

# Late Oligocene transgression of middle Atlantic Coastal Plain

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## ABSTRACT

The subsurface Piney Point Formation of the coastal plain of Maryland, Delaware, and New Jersey contains planktonic foraminifera of late Oligocene age. The transgressive Piney Point Formation was deposited in inner to middle shelf environments on an eroded Eocene surface. The disconformity that separates the Piney Point from the Eocene formations below resulted from a major lowering of global sea level in early Oligocene time. This eustatic regression correlates with severe climatic changes noted elsewhere in the geologic record of this time.

## INTRODUCTION

The Piney Point Formation is one of the most readily identifiable units in the Coastal Plain subsurface of Maryland and Delaware, on the basis of a distinctive electric-log signature. The unit has also been identified in the Coastal Plain subsurface of southern New Jersey (Richards, 1967; Nemickas and Carswell, 1976). The Piney Point, which has not been identified in outcrops, was first described by Otton (1955) and placed in the upper Eocene (Jackson Stage) on the basis of studies by Shifflett (1948), who identified "Jackson Eocene" foraminifera in Maryland wells. Later, Brown and others (1972) suggested a middle Eocene (Claibornian) age because typical Claibornian ostracodes were found in the type section of the Piney Point. As a consequence of the reported Eocene age, a major unconformity has been interpreted to exist between the Piney Point and the overlying Miocene Chesapeake Group (Maher, 1965; Weed and others, 1974).

Preliminary studies (Olsson and Miller, 1979) in New Jersey indicated that the Piney Point is, in fact, Oligocene in age. In this study we have examined rotary cuttings from 16 wells and conventional cores from 5 wells in Maryland and New Jersey. We included samples from the Piney Point and from the overlying and underlying formations (Fig. 1). Analysis of

these wells and electric logs from 11 other wells (Fig. 1) enabled us to trace the Piney Point from Maryland through New Jersey and to assess its relationship to the stratigraphic units above and below.

## LITHOSTRATIGRAPHY

In Maryland, the Piney Point is a light-olive-gray, slightly clayey to clayey, glauconitic, coarse- to medium-grained quartz sand. The quartz grains are either pitted and frosted, covered with a limonite coating, or clear. Both weathered and unweathered glauconite pellets occur. Mollusc shells are rare to abundant. Downdip the clay content increases to as much as 50%.

In downdip wells the overlying basal Calvert Formation is a diatomaceous clay with minor amounts of clear, coarse, quartz sand and fine sand- to silt-sized glauconite. Updip, the basal part of the Calvert is a fine quartz sand, and in wells where the Piney Point pinches out, differentiation of the two formations is difficult. Beyond the Piney Point pinch-out the Calvert overlies the glauconitic Eocene Nanjemoy Formation, from which it is easily distinguished.

In downdip wells, a higher clay and glauconite content distinguishes the underlying Nanjemoy Formation from the Piney Point. Updip, where the Nanjemoy is sandier and more glauconitic, reworking

of these sediments into the Piney Point often makes lithologic separation of the two units difficult.

In New Jersey, Richards (1967) identified the Piney Point Formation in the Anchor Dickinson I and USGS Island Beach wells. Nemickas and Carswell (1976) also identified the Piney Point Formation in southern New Jersey. Despite these reports the distribution of the Piney Point Formation in the subsurface of New Jersey has not been mapped.

Two cored wells in New Jersey, the Jobs Point and Leggette wells (Fig. 1), allow greater biostratigraphic and sedimentological control than the uncored Maryland and Delaware wells. In New Jersey, the Piney Point lies between the Eocene Manasquan Formation (Deal Member) and the Miocene Kirkwood Formation (Fig. 2). The Piney Point consists of olive-gray to brownish-yellow glauconitic silt and medium to coarse quartz and glauconite sand, which in places becomes very coarse and shelly. Although some of the glauconite is unweathered, much of it is weathered, well rounded, and polished. Also, weathered Eocene lithoclasts and reworked recrystallized Eocene foraminifera are present in the lower sections. The underlying Eocene unit is a light-ash-colored to yellow-gray clay, whereas the overlying

basal Kirkwood is a gray to gray-brown sand, silt, and clay. Updip (Chatsworth TC1 and Lebanon State Forest TC7 wells), the Piney Point Formation is replaced by the finer grained micaceous sand and silt of the Kirkwood Formation.

