Recent Peat Deposits – Louisiana Coastal Plain[1]

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ABSTRACT

Environments in which peat is forming today are present throughout coastal Louisiana and include small coastal basins between distributary channels and broader inland flood basins separated by major Mississippi River courses. Coastwise marsh belts between beach ridges of the chenier plain contain a relatively thin surface mantle of peat. Information from more than a thousand shallow borings shows that peats accumulated in similar environments during the past several thousand years. These deposits can be differentiated and related to older deltas of the Mississippi River.

In delta sequences, peat occurs in the aggradational delta-plain facies, interfingers laterally with inorganic natural-levee deposits, and overlies progradational sandy delta-front facies and basal prodelta silty clays. Repetitive sequences containing delta-plain peat occur in the subsurface. The thickest peat deposits accumulated in fresh-water inland swamps, which occupied broad flood basins, where environments were more stable. The stratigraphic relationships of delta-plain peats to enclosing facies and repetitive delta sequences are comparable to those in the Carboniferous Yoredale Series of northern England.

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[1]This paper, originally entitled Environments of Peat Accumulation in Coastal Louisiana, was to be prepared by the late Dr. Harold N. Fisk for presentation at the 1964 meeting in Miami Beach. His illness and untimely passing in the fall of that year prevented fulfillment of that effort. In his memory the authors have undertaken the task of preparation and have incorporated much of the basic data gathered under Fisk's direction, drawing heavily on his previous publications.

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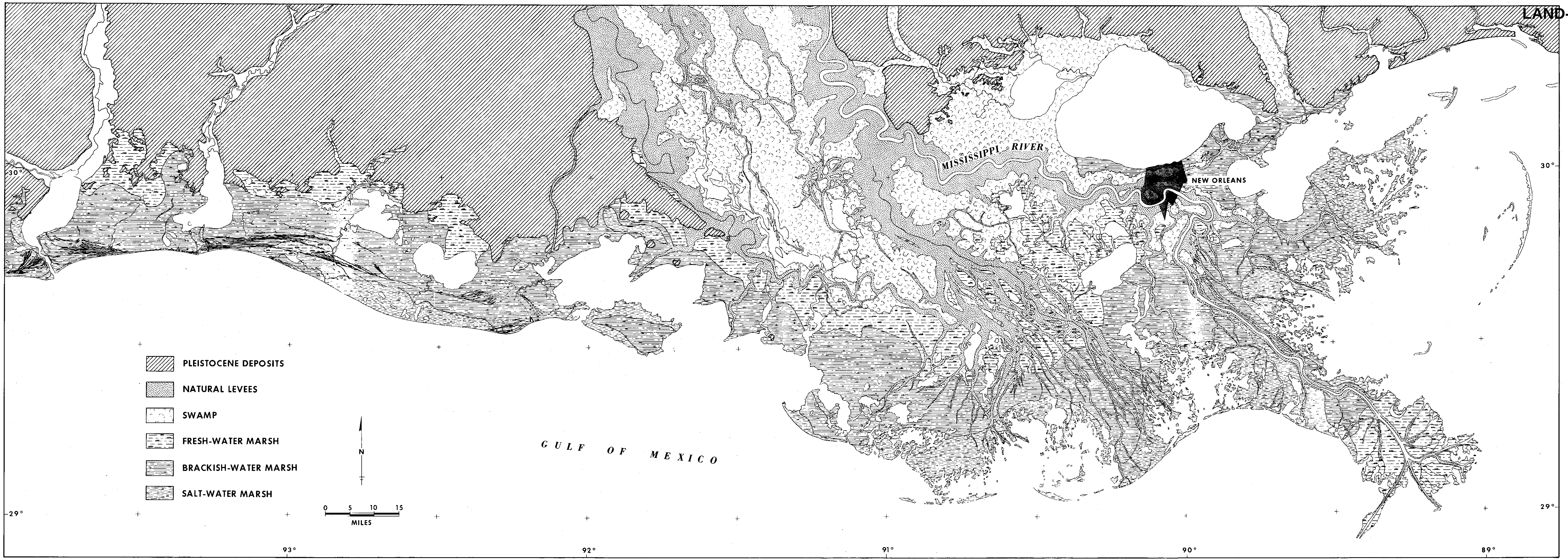
INTRODUCTION

That coals owe their origin to accumulations of peat which formed in ancient swamps and marshes has long been recognized, but not until recently have studies of coals shown that they originated in a variety of geographic settings, including deltas, lagoons, and estuaries (Wanless and others, this



SWAMP AND MARSH ZONATION OF COASTAL LOUISIANA

Marsh zonation modified from O'Neil (1949), and swamp distribution taken from air photographs. Characteristic swamp and marsh vegetation is listed on Table 1.

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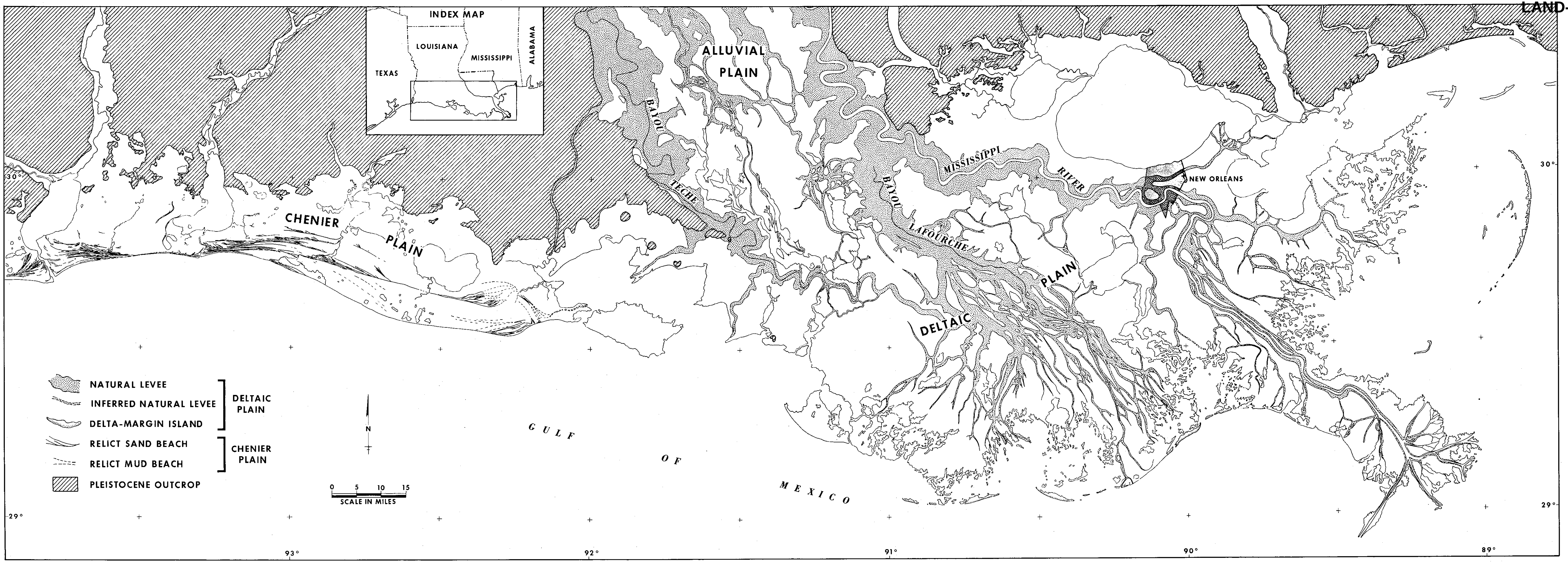

PHYSIOGRAPHIC FEATURES OF COASTAL LOUISIANA

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volume). In 1958, Fisk suggested that certain coals originated in environments on the deltaic plain, citing as examples those of the Carboniferous Yoredale Series (Moore, 1958) and of the Netherlands coal measures (Thiadens and Haites, 1944). Fisk based this contention on his study of the development of interdistributary peat in a local area on the Mississippi deltaic plain near New Orleans. Here he documented the "splitting" of peats by wedges of natural-levee deposits, the destruction of peats locally by tidal channels to create "washouts," and local absences ("wants") due to contemporaneous development of distributary channels and associated natural levees. He related these to similar features associated with coals.

