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# Pleistocene Terraces of The Atlantic Coastal Plain

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PLEISTOCENE TERRACES OF THE ATLANTIC COASTAL PLAIN

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A thesis

Presented to

the Faculty of the Department of Geology

University of North Dakota

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In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science of Geology

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by

Richard B. Moe

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## ABSTRACT

Pleistocene terraces on the Atlantic Coastal Plain have been recognized since the late 1800's, and from four to seven terraces have been described throughout Maryland, Virginia, North Carolina, South Carolina, and Florida. These terraces are now named Brandywine, Coharie, Sunderland, Wicomico, Penholoway, Talbot or Chowan, and Pamlico; and they are defined by relatively concordant shorelines at altitudes of 270-, 215-, 170-, 100-, 70-, 42-, and 25 feet above sea level. They have been correlated with respect to the glacial ages and substages and corresponding eustatic changes in sea level. The Various hypotheses regarding the origin of the terraces are: 1. Marine, with a cycle of marine deposition, uplift and erosion, and submergence with a continuous fall of sea level: 2. A dominantly fluvial origin; and 3. A combination fluvial-marine origin. No one hypothesis has been accepted completely, although the second marine hypothesis and the fluvial hypothesis have had more support than any other.

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# PLEISTOCENE TERRACES OF THE ATLANTIC COASTAL PLAIN

## INTRODUCTION

The Pleistocene terraces of the Atlantic Coastal Plain have been the subject of a great deal of literature as early as 1883. Since that time many publications have dealt with these terraces regarding their age, origin, aerial extent, and correlation along the Atlantic Coastal Plain.

This report is written with the purpose of presenting a summary of the material which was available to the writer regarding the extent, correlation, age, and origin, of these terraces.

## REVIEW OF THE LITERATURE

One of the earliest works dealing with the features of the Atlantic Coastal Plain was McGee, who, in 1888, described the Columbia "formation" (group) which he thought to be a deposit built "delta fashion into shallow estuaries when the land stood lower relative to sea level than it does now" (fide Flint, 1940, 758).

McGee stated (1888, p. 602) that the Chesapeake Bay region "abounds in terraces miles in extent," but did not locate or describe these features except referring to them as constructional terraces of marine origin.

In 1891 McGee described the upper limits of the Columbia sediments as rising northward as much as 150 feet from the Roanoke river to the Patapsco, and that the coarser material disappears southward.

McGee also carried the name "Lafayette" through from Mississippi, where it was first used by Hilgard, (1891, p. 130). The term was later applied throughout the Coastal Plain until it was dropped in 1915 because it referred to various deposits in different areas.

Darton, (1891, 1894,) believed the terraces in the region to be erosional rather than constructional, flanking the main streams, and that they were in part of fluvial-estuarine origin. He also divided the Columbia sediments into an "Earlier Columbia" on the higher terraces and a "Later Columbia" lying on the lower terraces.

Shattuck, (1906, p. 57-66) presented his opinions that the Columbia and "Lafayette" (Brandywine) sediments in Maryland are expressed as a system of four terraces that "wrap about each other in concentric arrangement---the oldest standing topographically highest" (1906, p. 66). He named these terraces Lafayette, Sunderland, Wicomico and Talbot in order from the highest to lowest.

He regarded the terraces as having a combined erosional-depositional origin with each surface one of marine aggradation and later modification by wave cutting. Flint's objections (1940, p. 761) to this theory are discussed on page 18-19.

Johnson, (1907, p. 640-642) described five well developed terraces, and two greatly dissected terraces on the North Carolina Coastal Plain, and a later work by Clark, Miller, Stephenson, et al. (1912, p. 266-290) recognized six subaerial terraces.

Matson (1913, p. 31-35) recognized three broad terrace-like plains in Florida, separated by scarps which he interpreted as marine, which was indicated by the presence of bars.

Veatch and Stephenson (1911, p. 35-39, 44-48, 424-445) recognized two terraces in Georgia. Cooke, (1925, p. 21-36) recognized five terraces in Georgia on the basis of his statement that: "A marine terrace may be defined as the part of the sea bottom uncovered and converted into land by the withdrawal of the sea from one level to a lower" (p. 30).

