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Mineral Resource Studies of Quaternary; Late Holocene Stratigraphy and Geological Evolution of Mississippi-Louisiana Offshore Chandeleur Area

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The Mississippi Mineral Resources Institute
University, Mississippi 38677

MINERAL RESOURCE STUDIES OF QUATERNARY; LATE HOLOCENE STRATIGRAPHY AND GEOLOGICAL EVOLUTION OF MISSISSIPPI-LOUISIANA OFFSHORE CHANDELEUR AREA

Final Report

to

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INTRODUCTION

The staff of the Mississippi Mineral Resources Institute, within the framework of an offshore mineral exploration program in the mid-late 1980's has undertaken investigation of various potential mineral resources in the Mississippi Sound and Mississippi barrier islands area (Woolsey and others, 1985; Otvos 1985). The project later was extended to the adjacent Chandeleur region. Our objective was the preliminary identification of certain areas where commercial quantities of quartz sand, fossil seashell and/or heavy mineral concentrates may be found in subsequent follow-up projects.

Our role was the sedimentological analysis of vibracores, recovered during MMRI exploration activities and by our own earlier vibracore exploration (along cross section lines, followed by the MMRI project), as well as the study of two vibracores donated by the Louisiana Geological Survey and gratefully acknowledged here. Our purpose was the stratigraphic integration of all the available data, identification of the various stratigraphic units and the update of our knowledge on the most recent coastal evolutionary phases in the subject area. As in the Mississippi Sound area, the stratigraphic identification of the sedimentary subunits will allow better regional correlation and, consequently, improved exploration results of those subbottom geological units in which commercial quantities of mineral resources may be discovered. Well over a thousand samples were processed.

Field Methods: Vibracore Drilling

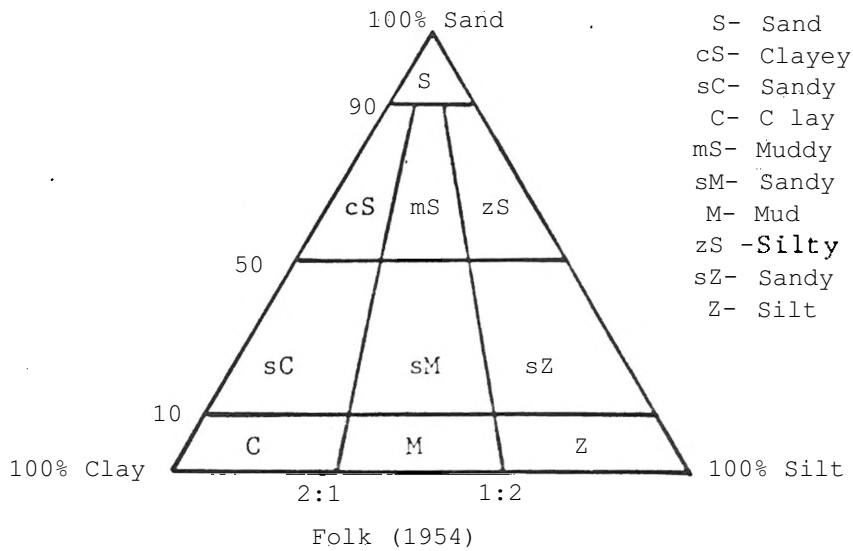
Eight of the holes were drilled by the Gulf Coast Research Laboratory in 1982 (VC-series; Fig. 2). Two island cores (CH-3 and CH-5) were donated by the Louisiana Geological Survey the following year, and nineteen additional vibracores were drilled by Mississippi Mineral Resources Institute personnel in June and November-December, 1987 (MMRI-series). 3 inch OD-aluminum pipes were used for the MMRI- and VC-series cores. The high sand content of the substrate limited core recovery and depth of penetration to generally less than 15-18'(Appendix). However, due to the thin Gulf shoreface sand veneer and lagoonal unit in which mineral concentrates and shallow clean sand resources were expected, this Late Holocene penetration depth provided a reasonably complete picture of the post-St. Bernard subdelta stratigraphy.

In a search for subbottom sand resources for beach nourishment, between 1981-87 the Louisiana Geological Survey obtained c. five thousand miles of high-resolution seismic profiles in the Chandeleur region. About 150 vibracores were drilled around and on N. Chandeleur Island, many 40 feet long (Suter and others, 1988). Apart from the cited cores, the material was unavailable for outside professionals. Extensive publications by the Survey are expected in the future.

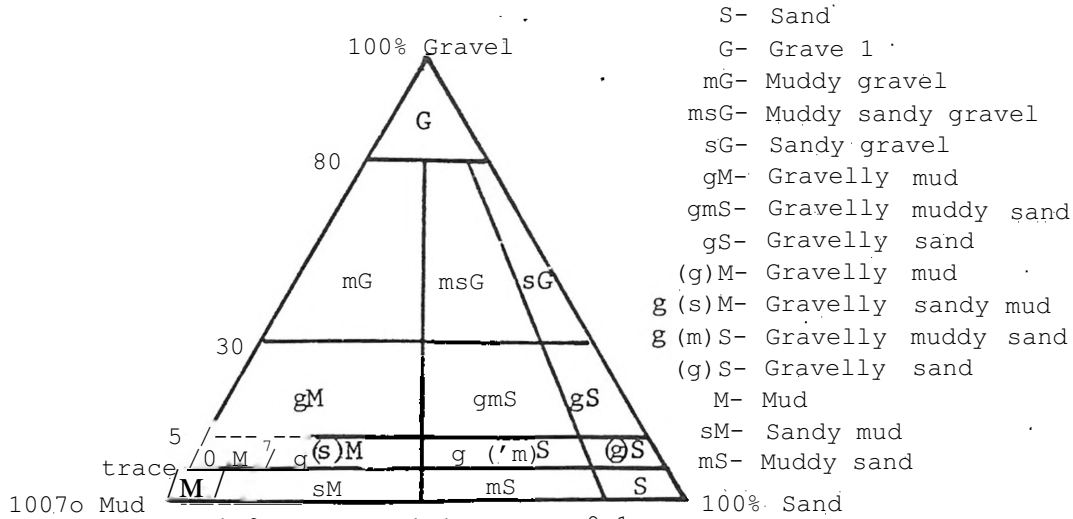
Laboratory Methods: Granulometric and Microfossil Analyses

(1) Macroscopic description

Before being processed, the cores were described in terms of color, apparent grain size composition, inclusions, and sedimentary structures (Oxidized surfaces, layering, bioturbation, trace and body fossils, etc.). Unconsolidated sandy units usually did not display useful structural traits. The USGS color chart was used for sediment color designations.



Folk (1954)



Folk (1954)

Figure 1. Sand-silt-clay, composition diagram in siliciclastic sediment nomenclature (Folk, 1961).

(2) Sample preparation and processing

Samples taken at close vertical intervals from cores were first used for granulometric studies, then for microfossil analysis. A 100 g (sandy sample) or 60-70 g (silty) or 30-40 g (clayey) air dried sample weighed and dispersed in 30 ml 0.5 n Calgon (Na-hydrophosphate; NaH_2PO_4) solution for several hours to 1-2 days, was used in preparation for granulometric analysis by sieving and the hydrometer method.

(i) After initial preparation, samples were blended for 5-10 minutes in an eletric blender and washed with distilled water into a 1000 ml cylinder. Hand-agitated thoroughly, until dispersed in a cylinder. Hydrometer readings were taken for up to 8 hours to measure density of slurry. After this, slurry was decanted from cylinder and wet-sieved. Wet-sieving by 230-mesh (62.5 micron diameter) sieve passes the silt (3.9-62.5 micron) and clay (less than 3.9 micron) fractions through the sieve. The retained sand fraction was oven-dried and sieved for 15 minutes by the Ro-Tap method in nested sieves of 1/4-phi mesh diameter intervals.

Sieving produced the following sand fractions:

1 .0-2.0 mm very coarse sand 0.125-0.25 mm fine sand
0.5-1.0 mm coarse 0.062-0.125 mm very fine
0.25-0.5 mm medium

Results were computed to provide an integrated account on the grain size fractions and the statistical parameters of sorting, skewness and kurtosis. Folk's sand-silty-clay triangle (Fig. 1; Folk 1961) was utilized in defining the granulometric sediment category. Skewness and kurtosis values were not employed in the sample descriptions but are still available on files. For sorting, Folk's inclusive graphic standard deviation (G,) was employed:

$$G = \frac{0\ 84 - 0\ 16}{4} + \frac{0\ 95 - 0\ 5}{6.6}$$

.35	very well sorted
.35-.50	well sorted
.50-.71	moderately well sorted
.71-1.00	moderately sorted
1.00-2.00	poorly sorted
2.00-4.00	very poorly sorted

(3) Microfossil analysis

Separate samples soaked in the dispersant solution were wet-sieved and air-dried. Carbon tetrachloride solution separated the light fraction that was decanted over filter paper and air-dried. In addition to marking presence of other microfossils (diatoms, ostracodes, sponge spicules, etc.), maximum 300-500 foraminifer specimens (depending on their abundance in given samples) were mounted on white-ruled paleontological slides under microscope. Tragacanth gum, treated with clove oil against bacterial growth was used for attachment. Identification to species rank was done at GCRL or by an outside specialist (Dr. W. Bock of Miami). The statistical composition data was evaluated in light of available salinity biotope information from various sources in the literature (Otvos, 1988). Table I provides a listing of the main salinity biotope categories encountered, as interpreted from the foraminifer populations. All the available core information was integrated on "strip logs" that formed the basis for the construction of geological cross sections (Figs. 11-15).

TABLE 1. SALINITY RANGE CATEGORIES, BASED ON FORAMINIFER ASSEMBLAGES

(1) Oligohaline — lower mesohaline (c. 2—16 ppt)

Dominant

Ammo nium salsum (0-100%)
Ammonia beccarii parkinsoniana (0-100%)

Secondary and minor (Each species usually less than 10-50%).
(Several are common in salt marshes).

Ammobaculites exiguus
A. exilis
Ammonia beccarii tepida
Trochammina sp.
M ¡Hommina fusca
Jadammina poiystoma
Arenoparella mexicana
Haplophragmoides subinvolutum
H. canariense
Ammoastuta inepta
thecamoebians

Very few (1—3) species dominate each sample.

(2) Mesohaline — lower polyhaline (c. 10-26 ppt)

Dominant

Ammonia beccarti parkinsoniana (10-60%)
Ammonia beccarti tepida (10—80%)
Elphidium galvestonense (10-50%)

Secondary

Ammotium salsum (0-20%)
Nonion depressulum matagordanum (0— 15%)

Minor (usually < 5% of total)

Cribroelphidium poeyanum
Palmehnella gardenislandensis
Elphidium latispatium pontium
E. incertum mexicanum

Altogether 15 or less species

(3) Polyhaline — lower euhaline (c. 20—30 ppt)

Dominant (40—60%)

Ammonia beccarii tepida (10—35%)
Nonion depressulum matagordanum (5—30%)
Elphidium galvestonense (10-30%)

Secondary (30-40%)

(a) Lower salinity subgroup
Cribroelphidium poeyanum (0— 10%)
Ammonia beccarii parkinsoniana (0—10%)
Buliminella elegantissima (0—10%) (significant organic content in sediments also favors this species)
Hanzawaia strattoni (0—5%)

(b) Higher salinity subgroup
Hanzawaia strattoni (0—10%)
Nonionella opima (0—15%)
Elphidium incertum mexicanum (0-5%)

Minor

Sum: c. 5—10% of total. Each species less than 1 %.
Fursenkoina sp.
Elphidium latispatium pontium
E. advenum
E. sp.
Brizalina lowmani
Quinqueloculina sp.
Triloculina sp.
Guttulina sp.
Cibicides sp.
Nonionella atlantica
Globigerinoides sp.
G lo bi ger ina sp.

Great species diversity

(4) Euhaline (c. 25—32 ppt)

Dominant

Hanzawaia strattoni (15.0—50.0%)

Secondary

Elphidium galvestonense (5—20%)
Ammonia beccarti tepida (10—15%)
Nonion depressulum matagordanum (10—15%)

Minor

Each species c. 5—10%
Quinqueloculina lamarckiana
Q. seminulum
Buliminella sp.
Ro salina columbiensis
Nonionella opima
Elphidium incertum mexicanum
Cribroelphidium poeyanum
miliolids

Each species c. 0-5%
Bigenerina irregularis
Textularia mayori
T. agglutinans
T. candeiana
Cibicides floridanus
Cassidulina subglobosa
C. crassa
Reussella atlantica
Elphidium discoidale
Buccella hannai
Trifarina bella
Sagrino pulchella primitiva
Globigerina sp.
Globigerinoides sp.

Highest species diversity

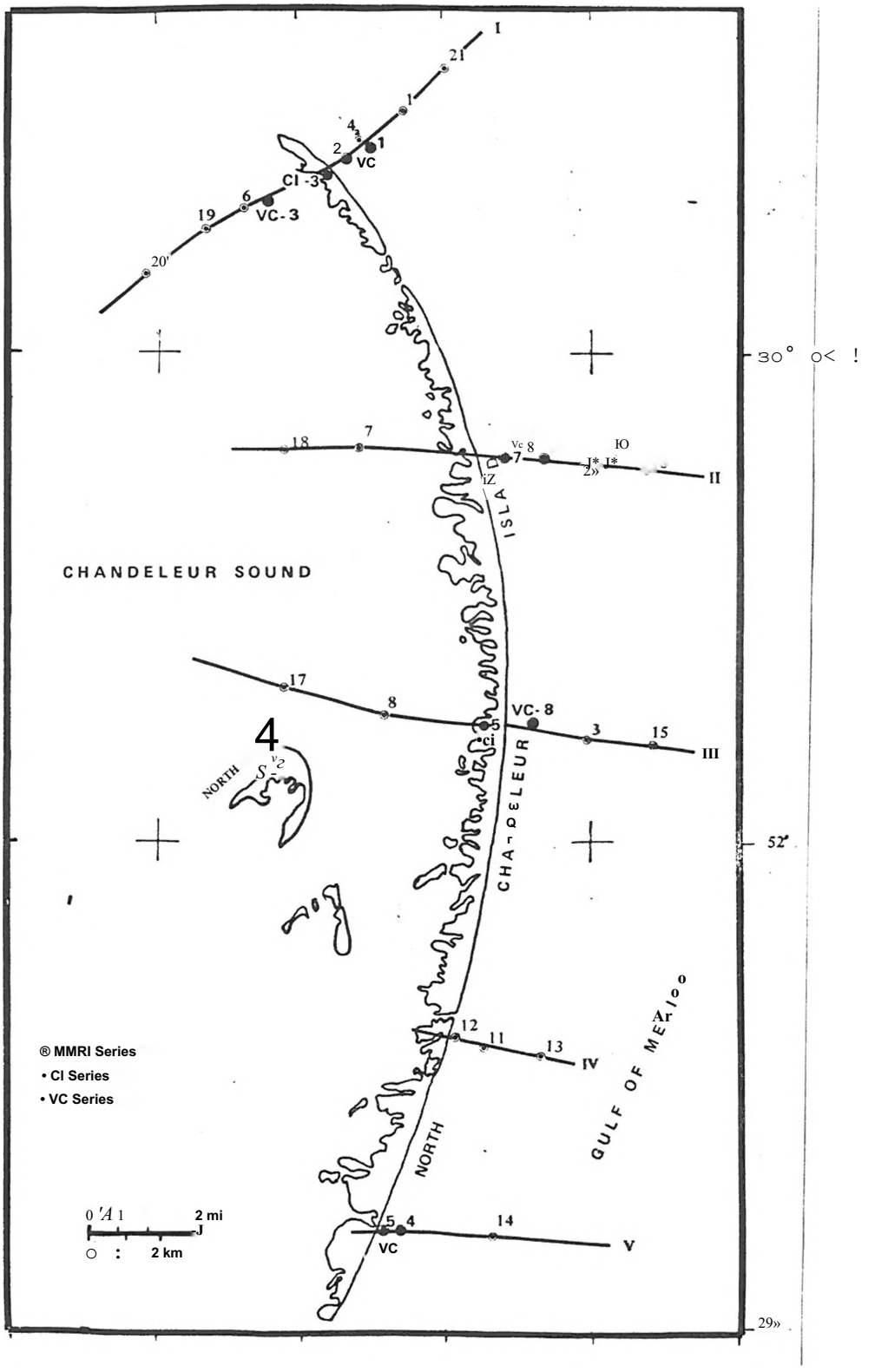


Figure 2. Chandeleur area vibracore locations.

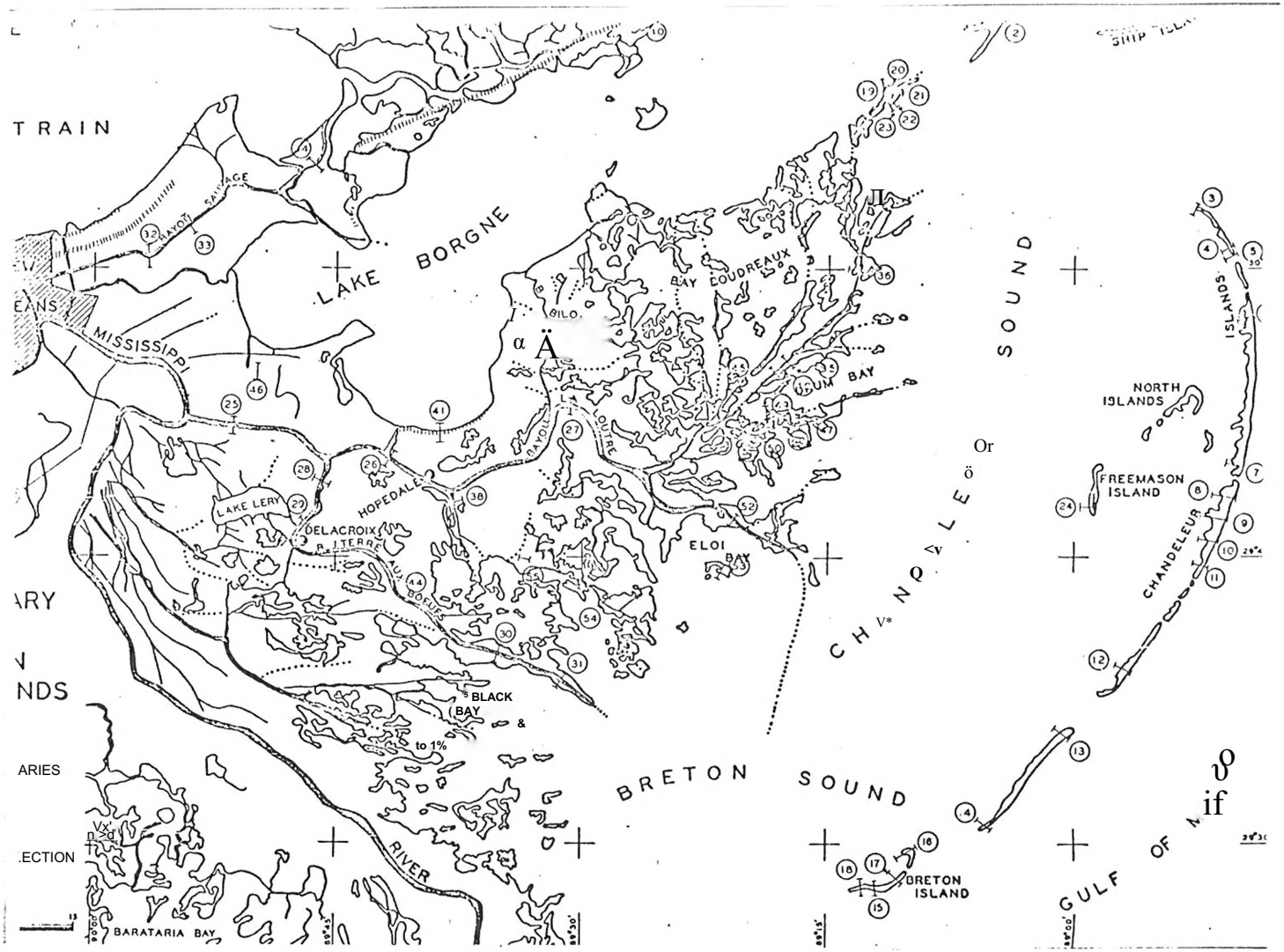


Figure 3 Chandeleur Islands - Chandeleur Sound area (after Treadwell, 1955).

Physiographic Units and Their Sedimentary Characteristics in Study Area

The arcuate Chandeleur chain of barrier islands and shoals, including their continuation to the southwest, Breton Island, stretches from the vicinity of the Mississippi barrier islands to within about 12 km of the active Mississippi River birdfoot delta shore. The narrow chain separates the Gulf of Mexico from the Chandeleur Sound. Breton Island had been cut decades ago into two island segments by storm activity. In contrast with the Chandeleur Islands, northern Breton Island displays somewhat more stability and a progradational history, marked by a relatively high strandplain sequence of beach-dune ridges.

(1) Chandeleur Islands

This unusally low island arc trends almost perpendicular to the Mississippi barrier chain (Fig. 4). Its concave, lagoonward side faces the mainland across Chandeleur Sound. By far the longest and widest member of the island chain, North Chandeleur Island is about 22 km long and 0.5-2.0 km wide. The generally narrow beaches widen to over 60 m during extended storm-free periods but are reduced to a narrow strip following hurricanes when the island also becomes segmented. Shell-rich fine quartz sand occur on the beaches. The Gulf foreshore is backed by low (1'-5'; 0.3-1.5 m), irregular, hummocky eolian dunes. One exceptionally high dune ridge (15'; 4.5 m), shown on the 1951 topographic chart at Chandeleur Light at the northern island tip has long since been reduced by erosion. Low, vegetated storm washover sand flats behind the dunes grade into salt marshes and growths of stunted black mangrove trees. The wetlands behind the dune zone are pockmarked by enclosed/semienclosed ponds and meandering tidal creeks (Figs. 5, 7). Wetlands represent the overwhelming portion of the island area and their deposits underlie the entire island. Charts show that the lagoonal shoreline remained remarkably stable since the mid-19th century, partly due to occasional hurricane-related sand transport from the Gulf side that counteracted erosion on the Sound shore.

Thickets of low black mangrove (Avicennia germinans; earlier; A. nitida) shrub occur in the marsh lagoonward of the Chandeleur dunes (Russell, 1936; Treadwell, 1955). Recurring freeze prevents development of full-grown mangrove trees this far north of the tropical zone. In the eroding Gulf beach face erosion frequently exhumes the marsh and swamp vegetation, buried under overwash and lagoonward shifting island dunes. On certain Gulf beaches, pebbles formed from indurated quartz sandstone and cemented coquina-quartz sand litter the beaches. Roberts and Whelan (1975) suggested that oxidized methane from the highly organic marsh deposits contributed to the carbon content of lime cement in the sandstone slabs.

Relatively frequent, storm-related modification of the island morphology is indicated by the scores of conspicuous storm washover channels, cut clear across the islands (Kahn and Roberts, 1982). Following a major storm the deeper channels, newly created or reopened by storm-driven currents, remain water-filled for a period of time and the Island stays fragmented into numerous islets (e.g., Hurricanes Betsy, 1965, Camille, 1969, Frederic, 1979, Elena, 1985). Healing of storm cuts on North Chandeleur is preceded by sand spit construction across the storm cuts from the adjacent tips of the new islets (Fig. 8). Beach foreshore accretion and dune development across these storm gaps completes the oft-repeated process. Lobate and finger-shaped salt marsh lobes, with tidal channels and pockmarked by thousands of round ponds (Fig.7) extend into the Sound, reflecting the earlier mentioned storm overwash events that created the large fans on the lagoon shores, stabilized later by wetland vegetation.

