PETROGRAPHY AND DIAGENESIS OF THE MCLISH FORMATION, SIMPSON GROUP (MIDDLE ORDOVICIAN), SOUTHEASTERN ANADARKO BASIN, OKLAHOMA

By

SCOTT JAMES WEBER

Bachelor of Science

University of Wisconsin-Madison

Madison, Wisconsin

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Thesis approved:

Zuhair al-Shaieb
Thesis Adviser

Arthur W. Cleaves

Gary F. Stewart

Norman N. Durham
Dean of the Graduate College

1275757

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I thank my Lord Jesus for guiding me and always being there (Psalm 71).

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CHAPTER I

INTRODUCTION

General Statement

In recent years a resurgence of exploration activity has taken place in the "Golden Trend" of Garvin and McClain Counties, Oklahoma. The original drilling play was for Pennsylvanian rocks, but now the targets of interest are in deeper horizons. Even at the current price for oil it is economically feasible to drill in the "Golden Trend." The Simpson Group is one of the deeper horizons attracting attention. The Simpson Group has performed the best of the deep horizons thus far. There are substantial quantities of hydrocarbons to be found in these older rocks.

The McLish Formation is the middle formation in the Simpson Group. The formation is a series of Middle Ordovician sandstones, carbonate rocks, interbedded carbonate rocks and shales, interbedded sandstones and shales, sandstones and shales that cover much of Oklahoma in the subsurface, and crop out in south-central Oklahoma in the Arbuckle Uplift and Criner Hills. There are two units in the McLish Formation: a lower unit that is sandstone and an upper unit consisting of thin to massively bedded carbonate rocks, interbedded carbonate rocks and shales, and sandstones and shales, sandstones and laminated shales.

Deposition of the McLish Formation took place in an epicontinental sea during the Middle Ordovician Age. The sea covered much of the North American continent. Of particular interest to this study is the region described as the Southern Oklahoma Aulacogen.

Objectives

The main objectives of this investigation are: 1) To analyze the petrography of the McLish Formation from wells at different depths in the southeastern end of the Anadarko Basin and in outcrops in the Arbuckle Uplift area. 2) To determine the diagenetic history and a paragenetic sequence for the McLish Formation, relating these to the geologic history of the formation. 3) To determine possible depositional environments for the McLish Formation. 4) To relate the petrography and diagenesis of the McLish Formation from core, in the Beard No. 1, Costello No. 1 and Mazur No. 1 wells to wireline-log characteristics of said wells.

Location of Study Area

The study area is located in south-central Oklahoma (Figure 1). There are two components to this study, the subsurface part and the surface part.

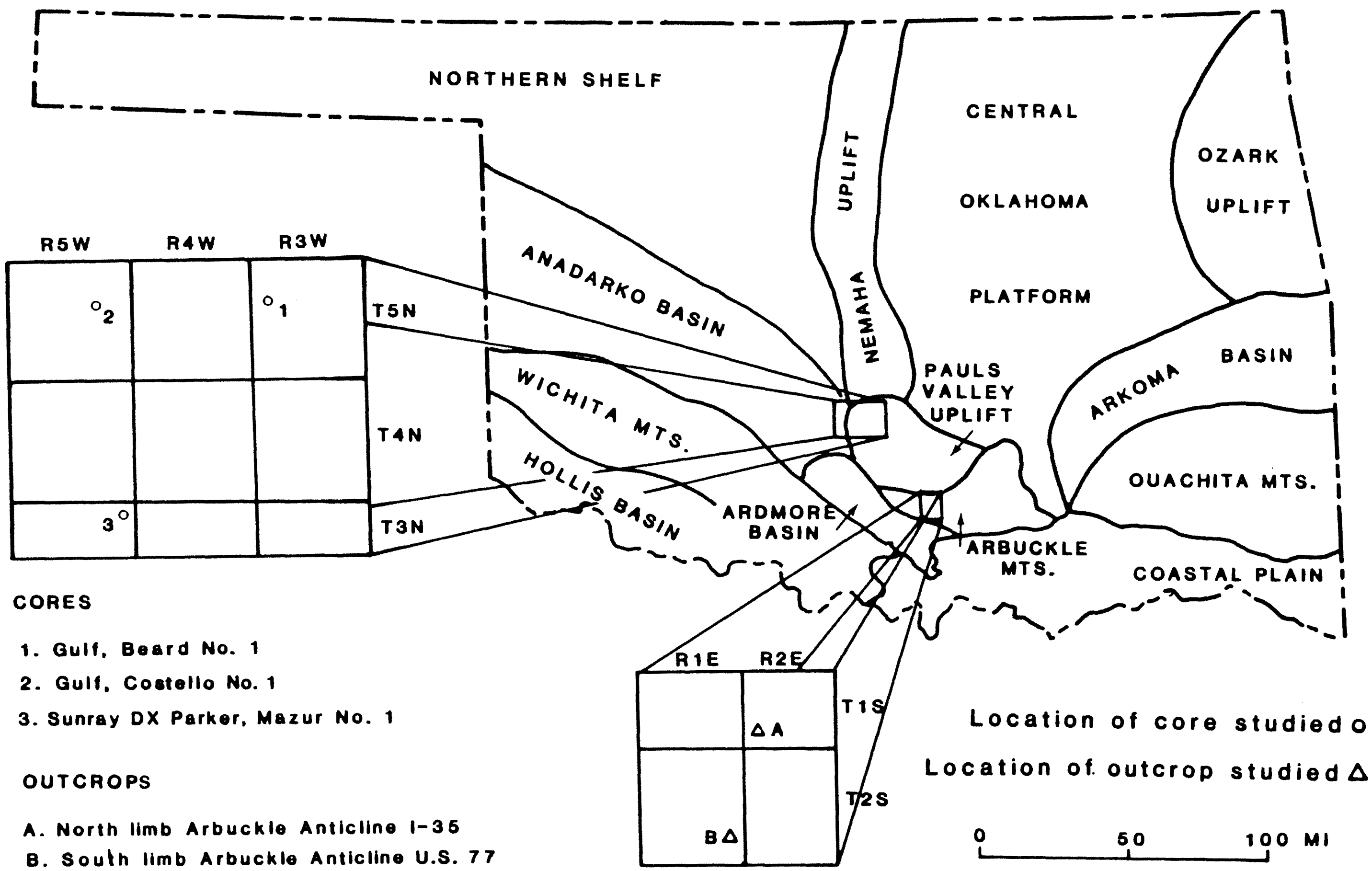


Figure 1. Location of cores and outcrops and tectonic features of Oklahoma.

Subsurface

The subsurface portion is located in Townships 3 to 5 North and Ranges 3 to 5 West, in McClain, Grady and Garvin Counties, Oklahoma, on the northeastern flank of the Anadarko Basin (Figure 1). Cores from three wells were studied: (1) the Gulf Oil Co., Beard No. 1, in section 18, T.5N., R.3W., McClain County, Oklahoma, (2) the Gulf Oil Co., Costello No. 1, in section 14, T.5N., R.5W., Grady County, Oklahoma, (3) the Sunray DX Parker, Mazur No. 1, in section 1, T.3N., R.5W., Grady County, Oklahoma. These three wells describe a traverse from the shelf edge to the deeper reaches of the Anadarko Basin.

Surface

The second part of this study concerns outcrops that are in the Arbuckle Uplift area, Townships 1 and 2 South and Ranges 1 and 2 East, Carter and Murray Counties Oklahoma (Figure 1). The Arbuckle Uplift is located east of the Anadarko Basin, north of the Ardmore Basin, south of the Nemaha Ridge and Northern Shelf areas, and west of the Arkoma Basin (Figure 1). In the Arbuckle Uplift area are the best exposed sections of lower Paleozoic rocks in the Mid-Continent region. This has been one of the most intensively studied localities of Paleozoic rocks in the United States. The Arbuckle Uplift is one of a series of northwest-southeast trending anticlines in south-central

Oklahoma. The outcrop area was chosen for completeness of sections and access to outcrops of the McLish Formation.

The northern exposure is on the north limb of the Arbuckle Anticline on the east side of Interstate Highway 35, in section 30, T.1S., R.2E., Murray County, Oklahoma (Figure 1). A map from Fay (1969) was used to locate the outcrop. The southern outcrop is located along State Highway 77 on the east and west sides of the road, in section 25, T.2S., R.1E., Carter County, Oklahoma (Figure 1). The outcrops are relatively well exposed to poorly exposed. Some parts are covered by soil and/or float. The outcrop along State Highway 77 has very low relief.

Method of Investigation

Analysis of the McLish Formation in the subsurface in southwestern McClain and southeastern Grady Counties, Oklahoma, was accomplished by using three cores. They were logged and sampled. Samples were taken from the Gulf Oil Co., Beard No. 1 (50 thin-sections, see Plate VI), the Gulf Oil Co., Costello No. 1, (50 thin-sections, see Plate VII) and the Sunray DX Parker, Mazur No. 1, (28 thin-sections, see Plate VIII). The Beard core is on file at the Oklahoma Core Library in Norman, Oklahoma. The other two cores were logged, sampled, and photographed at the United States Geological Survey Core Repository in Denver, Colorado. Each of the cores was slabbed, photographed, (see Plates X, XI, and XII) logged, and sampled for thin-sections. Thirty samples were collected from the two outcrop sections of the formation in the Arbuckle Uplift area. Twenty seven of the samples were made into thin-sections (see Plate IX). Three shale samples were used for X-ray diffraction. Each thin-section was analyzed using a petrographic microscope. Three hundred points were counted on each slide. All thin-sections were impregnated with blue epoxy to help aid identification of porosity. The slides were stained with potassium ferricyanide and Alizarin Red-S in a weak HCl solution to help in distinguishing among calcite, dolomite, ferroan calcite and ankerite. The thin sections from the United States Geological Survey were stained with sodium cobaltinitrite solution to stain potassium feldspars. X-ray diffraction was run on selected samples to help identify constituents. Petrologic Logs were compiled of the cores and outcrops, listing: lithology, structures, color, grain size, maturity, fossils and constituents both detrital and authigenic (see Plates I, II, III, IV, and V). Data from point-counting were collected on petrographic-analysis forms and input and compiled using LOTUS on an IBM PC (see Plates VI, VII, VIII, and IX).

Previous Investigations

Since Taff first proposed the name Simpson Formation in 1902, the rocks making up this section have been studied extensively. The early literature concentrates on correlation, paleontology and regional and local geologic mapping. In the 1930's, petroleum was discovered in the Simpson Group and since that time studies for economic and academic purposes have been pursued. In addition to having potential as a reservoir for hydrocarbons, the basal sandstone units, especially in the Oil Creek and McLish Formations, have been mined extensively for glass sand in the Arbuckle Mountains region (Ham, 1945).

Although the Simpson Group has been studied extensively for the larger part of a century, the petrography, diagenesis, paragenesis and depositional environments of the McLish Formation have not been thoroughly described in the existing literature. The Bromide Formation has been studied the most extensively of all formations in the Simpson Group. Much of what has been written about the Bromide Formation can be related to the McLish Formation in general. Although the upper four formations of the Simpson Group are similar in many respects, each formation has its own distinct identity.

The McLish was first used as a subdivision of the Simpson "Formation" by Ulrich (1928). In the eastern Arbuckle Mountains the unit between the Oil Creek and the Tulip Creek was the McLish, but in the western part of the Arbuckle Mountains the unit was called the Falls. Ulrich first thought that the Falls was overlain by the McLish, but in 1929 he placed the McLish under the Falls. In 1931 Decker and Merritt, in their publication "The Stratigraphy and Physical Characteristics of the Simpson Group," raised the Simpson from a formation, as Taff had originally proposed in 1902, to a group. Decker and Merritt listed five formations of the Simpson, in ascending order: Joins, Oil Creek, McLish, Tulip Creek and Bromide Formations. The Falls Formation was abandoned as a local clastic facies of the McLish Formation. The five formations listed by Decker and Merritt are still accepted today, with minor alterations.

The McLish Formation was named for the McLish Ranch, four miles northwest of the town of Bromide, Oklahoma (section 35, T.1S. R.7E.). In 1938 Loeblich, in an unpublished thesis, described the type section on the McLish Ranch. This section is thin (approximately 200 feet thick) in comparison to the average in the Arbuckle Uplift area (450 feet thick). North and east of the Arbuckle Uplift the Tulip Creek appears to pinch out. In this region the McLish is overlain by the Bromide (Ham, 1945). In 1941 Decker published descriptions of six more Simpson sections from the Arbuckle area and remeasured two sections described in Oklahoma Geological Survey, Bulletin 55, dated 1931.

In 1945 Ham wrote "the Geology and Glass Sand Resources, Central Arbuckle Mountains, Oklahoma." This publication centered on basal sandstones of the McLish and Oil Creek Formations. Ham mapped outcrops of the two basal sandstones and performed a detailed laboratory analysis of the constituents of the basal sandstone units of the two formations.

In a subsurface study of the Simpson Group, Disney

(1952) used electric logs to construct cross-sections through northern, central, and southern Oklahoma.

Ham and McKinley (1954) described the "birdseye" limestone of the McLish Formation, stating that it was formed by algae, in the supratidal or intertidal zone.

Dapples (1955) correlated the St. Peter Sandstone with the basal sandstones units of the McLish, Tulip Creek and possibly the Bromide Formations of the Simpson Group. He assigned these formations to the Chazyan Stage and postulated that the Canadian Shield was the source of sands in the Simpson Group.

In 1956 Cooper dropped the terms Chazyan and Blackriverian and used the term Mohawkian as the Series; for the five Stages he used in (ascending order) Whiterockian, Marmorian, Ashbyan, Porterfieldian and Wildernessian. He assigned the Joins and Oil Creek Formations to the Whiterockian Stage. The McLish was put with the Marmorian with an unconformity separating the Oil Creek and the McLish. The Tulip Creek was assigned to the Ashbyan Stage. The Bromide was placed in the Porterfieldian and Wildernessian Stages.

Harris (1957) wrote an Oklahoma Survey Bulletin No. 75 on the Simpson Group of Oklahoma. He concentrated on the ostracoda fauna. He also compiled a thorough review of the literature on the Simpson Group from the date of Taff's, work (1902) through the articles most current in 1957. It is a very thorough compilation of the literature of the Simpson

Group up to 1957.

Williams (1957) studied petrography of the sandstone members of the Simpson Group.

Schramm (1964) published a lithofacies study of the Simpson Group.

The next major work published on the Simpson Group was done by the Tulsa Geological Society (1965) in Digest 33 "Symposium on the Simpson". This publication is informative on the subsurface and surface features of the Simpson Group not only in Oklahoma but also in the neighboring states. In this publication is a bibliography of the Simpson Group and equivalents in Kansas, Oklahoma and Texas (Cramer, 1965). Also, Statler presented a lithofacies study of the Simpson Group.

In 1972 Shanmugen used standard petrographic techniques in an attempt to differentiate among the sandstones of the Simpson Group. He determined from the data that the sandstones could not be differentiated by the techniques used.

Longman (1976) covered the depositional history, paleoecology and diagenesis of the Bromide Formation in the Arbuckle Uplift area of Oklahoma. Lewis (1982) described depositional environments and paleoecology of the Oil Creek Formation in south-central Oklahoma. In press is an Oklahoma Geological Survey Bulletin by J. Bauer. It covers the conodont biostratigraphy of the McLish and Tulip Creek Formations.

CHAPTER II

STRUCTURAL AND STRATIGRAPHIC FRAMEWORK

Structural Setting

The study area is located in the southeasternmost part of the Anadarko Basin. The Anadarko Basin is an asymmetrical basin elongated northwesterly. Asymmetry is due to uplift of the Wichita Mountains during the Pennsylvanian Period. The southern part of the basin is separated from the Wichita-Uplift by a series of faults. The basin is bounded to the east by the Nemaha Ridge, Pauls Valley and Arbuckle Uplifts, and to the north, northeast and west by broad shelf areas.

Stratigraphy

The Simpson Group consists of the Joins, Oil Creek, McLish, Tulip Creek and Bromide Formations in ascending order (Decker and Merritt, 1931). See Figure 2. The Simpson Group includes all rocks from the top of the Arbuckle Group to the base of the Viola Group.

As stated above, the McLish is the middle formation in the Simpson Group (Decker and Merritt, 1931). It is underlain unconformably by the Oil Creek Formation and overlain conformably to disconformably by the Tulip Creek

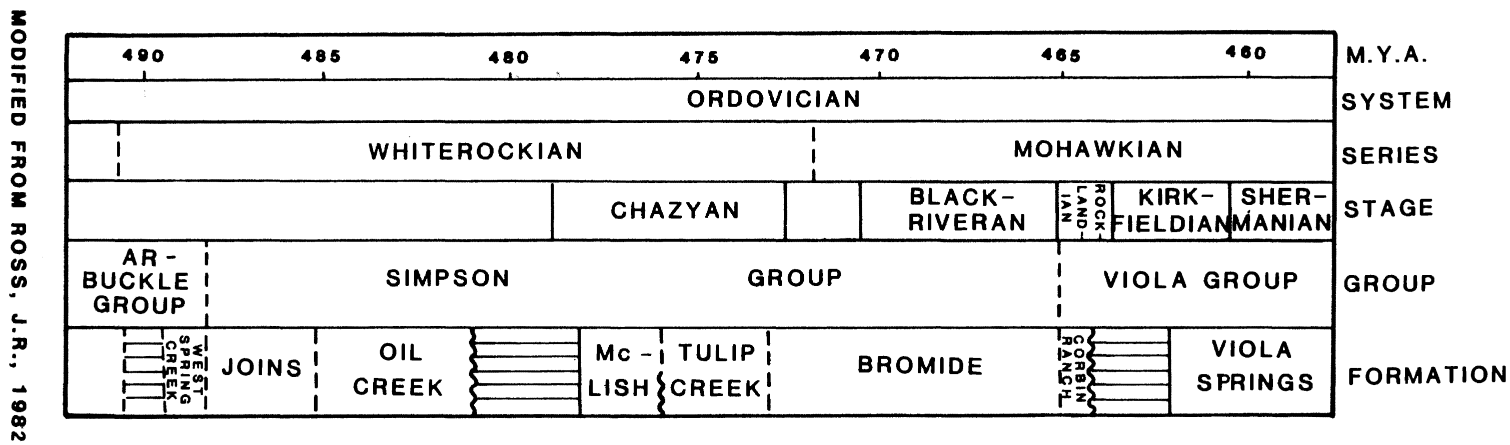


Figure 2. Stratigraphy of the Simpson Group (See Ross, 1982, for explanation of unlabeled stage names.

Formation (Ham, 1945). The McLish is considered to be of the middle Whiterockian Series (Cooper,1956) and traditionally of the Chazyian Stage, Middle Ordovician. The basal sandstone of the McLish Formation is thought to be equivalent to the basal St. Peter Sandstone of northern Arkansas, Missouri, Illinois and Wisconsin (Dapples, 1955 and Ireland, 1965). The McLish is a rock-stratigraphic unit, not a time-stratigraphic unit.

Stratigraphic Character

The lower unit of the McLish is a quartz-arenite, very fine to fine grained, rounded to well rounded, moderately well sorted to well sorted, and mature to supermature. The upper unit is composed of microcrystalline to coarsely crystalline fossiliferous carbonate rocks, interbedded carbonate rocks and shales, interbedded sandstones and shales, and sandstones. Some of the sandstones contain relatively large amounts of feldspar in comparison to other formations of the Simpson Group, and they contain shales in varying amounts. Carbonate rocks and sandstones are medium-bedded to massive. Shales tend to be green-gray to brown, laminated, fissile to blocky and pyritic.

Geologic History

The Precambrian stable craton was made up of crystalline rocks and, in northern Texas, of some meta-sediments.

In Middle to Late Cambrian time, formation of the Southern Oklahoma Aulacogen (Hoffman, Dewey and Burke, 1974 and Walper, 1976) began with rifting of the North American continent from Gondwanaland (Rankin, 1976). Uplift of the continent and igneous activity, both intrusive and extrusive, were widespread during this stage of development of the aulacogen (Wickham, 1978). Some of the evidence for formation of the aulacogen are the alkali volcanics (Carlton Rhyolite, 530 m.y.b.p.). Probable vertical movement along bounding faults of the aulacogen formed a graben during Cambrian time. This could account for the limited extent of the igneous rocks in the aulacogen (Wickham, 1978). As the active arms of the triple junction spread apart, (Burke and Dewey, 1973) the North American continent and Gondwanaland moved apart (Keller, et.al, 1983). The failed arm of the triple junction system extended into the continental interior and became the Southern Oklahoma Aulacogen (Burke, 1977 and Keller, et. al, 1983). The most likely position of the continental margin was in the vicinity of the present day Ouachita Foldbelt (Wickham, 1978).

From Late Cambrian to Early Mississippian time the Southern Oklahoma Aulacogen was in subsidence. A passive continental margin formed, and a thicker stratigraphic section formed in the aulacogen than on the more stable surrounding shelf areas (Donovan, 1983) see Figure 3. Lower Paleozoic sedimentary rocks in southern Oklahoma are

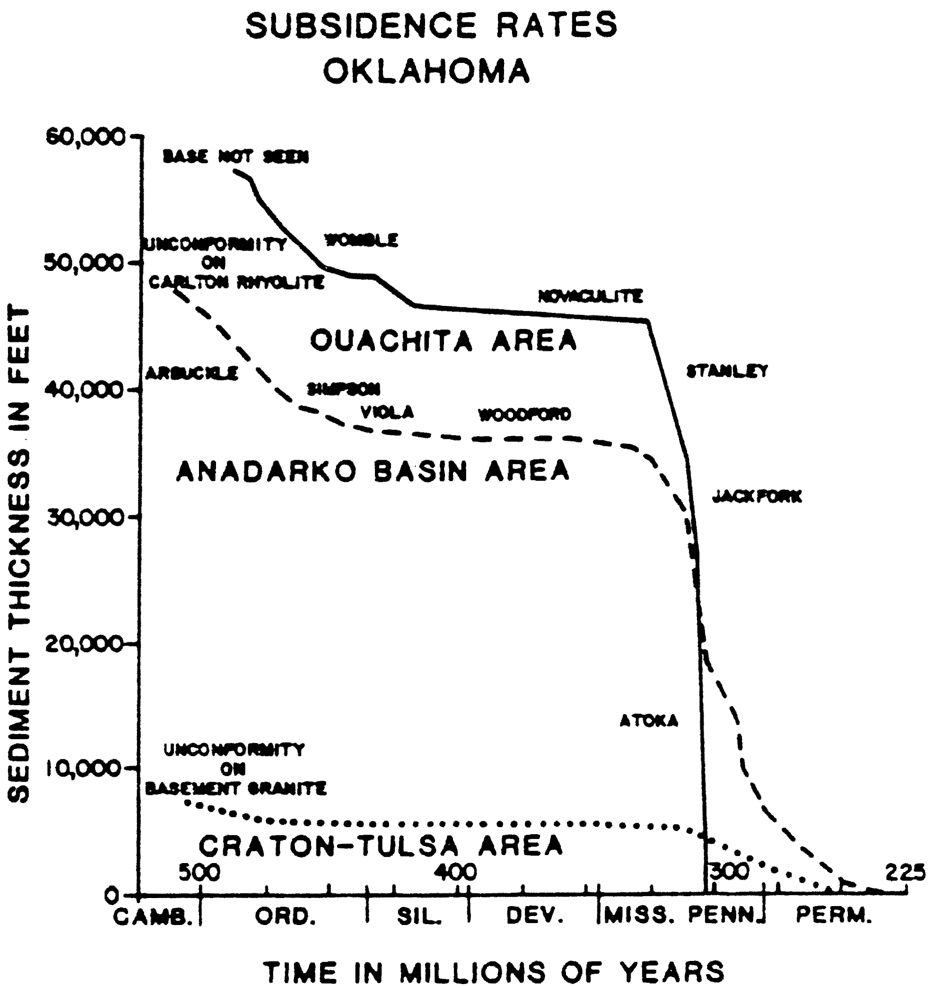


Figure 3. Sediment thickness as a function of time, and subsidence rate during Paleozoic time, (Donovan, et al., 1983).

predominantly carbonate rock, and clean, well sorted quartz sandstones. The abundance of fauna and flora and the sedimentary structures suggest that warm clear water was shallow enough for light to penetrate to the sea floor (Wickham, 1978).

The Reagan Sandstone was deposited on the eroded surface of the craton during a marine transgression. The distribution of the Reagan suggests that the Southern Oklahoma Aulacogen was a large embayment (Wickham, 1978).

Deposition of carbonate sediments was dominant by Canadian time. Approximately 7,000 feet of carbonate rock are preserved as the Arbuckle Group. Dolomite dominated deposition on the shallow restricted shelf, whereas limestone was deposited in the deeper aulacogen. Evidence of the graben's having subsided more rapidly than the craton is clear from isopachous maps of the Arbuckle Group (Wickham, 1978). Subsidence was accommodated by displacement along major faults bounding the aulacogen which were initiated in Late Precambrian during the rifting stage (Wickham, 1978).

A hiatus occurred in the Late Canadian and/or Early Whiterockian time. The upper part of the Arbuckle Group was eroded, deeply in some areas (Sloss, 1963). In the Southern Oklahoma Aulacogen, the period of erosion was not as prolonged as on the shelf areas. The Joins Formation, which is the lowermost formation of the Simpson Group, was deposited during a marine transgression. The cyclic appearances of the overlying Oil Creek, McLish, Tulip Creek and Bromide Formations indicate transgressive and regressive sequences. There is an unconformity at the top of the Oil Creek Formation. Between the McLish and the Tulip Creek there is a disconformity to paraconformity (Ham, 1945). The Tulip Creek and Bromide are conformable. In post Blackriveran time, there was a regression that eroded the top of the Bromide Formation.

Following deposition of the Simpson Group the most extensive inundation by the sea of the North American continent took place. The transgression appears to have been rapid because there were no well developed sand bodies at the base of the Viola Group. South of the Transcontinental Arch the Viola formation is primarily carbonate rock. In Oklahoma, this Cincinnatian carbonate is called the Viola Group. In Late Ordovician time, the Richmondian Stage, the Sylvan Shale was deposited in Oklahoma and adjacent areas above the Viola. The Sylvan may have been deposited in a shallow marine environment, or it may represent one of the first large-scale deepenings of the epicontinental sea.

The Hunton Group was deposited during the Silurian and Early Devonian. It is predominantly carbonate rock. Several unconformities are within the Hunton Group and they also bracket it (Manni, 1985). Slight deformation occurred during deposition. An angular unconformity between the lower and upper part of the Hunton (Amsden, 1975) may represent the end of the subsidence stage and the beginning of the deformational stage of the Southern Oklahoma Aulacogen. During Late Devonian time, sediments of the Woodford Shale were deposited over most of Oklahoma. The Woodford is black to brown and highly organic. It is overlain conformably by Mississippian carbonate and clastic strata.

Mississippian rocks consist of a series of carbonate rocks and shales. Deformation of the aulacogen and surrounding areas occurred during the last stage of the Southern Oklahoma Aulacogen, during Late Mississippian or Early Pennsylvanian time. Today, southern Oklahoma is a number of basins and uplifts that were not well defined during the subsidence stage. The Marietta, Ardmore, Anadarko and Arkoma Basins, and the Muenster, Criner, Arbuckle and Wichita Uplifts are the result of the deformation stage of the aulacogen.

Of the two periods of deformation the first is made evident by the formation, for the first time, of separate basins in the Southern Oklahoma Aulacogen. Thick sequences of Morrowan sediment were deposited in the Ardmore and Anadarko Basins. Some of the sediment was derived from adjacent uplifts. The first evidence of deformation is in Morrowan strata, in the form of carbonate conglomerates derived from the Criner Uplift (Wickham, 1978). In Middle Pennsylvanian time a second episode of orogenic activity occurred. Faults that bounded the aulacogen were reactivated as North America and Gondwanaland collided. The

Ouachita Foldbelt was formed. There is are theories that wrench faulting took place in this region (Wickham, 1978 and Donovan, 1986). At this point in time the basins and uplifts in the aulacogen were further defined. Rocks within the aulacogen were folded intensely; thrust faults are common on limbs of many folds (Wickham, 1978). No metamorphism or igneous activity accompanied the deformation.

Paleogeography

The North American continent moved across the equator from north to south, from Middle Cambrian to Late Silurian time (Witzke, 1980) see Figure 4. In Middle Cambrian time southern Oklahoma was on the equator and in the humid equatorial belt. This location is deduced from the established location of the North American continent in Lower Cambrian and Upper Ordovician time (McElhinny and Opdyke, 1973).

In Late Cambrian the Reagan Sandstone was deposited in an embayment in southern Oklahoma. The environment seems to have been hot and humid from the paleolatitude (Dott and Batten, 1976). The Transcontinental Arch and the Canadian Shield would have been the most likely source for the sand, because the Transcontinental Arch was an emergent feature possibly as early as Late Cambrian time. This relatively low positive feature extended almost continuously from New Mexico into central Minnesota (Ross, 1976). The

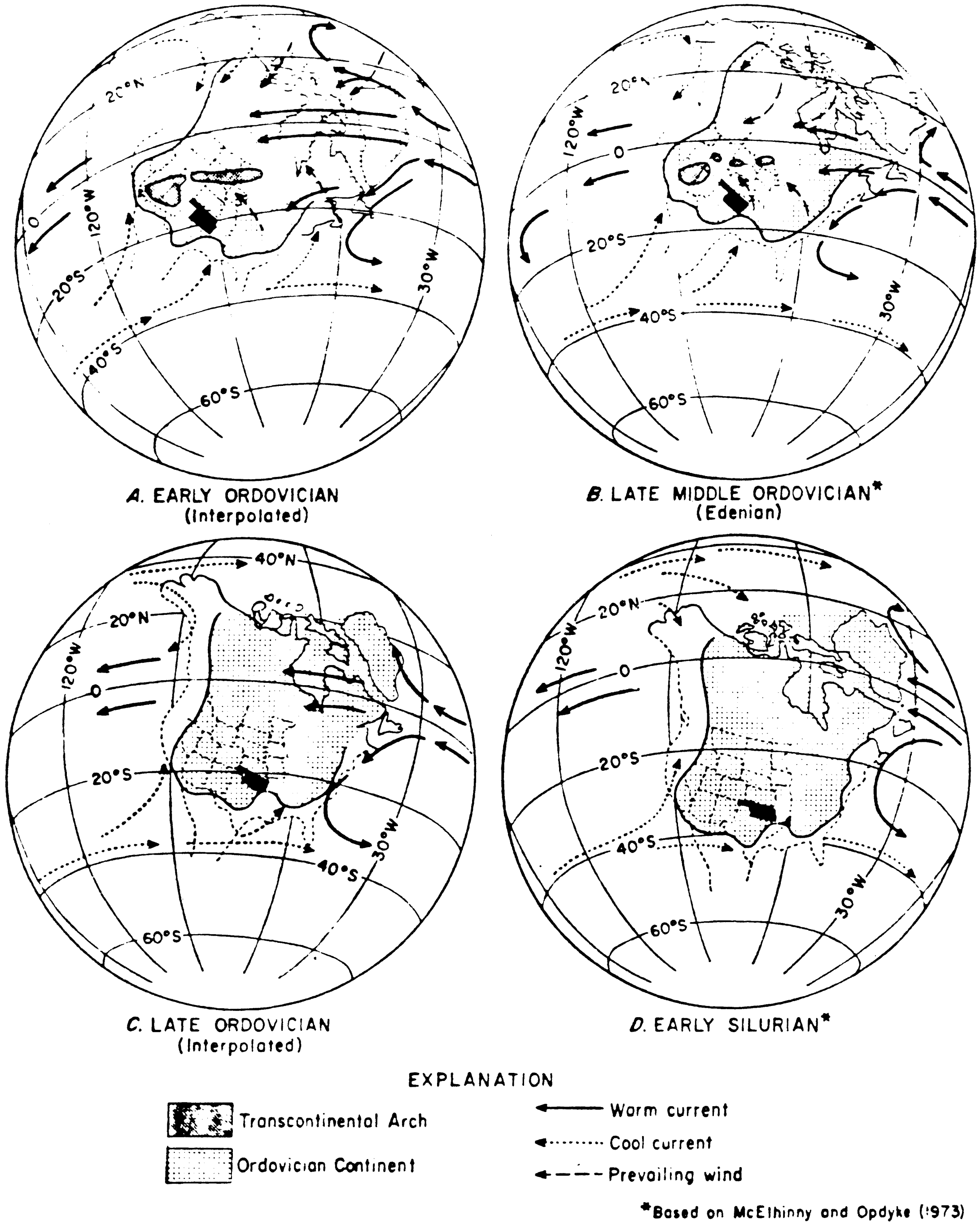


Figure 4. Probable location of North America during Ordovician and Silurian time, and possible effects on ocean currents, (after Ross, 1980, Based on McElhinney and Opdyke, 1973).

