FIRST VERTEBRATE FOSSILS REPORTED FROM CRETACEOUS STRATA ON LONG ISLAND WITH NEW SEDIMENTOLOGICAL DATA & OBSERVATIONS

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Summary

The geology of Long Island consists primarily of Pleistocene glacial deposits underlain by much older Cretaceous coastal plain layers below sea level. Allochthonous blocks of Cretaceous sediments attributed to the Raritan Formation were incorporated into the Harbor Hill moraine and are exposed in the shoreline cliffs along the necks of northwestern Long Island. The stratigraphy and paleontology of these exposures have been documented in the literature going back over 180 years, including descriptions of pollen (e.g. Sirkin, 1974) and plant fossils (e.g. Hollick, 1894, 1906). However, there are no confidently documented reports of vertebrate fossils in the Cretaceous of Long Island going back to Mather (1843). Herein, we report the first vertebrate remains (a bone fragment and a fish vertebra) to have been recovered from Cretaceous strata on Long Island and include some observations on the sedimentology of the Cretaceous deposits.

Stratigraphy

Cretaceous deposits identified as the Magothy and Raritan Formations are present in the subsurface beneath glacial deposits under most of Long Island and are part of the Northern Atlantic Coastal Plain Aquifer System (Figure 1) which is also a part of the "Island Series" of both subsurface and exposed formations of Mesozoic & Cenozoic strata that extend as far north as Martha's Vineyard (White, 1892) while terminating somewhere to the south of the Atlantic Coastal Plain Geomorphic Province (Richards, 1967). Strata correlative to the Magothy and Raritan under Long Island outcrop in central New Jersey. Outcrops on Long Island are limited to cliff exposures along the coast of Long Island Sound (Figure 2) which appear to be allochthonous blocks of sediment excavated and redeposited by glacial advance within the Harbor Hill moraine (Fleming, 1935). This occurred during the most recent Late Pleistocene glacial advance when the sediments were frozen in permafrost. Glaciotectonic deformation of the strata can be observed in folded layering and the strata are discontinuous along the shoreline, overlain and laterally truncated by deposits of Pleistocene outwash and till.

Paleontology and Sedimentology

Cretaceous plant fossils have been documented for over 150 years from the Cretaceous deposits on Long Island (e.g. Mather, 1843; Hollick, 1906). Plant fossils are common in slabs of hematitic sandstone and siltstone found on north shore beaches and pollen and lignite are found in Cretaceous clays (e.g. Fuller, 1914; Sirkin, 1974). Most of the plant fossils have been found as "float" in small slabs of hematitic siltstone and sandstone (Figure 3) and cannot be confidently attributed to either the Raritan or Magothy formations, although Berry (1915) states that the flora found on the north shore of Long Island is "unquestionably" of Magothy age. The slabs containing the plant fossils were likely reworked during glacial advances from Magothy strata and incorporated into the till and outwash exposed in the beach cliffs, where coastal erosion leaves them as a lag on the upper shoreline. Plant fossils include fragments of lignitic wood (sometimes replaced by hematite and limonite mineral), comminuted plant debris, and impressions of leaves from genera such as *Salix* (willow), *Sassafras*, and *Viburnum* (Hollick, 1894). Pollen from clays outcropping at Garvies Point and Eatons Neck correlate these deposits to the Raritan Formation in

New Jersey and yield a Early-Late ("Mid") Cretaceous age (Cenomanian to Turonian Stage) for these strata (Sirkin, 1974). The overall fossil flora is consistent with a subtropical/tropical climate.

