36. PALYNOLOGICAL STUDIES ON SAMPLES FROM DSDP LEG 42A

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ABSTRACT

This contribution analyzes the results of two palynological studies conducted on samples of Neogene sediments recovered by Leg 42A. The first was aimed at deducing climatic changes during the Neogene and found evidence of mild warm climates in the upper Tortonian of Site 375 and of cooler climates in the earliest Pliocene of Site 374. The second reports the results of detailed studies on individual sapropel layers recovered at Site 374 and relates the occurrence of such layers in the Pleistocene to phases of climate amelioration.

PRE-MESSINIAN POST MESSINIAN SAMPLES–SITES 374 AND 375

(D. Bertolani Marchetti)

Introduction

Palynological investigations were carried out on Messinian and pre-Messinian sediments recorded on DSDP Leg 42A (Figure 1). More meaningful results were obtained previously in the continuously cored Site 132 of Leg 13 in the Tyrrhenian Basin (Bertolani Marchetti and Cita, 1975). Unfortunately many samples recovered on Leg 42A were sterile and most levels contained insufficient pollen and spores to draw up a pollen spectrum. Consequently, this investigation is preliminary and represents only a minor contribution to our knowledge of the climatic-vegetational features of the Messinian and pre-Messinian environments.

Methods

The samples were prepared using standard procedures: thus they were treated with hydrofluoric acid at room temperature for 24 to 48 hours, then boiled in 10% NaOH for 10 minutes, this being repeated after washing in hot distilled water. Finally the samples were washed with a solution of water and glycerine. The resulting pollen material was stored in water/glycerine mixture. Analysis was carried out using a light microscope to compare samples with those reported in current literature (see Bibliography), and with acetolyzed recent samples in the collection in the Istituto Botanico of the University of Bologna.

Results.

A list of samples treated for this study appears as Table 1. Palynological analysis was worthwhile only on those polliniferous samples from Sites 374 and 375 (Table 2). Consequently the results reported here are applicable to the eastern Mediterranean only. Furthermore, of the eight samples analyzed, only three contained sufficient material to allow percentage calculations. For the remaining five only listings of taxa observed were possible, (+) or (++) depending on abundance. Substantially corroded grains, *Hystrichosphaeridia* and spores of *Bryophyta*, were not included in the percentage calculations.

Fern remains are considered with the non-arboreous plants (NAP). *Pinus* pollen (arboreous plants: AP) that were found, were mainly of the species *Pinus haploxylon* and *Pinus diploxylon.* Where classification to one of these was impossible, the pollen was assigned to a "*Pinus* sp. pl." group.

For details of the climatic inferences drawn from the various taxa the reader is referred to Bertolani Marchetti and Cita (1975, p. 286).

Climatic Interpretations

Samples from Site 374, Cores 12 and 22 provided no useful indications of climate during the Messinian. The sample from the side wall Core 25 which is assigned to the early Pliocene has a significant pollen content (Plates 1, 2). Species of pine are dominant (about 45%) and are associated with other mountain coniferous pollen, *Picea, Cedrus,* and *Podocarpus*, etc. Moderately thermophylous elements are scarce. Non-arboreous plant assemblages occur which are characteristic of moderately warm marsh environments, e.g., *Brasenia,* while the abundance of *Chenopotaceae* suggests beach environments were a probable source.

The data suggest a lowering of the boundary of the coniferous belt to near sea level in response to a cooling in climate. Marshes, perhaps as swamp land or salt marsh, were present on the coastal plain. The presence of nearby forests is supported by the occurrence of moss spores of *Polytrichum* type. A marine environment is indicated by a considerable percentage of *Hystrichosphaeridae* in vegetative form (about 18%).

Tortonian floras were analyzed at Site 375 (Plate 2). Only the oldest Sample 5-5, 135-137 cm, contained a rich assemblage which includes pollen from mountain conifers together with mediscratic forest elements, fern

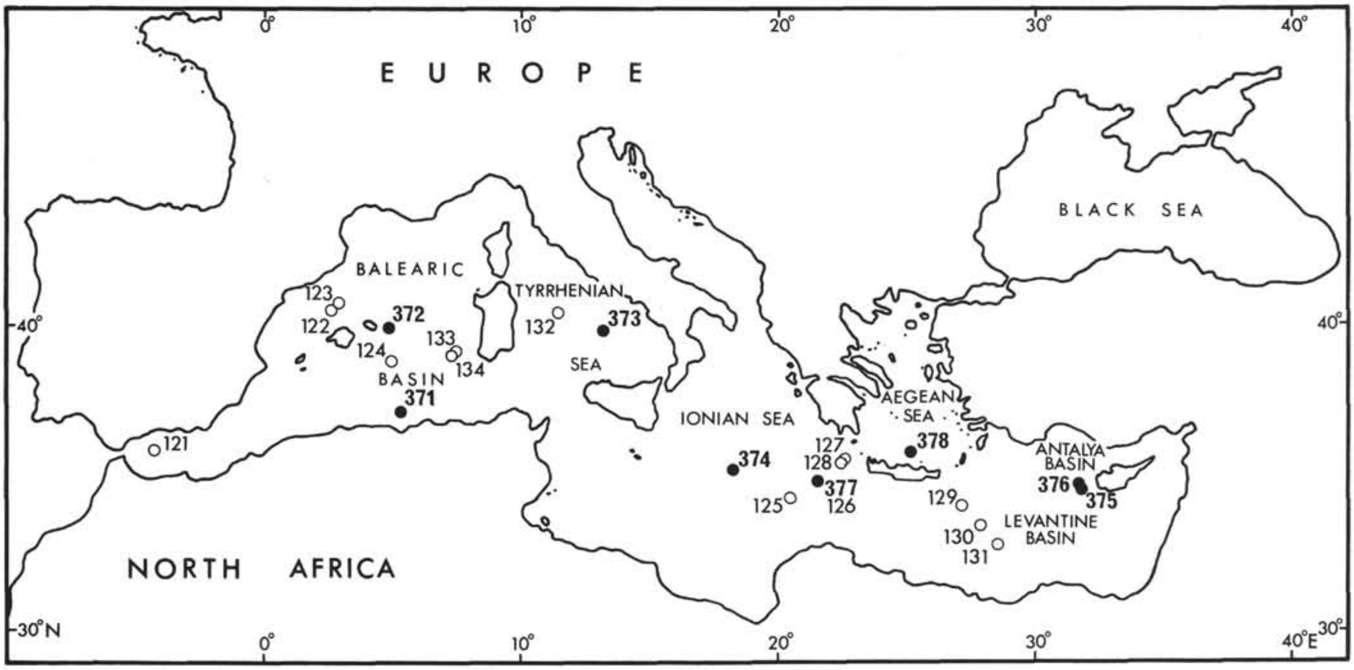

Figure 1. *Leg 42A drillsites in the Mediterranean Sea together with those of Leg 13.*

TABLE 1
List of Samples Processed

Site and Location	Sample (Interval in cm)	Age	Resulting Material
371			
South Balearic	8-2, 132-135	Messinian	Sterile
Basin	4-2, 42-44	Upper Pliocene	Sterile
	4-2, 83	Messinian	Sterile
	5-1, 135	Messinian	Sterile
	9-1, 83-84		
372			
Balearic		Serravalian	Sterile
Basin	9-2, 0-2	or	
	9-2, 12-13	Lower Tortonian	Almost sterile
	9-2, 41		
	9-2, 134-135		
	25-side wall (at 375m) subbottom)	Early Pliocene	Polliniferous
374	12-1, 111-113	Messinian	Almost sterile
Ionian	12-2, 64-66	Messinian	Polliniferous
Basin	19-1, 53-56	Messinian	Sterile
	22-1, 22	Messinian	Polliniferous
	4-3, 30-34	Upper Tortonian	Polliniferous
	4-4, 53-54	Upper Tortonian	Scarcely polliniferous
375			
Ionian Basin	4-4, 55-57	Upper Tortonian	Scarcely polliniferous
Florence Rise			
	5-5, 135-137	Upper Tortonian	Polliniferous

spores and non-arboreous types such as *Chernopodiaceae, Liliiflorae, Graminaceae* and *Cyperaceae.* During this part of the Tortonian a moderately thermophylous forest belt was probably present between a mountain coniferous belt and a coastal plain of open grassland. The climate would have been moderately warm.