Transcontinental Arch possibly influenced circulation patterns in the cratonic sea (Ross, 1976). Because there was no terrestrial plant life, rainfall in the equatorial latitudes would have eroded the land surface extremely fast.

By the Middle Ordovician the Southern Oklahoma Aulacogen was located approximately at 15 degrees south latitude; this is inferred from the distribution of paleoclimatic lithic indicators, (Witzke, 1980). This would have placed Oklahoma in the trade wind belt latitudes. Because the clastic supply diminished it is inferred that the Transcontinental Arch was transgressed. The climate in this region would have changed from hot and humid to a hot and dry climate (Witzke, 1980). The result would have been hypersaline depositional conditions. This idea would fit with the evidence of the Arbuckle Group, which had a restricted fauna. Dolomite was the main rock type that formed in the shallow restricted marine environment on the shelf. In the Southern Oklahoma Aulacogen proper the water depth was probably deeper and less restricted because limestone is the main rock type, and fauna and flora were much more diverse and abundant (Ross, 1976).

The Simpson Group was deposited in the Middle Ordovician, during a series of transgressive and regressive sequences, on a very low relief carbonate platform. In Whiterockian time it is presumed that the Transcontinental Arch and the Canadian Shield were emergent and supplied clastic sediment to the epicratonic sea. The Southern

Oklahoma Aulacogen possibly extended northwestward as far as Utah (Witzke, 1980).

In Oklahoma the Oil Creek Formation was deposited. The basal sandstone is supermature and approximately 99% monocrystalline quartz, indicating a distant source area (Dapples, 1955). The overlying member of the formation is composed of carbonate rocks and shales. A regression of the sea is indicated by an unconformity at the top of the Oil Creek Formation. In the area south of the Transcontinental Arch, Sloss (1963) reports much of the region shows evidence of a regression. In Chazyan time the sea transgressed and presumably reworked the wind-blown sands that had accumulated on the low relief carbonate shelf during Whiterockian time (Longman, 1976, Lewis 1982 and Ross, 1976).

The basal sand unit of the McLish and the St. Peter Sandstones are supermature and are approximately 99% monocrystalline quartz (Ham, 1945). The sands were probably reworked several times from the Precambrian until ultimate deposition in the Middle Ordovician. In Wisconsin the Baraboo Quartzite is a Precambrian quartz-arenite that had been exposed to erosion numerous times, and could have supplied vast quantities of pure quartz sand. According to Dapples (1955) the source of the St. Peter Sandstone was from the northeast, (easterly in Ordovician). The ultimate source presumably was the Canadian Shield. The St. Peter is a time transgressive unit and the upper portion of the sand is thought to be equivalent to the Tulip Creek basal sand unit (Ireland, 1965), and possibly to the basal sand of the Bromide. The shallow-water currents capable of moving sands in the cratonic sea would have been driven by the prevailing winds, from the east and southeast in Ordovician time (Ross, 1976). The upper part of the McLish Formation consists of carbonate rocks, sands and shales interbedded and in varying amounts; all were deposited in relatively shallow marine environments Longman, 1976 and Lewis, 1982). The sequence of quartz sandstones, carbonates and shales is also present in the Tulip Creek and Bromide Formations.

From this study it is proposed that the upper portion of the basal sandstone and the clastic component in the upper unit of the McLish Formation were possibly influenced by an additional source area. Ham (1945) reported that the basal sandstone of the McLish Formation had several heavy minerals present that were not present in the basal sandstone of the Oil Creek Formation. The data indicate a source area to the west and/or southwest. The relatively high percentage of feldspars in the McLish Formation compared to the other Simpson formations led to this conclusion. The relative abundance of the feldspars is greatest in the core farthest west (Sunray DX Parker, Mazur No. 1) and least abundant in the outcrop to the southeast (State Highway 77). The Bromide sands probably were derived from erosion of the Ozark Uplift as it became emergent in Blackriveran time (Longman, 1976). The pattern of a basal sandstone, overlain by carbonate rock, sandstones and shales is present predominantly in the Simpson Group of Oklahoma and West Texas. These cycles were probably related to localized tectonic events in the area surrounding the basins. The shelf areas beyond Oklahoma and West Texas do not show regular cyclic sedimentation of the Simpson type. This may indicate that the transgressions and regressions were not craton wide.

During Cinncinatian time the sea transgressed the source area of the sand and cut off the supply. This is believed to be true because there is no sand unit at the base of the Viola. It is thought that the Transcontinental Arch was completely submerged (Ross, 1976). Devonian erosion has made it impossible to know for sure, but inliers of what is thought to be Cinncinatian carbonates have been found on what would have been within the confines of the arch (Ross, 1976).

CHAPTER III

PETROGRAPHY AND DEPOSITIONAL ENVIRONMENTS

The McLish Formation consists of a lower unit, a basal sandstone and an upper unit consisting of interbedded carbonate rocks and shales, carbonate rocks, interbedded sandstones and shales, sandstones and shales.

Three cores located in Grady and McClain Counties, Oklahoma, were used to study the McLish in the subsurface. The McLish interval in the Gulf Oil Co., Beard No. 1, is 390 feet thick, from 11,079 to 11,470 feet. The subsea interval is 10,035 to 10,425. The basal sandstone is 75 feet thick and the upper unit is 315 feet thick. Three hundred seventy one feet of the McLish Formation was cored. The interval in the Gulf Oil Co., Costello No. 1, is 282 feet thick, from 12,111 to 12,391 feet. The subsea interval is 11,081 to 11,361 feet. The basal sandstone is 53 feet thick and the upper unit is 229 feet thick. Two hundred eight two feet of the McLish was cored. The interval in the Sunray DX Parker, Mazur No. 1, is 302 feet thick, from 16,378 to 16,680 feet. The subsea interval is 15,240 to 15,542 feet. The basal sandstone is 100 feet thick and the upper unit is 202 feet thick. Two hundred seventy eight feet of the McLish was cored.

Two outcrops, located in Murray and Carter Counties, Oklahoma, were used to study the surface expression of the McLish Formation. The logged section along Interstate Highway 35 is 416 feet thick, striking north 55 degrees west, dipping 75 degrees southwest. The basal sandstone is 75 feet thick and the upper unit is 341 feet thick. The logged section along State Highway 77 is 471 feet thick, striking north 60 degrees west, dipping 55 degrees southwest. The basal sandstone is 55 feet thick and the upper unit is 416 feet thick. For detailed descriptions of the individual cores and outcrops see the appendices and petrologs in the back of this thesis.

The presence of fossil fragments, glauconite and the sedimentary structures suggest that deposition of the McLish Formation took place in shallow intertidal to subtidal environments, from the upper shoreface to open marine shelf. The McLish Formation is interpreted as a transgressive-regressive cycle (Figure 5).

Lower Unit

Basal Sandstone

The basal sandstone unit of the McLish Formation is very fine to fine grained, rounded to very well rounded, moderately well sorted to well sorted, immature to supermature, massive quartz-arenite (Figure 6). This unit is friable to very friable.

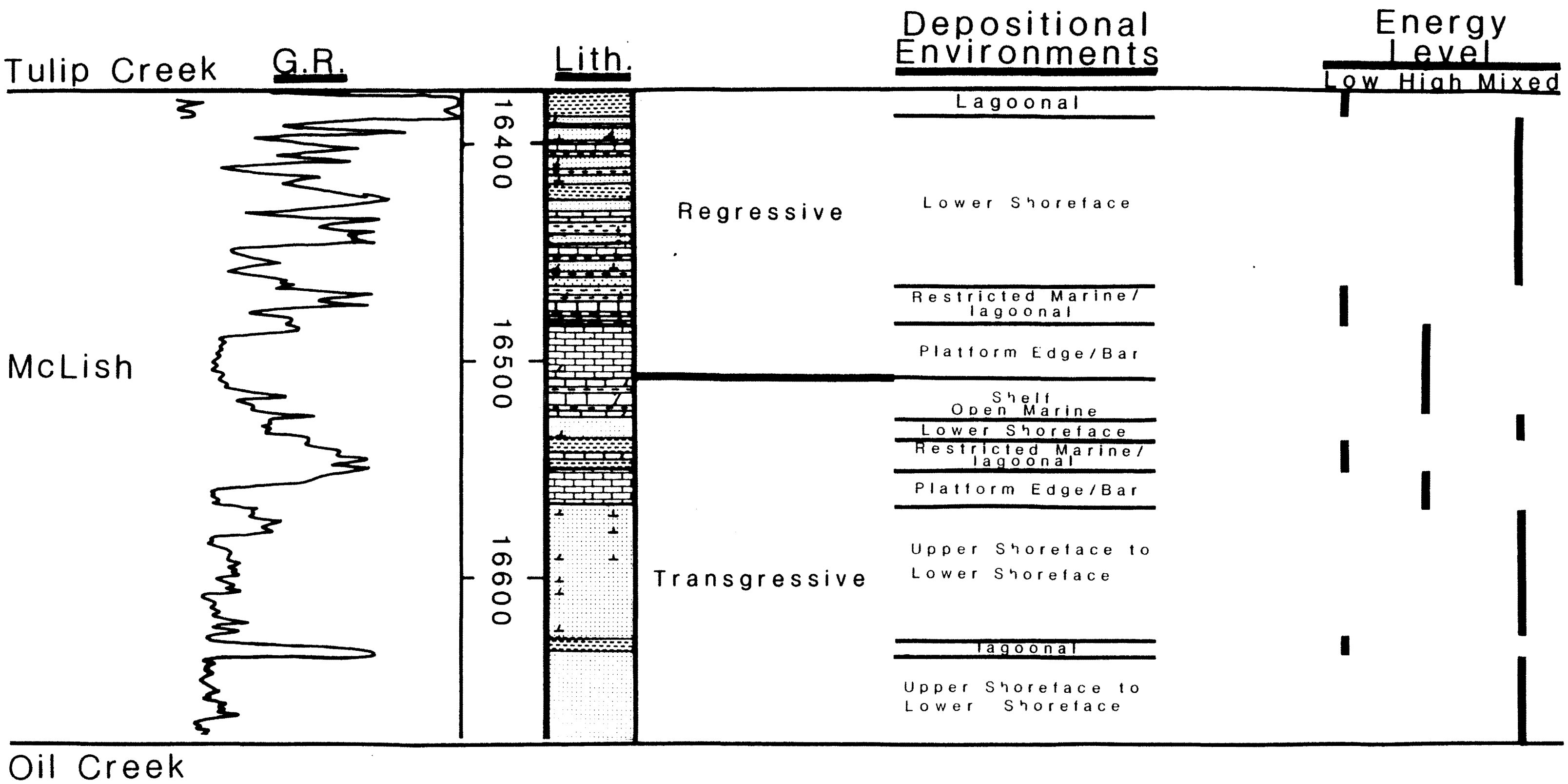


Figure 5. Gamma-ray curve (G.R.), lithology (Lith.), proposed depositional environments and energy level of the environments for the McLish Formation in the Sunray DX Parker, Mazur No. 1 well.

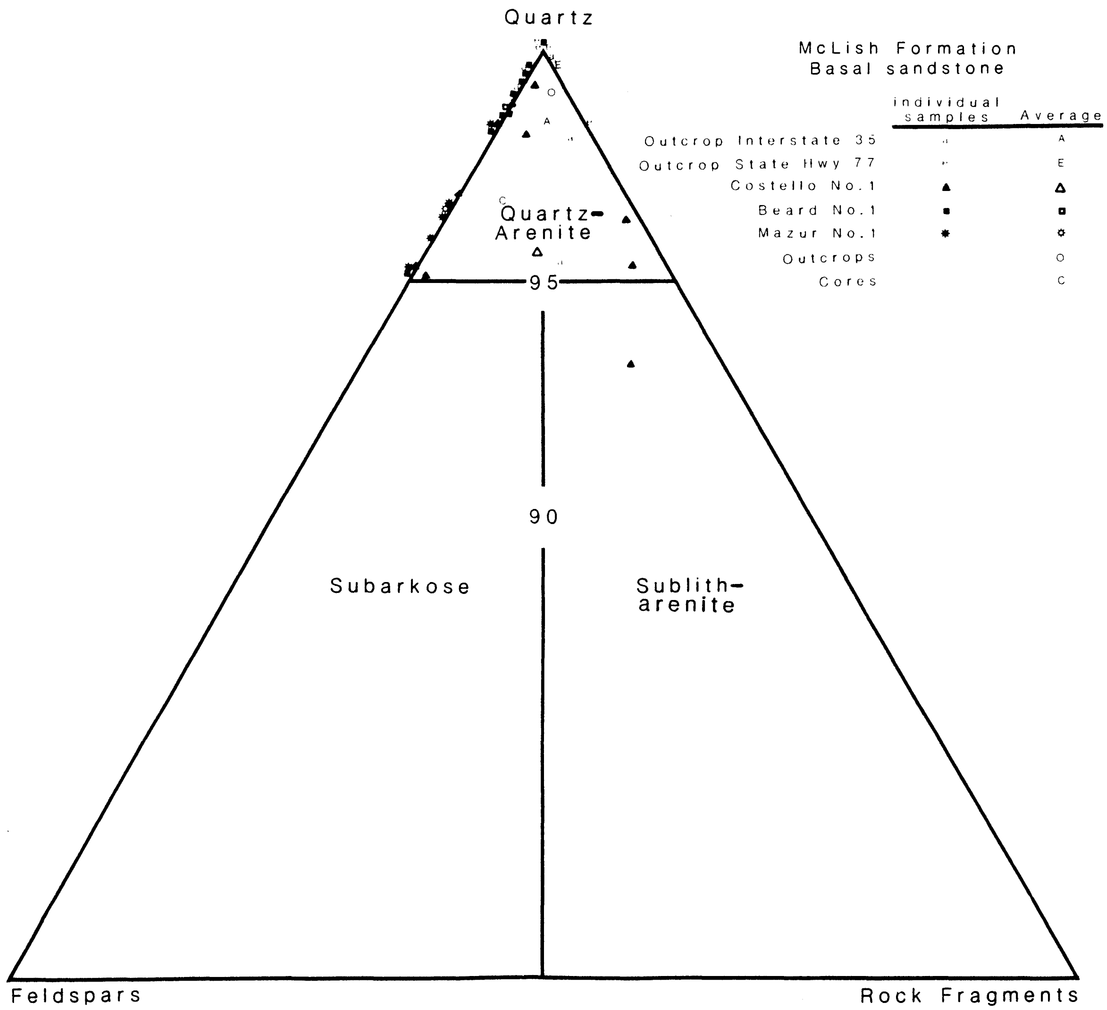


Figure 6. Sandstone composition of the basal unit of the McLish Formation in the cores and outcrops studied.

Detrital Constituents: Monocrystalline quartz is the most abundant detrital constituent in the basal sandstone of the McLish (Figure 7). Average percentages of detrital quartz grains range from 97.0% in cores to 99.1% in outcrops. Feldspars are the next most abundant constituent. Feldspars range from 0.3% in outcrops to 2.3% in cores. In outcrops plagioclase and microcline are present in equal amounts (0.1%) and orthoclase was not observed. Orthoclase and microcline are present in approximately equal proportions (0.3%) in the subsurface, plagioclase is twice as abundant (0.65%) as the other feldspars. Rock fragments are the least abundant. These range from 0.6% in outcrops and 0.7% in cores. There is a trace of carbonate shell debris in the cores, but none present in the outcrops. The average percentage of detrital clay range from 0.64% in the outcrops to 4.6% in the cores. Most of the clay is illitic and/or chloritic. This was determined from X-ray diffraction. Glauconite makes up 0.1% of the rock in the outcrops and 0.5% is present in the cores. Collophane, zircon and tourmaline are present in trace amounts in the cores and outcrops.

Authigenic constituents: In the McLish Formation the authigenic constituents are quartz overgrowths, microquartz, chalcedony, calcite overgrowths, dolomite, ankerite, ferroan calcite, illite and pyrite (Figure 7). On the average, authigenic minerals compose 16.7% of the quartz-arenites on the surface and 28.9% in the subsurface. Silica cements in

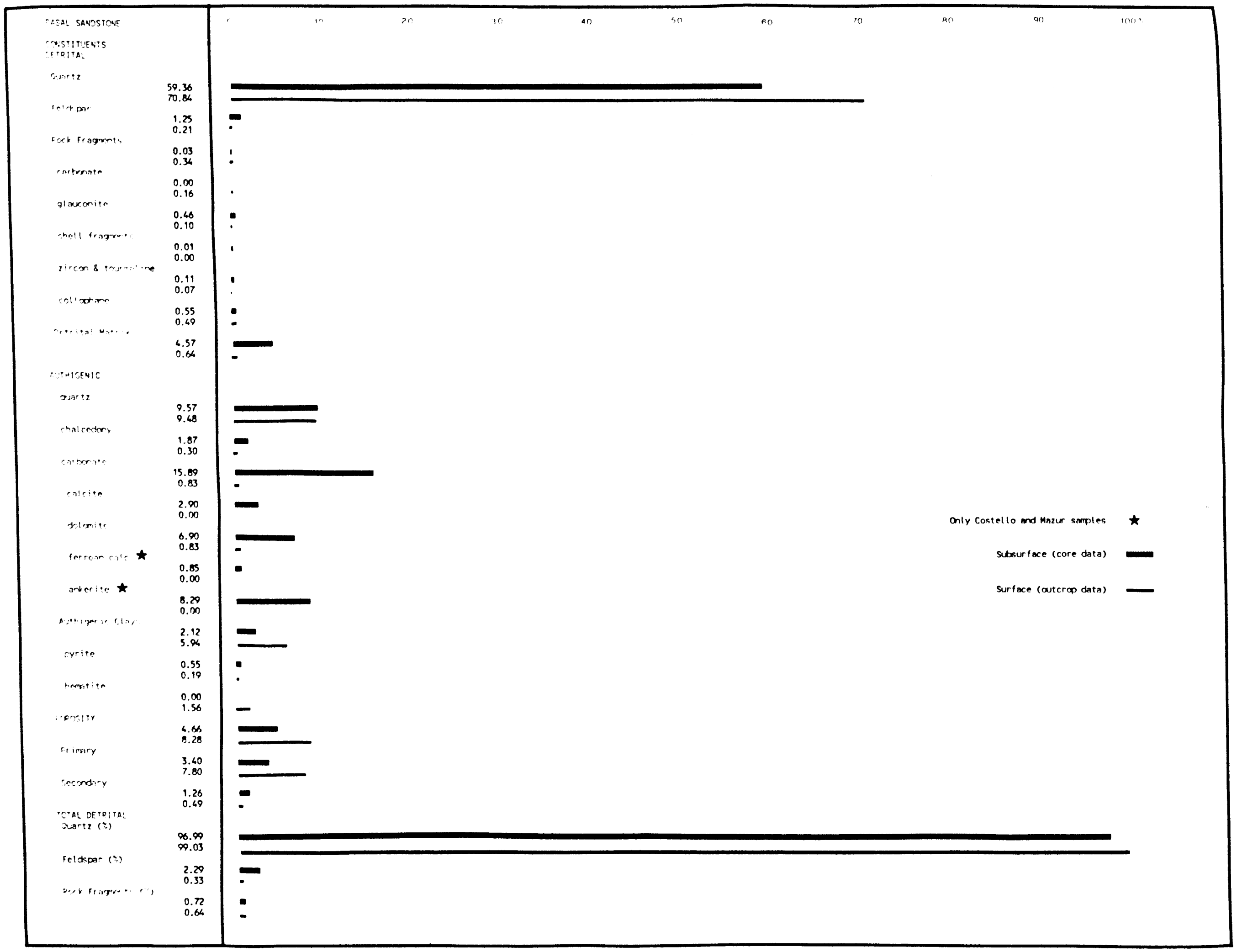


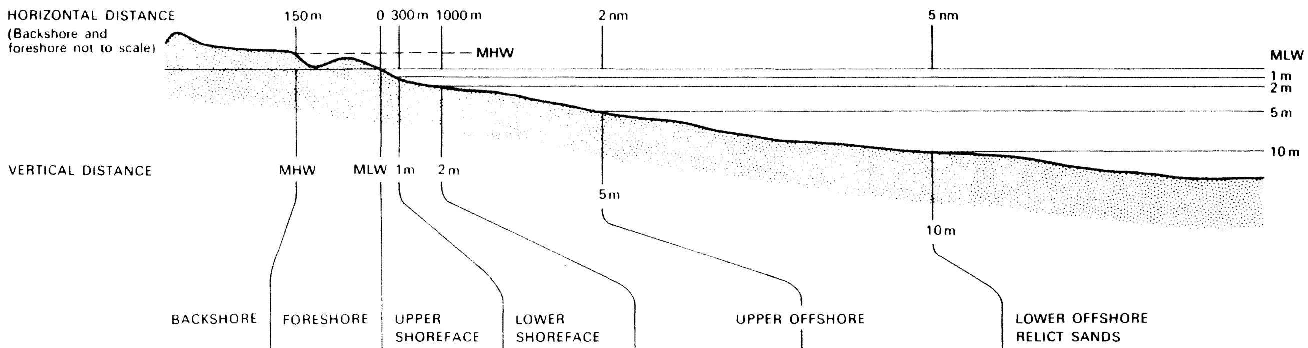
Figure 7. Constituents of the basal sandstone unit of the McLish Formation.

the outcrops average 9.8% and in cores 10.3%. Carbonate cements range from 0.8% in outcrops to 15.9% in cores. Ankerite and ferroan calcite were only observed in the cored sections of the McLish Formation below 11,000 feet sea level. Dolomite cement ranges from 0.8% in the outcrops to 6.9% in the cores. Calcite cement averages 2.9% in the cores and is not present in the outcrop. Dolomite and/or ankerite replace detrital clay in many instances. Authigenic clay ranges from 2.1% in the cores (illite, chlorite and kaolinite) to 5.9% in the outcrops (illite). Pyrite is present in trace amounts in the subsurface and the surface.

Porosity: Primary and secondary porosities are present in the basal sandstone (Figure 7). The percent of primary porosity ranges from 3.4% in the subsurface to 7.8% in outcrops. Secondary porosity ranges from 0.5% in the outcrops to 1.3% in cores. In the quartz-arenites porosity appears to have been preserved because a substantial amount of detrital clay coats grains. This coating inhibited syntaxial overgrowths. Secondary porosity commonly is observed as enlarged pores (Al-Shaieb and Shelton, 1981, Schmidt and McDonald, 1979). This porosity was generated by the dissolution of meta-stable components- clay matrix, feldspars, silica cement, fossil fragments, carbonate cements- as well as by fracturing.

Depositional Environments: The basal sandstone of the McLish Formation is almost devoid of sedimentary structures. Burrowing is evident in many places in the basal sandstone and destroyed or obscured many primary sedimentary structures (Tillman and Martinsen, 1985). The basal sandstone looks homogeneous. Therefore, it is difficult to say with certainty what the mode of deposition was. It is postulated that it was deposited in the upper to lower shoreface (Figure 8) of a slowly transgressing sea. The abundant monocrystalline quartz sands were transported a great distance by wind and water and were presumably reworked many times (Dapples, 1955). A long period of erosion is indicated by an unconformity between the McLish and Oil Creek Formations (Sloss, 1963). The fossils present in the cores of the basal sandstone indicate marine processes were at work (Selley, 1978). Glauconite is also indicative of marine processes (Tucker, 1981). Sedimentary features observed in both core and outcrop in the basal sandstone are, cross-bedding, ripple-bedding, horizontal-bedding, bioturbation and burrowing. These sedimentary structures are often found in shallow marine environments (Johnson and Baldwin, 1986, Collinson and Thompson, 1984). The evidence suggest that the basal sandstone in the cores were probably deposited in the lower shoreface and the basal sandstone in the outcrops were possibly deposited in the upper shoreface (Elliott, 1986).

The Ordovician sea transgressed the very low relief



	BACKSHORE	FORESHORE	UPPER SHOREFACE	LOWER SHOREFACE	UPPER OFFSHORE		LOWER OFFSHORE RELICT SANDS
STRUCTURES	Parallel and small-scale ripple lamination	Low and high angle sets of laminated sand, anti dune and ripple lamination	Parallel lamination	Small-scale ripple lamination	Parallel lamination, interbedded sand and mud, and bioturbation	Bioturbated sand	Megaripple lamination and bioturbation
TEXTURE	Fine sand	Fine and medium sand shell beds	Fine sand		Muddy fine sand		Medium to coarse sand
DOMINANT TRACE FOSSILS	*Ocypode quadrata* burrows	*Callianassa major* burrows	*Callianassa atlantica* burrows		*Callianassa biformis* burrows		*Moira atropos* bioturbation structures

Figure 8. Facies characteristics from backshore to lower offshore (from Elliott, 1986, modified from Howard and Reineck, 1972).

shelf of the Transcontinental Arch, (Ross, 1976) and possibly inundated sand dunes that had developed along the shelf margin when the unconformity between the Oil Creek and the McLish Formations formed. The dunes would have been reworked by marine processes, incorporating in some cases carbonate fossil fragments. There is no direct evidence for the accumulation of sand dunes; it was postulated by Longman (1976) and others in the literature as a possible scenario. The supply of sand appears to have been limited. This is postulated due to the abrupt change from clastics to carbonates. If the supply had been constant then clastics would be expected throughout the McLish Formation. Either the supply was limited as stated above or the supply was diverted or cut off abruptly. A possible modern analog is discussed by Shinn (1973) along the coast of Qatar in the Persian Gulf. The results of such processes would have been blanket sands (Shinn, 1973). The presence of abundant clay in this unit indicates that the environment was quiet for extended periods of time (Johnson and Baldwin, 1986). The presence of burrows indicates that the sedimentation rate was slow and the energy level was low along the coastline to allow the burrowing animals time to rework the sediment (Johnson and Baldwin, 1986). The presence of cross-bedding indicates that periodically the energy level along the coast rose (Elliott, 1986). This could have been due to storms (Longman, 1976). This could also help explain the abundance of detrital clay. A storm would stir up the muds that had been deposited further offshore, carrying them shoreward and hold it in suspension. When the storm would abate the clay would settle. Then burrowing animal would homogenize the detrital quartz grains and clays. In some places discrete layers of clay were undisturbed.

Upper Unit

The upper unit of the McLish Formation consists of interbedded carbonate rocks and shales, carbonate rocks, interbedded sandstones and shales, sandstones and shales. This sequence of rock is interpreted to be a continuation of the transgressive cycle followed by a regression of the Ordovician sea (Figure 5).

Interbedded Carbonate Rocks and Shales, and Carbonate Rocks

The carbonate rocks in this portion of the McLish Formation range from wackestones to grainstones. The shales range from dark brown to green and are laminated, waxy, fissile to blocky, and pyritic. The clays consist mainly of illite.

Detrital Constituents: The most abundant constituents in the carbonate rocks are fossil fragments (Figure 9). Fossil fragments make up 38.7% of the carbonate rock in both outcrops and cores. Other allochems and detrital grains are detrital quartz, feldspars, pellets, oolites, glauconite, and collophane. The carbonate rocks contain less than ten

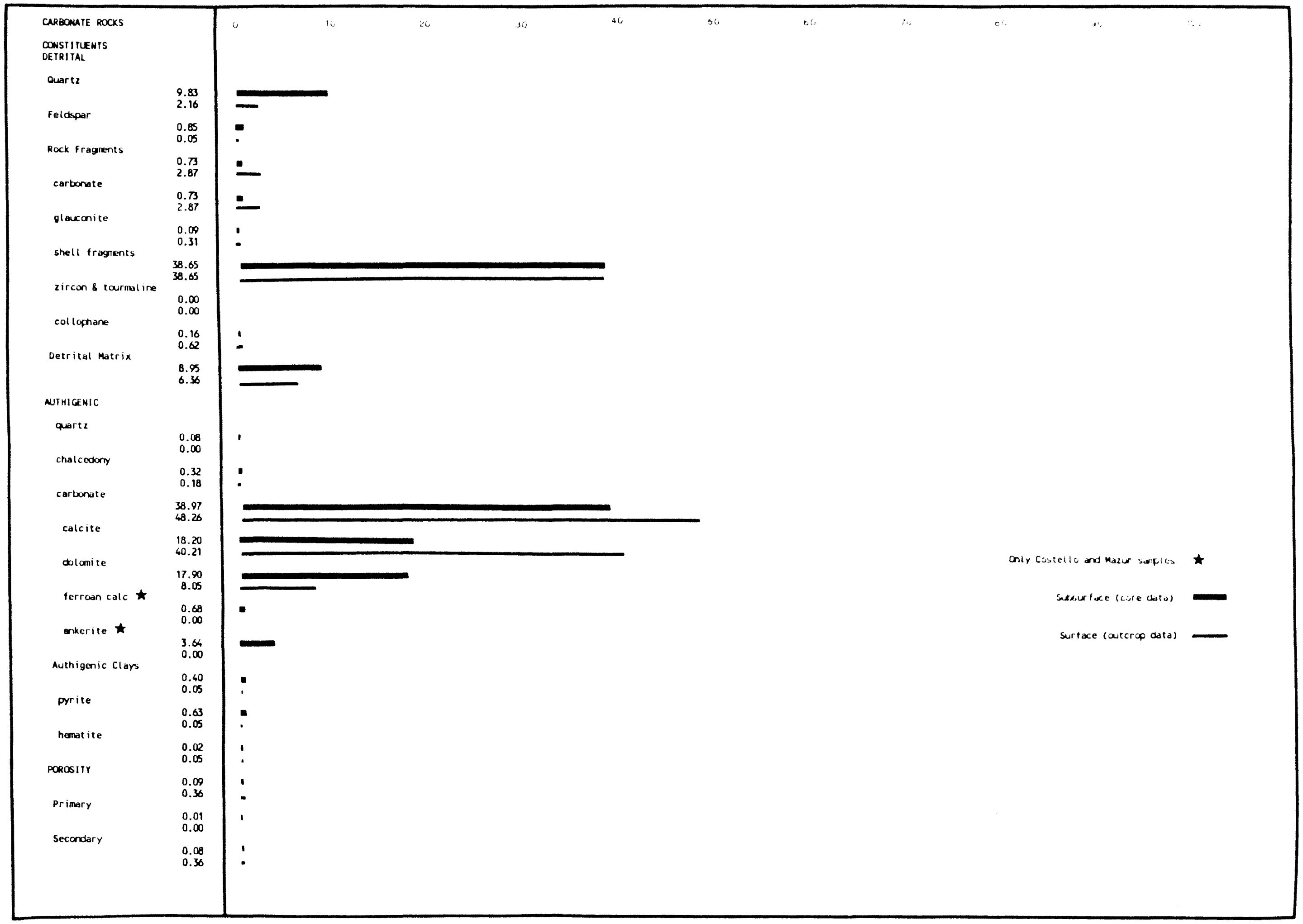


Figure 9. Constituents of the Carbonate Rocks of the McLish Formation.

percent detrital quartz grains. The outcrops average 2.2% and the cores average 9.8%. Feldspars range from 0.05% in outcrops and 0.85% in cores. Pellets and/or oolites make up 0.7% of the carbonate rock in the cores and 2.9% of the outcrops. Glauconite is present in trace amounts in both cores (0.1%) and outcrops (0.3%). Collophane ranges from 0.2% in cores to 0.6% in outcrops. Collophane is present as pellets and fossil fragments of brachiopods and conodonts. Detrital matrix ranges from 6.4% in outcrops to 9.0% in cores. Illite is the main constituent.

