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STUDIES OF MODERN AND HOLOCENE POLLEN PRECIPITATION IN SOUTHEASTERN TURKEY[1]

(Figs. 1–5).

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INTRODUCTION

As part of a program for the study of prehistoric man in the Near East (cf. Braidwood & Howe, 1960) the climatic and vegetational history of this region is being investigated. An examination of the Late Quaternary vegetation succession in western Iran was started in 1960 when lake sediments were sampled by Professor H. E. Wright (Minneapolis). In 1963 new sediment cores were taken by Wright and collaborators, while at the same time surface samples were collected and studies of the regional vegetation were carried out. The botanical, zoological and chemical

[1] This paper is respectfully dedicated to Professor F. Overbeck on the occasion of his 70th birthday on August 2, 1968.

studies of the samples from western Iran have not yet been completed. The results obtained up to now are discussed in the papers by Hutchinson & Cowgill (1963), Megard (1967), Van Zeist (1967), Van Zeist & Wright (1963), Wasylikowa (1967), and Wright, McAndrews & Van Zeist (1967).

During the period from May 26 to June 15, 1964 Professor H. E. Wright and the senior author collected material for a similar study in southeastern Turkey. The camp of the group of archaeologists who, under the direction of Professor R.J. Braidwood (Chicago) and Professor Halet Çambel (Istanbul) excavated the early Neolithic site of Çayönü near Ergani (Diyarbakir Vilayet), served as a base from which excursions to various parts of southeastern Turkey were made. For the field work we had the use of a vehicle of the archaeological expedition.

Sediment cores were sampled in two small lakes near Bozova (Urfa Vilayet; 37°21'N, 38°31'E), at the western end of Lake Hazar (Elazig Vilayet; 38°27'N, 39°19'E), in a lake near Gölbasi (Adiyaman Vilayet; 37°45'N, 37°33'E), and in a marsh near Ayingern, ca. 35 km west of Siirt (Siirt Vilayet; 37°55'N, 41°33'E). Moreover, surface samples were collected in various vegetation types. Due to a lack of time in general only hasty surveys could be made of the plant cover in the localities where surface samples were taken.

The palynological study of the material from southeastern Turkey was carried out by the junior authors in the palaeobotanical laboratory of the Institute for Biological Archaeology, University of Groningen. Of the lake sediment cores, only those from Gölbasi and from one of the lakes near Bozova turned out to be suitable for pollen analysis. The larger number of the surface samples produced a positive result. The location of the profiles and of the surface samples to be discussed in this paper is shown in Fig. 1.

Professor J.C. Vogel (Groningen) carried out the radiocarbon determinations of two samples. Mr. B. Kuitert and Mr. H. R. Roelink prepared the drawings for publication, and Miss G. F. Boers typed the successive drafts of the manuscript. The English text has been improved by Dr. J. J. Butler.

The field work was made possible by National Science Foundation Grant GS-50 to Professor Braidwood.

GEOGRAPHY AND CLIMATE

The landscape of southeastern Turkey is dominated by the East Taurus Mountains which in three parallel ranges extend from the Gulf of Iskenderun to the Iranian border (cf. Louis, 1939, Map 1). Between these mountain ranges rather flat basins are present such as those of Malatya and Mus. The East Taurus Mountains consist mainly of limestone and basic igneous rocks (Geol. Map of Turkey, 1961).

From the foot of the outer range of the East Taurus Mountains a moderately dissected plateau slopes gently in southern direction. This plateau, which is built up of Cretaceous and Tertiary deposits, is covered by basaltic flows over large areas. The so-called threshold of Mardin constitutes a rather broad but low, east-west oriented ridge on this plateau.

The drainage of by far the larger part of southeastern Turkey takes place through the Euphrates and the Tigris and their tributaries into the Persian Gulf. The western part of this region is drained by the Aksu river which debouches into the Mediterranean.

Walter's (1955) "Klima-Diagramme" provide information on temperature and precipitation. In the southern part of southeastern Turkey winters are relatively mild: the mean January temperatures in Urfa, Mardin and Diyarbakir amount to about 4°, 2,5°, and 2°C respectively. More towards the interior (Malatya, Elazig), the mean January temperatures are below zero.

Prevailing southwestern winds from the Mediterranean cause precipitation in the autumn, winter and spring. As the mountain ranges run in the same direction as the wind, rain and snow bearing clouds can penetrate far into the interior.

During the summer, with prevailing northerly winds, there is little or no rainfall in southeastern Turkey. As at the same time the temperatures are high (mean July temperatures in Urfa, Mardin, Diyarbakir, Siirt, Elazig, and Malatya are about 31.5°, 30°, 31°, 30.5°, 27°, and 27° respectively) the summer is a distinctly arid period in this region.

VEGETATION

The vegetation of southeastern Turkey is less well studied than that of most other parts of the country. The best documented description of the vegetation of southeastern Turkey is from Handel-Mazzetti (1914), while the forest types in this region have been discussed by Louis (1939). Besides, remarks on the vegetation in this part of Turkey can be found in the papers of Bobek (1938), Davis (1965, Introduction), Regel (1959), and Walter (1956a). Further, on the sheets of the 1:800,000 ordnance survey map of Turkey (1956) the occurrence of forest is shown. A map of the distribution of trees and shrubs in Turkey has been published by the Turkish Forestry Department (1962).

Fig. 1 shows a reconstruction of the distribution of the natural vegetation zones in southeastern Turkey. In this area three major vegetation types can be distinguished, viz. steppe, forest, and alpine vegetations. The geomorphological features of Fig. 1 are copied from the USAF Operational Navigation Chart 1:1,000,000 ONC G4, Tigris-Euphrates Valley (1962), while the distribution of the major vegetation units has been reconstructed on the grounds of the data provided by Louis (1939). Moreover, the existing forest as shown on the 1:800,000 Turkish ordnance survey sheets, is indicated on this map. In the few cases which, according to our own observations, the forest symbol on the ordnance survey map represents orchards, this is not shown as forest in Fig. 1.

Steppe. In southeastern Turkey two large steppe areas are present:

1. The steppe area which to the north and the west is bordered by the line Mardin – Siverek – Adiyaman – Nizip – Kilis, and which adjoins the North-Syrian steppe.
2. The steppe in the basin of Diyarbakir.

According to Louis (1939), in southeastern Turkey the lower forest line has to be placed at 700–800 m, as is suggested by forest remnants which occur down to this elevation. In this connection it should be kept in mind that in consequence of the activity of man for thousands of years the lower limit of the forest remnants may have been shifted upwards, so that it is not impossible that the 700–800 m limit does not coriespond with the original situation. More to the west the steppe/forest border apparently lies somewhat lower; according to the ordnance survey map forest is found at elevations of about 600 m near Kizilin and Nizip.

Northwest, north, and northeast of Urfa, some smaller areas with elevations above 800 m may originally have been covered by a more or less open forest. A remnant of this forest can be observed on the holy site of Kaplan Ziyaretti, ca. 4 km east of Bozova. Here, at an elevation of about 850 m, a forest remnant consisting of full-grown oak trees is present on the east-facing slope of a little hill.

The two steppe areas are separated by the threshold of Mardin, which before the interference of man with the natural vegetation would have been wholly forested. On the eastern part of this ridge fairly much forest is still present.

The isohyet of 250 mm of mean annual precipitation, which marks the limit of dry farming, occurs well south of the Syrian-Turkish border. Consequently, on most places in the steppe region of southeastern Turkey agriculture is practised. Where local conditions are unfavourable for farming, intensive grazing takes place, just as on fallow land on the fields after the harvest.

Handel-Mazzetti (1914) published a list of plants he found in the steppe of southeastern Turkey, which at that time had not yet been cultivated to such an extent. From his plant list are mentioned here: *Euphorbia* spp., *Astragalus* spp., *Onosma* spp., *Avena barbata* Brot., *Eryngium* spp., *Sideritis libanotica* Labill., *Dianthus multipunctatus* Ser., *Scabiosa ucranica* L., *Centaurea* spp., *Carthamus* spp., *Cirsium* *acarna* (L.) Moench, *Zoegea leptaurea* L., and *Onopordon heteracanthum* C.A.Mey. It is striking that Handel-Mazzetti does not mention *Artemisia herba-alba* Asso, although this species is very common in the steppe and desert steppe of Syria. According to the same author, *Artemisia* would have constituted nearly the only plant species in large parts of the Mesopotamian steppe. Apparently, in the steppe of southeastern Turkey *Artemisia herba-alba* was not common.

