43. PALYNOLOGICAL STUDY OF SAMPLES FROM HOLES 379A, 380A, LEG 42B

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ABSTRACT

A complete section of Pleistocene and probably Pliocene deposits was penetrated by the holes. Our palynological investigation enabled us to demonstrate a regular alternation of the floristic composition and, to a lesser extent, the vegetation cover of the Black Sea region during late Cenozoic time.

The vegetation cover in the Pliocene was characterized by a rich flora with abundant subtropical and other thermophilic elements containing various forest formations. Most subtropical forms ceased in the Pliocene. The early Pleistocene cold climate entirely changed the character of the vegetation cover. During the Pleistocene repeated alternation of glacial vegetation, consisting of steppe assemblages, and interglacial vegetation, consisting of forest coenoses, took place.

INTRODUCTION

Black Sea sediments obtained by coring have been studied for a long time by many researchers (e.g., Andrusov, 1890; Arkhangelsky and Strakhov, 1938; and many others). These studies dealt only with the upper layers that formed during Holocene and late Pleistocene. A thick sediment section from the deep-sea basin of the Black Sea was obtained by *Glomar Challenger* during Leg 42B in 1975. Palynological samples from the three sites were studied onboard ship by A. Traverse. He recognized an alternation of warm and cold phases in the evolution of the vegetation cover of the late Cenozoic in the Black Sea region (see Site Reports). The present authors studied samples from three holes (379A, 380, and 380A) drilled in the central and western parts of the Black Sea.

Hole 379A was drilled at a depth of 2173 meters in the central part of the Black Sea to a depth of 624.5 meters (43°00.29'N, 36°00.68'E). Holes 380 and 380A were drilled in the western part of the basin in a depth of 2127 meters (42°05'94"N, 29°36'82"E). The total penetration at Site 380 was 1073.5 meters. Core 1 of Hole 380A probably corresponds to Core 37 of Hole 380. These holes penetrated Quaternary and Pliocene sediments (Figure 1). As the preliminary studies showed, all horizons penetrated contained appreciable amounts of spore and pollen, frequently poorly preserved; other fossils (for example, foraminifers, diatoms, nannoplankton) were present only in some layers.

The uppermost layers of the Holocene section were not obtained during Leg 42B drilling; instead they were studied by examining materials from Cores 1433, 1474, and 1444 obtained by *Atlantis* II of the Woods Hole Oceanographic Institution in the summer of 1969 (Figure 2) (A-II Cruise 49, see Degens and Ross, 1974).

METHODS

A total of about 200 samples, mainly from the core catcher but including some from cores of Holes 379A, 380, and 380A, were studied. The specimens underwent a complex enrichment, including treatment with 10% HCl, 10% KOH, disintegration in a solution of pyrophosphate ($Na_4P_2O_7$), separation in a heavy liquid (CdI_2) of specific gravity 2.1-2.4, and release from silicates by cold treatment with HF. Processing of the specimens was terminated following the Erdman method with the help of acetolysis. From the glycerine-rich suspension the specimens were prepared in glycerine-gelatine. The collection of the serial material labeled by the individual indices is kept at the Geological Institute of the USSR Academy of Sciences, in the Palynological Laboratory of the Paleofloristic Department (No. 3946 GIN Acad. Sci. USSR).

Specimens were studied using a light microscope (Ergaval, Microphoto D-16-B biological), and by mass microphotos in oil immersion, with magnifications of 60×. The systematic indexing of spores and pollen was accomplished with the help of the standard collection, Atlases, and monograph descriptions.

RESULTS

The study resulted in distinguishing several pollen complexes that characterize the climatic rhythms of the Pleistocene and the Pliocene. These complexes can be related to the subdivision of Black Sea sediments proposed by Fedorov (1969) (Figure 3).

The results of the study (see Figure 3) are preliminary and will require further specification and detailization.

1) The lower part of Hole 380A, Cores 33 to 80, sub-bottom depth 631 meters to the base of the hole, is dated by us as Pliocene. The pollen complexes obtained

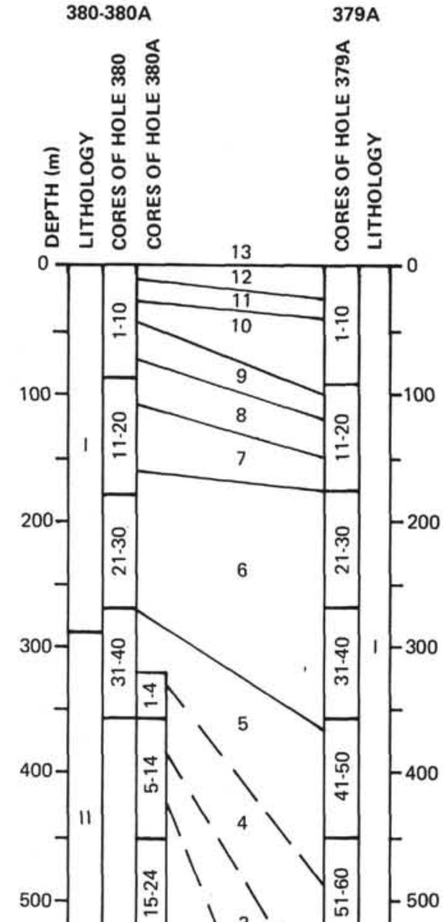

Figure 1. *Correlation scheme of stratigraphic horizons for Holes 380, 380A, and 379A. 1. Pliocene. 2. Gurijskie layers. 3. Chaudinskie layers. 4. Regression. 5. Paleouzunlarskie, old Euksinskie, early. 6. Old Euksinskie, late. 7. Uzunlarskie. 8. Late Uzunlarskie. 9. Karangatskie. 10. Post-Karangatskie. 11. Surozhskie(?). 12. Euksinskie. 13. Black Sea. I. Silty sediments and clays. II. Alternation of marls, clays and limestones with predominance of marls. III. Clay sediments with interbeds of marl and limestone. IV. Claystones.*

from this interval are rich and diverse and characterize a temperate-warm and subtropical flora. Pinaceae *(Pinus, Keteleeria, Tsuga, Cedrus, Abies, Picea)*, various Taxodiaceae (*Taxodium*, *Sequoia*, *Sciadopitys*, *Cryptomeria*), and Taxaceae (*Carya*, *Engelhardtia*, *Platycarya*, *Liquidambar*, *Magnolia*, *Nyssa*, etc.) are significant. On the whole, the amounts of angiosperms and gymnosperms are roughly equal. There are very few spores in the samples. The main forms of these complexes are shown in Plates 1-5. Among the predominant gymnosperms are various species of *Pinus*, *Picea*, *Abies*, *Tsuga*, and Taxodiaceae.

Pollen of broad-leaved plants, chiefly *Carya*, *Juglans*, *Ulmus*, *Carpinus*, and *Alnus*, are among the angiosperms. These deposits are also characterized by pollen of an angiosperm plant that yet has not been defined (Plate 3, Figures 1, 3, 4).

There is almost no pollen of herbaceous plants in the samples from the lower part of this hole. Above Core 76 there are small amounts of Chenopodiaceae pollen and herbage. There are considerable amounts of Chenopodiaceae, *Artemisia* pollen, and herbage in the upper part of the Pliocene section. Among the spores, single *Cyathea*, *Osmunda*, and Polypodiaceae are sporadic.

The pollen in the entire Pliocene section is poorly preserved. The grains are strongly mineralized and deformed, and those of coniferous are frequently ruptured, all of which makes identification difficult. The pollen in samples from Cores 31-36 is especially poorly preserved, thus making location of the boundary between the Pliocene and the Pleistocene somewhat conditional.

2) The succeeding flora, contained in Hole 380A, Cores 12-32, sub-bottom depth 437-631 meters, is of Gurian age. These deposits seem to have been formed in the cold epoch of the early Pleistocene. The pollen is poorly preserved, strongly mineralized, and limited in floristic composition. Pollen of various species of Chenopoidiaceae and other herbaceous types are predominant. Pollen of trees and shrubs are not abundant and few in species; these are mainly *Pinus* and *Betula*. *Picea*, *Abies*, *Ulmus*, *Alnus*, and *Quercus* are sporadic in occurrence.

The flora is temperate-cold, typical of the southern part of the European plain (Pashkevich, 1974; Artushenko, 1974). The most typical representatives of the pollen of these complexes are shown in Plate 6.

3) Sediments of Chauda age occur in Hole 380A, Cores 7-11, sub-bottom depth 390-437 meters, and in Hole 379A, Cores 67-68, sub-bottom depth 605-624.5 meters. The temperate-warm flora of these deposits contains a few elements of subtropical flora: *Taxodium*, *Sequoia*, *Carya*, *Rhus*, and *Liquidambar (Plate 7)*.

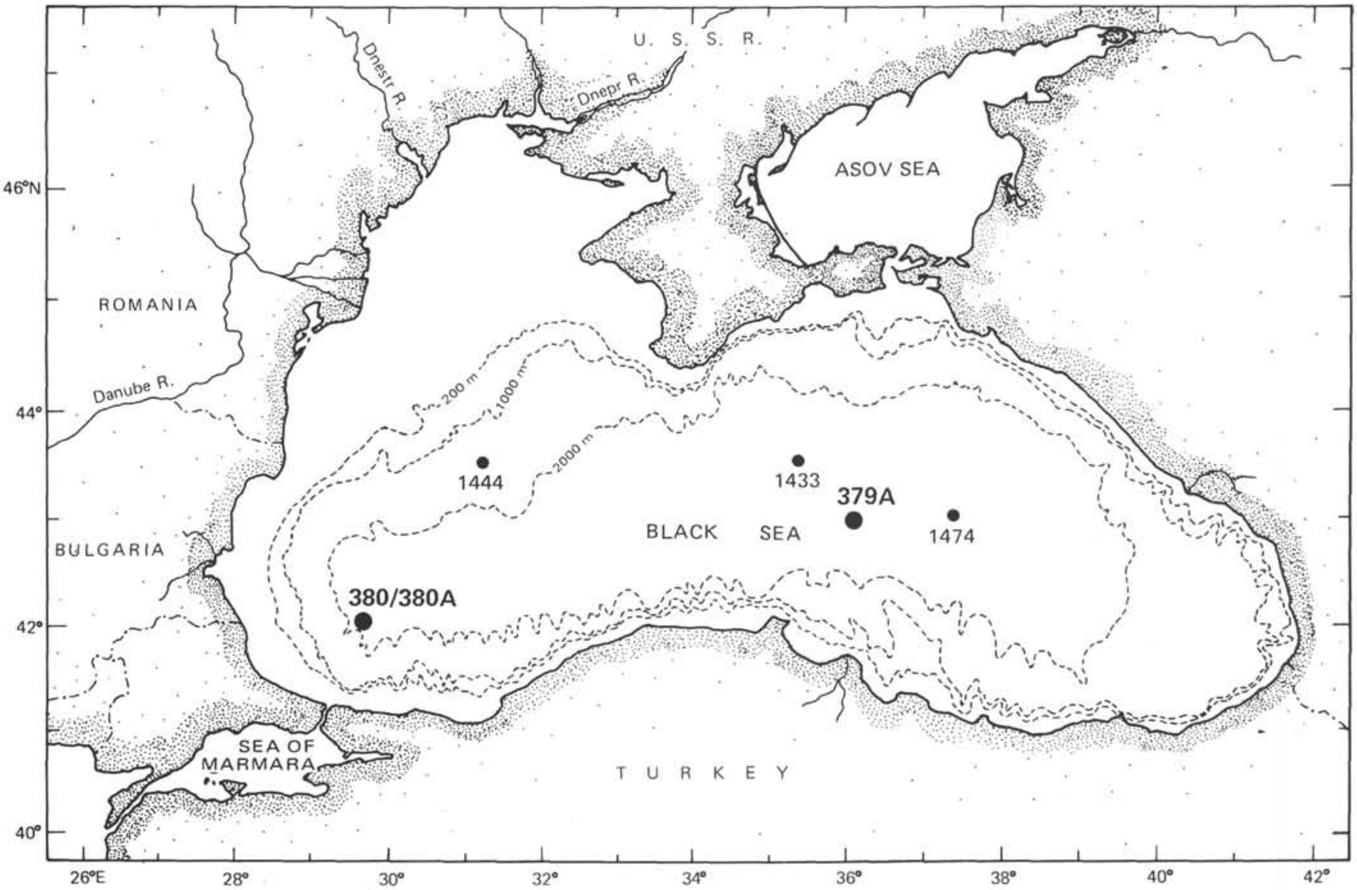

Figure 2. *Location of holes and cores.*

This flora abounds in angiosperm pollen, a considerable part of which is composed of non-arboreal types: Chenopodiaceae, *Artemisis*, and other Compositae. The composition of broad-leaved forms is diverse: *Ulmus*, *Quercus*, *Carpinus*, *Fagus*, *Juglans*, a great deal of *Alnus* pollen and less frequent, *Betula*. Conifers are common; spores (not numerous) are mostly Polypodiaceae. In Sample 380A-8, CC there were many redeposited Mesozoic spores (Plate 8).

4) Above the Chauda is a unit that represents marine regression. It occurs in Cores 2-7, sub-bottom depth 342-390 meters, and in Hole 379A, Cores 55-66, sub-bottom depth 539-596 meters. This complex represents a temperate-cold flora. The pollen is poorly preserved and composition is similar to the Gurian one, but differs in predominance of Chenopodiaceae, and *Artemisia*.

5) Paleouzunlarien-early Drevneeuxinien layers are represented in Hole 380, Cores 33-37, sub-bottom depth 304-351 meters, and in Hole 379A, Cores 43-54, sub-bottom depth 387-501 meters. These deposits contain a temperate-warm flora (Plates 9 and 10). Pollens of gymnosperms and angiosperms are present approximately in equal proportions, grass being predominant among angiosperms. The pollen of foliar arboreals is diverse by composition, but not abundant. That of *Carpinus*, *Corylus*, *Carya*, *Fagus*, *Quercus*, *Ulmus*, *Celtis*, *Yuglans*, *Pterocarya*, *Tilia*, and *Acer*, as well as *Alnus* and *Betula*, are especially abundant in the lower part. Among these gymnosperms, the most predominant are *Pinus* and, sometimes, *Taxodium*; Cupressaceae, *Picea*, and *Abies* are ever present; *Tsuga* is sporadic. Spores such as Polypodiacea, *Sphagnum*, and *Bryales* are not numerous.

6) Late Drevneeuxinien layers are characterized in Hole 379A, Cores 21-42, sub-bottom depth 187.5-387 meters, and in Hole 380, Cores 19-32, sub-bottom depth 171-304 meters.

The palynological complexes of these deposits contain a temperate-cold flora. They abound in grass pollens, among them Chenopodiaceae of various species composition (Plate 11) and *Artemisia*. Characteristic is the constant presence of the pollen *Ephedra*, and the arboreal, *Pinus* and *Betula*. Some pollen of dark conifers and leaved trees (*Abies*, *Picea*, *Carpinus*, *Corylus*, *Fagus*, *Tilia*, *Hippophae*, and *Alnus*) occur sporadically. Single spores of Polypodiaceae and *Selaginella selaginoides* were also recognized. The pollen here is better preserved than that in underlying deposits.

7) The Uzunlarien interval occurs in Hole 379A, Cores 16-20, sub-bottom depth 140-187.5 meters, and in Hole 380, Cores 11, CC to 19, sub-bottom depth 114.5-180.5 meters. In samples from the lower part of this unit the specimens are filled with fragments of organic matter. There are few poorly preserved pollen.