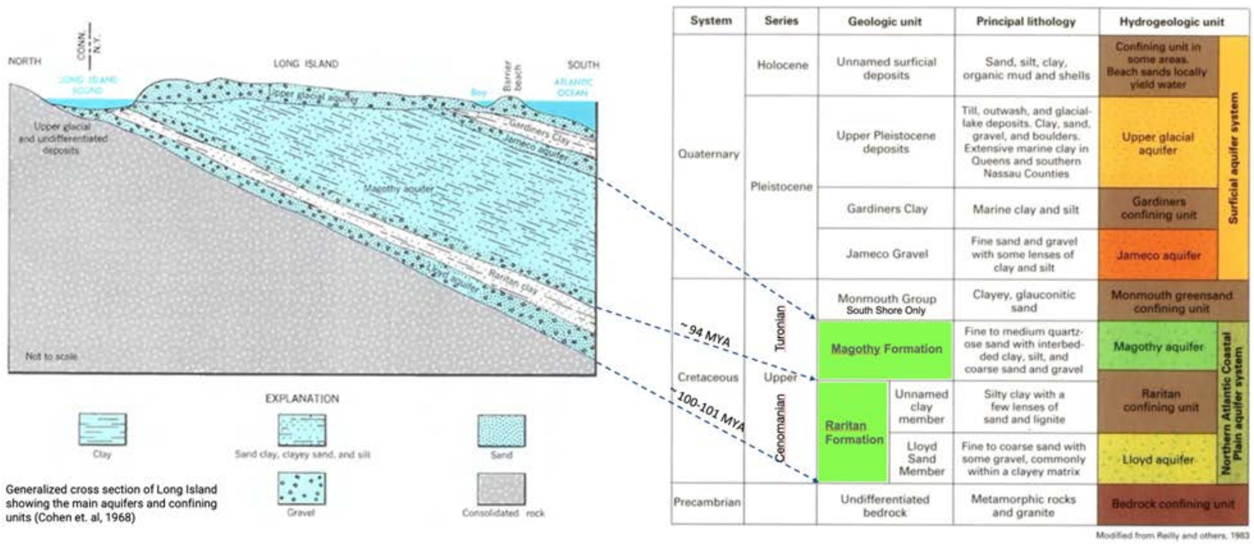


Figure 1 (above). Composite diagram showing stratigraphic and cross section position of Cretaceous Raritan and Lloyd Formation strata beneath Long Island, NY. Sources are cited within.

