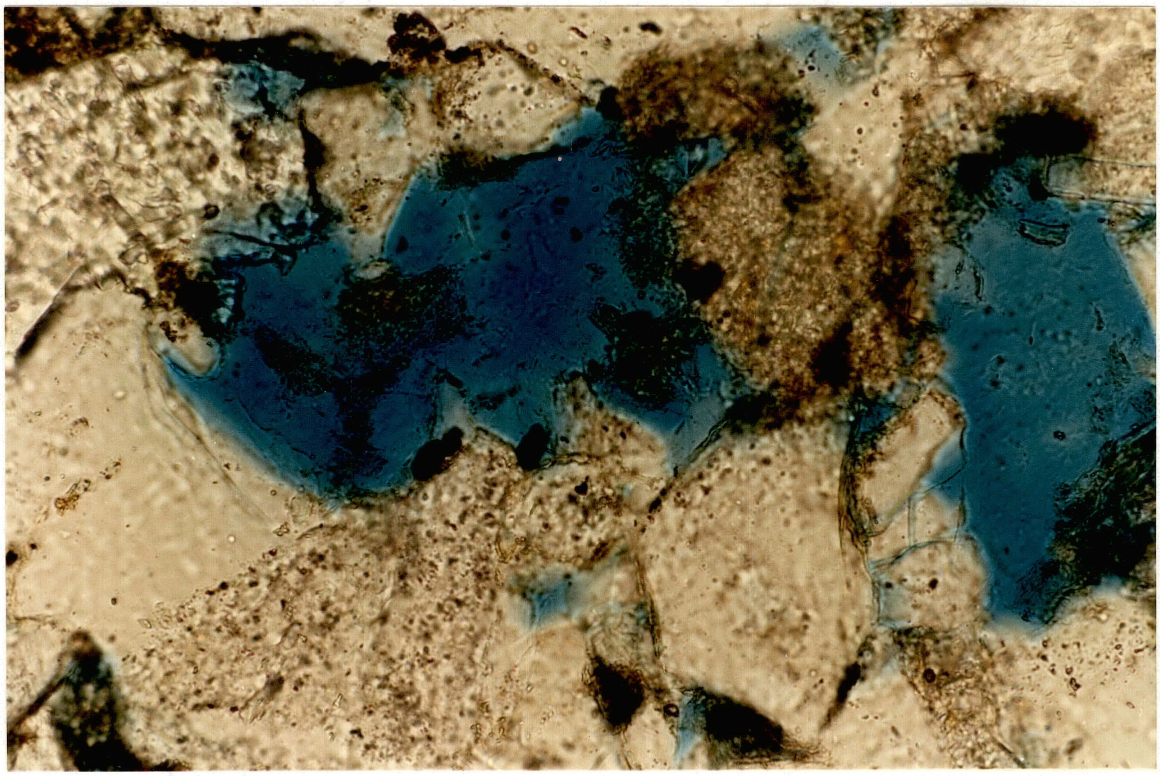

Figure 24. Authigenic Chlorite and Illite in lower Red Fork sandstone, J. N. C. Stidham No. 1A. Depth 9502 feet (plane polarized) (X400).

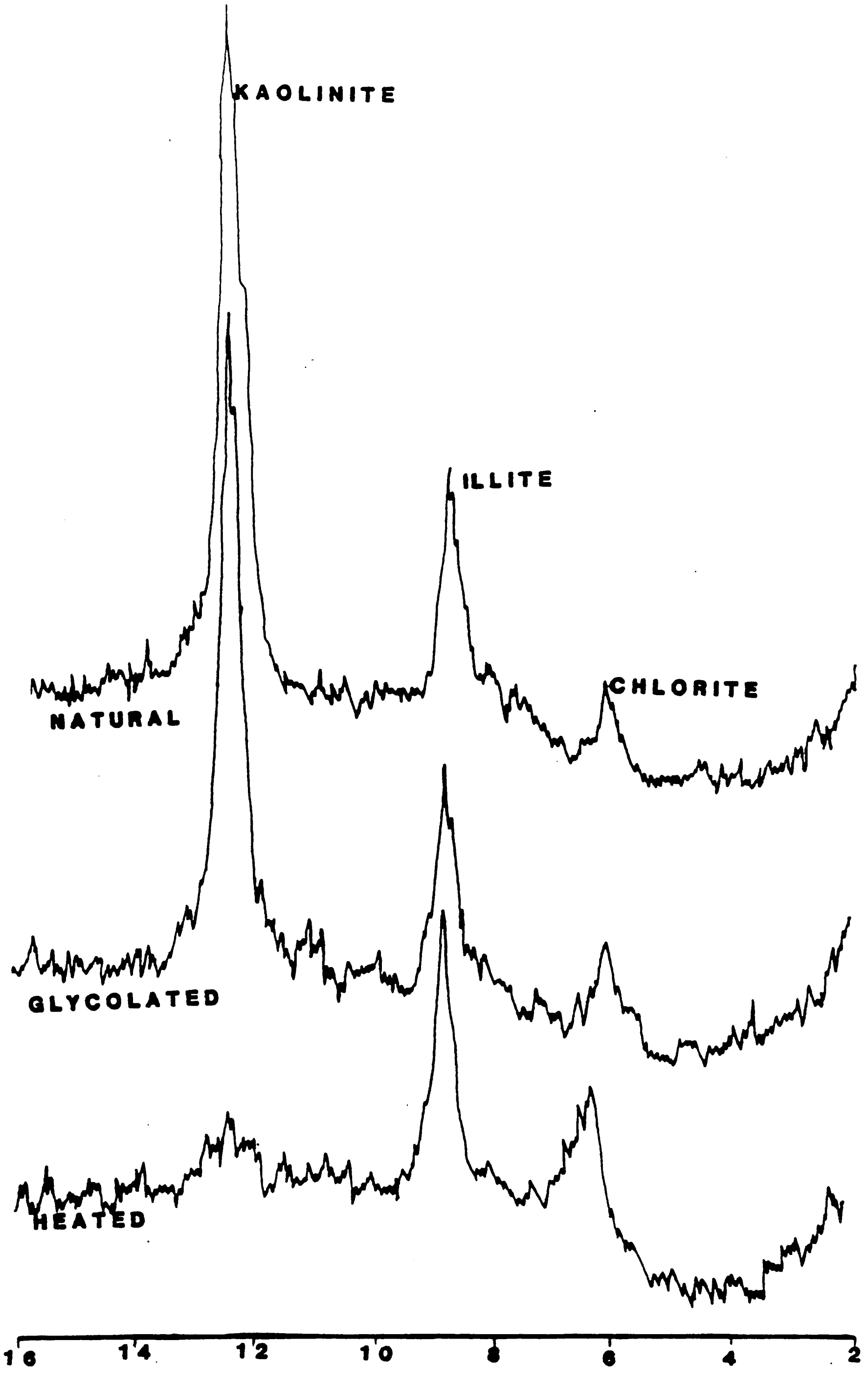

Figure 25. X-ray diffractograms of clay fractions (<3.9μm) from lower Red Fork sandstone.

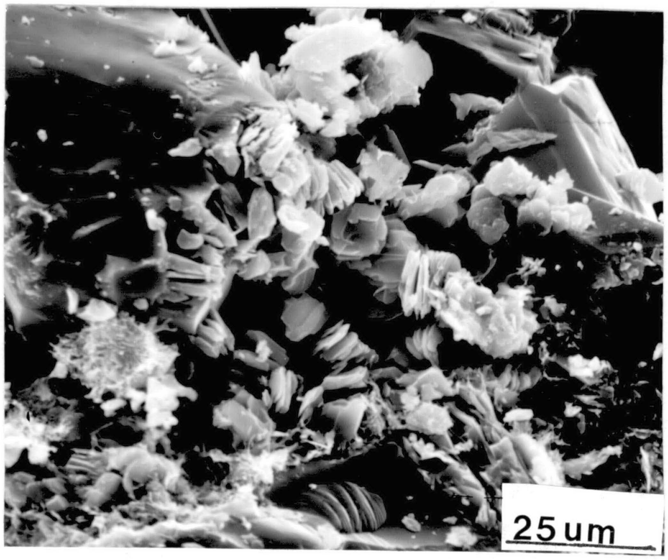

Figure 26. Authigenic Chlorite, authigenic kaolinite and authigenic illite in lower Red Fork Sandstone, J. N. C. Stidham No. 1A. Depth, 9520 feet, porosity, 14%.

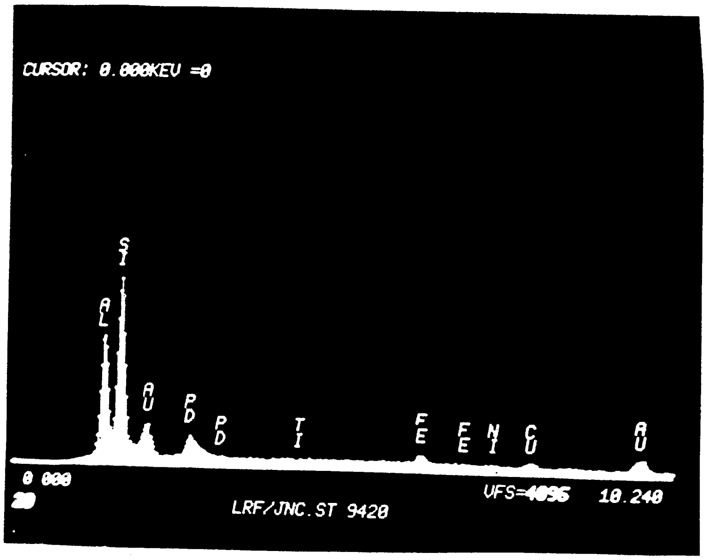

Figure 27. EDAX analysis showing the relative chemical composition of kaolinite in Figure 26. Magnification IX, EDAX.

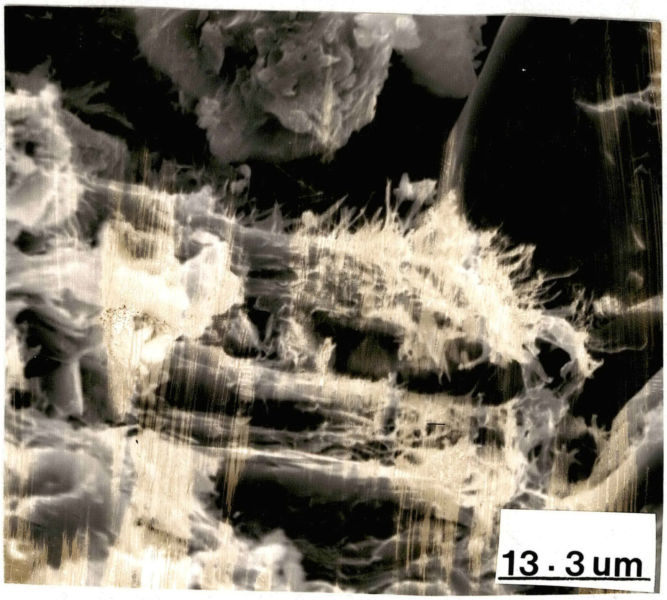

Figure 28. Partially dissolved Feldspar in lower Red Fork sandstone. Note the illite laths growing from feldspar. J. N. C. Stidham No. 1A. Depth 9520 feet, porosity 14%.

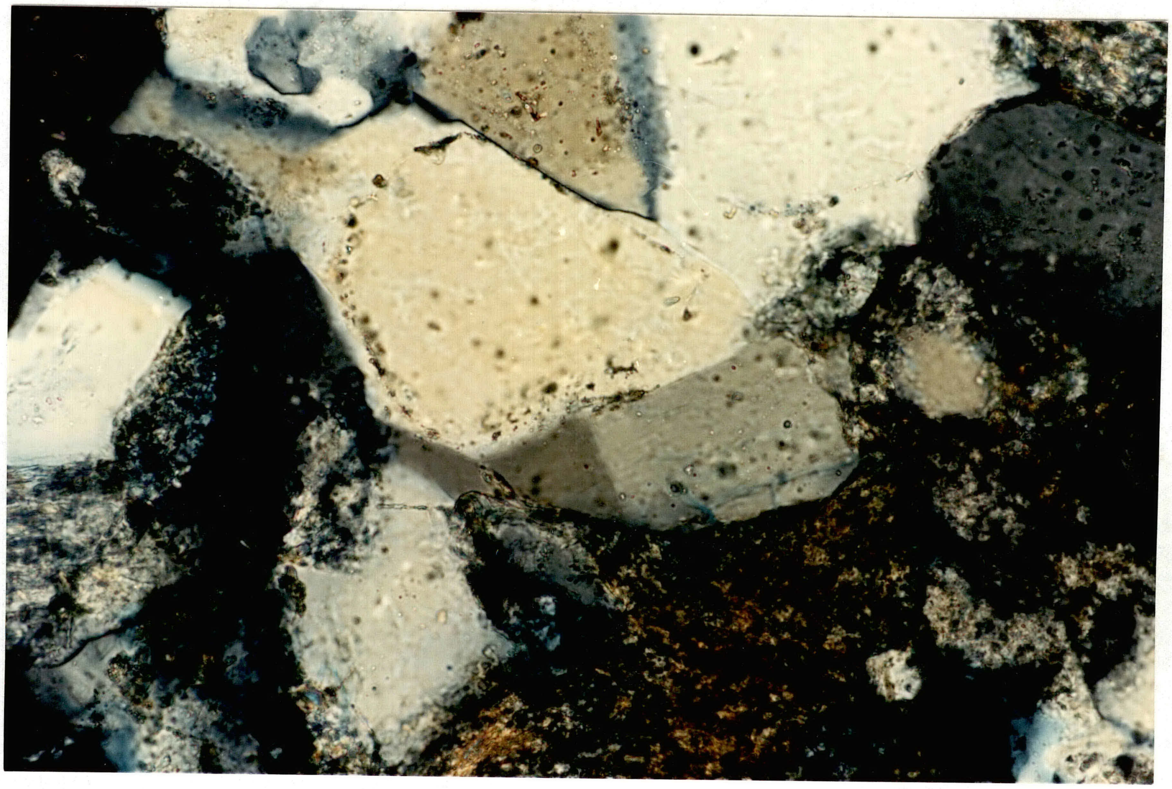

Figure 29. Authigenic silica overgrowth on detrital quartz grain in lower Red Fork sandstone. J. N. C. Stidham No. 1A. Depth, 9502 feet, porosity 15% (Crossed Nicols) (X400).

observed in samples from the upper part of the lower Red Fork interval where the sandstone is overlain by calcareous sandstone. Development of poikilotopic texture is a common feature in samples from the sandstone at this location (Figure 30).

Porosity

The porosity documented in the lower Red Fork sandstone is mainly of secondary nature. The porosity development is mainly through the dissolution of shale clasts, feldspars, and to a lesser extent the dissolution of quartz. Oversized pores, are the common types of secondary pores in the lower Red Fork sandstone. Honeycombed grains and elongate pores were also documented. Figures 31 shows the secondary porosity observed during the thin section study. The maximum secondary porosity recorded was 14%. Microporosity is likely to be present between the kaolinite books and chlorite plates. Development of silica cement has destroyed the primary porosity.

Paragenesis

Secondary porosity in sandstone can originate anywhere in the sedimentary crust: (1) before effective burial in the environment of deposition (eogenetic); (2) at any depth of burial above the zone of metomorphism (mesogenetic); and (3) during exposure following a period of burial (telogenetic) (Schmidt and McDonald, 1979). By far the largest amount of secondary porosity is generated during mesodiagenesis (mesogenetic stage) as a result of chemical, physiochemical, physical, biochemical and biophysical processes. Diagenetic events that have affected the sandstone and their timing are illustrated in Figure 32. Based

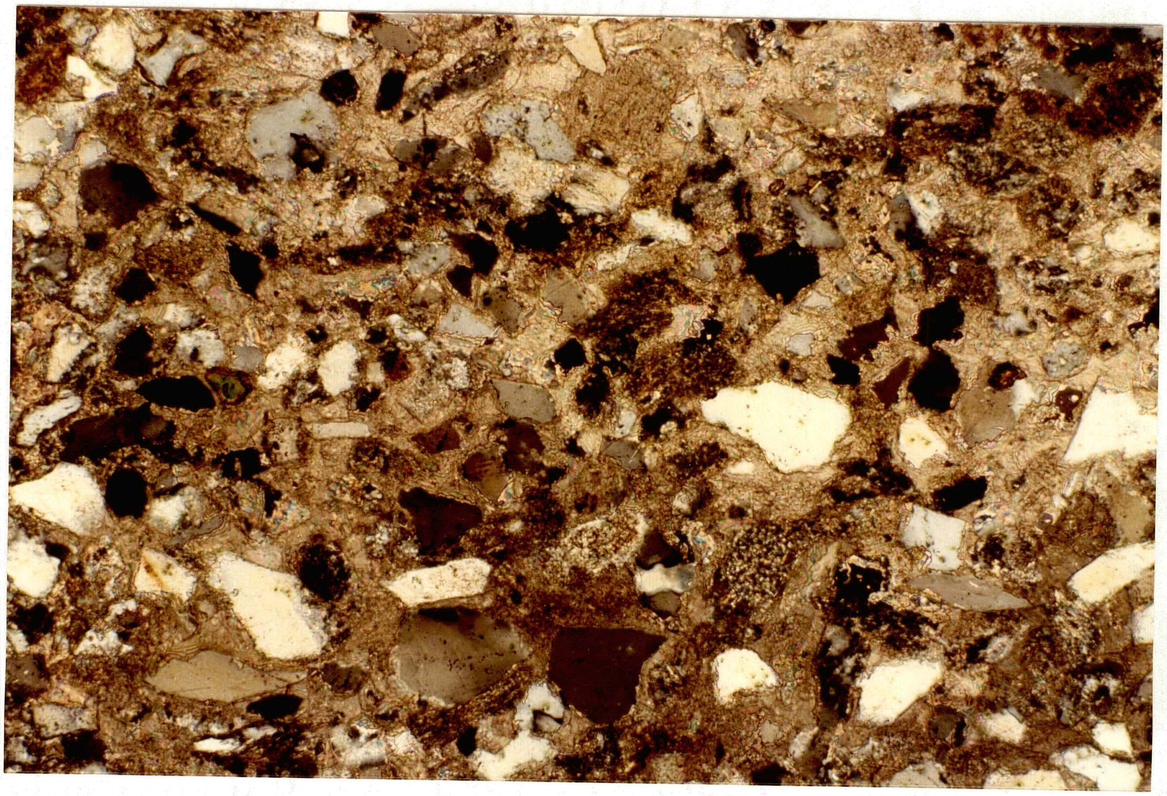

Figure 30. Calcite cemented lower Red Fork sandstone in which extensive replacement of detrital grains by Calcite has resulted in poikilotopic texture. J. N. C. Stidham No. 1A. Depth, 9500 feet, porosity 0% (Crossed Nicols) (X100).

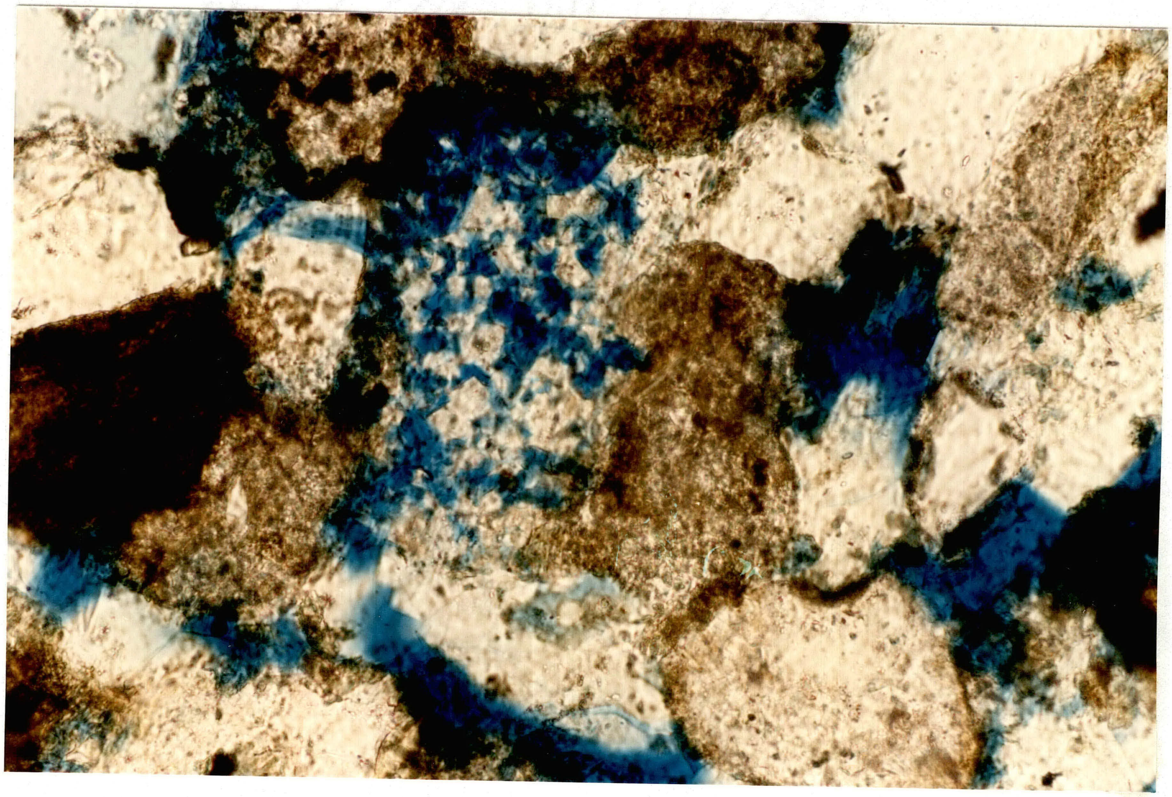

Figure 31. Partially dissolved Feldspar, Honeycombed grain (type of secondary porosity) in lower Red Fork sandstone, Wessely Clark 1A. Depth, 9607 feet (plane polarized) (X400).

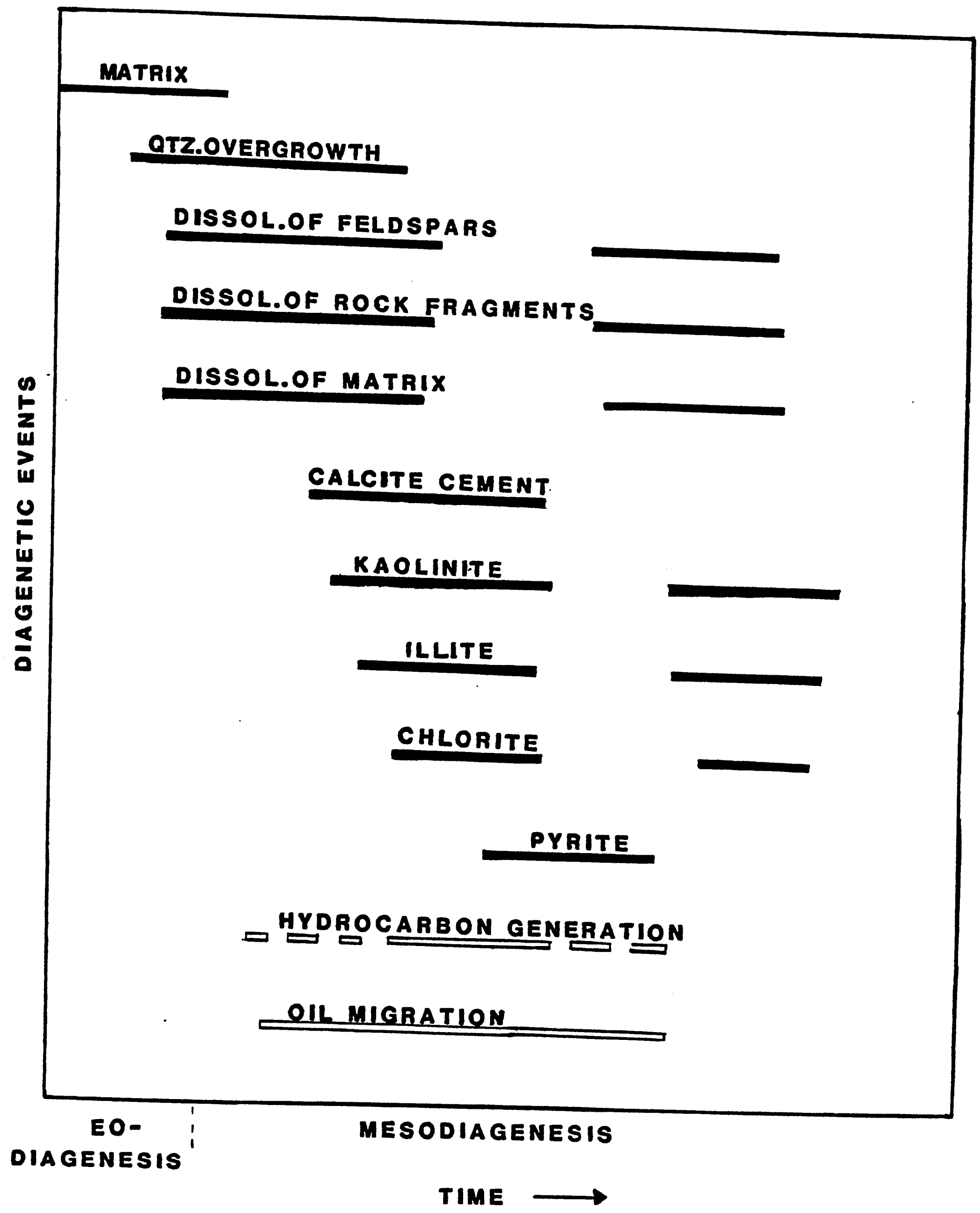

Figure 32. Paragenetic sequence of the lower Red Fork sandstone.

on criteria such as the development of secondary porosity and destruction of primary porosity it is interpreted that mesodiagenetic processes have acted on the sandstone.

Calcareous Sandstone

Figures 33 and 34 are the photomicrographs of the calcareous sandstone samples. A calcareous sandstone unit overlies the lower Red Fork sandstone zone in the Joe N. Champlin Stidham No. 1A and Wessely Clark 1A cores (Appendix A). Thin section study indicates the presence of carbonate detritus including shallow marine fossil fragments in the composition. Siltsized quartz grains are found interspersed in the carbonate detritus. The presence of calcareous sandstone overlying the lower Red Fork sandstone is interpreted as indicative of a minor transgressive episode.

Upper Red Fork

Texture

The petrographic analysis of one hundred and twenty-eight thin sections from the upper Red Fork interval indicates that the grain size varies from medium to very fine grain within the sandstone sections. Medium grain size is generally present at the base of the channel fill sandstone section and very fine grains near the top of the section (Figure 35 and 36). Overall the grain size ranges from medium or fine at the base of the sandstone unit to silt size near the top. The upper Red Fork sandstone is moderately sorted and is submature in composition.

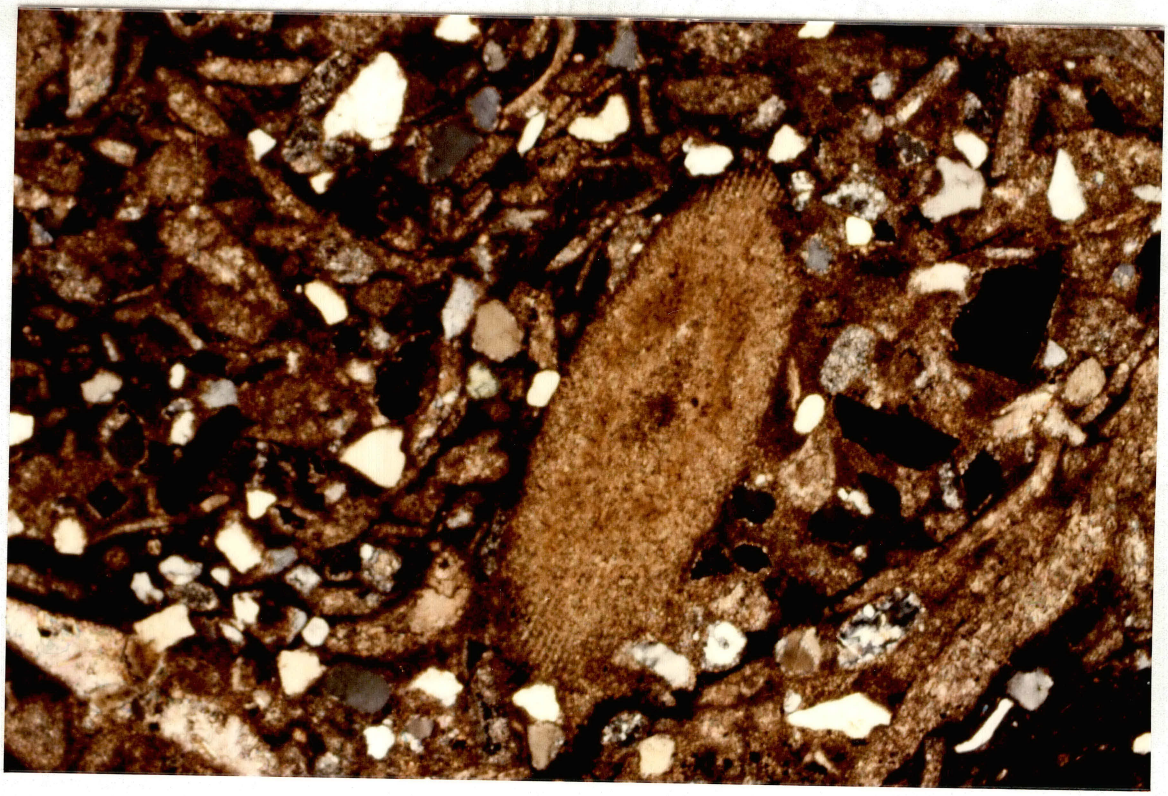

Figure 33. Very fine to silt-sized quartz grains and Echinoid and Brachiopod fragments. Wessely Clark No. 1A. Depth, 9597 feet (plane polarized) (X400).

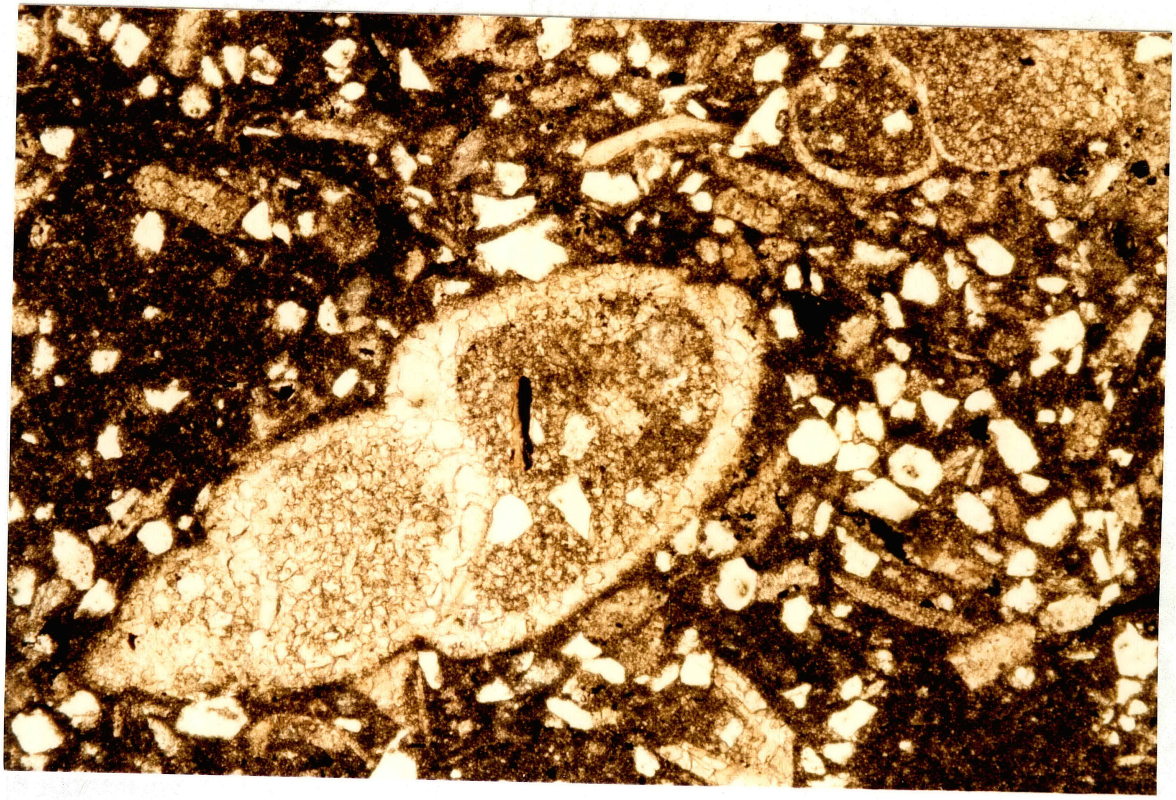

Figure 34. Very fine and silt-sized quartz grains, Gastropod and Brachiopod fragments. J. N. C. Stidham No. 1A. Depth, 9500 feet (plane polarized) (X400).