During lengthy hurricane-free periods the axial zone of the c. 36-km long, 2-3 km wide shoal stretch, located between the south tip of North Chandeleur Island and the pass at Breton Island, had been populated by low islands, generally 200-500 m wide and less than

Figure 4. North Chandeleur Island (view: to NW).

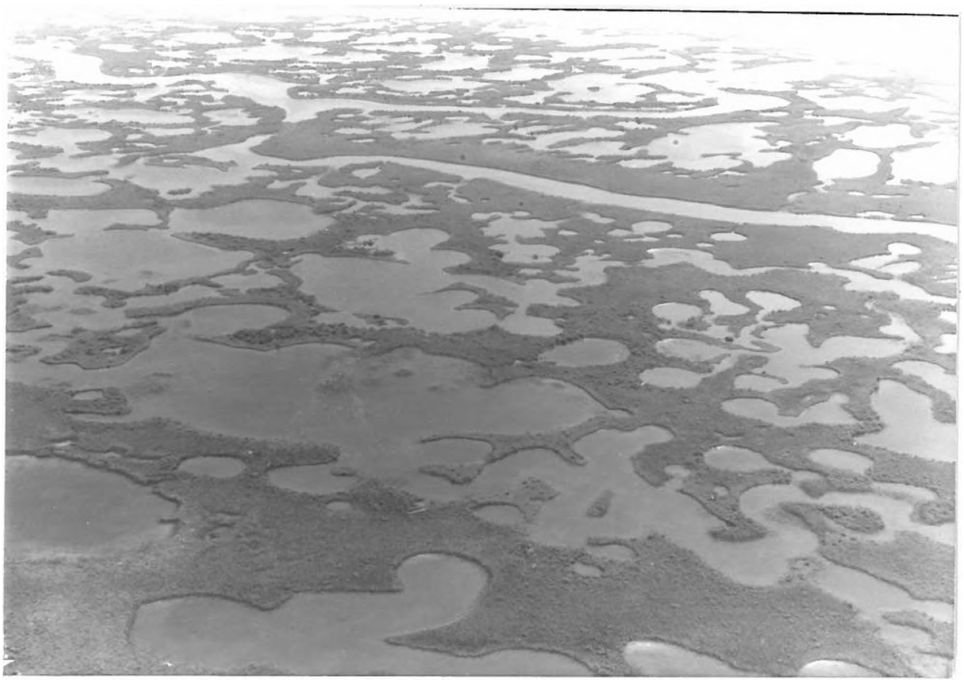


Figure 5. N. Chandeleur Island marshland with tidal channels and hundreds of enclosed and interconnected ponds (1980).

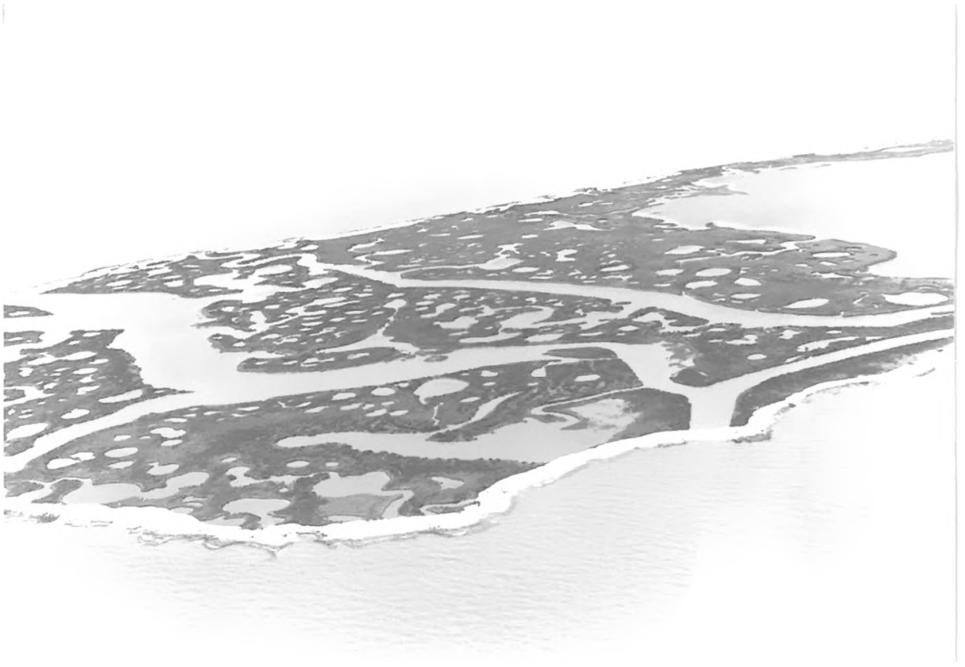


Figure 6. North Islands (Chandeleur Sound), fringed by narrow shell beach. (May, 1980). Islands are eroding, subsiding remnants of marsh-covered St. Bernard subdelta plains that originally extended east of present Chandeleur Islands.

Figure 7. N. Chandeleur Island (view: to NW), dissected by channels, freshly cut and/or reopened during Hurricane Fredric , 1979. Lobate, marshland-covered washover fans on Sound side. (Photo: May, 1980).

Figure 8. Post-hurricane healing of wide storm-cuts, N. Chandeleur Island, 1985. View toward Gulf (E).

Figure 9. Island emergence through paired split growth around shoal area, slowly filled by sand. N. Grand Gosier Island, south of Chandeleurs. View toward NE, Gulf to the right (Otvos, 1981).

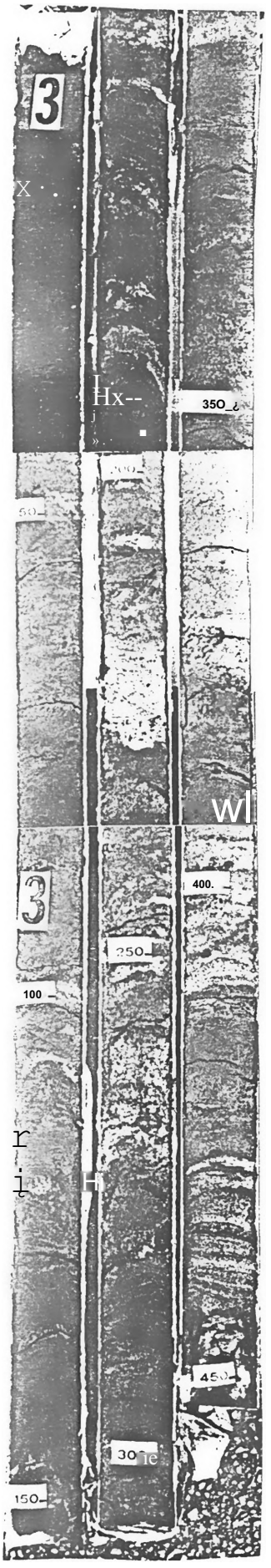


Figure 10. Interlayered muddy-sandy laminae of delta front facies. Especially conspicuous intervals (subbottom depths): 150-200 cm, 300-350 cm and 430-450 cm, Vibracore VC-3.

3.5 km long (named, from NE to SW: Stake, Curlew, North-and South Grand Gosier Islands). Periodic hurricane destruction reverts the islands to submerged shoals, only few feet below sea level. Due to the absence of major storms in the area since 1985, currently these islands are in an emergent/growth mode. Emergence takes place first by the appearance of aggrading intertidal bars on the Gulf and lagoon sides of the now island-free shoal zone, followed by the growth of long straight sand spits, curved (recurved) at their end, and by subsequent widening of the spit foreshore (Fig.9). The central, semi-enclosed newly formed shallow lagoons that the prograding spit arms thus enclose are gradually filled by overwash- and wind-blown sand. The establishment of marsh vegetation later helps in expanding the intertidal-supratidal island area.

(2) Nearshore Gulf Area

The relatively steeply inclined Gulf bottom reaches 30' depth within 2.4-4.0 km, and 50' within 9 km of the islands. Storm waves can thus easily reach the islands. The shoreface bottom, the narrow, steep concave zone, offshore from the beach foreshore, within which significant bottom sediment transport may take place, is underlain by sandy deposits, called the Chandeleur Sand Deposit by Ludwick (1964, p.223). According to him, these sands to the east and southeast are in gradational contact with Late Holocene relict St. Bernard prodelta muds. Silty clays underlie the shelf floor of North Chandeleur Island and sandy silts off the southern Chandeleurs (U.S. Dept. Interior, 1982). A large contiguous shelf sand area (the Mississippi-Alabama Sand Facies of Ludwick and the "Mafia Sand Sheet" of the MMS chart) occurs considerably farther eastward. A map displaying "subaqueous barrier sands" on the shelf floor, extending as far as 5-12 mi east from the islands, and to c. 3 km westward of the Chandeleurs in the Chandeleur Sound (Boyd and Penland, 1988, Fig.10), lacks supporting evidence.

The north-south boundary line between the heavy mineral provinces of the Eastern Gulf (dominantly of stable, recycled minerals: kyanite, sillimannite, staurolite, rutile, zircon) and of the Mississippi River (of less stable minerals: amphiboles, pyroxenes, epidote, ilmenite) lies well east of the Chandeleur Islands shoreface and nearhore shelf area (Goldstein, 1942, Fig.2). The Mississippi River-origins of the Chandeleur Island offshore and shore sands are also indicated by the fine median sand size of the beach and dune sands, in contrast with the uniformly medium-sized Eastern Gulf shore sands. Fine sand also characterizes the foreshores of southern and southwestern Mississippi delta plain beaches.

Vibracore sample data from within 4.5 km of the island shore indicate that the modern shoreface deposits consist of sand with high (generally 15-30%) mud content. At only four locations (VC-2, 6, 7, MMRI-14) was the mud content below 10% (Appendix A). Sediment samples from the Chandeleur Sound floor have a mud content in excess of 15%. The presence of dominantly muddy deposits, not well sorted sands, reduces chances for the presence of economic quantities and grades of heavy mineral placer concentrates on the Chandeleur shelf floor and shoreface.

(3) Chandeleur Sound

The Sound, 38.5 km at its widest,along its mainland shore is flanked by hundreds of small marsh islands, fast eroding remnants of the late Holocene Mississippi-St. Bernard delta plain (Fig.3). It is a shallow water body, 15-19' at the deepest in the central areas and 28-30' just landward of the passes that connect to the Gulf. Three, originally wishbone-shaped, highly segmented island groups with pond-studded marshy interiors that were remnants of the subrecent St. Bernard subaerial delta plains (Freemason, North and New Harbor Islands; Fig.6) occur in the very shallow eastern part of the Sound, opposite the southern half of N. Chandeleur Island. The largest group, North Islands originally was c. 5.2 km long. In recent decades its entire western half was lost to erosion.

Due to the scarcity of quartz sand in this low-energy lagoonal setting, island beaches are dominated by brackish molluscan shells (mostly Crassostrea and Rangia) and their fragments. Major concentrations of reworked molluscan shells (Table 2) occur both on the Gulf island shores and in the two Sounds.

The apexes of the wishbone-shaped islands point north-northeastward, suggesting island formation through southward-directed, refracted wave action, resulting in south-southwest-oriented littoral drift that, just as in the case of Northern Grand Gosier and North Breton Islands, developed pairs of spit-arms around a central shoal area (Fig.9).

Table 2. Molluscan Species at Chandeleur Islands Shell Concentrate Locations, Gulf Beaches (1982-83 Collections by Jacob M. Valentine, Jr. and William Grabei, Louisiana Wildlife Reservation Surveys. Dr.Edwin Cake, Jr. helped in identification.)

(1) N. Chandeleur Island

(a) northern island tip
predominant: Crassostrea virginica
secondary (also brackish, or ranging to brackish facies):
Dinocardium robustum, Mercenaria m.texana, Thais haemastoma, Littori na sp., Argopecten irradians conc, higher salinity; Olivia sayana, Anadara ovalis, Busycon contrarium, Cyrtopleura costata, Macoma constricta

(b) pipeline canal crossing
predominant: Crassostrea virginica, Rangia cuneata
secondary: Dinocardium robustum, Mercenaria m. texana

(c) Redfish Point
predominant: as in (b)
secondary: as in (b), plus Cantharus cancellarius, Neritina (reelivata) usnea, Anadara ovalis

(d) Monkey Bayou
predominant: (as above)
secondary: Mercenaria m. texana, Anadara ovalis, Venus sp.(?), Anadara sp.

(2) Curlew Island

- North predominant: (as above)
secondary: Dosi nia discus, Mercenaria m. texana, Busycon spiratum, Spisula solidissima, Anadara ovalis, Mytilopsis leucophaeta
- South predominant: as above
secondary: Dosi nia discus, Dinocardium robustum, Mercenaria m. texana

(3) Breton Island-North

- West side, SW-spit
predominant: Crassostrea virginica
secondary: Mercenaria m. texana, Rangia cuneata, R. flexuousa, Dinocardium robustum, Thais haemastoma, Taegulus, sp., Atryna sp., Macoma constricta, Dosinia discus
- Gulf (east) side, SE-spit
predominant: Crassostrea virginica (dark shells)

(4) Breton Island - South
predominant: as above
secondary: Rangia cuneata, Anadara ovalis, Dinocardium robustum, Busycon contrarium

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The Sound floor is underlain by muddy sand and sandy mud deposits, generally increasing in sand content from the mud-supplying, highly unconsolidated and eroding St. Bernard delta shores toward the island chain (Treadwell, 1955, Fig.36). The sand content of the Sound floor in the eight vibracores, drilled near N. Chandeleur Island (Fig.2), ranged between 35-86%; the most frequent sediment type being muddy-silty very fine sand. Heavy mineral placers, due to the absence of concentrating high-energy bottom conditions within the Sound, are unlikely to be located here. The shell content of the bottom sediments in the central Sound ranged between 10-50% (Treadwell, 1955; Fig.34); elsewhere this value was much lower.

Salinities, measured over a few summer days (Treadwell, 1955, Fig. 39) decreased from 28 ppt behind the islands, to 19-22 ppt along the western delta plain shores of the Sound. The bottom biotope salinities in the vibracore foraminifer samples, with the exception of one very brackish (1) interval, were uniformly "moderately brackish" (Type 2 biotope, Table I). A biotope contrast toward underlying, more saline (Type 3a) delta front deposits existed only in three of the eight bottom samples in the vibracores; in the other five instances the underlying delta front deposits were of equally low biotope salinity value.

Late Holocene Geological History and Representative Sedimentary Environments.

(1) St. Bernard Subdeltas Stage (3000-1800 yr B.P.). During its Late Holocene history, just as previously, the subdeltas of the Mississippi River continuously shifted their positions, due to river gradient changes and subsequent shifts of the trunk channel. Old subdeltas became abandoned and new ones developed along the ever-changing deltaic shoreline. According to Frazier (1967,Figs. 11 and 12), two subdeltas of the Mississippi that partly overlap chronologically and in areal distribution, have occupied this area during the time interval: the Mississippi-La Loutre Lobe (Lobe #8) between c.3000-2300 yr. B. P., and Lobe #9 between c. 2450-1800 yr. B.P.

Subbottom remnants of these delta complexes were encountered in high-resolution subbottom seismic profiles in the Chandeleur area, performed in the mid-1980's in conjunction with a survey, aimed at finding buried sand resources for barrier island restoration in Louisiana. Various seismic reflection features had been interpreted as tidal channels and deltas, stream distributary channels, lagoonal facies, and even as a beach ridge plain (Suter and others, 1987; Suter and Penland,1988).

Subaqueous delta facies.

Sedimentary analysis of the short vibracored intervals (Figs.11-15; Appendix A,B) identified the presence of two delta subenvironments; subaqueous delta front and prodelta facies. Erosion removed the shallow water and intertidal marsh, swamp, natural levee, distributary mouth bar, distributary channel and distal bar deposits prior to deposition of the overlying lagoonal and even later shoreface sediments.

(a) Delta front Facies, located just offshore from a deltaic shore, represents a transitional belt of deposition between the nearshore zone and the prodelta environments. It is influenced by intensive intermittent sand supply from flooding river channels-distributary mouth bars and the beach zone. The facies is characterized by sequences of alternating silt, mud, sandy mud and sand layers and laminae. Burrow-mottling and ripple crosbedding are common (Reineck and Singh, 1973; Tye and Kosters, 1986, p.582). In general, burrows are not as common as in the prodelta facies. Laminae of detrital organic (plant) matter are very common in Mississippi delta plain sediments.

This facies has been encountered in the majority of the coreholes. Vibracore VC-3 displayed one of the longest and most typical interlaminated (Fig.10) and burrowed delta front intervals. Fine laminae and nests of "coffee ground" consist of detrital, comminuted fine plant detritus that became carbonized after transport from adjacent marsh areas and burial. Foram biotopes indicated moderately brackish and brackish conditions, influenced by the intensity of stream runoff at a given depositional location.

Another indication of river influence and confirmation of delta front facies was the abundance and on several occasions even the predominance of reworked Upper Cretaceous planktonic foraminifers (Heterohelix réussi, Globigerinelloides bentonensis, Ticinella apica, and Guembelitria cretacea; Appendix B) in many of the samples. These sturdy tests, diagnostic of long-distance Mississippi River transport from Texas and/or Oklahoma, were found in Late Pleistocene and Holocene sediments in New Orleans and southern Hancock County (Otvos and Bock, 1976) and in the same St. Bernard delta front deposits in MMRI vibracores #916, #925, and #1037, north of the relict St. Bernard delta shore (Otvos, 1985, pp. 30,39-40).

(b) Prodelta Facies. Located between the delta front and the shelf environments. It is characterized by clayey, muddy sediments with minimum sand content and macroscopically generally massive, uniform appearance. However, color layering and thin laminae of silt and clay, especially near the delta front facies, are not uncommon (Reineck and Singh, 1973, p. 273; Tye and Kosters, 1986). Off the present Mississippi Delta lobe 35% of the sediment consists of silt, the remainder is clay. Bioturbation and shell remains also occur and sometimes are common. Gulfward our cross sections display this clayey facies and/or its transition toward the delta front environment (Figs. 11-15). Due to the large fresh water volumes emitted through the ancient St. Bernard subdelta(s) and the proximity of the delta shoreline, the prodelta biotope had been either brackish (e.g., Fig.11), or even moderately brackish (Fig. 12).

(2) Subdelta Deterioration-Destruction. A shift in the direction of the main Mississippi River channel gradually terminated deltaic sedimentation and as regional deltaic subsidence and sediment compaction continued, the St. Bernard delta plain was subjected to intensive erosion. At present the mainland St. Bernard Parish topography clearly reflects this ongoing process: the highest ground and its offshore continuation in the form of finger-shaped marsh islands in Chandeleur and Breton Sounds occupies areas of former natural levees (Fig.3). Intervening low zones, the former backswamp-, distal natural levee belts have already reverted or are in the process of reverting to fresh water and brackish ponds, channels and lakes. Finally, these wetlands become bays and then, part of the central lagoon area.

The lagoonal deposits encountered in our vibracores contained large quantities of sand that originated from reworked original delta plain river channel and natural levee deposits and, closer to the Gulf, from storm-washover and windblown sands. Salt water marshes and swamps fringe the Chandeleur and Breton Sound and thus contribute to sediments that accumulate in the lagoonal areas. Washover sand along the lagoonal sides of the islands overwhelm the local, semi-autochthonous (shell deposits, marsh peat, etc.), biogenic sediment types. Both moderately brackish and brackish sediment biotopes (#2 and #3a) have been identified, depending on the influence of the higher-salinity Gulf waters at a given location. Shell concentrates, occasional thin plant detritus-concentrates and sand nests and laminae did occur in the vibracores (Appendix A), but none of these sediment textures and structures are exclusively diagnostic of lagoonal setting.

(3) Barrier island evolution and shoreface development. The origins of the present Chandeleur island chain may date back to the active phase of the St. Bernard subdelta lobes a few thousand years ago or to a period following the start of desintegration and

subsidence of these deltaic plains. Evidence to prove that the ancestor of the chain evolved from original delta shore beach-dune ridges at an unknown distance from the present island shores, or from shoals that aggraded from the seafloor, or by other means, has disappeared a long time ago (Otvos, 1986). A long period of shoreward migration from a position along a more irregular ancient delta-front and adjustment to wave conditions is suggested by the smooth arc-like outline of the barrier chain. The historically documented landward retreat of North Chandeleur Island in the past 140 years involved extensive foreshore and shoreface retreat but the lagoonal shoreline remained essentially in place. While their front retreats, the total island area over the short run continuously increases or decreases in response to alternating multi-year cycles, each dominated either by accretional/balanced fair-weather or erosional storm conditions (Otvos, 1986; Fig. 16). The past decades brought about a significant overall net reduction in island areas.

Only the uppermost units of the moderately well-to-very well sorted sand in drillcore sequences CH-3 and CH-5, North Chandeleur Island (Figs. 11, 13 and Appendix A), formed in intertidal and supratidal eolian facies. The rest were washover deposits that gradually filled the lagoonal basin behind the islands. Thus, water depths in the Sound predetermined the maximum thickness of the accumulating washover sequence at a given location. According to Suter and others (1988, p.316), the "barrier sand body" is only 12-15’ thick in the southern area, 15-20’ northward, locally reaching over 30’. However, according to our data, only the 0-17’ interval of vibracore CH-3 contained deposits with over 76% sand content at this northernmost island location (Line I, Fig. 11). The maximum sand concentration was only 41% in the underlying sediments.

A scarcity of peat and plant fragments in the lagoon margin-overwash sands (probably due to chemical decomposition in this highly permeable medium) was typical of our limited lagoonal vibracore samples.

The shoreface zone extends shelfward over a relatively steep bottom from the beach to a slope break toward a more horizontal sea floor surface. Waves move sediments land (island-)ward over the shoreface where multiple breaker zones are common. Longshore bars and megaripples form here. During storms, the lower shoreface zone temporarily accumulates sand, removed from the beach (Reineck and Singh, 1973). The presence of the erosional "ravinement" surface that separates the delta front-prodelta deposits from the overlying veneer of shoreface sands-silty sands explains the complete lack of lagoonal deposits in the vibracores seaward of N. Chandeleur Island. Wave erosion is continuously removing these sediments from the landward-retreating shoreface. The accumulation of Crassostrea and other brackish shell concentrates on Gulf beaches is one indicator of breaker- and shoreface zone reworking of the eroded lagoonal deposits.

Potential mineral resources.

No layers and lenses of dark heavy mineral concentrates have been observed in any of the vibracores drillled through shoreface and island sands. These would be expected as diagnostic indicators of mineral placer deposits. Carefully planned exploitation of the considerable bottom and buried shell resources that would take into account environmental considerations, on the other hand, may be feasible in the lagoonal areas. Any development planning should also take into account future results of ongoing Louisiana Geological Survey vibracore studies.

