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7. For example, Sifco Metachemical gold plating solution, Cleveland, Ohio.
8. This work was supported in part by the U.S. Army, Navy, and Air Force under contract DA 36-039-AMC-03200(E), and in part by the Bell Telephone Laboratories, Inc., the NSF (grant GP-2495), NIH (grant MH-04737-04), NASA (grant NsG-496), U.S. Air Force [ASD contract AF 33(615)-1747], and ONR [contract Nonr-4315(00)]. One of us (S.F.) is an Inter-American Guggenheim Fellow.
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Holocene Submergence of the Eastern Shore of Virginia

Abstract. *Radiocarbon ages of basal peats 4500 years old or younger and the thickness of salt-marsh peat in the lagoon east of Wachapreague, Virginia, are nearly the same as those of equivalent samples from New Jersey and Cape Cod. This suggests that these coasts have had similar submergence histories. Data obtained from the coasts of Connecticut and northeastern Massachusetts indicate that the Atlantic coast of the United States has been differentially warped during the later Holocene.*

The tidal-marsh and lagoonal sediments in the area between Wachapreague and Wachapreague Inlet on the Atlantic coast of Virginia's Eastern Shore (Fig. 1) are in an area that is physiographically similar to most of the coast between Long Island and Cape Charles. The area is characterized by a series of barrier beaches that are separated from the upland by lagoons, bays, tidal marshes, mudflats, and anastomosing tidal channels. Subsurface samples of Holocene tidal-marsh, lagoonal, and swamp deposits were taken with a 1-m stroke piston sampler with an inside diameter of 4.75 cm. The Holocene sediments overlie an older surface ("basement") of compact silty sand, presumably of Pleistocene age (*1*); the sand is covered by a thin diachronous layer of freshwater-swamp and brackish-marsh peat evidently accumulated at the transgressing high-tide shoreline (*2*).

The maximum thickness of Holocene sediments in the area is 11 m (36 ft), measured from the surface of the high-salt marsh at about mean high water to the basement. Most of the Holocene sediment wedge consists of organic clayey silt containing a characteristic lagoonal microfauna; the silt is sandier adjacent to Wachapreague Inlet. The surface layer consists chiefly of organic silt containing rhizomes of salt-marsh grasses, particularly *Spartina* sp. Only locally, in protected areas adjacent to the upland, does the thickness of salt-marsh sediment exceed 1.8 m. The spring tidal range at Wachapreague is 1.45 m, suggesting that only recently has the salt marsh developed extensively.

All borings were initiated on the surface of the high (*S. patens*) salt marsh which was assumed to be at mean high water, the datum used for this investigation; work of other investigators in similar marshes indicate that this surface is within 30 cm of mean high water (*3*). Samples for radiocarbon dating were taken from the peat immediately above the basement surface. If the basal peat represents the level of the initial marine transgression (at a unique time and elevation below the surface of the high-tide marsh), and if consolidation and compaction of the basement have been negligible since the transgression, the ages and depths of these samples can be used to establish relative sea levels at different times and places. The ages of four samples, from four borings, were determined by radiocarbon analyses.

Samples ML-191 and ML-192 (*4*), from borings WC-1 and WC-2 at Bradford Bay (37°35′52″N, 75°41′13″W) and Wachapreague Channel (37°35′54″N, 75°40′50″W), respectively, showed

