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NOTES ON PLEISTOCENE FAUNAS FROM MARYLAND AND VIRGINIA AND PLIOCENE AND PLEISTOCENE FAUNAS FROM NORTH CAROLINA

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INTRODUCTION

In June, 1920, I visited two Pleistocene localities in St. Marys County, Md.—one at Wailes Bluff, in the low cliffs on the left bank of Potomac River about 1 mile above Cornfield Point; the other at Langleys Bluff, on the bay shore about 5½ miles south of Cedar Point. (See pls. 24, 25.) The main object of the trip was to collect additional fossil pyramidellid mollusks, which were subsequently turned over to Dr. Paul Bartsch, of the United States National Museum, for study, but other mollusks were also collected from each locality. In June, 1925, I again visited both localities, in company with L. W. Stephenson and Willis P. Popenoe, and made small collections.

In 1925 I obtained considerable fossil material from five localities along and near Neuse River in Craven County, N. C., ranging over a distance of 10 to 15 miles below New Bern, and one lot from a locality about 10 miles northeast of Beaufort. In 1918 J. A. Cushman made several collections of fossil material in Craven County, and the faunas at two of his stations are considered in this paper.

This paper describes the stratigraphic sections at each of the several localities, lists the species (exclusive of the pyramidellid mollusks) collected from each stratum, treats briefly the significance of the faunas, and, finally, seeks to establish as accurately as possible the age relations of these faunas in the deposits in Maryland and North Carolina.

I wish to express my appreciation to the authorities of the United States National Museum for the use of the facilities of that institution, and to L. W. Stephenson, of the United States Geological Survey, for his helpful suggestions. Dr. Mary J. Rathbun, of the United States National Museum, identified the Crustacea from the Wailes Bluff locality, and Dr. E. W. Berry, of Johns Hopkins University, identified a fossil cone from North Carolina. Dr. Albert Mann, diatomist, of the Carnegie Institution of Washington, identified the diatoms.

PLEISTOCENE LOCALITIES IN MARYLAND

HISTORICAL SUMMARY OF THE GEOLOGY OF WAILES BLUFF AND LANGLEYS BLUFF, ST. MARYS COUNTY, MD.

The localities of Wailes Bluff and Langleys Bluff, in St. Marys County, Md., attracted attention early in the history of Coastal Plain geology. Conrad [1] paid special attention to the Wailes Bluff locality (Cornfield Harbor) and in his publication describes the locality and lists the fossil species. Later he gave a section at Wailes Bluff, described the fauna, and listed the species from this locality.[2] His description of the section and the fauna is quoted as follows:

Section near the mouth of Potomac [Wailes Bluff]

Elevation, 15 feet

Sand and gravel.

Ostrea virginiana, *Mytilus hamatus* (estuary deposit), sand, 1 foot thick.

Clay with *Pholas costata*, *Mactra lateralis*, *Arca transversa*, *Solecurtus caribaeus*, etc. (marine deposit), 8 feet above tide.

About 3 miles above the low sandy point which forms the southern extremity of the western peninsula of Maryland, the bank of the Potomac rises to an elevation of about 15 feet at its highest point. The fossils are visible in this bank one-fourth of a mile in uninterrupted extent. The inferior stratum is a lead-colored clay, containing great numbers of *Mactra lateralis* (Say), a common recent bivalve of the coast, which in many instances appear in nearly vertical veins, having evidently fallen into fissures in the clay. *Pholas costata* is also abundant, and each individual remains in the position in which the living shell is usually buried in the mud—that is, vertical, with the anterior or short side pointing downward. They are very fragile and can rarely be procured entire. Over the clay reposes a bed of *Ostrea virginiana* in sand, in places a foot in thickness. It is nearly horizontal, varying from a height of 4 to 8 or 10 feet above high-water mark. The fossils of this locality, with two exceptions, are common recent species of the Atlantic coast, and in some instances the original colored markings remain upon the shells. Were it not for the occurrence of *Gnathodon cuneatus*, *Mytilus hamatus*, and *Arca ponderosa*, the group would not vary from that now inhabiting the coast as

[1] Conrad, T. A., On the geology and organic remains of a part of the Peninsula of Maryland: Acad. Nat. Sci. Philadelphia Jour., vol. 6, pp. 205–230, 1830.

[2] Conrad, T. A., Observations on a portion of the Atlantic Tertiary region, with a description of new species of organic remains: Nat. Inst. Promotion of Science Proc., Bull. 2, pp. 189–191, 1842.

far north as Massachusetts; but the presence of these three bivalves indicate that a climate equivalent to that of Florida prevailed when the shells of this locality were living in the sea. I have before alluded to the peculiar and highly important distribution of the existing *Gnathodon*, burrowing in myriads in the mud flats near Mobile and confined to the estuaries of the Gulf of Mexico. An occasional waterworn valve in the deposit on the Potomac, above described, seemed to indicate that the species lived in that river in the upper Tertiary period. This conjecture was converted into certainty by an exploration of the shore farther north, which resulted in discovering a bed composed exclusively of the *Gnathodon*, on the land of Mr. Ebb, above the mouth of St. Marys River. This bed, except that the shells are smaller, is precisely similar to those which line the bay shore near Mobile. The valves of the shells are frequently connected, and there can be no doubt that here was the spot where they lived and were embedded; that this was a region of sand flats bared at low tide, the water brackish, as it is now; and that the deposit near the mouth of the Potomac was of the same period but more directly communicating with the ocean.

Dall [3] states, in referring to the Cornfield Harbor clays, that they have generally been referred to the Pleistocene, but it is possible that further research will show them to be upper Pliocene.

In the more recent volume by Shattuck, Clark, and others [4] on the Pliocene and Pleistocene of Maryland, however, the Wailes Bluff and Langleys Bluff localities are assigned to the Talbot formation (Pleistocene), and their faunal contents are described and figured.

In previous publications the species from each of the different layers in these sections are not fully listed separately, although the upper bed, which is packed with oysters, is mentioned in several reports.

WAILES BLUFF

STRATIGRAPHIC SECTION

Wailes Bluff (pl. 24) rises about 15 feet above the beach sand, and the section given below is clearly exposed at all times on its face. The waves at this point are eating into the land and gradually destroying it along a distance of about half a mile.

Section at Wailes Bluff, St. Marys County, Md.

	Feet
4. Unfossiliferous buff sand and gravel	6–8
3. Mainly coarse to fine grained angular quartz sand packed with *Ostrea virginica*	1–3
Probably slight unconformity.	
2. Bluish clay	0–1
1. Mainly greenish compact clay mixed with a small amount of quartz sand and a few quartz boulders	4–5

The base of bed 1 is not exposed, but comparison with the similar section at Langleys Bluff, on the bay shore, suggests that this bed may rest upon Miocene deposits at a slight depth below sea level. The material in the upper part of bed 1 consists of shell fragments mingled with well-rounded quartz pebbles and fragments of lignitic material, and its upper surface is somewhat irregular. Nearly vertical pockets, the original openings of which may have been made by some boring crustacea or mollusks, are filled chiefly with *Mulinia lateralis*. In the lower part of this bed the valves of the mollusks are usually attached indicating deposition in quiet water, but in the upper part they are detached, indicating more agitated conditions of the water.

Bed 2 varies in thickness from place to place and is not everywhere present; it may be considered a part of bed 1. This bed contains *Rangia cuneata* and many shells of *Venus mercenaria*.

Bed 3 is composed almost entirely of *Ostrea virginica*. The contact between this bed and the clay on which it rests is not horizontal but undulates through a vertical distance of 2 feet or more in a horizontal distance of 20 yards along the beach. In places the materials of this bed penetrate those of the underlying bed, indicating that the oyster bed occupied a depression in the underlying bed and subsequently was covered with reworked sediments of this lower bed.

FAUNAL LIST

Station 8932, Wailes Bluff, left bank of Potomac River, about 1 mile above Cornfield Point. From lower part of section, beds 1 and 2. Collected by W. C. Mansfield.

