HOLOCENE VEGETATION AND CLIMATE OF NORTHWESTERN SYRIA

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CONTENTS

1. INTRODUCTION

In 1970, J. Niklewski and W. van Zeist published a pollen diagram prepared for an 11-m-long sediment core from the Ghab valley in northwestern Syria (fig. 1). This valley, through which the Orontes river flows, extends c. 50 km from south to north and has a maximum width of c. 12 km. Before the valley was drained in 1953-1955 it was covered for the greater part by lakes and swamps. To the west of the Ghab valley, the Alaouite Mountains (or Ansariye Mountains) reach elevations of over 1300 m (4000 ft). The Zawiyé Mountains to the east of the valley are much lower. For further particulars on the geography of the area and for climatic data the reader is referred to Niklewski & van Zeist (1970).

The diagram mentioned above (henceforth indicated as the Ghab I diagram) covers the greater part of the last glacial period, but the Holocene is not well represented. A date of c. 10,000 B.P. was obtained for the level of 1.29-1.37 m and the upper 40 cm of the deposit proved to be too poor in pollen for a satisfactory result. Consequently, only a section of 70 to 75 cm provided information on the Holocene vegetational history, and it was unclear how much of the later phases is missing in this diagram. Gradually the suspicion arose that a quite considerable part of the Holocene may not be represented in the Ghab I diagram. This made it desirable to carry out some more borings in the Ghab valley in an effort to obtain a longer Holocene pollen sequence than that in the Ghab I diagram.

The opportunity for additional coring presented itself in May 1974 when the first author took part in the excavation of Tell Selenkahiye, along the Euphrates in northern Syria, under the direction of Professor M. N. van Loon. Mr. Abdurrazzaq Zaqzuq, director of the Museum at Hama and representative of the Syrian Government at the excavations of Selenkahiye, kindly established contacts with the Maharde Office of the Ghab Development Project. Mr. Majad Farage, Mr. Bassam Sarraj and Mr. Zaid Zaqzuq of the said office provided information that was useful in connection with the selecting of suitable coring sites. Mr. Mousa Obeid of the Ghab Administration Project at Skelbiyé accompanied us in the field. In addition to the first author, Mr. P. A. Akkermans and Mr. R. W. Brandt, both of the staff of the Selenkahiye excavations, took part in the coring expedition.

The Netherlands Organisation for the Advancement of Pure Research (Z.W.O.) provided financial support for the excavations at Selenkahiye. The radiocarbon determinations were carried out under the direction of Professor W. G. Mook.

2. PRESENT-DAY NATURAL VEGETATION

In the publication of the Ghab I diagram (Niklewski & van Zeist, 1970) a description of the (reconstructed) natural vegetation of the area is presented. In this section the main vegetation zones will briefly be reviewed.

On the west flank of the Alaouite Mountains the following zones are distinguished. Between sea-level and c. 300 m altitude the Ceratonieto-Pistacietum lentisci occurs. This vegetation type includes *Ceratonia siliqua*, *Pistacia lentiscus*, *Quercus calliprinos*, *Pistacia palaestina*, *Myrtus communis*, *Phillyrea media* and *Olea europaea* var. *oleaster*. In the zone between c. 300 m and c. 800 m the Pistacieto-Quercetum calliprini is the natural vegetation. In addition to *Quercus calliprinos* and *Pistacia palaestina*, various other trees and shrubs, such as *Pyrus syriaca*, *Crataegus azarolus*, *Styrax officinalis*, *Juniperus oxycedrus* and the deciduous oak species *Quercus infectoria*, are found in this vegetation type. *Pinus brutia* is very likely also a natural constituent of the Pistacieto-Quercetum calliprini. Deciduous oak (*Quercus infectoria*, *Q. cerris*, *Q. brantii*, *Q. libani*) is the dominant tree above 800 m. Other trees present in the oak-dominated forests include *Ostrya carpinifolia*, *Carpinus orientalis*, *Acer monspessulanum* and *Juniperus oxycedrus*.

On the steep east flank of the Alaouite Mountains the same vegetation zones as on the west flank are assumed to be present. At elevations above 1000 m *Cedrus libani* forms part of the mixed-oak forest. Between the valley floor, at about 190 m, and an elevation of c. 300 m the Ceratonieto-Pistacietum lentisci would constitute the natural vegetation, while the Pistacieto-Quercetum calliprini occupies the belt between c. 300 and 800 m.

Before drainage, swamp vegetations covered the greater part of the Ghab valley. Trees which were

