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20. *DATA REPORT:* MIOCENE PALYNOLOGIC AND CLIMATIC RECORDS, NEW JERSEY COASTAL PLAIN[1]

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INTRODUCTION

Major changes in global climate occurred during the Miocene. Deep-sea $\delta^{18}O$ values provide the most detailed record of ice volume and global climate changes. General global warming in the late Oligocene to early Miocene was punctuated by at least four early Miocene glaciations (Mi1, Mi1a, Mi1b, and Mi2 of Miller et al., 1991). A major climatic transition began following the zenith of warmth in the late early to early middle Miocene (~17–15 Ma). A transient cooling/glaciation at ~16.5 Ma (= Mi2 of Miller et al., 1991) was followed by a warming and then a subsequent regrowth of the East Antarctic Ice Sheet from ~15 to 13 Ma (Miller et al., 1991; Flower and Kennett, 1994). Oceanic latitudinal thermal gradients increased in the middle Miocene (Savin et al., 1985). Although marine records constrain the timing of oceanographic and ice volume changes, there are few terrestrial or near-shore records of Miocene temperature history.

The New Jersey Coastal Plain Drilling Project (Ocean Drilling Program [ODP] Leg 150X) recovered thick near-shore Miocene sections that have been dated using Sr-isotopic stratigraphy (Miller, et al., 1994; Miller et al., 1996b; Miller et al., Chapter 14, this volume; Sugarman et al., Chapter 12, this volume). In this paper, we present Miocene pollen data collected from these and other boreholes in New Jersey (Fig. 1). Stratigraphic coverage of the pollen data is limited at present; however, our data provide evidence not only for longer term climate cooling during the Miocene but also for within-sequence variations in terrestrial temperatures.

METHODS

Stratigraphic Sections

Stratigraphic sections (Figs. 2, 3) were developed from published studies of Miocene boreholes in New Jersey (Owens et al., 1988; Sugarman et al., 1993; Miller, et al., 1994, 1996a; Owens et al., 1995a, 1995b). The Miocene sections, typically comprising clays and sands deposited in prodelta and shallow shelf (inner-middle neritic; 0–100 m paleodepth) environments, are assigned to the Kirkwood Formation (Sugarman et al., 1993; Miller et al., Chapter 14, this volume). Stratigraphic sequences were identified as unconformity-bounded transgressive-regressive sequences that typically shoal upward. Unconformities were identified using physical stratigraphy, biostratigraphy, and Sr-isotope stratigraphy. Miocene sequences were termed Kw0, Kw1a, Kw1b, Kw1c, Kw2a, Kw2b, Kw2c, Kw3, and Kw-Cohansey (Kw-C). The sequences typically consist of a lower silt and an upper quartz sand that coarsen and shallow upsection as a result of progradation. Lowermost Miocene sequences Kw0 and Kw1a have basal glauconite sands reflecting the deepest paleodepths.

Palynology

This report uses previously published, unpublished, and new pollen data (Tables 1–3; Plates 1, 2) for paleoclimatic interpretations of lower to middle Miocene sediments from the New Jersey Coastal Plain. T. Ager (in Owens et al., 1988) studied pollen from the ACGS#4 borehole. Ager (pers. comm., 1994) also performed a preliminary analysis of pollen from Miocene sediments at the Leg 150X Island Beach borehole. Pollen from the Belleplain State Forest borehole was identified by L. Sirkin (pers. comm., 1991). New data presented in this study are chiefly from the Leg 150X Atlantic City borehole (Table 2), and the Cape May borehole (Table 3).

Paleoclimatic indicators were based on pollen genera outlined in Table 1. Three generalized climatic assemblages were identified, including (1) warm temperate to subtropical, (2) temperate, and (3)

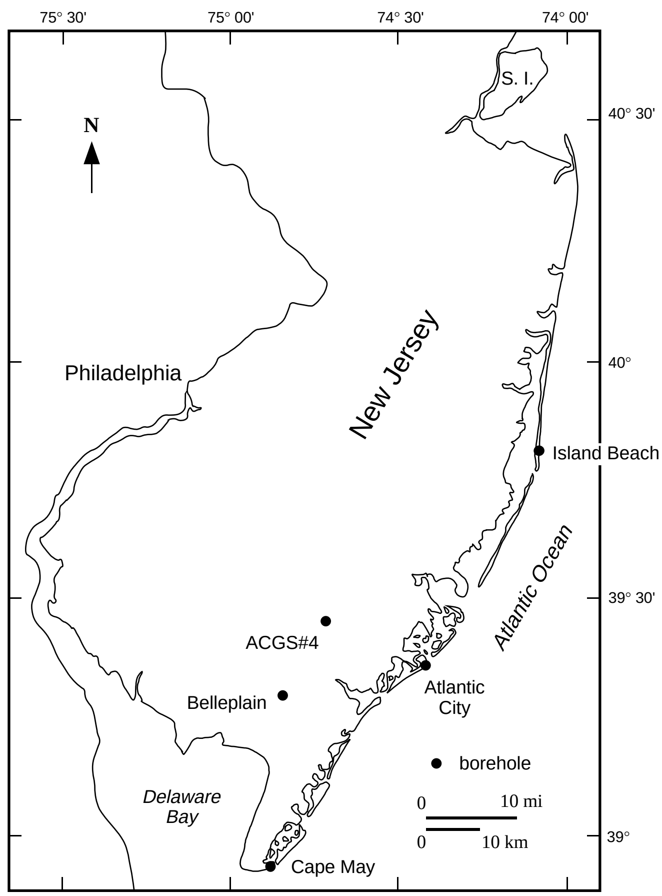

Figure 1. Location of boreholes used in the study.

