Geologic Framework, Processes and Rates of Subsidence in the Mississippi River Delta Plain

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Since the 1930's, Louisiana has lost an estimated 3,950 km^2 of coastal wetlands and barrier islands. The loss of these coastal lands resulted primarily from subsidence and erosion rather than the draining and filling of wetlands. More than 40% of the coastal wetlands in the U.S. are found in Louisiana and 80% of our nation's total wetland loss occurs here at alarming rates. Beach erosion rates exceed 10 m/yr and the rate of wetland loss is currently measured at 75 km^2/yr. The causes of Louisiana's coastal land loss include delta switching, storm impacts, man's impacts on this deltaic system, and high rates of subsidence. Recent studies indicate that the highest subsidence and coastal land loss rates occur where the underlying Holocene sediments are the thickest. This relationship suggests that subsidence through the consolidation and settlement of these young deposits is of primary importance to the coastal land loss problem found in Louisiana. To understand the role of subsidence in Louisiana's coastal land loss problem requires a knowledge of the Late Quaternary history of the lower Mississippi River, of the infilling of its incised valley during the Holocene transgression, and of the processes of delta switching.

The Eastern Chenier Plain: An Update on Downdrift Coastal Progradation Associated with the Building of A New Holocene Delta Lobe in the Mississippi Delta Complex

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Howe et al. (1935) and Russell and Howe (1935) interpreted the origin of the Chenier Plain of southwestern Louisiana as resulting from alternations between deposition and wave erosion caused by shifting Mississippi River discharge (delta switching). It was not until H. N. Fisk and R.J. LeBlanc cored the Chenier Plain that sediment body geometries became known (R.J. LeBlanc, personal communication). From this work, the first maps of Chenier Plain sedimentary thickness were constructed (Fisk, 1955). Later, more complete work by Gould and McFarlan (1959) defined the sedimentary architecture and temporal history of the Chenier Plain. Their work verified earlier interpretations by Howe et al. (1935) and Russell and Howe (1935) that suggested Chenier Plain development was intricately linked to the availability of suspended sediment from a nearby Mississippi River source. Their work identified the chenier ridges as transgressive sediment bodies, whereas muds between ridges represented regressive deposits. Recently, Penland and Suter (1989) suggested a new chronology for Chenier Plain construction incorporating new data indicating sea level was 5-6 m lower as recently as 3,000 yrs BP. They suggest that the most landward cheniers developed after the rapid rise to the near-present sea level. However, the formative processes interpreted by earlier workers have remained unchallenged.

Prior to the middle of the century, the Chenier Plain coast had been in retreat for hundreds of years. However, the Atchafalaya diversion changed this picture, and the eastern Chenier Plain coast began receiving fine-grained sediments of sufficient quantities in the late 1940's so that mudflats episodically and temporarily appeared in front of previously retreating beaches (Fisk, 1952). Recent research by Kemp (1986), Roberts et al. (1989), and Huh et al. (1991) has monitored this new era of Chenier Plain growth as a downdrift product of westward sediment transport associated with rapid delta lobe development in Atchafalaya Bay. Figure 1 illustrates the dramatic changes that were just beginning to take place in the late 1940s-early 1950s. This change from erosion and coastal retreat to deposition along the eastern Chenier Plain shoreline was the result of filling of the Atchafalaya Basin to near capacity with lacustrine deltas and swamp deposits. Filling of the basin allowed sediment to be passed through to Atchafalaya Bay and downdrift coasts.

By the early 1950s, the basin-filling process was nearly complete so that significant suspended sediments reached the coast to start a new delta-building event in Atchafalaya Bay and initiate progradation of the eastern Chenier Plain where coastal erosion (3-7m/yr) had been active for many centuries. Fine-grained sediments flushed through Atchafalaya Bay as a mudstream, flowing mostly westward, bringing volumes of fine sediment to the inshore zone. Onshore transport of fluid mud deposited on the inner shelf has resulted in mudflats that have prograded the eastern 20 km of this coast. Progradation rates during the late 1980s and early 1990s averaged 50m/yr in the most actively accreting coastal sectors. Recent research (Kemp, 1986; Roberts et al., 1989; and Huh et al., 1991) has confirmed that both winter cold front passages (20-30/year) and occasional tropical storms result in water level set-up along the coast and shore-normal transport of fluid mud from the nearshore shelf onto the shoreface where it is stranded. In the winter cold front case, water level set-down plus dry air and cloud-free post-frontal conditions promote rapid water loss in stranded muds resulting in dessication. Sheets of fluid mud composed of clay-sized particles are mudcracked into resistant polygonal clasts (centimeters in diameter) which armor the coast against erosion. Cores through new accretion units along the coast reflect a vertical accretion related to repeated deposition of 2-10 cm thick units of fluid mud over a thin layer of silt to sand. Each one of these sedimentary couplets is interpreted as a depositional response to a cold front passage or tropical storm. Time-series remote sensing data suggest that mudflat progradation is shifting westward with time.

