STRATIGRAPHY OF NEWLY EXPOSED QUATERNARY SEDIMENTS, EASTERN ORLEANS PARISH, LOUISIANA

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CONTENTS

I. ABSTRACT

Five Late Quaternary stratigraphic units are exposed at the Lake Carmel borrow pit in eastern Orleans Parish. These are, in ascending order: 1) deltaic equivalents of Deweyville terrace alluvium (Wisconsin); 2) a buried soil zone, herein informally named "Little Woods paleosol" (late Wisconsin-early Holocene); 3) bay-sound clay, herein formally designated the "Michoud Formation" (middle Holocene); 4) barrier bar sand of the New Orleans trend (middle Holocene); and 5) St. Bernard prodeltaic and delta front deposits (late Holocene). This succession of beds records the environmental history of the vicinity of the borrow pit as the following sequence of major events: 1) the emergence of a late Pleistocene delta lobe and pedogenic alteration of deltaic deposits; 2) the subsequent inundation of the southern Lake Pontchartrain and New Orleans area by transgressive Gulf waters forming the Pontchartrain Embayment; 3) progradation of the New Orleans barrier trend across the mouth of the embayment; and finally, 4) encroachment of a St. Bernard delta lobe on the New Orleans trend and eventual isolation of the embayment from the Gulf of Mexico to form the present Lake Pontchartrain.

II. INTRODUCTION

Although thousands of borings and temporary excavations of various kinds have penetrated the Holocene and late Pleistocene sediments beneath the New Orleans area, surface exposures of these deposits essentially do not exist. For the most part, stratigraphic information on these shallow subsurface deposits has come from borings that were originally used to collect data for engineering projects (*e.g.*, Saucier, 1963; Kolb *et al.*, 1975); paleontologic information has come mainly from a few temporary excavations and spoil piles in the area associated with road and canal construction (*e.g.*, Rowett, 1957; DeWindt, 1974; Hollander and Dockery, 1977). Likewise, information used to reconstruct the Quaternary history of the Mississippi Delta has necessarily come from subsurface borings (*e.g.*, Fisk and McFarlan, 1955; Coleman and Gagliano, 1964; Kolb and van Lopik, 1966; Frazier, 1967). In a region where surface elevations are at or just below sea level, borrow pit exposures represent extremely

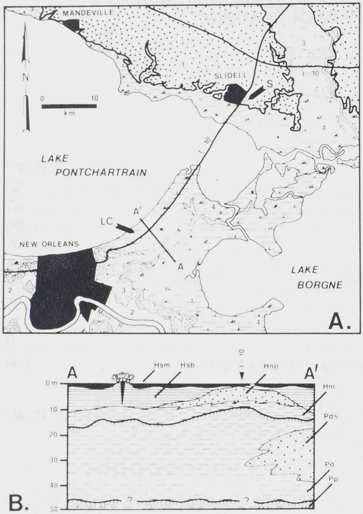

Fig. 1. Index map and general stratigraphy of eastern Orleans Parish. A, Location of Lake Carmel Borrow pit (LC). Symbols have the following meanings: 1 = Prairie Terrace, 2 = natural levee, 3 = back-levee swamp, 4 = marsh, S = borrow pit near Slidell with exposure of Prairie Formation. B, Cross-section showing formational units in eastern Orleans Parish, including: Pp = Pleistocene Prairie Formation; Pd = Pleistocene Deweyville equivalents; Pds = large sand body within the Deweyville beneath the south shore of Lake Pontchartrain; Hm = Holocene Michoud Formation (new name used herein); Hsb = Holocene St. Bernard deltaic blanket; and Hsm = Holocene swamp and marsh surface deposits. (See text for explanation of stratigraphic relationships. Map and cross-section after Saucier, 1963, Figs. 7 and 18, with modifications.)

important opportunities to study lithostratigraphic units that are usually only known from borings (*e.g.*, Otvos, 1978).

In 1980 and 1981, I had the opportunity to study an extraordinary 12 m vertical exposure of Quaternary deposits in eastern Orleans Parish, about 16 km from downtown New Orleans. The purpose of this report is to describe the lithostratigraphy of the Lake Carmel borrow pit, and to use well-exposed physical and biogenic sedimentary structures, textures, sequence of units, and fossils to reconstruct the late Pleistocene to Holocene environmental history of the area. In addition, I describe for the first time in detail the nature of the Pleistocene-Holocene contact in the New Orleans East area, propose two new stratigraphic unit names, and list over 140 fossils from the exposure.

III. ACKNOWLEDGMENTS

I wish to acknowledge the invaluable assistance provided by the late Dr. Charles R. Kolb in the preparation of this paper. Dr. Kolb encouraged my work, and provided critical information on local stratigraphy and allowed the use of radiocarbon dates obtained at the Lake Carmel pit.

Drs. Harold E. and Emily H. Vokes accompanied me in the field and provided the excellent photographs. Mr. George Mollyn identified the fossil mollusks listed in the Appendix. Mr. Nelson Chatelain, owner of the property on which the pit is located, gave permission to work at the site. The manuscript was carefully reviewed by Drs. Jules R. DuBar, Ervin G. Otvos, and Jesse O. Snowden, but I remain solely responsible for all observations, conclusions, and speculations embodied in the final version.

IV. LOCALITY AND METHODS

The Lake Carmel pit is located in an area of reclaimed wetland, between Lake Carmel housing development on the east and Jahncke Canal to the west, 0.5 km northeast of the junction of Bullard Avenue and U. S. Interstate Highway 10 on the outskirts of New Orleans (Fig. 1, A). Surface elevations in the vicinity of the pit average −1.5 to −2 m, and the deepest areas of excavation are about 15 m below mean sea level (13 m below the surrounding land surface). Surface deposits in the area consist of Recent marsh peats and organic muds, which are described in several reports on the environmental geology of the Mississippi deltaic plain in the environs of New Orleans (see Saucier, 1963; Kolb and van Lopik, 1966; Bankey, 1980; Snowden *et al.*, 1980).

The borrow pit was visited at irregular intervals during 1981 to measure the sec-

