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Refining the link between the Holocene development of the Mississippi River Delta and the geologic evolution of Cat Island, MS: implications for delta-associated barrier islands

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ABSTRACT

The geologic evolution of barrier islands is profoundly influenced by the nature of the deposits underlying them. Many researchers have speculated on the origin and evolution of Cat Island in Mississippi, but uncertainty remains about whether or not the island is underlain completely or in part by deposits associated with the past growth of the Mississippi River delta. In part, this is due to a lack of comprehensive geological information offshore of the island that could augment previous stratigraphic interpretations based on terrestrial borings. An extensive survey of Cat Island and its surrounding waters was conducted, including shallow-water geophysics (e.g., high-resolution chirp seismic, side-scan sonar, and swath and single-beam bathymetry) and both terrestrial and marine vibracoring. High-resolution seismic data and vibracores from south and east of the island show two horizontally laminated silt units; marine radiocarbon dates indicate that they are St. Bernard delta complex (SBDC) deposits. Furthermore, seismic data reveal that the SBDC deposits taper off toward the southern shoreline of Cat Island and to the west, morphology consistent with the distal edge of a delta complex. The sedimentology and extent of each unit suggest that the lower unit may have been deposited during an earlier period of continuous river flow while the upper unit may represent reduced or sporadic river flow. OSL dates from the island platform (beneath beach ridge complexes) indicate three stages of terrestrial evolution: island emergence resulting from relative sea-level rise (~5400 ybp) island aggradation via littoral transport (~2500–4000 ybp) and island degradation due to delta-mediated changes in wave direction (present– ~ 3600 ybp). Finally, the combination of terrestrial and marine data shows that portions of Cat Island that are lower in elevation than the central part of the island are younger and are likely underlain by a thin layer of deltaic sediments. This underscores the potential for increased future vulnerability of barrier islands that develop adjacent to major river delta complexes.

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1. Introduction

The connection between barrier island evolution and the characteristics of the geology seaward of and beneath them has been well-documented on the east coast of the United States (Belknap and Kraft, 1985; Demarest and Leatherman, 1985; Riggs et al., 1995; Schwab et al., 2000; Harris et al., 2005), the Gulf Coast of the United States ((Brooks et al., 2003, 1995; Evans et al., 1985; Twichell et al., 2009), the European coast (Pilkey et al., 1989; Morales, 1997; Storms et al., 2008), and elsewhere (Boyd and Penland, 1984; Ruz et al., 1992; Héquette et al., 1995; Martinez et al., 2000). Deltaic barrier islands, or barrier islands associated with river deltas, represent ~30% of the world's barrier islands (Stutz and Pilkey, 2001) and the influence of the character of underlying deposits on deltaic barrier island evolution has been documented in Louisiana (Penland et al., 1985) and in the Beaufort Sea (Ruz et al., 1992). In one of the examples from Louisiana, the barrier evolution model presented suggests that once the St. Bernard delta complex (SBDC) was abandoned, the Chandeleur Islands began to degrade as a result of the combination of reduced sediment supply and subsidence resulting from the compaction of deltaic sediments (Penland et al., 1985). However, that model did not acknowledge that because of the magnitude of the Mississippi River and the size of the depositional basin, the scope of delta influence on barrier island evolution may have extended beyond the limits of the delta lobe itself. This process of regional deltaic influence may have broader application in other deltaic systems where the unique evolutionary process specific to Louisiana barriers may not apply (Stutz and Pilkey, 2002).

Cat Island in Mississippi (Fig. 1) appears to be a good example of barrier island evolution mediated by regional deltaic influence in that previous work has suggested that the growth of the SBDC into the

