THE WACCAMAW AND CROATAN DEPOSITS OF THE CAROLINAS

By

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INTRODUCTION

Funds derived from a National Science Foundation grant have made possible initiation of a detailed stratigraphic-paleoecologic study of some of the marine Neogene deposits of coastal North and South Carolina. Special emphasis has been placed on the Waccamaw and Croatan formations. Much of the summer of 1959 was spent examining outcrops and making extensive collections. Field work in the area will be resumed during the summer of 1960.

It is hoped that as a result of this study a more accurate picture can be constructed of the mutual stratigraphic and age relationships of the various Neogene formations in the region, and that details of the depositional environments can be determined.

It is desirable that this study be coordinated with those of other investigators working concurrently on slightly different aspects of the same general problem, thus making possible a much more accurate account of the Neogene history of the Coastal Plains of the Carolinas and subsequently all of the southeastern seaboard.

Resume of Past Work

The Waccamaw Formation was named by William H. Dall (1892, p. 209) for fossiliferous marine deposits exposed along the banks of the Waccamaw River in Horry County, South Carolina. Dall (1892, p. 209) named the Croatan formation for fossiliferous marine sediments exposed along the banks of the Neuse River east of New Bern, North Carolina. He referred both of the formations to the Floridan Group (Pliocene) along with the Caloosahatchee marl of Florida.

Prior to the time of Dall's study the Waccamaw and Croatan formations were grouped by most geologists with other Neogene deposits of the Carolinas into the "Carolinian Beds", considered at the time to be Miocene in age. Tuckey and Holmes (1857) placed the Waccamaw and Croatan deposits in the Pliocene.

Dall concluded (1892, p. 202-203) that the fauna described by Tuckey and Holmes in their "Pliocene Fossils of South Carolina" (1857) was actually a mixture of several heterochronous faunas including some of Miocene and some of Pliocene age. He considered that the mixture was not attri-

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Butable to careless field work, but rather the result of mixing by running water, earth flows and other natural phenomena. Dall confined his study to the Waccamaw and Neuse River areas because he considered the faunas there to be stratigraphically in place.

Dall (1892, p. 215) found that 125 out of 180 mollusk species (or 80%) from the type Waccamaw deposits were still living, whereas 80 of 96 species (or 83%) from the Croatan formation were represented in the recent fauna. Considering these percentages and by comparing the fauna with those of other areas and other formations Dall concluded that the Waccamaw formation was Pliocene and that the Croatan was slightly younger but also Pliocene in age.

Most geologists have agreed since Dall's publication (1892) that the Waccamaw and Croatan formations are Pliocene in age and that they are correlative of the Caloosahatchee marl (Cole, 1931; Gardner and Woodring, 1943; Cooke, 1936; Gardner, 1943; Mansfield, 1938, 1936; Miller in Clark, 1912, and Richards, 1950).

Mansfield (1928, p. 135) thought that Dall had included both Pliocene and Pleistocene species in his Croatan faunal list. Mansfield re-examined the type area near Slocum's Creek where he decided the term Croatan (Pliocene) should be restricted to the lower few feet of the section, which were supposedly overlain unconformable by fossiliferous Pleistocene deposits. Neither Richards (1950) nor I could locate this unconformity and judging from field relationships, I have tentatively concluded that Mansfield's 'Pliocene' and 'Pleistocene' strata are actually intertonguing facies representing the same age.

Recently Brown (Legrand & Brown, 1955) has concluded on the basis of comparison of ostracode species that at least some of the 'Waccamaw' outcrops in North Carolina represent a facies of the Late Miocene Duplin formation.

Geology of the Waccamaw and Croatan Formations

Supposed Waccamaw and Croatan deposits crop out in scattered patches along the eastern edge of the Coastal Plain from Charleston, South Carolina to the Neuse River area in North Carolina, a distance of more than 200 miles. All the known outcrops lie below the Wicomico (100 foot shoreline). Exposures of the Croatan are restricted to the banks of the Neuse River east of New Bern, North Carolina and to the area immediately adjacent to the river.