#### OCCURRENCE OF THE PLEISTOCENE TERRACES

##### Maryland

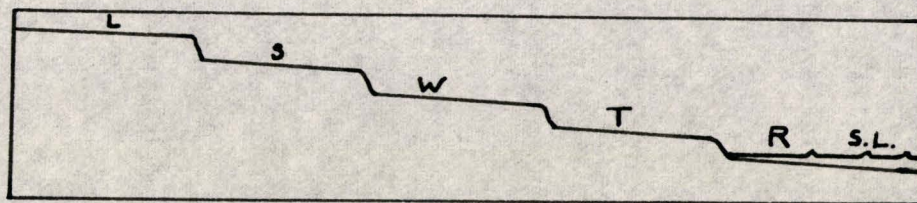
Following McGee and Darton, Shattuck (1906, p. 57-66) described four terraces as a part of the subaerial division of the Atlantic Coastal Plain in Maryland. These terraces, beginning with the highest, are the "Lafayette", Sunderland, Wicomico, and Talbot.

"Lafayette" terrace--The "Lafayette"<sup>1</sup> terrace was described by Shattuck (1906, p. 59) as ranging from 200 feet to nearly 500 feet above sea level.

Sunderland terrace--"Beneath the Lafayette terrace, wrapping around it like a border, extending up into its re-entrants, and separated from it by a scarp-line is the next younger terrace designated above as the Sunderland terrace" (Shattuck, 1906, p. 61). This terrace is described by Shattuck as ranging in altitude from 200 to 230 feet sloping to 90 and, in one case, 60 feet above sea level.

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<sup>1</sup> Clark, W. B., (1915, p. 449) proposed the name Brandywine to replace Lafayette as it was applied by McGee in 1891 to deposits of the Middle Atlantic Slope, but later considered inappropriate. Clark stated (1915, p. 500) that..."Shattuck in his study of the surficial formations of Maryland limited the term Lafayette to the highest of the terrace formations, the formation to which the author now gives the name of Brandywine."



L-Lafayette  
S-Sunderland  
W-Wicomico  
T-Talbot  
R-Recent

Fig. 1 Original terraces of Shattuck in Maryland.

(Modified from Shattuck, 1906, fig. 4, p. 67.)



Cooke (1930, p. 582) states that:

"The name Sunderland has been applied to two terraces corresponding to the 215-foot and to the 160-foot levels, but the typical Sunderland appears to be referable to the lower level. I therefore propose to apply the name Sunderland to the terrace corresponding to the 160 foot shore line, in conformity with Stephenson's (1912, p. 266-90) usage in North Carolina, and to apply the name Coharie to the terrace corresponding to the 215-foot level in Maryland and Virginia as well as in North Carolina."

Wicomico terrace--This terrace lies below the Sunderland terrace and--"bears the same relation to the Sunderland as the Sunderland does to the Lafayette terrace in that it wraps about it as a border----separated from it by a well-defined line of low rises." (Shattuck, 1906, p. 63). This terrace ranges from 90 or 100 feet to 45 and 60 feet above sea level.

Talbot terrace--The lowest of Shattuck's terraces, the Talbot terrace, lies adjacent to the Wicomico terrace at an altitude of about 40 to 45 feet, sloping gradually to sea level.

Cooke (1930, p. 582) expands Shattuck's Talbot terrace to include the Chowan terrace and the Pamlico terrace lying at approximately 65 and 25 feet above sea level, and suggests the abandonment of the name Talbot as a terrace name.

#### Virginia

The Coastal Plain terraces of Virginia were considered by Clark and Miller (1912, p. 48-51) as extensions of the terraces described in Maryland by Shattuck (1906, p. 57-66). These terraces are, in order of oldest to youngest: Lafayette (later termed Brandywine and now referred to the Pleistocene), Sunderland, Wicomico, Talbot, and a Recent

terrace, still in the process of formation. Cooke (1930, p. 582) proposed the name Coharie to a terrace level intermediate to the Brandywine and Sunderland at an altitude of 215 feet. Cooke also favors the usage here of Chowan and Pamlico as divisions of the Talbot terrace of Shattuck.

