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Christopher Cameron

William Hamilton

Kenneth Hamlin

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Environmental Facies, Petrology, and Diagenesis of Tuscaloosa Formation Sandstone Reservoirs in the McComb and Little Creek Oil Field, Southwest Mississippi

Dr. Christopher P. Cameron
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The Mississippi Mineral Resources Institute
University, Mississippi 38677

"ENVIRONMENTAL FACIES, PETROLOGY, AND DIAGENESIS OF TUSCALOOSA FORMATION SANDSTONE RESERVOIRS IN THE McCOMB AND LITTLE CREEK OIL FIELDS, SOUTHWEST MISSISSIPPI"

by

Christopher P. Cameron, William S. Hamilton
and Kenneth H. Hamlin

Department of Geology
University of Southern Mississippi
Hattiesburg, Mississippi 39406

Final Report

Prepared for the Mississippi Mineral Resources Institute
University, Mississippi 38677

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ABSTRACT

Excellent conventional core control and electric log (SP) signatures were used to compare stratigraphic facies relationships and depositional environments of the productive reservoir sandstones of McComb and Little Creek fields. Part of the "updip" Lower Tuscaloosa Formation (Upper Cretaceous) productive trend, these fields are structurally modified stratigraphic traps formed by the combination of gentle structural nosing and updip pinch out of the reservoir sandstones. Current studies confirm that this part of the trend is characterized by two major depositional facies; a lower fluvial sequence topped by nearshore marine deposits. Cumulative oil production exceeds 100 million barrels in the immediate study area.

Recognition of the depositional environments of productive sandstones in the McComb and Little Creek field areas is based on (1) sand body geometry as revealed by detailed isopach maps and cross sections; (2), vertical variations in sedimentary structure and texture based on detailed examination of 19 conventional cores; (3), the nature of boundaries with underlying and overlying sediments; (4), bedding architecture; and (5), regional stratigraphic setting.

Detailed core and electric log studies reveal that the main producing sandstone in the McComb field area ("McComb Sand") was deposited as a transgressive barrier island complex along a coastline influenced by wave action and tides. Transgressive sands are relatively thin and lenticular in strike and dip sections (Moslow, 1884). This type of geometry is classically refered to as "sheet like". The sands pinch out up-dip and thicken in a downdip (seaward) direction. McComb field cross sections show the same general architecture. Isopachs of the McComb sandstone exhibit a thickening of the sandstone to the west. This pattern of sandstone thickening is consistent with regional structural maps in the McComb field area which indicate that seaward directions during deposition of the Lower Tuscaloosa Formation lay to the west and southwest.

Sedimentary structures recognized in the McComb sandstone strongly resemble those described by Moslow (1984) and Galloway and Cheng (1985) as characteristic of a transgressive barrier complex. These structures include large-scale low-angle planar laminations and cross-bedded, burrowed sequences typical of foreshore and shoreface environments as well as thinly laminated, flasered, and burrowed sequences representative of lagoonal and tidal flat sequences. Coarsening-upwards sequences were identified in 10 of 14 McComb cores and probably represent shoreface and barrier facies. The remaining cores comprise generally thinner fining-upwards and mixed sequences typical of washover fan, tidal channel, and tidal inlet

sequences. Tidal inlets tend to migrate laterally along a shoreline, reworking barrier island sediments, which are re-deposited as sequences of fining upward inlet-fill. Tidal channel and/or inlet sequences in the McComb sandstone were identified in as many as 3 cores.

Sandstones of transgressive barriers migrate landward and commonly overly lagoonal, marsh, and/or tidal flat deposits comprised mostly of silts and muds. Intense bioturbation, especially that produced by burrowing, is often a feature of fine-grained and sandy tidal flat and lagoonal sediments. The core study revealed that strongly bioturbated and flasered silty and sandy mudstones (interpreted as tidal flat and lagoonal facies) occur throughout the McComb field immediately below the base of the productive sandstone

The producing sandstone in Little Creek field (Denkman sand) differs from those in McComb field with respect to depositional environment and stratigraphic position. The Denkman sand occupies a lower stratigraphic position in the "Stringer Sand" section than the McComb sand. The McComb sand is approximately 50-60 feet below the base of the Middle Marine Shale Formation, a unit clearly of marine origin on the basis of glauconite occurence and fossil evidence. The Denkman sand is 70-80 feet below the Middle Marine Tuscaloosa Formation, closer stratigraphically to the Dantzler Formation (Lower Cretaceous) which is continental in origin.

Eisenstatt (1960) and Busch (1974) report that sandstones of the Little Creek field are the product of meander belt deposition. Their conclusion is based on the Denkman sandstone isopach map produced by Eisenstatt (1960) which illustrates the concentric and ovoid pattern of irregular shape and thickness often observed in maps of meander belt deposits. The core analysis of this study is in accord with their conclusion regarding the depositional environment of the reservoir sandstones. However, the meandering stream responsible for the deposition of the Little Creek point bars was considerably smaller than that proposed by Busch (1974). Multi-story point bar cycles are clearly evident in the Sun Oil Co., #1 Busby A (Sec. 23-4N-8E) and Sun Oil Co., Atkinson B-1 (See. 2-4N-8E). The Little Creek reservoir sandstones are up to 66 feet thick and composed of at least two full or partial point bar cycles, the thickest of a single point bar being on the order of 30 feet. The thickness and continuity of full point bars identified in the core indicate that the sandstones were deposited by a stream approximately the size of the modern lower Brazos River (Texas).

The results of this study, supported by petrographic grain size analysis data, show that two major depositional facies characterize producing Lower Tuscaloosa Formation sanstone reservoirs in this area; a lower fluvial sequence (Little Creek) topped by nearshore marine deposits (McComb). Detailed core data, isolith maps, and

cross-sections of the McComb field area reveal that the McComb sandstone was deposited as a transgressed barrier island system at a time when sand supply was diminishing. Thus, the barrier complex marks the shore-zone of the Upper Cretaceous marine transgression in the McComb field area.

Petrographic studies reveal that the sandstones of both fields were deposited as very fine to medium-grained quartz arenites and quartz litharenites. A good secondary porosity developed by disolution of rock fragments and carbonate cements which replaced the margins of quartz grains. Results of the petrographic and X-Ray diffraction analysis of the clay mineral content of the sandstones indicate that most of the clays are authigenic and comprise a suite which includes kaolinite, chlorite, and illite. Illite appears to be considerably more abundant in the McComb reservoir sandstones than at Little Creek.

The combined petrographic and X-Ray diffraction results suggest a diagenetic history which begins with mechanical compaction of the sediments and the precipitation of quartz overgrowths. Replacement of quartz overgrowths by carbonate cement was accompanied by carbonate precipatation between framework grains during the first stages of mesodiagenesis. During a more mature diagenetic stage, perhaps corresponding to hydrocarbon migration and emplacement, decarboxylation of contained organic matter in the adjacent fine-grained units led to wide-spread decarbonization of the reservoir rocks and the creation of hybrid, oversized, moldic and intergranular pores with good pore-throat interconnection. Complete and partial alteration of rock fragments and feldspars was accompanied by neoformation of kaolinite, chlorite (as grain rims), and illite.

There is some evidence of further dissolution and reprecipitation of quartz and carbonate, as well as the formation of vermicular kaolinite, after the main phase of secondary porosity generation and hydrocarbon emplacement. Late stage diagenetic events also include the precipitation of euhedral quartz crystals in some pore spaces and over chlorite rims.

ACKNOWLEDGMENTS

This research was made possible through the offices of several organizations and individuals. The financial aid rendered to the project by the Mississippi Mineral Resources Institute (MMRI) is gratefully acknowledged as is that granted by the Atlantic Richfield Oil Company (ARCO) and the Gulf Coast Association of Geological Societies (G.C.A.G.S.). The study was made possible when Sun Oil Company agreed to provide nineteen conventional well cores from McComb and Little Creek fields on a loan basis to the University of Southern Mississippi. The continuing support and material assistance of other representatives of the Mississippi oil and gas exploration and production sector, (who are providing further cores, base maps, geophysical logs, and production data), insures the success of our on-going studies of the petroleum geology of Lower Tuscaloosa Formation sandstone reservoirs in southwest Mississippi.

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PART I: FACIES RELATIONSHIPS AND SANDSTONE DEPOSITIONAL ENVIRONMENTS

INTRODUCTION

The Edwards carbonate shelf margin (Lower Cretaceous) separates updip and deep Lower Tuscaloosa Formation oil production. The updip trend spans the central portions of the states of Louisiana and Mississippi with discovered oil reserves in the billions of barrels (Chasteen, 1983). This study deals with a portion of the updip trend in southwestern Mississippi (Fig. 1).

Since the discovery of Brookhaven field in the early 1940’s, more than fifty fields in the Interior Salt Basin of Mississippi have produced from the sandstones of the Lower Tuscaloosa Formation (Annual Report, MS. Oil and Gas Board, 1983). The Lower Tuscaloosa productive trend in Mississippi and Louisiana has received considerable attention since Shell Oil Company’s discovery of Olive field in 1981 and Liberty field in 1983 (Wheatley, 1983). Texaco’s recent Netonia and Thompson discoveries (in Wilkinson and Amite counties, respectively) have sparked even greater interest in the updip Tuscaloosa "play"[1]. A "play", as commonly used by today’s oil and gas explorers, comprises several hydrocarbon prospects that are geologically similar in terms of trap, timing, reservoir rock, hydrocarbon source(s), and seal(s).

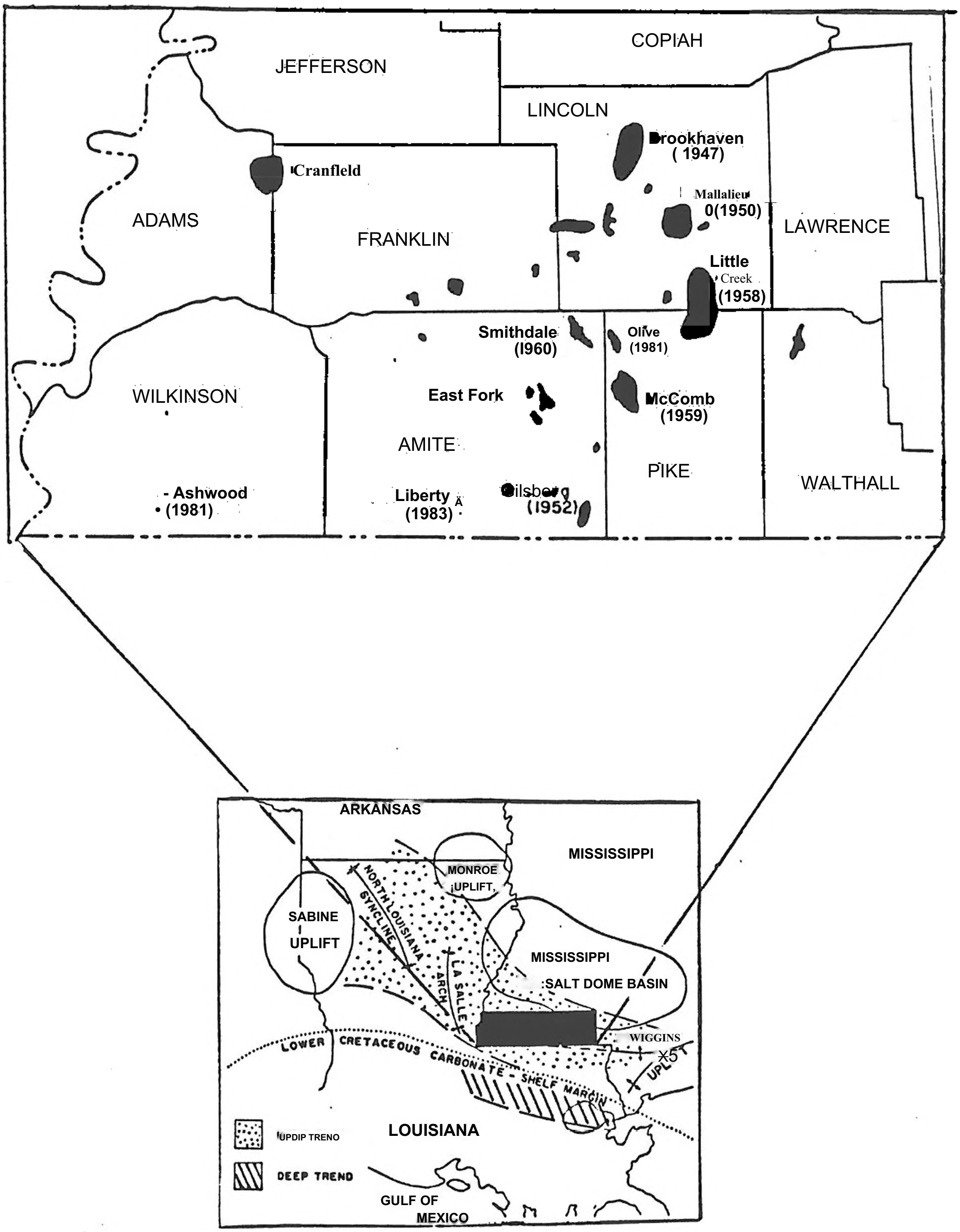


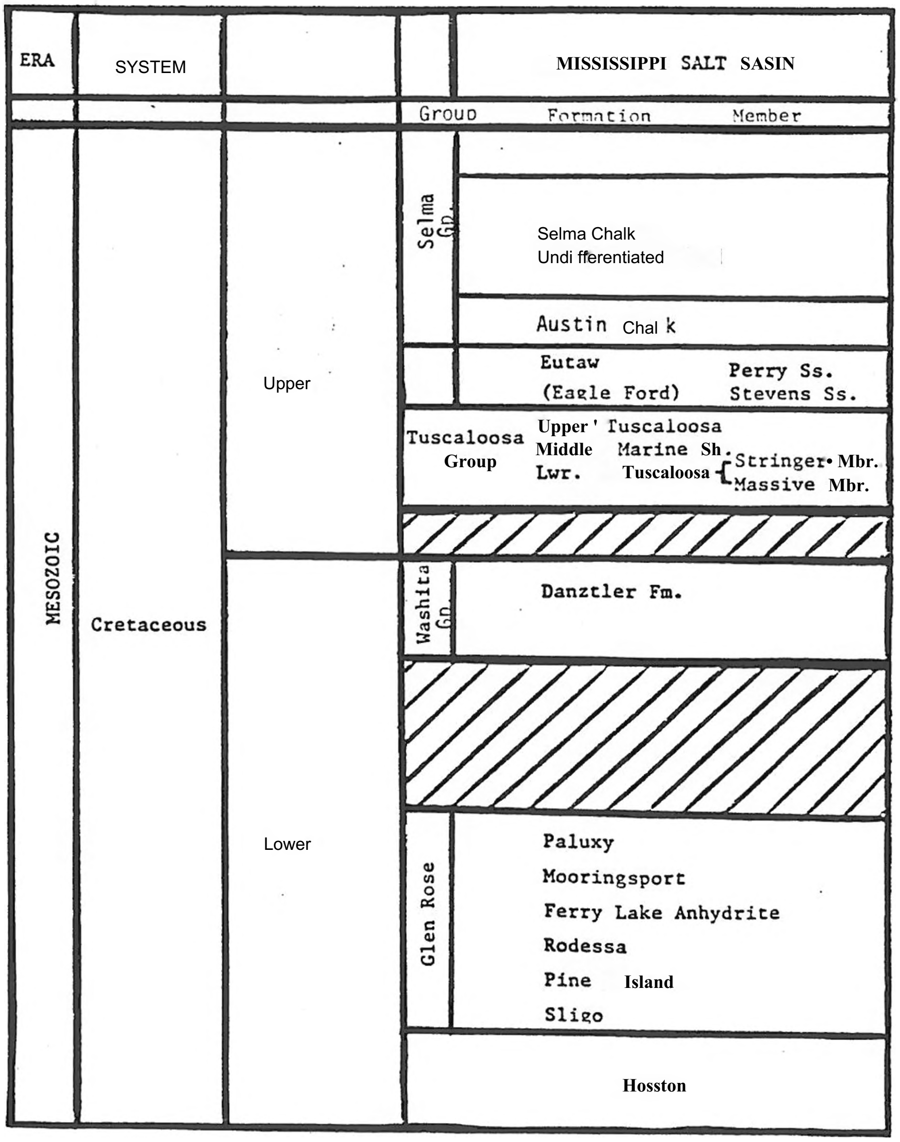
Figure 1. Location Maps of Lower Tuscaloosa Formation Production Trends.

This study defines the detailed physical stratigraphy and the depositional environment(s) of the Lower Tuscaloosa ”stringer sand” member in the McComb field area, Pike County, Mississippi (Fig. 2). McComb field was chosen for this investigation (1), because it is representative of Lower Tuscaloosa producing fields in this region, (2), because of the availability of conventional well cores and electric logs, and (3), because production drilling was conducted on forty acre drilling units which provide good control of structural and stratigraphic variations. Many subsequent Lower Tuscaloosa oil fields were completed on eighty acre well spacing which lessens structural and stratigraphic control.

Location

The study area, in southwest Mississippi, is located in Pike County, directly west of the town of McComb (Fig. 1). The field covers portions of Tier 3 and Tier 4 North, Range 7 East. McComb field is located in the center of the Mississippi and Louisiana updip Lower Tuscaloosa productive trend. During peak production in the early sixties the field contained 191 oil wells within 12,720 unitized acres, a substantial portion of which is shown on Figure 3.

Little Creek field is located approximately six miles to the northeast of McComb field. The field



ERA	SYSTEM		MISSISSIPPI SALT SASIN		
			Group	Formation	Member
MESOZOIC	Cretaceous	Upper	Selma Gp.		
				Selma Chalk Undifferentiated	
				Austin Chalk	
				Eutaw (Eagle Ford)	Perry Ss. Stevens Ss.
			Tuscaloosa Group	Upper Tuscaloosa Middle Marine Sh. Lwr. Tuscaloosa	Stringer Mbr. Massive Mbr.
			▨	▨	▨
		Lower	Washita Gp.	Danztler Fm.	
			▨	▨	▨
			Glen Rose	Paluxy Mooringsport Ferry Lake Anhydrite Rodessa Pine Island Sligo	
				Hosston	

Figure 2. Stratigraphic Column of the study area (after Parker, 1983 and PennWell Publishing Co., 1984).

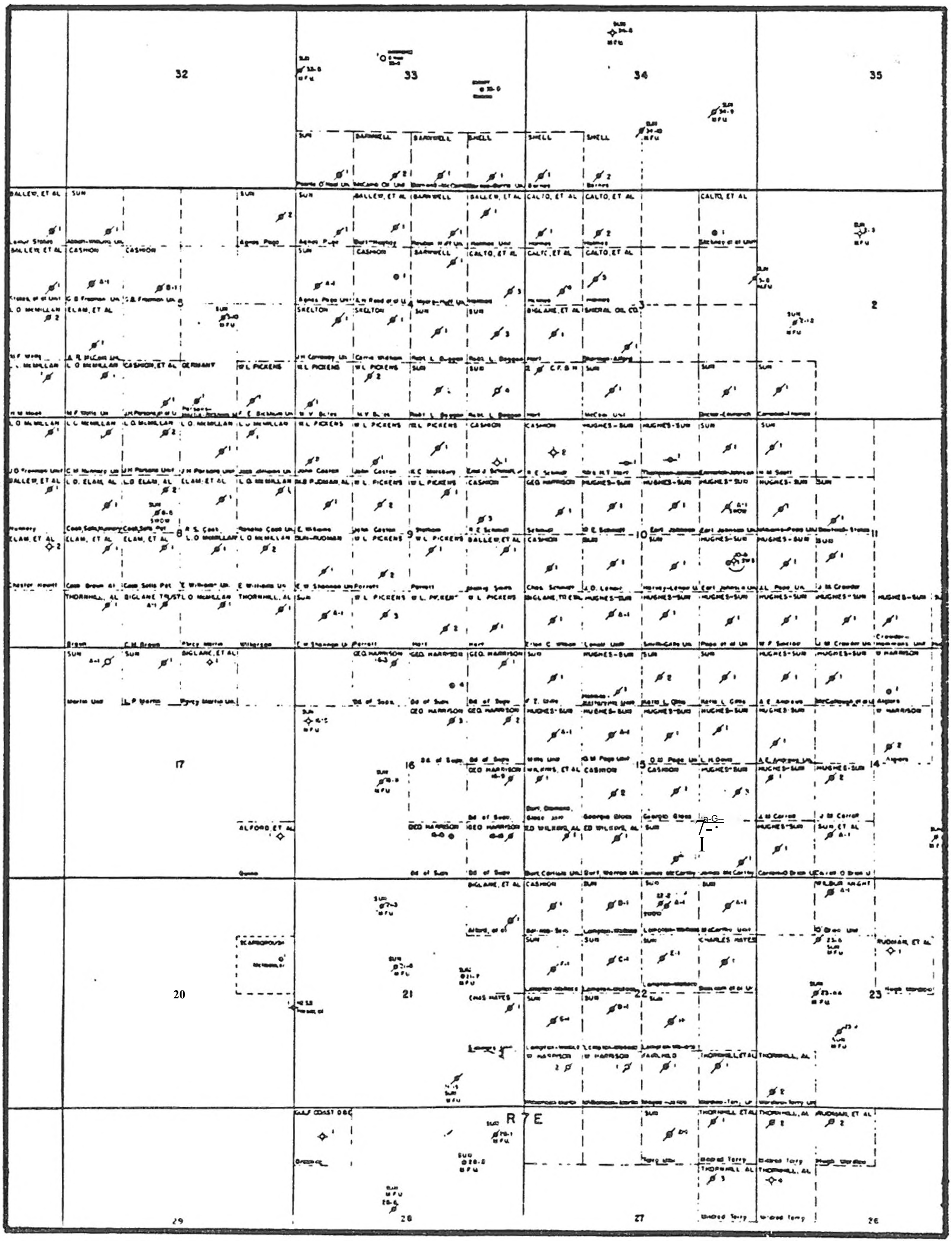


Figure 3. McComb field well location map, Pike County, Mississippi (from Mississippi Oil and Gas Board Annual Report, 1983).

covers portions of Tier 4 and Tier 5 North, Range 8 East, Pike and Lincoln counties (Fig. 4).

Exploration and Production History

McComb field was discovered by Sun Oil Company and J. Willis Hughes. The prospect was identified by seismic data and subsurface well control which indicated anticlinal nosing in the area. The discovery well, J. Willis Hughes and Sun Oil Company, #1 Pope Unit (Sec. 10-3N-7E), was completed on August 8, 1959. The well was drilled to a total depth of 11,219 feet and penetrated about 40 feet of the Dantzler Formation (Washita Group). Perforations were made from 10,882-10,886 feet in the ”stringer sand” member of the Lower Tuscaloosa Formation. The initial flow of the well was 244 barrels of oil per day through a 9/64-inch choke. The oil was 42.5 degree API gravity with a 1360:1 Gas-Oil Ratio (GOR). The producing sandstone is light gray to gray and is medium grained to very fine grained.

Sun Oil unitized the field and 191 development wells were completed in the Lower Tuscaloosa Formation ”stringer sand” member. The cumulative production for McComb field through December 31, 1983, was 29,705,615 barrels of oil and 27,350,000 MCF of gas. At its peak of production, McComb field was producing almost 15,000 barrels of oil per day. The average oil production of the 191 wells in the McComb field area through December 1983

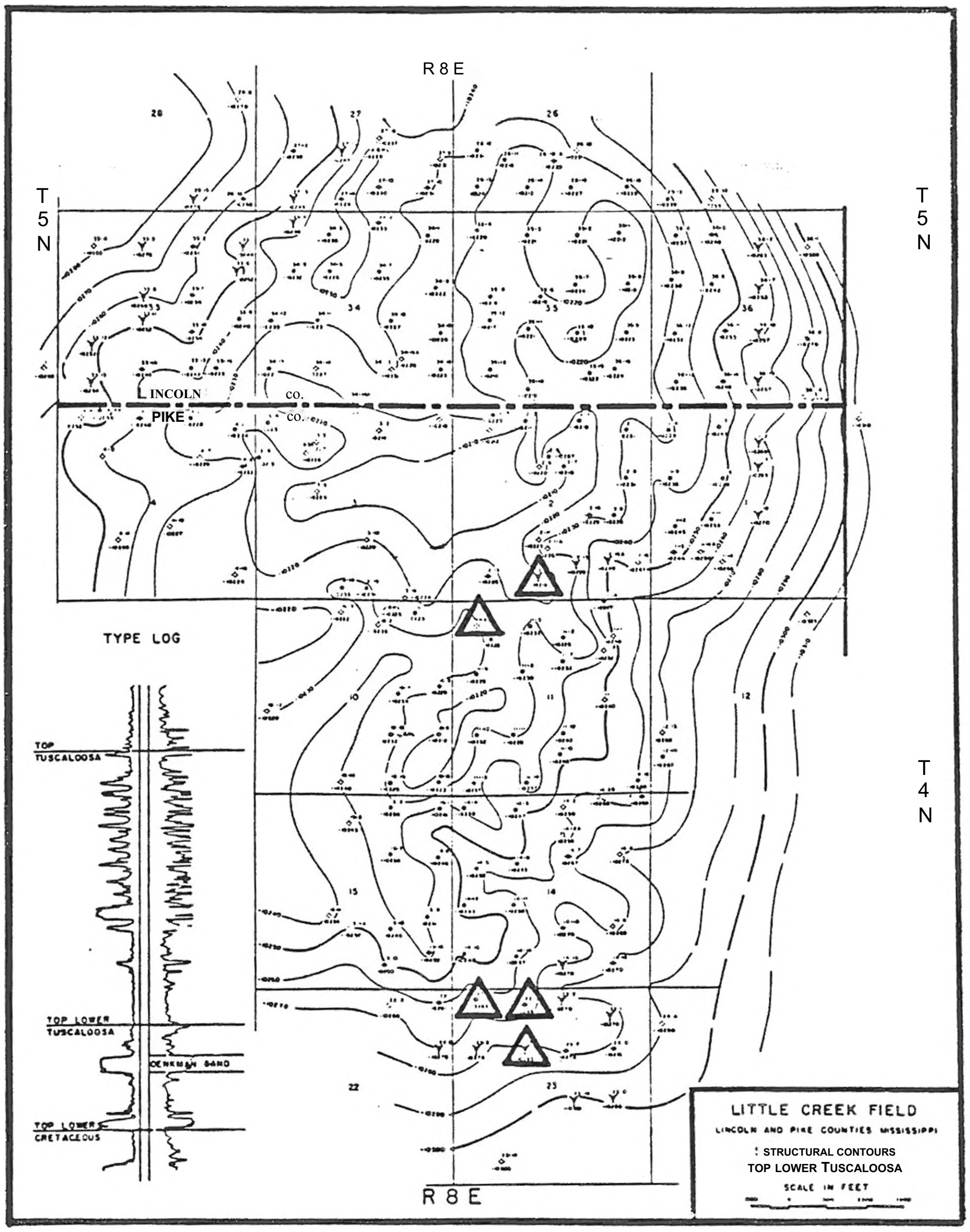


Figure 4. Little Creek field structure map, contoured on top of the Lower Tuscaloosa Formation. Heavy triangles indicate wells with core control used in this study (from Davis 1963).

was 155,526 barrels of oil per well. Basic reservoir data are given in Table 1.

McComb field underwent a water flood secondary recovery program in the 1960’s and 1970’s, but as of December of 1983, only two wells were still in production. Industry studies currently in progress will test the feasibility of enhanced oil recovery by CO2 injection for McComb and Little Creek fields. The Mississippi State Oil and Gas Board has divided the the McComb field area into (1) McComb field, (2) West McComb field, and (3) Southeast McComb field. Because of the distribution of available conventional core control, this study deals primarily with McComb and West McComb fields. However, a comparison of cores from the McComb field with those from Little Creek field aided in determining the depositional environment(s) of the McComb field area.

Stratigraphic Nomenclature

Tuscaloosa beds were first described from outcrops in central Alabama by Hilgard (1860). Smith and Johnson (1887) were the first to apply the name "Tuscaloosa Formation” to the beds in central Alabama cropping out between Paleozoic sediments and the Eutaw Formation (Upper Cretaceous). Stephenson (1911) initially assigned these beds to the Lower Cretaceous Series, but after further

TABLE 1. McCOMB FIELD RESERVOIR DATA

Average Porosity (%)	23
Permeability (Md.) (Average 91)	4.82-540
Connate Water (Average %)	60
Oil Water Contact (Feet MSL)	-10,493
Bottom Hole Temperature (°F)	251
Original Reservoir Pressure (PSI)	4904
Gravity of Oil (Degrees API)	41
Production Mechanism	Gas Expansion
Production Area (Unitized Acres)	12,720
Average Net Oil Sand Thickness (Feet)	14

(From Davis, 1963, and Fletcher, 1967)

study, he correctly assigned the Tuscaloosa Formation to the Upper Cretaceous.

Stephenson (1914) found glauconite in the Tuscaloosa strata and reported that the formation was, at least in part, of marine origin. Earlier investigators believed the Tuscaloosa Formation to be entirely of continental origin.

Blanpied and Hazzard (1939) were the first to correlate the Tuscaloosa Formation of Mississippi with the Eagle Ford of Texas on the basis of fossil data. The Mississippi Geological Society (1941) assigned the Tuscaloosa to the base of the Gulfian Series and indicated it was equivalent to the Eagle Ford and Woodbine formations of Texas and Louisiana. The "COSUNA" project (Correlation of Stratigraphic units of North America) recently recommended that the North American chronostratigraphic units for the Mesozoic be abandoned and that global units be substituted in their stead (Salvador, 1985). The adoption of this recommendation means that the above formations are now assigned to the Upper Cretaceous Cenomanian stage.

McGlothlin (1944) proposed a subdivision of the Tuscaloosa Formation into an upper and a lower unit, the lower unit being subdivided into an upper "sand and shale section”, a middle "marine section", and a lower "massive sand section"

. The Mississippi Geological Society (1957) assigned Group status to the subsurface Tuscaloosa sediments of Mississippi and Alabama using the following formational subdivisions: (1) ”The Upper Tuscaloosa Formation", (2) "The Marine Tuscaloosa Formation", and (3) "The Lower Tuscaloosa Formation". The Lower Tuscaloosa Formation was further divided into a lower "massive sand" member and an upper "stringer sand" member.

Although this nomenclature is widely used, it has not been formally accepted (Parker, 1983). Early studies traditionally concluded that the "Lower Tuscaloosa Formation" unconformably overlies the Lower Cretaceous Dantzler Formation of south Mississippi. The "Lower Tuscaloosa Formation" underlies the marine shales of the "Middle Tuscaloosa Formation". Chasteen (1983) reported that although an unconformity does exist in updip areas, no downdip unconformity exists between the Dantzler and the Lower Tuscaloosa. In his view, they are facies equivalents and form a single diachronous depositional unit which bridges the Upper-Lower Cretaceous boundary (Chasteen, 1983) .

Jules Braunstein (1950) accurately described the Lower Tuscaloosa Formation of southern Mississippi as a unit of "rapidly alternating sands and shales of shallow marine origin, overlying a nearly unbroken sand section of still shallower marine or continental origin". He reported that the oil-producing sandstones of the Lower Tuscaloosa of southern Mississippi are variable and lenticular, indicating deltaic or fluvial deposition.

Karges (1962) pointed out that the sandstone isopach patterns of the Lower Tuscaloosa Formation in southwestern Mississippi are suggestive of meandering stream channels in a deltaic environment.

Vaughan Watkins (1962) described the "stringer sand" member as alternating sandstones and shales with varying amounts of siltstone and mudstone representing a transitional sequence with marine rocks predominant in the upper part and less evident in the lower part. Rainwater (1960) described the environment of deposition of the basal part of the Upper Cretaceous in southern Mississippi as deltaic and shallow water marine. Scull and others (1966) studied the reservoir sandstones in the Smithdale field area in southwest Mississippi. They concluded that the sandstones were deposited as point bars in a meandering stream. Narrow channel-fill sandstones were also reported to be present.

Berg and Cook (1968) investigated the petrography and origin of Lower Tuscaloosa sandstones at Mallalieu field in Lincoln County, Mississippi, and assigned a "fluvio-deltaic" origin to the reservoir rocks. Berg and Cook subdivided the fluvial depositional environments into channel-fill and point-bar sub-environments based on mineralogy, texture, sedimentary structures, and areal geometry of the sandstones.

Chasteen (1983) divided the Lower Tuscaloosa into two main depositional facies: a marine facies and a nonmarine facies. The marine facies consist of the upper portion of the Stringer zone, just below the middle marine shale. The nonmarine facies is divided into sub-facies — namely, basal braided stream deposits overlain by meanderbelt point bar facies.

McComb Field Area Stratigraphy

According to V. Watkins (1962) the ”massive sand” member of the Lower Tuscaloosa Formation is not present in the McComb and Little Creek field areas. This is based on isopach data of the ”massive sand” member and regional cross sections constructed from electric logs of wells in southwest Mississippi. Only the ”stringer sand” member is present; however, there are numerous thick "box car” sandstones (so named for their distinctive electric log signature) present in and around the McComb and Little Creek fields (Fig. 5). These sandstones look very similar on electric logs to the "massive sand" member which is present east of the study area.

