Preliminary Ground Penetrating Radar and Geomorphologic Investigation of the Highly Incised Mappsville Escarpment of Northern Accomack County (Wallops Island National Wildlife Refuge), Eastern Shore, Virginia

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Abstract

The Pleistocene stratigraphic record of the Eastern Shore, Virginia (just south of the MD-VA line) is the focus of this study. Rising sea levels and recent erosion have exposed bluffs on the shore of Chincoteague Bay (SW of Greenbackville, VA). These strata were mapped as the post-Pliocene Accomack Member of the Omar Formation, and overlying Joynes Neck Sand by Mixon (1985). Even though these strata have been documented through core and some limited upland exposures, their age, geologic origin, and significance relative to glacial-interglacial chronologies remains poorly resolved. We have identified at least five distinctive depositional units in these exposures suggesting complex environmental histories. These are not yet well-aligned with core descriptions of Mixon who interprets the unit as a transgressive barrier island sequence. In contrast, Groot and others (1990) suggested the Omar represented multiple transgressive/regressive cycles. Our studies concur based on both GPR and field evidence.

Lidar mapping of the eroding bluffs shows these geomorphic features align with and are located immediately adjacent to a NE-SW-oriented geomorphic feature mapped as the Metomkin Scarp further south (Mixon 1985). However, several distinctive scarps merge northward and are likely composited or stacked in northern Accomack County. So herein, this scarp is referred to informally as the "Mappsville" scarp (not to be confused with the Mappsburg scarp further south) until regional relationships can be established. The scarp forms the western boundary of modern coastal bay marshes in the northern Mid-Atlantic Bight. This pilot study reports on the first Ground Penetrating Radar (GPR) investigation of the scarp at Wallops Island National Wildlife Refuge. Although work is ongoing, the newly obtained GPR datasets are being investigated in tandem with sediment data from Powell's Creek bluff and from Swan's Gut/Sinnickson bluff. The presence of a newly recognized paleosol (here named the Powell's Creek) and overlying lagoon deposit both located above modern sea-level suggest an MIS 5e age (or possibly older). Although further investigation is needed, this work is already providing additional insights necessary to resolving the record of environmental change on the Eastern Shore prior to the onset of the Holocene rise.

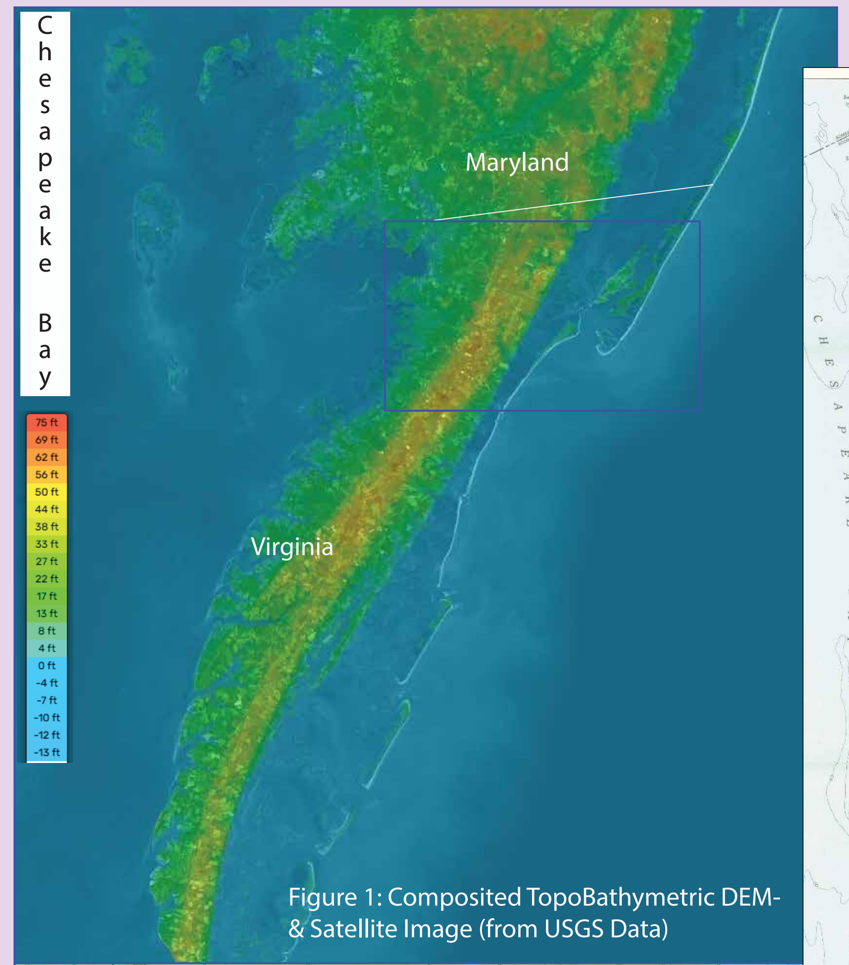

Figure 1: Composited TopoBathymetric DEM- & Satellite Image (from USGS Data)