The original terraces were named by Clark and Miller according to the formations which cover them.

Lafayette terrace--The "Lafayette" terrace is the highest, and best developed along the western margin of the province, representing.. "portions of a subaqueous terrace 480-500 feet in Fairfax county sloping eastward to approximately 200 feet, ending at the escarpment of the Sunderland terrace." (Clark and Miller 1912, p. 49).

Sunderland terrace--The Sunderland terrace, and probably the Coharie terrace, represent the greater part of the Coastal Plain in Virginia. According to Clark and Miller (1912, p. 50) the Sunderland terrace ranges in altitude from 200 to 250 feet, and separated from the "Lafayette" terrace by a distinct scarp at places and at other localities the separation is gradual.

Wicomico terrace--The Wicomico terrace borders the Sunderland terrace at an altitude of 80-90 feet. Like the others it is not a continuous plain, but a dissected, rolling surface separated from the Sunderland by "a well defined line of low cliffs, especially in the northern portion of the state." (Clark and Miller, 1912, p. 50).

The Talbot terrace of Clark and Miller is considered to be the lowest of the subaerial terraces---"wrapping about the preceding terrace like a border, penetrating it in re-entrants and separated from the Wicomico terrace by a scarp line." (Clark and Miller, 1912, p. 51).

This terrace varies from 10-20 feet above sea level and maintains much of its original form since it has not been subjected to very active erosion.

North Carolina

Stephenson, (1912, 266-290) recognized seven terraces on the Atlantic Coastal Plain of North Carolina. Six of them represent the subaerial division of the coastal plain, one being a submarine feature. These terraces are, in order of decreasing altitude: Lafayette, (later called Brandywine), Coharie, Sunderland, Wicomico, Chowan, Pamlico, and Recent.

Lafayette terrace--The Lafayette terrace is the dissected remains of an ancient terrace that extended into the piedmont burying the plateau and covering the western margin of the coastal plain.

Coharie terrace--The Coharie terrace ranges in altitude from 220 to 235 feet, sloping to 160 and 180 feet along its eastern margin.

Sunderland terrace--The Sunderland terrace has a greater aerial extent than the Coharie, and varies in altitude of 140 to 160 feet adjacent to the Coharie, to 100 to 110 feet at its eastern margin.

Wicomico terrace--The Wicomico terrace, larger than the Coharie and Sunderland terraces, forms deep re-entrants in the older terraces. It varies in elevation from 80-100 feet at its westward margin to 60 feet at its easternmost extent, and its greatest width is nearly 40 miles in the southern portion of the state.

Chowan terrace--The Chowan terrace ranges in altitude of 40-50 feet at the western border to 30 feet eastward. It is better developed in

the southern portion of the state where it is nearly 25 miles wide.

Pamlico terrace--The Pamlico terrace is the youngest terrace recognized in North Carolina. It is well developed in the northern portion of the state where it is nearly 50 miles wide and varies in altitude from 20 feet at its western margin to tide level eastward.

The Chowan and Pamlico terraces are Stephenson's (1912, p. 266-290) subdivisions of Johnson's earlier Talbot terrace (1907, p. 640-642).

#### South Carolina

Cooke, (1936, p. 6) describes "seven abandoned shore lines along the Atlantic coast---the part of the abandoned sea bottom between each shore line and the next lower one is treated as a separate terrace and given a distinctive name." These are, from highest to lowest, Brandywine, Coharie, Sunderland, Wicomico, Penholoway, Talbot, and Pamlico.

The Talbot is equivalent to the Chowan terrace of North Carolina, which was substituted earlier by Stephenson (1912, p. 266-290) in place of the Talbot. In Cooke's studies of South Carolina (1936, p. 149) he refers to the Talbot terrace as having priority over the name Chowan and therefore does not recognize the latter usage.