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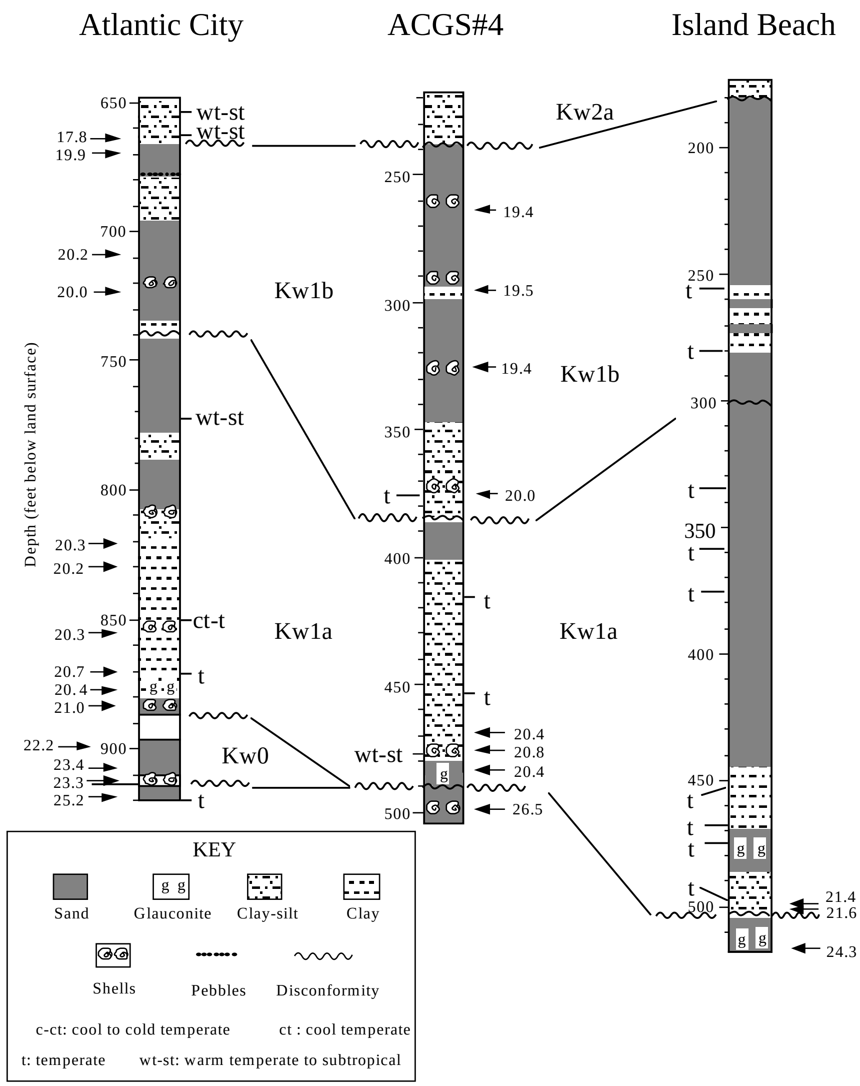

Figure 2. Correlation of the Kw0, Kw1a, and Kw1b sequences at ACGS#4, Atlantic City, and Island Beach boreholes. Also shown are Sr-isotope age estimates (in Ma) and paleoclimatic interpretation. The geologic timescale of Berggren et al. (1995) is used throughout. Depths in feet below land surface.

cool to cold temperate. In addition, Table 1 lists genera indicative of swamp environments and exotic genera including plants that are extinct or no longer grow in the region.

Picea, Tsuga, and, to a lesser extent, *Alnus* and *Abies*, are indicative of cool to cold temperate climates. *Alnus* and *Picea* have been documented as indicative of cool climates (Wolfe, 1978). A change to a *Picea*-dominated forest from a broadleaf deciduous forest is primarily controlled by summer temperatures, as expressed by the 21° July isotherm (Wolfe, 1971). In North America, *Picea* is not native to areas of high summer heat (Wolfe, 1971). *Tsuga* typically prefers cool microhabitats found in gullies and higher altitudes. Other methods for paleoclimatic interpretation include the use of the *Pinus*/*Picea* ratio, with low ratios interpreted as intervals of climatic cooling (Goldstein, 1974), and the ratio of temperate-warm temperate taxa (*Carya, Quercus, Luiquidambar, Nyssa,* and *Ilex*) to subtropical-tropical taxa (*Momipites, Cyrilla,* Sapotaceae, and *Alangium*), with high ratios interpreted as cool intervals (Groot, 1992).

RESULTS: POLLEN ASSEMBLAGES AND PALEOCLIMATES

We did not sample the lowermost Miocene Kw0 sequence for our initial pollen studies because of its limited stratigraphic extent and because the coarse sediments in the sequence are not favorable for pollen preservation. The overlying Kw1 and Kw1b are the most widely represented Miocene sequences in both the subsurface and outcrop (Sugarman et al., 1993). Overall, pollen preserved in the Kw1a (20.1–21.1 Ma; see Miller et al., Chapter 14, this volume, for discussion of chronology) and Kw1b (19.5–20.1 Ma) sequences at the Island Beach, Atlantic City, and the ACGS#4 boreholes is dominated by temperate to warm temperate forest vegetation (Fig. 2). *Quercus-Carya-Pinus* is typically the dominant assemblage. Other common to occasional genera include *Tsuga, Betula, Carya, Ilex, Podocarpus,* and *Engelhardia.* At the ACGS#4 borehole, a *Fagus-Quercus* assemblage, with lesser amounts of *Carya, Pinus,* and *Ulmus* was reported as the dominant assemblage in the Kw1a and Kw1b sequences (Owens et al., 1988). At Island Beach, relatively small amounts of *Pinus* were observed (T. Ager, pers. comm., 1994).