Our studies show that the Nanjemoy and Manasquan (Deal Member) Formations that lie immediately beneath the Piney Point are of early to middle Eocene age. Cross sections through Maryland and New Jersey (Figs. 3, 4) show that the Piney Point rests on progressively younger Eocene sedimentary strata downdip. Land-

ward of the Piney Point pinch-out, the basal Calvert and Kirkwood Formations lie upon this truncated Eocene surface. We suggest that the Piney Point inter-fingers with these overlying formations updip. In New Jersey the characteristic electric-log signature of the Piney Point can be observed in updip wells within the Kirkwood Formation, thus supporting this interpretation (Fig. 4). Further, Minard (1965) noted beds 0.8 to 1.2 m (2 to 4 ft) thick of glauconitic pebbly coarse sand in the basal Kirkwood in southern New Jersey. He also found stringers of glauconitic

sand 3 to 6.5 m (15 to 20 ft) above the base of the Kirkwood. This apparent interfingering supports our interpretation that the Piney Point and the updip basal parts of the Kirkwood and Calvert are facies of the same lithostratigraphic unit.

### BIOSTRATIGRAPHY

It is not clear that Shifflett's (1948) "Jackson Eocene" foraminifera came from intervals designated by Otton (1955) as Piney Point. In view of the extensive redeposition within the Piney Point and the difficulty in some areas of differentiating it lithologically, it is not surprising that ages of early Eocene (Rasmussen and others, 1958), middle Eocene (Brown and others, 1972), late Eocene (Shifflett, 1948), and Miocene (Valia and others, 1977) have been assigned to the Piney Point. In our study, the ages of the Piney Point and the adjacent formations are based on planktonic foraminiferal zonation.

In the Leggette and Jobs Point cores the planktonic foraminiferal species *Globigerina ciproensis* Bolli, *Globigerina angulifurcata* Bolli, and *Globorotalia opima opima* Bolli indicate the presence of the upper Oligocene *G. ciproensis* and *G. opima opima* Zones (P21-P22). In addition, the Jobs Point core contains upper Oligocene calcareous nannoplankton of the *Sphenolithus distentus* and *Sphenolithus ciproensis* (NP24-NP25) Zones (S. F. Percival, Jr., personal commun.). In rotary cuttings of the Piney Point, highest occurrences (tops) of *Globigerina ampliapertura* Bolli, *G. angulifurcata* Bolli, *G. ciproensis*, *G. officinalis* Subbotina, *G. ouachitaensis* Howe and Wallace, *Globorotalia opima nana* Bolli, *G. opima opima* and *G. postcretacea* (Myatliuk) identify the interval as Oligocene.

The benthic foraminiferal species of the Piney Point are common also in the overlying Miocene formations (Cushman and Cahill, 1933; McLean, 1956; Schnitker, 1970). Some of the more abundant species are *Bolivina multicostrata* Cushman, *B. paula* Cushman and Cahill, *Buliminella elegantissima* (d'Orbigny), *B. elongata* (d'Orbigny), *Cassidulina crassa* (d'Orbigny), *Cibicides lobatulus* (Walker and Jacob), *C. ornatus* (Cushman), *Epistominella pontoni* (Cushman), *Florilus pizzarensis* (Barry), *Hanzawaia concentrica* (Cushman), *Melonis umbilicatus* (Montague), *Trifarina bradyi* Cushman, and *Uvigerina juncea* Cushman and Todd. This assemblage indicates inner to middle shelf (about 100 m or less) environments during deposition of the Piney Point.

