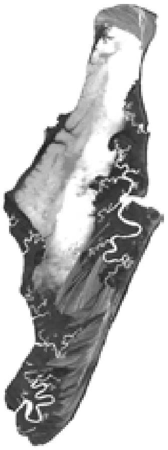

CHAPTER 4

DEVELOPMENT OF A LATE PLEISTOCENE-HOLOCENE GENETIC STRATIGRAPHIC FRAMEWORK FOR ST. CATHERINES ISLAND: ARCHAEOLOGICAL IMPLICATIONS

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Stratigraphers are becoming increasingly aware that relatively minor physical and biological events have played major, although often cryptic, roles in the accumulation of strata. Stratigraphic analyses have too often avoided the stratum-by-stratum (i.e., stratinomic) examination of sequences in favor of "broad brush" recognition of lithostratigraphic units (formations, members, alluvial facies, colluvial facies, etc.) (Busch and Brezinski, 1989).

GENETIC STRATIGRAPHY: INTRODUCTION

Although most stratigraphers would support a stratinomic approach, in practice they either group stratigraphic intervals of a single rock type (e.g., sandstones) into facies units, or group multiple types of strata (i.e., polytypic facies units) into presumed, but not always documented, single events (Busch and Brezinski, 1989). For example, researchers may regard a sequence of barrier island depositional units as marine island facies (monotypic facies units), ignoring the presence of polytypic facies (dune, beach, tidal mud flats, tidal channel, paleosols, etc.). Such overgeneralization ignores much event formation (e.g., basic genetic units such as storm events or soil horizons) and is particularly apparent in alluvial sequences, and now barrier island sequences, where the preserved stratigraphic record may account for only 5% of the included time interval (Bown and Kraus, 1987).

Allogenic and Autogenic Genetic Units

Genetic units can be categorized relative to their lateral extents. Walker (1990); Busch and Rollins (1984); Goodwin et al. (1986); Busch and West (1987); and Busch and Brezinski (1989) recognized allogenic genetic units and autogenic genetic units. Allogenic genetic units can be correlated widely, presumably reflecting the depositional signature of an event that affected a wide geographic area (allogenic event). Paleosols, specifically buried A horizons, which document episodes of barrier island stability, can be considered allogenic units. Autogenic genetic units, on the other hand, are locally developed, the result of a circumscribed event that is constrained geographically and/or environmentally (autogenic event). A sand horizon deposited as a result of a large storm event over several days is a classic autogenic unit, which is time parallel. Although these events are temporally constrained, their geographical reach or recognition within a soil profile is quite limited. Genetic units, when identified (e.g., in exposures, cores, etc.), are of unknown lateral extent prior to correlation. The scale of allogenicity and autogenicity is relative and is dependent upon the scale of observation and lateral extent. Allogenic events, for example, may be global or confined to a single depositional basin, coastal segment, or drainage system. Autogenic events may be correspondingly scaled from local tectonism down to delta switching, washover fan, storm scour, or channel avulsion. In order to determine the geographical extent of a genetic unit one must assume initially that it is extensively correlatable.

Genetic surfaces are, in addition, commonly associated with: (1) heterochronous deposition (exhumation and redeposition to form condensed, time-averaged intervals); (2) erosion or ravinement; or (3) little or no deposition (firmgrounds, hardgrounds, palimpsest surfaces, and paleosols). Genetic surfaces may change laterally: hardground may be represented laterally by an erosional disconformity; a distal paleosol with a well-developed A horizon may change laterally to a proximal immature paleosol with only a B horizon or C horizon preserved, or to an erosional disconformity.

Goal of Genetic Stratigraphy

The primary goal of genetic stratigraphy, whether applied to marine or terrestrial strata, is the development of a high-resolution pedostratigraphic or chronostratigraphic framework, which will facilitate predictive stratigraphy. The recognition of allogenic genetic surfaces that "punctuate" small-scale allogenic genetic units permits refined chronostratigraphy at archaeological sites (Vento et al., 2008). The basic genetic units can often be combined into a hierarchical framework of allogenic genetic units, leading to an integrative type of stratigraphic analysis (Busch and Rollins, 1984; Vento et al., 1994).

Application of Genetic Stratigraphy to Pedogenic Sequences

Genetic stratigraphy, as applied to marine sequences, has been adapted to alluvial sequences containing paleosols (Vento et al., 2008). Alluvial sequences are now viewed as representing long intervals of stasis (indicated by buried soils), punctuated by brief episodes of deposition or erosion (Bown and Kraus, 1987). Alluvial paleosols provide only a small fraction of the physical sediment package, but represent up to 95% of the involved time interval of accumulation of an alluvial sequence (Retallack, 1984; Bown and Kraus, 1987; Kraus and Bown, 1993). As such, paleosols are ideal genetic units for establishing a chronostratigraphic framework. Because they reflect extensive temporal stability, paleosols, in general, are allogenic genetic units traceable over considerable distances. The degree of temporal stability, or time interval represented by paleosols, varies widely. A horizons may form on alluvial, colluvial, or coastal deposits in humid regions in only a few hundred years (e.g., Scully and Arnold, 1981). On the other hand, paleosol formation may take tens of thousands of years in more arid regions (Bown and Kraus, 1987, and references therein).

The bulk of the physical stratigraphic record on St. Catherines Island is, in a sense, a record of the punctuational events—the brief and episodic deposition of an eolian sand sheet, washover fan, beach-dune ridge migration, tidal channel avulsion, etc. Thus, most of the late Pleistocene core deposits are predominantly autogenic genetic units, untraceable over extensive geographical areas. Alluvial sequences, as well as barrier island sequences, commonly vary greatly in thickness and contained facies over short lateral distances, making lithofacies correlation virtually impossible. However, such pronounced facies development is likely to be constrained within very distinct genetic surfaces connected with the identified paleosols. Paleosols can be used like the transgressive surfaces and climate-change surfaces in marine genetic stratigraphy. Walther's law will only operate within the boundaries of the allogenic genetic surfaces of the paleosols.

