

The study of the geography of this region has necessarily a very close relationship to the geologic studies of the range, but it may lead also to a study of anthropogeography, and to a study of how the present geographic conditions are influencing the settlement and commercial development within this district.²

¹Whitman Cross, U. S. Geol. Survey Geol. Atlas, Silverton folio (No. 120), 1905.

²This study is here published with the permission of the Director of the U. S. Geological Survey.

THE AGE OF THE MIDDLE ATLANTIC COAST UPPER CRETACEOUS DEPOSITS

By W. B. Clark, E. W. Berry, and J. A. Gardner

GEOLOGICAL LABORATORY, JOHNS HOPKINS UNIVERSITY

Received by the Academy, February 16, 1916

Distribution.—The Upper Cretaceous formations of the Middle Atlantic Coast area are most extensively developed in New Jersey from which state they thin rapidly to the northward through the islands off the New England coast, only a few remnants being left in southern Massachusetts; while to the south they gradually disappear, only the lowermost reaching the Potomac drainage basin. Beyond this point they have only been recognized in deep-well borings in Virginia although the deposits probably extend continuously beneath the mantle of Tertiary formations until they again appear in surface outcrops in the South Atlantic area.

Divisions.—Several formations have been recognized within the area of outcrop and have been designated under the names of Raritan, Magothy, Matawan, Monmouth, Raicocas, and Manasquan.

Numerous minor subdivisions have been described in New Jersey but have been unrecognized elsewhere. All the deposits are of shallow-water origin as shown by their contained faunas. The relatively slight differences in the faunas of these smaller units are evidently due to the varying proximity of stream mouths and sediment-bearing currents rather than to any differences in depth which may have existed.

The major divisions, on the other hand, are based on distinct differences in the faunas and floras which may be recognized when present not only in the Middle Atlantic Coast area but throughout the South Atlantic and Gulf regions as well.

The Raritan and Magothy formations are clearly separable on the basis of their contained floras while the Matawan and Monmouth, the only marine divisions with equivalents in the South Atlantic and Gulf

regions, are separable by the initiation in the Monmouth of a new fauna marked by the introduction of *Belemnitella americana*, *Exogyra costata*, *Turritella vertebroides*, *Anchura pennata*, *Eutrephoceras dekayi*, and probably of *Liopistha protexta* which have been made the basis for the differentiation of the two primary zones shown on the Federal Survey maps throughout this region. While it is true that several of the Matawan forms persist far into the Monmouth this does not in the last detract from the significance of the initiation of a new element of more than local importance at the opening of the Monmouth. The time of extinction of an old fauna is properly considered as less significant than the time of initiation of a new one, and if that new one be sufficiently virile to characterize the molluscan life from New Jersey south through Georgia and west to Texas it indicates something more than a minor oscillation in a restricted area and should be given the relatively higher rank which it deserves. The Rancocas fauna is very distinct from the preceding Monmouth but it is only known in the restricted area of New Jersey and Delaware. The same is also true in the case of the Manasquan which has an even more limited development in New Jersey. These two later formations have no equivalents in the South Atlantic and Gulf areas.

Correlation.—Raritan.—The Raritan formation of the Middle Atlantic Coast contains a flora of over 200 species, on the relations of which its correlation must be based since but a few uncharacteristic invertebrates have been found in these beds. The Raritan flora has been chiefly recorded from New Jersey where the sediments were more favorable for its preservation than farther southward. It is clearly separable into older and younger florules, the latter making its appearance in the upper beds near South Amboy, New Jersey, ranging southward to the Potomac, and reappearing in the lower part of the Tuscaloosa formation of the Eastern Gulf and the Woodbine formation of the Western Gulf. The Raritan flora is conclusively correlated with the Cenomanian stage of the European section by reason of a number of forms common to such well-known Cenomanian floras as those of Niedeschoena, Saxony; Moletain, Moravia; Perutz, Bohemia; and Alcantara, Portugal. In addition to this considerable element common to the old world Cenomanian a large number of identical genera have closely related species in the two regions and many new and identical types appear at this horizon on both sides of the Atlantic.