Although the majority of samples contained warm temperate to temperate pollen assemblages, some indications of cooler paleoclimates were found at the base of the Kw1a sequence at Island Beach (498 and 475 ft; 151.8 and 144.8 m) and near the base of Kw1a at Atlantic City (850 ft; 259.1 m). A well-preserved sample from 850 ft (259.1 m) at Atlantic City (Sr-isotope age estimate of 20.3 Ma) contained abundant *Quercus*, common *Ilex, Populus,* and *Tsuga,* and occasional *Picea, Carya, Nyssa, Engelhardia, Tilia, Alnus, Castanea, Pterocarya,* and *Betula* (Table 2). The mixture of spruce, hemlock,

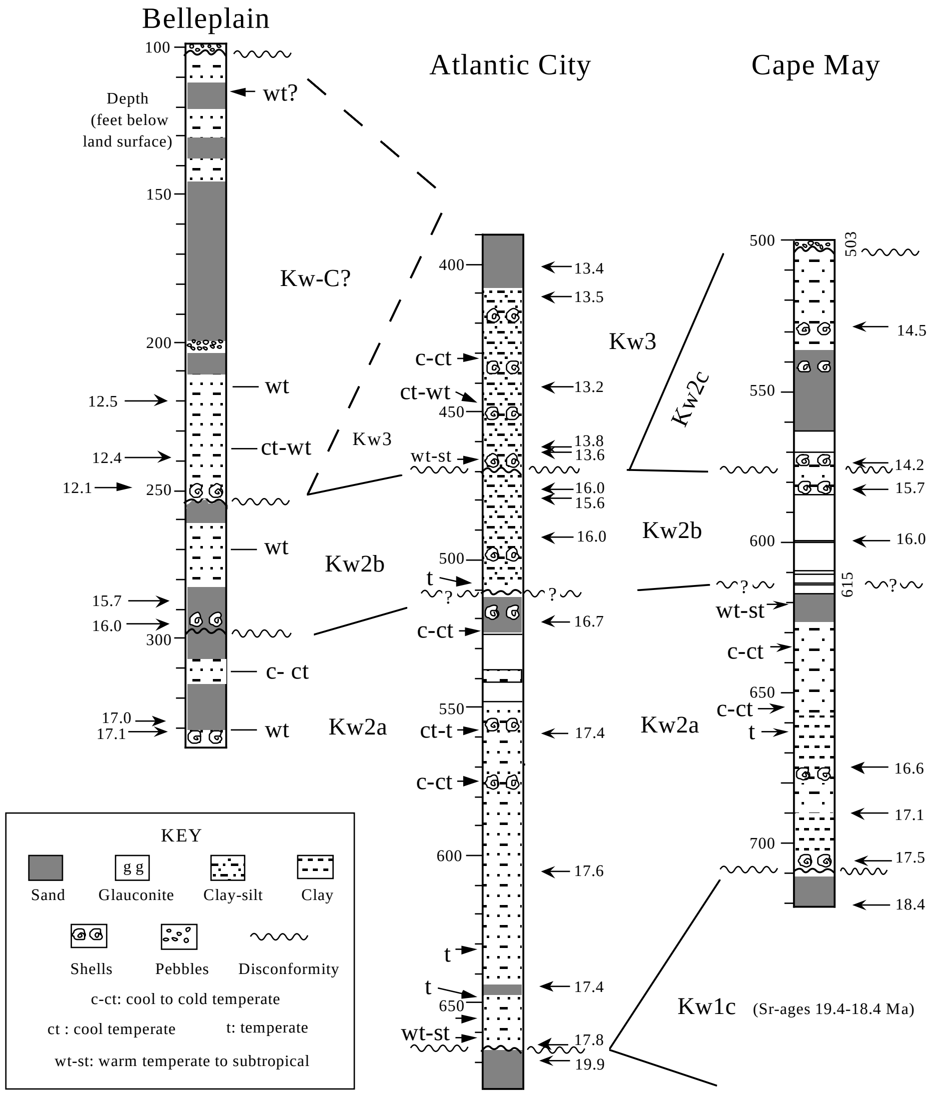

Figure 3. Correlation of the Kw2a, Kw2b, Kw2c, and Kw3 sequences from the Belleplain, Atlantic City, and Cape May boreholes. Also shown are Sr-isotope age estimates (in Ma) and paleoclimatic interpretation. The geologic time scale of Berggren et al. (1995) is used throughout. Depths in feet below land surface.

alder, and birch indicates a cool temperate climate with evidence of boreal forest assemblages near the source area. Groot (1992) also reports a minor cool interval in the lower Miocene near the base of the Calvert Formation. At Island Beach, samples from the base of the Kw1a sequence contained a higher diversity and greater abundance of conifer pollen (e.g., Pinaceae and Taxodiacea), along with *Picea* and *Alnus,* suggesting possible cooler (temperate instead of warm temperate) climatic conditions.

No pollen was examined from the Kw1c sequence, which was only recovered at Cape May.

