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Palynological Data from Pliocene Sediments, DSDP Leg 5 Site 32, Northeastern Pacific Ocean

by

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INTRODUCTION

Studies of Pliocene sea-surface temperatures of the North Atlantic Ocean indicate that there were intervals during the Pliocene substantially warmer than modern conditions (Dowsett and Poore, 1990; 1991). One of these intervals occurs at about 3 Ma (Dowsett and Poore, 1991). One goal of PRISM (Pliocene Research, Interpretation, and Synoptic Mapping) is to produce a paleoclimatic map for the world at 3 Ma. As part of this effort, the Pliocene Continental Climates Project within PRISM is attempting to reconstruct terrestrial vegetation patterns along the west coast of North America during the Pliocene, especially at 3 Ma.

This report contains palynological data from DSDP Site 32, located in the northeast Pacific Ocean approximately 380 km off the coast of California. The data reported here consist of a matrix of absolute count data (numbers of specimens) and a matrix of relative abundance data (percentages). These data will be used in the future as a basis for making semi-quantitative and quantitative estimates of climatic parameters during the Pliocene for western North America. Only preliminary interpretations are presented in this report.

MATERIALS AND METHODS

Locality and Setting

Leg 5 of the Deep Sea Drilling Project (DSDP, now the Ocean Drilling Program, ODP) drilled 12 sites in the northeast Pacific Ocean in 1969. Site 32 of Leg 5 was drilled near the seaward margin of the Delgada Fan, off the coast of California, at latitude 37° 7.63' North and longitude 127° 33.38' West (Shipboard Scientific Party, 1970). Figure 1 shows the position of Site 32 off the west coast of California.

The Delgada Fan contains a mixture of terrigenous and clastic sediments (McManus and others, 1970). Most of the terrigenous sediments are derived from areas now drained by the San Joaquin and Sacramento Rivers. At present, the San Joaquin River drains the southern part of the Great Valley and the Sacramento River drains the northern part of the Great Valley. During the Pliocene, the Delgada Fan presumably received sediment from the same general area, although a marine embayment filled much of the Great Valley (Cole and Armentrout, 1979).

Approximately 215 m of sediment were cored at Site 32. Cores 3 through 6 contain a total of 28.5 m of Pliocene sediments (Shipboard Scientific Party, 1970). Cores 3 through 6 were taken with little difficulty and represent a continuously cored sequence, although some disturbance of sediments was reported. On the basis of diatom analyses by Barron (in press), these cores preserve a nearly complete and relatively undisturbed record from about 3.0 Ma to 5.0 Ma. ODP stores the cores at the ODP Core Repository at Scripps Oceanographic Institute in La Jolla, California.

Sample collection and sample positions

Appendix 1 lists the USGS sample number, DSDP core and section numbers, and depth information for each of the 31 samples collected from Site 32 for this study. Each core at Site 32 was 9 m in length and was divided into 1.5 m sections, numbered 1-6 from the top down. Top and bottom data provided for each sample collected from Site 32 were measured from the top of the section from which the sample was taken. The depth of each sample below seafloor (meters below seafloor, mbsf) was calculated using published DSDP depth data for Site 32 (Shipboard Scientific Party, 1970) and the depth information for each core and section. The "DSDP depth" provided by DSDP was calculated for the top of each sample. The "midpoint depth" calculated for this study is for the middle of each sample interval.

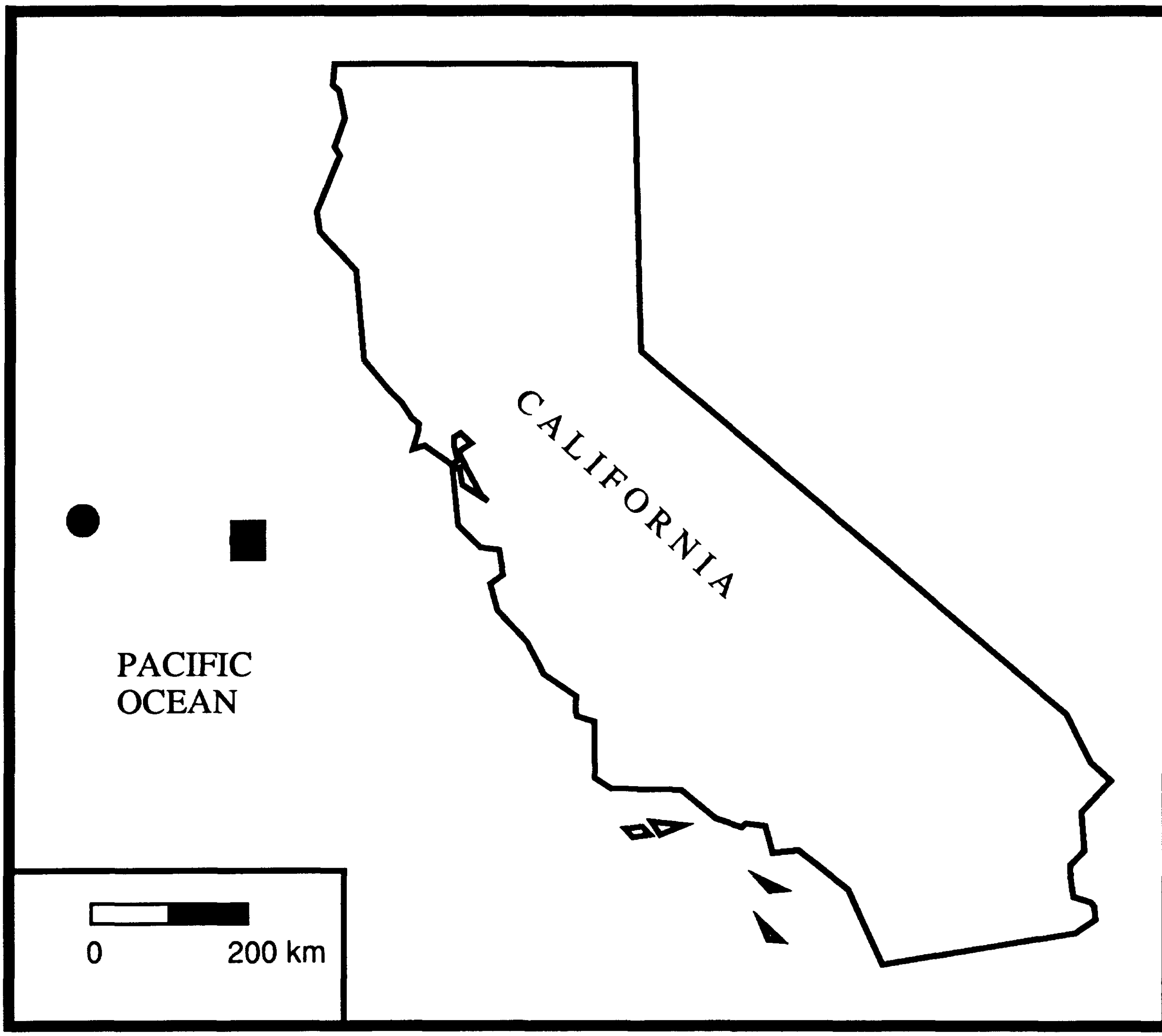

Figure 1. Sketch map showing position of DSDP Site 32 (circle) and Heusser and Balsam's core number 54 (square) off the coast of California.

Discrepancies are apparent between some depths provided by DSDP and the corresponding depths calculated in this report. Sample D7706(86.44) has a depth of 86.44 mbsf according to the sample listing provided by DSDP. However, calculating the depth using the figures in Table 1 reveals that 86.56 mbsf is more accurate for this sample. Similarly, sample D7706(105.9) has a DSDP depth of 105.9 mbsf and its depth calculated with Table 1 measurements is 105.80 mbsf. Appendices 2 and 3 use the depths calculated in this study, which are listed in "midpoint depth" column of Appendix 1.

AGE CONTROL

The initial paleontological study of Site 32 was based primarily on calcareous nannofossils (Shipboard Scientific Party, 1970). In the initial report, sediments from cores 3-6 were assigned to the Pliocene. All sediment from Core 3 was assigned to the upper Pliocene; all sediment from cores 4 and 5 and the upper 1.5 m of core 6 were assigned to the lower Pliocene.