The uppermost Tortonian Sample 375-4-3, 30-34 cm, is dominated by coniferous pollen (up to 68%) including *Pinus* and *Cedrus.* Only a few questionable mediscratic elements are present. *Hystrichosphaeridia,* often in vegetative form, are abundant, equaling the total pollen and spore count. These confirm that deposition was in a marine environment. The climate of the latest Tortonian is interpreted as having become decidedly cooler, since thermophylous elements are rare or absent.

Conclusions

The results of these, admittedly few, analyses suggest that the climate of the eastern Mediterranean during the Tortonian was moderately warm and that near the end of that stage it became cooler and thermophylous elements almost entirely disappear. Even cooler climatic conditions are indicated for the earliest Pliocene immediately after the Messinian event. During the Messinian period itself the climate was probably cool oscillations (Marchetti, 1961, 1966, 1972).

PLIOCENE AND PLEISTOCENE SAPROPELITIC SAMPLES, SITE 374 (C. A. ACCORSI)

Introduction

The results of an investigation of three horizons from Site 374 are reported here. They include two sapropels: one from Sample 374-5-2, 48-51cm containing 8.99% organic carbon (Kidd et al., this volume), the other from Sample 374-4, CC (2.03% org. C), which was received along with its associated host marls and was split into four subsamples as in Figure 2 and Table 3. The other sample was of a sapropelic layer containing 1.93% organic carbon, almost sufficient to also qualify as a sapropel. Ages range from early Pliocene to Pleistocene.

Methods

For each sample 1 gram of sediment was treated successively with HCl (30%) for 30 minutes, cold HF (50%) for 24 hours, and HCl (30%) for 30 minutes,

TABLE 2
Frequency of Occurrence of Pollen and Spores of Polliniferous Levels in Pre-Messinian and Messinian Samples of Sites 374 and 375

Sample (Interval in cm)	374-22-1, 22	374-12-2, 64-66	374-12-1, 111-113	374-25 (Side Wall)	375-5-5, 135-137	375-4-4, 55-57	375-4-4, 53-54	375-4-3, 30-34
Taxa / Age		Messinian		Early Pliocene		Tortonian		
AP (Arboreous Plants)				%	%			
Pinus sp. pl.	–	–	–	24.2	23.8	+	++	25.0
Pinus haploxylon	+	++	–	12.2	19.5	–	+	7.1
Pinus diploxylon	–	–	–	6.2	–	–	–	14.3
Abies	–	+	–	3.0	–	–	–	–
cf. *Keteleeria*	–	–	–	–	–	–	+	–
Picea	–	–	–	1.5	–	–	–	–
Cedrus	+	–	+	7.1	–	–	–	21.4
Larix	–	–	–	–	2.2	–	–	–
Podocarpos	–	+	+	21.4	–	–	–	–
Cryptomeria	–	+	–	–	2.2	–	+	–
cf. *Cephalotaxus*	–	–	–	–	–	+	–	–
Taxus	–	+	+	–	–	–	–	–
Taxodiaceae Seq./Tax. typus	–	–	+	–	2.2	–	+	–
Alnus	–	–	–	–	–	–	+	–
Quercus	–	+	+	–	2.2	–	+	–
Zelkova	–	–	–	–	2.2	–	–	–
Eucommia	–	+	–	–	–	–	–	–
Carya	–	–	–	–	2.2	–	–	–
Engelhardtia	–	–	–	–	4.3	–	–	–
cf. *Magnolia*	+	–	–	–	2.2	–	–	7.1
Myrica	–	–	–	1.5	–	–	–	–
Moraceae	–	+	–	–	–	–	–	–
Cornus	–	+	–	–	–	–	–	–
Rhus	–	+	–	–	–	–	–	–
Meliaceae	–	–	–	–	–	–	–	3.6
Hamamelidaceae	–	–	–	–	2.2	–	–	–
Ampelidaceae	–	–	+	–	–	–	–	–
NAP (Non-arboreous Plants)								
Graminaceae	–	–	–	3.0	2.2	+	–	3.6
Cyperaceae	–	–	–	1.5	2.2	+	–	3.6
Brasenia	–	–	–	4.5	–	–	–	–
Chenopodiaceae	++	+	–	6.2	2.3	+	–	–
Compositae	–	–	+	1.5	–	–	–	3.6
cf. *Thalictrum*	–	–	–	–	6.5	–	–	–
Liliiflorae	–	–	–	–	2.2	–	–	–
NAP *varia*	–	–	–	6.2	2.2	+	+	10.7
Filicales	–	+	+	–	8.7	–	+	–
Lycopodium	–	+	–	–	–	–	–	–
Bryophyta	–	–	–	3.0	4.3	–	–	–
Hystrichosphaeridia	–	+	–	18.4	4.3	–	–	99.9
Corroded grains	–	+	++	–	–	–	–	7.1
Mediocratic taxa	–	+	+	6.0	15.3	–	+	10.7
AP/NAP (approximate ratio)	–	–	–	77/23	72/28	–	–	79/21

each stage interspersed with washing. These were followed by two 7-minute periods of boiling in NaOH (10%) and then by immersion in HNO_3 (65%) for 3 minutes. If the sample was from the sapropel or sapropelic layer itself, additional treatment using an Erdtman's acetolysis was employed. The last stages of preparation for each sample were washings successively in distilled water, boiling water, and a solution of glycerine and distilled water. The resulting material was introduced into a solution of distilled water and glycerine and made up to a 5-cc volume.

For the calculation of absolute pollen frequency (APF), which expresses the number of pollen plus *Pteridophyta* spores in 1 gram of sediment, a modification of the method of Accorsi and Rodolfi (1975) was employed. This involved pipeting off a 0.02-cc drop from each 5-cc volume solution of distilled water and glycerine mixed with the treated sample material. The number of grains detected in each whole drop permitted the calculation of APF using the formula:

$$APF = \frac{ng \cdot Vp}{Wp \cdot Vd}$$

where ng =total number of grains in the drop;
Vp =preparation volume;
WP =preparation initial weight;
Vd =volume of drop.

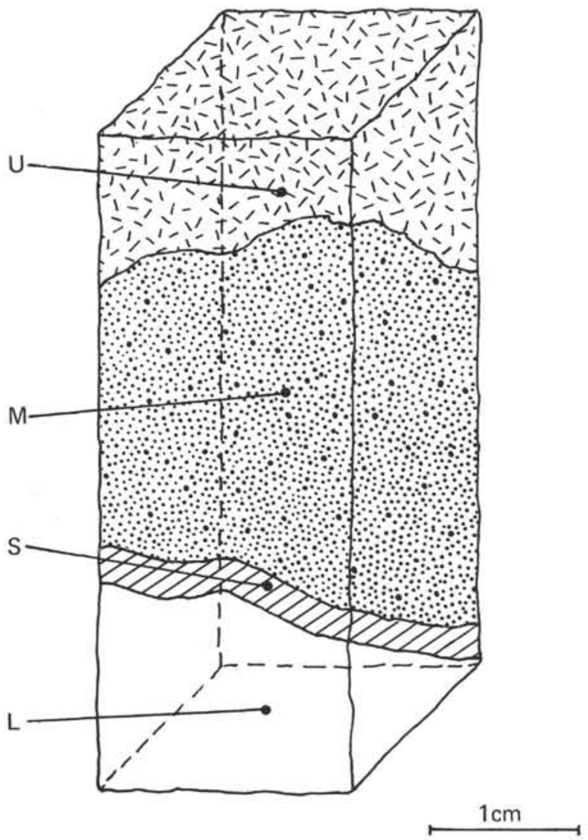

Figure 2. *Levels sampled in Sample 374-4, CC. (L = olive-gray marl; S = whitish marl; M = dark brown sapropel; U = olive-gray marl).*