The formations are thin where observed, averaging less than 10 feet at most outcrops. Miller (in Clark, 1912, p. 252-253) reports a thickness of 80-100 feet for the Wacca-
Lithologically the Waccamaw consists of unconsolidated sandy marls, argillaceous marls and sand as well as some thin, relatively hard limestones or calcareous marls. Most of the outcropping deposits are brownish in color on the surface, but unweathered material is commonly blue-gray. In general, megafossils, especially mollusks, are abundant and fairly well preserved.

The Croatan differs from the Waccamaw in being sandier, more argillaceous and less calcareous.

Both the Waccamaw and Croatan formations unconformable lie on older formations. The Waccamaw rests on deposits which range in age from Cretaceous to Late Miocene, where observed the Croatan formation rests on the Trent formation (Early Miocene).

Both the Waccamaw and Croatan are unconformably overlain by Pleistocene sands and clays.

Stratigraphic and Age Relationships

As mentioned above, the Waccamaw and Croatan formations are at present generally correlated with the Caloosahatchee marl of Florida, and these three formations collectively have been considered to represent the marine Pleistocene of Eastern United States. Recently, studies by myself (1958a, 1958b, and 1958c) and others (Puri and Vernon, 1959) have conclusively demonstrated that the Caloosahatchee marl is a Pleistocene deposit. In addition, the Tamiami formation, once regarded as a Pleistocene facies of the Caloosahatchee, is now classified as Late Miocene in age (Parker, 1951).

All marine Pleistocene strata of Florida younger than the Caloosahatchee marl, which contains marine fossils, lie below the Pamlico shoreline (30 feet above sea level). Probably all these younger Pleistocene deposits, which include the Ft. Thompson, Anastasia, Miami oolite and Key Largo formations, are more or less contemporaneous with the Pamlico formation of the Carolinas (Table 1). It is thought by me that all of these formations, including the Pamlico, were deposited at a time when the Wisconsinan glaciers retreated and sea level stood approximately 25-30 feet higher than today.

It is probable that one or more of the Florida Pleistocene shorelines above the Pamlico were formed by the Caloosahatchee Sea. Paleontological and paleogeographical evidence (Du Bar, 1958a, p. 152) suggests that the highest stand of the Caloosahatchee Sea correlates with the making of the Wicomico shoreline (100 feet above sea level).
## Table 1

**CORRELATION OF NEogene DEPOSITS OF SOUTHERN FLORIDA**

Cooke, Gardner and Woodring, 1943

| Miocene       | Upper (Sahelian?) | No record | | Lake Flirt marl | | Pamlico sand | | Fort Thompson fm. | | Anastasia fm. | | Miami Key Largo ls. | |
|---------------|------------------|-----------|---|-----------------|---|-----------------|---|-------------------|---|-------------------|---|
| Pliocene      | Upper (Astian)   | Buckingham marl member | | Caloosahatchee marl | | Tamiami limy sandstone facies | | No record | | No record | |
|               | Lower (Plaisancian) | | | | | | | | | |
| Pleistocene   | Nebraskan        | No record | | | | | | | No record | |
|               | Aftonian         | | | | | | No record | | No record | |
|               | Kansan           | | | | | | No record | | No record | |
|               | Yarmouthian      | | | | | | No record | | No record | |
|               | Illinoian        | | | | | | No record | | No record | |
| Wisconsinn    | Peorian Iowan    | | | | | | No record | | No record | | No record | | No record | | No record | | No record | | No record | | No record | | No record | | No record | | No record |
Considering all available evidence, especially that derived from vertebrate fossils, I (Du Bar, 1958a, p. 136-142) assigned the Caloosahatchee Marl to the Sangamonian Interglacial. Neither older marine Pleistocene nor marine Pliocene deposits in Florida are now definitely recognized by me.