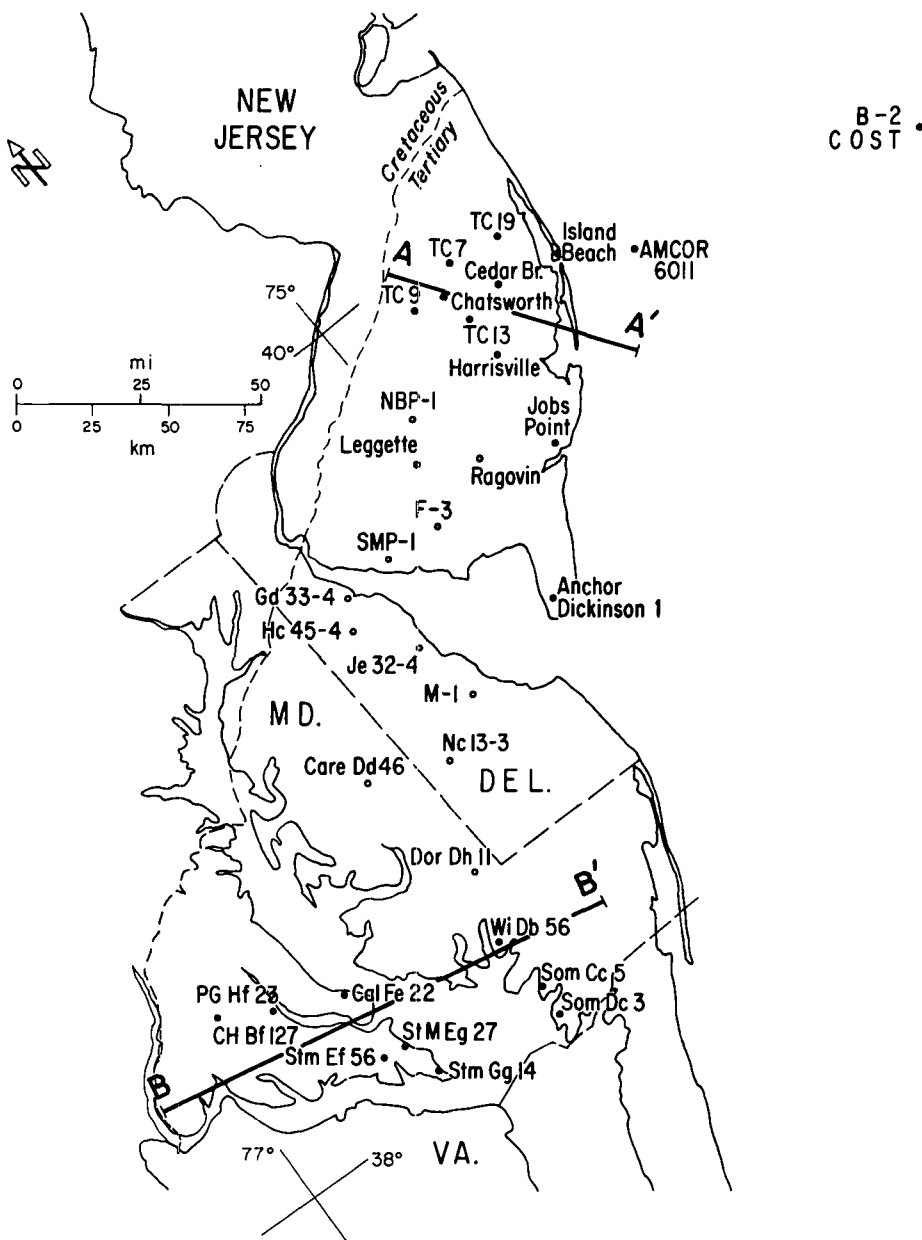


Figure 1. Map showing location of wells used in this study. Dots are wells from which samples were examined. Conventional core samples were used from AMCOR 6011, Cal FE 22, Jobs Point, Leggette, and St M Eg 27 wells. Open circles = wells correlated by electric logs. A-A' and B-B' = locations of cross sections shown in Figures 4 and 3, respectively.