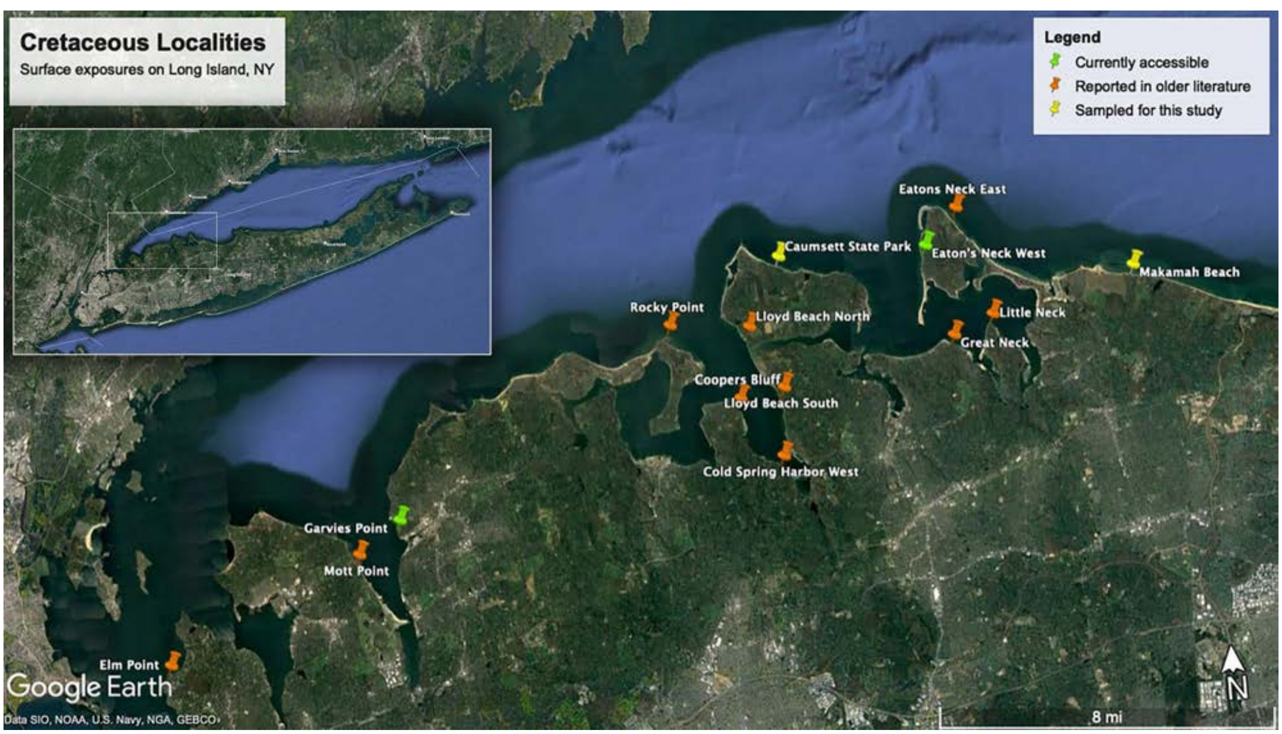


Figure 2. Map of reported shoreline exposures of Cretaceous strata on Long Island. Many localities reported in the older literature (mostly from Fuller's 1914 monograph) are no longer accessible due to erosion or shoreline development. Extensive exposures are still accessible at Garvies Point, Lloyd Neck (Caumsett State Park), Eatons Neck, and Makamah Beach.

No vertebrate remains from Cretaceous deposits on Long Island have been confirmed since Mather (1843, p. 261) reported "At the brick-yards on West neck (sic), Huntington, bones and shells are said to have been found in the clay; but the person who communicated the information, said so in such a way as to lead me to distrust his sincerity."

The depositional environments of the Raritan Formation are interpreted to represent a coastal river delta with channel sands and floodplain deposits of silt and clay (Fuller, 1914). Subaerial (oxygenated) deposition is demonstrated by the abundance of iron oxide (hematite and limonite) and its bright red to orange coloration, while contrasting darker clays were likely deposited subaqueously in swamps, ponds, or estuaries.

