Holocene Geologic Framework of Lake Pontchartrain Basin and Lakes of Southeastern Louisiana

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The Lake Pontchartrain Basin is a 12,170-km2 (4,700-mi2) watershed in southeastern Louisiana, stretching from the State of Mississippi on the north and east to the Mississippi River on the west and south, and to Breton Sound at the Gulf of Mexico. The Pontchartrain Basin is about 200 km along strike and 75 km along dip with modern lakes (Maurepas, Pontchartrain, and Borgne) covering the southern portion of the basin. Lake Pontchartrain and its adjacent lakes form one of the largest estuaries in the United States. Nearly 1.5 million people (one-third of the entire population of Louisiana) live in the 14 parishes within the Lake Pontchartrain Basin.

The basin is bounded by incised Pleistocene terraces to north, the Mississippi River delta plain to the south/southwest, and the Pine Island barrier shoreline to the south/southeast. Over the last 150 years, urban growth of New Orleans and the north shore communities and associated exploitation of natural resources have severely altered the environmental quality of the basin. In 1994, the USGS began a multidisciplinary evaluation of the geology, geomorphology, coastal processes, and environmental quality of the Pontchartrain Basin for use by Federal, state and local officials in coastal management and restoration planning.

Existing geological information has been integrated with newly acquired high-resolution seismic profiles (>700 line km), 76 vibracores, and more than 1000 samples for geochemical data to develop a geologic history and record of sediment distribution of the basin (Fig. 1).

The Pontchartrain Basin has a complex depositional history controlled by sea-level change. Lake Pontchartrain originated as a result of sedimentary processes. During the late Wisconsin lowstand, the region was entrenched by rivers. A buried incised channel of the ancestral Mississippi River, identified from seismic profiles (see Fig. 2 A-A’), underlies the southern margin of Lake Pontchartrain. The incision is three to four km across, was cut to a depth of 40 m, and can be traced from west to east into Lake Pontchartrain (Fig. 3). Sea-level rise during deglaciation truncated the filled paleochannel and the surrounding region of the Pontchartrain Basin. The ravinement surface is a sharp contact with siderite nodules and has been identified from vibracores as the Pleistocene-Holocene contact. The late Pleistocene unit is typically described as a stiff, olive-gray to light grayish-yellow clay that is highly bioturbated. The burrows are fill with oxidized organics or sand and silt. The structure contour map (Fig. 3) of the Pleistocene surface shows the contact is shallow (near the sediment surface, 2 m below sea level) in northeast Lake Pontchartrain and deeper (20 m below sea level) to the southwest. Cross section B-B’ (Fig. 3) illustrates how the Pleistocene contact crops out along the northeast shore and dips to the southwest.