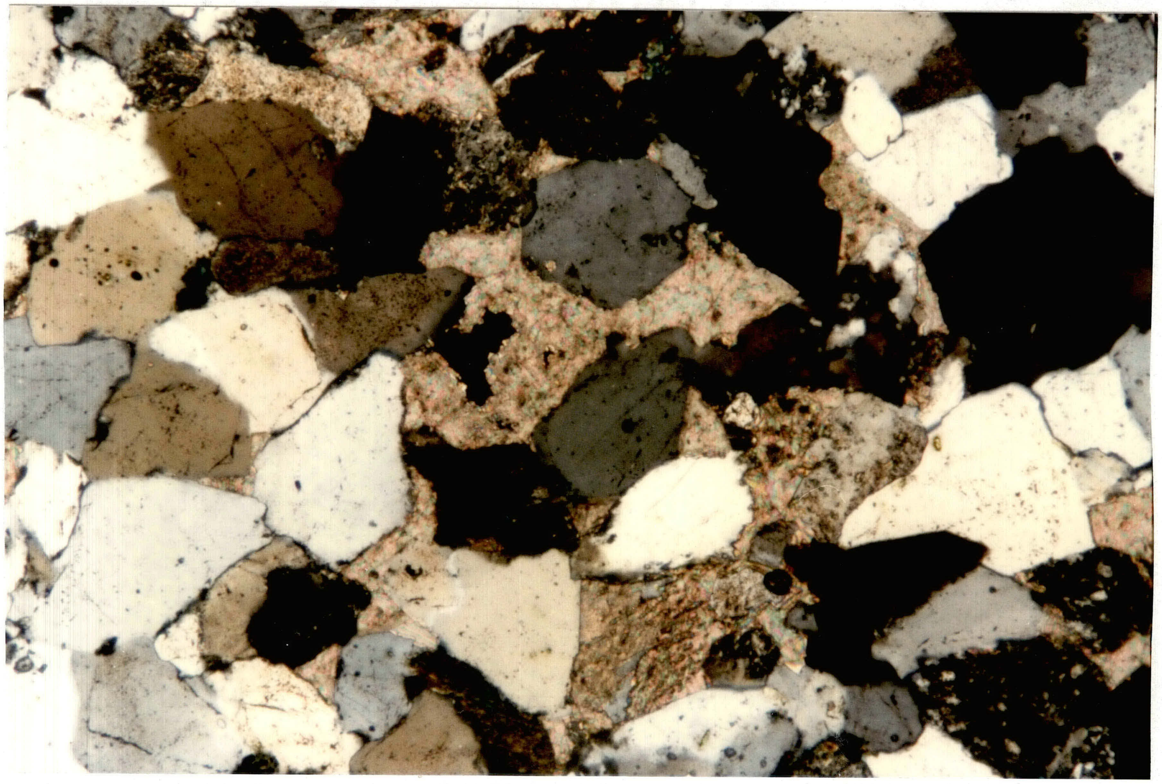

Figure 35. Medium grained quartz grains cemented by authigenic silica and calcite (Note the grain size) in upper Red Fork sandstone. W. C. P. Leslie No. 1. Depth, 9450 feet (Crossed Nicols) (X40).

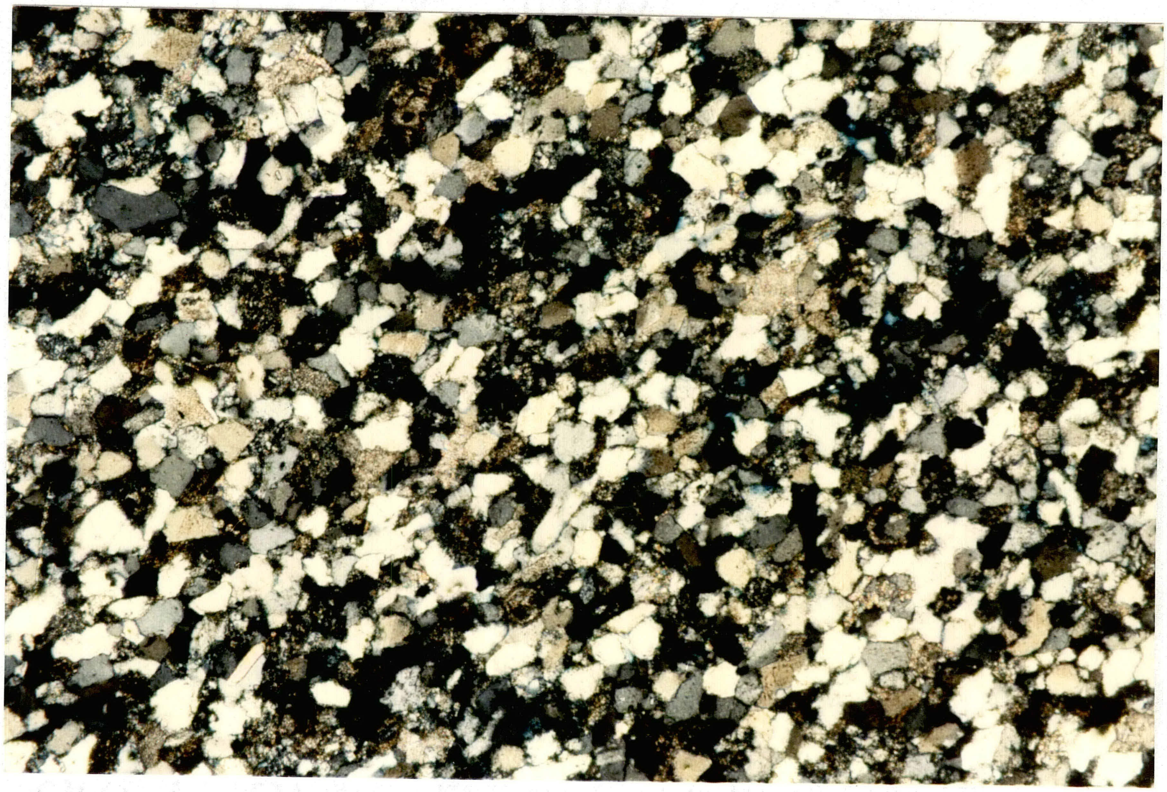

Figure 36. Fine grained quartz grains make up the framework structure in the upper Red Fork sandstone. W. C. P. Leslie No. 1. Depth, 9434 feet (Crossed Nicols) (X40).

Detrital Constituents

The detrital composition of the upper Red Fork sandstone generally remains the same as the lower Red Fork sandstone. Subangular to subrounded quartz (55% to 60%) grains make up the bulk of the framework structure. Monocrystalline grains are dominant over polycrystalline grains. Clay skins on quartz grains were observed in many thin sections (Figure 37).

Feldspars constitute about 1% to 3% of the rock composition. Plagioclases exhibiting albite twinning are the dominant varieties with minor amounts of potassium feldspar. Feldspar grains have a "dirty" appearance and are under various stages of alteration (Figure 38). Alteration to sericite along cleavage planes is generally observed. Untwinned potassium feldspars were identified by their crystal morphology, alteration characteristics, and optic sign. Partially dissolved feldspar grains were observed during the thin section study.

Rock fragments, mica and accessory minerals make up about 14% to 16% of the rock composition. Rock fragments are mainly low grade metamorphics, shale clasts, chert grains, and siltstones. Rock fragments alone make up 7% to 13% of the constituents. Low grade metamorphics include schist fragments, and quartzites (Figure 39). Fragments of metamorphic rock are commonly observed altered to sericite and chlorite. Sedimentary rock fragments, especially shale clasts are predominantly illitic in composition.

The presence of muscovite was documented in thin sections studied. Muscovite is characterized by highly birefringent elongate strands that commonly show evidence of compaction. Zircon is the common accessory

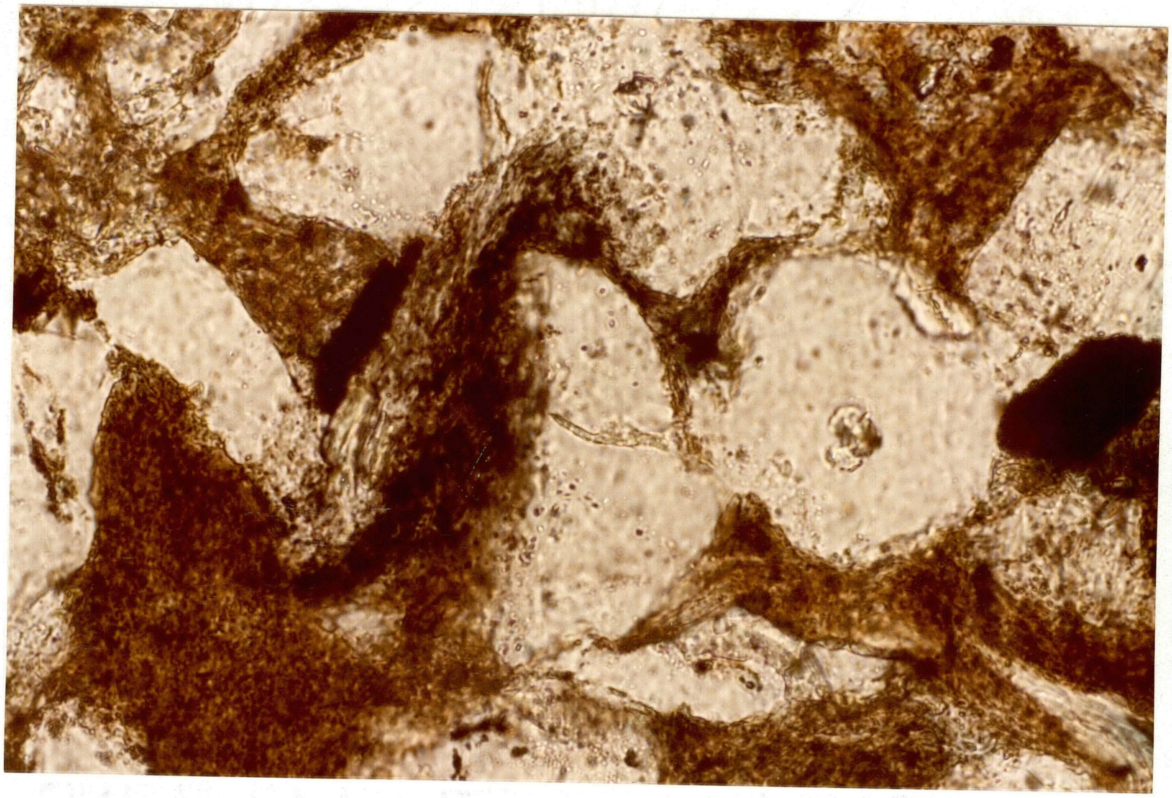

Figure 37. Illite grain rims on quartz grains and illitic shale clasts in upper Red Fork sandstone, ARCO, A. M. K. No. 3. Depth, 9441 feet (plane polarized) (X400).

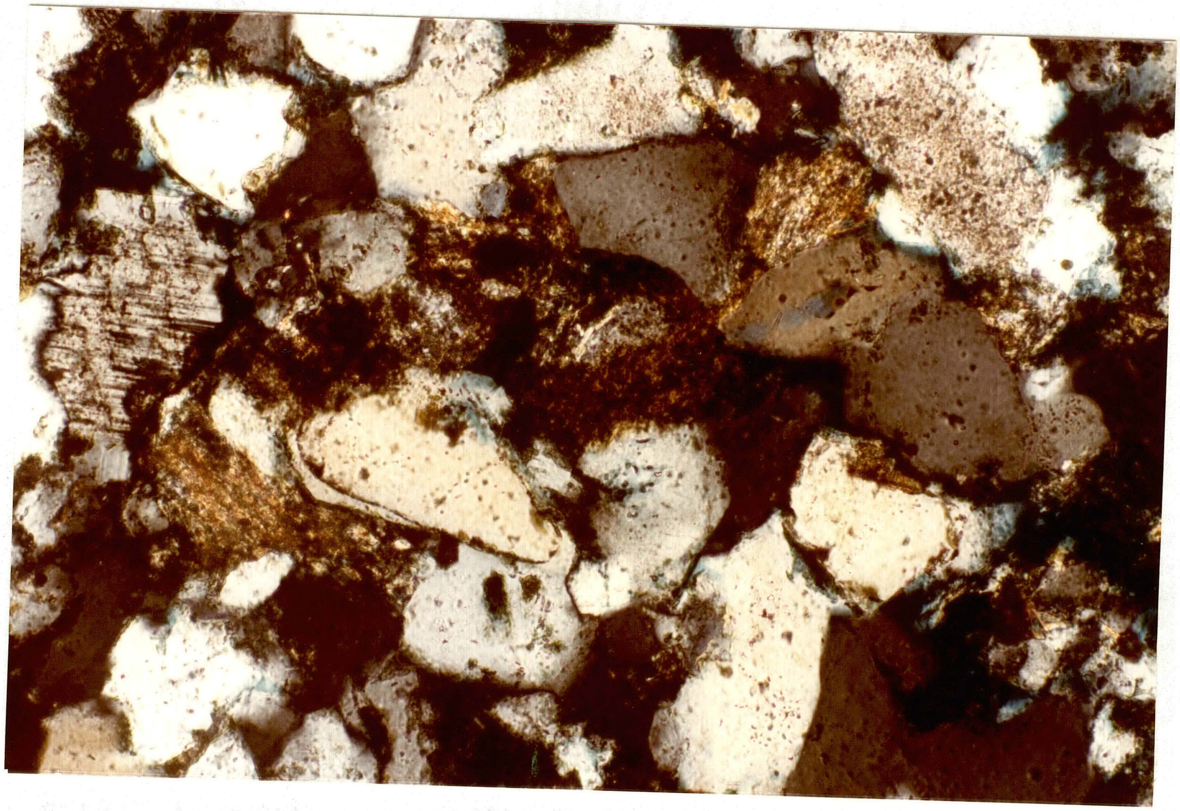

Figure 38. Mottled feldspar grain altered to sericite along cleavage planes in upper Red Fork sandstone. ARCO, A. M. K. No. 3. Depth, 9422 feet (Crossed Nicols) (X200).

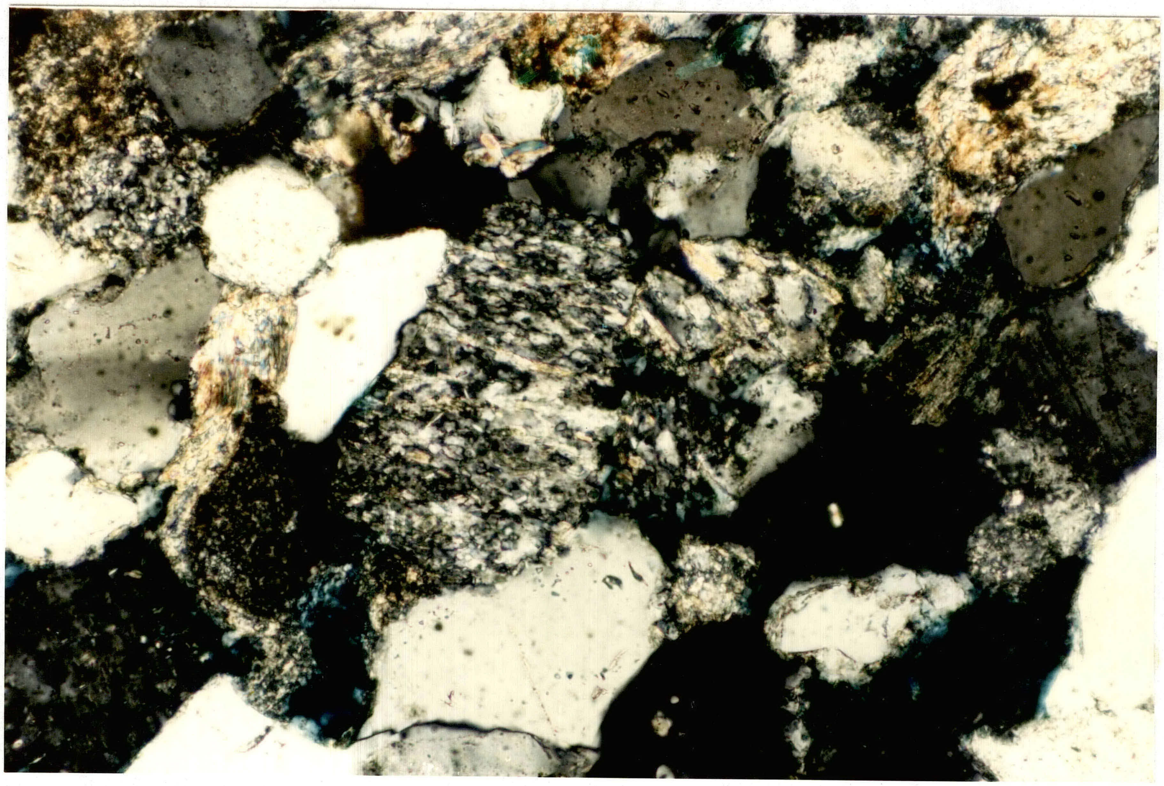

Figure 39. Metamorphic rock fragments in the upper Red Fork sandstone. W. C. P. Leslie No. 1. Depth, 9441 feet (Crossed Nicols) (X200).

mineral documented in this study. Presence of detrital matrix (4% to 7%) was observed in thin sections. Mechanical compaction of the shale clasts has resulted in their plastic flowage between framework grains creating pseudo matrix (Figure 40).

Illite is the dominant detrital clay in the upper Red Fork. Shale clasts present in the sandstone are illitic in composition. Minor amounts of detrital chlorite are also present.

The detrital constituent data was normalized and plotted on QRF sandstone classification diagram (Folk, 1968). The majority of the samples plotted in the sublitharenite corner (Figures 41).

Diagenetic Constituents

The upper Red Fork sandstones have undergone complex diagenetic processes such as compaction, cementation, dissolution, and replacement. Above mentioned processes in some instances have reduced and occluded pore space. However, not all diagenetic events were damaging to the reservoir quality; dissolution of chemically unstable grains has generated secondary porosity.

The diagenetic constituents documented in the upper Red Fork sandstone include authigenic clays, silica, and carbonate. Such materials precipitated from interstitial water whose chemical composition varied depending on the pressure and temperature conditions and the composition of the sandstone. Diagenetic clays along with the detrital clays play a significant role in cementation and porosity and permeability modification. Illite, chlorite and kaolinite are the authigenic clays (3% to 5%) present. The former two varieties are dominant over the latter variety. Illite is generally observed as grain coatings whereas

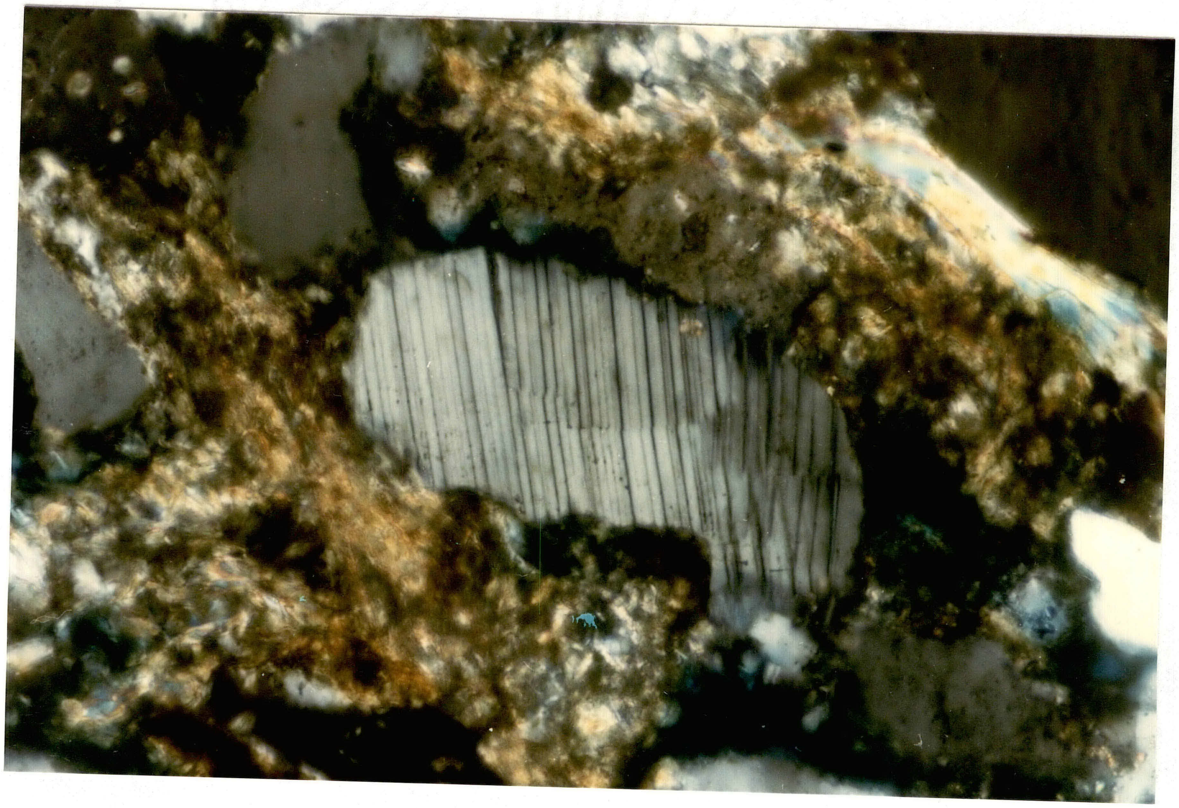

Figure 40. Pseudo-matrix and distorted plagioclase feldspar grain in the upper Red Fork sandstone, ARCO, A. M. K. No. 3, Depth, 9422 feet (Crossed Nicols) (X400).

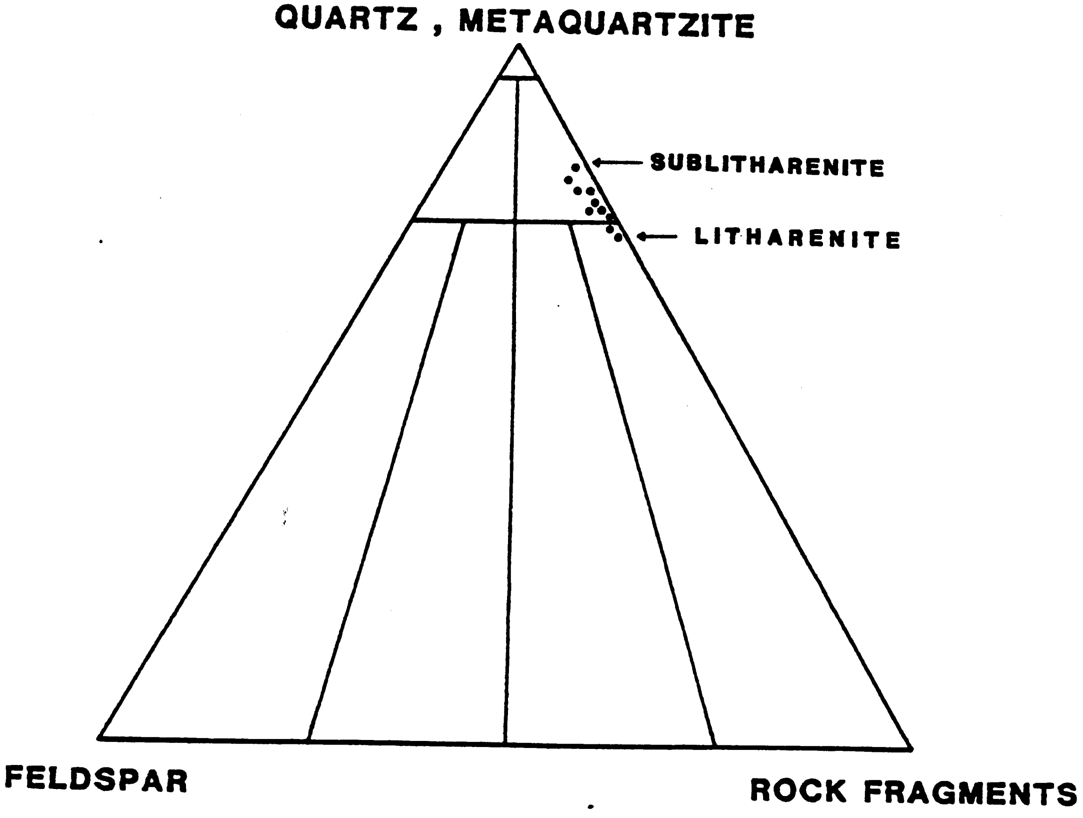

Figure 41. Ternary diagram (QRF) depicting the mineralogic composition of the upper Red Fork sandstone in the ten cores studied (Classification of Folk, 1968).

chlorite is observed as pore linings, pore bridges and grain coatings (Figure 42). Kaolinite books are found as pore filling (Figure 43). Authigenic clays identified in thin sections were confirmed through x-ray analysis and SEM/EDXA methods. Figures 44, 45, 46 and 47 show the various authigenic clays present.

Authigenic clays along with derital clays play a significant role in cementation and porosity and permeability modification. Grain coating illite is likely to increase the diameter of the grain. This would result in decrease in the size of the pore aperture in the case of intergranular porosity. Illite laths projecting into the pore space would reduce the permeability. Pore lining chlorite would not only reduce the size of the pore throats but also would reduce the permeability. Pore filling kaolinite is known to plug the pore space which would hinder the migration of oil and gas into the reservoir rock.

Authigenic silica occurs in most of the samples as syntaxial quartz overgrowths (Figure 48). Authigenic silica cement averages about 1% to 1.5%. In some instances syntaxial quartz overgrowths can be identified in thin sections by the presence of "dust rims" of clay around the detrital quartz grains (Figure 48). Silica cemented sandstone samples from the base of the channel have low porosity values.

Carbonate cement, on the average, is insignificant as an authigenic constituent in the upper Red Fork sandstone (1%). Calcite cement is observed in a significant quantity in sandstone samples from locations near to the shale bed. Carbonate cement observed is mostly sparry and patchy calcite (Figure 49). Sandstone samples from locations near to the shale beds show the development of poikilotopic texture (Figure 50). This development of calcite cement at these locations is thought to be

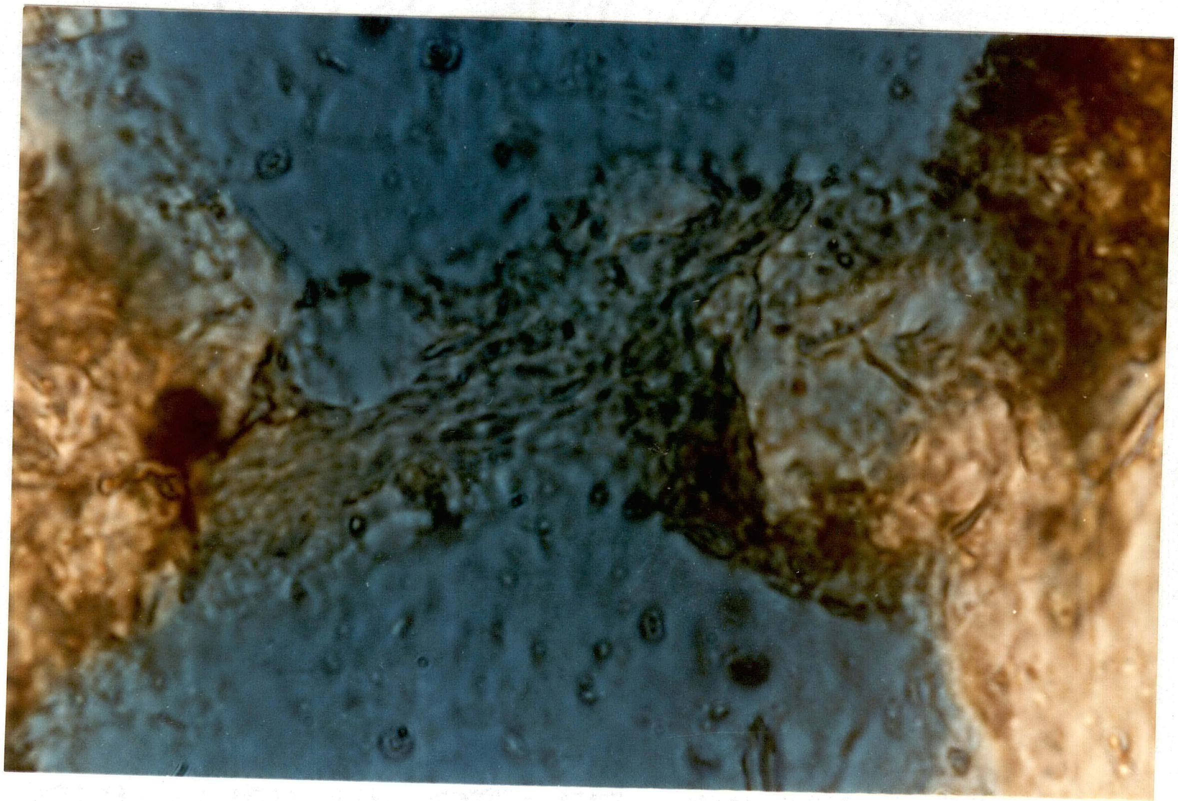

Figure 42. Pore-bridging and pore-lining authigenic chlorite in the upper Red Fork. ARCO, Presley No. 2. Depth 9324 feet (Crossed Nicols) (X1000).

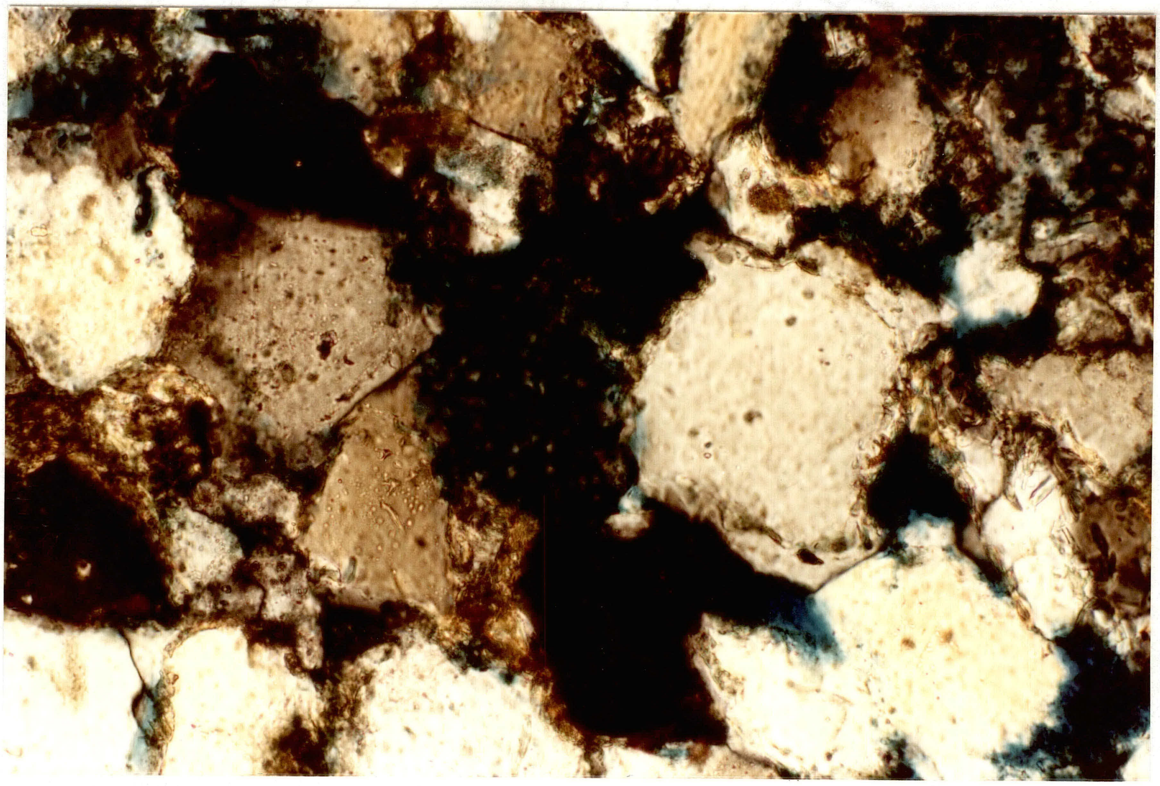

Figure 43. Pore-filling kaolinite in the upper Red Fork. ARCO, Presley No. 2. Depth 9330 feet (Crossed Nicols) (X400).