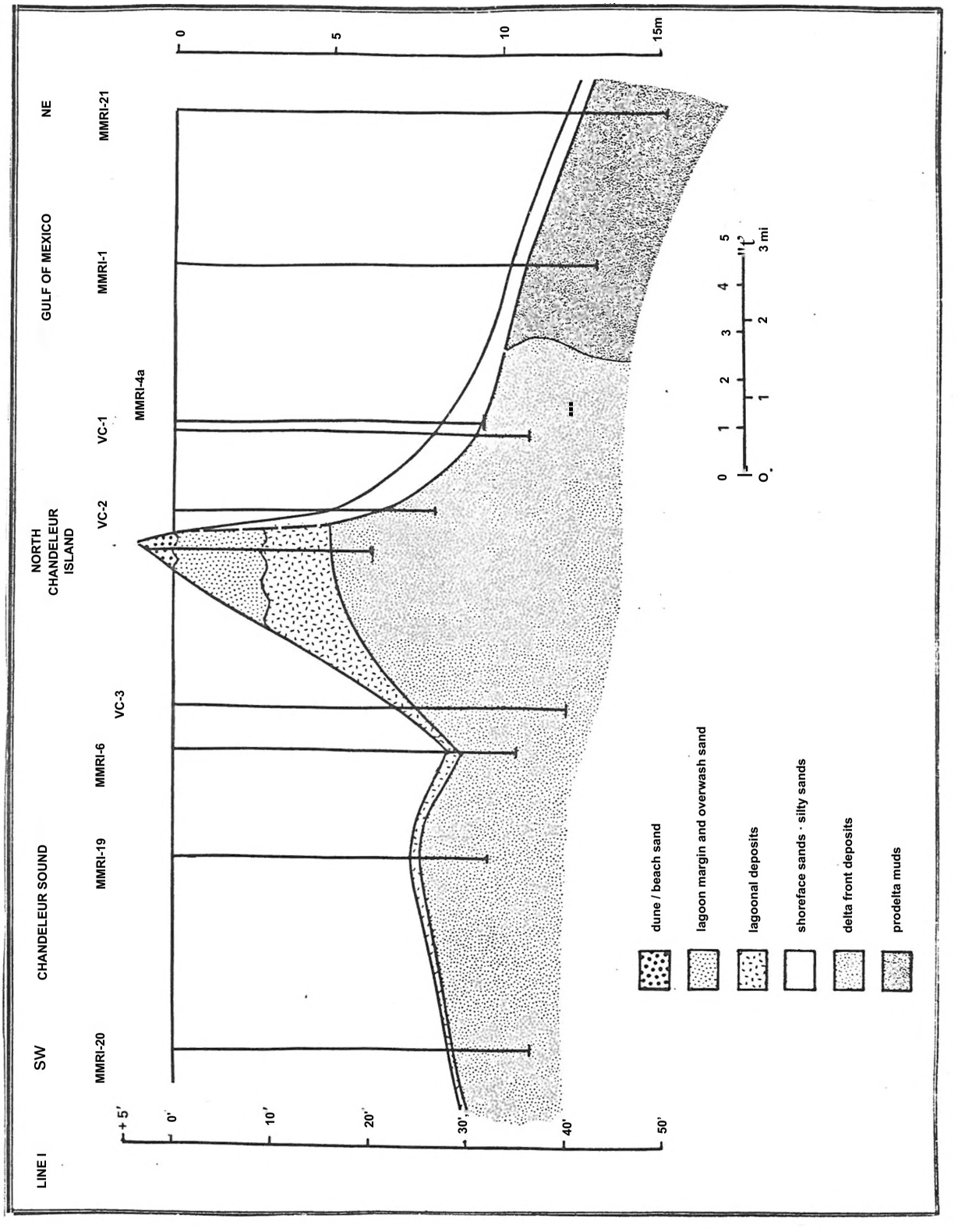


Figure 11. Line I

Figures 11-15. Geologic cross sections I-through-V; Chandeleur Sound to Gulf of Mexico.

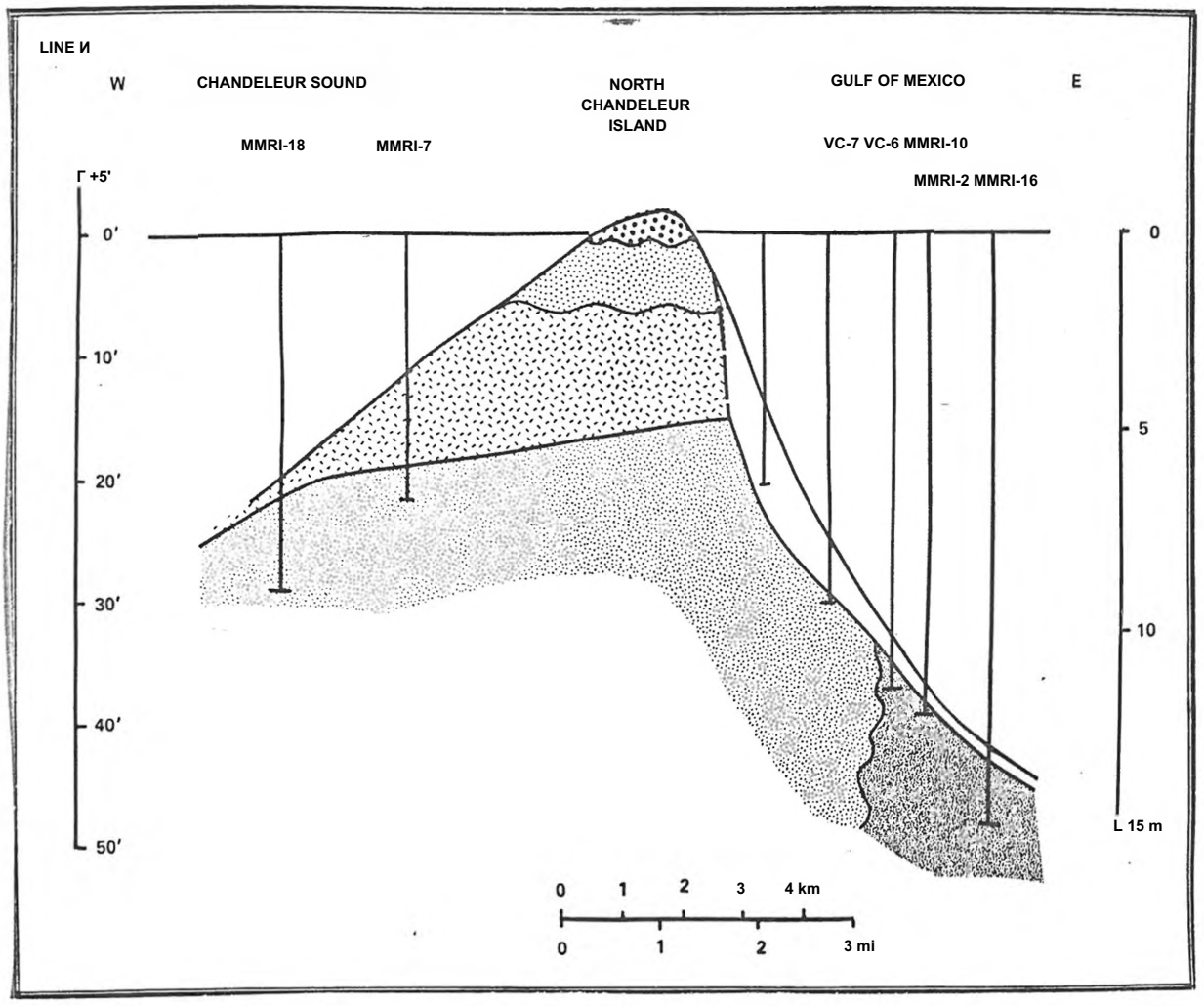


Figure 12. Line II.

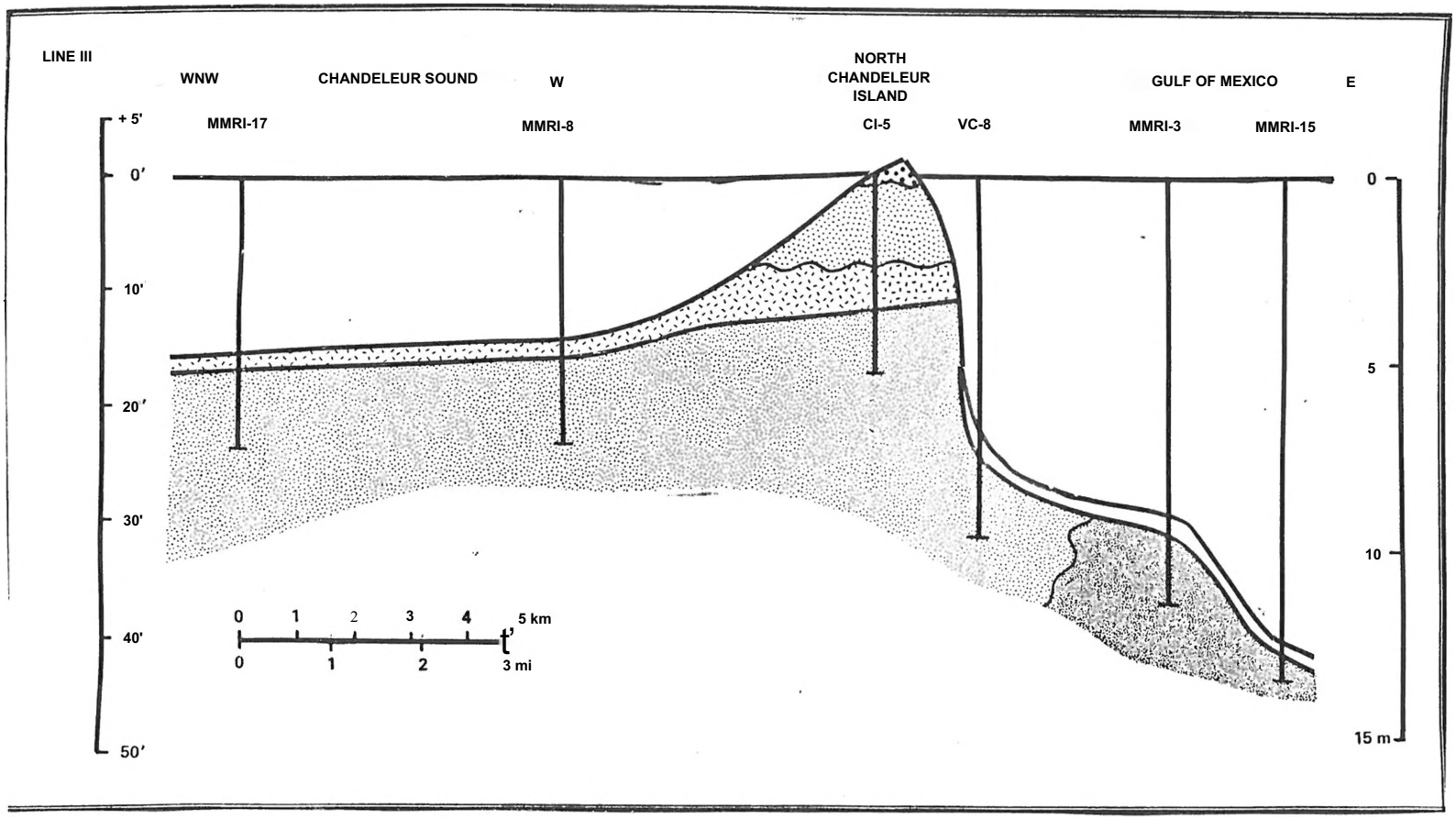


Figure 13. Line III.

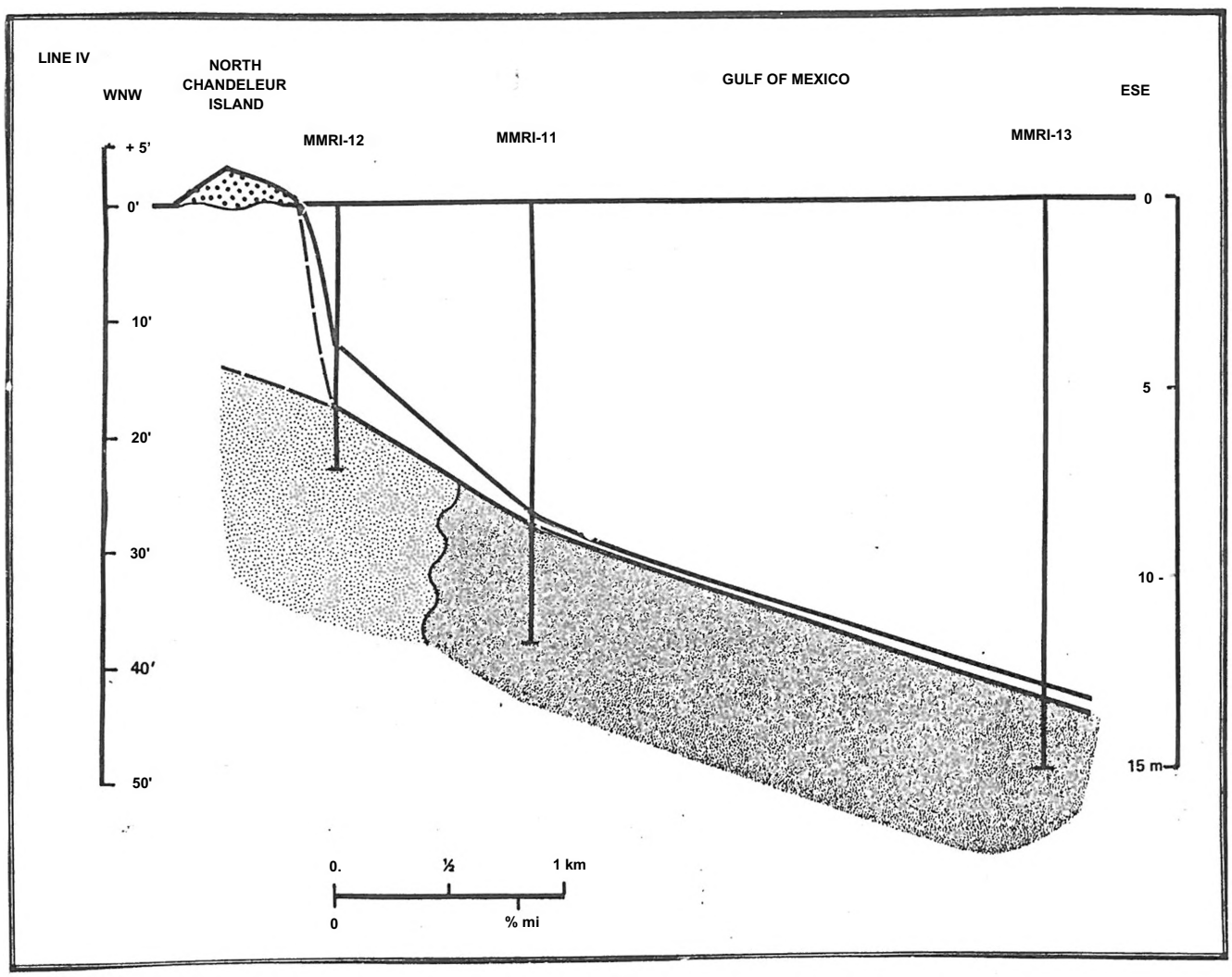


Figure 14. Line IV.

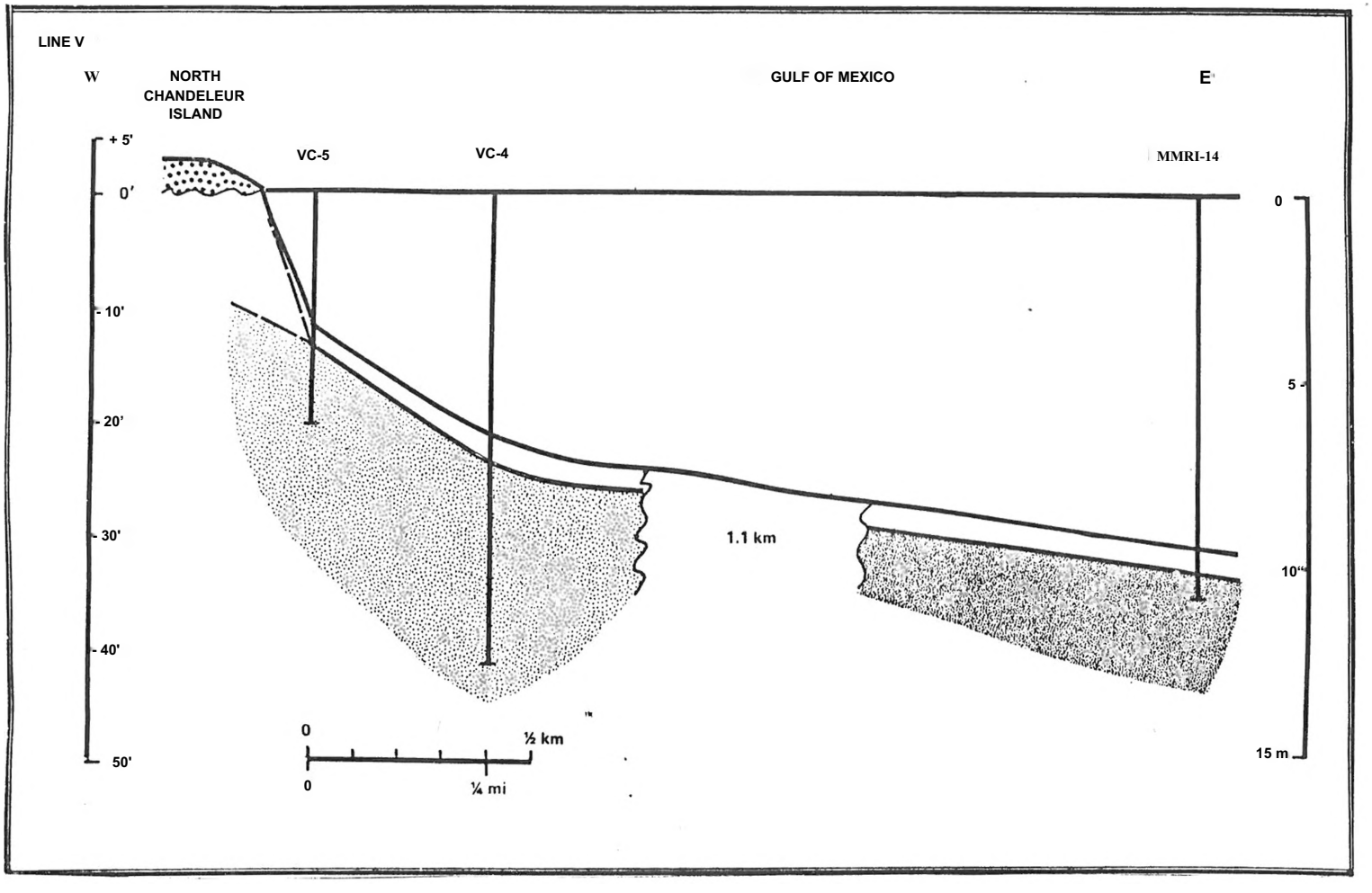
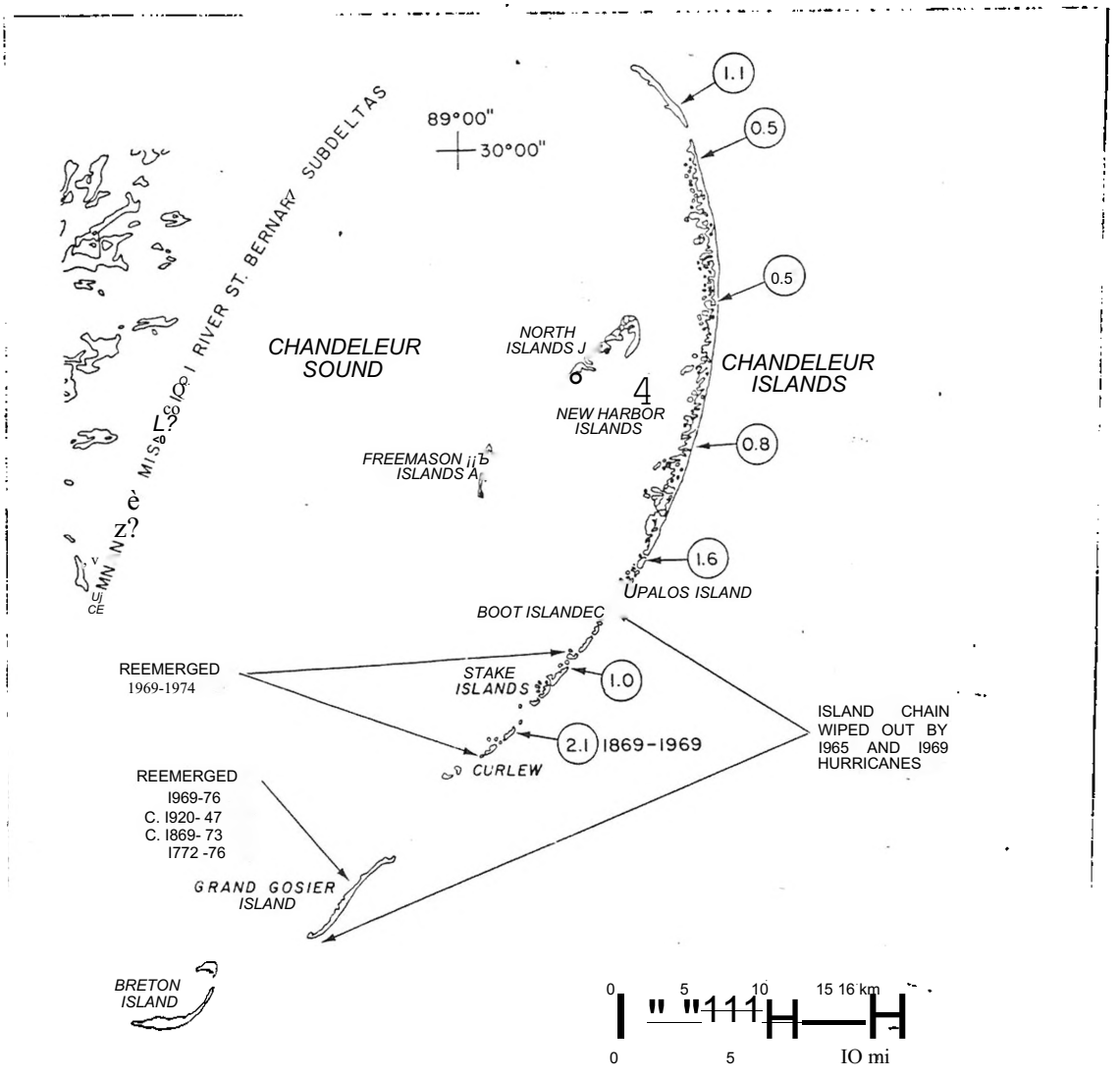


Figure 15. Line V.



Chandeleur barrier island chain, Louisiana. Figures in circles indicate landward migration distances (km) between 1885 (USCGS chart #H-1654) and 1969 (#1270). The 1869 positions were based on USCGS chart #H-999.

Figure 16. Recent shore changes and periods of hurricane destruction, Chandeleur barrier island chain (Otvos, 1981).

Tye , R. S. and Kosters, E. C., 1986, Styles of interdistributary basin sedimentation: Mississippi delta plain, Louisiana: Trans. Gulf Coast Asoc. Geol. Socs., v. 36, p. 575-588.

U.S. Department Interior, Outer Continental Shelf (O.C.S.) Regional Office, Minerals Management Service, 1982, Bottom Sediments and Selected Endangered and Threatened Species (chart), Scale: 1:1,200,000, New Orleans, La.

Woolsey, J.R., Reynolds, Wm., R., and Bargeron, D.L., 1985, Exploration for industrial minerals in Mississippi Sound and adjacent offshore territories of Mississippi and Alabama: Final Report, Miss.-Al. Sea Grant Consortium, #R/ER-11.

APPENDIX A

VIBRACORE LOG DATA

(Note: except where noted otherwise, depth intervals below sea level, in feet.)