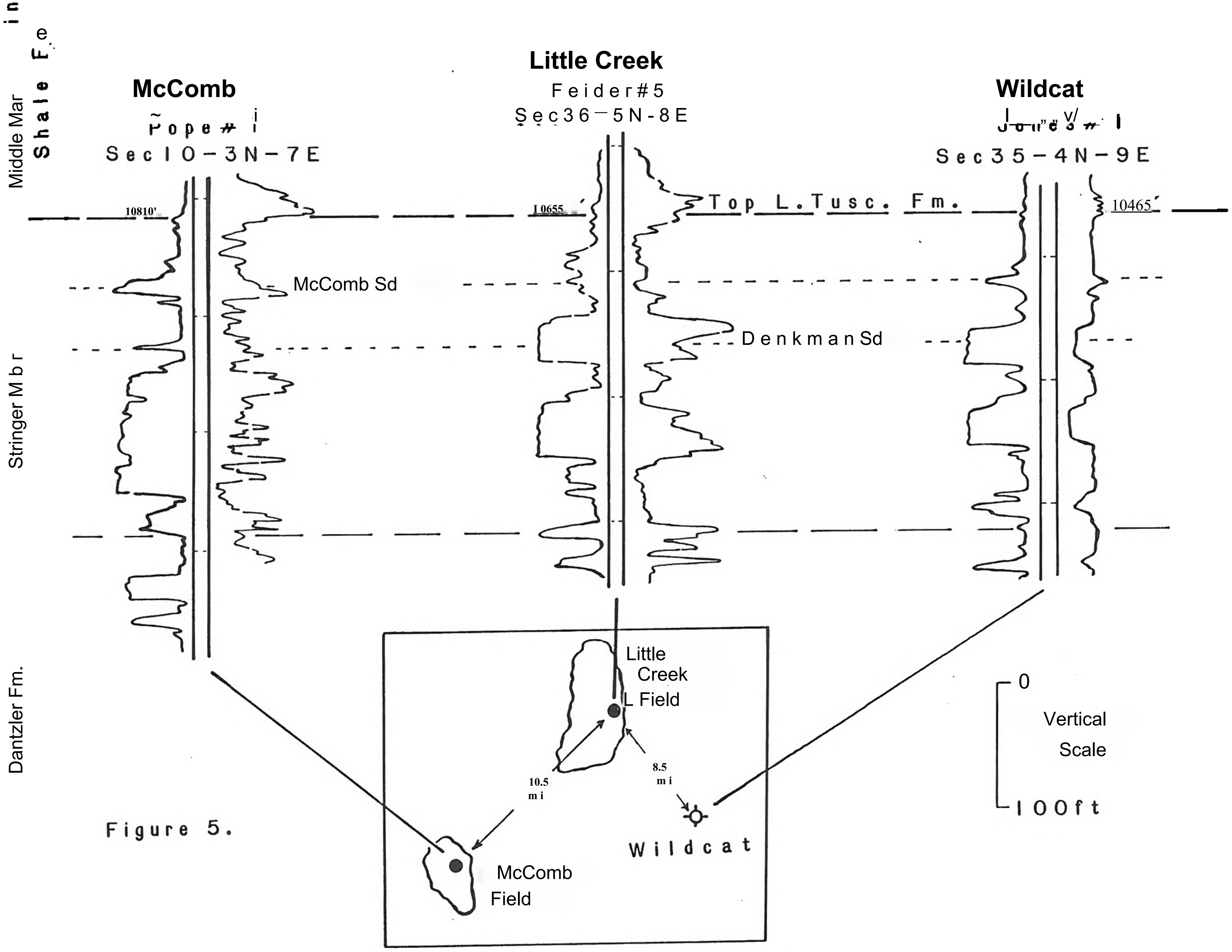

McComb
Pope # 1
Sec 10-3N-7E
Little Creek
Feider #5
Sec 36-5N-8E
Wildcat
Jones # 1
Sec 35-4N-9E
Middle Mar Shale Fe in
Stringer Mbr
Dantzler Fm.
10810'
10655
10465'
Top L. Tusc. Fm.
McComb Sd
Denkman Sd
Little Creek Field
McComb Field
Wildcat
10.5 mi
8.5 mi
0
Vertical Scale
100ft

Figure 5.

Biostratigraphy

Selected well cuttings from the John L. Harlan No. 1 well (Sec. 11-2N-7E), Pike County, Mississippi, were used by Dunn and others (1985) to evaluate the biostratigraphic zonation of the Lower Tuscaloosa Formation. The well is located approximately four miles south of the study area. The samples were analysed for their foraminiferal and microfossil content, using standard micropaleontological techniques. The foraminifera identified in the Lower Tuscaloosa Formation samples were classified by the taxonomy listed in Pessagno (1967), and the bio-zonal assignments used herein are those of Pessagno (1967) .

The fossiliferous samples from McComb field contain foraminiferal specimens that are badly recrystallized and poorly preserved, so these specimens were not definitively identified as to species. Foraminifera similar to Heterohelix moremani and Rotalipora greenhornensis in general form, chamber arrangement, and size were noted. If these taxonomic identifications are correct, then this section may be assigned to the Rotalipora greenhornensis zone of Pessagno (1967) which is Late Cenomanian (Woodbinian-Eaglefordian stage) age. This age assignment is in agreement with a more-detailed study by Mancini and others (1980), who found the Lower Tuscaloosa in southern Alabama to be of Cenomanian age.

Objectives

The primary objectives of this project were as follows ;

(1) To determine the detailed stratigraphy and depositional environment(s) of Lower Tuscaloosa Formation oil reservoir sandstones in and around McComb field. Pike County, Mississippi.

(2) To develop predictive depositional models in the area of intensive study in order to expand local interpretations to regional scales.

(3) To provide an enhanced stratigraphic and depositional environment framework for companion studies of sandstone petrology and diagenesis.

Scope

An understanding of the three-dimensional frameworks of modern clastic sedimentary environments is critical to the proper interpretation of vertical sequences of lithofacies, lateral facies relationships, sand body geometries, and inhomogeneities of sandstone reservoirs. The methods and techniques of process-oriented sedimentology are used to relate the data which describe an ancient depositional system to that which define its modern analog.

The four-step procedure described below was I utilized to provide the basic data which describe the reservoir sandstone trends in the McComb and Little Creek fields. This approach is useful in depositional environment analysis because it is flexible and maximizes available data to the fullest.

1. Determination of the Vertical Sequence of Lithofacies and Depositional Environments. Cores were examined using a binocular microscope and graphic lithologic logs were prepared. Vertical variations in texture and sedimentary structures as well as general mineralogy were recorded. A comparison of cores from the McComb field with those from Little Creek aided in determining the depositional environment(s) of the McComb field area.

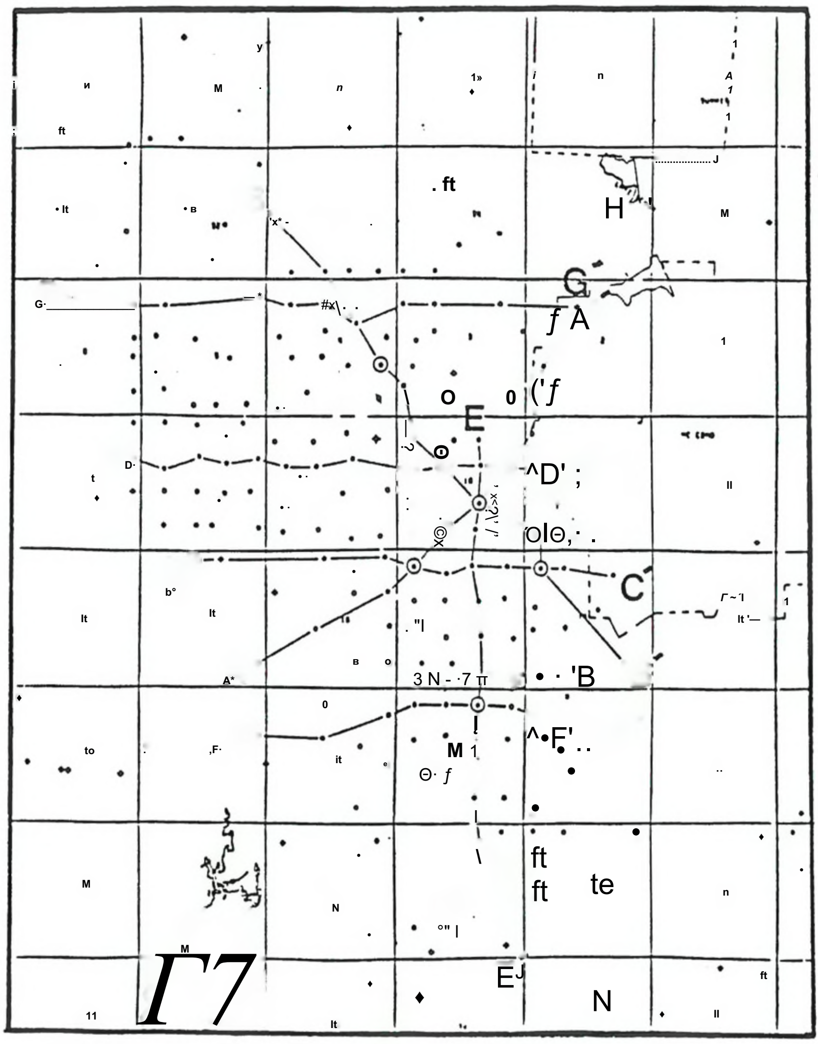
2. Determination of Lateral Variations of Lithofacies and Depositional Environments. Once the vertical distribution of lithofacies and depositional environments were recorded, stratigraphic cross-sections were constructed through areas of greater control to areas of lesser control.

3. Environment Analysis. At this stage, lithofacies and depositional environment models were constructed by preparing a network of correlated cross-sections which also integrated available core data. Aspect maps showing sand body sizes, shapes, and trends were generated using these data.

4. Regional Interpretation. Comparison of petrographic data from studies throughout the southwest Mississippi updip Tuscaloosa trend (e.g., H. Watkins, 1984; Berg and Cook, 1968).

Core Examination

Detailed environmental facies analysis of cores from McComb and Little Creek fields comprises a major part of this study. The location and distribution of cores and cross-sections used during this investigation are shown on Figure 6 and Table 2. The amount of core footage per well ranges from 11 to 70 feet with an average core footage of 34 feet per well.



McComb Field Cross Section Location Map

Oil Well ·

Dry Hole ⌖

Core Data ⊙

Figure 6. McComb field Cross Section and Core control location map.

TABLE 2. CORE DATA

OPERATOR	WELL NAME	LOCATION	COUNTY	CORE INTERVAL	FIELD
SUN	#3 Boggan	Sec. 4-3N-7E	Pike	10934 - 10954	McComb
SUN	#1 R. E. Schmidt	Sec. 10-3N-7E	Pike	10899 - 10915	McComb
SUN	Lenoir A-l	Sec. 10-3N-7E	Pike	10938 - 10964	McComb
SUN	#1 Harvey Lenoir Unit	Sec. 10-3N-7E	Pike	10885 - 10918	McComb
SUN	Johnson A-l	Sec. 10-3N-7E	Pike	10896 - 10949	McComb
SUN	Crowder M.F.U. 11-11	Sec. 11-3N-7E	Pike	10912 - 10946	McComb
SUN	#1 Sinclair	Sec. 11-3N-7E	Pike	10892 - 10954	McComb
SUN	#1 Andrews	Sec. 14-3N-7E	Pike	10876 - 10892	McComb
SUN	#1 F. Z. Mills	Sec. 15-3N-7E	Pike	10948 - 10024	McComb
SUN	#1 Jas. McCarthy	Sec. 15-3N-7E	Pike	10896 - 10907	McComb
SUN	#1 L. P. Martin	Sec. 17-3N-7E	Pike	10961 - 10976	McComb
SUN	Lampton Wallace G-l	Sec. 22-3N-7E	Pike	10939 - 10972	McComb
SUN	Lampton Wallace A-l	Sec. 22-3N-7E	Pike	10992 - 10948	McComb
SUN	McComb Field Unit 27	Sec. 27-3N-7E	Pike	10926 - 10949	McComb
SUN	Atkinson B-l	Sec. 2-4N-8E	Pike	10772 - 10821	Little Creek
SUN	#2 Kenna	Sec. 11-4N-8E	Pike	10773 - 10815	Little Creek
SUN	#1 Busby A	Sec. 23-4N-7E	Pike	10711 - 10769	Little Creek
SUN	#1 Mae Busby	Sec. 23-3N-7E	Pike	10745 - 10778	Little Creek
SUN	#1 Nunnery Busby	Sec. 23-4N-8E	Pike	10723 - 10767	Little Creek

The cores were examined in detail using standard methods of megascopic core analysis as described in the AAPG Sample Evaluation Manual (Swanson, 1983). Textural analysis was performed using a binocular microscope and a grain size comparitor chart. The textural, sedimentary structure, and mineralogical data were recorded on graphic lithological logs using common sedimentological symbols (Appendix A and B, Fig. 14).

SUBSURFACE GEOLOGY OF THE McCOMB FIELD AREA

The subsurface investigation of the McComb field area combined detailed studies of 19 conventional cores (14 from McComb field and 5 from Little Creek field), with interpretation of over 200 electric well logs.

Structural Setting

McComb field is situated on a broad gentle structural nose (Plate I, in pocket). The greatest amount of closure found in the field is only ten to fifteen feet. The gentle nosing reduces the regional southwest dip from 75 feet per mile (0.8 degrees) to 12.5 feet per mile (0.2 degrees). The oil trapping mechanism for McComb field combines this gentle structural nosing with a stratigraphic pinchout of permeable sandstone into updip impermeable shale. This mechanism is not unique to the McComb field but is the trapping mechanism for many of the fields in the Lower Tuscaloosa updip trend (e.g., Olive, Little Creek, East Fork) .

Sandstone Thickness and Geometry

The general shape of the producing sandstone is arcuate to lobate as derived from an isopach map of the McComb sandstone (Plate II, in pocket). The sandstone is thickest in the northwest portion of the field (30 - 35 feet) but shows an irregular pattern of thinning and thickening along an easterly and southeasterly trend. Thicknesses vary widely from well to well, particularly near the field margins where the sandstone pinches out. Sandstone thickness variations are commonly in the 5-10 feet range and are occasionally as much as 25 feet over a quarter of a mile.

Sandstone Composition

The Lower Tuscaloosa Formation in the McComb field area is characterized by alternating sandstone, siltstone, and shale lithologies. The approximate thickness of the formation is 320 feet. The sandstones are very-fine to medium grained quartz arenites (H. Watkins, 1984; based on the classification chart of Folk, 1980) with variable degrees of cementation, porosity and permeability. Detailed core descriptions of reservoir sandstones of McComb and Little Creek are given in appendices A and B.

Petrographic Analysis

A petrographic study was conducted by H. Watkins (1984) on the productive sandstone in the McComb field. A total of six thin sections from two wells was examined (Figures 7 and 8). The wells sampled included Sun Oil Company, R. L. Boggan #3 (Sec. 4-3N-7E), and Sun Oil

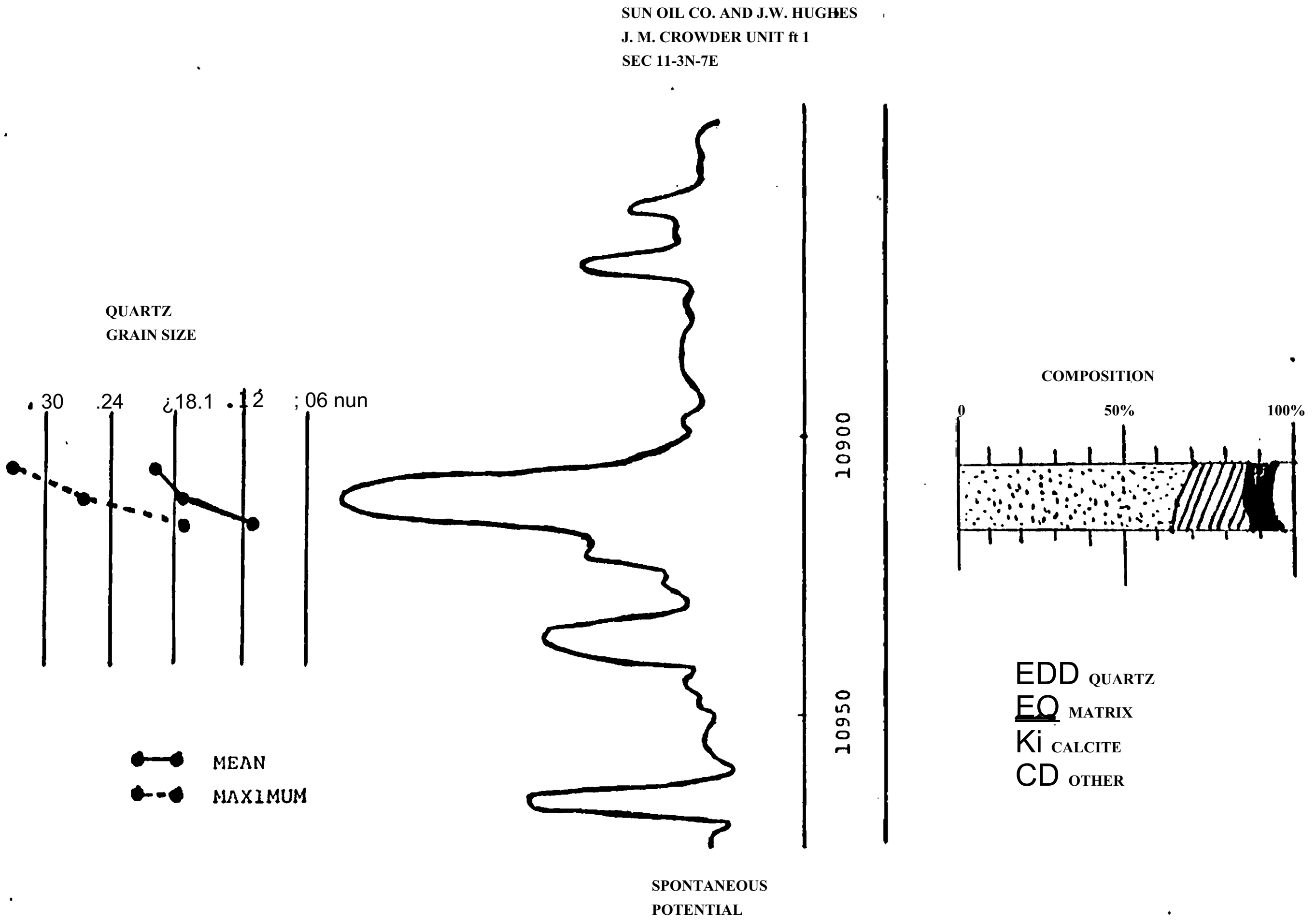


Figure 7. Characteristics of the McComb sandstone in Sun Oil Co, and J. W. Hughes, H Crowder Unit (Sec. 11-3N-7L), showing grain size variations and mineral composition (from 11. Watkins, 198A).

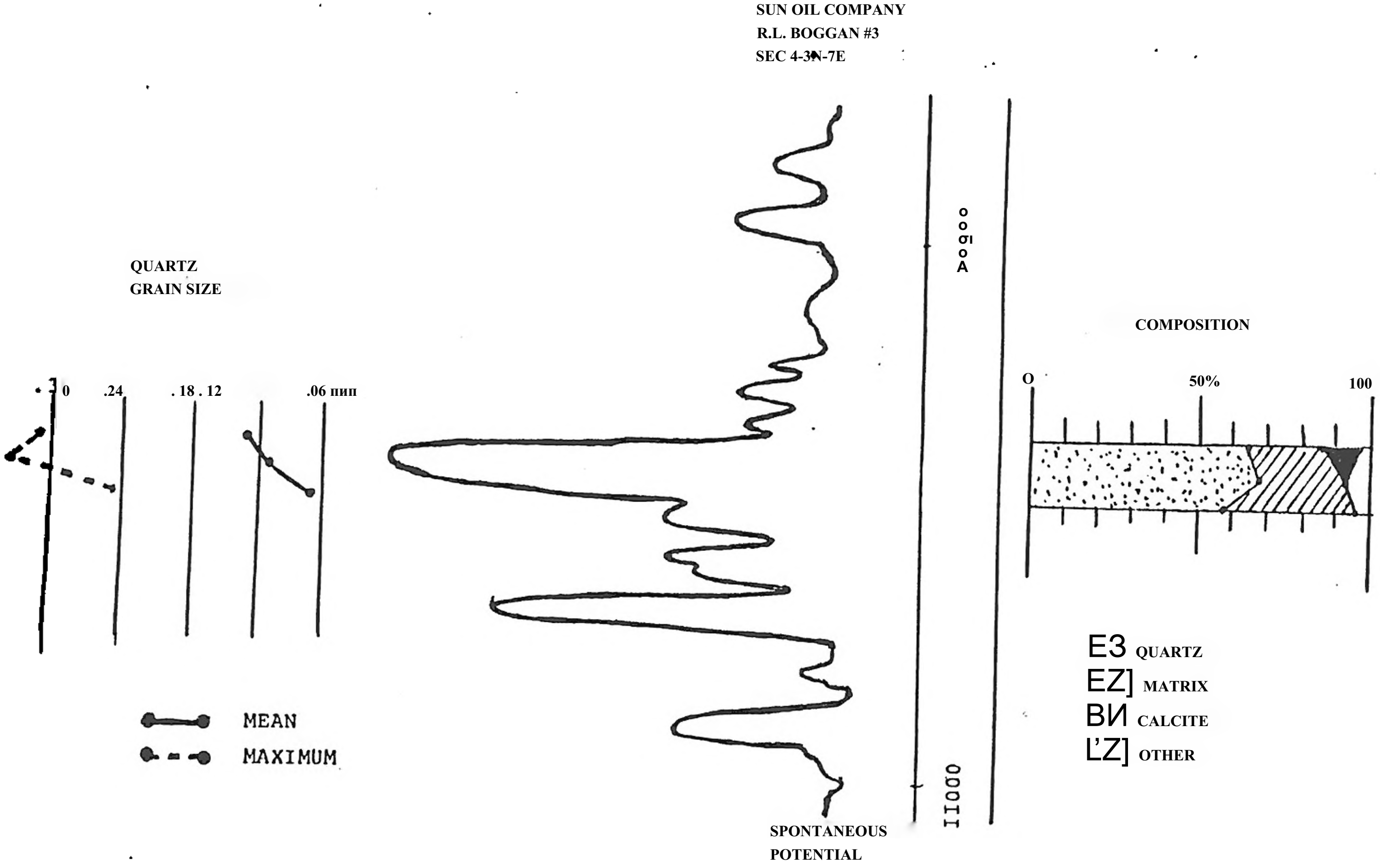


Figure 8. Characteristics of the McComb sandstone in Sun Oil Co., #3 Boggan (Sec. 4-3N-7E), showing grain size variations and mineral composition (from H. Watkins, 1984).

Company and J. W. Hughes, J. M. Crowder Unit #1 (Sec. 11-3N-7E). Samples were taken approximatly every three feet within the perforated intervals.

Three hundred point counts were made for each thin section to determine sandstone composition. Petrographic size analysis was also performed for each thin section.

Watkins' results revealed that the sandstones are quartz arenites with average composition as follows:

652	Quartz (12 Polycrystalline)
252	Matrix material
62	Carbonate cement
32	Rock fragments
<12	Detrital chert
<12	Muscovite
<12	Feldspar

The petrographic size analysis was performed according to methods used by Berg and Davies (1968). For each slide fifty quartz grains were measured along the long diameter, and the mean grain size calculated. The McComb sandstone in both wells coarsened upwards. Sandstone in the Boggan #3 well coarsens upward from a very fine grain sand to a fine grain sand and the Crowder well coarsens upward from a very fine to a medium grain sandstone.

A similar study was performed by Berg and Cook (1968) at Mallalieu field in Lincoln County, Mississippi.

They determined that the sands at Mallaleiu field fine upwards. Eisenstatt, 1960 and Bush, 1974 reported fining upwards cycles in sandstones of Little Creek field. Chasteen, 1983 reported that sandstone textures fine upwards in Smithdale field. These results are contrary to those derived from studies of the McComb field cores and indicate that at least two major depositional environments characterize the Lower Tuscaloosa Formation in this area; a lower fluvial sequence and an upper nearshore marine or marine section.

Vertical Variations in Structure and Texture

Of the fourteen McComb field logged in detail (Appendix A) ten are upward coarsening sequences, two are upward fining sequences and two cores exhibit mixed sequence of both coarsening and fining upward cycles within the cored interval (Appendix 1).

All of the Little Creek field cores, five in all, exhibit fining upwards textures with a comcomittant shift to lower energy sedimentary structures.

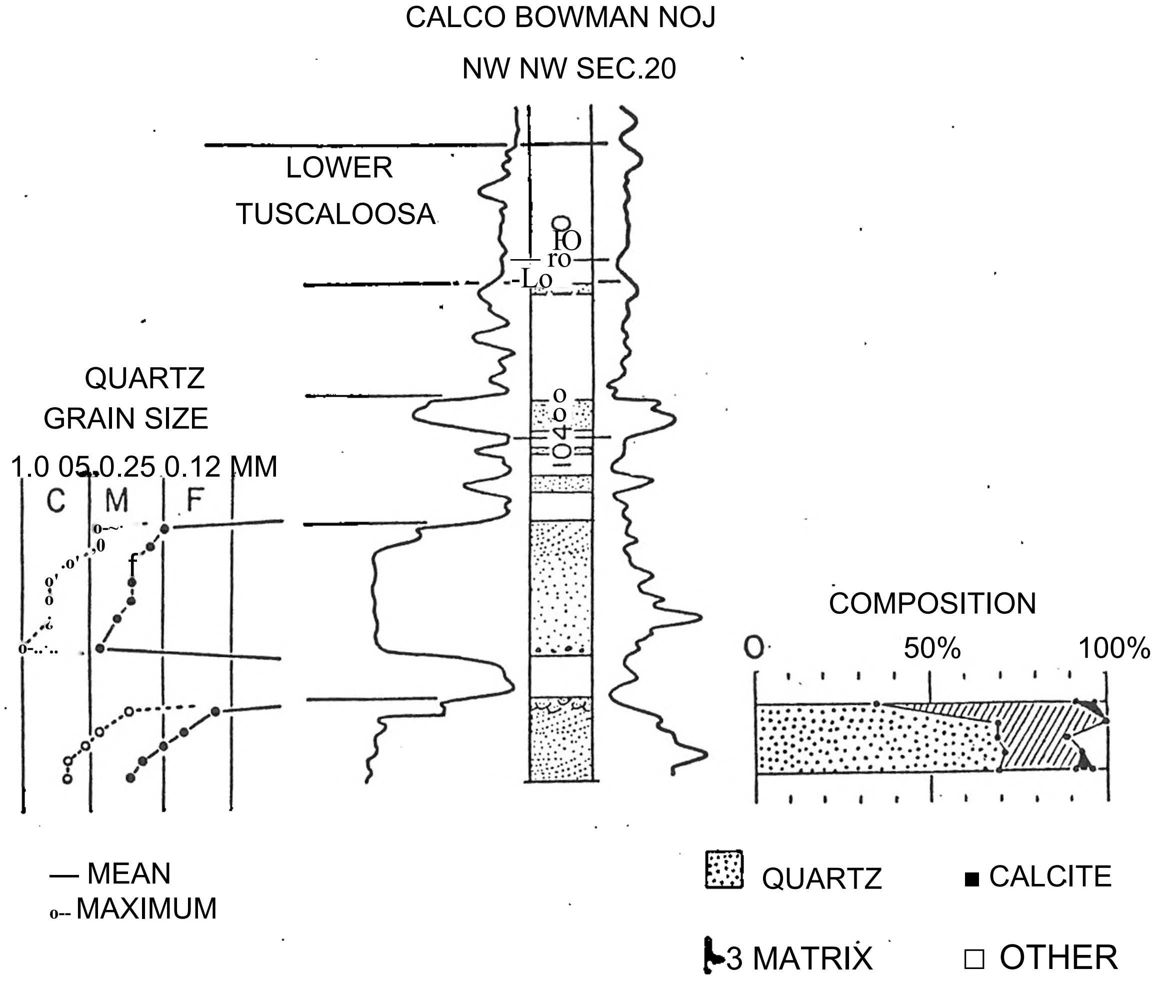


Figure 9 . Characteristics of reservoir sandstones in Mallalieu field, Lincoln County, Mississippi, (after Berg and Cook, 1968)

McComb Field Coarsening Upwards Sequences

A "typical" coarsening upward sequence can be seen in the Sun Oil Company, #1 Harvey Lenoir, in section 10-3N-7E, Pike County, Mississippi (Appendix A). This well was cored from 10,885-10,918 feet. The base of the core is composed of dark gray siderite-bearing mottled siltstone (4 feet), which grades upward into an intensely bioturbated, very fine grain sandstone (7 feet). This bioturbated zone is below the productive McComb sandstone, and generally is found throughout the field. Directly above the bioturbated zone is a gray siltstone (7 feet) which usually grades into a dark gray carbonaceous shale containing abundant plant fragments and occasional pyrite and or lignite. Some soft sediment deformation within this interval is also common. Above the shaley - silty zone is the McComb sandstone (24 feet) which is the main producing sandstone in McComb field. A sharp contact is usually found between the shaley - silty zone and the McComb sandstone. The base of the sand is generally fine to very fine grained with occasional small clay clasts. The cross-bedding throughout the sand varies from high to low angle planar. Overall coarsening upward from very fine grain to medium grain sandstone is quite evident. Calcium carbonate cement is commonly found throughout the sandstone; however, megascopic observations suggest that there may be an inverse covariance between carbonate cement and chlorite. It appears that wherever there is more clay mineral accumulation (chlorite) within the sandstone, there is less calcium carbonate cement present, and vice versa.

Permeability varies throughout the sandstone (4.82-540 millidarcies) with an average of 91 millidarcies (Davis, 1963, and Fletcher, 1967). Generally there is greater permeability within the sandstone wherever there are clay mineral accumulations. Throughout the middle and upper parts of the McComb sandstone, textures coarsen upwards. The dominant sedimentary structures are large scale, low to high angle, planar cross-beds. Sorting varies throughout, ranging from poorly sorted, usually at the base, to well sorted at the top of the sandstone. Roundness of the quartz sand grains varies from sub-angular to sub-rounded. Traces of carbonaceous organic debris are generally present throughout the sandstone.

Nine other cores from McComb field display much the same general variations in structure and texture as those described above (Appendix A).

McComb Field Fining Upwards Sequences

The Sun, #1 Sinclair, and the Sun, MFU 27-11, cores show evidence of overall fining upward sequences from medium to fine grain sandstones. Sedimentary structures generally exhibited lower energy structures grading upward, into flaser and lenticular bedding at the top of the sandstone. However, the Sun, #1 Sinclair, well was cored through only the base of the McComb sandstone; therefore, data throughout the upper parts of the sandstone are not available for study.

McComb Field Mixed Sequences

Cores from two wells in McComb field contain sequences of both coarsening and fining upward sandstones. Cores from pay zones in Sun, Johnson A-1 (Sec. 10-3N-7E), and Sun, Lampton Wallace G-1 (Sec. 22-3N-7E), exhibit intervals of flaser bedding and small scale cross-bedding. The fining upward sequence may be found directly above a coarsening upward cycle (Sun, Johnson A-1), or found directly below a coarsening upward cycle (Sun, Lampton Wallace G-1) (Appendix A).

Little Creek Fining Upward Sequences

All five cores in Little Creek display upward fining sequences (Appendix B). Throughout the Little Creek cores, sedimentary structures generally followed those described by Busch (1974) as being typical of point-bar sandstones. Four characteristic zones were generally recognized in each Little Creek field core. From the base of the sandstone upward, the zones included 1) poorly bedded sand or gravel, 2) giant-ripple cross-stratification, 3) very low angle laminated beds, and

4) small ripples. Two wells (Sun, Atkinson B-1, and Sun, #1 Busby A) contain two cycles of upward fining cycles within the cored interval.

The Sun Oil Company, #1 Mae Busby, well in section 23-4N-8E displays a typical fining upward sequence. The #2 Kenna, well in section 11-4N-8E, a dry hole, has only four feet of sand within the cored interval. The rest of the core in the #2 Kenna, well contains mostly gray and red mottled, siderite-bearing siltstone and shale. Sedimentary structures contained in the core include some small scale ripple cross-bedding, soft sediment deformation, thin laminated siltstone, and sandstone. Plant fragments, root structures, bioturbation, and mottling are also present throughout the core.

Electric Log Interpretation

Where core data were not available, electric well logs were used to provide information as to the general lithologies. Lack of nuclear logs (gamma, neutron) or sonic for lithology made it necessary to use the spontaneous potential (S.P.) curve on the electric log which yields a measure of permeability. The S.P. curve (for lithologies) must be used with extreme caution when attempting to determine lithology. The S.P. of sandstones, for example, can vary considerably with clay content and cement (Timmons, 1984). In this study, the S.P. curve was used for lithologic determination only after careful comparison with core. In general, S.P. curves usually followed grain size variations. The resistivity curves on the electric logs proved unreliable for porosity and oil indication mainly due to the chlorite build-up within the sandstone. These grain-coating clays have micropores (tiny pores between individual clay crystals). Water trapped within the micropores effectively coats the quartz grains with a thin layer of brine-saturated, very conductive clay. The increase in conductivity reduces resistivity, causing the resistivity curve to read ”wet”.

A problem with the evaluation of Lower Tuscaloosa Formation reservoir sandstones using modern gamma logs occurs when the sandstone contains small amounts of mica and/or illite clay. These constituents can raise the amount of radioactive potassium normally found in sandstone. As a result, the gamma log response may be mistakenly interpeted as a shale or "tight” sandstone instead of a porous and permeable productive sandstone (Timmons, 1984).