Authigenic Constituents: Up to 48.5% of the carbonate rocks are cements of one variety or another (Figure 9). Silica cement if present is very minor. When it is present it is mainly a replacement of fossil fragments by chalcedony. In cores the carbonate cement averages 39.0% of the rock, in outcrops it averages 48.3%. The breakdown of the carbonate cements are: cores; calcite 18.2%, dolomite 17.9%, ankerite 3.6% and ferroan calcite 0.68%. The ferroan carbonates were not observed in the McLish Formation above 12,000 feet. In outcrops; calcite 40.2%, dolomite 8.1%, and ferroan carbonates were not observed. Authigenic clays, pyrite and hematite were observed in trace amounts. Collophane was observed infilling zoecia in bryozoa.

Porosity Primary porosity is almost nonexistent in these rocks (Figure 9). Secondary porosity is present in the form of fractures and dissolution of meta-stable components- clay matrix, feldspars, and carbonate fragments. The dissolution of meta-stable constituents is much less than in the previously described basal sandstone.

Depositional Environments: The interbedded carbonate rock and shale sections are interpreted to have been deposited on an open shelf or open platform environments and the carbonate rocks are interpreted to have been deposited on the edge of a platform (Wilson, 1975).

The interbedded carbonate rock and shale sections are extensively bioturbated. Bryozoan and brachiopods are the most abundant fossils present in this section. This section is interpreted as having been deposited in slightly deeper water than the basal sandstone unit (Figure 8). On an open platform as described by Wilson. An alternative interpretation of this facies is that deposition took place on the open shelf below storm wave base (Figure 8). This would help explain the preservation of burrowing.

The energy level in these environments is interpreted to have been low; this allowed the accumulation of mud (Figure 5). Limited fauna were observed in the interbedded carbonate rocks and shales, possibly indicating a somewhat restricted environment. The delicate bryozoa present indicate a low energy environment. Bryozoa and brachiopods are filter feeders, so for these animals to thrive, the amount of clastic sediment in suspension is very important. If there is too much suspended clay material the filter feeders will be unable to live. It is very possible that periodic storms disrupted the environment. In the outcrops bryozoa were not observed in growth position. It is possible that these rocks were deposited close to storm wave base and that only the most intense storms would have affected these rocks. The abundance of bioturbation and the preservation of burrows would suggest this conclusion. The transgression of the Ordovician sea was possibly at a maximum when the carbonate rocks and shales were deposited.

The majority of the carbonate rocks are grainstones. The depositional environment of the carbonate rock is interpreted to have been on the edge of a platform (Figure 8). Evidence for this is the abundance and diversity of fauna observed. Fossil fragments of echinoderms, bryozoa, trilobites, brachiopods and ostrocods were observed. The fossil fragments are abraded, indicating transport to the location of deposition, and higher energy than the interbedded carbonate rocks and shales. The abraded fossil fragments could be an indication that the final environment of deposition was intertidal (Wilson, 1975). Phosphatic fossil fragments of brachiopods and conodonts were also observed.

Interbedded Sandstones and Shales and Sandstones

The sandstones in the interbedded sandstones and shales, and sandstones range from very fine grained, subrounded, poorly sorted, immature arkoses and sublitharenites to fine grained, well rounded, very well sorted quartz-arenites. There are four main sandstone types in the upper unit: quartz-arenite, and sublitharenite are present in both outcrop and core and subarkose and arkose are present in the cores (Figure 10). Sublitharenites characterize the sandstones in the outcrops and subarkoses characterize the sandstones of the upper unit of the McLish Formation in the cores (Figure 10).

Detrital Constituents: The most abundant detrital constituent in the upper unit sandstones is monocrystalline quartz (Figure 11). The amount of quartz ranges from 51.1% in the cores to 57.0% in the outcrops. Feldspars range from 0.14% in outcrops to 2.91% in cores. Carbonate rock fragments (pellets and/or oolites) were observed as a trace in the core. Glauconite was present in both the core (0.4) and outcrop (3.7%). Carbonate shell fragments were observed in both core (3.1) and outcrop (4.0%). Collophane ranged from 1.0% in cores to 2.6% in outcrops. Zircon and tourmaline are present in trace amounts. Detrital matrix ranged from 2.2% in outcrops to 5.2% in cores.

Authigenic Constituents: The total amount of cement present in the upper unit sandstones ranged from 17.3% in the outcrops to 33.2% in the cores (Figure 11). Silica cement accounted for 6.4% in both outcrop and core. Carbonate cement ranged from 7.0% in outcrops to 25.2% in cores. In outcrops calcite was 3.7%, dolomite was 3.3% and ferroan carbonates were not observed in the outcrop samples.

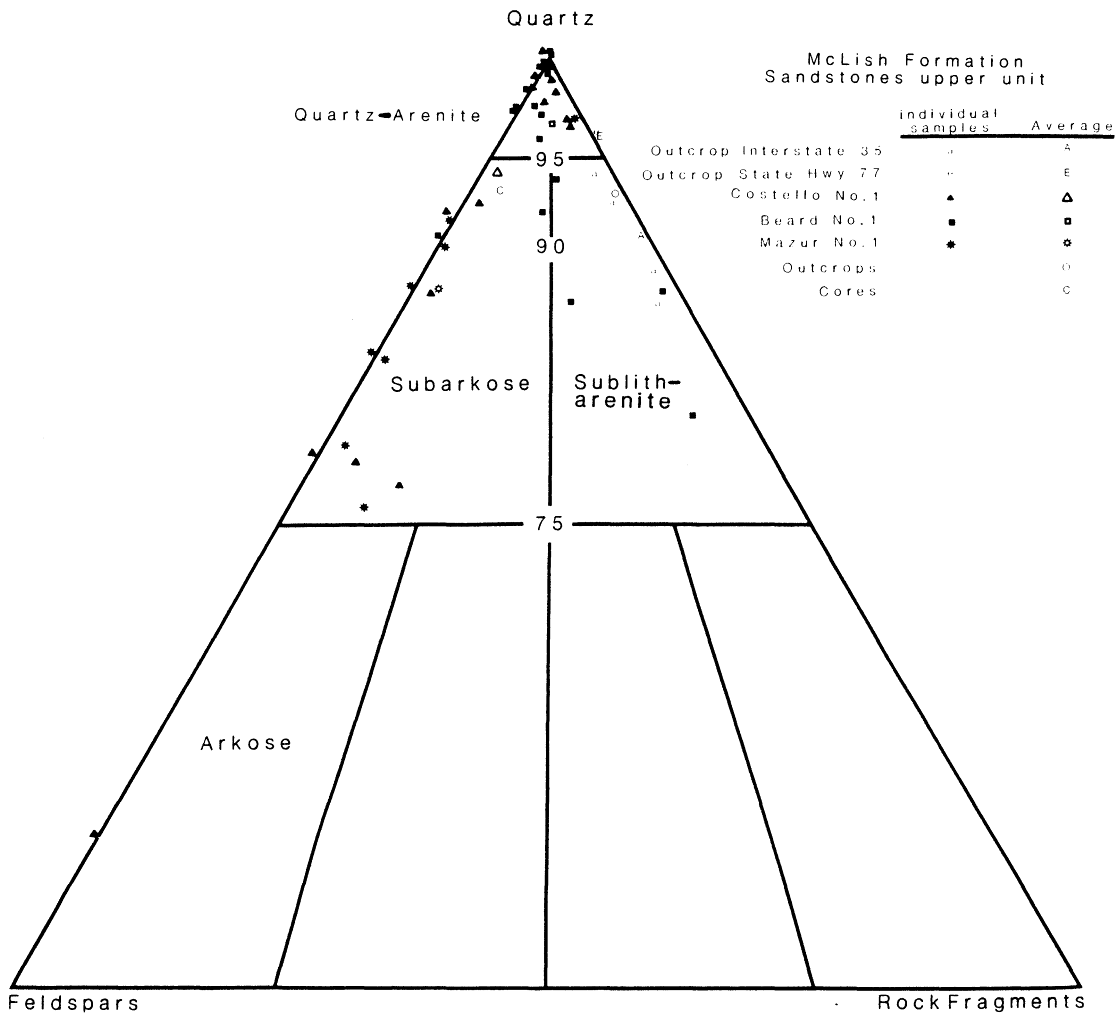


Figure 10. Sandstone composition of the upper unit of the McLish Formation in the cores and outcrops studied.

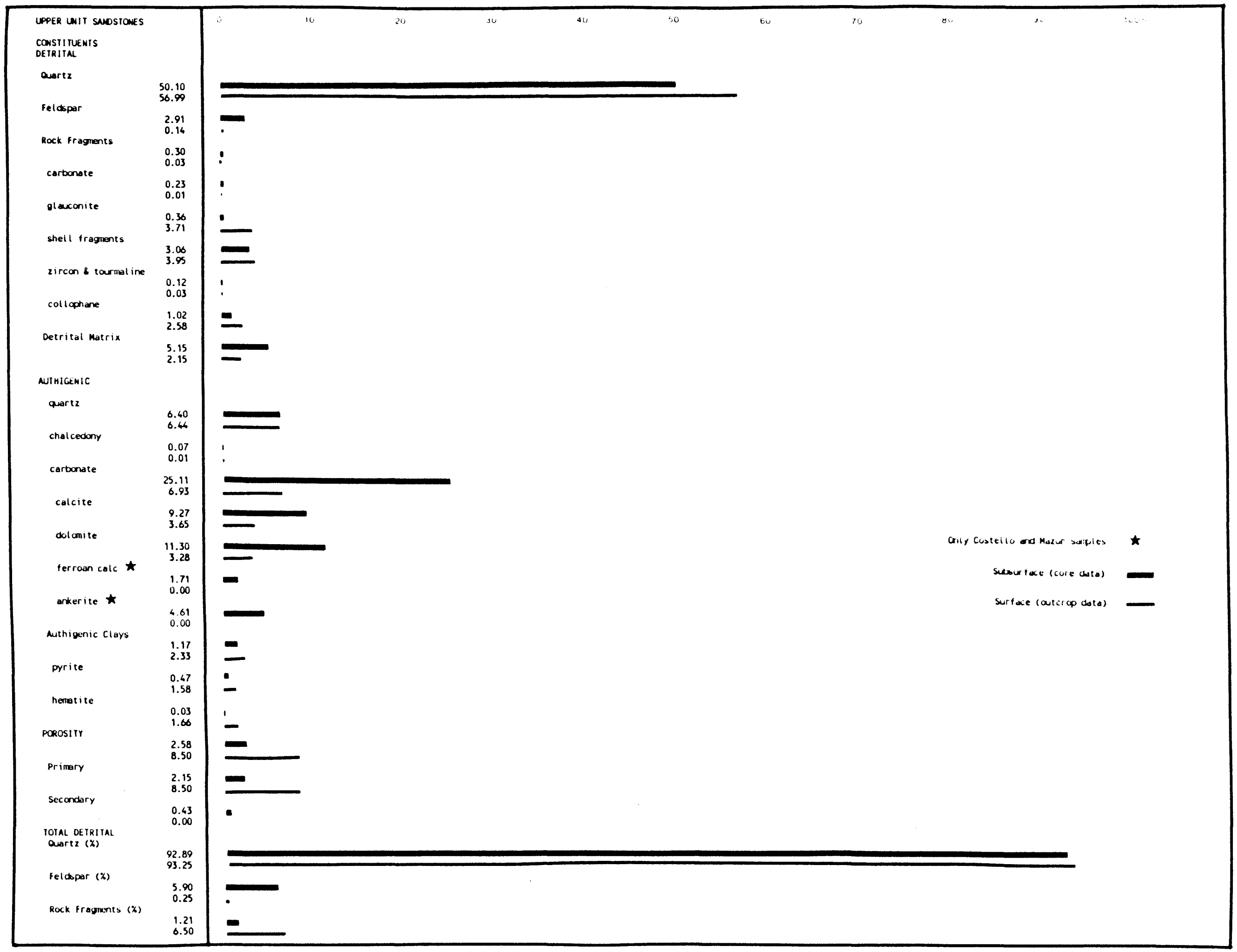


Figure 11. Constituents of the upper unit of the McLish Formation.

In the cores calcite was 9.3%, dolomite was 11.3%, ferroan calcite was 1.7% and ankerite was 4.6%. In the samples from the Beard core ferroan carbonates were not observed. Authigenic clay ranged from 1.2% in the cores to 2.3% in the outcrops. Pyrite averaged 0.5% of the core samples to 1.6% of the samples from the outcrops. Hematite averaged 0.03% in the core samples and 1.7% in the outcrop samples.

Porosity: Primary porosity is most widespread in the sandstone of the upper unit of the Mclish Formation (Figure 11). Intergranular porosity was observed to range from 2.2% in the cores to 8.5% in the outcrops. Secondary porosity was not observed in the outcrops, but 0.4% was observed in the core samples. The presence of clay is interpreted to have preserved primary porosity and to have helped develop secondary porosity.

Depositional Environments: The interbedded sandstones and shales are interpreted to have been deposited in the lower shoreface (Figure 8). The major sedimentary features present in these units are bioturbation, burrowing, cross-bedding, ripple-bedding and horizontal-bedding. These rocks were probably deposited in deeper water than the basal sandstone (Walker, 1985). This environment would normally not be affected by waves. Only storms would have affected this environment appreciably. The majority of the time deposition would be slow as indicated by glauconite. This slow sedimentation rate would have allowed burrowers plenty of time to thoroughly churn up the sediments (Tillman and Martinsen, 1985, Walker, 1985).

The quartz-arenites and arkosic sandstones in the upper unit of the McLish Formation could have been deposited in a wave dominated deltaic environment, similar to the present day Sao Francisco delta in Brazil (Galloway and Hobday, 1983). As the sediments exited the river system the detritus was reworked by wave and longshore currents into thin sheet sands.

Shales

The shales of the McLish Formation range from dark brown to waxy green. They are laminated, blocky to fissile, and pyritic. X-ray diffraction indicates the main constituent is illite with some chlorite. The shales are interpreted to have been deposited in a variety of environments, all low energy and shallow marine, ranging from lagoonal restricted inner shelf to open marine shelf, depending on the sequence of rock surrounding the shale unit.

Provenance of Feldspars

The source area for the feldspars in the upper unit of the McLish Formation appears to be different than that of the source of the monocrystalline quartz. The source appears to be from the west and northwest or possibly from the southwest (Figure 12). The Mazur well is furthest west-

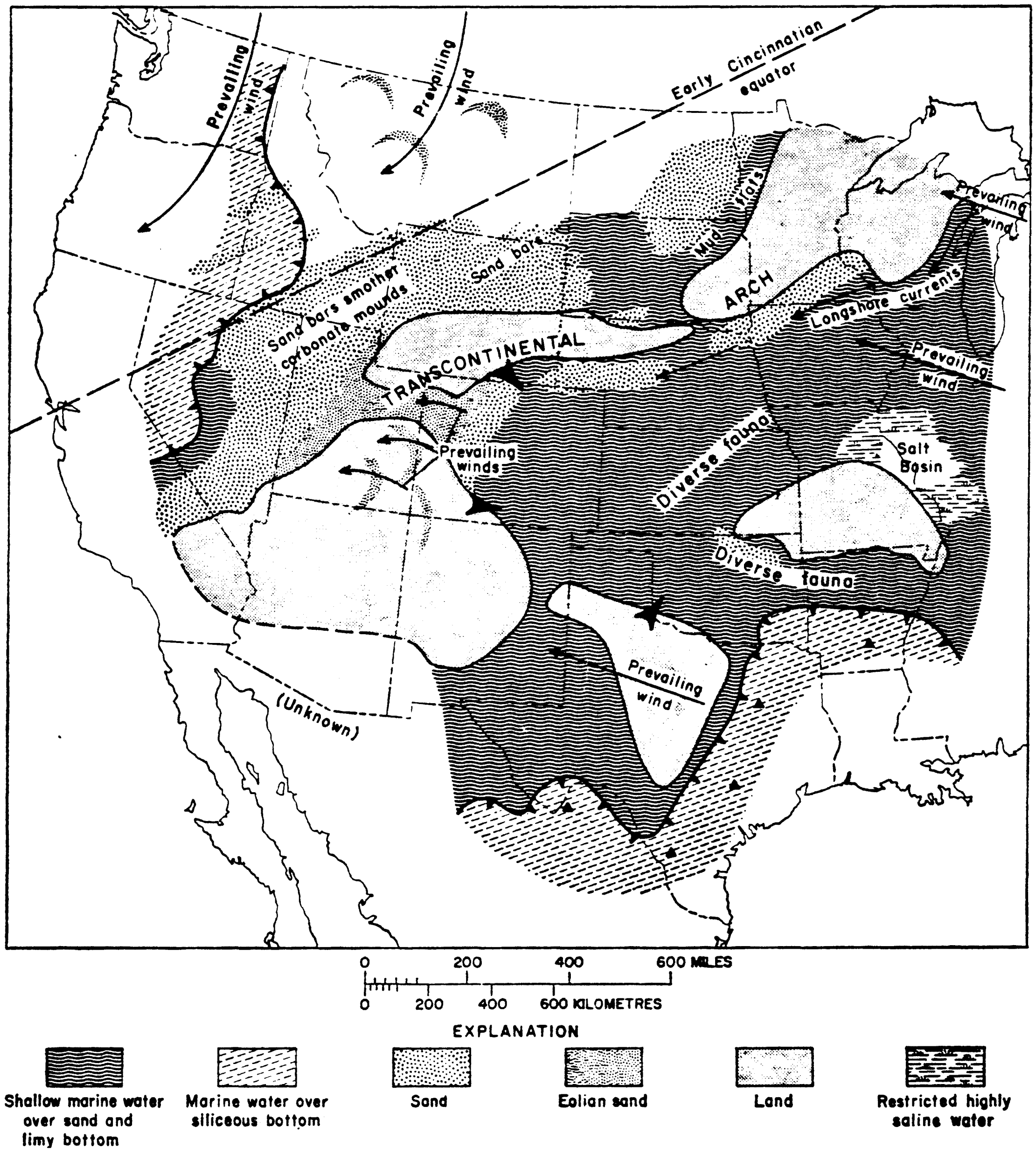


Figure 12. Interpretation of Middle Ordovician (post-Whiterockian--pre-Cincinnatian paleoenvironments, western United States and proposed sources for Feldspar in the McLish Formation, south central Oklahoma, indicated by ➤ (after Ross, 1976).

southwest of the cores (see Figure 1) and contains the highest percentages of feldspars. The Costello and Beard wells show decreasing amount of feldspars as the distance from the Mazur well increases. The outcrop along Highway 35 has only a trace amount of feldspars and the Highway 77 outcrop which is the furthest south-southeast and furthest away from the Mazur well shows a trend in the decrease in feldspars from the west to the east-northeast and from the northwest to the southeast. The source appears to be different than the other formations in the Simpson Group. After looking at thin-sections from the other formations in the Simpson Group, it was apparent that the McLish Formation had substantially more feldspars than the other formations in the same wells that were used in this study.

Other evidence that the McLish had an additional source, is from Ham, 1945. In his study of the basal sandstones of the Oil Creek and McLish Formations, he found that the McLish had several additional heavy mineral that were not present in the Oil Creek.

The main source of the monocrystalline quartz is postulated to have been from the northeast, (Dapples, 1955) transported by wind and longshore currents.

The most likely sources for the feldspars are the Transcontinental arch, in the vicinity of present day Colorado, to the northwest or the Texas arch to the southwest, which was emergent during much of the Middle Ordovician (Ross, 1976, Wickham, 1978 and Witzke, 1980).

CHAPTER IV

DIAGENESIS OF THE MCLISH FORMATION

Summary of Diagenesis

The diagenetic sequence for quartz-arenites, subarkoses, sublitharenites and carbonate rocks in the McLish Formation is summarized in Figure 13. The sequence of events in the diagenetic history of the McLish Formation are tied very closely to the the environment of deposition, interstitial fluids, abundance of fossil fragments, abundance of clay, adjacent rock types and migration of hydrocarbons. Quartz-arenites and subarkoses are proposed to have been deposited in intertidal to subtidal environments in relatively quiet, shallow water. The carbonate rocks in the McLish are thought to have been deposited in intertidal to subtidal environments from shelf edge to possibly restricted marine to open shelf.

Detrital illite was either deposited or worked into the sands after deposition by burrowing animals. Slow sedimentation is indicated by the presence of glauconite that possibly replaced fecal pellets. Collophane was present as pellets and fossil fragments, and was observed infilling zoecia of bryozoa in some samples. Slightly acidic and reducing conditions were necessary for the

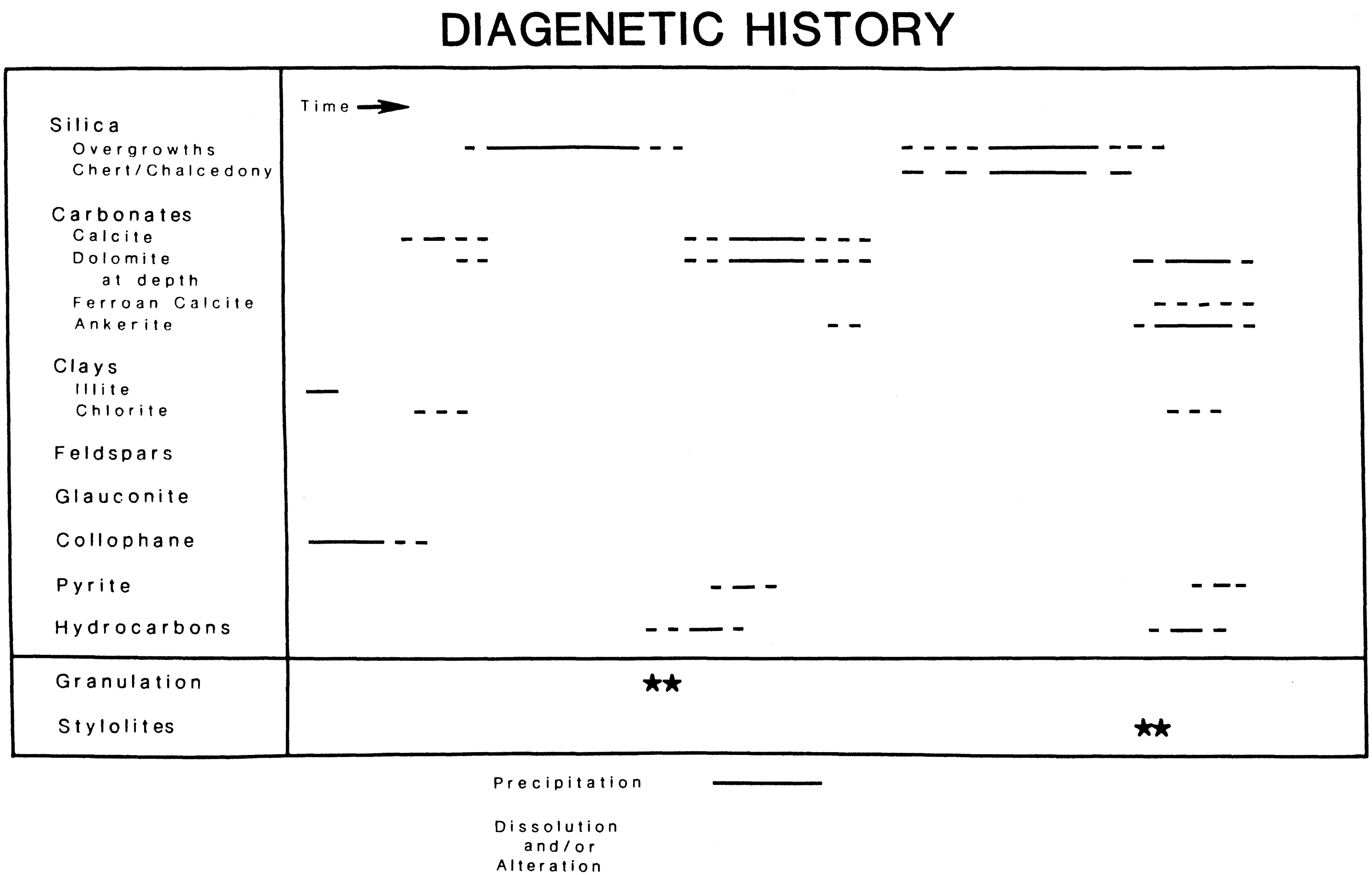


Figure 13. Diagenetic history of the McLish Formation.

formation of collophane and phosphatic matter (Figure 14). The collophane infilling voids in the bryozoa and pellets of collophane could have been caused by a micro environment, as decay of organic matter took place. The micro environment would have been acidic and reducing.

The corrosion and/or dissolution of feldspars occurred episodically throughout the diagenetic history of the McLish Formation (Figure 15A). In some samples authigenic chlorite rims grains.

Where fossils fragments were present, sparry calcite and poikilotopic calcite were observed surrounding fossil fragments and other detrital grains (Figure 15B). The interstitial waters would have to have been saturated with respect to calcium carbonate and be alkaline (Figure 14). Loose packing of the detrital grains in the carbonate rocks indicates early cementation (Longman, 1980). Where calcitic fossil fragments were not observed, calcite cements were not seen.

Evidence of early quartz overgrowths was observed in some sandstone samples. Silica cement as quartz overgrowths mainly was observed in quartz-arenites with little detrital matrix and no detrital carbonate grains (Figure 16A). The major source of silica is postulated to be the alteration and diagenesis of clay minerals during burial (McBride, 1976). As the fluids became saturated with respect to silica and became acidic the precipitation of silica ensued (Figure 14).

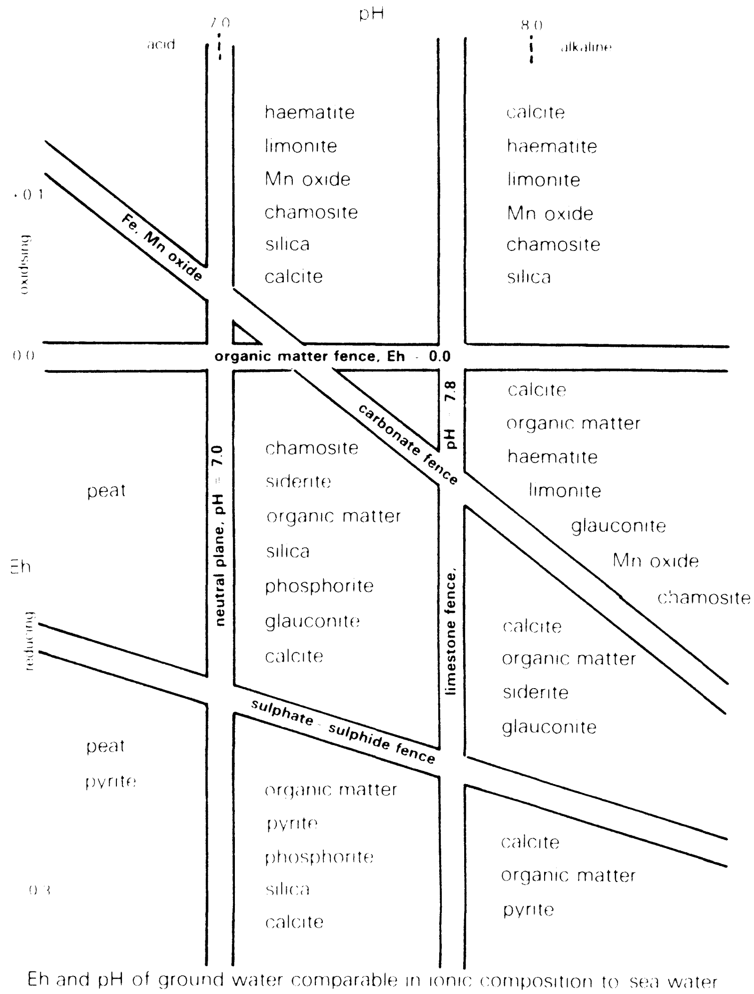
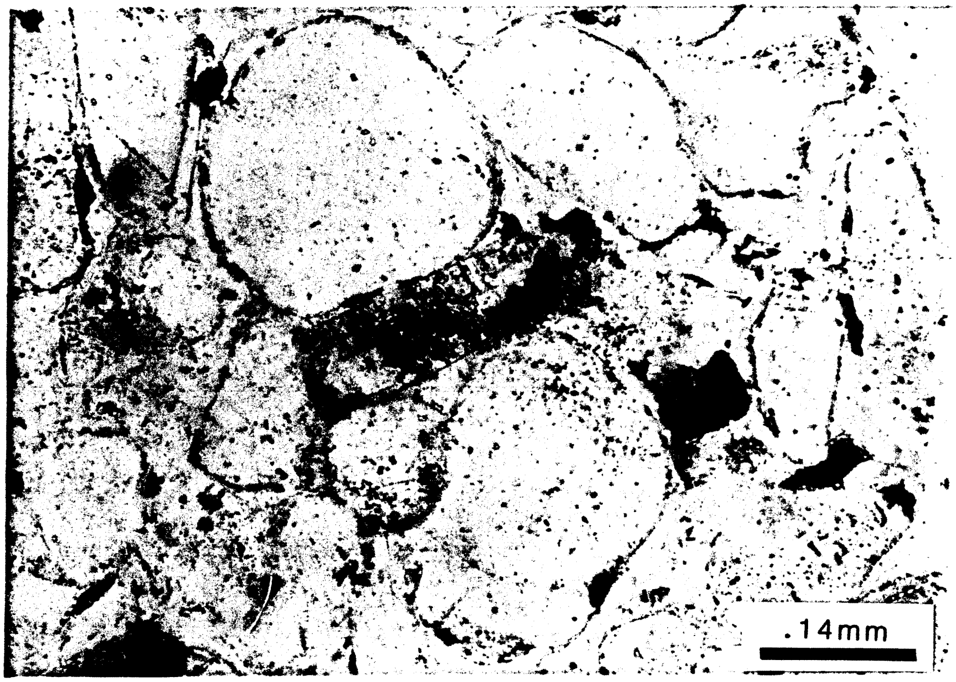
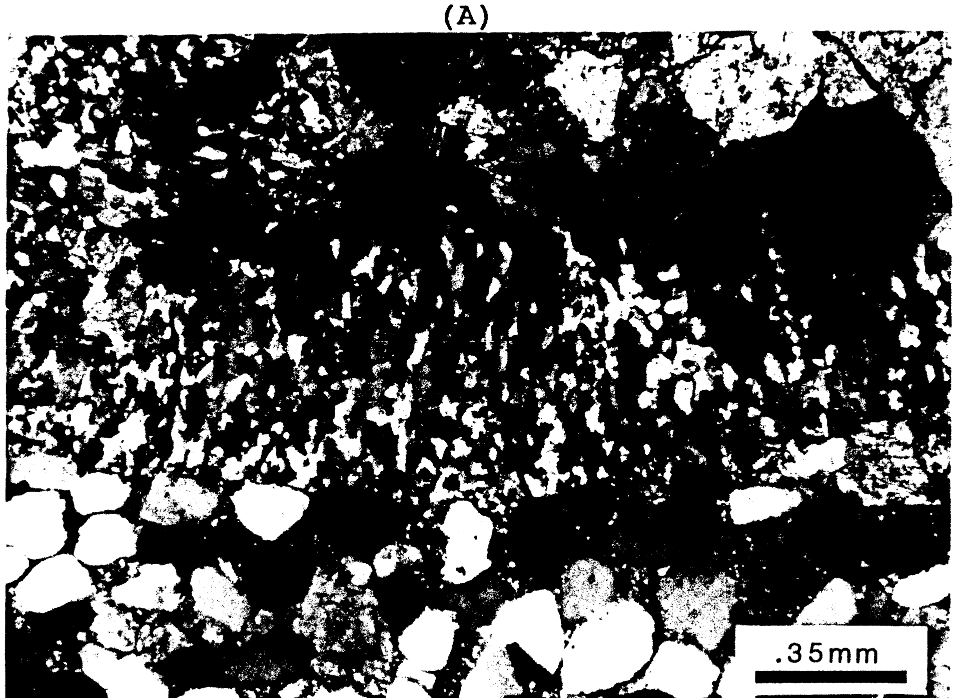


Figure 14. Stability fields of commonly occurring authigenic minerals found in sedimentary rocks expressed in terms of prevailing Eh and pH (after Collinson and Thompson, 1984).