It should be mentioned that for Syria Pabot (1957) postulates a fairly broad steppe-forest zone between forest and steppe. In extending Pabot's zoning into the adjacent part of Turkey, by far the larger part of the steppe area bordered by the line Mardin-Siverek-Adiyaman-Nizip-Kilis would belong to his steppe-forest zone.

In the Malatya basin the lower forest line would be situated at about 1000 m, so that originally this basin was covered by a steppe vegetation. More to the east, in the basin of Mus, the lower forest limit would occur at 1400–1500 m, increasing further in an easterly direction. This rise towards the east is caused by the decrease in precipitation, since these basins lie in the rain shadow of the mountains.

Louis (1939) emphasizes that the absence of trees on the high plateaus in eastern Turkey is not due to too low a temperature but to insufficient precipitation. Walter (1956b) is of opinion that originally the steppes of Central Anatolia were grassland vegetations which in consequence of grazing during thousands of years have been degraded into the modern steppes in which *Artemisia* (especially *A.fragrans* Willd.) is dominant.

Forest. It has already been mentioned that the lower forest line rises in an easterly direction. The upper forest limit increases likewise from west to east. According to Louis (1939), the upper forest line in the vicinity of Malatya occurs at about 2300 m, rising to about 2700 m near Lake Van.

The larger part of the forest of southeastern Turkey is a woodland in which the trees do not reach a considerable height. The forest in this part of Turkey belongs to Walter's (1956a) East-Anatolian oak-juniper region. In general, deciduous oaks are the dominant trees. *Quercus infectoria* Oliv. is the most common oak in this part of Turkey. Other oak species include *Q. longipes* Stev., *Q. libani* Oliv., and *Q. brantii* Lindl. Of the other trees and shrubs, *Juniperus excelsa* Bieb. and *Juniperus oxycedrus* L. must in the first place be mentioned. Also occurring, among others, are *Acer cinerascens* Boiss., *Pistacia khinjuk* Stocks, *Pyrus syriaca* Boiss., *Crataegus* spp., *Prunus* spp., *Paliurus spina-christi* Mill., and *Rhamnus kurdica* Boiss. et Hoh. As a result of the destruction by man, many areas of forest have been degraded into shrub vegetations or have disappeared altogether.

Louis (1939) distinguishes between a hardy and a moderately hardy forest. He places the border between both forest types at about 1200 m. Above this limit oak and juniper would alternately constitute the main components of the forest. Both

Quercus and *Juniperus* would occur up to the upper tree line. It has to be taken into account that in consequence of cutting, the upper tree line could have been pushed back in the course of time. Consequently, if at present a certain tree species is found at the upper tree line, this does not necessarily imply that this would also have been the case under natural conditions.

Below 1200 m, the forest would consist of a larger number of tree species, whereas *Juniperus* would be much less common than higher up. It should be remarked here that at elevations below 1200 m the senior author has observed much juniper on volcanic soils.

Handel-Mazzetti (1914) doubts whether it is possible to draw a line between an upper and lower forest zone. On the other hand, he does mention that in Turkish Kurdistan, Mediterranean shrubs such as *Cercis siliquastrum* L., *Jasminum fruticans* L., *Punica granatum* L., and *Cotinus coggygria* Scop. are never encountered at elevations above 1000 m.

In the river valleys are found, among others, *Populus euphratica* Oliv., *Platanus orientalis* L., *Juglans regia* L., *Tamarix* spp., *Salix* spp., and *Fraxinus* sp.

On the map of Fig. 1 no distinction is made between the various forest types; for that purpose the data are altogether insufficient. However, it should be kept in mind that in southeastern Turkey the composition of the forest would have shown and still shows considerable differences, depending upon temperature, precipitation, and edaphic factors.

Finally, it must be mentioned here that at some distance from Gölbasi, where a sediment core was taken, *Pinus* is present. According to the map of the Turkish Forestry Department, *Pinus brutia* Ten. and *Pinus nigra* Arn. occur at about 20 km south-southeast and at about 50 km northwest of Gölbasi respectively. Along the road to Malatya, between about 10 and 25 km northeast of Gölbasi, a well developed pine forest is present on volcanic soil. West of Gölbasi, in the eastern part of the Central Taurus Mountains, in addition to *Quercus*, *Juniperus* and *Pinus nigra*, *Abies cilicica* (Ant. et Kotschy) Carr. and *Cedrus libani* A. Rich. are found.

Alpine vegetations. At elevations above 2300 to 2700 m treeless, alpine vegetations are present. As no surface samples have been collected from these vegetation types they will not be discussed here. For a description of the alpine vegetations in this area the reader is referred to Handel-Mazzetti's paper (1914, p. 95–105).

Fig. 1. Map of southeastern Turkey, showing the modern occurrence of forest, a reconstruction of the distribution of the major vegetation units, and the location of the surface-sample and pollen-diagram sites discussed in this paper. Contour lines are given for every 1000 ft. Moreover, the 2500 ft contour line is indicated because of its importance in connection with the lower forest limit.