SYSTEM	SUBSECTION	CHRONOLOGIC SCALE 10^3 years	ALPINE STRATIGRAPHIC SCALE	MEDITERRANEAN SEA	SUBDIVISION OF THE PLEISTOCENE IN U.S.S.R.: EUROPEAN PART OF THE U.S.S.R.	SUBDIVISION OF THE PLEISTOCENE IN U.S.S.R.: BLACK SEA
	HOLOCENE	7-8		FLANDRIAN	HOLOCENE	BLACK SEA: LATE
						BLACK SEA: EARLY
QUATERNARY (ANTHROPOGENE)	UPPER PLEIST.	23	WÜRM	GRIMALDIAN (REGRESSION)	OSTASHKIAN	~NOVO-EUXINIAN
		45			MOLOGO-SCHEXNIAN	SURDZH(?)
		65			KALINIAN	POSLE-KARANGAT
		90-110	RISS-WÜRM	NEO-TYRRHENIAN	MICULIAN	KARANGAT
	MIDDLE PLEISTOCENE		RISS	REGRESSION	MOSKOVIAN	REGRESSION
				TYRRENIAN	ODINTSOVIAN	UZUNLAR
				REGRESSION(?)	DNEPRIAN	LATE DREVNE-EUXINIAN
		230				REGRESSION
		300	MINDEL-RISS	PALEO-TYRRHENIAN	LIKHVINIAN	PALEOUZUNLAR EARLY DREVNE EUXIN
	LOWER PLEISTOCENE		MINDEL	REGRESSION	OKAN	REGRESSION
		700	GÜNZ-MINDEL	SICILIAN		CHAUDA
	EOPLEISTOCENE		GÜNZ	EMILIAN	BELAVEZHSKIAN STAGES	GURIAN
			DONAU-GÜNZ DONAU	CALABRIAN		
PLIOCENE			PLIOCENE	ASTIAN	PLIOCENE	KUJALNIK

Figure 3. *Table of correlation of some schemes of the European upper Cenozoic.*

The flora represents a temperate-warm climate, containing almost no elements of the subtropical flora, except *Taxodium* (Plate 12). Among angiosperms, grass, such as Chenopodiaceae, *Artemisia*, and *Gramineae* is common. Herbage is widely represented, mostly Compositae, Umbelliferae, Caryophyllacae, Leguminisae, and Polygonaceae. Leaved trees are not numerous but are diverse, i.e., *Quercus*, *Fagus*, *Tilia*, *Ulmus*, *Corylus*, *Carpinus*, *Betula*, and *Alnus*. There are almost no spores. *Osmunda*, *Botrychium*, Polypodiaceae, and Bryales are sporadic.

In the upper part of the Uzunlarien deposits there are many dinoflagellate *Spiniferites cruciformis* Dale and Wall.

8) Postuzunlarien layers are characterized in Hole 379A, Cores 13-15, sub-bottom depth 111.5-140 meters, and in Hole 380, Cores 9-11, sub-bottom depth 76-114 meters. This is a cold complex very similar to that of late Drevneeuxinien.

9) Karangatien sediments were penetrated by Hole 379A, in Cores 10-6 to 12-1, sub-bottom depth 92.5-103 meters, and by Hole 380, Core 7, sub-bottom depth 57-66.5 meters. These layers contain abundant, perfectly preserved pollen. The Karangatien assemblages (Plate 14) are characterized by a rich floristic composition; the pollen of trees, mostly leaved types, are predominant. The latter abound in various broad-leaved trees: in the lower part *Pinus*, *Fagus*, and *Ulmus* prevail; in the middle part the amount of dark coniferous (*Abies* and *Picea*) increases, whereas in the upper layers *Carpinus* and *Alnus* are especially abundant among the leaved plants, and the amount of coniferous pollen sharply

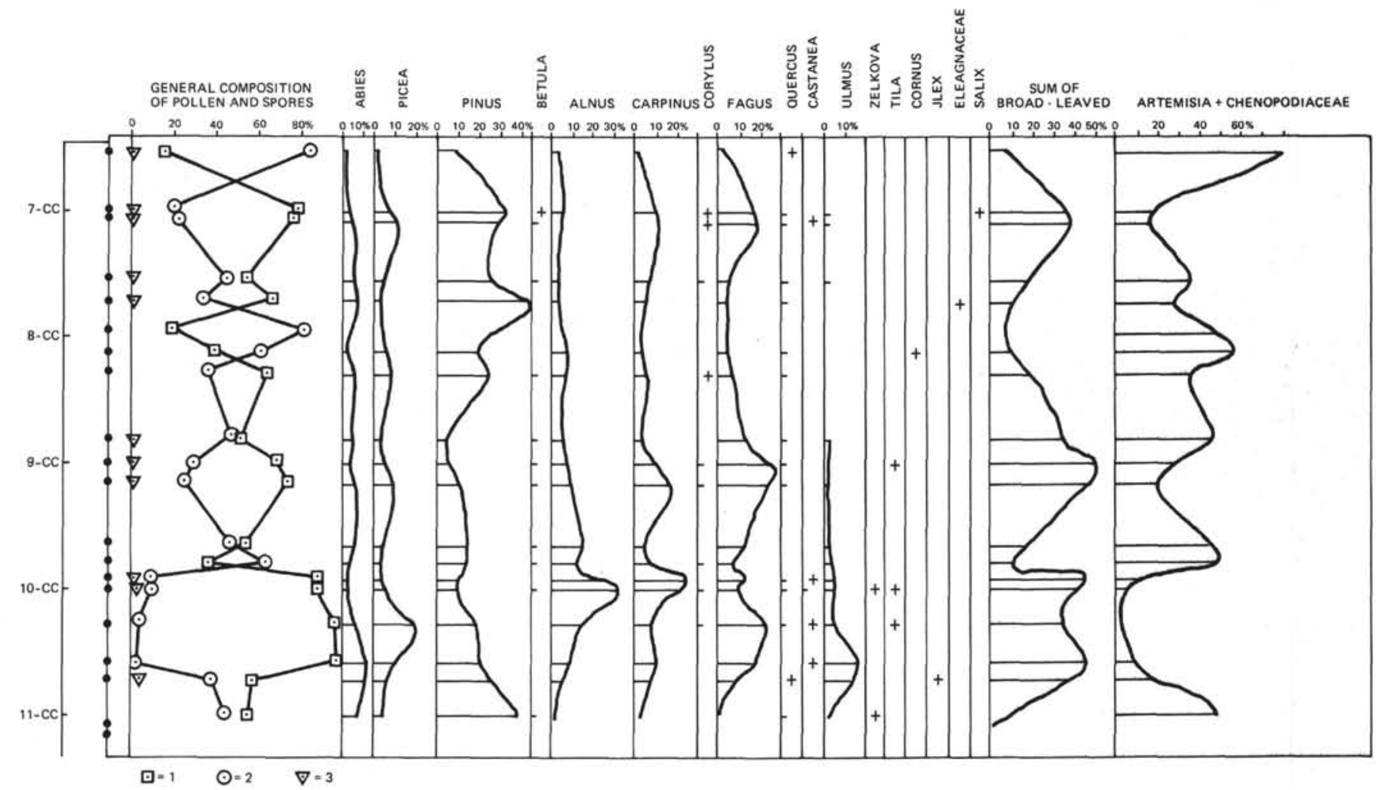

Figure 4. *Spore-pollen diagram of Karangatskie and post-Karangatskie layers for Hole 379A. Symbols: 1. Pollen of trees. 2. Pollen of shrubs and grass. 3. Spores.*

decreases. On the whole, it is a temperate-warm flora. The conifers are represented almost exclusively by the Pinaceae family (the pollen of the Cupressaceae and Taxodiaceae families is presented by sporadic grains). Broad-leaved plants include a great number of genera and species (Plates 13-15).

10) The post-Karangatien layers were penetrated above Core 7 in Hole 380, and in Hole 379A, Cores 4 to 10-5, sub-bottom depth 35.5-88 meters.

The lower part is characterized by palyno-assemblages indicating an alternation of forest and steppe vegetation (Figure 4). This appears to be due to fluctuations of climate preceding the principal glaciation of the Würm. The upper part of the post-Karangatien interval corresponds to the maximum glaciation of the Würm, and is characterized by palyno-assemblages of the steppe type (Plate 16).

The Karangatien and post-Karangatien palyno-assemblages relate well to the late Pleistocene of East Macedonia (van der Hammen et al., 1971).

11) Floras of Surozhskie (?) age are poorly characterized. Warming and moistening of the climate are indicated by an increase in tree pollen, mostly at the expense of *Pinus*; these were recognized in the samples from the upper part of Hole 380, Core 2, and Core 1444 (437-440 cm), and appear to represent the interstadial warming of the second half of the Würm.

12) Novo-Euxinian floras are present in samples from the lower part of Cores 1433, 1444, and 1474 (Figure 2), and the upper samples from Holes 380 and 379A. On the whole, the palyno-assemblages are temperate-cool with predominance of the grass pollen. Also predominant is the pollen of *Artemisia* and, somewhat less, the pollen of various species of Chenopodiaceae (Plate 17). Herbage is diverse and abundant. Among the prevalent tree plant pollen are *Pinus* and, in some areas, *Betula*. The role of the latter increases considerably compared to birch in the assemblages from the underlying horizons. The constant presence of the pollen of Hoppiphae is peculiar. Broad-leaved plant pollen are sporadic (Figures 5, 6). The upper part of Novo-Euxinian deposits belongs to the beginning of the Holocene stage.

13) Old Black Sea and Recent sediments were formed under conditions of the Black Sea transgression (Figures 5, 6). The lowermost Old Black Sea layers coincide with the climatic optimum of the Holocene. At this time the presence of pollen of arboreals increases, becoming predominant. *Alnus* is also important. The presence of *Betula* is negligible. Pine is predominant among the conifers. The presence of dark conifers is limited (1%-2%). Herbage is abundant and diverse (Plates 17-20). The pollen of *Artemisia* is predominant, and Chenopodiaceae and Gramineae are noticeable.

CONCLUSIONS

The present study of spore-pollen spectra permits discussion of the vegetation cover of the littoral areas only on a conditional basis, because the Black Sea is a site of concentration of the pollen brought from a vast area and from different vegetation zones. We can speak

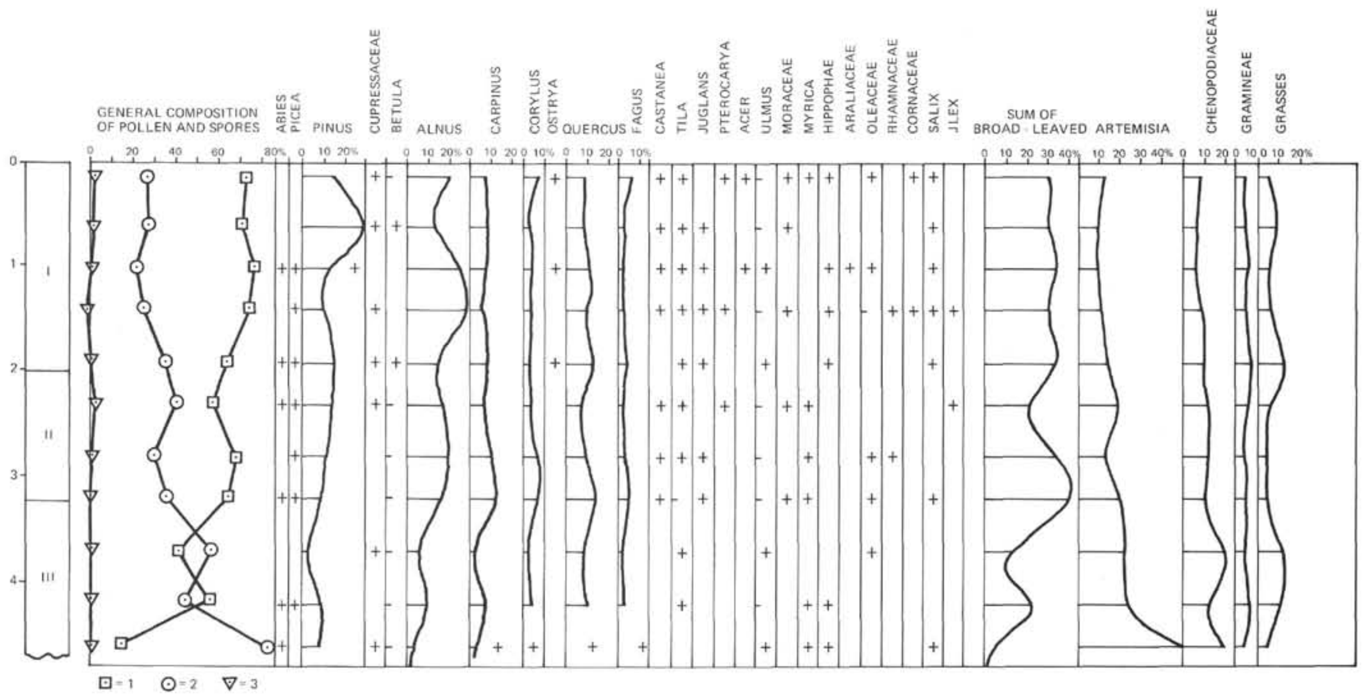

Figure 5. *Spore-pollen diagram of the Black Sea and new Euksinskie layers from Core 1433. Same symbols as Figure 4.*

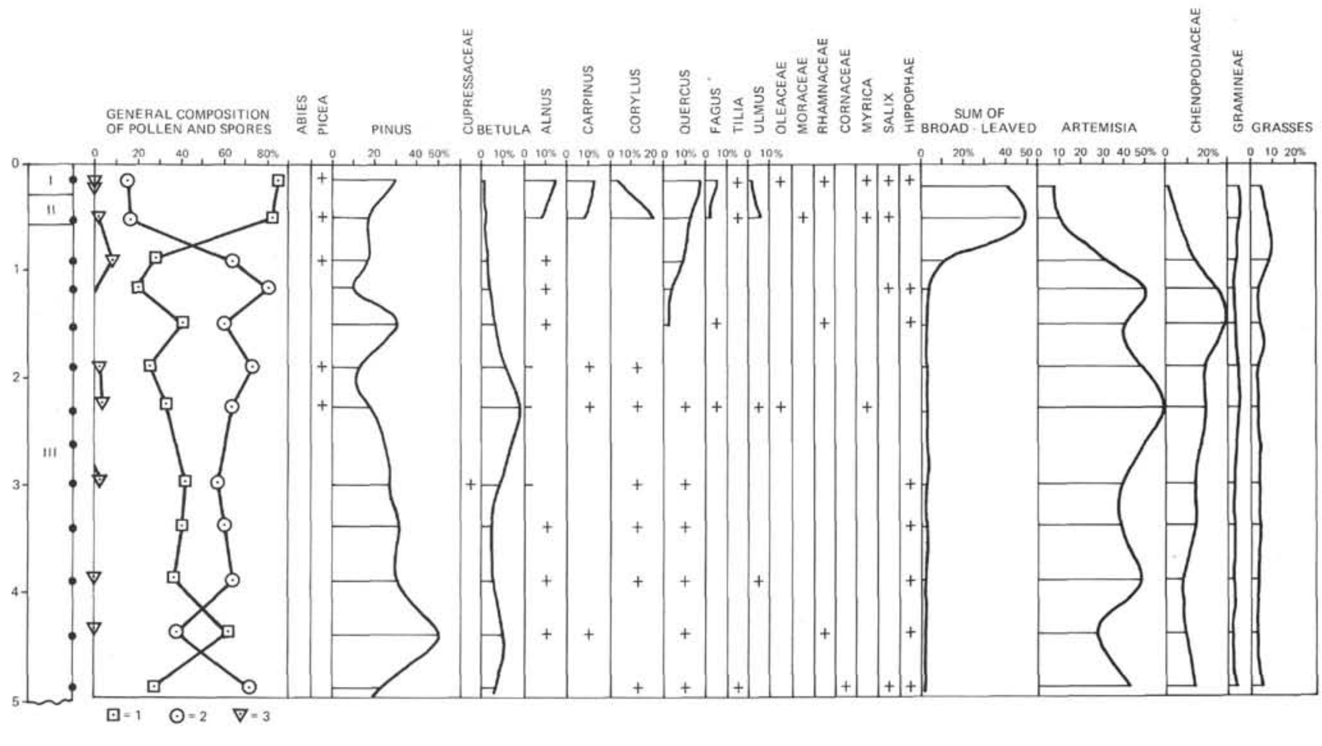

Figure 6. *Spore-pollen diagram of the Black Sea and new Euksinskie layers from Core 1444. Same symbols as Figure 4.*

more confidently of the flora of the surrounding territories, even though the floristic list is far from being complete. Large climatic changes clearly affect the composition of palynological complexes, and the succession of floras recovered from the Black Sea cores clearly indicate climatic changes that occurred in the area during the late Tertiary and Quaternary.

