Quaternary Science Reviews xxx (2010) 1–9

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Late Pleistocene upland stratigraphy of the western Delmarva Peninsula, USA

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ARTICLE INFO

Article history:
Received 7 October 2009
Received in revised form
2 March 2010
Accepted 9 March 2010

ABSTRACT

New pedological, geological, archaeological, and geochronological data from the Miles Point site in eastern Maryland are compared with similar data from other nearby sites to develop a framework for interpreting the upland stratigraphy in the western Delmarva Peninsula. Our results indicate the presence of two different intervals of loess deposition. The earlier loess (Miles Point Loess) was deposited between 41 and 25 ka. A paleosol (Tilghman Soil) formed in this loess was initially developed in grasslands and boreal environments during a subsequent period of landscape stability between 25 and 18 ka. Between 18 and 12.8 ka, the Miles Point Loess and the Tilghman Soil were eroded in many areas as evidenced by diagnostic ca. 12.8 ka Clovis-age artifacts lying unconformably on the Tilghman Soil. Cores adjacent to the deep channel area of the Chesapeake Bay confirm this erosional unconformity prior to 12.7 ka. A relatively uniform terminal-Pleistocene loess (Paw Paw), deposited prior to the Early Archaic period, buried Clovis-age lag artifacts and other archaeological remains older than 13.2 ka. Stratigraphic evidence from the Late Pleistocene lower Susquehanna River Valley suggests that the Paw Paw Loess is the result of eolian redeposition and reworking of non-glacial eroded upland sediments that filled the valley between 12.7 and 11.5 ka.

1. Introduction

Thin deposits of primarily silt-sized sediments, typically less than 1 m thick, blanket much of the uplands of the western half of the Delmarva Peninsula (Fig. 1). In many areas, erosion via both natural processes and historic agricultural activity has resulted in discontinuous cover or local deposits of varying thickness (Simonson, 1982). Thus, these surface sediments are often difficult to map and/or interpret geologically on a regional scale. In areas with large exposures, mostly in incised valleys and along coastal bluffs, these silt strata rest atop sequences of Pliocene, Miocene, and Pleistocene shallow marine to estuarine deposits (Shattuck, 1906). Consequently, many of the 20th century geologic interpretations of these silty strata have associated their origin with Quaternary fluvial terraces and/or estuarine sediments deposited during periods of high sea level (e.g., Shattuck, 1906; Miller, 1926; Rasmussen and Slaughter, 1957). Subsequent interpretations, built on these ideas, suggest that the silts were additionally entrained and redeposited by eolian processes during sea level lowstands (e.g., Carey et al., 1976; Owens and Denny, 1979). More recent soil and sedimentological analyses indicate a broader regional expanse of these sediments and support a purely wind blown origin with parent material derived from glacial outwash from the Susquehanna River during and after the Last Glacial Maximum (Reybold, 1970; Foss et al., 1978; Lowery, 2002; Wah, 2003; NRCS, 2009). However, these studies lack the detailed geochronological data necessary to definitively support an eolian source for these upland sediments in the context of Late Pleistocene and Holocene sea level rise (see Nikitina et al., 2000).

In this study, we use pedological, geological, and archaeological data, constrained by radiocarbon and optically stimulated luminescence (OSL) dates, to provide a geochronological framework for the timing of two Late Pleistocene episodes of loess deposition, each followed by a period of soil formation during landscape stability. Our results provide new information regarding the depositional and paleo-environmental conditions for a poorly understood Late Quaternary landscape of the Middle Atlantic U.S.A.

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doi:10.1016/j.quascirev.2010.03.007