The lateral changes in the distinguishing characteristics of marine allogenic genetic surfaces also have an analog in alluvial sequences. In the stratigraphic record of marine basins, proximal (marginal) hardgrounds may grade distally basinward into cryptic time-averaged shell lags. Similarly, Bown and Kraus (1987) and Kraus (1987) described morphological variation in laterally developed paleosols ("pedofacies") in early Eocene overbank deposits in the northern Big Horn Basin. Pedogenic sequences near channel margins (proximal) developed only incipient (stage 1) paleosols, whereas those in floodplain areas (distal) tended to exhibit relatively more mature (stage 2 or stage 3) paleosols. The more mature distal paleosols will usually be more easily traced over wide areas, but the more cryptic immature (proximal) paleosols will provide greater details of autogenic overprinting (episodic channel migration, avulsion, etc.). In practice, both the more mature distal and cryptic/immature proximal paleosols represent "marker" horizons or "events" that permit the floating of adjacent stratigraphic sections into a meaningful integrated chronostratigraphic framework. Judicious application of the criteria presented by Retallack and McDowell (1988) for the field recognition of paleosols should greatly enhance the genetic use of paleosols in Holocene depositional sequences, whether they are alluvial or coastal in origin.

Any carefully constructed chronostratigraphic framework using paleosols should investigate the merits of a hierarchical approach. Temporally extensive alluvial sequences are likely to record more than a single level of allogenic genetic units.

Kraus (1987) subdivided the early Eocene Willwood alluvial deposits into third-order sequences (small paleosol sequences, 3–7 m thick), second-order sequences (tens of meters thick and harboring a number of vertically stacked, third-order cycles), and first-order sequences (hundreds of meters thick, containing several second-order sequences). The larger genetic units (first-order) probably reflect such events as basinwide climatic and/or tectonic change. Smaller genetic units (third-order and second-order) most likely are controlled by such factors as channel migration, avulsion, overbanking, etc. (Kraus, 1987). Cycles of relative sea level change along the southeast coast of the United States might, for example, provide a control on the development of paleosol sequences via episodic deposition and stability.

METHODOLOGY AND PRACTICE OF GENETIC STRATIGRAPHY

The following discussion details how the methodological application of genetic stratigraphy can be applied to barrier island sedimentary units and, finally, as a predictive tool in archaeology. This methodology, including constraints and suggestions, is as follows:

(1) Stratigraphic Sections: Stratinomic (stratum-by-stratum) description and measurement of individual pedostratigraphic sequences is essential. Particular attention must be paid to the identification of all types of soil horizons.

(2) Paleosols as Allogenic Units: Buried soil horizons serve as the basic units in application of genetic stratigraphy to barrier island stratigraphy. Of particular value are the buried cumulic A horizons, such as those now exposed on St. Catherines Island along Yellow Banks Bluff, which reflect conditions of temporal stability in humid regions. A horizons are frequently traceable over wide areas of a single drainage basin, and even among drainage basins. As such, they can be ideal allogenic units, analogous to the use of seismically determined unconformities in the establishment of Atlantic and Gulf coastal plain chronostratigraphy (Poag and Schlee, 1984; Galloway, 1989). As is often the case with marine unconformities, alluvial soil horizons may encompass the bulk of time represented by a stratigraphic sequence (see Kraus, 1987). In this regard, genetic stratigraphy of alluvial sequences departs from the use of transgressive surfaces in high-resolution genetic stratigraphy of marine glacial-eustatic cycles (Busch and Rollins, 1984; Rollins, West, and Busch, 1989). In the latter situation, the genetic surfaces (e.g., transgressive surfaces) are more geologically “instantaneous” and are allogenic only because of the physical “forcing” of sea level change. Thus, in genetic stratigraphy of nearshore and alluvial sequences, the paleosol proper, not the enclosed alluvial deposits or the eolian sands, should be viewed as the basic genetic unit! Even buried soil horizons, however, may reflect very different durations of accumulation (different degrees of temporal stability) ranging from hundreds of years in humid regions (Scully and Arnold, 1981) to tens of thousands of years under more arid conditions (Bown and Kraus 1987). Paleosols like those on St. Catherines Island can occur as exhumed surfaces associated with erosional unconformities; as now deeply buried horizons mantled in some places by more than 4 m (13.5 ft) of late Wisconsin and Holocene eolian sands; and finally as relict surfaces that may document formation under a different set of climatic conditions.

(3) Initial Assumption of Allogenicity: Genetic stratigraphy depends upon the initial assumption of allogenicity. Operationally, one must “expect” to detect and trace buried A horizons among all sections. In practice, of course, individual sections may not contain specific A horizons. This reflects autogenic (local) influence, which, in the case of barrier island sequences, may be a result of such situations as:

(a) bluff erosion due to rising sea levels;

(b) eolian deflation of relict and once buried paleosols;

(c) scouring by washover fans or tidal channel migration.

(4) A horizons vs. B/C horizons on Barrier Islands: Stacked A and B or cumulic A horizons underlain by eolian or nearshore marine C horizons provide archaeologists with different interpretational opportunities. For example, the frequently thick eolian sands that both underlie and overlie now identifiable buried A horizons exposed along Yellow Banks Bluff provide surfaces that were not sufficiently stable for human occupation, either as a result of slow, continuous vertical accretion of an eolian sand sheet, or by more rapid deposition of eolian sands by large cyclonic storm events. A horizons, on the other hand, represent greater landform stability and were available for human occupation for decades or centuries and, therefore, are more likely to

contain evidence of multiple occupations.

(5) Floating Sections and Use of Marker Horizons: Stratigraphic sections are compared by tracing and matching of genetic units. In nearshore marine and alluvial sequences this involves correlating stacked A horizons whenever possible. Relative stratigraphic thicknesses play little or no role in the process of "floating" stratigraphic sections. However, "marker horizons," in the broadest sense, play an essential role in the formation of the pedostratigraphic or chronostratigraphic framework. Marker horizons can be faunally or florally defined (e.g., distinct pollen assemblages like the boreal pine/oak suite), culturally defined (e.g., fiber-tempered ceramics), or zones that have been radiocarbon dated. Such marker horizons permit first-order adjustment in the floating of the genetic units. The array of genetic units (e.g., soil horizons) between marker horizons (allogenic units) permits higher resolution chronostratigraphic adjustment of the matched sections.