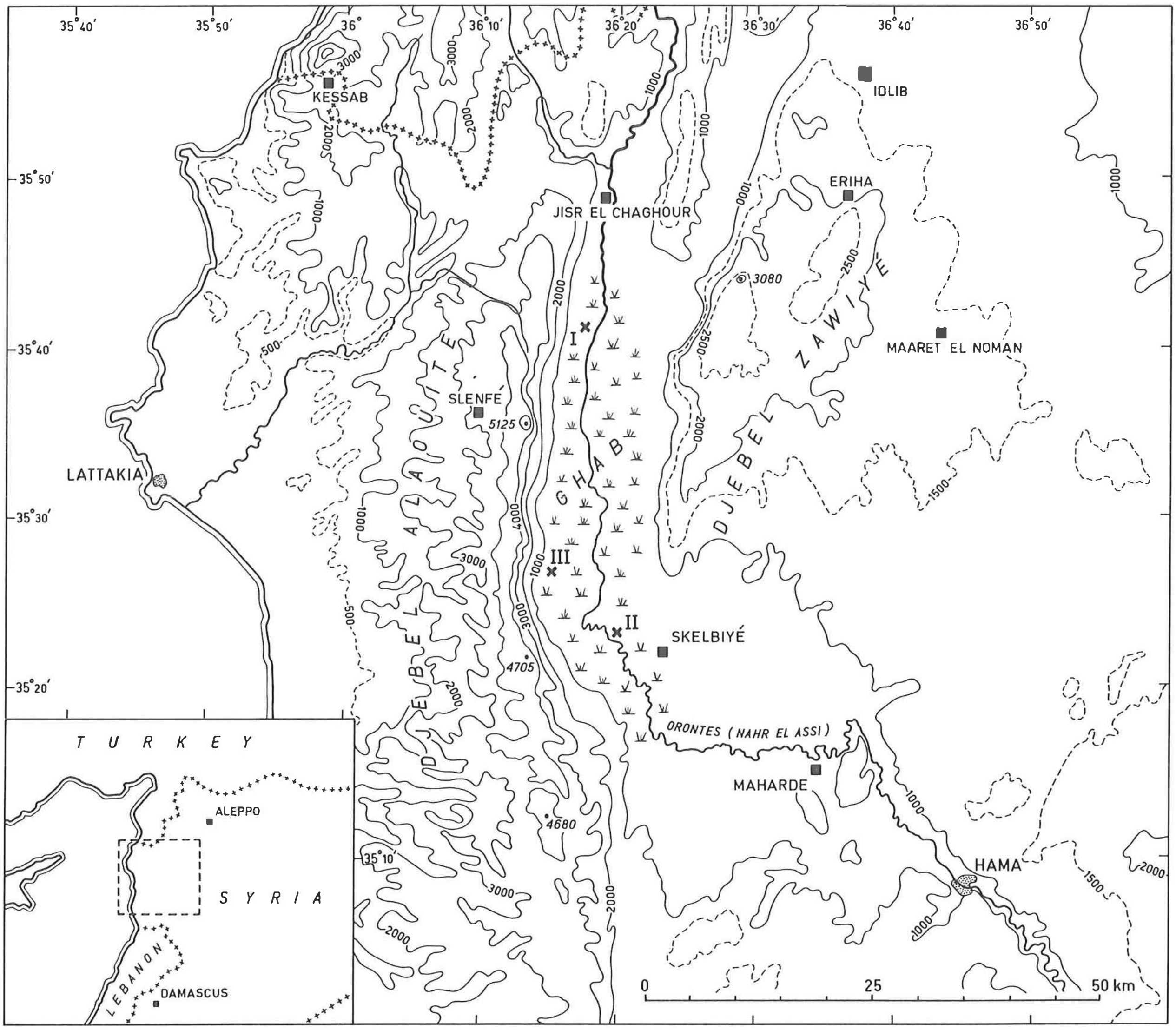


Fig. 1. Map of northwestern Syria. The coring sites Ghab I, II and III are indicated with an x. Elevation contour lines are given in feet.

found in the valley include *Fraxinus syriaca*, *Populus euphratica*, *Tamarix* spp., *Salix* spp. and *Platanus orientalis*. In the Zawiyé Mountains, to the east of the Ghab valley, forest steppe probably constitutes the climax vegetation above 500 m. At lower elevations and further eastward steppe vegetations occur naturally.

3. BORINGS AND LITHOLOGY

Two sediment cores were obtained with a Dachnowsky sampler with an inner diameter of 37 mm. The borings had to be carried out in one hole.

3.1. Ghab II

The Ghab II core was taken at a locality c. 5 km westnorthwest of Skelbiyé (fig. 1). Before the drainage of the Ghab valley, seasonal marshes were found in this area. The boring was carried out at the edge of a cotton field in unploughed soil. The following lithology was recorded:

0.17-0.37 m dark-grey clay with black spots
0.37-0.59 m red-brown clay with shell detritus
0.59-1.96 m dark-grey to grey-brown clay with red-brown (oxidation) spots
1.96-2.52 m grey to dark-grey clay with shell detritus
2.52-2.74 m grey clay with red-brown (oxidation) spots
2.74-3.16 m dark-grey clay
3.16-3.45 m dark-grey clay with red-brown (oxidation) spots

Up to 3.45 m the sediment remained compact.

3.2. Ghab III

The site of the Ghab III core is situated on the west side of the valley, west of the village of Ain el Taka, c. 14 km northwest of Skelbiyé. In this area perennial marshes were present formerly. The boring was carried out in a harvested grain field. Sampling started from the bottom of a 40-cm-deep pit. The following lithology was recorded:

0.40-1.42 m red-brown clay with shell detritus
1.42-1.84 m grey-brown clay with shell detritus
1.84-2.30 m grey-blue clay with shell detritus
2.30-2.43 m plastic grey-blue clay
2.43-2.83 m plastic grey-blue clay with shell detritus
2.83-3.43 m grey-blue clay with shell detritus

Because of a sampling error the section between 2.03 and 2.83 m had to be cored in a second hole c. 30 cm away from the first one.

The boring was terminated at a depth of 3.43 m because it was assumed that the bottom of the core sampled would date back to beyond the beginning of the Holocene. This assumption, which was based upon the results obtained for the Ghab I core, turned out to be wrong. The aim to obtain a new sediment core covering the whole of the Holocene (except perhaps for the last few hundred years) has not been achieved.

4. PRESENTATION OF THE RESULTS

The results of the examination of the Ghab II and Ghab III cores are presented in fig. 2. The upper part of the Ghab II core, above 1.45 m, proved to be too poor in pollen for a satisfactory result. Moreover, the upper section of the Ghab I diagram (Niklewski & van Zeist, 1970) is shown in fig. 2, although for the herbs only a selection of the pollen types established for the core section concerned is presented here. The sequence of the three diagrams as presented in fig. 2 is to a certain degree a chronological one. As will be discussed below (section 6) the earliest phases of the Holocene are represented only in the Ghab I diagram, whereas the upper part of the Ghab III diagram is definitely later than the upper sections of the Ghab I and Ghab II diagrams.

The construction of the pollen diagrams is the same as that of the original Ghab I diagram. All identified pollen and spore taxa are included in the basic pollen sum, with the exception of those of obvious marsh and water plants (to the right of the column with the pollen sums). Various herbaceous pollen types included in the basic sum, such as Gramineae, Cruciferae and Umbelliferae, may have originated at least partly from local marsh plants. Moreover, representatives of Compositae and Chenopodiaceae probably expanded locally on the valley floor (see section 6).

To the right of fig. 2 "main diagrams" showing the ratios between total tree pollen and the sum of *Artemisia* and Chenopodiaceae are presented. The latter ratios should provide a better picture of the upland vegetation pattern, that is to say, of the proportions of forest and steppe, than the AP/NAP ratios in which all herbaceous pollen types are included. However, this assumption is somewhat invalidated by the admission that Chenopodiaceae may also have formed part of the local vegetation.

5. POLLEN ASSEMBLAGE ZONES

The three Ghab pollen diagrams are subdivided into a number of zones. The zoning is mainly based upon changes in the AP/NAP ratios, but other features are also of importance in this respect. As will be discussed below, the correlation of the three diagrams presents serious difficulties, which must be ascribed at least in part to rather marked differences in the local pollen precipitation in the various parts of the Ghab valley. For that reason each of the three diagrams has its own zonation; that is to say, it has not been considered here to what extent the diagrams may overlap.

5.1. Ghab I (pollen assemblage zones 1-4)

The zonation of the section of the Ghab I diagram presented in fig. 2 is the same as that in Niklewski & van Zeist (1970). There are differences only in the zone designations (the original (sub)zone numbers are given between brackets).

Zone 1, spectra 57-60 (subzone Y5), is characterized by very low total arboreal pollen values. Of the tree pollen types, only *Quercus*, *Pinus*, *Salix*, *Juniperus* and *Cedrus* show continuous curves in this zone. *Artemisia* and in particular Chenopodiaceae show very high pollen percentages. As for the other herbaceous pollen types, the comparatively high values for *Polygonum aviculare*-type may be mentioned here.