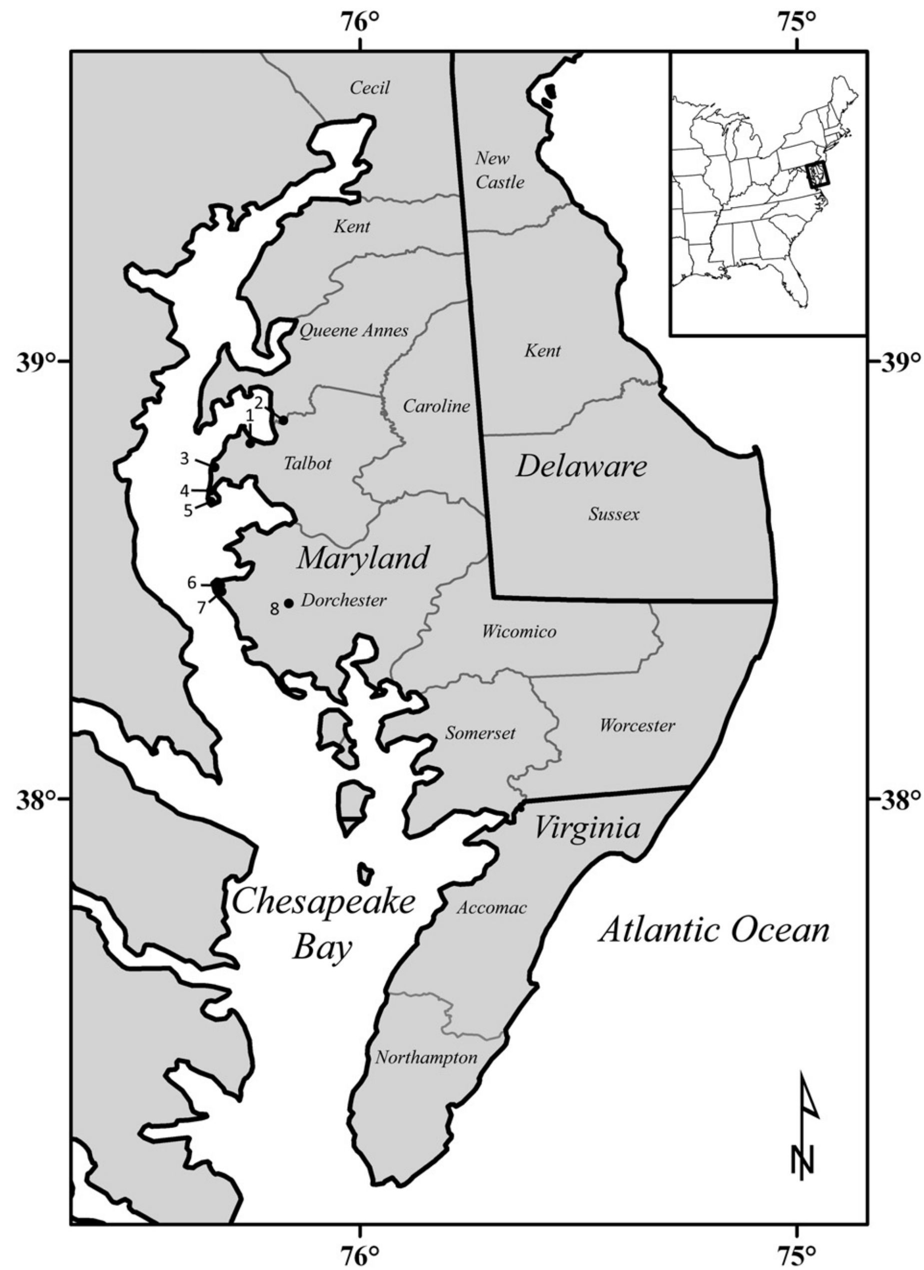

Fig. 1. Map of the Delmarva Peninsula displaying county names and the location of the Miles Point study site (1) and other locations discussed in this study, (2) Wye Island, (3) Crane Point, (4) Paw Paw Cove, (5) Blackwalnut Point, (6) James Island, (7) Oyster Cove, and (8) Blackwater Wildlife Refuge. Inset map shows the study area in the context of the eastern U.S.A.

2. Study area

The data collected for this study are from a bank, 2 m in height, and the adjacent terrace in the intertidal zone of the Miles River in western Talbot County, Maryland (Figs. 1 and 2). The exposed bank and associated archaeological site (18TA365) are located along the modern coastline and are in a heavily eroded agricultural field with the modern soil mapped as Typic Hapludults and Aquic Hapludults (NRCS, 2009). Although now part of an eroding coastal setting, this site was an upland interfluve during the Late Pleistocene and early Holocene (United States Geologic Survey, 1983).

The primary focus of this manuscript pertains to data collected from the Miles Point site; however, data from several other Maryland locations in western Talbot, Queen Annes, and northwestern Dorchester Counties are also discussed (see Fig. 1). All three counties are located to the east of the Chesapeake Bay within what is known as the "Eastern Shore" of Maryland. Each county lies entirely within the Atlantic coastal plain physiographic province and has natural exposures of Miocene to Quaternary age deposits. The sites discussed are almost completely surrounded by estuaries and small tidal bays with the highest elevation in each county only slightly more than 21 m above sea level. The western portion of Talbot County, which is the focus of this study, is less than 3 m above sea level.

3. Methods

Soil descriptions were compiled in the field from three locations along the approximately 15 m-long study section of the bank profile using standard USDA soil horizon nomenclature (Soil Survey

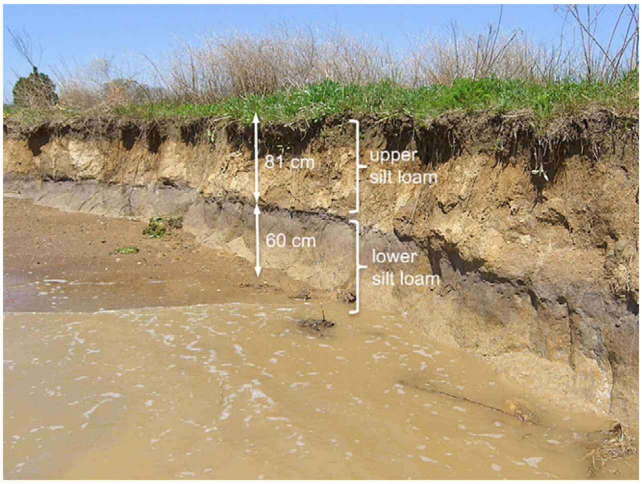

Fig. 2. Photograph of the eroding bank at the Miles Point study site showing the exposed thickness of our two silt loam deposits. A paleosol, developed in the lower deposit, defines the contact between these two units.

Staff, 1992). As a test of the lateral continuity of the exposed soil profiles, 100 split-spoon augur samples from 5 inland transects perpendicular to the current shoreline were collected to a depth of 1.25 m. Auger samples were collected every 5 m over each of the five 50-m-long transects.

To provide geochronological control for the study site, 8 sediment cores were retrieved from silt units for OSL dating. The OSL samples were obtained by hammering plastic tubes into cleaned sections of the bank profile. Once removed the tubes were sealed and placed in sampling bags. All OSL samples were processed at the Luminesence Dating Research Laboratory at the University of Chicago using the multiple aliquot regenerative dose technique. Additionally, three charcoal samples and one bulk soil sample were collected from an organic rich stratum for accelerator mass spectrometry (AMS) radiocarbon dating. Beta Laboratories processed all radiocarbon samples. Note that the laboratory identification numbers are presented in Section 4 next to the date provided for each sample.