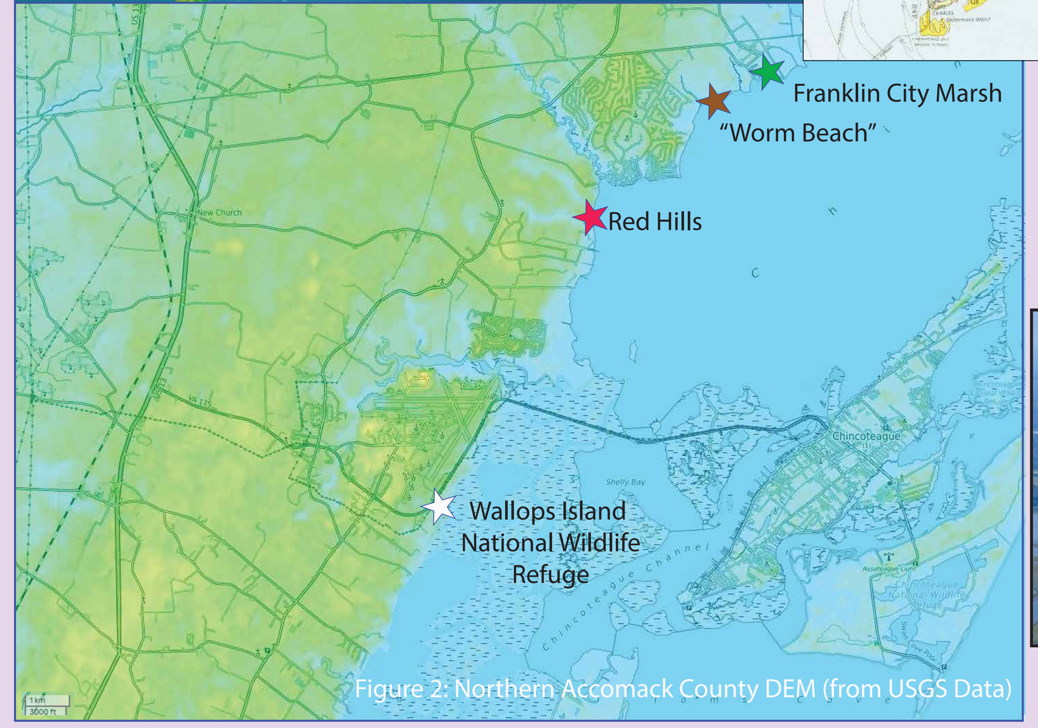

Figure 2: Northern Accomack County DEM (from USGS Data)

Study Area & Geologic Setting

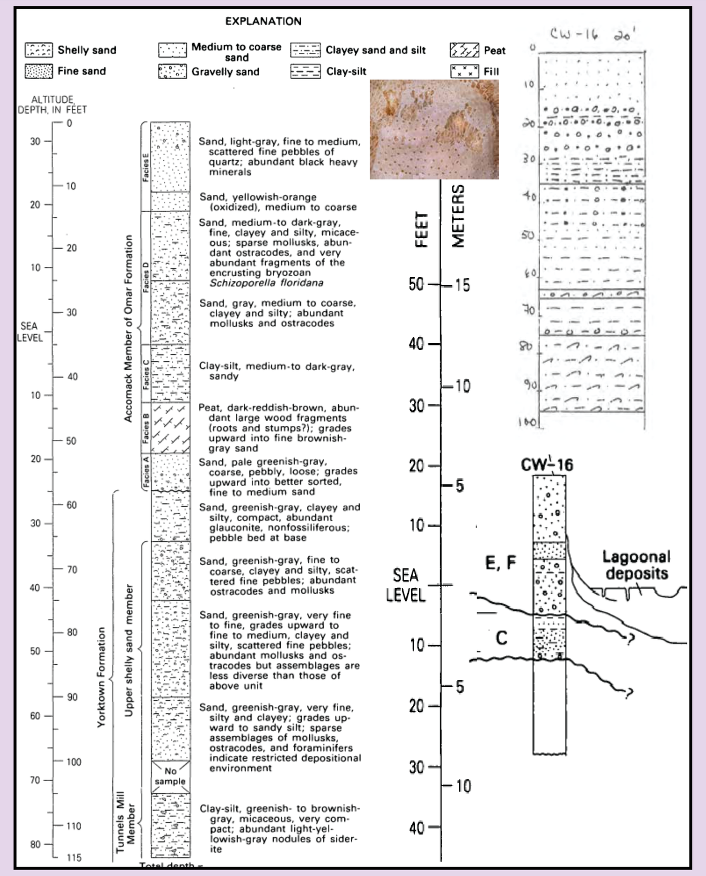
Figure 8: Generalized stratigraphic column from Mixon 1985 (left) and drafted section of core CW-16 (right) from WINWR