Since Fisk's study, additional data concerning the nature of the shallow subsurface deposits in coastal Louisiana have been published. Byrne and others (1959) described the stratigraphy of the central portion of the chenier plain of southwestern Louisiana, including the surface peat. Gould and Morgan (1962) described peat deposits at several localities across the deltaic and chenier plains and provided valuable information on the environment of accumulation of certain peats and on floral distribution in the coastal area. Recently, Coleman and Smith (1964) described two types of peat in the southwest area of the deltaic plain: interdistributary peats that accumulated in restricted basins between active distributaries, and blanket peats that developed on the coastal deltaic marshes, keeping pace with submergence during and following abandonment of the distributary network.

The present study is an attempt to relate deltaic-plain peats to the many environments in which they accumulated during development of the Mississippi River deltaic plain and to show the stratigraphic relationships of these peats to associated repetitive deltaic sequences. The study entails looking at deeper and more extensive Recent deltaic sediments than have previous investigations and utilizes data obtained from more than a thousand cored borings on the deltaic plain.

PHYSIOGRAPHY AND GEOLOGIC SETTING

The Louisiana Coastal Plain, which extends 300 miles east-west and covers an area of approximately 15,000 square miles, includes the Mississippi River deltaic plain, citing as examples those of the Carboniferous Yoredale of Recent sediments underlying this coastal plain was laid down during the last postglacial rise in sea level and after the sea had reached its present stand (Russell and Howe, 1935; Howe and others, 1935; Russell, 1936; Fisk, 1944, 1948, 1952, 1955, 1958, 1961; Fisk and McFarlan, 1955; Fisk and others, 1954; Van Lopik, 1955; Kolb, 1958, 1962; Byrne and others, 1959; Gould and McFarlan, 1959; McFarlan, 1961; and Gould and Morgan, 1962). In the basal portion of this wedge, directly overlying the weathered and eroded Pleistocene surface, are shoreline sands, bay sediments, and coastal peats deposited during late stages of rising sea level. The upper portion beneath the deltaic plain consists principally of progradational deposits laid down as a series of overlapping delta complexes before and after sea level reached its present stand. Immediately beneath the chenier plain, progradational sediments were deposited as a series of shoreline accretions after the sea had reached its present stand.

The positions of the five principal delta complexes recognized in past studies—the Maringouin, Teche, St. Bernard, Lafourche, and Plaquemines-Modern—are shown in Figure 1. The filled channel of the oldest course, the Mississippi-Maringouin, and its delta complex lie entirely in the subsurface. Subsequent shifts in the course of the Mississippi River led to development of the Teche, St. Bernard, and Lafourche complexes; the present course of the river continues to expand the Plaquemines-Modern complex.

In order to reconstruct the facies framework of Recent deposits beneath the Louisiana Coastal Plain, regional sections were constructed using hundreds of continuously cored borings. The stratigraphy was determined by utilizing all available data, including sediment composition, sedimentary textures and structures, faunal and floral assemblages, and radiocarbon age determinations of the carbonaceous deposits. The sediments penetrated represent delta and basal transgressive facies deposited in the past 7000 years. Through these studies, 16 separate overlapping delta lobes or subdeltas were identified, their approximate limits defined, and their relative ages determined.

ENVIRONMENTS OF PEAT ACCUMULATION

The Mississippi deltaic plain is an area of vast expanses of swamps and marshes transected by natural-levee ridges; the adjacent chenier plain is an extensive coastal marsh interrupted by stranded beach ridges. Marshlands, low-lying, water-saturated, boggy areas, characterize the chenier plain and interdistributary flood basins on the coastal portion of the deltaic plain. Grasses and sedges comprise the bulk of the marsh flora (Pl. 2). On the inland portion of the deltaic plain, slightly higher, broad flood basins separated by natural-levee ridges along major Mississippi River courses, are characterized by fresh-water swamplands. Although these swamplands are also low-lying and wet, the ground is relatively firm, and hardwood trees dominate the growth (Pl. 2).

Swamps and marshes are the principal sites of present peat accumulation on the Louisiana Coastal Plain. The marshes have been divided on the basis of water salinity and plant communities into saline, brackish, and fresh-water types or zones (Pl. 3). Plant communities which characterize the marsh

