Palaeoclimates, Palaeoenvironments and Human Communities in the Eastern Mediterranean Region in Later Prehistory

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John L. Bintliff and Willem Van Zeist

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CONTENTS

TWO

PART FOUR:

PALAEOBOTANY

VEGETATIONAL HISTORY OF THE EASTERN MEDITERRANEAN AND THE NEAR EAST DURING THE LAST 20,000 YEARS

W. van Zeist and S. Bottema
(Biologisch-Archaeologisch Instituut,
University of Groningen, Holland)

1. INTRODUCTION

In this paper it will be suggested along which lines palynological evidence may be utilized in reconstructing past vegetation and climate in the Eastern Mediterranean and the Near East. In this connection it may be remarked that detailed knowledge of the Late Quaternary vegetational and climatic history in various parts of the world is first and foremost based upon the results of palynological research. Under favourable circumstances palynological studies should ultimately result in the reconstruction of vegetation patterns of the past. For the drawing up of palaeo-vegetation maps a satisfactorily dense network of pollen diagrams is a first prerequisite. This implies that only those regions in which pollen-bearing sediments are quite common are really suitable for a study of vegetation patterns in prehistoric times.

What are the prospects of reconstructing the Late Quaternary vegetational history in the region to be discussed in this paper? As for Greece, it has turned out that contrary to former views pollen-bearing sediments are not rare. In the last 10 years our knowledge of the Late Quaternary vegetation of Greece has made spectacular progress. Although the potential for palynological research in the Near East is certainly not discouraging, the scarcity or absence of pollen-bearing sediments in large areas of this part of the world constitutes a serious handicap in reconstructing Late Quaternary vegetation patterns.

We shall first review briefly the palynological evidence available for various areas of the Near East and Greece. The presentation of the palynological evidence must remain confined to a short discussion of some selected pollen diagrams covering the whole or a greater part of the last 20,000 years. Some speculations on past vegetation and climate will be included in the discussion of the separate areas. Subsequently, a few palaeo-vegetation maps for the region under consideration will be discussed. Finally, a more general review of the climatic implications of the palynological evidence will be presented.

No pollen evidence from archaeological deposits will be considered here. It is true that in arid regions, where other pollen-bearing sediments are lacking, archaeological sites may constitute the only potential source of information on the vegetation of earlier times. However, one may query the extent to which pollen spectra from archaeological sites can compare with those obtained for peat and lake-bottom deposits.

Some of the pollen diagrams cover a greater section of the Late Quaternary than is presented in Figs. 14. 2-9. For practical reasons only the most important pollen curves are shown. For the complete information the reader is referred to the publications concerned. The pollen sums of the diagrams presented in this paper include trees, shrubs and herbs except marsh and water plants. It is sometimes difficult, if not impossible, to determine to what extent particular herbaceous pollen types, such as Gramineae and Chenopodiaceae, are of local or of regional origin. It will be clear that this uncertainty can be a handicap in determining the porportion of herbs in the upland vegetation.

The pollen-diagram sites mentioned in this paper are indicated in Fig. 14. 1.

2. WESTERN IRAN

In western Iran, the pollen diagrams prepared for sediment cores from Lake Zeribar cover the last 40, 000 years or so (van Zeist & Bottema 1977). Lake Zeribar is situated in an intramontane valley in the Zagros Mountains, at an elevation of c. 1300 m. The estimated annual precipitation amounts to 600-800 mm, while mean January and July temperatures would be about 2° and 28°C, respectively. The lake lies in the Zagros oak-forest belt. A simplified version of the Zeribar Ib diagram, covering the last 20, 000 years, is presented in Fig. 14. 2.

Pollen assemblage zone 3, the upper part of which is represented in Fig. 14. 2, is characterized by an almost complete absence of arboreal pollen. During zone 3 time, c. 35, 000-14, 000 B. P. , steppe and desert-steppe vegetations must have prevailed in the Zeribar area and in the whole of the Zagros Mountains. During this period, which coincides largely with the Upper-Pleniglacial of the European Würm-glacial chronology, climatic conditions in the Zagros Mountains must have been very unfavourable for tree growth. The lower temperatures during Würm-glacial times may be held partly responsible for the scarcity of trees in the Zeribar area, but dryness must also have been a major limiting factor for tree growth (cf. 9. 2). The climate of zone 3 was not only colder than at present, it was also much drier.

Pollen zone 4, which covers the period of c. 14, 000-10, 500 B. P. , coincides with the greater part of the Late-glacial of western Europe. During zone 4 time, conditions for tree trowth seem to have been somewhat better than in the preceding period, as is suggested by the slight increase in tree pollen values. Aridity must have prevented a more luxuriant tree growth. During the Late-glacial, the temperature must have risen quite considerably, but it remained very dry.

Pollen zone 5 is characterized by a slow increase in tree pollen values in which Quercus as well as Pistacia take part. Herbaceous pollen values remain high. An oak-pistachio forest-steppe, which in the course of time became somewhat more dense, is postulated for zone 5, which is dated from c. 10, 500 to c. 6000 B. P. It is self-evident that in the early Holocene, to which pollen zone 5 must be attributed, temperature cannot possibly have been the limiting factor for tree growth. One must assume that dryness prevented a more rapid expansion of trees. The early Holocene climate of western Iran must have been relatively warm and dry.

Pollen zone 6 represents the replacement of the forest-steppe by the Zagros oak forest. The marked increase in tree pollen percentages is entirely accounted for by Quercus. After a very slow expansion of trees in the preceding 4000 to 4500 years, zone 6 witnessed the establishment of the present-day natural forest cover within a period of c. 800 years (c. 6200-5400 B. P.). The upper zone of the Zeribar diagram reflects predominantly forest vegetation, suggesting that during the last 5500 years the Zagros oak-forest vegetation must have been present in the Zeribar area. During zone 6, humidity must have reached modern levels, while the climate of the last 5500 years (zone 7) would largely have been the same as that of today.

The pollen diagram prepared for a sediment core from Lake Mirabad, likewise in the Zagros Mountains, shows a similar Holocene vegetational development as that established for Zeribar (van Zeist & Bottema 1977).

3. SOUTHEAST TURKEY

Information on the Holocene vegetational history of southeastern Turkey is provided by the Lake Van pollen record (van Zeist & Woldring 1978a, 1978b). The present-day surface of Lake Van lies c. 1650 m above sea-level. To the north and the east of the lake mean annual precipitations of between 300 and 400 mm are recorded. To the south and southwest of the lake the precipitation amounts to 600-800 mm. For Van, to the east of the lake, mean January and July temperatures of -3° and +22°C, respectively, are reported. According to Zohary (1973, Map 7) the natural vegetation to the north and the east of the lake is a steppe with oak-forest stands at higher elevations, whereas forests would constitute the natural vegetation only to the south and southwest of the lake. The Lake Van area constitutes a transitional zone between forest and steppe.

The Lake Van pollen diagram (Fig. 14. 3) has been prepared for samples from sections of two sediment cores taken in the southwestern part of the lake. The dates are based upon varve countings (Kempe & Degens 1978, Fig. 1). As the samples are from two sediment cores, no depths are indicated; the vertical distance between the samples is 10 cm. The Lake Van diagram covers nearly the whole of the Holocene (the base of the diagram is varve-dated to 9800 B. P.).

The lower section of the diagram, zones 1-3, reflects predominantly desert-steppe vegetation, in which Chenopodiaceae, Ephedra and Artemisia alternately played an important part. It is out of the question that during zones 1-3, in the early Holocene, too low a temperature could have been the limiting factor for tree growth. It must have been the dryness which prevented an expansion of trees. The Ephedra-rich desert-steppe vegetation of zone 2 reflects extremely arid conditions.

Pollen zones 4 and 5 show a gradual increase in tree pollen values, suggesting that during the period concerned to the south and the southwest of the lake the desert-steppe was gradually replaced by forest. The spread of trees points to an increase in humidity, most probably caused by higher precipitation.

In the period covered by zone 6, forest vegetation with predominantly oak reached its maximum expansion in southeast Turkey; at that time humidity must have reached modern levels. Zones 7 and 8 show a decline in tree pollen values; most striking is the fall of Quercus percentages. The increase in herb pollen percentages should most likely be ascribed to human activity and not to drier climatic conditions.

Both in southeastern Turkey and in western Iran, steppe or desert-steppe vegetations were gradually replaced by oak-dominated forest. However, the period during which trees expanded in both areas was not the same. At Zeribar trees started to spread c. 10,500 B. P., and by c. 5500 B. P. the present-day natural forest had established itself. In the Lake Van area, on the other hand, the expansion of trees took place between c. 6400 and 3400 B. P. This discrepancy leads one to wonder whether perhaps the dates for one of the two sites are incorrect. In this connection the following remarks can be made.

Varve countings give a minimum age. Kempe & Degens (1978) believe that because of this possible error, the varve dates for the Lake Van cores may be 2-5% too young. The radiocarbon dates for the Zeribar cores form a consistent series, so there are no indications of incorrect results due to the nature of the sediment. However, deviations occur between radiocarbon years and calendar years. Thus, the radiocarbon years in the range 5000-7000 B. P. are 600-700 years too young. This implies that the differences in time during which trees expanded in both areas are greater than is suggested by the dates shown in Figs. 14.2 and 3, even assuming a maximum error of 5% in the varve counting.

4. NORTHERN TURKEY

A few pollen diagrams have been published from the Euxinian district of northern Turkey, viz. Sürmene-Ağaçbaşi, Trabzon province (Aytuğ et al. 1975) and Lake Abant and Lake Yeniçağa near Bolu (Beug 1967).

Only for the Yeniçağa diagram, which covers the last 5000-6000 years, are radiocarbon dates available. At the level dated to c. 4000 B. P. Pinus pollen percentages increase, whereas the curves for Abies and Fagus decline, suggesting a retreat of the beech-fir forests. If this change in the vegetation was brought about by a natural factor, it would point to drier climatic conditions after 4000 B. P. (the expansion of pine at the expense of beech and fir). On the other hand, one should seriously consider the possibility that part of the Abies-Fagus forest was cleared by man, as a result of which the proportion of pine pollen carried in from some distance increased. The higher frequencies of Erica pollen above the level of 4000 B. P. rather plead for an anthropogenic interpretation of the observed changes in the pollen curves.

The pollen diagrams from Sürmeme-Ağaçbaşi suggest distinct changes in the composition of the forest. During the period covered by these diagrams the area was wholly forested, except for recent times when man started to clear the forest. Aytuğ et al. (1975) arrived at the following climatic sequence: humid-cool, less humid-temperate, humid-temperate, humid-cool. For lack of radiocarbon dates this inferred climatic development cannot be compared with that established for other areas.

5. SOUTHWEST AND SOUTH-CENTRAL TURKEY

Information on the vegetational history of southwestern Turkey during the final stages of the Pleistocene and during the Holocene is provided by the pollen diagram prepared for a sediment core from the drained Lake Söğüt (van Zeist et al. 1975), situated in an intramontane depression in the West Taurus Mountains, at an elevation of c. 1400 m. The estimated annual precipitation at Söğüt is 700-800 mm.

In the lower sections of the Söğüt diagram (Fig. 14. 4) herbaceous pollen is dominant, but fluctuations in the AP/NAP ratios occur, suggesting an alternating expansion of steppe and forest vegetations. One can only speculate on the dating of these late Pleistocene fluctuations.

From the level radiocarbon dated to 9180 B. P. on, tree pollen percentages increase. The replacement of steppe vegetation by forest must have been the result of a rise in humidity. During zone 4, humidity had not yet reached modern levels. This conclusion is based upon a comparison of the present-day natural vegetation with that of zone 4 time. The upper part of the Söğüt diagram (zone 7) indicates that without the interference of man the slopes around the Söğüt basin would have been covered predominantly by pine forest. (At present the slopes around the basin are devoid of trees apart from some scattered juniper.) The large proportion of oak and juniper in the forest vegetation of zone 4 suggests that the climate was drier than at present.

In the Söğüt area the development of the natural vegetation was interrupted by large-scale interference by man with the vegetation (zone 6). For that reason it cannot be determined at which time pine would have become the dominant tree in the area. The high Pinus pollen value in spectrum 27 and the radiocarbon date of 2885 B. P. for the level just above spectrum 27 indicate that it must have been less than 3000 years ago that humidity reached modern levels.

As for south-central Turkey, the pollen diagram of Beyşehir (van Zeist et al. 1975) suggests a marked change in the composition of the upland forest to be dated shortly after 6000 B. P. At that time Cedrus gave way to a large extent to Pinus. Before 6000 B. P. cedar must have been predominant in the coniferous forest, but from then on pine became the most important tree quantitatively in the upland forests of the area. The marked increase of Pinus at the expense of Cedrus points to an increase in humidity. After 6000 B. P. the present-day natural vegetation pattern became established, in broad outline, in the Beyşehir area.

A pollen diagram is being prepared for a sediment core from Akgöl, a residual lake of the Pleistocene Lake Konya. The lower part of this core, which is 6 m long, yields ΣAP values of less than 6%, whereas Artemisia and Chenopodiaceae are alternately the predominant herb pollen types. The pollen record of this section suggests steppe vegetation in and around the Konya basin with scattered oak stands in favourable habitats in the mountains.

The spread of forest started with a conspicuous expansion of Betula. In the pollen diagram, the Betula maximum is succeeded by an increase of Quercus and Pinus, successively. The transition from predominantly steppe to predominantly forest points to an appreciable increase in humidity. As radiocarbon dates are not yet available, one can only speculate on the period during which this change in climate took place.

Other information on Late Quaternary vegetation of south-central Turkey is provided by the pollen diagrams of Karamik Batakligi and Hoyran (van Zeist et al. 1975, Figs. 12 and 17).

6. NORTHWEST SYRIA

In northwestern Syria, pollen diagrams have been prepared for sediment cores from the Ghab valley (Niklewski & van Zeist 1967; van Zeist & Woldring, in print). The mountains to the west of the valley are naturally covered by forest. Tree growth on the uplands to the east of the valley must have been scarce, while further eastwards treeless steppe vegetation constitutes the natural plant cover.

In Fig.14. 5 the upper section of the diagram obtained for a 11 m long core (Ghab I) has been combined with sections of two short pollen diagrams (Ghab II and Ghab III). The three diagram sections should together constitute a more or less continuous pollen record covering the last 25, 000 years or so. The last 1000-2000 years are probably missing.

The distance between the three Ghab coring sites is rather great (10-30 km), which may account for some of the differences between the diagrams. Not too much weight should be attached to the differences in the AP/NAP ratios between the diagrams.

The section of the Ghab I diagram presented in Fig. 14. 5 shows two phases with very high herbaceous pollen percentages (spectra 46-47 and spectra 57-60), suggesting that at the time steppe and desert-steppe vegetations were predominant in northwestern Syria. The upper phase with high ΣNAP values, zone 1 (subzone Y-5), coincides largely with the Late-glacial of the European Würm-glacial chronology. During this period temperature cannot possibly have been the limiting factor for tree growth. It is likely that the higher evaporation rate was not sufficiently compensated for by an increase in precipitation, in consequence of which the climate of zone 1 time was extremely dry.

From spectrum 60 onwards a marked increase in tree pollen values can be observed. Between 11, 000 and 10, 000 B. P. forest vegetations must have expanded rapidly in northwestern Syria. This increase in trees was not only brought about by Quercus, but various other taxa, such as Pistacia, Olea and Ostrya/Carpinus orientalis, became important constituents of the upland forest cover. Zone 2, the period of the sharp rise of the ΣAP curve, coincides wholly or in part with the Late Dryas time, 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 precipitation itself probably increased, too. Above spectrum 67 (Ghab I) ΣAP values decrease to some extent and they never regain (Ghab II and III) the values of zone 3 (subzone Z-2). The pollen evidence suggests that forest vegetations reached their greatest expansion in the period of c. 10, 000-8000 B. P. During this period conditions for tree growth were more favourable than during the later stages of the Holocene. It is likely that in the early Holocene humidity reached its highest level, to decrease again to some extent after 8000 B. P.

The activity of man is clearly reflected in zone 9, in which Juglans, Olea and Vitis reach comparatively high values. The marked decline in deciduous oak pollen percentages at the bottom of zone 9 points to a large-scale clearance of forest 3500-4500 years ago.

7. SOUTHERN LEVANT

Palynological evidence on Late Quaternary vegetation and climate in Israel is derived particularly from sediments in the Huleh basin. The slopes on both sides of the Upper Jordan valley, in which Lake Huleh and the surrounding marshes are situated, are covered by vegetation of the Quercetea calliprini (kermes-oak shrub vegetations) and open deciduous oak forest (Zohary 1962, pp. 112-115). Mean annual precipitation is 400-500 mm; the average temperatures for January and July amount to c. 14° and 30°C, respectively.

Horowitz (1968, 1971) published a pollen diagram for a core more than 120 m long from the Huleh basin. In this paper only the diagram prepared by M. Tsukada will be discussed. A report on Tsukada's study has not yet appeared, but the diagram has been reproduced in a Japanese textbook of palynology. A simplified version of this diagram is shown in Fig. 14. 6. The zonation is after Tsukada. This diagram is provided with a great number of radiocarbon dates.

Pollen zone A covers the final stages of the Pleistocene, from slightly over 30, 000 B. P. to c. 10, 000 B. P. In subzone A-0, ΣAP values average 40%. During this period open forest must have been found around the Huleh basin. In subzone A-1, c. 24, 000-14, 000 B. P., ΣAP values decrease to an average of c. 25%. After 24, 000 B. P. the open forest of the previous period changed into a forest steppe. Conditions for tree growth became more unfavourable, whereas steppe indicators, such as Artemisia and Chenopodiaceae, expanded. In the period of 24, 000-14, 000 B. P. it must have been drier than during any other period represented in this diagram. The subzone A-1/A-2 transition is placed at the rapid rise in oak-pollen percentages, up to 70%. The considerable expansion of oak in the period of 14, 000-10, 000 B. P., which coincides with the Late-glacial, points to an amelioration of climate. Precipitation must have increased enough to allow the spread of oak-dominated forest. The absence of Olea pollen in this subzone suggests that Ceratonieto-Pistacietum vegetations were not yet present around the Huleh basin. In Tsukada's diagram no distinction is made between pollen of evergreen oak and that of deciduous oak.

In zone B (c. 10, 000-7400 B. P.) arboreal pollen, mainly made up of Quercus, decreases again. In contrast, to subzone A-1, which is also characterized by low ΣAP values, Artemisia percentages are low in zone B. After 10, 000 B. P. open vegetations gained terrain at the expense of the oak forest. The greater climatic dryness was probably caused by a rise in temperature which was not or not sufficiently compensated for by an increase in precipitation.

Zone C (1 and 2) shows fairly high tree pollen values, but fluctuations from 30 to 70% occur. Among the tree pollen that of *Quercus* is less dominant than in the preceding sections, and, for instance, *Olea* and *Pistacia* display appreciable values. After 7400 B. P. forest expanded again, probably as the result of an increase in precipitation. It is likely that in subzone C-1 time the present-day natural vegetation pattern established itself in northern Israel. The decline in ΣAP values in subzone C-2 could be due to an increased human interference with the vegetation after *c.* 4500 B. P. (the inferred date for the subzone C-1/C-2 transition). On the other hand, it could also point to drier climatic conditions.

The pollen diagram prepared by Weinstein (1976) for a long sediment core from Birket-Ram, a crater lake on the Golan Heights, at an elevation of *c.* 950 m shows fluctuations in the AP/NAP ratios which are of the same order of magnitude as those in the Huleh diagram discussed above. Among the tree pollen, that of *Quercus* is usually dominant. The pollen evidence suggests that during the whole of the period covered by the Birket-Ram core forest vegetations must have been present on the Golan Heights, but that fluctuations in the forest cover occurred.

8. GREECE

8.1 Northeast Greece

In Fig.14.7 the uppermost part of the pollen diagram prepared for a very long sediment core from the marshes of Tenaghi Philippon, in the plain of Drama (*c.* 40 m above sea-level), is shown (Wijmstra 1969). Mean January and July temperatures for Kavalla, on the coast, *c.* 6 km southeast of Tenaghi, are 5^{o} and 29^{o}C, respectively. Eumediterranean shrub vegetations occur up to 300 m. Above 600 m, in addition to deciduous oak and *Carpinus orientalis*, *Pinus nigra* is found. With increasing elevation pine becomes more abundant, but deciduous trees continue to form part of the forest vegetation.

Various radiocarbon determinations permit a fairly accurate dating of the Tenaghi diagram sections. The base of the diagram presented in Fig. 14.7 has an inferred date of 24,000 B. P. In the lower part of the diagram, up to subzone Y-1, ΣAP values are generally low, but noticeably higher pine pollen percentages are recorded for subzone X-4, corresponding with the period of *c.* 20,000-16,000 B. P. From the level dated to about 13,500 B. P. onwards, tree pollen values increase markedly. This rise in ΣAP percentages is to a large extent brought about by *Quercus*, but other deciduous trees, such as *Ostrya*/*Carpinus orientalis*, *Tilia*, *Corylus*, *Ulmus* and *Pistacia*, also take part in it. The ΣNAP peak in subzone Y-3 is largely due to a gramineous pollen maximum. Wijmstra assumes a date of 10,900-10,300 B. P., corresponding with the Late Dryas period, for this ΣNAP maximum, but this assumption is invalidated by a ^{14}C date of 7850 B. P. for a level just above the zone Y/Z transition. Pollen zone Z shows continuously high arboreal pollen values.

In the period of *c.* 24,000-13,500 B. P., steppe vegetations in which *Artemisia* and Chenopodiaceae played an important part must have been predominant in northeastern Greece. The higher *Pinus* pollen values in subzone

X-4 indicate that pine expanded to some extent in the mountains, probably as a result of a slight increase in humidity. The expansion of oak-dominated forest in the Drama area must have started 13,000 to 14,000 years ago, that is to say in the early Late-glacial period.

8.2 East-Central Greece

A continuous pollen record, covering the last 45,000 years, has been obtained for a core from the drained Lake Xinias, at an elevation of *c.* 500 m (Bottema, 1979). Mean January and July temperatures amount to *c.* 7^{o} and 28^{o}C , respectively. The lower parts of the mountains around Xinias receive a mean annual precipitation of *c.* 500 mm; at higher elevations precipitation increases. The natural vegetation of the area consists of deciduous forest, the composition of which depends on elevation and exposure. Fig. 14.8 presents the upper half of the Xinias pollen diagram.

In the section of spectra 44-59, 25,600 to *c.* 15,000 B. P., ΣAP values are below 20%. *Artemisia* and Chenopodiaceae are the predominant pollen types. In the succeeding section, including spectra 60-76 (*c.* 15,000-10,500 B. P.), herbaceous pollen is still dominant, but *Pinus* shows values of up to 20%, although in the middle of the section a temporary fall in the pine curve occurs. *Atriplex*-type pollen reaches extraordinarily high values in this section. The marked rise in ΣAP values above spectrum 76 is mainly due to the increase in deciduous oak pollen percentages, but other types contribute likewise to the high arboreal pollen values in the upper section of the diagram.

In the period from *c.* 25,000 to *c.* 15,000 B. P., steppe vegetation prevailed in the Xinias area. Oak and perhaps pine must have been restricted to favourable habitats in the mountains. Although during this period it must have been much colder than at present, temperature was probably not the limiting factor for tree growth in this area. Dryness may primarily be held responsible for the scarcity of trees.

An increase in temperature and probably also in precipitation induced the spread of pine in the mountains around 15,000 B. P. At lower elevations steppe must still have prevailed. A noticeable reduction of pine is suggested by spectra 67-70. The extremely high chenopodiaceous values in the same spectra point to very arid conditions. One could speculate that the greatly increased dryness was caused by the fact that the rise in temperature (Late-glacial temperature maximum) was not compensated for by higher precipitation. The increase in humidity suggested by the renewed expansion of pine (spectra 71-75) could, at least in part, have been due to the lower temperatures of the Late Dryas period.

The pollen diagram prepared for Limni Kopais (Greig & Turner 1974; Turner & Greig 1975) suggests a Late Pleistocene and Holocene vegetational history which, in broad outline, is in conformity with that established for Xinias.

8.3 Northwest Greece

The pollen diagram of Ioannina (Bottema 1974) comprises the greater part of the last glacial period and the Holocene. For Ioannina, at an elevation of 470 m, a mean annual precipitation of 1200 mm is recorded. Average

January and July temperatures are 5.1° and 24.0°C, respectively. The mountains around the Ioannina basin are naturally covered with deciduous forest vegetations.

The upper part of the Ioannina diagram is presented in Fig. 14. 9. The beginning of subzone V-4 has an inferred date of 20,000 B. P. In subzones V-4 and V-5, ΣNAP show high percentages, but, on the other hand, various tree pollen types are present, together accounting for c. 40% in subzone V-4 and for c. 20% in subzone V-5. In pollen zone W, conifers (Pinus and Abies) display higher values, except for subzone W-2. In subzone X-1, Quercus robur-type pollen values increase, whereas the curves for Pinus, Abies, Artemisia and Chenopodiaceae decline. At higher levels other deciduous pollen types contribute to a major extent to the total arboreal values.

The vegetational history of the Ioannina area compares rather well with that established for the Xinias area (8.2). The Ioannina pollen record indicates that in the period of about 20,000 to 14,000 B. P. (the inferred date for the zone V/W transition) steppe vegetation was found at lower altitudes, whereas trees (conifers as well as deciduous species) must have been present at higher altitudes which received more precipitation. After 14,000 B. P., pine and fir expanded to some extent, but at lower elevations steppe vegetation maintained itself. The temporary decline of Pinus and Abies in subzone W-2 is comparable and probably synchronous with the Pinus minimun in spectra 67-70 at Xinias. The climatic explanation for the behaviour of the conifers at Ioannina during the Late-glacial period could be the same as that assumed for Xinias, viz. an increase in temperature in the early Late-glacial succeeded by a dry period as a result of a further rise in temperature (synchronous with the Allerød period).

8.4 Concluding remarks on Greek vegetational and climatic history

During the Upper Pleniglacial, in the period of c. 25,000 to 14,000 B. P., steppe vegetation prevailed in Greece. It was not only colder than at present but also considerably drier. The higher pine pollen values in zone X-4 at Tenaghi should point to a temporary increase in temperature and/or precipitation. However, a similar amelioration of climate does not find expression in the pollen evidence from Xinias and Ioannina. Also with respect to the Late-glacial vegetational development, the Tenaghi diagram shows a different picture than the diagrams of Xinias and Ioannina. In the areas of the latter diagrams conifers spread to some extent after about 14,000 B. P., but at Tenaghi it was deciduous oak which expanded markedly in the early Late-glacial. In other areas the spread of deciduous oak did not start until about 10,500 B. P. (see below).

In addition to the pollen evidence obtained for Ioannina, Xinias and Tenaghi, various other diagrams provide information on the Holocene vegetational history of Greece (Athanasiadis 1975; Bottema 1974, 1979, 1980b; Greig & Turner 1974; Turner & Greig 1975; unpublished material). Much of this information is summarized in Table 1.

In various pollen diagrams a marked incrase in deciduous oak pollen values starts from a level to be dated to 10,200-10,700 B. P. Only at Tenaghi does this increase occur at an earlier date. In the diagram section dated to

c. 9300-8200 B. P., Pistacia and Sanguisorba minor/Poterium show higher percentages. In the succeeding section coniferous pollen values increase markedly. The pronounced rise in the curve for the Ostrya/Carpinus orientalis pollen type is dated to about 6500 B. P., while the increase in Fagus started about 4000 years ago. Juglans, Castanea and Platanus show up in the pollen record from 3200-3500 B. P. on. These species were probably introduced by man.

In the early Holocene, oak-dominated forest covered most of Greece at lower and medium elevations. Temperature as well as precipitation must have increased considerably around 10,000 B P., but apparently climatic conditions were not yet favourable enough for the establishment of more diverse forest vegetations. About 9300 B. P. Pistacia and Poterium expanded in the oak forest. As a result of a further increase in temperature the climate may have become drier and the forest more open. At higher elevations, with greater humidity, not only oak but also various other tree species played an important part in the early Holocene forest.

Towards 8200 B. P. the forest at lower and medium elevations became denser; conifers started to expand. This points to an increase in precipitation. A further increase in humidity is suggested by the successive expansion of Carpinus orientalis/Ostrya and Fagus. It cannot be determined whether the more humid conditions were caused by an increase in precipitation or by a decrease in temperature. Be this as it may, it was not until 4000 B. P. that humidity reached modern levels. Changes in the composition of the forests that occurred after c. 3500 B. P. must have been due mainly to the activity of man.