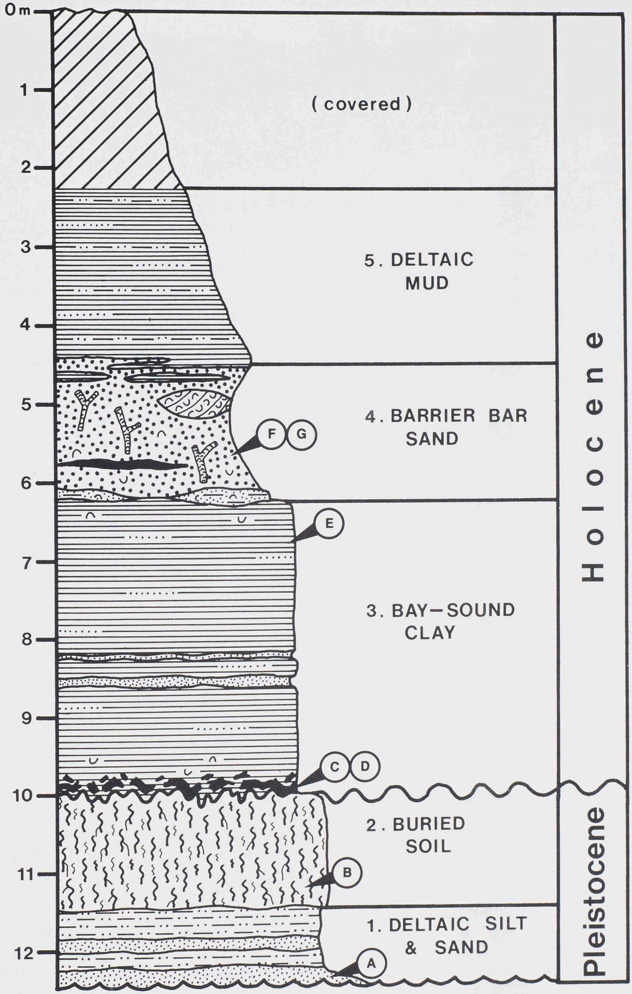

Fig. 2. Composite columnar section of the Lake Carmel borrow pit. Lithostratigraphic unit numbers correspond to unit numbers in Table 1. Circled letters are sample locations for radiocarbon dates: A, 31,270± 370 years B.P.; B, 7,690± 70 years B.P.; C, 7,290± 80 years B.P.; D, 7,200± 50 years B.P.; E, 4,290± 50 years B.P.; F, 11,090± 90 years B.P.; G, 29,860± 430 years B.P. Radiocarbon dates are discussed in the text and Table 2.

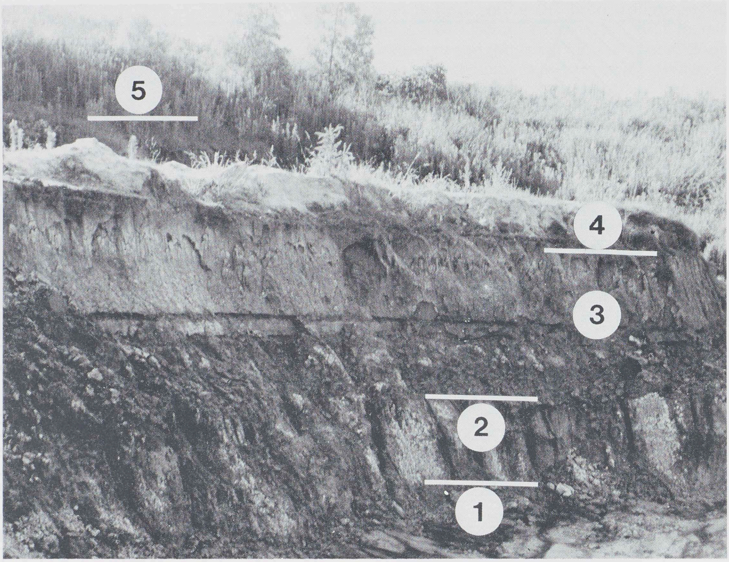

Fig. 3. Northeast wall of Lake Carmel pit, as it appeared in June, 1981. Unit numbers correspond to those used in Fig. 2 and Table 1.

tions exposed in the walls of the pit, to record information on sedimentary structures, and to make collections of fossils. Photographs and detailed sketches of contacts and structures were made, and bulk samples of fossiliferous intervals were collected and later wet-sieved to remove all identifiable fossils. Fossil collections were supplemented by hand-picking specimens from spoil piles, and organism-substrate relations were assessed by observing fossils *in situ* within entombing sediments. Lithostratigraphic units and the Pleistocene-Holocene contact exposed in the pit were traced into the surrounding area using published compilations of bore hole data (Saucier, 1963; Frazier, 1967; Kolb *et al.*, 1975). Lastly, the environmental history of the deposits was deduced by first comparing the sedimentologic and paleobiologic characteristics of units in the pit with published descriptions of modern and ancient depositional sedimentary environments (Shepard, 1962; Kolb and van Lopik, 1966; Frazier, 1967; Katuna and Ingram, 1974; Reineck and Singh, 1975; Friedman and Sanders, 1978; Reading, 1978; Walker, 1979; Howard and Frey, 1980), and then ordering the identified facies in vertical succession.

V. STRATIGRAPHIC FRAMEWORK

The stratigraphic section exposed in the Lake Carmel borrow pit is divisible into five formational units (Figs. 2, 3). The sequence of units is broken by a major unconformity near the base of the section (Fig. 4), which separates Pleistocene from overlying Holocene sediments in the New Orleans-Lake Pontchartrain region. Lithostratigraphic units identified at the pit are listed and described in Table 1. These units, including a new lithostratigraphic unit and new soil-stratigraphic unit, are discussed below in ascending order, starting at the base of the exposure.

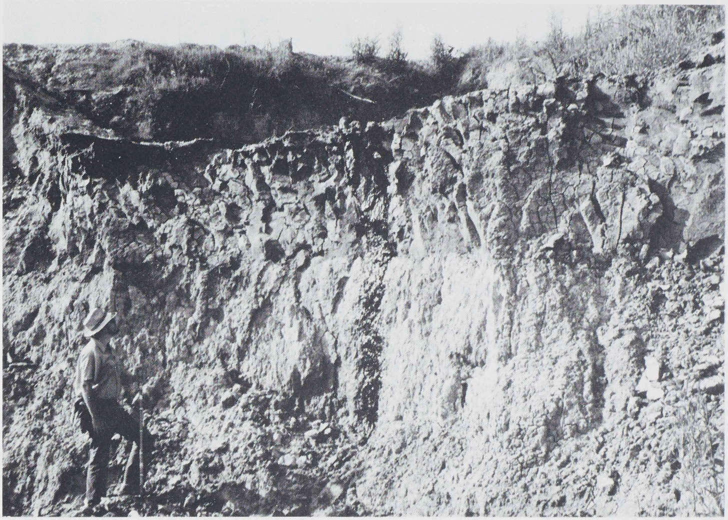

Fig. 4. Pleistocene-Holocene contact exposed in southwestern wall of borrow pit. Contact is an angular unconformity separating light-colored Little Woods paleosol (below) from dark-colored Michoud Formation (above). Man, to left, provides scale.

Pleistocene Sediments
(Deweyville Terrace Equivalents)*

The deepest parts of the pit expose the top of a Pleistocene unit of unknown total thickness that appears to represent a deltaic facies of the Deweyville Terrace (see Flint, 1971, p. 557). These sediments consist of an interbedded sequence of slightly indurated, greenish silts and micaceous sands containing occasional fragments of fossil wood. Pleistocene sediments encountered in subsurface borings directly beneath Holocene deposits in the New Orleans area traditionally have been assigned to the Sangamon Prairie Terrace (see Saucier, 1963; Hollander and Dockery, 1977; Snowden *et al.*, 1980). Recently, however, Kolb *et al.* (1975, p. 3-5, Plate 2) suggested that the downslope deltaic equivalents of the Wisconsin Deweyville Terrace in the Pearl River valley could possibly be found directly beneath the Holocene sediments in the vicinity of Lake Pontchartrain. Prairie equivalents might occur in the area,

*The river-valley and coastwise terraces of southern Louisiana are morphostratigraphic units like the terraces of the southern Atlantic Coastal Plain. However, the Atlantic Coastal Plain terraces have been intensively restudied, with the result that older terrace-formation terminology is currently being replaced by more conventional lithostratigraphic nomenclature (*e.g.*, Oaks and DuBar, 1974). The detailed reevaluation and clarification of Louisiana terrace-formation stratigraphy has not yet begun, so that the traditional morphostratigraphic designation "terrace" must be retained here to mean what it has always meant in this context — either the morphologic feature, the underlying sediments associated with that feature, or both. When the Deweyville, Prairie, and Montgomery Terraces are restudied, it is likely that this morphostratigraphic terminology also will be replaced by new formation names based on the careful delineation of lithologic units, with carefully described type and reference sections, and mapped using lithologic rather than geomorphic criteria.

but at a greater depth than previously recognized owing to vertical displacement along late Pleistocene faults. The Pleistocene sediments at the base of the borrow pit section are tentatively equated here to the Deweyville based on stratigraphic position and on a radiocarbon date on woody material of 31,270± 370 years B.P. (Charles R. Kolb, person. comm., 1981), which is very close to the time interval when Deweyville Terrace deposits are believed to have accumulated (*i.e.*, about 17,000 to 30,000 years B.P.; see Flint, 1971; Kolb *et al.*, 1975).