(I) GCRL (offshore) Series

VC-1
water depth: 27.0' latit.:30°03.1' long.:88°51.2'

Holocene

- 27.0- -30.9' Coarse, silty very fine sand (sand cont.: 58.4-88.8%), well-to-poorly sorted, massive with no apparent laminae, light olive gray (5 Y 6/1), carbonized plant fragments. Forams: Cribroelphidium poeyanum (28-65%), Ammonia beccarii tepida (3-21%), Elphidium incertum mexicanum 18.6-21%), Elphidium galvestonense (5-12%), Nonionella atlantica, Hanzawaia strattoni. Biotope: 3a (brackish).

- 30.9- -35.7' Interlayered coarse silty very fine sand and sandy mud laminae and layers (sand cont: 20-80%), 1 cm-clay laminae. 33': Tellina alternata molluscan. Forams: Cribroelphidium poeyanum (15-36%), Ammonia beccarii tepida (6-17%), Buliminella elegantissima (5.3-25%), Brizalina lowmani, Nonion depressulum matagordanum, Hanzawaia strattoni. Biotope: 3a (brackish).

  Interpretation: top interval: shelf (shoreface) silty sands, rest: Mississippi-St. Bernard delta front deposits.

VC-2
water depth: 17' latit. :30°2.95' long.:88°51.6'

Holocene

- 17.0- -22.0' Very fine sand (sand cont.:90.6-92%),well sorted, light olive gray (5Y 6/1), shell fragments. Forams: Ammonia beccarii parkinson. (12-28%), Cribroelphidium poeyanum (18.6-31.5%), Elphidium galvestonense (16-18%), E. incertum mexicanum (11-27%), Hanzawaia strattoni. Biotope: 3a (brackish).

-22.0- -26.2' Very fine sand, poorly-to-very well sorted layers (sand cont.: 68-94.7%), light olive gray (5Y 6/1). "Coffee-ground" nests and layers between 22.2-.6' and 25.4-.7'. Burrows between 24.3-24.9', mud laminae between 22.9-23.2'. Thecamoebians, echinoid spines, ostracods, diatoms, molluscan fragments. Forams: Cribroelphidium poeyanum (31.6-49.0%), Elphidium incertum mexicanum (20.5-29.1%), Ammonia becc. tepida (4.9-19.9%), Buliminella elegantissima, Nonionella atlantica, Nonion depressulum matagordanum. Biotope: 3a (brackish).

  Interpretation: top interval: shelf (shoreface) sand units; rest: Mississippi-St. Bernard delta front beds.

VC-3
water depth: 23’ latit. :30°2.3’ long.:88°52.0’

Holocene

- 23 - -26.1’ Muddy, very fine sand (sand cont.: 67-68%), poor-very poorly sorted, light olive gray (5Y 6/1), shell fragments, diatoms, echinoid spines, thecamoebians. Scattered nests of carbonized plant detritus "coffee grounds". Forams: Ammonia beccarii tepida (35.6-59.0%), Ammonia beccarii parkinsoniana (8.3-13.8%), Cribroelphidium poeyanum (12.6-14.7%), Elphidium galvestonense (7.7-13.2%), Trochammina lobata (4.5%). Biotope: 2 (moder, brackish).

- 26.1- -30.1’ Muddy, very fine sand, massive, with coarse silty very fine sand laminae, lenses (sand cont.: 54.5-83.3%), poorly sorted, olive gray (5Y 6/1). Forams in this and the following intervals: Cribroelphidium poeyanum (18.2-29.4%), Elphidium incertum mexicanum (10.3-15.0%), Ammonia beccarii tepida (12.1-13.8%), E. galvestonense, A. becc. parkinsoniana, Buliminella elegantissima, Nonion depressulum matagordanum, Brizalina lowmani (at 37.9’: reworked Cretaceous forams Globigerinelloides bentonensis and Heterohelix réussi). Biotope (from here to bottom): 3a (brackish).

- 30.1- -30.8’ Coarse silty, very fine sand, massive (sand cont.: 67.5-98.3%). Color as . above and as follows. Sorting (here and following): poor-to-very poor (occasionally moderate).

- 30.8- -31.1 Very fine sandy mud with sand lenses, nests.

- 31.1- -31.9’ Muddy, very fine sand, massive (sand content: 61.2%).

- 31.9- -34.2’ Very fine sandy mud with sand lenses, laminae (sand cont.: 46.4%).

- 34.2- -34.6’ Muddy very fine sand (sand cont.: 73.7%), massive.

- 34.6- -36.0’ Very fine sandy mud with sand lenses, laminae.

- 36.0- -36.5’ Coarse silty very fine sand (sand cont.: 82.4%), massive.

- 36.5- -36.9’ Fine sandy mud (sand content: 32%, silt: 41%).

- 36.9- -37.8’ Slightly granular coarse silty, very fine sand (sand cont.: 81.3%).

Interpretation: top unit: lagoonal; rest: typically interlayered Mississippi-St. Bernard delta front sequence.

VC-4
water depth:22’ latit.: 29°46.5’ long.:88°50.4’

Holocene

- 22.0- -24.0’ Coarse and medium silty very fine sand (sand content: 75-85%), poorly and moderately sorted, medium gray (N5) massive, shell fragments. Forams: Ammonia beccarii tepida (34.7-38.3%), Cribroelphidium poeyanum (13.6-16.0%), Elphidium galvestonense (10.3-12.5%), Amm. beccarii parkinsoniana

(3-8.5%), Quinqueloculina lamarckiana, Hanzawaia strattoni. Biotope: 2-3a (moder, brackish-to-brackish).

- 24.0- -25.0' Very fine sandy mud (sand content: 34%), better consolidated, fine laminations, molluscan fragments. Forams: very few extant forms, reworked Cretaceous Heterohelix réussi and Globigerinelloides bentonensis (total:35.1%I).

- 25.0- -26.8' Very fine sandy medium silt (25.9-26.5'; sand cont: 26%), very poorly sorted, coarse silty very fine sand, alternating layers. Thecamoabians, diatoms. Forams: reworked Cretaceous species, as before and Ticinella aprica; total: 56.9%(I).Fewer extant species, Ammonia beccarii tepida (19.5%), Nonion depressulum matagordanum (19.5%). No biotope designation.

- 26.8- -31.2' Very fine sandy medium-to-coarse silt (sand content: 29.6-44.7%), fine lamination esp. between -26.8-30.2'. Consolidated. Light olive gray (5Y 6/1). Occasionally, after coring, oxidized to pale reddish brown (10R 5/4). "Coffee ground" plant concentrate nests, laminae start at -29.5', abundant 30.2'-30.6'. Forams: the four reworked Cretaceous species total: 60.7% (including Heterohelix r., Globigerinelloides bent., Guembelitria cretacea, Rugoglobiger, pust.), Ammonia beccarli tepida, Ammonia beccarii Parkinson. No biotope designation possible from modern tests (too few).

- 31.2- -33.7' Coarse silty very fine sand (sand cont.: 53.6%), poorly sorted, homogenous. No forams. (Reworked three Cretaceous species total: 28.2-36.3%).

- 33.7- -36.7' Very fine sandy mud, medium silt (sand cont: 20.6-37.3%), very poorly sorted, extensive very thin (2 mm) laminations, between 33.7-35.6'. Laminae thicker (1-1.5 cm) 35.6-.7' (very fine sand and mud). Total of reworked Cretaceous foram species (Heterohelix r., Globigerinelloides bent., Ticinella apr.): 47.7%. Modern species very scarce, so no biotope identification possible.

- 36.7- -41.3' Muddy and fine silty very fine sand (sand cont.: 63-65%), poorly sorted. Regularly alternating, 3-cm muddier, and 6-cm sandier layers. After opening cores, muddier units acquired yellowish brown oxidized color. Diatoms, thecamoebians, abundant reworked Cretaceous forams (34.9-38.3% of total; the 36.7-39.1' interval includes also 2.9% Rugoglobigerina pustulata (among four Cretaceous species). Extant species too few for biota identification.

  Interpretation: top interval: lagoonal. Rest: typical finely interlayered, partly homogeneous sandy and sandy-muddy Mississippi-St. Bernard delta front facies, with differing intensities of nearshore marine and fluvial influences.

VC-5
water depth:12' latit.:29°46.5' long.:88°51.2'

Holocene

- 12.0- -13.2' Slightly granular coarse, silty very fine sand (sand cont.: 83-90.3%), massive (uniform), moderate-to-well sorted, light olive gray (5Y 6/1), molluscan fragments. Forams: Ammonia beccarii parkinsoniana (18.8-33.3%), Amm.

bece, tepida (17.7-31.3%), Elphidium galvestonense (13%). Biotope: 2 (moder, brackish).

-13.2- -13.8' Interlayered sand and clay layers.

-13.8--2 0.1' Very fine sandy medium silt, medium silt, mud (sand cont.: 3.5-16.4%). Massive, with occasional sand nests and laminae. Plant fragment concentrates, diatoms. Forams: 13.5-14.5' and 16.8-19.2': Haplophragmoides subinvolutum (19-41%), Trochammina inflata, Ammonia beccarii, Ammotium salsum, Elphidium galvestonense. Biotope: 1 (very brackish; partly salt marsh). 14.5-16.2' and 19.2-20.5': Elphidium galvestonense, Ammonia becc. parkins, and tepida, Nonion depressulum mataqordanum, Cribroelphidium poeyanum. Biotope: 2 (moder, brackish). 20.5-21': Cribroelphidium poeyanum (25.5%), Amm. becc. tepida (20.2%), Elphidium galvestonense (16.3%), E. incertum mexicanum (7.7%), Nonionella atlantica. Biotope: 3a (brackish).

Interpretation: top unit: shoreface sand; rest: Mississippi-St. Bernard delta front sequence with a wide range of fresh- and marine water influences.

VC-6

water depth:23' latit.: 29°58.4 long.: 88°48.4'

Holocene

-23.0- -29.0' Coarse, silty, very fine sand and very fine sand (sand cont.: 81.3-93.8%), homogenous appearance, moderately well-to-very well sorted, light medium gray (N6), gray burrow fills between 24.9-26.0' at several intervals, "coffee ground" concentrate laminae between 28.4-.5', 28.9-29.0'. Molluscan fragments, diatoms, echinoid spines. Foraminifera: Cribroelphidium poeyanum (23-32%), Ammonia beccarii tepida (8.9-21.1%), Elphidium galvestonense (9.7-17.5%). Biotope: 3a (brackish).

-29.0- -31.8' Very fine sandy mud, muddy very fine sand (sand cont.: 49-54%), very poor sorting, light medium gray (N6). Bottom two feet generally homogeneous-appearing. Clay layers (2 in), laminae, "coffee ground" laminae between -29.3-31.8', ostracods, molluscans. Forams: Cribroelphidium poeyanum (30.3%-31.9), Amm. becc. tepida (8.9-18.1%), Elphidium incert, mexicanum (5.8-31.0%), Hanzawaìa strattoni.

Reworked Cretaceous forms (Heterohelix réussi and Ticinella aprica) in trace amounts. Biotope: 3a, 3b (brackish; second interval (30.2-30.5'), with strong marine influence).

Interpretation: top unit: shoreface sands; lower: Mississippi-St.Bernard delta front sediments.

VC-7

water depth:14' latit: 29°58.4' long.88°49.2'

Holocene

-14.0- -18.0' Very fine sand (sand cont.:90.3-91.8%), well sorted, massive, medium light gray (N6), burrows, nests and laminae of clay, "coffee ground", plant fragments (15.4-.6'; 16.0-.4'), small molluscan shells between -14'-17'. Diatoms, ostracods, Foraminifera: Cribroelphidium poeyanum (22.8-28.2%), Elphidium galvestonense (14.6-17.7%), Ammonia beccarii tepida (14.1-20.8%), E. incertum mexicanum (9.9-13.7%), Hanzawaia strattoni (<5%), Ammonia beccarii parkinsoniana (5.0-9.3%). Biotope: 3a (brackish).

-18.0- -21.7' Coarse silty very fine sand (sand cont.: 78.1-87.8%), medium light gray (N6), moderately well-to-very well sorted, massive. Small stringers of silt and "coffee ground", plant fragments between 20.5-21.2'. Ostracods, diatoms. Forams: Ammonia beccarii tepida (32.3%), Cribroelphidum poeyanum (31%), Elphidium galvestonense (18.1%). Biotope: 2 (moderately brackish).

Interpretation (entire sequence) shoreface sands.

VC-8

water depth:23' latit:29°54.3' long.: 88°48.5'

Holocene

-23.0- -24.3' Coarse, silty very fine sand, underlain by very fine sandy medium silt layers (sand cont.:23.5-60.0.%). Massive, moderately-to-poorly sorted. Medium light gray (here and below). Minute plant fragments, "coffee ground" lenses in lower part of interval. Diatoms. Forams: Ammonia beccarii tepida (37-50%), Nonionella atlantica (14.4%), Cribroelphidium poeyanum (11.7%), Nonionella opima (8.9%). Reworked Cretaceous Globigerinelloides bentonensis. Biotope: 2-to-3a (brackish-to-moderately brackish).

-24.3- -26.5' Mud, sandy mud and very fine sandy medium silt with clay lenses (sand content: 3-10.3%). "Coffee ground" nests, laminae, sand lenses in mud. Forams between 26.1-.2': Nonion depressulum matagordanum (27.0%), Ammonia beccarii tepida (26%), Elphidium galvestonense (8.5%), Palmerinella gardenislandensis(8.5%), reworked U. Cretaceous Globigerinelloides bentonensis (5%) and Ticinella aprica. Thecamoebians. Biotope: 3a (brackish). Rest of intervals have too few foram specimens for biotope evaluation.

-26.5- -28.5' Very fine sand (sand cont.: 92.2%), light gray, massive, moderately sorted, fine lamination. Occasional plant fragments. "Coffee ground" carbonized plant fragment concentrates scattered throughout.

-28.5- -31.3' Slightly granular coarse silt and mud (sand cont: 3.6-4.6%). Alternating regular lamination of sand and mud layers typical. Laminae 0.5 cm thick; thinner below 29.6'. Sand lenses in mud, bioturbation. Laminae and nests of carbonized wood fragments.

Interpretation: top unit: shoreface sand veneer; rest: delta front sequence. Massive sand intervals between interlaminated muds/sand/silt units may indicate storm/hurricane episodes ("tempestates").

(II) North Chandeleur Island (Core sample source: Louisiana Geol. Survey/S. Penland)

Cl #3

North Chandeleur Island,north end.Center of Cross Section Line I. Between marsh margin and dune zone; Chandeleur Sound-side of Island. Estimated elevation: 2-3'.(Depth given below land surface.)

0.0 - 3.4' Fine sand, well-to-very well sorted. (Median: .12-.15 mm), light gray. Sand content: 93.2-97.2% Forams: Trochammina inflata (60-79.1%), Haplophraqmoides subinvolutum (6.6-28%), Ammotium salsum (7%). Biotope: back-barrier storm-overwash/wind- transported salt marsh sands.

3.4 - 12.9' Fine sand, very fine sand, silty fine sand. Sand content: 85.8-94.8%. Moderately well-to-very well (in one interval, poorly) sorted layers. Forams: Trochammina inflata (73.6-85.2%), Haplophraqmoides subinvolutum (7.4-20.8%). Biotope: back-barrier lagoon margin and marsh sands.

12.9 - 15.4' Very fine sand (sand content: 91-93.3%), well sorted. Forams (very few): Elphidium galvestonense, Chbroelphidium poeyanum, Nonion depressulum matagordanum. Biotope: moderately brackish, island overwash-influenced lagoonal facies.

15.4 - 17.0' Very fine silty sand (sand cont.:76.2-.9%), poorly sorted. Forams: Chbroelphidium poeyanum, Ammonia beccarii tepida, Elphidium galvestonense, Ammonia beccarii parkinsoniana, Hanzawaia strattoni, Nonion depressulum matagordanum. Biotope: moderately brackish (2)-to-brackish (3a) lagoonal and/or St. Bernard subdelta delta front sequence.

17.0 - 21.9' Very fine sandy silt, very fine sandy mud (sand cont.: 21.2-41.3%), very poorly (poorly) sorted. Forams (relatively few-very few tests): Elphidium galvestonense, Ammonia beccarii tepida, Chbroelphidium poeyanum, Nonion depressulum matagordanum, with few more marine species between 17.9-18.8'(Triloculina brevidentata, Hanzawaia strattoni, Buccella hannai). 21.1-21.9' interval includes diatoms, thecamoebians and ostracods. Moderately brackish(2)-to-brackish(3). Biotope: St. Bernard subdelta delta front sequence.

Cl #5

North Chandeleur Island, south-central area. Center of Cross Section Line III.

0 - 3.3' Fine sand (sand cont.: 92.5-98.7%), well-to-very well sorted. Median: 0.15 mm. No foram data. Biotope: dune-beach and backbarrier overwash sands.

3.3 - 8.1' Fine sand, well, moderately well-to-poorly sorted units (sand cont.: 73.7-97.6%), fine-very fine sand, one interval: muddy very fine-fine sand.

Forams: Trochammina inflata, T. macrescens, Haplophragmoides subinvolutum, Miliammina fusca, Elphidium galvestonense. Biotopes: backbarrier overwash sands in salt marsh, lagoon.

8.1 - 10.8' Silty fine-very fine sand (sand cont.: 86.6-92.6%), moderately-to-moderately well sorted. Forams: identical with those above. Biotope: as above.

10.8 - 18.3' Sandy silt, sandy mud (sand cont.: 13.4-55.8%), very poor-to-moderate sorting. Forams: Ammonia beccarii parkinsoniana and tepida, Elphidium mexicanum, E. galvestonense, occasional agglutinated tests. Biotope: lagoonal and (below) delta front facies.

(III) MMRI (offshore; Gulf and Chandeleur Sound) Core Series

MMRI-1
water depth:34.0' latitude:30°3.82' longitude: 88°50.75'

Holocene

- 34.0- -35.5' Coarse, silty very fine sand (sand content:80-82%), moderately sorted, light olive gray (5Y 5/2), mud lenses between 34.6-.8. Dominant foraminifer taxa: Elphidium galvestonense (20%), Cribroelphidium poeyanum (17%), Ammonia beccarii tepida (13%). Biotope: 3a (brackish).

- 35.5- -43.1' Clay and mud layers (sand content: 0.3-9.9%), light olive gray (5Y 5/2). Forams: Ammonia beccarli' parkinsoniana (4.6-21%), Nonionella opima (9.2-18.4%), Buliminella cf. B. bassendorfensis (13%), miliolids (11.5-14.6%). Biotope: 3a (brackish).

  Interpretation of depositional facies: top unit: shoreface sandy veneer; lower units: prodelta.

MMRI-2
water depth:33.0' latit.:29°58.2' long.:88°47.45'

Holocene

- 33.0- -33.4' Coarse silty, very fine sand (sand content: 78%), moderately sorted, light olive gray (5Y 5/2). Forams (very few): Ammonia beccarii tepida and very few other taxa. Not enough for biotope determination.

- 33.4- -36.7' Medium silt (3.1-8.6% sand content), light olive gray (5 Y 5/2), bioturbated, abundant coarse-silty nests, plant fragments. Forams: Ammonia beccarii tepida (31-35%), Elphidium galvestonense (20-24.7%), trace of miliolids. Biotope: 2 (moder, brackish).

  Interpretation: top: shoreface sand veneer; bottom: Mississippi-St. Bernard delta front facies.

MMRI-3

water depth:29.0' lat.:29°54.1' long.: 88°47.6'

Holocene

-29.0- -30.9' Coarse silty, very fine sand (sand content: 10.5-64%), poorly sorted. Light olive gray (5Y 5/2), moderate olive gray medium-silt laminae between -30.0-30.2'. Plant and molluscan fragments. Forams: very few, including Nonionella atlantica. No biotope determination possible.

-30.9- -37.1' Medium silt, very fine sandy medium silt, and mud layers (sand content: 0.7-8.5%), medium silt poorly sorted. Olive gray (5Y 4/2), molluscan fragments. Forams: Ammonia becca rii tepida (10.3%), A. b. parkinsoniana) 14%). Few foram tests. Reworked Cretaceous Heterohelix réussi and Globigerinelloides bentonensis specimens between 31'-37.7'. Biotope: generally brackish, precise definition not possible.

Interpretation: upper unit: shoreface sand veneer; lower units: Mississippi-St. Bernard prodelta silts (transitional from delta front facies).

MMRI-4a
water depth:28.0' latit.:30°3.3' long.:88°51.5'

Holocene

28.0- -31.5' Coarse silty, very fine sand and muddy very fine sand layers (sand content: 81-87%), with occasional high clay content (8.0%), very well-to-poorly sorted. Light olive gray (5Y 5/2), molluscan shell fragments abundant between 30.4-3I.5'. Forams: Cribroelphidium poeyanum (54.5%), Elphidium incertum mexicanum (30%). Biotope: 3a (brackish). Interpretation: shoreface sand veneer.

MMRI-6
water depth: 28.0' latit.:30°2.26' long.: 88°53.45'

Holocene

-28.0- -29.5' Very fine sandy medium silt, very fine sandy mud (sand content: 30-48%), very poorly sorted, light olive gray (5Y 5/2), plant and molluscan fragments. Forams: Ammonia beccarii tepida (14-36%) and Elphidium galvestonense (20-25%). Biotope: 2 (moder, brackish).

-29.5- -34.7' Coarse silty very fine sand (sand content: 53.5-67.0%), poorly sorted, olive gray (5 Y 4/2), plant and molluscan fragments. Forams: Cribroelphidium poeyanum (21-29.5%), Elphidium galvestonense (7.5-21%), E. incertum mexicanum (20-23%), E. q unte ri (8-20%), Buccella hannai, Hanzawaia strattoni. Biotope: 3a (brackish).

Interpretation: upper unit: lagoonal (Chandeleur Sound) silts, muds, lower units: Mississippi-St. Bernard delta front sands.

MMRI-7
water depth:11.0' latit.: 29°58.61 ' long.: 88°51.54'

Holocene

-11.0- -21.5' Coarse silty, very fine sand layers (sand content: 64.5-85.7%, the lower values occur below -19'), poorly-to-moderately sorted, olive gray (5Y 5/2), molluscan fragments. Foraminifers: Elphidium incertum mexicanum (16-45%), Cribroelphidium poeyanum (13-23%), Ammonia becc. tepida (7-17.5%). Biotope: 2 (moder, brackish).

Interpretation: lagoonal silty sands; the lowest silty layers (c.2.5') probably represent delta front sediments.

MMRI-8
water depth: 14' latit.:29°54.47' long.: 88°51.1Γ

Holocene

- 14.0- -15.4' Muddy to coarse silty, very fine sand (sand content: (78.4-86.2%), poorly sorted, light olive gray (5Y 5/2). Molluscan fragments. Forams: Ammonia beccarii tepida (26-27.5%), Elphidium qalvestonense (21.7-27.8%), Ammonia beccarii parkinson. (7-27.5%). Biotope: 2 (moder, brackish).

- 15.4- -24.8' Thin layers and lenses of very fine sandy coarse silt, very fine sandy medium silt, very fine sandy mud, medium silt (sand content: 3.6-37.3%); 23.6-24.8': coarse silty very fine sand, porly-to-moderately sorted (sand content; 51.6-60%). Olive gray (5Y 4/2), molluscan and plant fragments. Medium silt and very fine sand laminae at 17.3'. Foraminifers: Ammonia beccarii parkinson. (11.5-34%), Amm. becc. tepida (51-47%). Reworked Cretaceous species (Heterohelix réussi, Globigerinelloides bentonensis) between 15.6-25.3'. Biotope: 2 (moderately brackish)

Interpretation: top unit: lagoonal (Chandeleur Sound); bottom units: St. Bernard delta front deposits. Uncertain boundary.