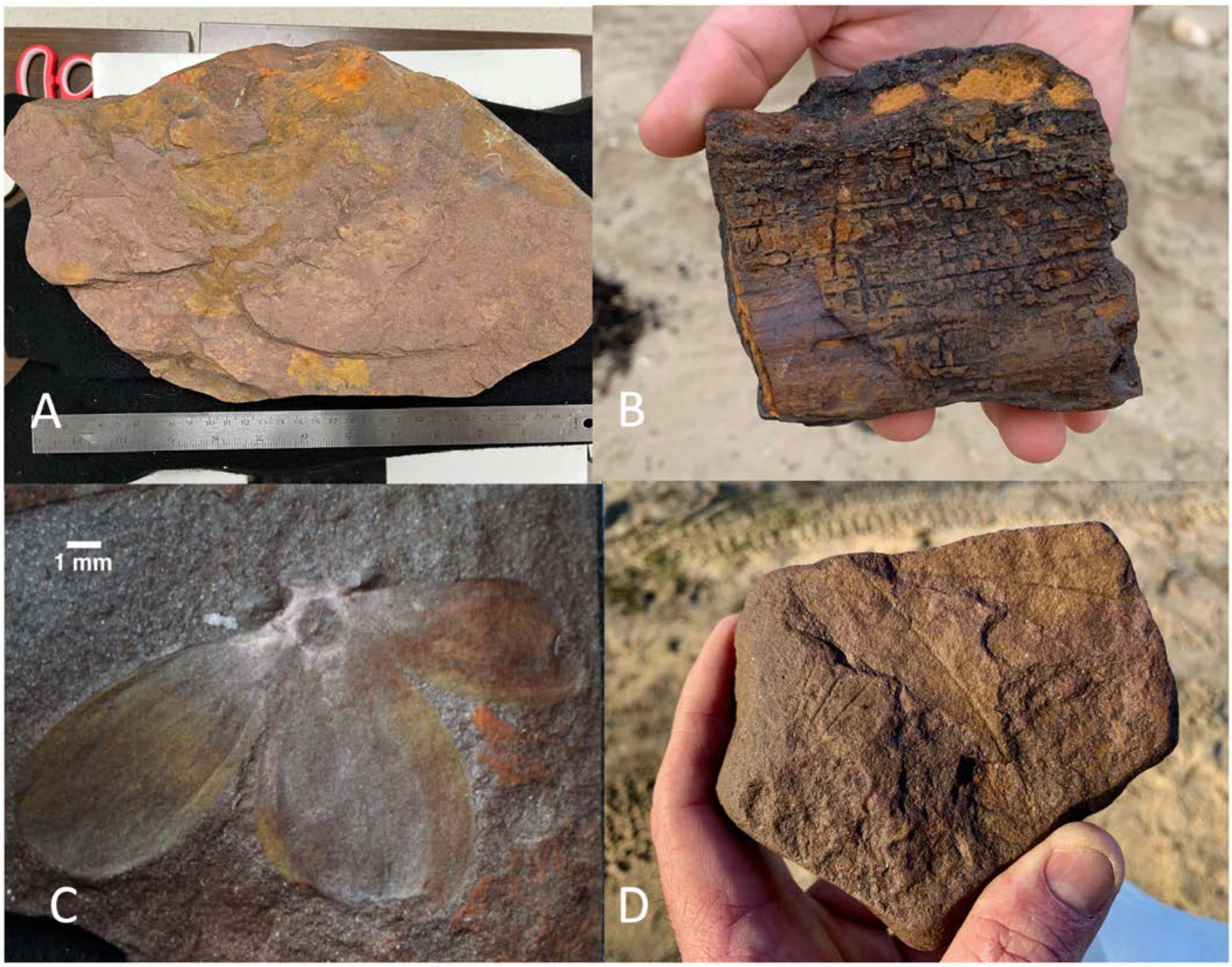


Figure 3. Float plant fossils preserved as impressions and permineralized remains from lithified, hematite-cemented sand, silt, and clay; collected by the authors (except C, collected by Greg Durso): A. typical slab of hematite-cemented sandstone which, when split open, reveals comminuted plant debris and impressions of plant tissue; B. block of petrified wood preserved by hematite permineralization; C. winged seed carpel and D. leaf impressions preserved on slabs of hematitic sandstone. All found on the beach at Caumsett State Park, Lloyd Neck, NY.

Methods

Bulk sediment samples were collected and GPS-located in the field from freshly excavated exposures to prevent contamination by overlying glacial deposits. In the laboratory, sediment samples were wet sieved through 250 & 63 µm sieves to separate coarse (sand) and fine (clay and silt) fractions respectively. The coarse fraction was retained, air-dried, then oven dried before being examined for vertebrate fossils under a compound-light microscope. The coarse fraction was also dry sieved via a Rotap shaker stack, to obtain a weight-percent grain-size distribution based on the Udden-Wentworth scale (Nichols, 2009). Clay-rich samples were disaggregated by washing in a solution of hot water and borax detergent to disperse the clay and release the sand and pebble size grains which were then collected by wet sieving. The processed sediment size fractions were then weighed to generate a grain size distribution based on the Udden-Wentworth phi-scale.

Results

Caumsett State Park

No vertebrate fossils are yet known from Caumsett State Park, which has extensive exposures of white and pink clayey sands with alternating pebbly beds, overlying white and gray clays at beach level. These strata are likely the Lloyd Sand member of the Raritan Formation with some underlying clay layers that outcrop at beach level. The Cretaceous sands appear low in the beach cliffs east of the fishing access in disconformable contact with overlying pebbly glacial outwash. The contact ramps upward to the east and about .6 km from the fishing access is a large exposure of the Cretaceous sands (Figure 4) overlain by a thin glacial till, separated by a disconformity.