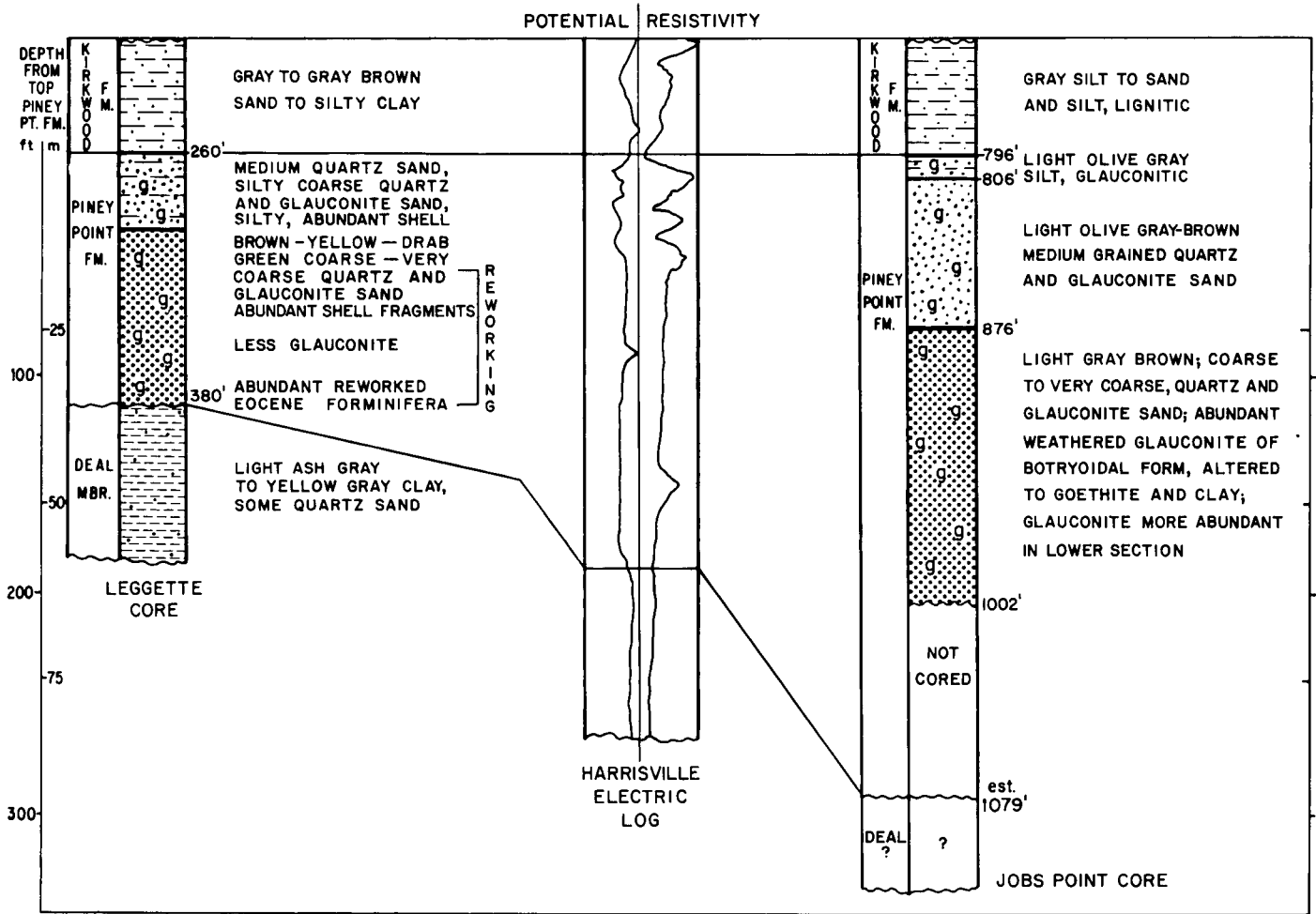


Figure 2. Lithostratigraphy of Piney Point Formation in Leggette and Jobs Point wells. Electric log of Harrisville well is typical for Piney Point Formation.