McComb Field Cross-Sections

Seven detailed stratigraphic cross-sections were constructed through McComb field (Fig. 6 and Plates III - IX). These cross-sections include graphic core data and interpretations of depositional environments. The cross-sections reveal the following general aspects of the McComb field.

(1) The McComb sandstone varies in thickness (0-35 feet) within the field.

(2) The top of the McComb sandstone is generally found about sixty feet below the top of the Lower Tuscaloosa Formation.

(3) The McComb sandstone and the thin sandstones above it are continuous and can be easily correlated throughout the field.

(4) Most of the sandstones below the McComb sandstone are discontinous and can not be correlated for any great distance.

(5) Oil production is generally limited by stratigraphic pinchout of the McComb sandstone to the northeast, east, and southwest.

(6) The only exception to (5) above is illustrated on section B-B' in the Cashon, #2 R. E. Schmidt, well where the sand is thin and the pronounced attenuation of the S.P. curve indicates a lack of permeability. A similar situation occurs in the Lyle Cashion well immediately adjacent to the west also a dry hole.

INTERPRETATION AND DISCUSSION OF RESULTS

Depositional Setting

Recognition of the depositional environment(s) of productive sandstones in the McComb and Little Creek field areas is based on 1) the sand body geometry, 2) the vertical variations in sedimentary structure and texture within the sand body, 3) the nature of boundaries with underlying and overlying sediments, 4) the bedding architecture, and 5) regional stratigraphic setting. The compiled results indicate that:

1) Productive sandstones of McComb field were deposited in a nearshore marine shoreline environment during a major marine transgression. Specifically, the data suggest that the producing sandstone was deposited as part of a barrier complex at a time when sand supply to the area was diminishing.

2) Productive sandstones of the Little Creek field were deposited in a well-developed, mature, high-sinuosity meander belt as concluded by Eisenstatt (1960) and Busch (1974). However, the meandering stream system responsible for the deposition of the Little Creek point bars was considerably smaller that that proposed by Busch (1974).

3. The McComb sandstone occupies a higher stratigraphic position relative to the base of the Middle

Marine Shale Formation than do producing sandstones of the Little Creek field.

The McComb Sandstone - A Barrier Island Shoreline System

Detailed core and electric log studies reveal that the main producing sandstone in the McComb field area, the McComb sandstone, was deposited as a transgressive barrier island complex along a coastline influenced by wave action and tides. Moslow (1984) lists the following characteristics of transgressive coastline barriers of this type:

a. Barrier complexes often assume arcuate, stunted ”drumstick” shapes as shown in Figure 10.

b. An individual barrier complex can extend for several miles and is often cut by tidal inlets and channels. Sand supply and the duration and strength of shoreline currents determine the size of barrier complexes.

c. Transgressive barriers will migrate in a landward (updip) direction as a result of sea level rise.

d. Barrier complexes display both upward coarsening textures and upward fining textures.

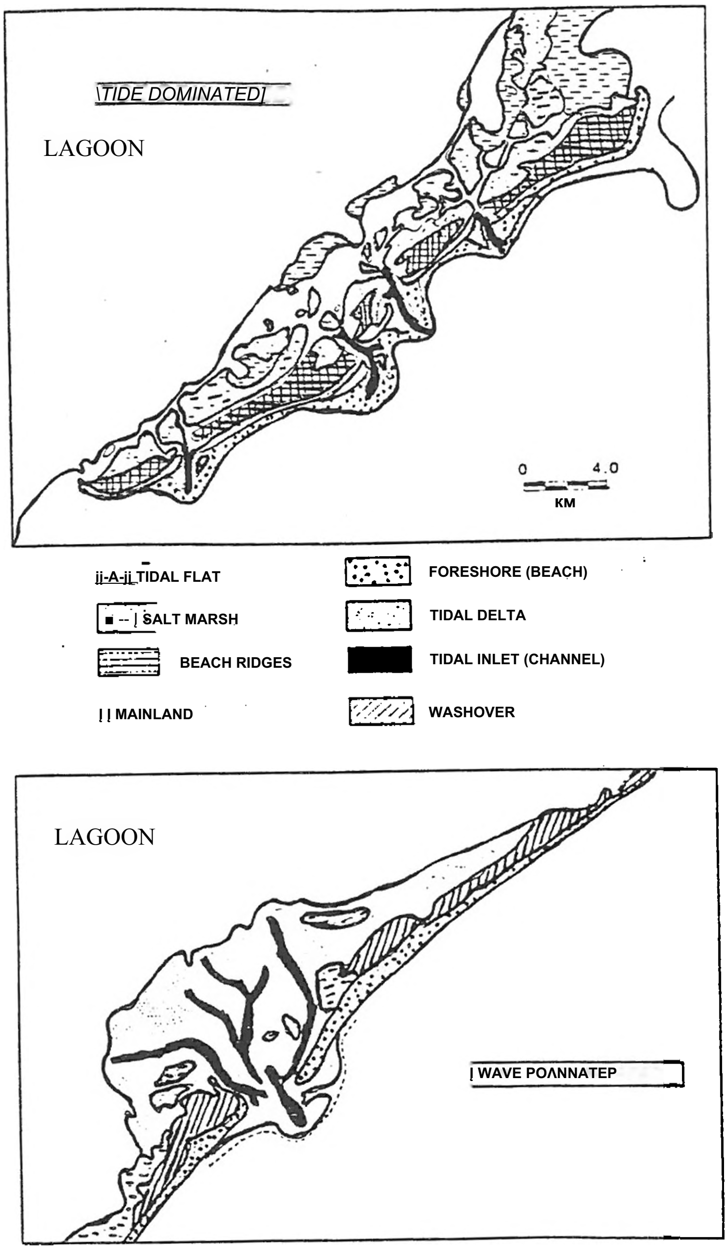


Figure 10« Geometry and distribution of depositional facies associated with barrier islands (from Moslow,1984A Heron et al./1984/ and Moslow and Tye, 1984)

The deposition of a transgressive barrier complex takes place when a relative rise in sea level exceeds sediment supply and barrier aggradation can no longer take place. The barrier complex migrates in a landward direction by storm washover and tidal flooding into shallow and restricted waters of the lagoon (Kraft and John, 1979; Penland and Suter, 1983; Heron and others, 1984). During the transgression, the shoreface is the zone of erosion and may not be preserved as well as other parts of the barrier complex. As recently documented by Galloway and Cheng (1985), thin and volumetrically small back-barrier facies and multiple inlet fills make up the bulk of the preserved sand body. Preserved barrier complex sediments may thus be topped by fining upward textural trends that reflect the marine incursion and deeper water environments. The result is a transgressed barrier complex surrounded by lagoonal and marine muds (Fig. 11).

Recognition Criteria of Transgressive Barriers

Transgressive barriers are generally erosional in nature and are referred to as retrograding or landward migrating. Vertical sedimentary sequences of the shoreline and barrier core tend to coarsen upward and are comprised of interbedded sands and muds (Table 3). Grain size can vary from fine to coarse sand and abrupt facies contacts within the sand body are frequent (Moslow, 1984).

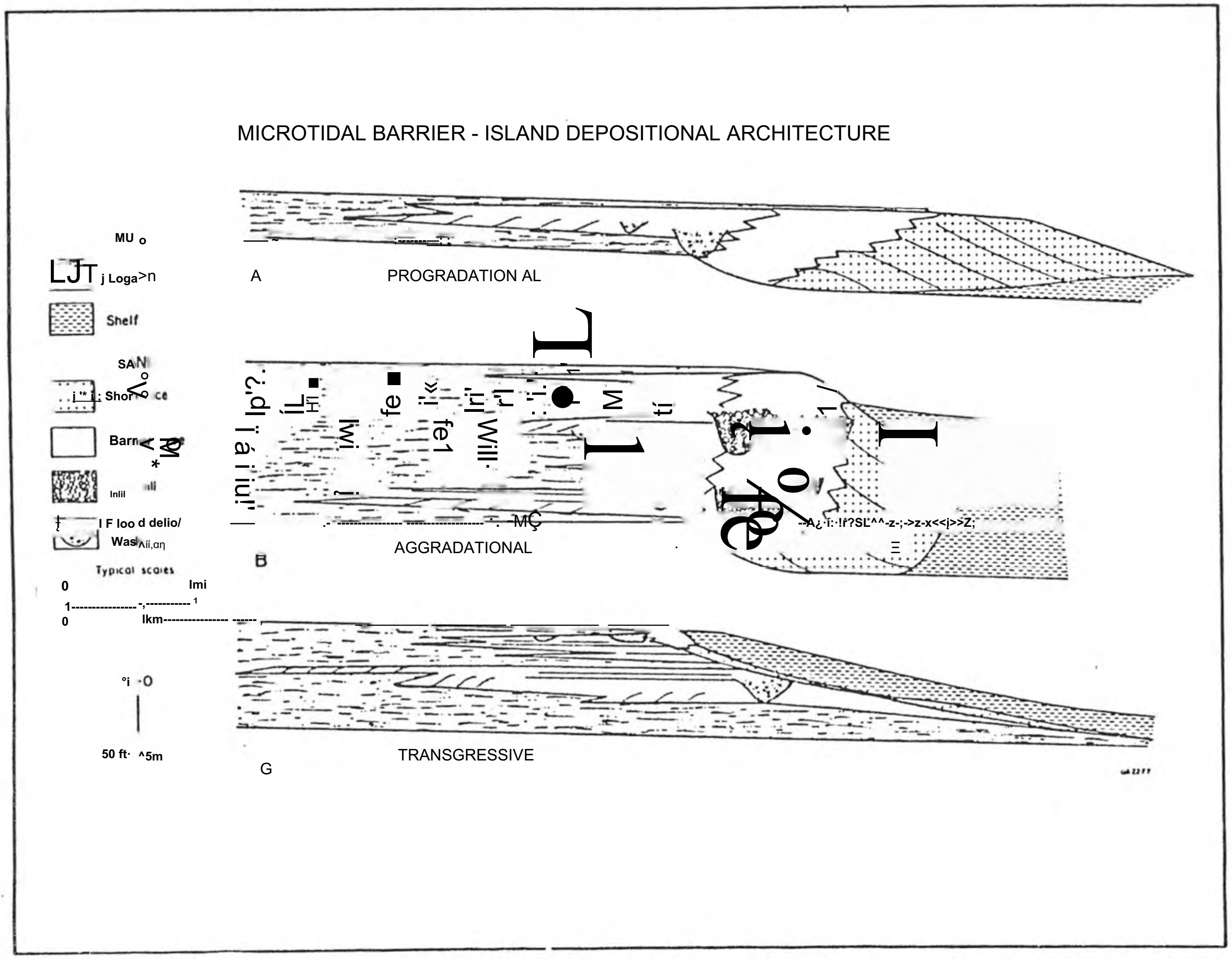


Figure 11. Stratigraphy of A. Progradational, B. Aggradational, and C. Transgressive barrier sand complex in a microtidal barrier system (from Galloway and Cheng 1985).

TABLE 3. TRANSGRESSIVE BARRIER CHARACTERISTICS

Deposit ional Environment	Lithology	Sedimentary Structures	Large Scale Features
Overwash and Foreshore	Clean, mod. sorted fine to med. sand	Horizontal and planar laminations	Caps inlet and barrier sequences
Shoreface	Well sorted, fine to med. sand and silt	Cross-bedded (upper half) and burrowed (lower half) sequence	Coarsening upward sequence; increase in mud content towards base.
Backbarrier (lagoon, tidal flat, salt marsh)	Well sorted, fine to med, silty sand and sandy clay	Burrowed ; thin parallel clay laminations	Capped by salt marsh; increasing mud and organic content upwards
Flood-Tidal Delta	Mod. sorted, med. to coarse silty sand	Gently dipping cross-laminae; burrowed	Interbedded with backbarrier facies; cyclic fining upward sequences

(Modified fron Moslow, 1984)

Sedimentary structures recognized in the McComb sandstone strongly resemble those described by Moslow (1984) and Galloway and Cheng (1985) as characteristic of a transgressive barrier complex. These structures include large-scale low-angle planar laminations and cross-bedded, burrowed sequences typical of foreshore and shoreface environments as well as thinly laminated, flasered, and burrowed sequences representative of lagoonal and tidal flat sequences.

According to Moslow, transgressive sands are relatively thin and lenticular in strike and dip sections. This type of geometry is classically referred to as ”sheet like". The sands pinch out updip and thicken in a downdip (seaward) direction. McComb field cross sections D-D’ and G-G' (Plates VI and IX) show the same general architecture, resembling that described by Galloway and Cheng (1985). Isopachs of the McComb sandstone (Plate II) exhibit a thickening of the sandstone to the west. This pattern of sandstone thickening is consistent with regional structural maps in the McComb field area which indicate that seaward directions during deposition of the Lower Tuscaloosa Formation probably lay to the west and southwest.

Transgressive barriers do not form an easily recognizable thick vertical sequence of sediments. Although generally they exhibit overall coarsening upward textures, trangressive barriers are complex mosaics of depositional sub-facies, including barrier-core, inlet fill, flood-tidal delta, washover fan, barrier-flat, and shoreface facies (Galloway, 1985; Fig. 12). Since they are landward migrating, sandstones of trangressive barriers commonly overlie lagoonal, marsh, and/or tidal flat deposits comprised mostly of silts and muds (Fig. 13). Intense bioturbation, especially burrows, is often a feature of fine-grained and sandy tidal flat and lagoonal sediments.

The core study revealed that strongly bioturbated, and flasered, silty and sandy mudstones (interpreted as tidal flat and lagoonal facies) occur throughout the McComb field immediately below the base of the productive sandstone (Appendix A).

Even though transgressive barriers are typically coarsening upward sequences, recognition of ancient barriers is difficult based on observation of this sequence alone (i.e., in a single core). Often, recognition of a transgressed barrier complex depends of the identification of directly associated fining upward cycles. Most transgressed barrier complexes will include washover fan, tidal inlet channel, and/or flood-tidal delta deposits which exhibit overall fining upward textures characterized by variations over short distances (Geehan, Grimes, and Swanson 1983; Hayes, 1967; Andrews, 1970; Balsley, 1980;

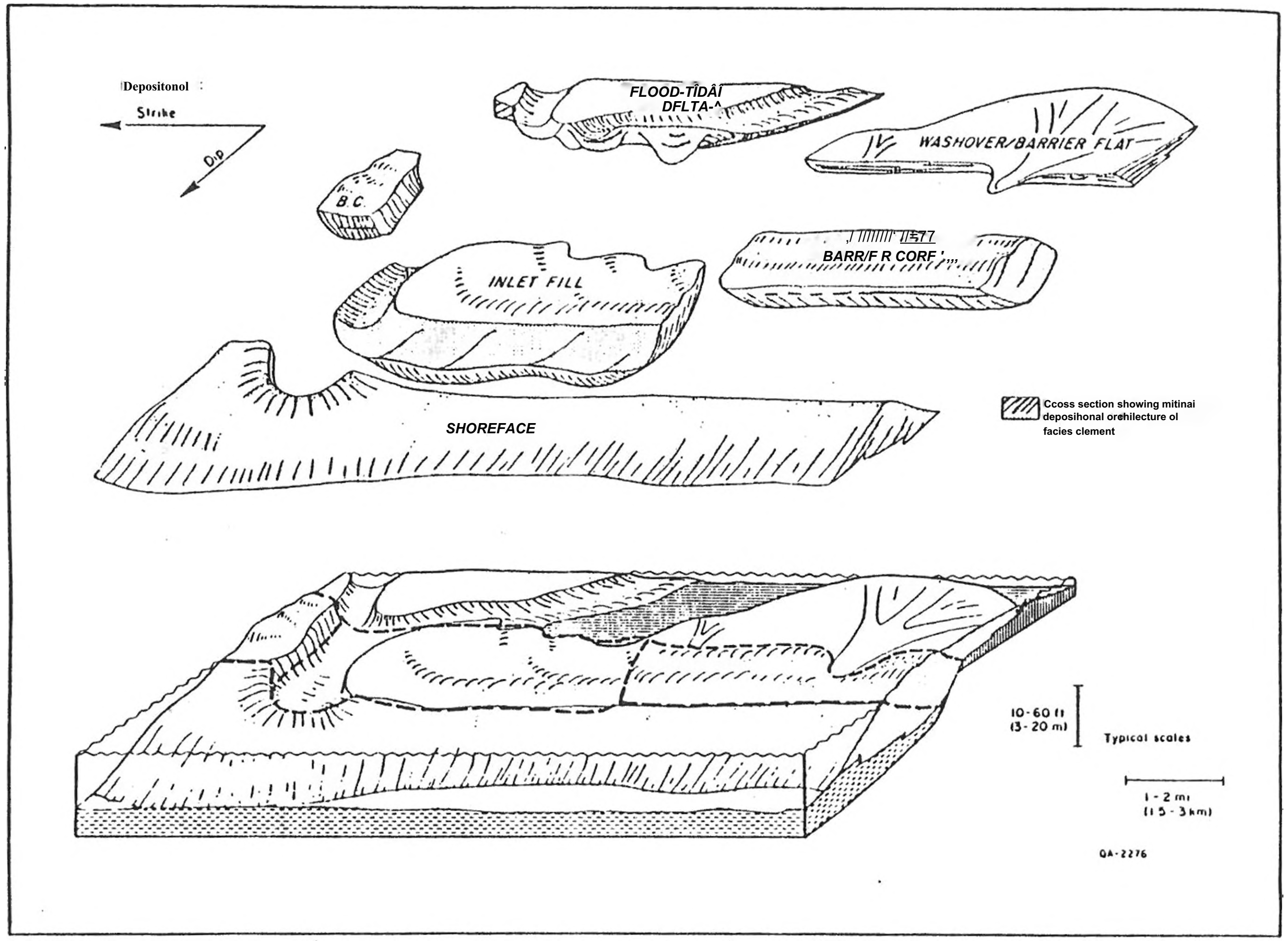


Figure 12. Barrier island sand body components in a microtidal barrier system (from Galloway and Cheng, 1985).

TRANSGRESSIVE BARRIERS

EROSIONAL (RETROGRADING))
WASHOVER MORPHOLOGY
COARSENING-UP SEQUENCE

INTERBEDDED SAND
ψ MUD
F-C GRAINED
ABRUPT CONTACTS

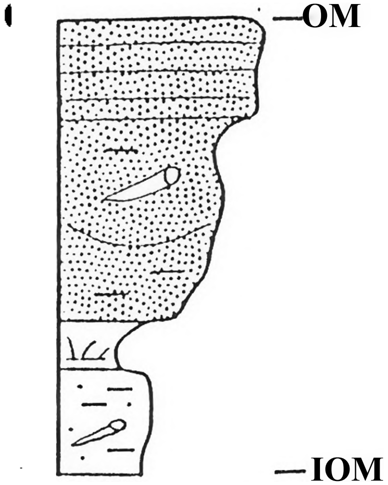


Figure 13. Geologic features of a coarsening upward sequence of a modern transgressive barrier island complex (from Moslow, 1984).

Hobday et al», 1980; Hayes and Kana, 1976; Moslow, 1984; and McCubin, 1982).

Channel sands and tidal deltas associated with inlets are common depositional sub-facies of the barrier environment. Processes associated with these features rework tidal flat and barrier sands (Moslow, 1984). Tidal inlets tend to migrate laterally along a shoreline, reworking barrier island sediments, which are re-deposited as sequences of fining upward inlet-fill. Tidal channel and/or inlet sequences in the McComb sandstone were identified in as many as three wells (Sun, MFU #27-11; Sun, Johnson A—1 ; and Sun, Lampton Wallace G-1). These tidal inlet sequences generally are bounded above and below by bioturbated fine-grained facies.

Recent studies have shown that as much as 50^ of the sediment associated with modern Holocene barrier shorelines is deposited as inlet deposits (Moslow, 1984).

Preservation Potential

Preservation of transgressive barrier island sequences depends on adequate rate of sand accumulation and on subsidence capable of progressively burying the deposits. The preserved sediments may be capped by fining upward cycles that reflect transgression and increasingly deeper water environments. The result is a transgressed barrier complex isolated between lagoonal muds in the landward direction and marine shelf muds in the seaward direction (Galloway and Cheng, 1985).

Ancient Examples

Reservoir facies thought to typify transgressive barrier complexes include the Upper Cretaceous Bell Creek field in Montana (Berg and Davies, 1968; McGregor and Biggs, 1968; Horne and Ferm, 1976). The Muddy Sandstone reservoir in Bell Creek field consists of a barrier island sequence with washover fan deposits pinching out updip into fine-grained lagoonal sediments.

The Glasscock reservoir of the West Ranch field of the Greta barrier strandplain play produces oil from the middle coastal plain of Texas (Galloway and Cheng, 1985). These transgressive barrier deposits consist mainly of large washover fan and associated barrier-flat sands. The Book Cliffs in Utah have also been reported to be at least, in part, transgressed barrier complexes (Balsley, 1980).

It is of interest to note that the geometry and thickness of the McComb field sandstone are similar in most respects to the producing sandstones in Bell Creek field, Montana, and Glasscock field reservoir sandstone in Texas.

Alternate Interpretations of the McComb Field Sandstone

The coarsening upward cycles of the McComb sandstone body resemble the textural pattern characteristic af distributary mouth bars, particularly those which have been reworked by shoreline processes. The fining upward cycles could be distributary channel deposits; however, these deposits normally thicken updip. Furthermore, there is no evidence of a major distributary system to the north or east (the assumed landward direction) and fluvial cycles have not been detected in this stratigraphic position in the McComb field area. Fluvial sand deposits do, however, occur lower in the section (e.g., Little Creek Denkman sandstone).

The McComb sandstone is arcuate convexly to the northwest-southeast which is the opposite of what one would expect to find if the sandstone had been deposited as a distributary mouth bar. This arcuate pattern to the northwest-southeast is more easily explained by washover barrier flat facies pinching out updip into lagoonal sediments. The presence of what appears to be tidal inlet channels in the McComb sandstone suggests that if it was a distributary mouth bar it was reworked by tidal currents.

Little Creek Depositional System

The producing sandstone in Little Creek field Denkman sandstone differs from that in McComb field with respect to depositional environment and stratigraphic position. The Denkman sandstone occupies a lower \ stratigraphic position in the ”stringer sand” sectuoVi than the McComb sandstone. The McComb sandstone (Fig. 5) is approximately 50-60 feet below the base of the Middle Marine Shale Formation, a unit clearly of marine origin on the basis of glauconite occurrence and fossil evidence. The Denkman sandstone is 70-80 feet below the Middle Marine Tuscaloosa Formation.

Eisenstatt (1960) and Busch (1974) reported that sandstones of the Little Creek field are the product of meander belt deposition. Their conclusion is based on the Denkman sandstone isopach map produced by Eisenstatt (1960) which illustrates the concentric and ovoid pattern of irregular shape and thickness often observed in point bar deposits. The core analysis of the present study is in accord with their conclusion regarding the depositional environment of the reservoir sandstones. Sandstone textures and structures typical of multi-story point bar cycles are clearly evident in the Sun Oil Co., #1 Busby A (See. 23-4N-8E) and Sun Oil Co., Atkinson B-1 (Sec. 2-4N-8E). The Little Creek reservoir sandstones are up to 66 feet thick and composed of at least two full or partial point bar cycles, the thickest of a single point bar being on the order of 30 feet.

The thickness of a full point bar, as measured in cores or on outcrops, is a good approximation of the depth of the channel (Leopold, Wolman and Miller, 1964). Empirical measurements of more than 50 modern meandering streams have established that there is a close relationship between stream depth, stream width, size (mean annual and bankfull discharge), and meander length (Lorenz and others, 1985; Carlson, 1965; and Cameron, 1985). Isopachs of point bar sandstones frequently have concentric and ovoid patterns and are often tightly spaced adjacent to channel fills and flood plain deposits, a pattern reproduced in the isopach maps of Eisenstatt (1960) and Busch (1974).

In general, high-sinuosity meandering streams (i. e., those with sinuosities in excess of 1.7) have the following characteristics:

1. Stream depth at bankfull discharge approximates that of the full point bar thickness.
2. Depth at average annual discharge is approximately one-third that at bankfull discharge.
3. Bankfull widths of asymmetric meandering stream channels usually vary between 1.3 and 1.6 times the width at mean annual discharge, values which give 2 to 4 degrees as the most likely depositional slopes of the point bar surface.

Size estimates for the streams which deposited the Little Creek point bars were made by using the core logs (for point bar thickness) and graphs published by the authors cited above. Two variables of point bar thickness were used to estimate the size of the Little Creek river system. The Little Creek ”A” river system parameters were calculated using a point bar thickness of 30 feet, and the

Little Creek "B" river system parameters were calculated using a 35 foot point bar. These estimates are presented in Table 4 which also provides hydraulic parameters and point bar sizes for some modern meandering streams. By comparison then, the stream which deposited the Little Creek point bars was in the same size range as the modern lower Brazos river (at Richmond, Texas).

Exploration and Production Guidelines

Moslow (1984) cites three features of transgressed barrier complexes which make them attractive exploration targets. The same features apply to the McComb field reservoir sandstone.

1. They are typically composed of clean, well-sorted, parallel-laminated sand with good primary porosity.
2. Locally, they are associated with organic-rich, fine grained lagoonal sediments, and they change facies downdip to basinal shales; both may provide excellent source rocks (Fig. 11).
3. Because they ”pinch out” up-dip into fine-grained lagoonal sediments they provide excellent stratigraphic traps.

Future exploration for barrier reservoir facies in the ”updip” Lower Tuscaloosa trend should concentrate on distinguishing between sandstones having characteristic upward coarsening sequences and which pinch out in a paleo-landward direction into lagoonal shales from fluvial

TABLE 4. RIVER TABLE

River-Location	Mean Annual Discharge cu. ft./sec.	Mean Annual Width feet	Point Bar Thickness feet
Mississippi at Natchez	540,000	2,900	130
Niger-Lower Delta	29,700	750	50
Brazos-Richmond, TX	15,700	560	33
Laramie-Wyoming	400	100	8
Little Creek A	12,000	500	30
Little Creek B	19,000	600	35

(modified after Cameron, 1985, Leopold et al., 1964 and Carlson, 1965) channel cycles which exhibit upward fining textures and which are commonly hosted in root-mottled floodplain deposits.

In the McComb field area, fluvial cycles occur stratigraphically lower in the "stringer sand" member of the Lower Tuscaloosa Formation than the barrier facies which is closer to the base of the Middle Marine Shale Formation. The barrier facies marks the shore-zone phase of the Upper Cretaceous marine transgression in the McComb field area.

Cuttings may indicate a rapid succesion of interbedded sandstone and carbonaceous shale. Cores through barrier complexes should display features similar to those described in Table 3. Care should be exercised in interpreting fining and coarsening cycles due to the effects of permeability changes throughout the sandstones. Where fining upward cycles occur in a barrier complex, the sandstones would generally be bounded above and below by bioturbated tidal flat sediments. Sandstone isopachs in a transgressive barrier island complex may reveal a shore-parallel trend of sand "thicks" with lobate sands consisting of washover fans or flood deltas.

Suggestions for Further Study

This study documents the different depositional systems and subfacies in the McComb field area which may have a profound influence on diagenetic paths and creation of secondary porosity in sandstones. A companion study is needed to document the details of the McComb and Little Creek reservoir petrology and diagenesis. The study should attempt to determine what causes local loss of production within the McComb field. The study should also attempt to verify the apparent inverse covariance between carbonate cement and chlorite within Lower Tuscaloosa Formation reservoir sandstones. Listed below are the suggested objectives of the recommended research:

1. To characterize the sandstones petrologically in order to gain a full appreciation of their compositional and textural variations, provenance implications, diagenetic alteration, distribution of secondary porosity, and any post-secondary porosity alterations which may have affected the reservoir quality of the rocks.

2. To determine aspects of diagenesis most closely linked to textural and sedimentological characteristics of specific depositional environments highlighted by the core study.

3. To ascertain if specific depositional facies or sub-facies have more favorable development of secondary porosity and hence, better reservoir quality. Can a reservoir "Continuity Index" be generated by the combined study of depositional environments and diagenetic aspects?

4« To estimate the response of these reserviors to secondary and tertiary recovery methods and enhance predictive modelling in such exercises.

Part II. PETROLOGY AND DIAGENESIS

Petrography-

Sixty standard thin sections were prepared from samples of 18 cores, 13 from McComb and 5 from Little Creek. These samples were point counted to determine compositional and textural variations in the sandstones. 300 point counts were completed for each slide the results of which are listed in Appendix C.

Rock fragments were counted and classified under three headings, metamorphic, sedimentary, and volcanic. Due to the advanced degree of alteration of these fragments this effort was not altogether fruitful and the degree to which these results exhibit the original composition of the rock can not be positively determined.

Monocrystalline quartz comprises approximately 95% of the frame work grain composition. Although a small amount of polycrystalline quartz is present both monocrystalline and polycrystalline grains were counted under one heading. The extreme alteration of feldspars again made the task of counting difficult therefore only "feldspar" was noted for these grains. The heading "matrix" includes opaques, dead oil, and all of the clay minerals including chlorite but excluding Vermicular-kaolinite. Vermicular-kaolinite is listed under the heading kaolinite and indicates that form of well crystallized kaolinite which occurs in the sandstone pores as authigenic books. Microcrystalline chert, grouped under its own heading, occurs as detrital grains. Pore space was filled by a blue dyed impregnation media during thinsection preparation and therefore the appearance of a clear blue space in the thin section indicates porosity.

The results of the point count data were tabulated on a microcomputer spreadsheet program from which percentages and totals were calculated.

Sandstones

General Description

The sandstones of the McComb and Little Creek fields sampled by the authors are classified as quartz arenites (Folk,1980) [figures 14,15].

Quartz is the most common grain in these samples and of the two types presented, monocrystalline and polycrystalline, monocrystalline is by far the most common.

Due to the varying degrees of rock fragment alteration the determination of the specific types of rock fragments is largely controlled by the ability to recognize grain shape and crystalline characteristics. Those materials that were too altered to be specifically identified were counted as matrix. Chlorite is commonly present as grain rims and pore-lining clay.

Shales and Siltstones

Silts and shales generally tend to be laminated and consist almost totally of matrix material and quartz. The matrix consist mostly of clays, siderite, calcite, pyrite, hematite, biotite, muscovite, organic debris, and dead oil. The quartz in these

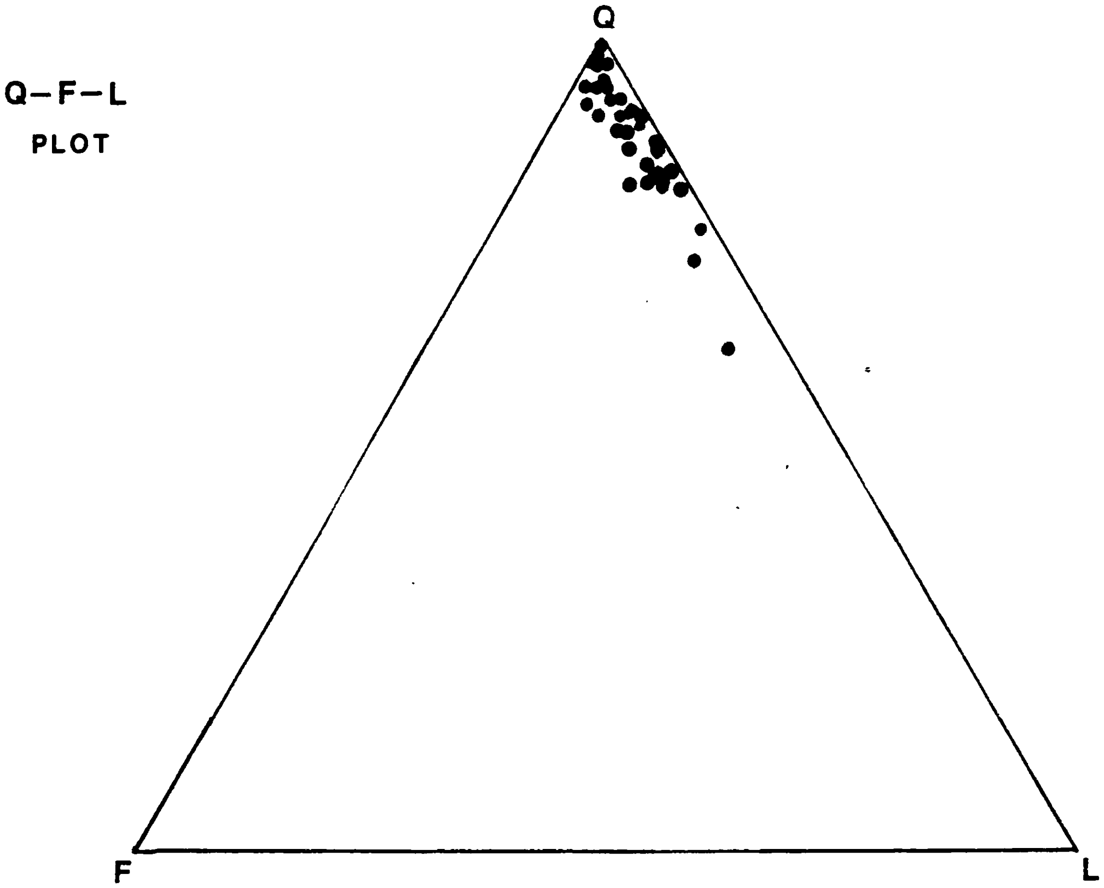


Figure 14. Quartz - feldspar - lithic fragment variation in sandstone reservoir rock, McComb Field.