Sea-level rise flooded the “Pontchartrain Embayment” and

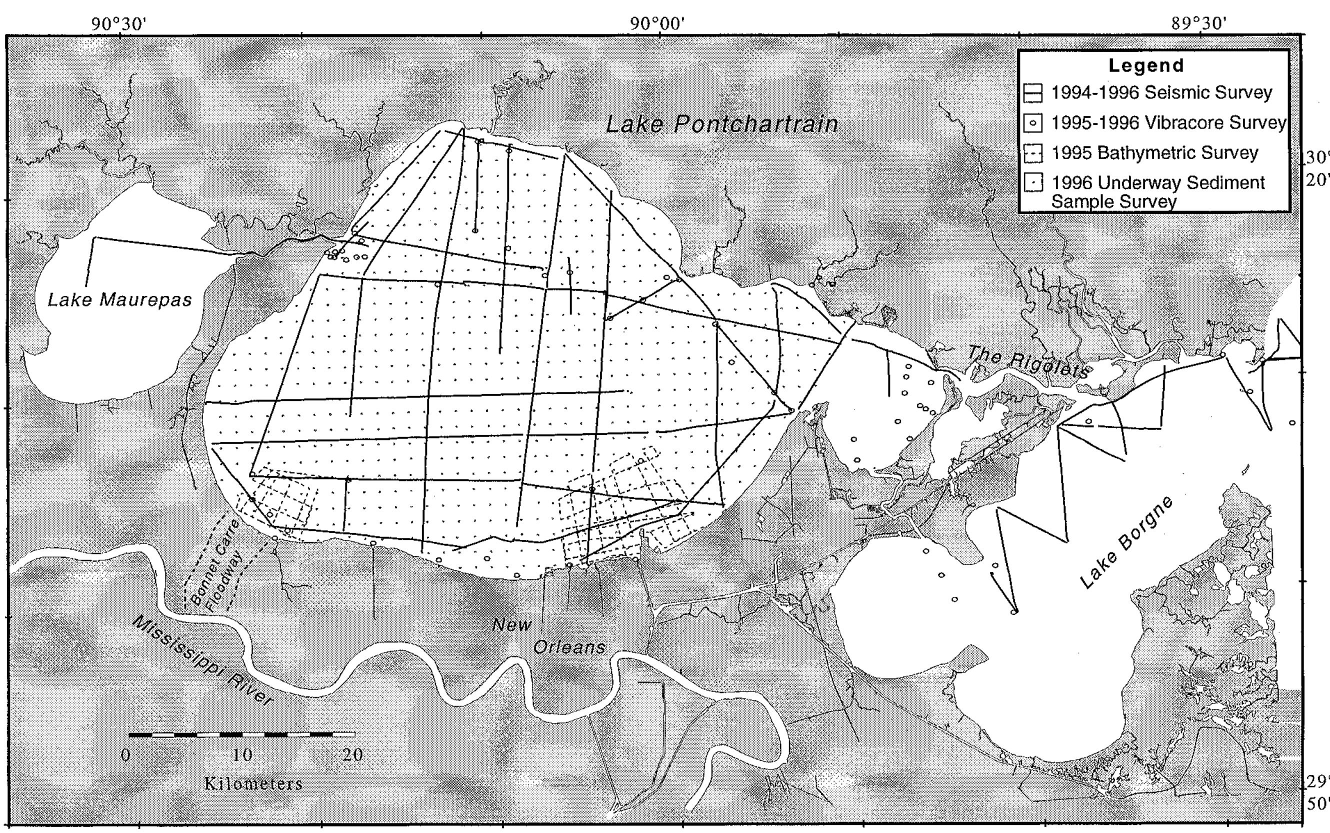

Figure 1. Location of Lake Pontchartrain study area showing location of seismic lines and sampling stations.