Magothy.—The Magothy formation of the Middle Atlantic coast has furnished a rather poor fauna, principally from the New Jersey area, and an extensive flora of upwards of 300 species found from Marthas Vineyard, Massachusetts, to the Potomac. The Magothy is separated

from the Raritan by an erosional unconformity. Its fauna has furnished but meager data for exact correlation but the large flora furnishes decisive evidence on this point. Compared with the underlying Raritan it may be noted that 61% of the Raritan flora becomes extinct before Magothy time and 70% of the flora of the latter, including many new and progressive types, is not found at horizons as old as the Raritan. Some of the most characteristic Magothy forms are found in the Mid-

Table Showing the Approximate Correlation of the Middle Atlantic Coast Upper Cretaceous Formations with those of other Areas

N. J.—MD.	N. C.—S. C.	EASTERN GULF	WESTERN GULF	WESTERN INTERIOR	EUROPE
Manasquan					
Rancocas				Laramie	Danian
Monmouth	Peedee	Ripley Selma	Navarro Taylor	Montana	Senonian
Matawan	Black Creek	Eutaw	Austin Eagle Ford	Colorado	
Magothy	Middendorf	Tuscaloosa	Woodbine	Dakota	Turonian
Raritan			Washita		Cenomanian

dendorf and Black Creek beds of the Carolinas, and in the upper Tuscaloosa and lower Eutaw of the Eastern Gulf.

Compared with European floras that of the Magothy shows several types identical with and many closely related to those of the lower basin of the Rhone, Bussaco, in Portugal, and the richly plant-bearing Turonian section of Bohemia. This floral similarity as well as the stratigraphic position of the Magothy leads to the conclusion that the Magothy formation is of Turonian age.

Matawan.—The earliest fauna of any extent occurs in the Matawan from which 175 to 185 species have been described in New Jersey and Maryland. Five faunal zones have been differentiated in north-central New Jersey, where the Matawan is best developed, but it has not been possible to carry any but the lowest of these south of the Delaware-Maryland line. The Merchantville, together with the Woodbury which merges into it in southern New Jersey, has been recognized along the Chesapeake and Delaware Canal just east of the state line. Although this fauna is a small one of only about 50 species, it contains the elements of one of the most widely distributed and best characterized biotas of the entire Upper Cretaceous, a fauna represented in the *Mortoniceras* subzone of the South Atlantic and Gulf states, the Austin Chalk of Texas, the Niobrara of the Western Interior, and the Emscher beds of north-central Europe.

The late Matawan deposits were probably laid down in more shallow waters. Their contained faunas are consequently more restricted in their distribution and less cosmopolitan in their affinities. The Marshalltown of New Jersey which is best characterized by the abundance of the ponderous Ostreids, such as *Exogyra* and *Gryphaea*, is quite possibly represented in the Matawan oyster banks along the Chesapeake and Delaware Canal west of St. Georges. These beds are doubtless the time equivalent of at least a part of the *Exogyra ponderosa* zone of the South Atlantic and Gulf states, a faunal zone which has been recognized in the upper Black Creek of North and South Carolina, the lower Ripley of Georgia and eastern Alabama, the lower Selma of central and western Alabama, Mississippi, and Tennessee, and the upper Eutaw of Mississippi and Tennessee.

Monmouth.—The Monmouth formation has furnished the most prolific and diversified fauna of any of the Upper Cretaceous, over 250 species having been determined and of these about 75% are peculiar.

Three faunal zones have been differentiated in New Jersey but it is impossible to trace the New Jersey horizons southward into Maryland with any assurance. The fauna of the Sassafras River area, although very prolific, is very poorly preserved and the determinable species are none of them diagnostic of a particular facies. However, the abundance of *Belemnitella americana*, in the Eastern Shore deposits of Delaware and Maryland suggests the Navesink, while *Sphenodiscus* is peculiarly characteristic both of the Tinton of New Jersey and the prolific Prince George's County fauna in Maryland. It is exceedingly improbable, however, that there is any appreciable time interval involved in these faunal differences.