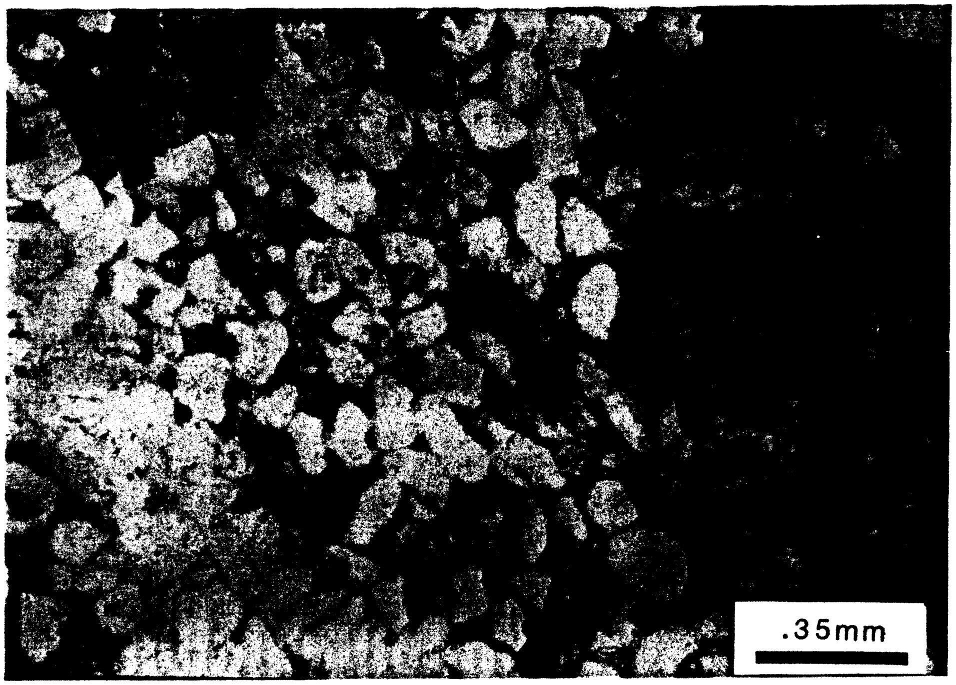


(A)

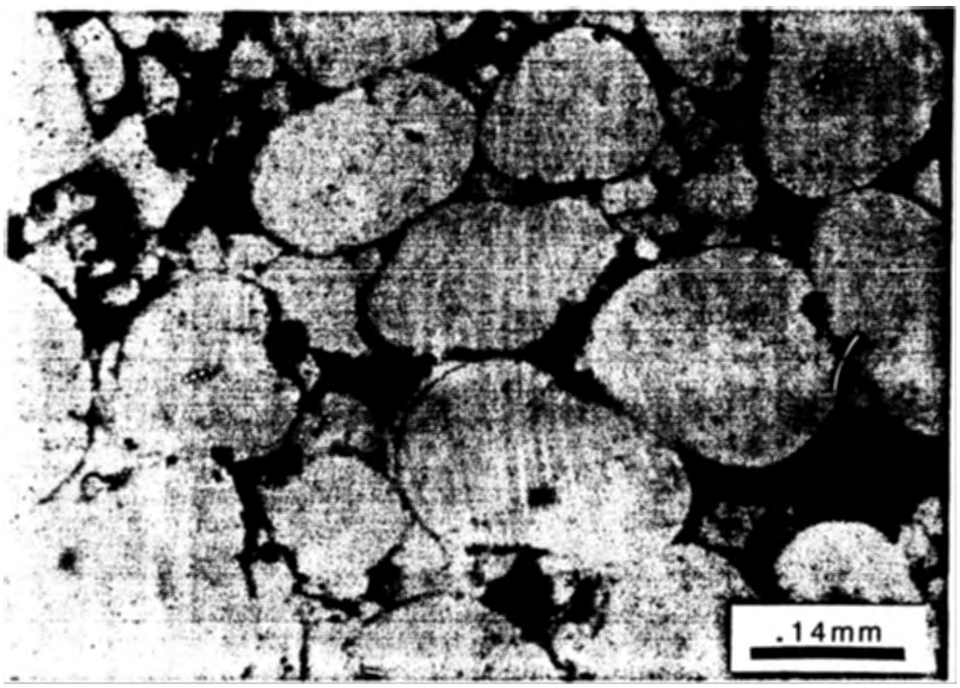


(B)

Figure 15. A. Feldspar partially dissolved. (plane-polarized light, (pp)) B. Brachiopod fragment partially replaced by chalcedony and quartz grains in calcite cement. (crossed nicols, (cn))



(A)



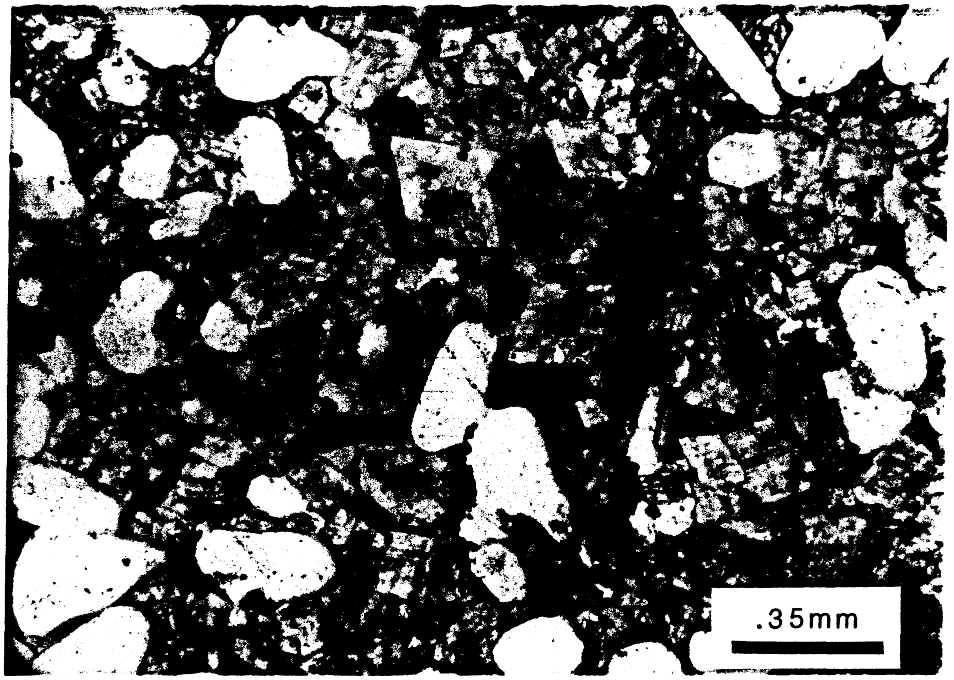
(B)

Figure 16. A. Quartz grains, illitic clay, and quartz overgrowths. (pp)
B. Hydrocarbons arrested silica overgrowth. (pp)

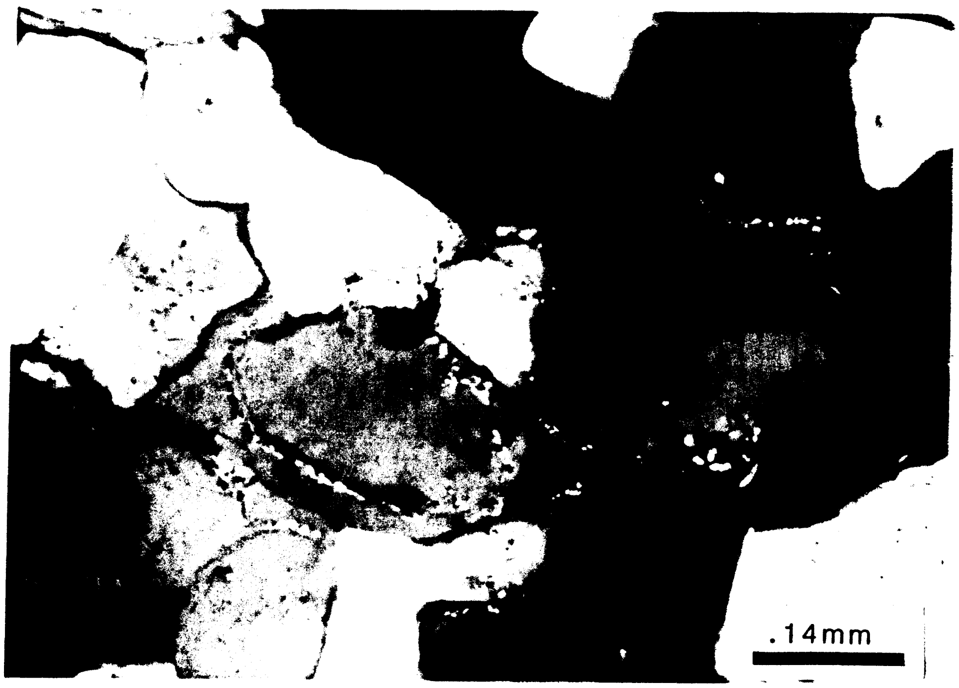
The first migration of hydrocarbons through the McLish Formation is postulated to have taken place shortly after quartz overgrowths began to form (Figure 16B). The presence of residual hydrocarbons indicate that the diagenetic processes were halted after they moved through the rock. Pyrite was observed in close proximity to zones where hydrocarbons were seen. The breakdown of organic matter would have caused the environment to become acidic and reducing (Figure 14).

Dolomite, and ankerite at depths greater than 11,000 feet below sea level, were often observed replacing detrital matrix (Figure 16A). As the detrital matrix was altered, ions were made available to form the dolomite and ankerite. The dolomite is sometimes zoned with ankerite which suggests episodic growth through time (Figure 17A). The formation of these carbonates would necessitate calcium carbonate rich pore water, alkaline conditions and reducing conditions would be favored for the formation of ankerite (Figure 14).

Subsidence and deposition of younger Paleozoic sediments resulted in tighter packing. Granulation was observed in some of the quartz rich sandstones. The granulation of quartz grains may have contributed minor amounts of silica to the pore waters. The major contributor to silica was compaction of the sediments. This would have altered clay minerals and enhanced the diagenetic processes acting on the shales. The dewatering of the shales would have supplied silica rich fluids (Hower et al., 1976).



(A)

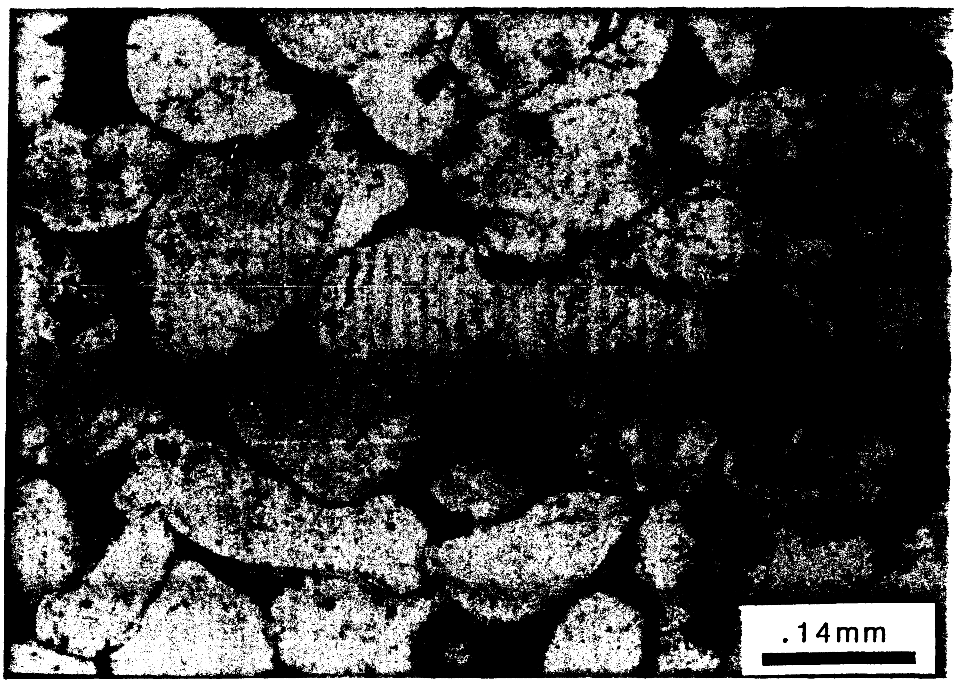


(B)

Figure 17. A. Alternating zones of ankerite and dolomite. (pp) B. Quartz-arenite with illite lining paleo-pore the cemented by silica. (pp)

Because of the silica rich fluids cementation by silica began for a second time. This is seen in areas where tighter packing of grains was observed. This episode of silica cementation continued until virtually all porosity was occluded in the quartz-arenites (Figure 17B). The replacement of dolomite by chert probably took place during this episode of silica cementation (Figure 18A), along with replacement of some fossil fragments by chalcedony (Figure 15B). As the formation pore fluids changed from more alkaline to acidic conditions the precipitation of carbonates ceased and the precipitation and replacement by silica ensued. Corrosion of dolomite and ankerite crystals indicate this shift in the chemistry of the pore fluids. The replacement of some of the calcite cement by ferroan calcite and the formation of ankerite are probably late because they are though to have formed at depths greater than 11,000 feet below sea level. Stylolites are present cutting across quartz overgrowths, indicating that they formed after the quartz cements. This could possibly be related to the orogenic activity in the Pennsylvanian Period. Along with the formation of the stylolites a second episode of hydrocarbon migration is postulated to have taken place. Pyrite was observed along stylolites, and was probably related to the hydrocarbon migration.

(A)



(B)

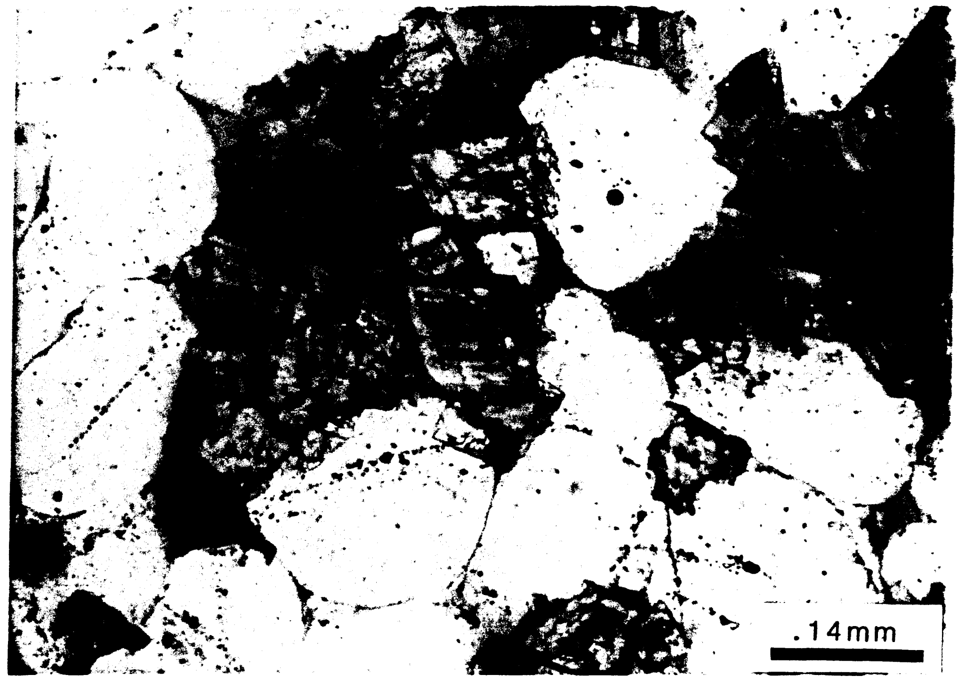
Figure 18. A. Chert rims on dolomite/ ankerite rhombs. (pp)
B. Primary porosity preserved by illitic clay. (pp)

Porosity

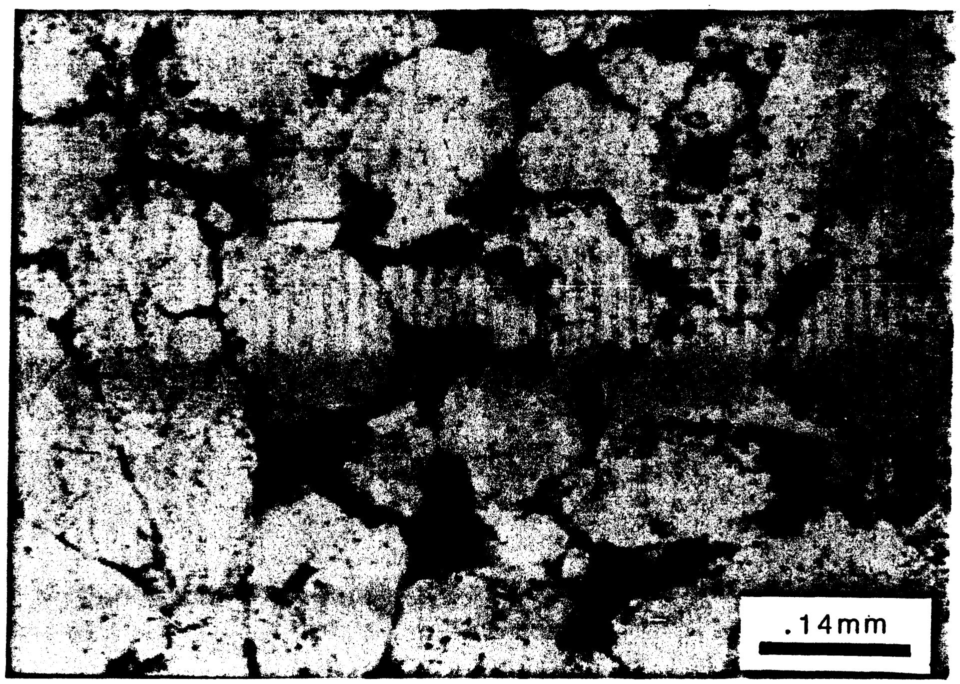
Primary and secondary porosity are present in the McLish Formation. The presence of clay matrix is interpreted to have been instrumental in the preservation of primary porosity (Figure 18B). Hydrocarbons were observed to inhibit the growth of syntaxial quartz overgrowths in the sandstones of the McLish Formation (Figure 16B). This preserved modified primary porosity. The presence of meta-stable components (Figure 19A) were very important in the generation of secondary porosity. Clay matrix, glauconite, feldspars (Figure 15A), fossil fragments, silica cement (Figure 19B), and carbonate cement were all observed in thin-sections to be dissolved or in a stage of dissolution in different locations in the cores and outcrops. Secondary porosity was observed as enlarged pores (Al-Shaieb and Shelton, 1981) and fractures. A very minor amount of secondary porosity was observed in the carbonate rocks of the McLish Formation in the form of fractures.

Hydrocarbons

There appear to have been two episodes of hydrocarbon migration. The first was relatively early after the first stage of silica cementation by quartz overgrowths (Figure 13 and 16B). It appears from the observed evidence that the migration of hydrocarbons arrested the silica overgrowths. This froze the diagenesis in some cases. The second episode occurred late, possibly during the Pennsylvanian or later



(A)



B

Figure 19. A. Enlarged pores due to dissolution of meta-stable components. (pp)
B. Dissolution of silica cement. (pp)

(Figure 13). The hydrocarbons observed in this episode were in stylolites. Pyrite is associated with the hydrocarbons in both episodes of migration. The shales in the Simpson Group and the carbonates of the Arbuckle Group could have been the source for the early hydrocarbons. The type of kerogen present in these rock could possibly have matured earlier than the type of kerogen in Pennsylvanian rocks. The hydrocarbons in the Simpson Group are of a higher gravity than those in the Pennsylvanian, unless the reservoirs in the Simpson Group had been breached and the hydrocarbons migrated up section to a reservoir in younger rocks.

Hydrocarbons may have migrated through the McLish Formation the first time, because the rock had excellent porosity and permeability. If there were no structural or stratigraphic traps to hold the hydrocarbons in place, they would have moved through the rocks up dip until they reached the surface or until they were trapped in a reservoir higher in the section. Evidence suggests that the second migration took place after orogenic activity in the Pennsylvanian or Permian Periods. The area in southern Oklahoma was deformed by both folding and faulting. Traps for hydrocarbons were formed during this orogenic episode.

CHAPTER V

RELATIONSHIP BETWEEN PETROGRAPHY LOG-SIGNATURES

The core and electric logs from the Mazur well were used for this chapter because a full suite of logs were run in this well. Hence, direct correlations could be drawn.

The wireline-log characteristics of the Mazur well were analyzed in relation to the detrital and authigenic components of the McLish Formation. The gamma-ray, induction resistivity, sonic, neutron and compensated formation density logs were used for this analysis (Figure 20).

Gamma-Ray Log

Potassium, thorium, and uranium are the primary elements that are sensed by the gamma-ray tool. In the McLish Formation, the basal sandstone is composed of monocrystalline quartz, minor amounts of feldspars (most of which contain potassium), and illitic clay, which contains potassium. Where feldspar and illite are concentrated, the gamma-ray log shows greater levels of radioactivity (for example see Figure 20). This makes sandstones appear "dirtier" or more

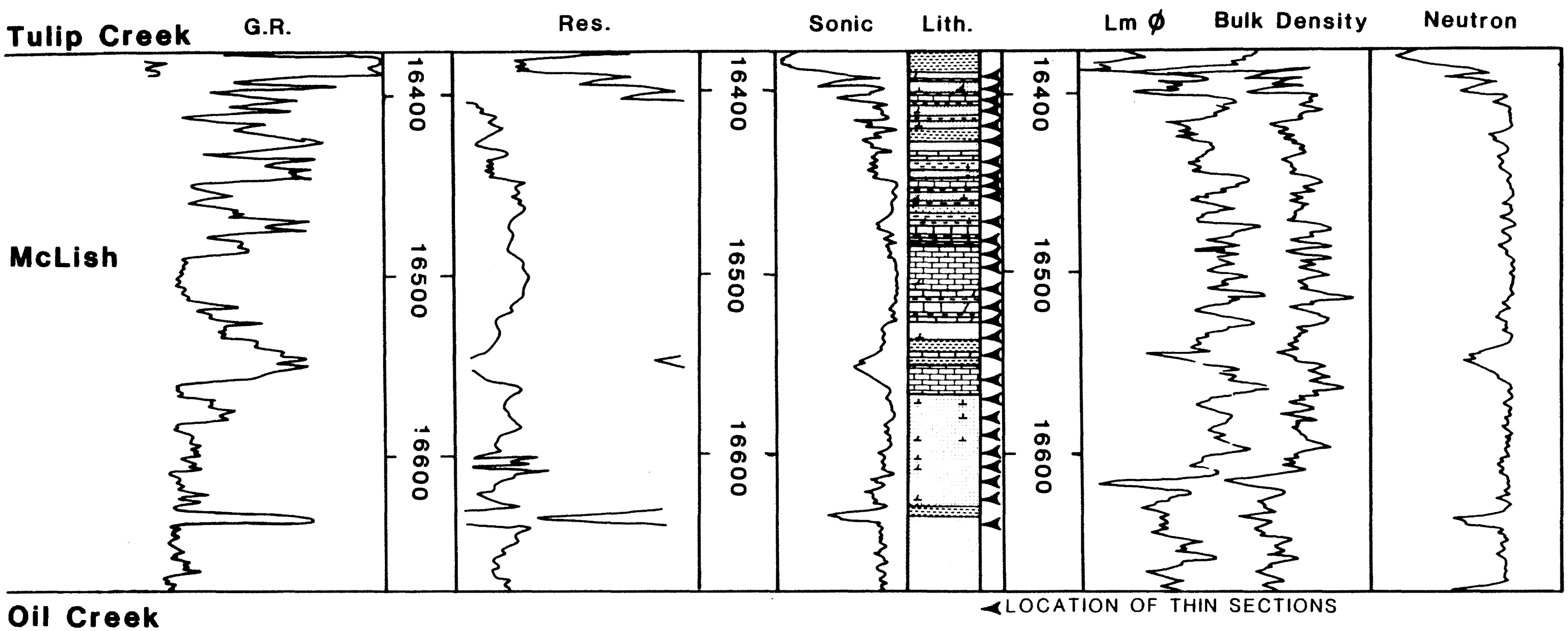


Figure 20. Wireline-log records over the McLish Formation in the Sunray DX Parker, Mazur No. 1 well, (Gamma-ray, G.R., Resistivity, Res., Sonic, Lithology, Lith., Formation Density Log; Limestone Porosity, Lm Ø, Bulk Density, Neutron).

shaly than they actually are. In the upper portion of the McLish Formation, carbonate rock and shale and sandstone and shale are interbedded. Minor amounts of chlorite are also present in the McLish Formation. Because chlorite does not generally contain potassium, thorium or uranium, high amounts of radioactivity will not be recorded by the gamma-ray tool. This could cause a chlorite-rich zone to appear less shaly than an illitic-rich zone.

Induction Resistivity Log

A spontaneous potential log was not run over the McLish Formation because of the high salinity of the drilling fluid and the depth of the section. Had a spontaneous potential log been run, the curve would have shown little deflection.

The resistivity curve recorded very large values over those sections in the McLish Formation that have large percentages of carbonate cement and fossil fragments. The increase in illitic clays in the upper portion of the formation suppressed the resistivity curve. Many of the beds in the upper portion of the McLish Formation are very thin, making accurate estimations of resistivity difficult (Figure 20).

Sonic Log

The sonic log records the travel time of sound waves. The denser a material the faster the sound waves travel through it. Thus, slower travel times indicate higher porosity. The sonic log in the Mazur core is calibrated for limestone porosity. The sonic log indicates that porosities in the sandstones and carbonate rocks in the McLish Formation range from none to trace amounts, whereas the thin-section analysis resulted in porosities ranging from a trace to approximately 9%. The shales show the slowest travel times, because of the increased surface area due to the grain size and bound water adhering to the grains.

Compensated Formation Density Log

The bulk density log in the Sunray DX Parker, Mazur No. 1, well is calibrated for limestone porosity. Values from the bulk density curve were crossplotted with the transit times for each thin-section sample, in order to estimate the porosities and/or lithologies (Figure 21). The porosity values were smaller than those estimated from thin-section analyses. The values for the quartz-arenites and subarkoses plot generally in the region between the limestone and dolomite lines (Figure 21), and beyond the lower limit of the sandstone line.

Two sand bodies comprise the basal sandstone unit in the McLish Formation. The basal quartz-arenite sands (indicated by triangles on the Quartz Arenite diagram in Figure 21) cluster in two areas: the first cluster includes sample 1 from the lower sand body and samples 2, 3, and 4 from the upper sand body. These four samples cluster around the lower end of the limestone line (Figure 21a). They are

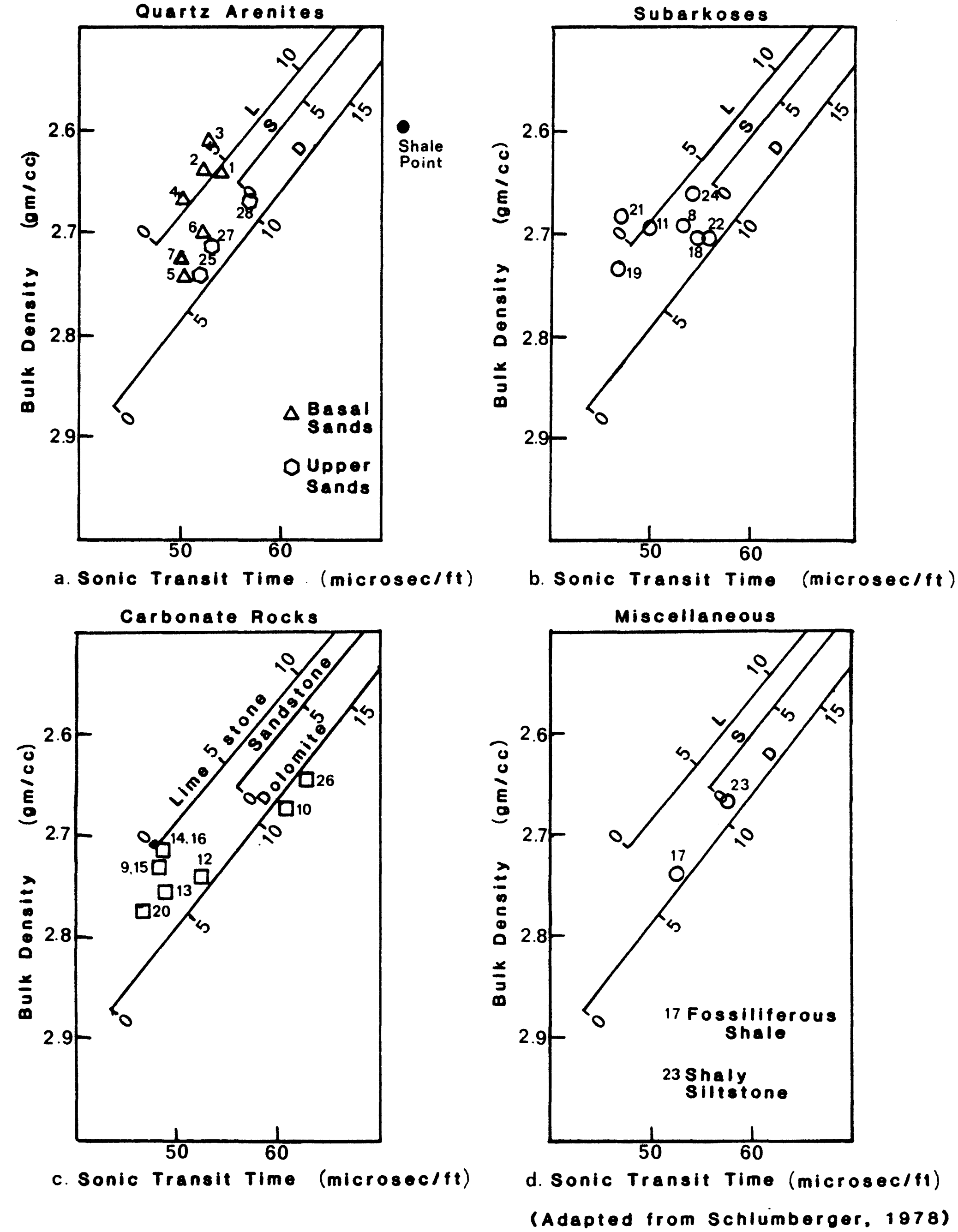


Figure 21. Crossplot of Bulk Density and Sonic Transit Times for Quartz Arenites, Subarkoses, Carbonate Rocks and Miscellaneous Samples.

located in this region perhaps because of a combination of total clay and carbonate in the samples. The three samples 5, 6, and 7, from the upper portion of the upper sand body, are clustered midway between the limestone and dolomite lines possibly because of the high percentage of dolomite and ankerite present. The quartz-arenite samples from the upper portion of the McLish Formation (hexagons) are clustered around the dolomite line (Figure 21a), possibly because of a combination of the detrital grains and the amount of dolomite and ankerite present in the samples.

The subarkoses cluster between the limestone and dolomite lines, beyond the lower limit of the sandstone line. A few of the samples are outside of the cluster. Sample 19 (Figure 21b) has double the average ankerite and dolomite of the subarkoses in the main subarkose cluster. Because dolomite and ankerite are denser than quartz and feldspar, the sample has a higher density value. Samples 21 and 11 both have high total clay percentages. Because of the clays' lower density, the samples have lower bulk density values. The relatively fast transit time probably is associated with the amount of carbonate cementation.

Carbonate rocks are clustered between the lower ends of the dolomite and limestone lines (Figure 21c). The relatively short transit times recorded from the carbonate rocks in the cluster could be due to the lack of porosity. Two samples are below the dolomite line. Sample 26 is very high in total clay, which could account for the lower density and the slow transit time. Sample 10 is relatively close to sample 26 but lacks similar characteristics and is anomalous.

Concerning the two samples in the miscellaneous chart: the fossiliferous shale contains a high percentage of dolomite, which probably accounts for its relatively high density. The clay slows the transit time.

CHAPTER VI

CONCLUSIONS

The McLish Formation represents a transgressive regressive cycle.

The McLish Formation consists of a basal sandstones unit and an upper unit consisting of interbedded carbonate rocks and shales, carbonate rocks, interbedded sandstones and shales, sandstones and shales.