Several factors have been given much weight by geologists who assign the Waccamaw and Croatan deposits to the Pliocene. Three of the most important criteria are discussed below:

1. Undoubtedly the "Pliocene School" has been influenced by the assumption that in places the Waccamaw is supposedly overlain by Early Pleistocene sediments, and that the youngest rocks which are known to directly underlie the Waccamaw are assigned to the Late Miocene Duplin Marl. This would narrow the possible age for the Waccamaw and Croatan formations to the range between Late Miocene and Early Pleistocene, thus virtually forcing them into the Pliocene.

2. Using the Lyellian method of percentage of living molluscan species contained in the faunas both the Waccamaw and Croatan formations seem clearly to fall into a Pliocene classification.

3. By comparison of the faunas with those of other Neogene formations, it was shown that, considering differences attributable to latitude, the Waccamaw and Croatan faunas are most similar to that of the Caloosahatchee Marl. From this observation it was deduced that the Waccamaw and Croatan deposits represent a cooler water facies of the tropical Caloosahatchee formation. The latter conclusion is strengthened by the fact that the Caloosahatchee Marl of northeastern Florida was apparently deposited in water with a temperature range intermediate between that for the type Caloosahatchee and that for the Waccamaw and Croatan formations.

Below the Pamlico shoreline the Waccamaw is nearly everywhere overlain by the Late Pleistocene Pamlico formation. Pleistocene deposits older than the Pamlico which contain marine fossils, have not been definitely recognized anywhere in Eastern United States (Richards, 1936, 1938, 1950). Where then are the fossiliferous deposits corresponding to the higher, older shorelines? Could the Waccamaw and Croatan formations represent older Pleistocene deposits?

All the known Waccamaw and Croatan deposits of the Carolinas lie below the Wicomico Shoreline, thought to be Sangamonian in age (Du Bar, 1958a). All the species of these two formations could have lived in water less than 100 feet in depth. Thus it is possible that the Waccamaw-Croatan Sea could have formed the Wicomico Shoreline during the Pleistocene. If this is true, then unfossiliferous sands
OVERLYING THE WACCAMAW AT ELEVATIONS BETWEEN 30 AND 100 FEET WOULD BE LATE PLEISTOCENE RATHER THAN EARLY PLEISTOCENE IN AGE.

THE LYELLIAN PERCENTAGE METHOD HAS BEEN LONG DIS-
CREDITED AS A PRECISE METHOD OF DETERMINING THE AGE OF A
CENOZOIC FORMATION (DALL, 1892, P. 215). FACTORS OF LOCAL
DEPOSITIONAL ENVIRONMENTS, RATE OF DISPERSION, EFFECT OF
геOGRAPHIC AND ECOLOGIC BARRIERS, AND INCREASING KNOWLEDGE
OF FOSSIL AND RECENT FAUNAS ALL CONTRIBUTE TO THE INVALIDA-
TION OF LYELL'S CONCEPT. AT BEST IT IS A METHOD WHICH MUST
BE USED WITH EXTREME CAUTION. IT IS UNLIKELY, HOWEVER, THAT
A MIOCENE FORMATION WOULD CONTAIN 80-83% RECENT SPECIES OF
MOLLUSKS; ON THE OTHER HAND, IT SEEMS QUITE POSSIBLE THAT
OLDER PLEISTOCENE DEPOSITS MIGHT CONTAIN 17-20% EXTINCT
SPECIES.

COMPARATIVE ANALYSES OF THE FAUNAS SUCH AS THAT
BY DALL (1892, P. 215-216) SEEM TO BE A MORE RELIABLE AP-
PROACH TO DETERMINATION OF THE RELATIVE AGE OF THE WACCAMAW
AND CROATAN FORMATIONS THAN THE LYELLIAN METHOD. HOWEVER,
EVEN COMPARATIVE STUDIES MAY ENCOUNTER SERIOUS PITFALLS.