In areas where potential anthropogenic materials were identified, the profile wall was excavated as a 1 m by 0.5 m unit in 10 cm intervals, with an attempt to follow the natural stratigraphy. All materials were water screened using 0.325 cm (1/8 inch) mesh. Bulk sediment samples were collected adjacent to cultural remains to identify the presence of materials that may be used as environmental indicators (i.e., woody debris, plant microfossils, hair, etc.).

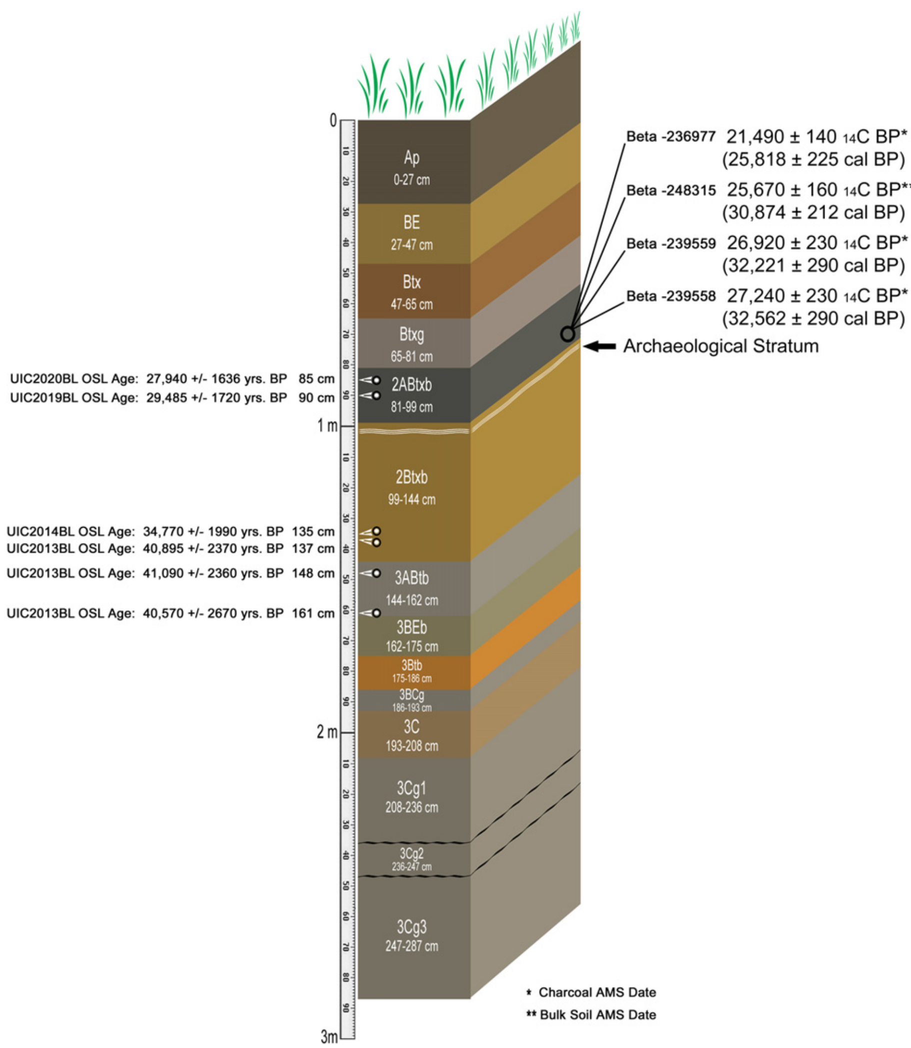

Fig. 3. The stratigraphic profile at Miles Point with soil descriptions, radiocarbon sample locations and ages, and OSL sample locations and ages.

