43. SUMMARY OF LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY OF ATLANTIC COASTAL PLAIN (NORTHERN PART)

Richard K. Olsson, Department of Geological Sciences, Rutgers University, New Brunswick, New Jersey

INTRODUCTION

The Atlantic coastal plain extends without interruption along the eastern margin of North America from Florida to New Jersey. To the north its extension lies beneath sea level except in a few places such as Long Island where coastal plain units are exposed. The sediments of this emerged portion of the Atlantic margin are relatively thin, being shoreward of the main hinge zones of sediment accumulation. They were deposited during Late Jurassic?, Cretaceous, and Cenozoic on a trailing edge margin during the development of the Mesozoic and Cenozoic Atlantic Ocean. The coastal plain is divided into two parts, a northern clastic province and a southern carbonate province. This discussion deals with the northern clastic part.

The Atlantic margin is interpreted as a block-faulted, rifted type which developed during the separation of North America from Africa (Brown et al., 1972; Sheridan, 1974). The structural blocks are exposed as a number of highs (arches) and lows(embayments) that transect the coastal plain along strike (Figure 1). Sedimentation was affected in a number of ways by these structural elements. We see this in the greater thickness of section in the embayments and in the regional facies changes that occur between adjacent structural elements. In addition, some evidence suggests that during certain marine cycles the lows subsided to greater depths than did the highs(Olsson and O'Grady, 1976).

The entire stratigraphic sequence of the coastal plain can be conveniently divided into three parts, a Lower Cretaceous and possibly Upper Jurassic non-marine section of sand, clay, with some gravel; an Upper Cretaceous to Eocene glauconitic marine section of alternating sand, silt, and clay; and an upper Oligocene to Holocene section of non-marine to shallow shelf sand and silt. The sequence is in general poorly exposed and consequently data from wells provide a large portion of our understanding of the history of these sediments. Unfortunately biostratigraphic analyses of a large number of coastal plain wells is incomplete so that interpretation of such wells is sketchy. Biostratigraphic control is best developed in the Cretaceous and lower Tertiary marine section. Perry et al. (1975) presented palynological data bearing mostly on the Cretaceous non-marine stratigraphy of the coastal plain.

LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY

Jurassic

Jurassic rocks of non-marine origin are now known to be present in the Triassic basins of eastern North America (Cornet et al., 1973; Cornet and Traverse, 1975) but none are exposed on the Atlantic coastal plain. Limestone, sandstone, and shale of questionable Jurassic age (Swain and Brown, 1972) have been reported in wells drilled in coastal areas at depths of 1500 meters or so below sea level (Figure 2). These occurrences are in the structural embayments and thus suggest that these areas were actively subsiding during the early phases of the opening of the Atlantic.

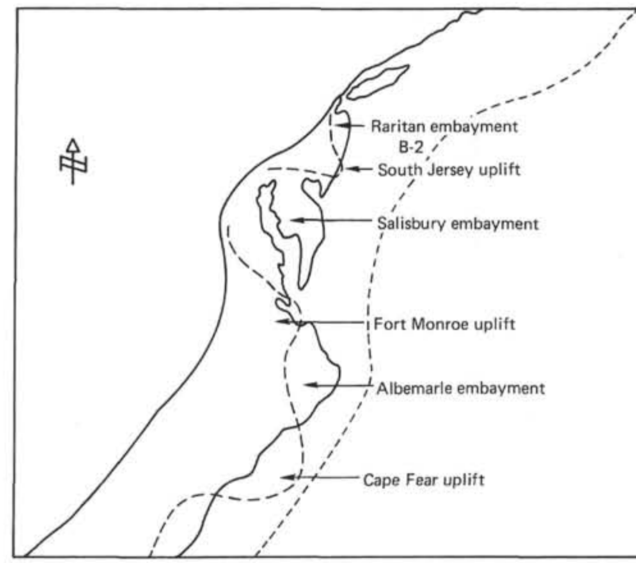

Figure 1. *Map showing outline of Atlantic coastal plain (northern part) and the major structural elements.*

Lower Cretaceous

Lower Cretaceous non-marine sediments consisting of sand, gravel, and clay are well exposed in the Atlantic coastal plain where they are known as the Potomac Group. In outcrop and in the subsurface these sediments lie beneath marine Upper Cretaceous throughout the entire coastal plain. They are encountered in the B-2 C.O.S.T. (Continental Offshore Stratigraphic Test)Well in association with some shallow-marine sediments. We can therefore envision that much of the Atlantic margin of this region lay above sea level during Early Cretaceous time.

Structural control of depositional sites of Lower Cretaceous sediments is evidenced by the greater thickness of section in the structural lows (embayments). The sediments are over twice as thick in the embayments as they are over the structural highs, suggesting greater subsidence in the embayments. The embayments also contain older Cretaceous sediments than do the highs (Figure 2). In the Salisbury Embayment the thickness of the Lower Cretaceous approaches 1500 meters (Weed et al., 1974). In the B-2 Well over 2380 meters of sediment have been reported (USGS open file report, 1976).