The Kw2a sequence (16.5–17.8 Ma) records a distinct regional climatic cooling. At Atlantic City, palynological results indicate that the transgressive deposits at the base of the Kw2a sequence at 662 ft and 656 ft (201.8 and 199.9 m) record warm to subtropical paleoclimates. *Quercus* and *Carya* are the dominant taxa, with lesser *Engelhardia.* A cooling from warm temperate to temperate paleoclimates is recorded slightly higher in the sequence (649 and 632 ft; 197.8 and 192.6 m). The dominant taxa are similar to those from 662 ft (201.8 m) and 656 ft (199.9 m), with the addition of *Pinus* at 649 ft (197.8 m). A major transition to cooler climates is observed in the regressive sediments from the upper part of the Kw2a sequence (Fig. 3). In this interval, the dominant assemblage changes from *Quercus* and *Carya* to *Quercus, Picea,* and *Carya,* a cool to cold temperate assemblage. In addition, *Tsuga* and *Alnus,* also indicative of cool climates, are present in trace amounts. The assemblage from 525 ft (160 m) also includes small amounts of *Pinus, Betula, Fagus,* and *Tilia.* Overall, the Kw2a sequence from Atlantic City can be characterized as an upward cooling sequence (Fig. 3).

Pollen data from the upper part of the Kw2a sequence at Belleplain (330 ft and 311 ft; 110.6 and 94.8 m; Sr age estimate of 17.0 Ma) also indicate a cooling. The sample at 311 ft (94.8 m) contains *Pinus* and *Picea,* in addition to the exotics *Clethra, Podocarpus, Cyrilla, Engelhardia/Momipites, Symplocus,* and *Gordonia.* This sample contains both warm temperate to subtropical trees and exotics, and warm to cool temperate trees with spruce (L. Sirkin, pers. comm., 1991). The sample from 330 ft (110.6 m) contains a less diverse assemblage dominated by *Quercus, Carya,* and *Pinus,* with lesser *Engelhardia* and *Planera.* This limited assemblage is typical of warm temperate to temperate paleoclimates.

The Kw2a sequence at Cape May is consistent with an upsection cooling. A sample at 663 ft (202.1 m) contains a poor pollen assemblage that nonetheless indicates a probable temperate paleoclimate. Above this, a *Quercus, Picea,* and *Carya*-dominated assemblage at 653 and 637 ft (199.0 and 194.2 m) indicates cool to cold temperate environments (Table 3). The assemblage at 653 ft (199.0 m) also contains sparse *Alnus* and *Tsuga,* whereas at 637 ft, *Betula, Fagus, Pterocarya,* and *Acer* are sparsely present. The overlying sample (620.6 ft [189.2 m]) had poor recovery of pollen, although it probably indicates a temperate environment.

Limited palynological data from the Kw2b sequence (15.6–16.1 Ma) at Atlantic City (509 ft [155.1 m]) and Belleplain (270 ft [82.3 m]) are dominated by temperate (and to a lesser extent, cool temper-

Table 1. Climatic and paleoenvironmental indicator genera.

Warm temperate to subtropical genera	Temperate genera	Cool to cold temperate genera	Swamp-associated genera	Exotic genera
Engelhardia	*Carya*	*Picea*	*Engelhardia*	*Glyptostrobus*
Alangium	*Quercus*	*Abies*	*Alnus*	*Engelhardia*
Manilkara	*Luiquidamber*	*Alnus*	*Ilex*	*Pterocarya*
Cyrilla	*Nyssa*	*Tsuga*	*Liquidamber*	*Alangium*
Planera	*Ilex*		*Nyssa*	*Symplocos*
Gordonia	*Fagus*		*Planera*	*Podocarpus*
Symplocos	*Tilia*		*Symplocos*	
Podocarpus	*Castanea*		*Taxodium*	
Taxodium	*Ulmus*		*Glyptostrobus*	
Glyptostrobus	*Pterocarya*		*Cyrilla*	
Jussiaea				
Cyathea				
Nyssa				
Magnolia				

ate) assemblages. The Kw2b sequence is thin, has poor recovery at Cape May, and is sandy, limiting further palynological interpretation.

No pollen was examined from the Kw2c sequence, which was only recovered at Cape May.

Incomplete data in the Kw3 sequence limits resolution, although there is an indication of an upsection cooling at Atlantic City. The base of the Kw3 at Atlantic City (463 ft [141.1 m]) contains a dominant *Quercus, Fagus, Ulmus* assemblage, along with minor percentages of taxa indicative of warm to subtropical paleoenvironments (Table 2). Sixteen feet (~5 m) higher in the borehole at 447 ft (136.2 m), common *Picea, Alnus,* with occasional *Tsuga* and *Abies,* characteristic of cool temperate conditions, signal a major change in pollen assemblages. At 432 ft (131.7 m), the assemblage is dominated by *Quercus, Picea,* and *Tsuga,* interpreted to indicate a cool to cold temperate paleoclimate. Thus, the Kw3 sequence at the Atlantic City borehole also appears to cool upward into the regressive section of the sequence, similar to the Kw2a sequence. At the base of the Kw-C sequence at the Belleplain State Forest borehole, a mixture of cool and warm temperate pollen assemblages are present at 236 ft (71.9 m). The sample contains a *Quercus, Carya,* and *Pinus*-dominated suite, along with abundant *Picea* and rare exotics indicative of warm temperate to subtropical conditions including *Podocarpus, Planera, Engelhardia/Momipites, Cyrilla,* and *Symplocus.* Additional samples from the Kw3 sequence at Belleplain at 216 ft and 115 ft (65.8 and 35.1 m) contained a poorly preserved warm temperate assemblage. Overall, the Kw-C sequence at Belleplain has some cool climatic indicators at its base, with the limited data indicating a possible warming trend upward. Further study of this section at Belleplain is required.

