LATE QUATERNARY VEGETATION AND CLIMATE OF SOUTHWESTERN TURKEY PART II

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ABSTRACT: In this paper additional information is given on the vegetational history of southwestern Turkey. The history of the area is extended in time and space. The area covered extends from the Mediterranean coast in the southwest to the plain of Konya in the east. The oldest periods studied date back to c. 15,000 B.P. but most of the information is from the Holocene. The vegetational and climatic history is treated for every core locality. General conclusions are in agreement with the study on the 'Late Quaternary vegetation and climate of southwestern Turkey' (van Zeist *et al.*, 1975). Especially the problematical high pollen percentages of *Centaurea solstitialis*-type are discussed.

An attempt has been made to reconstruct the environment of prehistoric man and the impact of early inhabitants upon the vegetation is analysed. Clear indications derived from the palynological record are from Late Neolithic and metal cultures only, as the early Neolithic has left no traces. An important agro-fruticultural period starting at about 3200 B.P. cannot be brought into line with the archaeological evidence.

KEYWORDS: Southwest Turkey, Pleniglacial, Late Glacial, Holocene, palynology, palaeoenvironment, climatic history, prehistoric man, *Centaurea solstitialis* pollen type.

1. INTRODUCTION

This contribution forms part of a study on Late Quaternary vegetation and climate development of Turkey. Information on the younger Holocene of the Adyaman region in eastern Turkey is given by van Zeist, Timmers & Bottema (1970). The Holocene of the Lake Van area was investigated by van Zeist & Woldring (1978). An outline of the history of vegetation and climate of southwestern Turkey is given by van Zeist, Woldring & Stapert (1975).

In 1977 W. van Zeist, H. Woldring and S. Bottema collected sediments at locations that had been shown to be promising in the study published in 1975. In addition to those cores, new cores were taken to supply more information on this part of Turkey.

For information on the geology, vegetation, climate and the modern pollen rain the reader is referred to van Zeist *et al.* (1975). Where additional information has been obtained, this will be given in the sections dealing with the particular core locations.

In 1984 a start was made with the palynological investigation of northern Turkey. During a joint expedition organized by Professor Burhan Aytuğ of the Orman Fakültesi, University of Istanbul and the Biologisch-Archaeologisch Instituut of the State University of Groningen, thirteen lakes and marshes were cored.

2. THE SEDIMENT CORES

The aim of the 1977 expedition, of which the results are given in this study, was twofold. Cores taken during the 1970 expedition, that had yielded promising information but that covered only the younger part of the Holocene, were extended in depth and thus in time. It is self-evident that an attempt was only made when the bedrock was not hit during the first coring. This was successfully performed in the Beyşehir basin, but in the drained lake of Söğüt the sediment had hardened so much since 1970 that deeper coring turned out to be impossible.

Besides, new locations were tried. Of these sites the sediment of Suğla Gölü turned out to be devoid of pollen. The majority of the cores were taken in the Oro-Mediterranean zone, *viz.* Avlan Gölü, Gölhisar Gölü, Pinarbaşi and the continuation of Beyşehir Gölü. A core near Elmali in the same zone, taken already in 1970, will also be treated in this study (fig. 1). A core taken from Akgöl, near Ereğli in the eastern Konya basin, lies in the steppe zone. Finally one core was obtained from former Ova Gölü at about sea-level in the Eu-Mediterranean vegetation belt.

2.1. Beyşehir Gölü II

2.1.1. *The geographical situation*

The geographical situation of the Beyşehir area is already given by van Zeist *et al.* (1975).

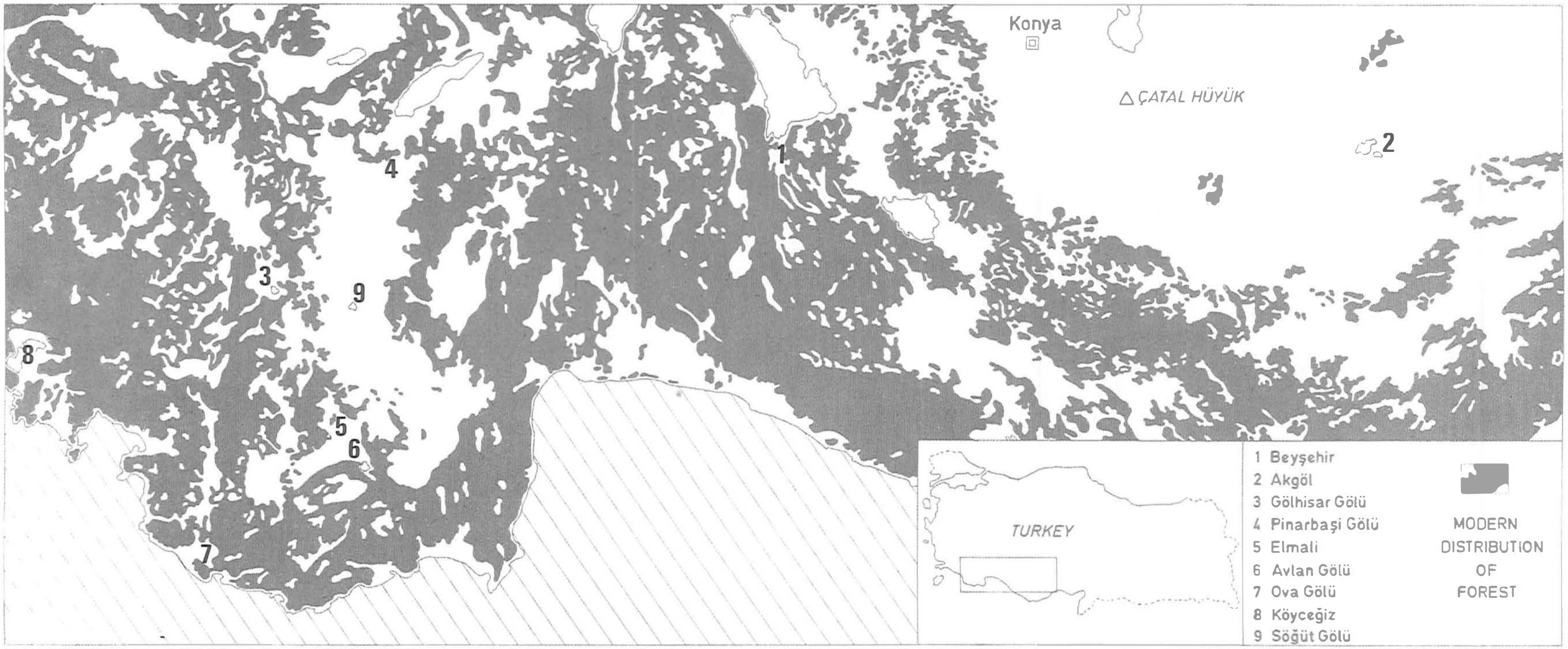

Fig. 1. Map of the area showing the modern distribution of forest according to Yeni Türkiye Atlasi, 1977. The numbers refer to the core locations.

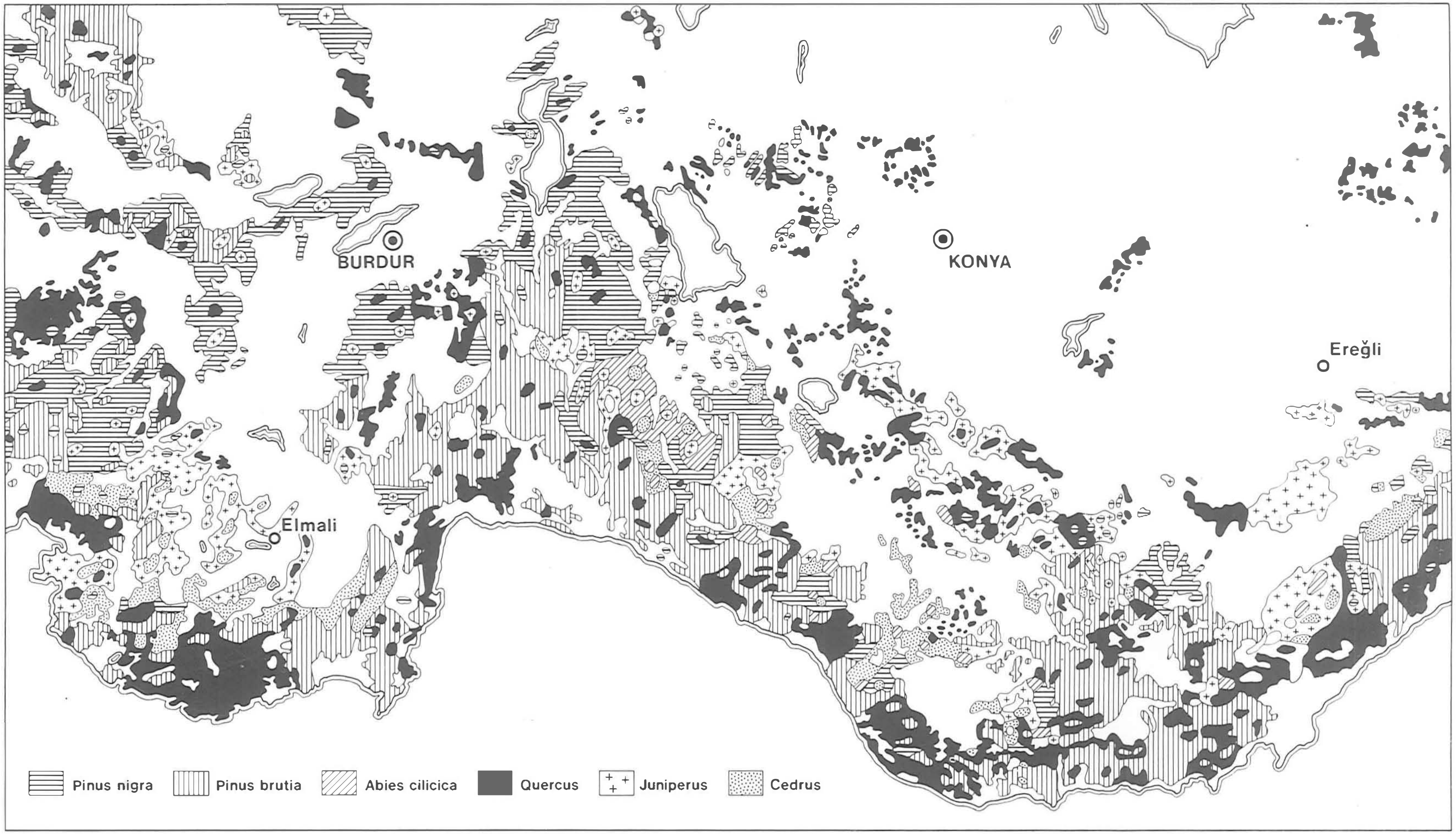

Fig. 2. Map showing the gravity point of various tree species (Orman Genel Müdürlügü Yayinlarindan, 1962).

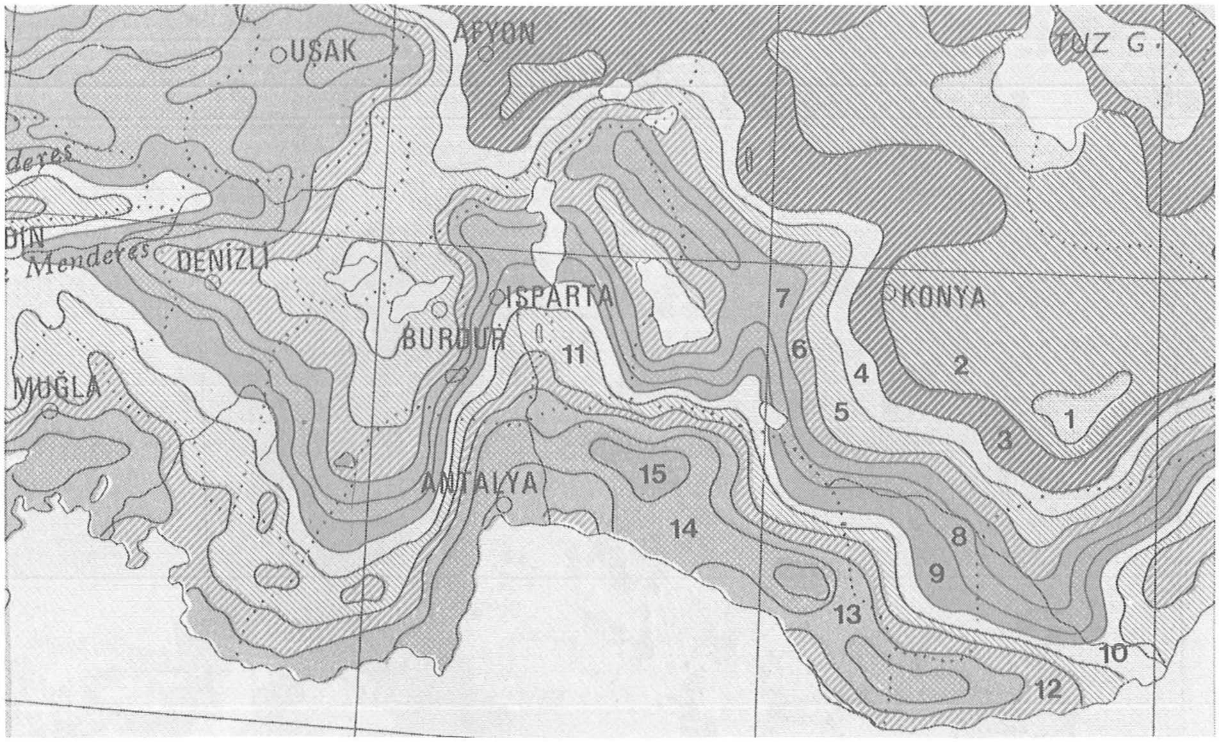

Fig. 3. Map showing the average precipitation for January (Yeni Türkiye Atlasi, 1977). 1. 20-30 mm; 2. 30-40 mm; 3. 40-50 mm; 4. 50-60 mm; 5. 60-70 mm; 6. 70-80 mm; 7. 80-90 mm; 8. 90-100 mm; 9. 100-125 mm; 10. 125-150 mm; 11. 150-200 mm; 12. 200-250 mm; 13. 250-300 mm; 14. 300-400 mm; 15. 400-500 mm.

2.1.2. *The vegetation*

Beyşehir Gölü is situated in between the Oro-Mediterranean and the Xero-Euxinian belt. For a description of the present vegetation the reader is referred to van Zeist *et al.* (1975).

2.1.3. *The climate*

To inform the reader, information on precipitation and temperature from the Yeni Turkiye Atlasi (1975) is given in figures 3-6.

2.1.4. *Lithology and radiocarbon dates*

For the lithology see also the lithological information on the coring in Beyşehir in 1970 (van Zeist *et al.*, 1975). The following lithology was recorded in 1977:

0 - 9.05 m	grey to blue-grey clay
9.05-10.05 m	blue-grey clay with some grit

The Beyşehir core is not very suitable for radiocarbon dating as the sediment contains little organic material. Below 9.00 m the organic content is too low for radiocarbon dating. The only date available for the core under discussion has been taken from blue-grey clay at the level of 8.90-9.00 m. The sediment is dated to 15,390±370 B.P. (GrN-10477), the low carbon content being responsible for the rather large standard deviation.