1. Steppe region; 2. Alpine vegetations; 3. Forest region; 4. Existing forest.

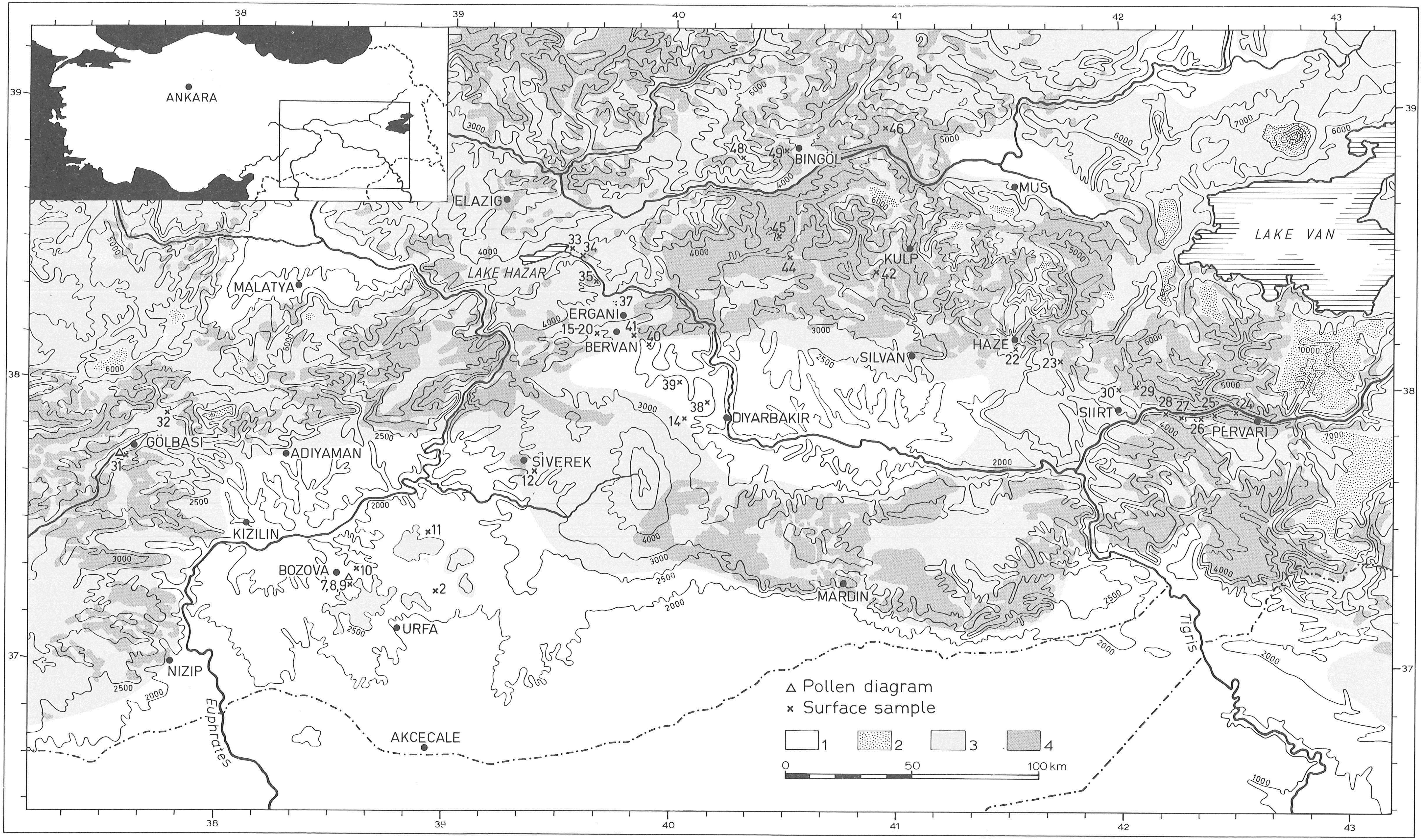
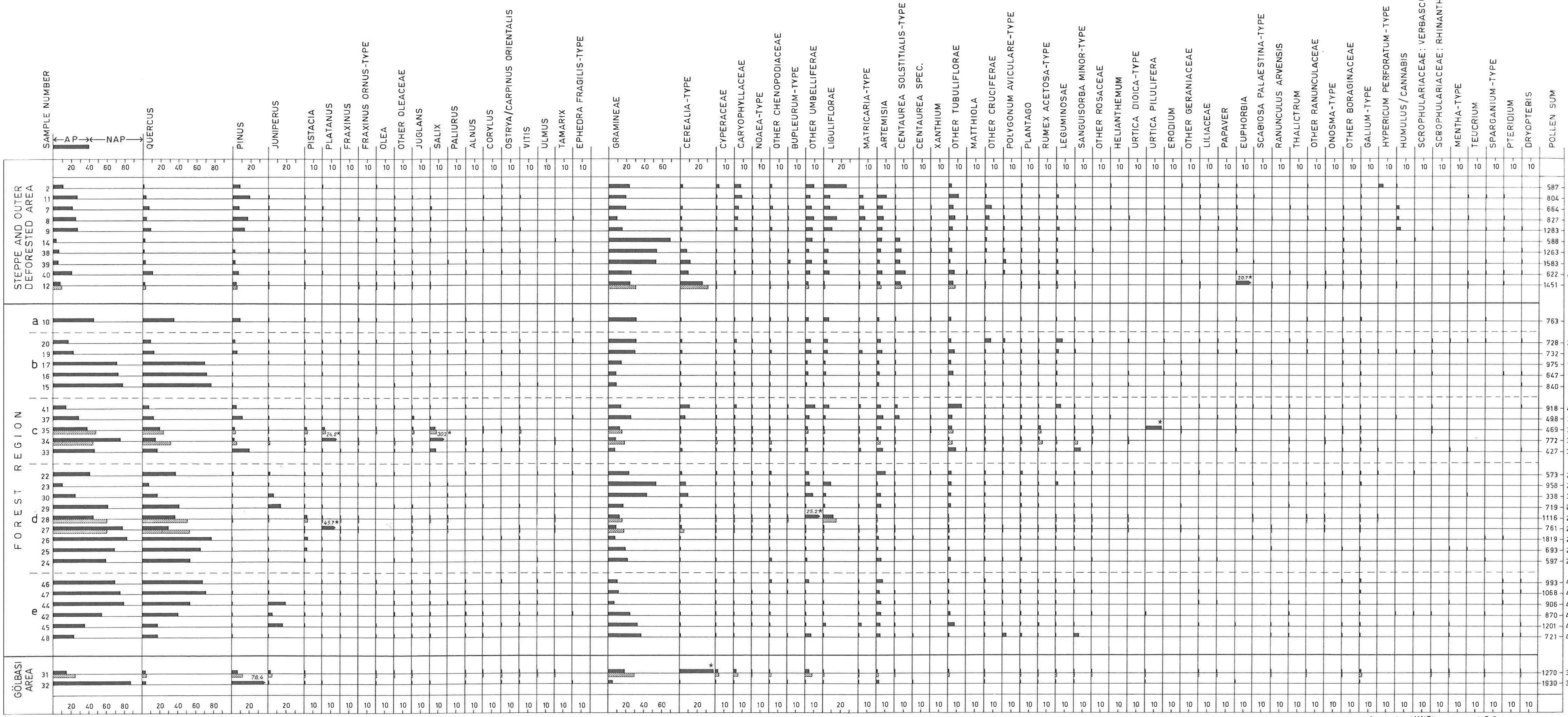

ANKARA
LAKE VAN
LAKE HAZAR
ELAZIG
BINGÖL
MUS
KULP
MALATYA
ERGANI
BERVAN
HAZE
SILVAN
SIIRT
PERVARI
DIYARBAKIR
GÖLBASI
ADIYAMAN
SIVEREK
KIZILIN
BOZOVA
URFA
MARDIN
NIZIP
AKCECALE
Euphrates
Tigris
△ Pollen diagram
× Surface sample
1
2
3
4
0
50
100 km

Fig. 2. Surface-sample spectra from southeastern Turkey. In this diagram are *not* included (the order of the samples is the same as in the diagram): sample 2: Solanum-type 0.2 %; sample 11: Ephedra distachya-type 0.1 %; sample 7: Fagopyrum 0.2 %, Carthamus 0.2 %; sample 8: Abies 0.1 %, Ranunculus repens-type 0.1 %; sample 9: Daphne 0.1 %, Ranunculus repens-type 0.1 %, Ericaceae 0.1 %, Fagopyrum 0.1 %, Myriophyllum verticillatum-type 0.1 %; sample 14: Rhamnaceae 0.2 %; sample 38: Castanea 0.1 %, Rumex hydrolapathum-type 0.1 %; sample 12: Fagus 0.1 %, Lythrum 0.1 %, Rumex scutatus-type 0.1 %, Carthamus 0.1 %; sample 10: Abies 0.1 %; sample 20: Castanea 0.1 %, Campanulaceae 0.1 %, Anemone biflora-type 0.8 %, Leontice 0.3 %; sample 19: cf. Rhamnus 0.3 %; sample 17: Plumbago cf. europaea 0.1 %; sample 41: Ranunculus asiaticus-type 0.1 %, Convolvulus 0.2 %, Haplophyllum tuberculatum-type 0.2 %; sample 35: Calligonum-type 0.2 %, Datisca 0.2 %, Cotinus 0.4 %; sample 34: Cotinus 0.1 %; sample 33: Valerianella 0.5 %, Datisca 0.2 %; sample 22: Myrtaceae 0.2 %, Morus 0.4 %; sample 23: Convolvulaceae 0.1 %; sample 29: Rhamnus 0.4 %, Calligonum-type 0.6 %, Gentiana 0.1 %; sample 28: Calligonum-type 0.1 %; sample 27: Morus 0.2 %, Ranunculus asiaticus-type 0.1 %, Datisca 0.1 %; sample 26: Acer 0.2 %, Haplophyllum tuberculatum-type 0.5 %; sample 25: Fagopyrum 0.1 %; sample 24: Acer 1.0 %; sample 46: Castanea 0.1 %; sample 47: Eucalyptus 0.1 %, Cotinus 0.1 %, Cuscuta 0.1 %; sample 44: Carpinus betulus 0.1 %, Thymelaea 0.1 %, Leontice 0.4 %; sample 42: Carpinus betulus 0.1 %; sample 48: Carpinus betulus 0.1 %; sample 31: Fagus 0.2 %, Lythraceae 0.1 %, Dryopteris thelypteris-type 0.2 %; sample 32: Sambucus 0.05 %, Labiatae 0.05 %.

SURFACE SAMPLES, SOUTH-EASTERN TURKEY



Analysis: M.W.Timmers and S.Bottema

percent of total pollen

percent of total pollen, excluding pollen type marked by*

PREPARATION OF SAMPLES

All samples were treated according to the acetolysis method (cf. Faegri & Iversen, 1964). After the acetolysis, the samples were stained with safranin and mounted in silicone oil. Preceding acetolyzation the Gölbasi lake sediment samples were gently boiled in a 35 % HF solution for 3–5 minutes in order to dissolve the mineral particles. In the other samples to be discussed in this paper the inorganic material was removed by means of a gravity separation method.

SURFACE SAMPLES

Surface samples were taken in the original steppe area and in the region where forest constitutes the climax vegetation. Most of the 48 surface samples collected in southeastern Turkey consist of moss which was growing on rock outcrops or on large boulders. If no moss was present a sample of the litter or of the upper centimeter of the surface soil was taken.

The spectra for 38 samples are represented in Fig. 2. Some of the samples turned out to contain little or no pollen, and in a few cases a choice was made between two samples from the same spot.

The surface samples are divided into two major groups:

A. Samples from the steppe and the outer deforested area. It is not possible to draw a clear line between the original steppe region and the presently deforested area adjoining the steppe. It should also be kept in mind that a part of our steppe region may belong to a steppe-forest zone (cf. Pabot, 1957).