[a=Abundant, c=common, r=rare]

Mollusca

Acteocina canaliculata (Say). c.
Mangilia cerina (Kurtz and Stimpson). c.
Busycon canaliculatum (Linnaeus). c.
Busycon caricum (Gmelin). r.
Alectrion trivittata (Say). a.
Ilyanassa obsoleta (Say). a.
Columbella (Astyris) lunata (Say). a.
Urosalpinx cinereus (Say). c.
Eupleura caudata (Say). a.
Epitonium lineatum (Say). a.
Epitonium aff. E. denticulatum (Sowerby). r.
Crepidula plana Say. c.
Crepidula fornicata (Linnaeus). c.
Polynices duplicatus (Say). a
Nucula proxima Say. c.
Leda acuta (Conrad). c.
Yoldia limatula Say. r.
Arca transversa Say. a.
Arca ponderosa Say. c.
Ostrea virginica Gmelin. c.
Pandora gouldiana Dall (1 valve).
Venus mercenaria Linnaeus. c.
Callocardia morrhuana Linsley. r.
Tagelus gibbus (Spengler). c. (Occurs at the top of bed 1.)
Tellina tenera Say? r.
Macoma balthica (Linnaeus). r. (One fragment.)
Ensis directus Conrad. r.
Rangia cuneata (Gray). r. (Mainly from bed 2, just below oyster bed.)
Mulinia lateralis (Say). a.
Corbula contracta Say. r.
Barnea (Scobina) costata (Linnaeus). a.

[3] Dall, W. H., A table of North American Tertiary horizons correlated with one another and with those of western Europe, with annotations: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, p. 336, 1898.

[4] Maryland Geol. Survey, Pliocene and Pleistocene, 1906.

Crustacea

[Identified by Dr. Mary J. Rathbun, of the United States National Museum]

Callinectes sapidus Rathbun. (Range in Recent fauna: Cape Cod to Texas.)

Cancer irroratus Say. (Range in Recent fauna: Labrador to South Carolina.)

Chloridella empusa (Say). (Range in Recent fauna: Vineyard Sound to Texas.)

Station 8933. From oyster bed, or bed 3, at Wailes Bluff. Collected by W. C. Mansfield.

[a=Abundant, c=common, r=rare]

Mollusca

Ilyanassa obsoleta (Say). r.
Urosalpinx cinereus (Say). c.
Epitonium lineatum (Say). (One specimen.)
Crepidula fornicata (Linnaeus). a.
Polynices duplicatus (Say). (One specimen.)
Ostrea virginica Gmelin. a.
Mytilus clava Meuschen. a.
Venus mercenaria Linnaeus. c.
Macoma balthica (Linnaeus). r.
Mya arenaria Linnaeus. a.
Rangia cuneata (Gray). (One fragment taken at lower contact and may belong to bed beneath.)
Corbula contracta Say. (One specimen.)

Additional species, aside from the pyramidellid, from Wailes Bluff, described in the volume of the Maryland Geological Survey on the Pliocene and Pleistocene, comprise the following:
Terebra dislocata (Say).
Cumingia tellinoides (Conrad).
Macoma calcarea (Gmelin).
Petricola pholadiformis Lamarck.
Aligena elevata (Stimpson).
Unio complanatus (Solander).

LANGLEYS BLUFF

STRATIGRAPHIC SECTION

Langleys Bluff (pl. 25), which is about 25 feet high and one-third to one-half mile long, exhibits the section given below, but some parts of it are obscured by a growth of vegetation.

Section at Langleys Bluff, St. Marys County, Md.

	Feet
Pleistocene:	
5. Unfossiliferous cross-bedded buff sand and gravel with a seepage of water along the base	4–15
4. Uniformly deposited unfossiliferous dark-gray sandy clay with a pebbly band at the base	2
3. Oyster zone, sediments with a few small pebbles. No unconformity was observed between this bed and the underlying one	0–1
2. Fossiliferous compact bluish sandy clay containing sandy pockets or filled borings. A thin oyster zone occurs at the base. In this bed are a few pebbles, the largest of which are 3 inches in diameter, and smoothly waterworn cobbles, which are most abundant at the contact with the underlying Miocene	6–8
Unconformity.	
Miocene:	
1. Sandy clay with Miocene (St. Marys) fossils	0–3

FAUNAL LIST

Station 8934. Langleys Bluff, Chesapeake Bay, about 5½ miles south of Cedar Point. From the lowermost Pleistocene bed, or bed 2. Collected by W. C. Mansfield.

[a=Abundant, c=common, r=rare]

Acteocina canaliculata (Say). a.
Mangilia cerina (Kurtz and Stimpson). r.
Busycon caricum (Gmelin). c.
Busycon canaliculatum (Linnaeus). c.
Alectrion trivittata (Say). a.
Ilyanassa obsoleta (Say). r.
Columbella lunata (Say). r.
Eupleura caudata Say. a.
Epitonium lineatum (Say). c.
Polynices duplicatus (Say). a.
Crepidula plana Say. c.
Leda acuta (Conrad). c.
Nucula proxima Say. r.
Arca transversa Say. c.
Ostrea virginica Gmelin. c.
Venus mercenaria Linnaeus. c.
Mulinia lateralis (Say). a.
Rangia cuneata (Gray). r.
Barnea (Scobina) costata (Linnaeus). c.

From the oyster bed, or bed 3. Collected by W. C. Mansfield.

Ostrea virginica Gmelin.
Venus mercenaria Linnaeus.

Additional species from Langleys Bluff, described in the volume of the Maryland Geological Survey on the Pliocene and Pleistocene, comprise the following:
Mya arenaria Linnaeus.
Tagelus gibbus (Spengler).
Unio complanatus (Solander).

ANALYSIS OF THE FAUNAS

WAILES BLUFF

The fauna in beds 1 and 2 of the section is in the main typically littoral marine, with a slight admixture of brackish-water forms, and is somewhat similar to the Recent fauna described by Henderson and Bartsch,[5] obtained chiefly from the shallow waters on the inner side of Chincoteague Island, Va. The material of both beds indicates a muddy bottom inhabited by a fauna that thrives best in comparatively quiet, shallow water protected from the rough breakers of the sea. Neither the material nor the fauna suggests an open sea. The fauna as a whole suggests a temperature about the same as that of the water along the coast in the same latitude at the present day, or perhaps a little warmer. None of the species indicate a colder condition with the exception of *Aligena elevata* (Stimpson) and *Macoma calcarea* (Gmelin), which are recorded by the Maryland Geological Survey from Wailes Bluff. I did not find the two species at Wailes Bluff, nor are they in the United States National Museum collections from this locality.

[5] Henderson, J. B., and Bartsch, Paul, Littoral marine mollusks of Chincoteague Island, Va.: U. S. Nat. Mus. Proc., vol. 47, pp. 411–421, 1914.

The figured specimen of *Aligena elevata* in the collection of the Maryland Geological Survey from Wailes Bluff was examined by me and is correctly identified. *Macoma calcarea* was identified from the fragments of the shell, but I have not seen these fragments. Both species are distinctly northern forms and do not occur on our coast this far south.

The species of mollusks listed are all represented somewhere in the Recent faunas except an *Epitonium*, which may be a new species and may not be represented in the Recent fauna. Nearly all are living somewhere on the coast from Cape Cod southward to Florida and on the Gulf. *Ostrea virginica* is smaller in size and proportionally wider than the representatives of the same species that occur abundantly in the bed above. *Arca ponderosa*, originally described by Say from the Recent fauna of Florida, where it is represented by many individuals, is abundant. This species is living on the present coast from Cape Cod to Florida, but the warmer waters south of Cape Hatteras appear to be a more favorable habitat.

In the upper part of bed 1 and bed 2 *Rangia cuneata* is associated with *Venus mercenaria*, which suggests a slight freshening of the water. The Recent geographic range of *Rangia cuneata*, as noted by other writers, is along the Gulf, from Alabama westward. There it lives in both salt and brackish water, but it thrives best in the brackish water.

Two species—*Yoldia limatula*, which ranges in the Recent fauna from Arctic seas to Cape Hatteras, and *Callocardia morrhuana*, which ranges from Prince Edward Island to North Carolina—indicate that the fauna lived in a temperature cooler than that which prevails to-day south of Cape Hatteras.

The uppermost fossiliferous bed, or bed 3, carries many individuals of *Ostrea virginica*, *Mytilus clava*, and *Mya arenaria*. The two species last mentioned were not obtained from beds 1 and 2. *Ostrea virginica* is large and elongate and has a modern aspect. *Mytilus clava*, which is usually associated with *Ostrea virginica* in both its fossil and its Recent occurrences, has a geographic range from Cape Cod to Nicaragua and Porto Rico. *Mya arenaria* is now living from Greenland to Beaufort, N. C. It also occurs at the mouth of Potomac River, but it is not abundant in Chesapeake Bay.

Kellogg [6] describes the habitat of this species as follows:

> In describing the conditions which are necessary for the existence of clams on natural beds it may be well to note the fact that, within certain very wide limits, clams appear to do equally well in water which is very salt or nearly fresh. Not only is this true, but they may be transplanted from one locality to another where the salinity is very different without being affected adversely.

The fauna of the upper fossiliferous bed, or bed 3, therefore could have lived in brackish water, and considerable evidence points to such an environment.