2.1.5. *Pollen assemblage zones*

The following characteristics have led to the establishing of the zones:

Zone 1 (spectra 1-11): AP values 10-15%, dominating Compositae, *Artemisia* 5-15%.

Zone 2 (spectra 12-15): AP values over 50%, no *Alnus* and *Betula*.

Zone 3 (spectra 16-31): increasing values for *Pinus*, *Cedrus*, *Juniperus* and *Quercus cerris*-type. Subzone 3a (spectra 16-22): high *Quercus* and *Juniperus*. Subzone 3b (spectra 23-25): lower *Quercus* and *Juniperus*. Subzone 3c (spectra 26-27): resembles subzone 3a. Subzone 3d (spectra 28-31): increase of *Pinus* and *Cedrus* relative to *Quercus* and *Juniperus*.

Zone 4 (spectra 32-41): low type-diversity, many arboreal types have disappeared, important Compositae values, continuous decrease of *Cedrus*. Subzone 4a (spectra 32-37): relatively high AP values compared to the next subzone. Subzone 4b

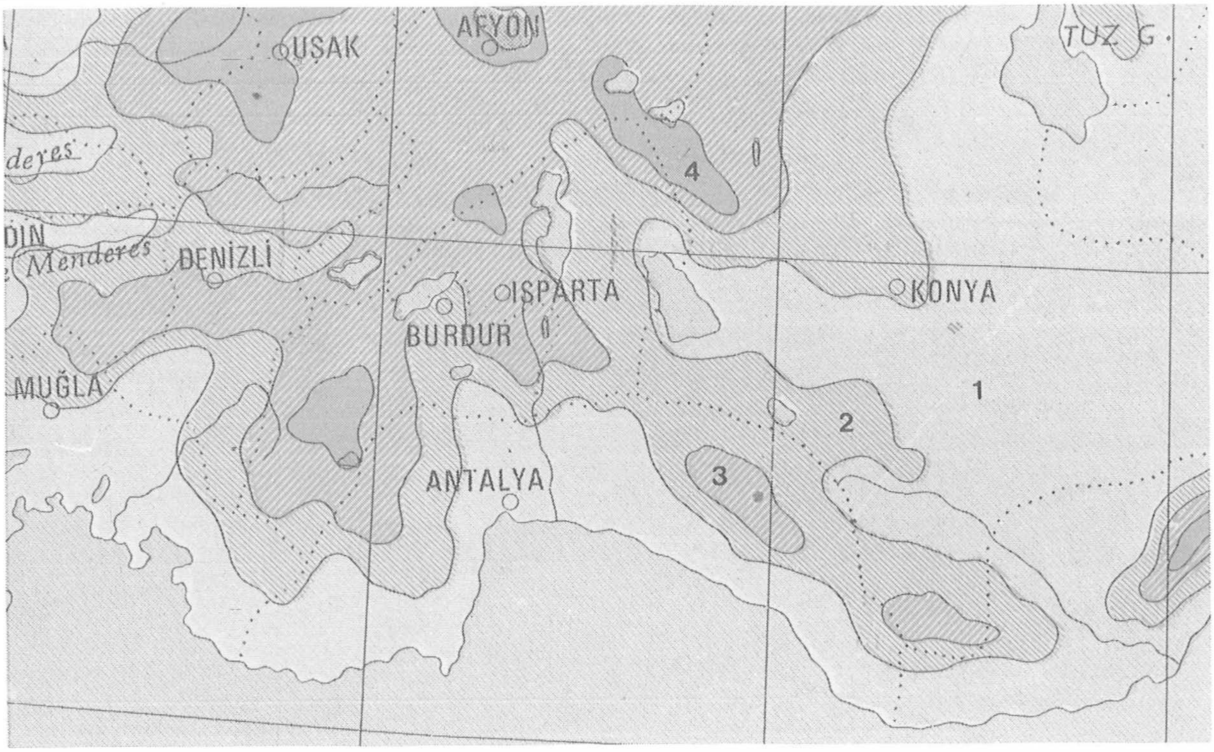

Fig. 4. Map showing the average precipitation for July (Yeni Türkiye Atlasi, 1977). 1. 0-5 mm; 2. 5-10 mm; 3. 10-15 mm; 4. 15-20 mm.

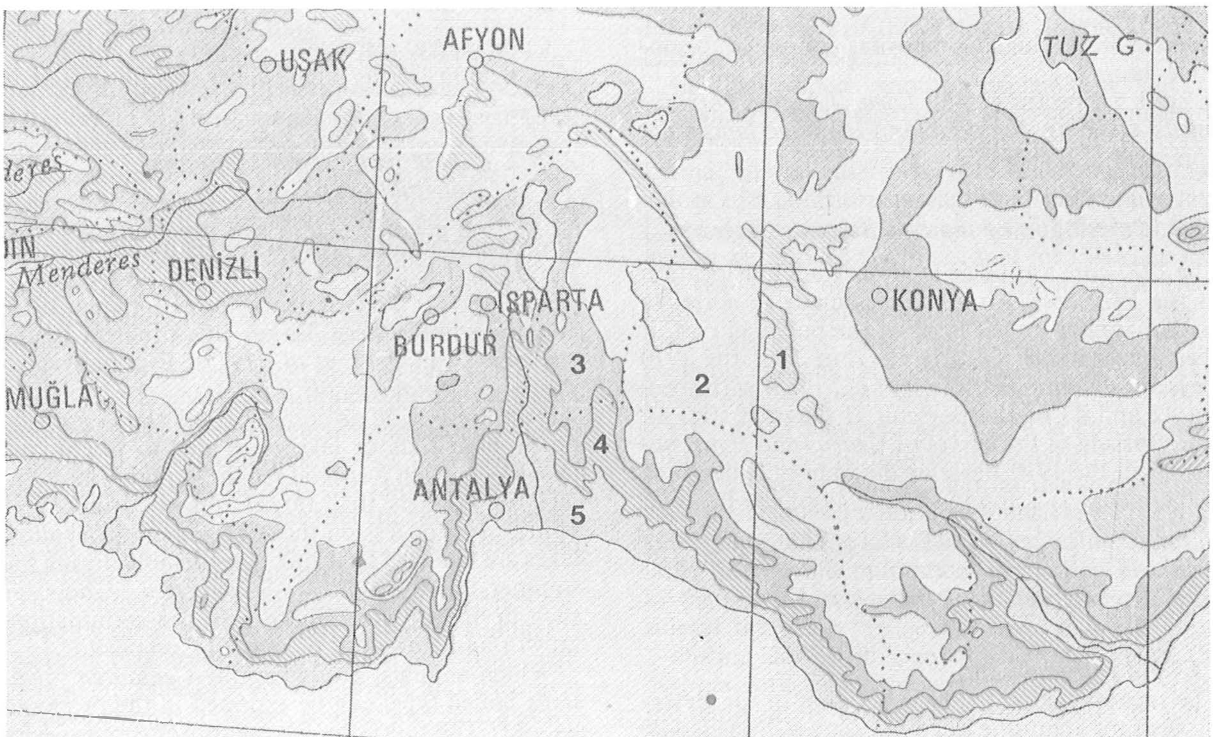

Fig. 5. Map showing the average temperature for January (Yeni Türkiye Atlasi, 1977). 1. ÷8-÷4 °C; 2. ÷4-0 °C; 3. 0-4 °C; 4. 4-8 °C; 5. 8-12 °C.

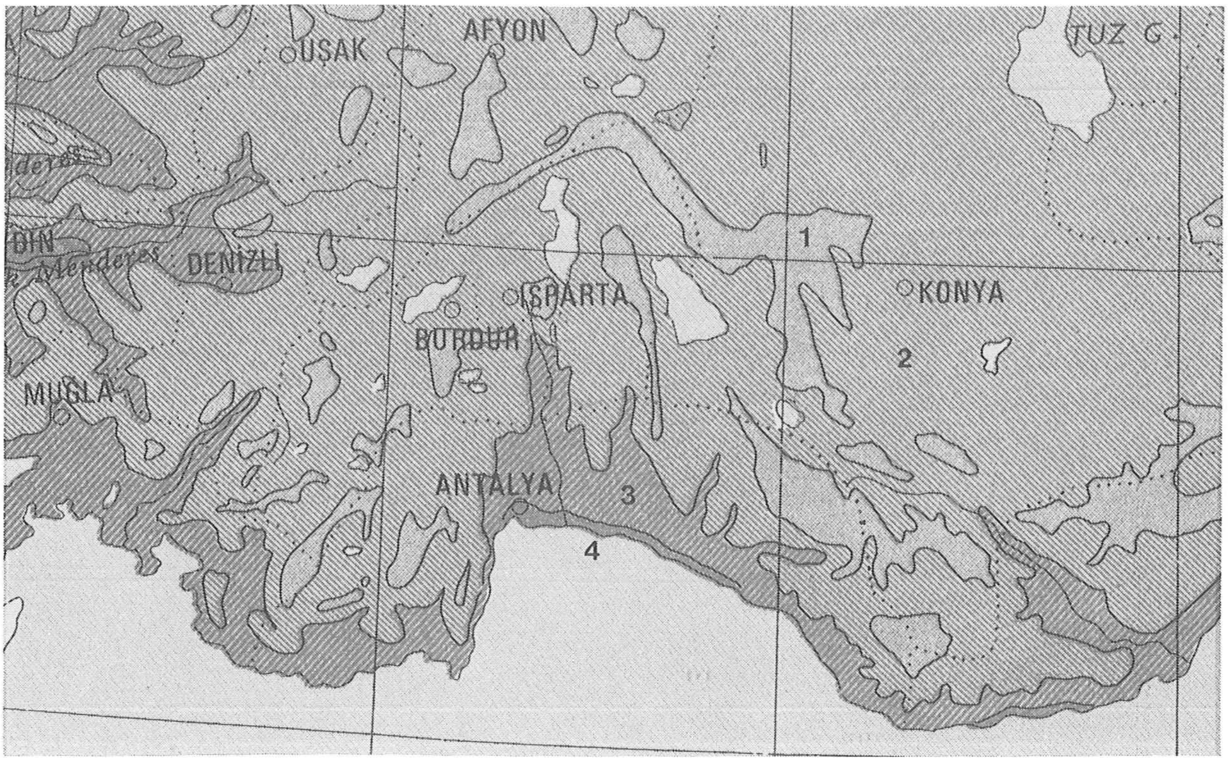

Fig. 6. Map showing the average temperature for July (Yeni Türkiye Atlasi, 1977). 1. 16-20°C; 2. 20-24°C; 3. 24-28°C; 4. 28-32°C.

(spectra 38-41): high Compositae compared to subzone 4a.

Zone 5 (spectra 42-45): *Olea*, *Juglans*, *Fraxinus ornus*, *Quercus*, *Juniperus* and *Plantago lanceolata* appear.

2.1.6. *Correlation of the two Beyşehir diagrams*

The 1977 core was taken at about the same location as the 1970 core. An attempt is made to correlate both diagrams on the basis of the pollen curves. It seems acceptable to correlate zone 3 of the 1970 Beyşehir diagram (van Zeist *et al.*, 1975) with spectra 42 and 43 of the Beyşehir II diagram (fig. 8). The crossing of the curves of *Cedrus* and *Pinus* observed in the 1970 Beyşehir diagram at a depth of 500 cm (fig. 7) is found in zone 4a of the Beyşehir II diagram.

2.1.7. *Reconstruction of the vegetation in the Beyşehir area*

2.1.7.1. *Introduction*

The reconstruction of the vegetation in the Beyşehir area for about the last 6000 years is discussed by van Zeist *et al.* (1975). Here we will discuss especially the period that precedes 6000 B.P. (fig. 8).

Compositae, especially *Centaurea solstitialis*-type demonstrating high values, are discussed in 2.1.7.2.

2.1.7.2. *Some remarks on Centaurea solstitialis-type*

In zone 1 the high values of Compositae pollen draw the attention. This phenomenon has been the subject of discussion in other studies on Mediterranean and Near Eastern palynology (Bottema, 1974) and for southwestern Turkey this problem is discussed by van Zeist *et al.* (1975). Especially high values of *Centaurea solstitialis*-type were explained by van Zeist *et al.* as coming from plants growing on exposed flats or lake edges due to fluctuating lake levels. Such a special regime would offer habitats for annuals that flower quickly and deliver pollen more or less on the spot. Especially shallow lakes are reported to shrink considerably during the summer but it has to be investigated in how far such drying up is in phase with the germination, growth and flowering of annual Compositae.

Which annuals, producing the *Centaurea solstitialis* pollen-type, can be expected in the proposed habitat? The following list comprises those species which, according to Davis (1975), belong phytotaxonomically to the *C. solstitialis* group. A very short description of their habitats and altitudinal distribution is also given here.

C. bruguierana	up to 300 m, in deserts
C. pulchella	900-1900 m, steppe, fallow land
C. hierapolitana	300-840 m, moist sand, steppe, roadsides, shores
C. solstitialis	up to 1900 m, pine forest, dry slopes, fallow land, waste places
C. iberica (*pamphylica*)	up to 2300 m, fields, road road sides, waste land
C. halolepis	300-370 m, steppe desert
C. calcitrapa	up to 400 m, fields
C. patula	400-1400 m, steppe, fields
C. laxa	? steppe, semi desert
C. halophyla	up to 920 m, salt steppe (only known from type collection)

In view of the elevation of the Beyşehir area the most likely species are *C. hierapolitana*, *C. solstitialis*, *C. iberica* and *C. patula*. *C. hierapolitana* nowadays grows under the level of the area studied but the other characteristics fit. *C. iberica* pollen has verrucae covering the tectum densely. Although resembling *C. solstitialis*-type, it could be separated when met with. Pollen reference material of *C. patula* is not present in the B.A.I. reference collection. *C. solstitialis* matches the demands. From the foregoing it can be concluded that a relatively small number of species may be responsible for the high pollen percentages, if one assumes that the plants grew on exposed mud flats.

If the curve of *Centaurea solstitialis*-type is compared with that of the Liguliflorae, it can be seen, that they do not run parallel. Often they seem to be negatively correlated. The curve for the *Matricaria*-type runs parallel with that of the *C. solstitialis*-type and so does the curve of the Cyperaceae. Where many Compositae types show a decline, an increase in percentages of some marsh plants as *Typha latifolia* and *Sparganium*-type is visible. Did marsh vegetations start to cover the exposed mud flats?

When the core was taken on May 24, 1977, it was observed that the fields around Lake Beyşehir were flooded. A very diverse marsh vegetation could be observed but no *Centaurea* species were seen. One could imagine that such species appear later in the season. It is, however, clear that the time for germination and growth would be much too short and bare mud flats were not available.