B. Samples from the forest region. In some areas relatively well preserved forest can still be found. However, frequently a shrub vegetation constitutes the remnant of the original forest. In the vicinity of a few samples from this group, trees and shrubs are very rare or have disappeared entirely.

The samples from the forest region are divided into five subgroups:

a. One sample (10) which was collected just outside the holy forest (Kaplan Ziyaretti) near Bozova (see p. 22).

b. Samples which were taken inside the cemetery forest near Bervan (15, 16, 17) and at 300 and 600 m from the edge of this forest (19, 20). This forest remnant is situated at an elevation of about 900 m.

c. Samples along the road between Ergani and the east side of Lake Hazar (sample 41 is from a few km south of Ergani). In general the forest vegetation in this region has suffered serious destruction.

d. Samples between Haze and Pervari. In the vicinity of samples 26 and 27 well developed trees were observed, although here also branches are cut. Near samples 24, 25, and 28 shrubs up to 3 m occur as well as small trees up to 4 m. At the localities of samples 29, 30, and 23 a low shrub vegetation is present. At some distance from sample 22 an oak woodland occurs.

e. The spectra from the Kulp-Bingöl region are arranged according to an increasing degree of destruction of the forest. Sample 46 originates from an area with a rather dense forest vegetation consisting mainly of oaks up to 5 m high. Sample 48 is from an area where only a few scattered shrubs of *Quercus* and *Crataegus* are left over from the original forest.

Finally, two surface samples (31, 32) were collected at some distance from Gölbasi.

The pollen percentages are calculated on a total pollen sum. If in consequence of local conditions a pollen type is seriously over-represented the taxa are also shown as percentages of a pollen sum in which the pollen type with the anomalously high value is not included. In the text the uncorrected percentages are given between brackets.

Mean percentages for a number of pollen types in the spectra from the steppe and outer deforested area and from the various subgroups in the forest region are represented in Table 1. The percentages in this Table are corrected for pollen types which are considerably over-represented.

Spectra from the steppe and the outer deforested area. For this group only relatively few spectra are available. It is especially to be regretted that the samples collected between Akcekale and Urfa turned out to be barren of pollen.

In spite of the high herbaceous percentages, the values for Chenopodiaceae and *Artemisia* are fairly low; the average frequencies amount to 1.5 and 5.0% respectively. It has already been stated that *Artemisia herba-alba*, which is very common in the desert steppe of Syria and Iraq, is not mentioned from the steppe region of southeastern Turkey by Handel-Mazzetti (1914). The authors have no information on the quantitative occurrence of Chenopodiaceae in the steppe remnants in this area. Saline soils on which chenopods are generally very common are not found in this part of Turkey. The *Plantago* frequencies are conspicuously low, viz. 0,9% on an average. This is in contrast to the surface-sample spectra from the low steppe and steppe forest in western Iran which show plantain values of 15–55% (Wright, McAndrews & Van Zeist, 1967).

With the exception of samples 14 and 40, *Pinus* shows the highest tree pollen values. It is likely that the relatively high percentages for pine are due to the good pollen dispersal of this tree. Besides, one may wonder whether a not unimportant part of *Pinus* in the pollen precipitation could have originated from pines which have been planted in various towns in southeastern Turkey. The results of the

TABLE I. AVERAGE POLLEN PERCENTAGES FOR VARIOUS GROUPS OF SURFACE SAMPLES

	Steppe and outer deforested area	Forest region				
		a	b	c	d	e
Quercus	4.4	34.7	48.1	18.3	44.9	44.4
Pinus	8.7	9.0	1.9	8.9	0.7	0.8
Juniperus	0.4	0.3	0.6	0.7	3.1	7.4
Gramineae	33.9	31.0	18.6	16.2	24.5	20.5
Cerealia-type	6.7	0.9	1.4	4.2	3.4	0.7
Chenopodiaceae	1.5	1.3	1.1	2.2	1.3	1.7
Plantago	0.9	0.4	0.8	1.7	1.3	1.6
Artemisia	5.0	2.9	3.5	6.0	3.6	4.8
Centaurea solstitialis-type	3.9	0.1	0.5	2.4	0.3	0.1
other Tubuliflorae	6.9	3.0	4.7	8.5	2.3	3.0
Liguliflorae	8.3	6.0	2.9	2.9	3.5	1.0
Umbelliferae	6.5	4.0	3.8	7.0	3.1*	2.9
Caryophyllaceae	3.0	0.5	1.3	1.3	0.2	0.3

* Umbelliferae in sample 28 are not included in this percentage.

palynological study of the Bozova lake sediment, which will be discussed later, suggest that the larger part of pine in the pollen precipitation in this region must be ascribed to long-distance transport.

Among the herbaceous pollen types, Gramineae (inclusive Cerealia-type), Umbelliferae and Compositae (except *Artemisia*) show the highest frequencies (average values are 40.6, 6.5, and 19.1 % respectively). The *Cannabis/Humulus* pollen-type met with in some quantities in samples 7, 8, and 9 would have originated from hemp which is cultivated in the area where the samples concerned have been taken.

Spectra from the forest region. The holy forest near Bozova consists of full-grown oaks with heavy trunks. In the cemetery forest near Bervan the trees are smaller, 4 to 6 m high, and the mutual distance amounts to about 10 m. In both cases a *Quercus brantii* grove is concerned in an otherwise treeless area. The high ΣAP percentage in spectrum 10 must be due to the circumstance that this sample was taken just outside the forest. The spectra from the samples which were collected in and near the Bervan forest demonstrate the effect of increasing distance from the forest on the tree pollen percentages. Samples 15, 16, and 17 from inside the forest show high *Quercus* frequencies. Oak values are distinctly lower in samples 19 and 20 taken at 300 and 600 m from the edge of the forest respectively.

It has already been mentioned that the upland forest between Ergani and Lake Hazar has been seriously affected by cutting and grazing. This undoubtedly accounts for the relatively low tree pollen values in the spectra from this area (33, 34, 35, 37, 41). This is also clear from Table 1: the average oak percentage for the samples from the Ergani-Lake Hazar transect amounts to 18.3 %, whereas for the other groups of samples from the forest zone the mean *Quercus* values range from 34.7 to 48.1 %. The fairly high ΣAP percentage in sample 34 is caused by the pollen of *Platanus* and *Salix* which are common in the river valley where this sample was taken. After exclusion of these pollen types ΣAP shows a relatively low value in this spectrum. It is not unlikely that the pines planted near the restaurant on the east side of Lake Hazar are partly responsible for the *Pinus* pollen value of 19 % in sample 33.

The spectrum for sample 34 demonstrates that *Tamarix* is heavily under-represented in the pollen precipitation. In addition to *Platanus* and *Salix* (see last paragraph), *Tamarix* has been observed in fairly large numbers in the river valley concerned. However, in contrast to those for plane tree and willow the pollen percentage for tamarisk is low, viz. 0.6 (0.3) %.

In the spectra from the Haze-Pervari transect, a decrease in the ΣAP percentages can be observed with increasing distances from the Pervari area, where the forest has suffered less destruction than more to the west. The shrub vegetation near sample 23 is certainly not worse than that in the vicinity of sample 29, but nevertheless there is a great difference in oak percentages. Apparently, the low oak shrubs produce little pollen, and most of the oak pollen originates from better developed shrubs and from trees. This hypothesis is supported by the relatively high oak pollen value in sample 22. In the immediate vicinity of this sample not even low oak shrub is present, but at some distance an oak woodland with full-grown trees is found.

In all samples from this transect *Quercus* is by far the most abundant tree pollen type. In the area of sample 26 *Pistacia* is a common tree. Consequently, it is not surprising that this spectrum shows a comparatively high pistachio percentage, viz. 3.9 %. *Quercus* pollen (77.1 %) is 20 times as numerous although the share of oak in the vegetation in only 2 to 3 times higher than that of *Pistacia*. This demonstrates that relative to *Quercus*, *Pistacia* is seriously under-represented in the pollen precipitation. The surface-sample study in western Iran led to the same conclusion (Wright, McAndrews & Van Zeist, 1967). In sample 28 the *Pistacia* value amounts to 4.8 % after exclusion of Umbelliferous pollen from the sum (3.6 % if Umbelliferae are included). The vegetation in this locality had been too seriously affected to allow a satisfactory comparison between the share of oak and pistachio in the vegetation and that in the local pollen rain.

The under-representation of *Acer* is likewise considerable. In sample 24, 1.0 % *Acer* pollen has been counted, whereas in the local vegetation maple is rather common. In addition to sample 24, *Acer* pollen has only been found in sample 27.