In the Pliocene all the areas surrounding the Black Sea were occupied by a forest vegetation. The forests were complex as indicated not only by their floristic composition but their structure as well (multistage, with a rich underbrush). Presence of a mountainous relief made the structure of the forest cover even more complex, forming belts of mountain forests. The upper belt most probably was occupied by dark coniferous forests as indicated by various species such as *Picea*, *Abies*, and *Tsuga*. Considerable areas were occupied by forest formations containing various kinds of *Pinus* and *Cedrus*. The lower belt of broad-leaved trees was situated within a large relief and included species that differed ecologically. Small-leaved trees (*Betula*) appeared and survived as a small admixture in the forests of the upper belt of the mountains. The lower belt of the mountains and the coast probably were covered by the most thermophilic broad-leaved forests and subtropical forms. In more humid regions of the coast there were forests of boggy *Taxodium* and *Nyssa*.

At the end of the Pliocene there were considerable areas of steppe vegetation. Early Pleistocene glaciation clearly changed the character of the vegetation cover. Most of the subtropical Pliocene forms ceased to exist. The floristic composition was poor consisting mostly of grass species. Forest formations remained preserved in the more favorable localities, in mountain refuges, and the main areas were covered by steppe associations. This type of vegetation was common to all stages of Pleistocene glaciation.

During the Interglacial stages, the predominant vegetation cover was the forest formations, having complicated floristic composition and ecology. At the same time, steppe associations played an important role. During the Pleistocene a gradual impoverishment of the flora of tree forms took place at the expense of thermophilic elements (subtropical leaved, exotic conifers, etc.). This may have been the result of many glaciations. At the same time, the diversity of the flora of grass plants was increasing. The latter formed plant associations (meadows and steppes), occupying vast territories during interglacials, and remained predominant in the glacial stages.

We have not completely analyzed all the core material available. It is probably that further detailed investigations will reveal new important peculiarities in the development of vegetation, of both the glacial and interglacial stages.

It is also likely that the optimal phases of some of the interglacials were not studied, and important stages of evolution of the vegetation cover may have been overlooked. As an example, a more thorough study of the Karangatien and Post-Karangatien layers show a rather complicated picture of the evolution of the vegetation cover of this period.

As a result of our studies we have been able to distinguish palynological complexes that reflect changes in the vegetation cover which, in turn, represent in gross the main stages of environment development. These stages agree well with the known scheme of stratigraphic subdivision of the Black Sea basin (Figure 3).

ACKNOWLEDGMENTS

The authors express their sincere gratitude to the Co-Chief Scientists of the expedition, Dr. David A. Ross and Dr. Yuri P. Neprochnov, for the opportunity to undertake this study and to Professor Alfred Traverse for sending us the samples.

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PLATE 1

Palynocomplex from Pliocene Deposits × 500.

Figure 1	*Tsuga* cf. *diversifolia* (Maxim.) Masters. Sample 380-71, CC; 632 k/m.
Figure 2	*Tsuga* cf. *canadensis* (L.) Carr. Sample 380A-71, CC; 632 k/m.
Figure 3	*Tsuga* cf. *krutzschii* Sivak. Sample 380A-60, CC; 630 k/m.
Figure 4	*Tsuga* sp. Sample 380A-65-2, 38-40 cm; 834 k/m.
Figure 5	*Podocarpus* sp. Sample 380A-71-1, 92-94 cm, 370 k/m.
Figure 6	*Pinus* cf. *taedaeformis* Zakl. Sample 380A, 66, CC; 631 k/m.
Figure 7	*Pinus* sect. Cembrae. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 8	*Pinus* sect. Cembrae. Sample 380A-80-1, 135-137 cm; 845 k/m.
Figure 9	*Cedrus* cf. *libani* Lavs. Sample 380A-80-1, 135-137 cm; 845 k/m.
Figure 10	*Picea schrenkianaeformis* Zakl. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 11	*Pinus* sp. Sample 380A-60, CC; 630 k/m.
Figure 12	*Pinus exelsaeformis* Zakl. Sample 380A-66, CC; 631 k/m.
Figure 13	*Picea schrenkianaeformis* Zakl. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 14	*Pinus cembraeformis* Zakl. Sample 380A-66, CC; 631 k/m.
Figure 15	*Cedrus* aff. *deodara* Loud. Sample 380A-66, CC; 631 k/m.

PLATE 1

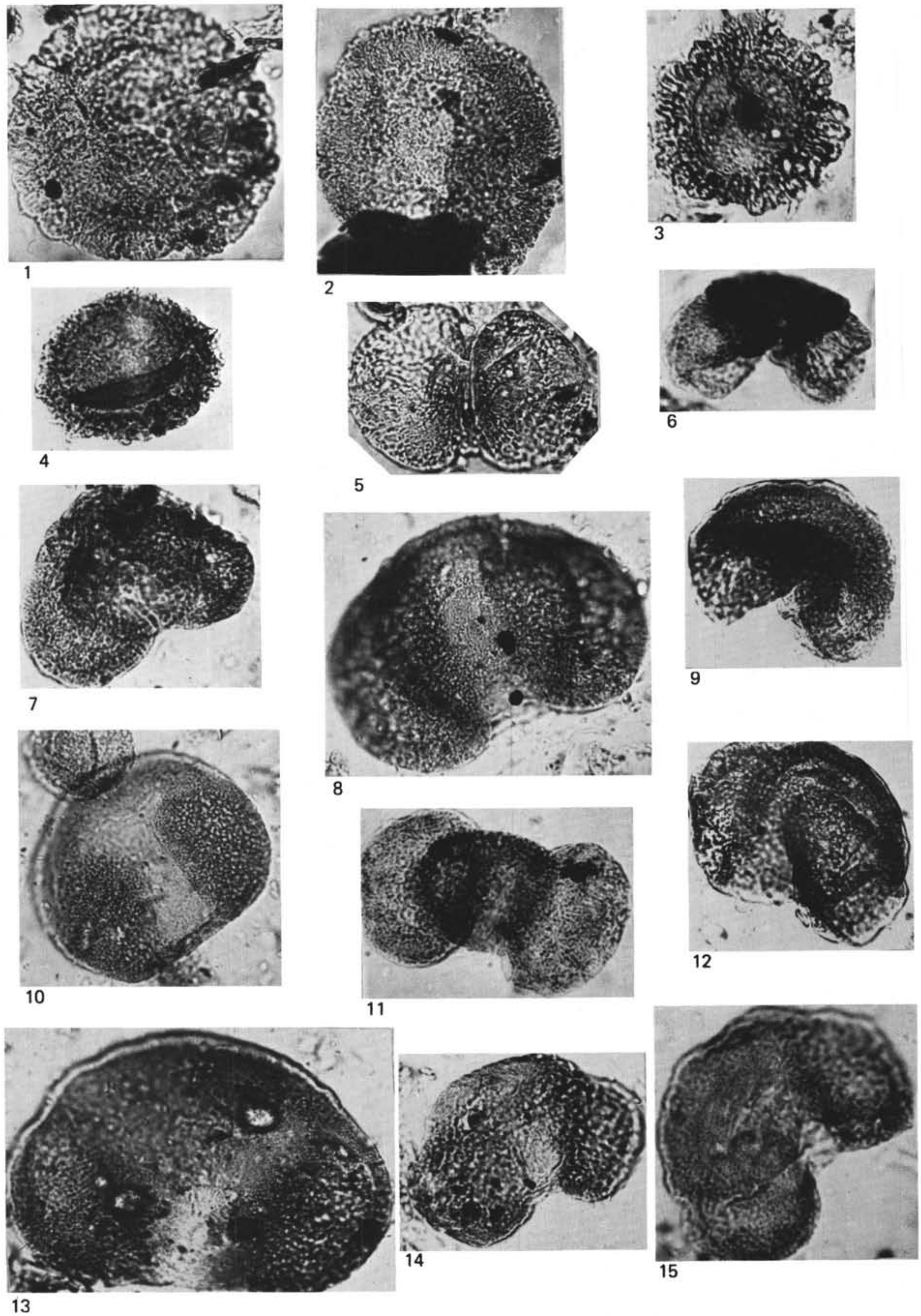

PLATE 2

Palynocomplex from Pliocene deposits. Figures 1-9, × 1000; Figures 10-14, × 500.

Figure 1	*Cryptomeria* sp. Sample 380A-60, CC; 630 k/m.
Figure 2	Cupressaceae. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 3	*Taxodium* sp. Sample 380A-60, CC; 630 k/m.
Figure 4	*Cryptomeria* sp. Sample 380A-66, CC; 631 k/m.
Figure 5	*Taxodium* sp. Sample 380A-80-1, 135-137 cm; 845 k/m.
Figure 6	*Taxodium* sp. Sample 380A-66, CC; 631 k/m.
Figure 7	*Leiotriletes* (Lygodium?). Sample 380A-71, CC; 632 k/m.
Figure 8	*Cyathea* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 9	*Lycopodium* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 10	*Pinus* cf. *minutus* Zakl. Sample 380A-66, CC; 631 k/m.
Figure 11	*Cedrus* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 12	*Sphagnum* sp. Sample 380A-60, CC; 630 k/m.
Figure 13	*Pinus* sect. Eupitys. Sample 380A-66, CC; 631 k/m.
Figure 14	*Pinus* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.

PLATE 2

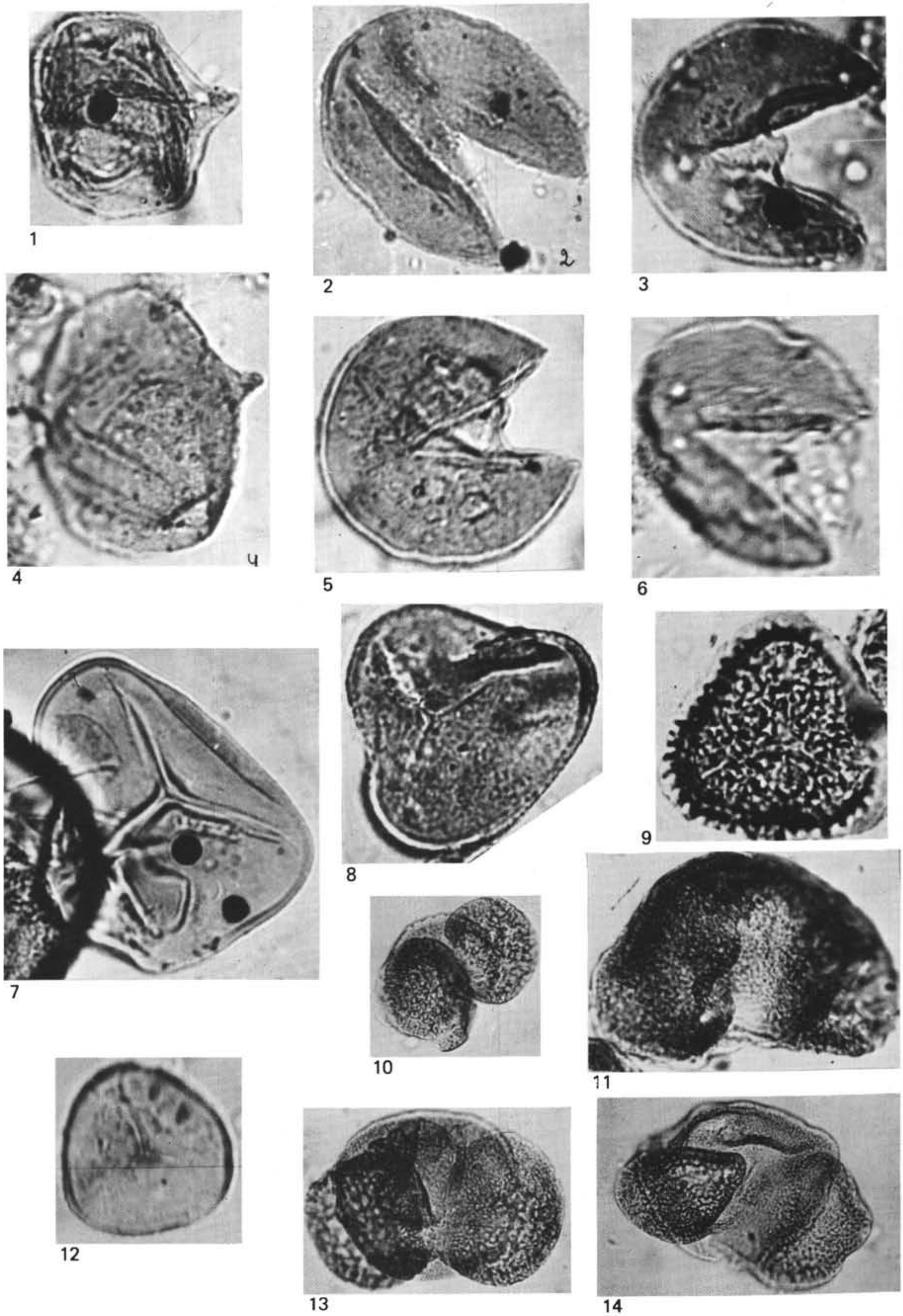

PLATE 3

Palynocomplex from Pliocene Deposits × 1000.

Figures 1, 3, 4	Indeterm. pollen angiosperma. Sample 380A-66, CC; 631 k/m.
Figure 2	*Tilia* sp.$_1$ Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 5	*Tilia* sp.$_2$ Sample 380A-80-1, 135-137 cm; 845 k/m.
Figure 6	*Carya* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 7	*Magnolia* sp. Sample 380A-60, CC; 630 k/m.
Figure 8	*Quercus* cf. *petraea* Liebl. Sample 380A-80-1, 135-137 cm; 845 k/m.
Figure 9	*Magnolia* sp. Sample 380A-60, CC; 630 k/m.
Figure 10	Ericaceae. Sample 380A-80-1, 135-137 cm; 845 k/m.

PLATE 3

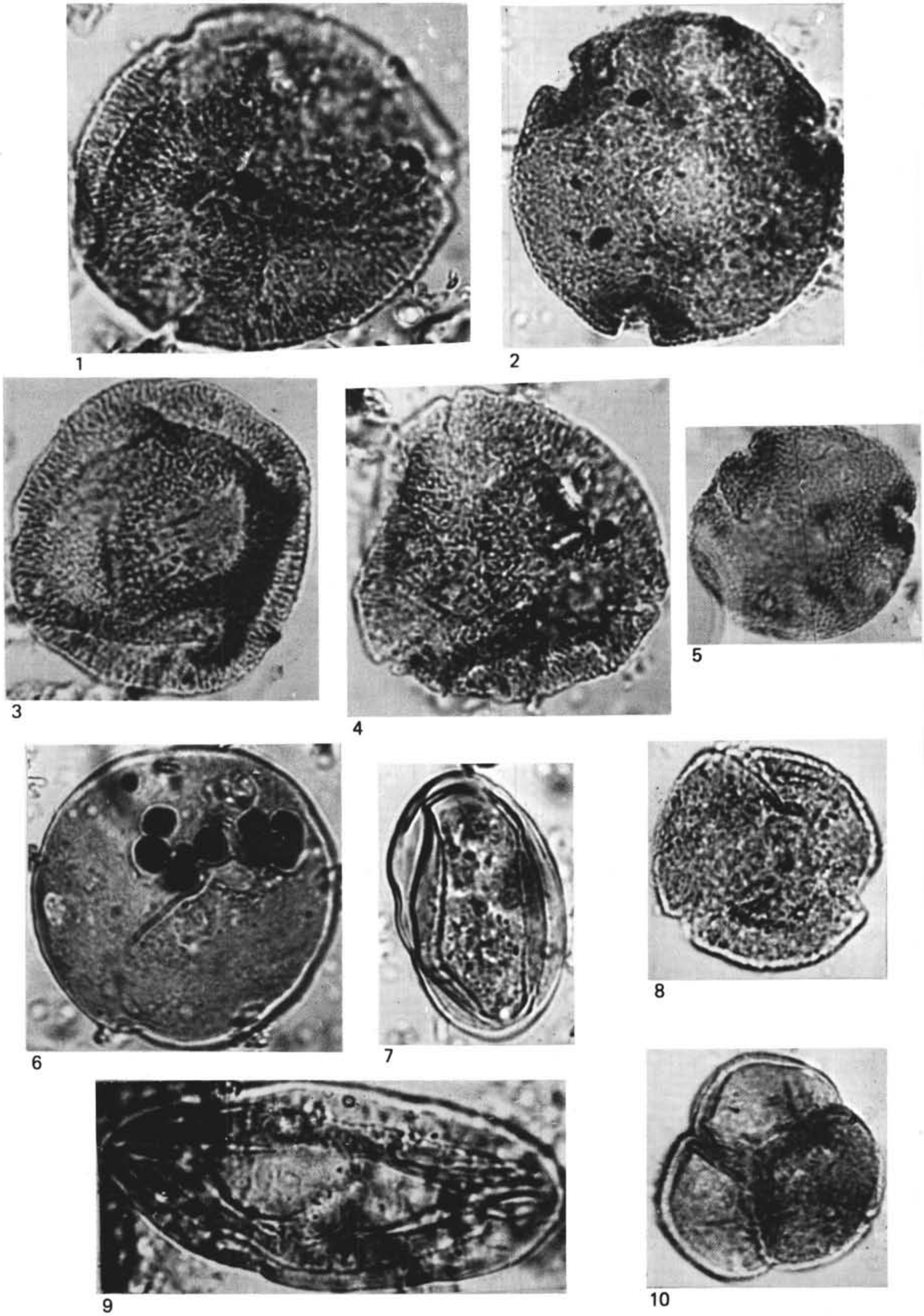

PLATE 4

Palynocomplex from Pliocene deposits. × 1000.