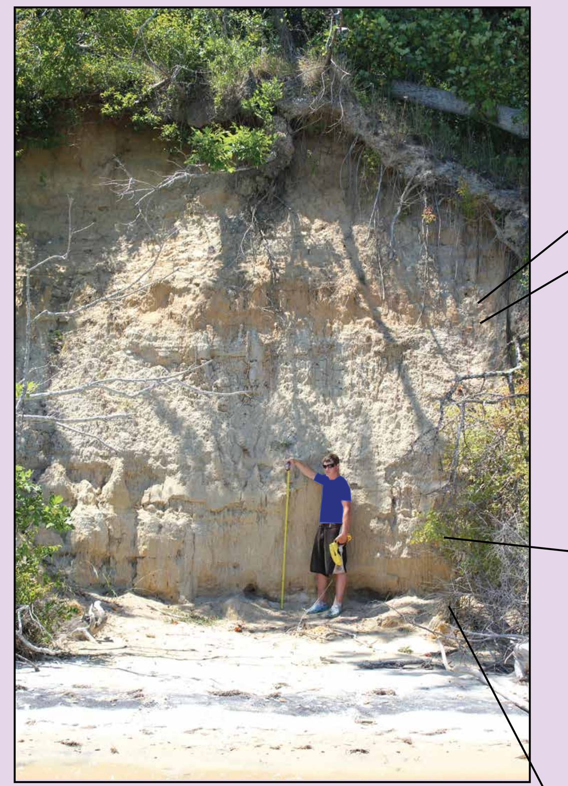
Figure 9: Red Hills Outcrop NE of WINWR, ~20' section of Upper Omar Formation (Facies D & E of Mixon)

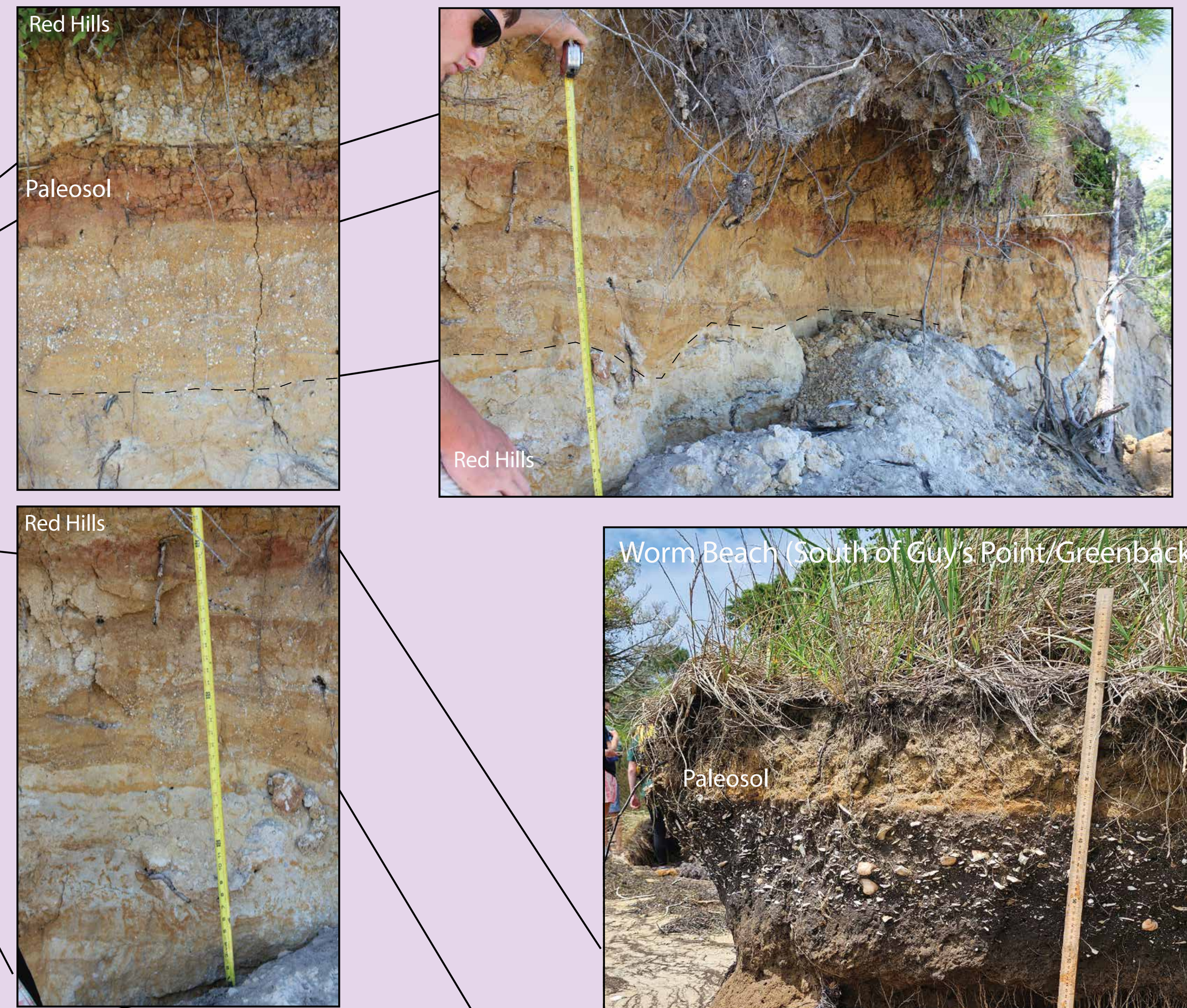

Figure 10: Outcrop Photo from "Worm Beach" SW of Greenbackville Marine and Guy's Point. Section is exposed in 1.5 meter high bluff. 3 major units are expressed, including at least 1 paleosol horizo in this section which sits on an organic-rich shelly clay-silt unit. Is this Facies C of Mixon? This unit has not been recognized further south at Red Hills.