(6) Hierarchical Packaging and the Question of Scale: The genetic stratigraphy of some marine sequences has involved the recognition that individual allogenic units can be packaged into a nested hierarchy (Busch and Rollins, 1984). The different hierarchical levels have their own "emergent properties" and, as such, are more than just a sum of the individual genetic units. Different controls function at the various levels of the hierarchy, and, to some extent, each level in the hierarchy can be studied and understood independently of the other levels. This is the modus operandi of hierarchical modeling and its primary departure from a purely reductionist approach. In genetic stratigraphy, the maturity and extent of small-scale pedogenic units (e.g., individual A horizons or B/C horizons) can be influenced by a variety of downward causalities, including broad fluctuations in zonal and meridional atmospheric circulation (Knox, 1983; Larsen and Schuldenrein, 1990) changes in sea level related to climate change or tectonism to climatic phases (e.g., preboreal and boreal), to (at a finer scale) relative length of temporal stability of the soil surface. An integrated genetic stratigraphic framework should be robust enough to include all interaction, upward and downward. Such framework has been developed for late Pleistocene and Holocene alluvial stratigraphy in the mid-Atlantic region; however no such stratigraphic framework has been attempted for the southeastern United States.

PREDICTIVE ASPECTS OF INTEGRATIVE GENETIC STRATIGRAPHY

If a genetic chronostratigraphic framework of barrier island deposits with spatially disparate sections is "floated" according to buried soil horizons, aided by integration of other types of marker horizons (e.g., radiocarbon dates, cultural horizons), that framework can then be used predicatively. First, the genetic framework permits the determination of motifs and rates of alluvial deposition in "slices of time," the immediate result of correlating the different sections by intervals of temporal stability (i.e., the buried A horizons). A spatial array of stratigraphic intervals, bounded by the same (correlated) A horizons, provides a lateral facies mosaic that encodes information regarding changes in environments of deposition, as well as differences in rates of aggradation and degradation. Intervals bounded by soil horizons might be used to establish sequential paleogeographic reconstructions (if a regional scale is involved), which display details of evolving landscapes. Or, isopleth maps might be used to convey information of temporally restricted lateral changes in magnitude or abundance or selected features (e.g., isopach map, showing thickness differences in alluvial sediments from floodplain to levee; isopleth map contouring changes in spatial abundance of organic carbon content, etc.).

Secondly, the incorporation of cultural attributes into the genetic framework might lead to predictive reconstruction of patterns of human dispersal, interaction, and/or trade. Of particular note is the capability of this integrative framework to utilize "negative" cultural information. The absence of artifacts in a stratigraphic interval, for example, has special significance in the integrated framework because it permits consideration of such questions as landform age and stability, changes in subsistence, and shifting environments (e.g., tidal marsh to washover), etc.

PRELIMINARY RESULTS FROM ST. CATHERINES ISLAND

Over the last year, geologists from Clarion University of Pennsylvania, in association with David Hurst Thomas of the American Museum of Natural History, have begun detailed soil stratigraphic mapping of the Yellow Banks Bluff area of St. Catherines Island, Georgia. This preliminary study serves to complement an existing extensive volume of previous geological studies completed on St. Catherines Island over the last 25 years (Thomas, 1980; 1988a; Linsley, 1993; Goodfriend and Rollins, 1998; Bishop et al., 2007a; Linsley, Bishop, and Rollins, 2008).

St. Catherines Island is one of a series of barrier islands that extends along the coast of Georgia for 175 km between the mouth of the St. Marys River to the south and the mouth of the Savannah River to the north. St. Catherines Island proper is situated at the head of the Georgia Bight, located between two major through-flowing rivers, the Savannah River to the north and the Altamaha River to the south. The northern end of St. Catherines Island is bound to the north by St. Catherines Sound, which has formed an extensive ebb delta tidal flat and to the south by Sapelo Sound. The island consists of 14,460 acres (5.929 ha), and is approximately 20 km long and 4 km to 2 km wide.

Geomorphologically, four gross landforms occur on the island and include: (1) a high standing late Pleistocene core which lies 4 m to >6 m above sea level; (2) an accretionary terrain on the north end of the island formed principally by the northern migration of St. Catherines Sound; (3) a series of arcuate beach-dune ridges of recent to late middle Holocene age on the southern margin of the island; and (4) marsh and broad tidal channels with dispersed hammocks to the west (chap. 3: figs. 3.1, 3.2, and 3.5).

Within 30 m (100 ft) of present sea level, six distinct marine terraces can be recognized. These include the Wicomico (30 m), Penholoway (23 m), Talbot (12–14 m), Pamlico (7.5 m), Princess Anne (4.5 m), and Silver Bluff (1–3m) (table 4.1; chap. 3, fig. 3.1). The Silver Bluff terrace forms the Pleistocene core of the island. This island core is bound to the north and south by late Holocene to recent accretionary terrain formed by the stabilization of a series of generally arcuate beach-dune ridges. The soils developed on these low-lying (less than 3 m) accretionary terrains can best be classified as Entisols with organic rich A horizons overlying minimally weathered eolian and washover fan sands. On the southern end of the island, these Holocene beach-dune ridge deposits document primary long shore drift to the south with the beach-dune ridges becoming progressively younger in a south-southeast direction (chap 3: fig. 3.5B). Preliminary soil studies appear to show better soil development

TABLE 4.1
Relict Shoreline of the Georgia Coastal Plain

Shoreline or terrace name	Elev. (MSL)	Estimated age
Hazlehurst (Brandywine)	82 m	early Pleistocene?
Pearson (Coharie)	66 m	early Pleistocene?
Argyle, Waycross, Okefenokee (Sunderland)	52 m	early Pleistocene?
Wicomico	30 m	1.5 Ma (“Aftonian”)
Penholoway	23 m	1 Ma (“Yarmouthian”)
Talbot	13 m	OIS 11, 15?
Pamlico	7.5 m	100–500 ka
“Sangamon”	5–7 m	80–115 ka, OIS 5e,7,9
Princess Anne	4.5 m	40–80 ka, OIS 3,5
Silver Bluff	1–3 m	26–55 ka
Holocene accretionary terrains	< 2 m	4 ka–present

(oxidation and humate increases in the underlying C horizons) as one proceeds from the younger beach-dune ridge on the east to older, late-middle Holocene age beach-dune ridges to the west, and abutting the island core. To the north, a prominent scarp marks the boundary between the Pleistocene core and the lower lying Holocene age accretionary deposits. Deposition of these Holocene age accretionary deposits on the northern end of the island is from beach-dune ridge migration in response to sound migration and formation of extensive tidal mud flats. Figures 3.2 and 3.5A (chap. 3) show the locations of Yellow Banks Bluff, the northern accretionary terrain, and the Pleistocene core.