Buried Soil (Little Woods Paleosol)

Pleistocene sediments at the borrow pit are capped by a moderately indurated, bluish-gray, root-mottled mud, which represents an ancient soil B horizon that developed in the top of the Deweyville deposits during a lengthy period of subaerial exposure (Figs. 2, 4). The original soil has been eroded so that only isolated pockets of the friable, silty A horizon remain below the unconformity. A single radiocarbon date, on a fragment of wood (root) near the bottom of this unit (Fig. 2), of 7,690± 70 years B.P. (Charles R. Kolb, person. comm., 1981) indicates that the soil was penetrated by roots and was probably still evolving during the early Holocene. This date is regarded as a "minimum age estimate" for the soil zone (see Geyh *et al.*, 1971); radiocarbon dating of peat from immediately above the soil at the base of the Holocene sequence (Fig. 2) would seem to indicate that the minimum age estimate for the soil is close to the true minimum age of the original solum. Soil forming processes preceded intrusion by the youngest series of roots, however, and may well have commenced in the late Pleistocene. Using the method outlined by Beckmann (1971), it can only be determined that the age of formation and development of the soil is bracketed between the age of the Deweyville sediments and that of the overlying peat (see following section) as determined by radiometric dating.

The soil zone at the top of the Pleistocene sediments is here informally named the "Little Woods paleosol," after the village of Little Woods, Orleans Parish, Louisiana, located northeast of the borrow pit, and the Lake Carmel pit is designated as the type locality. The Little Woods paleosol appears to be widely distributed in the New Orleans

Fig. 5. Close-up view of unconformity showing peat rip-up clasts (arrows) located immediately above the contact.

area between the paleofluves in the buried Pleistocene surface, as indicated by bore hole data (Kolb and van Lopik, 1966; Kolb *et al.*, 1975). The paleosol is truncated by an unconformity that separates the youngest Pleistocene deposits in the area from superjacent Holocene beds (Figs. 4, 5).

Originally, the paleosol may have been a weakly differentiated podzolic soil, which developed in silty surface deposits on an interfluvial plain during the late Pleistocene and early Holocene. The soil featured a thin, friable A_2 horizon overlying a thick, oxidized, clayey B_2 horizon. The B_2 horizon contains large root channelways, reminiscent of tap roots, and abundant rootlet channelways that usually only extend down to a limonite-cemented layer in the top of the underlying silt bed (Table 1). The upper part of this silt bed contains occasional roots and probably was the ancient C horizon associated with the superjacent paleosolum. As suggested by the bluish color of the Little Woods paleosol, the original solum became waterlogged and reduced after the differentiation of horizons (see Simonson, 1954, p. 728-729) when the Holocene transgression reached the New Orleans East area about 7,500 years ago.

Unconformity

The Pleistocene-Holocene contact at the borrow pit is marked by an unconformity that separates the bluish-gray Little Woods

Table 1. Composite stratigraphic section of the Lake Carmel borrow pit. Unit numbers are keyed to Figs. 2 and 3.

UNIT	DESCRIPTION	THICKNESS (in meters)
HOLOCENE		
Covered interval		2.2
Deltaic mud (St. Bernard delta complex)		
5.	Clay, with silt and fine sand interlaminations; sand subangular, moderately sorted; continuous, parallel to wavy laminations and some sand lenses; sand interlaminations become thicker and more frequent proceeding up-section; *Rangia cuneata* shells in upper part; dark greenish-gray (5 B 3/1) where fresh, weathers dark yellowish-brown (10 YR 4/2) with light brown (5 YR 5/6) mottles; top not exposed, bottom intertongues with Unit 4b.	2.0
Barrier bar sand (New Orleans barrier trend)		
4b.	Sand, fine to coarse, subangular, moderately to well-sorted; top 20 to 30 cm with variety of physical sedimentary structures (ripple cross-laminations, trough cross-laminations, shelly lenses, wavy clay laminations), remainder of unit with abundant *Ophiomorpha* and occasional peat and clay interbeds; light gray (N 7.5) where fresh, weathers pinkish-gray (5 YR 8/1) with dark yellowish-orange (10 YR 6/6) mottles; grades downward into either Unit 4a or 3.	1.6
4a.	Clayey sand to sandy clay, shelly; sand fine to medium, subangular, moderately sorted; separated from superjacent sand by *Mercenaria campechiensis* shell pavement encrusted by bryozoans and oysters; dark greenish-gray (5 GY 4/1) where fresh, weathers olive gray (5 Y 4/1); grades downward into Unit 3.	0 to 0.1
Bay-sound clay (Michoud Formation[1])		
3.	Silty clay to clayey silt, with occasional flat sand lenses; sand lenses distorted by burrowing; shelly near the top and bottom, with two very fine to fine, subangular, well-sorted sand beds, 0.08 and 0.12 m thick, in middle of unit; discontinuous layer of peat rip-up clasts at base; sand interbeds medium dark gray (N 4.5), peat clasts brownish-black (5 YR 2/1); clay dark greenish-gray (5 GY 3/1) where fresh, weathers olive gray (5 Y 4/1); rests unconformably on Unit 2.	3.6 to 3.8
Unconformity		
PLEISTOCENE		
Buried soil (Little Woods paleosol[2]; top of Deweyville equivalents)		
2.	Clayey silt to silty clay, slightly sandy, abundant root channelways, some containing original root material; moderately indurated; medium bluish-gray (5 B 6/1) with bluish-gray (5 B 5/1) clay coatings in fissures, weathers yellowish-gray (5 Y 8/1); grades downward into Unit 1d.	1.4
Deltaic silt and sand (unaltered Deweyville)		
1d.	Silt, clayey; parallel laminations, occasionally disrupted by root channelways extending from Unit 2; no fossils; greenish-gray (5 G 6/1); top cemented by limonite crust, bottom grades into Unit 1c.	0.4
1c.	Sand, fine, subangular to subround, well-sorted; parallel laminations; wood fragments; grayish-olive (10 Y 4/2) with moderate olive-brown (5 Y 4/4) mottles; bottom marked by micaceous laminations.	0.2
1b.	Same as Unit 1d, but lacks roots; grades downward into Unit 1a.	0.1 to 0.2
1a.	Sand, fine, subangular to subround, well-sorted; no fossils; olive gray (5 Y 4/2); base not exposed.	0.5+
	TOTAL	12.4