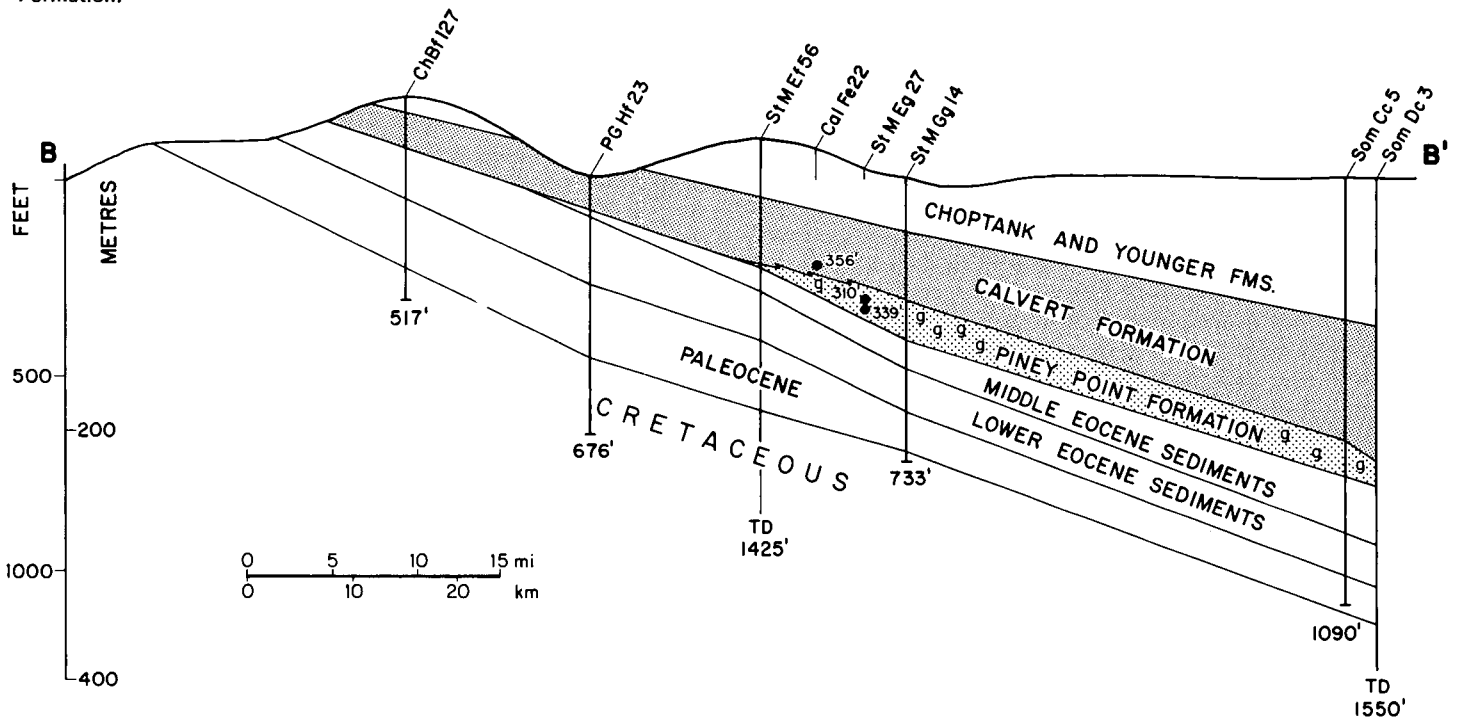


Figure 3. Cross section through Maryland (B-B' in Fig. 1). Note that Piney Point Formation rests on progressively younger Eocene sediments downdip and that Calvert Formation also lies on truncated-eroded Eocene surface landward of Piney Point pinch-out.