The vegetational development outlined above holds for northeast, north and east-central Greece. In the northwest (Ioannina) some of the changes discussed above are less pronounced, while in the south possible climatic changes of the last 6000 years are not reflected in the pollen precipitation.

9. PALAEO-VEGETATIONS MAPS

9.1 Introduction

From the above discussion of pollen diagrams from Greece and the Near East it will be clear that the vegetational history of the various regions differs considerably. Expansion and reduction of forest and steppe vegetations did not occur synchronously in the whole of the area under consideration. Sometimes two regions show a more or less opposite development. Thus, in northern Israel forest must have expanded markedly in the Late-glacial period, whereas a contraction of forest took place in the early Holocene. On the other hand, the Ghab pollen evidence points to a considerable reduction of the forest area in the Late-glacial and a maximum expansion of forest vegetation in the early Holocene. It is not possible to establish tendencies in the Late Quaternary vegetational development which apply to the whole of the Eastern Mediterranean and the Near East. This fact constitutes a serious handicap to the drawing of maps showing the former distribution of forest and steppe in the whole of the area. The vegetational history of regions for which no pollen diagrams are available cannot simply be deduced from the evidence obtained for other regions. In spite of the fact that various regions are not covered by one or more pollen diagrams and that subsequently the vegetational history of these areas is pure guesswork, an attempt has nevertheless been made to construct palaeo-vegetation maps showing the inferred distribution of forest, forest-steppe and steppe for a few selected periods. It will be obvious that these maps should be considered with the utmost reserve. It is to be expected that with increasing numbers of pollen diagrams the maps will need radical revision.

9.2 18,000-16,000 B.P. (Fig. 14.10)

In the period 18,000-16,000 B.P., the temperature had dropped to a minimum. The maximum snowline depression of 1000-1200 m in the Near Eastern mountain ranges (Messerli 1967) points to a temperature depression of 6-8°C. The considerably reduced temperatures must have brought about a drastic depression of the upper forest line. However, the pollen evidence suggests that dryness must at least as much as low temperature have been a limiting factor for tree growth. Dry steppe vegetations with Artemisia and Chenopodiaceae were of much greater extent than nowadays.

It is assumed that at 18,000-16,000 B.P. the mountainous regions to the south of the Caspian and the Black Sea, which at present are characterized by an extremely humid climate, supported forest vegetations at lower elevations where temperature was not the limiting factor for tree growth. Pollen evidence is still lacking for the Late Pleistocene of these regions.

Comparatively significant tree growth must have occurred in western Syria, Lebanon and Israel. Although in the western Levant the forest cover must have been markedly more open than it would be at present under natural conditions, it was nevertheless one of the areas richest in trees. The pollen record points to forest-steppe or steppe with scattered tree stands in Greece and western Turkey. Unfortunately, the fluctuations in the AP/NAP ratios in the Söğüt and Karamik diagrams cannot be dated at all accurately, but during the whole of the Late Pleistocene section covered by these diagrams at least some tree growth must have occurred.

The Zeribar pollen record indicates that in the period 18,000-16,000 B.P. trees were virtually absent in the area and probably in the greater part of the Zagros Mountains. Must low temperatures be held responsible for this absence of trees or was dryness the main limiting factor for tree growth? At elevations of 1300 m and more the temperature may have been too low for trees in the Zeribar area. On the other hand, in the Söğüt area, at elevations of 1400 m and more, trees could maintain themselves in the Upper Pleniglacial period. It is conceivable that in the coastal regions of western Turkey the temperature did not drop as much as in continental Iran. Thus, the record of planktonic foraminifera in deep-sea cores suggests that during the glacial maximum surface temperatures of the eastern Mediterranean Sea were only 2-4°C cooler than at present (Thiede 1978; Luz 1981). Although we tend to ascribe the Upper Pleniglacial treeless vegetation of western Iran to climatic dryness, we consider it quite possible that the temperature was likewise too low for tree growth (van Zeist & Bottema 1977, p. 66-67). It should be emphasized that trees may not have been completely confined to the areas indicated on the map of Fig. 14.10. In other areas, too, scattered tree stands may have been present in sheltered habitats.

9.3 12,000-11,000 B.P. (Fig. 14.11)

The period 12,000-11,000 B.P. coincides largely with the Allerød time, the warmest phase of the Late-glacial. It has been established for West and Central Europe that during this period mean July temperatures were only 2-3^{o}C lower than at present. This implies that during the Allerød even at higher elevations, such as in the Zeribar area, temperature cannot possibly have been the limiting factor for tree growth. The map of Fig. 14.11 suggests that during the warmest phase of the Late-glacial, trees occurred in the same areas as in the period 18,000-16,000 B.P. There are, however, differences as far as the density of the tree growth is concerned. In northwestern Syria tree growth was much sparser than in the period 18,000-16,000 B.P., whereas the Huleh pollen record points to a comparatively dense forest cover. Striking regional differences in the density of tree growth are assumed for Greece. Whereas the Tenaghi pollen diagram points to a continuous forest cover, albeit more open than the present-day natural forest of the area, the Xinias pollen record suggests rather scattered tree growth for east-central Greece. Northwestern Greece (Ioannina) is in an intermediate position as regards forest cover.

The considerable increase in temperature during the Late-glacial caused much higher evaporation than during the Upper Pleniglacial. In areas where trees could maintain themselves or even expand, precipitation must have increased appreciably to compensate for the higher evaporation rate.

9.4 8000 B.P. (Fig. 14.12)

4000 years later, c. 8000 B.P., in the early Holocene, trees must have expanded quite considerably in the Eastern Mediterranean and the Near East. Continuous forest covered the greater part of Greece, although the forest may still have been more open than later in the Holocene (8.4). In the coastal areas of Turkey and Syria forest vegetations had established themselves. In northwestern Syria (Ghab pollen evidence) forest reached its greatest extent in the early Holocene. In northern Israel, on the other hand, conditions for tree growth were less favourable than during the Late-glacial. In this area steppe had expanded at the expense of forest vegetation. In the interior of the Near East at best forest-steppes were found as is suggested by the pollen record of Zeribar and Mirabad in western Iran and of Lake Van in southeastern Turkey. In western Iran trees expanded very gradually in the period from c. 10,500 to c. 6000 B.P. In southeastern Turkey steppe vegetation prevailed in the period between c. 9800 and c. 6400 B.P.

After the temperature depression of the Late Dryas period (the final phase of the Late-glacial) the temperature must have risen quite markedly in the early Holocene. The general expansion of forest in that period implies that precipitation must have increased too.

9.5 4000 B.P. (Fig. 14.13)

It was not until c. 4000 B.P. that the present-day distribution of forest and steppe had established itself in broad outline. It should be emphasized that at least locally the composition of the forest vegetation may have changed to some extent after 4000 B.P.

10. CLIMATIC IMPLICATIONS

10.1 Introduction

In the Eastern Mediterranean and the Near East, temperature as well as precipitation must have shown considerable changes during the last 20,000 years. However, the pollen record, viz. the alternate expansion of steppe and forest, allows conclusions mainly on changes in humidity. In many instances it cannot be deduced from the pollen evidence whether changes in humidity were due to changes in temperature or in precipitation. In Fig. 14.14 the inferred fluctuations in humidity are presented for various pollen-diagram sites. It seems that changes in temperature were generally of a worldwide nature. For that reason it may be justified to assume for the area under consideration the same changes in temperature, or at least the same tendencies in temperature changes, that have been established for other areas. The Late Quaternary temperature history is also indicated in Fig. 14.14. From the changes in temperature and humidity conclusions on possible changes in precipitation can be drawn. It goes without saying that because of the many uncertainties the ideas on past climates presented in this paper are highly speculative. Moreover, other disciplines often arrive at conflicting conclusions.

As was to be expected from the discussion of the individual pollen diagrams, the humidity curves differ considerably. Even if one ignores smaller fluctuations (it should be taken into consideration that the humidity curves are largely the direct "translation" of the AP/NAP ratios and that fluctuations in the AP/NAP ratios may sometimes have been due to local conditions) and if one accounts for the uncertainties in the dating, the humidity curves cannot possibly be brought into line with each other. This implies that changes in precipitation cannot have been of a uniform nature in the whole of the Eastern Mediterranean and the Near East, but that there must have been regional differences.

10.2 Upper Pleniglacial (24,000-14,000 B.P.)

As has been mentioned before, in the period from 24,000 to 14,000 B.P., temperatures must have been much lower than at present. During this period it was not only colder, but the pollen evidence suggests that it must also have been markedly drier than nowadays. This does not imply that there would have been no fluctuations in humidity. On the contrary, most humidity curves, that is to say the AP/NAP ratios, show fluctuations in the section concerned. Thus, the Greek pollen diagrams suggest an increase in humidity around 20,000 B.P., which could have been brought about by an increase in precipitation. In theory it is possible that a decrease in temperature must be held responsible for this rise in humidity. However, in that case one could equally have expected a reaction in the Huleh pollen record. Moreover, the Ghab pollen evidence suggests an opposite course of the humidity around 20,000 B.P., although no accurate dating of the Upper Pleniglacial fluctuations in the AP/NAP ratios of this diagram is possible. Although some effect of changes in temperature cannot be excluded, it seems that fluctuations in precipitation must primarily have caused the fluctuations in humidity inferred for the Upper Pleniglacial.

Starting from the assumption that in the period 24,000-14,000 B.P. changes in humidity were mainly brought about by fluctuations in precipitation, the following conclusions are suggested by the pollen evidence. In Greece, precipitation increased to some extent around 20,000 B.P. to decrease again after about 18,000 B.P. (Ioannina, Tenaghi). In the period c. 18,000-14,000 B.P. precipitation was low. A reverse course of the precipitation is suggested by the Ghab pollen diagram. Here precipitation should have been relatively high in the period just before 14,000 B.P. The Huleh pollen diagram does not suggest any noticeable change in humidity in the period 24,000-14,000 B.P. and neither does the Zeribar pollen evidence. For northern Israel it must be assumed that no changes in precipitation occurred at all. For western Iran it is possible that precipitation fluctuated to some extent, but that too low a temperature prevented trees from reacting to an increase in humidity (cf. 9.2). The humidity curve inferred from the Karamik pollen record seems to be more in line with the Huleh curve than with that of the Ghab (10.3, 10.4). The Söğüt pollen diagram seems to point to a course of humidity that at least for the Upper Pleniglacial and the Late-glacial (10.3) was quite different from that established for Karamik, at a distance of c. 300 km. It should, however, be taken into consideration, that no radiocarbon date is available for the lower part of the Söğüt diagram, so that one can only guess at the dating of the fluctuations in the lower section of the humidity curve. For that reason this section of the curve is dashed. By stretching out the lower part of this curve it could be brought into line with the Karamik curve. It is clear that one should not attach much weight to the lower part of the Söğüt humidity curve.

It seems that in Greece, during the Upper Pleniglacial, precipitation fluctuated more or less uniformly over the whole of the country. On the other hand, in the Near East there can have been no question of changes in precipitation that were largely identical for the whole of the area. Here, considerable regional differences in precipitation history are suggested by the pollen record.

10.3 Late-glacial (14,000-10,000 B.P.)

Also for the period c. 14,000-10,000 B.P. conspicuous regional differences must be assumed. During this period, which coincides with the Late-glacial of the Würm-glacial chronology, temperatures increased markedly to reach a maximum in the Allerød time (12,000-11,000 B.P.). As has been mentioned before (9.3), during the Allerød period mean July temperatures were only 2-3°C lower than at present. For the final stages of the Late-glacial, for the Late Dryas period, a worldwide temperature depression has been established.

The Late-glacial increase in temperature brought about a higher evaporation rate. Nevertheless, most sites suggest a distinct rise in humidity around 14,000 B.P., implying that not only temperature but also precipitation increased. In northwestern Syria, the higher evaporation which resulted from the Late-glacial rise in temperature was apparently not compensated for by an increase in precipitation. At Zeribar, the arid conditions of the Pleniglacial continued in the Late-glacial. As for Greece, the course of the humidity in the northeast must have differed from that in other parts of the country. At Tenaghi, humidity remained rather high during the whole of the Late-glacial, whereas the Ioannina and Xinias diagrams point to marked fluctuations. In the Allerød period, c. 12,000-11,000 B. P., it became drier again; probably the further rise in temperature was not sufficiently compensated for by higher precipitation (8.2, 8.3). In the final phase of the Late-glacial, humidity rose again at Ioannina and Xinias which could have been due to the decrease in temperature. In northwestern Syria, the marked increase in humidity in the final phase of the Late-glacial may, at least in part, have been caused by the temperature depression, although it is assumed that there precipitation actually increased (6). The Karamik and Söğüt pollen diagrams, on the other hand, seem to point to dry climatic conditions in the last stages of the Late-glacial (and in the early Holocene).

From the above discussion it emerges that just as in the Upper Pleniglacial, so also in the Late-glacial, humidity and consequently precipitation did not fluctuate uniformly over the whole of the Eastern Mediterranean and the Near East. Most striking is the course of humidity in northwestern Syria which seems to have been more or less the opposite of that assumed for most other areas.

10.4 Holocene

In spite of the rise in temperature, in the early Holocene humidity increased (Ioannina, Xinias, Zeribar) or at least remained at the same level (Tenaghi, Ghab) in various areas, suggesting that precipitation must have increased markedly. At Huleh and Karamik, on the other hand, in the early Holocene, humidity was definitely lower than in the previous period. One must assume that there the rise in temperature was not or not sufficiently compensated for by an increase in precipitation. At Van, in southeastern Turkey, precipitation must have been low in the early Holocene.

The Ioannina, Xinias and other pollen diagrams from northern Greece point to a further increase in humidity, and consequently in precipitation, in the lower Holocene to reach approximately modern levels between 7000 and 6000 B. P. As for the depression in the Tenaghi humidity curve to be dated around 8000 B. P. (solid line), it cannot be excluded that the ΣNAP maximum was due to local conditions (8.1), so this increase in herbs may not point to a drier climate. The dashed line gives an alternative course of the Tenaghi humidity curve.

The Near East shows a less consistent pattern of the precipitation regime in Holocene times. Here regional differences must have been quite considerable. The only thing in common is the fact that in the upper Holocene, during the last 4000 to 5000 years, precipitation must have been comparatively high in the whole of the area, although humidity did not reach its highest level everywhere in this period (cf. Ghab).

The Huleh and Ghab pollen diagrams suggest a more or less opposite climatic development in the Late-glacial and in the lower Postglacial. This cannot be explained as the result of a simple northward shift of a climatic belt of higher precipitation (much precipitation first in the southern Levant and subsequently more to the north), because the course of the humidity curves inferred from the Karamik and Söğüt pollen record seems to be more in line with that from Huleh. In this connection the following may be remarked.

Wigley & Farmer (1981) have pointed out that precipitation in the Eastern Mediterranean and the Near East is mainly associated with cyclonic disturbances which generate in the Central Basin depressions and in the Eastern Basin depressions (Cyprus lows). Depressions from both areas tend to move to the northeast and east, but the steering of the depressions is not yet well understood. Precipitation in southwest Turkey originates mainly from the Central Basin depressions, whereas cyclonic disturbances generated in the Eastern Basin bring precipitation to the Levant. Consequently, differences in the Late Quaternary climatic history of southwestern Turkey and the Levant may be not too astonishing.

A prevailing eastward direction of the depressions generated by the Cyprus lows in early Holocene times could explain the differences in the vegetational history of western Iran (Lake Zeribar) and southeastern Turkey (Lake Van). At Zeribar trees started to spread around 10.500 B. P., and by 5500 B. P. the present-day natural forest had established itself. In the Lake Van area, the expansion of trees took place between 6500 and 3500 B. P.; desert-steppe vegetation indicates that the early Holocene climate of southeast Turkey had a very arid character. If in early Holocene times, the preferred tracks of the Eastern Basin depressions were to the east, southeastern Turkey would have received little precipitation. A subsequent shift to a more frequent northeastward direction of the cyclone tracks would have brought more precipitation to eastern Anatolia. In this respect it should be mentioned that the mountain ranges in eastern Turkey run in a southwest-northeast direction. As a consequence, rain- and snow-bearing southwesterly winds can penetrate far into the interior. With prevailing westerly winds precipitation may have been transported into East Anatolia less easily.

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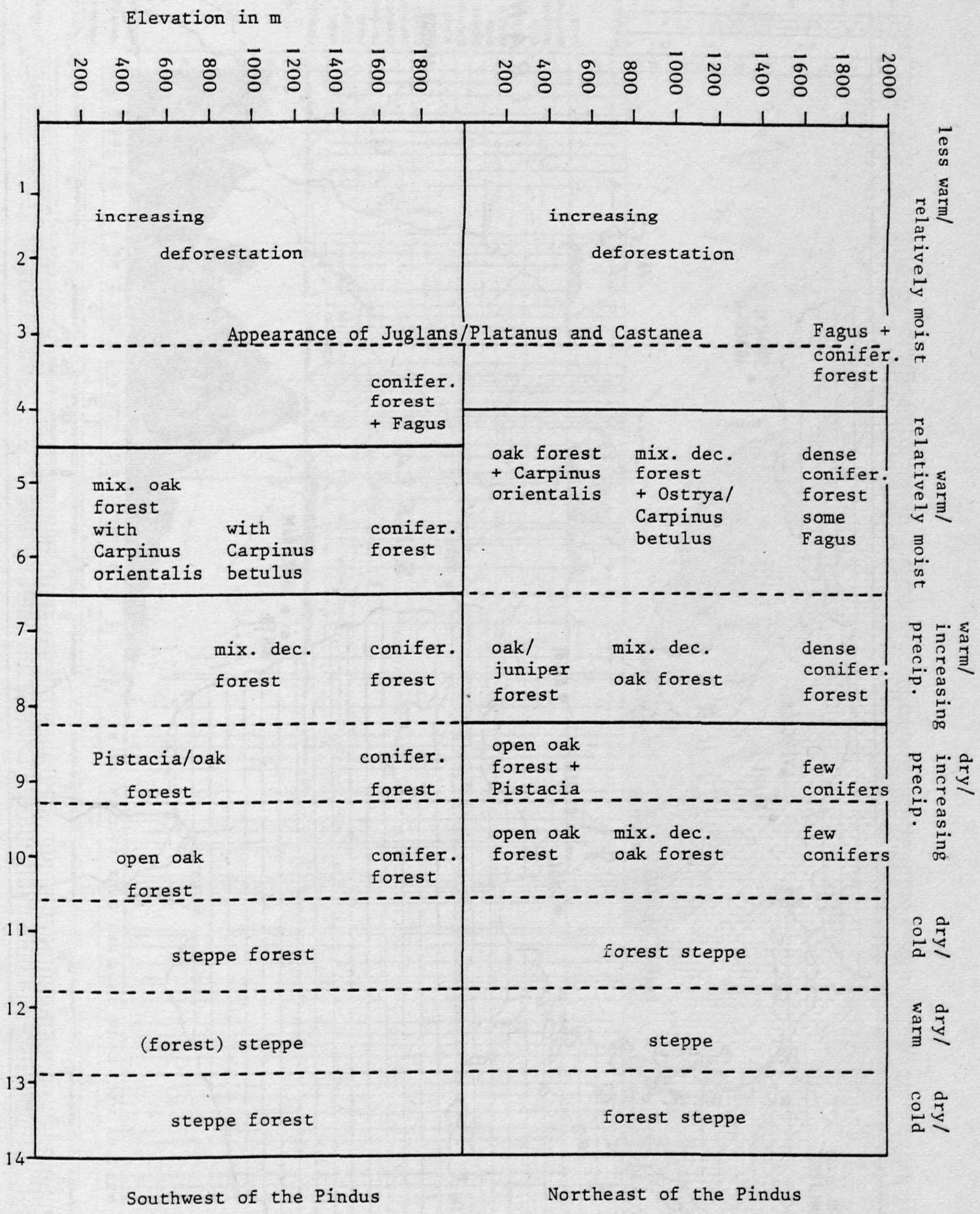

Table 1. Tentative scheme of vegetational and climatic changes in Northwestern Greece

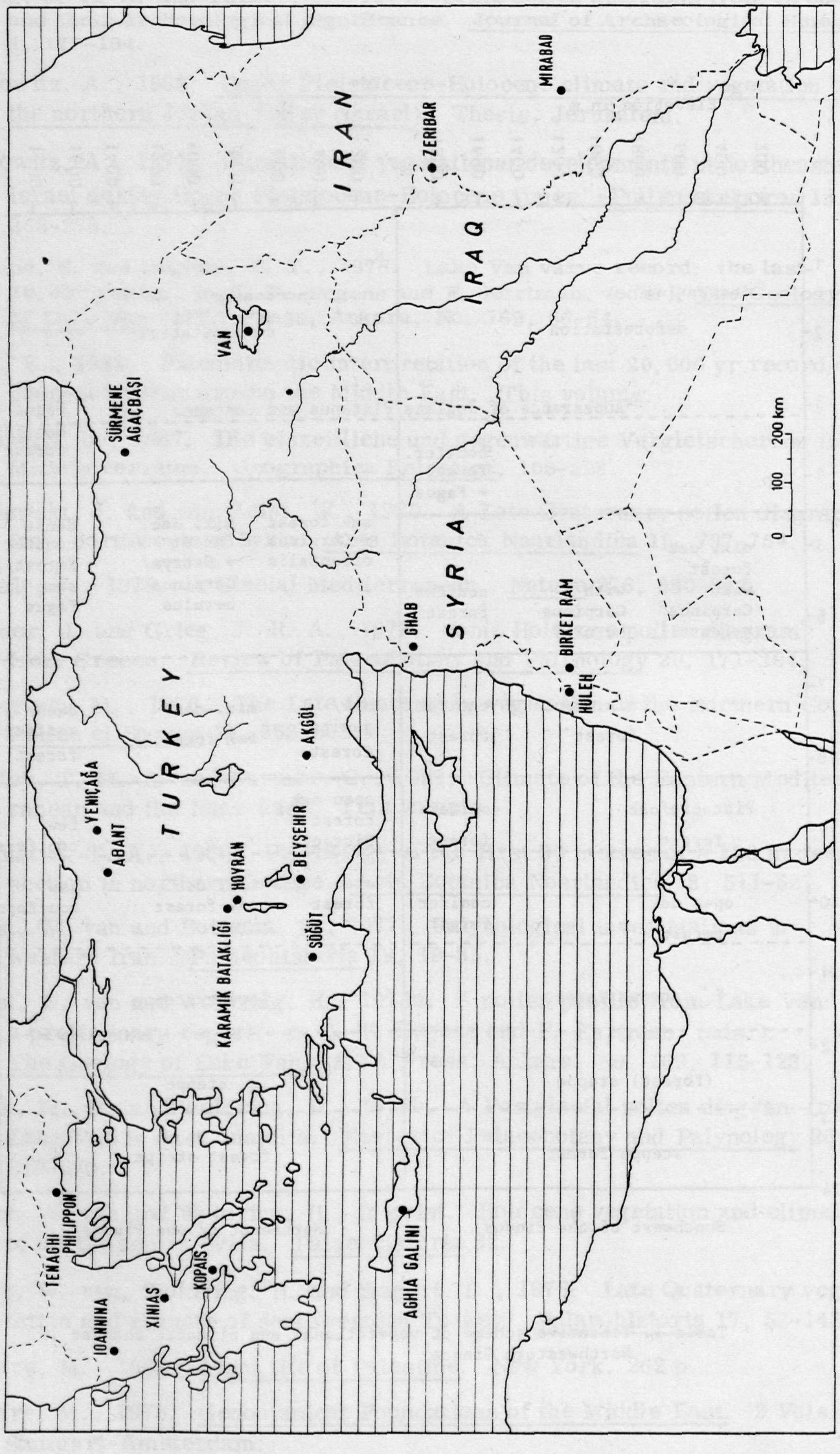

Fig. 14.1 Map of the Eastern Mediterranean and the Near East showing the location of Late Quaternary pollen-diagram sites mentioned in this paper.

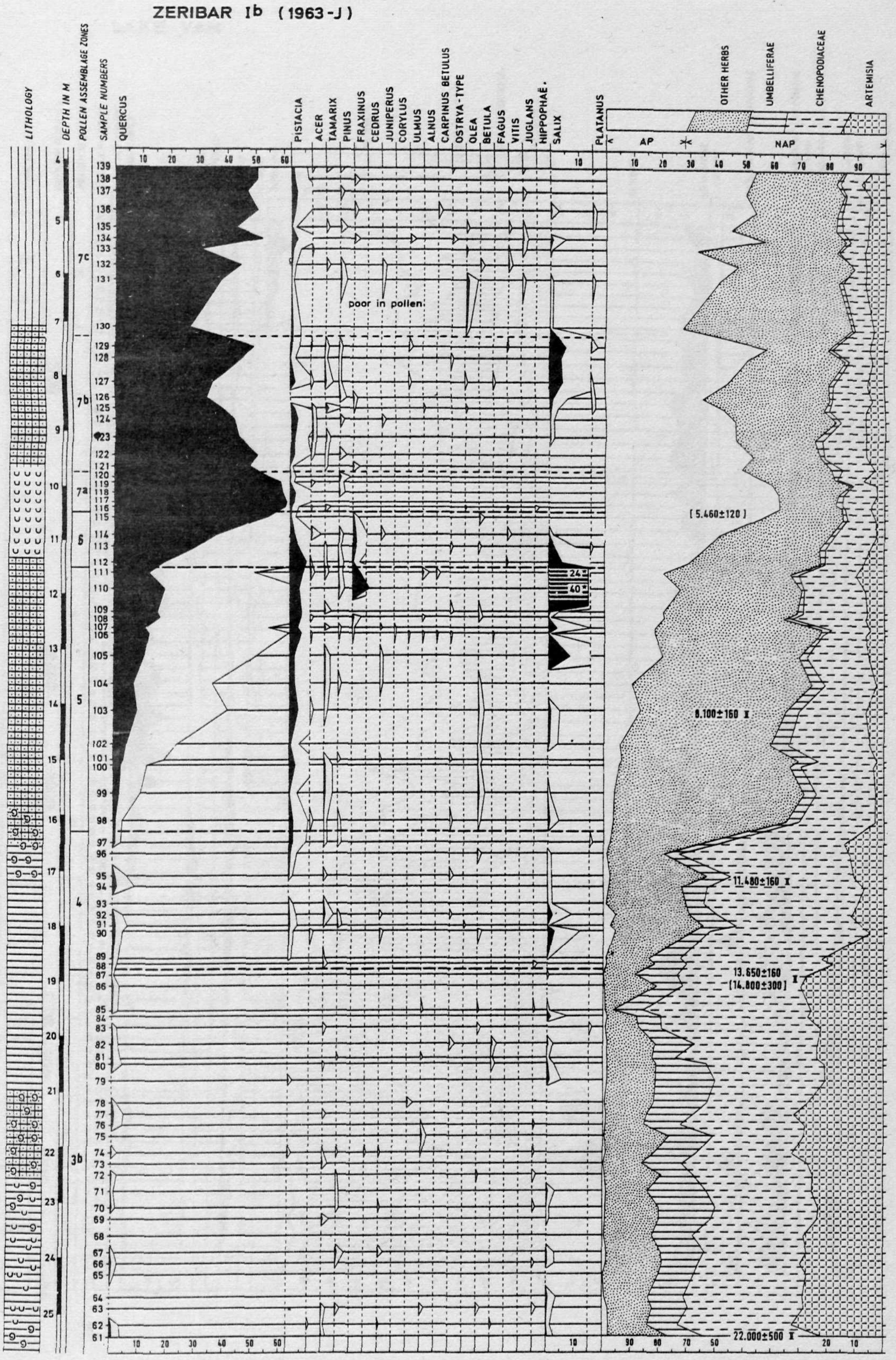

Fig. 14.2 Zeribar Ib diagram (van Zeist & Bottema 1977).