The Pleistocene core, which is of late Pleistocene age, is attributed to the Silver Bluff age shoreline. As noted by Bishop et al. (2007), the internal structure of the island core is still unclear and questions remain whether the core consists of one depositional unit or more than one unit; however, geomorphic features like the Central Depression argue for several episodes of island core construction.

Yellow Banks Bluff, the principal focus of this study, extends along the northeastern shoreline for a distance of 0.8 km (0.5 mi), from Seaside Inlet on the south to the southeastern edge of the St. Catherines Island Scarp on the north. Along its entire length the bluff attains a nominal height of 5 m (16.5 ft) above the spring high tide line. Over the last 30 years, the bluff has retreated eastward at a rate of more than 1.5 m (5 ft) per year (Bishop et al., 2007; chaps. 3 and 7, this volume). This landward retreat is evidenced by the numerous downed trees that litter the beach (fig. 4.1) and relict marsh muds.

The preliminary geomorphology studies at Yellow Banks Bluff entailed detailed mapping of more than 16 distinct segments along the eroded section of the Pleistocene core. In addition to performing on-site mapping, we collected soil/sediment samples from select profiles for granulometric, geochemical, thin section, and ^{14}C analysis.

As a result of the field mapping, as many as five distinct soil generations (e.g. A–B; A–C horizons) have been identified along sections of the bluff. These distinct pedostratigraphic units have formed during episodes of subaerial weathering of late Pleistocene through Holocene age

Fig. 4.1. General view of Yellow Banks Bluff (facing southwest). Note the large numbers of trees eroded from the island core on the shoreface. The bluff is retreating at a rate of >1.5 m per year. Photograph taken by Patty Stahlman, April 30, 2008.

eolian sands, which disconformably mantle the marine sands of the Silver Bluff marine terrace (fig. 4.2). In places along the base of the bluff, mid-Wisconsin age Silver Bluff marine sands are variously exposed and consist of quartz sands that contain a high percentage of heavy minerals. This is in sharp contrast to the overlying, extremely well sorted, eolian sands that contain a mineral suite depauperate in heavy minerals. The age of the marine sands at the base of the bluff, which comprise the late Pleistocene core of the island, has been debated extensively. Vibracoring of the Pleistocene core has identified marine horizons at depth that date to as early as 44,000 B.P. (Bishop et al., 2007; Linsley, Bishop, and Rollins, 2008), and possibly to as recent as 26,000 B.P. (Linsley, 1993). The mid-Wisconsin age (isotope age 3) for this marine submergence is supported by complementary dates on other segments of the southeastern coast (Hails and Hoyt, 1969; Hoyt and Hails, 1974; Sussman and Herron, 1979; Moslow, 1980; Finkelstein and Kearney, 1988). Arguments raised against these radiocarbon dates are that they represent older, reworked, and transported marine shells, or that the ages have been compromised by an episode of mid-Wisconsin solar radiation bursts that skewed the radiocarbon ages (Dockal, 1995). One possible mechanism for the occurrence of a mid-Wisconsinan submergence that does not include eustatic sea level fluctuations related to glacial ice ablation is submergence due to localized tectonism along the Georgia Bight. As noted by Thieme (2005), some problems with correlating subsurface deposits on the basis of surface elevation in the Atlantic coastal plain may be due to tectonic tilting or warping of the earth's crust (Winker and Howard, 1977; Zullo and Harris, 1979; Markewich, 1985). The effects of tectonic activity have long been recognized on the Cretaceous and Tertiary rock landward of the Hazlehurst (Brandywine) shoreline in the "middle" or "upper" coastal plain (Thieme, 2005). While there are few direct indications of tensional or compressional stress or catastrophic failure in the sediments themselves, the terrace remnants are offset in some locations, or stand at slightly higher elevations in adjacent states compared to those in Georgia (Thieme, 2005). One of the best indications for late Pleistocene tectonism in Georgia is the discontinuity

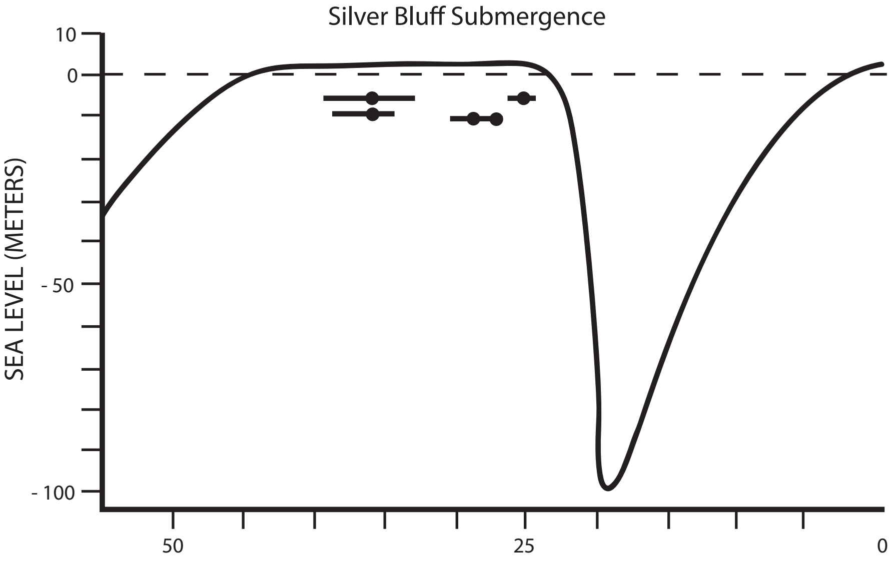

Fig. 4.2. Georgia sea level curve adapted from Hoyt (1968) showing Silver Bluff submergence; only the most recent part of the Pleistocene record is represented. Control points are from ^{14}C dates of shells from Sapelo Island. Length of horizontal line represents age uncertainty.

that offsets the positions of the Talbot and Penholoway shorelines along the present course of the Altamaha River (Georgia Geological Survey, 1976; Winker and Howard, 1977; Thieme, 2005). Approximately 10 m of the relief here are probably tectonic rather than eustatic, and the magnitude of the uplift appears to increase both toward the northeast in South Carolina, and toward the south in Florida. Geological skeptics for Quaternary tectonism argue that the Atlantic coast is a passive margin with little recorded seismic activity (Thieme, 2005). However, a major earthquake did occur in 1886, having its epicenter at Charleston, S.C. (Weems and Obermeier, 1989). The consensus, nevertheless, is adamantly opposed to any sea level higher than that following the OIS 5e ("Sangamon") interglacial (Bloom, 1983; Colman et al., 1989) whether from climate change or tectonics (Thieme, 2005).