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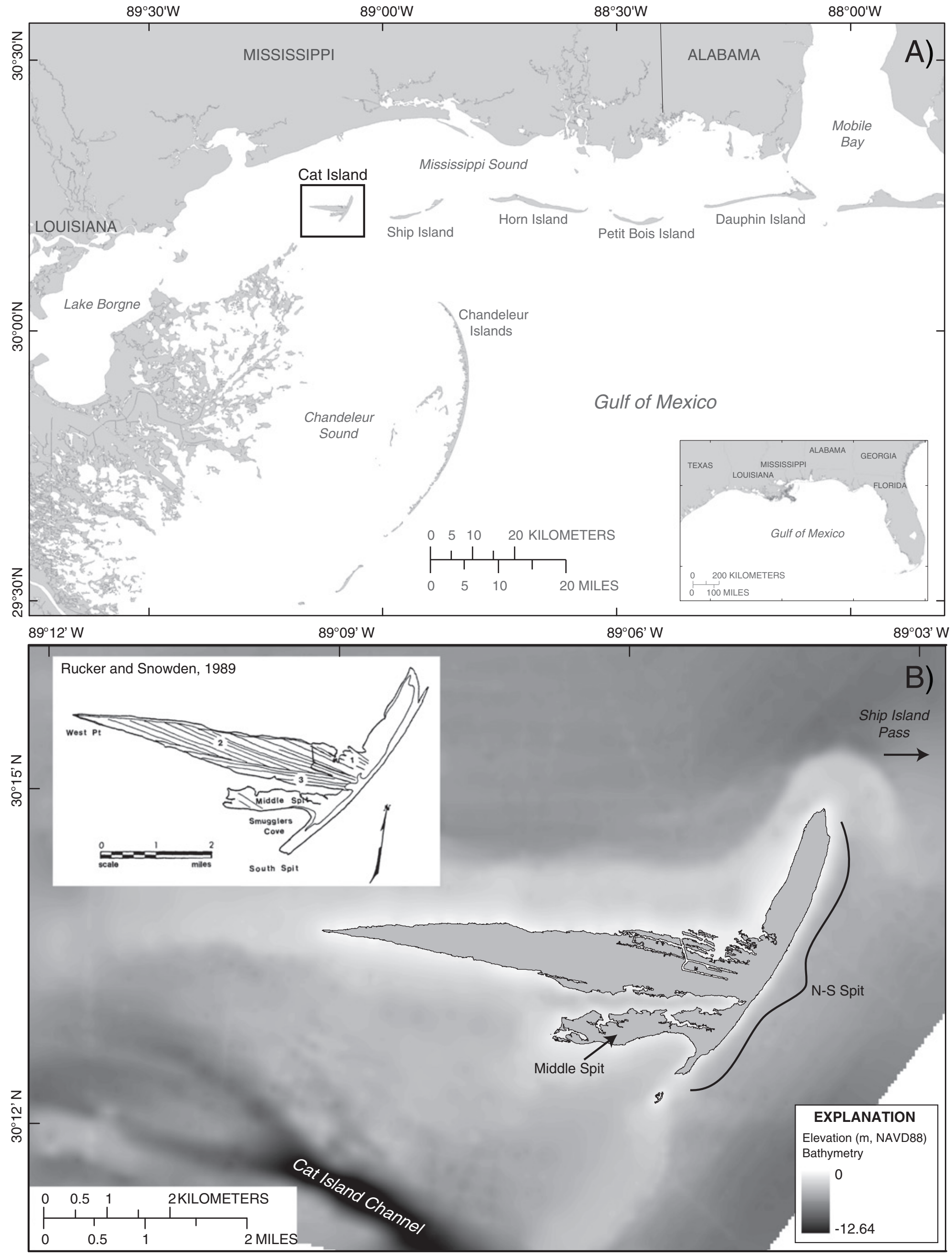

Fig. 1. A) Map of the study area showing the Mississippi–Alabama (MS–AL) barrier islands in the northern Gulf of Mexico, Mississippi Sound to their north, and the Chandeleur Islands and Gulf of Mexico to their south. The black box indicates the extent of the map shown in B. B) A map of Cat Island showing geomorphic features discussed in the text. The inset shows the northern (1), central (2), and southern (3) beach ridge complexes identified by Rucker and Snowden (1989) that comprise the east–west oriented portion of the island.

northern Gulf of Mexico altered a barrier island that was already in existence (Otvos, 1981, 1985; Otvos and Giardino, 2004). Prior to delta progradation in the late Holocene, westward-directed alongshore transport was thought to have supplied sediment for the formation of a barrier-island platform that extended from just south of Mobile Bay and into southeastern Louisiana, separating what is now Mississippi Sound from the Northern Gulf of Mexico (Otvos, 1981; Otvos and Giardino, 2004). After delta progradation, the westward growth of Cat Island was limited (Otvos, 2005) and it became sheltered from the dominant southeast wave direction (Morton, 2008; Otvos and Carter, 2008). This change in the direction and magnitude of wave energy that accompanied SBDC growth and the reduction in sediment supply from decreased alongshore transport is thought to have resulted in reworking of the eastern end of Cat Island into its characteristic north–south trending spits (Rucker and Snowden, 1989; Otvos and Carter, 2008).

However, there is uncertainty in the literature about the extent to which SBDC deposition encroached upon Cat Island and given that future trajectories of barrier island evolution are very different for transgressive barrier island arcs (Penland et al., 1985) than for barrier islands that form via nearshore aggradation (Otvos, 1981, 1985), it is important to understand if Cat Island is wholly or partially underlain by delta deposits. Frazier (1967) suggests that one of the SBDC lobes underlies the southern portion of the island (see Fig. 11 in Frazier (1967)). Otvos and Giardino (2004) suggest that the distal end of the delta lobe was much more variable, but well south of Cat Island and Ship Island (see Figs. 12 and 17 in Otvos and Giardino (2004)). However, these