Figure 4. Cretaceous sands and clays exposed at Caumsett State Park, in Lloyd Harbor, NY (Latitude 40.939108°, Longitude -73.470371°).

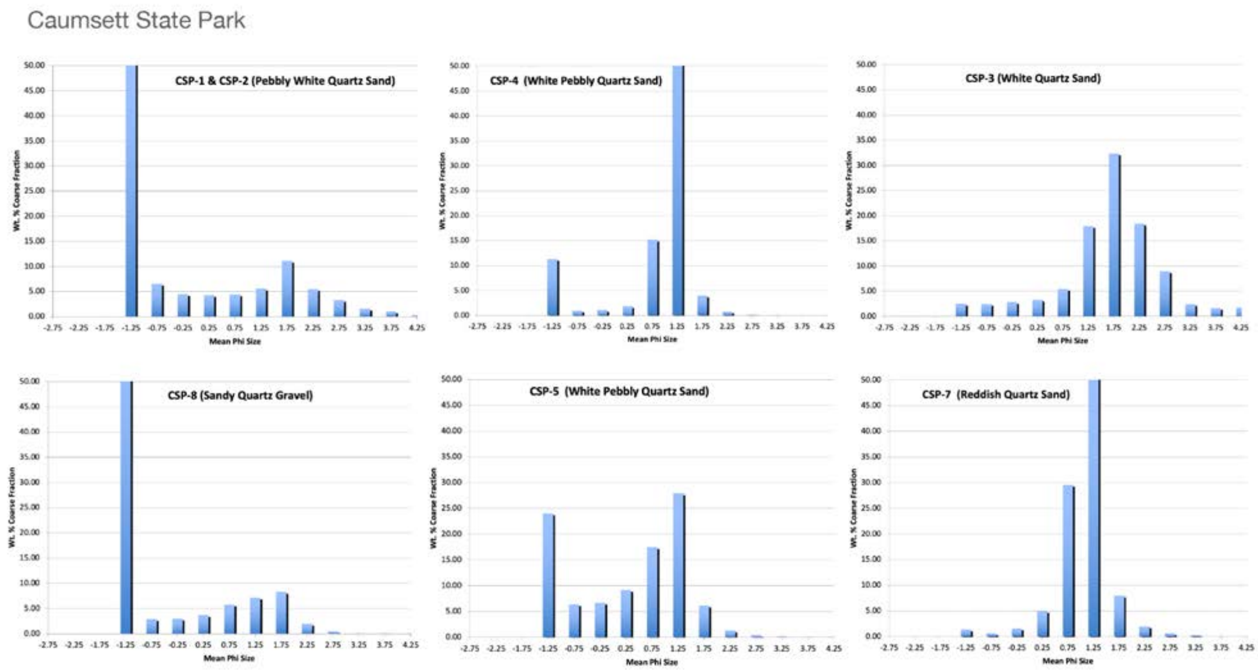


Figure 5. Grain size distributions for sediment samples collected from Cretaceous strata at Caumsett State Park, Lloyd Harbor, NY.

At Caumsett State Park sediment samples were collected from interbedded sandy and pebbly layers and processed as described above to search for vertebrate remains. Grain size distributions reveal a range of sediment types from thin pebble-dominated layers (Figure 5, left column) to mixed sand and pebble layers (Figure 5, middle column), to well-sorted sands (Figure 5, right column). The majority of sediment grains at Caumsett are composed of milky quartz, which few other minerals observed. No vertebrate remains were found. The sands are intermixed with a significant component of clay, which may be derived from the weathering of feldspar grains.