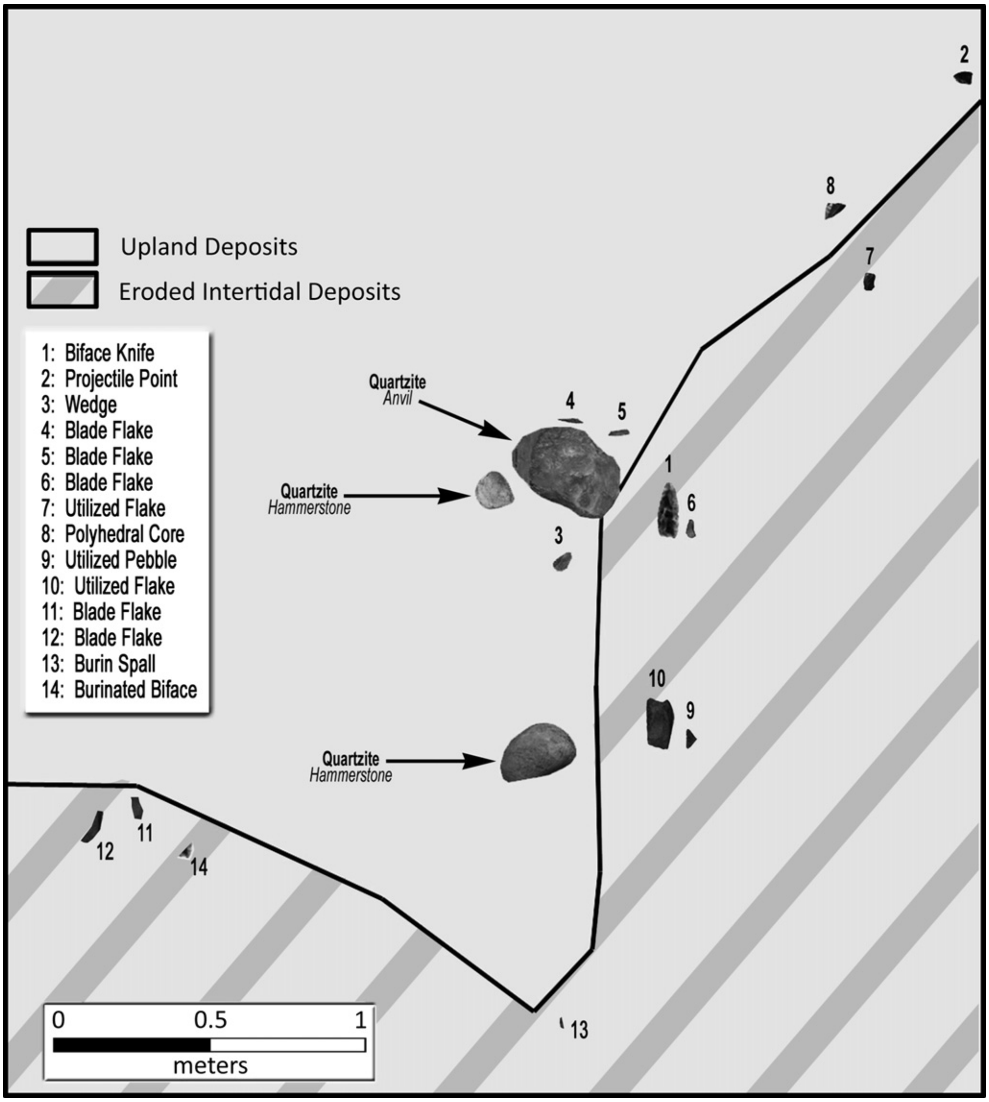

Fig. 4. Plan view of the Miles Point site showing the location of artifacts retrieved from along the eroded shoreline. Note that the site is on private property and the exact location remains confidential.

4. Results

Soils at Miles Point and other locations in the study area are multisequal and exhibit very strong subsoil development. Soils formed in two silt loam deposits overlie a third basal, fine-sandy sequum formed in either fluvial/estuarine sediments or possibly coarse eolian deposits (Fig. 3). Pedogenic welding of the successive sediment packages has resulted in somewhat complex labeling for buried surface horizons. In a representative profile, simple horizonation exists only for the soil formed in Paw Paw Cove Loess consisting of a surficial Ap horizon to 27 cm, a transitional BE horizon to 47 cm, and combined Btx and Btxg horizons to 81 cm, at which depth the second sequum formed in the underlying silts begins. Its surface has been fused with the overlying subsoil and is identified as a 2ABtxb horizon extending to 99 cm. Below this buried surface a 2Btxb horizon then extends to contact with the second buried and welded surface (3ABtb) at 144 cm, beneath which subsoil development ranges through normal horizonation (3BEb–3Btb–3BCgb) to largely unweathered sediments at 193 cm. Examination of auger samples that were retrieved to the level of the 2ABtxb horizon revealed that similar soil composition carries across the landscape; the representative profile described above is depicted in Fig. 3.

A scatter of artifacts was excavated directly beneath the 2ABtxb soil horizon. The location of artifacts that were eroded from the exposed bank profile is plotted with respect to the *in situ* artifact cluster (see Fig. 4). The artifacts excavated or mapped *in situ* include a large rounded quartzite anvil, two quartzite hammerstones, a chert bifacial lanceolate projectile point, a quartzite wedge or bipolar core, two unifacial retouched quartzite blade flakes or spalls, and a small chert polyhedral blade core (see Fig. 5). The artifacts eroded from the profile include a silicified sandstone bifacial knife, a unifacial retouched chert blade flake, a retouched chert flake, a split chert pebble with possible utilization scars, a large retouched basalt flake, two quartzite blade flakes, a possible burin spall, and a burinated chert biface fragment. The *in situ* artifacts appeared to be in their original stratigraphic position. All of the exposed and excavated artifacts were located at the same relative depth and were lying flat with respect to the overlying 2ABtxb soil horizon. The uniform depth and orientation of the artifacts does not suggest they are bioturbated and mixed.

The six OSL samples collected from our site yield the following age estimates: 27,940 ± 1635 BP to 29,485 ± 1720 BP for the 2ABtxb soil horizon; 34,770 ± 1990 BP and 40,895 ± 2370 BP for the base of the 2Btxb soil horizon; and 41,090 ± 2360 BP and 40,570 ± 2670 BP