Sandstones in the McLish Formation are very fine to fine grained, subrounded to well rounded, immature to supermature, subarkoses and sublitharenites to quartz-arenites.

Carbonate rocks in the McLish are wackestones to very coarsely crystalline grainstones. These contain calcitic fossil fragments of echinoderms, Bryozoa, brachiopods, trilobites and ostracods. Some fossil fragments are phosphatic brachiopods and conodonts.

The McLish Formation was deposited in environments from the Upper shorface, intertidal to open marine, below storm wave base. The coastline is postulated to have been storm dominated.

Primary and secondary porosity are both present in the McLish Formation. Zones with the least clay are not the sections with the best porosity development. It appears necessary to have had moderate amounts of clay present in order to have preserved primary porosity and in most cases clay and other meta-stable components are needed to developed secondary porosity. Porosity has not been completely occluded by cementation or compaction in the McLish Formation to a depth of 16,500 feet.

The diagenetic history is very similar for quartz-arenites, subarkoses, sublitharenites and carbonate rocks in the McLish. The sequence of events was dependent in large part on the depositional environment. The lower the energy the more clay matrix that was available to be mixed in the rock by burrowing animals. The higher the energy the cleaner the rock and the earlier the rock was cemented, by either carbonate cements or silica cements. Many of the diagenetic changes in the McLish Formation took place at shallow depths. This is concluded from the minor amount of compaction that has taken place in the formation even at 16,500 feet. At depth the major alterations were precipitation of ankerite and alteration of calcite to ferroan calcite.

There appear to have been two episodes of hydrocarbon migration. The first relatively early and the second late during the Late Paleozoic Period.

The feldspars in the McLish Formation appear to have been derived from a different source than the monocrystalline quartz. From the data accumulated in this study it is postulated that the source was from the west, either northwest or southwest. The source to the northwest could possibly have been the Transcontinental Arch, the source to the southwest could possibly have been the Texas Arch. More work is needed in this area to determine the provenance of the feldspars.

The calibration of the gamma-ray log with the samples is imperative in order to get accurate correlations. Illite and feldspars can cause the gamma-ray tool to register higher values and cause a sandstone to appear more shaly than it actually is. If the core and logs are calibrated correctly, productive strata are less likely to be overlooked. Ankerite and dolomite increase the bulk density values of samples. Carbonate and silica cements decrease the sonic transit times. Clays increase the sonic transit times and decrease the bulk density values of samples.

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APPENDICES

APPENDIX A

CORE; SUMMARIES

WELL: SUNRAY DX PARKER, MAZUR NO. 1.

LOCATION: SECTION 1, T.3N., R.5W., GRADY COUNTY, OKLAHOMA.

DEPTH: CORED INTERVAL, 16,383-16,661 feet; E-LOG INTERVAL, 16,378-16,655 feet.

STRATIGRAPHIC INTERVAL: MCLISH FORMATION.

CORE DESCRIPTION:

The cored interval consists of sandstone, carbonate rock, interbedded carbonate rock and shale, interbedded sandstone and shale, shale and sandstone. Depths will coincide with the electric log depths (Plates III and XII). The lower most section (16,579-16,655) is the basal sandstone unit of the McLish. A six foot thick shale (16,631-16,637) breaks the unit into two sand bodies. The lower sand body is a fine grained, unimodal, supermature, quartz-arenite with bioturbation in the bottom eight feet, and thin-bedding to massive-bedding above, with cross-bedding and ripple-bedding present. It grades into a six foot thick dark brown laminated shale. The contact between the shale and the sandstone above is abrupt. Above the contact is a fine grained, immature quartz-arenite. This section is highly bioturbated with some soft sediment deformation present. The quartz-arenite grades into a fine grained, unimodal, immature quartz-arenite, with ripple- and cross-bedding to massive-bedding. Above is a gradational contact, and a fine grained, unimodal, supermature, quartz-arenite with cross-bedding and some bioturbation and ripple-bedding. The arenite grades in reverse order back to a fine grained, immature, quartz-arenite that is highly bioturbated. The above interval is a fine grained, supermature, quartz-arenite, with cross-bedding and ripple-bedding. The next section (16,569-16,578) is interbedded to interlaminated sandstone and shale. The sandstone is a very fine grained, immature subarkose. The contact is gradational with the basal sandstone unit. Ripple-bedding is the most abundant sedimentary feature present. This unit is overlain by a dolomitic, coarsely crystalline grainstone (16,558-16,568). The contact is gradational. There are some shale partings present, indicating ripple-bedding. Overall, this section is highly bioturbated. The section above this carbonate rock is interlaminated to thinly-bedded carbonate rock and shale (16,541-16,557). There is a one foot thick ankeritic coarsely crystalline grainstone (16,546.5-16.547.5). Ripple-bedding and bioturbation are the most prominent sedimentary structures. The contact between this unit and the one above (16,530-16,540) is abrupt. It consists of a very fine, immature subarkose, interlaminated with shale partings. This unit is highly bioturbated and has ripple- and cross-bedding in places. An abrupt contact exists between the subarkose and the overlying carbonate rock unit (16,488-16,529). There are two very shaly sections from 16,515-16,518 and 16,523-16,524. The lower fifteen feet are interlaminated to interbedded shaly ankeritic grainstone. Bioturbation, stylolites and ripple-bedding are the most abundant sedimentary features. The upper twenty six feet are coarsely crystalline grainstone. This section is very fossiliferous: echinoderms, trilobites, bryozoan, brachiopods, ostrocods and some phosphatic fragments of brachiopods and conodonts are present. These make up the bulk of the section. Stylolites, inclined beds and ripple-bedding are the most prominent sedimentary structures. Above this carbonate rock is a laminated sequence of carbonate rock and shale (16,477-16,487). This ten foot interval is fossiliferous shale to shaly fossiliferous limestone. The shale is composed of illite and the carbonate is made up of calcitic fossils and dolomite, ankerite and some ferroan calcite. The contact between the above unit and this one is gradational. The unit above grades from a very fine, immature, subarkose to a very fine, submature, subarkose (16,454-16,476). This section is ripple-bedded, cross-bedded, and bioturbated. Above this sandstone is a thin grainstone (16,448-16,453). Stylolites are very abundant and bioturbation and ripple-bedding are prominent features. Shale partings are scattered throughout the section. There are abrupt contacts at the base and at the top of this carbonate rock section. Above is interbedded and interlaminated sandstones and shales (16,403-16,447). Bioturbation, burrowing, cross-bedding, ripple-bedding and inclined beds are all present in this section. At the base of this unit is a very fine, unimodal, immature, subarkose. Ten feet above is a bimodal, very fine to medium grained immature, subarkose and ten feet above this is a shaly feldspathic siltstone. This grades into a highly bioturbated and burrowed section, that is a very fine grained, unimodal, supermature, subarkose. Above is a fine grained, unimodal, supermature, quartz-arenite that is also very bioturbated. The contact above this sandstone and shale interval is abrupt. There is a six inch bed of shaly dolomitic ankeritic grainstone. This grades abruptly into a fine grained, supermature quartz-arenite (16,396.5-16,401.5). This sandstone is heavily bioturbated and grades transitionally into a dark brown laminated shale (16,394.5-16,396.5). The contact between the shale and the unit above is abrupt. The unit above is a fine grained, supermature, quartz-arenite (16,390.5-16,394.5). Bioturbation and ripple-bedding are the most prominent sedimentary structures. The contact between this sandstone and the above shale is abrupt. The shale is dark brown laminated and fissile. It is also the top of the McLish Formation.

WELL: GULF, COSTELLO NO. 1

LOCATION: SECTION 14, T.5N., R.5W., GRADY COUNTY, OKLAHOMA.

DEPTH: CORED INTERVAL, 12,105-12,387; E-LOG INTERVAL, 12,113-12,395.

STRATIGRAPHIC INTERVAL: MCLISH FORMATION

CORE DESCRIPTION:

The cored interval consists of sandstone, carbonate rock, interbedded carbonate rock and shale, interbedded sandstone and shale and shale and sandstone. Depths will coincide with the electric log depths (Plates II and XI). The lower most section (12,395-12,382) is the lower sand body of the basal sandstone unit of the McLish Formation. It is very fine to fine grained and mature to supermature quartz-arenite. Bioturbation and burrowing are the most prominent sedimentary features present. There are minor amounts of horizontal and slightly inclined bedding scattered throughout this section and cross-bedding at the top of this section. The contact between this section and the overlying unit is sharp. There is a 6 inch shale that is greenish gray, laminated and fissile. Above the shale is another sharp contact. This unit is very fine to fine grained, mature sublitharenite (12,381-12,380) highly bioturbated at the base and horizontally bedded and burrowed in the upper foot. A gradational contact exists between the sublitharenite and the unit over lying it. The unit over lying it is a very fine grained, immature quartz-arenite (12,379-12,378). The quartz-arenite is highly bioturbated and burrowed, at the top it shows evidence of soft sediment deformation. The contact at the top of the quartz-arenite is abrupt. Above is a 3 foot interbedded sandy coarsely crystalline grainstone and shale. The section is horizontally laminated and ripple-bedded. Above the interbedded carbonate rock and shale section is an abrupt contact with a very fine to fine grained, supermature to mature quartz-arenite (12,374-12,343). The lower 7 feet are supermature and very fine to fine grained, ripple-bedded and bioturbated. The middle 21 feet are very fine grained, mature and highly bioturbated and burrowed. The upper 3 feet are very fine to fine grained, supermature and ripple-bedded and cross-bedded. The basal sandstone unit of the McLish Formation is made up of the two sand bodies (12,395-12,378 and 12,374-12,343) mentioned above. Above the upper sand body of the basal sandstone is a gradational contact with coarsely crystalline grainstone (12,342-12,330). Feet 12,336-12,334 are missing. Fossil fragments of echinoderms, bryozoa, trilobites and brachiopods are abundant. Ripple-bedding, cross-bedding and shale partings are the most abundant sedimentary structures. Stylolites and fractures are also present. Above this ripple-bedded interval is a highly bioturbated and burrowed interval (11,329-12,324). The base is fossiliferous, coarsely crystalline grainstone, above is dolomitic oolitic packstone. Above this is 10 feet of laminated packstone and shale (12,323-12,313). Slightly inclined-bedding and ripple-bedding are the prominent sedimentary features. Above the laminated packstone and shale is highly bioturbated fossiliferous packstone (12,312-12,290). Feet 12,310-12,307 are missing. Above this carbonate rock unit is a abrupt contact with a very fine to fine grained, mature quartz-arenite (12,289-12,286). With ripple-bedding and cross-bedding being the most prominent sedimentary features and some burrowing at the top of the section. This unit has a gradational contact with the overlying very fine to fine grained, mature subarkose (12,285-12,280). The subarkose is highly bioturbated and burrowed. Above the subarkose is an abrupt contact with a fossiliferous packstone (12,279-12,243). The carbonate rock is interbedded with shale. The interval is highly bioturbated and burrowed. Feet 12,254 and 12,253 are missing. Above the carbonate rock is a very fine, immature to mature, highly bioturbated subarkose to arkose (12,242-12,215). The contact between the carbonate rock and the sandstone is gradational. Above the arkosic sandstone is a 2 feet thick fossiliferous coarsely crystalline grainstone. The grainstone is ripple-bedded, cross-bedded and burrowed. Fossil fragments of echinoderms, bryozoa, trilobites and brachiopods are abundant. Above the carbonate rock is a 6 inch thick green, laminated and fissile shale. Above the shale is interbedded sandstone and shale (12,211-12,204). The sandstone and shale are horizontally bedded and cross-bedded, with bioturbation in the upper portion of the unit. The sandstone is a very fine grained, immature subarkose.

Above the interbedded sandstone and shale is a 2 feet thick very fine to fine grained, mature quartz-arenite. Above the thin quartz-arenite is a sharp contact. Interbedded carbonate rock and shale overlie (12,201-12,177.5) the quartz-arenite. The next 3 feet are highly bioturbated. The next 5.5 feet are interbedded fossiliferous packstone and laminated, fissile shale. This section is horizontally bedded in the lower part of the section and bioturbated in the upper portion of the section. The 2.5 feet above this is composed of carbonate ripup clasts mixed with shale. The conglomeratic section appears to be bioturbated and/or soft sediment deformed. The next 12.5 feet are interbedded packstone to grainstone, sandstone and shale. Feet 12,184 and 12,183 are missing. Shale partings and bioturbation are prominent in the lower 7 feet. The upper 5.5 feet are ripple-bedded and bioturbated. Above this interbedded carbonate rock and shale unit is a sharp contact with a 2 feet thick green, laminated, fissile and pyritic shale (12,177.5-12,175.5). Above the shale is a greenish very fine to fine grained, supermature quartz-arenite (12,175.5-12,120). The contact between the shale and the quartz-arenite is abrupt. Bioturbation and burrowing are the most prominent sedimentary features. Stylolites are present throughout the section. Some inclined-bedding and ripple-bedding are also present. Above the quartz-arenite is a gradational contact with a light green, laminated, fissile and pyritic shale (12,119-12,113).

WELL: GULF, BEARD NO. 1

LOCATION: SECTION 18, T.5N., R.3W., MCCLAIN COUNTY, OKLAHOMA.

DEPTH: CORED INTERVAL, 11,079-11,450; E-LOG INTERVAL, 11,080-11,451.

STRATIGRAPHIC INTERVAL: MCLISH FORMATION

CORE DESCRIPTION:

The cored interval consists of sandstone, carbonate rock, interbedded carbonate rock and shale, interbedded sandstone and shale, and shale and sandstone. Depths will coincide with the electric log depths (Plates I and X). The interval from 11,472-11,452 was not cored. From the electric log the lower 15 feet appear to be a sandstone. The next 5 feet appears to be a shale. The cored interval begins with a quartz-arenite (11,451-11,399). The interval is a white to light greenish, very fine to fine grained, super mature to immature quartz-arenite. The unit is thin to massively bedded. Cross-bedding is the most prominent sedimentary structure present in the lower 25 feet, some stylolites are also present. Foot 11,428 is missing from the section. Bioturbation is the most prominent sedimentary feature present in the upper 27 feet. Cross-bedding and shale partings are also present in this upper unit. The sand body from 11,472-11457 and the sand from 11,451- 11,399 makeup the basal sandstone of the McLish Formation in this well. The 5 foot interval between the two sand bodies is a shale. The contact with the lower sand body appears to be transitional and the contact with the upper sand body appears to to be abrupt. This is inferred from the electric log. Above the basal sandstone is a 1 foot shale, with a gradational contact. The shale is greenish-black, laminated, fissile, pyritic and composed mainly of illitic clay. Above the shale is a sandy grainstone (11,397-11,393). The contact between the shale and the grainstone is abrupt. The carbonate is fine to medium bedded, highly bioturbated, fossiliferous and shaly. Core is missing from 11,392-11,375. Above this is a quartz-arenite (11,374-11.355). The contact is inferred to be transitional between the sandy grainstone and the quartz-arenite from the electric log. The quartz-arenite is very fine to fine grained, supermature and fossiliferous with bioturbation and burrowing prominent in the lower 5 feet and cross-bedding dominant in the upper 14 feet. Stylolites are also common. Above this is fossiliferous grainstone (11,354-11,317). The contact between this unit and the underlying unit is transitional. This grainstone has little or no quartz material present, the lower portion of this section is dominantly dolomitic and the upper portion is calcitic. Fragments of echinoderms, bryozoa, trilobites and brachiopods are abundant in the section. Cross-bedding, ripple-bedding, horizontal-bedding and stylolites are present throughout the section. Vertical fractures are also abundant in this section. Minor amounts of burrowing, bioturbation and shale partings are also present. Overlying the carbonate rock is fossiliferous quartz-arenite (11,317-11,270). The lower section is very fine to fine grained and supermature. Ripple-bedding and cross-bedding are the most prominent sedimentary features. Above this the quartz-arenite is still fossiliferous but, becomes fine grained, and immature. The rock is greenish in color from the illitic clay. Bioturbation and burrowing are the most prominent features present in this section. The interval from 11,273-11,271 are missing. Above this section is a carbonate rock unit with a high clay content (11,269-11,237). The contact between the quartz-arenite and the carbonate rock unit is abrupt. The carbonate rock unit is green gray, highly fossiliferous, sandy and shaly. Ripple-bedding and bioturbation are the most prominent sedimentary features. Stylolites and vertical fractures in filled with calcite are abundant. An abrupt contact exists between the carbonate rock and the sublitharenite to subarkose unit (11,236-11,211) above. The unit is mottled, white to green, very fine grained and mature. Ripple-bedding and bioturbation are the most prominent features in this section. The lower 3 feet are cross-bedded, with minor bioturbation present. Above this unit is an olive green shale (11,210-11,204). This is inferred from the electric log and the presence of shale in contact with the underlying unit. The contact between the shale and the underlying unit is abrupt. The shale is laminated, fissile and predominantly composed of illitic clay. The contact between the shale and the quartz-arenite (11,203-11,152) above is gradational. The quartz-arenite is very fine to fine grained and supermature to mature. The lower 38 feet are highly bioturbated and burrowed. There are several thin shale units present in this section (11,195, 11,180, 11,171, 11,164 and 11,158) all approximately one foot thick or less. These shale are green, laminated, fissile and composed of mainly illitic clay. There is a 3 foot section from 11,163-11,161 that is cross-bedded with laminated shale partings. Above this is a homogeneous section that has been highly bioturbated. A shale abruptly overlies the quartz-arenite. The shale is thin and is overlain by a one foot thick sublitharenite (11,151-11,150). The sublitharenite is very fine to fine grained, supermature and is cross-bedded. Shale clasts up to 4 mm are present. Above this unit is a quartz-arenite (11,149-11,127). The unit is silt to medium grained, supermature to mature and highly bioturbated and burrowed, with shale parting abundant. The lower 10 feet show soft sediment deformation features. Above the quartz-arenite is a sandy dolomite (11,126-11,123). The dolomite has replaced the original constituents and the original texture has been obliterated. Above this is a 4 foot section of quartz-arenite (11,122-11,119) The quartz-arenite is fine to medium grained, supermature and massively bedded. The section from 11,118 to 11,095 is missing, the electric log indicates a porous, relatively "clean" unit. It is possible that the missing rock would be a continuation of the quartz-arenite present from 11,122 to 11,119. Above the missing unit is a tan and white mottled sublitharenite (11,094-11,092). The sublitharenite is very fine to fine grained, mature with bioturbation giving the rock the mottled appearance. The sections from 11,091-11,085 and 11,084-11,082 are missing. The rock present at foot 11,084 and 11,081 are fine to medium grained, mature, massively bedded quartz-arenites. Above this last unit should be a shale unit which would be the top of the McLish Formation.

APPENDIX B

OUTCROP; SUMMARIES

OUTCROP: INTERSTATE HIGHWAY 35, NORTH LIMB OF ARBUCKLE ANTICLINE.

LOCATION: SECTION 30, T.1S., R.2E., MURRAY COUNTY, OKLAHOMA.

STRATIGRAPHIC INTERVAL: MCLISH FORMATION.

OUTCROP DESCRIPTION:

The logged interval of the outcrop consists of sandstone, carbonate rock, interbedded carbonate rock and shale, interbedded sandstone and shale and shale (Plate IV). The lower most 20 feet or so of the McLish Formation is covered. It is presumed to be quartz-arenite. Above this lower section is light tan to pale green, very fine to fine, unimodal and immature to mature quartz-arenite (21-77). The section not exposed and the quartz-arenite make up the basal sandstone unit of the McLish Formation. Thin-bedding to massive-bedding is present with some bioturbation present throughout. Cross-bedding and bioturbation the predominate sedimentary feature in the upper 15 feet. Above is interbedded sandstone and shale (78-82), with ripple- and cross-bedding. Above is very fine, mature quartz-arenite (83-84), cross-bedded. The contact between the quartz-arenite and the bluish-gray shale above is abrupt. The shale is 1.5 feet thick, laminated, fissile and pyritic. Above the shale is a 1.5 foot thick, very fine to fine grained, supermature, glauconitic quartz-arenite. This quartz-arenite is cross-bedded and bioturbated. Above the quartz-arenite is a 1 foot thick, bluish-gray, laminated, platy shale. Above the shale is a tan to bluish-gray, fine to medium grained, quartz-arenite (89-93). Ripple-bedding is the predominate sedimentary feature present. The contact between this bed and the above carbonate rock is gradational. The carbonate rock is fossiliferous, coarsely crystalline and dolomitic (94-115). The carbonate rock is cross-bedded and stylolitic, with some greenish-gray shales interbedded. Above this carbonate unit is interbedded carbonate rock and shale (116-175). The carbonates range from micrites to fossiliferous, coarsely crystalline, dolomitic grainstones. The carbonates are thin- to thick-bedded and stylolitic. There are some 1 to 2 inch thick, fine grained, nodular limestone beds in the shales. The shales are bluish- to greenish-gray, laminated and fissile. Some of the shales are up to 11 feet thick. Above this interbedded carbonate rock and shale is 36 feet of coarsely crystalline, dolomitic, sandy grainstone (176-211). This carbonate rock is thin- to thick bedded with shale partings abundant. Above in the section is a creek valley that is eroding the formation. It is probably shale and some carbonate rock (212-263). Next is a 5 feet carbonate rock unit fossiliferous, medium to coarse crystalline, grainstone with quartz grains. The bed is massive and cross-bedded. Above this is 4 feet of interbedded fossiliferous carbonate rock and greenish-gray shale. The section above (273-322) is soil covered. The next exposure is a very fine to fine grained, mature, fossiliferous and glauconitic sublitharenite (323-329). The sublitharenite is bioturbated and burrowed with some ripple-bedding. Above this is another soil covered section (330-254). This zone is probably interbedded shales and carbonate rock. Above the soil covered zone is a tan, fine to medium grained, mature quartz-arenite (355-379). This section is highly bioturbated and burrowed with some cross-bedding. There is some interbedded fossiliferous, coarsely crystalline limestone. At the top of this section is a very fine to fine grained, immature to mature glauconitic sublitharenite that grades into a shaly zone about 2 feet thick. Above the shaly zone is 22 feet of coarsely crystalline, fossiliferous grainstone. The predominate sedimentary feature is cross-bedding. Above the carbonate rock is a thin (6 inches) greenish-gray laminated fissile shale. Above the shale is interbedded sandstone, carbonate rock and shale (403.5-415.5). The sandstones are tan to gray, very fine to fine grained, supermature, fossiliferous sublitharenites. The sandstones are fine- to medium-bedded and bioturbated. The carbonate rocks are fine grained and nodular in the shales and cross-bedded, coarsely crystalline, fossiliferous grainstones interbedded with the sandstones. The shales are greenish-gray laminated and fissile. The top of the section is a 1 foot thick greenish-gray laminated shale (415.5-416.5).

OUTCROP: STATE HIGHWAY 77, SOUTH LIMB OF ARBUCKLE ANTICLINE

LOCATION: SECTION 25, T.2S., R.1E., CARTER COUNTY, OKLAHOMA.

STRATIGRAPHIC INTERVAL: MCLISH FORMATION.

OUTCROP DESCRIPTION:

The outcrop interval consists of sandstone, interbedded carbonate rock and shale and interbedded sandstone and shale and shale (Plate V). The contact between the Oil Creek and the McLish Formations is soil covered. The lower most section exposed consists of white very fine to fine grained, unimodal and mature quartz-arenite (1-55). The quartz-arenite is massively bedded and almost structureless, there is some bioturbation at the top of the section. Above the sandstone is a 6 feet zone soil covered. Above is a yellowish gray fossiliferous carbonate rock (61-70). Bioturbation is the most prominent sedimentary feature. A 19 feet section that is soil covered is above the carbonate rock. A thin fossiliferous limestone bed consisting of mainly bryozoa fragments is the next unit above the soil covered zone. Above this is interbedded shale and carbonate rock (90-104). The shale is greenish-gray, laminated and platy. The carbonate rock is fossiliferous, containing fragments of echinoderms and bryozoa. The next 8 feet are soil covered. Above this soil covered section is yellowish-gray coarsely crystalline, fossiliferous, immature grainstone (113-250). The carbonates are thin- to massively-bedded, shale partings and stylolites are abundant. Fossil fragments of echinoderms, bryozoa, trilobites and brachiopods are abundant. A light green to gray sandy shale interbedded with thin-bedded carbonate rock overlies the carbonate rock section (251-296). The shale is laminated and fissile. Above this section is a yellow gray, coarsely crystalline, fossiliferous grainstone (297-313). The section above this is green shale interbedded with thin fine grained nodular limestones (314-338). Much of the shale and carbonate rock is soil covered. Above this soil covered section is a better exposed section that is very similar to the soil covered section. This section is interbedded carbonate rock and shale (339-379). The carbonate rocks are thin-bedded and ripple-bedded, fossiliferous, and immature. The shales are light green to olive green, laminated and fissile. Above this interbedded carbonate rock and shale section is a gradational contact with a very fine to fine grained, mature, glauconitic quartz-arenite (380-382). The section is cross-bedded. Above this sandstone is a sandy limestone (383-386). The contact is gradational between the sandstone and the carbonate rock. Bioturbation is the predominant sedimentary feature. Above the carbonate rock is interbedded carbonate rock and shale (387-462). The carbonates are thinly-bedded, fossiliferous, fine to coarsely crystalline, and glauconitic at the top of the section. The shales are green, laminated and fissile. Some portions of the interbedded carbonate rock and shale section are soil covered. The top of the McLish Formation is a gray to olive green, laminated, fissile shale (463-471).

VITA

Scott James Weber

Candidate for the Degree of

Master of Science

Thesis: PETROGRAPHY AND DIAGENESIS OF THE MCLISH FORMATION SIMPSON GROUP (MIDDLE ORDOVICIAN), SOUTHEASTERN ANADARKO BASIN, OKLAHOMA.

Major Field: Geology

Biographical:

Personal Data: Born in Sheboygan, Wisconsin, December 8, 1955, the son of David B. and Elizabeth Jean Weber. Married to Julie Ann Carr on October 12, 1984.

Education: Graduated from James Madison Memorial High School, Madison, Wisconsin, in June 1974; received Bachelor of Science Degree from University of Wisconsin-Madison in December 1978; completed requirements for the Master of Science Degree in Geology at Oklahoma State University in May 1987.

Professional Experience: Lab technician, Department of Geology, University of Wisconsin-Madison, Wisconsin, September 1976 to February 1977; Assistant Geologist, Hawkins Oil and Gas Inc., Tulsa, Oklahoma, January 1980 to June 1980; Exploration Geologist, Amerada Hess Corporation, Tulsa, Oklahoma, June 1980 to March 1983; Teaching Assistant, School of Geology, Oklahoma State University, Stillwater, Oklahoma, August 1984 to May 1985; Geological Research Assistant, Terra Resources Inc., Tulsa, Oklahoma, April 1985 to July 1985; Graduate Student Representative, School of Geology, Oklahoma State University, Stillwater, Oklahoma, September 1985 to September 1986; Research Assistant, School of Geology, Oklahoma State University, Stillwater, Oklahoma, January 1986 to May 1987; Active member of the American Association of Petroleum Geologists, Tulsa Geological Society and Geological Society of America.

COMPANY Gulf Oil Co., Beard No. 1
LOCATION SW, NE, Sec.13 T.5N., R.3W., McClain County, Oklahoma

PETROLOGIC LOG

LITHOLOGY
- SANDSTONE
- SHALE
- LIMESTONE
- DOLOMITE
- MISSING SECTION OR COVERED INTERVAL

BEDDING
- MASSIVE
- HORIZONTAL

SEDIMENTARY STRUCTURES
- CROSS-BEDDING
- RIPPLE BEDDING A/O LAMINAE
- BURROW TRACE FOSSILS
- BIOTURBATION
- RIP-UP CLASTS
- STYLOLITES
- SOFT SEDIMENT DEFORMATION

CONSTITUENTS
- QUARTZ: Monocrystalline
- FELDSPAR
- ROCK FRAGMENTS
- CLAY
- FOSSILS
  - INVERTEBRATES: Echinoderms, Bryozoans, Brachiopods, Trilobites
- CARBONATES
- SILICA
- SULFIDES
- HEAVY MINERALS: Tourmaline, Zircon

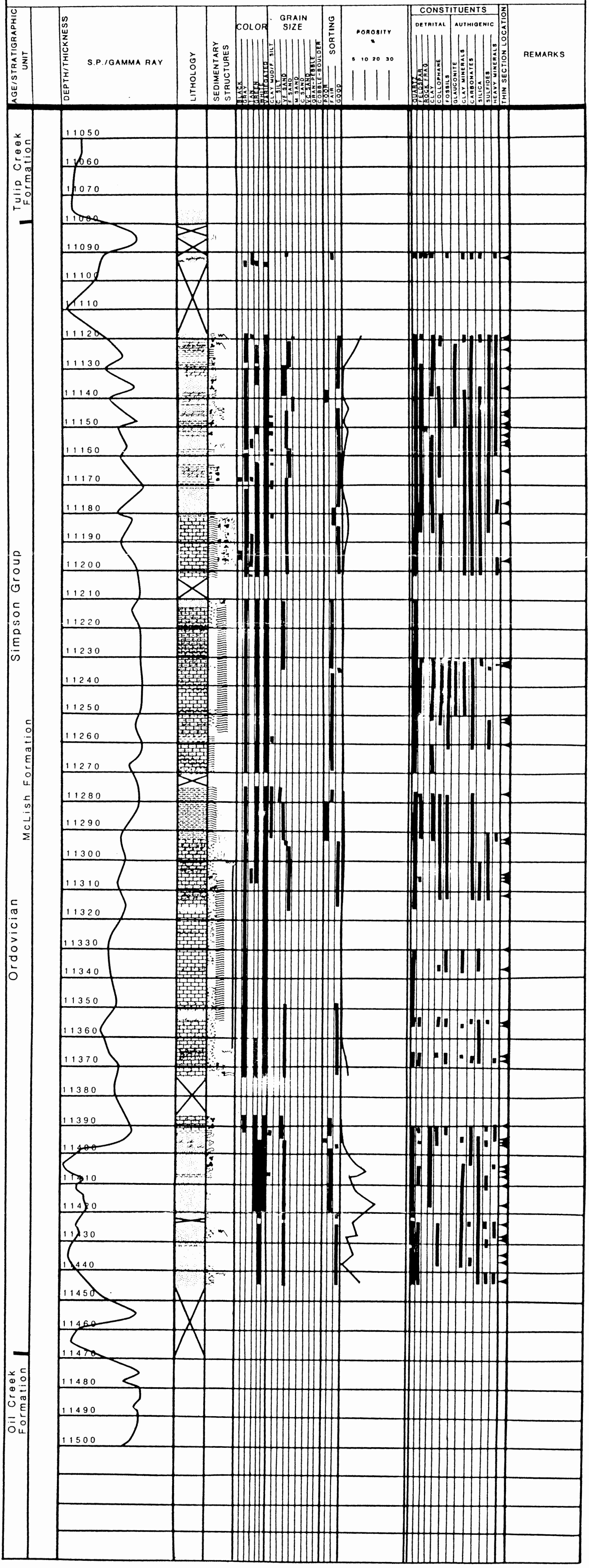

Plate I
Petrolog of the Beard Core
O.S.U. School of Geology
Scott Weber 1986

COMPANY Gulf Oil Co.Costello No. 1
LOCATION NE, SE, Sec. 14, T.5N., R.5W., Grady County, Oklahoma