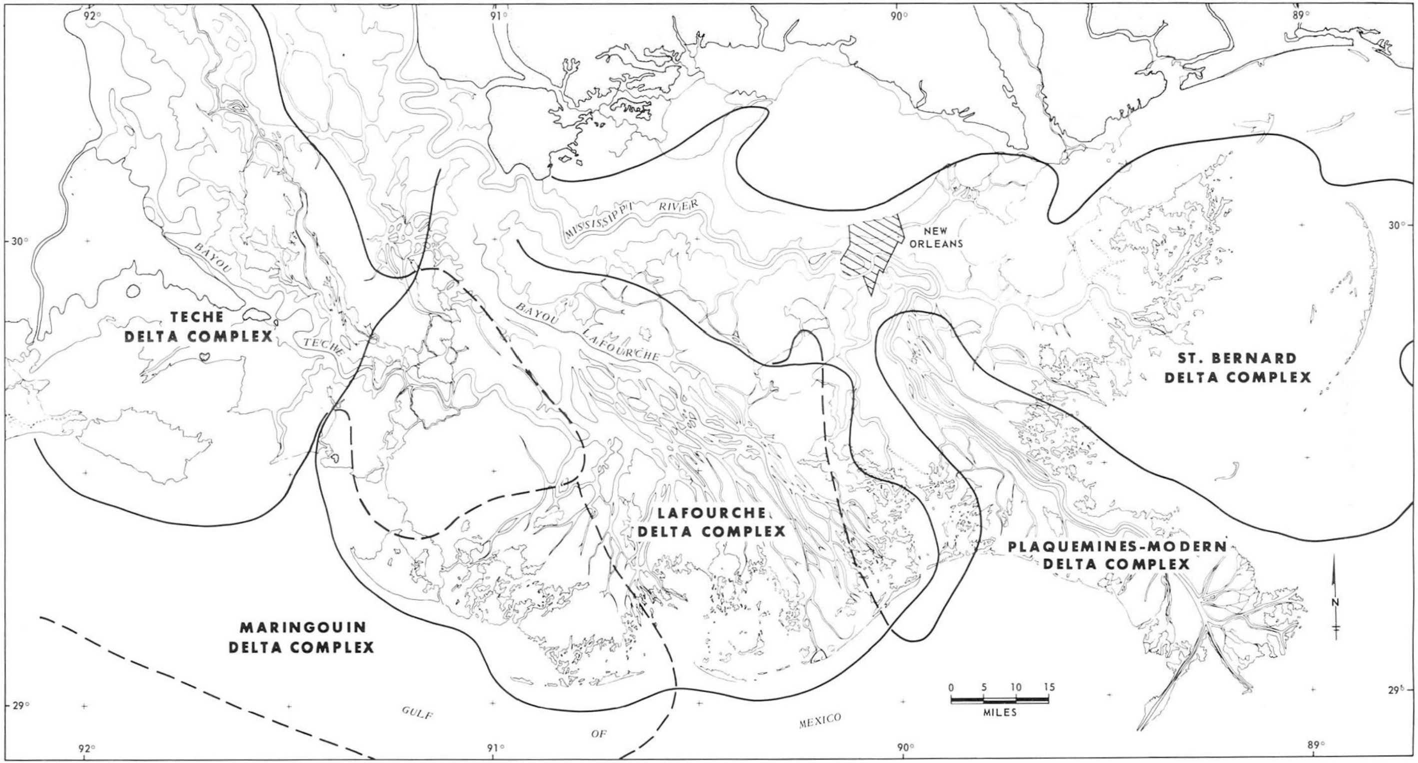

Figure 1. Major delta complexes of Mississippi River deltaic plain.

zones and the swamps are presented in Table 1. Low tidal surges of the Gulf of Mexico (1.0 to 1.5 feet) limit the saline marsh to those areas of the coastal plain dissected by tidal channels or adjacent to embayments. This general pattern is different only on the modern birdfoot delta, where sufficient fresh water is supplied by the Mississippi River and its distributaries to maintain a fresh-water marsh to the coastline.

INTERDISTRIBUTARY PEATS

Relationship to Delta-Lobe Development

Peat-forming environments are related directly to development of the delta lobes. During the progradational phase (Fig. 2a), natural sediment sorting occurs as the river load is debouched at the distributary mouth. Finer grained clastics are transported farther into the basin and deposited as a silty-clay basal unit—the prodelta facies. Coarser clastics are deposited in the proximity of the distributary mouths as the sandy delta-front facies; much of the sand remains where it is deposited to form distributary-mouth bars, but some is distributed laterally by waves and longshore currents. While these processes continue, the prodelta facies is extended basinward, thickening as the delta builds into deeper water. The delta-front facies progrades over prodelta deposits and also thickens, especially in the area of distributary-mouth bars, where greater deposition and loading cause more rapid compaction and displacement of the underlying water-saturated prodelta mud (Fisk and McClelland, 1959, p. 1383; Fisk, 1961, p. 33). The resulting surface, the delta platform, is the foundation for the delta plain. During continued progradation, the shoreline advances, and the delta plain is enlarged and vegetated. The distributary network develops during progradation when repeated bifurcation occurs around middle-ground bars at the shoaled stream mouths (Welder, 1959, p. 54–55).

As the delta plain is enlarged by progradation (Fig. 2b), it is maintained by contemporaneous flood-water deposition and peat accumulation. Sediment is deposited when flood water crosses the stream banks and the currents are diminished. The bulk of flood-water sediment is deposited adjacent to the distributaries to form natural levees. Normally, vegetation farthest from the levee is unaffected by flood-borne sediments, resulting in thick peat accumulations. Close to the levees the vegetation is periodically "choked-out" by inorganic deposition, causing splits in the peat (Fisk, 1958, p. 195). In many areas aggradation cannot keep pace with subsidence due to continuing compaction of the underlying clays and perhaps also to tectonic downwarping. In the marshlands such processes produce small water bodies which are enlarged by continuing subsidence and by wind-driven waves (Howe and others, 1935,

Figure 1. Typical expanse of brackish-water marsh; trees mark a natural-levee ridge in the background.

Figure 2. Typical dense vegetation of an inland fresh-water swamp.

MARSH AND SWAMP ENVIRONMENTS, MISSISSIPPI RIVER DELTAIC PLAIN

p. 57–59; Russell, 1936, p. 116–121) to form lakes with smooth, rounded shorelines. The development and enlargement of these lakes destroy portions of the marsh. In areas of fresh-water marsh dominated by the grass commonly called canouche (*Panicum hemitomon*), air-filled roots of this grass cause the rootmat to break away from the inundated substrate and form a floating marsh (O'Neil, 1949, p. 31–32). Although the peat-forming environment is not destroyed, the peat now overlies an essentially root-free sediment or underclay.

Gradual abandonment of a distributary system occurs as flow of the trunk stream is diverted slowly into one of steeper gradient (Fig. 2c). This diversion may proceed by reoccupation of older distributaries, which are upstream from the over-extended distributary network and which offer shorter courses to the sea, or by shift of the river into another course far upstream on the alluvial plain. Whatever the cause, flow is lessened until the entire distributary network is totally abandoned. When this sequence of events reaches its culmination, inundation of the delta margin begins, as subsidence exceeds aggradation.

During final stages of distributary abandonment, the nearshore processes of wave action and longshore currents predominate. Distributary-mouth bars which form headlands at the delta margin are the first areas to be affected. Sands are winnowed and transported along the shoreline to form accretionary beaches and spits. Such sand bodies are maintained for a time by littoral-zone deposition and remain emergent even though the area is subsiding. As subsidence continues, bays form and enlarge, the saline-marsh peats are eroded and redeposited, and the sand bodies become barriers, that is, delta-margin islands. Coarse detritus from the barriers, fine detritus and organic debris from marshes, and shells of organisms living within the bays are incorporated as deposits of the facies which accumulate on the bay floor. Ultimately the delta-margin islands are truncated and transgressed by marine invasion, and the sand thus derived is spread landward.

With river diversion, a new delta is developed either contiguous to the abandoned delta (Fig. 2d) or far removed in another part of the basin. Repeated diversions lead to the formation of a broad deltaic plain consisting of overlapping delta lobes. Each delta mass exhibits a progradational sequence consisting of basal, fine-grained, prodelta facies overlain by sandy delta-front deposits and of delta-plain sediments, including carbonaceous accumulations. Representative cores of the several progradational facies are illustrated in Plate 4. Above the progradational deposits in the seaward portion are sandy transgressive facies derived from reworking of delta-plain and delta-front deposits following abandonment and continuing subsidence of the

TABLE 1. CHARACTERISTIC SWAMP AND MARSH VEGETATION*

	Natural-levee flank	*Central portion*	*Semi-wooded fringe*
Inland fresh-water swamp — *Trees and shrubs*	Dwarf palmetto *Sabal minor* Live oak *Quercus virginiana* Overcup oak *Quercus lyrata* Willow Oak *Quercus phellos* Bitter pecan *Carya aquatica* Red maple *Acer drummondi* Green ash *Fraxinus pennsylvanica* var. *lanceolata* Black willow *Salix nigra* Wax myrtle *Myrica cerifera* Hackberry *Celtis laevigata* Red gum *Liquidambar styraciflua*	Bald cypress *Taxodium distichum* Tupelo gum *Nyssa aquatica* Sour gum *Nyssa uniflora* Red maple *Acer drummondi* Green ash *Fraxinus pennsylvanica* var. *lanceolata* Black willow *Salix nigra* Swamp elder *Baccharis halminifolia*	Black willow *Salix nigra* Bald cypress *Taxodium distichum* Red maple *Acer drummondi* Green ash *Fraxinus pennsylvanica* var. *lanceolata* Possum haw *Ilex decidua* Wax myrtle *Myrica cerifera* Buttonbush *Cephalanthus occidentalis*
Herbaceous vegetation		Bull tongue *Sagittaria lancifolia* Arrowhead *Sagittaria latifolia* Spider lily *Hymenocaulis occidentalis*	Bull tongue *Sagittaria lancifolia* Arrowhead *Sagittaria latifolia* Water millet *Zizaniopsis miliacea*
	Initial natural levee	*Stream-mouth mud flat*	*Initial interdistributary flood plain*
Stream-mouth fresh-water marsh	Roseau cane *Phragmites communis* Water millet *Zizaniopsis miliacea* Cattail *Typha latifolia*	Fresh three-cornered grass *Scirpus americanus* Delta duck potato *Sagittaria platyphylla*	Cattail *Typha latifolia* Widgeon grass *Ruppia maritima* Grayduck moss *Potamogeton foliosus* Dogtooth grass *Panicum repens* Oyster grass *Spartina alterniflora*