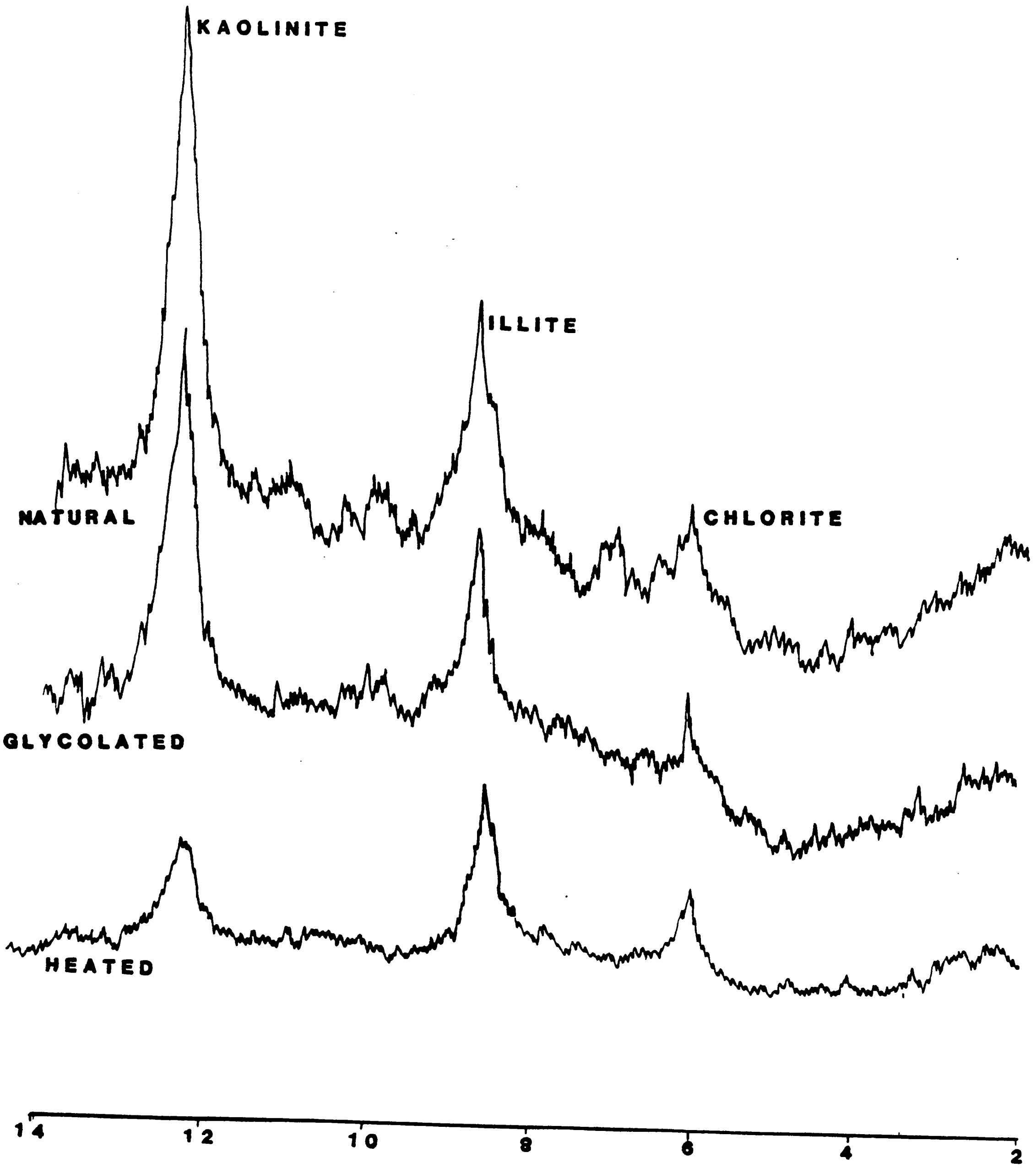

Figure 44. X-ray diffractogram of clay fractions (>29µm) in the upper Red Fork.

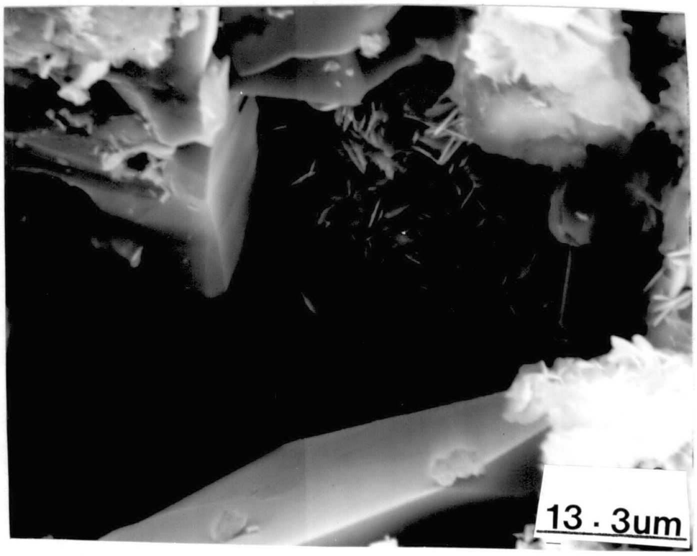

Figure 45. Pore-filling authigenic chlorite in upper Red Fork sandstone, ARCO, A. M. Kunc, No. 3. Depth, 9422 feet, porosity 8%.

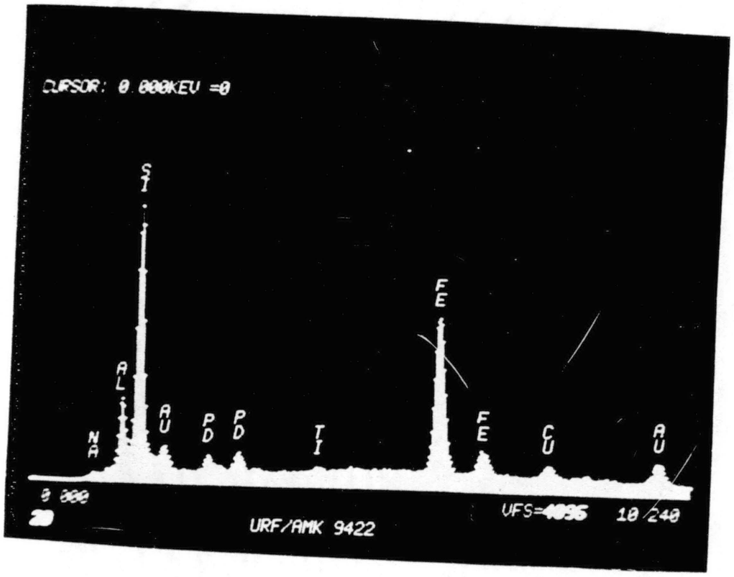

Figure 46. EDAX analysis showing the relative chemical composition of chlorite in Figure 45. Magnification IX, EDAX

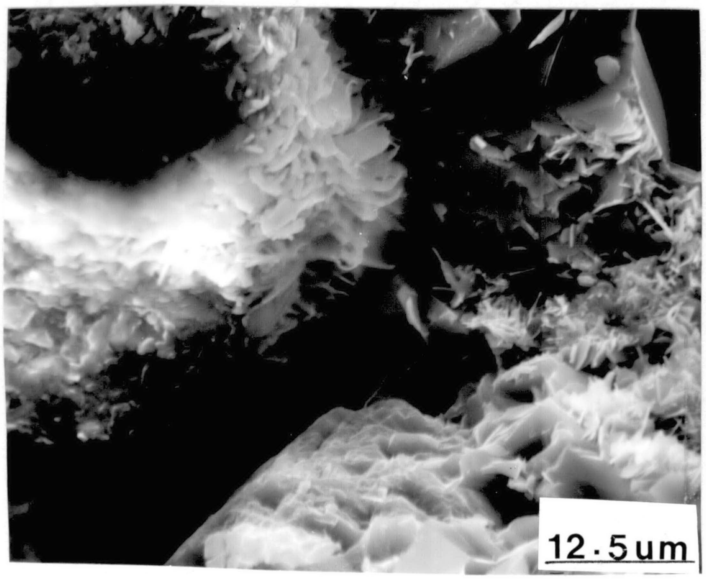

Figure 47. Authigenic chlorite and illite in upper Red Fork sandstone, ARCO, Presley No. 2. Depth, 9342 feet, porosity 15%.

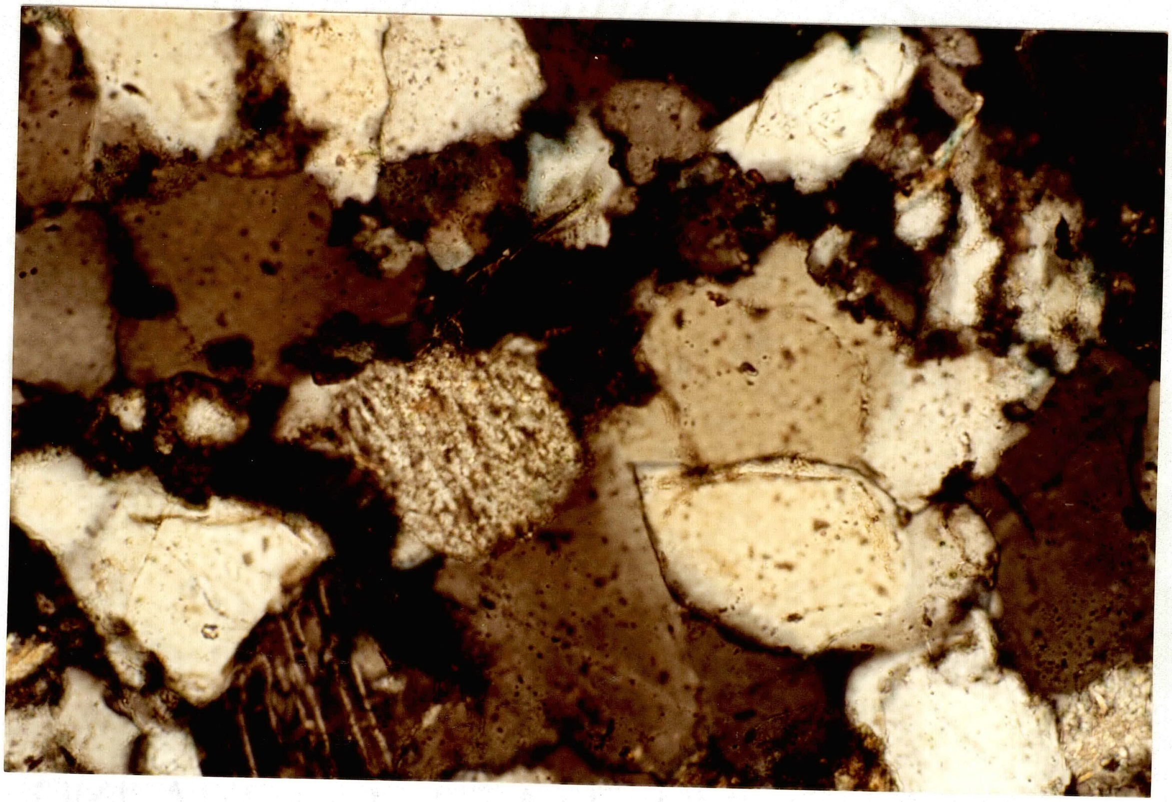

Figure 48. Authigenic silica overgrowth on detrital quartz grain in upper Red Fork. Note the clay rim around the quartz grain. ARCO, A. M. K. No. 3. Depth, 9435' (Crossed Nicols) (X200).

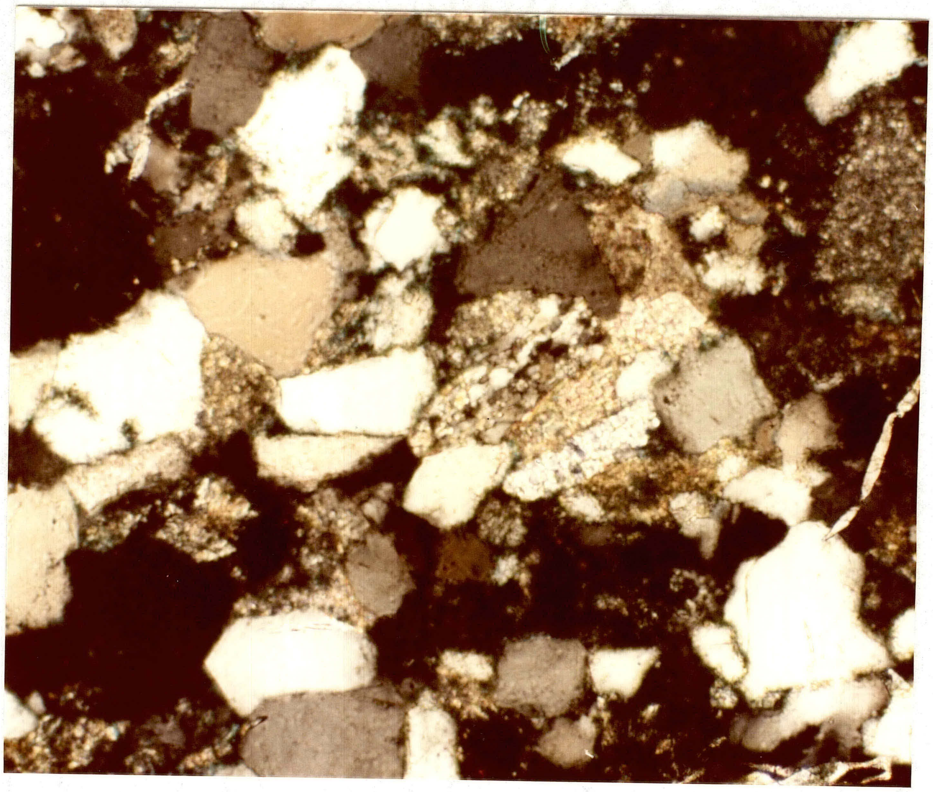

Figure 49. Calcite cemented upper Red Fork sandstone. Wessely Clark No. 1. Depth, 9538 feet, porosity 9% (Crossed Nicols) (X100).

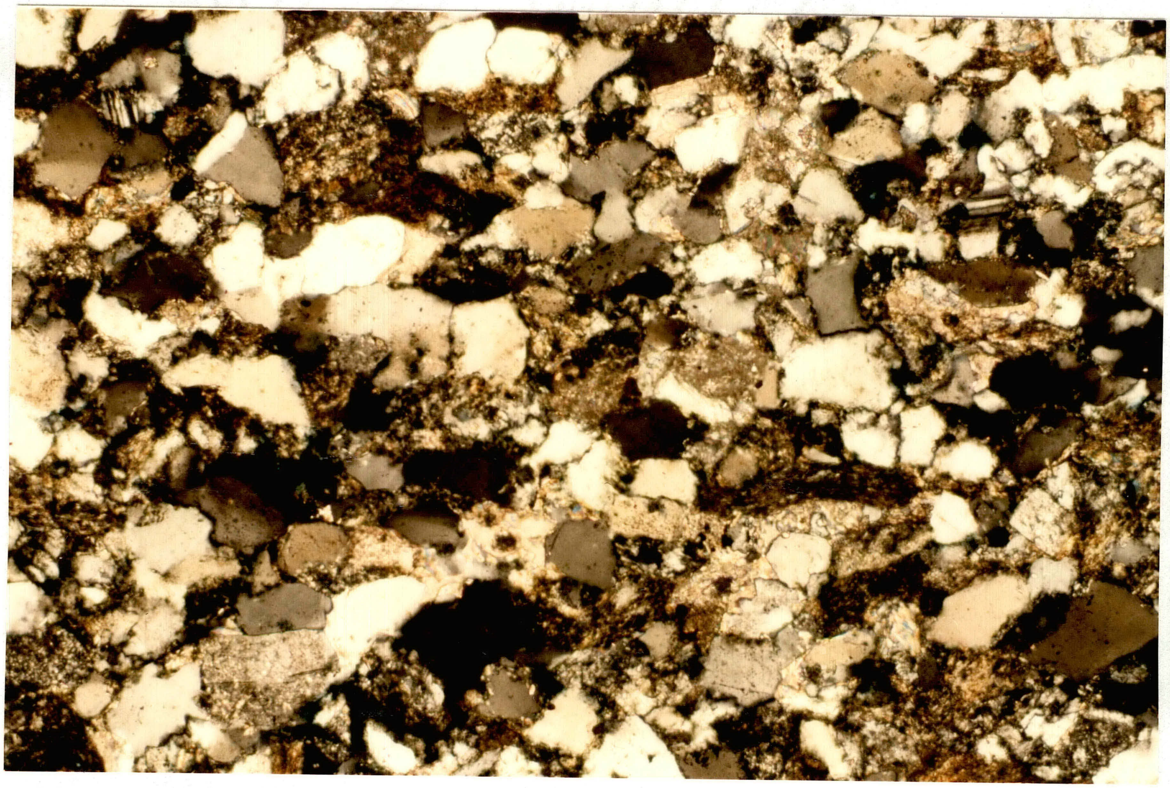

Figure 50. Development of poikilotopic texture in upper Red Fork sandstone. ARCO, Presley No. 2, 9307 feet, porosity 3% (Crossed Nicols) (X200).

due to dewatering of shale. Minute siderite rhombs were documented in the cement in a few samples.

Porosity

Thin section studies reveal that porosity in the upper Red Fork is mainly secondary. Maximum secondary porosity value obtained by the thin section point count is 14%. Intergranular type primary porosity is present but is relatively insignificant (Figure 51). Secondary pores are mainly of a dissolution type. Dissolution of chemically unstable constituents such as feldspars and metamorphic rock fragments is a common feature (Figure 52). Matrix leaching has resulted in elongate pores parallel to the bedding (Figure 53). Oversized pores, honeycombed grains, and elongate pores were documented during thin section study.

In the W. C. Pickens Leslie No. 1 and Presley No. 2 cores (Appendix A) petrographic study revealed the decreasing porosity trend within the sandstone section from the bottom to the top. Decrease in porosity is related to the grain size variation. Near the bottom of the sandstone section, grains are larger, and a relatively larger amount of porosity is present. Grain size is found to decrease towards the top of the sandstone section in the Leslie No. 1 core (Figures 35 and 36). Near the upper part silt and clay size grains are present in the sandstone. Sandstone is less porous at this location. Porosity variation in the sandstone section related to grain size variation and variation in log signature pattern were also considered in the interpretation of depositional environment. Based on petrographic and other evidences mentioned in the previous chapters it is inferred that the upper Red Fork sandstone was deposited in a channel environment.

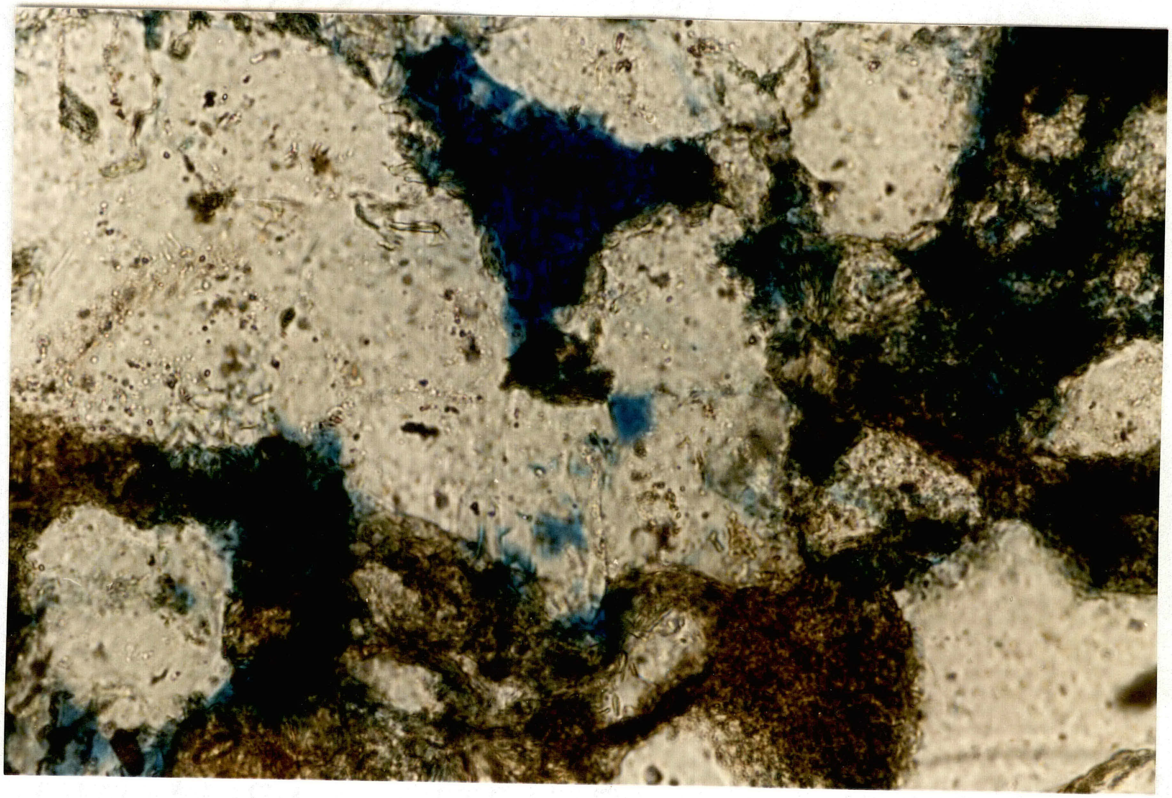

Figure 51. Intergranular porosity in upper Red Fork sandstone. ARCO, A. M. Kunc No. 3. Depth, 9419 feet (Crossed Nicols) (X400).

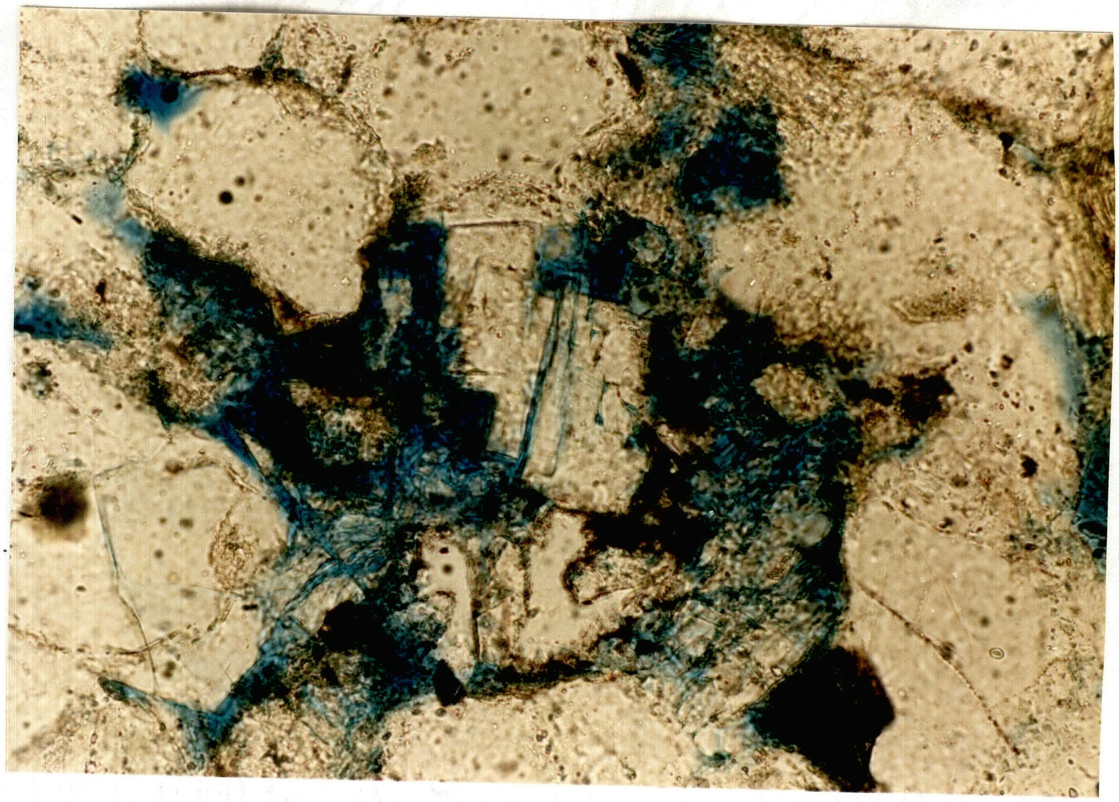

Figure 52. Partially dissolved feldspar in the upper Red Fork sandstone. ARCO, P. R. No. 2. Depth 9324 feet (Crossed Nicols) (X400).

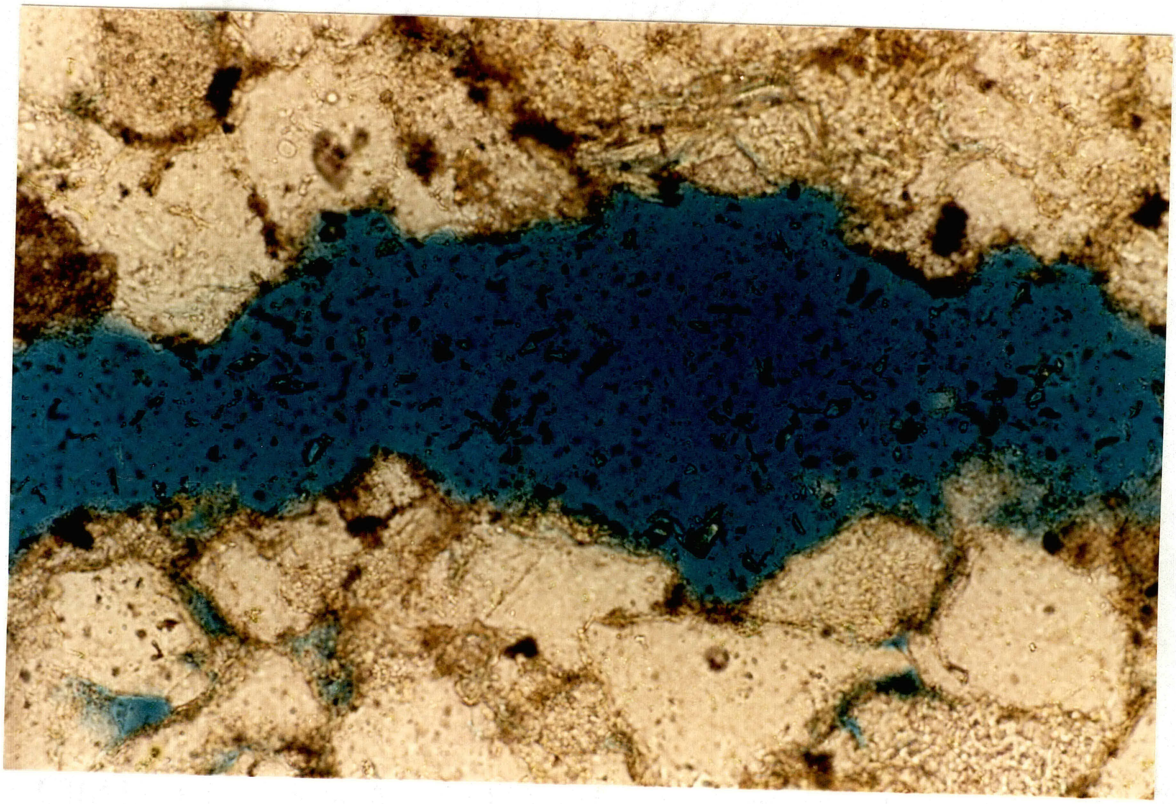

Figure 53. Secondary porosity (elongate pore) due to matrix leaching in upper Red Fork sandstone. W. C. P. Leslie No. 1. Depth 9487 feet (Crossed Nicols) (X200).

Paragenesis

The upper Red Fork sandstone has undergone eodiagenetic and mesodiagenetic processes. With the burial of the upper Red Fork sediments eodiagenetic (diagenetic regime nearer to the surface of the earth) processes were initiated. During this stage due to compaction of the sediments pseudo-matrix was created. Feldspars and metamorphic rock fragments underwent alteration during this stage. With the increase in the overburden pressure due to deeper burial it is probable that quartz grains were dissolved and the resulting silica precipitated at points of low pressure creating silica cement in the form of syntaxial quartz overgrowths. During the mesodiagenetic stage (subsurface regime during effective burial) generation of secondary porosity had taken place by the dissolution of feldspar, rock fragments and matrix. Insignificant amounts of secondary porosity had been generated by the dissolution of quartz grains. Patchy calcite cement present in the sandstone filling the secondary pores is indicative of the development of calcite cement after the generation of secondary porosity. Diagenetic clays present in the sandstone are Illite, Chlorite and Kaolinite. Crystallanity of these clays are preserved indicating their devlopment during the late mesodiagenetic stage. Oil and gas were generated during the mesodiagenetic stage by the thermal maturation of the shales in the Red Fork interval that are rich in organic matter. A minor amount of pyrite present in the sandstone is probably a product of chemical processes involving hydrogen sulfide. Primary porosity which is a syndepositional feature, though not totally destroyed, had been reduced to insignificant quantity in regards to the total porosity of the sandstone. Figure 54 depicts the paragenetic sequence and timing of the events (as explained above). The paragenetic sequence was determined by the study of cross cutting relationships of grains in thin sections.

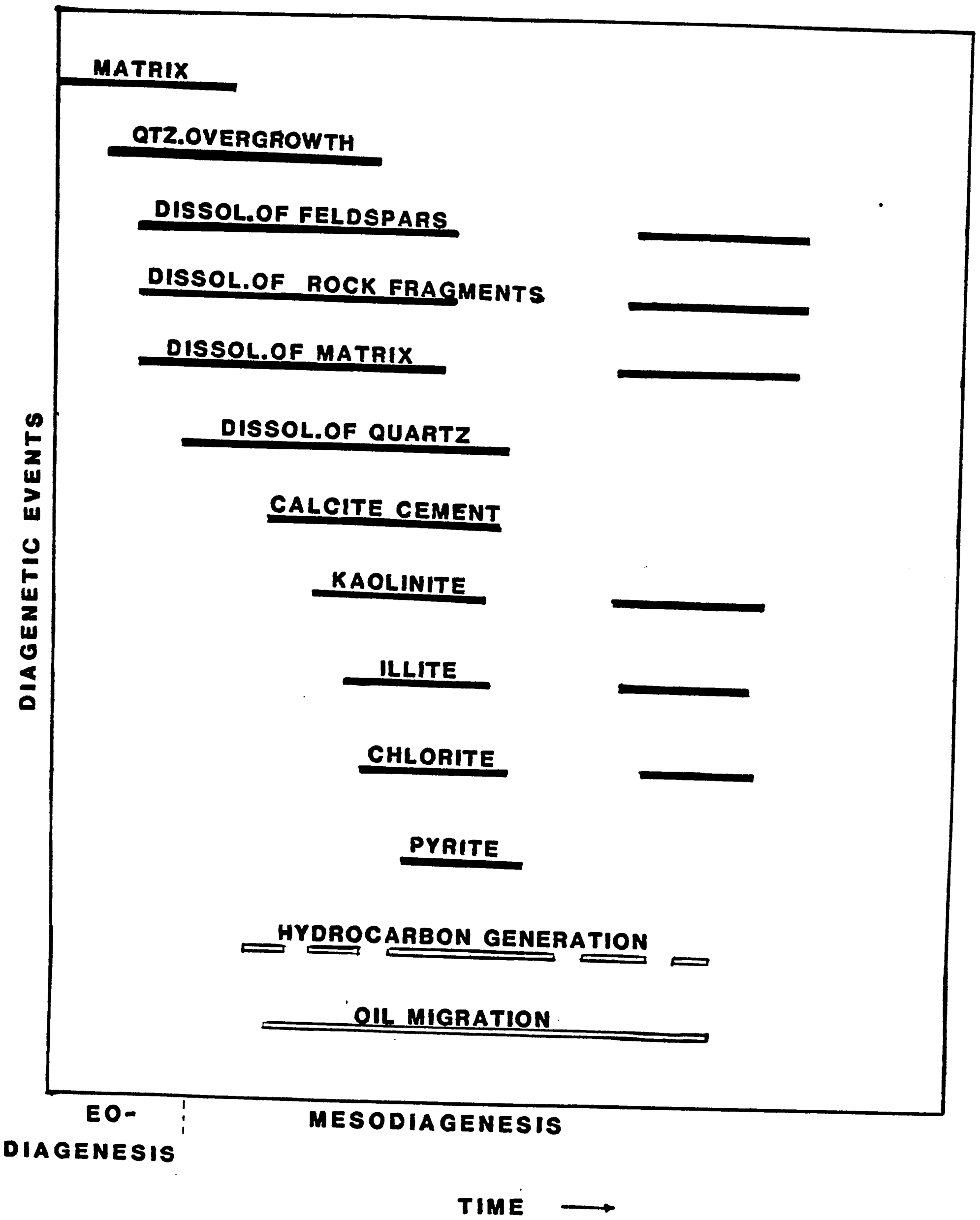

Figure 54. Paragenetic sequence of the upper Red Fork sandstone.

CHAPTER IX

PETROLEUM GEOLOGY

Four oil and gas fields are located within the study area. The Putnam Field (T.17N. and T.18N.; R.16W. through R.18W.), the South Trail Field (T.17N., R.20W.), the Northwest Hucmac Field (T.18N., R.15W., and R.16W. sections in the northwest and northeast parts of the two townships), and the North Camargo Field (T18N, R20W). Figure 55 is the map of the four oil and gas fields in the study area.

Petroleum was discovered in the area of study in the Red Fork sandstone in November, 1962. The first productive well was the Flagg Unit, C.SW.NE, Section 16, T.18N., R.18W. The discovery was in 22 feet of the upper Red Fork sandstone at a depth of 9242 feet. This well had produced through June, 1983.

Total production figures from the Red Fork wells located in the four fields in the area of study are given in Table I (location of fields shown in Figure 55). Most of the production in the area is from the Putnam Field. More than 2,265,162 barrels of oil and 73,985 million cubic feet of gas have been produced. At present, approximately 95 wells produce oil and gas from the Red Fork in the area of study.