MMRI-10
water depth:37' latit.:29°58.45' long.:88°47.17'

Holocene

-37.0- -37.6' Coarse silty very fine sand (sand content:78%), very well sorted, medium light olive gray (5Y 5/1), molluscan fragments, very few forams.

- 37.6- -39.5' Very fine sandy medium silt (sand content: 1.7-10.3%) and mud layers. Soft, moderate greenish gray (5G 5/1), molluscan fragments. Forams: Elphidium galvestonense (26.7%), Ammonia beccarii tepida (14.6%), Brizalina lowmani (14%). Biotope: 2 (moder, brackish).

Interpretation: upper unit: shoreface sands (see, MMRI #2,#16, this report), lower deposits: prodelta lutites, clays.

MMRI-11
water depth:27.0' latit.: 29°49.34' long.: 88° 49.36'

Holocene

27.0- -38.9' Mud, with layers, lenses of sandy mud, medium silt and clay (sand cont.:0.9-5.1%; top 0.1':10.3%). Molluscan (Crassostrea virgin.) fragments. Forams: Ammonia beccarii tepida (24-42%), Elphidium galvestonense. Biotope: too few forams for accurate identification, generally brackish. Interpretation: very top: shoreface sand veneer; below: prodelta muds.

MMRI-12

water depth" 13' latit.: 29°49.48' long.: 88°49.83'

Holocene

- 13.0- -16.7' Coarse, silty very fine sand (sand cont.: 58-79.7%), well-to-poorly sorted, light olive gray (5Y 6/1), molluscan and plant fragments. Bioturbation mottling. Forams: Elphidium galvestonense, Ammonia beccarii tepida (very few specimens). Reworked Cretaceous forams: Globigerinelloides bentonensis, Heterohelix réussi, and Ticinella aprica. Biotope: 2 (moderately brackish).

- 16.7- -23.3' Mud (sand cont.: 0.7-3.0%), soft, olive gray (5Y 4/1), bioturbation, plant fragments, medium silt fills burrows. Forams: Brizalina lowmani (95% in 17.5-17.7' interval), Elphidium gunteri (50% in 22.2-22.3' interval). Otherwise very few tests, biotope generally brackish. Reworked Cretaceous planktonic taxa Globigerinelloides bentonensis, Heterohelix réussi, Ticinella apica 16.0-.1' and 20.7-23.3'.

  Interpretation: top unit: shoreface sand veneer; bottom units: St. Bernard delta front muds.

MMRI-13

water depth: 42' latit.: 29°49.22' long.: 88°48.34'

Holocene

- 42.0- -43.0' Very fine sandy mud (sand content:26%), olive gray (5Y 4/1), with very fine sand lenses, molluscan fragments. Forams: Ammonia beccarii tepida (31%), miliolids, Ammonia becc. parkinsoniana (12%), trace of Hanzawaia strattoni. Biotope: 3a (brackish).

- 43.0- -49.3' Mud, medium silt and clay layers (sand content: 0.2-0.9%; 49.2- -.3' interval: 2.2%), light olive gray (5Y 5/1). Foraminifera (43.0-48.4'): Ammonia beccarii tepida (5-22%), Elphidium galvestonense (12-18%). Abundant Brizalina lowmani (c.45%)at -48.5'. One Heterohelix réussi (reworked Cretaceous) specimen 49.2-.3'. Biotope: 2 (moder, brackish).

Interpretation: top: shelf sandy mud veneer; rest: Mississippi-St. Bernard prodelta muds, clays.

MMRI-14

water depth:31.0' latit.: 29°46.4' long.: 88°49.23'

Holocene

- 31.0- -33.2' Coarse silty very fine sand (sand content: 88.1-91.3%), moderately-to-moderately well sorted, light olive gray (5Y 6/1), molluscan fragments. Forams: Ammonia beccarii tepida(11-37%), Elphidium gunteri (9.2%), miliolids (7%), Nonionella atlantica (8%), Hanzawaia strattoni (3%). Biotope: 3a (brackish). (4% Ammotium salsum: natural admixture from lagoonal coastal facies).

- 33.2- -35.7' Coarse, silty, very fine, poorly sorted sand (sand content: 66.1-89.3%), with clay and mud lenses, layers at -33.5-.6 and at core bottom (sand content: 2.5-4.7%), light olive gray (5Y 6/1), molluscan fragments. Scarce foram specimens: too few for biotope determination.

  Interpretation: top unit: shoreface (shelf) sand veneer, rest: Mississippi-St. Bernard deltafront-prodelta transition? facies.

MMRI-15

water depth:40.0' latit.: 29°53.93' long.:88°46.54'

Holocene

- 40.0- -41.25' Coarse silty, very fine sand (sand cont.:83.4-88.7%), moderately sorted, light olive gray (5Y 6/1), molluscan fragments. Forams: Ammon, becc. tepida (37%), Elphidium galvestonense (17.5%). Biotope: 2 (moder.brackish).

-41.25- -43.5' Coarse silty very fine sand (sand cont.:31.7-64.6%), poorly sorted, light olive gray (5Y 6/1) with coarse lenses at 41.25;, 43.4'. Plant fragments. Reworked Cretaceous forams (Heterohelix réussi and Globigerinelloides bentonensis). To few tests for biotope identification.

  Interpretation: top: shoreface silty sand veneer; rest: prodelta (deltafront) sediments

MMRI-16
water depth: 42' latit.: 29°58.23' long.:88°46.58'

Holocene

-42.0- -42.5' Coarse silty very fine sand (sand cont.:65.1%), moder, yellowish gray (5Y 6/2), molluscan fragments. Forams; Ammonia beccarii tepida (31%),

Elphidium gunteri (23%), Att, bece, parkinsoniana (17.1%) Biotope: 2 (brackish).

- 42.5- -48.1' Mud and clay layers (sand cont.:0.3-3.8%), with very fine sandy coarse silt (sand cont.: 25%), coarse silt lenses at 45.6-.7 and 45.0', plant fragments: 48', medium light gray (N6). Forams: Elphidium gunteri (14.7-34%), Amm. becc. parkinson. (2.6-17.6%). Reworked Cretaceous species Heterohelix réussi at 42.7-.8'. Biotope: 2 (moder, brackish).

  Interpretation: top: shoreface sandy veneer; rest: muddy prodelta facies

MMRI-I7

water depth:15.0 latit.:29°54.82' long.: 88°52.8l'

Holocene

- 15.0- -15.2' Coarse silty very fine sand (sand cont.:75.3%), poorly sorted, very light olive gray (5Y 6/2), molluscan fragments. Forams: Ammonia beccarii parkinsoniana (39.3%), Elphidium galvestonense (16%), Amm. becc. tepida (15%). Biotope: 2 (moder, brackish).

- 15.2- -16.8' Very fine sandy coarse silt (sand cont.:29.4-36.7%), very poorly sorted, moder, olive gray (5Y 4/2), bioturbations. Forams: Ammonia beccarii parkinsoniana (30-39.3%), Ammotium salsum (6.5%). Biotope: 1 (very brackish).

- 16.8- -18.2' Muddy, silty, very fine sand (sand cont.:71-82%), very poorly sorted, light olive gray (5 Y6/1), molluscan fragments. Foraminifera: Ammonia beccarii tepida (21-48.7%), Elphidium galvestonense. Biotope: 2 (moder, brackish).

- 18.2- -20.1' Very fine sandy medium silt, medium silt (21-60%), with very fine sandy lenses, bioturbation, olive gray, plant fragments. Molluscans: Crassostrea virginica. Forams: Ammonia beccarii parkinsoniana, Elphidium galvestonense, Amm. becc. tepida (too few, max. 62 specimens per sample). Biotope: 1 (highly-) or 2 (moderately brackish).

- 20.1- -23.6' Coarse silty, and muddy very fine sand layers, very fine sandy medium silt laminaeers (sand cont.: 21-86.7%), poorly sorted, light olive gray (5Y 6/1), plant and molluscan fragments. Very few foram tests, thecamoebians. Reworked Cretaceous forams Heterohelix réussi and Globigerinelloides bentonensis.

  Interpretation. 15.0'-16.8': lagoonal (Chandeleur Sound), rest: Mississippi-St. Bernard deltafront sands and silts.

MMR-18
water depth:20' latit. :29°58.61 ' long.:88°52.86'

Holocene

-20.0- -20.5' Muddy very fine sand (sand cont.:60.3%), very poorly sorted, greenish gray (5G 6/1), molluscan fragments. Forams: Ammonia beccarii tepida (36.8%),

Cribroelphidum poeyanum (26.5%), Amm. bece, parkinsoniana (12%). Biotope: 2 (moder, brackish).

- 20.5- -28.8' Mud, medium silt, coarse silt and clay layers (sand content: 0.1- 9.1%), soft, olive gray (5Y 6/1), medium to coarse silt lenses 22.45-.55' and 27.7-.9' very thin laminae at 23.9-24.1'. Molluscan fragments. Forams: Elphidium galvestonense (4-34.1%), E. gunteri (9.7-29.1), Ammon, becc. tepida (7.8-35.0%), Brizalina lowmani (3.6-5.4%), miliolid sp. Biotope: 3a (brackish).

  Interpretation: top: lagoonal muddy sands; rest: Mississippi-St. Bernard prodelta (delta front transition?) muds, clays.

MMRI-19
water depth:24.0'; lat.: 30°01.9' long.:88°54.12'

Holocene

- 24.0'- -24.5' Muddy very fine sand (55% sand cont.), poorly sorted, greenish gray (5G 6/1), plant fragments, molluscan fragments, forams: Ammonia beccarii tepida (51.9%), Ammonia beccarii parkinsoniana (10.4%), Cribroelphidium poeyanum (10.4%). Biotope: 2 (moder, brackish).

- 24.5' -29.4' Very fine sandy mud (46-17% sand cont., decreasing downward), soft, greenish gray (5G 6/1)-to-olive gray (5Y 4/1), plant fragmnts, molluscan fragments, forams: Ammonia beccarii tepida (35%), Amm. becc. parkinsoniana (15%), Cribroelphidium poeyanum (c.10%). Biotope: 2 (moder, brackish)

- 29,4' -32.0' Mud, very soft (1.7-0.2% sand cont., decreasing downward). Olive gray (5Y4/1), forams: Ammonia beccarii tepida (11-40%), Nonion depress. matagordanum (40%), Brizalina lowmani (12%), Elphidium incertum mexicanum (8.6%), E. galvestonense (4-68%). Biotope: 3a (brackish).

  Interpretation: top unit shoreface/shelf sand, muddy sand; bottom units: Mississippi- St. Bernard foredelta facies

MMRI-20
water depth:28.0' long.:30°01.23' lat.: 88°55.18'

Holocene

- 28.0- -28.5' Very fine sandy coarse silt (35.1% sand cont), grayish olive (10Y 4/2), plant and molluscan fragments. Forams: Ammonia beccarii tepida (31.5%), Ammonia beccarii parkinsoniana (19.8%), Ammotium salsum (10%). Biotope: 2 (moder, brackish).

-28.5- -36.2' Medium and coarse silt, mud, interlayered (27.6-.2% sand content, decreasing downward); grayish olive (10Y 4/2), light olive gray (5Y 5/1)-light olive brown (5Y 5/6), with traces of burrowing and silt laminae at five intervals. Forams: Ammonia beccarii tepida (16.7-34.7%), Elphidium galvestonense (7-14%), Cribroelphidium poeyanum) 8-26%). Cretaceous taxa (Heterohelix réussi, Globigerinelloides bentonensis) between 3O'-32.5'. Biotope: 2 (moder, brackish).

Interpretation: top layer: lagoonal; bottom units: Mississippi-St. Bernard delta front sequence.

MMRI-21
water depth:40.0' latit. :30°4.45' long.:88°50.05'

Holocene

-40.0- -41.1' Coarse silty very fine sand (56-81.6% sand content), loose, poorly sorted, light olive gray (5Y 5/1), molluscan fragments. Forams: Cribroelphidium poeyanum (29%), Ammonia beccarii tepida (19.5%), Elphidium galvestonense (11%), Quinqueloculina sp. (11%). Biotope: 3 (brackish).

-41.1- -46.9' Clay (0.7-4.4% sand content), very soft, olive gray (5Y 4/1), molluscan fragments. Forams: Buliminella cf.B. bassendorfensis (37%), Nonionella opima (5-18%), Brizalina lowmani (4.8-18.8%). Biotope: 3 (brackish).

Interpretation: top: shoreface (shelf) sand; bottom units: Mississippi-St. Bernard prodelta (delta front transition?) beds.

APPENDIX B

FORAMINFER ASSEMBLAGES USED IN DEPOSITIONAL FACIES INTERPRETATIONS
(*Reworked Cretaceous tests)

	specimen no.	percentage
VC-1		
27.0'-27.1'		
Cribroelphidium poeyanum	87	28.4
Ammonia beccarii tepida	65	21.2
Elphidium incertum mexicanum	57	18.6
Elphidium galvestonense	37	12.1
Ammonia beccarii parkinsoniana	18	5.9
Quinqueloculina lamarckiana	12	3.9
Nonionella atlantica	7	2.3
Hanzawaia strattoni	6	2.0
Nonionella opima	5	
Nonion depressulum matagordanum	3	1.0
Quinqueloculina fragments	3	
Buliminella c.f. B. bassendorfensis	2	
Elphidium advenum	2	0.6
Quinqueloculina tenagos	1	
Trochammina inflata	1	0.3
28.6'-28.'6		
Cribroelphidium poeyanum	53	65.4
Elphidium incertum mexicanum	17	21.0
Elphidium galvestonense	4	4.9
Ammonia beccarii tepida	3	3.7
Ammonia beccarii parkinsoniana	2	2.5
Nonion depressulum matagordanum	1	
Nonionella atlantica	1	1.2
30.8'-30.8'		
Cribroelphidium poeyanum	no	36.5
Ammonia beccarii tepida	49	16.3
Elphidium galvestonense	49	
Elphidium incertum mexicanum	27	9.0
Nonion depressulum matagordanum	13	4.3
Quinqueloculina lamarckiana	9	3.0
Ammonia beccarii parkinsoniana	7	
Nonionella atlantica	7	2.3
Nonionella opima	5	1.7
Brizalina lowmani	4	
Buliminella elegantissima	4	1.3
Buccella hannai	2	
Buliminella cf. B. bassendorfensis	2	0.7
Fursenkoina pontoni	2	
Haplophragmoides subinvolutum	2	
Quinqueloculina seminulum	2	
* Heterohelix réussi	1	
Guttulina australis	1	0.3

Quinqueloculina sp.	1	
Reussella atlantica	1	
Triloculina bermudezi	1	
Triloculina brevidentata	1	
Triloculina linneiana comis	1	
	301	99.9

32.5′-32.6′

Cribroelphidium poeyanum	77	36.2
Elphidium incertum mexicanum	34	16.0
Buliminella elegantissima	32	15.0
Elphidium galvestonense	30	14.1
Ammonia beccarii tepida	13	6.1
Nonion depressulum matagordanum	6	2.8
Nonionella atlantica	3	1.4
Quinqueloculina sp.	3	
Ammonia beccarii parkinsoniana	2	
Hanzawaia strattoni	2	0.9
Haplophragmoides subinvolutum	2	
Ammobaculites exiguus	1	
Brizalina lowmani	1	
Buccella hannai	1	
Buliminella cf. B. bassendorfensis	1	0.5
Fursenkoina pontoni	1	
Nonionella opima	1	
Quinqueloculina lamarckiana	1	
Quinqueloculina tenagos	1	
Triloculina trigonula	1	
	213	100.2

34.1′-34.7'

Buliminella elegantissima	62	25.0
Elphidium galvestonense	57	23.0
Cribroelphidium poeyanum	37	14.9
Ammonia beccarii tepida	32	12.9
Nonion depressulum matagordanum	11	4.4
Brizalina lowmani	10	
Elphidium incertum mexicanum	10	4.0
Buliminella cf. B. bassendorfensis	8	3.2
Ammonia beccarii parkinsoniana	7	2.8
Nonionella atlantica	5	2.0
Nonionella opima	4	1.6
Hanzawaia strattoni	2	0.8
Ammotium salsum	1	
Buccella hannai	1	0.4
Rosalina columbiensis	1	
	248	100.3

35.6′-35.7′

Cribroelphidium poeyanum	70	21.7

Ammonia beccarii tepida	55	17.0
Elphidium galvestonense	41	12.7
Brizalina lowmani	23	7.1
Nonion depressulum matagordanum	22	6.8
Elphidium incertum mexicanum	20	6.2
Nonionella atlantica	19	5.9
Buliminella elegantissima	17	5.3
Nonionella opima	12	3.7
Ammonia beccarii parkinsoniana	10	3.1
Buliminella cf. B. bassendorfensis	9	2.8
Hanzawaia strattoni	5	1.5
Buccella hannai	4	1.2
Quinqueloculina fragments	4	
Globigerinoides ruber	2	0.6
Quinqueloculina tenagos	2	
Uvigerina peregrina	2	
Brizalina lanceolata	1	
Brizalina striatula	1	0.3
Elphidium latispatium pontium	1	
Epistominella vitrea	1	
Haplophragmoides subinvolutum	1	
Trifarina bella	1	
	323	99.8

VC-2
17.0'

Ammonia beccarii parkinsoniana	12
Cribroelphidium poeyanum	8
Elphidium galvestonense	7
Ammonia beccarii tepida	5
Elphidium incertum mexicanum	5
Nonion depressulum matagordanum	2
Buliminella cf. B. bassendorfensis	1
Elphidium gunteri	1
Globigerina bulloides	1
Hanzawaia strattoni	1
Total	43

19.0'

Cribroelphidium poeyanum	81	31.5
Elphidium incertum mexicanum	70	27.2
Elphidium galvestonense	44	17.1
Ammonia beccarii parkinsoniana	31	12.1
Hanzawaia strattoni	14	5.4
Ammonia beccarii tepida	5	1.9
Quinqueloculina fragments	5	
Nonion depressulum matagordanum	3	1.2
Elphidium discoidale	2	0.8
Brizalina lowmani	1	0.4
Nonionella opima	1	

21.2'

Cribroelphidium poeyanum	50	49.0
Elphidium incertum mexicanum	28	27.5
Ammonia beccarii tepida	5	4.9
Elphidium galvestonense	5	
Nonionella atlantica	3	2.9
Hanzawaia strattoni	2	2.0
Quinqueloculina	2	
Trochammina inflata	2	
Ammobaculites exiguus	1	
Ammonia beccarii parkinsoniana	1	1.0
Nonion depressulum matagordanum	1	
Nonionella opima	1	
Rosalina floridana	1	
	102	100.2

22.9'

Cribroelphidium poeyanum	77	31.6
Elphidium incertum mexicanum	71	29.1
Ammonia beccarii tepida	26	10.7
Nonionella atlantica	17	7.0
Elphidium galvestonense	16	6.6
Nonion depressulum matagordanum	6	2.5
Ammonia beccarii parkinsoniana	5	2.0
Hanzawaia strattoni	5	
Buccella hannai	4	
Quinqueloculina fragments	4	1.6
Quinqueloculina lamarckiana	3	1.2
Brizalina striatula	2	
Quinqueloculina seminulum	2	
Triloculina brevidentata	2	0.8
Buliminella cf. B. bassendorfensis	1	
Buliminella elegantissima	1	
Nonionella opima	1	
Quinqueloculina tenagos	1	
	244	99.9

24.6'

Elphidium incertum mexicanum	7
Nonion depressulum matagordanum	3
Elphidium galvestonense	2
Ammonia beccarii parkinsoniana	1
Ammonia beccarii tepida	1
	14

26.2'

Cribroelphidium poeyanum	109	34.4
Elphidium incertum mexicanum	65	20.5
Ammonia beccarii tepida	63	19.9
Buliminella elegantissima	21	6.6

Elphidium galvestonense	12	3.8
Ammonia beccarii parkinsoniana	7	2.2
Nonion depressulum matagordanum	7	
Brizalina lowmani	6	1.9
Nonionella atlantica	6	
Hanzawaia strattoni	4	1.3
Quinqueloculina lamarckiana	3	0.9
Ammobaculites exiguus	2	
Brizalina striatula	2	0.6
Nonionella opima	2	
Trochammina inflata	2	
Elphidium discoidale	1	
Elphidium sp.	1	0.3
Fursenkoina pontoni	1	
Globigerinoides ruber	1	
Guttulina australis	1	
Nonion sp.	1	

VC-3
23.0'-23.1*

Ammonia beccarii tepida	184	59.0
Cribroelphidium poeyanum	46	14.7
Ammonia beccarii parkinsoniana	26	8.3
Elphidium galvestonense	24	7.7
Trochammina lobata	14	4.5
Buliminella elegantissima	5	1.6
Ammotium salsum	3	1.0
Gaudryina minuta	3	
Elphidium gunteri	2	0.6
Ammobaculites exiguus	2	
Brizalina striatula	1	
Elphidium incertum mexicanum	1	0.3
Elphidium sp.	1	
	312	99.9

24.6'-24.6'

Ammonia beccarii tepida	62	35.6
Ammonia beccarii parkinsoniana	24	13.8
Elphidium galvestonense	23	13.2
Cribroelphidium poeyanum	22	12.6
Elphidium incertum mexicanum	12	6.9
Ammobaculites exiguus	7	4.0
Ammotium salsum	5	2.9
Nonion depressulum matagordanum	5	
Nonionella atlantica	4	2.3
Buliminella cf. B. bassendorfensis	3	
Buliminella elegantissima	3	1.7
Elphidium latispatium pontium	1	
Nonionella opima	1	0.6
Fissurina sp.	1	
Trochammina inflata	1	
	174	100.0

26.1'-26.3[1]

Cribroelphidium poeyanum	80	29.4
Elphidium incertum mexicanum	40	14.7
Ammonia beccarii tepida	33	12.1
Elphidium galvestonense	32	11.8
Ammonia beccarii parkinsoniana	15	5.5
Nonionella atlantica	12	4.4
Buliminella elegantissima	11	4.0
Ammobaculites exiguus	10	3.7
Hanzawaia strattoni	8	2.9
Nonion depressulum matagordanum	8	
Brizalina lowmani	7	2.6
Buliminella cf. B. bassendorfensis	3	0.1
Nonionella opima	3	
Ammotium salsum	2	0.7
Buccella hannai	2	
Fissurina sp.	1	
Guttulina australis	1	0.4
Quinqueloculina seminulum	1	
Quinqueloculina fragment	1	
Triloculina brevidentata	1	
Trochammina inflata	1	
	272	100.4

27.9'-28.1'

Elphidium galvestonense	56	18.2
Cribroelphidium poeyanum	53	17.3
Elphidium incertum mexicanum	46	15.0
Ammonia beccarii tepida	37	12.1
Ammonia becarii parkinsoniana	28	9.1
Nonion depressulum matagordanum	19	6.2
Nonionella atlantica	16	5.2
Buliminella elegantissima	12	3.9
Brizalina lowmani	10	3.3
Quinqueloculina sp.	6	2.0
Hanzawaia strattoni	5	
Nonionella opima	5	1.6
Buliminella cf. B. bassendorfensis	3	1.0
Elphidium latispatium pontium	2	
Quinqueloculina subpoeyana	2	0.7
Ammobaculites exiguus	1	
Buccella hannai	1	
Epistominella vitrea	1	
Fursenkoina pontoni	1	0.3
Haplophragmoides subinvolutum	1	
Quinqueloculina sp.	1	
Trochammina inflata	1	
	307	100.0

33.0'-33.1'