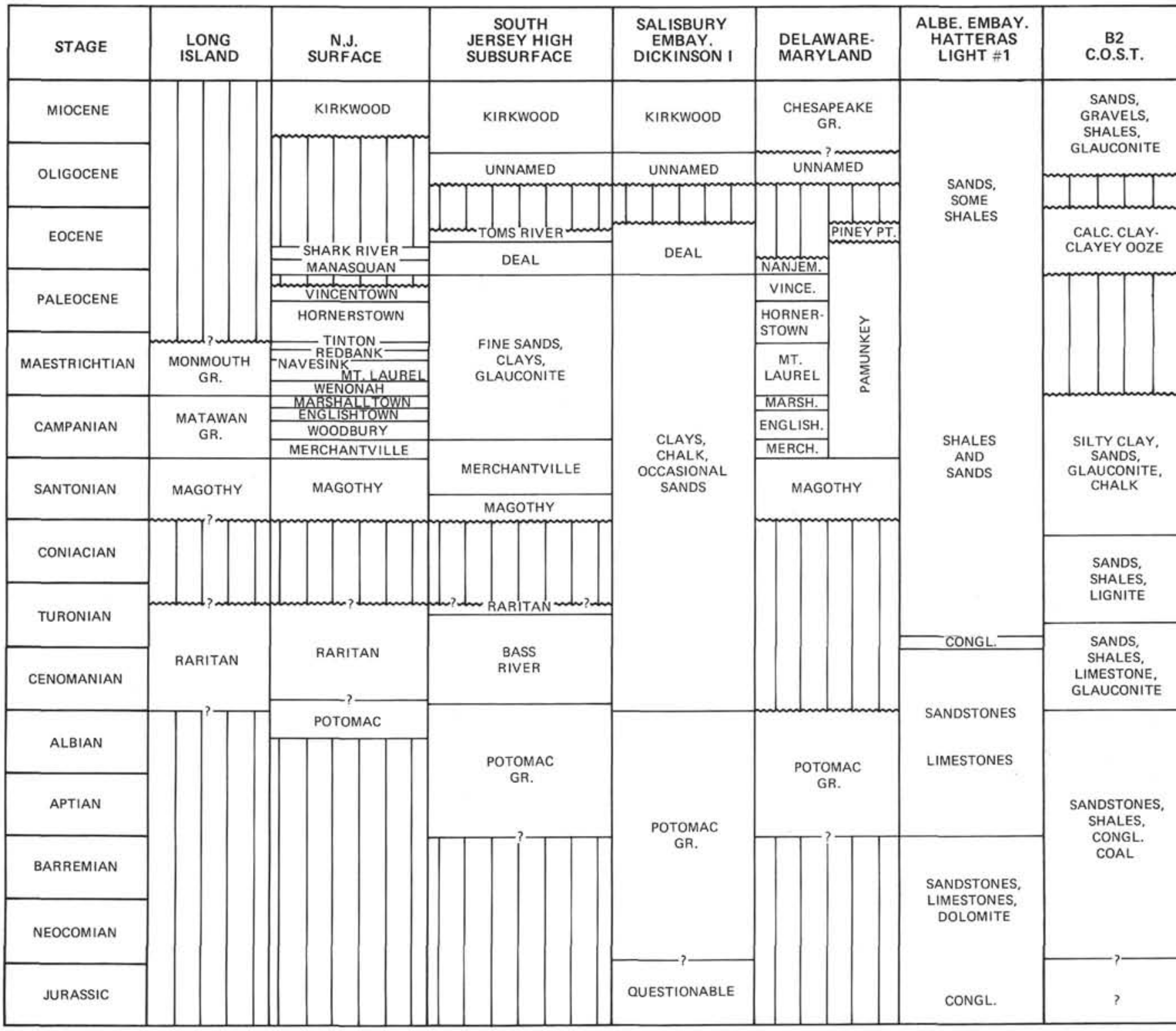

Figure 2. *Comparison of stratigraphic columns at various points in the coastal plain. B-2 Well is shown for comparison.*

Two Neocomian-Albian pollen zones are recognized in the Potomac Group sediments (Brenner, 1963; Doyle and Hickey, 1972).

Upper Cretaceous

Marine processes in the Atlantic coastal plain began with the well-known extensive Albian-Turonian transgression (Petters, 1976). This transgression which began in the coastal plain during the Cenomanian flooded some 160 km of the Atlantic margin. Upper Cretaceous sediments consist of alternating series of sand, silt, and clay. Glauconite is abundant in many of the marine units. Although the Albian-Turonian transgression can be considered as the beginning of a major marine cycle that lasted until Eocene time, it actually comprised a number of transgressive and regressive phases.