It is often stated that flooding of marshes followed by their drying up during the hot summer is the main reason for pollen to disappear from sediments. The change from dry to wet and back also means a change in oxygen content and such a situation is thought to cause corrosion of pollen rapidly. The preservation of pollen in the Beyşehir core, below 5.00 m, was poor, probably due to such conditions. *Centaurea solstitialis*-type is, however, not restricted to that part but has high values also above 3.00 m. Thus, the presence of *Centaurea solstitialis*-type is not connected with poor pollen preservation in the majority of the samples.

The problem remains where to expect a vegetation dominated by *Centaurea solstitialis*. The high pollen values found in the Beyşehir diagrams and also in other diagrams from Turkey are never found in surface samples, not for the special species discussed here, but also not for other Compositae. Even where Compositae are present in the vegetation, pollen values are much lower. Surface samples from mud flats were unfortunately not taken.

During fieldwork in Turkey in 1984, special attention was paid to the occurrence of *Centaurea*. It could be seen that yellow flowering *Centaurea* species resembling *C. solstitialis* were met with on slopes bordering lakes but then only when the soil had been ploughed. Grazed slopes did not show *Centaurea*. On grazed fallow fields on a slope bordering Büyük Gölü (in between Hafik and Sivas) H. Woldring listed the following species: yellow flowering *Centaurea*, *Plantago major*, *Cirsium vulgare*, *Plantago lanceolata*, *Ranunculus* cf. *flammula*, *Convolvulus*, *Lamium* cf. *amplexicaule*, *Malva* cf. *moschata*, *Lathyrus*, *Onopordon* cf. *acanthium*, *Lycopus*, *Veronica* cf. *arvensis*, *Capsella bursa-pastoris*, *Cerastium*, *Vicia*, *Adonis*, *Arum*, *Galium* (2 species), cf. *Scandix*. It is not impossible that high values of *Centaurea solstitialis*-type pollen in the younger part of the Holocene are the effect of (sideboard?) ploughing.

In this respect another explanation will be brought forward, based upon observations made by the authors during field work in Thessaly (Greece). In that special case there were problematical high values of Liguliflorae pollen in a small crater lake (steep depression of volcanic origin) and an explanation was looked for to account for this. The site, the two lakes of Zirelia in Thessaly, have steep slopes so that even if the water level were to fluctuate considerably, hardly any space would become available for annual Compositae. Besides, the exposed edge does not consist of mud flats but it is a mixture of clay and gravel and is covered with olive groves and cotton fields. Even if the Liguliflorae pollen is washed in from the steep slopes, such high values are not likely considering the total surface around the lake. The pollen influx from this large area would outnumber the pollen produced by the Liguliflorae assumed for the slope of the inside of the basin.

During coring in one of the small lakes the authors witnessed a peculiar phenomenon. When the temperature at that time (July 1982) at about 1.00 p.m. had risen high (sometimes over 40 °C) a constant pouring down of debris and dust could be observed to happen in the lake. The constant dust

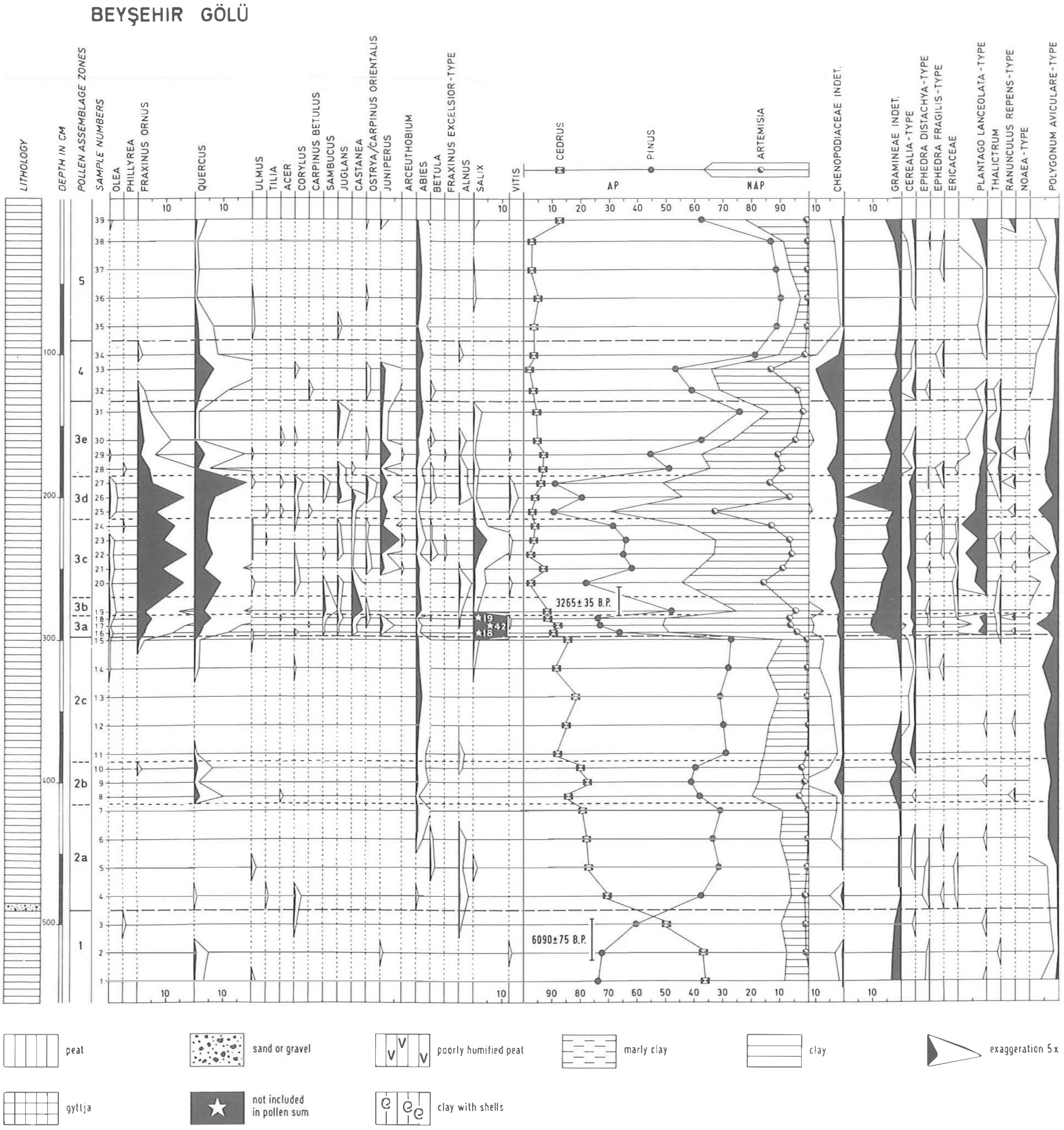

Fig. 7. Part of the pollen diagram of Beyşehir Gölü (after van Zeist *et al.*, 1975). Key to pollen diagrams.

rain was made especially visible by the work of harvesting machines at some distance. They brought small pieces of straw and chaff into the air, rapidly taken by the upward flow of hot air over the landscape, baked by the sun. The crater lake obviously was a point of much lower temperature as the water was warming up much more slowly. There a reverse movement of the air seemed to happen and caused visible precipitation of mineral and organic material.

In the pollen record of the Zirelia lake the final degrádation of natural oak forest took place a few hundred years ago. From that time on high Liguliflorae pollen percentages are found. The definite deforestation of that part of Thessaly also caused an increase in soil temperature. According to

Geddes (1983), Mediterranean soils will rise about 5 °C in temperature when the protective vegetal cover has been removed. One could postulate that the high Compositae pollen values are caused by the phenomenon as it is described here.

Many Liguliflorae, but also many other Compositae, will flower during the summer, this in contrast to for instance oaks which flower in spring. The pollen of the summer flowering plants are taken up by the upward stream and deposited in lakes with a lower temperature than the surrounding land. This would cause an over-representation of such types. Ogden *et al.* (1974) describe that Liguliflorae are occasionally trapped in significant amounts in air samples. Often this concerns clumps kept together by oily droplets. For the Turkish lakes an identical situation may have occurred. In two situations bare soil that could be warmed up rapidly during the summer was present: glacial or early Holocene natural steppe and later man-made culture steppe.

2.1.7.3. *The vegetation history*

From the pollen assemblages in zone 1 it may be concluded that open steppic vegetations occurred in the Beyşehir area during that period. Trees were to be found at some distance in the mountains or in those scarce localities in the area where conditions were favourable enough for tree growth.

During zone 2, the (almost) treeless landscape was invaded by pine. Herb-pollen values decrease from about 90% to 50%. *Centaurea solstitialis*-type values drop to less than 7%. *Centaurea solstitialis* is reported by Davis (1975) to grow in pine forests. Production of pine pollen will have suppressed the relative value of *Centaurea solstitialis*-type, but the shade of the pine trees may have influenced also the absolute numbers of plants and the shade will have changed the intensity of the upward airflow.

The disappearance of birch pollen suggests that pine trees may have taken the place of birch. After the pine maximum during zone 2, deciduous oak and *Juniperus* expand. *Juniperus*-type is generally under-represented in the pollen rain and it is likely that some junipers were present all the time. *Quercus* showing pollen values of less than 1% must have been absent from the area during zone 2. Modern values for deciduous oak pollen of up to 2.5% are found all over the Syrian steppe or desert-steppe, whereas the nearest oak stands are up to 400 km away (Bottema & Barkoudah, 1979). When deciduous oak pollen values have reached c. 7% during zone 3a, it is possible that some oak was present in the area.

During the next period, subzone 3b, oak pollen had disappeared and the forest cover was formed by cedar and pine, with an admixture of Cupressaceae (*Juniperus excelsa*?). Gradual change of the vegetation of deciduous oak, juniper and *Artemisia herba-alba* towards conifer forest and the reverse, took place again during subzones 3c and 3d.

During zone 4a conditions for tree growth around Lake Beyşehir became unfavourable once more. Pine seems to have maintained itself reasonably but cedar gradually decreased. One may still speak of a cedar/pine forest during the first part of zone 4, but it must have been an open forest where herbs played an important role. During zone 4b conditions must have resembled those of zone 2. Open pine forest prevailed with a slight admixture of cedar. *Centaurea solstitialis* was very common in the herb cover. Values for *Artemisia herba-alba*-type and *Chenopodium* are low compared to other pollen diagrams from Turkey. This suggests a less steppic character for the Beyşehir area than for instance in the Söğüt and Konya area. The open vegetations that occurred in the Beyşehir area had a different composition from those in the Söğüt area or in the Konya plain.

Zone 4 will not be discussed as this is believed to be the same as zone 3 in the Beyşehir diagram described by van Zeist *et al.* (1975).

2.1.7.4. *The dating of the diagram*

The middle of zone I is radiocarbon dated to 15,390 ± 370 B.P. (GrN-10477) at a depth of 8.90-9.00 m. Compared with the information from the dated diagram of Akgöl (Ereğli) zone 2 could be c. 12,000-10,000 B.P. The transition from subzone 3a to subzone 3b is estimated at c. 8000 B.P. according to the Akgöl dates. The first 4 spectra of subzone 3a could correspond to the Younger Dryas in the West European sequence.

2.2. Akgöl

2.2.1. *The geographical situation*

Akgöl (part of it called Adabağköyü) is found in the Ereğli basin, west of the town of Ereğli in the Konya plain, at an elevation of about 1000 m (Erol, 1978). The name Akgöl is very common in Turkey and this location should not be confused with other lakes of that name. The marshes and small pools called Akgöl form part of the Konya/Ereğli basin, a large lake in late Pleistocene times. The detailed history of Lake Konya is still not known (Roberts, 1979; 1983). The lake has decreased in size, partly also during the Holocene. Limits are also given by the presence of Neolithic settlements (*hüyüks*) dating back to the ninth millennium B.P. During the Holocene a large amount of material has been deposited by the rivers discharging towards the plain. Here and there the drying up of the basin has caused salinization.

West, northwest and north of the Ereğli area, three volcanoes rise from the plain: the Kara Dağ, the Karacadağ and the Hasan Dağ. The peaks are

2288 m, 2025 m and 3253 m high, respectively. The Karadağ and the Karacadag partly separate the Ereğli basin from the Konya basin.

2.2.2. *The vegetation*

The natural vegetation of the Konya plain must be of steppic character (figs. 1-2). In many places one can hardly trace remnants of a natural vegetation due to irrigation agriculture or grazing. Parts of the plain have been drained by canals leaving barren soil. Marsh vegetation as seen in Hotamis Gölü was very much destroyed by grazing cattle. At the time of the coring, in May, the marsh vegetation in Akgöl had not yet developed well and the islands in the shallow lake looked black because the cover had been burned.

According to Zohary (1973) natural cover would belong to the Artemisietea fragrantis anatolica. It is not known whether *Elaeagnus* along the roads is a natural feature or that this shrub is planted by man.

2.2.3. *The climate*

Information on the climate of the Ereğli area is obtained from Yeni Türkiye Atlasi (1977; figs. 3-6). Akgöl is situated in the zone where the average July temperature amounts to 20-24 °C. For January the area falls in the zone which is delimited by the 0-4 °C isohyetes. The average annual precipitation is less than 300 mm of which the majority falls during the winter months. The summer months have less than 60 mm rain. Prevailing winds come from the southwest and the northeast, the first direction most common during the spring, the second dominating during the winter.

2.2.4. *The coring*

The coring was performed on May 21, 1977 in the drained marshes, a landscape of eroding and oxidizing peat islands in shallow water. The coring was stopped when recovery was no longer possible because the sediment turned to loose watery material.

2.2.5. *Lithology and radiocarbon dates*

0.00-0.03 m	yellow clay
0.03-0.50 m	monocot peat
0.50-0.90 m	no recovery
0.90-1.15 m	peaty clay
1.15-1.25 m	yellow clay
1.25-2.13 m	dark grey clay
2.13-2.16 m	sandy gyttja
2.16-2.21 m	peat clay
2.21-6.07 m	light grey, marly clay; here and there with shells, changing in colour from grey to white at 3.29 m
6.07-6.43 m	loose watery material, no recovery

For the following levels radiocarbon measurements have been carried out:

2.17-2.21 m	8040 ± 140 B.P.	(GrN-10474)
3.20-3.30 m	10,920 ± 150 B.P.	(GrN-10475)
3.20-3.30 m	13,050 ± 950 B.P.	(GrN-10476).

2.2.6. *Methods*

The Akgöl diagram (fig. 9) consists of 40 spectra. The pollen percentages are calculated on the basis of a pollen sum including all types apart from those of water and marsh plants. Pollen sums vary considerably from 164 to 1434. When pollen sums remained under 500, pollen preservation and/or concentration were minimal. The upper part of the core was largely devoid of pollen.