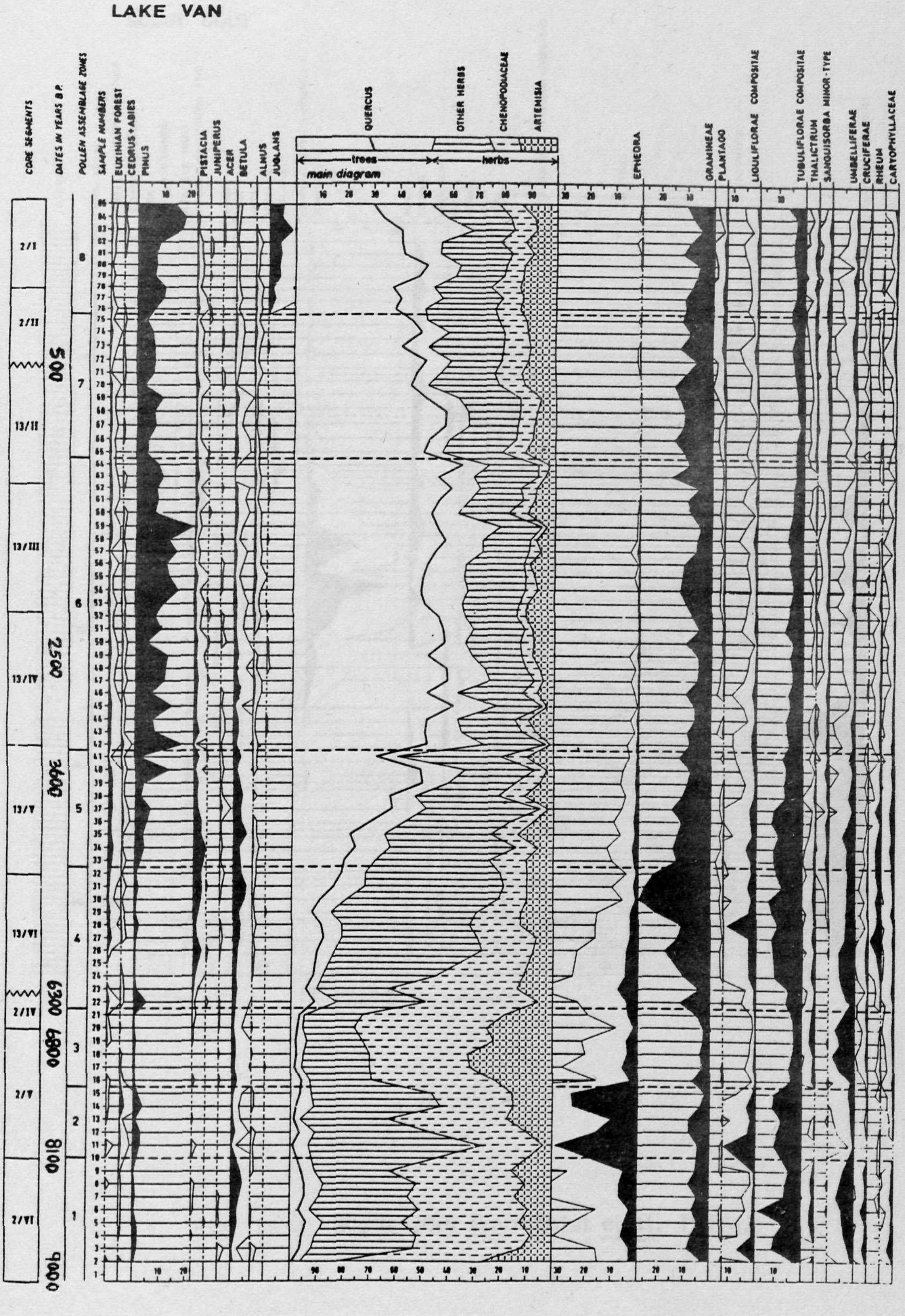

Fig. 14.3 Lake Van (van Zeist & Woldring 1978a).

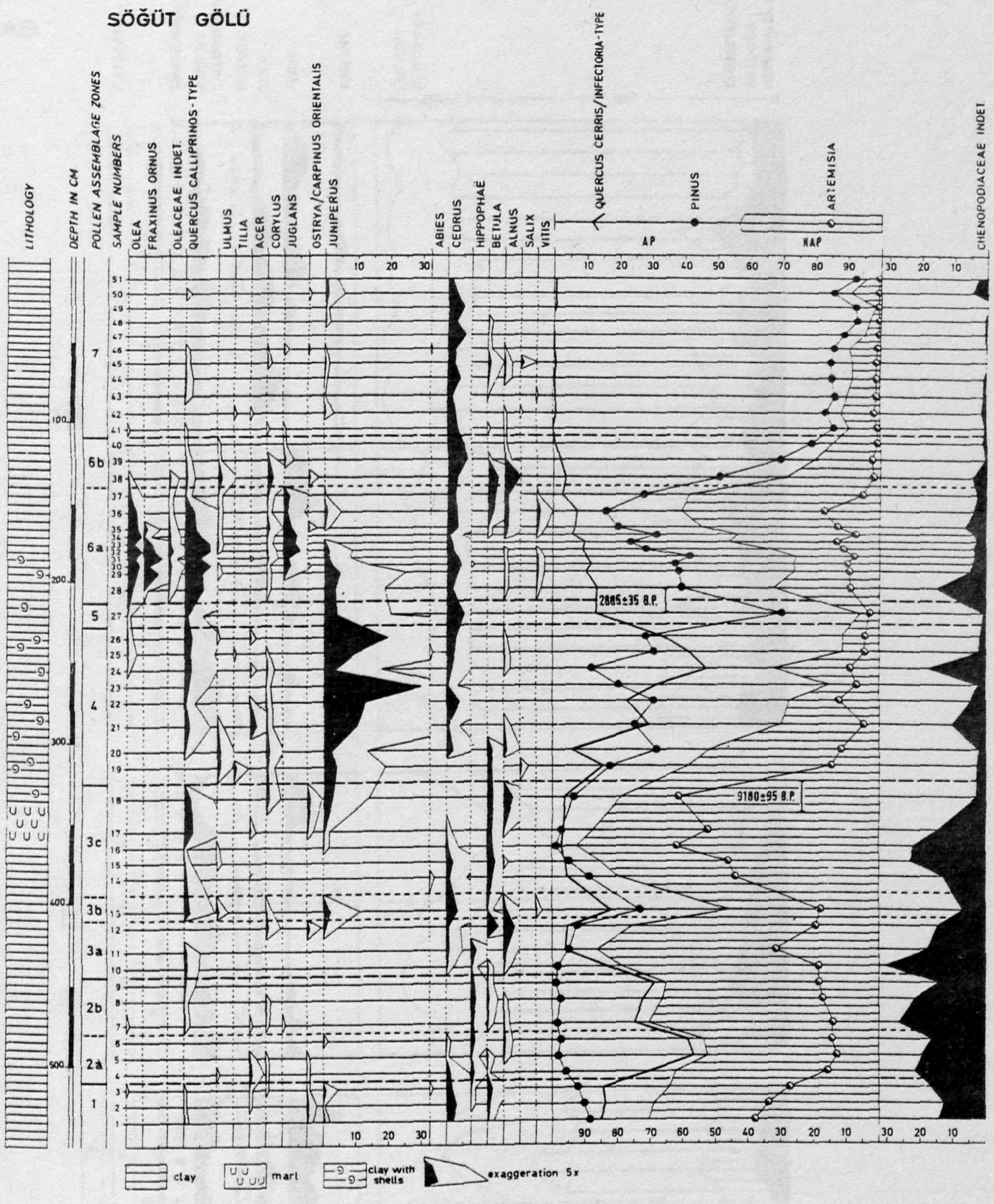

Fig. 14. 4 Sögüt Gölü (van Zeist et al. 1975).

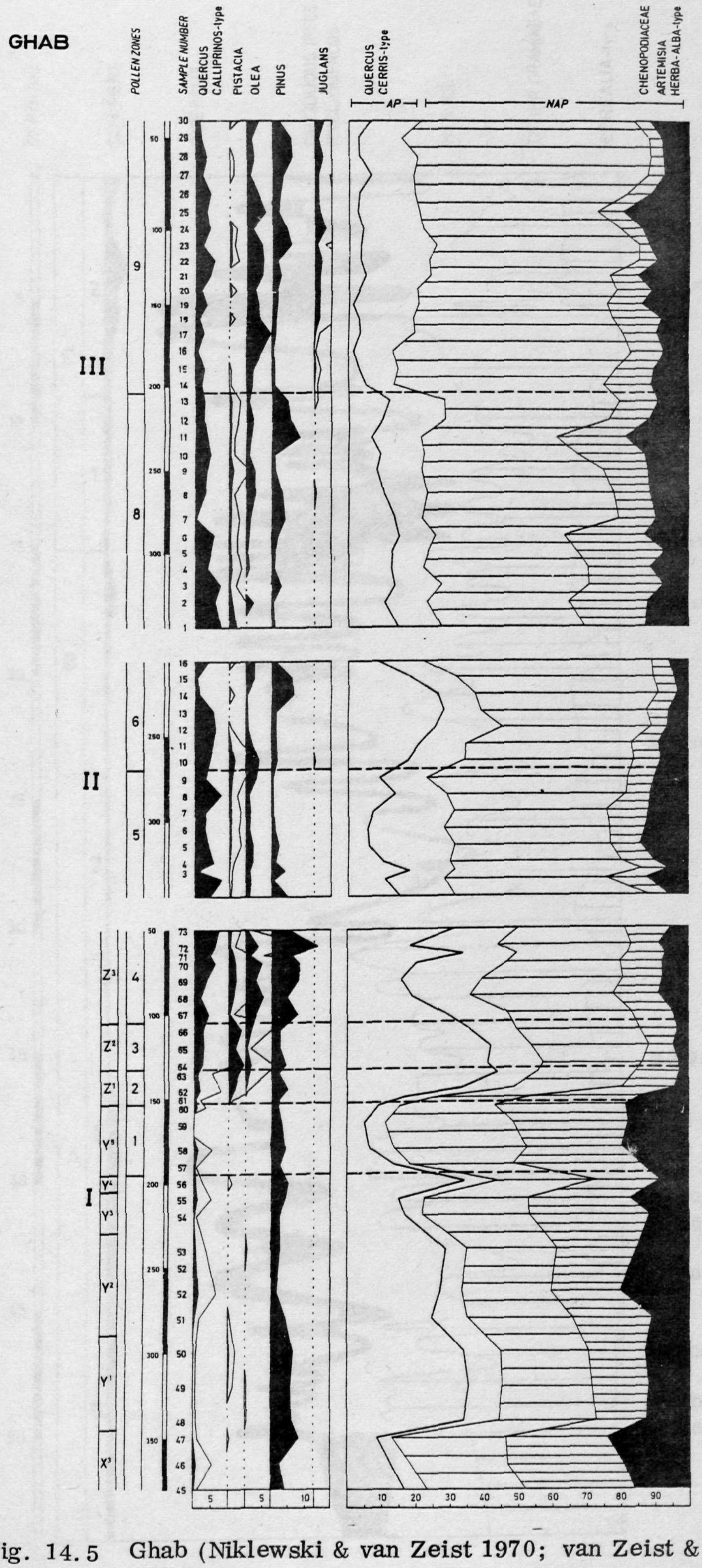

Fig. 14.5 Ghab (Niklewski & van Zeist 1970; van Zeist & Woldring, in print).

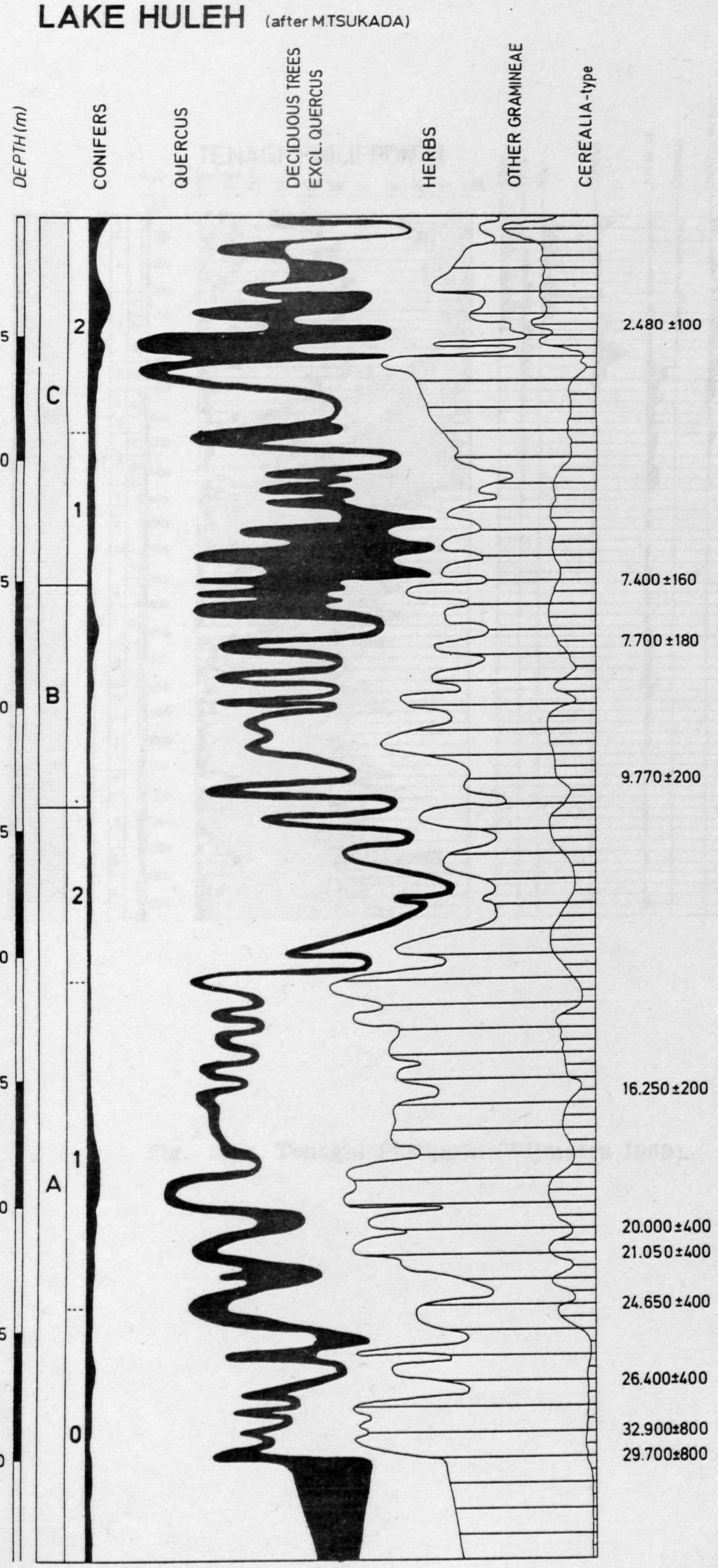

Fig. 14.6 Huleh (after M. Tsukada).

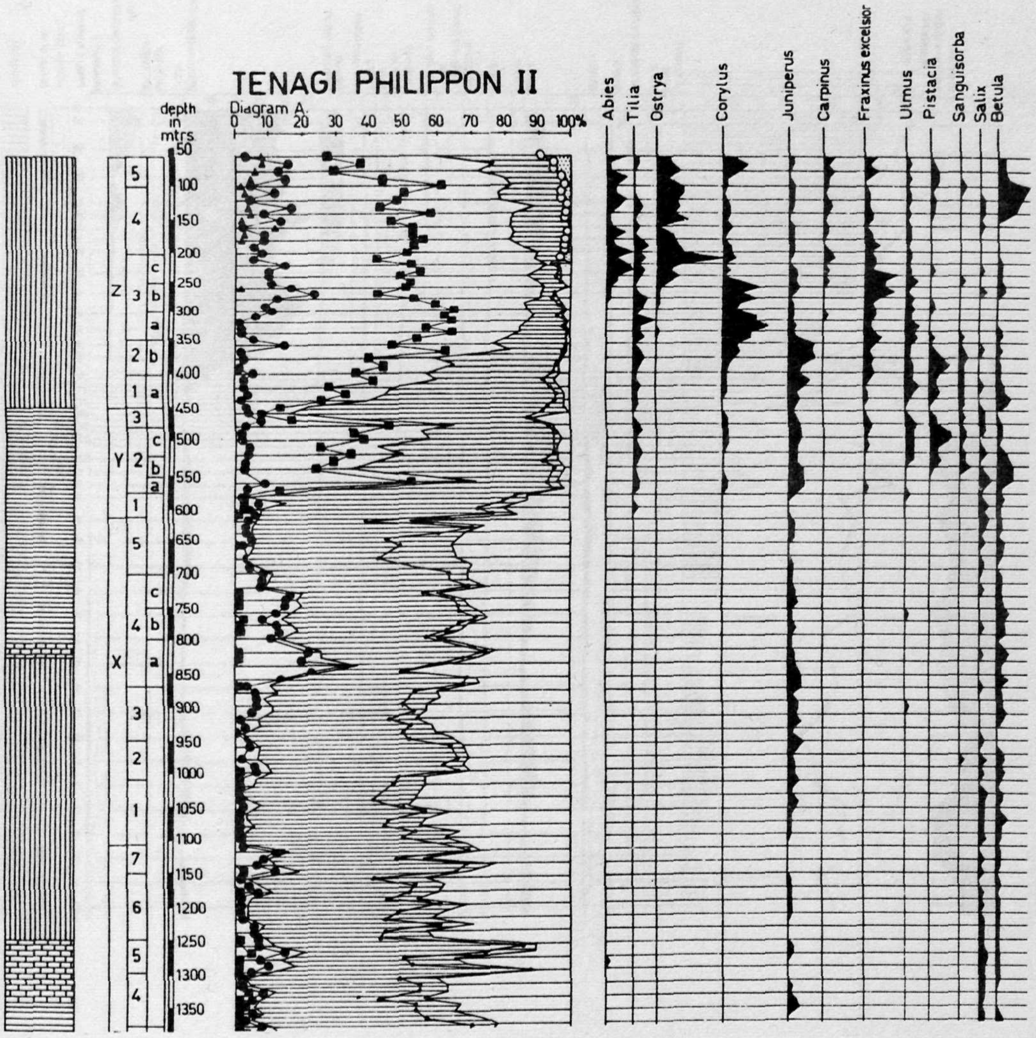

Fig. 14.7 Tenaghi Philippon (Wijmstra 1969).

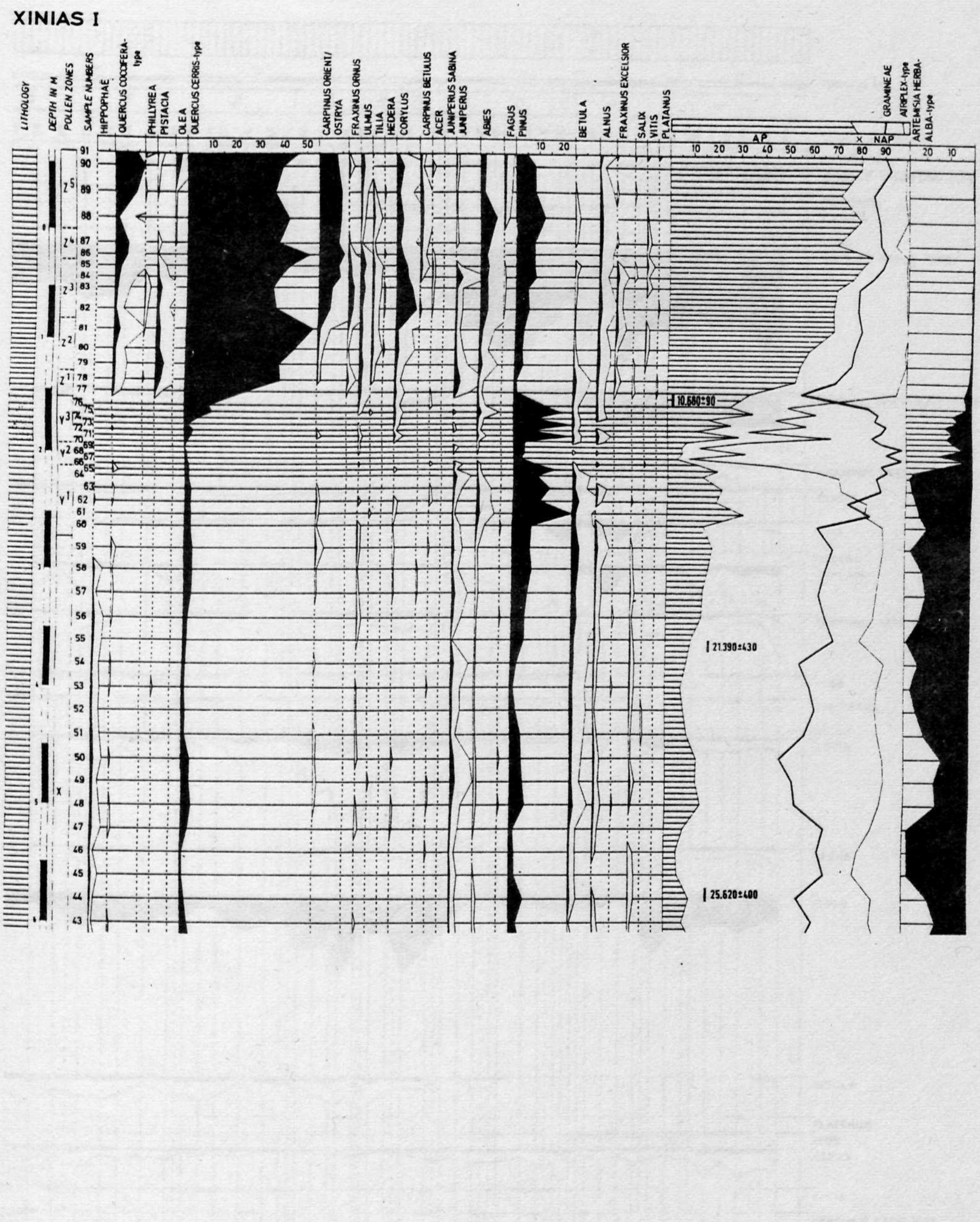

Fig. 14.8 Lake Xinias (Bottema 1979).

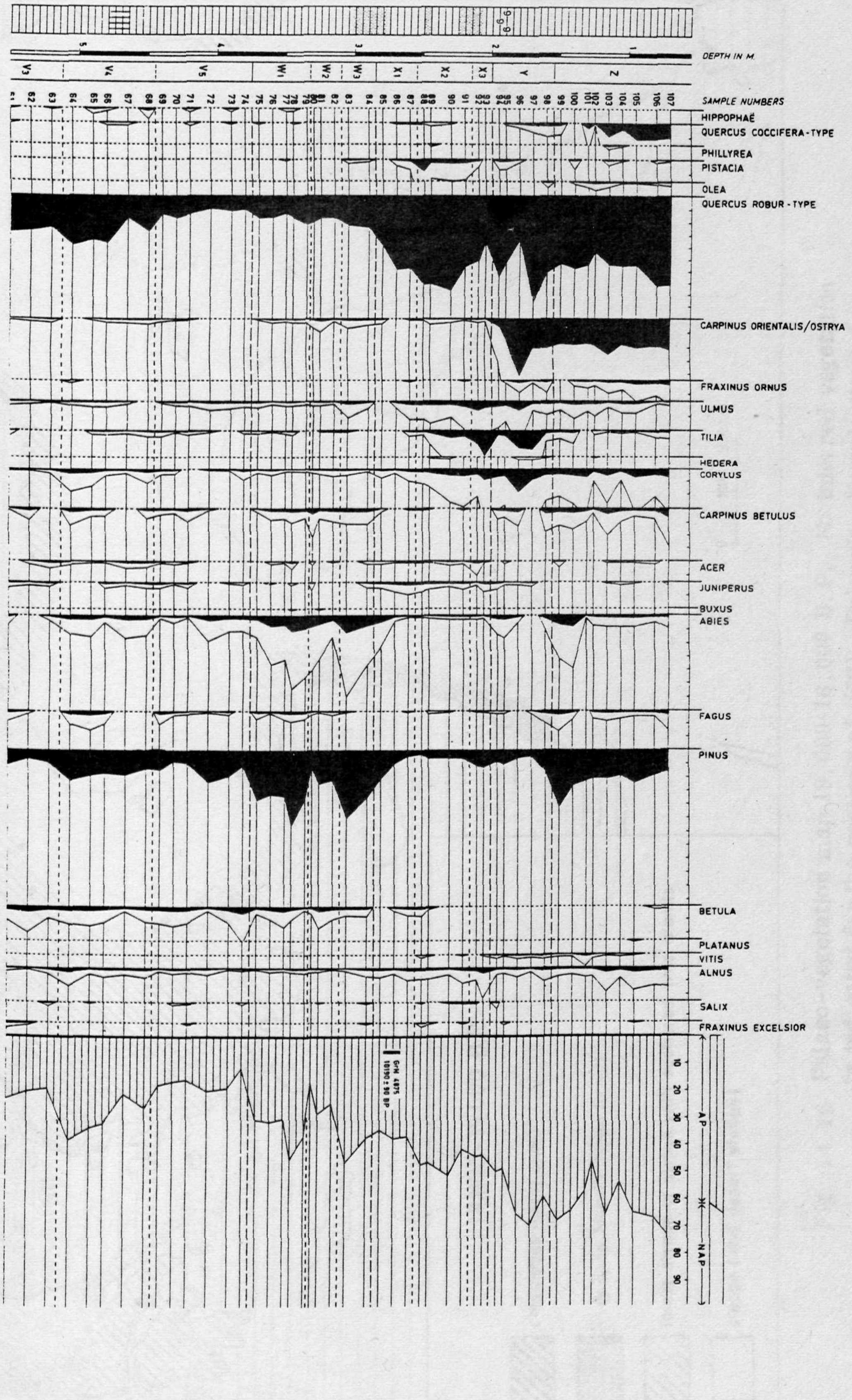

Fig. 14.9 Ioannina (Bottema 1974).

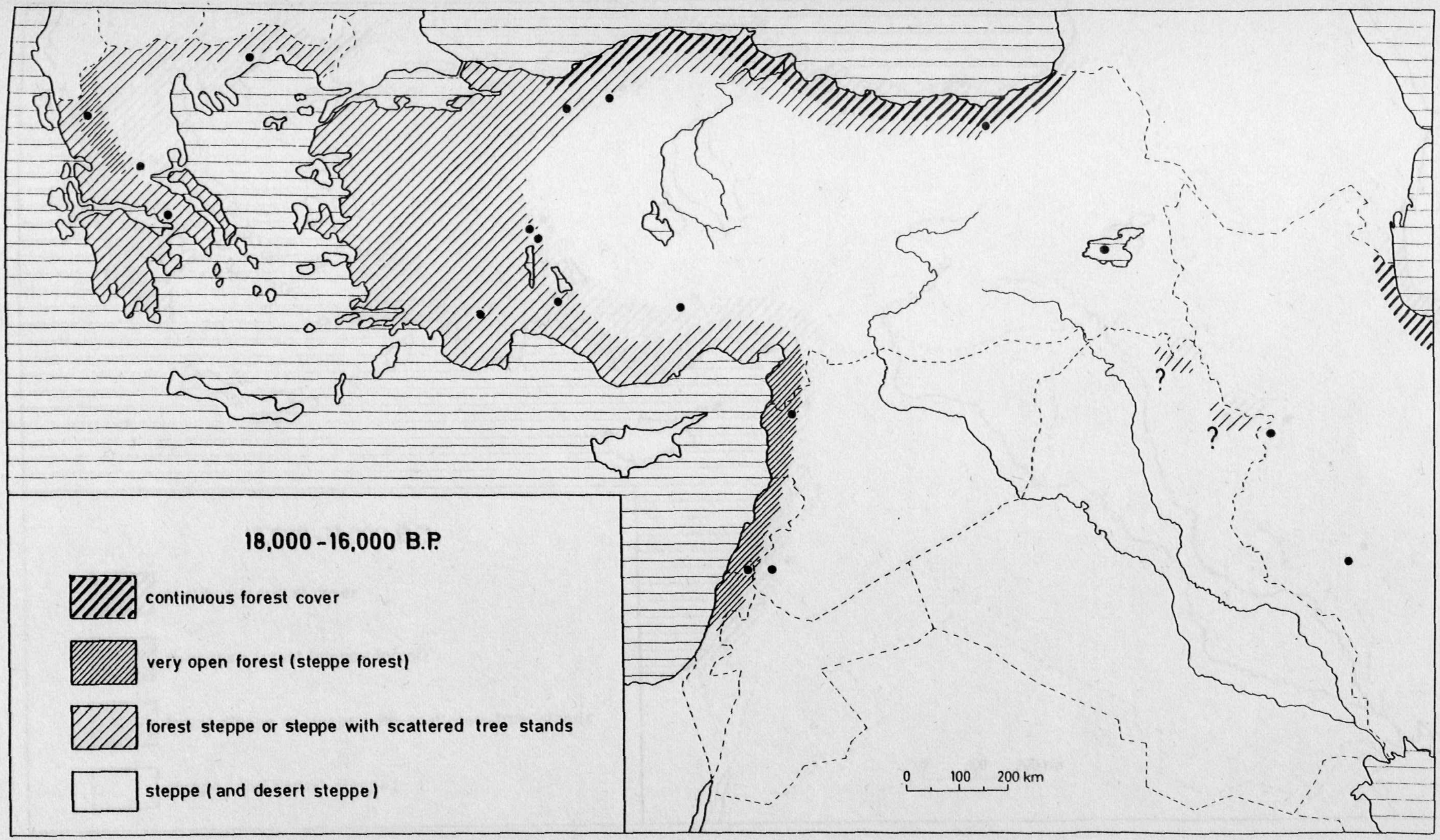

Fig. 14.10 Palaeo-vegetation map 18,000-16,000 B.P. No inferred vegetation is indicated for the sections of USSR, Bulgaria, Yugoslavia and Albania shown in Figs. 14.10-13. No palynological information is available for the greater part of Syria, for Iraq, Saudi Arabia and Jordan. For lack of palynological data no vegetation is suggested for Crete and Cyprus.