Barron (in press) integrated his diatom stratigraphy with the biostratigraphic studies of Bukry and Bramlette (1970) and Gartner (1970) and concluded that a nearly complete interval was recovered in cores 3-6 that ranges from 3.0 to 5.0 Ma. Also, Barron (in press) refined the Pliocene diatom stratigraphy for California based on calibration with paleomagnetic and radiometric studies in the Centerville Beach outcrop section (northern California), the Harris Grade outcrop section (southern California), and DSDP Site 32. His study provides critical absolute ages for diatom horizons in the interval between 5.0 and 2.8 Ma (Barron, in press). This allows more accurate and precise dating of samples from Site 32.

Appendix 1 lists the age estimates for all samples from Site 32 used in this study. J. Barron provided the first set of samples from Site 32 with his age assignments based on his calibration of diatom datums, and these dates are italicized under "age" in Appendix 1. I collected additional samples from Site 32 cores and extrapolated and interpolated the ages for these samples based on Barron's analyses. This approach accepts Barron's conclusion that the core records a complete and uniform record for the interval 3-5 Ma and assumes a constant sedimentation rate of 18 m/m.y.

DATA MATRICES

The data matrix of Appendix 2 contains the absolute count data for the 31 samples from Site 32. Some samples were too sparse for adequate statistical counts. For four of the sparse samples, only the presence of a taxon or category is noted; two of these samples have preliminary count data that are not considered reliable but is reported nonetheless. Some fossils were observed during preliminary scans (i.e., before statistical counts were made) that were not encountered in the sample counts. These are listed in Appendix 2 as "trace." Appendix 2 also presents fossils that were unidentified because of their preservation. These are listed as "broken," "concealed," "corroded," or "crumpled."

The data matrix of Appendix 3 contains relative abundances for most of the pollen categories listed in Appendix 2. Appendix 3 omits two categories of Appendix 2, *Pinus* bladders and *Pinus* bodies. The percentage of *Pinus* includes one-half of the *Pinus* bladders counts and excludes *Pinus* bodies. The percentages are based on the sum of the terrestrial pollen and exclude spores, algae (freshwater and marine), and pollen of aquatic plants (i.e., *Potamogeton/Triglochin*). Occurrences listed as "trace" in Appendix 2 are listed as "0" in Appendix 3. The unidentified categories of Appendix 2 are combined as a single percentage in Appendix 3 and entered under "indeterminates." Appendix 3 contains count data for 27 of the 31 samples collected from Site 32. The four samples excluded from Appendix 3 are the barren samples of Appendix 2.

TAXONOMIC COMMENTS

Some categories included in the raw data matrix (Appendix 2) and the relative abundance data matrix (Appendix 3) need explanation. All samples from Site 32 contained common to abundant pollen referable to the Taxodiaceae, Cupressaceae, or Taxaceae. Pollen morphology in these three gymnosperm families is basically the same, with subtle differences that may permit identification at the individual family or genus level. All pollen of this group lacking diagnostic features for family or generic level taxa were referred to "TCT undifferentiated." If the pollen grain exhibited a papilla without critical details of the wall structure preserved, it was assigned to the Taxodiaceae. If a papillate fossil within this group preserved details of the wall structure associated with the tenuitas, then it was assigned to *Sequoia* or *Taxodium* as appropriate.

There are six morphological categories that were not assigned to a particular botanical group. "Monosulcate type 1" is simple monosulcate pollen that could be produced by gymnosperms (e.g., cycads) or angiosperms (e.g., magnoliids). "Monosulcate type 2" is reticulate monosulcate pollen possibly produced by palms or the Agavaceae, but too few specimens were observed to allow definitive assignment at this time. "Tricolpate type 1" is simple tricolpate pollen that is prolate, psilate, and relatively small. This type is produced by a number of plant families. "Tricolpate type 2" pollen is prolate to spheroidal pollen with long colpi and a eureticulate wall having a fine reticulum. "Tricolporate type 1" is tricolporate, prolate, psilate pollen similar to tricolpate type 1 except that it is tricolporate; this type is also produced by a number of plant families. "Tricolporate type 2" is the most abundant of the types assigned to morphological categories. This pollen is tricolporate and prolate and has a very fine reticulate or foveolate pattern on the surface of the grain.

Besides "dinoflagellates undifferentiated," two additional dinoflagellate types were counted. "Dinoflagellate type 1" is a small chorate cyst. "Dinoflagellate type 2" is a distinctive cyst that lacks processes, has a intercalary archeopyle, and a surface ornamentation that appears finely reticulate.

Question marks beside generic names (e.g., *Acer*?) indicate that the identification is only tentative. This usually indicates that only one specimen was recovered and preservation or orientation allowed only tentative assignment. Familial categories are included for families that have more or less distinctive pollen but for which generic distinctions are lacking or difficult to determine.

DISCUSSION

Preliminary analysis of the data of Appendix 3 reveals patterns that suggest departures from modern climatic conditions during the Pliocene. In Appendix 4, relative abundances of selected taxa are plotted against absolute time. These data are compared with modern palynological data from Heusser and Balsam (1977), who determined absolute and relative abundance of palynomorphs in core top samples from 61 cores taken along the continental margin of the northeast Pacific. One of Heusser and Balsam's cores, number 54, was taken approximately 200 km east of Site 32 (Figure 1); this core will be used for comparison with Pliocene sediments from Site 32. Heusser and Balsam (1977) also compared pollen relative abundance with modern terrestrial vegetation distribution along the Pacific northwest, which may allow inferences to be made about the differences between modern and Pliocene vegetation. Although Heusser and Balsam provide a useful basis for comparison, they did not report the presence of undifferentiated TCT pollen. As discussed below, TCT is the dominant fossil in most Site 32 samples. At this time, data on TCT abundance in modern marine sites near Site 32 is lacking.

All samples from Site 32 are dominated by pollen of TCT and *Pinus*. Plot 1 (Appendix 4) shows the relative abundance of these two groups plotted against age. In general, TCT is dominant from 4.5 Ma to 2.8 Ma. *Pinus* becomes dominant at about 3.75 Ma and again at 3.0 Ma. Plot 2 shows the *Pinus* relative abundance profile with the level of *Pinus* in Heusser and Balsam's modern site shown with a horizontal arrow. This comparison suggests that, except for the times around 3.75 Ma, *Pinus* is not as abundant in Site 32 as it is in the modern site. Adam and others (1990) reported higher TCT values in the Pliocene than in younger sediments at Tule Lake. They developed a model in which increased TCT with respect to *Pinus* indicates warmer conditions. Using this model, they inferred warmer conditions in the Pliocene from 2.8 Ma to 2.6 Ma (Adam and others, 1990).

Sequoia pollen was present in low amounts in Site 32. Although fossils referred to the Taxodiaceae could be *Sequoia* or *Taxodium*, they are more likely to be *Sequoia*. Even if the Taxodiaceae and *Sequoia* are added together (thus representing the maximum possible *Sequoia*), the relative abundance of this type is significantly lower than values for *Sequoia* in Heusser and Balsam's modern sample (see Plot 3). Heusser and Balsam's data indicate that *Sequoia* stands today contribute significant amounts of pollen to adjacent marine environments. Data from Site 32 indicate that *Sequoia* stands were significantly reduced during the Pliocene.

Other taxa in Site 32 have relative abundances similar to the modern values. For example, the relative abundance of *Alnus* in Site 32 (Plot 4) was more or less similar to modern values except at 3.0 Ma, when *Alnus* increased significantly.

Several exotic taxa are present in Pliocene sediments from Site 32 that were apparently present in the Pliocene but have since been extirpated from California. These taxa are *Carpinus*, *Carya*, *Ilex*, *Taxodium*, *Tilia*, *Pterocarya*, and *Ulmus*. The presence of these taxa in the California Neogene is already known. For example, Axelrod (1950, 1980) reports *Pterocarya* and *Ilex* from Pliocene Sonoma florules of California; Daubenmire (1978) reports the presence of *Tilia*, *Ulmus*, and *Carya* in the Neogene of west central North America. Heusser (1981) recovered pollen of *Ilex*, *Ulmus*, *Tilia*, and *Pterocarya* from lower Pliocene sediments of DSDP Leg 63.