The basal marine sands of Silver Bluff age (26–60 ka) that are generally exposed along the base of Yellow Banks Bluff are consistently overlain by either a thin, white eolian sand that, in turn, is capped by a strongly developed paleosol (designated 4A or 5A), or directly by one of the other lower paleosols (see alternative interpretation in chap. 5). The now buried A horizon contains abundant organics and redoximorphic iron oxides. A recent ^{14}C assay has dated this basal paleosol to 22,820 ± 130 B.P. (Beta-244622). This date corresponds with a previously dated shell lag horizon collected from a vibracore along North Beach (transect A-A′, 22,600 ± 310 B.P., Pitt-381: Linsley, 1993; Linsley, Bishop, and Rollins, 2008).

The lower paleosols (designated 4A and 5A) that can be traced along most of the exposed bluff were originally interpreted as marine firmground or hardground. This assignation is unlikely given the fact that this unit lacks any marine fauna, is extensively bioturbated, lacks laminations, exhibits a general absence of the heavy minerals that occur in abundance in the basal upper foreshore sands, has a high organic matter content (composed of small rounded fecal pellets and disseminated organics), and is bracketed stratigraphically above and below by eolian sands. Rich and Booth (chap. 6) recently conducted a preliminary pollen analysis of this lower paleosol along Yellow Banks Bluff and noted that, given its stratigraphic position, it is of probable late Pleistocene age. While pollen preservation was generally poor due to in situ weathering and diagensis, *Alnus* (alder) or Tubuliflorae (composites) grains that had lost part of the external pollen wall (ektexine) were identifiable. Among the numerous identifiable grains, the most abundant arboreal taxa were *Carya* (hickory and pecan) and *Pinus* (pine); however, a very large amount of pollen from herbaceous plants and woody shrubs characterized the sample, including abundant Tubuliflorae (41% of the palynoflora), *Alnus* (17%), Poaceae (grasses, 10%), and *Ambrosia* (ragweed, 5%) (see chap. 6). This research indicates that the lower paleosol sample suggests the local presence of an alder-composite-grass community unlike anything that occurs on St. Catherines Island now. This community appears to be potentially more similar to the tag alder wetlands of the upper Midwest, which are commonly dominated by *Alnus rugosa*, species of the composite *Eupatorium*, and several species of grasses. Additionally, there is little or no indication of halophytic species in the Yellow Banks Bluff sample; there were no Chenopodiaceae/Amarathaceae (lamb's quarters, goosefoot, etc.), and *Iva* (marsh elder, a common seaside inhabitant) constituted less than 1% of the pollen/spores.

As further support of a terrestrial origin for the lower paleosol, the 22 ka date corresponds to a time when sea levels were some 120 m (394 ft) lower than current levels, and when St. Catherines Island was attached or welded to the continent (fig. 4.3). In examining earlier vibracore profiles and associated radiocarbon dates, the 22,820 B.P. age for organics has been identified in other parts of the island core (Linsley, 1993; Bishop et al., 2007). These dates document a stable surface at approximately 22,000 B.P. for the island core during the maximum glacial eustatic sea level drop when the island lay as much as 100 m (330 ft) above sea level and was essentially "welded" to the mainland.

Using profile 2-A along Yellow Banks Bluff as type section, the basal stratum designated 5A (lowermost paleosol) is underlain by heavy mineral-rich marine sands and overlain by a variably thick (20–50 cm) eolian sand horizon, designated 4C. The 4C white eolian sands are capped by a second cumulic A horizon designated 4A. The 4A horizon is slightly less developed than the lower 5A paleosol, but also exhibits high organic matter content, evidence of bioturbation, and redox of iron. Although this horizon is not dated at profile 2-A, it may correlate to a dated paleosol along the southern end of the bluff. At this location, a

Fig. 4.3. Photograph of two exposed paleosols (arrows) along Yellow Banks Bluff. The lower paleosol in photo has been dated to 22,820 ± 130 B.P. (Beta-244622). Note mapped soil horizons in photo. Photograph taken by Patty Stahlman, May 1, 2008..

paleosol consisting of a dark black peat occurs in a deep swale or slough (fig. 4.4). Radiocarbon dating of organics from the swale (or slough) has yielded a date of 13,610 ± 40 B.P. (Beta-244621), and may correspond with the climate amelioration during the warmer Boelling-Allerod Subage. In a similar fashion to the lower paleosol, the 4A paleosol (or allogenic genetic unit) documents a period of stability and A horizon development probably associated with warm and moist climatic conditions. During the Fourth Caldwell Conference, Rich and Booth concurred that the vegetation present in the swale dated 13.6 ka was of freshwater origin (personal commun., 2009). Martin indicated that the insect and vegetation traces were of freshwater taxa, clearly different from that which is observed in the island's salt marsh communities today (personal commun. 2009).

The 4A horizon is then overlain by a variably thick package of white, fine-grained, well-sorted eolian sands, designated 3C. These eolian sands may document a period of dry climatic conditions associated with the Younger Dryas (ca. 11,000 B.P.). During this time, sea levels would have been more than 40 m (131 ft) below their present position, and the island would have remained welded to the coast (see chap. 3: fig. 3.3). The 3C sands are then overlain by a moderately well-developed cumulic A horizon that has yielded a date of 10,790 ± 60 B.P. (Beta-255650). This horizon documents at least a moderately lengthy episode of moister or wetter conditions that favored A horizon development and the termination of the warm and dry conditions of the Younger Dryas. The 3A horizon is then overlain disconformably by a thin (20–30 cm thick) white eolian sand 2C horizon. The 2C horizon is once again overlain by a 10–12 cm thick 2A horizon. The 2A horizon has yielded a date of 6440 ± 40 B.P. (Beta-255651). This date documents an interval of wetter climatic conditions during the middle Holocene Atlantic climatic phase.