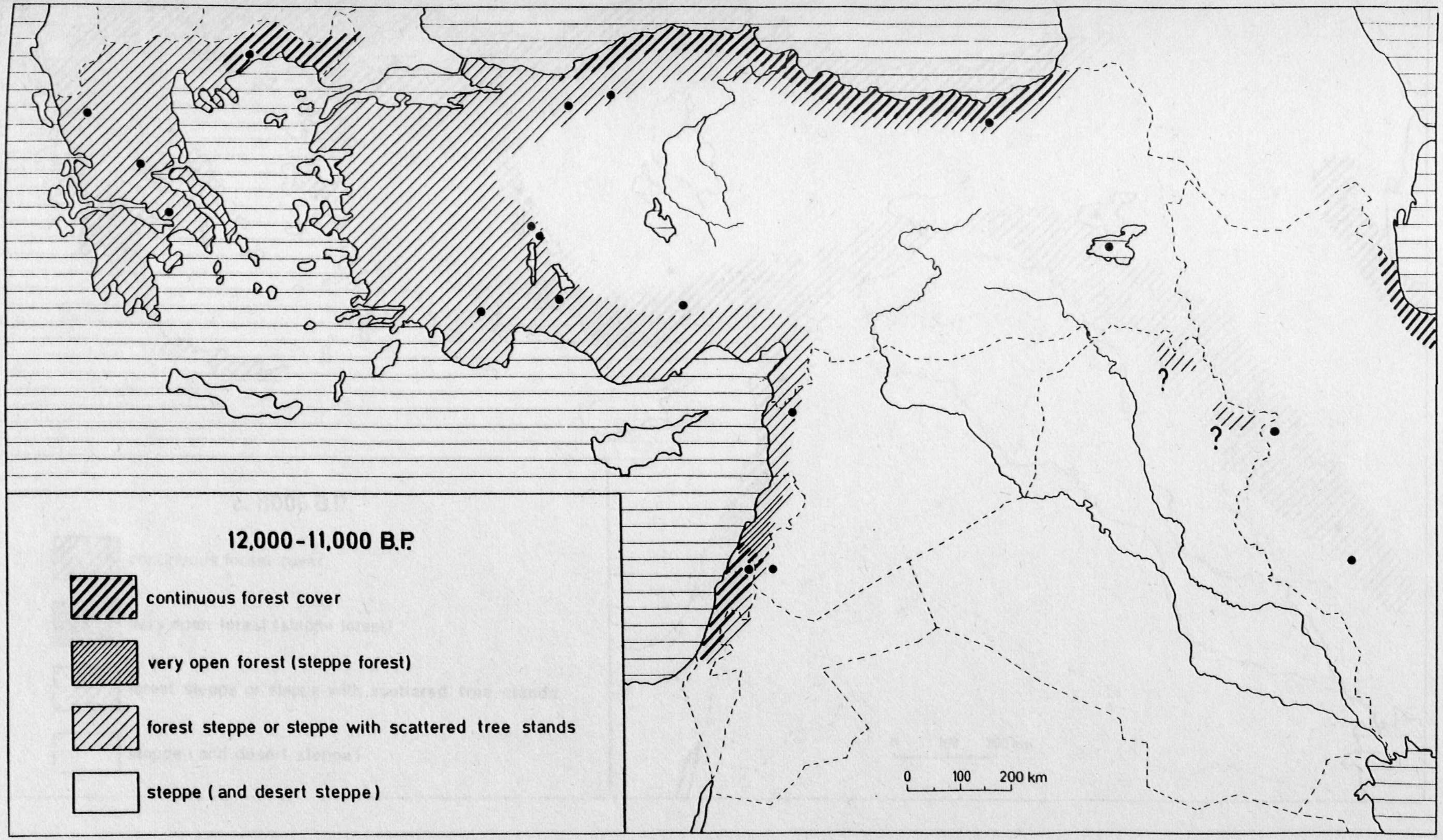

Fig. 14.11 Palaeo-vegetation map 12,000-11,000 B.P. See caption Fig. 14.10.

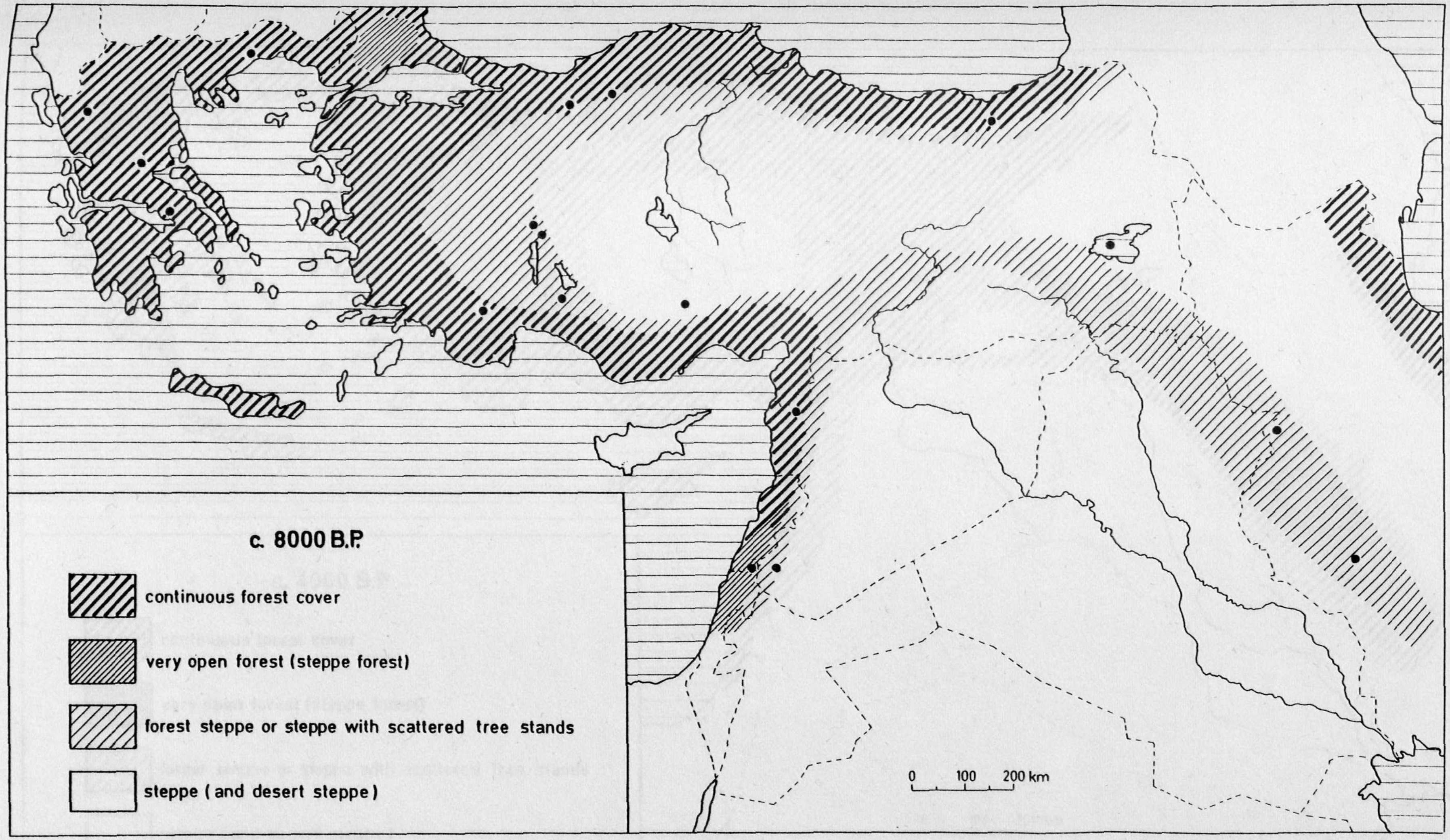

Fig. 14. 12 Palaeo-vegetation map c. 8000 B. P. For this period the type of vegetation on Crete could be determined.

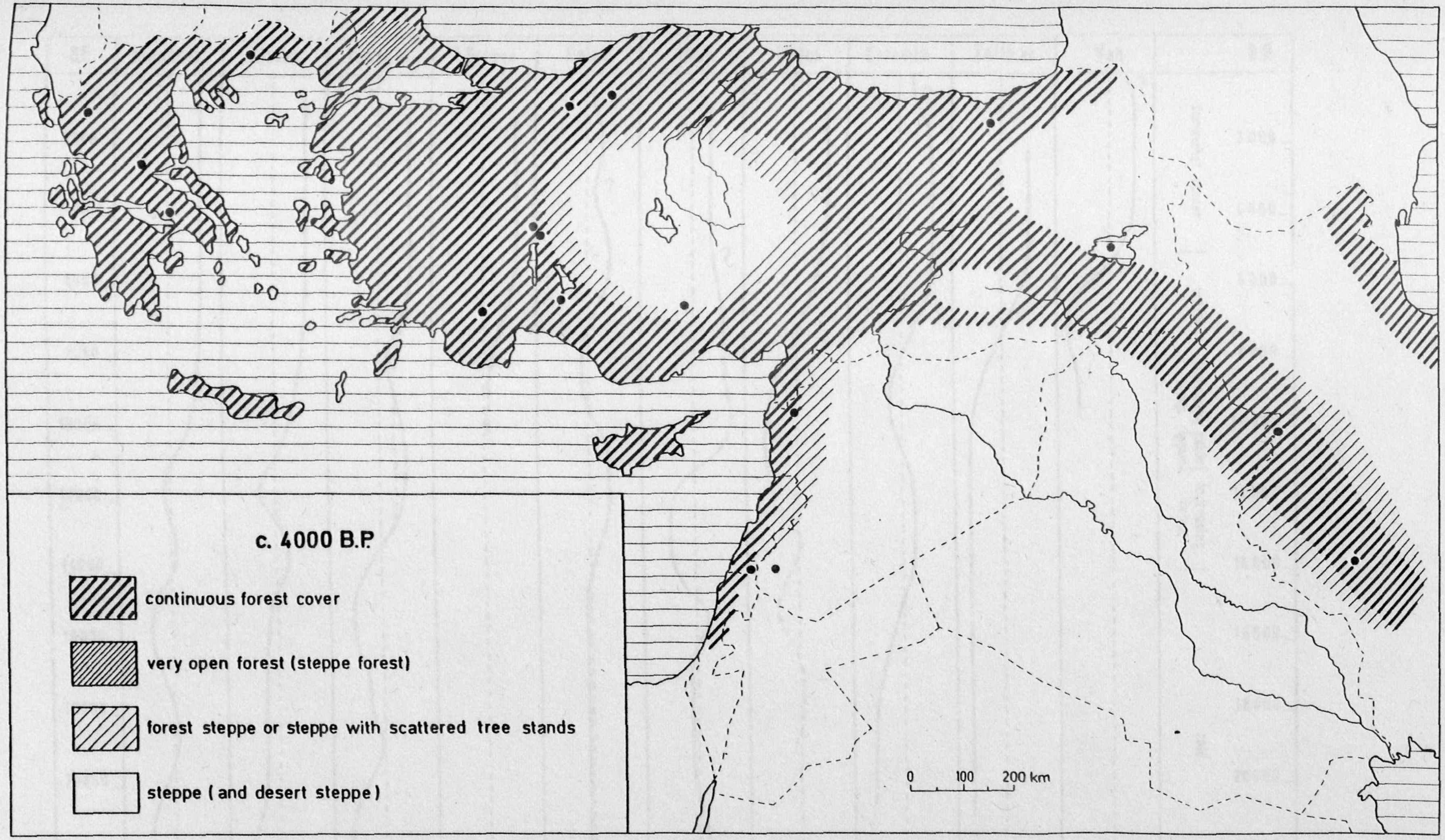

Fig. 14.13 Palaeo-vegetation map c. 4000 B.P.

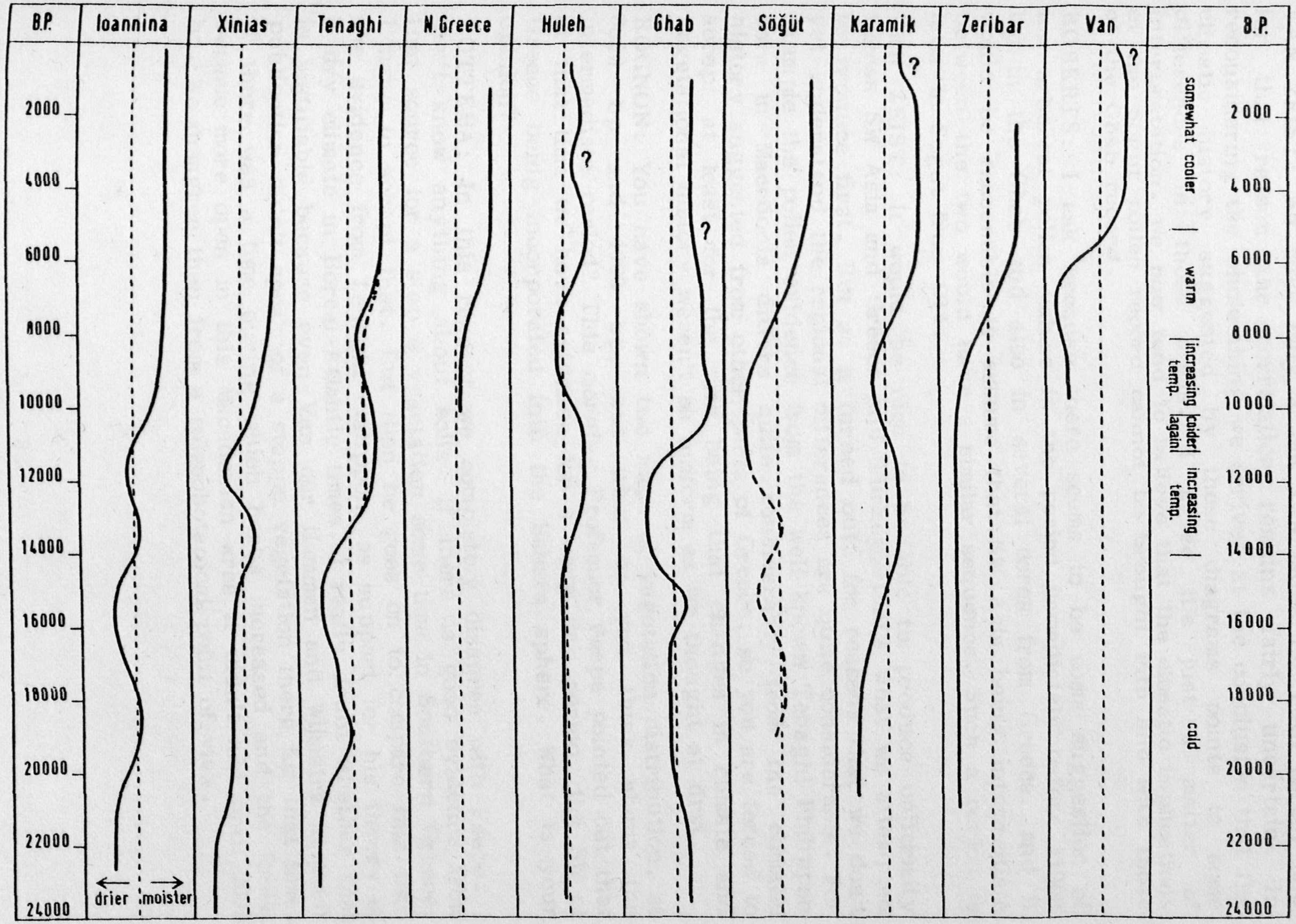

Fig. 14.14 Humidity curves inferred from pollen data (discussed in section 10).

DISCUSSION

ROBERTS: In the Sogut curve and the Ghab diagram in a paper you published a couple of years ago, you suggested that the sequences, with their respective A/NAP ratio were very closely in parallel, and with only slight differences in the dating. Now you are suggesting that the two were much less in phase.

VAN ZEIST: We have only a few C14 dates for both cores, and for that reason the correlation remains fairly uncertain. In reconsidering the whole thing we arrived at the conclusion that the climatic history suggested by those diagrams points to some differences in those areas. I agree it's just a matter of interpretation. We now tend to believe that the climatic implications of the Sogut pollen record cannot be brought into line with those of the Ghab record.

ROBERTS: I ask because there seems to be some suggestion of low arboreal pollen values in the period immediately before 11000 bp in the Ghab and also in several cores from Greece, and it would be reasonable to assume that SW Asia being intermediate between the two would have a similar sequence. Such a period is later in Sogut from C14.

VAN ZEIST: It would be nice to be able to produce uniformity across SW Asia and Greece and Turkey, that's what we attempted to produce first. But as it turned out, for reasons that we don't yet understand the regional differences are quite considerable. For example the pollen evidence from the well known Tenaghi Philippon core in Macedonia differs quite considerably from the climatic history suggested from other parts of Greece, so you are forced to accept at least for the time being that changes in climate and vegetational history weren't so uniform as we thought at first.

ROGNON: You have shown two maps of vegetation distribution, at 8000 bp and 4000 bp, but what do you think about the intermediate period? This morning Professor Paepe pointed out that at that time we have evidence for a very dry period, the SW of Greece being incorporated into the Sahara sphere. What is your opinion?

BOTTEMA: In this respect we completely disagree with Paepe. I don't know anything about soils. If there is good evidence from that source for a steppe vegetation some time in Southern Greece, I have to accept that. But then he goes on to compare this with the evidence from Tenaghi Philippon, as support for his theory of a dry climate in Boreal-Atlantic times. I really doubt whether that is justifiable because even Van der Hammen and Wijmstra in their publication didn't speak of a steppe vegetation there for that time. If there was a time during which herbs increased and the forest became more open in this Macedonian area it didn't last until 3000 bc. We disagree then from a palaeobotanical point of view.

VEGETATIONAL AND CLIMATIC HISTORY OF THE WESTERN PART OF THE KURA RIVER BASIN

Liana K. Gogichaishvili
(Institute of Botany,
Academy of Sciences of the Georgian S. S. R.,
Tbilisi U. S. S. R.)

Before discussing the history of the vegetation and the main climatic changes that took place in the last 20,000 years, I would like to review briefly the research work done in Georgia. The study of the vegetation history in a mountainous country, such as the Caucasus, is a complex matter. The historical development of the vegetation here has been peculiar and complex owing to such natural factors as the huge, glacier-covered mountains, the lowlands going down below sea-level, the piedmonts and the narrow gorges. Each of the major orographic elements of the Caucasus, such as the Greater Caucasus, the Transcaucasian depression, the Transcaucasian upland and the Talysh mountains, had its own specific history of relief formation, river drainage, climate, flora and fauna.

Pollen analyses were first published in the thirties by V. S. Dokturovski (1936), followed by Prof. I. I. Tumajanov's studies on the history of forests of the Greater Caucasus' north slopes, his results of the sporo-pollen analyses evidencing basic regularities in the Holocene vegetation development and proving the existence of regional diversity (I. I. Tumajanov, 1955, 1961 and others).

These studies were followed by more intensive investigations and by data accumulation for individual parts of Georgia. These studies were carried out by M. I. Neustadt (1957), M. I. Neustadt and N. A. Khotinski (1965), V. P. Sluka (1969, 1973), E. E. Kvavadze (1978) in western Georgia. N. A. Margalitadze (1967, 1973) studied the vegetation history of the Javakheti volcanic area. My own studies mainly concern the territory of eastern Georgia (L. K. Gogichaishvili, 1962, 1969, 1971, etc.).

Since eastern Georgia is almost completely devoid of peat bogs and has scarcely any lakes, the sporo-pollen analysis was made possible only after a careful search for samples from fossil soils and from lake sediments locally covered by thick series of freshwater deposits.

The region within our sphere of studies is confined to the Transcaucasian depression divided by the Surami (Likhi) Range into two parts: the eastern part including the Kura river basin, and the western part including the Upper and Lower Kartli plains and the Kakheti basin.

The research results presented in this paper concern the basins of the rivers Kura, Aragvi and Iori. The studies were mainly carried out in the low-mountain and middle-mountain regions and on the plains of this part of Georgia.

The climate is between temperate-moist and warm, dry subtropical with a not very hot summer. The mean January and July temperatures are -3 to -0. 07°C and +18 to +22°C, respectively. The annual precipitation is 450-500 mm, the heaviest precipitation occurring in May (70-100 mm) and September (40-50 mm). The snow cover stays for 1-1. 5 months (Khordzakhia, 1961). Continentality of the climate increases in an eastward direction.

The territory under study belongs to the Caucasian or Iberian type of area which embraces those species which are more typical of the south slopes of the Asia Minor mountains. "The species belonging here are devoid of a clearly pronounced ecological countenance: one can find typical inhabitants of forests, forest edges and dry grassy mountain slopes, and also a number of species of a clearly xerophilous character including those which inhabit rocks, taluses and exposures" (A. Grossheim, 1936, p. 76).

Such a diversity of vegetation complicates the task of the palynologist in reconstructing the Holocene phyto-landscapes. Moreover, as man has inhabited eastern Georgia since ancient times, the vegetation has drastically changed due to human activity. Therefore, the availability of a comparatively great number of sites and of analytical results for soil-dated fossils is one of the most important points in this complicated situation.

In this paper I shall discuss only some of the key sections: the exposures near the village of Kvishkheti (the Kura basin, Fig. 15. 1, no. 1), near Shio Mgvime (the Kura basin, Fig. 15. 1, no. 2), Lake Bazaleti (the Aragvi basin, Fig. 15. 1, no. 3), and near the town of Sagarejo (the Iori basin, Fig. 15. 1, no. 4).

Section 1 (Fig. 2) was sampled near the village of Kvishkheti, in the Central Kartli Plain, at an elevation of 725 m above sea-level. The samples were taken from natural exposures on the left bank of the river. The depth of the lacustrine, lake-alluvial deposits reached 320 cm. The samples represent the Middle and Late Holocene. The beginning of the Middle Holocene is characterized by a large area of oak forests, which is presented by a low proportion of tree species and a high percentage of Gramineae. Subsequent layers reveal a pronounced abundance of Quercus pollen and a greater proportion of Ulmus and Castanea. Of the herb species, those of Compositae, Chenopodiaceae, Caryophyllaceae and some others were dominant.

Towards the end of the Middle Holocene the zone of Quercus and Castanea reduced gradually, while that of Salix, Populus and Alnus increased.

In the Late Holocene the large percentage of Quercus returned, but that of Castanea remained low. At the same time the flood-plain forests reduced in area, Rubus, Elaeagnus, Amygdalus, Morus and other species taking increasing possession.

The data obtained for this section of the Kura river have shown: a) that the forests here were mainly of mixed-oak and of the flood-plain type; b) that the Middle Holocene had extensive areas covered mainly by oak forests with chestnut; c) that the north slopes of the Trialeti Range were covered by hornbeam forests (evidenced by the permanent presence of Carpinus pollen) with some spruce groves being mixed in (the Picea percentage being 30% at the zone 5/6 boundary).

Section 2 (Fig. 15. 3) was sampled in the neighbourhood of Dzegvi-Armazi, at an elevation of 450 m above sea-level, and was named "Shio-Mgvime core". Near the village of Dzegvi the Kura crosses the convergence of the Kvernaki and the Satskepela Ranges, creating the Kldekari Gorge. Some fossil soils were exposed on the right bank of the river at the beginning of the gorge, and were locally covered by lacustrine, lake-alluvial and alluvial sediments.

Some remnants of dry forests are found on the south slopes of the Sarkineti Mountain and the Armazi Range within this section of the valley.

The available sporo-pollen material includes the Early, Middle and Late Holocene: zones 3 and 4 corresponding to the Early Holocene, zones 5, 6 and 7 representing the vegetation changes in the Middle Holocene, and zones 8 and 9 those in the late Holocene. The data prove that the piedmonts of the Early Holocene were characterized by hornbeam-oak forests in which hornbeam was predominant. The presence of Juniperus, Celtis, Pinus and Pistacia pollen points to a wide extension of dry forests, whereas the riverside areas were covered by flood-plain forests, however not so widespread. Fagus is represented in this zone.

An insignificant decline in the hornbeam-oak forests is typical of the second half of the Early Holocene. One would expect that the areas which had become open by that time, could later be occupied by dry-forest elements. However, this was not the case; the dry forest areas did not increase.

At the start of the Middle Holocene the dry forest area began to expand. At the same time Gramineae show maximum pollen percentages. Therefore, the Middle Holocene reveals the spread of two forest types: hornbeam-oak forests in the higher mountain belts and dry forests in the middle mountain belts. In the Late Holocene, in particular at its beginning, the flood-plain forest areas tended to increase. The hornbeam-oak forests were still widespread on the piedmont lands, their areas being reduced in the second half of the Late Holocene.

Section 3 (Fig. 15. 4) was taken from Lake Bazaleti, at an elevation of 800-900 m above sea-level. The present landscape is nearly without forest; only occasional remnants of hornbeam-oak forest are found. The total depth of the boring was 3.5 m. The core is divided into successive Middle and Late Holocene levels.

The Middle Holocene is characterized by maximally developed broad-leaved forests with Quercus, Carpinus, Ulmus, Tilia, Zelkova and other species, and by a drastic decline in beech forests. The broad-leaved forests began to reduce gradually at the beginning of the Late Holocene, whereas inundated areas with marsh vegetations of Phragmites communis, Typha latifolia and other species expanded.

Section 4 (Fig. 15. 5) was taken near the town of Sagarejo, in the middle course of the Iori river. In contrast to the other regions, the lake sediments here are locally covered by a more or less thick layer of grass-wood peat. The forests of Gare Kakheti consisted of impoverished broad-leaved tree stands and were related by N. Kuznetsov (1909) to the Older Tertiary types of Colchis and Girkan forests. The present-day landscape is devoid of forest.

On the basis of the pollen diagrams prepared for sediment sections and of the pollen spectra of buried soils (Fig. 15.6) we propose the following periodization of the pollen record:

Zone A. The spectra of this zone are dated to 20,580 ± 680 B. P. (Tb-17). The spectra display 75% Pinus, 5% Quercus, 4% Carpinus caucasica, 8% Ulmus, 7% Acer, 3% Tilia and others. Of the herbs, Gramineae, Umbelliferae, Leguminosae, Caryophyllaceae and some others are well represented.

The Late-glacial series of pollen spectra starts with the date of 14,160 ± 500 B. P. (T b-18). Pinus pollen percentages are high in these spectra and broad-leaved tree pollen percentages are still insignificant, although the latter include Juglans, Pterocarya, Alnus, Ulmus and Salix. The decline in pine pollen percentages is evident at the depth of 11.75 m with a simultaneous increase of broad-leaved tree pollen percentages.

Zones 3 and 4 cover the Early Holocene. For the first time the hemixerophytic tree-shrub complex, with a high percentage of Carpinus orientalis, Quercus, Tilia, Acer and others, is clearly visible in the pollen spectra.

Zones 5, 6 and 7 cover the Middle Holocene with an increased area of hemixerophytic piedmont forest vegetation. Pterocarya and Juglans have disappeared, whereas Quercus percentages tend to go up. At the end of the Middle Holocene (zone 7) pollen spectra change once more, which corresponds with the increase of lowland forest pollen percentages (Alnus, Ulmus, Salix etc.); the pollen values of the hemixerophytic tree-shrub species reduced significantly. The vegetation remnants are dated to 3450 ± 270 B. P. (T b-19).