Four phases are recognized in the Upper Cretaceous (Petters, 1976; Olsson, 1975). The Cenomanian-Turonian transgression, the first phase, is followed by a Coniacian regression which is expressed by a disconformity on the outcrop belt and in much of the subsurface. The regressive second phase is followed by a major transgression which established a strandline beyond that of the initial phase one transgression. This is followed by a fourth phase, an oscillation phase, in which several minor transgressions and regressions occurred. However, unlike the Coniacian, the regressions did not lead to recognizable unconformities. The fourth phase did not end during the Cretaceous but continued into Paleocene time. The stratigraphy and planktonic foraminiferal zonation of the Upper Cretaceous section in New Jersey is shown in Figure 3, and the planktonic foraminiferal zonation of the transgressive and regressive phases is shown in Figure 4. Transgressive and regressive phases are also evident in the Upper Cretaceous of the B-2 Well (U.S.G.S., Open File Report, 1976) but have yet to be more clearly defined biostratigraphically.

Subsidence in the embayment areas, at least as observed in the Salisbury Embayment, apparently resulted in greater depth than on the structural highs. The difference, for exam-

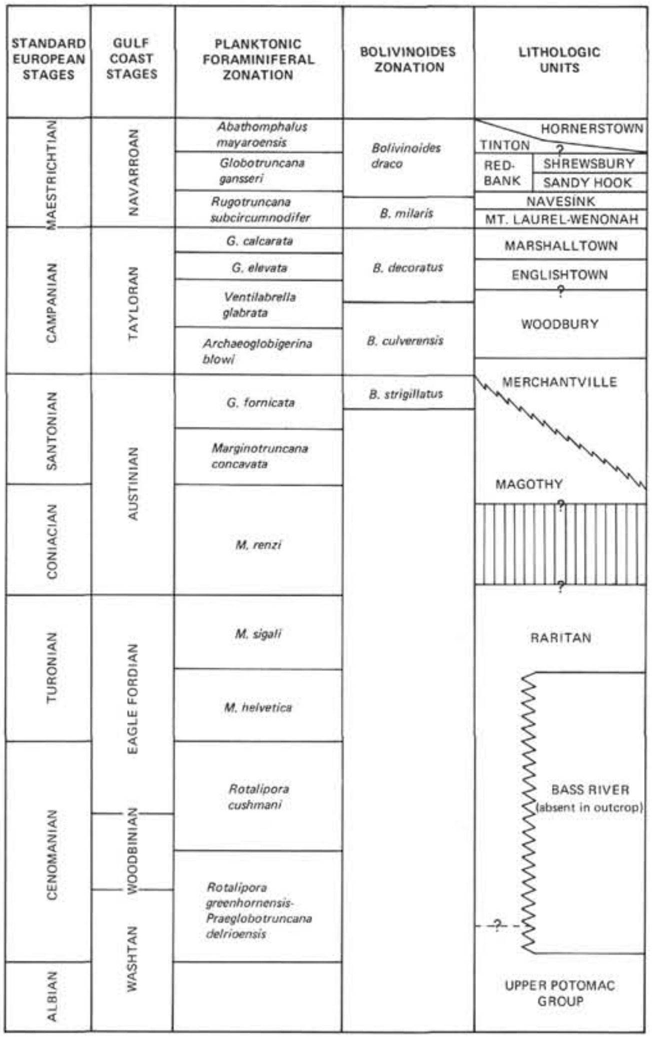

Figure 3. *Planktonic foraminifera biostratigraphy and lithostratigraphy of the Upper Cretaceous section in New Jersey (after Petters, 1976).*

ple, between the South Jersey High and the Salisbury Embayment is one from shelf deposition to slope (bathyal) deposition (Olsson and O'Grady, 1976). Furthermore, there is a major facies change between the two areas. The shelf sediments of the South Jersey High, consisting of coastal to shelf sand, silt, and clay are replaced by clay and chalk in the embayment (Figure 2).

Fourteen planktonic foraminifer zones are recognized in the marine Upper Cretaceous section (Olsson, 1964; Petters, 1976). The zonation is similar to those proposed from lower latitude sections (Bolli, 1957; Pessagno, 1967; Van Hinte, 1976), thus indicating the influence of low latitude warm waters in this region during Late Cretaceous time. Although there is a decided tethyan influence evident in the planktonic foraminifer assemblages, there is also a marked boreal influence shown in the presence of a number of boreal species.

Four pollen zones are recognized in the Cenomanian to lower Campanian interval (Doyle, 1969; Sirkin, 1974). Petters (1976) discussed the relationship of the foraminifer zones to the pollen zones, thus relating the marine facies to the non-marine facies.