The boundary of the Putnam Field (Figure 55) defines the channel course in the area. The upper Red Fork sandstone is the reservoir rock in the study area. The presence of thick sandstone in the lower Red Fork interval is confined to a few narrow regions in T.17N., R.16W. and

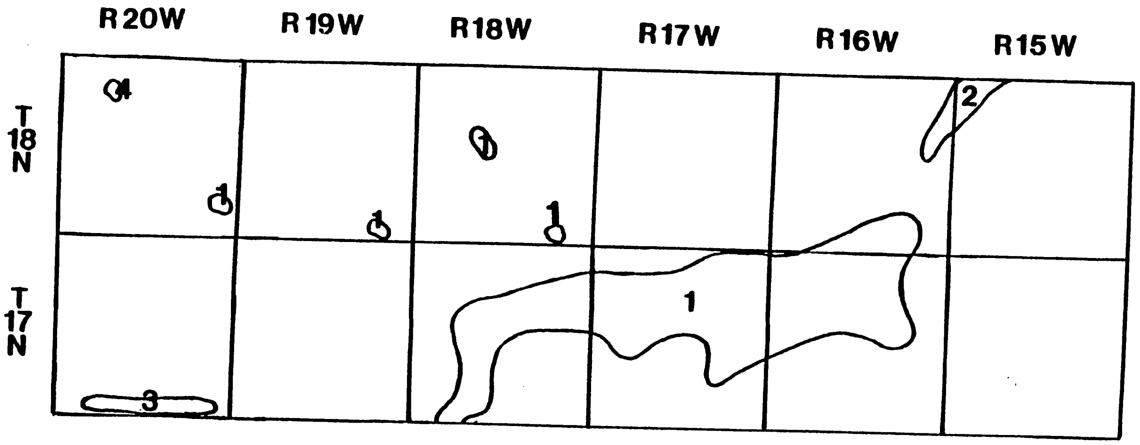

Figure 55. Map showing locations of Fields Numbered 1-4

1. Putnam Field
2. North West Hucmac Field
3. South Trail Field
4. North Camargo Field

T.18N., R.16W. (Plate IV). The core Joe N. Champlin Stidham No. 1A (Appendix A) consists of the lower Red Fork. Presence of reservoir quality sandstone (porosity 10%) in the lower Red Fork at this well location is notable. Joe N. Champlin Stidham No. 1 initially produced 311 barrels of oil and 861,000 cubic feet of gas per day.

Traps in Red Fork reservoirs are stratigraphic. With the reservoir sandstone encased in impermeable shale, the lenticular and gradational boundaries of the sandstone, in conjunction with the post depositional dip, has created the trapping mechanism. Paleotopography is thought to have influenced the channel course which has resulted in the deposition of sand in the topographic lows in the Putnam Field (T.17N., R.17W., and R.18W.).

The source of oil for the Pennsylvanian sandstone on the Northern Shelf has been suggested to be the enclosing Cherokee shales (Hatch and Levenhall, 1982; Mason, 1982; Robertson, 1983). Abundant organic matter is observable in the shales in the cores. In light of this fact it is thought that the enclosing shales were the source rocks for the oil and gas production from the Red Fork.

From an exploration point of view the upper Red Fork sandstone provides a more promising target for oil production than the lower Red Fork sandstone. Thick channel fill sandstones are the most promising exploration targets and are the most prolific producers in the Putnam Field. Crevasse splay sediments are not as promising a target because of their silt and shale content, but they may be productive where the sands are thicker than 30 feet. Levee type deposits (overbank environment) are poor exploration targets in the area because of their high silt and clay content.

CHAPTER X

CONCLUSIONS

The principal conclusions of this study are:

1. The Red Fork interval may be divided into two genetic units, the upper Red Fork and the lower Red Fork based on the presence of a calcareous sandstone marker bed between the two units.
2. The calcareous sandstone marker bed underlying the upper Red Fork interval is interpreted as deposited during a minor transgressive episode.
3. Strike and dip cross sections indicate that the thickness of the Red Fork interval remains more or less consistent. This fact suggests that the study area was part of the paleoshelf.
4. Linear pattern of the sandstone bodies in the net sandstone isolith maps (Plates III and IV), their orientation at large angles to the structural-depositional strike of the Anadarko basin and the sedimentary structures, textures and composition are suggestive of a deltaic distributary channel depositional setting of the Red Fork sandstone.
5. Diagenetic processes have destroyed the primary porosity in the Red Fork sandstones and have generated secondary porosity. Dissolution type secondary porosity is very common. Diagenetic processes have proceeded to the mesodiagenetic stage.

6. Illite and chlorite are the common clays in the Red Fork sandstone (both detrital and authigenic). Illite is dominant. Pore filling kaolinite is present in an insignificant quanity.
7. Presence of illitic shale clasts and matrix material along with authigenic illite in the Red Fork sandstone was observed to affect the gamma ray signature by way of a large API unit reading.
8. The primary trapping mechanism in the Red Ford sandstone is stratigraphic with some slight structural influence.

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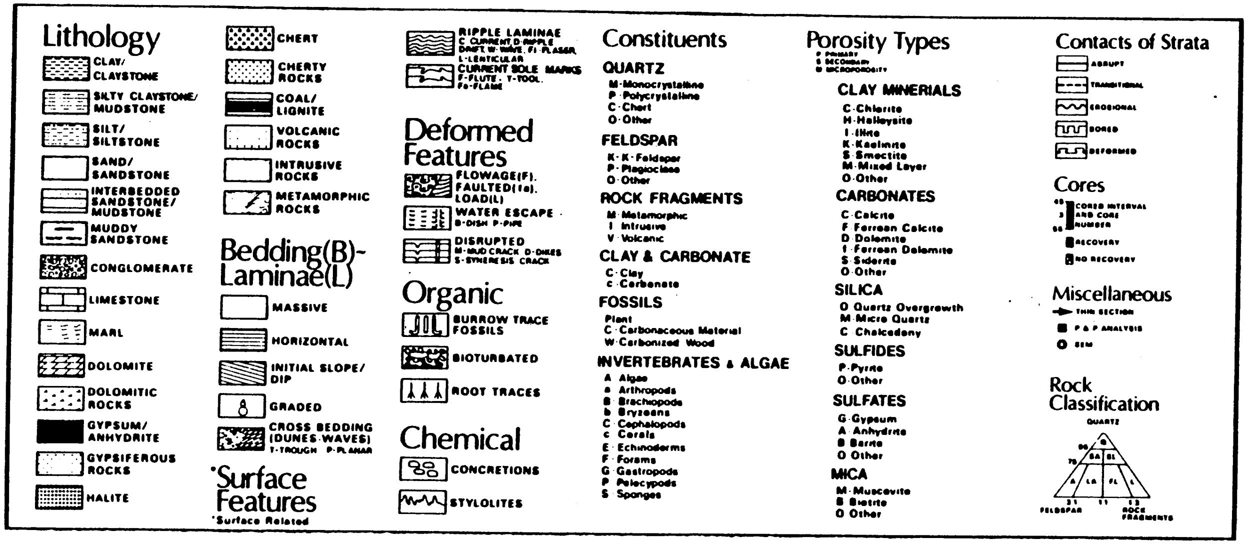
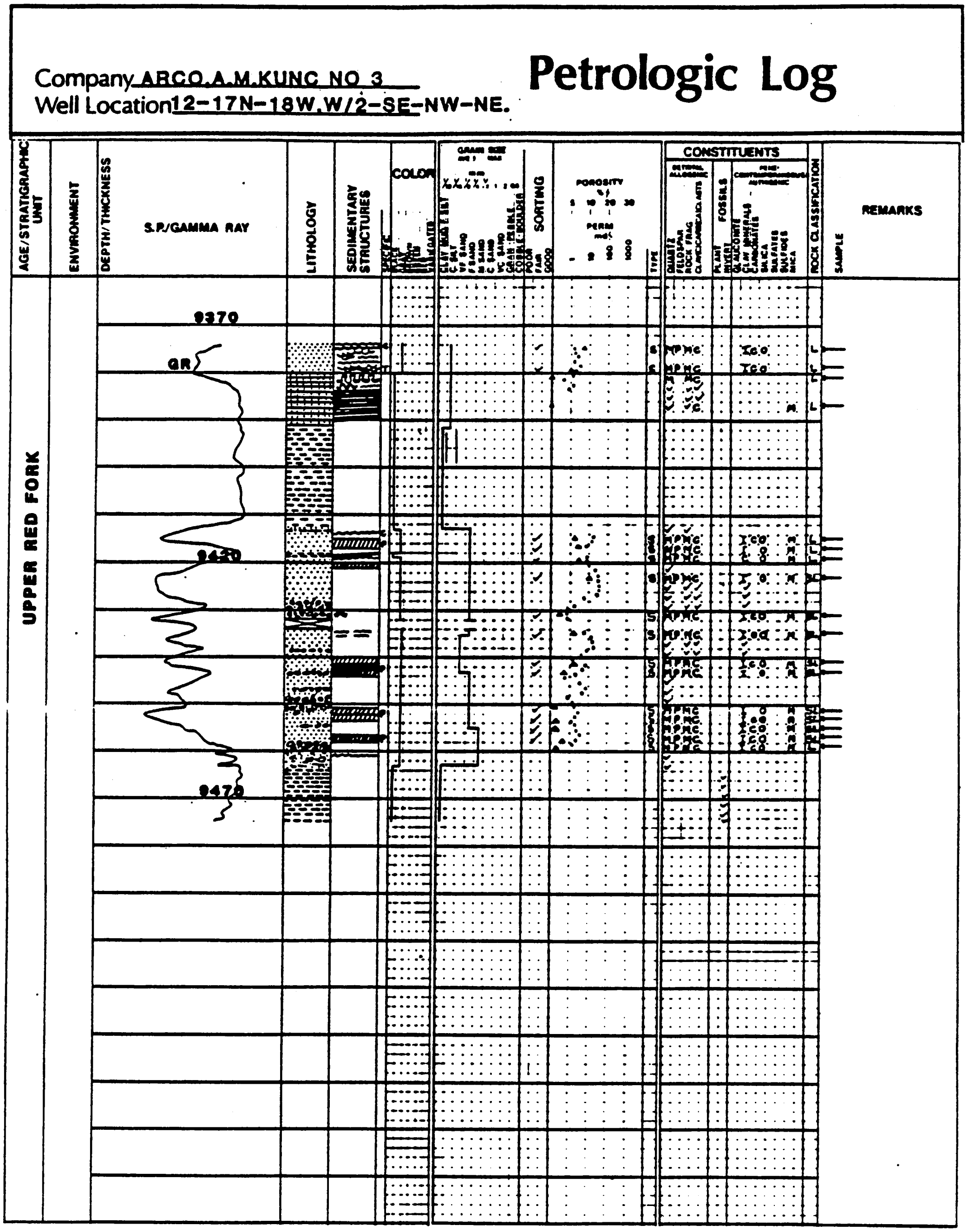
APPENDIX A

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, Fl-FLASER, L-LENTICULAR
CURRENT SOLE MARKS F-FLUTE, T-TOOL, Fe-FLAME
Deformed Features
FLOWAGE(F), FAULTED(fa), LOAD(L)
WATER ESCAPE B-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
Q
95
75
SA
SL
A
LA
FL
L
3 1
1 1
1 3
FELDSPAR
ROCK FRAGMENTS



Petrologic Log

Company ARCO A.M.KUNC NO 3

Well Location 12-17N-18W,W/2-SE-NW-NE.

Well: ARCO, Anton M. Kunc Unit No. 3

Location: Sec. 12-T.17N.-R.18W.; W1/2-SE-NW-NE

Depth: 9374'-9475'

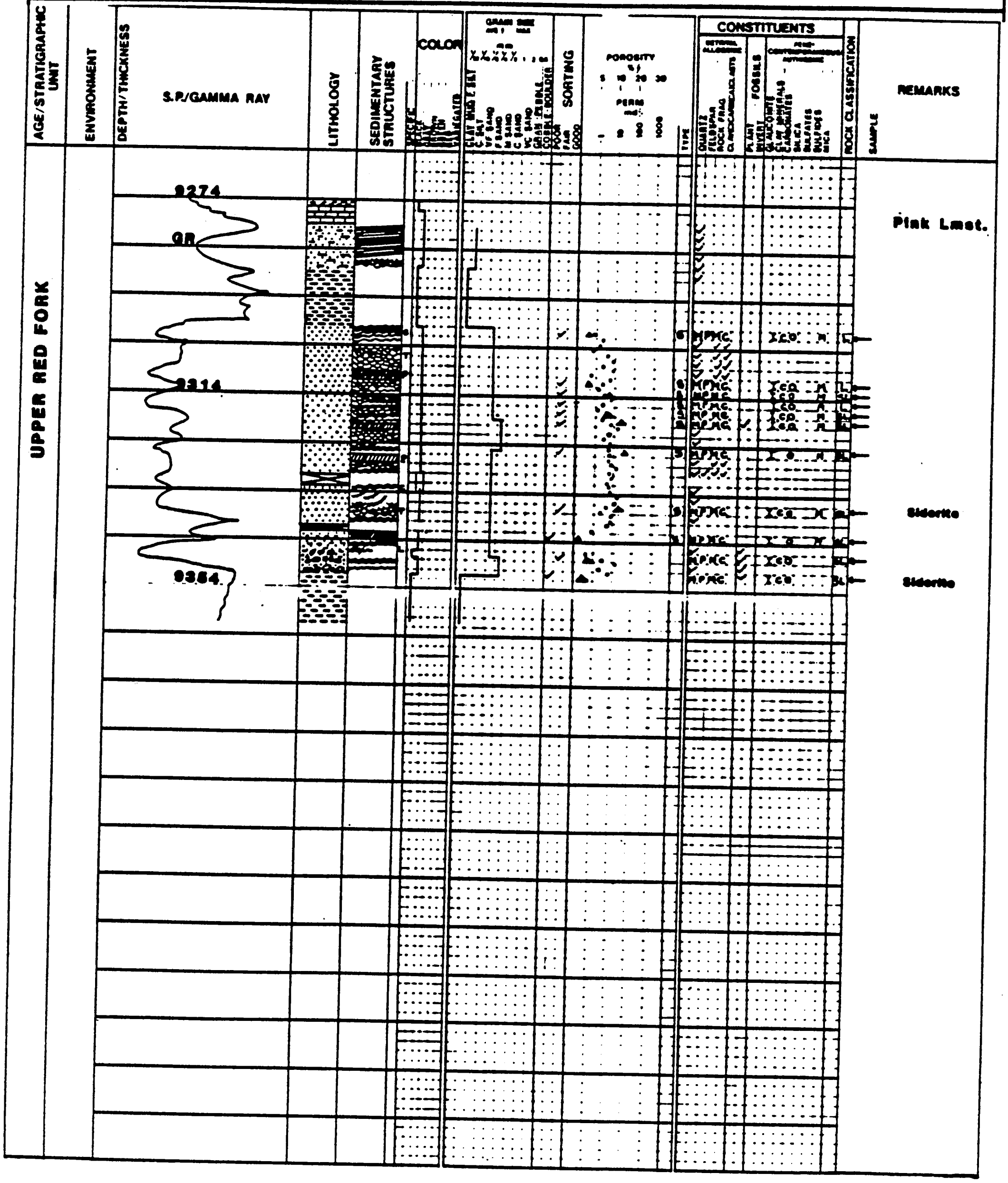
Stratigraphic Interval: Upper Red Fork

The cored interval consists of shale, sandstone, shale, siltstone and sandstone beds in ascending order. The lowermost zone from 9464 feet to 9475 feet comprises of dark colored shale bed rich in organic matter. Organic matter is identified as plant derived. Shallow marine fossils are found in this zone. At some locations the shale is found to be rich in calcareous matter. Shale bed is thought to be pro-deltaic in origin. Overlying the shale, the zone from 9414 feet to 9464 feet consists of fine grained sandstone section. Channel base conglomerates, planar cross bedding, ripple laminae and soft sediment deformation are the sedimentological features displayed by the sandstone section. More than one zone of rip up clasts were recorded which is indicative of multistoried nature of the sands. The contact between sand section and the shale bed below (9464'-9475') is erosive one (indicated by the presence of rip up clasts). The sandstone zone is interpreted as channel fill deposit.

The zone from 9380 feet to 9414 feet consists of shale and interbedded sandstone and shale sequence. Burrows filled with pyritized organic matter is common in the shale bed. The upper 1 feet interval of this zone (9380' to 9391') comprises of siltstone which displays horizontal laminae, soft sediment deformation features and burrows. The shale and interbedded sand and shale are interpreted as interdistributary bay in origin. The interval from 9374' to 9380' consists of fine grained sandstone which shows ripple laminae and trough cross bedding features. The sandstone section is probably levee deposit.

Company ARCO,PRESLEY NO 2
Well Location 7-17N-17W,N/2-SW-NW-SE.

Petrologic Log



Well: ARCO, Presley No. 2

Location: Sec. 7-T.17N.-R.17W.; N/2-SW-NW-SE

Depth: 9274'-9361'

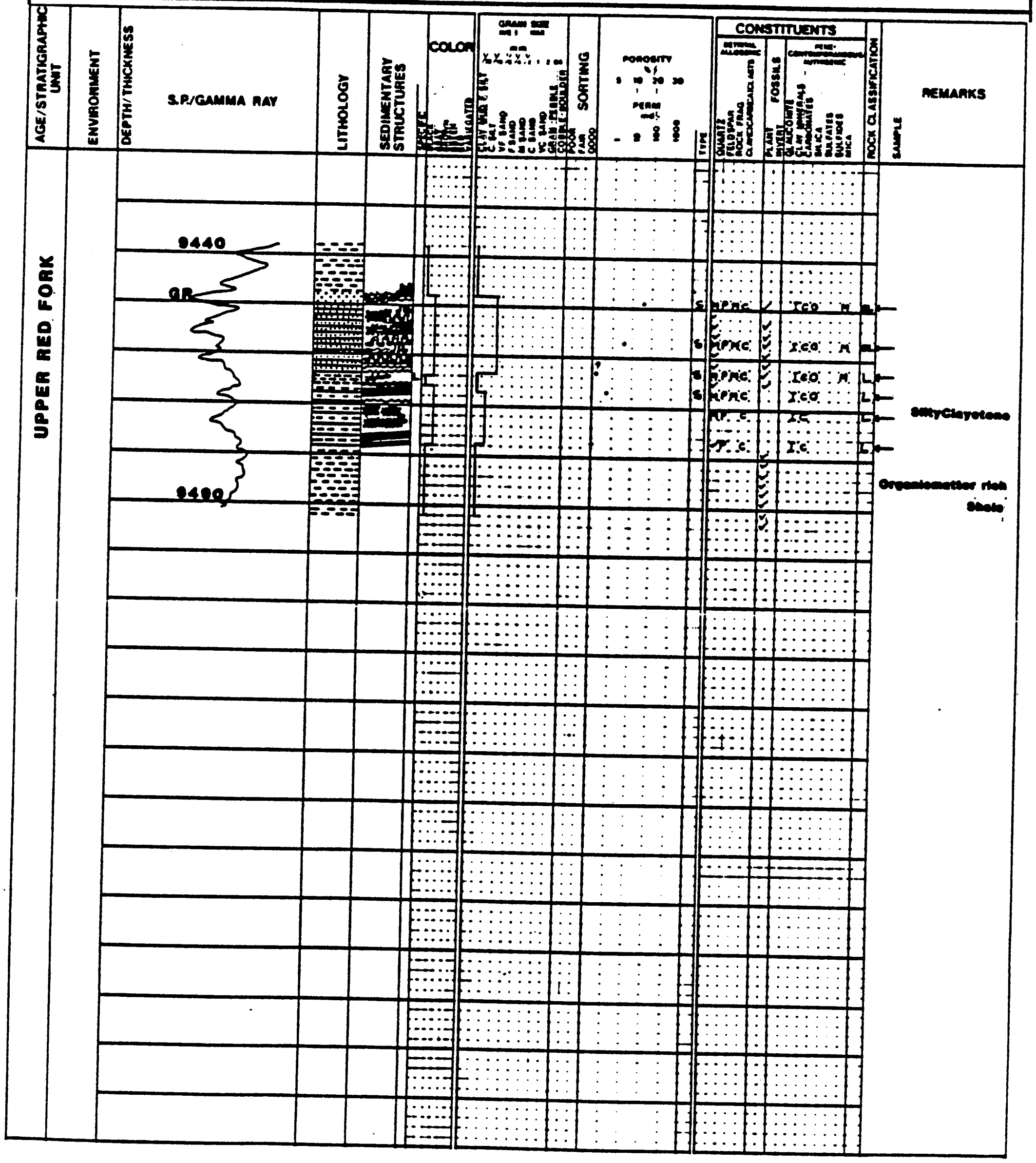
Stratigraphic Interval: Upper Red Fork

The cored interval consists of shale, sandstone, shale and Pink limestone sections. The lower most zone from 9350'-9361; comprises of dark shale bed. The interval from 9300'-9350' consists of sandstone which displays channel lag features (rip up clasts), trough cross bedding, planar cross bedding, climbing ripples, tabular cross bedding and ripple laminae. The contact between the sandstone and shale unit below is sharp and is marked by the channel lag features. The shale is thought to be pro-deltaic in origin and the sandstone is channel fill deposit. Sandstone is fine grained. Overlying the sandstone, the zone from 9295' to 9300' consists of shale bed containing pyritized wood fragments. The interval from 9279' to 9290' consists of muddy sandstone which exhibits inclined laminae and cross-stratification. The shale and muddy sandstone are interpreted as delta plain in origin. The uppermost zone from 9274' to 9279' consists of limestone and shale.

Overall, the sandstone section of the core shows fining upward sequence.

Company ARCO,PEARL KUNC UNIT A NO 2
Well Location 7-17N-17W,NE-SW-NW-NW.

Petrologic Log



Well: ARCO, Pearl Kunc Unit A No. 2

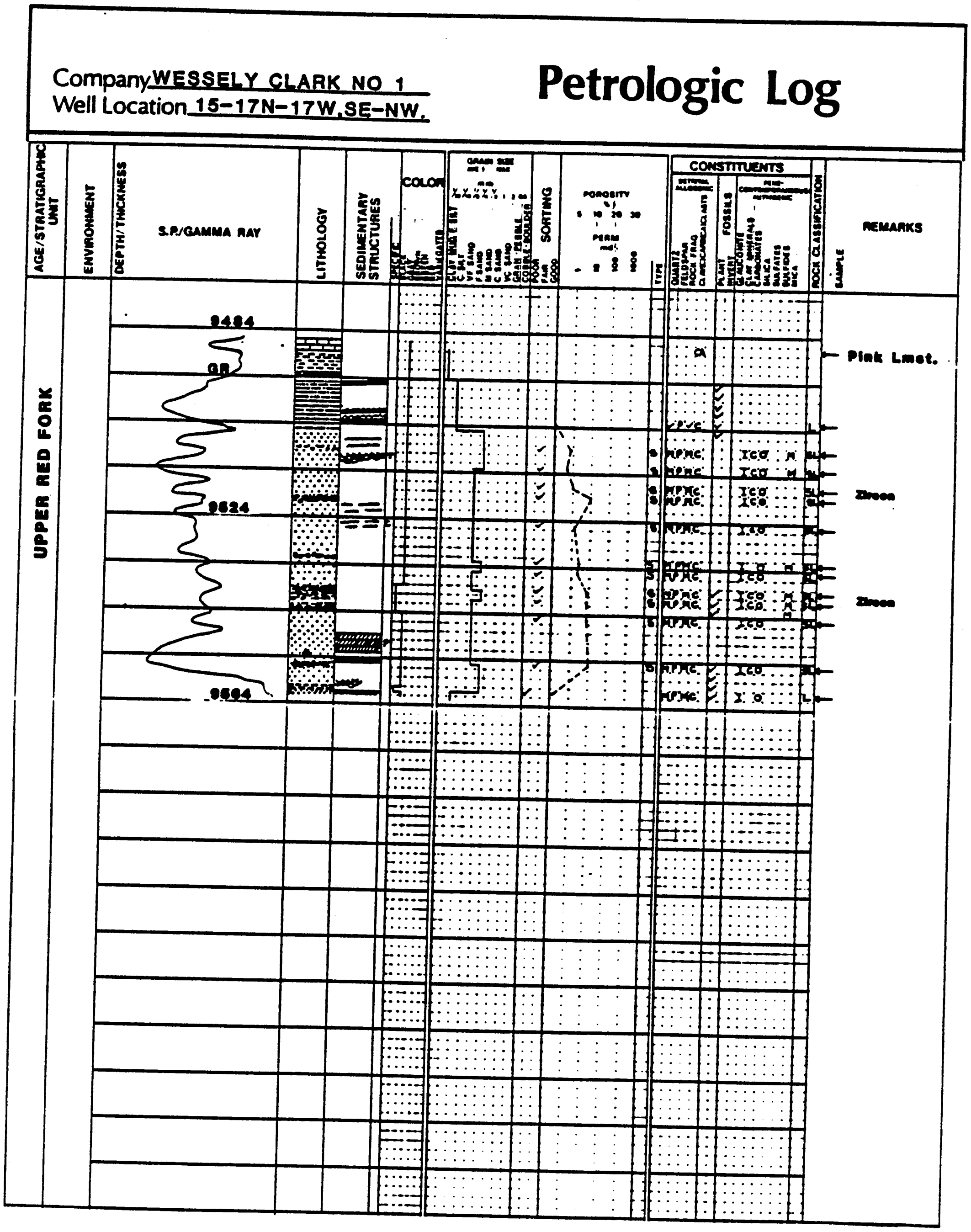
Location: Sec. 7-T.17N.-R.17W.; NE-SW-NW-NW

Depth: 9438.5'-9492'

Stratigraphic Interval: Upper Red Fork

The cored interval comprises of dark shale beds, mudstone and interbedded sand and shale. The interval from 9492' to 9478' consists of dark colored shale bed. These shale beds are rich in carbonaceous plant matter. Overlying the shale beds, the zone from 9478 feet to 9468 feet consists of massive mudstone beds. The interval from 9468 feet to 9465 feet consists of siltstone. Mudstone beds show evidence of bioturbation and burrowing. Burrows are filled with pyritized organic matter. Siltstone beds are rich in carbonaceous plant matter. Slump features are recorded in this zone. The interval from 9465' to 9450' consists of interbedded sandstone and shale which shows flowage features. This zone shows evidence of bioturbation. Carbonized plant matter is recorded in this zone. Ripple laminae and rippled surfaces were common sedimentary structures observed. About two feet of interbedded sandstone and shale but prodominantly sandstone zone is located at 9450' through 9448' interval. The sandstone beds display trough cross bedding, ripple laminae and water escape features. The interval from 9446' to 9438' comprises of shale beds.

The entire sequence is interpreted as deposited in pro-deltaic to interdistributary bay environment. The interbedded sandstone and shale were probably deposited during high flow regime by the waters overflowing the channel banks.



Company WESSELY CLARK NO 1
Well Location 15-17N-17W, SE-NW.

Petrologic Log

Well: Wessely Clark No. 1

Location: Sec. 7-T.17N.-R.17W.; SE-NW

Depth: 9486'-9572'

Stratigraphic Interval: Upper Red Fork and Pink Limestone

The cored interval consists of sandstone, interlaminated sandstone and shale, and shale. The shale bed is overlain by the Pink Limestone. The fine grained sandstone (9515'-9572') exhibits planar cross bedding, trough cross bedding, channel lag features (rip-up clasts) and ripple laminae. Carbonized plant matter and calcite cement are present in the sandstone located at the bottom of the cored interval. The upper part of this interval is muddy sandstone which is ripple laminated. The sandstone zone is thought to have been deposited by distributary channels. The presence of several zones of channel lag features is indicative of the multistoried nature of the sandstone body.

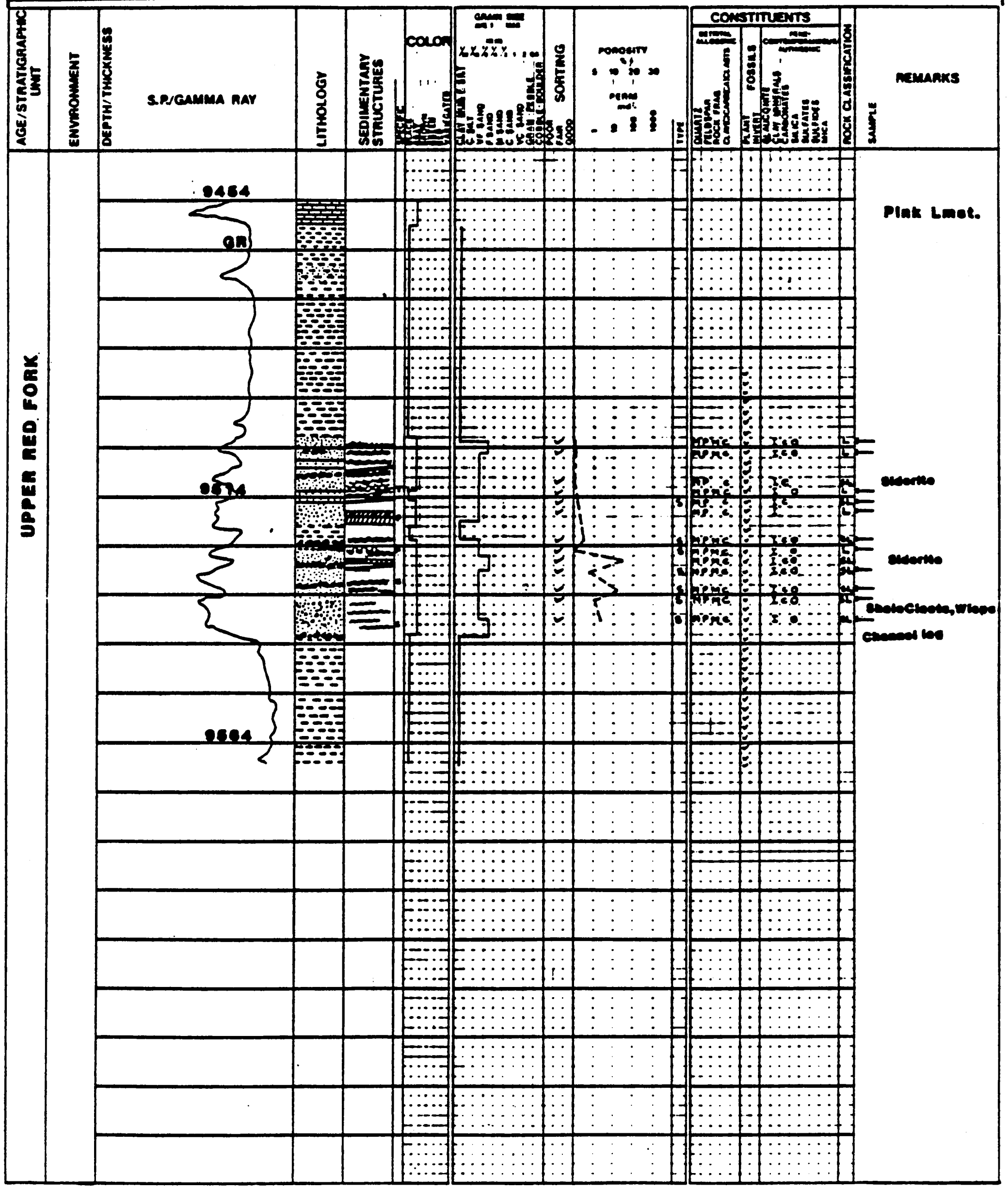
The sandstone is overlain by siltstone (9504'-9515'). This zone is interpreted as being deposited in an overbank environment (levee type deposit).

The shale bed (9488'-9504') overlying the siltstone zone is thought to be representative of delta plain facies. The interval from 9486'-9488' consists of Pink Limestone.

Company WESSELY CLARK NO 2

Well Location 15-17N-17W.W/2-NE-NW.