TABLE 3
Samples of Pliocene and Pleistocene Sapropelitic Sediments and Associated Marls Investigated From Site 374

Core	Section	Meters Subbottom	Lithology	Age
4	CC (Level Upper)		Olive-gray marl	
4	CC (Level Middle)	~250	Dark brown sapropel	Pleistocene
4	CC (Level Sterile)		Whitish marl	
4	CC (Level Lower)		Olive-gray marl	
5	2, 48-51cm	~300	Black sapropel layer	Late Pliocene
9	2, 0-7cm	~360	Black sapropelic layer	Early Pliocene

Results

All samples were polliniferous (Table 3) except the whitish marl, Level S, of Sample 4, CC (Figure 2). The five other samples were sufficiently rich in pollen and spore material (total grain counts range from 351 to 2093) to allow the calculation of percentage frequencies as in Table 4.

An examination of the taxa recorded during the light microscopic analysis allows the identification of a number of groups which have environmental significance:

1) Conifers and other associated types typical of a mountain forest belt: *Pinus, Abies, Truga, Cedrus,* etc. Additionally some species of *Pinus* may have been derived from lowerlying vegetational belts (e.g., *Pinus* type *halepensis* and *Pinus* type *brutia*).

2) More or less thermophylous hardwoods such as *Quercus, Ulmus, Zelkova, Carya,* and *Pterocarya.*

3) Typical elements of steppe (*Artemisia*) and Mediterranean macchia or gariga environments such as the arboreous plants (AP) *Pistacia, Phyllirea,* and *Buxus* and the non-arboreous plants (NAP) *Umbelliferae* and *Labiatae.* Also within this group is the xerophytic taxon *Ephedra.*

4) Characteristic elements of salt grassland vegetation, from areas at times flooded by the sea, such as *Chenopodiaceae, Graminaceae, Compositae* pro parte, and *Statice.*

5) Hydrophytes: including a group of plants that grow in slow running or almost stagnant water, such as *Potamogeton, Hydrocharis, Ceratophyllum, Alisma* pro parte, *Sagittaria, Lemna, Nymphaea,* and *Nuphar,* together with a group that is characteristic of the shores of fresh water lakes or riverbanks, such as *Lythrum, Alisma, Typha, Graminaceae,* and *Cyperaceae* pro parte. A tropical association including *Nymphaea* and *Brasenia* is also characteristic of this latter environment.

Climatic and Environmental Interpretation

Sample 9-2, 0-7 cm—Early Pliocene: In this sample non-arboreous material is dominant (AP/NAP = 34/66) (Plates 3 to 7). Conifers are abundant; for example, *Pinus* makes up about 20% of the total, much of which is *Pinus haploxylon.* The other conifers are recorded in low percentages, but nevertheless show a much greater variation in tertiary entities (see *Sequoia, Sciadopitys, Podocarpus dacrydiodes, Tsuga, Cedrus,* etc.) than in the other samples examined. Hardwood types are represented by *Quercus* (about 2%), together with the thermophylous *Zelkova, Carya, Platycarya,* and *Ulmus.* Elements of a tertiary thermophylic bushy vegetation are represented by *Palmae, Buxus, Laurus, Ampelidaceae, Myrica,* and *Pistacia.* The Hydrophyte group is well represented in this sample indicating fresh and slow running or almost stagnant water conditions. A further feature of this sapropelic layer is the presence of fungal spores in much higher percentages than in the other samples examined.

The dominance of the NAP can be explained by derivation from a far forest source and from a belt of herbaceous dry vegetation in the neighborhood. The conifer elements may have come from a higher forest belt. The remarkable amount of Hydrophyte elements, along with the associated *Chenopodiaceae,* suggest a coastal salt lake environment, although a delta region remains a possibility. The climate which would be associated with this vegetational picture is interpreted as temperate, cool, and damp.

Sample 5-48-51cm—Late Pliocene: In comparison with the assemblage described above, this sample has a lower amount of arboreous plant derivatives and *Pinus* makes up about half of these (Plates 5 to 7). The *Pinus haploxylon* percentage is considerably diminished and several mountain elements disappear. Thermophylous wood derivatives are more prominent and the steppe and xerophytic elements are well repre-

TABLE 4
Frequency of Occurrence of Pollens and Spores Recorded in Pliocene and Pleistocene Samples of Site 374

Core, Section	9-2	5-2	4, CC Level L	4, CC Level M	4, CC Level U
Meters subbottom	360	300		250	
Age / Taxa	Early Pliocene	Late Pliocene		Pleistocene	
AP (Arboreous Plants)	%	%	%	%	%
Pinus haploxylon	7.37	1.48	1.71	2.27	0.27
Pinus diploxylon	11.96	10.37	25.64	29.24	4.85
Abies	0.15	0.24	–	0.67	0.27
cf. *Keteleeria*	–	–	–	0.27	–
Picea	0.15	–	0.29	–	–
Cedrus	2.03	0.28	–	0.27	–
Tsuga	0.22	0.10	–	–	–
Larix-Pseudotsuga	0.08	–	–	0.13	–
Podocarpus dacrydioides	0.08	–	–	–	–
Podocarpus	0.37	0.05	–	0.27	0.27
Cephalotaxus	0.52	–	–	–	–
Taxus	0.15	–	–	–	–
Sciadopitys	0.08	–	–	–	–
Sequoia	0.68	–	–	–	–
Callitris	0.45	0.14	–	–	–
Juniperus	0.45	0.28	0.57	0.53	0.54
Libocedrus	0.15	–	–	–	–
Other *Cupressaceae*	–	0.48	–	0.27	–
cf. *Ginkgo*	0.08	–	–	–	–
Fagus	–	0.05	–	0.27	–
Castanea	0.15	0.19	–	0.27	–
Betula	–	0.14	0.85	1.20	–
Alnus	0.15	0.43	1.71	0.80	0.81
Salix	0.90	0.38	1.14	1.07	0.81
Corylus	0.45	0.24	–	1.20	1.35
Carpinus	0.15	0.24	0.29	0.53	–
Quercus	2.03	4.97	6.55	7.74	2.69
Ulmus	0.30	0.19	1.13	0.67	1.35
Zelkova	0.45	0.19	0.29	0.94	0.27
Fraxinus	–	0.05	–	–	–
Tilia	–	–	–	0.27	–
Acer	–	–	–	0.13	–
Ostrya	–	0.05	–	–	–
Carya	0.22	–	–	–	0.54
Pterocarya	–	0.14	–	–	–
Platycarya	0.08	0.05	–	–	0.54
Juglans	0.08	–	–	–	–
Magnolia	0.08	0.05	–	–	–
Celtis	–	–	–	–	0.27
Palmae	0.15	0.10	–	–	–
Moraceae	0.37	0.14	0.29	–	1.08
Laurus	0.22	0.05	0.57	0.13	0.54
Buxus	0.08	0.10	0.29	0.13	1.88
Pistacia	1.05	0.10	–	0.40	1.08
Phillyrea	1.28	0.81	0.57	0.27	0.54
Myrica	0.22	0.05	–	–	–
cf. *Tamarix*	0.60	–	0.29	–	–
Cornus	–	0.10	–	–	0.27
Ceratonia	–	0.05	–	–	–
Caprifoliaceae	–	–	–	–	0.27
Ilex	–	0.05	–	0.27	–
Rhamnus	–	0.19	–	0.13	–
Myrtaceae	–	–	–	0.13	–
Ampelidaceae	–	0.14	0.29	–	–
Sapotaceae	0.30	–	–	–	–
NAP (Non-Arboreous Plants)					
Graminaceae	7.36	7.88	8.83	6.38	14.28
Cyperaceae	3.08	1.91	3.42	0.94	2.69
Chenopodiaceae	25.86	20.83	12.25	9.45	5.66
Statice	0.16	0.14	–	0.13	–
Artemisia	0.15	28.86	7.97	12.25	–