TABLE 1. (CONTINUED)

Inland fresh-water marsh	*Chenier plain*† Paille fine or canouche *Panicum hemitomum* Cattail *Typha latifolia* Bull tongue *Sagittaria lancifolia* Saw grass *Cladium jamaicense* Spike rush *Eleocharis quadrangulata* *Eleocharis pallustris* *Eleocharis cellulosa* Water millet *Zizaniopsis miliacea* Roseau cane *Phragmites communis* Bulrush *Scirpus californicus*	*Deltaic plain* Paille fine or canouche *Panicum hemitomum* Cattail *Typha latifolia* Bulrush *Scirpus californicus* Saw grass *Cladium jamaicense* Delta duck potato *Sagittaria platyphylla*
Brackish marsh	*Chenier plain*† Saw grass *Cladium jamaicense* Cattail *Typha angustifolia* Roseau cane *Phragmites communis* Hog cane *Spartina cynosuroides* Spike rush *Eleocharis palustris* Water millet *Zizaniopsis miliacea*	*Deltaic plain* Three-cornered grass *Scirpus olneyi* Paille fine or canouche *Panicum hemitomum* Wire grass *Spartina patens* Cattail *Typha latifolia* *Typha angustifolia* Arrowhead *Sagittaria latifolia*
Saline marsh	*Chenier plain*† Coco or leafy three-cornered grass *Scirpus robustus* Wire grass *Spartina patens* Salt marsh grass *Distichlis spicata* Clump grass *Spartina spartinae*	*Deltaic plain* Wire grass *Spartina patens* Oyster grass *Spartina alterniflora* Black rush *Juncus roemerianus* Salt marsh grass *Distichlis spicata* Saltwort *Batis maritima* Glasswort *Salicornia perrenis* *Salicornia europea* Sand rush *Fimbristylis castanea*

*After O'Neil, 1949; Penfound and Hathaway, 1938; Hall and Penfound, 1939; Gould and Morgan, 1962.

†The chenier-plain marshes are slightly firmer than the deltaic-plain marshes.

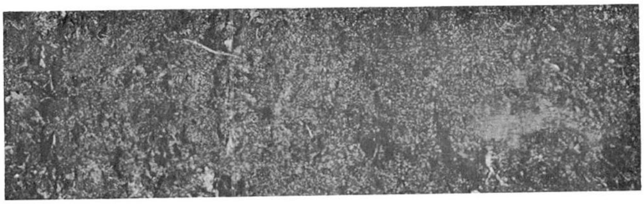

Figure 1. (–20 to 2.5 feet; top at right) Fibrous brackish-marsh peat; contains an *Ammoastuta-Trochammina-Haplophragmoides* foraminiferal assemblage.

Figure 2. (–5.0 to 5.5 feet) Irregularly laminated, root-riddled, inorganic flood-basin silty clay; barren of fauna.

Figure 3. (–11.0 to 11.5 feet) Current-rippled, delta-front distributary-mouth-bar silty sand with finely comminuted carbonaceous debris in cross laminae; contains only the fresh-water ostracod *Candona*.

Figure 4. (–17.5 to –18.0 feet) Thinly layered, strongly brackish, prodelta clayey silt and silty clay; contains an ostracod assemblage of *Perissocytheridea*, *Cyprideis*, *Candona*, and *Limnocythere*, a foraminiferal assemblage of *Elphidium*, *Ammotium*, and *Ammobaculites*, and shells of *Rangia cuneata*. Scale 1⅛ inches = 2 inches.

CORES FROM BORING LAT 29°20.2′N., LONG 90°39.3′W.

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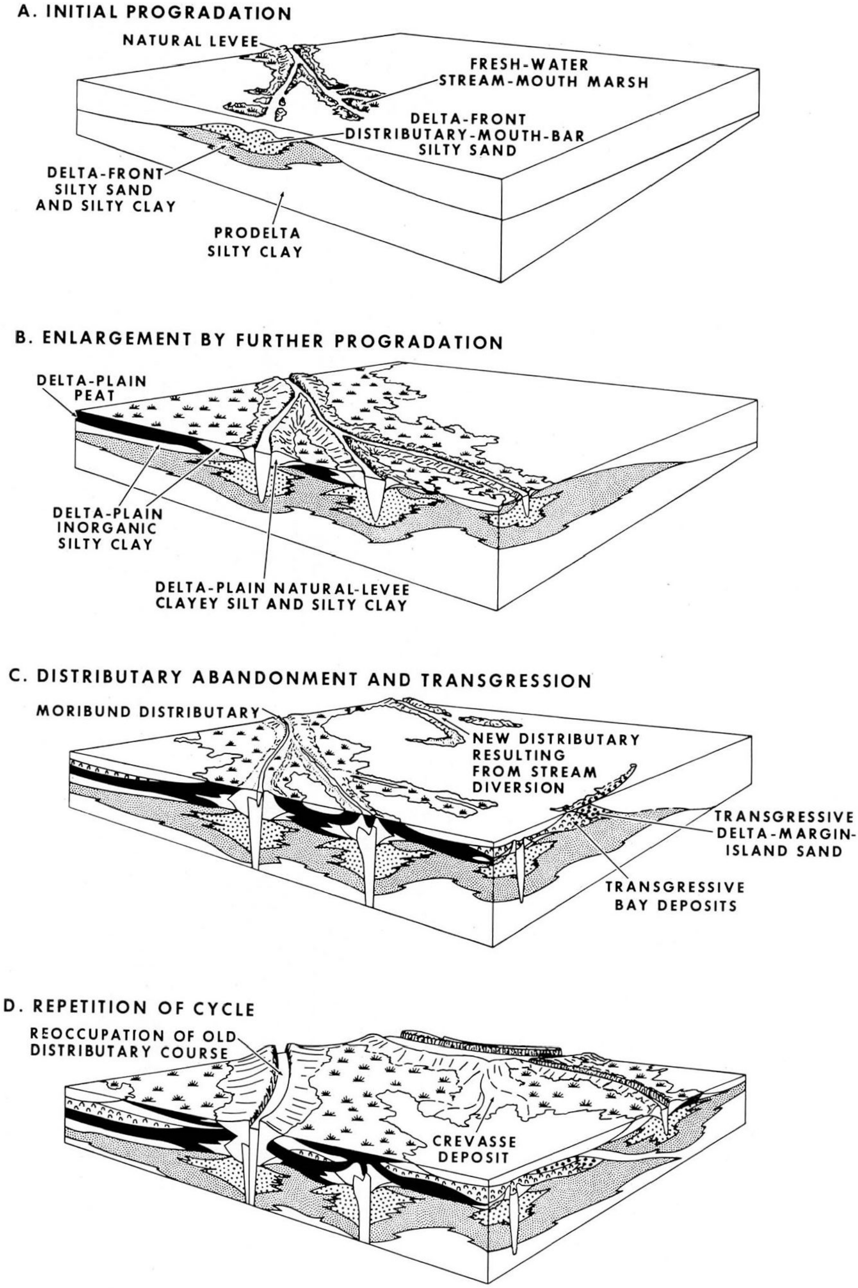

Figure 2. Development of delta sequences.

distributary network. As subsidence continues, the area may provide a favorable location and gradient for another diversion of the river to develop a new deltaic sequence overlapping the original delta mass; thus, several repetitive sequences are developed. Each sequence contains at least one deposit of delta-plain peat.