2.2.7. *Pollen assemblage zones*

The following pollen zones have been established:

Zone 1 (spectra 1-21): very low AP values, well under 10%,
ceae and Gramineae. Subzone 1a (spectra 1-5): Gramineous values are much lower than those of *Artemisia* and Chenopodiaceae, Noaea-type and *Nitraria* are relatively well represented. Subzone 1b (spectra 6-12): important increase of Gramineae, appearance of *Quercus calliprinos*-type and slight increase of *Betula*. Subzone 1c (spectra 13-17): *Artemisia* drops from 40-50% to 10-15%, Gramineae show a slight increase. Subzone 1d (spectra 18-21): decrease of Gramineae, increase of *Artemisia*.

Zone 2 (spectra 22-30): comparatively high AP values. Subzone 2a (spectra 22-26): high *Betula*, *Hippophaë* present, Gramineae up to 40%, *Artemisia* and Chenopodiaceae decrease. Subzone 2b (spectra 27-30): important values of *Quercus cerris*-type, decreasing *Betula*, *Juniperus* increases.

Zone 3 (spectra 31-40): high AP values. Subzone 3a (spectra 31-37): relatively important values of *Quercus*, *Cedrus* and *Juniperus*. Subzone 3b (spectra 37-38): relatively high values for *Plantago*. Subzones 3c and 3d (spectra 39-40) are only separated because of hiatuses.

2.2.8. *Reconstruction of vegetation and climate in and around the Konya/Ereğli basin*

2.2.8.1. *The Late Glacial*

The lower part of the sediment in the Akgöl core (subzone 1a) must have been deposited under extreme climatic conditions. It is postulated that in modern times the Konya basin is naturally covered by steppe (van Zeist & Bottema, 1982; Yeni Türkiye Atlasi, 1977). The Late Glacial pollen assemblages, however, not only indicate that the Konya basin was treeless but that the same is also valid for the sur-

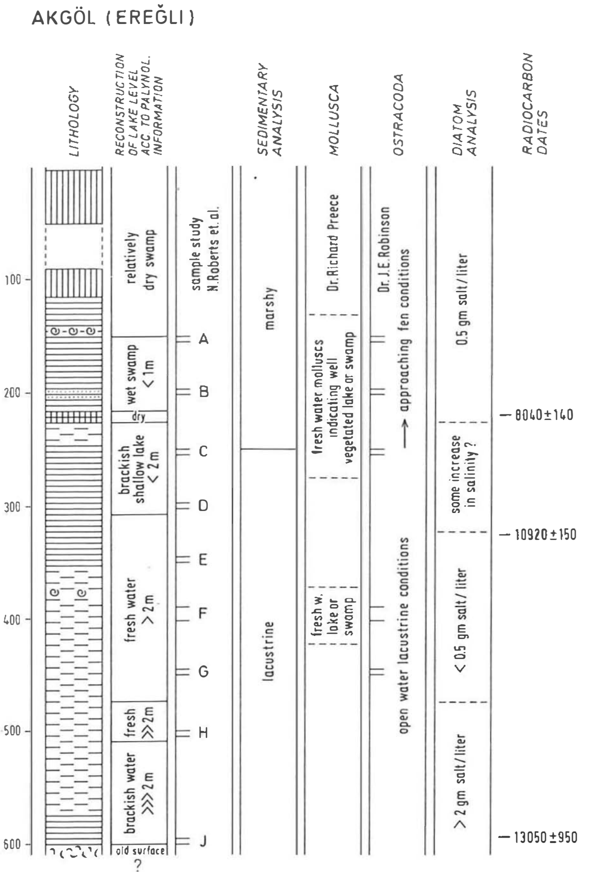

Fig. 10. Reconstruction of the Akgöl development according to various disciplines. Samples A-J done by Roberts *et al.* (1979).

rounding mountains. Around Akgöl (Ereğli area) during subzone 1a a steppe vegetation was present, characterized by *Artemisia* species, members of the Goose-foot family including species delivering *Noaea*-type pollen. Furthermore, *Ephedra distachya*-type, *Nitraria* and *Atraphaxis* were present. Especially *Nitraria* and *Atraphaxis* draw attention as both types are hardly or not found after subzone 1a. In Turkey, *Nitraria schoberi* L. is reported by Davis (1967) for the Tüz Gölü area. The species is said to prefer sandy or saline soils at an elevation of 200-1000 m. *Nitraria retusa* (Forsk.)Asch. is reported as a Saharo Sindian element common along the Dead Sea shore where it grows in soils with a relatively low moisture content and 8-13% soluble salts (Zohary, 1962; 1973). Rikli (1943) also mentions *Nitraria retusa* for the Mediterranean. Information on the present ecological demands of *Nitraria* suggests that during subzone 1a relatively dry, saline soils occurred in the Akgöl area and that evaporation played an important role.

Before 13,000 B.P. conditions must have differed from those occurring after this time, as can be concluded from the change in sediment. Practical experience in coring shows that certain sediments will not stay in the sampler. In general such material has not firmly settled. Often this concerns weathered soils, old surfaces that were exposed to the air for a certain amount of time before they were covered. In those cases where the water level rose and such old surfaces were covered with water again, sampling may be very difficult. Often water lenses are present. The information on the lithology suggests that such a situation occurred in Akgöl; the weathered soil of a dried up lake bottom on which a lake was formed again around 13,500 B.P. Pollen from water and marsh plants is either absent or present in the beginning of the pollen-bearing sediment, and that suggests that the water level rose rapidly. In 2.2.8.2. we will mention karstic phenomena occurring in Suğla Gölü that resulted in a very instable lake. The relation between such a karstic region and the Konya basin is vague, but it is likely that a sudden draining of Suğla influences the water level in the plain. This is also mentioned by Roberts (1983).

The presence of *Atraphaxis* pollen also points to dry conditions for at least part of the year. Extreme conditions are also indicated by the pollen of *Statice spicata/Psylliostachys.* These Plumbaginaceae can stand extreme conditions, especially high salt content of the soil.

If a constant sedimentation rate is assumed, the pronounced steppe period could have lasted until c. 12,500 B.P.

During subzone 1b a slight change in conditions must have taken place. Chenopodiaceae retreated to some extent and grasses became more important. In the mountains, very likely on the volcanoes in the area, birches started to spread and one or more members of the Cupressaceae settled on the slopes. Subzone 1b may have lasted about 500 years, up to c. 11,720 B.P. The slight increase in trees, local or more regional, points to a change in climate, probably to some increase in precipitation. Local fresh water conditions are indicated by the presence of algae like *Pediastrum boryanum.*

Around 11,720 B.P., at the beginning of subzone 1c, the most conspicuous event is the strong decrease of *Artemisia.* An important change in the steppe vegetation must have taken place as the reaction of the trees is, although visible, not very high. The steppe around the Konya/Ereğli marshes and in the foothills over 1000 m must have changed from an open shrubby cover into a grass steppe. The pollen percentages of deciduous oak and cedar show a slow but steady increase, indicating that conditions for trees somewhere in the mountains were getting a little better during the period that grass steppe was the dominant vegetation in the plain.

At about 11,160 B.P. (inferred date), at the beginning of subzone 1d, the climate seems to have deteriorated again, as is evident from the palynological information. *Artemisia* spread again at the expense of the grasses. This situation lasted a few hundred years only. It seems that the conditions prevailing during subzone 1d were not so unfavourable as to depress the numbers of trees drastically. The change in conditions may not so much have harmed the older trees as the propagation of trees.

The subdivision of zone 1, described above shows close similarity with the Late Glacial zonation as we know it from Northwestern Europe. In the Akgöl sequence, subzone 1b resembles the Older Dryas, subzone 1c the Allerød and subzone 1d the Younger Dryas. The radiocarbon date of 10,920 B.P. at a depth of 3.20-3.30 m, a little before the end of zone 1, does not confirm the synchroneity, however.

2.2.8.2. *The Holocene*

The beginning of zone 2 would be about 10,840 B.P., assuming a constant sedimentation rate. This is about the beginning of the Younger Dryas. Such an early increase of arboreal pollen values is also found in the Ghab valley in northern Syria (Niklewski & van Zeist, 1970) and near Lamia in Thessalian Greece (Bottema, 1979).

Characteristic of the beginning of zone 2 in Akgöl is the rapid expansion of birch, *Betula* pollen soon reaching a maximum of almost 20%. At the same time relatively high values for *Hippophaë* are found. This shrub must have been very common in the area, probably not too far away because *Hippophaë* has a poor pollen distribution. The grass steppe is again spreading at the expense of steppe vegetations with Chenopodiaceae and *Artemisia*.

If the palynological picture is translated into vegetation the following reconstruction appears. According to the non-arboreal pollen values, treeless vegetations still dominate the dry parts of the Konya basin and the foothills of the mountains around the basin. This vegetation must have resembled the steppe vegetation described for subzone 1c, *viz.* a steppe vegetation dominated by various grass species. On favourable locations *Hippophaë* shrub was common.

Somewhere birches were common, but it is not likely that *Betula* and *Hippophaë* grew closely together as these two species have different demands. Nowadays four species of birch are found in Eastern Anatolia. The taxonomical position of some of these species is not too clear. The nearest stands of *Betula pendula* are on the Erciyas Dağ at about 250 km (Davis, 1965-1985). In the vegetation history of the Near East *Betula* never played the important role that related species played in northwestern Europe. Akgöl forms an important exception to this rule. The presence of a reasonable amount of birch during the beginning of the Holocene in the Konya basin may be explained by the presence of volcanic soils. In the Mediterranean realm one can still see birch growing for instance on the high slopes of Etna in Sicily (Italy). Davis (1965-1985) also reports birches growing on volcanic soils. It is very likely that the *Betula* pollen found in the Akgöl sediment originated from birch growing on the slopes of the Hasan Dağ, the Karadağ and the Karacadağ.

During the first part of the Holocene, deciduous oaks did not increase. One may conclude that conditions for birches were favourable only on the higher part of the volcanoes, and that *Hippophaë* and grasses replaced part of the steppe elements *Artemisia* and Chenopodiaceae.

The water level of Akgöl was still high enough to prevent marsh and peat formation on the place where the core was taken. That also in the lake itself conditions differed to some extent can be concluded from the curve of *Pediastrum boryanum*, which stops at the beginning of the Holocene. An increase in salinity may have started at that time.

At about 9000 B.P. important changes must have taken place in the mountain belt. Deciduous oaks spread, *Juniperus* increased, *Corylus* and *Ostrya* and/or *Carpinus orientalis* appeared. In the plain of Konya steppic vegetation, mainly grasslands, prevailed. *Hippophaë* disappeared and *Alnus* grew along the marshes. This situation lasted up to about 8040 B.P.

The next period, zone 3, starts with an abrupt change in the pollen record (see also section 4). Between spectra 30 and 31 the sediment was devoid of pollen, which could point to a hiatus in the pollen profile. Be this as it may, coniferous forest must have expanded quite rapidly around 8000 B.P. This included *Pinus* and *Cedrus*, but Cupressaceae also played an important part. Deciduous elements must have been widely replaced by evergreen conifers. It is difficult to explain the cause of such a shift in the mountain forest. As oaks in Anatolia can stand dry conditions better than conifers, it is likely that an increase in precipitation must have taken place. Judging from the modern situation (apart from large-scale forest destruction by man), present-day climatic conditions were established about 8000 years ago in and around the eastern Konya plain.

During zone 3b a slight change occurred in the vegetation of the mountains surrounding the plain of Konya. In the first place a new species became established in the mountains, *viz. Abies.* Cupressaceae (very likely juniper) would have been replaced by *Abies* as pollen from the first type strongly decreased. At the same time *Plantago*, partly *Plantago lanceolata*-type, shows important values. Interpolated this would be around 6000 B.P. *Plantago lanceolata*-type could be a sign of herding in the mountain belt.

Towards the end of zone 3b, *Pinus* and *Cedrus* must have suffered much as their values decreased considerably. The same can be said for various deciduous types. The sediment changes from clay to organic material that must have been exposed to oxidation as pollen had disappeared. Interpolation gives a date of about 4000 B.P. for the lowering of AP values and the change in sediment in spectrum 38.

Experience has taught that in the Mediterranean and the Near East the upper parts of Holocene sediments generally have a higher sedimentation rate than the lower parts because of increasing erosion and that the lower sediments are more compact because of the weight of the upper part. One would rather have expected a date younger than 4000 B.P. for the beginning of the strongly increased interference of man with the vegetation at Akgöl. At least in other diagrams a similar phenomenon is dated to c. 3000 B.P.

Spectra 39 and 40 (subzones 3c and 3d) represent more or less modern conditions. Differences are mainly due to herb pollen values that may be local as is indicated by the presence of monocot peat.

2.2.8.3. *Environment and climate of Late Glacial and Holocene Akgöl*

The water regime of the Konya/Ereğli basin of which Akgöl forms part, was studied by de Meester (1971), Erol (1978), Roberts *et al.* (1979) and Roberts (1980; 1982a; 1982b; 1983).

Erol tried to establish a chronology for the Konya lake on the basis of the relative heights of the various shorelines. Levels at 1017 and 1010 m were attributed to the Würm glacial and the 1006 m subfossil beach was thought to mark the beginning of the Holocene. Artefacts thought to be of Mesolithic age were used for dating but their dating value is doubted. De Meester (1971) doubted the value of the shoreline elevations as a dating mechanism of former lake levels.

The radiocarbon dating of the molluscs from terraces is discussed by Roberts (1983) and Roberts *et al.* (1979). The reliability varies with the history of the subfossil shells and often only minimum ages can be considered. Roberts (1983) thinks the sequence of lake-level fluctuations to have important implications for our understanding of regional palaeoclimates and for relationships which have been postulated between environmental change and the origins of agriculture. This statement is weakened by his explanation of Lake Konya being not entirely a closed hydrological system on account of a few karstic outlets, such as sink holes, which have prevented the plain from becoming a hypersaline playa like Tuz Gölü. In an extreme situation, this has happened in Lake Suğla where underground outlets sometimes completely empty the lake and on other occasions get blocked causing flooding of the area. Such a water regime rendered the Lake Suğla core useless for pollen analysis as it did not contain any pollen.

The Akgöl core is a reliable sedimentation sequence as it most likely survived as a (residual) lake during the 13,000 years represented in the record. The clastic lower part of the sediment would have been sealed off porous marl.

Roberts *et al.* (1979) treated a series of our samples of the Akgöl core (in their study called Adabağ) (fig. 10). Samples A-J were examined for sedimentation, molluscs, ostracods and diatoms. The first column shows the lithology. The second one gives the tentative reconstruction of the lake level according to the palynological information, the pollen values of local water plants and the presence or absence of *Pediastrum* species. The fourth column contains the sedimentary analysis which shows the same trend as the palynological information. From 600-250 cm deposits are of lacustrine origin and above 250 cm the local situation must have been marshy. This could be deduced of course from the lithology too.

Molluscs are treated by Richard Preece. A suitable number of shells were found in A, B, C and F only. The conclusions of the mollusc study agree well with those from the palynological study. The same is true for J.E. Robinson's conclusions on the Ostracoda. The diatom analysis shows about the same results as the other disciplines. Samples C and D did not contain enough diatoms for a reliable conclusion.