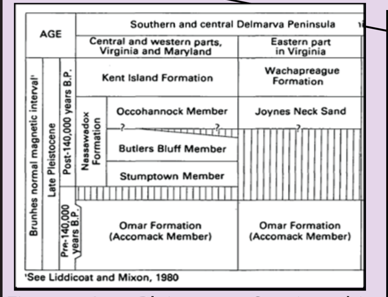
Figure 7: Late Pleistocene Stratigraphic Units of VA Eastern Shore


Red Hills Core (Below High Tide)

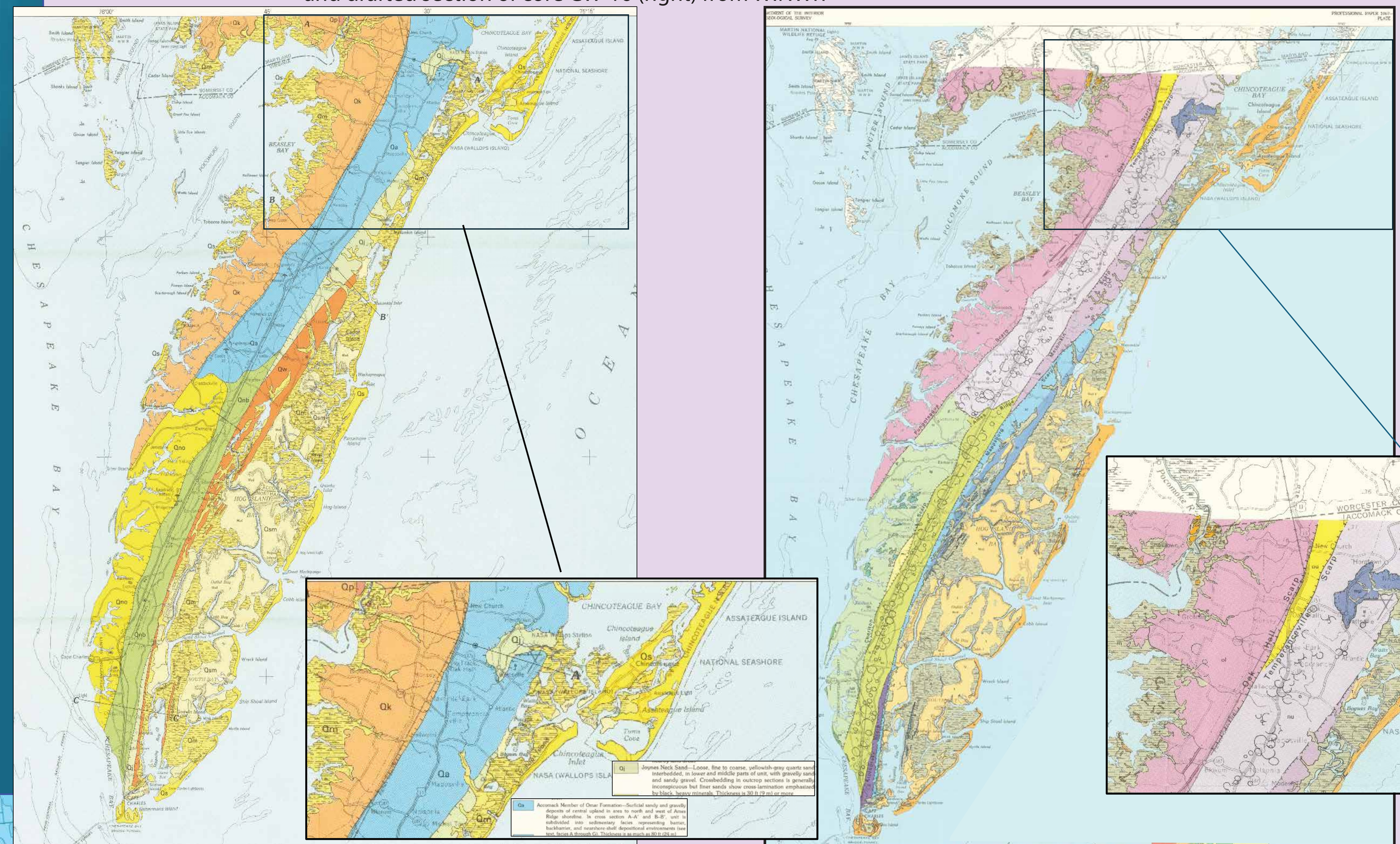

Figure 3 & 4: Geologic (above left) and Geomorphic (above right) Maps of the Eastern Shore of Virginia. The study area in Northern Accomack County formed by both elongation of the Delmarva Peninsula to SSW by barrier spit progradation as well as widening of the spit due to onlap during transgressive phases of the late Pleistocene to Holocene interval (from Mixon, 1985). Several key escarpments are recognized on both the western and eastern sides of the central Delmarva Ridge (spit). These escarpments appear to be oldest to the north and young to the south. During glacial advance, sea level fall coupled with glacial bulge uplift led to incission and erosion of interglacial highstand deposits. This study focused on the stratigraphic units mapped as the Omar Fm. and the Joyne's Neck Sand (see Figures 6 & 7). Mixon (1985) recognized an unconformity between the older Omar and younger Joynes Neck Sand).

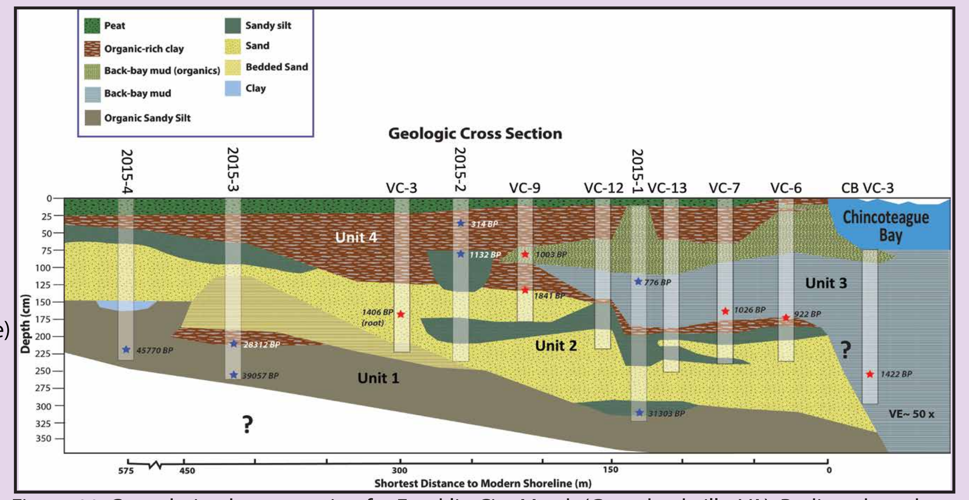