The 2A horizon at profile 2A is then overlain by the upper soil sequa (or generation): A-AB-Bh/Bw-C. This upper soil sequa typically attains a nominal thickness of 150 cm (fig. 4.5). During the field studies, three probable prehistoric fire features were noted within the Bh horizon along the northern portion of the bluff. One of the features (designated feature 44) was identified at a depth of 80–120 cm below ground surface in the Bh horizon and was submitted for conventional ^{14}C dating (fig. 4.6). The feature has now yielded a date of 6270 ± 40 B.P. (Beta-255652). This date corresponds nicely in that it overlies the 6440 B.P. date on the 2A horizon and underlies Late Archaic period artifacts that have been recovered from the A/AB horizons along the bluff (Thomas, 2008: chap. 20, 535–601). Given the age of the 2A ho-

Fig. 4.4. Photograph of a section of Yellow Banks Bluff (facing west). The extensive organic horizon (2A1/2A2; arrow) is likely attributable to a freshwater pond or slough. The 2A horizon at this location has been dated to 13,610 ± 40 ^{14}C yr B.P. (Beta-244621), and may correspond with the 4A horizon at profile 2-A. Photograph taken by Patty Stahlman, April 30, 2008.

rizon and the date from the probable feature, it is clear that the eolian sands that comprise the upper soil generation (A/AB-Bh/Bw-C) along Yellow Banks Bluff are entirely of Holocene age.

An interesting observation concerning the upper solum (A and underlying B horizon) present on the southern end of Yellow Banks Bluff, which lies in places more than 1.5 m (5 ft) below the higher standing northern section of the bluff, is that the B horizon is markedly less developed (or weakly cambic) and exhibits a darker chroma, less oxidation, and evidence of humate translocation. This may indicate less stability (e.g., greater eolian deflation and heightened effects of washover) due to a lower topographic position relative to sea level. An examination of the age of previously recorded prehistoric sites present on the bluff may help to answer whether the age of the upper solum varies north to south.

SUMMARY DISCUSSION OF PETROGRAPHIC AND SOIL GRAIN SIZE ANALYSES

Martin and Rindsberg (2008) have proposed that the lower two humate-rich horizons (4A–5A) may represent strongly bioturbated washover fan deposits. To examine more fully the depositional origin of these horizons, both thin section and grain size analyses were completed for profile 2-A along Yellow Banks Bluff (see fig. 4.5). We believe that the results of the grain size studies provide further support for subaerial eolian deposition of the sands along Yellow Banks Bluff. Only the lower 1 m (3.3 ft) of the exposed bluff profile is comprised of heavy mineral-rich littoral marine sands of Silver Bluff age. Grain size analysis of the 5A, 4C, and 4A horizons capping these marine sands was strongly unimodal, lepto-

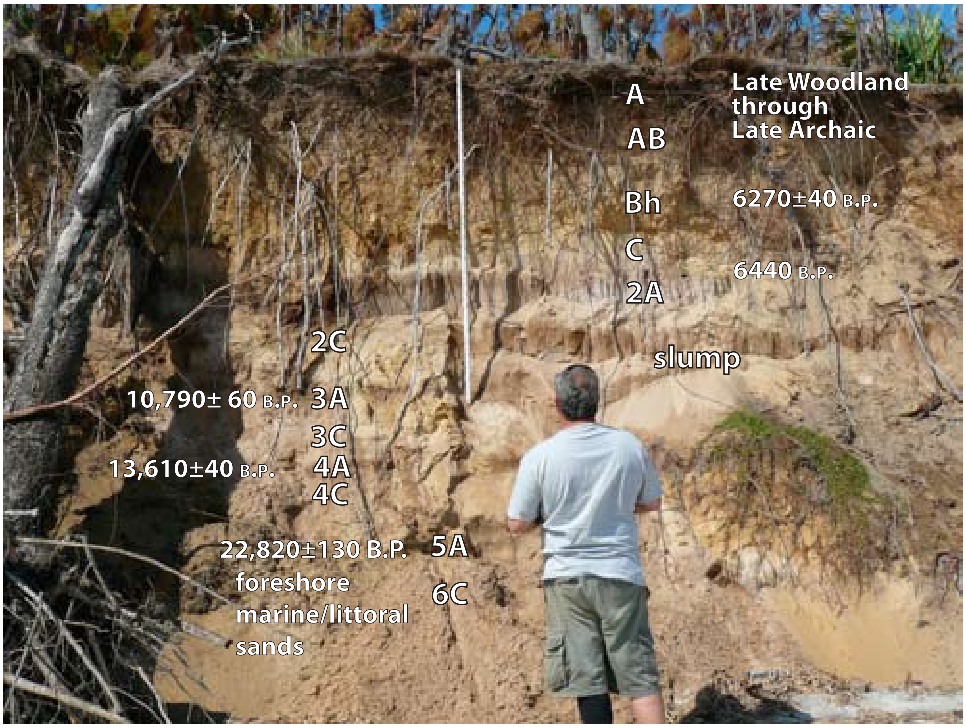

Fig. 4.5. Photograph at profile 2-A location along Yellow Banks Bluff (facing west). Note the occurrence of at least four buried A horizons (2A, 3A, 4A, and 5A) each of which is capped by minimally weathered eolian sands. The upper sola consists of an A/AB horizon overlying a spodic Bh horizon. Photograph taken by Patty Stahlman, October 10, 2008.

Fig. 4.6. Photograph (facing 310°) of a probable prehistoric cultural feature in the B horizon exposed along Yellow Banks Bluff. Recent radiocarbon dating has yielded a date of 6440 ± 40 ^{14}C yr B.P. Beta-255651. Photograph taken by Patty Stahlman, October 10, 2008.

kurtic, and extremely well sorted (fig. 4.7). The argument against a washover origin include: (1) absence of any marine forams or other faunal elements; (2) no evidence of a fining upward trend; (3) a clear absence of marsh muds; (4) the lack of sharp basal contact for these horizons; (5) a high degree of sorting and low percentage of heavy minerals—1% to 2%; and (6) absence of shell or coarse sand basal lag deposits. An alternative hypothesis is that these are highly bioturbated eolian sands that exhibit a high organic matter content caused by elevated water table conditions that may reflect broad regional climate controls or localized water table conditions.