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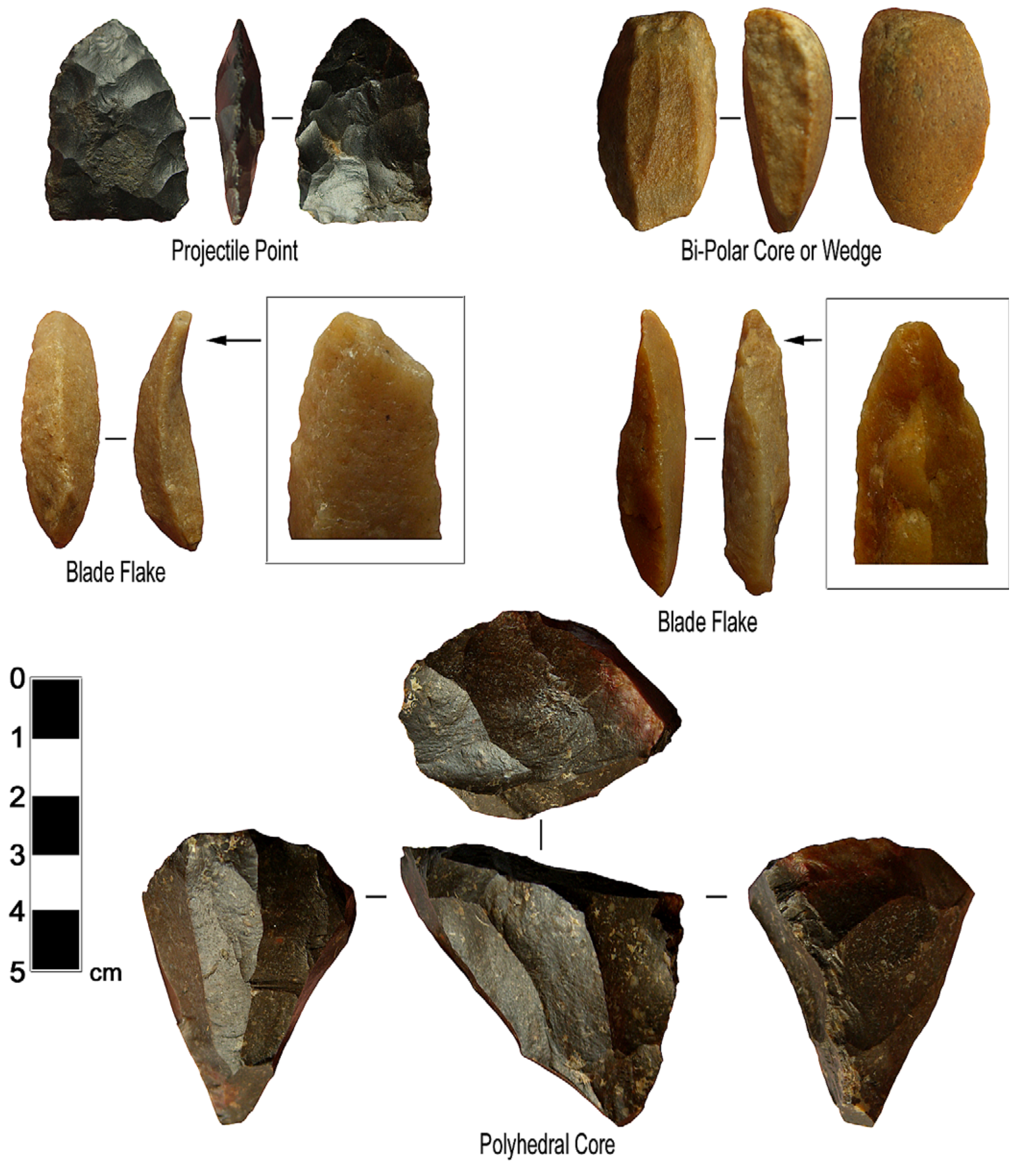

Fig. 5. A selection of the Paleo-American artifacts found *in situ* at Miles Point directly beneath the 2ABtxb soil horizon.

from the surface and the base of the 3ABtb soil horizon, respectively (see Fig. 3). The three accelerator mass spectrometry dates on carbonized plant material from the 2ABtxb paleosol provided age estimates of 25,818 ± 225 cal BP (21,490 ± 140 ^{14}C BP; Beta-236977), 32,221 ± 290 cal BP (26,920 ± 230 ^{14}C BP; Beta-239559), and 32,562 ± 290 cal BP (27,240 ± 230 ^{14}C BP; Beta-239558). The bulk organic matter from the 2ABtxb soil horizon provided an age estimate of 30,874 ± 212 cal BP (25,670 ± 160 ^{14}C BP; Beta-248315). Note that all radiocarbon calibration ages were completed using the curve presented in Fairbanks et al. (2005).

Soil samples collected from the 2ABtxb paleosol, above the zone with the artifacts, contained carbonized wood fragments and a large quantity of hair. Scanning electron microscopy (SEM) analyses of these materials indicated the wood fragments were of krummholz yellow birch (*Betula alleghaniensis*), red spruce (*Picea rubens*), and balsam fir (*Abies balsamea*), and the hairs were from the families *Canidae*, *Felidae*, and an unidentifiable source (Dr. Barrett Rock, pers. com.). Note that the krummholz or "twisted wood" is a growth form exhibited by trees at locations of continued exposure to environmental stress, such as high wind. There was no evidence of recent or old animal burrows, or rodent tunnels, detected in the bank profile to suggest a recent deposition of the hair follicles. The bulk soil date from the horizon from which they were collected is the 25,670 ± 160 ^{14}C BP reported in the previous paragraph.