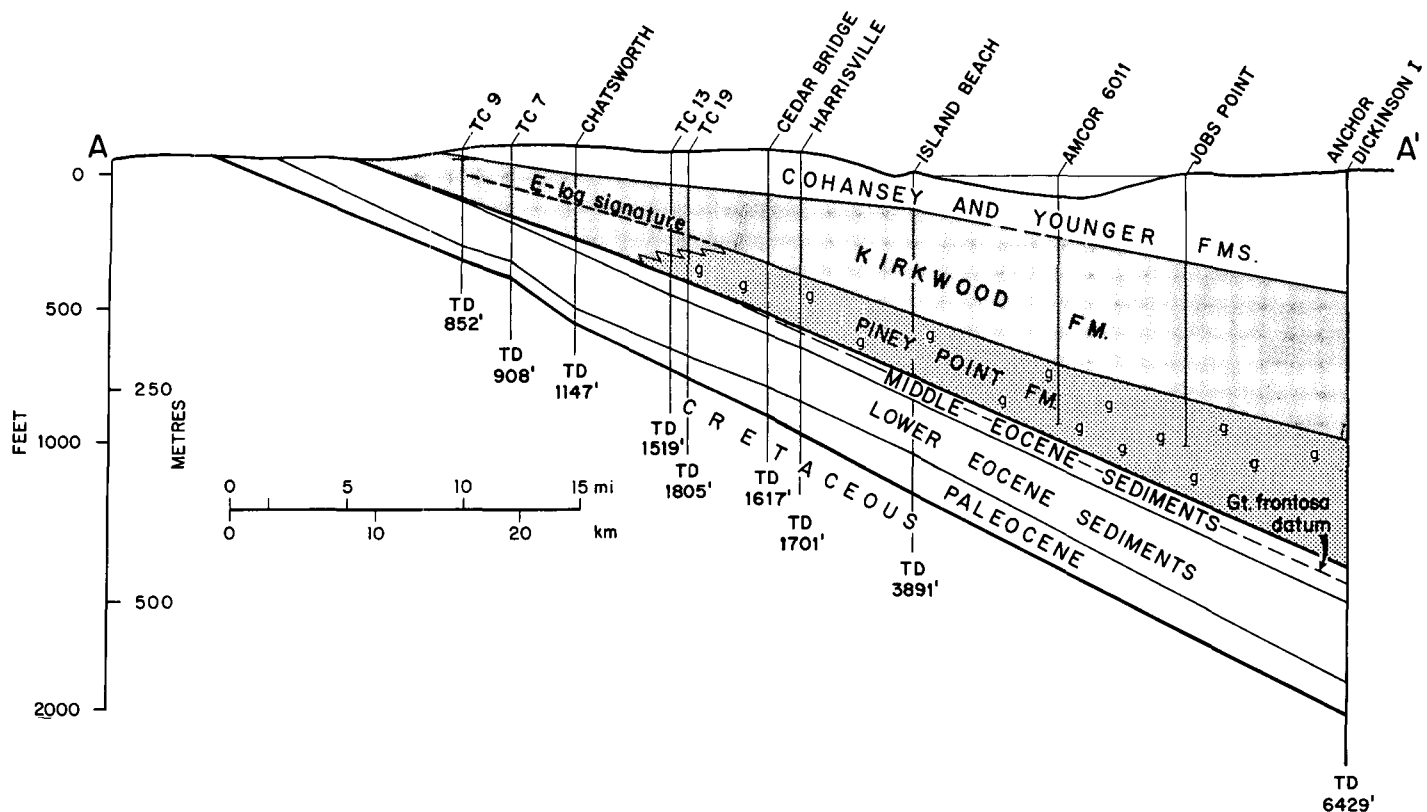


Figure 4. Cross section through New Jersey (A-A' in Fig. 1). Note that Piney Point Formation rests on progressively younger Eocene sediments downdip and that Kirkwood Formation also lies on truncated-eroded Eocene surface landward of Piney Point pinch-out. Note also Piney Point electric-log signature in updip basal Kirkwood Formation. *Globorotalia frontosa* extinction datum illustrates truncation in middle Eocene section.

In the basal parts of the Piney Point, typical Eocene foraminifers are in places present. They are completely recrystallized and are clearly distinguishable from the well-preserved indigenous forms. In contrast, underlying Eocene formations contain abundant well-preserved Eocene foraminifera. Planktonic species such as *Acarinina pentacamerata* (Subbotina), *Morozovella formosa* (Bolli), *M. lehneri* (Cushman and Jarvis), and *Globorotalia frontosa* (Subbotina) establish that these formations range in age from early to middle Eocene (Figs. 3, 4).

There are no studies that deal with the age of the lower Kirkwood Formation, but one outcrop section of the lower part of the Calvert has been dated as early Miocene (Andrews, 1978). However, we have observed the Oligocene species *Globigerina ciperoensis* in the basal parts of both these formations in some wells.

#### EOCENE-OLIGOCENE HIATUS

The pre-Miocene disconformity separating the Piney Point Formation from Eocene sedimentary strata below is widely recognized in the Atlantic Coastal Plain in both outcrop and the subsurface (Maher, 1965; Weed and others, 1974). We have used a time-distance plot (Van

Hinte, 1978) to define the extent of this disconformity. By plotting the estimated ages of planktonic foraminiferal zones (Berggren, 1972), the durations of the hiatuses were calculated (Fig. 5) in wells and in the offshore COST B-2 well (Fig. 1), where the same disconformity is present (Olsson and Miller, 1979). Figure 5 shows that the time gap decreases in magnitude as the disconformity is traced from the hinge line basinward. Such a pattern typically results from a drop in sea level, which we estimate (Fig. 5) occurred somewhere near the end of Eocene time. The subsequent rise in sea level began during mid-Oligocene time. This rise in sea level appears to have been rapid, because benthic foraminifera show an overlapping of shallow-water biofacies. A subsequent gradual regression in latest Oligocene to early Miocene time is also indicated by benthic foraminifera (Fig. 6; Olsson and Miller, 1979, and unpub. data).