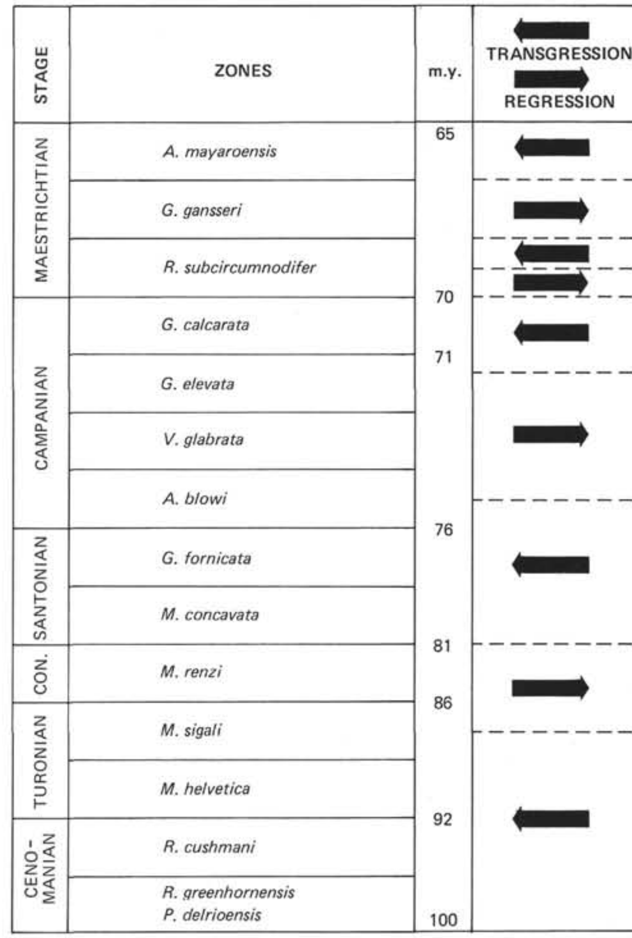

Figure 4. *Comparison of planktonic-foraminifera biostratigraphy with transgressive and regressive phases in the Upper Cretaceous of New Jersey.*

Tertiary

Two broad stratigraphic divisions (separated by a disconformity) are discernible in the Tertiary of the coastal plain, a lower Paleogene consisting of glauconite-rich units, sand, silt, and clay and an upper, mostly Neogene, section consisting of fine to coarse sand and gravel with some clay interbeds. A glauconitic upper Oligocene unit occurs at the base of the upper division.

The Paleogene section is part of the major marine cycle that began in the Atlantic coastal plain at the beginning of the Late Cretaceous. The Paleocene belongs to the oscillation phase that began during the Campanian. A small disconformity at the end of this phase is noted in sediments cropping out in New Jersey. A major Eocene transgression followed and, judging from the ecology of the contained microfossil assemblages, the increase in water depth was significant. Glauconitic sediments in outcrop give way to silty sediments and then to clay and chalky clay in the subsurface. In places these sediments are siliceous. In the coastal plain subsurface of New Jersey the Eocene clay is yellow-gray just as is the Eocene sediment in the B-2 Well. This unit was deposited at water depths ranging from outer shelf on the south Jersey high to upper-mid bathyal in the Salisbury embayment and mid-lower bathyal in the B-2 Well. The stratigraphy and planktonic foraminifer zonation of this section in New Jersey is shown in Figure 5 and the zonation of the transgressions and regressions is shown in Figure 6.

The planktonic foraminifer zonation (Figure 5) of the lower Tertiary section contains sixteen zones in the Paleocene-middle Eocene section (Olsson, 1970; Ulrich, 1976). Two upper Eocene zones are recognized in the B-2 Well (Figure 8). The Paleocene and lower Eocene zones compare to those recognized in low latitude sections (Bolli, 1957b, 1966), whereas the middle and upper Eocene zones follow the zonation based on the evolution of *Globorotalia cerroazulensis* (Cole) which is established on the basis of the Possagno section of Italy (Toumarkine and Bolli, 1970).

The marine cycle that began in the Atlantic coastal plain in Cenomanian time ended with a major regression. The disconformity that resulted from this regression is very extensive in the coastal plain and is also seen in the B-2 Well drilled near the edge of the Atlantic shelf. The stratigraphic extent of the disconformity can be dated paleontologically using planktonic foraminifers (Figures 7 and 8). This dating shows that the disconformity encompasses the upper Eocene and lower Oligocene in New Jersey and this is probably so elsewhere in the coastal plain, although there is not much biostratigraphic data available in other parts of the coastal plain. A disconformity is probably present in the Hatteras Light #1 Well (Figure 1), but definite biostratigraphic data have not been developed there. In the B-2 Well the top part of the upper Eocene and the lower Oligocene is missing. The entire Atlantic margin of the coastal plain probably was exposed by the regression—a retreat of probably well over 200 km.