Brandywine terrace--The Brandywine terrace in South Carolina is the highest and oldest terrace, being defined by the limits of 215-and 270 feet above sea level.

Coharie terrace--The Coharie terrace ranges between 170-215 feet above sea level, and varies in width from 1 to 15 miles. The Coharie

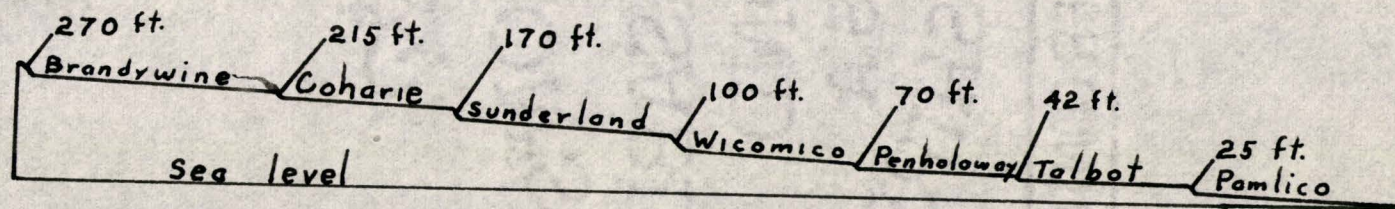


Fig. 2, Profile across the coastal terraces in South Carolina.

(Cooke, 1936, fig. 2, p. 6)

terrace appears flatter than the Brandywine and in some places is separated from the older terrace which rises above it by as much as 40 to 50 feet.

Sunderland terrace--The Sunderland terrace extends from an altitude of about 100 feet to 170 feet above sea level. It has been modified by erosion, and its estuarine re-entrants extend up all the large rivers to the Fall line.

Wicomico terrace--The Wicomico terrace lies between 70 and 100 feet above sea level, and ranges from 8 to 30 miles wide with its re-entrants extending even further inland.

Penholoway terrace--This terrace lies between 40 and 70 feet above sea level. It is very narrow and sometimes absent in the southern portion of the state, becoming wider northward to nearly 25 miles. On this terrace are remnants of wave-built bars, spits, and barriers.

Talbot terrace--The Talbot terrace ranges in altitude from about 25 to 40 feet above sea level, and is characterized by remains of what were islands during the presence of the Pamlico Sea.

Pamlico terrace--This terrace lies between the present shore line and an abandoned shore line (Pamlico) 25 feet above sea level. On this surface there are many remnants of bars, barriers, spits, inland waterways, and patches of sea islands.

Georgia

Veatch and Stephenson (1911, p. 35-39, 44-48, 424-445) recognized two broad terrace-like plains in Georgia. These were named

Okefenokee and Satilla, the former recognized at an altitude of 60 to 125 feet and the latter at 40 to 150 feet.

Cooke, (1925, p. 21-36) recognized five terraces on the basis of his definition as stated on page 3. These were, in order of decreasing altitude; Hazelhurst, Claxton, Okefenokee, Penholoway, and Satilla.

Hazelhurst terrace--The Hazelhurst terrace ranges from about 215 feet at its eastern margin to 260 feet "at the edge of the Tifton Upland" (Cooke, 1925, p. 29). Cooke (1931, p. 506) later substituted the name Brandywine for this terrace.

Claxton terrace--The Claxton terrace ranges in altitude from 160 to 215 feet. This terrace includes some swamp land.

Okefenokee terrace--The next lowest terrace is the Okefenokee terrace, ranging from 100 to 160 feet above sea level. It is the flattest of the coastal terraces and occupies a greater area in Georgia than any other terraces. It is flat, incompletely drained, and is occupied by the Okefenokee swamp, the second largest swamp in the United States.

Penholoway terrace--The Penholoway terrace is a flat poorly drained surface which rises from 16-18 feet above sea level to 60 and 70 feet inland where it meets the Okefenokee terrace.

Satilla terrace--The Satilla terrace ranges from sea level to an average height of 20 feet, and is considered by Cooke (1925, p. 22) to occur as three natural subdivisions, the mainland, the marshes, and the Sea Islands.