DALL LISTED (1892, P. 215) THE FOLLOWING GEOLOGIC
RANGE DATA FOR 180 MOLLUSCAN SPECIES FROM THE TYPE WACCAMAW.

| Miocene        | 2 species |
| Miocene-Pliocene | 16 species |
| Pliocene       | 17 species |
| New species    | 7 species |
| Doubtful range | 13 species |
| Pliocene-Pleistocene | 1 species |
| Recent         | 51 species |
| Pliocene and Recent | 64 species |
| Recent         | 9 species |

SUCH A FAUNA, IF THE DATA WERE ACCURATE, WOULD
INDEED APPEAR TO BE PLIOCENE IN AGE. HOWEVER, THE PLIOCENE
PART OF ALL THE RANGES LISTED BY DALL WERE BASED ON THE RE-
CORD OF THE SPECIES IN THE CALOSAHATCHEE MARL, INCORRECTLY
JUDGED TO BE A Pliocene FORMATION. NONE OF THE SO-CALLED
"PLIOCENE GUIDE FOSSILS" IN THE WACCAMAW AND CROATAN ARE
RESTRICTED ELSEWHERE TO UNQUESTIONED PLIOCENE DEPOSITS.
THERE IS NO REASON TO ASSUME THAT THE TWO "MIocene SPECIES"
LISTED BY DALL, OR THE 13 "MIocene-PLIOCENE SPECIES" COULD
NOT HAVE SURVIVED INTO THE EARLY AND MIDDLE PLEISTOCENE.
SIMILAR EVIDENCE PRESENTED BY DALL AND OTHERS FOR THE PLIO-
CENE AGE OF THE CROATAN FORMATIONS SEEMS EQUALLY UNCONVINC-
ING.

IT APPEARS FROM THE ABOVE DISCUSSION THAT AT LEAST
THE TYPE WACCAMAW AND CROATAN FAUNAS COULD BE PLEISTOCENE IN
AGE. CERTAINLY THE PLIOCENE AGE DETERMINATION IS OPEN TO
SERIOUS QUESTION, AND THERE SEEMS PRESENTLY TO BE LITTLE EVID-
ENCE SUPPORTING CLAIMS OF A MIocene AGE FOR EITHER THE
WACCAMAW OR CROATAN FORMATIONS. IT IS QUITE POSSIBLE, HOW-
EVER, THAT OUTSIDE THE TYPE AREAS OUTCROPS ASSIGNED TO THE WACCAMAW AND CROATAN FORMATIONS COULD HAVE BEEN MISIDENTIFIED AND SOME OF THESE ARE PERHAPS ACTUALLY OLDER THAN THE TYPE DEPOSITS, BEING CORRELATIVES OF THE DUPLIN MARL (LATE MIocene).


FUTURE WORK


IT WILL NOT SUFFICE TO RESTRICT EXAMINATION TO THE SHALLOW MARINE DEPOSITS NEAR THE PRESENT SHORE AND SUCH DOWN-DIP DATA AS WE SHALL BE ABLE TO ACQUIRE. STUDIES ALSO NEED TO BE DIRECTED TO THE NON-MARINE FACIES FOUND GENERALLY WESTWARD FROM THE MARINE FACIES. GEOMORPHOLOGICAL INVESTIGATIONS SHOULD BE ENCOURAGED AND DETAILED MAPPING OF PLEISTOCENE SHORELINE FEATURES IS ESPECIALLY DESIRABLE.

MORE WORK NEEDS TO BE DONE IN FLORIDA. AS YET THE CALOOSAHATCHEE MARL AND CHARLTON FORMATIONS OF NORTH-EASTERN FLORIDA ARE NOT WELL ENOUGH UNDERSTOOD. THE STRATIGRAPHIC ASPECTS AND DEPOSITIONAL ENVIRONMENTS OF THE VARIOUS FLORIDA MIocene FORMATIONS NEED MORE STUDY. THE SAME COMMENTS ARE PERHAPS APPLICABLE, TO A LESSER DEGREE, TO THE MIocene FOUND NORTH OF NORTH CAROLINA.
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