Oligocene sediments have only recently been identified in the coastal plain where they are absent in outcrop. Oligocene glauconitic coarse sand and sandy clay have been reported in wells along coastal North Carolina (Maher and Applin, 1971; Weed et al., 1974). Coarse glauconitic sand in the New Jersey subsurface and fine sandy silt in the Maryland subsurface are also Oligocene (Figure 1). Oligocene glauconitic, silty clay is encountered in the B-2 Well. These sediments which were deposited under inner shelf (coastal plain) to middle shelf(B-2) conditions reflect renewed marine processes in the coastal plain area. The sea did not transgress as far inland as during the previous marine cycle so that Neogene sediments in the coastal plain were deposited under inner shelf, coastal, and coastal non-marine conditions. They consist of sands, some clay interbeds, and gravels. They are characterized in certain places by diatomaceous sediments.

Structural control during deposition of the Neogene sediments is evident in the greater sediment thickness in the embayments than over the highs, thus indicating continued subsidence in the embayment areas.

SUMMARY

The Atlantic coastal plain under discussion here represents deposition on a trailing margin during development of the Atlantic Ocean. The tectonic history of the coastal plain is one of general subsidence which began probably during Jurassic time. The Atlantic margin was broken into a series of blocks (Brown et al., 1972; Sheridan, 1974) which experienced differential movements. Those which moved negatively became structural embayments in which sediments accumulated in greater thicknesses than on the blocks which moved in a relative positive sense and became structural highs. During the marine cycle of the Late Cretaceous and early Tertiary there is evidence (Salisbury embayment) that subsidence of the embayment blocks led to greater water depths than on the high blocks.

The development of the Atlantic coastal plain is divided into four parts, a Lower Cretaceous non-marine interval (possibly including Jurassic) an Upper Cretaceous-lower Tertiary marine interval with several phases of transgression and regression, an upper Eocene-lower Oligocene erosional interval, and an upper Oligocene-Neogene nearshore to coastal non-marine interval. The general characteristics, lithologic and otherwise, of these intervals can be recognized over the coastal plain and probably beneath the present shelf as indicated in the B-2 Well (Table 1).

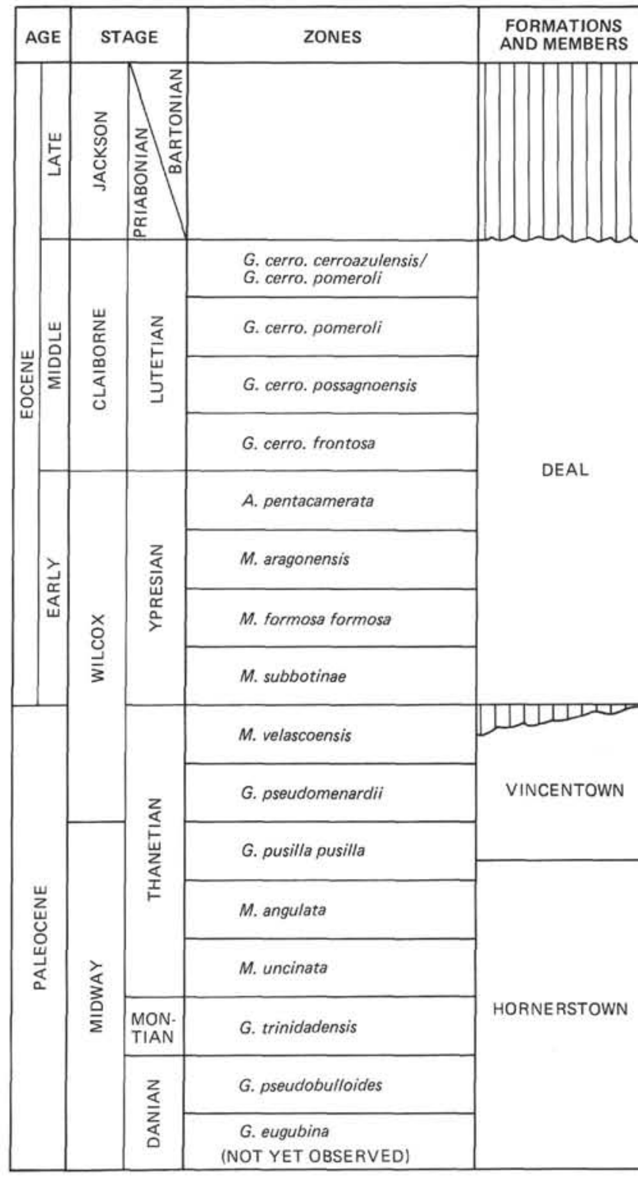

Figure 5. *Planktonic foraminifera biostratigraphy and lithostratigraphy of the lower Tertiary section in New Jersey. (The Deal is most extensively developed in the subsurface and is equivalent to several thin updip units.)*

