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Subaqueous deltaic formation on the Atchafalaya Shelf, Louisiana

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Abstract

The Atchafalaya River in Louisiana shares the third largest drainage basin in the world with the Mississippi River. Sediment cores and seismic profiles were used to examine the development and impact on land accretion of an early-stage subaqueous delta accumulating on the shallow (<25 m water depth) continental shelf seaward of the Atchafalaya River mouths in the period (~100 years) since the Atchafalaya has captured a significant fraction of the overall Mississippi discharge. The subaqueous clinoform is muddy (70–100% finer than 63 μm) and extends approximately 21–26 km seaward of the shell reef (to 8 m water depth) across the mouth of the Atchafalaya Bay, with a discontinuous, and, in places, mobile modern mud layer <20 cm thick covering a relict deltaic shoal area further seaward. The sigmoidal clinoform has a topset surface that steepens from east to west (1:2500 to 1:1600), a foreset with maximum slopes of about 1:550, and a limited bottomset region (<0.5 km wide). ^{210}Pb and ^{137}Cs geochronology show maximum sediment accumulation rates (>3 cm/year) correspond to the foreset and bottomset region, with rates decreasing to as low as 0.9 cm/year on the shelf topset region and its extension inside Atchafalaya Bay. Seven sedimentary facies are observed in the subaqueous delta, with differences created by degree of biological destruction of physical stratification, which is inversely related to sediment accumulation rate, and by the proximity of an area to the riverine sand source. There is a marked alongshore sediment dispersal pattern observed by the progressive winnowing of sand and coarse silt to the west. There is also a significant increase in shell content in Atchafalaya Bay relative to shelf facies. The resulting sigmoidal clinoform deposit (<3 m thick) more closely resembles strata geometries of subaqueous mud deltas associated with energetic systems (e.g., Amazon, Ganges–Brahmaputra, Fly), than it does the mature Mississippi delta 180 km to the east, albeit on a smaller scale and in shallow water.

Keywords: Atchafalaya River; delta; Mississippi River; clinoform; Louisiana

1. Introduction

The mature, modern (Plaquemine) lobe of the Mississippi River delta is a well-studied archetype of a sediment-rich system emptying into a low energy receiving basin. The Atchafalaya River is a second, early-stage distributary of the Mississippi River, but is

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significantly different in that it empties into a shallow bay and low gradient inner shelf area that is more energetic than the shelf-edge Plaquemine lobe 180 km to the east (Fig. 1). The Atchafalaya discharges into Atchafalaya Bay in southern Louisiana (Fig. 1) through two outlets (Lower Atchafalaya and Wax Lake). Water discharge of the Atchafalaya has been regulated at 30% of the total Mississippi River discharge since the 1963 construction of a control structure at the point of divergence from the Mississippi 216 km upstream near Simmesport, LA. In the century prior to construction of the control works in 1963, the Atchafalaya River was capturing an increasing amount of water and sediment from the Mississippi each year, as part of the natural process of distributary lobe switching (Roberts, 1998).

By the 1970s, the increased diversion of sediment to the Atchafalaya distributary had led to the growth of sandy subaerial (bayhead) deltas at the two points where the Atchafalaya discharges into the Atchafalaya Bay. Detailed stratigraphic analysis of these emerging ~5 m thick sand features (Shlemon, 1975; Van Heerden and Roberts, 1980, 1988) led to a model for the formation of bifurcating distributary mouth bar sands in the Mississippi delta (summarized in Roberts, 1998), but did not incorporate potential "prodelta" mud deposits on the adjacent inner shelf. The specific objectives of the present study were to determine the geometry, accretion rates, and stratigraphic character of the subaqueous mud deposit forming seaward of Atchafalaya Bay. This information provides an opportunity to develop a comprehensive (subaerial and subaqueous) model of Mississippi delta growth in its early stages when it is confined to the more energetic inner shelf and to utilize that information to improve stratigraphic and numerical models of highstand delta formation in general.

The present study of subaqueous sediment accretion associated with the Atchafalaya River is also timely in

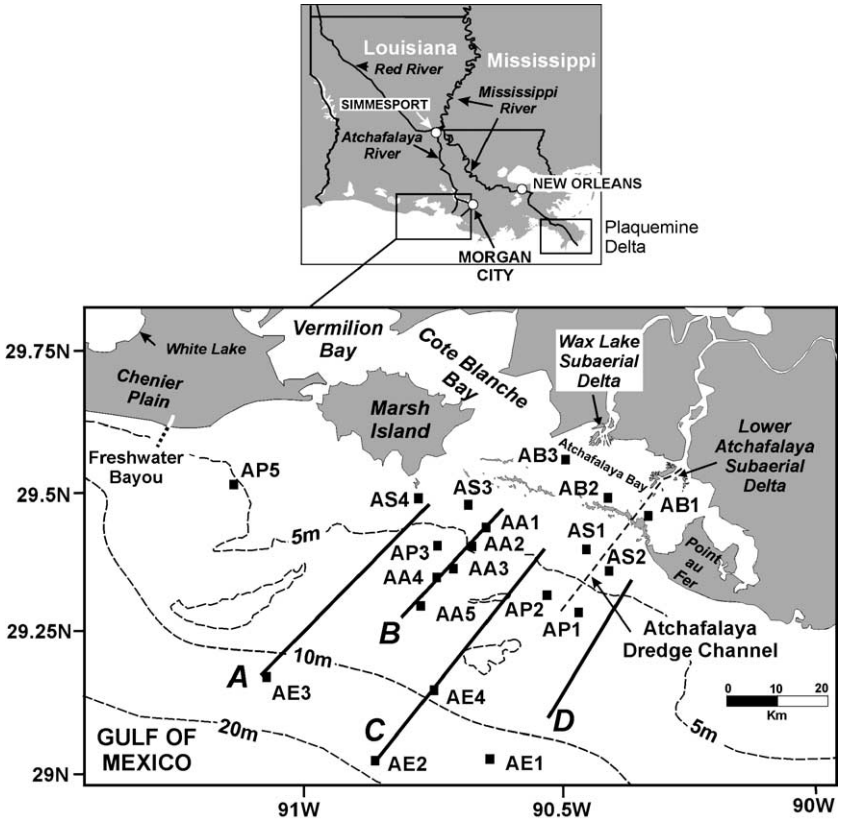

Fig. 1. Map of the study area in southern Louisiana. The location of cores mentioned in the text and the four CHIRP seismic transects shown in Fig. 10 are noted.