Zones 8 and 9 cover the late Holocene. At the early stages the tree pollen composition still keeps changing, particularly as far as lowland forest species are concerned. The proportions of arboreal and herbaceous pollen in zone 9 remain the same as in the first half of the Late Holocene.

The above brief discussion shows that the Late Quaternary of this territory was characterized by a dynamic forest succession, the initial stages of which were markedly different from the present-day forest stands. This statement is supported by the sporo-pollen spectra of the buried soil levels which reveal the vegetation character during the Late Pleistocene glaciation of 20,580 ± 680 B. P. The widespread pine descended to the piedmont regions as far down as 400-500 m above sea-level. The broad-leaved piedmont species occupied rather small areas. It is common knowledge that in the Soviet Union and elsewhere the climate of that period was extremely severe. The climate improved slightly in the Late-glacial period when pine still remained a predominant tree, although other species, such as Carpinus, Quercus, Acer, Ulmus, Tilia, Juglans and Pterocarya, were present in the forest.

A sudden change took place 11,000 years ago when deciduous tree species became widely distributed, whereas pine decreased markedly. The diagram of Fig. 15.6, showing the spectra corresponding to the last glaciation, the Late-glacial and the early Holocene, illustrates the above statements. There is another curious point to be mentioned: however severe the climate was, the Iori lowland remained one of the refuge areas where Pterocarya, Juglans regia and others were distributed within a relatively short period. These plants seem to have survived the last glaciation in better protected side gorges of the Tsiv-Gombori Range, and as soon as the climate began to improve they proceeded to inhabit the lowland which had been a zone of intensive river sedimentation.

The tendency to a certain regularity in the forest distribution can be traced in the early Holocene. In the Iori region forests were of hemixerophytic character with high percentages of Quercus iberica, Tilia, Acer and others. Only occasional specimens of Fagus descended into the ravines and even into the lowlands, an exceptional case never reported before in any other region. At the same time flood-plain-forests with Populus hybrida, Salix australior, Ligustrum vulgare and others spread in the Aragvi valley.

In the Early Holocene the piedmonts in the Kura valley were occupied by oak-hornbeam forests with a great proportion of hornbeam. At the same time occasional dry forest indicators appear in the Dzegvi-Mtskheta section. Therefore, the boreal period was characterized by an extreme expansion of forest vegetation due to the improved climatic conditions.

It is common knowledge that the Middle Holocene was a period of the most intensive afforestation in the greater part of the Caucasus. The improvement of climate and maximum temperatures caused changes in the vegetation in various regions. For instance, oak forests with chestnut began to develop in the Kura valley near the village of Kvishkheti; dry forests, consisting of Juniperus, Pistacia and others, covered the Dzegvi-Mtskheta section. The broad-leaved forests grew maximally in the Bazaleti basin, while the mixed lowland forests of the Mid-Iori lowland decreased; Pterocarya and Juglans regia disappeared.

The rise of groundwater in the Late Holocene, which was due to the remoistening of the climate, caused a new succession. The areas of flood-plain and lowland forests and, in some places (e.g. Lake Bazaleti) of inundated lands, expanded. The more recent stages display a considerable decline in the oak-hornbeam forests, whereas those with Carpinus orientalis and Paliurus spina-christi expanded. The reduction of the forest area at that time was due to the increasing human activity. As we know, man has started to destroy nature since the Late Palaeolithic, and we can recall numerous examples of anthropogenic ecological crises.

I have not mentioned the vegetation history of other natural zones of eastern Georgia, such as the semi-desert and steppe areas. We have no data from the Alazani valley which has retained some representatives of mesophilous and thermophilous relict tree species typical of the Colchis and the Talysh.

The diversity of the east Georgian vegetation landscape would be more obvious if we summed up the total material for the region. The contributions made by W. van Zeist, S. Bottema, H. Freitag, H. E. Wright and others have played and will continue to play an important role in the interpretation of various features of the history of vegetation and climate. I strongly believe that before long all this research work will lay a foundation for creating a common model for the Postglacial vegetation development and climatic changes in the Middle East and the Eastern Mediterranean.

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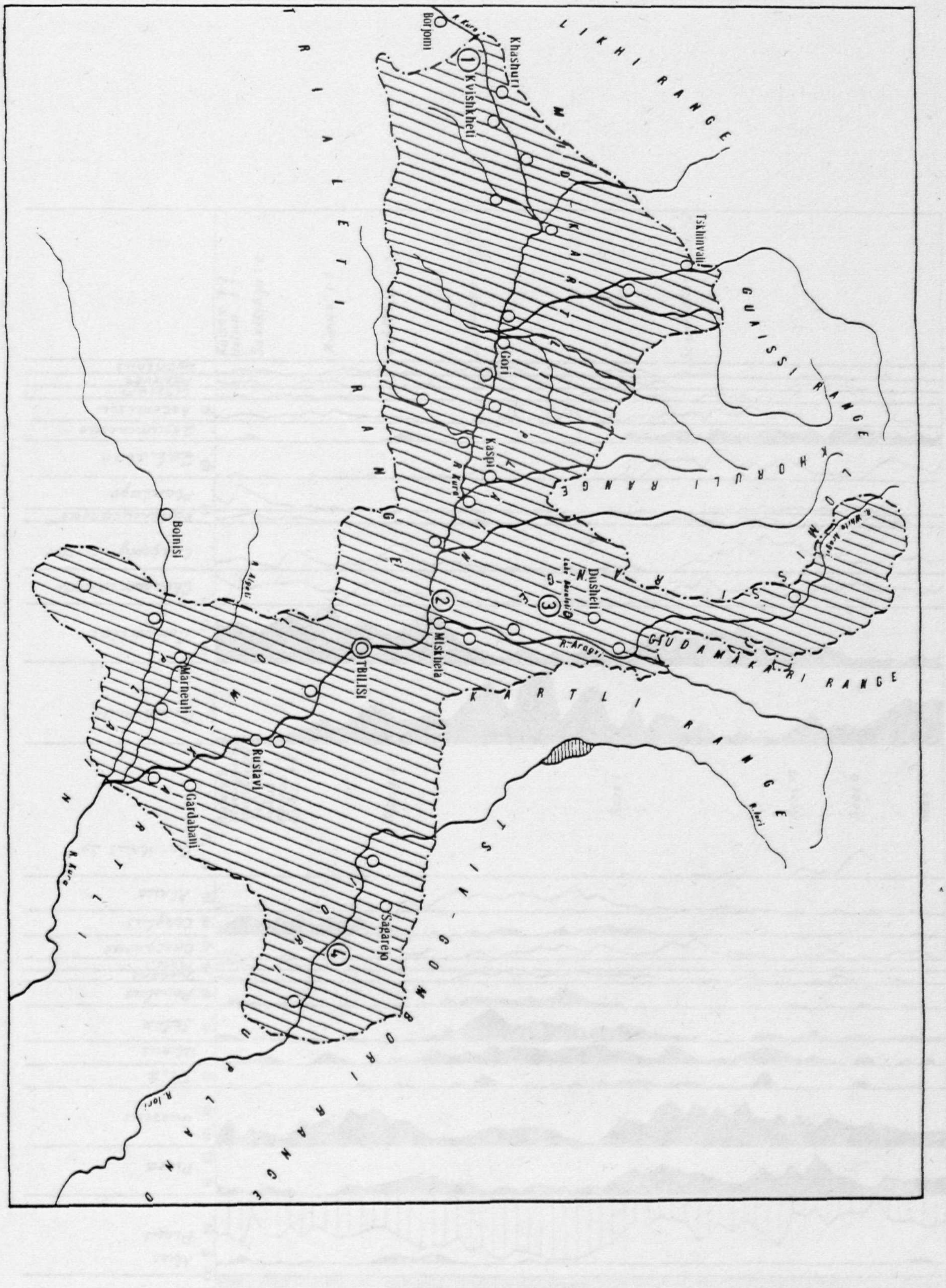

Fig. 15.1 Location of sporo-pollen diagram sites. 1. Kvishkheti; 2. Shio Mgvime; 3. Lake Bazaleti; 4. near Sagarejo.

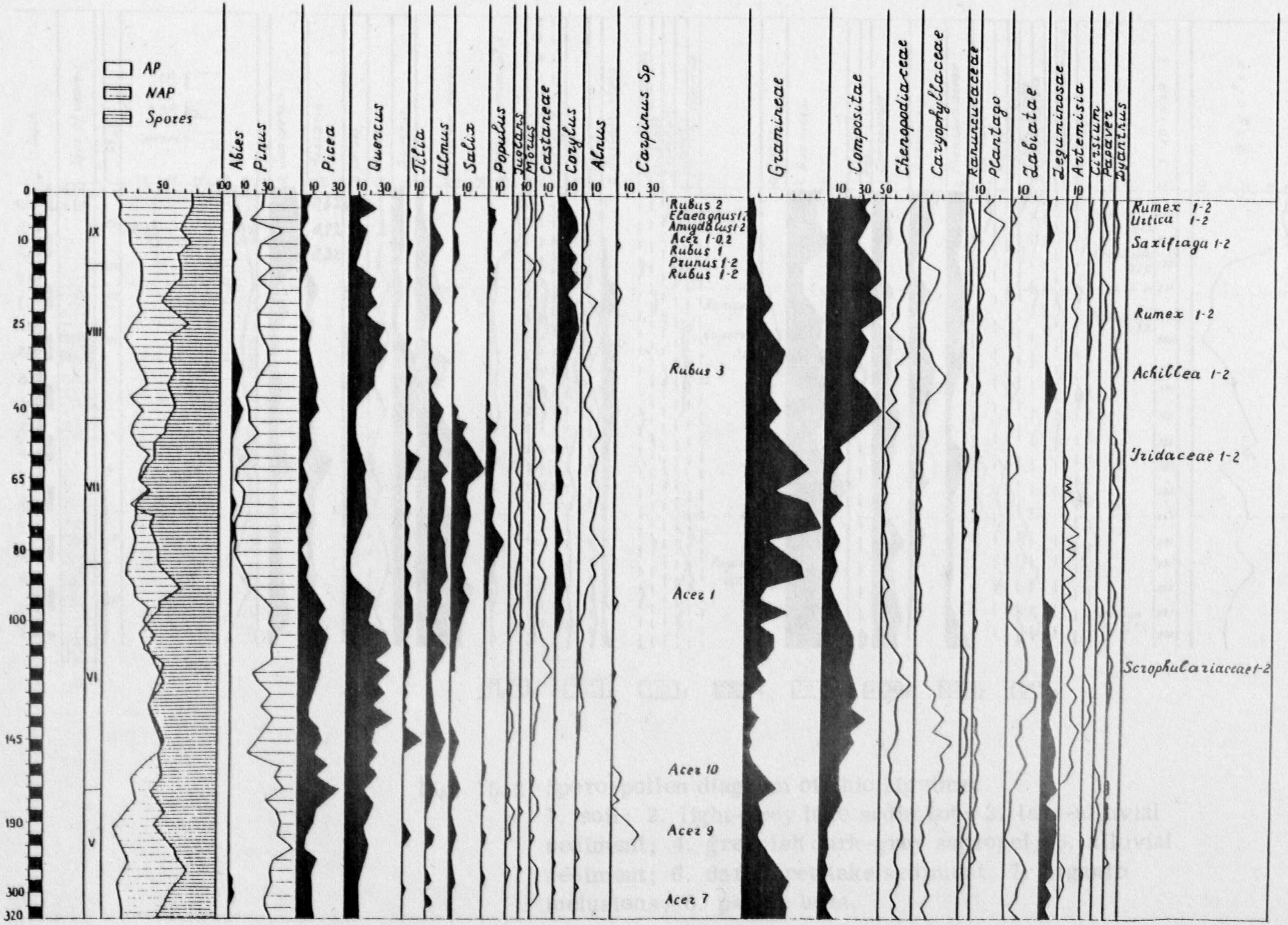

Fig. 15.2 Sporo-pollen diagram of Kvishkheti.

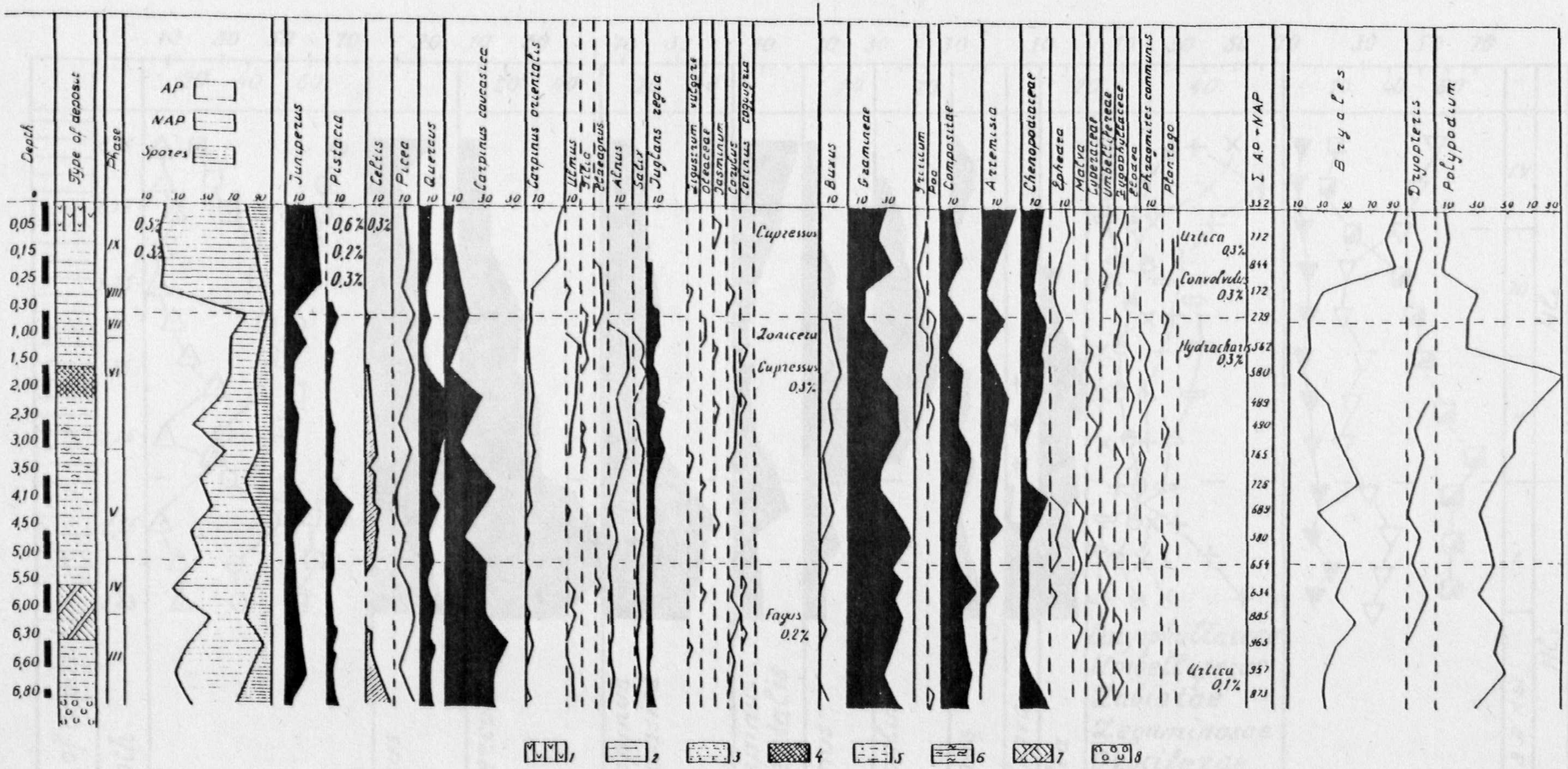

Fig. 15. 3 Sporo-pollen diagram of Shio Mgvime.
1. soil; 2. light-grey lake sediment; 3. lake-alluvial sediment; 4. greenish dark-grey sapropel; 5. alluvial sediment; 6. dark-grey lake sediment; 7. organic inclusions; 8. pebble beds.

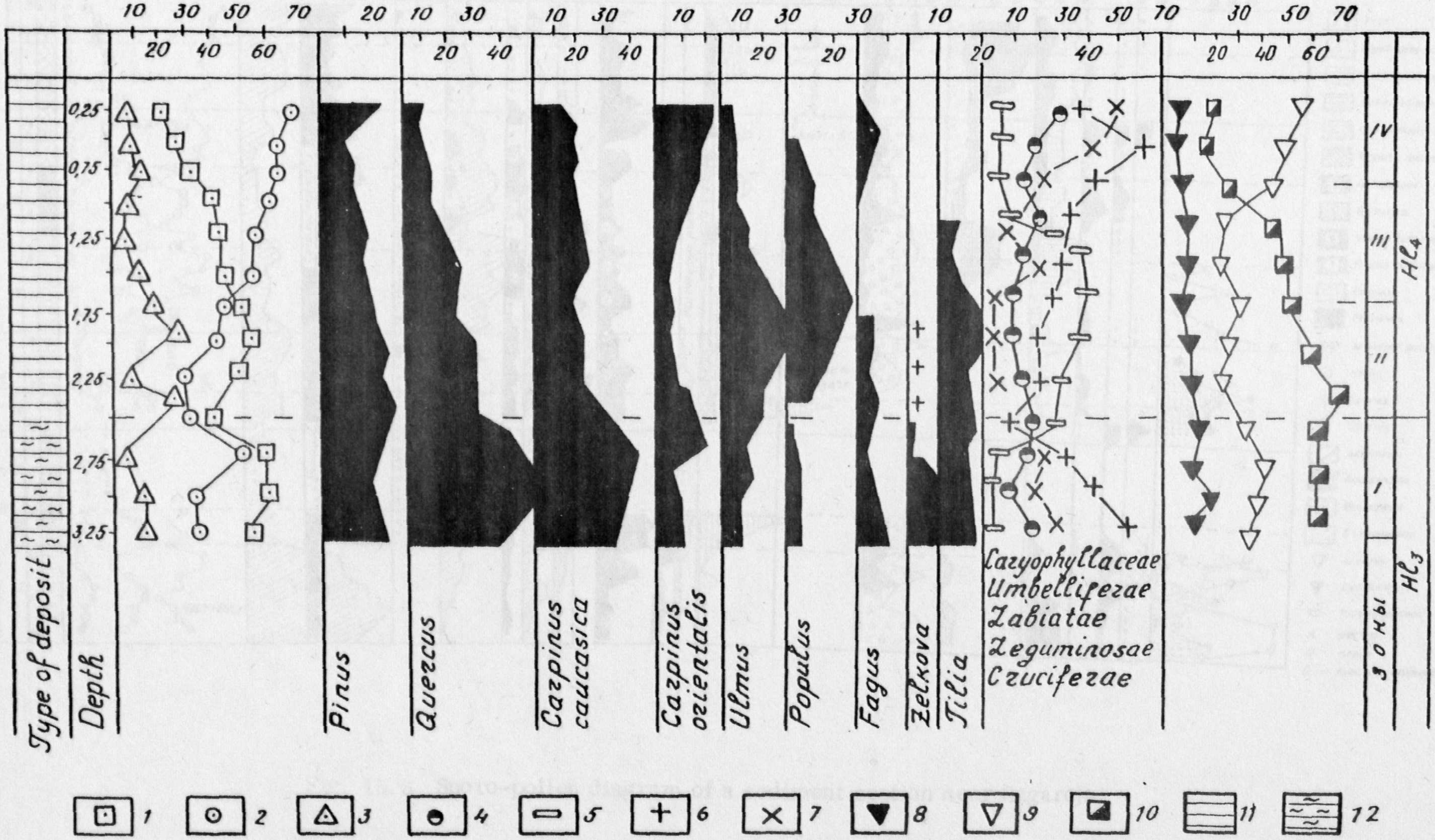

Fig. 15.4 Sporo-pollen diagram of Lake Bazaleti.
1. arboreal pollen; 2. herbaceous pollen; 3. spores; 4. Gramineae; 5. Cyperaceae; 6. Compositae; 7. Chenopodiaceae; 8. Lycopodium; 9. Bryales; 10. Polypodiaceae; 11. light-grey lake sediment; 12. dark-grey lake sediment.

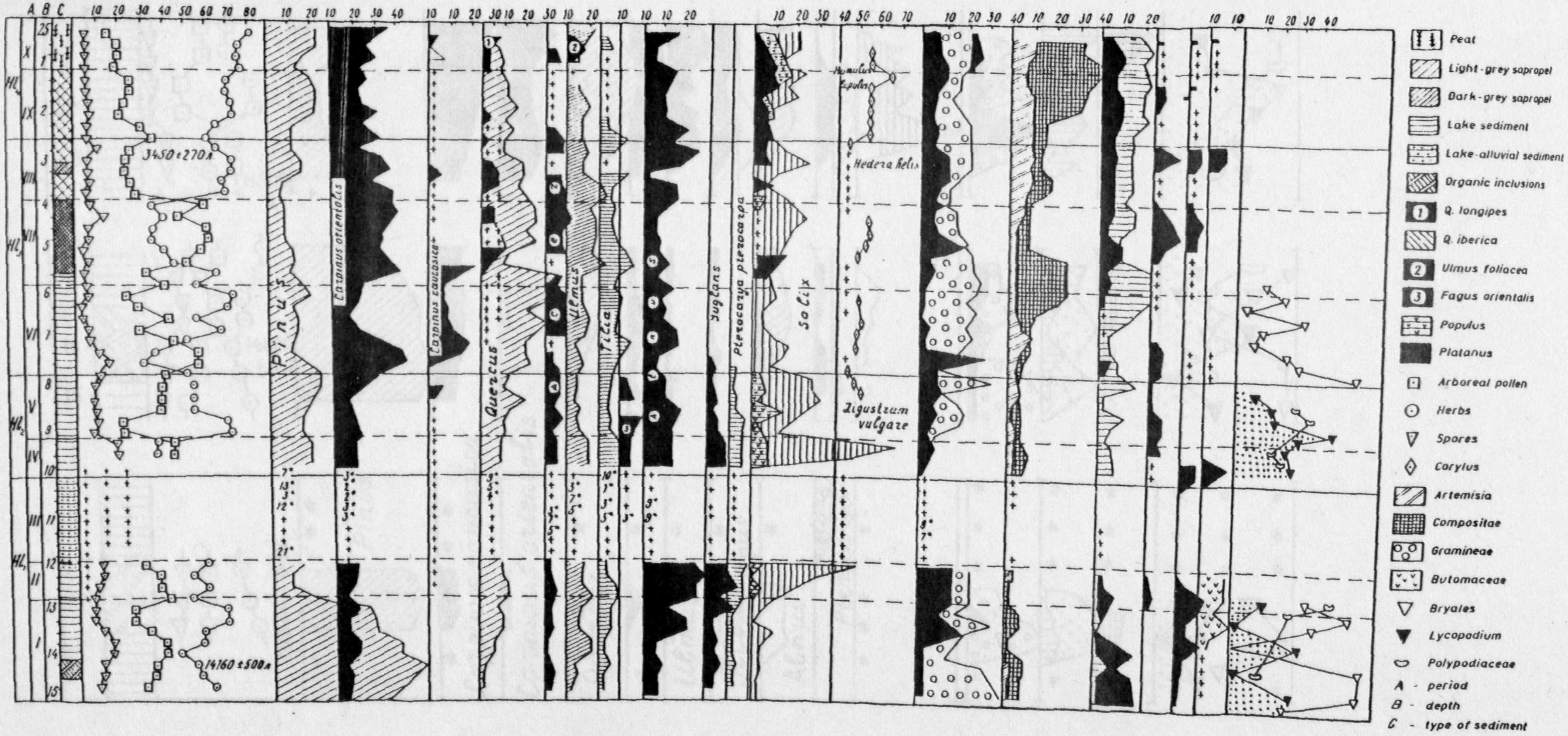

Fig. 15.5 Sporo-pollen diagram of a sediment section near Sagarejo.

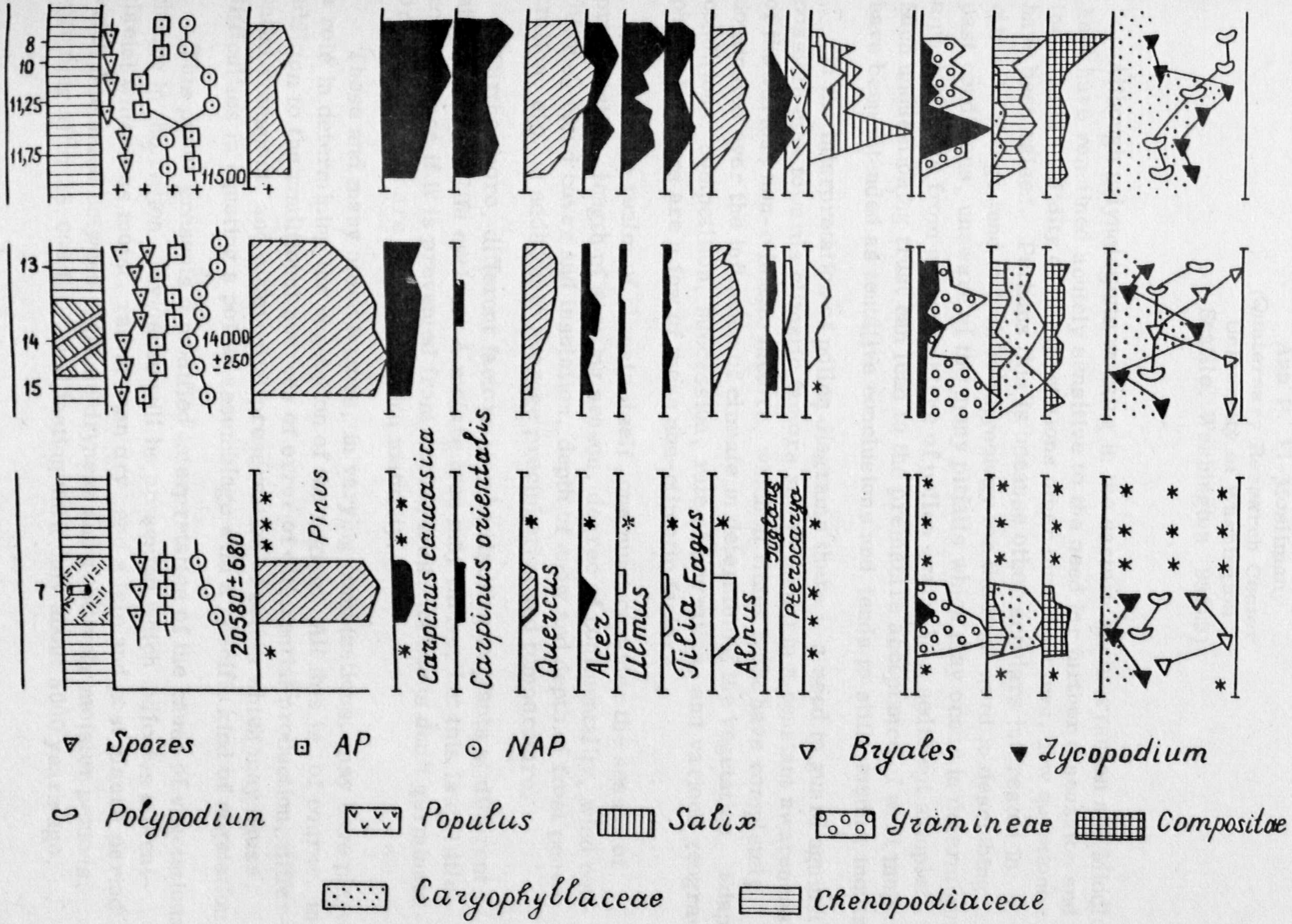

Fig. 15.6 Late Pleistocene and Holocene sporo-pollen diagram prepared for buried soil sections near Sagarejo.

THE LATE QUATERNARY VEGETATIONAL HISTORY OF THE ZAGROS AND TAURUS MOUNTAINS IN THE REGIONS OF LAKE MIRABAD, LAKE ZERIBAR AND LAKE VAN - A REAPPRAISAL

Ann P. El-Moslimany
(Quaternary Research Center,
University of Washington,
Seattle, Washington 98105)

Although palynologists working in the eastern Mediterranean and Middle East have remained acutely sensitive to the need for further discussion and the possible validity of interpretations other than their own, few questions have been raised. Perhaps this is because other scholars interested in climatic change tend to look to palynology for the final word in describing past conditions, unaware of the many pitfalls which may occur in determining a past climate from an assemblage of pollen grains in a sediment sample. Such unquestioning trust can lead to the premature acceptance of what may have been intended as tentative conclusions and tends to stifle further inquiry.