Figure 11: Core-derived cross section for Franklin City Marsh (Greenbackville, VA). Radiocarbon dates are provided for several of the units sampled from the subsurface. Deepest unit lies ~2 meters below sea-level. The oldest dates from unit 1 are ~45,770 ybp and were deposited during MIS 3 (as sea levels would have been regressing during onset of the Wisconsin Glaciation. (From Oakley et al., 2018). Units 2, 3, and 4 all onlap unit 1 as part of the Holocene transgression emplaced during MIS 1. The stratigraphic relationship between Unit 1 here is still unknown relative to the units exposed at Worm Beach.


Figure 5: Aerial photo of the Mappsville/Metompkin Escarpment and the Holocene (foreground) Lagoons behind Wallops Island. Wallops Island National Wildlife Refuge, NASA Wallops and other sites are identified. (Photo courtesy of Patrick J. Henderson Highcamera.com)

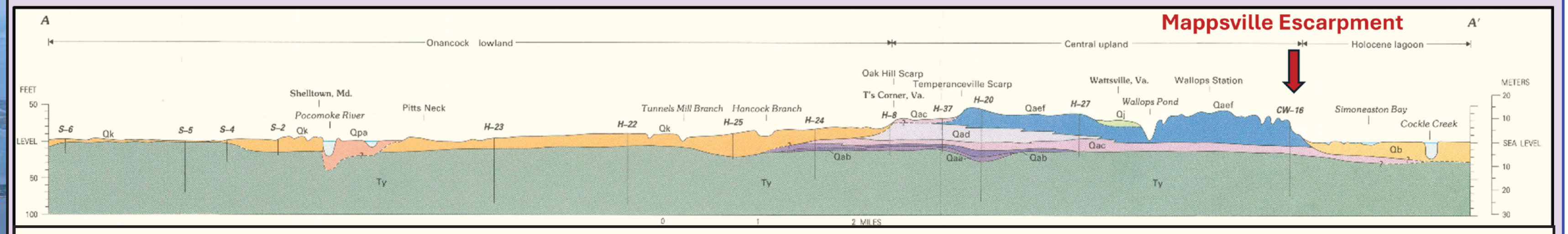

Figure 6: Geologic cross section (W to E) across northern Accomack County, Virgnia and Southern Maryland. Section (from Mixon 1985) crosses the Wallops Island Refuge and core CW-16 (Chincoteague West Core) of Hess (1980) and Mixon (1985) was taken at the location where GPR data were collected from the nothern terminus of the Mappsville Escarpment which is tentatively correlated with the Metompkin Escarpment further south (see Figure 4).