Figure 1	*Liquidambar* sp.$_1$ Sample 380A-80-1, 135-137 cm; 845 k/m.
Figure 2	*Liquidambar* sp.$_2$ Sample 380A-66, CC; 631 k/m.
Figure 3	Triporopollenites (Juglandaceae ?). Sample 380A-66, CC; 631 k/m.
Figure 4	*Liquidambar* sp.$_3$ Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 5	*Carya* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 6	*Triporopollenites* (Juglandaceae?). Sample 380A-60, CC; 630 k/m.
Figure 7	Juglandaceae *(Engelhardtia?)*. Sample 380A-66, CC; 631 k/m.
Figure 8	*Alnus* sp.$_1$ Sample 380A-66, CC; 631 k/m.
Figure 9	*Alnus* sp.$_2$ Sample 380A-66, CC; 631 k/m.
Figure 10	*Pterocarya* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.
Figure 11	*Juglans* sp. Sample 380A-60, CC; 630 k/m.
Figure 12	*Zelkova* sp. Sample 380A-60, CC; 630 k/m.
Figure 13	*Ulmus* sp. Sample 380A-66, CC; 631 k/m.
Figure 14	*Celtis* sp. Sample 380A-73-1, 92-94 cm; 839 k/m.

PLATE 4

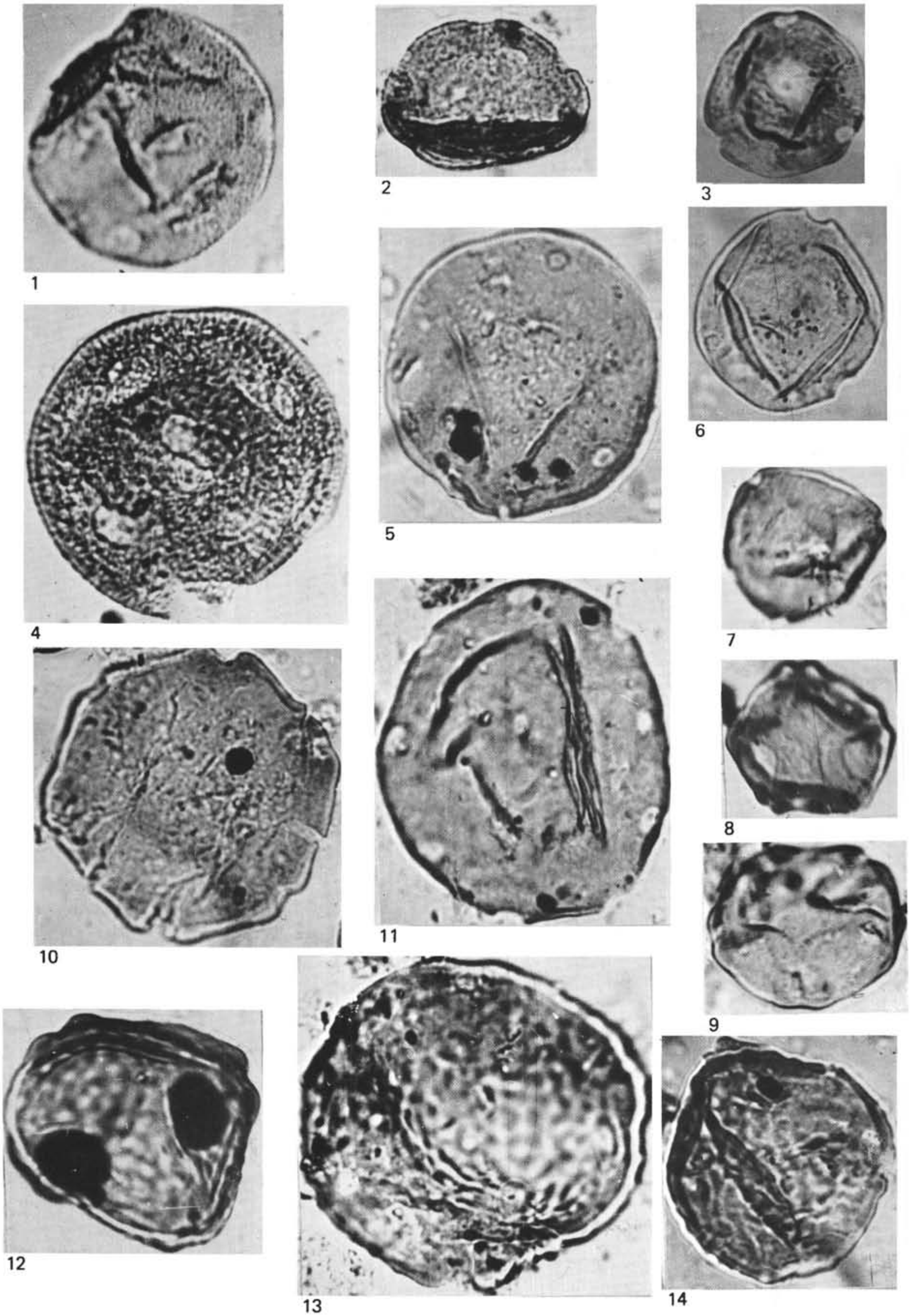

PLATE 5

Palynocomplex from upper part of the Pliocene deposits. Sample 380A-48, CC; 662 k/m.
Figures 1-4, × 500; Figures 5-14, × 1000.

Figure 1	*Tsuga* sp.
Figure 2	*Pinus* sect. Cembrae.
Figure 3	*Pinus* sect. Cembrae.
Figure 4	*Keteleeria* sp.
Figure 5	Cupressaceae.
Figure 6	Chenopodiaceae.
Figure 7	*Tilia* sp.
Figure 8	*Carya* sp.
Figure 9	*Magnolia* sp.
Figure 10	*Pterocarya* sp.
Figure 11	*Amygdalus* sp.
Figure 12	*Platycarya* sp.
Figure 13	*Triporopollenites* sp.
Figure 14	*Triporopollenites* sp.
Figure 15, 16	Dinoflagellates.

PLATE 6

Palynocomplex from Gurian sediments. Figures 1-14, 16, ×100;
Figure 15, 17-23, ×500.

Figures 1, 2 5-11	Chenopodiaceae (different species). Sample 380A-22, CC; 654 k/m.
Figure 3	*Ephedra* sp. Sample 380A-28, CC; 748 k/m.
Figure 4, 8	*Pinus* sect. Eupitys. Sample 380A-22, CC; 654 k/m.
Figure 13	*Betula* sp. Sample 380A-26, CC; 655 k/m.
Figure 14	Rosaceae. Sample 380A-22, CC; 654 k/m.
Figure 15, 16	Compositae. Sample 380A-26, CC; 655 k/m.
Figures 12, 17-23	Dinoflagellates. Sample 380A-27, CC; 747 k/m.

(see p. 968)

PLATE 5

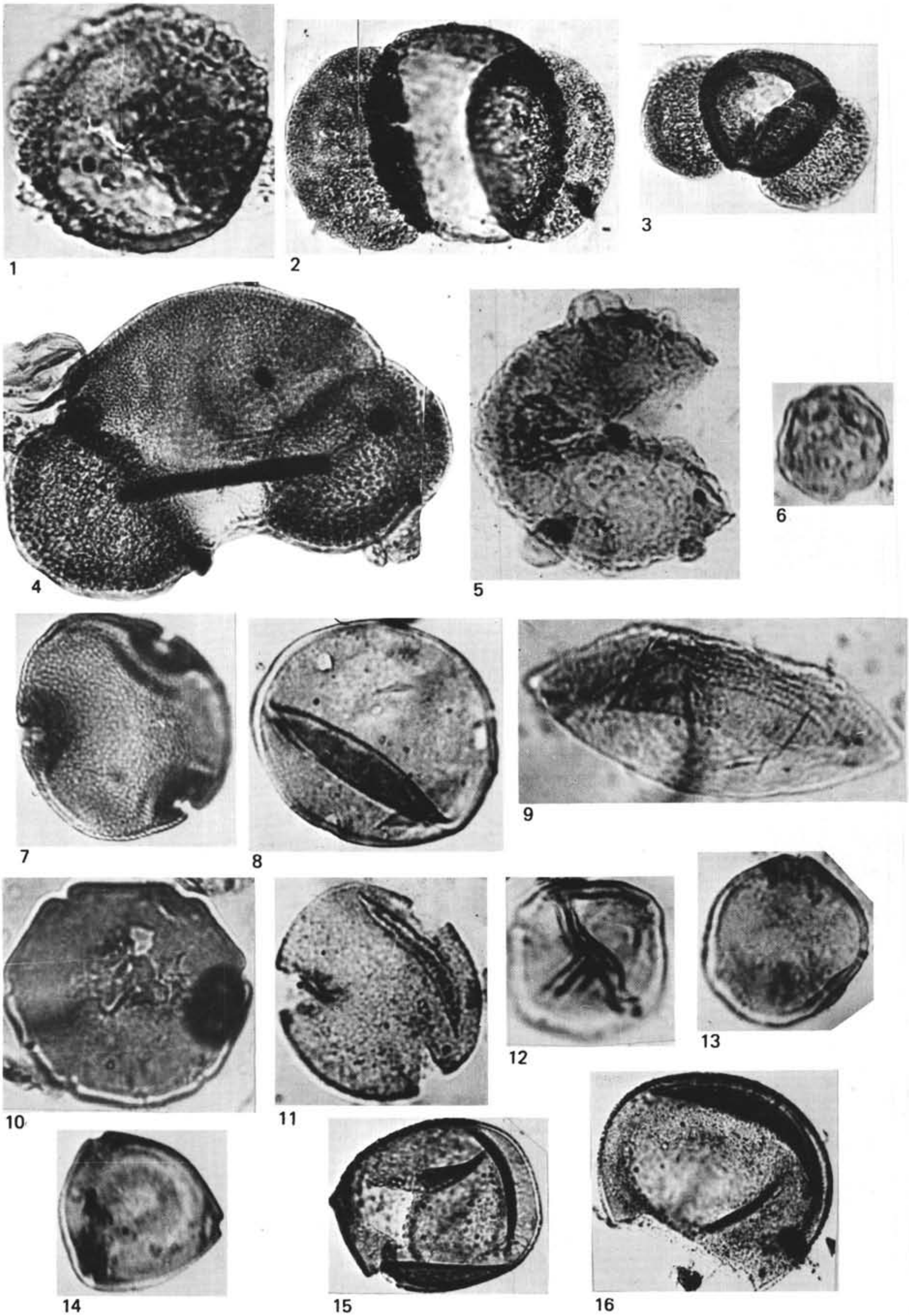

PLATE 6

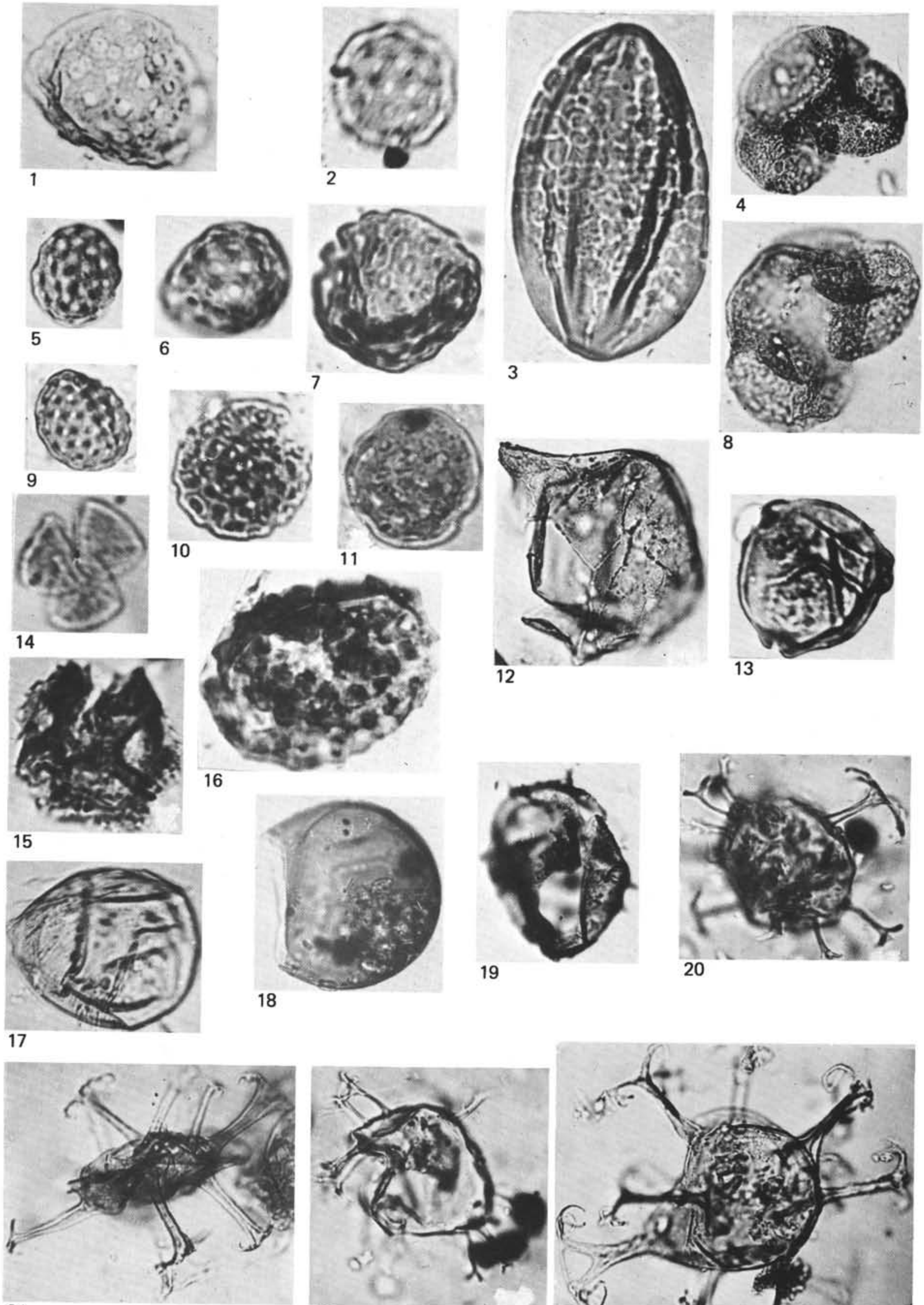

PLATE 7

Palynocomplex from Chauda sediments.