TABLE 4 – *Continued*

Core Section	9-2	5-2	4, CC Level L	4, CC Level M	4, CC Level U
Meters subbottom	360	300		250	
Age / Taxa	Early Pliocene	Late Pliocene		Pleistocene	
Ericales	0.08	0.14	1.99	0.40	0.27
Ephedra	2.63	4.44	5.12	4.54	1.35
Gnetum	0.15	–	–	–	–
Compositae (*Tubuliflorae* type)	1.50	2.00	1.99	2.54	1.62
Compositae (*Liguliflorae* type)	0.53	0.67	0.85	0.53	1.08
Plantago	2.18	0.72	0.57	1.07	0.27
Umbelliferae	0.45	1.15	0.57	0.27	–
Liliiflorae	0.97	0.10	0.85	1.07	39.88
Amaryllidaceae	–	0.05	–	–	–
Potamogeton	9.25	–	0.29	0.13	0.27
Juncaceae	2.25	–	–	–	–
Alisma	1.88	0.67	–	–	0.27
Lemna	0.45	0.14	0.29	–	0.81
Nymphaea	0.08	–	–	–	–
Nuphar	0.08	–	–	–	–
Ceratophyllum	0.15	–	–	–	–
Sagittaria	0.15	–	–	–	–
Hydrocharis	0.08	–	–	–	–
Brasenia	0.75	–	–	–	–
Lythrum	–	0.91	–	–	–
Typha	0.97	0.10	0.29	–	0.27
Stratiotes	0.08	–	–	–	–
Araceae	0.15	–	–	–	–
Thalictrum	0.53	1.91	–	0.94	–
Other *Ranuncolaceae*	0.53	0.57	2.28	1.20	0.27
Rosaceae	0.08	0.33	2.28	1.21	0.81
Labiatae	0.15	0.19	1.14	0.27	–
Scrophulariaceae	–	–	1.14	–	–
Cistaceae	–	–	–	0.27	–
Geraniaceae	–	–	–	0.27	0.27
Leguminosae	0.08	0.38	1.71	0.80	0.27
Caryophyllaceae	0.08	0.33	–	0.27	–
Rubiaceae	0.37	0.20	–	0.13	1.62
Thymeleaceae	–	–	–	0.13	0.54
Urticaceae	0.22	–	–	–	0.27
Campanula	0.08	0.19	–	0.13	0.27
Polygonum	–	0.05	–	–	–
Amaranthaceae	0.08	–	–	–	–
Saxifragaceae	0.30	0.38	–	–	–
Hypericum	–	0.19	–	0.13	–
Rumex	–	0.03	–	0.13	–
Euphorbiaceae	0.15	–	–	–	–
NAP *varia*	0.46	1.20	1.71	2.08	3.23
Filicales	0.83	0.38	1.99	1.87	2.97
Equisetales	0.37	–	–	–	–
Lycopodium	–	–	–	–	0.27
Fungal spores	510	84	32	82	45
Hystrichosphaeridia	4.5	3.9	2.4	4.7	2.9
Mediocratic taxa	8.34	8.24	10.56	13.21	12.67
Mediocratic taxa (% on AP)	24.33	36.36	24.86	26.17	61.84
AP/NAP (approximated ratio)	34/66	23/77	43/57	51/49	21/79
Total Pollen and Pteridophyta spores	1330	2093	351	749	371
APF	22750	35500	1500	14750	1750

sented. Elements of fresh water environments are almost absent and those of the herbaceous xerophylous belt considerably increase (*Artemisia* and *Chenopodiaceae*).

The late Pliocene environments suggested by this assemblage indicate a marine coast with a climate comparatively warmer and drier than that of the early Pliocene. This change may be related to a eustatic rise in sea level which broke into the early Pliocene coastal basins.

Sample 4, CC–Pleistocene: In the lowest subsample (Level L) the APF was calculated at 1500, the lowest pollen abundance recorded for any of the samples, which is probably related to its marl composition.

Percentages of arboreous plant derivatives, represented mainly by conifers, are considerably lower than those of herbaceous types. The only tertiary elements are *Pinus haploxylon* and *Zelkova* (Plate 7).

As noted previously the whitish marl of Level S between Levels L and M was entirely devoid of pollen.

The central part of this sapropel horizon, Level M, contained a fairly rich assemblage (APF = 14,750) but one which was poorly conserved and showed frequent conclusions (Plate 7). In comparison with Level L, the arboreous elements show a slight increase (AP/NAP = 51/49) mostly in the form of *Pinus* in relatively high percentages. Thermophylous derivatives are in the minority, but they make up a greater proportion of the AP total and are more varied.

The marl of the uppermost subsample, Level U, has an expectedly low pollen frequency (APF = 1750) (Plate 5), and the arboreous vegetation is again dominated by the non-arboreous, with the AP/NAP reverting to 21/79. The arboreous elements are mostly thermophylous types including *Zelkova*, together with *Carya* and *Pterocarya* which were not present in the underlying levels. The total assemblage is entirely dominated by herbaceous elements such as *Graminaceae, Chenopodiaceae, Cyperaceae, Liliiflorae.*

The results of analyzing the subsamples of this core catcher allow an interpretation of changing environments within a narrow period of sediment deposition. The assemblages show an upward warming in climate which is interpreted as a regression phase of a cold oscillation. According to this interpretation, the derivatives of a coniferous belt, indicative of cold conditions, almost dominate in the lower and middle levels. In Level M, we can identify the development of thermophylous forest with a rich undercover. This hardwood vegetation is replaced by a herbaceous cover in the upper level which would be developed in a warm dry climate.

Conclusions

Only the core catcher group of subsamples can give an insight to continuous environmental changes during the deposition of an individual sapropel horizon. This shows that the sapropel in question was deposited during a warming in climate. The other samples allow some comparison with conditions during deposition of similar sediments in the Pliocene. On the other hand, the small number of samples studied do not permit discussion of the causes of basinwide stagnation.

The early Pliocene assemblage characterizes a damp, cool, temperate climate. This can be compared with the results of the analysis of a sample from the lowermost Pliocene (374-side wall Core 25), as described in the first part of this contribution. This exercise shows a climatic change from cold to somewhat warmer conditions in the sapropelic layer. In all three Pliocene samples examined the floras are impoverished and many tertiary elements are absent.

The early Pleistocene group of subsamples from Sample 374-4, CC, are interpreted as the result of a warming trend following a cold oscillation in climate. It is possible that this may also have been the case for the Pliocene sapropel and sapropelic layers investigated and that we should confirm whether cold (glacial?) climates may have extended into pre-Quaternary time.