DISCUSSIONS AND CONCLUSIONS

Overall, the pollen assemblages from the Kw1 sequence (19.5–21.1 Ma) represent temperate to warm temperate predominantly broadleaf, deciduous forest vegetation. The dominance of *Quercus, Carya,* and *Pinus* pollen, along with the minor presence of taxa that grow in subtropical to tropical regions, indicate a warm temperate climate prevailed during the early Miocene. Some minor cooling events may have marked this period of relative climatic stability. For example, the pollen sample from the Atlantic City borehole at 850 ft (259.1 m) contained a cooler assemblage, including *Picea, Tsuga,* and *Alnus,* indicating a cooler climatic interval at 20.3 Ma.

The long hiatus (19.5–17.8 Ma) between the Kw1 and Kw2 sequences at most boreholes precludes any possible palynologic analysis and paleoclimatic interpretations for this early Miocene interval, although future studies of the Kw1c (18.4–19.4 Ma) may shed some light on paleoclimate at this time.

A change in palynologic assemblages occurred at ~17.6 Ma (within the Kw2 sequence), recording a major climatic transition in the late early Miocene. *Picea* becomes common, whereas taxa indicative of warm temperate to subtropical conditions become rare at both Atlantic and Cape May (Fig. 3; Table 2). This major cooling is several million years older than the major middle Miocene cooling and ice growth event recorded in the marine realm (Miller et al., 1991; Flower and Kennett, 1994), although it may correlate with cooling associated with the Mi1b $\delta^{18}O$ maxima (Fig. 4).

Our preliminary sequence stratigraphic interpretations of pollen and terrestrial climate changes are inconclusive. Groot (1992) suggested that the cooler taxa preserved in coastal plain deposits may not be controlled by regional or global climate, but by relative sea level. For example, during transgressions (i.e., in the basal portions of sequences) and times of higher sea level, pollen may be derived directly from regions of higher elevation than the coastal plain, such as the Piedmont or Appalachians, allowing higher percentages of cooler taxa to be preserved. This study does not confirm this hypothesis as the warmer assemblages have been found at the base, or transgressive portion of the Kirkwood 2a sequence, whereas the cooler assemblages occur in the regressive, or shallower water facies.

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Table 2. Pollen assemblages and paleoclimates of the Atlantic City borehole.

Paleoclimate:	Temperate	Temperate	Temperate	Warm to subtropical	Warm to subtropical	Warm to subtropical	Temperate	Temperate	Cool to temperate	Cool to cold temperate	Cool to cold temperate	Temperate	Warm to subtropical	Cool to warm temperate	Cool to cold temperature
Dominants:	Pine-Hickory	Pine-Oak	Oak-Hickory-Hemlock	Oak-Pine	Hickory	Oak-Hickory	Oak-Hickory-Pine	Oak-Hickory	Oak-Spruce-Hickory	Oak-Spruce-Hickory	Oak-Spruce-Hickory	Oak-Hickory	Oak-Beech-Elm	Oak-Spruce-Pine	Oak-Spruce-Hemlock
Sample depth (ft):	932.2	870	850	773	662	656	649	632	575	554	525	509	467.2	447	431.7
Palynological recovery:	Very poor	Fair	Excellent	Poor	Poor	Fair	Poor	Fair	Good	Excellent	Good	Good	Excellent	Excellent	Excellent
Kw sequence:	-	1a	1a	1a	2a	2a	2a	2a	2a	2a	2a	2b	3	3	3
Cool/cold genera															
Picea	R	-	O	R	-	-	R	O	C	C	C	R	R	C	C
Abies	-	-	-	-	-	-	-	-	-	-	-	O	R	O	O
Tsuga	-	-	C	R	-	-	-	-	-	R	R	-	R	O	C
Alnus	-	-	O	-	-	-	-	-	R	R	-	O	R	C	O
Temperate genera															
Pinus	C	A	-	O	-	-	C	O	-	R	O	-	R	C	C
Betula	-	-	O	-	-	-	R	R	R	O	O	-	R	R	-
Carya	A	-	C	R	C	O	A	C	C	C	C	A	-	C	C
Quercus	O	C	A	O	-	C	A	A	A	A	A	A	A	A	A
Liquidamber	-	-	-	-	R	-	-	-	-	R	-	-	R	C	C
Fagus	-	-	-	R	-	-	R	-	R	R	O	R	C	R	R
Tilia	-	O	O	-	-	R	-	-	-	-	O	R	-	R	R
Ulmus	-	-	-	-	-	-	R	-	R	R	-	R	O	C	O
Pterocarya	-	-	-	-	-	-	-	R	-	-	R	R			
Ilex	-	-	C	-	-	-	-	-	-	C	-	-	R	R	
Castanea	-	-	O	-	-	-	R	-	-	-	-	R	-	-	-
Juglans	-	-	R	-	-	-	-	-	-	-	R	-	-	-	O
Acer	-	-	-	-	-	-	-	-	-	-	R	-	R	R	R
Warm temperate to subtropical genera															
Engelhardia	R	-	O	-	-	O	-	-	-	-	R	C	R	R	-
Alangium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manilkara	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Cyrilla	-	-	-	R	-	-	-	-	-	-	-	-	R	-	-
Planera	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Gordonia	-	-	R	-	-	O	R	-	-	-	-	--	-	-	-
Symplocos	-	-	-	-	-	-		-	-	-	-	-	R	R	-
Podocarpus	O	R	R	-	-	-	-	-	-	-	R	R	R	-	-
Taxodium	-	R	-	-	R	-	-	-	-	-	-	-	O	-	-
Glyptostrobus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jussiaea	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
Cyathea	-	-	-	-	-	R	-	-	-	-	-	R	-	-	-
Nyssa	-	-	R	-	-	R	-	-	-	-	R	-	-	R	
Cycadaceae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R
Ostrya	-	-	R	R	R	-	-	-	-	-	-	-	-	-	R
Magnolia	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-