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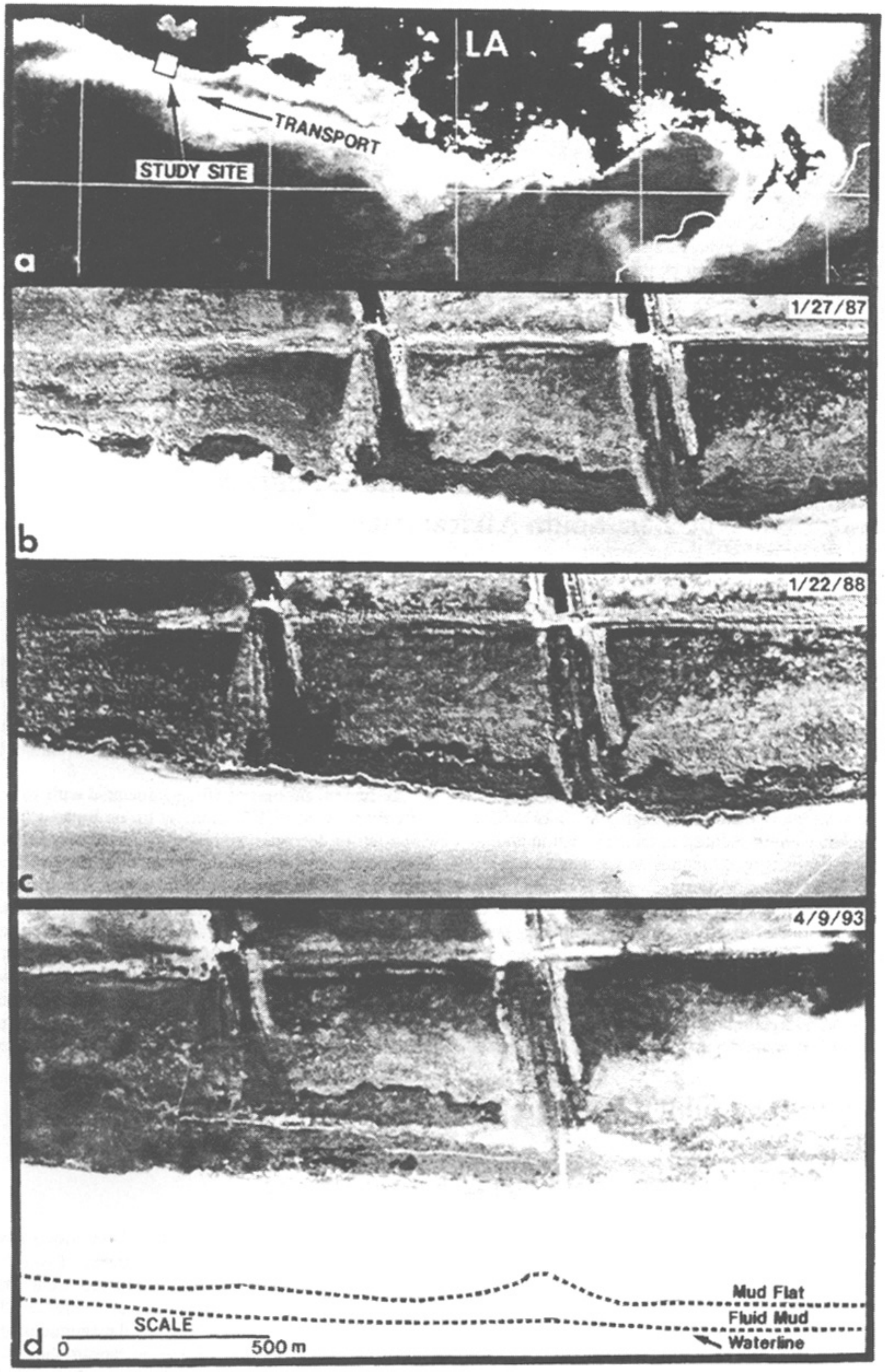

See next page for figure caption.

