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Geochronologic evidence for a possible MIS-11 emergent barrier/beach-ridge in southeastern Georgia, USA

H.W. Markewich [a,*], M.J. Pavich [b], A.P. Schultz [b], S.A. Mahan [c], W.B. Aleman-Gonzalez [b], P.R. Bierman [d]

[a] U.S. Geological Survey, 3039 Amwiler Rd., Ste. 130, Atlanta, GA 30360-2824, USA
[b] U.S. Geological Survey, 12201 Sunrise Valley Drive, MS 926A National Center, Reston, VA 20192, USA
[c] U.S. Geological Survey, Box 25046, Denver Federal Center, MS 974, Denver, CO 80225-0046, USA
[d] Department of Geology, Delehanty Hall, University of Vermont, Trinity Campus, 180 Colchester Ave., Burlington, VT 05405-1758, USA

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ABSTRACT

Predominantly clastic, off-lapping, transgressive, near-shore marine sediment packages that are morphologically expressed as subparallel NE-trending barriers, beach ridges, and associated back-barrier areas, characterize the near-surface stratigraphic section between the Savannah and the Ogeechee Rivers in Effingham County, southeastern Georgia. Each barrier/back-barrier (shoreline) complex is lower than and cut into a higher/older complex. Each barrier or shoreline complex overlies Miocene strata. No direct age data are available for these deposits. Previous researchers have disagreed on their age and provenance. Using luminescence and meteoric beryllium-10 (^{10}Be) inventory analyses, we estimated a minimum age for the largest, westernmost, morphologically identifiable, and topographically-highest, barrier/beach-ridge (the Wicomico shoreline barrier) and constrained the age of a suite of younger barrier/beach-ridges that lie adjacent and seaward of the Wicomico shoreline barrier.

At the study site, the near-shore marine/estuarine deposits underlying the Wicomico shoreline barrier are overlain by eolian sand and an intervening zone-of-mixing. Optically stimulated luminescence (OSL) data indicate ages of $\leq$43 ka for the eolian sand and 116 ka for the zone-of-mixing. Meteoric ^{10}Be and pedostratigraphic data indicate minimum residence times of 33.4 ka for the eolian sand, 80.6 ka for the zone-of-mixing, and 247 ka for the paleosol. The combined OSL and ^{10}Be age data indicate that, at this locality, the barrier/beach ridge has a minimum age of about 360 ka. This age for the Wicomico shoreline-barrier deposit is the first for any Pleistocene near-shore marine/estuarine deposit in southeast Georgia that is conclusively older than 80 ka. The 360-ka minimum age is in agreement with other geochronologic data for near-coastline deposits in Georgia and South Carolina. The geomorphic position of this barrier/beach-ridge is similar to deposits in South Carolina considered to be $\sim$450 ka to $>$1 Ma. The age and geomorphic data for Georgia and South Carolina possibly suggest the presence of MIS-11 ($\sim$420–360 ka) shoreline deposits between 15 m and 28 m above present sea level in the Southeastern Atlantic Coastal Plain.

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1. Introduction

The post-Miocene geology of the low-relief lower Atlantic Coastal Plain in southeastern Georgia has been the subject of numerous investigations but no detailed mapping. This part of the Southeastern Atlantic Coastal Plain is in the structural low known as the Southeast Georgia Embayment and is characterized by numerous coastal barrier islands and intervening marshes. Markewich et al. (1992) described the emergent Pliocene and Pleistocene sediments as being predominantly fossil-poor, transgressive, regressive, or prograding barrier and back-barrier sand. They note that: (a) the deposits are thin and generally carbonate poor; (b) each sedimentary sequence of barrier, back barrier, and(or) shelf sediment is cut into older topographically higher sequences; (c) except for a few localities within 12 km of the present coast, stacked sequences are not common; each sequence overlies Miocene strata.

Geologic mapping of post-Miocene strata in southeastern Georgia has been only on a regional 1:500,000 scale (Cooke, 1943; Hoyt and Hails, 1967; Lawton et al., 1976). Lacking time-stratigraphic data, particularly for Quaternary strata, correlation

* Corresponding author. Tel.: +1 770 903 9133; fax: +1 770 903 9199.
E-mail address: helainem@usgs.gov (H.W. Markewich).

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of units was based largely on concordant elevations, regional morphostratigraphic features identified using topographic maps and aerial photography, natural and man-made exposures (river bluffs, road and railroad embankments, and borrow pits), hundreds of shallow auger holes, dredgings, and a few cores.

In this paper we present new age data for: (a) non-fossiliferous, siliciclastic, fluvial/estuarine to near-shore marine/estuarine sand that underlies the western-most and topographically-highest (22–27-m), emergent, morphologically-identifiable, barrier/beach ridge between the Savannah and the Ogeechee Rivers (Fig. 1A, B); and (b) eolian sand that at the study site overlies the barrier/beach-ridge deposit (Fig. 1B, C). These eolian and near-shore marine/estuarine deposits were exposed in the walls of the Springfield-Stillwell borrow pit located on the east side of Ebenezer Creek in Effingham County, GA (Fig. 1A–C). This study was part of a broader effort to map and estimate ages for post-Miocene coastal deposits in the Savannah River area of Chatham and Effingham Counties, Georgia (GA), and western Jasper County, South Carolina (SC) (the Savannah project area). We present a preliminary landscape-evolution model for the Quaternary deposits within the Savannah project area based on all the age data for the project area (Figs. 1D, E and 2A). Fig. 1A–C show the topographic and morphologic expression of the south-east Georgia Coastal Plain in the Savannah project area as expressed in a 1.22-m-raster digital-elevation model generated from 1.0-point m^{-2} LiDAR-elevation data (Coastal Georgia Elevation Project, 2011) and the land-surface morphology at the study site.