Notes: - = none present. R = rare; less than 1%.O = occasional; 1%-5%. C = common; 6%-10%.A = abundant; greater than 10%. 200 grains were counted per sample.

Table 3. Pollen assemblages and paleoclimates of the Cape May borehole.

Paleoclimate:	?	Temperate	Cool to cold temperate	Cool to cold temperate	Warm to subtropical
Dominants:			Spruce-Pine-Oak	Spruce-Pine-Oak	
Sample depth (ft):	673–673.8	663.2	651.4	636.6–636.8	620.4–620.6
Palynological recovery:	Very Poor	Poor	Good	Good	Poor
Kw sequence:	2a	2a	2a	2a	2a
Sr-isotopic age (Ma):	16.9	-	16.8	16.6	16.5
Cool/Cold genera					
Picea	X	X	C	A	-
Abies	-	X	-	-	-
Tsuga	-	-	O	R	O
Alnus	-	-	O	-	-
Temperate genera					
Pinus	-	X	A	C	O
Betula	-	-	-	O	R
Carya	X	-	C	C	O
Quercus	-	-	A	C	R
Liquidamber	-	-	-	-	R
Fagus	-	X	-	O	-
Tilia	-	-	-	-	-
Ulmus	-	-	-	-	-
Pterocarya	-	-	-	O	-
Ilex	-	-	-	-	-
Castanea	-	-	-	-	-
Juglans	-	X	-	-	-
Acer	-	-	-	O	R
Warm temperate to subtropical genera					
Engelhardia	-	-	-	-	-
Alangium	-	-	-	-	-
Manilkara	-	-	-	-	-
Cyrilla	-		-	-	R
Planera	-	-	-	-	-
Gordonia	-	-	-	-	-
Symplocos	-	-	-	-	-
Podocarpus	-	-	-	-	-
Taxodium	-	-	-	-	R
Glyptostrobus	-	-	-	-	-
Jussiaea	-	-	-	-	-
Cyathea	-	-	-	-	R
Nyssa	-	-	-	-	-
Cycadaceae	-	-	-	-	-
Ostrya	-	-	-	-	-
Magnolia	-	-	-	-	-

Notes: - = none present. X = present; used in samples with poor to very poor palynological recovery. C = common; 6–10%. A = abundant; greater than 10%. O = occasional; 1%–5%. R = rare; less than 1%. 200 grains were counted per sample.

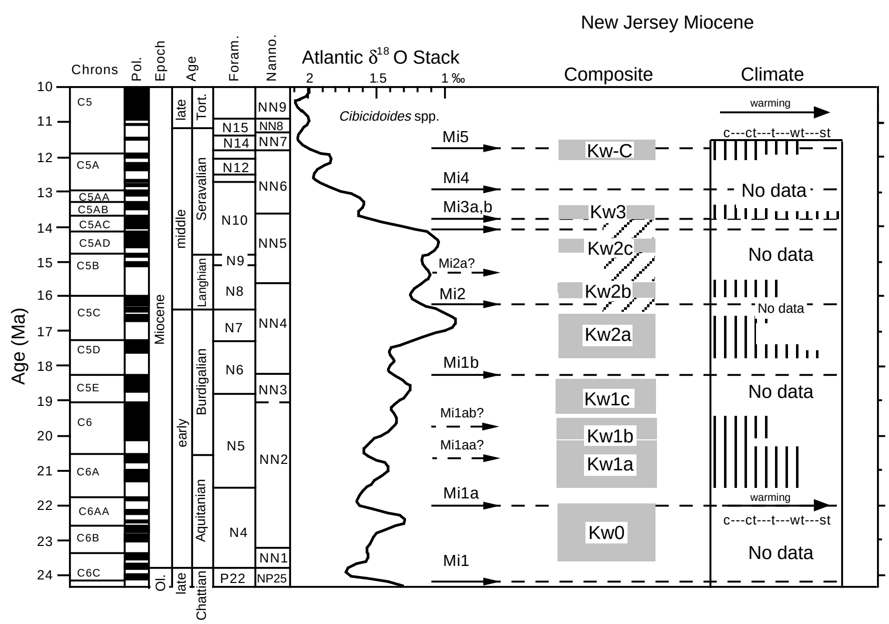

Figure 4. Comparison of the stacked Atlantic $\delta^{18}O$ record with the composite record of deposition at the three Leg 150X boreholes, and the generalized paleoclimatic records developed from pollen data. Pol. = polarity; Foram. = foraminiferal zonation; Nanno. = nannofossil zonation. Other abbreviations as in Figures 2 and 3.