Makamah Beach

The Cretaceous exposures at Makamah Beach extend from the access point at Geisslers Beach Park at the end of Makamah Road about 1 km east to the shoreline at the Indian Hills Country Club golf course. The strata exposed are mostly clays exhibiting a variety of colors from beige, to brown, to red, with some interbedded sandy units stained red by hematite (Figure 6, left column). Lignitic plant fragments are common in the clays, as are pebbles and sand grains (Figure 6, right column). The exposed strata are complexly interbedded and discontinously exposed along the low cliff line. Clays and hematite stained sands are similar to some of the strata observed at Caumsett State Park, but the milky quartz pebble and sand deposits are not present at Makamah Beach.

A vertebrate bone pebble (Figure 7) was extracted from one silty clay sample (MB3-C) and a small fish vertebra (Figure 9 - likely from a ray-finned / actinopterygian fish - William Bemis, pers. comm.) was found in a sample of one of the sandy layers (MB3-B2).

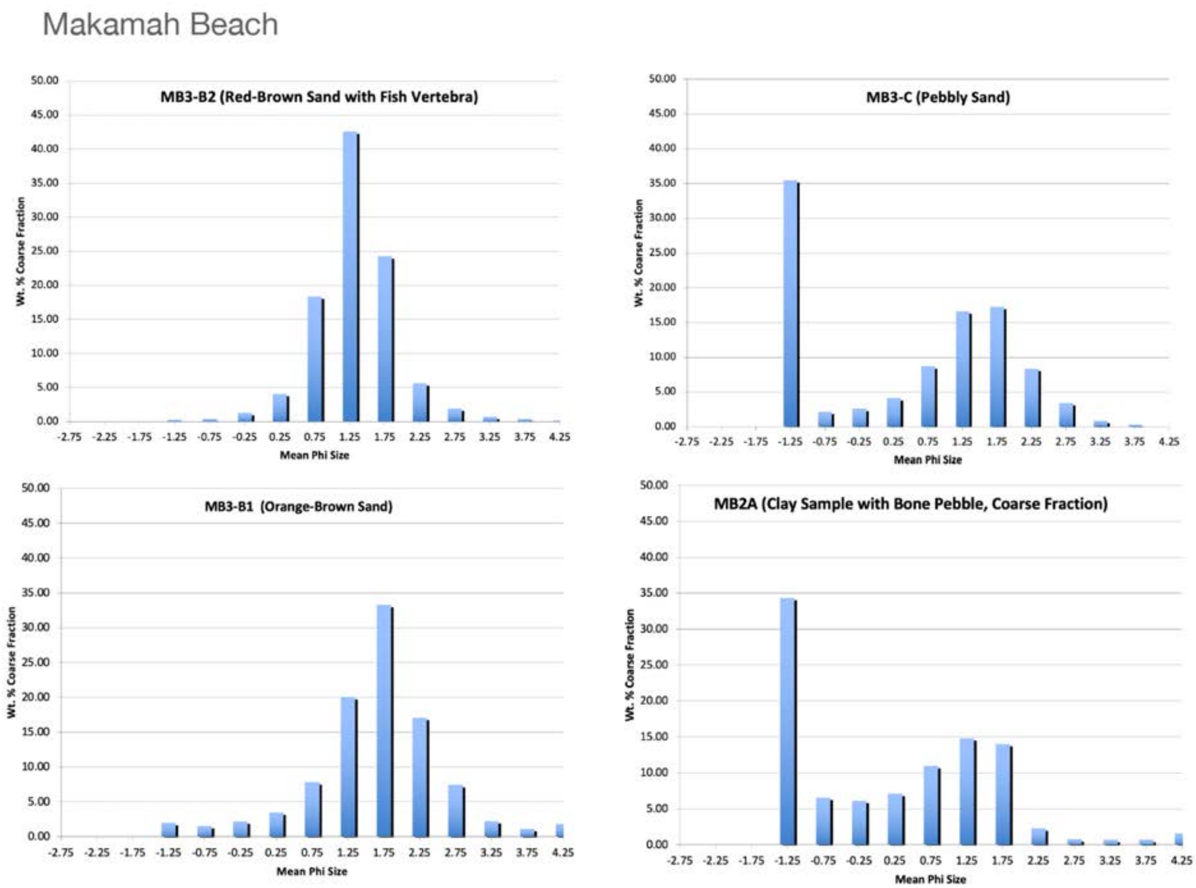
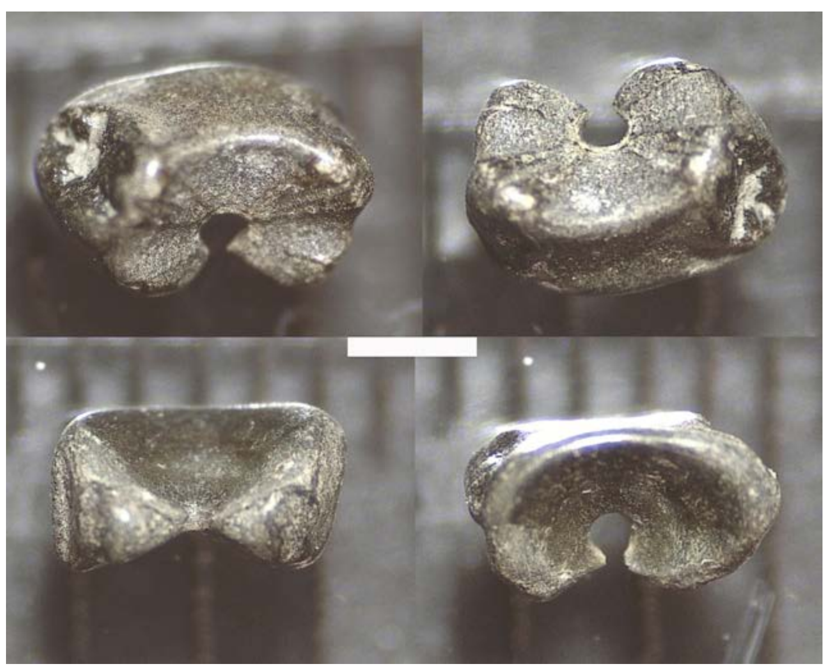