[1]New lithostratigraphic unit, described herein
[2]New soil-stratigraphic unit, described herein

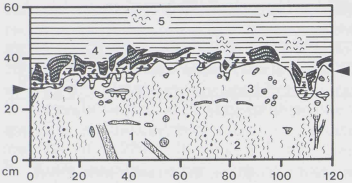

Fig. 6. Sketch of Pleistocene-Holocene contact exposed in south corner of borrow pit. 1, large root channelways filled with light gray (N 5) clay; 2, rootlets and rootlet tubes; 3, burrows and root channelways filled with the superjacent dark greenish-gray (5 GY 3/1) clay; 4, brownish-black (5 YR 2/1), laminated peat rip-up clasts and smaller woody fragments; 5, mollusk shells. Arrows at sides of drawing indicate trace of contact.

paleosol from overlying dark greenish-gray bay-sound clay (Figs. 2, 5). Because the paleosol weathers yellowish-gray and is moderately indurated, the unconformity is easily traced throughout the pit (Fig. 4) and easily identified in subsurface borings (Kolb and van Lopik, 1966; Kolb *et al.*, 1975). Although the unconformity is a very wavy, pitted surface varying in vertical relief by as much as 20 cm over only 40 to 50 cm of outcrop distance (Fig. 6), its average elevation is remarkably uniform at about 10 m below the surrounding land surface in all parts of the pit. Localized depressions in the unconformity may represent old tree-throw pits, as root channelways are often more abundant in the Little Woods paleosol beneath these depressions.

This unconformable contact corresponds to the "First Pleistocene Horizon" in the cross-sections of Kolb *et al.* (1975). Subjacent Pleistocene beds are tilted slightly seaward on a regional scale as a result of subsidence and flexure along growth faults, so the unconformity exposed in the Lake Carmel pit should be regarded as an angular unconformity. In the New Orleans area, the top of the Pleistocene varies in elevation from −10 m on ancient interfluvial plains (which includes the Lake Carmel borrow pit area) to around −40 m in paleochannels and beneath the Mississippi River; the Pleistocene surface is near sea level in the northeastern part of Lake Pontchartrain (Kolb *et al.*, 1975, Plates 2, 5).

Bay-Sound Clay (Michoud Formation)

The oldest Holocene unit in the Lake Carmel pit is the slightly shelly, greenish-gray, soft silty clay to clayey silt immediately above the unconformity. The clay contains occasional flat lenses of sand and two laterally continuous sand beds located near the middle of the unit (Figs. 2, 7). The bottom of the clay contains abundant, brownish-black rip-up clasts of peat (Fig. 6), from which radiocarbon dates of 7,290± 80 and 7,200± 50 years B.P. have been obtained (Charles R. Kolb, person. comm., 1981). These dates mark the time when marshy paralic depositional environments reached the New Orleans East area at the advancing edge of the modern transgression of Gulf waters; adjacent paleofluves were probably flooded at this time and contained subtidal estuarine environments (see Saucier, 1963, p. 42-44). That is, sea level had reached an elevation of about −10 m around 7,300 years ago, and shortly thereafter former interfluvial plains were inundated in the Lake Carmel pit area (Saucier, 1963, Fig. 19). The top of the unit is

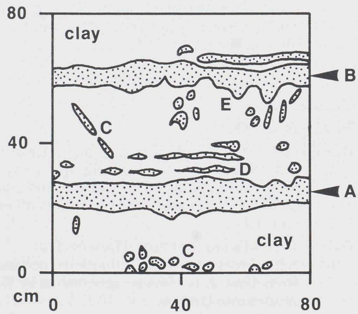

Fig. 7. Detailed sketch of sand interbeds occurring within the Michoud Formation, as exposed in the southeast wall of the pit. A, lower fine sand interbed; B, upper fine sand interbed; C, burrows originating in superjacent sand layers and filled with the sand; D, flat sand ripples surrounded by clay; E, load structures on underside of sand bed, indicating original hydroplastic nature of underlying clay.

an old firm-ground bored by *Petricola pholadiformis*, *Barnea truncata*, and *Cyrtopleura costata*. A radiocarbon date of 4,270± 50 years B.P. was obtained on a clam shell located just beneath this old firm-ground (see section below).

This clay unit can be traced beneath the city of New Orleans and Lake Pontchartrain in cross-sections published by Saucier (1963, Fig. 18) and Kolb *et al.* (1975, Plates 10, 12a, 12b, 17, 19, 20, 21, 22, 24, 27, 28, 29, 31, 32, 36, and 27). Although the unit has been identified in several studies of shallow subsurface stratigraphy in this area, no formal lithostratigraphic nomenclature has been applied. Therefore, for convenience of reference and emphasis, I propose the name "Michoud Formation" for the generally fine-grained Holocene transgressive deposits (mainly silts and clays with occasional sandy subunits) situated stratigraphically above the regional unconformity at the top of Deweyville deposits and below either Holocene barrier island sands (New Orleans barrier trend; Otvos, 1978) or deltaic deposits associated with the modern Mississippi River. The formation is named for the village of Michoud (pronounced *mē'shü)*, Orleans Parish, Louisiana, located just southeast of the borrow pit. The Lake Carmel borrow pit is designated as the type locality and the east wall of the pit is regarded as the type section (Figs. 2, 3). Bore holes 19-8, 19-9, 20-30, 24-1, 81-398, 83-10, 83-16-W, and 89-1 illustrated in Kolb *et al.* (1975) penetrated the Michoud Formation at the bottom of sequences of Holocene sediments, and can be used as reference sections in lieu of additional surface outcrops. The formation includes the nearshore Gulf and bay-sound deposits of Saucier (1963, Fig. 18), bay deposits of Frazier (1967, Fig. 9, north end of section D-D′), and offshore-lower shoreface and bay-sound facies of Hollander and Dockery (1977, Fig. 2). The physical sedimentology of the Michoud Formation has been described by Tagett (1982).

Barrier Bar Sand
(New Orleans Barrier Trend)

The Michoud Formation grades upward into a thin, discontinuous clayey sand containing abundant mollusk shells (Fig. 2; Table 1). This clayey sand forms the bottom of a locally shelly, fine to coarse sand unit containing numerous burrow systems referable to the ichnogenus *Ophiomorpha*.

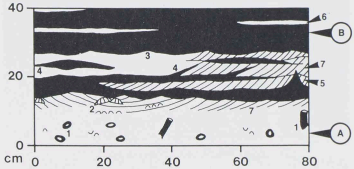

Fig. 8. Detailed sketch of intertongued contact between barrier bar sand (A) and overlying deltaic mud (B), as exposed in northeast wall of pit. 1, *Ophiomorpha* burrows; 2, accumulations of mollusk shells, larger shells being mainly those of *Dinocardium robustum;* 3, wavy contact caused by rippled bedding surface; 4, mud drapes and lenses; 5, clay tongue or flame; 6, fine sand lens; 7, ripple cross-lamination.