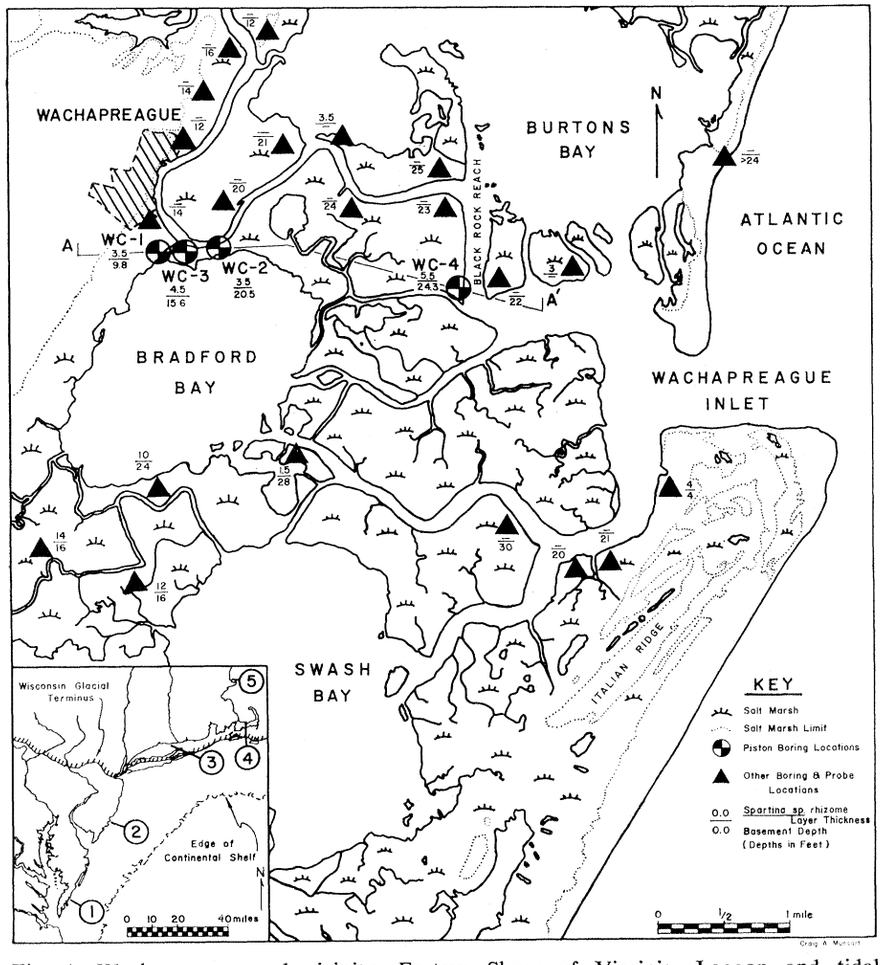

Fig. 1. Wachapreague and vicinity, Eastern Shore of Virginia. Lagoon and tidal marshes, showing bore locations and geographic distribution of environments. Insert locates: *1*, Wachapreague; *2*, Brigantine, New Jersey (*7*); *3*, Clinton, Connecticut (*2, 8*); *4*, Barnstable, Cape Cod (*9*); and *5*, Plum Point, Massachusetts (*10*).