PETROLOGIC LOG

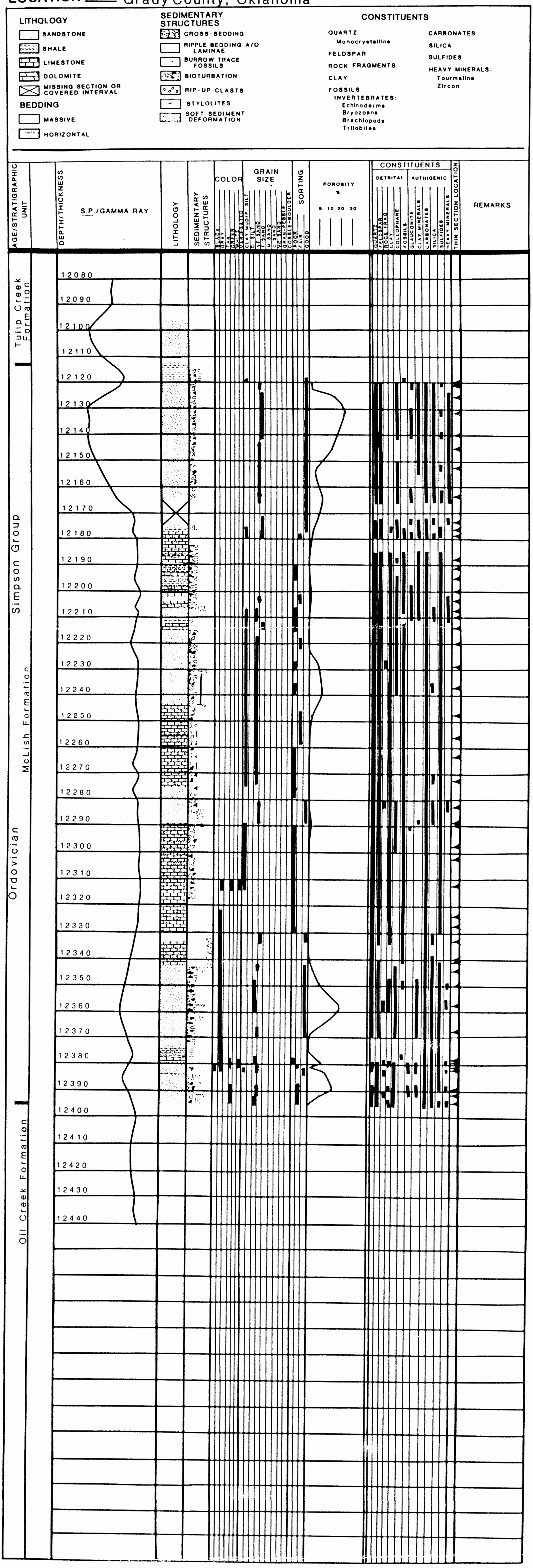

Plate II
Petrolog of the Costello Core
O.S.U. School of Geology
Scott Weber 1986

COMPANY SunrayDX Parker, Mazur No.1
LOCATION SW, NE, Sec.1, T.3N., R. 5W. —— Grady, County, Oklahoma

PETROLOGIC LOG

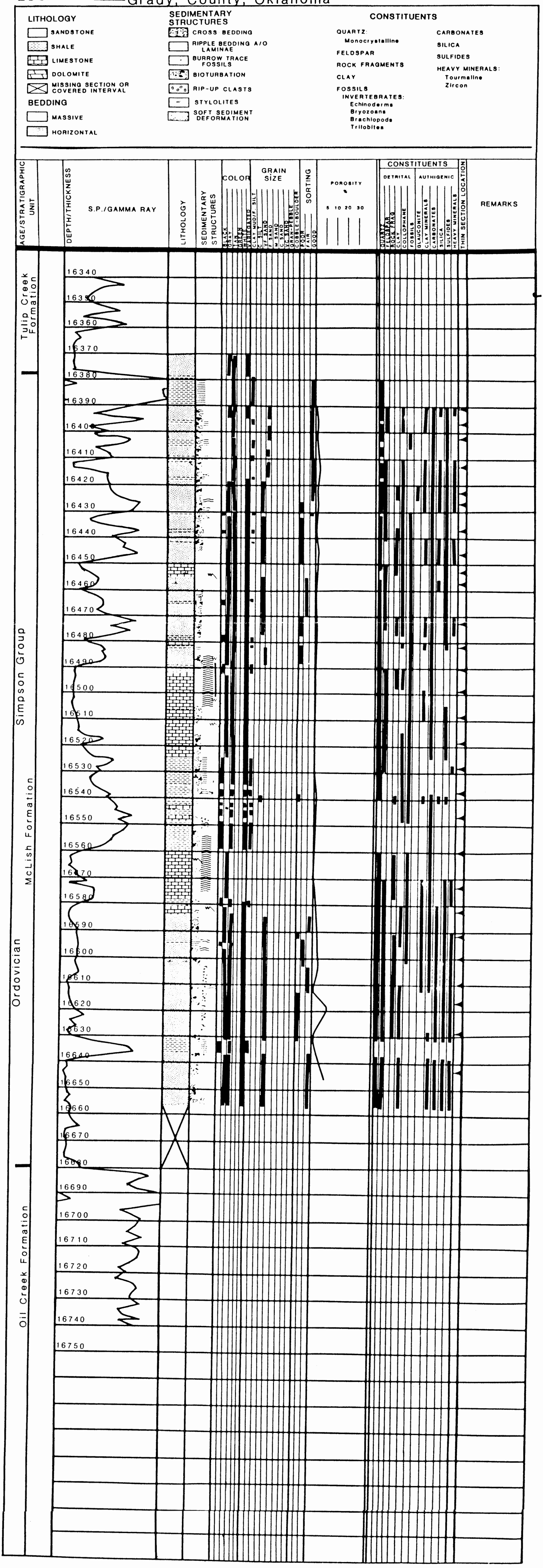

Plate III
Petrolog of the Mazur Core
O.S.U. School of Geology
Scott Weber 1986

COMPANY Outcrop Interstate Highway 35

LOCATION Sec. 30, T.1s., R.2E. MurrayCo.OK

PETROLOGIC LOG

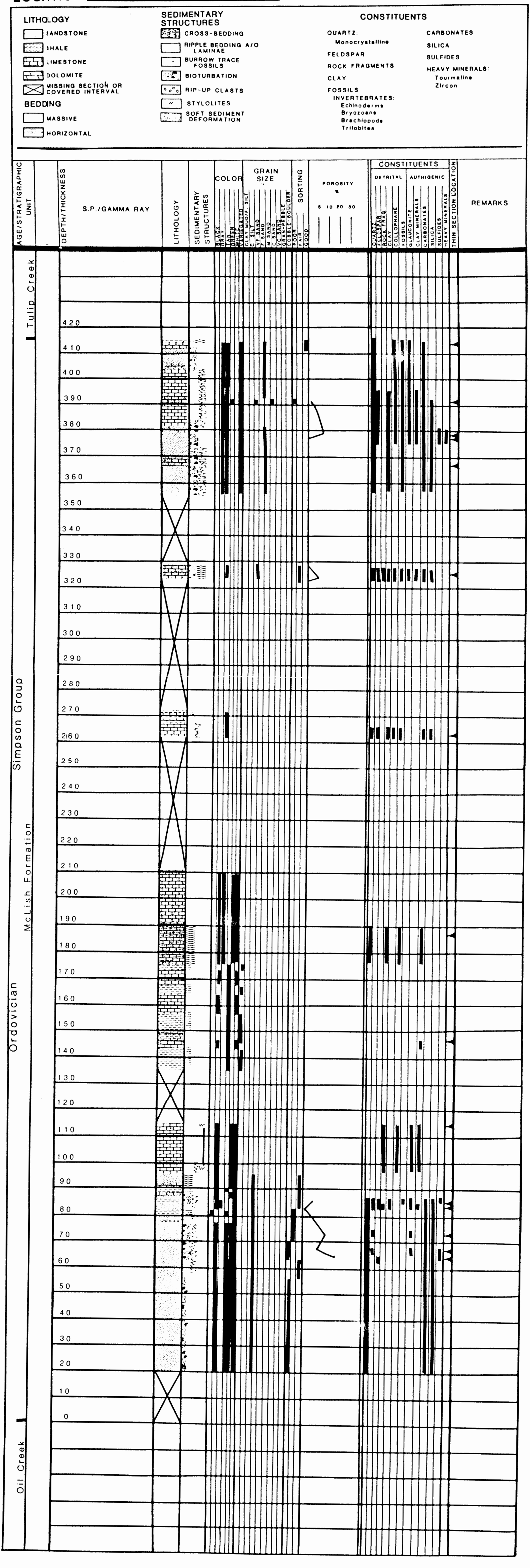

Plate IV

Petrolog of Interstate 35

O.S.U. School of Geology

Scott Weber 1986

COMPANY Outcrop State Highway 77

LOCATION Sec. 25, T.2S., R.1E. Carter Co. OK

PETROLOGIC LOG

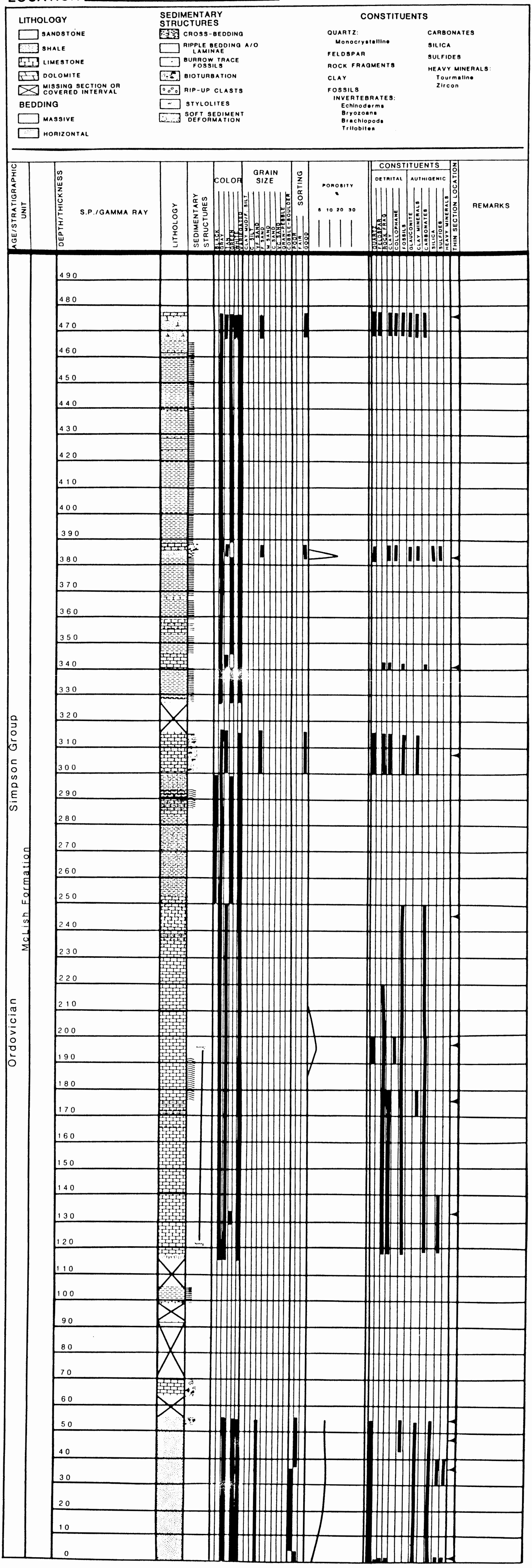

Plate V

Petrolog of State Highway 77

O.S.U. School of Geology

Scott Weber 1986

GULF BEARD NO. 1
McCLAIN CO. OK

SAMPLE ID	GB 50	GB 49	GB 48	GB 47	GB 46	GB 45	GB 44	GB 43	GB 42	GB 41	GB 40	GB 39	GB 38	GB 37	GB 36	GB 35	GB 34	GB 33	GB 32	GB 31	GB 30	GB 29	GB 28	GB 27	GB 26
CONSTITUENTS																									
DETRITAL																									
Quartz	73.30	58.90	76.30	78.00	73.30	72.00	64.00	62.60	66.00	62.70	59.30	56.00	45.40	73.80	29.00	35.00	42.00	44.30	55.60	1.00	0.10	19.50	27.00	14.00	10.00
monocrystalline	73.30	58.90	76.30	78.00	73.30	72.00	64.00	62.60	66.00	62.70	59.30	56.00	45.40	73.80	29.00	35.00	42.00	44.30	55.60	1.00	0.10	19.50	27.00	14.00	10.00
undulose																									
Feldspar	1.00	0.20	0.70	0.90	0.70	0.20	0.00	1.10	1.00	0.20	0.20	0.00	0.30	0.00	3.10	0.10	0.60	0.20	0.40	0.00	0.00	0.00	0.10	0.30	0.00
orthoclase	0.30			0.30					1.00	0.10							0.10	0.10	0.10						
plagioclase	0.10	0.10	0.10	0.60	0.30	0.10		0.10		0.10	0.10		0.30		2.80		0.50	0.10	0.30				0.10	0.30	
microcline	0.60	0.10	0.60		0.40	0.10		1.00			0.10				0.30	0.10									
Rock Fragments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.30	0.00	0.00
shale																									
chert																									
carbonate																					4.00		0.30		
Other Grains	1.10	0.10	0.10	0.30	0.20	1.40	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.50	1.20	0.10	0.50	0.40	0.10	25.00	59.80	38.90	41.80	16.30	53.10
glauconite																		0.30							
shell fragments																				25.00	59.80	38.80	41.70	16.30	53.00
tourmaline					0.10									0.10	0.10	0.10									
zircon	0.10					0.10					0.10			0.30	0.10										
collophane	1.00	0.10	0.10	0.30	0.10	1.30								0.10	1.00		0.50	0.10	0.10			0.10	0.10		0.10
Detrital Matrix	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	9.00	3.30	0.00	0.00	16.00	4.30	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chlorite																									
illite								3.00	9.00	3.30			16.00	4.30	6.00										
AUTHIGENIC																									
Cements	16.20	40.60	16.60	18.40	19.10	20.80	23.70	27.90	20.00	23.80	31.10	43.00	38.30	20.40	60.60	62.60	56.90	55.10	42.60	73.00	35.10	41.20	29.30	69.20	35.80
quartz	16.10	5.00	15.30	18.20	11.00	10.60	7.00	16.30	10.00	6.60	15.20	12.00	6.00	11.00	0.00	10.20	6.50	11.00	16.60	0.00	0.00		2.30	0.00	0.00
syntaxial	16.10	5.00	15.30	18.20	11.00	10.60	7.00	16.30	10.00	6.60	15.20	12.00	6.00	11.00		10.20	6.50	11.00	16.60				2.30		
other																									
chalcedony		29.00		0.10	0.10					1.30				0.10	3.00							0.10			
carbonate	0.00	5.60	0.00	0.00	0.00	7.60	0.00	0.00	0.00	4.60	9.60	31.00	32.00	7.30	55.60	52.30	48.40	42.80	25.90	72.90	35.00	41.00	26.70	68.30	34.80
calcite		2.00									9.60				20.00	11.00	16.00	10.60	21.30	15.00	20.00	16.00	14.00	2.30	14.00
dolomite		3.60				7.60				4.60		31.00	32.00	7.30	35.60	41.30	32.40	32.20	4.60	57.90	15.00	25.00	12.70	66.00	20.80
siderite																									
ferroan calc																									
ankerite																									
Authigenic Clays	0.00	1.00	1.30	0.00	8.00	1.60	16.70	9.30	9.00	11.30	6.30	0.00	0.00	2.00	0.00	0.00	2.00	1.30	0.00	0.00	0.00	0.00	0.00	0.60	0.00
kaolinite																									
chlorite																									
illite		1.00	1.30		8.00	1.60	16.70	9.30	9.00	11.30	6.30			2.00			2.00	1.30						0.60	
OTHER																									
pyrite	0.10			0.10		1.00		2.30	1.00				0.30		2.00	0.10			0.10	0.10	0.10	0.10	0.30	0.30	1.00
dead oil	0.10	0.10		0.10	0.10			0.10							0.10	0.10			1.30	1.00	1.00	0.30	1.50	0.10	1.00
hematite																0.10						0.10			0.10
POROSITY	8.30	0.10	6.30	2.30	6.60	5.60	12.30	5.30	4.00	10.00	9.30	1.00	0.00	1.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
Primary	7.00		5.00	2.00	6.00	5.00	12.30	5.30	4.00	10.00	9.30	1.00		1.00										0.10	
Secondary	1.30	0.10	1.30	0.30	0.60	0.60										2.00									
DEPTH (FT)	11448.70	11442.70	11439.00	11434.00	11433.20	11429.20	11423.20	11415.70	11413.00	11410.20	11408.70	11402.50	11401.50	11400.80	11395.70	11368.70	11366.50	11356.70	11355.90	11337.70	11330.80	11311.30	11307.00	11306.20	11305.50
corrected depth (ft)	11443.70	11437.70	11434.00	11429.00	11428.20	11424.20	11418.20	11410.70	11408.00	11405.20	11403.70	11397.50	11396.50	11395.80	11390.70										
TOTAL DETRITAL	74.30	59.10	77.00	78.90	74.00	72.20	64.00	63.70	67.00	62.90	59.50	56.00	45.70	73.80	32.10	35.10	42.60	44.50	56.00	1.00	4.10	19.50	27.40	14.30	10.00
Quartz (%)	98.65	99.66	99.09	98.86	99.05	99.72	100.00	98.27	98.51	99.68	99.66	100.00	99.34	100.00	90.34	99.72	98.59	99.55	99.29	100.00	2.44	100.00	98.54	97.90	100.00
Feldspar (%)	1.35	0.34	0.91	1.14	0.95	0.28	0.00	1.73	1.49	0.32	0.34	0.00	0.66	0.00	9.66	0.28	1.41	0.45	0.71	0.00	0.00	0.00	0.36	2.10	0.00
Rock Fragments (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.56	0.00	1.09	0.00	0.00
total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	0.00	1.00	1.30	0.00	8.00	1.60	16.70	12.30	18.00	14.60	6.30	0.00	16.00	6.30	6.00	0.00	2.00	1.30	0.00	0.00	0.00	0.00	0.00	0.60	0.00
Detrital	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	9.00	3.30	0.00	0.00	16.00	4.30	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Authigenic	0.00	1.00	1.30	0.00	8.00	1.60	16.70	9.30	9.00	11.30	6.30	0.00	0.00	2.00	0.00	0.00	2.00	1.30	0.00	0.00	0.00	0.00	0.00	0.60	0.00
TOTAL CARBONATE	0.00	5.60	0.00	0.00	0.00	7.60	0.00	0.00	0.00	4.60	9.60	31.00	32.00	7.30	55.60	52.30	48.40	43.10	25.90	97.90	98.80	79.80	68.70	84.60	87.80
Detrital	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	25.00	63.80	38.80	42.00	16.30	53.00
Cement	0.00	5.60	0.00	0.00	0.00	7.60	0.00	0.00	0.00	4.60	9.60	31.00	32.00	7.30	55.60	52.30	48.40	42.80	25.90	72.90	35.00	41.00	26.70	68.30	34.80
TOTAL QUARTZ	89.40	92.90	91.60	96.30	84.40	82.60	71.00	78.90	76.00	70.60	74.50	68.00	51.40	84.90	32.00	45.20	48.50	55.30	72.20	1.00	0.10	19.60	29.30	14.00	10.00
qtz grains	73.30	58.90	76.30	78.00	73.30	72.00	64.00	62.60	66.00	62.70	59.30	56.00	45.40	73.80	29.00	35.00	42.00	44.30	55.60	1.00	0.10	19.50	27.00	14.00	10.00
qtz cements	16.10	34.00	15.30	18.30	11.10	10.60	7.00	16.30	10.00	7.90	15.20	12.00	6.00	11.10	3.00	10.20	6.50	11.00	16.60	0.00	0.00	0.10	2.30	0.00	0.00
POROSITY phi TS	8.30	0.10	6.30	2.30	6.60	5.60	12.30	5.30	4.00	10.00	9.30	1.00	0.00	1.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
SAMPLE NO.	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00
ROCK TYPE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	SUB ARK	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	BIOSPAR	BIOSPAR	BIOSPAR	BIOSPAR	BIOSPAR	BIOSPAR
MATURITY	SUP MAT	SUP MAT	SUP MAT	SUP MAT	MATURE	SUP MAT	IMMATUR	IMMATUR	IMMATUR	IMMATUR	MATURE	SUP MAT	IMMATUR	MATURE	MATURE	SUP MAT	SUP MAT	SUP MAT	SUP MAT						
MODE QTZ	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	BIMOD	UNIMOD	BIMOD	UNIMOD	UNIMOD	UNIMOD	BIMOD	BIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD						
GRAIN SIZE	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN	VFN-FN	VFN	VFN-FN	VFN-FN	COARSE	COARSE				
															DOLO	DOLO				DOLO	DOLO	DOL QTZ	QTZ DOL	DOL QTZ	DOL QTZ
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GULF BEARD NO. 1
McCLAIN CO. OK

SAMPLE ID	GB 25	GB 24	GB 23	GB 22	GB 21	GB 20	GB 19	GB 18	GB 17	GB 16	GB 15	GB 14	GB 13	GB 12	GB 11	GB 10	GB 9	GB 8	GB 7	GB 6	GB 5	GB 4	GB 3	GB 2	GB 1
CONSTITUENTS																									
DETRITAL																									
Quartz	46.90	37.00	36.70	23.00	13.60	28.00	42.00	28.30	37.30	69.60	69.10	72.80	44.90	75.10	80.10	72.90	69.00	69.30	49.00	80.00	54.40	26.50	8.00	79.00	56.10
monocrystalline	46.90	37.00	36.70	23.00	13.60	28.00	42.00	28.30	37.30	69.60	69.10	72.80	44.90	75.10	80.10	72.90	69.00	69.30	49.00	80.00	54.40	26.50	8.00	79.00	56.10
undulose																									
Feldspar	0.00	0.30	0.20	0.00	0.00	0.00	1.20	1.30	0.90	0.00	0.60	0.30	1.30	1.20	0.30	0.30	0.30	4.20	0.60	0.30	1.30	0.60	0.00	0.30	0.60
orthoclase		0.10											1.00	1.00	0.30	0.30	0.30	0.10	0.30	0.10		0.30			0.30
plagioclase		0.10	0.10				0.60	0.30	0.30		0.30	0.30	0.30	0.10				4.00		0.10	0.30	0.30		0.30	0.30
microcline		0.10	0.10				0.60	1.00	0.60		0.30			0.10				0.10	0.30	0.10	1.00				
Rock Fragments	0.00	0.60	0.00	0.00	0.00	0.00	0.60	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.10
shale																									
chert																									0.10
carbonate		0.60					0.60		7.00								0.30								7.00
Other Grains	11.10	16.80	12.00	33.90	18.00	46.80	14.20	1.40	30.50	4.30	4.00	0.20	3.00	2.20	0.10	2.10	0.40	10.20	0.70	1.00	2.10	0.10	2.10	0.50	0.10
glauconite							1.00	1.00	0.60									6.00	0.60		1.00		2.00		
shell fragments	11.00	15.00	11.00	33.90	18.00	46.50	12.60		29.30									1.00							
tourmaline												0.10		0.10				0.10						0.10	
zircon		0.10						0.10		0.30		0.10		0.10	0.10	0.10	0.10	0.10	0.10	1.00	0.10	0.10		0.10	0.10
collophane	0.10	1.70	1.00			0.30	0.60	0.30	0.60	4.00	4.00		3.00	2.00		2.00	0.30	3.00			1.00		0.10	0.30	
Detrital Matrix	0.00	11.00	21.00	29.00	36.70	0.00	0.00	0.00	3.00	0.00	3.00	0.30	1.00	0.30	0.00	0.30	0.00	0.00	0.00	[illegible]	4.00	0.00	0.00	0.30	0.00
chlorite																									
illite		11.00	21.00	29.00	36.70				3.00		3.00	0.30	1.00	0.30		0.30					4.00			0.30	
AUTHIGENIC																									
Cements	41.70	33.00	29.10	14.00	31.30	25.10	42.00	68.70	21.20	26.10	20.30	24.40	49.10	20.10	18.40	22.30	27.40	16.00	48.60	16.70	38.10	72.10	89.70	11.80	36.00
quartz	0.00	0.00	0.00	0.00	0.00	0.00	5.00	4.00	3.60	4.00	3.00	5.00	4.00	4.00	3.00	4.00	1.00	6.70	4.00	7.30	2.00	0.00	0.00	6.70	3.00
syntaxial							5.00	4.00	3.60	4.00	3.00	5.00	4.00	4.00	3.00	4.00	1.00	6.70	4.00	7.30	2.00			6.70	3.00
other																									
chalcedony													0.30			0.10									
carbonate	40.70	30.00	29.10	10.00	31.00	25.00	33.30	58.70	15.70	21.80	16.00	19.00	43.70	14.00	15.00	16.00	26.00	5.00	44.00	9.00	34.00	72.00	87.70	3.00	30.00
calcite	6.70	15.00	12.00		11.00	21.00	23.70	41.30	5.10	4.00	1.00	5.00	12.00	2.00	5.00	1.00	7.00	1.00	5.00	1.00	3.00	40.00	0.10	3.00	28.00
dolomite	34.00	15.00	17.10	10.00	20.00	4.00	9.60	17.40	10.60	17.80	15.00	14.00	31.70	12.00	10.00	15.00	19.00	4.00	39.00	8.00	31.00	32.00	87.60		2.00
siderite																									
ferroan calc																									
ankerite																									
Authigenic Clays	0.00	0.00	0.00	0.00	0.00	0.00	3.60	6.00	1.90	0.30	1.00	0.30	1.00	2.00	0.30	1.20	0.30	0.30	0.30	0.30	2.00	0.00	0.00	2.00	3.00
kaolinite																									
chlorite									0.30																
illite							3.60	6.00	1.60	0.30	1.00	0.30	1.00	2.00	0.30	1.20	0.30	0.30	0.30	0.30	2.00			2.00	3.00
OTHER																									
pyrite	1.00	3.00		4.00	0.30	0.10	0.10				0.30	0.10	0.10	0.10	0.10	1.00	0.10	4.00	0.30	0.10	0.10	0.10	2.00	0.10	
dead oil	0.30	1.00			0.30	0.10			0.10				0.10	0.10		0.10		0.10	0.10		0.10		0.10	0.10	
hematite			1.00	0.10	0.10			0.30					0.30		0.10			0.10				0.10	0.10		
POROSITY	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	2.00	0.30	1.00	1.00	2.00	2.60	0.10	1.00	2.00	0.00	0.60	0.00	8.00	0.10
Primary																	2.60			2.00				8.00	0.10
Secondary		0.30									3.00	2.00	0.30	1.00	1.00	2.00		0.10	1.00			0.60			
DEPTH (FT)	11293.20	11292.80	11277.70	11260.50	11251.20	11252.50	11233.70	11233.40	11232.70	11197.50	11183.70	11177.30	11166.70	11157.50	11156.00	11152.00	[illegible]	11149.00	11146.00	11145.30	11137.50	11130.30	11123.50	11119.80	11091.50
corrected depth (ft)																									
TOTAL DETRITAL	46.90	37.90	36.90	23.00	13.60	28.00	44.80	30.60	45.80	69.60	69.70	73.10	46.20	76.30	80.40	73.20	69.60	79.50	50.20	80.30	56.70	27.10	10.00	79.30	63.80
Quartz (%)	100.00	97.63	99.46	100.00	100.00	100.00	93.75	92.48	81.44	100.00	99.14	99.59	97.19	98.43	99.63	99.59	99.14	87.17	97.61	99.63	95.94	97.79	80.00	99.62	87.93
Feldspar (%)	0.00	0.79	0.54	0.00	0.00	0.00	2.68	4.25	1.97	0.00	0.86	0.41	2.81	1.57	0.37	0.41	0.43	5.28	1.20	0.37	2.29	2.21	0.00	0.38	0.94
Rock Fragments (%)	0.00	1.58	0.00	0.00	0.00	0.00	3.57	3.27	16.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	7.55	1.20	0.00	1.76	0.00	20.00	0.00	11.13
total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	0.00	11.00	21.00	29.00	36.70	0.00	3.60	6.00	4.90	0.30	4.00	0.60	2.00	2.30	0.30	1.50	0.30	0.30	0.30	0.30	6.00	0.00	0.00	2.30	3.00
Detrital	0.00	11.00	21.00	29.00	36.70	0.00	0.00	0.00	3.00	0.00	3.00	0.30	1.00	0.30	0.00	0.30	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.30	0.00
Authigenic	0.00	0.00	0.00	0.00	0.00	0.00	3.60	6.00	1.90	0.30	1.00	0.30	1.00	2.00	0.30	1.20	0.30	0.30	0.30	0.30	2.00	0.00	0.00	2.00	3.00
TOTAL CARBONATE	51.70	45.60	40.10	43.90	49.00	71.50	46.50	58.70	52.00	21.80	16.00	19.00	43.70	14.00	15.00	16.00	26.30	6.00	44.00	9.00	34.00	72.00	87.70	3.00	37.00
Detrital	11.00	15.60	11.00	33.90	18.00	46.50	13.20	0.00	36.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	1.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00
Cement	40.70	30.00	29.10	10.00	31.00	25.00	33.30	58.70	15.70	21.80	16.00	19.00	43.70	14.00	15.00	16.00	26.00	5.00	44.00	9.00	34.00	72.00	87.70	3.00	30.00
TOTAL QUARTZ	46.90	37.00	36.70	23.00	13.60	28.00	47.00	32.30	40.90	73.60	72.10	77.80	49.20	79.10	83.10	77.00	70.00	76.00	53.00	87.30	56.40	26.50	8.00	85.70	59.20
qtz grains	46.90	37.00	36.70	23.00	13.60	28.00	42.00	28.30	37.30	69.60	69.10	72.80	44.90	75.10	80.10	72.90	69.00	69.30	49.00	80.00	54.40	26.50	8.00	79.00	56.20
qtz cements	0.00	0.00	0.00	0.00	0.00	0.00	5.00	4.00	3.60	4.00	3.00	5.00	4.30	4.00	3.00	4.10	1.00	6.70	4.00	7.30	2.00	0.00	0.00	6.70	3.00
POROSITY phi TS	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	2.00	0.30	1.00	1.00	2.00	2.60	0.10	1.00	2.00	0.00	0.60	0.00	8.00	0.10
SAMPLE NO.	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00	48.00	49.00	50.00
ROCK TYPE	QTZ ARE	QTZ ARE	QTZ ARE	BIO SHL	BIOSPAR	BIOSPAR	SUB LIT	SUB ARK	SUB LIT	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	SUB LIT	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	DOLO	QTZ ARE	SUB LIT
MATURITY	SUP MAT	IMMATUR	IMMATUR				MATURE	MATURE	MATURE	SUP MAT	MATURE	SUP MAT	SUP MAT	MATURE	SUP MAT	SUP MAT	SUP MAT	SUP MAT	SUP MAT	SUP MAT	MATURE	SUP MAT		SUP MAT	MATURE
MODE QTZ	BIMOD	BIMOD	BIMOD				UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	BIMOD	BIMOD		BIMOD	UNIMOD		UNIMOD	UNIMOD
GRAIN SIZE	VFN-FN	VFN	VFN				VFN	VFN	VFN	VFN-FN	VFN-FN	VFN-FN	FINE	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	FN-MED	SILT-MED	VFN-FN		FN-MED	VFN-FN
		FOS DOL	BIO DOL	QTZ DOL	SH QZ DO	QTZ																	QTZ		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GULF BEARD NO. 1
MCCLAIN CO. OK