Petrologic Log



Well: Wessely Petroleum Clark No. 2

Location: Sec. 15-T.17N.-R.17W.; W/2-NE-NW

Depth: 9454'-9568'

Stratigraphic Interval: Upper Red Fork and Pink Limestone

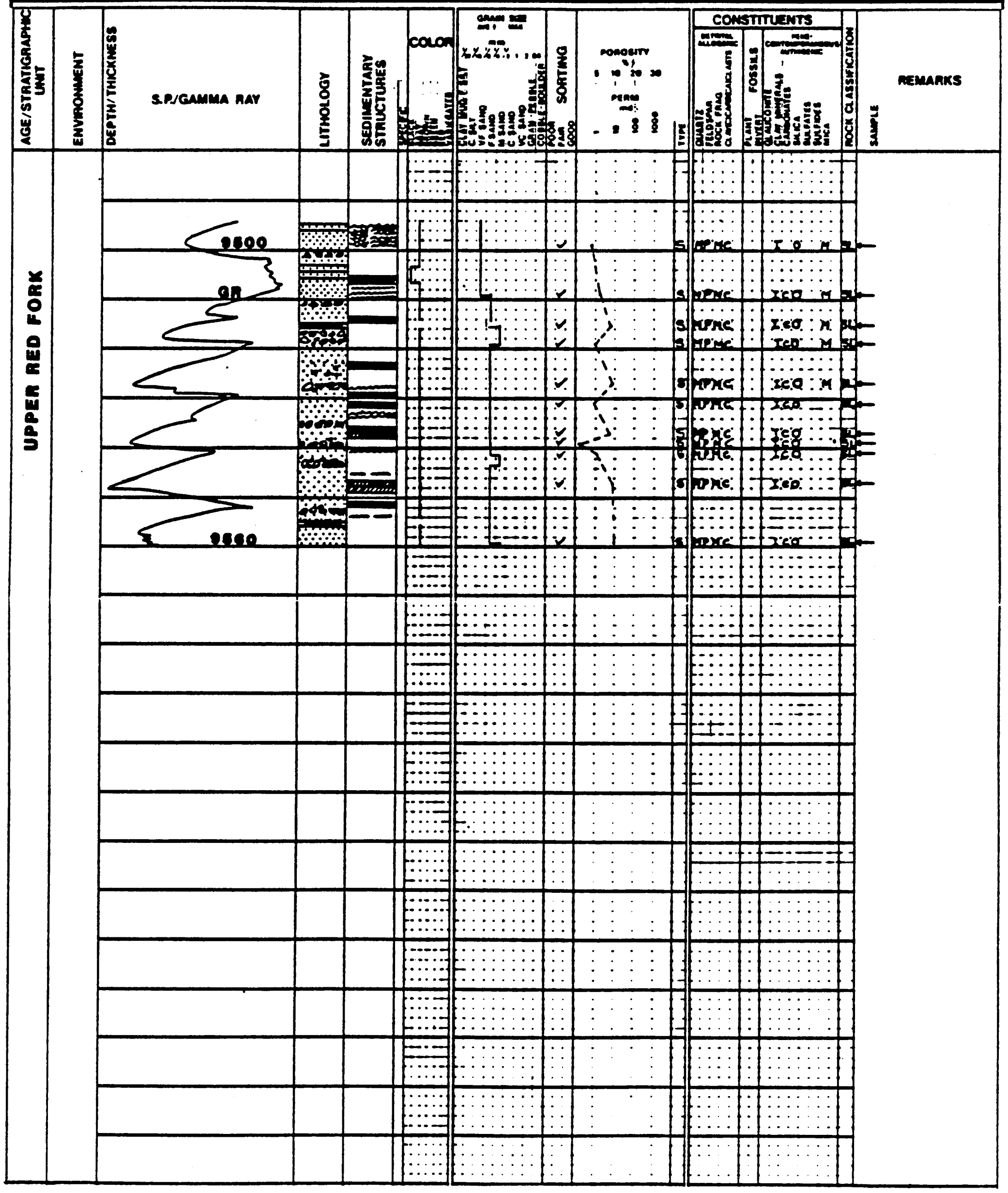
The cored interval contains two shale units separated by a sandstone zone. The upper shale section (9459'-9502') is overlain by the Pink limestone. The lower most shale bed (9544'-9568') is rich in carbonaceous plant matter. The shale is interpreted as pro-deltaic in origin.

A sharp erosive base separates the overlying, fine grained sandstone (9502'-9544') from the lower shale unit (9544'-9568'). Ripple laminae, channel lag features (shale clasts), trough cross bedding, planar cross bedding and inclined laminations are the sedimentological features present in this unit. Carbonized plant matter, leaf imprints and calcite cement are also observed. The depositional environment is thought to be distributary channels. The presence of several zones of channel base conglomerates is indicative of the multistoried nature of the channel sediments.

The sandstone is overlain by a dark shale bed rich in carbonized plant matter (9459'-9502'). This shale is thought to have been deposited in an interdistributary bay environment.

Company WESSELY M.F.CLARK NO 1
Well Location 15-17N-17W,C-W/2-NE

Petrologic Log



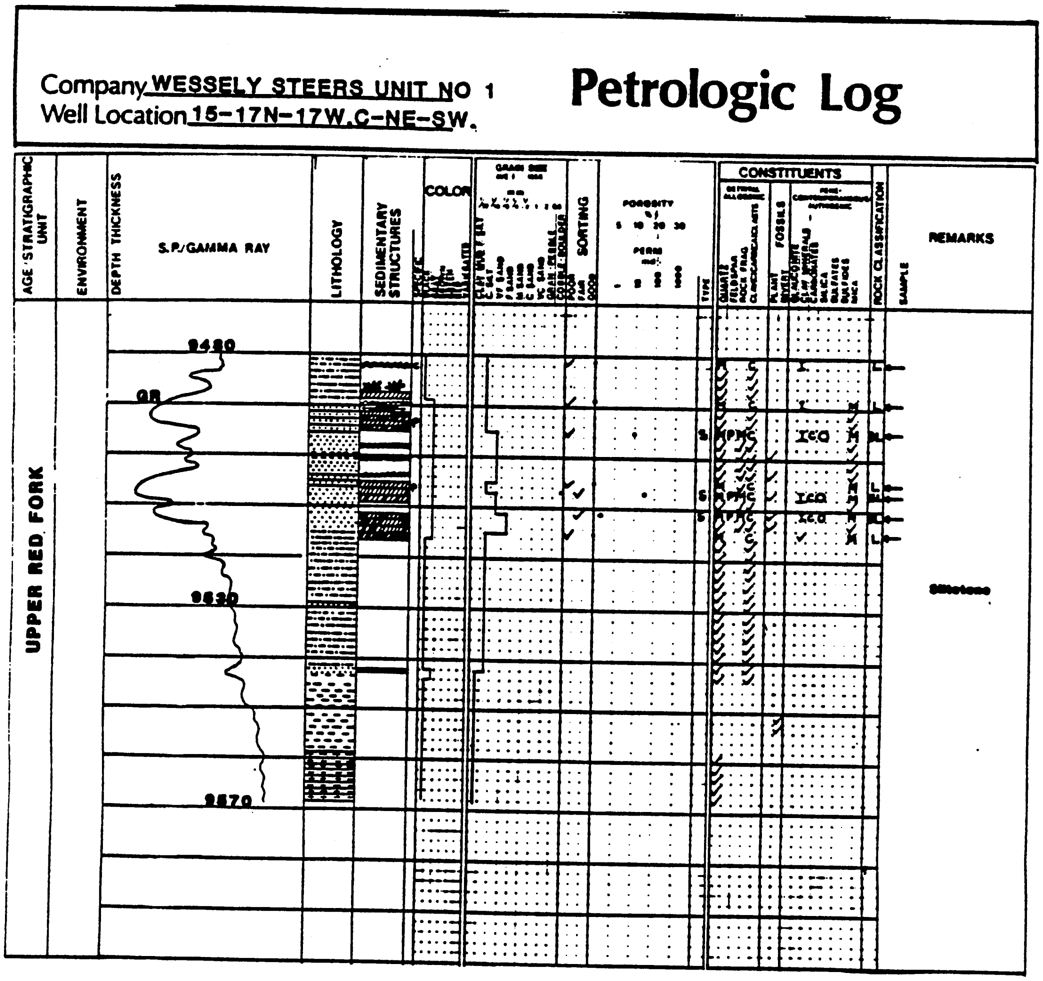
Well: Wessely Petroleum Ltd. M. F. Clark No. 1

Location: Sec. 15-T.17N.-R.17W.; C-W/2-NE

Depth: 9495'-9560'

Stratigraphic Interval: Upper Red Fork

The cored interval consists entirely of fine to very fine grained sandstone. The interval displays ripple laminae and planar corss bedding throughout while trough cross bedding is observed near the top of the section. Carbonized plant matter and calcite are also present. Several zones of channel lag features (rip up clasts) are observed in the section indicating the multistoried nature of the sediments. Based on the sedimentological features, the depositional environment is interpreted as distributary channel.



Company WESSELY STEERS UNIT NO 1
Well Location 15-17N-17W,C-NE-SW.

Petrologic Log

Well: Wessely Steers Unit No. 1

Location: Sec. 15-T.17N.-R.17W.; C-NE-SW

Depth: 9480'-9568'

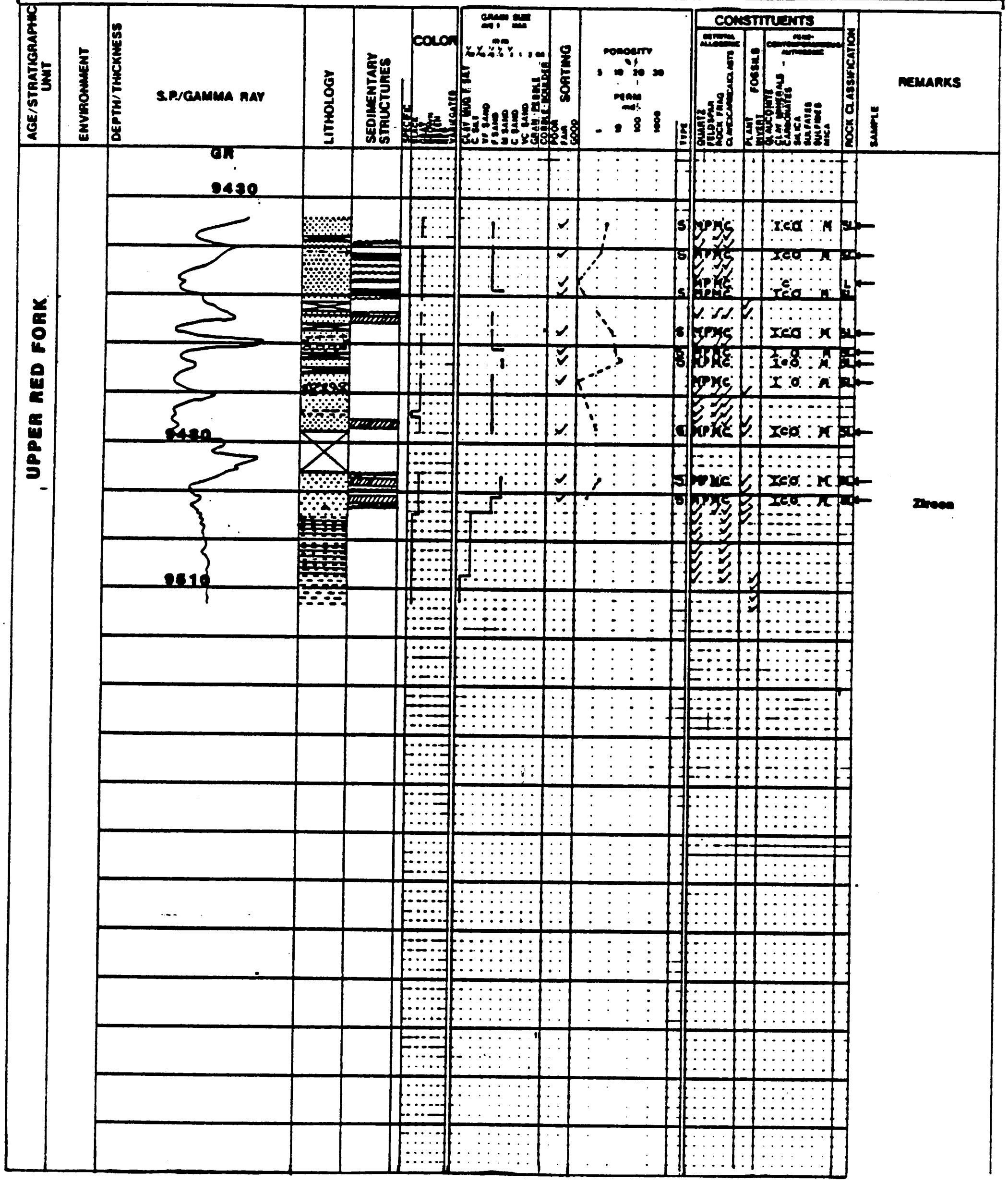
Stratigraphic Interval: Upper Red Fork

The cored interval comprises of silty claystone, shale, siltstone, sandstone and interlaminated sand and shale. The lowermost interval, 9558'-9568' consists of silty claystone and the overlying zone, 9543'-9558' consists of dark shale rich in carbonaceous plant matter. The silty claystone and the shale bed are interpreted as pro-deltaic in origin.

Siltstone bed (9515'-9543') overlies the dark shale bed. Siltstone bed is interpreted as overbank deposit. This unit grades into a fine grained sandstone (9496'-9515'). Planar cross bedding and ripple laminae are present in the sandstone. Rippled, interlaminated sandstone and shale (9504'-9506') bed are located within the sandstone bed. Calcite cement, siderite and carbonized plant matter are present in the sandstone. The sandstone fines upward into interbedded sandstone and shale sequence (9490'-9496'). Planar cross bedding is a common feature in this zone. Siltstone bed (9480'-9490') is the uppermost unit in the core. Ripple laminae, bioturbation and planar cross bedding are the features observed in this zone. The sandstone bed is thought to be deposited in distributary channel environment and the interlaminated sandstone and shale sequence and siltstone bed at the top are interpreted as levee deposits.

Company W.C.PICKENS LESLIE NO 1
Well Location 14-17N-17W,C-NW-NW

Petrologic Log



Well: W. C. Pickens Leslie No. 1

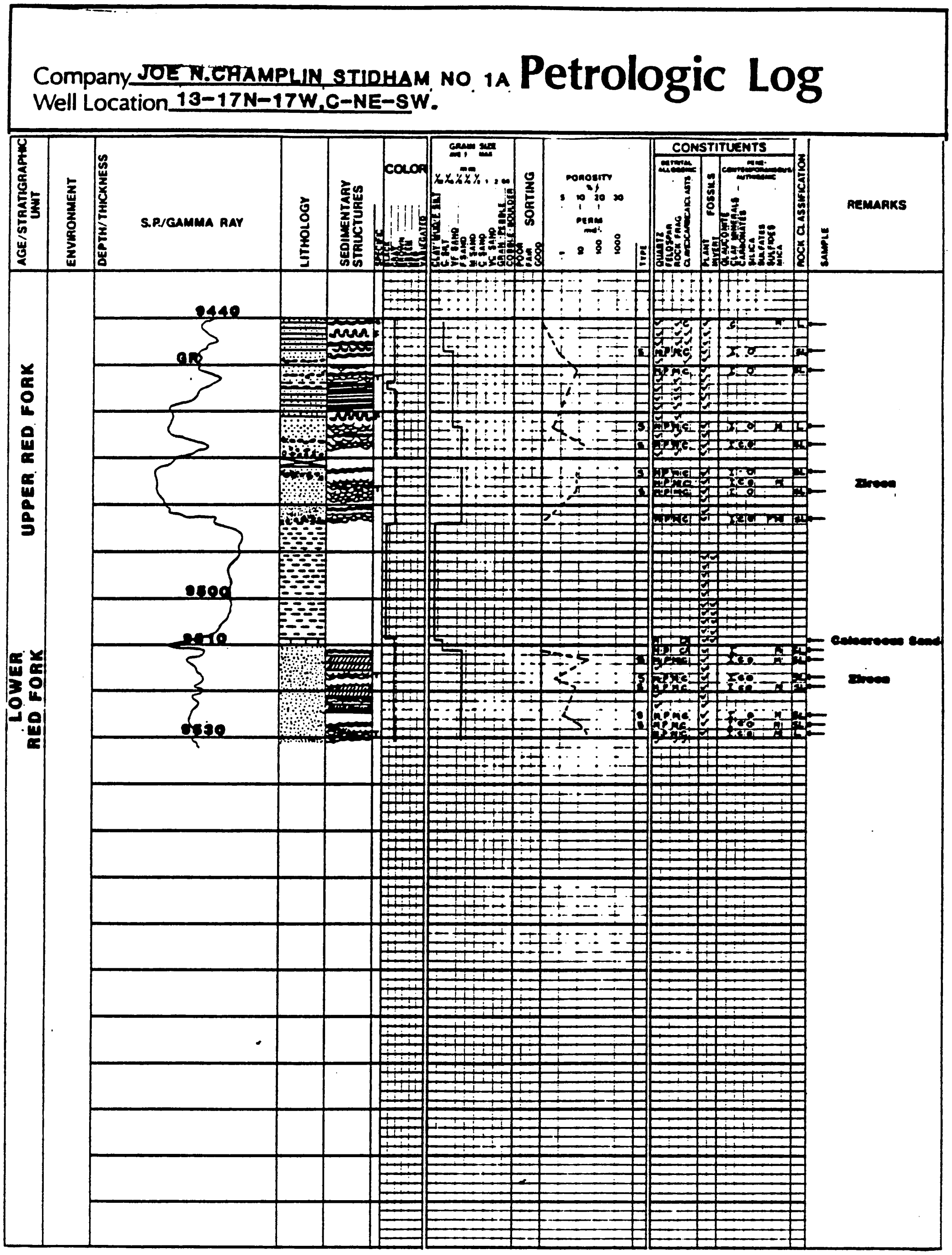
Location: Sec. 14-T.17N.-R.17W.; C-NW-NW

Depth: 9433'-9513'

Stratigraphic Interval: Upper Red Fork

The cored interval consists of shale, silty claystone and sandstone. The shale (9507-9513) is calcareous and rich in carbonaceous plant matter. Shale bed contains brachiopod fossils. This unit is interpreted as deposited in pro-deltaic environment.

A silty claystone bed (9495'-9507') is present as a gradational unit between the shale and overlying fine grained sandstone (9433'-9495'). Ripple laminae and planar cross bedding were the sedimentary structures observed in the sandstone. Interlaminated sandstone and shale zones are present within the sandstone. Channel lag features (rip-up clasts) are also present in the sandstone section. The presence of more than one channel lag zone within this section is indicative of the multistoried nature of the sandstone body. This interval is interpreted as deposited by distributary channels in a deltaic environment.


Company JOE N.CHAMPLIN STIDHAM NO. 1A
Well Location 13-17N-17W,C-NE-SW.
Petrologic Log
AGE/STRATIGRAPHIC UNIT
ENVIRONMENT
DEPTH/THICKNESS
S.P./GAMMA RAY
LITHOLOGY
SEDIMENTARY STRUCTURES
COLOR
GRAIN SIZE
SORTING
POROSITY
PERM
TYPE
CONSTITUENTS
FOSSILS
ROCK CLASSIFICATION
SAMPLE
REMARKS
UPPER RED FORK
LOWER RED FORK
9440
GR
9500
9510
9530
Zircon
Calcareous Sand
Zircon

Well: Joe N. Champlin 1. A. Stidham

Location: Sec. 13-T.17N.-R.17W.; C-NE-SW

Depth: 9440'-9531'

Stratigraphic Interval: Lower and Upper Red Fork

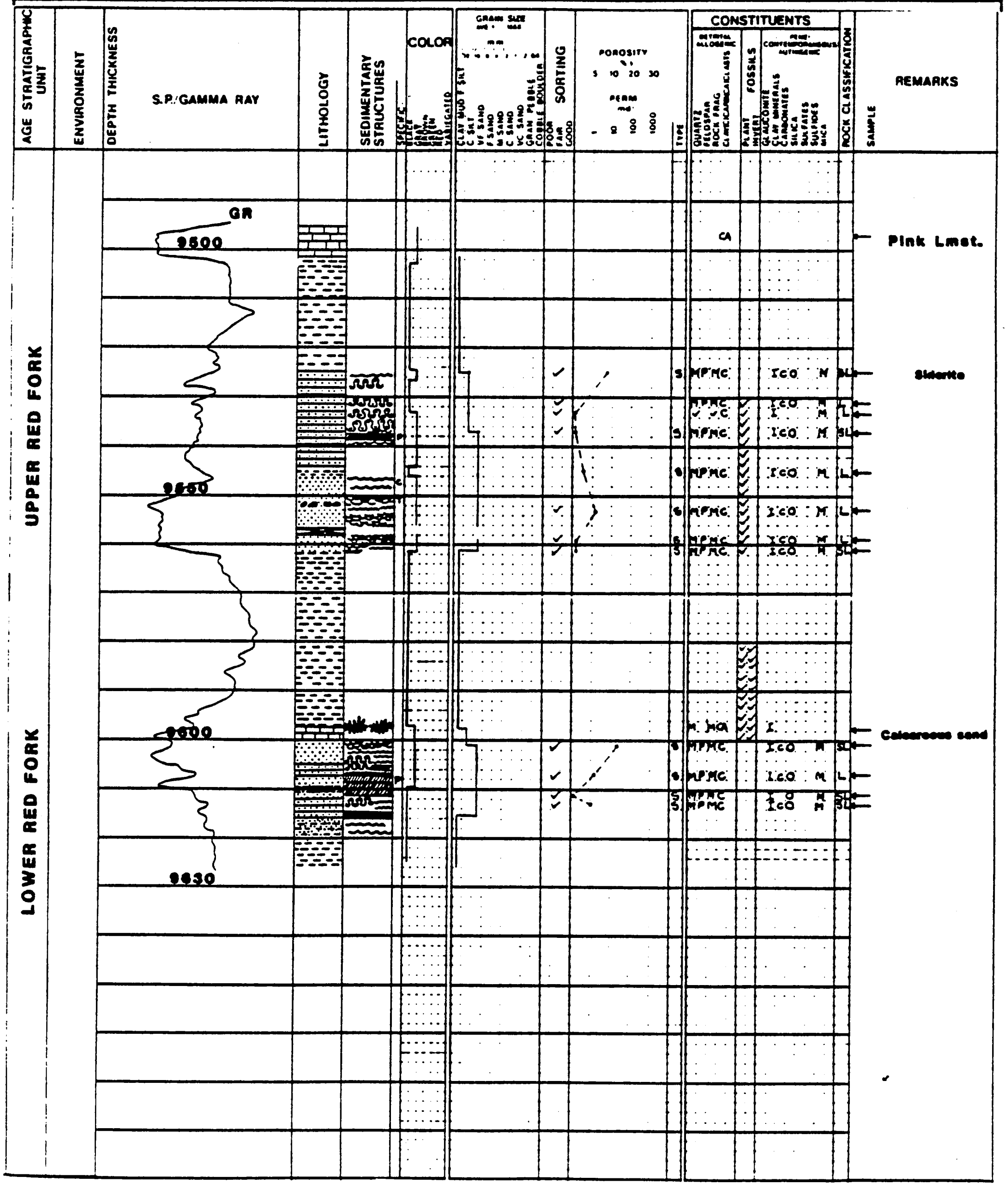
The cored interval consists of lower Red Fork and upper Red Fork sandstone sections separated by shale. The lower Red Fork sandstone section (9510'-9531') is fine grained. The interval from 9508'-9510' consists of calcareous sandstone with shallow marine fossils. Planar cross bedding, trough cross bedding and shale clasts are present in the sandstone interval. The calcareous sandstone is considered to be the marker bed separating the lower and upper Red Fork intervals. The lower Red Fork sandstone was deposited in a distributary channel environment within a delta complex. The calcareous sandstone bed is thought to be deposited during a minor transgressive episode.

The massive black shale bed (9484'-9508') is rich in carbonized plant matter and contains shallow marine fossils. The contact between the shale and the overlying sandstone is sharp and is characterized by the presence of channel lag features. The dark shale bed rich in carbonized plant matter is interpreted as pro-deltaic in origin.

The upper Red Fork sandstone section (9440'-9484') is fine to very fine-grained. Interlaminated sand and shale sequence is also present within this interval (9440'-9447' and 9455'-9461'). Channel lag features (rip-up clasts), trough cross bedding, ripple laminae, inclined laminae and climbing ripples are present in this zone. This sandstone section was deposited by prograding distributary channels during a regressive phase. Presence of channel lag features at three locations within the sandstone is indicative of the multistoried nature of the channel sandstone.

Company WESSELY CLARK NO1A
Well Location 13-17N-17W, C-NW-NW.

Petrologic Log



Well: Wessely Clark 1A

Location: Sec. 13-T.17N.-R.17W.; C-NW-NW

Depth: 9495'-9625'

Stratigraphic Interval: Lower and Upper Red Fork, Pink Limestone

The cored interval consists of shale, muddy sandstone, interlaminated sandstone and shale, and sandstone representing the lower Red Fork interval (9625'-9598'), and shale, sandstone, interlaminated sand and shale and shale bed which represent the upper Red Fork (9502'-9598') interval. The two Red Fork intervals are separated by a thin calcareous sandstone bed (9598'-9600'). The Pink Limestone, is present within the cored interval overlying the upper Red Fork interval (9496'-9501).

The lowermost interval (9620'-9625') in the lower Red Fork interval consists of shale bed. The zone from 9620'-9616' consists of ripple laminated muddy sandstone unit. The section from 9600'-9616' consists of alternating sequences of interlaminated sandstone and shale beds and sandstones. Flowage features, ripple laminae and planar cross bedding are present throughout most of this section. Trough cross bedding is the dominant feature in the sandstone zone (9600'-9605') in this interval. The shale beds (9620'-9625') are interpreted as pro-deltaic in origin. The rest of the sequence is thought to be distributary channel in origin. The two feet interval from 9598'-9600' comprises of calcareous sandstone. Shallow marine fossils are found in this zone. Calcareous sandstone is interpreted as deposited during a transgressive episode. This calcareous sandstone bed is considered as the marker bed between the lower Red Fork and the upper Red Fork intervals.

The lowermost unit (9562'-9598') of the upper Red Fork is a massive, shale bed rich in carbonized plant matter and contain marine fossils. The contact between the shale and the overlying sandstone is very sharp. The interval from 9546' to 9562' consists of fine grained sandstone which displays sedimentological features such as trough cross bedding and ripple laminae. The zone from 9525' to 9546' comprises of interlaminated sandstone and shale sequences which shows cross bedding and flowage features. The zone from 9501'-9525' comprises of dark shale bed.

The shale beds immediately above the lower Red Fork interval is interpreted as pro-deltaic in origin and the sandstone beds and the interbedded sandstone and shale were deposited by the prograding distributary channels. The shale bed (9501'-9525') is thought to be interdistributary bay in origin.

APPENDIX B

PHOTOGRAPHS OF CORES

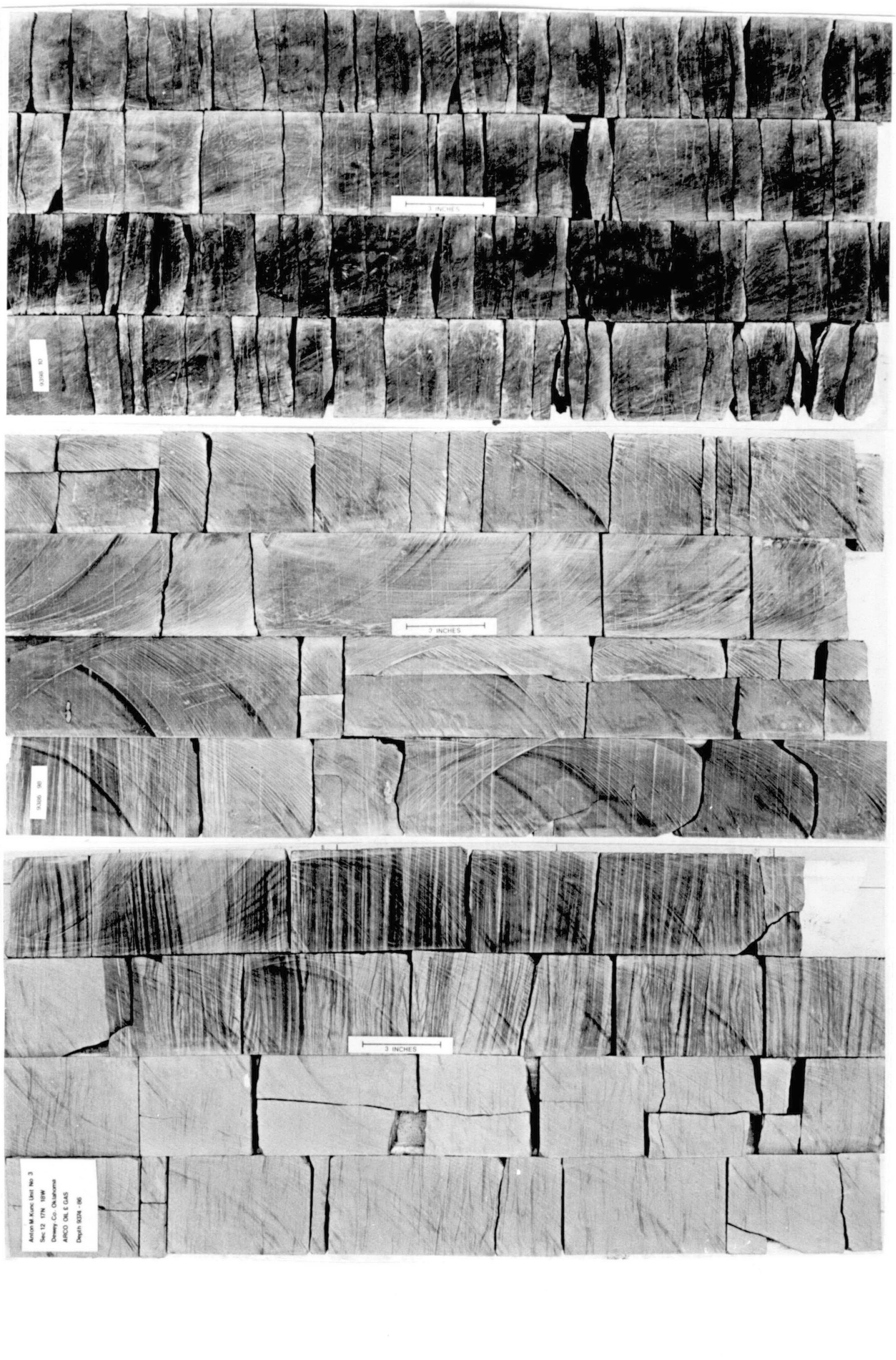


Figure 1. Upper Red Fork, ARCO, Anton M-Kunc No. 3.