LANGLEYS BLUFF

The Pleistocene fauna from bed 2 at Langleys Bluff is similar to that in beds 1 and 2 at Wailes Bluff. Bed 3 carries many individuals of *Ostrea virginica* and a few of *Venus mercenaria*. This bed is present only for a short distance in the bluff, and where it is absent bed 4 rests on bed 2. No specimens of *Mya arenaria* or *Mytilus clava* were obtained by the writer from this upper fossiliferous bed (No. 3), but *Mya arenaria* is reported from Langleys Bluff by the Maryland Geological Survey in its volume on the Pliocene and Pleistocene. This bed may or may not represent the oyster bed at Wailes Bluff, but the two beds must differ in age only slightly, if at all.

Only two valves of *Rangia cuneata* were obtained from Langleys Bluff, and they were taken from bed 2.

COMPARISON OF LOCALITIES IN MARYLAND WITH LOCALITIES IN VIRGINIA

Shattuck,[7] in commenting on the deposits at Wailes Bluff, says:

> The lower portion carrying the marine organisms points to salt-water conditions and contains remains of sea animals which live to-day along the Atlantic coast. * * * Later, however, it would appear that a barrier beach was constructed, shutting off a portion of the sea bed which had formerly been occupied by marine animals and gradually allowing it to be transformed from salt-water conditions to those of brackish water. In this brackish-water lagoon the fauna changed to that found along our estuaries to-day, and huge oysters flourished and left behind them a deposit of shell rock. With the bar advancing landward, this lagoon was gradually filled up with sand and gravel and finally obliterated.

Shattuck finds no indication of an appreciable lapse of time between the deposition of the oyster bed and that of the underlying clay bed, and I am inclined to agree with his interpretation. The faunal change and the irregular contact between the two beds probably indicate a minor unconformity.

Clays of Talbot age at several places in Virginia, whether carrying a brackish-water fauna, plant remains, or peaty material, appear to be approximately contemporaneous with each other and probably are contemporaneous with the clay that carries the littoral or brackish-water fauna at Wailes Bluff and Langleys Bluff in Maryland. This relationship was especially noted in exposures on the right bank of lower Rappahannock River in Virginia, between Taft post office and Mosquito Point. Here a peat bed or a clay bed carrying either oysters or *Rangia cuneata* reposes upon the Yorktown Miocene and crops out at the same level along the bluff.

[6] Kellogg, J. L., Conditions governing existence and growth of the soft clams (*Mya arenaria*): U. S. Comm. Fish and Fisheries Rept. for 1903, p. 200, 1905.

[7] Shattuck, G. B., The Pliocene and Pleistocene deposits of Maryland: Maryland Geol. Survey, Pliocene and Pleistocene, p. 132, 1906.

If these clays that carry a brackish-water fauna or plant remains or peaty material in Virginia are approximately contemporaneous with the clays that carry a littoral or brackish-water fauna at Wailes Bluff and Langleys Bluff in Maryland, it would appear that the overlying beds in the two areas, composed of cross-bedded sand and gravel and occasional boulders, are approximately contemporaneous.

At Wailes Bluff the line of separation between the oyster bed and the gravel and sand above is a sharp one. Shattuck [8] states that there is no indication of an appreciable lapse of time at this point. I have noted a sharp line of demarkation between the clay that carries a brackish-water fauna, or vegetable remains, and the overlying sand and gravel at several exposures in Virginia. Only two are mentioned here.

In the bluff on the right bank of Rappahannock River about 2 miles above Tappahannock a cypress stump bed crops out along the beach and is overlain by a bed of considerably cross-bedded sand and gravel with boulders at the base.

In the bluff on Godfrey Bay, on the left bank of Piankatank River, a bed of carbonaceous material carrying many shells of *Rangia cuneata* is exposed about 2 feet above the beach. This bed is overlain by sand and pebbles. The height of the bluff is 15 to 20 feet.

On the other hand, exposures have been observed in which the evidence of an unconformity at the contact between the beds that carry vegetable or other organic remains and the gravel and cross-bedded sand is not convincing. At one place on the left bank of Rappahannock River, between Taft post office and Mosquito Point, an exposure near water level reveals a bed of gravel between peat beds.

It would then appear that the contact between the beds that carry either a littoral or brackish-water fauna or vegetable remains and the overlying cross-bedded sand and gravel, although it appears to be unconformable in some exposures and less so in others, does not represent an appreciable lapse of time.

PLIOCENE AND PLEISTOCENE LOCALITIES IN NORTH CAROLINA

HISTORICAL SUMMARY

In 1835 H. B. Croom [9] gave an account of organic remains obtained from marl pits dug on the estate of Lucas Benners, on the north bank of Neuse River 16 miles below New Bern, N. C. The pits were dug to a depth of about 25 feet, and their bottoms were about 10 feet below the water level of the river. Croom gives a list of genera, comprising mainly mollusks, obtained from this marl, and mentions bones and teeth of fishes and land animals. He was informed that the remains of the land animals were taken from depths of 20 to 25 feet below the surface. The same year Conrad [10] published a list of 66 species of mollusks received from H. B. Croom, which were taken from the marl pits on Mr. Benners's plantation. Of these species seven had not been found by Conrad in the Recent fauna. The beds were referred to the "Newer Pliocene." Conrad compares this fauna with the fossiliferous material found in Maryland near the mouth of Potomac River [Wailes Bluff].

Later Conrad [11] listed 34 species from the same pits. He states that his "medial and upper Tertiary" are in juxtaposition here. He was informed that the bones of land animals were above the "medial Tertiary," being mixed with the upper Tertiary, which he calls "Pleistocene or post-Pliocene." In referring to the state of preservation of these bones Conrad [12] writes:

> These remains are nearly all waterworn, black, and silicified and have evidently been transported from a distance, probably carried by ice down the ancient Neuse and dropped among the shells of the upper Tertiary period.

It appears from Conrad's later list of molluscan species from the marl pits on Benners's plantation that the specimens were taken from the upper part of the pits. Conrad [13] correlates this stratum on Neuse River with beds of "*Gnathodon*" on Potomac River, in Maryland, and refers it to the post-Pliocene.

In 1885 Holmes [14] described the occurrence of fossil cypress stumps overlain by shell marl on the southwest bank of Neuse River 10 to 12 miles below New Bern. This section is evidently the same as the section described on page 134 of this paper, and the shell marl mentioned by Holmes probably corresponds to the shell marl from which my collection No. 10896 was taken.

Dall [15] proposed the name Croatan beds to include those beds which are found on the estuary of Neuse River. He lists the species and analyzes the fauna from the Croatan beds, as obtained by Charles W. Johnson on Neuse River at Mr. Mallison's place,[16] 13 miles below New Bern, and at the mouth of Slocum Creek, 15 miles below New Bern. The Mallison section is evidently the same as section 3, described on page 134 of this paper, and the Slocum Creek section is the same as section 4, described on page 135. From these beds Dall reports 80 out of 96 recognized species as also occurring in the Recent fauna, or 83 per cent

[8] Idem, p. 132.

[9] Croom, H B., [Organic remains found in the marl pits in Craven County, N. C.:] Am. Jour. Sci., 1st ser., vol. 27, pp. 168–171, 1835.

[10] Conrad, T. A., Observations on the Tertiary strata of the Atlantic coast: Am. Jour. Sci., 1st ser., vol. 28, pp. 104–111, 280–282 (see pp. 109, 110), 1835.

[11] Conrad, T. A., Observations on a portion of the Atlantic Tertiary region, with a description of new species of organic remains: Nat. Inst. Promotion of Science Proc., Bull. 2, pp. 191–192, 1842.

[12] Idem, p. 191.

[13] Idem, p. 177.

[14] Holmes, J. A., *Taxodium* (cypress) in North Carolina Quaternary: Elisha Mitchell Sci. Soc. Jour., vol. 2, pp. 92, 93, 1885.

[15] Dall, W. H., Contributions to the Tertiary fauna of Florida, with especial reference to the Miocene Silex beds of Tampa and the Pliocene beds of the Caloosahatchie River: Wagner Free Inst. Sci. Trans., vol. 3, pt. 2, pp. 209, 213–217, 1892.

[16] Idem, p. 205.

Recent. The fauna is referred to the Pliocene but is regarded as younger than the Waccamaw Pliocene. Dall's list of the Croatan fauna, as will be shown later, includes both characteristic Pliocene and Pleistocene species.

Miller,[17] in 1912, described a section at Riverdale Wharf, on the right bank of Neuse River 9 miles below New Bern, the upper 12 to 15 feet of which he referred to the Pleistocene and the lower 4 to 5 feet to the Pliocene (Waccamaw). He says:[18]

> The lower part of this section is undoubtedly Pliocene or Pleistocene, but fossils that are represented by casts are not distinctive. However, it is probable that the strata belong to the same period as those exposed at Slocum Creek, and probably will be found to be of Pliocene age.