Akgöl, whether or not part of a larger lake, started to contain water again c. 13,000 B.P. For its history before that time, the reader is referred to Roberts (1980; 1982a; 1982b; 1983). It is often stated that Late Glacial lakes in arid zones had their maximum extension not because of increased precipitation but because of very low evaporation. In Akgöl we could not obtain samples older than 13,000 B.P. and the loose marly and watery material underneath the layer of that date ran out of the sampler. From our experience with other lakes we think that we hit an old surface. If that is true, why was there no sediment from before 13,000 B.P.? Evaporation must have been low before 13,000 B.P. also. Was Akgöl drained then by its outlets? Or was the lake formed after a slight increase in precipitation occurring around 13,000 B.P.? Or had the marly valley floor first to be sealed off by clastic sediment to build up a body of standing water? Maybe Akgöl compares in time with Lake Urmia that was formed not before the Late Glacial either (Shahrabi, 1981; Bottema, 1982). Evaporation as a factor to control lakes must of course be very important. It is, however, questionable whether direct evaporation alone caused Akgöl to shrink until it finally disappeared. In this respect the history of Lake Van is very interesting (Degens *et al.*, 1984). Lake Van is 400 m deep, but it nevertheless almost dried up during the Holocene for some time.

As soon as the climate became more suitable for vegetal cover, including trees, is it obvious that it was this vegetal cover that consumed a large part of the precipitation. Not only the foliage forms an important source of evaporation, but soil development, root systems and possible litter retained water that was transported downhill at the time when very open steppic cover was still present. That the force of water in discharging streams is greater during steppic time than during periods with denser vegetation, could be shown in a study on Lake Urmia (Shahrabi, 1981; Bottema, 1982). In Lake Urmia detrital minerals are far more abundant during *Artemisia*-dominated steppe periods than during periods when trees and grasses expanded.

In shallow lakes the effect of an increase in precipitation/influx is a rapidly growing surface. If, however, the influx does not change, gradual filling in with sediment automatically causes a rise of the lake level, an increase in water surface and in evaporation. It is obvious that such a process causes a lower water depth although the volume of the total body of water is still the same.

Although precipitation increased, as can be concluded from the palynological information during the Holocene, for some reason or another this did not result in a higher water table in Akgöl. On the contrary, the lake dried up towards the end of zone 2b (figs. 9-10) at about 8000 B.P. Through the Late Glacial and the early Holocene the scales slowly tipped towards the negative. Because of an increase in precipitation shortly after 8000 B.P., not an unknown fact in Northwestern Europe for instance, the balance was restored and a shallow lake was formed again that may have lasted c. 2000 years, gradually developing into a marsh with very little open water. The marsh dried up at certain times, whereas on other occasions excessive flooding caused the vegetation to float, and even peat layers may have done so. This may explain the water lens met with between 50 and 80 cm.

2.3. Gölhisar Gölü

2.3.1. *The geographical situation*

Gölhisar Gölü is found at the southeastern end of a northwest-southeast oriented intramontane valley (fig. 1). The lake lies at an elevation of c. 930 m (37°8′N, 29°36′E). For the geology of the area see van Zeist *et al.* (1975).

2.3.2. *The vegetation*

Gölhisar Gölü lies in the zone of the Oro-Mediterranean vegetation (figs. 1-2). At present the area is cultivated and almost barren where crop farming is not practised. The slopes around the basin are partly covered with shrub vegetations and rarely with pine. *Phragmites* grows in a belt in and around the lake.

2.3.3. *The climate*

Gölhisar Gölü is situated in the zone of average temperatures of 0-4 °C for January and of 20-24 °C for July. Average annual precipitation amounts to 500-600 mm of which 50% falls during the winter and 10% during the summer (figs. 3-6).

2.3.4. *Coring and methods*

The coring took place at the edge of the lake, c. 15 km south of the village of Yamadi. The pollen sum includes all pollen types of trees and herbs and excludes those of aquatics and marsh plants (fig. 11).

2.3.5. *Lithology and dating of the diagram*

0 - 20 cm	soft peat, discarded
20 - 55 cm	black peat
55 - 90.5 cm	brown peat
90.5-121 cm	olive green gyttja
121 -127 cm	brown peat
127 -205 cm	grey clay
205 -215 cm	granulated blue grey clay
215 -235 cm	clayey sand and loose fine gravel

The dating of the Gölhisar diagram must be done by correlating with nearby radiocarbon-dated diagrams. The diagram of Söğüt (van Zeist *et al.*, 1975) at an elevation of 400 m above Gölhisar dates the beginning of subzone 2b at about 2900 B.P. According to the Söğüt information, the age of spectra 2-3 in Gölhisar may be about 9000 B.P.

2.3.6. *Pollen assemblage zones*

Zone 1 (spectra 1-7): dominant *Artemisia*, Chenopodiaceae and Compositae; AP increases from 15 to 30%, mainly *Pinus*. Subzone la (spectra 1-4): high *Artemisia*. Subzone lb (spectra 5-7): high Chenopodiaceae.

Zone 2 (spectra 8-18): relatively important values of deciduous trees, *Juniperus* and *Pinus* (extremely high Gramineae in spectra 13 and 14 have been excluded from the pollen sum). Subzone 2a (spectra 8-11): increase of Pinus. Subzone 2b (spectra 12-13): *Quercus*, *Juniperus* and *Olea* increase but total AP decrease; Gramineae increase. Subzone 2c (spectra 14-18): decreasing *Quercus* and *Juniperus*.

2.3.7. *Reconstruction of the vegetation in the Gölhisar area*

During subzone 1a, open vegetation prevailed in the Gölhisar area. High *Artemisia* and Chenopodiaceae pollen values point to steppe vegetation, but the absence of *Ephedra*, frequently found under extreme dry conditions in southwestern Turkey, may be an indication that a milder climate occurred in the area. Many Compositae (apart from *Artemisia*) show high pollen percentages during this period, *e.g.* Liguliflorae, *Matricaria*-type, *Cirsium*-type, *Centaurea solstitialis*-type and even some *Carthamus*. The presence of high pollen percentages of Compositae is discussed in 2.1.5.

During subzone 1b the situation had changed to some extent. An increase in *Pinus* pollen indicates that scarce trees which at first were found on few suitable locations in the mountains only, now increased a little. All Compositae types decrease during subzone 1b, but values of chenopodiaceous pollen increase to almost 40%. It remains difficult to trace the origin of these Chenopodiaceae; they may have been local, growing on the edges of the lake or they may have formed part of a steppe on the uplands bordering the valley.

At the beginning of subzone 2a a rapid increase of forest took place. In the Oro-Mediterranean vegetation pine increased but *Cedrus* did not visibly change as can be concluded from the relative pollen frequencies. Pollen of some Eu-Mediterranean and Sub-Mediterranean taxa is found in the Gölhisar pollen spectra. It is, however, unlikely that species such as *Olea*, *Fraxinus ornus* and *Punica* grew in the Gölhisar area and the origin of this pollen must be looked for in the coastal zone.

During subzone 2a, evergreen as well as deciduous oaks became established in the Gölhisar area and so did *Juniperus*. *Abies* values in Gölhisar are so low that it is not likely that fir grew in the area. In southwestern Turkey *Abies* is relatively well represented in pollen diagrams from more northerly locations, such as Hoyran, Karamik and Beyşehir Gölü (van Zeist *et al*., 1975). Pure stands of *Abies cilicica* are reported to occur nowadays north of Akseki, c. 200 km to the east.

A species appearing for the first time in zone 2a is *Platanus*. As the plane tree is under-represented in the pollen rain, it is likely that this species occurred in the vicinity of the lake. During this period grazing effects are made visible by *Plantago lanceolata*-type pollen starting a continuous curve from spectrum 8 onwards. We may conclude that during the beginning of zone 2a forest started to spread over the slopes and in the valleys and that an increase in diversity of species took place.

During the subzone 2b, arboreal pollen values decrease again, caused by a strong decrease of *Pinus*. Oak and juniper profited from this decline in relative percentages, though a real profit may not have occurred. The influence of farmers who grew crops is indicated by very high Cerealia-type pollen percentages and for instance *Rumex acetosa*-type. Cerealia values in the diagram are so high that farming must have occurred close to the lake and pollen was washed in more than blown into the lake. The pollen distribution of wheat and barley fields is very poor and percentages are already low, directly outside of the field (verb. comm. P. Reynolds, J. Troels-Smith). At the same time that the pine forest diminished, probably destroyed by man, gramineous pollen values increase enormously. Also pollen of local marsh vegetation increases suddenly and the grasses may have formed part of it. For that reason pollen of Gramineae is excluded from the pollen sum in spectra 12 and 13.

When we compare the sediment sequence, the pollen curves of regional types and the curves of local marsh types, the picture emerges (as in other diagrams from southwestern Turkey) of an increase in precipitation which stimulated the spread of certain tree species over the inland mountains. Shepherds profited from the vegetational change and invaded the area. The increase in forest cover prevented erosion and local aquatics indicate that the level of the lake rose. Not much clay was washed in and a gyttja developed in the Gölhisar lake.

The period of pronounced human activity is followed by a decrease in farming pressure indicated by a slight regeneration of the vegetation. Plantain and grass pollen show a decrease and evergreen and deciduous oaks recovered a little. Many Mediterranean pollen types are very well represented during the upper subzone 2c. *Olea* must have been cultivated, *Phillyrea*, *Pistacia* and *Punica* pollen may come (partly) from more westerly regions. These Mediterranean types may point to a low pollen production, in fact to the absence of forest cover in the Gölhisar area. Apart from *Olea*, they are underrepresented in the pollen rain (Bottema, 1974) and they became important either in an absolute sense because maquis was spreading over the slopes, or they gained in a relative way because of the disappearance of *Pinus brutia* forest caused by man.

Juglans and *Castanea* were quite probably favoured by man also. Species diversity was still increasing during the upper subzone demonstrated by the appearance of *Carpinus orientalis*, *Fagus* and *Corylus*.

2.4. Pinarbaşi

2.4.1. *The geographical situation*

The drained lake and marshes of Pinarbaşi are situated at an elevation of 980 m above sea-level (37°28′N, 30°3′E) (fig. 1). The Pinarbaşi basin is drained by the river Eren towards Lake Burdur. The lake and marshes were drained and the exposed peat has partly been burned.

2.4.2. *The climate*

Pinarbaşi lies in the 400-500 mm precipitation zone. Most of the rain falls during the winter half year and only 40-60 mm during the three summer months. The Burdur weather station north of Pinarbaşi receives 434 mm precipitation annually on average. The temperature zones in which the area is found are 0-4 °C for January and 20-24 °C for July. The geology of this region is treated in van Zeist *et al.* (1975).

2.4.3. *The vegetation*

Pinarbaşi lies in the Oro-Mediterranean vegetation belt. No natural vegetation is left nowadays (figs. 1-2). The valley, except the part that was covered by water or marsh, would have been forested with deciduous trees and pine. As for pine, it is likely that *Pinus nigra* would have formed part of the natural vegetation. *Pinus nigra*, *Cedrus* and perhaps *Abies cilicica* must have been constituents of the forest that grew on the mountain slopes. For details the reader is referred to van Zeist *et al.* (1975).

2.4.4. *Methods*

The percentages of the various types described in the diagram (fig. 12) are calculated on the basis of a pollen sum including all types except those from water and marsh plants. Where Gramineae attain exceptionally high values they are not included in the pollen sum. Grass pollen is assumed to be of local origin because percentages for Cyperaceae and *Sparganium*-type also demonstrate high values in these spectra.

From 255-360 cm and from 380-545 cm the sediment was found to be devoid of pollen.

2.4.5. *Lithology and radiocarbon dating*

0- 40 cm	burned/ploughed peat
40-102 cm	peat
102-130 cm	dark grey clay
130-149 cm	grey clay
149-305 cm	blue grey clay
305-405 cm	dark grey clay
405-630 cm	grey clay with some white spots
630-701 cm	blue grey clay
701-715 cm	sandy with fine gravel, further coring not possible.

The following levels have been radiocarbon dated:

290-300 cm	6550 ± 600 B.P. (GrN-10480)
90-100 cm	1370 ± 70 B.P. (GrN-10479)

2.4.6. *Pollen assemblage zones*

In the establishing of zones the two hiatuses are also considered.

Zone 1 (spectra 1-15): very high NAP, including *Artemisia*, Chenopodiaceae and Compositae, low *Cedrus* and *Pinus*.

Zone 2 (spectra 16-18): *Pinus* over 90%, Chenopodiaceae absent.

Zone 3 (spectra 19-29): spectrum 19 resembles zone 2 to some extent but herb types are absent in the latter. Subzone 3a (spectra 19-25): decreasing *Pinus*, increase of Tubuliflorae and Liguliflorae. Subzone 3b (spectra 26-29): increasing *Cedrus*.

Zone 4 (spectra 30-38): appearance or increase of various AP types. Subzone 4a (spectra 30-35): *Quercus cerris*-type, *Q. calliprinos*-type, *Olea*, *Fraxinus ornus*, *Vitis*, *Castanea* and *Juglans* present. Subzone 4b (spectra 36-38): decreasing AP apart from *Pinus*.

2.4.7. *Reconstruction of past vegetation and climate of the Pinarbaşi area*

During zone 1, the Pinarbaşi basin as well as the surrounding mountains were devoid of trees. Arboreal pollen percentages under 5% indicate that trees occurred at great distances only. An exception may be *Cedrus* which may have been present somewhere in the area. Suitable biotopes for trees would have been further south towards the Mediterranean Sea. The composition of the herbs in the prevailing steppe is difficult to determine not in the least because of the high percentages of Compositae pollen that may mask other types. The possible origin as well as the over-representation of Compositae pollen is discussed in 2.1.5.

Towards the end of zone 1, herb types as *Artemisia* and Chenopodiaceae increase at the cost of Tubuliflorae and Liguliflorae. It is possible that the first part of zone 1 took place under a desert-type climate but that during the second part of this zone conditions had changed towards a steppe climate. *Artemisia*, Chenopodiaceae and *Ephedra* expanded while also Plumbaginaceae, *e.g. Armeria*, were regularly found. The problem remains that no date is available for this period and that the link with the following period, with a sharply contrasting situation, is made impossible by a hiatus in the pollen record over 170 cm.

The lower part of zone 1 represents the most extreme conditions of the Pleniglacial, whereas during the upper part it represents some amelioration of the climate which had changed the desert-steppe into steppe vegetation. The Late Glacial is not represented in the pollen evidence, at least judging from the Söğüt and Karamik diagrams.

Because of the hiatus in pollen between 545 and 380 cm the development of the vegetation can only be guessed. The only conclusion from this part of the core is that during this period sediment was deposited in a lake that held water mainly during the winter half-year, while during the summer oxidation of the dry basin caused the disappearance of pollen.