In the interpretation of pollen diagrams there is a need to guard against possible bias towards climatic factors and to maintain a constant awareness of the various non-climatic factors, which at times must have completely dominated over the influence of climate in determining the vegetation. Edaphic conditions, competition, succession, rate of migration, and various geographical barriers are a few of these non-climatic factors.

Within the realm of climate itself one must consider the season of precipitation, length of growing season, degree of continentality, wind conditions, cloud cover and insulation, depth of snow and depth of frost penetration, etc. in addition to average precipitation and temperature.

Furthermore, different factors may be limiting to plants at different stages of their life cycles. A mature tree may thrive, but this is of little consequence if it is prevented from setting fruit, its seeds don't germinate or its seedlings are unable to reach maturity.

These and many other factors, in varying combinations, may have played a role in determining the vegetation of the region. All this is, of course, in addition to the traditional sources of error of differential production, differential transport, and differential preservation of pollen which may cause difficulties in equating a pollen assemblage with a specific kind of vegetation.

This paper presents a modified interpretation of the cause of vegetational change in the region. Evidence will be presented which indicates a pleniglacial which was moist, rather than dry , and a late and post glacial period which fluctuated between extreme dryness and relatively moister periods, beginning after 16, 000 B. P. and lasting until only about 5000 years ago.

We are fortunate to have at our disposal, in the existing pollen diagrams, a wealth of information, due largely to the detailed and precise work of Professor van Zeist and his colleagues at Groningen University. The accumulation of data continues, but perhaps top priority should go towards the effective processing of that which already exists.

Only the areas surrounding Lake Mirabad and Lake Zeribar in the Zagros Mountains of western Iran and Lake Van in the Taurus Mountains of eastern Anatolia will be discussed in detail here. For the diagrams of Lake Zeribar and Lake Van, please see pages 297 and 299 in the article by van Zeist and Bottema in this volume.

According to van Zeist and Bottema (1977, this volume) the lack of trees and the high values of Artemisia and Chenopodiaceae during the pleniglacial are indicative of dry as well as of cold conditions.

Many trees have been permanently excluded from the area by the long, dry summer. The only oak in the Zeribar region today is Quercus aegilops L. subsp. brantii (Q. brantii). It is a strongly drought resistant oak which can occur where rainfall is only half of the rainfall which occurs at Zeribar today. The other leading tree, Pistacia spp. can also survive at quite low levels of precipitation. The elimination of these two trees during the glacial period, if attributed to moisture alone, would have required the unlikely reduction to 1/4 - 1/2 of today's precipitation, especially taking into account the decreased evaporation which must have occurred.

On the other hand Q. brantii is not very cold-hardy. In Iraq where it occurs with two species which are more mesic, Q. boissieri and Q. libani, it is never found above 1800 m and rarely above 1650 m. At the higher altitudes, as well as on north and west facing slopes it is replaced by these two other species. It may be the lack of competition in addition to the lower latitude which allows Q. brantii to reach somewhat higher elevations towards the south. The upper tree-line of 2300-2500 m, reported by van Zeist and Bottema (1977 p. 26), is almost certainly too high for the Zagros region as it was based on forest at the still lower latitudes of Khuzistan and Manisht Kuh. If we assume an upper treeline of 2000 m at Zeribar, a temperature depression of 5^{o}C would have been sufficient to eliminate it from the area based on the lapse rate of 0.7^{o}C/100 m as determined by Wright (1961). At Mirabad, assuming a tree-line of 2300 m a 10^{o}C drop in temperature could have eliminated the trees, if indeed they were absent during the pleniglacial from Mirabad.

As for the Artemisia and Chenopodiaceae pollen which was so prevalent during this time period, it need signify nothing more than treeless vegetation. The dominance of these two groups may be explained by two different sets of circumstances, neither of which requires a decrease in moisture.

The relative poverty of the tree species is an important consideration When Q. brantii, Pistacia, and other less important plants were eliminated during the glacial period, for whatever reason, trees to fill the vacated niche were lacking and instead it was filled by those herbs or shrubs which were available. We do not find Picea or Abies taking the place of the oaks because they have been excluded from the region by the dry summer.

Whether Chenopodiaceae and Artemisia were actually present in the area is a difficult question to answer. The plants of the alpine and sub-alpine (tragacanthic) vegetation are insect pollinated and therefore supply only meagre amounts to the pollen rain. Faegri and Iversen (1975, p. 63, 146) have pointed out that thermal up-winds along mountain sides cause vertical transport from lowland to subalpine regions. It can easily be conceived that the strongly prevailing northwesterly winds would have carried the desert (Chenopodiaceae) and steppe (Artemisia) pollen up into the mountains where it would have been washed down with the precipitation.

An additional factor may have been at work during the glacial period. Maher (1963) demonstrated how phenology affects the incorporation of pollen into lake sediments at high altitudes. The early pollinators shed their pollen while the lakes are still frozen in the spring. As the melt-water from the surrounding snow flows over the surface of the frozen lake it washes away any pollen which may have fallen onto it. Only the pollen of those plants which flower in the summer or early autumn are able to become incorporated in the sediments in important amounts. Chenopodiaceae and Artemisia are among the few late flowering plants. The only summer flowering plants mentioned by Guest (1966, p. 90) for the subalpine region are Cirsium, Cousinia and Prangos, a giant Umbelliferae. It may be significant that both Umbelliferae and Cousinia pollen were more prevalent during the glacial period than later on.

Although Chenopodiaceae and Artemisia are common under similar conditions of dry summer—cold winter climate, their needs are sufficiently different to allow their relative fluctuations to be meaningful. An increase in Artemisia should occur under more favourable moisture conditions while the more xerophytic chenopods would increase when less moisture is available.

That this is the case can be verified by the ratios of these two groups in surface samples taken from Middle Eastern regions of summer-dry climate. Surface studies from western Iran (Wright et al., 1967), the Mediterranean zones of Turkey (van Zeist, et al., 1975), Lebanon and Syria (Bottema and Barkoudah, 1979) have been carried out. When samples within each region are grouped according to moisture-dependent vegetational zones and the chenopod/Artemisia ratio is determined for the sum of samples in each zone, a clear trend appears. Within each region the ratios vary from relatively high values in the dry region to lower values in the moister regions.

When the chenopod/Artemisia ratios are graphed from the pollen diagram of Lake Zeribar, the pleniglacial stands out as a moist period. After about 16,000 B. P. conditions began to become drier. Strong fluctuations between extreme dryness and periods of relative moisture characterised the next several thousand years until stable moist conditions were established about 5000 years ago. See Figure 16.1. Supporting evidence for this sequence of moisture conditions comes also from various paleolimnological evidence (Hutchinson and Cowgill, 1963; Megard, 1967; Wasilikowa, 1967).

If trees were limited by temperature rather than by moisture, an indication should be seen in the comparison of the Zeribar diagram with Lake Mirabad. Since Mirabad is warmer but drier we would expect trees to have been established earlier there if they had been limited by temperature and their refuges were at lower altitudes and/or latitudes. Unfortunately there is only one date for Lake Mirabad (10,370 ± 120 B. P.) at the base of the core. This makes it nearly impossible to estimate a date for the establishment of the oak forest. The bottom sample at Mirabad shows no oak pollen at all but by the second sample it had already reached 10% although it later dropped again. It may be of some significance that oak pollen did not reach the level of 10% at Zeribar until at least 2000 years later.

If oak was not limited by moisture how can its long, slow immigration into the Zeribar region be explained? First, if oak had been confined to lower altitudes, it would have become subject to the strong fluctuations of aridity. Today it does not occur below about 500 m (Guest, 1966, p. 67). During each arid period it shrank back into the most favourable habitats which must have been few indeed. This can be seen in Figure 16. 2 which compares the graph of the chenopod/Artemisia ratio and the percentage of tree pollen. A pulse of oak occurs each time there is an increase in moisture signified by a drop in the chenopod/Artemisia ratio. Overall, however, the expansion of oak into the higher altitudes from which it had previously been excluded continued in spite of the aridity.

The slowness was probably due not only to the set-backs which occurred during the dry phases at lower altitudes, but also because of the difficulty with which the seedlings are able to become reestablished (Zohary, 1962, p. 75). It is likely that the seedlings require shade in order to survive the hot summers of their first few years and therefore spread very slowly either close to the edges of the existing stand or as the successional stage following the Pistacia-Amygdalus community.

The moistest period between 16,000 and 5000 B. P. occurred between about 7500 and 6000 B. P. The final thrust of oak into this region did not occur during this time but in the dry phase which followed. During the moist period, Pistacia as well as other deciduous tree pollen reached its peak. Their presence may have allowed the oaks to finally take over the area by providing shade for the establishment of the seedlings.

The still slower establishment at Lake Van can be explained by a combination of several factors. The most important is probably due to its location at still higher altitude and latitude. Unlike Lake Zeribar no obvious relationship is seen between fluctuations in the chenopod/Artemisia ratio and the positive pulses of oak. Since more than one species of oak is present at Lake Van it may be that immigration was occurring from more than one direction and in response to different factors. The moist phase during which deciduous trees expanded at Zeribar had no effect at Lake Van and the dry period which followed appears to have been more severe than it was at Zeribar, although Quercus pollen continued to increase. It may be that Q. brantii simply had not immigrated that far north or to elevations of that height, while Q. libani and Q. boissieri were limited by the last arid period.

Although one relatively small area of the Middle East has been considered here, there is evidence that this general pattern of moisture trends was region-wide. The pleniglacial chenopod/Artemisia ratios are low for every location for which pollen diagrams are available, including Tenaghi Philippon

(Wijmstra, 1969), Xinias (Bottema, 1978) and Ioannina (Bottema, 1974) in Greece; Karamik Batakligi (van Zeist et al., 1975) in Turkey and the Ghab valley (Niklewski and van Zeist, 1970) in Syria. In addition, fluctuations occurred after about 16,000 B. P. although they were of greater amplitude in some regions than in others. More intensive ecological investigation of these other sites should help to further elucidate the situation.

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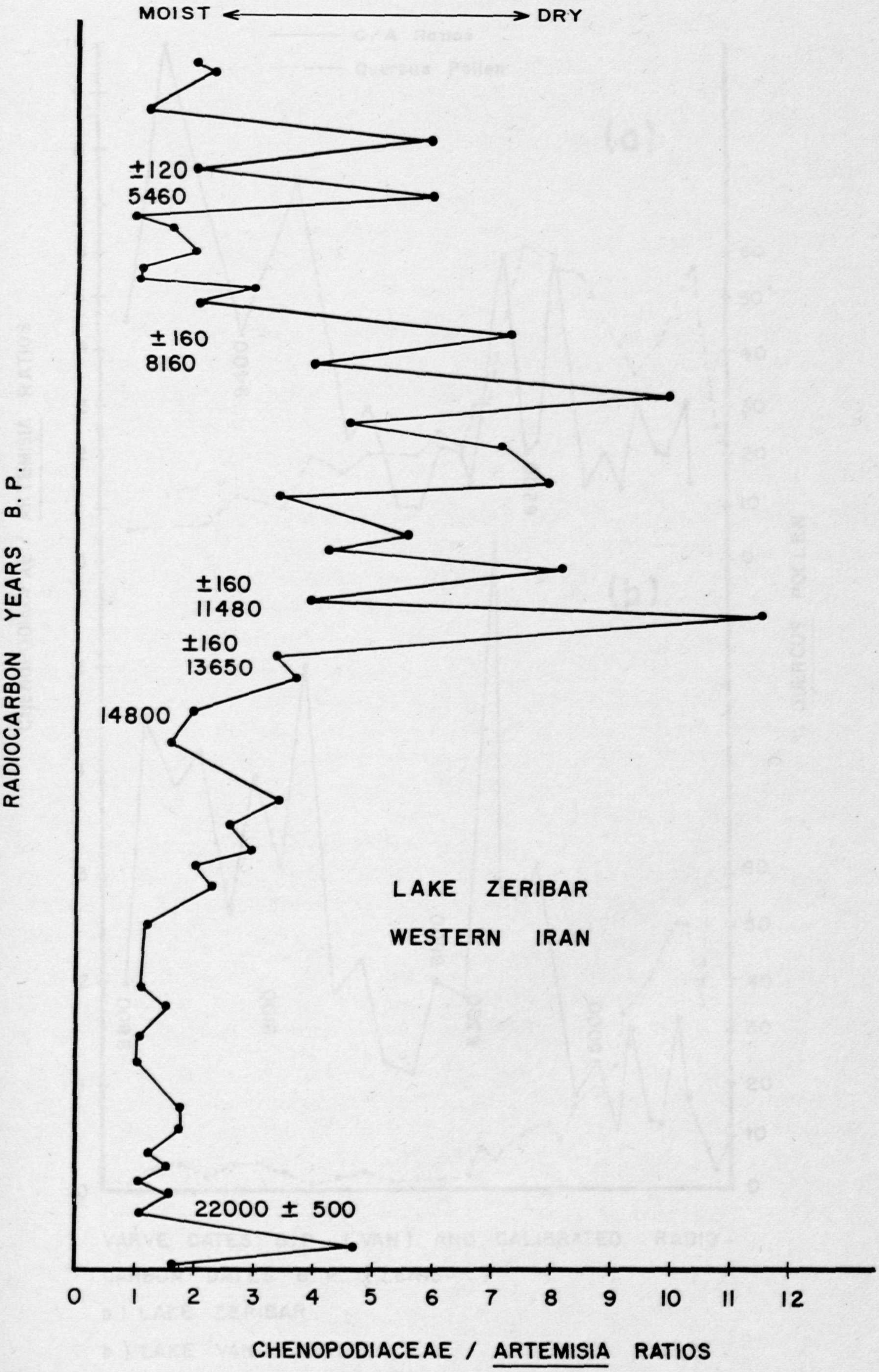

Figure 16.1 The Chenopodiaceae/Artemisia ratios for Lake Zeribar I.

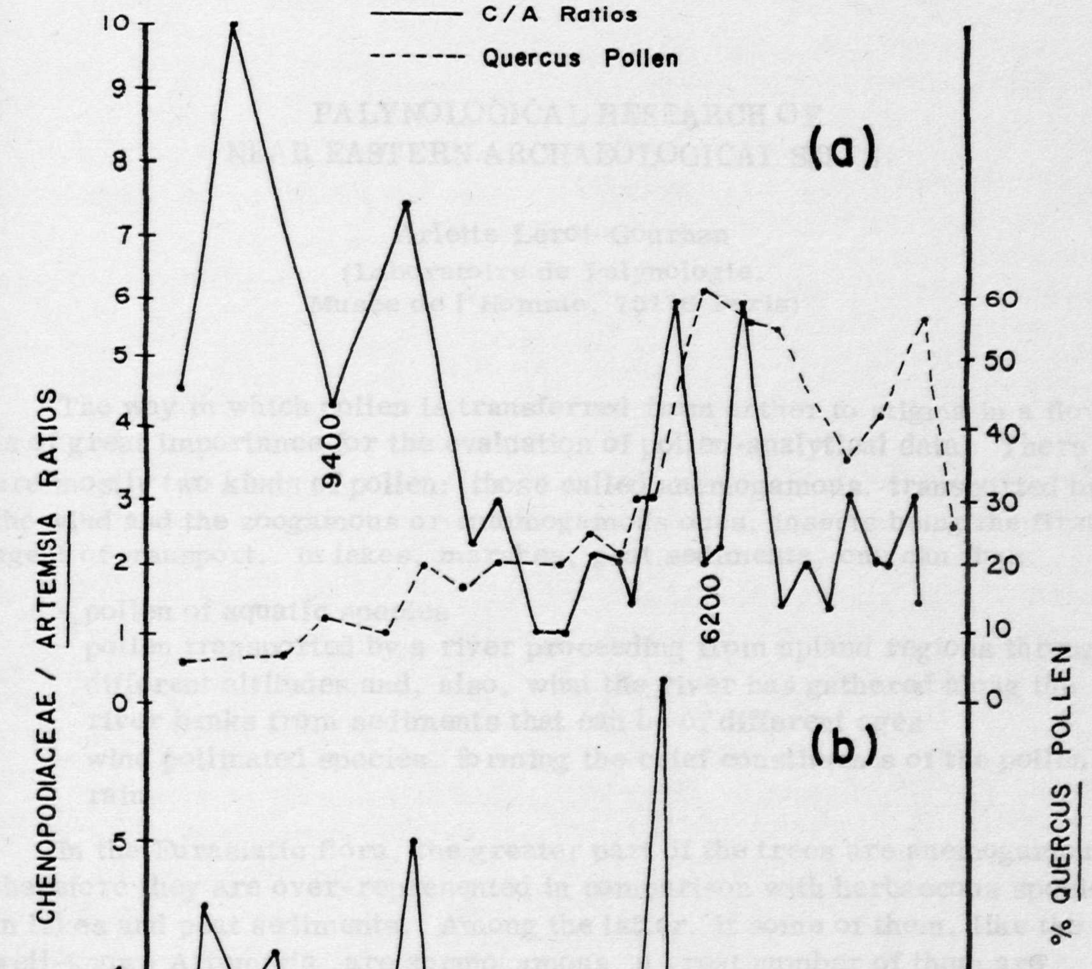

Figure 16.2 Chenopodiaceae/*Artemisia* ratios and percentages of *Quercus* pollen. Dates at Lake Van are based on varves while Zeribar dates have been calibrated (Stuiver, personal communication) to coincide more closely with those of Lake Van.

PALYNOLOGICAL RESEARCH OF NEAR EASTERN ARCHAEOLOGICAL SITES

Arlette Leroi-Gourhan
(Laboratoire de Palynologie,
Musée de l'Homme, 75116 Paris)

The way in which pollen is transferred from anther to stigma in a flower is of great importance for the evaluation of pollen-analytical data. There are mostly two kinds of pollen: those called anemogamous, transported by the wind and the zoogamous or entomogamous ones, insects being the first agent of transport. In lakes, marshes, peat sediments, one can find:

- pollen of aquatic species
- pollen transported by a river proceeding from upland regions through different altitudes and, also, what the river has gathered along the river banks from sediments that can be of different ages
- wind pollinated species, forming the chief constituents of the pollen rain

In the Eurasiatic flora, the greater part of the trees are anemogamous, therefore they are over-represented in comparison with herbaceous species, in lakes and peat sediments. Among the latter, if some of them, like the well-known Artemisia, are anemogamous, a great number of them are entomogamous: it is the case with the Compositae-Liguliflorae, being the dominant group on the Würmian steppes during the coldest and driest periods in Europe and some regions of the Middle East. Although pollen grains of zoogamous species are occasionally found in peats and lakes, they are always infrequent and their occurrence rather irregular; nothing can be concluded from their absence.

Thus, marsh and lake diagrams show a broad regional vegetation, and, as they are very rich in pollen and can offer some long cores, they are very important for showing climatic fluctuations.

Terrestrial sediments are not as rich in pollen, but, in most cases, one can get enough for establishing a diagram. Such spectra give a more complete picture of the dry soil vegetation than lake spectra, as they enclose the two types of pollen dispersal. Instead of a regional view of the flora, dry soil pollen analysis offers a local view, but, depending on the geographical area, the evolution of the vegetation can still be very well marked.

Lakes and marshes are not found everywhere, just so is the case with archaeological sites: joining the results of both contexts is a better way to obtain the maximum of data. This type of analysis is specially important where there are semi-arid zones in the Near East. There, trees are very scarce and the palynologist has to work with the fluctuations of herbaceous species. We are beginning, mostly in South Jordan, to study different ways of advancing with this kind of work.

The Groningen symposium was concerned with the last 20,000 years. But, for comparison, reference to older periods is desirable.

In the Zagros Mountains, it is now possible to see how important are the alternations of highly forested periods, and others quite unfavourable for tree growth. At Houmian (Iran), an Early Würm Mousterian site shows the development of an oak forest with 75% of A. P. (Arboreal Pollen). During the Upper Würm, at Shanidar cave, the diagram suggests a steppe. Just the same is seen in the Zarzi Upper Paleolithic site, dated around 13,000 B. P., where tree pollen are virtually absent; it is later on, during the Shanidar Mesolithic that we can see the beginning of a savannah. In Zeribar, this savannah becomes an oak forest in the Holocene. So for this region, there is now a broad overview of the floral evolution and the climate during the Last Glacial but, as yet, no short fluctuation has been seen.

On the Lebanese coast, the long diagram of Nahr Ibrahim shows some fluctuations during the Early-Middle Würm, with highly humid times bringing the development of a dense forest. With the cold maximum, 23,000 to 20,000 B. P. in Europe, probably synchronous with the driest maximum in the Levant, archaeological sites become rather rare here, so insufficient information is available for that time. Subsequently, some fluctuations in humidity are recorded. One can probably be connected with Kebaran levels around 17,000 B. P. With the end of this palaeolithic industry and the beginning of Natufian, sites seem to grow more numerous. Even if very few of them have been studied for pollen research, there is potential information here. The contribution of archaeology in that period is important in setting up a chronological scale; even if a pollen diagram is only recording a 2 or 3 thousand year period, lithic and bone typology gives a relative dating. Moreover, a Carbon 14 series can be obtained.

In Israel, at Hayonim terrace, the end of the Kebaran seems to correspond with a very cold-dry time, coming after an amelioration. Then, the Natufian begins (11,920 B. P., 9,970 B. C.) with a new fluctuation marked by an increase of trees and a greater variety in herbaceous species. As for the chronology, these two periods of amelioration look synchronous with the European Bölling and Allerød, but local names are needed for the Middle East, as we don't yet know if there really is a link between the climatic behaviour of the two regions.

At Hayonim as in northern Syria, a new dry phase takes place around 10,500 B. P. (8.500 B. C.). On the Mureybet diagram, there is a regular decrease of the chenopods through five hundred years. Then, with the first appearance of the PPNA industry, and with the development of Gramineae and an increase in tree pollen, a new humid period begins, synchronous with the date of the Holocene.

There are other palynological sequences on archaeological sites for the VIII and VIIth millennium B. C.: Tell Aswad, Ghoraifé, Tell Ramad, Ras Shamra... If, at Mureybet, the pollen analysis has led us to propose there the possibility of a "proto-agriculture", we know now that—at the same time—

agriculture had begun in Damascène, as the Tell Aswad seeds reveal. So from this time onwards, if there are changes in the vegetation reflected by pollen diagrams, the question is to separate those which are determined by climatic fluctuations from those where the activity of Man has to be given as the main cause. A decrease in the woodland indicators can be dryness, or deforestation and grazing pressure, an increase can be an amelioration of climate or a new plantation of olive-trees, almond-trees, etc.

In some cases, human activities can be shown by the palynological results: cereal or legume agriculture (crop rotation), dwelling-places with ruderal species (Tell Aswad); an increase of human interference, a movement of the people to the site or from the site (Ras Shamra, Ras Bassit).

Classical pollen diagram results are summarised as an "alternation of periods in which steppe vegetations expanded and those in which forest increased" (van Zeist). But, even in treeless regions, there was some evolution in the vegetation due to climatic fluctuations. For that new kind of palynological research, different approaches are being tried; with the role played by typical steppic species, it has already been noticed that botanical families or groups change through time, as does pollen size. If it is quite impossible to obtain palynological evidence from desert sediments where all the pollen is allochthonous, there is some hope for semi-desertic areas with dense-herbaceous cover.

Much more work is required before we can reconstruct the past vegetation in the individual regions of this part of the world.

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DISCUSSION

UERPMANN: Is it correct that the Mousterian site that you were evaluating is high up in the Zagros mountains?

LEROI-GOURHAN: 1800 metres, a little higher than Zeribar, and rather near it. We have oak forest, here one can find Mediterranean oak, Q. calliprinus, so really rather warm and probably wet at that time.

BAR YOSEF: You mentioned the pollen from Aswad as mainly anthropogenic. So what is the possibility that the material from Mallaha and from Hayonim terrace was also influenced by human activity and therefore there would be no contradiction between e.g. Mallaha on the one hand and the Huleh pollen diagram?

LEROI-GOURHAN: Because the most numerous pollen are natural pollen. And also I have compared the dominance of herbs between Hayonim and Mallaha, because at first it was impossible for me to know how to place Mallaha looking at the two diagrams. It's the curve of herbs, of Tubuliflorae and Gramineae, that leads me to try and put them together, and you can see if it works but it's via the herbs, there are not enough trees for an arboreal curve.

BOTTEMA: In Lyons you showed me your interesting results from measurements of the Liguliflorae and chenopods, which you connected with a warm climate. I must say that you convinced me that in fact the sizes were different and that these got bigger. But when I look at sediments from other origins, as distinct from settlements, they don't show this increase. Of course I am not referring to subtypes, I am speaking of the main type of chenopod and the main type of Liguliflorae. Although this data also covers a period in which you'd say temperature fluctuated from time to time, there is no fluctuation in sizes. An exception is a situation the Germans call 'Sedimentbedingt' or, a function of sediment variation. So when you say there is a constant increase in size in Liguliflorae and chenopods going along with temperature, don't you think that there's another factor here that in the course of time could have had a sort of corrosional effect, because in the parallels in waterlogged sediments you don't see this variation? Don't you think that it's not that the pollen really increase in size, but that the oldest ones get smaller?

LEROI-GOURHAN: I don't think that is possible from my data, especially that from Nahr Ibrahim.

PART FIVE:

ARCHAEOLOGY, HISTORY AND PALAEOENVIRONMENTAL RESEARCH

ARCHAEOLOGICAL EVIDENCE FOR SETTLEMENT PATTERNS IN MESOPOTAMIA AND EASTERN ARABIA IN RELATION TO POSSIBLE ENVIRONMENTAL CONDITIONS

Joan Oates
(Girton College, Cambridge)

Evidence for Late Pleistocene man in the area with which this paper is concerned comes from the Zagros and from Arabia. Later, within the Holocene, three areas in particular offer settlement data which may possibly be interpreted as indicating minor fluctuations of climate: the Jazirah, an area of dry steppe between the Tigris and the Khabur; the Khabur basin itself in northeastern Syria; and the Gulf Coast and Eastern Province of Saudi Arabia (Figs. 18.1, 18.3).

Before commenting on these data I should perhaps warn my non-archaeological colleagues that settlement evidence must be employed with great caution. Although presence of settlements is undoubtedly a useful indicator that an area is "habitable", even a knowledge of the economy practiced at the site does not always provide reliable clues to environmental conditions. More important, the apparent absence of sites at any particular period may reflect no more than archaeological ignorance of the ceramic or chipped stone industries characteristic of the region at the time. For example, we have no "type fossils" whatsoever for the identification of early first millennium B. C. sites in Mesopotamia; thus the absence of sites of this date in settlement studies in no way necessarily indicates lack of settlement. Equally, the apparent absence of early Holocene sites in lowland northern Mesopotamia is as likely to reflect lack of archaeological exploration as of occupation. For these reasons I shall be examining positive data for the most part, i. e. data indicating presence rather than absence of settlement, in particular in areas that are today from an agricultural point of view climatically marginal.

Zagros

The archaeological evidence from northeastern Mesopotamia (especially that from Shanidar cave, Solecki 1963, 13) has in the past been interpreted as indicating the absence of man in the Zagros for the period coinciding with the most intensive phase of Würm glaciation in Europe and preceding the Zarzian (Upper Palaeolithic) "re-occupation" round about 14,000 b.p., a date very approximately coinciding with palynological evidence for the beginning of climatic amelioration. However, more recent archaeological data seem to suggest that man did inhabit this region, and hunt onagers among other animals, throughout the Upper Palaeolithic, even in the higher and presumably colder environment of West Central Iran (e.g. Warwasi cave, 11 km NE of Kermanshah, excavated by Bruce Howe). At Pa Sangar, elevation c. 1170 m in the Khorramabad Valley (Luristan), excavations indicate the direct development of the Zarzian from the preceding Baradostian (for which radiocarbon determinations range from 21,000 to before 40,000 b.p., with most samples falling within the range 38-29,000 b.p.), with no stratigraphical or typological hiatus (Hole and Flannery 1967, 153). At the same time the realization that human occupation in the Late Pleistocene was not confined solely to caves has led to the identification of a number of open air sites, inter alia the Zarzian or possibly even earlier sites of Turkaka, where over 1600 artefacts were collected from the surface, and Kowri Khan, both in the Chemchemal Valley not far from Jarmo (Fig. 18.2; elevation 750 m, Braidwood and Howe 1960, 28, 55-7). In a recent survey of the Holailan Valley, Luristan, Mortensen (1975) found Upper Palaeolithic materials in "7 caves and shelters, 8 open-air sites and a rich scatter of single finds." Faunal studies provide a further indication that climatic changes in the Zagros were not drastic in that Late Pleistocene archaeological sites yield the range of fauna one would expect in the area today were it not for over-grazing and motorized hunting. Thus archaeological data from the Zagros are of little value in assessing climatic fluctuation, but they do indicate that during the Late Pleistocene the region was far from uninhabitable, even at elevations over 1000 m.