SAMPLE ID / CONSTITUENTS	LOWER BASAL SAND AVERAGE %	UPPER CARBONATE AVERAGE %	SANDSTONE AVERAGE %	UPPER QTZ-ARE AVERAGE %	SANDSTONES SUB-LITH AVERAGE %	SANDSTONES SUB-ARK AVERAGE %
DETRITAL						
Quartz	63.37	14.42	54.92	57.00	51.18	28.30
monocrystalline	63.37	14.42	54.92	57.00	51.18	28.30
undulose						
Feldspar	0.64	0.04	0.70	0.46	1.73	1.30
orthoclase	0.11	0.00	0.18	0.20	0.10	
plagioclase	0.31	0.04	0.34	0.16	1.30	0.30
microcline	0.21	0.00	0.18	0.11	0.33	1.00
Rock Fragments		0.43	0.62	0.05	3.68	0.00
shale				0.00	0.00	
chert				0.00	0.03	
carbonate		0.43	0.62	0.05	3.65	
Other Grains	0.33	33.57	4.72	3.09	13.75	1.40
glauconite		0.20	0.41	0.08	1.90	1.00
shell fragments		33.30	3.21	1.87	10.73	
tourmaline	0.10	0.00	0.02	0.02	0.03	
zircon		0.00	0.10	0.12	0.05	0.10
collophane	0.27	0.07	0.98	1.01	1.05	0.30
Detrital Matrix	2.77	6.57	1.77	2.06	0.75	0.00
chlorite						
illite	6.93	6.57	1.77	2.06	0.75	
AUTHIGENIC						
Cements	28.03	44.37	36.01	35.82	28.80	68.70
quartz	10.69	0.23	4.58	4.62	4.58	4.00
syntaxial	10.69	0.23	4.58	4.62	4.58	4.00
other						
chalcedony	5.60	0.01	0.02	0.02	0.00	
carbonate	10.22	43.24	29.82	30.14	21.00	58.70
calcite	2.11	11.34	11.23	9.08	14.45	41.30
dolomite	8.11	31.90	18.59	21.06	6.55	17.40
siderite						
ferroan calc						
ankerite						
Authigenic Clays	4.43	0.06	1.16	0.72	2.20	6.00
kaolinite						
chlorite		0.00	0.01	0.00	0.08	
illite	4.43	0.06	1.15	0.72	2.13	6.00
OTHER						
pyrite	0.45	0.83	0.43	0.34	1.03	
dead oil	0.10	0.54	0.14	0.17	0.05	
hematite		0.05	0.08	0.08	0.03	0.30
POROSITY	4.81	0.01	1.04	1.29	0.05	0.00
Primary	4.53	0.01	0.51	0.63	0.03	
Secondary	0.28	0.00	0.53	0.66	0.03	
DEPTH (FT)						
corrected depth (ft)						
TOTAL DETRITAL	64.01	15.09	56.64	57.58	58.48	30.60
Quartz (%)	98.72	87.89	96.81	98.88	87.57	92.48
Feldspar (%)	1.28	0.25	1.31	0.88	2.72	4.25
Rock Fragments (%)	0.00	11.87	1.88	0.25	9.71	3.27
total	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	7.21	6.63	2.93	2.78	2.95	6.00
Detrital	2.77	6.57	1.77	2.06	0.75	0.00
Authigenic	4.43	0.06	1.16	0.72	2.20	6.00
TOTAL CARBONATE	10.22	76.97	33.64	32.05	35.38	58.70
Detrital	0.00	33.73	3.83	1.91	14.38	0.00
Cement	10.22	43.24	29.82	30.14	21.00	58.70
TOTAL QUARTZ	76.30	14.66	59.52	61.63	55.78	32.30
qtz grains	63.37	14.42	54.92	57.00	51.20	28.30
qtz cements	12.93	0.24	4.60	4.64	4.58	4.00
POROSITY phi TS	4.81	0.01	1.04	1.29	0.05	0.00
SAMPLE NO.						
ROCK TYPE						
MATURITY						
MODE QTZ						
GRAIN SIZE						

Plate VI

Thin-section Data Sheet of the Beard Well Samples

O.S.U. School of Geology
Scott Weber 1986

GULF COSTELLO NO. 1
GRADY CO. OK

SAMPLE ID	GC 12387	GC 12383	GC 12381	GC 12374	GC 12372	GC 12371	GC 12370	GC 12360	GC 12350	GC 12342	GC 12336	GC 12333	GC 12332	GC 12325	GC 12320	GC 12316	GC 12304	GC 12294	GC 12290	GC 12282	GC 12281	GC 12274	GC 12264	GC 12255
POROSITY	1.10	6.00	11.60	8.20	1.60	6.00	0.00	0.60	16.10	6.30	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.00	0.00	0.00
Primary	1.10	6.00	11.60	3.00	1.60	1.00			16.10	6.00	2.00										1.00	2.00		
Secondary				5.20		5.00		0.60		0.30														
DEPTH (FT)	12387.90	12383.40	12381.80	12374.40	12372.80	12371.80	12370.30	12360.20	12350.00	12342.00	12336.30	12333.40	12332.00	12325.40	12320.10	12316.00	12304.50	12294.80	12290.20	12282.70	12281.00	12274.90	12264.60	12255.30
corrected depth (ft)	12395.90	12391.40	12389.80	12382.40	12380.80	12379.80	12378.30	12368.20	12358.00	12350.00	12344.30	12341.40	12340.00	12333.40	12328.10	12324.00	12312.50	12302.80	12298.20	12290.70	12289.00	12282.90	12272.60	12263.30
TOTAL DETRITAL	51.40	77.90	58.40	66.70	60.00	57.00	30.20	47.80	58.40	43.80	54.70	10.30	2.00	17.50	17.90	0.30	4.00	17.90	5.80	20.00	40.00	19.80	10.00	12.00
Quartz (%)	95.33	95.38	95.21	96.40	93.33	98.25	99.34	96.86	99.32	98.40	98.72	97.09	100.00	40.00	11.17	66.67	50.00	83.80	86.21	60.00	96.50	92.42	50.00	41.67
Feldspar (%)	4.67	0.64	4.62	0.30	1.67	1.23	0.66	3.14	0.51	1.60	1.28	2.91	0.00	2.86	5.03	33.33	50.00	16.20	13.79	35.00	3.50	7.07	50.00	58.33
Rock Fragments (%)	0.00	3.98	0.17	3.30	5.00	0.53	0.00	0.00	0.17	0.00	0.00	0.00	0.00	57.14	83.80	0.00	0.00	0.00	0.00	5.00	0.00	0.51	0.00	0.00
total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	5.00	0.10	5.90	3.70	3.70	18.20	0.00	1.00	1.80	1.60	0.00	0.00	0.00	2.00	5.00	20.00	15.00	15.00	10.00	8.00	5.30	6.60	20.00	29.60
Detrital	5.00	0.00	4.60	0.00	1.00	16.00	0.00	0.00	0.30	1.30	0.00	0.00	0.00	2.00	5.00	20.00	15.00	15.00	10.00	8.00	5.30	6.60	20.00	29.60
Authigenic	0.00	0.10	1.30	3.70	2.70	2.20	0.00	1.00	1.50	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CARBONATE	26.90	7.00	17.30	0.60	22.60	11.90	67.60	48.70	8.20	39.20	22.70	87.50	83.00	90.20	91.00	78.60	80.00	65.00	83.00	69.90	50.80	69.90	68.90	58.00
Detrital	0.00	0.00	0.00	0.00	0.00	0.00	42.60	0.00	0.00	1.00	0.00	42.50	39.00	46.30	46.00	29.00	45.00	25.00	42.00	38.90	19.30	13.60	39.90	28.00
Cement	26.90	7.00	17.30	0.60	22.60	11.90	25.00	48.70	8.20	38.20	22.70	45.00	44.00	43.90	45.00	49.60	35.00	40.00	41.00	31.00	31.50	56.30	29.00	30.00
TOTAL QUARTZ	62.00	83.30	59.60	83.60	66.00	62.40	32.00	46.90	72.40	51.40	73.70	12.00	17.00	7.10	2.00	0.20	2.00	15.00	5.00	12.00	39.90	18.50	5.10	5.00
qtz grains	49.00	74.40	55.60	64.40	56.00	56.10	30.00	46.30	58.10	43.10	54.00	10.00	2.00	7.00	2.00	0.20	2.00	15.00	5.00	12.00	38.60	18.40	5.00	5.00
qtz cements	13.00	8.90	4.00	19.20	10.00	6.30	2.00	0.60	14.30	8.30	19.70	2.00	15.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.10	0.10	0.00
POROSITY																								
phi TS	1.10	6.00	11.60	8.20	1.60	6.00	0.00	0.60	16.10	6.30	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.00	0.00	0.00
SAMPLE NO.	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
ROCK TYPE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	SUB LIT	QTZ ARE	BIOSPAR	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	BIOSPAR	BIOSPAR	BIOSPAR	BIOCOM	BIOMIC	BIOMIC	BIOMIC	BIOMIC	BIOMIC	QTZ ARE	SU3 ARK	BIOMIC	BIOMIC
MATURITY	MATURE	SUP MAT	MATURE	MATURE	MATURE	IMMAT		SUP MAT	MATURE	MATURE	SUP MAT					IMMATUR	IMMATUR	IMMATUR	IMMATUR		MATURE	MATURE	IMMATUR	VIMMAT
MODE QTZ	BIMOD	BIMOD	BIMOD	UNIMOD	BIMOD	UNIMOD		UNIMOD	UNIMOD	UNIMOD	UNIMOD										UNIMOD	UNIMOD		
GRAIN SIZE	VFN	VFN-FN	VFN-FN	VFN-FN	VFN-FN	VFN	COARSE	VFN-FN	VFN	VFN	VFN-FN	COARSE	COARSE		DOLMIC	DOLMIC					VFN-FN	VFN-FN		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	103.00	100.00	100.00

GULF COSTELLO NO. 1
GRADY CO. OK

SAMPLE ID	GC 12249	GC 12240	GC 12230	GC 12221	GC 12212	GC 12206	GC 12202	GC 12200	GC 12195	GC 12192	GC 12187	GC 12183	GC 12180	GC 12171	GC 12169	GC 12166	GC 12155	GC 12144	GC 12138	GC 12132	GC 12123	GC 12118	GC 12113	GC 12113	GC 12112	GC 12104
CONSTITUENTS																										
DETRITAL																										
Quartz	10.00	15.00	33.30	22.50	23.60	15.00	39.30	56.00	51.60	12.30	9.00	2.00	14.00	20.00	20.50	59.20	48.30	63.40	67.40	69.00	64.60	70.50	74.30	62.60	66.60	40.60
monocrystalline	10.00	15.00	33.30	22.50	23.60	15.00	39.30	56.00	51.60	12.30	9.00	2.00	14.00	20.00	20.50	59.20	48.30	63.40	67.40	69.00	64.60	70.50	74.30	62.60	66.60	40.60
undulose																										
Feldspar	0.30	3.00	9.10	3.00	17.00	2.00	9.90	5.70	0.70	4.40	1.90	0.10	0.20	0.20	0.30	0.20	0.20	0.20	0.10	0.10	0.20	0.10	0.00	0.30	0.40	0.30
orthoclase	0.20	1.50	7.00	2.00	12.00	1.00	8.00	4.10	0.10	4.00	1.60		0.10	0.10	0.30	0.10	0.10	0.10	0.10	0.10	0.10			0.30	0.10	0.30
plagioclase	0.10	1.50	2.00	1.00	5.00	1.00	1.30	1.30	0.60	0.30	0.30		0.10	0.10			0.10	0.10			0.10	0.10			0.30	
microcline			0.10				0.60	0.30		0.10		0.10				0.10										
Rock Fragments	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
shale																										
chert																										
carbonate				0.20																						
Other Grains	35.00	26.60	1.90	14.60	16.30	23.10	1.50	4.70	19.50	44.30	43.70	51.70	35.80	9.00	33.70	1.70	0.60	0.20	0.10	0.30	0.30	0.20	0.10	1.90	2.60	3.30
glauconite							1.00	3.00	0.30	0.30						1.30	0.30			0.10	0.10			0.60	0.60	1.00
shell fragments	35.00	26.60	1.60	13.60	15.30	23.00			14.80	43.00	43.60	51.70	34.80	8.00	33.60											1.00
tourmaline							0.10										0.20		0.10	0.10	0.10	0.10				
zircon							0.10	0.10	0.10							0.10		0.10								
collophane			0.30	1.00	1.00	0.10	0.30	1.60	4.30	1.00	0.10		1.00	1.00	0.10	0.30	0.10	0.10		0.10	0.10	0.10	0.10	1.30	2.00	1.30
Detrital Matrix	19.40	38.00	31.20	27.60	8.60	5.00	35.00	12.00	1.60	17.00	10.00	18.00	1.00	0.00	4.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	10.30
chlorite																										
illite	19.40	38.00	31.20	27.60	8.60	5.00	35.00	12.00	1.60	17.00	10.00	18.00	1.00		4.60									0.60		10.30
AUTHIGENIC																										
Cements	35.30	17.00	17.50	32.00	29.00	54.80	13.90	21.50	26.50	20.80	35.30	28.00	49.00	69.70	40.20	35.20	44.10	31.50	21.30	17.50	18.20	16.80	22.60	33.60	29.70	44.10
quartz	0.00	0.00	0.60	0.00	0.00	0.00	1.30	1.60	0.00	0.00	0.00	0.00	0.00	0.10	0.00	14.00	11.50	13.30	14.00	16.00	8.60	9.60	20.20	17.70	5.60	0.00
syntaxial			0.60				1.30	1.60						0.10		14.00	11.50	13.30	14.00	16.00	8.60	9.60	20.20	17.70	5.60	
other																										
chalcedony							0.30																		1.00	
carbonate	35.00	15.00	15.90	31.00	28.70	54.70	10.60	14.30	24.90	19.20	30.00	26.00	47.00	62.70	32.30	18.90	28.90	17.00	5.00	0.10	4.30	3.60	2.30	12.60	22.00	42.90
calcite	15.00	5.00		11.00	4.40	39.70		2.00	5.00	9.30	28.00	6.00	27.00	12.00	8.00											0.30
dolomite	10.00	10.00	8.30	11.00	11.30	10.00	1.30	2.00	4.00	8.30	1.00	16.00	15.00	35.50	18.00	2.30	6.30	6.00	2.00		0.30	0.30		3.30	5.20	13.00
siderite																										
ferroan calc			4.30	6.00	8.00		0.60	1.00	14.30	1.30				4.60											9.50	1.60
ankerite	10.00		3.30	3.00	5.00	5.00	8.70	9.30	1.60	0.30	1.00	4.00	5.00	10.60	6.30	16.60	22.60	11.00	3.00	0.10	4.00	3.30	2.30	9.30	7.30	28.00
Authigenic Clays	0.00	0.00	0.00	0.00	0.00	0.00	1.60	5.30	1.00	1.30	5.00	1.00	1.00	6.30	7.60	2.30	3.60	1.10	2.30	1.30	4.30	3.60	0.10	3.30	1.00	0.60
kaolinite																		0.10					0.10			
chlorite														0.30		2.00										
illite							1.60	5.30	1.00	1.30	5.00	1.00	1.00	6.00	7.60	0.30	3.60	1.00	2.30	1.30	4.30	3.60		3.30	1.00	0.60
OTHER																										
pyrite	0.30	2.00	1.00	1.00	0.30	0.10	0.10	0.30	0.60	0.30	0.30	1.00	1.00	0.60	0.30		0.10	0.10		0.10	1.00				0.10	0.60
dead oil		0.10		0.10	0.10	0.10	0.10	0.10	0.10		0.10	0.10		0.10	0.10	0.10		0.10	0.10	0.10	0.10	0.10			0.10	
hematite										0.10		0.10														0.10
POROSITY	0.00	0.30	7.00	0.00	5.40	0.00	0.30	0.00	0.00	1.10	0.00	0.00	0.00	1.00	0.60	3.60	6.80	4.60	11.00	13.00	16.60	12.30	3.00	1.00	0.60	1.30
Primary			5.50		5.40		0.30							1.00	0.60	3.00	6.00	4.60	11.00	13.00	16.60	12.30	3.00	1.00	0.60	1.30
Secondary		0.30	1.50							1.10						0.60	0.80									
DEPTH (FT)	12249.00	12240.60	12230.00	12221.00	12212.20	12206.10	12202.50	12200.10	12195.20	12192.80	12187.80	12183.10	12180.10	12171.70	12169.70	12166.40	12155.60	12144.20	12138.80	12132.50	12123.90	12118.10	12113.60	12113.20	12112.00	12104.60
corrected depth (ft)	12257.00	12248.60	12238.00	12229.00	12220.20	12214.10	12210.50	12208.10	12203.20	12200.80	12195.80	12191.10	12188.10	12179.70	12177.70	12174.40	12163.60	12152.20	12146.80	12140.50	12131.90	12126.10	12121.60	12121.20	12120.00	12112.60
TOTAL DETRITAL	10.30	18.00	42.40	25.70	40.60	17.00	50.20	64.70	52.60	17.00	10.90	2.10	14.20	20.20	20.80	60.70	48.80	63.60	67.50	69.20	64.90	70.60	74.30	63.50	67.60	41.90
Quartz (%)	97.09	83.33	78.54	87.55	58.13	88.24	78.29	86.55	98.10	72.35	82.57	95.24	98.59	99.01	98.56	97.53	98.98	99.69	99.85	99.71	99.54	99.86	100.00	98.58	98.52	96.90
Feldspar (%)	2.91	16.67	21.46	11.67	41.87	11.76	19.72	8.81	1.33	25.88	17.43	4.76	1.41	0.99	1.44	0.33	0.41	0.31	0.15	0.14	0.31	0.14	0.00	0.47	0.59	0.72

Plate VII

Thin-section Data Sheet of the Costello Well Samples

O.S.U. School of Geology
Scott Weber 1986

SUNRAY DX PARKER MAZUR NO. 1
GRADY CO. OK

SAMPLE ID	SM 16648	SM 16635	SM 16624	SM 16616	SM 16606	SM 16597	SM 16588	SM 16579	SM 16566	SM 16553	SM 16544	SM 16534	SM 16525	SM 16515
CONSTITUENTS														
DETRITAL														
Quartz	78.80	60.20	68.60	54.40	34.60	38.10	53.90	35.60	12.00	0.00	49.60	7.00	1.90	3.00
monocrystalline	74.30	54.00	65.30	49.70	33.00	36.60	53.30	32.30	12.00		45.30	7.00	1.90	3.00
undulose	4.50	6.20	3.30	4.70	1.60	1.50	0.60	3.30			4.30			
Feldspar	1.30	2.60	2.40	1.70	1.10	2.00	2.00	7.70	0.20	0.00	9.20	0.30	0.60	1.90
orthoclase	0.50			0.30				2.60			4.60	0.10	0.30	0.70
plagioclase	0.50	1.60	2.30	1.30	1.00	2.00	2.00	4.50	0.10		3.00	0.10	0.30	0.60
microcline	0.30	2.00	0.10	0.10	0.10			0.60	0.10		1.60	0.10		0.60
Rock Fragments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	5.00	0.00	0.30	0.00	0.00	0.00
shale														
chert								1.00			0.30			
carbonate								0.60	5.00					
Other Grains	0.20	0.20	0.10	0.80	0.10	0.50	0.20	6.90	69.50	58.30	1.50	30.20	50.20	39.70
glauconite														
shell fragments						0.10	0.10	6.60	69.50	58.00	1.50	30.00	50.10	39.70
tourmaline				0.10	0.10									
zircon	0.10	0.10		0.10		0.30		0.30				0.10		
collophane	0.10	0.10	0.10	0.60		0.10	0.10			0.30		0.10	0.10	
Detrital Matrix	0.00	8.60	19.00	3.60	8.40	6.00	0.00	8.70	0.00	1.00	7.30	19.00	0.00	2.00
chlorite														
illite		8.60	19.00	3.60	8.40	6.00		8.70		1.00	7.30	19.00		2.00
AUTHIGENIC														
Cements	10.40	28.10	1.90	39.00	52.90	49.80	42.50	37.80	13.20	40.40	30.80	43.30	47.10	52.80
quartz	8.00	9.10	0.40	18.60	7.00	1.50	10.10	0.00	0.00	0.00	1.30	0.00	0.00	0.00
syntaxial	8.00	9.00	0.40	13.30	6.70	1.00	10.00				1.30			
other		0.10		5.30	0.30	0.50	0.10							
chalcedony								0.10						
carbonate	2.00	18.90	0.90	19.80	44.30	44.10	31.50	36.40	13.00	40.00	28.60	42.00	47.00	52.00
calcite						24.50	21.20	22.70	11.00	30.00	1.30	20.00	34.00	37.00
dolomite	1.00	7.60	0.30	11.50	23.70	16.00	3.00	10.70	2.00	1.50	10.70	8.00	12.00	15.00
siderite														
ferroan calc					0.30	2.60	5.30	3.00			14.00	2.00	1.00	
ankerite	1.00	11.30	0.60	8.30	20.30	1.00	2.00			8.50	2.60	12.00		
Authigenic Clays	0.30	0.00	0.00	0.30	0.30	0.60	0.30	0.70	0.10	0.30	0.60	1.00	0.00	0.50
kaolinite														
chlorite														
illite	0.30			0.30	0.30	0.60	0.30	0.70	0.10	0.30	0.60	1.00		0.50
OTHER														
pyrite	0.10	0.10	0.60	0.30	1.30	3.60	0.60	0.60	0.10	0.10	0.30	0.30	0.10	0.30
dead oil	0.10	0.10	0.30	0.10	0.30	1.00	0.10	0.30	0.10		0.30	0.10	0.10	0.30
hematite														
POROSITY	9.20	0.20	7.70	0.40	2.60	2.60	1.30	1.40	0.00	0.30	1.00	0.10	0.10	0.30
Primary	1.60	0.10	5.00	0.10	0.60	2.60	1.30	1.00						
Secondary	7.60	0.10	2.70	0.30	2.00			0.40		0.30	1.00	0.10	0.10	0.30
DEPTH (FT)	16648.60	16635.90	16624.50	16616.70	16606.10	16597.30	16588.10	16579.70	16566.70	16553.40	16544.30	16534.80	16525.20	16515.30
corrected depth (ft)	16642.60	16629.90	16618.50	16610.70	16600.10	16591.30	16582.10	16573.70	16560.70	16547.40	16538.30	16528.80	16519.20	16509.30
TOTAL DETRITAL	80.10	62.80	71.00	56.10	35.70	40.10	55.90	44.90	17.20	0.00	59.10	7.30	2.50	4.90
Quartz (%)	98.38	95.86	96.62	96.97	96.92	95.01	96.42	79.29	69.77		83.93	95.89	76.00	61.22
Feldspar (%)	1.62	4.14	3.38	3.03	3.08	4.99	3.58	17.15	1.16		15.57	4.11	24.00	38.78
Rock Fragments (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.56	29.07		0.51	0.00	0.00	0.00
total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00		100.00	100.00	100.00	100.00
TOTAL CLAYS	0.30	8.60	19.00	3.90	8.70	6.60	0.30	9.40	0.10	1.30	7.90	20.00	0.00	2.50
Detrital	0.00	8.60	19.00	3.60	8.40	6.00	0.00	8.70	0.00	1.00	7.30	19.00	0.00	2.00
Authigenic	0.30	0.00	0.00	0.30	0.30	0.60	0.30	0.70	0.10	0.30	0.60	1.00	0.00	0.50
TOTAL CARBONATE	2.00	18.90	0.90	19.80	44.30	44.20	31.60	43.60	87.50	98.00	30.10	72.00	97.10	91.70
Detrital	0.00	0.00	0.00	0.00	0.00	0.10	0.10	7.20	74.50	58.00	1.50	30.00	50.10	39.70
Cement	2.00	18.90	0.90	19.80	44.30	44.10	31.50	36.40	13.00	40.00	28.60	42.00	47.00	52.00
TOTAL QUARTZ	86.80	69.30	69.00	73.00	41.60	39.60	64.00	36.70	12.00	0.00	51.20	7.00	1.90	3.00
qtz grains	78.80	60.20	68.60	54.40	34.60	38.10	53.90	36.60	12.00	0.00	49.90	7.00	1.90	3.00
qtz cements	8.00	9.10	0.40	18.60	7.00	1.50	10.10	0.10	0.00	0.00	1.30	0.00	0.00	0.00
POROSITY														
phi TS	9.20	0.20	7.70	0.40	2.60	2.60	1.30	1.40	0.00	0.30	1.00	0.10	0.10	0.30
ELECTRIC LOGS														
GR-API UNITS	14.40	25.60	20.80	20.80	28.80	30.40	17.60	54.40	22.40	100.80	68.80	48.00	40.00	28.80
RES (lat)	158.00	148.00	105.00	156.00	148.00	149.00	170.00	160.00	168.00	76.00	132.00	150.00	142.00	175.00
SONIC T.T.	55.00	53.00	53.50	54.00	51.00	52.50	51.50	53.00	49.00	61.50	53.00	53.00	49.50	49.00
NEUTRON-API UNITS	1612.00	1508.00	1560.00	1625.00	1599.00	1612.00	1592.50	1651.00	1631.50	1371.50	1560.00	1625.00	1573.00	1612.00
BULK DENSITY	2.64	2.64	2.61	2.67	2.74	2.70	2.72	2.69	2.73	2.67	2.69	2.74	2.75	2.71
LIME POROSITY	18.00	16.00	18.00	15.00	9.00	13.00	11.50	12.50	11.00	15.50	14.00	9.00	9.50	12.50
SAMPLE NO.	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00
ROCK TYPE	QTZ AR	QTZ AR	QTZ AR	QTZ AR	QTZ AR	QTZ AR	QTZ AR	SUB ARK	BIOSPAR	BIOSPAR	SUB ARK	BIOSPAR	BIOSPAR	BIOSPAR
MATURITY	SUPER	IMMATURE	IMMATURE	SUPER	MATURE	IMMATURE	SUPER	IMMATURE			IMMATURE			
MODE QTZ	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD			UNIMOD			
GRAIN SIZE	FINE	FINE	FINE	FINE	FINE	FINE	FINE	VFINE			VFINE			

SAMPLE ID	SM 16505	SM 16496	SM 16487	SM 16478	SM 16464	SM 16458	SM 16453	SM 16443	SM 16433	SM 16428	SM 16418	SM 16408	SM 16403	SM 16396
CONSTITUENTS														
DETRITAL														
Quartz	4.00	1.00	10.00	43.70	39.30	0.30	57.00	38.00	38.60	44.30	58.70	15.00	65.60	65.90
monocrystalline	4.00	1.00	10.00	40.00	37.00	0.30	54.30	37.70	38.60	42.70	55.40	15.00	62.00	63.70
undulose				3.70	2.30		3.00	0.30		1.60	3.30		3.60	2.20
Feldspar	1.90	0.10	0.20	5.20	3.60	0.30	7.90	7.20	9.90	11.90	0.80	0.10	0.10	0.30
orthoclase	0.60	0.10		2.00	2.00	0.10	4.60	3.60	5.60	5.60	0.60	0.10	0.10	
plagioclase	0.60		0.10	1.60	1.30	0.10	2.30	1.60	2.00	5.00	0.10			
microcline	0.70		0.10	1.60	0.30	0.10	1.00	2.00	2.30	1.30	0.10			0.30
Rock Fragments	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.60	0.00	0.10	0.00	0.10	0.10
shale														
chert				0.10					0.60		0.10		0.10	0.10
carbonate														
Other Grains	51.30	53.60	23.30	5.60	0.40	39.00	4.40	17.60	2.90	3.00	0.50	48.60	0.30	2.20
glauconite										2.00				1.60
shell fragments	51.00	53.50	23.00	2.20	0.30	38.70	1.50	13.30				47.60		
tourmaline									0.20	0.10	0.10			
zircon				0.10			0.30		0.10	0.60	0.10			
collophane	0.30	0.10	0.30	3.30	0.10	0.30	2.60	4.30	2.60	0.30	0.30	1.00	0.30	0.60
Detrital Matrix	2.00	0.00	30.00	7.30	0.00	10.00	10.70	8.30	37.00	1.70	0.60	20.00	4.00	0.50
chlorite														
illite	2.00		30.00	7.30		10.00	10.70	8.30	37.00	1.70	0.60	20.00	4.00	0.50
AUTHIGENIC														
Cements	40.40	45.20	36.30	36.50	55.10	50.30	16.10	28.20	7.90	37.50	35.60	15.90	27.60	29.30
quartz	0.00	0.00	0.00	0.30	6.30	0.00	0.30	2.00	4.30	24.60	23.60	0.00	0.00	17.60
syntaxial					5.30		0.30		1.00	24.60	23.60			15.60
other				0.30	1.00			2.00	3.30					2.00
chalcedony														0.30
carbonate	40.00	45.00	35.00	34.60	48.20	50.00	14.20	25.60	2.30	11.60	10.90	13.90	27.20	8.30
calcite	35.00	40.00	10.00	23.30	24.30	30.00	8.60	16.00		1.60	0.60		10.30	
dolomite	5.00	5.00	13.00	11.30	20.60	20.00	5.30	3.60	1.60	8.60	5.30	9.00	10.30	2.00
siderite														
ferroan calc			4.00					4.00					0.60	
ankerite			8.00		3.30		0.30	2.00	0.70	1.40	5.00	5.00	6.00	6.30
Authigenic Clays	0.30	0.10	1.00	0.60	0.00	0.00	0.30	0.00	0.30	0.30	1.00	0.00	0.30	3.00
kaolinite														
chlorite														2.00
illite	0.30	0.10	1.00	0.60			0.30		0.30	0.30	1.00		0.30	1.00
OTHER														
pyrite	0.10	0.10	0.30	1.00	0.60	0.30	1.30	0.60	1.00	1.00	0.10	2.00	0.10	0.10
dead oil	0.10		0.10	0.60	0.30	0.10	0.30	0.10	0.10	0.30	0.10	0.10		0.10
hematite														
POROSITY	0.30	0.10	0.10	1.00	1.30	0.00	3.60	0.60	3.00	1.30	3.60	0.30	2.30	1.60
Primary					1.30		3.60		2.00	0.30	3.00		1.30	1.60
Secondary	0.30	0.10	0.10	1.00				0.60	1.00	1.00	0.60	0.30	1.00	
DEPTH (FT)	16505.60	16496.50	16487.60	16478.70	16464.10	16458.30	16453.00	16443.60	16433.00	16428.00	16418.90	16408.20	16403.30	16396.60
corrected depth (ft)	16499.60	16490.50	16481.60	16472.70	16458.10	16452.30	16447.00	16437.60	16427.00	16422.00	16412.90	16402.20	16397.30	16390.60
TOTAL DETRITAL	5.90	1.10	10.20	49.00	42.90	0.60	64.90	45.20	49.10	58.20	59.60	15.10	65.80	67.90
Quartz (%)	67.80	90.91	98.04	89.18	91.61	50.00	87.83	84.07	78.62	76.12	98.49	99.34	99.70	97.05
Feldspar (%)	32.20	9.09	1.96	10.61	8.39	50.00	12.17	15.93	20.16	20.45	1.34	0.66	0.15	0.44
Rock Fragments (%)	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	1.22	3.44	0.17	0.00	0.15	2.50
total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	2.30	0.10	31.00	7.90	0.00	10.00	11.00	8.30	37.30	2.00	1.60	20.00	4.30	3.50
Detrital	2.00	0.00	30.00	7.30	0.00	10.00	10.70	8.30	37.00	1.70	0.60	20.00	4.00	0.50
Authigenic	0.30	0.10	1.00	0.60	0.00	0.00	0.30	0.00	0.30	0.30	1.00	0.00	0.30	3.00
TOTAL CARBONATE	91.00	98.50	58.00	36.80	48.50	88.70	15.70	38.90	2.30	11.60	10.90	61.50	27.20	8.30
Detrital	51.00	53.50	23.00	2.20	0.30	38.70	1.50	13.30	0.00	0.00	0.00	47.60	0.00	0.00
Cement	40.00	45.00	35.00	34.60	48.20	50.00	14.20	25.60	2.30	11.60	10.90	13.90	27.20	8.30
TOTAL QUARTZ	4.00	1.00	10.00	44.10	45.60	0.30	57.30	40.00	43.50	68.90	82.40	15.00	65.70	83.90
qtz grains	4.00	1.00	10.00	43.80	39.30	0.30	57.00	38.00	39.20	44.30	58.80	15.00	65.70	66.00
qtz cements	0.00	0.00	0.00	0.30	6.30	0.00	0.30	2.00	4.30	24.60	23.60	0.00	0.00	17.90
POROSITY														
phi TS	0.30	0.10	0.10	1.00	1.30	0.00	3.60	0.60	3.00	1.30	3.60	0.30	2.30	1.60
ELECTRIC LOGS														
GR-API UNITS	22.40	24.00	62.40	73.60	27.20	41.60	38.40	72.00	102.40	89.60	27.20	91.20	41.60	67.20
RES (lat)	180.00	172.00	164.00	166.00	173.00	166.00	170.00	137.00	110.00	135.00	143.00	68.00	90.00	70.00
SONIC T.T.	49.00	49.50	53.00	55.00	47.00	47.00	47.00	56.00	58.00	54.00	53.00	63.00	54.00	58.00
NEUTRON-API UNITS	1625.00	1618.50	1566.50	1638.00	1618.50	1612.00	1612.00	1560.00	1514.50	1612.00	1605.00	1261.00	1547.00	1462.50
BULK DENSITY	2.73	2.71	2.74	2.70	2.73	2.76	2.63	2.70	2.67	2.66	2.74	2.64	2.71	2.67
LIME POROSITY	10.00	13.50	8.50	13.00	10.50	9.00	14.00	12.00	15.50	16.50	10.50	18.00	12.00	10.00
SAMPLE NO.	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00
ROCK TYPE	BIOSPAR	BIOSPAR	FOSS SH	SUB ARK	SUB ARK	BIOSPAR	SUB ARK	SUB ARK	SHY SILT	SUB ARK	QTZ AR	BIOSPAR	QTZ AR	QTZ AR
MATURITY				IMMATURE	SUB MAT		IMMATURE	IMMATURE		SUPER	SUPER		SUPER	SUPER
MODE QTZ				UNIMOD	UNIMOD		UNIMOD	BIMODAL		UNIMOD	UNIMOD		UNIMOD	UNIMOD
GRAIN SIZE				VFINE	VFINE		VFINE	VFN-MED		FINE	FINE		FINE	FINE