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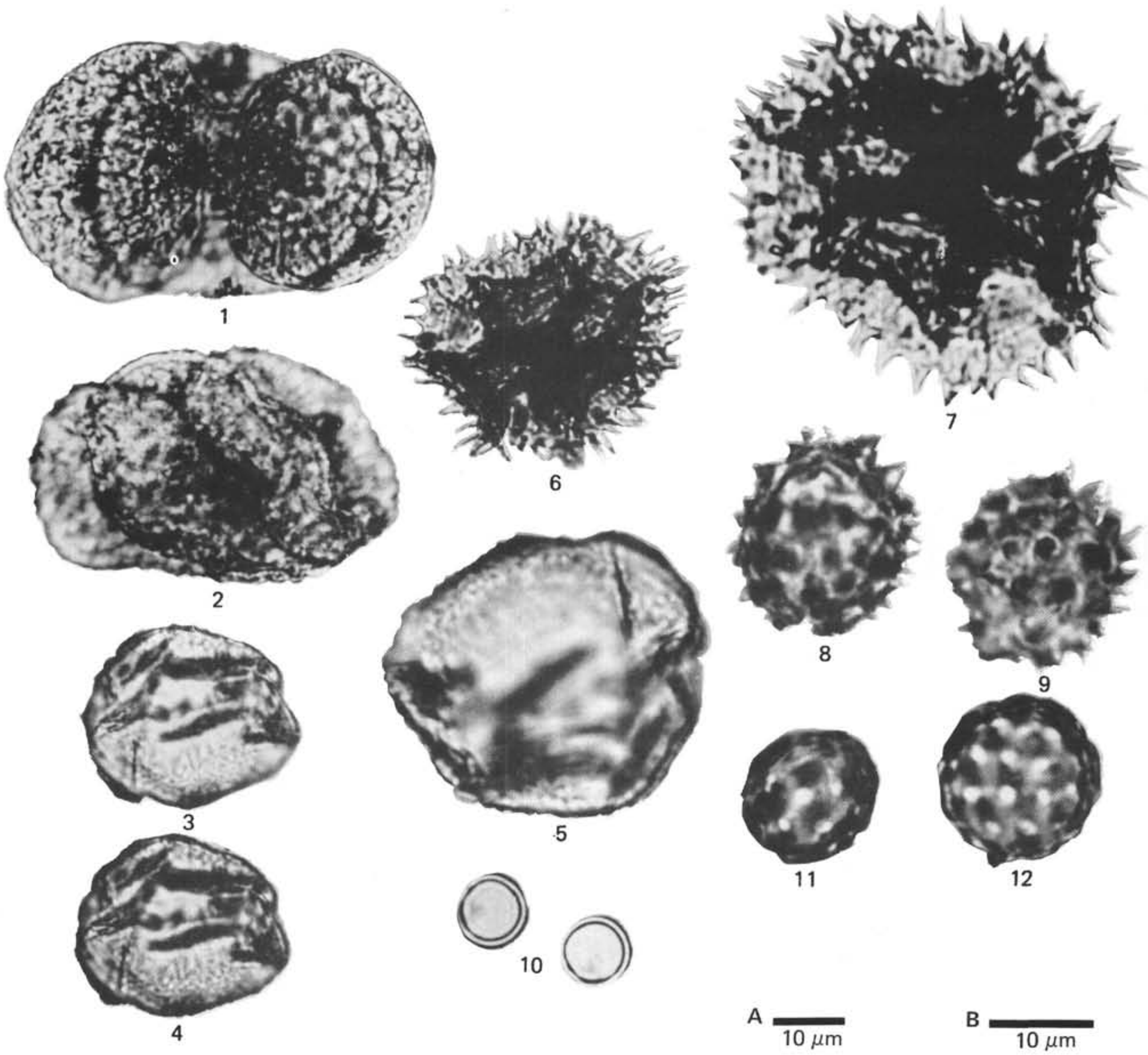
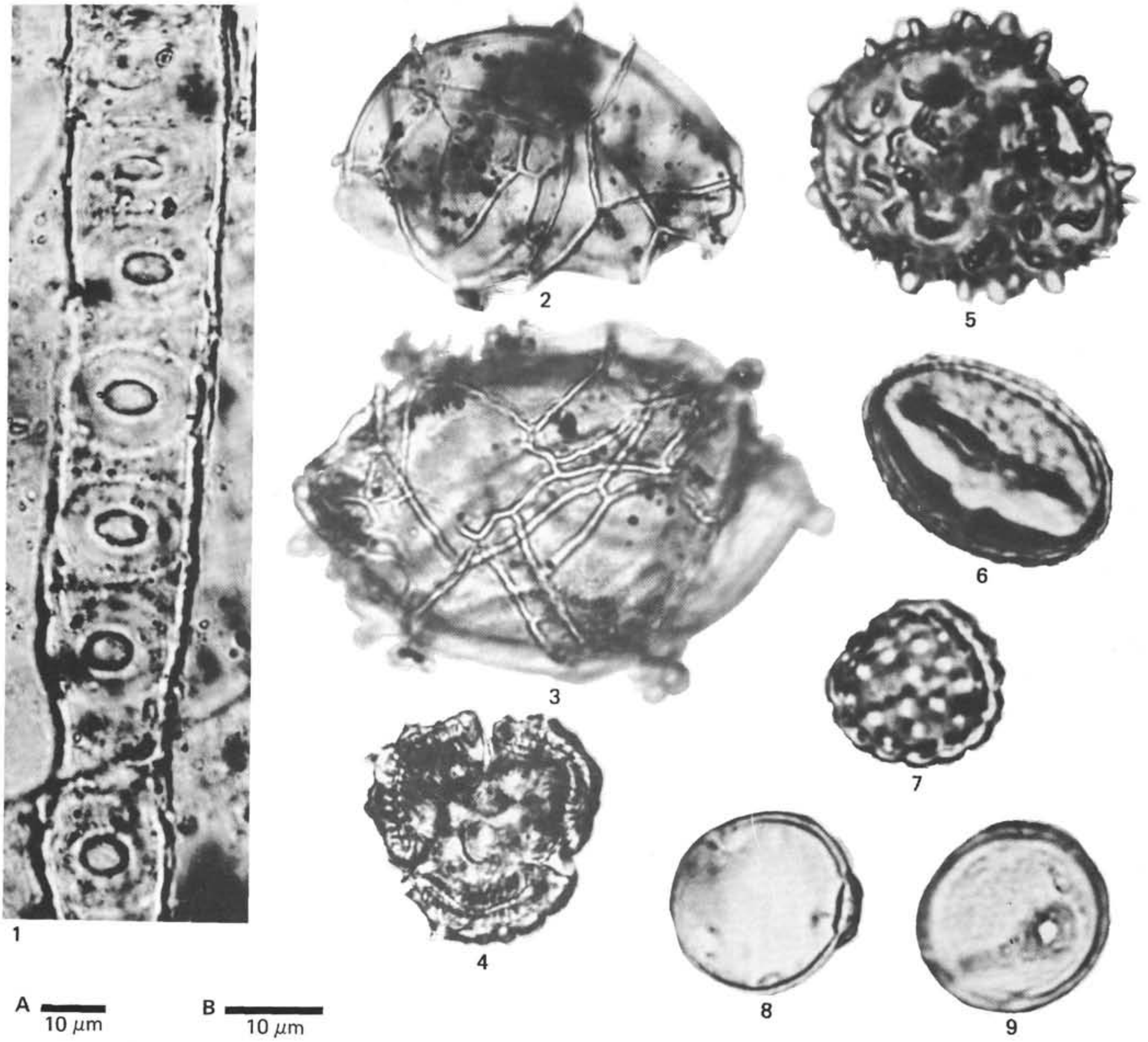
PLATE 1



Figures 1, 2, 3, 4, and 6 - Scale A. Figures 5, 7, 8, 9, 10, 11, and 12 - Scale B. All the grains figured in this plate were obtained from Site 374, Side Wall Sample 25.

Figure 1	*Pinus.*
Figure 2	*Pinus.*
Figure 3	*Brasenia.*
Figure 4	The same grain using a different focus.
Figure 5	The same grain at higher magnification.
Figure 6	*Compositae* (*Liguliflorae*-type).
Figure 7	The same grain at higher magnification.
Figure 8	*Compositae* (*Tubuliflorae*-type).
Figure 9	The same grain using a different focus.
Figure 10	*Polytrichum* spores (*Bryophyta*).
Figure 11	*Chenopodiaceae.*

PLATE 2



Figures 1, 2, 3, and 4-Scale A. Figures 5, 6, 7, 8, and 9-Scale B.

Figure 1 Tracheid in radial section; bordered pits of "modern" type (Abies?). Sample 374-12-1, 111-113 cm.