Figures 1, 3-5, 8-11, 13-16, 18, × 1000;
Figures 6, 7, 12, 17, 19, × 600.

Figure 1	*Pinus* sp. Sample 380A-8, CC; 639 k/m.
Figure 2	*Picea* sp. Sample 380A-10, CC; 624 k/m.
Figure 3	*Betula* sp. Sample 380A-8, CC; 639 k/m.
Figure 4	*Pinus* sect. Cembrae. Sample 380A-8, CC; 639 k/m.
Figure 5	*Castanea* sp. Sample 380A-8, CC; 639 k/m.
Figure 6	*Sequoia* sp. Sample 380A-8, CC; 639 k/m.
Figure 7	*Taxodium* sp. Sample 380A-8, CC; 639 k/m.
Figure 8	*Carya* sp. Sample 380A-8, CC; 639 k/m.
Figures 9, 13	Anacardiaceae (Rhus?). Sample 380A-8, CC; 639 k/m.
Figure 10	*Fagus* sp. Sample 380A-8, CC; 639 k/m.
Figure 11	*Triporopollenites*. Sample 380A-8, CC; 639 k/m.
Figure 12	Leguminosae(?). Sample 380A-8, CC; 639 k/m.
Figure 14	*Myrica* sp. Sample 380A-7, CC; 651 k/m.
Figure 15	Chenopodiaceae. Sample 380A-10, CC; 624 k/m.
Figure 16	*Liquidambar* sp. Sample 380A-10, CC; 624 k/m.
Figure 17	*Carpinus* sp. Sample 380A-8, CC; 639 k/m.
Figure18	*Betula* sp. Sample 380A-8, CC; 639 k/m.
Figure 19	Polypodiaceae. Sample 380A-8, CC; 639 k/m.

(see p. 970)

PLATE 8

Redeposited Mezosoic spores. Sample 380A-8, CC; 639 k/m. × 1000.

(see p. 971)

PLATE 7

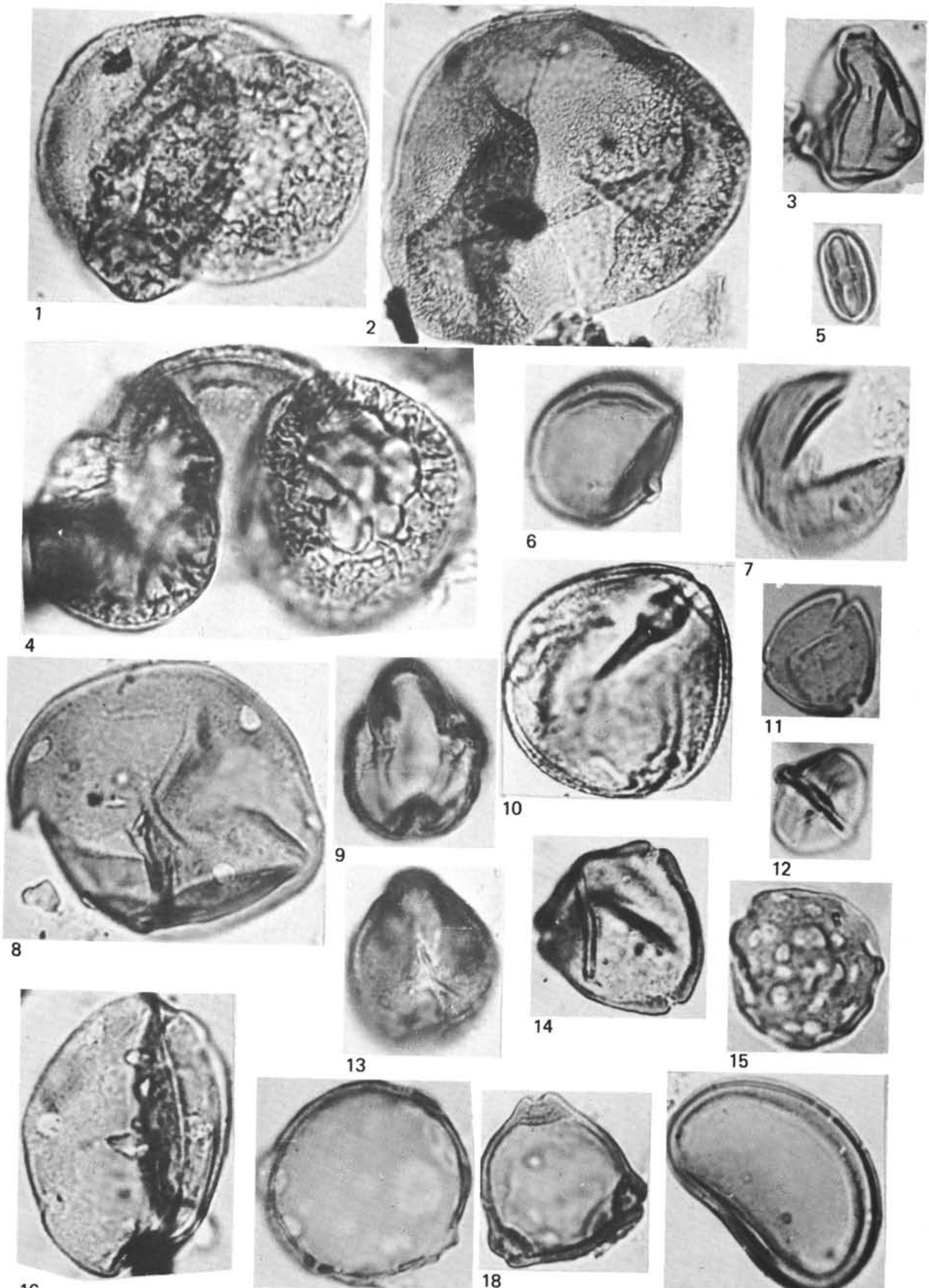

PLATE 8

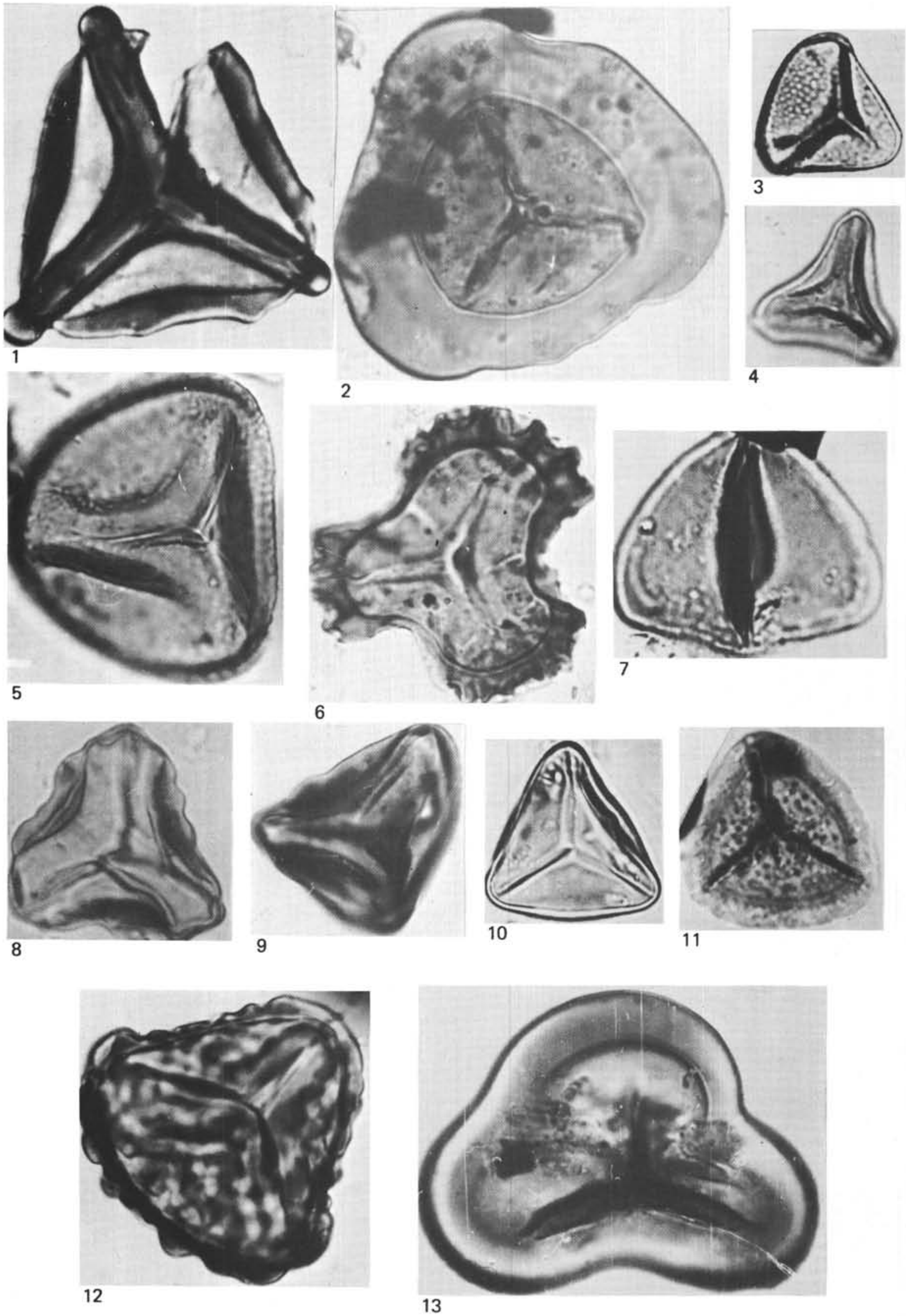

PLATE 9

Palynocomplex from Paleouzunlar sediments. Figures 1, 6, × 500; Figures 2-5, 7-11, × 1000.

Figure 1	*Abies* sp. Sample 380-33, CC; 646 k/m.
Figure 2	*Pinus* sp. Sample 379-52, CC; 803 k/m.
Figure 3	*Taxodium* sp. Sample 380-36, CC; 647 k/m.
Figure 4	*Taxodium* sp. Sample 380-33, CC; 646 k/m.
Figure 5	*Quercus* sp. Sample 380-36, CC; 647 k/m.
Figure 6	*Tsuga* sp. Sample 379A-52, CC; 803 k/m.
Figure 7	*Acer* sp. Sample 380-36, CC; 647 k/m.
Figures 8, 9	*Alnus* sp. Sample 380-36, CC; 647 k/m.
Figure 10	*Carpinus* cf. *caucasica* Grossh. Sample 380-36, CC; 647 k/m.
Figure 11	*Carpinus* cf. *betulus* L. Sample 380-33, CC; 646 k/m.

PLATE 9

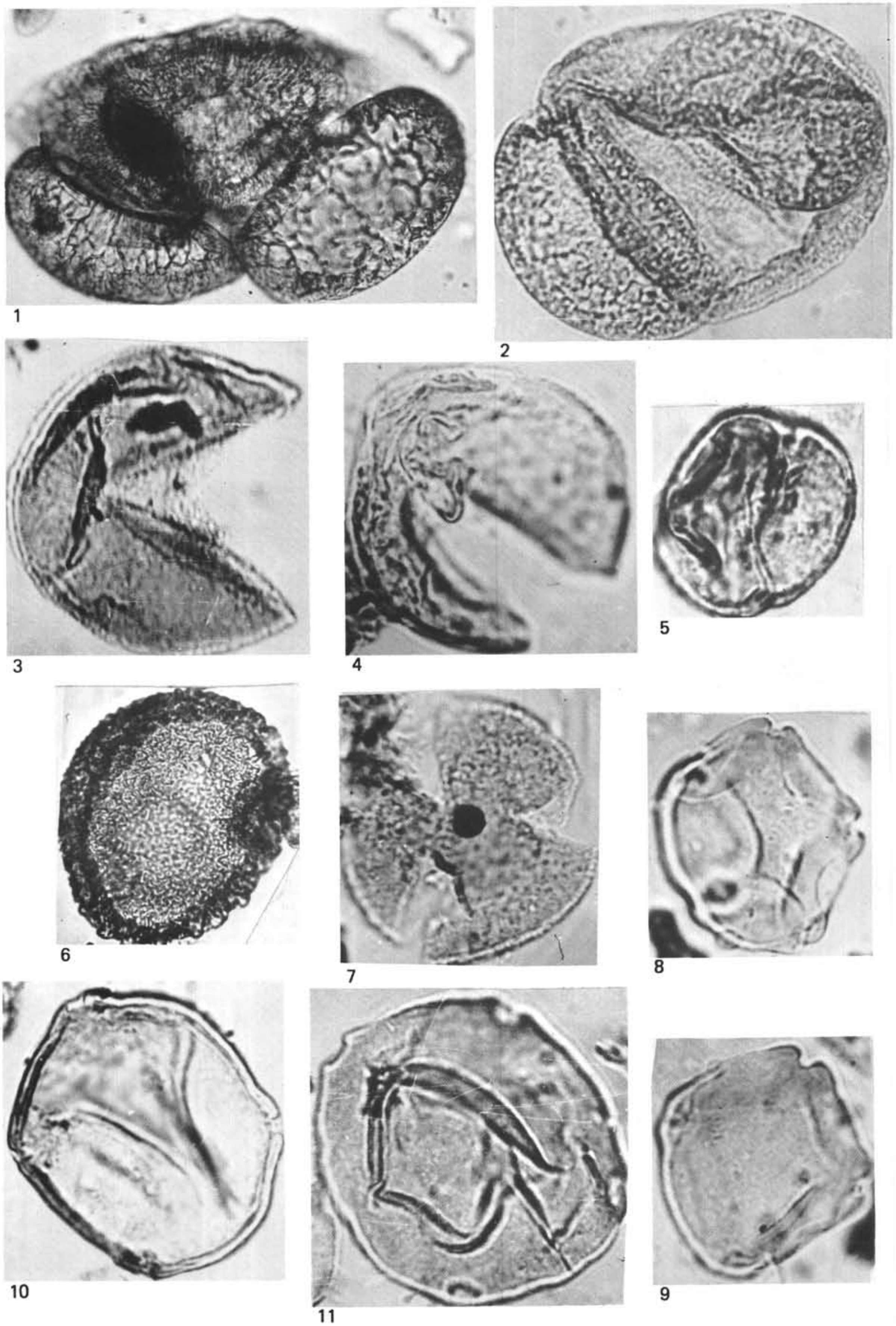

PLATE 10

Palynocomplex from Palaeouzunlar sediments. Figures 1-11, 13-15, × 1000; Figure 12, × 500.

Figure 1	*Carpinus* cf. *betulus* L. Sample 380-36, CC; 647 k/m.
Figure 2	*Triporopollenites* sp. Sample 380-36, CC; 647 k/m.
Figure 3	*Triporopollenites* sp. Sample 380-36, CC; 647 k/m.
Figure 4	Rosaceae. Sample 380-36, CC; 647 k/m.
Figure 5	Polygalaceae. Sample 380-33, CC; 646 k/m.
Figure 6	Leguminosae. Sample 380-36, CC; 647 k/m.
Figure 7	Betulaceae (Corylus?). Sample 380-33, CC; 646 k/m.
Figures 8, 9	Indeterm. pollen Angiosperms. Sample 380-33, CC; 646 k/m.
Figure 10	*Polygonum* cf. *persicaria*. Sample 380-36, CC; 647 k/m.
Figure 11	*Triporopollenites*. Sample 380-33, CC; 646 k/m.
Figure 12, 13	Dinoflagellates. Sample 380-36, CC; 647 k/m.
Figures 14, 15	*Cimatosphaera* sp. Sample 380-36, CC; 647 k/m.

PLATE 11

Palynocomplex from Drevneeuxinien sediments. Figures 1, 2, × 500; Figures 3-20, × 1000.