SUNRAY DX PARKER MAZUR NO. 1
GRADY CO. OK

SAMPLE ID	LOWER BASAL SAND AVERAGE %	UPPER CARBONATE AVERAGE %	SANDSTONE AVERAGE %	UPPER QTZ ARE AVERAGE %	UPPER SUBARKOSE AVERAGE %	MISC. AVERAGE %
CONSTITUENTS						
DETRITAL						
Quartz	55.51	5.42	48.75	63.40	43.93	38.60
monocrystalline	52.31	5.42	46.25	60.37	41.29	38.60
undulose	3.20	0.00	2.51	3.03	2.64	
Feldspar	1.87	0.56	5.80	0.40	7.53	9.90
orthoclase	0.11	0.20	2.85	0.23	3.57	5.60
plagioclase	1.53	0.19	1.95	0.03	2.76	2.00
microcline	0.37	0.17	1.01	0.13	1.20	2.30
Rock Fragments	0.00	0.50	0.26	0.10	0.29	0.60
shale	0.00	0.00	0.00	0.00	0.00	
chert	0.00	0.00	0.21	0.10	0.20	0.60
carbonate	0.00	0.50	0.05	0.00	0.09	
Other Grains	0.30	46.37	4.12	1.00	5.63	2.90
glauconite	0.00	0.00	0.33	0.53	0.29	
shell fragments	0.03	46.11	2.31	0.00	3.63	
tourmaline	0.03	0.00	0.04	0.03	0.01	0.20
zircon	0.09	0.01	0.14	0.03	0.19	0.10
collophane	0.16	0.25	1.31	0.40	1.51	2.60
Detrital Matrix	6.51	8.40	7.83	1.70	6.29	37.00
chlorite	0.00	0.00	0.00	0.00	0.00	
illite	6.51	8.40	7.83	1.70	6.29	37.00
AUTHIGENIC						
Cements	32.09	38.49	31.13	30.83	34.57	7.90
quartz	7.81	0.00	7.30	13.73	4.97	4.30
syntaxial	6.91	0.00	6.52	13.07	4.50	1.00
other	0.90	0.00	0.78	0.67	0.47	3.30
chalcedony	0.00	0.00	0.04	0.10	0.01	
carbonate	23.07	37.79	22.54	15.47	28.46	2.30
calcite	6.53	24.70	9.88	3.63	13.97	
dolomite	9.01	9.05	8.18	5.87	10.11	1.60
siderite	0.00	0.00	0.00	0.00	0.00	
ferroan calc	1.17	0.70	1.96	0.20	3.00	
ankerite	6.36	3.35	2.51	5.77	1.37	0.70
Authigenic Clays	0.26	0.33	0.65	1.43	0.36	0.30
kaolinite	0.00	0.00	0.00	0.00	0.00	
chlorite	0.00	0.00	0.18	0.67	0.00	
illite	0.26	0.33	0.46	0.77	0.36	0.30
OTHER						
pyrite	0.94	0.37	0.61	0.10	0.77	1.00
dead oil	0.29	0.10	0.23	0.07	0.31	0.10
hematite	0.00	0.00	0.00	0.00	0.00	
POROSITY	3.43	0.16	1.88	2.50	1.46	3.00
Primary	1.61	0.00	1.28	1.97	0.89	2.00
Secondary	1.81	0.16	0.60	0.53	0.57	1.00
DEPTH (FT)						
corrected depth (ft)						
TOTAL DETRITAL	57.39	7.20	55.15	64.43	52.03	49.10
Quartz (%)	96.60	78.77	87.81	98.41	84.57	78.62
Feldspar (%)	3.40	18.00	11.12	0.65	14.32	20.16
Rock Fragments (%)	0.00	3.23	1.07	0.94	1.10	1.22
total	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	6.77	8.73	8.47	3.13	6.64	37.30
Detrital	6.51	8.40	7.83	1.70	6.29	37.00
Authigenic	0.26	0.33	0.65	1.43	0.36	0.30
TOTAL CARBONATE	23.10	84.40	24.90	15.47	32.17	2.30
Detrital	0.03	46.61	2.36	0.00	3.71	0.00
Cement	23.07	37.79	22.54	15.47	28.46	2.30
TOTAL QUARTZ	63.33	5.42	56.30	77.33	49.11	43.50
qtz grains	55.51	5.42	48.96	63.50	44.13	39.20
qtz cements	7.81	0.00	7.34	13.83	4.99	4.30
POROSITY						
phi TS	3.43	0.16	1.88	2.50	1.46	3.00
ELECTRIC LOGS						
GR-API UNITS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	102.40
RES (lat)	147.71	148.30	135.27	101.00	153.57	110.00
SONIC T.T.	52.93	52.35	53.18	55.00	51.71	58.00
NEUTRON-API UNITS	1586.93	1549.60	1580.05	1538.17	1607.36	1514.50
BULK DENSITY	2.67	2.72	2.69	2.71	2.69	2.67
LIME POROSITY	14.36	11.65	12.77	10.83	13.21	15.50
SAMPLE NO.						
ROCK TYPE						
MATURITY						
MODE QTZ						
GRAIN SIZE						

Plate VIII

Thin-section Data Sheet of the Mazur Well Samples

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MCLISH OUTCROP HWY I-35
MURRAY CO. OK

SAMPLE ID	ML 3501	ML 3502	ML 3503	ML 3505	ML 3506	ML 3507	ML 3508	ML 3510	ML 3511	ML 3512	ML 3513	ML 3514	ML 3515	ML 3516	ML 3517
CONSTITUENTS															
DETRITAL															
Quartz	69.20	67.70	65.60	58.50	69.00	0.00	0.00	1.00	11.70	63.00	2.00	40.60	62.80	41.50	3.00
monocrystalline	69.20	67.70	65.60	58.50	69.00			1.00	11.70	63.00	2.00	40.60	62.80	41.50	3.00
undulose															
Feldspar	0.00	0.30	0.40	1.20	0.20	0.00	0.00	0.00	0.30	0.40	0.00	0.20	0.20	0.30	0.00
orthoclase															
plagioclase		0.30	0.30	0.60	0.10					0.30		0.10	0.10		
microcline			0.10	0.60	0.10				0.30	0.10		0.10	0.10	0.30	
Rock Fragments	0.10	0.00	0.00	1.60	0.10	1.70	0.00	2.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
shale	0.10			1.60	0.10										
chert										0.10					
carbonate						1.70		2.00		0.10					
Other Grains	0.20	0.10	0.00	1.60	4.40	48.00	0.00	54.00	48.00	10.60	53.40	7.40	11.40	33.90	35.00
glauconite					1.00					3.30		5.00	5.00	5.60	2.00
shell fragments						48.00		54.00	45.00	4.00	53.40		2.30	25.30	32.00
tourmaline	0.10	0.10			0.10							0.10	0.10		
zircon	0.10														
collophane				1.60	3.30				3.00	3.30		2.30	4.00	3.00	1.00
Detrital Matrix	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	2.00	0.00	4.00	8.60	0.30	0.30	0.00
chlorite															
illite				2.60					2.00		4.00	8.60	0.30	0.30	
AUTHIGENIC															
Cements	14.30	20.00	12.10	31.20	15.40	50.30	100.00	43.00	38.00	17.50	40.30	31.90	16.00	22.00	62.00
quartz	2.00	2.30	11.40	18.60	15.00	0.00	0.00	0.00	0.00	11.30	0.00	6.60	6.60	0.60	0.00
syntaxial	2.00	2.30	11.40	18.60	15.00					11.30		6.60	6.60	0.60	
other															
chalcedony				1.00					1.00		0.30		0.10		
carbonate	0.00	0.00	0.00	8.30	0.00	50.00	100.00	43.00	37.00	5.60	40.00	21.60	6.90	21.30	62.00
calcite						30.00	100.00	28.00	31.00	3.00	35.00	6.60	4.30	15.30	56.00
dolomite				8.30		20.00		15.00	6.00	2.60	5.00	15.00	2.60	6.00	6.00
siderite															
ferroan calc															
ankerite															
Authigenic Clays	12.00	17.60	0.60	2.30	0.30	0.30	0.00	0.00	0.00	0.60	0.00	3.60	2.30	0.10	0.00
kaolinite															
chlorite						0.30									
illite	12.00	17.60	0.60	2.30	0.30					0.60		3.60	2.30	0.10	
OTHER															
pyrite	0.30	0.10	0.10	1.00	0.10							0.10	0.10		
dead oil		0.30	5.30	1.00	0.30					1.00		0.70	1.30	1.00	
hematite		4.00	6.00	2.00	3.60						0.30	5.30			
POROSITY	16.20	7.60	10.60	0.30	7.00	0.00	0.00	0.00	0.00	7.30	0.00	5.30	8.00	1.00	0.00
Primary	16.20	7.60	10.60	0.30	7.00					7.30		5.30	8.00	1.00	
Secondary															
DEPTH (FT)	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE
Feet from base	44.00	47.00	52.00	63.00	65.00	94.00	127.00	168.00	242.00	305.00	348.00	358.00	359.00	371.00	394.00
TOTAL DETRITAL	69.30	68.00	66.00	61.30	70.30	1.70	0.00	3.00	12.00	66.90	2.00	45.80	68.00	47.40	5.00
Quartz (%)	99.86	99.56	99.39	95.43	98.15	0.00		33.33	97.50	94.17	100.00	88.65	92.35	87.55	60.00
Feldspar (%)	0.00	0.44	0.61	1.96	0.28	0.00		0.00	2.50	0.60	0.00	0.44	0.29	0.63	0.00
Rock Fragments (%)	0.14	0.00	0.00	2.61	1.56	100.00		66.67	0.00	5.23	0.00	10.92	7.35	11.81	40.00
total	100.00	100.00	100.00	100.00	100.00	100.00		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	12.00	17.60	0.60	4.90	0.30	0.30	0.00	0.00	2.00	0.60	4.00	12.20	2.60	0.40	0.00
Detrital	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	2.00	0.00	4.00	8.60	0.30	0.30	0.00
Authigenic	12.00	17.60	0.60	2.30	0.30	0.30	0.00	0.00	0.00	0.60	0.00	3.60	2.30	0.10	0.00
TOTAL CARBONATE	0.00	0.00	0.00	8.30	0.00	99.70	100.00	99.00	82.00	9.70	93.40	21.60	9.20	46.60	94.00
Detrital	0.00	0.00	0.00	0.00	0.00	49.70	0.00	56.00	45.00	4.10	53.40	0.00	2.30	25.30	32.00
Cement	0.00	0.00	0.00	8.30	0.00	50.00	100.00	43.00	37.00	5.60	40.00	21.60	6.90	21.30	62.00
TOTAL QUARTZ	71.20	70.00	77.00	78.10	84.00	0.00	0.00	1.00	12.70	74.40	2.30	47.20	69.50	42.10	3.00
qtz grains	69.20	67.70	65.60	58.50	69.00	0.00	0.00	1.00	11.70	63.10	2.00	40.60	62.80	41.50	3.00
qtz cements	2.00	2.30	11.40	19.60	15.00	0.00	0.00	0.00	1.00	11.30	0.30	6.60	6.70	0.60	0.00
POROSITY															
phi TS	16.20	7.60	10.60	0.30	7.00	0.00	0.00	0.00	0.00	7.30	0.00	5.30	8.00	1.00	0.00
SAMPLE NO.	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00
ROCK TYPE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	BIOSPAR	MICRITE	BIOSPAR	BIOSPAR	SUB LIT	BIOSPAR	SUB LIT	SUB LIT	SUB LIT	BIOSPAR
MATURITY	IMMATUR	IMMATUR	MATURE	MATURE	SUP MAT					MATURE		IMMATUR	MATURE	SUP MAT	
MODE QTZ	UNIMOD	UNIMOD	UNIMOD	UNIMOD	UNIMOD					UNIMOD		UNIMOD	UNIMOD	UNIMOD	
GRAIN SIZE	VFN-FN	VFN-FN	VFN-FN	VFN	VFN-FN	COARSE DOLO	MICRO	DOLO	QTZ	VFN-FN		VFN-FN	VFN-FN	VFN-FN	COARSE
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

MCLISH OUTCROP HWY I-35
MURRAY CO. OK

SAMPLE ID	LOWER BASAL SAND AVERAGE %	UPPER CARBONATE AVERAGE %	SUBLITH AVERAGE %
CONSTITUENTS			
DETRITAL			
Quartz	66.00	2.95	51.98
monocrystalline	66.00	2.95	51.98
undulose	0.00	0.00	0.00
Feldspar	0.42	0.05	0.28
orthoclase	0.00	0.00	0.00
plagioclase	0.26	0.00	0.13
microcline	0.16	0.05	0.15
Rock Fragments	0.36	0.62	0.05
shale	0.36	0.00	0.00
chert	0.00	0.00	0.03
carbonate	0.00	0.62	0.03
Other Grains	1.26	39.73	15.83
glauconite	0.20	0.33	4.73
shell fragments	0.00	38.73	7.90
tourmaline	0.06	0.00	0.05
zircon	0.02	0.00	0.00
collophane	0.98	0.67	3.15
Detrital Matrix	0.52	1.00	2.30
chlorite	0.00	0.00	0.00
illite	0.52	1.00	2.30
AUTHIGENIC			
Cements	18.60	55.60	21.85
quartz	9.86	0.00	6.28
syntaxial	9.86	0.00	6.28
other	0.00	0.00	0.00
chalcedony	0.20	0.22	0.03
carbonate	1.66	55.33	13.85
calcite	0.00	46.67	7.30
dolomite	1.66	8.67	6.55
siderite	0.00	0.00	0.00
ferroan calc	0.00	0.00	0.00
ankerite	0.00	0.00	0.00
Authigenic Clays	6.56	0.05	1.65
kaolinite	0.00	0.00	0.00
chlorite	0.00	0.05	0.00
illite	6.56	0.00	1.65
OTHER			
pyrite	0.32	0.00	0.05
dead oil	1.38	0.00	1.00
hematite	3.12	0.05	1.33
POROSITY	8.34	0.00	5.40
Primary	8.34	0.00	5.40
Secondary	0.00	0.00	0.00
DEPTH (FT)			
corrected depth (ft)			
TOTAL DETRITAL	66.98	3.95	57.03
Quartz (%)	98.48		90.68
Feldspar (%)	0.66		0.49
Rock Fragments (%)	0.86		8.83
total	100.00		100.00
TOTAL CLAYS	7.08	1.05	3.95
Detrital	0.52	1.00	2.30
Authigenic	6.56	0.05	1.65
TOTAL CARBONATE	1.66	94.68	21.78
Detrital	0.00	39.35	7.93
Cement	1.66	55.33	13.85
TOTAL QUARTZ	76.06	3.17	58.30
qtz grains	66.00	2.95	52.00
qtz cements	10.06	0.22	6.30
POROSITY			
phi TS	8.34	0.00	5.40
SAMPLE NO.			
ROCK TYPE			
MATURITY			
MODE QTZ			
GRAIN SIZE			

MCLISH OUTCROP HWY 77
CARTER CO. OK

SAMPLE ID	ML 7701	ML 7702	ML 7703	ML 7704	ML 7705	ML 7706	ML 7707	ML 7709	ML 7710	ML 7711	ML 7712	ML 7713
CONSTITUENTS												
DETRITAL												
Quartz	77.70	76.80	72.10	76.10	0.00	0.00	0.30	2.00	0.30	0.00	62.00	7.00
monocrystalline	77.70	76.80	72.10	76.10			0.30	2.00	0.30		62.00	7.00
undulose												
Feldspar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
orthoclase												
plagioclase												0.30
microcline												
Rock Fragments	1.30	0.00	0.00	0.00	4.00	9.60	10.00	0.00	0.30	12.00	0.00	0.00
shale												
chert												
carbonate	1.30				4.00	9.60	10.00		0.30	12.00		
Other Grains	0.10	0.10	0.00	0.00	37.00	39.00	41.00	42.00	41.00	32.00	4.70	44.00
glauconite											2.70	2.00
shell fragments					37.00	39.00	40.00	42.00	41.00	32.00		39.00
tourmaline	0.10	0.10										
zircon												
collophane							1.00				2.00	3.00
Detrital Matrix	3.00	0.00	0.00	0.00	16.00	14.00	0.00	10.00	20.00	18.00	2.00	4.00
chlorite												
illite	3.00				16.00	14.00		10.00	20.00	18.00	2.00	4.00
AUTHIGENIC												
Cements	13.00	13.00	18.60	14.90	42.70	37.30	43.70	46.00	38.00	38.00	12.70	44.60
quartz	9.60	3.60	12.60	10.60	0.00	0.00	0.00	0.00	0.00	0.00	6.60	0.00
syntaxial	9.60	3.60	12.60	10.60							6.60	
other												
chalcedony	1.30	0.30										1.00
carbonate	0.00	0.00	0.00	0.00	42.00	37.00	43.70	46.00	38.00	38.00	0.00	43.60
calcite					36.00	30.00	42.70	31.00	33.00	24.00		39.60
dolomite					6.00	7.00	1.00	15.00	5.00	14.00		4.00
siderite												
ferroan calc												
ankerite												
Authigenic Clays	2.00	9.00	6.00	4.30	0.00	0.30	0.00	0.00	0.00	0.00	3.00	0.00
kaolinite												
chlorite						0.30						
illite	2.00	9.00	6.00	4.30							3.00	
OTHER												
pyrite	0.10	0.10			0.70						3.10	
dead oil	0.30	0.10			0.30	0.10			0.10		5.00	
hematite									0.30		2.00	0.10
POROSITY	4.60	10.00	9.30	9.00	0.00	0.00	5.00	0.00	0.00	0.00	11.60	0.00
Primary	4.00	9.00	8.00	8.00							11.60	
Secondary	0.60	1.00	1.30	1.00			5.00					
DEPTH (FT)	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE
Feet from base	1.00	36.00	48.00	54.00	133.00	176.00	197.00	246.00	308.00	339.00	383.00	476.00
TOTAL DETRITAL	79.00	76.80	72.10	76.10	4.00	9.60	10.30	2.00	0.60	12.00	64.70	9.30
Quartz (%)	98.35	100.00	100.00	100.00	0.00	0.00	2.91	100.00	50.00	0.00	95.83	75.27
Feldspar (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23
Rock Fragments (%)	1.65	0.00	0.00	0.00	100.00	100.00	97.09	0.00	50.00	100.00	4.17	21.51
total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL CLAYS	5.00	9.00	6.00	4.33	16.00	14.30	0.00	10.00	20.00	18.00	5.00	4.00
Detrital	3.00	0.00	0.00	0.00	16.00	14.00	0.00	10.00	20.00	18.00	2.00	4.00
Authigenic	2.00	9.00	6.00	4.33	0.00	0.30	0.00	0.00	0.00	0.00	3.00	0.00
TOTAL CARBONATE	1.30	0.00	0.00	0.00	83.00	85.60	93.70	88.00	79.30	82.00	0.00	82.60
Detrital	1.30	0.00	0.00	0.00	41.00	48.60	50.00	42.00	41.30	44.00	0.00	39.00
Cement	0.00	0.00	0.00	0.00	42.00	37.00	43.70	46.00	38.00	38.00	0.00	43.60
TOTAL QUARTZ	88.60	80.70	84.70	86.70	0.00	0.00	0.30	2.00	0.30	0.00	68.60	8.00
qtz grains	77.70	76.80	72.10	76.10	0.00	0.00	0.30	2.00	0.30	0.00	62.00	7.00
qtz cements	10.90	3.90	12.60	10.60	0.00	0.00	0.00	0.00	0.00	0.00	6.60	1.00
POROSITY												
phi TS	4.60	10.00	9.30	9.00	0.00	0.00	5.00	0.00	0.00	0.00	11.60	0.00
SAMPLE NO.	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00
ROCK TYPE	QTZ ARE	QTZ ARE	QTZ ARE	QTZ ARE	BIOSPAR	BIOSPAR	BIOSPAR	BIOSPAR	BIOSPAR	BIOSPAR	QTZ ARE	BIOSPAR
MATURITY	MATURE	IMMATUR	MATURE	MATURE	IMMATUR	IMMATUR		IMMATUR	IMMATUR	IMMATUR	MATURE	
MODE QTZ	UNIMOD	UNIMOD	UNIMOD	UNIMOD							UNIMOD	
GRAIN SIZE	VFN-FN	VFN-FN	VFN-FN	VFN-FN	COARSE SHY	COARSE SHY	COARSE PELLETS	COARSE DOL SHY	COARSE PEL CO	COARSE DOL SH	VFN-FN	COARSE
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

MCLISH OUTCROP HWY 77
CARTER CO. OK

SAMPLE ID	LOWER BASAL SAND AVERAGE %	UPPER CARBONATE AVERAGE %	QUARTZ-ARE AVERAGE %
CONSTITUENTS			
DETRITAL			
Quartz	75.68	1.37	62.00
monocrystalline	75.68	1.37	62.00
undulose	0.00	0.00	
Feldspar	0.00	0.04	0.00
orthoclase	0.00	0.00	
plagioclase	0.00	0.04	
microcline	0.00	0.00	
Rock Fragments	0.33	5.13	0.00
shale	0.00	0.00	
chert	0.00	0.00	
carbonate	0.33	5.13	
Other Grains	0.05	39.43	4.70
glauconite	0.00	0.29	2.70
shell fragments	0.00	38.57	
tourmaline	0.05	0.00	
zircon	0.00	0.00	
collophane	0.00	0.57	2.00
Detrital Matrix	0.75	11.71	2.00
chlorite	0.00	0.00	
illite	0.75	11.71	2.00
AUTHIGENIC			
Cements	14.88	41.47	12.70
quartz	9.10	0.00	6.60
syntaxial	9.10	0.00	6.60
other	0.00	0.00	
chalcedony	0.40	0.14	
carbonate	0.00	41.19	0.00
calcite	0.00	33.76	
dolomite	0.00	7.43	
siderite	0.00	0.00	
ferroan calc	0.00	0.00	
ankerite	0.00	0.00	
Authigenic Clays	5.33	0.04	3.00
kaolinite	0.00	0.00	
chlorite	0.00	0.04	
illite	5.33	0.00	3.00
OTHER			
pyrite	0.05	0.10	3.10
dead oil	0.10	0.07	5.00
hematite	0.00	0.06	2.00
POROSITY	8.23	0.71	11.60
Primary	7.25	0.00	11.60
Secondary	0.98	0.71	
DEPTH (FT)			
Feet from base			
TOTAL DETRITAL	76.00	6.83	64.70
Quartz (%)	99.59	32.60	95.83
Feldspar (%)	0.00	0.46	0.00
Rock Fragments (%)	0.41	66.94	4.17
total	100.00	100.00	100.00
TOTAL CLAYS	6.08	11.76	5.00
Detrital	0.75	11.71	2.00
Authigenic	5.33	0.04	3.00
TOTAL CARBONATE	0.33	84.89	0.00
Detrital	0.33	43.70	0.00
Cement	0.00	41.19	0.00
TOTAL QUARTZ	85.18	1.51	68.60
qtz grains	75.68	1.37	62.00
qtz cements	9.50	0.14	6.60
POROSITY			
phi TS	8.23	0.71	11.60
SAMPLE NO.			
ROCK TYPE			
MATURITY			
MODE QTZ			
GRAIN SIZE			

Plate IX

Thin-section Data Sheet of the Interstate 35 and State Highway 77 Outcrop Samples

O.S.U. School of Geology
Scott Weber 1986

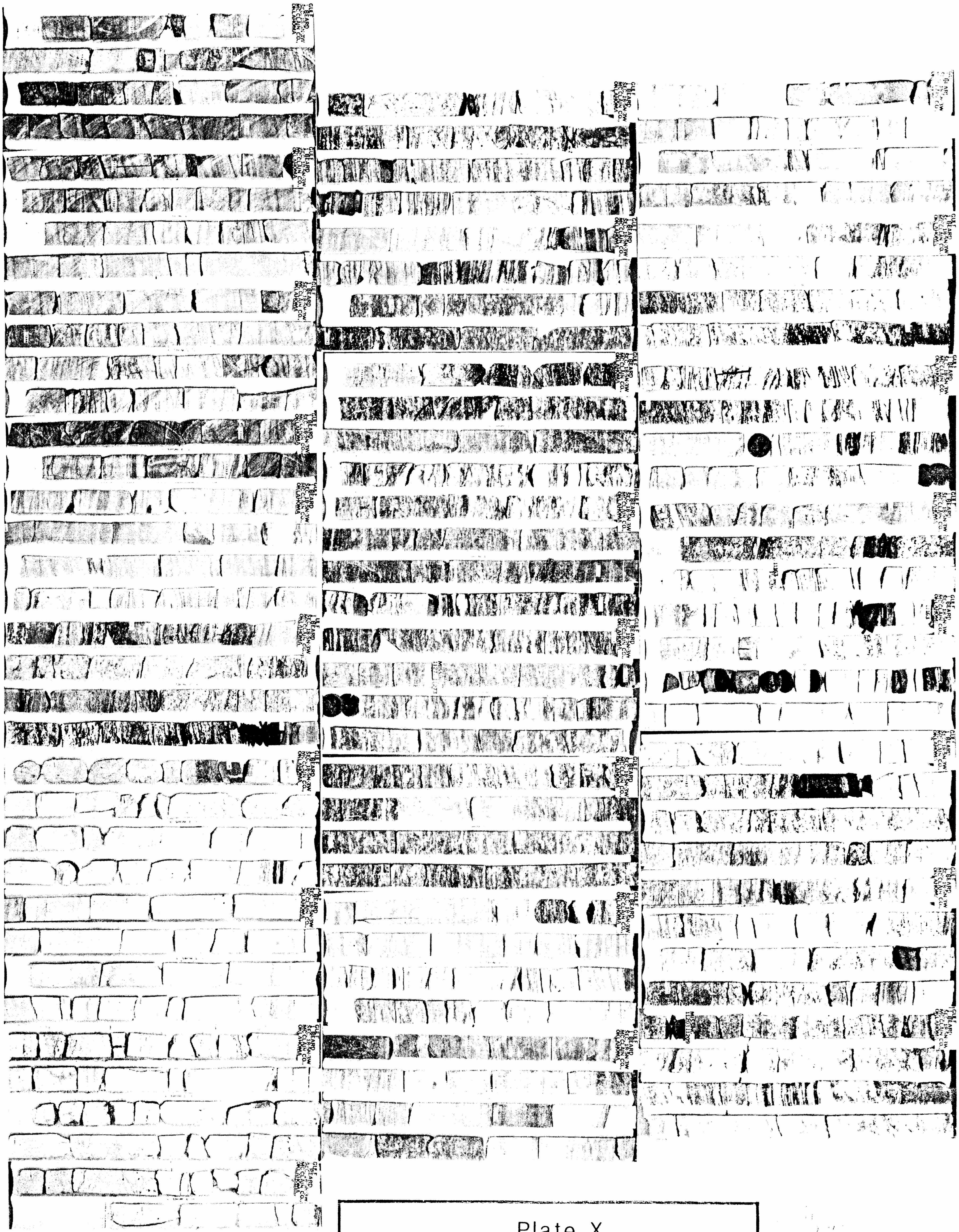

Plate X

Photographs of the Beard Core

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Plate XI

Photographs of the Costello Core

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Scott Weber 1986

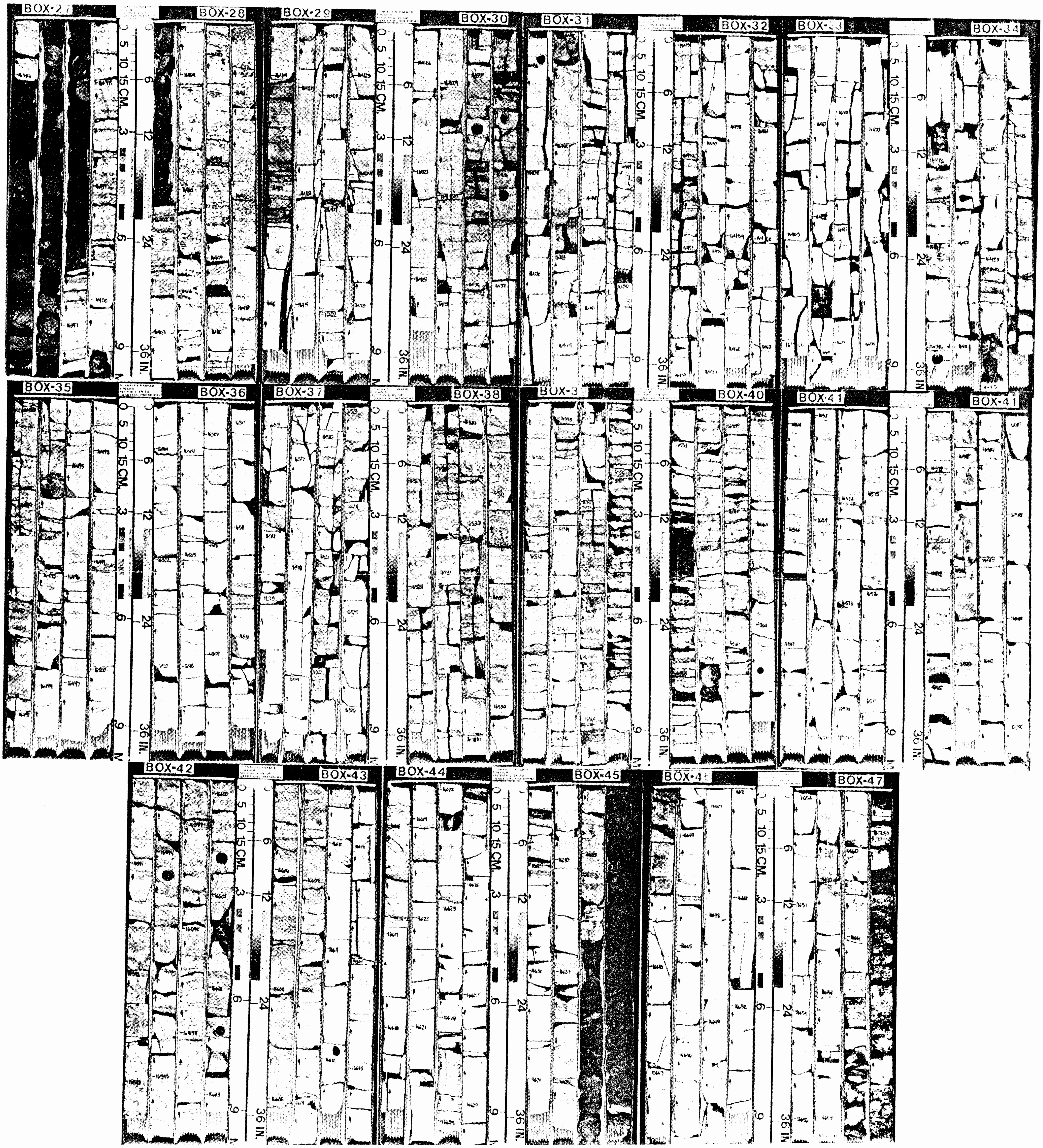

Plate XII

Photographs of the Mazur Core

O.S.U. School of Geology

Scott Weber 1986