During an unknown stretch of time, somewhere in the order of 3000-5000 years, after zone 1, steppic conditions had made place for a dense coniferous forest, leaving no open space for herbs around Lake Pinarbaşi. The forest was dominated by pine but some cedar was also present. The study of modern surface samples (van Zeist *et al.*, 1975) demonstrate that pollen of *Cedrus* is very much under-represented compared to *Pinus*.

The age of zone 2 is calculated on the basis of the two radiocarbon dates, assuming a constant sedimentation rate. Thus, this short zone would be c. 7500-8000 years old. The pollen assemblage of zone 2 does not compare to those of zone 4 in the diagram of Sögüt, c. 50 km south of Pinarbaşi. Zone 4 in Söğüt is dated younger than 9180±95 B.P. *Pinus* percentages measure about maximally 30% there, whereas in zone 2 of the Pinarbaşi diagram they measure c. 95%.

Zone 2 is separated from zone 3 by a hiatus in the pollen record over about one metre of sediment. Nevertheless many curves can be connected with each other without much difficulty. During zone 3, forest was still the dominant vegetal cover in the Pinarbaşi area. This forest or part of it strongly decreased from the beginning of this zone onwards. The decrease was due to diminishing numbers of pine which made place for open vegetations that were characterized to some extent by Chenopodiaceae and *Artemisia* and especially by various Compositae. Cedar remained a common tree and towards the upper part of zone 3 this tree even increased and must have formed the dominant feature on the mountains bordering the Pinarbaşi basin. Other tree species were not present, neither in the basin nor on the slopes. The high NAP values show that open vegetations became more and more common during zone 3. The vegetation must have resembled that of zone 1, but even more Compositae species were present, including *Carthamus*, *Onopordon*, *Cirsium*-type and *Centaurea cyanus*. Referring to the date of 6550±600 B.P. for the level of 290-300 cm, zone 3 started at c. 5700 B.P., assuming a constant sedimentation rate.

During the course of zone 3a, pine forest, most likely *Pinus nigra*, was cleared to a great extent. This must have resulted in dominating cedar pollen percentages in subzone 3b, which perhaps do not indicate an increase in cedar trees in absolute numbers but which may be only relative. Towards the end of subzone 2b (spectrum 29) a sudden increase of *Pinus* took place at the expense of *Cedrus* values. The decrease of *Cedrus* coincides with the appearance of Cerealia-type pollen. It is possible that human activities, not only cereal-growing but also herding, burning for pasture, woodcutting *etc.*, are responsible for the disappearance of the cedars.

Zone 4 is marked by the settling of deciduous and evergreen species, completely new for the area. Deciduous oak, *Pistacia*, *Olea* and *Fraxinus ornus* are soon found in reasonably large numbers. Pollen of the herbaceous part of the vegetation, especially various Compositae, Caryophyllaceae, Cruciferae, Umbelliferae and *Scabiosa palaestina*-type, decrease or disappear altogether. They are replaced either by types indicating farming activity or types from aquatic or marsh plants. *Juglans* and *Castanea* are profitable for man and so they would have been protected; Cerealia belong to the farming assortment; *Plantago lanceolata* and *Poterium* are the result of grazing and over-grazing. *Cladium*, Gramineae, Cyperaceae and *Sparganium*-type are connected with increasing marsh vegetations.

The beginning of subzone 4a is dated to c. 3000 B.P. calculated from the radiocarbon dates. The development of the vegetation and the date that accompanies this phase are witnessed in many sites in Turkey including the diagrams discussed in this study. The problem is whether the changes in the vegetation are caused by man, by climate or by a combination of the two (see also section 4).

One can even postulate that the mountains in the Pinarbaşi area were completely deprived of their forests and that all the pollen appearing in zone 4 came from the coastal area, or that part of the pollen was from local stands of for instance *Juniperus*.

It is mentioned by van Zeist *et al.* (1975) that a decrease in *Pinus* values connected with a landnam phase during the late Holocene is always accompanied by an increase in *Quercus* percentages where this part of Turkey is concerned. This does not imply that every decrease in *Pinus* pollen results in an increase in *Quercus* pollen. Pine forests in Turkey often have an undergrowth of deciduous oak. The pines do not recover from cutting but the oaks do regenerate. Thus, pine forests are easily transformed into oak forest as long as grazing is not too heavy. The first *Pinus* decrease in the Pinarbaşi diagram does not show any reaction on the part of the oak. Only rather recently conditions changed in such a way that oak species profited in the Pinarbaşi area.

For northwestern Europe, at c. 3000 B.P. a change in climate is postulated resulting in lower temperatures and moister conditions. It is possible that the same happened in Turkey and that man immediately made use of the climatic effect or that the agro-economy was rapidly adapted to the changes. On the other hand, the use of iron may have been responsible.

At about 1400 B.P. (see 2.4.5.), however, oak gave way to pine again. *Cedrus* does not seem to profit but *Juniperus* (*excelsa*?) consolidates its role in the vegetation. During subzone 4b, a pine/juniper forest developed in the mountains around the Pinarbaşi basin. At that time species such as *Pistacia*, *Olea*, *Fraxinus ornus*, *Vitis* and *Juglans* have already disappeared.

To ascribe the course of events in Pinarbaşi (as in other comparable Turkish sites) to the climate is not very convincing if pollen types indicating human activity are more closely looked at. Trees like *Olea*, *Fraxinus ornus*, *Vitis* and *Juglans* would have been favoured or were planted by man. Cerealia-type and *Plantago lanceolata*-type point to agriculture and herding. *Juniperus* and *Sanguisorba minor/Poterium* pollen indicate cutting of forest followed by grazing or overgrazing.

There are, however, indications that other mechanisms may have played a role too. The pollen of water and marsh plants and the ecologically less well defined group of Gramineae show an increase and one may conclude that the lake turned into a marsh. The development of marshes happened at the same time as the increase of the activity of man.

A peculiar detail is the appearance of Mediterranean elements in the Pinarbaşi area and in the whole of southwestern Turkey. Nowadays there is no olive culture in the Pinarbaşi area. Rikli (1943) mentions some olive culture for south and southwestern Turkey, and according to his map olive is restricted to the area north of Antalya and northwest of Fethiye. There it penetrates inland up to about the 900 m contour line. Olive seems to be endangered most on south-facing slopes and protected depressions. This seems contradictory but it is caused by the fact that olives cannot stand spring frost when the growth process of the tree has already started. On the colder locations the growth process starts later and frost has less influence. During the winter *Olea* is known to survive temperatures of up to -16.5 °C.

If man had selected suitable locations for growing olive trees in the Pinarbaşi area, at altitudes above 1000 m, not too many trees would have occurred under the present-day climatic conditions. The limited number of trees could not have produced the amounts of pollen found in subzone 4b. The conclusion is either that conditions more inland in Turkey were more favourable for olive culture during that period or, that at that time the local vegetation (pine/cedar forest) had been destroyed to such an extent that pollen from lower areas, *viz.* the coastal region, became dominant in the local pollen precipitation.

If olive was indeed cultivated in the interior, more favourable climatic conditions must be the explanation. Such a climate did not necessarily differ much from that of today. In fact the absence of spring frost would be enough to allow olive cultivation in the interior. It may be possible that the Mediterranean climate extended its regime more inland for a short period lasting from about c. 3200 until c. 1370 B.P. A period of greater evaporation or less precipitation during zone 4 is suggested by local changes, *viz.* the lake changed to a marsh developing into a peat-bog. It is clear that this explanation is not in line with that of the development of the climate in northwestern Europe.

Soon after the increase of deciduous oaks and *Quercus calliprinos* (*Quercus ilex* has the same pollen type but it does not occur in the area east of Fethiye nowadays), pine also increases and finally gains over the oaks. If local pine is considered this must have been *Pinus nigra*, still common in the west (see the map published by the State Forestry Service, Türkiye Orman Agaç Ve Ağaçciklarinin Yayilişi, Orman Genel Müdürlügü Yayinlarindan, 1962). However, if the area was barren, pollen from *Pinus brutia* more to the south may be responsible.

The landscape that developed after medieval times shows close palynological affinity with the pollen assemblages of zone 2 at c. 5000-6000 B.P., apart from the marshes that had developed since then. As in other Turkish diagrams the final attack of man upon the pine forest is not included in the Pinarbaşi sequence. This must be an indication that such a deforestation occurred very late in history.

2.5. Elmali

2.5.1. *The geographical situation*

This core was taken in 1970 by van Zeist *et al.* at the edge of Kara Göl near Elmali at an elevation of c. 930 m (37°4′20″N, 29°53′30″E). The core location is on the southeastern side of the lake. Kara Göl seems to have extended its surface during some years before 1970. In the mean time Kara Göl has been drained (Yeni Turkiye Atlasi, 1977). Van Zeist describes Kara Göl in his field notes as a residual lake in an intramontane plain. The former Kara Göl was situated 14 km north of Avlan (fig. 1) and 40 km south of Söğüt. For the geology of the area the reader is referred to van Zeist *et al.* (1975).

2.5.2. *Lithology*

0- 10 cm	not sampled
10- 18 cm	blue-grey clay, possibly disturbed
18-119 cm	grey clay, with rusty patches
119-141 cm	coarse sand
141-142 cm	clay lense
142-170 cm	very wet sand that could not be sampled

170-235 cm	grey clay with rusty patches
235-255 cm	grey-brown sand with some clay lenses
255-275 cm	grey clay with rusty patches
275-278 cm	sand
278-292 cm	clay with rusty patches
292-305 cm	sand

2.5.3. *Methods*

The Elmali diagram (fig. 13) presents the curves of pollen types as percentages calculated from a basic sum including all pollen types, excluding local marsh and water plants. Pollen of some Compositae are also excluded from the basic sum. A discussion on the origin of composite pollen types is given in 2.1.5.

2.5.4. *Pollen assemblage zones*

Zone 1 (spectra 1-4): *Fraxinus ornus* and *Juglans* are hardly present, *Quercus* decreases, high Cyperaceae and *Sparganium*-type. This zone is separated from the next zone by a hiatus.

Zone 2 (spectra 5-12): high *Juglans*.

Zone 3 (spectra 13-19): increase of *Artemisia*, decrease of *Pinus*. Subzone 3a (spectra 13-14): high *Artemisia* percentages. Subzone 3b (spectra 15-19): *Pinus* increases again, *Artemisia* remains under 5%.

2.5.5. *Reconstruction of the vegetation in the Elmali area*

The Elmali core did not contain organic material, consequently no radiocarbon dating was done. Thus, the age of the sediment has to be obtained by comparing the pollen curves of the Elmali diagram with those of nearby dated diagrams: Söğüt, Pinarbaşi, Beyşehir. The sediment turned out to be about 4000 years old, and the vegetation was clearly influenced by man.

During zone 1, cedar and pine forest with possibly *Juniperus excelsa* covered the slopes of the mountains of 1000 m and higher. It is thought that such a postulated vegetation resembles the present vegetation described for the Avlan area (van Zeist *et al.*, 1975) south of Elmali. Similar forests of *Cedrus*, *Juniperus excelsa* and *Pinus nigra* do not occur near Elmali at present. Some remnants of *Juniperus excelsa* are found together with secondary growth of *Quercus calliprinos*.

On lower levels, around Kara Göl, scarce deciduous trees such as *Ulmus*, *Ostrya*, and *Corylus* could have been found. Deciduous and evergreen oaks were more common, as can be concluded from the pollen percentages. The majority of the forest was formed by conifers, predominantly *Cedrus* and *Pinus*. In the upper two spectra of zone 1 *Juglans* was present in small numbers. This dates spectra 2 and 3 to about 3000 B.P. on the basis of dates for the Beyşehir and Söğüt diagrams (van Zeist *et al.*, 1975).

The hiatus between pollen zones 1 and 2 will not represent a disproportionate stretch of time as spectra 4 and 5 can be linked with each other without difficulty. During zone 2 trees such as *Olea*, *Fraxinus ornus* and *Juglans* are represented in the diagram. *Olea* values are not very high and olive trees would not have occurred around Elmali. As for the walnut, this tree must have been planted in large numbers as pollen percentages amount to 20%. Special attention has to be paid to *Citrus*, present in very low numbers. *Citrus* has a very poor pollen dispersal and is very much under-represented in the pollen rain. The *Citrus* pollen in the Elmali core remains problematical. Connected with man's activities is the increasing number of junipers which must have spread over the deforested slopes. This deforestation is in turn indicated by increasing values of *Sanguisorba minor*/*Poterium* and *Pteridium*. *Poterium* indicates barren slopes where even secondary shrub had been destroyed, whereas *Pteridium* spread on forest clearings. On the other hand, the increase of some deciduous tree species such as *Corylus*, *Ostrya carpinifolia* and *Alnus* is difficult to reconcile with farming or grazing. It is possible that these species settled on abandoned farm land but under a herding regime they hardly had a chance. One is inclined to think of climatic reasons that enabled these Betulaceae to spread in the mountains.

Towards zone 3, steppe elements increased and many trees disappeared from the Elmali area including also many orchard trees. Man exerted much pressure upon the environment and the destruction of the vegetation is also visible from the high percentages of *Centaurea solstitialis*-type (2.1.5.).

During subzone 3b, coniferous forest recovered whereas the other species represented in the pollen diagram remain at the same level as in zone 2. On the mountain slopes a *Pinus* (*nigra*)-*Juniperus* (*excelsa*)-*Cedrus* forest developed or expanded. Such forest would have looked the same as the present-day forest on the slopes bordering former Avlan Gölü, to the south (2.6.1.).

In the upper three spectra of subzone 3b a slight increase in Cerealia-type and *Centaurea cyanus*-type is visible, pointing to an increase in farming intensity, including winter corn.

For a comparison of the Elmali diagram with other diagrams from southwestern Turkey, see section 3.

2.6. Avlan Gölü

2.6.1. *The geographical situation*

Avlan Gölü is found at an elevation of 1043 m in the same intramontane valley in which Elmali is located, in between the northeast-southwest oriented ridges of the Akdağlari in the west and the Beydağlari in the east (36°35′N, 24°57′E). For information on the geology and the vegetation of the area, see van Zeist *et al.* (1975).

In 1970, when van Zeist visited the lake and described the surrounding vegetation, the lake still existed. In 1977, the lake had been drained obviously for a few years already. Some parts of the former lake bottom were already in use for cereal growing. The lake had been drained by a north-south running canal. At about 500 m from the road that runs along the southern edge of the basin a gully was found, perpendicular to the canal. From this gully the exposed side had been set back for about 50 cm and samples were taken from the section.

2.6.2. *The vegetation*

Van Zeist *et al.* (1975) gave a description of almost undisturbed *Cedrus libani*, *Juniperus excelsa* forest on the slopes southeast of Avlan Gölü. In 1977, the present authors also visited the forest which is mainly formed by cedars and tall junipers. In the shrub layer *Juniperus* sp., *Acer* cf. *monspessulanum*, *Pistacia palaestina* and *Quercus calliprinos* were observed.

2.6.3. *Lithology*

The 270 cm long sediment section from which the samples were secured consisted completely of clay. Samples were taken at 5 cm intervals.