Peats in the St. Bernard Delta Complex

The St. Bernard delta complex demonstrates the facies framework and the relationship among peats within typical repetitive delta sequences. Approximate limits of the delta lobes which constitute the St. Bernard complex are shown on Figure 3 along with locations of control borings and position of a line of section through these deposits illustrated in Plate 5. The upper section has been simplified to show the repetitive sequences of progradational, aggradational, and marine transgressive units associated with five lobes of the St. Bernard delta complex (lettered A, B, D, E, and F), and aggradational and transgressive units associated with the Plaquemines-Modern delta complex (lettered G). Shown in the lower section of Plate 5 are facies relationships of the sediments involved, including the interdistributary peat and clayey peat accumulations. Each delta lobe is defined by the sequence of sediments and by chronology based on radiocarbon dates of peats.

The oldest Recent deposits shown on the sections (Pl. 5) are those of the basal transgressive sand facies (miles 5 to 21), which overlie the weathered and eroded Pleistocene surface (miles 6 to 19). Redeposited marine shells incorporated in these sands, from –50 feet at mile 16, were dated as 7150 years B.P. The occurrence of bay deposits on the landward (northwest) side indicates that the sands accumulated as barrier islands, later transgressed, in part reworked, and spread landward as sea level continued to rise. The similarity is striking between these deposits and the transgressive facies resulting from subsidence at the southeastern end of the section (miles 90 to 78). The discontinuity of the delta-front facies suggests that the line of section cuts the oldest subdelta (lobe A, miles 0 to 44) near its seaward margin. Interdistributary clayey peats occur locally between miles 27 and 32. Accumulation of extensive delta-plain peats on the distal portion of this subdelta evidently was precluded because of rapid subsidence, due to compaction of underlying clays, coupled with sea-level rise. Associated with this oldest lobe are delta-margin-island facies and bay deposits (miles 11 to 14). The initial subdelta was overlapped by the next progradation (lobe B, miles 0 to 19), and discontinuous deposits of peat and clayey peat occur between miles 4 and 14. Clayey peat found at –16 feet (mile 12) has been dated 4050 years B.P.

Radiocarbon dates of 3000 to 2600 years B.P. have been obtained from the peat deposits on lobe D (miles 0 to 57). This subdelta was followed by

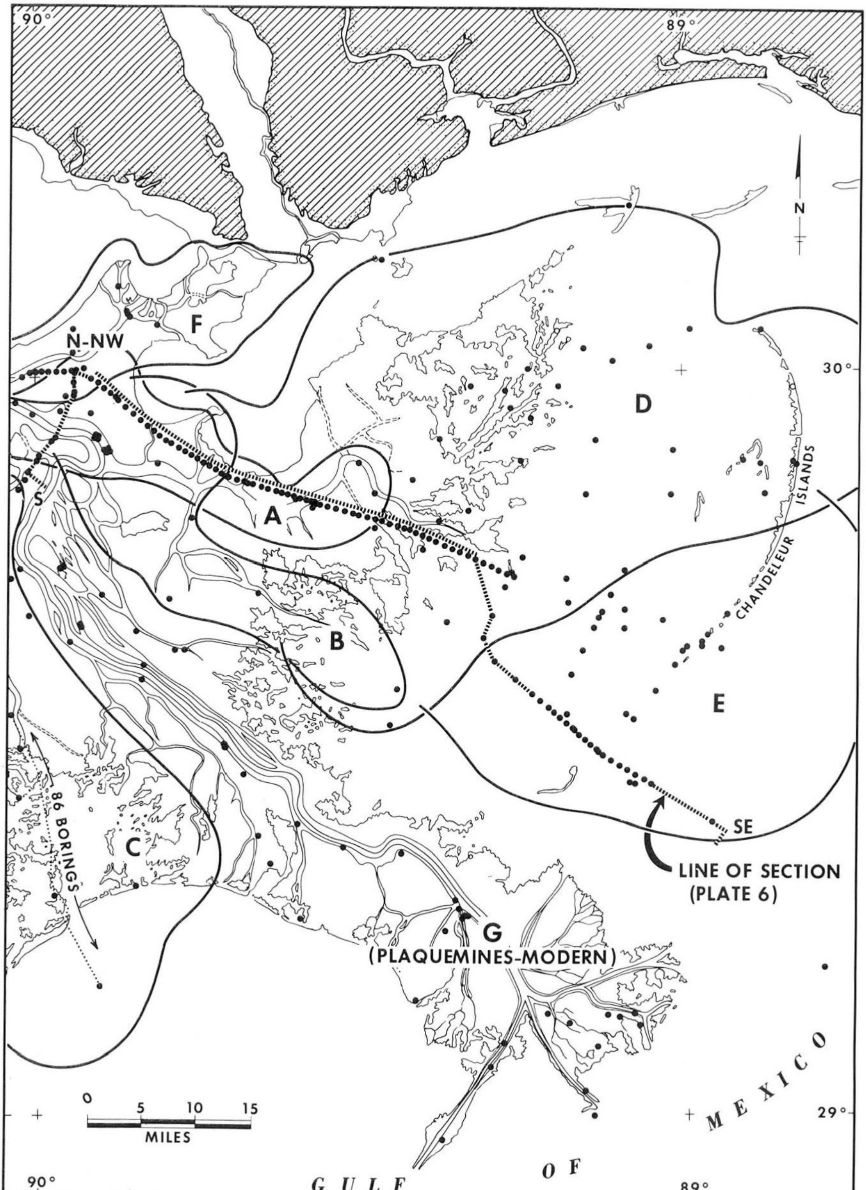

Figure 3. Approximate limits of the St. Bernard delta lobes. Lobe A is oldest; lobe F is youngest.

lobe E, which contains peats dated 2400 to 2000 years B.P. Between miles 0 to 54 only the aggradational facies are present, whereas the entire delta sequence occurs southeast of mile 54. Lobes D and E represent widespread progradations, which extend the deltaic plain beyond the Chandeleur Islands (Fig. 2). Following stream abandonment, subsidence in the seaward portion led to marine transgression, as reflected by the transgressive facies of lobe E (miles 90 to 60).

Along the line of section (Pl. 5) lobe F is encountered only between miles 6 and 14. Its prodelta and delta-front facies overlap the carbonaceous accumulations of the three older lobes. Radiocarbon dates of the underlying and overlying peats indicate that this lobe prograded between 2675 and 1850 years B.P.