In referring to the fossiliferous blue clays that crop out below and a little above water level a short distance above the mouth of Slocum Creek, Miller says:

> It is probable they form a part of the upper Pliocene. Sufficient work in the determination of the fossils has not as yet been done to definitely settle this point, and for that reason they are retained in the Pliocene, where they have formerly been placed.

In referring to the fossil organisms listed by Conrad in his two publications and obtained from the Lucas Benners estate, on the north bank of Neuse River 16 miles below New Bern, Stephenson [19] writes:

> The large percentage of recent forms enumerated in both lists indicates the Pleistocene age of the bed.

In referring to the beds which furnished the fossils that were obtained from the marl pits on the northern shore of Neuse River 16 miles below New Bern, Hay [20] writes:

> It is not improbable that the deposit which furnished these fossils belongs to the earliest Pleistocene stage, the Nebraskan.

Berry [21] gives an account of what is known of the Pleistocene flora of North Carolina and the conclusions that may legitimately be derived from it. *Pinus serotina* [22] Michaux is reported from the Pamlico formation [Chowan?], below New Bern, Neuse River, Craven County, N. C. *Taxodium distichum* [23] (Linnaeus) L. C. Richard is reported from the Pamlico formation [Chowan?] below New Bern. This locality evidently is the same as that of section 2, in the next column.

[17] Miller, B. L., The Coastal Plain of North Carolina; the Tertiary formations: North Carolina Geol. and Econ. Survey, vol. 3, pp. 253, 254, 1912.

[18] Idem, p. 254.

[19] Stephenson, L. W., The Coastal Plain of North Carolina; the Cretaceous, Lafayette, and Quaternary formations: North Carolina Geol. and Econ. Survey, vol. 3, p. 289, 1912.

[20] Hay, O. P., The Pleistocene of North America and its vertebrated animals from the States east of the Mississippi River and from the Canadian provinces east of longitude 95°: Carnegie Inst. Washington Pub. 322, p. 359, 1923.

[21] Berry, E. W., Pleistocene plants from North Carolina: U. S. Geol. Survey Prof. Paper 140, pp. 97–117, pls. 45–57, 1926.

[22] Idem, p. 105.

[23] Idem.

STRATIGRAPHIC SECTIONS

The following sections were measured on the right bank of Neuse River:

1. *Section at Riverdale Wharf, 9 miles below New Bern, N. C.*[24]

	Feet
Pleistocene: Laminated alternating layers of drab clay and sand, poorly exposed	12–15
Pliocene (Waccamaw) [Croatan sand of this report]:	
Indurated ferruginous sandstone containing many small quartz pebbles, few larger than a pea in size. The rock contains many fossil casts of *Pecten, Ensis, Leda, Cardium,* and other forms. The rock varies in the amount of induration. Exposed about	4
Compact drab clay, poorly exposed	½–1

2. *Section near residence of W. B. Flanner, about 10 miles below New Bern, N. C.*

[By W. C. Mansfield]

	Feet
Loamy soil	2
Pleistocene (Chowan? formation):	
Laminated, gray to reddish medium-grained sand	4
Compact, laminated gray clay with thin partings of sand. Contains impressions of shells	4
Gray clayey sand	4
Very fossiliferous grayish sand. Many individuals of *Mulinia lateralis* present throughout, and *Rangia cuneata* is present in the lower 1 foot (collection 10896 [25])	8
?Unconformity:	
Truncated cypress stumps, 6 to 8 feet in diameter, embedded in dark carbonaceous clay	4
	26

3. *Section about 11 miles below New Bern, N. C.*

[By W. C. Mansfield]

	Feet
Sandy soil	2
Pleistocene:	
Laminated reddish sand and clay, with a water seepage at the base	6
Gray clayey sand	8
Very fossiliferous fine-grained gray sand (collection 10895)	4
Unconformity.	
Pliocene (Croatan sand):	
Concretionary, ferruginous coarse sand and gravel, carrying corals and mollusks (collection 10895*a*)	0–2

About 100 yards downstream from section 3 many individuals of *Rangia cuneata* were scattered along the shore, but none were observed in place in the section.

About 1 mile below section 3, at a place locally called "Shell Slough," many Pliocene shells are scattered along the beach, of which *Mulinia congesta* is the most abundant (collection 10894).

[24] North Carolina Geol. and Econ. Survey, vol. 3, p. 253, 1912.

[25] Tertiary locality numbers above 10000 are recorded in the U. S. Geological Survey station books and on the specimens in the form $\frac{1}{10}\frac{0}{6}$ (=10896).

4. *Section about 15 miles below New Bern and half a mile below the mouth of Slocum Creek*

[By W. C. Mansfield]

	Feet
Sandy soil	2
Pleistocene:	
Partly slumped laminated clay and sand, in which no fossils were observed	12–14
Gray plastic clay	2
Unconformity.	
Pliocene (Croatan sand):	
Shell bed, the upper part of which is highly oxidized and contains coarse sand and pebbles (collection 10893)	2–4

FOSSIL LOCALITIES

The fossil material from North Carolina was collected by me at the following stations:

10896. Neuse River, right bank, about 10 miles below New Bern, near the residence of W. B. Flanner. Taken from the bed in section 2 that directly overlies the truncated cypress stumps.

10897. Marl pile from pit on Brice Creek, about 1½ miles west of Croatan station.

10895. Neuse River, right bank, about 11 miles below New Bern; upper fossiliferous bed in section 3.

10895*a*. Same section as the preceding but taken from the lowest bed exposed.

10894. Neuse River, right bank, about 12 miles below New Bern, locally known as "Shell Slough." Fossils scattered along the beach.

10893. Neuse River, right bank, about 15 miles below New Bern, about 3 miles above Cherry Point, and half a mile below the mouth of Slocum Creek, section 4.

10892. Open land project about 10 miles northwest of Beaufort and 6 miles from North River. Marl thrown out of lower part of wide ditches constructed for drainage. The surface of the terrace is about 11 feet above sea level, and the marl came from about 8 feet below the surface.

Stations at which fossil material was collected from Craven County, N. C., in 1918 by Joseph A. Cushman:

8167. From pits 10 to 12 feet in depth on the John L. Roper property, 3 miles southwest of Riverdale.

8168. Blue shell marl from pits on the Ballinger farm, close to Croatan station

GEOLOGIC RANGE OF SPECIES FROM THREE LOCALITIES

The following table shows the number of species from beds at three localities in North Carolina which represent the different epochs from the Miocene to the Recent and also the number which occur either at Wailes Bluff or Langleys Bluff, Md., and at Simmons Bluff, Yonges Island, S. C. In determining the occurrence of species at Yonges Island, S. C., I have consulted the collection deposited in the United States National Museum and the table by Pugh.[26]

[26] Pugh, G. T., Pleistocene deposits of South Carolina, a thesis submitted to the faculty of Vanderbilt University for a degree of Doctor of Philosophy, Nashville, Tenn., 1905.

Geologic range of species of mollusks and corals

Station	Number of forms considered	Miocene	Pliocene	Pleistocene	Recent	Wailes Bluff and Langleys Bluff below oyster bed	Simmons Bluff, Yonges Island, S. C.
10892, 10 miles northwest of Beaufort.	30	9 and 2 queried	18 and 3 queried	30	30	12	22
10896, Neuse River, 10 miles below New Bern.	39	13 and 2 queried	29 and 2 queried	38 and 1 queried	38	22	31
10893, Neuse River, 15 miles below New Bern.	42	23 and 1 queried	39 and 1 queried	29 and 1 queried	27 and 1 queried	13	24

AGE AND STRATIGRAPHIC RELATIONS OF THE STRATA

PLIOCENE DEPOSITS

The fauna listed by Dall[27] from his Croatan beds at Slocum Creek and at Mallisons evidently includes a mixture of both characteristic Pliocene and Pleistocene species. A few species in the list that I regard as characteristic Pleistocene forms are *Ilyanassa obsoleta* (Say), *Urosalpinx cinereus* Say, *Arca ponderosa* Say (typical), *Arca pexata* Say, and *Anatina* [*Labiosa*] *canaliculata* (Say). Some of the species in his list that are believed to occur not later than Pliocene are *Drillia tuberculata* Emmons, *Ostrea meridionalis* Heilprin = *O. sculpturata* Conrad, *Carditamera arata* Conrad, and *Mactra* [*Mulinia*] *congesta* Conrad.