Apparently *Taxodium* has not previously been reported from the Pliocene of California, although Leopold and Denton (1987) report *Taxodium* leaf fossils from Miocene rocks in the Columbia basin west of the Rocky Mountains and east of the Cascades. Some *Taxodium* is present at 3.61 Ma and 3.08 Ma in Site 32. *Taxodium* is present in swamps in southeastern U.S. today and thrives in habitats that have standing water throughout the year.

Today *Pterocarya* occurs only in the Old World, in the Caucasus Mountains and in China and Japan (Leopold and MacGinitie, 1972). Leopold and MacGinitie (1972) estimate that modern *Pterocarya* grows in areas with effective temperatures equivalent to those found in central California today. In areas where it grows today, it appears to require summer rainfall. Also, Axelrod (1950) concludes that the presence of *Ilex* and *Pterocarya* indicate summer precipitation during the Pliocene. This is consistent with the presence of *Taxodium* and its need for year-round precipitation.

These data are preliminary but some of the patterns suggest that paleoclimate in California during the Pliocene was different from the present climate. The presence of *Ilex*, *Pterocarya* and *Taxodium* suggests that adequate moisture was present year-round. The reduction in *Sequoia* suggests that, even though there was enough moisture for *Taxodium*, climatic conditions did not allow enough fog for *Sequoia* to exist in amounts comparable to today. Today *Sequoia* occupies foggy coastal areas (Axelrod, 1986).

Additional sites along the west coast of North America (e.g., the Centerville Beach section near Eureka, California) may provide corroborative trends that will increase confidence in the patterns observed at Site 32. Results from Site 32 will be integrated with results from other sites to reconstruct a paleovegetational and paleoclimatic picture of western North America during the Pliocene.

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APPENDIX 1

Appendix 1 contains sample data for the 31 samples from DSDP Site 32. Italicized numbers in age column are dates provided by John Barron and are based on his analysis of DSDP Site 32 (Barron, in press). Depths are given in meters below seafloor (mbsf).

USGS sample number	Core	Section	Top (cm)	Bottom (cm)	DSDP depth (mbsf)	Midpoint depth (mbsf)	Age (Ma)
D7706 (80.3)	3	1	30	32	80.3	80.31	2.97
D7706 (80.5)	3	1	50	52	80.5	80.51	2.98
D7706 (80.8)	3	1	80	82	80.8	80.81	*3.00*
D7706 (81.85)	3	2	35	37	81.85	81.86	3.06
D7706 (82.3)	3	2	80	82	82.3	82.31	*3.08*
D7706 (83.1)	3	3	10	12	83.1	83.11	3.13
D7706 (83.77)	3	3	77	79	83.77	83.78	*3.16*
D7706 (84.66)	3	4	16	18	84.66	84.67	3.21
D7706 (85.23)	3	4	73	75	85.23	85.24	*3.25*
D7706 (85.43)	3	4	93	95	85.43	85.44	3.26
D7706 (86.44)	3	5	55	57	86.44	86.56	*3.31*
D7706 (87.8)	3	6	30	32	87.8	87.81	3.39
D7706 (88.14)	3	6	64	66	88.14	88.15	3.41
D7706 (88.42)	3	6	92	100	88.42	88.43	*3.42*
D7706 (91.8)	4	2	30	32	91.8	91.81	3.61
D7706 (92.29)	4	2	79	81	92.29	92.30	*3.64*
D7706 (93.27)	4	3	27	29	93.27	93.28	3.69
D7706 (93.7)	4	3	70	72	93.7	93.71	*3.72*
D7706 (94.8)	4	4	30	32	94.8	94.81	3.78
D7706 (95.2)	4	4	70	72	95.2	95.21	*3.80*
D7706 (96.3)	4	5	30	32	96.3	96.31	3.86
D7706 (96.79)	4	5	79	81	96.79	96.80	*3.89*
D7706 (97.8)	4	6	30	32	97.8	97.81	3.95
D7706 (98.15)	4	6	65	67	98.15	98.16	*3.96*
D7706 (99.59)	5	1	59	61	99.59	99.60	*4.04*
D7706 (101.04)	5	2	54	56	101.04	101.05	*4.12*
D7706 (101.08)	5	2	58	60	101.08	101.09	4.13
D7706 (102.76)	5	3	76	78	102.76	102.77	*4.22*
D7706 (105.9)	5	5	79	81	105.9	105.80	*4.39*
D7706 (105.8)	5	5	80	82	105.8	105.81	4.39
D7706 (107.31)	5	6	81	83	107.31	107.32	*4.47*

APPENDIX 2

Appendix 2 contains absolute count data for the 31 DSDP Site 32 samples in this study. Numbers in each cell are the numbers of specimens counted in the samples for each palynomorph category.

Appendix 2 (part 1)

Age (Ma)	2.97	2.98	3.00	3.06	3.08	3.13	3.16	3.21	3.25	3.26	3.31
Depth (mbsf)	80.31	80.51	80.81	81.86	82.31	83.11	83.78	84.67	85.24	85.44	86.56
Weight of Processed sample	10	10	15	10	14	10	11.5	10	10	19.5	10.5
Abies	1	6	0	0	1	0	4	2	1	3	3
Picea	0	4	5	trace	1	0	4	2	1	0	6
Pinus	77	115	73	60	39	46	122	17	48	76	94
Pine bladders	116	134	44	76	66	88	100	16	22	78	60
Pine bodies	26	13	12	14	10	7	14	13	2	7	8
Pseudotsuga/Larix	0	6	0	0	0	0	1	2	0	0	4
Sequoia	1	0	0	0	4	2	1	0	0	2	0
Taxodium	0	0	0	0	1	0	0	0	0	0	0
Tsuga canadensis?	0	0	0	0	0	0	0	0	0	0	0
Tsuga heterophylla	2	1	1	trace	0	0	0	0	0	1	4
Tsuga mertensiana	0	0	0	0	0	0	0	0	0	0	0
Taxodiaceae	0	1	0	0	0	0	1	6	0	0	1
TCT undifferentiated	330	331	69	311	235	367	322	229	9	313	264
Conifer undifferentiated	8	17	10	3	10	13	25	22	0	11	13
Ephedra	0	0	6	0	0	0	7	0	0	0	2
Acer?	0	0	0	0	0	0	0	1	0	0	0
Alnus	8	9	22	2	0	3	10	4	0	13	12
Ambrosia	1	0	0	1	1	2	1	0	0	1	0
Artemisia	6	5	11	2	1	6	11	0	0	3	9
Betula	0	0	1	0	0	0	0	0	0	0	1
Carpinus	0	0	0	0	0	0	0	0	0	0	0
Carya	1	0	0	trace	0	0	0	1	0	1	0
Cercocarpus	0	4	0	0	0	0	0	0	0	0	0
Corylus	0	0	0	0	0	0	0	0	0	0	0
Eriogonum	0	0	0	0	0	0	0	0	0	0	0
Fraxinus	0	0	0	0	0	0	0	0	0	0	0
Fremontodendron	2	0	1	0	0	0	2	0	0	0	0
Ilex	1	1	0	0	0	1	0	0	0	0	0
Juglans	1	2	0	0	0	0	0	0	0	0	0
Lithocarpus?	0	0	0	0	0	0	0	0	0	0	0
Myrica	0	0	0	0	0	0	0	0	0	0	0
Platanus?	0	0	0	0	0	0	0	0	0	0	0
Potentilla	1	0	0	0	0	5	1	0	0	1	1
Prunus	0	0	0	0	0	0	0	0	0	0	0
Pterocarya	0	1	0	0	0	0	0	0	0	0	0
Quercus	28	4	15	24	4	36	20	0	0	32	20
Salix	4	3	0	0	2	9	1	3	0	2	3
Sarcobatus	0	0	1	0	0	0	0	0	0	0	0
Tilia	0	0	0	0	1	0	0	0	0	0	0
Ulmus	0	0	0	0	0	0	1	1	0	0	0
Asteraceae-Liguliflorae	1	3	0	0	0	1	0	0	0	0	1
Asteraceae-Tubuliflorae	29	23	5	17	9	14	19	0	0	12	13
Caprifoliaceae	0	0	0	0	0	2	0	0	0	0	0
Caryophyllaceae	0	0	0	0	0	0	0	0	0	0	0
Chenopodiineae	12	4	0	8	2	13	8	0	0	10	9
Elaeagnaceae	0	0	0	0	0	0	0	0	0	0	0
Ericaceae	0	0	0	0	0	0	0	0	0	0	0
Juglandaceae	1	0	0	0	0	0	1	1	0	0	2
Malvaceae	0	0	0	0	0	0	0	0	0	0	0
Onagraceae	0	0	0	trace	0	0	0	0	0	0	0
Poaceae	4	2	3	0	0	4	1	1	0	1	1
Polygonaceae	1	0	2	0	0	0	3	0	0	0	3
Rhamnaceae	0	0	0	0	0	0	0	0	0	0	0
Rosaceae	0	3	0	0	2	0	6	3	0	0	2
Umbelliferae	5	1	0	1	0	0	0	0	0	1	0
Monosulcate type 1	2	0	2	1	1	2	2	0	0	1	4
Monosulcate type 2	0	0	0	0	0	0	0	0	0	0	0
Tricolpate type 1	2	0	0	0	0	0	2	0	0	1	5
Tricolpate type 2	0	0	0	0	0	0	0	0	0	0	0
Tricolporate type 1	4	3	0	6	1	5	0	2	0	6	0
Tricolporate type 2	9	7	0	3	0	5	2	2	0	0	3
Broken	10	10	1	12	7	11	1	5	0	1	4
Concealed	2	5	3	10	3	7	5	4	0	8	8
Corroded	3	9	2	5	0	2	4	5	0	6	8
Crumpled	11	10	8	6	6	16	22	4	0	18	9
Monolete spores	2	2	0	1	0	0	1	5	0	2	6
Trilete spores	4	3	2	0	1	3	3	7	0	1	2
Polypodium	0	0	0	0	0	0	0	0	0	0	0
Azolla glochidia	0	0	0	0	0	0	0	0	0	0	0
Potamogeton/Triglochin	1	0	0	0	0	1	0	0	0	0	1
Pediastrum	1	1	0	0	0	0	0	0	0	0	0
Dinoflagellates undifferentiated	15	10	0	4	0	10	1	2	0	0	2
Dinoflagellate type 1	0	3	0	0	1	0	1	1	0	0	0
Dinoflagellate type 2	10	9	0	21	14	0	1	58	0	3	5
Tasmanites	0	0	0	0	0	8	2	0	1	1	0
Reworked	0	1	0	0	2	0	5	7	0	0	0
Tracers	41	56	81	17	40	38	76	12	0	18	93
Total specimens counted	743	766	299	588	425	689	738	425	84	616	593
Terrestrial total	626	657	263	510	364	616	660	325	70	563	539