Figure 2 *Hystrichosphaeridia.* 374, Side Wall Sample 25.

Figure 3 *Hystrichosphaeridia.* 374, Side Wall Sample 25.

Figure 4 *Compositae* (*Liguliflorae*-type). Sample 375-4-3, 30-34 cm.

Figure 5 *Filicales* (cf. *Cystopteris*). Sample 375-5-5, 135-137 cm.

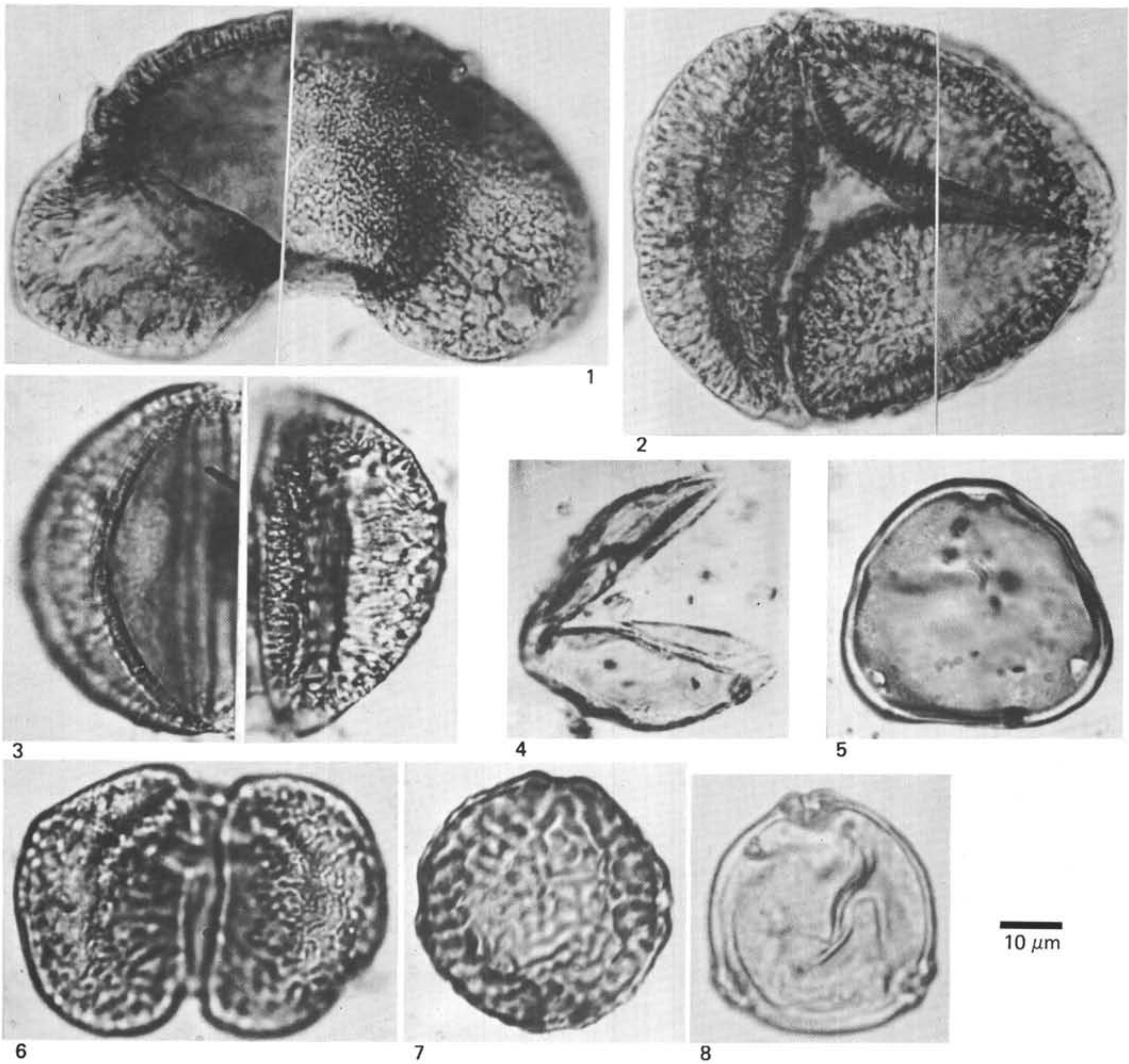
Figure 6 Unidentified pollen. Sample 374-12-2, 66-68 cm.

Figure 7 *Chenopodiaceae.* Sample 375-4-3, 30-34 cm.

Figure 8 *Graminaceae.* Sample 375-5-5, 135-137 cm.

Figure 9 The same grain in a different position and focus.

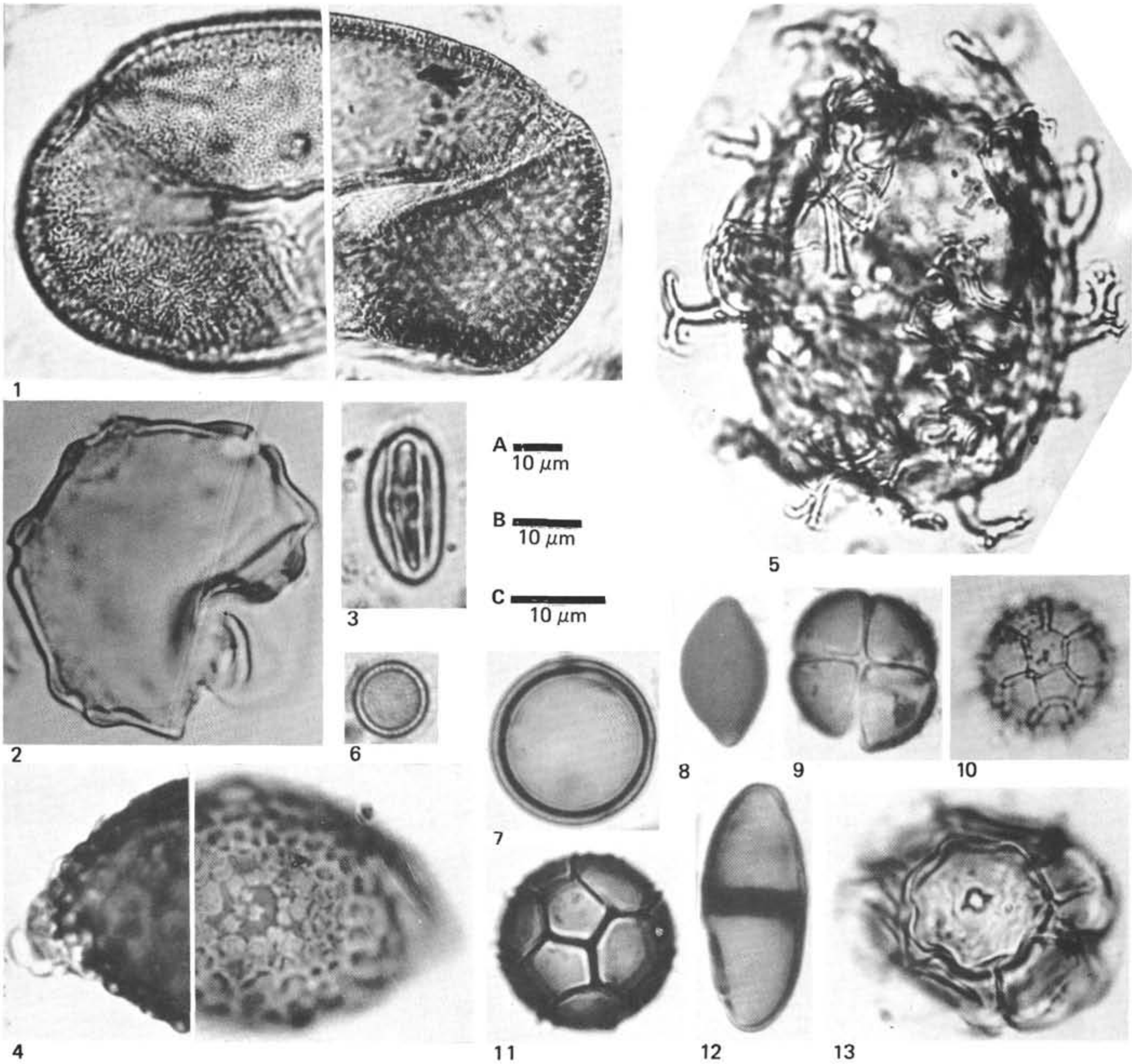
PLATE 3



All the grains figured in this plate are from Sample 374-9-2, 0-7 cm.