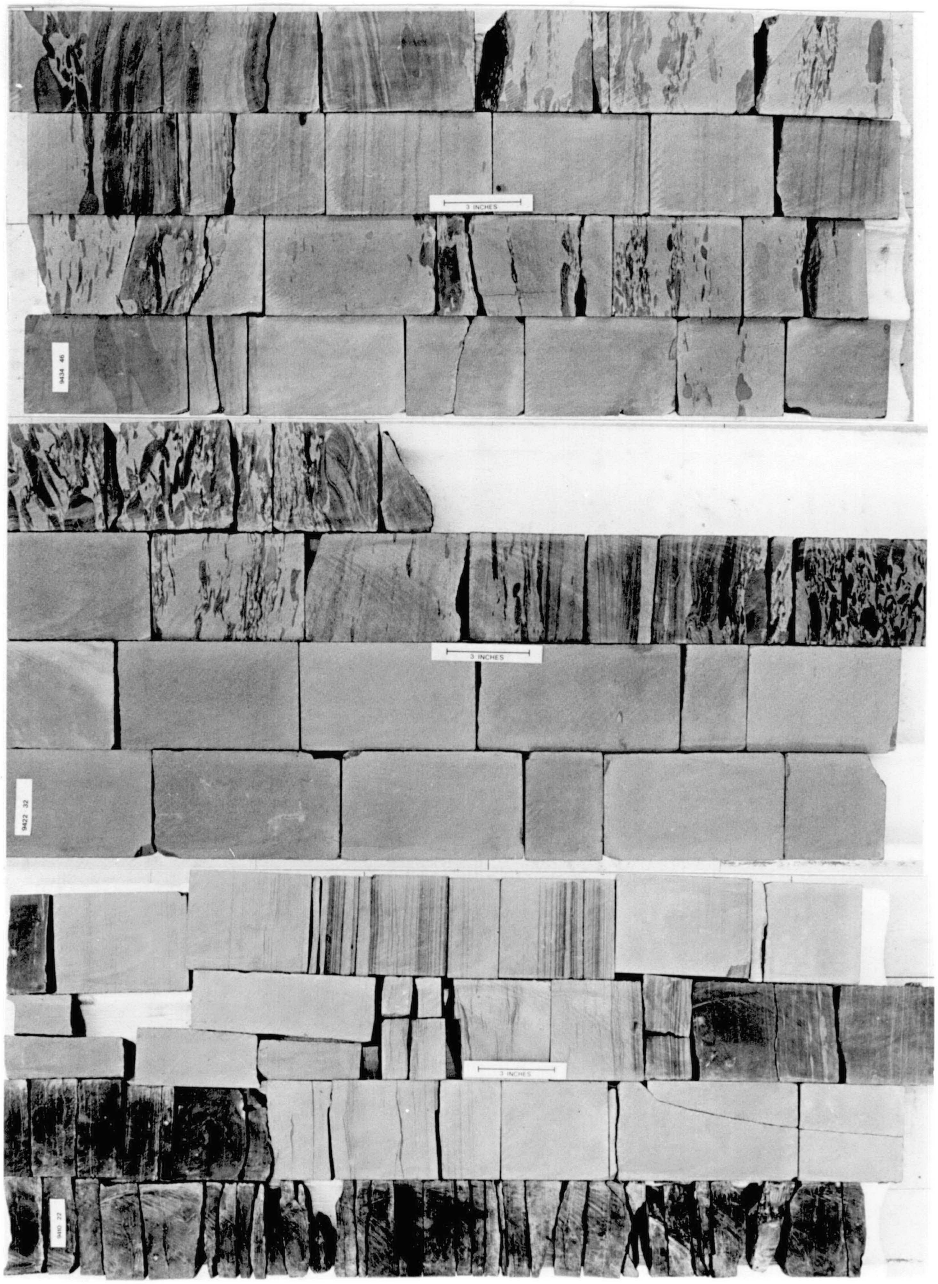


Figure 1. Continued

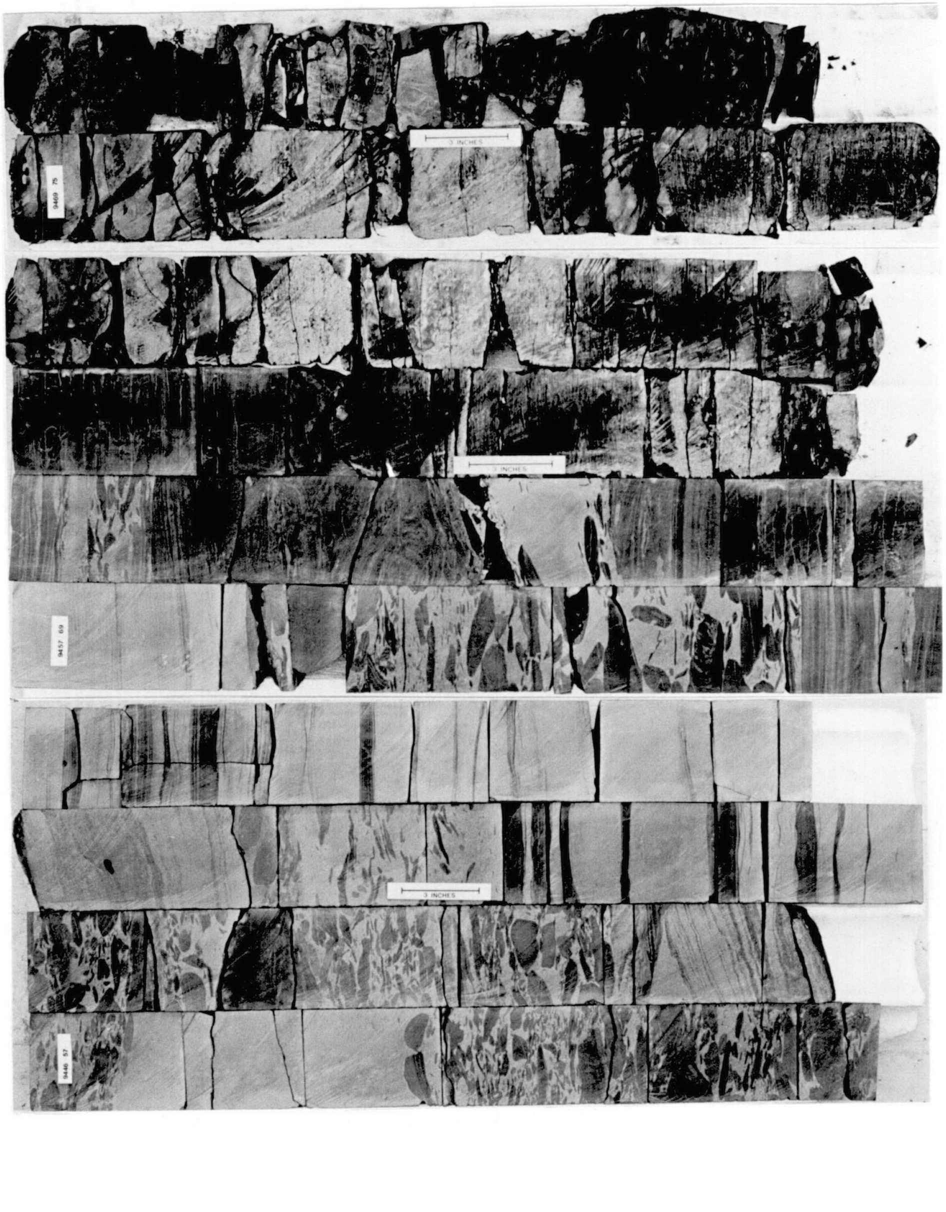


Figure 1. Continued

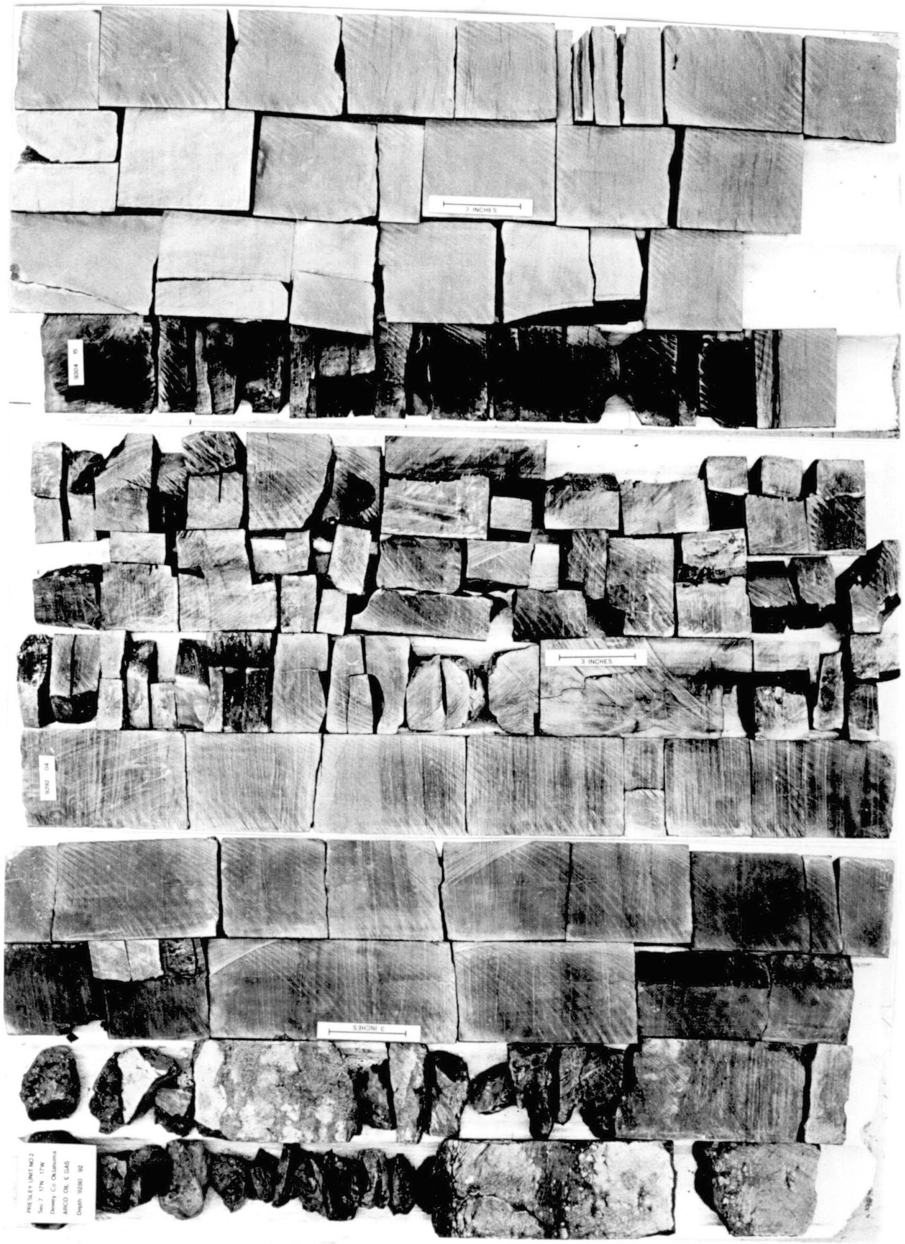


Figure 2. Upper Red Fork, ARCO, Presley No. 2.

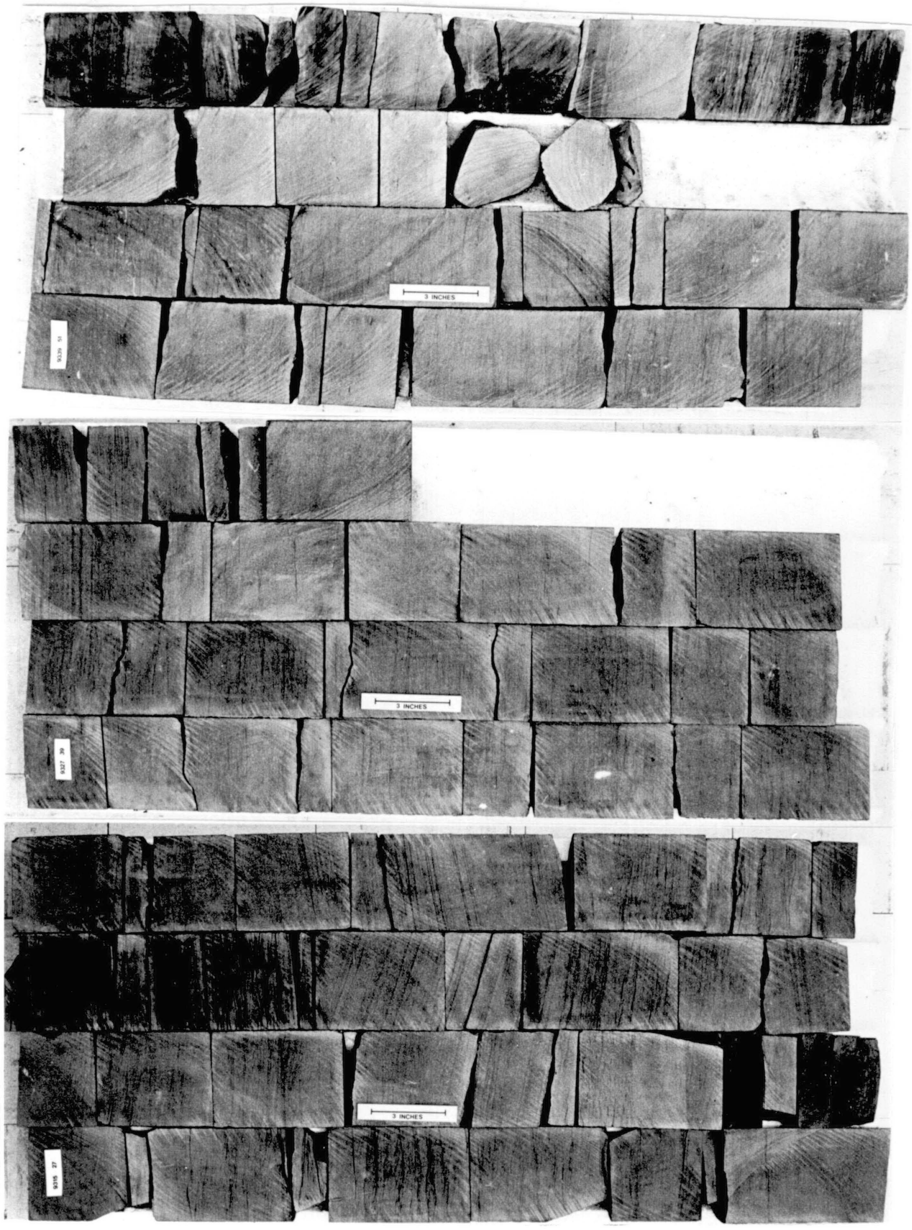


Figure 2. Continued

Figure 2. Continued

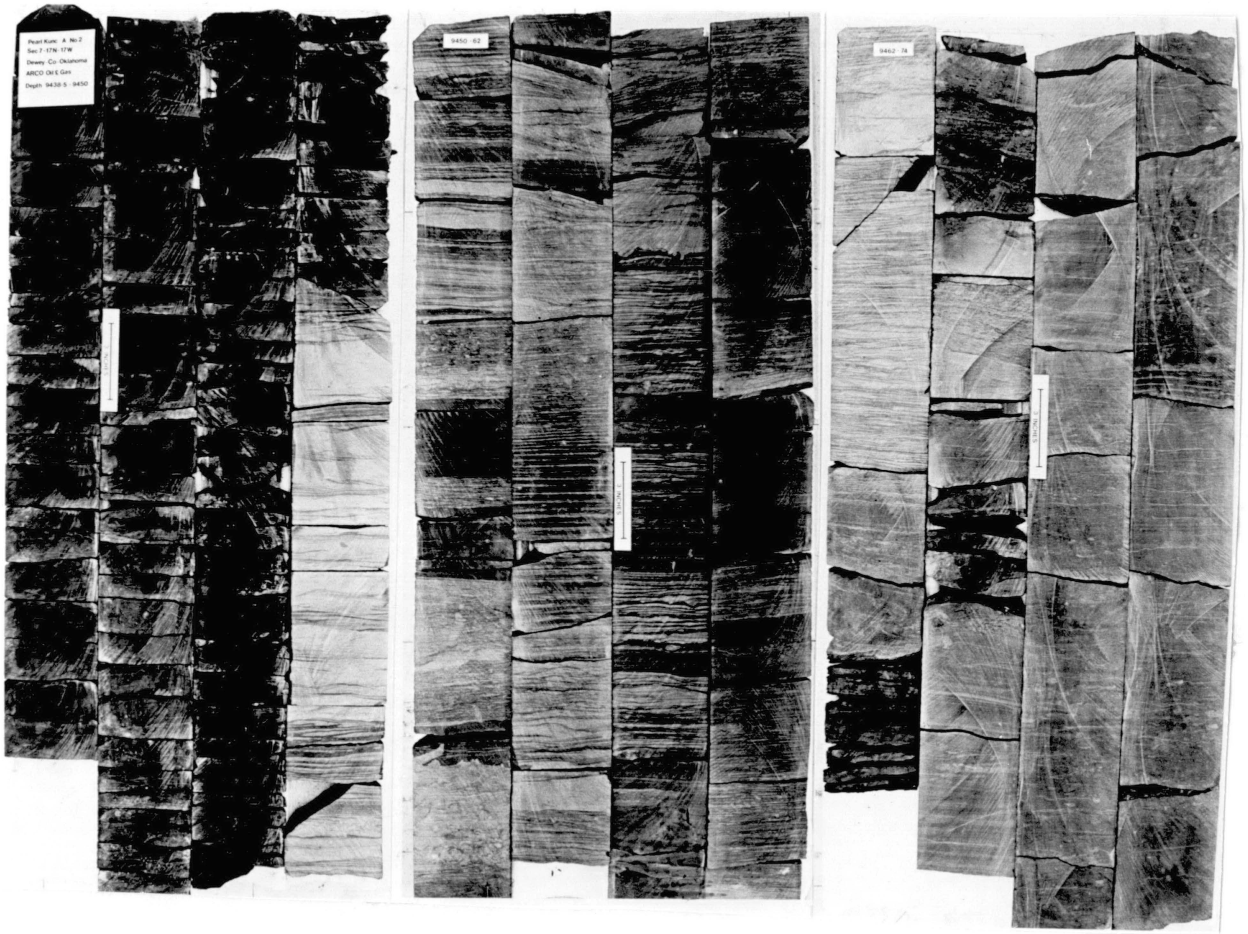


Figure 3. Upper Red Fork, ARCO, Pearl Kunc A No. 2.

Figure 3. Continued

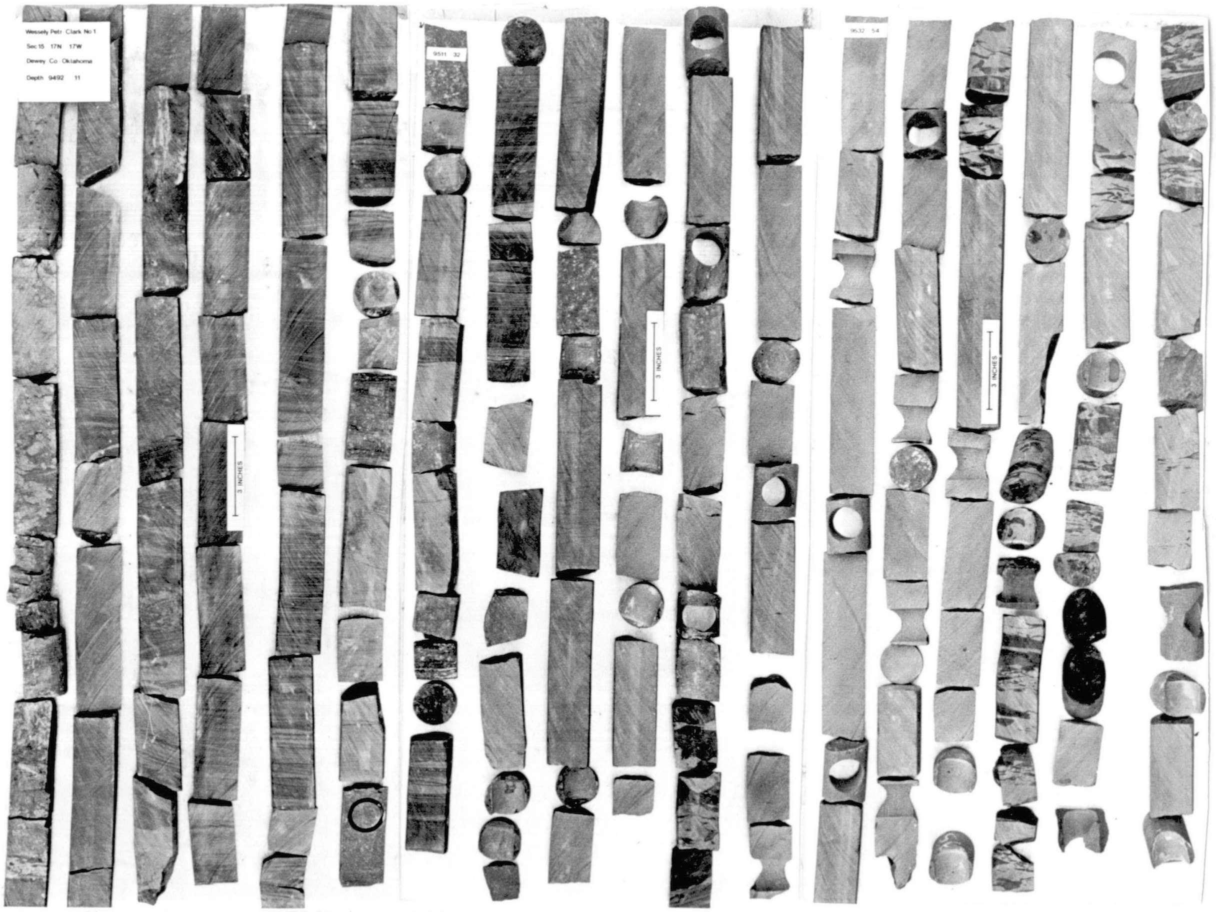


Figure 4. Upper Red Fork, Wessely, Clark No. 1.

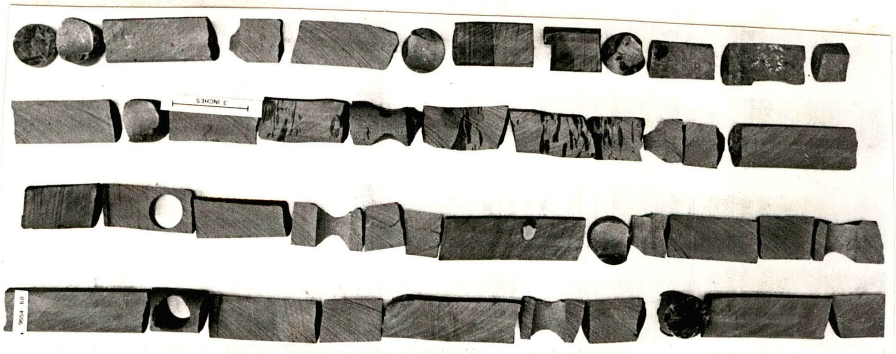


Figure 4. Continued

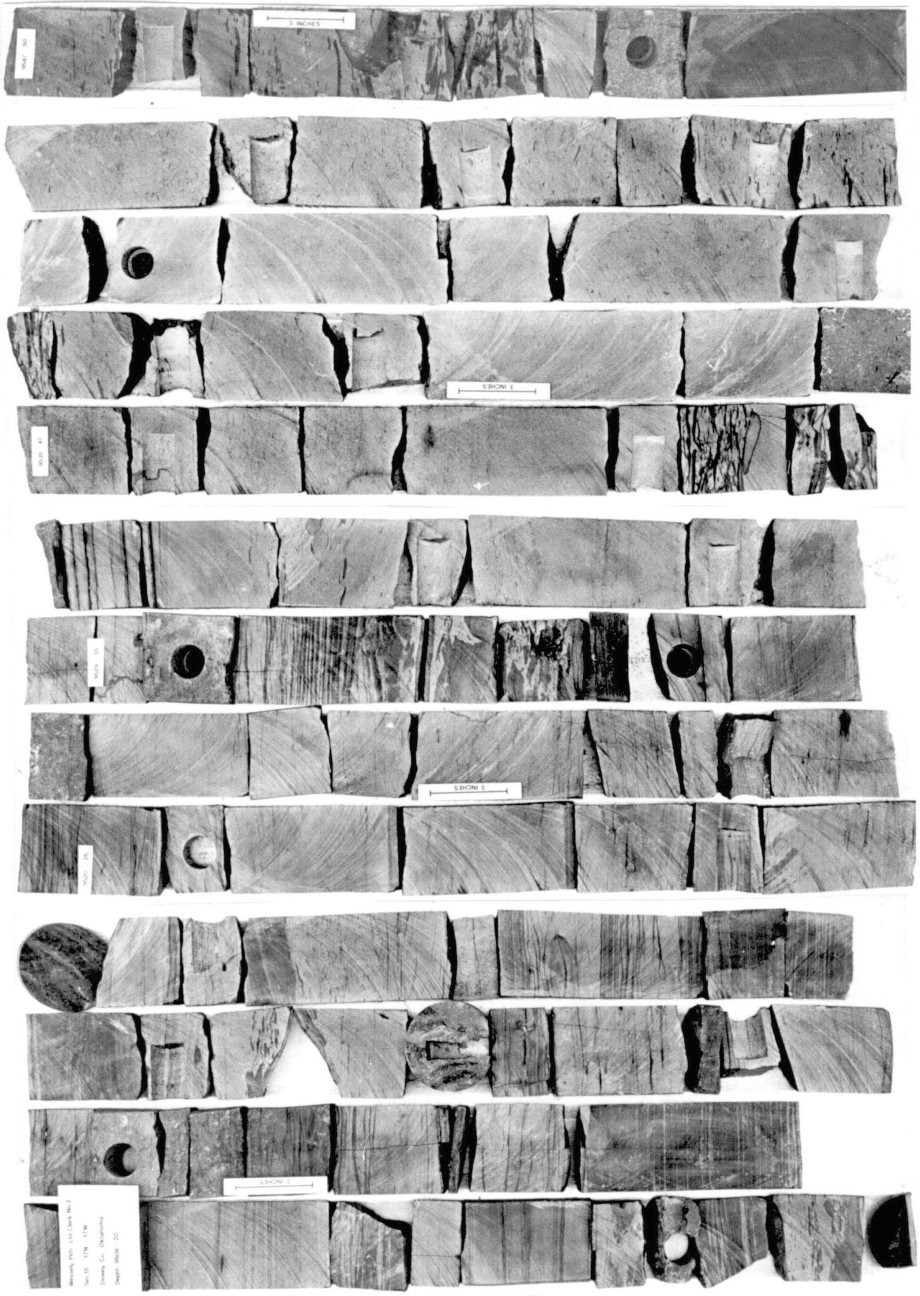


Figure 5. Upper Red Fork, Wessely, Clark No. 2.

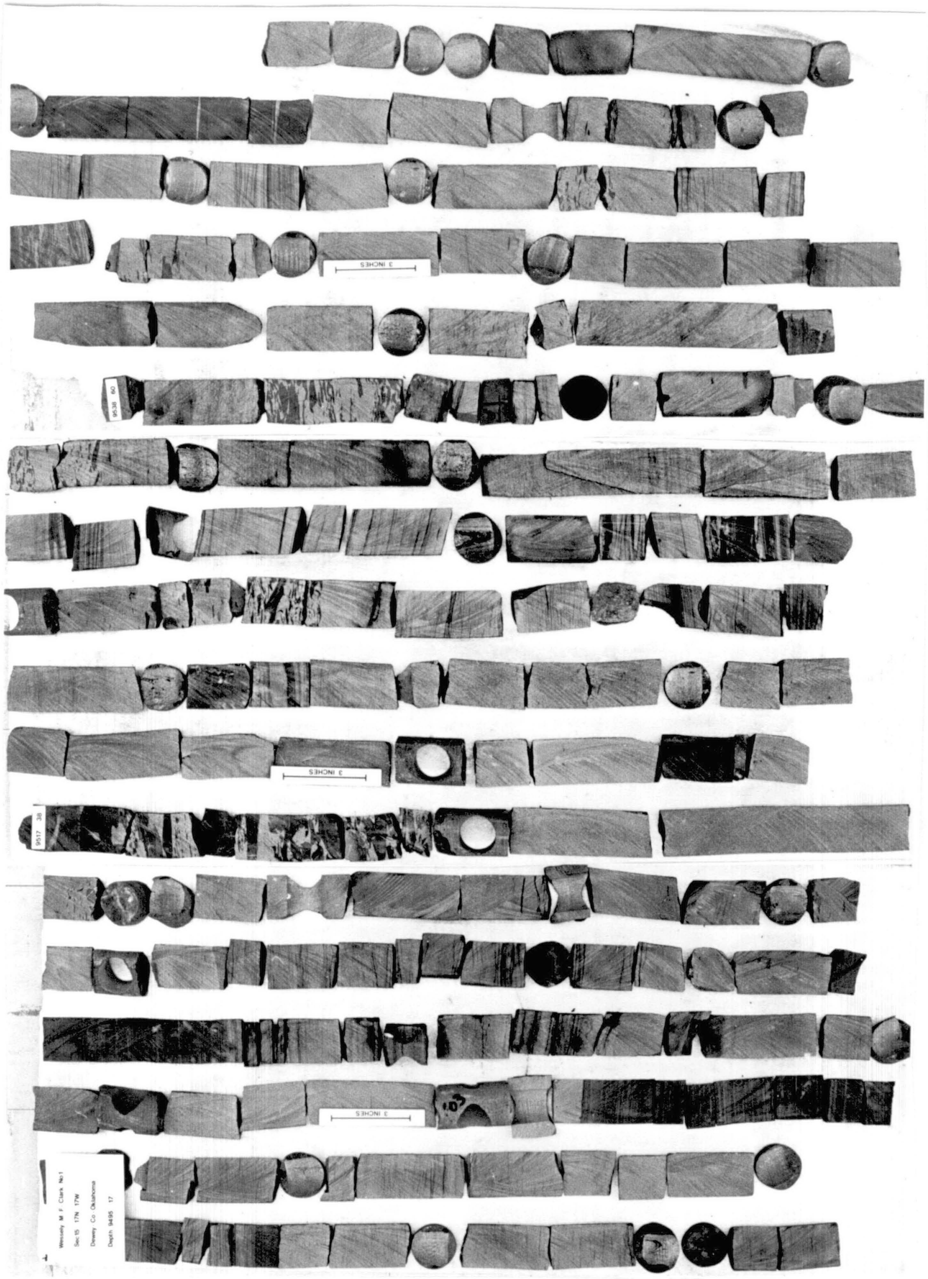


Figure 6. Upper Red Fork, Wessely, M. F. Clark No. 1.

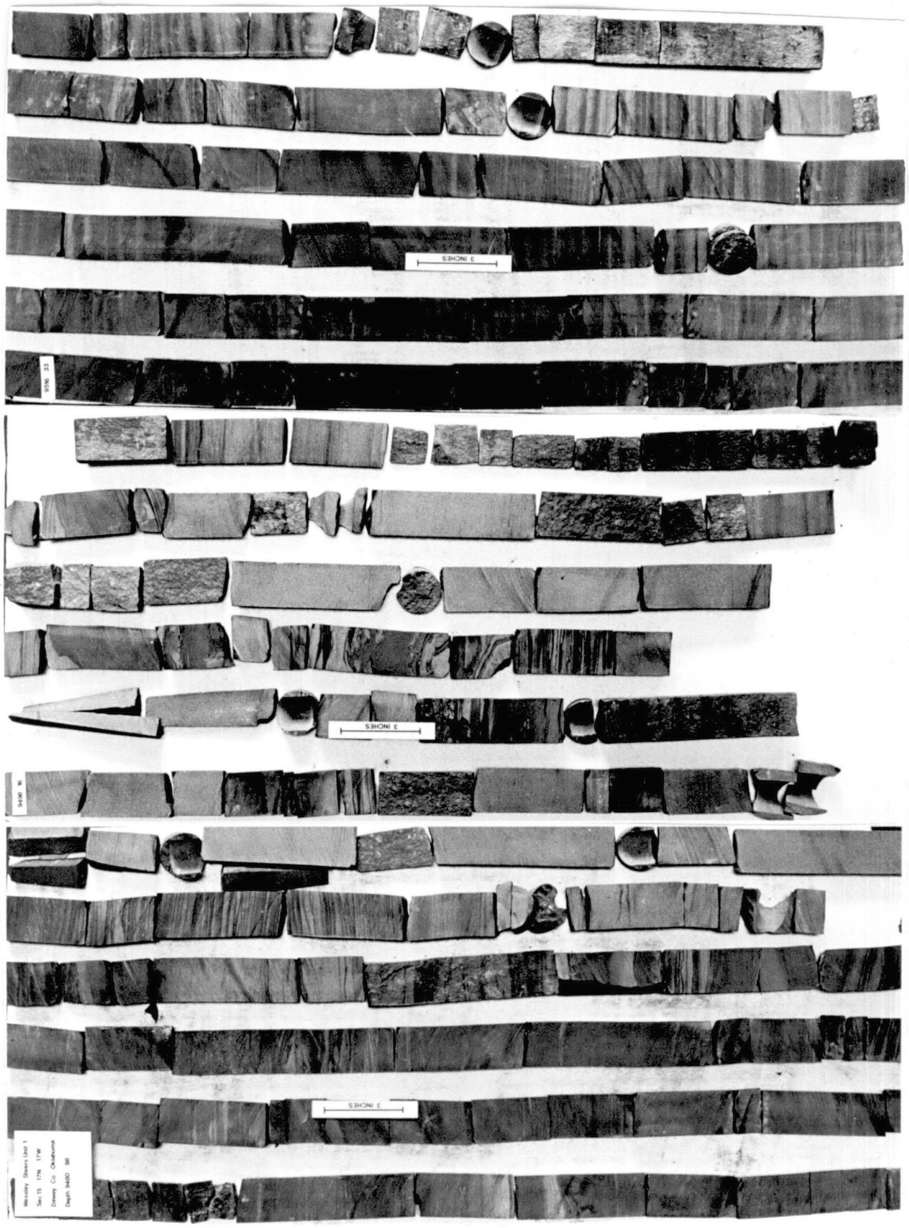


Figure 7. Upper Red Fork, Wessely, Steers Unit No. 1.

