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 (Na₄P₂O₇), separation in a heavy liquid (CdF₂) 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, subbottom 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. Chaudinskije layers. 4. Regression. 5. Paleouznanski. 6. Old Eukuinskije, early. 7. Old Eukuin-
skije, late. 8. Uznanski. 9. Karangatski. 10. Post-Karangatski. 11. Surozh-
skije(?). 12. Eukuin. 13. Black Sea. I. Silty sediments and clays. II. Alteration of marls, clays and limestones with predominance of
marls. III. Clay sediments with interbeds of marl and limestone. IV. Clay-
stones.

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
Chenopodiaceae 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).
This flora abounds in angiosperm pollen, a considerable part of which is composed of non-arboreal types: Chenopodiaceae, Artemisia, 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, Juglans, 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 Polypodiaceae, 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.
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, Caryophyllaceae, Leguminosae, 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 Drevneuxinien.

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.

declines. 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 (?) jage 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
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
Palynological study of samples

Belts most probably were 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 forest 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, both of 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).

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References

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 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 3
Palynocomplex from Pliocene Deposits × 1000.

Figures 1, 3, 4 Indeterm. pollen angiosperma. Sample 380A-66, CC; 631 k/m.

Figure 2 Tilia sp., Sample 380A-73-1, 92-94 cm; 839 k/m.

Figure 5 Tilia sp., 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 4

Palynocomplex from Pliocene deposits. × 1000.

Figure 1  Liquidambar sp., 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., 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 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 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.
Figure 18  *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 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 10
Palynocomplex from Palaeouzunlar sediments. Figures 1-11, 13-15, \(\times\) 1000; Figure 12, \(\times\) 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 Drevneuxinien sediments. Figures 1, 2, \(\times\) 500; Figures 3-20, \(\times\) 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 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 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., Sample 380-5, CC; 637 k/m.

Figure 2  
*Ulmus* sp., 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.

Figure 9  
*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 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 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 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

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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 20

Pollen from Holocene sediments. × 1000.

Figure 1  
*Tilia* sp. Sample 1433-100-103; 278 k/m.

Figures 2-4  
*Fagus sylvatica* L. Sample 1433-15-17 cm; 275 k/m.

Figures 5, 6  
*Fagrus taurica* Pl. 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)