2. Regional and local stratigraphic setting and available age data

Areal mapping and regional correlation of Pliocene and Pleistocene marine terraces and(or) lithostratigraphic units in the Southeastern Atlantic Coastal Plain (Figs. 1E and 2A) has been based on either a relatively simple model of correlation by concordant elevations or range in elevations, or a more complicated model of significant uplift due to: (a) epeirogenic movement resulting from continued flexure of broad arches and basins, such as the Cape Fear Arch and Southeast Georgia Embayment (Fig. 2A, B); (b) isostatic uplift resulting from karstification or from retreat of glacial ice; and(or) (c) localized neotectonism. Large differences in data type, density, and quality exist among map areas. Published interpretations based on these differences in approach and data have resulted in confusion between, and a large array of, proposed morphostratigraphic, lithostratigraphic, and geochronologic units. In discussing the stratigraphy of central South Carolina, Colquhoun et al. (1968, p. 1212) described well the complications in Atlantic Coastal Plain terminology,

> "The terminology is complicated because some names have been applied to stratigraphic units and later have been expanded to terraces; other names have been applied to terraces and later have been extended to stratigraphic units."

This mixing of names between stratigraphic units and terraces continues to complicate the terminology for Pliocene and Pleistocene shoreline complexes in the Southeastern Atlantic Coastal Plain. Table 1 is a correlation chart for Quaternary marine terraces, shorelines, sediment terrace complexes, and lithostratigraphic units that have been mapped at a regional or larger scale in the Savannah area of southeastern Georgia and in eastern South Carolina. Emphasis in Sections 2.1–2.3 are on the units and the available age data that are relevant to this study of the 22–27-m-high barrier in Effingham County, GA.

2.1. Regional stratigraphic setting

2.1.1. Extreme southeastern Georgia and northern Florida

Early mapping and correlation of Coastal Plain Quaternary terraces and deposits of northeastern Florida (Cooke, 1939; Healy, 1975) and southeastern Georgia (Veatch and Stephenson, 1911; Cooke, 1925) were based primarily on elevation. Flint (1940), Hoyt (1969), Winker and Howard (1977), and Blackwelder (1981) all recognized that relatively continuous features along the Atlantic Coastal Plain had been deformed by epeirogenic movements that differed both spatially and temporally from region to region (Fig. 2). They all recognized that numerous shoreline features rise in elevation southward from Georgia into Florida. Opdyke et al. (1984) and Adams et al. (2010) indicated that in northern Florida, isostatic uplift is primarily in response to karstification of the area's subsurface carbonate terrain and suggested that the southward increase in elevation of the prominent Trail Ridge barrier/beach-ridge, in extreme southeastern Georgia and northern Florida (Fig. 1D), was probably due to this process. Scott et al. (1986) compiled/mapped the Quaternary geology of the Jacksonville 4° × 6° quadrangle (1:1,000,000) of southeastern Georgia (not including the Savannah area) and northeastern Florida. Based on the work of Pirkle and Czel (1983), Scott et al. (1986) considered the near-shore marine/estuarine deposits underlying Trail Ridge to be early Pleistocene and correlated these deposits with the Wicomico Formation in Georgia. Huddlestun (1988) argued against this correlation based on the 10–20-m elevation difference between the Wicomico and Trail Ridge barriers in Georgia. On their geologic map of Florida, Scott et al. (2001) placed their Qtr (Trail Ridge) map unit in the lower half of the Pleistocene.

2.1.2. Georgia

Veatch and Stephenson (1911) recognized and named two coastal terraces in Georgia, the Satilla Coastal Lowland and the higher and older Okefenokee Plain, largely on the basis of the abrupt change in elevation and topography landward and seaward of Trail Ridge south of the Altamaha River (Fig. 1D). There are similar physiographic differences landward and seaward of a distinct scarp, in the same position as Trail Ridge, between the Altamaha and the Canoochee rivers (Fig. 1D). Cooke (1925) identified five physiographic terraces in what he referred to as the Coastal Terrace topographic region of the Georgia Coastal Plain. Cooke (1925, p. 30) considered these terraces to be, "…the part of the sea bottom uncovered and converted in to land by the withdrawal of the sea from one level to a lower." Cooke (1936) identified seven terraces, their corresponding formations, and their shoreline elevations in South Carolina and later identified these same terraces and corresponding formations in Georgia (Cooke, 1943). Citing the work of MacNeil (1950) and Doering (1960), Hoyt and Hails (1967, 1974) and Hails and Hoyt (1969) felt that the terms *terraces* and *scarps* had been applied incorrectly to coastal subaerial depositional features/deposits. Using morphostratigraphic criteria, Hoyt and Hails (1967) defined a sequence of coastlines in south-eastern Georgia, each with a corresponding formation of the same name that included a lagoon/salt-marsh and barrier-island facies (Table 1). For the *Geologic Map of Georgia*, Lawton et al. (1976) essentially agreed with the terminology of Hoyt and Hails (1967, 1974) and mapped six Pleistocene shoreline complexes with barrier island and lagoonal facies.

Winker and Howard (1977) suggested that there are three well-preserved shoreline sequences in Georgia, South Carolina, and southeastern North Carolina and that all three shorelines were deformed (Fig. 2B). They suggested that deformation was associated with continued flexure of the Cape Fear Arch and the South-east Georgia Embayment (Fig. 2A, B). In the Savannah area of