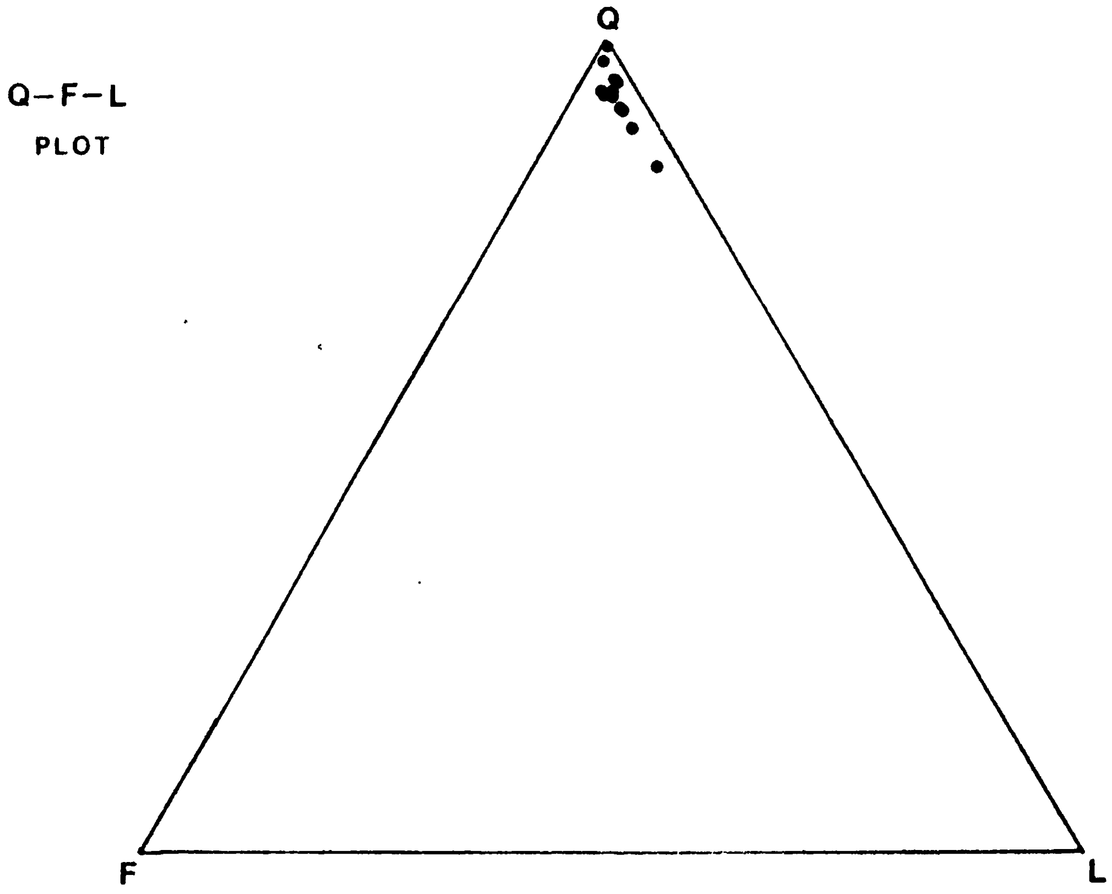


Figure 15. Quartz - feldspar - lithic fragment variation in sandstone reservoir rock Li ttle Creek field.

samples is always monocrystalline.

Texture

The samples could not be adequately disaggregated to perform sieve analysis. Instead, a size analysis was performed on the sandstones petrographically by measuring the intermediate diameter of several of the dominant mineral clast. Information on the average size of individual grains is given in Appendix [C] .

In both McComb and Little Creek samples the sandstone grains are coated with authigenic chlorite clay. In areas where the chlorite does not occur the grains are severely embayed and corroded. Some grains are almost completely dissolved. It is difficult to determine the original grain shape in many instances. Where the clay (chlorite) coating on a grain is well developed it is reasonable to assume that the grain was isolated from other diagenetic changes which affected the sediment and the original grain shape was probably preserved. In most cases where chlorite rims a dissolved grain the shape is moderately to well rounded. Where grains are unprotected by chlorite grain shapes are very angular.

The relationship of grains to matrix and cement was determined petrographically and is represented in the ternary diagram ill strated in figures [16,17]. These relationships show that in general there is very little carbonate cement remaining in the rocks sampled. However, the detailed core logs [Appendix A] show that in many places cementation of the sandstones is

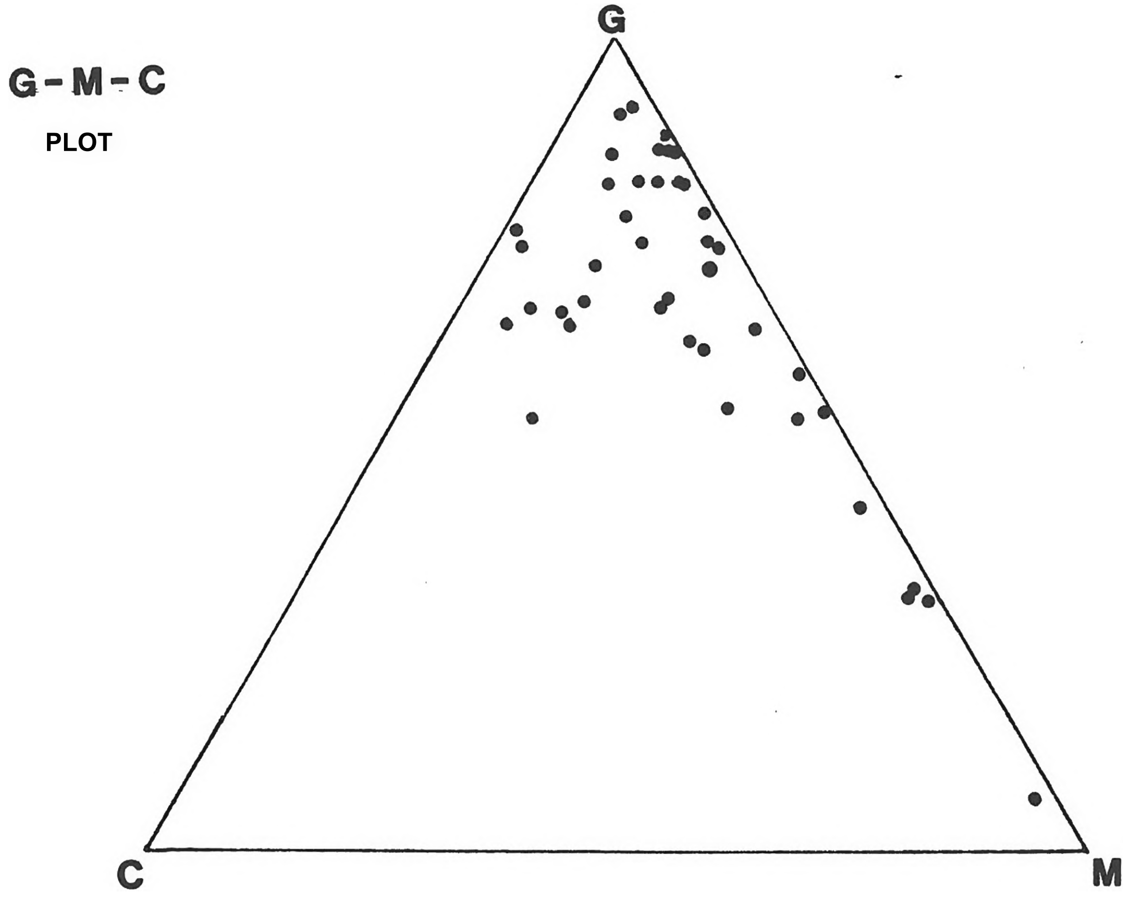


Figure 16. Grain - Matrix - Cement relationships in sandstone reservoir rock, McComb field.

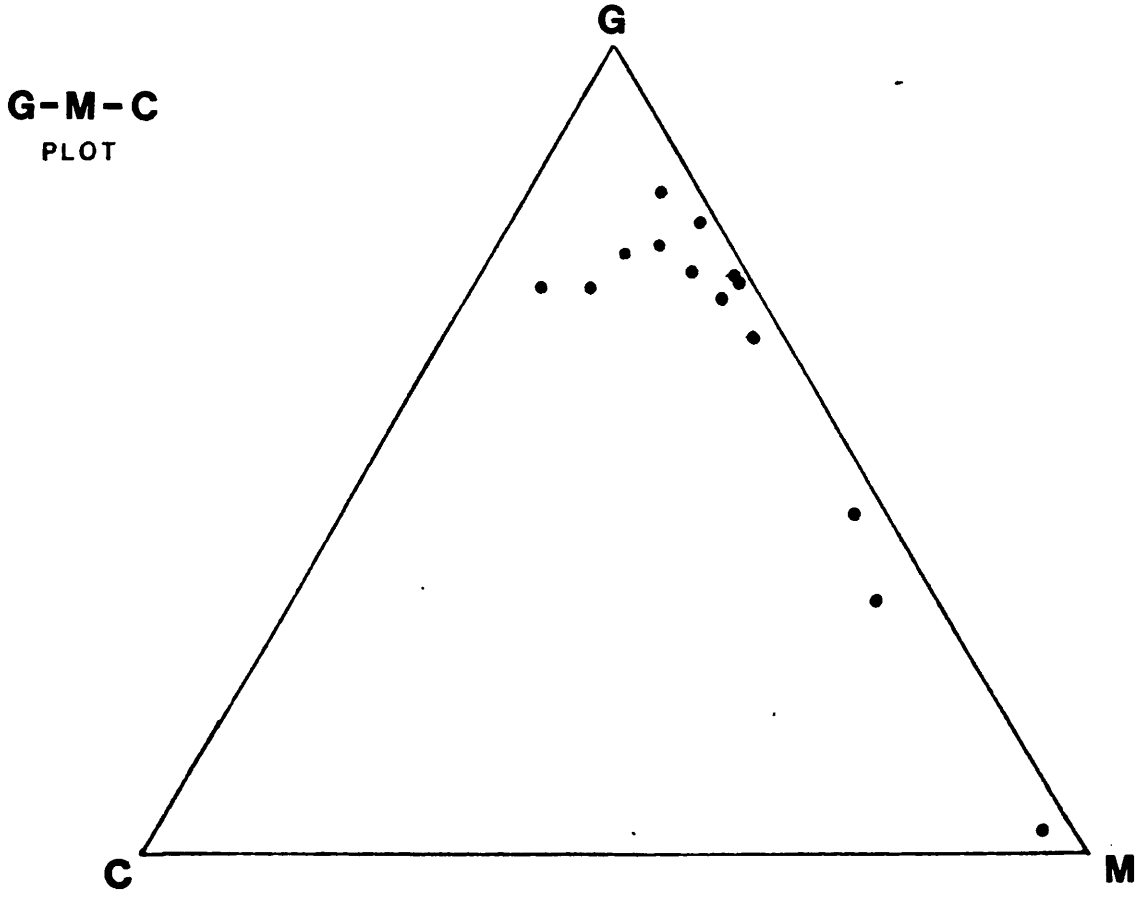


Figure 17. Grain - matrix - cement relationships in sandstone reservoir rock, Little Creek field.

pervasive and laminar zones of well-cemented sandstone alternate with relatively uncemented zones on a regular and frequent basis.

Sedimentary structures include horizontal and gently inclined planar laminations, and occasional burrows in the fine - medium grained sandstone. The uncemented zones in the sandstones are commonly friable.

Clay Mineralogy

Off cuts of core samples taken for petrographic slide preparation were used for clay mineral analysis. These samples were ground to a powdered in a ball mill for 10 minutes and sieved through a(#230) 0.0025 inch sieve. Approximately 10 cc. of the powered sample was placed in a 75 cc. beaker containing a solution of 15 gm. calgon (hexa-metaphosphate) to 1 gal. of water. The mixture, after being well homogenized, was allowed to stand for at least 24 hours. Oriented clay slides were prepared by withdrawing a sample of solution containing the 9.0 *phi* and finer size fraction and allowing it to dry on a glass slide. Pipette withdrawal times were calculated from Stokes' law and are listed in (Carver,1971).

Selected oriented clay slides from both McComb and Little Creek were heated for 1 hour at 600 degrees Centigrade converting kaolinite into metakaolinite and therefore eliminating the 7A peak and causing an increased intensity of the 14A Chlorite reflection

X-ray clay mineral identification was accomplished using a General Electric Co. X-ray Defractometer 700D. Best machine settings for 2 *Theta* angles from 2 degrees to 30 degrees were determined using American Petroleum Institute Clay Mineral Standards samples of Kaolinite and Illite. These settings are 50 KVP, 19 ma, 2.5 seconds time constant, a range setting of 100, 4 amplitude gain, 0.4 degree defining beam slit, 0.02 detector slit, and 2 degree/min. scanning speed.

Results of x-ray diffraction showed that the clay composition of the McComb sands consist of 7A, 10A, and 14A clay minerals. This data has been interpreted as representing Kaolinite/Chlorite, Illite, and chlorite, respectively. Sandstones of the Little Creek field showed a sharp reduction of 10A minerals or illite, a more well ordered 14A mineral (Chlorite) and kaolinite.

Shales from both fields are characterized by large amounts of mixed layer clays ranging from 22A - 32A, and shifting to as much as 80A when exposed to ethylene glycol for a period of 24 hours. Also present in the shales are kaolinite, Illite, and chlorite.

Diagenesis

Introduction

The diagenesis of the McComb and Little Creek sandstone reservoirs affected the whole body of the sandstone resulting in greatly enhanced porosity by the dissolution of detrital grains and cements. Evidences of secondary porosity include the presence of partially dissolved feldspars, rock fragments, and quartz; oversized pores; relic clay rims that outline totally dissolved grains; a patchy distribution of carbonate cement; and broken chert grains in carbonate-free zones.

Franks (1980) performed a petrographic analysis of the lower Tuscaloosa interpreting a diagenetic sequence as follows:

1) Precipitation of authigenic smectite clay rims at shallow depths (converted to chlorite during burial).

2) Cementation of some sandstones by ferroan calcite which post-dates clay rims and replaces many framework grains.

3) Progressive silica cementation by quartz overgrowths in sandstones not cemented earlier by ferroan calcite (stage 2). sandstones with more than 10-15% volcanic clasts generally do not develop quartz overgrowths.

Watkins (1985) added a fourth diagenetic process which is contemporaneous with Frank's sequence: rock fragment alteration.

Mechanical Compaction of Sediments

Diagenetic processes are largely the result of compaction and of the interaction of pore fluids with detrital constituents and cements (Schmidt 1980). Mechanical compaction of the sandstones is indicated by the appearance of deformed ductile grains (detrital mica minerals) and broken chert grains (figures 18,19). This type of compaction is indicative of the first stage in diagenesis and indicates a reduction of primary rock volume as well as initial diminishment of primary porosity and permeability.

Quartz Overgrowths

The occurrence of quartz overgrowths represents a period of chemical compaction and is accomplished by the dissolution of sand grains at points and interfaces of contact (Schmidt 1983). Due to the relatively few quartz grains that exhibit substantial quartz overgrowths it is possible that a large volume of dissolved silica was removed from the sandstone bed. This process could reduce rock volume and the percentage of intergranular primary porosity.

Carbonate Cement

Carbonatization began shortly after the beginning quartz dissolution. Calcite filled the remaining intergranular porosity and replaced quartz cement and part of the margins of quartz grains. The completion of the carbonatization process halted chemical compaction and no further changes took place until the onset of decarbonatization [figures 20,21].

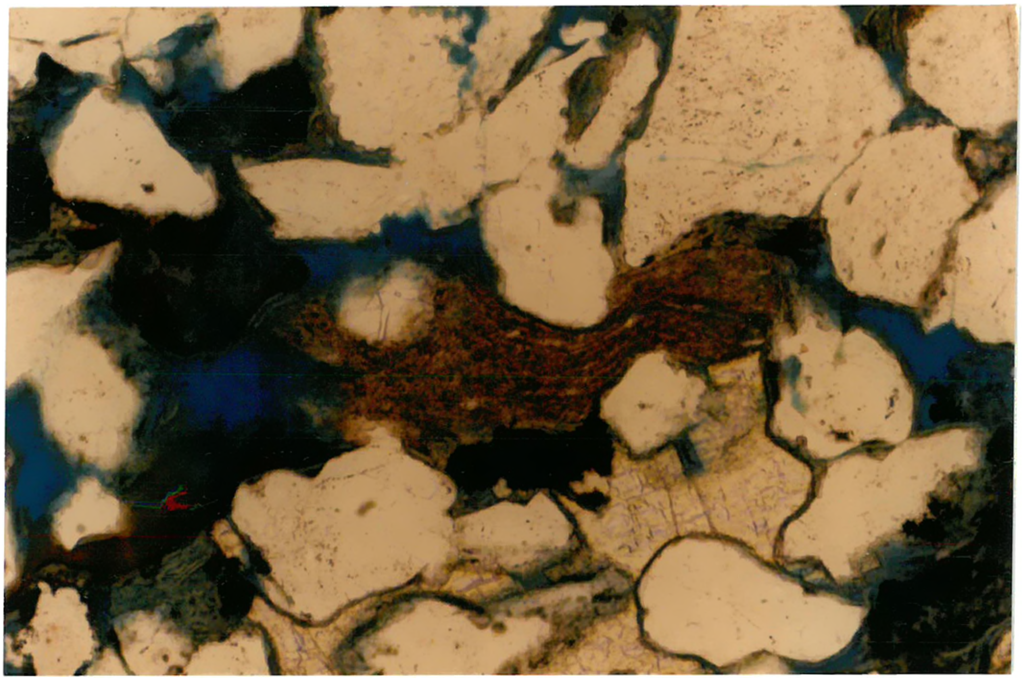


Figure 18. Photomicrograph of reservoir sandstone from the No. 1 F. Z. Mills well (10,957 feet) illustrating mechanical compaction of the sandstone as indicated by the appearance of deformed ductile grains (mica minerals) and broken chert grains.

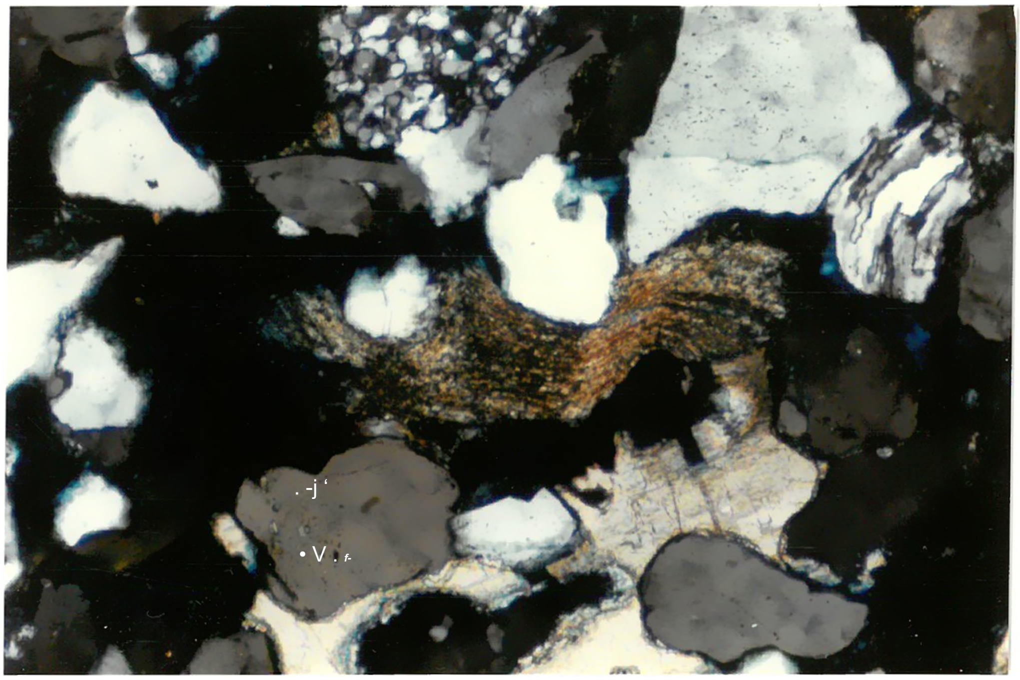


Figure 19. The photomicrograph illustrated in Figure 18 is shown here under crossed niçois.

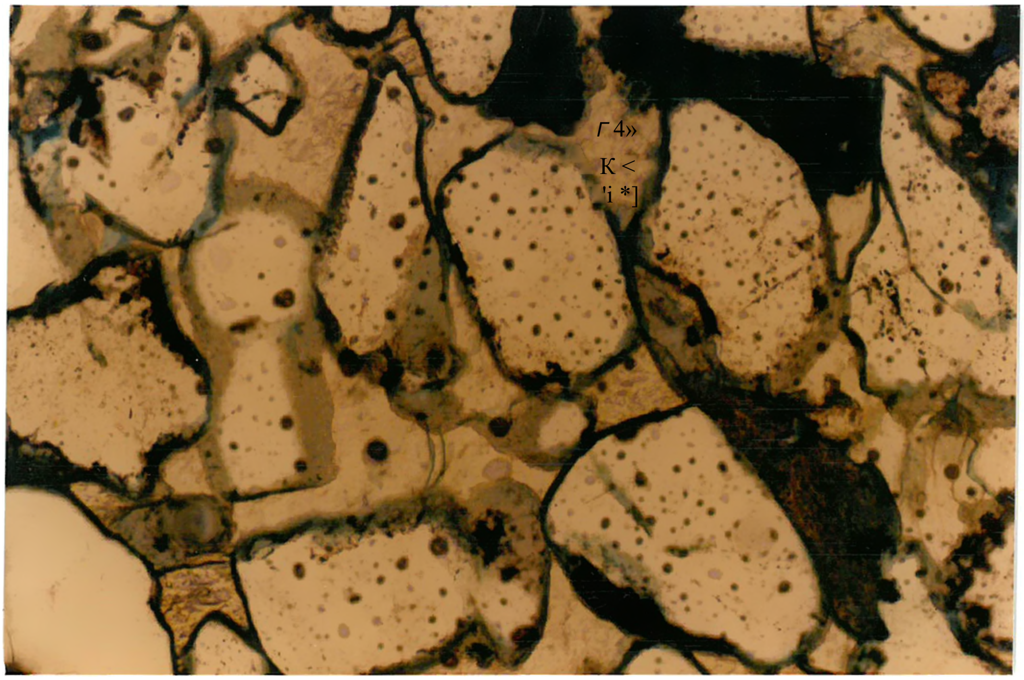


Figure 20. Quartz grain margins are replaced, by calcite which filled remaining intergranular porosity. This photomicrograph is from a sample taken from the No. 1 Jas. McCarthy at 10,906 feet.

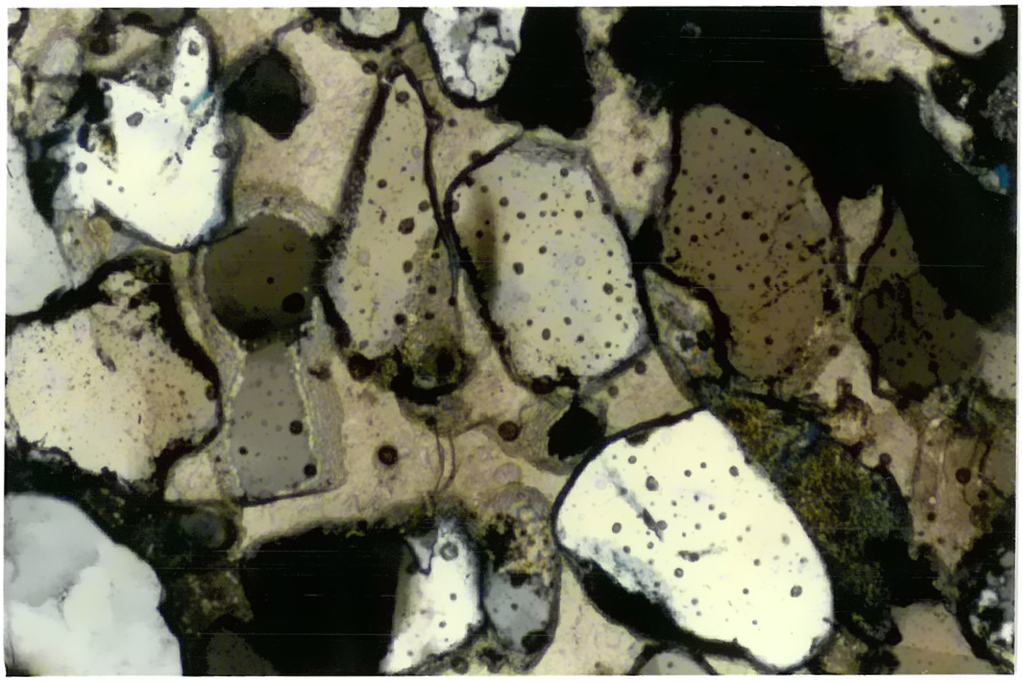


Figure 21. The photomicrograph shown in Figure 20 is viewed here under crossed niçois.

Decarboxylation

Decarboxylation of maturing organic matter, possibly including the maturation of organic-rich oil source rocks, is related to the generation of carbon dioxide which, in the presence of water, produces carbonic acid (Schmidt 1980). This acid reacts with carbonate and rock fragments causing grain dissolution, partial and complete [figures 22,23].

Rock Fragment Alteration and Clay Mineral Production

Dissolved rock constituents include the majority of the minerals found in clastic sediments (Schmidt 1980). Alteration of rock fragment constituent minerals such as feldspars, micas, amphiboles, and pyroxenes resulted in the precipitation of clay minerals (kaolinite, illite,and chlorite) as well as formation of pyrite and siderite [figures 24,25].

Vermicular kaolinite appears late in the diagenesis of the sandstones. This is indicated by the appearance of kaolinite in pore spaces which have been formed during the development of the secondary porosity [figure 26].

Stewart (1981) places the occurrence of authigenic chlorite before the appearance of calcite cement in his description of the Tuscaloosa of south Louisiana. In the thin sections of the McComb field there are sections in which calcite has not been completely dissolved. In areas such as this chlorite has overgrown quartz grains along the outer portions of the cemented area. In the center of these areas there is no chlorite overgrowths present indicating that the occurrence of chlorite

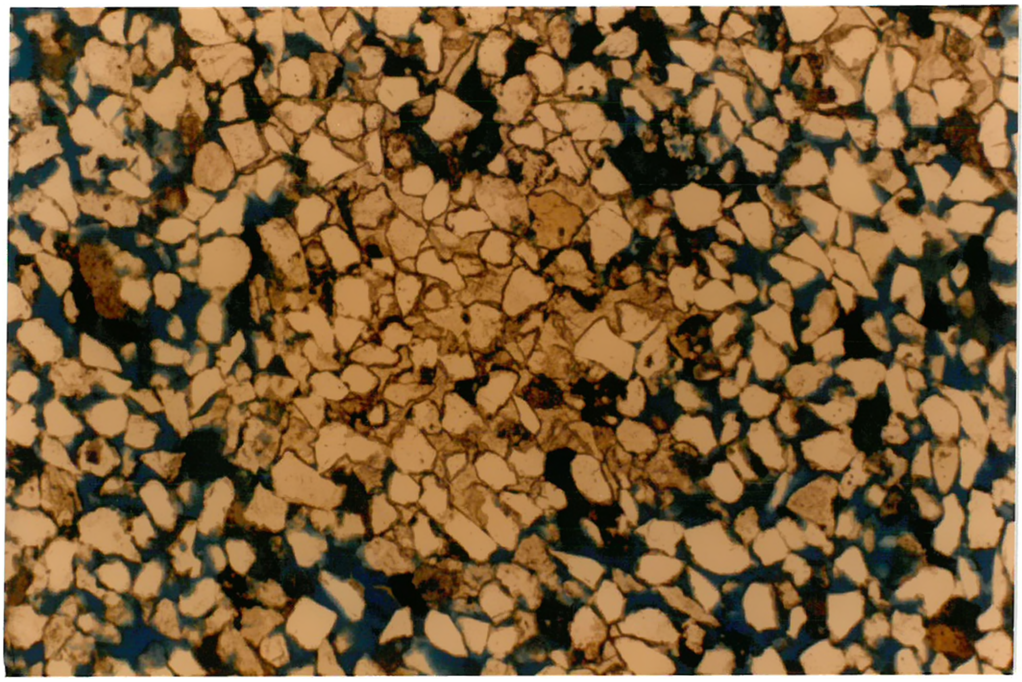


Figure 22. Partial and complete dissolution of carbonate cement and rock fragments is shown in this photomicrograph (plane-polarized light) of a sample taken at 10,935 feet from the No. 3 R. L. Boggan well, (McComb Field).

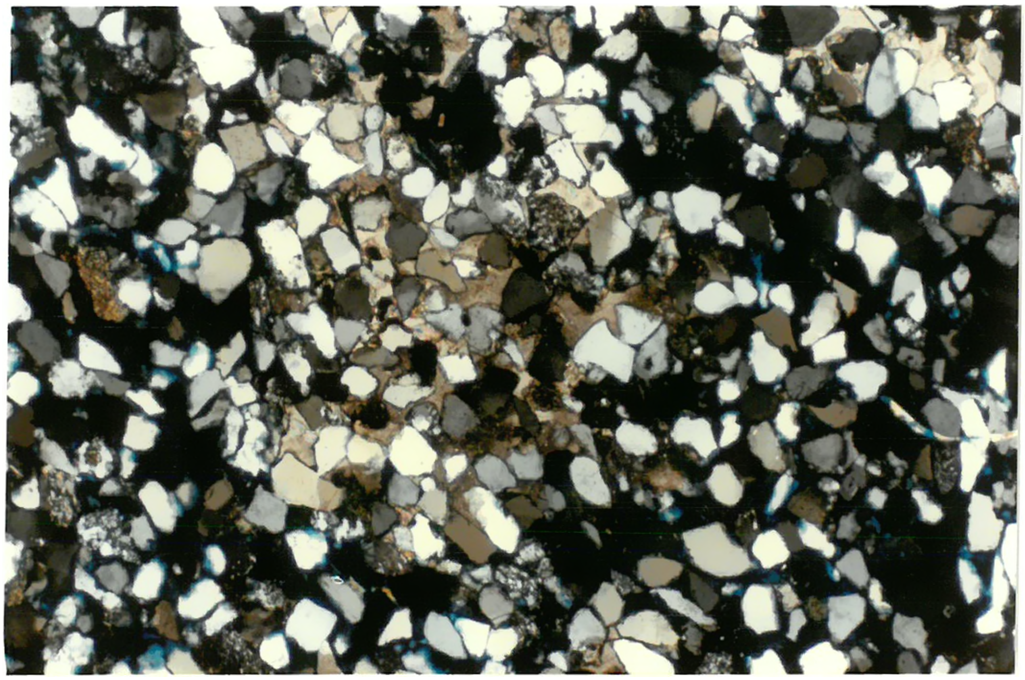


Figure 23. Same photomicrograph as that shown in Figure 22 viewed under crossed niçois.

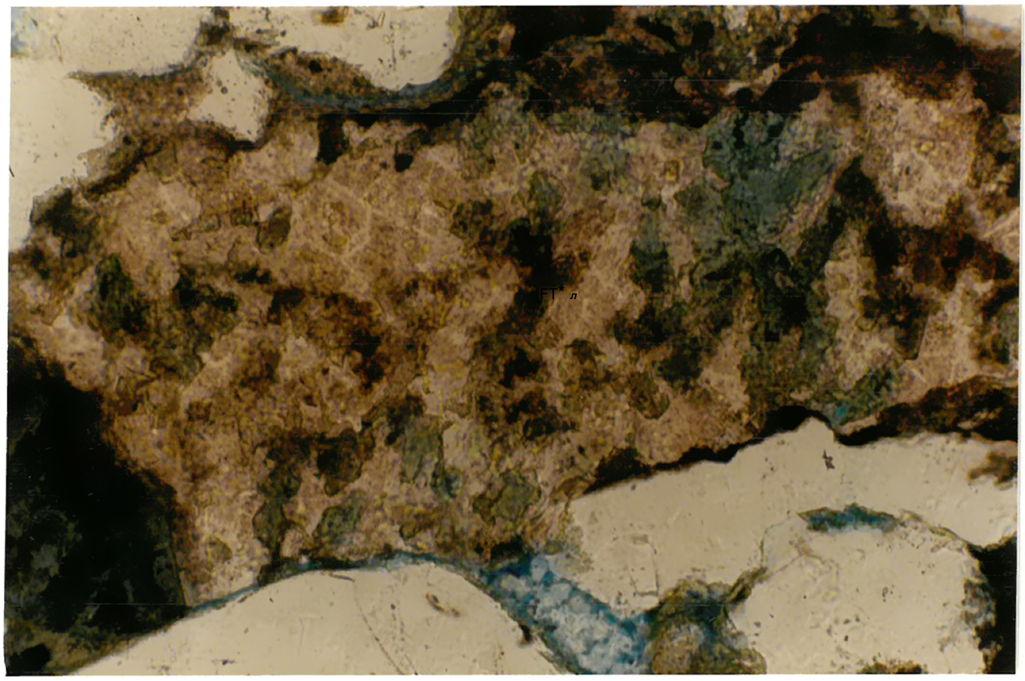


Figure 24. Alteration of rock fragments resulted in the precipatation of clay minerals as well as the formation of pyrite and siderite.