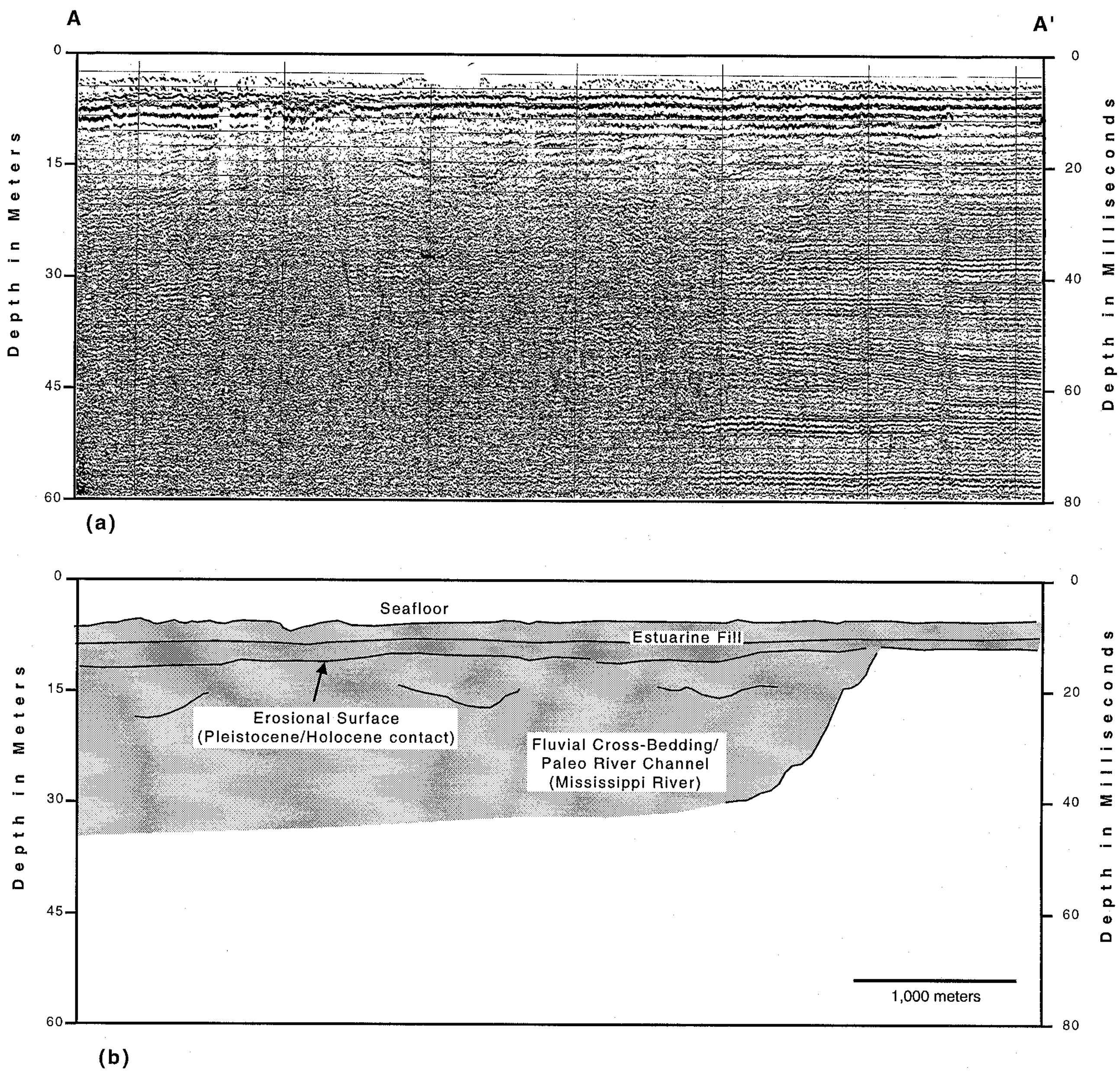

Figure 2a-b. 2a. High-resolution single-channel seismic profile. 2b. Line drawing interpretation showing the buried incised valley of the Pleistocene Mississippi River overlain by estuarine fill. Seismic profile A-A' is located on Figure 3.

deposited transgressive nearshore or lagoonal/estuarine sediments across the area over the ravinement surface. A stillstand at ~4,000 BP initiated formation of a barrier shoreline. Sediments eroding from Pleistocene terraces and Pearl River delta shores to the east of the Pontchartrain Embayment, combined with sandy material moving westward along the Alabama-Mississippi shore, built the large recurved spit and barrier (Pine Island Barrier Trend) that bounds the southeast part of the basin. Back-barrier deposits and shell reefs partially filled the open estuary. The next depositional event (at ~3,000 BP) was the eastward progradation of the St. Bernard delta complex and other subdeltas from the Mississippi River valley. Deltaic sediments enclosed the Pontchartrain Basin to the south and eventually covered the Pine Island Barrier, forming Lake Pontchartrain. At that time, the basin began to accumulate prodelta, delta front, and crevasse deposits. Cypress swamp and fresh water marshes formed in the upper basin and intermediate to saline marshes formed in the lower basin. From ~3,000 BP to the present, active growth faults have also influenced basin geometry and geomorphology, particularly along the north shore.

Due in part to structure of the Pleistocene surface and in part to deltaic deposition from the Mississippi River, Holocene sedimentation has occurred in at least five episodes. Holocene sediments in Lake Pontchartrain were differentially deposited to the north (~0.3 m thick) and south (~5.0 m thick). Of the five episodes, two were not extensive and could not be mapped, but three units above the Pleistocene-Holocene contact have been delineated (Fig. 4). As the basin flooded, the first sediment unit began to accumulate in topographic lows in the west-central part of the lake near the Mississippi River (Fig. 3). The oldest Holocene unit (B2, thickness of 2.0+ m) is described as soft gray clay sporadically interbedded with fine sand, horizontal laminations, isolated lenticular bedding, sand-filled burrows, and rafted organics. Unit B2 is completely burrowed. Unit B1 overlies unit B2 and is composed of a soft, silty, fine sand interbedded with clay and/or clay clastics, shell fragments, and small rafted organics "coffee grounds". Unit B1 averages 1.0 m thick. The uppermost unit in the section, A1 (>1.0 m thick), is a burrowed, Disc Contents Contents Search