As it is undesirable to apply the name Croatan to a group of beds part of which are of Pliocene and part of Pleistocene age, I propose to restrict the name to those beds on and near Neuse River which are of Pliocene age.

The Pliocene was observed by me in three of the sections examined on the right bank of Neuse River. (See fig. 3.) I infer that the basal 3 to 4 feet in Miller's section[28] at Riverdale Wharf, on the right bank of Neuse River 9 miles below New Bern, also belongs, as he placed it, in the Pliocene. The Pliocene beds consist chiefly of coarse ferruginous more or less fossiliferous sand that rises to an observed maximum height of about 4 feet above the beach. The name Croatan sand is therefore appropriate. The Pliocene stratum is unconformably overlain by the Pleistocene deposits. The contact of the Pliocene with the Pleistocene deposits was observed in two exposures—one about 11 miles below New Bern (section 3) and the other about 15 miles below New Bern (section 4).

The fossil collection from station 10893, 15 miles below New Bern, contains mainly Pliocene species.

[27] Dall, W. H., op. cit., pp. 209, 213–217.

[28] Miller, B. L., op. cit., p. 253.

A few Pleistocene species, which are believed to have fallen from the overlying Pleistocene beds, are included in the list. (See stratigraphic section 4.) The following species collected there which are believed to have lived not later than the Pliocene include *Busycon caricum* Gmelin var., *Ilyanassa irrorata* (Conrad), *Urosalpinx* sp. aff. *U. perrugatus* Conrad, *Crassinella duplinana* Dall, *Cardita arata* Conrad, *Chama striata* Emmons, *Venus rileyi* Conrad, *Gemma trigonia* Dall, *Mulinia congesta* Conrad (not typical), *Septastraea crassa* (Holmes).

A collection of fossils was obtained from a marl pile thrown out of a pit dug in Brice Creek, about 1½ miles west of Croatan station (station 10897). This fauna indicates a mixture of Pliocene and Pleistocene species.

Two collections were obtained from Craven County, N. C., at stations 8167 and 8168, by Joseph A. Cushman. At station 8167 the material was obtained from pits on the John L. Roper property, 3 miles southwest of Riverdale. According to notes furnished by Mr. Cushman, the section here consists of 4 feet of soil, sandy Pleistocene, underlain by a bluish marl 6 to 8 feet in thickness, extending down to a reddish marl that carries abundant oyster shells [*Ostrea sculpturata*]. At station 8168 the fossil material was obtained from a blue shell marl in pits on the Ballinger farm, close to Croatan station. The fauna at both stations is similar to that at my station 10897 and also indicates a mixture of Pliocene with a few Pleistocene species.

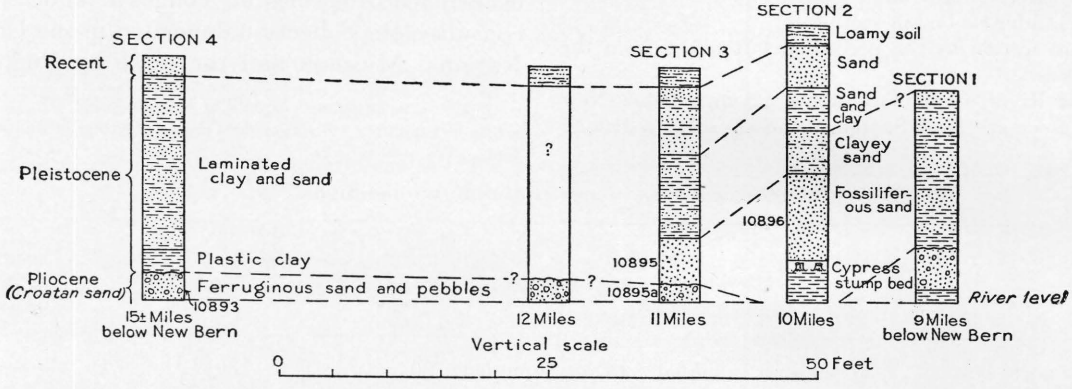


FIGURE 3.—Detailed columnar sections of Pliocene and Pleistocene strata along Neuse River, N. C.

PLEISTOCENE DEPOSITS

I have assigned all the deposits above the Pliocene examined by me on the right bank of Neuse River, except the loamy top soil, to the Pleistocene. These deposits below the top soil may represent the Chowan formation of the Pleistocene. These deposits include the cypress stump bed and the fossiliferous bed that immediately overlies it and also the poorly fossiliferous beds exposed in the upper part of the bluffs. These deposits were observed in exposures 10, 11, and 15 miles below New Bern. (See stratigraphic sections 2, 3, and 4.) At the exposures 11 and 15 miles below New Bern the bed that carries a littoral Pleistocene fauna rests upon the Pliocene deposit. At the exposure 10 miles below New Bern this same bed is underlain by a cypress stump bed, thus indicating that the Pleistocene material occupies a shallow depression in the surface of the Pliocene.

The age of these deposits is probably late Pleistocene. The table on page 135 has been compiled to show the geologic time range of the species in outside formations. Of 39 species obtained from the bed that immediately overlies the cypress stump bed 10 miles below New Bern, represented by collection 10896, all except one queried form are represented in the Pleistocene, 38 are known in the Recent fauna, 22 in Pleistocene clay either at Wailes Bluff or at Langleys Bluff, Md., and 31 are believed to occur at Simmons Bluff, Yonges Island, S. C.

Another collection was obtained about 10 miles northwest of Beaufort, N. C., at station 10892. In constructing a ditch or canal for drainage the marl had been thrown out and left on both sides of the ditch. The surface of the terrace here is about 11 feet above sea level. The top of the marl is about 8 feet below the surface. These fossils came from the Pamlico formation or terrace. In the table compiled to show the geologic time range of species in outside formations, out of 30 species considered, all are represented in the Recent fauna, 12 occur in the Pleistocene clays, either at Wailes Bluff or at Langleys Bluff, Md., and 22 are believed to occur at Simmons Bluff, Yonges Island, S. C. The age of the fauna is late Pleistocene.

PHYSICAL CONDITIONS ATTENDING THE DEPOSITION OF THE MATERIAL

The irregular contact between the Pliocene and Pleistocene beds on Neuse River below New Bern indicates that they are unconformably related. The episode that preceded the submergence of the land and the deposition of the Pleistocene beds appears to have been one of uplift and erosion. During this period of erosion stream channels were cut in the Pliocene surface, after which the land was lowered

sufficiently to permit the accumulation of Pleistocene deposits upon the irregular Pliocene surface. The cypress stump bed probably occupies a stream-cut channel.

The succession of the deposits as shown in stratigraphic section 2, about 10 miles below New Bern, affords a basis for inferring the physical conditions which prevailed during the deposition of the Pleistocene beds. The sequence of the beds from the base of the cliff upward consists of truncated cypress stumps embedded in a dark carbonaceous clay, gray sand carrying in the lower part a mixed littoral and brackish-water fauna and in the upper part a typical littoral fauna, and, finally, poorly fossiliferous sand and clay.

The cypress stumps indicate fresh water. Concerning the distribution of the Recent bald cypress, *Taxodium distichum* Richard, Sargent [29] writes:

> River swamps usually submerged during several months of the year, low wet banks of streams, and the wet depressions of pine barrens from southern Delaware southward near the coast to the shores of Mosquito Inlet and Cape Romano, Fla.

Dr. Albert Mann, diatomist, of the Carnegie Institution of Washington, identified the more prevalent species of diatoms taken from this cypress-stump bed. The following list of species, showing their abundance, and the remarks that follow are furnished by Doctor Mann:

[v. c.=Very common; c.=common; f.=frequent; s.=scarce]

Cymbella lanceolata (Ehrenberg) Kuetzing. f.
Eunotia major (W. Smith) Rabenhorst. f.
Navicula brasiliensis Grunow. f.
Navicula cuspidata Kuetzing. s.
Navicula elliptica Kuetzing. s.
Navicula formosa Gregory, var. s. (A marine species.)
Navicula maculata (Bailey) Cleve. f. (A marine species.)
Navicula nobilis (Ehrenberg) Kuetzing, var. approaching N. dactylus (Ehrenberg) A. Schmidt. c.
Navicula (Stauroneis) phoenicenteron, var. gracilis, S. gracilis W. Smith. s.
Navicula transversa A. Schmidt. s.
Nitzschia scalaris W. Smith. v. c. (Outnumbers all the others.)
Rhopalodia gibba (Ehrenberg) O. Müller. c.

[29] Sargent, C. S., Manual of the trees of North America, p. 72, 1905.