2.6.4. *Pollen assemblage zones*

Zone 1 (spectra 1-12): low *Quercus*, high Compositae. Subzone 1a (spectra 1-6): *Cedrus* dominates *Pinus*, *Centaurea solstitialis*-type averages 30%. Subzone 1b (spectra 7-12): *Pinus* dominates over *Cedrus*, *Centaurea solstitialis*-type averages 50%.

Zone 2 (spectra 13-25): important values of *Quercus cerris*-type, *Quercus calliprinos*-type and *Juniperus*, Compositae decrease apart from *Artemisia vulgaris*-type; *Plantago lanceolata*-type and *Sanguisorba minor/Poterium* are relatively important.

2.6.5. *Reconstruction of the vegetation in the Avlan area*

During zone 1a (fig. 14), relatively open forest of cedar and pine was found on the slopes around Avlan Gölü. The open character is especially indicated by the important values of Compositae. For an explanation of the consequences of such composite types, the reader is referred to 2.1.5. Especially in this part of southwestern Turkey the surface covered by alpine vegetation, 2000 m above sea-level, is relatively large. However, it is not likely that in the alpine vegetations Compositae were much more abundant than at lower elevations.

The coniferous forest must to a great extent have resembled the forest found at present. Cedars were more common than pine, the latter species most likely being *Pinus nigra*. An important difference, however, was the proportion of *Juniperus excelsa*. Surface samples collected in the area (van Zeist *et al.*, 1975) yield 23.9-57.6% juniper pollen, whereas this type is lacking in the subfossil spectra. Other tree species represented by very low pollen percentages obviously grew outside the area, further towards the coast. As for *Betula*, scarce birches may have been found at high levels (see also van Zeist *et al.*, 1975: p. 119).

During the next period 1b, some, mainly quantitative, changes occurred. *Pinus* became more important at the expense of *Cedrus*. The vegetation became more open as is suggested by increasing Compositae values. This can also be concluded from a light-demanding species such as *Ephedra fragilis*(-type).

The appearance of Cerealia-type pollen and of some *Plantago lanceolata*-type and *Rumex acetosa*-type point to the presence of farmers. During this zone, man was, at least to some extent, responsible for the changes in the vegetation. It is not clear whether the changes took place in the area of Avlan or whether the pollen influx records man's activities somewhere else. The steep slopes to the south which are still forested today do not offer possibilities for farming. Forest may have been cut for timber or destroyed for herding purposes, but it is not likely that *Olea* was planted. The Avlan area at 1000 m and higher would not have been the most suitable place for a demanding species like the olive. However, if *Centaurea solstitialis*-type had been included in the pollen sum, the indication of open landscape would have been more pronounced. Increase in grazing ground is obvious, whereas crop farming may have been practised north of the lake.

The next period, zone 2, shows the conspicuous pollen assemblage also met with in other diagrams from this region. At first conifers do not change much, but in due time cedars gain over pine. More striking, however, is the appearance of pollen types of deciduous and evergreen oaks, *Pistacia* and *Carpinus orientalis*. At the same time *Juniperus* pollen forms a continuous curve. Pollen of *Platanus*, *Juglans* and *Vitis* is found in low numbers. The various Compositae now occur in percentages that are normally found in surface samples. AP values increased to about 90% indicating that forest must have been quite extensive. On the other hand, a number of indicators of human influence are present, some of them, for instance *Poterium*, pointing to overgrazing. For other sites there are indications that the replacement of *Pinus* by *Quercus* was occasioned by the destruction of pine forest by man (2.4.7.). However, it is less likely that this explanation can be applied to the Avlan pollen evidence, because in this case there are no indications of large-scale human activity. In spectra 13-15, at the level where other tree pollen percentages start to increase, a slight rise of the pine pollen curve can be observed. The problem also remains to what extent the pollen was produced by *Pinus nigra*, the pine that grows more inland at higher elevations, or by the more warmth-demanding *Pinus brutia* that nowadays is found in the coastal area and at elevations up to maximally 1000 m on southern exposures.

Pollen types of some water and marsh plants show an important increase during zone 2. *Butomus*, present during zone 1, however, disappears. At first in zone 2, Cyperaceae, some *Ranunculus* species and *Myriophyllum* spread in the lake or on the edges. After spectrum 16 the percentages of *Myriophyllum* demonstrate very high values. Either the water depth changed from deep water to a depth suitable for *Myriophyllum*, or the water depth turned from shallow water to a depth optimal for *Myriophyllum*. The presence of *Butomus* in the lower part of the core points to marshy conditions as this plant cannot grow in water that is deep enough for *Myriophyllum*.

An increase in certain marsh and aquatic species, coinciding with the phase of oak pollen and other types indicative of farming, is recorded in other Turkish diagrams too, *e.g.* Elmali and Beyşehir. From the suggested increase in water depth one would conclude an increase in precipitation during the oak-pollen period. At the same time human influence remains clearly visible. To what extent did a change in forest cover alter the water influx? The development of the vegetation is most likely influenced by two factors, that of man and that of climate.

The *Olea* percentages in the Avlan diagram vary from 0.1-0.5%. Information on the modern pollen precipitation of *Olea* in the Near East and Eastern Mediterranean shows that *Olea* has a very good pollen production as well as distribution. The percentages mentioned above are too low to expect olive-yards in the Avlan area, either during zone 1 or for zone 2.

Herding activity seems to have increased during zone 2, indicated by the appearance of *Plantago lanceolata*-type pollen. Maybe zone 2 was much more profitable for sheep/goat herding than zone 1. Still, although composites decrease in pollen percentages, other herbs such as grasses did not visibly profit from this. On the other hand, the increase of *Poterium* (*Sanguisorba minor*/*Poterium*) points to intensive grazing.

Although Avlan lies at about the same elevation as Elmali and only 20 km further south, the difference in the presence of *Juglans* is striking. Elmali must have had extensive orchards or at least planted walnut trees, whereas this species is lacking in the Avlan region. This could even lead to the conclusion that the Avlan area itself was not inhabited in prehistoric times.

2.7. Ova Gölü

2.7.1. *The geographical situation*

Ova Gölü is situated on the coast (fig. 1) of southwestern Turkey between Fethiye and Kas. The lake itself has been drained recently and at present only a small marsh is found in the centre. The Ova basin lies c. 15-20 m above sea-level. Outlets from rivers connect the basin with the sea. For details on the geology of the area, the reader is referred to van Zeist *et al.* (1975).

2.7.2. *The climate*

Climatic conditions in the Ova basin are typical Mediterranean. Winter temperatures are c. 12 °C on average. The average summer temperature is c. 28 °C. Annual precipitation amounts to c. 1000 mm, most of which falls during the winter half-year.

2.7.3. *The vegetation*

The Ova basin lies in the Eu-Mediterranean zone. On the hills around the basin, maquis and *Pinus brutia* forest are found. The local marsh vegetation is dominated by *Cladium mariscus*. During the fieldwork in June 1977, *Nymphaea alba* was observed among the *Cladium* on the dry marsh. Such water lily plants point to a much higher water level during other parts of the year.

2.7.4. *Lithology and radiocarbon dating*

0- 10 cm	clay
10- 75 cm	clayey peat
75- 78 cm	clay
78- 81 cm	peat
81- 85 cm	clay
85-130 cm	clayey peat
130-190 cm	blue-grey clay with plant remains and narrow organic bands
190-196 cm	clayey peat
196-220 cm	peat
220-248 cm	clay
248-279 cm	clayey peat
279-295 cm	blue-grey clay with plant remains
295-379 cm	peat
379-410 cm	peaty clay
410-440 cm	peat
440-445 cm	blue-grey clay with plant remains

445-460 cm	peaty clay
660-740 cm	plastic blue-grey clay
740-762 cm	grey clay with black stripes
762-778 cm	sandy, no recovery

For the following depths of the sediment core radiocarbon measurements have been carried out:

170-175 cm	2150 ± 100 B.P.(GrN-10482)
730-740 cm	6500 ± 380 B.P. (GrN-10483)

2.7.5. *Methods*

The pollen values are expressed as frequencies of a pollen sum including all types apart from aquatics. Hiatuses in the pollen profile occur at a depth of 180-310 cm and 405-540 cm.

2.7.6. *Pollen assemblage zones*

Because of the low pollen sums and two large gaps in the pollen record, no pollen zones are established as is done in the other diagrams in this study. The two hiatuses divide the diagram (fig. 15) into three parts which are considered as zones: zone 1, spectra 1-7, zone 2, spectra 8-11, zone 3, spectra 12-15.

2.7.7. *Reconstruction of the vegetation in the Ova basin*

Arboreal pollen percentages in zone 1 average about 60%, mainly due to the presence of *Quercus cerris*-type and *Quercus calliprinos*-type. The herb pollen percentages include *Artemisia*, *Sanguisorba minor/Poterium*, *Centaurea solstitialis*-type and Liguliflorae. As Ova Gölü is situated in the Eu-Mediterranean vegetation zone, one might expect pollen from that vegetation to dominate the spectra, especially in the oldest part where human influence will be less than in younger times. However, the Eu-Mediterranean vegetation has the disadvantage of being severely under-represented in the pollen rain (Bottema & Barkoudah, 1979; Bottema, 1974). This explains why pollen of typical Mediterranean tree or herb species is lacking, whereas on the other hand pollen from tree species from the Oro-Mediterranean zone is present with relatively high percentages. This concerns the deciduous oaks, indicated by *Quercus cerris*-type. One has to keep in mind that *Quercus cerris* stands for the deciduous oak type that includes pollen of all the deciduous oak species and even semi-evergreens in Turkey.

The Eu-Mediterranean vegetation would produce for instance *Quercus calliprinos*-type pollen. In Turkey two evergreen oaks species produce such a pollen type, which is in fact the same type as *Quercus coccifera*-type from the western Mediterranean. *Quercus coccifera* is replaced in Turkey by *Quercus calliprinos* and furthermore *Quercus ilex* is found in western Turkey. *Quercus ilex* reaches as far east as the coastal area near Fethiye. Thus, at the moment *Quercus ilex* plays no role in the Ova basin, and it is possible that the evergreen oak pollen concerns *Quercus calliprinos* only. *Q. calliprinos* is by no means restricted to the Eu-Mediterranean zone only but occurs inland at elevations of over 1000 m. This oak spreads quickly on forest clearances where it forms a secondary cover. Just like its close relative *Q. coccifera* this oak is quite resistant to grazing.

Other pollen types originating from higher elevations are *Carpinus orientalis* (*Ostrya carpinifolia* is less likely), *Ulmus*, *Cedrus* and to some extent *Pinus*. *Pinus* species to be found in southwestern Turkey are *Pinus nigra*, *P. brutia* and at coastal levels *P. halepensis*. *Pinus brutia* covers the range from the coastal slopes up to southern exposures into the interior, for instance directly south of Avlan, up to c. 1200 m.

During the time of Ova zone 1 some pollen of *Olea* is present and more rarely *Phillyrea*. Both species form part of the natural Mediterranean vegetation. The presence of *Platanus* draws the attention. Pollen of this tree is found from the lowest spectra on, where its presence is dated to 6500 ± 380 B.P. In many parts of Turkey, but in fact over a much larger area, from Greece up to northern Iran, *Platanus* appears towards the end of the 4th millennium B.P. The Ova basin is an example of the kind of natural habitat from which *Platanus* could have spread in the 4th millennium.

Herb pollen produced by local vegetation around the Ova basin includes that of Ericaceae, *Helianthemum*, *Cistus* and *Asphodelus*. The open aspect of the vegetation is indicated by relatively high values of *Poterium*, *Centaurea solstitialis*-type, *Artemisia* and Liguliflorae. As the Mediterranean Sea is very near to the coring site, one could conclude that saline conditions were prevalent because Chenopodiaceae amount to 30%. Salt water could have entered the basin by the natural inlets through which the river Esen discharges. Fresh water is also brought in by the easterly tributaries of this river fed by wells at the feet of the Akdağlar mountains. The elevation of the Ova basin above the sea, however, is too high to expect direct influence of the sea. The basin is situated at least at +15 m, whereas the core is 7 m long. There is no evidence that salt water penetrated the Ova basin during the Holocene. Also conclusive is the presence of fresh-water snails in the sediment. At a depth of 660-665 cm *Lymnaea* cf. *ovalis* and *Anisus leucostomus* are present, indicating fresh-water conditions.

Obviously the sediment between zones 1 and 2 had been exposed to the hot Mediterranean sun and pollen was corroded. There are no indications that this summer drought was caused by a change in climate. It is more likely that local conditions changed. Geomorphological changes in the basin may have altered the water regime, especially the drainage towards the sea. Towards the end of the hiatus organic deposits started to form, indicating marshy conditions.

The vegetation found in and around the Ova basin during zone 2 differed to some extent from that in zone 1. Of course the transition remains hidden in the hiatus. Both the deciduous as well as the evergreen oaks have diminished, a trend that may be visible already towards the end of zone 1. *Olea* and *Phillyrea* increased in numbers, as can be concluded from their pollen percentages. The first species may have been actively stimulated by man. It is generally accepted that olive culture started during the Bronze Age.

The age of zone 2 can be calculated on the basis of the two radiocarbon dates, assuming a constant sedimentation rate. Thus, zone 2 would represent the 4th millennium B.P. *Phillyrea* is a shrub that spreads as part of the maquis, a secondary vegetation type that is found when the original Mediterranean forest had been destroyed. The increasing percentages of *Sanguisorba minor/Poterium*, probably produced by *Poterium*, point to an increase in grazing pressure.

During zone 2 *Juglans* appears. The presence of *Olea*, *Juglans* and the types that indicate farming activity, mentioned above, show a clear resemblance to the corresponding situation in the other Turkish pollen diagrams.

The hydrostatic situation of the basin during zone 2 is concluded from a continuous curve of *Nymphaea*. This situation must be identical with the present-day situation before drainage. Shallow water occurred all the year round, dominated by high *Cladium* and under them water lilies. In many situations we observed that water lily can survive the summer even in dried up lakes. In some cases *Nymphaea* even flowered without any water. After zone 2 there is another hiatus in the pollen record.

The upper metre did not contain pollen but a record from 100-180 cm is available (zone 3). In time this covers about the first millennium A.D. The trees and vegetations had suffered to a great extent compared to the previous period. Further towards the interior, pine and cedar were still important. They may be over-represented in the pollen precipitation because of the lower production in a diminished local vegetation.