The thin section analysis of profile 2-A along Yellow Banks Bluff also strongly supports an eolian origin for all but the lower 1m (3.3 ft) of exposed sands along the bluff. The 6C horizon at the base of the bluff is clearly comprised of Silver Bluff age littoral marine sands (fig. 4.8). These sands contain a higher percentage of heavy minerals and much lower organic matter content than the overlying 5A, 4C, and 4A horizons (figs. 4.9, 4.10). The petrographic study also indicates that while the eolian sands along Yellow Banks Bluff exhibit a high degree of sorting, most of the grains examined were typically subangular to subrounded (fig. 4.11). The absence of rounding documents short eolian transport and limited subsequent reworking of the sands.

CONCLUSIONS

Although the study to date has generated more questions than answers, the following tentative observations and recommendations for further study are proposed:

(1) A mid-Wisconsin age (26–60 ka) for the Silver Bluff submergence that formed the core of St. Catherines Island is now further supported by the dating of a basal paleosol (22 ka) that lies only 1 m (3.3 ft) above nearshore marine sands of Silver Bluff age. The age of this lower paleosol is, however, problematic. If, in fact, the horizon is actually bioturbated, then the date is in error, given that sea level at 22 ka would have been some 100 m below present-day sea level. Secondly, one might consider whether the 22 ka date is from organics contributed to a palimpsest surface that is significantly older (e.g., 45–100+ ka) and that the date represents later organic contribution to this relict surface. As a planned "next step," samples of both the lower paleosol and the underlying marine sands will be submitted for OSL dating. These dates should answer the question as to the age and timing of the Silver Bluff submergence and negate concerns regarding the mid-Wisconsin cosmic bombardment effect on ^{14}C samples. In addition, we hope to collect and submit a sample from the probable Younger Dryas age eolian sands that overlie the 13.6 ka organic rich, freshwater slough and underlie the 10.7 ka paleosol. This sample will also be analyzed for its nanodiamond content to elicit either supportive or negative data for a late-Wisconsin-age meteorite event that has recently been offered as a causal mechanism for the Younger Dryas climate interval and also late-Wisconsin extinctions (Firestone et al. 2007; Kennett et al. 2009; Surovell et al. 2009).

(2) The fact that at least four buried A horizons dating to 6440 B.P., 10,790 B.P., 13,610 B.P., and 22,820 B.P. (as well as one additional undated paleosol) have been identified within 4 m (13.5 ft) of the bluff surface argues that soils on St. Catherines Island have the potential to contain prehistoric occupations that predate the Late Archaic. A recent date of 6270 ± 40 B.P. (Beta-255652) from a probable prehistoric fea-

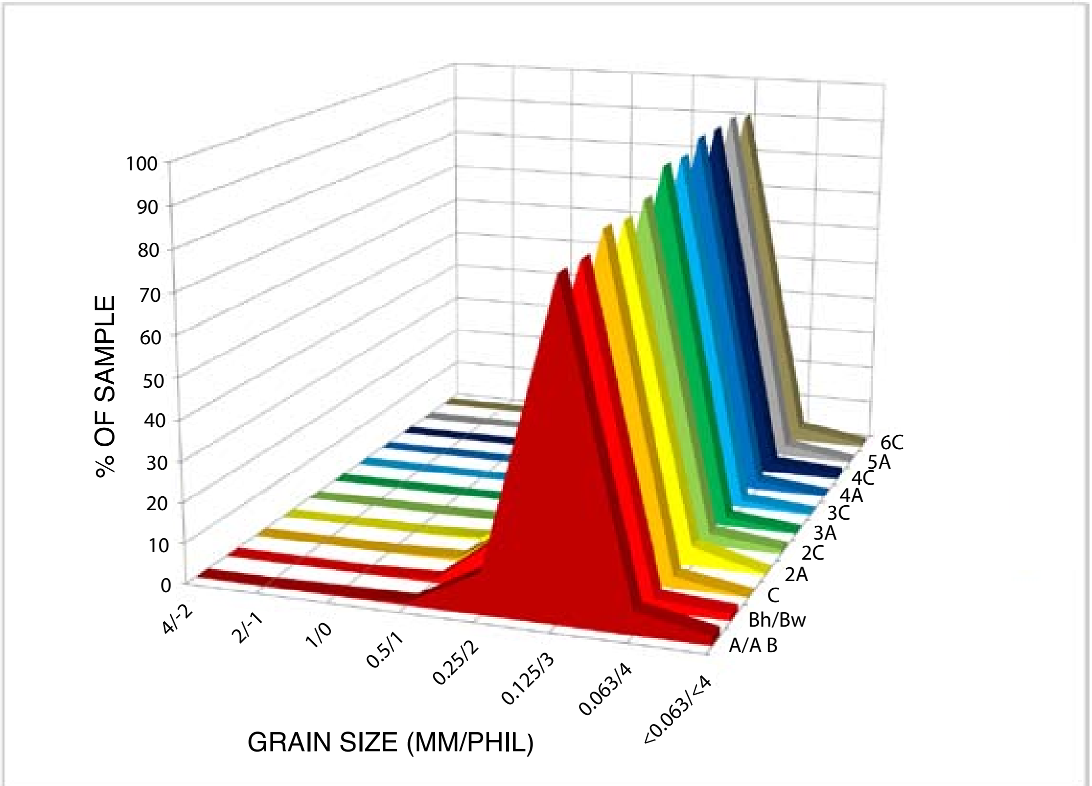

Fig. 4.7. Chart of soil grain size (profile 2-A) of Yellow Banks Bluff, St. Catherines Island, demonstrating the uniform grain size for the entire bluff sediment package. All samples were strongly unimodal, leptokurtic, and very well sorted. The grain size, sorting, and mineralogy all argue for an aoelian origin for all but the lower 1 m of strata along the exposed bluff.

ture identified at a depth of 80–120 cm below ground surface in the spodic B horizon provides additional support for this conclusion.

(3) The buried A horizons clearly document episodes of island core stability during probable warm and moist climatic intervals. The paleosols are consistently capped by eolian sand deposits that may document episodes of enhanced eolian deflation during warmer and drier climatic intervals. Given the preservation of organic material in some of these horizons, it should be possible to provide important new information on vegetation and climate change on the Georgia Bight over the past 22,000 years.

(4) None of the paleosols that occur along Yellow Banks Bluff is traceable along the entire length of the escarpment, due to localized erosion by eolian deflation, rapid rates of eolian accretion, or erosional ravinement by interior channels and sloughs.