5. Discussion

Although there is an extensive body of literature regarding Late Quaternary surface sediments at individual sites within western Delmarva, there are few data that provide a unifying framework for their geochronological and environmental interpretation. Because Miles Point has the most complete stratigraphic sequence (i.e., two paleosols and two inferred loess units) with extensive geochronology based on OSL and radiocarbon dating, and artifact assemblages, it provides the basis by which other regional data can be compared. When the data from Miles Point are interpreted in the context of similar stratigraphies at other well-studied archaeological sites in which there are two silty strata separated by an eroded paleosol, we are able to develop a regional chronostratigraphy for

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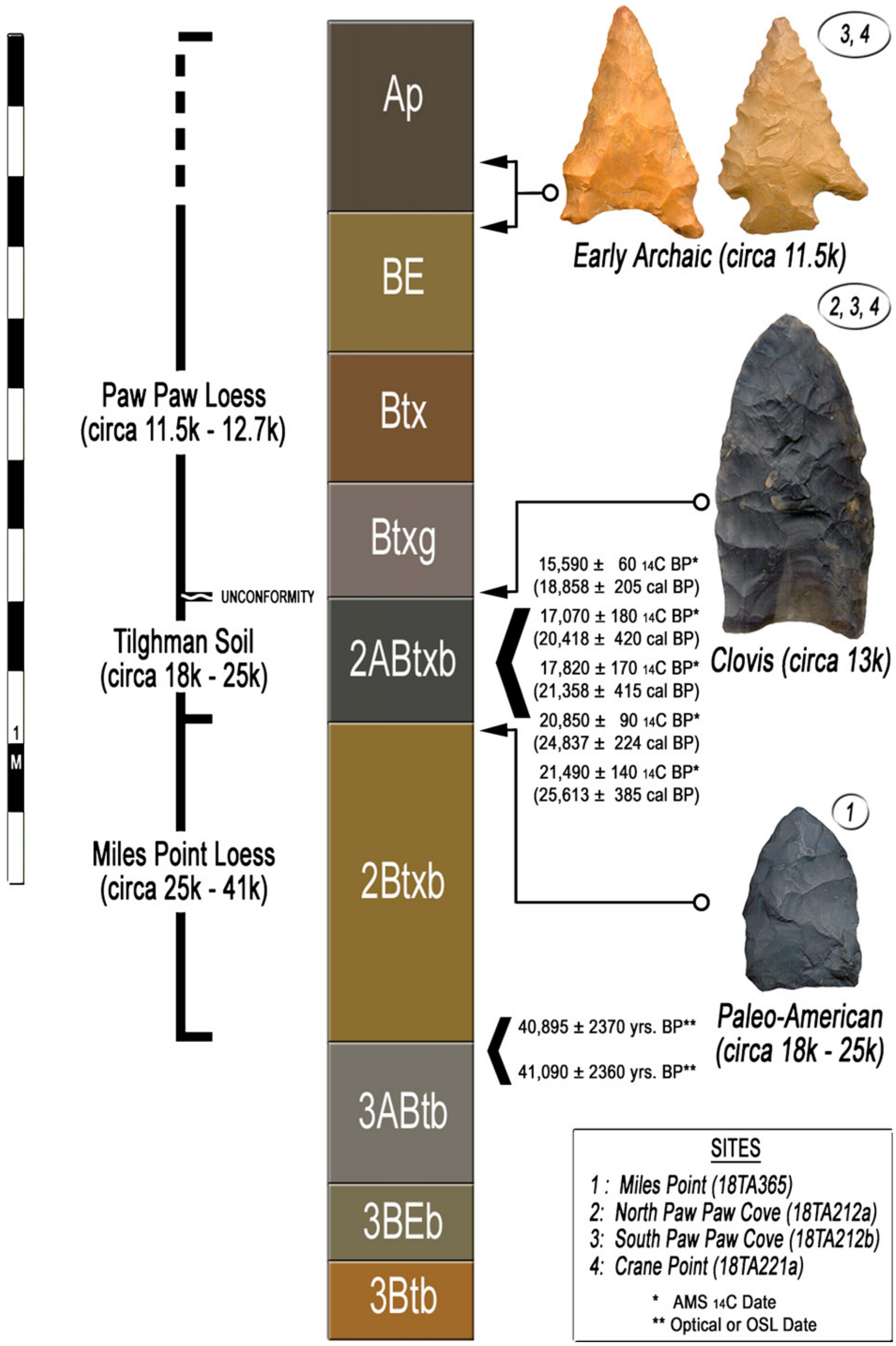

Fig. 6. A synthesis of western Delmarva pedological, archaeological, and geochronological data.

the western Delmarva Peninsula that spans the last 40,000 years (Fig. 6). Note that these correlations are between Miles Point and the following sites with similar stratigraphic and archaeological data shown in Fig. 1: Wye Island (Wah, 2003), Crane Point (Lowery and Custer, 1990), Paw Paw Cove (Lowery, 1989, 1990, 2007), Blackwalnut Point (Wah, 2003), James Island (Wah, 2003), Oyster Cove (Wah, 2003), and Blackwater Wildlife Refuge (Walker, 2007), and Mockhorn Island (Finkelstein and Kearney, 1988; Lowery, 2003).

The paleosol at the base of the Miles Point profile (3ABtb) documents the oldest reported, Late Pleistocene paleosol in the study region (see Fig. 6). The ca 40,000 year old OSL dates from the bounding silt and sand strata bracket its age, which correlates to the early portion of marine Oxygen Isotope Stage 3 when sea levels in the Middle Atlantic were roughly 30 meters lower (Sheridan et al., 2001; Wright et al., 2009). Thus, it likely that this soil formed in an upland landscape, an interpretation supported the wet-boreal forest macro material found in ca. 35,000-year-old peat deposits on nearby Mockhorn Island (Finkelstein and Kearney, 1988).