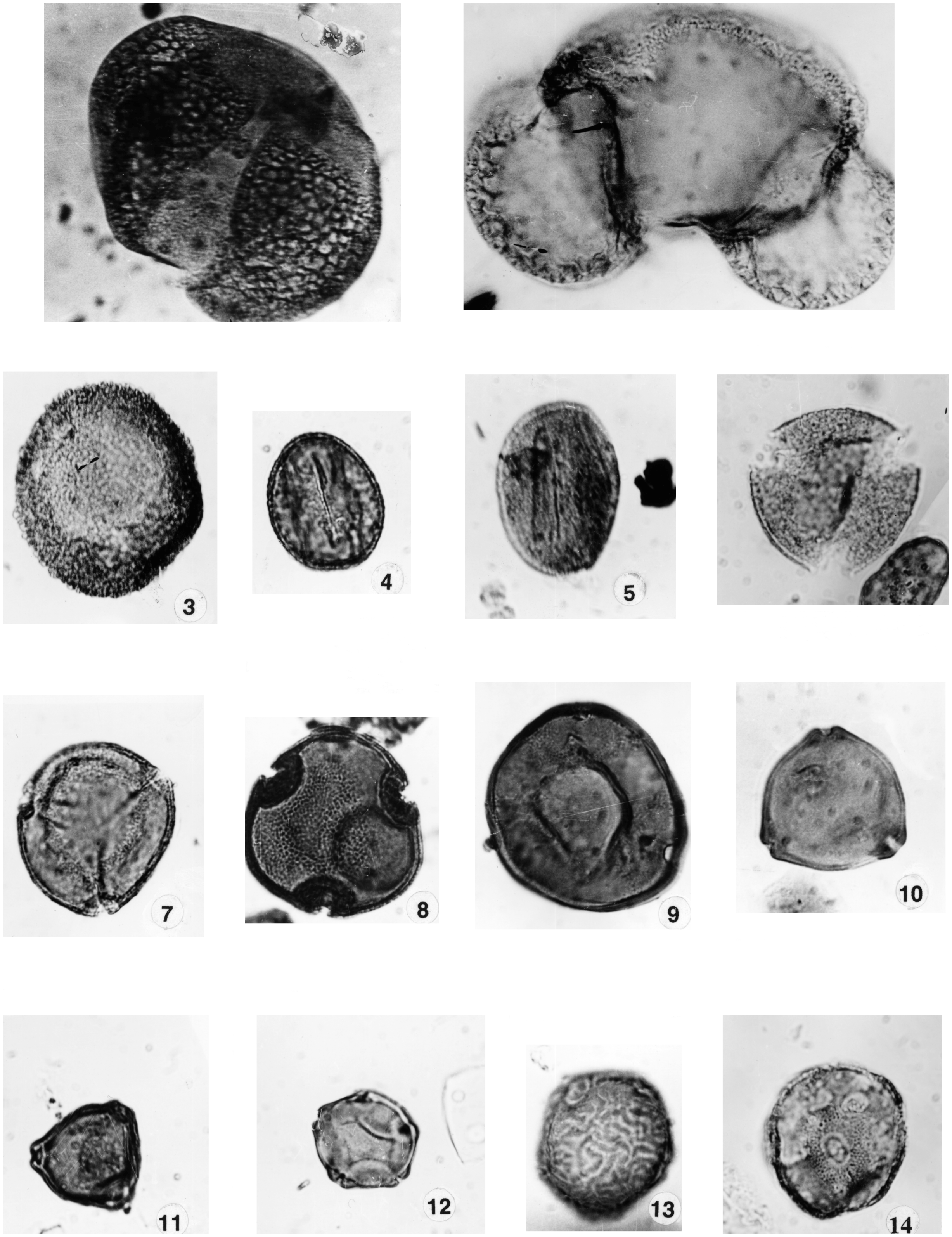

Plate 1. Common lower to middle Miocene pollen taxa, Leg 150X, Atlantic City (AC) and Cape May (CM) boreholes. **1.** *Picea* (spruce), Sample CM 150X, 636.6–636.8 ft, maximum diameter 140.4 µm. **2.** *Pinus* (pine), AC 150X, 431.7–432 ft, maximum diameter 71 µm. **3.** *Tsuga* (hemlock), CM 150X, 636.6–636.8 ft, maximum diameter 91 µm. **4.** *Quercus* type 1, AC 150X, 467.2–467.4 ft, maximum diameter 29 µm. **5.** *Quercus* type 2, AC 150X, 467.2–467.4 ft, maximum diameter 35 µm. **6.** *Acer* (maple), AC 150X 467.2–467.4 ft, maximum diameter 34 µm. **7.** *Fagus* (beech), AC 150X, 431.7–432 ft, maximum diameter 35 µm. **8.** *Tilia* (linden), CM 150X, 651.4 ft, maximum diameter 37 µm. **9.** *Carya* (hickory), CM 150X, 651.4 ft, maximum diameter 43 µm. **10.** *Betula* (birch), CM 150X, 636.6–636.8 ft, maximum diameter 31 µm. **11.** *Betula* (birch), CM 150X, 651.4 ft, maximum diameter 22 µm. **12.** *Alnus* (alder) AC 150X, 431.7–432 ft, maximum diameter 23 µm. **13.** *Ulmus* (elm), AC 150X, 431.7–432 ft, maximum diameter 29 µm. **14.** *Liquidamber* (sweet gum) AC 150X 431.7–432 ft, maximum diameter 31 µm.