Críbroelphidium poeyanum	46	23.6
Elphidium galvestonense	33	16.9
Ammonia beccarii tepida	26	13.3
Elphidium incertum mexicanum	20	10.3
Ammonia beccarii parkinsoniana	16	8.2
Nonionella atlantica	15	7.7
Nonion depressulum matagordanum	11	5.6
Buliminella elegantissima	6	3.1
Nonionella opima	6	
Brizalina lowmani	5	2.6
Hanzawaia strattoni	3	1.5
Buliminella cf. B. bassendorfensis	2	1.0
Brizalina striatula	1	
Buccella hannai	1	
Fursenkoina pontoni	1	0.5
Quinqueloculina seminulum	1	
Quinqueloculina subpoeyana	1	
Quinqueloculina sp.	1	
	195	99.9

37.7'-37.7'

Críbroelphidium poeyanum	65	24.9
Ammonia beccarii tepida	36	13.8
Elphidium galvestonense	36	
Elphidium incertum mexicanum	34	13.0
Brizalina lowmani	21	8.0
Nonion depressulum matagordanum	9	3.4
Ammonia beccarii parkinsoniana	8	3.1
Buliminella elegantissima	7	
Quinqueloculina fragments	7	2.7
Nonionella atlantica	5	
Triloculina brevidentata	5	1.9
Nonionella opima	4	
Buccella hannai	3	
Buliminella cf. B. bassendorfensis	3	
Hanzawaia strattoni	3	1.1
Elphidium latispatium pontium	2	
Fursenkoina pontoni	2	
Quinqueloculina compta	2	0.8
Quinqueloculina sp.	2	
Ammobaculites exiguus	1	
Brizalina striatula	1	
* Globigerinelloides bentonensis	1	
Trochammina inflata	1	0.4
Quinqueloculina poeyana	1	
Triloculina linneiana comis	1	
* Heterohelix réussi	1	
	261	99.6

VC-4
22.0-22.1

Ammonia beccarii tepida	108	38.3

	Cribroelphidium poeyanum	45	16.0
	Elphidium galvestonense	29	10.3
	Ammonia beccarii parkinsoniana	24	8.5
	Elphidium incertum mexicanum	19	6.7
	Quinqueloculina lamarckiana	12	4.3
	Hanzawaia strattoni	9	3.2
	Nonion depressulum matagordanum	8	2.8
	Quinqueloculina sp.	7	2.5
	Nonionella opima	6	2.1
	Nonionella atlantica	4	1.4
	Brizalina striatula	2	0.7
	Buliminella elegantissima	2	
	Buccella hannai	1	
	Epistominella vitrea	1	
*	Globigerinelloides bentonensis	1	0.4
*	Heterohelix réussi	1	
	Quinqueloculina compta	1	
	Quinqueloculina seminulum	1	
	Quinqueloculina subpoeyana	1	
		282	100.3

23.7′-23.8′

	Ammonia beccarii tepida	92	34.7
	Criboelphidium poeyanum	36	13.6
	Elphidium galvestonense	33	12.5
	Elphidium incertum mexicanum	22	8.3
	Quinqueloculina lamarckiana	22	
	Quinqueloculina sp.	9	3.4
	Ammonia beccarii parkinsoniana	8	3.0
	Nonion depressulum matagordanum	7	2.6
	Hanzawaia strattoni	6	2.3
	Nonionella atlantica	6	
	Buliminella elegantissima	5	1.9
	Nonionella opima	4	1.5
*	Heterohelix réussi	3	1.1
	Brizalina lowmani	2	
	Buccella hannai	2	0.8
	Reussella atlantica	2	
	Buliminella cf. B. bassendorfensis	1	
	Elphidium discoidale	1	
	Fursenkoina pontoni	1	0.4
	Quinqueloculina compta	1	
	Rosalina concinna	1	
	Trochammina inflata	1	
		265	100.3

24.3′-24.4′

	Ammonia beccarii tepida	19	24.7
*	Heterohelix réussi	17	22.1
*	Globigerinelloides bentonensis	10	13.0
	Cribroelphidium poeyanum	7	9.1
	Ammonia beccarii parkinsoniana	5	6.5

Elphidium galvestonense	4	5.2
Hanzawaia strattoni	3	
Noníonella atlantica	3	3.9
Fursenkoina pontoni	2	
Noníonella opima	2	2.6
Buccella hannai	1	
Buliminella cf. B. bassendorfensis	1	
Epistominella vitrea	1	1.3
Nonion depressulum matagordanum	1	
Trochammina inflata	1	
	77	100.1

25.9'-26.1'

* Heterohelix réussi	60	34.5
Ammonia beccarii tepida	34	19.5
* Globigerinelloides bentonensis	34	
Nonion depressulum matagordanum	8	4.6
Cribroelphidium poeyanum	6	3.4
* Ticinella aprica	5	2.9
Buliminella cf. B. bassendorfensis	3	1.7
Elphidium incertum mexicanum	3	
Hanzawaia strattoni	3	
Noníonella opima	3	
Elphidium galvestonense	2	1.1
Noníonella atlantica	2	
Ammonia beccarii parkinsoniana	1	0.6
Brizalina lanceolata	1	
Triloculina brevidentata	1	
Brizalina lowmani	1	
Buliminella elegantissima	1	
Cibicides floridanus	1	
Elphidium latispatium pontium	1	
Globigerinoides ruber	1	
Planulina? sp.	1	
Pseudopolymorphina rutila	1	
Quinqueloculina lamarckiana	1	
	174	100.0

27.1*

* Heterohelix réussi	64	38.8
* Globigerinelloides bentonensis	26	15.8
Ammonia beccarii tepida	17	10.3
* Ticinella aprica	10	6.1
Ammonia beccarii parkinsoniana	5	3.0
Nonion depressulum matagordanum	5	
Buliminella elegantissima	4	2.4
Elphidium galvestonense	4	
Hanzawaia strattoni	4	
Palmerinella gardenislandensis	4	
Buliminella cf. B. bassendorfensis	3	1.8
Elphidium incertum mexicanum	3	
Noníonella atlantica	3	

	Brizalina lowmani	2	1.2
	Nonionella opima	2	
	Sagrina pulchella primitiva	2	
	Cribroelphidium poeyanum	1	
	Epistominella vitrea	1	
	Guttuiina laevis	1	0.6
	Quinqueloculina Lamarckiana	1	
	Quinqueloculina seminulum	1	
	Quinqueloculina sp.	1	
	Rosalina floridana	1	
		165	99.8

28.3'-28.4'

	Ammonia beccarii tepida	7	
*	Heterohelix réussi	6	
	Elphidium galvestonense	3	
	Nonion depressulum matagordanum	3	
	Palmerinella gardenislandensis	3	
*	Globigerinelloides bentonensis	2	
	Ammonia beccarii parkinsoniana	1	
	Buliminella cf. B. bassendorfensis	1	
	Elphidium incertum mexicanum	1	
	Elphidium sp.	1	
	Epistominella vitrea	1	
	Nonionella opima	1	
	Rosalina columbiensis	1	
*	Ticinella aprica	1	
		32	

30.9'-31.0'

*	Heterohelix réussi	36	22.5
	Ammonia beccarii tepida	22	13.4
	Hanzawaia strattoni	17	10.6
*	Globigerinelloides bentonensis	14	8.8
	Elphidium galvestonense	13	8.1
	Cribroelphidium poeyanum	10	6.3
	Ammonia beccarii parkinsoniana	7	4.4
	Nonionella atlantica	6	3.8
*	Ticinella aprica	6	
	Elphidium incertum mexicanum	5	3.1
	Nonion depressulum matagordanum	5	
	Buliminella cf. B. bassendorfensis	3	1.9
	Elphidium latispatium pontium	2	
	Nonionella opima	2	1.3
	Quinqueloculina seminulum	2	
	Brizalina lowmani	1	
	Brizalina striatula	1	
	Globigerina bulloides	1	0.6
	Epistominella vitrea	1	
	Globigerinoides ruber	1	
*	Guembelitria cretacea	1	
	Quinqueloculina sp.	1	

Rosalina columbiensis	1	
* Rugoglobigerina reicheli pustulata	1	
Textularia mayori	1	
	160	100.1
34.8′-34.9′		
* Globigerinelloides bentonensis	1	
36.7′		
* Heterohelix réussi	14	
Ammonia beccarii tepida	10	
* Globigerinelloides bentonensis	6	
Hanzawaia strattoni	2	
Ammonia beccarii parkinsoniana	1	
Buliminella sp.	1	
Cribroelphidium poeyanum	1	
Elphidium galvestonense	1	
Epistominella vitrea	1	
Fursenkoina sp.	1	
Nonion depressulum matagordanum	1	
Palmerinella gardenislandensis	1	
Quinqueloculina seminulum	1	
Quinqueloculina tenagos	1	
Quinqueloculina fragment	1	
* TicineIla aprica	1	
	44	
39.1'-39.2′		
* Heterohelix réussi	16	23.5
Ammonia beccarii tepida	10	14.7
* Globigerinelloides bentonensis	8	11.8
Elphidium galvestonense	6	7.8
Cribroelphidium poeyanum	3	
Nonionella atlantica	3	4.4
Elphidium incertum mexicanum	2	
Globigerinoides ruber	2	
Hanzawaia strattoni	2	
* Rugoglobigerina reicheli pustulata	2	2.9
* Ticinella aprica	2	
Ammonia beccarii parkinsoniana	1	
Bulimina affinis	1	
Buliminella elegantissima	1	
Elphidium advenum	1	
Epistominella vitrea	1	
Nonion depressulum matagordanum	1	1.5
Nonionella opima	1	
Palmerinella gardenislandensis	1	
Quinqueloculina fragment	1	
Rosalina columbiensis	1	
Sagrina pulchella primitiva	1	
Triloculina brevidentata	1	

	68	100.1
41.3'		
* Heterohelix réussi	16	25.4
* Ammonia beccarii tepida	7	11.1
Hanzawaia strattoni	7	
Cribroelphidium poeyanum	6	9.5
* Globigerinelloides bentonensis	6	
Ammonia beccarii parkinsoniana	5	7.9
Elphidium incertum mexicanum	4	6.3
Elphidium galvestonense	3	4.8
* Ticinella aprica	2	3.2
Brizalina lowmani	1	
Epistominella vitrea	1	
Guttulina laevis	1	1.6
Nonionella opima	1	
Quinqueloculina seminulum	1	
Quinqueloculina sp.	1	
Rosalina columbiensis	1	
	63	100.0

VC-5

12.0'-12.I

Ammonia beccarii parkinsoniana	15
Ammonia beccarii tepida	8
Elphidium galvestonense	6
Nonion depressulum matagordanum	4
Quinqueloculina lamarckiana	4
Cribroelphidium poeyanum	2
Buccella hannai	1
Elphidium gunteri	1
Elphidium incertum mexicanum	1
Nonionella atlantica	1
Quinqueloculina seminulum	1
Quinqueloculina tenagos	1
	45

12.9'-13.0'

Ammonia beccarii tepida	10
Ammonia beccarii parkinsoniana	6
Cribroelphidium poeyanum	4
Elphidium galvestonense	4
Elphidium incertum mexicanum	3
Quinqueloculina lamarckiana	2
Elphidium latispatium pontium	1
Nonion depressulum matagordanum	1
Nonionella atlantica	1
	32

14.0’

Haplophragmoides subinvolutum	13	19.4
Ammonia beccarii tepida	10	14.9
Elphidium galvestonense	10	
Ammotium salsum	9	13.4
Nonion depressulum matagordanum	8	11.9
Ammonia beccarii parkinsoniana	6	9.0
Trochammina inflata	6	
Fissurina sp.	2	3.0
Cribroelphidium poeyanum	1	
Quinqueloculina tenagos	1	1.5
Quinqueloculina sp.	1	
	67	100.0

15.0'

Ammonia beccarii tepida	106	41.7
Cribroelphidium poeyanum	43	16.9
Elphidium galvestonense	36	14.2
Nonion depressulum matagordanum	27	10.6
Palmerinella gardenislandensis	12	4.7
Ammonia beccarii parkinsoniana	10	3.9
Buliminella elegantissima	5	2.0
Brizalina striatula	4	1.6
Brizalina lowmani	2	0.8
Elphidium delicatulum	2	
Trochammina inflata	2	
Brizalina sp.	1	0.4
Elphidium latispatium pontium	1	
Haplophragmoides subinvolutum	1	
Nonionella atlantica	1	
Quinqueloculina seminulum	1	
	254	100.0

16.8'

Haplophragmoides subinvolutum	19	41.3
Elphidium galvestonense	12	26.1
Ammotium salsum	3	6.5
Cribroelphidium poeyanum	3	
Trochammina inflata	3	
Ammonia beccarii tepida	2	
Nonion depressulum matagordanum	2	4.3
Ammonia beccarii parkinsoniana	1	2.2
Quinqueloculina fragments	1	
	46	99.9

18.9'

Trochammina inflata	7
Haplophragmoides subinvolutum	2
Rosalina sp.	1

	10	
19.8′		
Elphidium galvestonense	71	33.2
Ammonia beccarii tepida	68	31.8
Ammonia beccarii parkinsoniana	31	14.5
Nonion depressulum matagordanum	22	10.3
Cribroephidium poeyanum	8	3.7
Elphidium delicatulum	4	1.9
Elphidium latispatium pontium	4	
Palmerinella gardenislandensis	2	0.9
Brizalina striatula	1	
Elphidium incertum mexicanum	1	0.5
Quinqueloculina seminulum	1	
Quinqueloculina sp.	1	
	214	100.2
20.0′-20.1'		
Elphidium galvestonense	5	
Ammonia beccarii parkinsoniana	4	
Ammonia beccarli tepida	3	
Nonion depressulum matagordanum	2	
Cribroelphidium poeyanum	1	
Elphidium incertum mexicanum	1	
Haplophragmoides subinvolutum	1	
Nonionella opima	1	
Trochammina inflata	1	
	19	
20.8′		
Cribroelphidium poeyanum	53	25.5
Ammonia beccarii tepida	42	20.2
Elphidium galvestonense	34	16.3
Elphidium incertum mexicanum	16	7.7
Nonion depressulum matagordanum	16	
Nonionella atlantica	11	5.3
Quinqueloculina tenagos	6	2.9
Ammonia beccarii parkinsoniana	5	2.4
Quinqueloculina sp.	5	
Hanzawaia strattoni	4	1.9
Elphidium latispatium pontium	3	
Quinqueloculina seminulum	3	1.4
Buliminella cf. B. bassendorfensis	2	1.0
Brizalina inflata	1	
Discorbis aguayoi	1	0.5
Elphidium delicatulum	1	
Haplophragmoides subinvolutum	1	
Quinqueloculina lamarckiana	1	
Reussella atlantica	1	
Triloculina brevidentata	1	
Trochammina inflata	1	

	208	100.1

VC-6

23.0'-23.1'

Cribroelphidium poeyanum	38	22.9
Ammonia beccarii tepida	35	21.1
Elphidium galvestonense	29	17.5
Elphidium incertum mexicanum	29	
Ammonia beccarii parkinsoniana	16	9.6
Nonionella atlantica	5	3.0
Nonion depressulum matagordanum	3	1.8
Buccella hannai	2	1.2
Elphidium latispatium pontium	2	
Hanzawaia strattoni	2	
Quinqueloculina lamarckiana	2	
Elphidium gunteri	1	0.6
Quinqueloculina tenagos	1	
Quinqueloculina sp.	1	
	166	100.0

24.8'-24.9'

Cribroelphidium poeyanum	17	23.6
Ammonia beccarii tepida	12	16.7
Elphidium galvestonense	10	13.9
Elphidium incertum mexicanum	10	
Ammonia beccarii parkinsoniana	8	11.1
Nonion depressulum matagordanum	7	9.7
Hanzawaia strattoni	3	4.2
Brizalina striatula	1	
Elphidium latispatium pontium	1	1.4
Nonionella atlantica	1	
Nonionella opima	1	
Trochammina inflata	1	
	72	100.1

26.9'

Ammonia beccarii parkinsoniana	2
Cribroelphidium poeyanum	2
Elphidium incertum mexicanum	2
Hanzawaia strattoni	1
	7

28.9'-29.0'

Cribroelphidium poeyanum	72	31.9
Elphidium incertum mexicanum	70	31.0
Elphidium galvestonense	22	9.7
Ammonia beccarii tepida	20	8.8
Ammonia beccarii parkinsoniana	16	7.1
Hanzawaia strattoni	12	5.3
Nonion depressulum matagordanum	10	4.4

Elphidium latispatium pontium	1	0.4
Globigerinoides ruber	1	
Guttulina laevis	1	
Haplophragmoides subinvolutum	1	
	226	99.8

30.3'-30.4'

Cribroelphidium poeyanum	84	30.3
Ammonia beccarii tepida	50	18.1
Elphidium galvestonense	23	8.3
Hanzawaia strattoni	18	6.5
Elphidium incertum mexicanum	16	5.8
Nonionella opima	12	4.3
Nonion depressulum matagordanum	11	4.0
Nonionella atlantica	11	
Trochammina inflata	9	3.2
Triloculina brevidentata	7	2.5
Ammonia beccarii parkinsoniana	5	1.8
Quinqueloculina sp.	5	
Brizalina lowmani	4	1.4
Quinqueloculina seminulum	4	
Buliminella elegantissima	3	1.1
Quinqueloculina compta	2	0.7
Brizalina striatula	1	
Buccella hannai	1	0.4
Buliminella cf. B. bassendorfensis	1	
Palmerinella gardenislandensis	1	
Cancris sagra	1	
Elphidium delicatulum	1	
Elphidium latispatium pontium	1	
Haplophragmoides subinvolutum	1	
* Heterohelix réussi	1	
Lagena laevis	1	
Quinqueloculina lamarckiana	1	
Quinqueloculina tenagos	1	
* Ticinella aprica	1	
	277	100.4

VC-7
14.0'-14.1

Cribroelphidium poeyanum	70	28.2
Elphidium galvestonense	44	17.7
Ammonia beccarii tepida	35	14.1
Elphidium incertum mexicanum	34	13.7
Ammonia beccarii parkinsoniana	23	9.3
Hanzawaia strattoni	12	4.8
Nonionella atlantica	8	3.2
Nonionella opima	8	
Buccella hannai	2	0.8
Nonion depressulum matagordanum	2	
Quinqueloculina compta	2	
Quinqueloculina sp.	2	

Buliminella cf. B. bassendorfensis	1	
Elphidium latispatium pontium	1	0.4
Fursenkoina pontoni	1	
Globigerinoides ruber	1	
Quinqueloculina lamarckiana	1	
Quinqueloculina tenagos	1	
	248	99.8

15.5'-15.6'

Cribroelphidium poeyanum	46	22.8
Ammonia beccarii tepida	42	20.8
Elphidium galvestonense	32	15.8
Elphidium incertum mexicanum	20	9.9
Ammonia beccarii parkinsoniana	10	5.0
Buliminella elegantissima	10	
Hanzawaia strattoni	10	
Nonion depressulum matagordanum	6	3.0
Brizalina lowmani	5	
Nonionella atlantica	5	3.5
Nonionella opima	3	1.5
Buccella hannai	2	
Buliminella cf. B. bassendorfensis	2	1.0
Elphidium latispatium pontium	2	
Trochammina inflata	2	
Gaudryina minuta	1	
Palmerinella gardenislandensis	1	0.5
Quinqueloculina compta	1	
Quinqueloculina lamarckiana	1	
Quinqueloculina sp.	1	
	206	100.3

17.1'

Cribroelphidium poeyanum	11
Ammonia beccarii tepida	9
Elphidium incertum mexicanum	7
Elphidium galvestonense	6
Elphidium latispatium pontium	3
Ammonia beccarii parkinsoniana	2
Buliminella elegantissima	1
Hanzawaia strattoni	1
Quinqueloculina sp.	1
	41

18.9'-19.0'

Ammonia beccarii tepida	5
Elphidium galvestonense	3
Ammonia beccarii parkinsoniana	2
Cribroelphidium poeyanum	1
Elphidium incertum mexicanum	1
Elphidium latispatium pontium	1
	13

20.4'-20.6'

Elphidium galvestonense	2	
Ammonia beccarii parkinsoniana	1	
Elphidium incertum mexicanum	1	
Nonion depressulum matagordanum	1	
Trifarina bella	1	
Trochammina laevigata	1	
	7	

21.6'-21.7'

Ammonia beccarii tepida	75	32.3
Cribroelphidium poeyanum	72	31.0
Elphidium galvestonense	42	18.1
Elphidium incertum mexicanum	19	8.2
Ammonia beccarii parkinsoniana	10	4.3
Nonion depressulum matagordanum	8	3.4
Nonionella atlantica	3	1.3
Palmerinella gardenislandensis	1	
Quinqueloculina fragment	1	0.4
Trochammina inflata	1	
	232	99.8

VC-8
23.0'-23.1'

Ammonia beccarii tepida	97	37.7
Nonionella atlantica	37	14.4
Cribroelphidium poeyanum	30	11.7
Nonionella opima	23	8.4
Elphidium galvestonense	21	8.2
Ammonia beccarii parkinsoniana	8	3.1
Nonion depressulum matagordanum	6	2.3
Buliminella cf. B. bassendorfensis	5	1.9
Fursenkoina pontoni	6	3.1
Elphidium latispatium pontium	4	1.6
Brizalina lowmani	3	
Buliminella elegantissima	3	
Quinqueloculina seminulum	3	
Quinqueloculina sp.	2	
Triloculina brevidentata	2	0.8
Ammotium salsum	1	0.4
Cancris oblonga	1	
Cassidulina subglobosa	1	
Hanzawaia strattoni	1	
Quinqueloculina compta	1	
Quinqueloculina lamarckiana	1	
Trochammina inflata	1	
	257	100.1

24.1'-24.2'

	Ammonia beccarii tepida	29	50.0
	Nonion depressulum matagordanum	6	10.3
	Ammonia beccarlî parkinsoniana	5	
	Elphidium galvestonense	3	
	Cribroelphidium poeyanum	2	
*	Globigerinelloides bentonensis	2	
	Hanzawaia strattoni	2	
	Nonionella atlantica	2	
	Nonionella opima	2	
	Buliminella cf. B. bassendorfensis	1	
	Epistominella vitrea	1	
	Palmerinella gardenislandensis	1	
	Quinqueloculina sp.	1	
	Rosalina columbiensis	1	
		58	

24.6’-24.7’

	Cribroelphidium poeyanum	2	
	Ammonia beccarii tepida	1	
	Hanzawaia strattoni	1	
*	Heterohelix reuss	1	
	Textularia mayori	1	
	Total	6	

26.1’-26.2*

	Nonion depressulum matagordanum	54	27.0
	Ammonia beccarii tepida	52	26.0
	Elphidium galvestonense	17	8.5
	Palmerinella gardenislandensis	17	
	Elphidium incertum mexicanum	14	7.0
*	Globigerinelloides bentonensis	10	5.0
	Elphidium latispatium pontium	9	4.5
*	Heterohelix réussi	9	
	Ammonia beccarii parkinsoniana	5	2.5
	Buliminella cf. B. bassenforfensis	4	2.0
	Nonionella atlantica	3	1.5
	Brizalina lowmani	1	
	Cribroelphidium poeyanum	1	
	Epistominella vitrea	1	0.5
	Fursenkoina pontoni	1	
	Nonionella opima	1	
*	Ticinella aprica	1	
		200	100.0

28.1’-28.3'

	Palmerinella gardenislandensis	1	
	Rectobolivina advena	1	
		2	

29.7’-29.8‘

Ammonia beccarii parkinsoniana	1	
Buliminella cf. B. bassendorfensis	1	
Elphidium incertum mexicanum	1	
	3	

30.9'