Pollen of Rhamnaceae (*Paliurus spina-christi*, *Rhamnus kurdica*) is likewise heavily under-represented. This is demonstrated, among other things, by the circumstance that in sample 28 *Paliurus* pollen amounts to 1.8 (1.3) %, whereas this species plays an important part in the local shrub vegetation. In other samples *Paliurus* pollen never reaches more than 0.4 %. It is, of course, according to expectation that insect-pollinated taxa are poorly represented in the pollen precipitation.

Although in the vicinity of sample 29 *Juniperus* is the most abundant shrub, its pollen value amounts to 14.7% only, whereas that for *Quercus* is 41 %. In the spectrum of sample 30 the pollen values for juniper and oak are 6.5 and 17.2 % respectively, although in the shrub vegetation on this site both taxa are about equally represented. For a further discussion of the share of juniper in the pollen rain see below.

Apparently, *Juglans*, which is mainly confined to river valleys, has a good pollen dispersal. Even in samples at a fairly great distance from suitable habitats for walnut trees its pollen has been observed. Pollen of insect-pollinated *Salix*, which likewise occurs near water, has been found rather regularly. The large quantity of *Platanus* pollen in sample 27 is due to the fact that this sample was taken under a plane tree.

In the samples from the Kulp-Bingöl region the ΣAP percentages are reasonably well in accordance with the share of trees and shrubs in the vegetation. In the area where sample 46 was collected the tree cover amounts to 60–70%, and at the locality of sample 47 the fairly high oak shrubs form a dense vegetation.

Sample 44 shows the highest *Juniperus* pollen value (20 %) of all surface samples from southeastern Turkey that have been analysed. The rather open vegetation on this site consists of tall shrubs of *Quercus* and *Juniperus* in addition to *Paliurus spina-christi*, *Colutea arborescens* L., *Prunus* sp., and *Amygdalus* sp. Oak and juniper are equally common, but the *Quercus* pollen percentage is more than twice as high as that of *Juniperus*. Sample 45 also shows a high juniper value (16.4 %). In the immediate vicinity of this sample, which was collected on the Javla Gecidi pass, scattered shrubs of *Juniperus*, *Prunus*, *Crataegus*, *Amygdalus*, and *Quercus* are found, but at some distance well developed juniper is common. From the results of this study it is clear that when interpreting pollen diagrams from southeastern Turkey, one must remember that *Juniperus* is under-represented, in relation to *Quercus*, in the pollen rain.

Of both samples from the Gölbasi area, number 31 will be discussed later (p. 34).

Sample 32 was collected in a nearly pure pine forest which accounts for the high *Pinus* pollen value (78.4 %).

Pollen of *Fagus* found in a few samples (12, 31, 47) must have been transported from the region adjoining the Black Sea, or from the Amanus Mountains (Gavur Dag), east of the Gulf of Iskenderun (Walter 1956a).

Carpinus betulus is represented only in samples from the Kulp-Bingöl region (42, 44, 48). From the areas covered by the surface-sample study, that of Kulp-Bingöl is nearest to the region along the Black Sea where hornbeam is native.

Although Rosaceous pollen, which includes trees and shrubs such as *Pyrus*, *Crataegus*, *Prunus*, *Amygdalus*, and *Rosa*, as well as herbaceous plants, was counted in a fairly large number of samples, it shows never high values. In the immediate vicinity of sample 35, which shows the highest Rosaceous pollen value (1.1%), rose shrubs have been observed. The wind-pollinated *Sanguisorba minor*-type, on the other hand, shows rather high percentages in a few samples (33, 34, 48).

It is striking that pollen of Leguminosae is met with frequently, and that in samples 9, 20, and 41 this insect-pollinated taxon shows relatively high frequencies (3.0, 6.6, and 5.6% respectively). This must undoubtedly be ascribed to the important part that Leguminosae often play in the vegetation in southeastern Turkey (*Astragalus*, *Trifolium*, *Trigonella*, *Medicago*).

Galium-type pollen is likewise present in most samples, while *Euphorbia* pollen is more or less confined to samples from localities with an open vegetation (treeless vegetations, heavily degraded forest).

Finally, it can be mentioned that the mean values for *Artemisia*, *Plantago* and Chenopodiaceae in the spectra from the forest region do not differ considerably from those in the spectra from the steppe and outer deforested zone (Table 1). This indicates that not only in the steppe area but also in the forest region of southeastern Turkey grazing did not cause a strong expansion of plantain, which in other regions in the Near East can be very common on grazed terrains.

GÖLBASI LAKE

Geography and vegetation. In the valley of the upper reaches of the Aksu river, near the town of Gölbasi (Adiyaman Vilayet), three lakes are present (Fig. 3). These lakes, which have an oval shape and are about 3 km long, are separated from each other by alluvial fans from lateral tributaries. In the area of the lakes, the valley is 2 to 3 km wide, and is situated at about 890 m above sea level. The core, which will be discussed here, was taken in the middle lake (37°45′N, 37°33′E).

The headwater valley of the Aksu is marshy, and on the east side of the middle lake a vegetation of mainly *Carex*, *Scirpus*, and *Eleocharis* is found. This vegetation is cut, very probably in order to serve as fodder for the animals. Vegetations in which Gramineae play an important part are found in less wet places.

Near the coring site the following vegetation zones have been observed:

1. Zone with *Iris*, *Sparganium*, and *Scirpus lacustris* L.
2. *Phragmites* vegetation with *Myriophyllum* undergrowth in water up to 1 m deep. This zone is about 100 m wide.

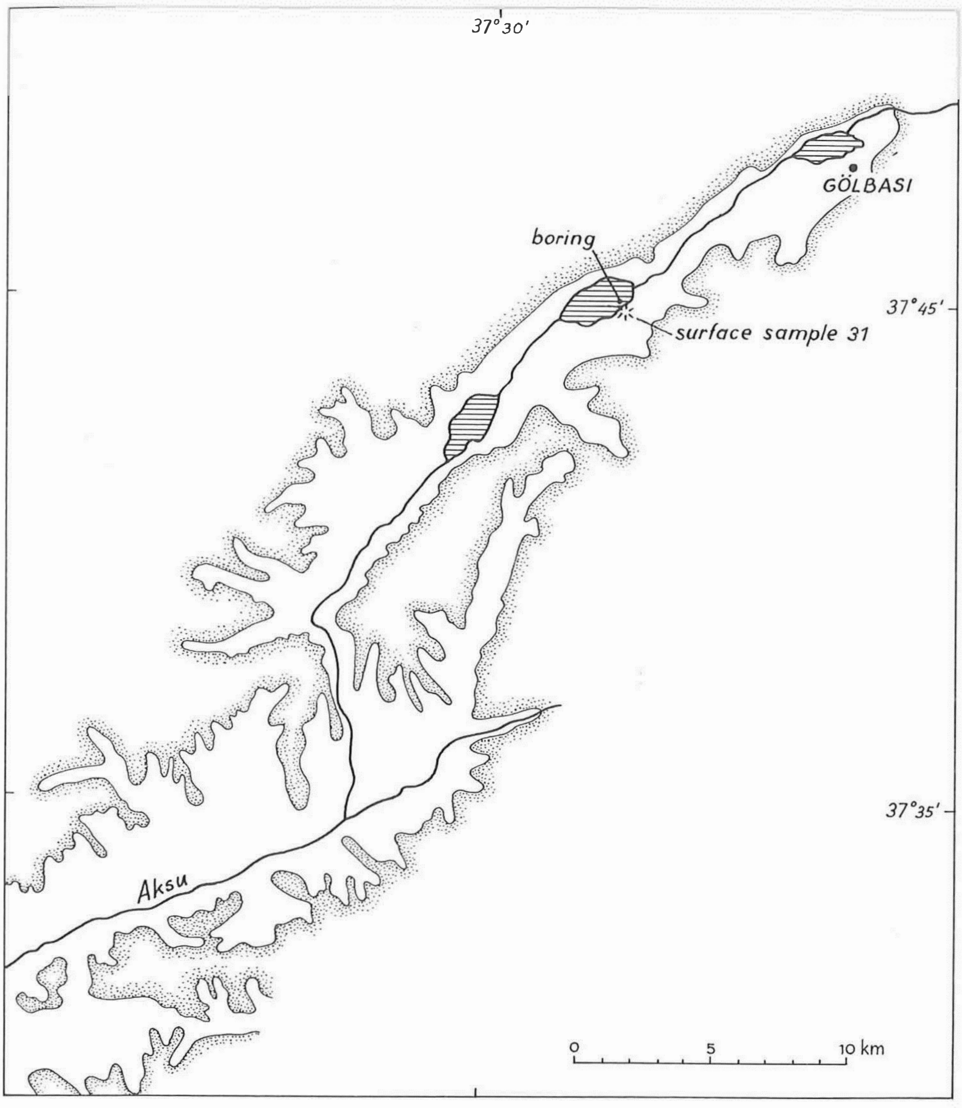


Fig. 3. Map of the Gölbasi area.