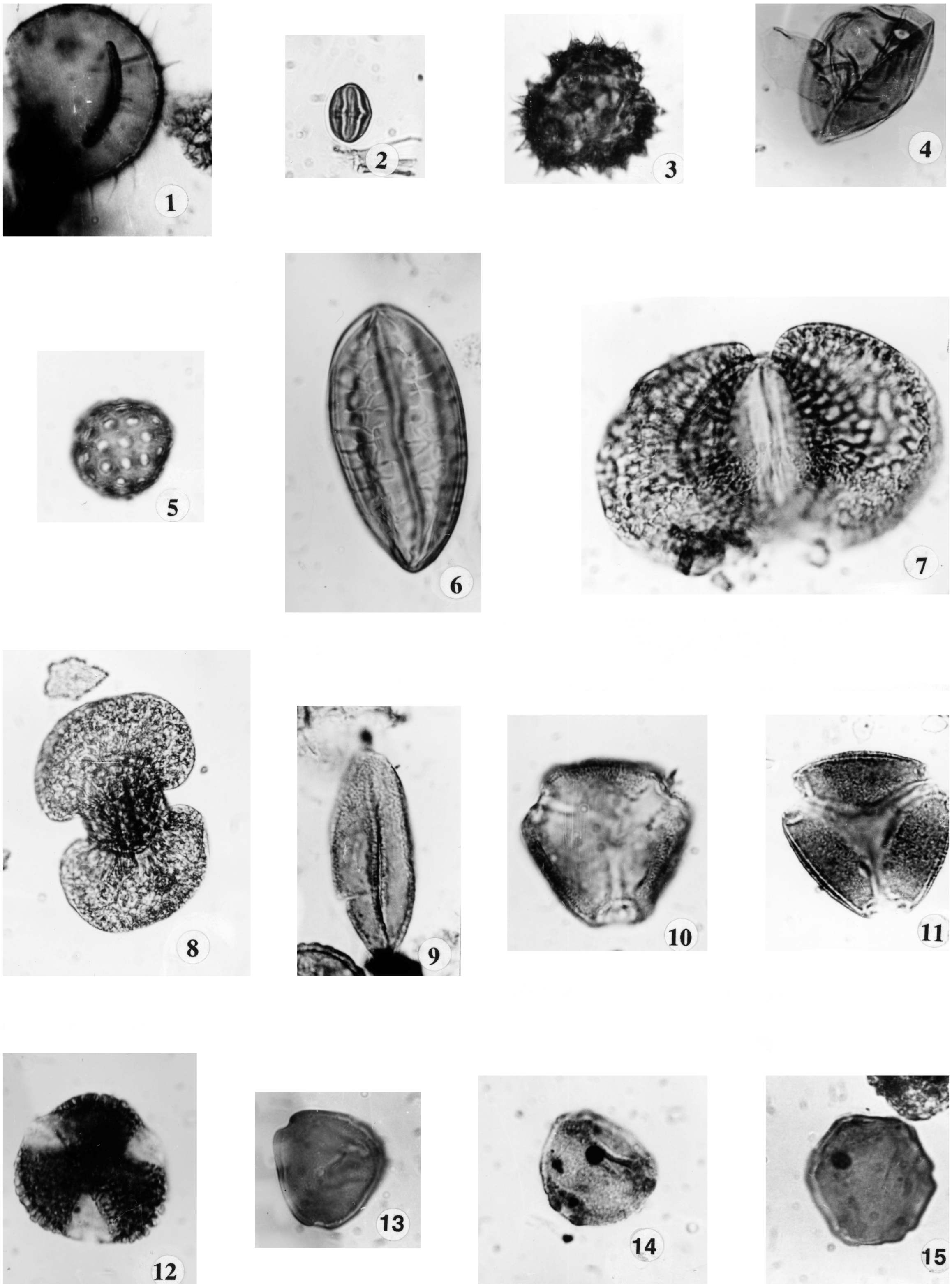

Plate 2. Rare and exotic lower to middle Miocene pollen taxa, Leg 150X, Atlantic City (AC) and Cape May (CM) boreholes. **1.** *Nymphea* (water lily), AC 150X, 467.2–467.4 ft, maximum diameter 38 µm. **2.** *Castanea* (chestnut), AC 150X, 467.2–467.4 ft, maximum diameter 12 µm. **3.** Compositae-Tubuliflorae, AC 150X, 431.7–432 ft, maximum diameter 28 µm. **4.** *Gramineae* (grass) AC 150X, 467.2–467.4 ft, maximum diameter 34 µm. **5.** *Chenopodium* (goosefoot), AC 150X, 431.7–432 ft, maximum diameter 21 µm. **6.** *Ephedra,* CM 150X, 651.4 ft, maximum diameter 53 µm. **7.** *Podocarpus* type 1, AC 150X, 447–448 ft, maximum diameter 107 µm. **8.** *Podocarpus* type 2, AC 150X, 447–448 ft, maximum diameter 70 µm. **9.** *Magnolia,* AC 150X, 431.7–432 ft, maximum diameter 42 µm. **10.** *Nyssa* type 1 (gum), AC 150X 447–448 ft, maximum diameter 34 µm. **11.** *Nyssa* type 2 (gum), AC 150X, 431.7–432 ft, maximum diameter 34 µm. **12.** *Gordonia,* AC 150X, 467.2–467.4 ft, maximum diameter 30 µm. **13.** *Engelhardia,* AC 150X, 467.2–467.4 ft, maximum diameter 24 µm. **14.** *Symplocos,* AC 150X, 467.2–467.4 ft, maximum diameter 23 µm. **15.** *Pterocarya,* CM 150X, 636.6–636.8 ft, maximum diameter 26 µm.

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