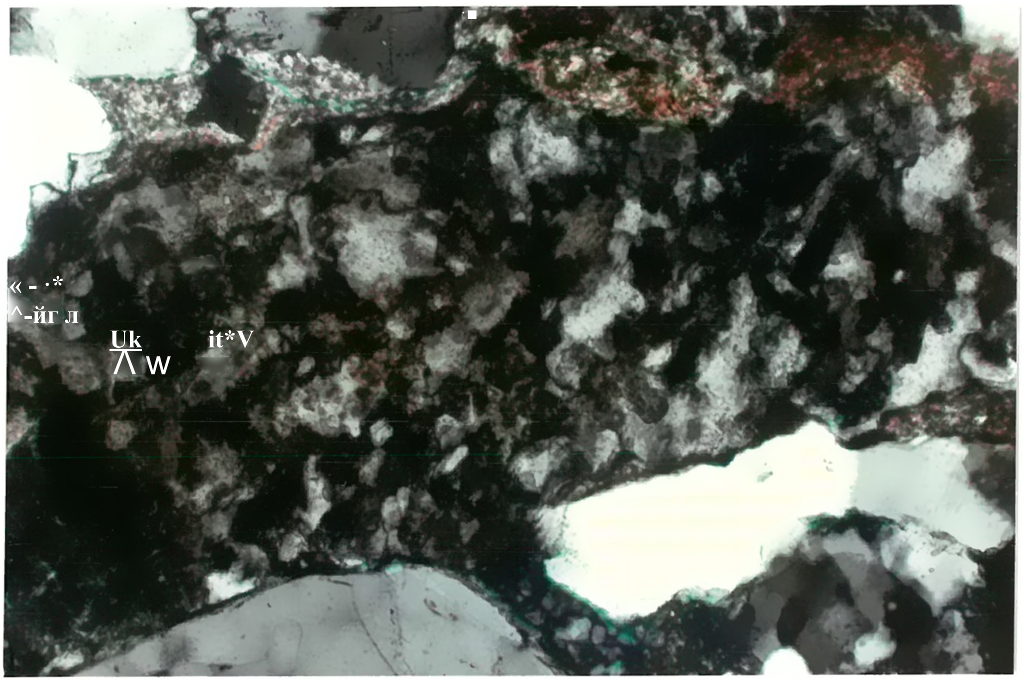


Figure 2э. Crossed nichols view of the thin section shown in Figure 24. Core sample taken at depth 10,900 feet from the No. 1 Harvey Lenoir well at McComb Field.

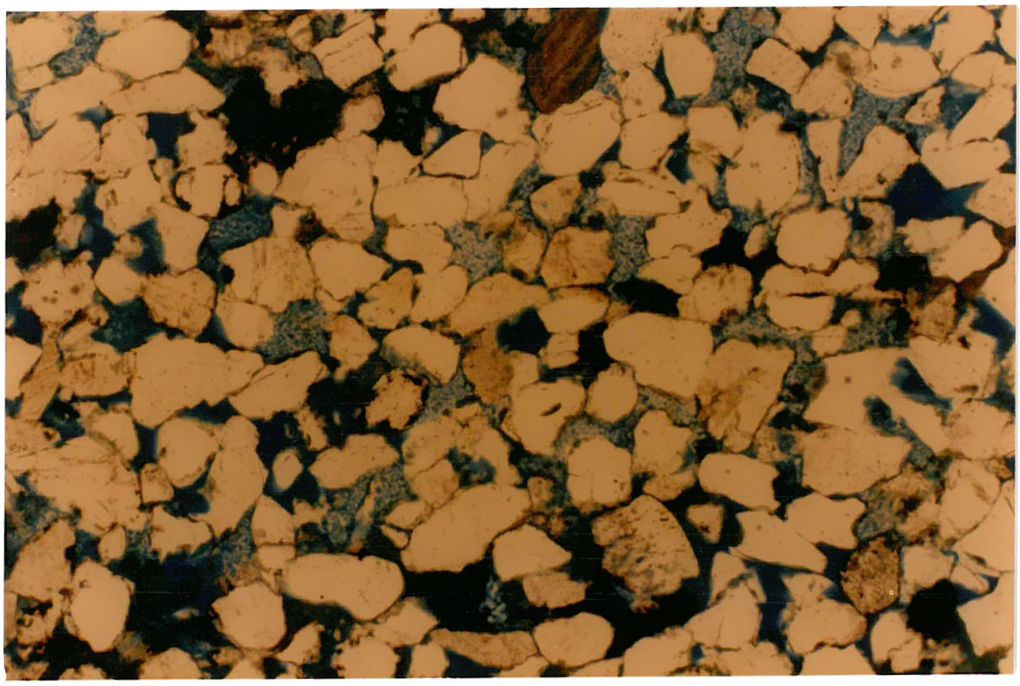


Figure 26. Vermicular kaolinite exhibiting intercrystalline porosity is shown here filling previously formed secondary porosity in a sandstone at a depth of 10,020 feet, No. 1 F. Z. Mills, McComb Field.

precipitation or formation postdates the cementation of the sand by calcite.

The determination of the clay mineral diagenesis in these rocks is limited by the equipment available to the authors. Microprobe analysis of these rocks is greatly needed in order to determine not only what clay minerals appear where but the precise composition and zonation of the minerals. In general the formation of illite, chlorite, and kaolinite occurred as a result of the alteration of feldspars and rock fragments during and after the formation of carbonate cement.

Diagenetic Reactions and Sequence

The following diagenetic history for the McComb and Little Creek reservoirs is inferred from the combined petrographic and x-ray diffraction results:

1) Mechanical compaction of the sediments and the precipitation of quartz overgrowths.

2) Replacement of quartz overgrowths by carbonate cement was accompanied by carbonate precipitation between framework grains during the first stages of mesodiagenesis.

3) During a more mature diagenetic stage, perhaps corresponding to hydrocarbon migration and emplacement, decarboxylation of contained organic matter in the adjacent fine-grained units led to wide-spread decarbonatization of the reservoir rocks and the creation of hybrid, oversized, moldic and intergranular pores with good pore-throat interconnection. Complete and partial alteration of rock fragments and feldspars was accompanied by neoformation of kaolinite, chlorite (as grain rims), and illite.

4) There is some evidence of further dissolution and reprecipitation of quartz and carbonate, as well as the formation of vermicular kaolinite, after the main phase of secondary porosity generation and hydrocarbon emplacement. Late stage diagenetic events also include the precipitation of euhedral quartz crystals in some pore spaces and over chlorite rims.

CONCLUSIONS

The results of this study, supported by petrographic size analysis data, show that two major depositional facies characterize the Lower Tuscaloosa Formation in the study area; a lower fluvial sequence topped by nearshore marine deposits.

1) Detailed core data, isolith maps, and cross-sections of the McComb field area reveal that the McComb sandstone closely resembles a transgressed barrier island system as described by Moslow (1984); Galloway and Cheng (1985); and Geehan, Grimes, and Swanson (1983).

2) Future exploration for barrier reservoir sandstones within the ”stringer sand” member of the Lower Tuscaloosa Formation should attempt to target sandstones having characteristic upward coarsening sequences and which pinch out in a paleo-landward direction into lagoonal shales. The sand body geometry, the vertical variations in sedimentary structure and texture within the sand body, the nature of boundaries with underlying and overlying sediments, the bedding architecture, and regional stratigraphic setting provide the best criteria for identification of ancient transgressive barrier complexes. Such interpretations require the use of available well log, drill cuttings, and, most importantly, conventional core control.

3) The sandstone units of reservoir sandstones in McComb field are higher stratigraphically in the "stringer sand" member (approximately 50-70 feet below the top of the Lower Tuscaloosa Formation) than the productive meanderbelt facies of Little Creek field (approximately 70-100 feet below the top of the Lower Tuscaloosa Formation).

4) Productive sandstones of the Little Creek field appear to have been deposited by a well-developed, mature, high-sinuosity meandering stream, as reported by Eisenstatt (1960) and Busch (1974). Isopachs of point bar sandstones frequently have concentric and ovoid patterns and are often tightly spaced adjacent to channel fills and flood plain deposits.

5) Core examination reveals that the fining upward sandstone cycles identified as point bars at Little Creek field occur as stacked, multistoried sandstone units. The thickness of full point bar cycles preserved in cores from two wells suggests that the sandstones were deposited by a medium-sized stream (e.g., the modern lower Brazos River) which meandered with high to moderate sinuosity across a low gradient floodplain.

6) Petrological studies reveal that the sandstones of both fields were deposited as very fine to medium-grained quartz arenites and quartz litharenites. A good secondary porosity developed by disolution of rock fragments and carbonate cements which replaced the margins of quartz grains.

7) Results of the petrographic and X-Ray diffraction analysis of the clay mineral content of the sandstones indicate that most of the clays are authigenic and comprise a suite which includes kaolinite, chlorite, and illite. Illite appears to be considerably more abundant in the McComb reservoir sandstones than at Little Creek.

8) The combined petrographic and X-Ray diffraction results suggest a diagenetic history which begins with mechanical compaction of the sediments and the precipitation of quartz overgrowths. Replacement of quartz overgrowths by carbonate cement was accompanied by carbonate precipatation between framework grains during the first stages of mesodiagenesis. During a more mature diagenetic stage, perhaps corresponding to hydrocarbon migration and emplacement, decarboxylation of contained organic matter in the adjacent fine-grained units led to wide-spread decarbonization of the reservoir rocks and the creation of hybrid, oversized, moldic and intergranular pores with good pore-throat interconnection. Complete and partial alteration of rock fragments and feldspars was accompanied by neoformation of kaolinite, chlorite (as grain rims), and illite.

9) There is some evidence of further dissolution and reprecipitation of quartz and carbonate, as well as the formation of vermicular kaolinite, after the main phase of secondary porosity generation and hydrocarbon emplacement. Late stage diagenetic events also include the precipitation of euhedral quartz crystals in some pore spaces and over chlorite rims.

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APPENDIX B

LITTLE CREEK FIELD CORE DATA

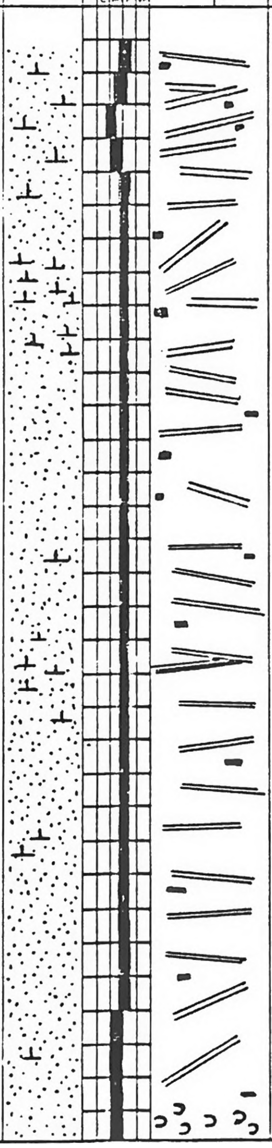
LOCATION SI'N 0ŁL COMPANY

Atkinson B-l
Sec. 2-4N-8E

SHEET NO. 1 OF 2
D AT E: Foburuary» 1985
LOGGED RY W-S·H.

STRATIGRAPHIC UNIT: Tittle Creek Field

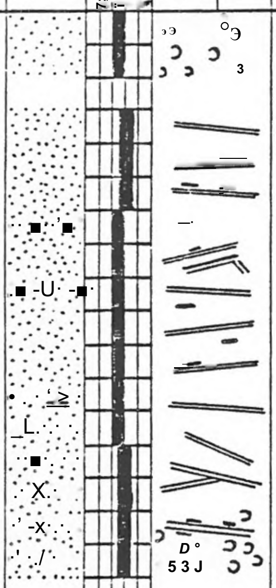
UNIT OR CORE NO | COMPOSITION | MODAL SAND SIZE | STRUCTURES: CURRENT-FLOW, DEFORMATION, ORGANIC | COLOR | OPEN CATEGORIES | FACIES, INTERPRETATIONS | SPL LOC



DEPTII	COMMENTS. MISCELLANEOUS OATA
10772	Puff Planar cross-bedded, tr. orcs.
773	mod. sor ted. CпСПд cemented
774	med- to fn trained sandstone.
775	Overall fining unward
776	Clay in. .matrix. throughout sandstone
777	
778	
779	Ud^h er сшд1p cmчs—hedd i nP. tr.or
10780	20 cm zone of well cemented sand
781	Good Porosity and Permeability
782	Tabular forset visible in cross-
783	bedding, mod, sorting, sub-rounded
784	sand grains, carbonaceous organic
785	**material thrcughou.t**
786	
787	
783	
78 9	
L079O	Low angle cross-bedding, CaCO3
7911	cement, tr. organic material,
79 2	Well indurated quartz sandstone
793	
79 4	Good Por, and Perm, . clay in
79 5	matrix, Mod, sorting, sub-angular
79*6	to sub-rounded sandstone, Slightl y
79 7	calcareous
798	
799	Very nood Porositv and Permeabilità
10800	
801	High angle Planar cross-bedds
802,	
803	Clay pebble conglomerate with sand
804	matrix. 1-2cm clay clast

LOCATION SVN OIL COMPANY
Atkinson B-1
Sec. 2-4N-8E
STRATIGRAPHIC UNIT: Little Creek Field

SHEET NO. 2 OF 2
DATE ; Echruary.1985
LOGGED ЯY M R »



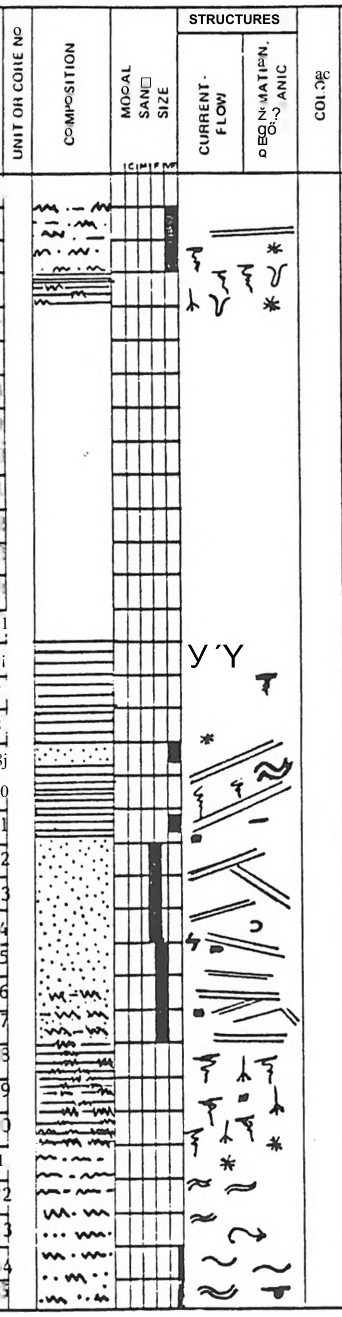
DEPTH	COMMENTS. MISCELLANEOUS DATA	FACIES INTERPRETATIONS
10805	Clay clast conglomerate with sand	
806	matrix. clay clast l-2cm.	
807	Core Missing	
808	Buff planar cross-bedded, fine to	
809	v-fine, quartz sandstone. No $CaCO_3$	
0810	Micro laminations with carbonaceou	5
811	material on bedding plane	
812	small scale ripple cross-bedding	
813	Trace of $CaCO_3$ cement	
814	Trace of carbonaceous matter	
815	4 r. terhedded in «ЛпИчСОПР	
816		
817	Richer ancle cross-bedding.	
818	moderately sorted, sub-rounded	
819	calcite cemented fn-med quartz san	d
10820	Clay clast with sand matrix ,	
821	carbonaceous matter along bedding	
822	plane	

B4

LOCATION SUN ○11' C0MPANÏ
//2 Kenna
Soe. 11-4N-8E

SHEET NO. _J_____ OF _2_
DATE: ~~January.~~ 1985
LOGGED BM.S.l.

STRATIGRAPHIC UNIT: Little Creek Field



DEPTH	COMMENTS. MISCELLANEOUS DATA
1077t	
773	Light gray, tr. siderite, planar
774	cross-bedded- silty sandstone·
775	clay in matrix throughout sandstone
776	root structures, bioturbation and
777	mottling presene.
778	
779	
078Õ	CORE MISSING 10776-785
781	
782	
783	
784	
7851	
786¡	Hery fragile gray-maroon silty-
787	shnle (fi sailc3
788	
78j	½ foot sand with tr. siderite
10790	Gray-green shale carbonaceous
79 1	plant fragments present
79 2	Light gray cross-bedded fn.-med sd.
79 3	sub-rounded to sub-angular sand
79'4	Occasional clay clast within sand
79'5	matrix
796	Thin bedded sand, gilt and shal e
797	Sma 11_ sralp.rippip rras.s^hrddi ng
79;3	Gray and red mottled silt v shale
79 9	root structures common throughout
1080i 0	Siderite present (1-2%)
801	
80 2	Small scale ripples mostly silts
80 3	and shales
80 4	E v.i.d a n c, ft n.f—sn ДР, -soft—sediment-
805	deformation, thinly laminated

FACIES INTERPRETATIONS

SPL. LOC.

LOCATION OIL SUN COMPANY

#I Mae Busby

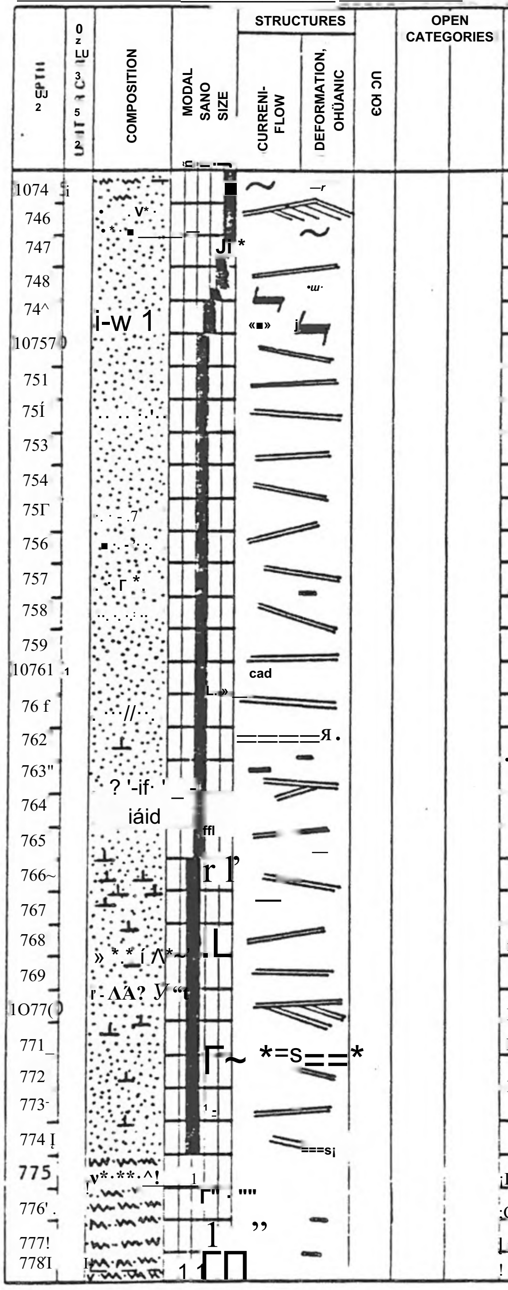
Sec. 23-4N-8E

STRATIGRAPHIC UNIT: Little Creek Field

SHEET NO. 1 OF 1

DATE: January, 19 4L

LOGGED BY W. S.



COMMENTS. MISCELLANEOUS DATA

Buff, thinly bedded, silty sandstone soft seek def. poorly sorted, clay material throughout matrix. Low angle cross-bedding, carbonaceous matter, 1-3cm clay clast. Coni porosity 5. permeability Moderately sorted, overall fining upward sequence, sub-rounded quartz grains. Low angle planar cross-beds, Very good porosity and permeability,

Same as above but, with a trace of CaCO3 cement, small scale cross-bedding, sub-rounded sand grains

Increased CaCO3 cement, well indurated, trace of carbonaceous material

Large scale festooned cross-beds Moderately well sorted, good porosity and permeability

Dark gray sandy siltstone, no CaCO3 cement tr. carbonaceous material,

Dark gray silty shale

FACIES INTERPRETATIONS

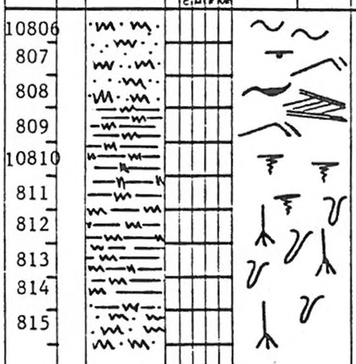
SPL LOC.

LOCATION SUN OIL COMPANY
2 Kenna
Sec. 11-4N-8E

SHEET NO. 2 OF 2
DATE: January, 1985
LOGGED BY W.S.H

STRATIGRAPHIC UNIT: Little Creek Field

DEPTH | UNIT OR CORE NO | COMPOSITION | MODAL SAND SIZE | STRUCTURES: CURRENT-FLOW, DEFORMATION. ORGANIC | COLOR | OPEN CATEGORIES | COMMENTS. MISCELLANEOUS DATA | FACIES. INTERPRE TATIONS | SPI IOC



Small scale ripple cross-bedding slightly flasered, some soft sed. deformation, thin interlaminated vf. sand, silt, and shale, small scale cross-bedding, grading into Gray-maroon mottled silty shale Very friable, abundant root structures, some apparent bioturbation.

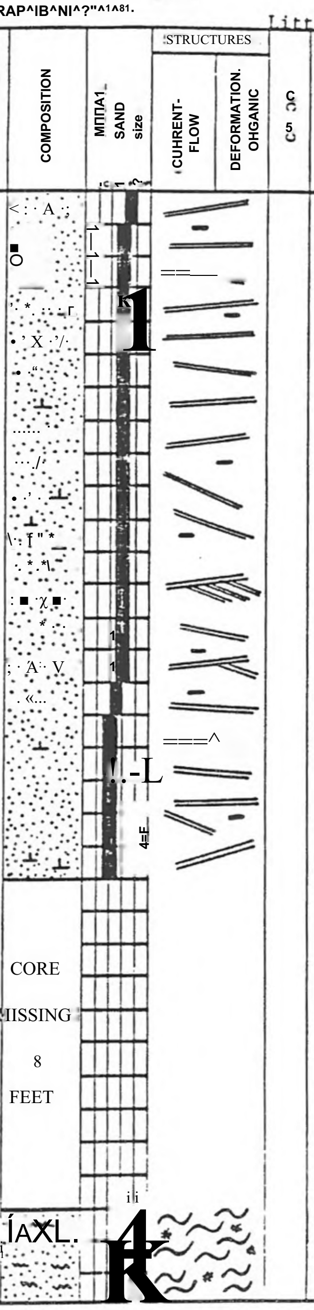
LOCATION S VN OIL COMPANY

1 Nunnery Busby

STRATIGRAP^IB^NI^?"^1^81.

Little Creek Field

SHEET NO. 1 OF 2
DATE: February, 1985
LOGGED BY K.S-H.



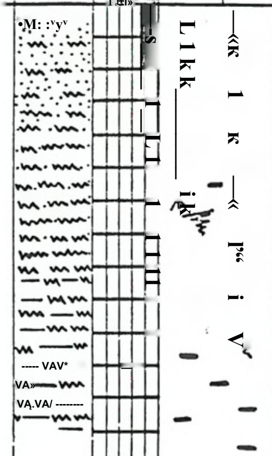
OPEN CATEGORIES

DEPTH	UNIT OR CODE NO	COMMENTS. MISCELLANEOUS DATA	FACIES INTERPRETATIONS	SPL. LOC.
1072	1	Buff tr. carbonaceous matter. tr.		
724		mica. mod. sorted, sub-rounded.		
725		low angle planar cross-bedded.		
726		CaCO? cemented, quartz sandstone.		
727		clay material throughout sandstone		
728		matrix. Nearly horizontal laminae		
729		Good porosity Λ permeability		
1073				
731				
732		High angle planar cross-bedding.		
733		tr. organic material, well indurat	Pd	
734		CaCOi cemented.		
735		Small scale cross-bedding. tr. mie	3	
736		tr. carbonaceous matter, mod. sort	Pd	
737		fine-medium grained quart? sandste	че	
738		tr. plant fragments on bedding		
739		plane. Overall fining upward sen-		
1074	1	uence. Good por. & perm.		
741				
742				
743				
J		1		
1075		Buff, laminated, (sub-parallel)		
753		SILTY. sand stone . tr ςτ A orite,		
754		well cemented, wavy bedding		

LOCATION SUN OIL COMPANY
// 1 Nunnery Busby
Sec. 23-4N-8E

SHEET NO. 2 OF 2
DATE:-Jehrnarv. 19.45
LOGGED RY W.S.H.

STRATIGRAPHIC UNIT: Little Creek Field

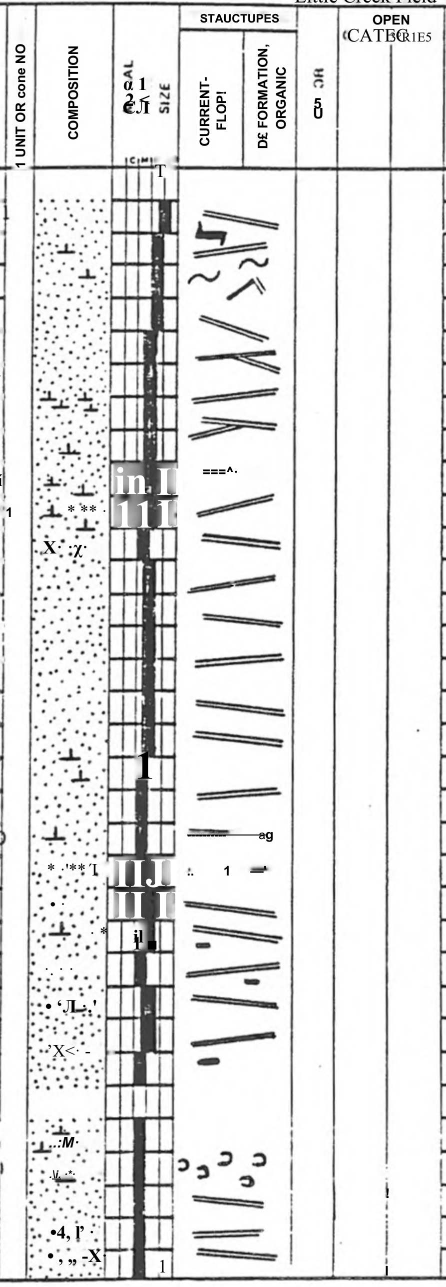


DEPTH	1 UNIT OH COПE NO	COMPOSITION	GRAIN SIZE	STRUCTURES CURRENT-FLOW	STRUCTURES DEFORMATION, ORGANIC	COI 3H	OPEN CATEGORIES	OPEN CATEGORIES	COMMENTS. MISCELLANEOUS DATA	FACIES. INTEHPHE TAIKINS	PL LOC. Lo
1075;									Very fine grained silty sandstone		
756'									-Maroon mottling, root structures.		J1
757*									niant fragments... wel 1 cemented		
758											
759									(Gray-maroon siltstone, mottling		
IO76(									throughout, root structures.		
761'									Yellow-erav sha ley siltstone, uiti		
762~									black vitreous niant fragments		
763											
764'											
765'									Dark grav siltv shale, (fissie)		
766									abundant carbonaceous material		
767											

LOCATION SUN 01L COMPANY
//1 Busby "A"
Sec. 23-4N-8E

SHEET NO. _!_OF 2
DATE: February· IQS'
LOGGED BY W.Ś.H.

STRATIGRAPHIC U NIT : Little Creek Field



DEPTH	COMMENTS. MISCELLANEOUS DATA
1071"	Buff, small scale cross-bedded
712"	sandstone. tr. clay cl ast .moderate
713	sorting, clay throughout matrix
714	tr. CaCO3 cement, small scale
715*	riñóle cross-bedding. good P & P
716~	trace of carbonaceous material
717"	thrcuchout sandstone, increase
718"	CaCO3 .
7 lí	
10727	
721"	
722~	Пecгр.яяр CaCm. Low angle
723"	cross-bedding
724"	
725"	
726"	
727	
728"	Cao cement
729"	
10730	
731'	
732	
733	
734	Slight increase in carbonaceous
735	material, trace of mira in matriv
736"	
737"	
738"	Missing 1 foot of core.
7391	Buff, cross-bedded. CaCOa cemented
10747	sandstone. Clay clast in sand
741	matrix, good porosity and perm.
742	
743	

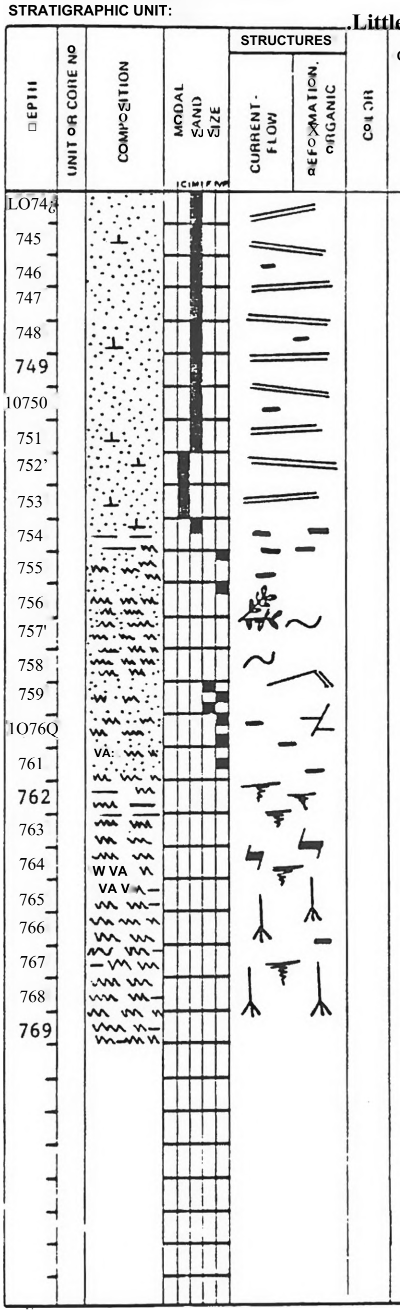
TACHS. INTERPRE TAIKINS

BIO

LOCATION ~~SUN 01L C~~0MPANY
//1 Busby "A"
Sec. 23-4N-8E

SHEET NO. z OF 2
DATE: Echruaru_1985
LOGGED BYW.S.H.

STRATIGRAPHIC UNIT: .Little Çreek. .Field



COMMENTS.
MISCELLANEOUS DATA

Buff, cross-bedded .moderately
sorted, sub-rounded, quartz
.saada. tone, clay in matrix, tr.
CaCOl cement, tr. carbonaceous
material throughout sandstone.
Very good porosity and permeability

Apparent scaur into dark gray silty
shale and siltstonoj with abundant
plant fragments, wavy to lenticular
bedding, small scale ripple cross-
bedding

Interhedded vf. grain sandstone
and siltstone. evidence of soft
sed. slirkpns1idies.

Silty shale, red mottling, fissile
occasional clay clast within matrik

Dark gray- maroon mottling, root
cast common

FACIES INTERPRETATION
SPL LOC.