(These frequently branching, mud-lined subhorizontal tubes are probably the resul of the burrow-building behavior of the decapod crustacean *Callianassa biformis* (Hertweck, 1972, Fig. 7; Howard and Dorjes, 1972, Fig. 8; Frey *et al.*, 1978; Howard and Frey, 1980).) Interbeds of peat and clay occur near the middle and bottom of the *Ophiomorpha*-bearing interval. The clean sand with burrows is separated from the underlying clayey sand by a shell pavement formed by current-oriented valves of *Mercenaria campechiensis* encrusted by oysters and bryozoans; the top of the sand lacks callianassid burrow systems and is trough cross-bedded and ripple cross-laminated (Fig. 8). Many of the fossil shells collected at the borrow pit were derived from this uppermost subunit of the New Orleans trend sand, where they occurred as concentrations in cross-bedded, shelly sand lenses.

Radiocarbon dates on peat, collected near the middle and bottom of the sand, of 11,090± 90 and 29,860± 430 years B.P., are clearly too old (Charles R. Kolb, person. comm., 1981). Most authors believe that the barrier bar deposits accumulated between 5,000 and 4,000 years ago (see Corbeille, 1962; Saucier, 1963; Otvos, 1978).

The barrier bar sand is a part of a subsurface sand body that has been variously labeled "New Orleans barrier island," "Pine Island beach trend," "Pine Island Barrier," and "New Orleans barrier trend" (Corbeille, 1962; Saucier, 1963; Frazier,

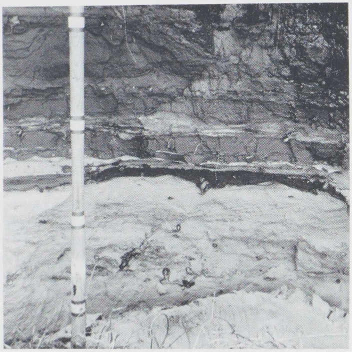

Fig. 9. Close-up view of contact between light-colored New Orleans barrier trend sand and superjacent, dark-colored St. Bernard Delta complex mud. Handle of digging tool is marked in 20 cm increments. (Not the same location as Fig. 8.)

1967; Otvos, 1978). At the Lake Carmel pit the sand has a rather constant thickness of 1.6 to 1.8 m, and at least locally must have a tabular shape. However, as revealed in subsurface borings, the overall geometry of the New Orleans barrier trend is actually a transversely notched, curvilinear prism (see Corbeille, 1962; Saucier, 1963). In outcrop, the light gray sand stands out in sharp contrast to the dark clays occurring above and below it (Fig. 9). The unit can be traced from near Pointe aux Herbes in eastern Orleans Parish, to Metairie in northeastern Jefferson Parish, through a distance of 30 km (Otvos, 1978; 1979).

Deltaic Mud

The uppermost unit exposed in the pit is a greenish-gray mud with silt and sand interlaminations (Fig. 2; Table 1). Although the upper half of the mud is overgrown and covered by weeds, a general coarsening upward pattern, involving addition of thicker and more numerous fine sand laminations, is apparent. The base of the mud is complexly interfingered with the ripple cross-laminated sand at the top of the barrier bar deposits (Fig. 8). The most typical sedimentary structures in exposed portions are continuous, parallel to wavy laminations; but sand lenses and beds are common near the contact, as are small vertical burrows filled with sand. Float derived from the upper part of the mud contains abundant *Rangia cuneata*, *Mytilopsis leucophaeata*, and *Littorina irrorata*. The unit is probably part of one of the older subdeltas of the St. Bernard delta complex (see Frazier, 1967, p. 301-306; Otvos, 1978, p. 342-345). Radiocarbon dates obtained by Otvos (1978) on deltaic deposits overlying barrier bar sand in a borrow pit on Morrison Road, about 5 km southwest of Lake Carmel, suggest an early St. Bernard subdelta buried the New Orleans barrier trend around 4,000 years ago in that area.

VI. SIGNIFICANCE OF RADIOCARBON DATES

Of the seven radiocarbon dates obtained from samples of peat and shell at the borrow pit, five dates appear to accurately reflect the age of the enclosing deposits. Stratigraphic positions of dated material are shown in Fig. 2, and Table 2 contains a list of the dates.

Sample A provided the oldest date (31,270± 370 years B.P.), and is the chief evidence that the youngest Pleistocene beds in the area are Wisconsin in age, rather than Sangamon as previously thought. If this single date is representative of the lowest unit exposed at the pit, then it seems likely that the youngest Pleistocene sediments beneath the New Orleans East area are possibly *not* time correlative with sediments occurring directly beneath the Prairie Terrace on the northern side of Lake Pontchartrain (Fig. 1, A). A later Pleistocene episode of deposition is indicated, and time-equivalence with sediments occurring beneath the Deweyville Terrace in Gulf Coastal Plain river valleys is a possibility. Clearly, more dates are needed to firmly establish the age and correlation of upper Pleistocene beds beneath New Orleans.

The radiocarbon date from the Little Woods paleosol (7,690± 70 years B.P.) is the minimum age for the soil, as discussed in the previous section. This is confirmed by radiocarbon dates from the peaty layer (7,290± 80 and 7,200± 50 years B.P.) at the base of the Holocene Michoud Formation located directly above the paleosol. The soil date probably reflects the latest series of root penetrations in the original soil, before

Table 2. Radiocarbon dates from the Lake Carmel borrow pit. All dates obtained and supplied by Dr. Charles R. Kolb, Institute for Environmental Studies, Louisiana State University.

SAMPLE	MATERIAL USED	DATE (years B.P.)	COMMENTS
A	Wood	31,270± 370	Oldest undisturbed organic material in section
B	Wood (root)	7,690± 70	Good estimate of minimum age of Little Woods paleosol
C	Peat rip-up clast	7,290± 80	Slightly disturbed, but *in situ* bedded peat; dates beginning of deposition in Pontchartrain Embayment in vicinity of borrow pit
D	Peat rip-up clast	7,200± 50	Slighty disturbed, but *in situ* bedded peat; dates beginning of deposition in Pontchartrain Embayment in vicinity of borrow pit
E	Bivalve shell	4,270± 50	*In situ* fossil; dates top of Michoud Fm. and estimates arrival of New Orleans trend barrier bar in area
F	Peat lens	11,090± 90	Woody material probably reworked from older deposits; date is out of place stratigraphically
G	Sandy peat	29,860± 430	Woody material probably reworked from older deposits; date is out of place stratigraphically

the solum layer was partially eroded and covered by marsh sediments.

Dates from the Michoud Formation are particularly interesting because they bracket the accumulation of sediments in that part of the Pontchartrain Embayment which once covered the Lake Carmel area. The estimate for the time span represented by the Michoud Formation at the pit, then, is about 3,000 years. If a uniform sedimentation rate is assumed, the Michoud accumulated at a rate of something like 1.33 mm/year, not taking into account effects of compaction. This points to a rather slow accumulation of fine-grained sediments in the Pontchartrain Embayment compared to other similar bay-sound environments (see Schindel, 1980).

Samples F and G from the New Orleans trend sand are obviously too old by factors of two and six, respectively. Dates in the range of 4,000 to 5,000 years were anticipated. There are three possible explanations for these anomalous dates from the same unit: 1) samples were misdated and laboratory technique is to blame; 2) samples have been contaminated since entombment with "dead" carbon and the surrounding sand has not acted as a closed system to isolate the dated material from natural contamination; or 3) Pleistocene woody material was reworked from headlands or perhaps brought downstream from old alluvial deposits, and was subsequently incorporated into the New Orleans barrier trend as a kind of beach drift deposit (see Howard and Frey, 1980, p. 88). The particulate, bedded nature of the peat, and the fact that the two anomalous dates are from the same ripple cross-laminated sand bed suggest transport and resedimentation of woody material originating in older Quaternary deposits.