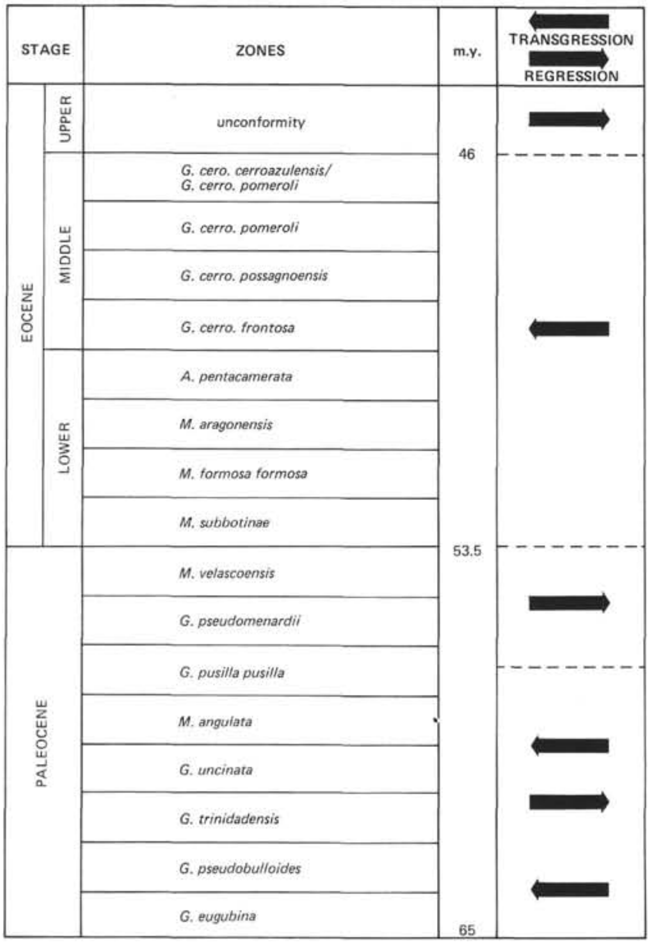

Figure 6. *Comparison of planktonic foraminifera biostratigraphy with transgressive and regressive phases in the lower Tertiary of New Jersey.*