Figure 1. copy continued from page 11. A time-series of photographs of the eastern Chenier Plain coast illustrating rapid coastal progradation between 1987 to 1993. In this sector of the coast the average progradation rate has been about 50 m/yr during this time period. The "flood" of fine-grained sediments supplied by the Atchafalaya River coastal mudstream initiates and feeds these dramatic coastal changes.

(a) NOAA-12 satellite AVHRR image of coastal turbidity. Turbid waters from the Atchafalaya are advected westward to the prograding Chenier Plain coast.

(b) Aerial photograph from January 27, 1987 illustrates a sector of the coastline at the initial stages of rapid progradation.

(c) Aerial photograph from January 22, 1988 illustrates that a mud arc is starting to form along the coast.

(d) Aerial photograph from April 1993 reveals a 0.5 km zone of new land which is being rapidly colonized by coastal plants on the landward side and is fronted by semi-consolidated mudflats on the seaward side.

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Deep Water Deposits of the Tanqua and Laingsburg Subbasins, Southwest Karoo Basin, South Africa: Analog for the Gulf of Mexico

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The Tanqua and Laingsburg subbasins in South Africa had near-contemporaneous formation and filling and contain Permian-age basin-floor and slope fans that display characteristics similar to deposits in the northern Gulf of Mexico. Outcrop area for each subbasin is about 650 km^2 and individual fans range from 150 to 450 km^2 with lateral continuity of individual fans up to 34 km. With a sandstone/shale ratio of 75 - 90%, the arenaceous fans vary in thickness from 20 to 60 m with interlying shales ranging from 20 to 75m in thickness. Both subbasins were influenced in their formation and in the architecture of their deposits by structures and events associated with the Cape Fold Belt.

Having undergone little tectonic tilting, the highly continuous outcrops in the Tanqua subbasin expose two fans continuing from mid-fan channel complexes with associated levee-overbank deposits to sheet-like outer fan lobes, while three other fans expose outer fan depositional lobes. Paleocurrent directions for four of the fans are from SSW to S and a direction of W to WNW for the fifth. These fans most likely had a single point source which migrated over the time of basin fill. Unrestricted deposition suggests an open basin depositional setting. The Laingsburg subbasin was strongly influenced by the tectonism associated with the Cape Fold Belt. Deposition occurred in a deeper and narrower basin and the deposits, except for the overlying deltaics cannot be correlated with those of the Tanqua subbasin.

The two subbasins, while associated with an active margin, were likely filled at slightly different times. Both had a distant source area which led to deposits exhibiting characteristics of a passive margin depositional environment. Understanding the evolution of the subbasins and the tectonic conditions under which the submarine fans were deposited leads to the determination of the mechanisms that influenced the formation of the fans and their resulting architecture. These fans permit detailed studies on their architecture necessary to 1) increase our understanding of fine-grained, "low" sandstone/shale ratio fans, 2) determine influences of paleostructures and tectonics on basin fill, 3) carry out detailed reservoir simulation programs, and 4) make predictive models of deep-water sands in the northern Gulf of Mexico.

Sudden Change: Climate and Sea Level

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Dates, magnitudes and rates of Holocene sea-level changes were reviewed at the 1995 meeting of the American Association for the Advancement of Science.

Richard B. Alley (Penn. State U.) described laminae in Greenland ice cores, with details at the annual level. A major event of unknown nature occurred at roughly 8,000 B.P. Gerard Bond (Lamont-Doherty Observ., N.Y.) described sediment cores from the North Atlantic, with a major event at 8,000 B.P. Published work of K. S. Petersen (Danish Geol. Survey) from a well near Vust (Denmark) was reviewed: A rapid sea level rise (25 m), then a similar drop centered at 8,000 B.P. at 8-15 cm/yr

W. F. Tanner (Florida State U.) described the beach ridge plain in northern Denmark, where a sequence of more than 270 Holocene ridges shows the date of the big Mid-Holocene sea level change couplet, 8,000 B.P., with a magnitude of "more than 14 m," plus smaller changes. These data showed vertical magnitudes of the larger sea level events (except the Mid-Holocene catastrophe) in the range of 1-to-5 meters. W. C. Parker (Florida State) sought possible cycles in the same sequence, but they were too poorly defined for detailed forecasts.

Charles R. Bentley (U. of Wisconsin) examined the possibility of an early collapse of the West Antarctic marine ice sheet, with a sea level rise of about 5 meters, but concluded that it is unlikely.