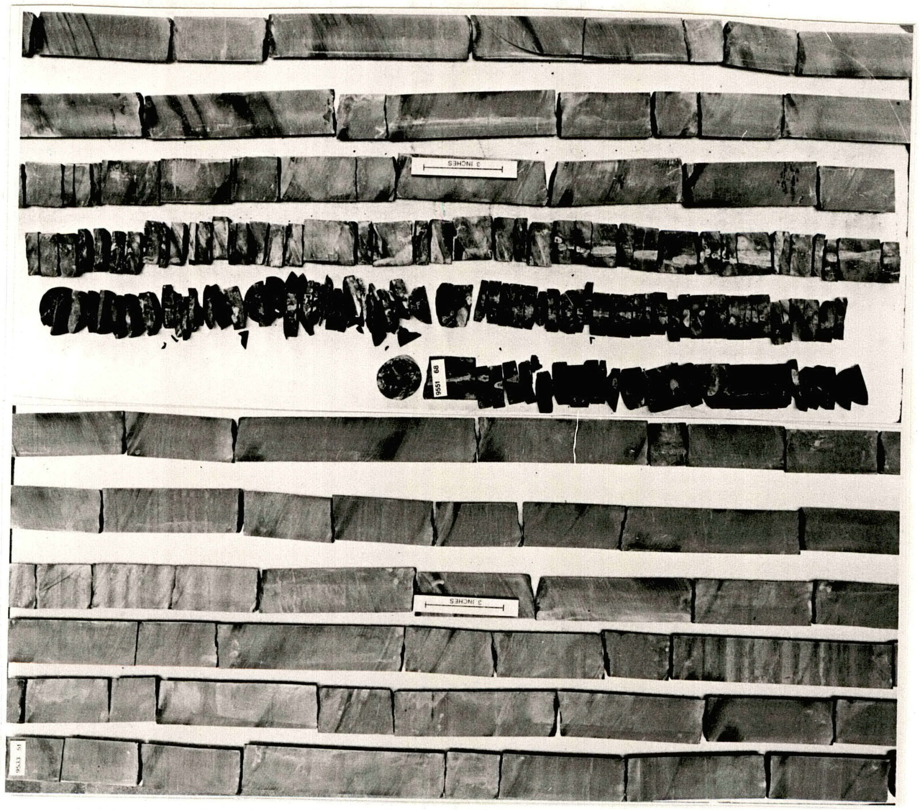


Figure 7. Continued

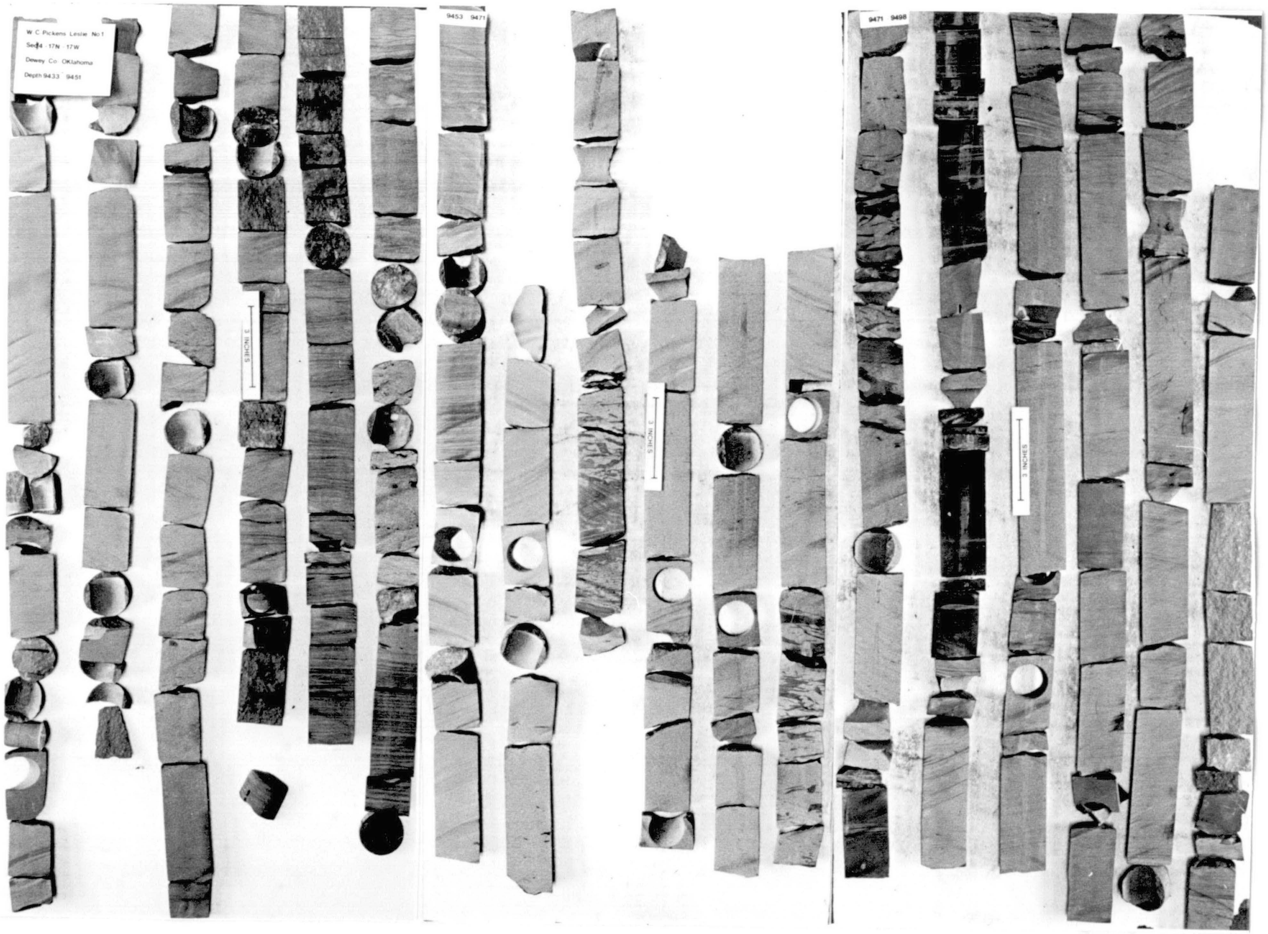


Figure 8. Upper Red Fork, W. C. Picken's, Leslie No. 1.

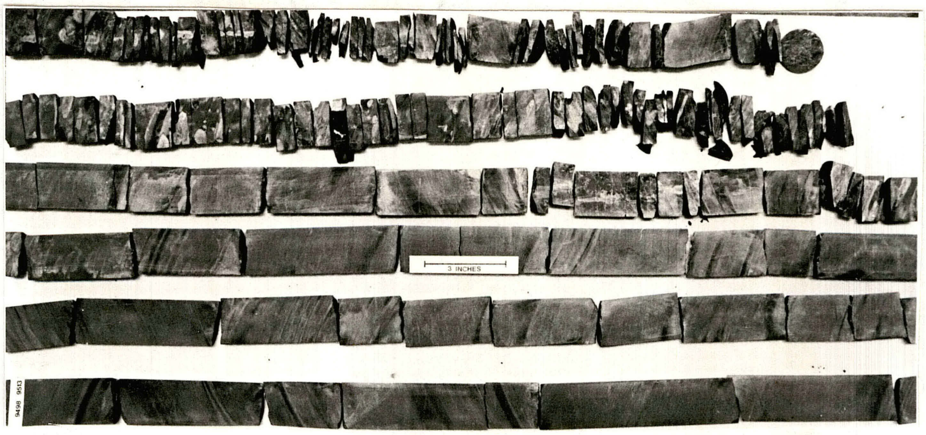


Figure 8. Continued

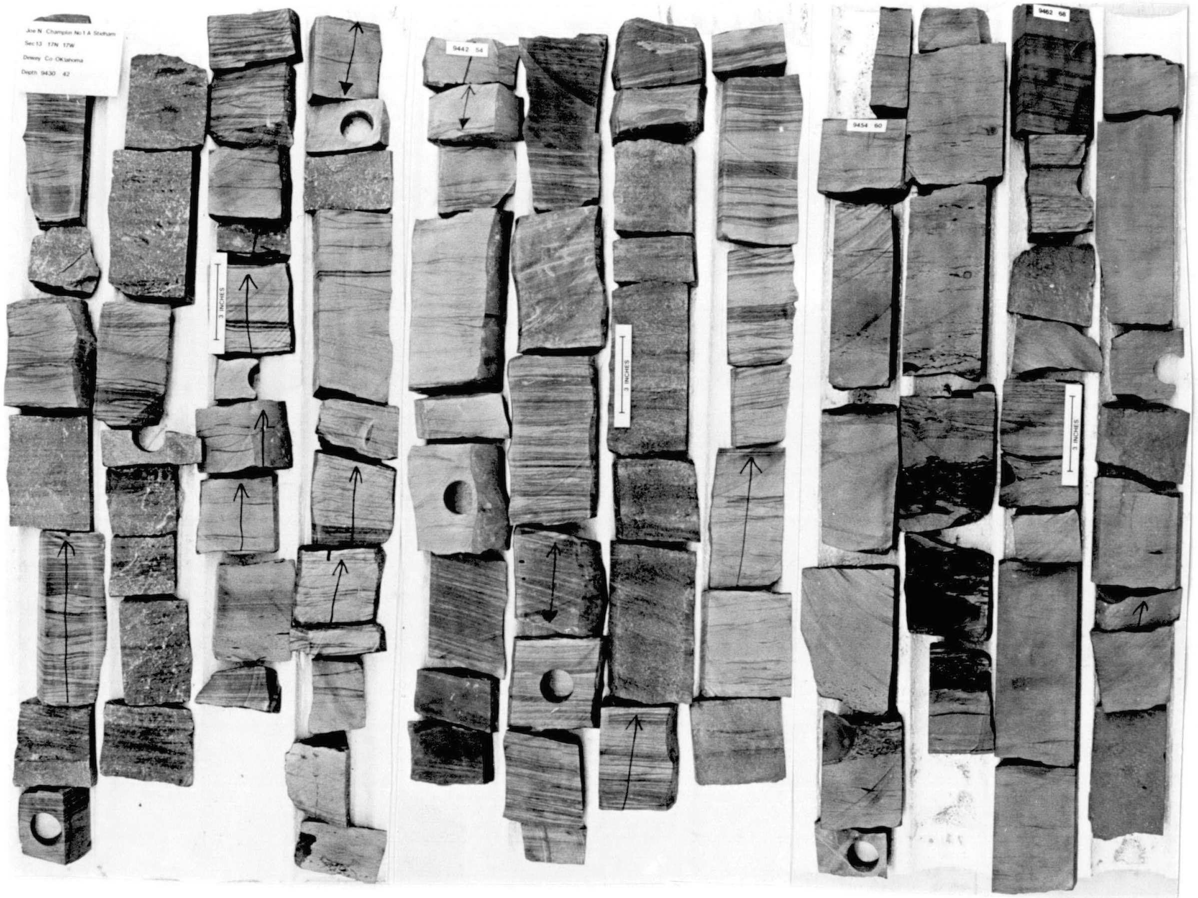


Figure 9. Upper Red Fork and lower Red Fork, Joe N. Champlin, Stidham No. 1 A.

Figure 9. Continued

Figure 9. Continued

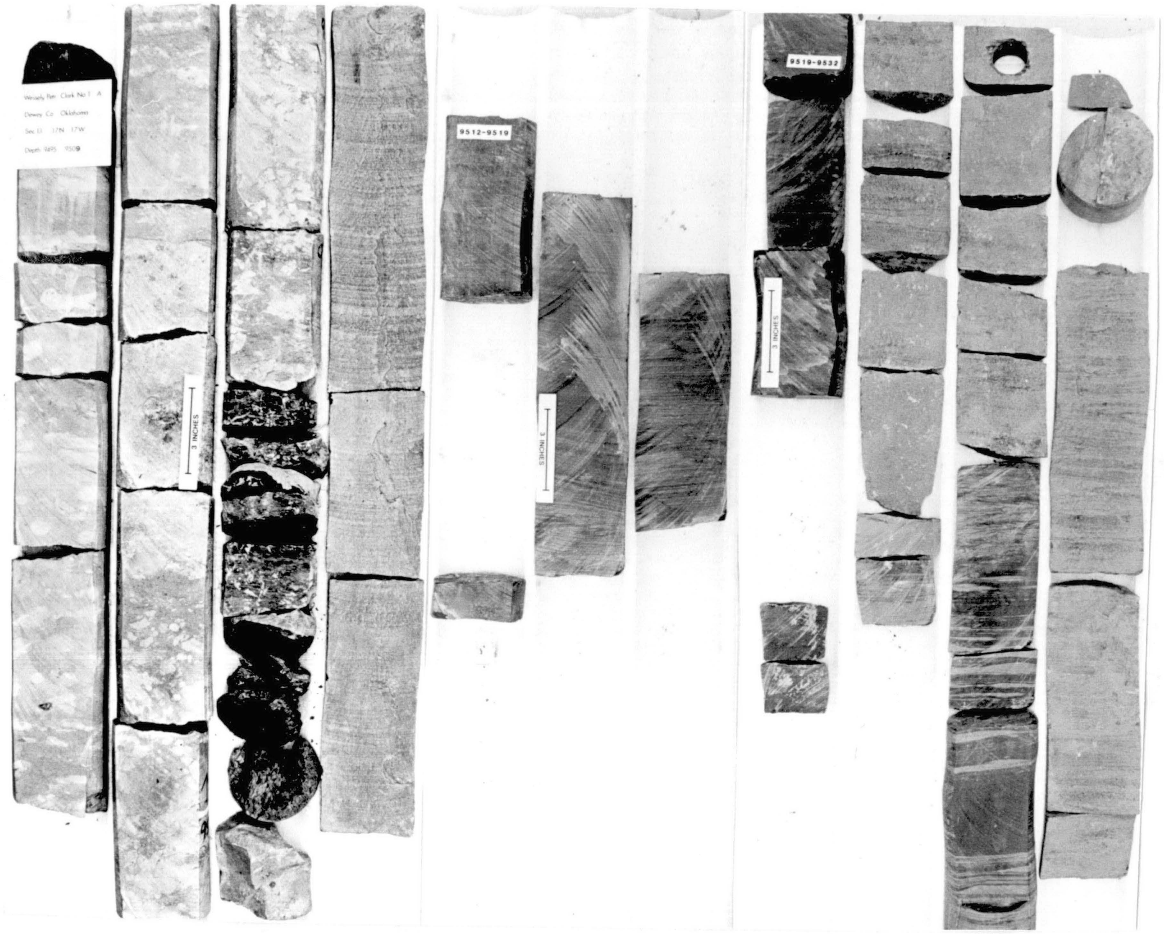


Figure 10. Upper Red Fork and lower Red Fork, Wessely, Clark No. 1A.

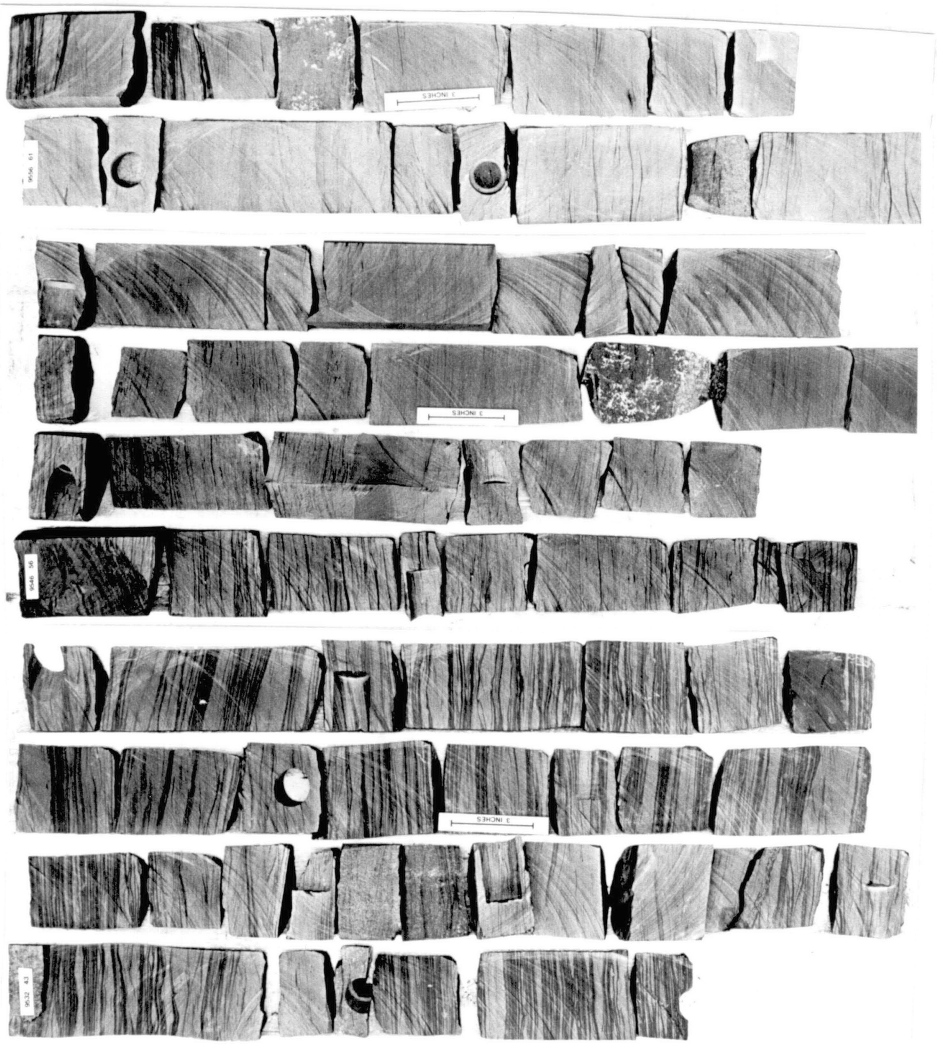


Figure 10. Continued

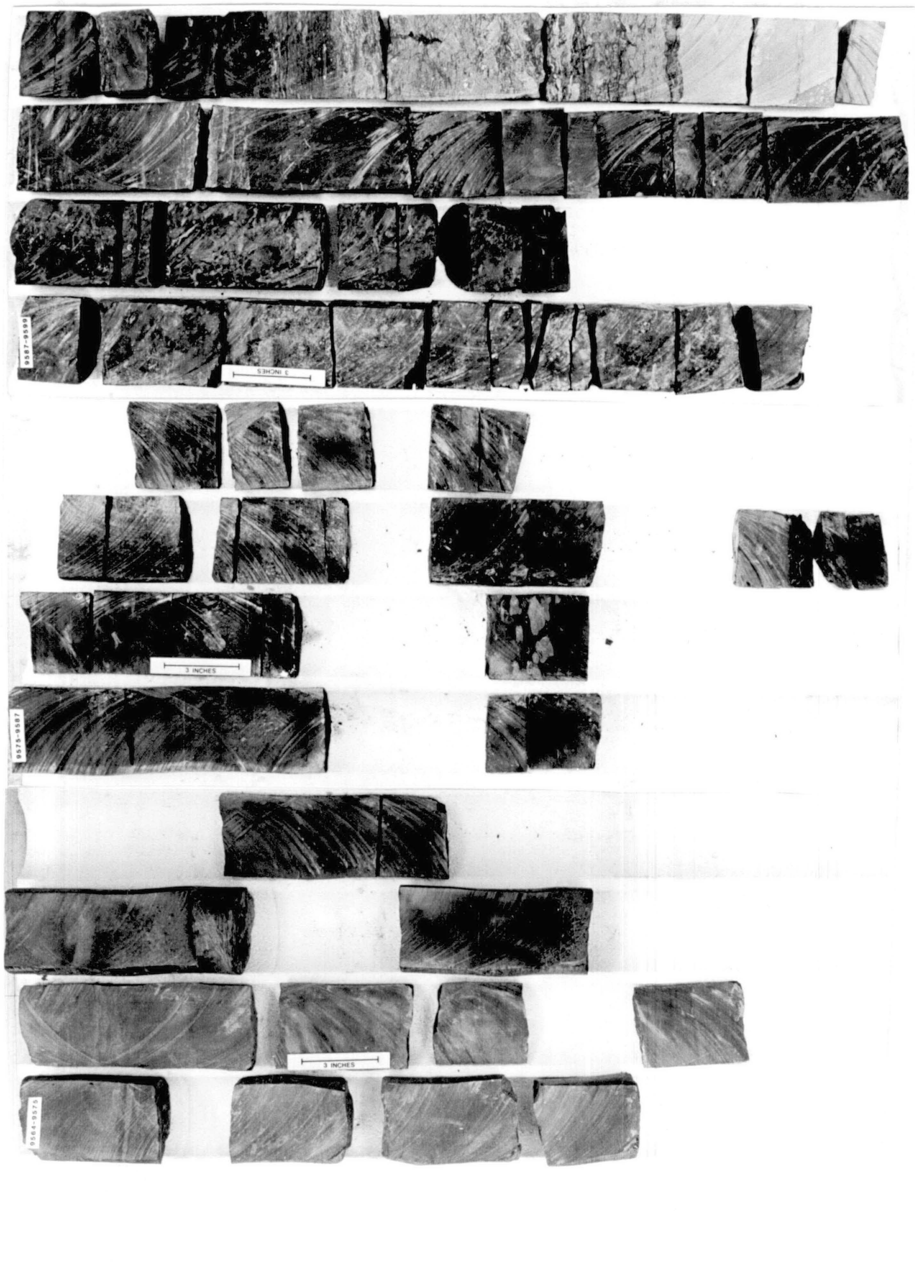


Figure 10. Continued

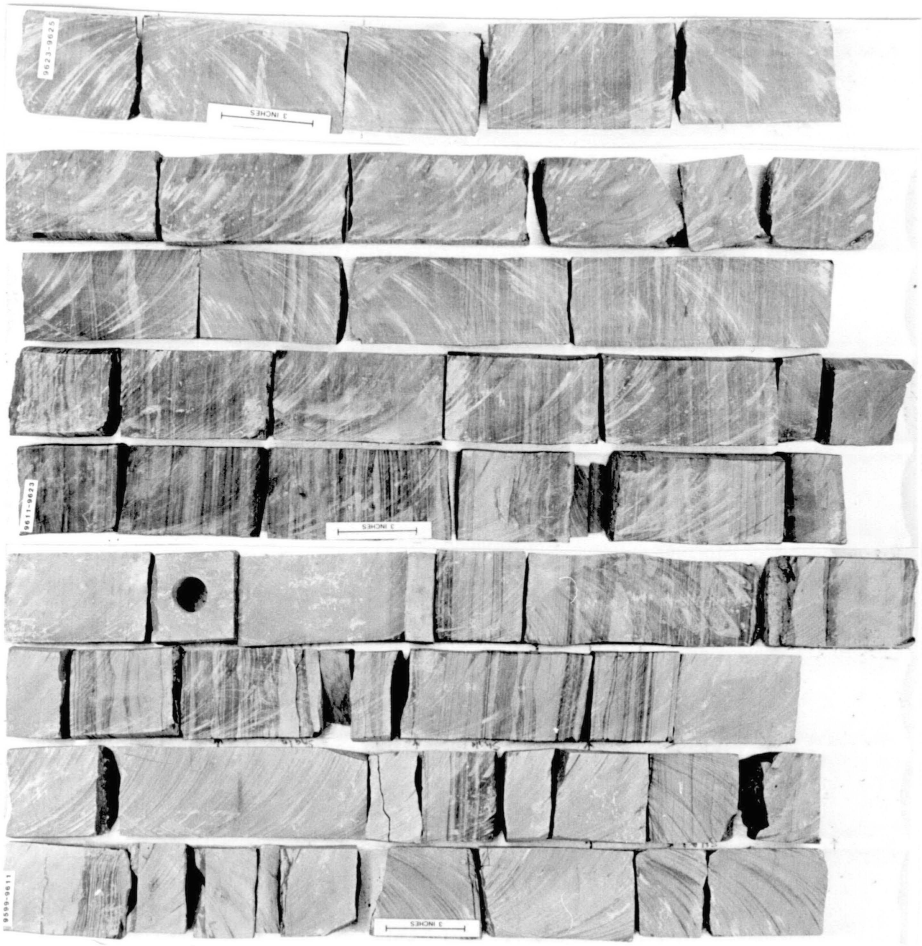


Figure 10. Continued

APPENDIX C

OIL AND GAS PRODUCTION DATA

TABLE I

OIL AND GAS PRODUCTION FROM RED FORK SANDSTONES

	Location							
No.	SEC	TWP	RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/83	Cumulative Gas Production MMCF 2/84
1	2	17N	16W	Putnam	6/80	1	4,000	---
2	3	17N	16W	"	3/82	1	3,592	---
3	3	17N	16W	"	5/80	1	50,000	---
4	3	17N	16W	"	2/80	2	200,000	---
5	4	17N	16W	"	9/78	1	50,000	5,000
6	4	17N	16W	"	4/79	1	41,323	4,136
7	4	17N	16W	"	10/81	1	3,300	370
8	4	17N	16W	"	5/79	1	120	---
9	5	17N	16W	"	11/78	1	20,000	---
10	6	17N	16W	"	1/82	1	16,783	---
11	7	17N	16W	"	12/80	1	3,303	---
12	7	17N	16W	"	5/76	1	11,860	---
13	8	17N	16W	"	8/78	1	43,932	442

TABLE I (Continued)

No.	Location SEC TWP RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/83	Cumulative Gas Production MMCF 2/84
14	8 - 17N - 16W	Putnam	10/83	1	829	---
15	8 - 17N - 16W	"	11/77	1	83,794	3,467
16	9 - 17N - 16W	"	11/81	1	26,579	---
17	9 - 17N - 16W	"	6/82	1	14,136	---
18	9 - 17N - 16W	"	12/74	1	30,803	---
19	9 - 17N - 16W	"	8/79	1	30,000	---
20	9 - 17N - 16W	"	9/75	1	55,234	2,225
21	9 - 17N - 16W	"	6/74	1	185,110	---
22	10 - 17N - 16W	"	2/81	1	14,410	---
23	16 - 17N - 16W	"	7/83	1	4,734	---
24	16 - 17N - 16W	"	8/67	1	146,563	---
25	17 - 17N - 16W	"	3/83	1	17,916	145
26	17 - 17N - 16W	"	5/83	1	8,021	611
27	17 - 17N - 16W	"	6/83	1	5,006	---

TABLE I (Continued)

No.	Location SEC TWP RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/83	Cumulative Gas Production MMCF 2/84
28	17 - 17N - 16W	Putnam	7/83	1	4,537	778
29	17 - 17N - 16W	"	1/83	1	14,640	44
30	17 - 17N - 16W	"	9/83	1	673	---
31	18 - 17N - 16W	"	9/83	1	1,854	---
32	18 - 17N - 16W	"	1/68	1	61,959	---
33	22 - 17N - 16W	"	9/81	1	20,360	---
34	23 - 17N - 16W	"	7/81	1	3,381	---
35	1 - 17N - 17W	"	7/79	1	9,632	---
36	3 - 17N - 17W	"	7/66	1	49,531	---
37	3 - 17N - 17W	"	4/83	1	3,245	---
38	7 - 17N - 17W	"	5/80	1	21,703	---
39	7 - 17N - 17W	"	6/81	1	68,468 (8/84)	12932 (8/84)
40	7 - 17N - 17W	"	5/81	1	4,969 (8/84	10 (8/84)
41	7 - 17N - 17W	"	5/81	1	42,206 (8/84)	11361 (8/84)

TABLE I (Continued)

No.	Location SEC TWP RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/83	Cumulative Gas Production MMCF 2/84
42	7 - 17N - 17W	Putnam	5/81	1	23,433 (8/84)	653 (8/84)
43	9 - 17N - 17W	"	12/70	1	34,535	---
44	9 - 17N - 17W	"	5/86	1	134,297	---
45	9 - 17N - 17W	"	1/69	1	81,108	---
46	11 - 17N - 17W	"	1/67	1	98,120	---
47	13 - 17N - 17W	"	3/82	1	1,388	144
48	13 - 17N - 17W	"	6/73	1	22,076	---
49	14 - 17N - 17W	"	8/67	1	19,007	---
50	14 - 17N - 17W	"	5/67	1	88,158	---
51	14 - 17N - 17W	"	1/68	1	67,904	---
52	14 - 17N - 17W	"	11/66	1	38,883	---
53	14 - 17N - 17W	"	11/67	1	71,208	---
54	15 - 17N - 17W	"	12/66	1	71,274	---
55	15 - 17N - 17W	"	10/66	1	110,261	---

TABLE I (Continued)

No.	Location SEC TWP RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/83	Cumulative Gas Production MMCF 2/84
56	15 - 17N - 17W	Putnam	8/69	1	96,006	---
57	16 - 17N - 17W	"	2/66	1	64,886	---
58	16 - 17N - 17W	"	4/71	1	40,709	20,973
59	17 - 17N - 17W	"	8/73	1	4,192	3,206
60	20 - 17N - 17W	"	1/77	1	---	2,462
61	23 - 17N - 17W	"	7/82	1	4,627	---
62	27 - 17N - 17W	"	6/69	1	22,184	---
63	27 - 17N - 17W	"	2/67	1	48,198	---
64	12 - 17N - 18W	"	6/82	2	26,481 (8/84)	6,745 (8/84)
65	12 - 17N - 18W	"	5/84	1	2,422 (8/84)	---
66	15 - 17N - 18W	"	12/83	1	4,050 (8/84)	194 (8/84)
67	28 - 17N - 18W	"	7/69	1	17,820	473
68	32 - 17N - 18W	"	8/72	1	46,298	---
69	33 - 17N - 18W	"	1/79	1	---	300

TABLE I (Continued)

No.	Location SEC TWP RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/83	Cumulative Gas Production MMCF 2/84
70	27 - 17N - 20W	South Trail	7/81	1	1,095	183
71	32 - 17N - 20W	"	10/79	1	5,208	---
72	33 - 17N - 20W	"	11/79	1	32,717	14,175
73	34 - 17N - 20W	"	7/77	1	78,687	---
74	35 - 17N - 20W	"	2/78	1	1,916	1,180
75	36 - 17N - 20W	"	2/77	1	---	4,038
76	5 - 18N - 15W	NW Hucmac	7/82	1	4,928	---
77	5 - 18N - 15W	"	6/82	1	26,071	---
78	6 - 18N - 15W	"	12/82	1	11,475	---
79	6 - 18N - 15W	"	10/82	1	29,908	---
80	7 - 18N - 15W	"	4/82	1	11,012	---
81	14 - 18N - 16W	"	6/82	1	24,322	---
82	26 - 18N - 16W	Putnam	1/82	1	9,199	---
83	33 - 18N - 16W	"	1/78	1	8,519	---

TABLE I (Continued)

No.	Location SEC TWP RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/84	Cumulative Gas Production MMCF 2/84
84	34 - 18N - 16W	Putnam	10/81	1	29,979	---
85	34 - 18N - 16W	"	10/81	1	31,513	---
86	34 - 18N - 16W	"	3/82	1	12,554	---
87	34 - 18N - 16W	"	3/82	1	6,667	---
88	34 - 18N - 16W	"	6/82	1	5,000	---
89	35 - 18N - 16W	"	6/82	1	3,394	---
90	35 - 18N - 16W	"	7/82	1	1,938	---
91	35 - 18N - 16W	"	5/82	1	5,596	---
92	35 - 18N - 16W	"	5/82	1	3,386	---
93	35 - 18N - 16W	"	9/81	1	3,200	---
94	16 - 18N - 18W	"	11/62	1	48,451	---
95	22 - 18N - 18W	"	6/81	1	1,622	---
96	35 - 18N - 19W	"	7/81	1	---	7,528

TABLE I (Continued)

No.	Location SEC TWP RGE	Field Name	Discovery Date	Number of Wells	Cumulative Oil Production Barrels 11/84	Cumulative Gas Production MMCF 2/84
97	9 - 18N - 20W	North Camargo	2/82	1	4,069	---
98	25 - 18N - 20W	"	9/81	1	4,747	---
Total production from Red Fork Sandstone					2,464,729	105,883 MMCF

APPENDIX D

DATA USED IN PREPARING STRUCTURE AND ISOPACH MAPS

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
2-17N-15W, C-N/2	6986	7072	7196	178
3-17N-15W, SE, 1120'FSL&1320'FWL	6986	7072	7194	172
4-17N-15W, C-NW/4	7066	7158	7274	168
5-17N-15W, C-SW-NE	7086	7182	7300	174
9-17N-15W, C-NE/4	7118	7209	7239	168
15-17N-15W, 1320'FNL&1320'FWL	7244.5	7340	7472.5	186
19-17N-15W, 100'E OF C-S/2	7441	7551	7687	194
24-17N-15W, C-NW-SE	7207	7293	7435	198
26-17N-15W, 1320'FSL&1320'FWL	7350	7440	7580	190
27-17N-15W, C-SE	7371	7467	7609	204
27-17N-15W, C-SW	7400	7500	7646	202
28-17N-15W, C-SW/4	7447	7551	7689	194
29-17N-15W, C-SW/4	7489	7595	7727	190
30-17N-15W, 100' N OF CENTER SW	7487	7601	7737	200
30-17N-15W, C-SE/4	7492	7604	7734	190
31017N-15W, SW-SE-NW	7543	7659	7799	208
32-17N-15W, 1200'FWL&1270'FWL	7574.3	7684.3	7824.3	202
33-17N-15W, SW/4	7517	7123	7777	214
34-17N-15W, 100' S OF 100' W OF C/NW	7428	7528	7668	200
34-17N-15W, C-SW/4	7458	7560	7714	212
35-17N-15W, C-NW	7376	7470	7616	200
36-17N-15W, NE-NE-SW	7385.5	7481.5	7617.5	194

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
1-17N-16W, SE-SE-NW	7204	7314	7436	[illegible]
2-17N-16W, SE-SE-NW	7204	7314	7436	184
2-17N-16W, C-NW	7177	7307	7407	166
3-17N-16W, NW-C	7233	7365	7469	182
2-17N-16W, C-SW-SE-SW	7163	7291	7405	186
3-17N-16W, 100' N OF C-SE-NE	7184	7308	7422	178
3-17N-16W, C-SW-NE-SW	7236	7370	7472	180
4-17N-16W, S/2-NW/4-NW/4-NE/R	7164	7298	7400	166
4-17N-16W, C-S/2-NE/4-SE/4	7244	7378	7478	186
4-17N-16W, 660'FE/L 1780'FS/L	7185	7317	7421	186
4-17N-16W, C-NW/4	7213	7354	7456	174
4-17N-16W, C-S/2-SE/4	7246.5	7382.5	7492.5	194
4-17N-16W	9257	7391	7491	147
5-17N-16W, 110'E OF C-NE-SW	7231	7379	7485	194
6-17N-16W, C-SE-NW	7214	7364	---	---
6017N-16W, 1320'FN & EL	7193	7341	7449	184
7-17N-16W, S/2-NE-SE	7309	7459	---	---
7-17N-16W, 300'E OF C-SW	7327	7483	7600	209
8-17N-16, C S/2-NE-SW	7297	7449	---	---
8-17N-16W, NW/4	7285	7431	7537	182
8-17N-16W, C-SE-NW	7283	7429	7537	194
9-17N-16W, 330'FNL 660'FEL	7258	7396	7504	188