Age (Ma)	3.39	3.41	3.42	3.61	3.64	3.69	3.72	3.78	3.80	3.86
Depth (mbsf)	87.81	88.15	88.43	91.81	92.3	93.28	93.71	94.81	95.21	96.31
Weight of Processed sample	10	10	13	10	8	15	16	10	6	10
Abies	1	4		3	3	6	1	2	0	0
Picea	3	2		2	4	0	0	3	3	1
Pinus	36	41	present	70	134	88	64	53	41	51
Pine bladders	106	56		140	89	126	61	75	44	86
Pine bodies	11	8		8	7	16	12	10	7	34
Pseudotsuga/Larix	7	1		0	1	5	2	4	0	6
Sequoia	4	1		0	0	0	1	0	0	1
Taxodium	0	0		1	0	0	0	0	0	0
Tsuga canadensis?	0	0		0	0	1	0	0	0	0
Tsuga heterophylla	1	1		0	0	0	0	3	0	0
Tsuga mertensiana	0	0		0	0	1	1	0	0	0
Taxodiaceae	2	0		3	1	2	0	1	0	3
TCT undifferentiated	321	270		316	155	310	70	309	203	422
Conifer undifferentiated	14	16		11	15	12	6	17	3	4
Ephedra	0	0		0	1	1	0	0	1	0
Acer?	0	0		0	0	0	0	0	0	0
Alnus	7	9		3	4	4	0	6	2	5
Ambrosia	1	1		0	0	0	0	0	0	0
Artemisia	2	6		14	15	25	4	9	17	20
Betula	0	1		0	2	0	0	3	1	0
Carpinus	0	0		1	0	0	0	0	0	0
Carya	0	0		4	0	0	0	0	0	0
Cercocarpus	1	1		2	0	0	0	1	0	1
Corylus	0	1		0	0	0	0	0	0	0
Eriogonum	0	0		0	0	0	0	0	0	0
Fraxinus	0	1		0	0	0	0	0	0	0
Fremontodendron	trace	0		3	0	0	0	2	0	2
Ilex	0	0		1	0	0	0	1	0	0
Juglans	0	0		3	0	0	0	0	0	1
Lithocarpus?	0	0		0	0	0	0	0	0	0
Myrica	0	0		1	0	0	0	0	0	0
Platanus?	0	0		0	0	0	0	0	0	1
Potentilla	0	0		0	0	0	0	0	0	0
Prunus	0	1		0	0	0	0	0	0	0
Pterocarya	1	1		1	0	1	0	1	0	0
Quercus	21	10		26	14	34	4	21	4	35
Salix	5	3		9	0	8	1	2	1	7
Sarcobatus	0	0		1	2	1	1	0	2	2
Tilia	0	0		0	0	0	0	0	0	0
Ulmus	0	0		0	0	0	0	0	0	0
Asteraceae-Liguliflorae	0	0		2	0	0	0	0	1	0
Asteraceae-Tubuliflorae	14	12		23	6	25	0	5	4	3
Caprifoliaceae	0	1		0	0	0	0	0	0	0
Caryophyllaceae	0	0		0	0	0	0	0	0	0
Chenopodiineae	9	2		14	9	17	0	3	13	11
Elaeagnaceae	0	0		0	0	0	0	0	1	0
Ericaceae	0	0		0	0	1	0	1	0	1
Juglandaceae	0	0		0	0	0	0	1	0	0
Malvaceae	0	0		0	0	1	0	0	0	0
Onagraceae	0	0		0	0	0	0	0	0	0
Poaceae	1	4		9	3	0	0	0	5	1
Polygonaceae	0	1		1	1	2	0	1	0	1
Rhamnaceae	0	0		4	0	0	0	0	0	0
Rosaceae	1	8		13	5	7	0	0	0	9
Umbelliferae	0	1		2	2	3	0	0	0	0
Monosulcate type 1	0	0		0	10	0	2	0	0	2
Monosulcate type 2	0	0		0	0	0	0	0	0	0
Tricolpate type 1	1	2		0	6	4	0	6	7	0
Tricolpate type 2	1	7		6	1	2	0	0	0	0
Tricolporate type 1	1	0		3	0	2	1	1	0	2
Tricolporate type 2	7	4		13	0	23	0	9	0	13
Broken	5	6		9	4	7	0	10	1	9
Concealed	33	4		12	11	7	0	19	2	3
Corroded	3	4		12	6	9	0	1	0	4
Crumpled	7	16		5	2	8	0	6	10	20
Monolete spores	0	2		1	4	9	0	0	4	2
Trilete spores	0	2		1	2	7	0	2	1	1
Polypodium	0	0		0	0	0	0	0	0	0
Azolla glochidia	1	0		0	0	0	0	0	0	0
Potamogeton/Triglochin	1	0		0	0	0	0	0	0	0
Pediastrum	2	1		0	0	0	0	1	0	1
Dinoflagellates undifferentiated	16	11		13	0	0	0	16	0	30
Dinoflagellate type 1	12	10		62	3	19	0	26	0	27
Dinoflagellate type 2	41	12		21	2	34	3	59	0	50
Tasmanites	0	0		0	0	1	0	0	0	0
Reworked	0	1		6	0	2	1	2	0	10
Tracers	16	13		5	50	13	5	15	34	15
Total specimens counted	700	546		855	524	831	235	692	378	882
Terrestrial total	563	471	Barren	673	461.5	680	188.5	538.5	344	684

Appendix 2 (part 3)