Figures 1, 2	*Pinus* sect. Eupitys. Sample 380-22, CC; 622 k/m.
Figure 3	*Carpinus* cf. *betulus*. Sample 380-23, CC; 623 k/m.
Figures 4-19	Chenopodiaceae (different species). Sample 380-22, CC; 622 k/m.
Figure 20	*Betula* sp. Sample 380-27, CC; 644 k/m.

(see p. 976)

PLATE 10

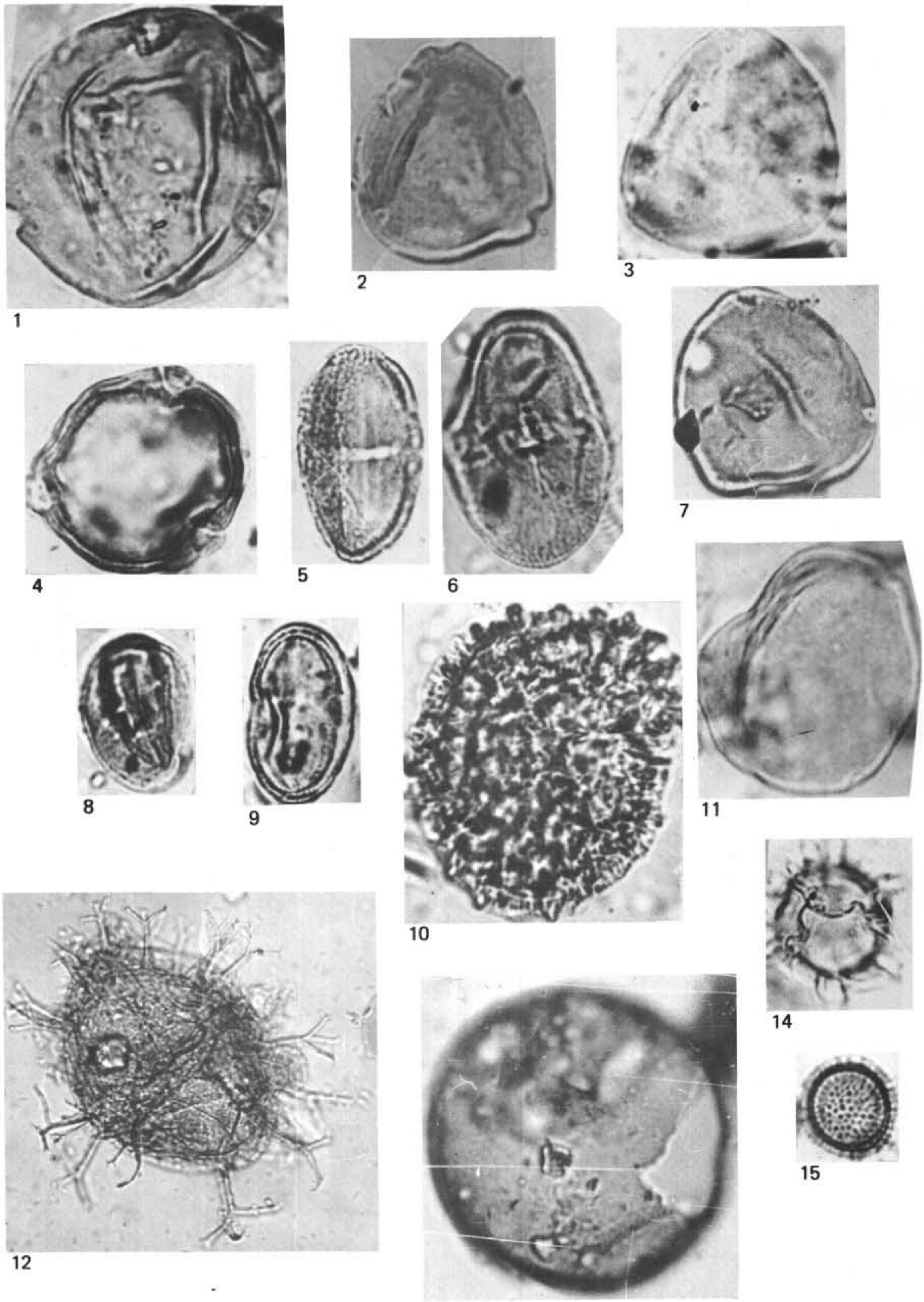

PLATE 11

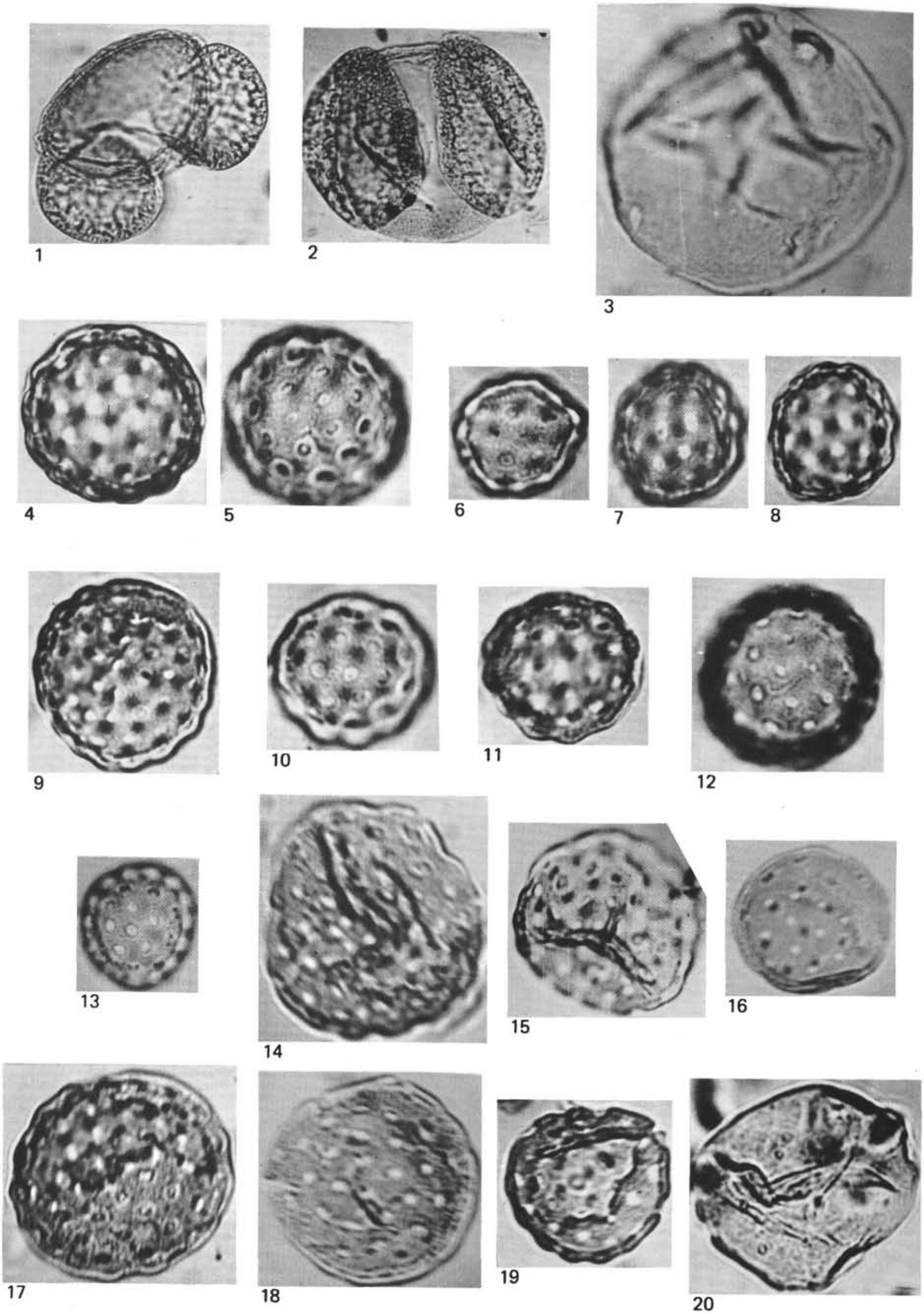

PLATE 12

Gymnosperma pollen from Uzunlar sediments. Sample 380-11, CC; 619 k/m. Figure 1, × 600; Figures 2-6, × 500; Figures 7, 8, × 1000.

Figure 1	*Picea* sp.
Figure 2	*Pinus* sect. Eupitys.
Figure 3, 5	*Pinus* sect. Cembrae.
Figure 4	*Abies* sp.
Figure 6	*Abies* sp.
Figure 7	*Taxodium* sp.
Figure 8	*Taxodium* sp.

(see p. 978)

PLATE 13

Angiosperma Pollen from Uzunlar sediments. Sample 380-11, CC; 619 k/m. × 1000.

Figures 1, 2	*Tilia* sp.
Figure 3	*Quercus* sp.
Figure 4	*Carpinus* cf. *betulus* L.
Figure 5	*Ulmus* cf. *scabra* Mill.
Figures 6, 9	*Hedera* sp.
Figures 7, 8	Compositae.
Figures 10, 11	Indeterm. pollen.

(see p. 979)

PLATE 12

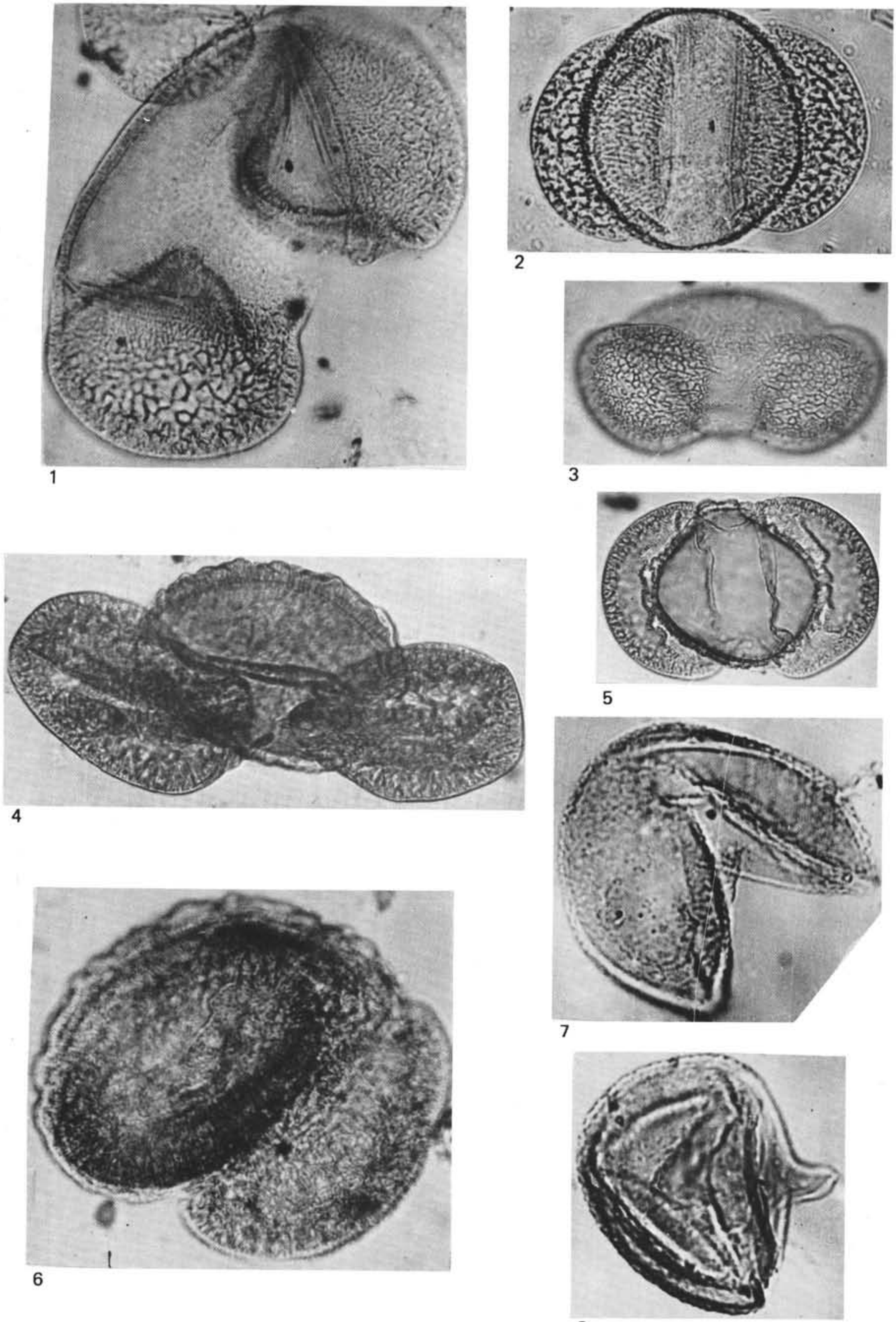

PLATE 13

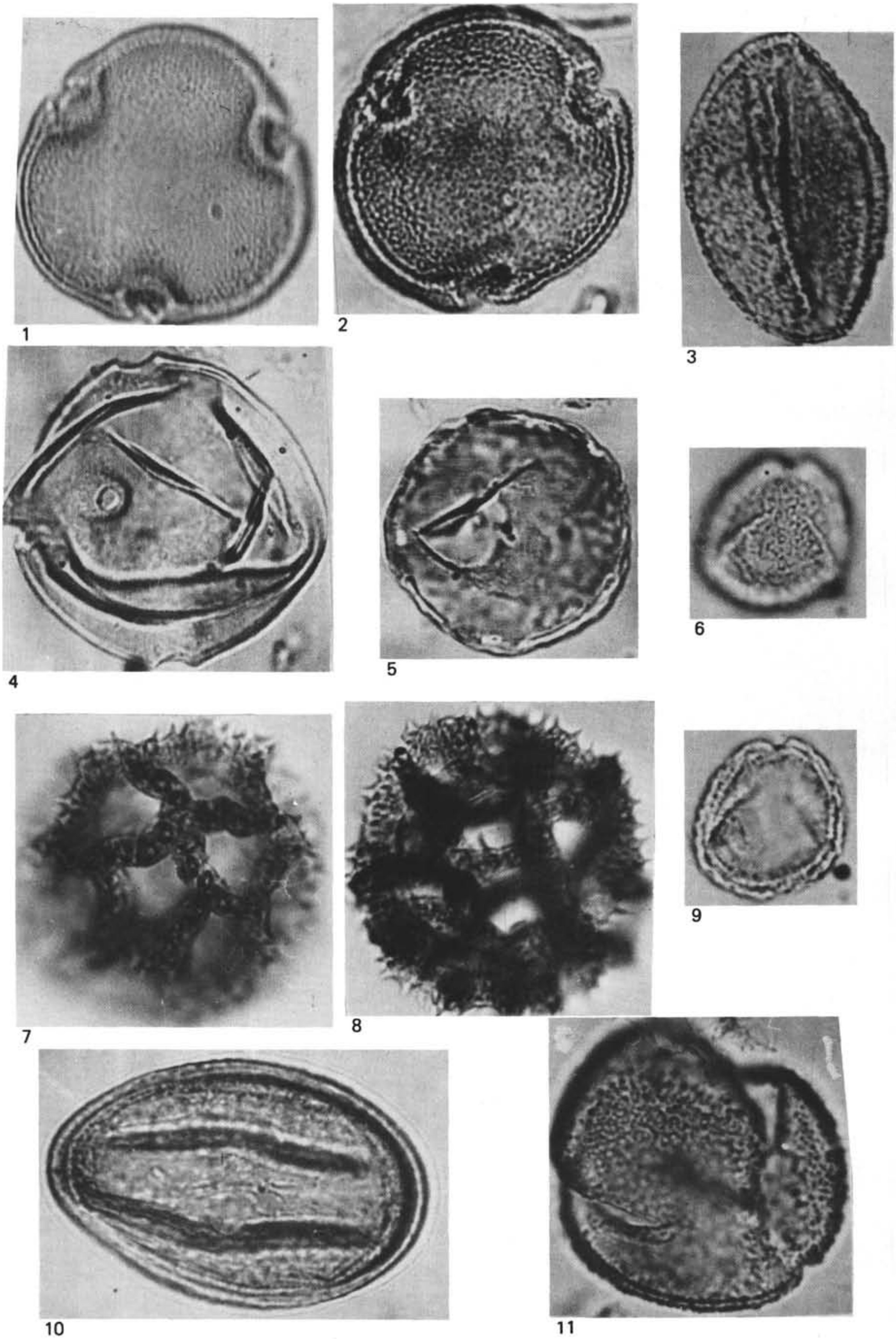

PLATE 14

Palynocomplex from Karangat sediments. Figures 1-6, ×500; Figures 7-10, ×1000.