The material is a brown peaty mud, with considerable plant detritus, and the diatoms make up 5 to 10 per cent of the mass. They prove it to be a comparatively recent fresh-water deposit, though it contains a few forms that are unmistakably marine or brackish. This fact suggests that when the diatoms flourished the locality was close enough to the sea for tidal inflow to penetrate and thereby affect the diatom flora. Although this inference is warranted, it must be understood to be merely an inference.

Sponge spicules are also rather abundantly present. I am no authority on these structures, but I am pretty certain that, although the great majority are fresh-water forms, a few are marine, thus strengthening the inference as to the tidal inflow of the sea water.

It would be unsafe to attempt a comparison between this material and other subfossil deposits of similar latitude, such as the Pleistocene bed of the "Walker Hotel" swamp, Washington, D. C. Although a number of species are present in both they are common forms that have persisted from late geologic strata up to the present day and are in no sense indicative of any particular formation.

The fauna in the material that overlies the cypress stump bed indicates an invasion of the sea. The invasion of saline waters appears first to have destroyed the cypress forest, after which the advancing waves beveled off the upper part of the swamp deposit, leaving the large cypress stumps embedded in the carbonaceous clay. The presence of *Rangia cuneata* at and near the base of the fossiliferous sand that overlies the swamp deposit indicates brackish-water conditions at first, followed by a more typical littoral marine condition. The succeeding deposits above the fossiliferous sand, although of marine origin, are almost barren of organic remains. Just what caused the diminution of the fossil remains the writer is unable to explain.

PRESENT GEOGRAPHIC RANGE OF RECENT SPECIES FROM THREE OF THE FOSSIL LOCALITIES

The following table shows the present geographic distribution of those species at three of the fossil localities, which range upward to the Recent. I have ascertained the geographic distribution by consulting Dall's tables [30] and the collections of Recent mollusks in the United States National Museum.

[30] Dall, W. H., A preliminary catalogue of the shell-bearing marine mollusks and brachiopods of the southeastern coast of the United States, with illustrations of many new species: U. S. Nat. Mus. Bull. 37, 1889.

Present geographic distribution of Recent species from three fossil localities

Station	Number of forms considered	Cape Hatteras and northward	Cape Hatteras, northward and southward	Cape Hatteras and southward	Off North Carolina coast	West coast of Florida and Gulf Mexico
10892, 10 miles northwest of Beaufort	29	0	19	9	----------	1
10896, Neuse River, 10 miles below New Bern	37	1	28	6	1	1
10893, Neuse River, 15 miles below New Bern	28	1	20	7	----------	----------

CONDITIONS OF TEMPERATURE INDICATED BY THE FAUNAS

The fauna in collection 10893, which represents mainly Pliocene species, shows that out of 28 Recent species, 20 are now living both north and south of Cape Hatteras, 7 are living at and south of Cape Hatteras, and 1 (*Yoldia limatula*) is living at and north of Cape Hatteras. This distribution indicates that the temperature of the water in which they lived was no colder than that off the coast at Cape Hatteras to-day, and there is a suggestion that the water may have been a little warmer.

The Pleistocene fauna in the bed above the cypress stumps, represented by collection 10896, shows that out of 37 Recent species, 28 are now living both north and south of Cape Hatteras, 6 are living at and south of Cape Hatteras, 1 (*Yoldia limatula*) is living at and north of Cape Hatteras, and 1 is living on the west coast of Florida and in the Gulf of Mexico. This fauna suggests the presence of slightly cooler water than that which prevailed in Pliocene time but affords no positive evidence that the fauna could not have lived on the shores in the vicinity of Cape Hatteras to-day.

The fauna obtained from the Pamlico formation, represented by collection 10892, contains no species now living exclusively north of Cape Hatteras. Nine are found at and south of Cape Hatteras. This fauna could have lived under present conditions of temperature in the same latitude.

CORRELATION OF THE DEPOSITS IN MARYLAND AND NORTH CAROLINA

The accompanying table shows the occurrence and geologic range of species from the localities in Maryland and North Carolina and also a locality on Yonges Island, S. C., inserted for comparison. Only those species that occur at localities either in Maryland or North Carolina are recorded from Yonges Island.

Species of fossils from localities in Maryland, North Carolina, and South Carolina and their geologic range

	North Carolina									Maryland		South Carolina	Geologic range			
	Pliocene		Pliocene with admixture of Pleistocene				Pleistocene									
	10894. 12 miles below New Bern	10895a. 11 miles below New Bern	10893. 15 miles below New Bern	8167. 3 miles southwest of Riverdale	8168. Near Croatan	10897. 1½ miles west of Croatan	10896. 10 miles below New Bern	10895. 11 miles below New Bern	10892. 10 miles northwest of Beaufort	Wailes Bluff	Langleys Bluff	Yonges Island	Miocene	Pliocene	Pleistocene	Recent
MOLLUSKS																
Gastropods																
Acteocina canaliculata (Say)			×				×	×		×	×	×	×	×	×	×
Terebra concava (Say) var							×	?				×			×	×
Terebra dislocata (Say)				×			×	×	×	[a]×		×	×	×	×	×
Drillia tuberculata (Emmons) var.?				×	×								?	×		
Mangilia cerina (Kurtz and Stimpson)							×	×		×	×	×		×	×	×
Marginella limatula Conrad			×	×	×	×						×	×	×	×	×
Olivella mutica (Say)					?	?		×	×			×	×	×	×	×
Oliva sayana Ravenel			×						×			×	×	×	×	×
Busycon canaliculatum (Linnaeus)			×				×		×	×	×	×		×	×	×
Busycon caricum (Gmelin) var			×		×									×	?	
Busycon caricum (Gmelin)						×	×	×	×	×	×	×			×	×
Alectrion consensa (Ravenel)				×										×	×	×
Alectrion trivittata (Say)			×				×	×	×	×	×	×		?	×	×
Alectrion acuta (Say)			×				×	×				×		×	×	×
Alectrion vibex (Say)						×								×	×	×
Ilyanassa obsoleta (Say)			×				×	×		×	×	×			×	×
Ilyanassa irrorata (Conrad)			×	×	×									×		
Anachis obesa C. B. Adams			×				×	×						×	×	×
Anachis obesa C. B. Adams var				×	×									×		
Anachis avara Say var.? (Young)							×									
Anachis avara Say var				×										×		
Astyris lunata (Say)			×	×			×	×		×	×	×		×	×	×
Urosalpinx cinereus (Say)				×				×		×		×			×	×
Urosalpinx sp				×										×		
Urosalpinx sp. aff. U. perrugatus Conrad			×			×								×		
Coralliophila n. sp. ?				×										×		
Eupleura caudata (Say)						?	×			×	×	×		×	×	×
Epitonium lineatum (Say)							×			×	×	×		×	×	×
Epitonium aff. E. denticulatum (Sowerby)										×						
Seila adamsii (H. C. Lea)			×	×	×	×						×	×	×	×	×
Vermicularia spirata Philippi			×	×				×					×	×	×	×
Crepidula fornicata (Linnaeus)	×		×	×	×	×	×		×	×		×	×	×	×	×
Crepidula plana Say			×				×		×	×	×	×	×	×	×	×
Polynices duplicatus (Say)			×		×		×	×	×	×	×	×	×	×	×	×
Natica pusilla Say? (Young)			×													
Sinum perspectivum (Say)			×				×		×			×		×	×	×
Vitrinella (Episcynia) multicarinata Stimpson				×									×	×	×	×
Fissuridea alternata Say	×		×									×		×	×	×
Teinostoma sp								×								
Adeorbis? sp							×									

[a] Recorded here by the Maryland Geol. Survey in the volume on the Pliocene and Pleistocene.