3. GENERAL CONCLUSIONS AND COMPARISON WITH OTHER POLLEN DIAGRAMS FROM TURKEY

The area under discussion (see figs. 1 and 16) can be divided into three parts. On the *western* part we

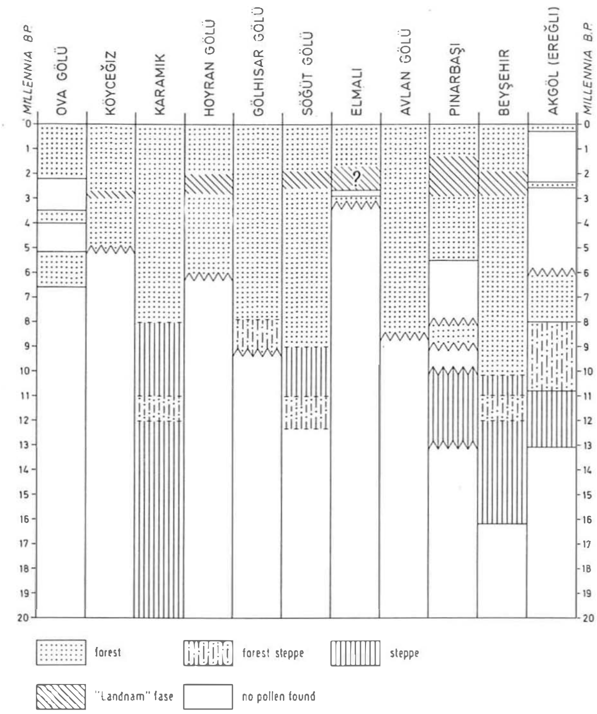

Fig. 16. Tentative scheme showing the rough outline of the vegetation development for 11 locations in southwestern Turkey.

are relatively well informed as nine pollen diagrams distributed rather evenly over the area are available (see also van Zeist *et al.*, 1975). For the *middle* part we are informed by two diagrams of Beyşehir and for the eastern part by the Akgöl diagram (fig. 1).

The level of the coast is covered by information from Köyceğiz and Ova Gölü. Towards the interior, after a series of mountain ridges, pollen diagrams for sites at elevations varying from c. 1000 to c. 1400 m have been prepared. Next we are informed about Beyşehir Gölü, c. 100 km to the east. Separated from Beyşehir Gölü by a mountain ridge of c. 2300-2400 m altitude, lies the Konya plain at c. 1000 m above sea-level. At about 200 km east from Beyşehir, the Akgöl (Ereğli) diagram informs us on the vegetation history of the Konya plain.

3.1. The Pleniglacial

The Pleniglacial is only present in the diagrams of Beyşehir II and Pinarbaşi. It has been mentioned above (2.1.5.) that the vegetational development of the Beyşehir area differed from that of the western part of the area studied and from that of the Konya area to the east by the limited role of *Artemisia* and Chenopodiaceae. On the other hand, many Compositae occur with high pollen percentages. The role of such Compositae is discussed in 2.1.5. They must be over-represented to a great extent but they do nevertheless indicate open space. The lower spectra of the diagram of Beyşehir II, representing the Pleniglacial suggest mainly open vegetation.

Trees were probably absent unless some *Cedrus* grew at a few rare locations where temperature and moisture demands of this species were just met. The other scarce tree pollen must have been blown in from the coastal mountain ranges. Under such apparently extreme conditions, one would expect various Chenopodiaceae, Plumbaginaceae, *Artemisia* etc. However, climatic conditions at this elevation must have been unsuitable for these taxa; especially temperature would have been the limiting factor. The typical steppe vegetation as deduced from many pollen diagrams in the Near East must have been found at elevations lower than 1400 m as is concluded from the Beyşehir evidence. *Euphorbia* pollen found during this period may belong to the large *Euphorbia* plants growing in the marshes on the southwest of the lake at the present time.

The lower part of the Pinarbaşi diagram may represent Pleniglacial times, but dates are not available for this section. The Pinarbaşi area was completely devoid of trees during that time. Even steppic elements are scarce and most pollen comes from Compositae.

3.2. The Late Glacial

We are not informed on the Late Glacial development of the vegetation of the Mediterranean coast (fig. 1: 7, 8). More can be said about the large intramontane part (fig. 1: 4, 9) (van Zeist *et al.*, 1975). The most southwestern part of the area studied was mostly treeless during the Late Glacial. Steppic elements like *Artemisia*, Chenopodiaceae, Plumbaginaceae, *Ephedra*, *Plantago* etc., were largely dominating.

Where trees or shrubs were found, mostly light-demanding pioneers are concerned, for instance *Hippophaë* and *Betula*. On favourable locations at higher altitudes deciduous oaks occurred. *Pinus* did not play a role, but *Cedrus* was fairly common. There is no even gradient in the distribution of forest or tree species. More inland, north of the lake of Hoyran, *Abies* pollen was relatively common according to the Karamik diagram (van Zeist *et al.*, 1975), whereas south of this lake this tree was absent. Even today *Abies cilicica* does not occur in the Söğüt-Pinarbaşi area. Possible secondary origin of *Abies* pollen in the Karamik diagram is discussed in 3.3.

More to the east, in the Beyşehir area, the herb vegetation that was dominant during the Late Glacial differed from that of the other regions. The elevation is a few hundred metres higher. No large valleys or plains occur and even today more forest can be found there than in the neighbourhood of Karamik, Söğüt and Pinarbaşi. The herb vegetation was not dominated by *Artemisia* and Chenopodiaceae, but by various *Ephedra* species, many Compositae, *Euphorbia* and Umbelliferae. In contrast to the western part, pine played an important role; *Pinus* pollen reached 50% during Beyşehir zone 2 which could be identical with the Allerød period. Oak/juniper woodland was more important after the Allerød. It seems that because of the elevation of Beyşehir such types of forest occurred earlier, to descend to lower elevations in the course of time with changing climate.

The eastern part, the Konya plain was completely devoid of trees during the Late Glacial. The three volcanoes standing in or near the plain only bore some birch and juniper. *Artemisia* vegetation and grass steppe dominated alternately.

3.3. The Holocene

No information on the early Holocene vegetation development of the coastal area is available. For the western part of the area studied no more information is in fact available than is given by van Zeist *et al.* (1975). The four new diagrams presented in this study do not cover the lower part of the Holocene, or there is some uncertainty about the dates.

During the beginning of the Holocene, steppic vegetation dominated the western part of the area. In the first 2000 years hardly any changes happened. Then, at first rather slowly, evergreen needle-leaved forest started to spread. The components of this evergreen forest were not the same all over the western part. Where the intramontane part is large as in Söğüt, deciduous oaks also played a role. In the area of Avlan and Elmali as well as more to the north in Karamik, cedar and pine were the main constituents. In Pinarbaşi the forest was completely formed by pine, but in Gölhisar the pines were accompanied by juniper and some deciduous oaks. The area has in common that everywhere in between 9000 and 7000 B.P. forest became established. The species composition of the forest has not changed essentially since that time (compare the map published by the State Forestry Service, Türkiye Orman Agaç Ve Ağaçciklarinin Yayilişi, Orman Genel Müdürlügü Yayinlarindan, 1962).

Some of the changes in the vegetation that occurred in the last 8000 years must be ascribed to natural factors. Thus, in Sögüt *Juniperus* played a role from c. 9000 to 3000 B.P., while in the Pinarbaşi area *Cedrus* increased gradually from c. 7000 B.P. onwards, to decrease c. 3000 B.P. However, the most important changes were caused by man, who in some parts destroyed the forest completely. The destruction of evergreen needle-leaved forest caused a succession in which oak and juniper took part, whereas a series of trees for domestic use appeared. These *landnam* effects will be discussed in section 4.

The middle part, the Beyşehir area, also shows a coniferous forest that developed during the Holocene with a slight admixture of oak and juniper as can be seen in Söğüt. Somewhere around 5500 B.P. oak and juniper disappeared and *Abies* gained a foothold in the area and is still present today. In the Karamik area north of Hoyran *Abies* pollen is already present from 20,000 B.P. onwards. It is difficult to explain the Karamik and Hoyran spectra, as also pollen from *Carya* is present. The area is almost treeless nowadays and the question is whether *Abies* was growing there during prehistoric times or whether its pollen is of secondary origin. The history of the younger half of the Holocene in Karamik/Hoyran runs parallel to that of the western part.

The vegetation development of the Konya plain, and more especially the eastern part of it, differs from that of the Beyşehir and Söğüt areas more to the west. During the first 2000 years of the Holocene conifers did not play any role at all. The combination of *Betula* and *Hippophaë* is not found in the western mountainous part. Before conifers started to spread around 8000 B.P., oak woodland on the mountains bordering the plain must have been common for about 500 years. Not much can be said of the younger Holocene because samples from that period turned out to be devoid of pollen. In the uppermost sample the *Pinus* percentages are c. 75%. When the vegetation of today is considered it is likely that such high values must be explained by long-distance transport of pollen produced by *Pinus* from the southeastern Bolker Dağlari, including *Pinus nigra* as well as *P. brutia*.

4. MAN AND VEGETATION IN SOUTHWESTERN TURKEY

One of the aims of the palynological investigations as presented in this study is the reconstruction of the environment of prehistoric man. As soon as prehistoric man took to farming he undoubtedly changed the natural vegetation. Early farming in Anatolia occurred already in the seventh millennium B.C. Aşikli Hüyük (7008 ± 130 B.C.) east of Aksaray, aceramic Hacilar (6750 ± 180 B.C.) west of Burdur, Suberde (second half of the seventh millennium B.C.) on the edge of Lake Suğla. The oldest date of Çatal Hüyük is 6240 ± 99 B.C.; deeper layers pointing to older habitation have not been excavated (Mellaart, 1975). Also in the Konya basin (fig. 1) the site of Can Hasan III, an aceramic farmers' settlement, is roughly dated to 6500 B.C.

The early farmers who settled on the southern edge of the Konya plain chose a habitat characterized by rich alluvial soil in an open landscape of meadows and marshes. Early farmers who settled on the plain of Macedonia and the Thessalian plain in Greece made a comparable choice. It is logical that early farmers did so as their predecessors chose land where the vegetal cover was limited to herbs or steppe forest at most.

For a reconstruction of the environment of the habitation on the Konya plain, the pollen diagram of Akgöl (Ereğli) provides the nearest information (fig. 1). Can Hasan III is situated at c. 50 km and Çatal Hüyük at c. 100 km from the coring site. This distance is too far to enable us to trace the influence of those people in the pollen record, and possible changes in the pollen curves may just as well have been caused by settlers living closer to the coring locality. Information on Neolithic habitation in the area of the coring locality is not available. However, for a reconstruction of the environment of the early farmers living on the edge of the Konya lake, the pollen diagram is very useful.

The palynological picture around 9000 B.P. suggests some salinization of the Konya plain and expanding deciduous (steppe) forest on the surrounding mountains. Increase of oaks and even some elm could point to an increase in moisture, whereas, on the other hand, salinization, indicated by increasing Chenopodiaceae, suggests drier conditions. Information obtained from palynological investigations of Lake Urmia points to less run off towards that basin with increasing vegetal cover. It is supposed that denser vegetation absorbs so much water that the contradictory result is less water supply to the lake. Indeed, the sediment in the Akgöl core shows a lowering of the water table. Undoubtedly large herbivores must have profited from increasing food supplies. Consequently, hunting became more profitable, starting somewhere around 12,300 B.P. in the Akgöl area.

After 9000 B.P. the available grass biomass decreased, assuming that upland grass pollen is represented in the pollen diagram. Did such changes induce man to take to farming or do we need another explanation? Did the slight increase in precipitation permit or stimulate dry farming on the edge of the steppe in the Konya basin?

The borders of seasonal lakes and pools of the contracting Lake Konya were excellent natural grazing ground for cattle. While sheep did not want to risk wet feet and had to be herded on dry plains or slopes, wild or domesticated cattle could not only exploit the natural slightly saline meadows but could penetrate also into the marsh or over floating reed mats as can be seen at present. The extensive grazing grounds explain the wealth of the Çatal Hüyük farmers. They never seem to have led their herds to the mountains to graze the open oak forest and later to turn the conifer forest, which had developed after 8000 B.P., into grazing ground. Such an exploitation happened much later, as is shown by pollen of *Plantago lanceolata* appearing in the record.

From the pollen evidence one can conclude that there was a situation suitable for cattle breeding. It is far more difficult, or even impossible, to prove the presence of early crop cultivation. The nature of the pollination of the various cereal species as well as of the legumes found in prehistoric settlements is responsible for that. As the Konya plain had enough open space for dry farming, human influence on forest higher up in the mountains was either nil or not enough to be visible in the pollen precipitation of Akgöl.

The inhabitants of Çatal Hüyük and Can Hasan III used clay as building material and only little wood. That indicates that they came from regions where trees were almost absent. They did not take the trouble to transport oak wood from the mountains bordering the plain.

We have seen that the Early Neolithic farmers did not leave recognizable traces in the pollen diagram of Akgöl (Ereğli). The same is true for the other pollen diagrams prepared for southwestern Turkey. In pollen diagrams from mainland Greece indicator types for the effect of the Early Neolithic are also not found (Bottema, 1982). In the diagrams under discussion the presence of *Plantago lanceolata* pollen starts during or Chalcolithic times or even later. It is obvious that as the area from the Konya basin to the Mediterranean coast is very diverse, it did not meet the demands of prehistoric farmers everywhere. Only scanty information on the distribution of sites in time and space is available for southwestern Turkey. Settlement mounds are found near lake edges, for instance the sites of Suberde and Erbaba, where natural grazing ground may have bordered the water. Roughly in between 4000 and 5000 B.P. farmers started to exploit the mountain slopes. At this time a *landnam* effect is visible, suggested by the appearance of *Plantago lanceolata*-type pollen, sometimes accompanied by *Poterium*-type. This 'landnam' effect may have affinities with early Neolithic pollen spectra from northwestern Europe.

When farmers started to exploit the forested mountain slopes, it is likely that some parts were exploited earlier than others. Accessibility, local habitation density *etc.* must have influenced the pattern.

Because of the nature of the sediments radiocarbon dates are few. Undated diagrams are correlated palynologically with dated diagrams. To link the pollen zones ascribed above with archaeological events or cultural periods remains difficult as only few radiocarbon dates are available.

A difficult picture appears a little before around 3000 B.P. (van Zeist *et al.*, 1975). All over the mountains the effect of farming and especially fruticulture is observed. Especially for the Beyşehir area the second author studied this phenomenon in detail, a study that will appear separately. Also in this case dating is done by palynological correlation with radiocarbon-dated diagrams. The cross dating is reasonably reliable particularly as this clear phenomenon always occurs in the upper part of the diagrams. Of course the effect is not felt as strongly everywhere. In Avlan there may have been no settlers, walnut plantations were most abundant in Elmali, the effect of cereal growing is most pronounced in Gölhisar, Beyşehir seems to have had more manna-ash growing than other locations, olives must have been grown towards the Mediterranean Sea.

It seems rather difficult to correlate political chaos (the fall of the Hittite empire) with a high level of farming and fruticulture. Not even when we bring in the use of iron starting at about this time. Did the central Hittite authority force the population to grow cereals mainly for keeping garrisons and armies, and did the farmers turn to a more autonomic system after the collapse of central organisation? Did autonomic groups develop fruticulture to supply their own local market with a necessary diversity because trading had stopped? We can only speculate about such matters, and we shall have to wait until a clear economic and political picture is brought forward.

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Figs. 8, 9, 11, 12, 13, 14 and 15 are to be found in the fold at the back of this volume.