Ammonia beccarii tepida	7	
Ammonia beccarii parkinsoniana	3	
Cribroelphidium poeyanum	3	
Nonion depressulum matagordanum	3	
Elphidium galvestonense	2	
Elphidium incertum mexicanum	1	
Nonionella atlantica	1	
	20	

C-3
1.5'-0.7'

Trochammina inflata	84	60.0
Haplophragmoides subinvolutum	39	27.9
Ammotiurn salsum	10	7.1
Textularia earlandi	4	2.9
Ammobaculites exiguus	2	1.4
Miliammina fusca	1	0.7
	140	100.0

. 7 *-1.8'

Trochammina inflata	72	79.1
Ammotium salsum	8	8.8
Haplophragmoides subinvolutum	6	6.6
Miliammina fusca	3	3.3
Ammoastuta inepta	1	1.1
Textularia earlandi	1	
	91	100.0

1.8'-2.6'

Ammotiurn salsum	1

2.6'-3.4'

Ammonia beccarii parkinsoniana	1

5.1'-5.9'

Trochammina inflata	106	73.6
Haplophragmoides subinvolutum	30	20.8
Trochammina macrescens	3	2.1
Ammotium salsum	1	0.7
Miliammina fusca	1	
Rosalina columbiensis	1	
	142	100.0

5.9′-6.7′

Trochammina inflata	69	85.2
Haplophragmoides subinvolutum	6	7.4
Trochammina macrescens	5	6.2
Miliammina fusca	1	1.2
	81	

6.7′-7.4′

Trochammina inflata	45
Haplophragmoides subinvolutum	1
Quinqueloculina poeyana	1
	47

7.4'-8.2′

Trochammina inflata	1

10.6′-11.5′

Haplophragmoides subinvolutum	1

11.5′-12.3'

Ammonia beccarii parkinsoniana	6
Elphidium galvestonense	6
	12

12.3′-12.9'

Trochammina inflata	2
Buliminella elegantissima	1
	3

12.9[1]-13.8'

Elphidium galvestonense	3
Nonion depressulum matagordanum	2
Ammonia beccarlî tepida	1
Cribroelphidium poeyanum	1
Elphidium incertum mexicanum	1
Hanzawaia strattoni	1
	9

14.6′-15.4′

Elphidium galvestonense	2
Ammonia beccarlî parkinsoniana	1
Cribroelphidium poeyanum	1
	4

15.4'-16.2'

(Cribroelphidium poeyanum	13	
Ammonia beccarli tepida	12	
Elphidium galvestonense	6	
Ammonia beccarii parkinsoniana	3	
Buccella hannai	2	
Elphidium incertummexicanum	2	
Brizalina inflata	1	
Brizalina lowmani	1	
Hanzawaia strattoni	1	
Nonion depressulum matagordanum	1	
Quinqueloculina sp.	1	

16.2[1]-17.0[1]

Elphidium galvestonense	74	40.4
Ammonia beccarii tepida	25	13.7
Cribroelphidium poeyanum	23	12.6
Ammonia beccarii parkinsoniana	18	9.8
Elphidium incertum mexicanum	17	9.3
Nonion depressulum matagordanum	15	8.2
Brizalina lowmani	6	3.3
Hanzawaia strattoni	2	1.1
Ammotium salsum	1	0.5
Buccella hannai	1	
Nonionella atlantica	1	
	183	99.9

17.0'-17.9'

Ammonia beccarii tepida	12
Cribroelphidium poeyanum	12
Elphidium galvestonense	12
Ammonia beccarii parkinsoniana	3
Elphidium incertum mexicanum	3
Nonion depressulum matagordanum	2
Trochammina inflata	1
	45

17.9'-18.8'

Elphidium galvestonense	17	21.5
Ammonia beccarii tepida	14	17.7
Cribroelphidium poeyanum	13	16.5
Nonion depressulum matagordanum	11	13.9
Ammonia beccarii parkinsoniana	9	11.4
Elphidium incertum mexicanum	5	6.4
Buliminella elegantissima	2	2.5
Triloculina brevidentata	2	
Trochammina inflata	2	
Buccella hannai	1	
Elphidium discoidale	1	1.3
Hanzawaia strattoni	1	

Síphotextularia curta	1	
	70	100.1

18.8′-19.5′

Ammonia beccarii tepida	2
Elphidium galvestonense	2
Ammonia beccarii parkinsoniana	1
Cribroelphidium poeyanum	1
Goesella? sp.	1
Haplophragmoides subinvolutum	1
Total	8

21.1'-21.9′

Ammonia beccarlî tepida	2
Ammotium salsum	1
Cribroelphidium poeyanum	1
Elphidium galvestonense	1
Nonion depressulum matagordanum	1
	6

	number of specimens (tests)	percentage
MMRI-1		
34.0'-34.4'		
Elphidium galvestonense	15	20.0%
Cribroelphidium poeyanum	13	17.3
Ammonia beccarii tepida	10	13.3
A. parkinsoniana	7	9.3
Buliminella elegantissima	7	
Brizalina lowmani	6	8.0
miliolid sp.	5	6.7
Buliminella cf. B. bassendorfensis	3	4.0
Elphidium sp.	2	2.7
Nonionella opima	2	
Brizalina sp.	1	1.3
Elphidium advenum	1	
E. incertum mexicanum	1	
Hanzawaia strattoni	1	
Nonion sp.	1	
	75	99.8
36.0 *-36.2*		
Brizalina lowmani	18	20.7
Nonionella opima	16	18.4
miliolid sp.	10	11.5
Ammonia beccarii tepida	9	10.3
Buliminella elegantissima	9	
B. cf. B. bassendorfensis	6	6.9
Elphidium galvestonense	6	
Ammonia beccarii parkinsoniana	4	4.6
Epistominella vitrea	3	3.5
Buccella hannai	1	
Ammotium salsum(?)	1	
Cribroelphidium poeyanum	1	1.1
Hanzawaia strattoni	1	
Nonionella atlantica	1	
Lagena sp.	1	
	87	99.7
37.8'-38.0'		
Ammonia beccarii parkinsoniana	27	20.8
miliolid sp.	19	14.6
Buliminella cf. B. bassendorfensis	17	13.1
Elphidium galvestonense	16	12.3
Brizalina lowmani	13	10.0
Nonionella opima	12	9.2
Buliminella elegantissima	10	7.7
Ammonia beccarii tepida	7	5.4
Bulimina sp.	3	2.3

Nonion sp.	2	1.5
Elphidium sp.	1	0.8
Brizalina sp.	1	
Fursenkoina sp.	1	
Epistominella vitrea (pyrite-filled)	1	
	130	100.1

42.1′-42.3′

Buliminella cf. B. bassendorfensis	35	29.2
Ammonia beccarii parkinsoniana	25	20.8
A. tepida	18	15.0
miliolid sp.	17	14.2
Elphidium galvestonense	13	10.8
Epistominella vitrea	7	5.8
Nonionella opima	5	4.2
	120	100.0

MMRI-2
33.2'-33.4′

Ammonia beccarii tepida	2
Cribroelphidium poeyanum	1
Nonion depressulum matagordanum	1
Nonionella atlantica	1
	5

33.4′-34.6′

Ammonia beccarii tepida	35	31.3
Elphidium galvestonense	22	19.6
E. gunteri	16	14.3
Ammonia beccarii parkinsoniana	9	8.0
miliolid sp.	6	5.4
Buccella hannai	5	4.5
Nonion depressulum matagordanum	5	
Nonionella atlantica	5	8.1
Elphidium sp.	4	3.6
Nonionella opima	2	1.8
Brizalina lowmani	1	0.9
Elphidium adventum	1	
E. latispatium pontium	1	
	112	100.2

36.5′-36.7′

Ammonia beccarii tepida	30	35.3
Elphidium galvestonense	21	24.7
E. gunteri	11	12.9
Elphidium sp.	7	8.2
Ammonia beccarii parkinsoniana	2	
Buliminella elegantissima	2	2.4
B. striatula	2	
Cribroelphidium poeyanum	2	

	Nonionella atlantica	2	
	Buliminella cf. bassendorfensis	1	fragment
	Buccella hannai	1	
	Brizalina lowmani	1	1.2
	Hanzawaia strattoni	1	
	miliolid sp.	1	
	Nonionella opima	1	
			100.3

MMRI-3
29.2′-29.4′

	Nonionella atlantica	2	
	Ammonia beccarii tepida	1	
	Cribroelphidium poeyanum	1	
	Elphidium sp.	1	
	milolid	1	
		6	

31′-31.2′

	Ammonia beccarii tepida	1	
	Brizalina lowmani	1	
	Hanzawaia strattoni	1	(badly eroded)
	Nonion sp.	1	
*	Heterohelix réussi	1	
	(all tests have limonitic stain)	5	

32.1′

	Brizalina lowmani	1	

32.5′-32.7′

	Ammonia beccarii tepida	3	
	Nonionella atlantica	2	
	Ammonia beccarii parkinsoniana	1	
*	Globigerinelloides bentonensis	1	
*	Heterohelix réussi	1	
		8	

34.6′-34.8′

	Ammonia beccarii parkinsoniana	4	
	Elphidium galvestonense	4	
	Nonion depressulum matagordanum	4	
	Ammonia beccarii tepida	3	
*	Heterohelix réussi	3	
	Brizalina lowmani	2	
*	Globigerinelloides bentonensis	2	
	milolid sp.	2	
	Buliminella elegantissima	1	
	B. cf. B. bassendorfensis	1	
	Elphidium incertum mexicanum	1	

	Nonionella sp.	1
	Cibicides sp.	1
	36.4*-36.7 *	
	Ammonia beccarli tepida	2
	Elphidium galvestonense	2
	Ammonia beccarii parkinsoniana	1
	Buliminella cf. B. bassendorfensis	1
	Brizalina lowmani	1
*	Globigerinelloides bentonensis	1
*	Heterohelix réussi	1
		9
	37.5'-37.7′	
	Ammonia beccarii tepida	3
	Buliminella elegantissima	1
*	Heterohelix réussi	1
		5
	38.5′-38.7′	
	Ammonia beccarii tepida	1
	Buliminella cf. B. bassendorfensis	1
	Elphidium sp. (badly eroded)	1
	Palmerinella gardenislandensis	1
	39.8′-40′	
	Palmerinella gardenislandensis	1
	MMRI~4a	
	29.2′-29.4·	
	Cribroelphidium poeyanum	42
	Elphidium incertum mexicanum	23
	E. galvestonense	5
	E. sp.	4
	Ammonia beccarii tepida	1
	A. parkinsoniana	1
	miliolid	1
		77
	(MMRI-5: no samples taken)	
	MMRI-6	
	28.2′-28.4′	
	Ammonia beccarii tepida	18
	Elphidium galvestonense	13
	Ammonia beccarii parkinsoniana	7
	Cribroelphidium poeyanum	4
	Buccella hannai	3

Elphidium sp.	1	
Nonion sp.	1	
Nonionella opima	1	
Trochammina sp.	1	
Ammotium salsum	1	
	50	

30.2'-30.4'

Cribroelphidium poeyanum	10	
Elphidium galvestonense	10	
Ammonia beccarii tepida	7	
Ammonia beccarii parkinsoniana	7	
Buccella hannai	4	
Elphidium incertum mexicanum	2	
Nonionella atlantica	2	
Ammotium salsum	1	
Buliminella elegantissima	1	
Trochammina sp.	1	
Unidentified agglutinated sp.	1	
Arenoparrella mexicana?	1	
	47	

32.2'-32.4'

Cribroelphidium poeyanum	36	29.5
Elphidium incertum mexicanum	24	19.7
Ammonia beccarii tepida	16	13.1
E. gunteri	10	
E. galvestonense	9	7.5
Nonionella atlantica	9	
Ammonia beccarii parkinsoniana	7	
Elphidium sp. (eroded)	5	
Hanzawaia strattoni	3	
Nonion depressulum matagordanum	3	
	122	

34.5'-34.7'

Elphidium incertum mexicanum	28	22.8
Cribroelphidium poeyanum	27	22.0
Elphidium gunteri	22	17.9
Ammonia beccarii tepida	10	8.1
Ammonia beccarii parkinsoniana	11	8.9
Nonionella opima	5	4.1
N. atlantica	4	3.3
Nonion depressulum matagordanum	3	2.4
Buccella hannai	2	1.6
Hanzawaia strattoni	2	
Elphidium sp.	3	
Buliminella elegantissima	1	0.8
Fursenkoina cf. F. mexicana	1	
Nonion sp.	1	
Brizalina sp. (eroded)	1	
	121	99.9

MMRI-7

11.0'-11.2'

Elphidium incertum mexicanum	12	19.0
Ammonia beccarii tepida	11	17.5
Elphidium gunteri	10	15.9
Ammonia beccarii parkinsoniana	8	12.7
Críbroelphidium poeyanum	7	11.1
Elphidium galvestonense	5	7.9
Elphidium sp.	4	6.3
Buliminella elegantissima	1	
B. cf. B. bassendorfensis	1	
Buccella hannai	1	
miliolid sp.	1	
Nonion sp.	1	
Unidentified agglutinated sp.	1	1.6
Unidentified calcareous sp.	63	100.0

13.3[1]-13.5 *

Críbroelphidium poeyanum	8
Ammonia beccarii tepida	6
Elphidium incertum mexicanum	6
E. gunteri	4
Ammonia beccarii parkinsoniana	3
Elphidium galvestonense	3
E. sp. fragments	2
Nonion sp.	2
Nonionella opima	1
Lagena sp.	1
	36

14.5'-14.7'

Elphidium incertum mexicanum	11
Críbroelphidium poeyanum	7
Elphidium galvestonense	5
Ammonia beccarii tepida	2
Ammonia beccarii parkinsoniana	2
Elphidium gunteri	1
	28

15.5'-15.7'

Elphidium incertum mexicanum	10
Críbroelphidium poeyanum	8
Elphidium galvestonense	7
E. gunteri	6
Ammonia beccarii tepida	2
A. parkinsoniana	1
	34

17.8'-18.0'

Elphidium galvestonense	13	
Ammonia beccarii parkinsoniana	9	
Elphidium incertum mexicanum	7	
Ammonia beccarii tepida	3	
Cribroelphidium poeyanum	2	
Elphidium gunteri	2	
E. sp.	2	
miliolid sp.	1	
Nonion sp.	1	
	40	

18.7'-18.9'

Elphidium incertum mexicanum	13	
Ammonia beccarii parkinsoniana	9	
Cribroelphidium poeyanum	7	
Ammonia beccarii tepida	6	
Elphidium gunteri	5	
E. galvestonense	5	
miliolid sp.	3	
Elphidium sp.	2	
E. latispatium pontium	1	
Nonion sp.	1	
	52	

21.0'-21.2'

Elphidium incertum mexicanum	65	44.8
Cribroelphidium poeyanum	26	17.9
Elphidium galvestonense	16	11.0
Elphidium gunteri	15	10.3
Ammonia beccarii tepida	12	8.3
Ammonia beccarii parkinsoniana	6	4.1
milolid sp.	2	1.4
Nonion sp.	2	
	144	99.9

MMRI-8

14.0'-14.2*

Ammonia beccarii tepida	19	27.5
A. parkinsoniana	15	21.7
Elphidium galvestonense	15	
Cribroelphidium poeyanum	5	7.2
Nonion sp.	4	5.8
miliolid sp.	3	4.3
Trochammina sp.	3	
Elphidium sp.	2	2.9
Ammotium salsum	1	1.4
Ammobaculites exiguus	1	
Elphidium latispatium pontium	1	
	69	99.6

15’-15.2*

Elphidium galvestonense	35	27.8
Ammonia beccarii tepida	33	26.2
Cribroelphidium poeyanum	18	14.3
Elphidium incertum mexicanum	10	7.9
Ammonia beccarii parkinsoniana	9	7.1
Elphidium gunteri	6	4.8
E. sp. (eroded test)	5	4.0
Elphidium sp.	3	2.4
miliolid (eroded test)	2	1.6
Elphidium latispatium pontium	1	
Nonion sp.	1	0.8
Nonionella atlantica	1	
Guttulina sp.	1	
Buccella hannai	1	
	126	100.1

15.6'-16’

Ammonia beccarii tepida	12	
Criboelphidium poeyanum	6	
Ammonia beccarii parkinsoniana	3	
Ammobaculites exiguus	2	
Nonion sp.	1	
* Heterohelix réussi		
Elphidium galvestonense	2	
	26	

18.5'-18.8’

Ammonia beccarii tepida	62	51.2
A. parkinsoniana	34	28.1
Elphidium gunteri	6	5.0
Nonion depressulum matagordanum	4	
Palmerinella gardenislandensis	4	3.3
Cribroelphidium poeyanum	2	1.6
Elphidium latispatium pontium	2	
Nonion sp.	2	
Elphidium galvestonense	1	
Elphidium incertum mexicanum	1	0.8
E. sp.	1	
miliolid sp.	1	
* Heterohelix réussi	1	
	121	99.7

20.6’-20.8’

Ammonia beccarii tepida	34	47.2
A. parkinsoniana	25	34.7
Elphidium gunteri	4	5.6
Nonion sp.	4	
Elphidium galvestonense	2	2.8

E. sp.	1	1.4
E. latispatíum pontium	1	
* Globigerinelloides bentonensis	1	
	72	100.1

22.5'-22.7'

Ammonia beccarii parkinsoniana	8	
* Heterohelix réussi	7	
Ammonia beccarii tepida	5	
Elphidium gunteri	2	
E. galvestonense	2	
*Globigerinelloides bentonensis	2	
Elphidium incertum mexicanum	1	
Nonionella atlantica	1	
Rosalina sp.	1	
Sagrina pulchella primitiva	1	
Nonion sp.	1	
	31	

23.6'-23.8'

* Heterohelix réussi	8	
Ammonia beccarii tepida	2	
Rosalina sp.	2	
Ammonia beccarii parkinsoniana	1	
Brizalina sp.	1	
* Globigerinelloides bentonensis	1	
	15	

25.1 *-25.3'

* Heterohelix réussi	52	55.3
* Globigerinelloides bentonensis	9	9.6
Ammonia beccarii tepida	9	
Elphidium discoidale	3	3.2
miliolid sp.	6	6.4
Nonion sp.	3	3.2
Brizalina sp.	1	
Elphidium galvestonense	1	1.1
E. incertum mexicanum	1	
E. sp.	1	
Nonion atlantica	1	
planktonic sp.	2	2.1
Sagrina pulchella primitiva	2	
Planulina? sp.	1	
Nodosaria sp.	1	
Rosalina sp.	1	
	94	100.3

27.4'-27.6'

* Heterohelix réussi	7	
Nonion depressulum matagordanum	5	

*	Globigerinelloides bentonensis	4	
	Ammonia beccarii tepida	3	
	Buliminella elegantissima	1	
	B. cf. B. bassendorfensis	1	
	Elphidium incertum mexicanum	1	
	Nonionella opima	1	
	Trochammina sp.	1	
		24	

(MMRI-9: no samples recovered)

MMRI-10
39'-39.1

Elphidium galvestonense	55	26.7
Ammonia beccarii tepida	30	14.6
Brizalina lowmani	29	14.1
Ammonia beccarii parkinsoniana	18	8.7
Cribroelphidium poeyanum	18	
Quinqueloculina sp.	17	8.3
Buliminella cf. B. bassendorfensis	8	3.9
Nonionella opima	7	3.4
Nonion depressulum matagordanum	6	2.9
Buliminella elegantissima	5	2.4
Buccella hannai	3	1.5
Nonionella atlantica	2	1.0
Brizalina sp.	1	
Elphidium latispatium pontium	1	0.5
Triloculina sp.	1	
Trifarina bella	1	
	206	100.1

MMRI-11
27'-27.1

Ammonia beccarri tepida	4
Cribroelphidium poeyanum	2
Buccella hannai	1
Elphidium sp.	1
E. galvestonense	1
Nonionella atlantica	1
N. opima	1
	11

29'-29.1*

Nonion depressulum matagordanum	54	94.7
Brizalina lowmani	2	3.5
Ammonia beccarii parkinsoniana	1	1.8
	57	100.0

30.9′-31′

miliolid sp.	2	
Nonion sp.	1	
Ammonia beccarii parkinsoniana	1	

32.9′-33'

Elphidium galvesonense	23	
Ammonia beccarii tepida	2	
Brizalina lowmani	2	
* Globigerinelloides bentonensis	1	
	28	

35′-35.1′

Ammonia beccarri tepida	30	42.3
A. parkinsoniana	20	28.2
miliolid sp.	7	9.9
Elphidium galvestonense	6	8.5
E. gunteri	3	4.2
E. incertum mexicanum	3	
Brizalina lowmani	1	1.4
Elphidium sp.	1	
	71	100.1

37′-37.1′

Ammonia beccarii tepida	16	24.6
Nonion depressulum matagordanum	12	18.5
Ammonia beccarii parkinsoniana	8	12.3
Brizalina lowmani	7	10.8
miliolid sp.	5	7.7
Buliminella elegantissima	4	6.2
Elphidium galvestonense	3	4.6
E. incertum mexicanum	3	
E. sp.	3	
E. gunteri	2	3.1
Nonion sp.	2	
	65	100.1

MMRI-12
13′-13.2′

Elphidium galvestonense	7
Ammonia beccarii tepida	5
Ammotium salsum	1
Cribroelphidium poeyanum	1
Elphidium incertum mexicanum	1
Hanzawaia strattoni	1
Nonion depressulum matagordanum	1
Nonionella atlantica	1
	18

14.9′-15′

	Elphidium incertum mexicanum	1	
	miliolid sp.	1	

16 ′ -16.i [1]

	Ammonia beccarii tepida	3	
	Elphidium galvestonense	1	(poorly preserved)
	miliolid	1	
	Unidentified agglunated fragment	1	
*	Globigernelloides bentonensis	4	
*	Heterohelix réussi	4	
*	Ticinella aprica	1	
		15	

16.6'-16.8'

	Ammonia beccarii parkinsoniana	2	

17.6'-17.9′

	Brizalina lowmani	41	
	Ammonia beccarlî tepida	1	
	Elphidium sp.	1	
		43	

20.7′-20.8′

	Elphidium incertum mexicanum	1	
*	Heterohelix réussi	1	
		2	

22.2'-22.3′

	Elphidium gunteri	36	50.0
	Ammonia beccarii tepida	9	12.5
	Brizalina lowmani	7	9.7
	Ammonia beccarii parkinsoniana	5	6.9
	Nonion depressulum matagordanum	5	
	Buliminella elegantissima	2	2.8
	Buliminella cf. B. bassendorfensis	2	
*	Heterohelix réussi	2	
	Ammotium salsum	1	1.4
	Buccella hannai	1	
	Nonionella opima	1	
		72	100.0

23.2*-23.3′

Ammonia beccarii tepida	32	55.2
milolid sp.	11	19.0
Elphidium incertum mexicanum	5	8.6
E. sp.	4	6.9
Ammonia beccarii parkinsoniana	3	5.2
Cribroelphidium poeyanum	1	1.7
Nonionella opima	1	
* Heterohelix réussi	1	
	58	100.0

MMRI-13
42.2′-42.3′

Ammonia beccarii tepida	45	31.3
miliolid	18	12.5
Ammonia beccarii parkinsoniana	17	11.8
Elphidium galvestonense	10	6.9
Nonionella atlantica	7	4.9
Cribroelphidium poeyanum	6	4.2
Elphidium gunteri	5	3.5
E. discoidale	4	2.8
E. incertum mexicanum	4	
Buccella hannai	4	
Ammotium salsum	3	2.1
Hanzawaia sp.	3	
Nonion sp.	3	
Nonionella opima	3	
Buliminella cf. B. bassendorfensis	2	
Elphidium sp.	2	
Rectobolivina advena	2	1.4
Ammobaculites exiguus	1	0.7
Buliminella elegantissima	1	
Guttulina sp.	1	
Trifarina bella	1	
Reussella atlantica	1	
	143	100.3