This late Eocene-early Oligocene disconformity is traceable throughout the northeast Atlantic continental margin from North Carolina to Long Island (Weed and others, 1974). We propose that the late Eocene to early Oligocene disconformity resulted from a eustatic lowering of sea level, which resulted in the largest

regional hiatus of the Late Cretaceous to Tertiary in the northeast Atlantic continental margin.

The stratigraphic record and changes in relative sea level for the northeast margin are compared (Fig. 6) with the sea-level curve of Vail and others (1977). Although Vail and others (1977) recognized a global lowering of sea level at the end of the Eocene similar to that seen in our study, they showed an early Oligocene transgression and a major mid-Oligocene regression. Stratigraphic evidence for such an early Oligocene highstand and mid-Oligocene lowstand is lacking in the passive northeast margin. We suggest that the sea-level curve of Vail and others (1977) is either miscorrelated or that the early Oligocene event was not very great. This is supported by Pitman's (1978) sea-level curve derived from volume changes of the mid-ocean ridge system which indicates a major late Eocene-early Oligocene lowstand of sea level. The late Eocene-early Oligocene hiatus is also observed in other passive margin stratigraphic sequences throughout the world (for example, Jackson-Vicksburg boundary in the Gulf Coast: Murray, 1961; Priabonian-Ludian-Rupelian-Stampian boundary in Europe: Pomerol, 1973).

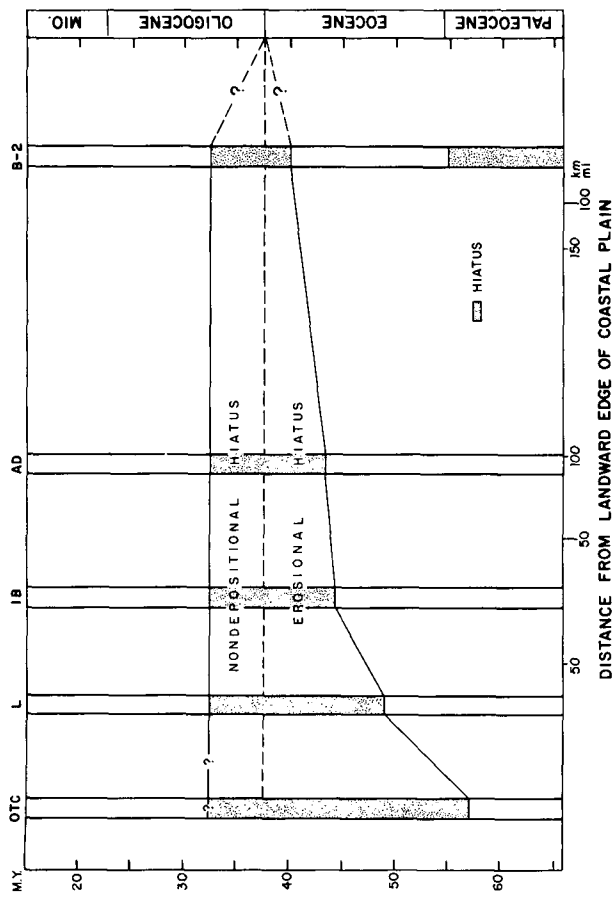


Figure 5. Time-distance plot of Eocene-Oligocene hiatus from outcrop to COST B-2 well (Fig. 1). OTC = outcrop, L = Leggette well, IB = Island Beach well, AD = Anchor Dickinson I well, B-2 = COST B-2 well.