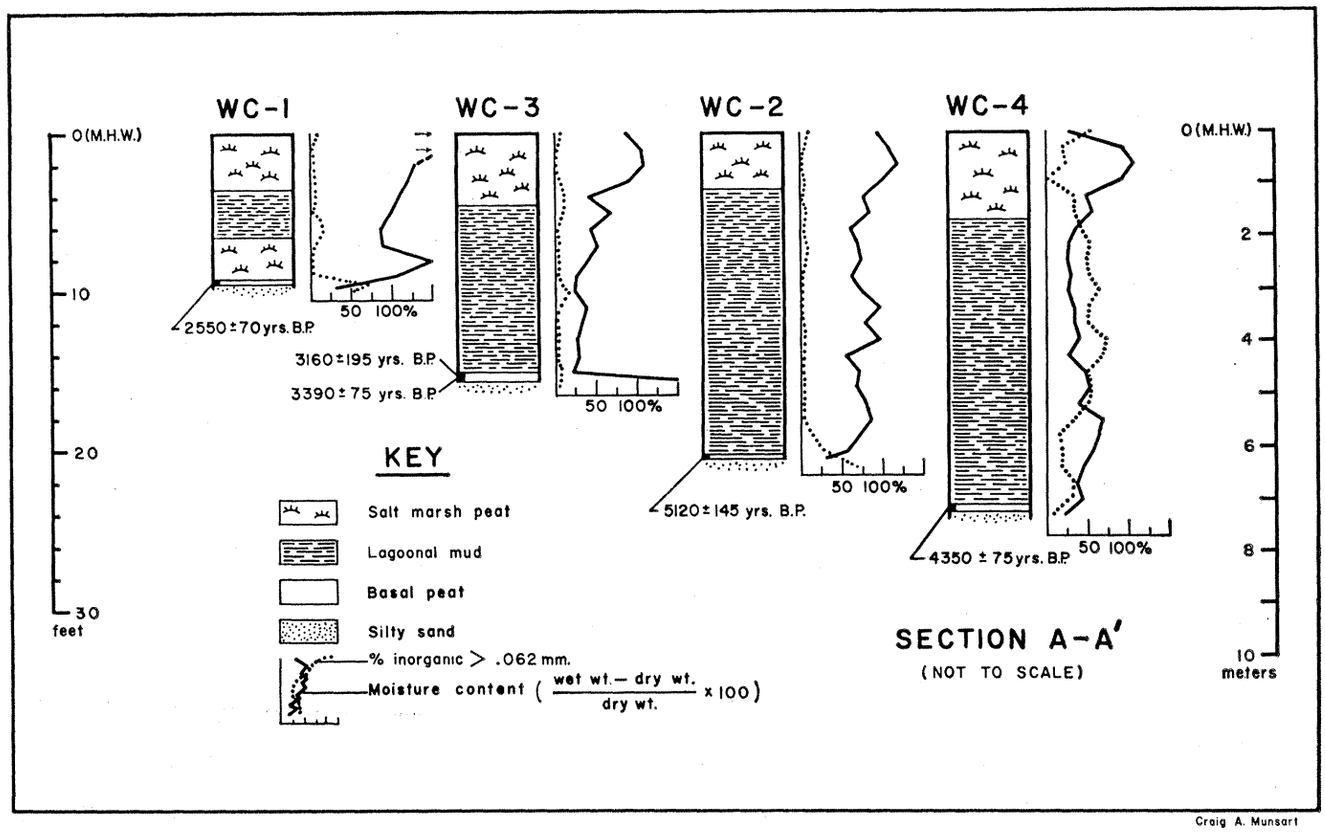

Fig. 2. Logs of borings obtained with a piston sampler along section *A–A'* (see Fig. 1) between Wachapreague and Wachapreague Inlet. *B.P.*, before present.

radiocarbon ages of 2550 ± 70 and 5120 ± 145 years, respectively. The former consisted of organic silt from the base of salt-marsh sediments at a depth of 2.8 to 2.9 m; the latter, of a gray, organic, silty sandy clay from the base of salt-marsh sediments at 6.08 to 6.13 m. Each age was derived by C^{14} analysis of the humic acid fraction and thus may be less than that of peat fiber. In both samples the peat fraction was too meager for assay. The ages for the deposits are therefore minimal.

Sample ML-193, from boring WC-3 at Wachapreague Channel (37°35′51″ N, 75°41′02″W) consisted of peaty, clayey silt from the base of salt-marsh and lagoonal sediments at a depth of 4.57 to 4.77 m. The age of the peaty fraction was 3160 ± 195 years, while the humic acid fraction gave an age of 3390 ± 75 years. The greater age for the latter fraction indicates either that the humic acid fraction was squeezed up from below or that the peaty sample has been contaminated by younger root systems penetrating older materials (see 5).

Sample ML-194, from boring WC-4 at Black Rock Reach (37°35′38″ N, 75°38′38″W), consisted of peat from the base of salt-marsh and lagoonal sediments at a depth of 7.13 to 7.25 m. Its age was 4350 ± 75 years, obtained by C^{14} analysis of the humic acid fraction, the use of which may result in some error: such samples are frequently contaminated by downward percolation of younger material. Sample ML-193, however, showed an opposite effect, that is, possible upward migra-

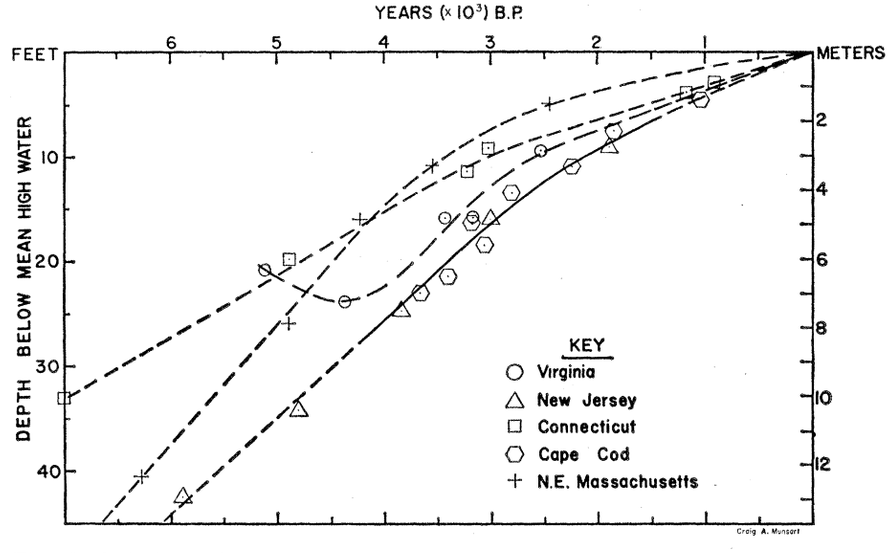

Fig. 3. Relative submergence curves for five coastal sites between Virginia and Massachusetts. *B.P.*, before present.

tion, giving a greater age for humic acid than for peat.