In *zone 2, spectra 61-63 (subzone Z1)*, a conspicuous rise in tree pollen values takes place. In addition to *Quercus*, *Pistacia*, *Olea* and *Carpinus orientalis*/*Ostrya*-type increase markedly. *Cedrus* has relatively high values. The decline in the Σ NAP values is largely accounted for by Chenopodiaceae and *Artemisia*. The *Polygonum aviculare*-type curve falls drastically.

Zone 3, spectra 64-66 (subzone Z2), shows high Σ AP values in which all tree pollen types mentioned above take part except *Cedrus* which declines markedly at the zone 2/3 border. *Pinus* pollen percentages remain rather low. The zone 2/3 transition (1.29-1.37 m) has been radiocarbon dated to 10,080 ± 55 B.P. (GrN-5810).

In *zone 4, spectra 67-74 (subzone Z3)*, Σ AP values are somewhat lower than in the previous zone. *Pinus* and *Quercus calliprinos* percentages increase to some extent. *Alnus* shows a continuous curve from spectrum 68 onwards, but its values remain low.

5.2. Ghab II (pollen assemblage zones 5-7)

In the whole of the Ghab II diagram, Compositae values are noticeably higher than in the Ghab I diagram. Gramineous pollen percentages are, on the average, lower. These differences are very likely due to local conditions.

Zone 5, spectra 1-9, is characterized by rather low *Quercus cerris*-type values. *Alnus* shows a distinct maximum in this zone. *Pinus* has rather low percentages.

In *zone 6, spectra 10-15*, Σ AP values show a maximum, which is accounted for completely by *Quercus cerris*-type pollen. The *Pinus* curve rises in the upper part of the zone, where *Quercus* values decrease again. In this zone various Compositae pollen types show lower values or occur less frequently than in zones 5 and 7.

Zone 7, spectra 16-22, is characterized by a marked decline in the *Quercus cerris*-type curve. *Quercus calliprinos*-type, *Olea* and *Ostrya*/*Carpinus orientalis* decrease likewise, but other types, such as *Pinus*, maintain themselves. Compositae, in particular Liguliflorae, reach high percentages in this pollen zone.

5.3. Ghab III (pollen assemblage zones 8 and 9)

In the Ghab III diagram, chenopodiaceous pollen values are markedly higher and those of Liguliflorae Compositae are lower than in the Ghab II diagram. On the basis of the *Quercus cerris*-type values two zones are distinguished in this diagram.

Zone 8, spectra 1-13, shows comparatively high *Quercus cerris*-type percentages. The zone 8/9 boundary is marked by a decline in the deciduous oak curve. The subdivision into subzones 8a and 8b is based only upon the comparatively high *Fraxinus ornus* values in spectra 12 and 13, which indicate the beginning of manna ash cultivation in the area. Consequently, subzone 8b provides the first palynological evidence for the activity of man.

In *zone 9, spectra 14-30*, indications of human interference are quite numerous. The conspicuous decline of deciduous oak and pistachio at the beginning of the zone must very probably be ascribed to the clearance of forest. *Fraxinus ornus*, *Olea*, *Juglans* and to a minor extent *Vitis* reach comparatively high percentages in this zone. As for the herbaceous pollen, *Sanguisorba minor*-type and *Polygonum aviculare*-type increase distinctly. *Plantago lanceolata*-type is more common than in the previous zone. Chenopodiaceae decrease, but this may have been due to changes in the local marsh vegetation. The border between subzone 9a (spectra 14-17) and subzone 9b (spectra 18-30) is placed at the increase in *Fraxinus ornus*, *Juglans* and *Sanguisorba minor*-type. In subzone 9b culture indicators show in general the highest frequencies.

For the level of 184-192 cm, in the lower part of zone 9, two radiocarbon dates have been obtained. The shell fraction gave an age of 4460 ± 40 B.P. (GrN-9295), while the organic fraction of the same sample has been dated to 3560 ± 240 B.P. (GrN-9471). Because of the small amount of organic material the latter fraction has not been pretreated. Consequently, the age obtained may be somewhat too late because of younger contaminant (infiltration of humic acids). On the other hand, the shell determination may be somewhat too old because of the presence of fossil carbonates in the water of the Orontes river. It seems fair to state that 3560 B.P. is a minimum age and 4460 B.P. a maximum age for this sample.

6. CORRELATION OF THE POLLEN DIAGRAMS

It has already been mentioned that the correlation of the three diagrams presents difficulties. This may be partly due to the considerable distance between the coring sites (the sites of Ghab I and II lie more than 30 km apart). As a result, the influx of regional pollen may have shown differences in the localities from which the sediment cores originate. In this connection it should be mentioned that particularly on the west side of the valley substantial amounts of pollen may have been washed in from the steep east flank of the Alaouite Mountains.

Differences in the local marsh vegetation are probably a much more serious disturbing factor. In the case of Cyperaceae, *Sparganium*-type, *Isoetes*, *Myriophyllum* and some other marsh and water plants, there can be no doubt that these formed part of the local vegetation. Various other taxa may be represented in the local as well as in the regional vegetation. A well-known example is constituted by Gramineae. High values for Tubuliflorae and Liguliflorae Compositae and *Centaurea* point to the local expansion of the taxa concerned on temporarily exposed parts of the valley floor (cf. van Zeist *et al.*, 1975, p. 106). Chenopodiaceae may likewise have found suitable habitats in the valley itself, for instance, in places with permanently or temporarily higher salt concentrations. On the other hand, chenopodiaceous species must also have been important constituents of the upland steppe vegetations. Thus, there can be no doubt that the conspicuously high chenopodiaceous percentages in zone 1 (subzone Y5) of the Ghab I diagram are predominantly of upland origin, but the chenopod maxima in zone 8 of the Ghab III diagram must very likely be ascribed to the local expansion of representatives of this family. Fluctuations in the *Alnus* and *Salix* percentages must have been mainly of local significance.

A comparison of the diagrams could further be handicapped by possible gaps in the sedimentation and consequently in the pollen record. However, no obvious hiatus can be demonstrated in any of the three Ghab pollen diagrams.

A conspicuous *Quercus cerris*-type maximum is present both in Ghab I (zones 2 and 3) and in Ghab II (zone 6). These maxima cannot be correlated with each other. In the Ghab I diagram, the deciduous oak pollen maxima are preceded by a section (zone 1, subzone Y5) with very low Σ AP values and notably high *Artemisia* and chenopod percentages. A similar pollen assemblage is not found in the section below zone 6 of Ghab II. The Ghab II diagram must chronologically be placed above zone 3 in Ghab I.