Aggradational facies associated with development of the Plaquemines-Modern subdeltas (G) occur as uppermost deposits between miles 2 and 62. These facies are natural-levee and inorganic flood-plain sediments deposited contemporaneously with the accumulation of peat dated 1100 years B.P. to modern. Facies associated with the prodelta and delta-front of these lobes are to be found southwest of the line of section (Fig. 3). Continuing subsidence induced further transgression, from mile 62 to the present shoreline at mile 49, and at present the surficial peat and clayey peat are being washed out by tidal action in the channels and by wave erosion along the shoreline.

Lateral changes in environments of peat accumulation similar to those on the surface of the deltaic plain are recorded in the subsurface peats. Peats in lobe D, adjacent to natural levees which are inland, contain pollen of narrow-leaf cattail (*Typha angustifolia*) and saw grass (*Cladium jamaicense*), which indicate a fresh to brackish marsh environment. A lateral transition to a slightly more brackish marsh environment in the interdistributary basins and adjacent to levees near the distal portions of the delta is recorded by pollen assemblages dominated by sedges (*Eleocharis* spp.) and broad-leaf cattail (*Typha latifolia*). Peats in the seaward portions of the interdistributary basins contain a nondefinitive grass-pollen assemblage; however, a diatom assemblage of *Caloneis westii, Campylodiscus echeneis, Diploneis* cf. *D. cynthia,* and *Epithemia argus* indicates a strongly brackish marsh environment.

Vertical as well as lateral changes in environment are recorded; these reflect stability and decreasing salinity during development of the delta complex. Between miles 7 and 13, peat in lobe D contains pollen of narrow-leaf cattail (*Typha angustifolia*), broad-leaf cattail (*Typha latifolia*), and sedges (*Eleocharis* spp.), indicating a brackish marsh environment. The overlying peat (lobe F) developed in a fresh-water, levee-flank swamp, as recorded by a pollen assemblage of bald cypress (*Taxodium distichum*), bitter pecan (*Carya aquatica*), and red gum (*Liquidambar styraciflua*).

INLAND SWAMP PEATS

Peat accumulations as thick as 20 feet are found in the broad, inland flood basins separated by natural-levee ridges along Bayous Teche and Lafourche and the Mississippi River (Pl. 1). The peats were derived from cypress-gum swamp vegetation during the past 3700 years, as indicated by pollen assemblages and radiocarbon dates obtained from many cores. These extensive swamps were established by the initial progradational and aggradational phases of major Mississippi River courses and were able to persist because their rate of peat accumulation of 2.0 feet per century kept pace with subsidence. Furthermore, they were sufficiently far removed from the active courses to preclude any large influx of sediment to inhibit growth of vegetation.

Relationship to Delta-Complex Development

The relationship between repetitive delta sequences in the coastal area of a delta complex and the inland sequence associated with the major stream course is shown diagrammatically in Figure 4. Relationships in the coastal area (Fig. 4, Block A) have been discussed previously. The inland sequence of facies associated with the major stream course (Fig. 4, Block B) is similar to that of a single delta lobe, except for the greater thickness of the aggradational facies. These deposits represent accumulation during the development of the entire delta complex by the major stream.

Peats in the St. Bernard Delta Complex

A section 30 miles west of New Orleans shows an accumulation of thick peat in an inland sequence associated with both the St. Bernard and Plaquemines-Modern delta complexes (Pl. 6). The upper section delineates the approximate boundaries of the deposits which correlate with separate delta lobes in the coastal area. Each unit has been lettered to correspond to the equivalent lobe on the map (Fig. 3) and on the upper section of Plate 5. Facies relationships are shown on the lower section (Pl. 6).

The oldest Recent deposits, the basal transgressive sands, occur as a trench filling (mile 8) and as a shoreline deposit (miles 32–39) which onlaps the weathered Pleistocene surface at the south end of the section. The progradational prodelta and delta-front facies are encountered only at the base of the section (miles 6 to 39), where they overlie either basal transgressive deposits or the weathered Pleistocene surface. Overlying aggradational facies consist of inorganic flood-plain silty clays, natural-levee deposits, clayey peat and peats, and sandy crevasse deposits.