There is little relevant palaeobotanical evidence but pollen data from archaeological deposits give some useful indications of local flora and environment. These are discussed in detail by Madame Leroi-Gourhan, but a brief comment on their relative dating may be useful. Shanidar (elevation 765 m) remains the sole published pollen sequence for the period of the Würmian glaciation in the Zagros, but this material has presented certain problems and "with a few exceptions the same pollens are found throughout the sequence. However, their frequencies vary, particularly those of the arboreal pollens, which are clearly more numerous in the older levels" (Leroi-Gourhan 1975, 562). Other unpublished Mousterian (Middle Palaeolithic) samples, e.g. Khoumian (Leroi-Gourhan, this volume), also suggest relatively high percentages of arboreal pollens. For the end of the Pleistocene the unpublished data from Ghanim Wahida's 1971 excavations at Upper Palaeolithic Zarzi (elevation 760 m) are of considerable importance. These have also been studied by Leroi-Gourhan and indicate vegetation characteristic of very dry steppe (G. Wahida, pers. comm.). Although there are no radiocarbon determinations from Zarzi, material from the 6 layers excavated appears to be typologically earlier than that from Palegawra, with radiocarbon determinations of 14,400 ± 760 b.p. (UCLA-1703A) and 13,350 ± 460 b.p. (UCLA-1714D). That is, Zarzi is likely to be dated no later than 15,000 b.p. Of more than 500 pollen grains from the lowest two levels, not one is arboreal. There is a very high percentage of liguliflorous Compositae. In the later samples both oak and pine occur but are rare; lilac (Syringa persica), almond and Oleaceae appear only sporadically. The number of grains of cereal type is also small. Curiously, only one grain of Artemesia was preserved. However, it should be reemphasized that, although the valley at Zarzi is narrow, the site is 100 m above the nearest stream, which flows about a km away; thus it is possible that pollen from trees growing along the stream might not have been carried upslope.

At Palegawra, (elevation 990 m, c. 14,000 b.p.) charcoal of oak, tamarisk, poplar and a conifer has been identified (Braidwood and Howe 1960, 59), roughly contemporary with the first continuous curves of oak and pistachio at Zeribar some 120 km to the east and 370 m higher. However, at Zeribar at this time "tree pollen remains very scarce" (van Zeist 1967, 308). At Shanidar B2 (elevation 765 m, 12,000 ± 400 b.p. W-179) a scrub savanna had already begun to develop and oak had reached 6%; Oleaceae and Pistachio are also found. Unlike Zarzi, Liguliflorae Compositae are present only in small quantities (G. Wahida, n.d.) Shanidar B1 (10,600 ± 300, W-667) and the nearby open air site Zawi Chemi Shanidar, which extends over an area of approximately 215 x 275 m (10,000 ± 300 b.p. W-681; elevation 425 m; R. L. Solecki 1964) would appear to be approximately contemporary with the early "Mesolithic" of Abu Hureyra in north Syria (elevation 275 m). At nearby Mureybet pollen data suggest steppic conditions in the 9th millennium b.c., an observation perhaps qualified by the very presence of these Mesolithic sites in what is today a relatively arid zone (Figs. 18.1, 18.7), with perhaps a "wet" phase beginning about 8000 b.c., increasing after 7800. This is indicated by diminishing Chenopodiaceae, which had been abundant in the Mesolithic levels, and by an increase in arboreal pollen. Percentages of the latter, however, continue low. Around 6500 b.c. numerous Compositae (Liguliflorae) indicate a new stage, possibly towards dryness, "but it remains unexplained why, at Ramad as at Mureybet, it is the Compositae tubiflores that are predominant towards 6000 b.c." (Leroi-Gourhan 1974). It hardly needs emphasizing, of course, that pollen data from archaeological sites, invaluable as they are in relation to specifically local conditions, can be locally idiosyncratic in reflecting unusual geographical situations, in themselves possibly important in the choice of site location, or the degradation of environment that human interference effects. It will be seen (below) that settlement data from the Iraqi Jazirah would seem to indicate a marginally wetter phase during the period c. 6500-5000 b.c., and perhaps extending into the 5th millennium.

To return to the Mesolithic—in the lowland areas of northern Iraq only one or two sites are known that are perhaps comparable with Zawi Chemi and Euphrates sites like Mureybet. Such negative evidence, unfortunately, is as likely to reflect lack of intensive archaeological exploration as lack of sites. Moreover, in northern Mesopotamia, where optimal site locations (especially with regard to water supply) may have been occupied for millennia, identification of possible Mesolithic or even early Neolithic occupation, now possibly lying well below modern plain level, becomes a virtual impossibility. If there are other Jericho's, they will be difficult to detect from surface collections, however, sophisticated the sampling techniques! One can only hope to find such sites in the situation of marginal environments, where settlement has not been intensive. However, it should be reiterated that much of northern Iraq remains unexplored; indeed largely for political reasons archaeological survey has rarely been possible in recent years.

One comparatively early site, perhaps comparable with Zawi Chemi, is M'lefaat, situated not far east of Nineveh (Fig. 18.2), elevation c. 300 m, at the junction of the foothill zone and the rolling rainfed plains of later Assyria (Braidwood and Howe 1960, 27; Oates 1973, 151). A new discovery is the 7th millennium b.c. (?earlier) site of Maghzaliyah, identified by the Russian expedition working at Yarim Tepe near Tell Afar, a tell with some 8 m of aceramic deposits, rich lithic industries, circular stone house foundations, stone bowls, beads, bracelets, figurines, etc. The fact that this tell (to some extent masked by the natural hill beneath it) lies just off the main Mosul-Sinjar road, in an area which is archaeologically well-known, only serves to emphasize the point that absence of evidence in archaeology cannot be assumed to imply the actual absence of the feature being sought.

Eastern Arabia and the Gulf

In Saudi Arabia recent studies of lacustrine sediments, especially in the Rub'al Khali, indicate two main periods of high water level, ~36, 000-17, 000 b.p., with a concentration of dates between 30, 000-21, 000, and a "sub-pluvial", ~9, 000-6, 000 b.p. /c. 7000-4000 b.c. (McClure 1976, 1978), or perhaps beginning as early as 10, 000 b.p. on the basis of a new radiocarbon determination from the currently inactive Wadi Dawasir just to the north (see below). At the same time isotope dating of aquifer ground water in the Kharj Oasis, southeast of Riyadh, averages 35, 000-20, 000 b.p., and indicates that some recharge may have taken place as late as 5000 b.p. (Zarins et al. 1979, 10). Active terrace formation within the Central Province has been dated to c. 8000 b.p. and in the Dawasir hinterland to c. 6500 b.p. (ibid.). In the Rub'al Khali the earlier "wet" phase appears to have been followed by a period of "intense aridity" during which the first dune systems were deposited in the region; the Holocene lakes, apparently largely playa or "mud lakes", were perched in silty hollows in these dunes, frequently associated with bovid bones and flint tools of "Neolithic" type. Similar evidence comes from the region of Jubbah in the Great Nefud (Parr et al. 1978) where one deposit of lacustrine origin yielded a radiocarbon determination of 25, 630 ± 430 b.p. (Q-3117) and a palaeosol or swamp deposit, 6685 ± 50 b.p. (Q-3118) (Garrard n.d.). Here Middle Palaeolithic (Mousterian) sites, presumably associated with the first wet phase, were found both on the ridges and slopes overlooking valleys and inland basins, and on alluvial surfaces adjacent to drainage channels and sabkha. In the Wadi Dawasir "substantial archaeological remains from the Mousterian period" were also situated on alluvial terraces (Zarins et al. 1979, 10). These data and those from the Rub'al Khali suggest that the Arabian interior was better watered and supported more vegetation during the periods in question.

No unequivocal evidence of intervening Upper Palaeolithic or Epipalaeolithic occupation has been found in Arabia (Parr et al. 1978, 35; Zarins et al. 1979, 13). These data agree well with those from elsewhere in the Arabian area, e.g. Qatar, Oman, etc., where no typologically identifiable Upper Palaeolithic industries have been discovered, a situation which appears to obtain also in the desert margins of southern Iraq, west of the Euphrates, although the latter area is archaeologically even less well explored. This apparent lack of occupation may possibly be related to the period of Late Glacial aridity c. 15, 000-13, 000 b.p.) for which there is evidence, inter alia, in East Africa (Street and Grove 1976, 386). One must note, however, the lack of any typological sequence of chipped stone materials from Arabia and therefore the lack of certain dating criteria. As we have seen, there is no lack of evidence for occupation in the Zagros at this time, when charcoal of oak, tamarisk, poplar and a conifer have been identified at Palegawra (c. 14, 000 b.p.).

More archaeologically informative are later sites in the Eastern Province, Qatar and Bahrain at which a type of Mesopotamian pottery known as 'Ubaid has been found (Fig. 18.3). Pottery of this type ('Ubaid 3-4) occurs throughout Mesopotamia and from Western Iran to Northeastern Syria. Relevant radiocarbon determinations are somewhat erratic but suggest that this period is to be dated very approximately between 6500-5500 b.p. /4500-3500 b.p. (Oates n.d.; Oates and Oates 1976, 138-9). [It should perhaps be remarked that in relation to historically established dates from Mesopotamia and Egypt, a date as late as 3500 is not acceptable for the end of the 'Ubaid phase; thus, "historically", the calibrated range of c. 5400-4400 B. C. is to be preferred. However, b.p./b.c. determinations are used throughout this article for reasons of consistency; approximations of radiocarbon determinations for dates falling within the historical periods (below), and therefore based on calendric as opposed to radiocarbon calculations, are estimated by following Clark's calibration curve (1975) in reverse.]

The coastal distribution of the Arabian 'Ubaid sites is clear from Fig. 18.3 Lack of sweet water explains the absence of sites further north. Indeed the 'Ubaid sites lie in areas that still today provide sweet water, good fishing, abundant shell-fish and good harbours. A few are found inland, especially around Hofuf in the well-watered al-Hasa oasis. The Mesopotamian component of these sites (i.e. the painted and plain 'Ubaid pottery) has been shown to be of non-local origin, in that some 50% of sherds so far tested by neutron activation can be shown to have originated not only in Mesopotamia but specifically from the southernmost group of 'Ubaid sites so far identified in Iraq (Ur, Eridu and Tell al 'Ubaid), that is, from those sites closest to the Gulf and the Arabian coast; none of the painted wares tested matched local Arabian clays (Oates et al. 1977). Thus this material evidence seems to represent repeated and short-term incursions by people from Mesopotamia, almost certainly by sea, during the period sometime before and after 6000 b.p./4000 b.c. Indeed, most of the Arabian 'Ubaid sites are little more than temporary camping grounds, often with only one or two, at most a handful, of sherds; even at the four larger mound sites evidence for occupation appears to have been intermittent (Masry 1974). Accompanying the 'Ubaid pottery is a local "Neolithic" flint industry dominated by small tanged arrowheads exhibiting fine pressure flaking (Qatar D, Kapel 1967). Comparable flint material has been recovered from numerous sites in the Eastern Province, especially around the major oases at Hofuf and Yabrin. Similar materials are reported also from the Rub' al Khali and from Central Arabia. Indeed chipped stone industries with virtually identical tanged arrowheads have a very broad distribution on the Arabian peninsula and to the east in Africa.

In the Central Province recent survey has revealed a number of such "Neolithic" flint sites in the Wadi Dawasir region, associated with radiocarbon determinations of 9790 ± 250 b.p. (GX-5726, "marsh deposit", c. 7840 b.c.) and 8025 ± 260 b.p. (GX-5725, gastropod shells, c. 6075 b.c.). Shells apparently associated with an active phase of the Wadi Dawasir have provided a further date of 10890 ± 560 b.p. (GX-5727, c. 8940 b.c.) (Zarins et al. 1979, 20). In the Eastern Province some 40 "Neolithic" flint sites have been identified to the east of Abqaiq (Potts et al. 1978, 8), while in the al-Hasa region around Hofuf another 15 or so are known (Adams et al. 1977, 31).

The latter were situated "near springs or overlooking shallow channels or interior drainage bains". Such sabkha deposits today contain surface water only after the periodic heavy rains, but they were presumably more regularly supplied at the time the sites were in use. At Al-Hasa "occupation was apparently associated with the middle and upper reaches of a wadi network channelling run-off from higher, more desiccated areas, in which shallow lakes formed at intervals behind aeolian sands then being actively laid down. A much larger flow was added at a lower elevation by artesian springs within the oasis itself, as it still is today" (ibid. 27).

Undoubtedy the most informative of the spring sites is Ain Qannas, excavated by Masry in 1972. The site is a "spring-mound" consisting of spring-head sediments interspersed with archaeological materials. Of 14 levels the lowest 10 appeared to contain only chipped stone artefacts similar to Holocene materials in Qatar and elsewhere in Arabia; to these in the upper strata was added the distinctive 'Ubaid ceramic. The sediments, analyzed by Butzer (Masry 1974, 206 ff.), show considerable climatic fluctuation—short pluvials interrupting relatively long dry intervals. Unfortunately there is no way of estimating the time lag between recharge of the relevant aquifer and the actual flooding of the spring. Radiocarbon determinations place the earliest (apparently aceramic) levels sometime around 7000 b.p. (Masry 1974):

level 9	charcoal	7060 ± 445 b.p.	5110 b.c.	GX-2821
level 11	charcoal	6655 ± 320 b.p.	4705 b.c.	GX-2823
level 12	charcoal	6885 ± 325 b.p.	4935 b.c.	GX-2824

Radiocarbon determinations obtained from samples associated with the 'Ubaid "intrusion" in Eastern Arabia are reasonably consistent with those from Mesopotamia itself (Oates, n.d.). The following come from the major Arabian sites (Golding 1974):

Dosariyah	surface	shell	6135 ± 120 b.p.	4185 b.c.	I-5786
	level 7	shell	6900 ± 330 b.p.	4950 b.c.	GX-2818
Khursaniyah	surface	shell	6157 ± 238 b.p.	4207 b.c.	SM-1263
Abu Khamis	surface	shell	5750 ± 65 b.p.	3800 b.c.	UGa-315
	level 8	charcoal	5565 ± 255 b.p.	3615 b.c.	GX-2819
	level 8	shell	5660 ± 182 b.p.	3710 b.c.	GX-2820

The 'Ubaid presence along the Gulf coast and inland around Hofuf (a single sherd has been reported as far south as Yabrin) is well-documented. It seems likely that this period and the earlier phase apparently represented by the aceramic campsites at Ain Qannas must represent a time of relative climatic amelioration.

Perhaps a reflection of increasing aridity in the 4th millennium, following the 'Ubaid phase which seems to have ended around 35-3600 b.c., is the apparent absence in Arabia of sites attributable to the succeeding (Uruk) phase in Mesopotamia (4th millennium B.C.; Late Uruk = approximately 5000-4400 b.p., 3200-2500 b.c.). Although it is clear throughout the Gulf area that contact with Mesopotamia is lost at this time (??perhaps coinciding with a sea level maximum that may have affected navigation in the region of the present Shatt al-Arab), the ambiguity and imprecision of dating by flint tool typology must again be emphasized. It has often been assumed that all aceramic "Neolithic" flint sites are necessarily pre-'Ubaid, but the settlement of Al Markh on Bahrain demonstrates the persistence of the "Neolithic" chipped stone tradition after the loss of contact with 'Ubaid Mesopotamia. Thus one cannot certainly argue lack of occupation in the post-'Ubaid Eastern Province. All that is beyond doubt is that contact with Mesopotamia is lost until, at the earliest, perhaps 3000-2800 B. C. (roughly 4300-4100 b.p. on the basis of reverse calibration). One should note, however, that fourth/third millennium B. C. radiocarbon determinations from archaeological samples are far from consistent; moreover, the typological dating of third millennium materials in Arabia remains contentious (cf. e.g. Frifelt 1975, Tosi 1976).

Al Markh is also of interest in relation to changes in sea level. Suggestions of a maximum rise in the 4th millennium of some 3 to 4 m above today's level (inter alia, Nützel 1978)—supposedly substantiated by the presence of a piece of barnacle-covered plaster on an 'Ubaid coastal site some 5. 5 m above present sea level (Golding 1974, 24) must be questioned in view of the situation of Al Markh, which at the time of its occupation (probably sometime not long after 5600 b.p. /3600 b. c.) lay on a small island off the west coast of Bahrain (Site 2027, Fig. 18. 4). "The channel between these islands silted up at some later date forming an area of sabkha... Al Markh lies at the eastern end of a range of sand dunes which stretch under the sea all the way to Saudi Arabia. As the sea level rose these dunes were drowned, and by c. 4000 b. c. all that remained above water was a small island extending further to the north and west than the present coastline, with Al Markh close to its eastern edge" (Roaf 1976, 158).

Al Markh is now c. 1400 m from the shoreline. Its earliest occupation level lies only some 1.40 m above present high tide level, while the uppermost level, representing the later, post-'Ubaid, flint-using inhabitants is situated at less than 2. 0 m above present high tide (Fig. 18. 5). Indeed the maximum height of the surviving mound surface is only +2. 35 m. This would seem to suggest a sea level maximum in the 4th millennium not much more than one metre above present (see also Vita Finzi 1978, 63). The shell mound of Ras al Jazayir (2051, Fig. 18. 4), excavated by a Danish expedition, which provded to be of the Barbar period (c. 2000 B. C. , ??1650 b. c.) lay on the western coast of the original small island (Roaf 1976, 158-9). The exact date of the in-filling of the channel is unknown, but it is possible that this coincided with the latter, apparently post-'Ubaid phase at Al Markh when goat herding was introduced and the dugong and large carnivorous fish appear among the faunal remains (the earlier 'Ubaid phase was characterized by a reliance on medium-sized ground feeding fish such as Sea Bream, Roaf 1974).

Mid to late third millennium B. C. occupation is well-attested in Bahrain, Oman and Abu Dhabi, especially on the island of Umm an-Nar and at the inland oasis of Al Ain/Buraimi. What appear to be third millennium ceramic types occur around the Al-Hasa and Yabrin oases and south of Abqaiq (Potts et al. 1978, 8). Late third millennium "Dilmun red-ridged ware" is found in the area of Dhahran and to the east, although not directly on the coast (op. cit. , 9). Except on Bahrain (and possibly Buraimi) there is an apparent absence of ceramic material attributable to the period from the early second to the early first millennium B. C. (? ?3500-2500 b. p.). Present evidence, however, is far too minimal to argue any widespread abandonment of Eastern Arabia during this time, although it does coincide with certain tribal movements out of Arabia attested in Mesopotamian historical sources (Aramaeans, Chaldeans, Arabs, etc.). Although some Abu Dhabi material may date from the late second, early first millennium B. C. (W. Y. Al-Tikriti, pers. comm.), and a number of Iron Age (first millennium B. C.) cemeteries and settlements are attested, especially in the vicinity of Buraimi, it is not until the Hellenistic period, clearly a flourishing time in southern and eastern Arabia, that there is abundant evidence for settlement. To what extent this reflects the ambitions of Alexander and his generals rather than any climatic amelioration cannot of course be ascertained.

To sum up, in most respects the archaeological data from Eastern Arabia are too tenuous to argue subtleties of climate. However, the widespread "Neolithic" flint sites and the associated 'Ubaid intrusion would seem to support the suggested subpluvial ∼9000-6000 b. p. , and indeed probably its extension into the early 6th millennium b. p. (? ? down to c. 3500 b. c.). The apparent absence of late 4th and 2nd millennium B. C. occupation might suggest conditions of greater aridity roughly 5000-4400 b. p. and 3500-2500 b. p. , but here one must emphasize the essentially negative nature of the evidence and remark both on the general lack of settlement data and the presence of large numbers of undated tumuli. One should also note the recent radiocarbon determination for recharge of the aquifer ground water in the Kharj Oasis, perhaps as late as 5000 b. p. Settlements of Umm an-Nar attribution on the island itself and at Buraimi might suggest some climatic amelioration around and probably before 4000 b. p. , but here especially there remains an unresolved discrepancy between radiocarbon and assumed calendar dates. Iron Age and Hellenistic data may support a further amelioration of climate in the latter part of the first millennium B. C. , although by this time political factors may well mask the possible relevance of settlement data to climate.

Mesopotamia

Several agriculturally marginal regions in Mesopotamia offer some insight into possible past fluctuations of climate, in particular the Jazirah of northern Iraq and the Khabur basin to the northeast in Syria. Our own archaeological field work, both excavation and survey, has been concentrated in such regions precisely for this reason (Tell al Rimah, Tell Brak, Choga Mami).

Hatra: Jazirah sites

The Parthian site of Hatra is situated in the Jazirah or dry steppe which extends from the Tigris to the Khabur in northern Mesopotamia (Figs. 18. 1, 18. 6-8). Today this area consists of many thousands of square km of treeless and salty steppe, with seasonal watercourses and brackish lakes, bitter springs and waterholes. Annual rainfall is in the region of 200 mm or less. When it does rain, storm water drains in the form of sheetwash to form playa lakes in low-lying depressions. A pattern of unconnected playa starts a few km to the west of Hatra and continues far into the Jazirah (Dorrell 1972, 69).

Hatra itself was essentially a tribal camping ground which assumed great religious and political importance in the Parthian period. A number of sweet water wells are to be found at the site itself—indeed Hatra represents the westernmost point in the Jazirah where sweet water can now be found—while the nearby Wadi Tharthar provided a perennial though brackish water supply (Fig.18.8). Archaeological surveys carried out by Diana Kirkbride in 1970 and more recently by Sayyid Jabir Ibrahim of the State Organization of Antiquities, Baghdad, have revealed over 100 small archaeological sites in the vicinity of Hatra, by far the majority of which are prehistoric. As can be seen from the various rainfall maps the area is well outside the modern limits of reliable agriculture (reliable minimum 200 mm per annum, which is approximately the 300 mm isohyet), i. e. not an area in which one would expect to find prehistoric village settlements. About 20 km north of Hatra the line of early tells deepens towards the west and northwest, running in an arc up to the region of Tell Afar (Fig. 18. 9), scene of the Russian excavations at prehistoric Yarim Tepe and the British at second millennium Tell al-Rimah. In general the prehistoric sites appear to increase in size as one moves from Hatra into the rainfall zone; from c. 50 km north of Hatra the prehistoric deposits tend to be covered by later ones, i. e. settlement becomes more persistent in later periods (Kirkbride 1971, 4). In recent times the land around Hatra has been farmed by absentee large landowners who can afford the constant loss of crops for the compensation of a very rich harvest in the occasional year of heavy rain, certainly not a situation that could have been tolerated by prehistoric farmers.

Seven sites in the Hatra area yielded surface material attributable to an early phase of the Hassuna culture chronologically comparable with Bouqras (6400-5900 b. c., GrN 8258-8264; Akkermans et al., n.d.). This phase was first identified in northern Iraq by the excavation of Umm Dabaghiyah (Fig. 18.2)(Kirkbride 1972). Similar occupation has been discovered by the Russians at Yarim Tepe, Tell es-Sotto and Kul Tepe near Tell Afar (Bashilov, Bolshakov and Kouza 1980), and by the Japanese at the nearby site of Telul eth-Thalathat. With the exception of Maghzaliyah and M'lefaat (cf. above) these sites constitute the earliest phase of settlement so far identified in the northern plain. Palaeobotanical data from the lowest level excavated at Umm Dabaghiyah included large numbers of salt swamp seeds (Chenopodiaceae, Sea-blite and Salsola); indeed it would appear that the site lay near the edge of a brackish lake which still survives as a large playa about a km south of the site. Conspicuously little arboreal charcoal was found. Fragments of wall plaster included imprints of glumes and inner dorsal husks of Triticum dicoccum, as well as one well-preserved spikelet fork, suggesting that the emmer was actually grown and harvested somewhere in the vicinity (pace Kirkbride 1974, 88). Einkorn and naked barley (Hordeum vulgare var. nudum) are also present (Helbaek 1972, 17-18). A high percentage of onager bones (c. 70% of the faunal samples recovered) and the presence of wall paintings that appear to represent hunting scenes and what seem to have been communal storage units have led to the interpretation of Umm Dabaghiyah as an onager-hunting "trading outpost" (Kirkbride 1974). However, it should be noted that all five Neolithic domestic animals were represented among the fauna (10-13%, Bökönyi 1973) and that the evidence for cultivated foods may be small owing to the very limited number of soil samples actually examined (flotation was not carried out at the site, Kirkbride 1972, 12). None of the numerous other prehistoric sites in the area has as yet been excavated; thus it is not possible to determine how representative is the assumed economy of Umm Dabaghiyah, the furthest south of the known settlements of this early Hassuna phase.

Comparable archaeological materials come from Bouqras, to the west in Syria (Fig. 18.7), where modern rainfall averages only c. 150 mm per annum and, as at Hatra, does not normally permit dry farming (Akkermans, van Loon, Roodenberg and Waterbolk, n.d.). I do not intend to elaborate on Bouqras in the home of its excavators, only to note here the extensive evidence for settled life and the presence, as at Umm Dabaghiyah, of domesticated sheep, goat, cattle and pig. Irrigation of the river valley may explain the situation of Bouqras, as later Baghouz (Euphrates) and Tell es-Sawwan (Tigris) (Fig. 18.7), in areas of even more limited rainfall (Table 1), but there can be little doubt that the evidence from the Jazirah at this time is suggestive of climatic amelioration in the period from c. 8500-8000 b.p., and, in the case of the Iraqi evidence, continuing throughout at least the 8th millennium b.p. (Hassuna/Samarra). Some Halaf and 'Ubaid sites (c. 7000-6000 b.p.) are also found in the Hatra area. However, these are fewer in number (?? though perhaps larger with comparable population) than the Hassuna/Samarra settlements.

Of 17 sites recorded by Sayyid Jabir Ibrahim in the immediate vicinity of Hatra, 9 produced materials datable to the 8th millennium b.p./6th millennium b.c. and 7 were attributed to the succeeding 7th millennium b.p.; only two, however, yielded surface materials of the later 4th millennium B.C. Uruk phase (? 5500-4300 b.p.). This seemingly striking decrease in settlement numbers coincides very approximately with the assumed abandonment of post-'Ubaid Arabia. Four third millennium (following Clark, roughly 4200-3600 b.p.) and no second millennium B.C. sites were identified, a situation again apparently comparable with the Arabian data. Ten Late Assyrian sites were recorded (900-600 B.C.; ? 2700-2450 b.p.) and there is also evidence for some Hellenistic, Parthian and Sassanian occupation. To some extent these later settlements must have been influenced by political considerations, but Late Assyrian occupation, for example, is unlikely to have been as extensive if conditions had been comparable with those of today. Kirkbride's survey yielded similar results: of her 87 sites, some 40 were prehistoric, for the most part Hassuna/Samarra. About half of these prehistoric villages yielded Halaf pottery as well. Most of the sites of historical date were Late Assyrian, with some Parthian (1972, 3).

Further evidence in support of a wetter phase in Northern Mesopotamia beginning sometime after 9000 b.p. comes from Persian Gulf cores recording the varying deposition of sediments deriving from the Tigris and Euphrates and presumably reflecting conditions of precipitation in the highland areas which are their source. Such cores are not closely dated, but would appear to indicate "dry" conditions c. 9000 b.p. followed by a "wetter" phase (Diester-Haass 1973). By the 6th millennium b.c. the development of irrigation techniques permitted extensive settlement in such arid regions as that between Baiji and Samarra on the Tigris and on the Euphrates at Baghouz.

Modern rainfall figures for these areas can be found in Table 1. From this time onward, and perhaps even earlier (?Bouqras), the use of irrigation obscures the relevance of settlement patterns to environmental conditions in the alluvial regions of Mesopotamia. In the north, however, where irrigation is possible only within the very narrow river valleys, some later shifts in pattern of settlement may be significant.