Age (Ma)	3.89	3.95	3.96	4.04	4.12	4.13	4.22	4.39	4.39	4.47
Depth (mbsf)	96.8	97.81	98.16	99.6	101.05	101.09	102.77	105.8	105.81	107.32
Weight of Processed sample	9	10	15	7.5	12	10	12.5	11.5	10	7.5
Abies	0	11	3	4		present	2		2	4
Picea	3	1	10	0		present	1		2	8
Pinus	51	98	108	108	present	present	4	present	65	134
Pine bladders	61	128	88	107			0		103	104
Pine bodies	12	22	12	22			0		15	16
Pseudotsuga/Larix	6	4	7	9			3		1	5
Sequoia	0	0	1	0			0		3	0
Taxodium	0	0	0	0			0		0	0
Tsuga canadensis?	0	1	0	0			0		0	0
Tsuga heterophylla	0	0	3	1			0		1	trace
Tsuga mertensiana	0	0	0	0			0		0	1
Taxodiaceae	0	3	2	5			2		5	0
TCT undifferentiated	163	312	193	273	present		11		229	230
Conifer undifferentiated	6	43	6	11			3		8	38
Ephedra	0	0	1	0			0		0	0
Acer?	0	0	0	0			0		0	0
Alnus	3	11	1	3		present	1	present	6	9
Ambrosia	1	0	0	0			0		1	0
Artemisia	5	15	9	19			0		14	14
Betula	2	1	1	1			0		3	2
Carpinus	0	0	0	0			0		0	0
Carya	0	0	0	1			0		trace	3
Cercocarpus	0	1	0	0			0		7	0
Corylus	0	0	0	1			0		0	0
Eriogonum	0	0	1	0			0		0	0
Fraxinus	0	0	0	0			0		0	0
Fremontodendron	0	0	0	1			2		0	0
Ilex	0	0	0	0			0		0	1
Juglans	0	0	0	0			0		0	2
Lithocarpus?	0	1	0	0			0		1	0
Myrica	0	0	0	0			0		0	0
Platanus?	0	0	0	0			0		0	0
Potentilla	1	0	0	1			0		0	2
Prunus	0	1	0	0			0		0	0
Pterocarya	0	1	0	0			0		0	2
Quercus	21	20	32	36			3		36	46
Salix	3	11	0	2		present	0		9	3
Sarcobatus	0	1	1	0			0		0	0
Tilia	0	0	0	0			0		0	1
Ulmus	1	0	0	0			0		0	0
Asteraceae-Liguliflorae	1	0	0	3			1		0	0
Asteraceae-Tubuliflorae	10	10	8	8			1		6	12
Caprifoliaceae	0	0	0	0			0		0	0
Caryophyllaceae	0	0	0	0			0		0	trace
Chenopodiineae	3	4	24	5			0		3	2
Elaeagnaceae	0	0	0	0			0		0	0
Ericaceae	0	0	0	1			0		0	0
Juglandaceae	0	0	0	0			0		1	0
Malvaceae	0	0	0	0			0		0	0
Onagraceae	0	0	0	0			0		0	1
Poaceae	1	5	0	1			1		1	1
Polygonaceae	0	0	0	0			0		0	0
Rhamnaceae	0	0	0	0			0		0	0
Rosaceae	0	5	3	3			1		10	0
Umbelliferae	2	2	3	1			0		0	1
Monosulcate type 1	1	1	0	0			1		0	0
Monosulcate type 2	0	0	0	0			0		1	0
Tricolpate type 1	1	4	7	1			0		1	3
Tricolpate type 2	0	0	0	0			0		0	0
Tricolporate type 1	3	0	0	0			0		0	1
Tricolporate type 2	4	15	3	15			3		0	0
Broken	10	12	5	8			0		6	4
Concealed	7	7	12	2			0		4	7
Corroded	2	9	4	6			0		2	0
Crumpled	3	12	6	22			0		20	19
Monolete spores	1	1	3	1			0		3	1
Trilete spores	3	0	9	1			0		3	3
Polypodium	0	0	1	0			0		0	0
Azolla glochidia	0	0	0	0			0		0	0
Potamogeton/Triglochin	0	0	0	1			0		0	0
Pediastrum	0	1	0	0			0		0	0
Dinoflagellates undifferentiated	29	21	2	22		present	0		7	17
Dinoflagellate type 1	0	41	6	3			1		34	0
Dinoflagellate type 2	13	110	0	25			0		3	0
Tasmanites	0	0	1	0			0		1	0
Reworked	0	4	0	1	present	present	0	present	12	3
Tracers	26	11	26	61	present	present	0		3	39
Total specimens counted	433	950	576	735			41		629	700
Terrestrial total	344.5	686	498	605.5	Barren	Barren	40	Barren	499.5	608

APPENDIX 3

Appendix 3 contains relative abundances for selected pollen categories. All values are percentages calculated using the data in Appendix 2. See text for discussion of the categories included in this appendix. Four samples of Appendix 3 are not included because of insufficient palynomorph recovery -- these are labeled "barren" in Appendix 2.