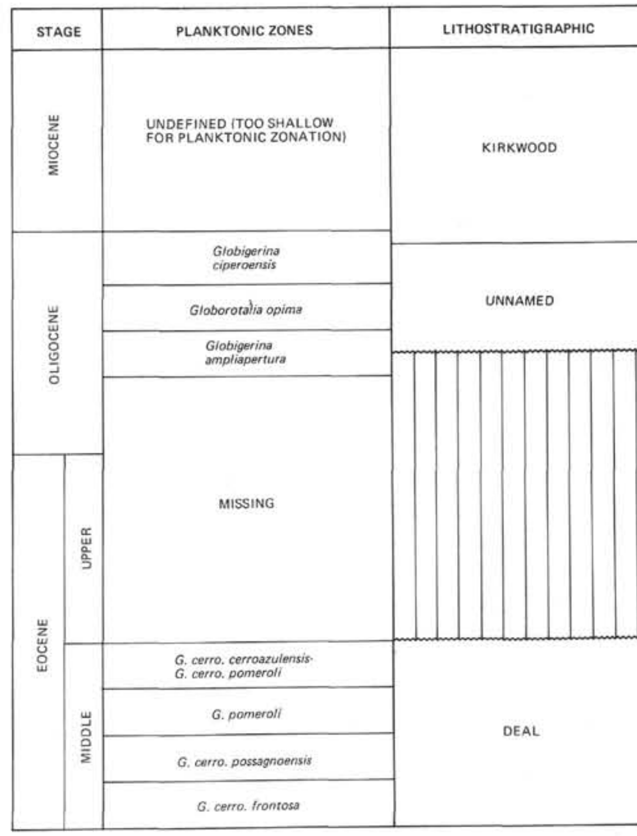

Figure 7. *Dating of the Eocene-Oligocene unconformity in New Jersey.*

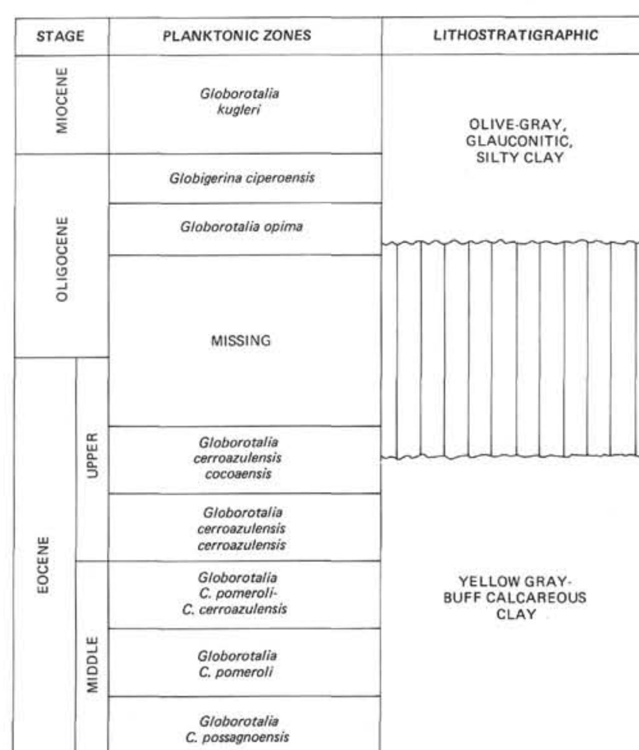

Figure 8. *Dating of the Eocene-Oligocene unconformity in the B-2 Well.*

The upper Eocene-lower Oligocene unconformity represents a major event widely recognized in many parts of the world and linked to severe cooling (Ingle et al., 1976), thus resulting in significant lowering of sea level. A subsequent warming cycle in late Oligocene-earliest Miocene time (Haq and Lohmann, 1976) corresponds with the age of the transgressive sediments overlying the eroded Eocene surface. However, some uplift or tilting of the Atlantic margin during this time (Sheridan, 1976) may have accompanied or followed the regression. This seems to be the most logical explanation for shallow shelf upper Oligocene sediments overlying bathyal Eocene strata and apparently the present-day shelf profile developed from this point in time. In contrast, the slope of the Eocene profile was probably much more gradual from the continent to the deep sea.

REFERENCES

Bolli, H.M., 1957. The genera *Praeglobotruscana, Rotalipora, Globotruncana*, and Abathomphelus in the Upper Cretaceous of Trinidad, B.W.I.: *U.S. Nat. Mus. Bull.*, no. 215, p. 51-60.

________, 1966. Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera: *Bol. Inform. Asoc. Venezolana Geol., Min., Petr.*, v. 9, p. 1-33.

TABLE 1
Lithostratigraphy and Environments of Deposition of Cretaceous and Tertiary Stages in Atlantic Coastal Plain and B-2 Well

Interval	Outcrop		Subsurface		B-2 C.O.S.T. Well	
	Dominant Lithologies	Environment Deposition	Dominant Lithology	Environment Deposition	Dominant Lithology	Environment Deposition
Miocene Upper Oligocene	Sands, silts, clays, diatomaceous earth	Near Shore – Coastal N.M.	Same	Same	Sands, gravels, shale	Nonmarine – shelf
Upper Eocene-Lower Oligocene			MAJOR UNCONFORMITY			
					Extends into Upper Eocene	
Lower-Middle Eocene	Sands, silts, clays, glauconite, siliceous in parts	Inner-mid Shelf	Yellowish gray silts, clays siliceous in parts	Outer shelf, Bathyal in Embayment	Yellowish gray to Buff Calcareous clays, limestone	Mid-Lower Bathyal
Paleocene	Sands, silts, clays, glauconites	Inner shelf	Gray clays, silts	Mid-outer shelf Bathyal in Embayment	Paleocene-Maestrichtian unconformity	
Campanian-Maestrichtian	Sands, silts, clays, glauconites	Near shore, inner, mid shelf	Gray silts, clays, chalks	Mid-outer shelf Bathyal in Embayment	Sands, shales, limestones	Mid-Outer Shelf
Santonian	Sands, silts, lignitic	Near shore, coastal N.M.	Sands, silts, clay	Near shore-mid shelf outer shelf – Bathyal in Embayment	Sands, shales, limestone, lignite	Nonmarine-Outer Shelf
Coniacian	Unconformity		Clay	Embayment only shelf	Sands, shales, lignite	Nearshore-Nonmarine
Cenomanian-Turonian	Sands, silts, clays	Nonmarine	Same with some limestones	Nonmarine, shelf in upper part	Sands, shales, limestone, Glauconite	Inner-Outer Shelf
Aptian-Albian	Sands, silts, clay, conglomerates	Nonmarine	Same	Same	Sandstones, shales, conglomerates	Nearshore-Inner shelf Nonmarine
Neocomian-			Sands, silts, clays, conglomerates	Nonmarine	Sandstones, shales, lignite, coal	Nearshore-Nonmarine

Brenner, G.J., 1963. The spores and pollen of the Potomac Group of Maryland: *Maryland Dept. Geology, Mines, and Water Resources Bull.* 27, p. 1-215.

Brown, P.M., Miller, J.A., and Swain, F.M., 1972. Structural and stratigraphic framework and spacial distribution of permeability of the Atlantic Coastal Plain, North Carolina to New York: *U.S. Geol. Surv. Prof. Paper* 796, p. 1-79.

Cornet, B. and Traverse, A., 1975. Palynological contribution to the chronology and stratigraphy of the Hartford Basin in Connecticut and Massachusetts: *Geosci Man,* v. XI, p. 1-33.