The Ghab I diagram covers the Late-glacial and at least the early phases of the Holocene. In this connection it should be mentioned that zone 1 (subzone Y5) coincides largely with the Late-glacial of the European Würm-glacial chronology. For the zone 2/3 transition a radiocarbon date of c. 10,000 B.P. was obtained. It cannot be determined with any degree of accuracy how much of the Holocene is missing in Ghab I, but one may safely assume that the last 4000 years are neither represented in this diagram nor in the Ghab II diagram. This conclusion follows from the comparison with the Ghab III diagram. The comparatively high values for *Juglans*, *Fraxinus ornus*, *Sanguisorba minor*-type and *Polygonum aviculare*-type of zone 9 are not matched by similarly high frequencies in the other Ghab diagrams. Pollen zone 9, the base of which may tentatively be dated to about 4000 B.P. (see 5.3.), has no counterpart in Ghab I and II and consequently the upper levels of the latter diagrams must date from before 4000 years ago.

From the above it is clear that the early Holocene is represented only in the Ghab I diagram, whereas the period after c. 4000 B.P. is shown only in the Ghab III diagram (zone 9). There can be no doubt that chronologically zone 9 has to be placed above zone 4. However, it remains uncertain how much of zones 5 to 8 fits in between zones 4 and 9; in other words, which section of zones 5-8 fills the gap between the end of zone 4 and the beginning of zone 9. The course of the pollen curves does not give any clues for solving this problem satisfactorily. Consequently, for the sequence proposed in fig. 3 no convincing arguments can be adduced. Zone 5 links up fairly well with zone 4, particularly if spectrum 74 with the anomalously high *Pinus* percentages is left out. As for zone 7, it is assumed that the pollen contents of the core section concerned differs quite markedly from the original pollen influx. The high Compositae percentages in this pollen zone point to an intermittent drying out of the section concerned of the valley floor, which may have resulted in a selective preservation of durable pollen types. In the sediment above zone 7 very little pollen had been preserved, so that it was unsuitable for palynological examination. Because of its possibly distorted pollen picture, zone 7 had to be disregarded in attempting to reconstruct the Holocene pollen sequence. One may wonder to what extent the high *Quercus cerris*-type values in zone 6 could have been due to local factors. The question whether the deciduous oak maximum in zone 6 is of regional or of local nature is not without consequences for the reconstruction of the Holocene climatic history (see 7.3.).

It should be stressed that the reconstruction of the "middle Holocene" sequence (zones 5, 6 and 8) is mainly guesswork. It is very well possible that the section covering zones 5 and 6 overlaps with zone 4 on the one hand and with zone 8 on the other. However, for the time being there is no better alternative.

7. VEGETATIONAL AND CLIMATIC HISTORY

7.1. Zone 1

The extremely high herbaceous pollen percentages indicate that during zone 1, steppe and desert-steppe vegetations were predominant in northwestern Syria. Larger parts of the Alaouite Mountains, the present-day natural vegetation of which consists of forest, would have been covered by steppe vegetations. The climate of zone 1 must have been very unfavourable for tree growth. This phenomenon is not confined to northwestern Syria, but pollen diagrams from other areas in the Eastern Mediterranean basin show comparable pollen assemblages. The scarcity of tree growth must have been caused by climatic dryness. During zone 1, which period coincides largely with the Late-glacial of the European Würm-glacial chronology, temperature must have risen markedly, so this cannot possibly have been the limiting factor for tree growth. One could imagine that a possible increase in precipitation did not keep pace with the rise in temperature. The higher evaporation rate was not or only insufficiently compensated for by an increase in precipitation, in consequence of which the climate of zone 1 was extremely dry.

7.2. Zones 2 and 3

The expansion of trees which probably started about 11,000 B.P. must have been induced by a marked increase in humidity. Zone 2, the period of the rapid spread of forest vegetations, coincides wholly or in part with the Late Dryas period, the final phase of the Late-glacial. During this period, the temperature dropped again which must already have resulted in a rise in humidity, but also precipitation itself may have increased. Considerably higher precipitation, compared to that of zone 1, must certainly be assumed for zone 3 and subsequent zones, which can be placed in the Holocene (the zone 2/3 transition is radiocarbon dated to 10,080 B.P.). In spite of the early Holocene rise in temperature, forest constituted the natural plant cover of the mountains to the west of the Ghab valley during the whole of the Holocene. In this connection it must be taken into consideration that the high Σ NAP percentages in some pollen zones must be ascribed at least partly to local vegetations on the valley floor (see section 6).

In the final stages of the Late-glacial, and particularly in the early stages of the Holocene, in the period between c. 11,000 and say 8000 B.P., precipitation must have increased markedly. It should be remarked here that from the Ghab pollen record discussed in this paper, changes in humidity can be deduced, but that with one possible exception the