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
9-17N-16W, C-NW/2	7301	7449	7551	184
10-17N-16W, 860'FNL&1980'FWL	7267	7399	7507	186
10-17N-16W, C-SW-NE	7319	7455	7567	196
12-17N-16W, SE-NW	7267.7	7393.7	7495.7	170
14-17N-16W, NW-E/2-W/2-NE-NW	7351.3	7481.3	7597.3	182
14-17N-16W, NE-SE	7296	7418	7548	186
15-17N-16W, C-NE-NE	7239	7471	7589	200
18-17N-16W, S/2-NW	7386	7544	---	---
18-17N-16W, 330'FEL&330'FSL	7440.4	7588.4	7692.4	182
19-17N-16W, 150'W&100'S OF C OF N/2 NW	7463	7604	---	---
19-17N-16W, SE-NE	7490	---	---	---
20-17N-16W, C-SE-NW	7487	7649	7753	206
20-17N-16W, C-NW-SW	7519	7682	7785	192
20-17N-16W, SE-NW	7487	7649	7553	212
22-17N-16W	7433	7573	7685	198
22-17N-16W, 1980'FSL 510'FEL	7446	7580	---	---
22-17N-16W, C-NE-NE	7422	7553	7688	206
23-17N-16W, 100W OF C OF NW	7437	7567	7689	190
23-17N-16W, 1770'FNL&1420'FEL	7428.5	7552.5	7672.5	196
24-17N-16W, C-SW/4	7447	7573	7695	194
24-17N-16W, C-NW-SE	7419	7545.	7661	194
25-17N-16W, C-NE-SE	7475	7587	7725	206

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
26-17N-16W, C-NE/4	7479.2	7609.2	7731.2	200
25-17N-16W, NE-SE-SW-SE	7527	7663	7785	210
29-17N-16W, C-NE/4	7543.3	7689.3	7795.3	188
33-17N-16W, NE/4	7649.2	7803.2	7909.2	208
35-17N-16W, C-NW-SE	7580.7	7724	7836.6	200
35-17N-16W, C-NE-NW	7547	7685	7803	206
1-17N-17W, SE-NW	7211.4	7359.4	7481.4	198
1-17N-17W, C-NE	7211	7365	7475	182
2-17N-17W, SW-NE-SW	7275	7437	7543	196
3-17N-17W, SW-NE-SW	7288.5	7449.5	7569.5	208
5-17N-17W, C-SW/4	7346	7522	7610	180
5-17N-17W, W/2-W/2-NE/4	7308	7482	7594	206
5-17N-17W, C-SE-SE	7334.6	7498.6	7604.6	186
5-17N-17W, SE/SE-NW/SE	7332.8	7496.8	7606.8	186
6-17N-17W, C-SE/4	7364	7556	7638	168
7-17N-17W, NE-SE-NW-NW	7495	7703	7801	196
7-17N-17W, NW/4-SE/4	7419	7625	---	---
7-17N-17W, C-SW-NE	7422	7622	7706	180
7-17N-17W, C-SW/4	7461	7649	7737	172
7-17N-17W, 1320'FSL&1320'FWL	7434.5	7636.5	7724.5	200
8/17N-17W, SW-NE-SW	7423	7616	7699	192
9-17N-17W, SW-SW-NW-SE	7391.5	7565.5	7661.5	200

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
10-17N-17W, C-SE-SW	7399	[illegible]	---	---
9-17N-17W, C-SE-SE	7322	7502	7600	206
9-17N-17W, NW-SE	7401	7577	7679	202
9-17N-17W, SE-SW	7424.5	7610.5	7698.5	192
10-17N-17W, C-SW-SE	7390	7560	---	---
11-17N-17W, NE-SW	7344	7504	7610	198
11-17N-17W, C-SW-SW	7374	7534	---	---
12-17N-17W, C-NW/4	7316	7478	7584	188
7-17N-17W, SE-SE	7410	7598	7680	190
13-17N-17W, C-NE-SW	7429	7581	---	---
13-17N-17N, SW-SW-NE	7408	7564	---	---
13-17N-17W, C-NW-NW	7424	7588	---	---
15-17N-17W, C-W/2, NE/4	7448	7628	---	---
15-17N-17W, NE-NW	7423	7605	---	---
15-17N-17W, C-NE-SW	7472	7646	---	---
15-17N-17W, SE-NW	7448	7628	---	---
15-17N-17W, C-W/2, NE/4	7430	7623	---	---
13-17N-17W, C-NE-SE	7420	7580	7698	220
14-17N-17W 150'N OF CENTER SE-NE	7437	7595	---	---
14-17N-17W, NE-SE	7450	7606	---	---
14-17N-17-W, 150'N OF C-SW-NW	7425.5	7599.5	7745.5	210
14-17N-17W, C-NW-SW	7461	7623	---	---
14-17N-17W, C-NW-NW	7410	7472	---	---

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
15-17N-17W, C-NE	7426	7506	7702	178
15-17N-17W, 150'N OF C-NE-SE	7462	7634	7736	202
16-17N-17W, NE-NE-2	7441	7621	7713	178
16-17N-17W, 660'FWL-1650'FSL	7504	7692	7772	190
16-17N-17W, 845'FNL&710'FWL	7442	7635	7720	200
16-17N-17W, C-NW	7454	7644	7728	200
16-17N-17W, 1980'FNL&2180'FEL	7461	7643	---	---
17-17N-17W, 990'FNL&360'FEL	7442	7628	---	---
17-17N-17W, C-W/2	7473.5	7661.5	7743.5	192
18-17N-17W, 1520'FNL 1320'FEL	7457	7647	7727	160
18-17N-17W, C-SW/4	7452	7648	7720	172
19-17N-17W, NW-SE-NW	7509	7699	7775	188
20-17N-17W, C-NW/4	7512	7696	7764	184
22-17N-17W, W/2-NE-SW	7583	7757	---	---
23-17N-17W, C-SW-SW	7591	---	---	---
23-17N-17W, C-SE-NW	7537	7709	7807	194
24-17N-17W, 1650'FSL&1650'FWL	7541	7717	7813	184
27-17N-17W, C-NE-NE	7611	7791	7885	204
27-17N-17W, C-NW-SE	---	7828	---	---
28-17N-17W	7624	7808	7892	190
29-17N-17W, C-NW/4	7582	7768	7846	190
30-17N-17W, NW	7538	7720	7788	178

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
30-17N-17W, N/2-N2	7562	7744	7814	178
34-17N-17W, C-SW-NE	7729	7925	8017	196
86-17N-17W, 1320'FSL&1045'FWL NE/4	7697.7	7871.7	7977.3	212
3-17N-18W, 225'S OF C-SE/4	7445	7667	7746	190
3-17N-18W, SW-NE	7429.6	7557.6	7727.6	170
10-17N-18W, C-NW-SE	7457	7675	7737	156
11-17N-18W, C-SE-NE	7498	7702	7770	160
12-17N-18W, C-SE	7511	7721	7805	188
12-17N-18W, C-NE-NE-SE	7483	7685	7803	220
9-17N-18W, 2355'FNL&1980'FWL	7601	7843	7929	200
28-17N-18W, E/2,1/4 NW/4, NE/4	7809	8053	8141	222
16-17N-18W, 830'FSL&900'FWL	7704	7946	8036	200
12-17N-18W, 330'FSL 1880'FWL NW/4	7474	7694	7776	210
15-17N-18W, 1650'FEL&1320'FSL SE/4	7480	7688	7756	144
12-17N-18W, C-NE-SW	7485	---	---	---
12-17N-18W, C-NE-SW	7485	---	---	---
12-17N-18W, C-SE-NE	7477	7689	7779	180
12-17N-18W, C-NE-NE-SE	---	7641	7783	204
12-17N-18W, C-SE	7511	7721	7793	190
12-17N-18W	7477	7687	7763	196

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
12-17N-18W, 990'FNL&1780'FEL	7461	7671	---	---
12-17N-18W, C-NE-SW	7498	---	---	---
13-17N-18W, C-SE/4	7444	7650	7722	184
13-17N-18W, C-SE-NW	7508	7676	---	---
13-17N-18W, NW/2-NW/2-NW/2-SE/4	7452	7650	7722	180
13-17N-18W, 1576'FSL&1505'FEL SE/4 OF C	7483	7632	7710	186
14-17N-18W, C-SE-NW	7499	---	---	---
15-17N-18W, C-NE-NE	7466	---	---	---
16-17N-18W, SW-NE	7690.5	7919.5	8003.5	195
24-17N-18W, 1520'FNL&1480'FEL	7447	7639	7713	184
24-17N-18W, NE-SW	7504	7702	7776	184
27-17N-18W, NE/4	7668	7846	7884	120
28-17N-18W 400'FWL&FNL OF SE/4	7838	8082	8170	224
29-17N-18W, 1320'FSL&1320'FEL	7960	8214	8302	222
32-17N-18W, 2340'FSL&300'FWL OF SE/4	8207.2	8337.2	8435.2	224
33-17N-18W, C-NE-SW	8016	8253	8346	222
33-17N-18W, C-SW	8121	8345	8443	232
35-17N-18W, SW	7872	8078	7160	190
36-17N-18W, C-NE	7648	7832	7902	188
1-17N-19W, C-SW	7555	7825	7911	208
13-17-19W, SW-NE	7775	8049	8137	210

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
22-17N-19W, C-NW-NW-SE	7969	8287	8373	202
3-17N-19W	7642	7932	8024	222
25-17N-19W, C-SE-NW	7992.5	8314.5	8412.5	230
25-17N-19W, C-NW	7994	8316	8414	240
31-17N-19W, C-NE	8165	---	---	---
6-17N-20W, 2640'FSL&2640'FEL	8016	8234	8356	290
16-17N-20W, 164'S OF CENTER OF SW-SW-NE	8088	8476	8654	432
25-17N-20W, 110'W OF C-S/2	8181	---	---	---
26-17N-20W, E1/2, E1/2, W1/2, SW	8446	8776	8954	484
27-17N-20W, C-SW	8279	---	---	---
28-17N-20W, 1320'FNL&1770'FWL	8223	8943	9013	590
32-17N-20W	8443	---	---	---
33-17N-20W, C-SE	8470	8592	---	---
35-17N-20W, C-NE/4	8359	8841	8951	394
36-17N-20W, C-NW	8270	8790	8992	538
34-17N-20W, C-NW	8491.8	---	---	---
2-17N-21W, C-SE-NW	8261	8517	8649	258
5-17N-21W, C-NE-SW	8047	8279	8395	260
2-17N-21W, C-SE-NW-SE	8229	8379	8701	440
19-17N-21W, 1470'FNL&1230'FWL	8355.8	8605.8	9137.8	728
25-17N-21W	8320	8758	9132	684

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
29-17N-21W, 1320 FSL&2070'FWL	8236.5	8622.5	9200.5	898
1-18N-15W, C-NE-SE	6635	6681	6767	137
1-18N-15W, 990'FSL-765'FWL	6628	6712	6812	150
1-18N-15W, SW-NE	6571	6651	6757	150
2-17N-15W, C-SE-NW	6601	6691	---	---
5-18N-15W, C-NE-SW-SW	6640	6772	6847	165
5-18N-15W, NW/4	6581	6743	6833	170
7-18N-15W, C-NW-SE	6675	6835	6919	164
8-18N-15W, C-NW-SE	6702.5	6794.5	6896.5	154
10-18N-15W, C-SW-NW	6658	6748	6856	162
10-18N-15W, C-NW-SW	6679	6767	6777	160
12-18N-15W, C-SE/4	6658	6736	6844	149
13-18N-15W, C-NW/4	6725	6805	6915	160
13-18N-15W, C-E/2-SE/4	6757.4	6849.4	6947.4	162
14-18N-152, SW-SW-NE	6758	6840	6950	156
17-18N-15W, C-SW	6799	6887	---	---
22-18N-15W, C-SE-NW	6790	6870	6988	168
23-18N-15W, C-NE/4	6787	6865	6977	154
24-18N-15W, C-SE/4	6780	6818	6968	150
25-18N-15W, C-SE/4	6850	6934	7034	141
26-18N-15W, C-NE/4	6850.3	6958.3	7048.3	168
26-18N-15W	6840	6946	7040	162
29-18N-15W, C-SE-NW	6918	7036	7123	152
34-18N-15W, NW-SW-NE	6918	7032	7136	188

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
34-18N-15W, SE/4 1500'FSL OF 1/4 SEC 1320'FWL OF 1/4 SEC	6937	7045	7147	184
35-18N-15W, C-NE/4	6887	7003	7099	166
36-18N-15W, C-NE/4	6862	6992	7061	158
2-18N-16W, C-NE/4	6648	6760	6842	154
4-18N-16W, C-N/2-SW/4	6718	6854	6934	162
5-18N-16W, NW-NW-SW-NE	6697	6835	6913	162
5-18N-16W, C-NW	6710	6852	6932	168
5-18N-16W, C-NW-SE	6759	6895	6973	162
6-18N-16W	6724	6864	6946	150
7-18N-16W, E/2-W/2-SW/4	6840	6988	7070	151
8-18N-16W, C-SW-SW	6848	6988	7066	146
11-18N-16W, 1650'FNL 1650'FEL	6721	6841	6927	142
13-18N-16W, 1980'FS/L 660'FW/L	6832	6980	7054	176
13-18N-16W, C-NE	6804	6912	7018	166
14-18N-16W, C-N/2-N/2 OF SW	6831.5	6941.5	7041.5	158
17-18N-16W, 2140'FNL&2140'FEL	6826	6960	7046	156
17-18N-16W, 1830'FNL&1320'FWL	6826	6968	7050	162
18-18N-16W, 1980'FNL&1320'FWL	6878.8	7034.8	7108.8	170
19-18N-16W, NE-SW	6930	7080	7172	172
19-18N-16W, C-NE	6927	7077	7161	170
24-18N-16W, NE-SW	6927.5	7035.5	7133.5	152

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
25-18N-16W, C-SE	7008	7124	7228	162
26-18N-16W, SE-SE-SW	7071	7223	7301	185
26-18N-16W, C-W/2, SW	7141	7263	7365	178
28-18N-16W, 200'N OF C-SW-SW	7061	719	7299	186
28-18N-16W, 340'E OF C-SE-NW	7012	7148	7242	174
3-18N-16W, SW-SW	7044	4194	7290	170
3-18N-16W, NW	6996	7152	7244	184
31-18N-16W, NE-SW	7132	7280	7380	186
32-18N-16N, 1825'FNL&2010'FWL	7097.5	---	---	---
33-18N-16W, C-SW	7136	7272	7380	184
34-18N-16W, W-SE	7149	7279	7389	193
34-18N-162, C-SE-SW	7143.5	7275.5	7383.5	190
34-18N-16W, C-NE-NE	7082	7207	7312	183
34-18N-16W, NE/4	7105	7237	7345	192
34-18N-16W, C-SE-NW	7114	7246	7354	188
34-18N-16W, NE-SE	7115	7249	7361	200
35-18N-16W, CENTER E/F	7127	---	---	---
35-18N-16W, C-NW-NE	7063	7197	7287	178
35-18N-16W, S/2-NW-NW	7113	7255	---	---
35-18N-16W, W/2-E/2-NW	7064	7206	7292	176
35-18N-16W, SW-NE-SW	7119	7235	7343	174
37-18N-16W, SW-NE-SW	7130	7254	7348	172
36-18N-16W, C-SW/4-NE/4	7058	7168	7280	177

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
2-18N-17W, C-SW/4	6873	7033	7109	156
3-18N-17W, SW-NW-SE	6900	7070	7144	158
5-18N-17W, SW-NE	6962	7142	7204	140
6-18N-17W, 1320'FSL 1320'FWL C-SW	6930	7116	7180	140
6-16N-17W, C-SW-SW	6946	7134	7200	152
6-18N-17W, 2440'NSL&1440'EWL	6907	7095	7165	150
6-18N-17W, NW-SE	6916	7100	7168	144
7-18N-17W, 1000' S OF CENTER	6991.5	7187.5	7255.5	154
8-18N-17W, SW	6966	7156	7222	164
8-18N-17W, 1000'SW OF C	6969.5	7159.5	7225.5	158
9-18N-17W, 300'W & 150'S OF 1000' SE OF C	6978	7166	7234	134
9-18N-17W, C/SW/4	6977	7175	7247	142
10-18N-17W, C-NE/4	6952	7124	7194	158
11-18N-17W, C-SW/4	6935	7106	7183	162
12-18N-17W, 400'FNL&1320'FWL	6871	7035	7125	178
13-18N-17W, NW-NE-NW	6870	7028	7106	144
13-18N-17W, 660'FNL&300'FWL SE/4	6899	7055	7129	140
15-18N-17W, C-SW	7026	7209	7282	146
15-18N-17W, C-NW/4	7009	7195	7269	146
16-18N-17W, C-NE-SW	7052	7241	7311	162
17-18N-17W, C-NE-SW	7044	7144	7300	156

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
18-18N-17W, C-NE-SW	7086	7286	7348	162
19-18N-17W, NE-SW	7169	7371	7445	175
20-18N-17W, SE-NW-NW	7109	7313	7397	158
36-18N-17W, C-SW-NE	7137.5	7285.5	7383.5	180
20-18N-17W, C-NE-SW	7193	7408	7494	164
21-18N-17W, C NE/4	7110.8	7298.8	7374.8	146
21-18N-17W, C NW/4, 1300'FNL&1300'FWL	7098	7294	7364	174
21-18N-17W, SE-SE	7119.5	73.7.5	7389.5	165
22-18N-17W, SE-NE-SW	7099	7287	7369	178
23-18N-17W, C-SE-SE	7005.5	7171.5	7255.5	158
23-18N-17W, C-NE-SW	7009	7181	7259	150
24-18N-17W, NW-SE-SE	6971	7131	7217	162
25-18N-17W, C-NE-SW	7061	7229	7335	194
26-18N-17W, NE-SW	7092.1	7252.1	7346.1	182
27-18N-17W, C-SW-NE	7071	7239	7333	174
28-18N-17W, C-W/2	7192	7377	7468	188
28-18N-17W, NE-SW-NE	7148	7334	7432	186
29-18N-17W, C-SE-NW	7197	7399	7473	174
30-18N-17W, C-NE	7213	7417	7491	166
30-18N-17W, C-NW	7237	7447	7521	156
31-18N-17W, NE-SW	7351	7557	7637	180
31-18N-17W, C-NW	7336	7548	7626	183
32-18N-17W, C-NW/4	7257	7445	7533	184
32-18N-17N, C-NE-NW	7260	7438	7512	156
33-18N-17W, C-N/2-SW	7281	7415	7523	186

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interva Thickness (ft.)
33-18N-17W, C-NW-NW-NW	7225	7395	7491	182
34-18N-17W, C-SW-NE 1980'FNL&FEL	7192	7350	7456	192
34-18N-17W, C-SE-SE	7221	7385	7483	186
35-18N-17W, C-SE-NW	7145	7301	7401	186
35-18N-17W, C-N/2-N/2	7121	7277	7375	170
36-18N-17W, C-SW-NE	7137.5	7285.5	7383.5	180
1-18N-18W, C-SE/4	6934	7126	7194	160
1-18N-182, NE-SW	6940	7142	7208	162
2-18N-18W, C-SE-SE	6989	7165	7245	168
2-18N-18W, C-SE	6958	7168	7250	188
2-18N-18W, 150'S OF C-E/2-SW/4	6965	7167	7301	220
3-18N-18W, 135'E OF C-SW/4	6931	7149	7233	178
3-18N-18W, C-SE	6919	7141	7215	162
3-18N-18WC SW-NE	6933	7153	7233	184
4-18N-18W, E/SE/4	6934	7150	7238	186
4-18N-18W, SE-SW	6971	7197	7281	162
4-18-18W, C-NW-SE	6931	7153	7235	184
45-18N-18W, SE-NE-SW	6968.5	7208.5	7292.5	170
5-18N-18W, SE-SE	7001	7233	7321	192
6-18N-18W, C-NW/4	6967	7195	7277	180
7-18N-18W, C-E/2-SE	7085	7323	7407	182
7-18N-18W, 330'FNL&600'FEL	7053	7293	7381	188
7-18N-18W, SE-NE	7089	7323	7411	190

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
7-18N-18W, SE-SE-NE	7068.4	7326.4	7414.4	190
8-18N-18W, 1880'FEL 2080'FSL SE/4	7074	7310	7398	180
9-18N-18W, C-NE-SW	7042	7266	7354	178
10-18N-18W, SW-SW	6996	7220	7302	156
11-18N-18W, 102'E OF C SW/4	7041	7249	7327	168
12-18N-18W, 1000' SE OF C	7008	7202	7268	158
13-18N-18W, C-SW-SW	7118	7324	7392	164
14-18N-18W, C-NE-SW	7103	7305	7377	130
15-18N-18W, NE-SW	7090.5	7304.5	---	---
16-18N-18W, SW-NE	7073	7317	7409	200
16-18N018W, 320'FNL 1270'FEL NE/4	7052.6	---	7366.6	138
17-18N-18W, C-SW-NE	7128	7360	7444	190
19-8N-18W, SE/4	7306	7548	7638	184
21-18N-18W, SW-NE	7207	7433	7523	172
21-18N-18W, 150' NE OF NE-NE	7145	7365	7451	166
21-18N-18W, C-NE-NE	7153	7377	7463	168
21-18N-18W, NW/SE	7234	7463	7556	178
22-18N-18W, SE	7207	7423	7501	160
22-18N-18W, 660'FNL&660'FEL	7145	7359	7439	162
22-18N-18W, C-SW-NE	7168	7386	7464	164
23-18N-18W, C-NE/4	7173	7373	7455	174
23-18N-18W, C-NE-SW	7197	7401	7476	141

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm (subsea elev.)	Red Fork Interval Thickness (ft.)
24-18N-18W, E/2-NE-SW	7187	7399	7475	174
24-18N-18W, 1320'FSL-1320'FWL	7192	7404	7482	184
25-18N-18W, 975'N & 200'W OF C	7257	7469	7545	174
25-18N-18W, C-N/2-NE	7241	7449	7517	148
25-18N-18W, C-SW	7294	7502	7574	176
26-18N-18W, C-NE-SW	7318	7504	7620	186
26-18N-18W, C-NW-NE	7229.6	7443.6	7521.6	182
26-18N-18W, NW-SW-NE	7258	7472	7552	176
26-18N-18W, C-NE-SW	7318	7536	7618	180
27-18N-18W, C-NE-SW	7341	7559	7645	176
27-18N-18W, N/2-S/2-NE/4 200'S - C-NE	7303	7517	7601	180
30-18N-18W, C-NE	7352	7604	7684	176
34-18N-18W, 1320'FNL&1320'FEL	7394	7606	7686	168
35-18N-18W, C-NE/4	7357	7571	7655	184
35-18N-18W, C-SW	7411	7619	7705	172
36-18N-18W, C-NW	7359	7565	7645	168
4-18N-19W, 2310'FNL&2310'FEL	7224	7446	7582	244
6-18N-19W, C-NW	7110	7348	7494	258
8-18N-19W, 2020'FWL&1420'FSL	7235	7475	7617	244
9-18N-19W, C-W/2	7194	7428	7566	224
10-18N-19W, C-S/2	7177	7445	7577	228
11-18N-19W, C-E/2	7135	7391	7487	194

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
12-18N-19W, SW-SW-NE	7112.5	7360.5	7452.5	174
13-18N-19W, E/2-W/2-NE/4	7168	7414	7510	190
14-18N-19W, C-SE/4	7238	7500	7592	194
22-18N-19W	7322	7596	7702	206
23-18N-19W, C-NE-SW	7308	7576	7664	192
26-18N-19W, C-NE-SW	7444	7712	7800	194
3-18N-20W, 1320'FW/L330'FS/L	6992	7230	7298	174
3-18N-20W, C-NW/4	6986	7219	7288	172
4-18N-20W, 220'S OF C S/2-NW/4	7045	7295	7367	182
5-18N-20W, C-NE	7062	7320	7384	184
9-18N-20W, C-SE-NW-SE	7183	7451	7533	208
12-18N-20W, 1320'FNL&FWL NW	7204	7519	7652	260
16-18N-20W, C-NW/4	7239	7545	7625	210
17-18N-20W, C-SE/4	7349.2	7635.2	7717.2	202
21-18N-20W, C-NE/4	7314	7674	7764	212
33-18N-20W, 2055'FNL-1350'FWL	7744	8094	8234	310
3-18N-21W, 1000'FNL&FEL	7205	7493	7553	192
11-18N-21W, W/2,3/2-NW	7339	7605	7671	186
12-18N-21W, NW-SE	7312	7618	7692	192
16-18N-21W, C-NE/4	7457.2	87717.4	7805.4	224
19-18N-21W, C-NE	7522	7946	8034	194
23-18N-21W, NW-NW-SE	7577.5	7903.5	7987.5	220

Well Location	Top Pink Lm. (subsea elev.)	Top L. Red Fork (subsea elev.)	Top Inola Lm. (subsea elev.)	Red Fork Interval Thickness (ft.)
30-18N-21W, 1742'FNL&1622'FWL	7632.5	7688.5	7984.5	228
33-18N-21W	7817	---	---	---
5-18N-21W, C-NE/4	7297	7527	7617	198
14-18N-21W, C-NE	7338.2	7696.2	7764.2	216
16-18N-21W, C-NE/4	7457.4	7717.4	7805.4	224
14-17N-18W, 1320'FSL&1440'FWL	7514	---	7778	150

VITA

UdayaShankar K. V.

Candidate for the Degree of

Master of Science

Thesis: DEPOSITIONAL ENVIRONMENT, PETROLOGY, AND DIAGENESIS OF RED FORK SANDSTONE IN CENTRAL DEWEY COUNTY, OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in India on May 30, 1956, son of Mr. and Mrs. K. Venkatramana Bhat.

Education: Received Bachelor of Science degree in Geology, December, 1977 from University of Calicut, India. Received Master of Science degree in Geology, March, 1979 from Karnatak University, Dharwar, India. Received Diploma of Indian Institute of Technology, Bombay, India in Hydrology, September, 1979. Completed requirements for the Master of Science degree at Oklahoma State University in July, 1985.

Junior Member of the American Association of Petroleum Geologists.

LEGEND

○ LOCATION	☼ GAS WELL
✧ DRY HOLE	✳ ABANDONED GAS WELL
• OIL WELL	✱ OIL & GAS WELL
✦ ABANDONED OIL WELL	△ CORE LOCATION
◎ RED FORK PRODUCER	

CONTOUR INTERVAL 100'

SCALE IN MILES

0 1/2 1 2 3

PLATE I

STRUCTURAL CONTOUR MAP ON TOP OF PINK LIMESTONE

DEWEY Co., OKLAHOMA

DRAWN BY DJT CONTOURED BY UDAYA SHANKAR

LEGEND

○	LOCATION	✲	GAS WELL
✧	DRY HOLE	✲	ABANDONED GAS WELL
•	OIL WELL	✱	OIL & GAS WELL
✦	ABANDONED OIL WELL	△	CORE LOCATION
⊙	RED FORK PRODUCER		

CONTOUR INTERVAL 100'

SCALE IN MILES

0 1/2 1 2 3

PLATE II

STRUCTURAL CONTOUR MAP ON TOP OF INOLA LIMESTONE

CONTOURED BY UDAYA SHANKAR

LEGEND

○ LOCATION	☼ GAS WELL
✧ DRY HOLE	☼ ABANDONED GAS WELL
• OIL WELL	✷ OIL & GAS WELL
✦ ABANDONED OIL WELL	△ CORE LOCATION
◎ RED FORK PRODUCER	— — — HYPOTHETICAL CONTOUR LINES

CONTOUR INTERVAL 10'

SCALE IN MILES

0 1/2 1 2 3

PLATE III

ISOLITH MAP OF UPPER RED FORK SANDSTONE

NET SANDSTONE

CONTOURED BY UDAYA SHANKAR

——LEGEND——

○ LOCATION
✧ DRY HOLE
• OIL WELL
✦ ABANDONED OIL WELL
◎ RED FORK PRODUCER
☼ GAS WELL
✳ ABANDONED GAS WELL
✱ OIL & GAS WELL
△ CORE LOCATION

CONTOUR INTERVAL 10'

SCALE IN MILES
0 1/2 1 2 3

PLATE IV

ISOLITH MAP OF LOWER RED FORK SANDSTONE

NET SANDSTONE

CONTOURED BY UDAYA SHANKAR

PLATE V

ISOPACH MAP OF THE ENTIRE RED FORK FORMAT.

Top of the Inola Limestone to
Top of the Pink Limestone

CONTOURED BY UDAYA SHANKAR

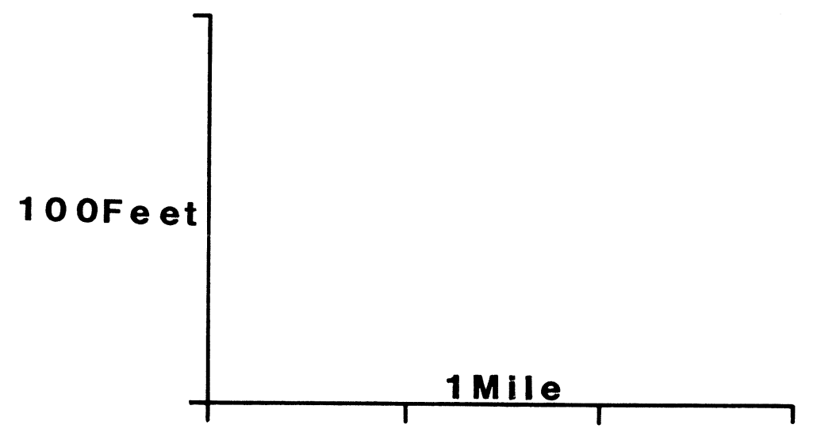
SCALE IN MILES

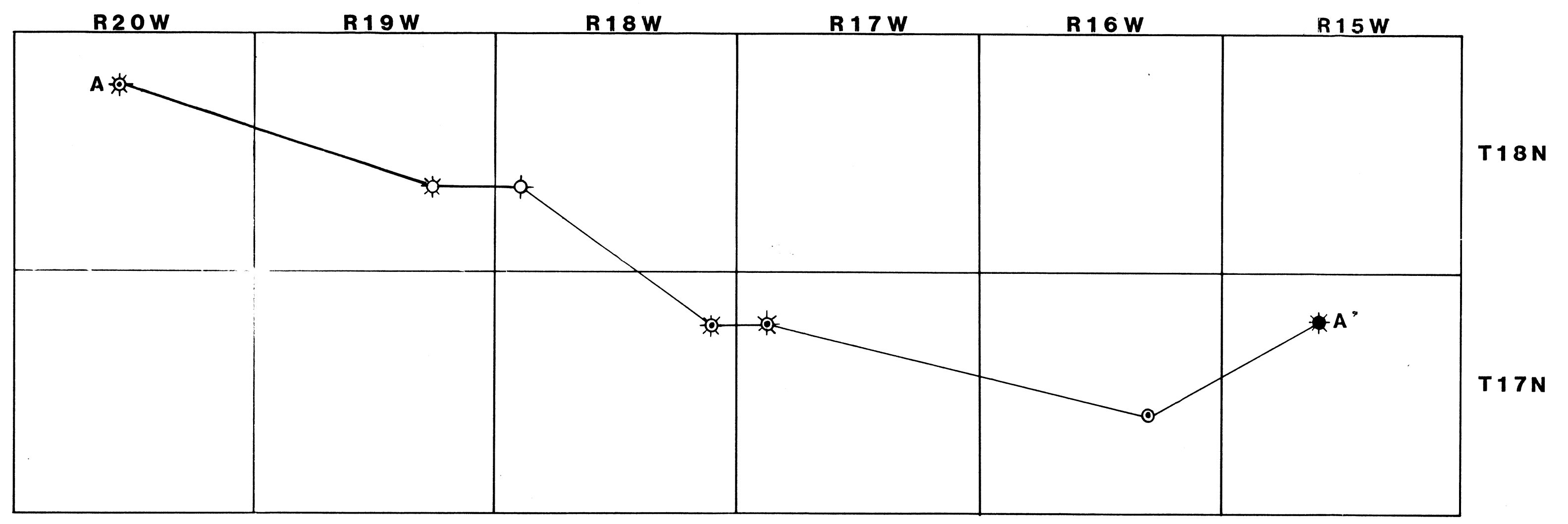
0 1/2 1 2 3

LEGEND

○ LOCATION	✳ GAS WELL
✧ DRY HOLE	✳ ABANDONED GAS WELL
• OIL WELL	✱ OIL & GAS WELL
✦ ABANDONED OIL WELL	△ CORE LOCATION
⊙ RED FORK PRODUCER	

CONTOUR INTERVAL 20'





◎ RED FORK PRODUCER

STRIKE ORIENTED STRATIGRAPHIC CROSS-SECTION A-A'

PLATE VI

UDAYASHANKAR.K.V.

DIP ORIENTED
STRATIGRAPHIC
CROSS-SECTION B-B'
PLATE VII

UDAYASHANKAR.K.V.

DIP ORIENTED STRATIGRAPHIC
CROSS-SECTION C-C'
PUTNAM FIELD
PLATE VIII

UDAYASHANKAR.K.V.

DIP ORIENTED STRATIGRAPHIC
CROSS-SECTION D-D'
PUTNAM FIELD
PLATE IX

UDAYASHANKAR.K.V.