(5) Does the age of the upper solum or soil generation (A-Bh/Bw) along Yellow Banks Bluff decrease from north to south? The observed soils along Yellow Banks Bluff indicate that the spodic B horizon underlying the surface A horizon on the north end of the bluff is comprised of strong yellowish-brown sands that are more deeply weathered than the weak, brown cambic B horizon occurring on the southern margin of the bluff. Do these changes in soil development reflect greater stability of the slightly higher island core on the north end of the bluff and, if so, how does this occurrence correlate with the age of observed prehistoric sites? Finally, does

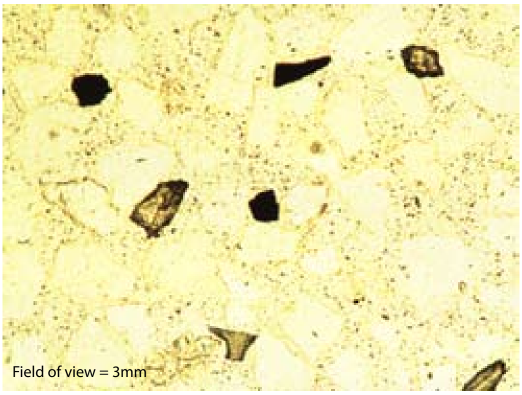

Fig. 4.8. Photomicrograph under plain polarized light showing abundant heavy minerals present in lower basal marine (littoral) sand unit. The percentage of heavy minerals drops off significantly in the overlying eolian sands. Photomicrograph taken by Frank Vento.

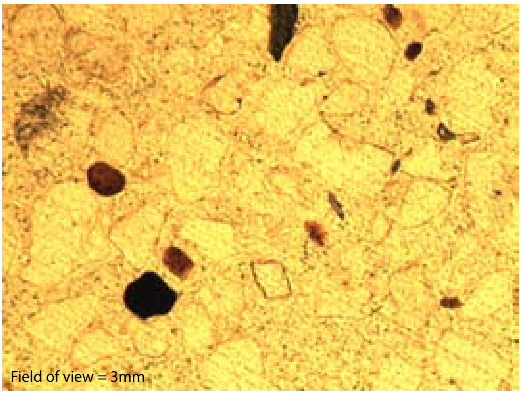

Fig. 4.9. Photomicrograph under plain polarized light at 50× showing abundant organics in 5A horizon from profile 2-A. The rounded organics are likely either fecal pellets or seeds. Photomicrograph taken by Frank Vento.

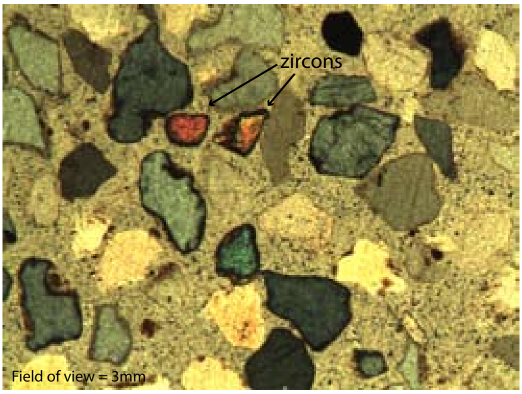

Fig. 4.10. Photomicrograph of 5A horizon under cross-polarized light at 50×. Note zircons in photo (high birefringence grain) and strong angularity of the fine sand-sized quartz grains. Also note abundant disseminated organics. Photomicrograph taken by Frank Vento.

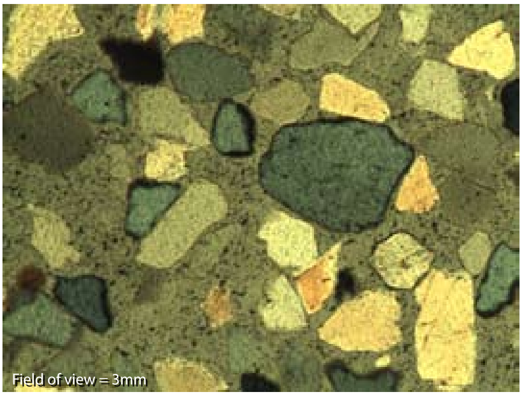

Fig. 4.11. Photomicrograph of 3C horizon from profile 2-A under cross-polarized light at 50×. Note angular, subangular to subrounded character for the fine sand-sized quartz grains. The sparse heavy mineral assemblage in the eolian sands consists primarily of zircons, almandine garnets, and various opaques (e.g., magnetite, ilmomite). Photomicrograph taken by Frank Vento.

this change in soil character affect the potential for the occurrence of more deeply buried prehistoric cultural resources?

(6) The apparent absence of the upper buried paleosols, at least on the western margin of the Pleistocene core, may reflect greater stability farther from its oceanward edge, essentially documenting less autogenic influence from nearshore depositional processes (hurricanes, eolian scour, and deposition etc.).

(7) Bishop and others (2007) have proposed that a "ghost" island named Guale Island existed east of Yellow Banks Bluff and was the sediment source for the late middle to late Holocene (4 ka to present) accretionary terrain on the southern end of the island. If present, how did Guale Island

affect sediment transport and subsequent paleosol development on the Pleistocene core of the island now exposed along Yellow Banks Bluff? Additionally, how did the eventual destruction of this "ghost" island influence the development of the southerly accretionary terrain and, in turn, prehistoric occupation of these now stabilized beach-dune ridges over time?

(8) Do the stratigraphic profiles exposed along Yellow Banks Bluff and to the south along the now stabilized beach-dune ridges provide supportive data for a proposed sea level regression or still stand (DePratter and Howard 1981; Gayes et al., 1992; Colquhoun, Brooks, and Stone, 1995; Goodfriend and Rollins, 1998; Chowns et al., 2008) between approximately 4300 and 3600 B.P.?

(9) Additional mapping and vibracoring of the Yellow Banks Bluff zone should be conducted to determine whether the paleosols present along Yellow Banks Bluff extend further westward into the Pleistocene core of the island.

(10) Finally, an ultimate objective of geomorphological studies on St. Catherines Island is the construction of a genetic stratigraphic sequence for the barrier islands of the Georgia Bight. It may eventually be possible to float stratigraphic sections among islands, permitting interisland stratigraphic correlation. Careful construction of this sequence will demand attention to the effects of climate change, sea level fluctuation, and tectonism. Once completed, this genetic sequence will aid in predictive archaeological stratigraphy and in identifying those landforms with the potential to contain deeply buried prehistoric cultural resources.