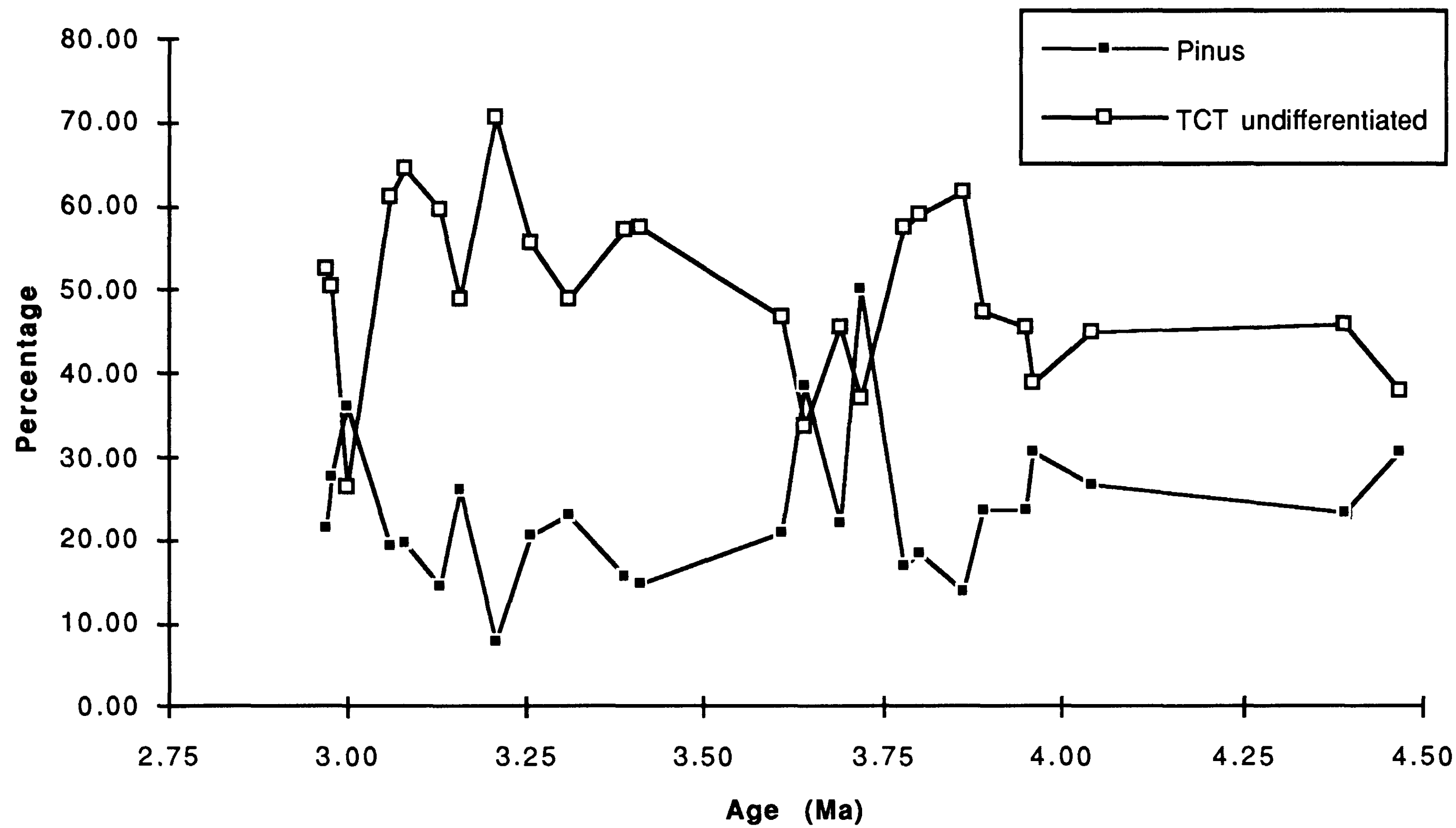
Age (Ma)	2.97	2.98	3.00	3.06	3.08	3.13	3.16	3.21	3.25
Depth (mbsf)	80.31	80.51	80.81	81.86	82.31	83.11	83.78	84.67	85.24
Abies	0.16	0.91	0.00	0.00	0.27	0.00	0.61	0.62	1.43
Picea	0.00	0.61	1.90	0.00	0.27	0.00	0.61	0.62	1.43
Pinus	21.57	27.70	36.12	19.22	19.78	14.61	26.06	7.69	84.29
Pseudotsuga/Larix	0.00	0.91	0.00	0.00	0.00	0.00	0.15	0.62	0.00
Sequoia	0.16	0.00	0.00	0.00	1.10	0.32	0.15	0.00	0.00
Taxodium	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00
Tsuga canadensis?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga heterophylla	0.32	0.15	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga mertensiana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taxodiaceae	0.00	0.15	0.00	0.00	0.00	0.00	0.15	1.85	0.00
TCT undifferentiated	52.72	50.38	26.24	60.98	64.56	59.58	48.79	70.46	12.86
Conifer undifferentiated	1.28	2.59	3.80	0.59	2.75	2.11	3.79	6.77	0.00
Ephedra	0.00	0.00	2.28	0.00	0.00	0.00	1.06	0.00	0.00
Acer?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00
Alnus	1.28	1.37	8.37	0.39	0.00	0.49	1.52	1.23	0.00
Ambrosia	0.16	0.00	0.00	0.20	0.27	0.32	0.15	0.00	0.00
Artemisia	0.96	0.76	4.18	0.39	0.27	0.97	1.67	0.00	0.00
Betula	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Carpinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carya	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00
Cercocarpus	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corylus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eriogonum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fraxinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fremontodendron	0.32	0.00	0.38	0.00	0.00	0.00	0.30	0.00	0.00
Ilex	0.16	0.15	0.00	0.00	0.00	0.16	0.00	0.00	0.00
Juglans	0.16	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lithocarpus?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Myrica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Platanus?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potentilla	0.16	0.00	0.00	0.00	0.00	0.81	0.15	0.00	0.00
Prunus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pterocarya	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	4.47	0.61	5.70	4.71	1.10	5.84	3.03	0.00	0.00
Salix	0.64	0.46	0.00	0.00	0.55	1.46	0.15	0.92	0.00
Sarcobatus	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Tilia	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00
Ulmus	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.31	0.00
Asteraceae-Liguliflorae	0.16	0.46	0.00	0.00	0.00	0.16	0.00	0.00	0.00
Asteraceae-Tubuliflorae	4.63	3.50	1.90	3.33	2.47	2.27	2.88	0.00	0.00
Caprifoliaceae	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00
Caryophyllaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chenopodiineae	1.92	0.61	0.00	1.57	0.55	2.11	1.21	0.00	0.00
Elaeagnaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ericaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juglandaceae	0.16	0.00	0.00	0.00	0.00	0.00	0.15	0.31	0.00
Malvaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Onagraceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poaceae	0.64	0.30	1.14	0.00	0.00	0.65	0.15	0.31	0.00
Polygonaceae	0.16	0.00	0.76	0.00	0.00	0.00	0.45	0.00	0.00
Rhamnaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rosaceae	0.00	0.46	0.00	0.00	0.55	0.00	0.91	0.92	0.00
Umbelliferae	0.80	0.15	0.00	0.20	0.00	0.00	0.00	0.00	0.00
Monosulcate type 1	0.32	0.00	0.76	0.20	0.27	0.32	0.30	0.00	0.00
Monosulcate type 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tricolpate type 1	0.32	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00
Tricolpate type 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tricolporate type 1	0.64	0.46	0.00	1.18	0.27	0.81	0.00	0.62	0.00
Tricolporate type 2	1.44	1.07	0.00	0.59	0.00	0.81	0.30	0.62	0.00
Indeterminates	4.15	5.18	5.32	6.47	4.40	5.84	4.85	5.54	0.00

Age (Ma)	3.26	3.31	3.39	3.41	3.61	3.64	3.69	3.72	3.78
Depth (mbsf)	85.44	86.56	87.81	88.15	91.81	92.30	93.28	93.71	94.81
Abies	0.53	0.56	0.18	0.85	0.45	0.65	0.88	0.53	0.37
Picea	0.00	1.11	0.53	0.42	0.30	0.87	0.00	0.00	0.56
Pinus	20.43	23.01	15.81	14.65	20.80	38.68	22.21	50.13	16.81
Pseudotsuga/Larix	0.00	0.74	1.24	0.21	0.00	0.22	0.74	1.06	0.74
Sequoia	0.36	0.00	0.71	0.21	0.00	0.00	0.00	0.53	0.00
Taxodium	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Tsuga canadensis?	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00
Tsuga heterophylla	0.18	0.74	0.18	0.21	0.00	0.00	0.00	0.00	0.56
Tsuga mertensiana	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.53	0.00
Taxodiaceae	0.00	0.19	0.36	0.00	0.45	0.22	0.29	0.00	0.19
TCT undifferentiated	55.60	48.98	57.02	57.32	46.95	33.59	45.59	37.14	57.38
Conifer undifferentiated	1.95	2.41	2.49	3.40	1.63	3.25	1.76	3.18	3.16
Ephedra	0.00	0.37	0.00	0.00	0.00	0.22	0.15	0.00	0.00
Acer?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alnus	2.31	2.23	1.24	1.91	0.45	0.87	0.59	0.00	1.11
Ambrosia	0.18	0.00	0.18	0.21	0.00	0.00	0.00	0.00	0.00
Artemisia	0.53	1.67	0.36	1.27	2.08	3.25	3.68	2.12	1.67
Betula	0.00	0.19	0.00	0.21	0.00	0.43	0.00	0.00	0.56
Carpinus	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Carya	0.18	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00
Cercocarpus	0.00	0.00	0.18	0.21	0.30	0.00	0.00	0.00	0.19
Corylus	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00
Eriogonum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fraxinus	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00
Fremontodendron	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.37
Ilex	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.19
Juglans	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00
Lithocarpus?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Myrica	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Platanus?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potentilla	0.18	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prunus	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00
Pterocarya	0.00	0.00	0.18	0.21	0.15	0.00	0.15	0.00	0.19
Quercus	5.68	3.71	3.73	2.12	3.86	3.03	5.00	2.12	3.90
Salix	0.36	0.56	0.89	0.64	1.34	0.00	1.18	0.53	0.37
Sarcobatus	0.00	0.00	0.00	0.00	0.15	0.43	0.15	0.53	0.00
Tilia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ulmus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asteraceae-Liguliflorae	0.00	0.19	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Asteraceae-Tubuliflorae	2.13	2.41	2.49	2.55	3.42	1.30	3.68	0.00	0.93
Caprifoliaceae	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00
Caryophyllaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chenopodiineae	1.78	1.67	1.60	0.42	2.08	1.95	2.50	0.00	0.56
Elaeagnaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ericaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.19
Juglandaceae	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Malvaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00
Onagraceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poaceae	0.18	0.19	0.18	0.85	1.34	0.65	0.00	0.00	0.00
Polygonaceae	0.00	0.56	0.00	0.21	0.15	0.22	0.29	0.00	0.19
Rhamnaceae	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00
Rosaceae	0.00	0.37	0.18	1.70	1.93	1.08	1.03	0.00	0.00
Umbelliferae	0.18	0.00	0.00	0.21	0.30	0.43	0.44	0.00	0.00
Monosulcate type 1	0.18	0.74	0.00	0.00	0.00	2.17	0.00	1.06	0.00
Monosulcate type 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tricolpate type 1	0.18	0.93	0.18	0.42	0.00	1.30	0.59	0.00	1.11
Tricolpate type 2	0.00	0.00	0.18	1.49	0.89	0.22	0.29	0.00	0.00
Tricolporate type 1	1.07	0.00	0.18	0.00	0.45	0.00	0.29	0.53	0.19
Tricolporate type 2	0.00	0.56	1.24	0.85	1.93	0.00	3.38	0.00	1.67
Indeterminates	5.86	5.38	8.53	6.37	5.65	4.98	4.56	0.00	6.69