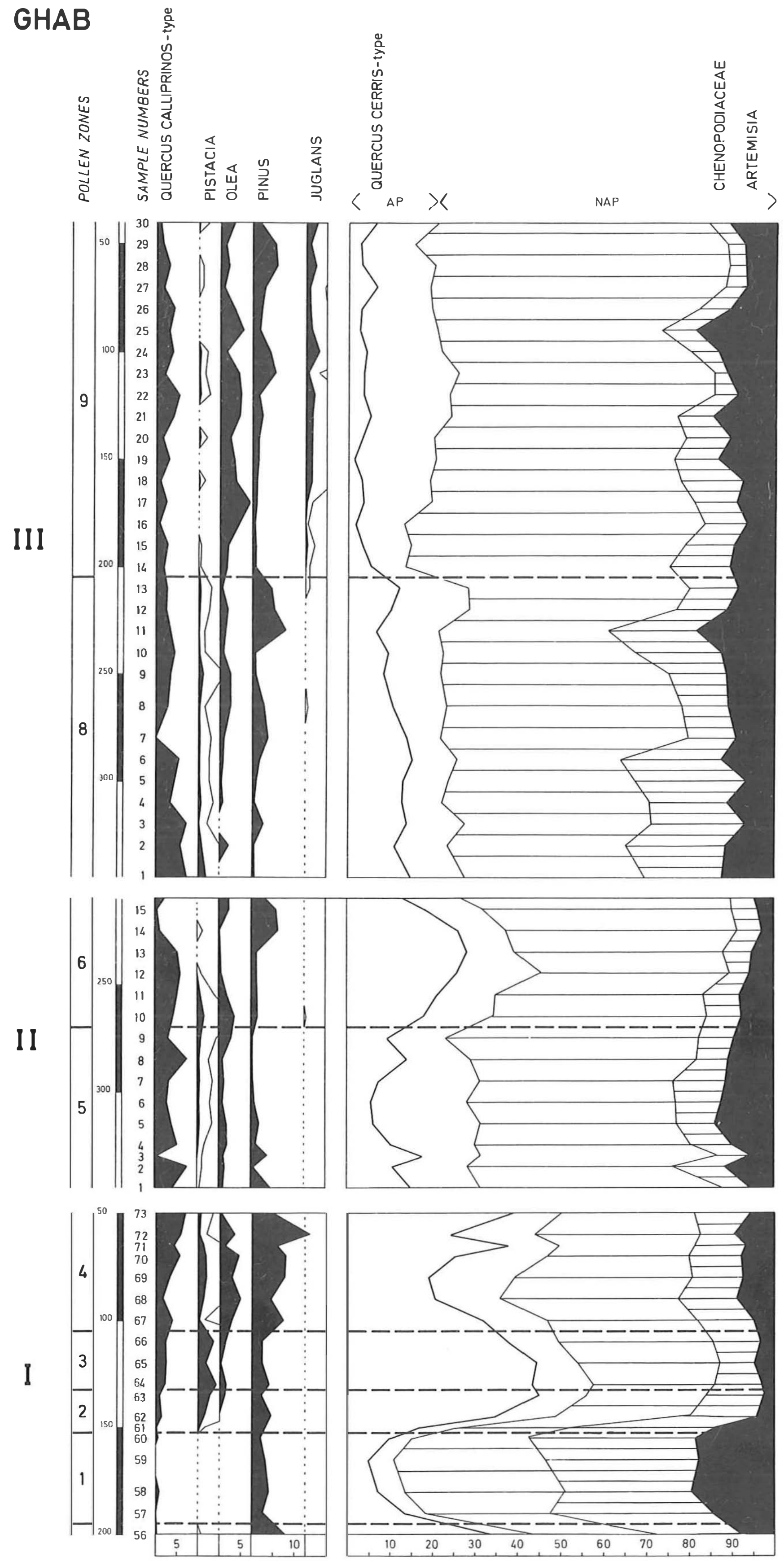


Fig. 3. Proposed sequence of Lateglacial and Holocene pollen record (discussed in section 6).

pollen data do not allow any conclusions on temperature or precipitation separately. Suggested changes in temperature are based on temperature data established elsewhere, particularly in Europe. Conclusions on precipitation, in turn, must be deduced from the inferred temperature and humidity data. Moreover, it should be stressed that the type of vegetation depends not only on mean annual temperature and precipitation, but also on the distribution of these climatic factors throughout the year. Thus, in the Mediterranean area the length of the period of summer dryness plays an important part.

During zone 2 (subzone Z1), the present-day natural vegetation pattern must, in broad outline, have established itself in northwestern Syria. In the Alaouite Mountains, forest vegetations expanded on the west flank as well as on the east flank. From the relatively high values for *Olea* and *Pistacia* one may conclude that already in zone 2 time Ceratonieto-Pistacietum vegetations (see section 2) with *Pistacia lentiscus*, *P. palaestina* and *Olea europaea* var. *oleaster* (wild olive) were found on the east flank, at elevations just above the valley floor. *Quercus calliprinos* should likewise have formed part of this vegetation type, but kermes oak must also have been an important constituent of the Pistacieto-Quercetum calliprini, the vegetation belt above the Ceratonieto-Pistacietum. At higher elevations, forests dominated by deciduous oak expanded.

It has been discussed above that already during zone 2 the Eu-Mediterranean Ceratonieto-Pistacietum was found on the east flank of the Alaouite Mountains, implying that at that time winter temperatures must have been fairly high, as this vegetation type is very sensitive to cold winters. Thus, in spite of the general decline in temperature during the Late Dryas period, after the temperature maximum of the Allerod period, winter temperatures apparently remained high enough to allow the establishment of the Ceratonieto-Pistacietum.

On the other hand, the fairly frequent occurrence of *Cedrus* during zone 2, as is suggested by the relatively high pollen values, can be explained as the result of a rather cool climate, that is to say cooler than at any time during the Holocene. At present, a separate *Cedrus* zone is not present in the Alaouite Mountains, which is very probably because these mountains are not high enough. In Lebanon, the cedar zone (Cedretum libani) is found at elevations between 1500 and 2000 m (Pabot, 1959). The lower temperatures during the Late Dryas period must, with sufficient humidity, have favoured the expansion of cedar.

7.3. Possible changes in climate

In this section the question will be discussed as to how far the pollen evidence points to changes in climate, in particular changes in humidity, during the Holocene. Which pollen curves could be indicative of climatic change? Changes in the AP/NAP ratios should reflect changes in the distribution of forest and steppe. Consequently, fluctuations in the proportions of Σ AP and Σ NAP could be interpreted as evidence of changes in humidity. The interpretation of the AP/NAP ratios in terms of forest/steppe distribution is handicapped by the fact that for various herbaceous pollen taxa it cannot be determined to what extent they are of local or of regional origin (Chenopodiaceae, Gramineae, Compositae). Moreover, the Ghab Holocene pollen record is composed of the information obtained for three cores. In each of the localities from where the cores were taken the local vegetation may have been different. This implies that in the three diagrams, the absolute Σ AP percentages may not be comparable. Fluctuations in the AP/NAP ratios in one and the same diagram may generally be the outcome of changes in the upland vegetation pattern, but differences in the Σ AP percentages between two diagrams, such as between zone 4 (Ghab I) and zone 5 (Ghab II), may have been brought about by local conditions.

Leaving aside zone 6 (because of its possibly distorted pollen picture) and zone 9 (to be discussed in 7.4.), only a few tree pollen curves show rather distinct fluctuations. The most marked fluctuations are displayed by *Quercus cerris*-type. *Pinus* pollen percentages suggest that the proportion of pine in the forest vegetation underwent alterations. It is doubtful whether the pine pollen percentages could provide information on possible climatic changes. *Pinus brutia*, which pine species is most probably the one concerned here, occurs in humid as well as in semi-arid environments (Nahal, 1962, p. 576). Consequently, from a climatic point of view the fluctuations in the pine pollen values can be explained in two different directions. Moreover, *Pinus brutia* could have profited from human activity (this tree invades forest clearings), but it should be admitted that even for zone 9, with distinct indications of the interference of man with the vegetation (7.4.), no evidence of a large-scale pine expansion could be established.

The rather pronounced fluctuations in the *Alnus* pollen percentages are most likely due to local conditions. One must assume that alder occurred in the Ghab valley. Zohary (1973, p. 378) mentions that *Alnus orientalis* is often found in riverine jungles together with *Salix*, *Platanus* and other trees. At present, *Alnus* seems to be rare in northwestern Syria.

The maximum *Quercus* and Σ AP values in zone 3 suggest that during this period forest underwent a greater expansion than ever since in the Holocene. It seems justified to assume that zone 3 experienced the most humid climate of the whole of the Holocene. It is likely that during this period deciduous-oak dominated forest covered a greater area than it would at present under natural conditions. One wonders whether during zone 3 deciduous oak was perhaps found also in the Zawiyé Mountains to the east of the valley (see section 2).