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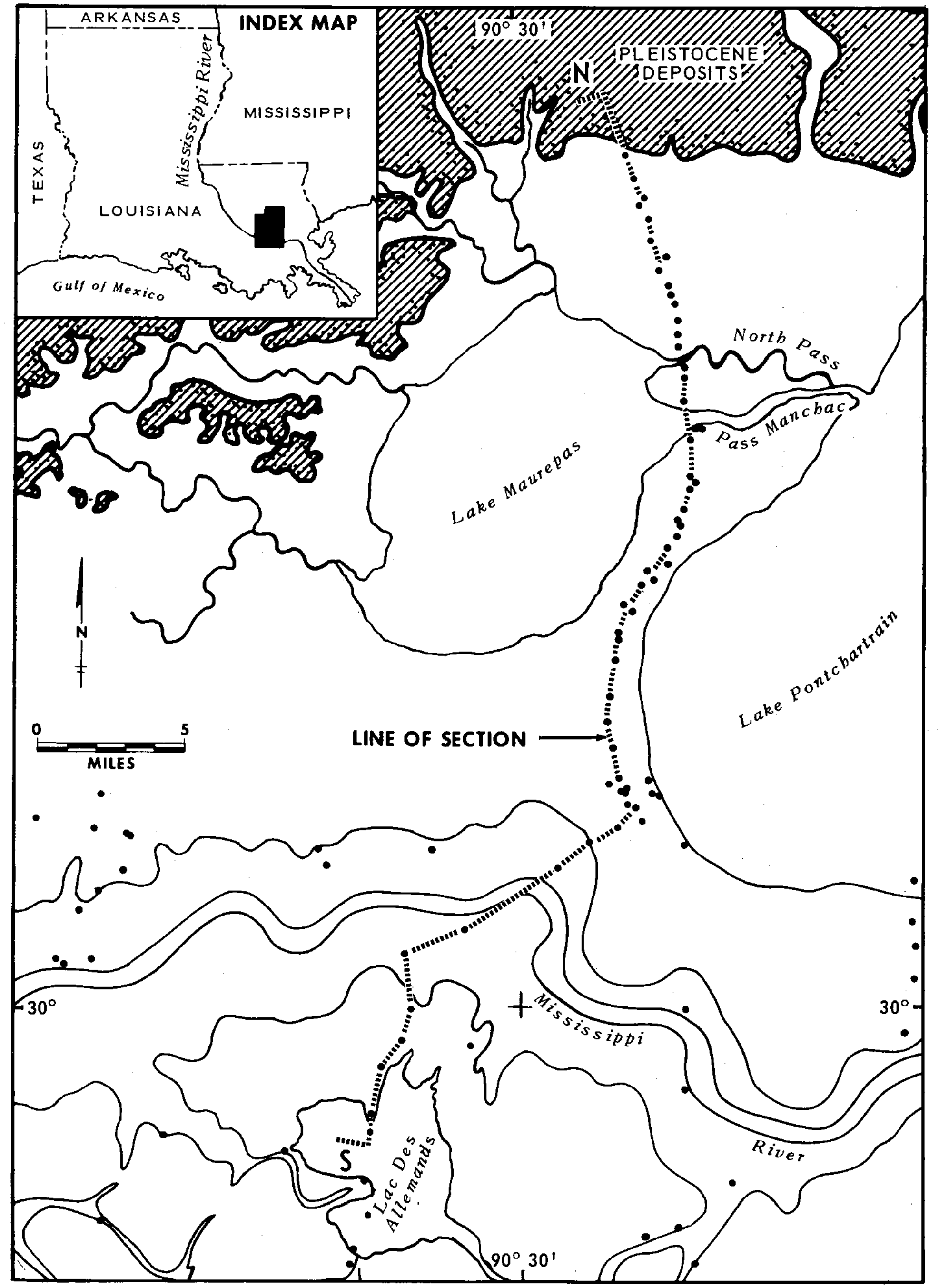
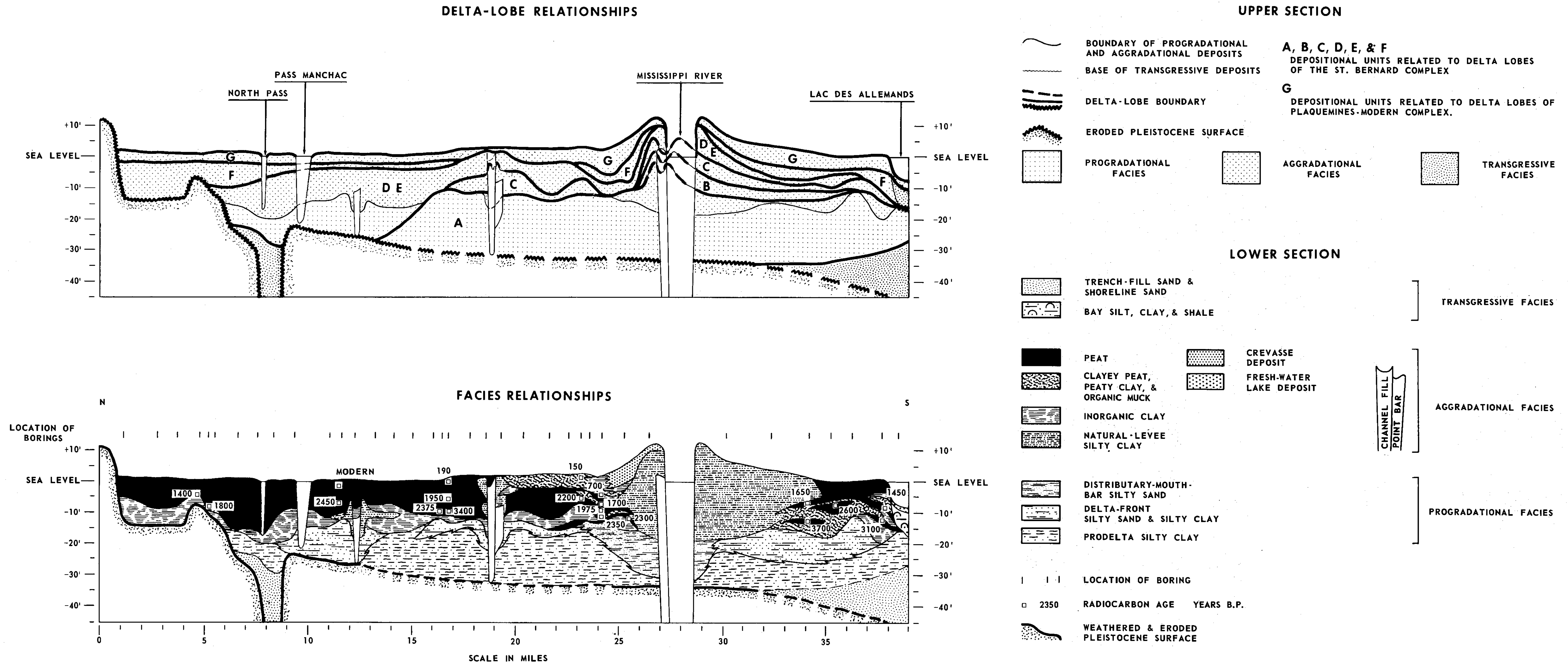
CROSS SECTION THROUGH COASTAL PORTION OF ST. BERNARD DELTA COMPLEX





CROSS SECTION THROUGH INLAND PORTION OF ST. BERNARD DELTA COMPLEX

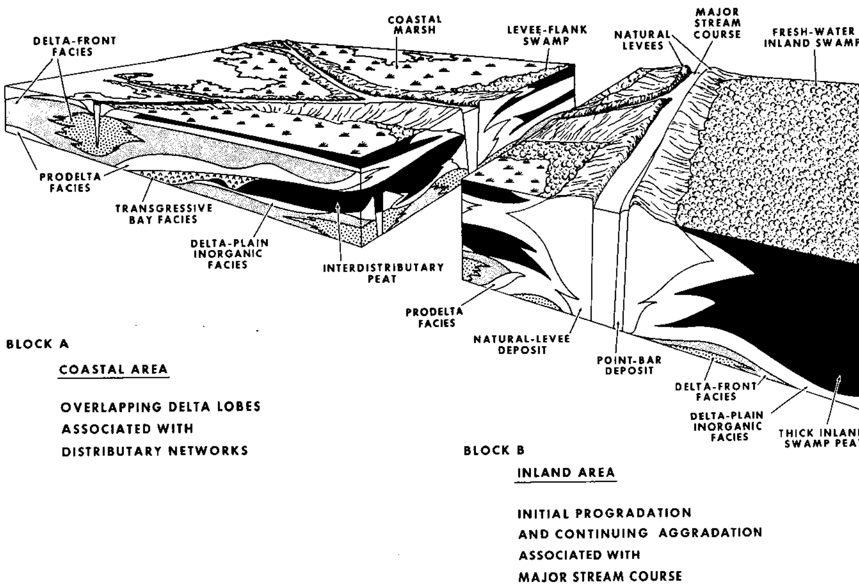


Figure 4. Facies relationships between coastal repetitive sequences and the inland sequence of a typical delta complex.

Thick peats in the broad flood basin to the north of the Mississippi River accumulated in a cypress-gum swamp which persisted locally for 3000 years. South of the river, peat accumulation began in a swamp-fringe marsh adjacent to the natural levee, as indicated by pollen of bald cypress (*Taxodium distichum*), bitter pecan (*Carya aquatica*), and saw grass (*Cladium jamaicense*) found in the peat. Farther from the levee the initial marsh was more brackish, as shown by the incorporated diatoms *Caloneis westii* and *Campylodiscus echeneis*. Today, the area adjacent to the levee remains as a swamp, but near the shore of Lac Des Allemands (mile 38) the environment is a fresh-water marsh.

Deep "wants" through the thick peat, caused by flow through North Pass and Pass Manchac (at miles 8 and 10), are still enlarging. "Splits" in the peat and clayey peat, resulting from deposition of inorganic crevasse, natural-levee, and flood-plain sediments (contemporaneous with peat development), are evident in the vicinity of miles 24 and 34.