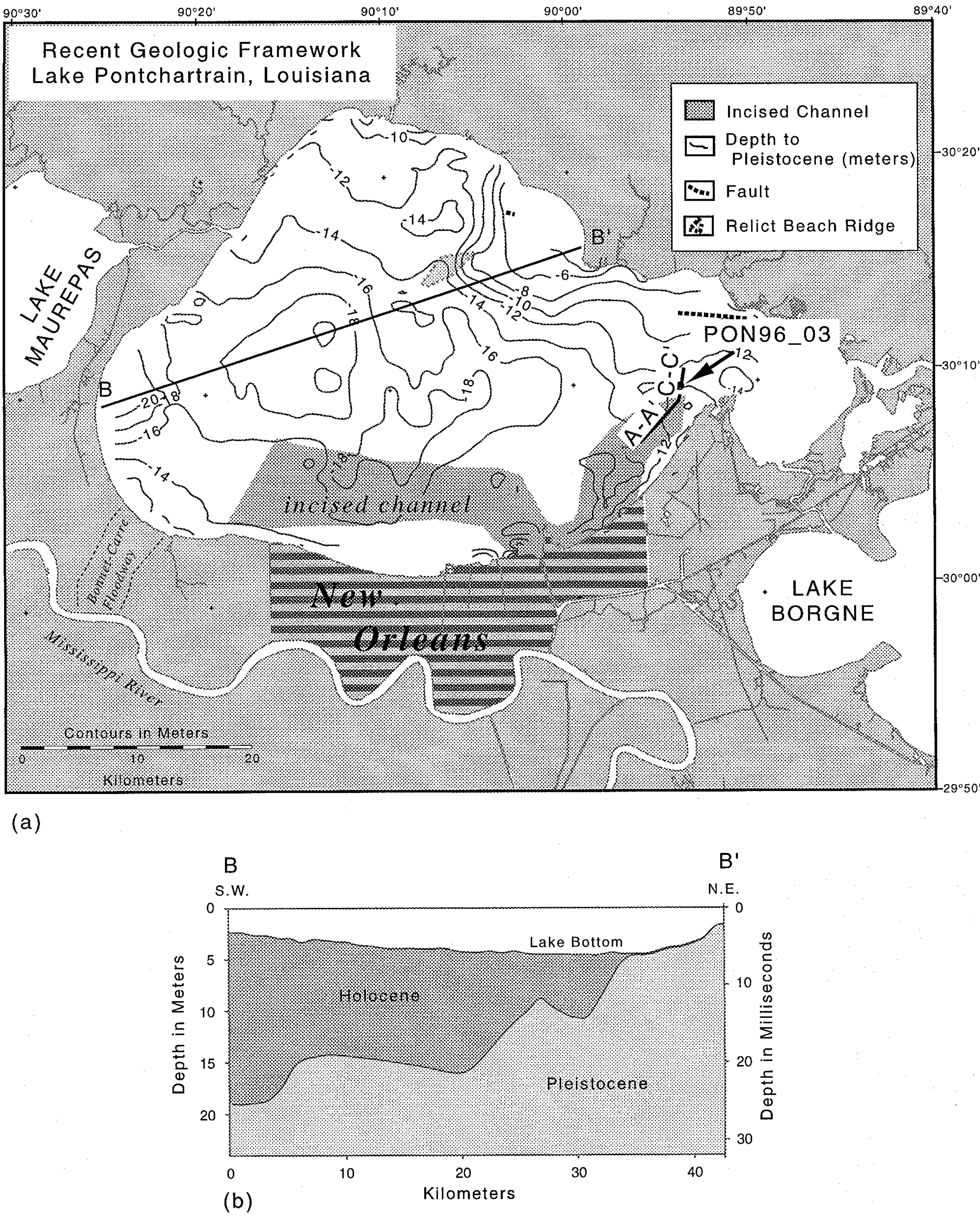

Figure 3a-b. 3a. Structure contour map indicating depth to Pleistocene surface (C1) from sea level. Locations of buried incised channel of the Mississippi River and location of cross sections A-A', B-B', C-C', and vibracore PON96_03. 3b. Schematic interpretation of profile B-B' shows general cross section of Lake Pontchartrain with Holocene/Pleistocene contact.