The decline in *Quercus* and Σ AP percentages at the zone 3/4 transition points to a certain reduction in extent of the deciduous forest, most likely due to a decrease in humidity. The increase in *Quercus calliprinos*-type percentages in zone 4 suggests that part of the deciduous oak was replaced by the more drought-resistant kermes oak. The decline in *Pistacia* pollen values at the zone 3/4 boundary could indicate that the Eu-Mediterranean Ceratonieto-Pistacietum lentisci vegetations at the foot of the east flank of the Alaouite Mountains became impoverished to some extent as a result of greater aridity. The decrease in humidity as inferred from the pollen evidence was not necessarily brought about by lower precipitation. It is possible that during zone 3, at the beginning of the Holocene, temperature was still somewhat lower than during the succeeding zones. The lower humidity of zone 4 could have resulted from a further rise in temperature, precipitation remaining at the same level.

Another change in the distribution of forest and steppe is suggested by the course of the *Quercus* and Σ AP curves in zone 6. The pollen record of zone 6 points to a temporary expansion of forest at the expense of the steppe, implying moister climatic conditions compared to those of zone 5. Because of the supposedly deviating pollen contents of the succeeding zone 7 one ought perhaps be somewhat cautious in attaching too much weight to the increased *Quercus cerris*-type percentages in zone 6. On the other hand, a temporary increase in humidity during some period in the mid-Holocene, which at present cannot be dated more accurately, should not be ruled out. The effect of possible climatic changes on the vegetation in the period after c. 4000 B.P. (zone 9) must have been completely suppressed by the effect of the interference of man with the vegetation.

In summary, one may remark that at the beginning of the Holocene, in the period which may be dated from c. 10,000 to 8000-9000 B.P., the climate of northwestern Syria was moister than at present. Another period of increased humidity may have occurred in the mid-Holocene period.

7.4. The influence of man

Palynological evidence for the activity of man is not evident until subzone 8b which shows comparatively high values for *Fraxinus ornus* (manna ash). This tree must have occurred naturally in the Oro-Mediterranean forest vegetations of northwestern Syria as is attested by the pollen record. The considerably increased pollen values in subzone 8b and zone 9 point to the cultivation of *Fraxinus ornus* for its sweetish exudate called manna which can be obtained by making incisions in the bark. Van Zeist *et al.* (1975) found evidence for the cultivation of manna ash in southwest Turkey.

The sharp decline in deciduous-oak pollen percentages at the bottom of zone 9 points to large-scale clearances of forest. As for farming practices, the pollen record provides evidence particularly for fruit tree cultivation. *Olea*, *Vitis* and *Juglans* reach comparatively high values in zone 9, especially in subzone 9b, suggesting that olive, grape and walnut were widely grown. The cultivation of manna ash, which is strictly speaking not a fruit tree, has already been mentioned. The marked decline of *Pistacia* at the zone 8/9 transition seems to indicate that olives especially were planted in the Ceratonieto-Pistacietum belt, the natural habitat zone of *Olea*. The regular occurrence of *Elaeagnus* pollen indicates that also oleaster was planted, probably for its edible fruits.

There are no obvious palynological indications of cereal growing. It is true that Cerealia-type pollen is present in zone 9, but its percentages are not higher than in various other sections of the Ghab pollen record. In this connection it may be remembered that in southwest Asia, Cerealia-type pollen is in itself not indicative of grain growing. Various Near Eastern wild grass species produce pollen grains of the Cerealia-type (cf. van Zeist *et al.*, 1975).

Grazing, or at least open terrain in formely forested areas, is particularly suggested by the notably increased values for *Polygonum aviculare*-type and *Sanguisorba minor*-type pollen. *Plantago lanceolata*-type pollen shows likewise higher percentages in zone 9. One wonders whether the somewhat higher values for *Quercus calliprinos* and *Pinus* in the upper part of the zone could indicate that kermes oak and pine spread to some extent on abandoned forest clearings. However, there can have been no question of a large-scale expansion of these trees.

On the assumption of an approximately constant sedimentation rate for the upper two metres of the Ghab III core, the last 800-1000 years should not be represented in the pollen record.

8. TELL MOUREYBIT AND THE GHAB POLLEN EVIDENCE

8.1. Pollen analysis of settlement sites

Finally, a few comments will be made with reference to the pollen diagram prepared by Leroi-Gourhan (1974) for Tell Moureybit, about 175 km eastnortheast of the Ghab valley. This is the only other Holocene pollen record obtained so far for northwestern Syria and it has played a part in speculations on pre-Neolithic farming.

Before a large section of the north Syrian Euphrates valley was flooded by a barrage constructed near Tabqa, Moureybit was situated on the left bank of the river. Excavations of Moureybit were started by M. N. van Loon in 1964 and 1965 (van Loon, 1968) and continued by J. Cauvin in 1971-1974 (Cauvin, 1977). A series of radiocarbon determinations date the late-Palaeolithic habitation of the site from c. 10,500 to c. 9500 B.P. Stone tools for grinding, such as querns and mortars, were found frequently, while among the tools made of flint, sickle blades were present. In addition to this indirect evidence for harvesting and preparing seeds, the plants themselves are also represented. Among the seed types which could be identified, those of one-grained wild einkorn (*Triticum boeoticum* ssp. *thaoudar*) constitute the majority. Only seeds of morphologically wild-type plants were found (van Zeist, 1970 and unpublished data). The animal bones recovered from Moureybit are likewise exclusively of wild species.

Leroi-Gourhan (1974) carried out the palynological examination of a few series of samples collected from tell sections exposed by the excavation. The results of Leroi-Gourhan's study are shown in fig. 4. With the help of the radiocarbon dates the results for the different sections (Q33, Q32, etc.) could be arranged in chronological order. At present the natural vegetation of the uplands in the Moureybit area, with a mean annual precipitation of about 200 mm, is a steppe. The pollen evidence obtained for this site suggests that in the early Holocene, too, steppe vegetations were found here. Σ AP values are extremely low. In pollen diagrams prepared for sediment cores from Syria, Turkey and Iran periods with predominantly steppe vegetations are characterized by high values for Chenopodiaceae and *Artemisia*. In the Moureybit spectra, chenopodiaceous percentages are high, but those for *Artemisia* are conspicuously low. On the other hand, Compositae show high pollen values at Moureybit, this in contrast to the generally low values in sediment cores. Bottema (1975) has discussed at length the phenomenon of the generally high proportions of Compositae among the pollen preserved in cave and rock shelter deposits and in other archaeological sites where an accumulation of material had taken place, such as tells. Bottema argues that the high Compositae pollen percentages do not necessarily point to a predominant role of representatives of this family in the vegetation in the vicinity of the site, but that they must be ascribed to other factors, of which contamination by burrowing bees and differential corrosion (and dif-