Figure 1	*Abies* sp. Sample 379A-11-2, 93-95 cm; 832 k/m.
Figures 2, 3	*Pinus* sect. Eupitys. Sample 379A-11-2, 93-95 cm; 832 k/m.
Figure 4	*Pinus* sect. Eupitys. Sample 380-5, CC; 637 k/m.
Figure 5	*Pinus* sect. Eupitys. Sample 380-7, CC; 638 k/m.
Figure 6	*Picea* sp. Sample 380-5, CC; 637 k/m.
Figures 7-10	*Polypodiaceae.* Sample 380-5, CC; 637 k/m.

PLATE 15

Palynocomplex from Karangat sediments. × 1000.

Figure 1	*Ulmus* $sp._1$ Sample 380-5, CC; 637 k/m.
Figure 2	*Ulmus* $sp._2$ Sample 380-7, CC; 638 k/m.
Figure 3	*Fagus silvatica* L. Sample 380-7, CC; 638 k/m.
Figures 4, 5	*Fagus orientalis* Lipsky. Sample 380-7, CC; 638 k/m.
Figure 6	*Betula* sp. Sample 380-5, CC; 637 k/m.
Figure 7	*Quercus* cf. *robur* L. Sample 380-7, CC; 638 k/m.
Figure 8	*Quercus* cf. *pubescens* Willd. Sample 380-5, CC; 637 k/m.
Figure9	*Alnus incana* (L.) Moench. Sample 380-7, CC; 638 k/m.
Figure 10	*Alnus* sp. Sample 380-7, CC; 638 k/m.
Figure 11	*Carpinus betulus* L. Sample 380-7, CC; 638 k/m.
Figure 12	*Carpinus caucasica* Grossh. Sample 380-5, CC; 637 k/m.
Figure 13	*Tilia* sp. Sample 380-7, CC; 638 k/m.

(see p. 982)

PLATE 14

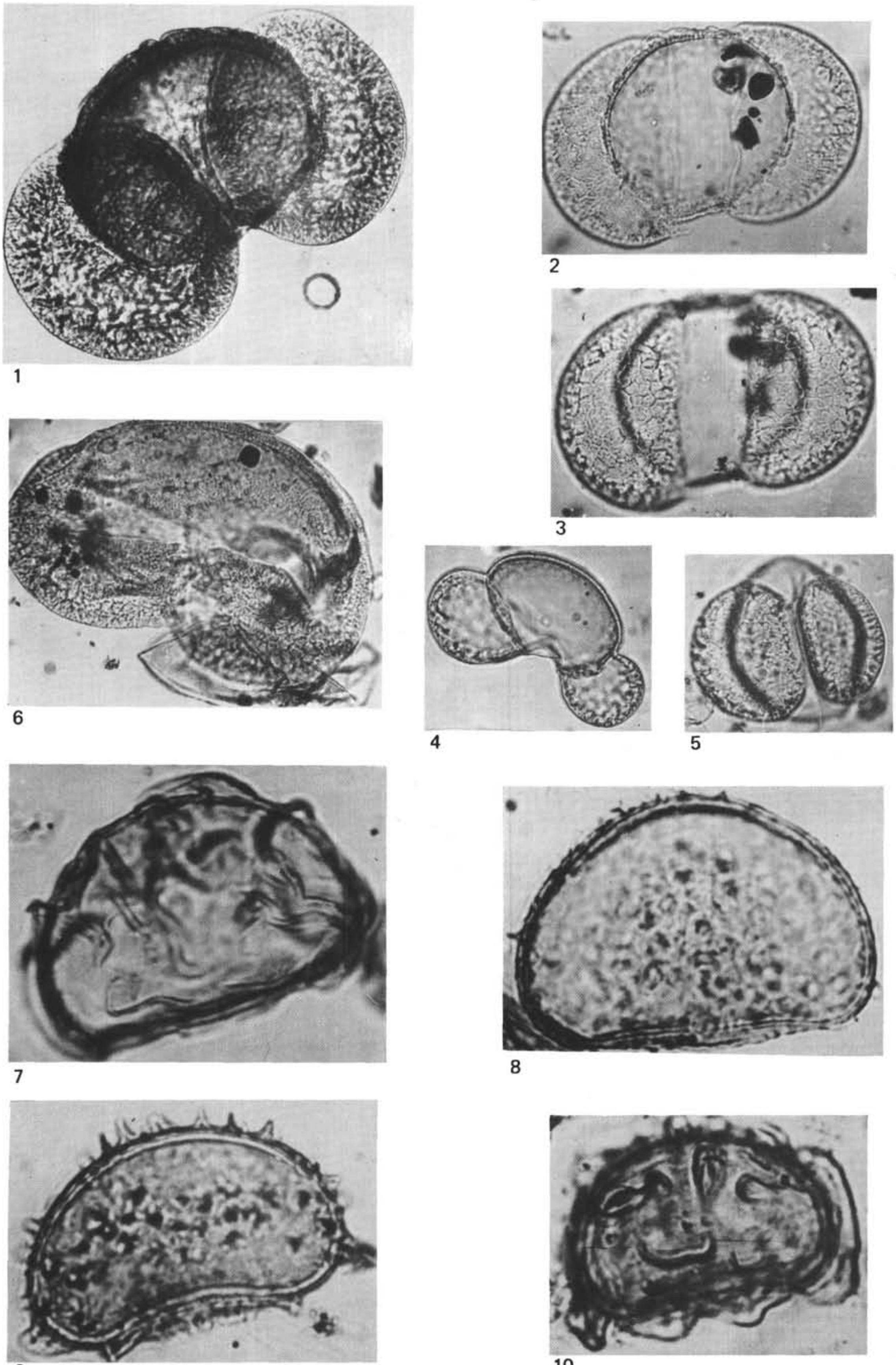

PLATE 15

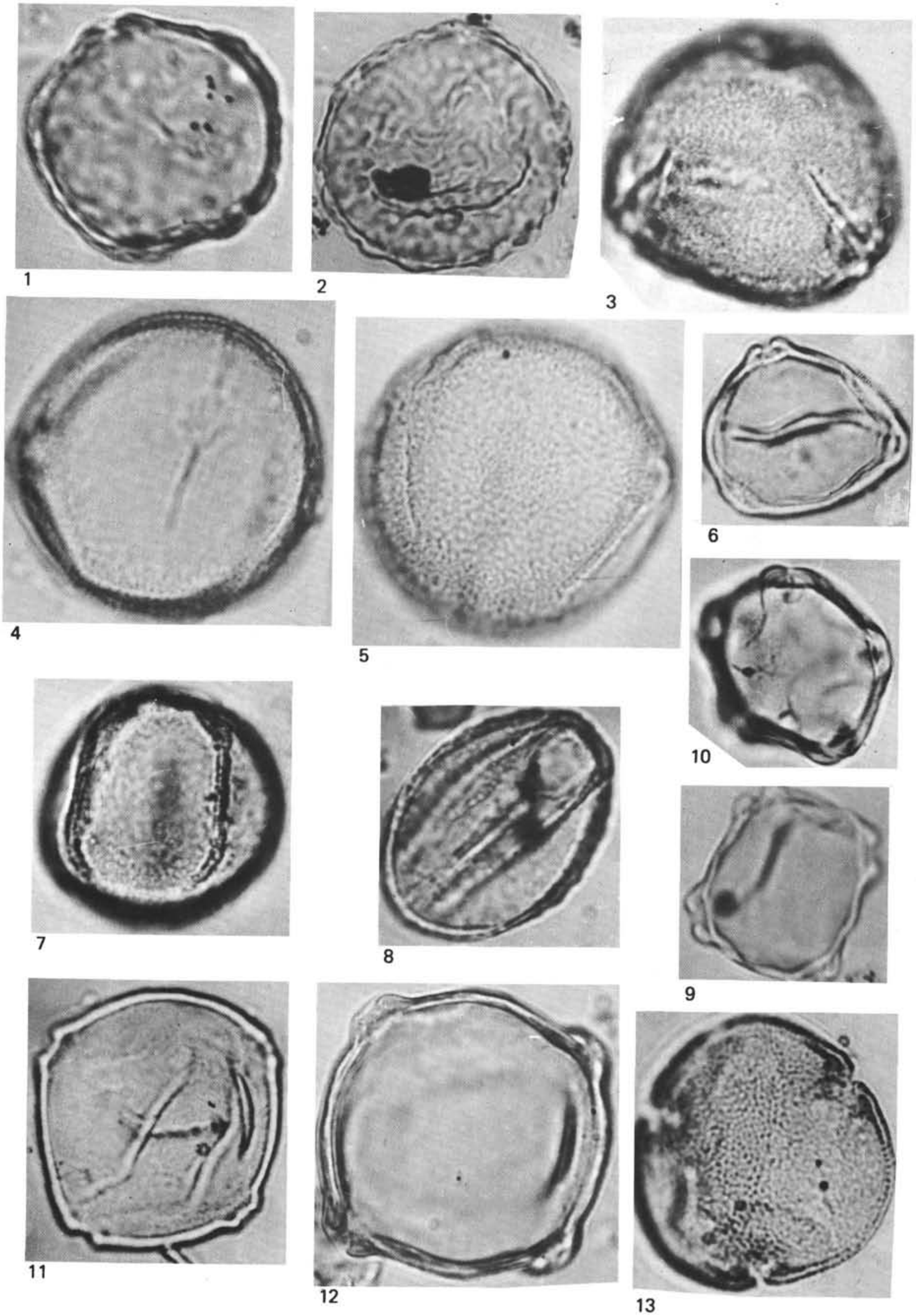

PLATE 16

Palynocomplex from Karangat sediments. × 1000.

Figure 1	*Carpinus orientalis* Mill. Sample 380-7, CC; 638 k/m.
Figure 2	*Corylus* sp. Sample 380-7, CC; 638 k/m.
Figure 3	*Ephedra* sp. Sample 380-5, CC; 637 k/m.
Figure 4	*Sueda* sp. Sample 380-5, CC; 637 k/m.
Figure 5	*Atriplex* sp. Sample 380-5, CC; 637 k/m.
Figures 6, 7	*Kochia* sp. Sample 380-7, CC; 638 k/m.
Figures 8, 12	*Artemisia* sp. Sample 380-5, CC; 637 k/m.
Figure 9	*Salsola* sp. Sample 380-7, CC; 638 k/m.
Figures 10, 11	*Chenopodium* sp. Sample 380-7, CC; 638 k/m.
Figure 13	Labiatae. Sample 380-7, CC; 638 k/m.
Figures 14, 15	*Ribes* sp. Sample 380-7, CC; 638 k/m.
Figures 16, 17	Umbelliferae. Sample 380-7, CC; 638 k/m.
Figures 18, 19	Compositae. Sample 380-5, CC; 637 k/m.

(see p. 984)

PLATE 16

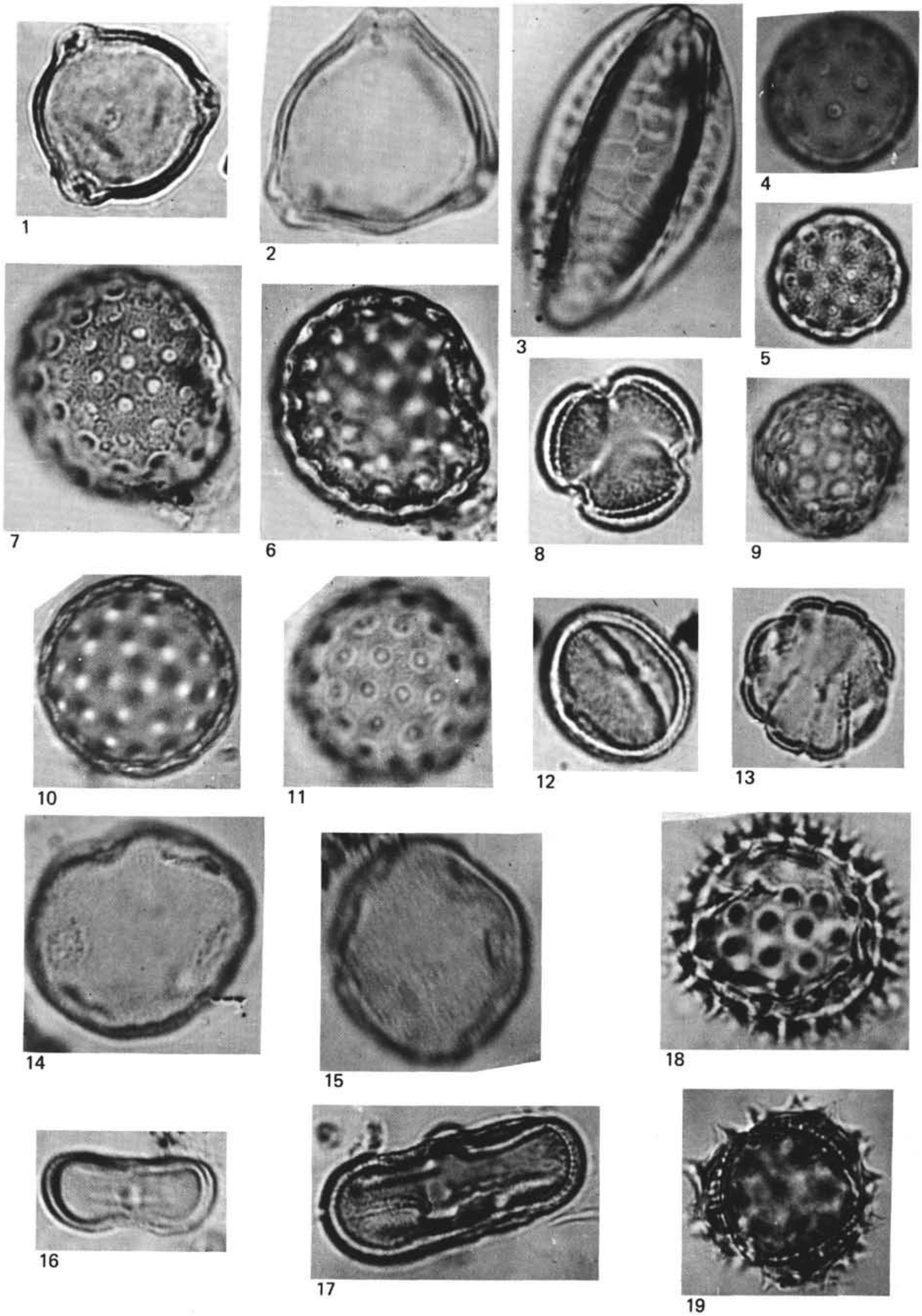

PLATE 17

Pollen from WHOJ Black Sea Cores 1433 and 1444. New-Euxinien and Holocene sediments. × 1000.

Figures 1, 2	*Chenopodium* sp. Sample 1433-190-193 cm; 280 k/m.
Figures 3, 4	Chenopodiaceae. Sample 1433-190-193 cm; 280 k/m.
Figures 5, 6	*Kochia* sp. Sample 1444-150-154 cm; 290 k/m.
Figures 7, 8	*Sueda* sp. Sample 1433-15-17 cm; 275 k/m.
Figures 9, 10	*Chenopodium* sp. Sample 1433-15-17 cm; 275 k/m.
Figures 11, 12	Chenopodiaceae. Sample 1433-15-17 cm; 275 k/m.
Figure 13	*Eurotia* sp. Sample 1433-415-418 cm; 285 k/m.
Figure 14	*Kochia* sp. Sample 1433-415-418 cm; 285 k/m.
Figures 15, 16	*Atriplex* sp. Sample 1433-15-17 cm; 275 k/m.
Figures 17, 18	*Salsola* sp. Sample 1433-15-17 cm; 275 k/m.
Figures 19	*Artemisia* sp. Sample 1433-15-17 cm; 275 k/m.
Figure 20	*Gramineae.* Sample 1433-190-193 cm; 280 k/m.