Cooke (1943, p. 104) expanded the number of terraces to include eight Pleistocene stages of sea level. These are: Brandywine, Coharie,

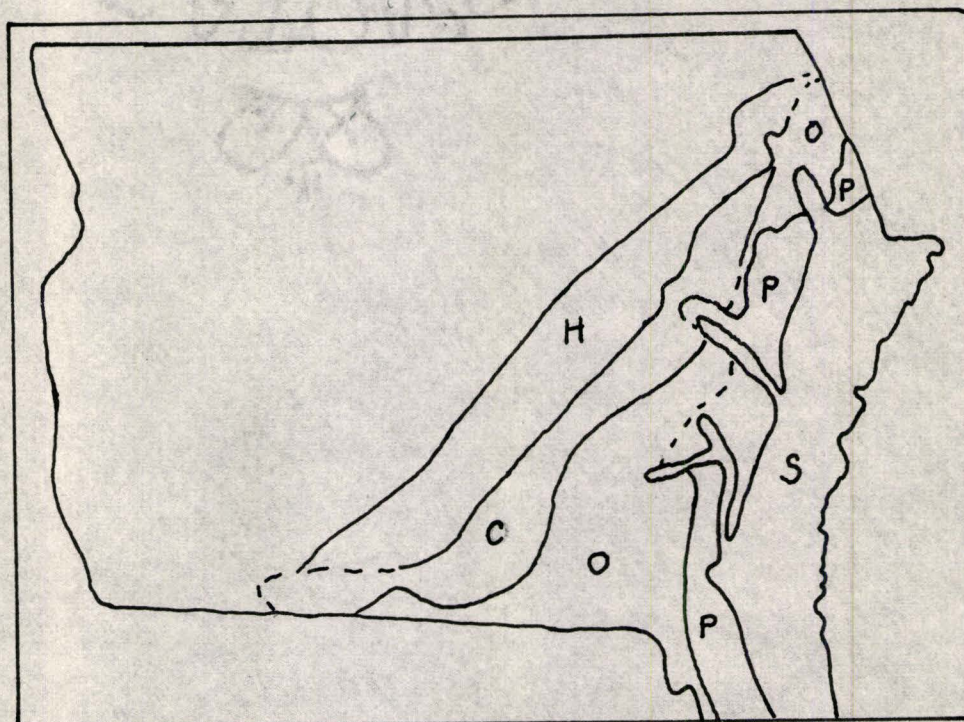


Fig. 3 Coastal Terraces of Georgia

(Cooke, 1925, pl. X, p. 29.)

H-Hazelhurst terrace

C-Coharie terrace

O-Okefenokee terrace

P-Penholoway terrace

S-Satilla terrace



Sunderland, Wicomico, Penholoway, Talbot, Pamlico, and Horry, with their corresponding elevations as 270 feet, 215 feet, 170 feet, 100 feet, 70 feet, 42 feet, 25 feet, and sea level.

To prevent confusion to the reader it should be noted that earlier (1931, p. 506) Cooke had substituted the older name Brandywine for the Hazelhurst terrace which he described in 1925.

#### Florida

Matson (1913, p. 31-35) recognized three terrace-like plains bordered by seaward-facing scarps. These terraces were the Pensacola terrace, ranging from sea level to about 40 feet above it; Tsala Apopka, from 40 to 60 feet above sea level; and the Newberry terrace.

The Pensacola terrace, according to Matson, (1913, p. 34) included two sub-divisions which he did not attempt to differentiate except that the division was present at or near the 20 foot level.

Cooke (1945, p. 12, 248) has recognized seven shorelines and corresponding terraces, and possibly an eighth. The shorelines of the terraces and their altitudes are:

Brandywine terrace . . . . .	270 feet
Coharie terrace . . . . .	215 feet
Sunderland terrace . . . . .	170 feet
Wicomico terrace . . . . .	100 feet
Penholoway terrace . . . . .	70 feet
Talbot terrace . . . . .	42 feet
Pamlico terrace . . . . .	25 feet

Flint (1940, p. 773) noted two seaward facing scarps, the Suffolk and Surry scarps at 20-30 feet and 90-100 feet above sea level. Flint believes that these scarps are the only evidence of ancient shorelines existing at the present time, not only in Florida, but throughout the Atlantic Coastal Plain.