3. In deeper water *Potamogeton*, *Chara*, and locally *Nuphar* are present. *Chara* grows on the lake bottom in water at least up to 4 m deep.

The slopes on both sides of the valley are covered with a heavily grazed shrub vegetation, the remnant of the original forest. On the east side of the valley the shrubs consist mainly of deciduous oaks, while also *Juniperus*, *Paliurus spina-christi*, *Rhus coriaria* L., *Prunus*, and *Amygdalus* are present. In the valley *Populus* has been planted, and on the upland adjoining the valley vineyards and fields are found.

Boring. The middle lake was cored at a point about 200 m from the edge, opposite to a dome-shaped bedrock hill which is situated in the valley east of the lake and on which cereals are grown. The boring was carried out from a primitive raft with a Livingstone sampler (cf. Wright, Cushing & Livingstone, 1965) with an inner diameter of 2.5 cm. At the spot of the coring the water is 3.30 m deep. The bottom of the sediment was not reached.

The following, somewhat simplified lithology could be established:

3.30– 4.45 m	grey clay (not sampled because it was too soft)
4.45– 5.05	grey clay with organic bands in lower part
5.05– 9.90	marl with clay bands below 7.45 m
9.90–10.65	clay with marl bands in upper part
10.65–11.15	marl with clay bands
11.15–11.45	clay with marl bands
11.45–11.65	marl
11.65–12.55	clay with bands of marl or organic matter
12.55–13.35	marl with clay bands
13.35–13.45	clay

Pollen diagram. The results of the analysis of the Gölbasi core are represented in the pollen diagram of Fig. 4. The pollen frequencies are graphed as percentages of a pollen sum in which all pollen types are included except those types which wholly or for the greater part originate from water and marsh plants. These latter pollen types are shown as white silhouette curves.

As for the Pinaceae curve, a re-examination a few years after the core had been analysed, showed that among the pollen counted as *Pinus*, small numbers of *Cedrus* occur. Moreover, it turned out that *Abies* pollen – mostly only bladders – is present in some samples. As has already been mentioned on p. 24, at present *Cedrus libani* and *Abies cilicica* are found in the eastern part of the Central Taurus Mountains. According to the map of the Turkish Forestry Department, the nearest occurrences of *Cedrus* are found at about 40 km southwest and west of Gölbasi. *Abies cilicica* stands occur at about 100 km west of the coring site. The presence of *Cedrus* and

Fig. 4. Pollen diagram of Gölbasi Lake. In this diagram are *not* included: spectrum 1: Vitex 0.3 %, Cotinus 0.3 %; spectrum 2: Menyanthes 0.2 %; spectrum 4: Daphne 0.2 %, Hypericum 0.2 %, Typha latifolia 0.2 %; spectrum 5: Ephedra fragilis-type 0.4 %, Ephedra distachya-type 0.4 %; spectrum 6: Rhamnaceae 0.2 %, Datisca 0.2 %; spectrum 7: Labiatae 0.3 %; spectrum 10: Carpinus betulus 0.4 %; spectrum 17: Papaver 0.4 %, Ericaceae 0.2 %; spectrum 21: Campanula 0.3 %, Typha latifolia 0.3 %; spectrum 23: Lythrum 0.4 %; spectrum 24: Ulmus 0.3 %, Nuphar 0.6 %.

GÖLBASI, ADIYAMAN VILAYET

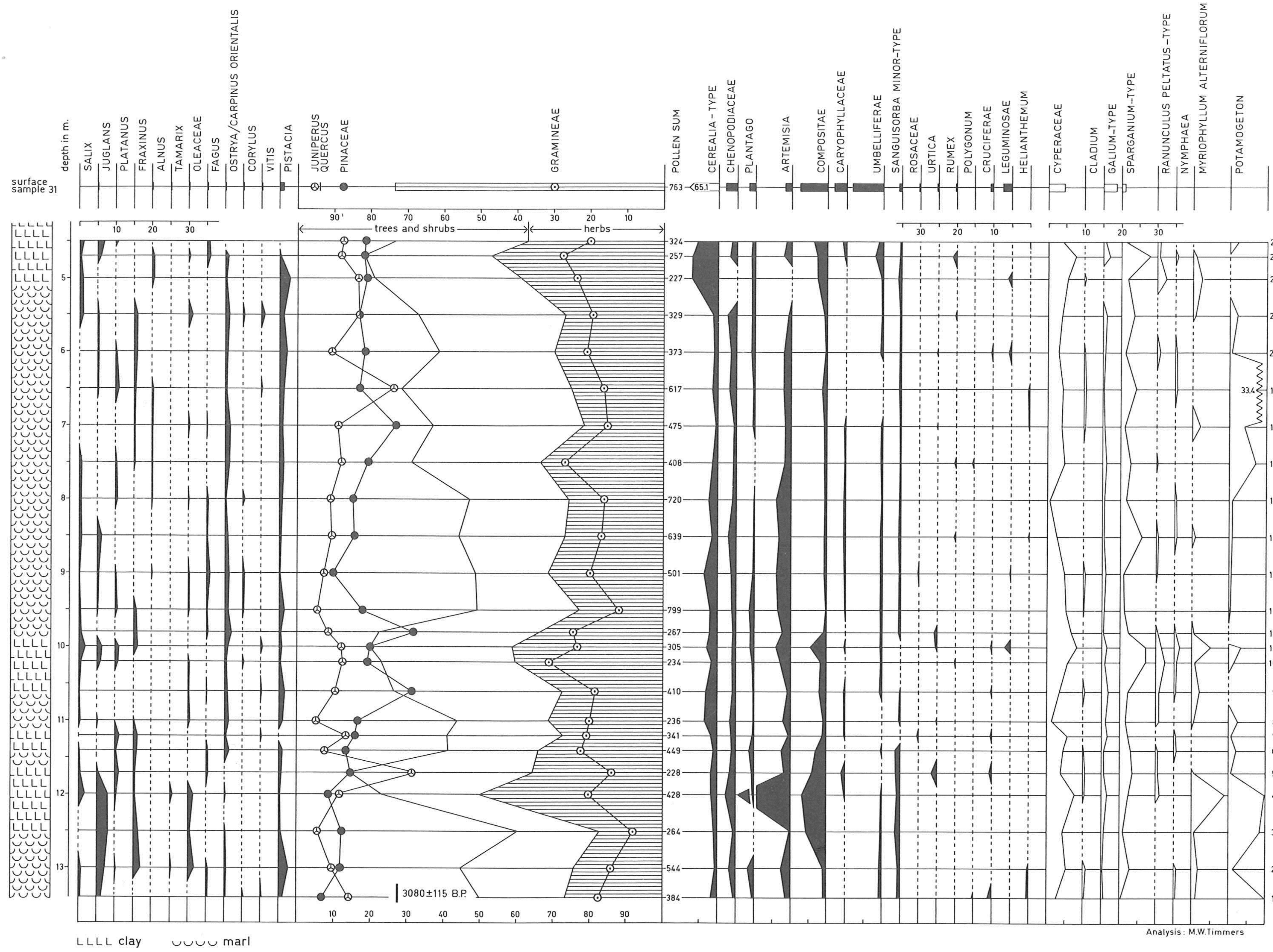
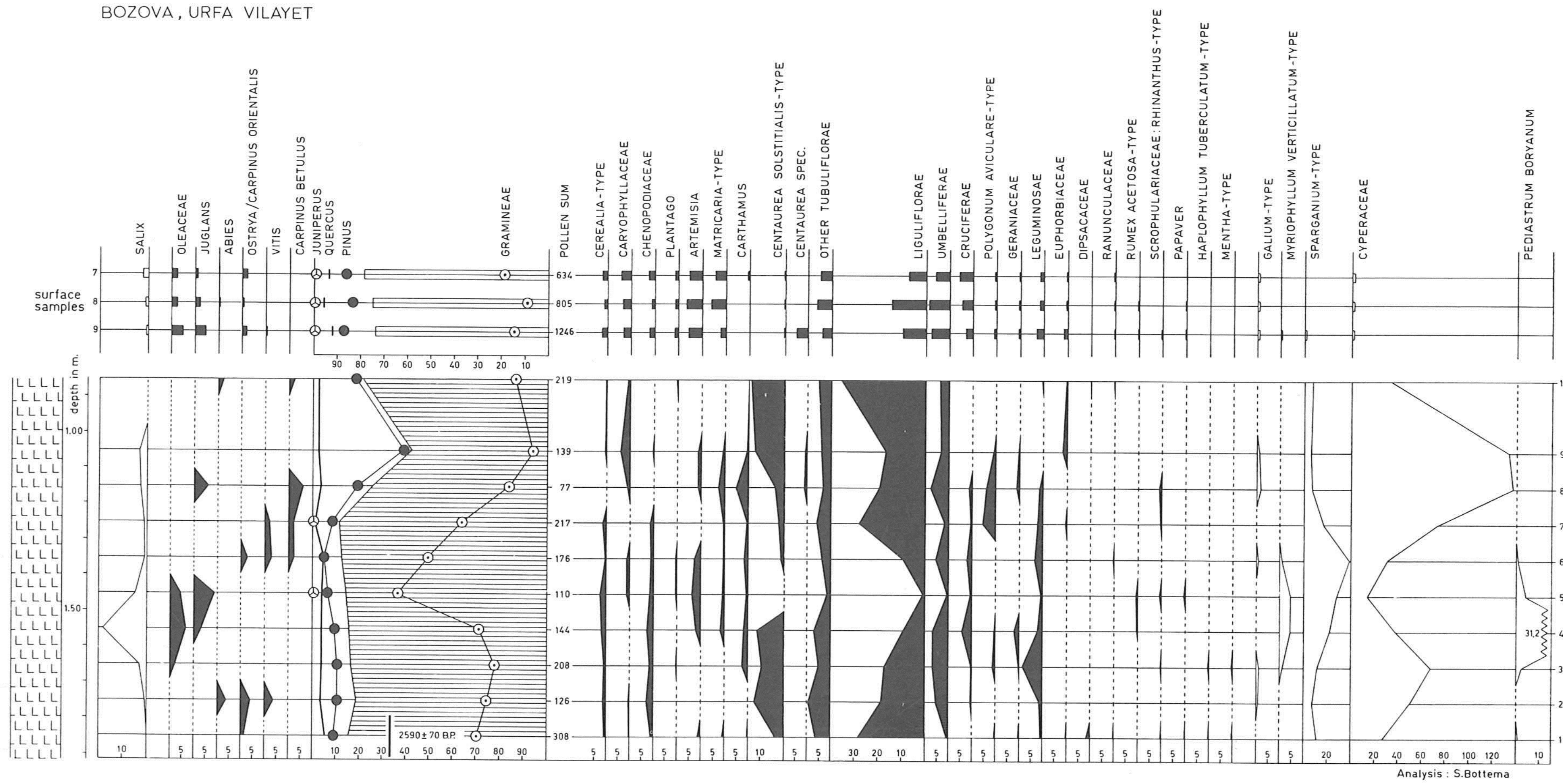