These radiocarbon ages, along with others, appear in Fig. 3. The ages reported by other investigators are for four similar salt-marsh deposits along the northeast coast of the United States. Our youngest age, given by a sample from about 2.9 m below mean high water, indicates that the salt-marsh intertidal peat, which has a maximum thickness of 1.8 m over most of the project area, evidently began to form extensively at some time after 2500 years ago. This conclusion is confirmed by the fact that pollen associated with Caucasian settlement (after about 1600 A.D.) occurs only in the upper meter of the cores (*6*). These data support earlier conclusions (*7, 8*) that the rate of submergence decelerated appreciably at some time between 2500 and 350 years ago and that this deceleration permitted the extensive development of salt marshes in the Wachapreague area.

The Virginia and New Jersey plots are similar except for the oldest date (ML-192) from Virginia. These coastal segments have had similar submergence histories since about 4500 years ago, and the upper layers of salt-marsh sediment containing *Spartina* sp. rhizomes are of similar thickness. Ages and salt-marsh sediment thicknesses reported for Barnstable marsh, Cape Cod (*9*), are comparable with the data from Virginia and New Jersey. The submergence histories of these three localities (the VNC sites) have been similar, and extensive salt-marsh development has occurred only within the past 2500 years, concurrently with deceleration in submergence.

The submergence curves constructed from sets of ages obtained from the coasts of Connecticut (*2, 8*) and northeast Massachusetts (*10*) (the CM sites) differ markedly from the equivalent curves for the VNC sites. The rate of submergence at the latter sites has been approximately twice that at the former. The greater thickness of the *Spartina* sp. rhizome layer at the CM sites (2.8 m in Connecticut and 3.7 m in Massachusetts) also indicates that submergence at these sites has been slower than at the VNC sites. Finally, the radiocarbon ages indicate that the CM-site marshes are several thousand years older than marshes at the VNC sites.

All these curves cannot represent a purely eustatic rise in sea level because they differ by a meter or more at several points in time. It appears likely that, in addition to eustatic rise of sea level, differential crustal warping has occurred along this length of coast. Warping seems clearly indicated by sample ML-192. The exact nature of the warping is difficult to discern. It may be that the crust at the VNC sites has been essentially stable for the past 4500 years and that the CM sites are still undergoing postglacial isostatic rebound or some other kind of upwarp. The rate of uplift is apparently being exceeded by eustatic rise of sea level at the CM sites because there are no features indicating a later Holocene shoreline of emergence. It is also possible that the five localities are subsiding differentially, or that the crust at Virginia, New Jersey, and Cape Cod is subsiding while the CM sites are rising at rates less than the eustatic rise. There is evidence of local structural uplift at the mouth of Chesapeake Bay (*11*) and in the Wachapreague locality more than 4500 years ago. Still another possibility is differential depression of the edge of the continental block by water loading during postglacial submergence (*12*).

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5. These ages apparently confirm a prediction of Kay and Barghoorn (*3*) concerning the effect of root contamination.
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13. The work, carried out by the Institute of Marine Science, University of Miami, was supported by NSF grant GP-887. W.S.N. was supported by NSF grant GE-471. Craig Munsart drew the figures. Contribution 159 from the Virginia Institute of Marine Science.

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Radiocarbon Age of a Nevada Mummy

Abstract. *Skin tissue, bone collagen, and vegetal clothing from a well-preserved Indian mummy from a dry cave in Nevada have been analyzed radiochemically. The age is about 2500 years; the ages obtained for the various samples were in close agreement.*

A well-preserved mummy, commonly referred to as Whiskey Lil (Fig. 1), was discovered in 1955 in Chimney Cave, Lake Winnemucca, Nevada. Chimney Cave is one of the shallow sea caves formed along the shore of Pleistocene Lake Lahontan that became habitable by man when the lake level fell 11,400 years ago (*1*). It was used intermittently until about 1500 years ago. The area is now inhabited by the Northern Paiutes, whose exact time of arrival is unknown. The good preservation of skin, basketry, matting, cordage, and other perishables associated with the mummy is due to the extremely dry desert air.

The mummy is that of an adult female, cranial index 76.1, buried in a tightly flexed position; the face is to the side and the head pointed NNE. Apart from the face, most of the skin is intact, though withered. The hair has been devoured by dermestid beetles, but preservation of nails and "finger prints" is excellent. Around the waist of the body are twisted strips of rabbit skin and a fringed apron made of cord. A small bag or "compact" of mountain sheepskin was x-rayed, but contained no dense objects. The body was wrapped in a poorly tanned mountain-sheep hide with no decorations and was covered with a loosely woven blanket or mat of cedar bark.

Burial was accomplished by digging a shallow hole in the floor of the cave, which disturbed another burial beneath. The wrapped body was then left on the surface, and during the next 2500 years windblown dust and rat debris covered it to a depth of a