Four, and possible five marine terraces have been recognized by MacNeil (1950, p. 98-104) on the basis of..."the co-existence of shore-line scarps, which are presumably wave-cut cliffs." (1950, p. 98). Mac Neil states that "all terraces up to an altitude of 150 feet are bounded on the landward side by seaward-facing scarps, but there is no scarp at the upper edge of the high terrace." (1950, p. 99) and their altitudes are: Okefenokee, 150 feet; Wicomico, 100 feet; Pamlico, 25-35 feet; and Silver Bluff, 8-10 feet.

#### CORRELATION OF THE PLEISTOCENE TERRACES

Throughout the Atlantic Coastal Plain Cooke (1930, p. 580) recognizes a general accordance of ancient shore line levels which can be traced from state to state. Discrepancies do arise in the local names used for the terraces, and in the degree of accuracy used in mapping and measuring the elevations of them.

In view of the uniformity of these shore lines Cooke, (1930, p. 581) states:"...it is only a problem regarding correlation of the local names that have been applied to the terraces and determining to which shore line each should be referred."

Shattuck has presented evidence that the terraces were formed during a period of submergence, followed by emergence and erosion. The successive periods of submergence and emergence were caused either by eustatic changes in sea level, or regional uplifting and down-sinking of the land. Cooke (1930, p. 583) feels that if the latter were the case, there should be evidence of local warping or tilting, which is not evident from the concordance of the shore lines. Therefore, Cooke favors eustatic changes of sea level, either through glacial control of sea level or tectonic control of the ocean bottoms.

In support of the theory concerning eustatic changes in sea level Cooke (1930, p. 585) gives evidence of world wide fluctuations in sea level which resulted in..."the presence of elevated shore lines at identically the same altitudes in many widely separated regions." The regions that Cooke mentions are the Western Mediterranean, Atlantic coast of France, English Channel, and coast of South Africa.

In correlating the terraces of the Atlantic Coastal plain, Cooke attributes the various stands of the sea to eustatic changes of sea level resulting from glacial control.

The coastal terraces can therefore be dated by glacial chronology, each terrace being shaped during a high-water interglacial stage, and the periods of low water and erosion corresponding to a glacial stage.

"It is based on the assumption that the series of shore lines as now interpreted is complete; that the highest is the oldest and the lower are younger in regular sequence." (Cooke, 1930, p. 587).

Table 1. Correlation of Pleistocene Shorelines and Corresponding Terraces

Stage of sea level (feet)	Maryland	Virginia	North Carolina	South Carolina	Georgia	Florida	Age in glacial chronology
0	Recent	Recent	Recent	Recent	Horry	Recent	
Low Water						Silver Bluff (8-10')	Late-Wisconsin
25	Pamlico	Pamlico	Pamlico	Pamlico	Satilla-Pamlico	Pensacola-Pamlico	Mid-Wisconsin
Low Water				Talbot (42' shore line)	Talbot (42' shore line)		Early-Wisconsin
65	Chowan	Chowan	Chowan	Penholoway	Penholoway	Tsala Apopka	Peorian
Low Water							Iowan
95	Wicomico	Wicomico	Wicomico	Wicomico	Penholoway-Wicomico	Wicomico-Newberry	Sangamon
Low Water							Illinoian
160	Sunderland	Sunderland	Sunderland	Sunderland	Okefenokee-Sunderland	Okefenokee-Sunderland	Yarmouth
Low Water							Kansas
215	Coharie	Coharie	Coarie	Coharie	Claxton-Coharie	High Terrace	Aftonian
Low Water							Nebraskan
265	Brandywine	Brandywine	Brandywine	Brandywine	Brandywine Hazelhurst		Pre-glacial

Cooke (1930, p. 588) has correlated the terraces of Maryland, North Carolina, Georgia, and Florida, with respect to glacial and interglacial periods, as reproduced in Table 1. The writer has included in the table the terraces of Virginia and South Carolina, and modified the original table to include the most recent terrace names used.