APPENDIX C

PETROGRAPHIC DATA

SANDSTONE PETROLOGY AND DIAGENESIS OF TUSCALOOSA

POINT COUNT DATA

SAMPLE	FIELD	WELL NAME
1	McComb	Lenoir A-1
8	McComb	Lenoir A-1
17	McComb	#1 F.Z. Mills
23	McComb	#1 F.Z. Mills
25	McComb	#1 F.Z. Mills
26	McComb	#1 F.Z. Mills
27	McComb	#1 F.Z. Mills
30	McComb	R.L. Boggan #3
32	McComb	R.L. Boggan #3
34	McComb	R.L. Boggan #3
39	McComb	R.L. Martin
41	McComb	R.L. Martin
43	McComb	Johnson A-1
48	McComb	Johnson A-1
50	McComb	Johnson A-1
52	McComb	Johnson A-1
57	McComb	Johnson A-1
58	McComb	Johnson A-1
64	McComb	#1 Harvey Lenoir
68	McComb	#1 Harvey Lenoir
70	McComb	#1 Harvey Lenoir
71	McComb	#1 Harvey Lenoir
73	McComb	#1 Harvey Lenoir
76	McComb	#1 Jas. McCarthy
80	McComb	#1 Jas. McCarthy
81	McComb	#1 Andrews
83	McComb	#1 Andrews
86	McComb	#1 Andrews
89	McComb	#1 Andrews
91	McComb	#1 R.E. Schmidt
93	McComb	#1 R.E. Schmidt
96	McComb	#1 R.E. Schmidt
101	McComb	#1 Sinclair
109	McComb	#1 Sinclair
110	McComb	Lampton Wallace A-1
112	McComb	Lampton Wallace A-1
117	McComb	Lampton Wallace A-1
118	McComb	Lampton Wallace A-1
119	McComb	#1 M.F.U. 27-11
125	McComb	#1 M.F.U. 27-11
127	McComb	#1 M.F.U. 27-11
130	McComb	Lampton Wallace G-1
133	McComb	Lampton Wallace G-1
136	McComb	Lampton Wallace G-1
140	McComb	Lampton Wallace G-1
145	McComb	Lampton Wallace G-1

SANDSTONE PETROLOGY AND DIAGENESIS OF TUSCALOOSA

POINT COUNT DATA

SAMPLE 4	FIELD	WELL NAME	DEPTH
212	Little Creek	41 Mac Bushy	10,766
230	Little Creek	41 Mac Busby	10,746
23?	Little Creek	42 Kenna	10,795
242	Little Creek	42 Kenna	10,790
249	Little Creek	41 Nunnery Busby	10,762
254	Little Creek	41 Nunnery Busby	10,743
2:4	Little Creek	41 Nunnery Busby	10,723
26S	Little Creek	Atkinson B-l	10,812
271	Little Creek-	Atkinson B-l	10,802
27A	Little Creek	Atkinson B-l	10,790
2S4	Little Creek	Atkinson 8-1	10,773
295	Little Creek	Busby A-1	10,752
300	Little Creek	Busby A-1	10,732
315	Little Creek	Busby A-1	10,713

SANDSTONE PETROLOGY AND DIAGENESIS GF TUSCALOOSA

POINT COUNT DATA

SAMPLE	“RF X	SRF X	VRF X	RF TOTAL	FELDS X	QTZ X	CŪ3 X	MTX X	POR X	CHERT X	KÃCL X	TOTAL X
001	1.61	8.03	0.40	10.04	0.40	61.04	2.41	10.84	10.44	4.02	0.80	100.00
»3	2.58	7.30	0.00	9.87	0.86	53.-65	3.43	10.30	19.31	2.15	0.43	100.00
017	0.67	8.75	1.01	10.44	0.34	54.88	2.69	10.77	17.17	2.69	1.01	100. GO
025	1.94	11.00	0.00	12.94	0.32	55.66	2.27	7.77	16.50	2.91	1.62	100,00
026	1.12	8.40	0.56	10.08	0.56	61.34	2.24	8.12	11.20	3.64	2.80	100.00
027	1.42	4,61	1.77	7.80	0,00	•66.31	1.06	1.77	15.96	3.55	3.55	100.00
030	0.66	2.97	0.00	3.63	0.66	48.18	0.00	45.87	0.00	1.65	0.»	1».»
032	1.26	2.21	0.00	3.47	0.00	60.25	0.00	31.86	0.00	4.42	0. co	100.00
034	1.01	3.29	0.00	4.30	0.25	63.54	7.85	4.81	17.22	1.77	0.25	100. co
039	2.57	0,96	1.93	5.47	0.00	57.23	4.50	8.68	18.33	5.47	0.32	100,00
041	0.72	1.08	0.00	1.79	0.00	63.08	0.72	8.60	24.73	1.08	0.00	100,00
043	0.00	0.00	0.00	0.00	0.32	31.51	0.00	68.17	0.00	0. CO	0,00	100.1»
048	0.00	0.00	0.00	0.00	0.00	33.44	0.00	66.56	0.00	0.00	0.00	100.00
050	0.00	0.00	0.00	0.00	0.00	58.23	0.00	40.85	0.00	0.91	0.00	100.00
052	0.98	4.59	0.33	5.90	0.66	59.02	7.87	2.95	17.70	2.30	3.61	100.00
057	0.64	5.14	0.32	6.11	0.32	54.02	26.69	6.75	Ī.77	2.57	0.32	100.00
058	0.00	5.38	0.00	■2.38	1.58	59.18	0.63	31.96	0.00	1.27	0.00	100,00
064	0.67	0.00	0.00	0.67	0.67	53.18	0.00	34.45	9.70	1.34	0.00	100.00
CÓS	2.32	6.09	0.87	9.28	232	40.29	0.00	20.87	17.97	3.48	5.30	100.00
070	2.31	5.94	0.00	8.25	2.64	57.10	20.79	0.33	9.57	1.32	0.00	100.00
07i	3.09	6.79	0.»	9.88	1.2-3	56.48	0.00	9.26	19.75	1.85	1.54	100.00
073	J « 52	0.95	0.00	3.47	0.32	54.89	0.00	17.67	19.24	1.58	2.84	100.00
076	1.25	0.94	0.00	2.19	0.31	56.25	21.56	3.13	15.66	0.94	0.00	100.»

SANDSTONE PETFŪLŪ8Y AND DIASENESIS OF TUSCALOOSA

POINT COUNT DATA

SAMPLE	YRF X	SRP X	ORF X	RF X	FEDS X	STZX	ИЗ	MTX x	POR X	CHERT X	KAGL X	TOTAL X
07 è	025	0.94	0.00	2.19	0.31	56.25	21.56	3.13	15.63	0.94	0.60	100, C0
080	2,54	20.00	0.28	22.82	1.69	43.94	2,25	4.51	22.32	1.69	0.28	100.00
081	0.94	0.31	0.00	1.26	0,31	49.69	0. CO	45.28	1.26	2.20	0.00	100.00
083	0.00	1.35	0.45	1.80	0.00	67.57	0.00	16.22	13.06	1.35	0.00	100.00
086	1.66	[illegible]	0.33	4.32	0,66	58.14	7.64	8.97	18.60	1.00	0.66	100.00
089	3.44	1.56	1.25	6.25	0.94	46.88	2.19	18.44	21.25	2.19	1,88	100.00
091	2.47	0.55	0.55	3.06	0.82	51.23	21.10	5.75	14.79	1.37	1.37	100.00
093	J x ¿3	4.25	0.00	9.48	1.31	[illegible]	Ó.98	12.09	21.57	1.31	0,98	100.00
09è	1.22	1, 53	0.00	2.75	0.00	53.82	21.41	8.87	7,34	3.06	2.75	100.00
101	0.00	0.00	0.00	0.00	0.00	8.75	0.00	91,25	ô. 00	0.00	0.00	100.00
109	2.64	1.76	0.29	4.69	4.40	55,43	21.41	11.14	0,00	2.93	0.00	100.00
ΠΟ	0.33	0.00	0.00	0.33	0.33	63.93	0.00	34.10	0.66	0.66	0.00	100.00
112	1.82	0.91	1.22	3.95	0.00	57.75	14.59	6.99	11.85	1.82	3.04	100.00
117	3.28	3.93	0.33	7.54	0.98	50.82	0.33	17.70	17.70	3,28	1.64	100.00
112	0.32	2.85	0.00	3.16	1.58	5í). 32	0.00	14.24	29.75	0.95	0.00	100.00
119	0.30	0.30	0.30	0.91	0.00	52.13	0.00	46.65	0.00	0.30	0.00	100.00
125	0.00	3.90	0.00	3.90	0.32	52.60	8.12	20.78	10.71	0.65	2.92	100.00
127	0.33	0.33	Ô. 00	0.65	0.00	31.37	0,00	67.97	0.00	0.00	0.00	100.00
130	0. CO	0,00	0.00	0.00	2.19	51.88	29.69	15,63	0.00	0.63	0.00	100.00
133	1.73	1.45	0.29	3.47	0.00	50.87	15.03	10.12	16.76	3,18	0.58	ICO.oo
136	0.62	1.85	0.31	2.78	2.16	54.32	6.79	11.11	20.99	0.62	1.23	100,00
140	0.65	0.65	0.00	1.30	0.32	55.84	3,25	10.39	28.25	0,65	0.00	100.00
145	0.32	0.00	0.00	0.32	0.00	43.83	0.00	55.84	Ó. 00	0.00	0.00	100.00
212	0.90	0.30	0.00	1.20	0.00	57.36	17.12	7.51	15.92	0.90	0.00	ΠΟ

SANDSTENE PETROLOGY AND DIAGENESIS UF TUSCALOOSA

POINT COUNT DATA

SAMPLE	MRP 7.	5RF 7.	ORF X	S- X	FELDS X	QTZ X	CO3 X	MTX X	FOR X	CHERT X	KAOL X	TOTAL X
239	0.00	1.01	0.00	1.01	0.00	64.19	0.00	15.54	7.43	1.01	10.81	100.00
242	0.32	0.00	0.00	0.32	0.32	32.38	3.81	63.17	0.00	0.00	0.00	100.00
249	0.00	0.00	0.00	0.00	0.00	5.50	0.00	94.50	0.00	0,00	0.00	100.00
254	2.39	0.32	0.00	3.22	0.00	55.31	2.25	10.61	27.33	0.96	0.32	100.00
264	0.96	0.32	0.00	1.28	0.96	50.96	1.60	22.44	21.79	0.96	0.00	100. (M)
276	1.46	1.17	0.29	2.92	1.46	60.06	17.78	10.50	5.54	1.75	0.00	100.00
284	1.43	1.71	0.57	3.71	1.14	55.43	7.71	12.29	12.57	4.86	2.29	100.00
295	0.96	0.00	0.00	0.96	0.32	56.23	5.75	13.10	21.73	1.28	0.64	100.00
Ж	2.56	0.32	0.64	3.51	0.00	57.51	0.96	15.02	22.36	0.00	0.64	100.00
' 315	0.26	0.53	0.26	1.06	0.00	40.48	0.53	21.43	34.66	1.32	0.53	100.00
306	0.32	0.00	0.00	0.32	0.00	43.83	0.00	55.84	0.00	0.00	0.00	100.00
263	2.33	0.29	0.29	2.92	1.17	51.31	4.37	14.87	20.12	1.75	3.50	100.00

APPENDIX A

McCOMB FIELD CORE LOGS

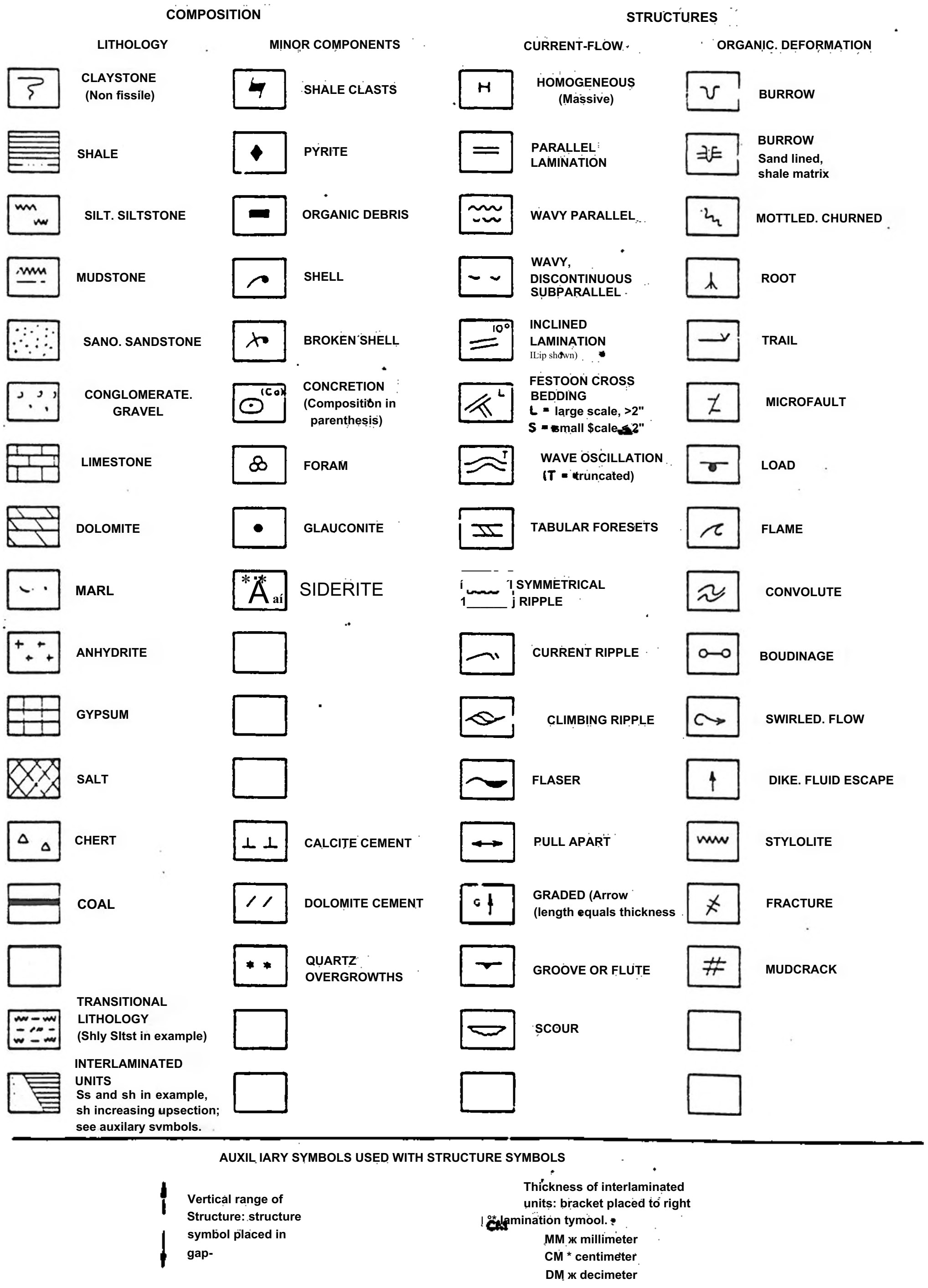


Figure A1. Symbols used in core logs in appendix A»

LOCATION SUN 0IL COMPANY

#3 Boggan

Sec 4-3N-7E

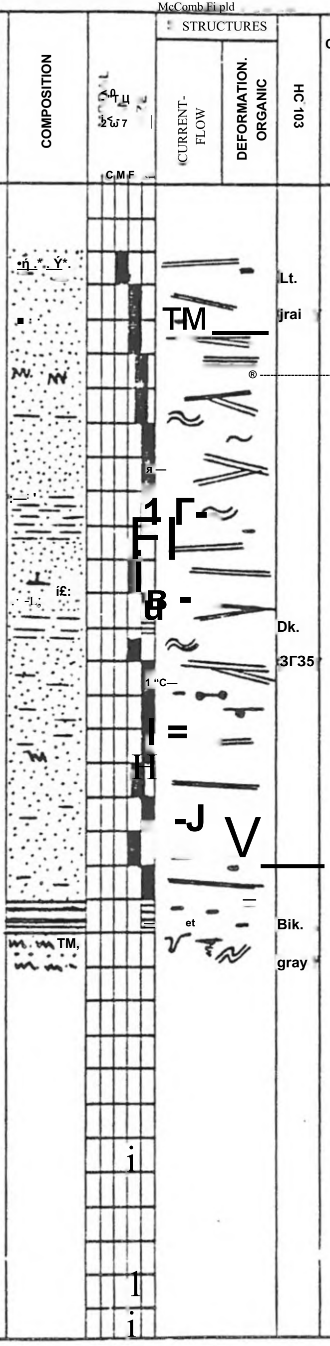
STRATIGRAPHIC UNIT:

McComb Fi pld

SHEET NO. □— OF _L_

DATE: -Aus—12Я4------------------

LOGGED B Y c . p .c . .^ .s .H



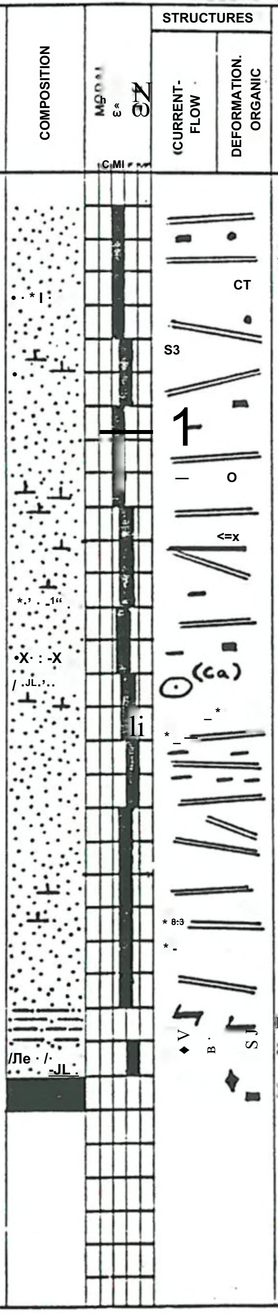
OEPTH	' UNIT OR CORE NO 1	HC 103	OPEN CATEC ORIES		COMMENTS, MISCELLANEOUS DATA	FACIES. INTERPRE TATIONS	×L LOC on
1093" 4		Lt.			Moderately well sorted, tr CaCO3		
935		jrai			coarsen upward sequence		
936"					Ripple cross-bedding, tr. organics		
9 37~					interlaminated silt & sandstone,		
938					small scale cross-bedding		
9 39"							
10947							
941"					Whaley streaks with some soft sed.		
94 2"					defarmation, _ _ .		
94 3~					CaCOт cemented vf. grain sandstone		
94 4		Dk.			vf. wavy sub-parallel bedding		
945~		3Γ35			sand with shale, soft sed. def.		
946					boudinage and load structures		
947"							
948					verv fine sand with clav and silt		
949					in matrix		
10950					tr. pyrite, siderite, and organics		
951					Planer laminations, wood chips		
952							
953		Bik.			Black shale, organic-rich		
954		gray			bioturbated, churned		
					zf. sand & siltstone		

LOCATION SHN OIL COMPANY

Lenoir Л-1
Sec. 1O-3N-7E

STRATIGRAPHIC UNIT: Mccomb $_{Field}$

SHEET NO. ^{1} OF I
DATE:November, 198A
LOGGED RY W.S.H.

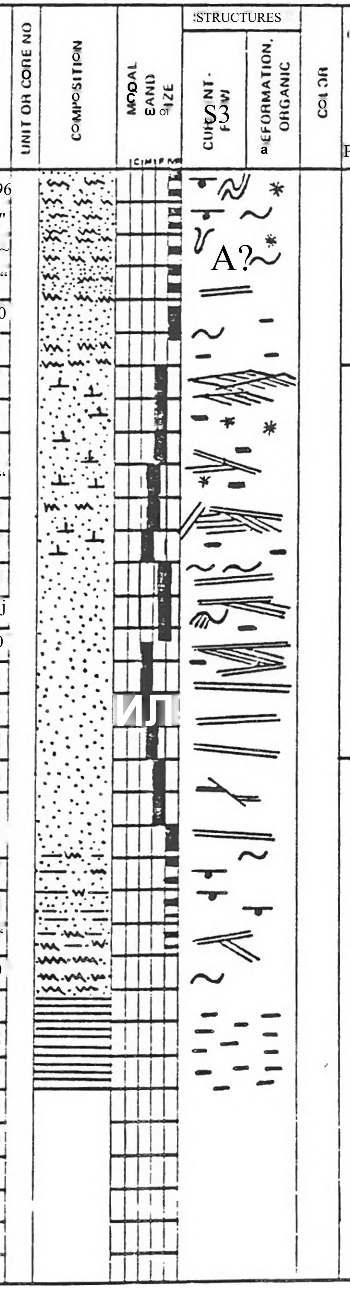


D ˉTII	UNIT OH COBE NO I	C5 ɔc	OPEN CATEGORIES Perf	■ COMMENTS. MISCELLANEOUS DATA	FACIES. INTERPRE IATIONS	SPI toe
10937		lt.		Low angle planar cross-bedded sand		
93t		buf f		Mod. sorted. Good P & P, $CaCO_3$ cem		
93<				Ruh-rounded sand erains, tr. orgs.		
10947				tr. glauconite ?, clay in matrix		
94'				csn. upward.		
942						
943						
944				Carbonaceous plant fragments &		
945				tr. clay clast in sandstone		
946				tr. siderite		
947				inerease angle planar cross-beds		
948				sand grains sub-prismoidal to		
949				snh-di srni dal		
10950						
95 Γ				Zoned $CaCO_3$ cemented concretion		
952*				tr. siderite less than 1%		
953				Carbonaceous matter abundant		
954				thrnuphout sandstone		
955				Ui'nhof angin____ planar cross beds		i
956				1 mm carbonaceous layer		
957				rsn. unward. mod. sorted, tr. sid.		H
958				Decrease Porosity and Permeability		H
959				Cuk-rcnnHtirl tn swh-anpnlnr grains		
10960						J
961		Dk.		Sandy shale, soft sediment deform,		
962		gra		clay clast throughout, plant frag.		
963		B Ik		Black lignite with pyrite & sulfui		
964			o			
965			o			
			o			
			o			
			o			

LOCATION ~~SUN OIL~~ COMPANY
Johnson A-1
Sec. 10-3N-7E
McComb Field

SHEET NO. 1 of 2
DATE : April, 1985
LOGGED BY W. S. H.

STRATIGRAPHIC UNIT:



DEPTH	OPEN CATEGORIES Perf	COMMENTS. MISCELLANEOUS DATA	FACIES INTERPRETATIONS	SPL LOC.
10896		Gray lenticular bedded sandstone		
897		and siltstone interbedded, soft		
898		sediment deformation, load structure		
899		tr. siderite, bioturbated, wavy		
10900		bedding, small scale cross-bedding		
901		trace carbonaceous material.		
902	○	Off-white, moderately sorted, CaCO3		
903	○	cemented, fine grained quartz sand.		
904	○	Good por. & Perm., tr. siderite		
905	○	small scale cross-bedding, sub-		
906	○	rounded sand grains.		
907	○			
908	○	Wavy bedding		
909	○	trough cross bedding, sharp contact		
10910	○	[illegible] high angle cross-beds		
911	○	Med. grained, no CaCO3 cement		
912	○	Low angle planar cross-beds		
913	○			
914		Micro faulting within sandstone		
915				
916		Parallel laminated dark and light		
917		siltstone and sandstone, load		
918		structures, lenticular bedding		
919		small scale cross-bedding		
10920		Gray sandy siltstone		
921		Dark gray fissile shale		
922		very carbonaceous		
923				
924				
925				

LOCATION SUN 0IL COMPANY

Johnson A-l

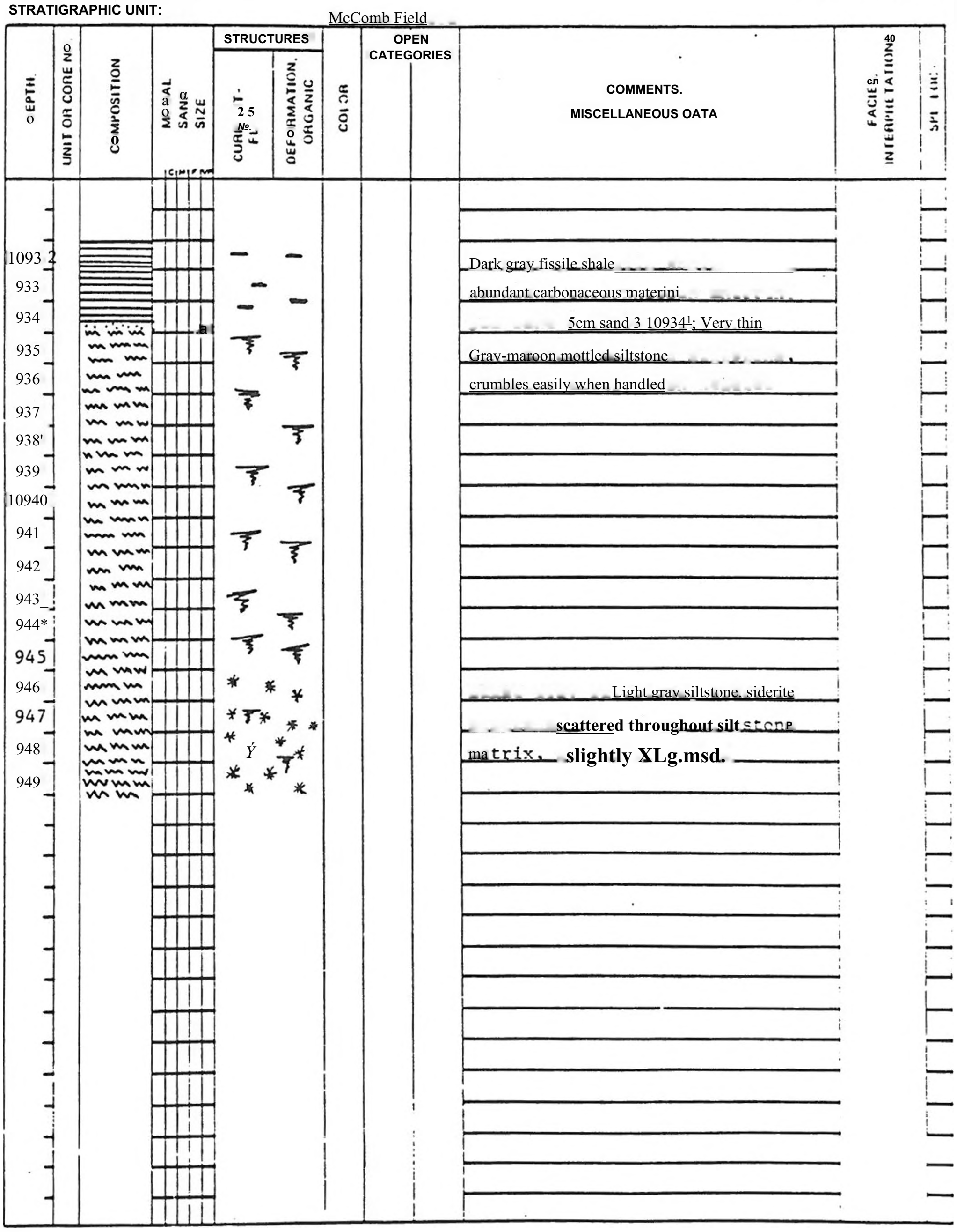
Sec. 10-3N-7E

STRATIGRAPHIC UNIT: McComb Field

SHEET MO. 2 OF 2

DATE: April, 1985

LOGGED RY W-S-H



Dark gray fissile shale

abundant carbonaceous materini

5cm sand 3 10934¹; Verv thin

Gray-maroon mottled siltstone

crumbles easily when handled

Light gray siltstone, siderite

scattered throughout siltstone

matrix, slightly XLg.msd.

LOCATION - SUN OIL COMPANY

\# 1 Harvey Lenoir Un.

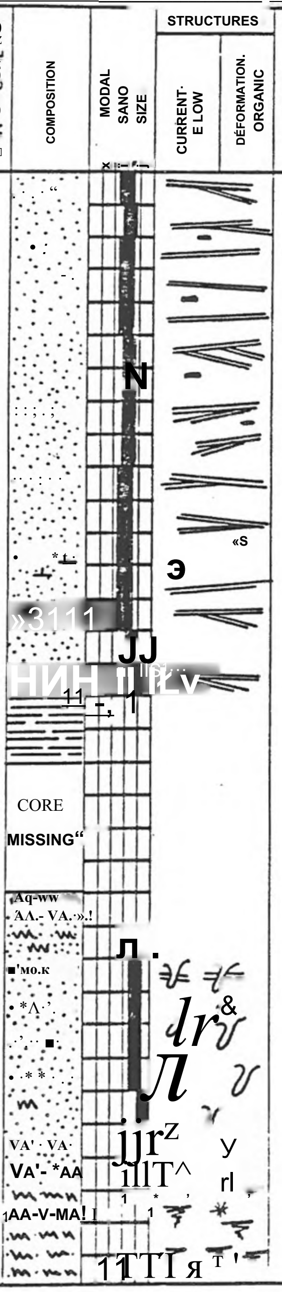
Sec 10-3N-7E

STRATIGRAPHIC UNIT: McComb Field

SHEET NO. 1 **OF** 1

DATE: March, 1985

LOGGED BY W.S.H.



DEPTH	COMMENTS. MISCELLANEOUS DATA
1088	Buff, low angle planar cross-bedd«
886'	wpll члгТрг! suh-angular rn Riib-
887'	rounded quartz grains, clay
888'	material throughout sandstone.
889	Good porosity & permeability,
L089(	no CaCO3 cement.
891	
892	
893	
894	
895"	Very good porosity and permeability
896"	Abrupt change into highly cemented
897	(CaCO3) Sandstone, no change in
898"	grain size or sed. structures
899	small clay clast.
1090C	Overall coarsen upward sequence
901	Dark gray carbonaceous shale
902"	abundant plant fragments
903	
904	
905	
906	
907	Crav 4 i 1 r c r nn p
908	
909	Rinrnrhqfod silry candcrnne,
1091g	soft sediment deformation
911	Intensely bioturbated
912	
913	
914	
915	Dark gray mottled siltstone
91У	siderite, bearing
917	
918"	

LOCATION SUN OIL COMPANY'

#1 R. E. Schmidt

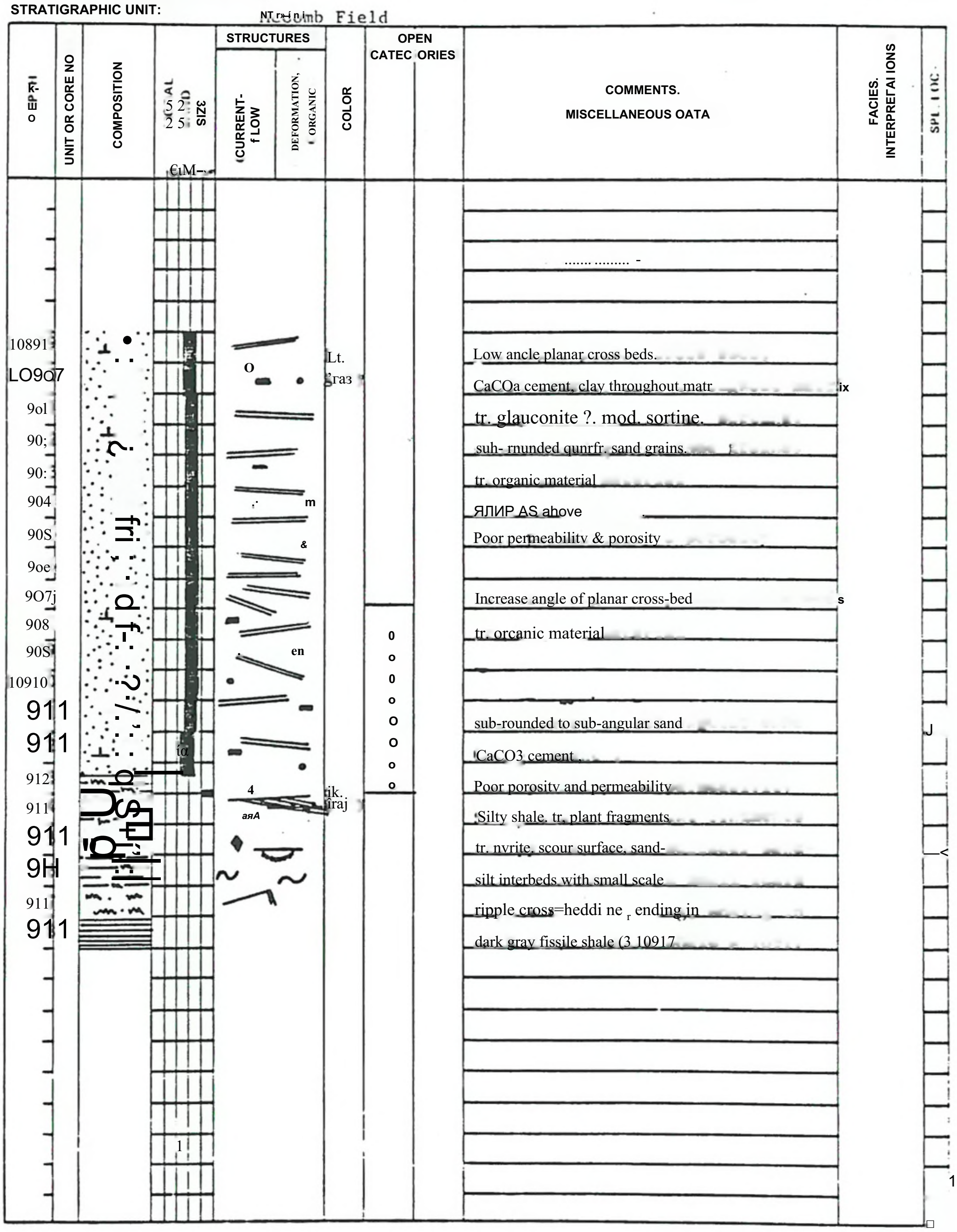
Sec. 10-3N-7E

STRATIGRAPHIC UNIT: McComb Field

SHEET NO. 1 OF 1

DATE: -December1984

LOGGED BYW. S. H.