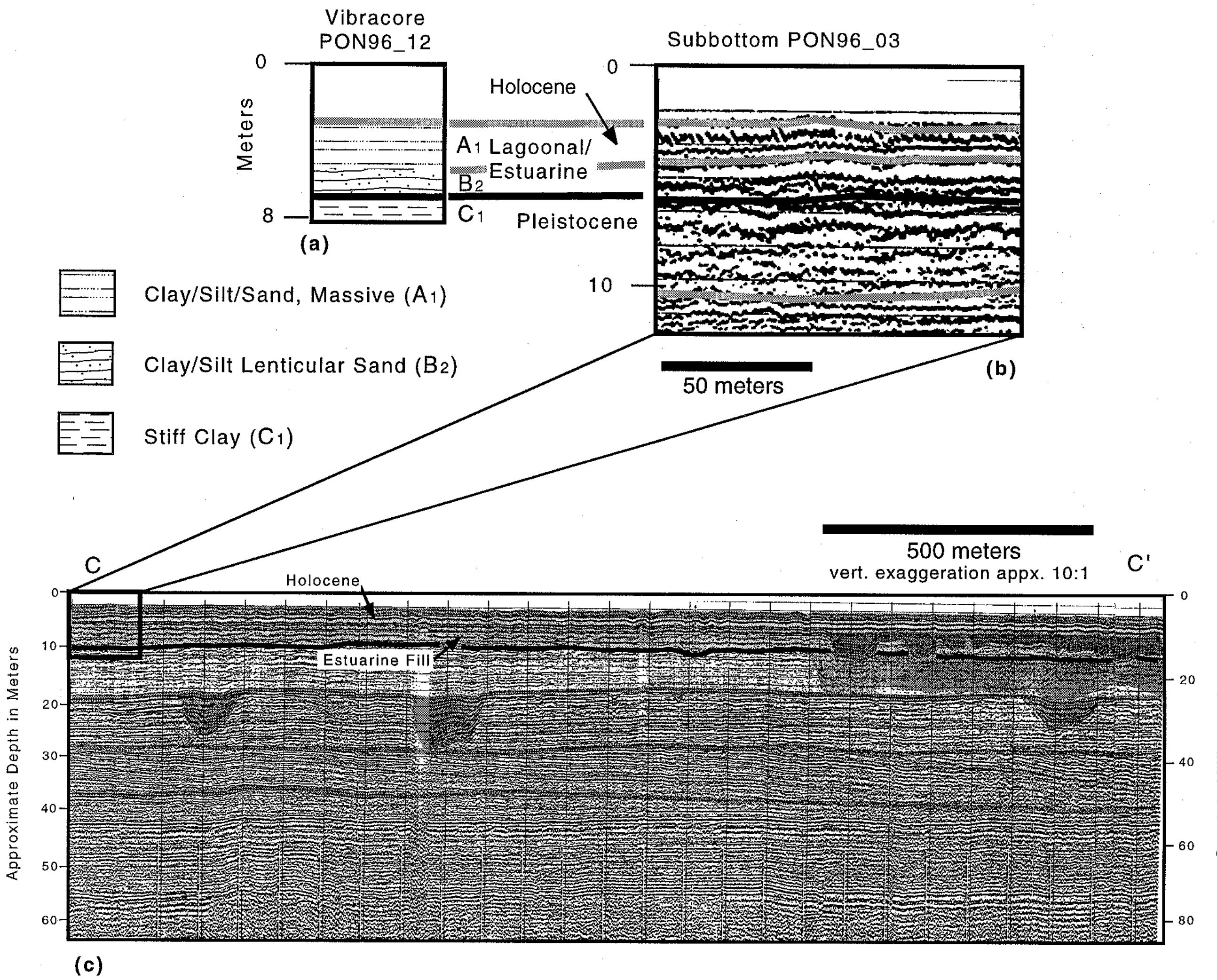

Figure 4a-c. **4a.** Vibracore shows units A1, B2 and C1. 4b. High-resolution single-channel seismic profile C-C' and a lithologic description of vibracore PON96_03 shown to scale. 4c. Profile C-C' shows estuarine fill. Location of vibracore and seismic profile are shown in Figure 3.

soft dark gray to grayish-brown clay with massive bedding containing small shells and shell fragments. Each of these units has sharp basal contact. Units A1 and B1 have the largest aerial distribution.

Although the depositional history is complex, sea-level change has controlled the development of estuaries in the northern Gulf of Mexico. Many similarities exist among the Gulf estuaries. The same processes that formed and flooded the incised valleys of Mobile Bay to the east and Sabine Lake to the west formed Lake Pontchartrain. Each of these estuaries was an open bay that was closed or partially closed by westward movement of shoreline sands that formed spits or cheniers. Mobile Bay was partially closed by sands forming Morgan Peninsula. Sabine Lake was fully closed by the sands and muds forming the Chenier Plain of western Louisiana. Lake Pontchartrain was partially closed by sands forming the Pine Island Barrier Trend. The embayment was then fully cut off by Mississippi River subdeltaic deposition. Evolution of each of these bays is linked by the processes that have formed them.