#### ORIGIN of the PLEISTOCENE TERRACES

Flint (1940, p. 760-771) refers to three hypotheses regarding the origin of the terraces along the Atlantic Coastal Plain; a hypothesis of marine origin, one of fluvial origin, and a combined fluvial-marine hypothesis.

The hypothesis of marine origin was proposed by Shattuck (1906, p. 137) which regards the terraces present in Maryland a product of a cycle of deposition under marine conditions, uplift and subaerial erosion, and subsequent submergence and marine aggradation. This theory was based on morphological criteria and continuity of the terraces. To explain the overlap of the original terraces Shattuck (1906, p. 67) considered the terraces to have been warped, but Flint (1940, p. 761) states..."Such proof is not offered by Shattuck".

Flint's objections to Shattuck's hypothesis are, briefly: (1940, p. 761)

1. The vertical range of one terrace overlaps the range of the next one.

2. Intermediate terraces occur between the four principal terraces which Shattuck explains as fluvial, but he does not differentiate between them.

Other objections of Flint to Shattuck's hypothesis are: the absence of wave-cut scarps; the presence of erosional outliers is... "inconsistent with a hypothesis of marine planation" (1940, p. 761); crossbedding as illustrated by Shattuck suggests a fluvial origin; the fact that the sediments of the three lower terraces are indistinguishable strongly indicates a fluvial origin; the higher sediments contain no marine fossils, while they do contain some terrestrial plants and animal fossils.

Flint (1940, p. 762) states that:

"Shattuck (1906, p. 119) rejected a fluvial hypothesis for two reasons: there is no "opposing bank" for the implied river; the time required for cutting the Talbot terrace by streams would have been sufficient for the complete dissection of the Wicomico surface, including its scarp."

Schlee, (1957, p. 1395) regards a marine origin for the gravels in Maryland... "untenable from a petrologic standpoint because the sorting is too poor; the bimodal size distribution does not appear characteristic of marine gravel."

Cooke (1952, p. 37-46) considers the Brandywine and higher terrace as fluvial deposits, and the Sunderland as a deltaic deposit when the sea stood at 215 feet above its present shore line.

#### Hypotheses Favoring Fluvial Origin

Chamberlain and Salisbury (1906, p. 305-308, 452-454) consider the terraces a product of fluvial sedimentation on the basis of poor size

sorting, crossbedding, oxidation of materials, increase in altitude upstream of the sediments, absence of marine fossils and of shore features.

Clark (1915, p. 505) considered the Brandywine formation as the result of combined fluvial-marine processes.

Campbell (1931, p. 821-852) considered the Brandywine and Sunderland terraces as fluvial, resulting from an extensive fan built by the Potomac River on the basis of absence of delta stratification, on increasing thickness upstream, stratification and sorting, and limited extent of wave-cut scarps which could be better explained through sub-aerial processes.

Wentworth (1930, p. 104) proposed an alluvial fan origin for the deposits in Virginia, but Schlee (1957, p. 1396) doubts this theory because of the fairly constant thickness of the sediments, the southwest slope, lack of torrential cross-bedding and interfingering of sand and gravel lenses.

#### CONCLUSION

The purpose of this paper has been to present to the reader the most significant facts regarding the extent, correlation, and origin of the Pleistocene terraces of the Atlantic Coastal Plain.

A great deal of literature has been published about the terraces, the most important of which this writer has attempted to bring to the readers attention.

The presence of from four to seven or eight terraces at fairly continuous horizons on the coastal plain has not been discredited,

but the controversy that prevails is whether these terraces are the result of fluvial processes or that they originated as a result of marine aggradation following repeated uplifts and submergences.

The correlation of the terraces with respect to glacial chronology is not difficult if it is assumed that the highest terrace recognized is the oldest, and thereby originating during the pre-glacial sea level. The successively lower levels can then be correlated with corresponding stages, low water levels, and ages, high water marks.



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