Geophysical Methods & Data Assessment

Figure 12: Aerial photo of the Wallops Island National Wildlife Refuge and locations where GPR radargram transects were collected.


Figure 13. Photos of Mala X3M GPR system outfitted with 250 Mhz shielded antenna. Kutztown University Students helped to clear debris and collected the data in spring of 2024. Ground Vision software was used.

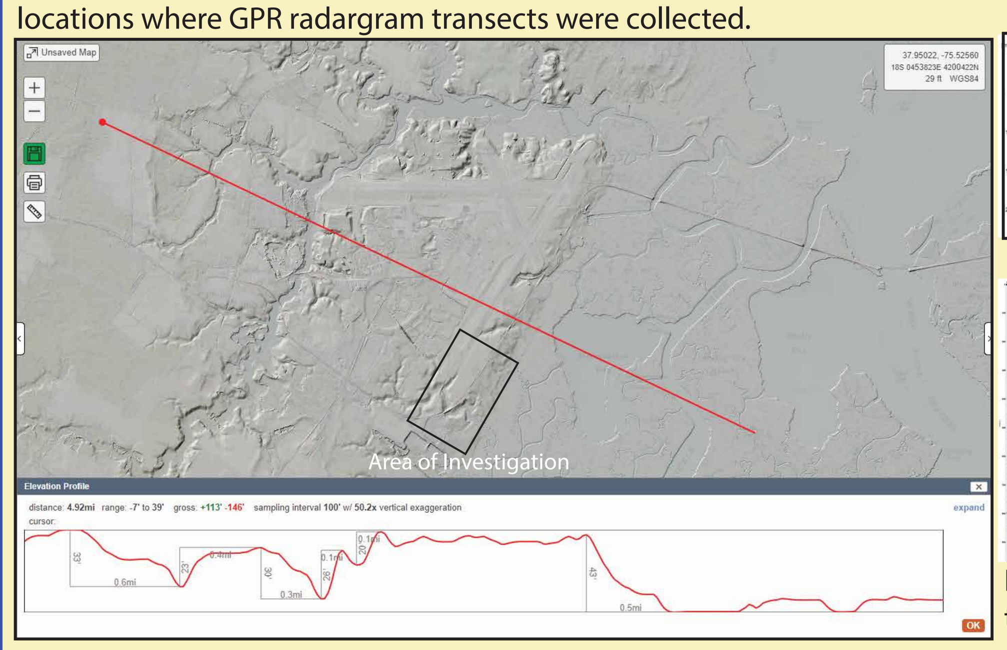

Figure 14: Digital Elevation Model and Topographic Profile of NASA Wallops mainland site and the WINWR. Inset shows location of the aerial photo and area of geophyiscal investigation. (Profile extracted from Cal Topo).

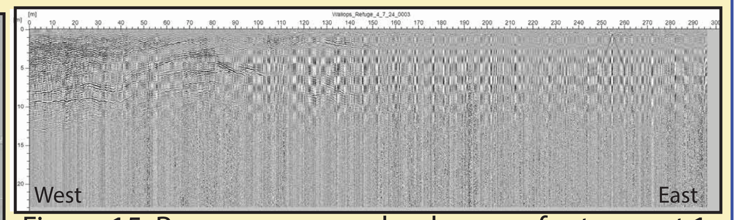

Figure 15: Raw, unprocessed radargram for transect 1.

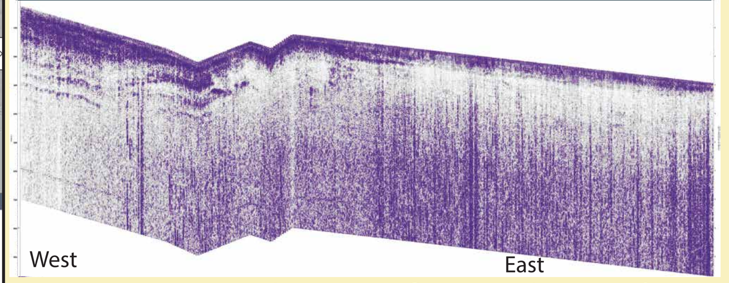

Figure 16: Processed (using ReflexW) radargram for transect 1. Elevation was corrected.