I was unable to obtain dates from the St. Bernard deposits exposed in the pit.

VII. ENVIRONMENTAL HISTORY

The history of environmental changes in the vicinity of the Lake Carmel pit is typical of the Quaternary environmental history of the New Orleans area in being controlled by the interaction of four major geologic processes: 1) the construction of delta lobes associated with major river systems, such as the Mississippi and Pearl Rivers; 2) the loading of the continental terrace with immense quantities of terrigenous clastics delivered to the coast by these major rivers, and subsidence of the southeastern Louisiana area along growth faults; 3) the abandonment of delta lobes, and the deposition of marine barrier bar and sound sediments in areas not being covered by prograding deltas; and 4) glacio-eustatic sea level fluctuations controlled by the expansion and recession of continental glaciers, and the resultant changes in the volume of the world ocean. The onshore stratigraphic framework that results from the interaction of such large-scale processes includes down-faulted sequences of intercalated deltaic and paralic/marine deposits, separated by unconformities and capped with soil zones (see cross-sections in Kolb *et al.*, 1975).

Pleistocene Environments

Because unaltered Pleistocene sediments at the base of the Lake Carmel section are not very well exposed, environmental interpretation must be somewhat tentative. However, the repeated interlaying of silt and sand, micaceous laminations, occasional wood fragments, and paleogeographic position basinward of the valleys of the Mississippi and Pearl Rivers suggest deposition in a delta front setting, probably as a distal distributary mouth bar (Elliot, 1978; Miall, 1979). These deposits are lithologically similar to delta front deposits occurring higher in the section within the St. Bernard Delta complex (Fig. 2, Table 1). Interestingly, like the St. Bernard deposits, the Pleistocene sediments cover a large sand body that could be an ancient barrier island or bar located beneath the south shore of Lake Pontchartrain (Fig. 1, B).

The Pleistocene deltaic sediments were deposited about 30,000 years ago when Gulf level was at or slightly lower than the present level. Shortly after this, Gulf level began to rapidly fall in response to the last series of Wisconsin glacial pulses, and the Deweyville deltaic environments in the New Orleans area were abandoned on the newly emergent coastal plain. The exposed surface of the Deweyville sediments underwent pedogenic alteration during the ensuing period of subaerial exposure, resulting in the formation of the Little Woods paleosol. This coastal plain soil evolved over a period beginning as early as 25,000 years B.P. and extending into the Holocene, to about 7,500 years B.P.

Older unconformity-bounded sequences occurring in the subsurface of the New Orleans area are similarly "punctuated" at their tops by buried soils, indicating long periods of exposure above sea level (Kolb and van Lopik, 1966; Kolb *et al.*, , 1975). The glacio-eustatic master control, then, seems to have superimposed a higher-order cyclic pattern on local Quaternary sequences, which are each composed internally of lower-order cyclic deltaic/marine units. Continued loading of the continental terrace in southeastern Louisiana has resulted in the vertical stacking of these cycles. Recognition of extensive paleosol units like the Little Woods and their associated major unconformities is crucial in identifying these higher-order cycles (Fig. 10). However, these important indicators of prolonged, widespread shelf emergence should not be confused with localized pedogenic features and hiatuses associated with delta plain and delta abandonment facies (*cf.* Elliot, 1978, p. 129).

Holocene Environments

As a result of downwarping and subsidence along faults in the area, the environs of New Orleans and southern Lake Pontchartrain were probably topographically lower than adjacent segments of the Gulf Coastal Plain in southwestern Louisiana and southern Mississippi when the Holocene transgression began. This low-lying coastal depression was flooded while the surrounding coastal plain remained emergent (Saucier, 1963, Figs. 5, 13, 15); the bay-sound environment that formed in the depression is known as the Pontchartrain Embayment. The embayment existed from about 7,500 to 3,000 years B.P., until first barrier bars and later St. Bernard Delta lobes isolated this coastal compartment and restricted communication with the Gulf (Otvos, 1978, Fig. 16). The relict geomorphic feature corresponding to the embayment is Lake Pontchartrain, and the lithostratigraphic evidence that remains of this bay-sound environment is the Michoud Formation. The history of the south-central portion of the Pontchartrain Embayment is preserved in the Lake Carmel section.

About 7,300 years B.P. Gulf waters reached the Lake Carmel area, as demonstrated by the radiocarbon dates on peat rip-up clasts found at the base of the Michoud. The clasts were formed from originally continuous peat layers that were deposited in a fresh to brackish marsh environment. As the coastal marshes in the Lake Carmel area were submerged, the peat was reworked by currents and waves to form flat, rotated fragments that eventually became embedded in the overlying blanket of bay-sound mud. As the transgression proceeded, water depth within the embayment probably increased to several meters, although the low diversity of mollusks contained within the bay-sound mud suggests that salinity remained rather low until the sand of the New Orleans trend began to accumulate in the area (see Appendix). Estuarine taxa occur in limited numbers throughout the Michoud at the borrow pit, with open-bay species only becoming slightly more abundant toward the top of the unit. Boring clams are numerous near the top of the Michoud indicating that clay firm-grounds were common in the vicinity of the borrow pit.

One of the most interesting features of the bay-sound deposits is the two sand interbeds located near the middle of the unit (Fig. 2). The beds are composed of well-sorted, fine-grained quartz sand, can be traced throughout the borrow pit, and have load structures formed on their lower contacts with the bay-sound clay (Fig. 7). These characteristics would seem to indicate that the sand interbeds were transported into the Pontchartrain Embayment and deposited, perhaps as tempestites, on a soft clay substratum. Internally, the sand interbeds have been more or less homogenized as a result of bioturbation. Sand clasts and flat sand lenses occurring in the surrounding mud may have had similar origins, with clasts representing the obliteration of originally continuous sand layers by burrowing organisms and lenses indicating reworking of sand layers by currents into minor sand-starved ripples that migrated over a muddy sound floor. The sand may have been derived by storm erosion of a sand bar lying seaward of the embayment, by storm transport from the incipient New Orleans trend some distance to the northeast, or perhaps through erosion of a nearby Pleistocene

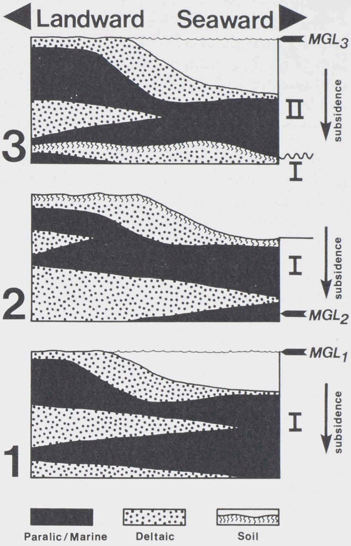

Fig. 10. Stacking of unconformity-bounded coastal sequences of deltaic and paralic/marine deposits in the shallow subsurface Pleistocene of southeastern Louisiana. 1, Deltaic, paralic, and marine sediments interlayered during high stand of mean Gulf level (MGL_1) as the result of shift in locations of delta lobes and associated coastal environments. 2, Lowering of gulf level (MGL_2) during full glaciation exposes large areas of continental shelf and extensive soil development ensues. 3, Cycle is repeated beginning with a rise in gulf level (MGL_3), resubmergence of the continental shelf, and deposition of sediments in sequence II. Subsidence is more or less continuous throughout. Intercalation of deltaic with paralic/marine deposits, resulting mainly from changes in locations of delta lobes, sounds, and open shelf areas, gives rise to cyclothem-like units; stacking of unconformity-bounded sequences gives rise to mesothem-like units (see Hallam, 1981, p. 129-132). Higher-order cyclic sequences are separated by major unconformities marked by extensive, well-developed paleosols. (Not drawn to scale.)

headland somewhere in the vicinity of Slidell.