CHEMICAL COMPOSITION OF COASTAL-PLAIN PEATS

Four brackish-marsh peats, six freshwater swamp peats (including three clayey peats and one woody peat), and two samples of peat detritus were

TABLE 2. CHEMICAL ANALYSES OF CARBONACEOUS ACCUMULATIONS

	Environment	Brackish marsh	Shoreline		Swamp		Swamp
	Lat. N	29°51.2′	30°00.8′		30°05.1′		30°11.3′
	Long. W	89°40.7′	90°07.7′		90°26.6′		90°26.2′
	Sample type	Peat	Detrital peat debris	Clayey peat	Peat	Clayey peat	Peat
	Elevation	+1.0′ to +0.5′	–4.5′ to –5.5′	–7.5′ to –7.8′	–10.0′ to –10.5′	–10.5′ to –12.0′	–3.5′ to –4.1′
Proximate Analysis As Received	Moisture	84.39	80.26	56.63	78.19	71.62	84.24
	Volatiles	4.22	4.83	11.29	8.35	8.25	8.10
	Fixed carbon	0.09	1.33	1.92	3.33	2.61	2.33
	Sulfur	0.59	0.25	0.15	0.83	0.09	0.51
	Ash	10.71	13.33	30.01	9.30	17.43	4.82
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Moisture Free	Volatiles	27.00	24.46	26.02	38.27	29.02	51.42
	Fixed carbon	0.58	6.74	4.39	15.25	9.24	14.78
	Sulfur	3.78	1.26	0.35	3.85	0.32	3.23
	Ash	68.64	67.54	69.24	42.63	61.42	30.57
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate Analysis	Carbon	48.01	53.22	49.84	62.13	55.02	56.74
	Hydrogen	0.69	0.65	6.21	0.77	7.45	1.53
	Oxygen	47.58	44.51	40.70	34.70	37.25	40.39
	Nitrogen	3.72	1.62	3.25	2.40	0.28	1.34
	Total	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 2. CHEMICAL ANALYSES OF CARBONACEOUS ACCUMULATIONS (CONTINUED)

	Environment	Swamp		Brackish marsh	Brackish marsh		Shoreline
	Lat. N	29°47.6′		29°20.4′	29°38.9′		29°46.5′
	Long. W	91°17.7′		90°40.1′	92°28.2′		93°17.5′
	Sample type	Clayey peat	Woody peat	Peat	Peat*	Peat*	Detrital peat debris*
	Elevation	−9.2′ to −9.7′	−23.1′ to −23.3′	+1.6′ to −1.9′	−2.0′ to −2.2′	−12.0′ to −12.3′	Sea level to −0.5′
Proximate Analysis As Received	Moisture	73.73	70.30	85.25	73.0*	82.1*	73.5*
	Volatiles	7.05	13.97	6.60	6.3	7.7	9.0
	Fixed carbon	2.08	5.30	1.93	2.9	4.2	3.5
	Sulfur	0.21	0.31	0.54	0.7	0.7	0.8
	Ash	16.93	10.12	5.68	17.1	5.3	13.2
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Moisture Free	Volatiles	26.84	47.04	44.75	23.4	42.9	34.0
	Fixed carbon	7.97	17.83	13.07	10.7	23.6	13.2
	Sulfur	0.78	1.06	3.67	2.5	3.7	3.0
	Ash	64.41	34.07	38.51	63.4	29.8	49.8
	Total	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate Analysis	Carbon	17.70	37.78	39.98	..	..	..
	Hydrogen	2.45	4.09	4.16	..	..	..
	Oxygen	79.79	58.05	55.84	..	..	..
	Nitrogen	0.06	0.08	0.02	..	..	..
	Total	100.00	100.00	100.00	..	..	..

*Collected by James M. Schopf, U.S.G.S. Coal Geology Lab., Ohio State Univ., and analyzed by F. E. Walker, U.S. Dept. of Interior, Bureau of Mines.

chemically analyzed (Table 2). The analyses show a range of high percentage values for ash in each type of peat and no relation between grade and environment of accumulation is evident. There is a suggestion that the amount of fixed carbon increases with age. The five samples with less than 45 percent ash (moisture free basis, Table 2) range in age from approximately 200 to 5,000 years old. The nearsurface peats which are less than 500 years old contain the smallest amounts of fixed carbon (0.58 to 13.07 percent). The brackish-marsh peat from –12 feet and the swamp peat from –23 feet, both approximately 5000 years old, are the oldest peats analyzed, and they contain the largest amounts of fixed carbon (23.6 and 17.83 percent respectively). The smaller amount of fixed carbon in the swamp peat may be attributed to the relatively slow rate of decomposition of the incorporated wood indicating a possible correlation between the rank of older peats and their environment of accumulation.

COALS ASSOCIATED WITH DELTA SEQUENCES

There is little doubt that some ancient coals developed from peats which accumulated in delta-plain environments. As more studies of ancient coal measures appear in the literature, the role of deltas becomes more apparent. Many comparisons can be made between repetitive sedimentary cycles of coal measures and repetitive sequences of Recent deltaic deposits beneath the coastal plain of Louisiana. In the viewpoint of the writers, the best example is perhaps the Yoredale Series (Fig. 5) in northern England (Moore, 1959). These Carboniferous repetitive sequences, which include progradational, aggradational, and transgressive units, have their counterparts in the Recent delta sequences and can be compared directly as illustrated in the sections on Plate 5. Differences exist only in the more calcareous nature of the transgressive units in the Yoredale Series, as compared to those present in the Mississippi delta complex.

CONCLUSIONS

Significant peat deposits are derived from vegetation of fresh- to brackish-water marshes and levee-flank swamps located in coastal interdistributary basins and from vegetation of cypress-gum swamps in broad inland flood basins of the Mississippi deltaic plain. The cypress-gum swamp peats are thickest because the environment of their accumulation remains more stable. Except for a few local occurrences of detrital peat debris, all peat accumulations encountered in this study are autochthonous. Peat derived from the floating-marsh environment, however, could appear as an allochthonous variety, since it may overlie a rootless underclay.

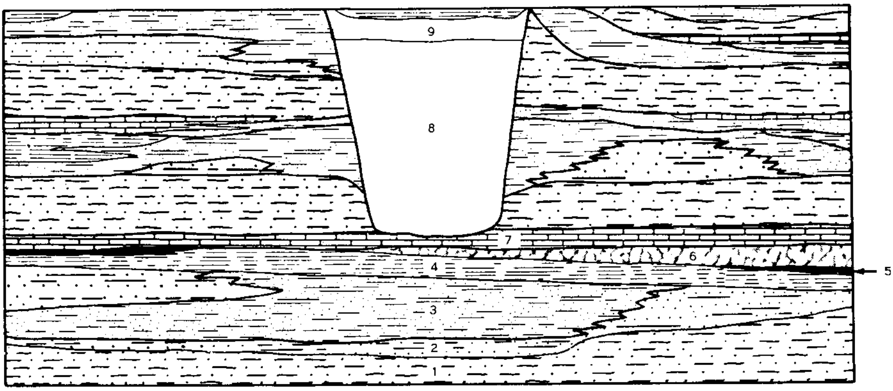


Figure 5. Repetitive delta sequences in the Carboniferous Yoredale Series, northern England (after Moore, 1958, 1959): (1) prodelta facies; (2, 3) delta-front facies; (4) flood-plain facies with root casts; (5) coal; (6) organic-rich flood-plain facies; (7) transgressive facies; (8, 9) lower and upper channel-fill facies. Width of section, 4 miles; thickness, 80 feet.

Interdistributary peats occur in delta-plain facies of the delta sequences. Each sequence consists of basal prodelta facies, overlain by delta-front and delta-plain facies, which themselves are unconformably overlain in the seaward portions by transgressive deposits. Complete repetitive sequences are found beneath the coastal region of the deltaic plain. These sequences provide a clue to some of the depositional environments and facies relationships within coal sequences of the geologic past.

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