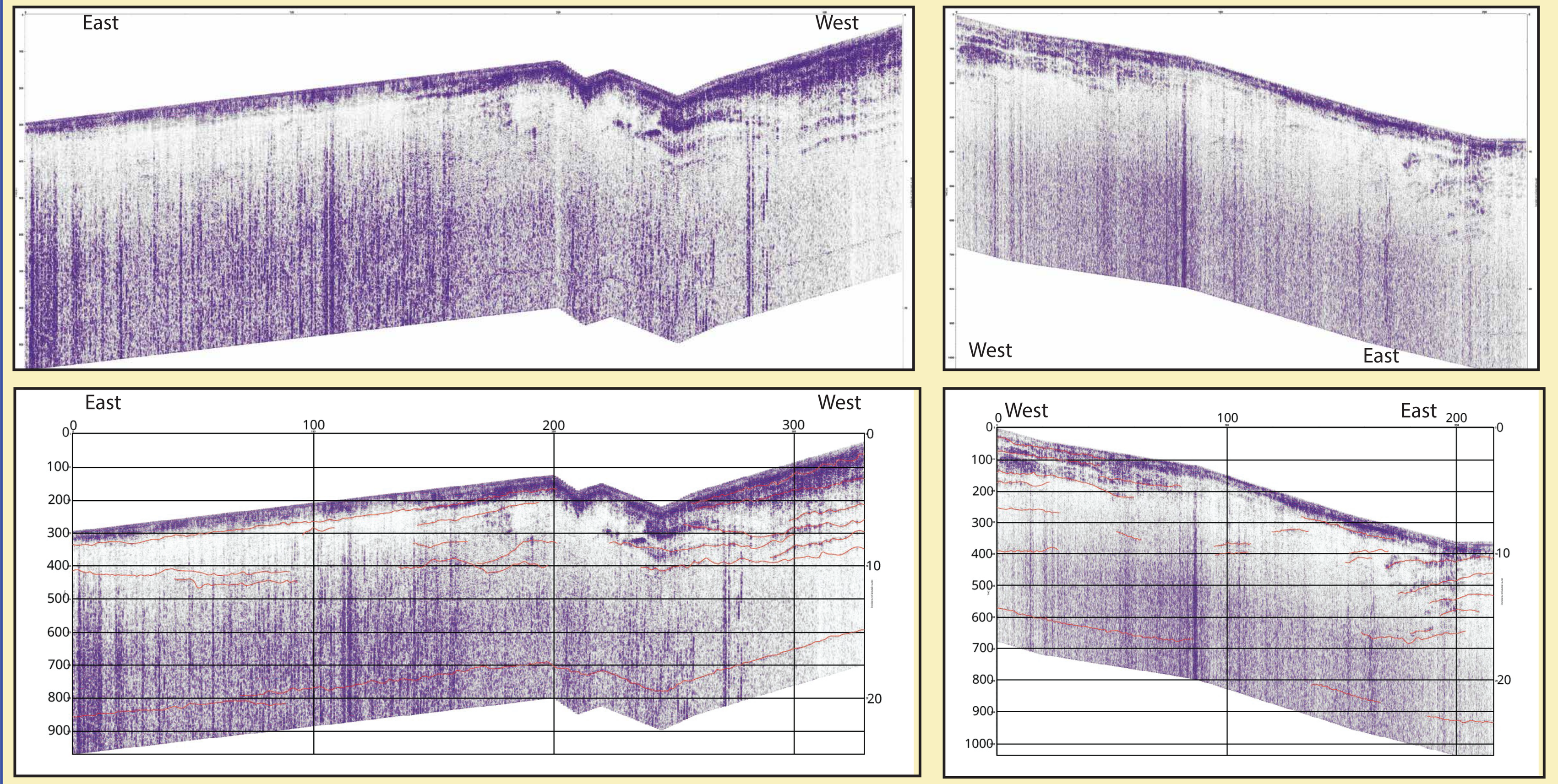

Figure 17: Radargrams for Transect 1 (left), and Transect 4 (right). Although data is still being processed and refined, the initial data show the presence of several subsurface reflectors and complex stratigraphic patterns.

Discussion & Preliminary Conclusions

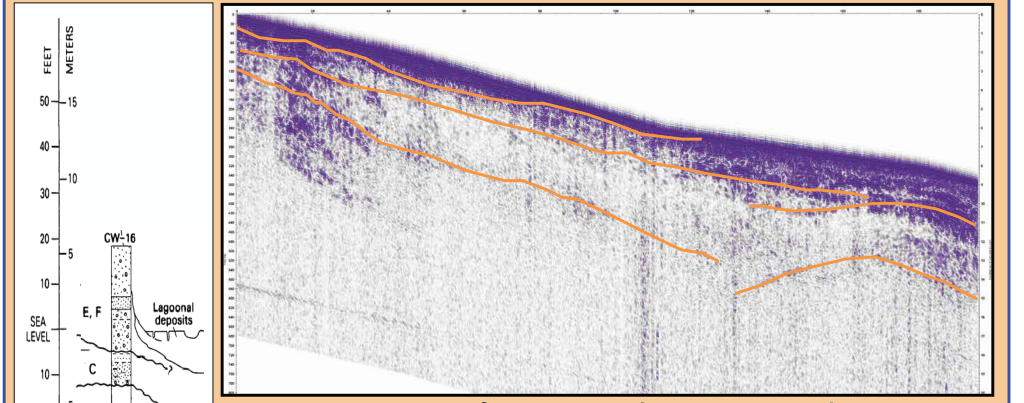
Figure 18: Excerpt of transect 4 showing several prominent reflectors that likely represent different stratigraphic units observed by Mixon (1985) to be within the Omar Fm (Accomack Member). Deeper reflectors are likely within the Yorktown Formation.