Species of fossils from localities in Maryland, North Carolina, and South Carolina and their geologic range—Continued

	North Carolina									Maryland		South Carolina	Geologic range			
	Pliocene		Pliocene with admixture of Pleistocene				Pleistocene									
	10894. 12 miles below New Bern	10895a. 11 miles below New Bern	10893. 15 miles below New Bern	8167. 3 miles southwest of Riverdale	8168. Near Croatan	10897. 1½ miles west of Croatan	10896. 10 miles below New Bern	10895. 11 miles below New Bern	10892. 10 miles northwest of Beaufort	Wailes Bluff	Langleys Bluff	Yonges Island	Miocene	Pliocene	Pleistocene	Recent
MOLLUSKS—Continued																
Pelecypods																
Nucula proxima Say			×	×	×	×	×	×		×	×	×	×	×	×	×
Yoldia limatula Say						?	×			×		×			×?	×?
Yoldia limatula Say var			×	×	×									?	?	?
Leda acuta (Conrad)	?		×	×	×	×	×	×		×	×	×	×	×	×	×
Arca (Noëtia) ponderosa Say (typical)							×		×	×		×			×	×
Arca (Noëtia) ponderosa var			×													
Arca (Noëtia) limula Conrad, grading toward A. ponderosa Say			×													
Arca (Noëtia) limula Conrad var	×		×	×	×	×										
Arca (Argrina) campechensis var. pexata Say							×								×	×
Arca (Argrina) campechensis Gmelin var.?									×						×	×
Arca (Cunearca) incongrua Say									×			×			×	×
Arca (Scapharca) transversa Say (large and robust form)									×					×	×	×
Arca (Scapharca) transversa Say (light form)						×	×	×		×	×	×		×	×	×
Arca (Scapharca) subsinuata Conrad			×	×										×	×	
Arca (Scapharca) sp. aff. A. subsinuata Conrad	×					×										
Arca (Scapharca) n. sp. aff. A. plicatura Conrad	×		×	×	×	×										
Arca (Scapharca) plicatura Conrad var			×													
Arca sp. aff. A. compyla Dall	×					×										
Arca n. sp.?			×													
Arca (Fossularca) adamsii (Shuttleworth)						×							×	×	×	×
Ostrea virginica Gmelin			×		×	?			×	×	×	×	?	×	×	×
Ostrea sculpturata Conrad				×		×							×	×		
Anomia simplex D'Orbigny			×		×	×	×	×	×			×	×	×	×	×
Pecten gibbus Linnaeus									×			×		×	×	×
Pecten gibbus Linnaeus var			×													
Pecten n. sp. aff. P. eboreus Conrad		×														
Plicatula marginata Say?					×	×		×								
Mytilus clava Meuschen=M. hamatus Say										[b]×				×	×	×
Pandora trilineata Say							×	×				×	?	×	×	×
Pandora gouldiana Dall										×					×	×
Crassinella lunulata (Conrad)			×	×				×	?			×	×	×	×	×
Crassinella sp. cf. C. mactracea Linsley					×	×										
Crassinella duplinana Dall		×	×										×	×		
Cuna? n. sp.?			×													
Cardita floridana Conrad								×	×			×		×	×	×
Cardita arata (Conrad)	×		×		×	×							×	×		
Venericardia tridentata Say			×	×	×	×		×	×			×	×	×	×	×
Venericardia perplana Conrad					×								×	×	×	×
Venericardia perplana var. abbreviata Conrad			×	×									×	×		
Chama macerophylla Gmelin									×						×	×
Chama striata Emmons			×										×	×		
Phacoides (Bellucina) waccamawensis Dall					×	×								×		
Phacoides (Bellucina) sp. cf. P. amiantus Dall								×								
Phacoides (Parvilucina) multilineatus Tuomey and Holmes				×	×	×		×				×	×	×	×	×
Divaricella sp.									×							
Diplodonta sp. cf. D. caloosaensis Dall		×	×													
Diplodonta punctata Say							×	×							×	×
Bornia n. sp.? aff. B. lioica Dall								×								
Rochefortia planulata aff. var. fragilis Verrill and Bush			×				×	×						×	×	×
Sportella protexta (Conrad)				×								×	×	×	×	×
Sportella constricta (Conrad)					×		×	×					×	×	?	
Aligena elevata (Stimpson)										[a]×		×			×	×
Cardium robustum Solander			×				×	×				×		×	×	×
Chione cancellata Linnaeus				×		×			×			×		×	×	×
Venus rileyi Conrad			×	×									×	×		
Venus mercenaria Linnaeus				×			×		×	×	×	×	?	?	×	×
Venus campechiensis var. quadrata Dall									×						×	×
Callocardia sayana (Conrad)					×	×							×	×		
Callocardia morrhuana Linsley										×					×	×
Gemma purpurea H. C. Lea									×						×	×
Gemma magna Dall			×		×			×					×	×	×	
Gemma trigona Dall			×										×	×		
Petricola pholadiformis Lamarck										[a]×		×			×	×
Tellina tenera Say										[a]×						
Tellina sayi Deshayes			×				×	×				×		×	×	×
Tellina sp. a aff. T. sayi Deshayes									×							
Tellina sp. b aff. T. sayi Deshayes								×								
Macoma calcarea (Gmelin)										[a]×					×	×
Macoma balthica Linnaeus										×		×			×	×
Cumingia tellinoides (Conrad)										[a]×		×			×	×
Abra aequalis (Say)							×	×				×	×	×	×	×
Abra aequalis (Say) var			×	×	×	×		×								
Donax variabilis Say									×			×			×	×
Tagelus divisus Spengler							×							×	×	×
Tagelus gibbus (Spengler)										×	[a]×	×	×	×	×	×
Ensis directus Conrad			×				×	×	×	×		×	×	×	×	×
Spisula procera Solander									×						×	×
Spisula subparilis Conrad, grading toward S. similis Say			×										×	×		
Mulinia lateralis Say (heavy form)									×					?	×	×
Mulinia lateralis Say (light form)							×	×		×	×	×	×	×	×	×
Mulinia congesta (Conrad) (not typical)	×		×	×	×	×							×	×		
Rangia cuneata (Gray)							×		×	×	×			×	×	×
Rangia clathrodonta Conrad				×									×	×		

[a] Recorded here by the Maryland Geol. Survey in the volume on the Pliocene and Pleistocene.

[b] Obtained only from bed 3, or oyster bed.

Species of fossils from localities in Maryland, North Carolina, and South Carolina and their geologic range—Continued

	North Carolina									Maryland		South Carolina	Geologic range			
	Pliocene		Pliocene with admixture of Pleistocene				Pleistocene									
	10894. 12 miles below New Bern	10895a. 11 miles below New Bern	10893. 15 miles below New Bern	8167. 3 miles southwest of Riverdale	8168. Near Croatan	10897. 1½ miles west of Croatan	10896. 10 miles below New Bern	10895. 11 miles below New Bern	10892. 10 miles northwest of Beaufort	Wailes Bluff	Langleys Bluff	Yonges Island	Miocene	Pliocene	Pleistocene	Recent
MOLLUSKS—Continued																
Pelecypods—Continued																
Anatina canaliculata (Say)							×					×				
Paramya subovata Conrad							×						×	×	×	×
Mya arenaria Linnaeus										[b]×	[a]×	×	×		×	×
Corbula contracta Say			×		×		×	×	×	×		×		×	×	×
Corbula inaequalis Say			×	×	×	×							×	×		
Barnea (Scobina) costata (Linnaeus)										×	×	×		×	×	×
Martesia sp. cf. M. cuneiformis Say							×					×				
CORAL																
Septastraea crassa (Holmes) [c]		×	×	×									×	×		
CRUSTACEA																
Callinectes sapidus Rathbun										×			×		×	×
Cancer irroratus Say										×						×
Chloridella empusa (Say)										×						×
PLANT																
Pinus serotin a Michaux [d]							×									

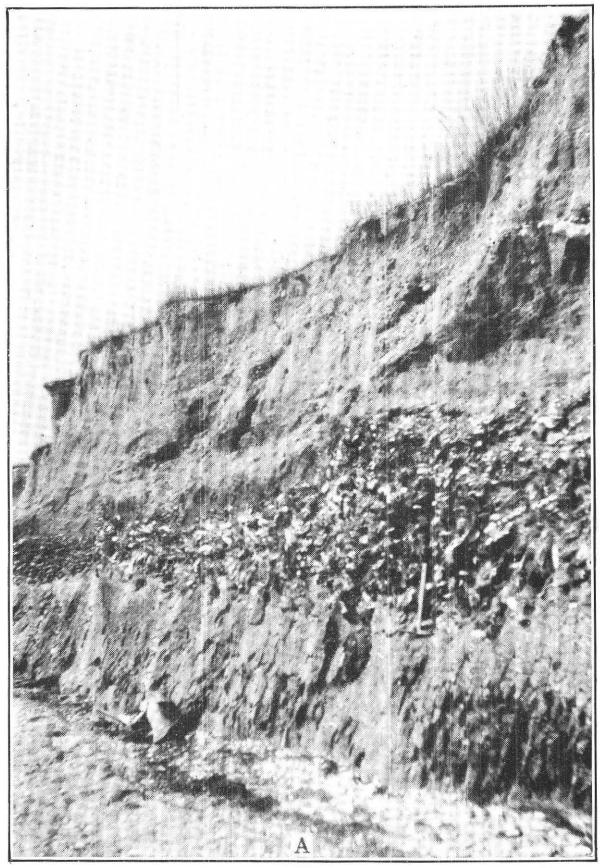
[a] Recorded here by the Maryland Geol. Survey in the volume on the Pliocene and Pleistocene.
[b] Obtained only from bed 3, or oyster bed.
[c] Identified by J. E. Hoffmeister at stations 10893 and 10895*a*.
[d] Identified by E. W. Berry, probably from cypress stump bed.