Fig. 5. Pollen diagram of Bozova Lake. In this diagram are *not* included: spectrum 1: Ulmus 0.3 %, Thalictrum 0.3 %, Asphodelus 0.6 %, Campanulaceae 0.6 %, Typha latifolia 0.3 %, Alisma 0.3 %, Potamogeton 0.3 %; spectrum 2: cf. Fagopyrum 0.8 %; spectrum 3: Verbascum-type 1.0 %, Malvaceae 0.5 %, Cistaceae 0.5 %; spectrum 4: Boraginaceae 0.7 %; spectrum 5: Bupleurum-type 0.9 %, Pteridium 0.9 %; spectrum 6: Fraxinus ornus-type 1.1 %, cf. Hypericum 0.6 %, Potentilla-type 0.6 %; spectrum 7: Sanguisorba minor-type 0.5 %; spectrum 9: cf. Centaurea 0.7 %.

BOZOVA, URFA VILAYET



Abies pollen in the Gölbasi core must be ascribed to long-distance transport. Since the pollen grains originally counted as *Pinus* turned out to include *Cedrus* and very likely some *Abies*, this type is indicated as Pinaceae. It should be stressed that at least 95 % of the Pinaceae consists of *Pinus*, so that in practice this curve reflects fairly accurately the share of pine in the pollen precipitation.

Olea-type pollen constitutes the larger part of the Oleaceae. The category "other Compositae" includes *Centaurea solstitialis*-type pollen which has been met with in small numbers.

The Cerealia-type pollen is larger than 39–40 μ (silicone oil slides), and it has a thick wall as well as a very pronounced annulus. All Cerealia-type pollen grains which were studied under the phase-contrast microscope showed a *Triticum*-type wall structure. Although it is not impossible that the Cerealia-type pollen also includes pollen of wild grasses, it is likely that mainly pollen of cereals is concerned.

The lower three spectra of the Gölbasi diagram show high ΣAP percentages, and among the tree pollen that of *Quercus* is by far the most important. It is likely that these spectra represent a period in which the upland forest in the Gölbasi area had not yet suffered serious destruction. Deciduous oaks would have constituted the main component of the upland forest. *Juniperus* values of 5 to 13 % may indicate that representatives of this genus played an important part in the forest vegetation in the area.

Pistacia would also have been present in the upland forest. As this tree is seriously under-represented in the pollen rain pistachio frequencies of about one per cent suggest that it was fairly common in the regional forest vegetation.

As for the other arboreal pollen met with in the Gölbasi samples, *Platanus*, *Juglans*, *Fraxinus*, *Alnus*, *Tamarix*, and *Salix* would have originated from trees and shrubs in the river valleys. The presence of *Fagus* pollen in the Gölbasi lake sediment would have to be ascribed to long-distance transport (see p. 30). It cannot be excluded that the pollen of *Corylus* and *Ostrya/Carpinus orientalis* is derived from trees which were present in the Gölbasi area. At least the distribution maps of *Corylus* and *Carpinus orientalis* published by Meusel, Jäger & Weinert (1965) suggest that these species are native in this region.

The marked decline in the *Quercus* curve above 12.50 m suggests that at least a part of the upland forest suffered serious destruction. The *Artemisia* maximum at 12.00 m points to a strong increase of this herb in forest clearings. From the *Juniperus* maximum at 11.70 m, it may be concluded that juniper first expanded in the deforested parts, after which oak regenerated to a certain extent. The low *Quercus* pollen percentages between 10.60 and 9.80 point to a renewed clearance of the upland forest.

The *Pinus* maxima at 10.60 and 9.80 m cannot easily be explained. A deforestation of the adjoining upland to such an extent that the share of pine in the pollen rain increased so considerably is very unlikely. The *Pinus* maxima are not accompanied by herbaceous pollen maxima, and, moreover, pine shows no increase at the minimum in the oak pollen curve at 12.00 and 11.70 m.

As for the relatively high Cerealia-type pollen percentages between 11.00 and 9.00 m, it is difficult to imagine that this could have been caused by cereal growing on the slopes at a distance of 1500 m and more from the coring site. Cultivation of these self-pollinated crop plants on the small dome-shaped bedrock hill mentioned on p. 32 can neither be held responsible for the fairly large numbers of Cerealia-type pollen. One must assume that the cereals were grown in the valley itself and not, or at least not only, on the upland slopes. This could only have been possible if the valley was less wet than it is to-day. The fact that a conspicuous increase of Compositae precedes the relatively high values for cereal-type pollen could indicate that at first the part of the valley close to the boring site was mainly in use as grazing land.

Apparently, the section between 12.50 and 9.00 m represents a period of more intensive human activity in the Gölbasi area. On the one hand, there was a rather serious interference with the upland forest vegetation, and, on the other hand, it looks as if in the valley itself cereals were grown on a fairly large scale.

For the level between 13.20 and 13.45 m a radiocarbon date of 3080 ± 115 B.P. (GrN-4873) was obtained. Assuming a more or less constant rate of accumulation of the lake sediment, the period of more intensive human activity (12.50–9.00 m) should be dated from about 2850 to 1750 B.P. However, the upper part of the sediment consists of soft to very soft material, and consequently, it will represent a shorter time period than an equally long section at a lower level where the sediment is more compact. Because of the compression factor the calculated dating of about 900 B.C. to 200 A.D. for the period of more intensive human activity may be somewhat too old, but the deviation will not be more than 100 and 200 years respectively for the beginning and the end of this period. Moreover, the statistical error of the radiocarbon date has to be taken into account.