Figure 1	*Cedrus.*
Figure 2	*Podocarpus dacrydioides.*
Figure 3	*Pinus haploxylon.*
Figure 4	*Sequoia.*
Figure 5	*Carya.*
Figure 6	*Podocarpus.*
Figure 7	*Zelkova.*
Figure 8	*Carpinus.*

PLATE 4



Figures 1, 2, 7, and 8-Scale A. Figures 3, 4, 5, 6, 9, 10, 11, 12, and 13-Scale B. Location: grains 1 and 2 from Sample 374-5-2, 48-51 cm; grains 3, 4, 5, and 6 from Sample 374-4, CC, level U; grains 7, 8, 9, 10, 11 and 12 from Sample 374-9-2, 0-7 cm.

Figure 1 *Tsuga* (*canadensis*-type).

Figure 2 *Pinus diploxylon.*

Figure 3 *Liliiflorae.*

Figure 4 The same grain in a different position and focus.

Figure 5 The same grain at one extremity.

Figure 6 *Liliiflorae.*

Figure 7 *Liliiflorae.*

Figure 8 The same grain at a different focus.

Figure 9 *Pistacia.*

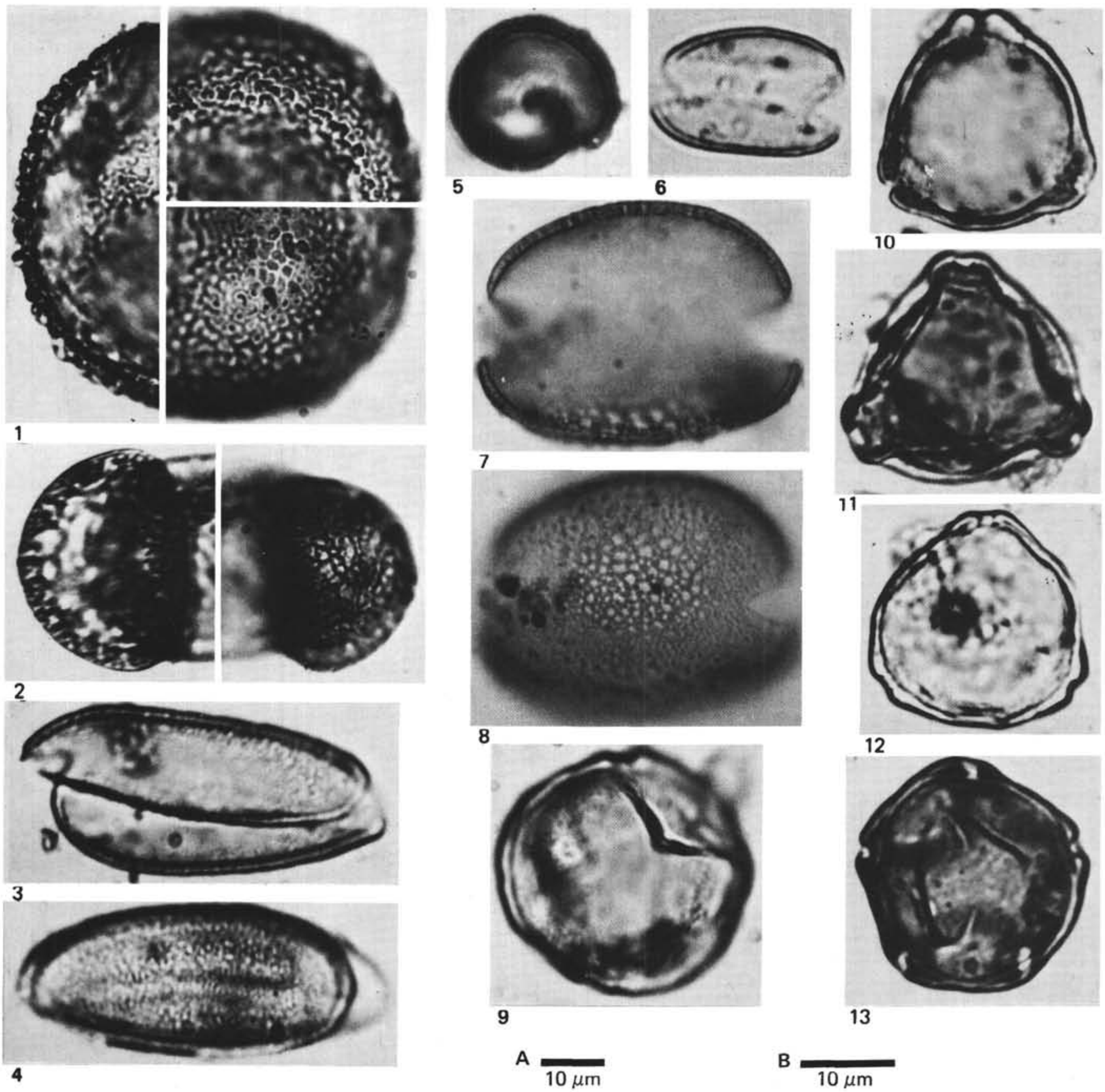
Figure 10 *Myrica.*

Figure 11 *Myrica.*

Figure 12 *Corylus.*

Figure 13 *Alnus.*

PLATE 5



All grains are from Sample 374-5-2, 48-51 cm, except 4 and 5 which are from Sample 374-9-2, 0-7 cm.

Figure 1 *Ephedra* (*distachya*-type).

Figure 2 *Ephedra* (*fragilis*-type).

Figure 3 *Graminaceae.*

Figure 4 *Compositae* (*Liguliflorae*-type).

Figure 5 *Cyperaceae.*

Figure 6 *Chenopodiaceae.*

Figure 7 The same grain using a different focus.

Figure 8 *Chenopodiaceae.*

Figure 9 The same grain using a different focus.