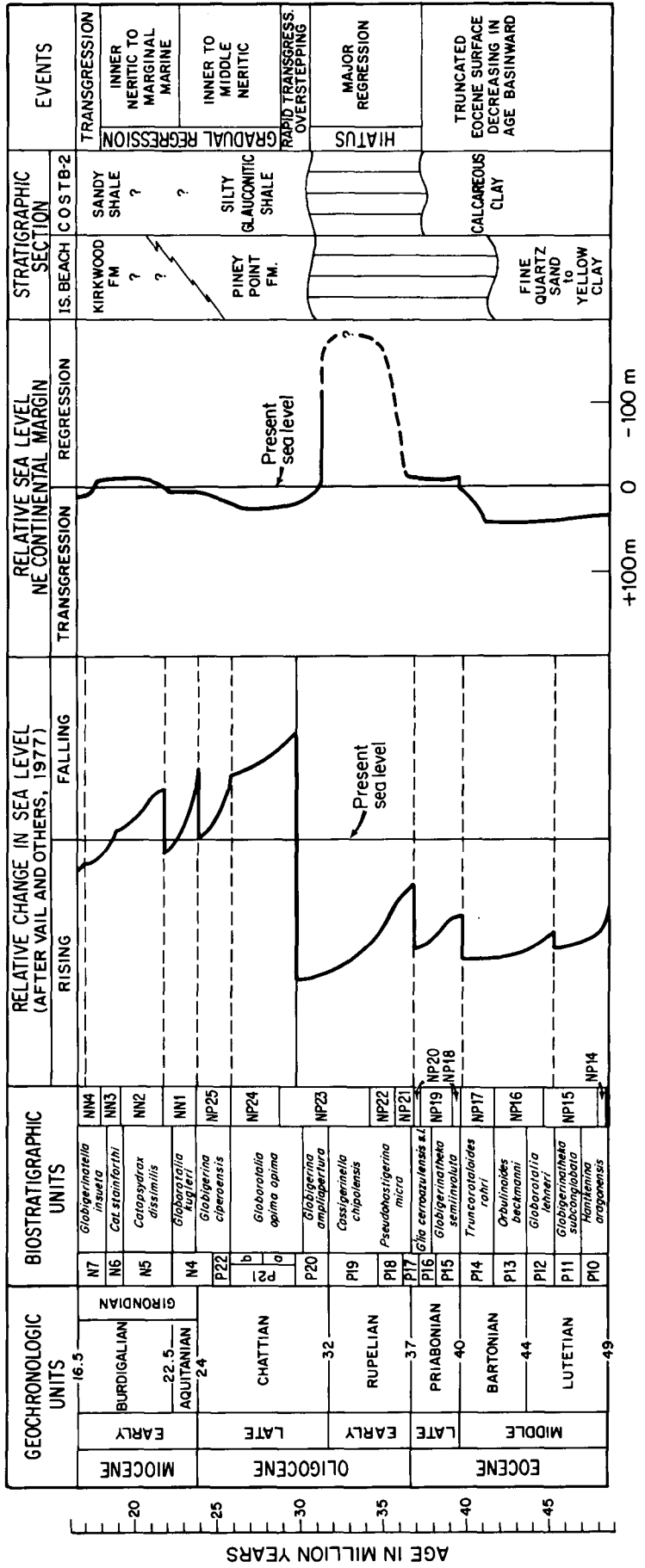


Figure 6. Stratigraphy and sea-level changes on northeast continental margin, comparison with curve of Vail and others (1977). Time scale after Hardenbol and Berggren (1978).

The late Eocene–early Oligocene fall in sea level correlates with other major late Eocene to early Oligocene geologic events. The Tertiary climatic record shows that a period of major cooling commenced at the end of Eocene time (Devereaux, 1967; Savin and others, 1975; Shackleton and Kennett, 1975; Wolfe, 1978). Shackleton and Kennett dated the beginning of this period of refrigeration at approximately 38 m.y. B.P. Their study shows that the mean annual temperature in higher southern latitudes was near freezing at this time and that glacial ice began to form on Antarctica. A paleobotanical analysis of Tertiary climates in the Northern Hemisphere by Wolfe (1978) indicated that the most profound climatic event of the Tertiary took place at the end of the Eocene. A major decline in mean annual temperature at this time is reflected in the drastic taxonomic turnover in late Eocene and early Oligocene floras. In addition to correlating with climatic deterioration, the terminal Eocene lowering of sea level (Vail and others, 1977; Pitman, 1978; this study) correlates with a global drop in the carbonate compensation depth (Heath, 1969; Berger, 1973; van Andel and others, 1975) and the development of widespread deep-sea unconformities (Moore and others, 1978).

## SUMMARY

The subsurface lithostratigraphic and biostratigraphic record of the continental margin of Maryland, Delaware, and New Jersey indicates that a late Eocene to early Oligocene regression was followed by a rapid middle to late Oligocene transgression. The absence of lower Oligocene rocks in offshore wells (Olsson and Miller, 1979; Poag, 1980) suggests that an Eocene surface may have been exposed to erosion as far from the hinge line as the present shelf edge.

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