45.6'-45.7′

Elphidium galvestonense	8
Ammonia beccarii tepida	1
Nonion depressulum matagordanum	1
	10

46.6'-46.7′

Ammonia beccarii tepida	8
Elphidium gunteri	7
E. galvestonense	3
Buliminella cf. B. bassendorfensis	2
Ammonia beccarii parkinsoniana	2
miliolid sp.	2
Buliminella elegantissima	1
	25

47.5'-47.7'

Elphidium galvestonense	22	
E. gunteri	8	
Ammonia beccarii tepida	2	
Buliminella elegantissima	2	
Brizalina lowmani	2	
miliolid sp.	2	
Nonionella atlantica	1	
	39	

48.4'-48.5'

Brizalina lowmani	17	
Elphidium galvestonense	5	
miliolid sp.	4	
Ammonia beccarii parkinsoniana	3	
Elphidium gunteri	3	
Buliminella elegantissima	2	
Ammonia beccarii tepida	1	
Ammotium salsum	1	
Buliminella cf. B. bassendorfensis	1	
	37	

49.2'-49.3'

Ammonia beccarii tepida	20	22.0
A. parkinsoniana	16	17.6
Elphidium galvestonense	16	
Buliminella elegantissima	8	8.8
Cribroelphidium poeyanum	8	
Elphidium gunteri	5	5.5
E. sp.	4	4.4
Brizalina lowmani	3	3.3
miliolid sp.	3	
Nonionella atlantica	2	2.2
Buliminella cf. B. bassendorfensis	1	
Buccella hannai	1	1.1
Elphidium incertum mexicanum	1	
Elphidium sp. (aberrant)	1	
Nonionella opima	1	
* Heterohelix réussi	1	
	99	100.1

MMRI-14
31.0'-31.1

Ammonia beccarii tepida	30	36.6
Elphidium gunteri	9	9.2
Nonionella atlantica	8	8.2
miliolid		
Cribroelphidium poeyanum	6	6.1
Ammonia beccarii parkinsoniana	5	5.1

Ammotium salsum	4	4.1
Brizalina lowmani	4	
Elphidium galvestonense	4	
Buliminella elegantissima	3	3.1
Hanzawaia strattoni	3	
Textularia agglutinans	2	2.0
Globigerinoides ruber	2	
Ammobaculites sp.?	1	1.0
Bulimina sp.	1	
Brizalina striatula	1	
Buccella hannai	1	
Elphidium incertum mexicanum	1	
Guttulina sp.	1	
Nonionella opima	1	
Reophax sp.	1	
	95	99.8

33.0'-33Л*

Elphidium incertum mexicanum	12
Ammonia beccarii tepida	4
Cribroelphidium poeyanum	4
Hanzawaia strattoni	3
Buliminella cf. B. bassendorfensis	2
Elphidium sp.	2
E. galvestonense	2
Nonion sp.	2
Brizalina lowmani	1
Bucccella hannai	1
Guttulina sp.	1
Nonionella atlantica	1
N. opima	1
Sagrina pulchella primitiva	1
	37

34'-34.1'

Ammonia beccarii parkinsoniana	1
Planulina? sp.	1
	3

MMRI-15
40'-40.4*

Ammonia beccarii tepida	36	37.1
Elphidium galvestonense	17	17.5
Ammonia beccarii parkinsoniana	11	11.3
Elphidium gunteri	7	7.2
Quinqueloculina sp.	6	6.2
Buliminella cf. B. bassendorfensis	3	3.1
Cribroelphidium poeyanum	3	
Buliminella elegantissima	2	2.1
Hanzawaia strattoni	2	
Textularia agglutinans	2	

	Bulimína sp?	1	1.0
	Guttulína australis	1	
	(Globigerinoides ruba	1	
	(Globorotalia?' sp.	1	
	Trochammina lobata	1	
	Trifarina bella	1	
	Elphidium advenum (aberrant)	1	
		96	99.8

41.25'-41.35[1]

*	Heterohelix réussi (limonitic stained test)	6	
	Nonionella opima	5	
*	Globigerinelloides bentonensis	3	stained
	Ammonia beccarli tepida	1	stained
	Brizalina sp (?)	1	stained
	Buccella hannai	1	unstained
	Elphidium advenum	1	stained
	E. gunteri	1	"
	E. incertum mexicanum	1	"
	Pyrgo nasutus (?)	1	
		21	

41.6'-41.7'

	Ammonia beccarii tepida	1	
	A. parkinsoniana	1	unstained
	Buliminella cf. B. bassendorfensis	1	
	Buccella hannai	1	stained
	Elphidium gunteri	1	
		5	

42.6'-42.7'

	Bulimina sp.	1	

43.4'-43.5'

*	Heterohelix réussi	4	
	Quinqueloculina sp.	3	
*	Globigerinelloides bentonensis	2	
	Ammonia beccarii tepida	1	
	Nonion sp.	1	
		11	

42'-42.1'

	Ammonia beccarii tepida	49	31.0
	Elphidium gunteri	36	22.8
	Ammonia beccarii parkinsoniana	27	17.1
	Elphidium galvestonense	12	7.6
	Buccella hannai	7	
	Hanzawaia strattoni	7	4.4

Ammotium salsum	5	3.2
Nonionella atlantica	3	1.9
N. opima	2	
Buliminella elegantissima	2	
Cribroelphidium poeyanum	2	1.3
Ammobaculites exilis	1	
Elphidium incertum mexicanum	1	
Buliminella cf. B. bassendorfensis	1	0.6
Elphidium sp.	1	
Reussella atlantica	1	
Brizalina striatula	1	
	158	99.9

MMRI-16

42.7'-42.8'

Elphidium gunteri	39	34.2
Ammonia beccarii tepida	23	20.2
Elphidium galvestonense	11	9.6
Cribroelphidium poeyanum	13	11.4
Nonion depressulum matagordanum	4	3.5
Nonionella atlantica	4	
Brizalina lowmani	4	
Ammotium salsum	2	
Ammonia beccarii parkinsoniana	3	
Buliminella cf. B. bassendorfensis	2	
Elphidium incertum mexicanum	2	1.8
milolid sp.	3	2.6
Elphidium sp.	1	
Hanzawaia strattoni	1	0.9
Buccella hannai	1	
Heterohelix réussi	1	
	114	100.1

44.5'-44.6'

Ammonia beccarii tepida	17	16.7
Elphidium gunteri	15	14.7
E. galvestonense	14	13.7
Ammonia beccarii parkinsoniana	9	8.8
Buliminella elegantissima	11	10.8
Nonionella opima	8	7.8
milolid sp.	7	6.9
Brizalina lowmani	5	
Elphidium incertum mexicanum	5	4.9
Nonion depressulum matagordanum	5	
Buliminella cf. B. bassendorfensis	3	2.9
Nonion sp.	1	
Nonionella atlantica	1	
Brizalina striatula	1	1.0
	102	100.0

46.5'-46.6'

Elphidium gunteri	25	18.4
Ammonia beccarii parkinsoniana	24	17.6
miliolid sp.	18	13.2
Nonionella opima	17	12.5
Ammonia beccarii tepida	16	11.8
Elphidium galvestonense	15	11.0
Buliminella cf. B. bassendorfensis	6	4.4
Brizalina lowmani	4	2.9
Nonionella atlantica	3	2.2
Buccella hannai	2	
Buliminella elegantissima	2	1.5
Elphidium latispatium pontium	1	
Elphidium sp.	1	
	134	99.8

MMRI-17
15[1]-15.2'

Ammonia beccarii parkinsoniana	42	39.3
Elphidium galvestonense	17	15.9
Ammonia beccarii tepida	16	15.0
Cribroelphidium poeyanum	14	13.1
Ammotium salsum	7	6.5
Trochammina lobata	4	3.7
Elphidium sp.	3	2.8
Ammobaculites exiguus	1	
Elphidium incertum mexicanum	1	0.9
miliolid sp.	1	
Nonion depressulum matagordanum	1	
	106	99.9

16.5'-16.6'

Ammotium beccarii parkinsoniana	8
A. tepida	7
Elphidium galvestonense	6
Cribroelphidium poeyanum	3
Ammotium salsum	1
Unidentified agglutinated sp.	1
	26

17'-17 1/2*

Ammonia beccarii tepida	55	48.7
A. parkinsoniana	45	39.8
Elphidium sp.	6	5.3
Elphidium galvestonense	2	1.8
E. gunteri	2	
Cribroelphidium poeyanum	1	0.9
Nonion depressulum matagordanum	1	
	112	100.1

18'-18.2[1]

Elphidium galvestonense	13	
Ammonia beccarii parkinsoniana	5	
A. tepida	5	
Cribroelphidium poeyanum	4	
Elphidium latispatium pontium	1	
E. sp.	1	
Nonion depressulum matagordanum	1	
	30	

19'-19.1 '

Ammonia beccarii parkinsoniana	18	29.0
A. tepida	13	21.0
Elphidium galvestonense	11	17.7
E. sp.	9	14.5
E. gunteri	4	6.5
Cribroelphidium poeyanum	3	4.8
Elphidium latispatium pontium	1	1.6
Nonion depressulum matagordanum	3	
	62	99.9

20'-20.1 '

Ammonia beccarii tepida	2
A. parkinsoniana	2
Elphidium galvestonense	2
Nonion depressulum matagordanum	1
Palmerinella gardenislandensis	1
	8

21'-21.2'

Heterohelix réussi	4
Bucella hannai	1
* Globigernielloides bentonensis	1
Nonion sp.	1

23.4'-23.6'

Ammonia beccarii tepida	2
A. parkinsoniana	1
Ammotium salsum	1
Elphidium galvestonense	1
	5

MMRI-18
20'-20.2'

Ammonia beccarii tepida	107	36.8
Cribroelphidium poeyanum	77	26.5
Ammonia beccarii parkinsoniana	35	12.0
Elphidium galvestonense	17	5.8

Trochammina lobata	14	4.8
Ammotium salsum	6	2.1
Elphidium sp.	13	4.5
Ammobaculities exiguus	4	1.4
Textularia sp.	3	1.0
Buliminella elegantissima	2	0.7
Brizalina lowmani	2	
Elphidium gunteri	2	
Quinqueloculina sp.	2	
Trochammina inflata	2	
Arenoparella mexicana	1	0.3
Brizalina striatula	1	
Cibicides sp.?	1	
Nonion sp.	1	
Planulina exorna?	1	
	291	99.9

21.0'-21.2[r]

Brizalina lowmani	40	32.3
Nonion depressulum matagordanum	34	27.4
Ammonia beccarii tepida	18	14.5
Elphidium gunteri	12	9.7
Ammonia beccarii parkinsoniana	5	4.0
Elphidium galvestonense	5	
Cribroelphidium poeyanum	4	3.2
Buliminella elegantissima	2	1.6
Elphidium sp.	1	0.8
E. latispatium pontium?	1	
miliolid sp.	1	
Nonion sp.?	1	
	124	99.9

23.9'-24.0'

Elphidium galvestonense	44	34.1
E. gunteri	29	22.5
miliolid sp.	18	14.0
Nonion depressulum matagordanum	14	10.9
Ammonia beccarii tepida	10	7.8
Brizalina lowmani	7	5.4
Ammonia beccarii parkinsoniana	3	2.3
Buliminella elegantissima	2	1.6
Nonionella opima	2	
	129	100.2

26.0'-26.2'

Elphidium galvestonense	63	33.3
E. gunteri	55	29.1
Ammonia beccarii tepida	47	24.9
Brizalina lowmani	8	4.2
Ammonia beccarii parkinsoniana	6	3.2
Elphidium sp.	5	2.6

Quinqueloculina seminulum	2	1.1
miliolid sp.	1	0.5
Elphidium incertium mexicanum	1	
Nonionella opima	1	
	189	99.9

28.6[1]-28.8′

Ammonia beccarii tepida	49	35.0
Elphidium galvestonense	27	19.3
E. gunteri	22	15.7
miliolid sp. (tan colored test)	20	14.3
Ammonia beccarii parkinsoniana	8	5.7
Brizaiina lowmani	5	3.6
Buliminella elegantissima	3	2.1
Elphidium sp.	3	
Buliminella cf. B. bassendorfensis	1	0.7
Nonion depressulum matagordanum	1	
Nonionella opima	1	
	140	99.9

MMRI-19

24-‘24.2′

Ammonia beccarii tepida	55	51.9
Ammonia beccarii parkinsoniana	11	10.4
Cribroelphidium poeyanum	11	
Elphidium incertum mexicanum	5	4.7
Buliminella elegantissima	3	2.8
Ammotium salsum	2	1.9
Bigenerina sp.	2	
Elphidum sp.	2	
Elphiduim galvestonense	1	
Nonionella opima	1	0.9
Brizalina striatula	1	
Fursenkoina sp. (pontoni?)	1	
Hanzawaia strattoni	1	
Haplophragmoides sp.	1	
Trochammina sp.	1	
	100	99.4

27.5[f]-27.7 »

Ammonia beccarii tepida	47	35.1
Ammonia beccarii parkinsoniana	20	14.9
Cribroelphidium poeyanum	13	9.7
Buliminella elegantissima	9	6.7
Elphidium incertum mexicanum	8	6.0
Ammobaculites exiguus	7	5.2
Elphidium galvestonense	5	3.7
Elphidium sp.	5	
Nonionella atlantica	4	3.0
Brizalina lowmani	3	2.2

Ammotium salsum	3	
Haplophragmoides subinvolutum	3	
Nonion depressulum matagordanum	2	1.5
Elphidium latíspatium pontium	1	
Textularia sp.	1	0.7
Nonion sp.	1	
Reussella atlantica	1	
Trochammina inflata	1	
	134	99.6

29.8′-30′

Ammonia beccarii tepida	61	40.4
Nonion depressulum matagordanum	28	18.5
Brizalina lowmani	18	11.9
Elphidium incertum mexicanum	13	8.6
Palmerinella gardenislandensis	10	6.6
Elphiduim galvestonense	6	4.0
milolids	6	
Ammonia beccarii parkinsoniana	3	2.0
Buliminella elegantissima	3	
Elphidium sp.	1	0.7
Buliminella bassendorfensis	1	
Brizalina striatula	1	
	151	100.1

29.8′-30′

Ammonia beccarii tepida	61	40.4
Nonion depressulum matagordanum	28	18.5
Brizalina lowmani	18	11.9
Elphidium incertum mexicanum	13	8.6
Palmerinella gardenislandensis	10	6.6
Elphidium galvestonense	6	4.0
miliolid sp.	6	
Ammonia beccarii parkinsoniana	3	2.0
Buliminella elegantissima	3	
Elphidium sp.	1	0.7
Buliminella bassendorfensis	1	
Brizalina striatula		
	151	100.1

31.8′-32′

Elphidium galvestonense	41
Ammonia beccarii tepida	7
Buliminella elegantissima	5
milord sp.	3
Nonion sp.	1
Brizalina sp.	1
Brizalina lowmani	2
	60

26.4'-26.5[1]

Ammonia beccarii tepida	2
A. parkinsoniana	2
Cribroelphidium poeyanum	2
Elphidium incertum mexicanum	2
Elphidium galvestonense	1
Ammotium salsum	2
Ammobaculites exiguus	1
Haplophragmoides subinvolutum	1
	13

MMRI-20

28.0'-28.3'

Ammonia beccarii tepida	35	31.5
A. parkinsoniana	22	19.8
Ammotium salsum	11	9.9
Cribroelphidium poeyanum	9	8.1
Elphidium galvestonense	8	7.2
Buliminella elegantissima	6	5.4
Ammobaculities sp.	4	3.6
Elphidium gunteri	3	2.7
Brizalina lowmani	2	1.8
Textularia agglutinans	2	
Nonionella opima	2	
Buliminella cf. B. bassendorfensis	1	0.9
Elphidium advenum (?)	1	
E. sp. fragment	1	
E. incertum mexicanum	1	
Trochammina inflata	1	
T. lobata	1	
	110	99.9

29.0 *-29.1[1]

Ammonia beccarii tepida	17
Cribroelphidium poeyanum	13
Elphidium galvestonense	7
E. gunteri	7
Ammonia beccarii parkinsoniana	2
Hanzawaia strattoni	1
Quinqueloculina sp.	1
Nonionella opima	1
Total	49

30'-30.1*

*	Heterohelix réussi	4
	Ammonia beccarii tepida	2
	A. parkinsoniana	2
*	Globigerinelloides bentonensis	2
	Brizalina lowmani	1

	Palmerínella gardenislandensis	1	
		12	
	31.3′-31.4'		
	Ammonia beccarii tepida	3	
*	Heterohelix réussi	2	
	Brizalina sp.	1	
	Quinqueloculina sp.	1	
		7	
	32.4′-32.5[1]		
	Ammonia beccarii tepida	38	58.5
*	Heterohelix réussi	12	18.5
	Nonion depressulum matagordanum	6	9.2
	Ammonia beccarii parkinsoniana	2	
	Brizalina lowmani	2	
*	Globigerinelloides bentonensis	2	3.1
	Elphidium galvestonense	1	
	Fursenkoina sp.	1	1.5
	Palmerínella gardenislandensis	1	
		65	100.0
	33.9′-34′		
	Elphidium galvestonense	72	66.7
	E. gunteri	15	13.9
	Ammonia beccarii tepida	12	11.1
	Quinqueloculina sp.	5	4.6
	Palmerínella gardenislandensis	2	1.9
	Nonion sp.	1	0.9
	Nonion depressulum matagordanum	1	
		108	100.0
	36.0′-36.1'		
	Ammonia beccarii tepida	2	

MMRI-21

	40.0′-40.3′		
	Cribroelphidium poeyanum	57	29.2
	Ammonia beccarii tepida	38	19.5
	Elphidium galvestonense	21	10.8
	Quinqueloculina sp.	21	
	Ammonia beccarii parkinsoniana	12	6.2
	Elphidium gunteri	9	4.6
	E. incertum mexicanum	4	2.1
	Hanzawaia strattoni	4	
	Nonionella atlantica	4	
	Ammotium salsum	3	1.5

Buliminella cf. B. bassendorfensis	3	
Elphidium sp.	3	
Trochammina lobata	3	
Buccella hannai	2	1.0
Textularia sp.	2	
Reussella atlantica	2	
Unidentified agglutinate (Ammobaculites sp.?)	1	
Brizalina sp. (lowmani?)	1	0.5
Brizalina stratula	1	
Elphidium latispatium pontium	1	
Epistominella vitrea	1	
Globigerinoides rubra	1	
Trochammina inflata	1	
	195	99.9

41.3'-41.5'

Buliminella cf. B. bassendorfensis	69	37.1
Elphidium galvestonense	22	11.8
Ammonia beccarii tepida	13	7.0
A. parkinsoniana	13	
Brizalina lowmani	12	6.5
Quinqueloculina sp.	11	5.9
Nonionella opima	20	10.7
Buliminella elegantissima	7	3.8
Nonionella atlantica	6	3.2
Brizalina stratula	3	1.6
Epistominella vitrea	3	
Triloculina sp.	3	
Elphidium gunteri	2	1.1
Bulimina sp.	1	0.5
Brizalina sp.	1	
Lagena sp.	1	
Textularia sp.	1	
	186	99.8

44.1'-44.2'

Buliminella cf. B. bassendorfensis	61	32.8
Brizalina lowmani	35	18.8
Nonionella opima	33	17.7
Quinqueloculina sp.	14	7.5
Nonionella atlantica	8	4.3
Elphidium galvestonense	7	3.8
Ammonia beccarii tepida	6	3.2
Epistominella vitrea	6	
Ammonia beccarii parkinsoniana	5	2.7
Buliminella elegantissima	5	
Quinqueloculina sp.	4	2.2
Brizalina sp.	1	0.5
	185	99.9

46.6[1]-46.8 *

Buliminella cf. B. bassendorfensis	90	43.5
Quinqueloculina sp.	34	16.4
Nonionella opima	29	14.0
Ammonia beccarii tepida	10	4.8
A.b. parkinsoniana	10	
Brizalina lowmani	10	
Nonionella atlantica	6	2.9
Elphidium galvestonense	4	1.9
Epistominella vitrea	3	1.4
Buliminella elegantissima	2	1.0
Unidentified agglutinated sp. (Miliammina?)	2	
Bigenerina irregularis	1	0.5
Elphidium advenum	1	
E. incertum mexicanum	1	
Triloculina sp.	1	
Textularia sp.	1	
	204	99.5

REFERENCES

Folk, R., 1961, Petrology of Sedimentary Rocks, Hemphill's, Austin, Tx, 160 p.

Frazier, D. E., 1967, Recent deltaic deposits of the Mississippi River-their development and chronology: Trans. Gulf Coast Geol. Socs., vol. 17, p. 287-315.

Goldtstein, A., Jr., 1942, Sedimentary petrologic provinces of the northern Gulf of Mexico: Jour. Sed. Petrology, vol. 12, p.77-84.

Kahn, J. H. and Roberts, H. H., Variations in storm response along a microtidal transgressive barrier-island arc: Sedimentary Geology, vol. 33, p. 129-146.

Ludwick, J. C.,1964, Sediments in Northeastern Gulf of Mexico, p. 204-238; in: Papers in Marine Geology, R. L. Miller, Editor, The Macmillan Co., New York, 53I p.

Otvos, E. G., 1976, Massive long-distance transport and redeposition of Upper Cretaceous planktonic foraminifers in Quaternary sediments (with W. D. Bock): Jour. Sed. Petrology, vol. 47, p.978-984.

Otvos, E. G., 1981, Barrier island formation through nearshore aggradation-stratigraphic and field evidence: Marine Geology, vol. 43, p.195-243.

Otvos, E. G.,1985, Geologic evolution and potential economic sand resources in the Mississippi Sound area, Mississippi-Alabama: Miss. Mineral Resources Institute, Open File Rpt. #85-7F, 71 p.

Otvos, E. G., 1986, Island evolution and "stepwise retreat": Late Holocene transgressive barriers, Mississippi Delta Coast-Limitations of a model, Marine Geology, vol. 72, p. 325-340.

Otvos, E. G., 1988, Late Holocene barrier and marshland evolution, Southwest Mississippi: Mississippi Geology, vol. 8, p. 5-11.

Reineck. H.E. and Singh, I. B., 1973, Depositional Sedimentary Environments, Springer Verlag, New York, 439 p.

Roberts, H. H. and Whelan, T., 3rd, 1975, Methane-derived carbonate cements in barrier and beach sands of a subtropical delta complex: Geochim. et Cosmochim. Acta, vol. 39, p. 1085-1089.

Russell, R. J.,1936, Physiography of Lower Mississipi River Delta, p. 3-199, in: Lower Mississippi Delta. Louisiana Geol. Survey Geol. Bull. No. 8, 455 p.

Suter, J. R. and others, 1988, Transgressive evolution of the Chandeleur Islands, Louisiana: Trans. Gulf Coast Assoc. Geol. Socs., v. 38, p. 3I5-322.

Suter, J. R. and Penland, S., 1987, Preliminary assessment of the sand and aggregate resources of three areas of Louisiana inner continental shelf: Louisiana Geol. Survey Open File Rpt. 87-04, 87 p.

Treadwell, R. C., 1955, Sedimentology and ecology of southeast coastal Louisiana: LSU-U.S. Office Naval Research Techn. Report, No. 6, 79 p.