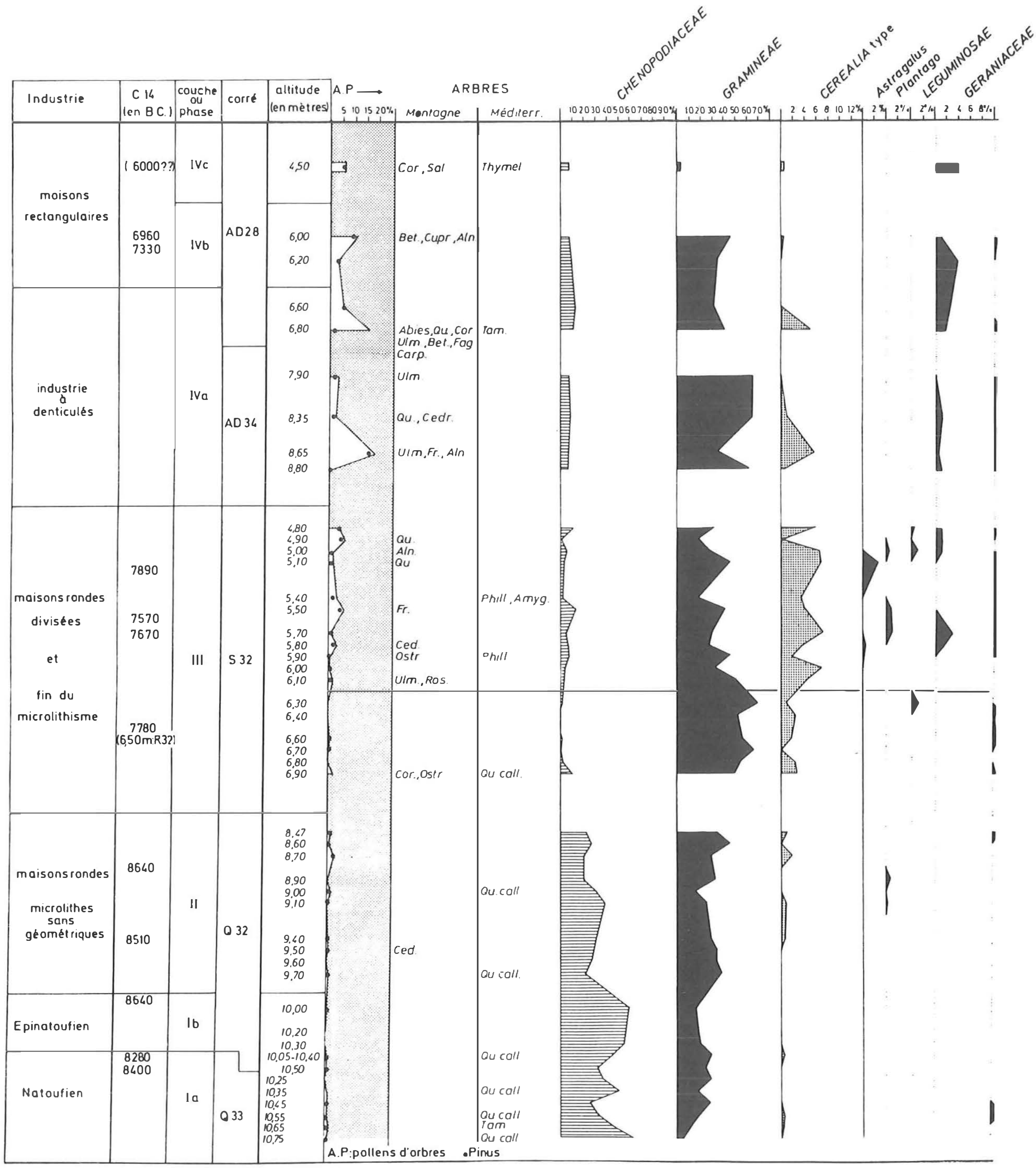
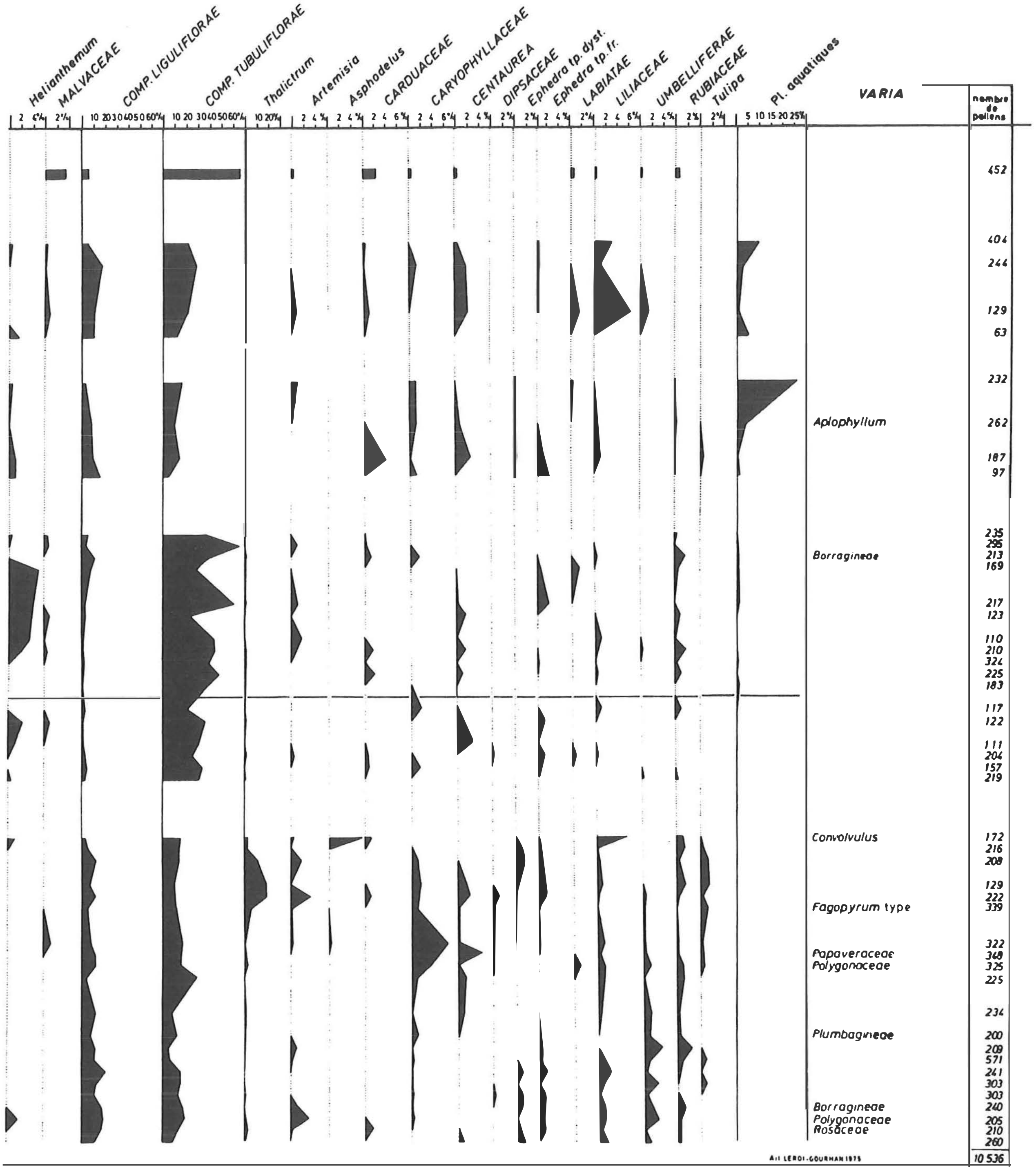


Fig. 4. Pollen diagram prepared for samples from Tell Mooureybit (after Leroi-Gourhan, 1974, fig. 2).

ferential identifiability) are the most important

In this connection it may yet be mentioned that surface-sample spectra from steppe and desert-steppe areas in Syria do not show such high percentages for Liguliflorae Compositae as have been



established in the pollen counts of Tell Moureybit (Bottema & Barkoudah, 1979). The proportion of Liguliflorae Compositae in the modern pollen precipitation in Syrian steppe and desert-steppe areas in generally low (less than 2.5%).