Figure 10 *Thalictrum.*

Figure 11 *Chenopodiaceae.*

Figure 12 *Campanula.*

Figure 13 *Artemisia.*

PLATE 6

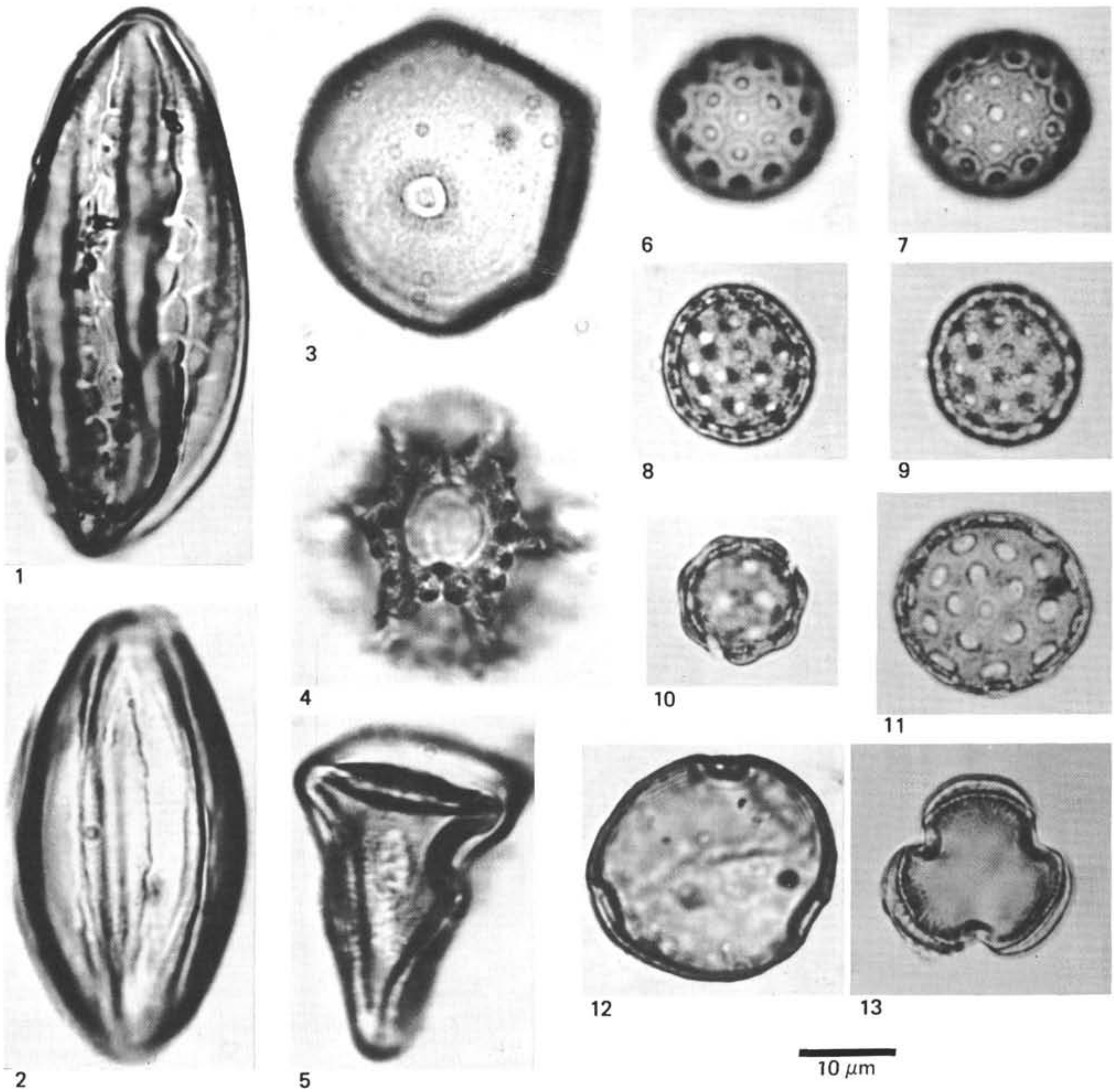
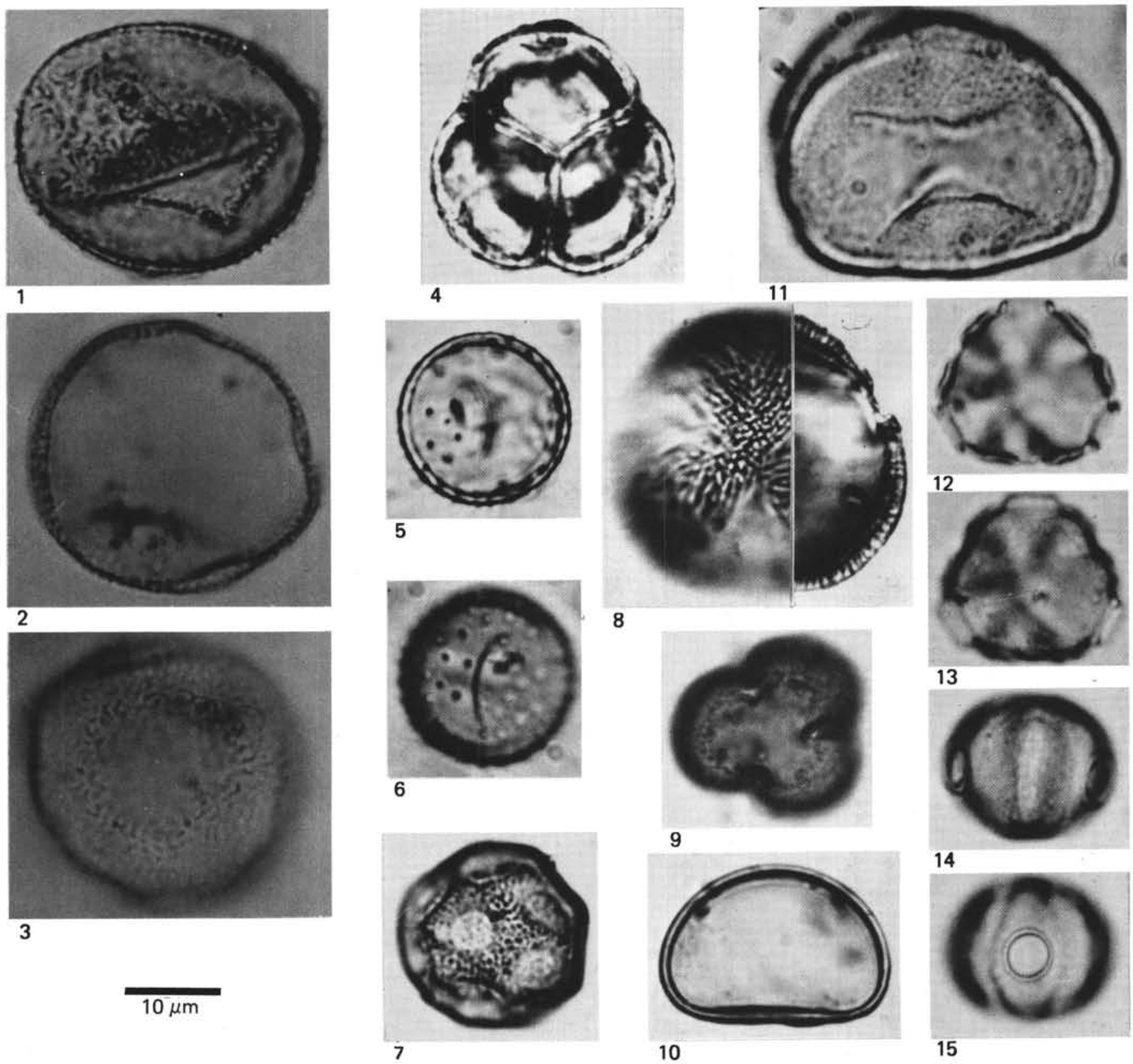


Figure 1-Scale A. Figures 2 and 5-Scale B. Figures 3, 4, 6, 7, 8, 9, 10, 11, 12, and 13-Scale C. All Figures are from Sample 374-9-2, 0-7 cm except Figure 2.

Figure 1 *Picea.*
Figure 2 *Pterocarya.*
Figure 3 *Castanea.*
Figure 4 Unidentified pollen.
Figure 5 *Hystrichosphaeridia.*
Figures 6-12 Fungal spores.
Figure 13 *Fungal spores?*

PLATE 7



Location: grains 1, 2, 3, 5, 6, 7, and 11 from Sample 374-9-2, 0-7 cm; grain 4 from Sample 374-4, CC, level L; grain 8 from Sample 374-4, CC, level M; grains 9, 10, 12, 13, 14, and 15 from Sample 374-5-2, 48-51 cm.

Figure 1 — *Potamogeton.*

Figures 2, 3 — *Potamogeton* at different foci.

Figure 4 — *Ericales.*

Figures 5, 6 — *Lemna* at different foci.

Figure 7 — *Alisma.*

Figure 8 — *Geraniaceae.*

Figure 9 — *Hypericum.*

Figure 10 — monolete spora.

Figure 11 — *Brasenia.*

Figures 12, 13 — *Lythrum* in polar view at two different foci.

Figures 14, 15 — The same grain, two different equatorial views.