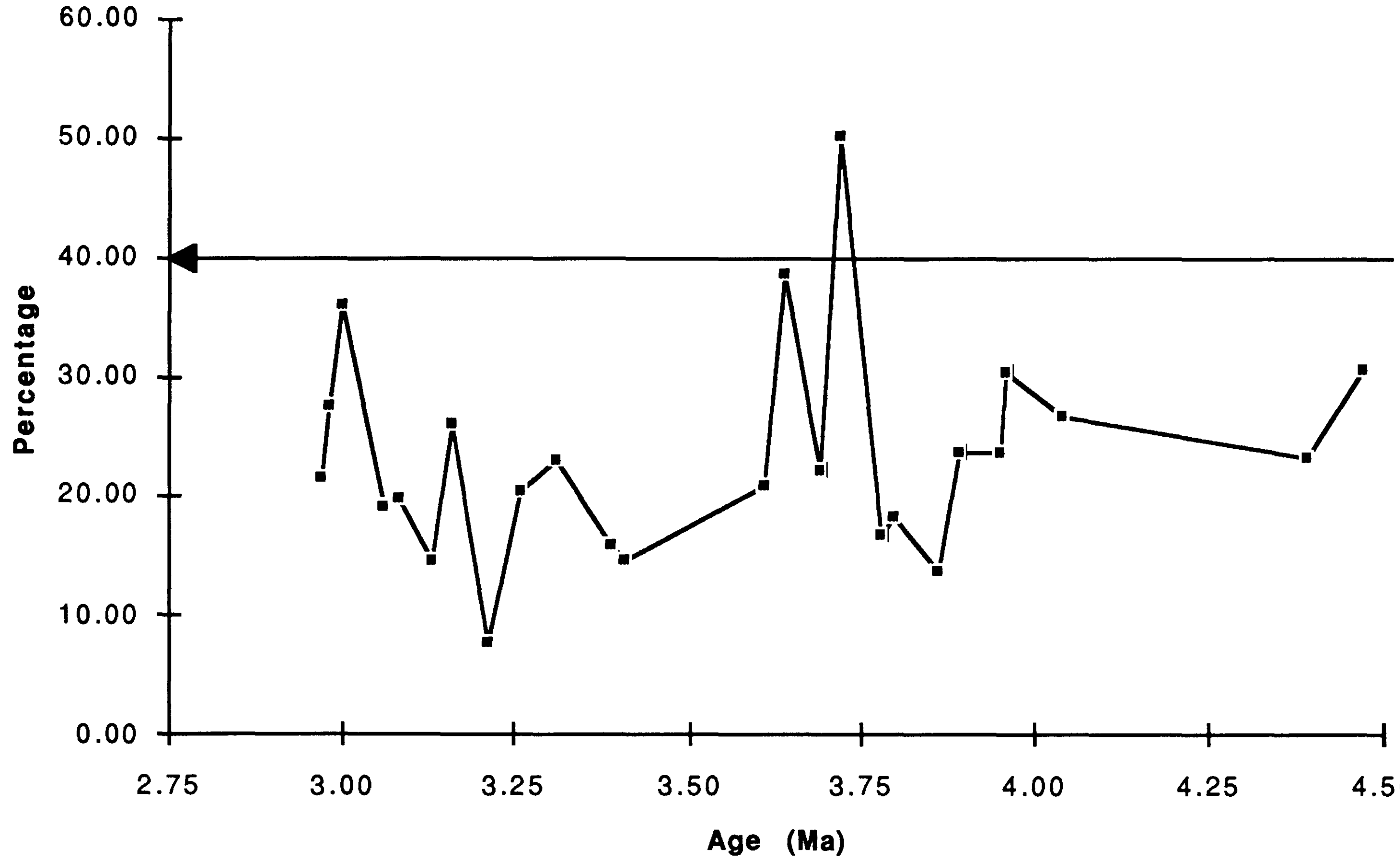
Age (Ma)	3.80	3.86	3.89	3.95	3.96	4.04	4.22	4.39	4.47
Depth (mbsf)	95.21	96.31	96.80	97.81	98.16	99.60	102.77	105.81	107.32
Abies	0.00	0.00	0.00	1.60	0.60	0.66	5.00	0.40	0.66
Picea	0.87	0.15	0.87	0.15	2.01	0.00	2.50	0.40	1.32
Pinus	18.31	13.74	23.66	23.62	30.52	26.67	10.00	23.32	30.59
Pseudotsuga/Larix	0.00	0.88	1.74	0.58	1.41	1.49	7.50	0.20	0.82
Sequoia	0.00	0.15	0.00	0.00	0.20	0.00	0.00	0.60	0.00
Taxodium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga canadensis?	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Tsuga heterophylla	0.00	0.00	0.00	0.00	0.60	0.17	0.00	0.20	0.00
Tsuga mertensiana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Taxodiaceae	0.00	0.44	0.00	0.44	0.40	0.83	5.00	1.00	0.00
TCT undifferentiated	59.01	61.70	47.31	45.48	38.76	45.09	27.50	45.85	37.83
Conifer undifferentiated	0.87	0.58	1.74	6.27	1.20	1.82	7.50	1.60	6.25
Ephedra	0.29	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Acer?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alnus	0.58	0.73	0.87	1.60	0.20	0.50	2.50	1.20	1.48
Ambrosia	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.20	0.00
Artemisia	4.94	2.92	1.45	2.19	1.81	3.14	0.00	2.80	2.30
Betula	0.29	0.00	0.58	0.15	0.20	0.17	0.00	0.60	0.33
Carpinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carya	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.49
Cercocarpus	0.00	0.15	0.00	0.15	0.00	0.00	0.00	1.40	0.00
Corylus	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00
Eriogonum	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Fraxinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fremontodendron	0.00	0.29	0.00	0.00	0.00	0.17	5.00	0.00	0.00
Ilex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Juglans	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Lithocarpus?	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.20	0.00
Myrica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Platanus?	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potentilla	0.00	0.00	0.29	0.00	0.00	0.17	0.00	0.00	0.33
Prunus	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Pterocarya	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.33
Quercus	1.16	5.12	6.10	2.92	6.43	5.95	7.50	7.21	7.57
Salix	0.29	1.02	0.87	1.60	0.00	0.33	0.00	1.80	0.49
Sarcobatus	0.58	0.29	0.00	0.15	0.20	0.00	0.00	0.00	0.00
Tilia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Ulmus	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Asteraceae-Liguliflorae	0.29	0.00	0.29	0.00	0.00	0.50	2.50	0.00	0.00
Asteraceae-Tubuliflorae	1.16	0.44	2.90	1.46	1.61	1.32	2.50	1.20	1.97
Caprifoliaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caryophyllaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chenopodiineae	3.78	1.61	0.87	0.58	4.82	0.83	0.00	0.60	0.33
Elaeagnaceae	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ericaceae	0.00	0.15	0.00	0.00	0.00	0.17	0.00	0.00	0.00
Juglandaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
Malvaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Onagraceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Poaceae	1.45	0.15	0.29	0.73	0.00	0.17	2.50	0.20	0.16
Polygonaceae	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhamnaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rosaceae	0.00	1.32	0.00	0.73	0.60	0.50	2.50	2.00	0.00
Umbelliferae	0.00	0.00	0.58	0.29	0.60	0.17	0.00	0.00	0.16
Monosulcate type 1	0.00	0.29	0.29	0.15	0.00	0.00	2.50	0.00	0.00
Monosulcate type 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
Tricolpate type 1	2.03	0.00	0.29	0.58	1.41	0.17	0.00	0.20	0.49
Tricolpate type 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tricolporate type 1	0.00	0.29	0.87	0.00	0.00	0.00	0.00	0.00	0.16
Tricolporate type 2	0.00	1.90	1.16	2.19	0.60	2.48	7.50	0.00	0.00
Indeterminates	3.78	5.26	6.39	5.83	5.42	6.28	0.00	6.41	4.93