After a temporary recovery of the *Quercus* pollen percentages a gradual decline in the oak curve takes place from 8.00 m onwards. This points to an increasing degradation of the upland forest in this area. In the upper spectra of the diagram higher pollen values for Cerealia-type and Compositae can be observed, suggesting again a more intensive use of the valley east of the lake.

Surface sample 31, which was taken on the bedrock hill opposite the boring site, is shown above the Gölbasi diagram. As this sample was collected near a wheat field, Cerealia-type pollen is very abundant, and for that reason it is not included in the pollen sum. The *Quercus* pollen value in this sample is distinctly lower than those in the upper spectra of the diagram, indicating that after the deposition of the sediment at 4.50 m, that is since a few centuries at most, an intensified degradation of the upland forest has taken place. The fact that in the surface-sample spectrum *Pinus* constitutes the dominant tree pollen type points likewise to a serious reduction of trees in the Gölbasi area.

It has already been mentioned that Cerealia-type pollen shows particularly high values in the sections between 11.00 and 9.00 m and between 5.00 and 4.50 m, suggesting that cereals were grown in the valley, at a short distance from the boring site. However, in the other sections of the diagram the percentages for this pollen type are still too high to attribute them to cereal cultivation on the upland only. It is tempting to assume that throughout the whole period represented by the Gölbasi diagram the valley, or at least a part of it, was in use as arable land. This would imply that it was not until a few centuries ago at most that the valley became unsuitable for agriculture because of a rise in the water table.

This rise has not necessarily been caused by climatological factors such as changes in precipitation or temperature. The lakes in the headwater valley of the Aksu river thank their origin to damming up by alluvial fans. It is clear that changes in the height of the threshold will affect the maximum water level in the lake concerned. Consequently, the rise in the water table in the middle Gölbasi lake mentioned above could have been caused by a raising of the threshold level. This, in turn, could have been the effect of an intensified erosion induced by the large-scale clearing of the upland forest.

Summarizing, it may be concluded that the changes in the upland vegetation which are suggested by the course of the pollen curves in the Gölbasi diagram are due to the activity of man. There are no indications that during the last 3000 years changes in climate would have exercised a marked influence on the upland vegetation.

Beug (1967) arrived at a similar conclusion for the area around Yeniçaga Lake, ca. 35 km east-northeast of Bolu, in northwestern Turkey (40°47′N, 32°2′ E). The pollen diagram obtained for a core from this lake suggests that the character of the forest changed little during the last 4000 years.

BOZOVA LAKE

Site and boring. Near the tea house at about 3 km southwest of Bozova (Urfa Vilayet) two small, spring-fed lakes are present. The northern half of the basin of the larger lake (37°21′N, 38°31′E), opposite the tea house, is filled with clay, and it supports a poplar plantation with an undergrowth of willow and a few other shrubs. *Platanus* and some *Fraxinus* occur along irrigation canals. The Bozova area is situated at an elevation of about 600 m, and consequently, according to Louis (1939) a steppe would constitute the natural upland vegetation.

The site was cored in the center of the basin, near the edge of the water. For the boring a Dachnowsky sampler with an inner diameter of 3.7 cm was used.

The following, somewhat simplified lithology was recorded:

0–2.05 m	grey clay, becoming mottled near base
2.05–2.25	brown clay
2.25–4.80	red brown clay with concretions
4.80	? bedrock; further penetration proved to be impossible

Only the section between 0.85 and 1.85 m proved to be suitable for pollen analysis, but in most of the samples from this section the pollen concentration was too low to obtain a satisfactorily high pollen sum.

The sediment in the smaller lake, about 1250 m southeast of the larger one, turned out to be barren of pollen.

Pollen diagram. The diagram which was prepared from the section between 0.85 and 1.85 m is shown in Fig. 5. The pollen sum includes all pollen types, with the exception of *Salix*, Cyperaceae, *Typha latifolia*, *Sparganium*-type, and *Myriophyllum*.

For comparison the spectra of surface samples 7, 8, and 9, which were collected at about 150 to 250 m from the lake, are shown above the Bozova diagram. For the section between 1.78 and 1.90 m a radiocarbon date of 2590 $\pm$ 70 B.P. (GrN-4874) was obtained.

The ratio between tree and herbaceous pollen indicates that during the period represented by the Bozova diagram, no important changes in the vegetation pattern took place. Comparison with the surface-sample spectra from Bozova suggests a treeless upland vegetation in the vicinity of the lake, and, somewhat farther away, woodland at elevations above 700–800 m.

Quercus pollen values remain low throughout the whole diagram, but in the upper part they are noticeably lower than in the bottom part. It is not unlikely that this is the result of an increased interference of man with the oak woodland at some distance from Bozova.

Except for the sample at 1.35 m, pollen of *Pinus* is more abundant than that of *Quercus*. In discussing the surface-sample spectra the question has been raised whether the relatively high *Pinus* pollen values in samples from areas with little or no tree growth could at least partly be attributed to pines which have been planted in the towns (p. 26–7). In the lowermost spectra of the Bozova diagram, *Pinus* pollen values are 1.5 to 3 times higher than those for *Quercus*. It is very unlikely that pines would have been planted more than 2000 years ago in the Bozova area. Consequently, the pine pollen in the lower spectra of the diagram must be wholly ascribed to long-distance transport. In most surface-sample spectra from the steppe and outer deforested area the *Pinus/Quercus* ratio is of the same order as that in the Bozova diagram. For that reason it seems justified to assume that most of the pine in the modern pollen rain, not only in the original steppe region, but in the whole of southeastern Turkey, has travelled far from its source.

While *Plantago* is scarcely represented in the Bozova diagram, the surface samples from this site yielded somewhat higher frequencies; averaging 0.23 and 1.4 % respectively. In these surface-sample spectra *Artemisia* values are also higher than those in the diagram (averaging 6.1 and 1.1 % respectively). This may point to a recent increase of plantain and wormwood as a result of intensified grazing.

The high Gramineous pollen values in the samples at 1.25, 1.35, and 1.45 m are accompanied by distinct minima in the curves for *Centaurea solstitialis*-type and Liguliflorae. One could imagine that this would indicate a temporary decrease in the grazing pressure in the vicinity of the site. On the other hand, the grass pollen maxima coincide also with high Cyperaceous pollen values and with a peak in the curve for *Sparganium*-type, both pollen types which would almost exclusively have originated from plants in the marsh vegetation around the lake. For that reason the conspicuous changes in the percentages for various herbaceous pollen types in the middle part of the diagram could very well reflect changes in the local marsh vegetation probably caused by fluctuations in the water level of the lake.

EPILOGUE

It is to be regretted that the results of the surface-sample study of southeastern Turkey could only to a limited extent be applied to the interpretation of pollen diagrams from lake sediments in this area. One may hope that in the near future pollen diagrams can be prepared for southeastern Turkey which will cover a much longer period than the Gölbasi and Bozova diagrams and which will provide information on vegetation and climate during the time that the evolution to agriculture and stock-breeding took place.

The diagrams of Yeniçaga (Beug, 1967), Gölbasi and Bozova suggest that in Turkey the climate did not change noticeably during the last 3000 to 4000 years. In this connection it should be mentioned that the palynological study of lake sediments in western Iran led to the conclusion that after about 5500 B.P. the climate there may have shown minor fluctuations but no major changes (Van Zeist & Wright, 1963; Van Zeist, 1967).

SUMMARY

Altogether 38 spectra were obtained for surface samples taken in the steppe and forest regions of southeastern Turkey. The spectra from the steppe and the outer deforested area show high herbaceous percentages, but the frequencies for *Artemisia*, *Plantago* and Chenopodiaceae are low. In these samples *Pinus* values are higher than those for *Quercus*, presumably because of a better long-distance transport of pine pollen.

In the spectra from the forest region *Quercus* generally shows fairly high values, but oak pollen frequencies can be low in areas where the forest suffered serious destruction. In relation to *Quercus*, most other trees and shrubs such as *Pistacia*, *Acer*, and *Paliurus* are under-represented in the pollen rain. The pollen percentages of *Juniperus* are also smaller than the share of this species in the vegetation would suggest.

The pollen diagram obtained for a core fiom a lake near Gölbasi indicates that about 3000 years ago a fairly undisturbed forest, in whick oak, juniper, and pistachio played an important part, covered the higher grounds in that area. Changes in the upland vegetation which took place after about 2850 B.P. would have been caused by man.

The results of a palynological study of the sediment in a small basin near Bozova, in the steppe region, suggest that during the last 2500 years no important changes took place in the vegetation pattern in the vicinity of this site.

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