Pliocene.—The fauna of the Croatan sand is approximately equivalent to both the fauna of the Waccamaw formation in North Carolina and South Carolina and to the faunas of the Nashua marl and the Caloosahatchee marl in Florida.

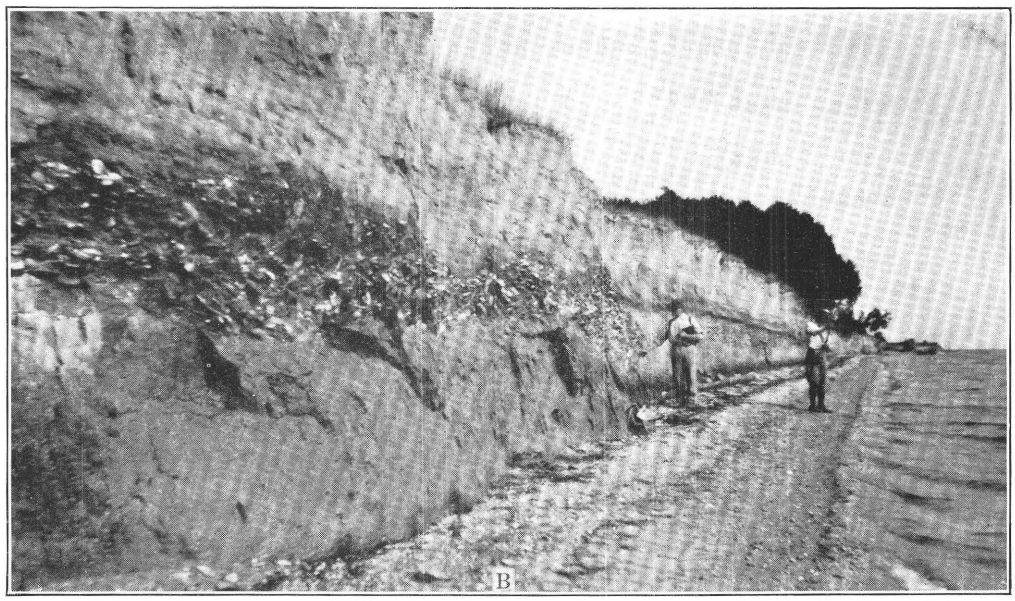
Pleistocene.—The littoral and brackish-water faunas along the Neuse, in North Carolina, represented by collections 10896 and 10895, appear to be equivalent in age to the fauna below the oyster bed at Wailes and Langleys Bluffs, Md., and to the fauna at Rose Bluff, Fla. It is probably a little older than the fauna of Simmons Bluff, Yonges Island, S. C.

The fauna from the Pamlico formation, represented by collection 10892, is probably of about the same age as the fauna of Simmons Bluff, Yonges Island, S. C. The fauna of Simmons Bluff contains a number of species—some of which are represented by many individuals—which are absent in my collections. A few of these species are *Tritonidea cancellata* Conrad, *Strombus pugilis* Linnaeus, *Dosinia discus* Reeve, *Tellidora cristata* Recluz, and *Tellina alternata* Say.

The fauna of Simmons Bluff indicates warmer water than that of the Pleistocene fauna in collection 10892, as might be expected from its more southern position.



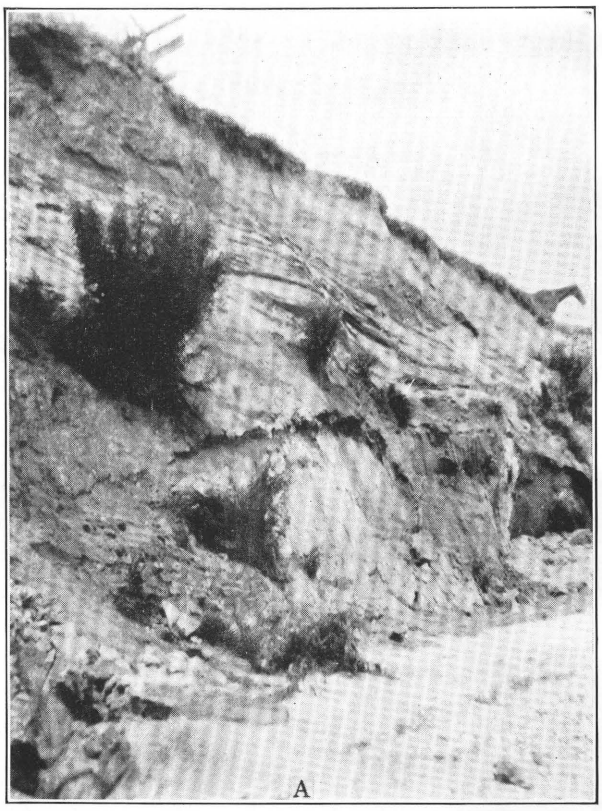
A. CONTACT OF OYSTER BED AND UNDERLYING CLAY BED, INDICATED BY HEAD OF HAMMER



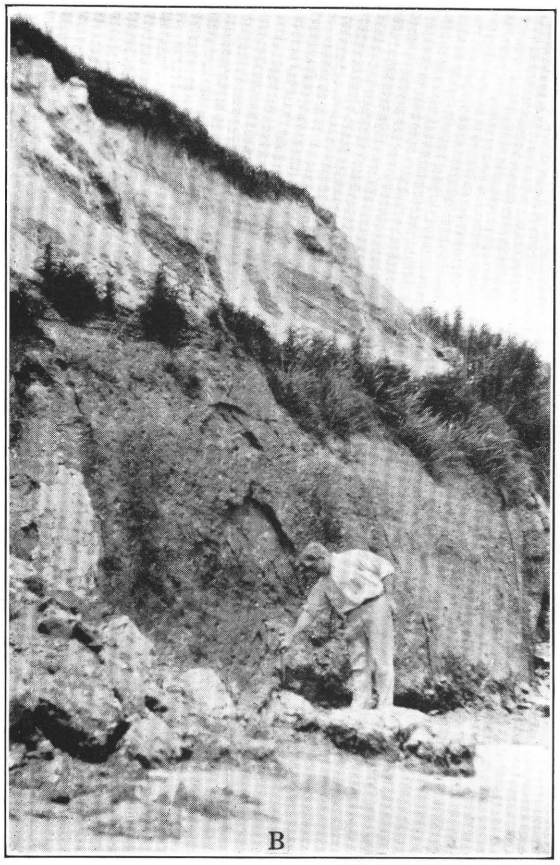
B. VIEW OF EASTERN END OF BLUFF

Sag in oyster bed at place indicated by man standing near bluff

WAILES BLUFF, ST. MARYS COUNTY, MD.

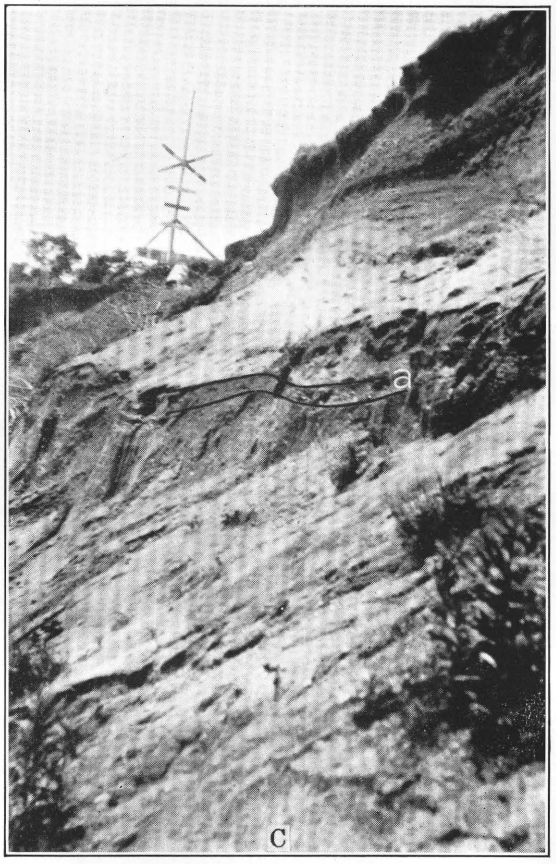


A, FOSSILIFEROUS PLEISTOCENE CLAY OVERLAIN BY CROSS-BEDDED SAND AND GRAVEL



B. CONTACT OF MIOCENE WITH OVERLYING PLEISTOCENE

Indicated by head of hammer



C. UNDULATING UPPERMOST PLEISTOCENE CLAY BED

Indicated by "a"

LANGLEYS BLUFF, ST. MARYS COUNTY, MD.

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