APPENDIX 4

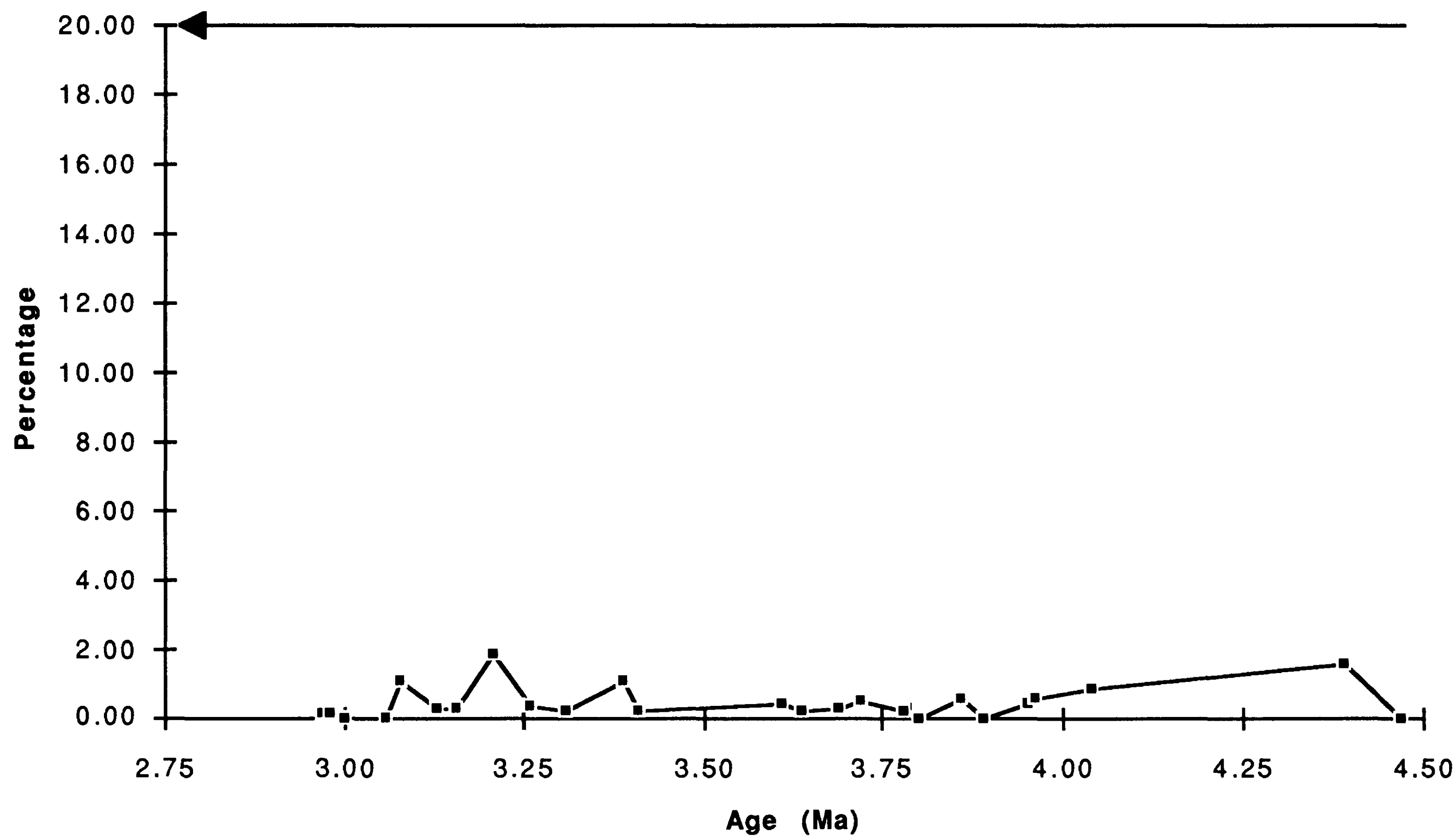
Appendix 4 contains plots of relative abundance profiles (percentage versus age) for selected taxa from DSDP Site 32. See text for discussion.



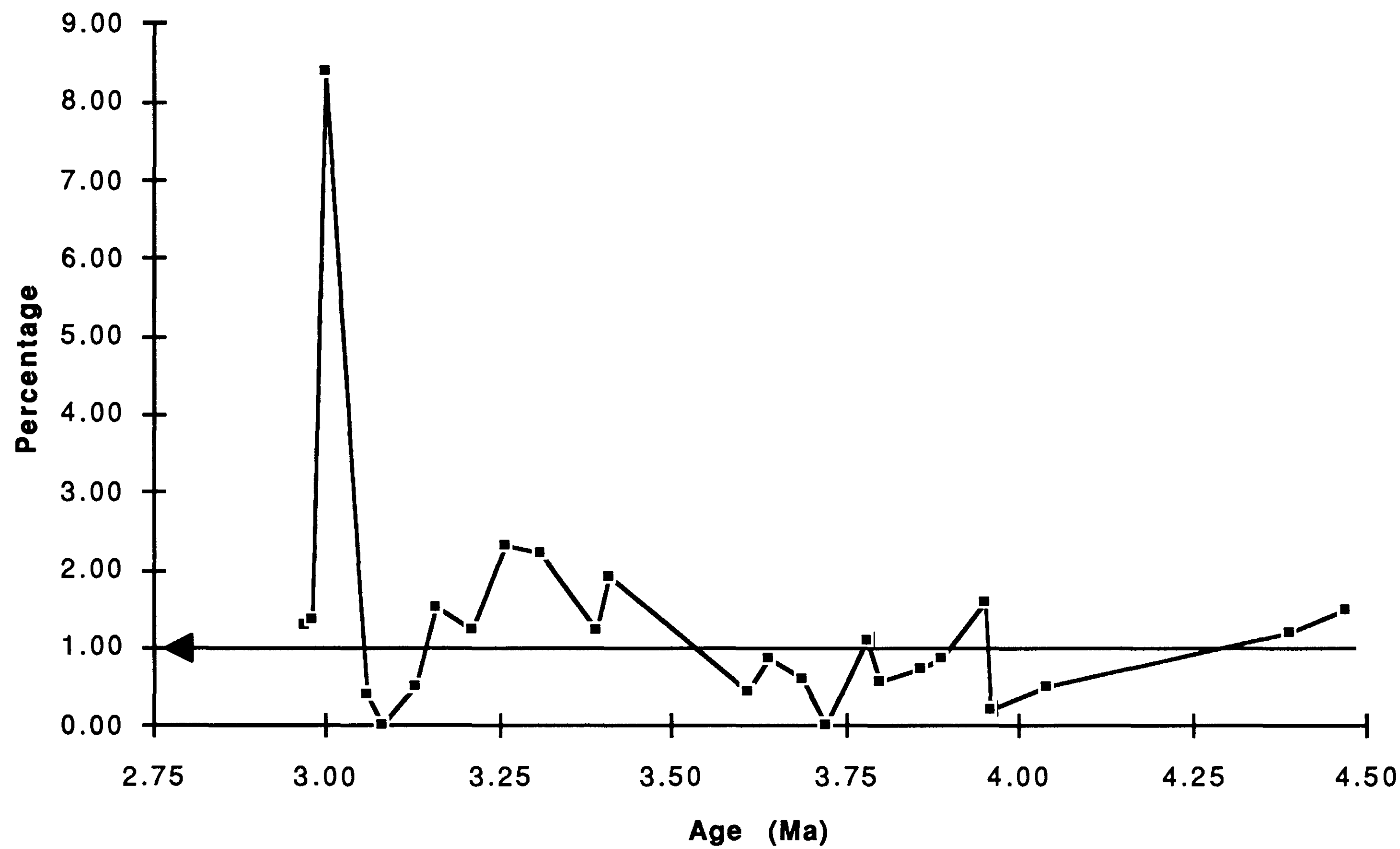
PLOT 1. Relative abundance profile of *Pinus* and TCT pollen from DSDP Site 32.



PLOT 2. Relative abundance profile of *Pinus* from DSDP Site 32. Arrow shows modern level of *Pinus* based on Heusser and Balsam (1977).



PLOT 3. Relative abundance profile of *Sequoia* plus Taxodiaceae from DSDP Site 32. Arrow shows approximate modern value for *Sequoia* based on Heusser and Balsam (1977).



PLOT 4. Relative abundance profile of *Alnus* from DSDP Site 32. Arrow shows approximate modern percentage of *Alnus* based on Heusser and Balsam (1977).