Cornet, B., Traverse, A., and McDonald, N.G., 1973. Fossil spores, pollen and fishes from Connecticut indicate Early Jurassic age for part of the Newark Group: *Science,* v. 182, p. 1243-1247.

Doyle, J.A., 1969. Angiosperm pollen evolution and biostratigraphy of the basal Cretaceous formations of Maryland, Delaware, and New Jersey (Abstracts): *Geol. Soc. Am. Ann. Mtg.,* Atlantic City, N.J., p. 51.

Doyle, J.A. and Hickey, L.V., 1972. Coordinated evolution in Potomac Group angiosperm pollen and leaves (Abstracts): *Am. Jr. Botany,* v. 59, p. 660.

Haq, B.U. and Lohmann, G.P., 1976. Calcareous nannoplankton evidence for major climatic changes in the Miocene Atlantic Ocean (Abstracts): *Geol. Soc. Am., Ann. Mtg.,* Denver, Colo., p. 902-903.

Ingle, J.C., Jr., Graham, S.A., and Dickinson, W.R., 1976. Evidence and Implications of Worldwide Late Paleogene Climatic and Eustatic Events (Abstracts): *Geol. Soc. Am., Ann. Mtg.,* Denver, Colo., p. 934-935.

Maher, J.C. and Applin, E.R., 1971. Geologic framework and petroleum potential of the Atlantic Coastal Plain and continental shelf: *U.S. Geol. Survey Prof. Paper* 659, p. 98.

Olsson, R. K., 1964. Late Cretaceous planktonic foraminifera from New Jersey and Delaware: *Micropaleontology*, v. 10, p. 157-188.

_______, 1970. Paleocene planktonic foraminiferal biostratigraphy and paleozoogeography of New Jersey: *J. Paleontol.* v. 44, p. 589-597.

_______, 1975. Upper Cretaceous and Lower Tertiary Stratigraphy of New Jersey Coastal Plain: Second Annual Field Trip Guidebook, Petrol. Exploration Soc. N.Y., p. 1-49.

Olsson, R.K., and O'Grady, M.D., 1976. Cretaceous and early Tertiary paleobathymetric history of New Jersey Coastal Plain (Abstracts): *Am. Assoc. Petrol. Geol. Bull.,* Ann. Mtg., New Orleans, v. 60, p. 704.

Perry, W.J., Jr., Minard, J.P., Weed, E.G.A., Robbins, E.I., and Rhodehamal, E.C., 1975. Stratigraphy of Atlantic Coastal margin of United States north of Cape Hatteras — Brief Survey: *Am. Assoc. Petrol. Geol., Bull.,* v. 59, p. 1529-1548.

Pessagno, E.A., Jr., 1967. Upper Cretaceous planktonic foraminifera from the Western Gulf Coastal Plain: *Paleontographica Americana* v. 5, p. 245-445.

Petters, S.W., 1976. Upper Cretaceous subsurface stratigraphy of Atlantic Coastal Plain of New Jersey: *Am. Assoc. Petrol. Geol. Bull.,* v. 60, no. 1, p. 87-107.

Sheridan, R.E., 1974. Conceptual model for the block-fault origin of the North American continental margin geosyncline: *Geology,* v. 2, p. 465-468.

________, 1976. Sedimentary basins of the Atlantic margin of the United States. *In* Thompson, A.M. (Ed.), *Guidebook to the stratigraphy of the Atlantic Coastal Plain in Delaware:* (Petr. Explor. Soc.), p. 37-58.

Sirkin, L.A., 1974. Palynology and stratigraphy of Cretaceous strata in Long Island, N.Y., and Block Island, R.I.: *U.S. Geol. Sur. J. Res.,* v. 2, p. 431-440.

Swain, F.M. and Brown, P.M., 1972. Lower Cretaceous, Jurassic (?), and Triassic Ostracoda from the Atlantic Coastal region: *U.S. Geol. Sur. Prof. Paper* 795, p. 1-72.

Toumarkine, M. and Bolli, H.M., 1970. Evolution de *Globorotalia cerroazulensis* (Cole) dans L'Eocene Moyen et Superieur de Possagno (Italie): *Rev. Micropaleontologie,* v. 13, p. 131-145.

Ulrich, B.C., 1976. The Eocene foraminiferal biostratigraphy of the Atlantic Coastal Plain of New Jersey: Unpublished Masters thesis, Rutgers Univ., p. 1-73.

1976 U.S. Geological Survey Open File Report B-2 C.O.S.T. Well.

van Hinte, J.E., 1976. A Cretaceous time scale: *Am. Assoc. Petrol. Geol. Bull.,* v. 60, p. 498-516.

Weed, E.G.A., Minard, J.P., Perry, W.J., Jr., Rhodehamel, E.C., and Robbins, E.I., 1974. Generalized Pre-Pleistocene geologic map of the northern United States Atlantic continental margin: *U.S. Geol. Surv.,* Misc. Ser., Map I - 861, p. 1-8.