Overlying the 3ABtb paleosol at Miles Point is approximately 0.63 m of silty sediments, which we designate as the “Miles Point Loess”. Although this loess has been well documented in all of the aforementioned sites in Queen Annes, western Talbot, and

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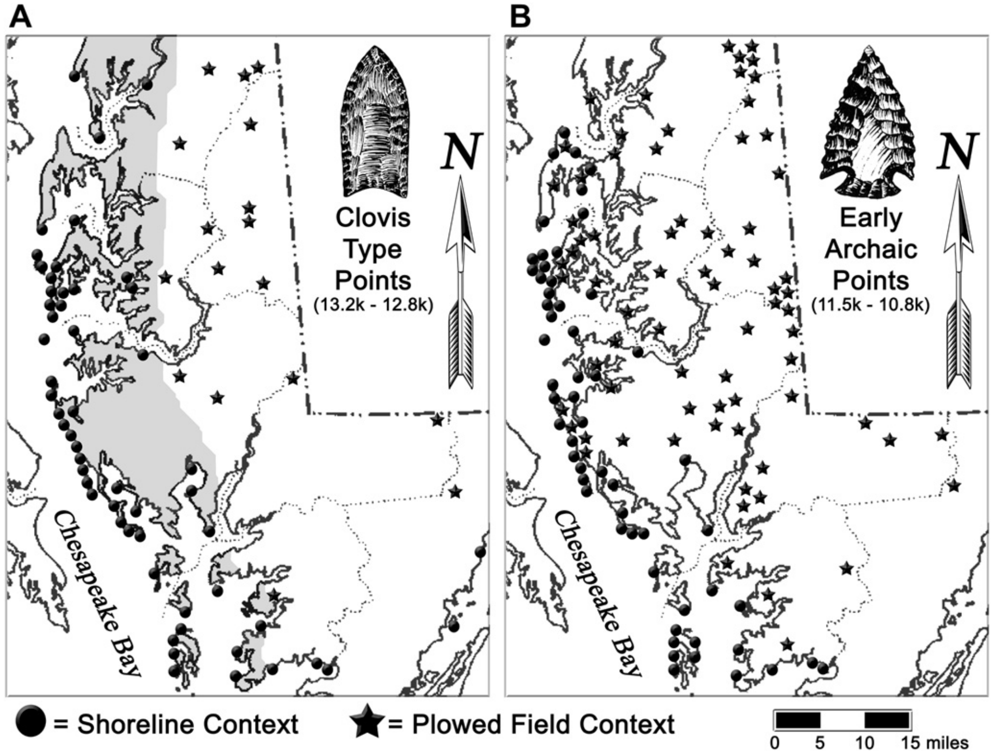

Fig. 7. The regional discovery contexts of (A) Paleoindian-age diagnostic artifacts compared to the discovery contexts of (B) Early Archaic-age diagnostic artifacts. Note a recognizable pattern that indirectly addresses the aerial extent of the Paw Paw Loess is shown in panel A (gray).

northwestern Dorchester Counties (see Fig. 1), it is not uniformly distributed in western Delmarva and can only be differentiated from overlying silty sediments when separated by a buried surface horizon or other definitive soil morphologic properties (Lowery, 2002; Wah, 2003). OSL dates from the underlying 3ABtb paleosol and within this loess unit, along with radiocarbon dates from the overlying paleosol, suggest that it was deposited between ca 40,000 years and 25,000 years ago. During this period, the nearby Susquehanna River was a principal meltwater channel for the southern margin of the advancing Laurentide Ice Sheet. Its discharge carried silt and fine sand southward where they were deposited along channel margins, a likely source for entrainment by westerly winds that carried them to the east.

The paleosol formed in the Miles Point Loess is designated herein as the "Tilghman Soil" because of the association with correlative units at Blackwalnut Point and Paw Paw Cove on Tilghman Island. The 2ABtxb of the Tilghman Soil at Miles Point yielded a range of radiocarbon dates from 32,562 ± 290 cal BP to 25,818 ± 225 cal BP while the correlative soil horizons at Paw Paw Cove and Wye Island yielded dates of 21,116 ± 251 cal BP (17,820 ± 170 ^{14}C yr; AA-3870) and 20,248 ± 190 cal BP (17,070 ± 180 ^{14}C yr; Beta-165424), respectively (Lowery, 2002; Wah, 2003). This range of dates for this paleosol suggests relative surface stability for a period of approximately 7000 calendar years. Samples from the Paw Paw Cove paleosol show an increase in phytoliths associated with cold-adapted grasslands with some arboreal elements, such as red spruce, balsam fir, and yellow birch, consistent with climatic expectations of this region before and/or during the Last Glacial Maximum (Wah, 2003). A lag of Clovis artifact assemblages on the 2ABtxb soil horizon at Paw Paw Cove and Crane Point suggests that the paleosol may have been much thicker and was deflated between 18,000 and 12,700 years ago.