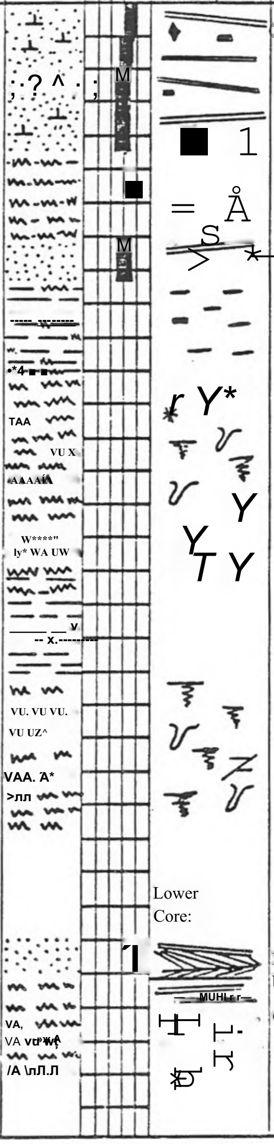


10891	Lt.	Low ancle planar cross beds.	
LO9o7	graз	CaCOa cement, clay throughout matr	ix
9ol		tr. glauconite ?. mod. sortine.	
90;		suh- rnunded qunrfr. sand grains.	
90:		tr. organic material	
904		ЯЛИР AS above	
90S		Poor permeabilitv & porosity	
9oe			
9O7j		Increase angle of planar cross-bed	s
908		tr. orcanic material	
90S			
10910			
911		sub-rounded to sub-angular sand	J
911		CaCO3 cement .	
912	ik.	Poor porositv and permeability	
911	iraj	Silty shale. tr. plant fragments	
911		tr. nvrite. scour surface. sand-	
9H		silt interbeds with small scale	
911		ripple cross=heddi ne r ending in	
911		dark gray fissile shale (3 10917	

LOCATION JUN 0Ik £0MPA*Y
fl Sinclair
C 11 ™ 7Г
Sec. 11-3N-7E

SHEET NO. J______ OF J_
DATE:
LOGGED 3Y._::^·1----------------

STRATIGRAPHIC UNIT: McComb Field



DEPTH	COLOR	COMMENTS. MISCELLANEOUS DATA
1089	Iray	Low anele planar cross-bedding.
893"		trarp nvri te_CaCO3 cement.
894·		moderate sorting, sub-rounded sand
895		Good Porosity & Permeability .
896		tr. mica, sharp contact with
897		dark grav siltstone, abundant plant
898		fragments & root structures
899		1 foot sandstone with tr. siderite
10900		Silty shale.carbonaceous plant
90Г		fragments
902		
903		Bioturbated sandv siltstone
904		Siderite bearing. Grav to Maroon
905		Tn rninr some mottiine
906·		
90^		
9oa		
90^		Siltv shale
10910		Dark grav shale tr. pvrite
91S		tr. mica
91"2		Mottled siltstone Grav-green to
9i: 3		Maroon color evidence of soft
9 b		sediment slickenslides,
91_5		Bioturbated
1095 1	Lt.	Lower core. Small scale ripple
952	buf:	crass-bedding. Interbedded light
953	Gra·	and dark colored siltstone, soft
954		e ATm«nr def., tr. siderite
955		red & maroon mottling

AЮ

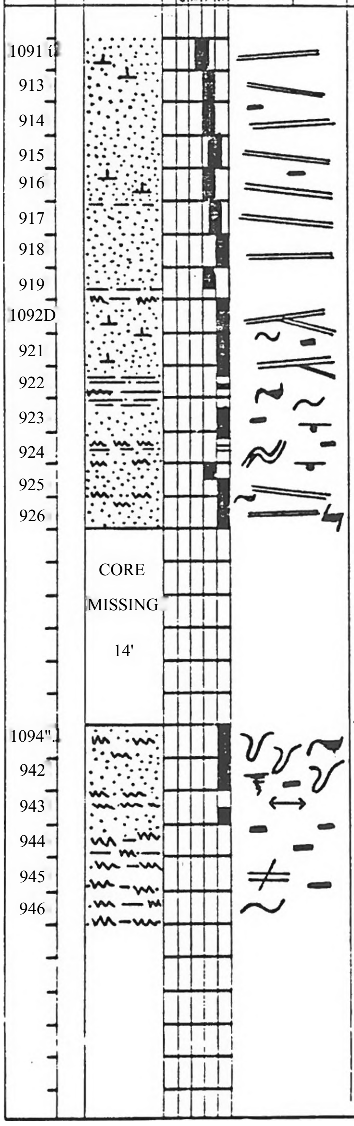
LOCATION SUN OIL COMPANY

I J. M. Crowder MFU 11-11
Sec. 11-3N-7E

SHEET NO. —OF 1
DATE : June. 1984
LOGGED BYÇ.L. G. ft ŁS.H

STRATIGRAPHIC UNIT: NgÇpnb Field

DEPTH | UNIT OR CORE NO | COMPOSITION | SIZE | STRUCTURES: CURRENT-FLOW, DEFORMATION, ORGANIC | COLOR | OPEN CATEGORIES | COMMENTS. MISCELLANEOUS DATA | FACIES INTERPRETATIONS | SPL LOC.



bight 2. ray, moderately sorted
CaCOa cemented, tr. organics, clay
in matrix. G°od Por. & Perm., Low
angle planar cross-bedded sandstone.
coarsen upward sequence
2cm layer of friable shale
Low angle cross-bedded sandstone
Inter-layered sand, siltstone,
and shale, tr. CaCOa cement
Small scale ripple cross-bedding
tr- rnrhonarpnu s matter in matrix
interhedded shale and siltstone
Soft- sedimene deformation, load
structure- flaser bedding
small scale cross-bedding, clay
cl ад Ł.

Gray, extremely bioturbated and
churned silty sandstone., soft-
sediment deformation, tr. orgs
burrowed, pull apart strurtnrp
micro fractures, some mottling

LOCATION SUN OIL COMPANY

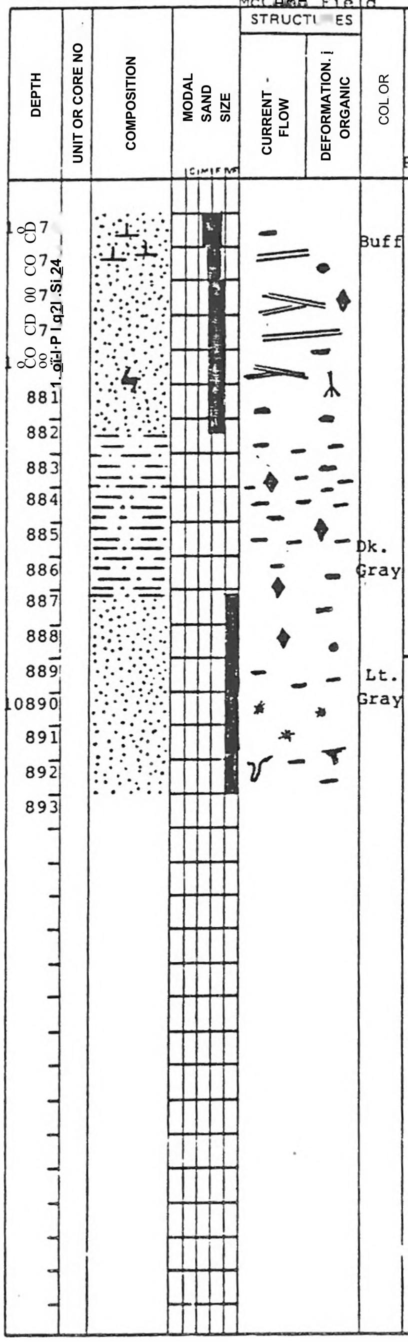
#1 Andr[illegible]

STRATIGRAPHIC UNIT: 14-3N-7E McC[illegible] Field

SHEET NO. 1 OF 1

DATE: August, 1984

LOGGED BY W.S.H.



ORE CATEGORIES

Perf.

875

888

COMMENTS. MISCELLANEOUS DATA

mod. well sorted, CaCO3 cement,

tr. glauconite ?. Good P & P.

tr. organic matter. tr. pyrite.

clay in matrix throughout.

Plant fragments. tr. rock fragments

Same as above

Interbedded vf. grain sand & shale

organic rich. (Plant fragments).

tr. pyrite. lignitic. No CaCO3 cem.

Laminated siltstone & shale,

very fissile. organic rich

Mod. sorted vf. grain sandstone.

tr. pyrite. tr. glauconite ?.

tr. mica, tr. organic material,

tr. siderite

Poor P & P, Increased clay in matrix

tr. mica

FACIES. INTERPRETATIONS

SPL. LOC.

LПГ. Д TLON SUN OIL COMPANY

#1 Jas. McCarthy

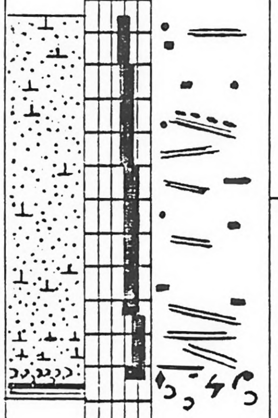
Sec 15-3N-7E

STRATIGRAPHIC UNIT; McComb Field

SHEET NO. J. OF 1

DATE : December 1984

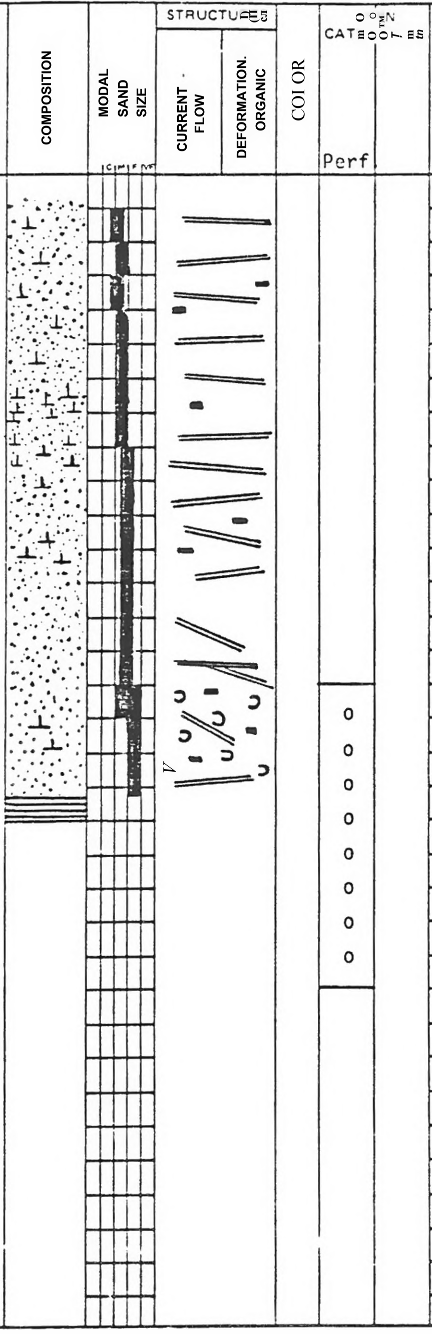
LOGGED RY w.S-П.



DEPTH	UNIT OR CORE NO	COMPOSITION	MODAL SAND SIZE	STRUCTURES		COLOR	OPEN CATEGORIES		COMMENTS. MISCELLANEOUS DATA	FACIES. INTERPRETATIONS	SPL LOC
			CEMENT	CURRENT-FLOW	DEFORMATION. ORGANIC		Perf				
1089í									Lt. oray cross-bedded, tr. qlau.		
89;									tr. organic material, CaCO^3 cement		
89í									Moderately sorted, sub-rounded sd.		
89í									Good porosity and permeability		
1090í									clay throughout matrix, tr. mica		
901									low angle cross-bedding		
9o;						o	902		.Streak., poor POГ. $ perm		
90í						o			tr. organic material throughout		
90¿						o			Well cemented, CaCOt cement		
90í						o			■Sanie as aboye		
90(						o			Higher anole cross-bedding, shell?		
9o:						o			Abrupt change to solid dark gray		
90í						o			shale, 10cm layer with clay clast		
909						o					
1091í						o					
91 1						o	912				
91 2											

LOCATION [illegible] OIL COMPANY
#1 F.Z. Mills
Sec 15-3N-7N
STRATIGRAPHIC UNIT: McComb Field

SHEET NO. 1 OF 2
DATE: March 1985
LOGGED BY W.S.H.



DEPTH	COMMENTS, MISCELLANEOUS DATA	FACIES. INTERPRETATIONS	SPL. LOC.
10948	Low angle cross-bedded sandstone		
949	tr. rock frags. Mod. sorted, CaCO3		
950	cement, tr. organic material,		
951	Good Porosity & Permeability,		
952	clay in matrix throughout sandstone		
953	Very calcareous, decrease in P & P		
954	cross-bedded Mod. sorted, tr. orgs,		
955	decrease CaCO3 cem., increase P & P		
956	Same as above		
957	thin, bedded organic rich sand		
958	Mod. sorted, subrounded sand grains		
959	Same as above		
10960	decrease in CaCO3 cement.		
961	Good Porosity and Permeability		
962	Poorly sorted sand with clay rip-up		
963	clast CaCO3 in cement higher angle		
964	cross-bedding, organic rich,		
965	Abrupt contact with black fissile		
966	shale		

A14

LOCATION SI'M OIL COMPANY

//1 F. Z. Mills

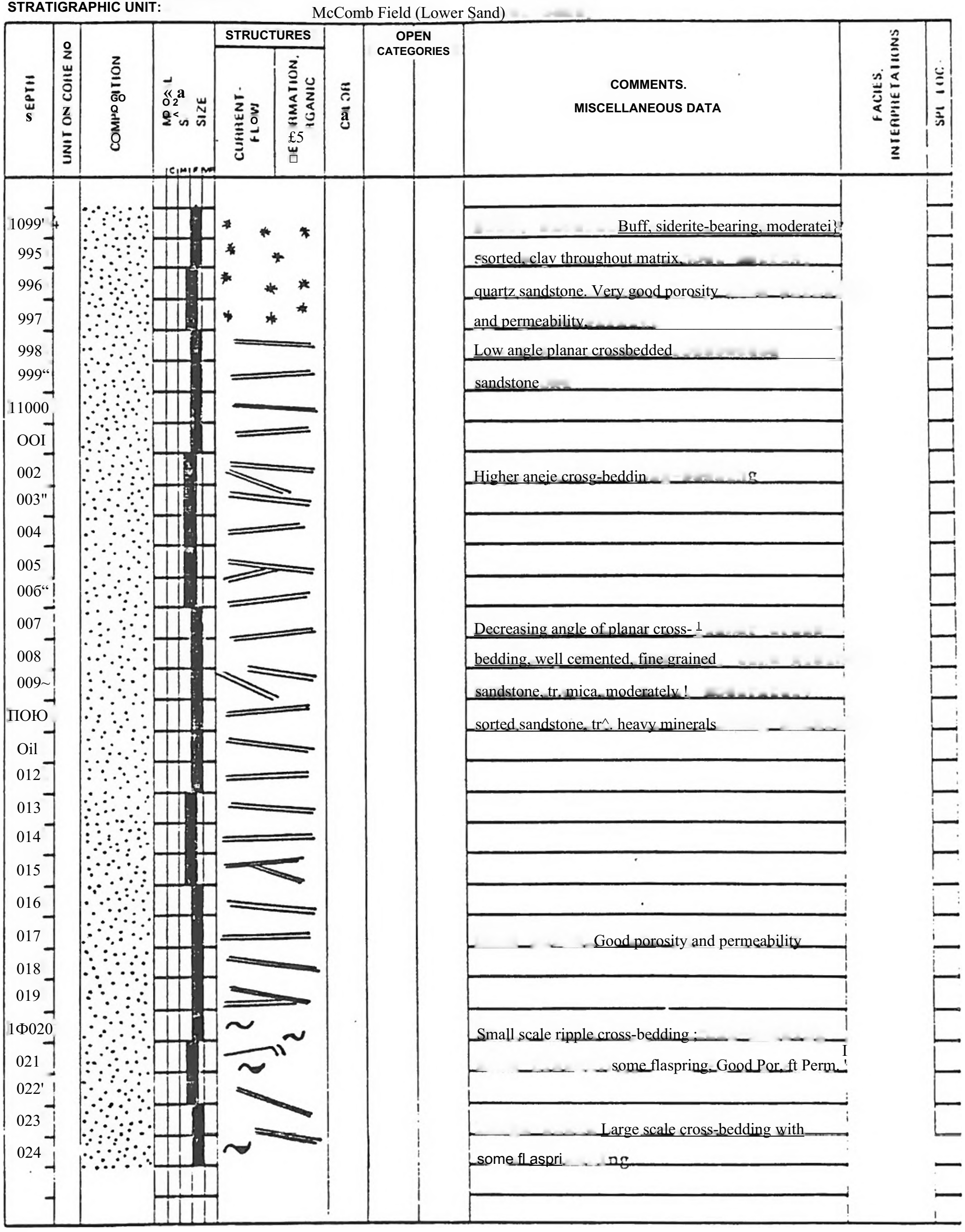
Sec. 15-3N-7E

SHEET NO. 2 . OF L

DATE : Varrh. inp.S

LOGGED RY W.S.H.

STRATIGRAPHIC UNIT: McComb Field (Lower Sand)



Buff, siderite-bearing, moderatei}
sorted, clav throughout matrix,
quartz sandstone. Very good porosity
and permeability,

Low angle planar crossbedded
sandstone

Higher aneje crosg-beddin g

Decreasing angle of planar cross- 1
bedding, well cemented, fine grained
sandstone, tr. mica, moderately !
sorted sandstone, tr^. heavy minerals

Good porosity and permeability

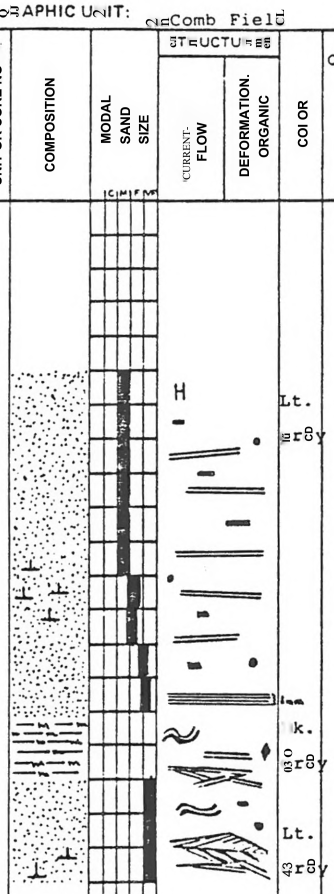
Small scale ripple cross-bedding ;
some flaspring, Good Por, ft Perm.

Large scale cross-bedding with
some fl aspri ng

LOCATION SUN OIL COMPANY
L.P. Martin #1
Sec 17-3N-7E

STRATIGRAPHIC UNIT: Comb Field

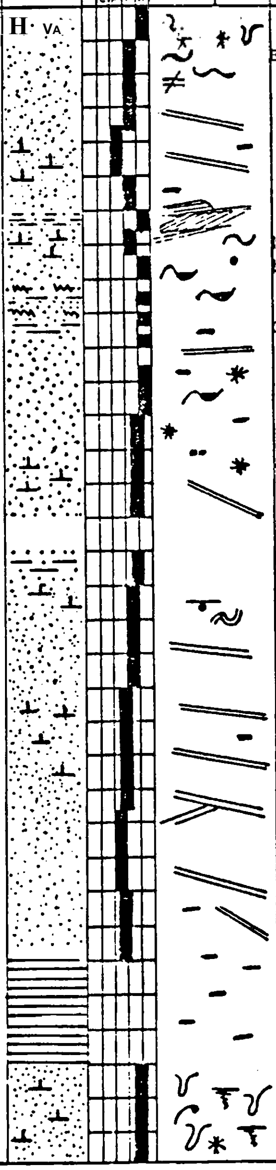
SHEET NO. 1 **OF** 1
DATE: August 1984
LOGGED BY: E.H.



DEPTH	UNIT OR CORE NO	COLOR	OPEN CATEGORIES		COMMENTS. MISCELLANEOUS DATA	FACIES. INTERPRETATIONS	SPL LOC
10960							
961							
6		Lt.			Moderately well sorted, good P&P		
96		gray			tr. organic material, tr. mica		
96					sub-rounded sand grains, tr. glauc.		
96					clay throughout matrix		
96					planar bedding		
96					tr. CaCO$_3$ cement, tr. organic mat.		
96					increase CaCO$_3$ cem., lower P&P.		
96					coarsen upward sequence		
1097							
971					thinly laminated f.-vf. sandstone		
97		Dk.			shaley-siltstone, tr. organics,		
973		gray			soft sed. deformation, tr. pyrite		
974					small scale ripple cross-bedding		
		Lt.			tr. glauconite, tr. CaCO$_3$ cement		
7		gray					
972							
97							

LOCATION J^2L£LL_COMPANY
Lampton Wallace G-l
Sec 22-3N-7E Pike Co. Miss
STRATIGRAPHIC UNIT: McComb Field

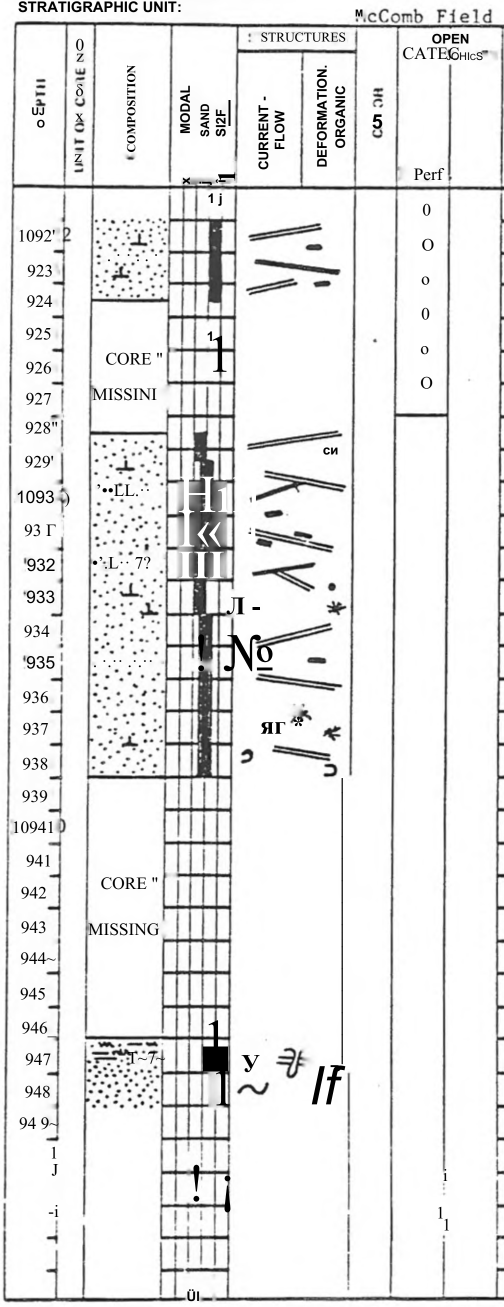
SHEET NO.1 OF A
DATE: October 1984
LOGGED RY W.S.H.



DEPTH	UNIT OR CORE NO.	COMPOSITION	MODAL SAND SIZE	STRUCTURES CURRENT-FLOW	STRUCTURES DEFORMATION. ORGANIC	COLOR	OPEN CATEGORIES Perf.		COMMENTS. MISCELLANEOUS DATA	FACIES. INTERPRETATIONS	SPL. LOC.
10939						Lt.			Slightly bioturbated, poor sortine		
940						Buff	O		tr. Siderite, fines upvard		
941							o		Micro fractures filled with brn st		
942							o o		Tabular cross-bedding. good PSP		
942							o		CaCOz cement, tr. organic matter		
944							o o				
945						lt.	o		Flase- bedding. High CaCO3. tr		
94r						Brn	o o		Glauconite ?,small scale x-bedding		
94J						Dk.	o		interbedded sand silt, tr orgs.		
94£						Gray	◦ o		fissile silty-shale interbedded sc		
94°							o		tr. siderite. tr. oras.		
109 и							o		Moderately sorted, flaser bedding		
95j							o o		breaks into clean med, sand 3 951		
95.2						Gray	θ		Good P&P.CaCOzcement. tr. Siderite		
951									High anale cross-bedding		
954									Core Missino		
955									Interbedded sand & silt Caco cem.		
95£									Soft sediment deformation		
9 5Z											
95fi											
953									Moderately sorted Good P&P.CaCOт		
10960									Sand grains suh-rounded to rounder		
961									Clay and silt throughout matrix		
9 62									Well developed cross-bedding		
9 62									Med. qrained moderately well sort		
9 64											
965									High anale vzeli developed x-beds		
96^									tr. organic material		
96j									Dark qray shale break		
96J											
9 6											
10974						Dk.			Zone of intense bioturbation		
97-						Gray			shell fragment. CaCO3. poor sort.		
97:									tr. Siderite		

LOCATION SUN 011, COMPANY
Lampton Wallace //Л-1
Sec. 22-3N-7E
STRATIGRAPHIC UNIT:
McComb Field

SHEFT NO. ‡ ПР _ЈL
D A T E : December, 1984
LOGGED RY W-S.H.



COMMENTS.
MISCELLANEOUS OATA

T.ifht buff. tr. rarbnnarenns matt
poorly sorted, suh-aneular.quartz
canHctono good Por. Ä Perm.

Ruff, organic-rich . tr. CaCO3.
tr. mira. pnnrlv sorted, rrocc-
bedded sandstone, abundant woodv
plant fragments, good Por. & Perm
trace of 1 - 2cm size clav clast
tr. siderite. tr. CaCOa cement
residual oil or lignite in 1mm
lavers interbedded in sandstone
good Por. 5 Perm.. moderatelv
sorted, tr. sand-size rock frags.
tr. clav clast

Dark grav shalev siltstone. soft
sed. deformation, tr. mira. intene
bioturbation. small scale cross-beds

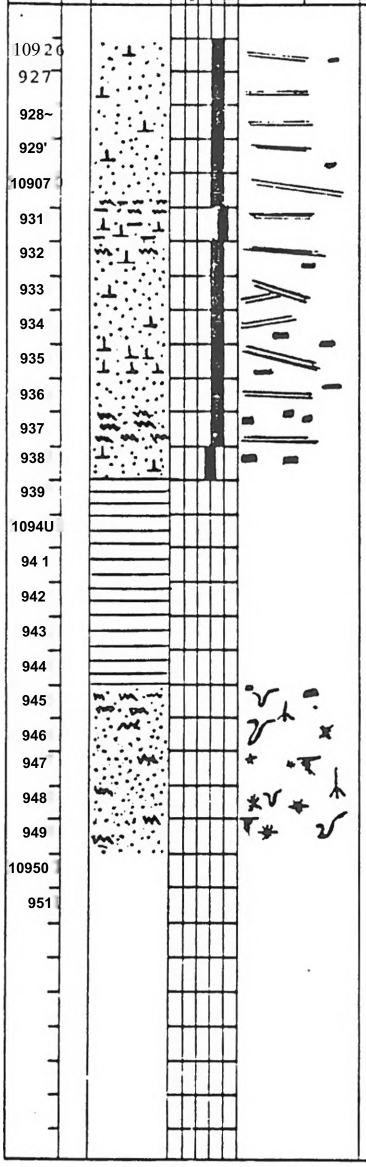
FACIES. INTERPRETATIONS

LOCATION LUU OIL COMPAПУ
It 1 McComb Field unit 2 7·* 11
Sec. 27-3N-7E
McComb field

SHEET NO. J OF_J
ПДТР: March 1985
LOGGED BY_W.^_U

STRATIGRAPHIC UNIT:

DEPTH | UNIT OR CORE NO | COMPOSITION | STRUCTURES: CURRENT-FLOW, DEFORMATION, ORGANIC | COLOR | OPEH CATEGORIES | COMMENTS. MISCELLANEOUS ОЛТА | FACIES INTERPRETATIONS | SPL LOG



Low angle cross-bedded trę orgs. mod
well sorted.CaCOg cement , t r. sma 1 1
slay clast. Good PM> , clay inmatri x

Thinly layered shaley-silistone
tr, olant frags,, CaCO3 cement ,
moderately sorted crossbedded sand
Good P&P
Increase CaCOg cement. Organic-rich
Sandstone with interbedded silt
interlaminated with orgs,& small
Clay clast, plant fragments, lignite
Dark gray shale. Fissile

Bioturbated siltstone, tr. mica
Lt. gray sjltv sandstone, tr. side r ite
some root casts, bioturbation

DEPOSITIONAL FACIES INDEX

SF	Shoreface
BC	Barrier Core
TI	Tidal Inlet Fill
WF	Washover Fan
LG	Lagoon

PLATE III

CROSS SECTION A—A ′

McCOMB FIELD

PIKE COUNTY MISSISSIPPI

DATUM: TOP LOWER TUSCALOOSA

W. STEWART HAMILTON JR. USM M.S. 1986

DEPOSITIONAL FACIES INDEX

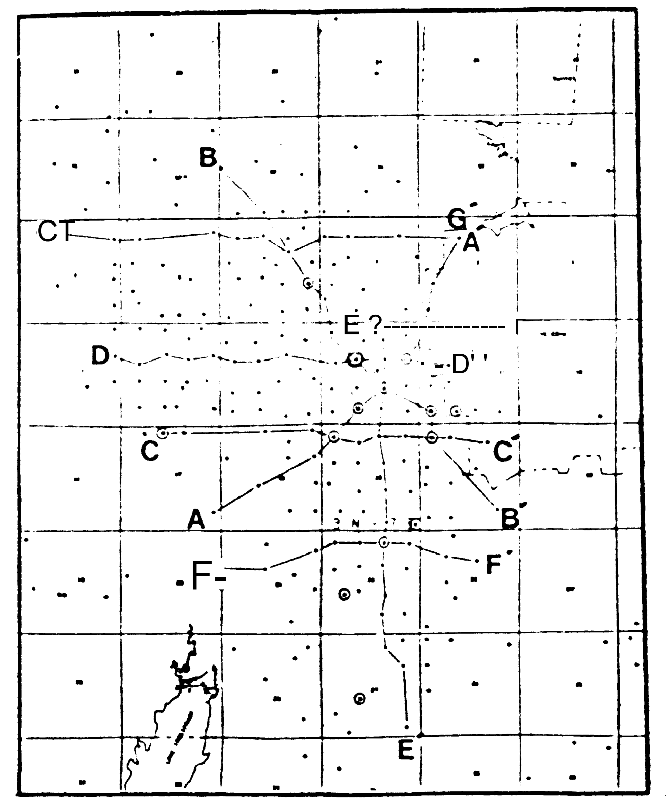
SF	Shoreface
BC	Barrier Core
TI	Tidal Inlet Fill
WF	Washover Fan
LG	Lagoo n