The discontinuous layer of muddy sand located directly above the Michoud Formation (Fig. 2) contains the highest diversity and numbers of untransported mollusks at the borrow pit. The overlying cleaner sand contains many more taxa, but most have been transported from marine environments (see Appendix). The muddy sand probably represents a subtidal Gulf floor environment; whereas the large-ripple cross-laminated sand above it, containing clay drapes in ripple troughs, thin peat interbeds and abundant *Ophiomorpha* tubes of the type produced by callianassid decapods in protected settings, accumulated in bar trough and lower bar flank environments. The top of the New Orleans trend deposits at Lake Carmel is a ripple cross-laminated fine to coarse sand with trough cross-laminated shelly lenses, indicating very shallow subtidal to intertidal bar crest and upper bar flank environments. It does not appear that the New Orleans trend was an emergent sand ridge in this part of Orleans Parish, except perhaps during very low tides. The sand probably began accumulating at the Lake Carmel borrow pit after about 4,300 years B.P., as suggested by the radiocarbon date from the top of the Michoud (Table 2; *cf.* Otvos, 1978, Fig. 16).

Complete isolation of the Pontchartrain Embayment occurred when early St. Bernard delta sublobes encroached upon and buried the New Orleans trend in eastern Orleans Parish. Otvos (1978) believes that the process of deltaic encroachment began around 3,800-4,000 years B.P. and that isolation was completed about 2,800 years B.P. At Lake Carmel the top of the barrier trend sand interfingers with dark-colored mud with parallel and wavy-horizontal silt and sand interlaminations. The mud unit seems to be the basal layer of one of the older St. Bernard lobes, and displays an overall coarsening upward owing to incorporation of thicker and more numerous sand interlaminations. This suggests that the New Orleans trend sand was first blanketed by prodeltaic mud and later by coarser delta front deposits. Thickness of St. Bernard deltaic deposits at the borrow pit is 4.5 m; to the south of Lake Carmel, where three or four lobes are stacked in vertical succession, total thickness of deltaic deposits exceeds 14 m. The deltaic blanket exposed at the borrow pit is perhaps part of the Bayou Terre aux Boeufs lobe described by Frazier (1967), but unfortunately geochronometric control at Lake Carmel is lacking.

VIII. FUTURE WORK

The exposures of sediments and fossils at the Lake Carmel borrow pit presented the rare opportunity to collect detailed stratigraphic information relating to the development of the southern portion of the Pontchartrain Embayment, the sedimentary environments of the New Orleans trend, and to the entombment of the barrier trend by St. Bernard deltaic deposits. The unconformity between Pleistocene and Holocene deposits, and the age and nature of the subjacent Pleistocene beds also could be studied at the pit allowing for the first time a close look at the contact separating two Quaternary depositional sequences in southeastern Louisiana.

However, many questions remain to be answered. Future investigations might profitably focus upon the following "loose ends" of local Quaternary stratigraphy:

1) What role has faulting played in shaping the paleogeography of the Mississippi Delta region and controlling the positions of basins and depositional landforms?

2) Are the Pleistocene unconformity-bounded sequences beneath the New Orleans area composed of paralic and deltaic units similar to the Holocene sequence, and what are the ages of these essentially unstudied Pleistocene deposits?

3) What are the coastwise equivalents of the Pleistocene units in the subsurface of Orleans Parish? Are the units mapped and described by Otvos in southern Mississippi recognizable in downfaulted sequences beneath southern Lake Pontchartrain and New Orleans?

4) What do the downfaulted sequences of intercalated deltaic and paralic/marine deposits capped by paleosols of regional extent tell us about the origin of large terrigenous clastic wedges in nearshore settings affected by eustatic changes in sea level? Are the pre-Quaternary deltaic deposits in the northern Gulf Coastal Plain, like the economically important Fleming Group, composed of similar sequences?

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X. APPENDIX

MOLLUSKS FROM THE LAKE CARMEL BORROW PIT

All taxa collected and identified by Mr. George Mollyn. (Symbols representing relative abundance estimates have the following meanings: 5 = abundant, 4 = common, 3 = moderately common, 2 = uncommon, 1 = rare, ? = from float material. Sample intervals refer to Fig. 2.)

TAXA	Lower Bay-Sound Clay (9.0 to 10 m)	Middle Bay-Sound Clay (7.5 to 9.0 m)	Upper Bay-Sound Clay (6.3 to 7.5 m)	Base of Barrier Bar (6.0 to 6.3 m)	Barrier Bar Sand (4.5 to 6.0 m)
GASTROPODA					
Fissurellidae					
Diodora cayenensis (Lamarck)					1
Neritidae					
Neritina reclivata (Say)					3
N. virginea (Linné)					1
Littorinidae					
Littorina irrorata (Say)	1				1
Vitrinellidae					
Cyclostremiscus suppressus (Dall)					1
C. pentagonus (Gabb)					2
Teinostoma biscaynense Pilsbry & McGinty					2
Solariorbis infracarinata Gabb					2
S. mooreana Vanatta					1
Caecidae					
Caecum imbricatum Carpenter					1
C. johnsoni Winkley					1
Cerithidae					
Diastoma varium (Pfeiffer)					5
Seila adamsi (H. C. Lea)					1
Litiopa melanostoma Rang					1
Triphoridae					
Triphora perversa nigrocincta (C. B. Adams)					1
Epitoniidae					
Epitonium angulatum (Say)				1	1
E. rupicola (Kurtz)					1?
Epitonium cf. *E. tollini* Bartsch					1
Epitonium cf. *E. multistriatum* (Say)					1