The Clovis archaeological lag on the Tilghman Soil at Paw Paw Cove and Crane Point (Fig. 6) defines the maximum age for the onset of a second phase of loess deposition at ca 12,700 yrs BP, which is a simple correlation to the youngest dated Clovis occupation in North America (Waters and Stafford, 2007). Non-diagnostic artifacts at the Blackwater Wildlife Refuge and Oyster Cove sites on the Delmarva Peninsula (see Fig. 1; Walker, 2007; Wah, 2003) and Clovis artifacts at the Cactus Hill site in southern Virginia (Wagner and McAvoy, 2004) lie on top of buried paleosols with chronostratigraphies similar to that of Miles Point. At Cactus Hill, three radiocarbon dates on the paleosol of 16,940 ± 50 ^{14}C yr (20,132 ± 82 cal BP), 16,670 ± 730 ^{14}C yr (19842 ± 786 cal BP), and 15,070 ± 70 ^{14}C BP (18243 ± 177 cal BP) are younger than the dates obtained from similar stratigraphic units on the Delmarva Peninsula. This second episode of loess deposition covers a larger areal extent than the previous Miles Point Loess (Reybold, 1970; Foss et al., 1978; Wah, 2003). We have designated this regionally recognized silt, commonly associated with modern soil horizons, as the "Paw Paw Loess" based on the original archaeological discovery made at Paw Paw Cove on Tilghman Island. We can deduce that non-glacial sources provided the parent material, recognizing that meltwater and sediment from the Laurentide Ice Sheet no longer drained into the Susquehanna River watershed during this time. Entrainment of the thick deposits of fine sand and silt that choked the main channel of the Susquehanna at ca 12,340 years ago are a likely source for this loess (Cronin, 2000). Note that this age correlates well with the timing of the Younger Dryas climatic event (Stuiver et al., 1995; Bjorck et al., 1998).

Although there is no direct evidence for the timing of the termination of Paw Paw Loess at the Miles Point site, early Holocene age archaeological remains within and at the base of the Ap soil horizon at Paw Paw Cove, and within the BE soil horizon at Crane Point and Oyster Cove, indicate that loess deposition ceased at ca 11,500 years ago. Within the Northeast and the Middle Atlantic, Early Archaic-age corner-notched points and serrated projectile points found at Paw Paw Cove, Crane Point, and Oyster Cove are

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identical to the examples excavated at Dutchess Quarry Cave No. 8 in New York (Funk and Steadman, 1994) and at the Cactus Hill site in Virginia (McAvoy and McAvoy, 1997), which are ca 11,300 calendar years old. Plants common to the warmer conditions of the Holocene, such as pigweed, goosefoot, blackberry, grape, hackberry, hawthorn, hickory, smartweed, and winter cress, have been identified in a hearth at the Clovis-age Shawnee-Minisink site along the west bank of the upper Delaware River in Pennsylvania; these data suggest that the regional environment may have been relatively warm and wet by 13,200 years ago (Gingerich, 2007).

The archaeological data not only provide geochronological control, but also yield insight into the nature of loess deposition for the study region. Examining the regional discovery contexts of Paleoindian-age diagnostic artifacts compared to the discovery contexts of Early Archaic-age diagnostic artifacts reveals a recognizable pattern that indirectly addresses the aerial extent of the Paw Paw Loess (see Fig. 7). In the northwestern section of the Delmarva Peninsula, adjacent to the modern Chesapeake Bay and 15 miles east of the shoreline, Early Archaic-age Charleston-Palmer notched points have been found within the plowed fields and along the eroded coastline. In the same area, Paleoindian-age Clovis points have been found only along eroded coastlines. Because Clovis points have not been found in tilled fields within the northwestern section of Delmarva, it is assumed that the Paleoindian-age archaeological sites are present, but buried beneath the Paw Paw Loess. Erosion along the coastline is the only way these sites are exposed to archaeologists.

6. Conclusions

The luminescence and radiometric summaries we present suggest that the blanket of silty sediments on the northwestern Delmarva Peninsula was deposited on an upland landscape between 41,000 and 13,000 years ago during a period of lower sea levels than present. Our collective data allow us to develop a framework for interpreting the timing of two different intervals of loess deposition, extended periods of landscape stability during which soils formed, and widespread erosional events for the northwestern Delmarva Peninsula. Correlation of our data with those at other regional locations has also permitted us to formally define the loess deposits and paleosols. The earliest loess, named here as the Miles Point Loess, was deposited between ca 41,000 and 25,000 years ago. The paleosol formed in this loess, named here as the Tilghman Soil, was developed in a grassland environment with some boreal elements during a subsequent period of landscape stability between ca 25,000 and 18,000 years ago. The Paw Paw Loess, which is relatively uniform terminal-Pleistocene loess, was deposited after Clovis and prior to the Early Archaic period, at ca 12,700–11,500 years ago. The Paw Paw Loess buried the lag of Clovis-age artifacts and other archaeological remains greater than 13,200 years old. The geoarchaeological investigations within the uplands of the northwestern Delmarva Peninsula indicate that Late Pleistocene and Early Holocene age archaeological sites are essential for defining the timing and duration of Paw Paw Loess deposition.

The local expression of a Younger Dryas-age loess deposit along the northwestern sections of the Delmarva Peninsula seems to be a by-product of several interrelated variables (e.g. upland erosion, climate change, isostatic adjustments, and sea level rise). Thus, it reflects a localized eolian redeposition of the accumulated fine-sediment within the lower Susquehanna floodplain into the uplands in which we do not suggest a dominant forcing. With respect to the timing, abruptness, and the expression of North American loess events, the Delmarva loess record is temporally more restricted and much thinner than the long-lasting and meters-thick Middle to Late Pleistocene sequences documented in the mid-continental and western United States (e.g., Ruhe, 1983; Bettis et al., 2003; Mason et al., 2008; Roberts et al., 2003).

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Please cite this article in press as: Lowery, D.L., et al., Late Pleistocene upland stratigraphy of the western Delmarva Peninsula, USA, Quaternary Science Reviews (2010), doi:10.1016/j.quascirev.2010.03.007

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Please cite this article in press as: Lowery, D.L., et al., Late Pleistocene upland stratigraphy of the western Delmarva Peninsula, USA, Quaternary Science Reviews (2010), doi:10.1016/j.quascirev.2010.03.007