8.2. Evidence for increased humidity

The problem whether or not the Moureybit pollen spectra provide a reliable picture of the composition of the early Holocene steppe vegetation of the area will not be pursued in this paper. Of more relevance in connection with the Ghab pollen record is the fact that Leroi-Gourhan concludes an increase in humidity around 10,000 B.P. This conclusion is based mainly upon a small increase in tree-pollen percentages at a depth of 6.10 m (square S32). This increase is nearly exclusively brought about by *Pinus*, but other tree pollen types are also slightly more frequent in the section above 6.10 m. Leroi-Gourhan is of the opinion that trees did indeed not occur in the Moureybit area, but that at least forest vegetations had come nearer to the site. The inference of a more humid climate would be in agreement with the situation in the Ghab, where the pollen record points to optimum moisture conditions around 10,000 B.P. However, one may wonder whether the increased numbers of pine pollen really point to the approach of coniferous forest.

Leroi-Gourhan suggests herself that the pine pollen may not have arrived at Moureybit by air but that it was brought down by the river. In addition to pollen, wood remains of pine were found in the Moureybit samples. Above 6.10 m the curve for aquatic plants attains relatively high values. This could indicate that the clay used for the construction of the houses was taken from other places than in the previous period. From the level of 6.10 m (in square S32) onwards clay was obtained from low-lying places which were flooded each time the water-level of the Euphrates rose. In these places, fresh clay was deposited regularly and with the clay, pollen of pine and possibly other trees originating from the mountains of Turkey was carried in. The clay from the chronologically lower levels may have been taken from other places in the river valley. This would imply that the change in the pollen content was not due to an alteration in the regional pollen influx but to a shift by the inhabitants of the site to other places for digging clay.

Some emphasis has been laid on an alternative explanation for the observed changes in the pollen curves at Moureybit in order to focus attention on a possible additional complication in interpreting pollen spectra obtained for this site in terms of regional vegetation. This does not alter the fact that very likely in early Holocene times, during the habitation of Moureybit, the climatic conditions of the area were more favourable than at present. For, the Ghab pollen evidence clearly indicates that in the early Holocene, humidity reached its highest level; for northwestern Syria this must have been the period with optimum moisture conditions. This assessment is not without significance in interpreting the economy of the Moureybit settlement.

It has already been mentioned that wild einkorn wheat must have played an important part in the vegetable diet of the inhabitants of the site. At present, *Triticum boeoticum* is not found in the plain of northern Syria, but it grows in massive stands in southeastern Turkey, at elevations between 600 and 2000 m (Harlan & Zohary, 1966). On the assumption that the climate, in particular the humidity, of 9000 to 10,000 years ago did not differ noticeably from that of to-day, van Zeist & Casparie (1968) suggest that the wild einkorn was harvested in the adjacent part of Turkey, at about 100-150 km from the site. However, as we now have evidence for more humid conditions in the early Holocene, it seems more likely that the inhabitants of Moureybit, as well as those of late-Palaeolithic Abu Hureyra (see 8.3.), c. 20 km downstream, could have harvested the wild einkorn wheat at a short distance from the site. This makes it easier to understand the prominent role of wild einkorn in the economy of both sites.

8.3. Plant-growing in late-Palaeolithic times?

Leroi-Gourhan (1974) and Cauvin (1977) conclude a kind of proto-agriculture for Moureybit, which assumption is based upon the increase in Cerealia-type pollen at the level of 6.10 m in S32 (fig. 4). Leroi-Gourhan argues that up to 8% of Cerealia-type pollen implies that wild cereals must have been quite numerous at the foot of the tell, and she suggests that the growth of these plants was promoted by the inhabitants of the site by means of weeding and watering. In this proto-agricultural stage there would have been no question of domestication.

Against the above conclusion two objections can be raised. In the first place, it must once again be repeated that in the Near East various wild grasses, and not only wild cereals, produce Cerealia-type pollen. The increase in Cerealia-type pollen at Moureybit coincides with the increase in aquatic pollen types. It has been suggested above (8.2.) that starting from the level of 6.10 m clay was dug in marshy places. One wonders whether a grass species with Cerealia-type pollen grains was a common constituent of the vegetation of regularly flooded parts of the river valley. If, on the other hand, the Cerealia-type pollen had originated largely from wild cereals growing in the vicinity of the site (wild einkorn wheat and to a minor extent wild barley), it is unlikely that it was blown in. Most cereals, wild as well as cultivated, release only very little pollen in the air and, consequently, they are seriously under-represented in the pollen precipitation. In this case the markedly large numbers of Cerealia-type pollen may point to the threshing of cereals on the site. Mature ears contain a fairly large amount of pollen (cf. Robinson & Hubbard, 1977) which is released in threshing.

So far, there is no conclusive evidence for cereal agriculture or proto-agriculture at Moureybit. This applies also to late-Palaeolithic (Mesolithic) Abu Hureyra, for which site Moore (1979) claims cereal cultivation. Hillman (in: Moore *et al.*, 1975) who examined the plant remains of Abu Hureyra is much more cautious and suggests three possible sources for the einkorn wheat, viz. (1) natural stands in the vicinity of the site, (2) the gathering of this wild cereal at a greater distance, and (3) its cultivation by the inhabitants of the site. Without any further evidence the excavator of the site now makes a firm stand for pre-Neolithic farming at Abu Hureyra. It is hard to avoid the impression that wishful thinking played a decisive part in Moore's interpretation of the botanical results. It is, of course, very attractive to have discovered the earliest farmer's site: late-Palaeolithic Abu Hureyra is dated from about 11,500 to 10,500 years ago.

The late-Palaeolithic habitation of Abu Hureyra and Moureybit covered some 2000 years. If einkorn indeed had been grown by the inhabitants of these sites, it is remarkable that so much time elapsed with no perceptible change in the morphology of the seed. Two thousand years of cultivation or at least of some kind of manipulation would not have resulted in the appearance of morphologically defined domestic einkorn wheat.

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