Figure 6. Grain size distributions for sediment samples collected from Cretaceous strata at Makamah Beach, Northport, NY.

Figure 7. A permineralized “bone chip”/”bone pebble” of an indeterminate vertebrate from Makamah Beach showing both dense exterior and spongy interior bone. Extracted from an interbedded red and brown silty clay. Scale bar = 1 mm.

Figure 8. A. large outcrop of clay and sand layers near the Makamah beach access point; B. outcrop of multicolored clay layers with thin silty beds (author William J. Hart for scale); C. bulk sample of silty clay prior to wet/dry sieving (this is the sample that yielded the bone pebble); D. sorted size fractions after wet/dry sieving of a sandy interval that yielded a small fossil fish vertebra on the highest observable-processed grain size post-processing.

Figure 9 (right). An (?) actinopterygian fish vertebra found in a transitional layer between a yellow-orange predominantly sandy layer (MB3-B2) and a clay layer at Makamah Beach. The fossil is noticeably worn and polished, likely due to stream transport. Scale bar = 1 mm.



Conclusions and Significance

Our preliminary sedimentological survey implies a complex array of depositional environments preserved in the Raritan strata. This is apparent in the contrasting sediments found at Makamah Beach and Caumsett State Park. We hope to continue these studies, so that better stratigraphic profiles can be generated for Cretaceous outcrops on Long Island to assist in the search for layers productive for vertebrate remains as well as mineral grains that could point to the source of the Raritan strata sediment based on provenance analysis (Gibson, 1985).

We believe that these fossils represent the first confirmed occurrence of Cretaceous vertebrate body fossils on Long Island. These finds, although fragmentary, suggest that additional vertebrate fossils, including the remains of Cretaceous dinosaurs, birds, and mammals, should be present in the Raritan strata outcropping along the north shore of western Long Island. More significant finds such as dinosaurs have been found in similar age strata representing similar depositional environments outside of Long Island (e.g. Brownstein, 2018).

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