TAXA	Lower Bay-Sound Clay (9.0 to 10 m)	Middle Bay-Sound Clay (7.5 to 9.0 m)	Upper Bay-Sound Clay (6.3 to 7.5 m)	Base of Barrier Bar (6.0 to 6.3 m)	Barrier Bar Sand (4.5 to 6.0 m)
Eulimidae					
Eulima cf. *E. bilineatus* (Alder)					1
Balcis cf. *B. arcuata* (C. B. Adams)					1
Balcis cf. *B. jamaicensis* (C. B. Adams)				1	
Balcis cf. *B. gracilis* (C. B. Adams)					1
Strombidae					
Strombus alatus Gmelin					3
Calyptraeidae					
Crepidula fornicata (Linné)				3	3
C. plana Say					3
Naticidae					
Neverita duplicatus (Say)	2	1	1	2	3
Sinum perspectivum (Say)					3
Tectonatica pusilla (Say)					3
Cassididae					
Phalium granulatum (Born)					3
Cymatiidae					
Distorsio clathrata (Lamarck)					1?
Tonnidae					
Tonna galea (Linné)					1?
Ficidae					
Ficus communis Röding					1?
Muricidae					
Hexaplex fulvescens (G. B. Sowerby, I)					1?
Thais haemastoma floridana (Conrad)					2
T. h. canaliculata (Gray)					1
Columbellidae					
Anachis obesa (C. B. Adams)					4
A. semiplicata (Stearns)	1				1
Mitrella lunata (Say)					3
Buccinidae					
Cantharus cancellarius (Conrad)				3	3
Melongenidae					
Melongena corona (Gmelin)					1?
Busycon perversum pulleyi Hollister					2
B. spiratum plagosum (Conrad)					2
Nassariidae					
Nassarius vibex (Say)	4		1	5	3
N. acutus (Say)	2	1	3	3	4
Fasciolariidae					
Fasciolaria lilium hunteria (Perry)					1?
Olividae					
Oliva sayana Ravenel				1	2
Olivella mutica (Say)					4
Volutidae					
Scaphella junonia (Lamarck)					1?
Cancellaridae					
Cancellaria reticulata (Linné)					1
Marginellidae					
Marginella apicina Menke				1	1

TAXA	Lower Bay-Sound Clay (9.0 to 10 m)	Middle Bay-Sound Clay (7.5 to 9.0 m)	Upper Bay-Sound Clay (6.3 to 7.5 m)	Base of Barrier Bar (6.0 to 6.3 m)	Barrier Bar Sand (4.5 to 6.0 m)
Terebridae					
Terebra dislocata (Say)					2
T. concava Say					1
Hastula salleana (Deshayes)			1?		1
Turridae					
Kurtziella atrostyla (Tryon)					2
K. serga (Dall)					1
Nannodiella oxia (Bush)					1
Acteonidae					
Acteon punctostriatus (C. B. Adams)					1
Acteocinidae					
Acteocina canaliculata (Say)	1	1		1	3
Atyidae					
Volvulella persimilis (Mörch)					1
Pyramidellidae					
Pyramidella crenulata (Holmes)					2
Odostomia impressa (Say)					2
O. seminuda (C. B. Adams)					1
Odostomia cf. *O. gibbosa* Bush					1
Odostomia cf. *O. livida* Rehder					1
Turbonilla interrupta (Totten)	1		2		1
Peristichia agria Dall					1
Eulimastoma cf. *E. weberi* (Morrison)					3
Eulimastoma cf. *E. teres* (Bush)					2
Ellobiidae					
Melampus bidentatus (Say)					1
Cuvieridae					
Creseis acicula (Rang)					1
BIVALVIA					
Nuculanidae					
Nuculana concentrica (Say)	1	1	2	1	2
N. acuta (Conrad)					1
Arcidae					
Anadara transversa (Say)					5
A. ovalis (Bruguière)	1	1	1	2	4
A. brasiliana (Lamarck)					4
Noetia ponderosa (Say)					3
Mytilidae					
Geukensia demissa granosissima (G. B. Sowerby, III)	1				1
Brachidontes exustus (Linné)	1				1
Pinnidae					
Atrina serrata (G. B. Sowerby, I)		1			1
Pectinidae					
Argopecten irradians concentricus (Say)					2
A. gibbus (Linné)					1
Plicatulidae					
Plicatula gibbosa Lamarck					1
Anomiidae					
Anomia simplex d'Orbigny					3

TAXA	Lower Bay-Sound Clay (9.0 to 10 m)	Middle Bay-Sound Clay (7.5 to 9.0 m)	Upper Bay-Sound Clay (6.3 to 7.5 m)	Base of Barrier Bar (6.0 to 6.3 m)	Barrier Bar Sand (4.5 to 6.0 m)
Ostreidae					
Crassostrea virginica (Gmelin)	2			2	5
Lucinidae					
Linga amiantus (Dall)					5
Parvilucina multilineata (Tuomey & Holmes)					4
Pseudomiltha floridana (Conrad)					2
Anodontia alba Link					1?
Ungulinidae					
Diplodonta semiaspera (Philippi)					2
Diplodonta cf. *D. soror* C. B. Adams			4	3	
Chamidae					
Arcinella cornuta Conrad					1
Chama congregata Conrad					1?
Lasaeidae					
Aligena texasiana Harry					1?
Leptonidae					
Lepton lepidum Say					1
Nearomya floridana (Dall)					1?
Crassatellidae					
Crassinella lunulata (Conrad)					5
Cardiidae					
Trachycardium muricatum (Linné)					2
T. isocardia (Linné)					1?
Laevicardium laevigatum (Linné)					2
Dinocardium robustum (Lightfoot)				2	4
Mactridae					
Mactra fragilis Gmelin					1
Spisula solidissima similis (Say)					3
Mulinia lateralis (Say)		1	3	4	5
Rangia cuneata (Gray)	1				2
R. flexuosa (Conrad)					2
Raeta plicatella (Lamarck)			2	2	3
Mesodesmatidae					
Ervilia cf. *E. concentrica* (Holmes)					1?
Solenidae					
Ensis minor Dall			1		3
Tellinidae					
Tellina aequistriata (Say)					2
T. alternata Say			2	4	2
T. texana Dall	1		2	2	2
T. iris Say					1
Tellidora cristata (Récluz)				2	2
Strigilla mirabilis (Philippi)					4
Macoma constricta (Bruguière)			1		4
M. tenta (Say)	1		2	3	
Donacidae					
Donax texasianus Philippi				2	5
D. variabilis roemeri Philippi					2

TAXA	Lower Bay-Sound Clay (9.0 to 10 m)	Middle Bay-Sound Clay (7.5 to 9.0 m)	Upper Bay-Sound Clay (6.3 to 7.5 m)	Base of Barrier Bar (6.0 to 6.3 m)	Barrier Bar Sand (4.5 to 6.0 m)
Semelidae					
Semele proficua (Pulteney)					2
S. bellastriata (Conrad)					1
Abra aequalis (Say)			2	3	5
Solecurtidae					
Tagelus plebeius (Lightfoot)					4
T. divisus (Spengler)			1	2	2
Dreissenidae					
Mytilopsis leucophaeata (Conrad)					1
Veneridae					
Agriopoma texasiana (Dall)	2	1	1	1	
Macrocallista nimbosa (Lightfoot)					1
Dosinia discus (Reeve)			2	4	3
Cyclinella tenuis (Récluz)			1?		
Gemma gemma Totten					2
Chione cancellata (Linné)					4
C. intapurpurea (Conrad)					2
Timoclea grus (Holmes)					1
Mercenaria campechiensis (Gmelin)	2			5	3
Anomalocardia auberiana (d'Orbigny)					1
Petricolidae					
Petricola pholadiformis (Lamarck)			4		2
Myidae					
Paramya subovata (Conrad)			1		1
Corbulidae					
Corbula contracta Say	5	1			3
C. swiftiana C. B. Adams					5
Pholadidae					
Barnea truncata (Say)			3	1	
Cyrtopleura costata (Linné)	1		3	2	1
Diplothyra smithii Tlryon				2	
Pandoridae					
Pandora trilineata Say					1
Periplomatidae					
Periploma margaritaceum (Lamarck)				1	2
SCAPHOPODA					
Dentaliidae					
Dentalium texasianum Philippi					2
Dentalium sp.					1

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