(see p. 986)

PLATE 17

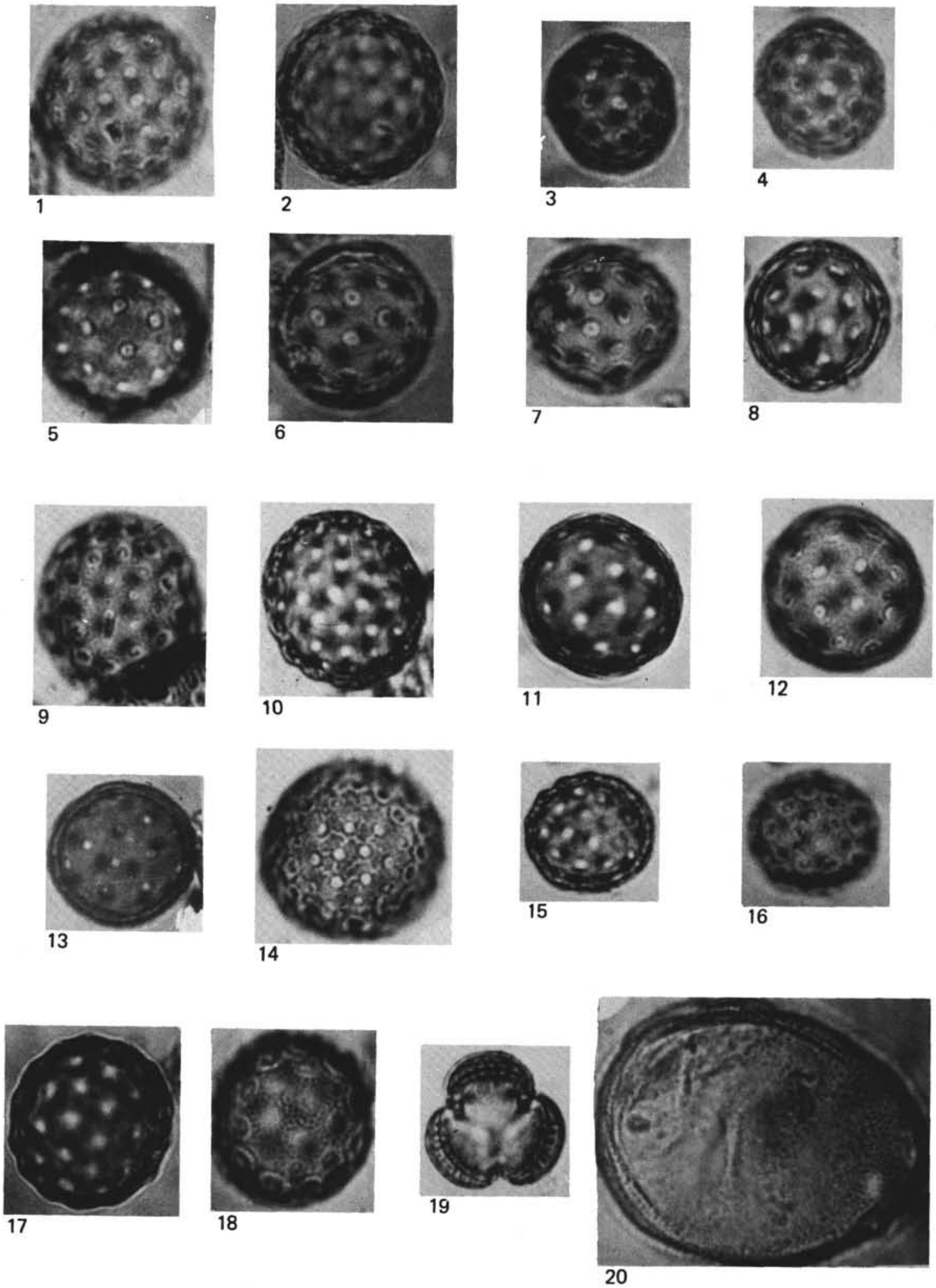

PLATE 18

Pollen from Holocene sediments. × 1000.

Figures 1, 2	*Pinus* sp. Sample 1433-15-17 cm; 275 k/m.
Figures 3, 4	*Pinus* sect. Eupitys. Sample 1433-15-17 cm; 275 k/m.
Figure 5	*Alnus subcordata* C.A. Mey. Sample 1433-100-103 cm; 278 k/m.
Figure 6	*Alnus incana* (L.) Moench. Sample 1433-15-17 cm; 275 k/m.
Figure 7	*Betula pendula* Roth. Sample 1433-15-17 cm; 275 k/m.
Figure 8	*Betula* sp. Sample 1433-15-17 cm; 275 k/m.
Figure 9	*Corylus avellana* L. Sample 1433-140-143 cm; 279 k/m.
Figure 10	*Corylus* sp. Sample 1433-100-103 cm; 278 k/m.
Figure 11	*Betula* sp. Sample 1433-15-17 cm; 275 k/m.
Figure 12	*Betula* sp. Sample 1444-150-154 cm; 290 k/m.
Figures 13-15	*Hippophae* sp. Sample 1433-190-193 cm; 280 k/m.
Figures 16, 17	*Salix* sp. Sample 1433-15-17 cm; 275 k/m.

1-17- × 1000

(see p. 988)

PLATE 18

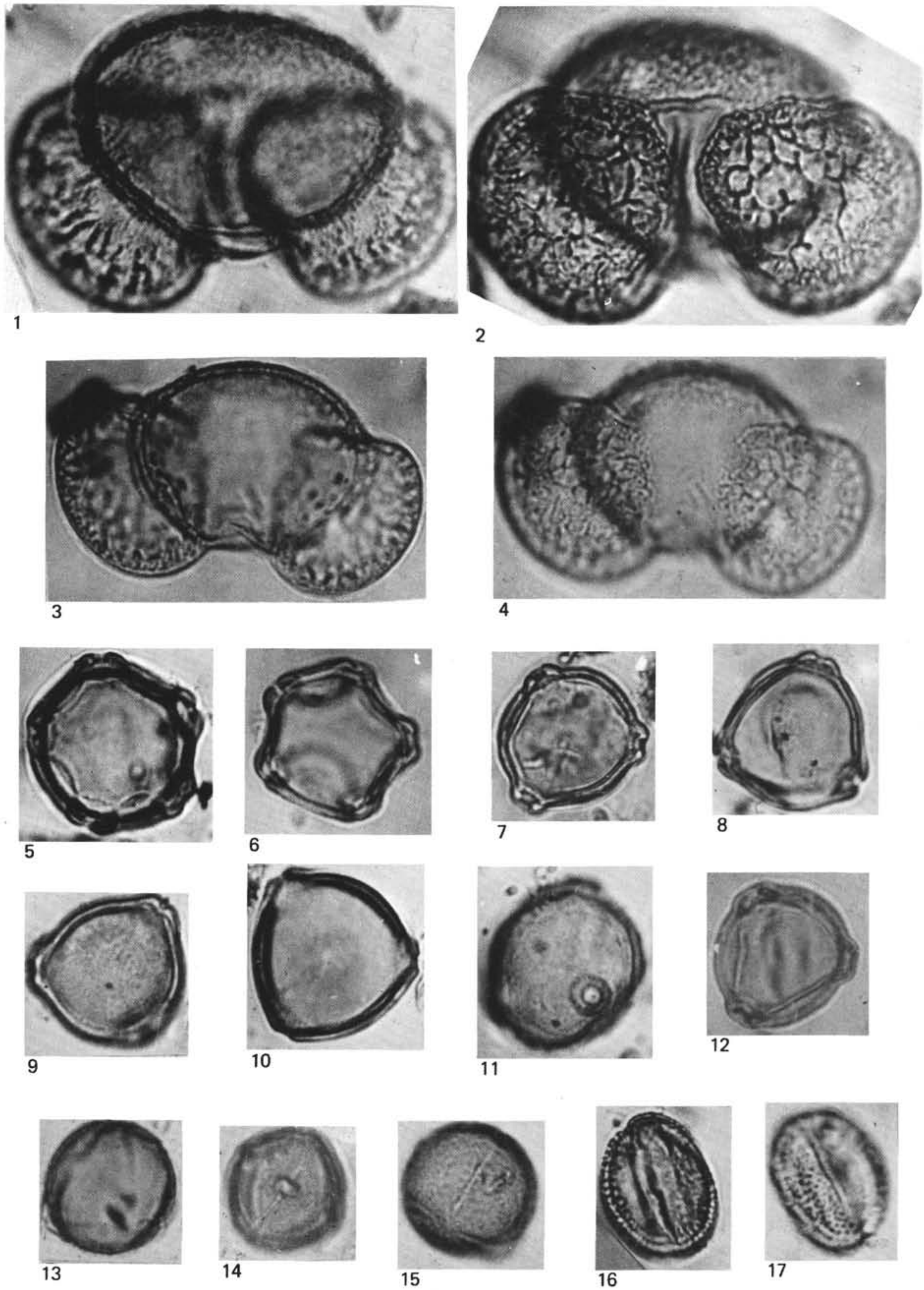

PLATE 19

Pollen from Holocene sediments. × 1000.

Figure 1	*Carpinus betulus* L. Sample 1433-15-17 cm; 275 k/m.
Figure 2	*Carpinus caucasica* Grossh. Sample 1433-15-17 cm; 275 k/m.
Figure 3	*Carpinus* sp. L. Sample 1433-190-193 cm; 280 k/m.
Figure 5	*Carpinus orientalis* Mill. Sample 1433-15-17 cm; 275 k/m.
Figure 6	*Ostrya carpinifolia* Scop. Sample 1433-15-17 cm; 275 k/m.
Figures 7, 8	*Quercus robur* L. Sample 1433-100-103 cm; 278 k/m.
Figure 9	*Quercus* sp. Sample 1433-100-103 cm; 278 k/m.
Figures 10-12	*Quercus petraea* Liebl. Sample 1433-415-418 cm; 285 k/m.
Figure 13	*Quercus* sp. Sample 1433-15-17 cm; 275 k/m.
Figure 14	*Ulmus scabra* Mill. Sample 1433-15-17 cm; 275 k/m.
Figure 15, 16	*Juglans cinerea* L. Sample 1433-190-193 cm; 280 k/m.
Figure 17	*Ulmus* sp. Sample 1433-100-103 cm; 278 k/m.

(see p. 990)

PLATE 19

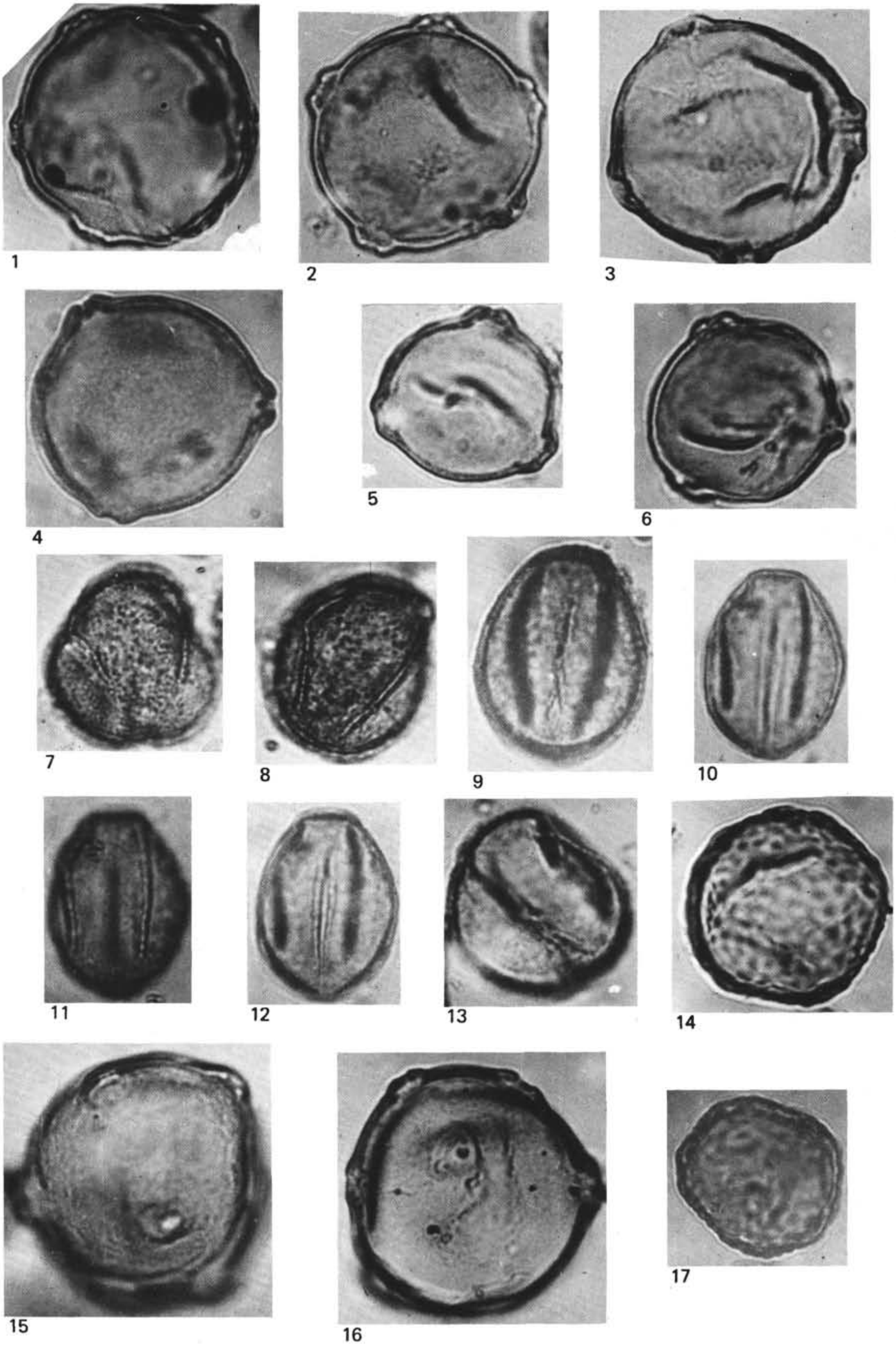

PLATE 20

Pollen from Holocene sediments. × 1000.

Figure 1	*Tilia* sp. Sample 1433-100-103; 278 k/m.
Figures 2-4	*Fabus taurica* Popl. Sample 1433-15-17 cm; 275 k/m.
Figures 5, 6	*Fagus silvatica* L. Sample 1433-415-418 cm; 285 k/m.
Figure 7	*Pterocarya pterocarpa* (Michx) Kunth. Sample 1433-15-17 cm; 275 k/m.
Figure 8	*Humulus* sp. Sample 1433-60-64 cm; 276 k/m.
Figure 9	*Leontice* sp. Sample 1433-15-17 cm; 275 k/m.
Figure 10	Compositae. Sample 1433-15-17 cm; 275 k/m.
Figure 11	Compositae. Sample 1433-140-143 cm; 279 k/m.
Figures 12, 14	Plantaginaceae. Sample 1433-15-17 cm; 275 k/m.
Figure 13	*Galium* sp. Sample 1433-190-193 cm; 280 k/m.
Figure 15	Cyperaceae. Sample 1433-190-193 cm; 280 k/m.
Figure 16	Cyperaceae. Sample 1433-140-143 cm; 279 k/m.
Figure 17	Plantaginaceae. Sample 1433-100-103 cm; 278 k/m.
Figures 18, 19	*Sparganium* sp. Sample 1433-15-17 cm; 275 k/m.
Figures 20 21	Polygonaceae. Sample 1433-190-193 cm; 280 k/m.

(see p. 992)

PLATE 20