VERTICAL SCALE

100 Feet

1000 Feet 500 0

HORIZONTAL SCALE



McComb Field Cross Section Location Map

Oil Wen ●

Dry Hole ⌖

Core Data ⊙

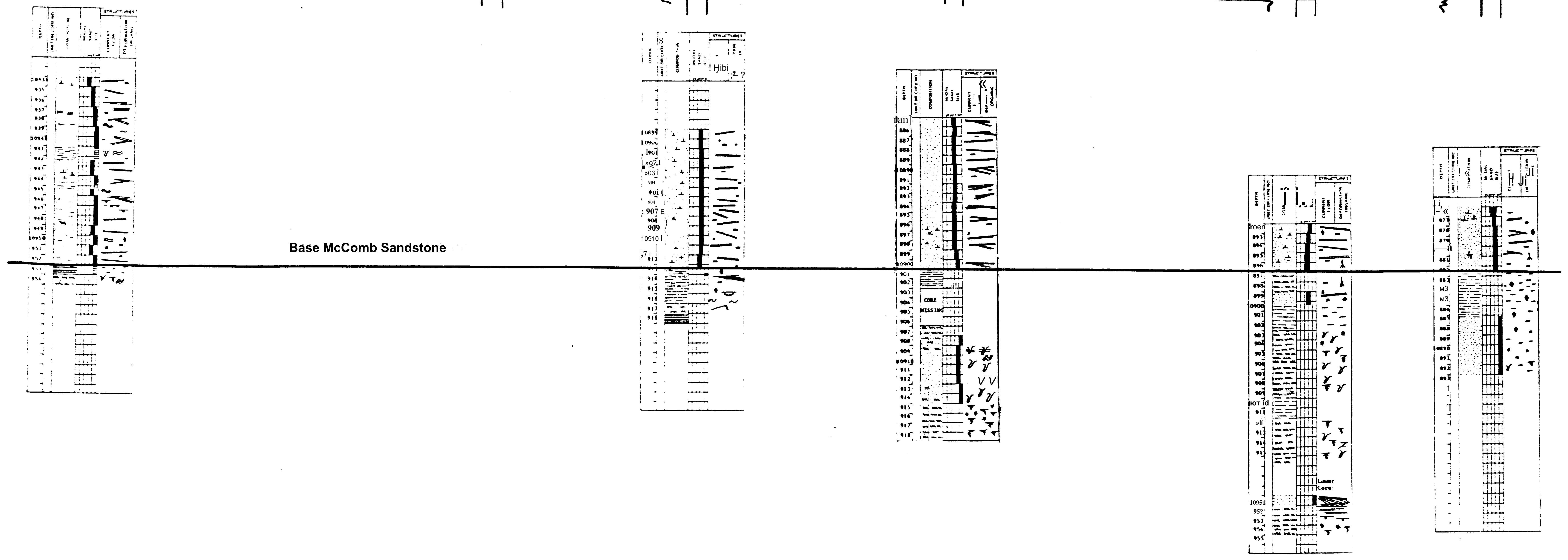


PLATE IV

CROSS SECTION B—B ′

McCOMB FIELD

PIKE COUNTY MISSISSIPPI

DATUM: TOP LOWER TUSCALOOSA

W. STEWART HAMILTON JR. . USM M.S. 1986

DEPOSITIONAL FACIES INDEX

SF	Shoreface
BC	Barrier Core
TI	Tidal Inlet Fill
WF	Washover Fan
LG	Lagoon

PLATE V

CROSS SECTION C-C′

McCOMB FIELD

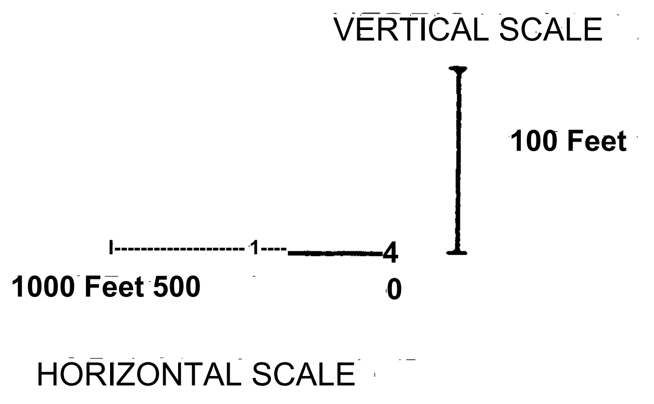
PIKE COUNTY MISSISSIPPI

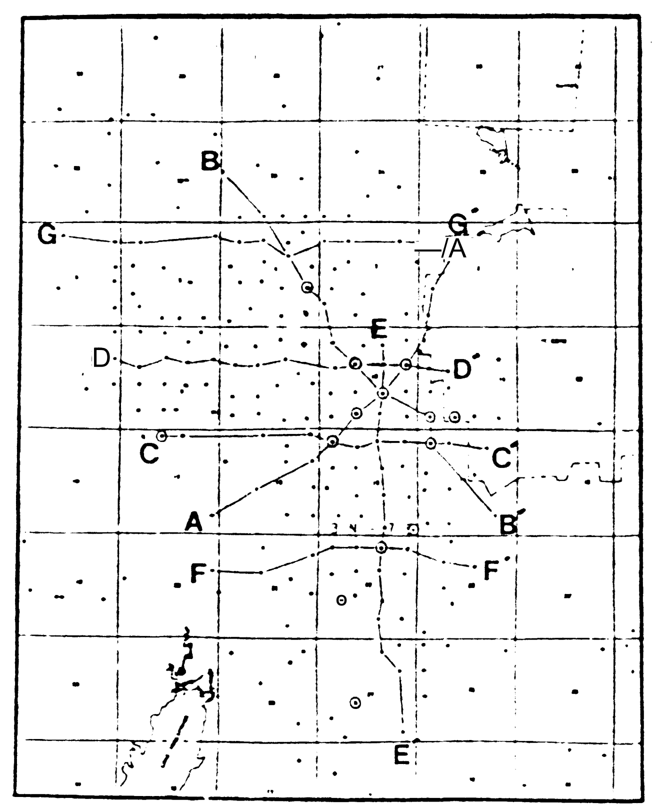
DATUM: TOP LOWER TUSCALOOSA

W. STEWART HAMILTON, JR. USM M.S. 1986

DEPOSITIONAL FACIES INDEX

SF	Shoreface
BC	Barrier Core
TI	Tidal Inlet Fill
WF	Washover Fan
LG	Lagoon





McComb Field Cross Section Location Map

Oil WeN ●

Dry Hole ✧

Core Data 0

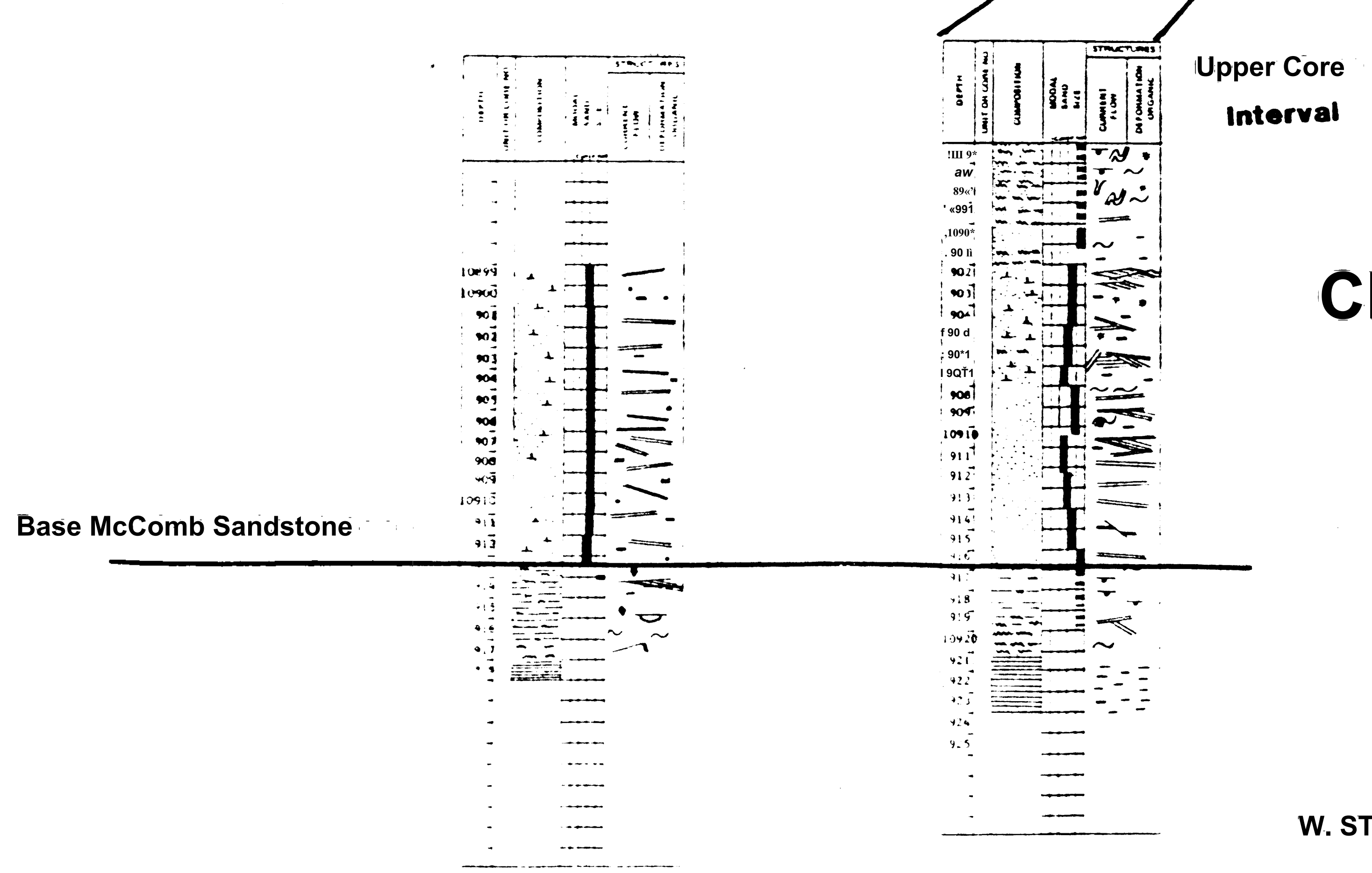


PLATE I

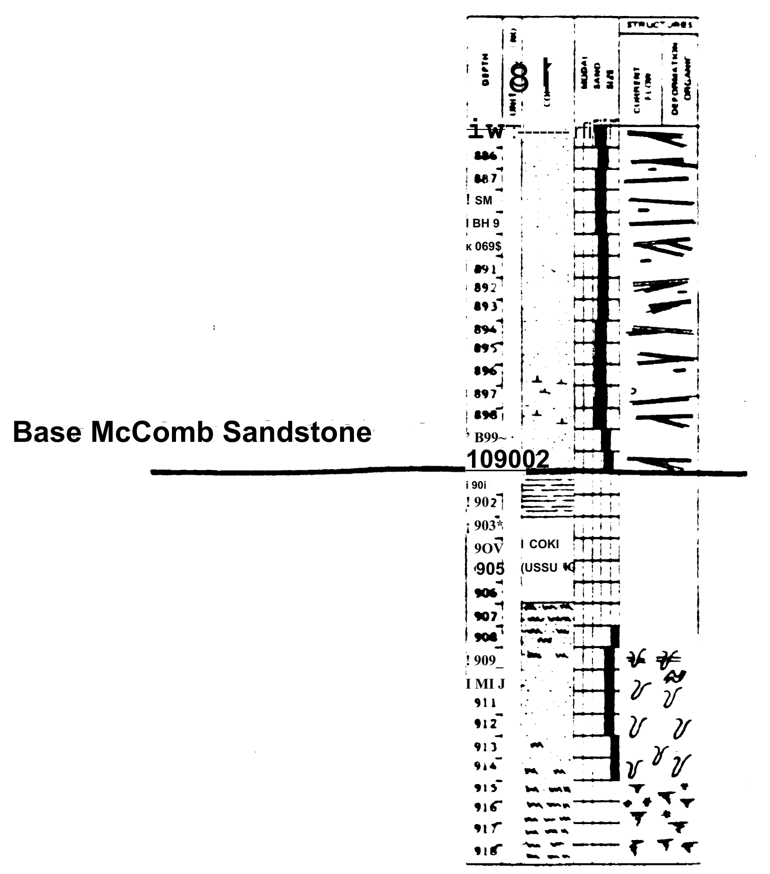
CROSS SECTION D-D´

McCOMB FIELD

AKE COUNTY MISSISSIPPI

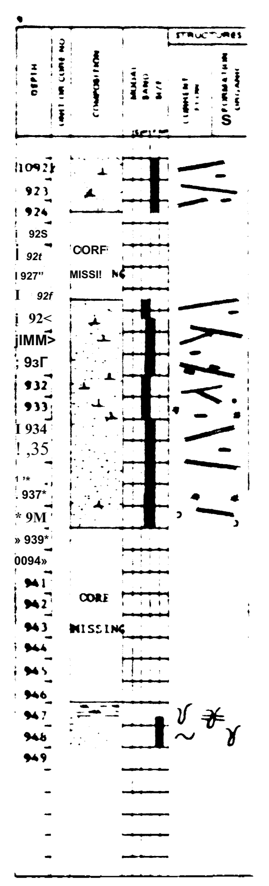
DATUM: TOP LOWER TUSCALOOSA

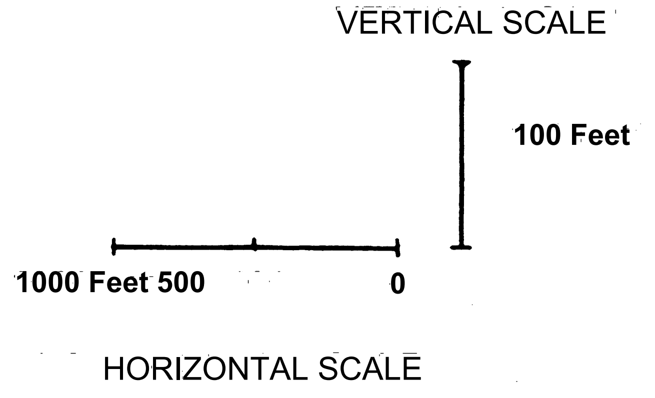
W. STEWART HAMILTON JR. USM M.S. 1986

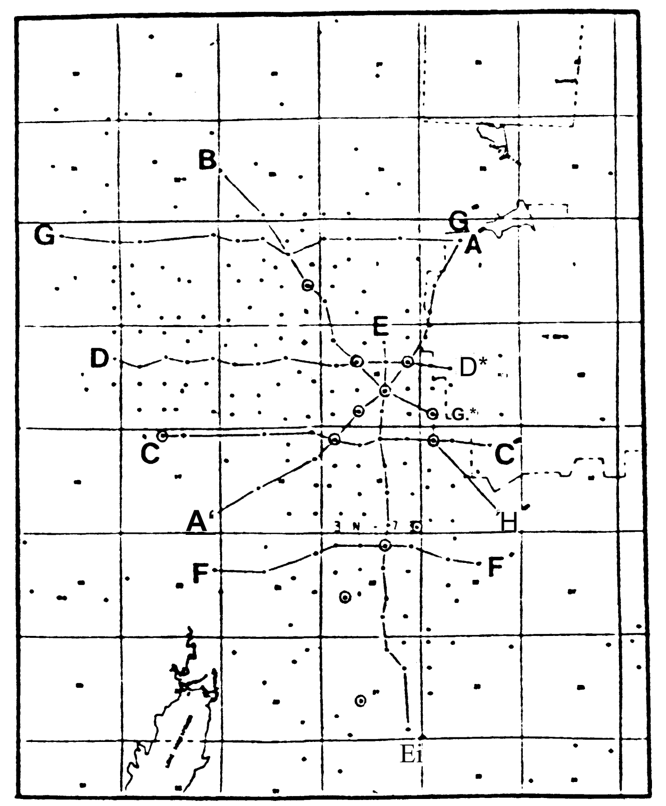


CEPOSITIONAL ENVIRONMENT INDEX

SF	Shoreface
BC	Barrier Core
TI	Tidal Inlet Fill
WF	Washover Fan
LG	Lagoon
FT	Flood Tidal Delta







McComb Field Cross Section Location Map

OЯ Well	●
Dry Hole	⌖
Core Data θ	

PLATE VII

CROSS SECTION E-E ′

McCOMB FIELD

RKE COUNTY MISSISSIPPI

DATUM: TOP LOWER TUSCALOOSA

W. STEWART HAMILTON JR. USM M.S. 1986

DEPOSITIONAL FACIES INDEX

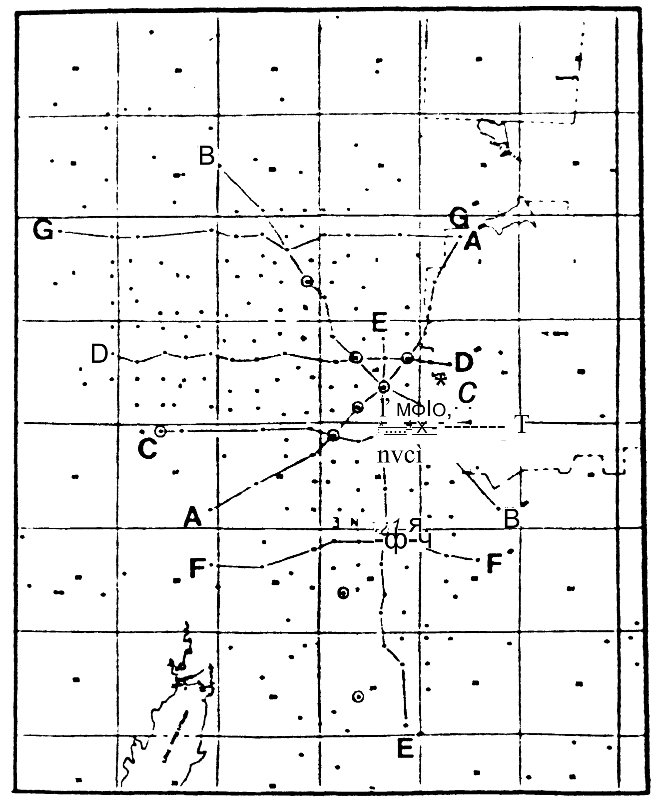
SF	Shoreface
BC	Barrier Core
LG	Lagoon

VERTICAL SCALE

100 Feet

1000 Feet 500 0

HORIZONTAL SCALE



McComb Field Cross Section Location Map

Oil Well	●
Dry Hole	✧
Core Data	⊙

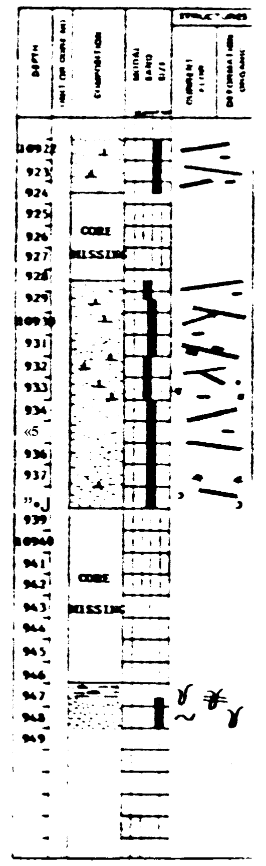


PLATE VIII

CROSS SECTION F -F ′

McCOMB FIELD

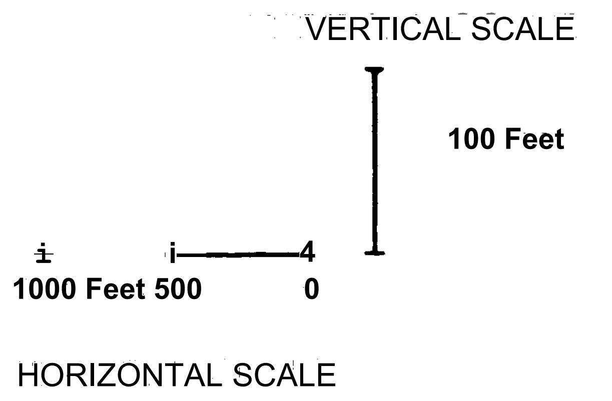
PIKE COUNTY MISSISSIPPI

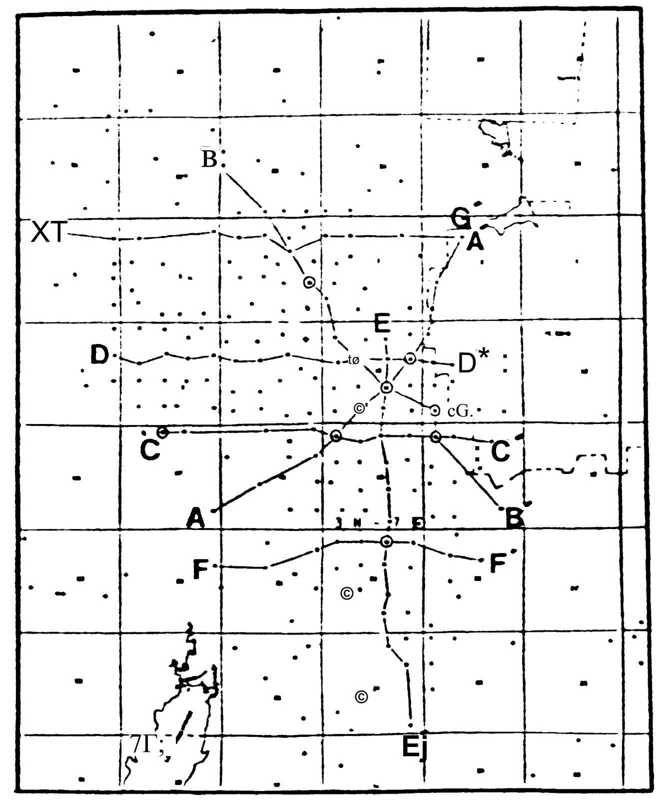
DATUM: TOP LOWER TUSCALOOSA

W. STEWART HAMILTON JR. USM M.S. 1986

DEPOSITIONAL FACIES INDEX

SF	Shoreface
BC	Barrier Core
TI	Tidal Inlet Fill
WF	Washover Fan
LG	Lagoon





McComb Field Cross Section Location Map

Oil Well ●

Dry Hole ⌖

Core Data θ

PLATE IX

CROSS SECTION G-G'

McCOMB FIELD

PIKE COUNT MISSISSIPPI

DATUM: TOP LOWER TUSCALOOSA

W. STEWART HAMILTON JR. USM KS. 1986

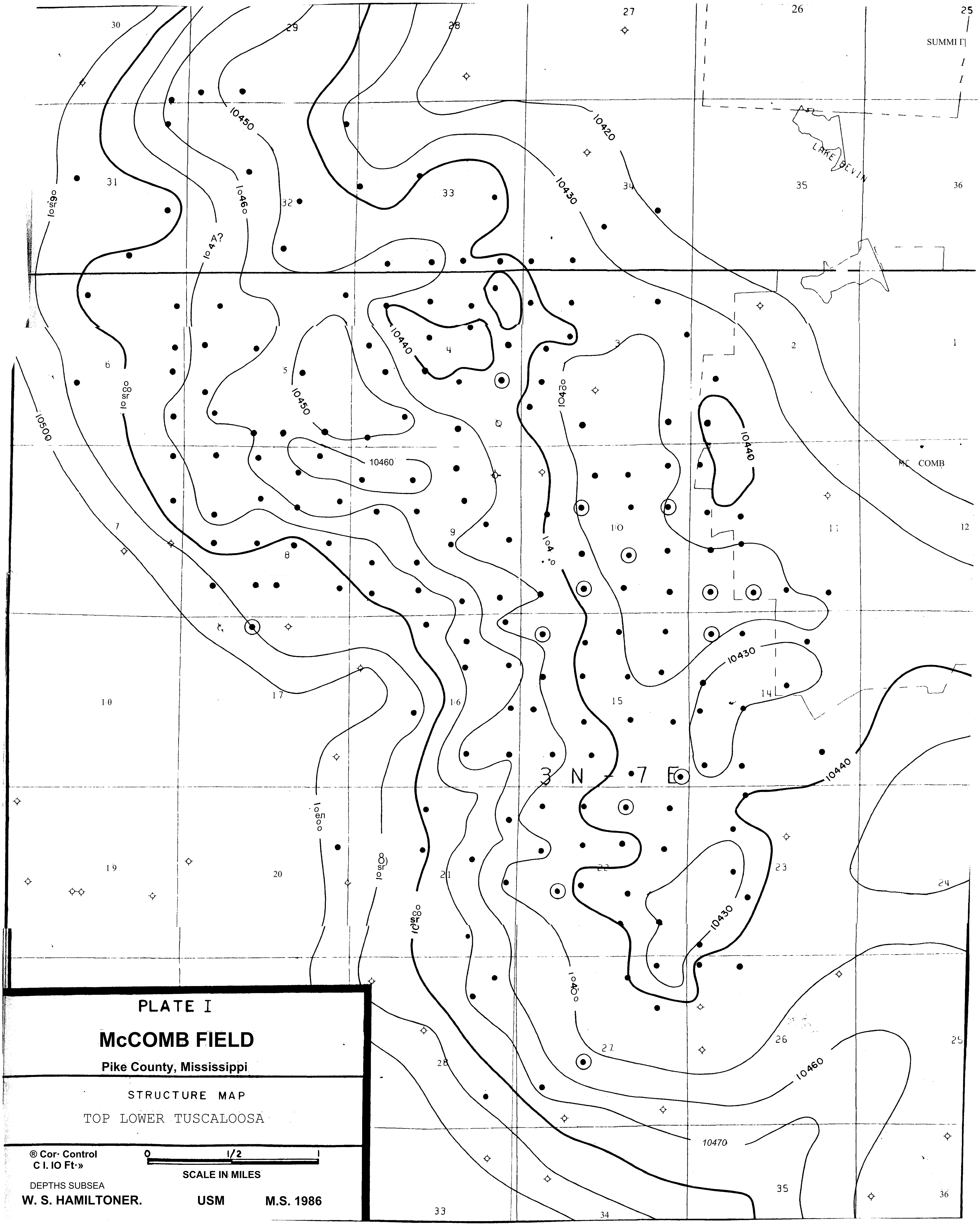


PLATE I

McCOMB FIELD

Pike County, Mississippi

STRUCTURE MAP

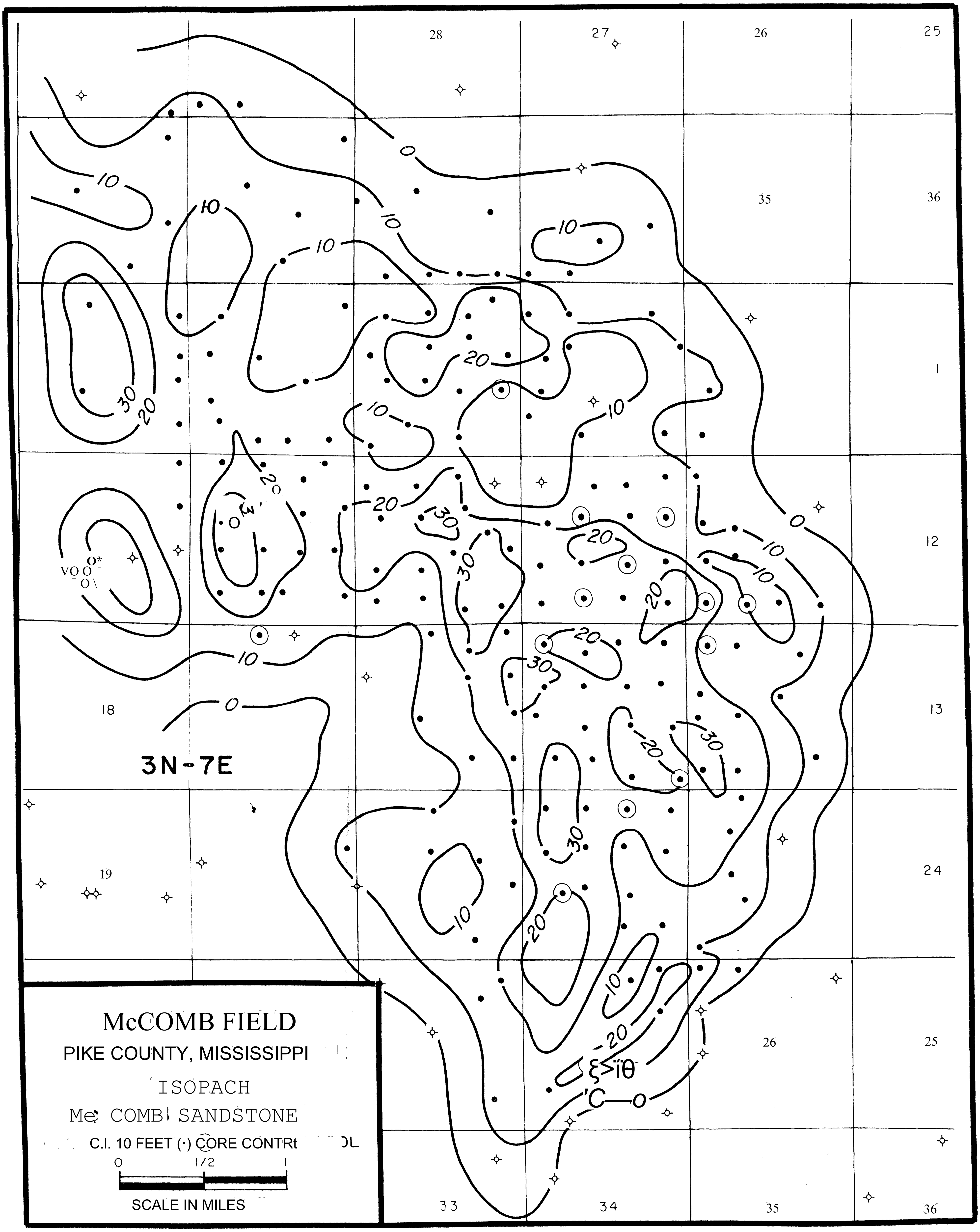
TOP LOWER TUSCALOOSA

® Cor· Control
C I. IO Ft·»

0 1/2 1
SCALE IN MILES

DEPTHS SUBSEA

W. S. HAMILTONER. **USM** **M.S. 1986**



McCOMB FIELD

PIKE COUNTY, MISSISSIPPI

ISOPACH

McCOMB SANDSTONE

C.I. 10 FEET (·) CORE CONTROL

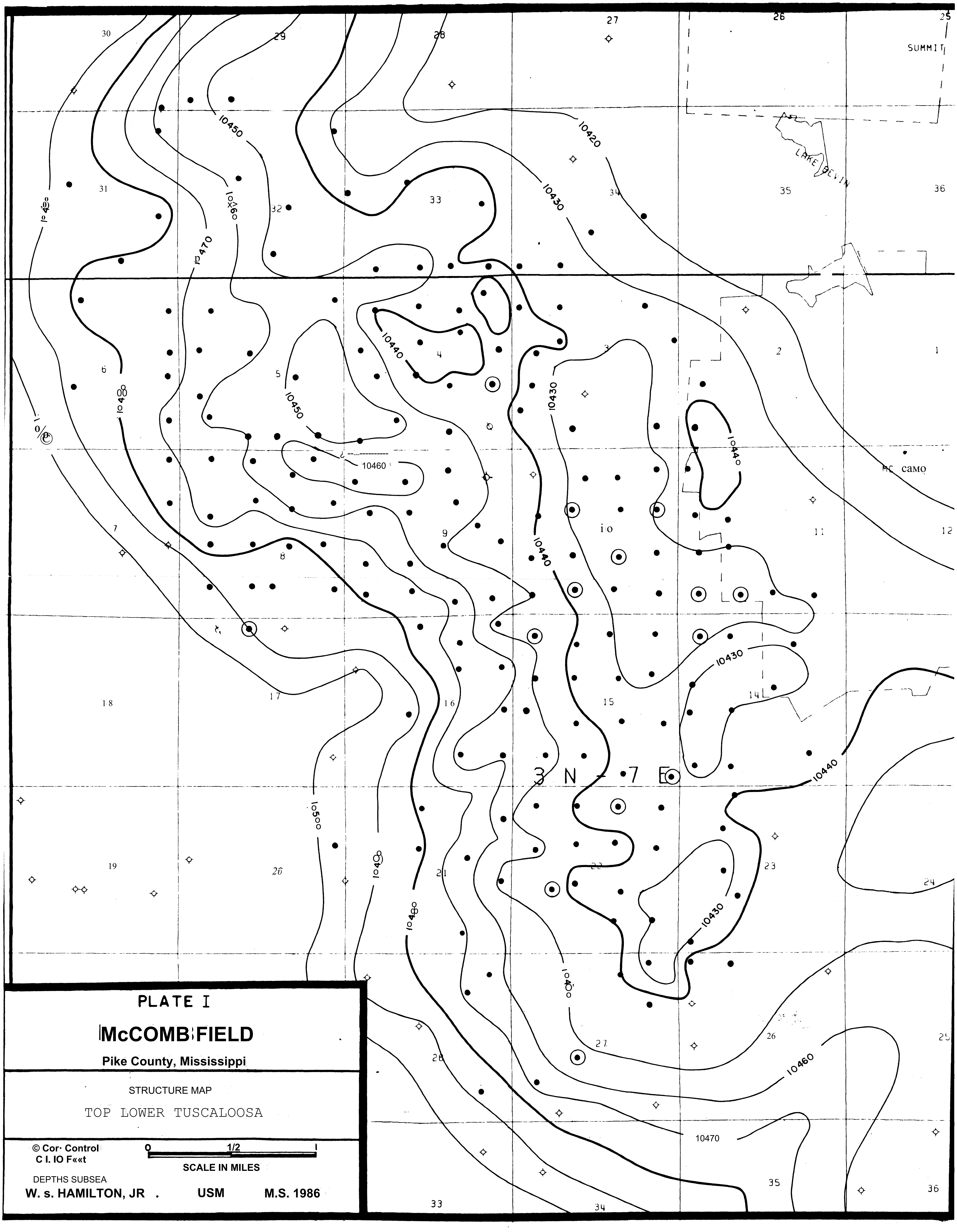


PLATE I

McCOMB FIELD

Pike County, Mississippi

STRUCTURE MAP

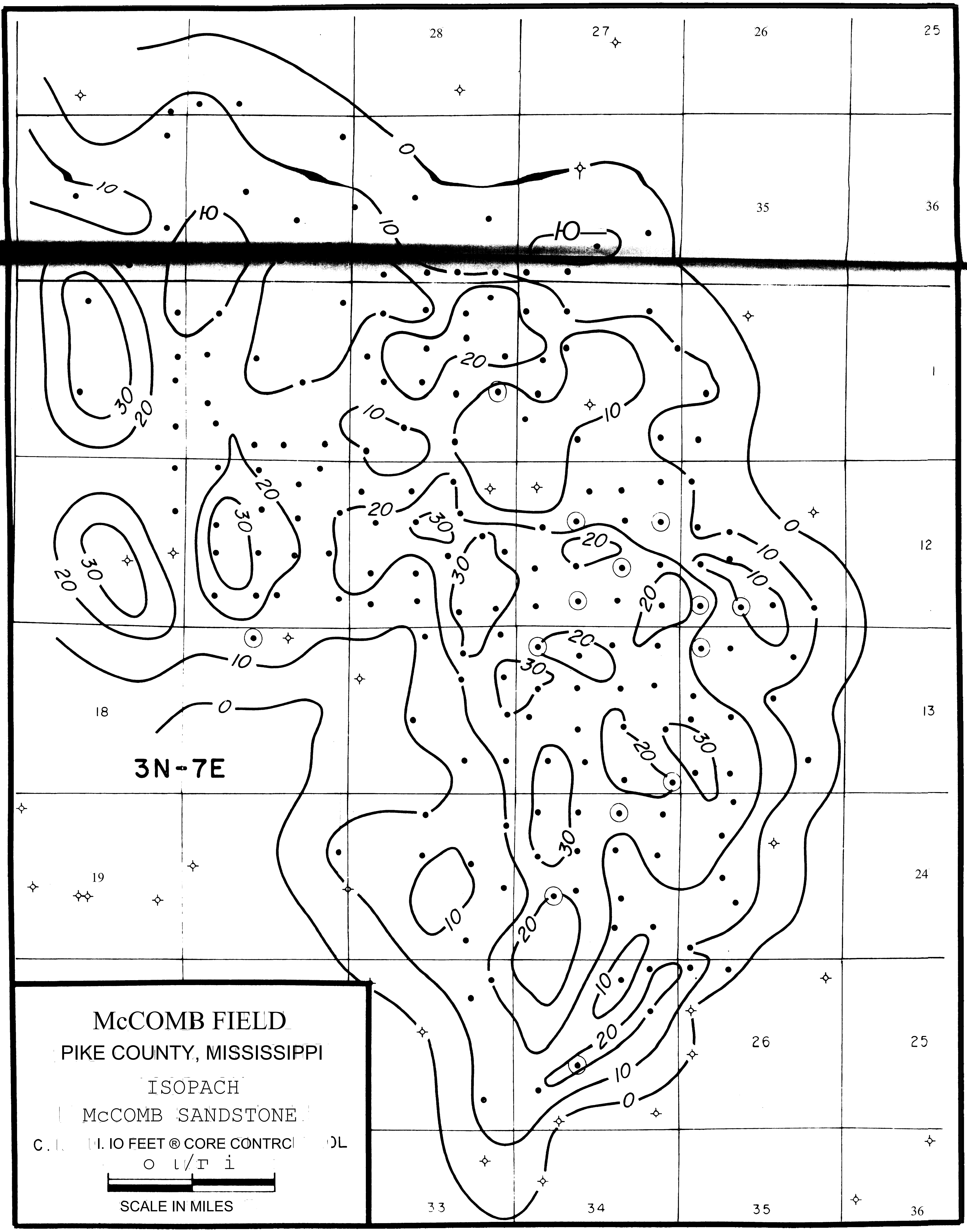
TOP LOWER TUSCALOOSA

⊙ Core Control
C.I. 10 Feet

0 1/2 1
SCALE IN MILES

DEPTHS SUBSEA

W. S. HAMILTON, JR. **USM** **M.S. 1986**



McCOMB FIELD

PIKE COUNTY, MISSISSIPPI

ISOPACH

McCOMB SANDSTONE

C.I. 10 FEET ⊙ CORE CONTROL

0 1/2 1

SCALE IN MILES