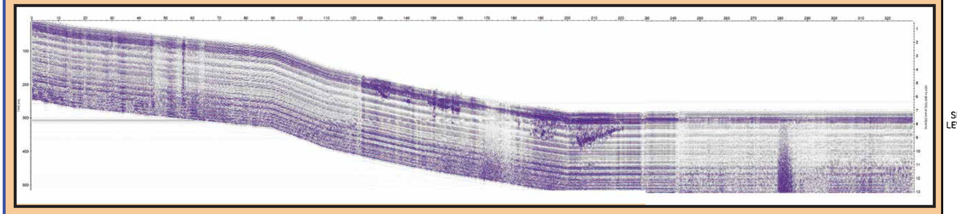
Figure 19: The seaward (eastern) end of this transect terminates at the modern onlapping salt marsh. Saltwater intrusion in the subsurface prevents accurate imaging in these areas, but prominent subsurface reflectors show evidence of incission and channelization (and subsequent infilling) at the toe of the slope. These features may correlate to similar features identified with paleosol and paleoforest horizons at Savage Neck on the SW side of the Delmarva Peninsula that we are working on. These incised features may reflect downcutting into the Accomack Member prior to deposition of the Joynes Neck Sand (as recognized by Mixon, 1985). Ensuing transgressive events allowed back-stepping of barrier island and back-barrier lagoon facies (Figure 20/21) to be deposited up to and along the the Mappsville Escarpment. These units reveal a complex relationship related to dramatic sea level changes during the Late Pleistocene. Brothers et al (2020; Figure 22) discussed the significance of sea level rise/fall events in the formation of the NE to SW elongated Delmarva Barrier Spit, and its widening as progressive transgressive events helped to widen it from both the Atlantic and Chesapeake Bay sides of the peninsula. During glaciations sea levels were significantly lower, erosion and downcutting allowed for progressive re-organization of Susquehanna River paleochannels from N-S.

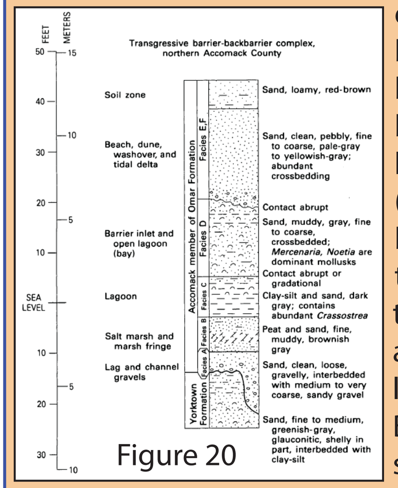

Figure 20

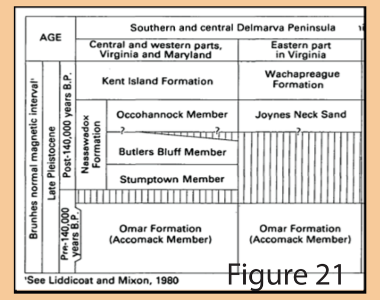

Figure 21

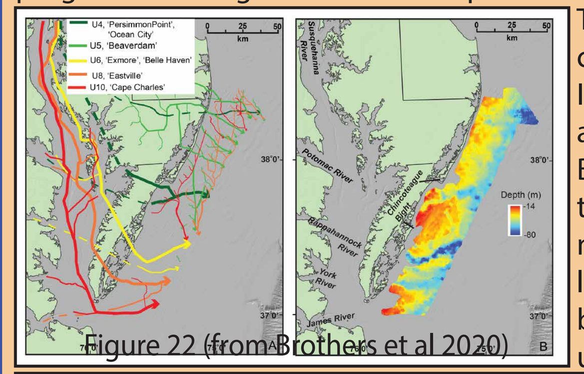

Figure 22 (from Brothers et al 2020)

The study area is located within close proximity to the Wallops Island paleochannel (Figure 22) and based on data from Brother's work, we hypothesize that the Omar Formation in northern Accomack County is likely no younger than MIS 5e, but that unit and underlying units could be significantly older.

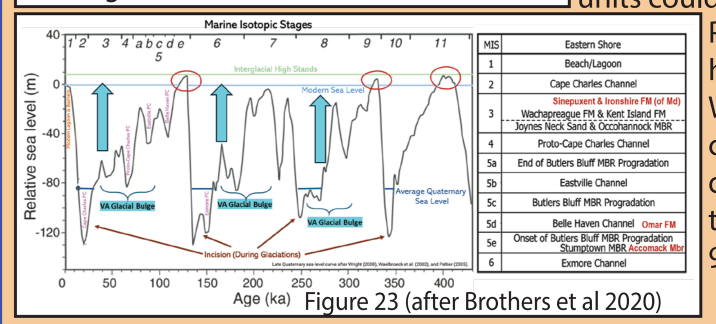

Figure 23 (after Brothers et al 2020)

Perhaps the units we have imaged at WINWR with GPR could have been deposited during transgressions of MIS 9, or even MIS 11.