The general aspect of the Monmouth biota is more southern than that of the Matawan and it is probable that the slight depression of the seas which initiated the Monmouth broke down the barriers which had earlier prevented free communication with the inshore life of the south Atlantic.

The Monmouth is at least the partial time equivalent of the *Exogyra costata* zone which has been recognized in the Peedee sand of North and South Carolina and in the Ripley and Selma chalk of the Gulf states. A number of identical species occur in the Fox Hills of the Western Interior while the ensemble is very similar to that of the Upper Campanian of the Belgian border and the so-called Maestricht beds.

Rancocas.—Two horizons have been recognized in the Rancocas of New Jersey, the Hornerstown glauconitic marl and the Vincentown "yellow sand" but these divisions are absent south of the Delaware Bay. The diagnostic features of the fauna developed in Delaware are essentially those of the Vincentown—a prolific bryozoan fauna with *Terebratula harlani* in abundance and a very meager molluscan representation. Only about 15 species have been determined, all of them bivalve, over half of which are restricted to the Rancocas. Five have been found at older horizons, while *Ostrea vomer* and *Terebratula harlani* have been reported as surviving the break between the Mesozoic and Cenozoic although there is doubt in both cases as to the identity of the species.

The mollusca of Delaware are curiously dissimilar from those of New Jersey, none of the few characteristic species of New Jersey occurring in Delaware, while the abundant Delaware *Gryphaea* to which the characteristic Vincentown bryozoa attach themselves, is apparently not present in New Jersey.

There is no closely allied fauna in this country and its closest analogue is apparently in northern Europe. Although there is little direct evidence for its correlation with the Danian yet the general facies of the two faunas is very similar. Both are characterized by an extensive bryozoan fauna and the absence of *Belemnitella*. At the same time the fauna is not Tertiary in aspect and it seems improbable that it can belong to that horizon.

Manasquan.—The Manasquan is closely related to the Rancocas both faunally and stratigraphically. Its fauna is not characteristically Cretaceous although the general assemblage of forms suggests its association with that division rather than with the Tertiary. It is regarded as Danian. It has no equivalents as far as known among American formations elsewhere.

Conclusions.—The several Upper Cretaceous formations of the Middle Atlantic Coast represent all of the major divisions of the European series. The Raritan must be regarded from its contained flora as Cenomanian while the flora of the Magothy is considered Turonian. The fauna of the lower Matawan is regarded as lower Senonian or Emscherian because of the presence of *Mortoniceras* and associated forms. Equivalent strata to the Magothy and Matawan combined are found in the Carolinas in the Black Creek formation where beds containing the Magothy flora are interstratified throughout the upper part of the formation with beds containing a Matawan fauna. The evidence is apparently conflicting and the dividing line between the Turonian and Senonian is therefore placed midway in the Matawan although this must be regarded as a compromise position. The Monmouth fauna is Senonian in age and probably represents the middle and upper Senonian. The Rancocas and Manasquan are regarded as Danian.

UPPER CRETACEOUS FLORAS OF THE WORLD

By Edward W. Berry

GEOLOGICAL LABORATORY, JOHNS HOPKINS UNIVERSITY

Received by the Academy, February 16, 1916

The writer has prepared a detailed account of the Upper Cretaceous floras of the world for a report on the Upper Cretaceous of Maryland which will be published later by the Geological Survey of that State.

Since the question of the age relations of the Upper Cretaceous floras of the United States has been the occasion of considerable discussion in recent years it is believed that a summary of the contemporaneous floras from other parts of the world will prove useful to paleontologists and geologists.

The stratigraphic position of the more important of these is indicated in the accompanying diagram.

The typically marine series of sediments developed in most European countries has furnished little that is of interest to the paleobotanist. The floras of the Turonian of the lower basin of the Rhone, and of the Coniacian and Campanian in the same region are well represented but largely undescribed, while the earlier Upper Cretaceous floras of France are scattered and unimportant. In Portugal extensive and important floras are intercalated in a fossiliferous marine series ranging from the Cenomanian through the Turonian and Emscherian, but these also are largely undescribed. Bohemia furnishes a splendid section from the base of the Upper Cretaceous through the Emscherian, with extensive