Khabur Basin

In 1975 a brief survey of the Khabur basin was carried out by David Oates and Kassim Tuweir of the Department of Antiquities in Damascus. This survey was deliberately confined to the area where rain-fed crops are at present not wholly reliable, between modern Hasake, south of which cultivation is now possible only by irrigation (now of course pump-assisted), and Chagar Bazar, some 45 km to the northeast, north of which rain-fed crops are at present reliable (Fig. 18.10). The survey concentrated on the larger mounds that offer longer sequences of occupation. The results may thus be somewhat distorted, but are nonetheless interesting (D. Oates 1977). Pottery of the Halaf period (7th millennium b.p.) was rare, despite the fact that Halaf sites are plentiful in the northern part of the Khabur region and particularly numerous in the Wadi Dara drainage system to the north of Chagar Bazar (Meijer 1978/79, 174; Davidson and KcKerrell 1976) "In the fourth millennium, however, there seems to have been a startling expansion of settlement, for only three sites failed to yield Uruk pottery" (D. Oates 1977, 234). Tell Bezari, for example, (Fig. 18.10) consists of over 10 metres of Uruk deposits. This period of extensive occupation seems to have continued through most of the third millennium B.C. A considerable contraction of settlement, however, appears to have occurred in the early and middle second millennium B.C., a phenomenon noted also in the Jazirah in Iraq. Second millennium occupation is characterized by a line of medium-sized towns with irregular polygonal enceintes, such as Tell Beidar, Tell Bati and Tell Hamidi in the Khabur (Fig. 18.10) and Tell al Rimah, Tell Hadhail and Tell Huwaish to the south of Jebel Sinjar (Fig. 18.9). In both areas there appears to have been a total breakdown of settlement c. 1200 B.C. Obviously in historical times the ability of communities to maintain themselves on the fringes of the Jazirah has depended as much on the existence of a strong central government as on the vagaries of climate (unfortunately we are unable to assess the possible importance of the former factor in prehistoric times). But one of the most common reasons for political unrest is crop failure or the loss of agricultural or grazing land. As around Hatra there appears to have been a revival of settlement in Late Assyrian times both in the Khabur and south of Jebel Sinjar (D. Oates 1977, 234-5).

With the single exception of the Uruk period in the 4th millennium (from sometime before 5000 b.p. to c. 4300 b.p.) the data from northern Mesopotamia appear generally comparable with those from Eastern Arabia. As we have already noted, however, in the case of 4th millennium B.C. Arabia loss of contact with Mesopotamia, and thereby the loss of precisely datable surface materials, may reflect no more than the rise in sea level attested at this time. Certainly in the Khabur basin it would appear that rainfall was either marginally greater or more reliable in Uruk times. The settlement pattern at this period contrasts markedly with that of the earlier Halaf, which is concentrated to the north of Chagar Bazar and along the foothills, and with that in the second millennium B. C. attested along the Beidar, Bati, Barri line. Although Tell Brak, which was undoubtedly a major Uruk and earlier prehistoric site (at which time the Jaghjagha flowed much closer to the tell), was still inhabited in the second millennium, it was by this time a settlement of considerably less importance.

Hamrin Basin

Intensive survey and environmental studies recently carried out as part of a salvage operation in the Hamrin basin, just to the east of Jebel Hamrin and west of Khanaqin (Figs. 18.2, 18.7), may also add to our knowledge of prehistoric climate in Mesopotamia. This is today an area of agriculturally marginal rainfall (cf. Jalaula, Table 1), Here it would be especially interesting to know whether the absence of 6th millennium b.c. settlement (the earliest sites are very approximately attributable to the Choga Mami 'Transitional' phase, 6846 ± 182 b.p., 4896 b.c., BM-483) and, more unexpectedly, the almost total lack of Uruk sites might reflect a marginal increase in precipitation at these times, as apparently attested elsewhere, and thus possibly a corresponding extension of the marsh areas which today in the Hamrin prevent settlement over much of the basin (Sumer 34, 1978, 12-13). Certainly there are numerous Samarran and Uruk settlements in the vicinity of Mandali, just to the south (Fig. 18.2; cf. Oates 1966, 1968).

Conclusions

The very considerable limitations of archaeological evidence must be recognized in any attempt to infer associated climatic conditions. Nonetheless there would appear to be some degree of consistency among settlement data from the arid zones of Mesopotamia and Arabia. In both regions archaeological data (Middle Palaeolithic and "Neolithic") lend general support to the Late Quaternary 'moist' phases argued on the basis of studies of lacustrine sediments and other geomorphological features in Saudi Arabia and East Africa. However, dating criteria, especially among the chipped stone industries, are inadequate to establish whether or not there was any abandonment of the desert margins during the postulated period of Late Glacial "intense aridity" (cf. above), and it should be noted that at least in the Zagros at this time not only is there evidence of widespread occupation but at Palegawra (c. 14,000 b.p.) the presence of oak, tamarisk, poplar and a conifer is attested.

Although pollen evidence (Mureybet) is interpreted as indicating a 'dry' phase in the 9th millennium b.c., it is perhaps significant that many 'arid' sites, including Mureybet itself, were actually settled for the first time during this period. From the late 7th throughout the 6th millennium b.c. it is difficult to argue other than a 'moist' phase in both lowland Mesopotamia and eastern Arabia; this is in contradiction to the widely accepted pattern of desiccation proposed elsewhere (e.g. Palestine) at this time. In both Mesopotamia and Arabia a later 'wet' phase can be argued for the 3rd millennium B.C., while at least in northeastern Syria this phase must have begun at least as early as the mid 4th millennium. During the 2nd millennium B.C. settlement patterns in all areas indicate some retrenchment, and there is a consistent pattern of expansion towards the latter part of the first millennium.

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TABLE 1: Rainfall figures based on Republic of Iraq Meteorological Department and Development Board Statistics; approximate mean annual figures drawn from Guest and al-Rawi (1966)

Station	Years Recorded	Lat.	Long.	Elevation	Maximum water year (mm)	Approx. mean	Minimum water year (mm)	Month of May			Month of October			Nearby archaeological sites
								Max.	Mean	Min.	Max.	Mean	Min.	
A. Mountain Region														
Amadiya	1936-58	37°05'	43°20'	1236 m	1375.4	870	540.4	175		–	84.6		0.0	
Chemchemal	1939-58	35°32'	44°51'	701 m	1110.5	556	187.1	118.4		0.0	29.9		0.0•	Jarmo, elevation *c.* 750 m
Halabja	1936-58	35°11'	45°59'	724 m	2301.0	815	353.9	120.6		0.0	423.0		0.0†	
Penjwin	1939-58	35°37'	45°58'	1311 m	1843.3	1220	200.6	223.0		–	99.0		0.0†	
B. Northern Plain and Steppe														
Mosul	1923-58	36°19'	43°09'	222 m	643.2	385	188.4	79.2	20.3	tr.	54.6	7.1	0.0†	Hassuna
Erbil	1935-58	36°11'	44°00'	414 m	1095.5	494	202.7	108.1		0.0	54.2		0.0†	
Tell Afar	1939-58	36°22'	42°28'	373 m	478.8	337	193.9	105.7		0.0†	34.3		0.0•	Yarim Tepe
Tuz Khurmatli	1935-58	34°53'	44°39'	220 m	404.4	280	178.0	30.0††		0.0	0.0		0.0	Matarrah
Mandali	1935-58	33°54'	45°33'	137 m	549.0	300	191.9	16.3		0.0†	14.7		0.0•	Choga Mami
Baiji	1936-58	34°56'	43°29'	115 m	218.4		—	51.8		0.0	16.3		0.0	
Samarra	1935-58	34°11'	43°50'	65 m	215.0	155	67.0	49.3		0.0†	43.5		0.0•	Tell es-Sawwan
Anah	1935-58	34°28'	41°57'	150 m	207.7	132	74.4	30.0		0.0†	26.0		0.0•	Baghouz
Rutba	1928-58	33°02'	40°17'	615.5 m	248.4	121	46.8	67.9	9.7	tr.†•	65.3	5.0	0.0•	
Jalaula	1936-58	34°16'	45°09'	119 m	365.0	235	75.0	17.0		0.0	18.0		0.0	Hamrin
C. Southern Alluvium														
Baghdad	1887-1958	33°20'	44°24'	34.1 m	483.2 ⊕	149	50.6	31.7	7.1	0.0†	21.2	3.0	0.0•	
Diwaniya	1929-58	31°39'	44°59'	20.4 m	195.3	116	42.9	113.6	9.0	0.0†	3.8	1.3	0.0•	Nippur
Nasiriya	1940-58	31°01'	46°14'	3.0 m	249.3	121	33.5	46.8	5.4	0.0†	10.8	1.3	0.0•	Ur, Eridu
Basra	1900-58	30°34'	47°47'	2.4 m	314.1	169	53.7	56.2	7.3	0.0	20.8	0.8	0.0•	
Fao	1935-58	29°59'	48°30'	2.0 m	339.0	190	54.5	20.5		0.0†	17.6		0.0•	

†† only recorded May rain.

⊕ in 1893-4; the maximum figure for a period comparable with the rest of the table is 255.6 in 1954-55.

† frequently no rain or very small amounts.

• frequently no rain in November as well as October.

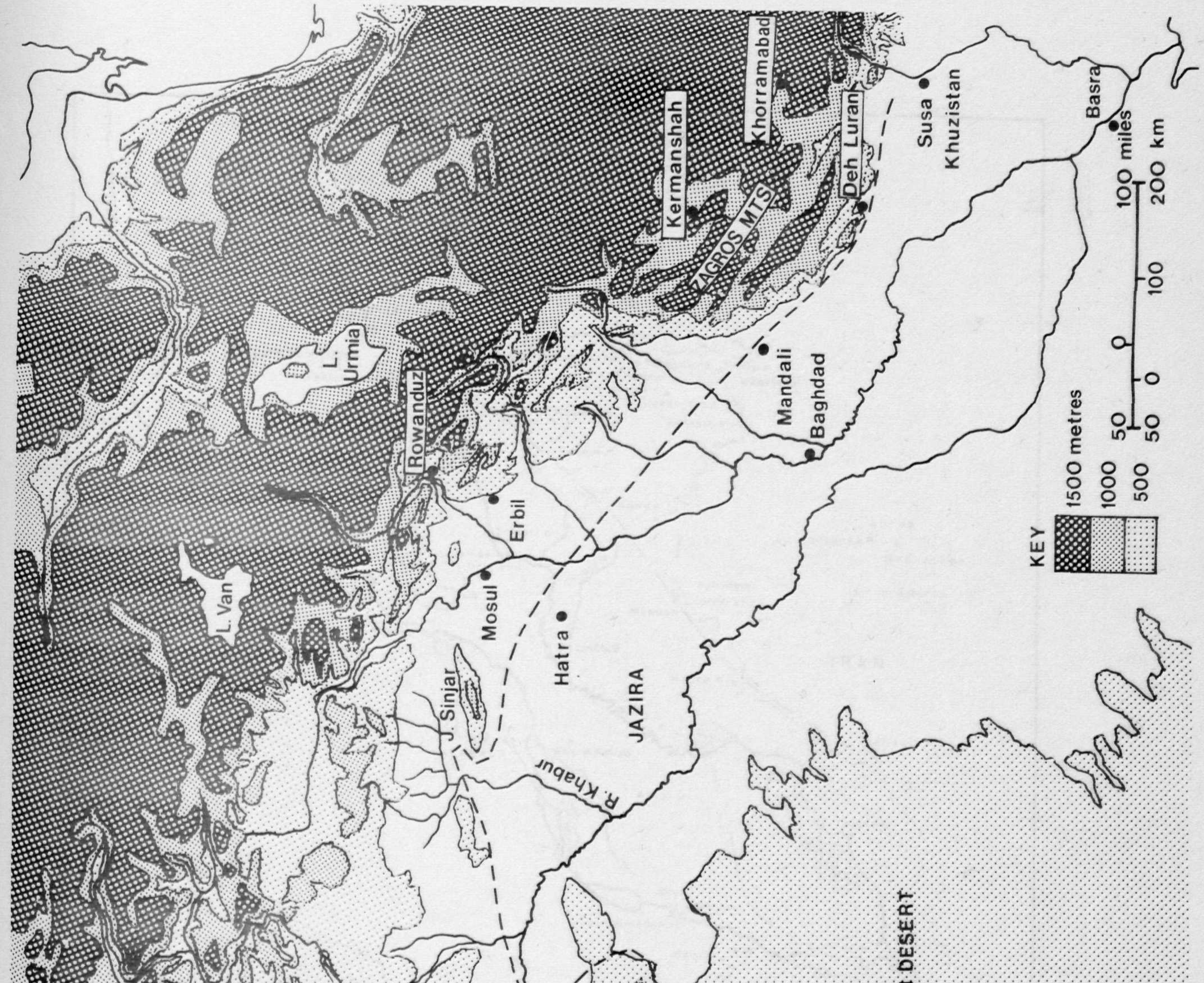

Fig. 18.1 Western Asia: the dashed line represents an approximation to the present limits of rainfed agriculture (reliable 200 mm isohyet).

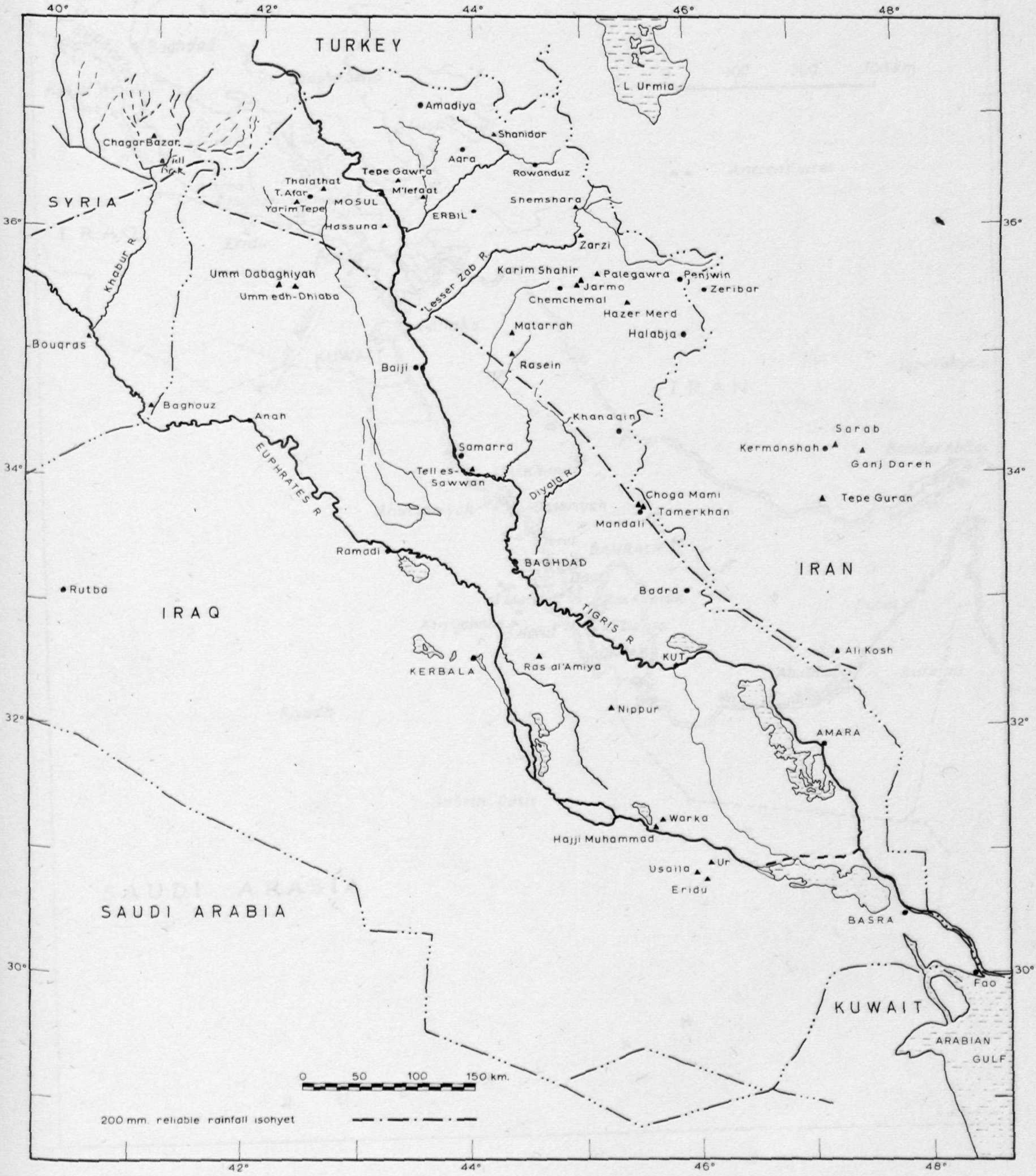
40°
42°
44°
46°
48°
36°
34°
32°
30°
TURKEY
L. Urmia
Amadiya
Shanidar
Aqra
Rowanduz
Chagar Bazar
Tell Brak
Tepe Gawra
Thalathat
T. Afar
M'lefaat
MOSUL
Yarim Tepe
SYRIA
Hassuna
ERBIL
Shemshara
Zarzi
Khabur R.
Lesser Zab R.
Umm Dabaghiyah
Umm edh-Dhiaba
Karim Shahir
Palegawra
Penjwin
Jarmo
Zeribar
Chemchemal
Hazer Merd
Matarrah
Halabja
Bouqras
Rasein
Baiji
Baghouz
Anah
Khanaqin
Sarab
Kermanshah
Ganj Dareh
Samarra
Tell es-Sawwan
EUPHRATES R.
Diyala R.
Choga Mami
Tamerkhan
Tepe Guran
Mandali
Ramadi
BAGHDAD
IRAN
Badra
Rutba
IRAQ
TIGRIS R.
Ali Kosh
KUT
KERBALA
Ras al'Amiya
Nippur
AMARA
Warka
Hajji Muhammad
Usaila
Ur
Eridu
SAUDI ARABIA
BASRA
Fao
KUWAIT
ARABIAN GULF
0
50
100
150 km.
200 mm. reliable rainfall isohyet

Fig. 18.2

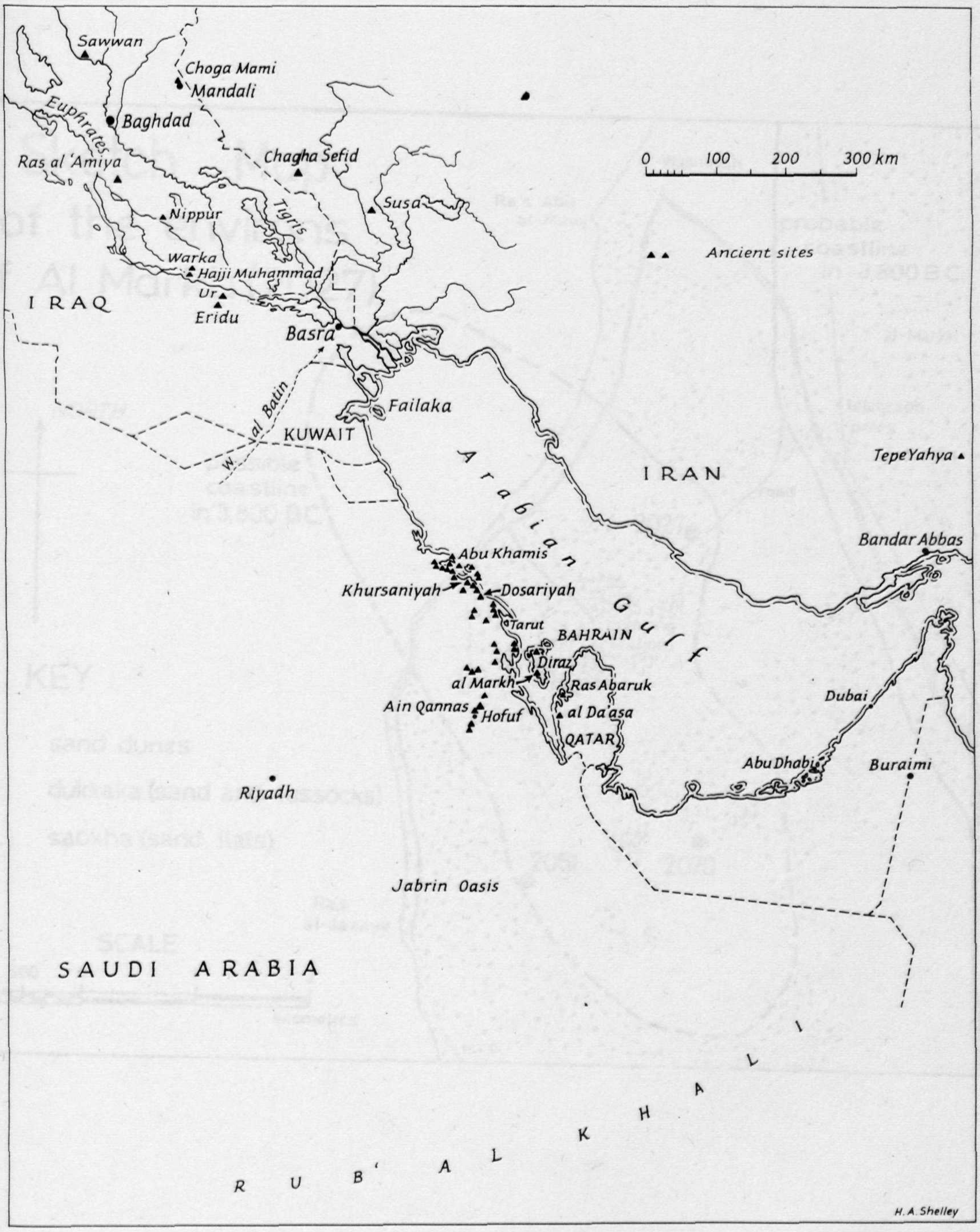

Fig. 18.3 Map showing Arabian sites on which 'Ubaid pottery has been found (Antiquity 51, 223).

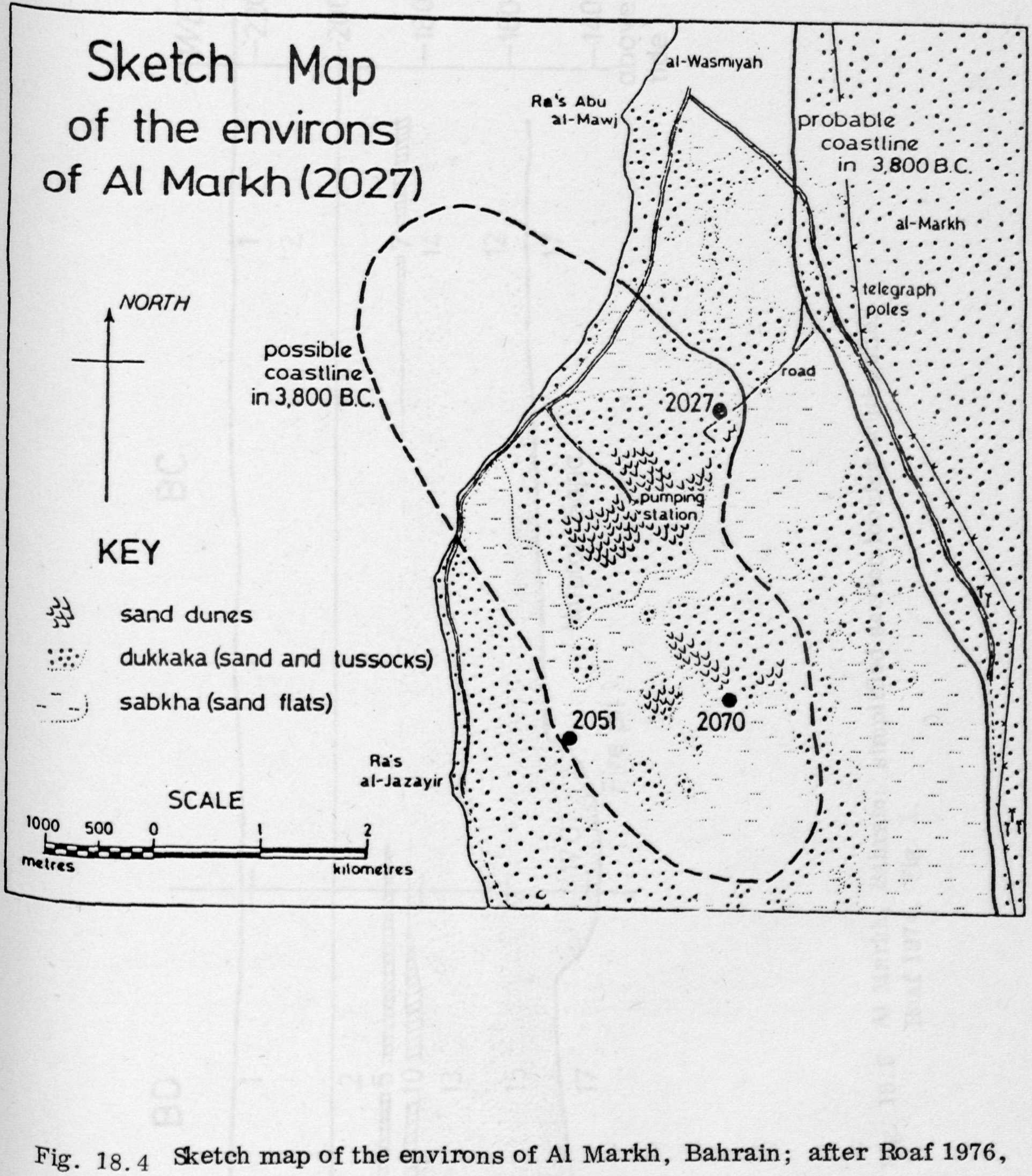

Fig. 18.4 Sketch map of the environs of Al Markh, Bahrain; after Roaf 1976, Fig. 6.

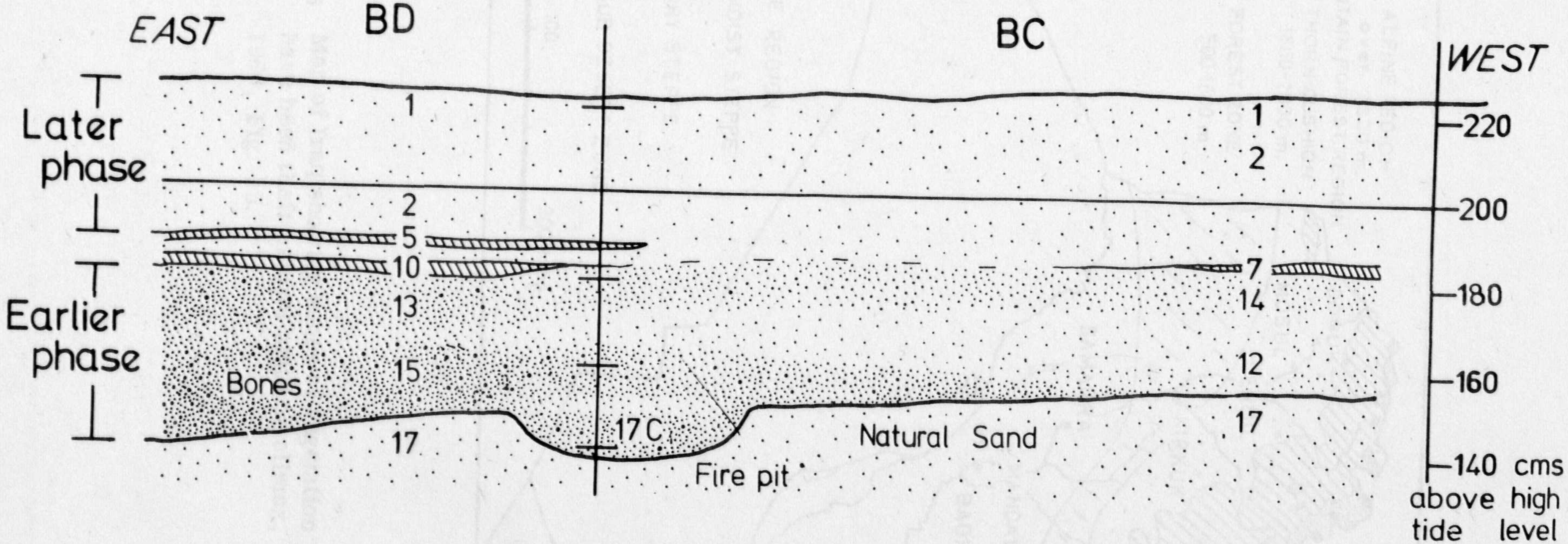

Fig. 18.5 Al Markh, Bahrain: simplified section looking south, after Roaf 1974, Fig. 1.

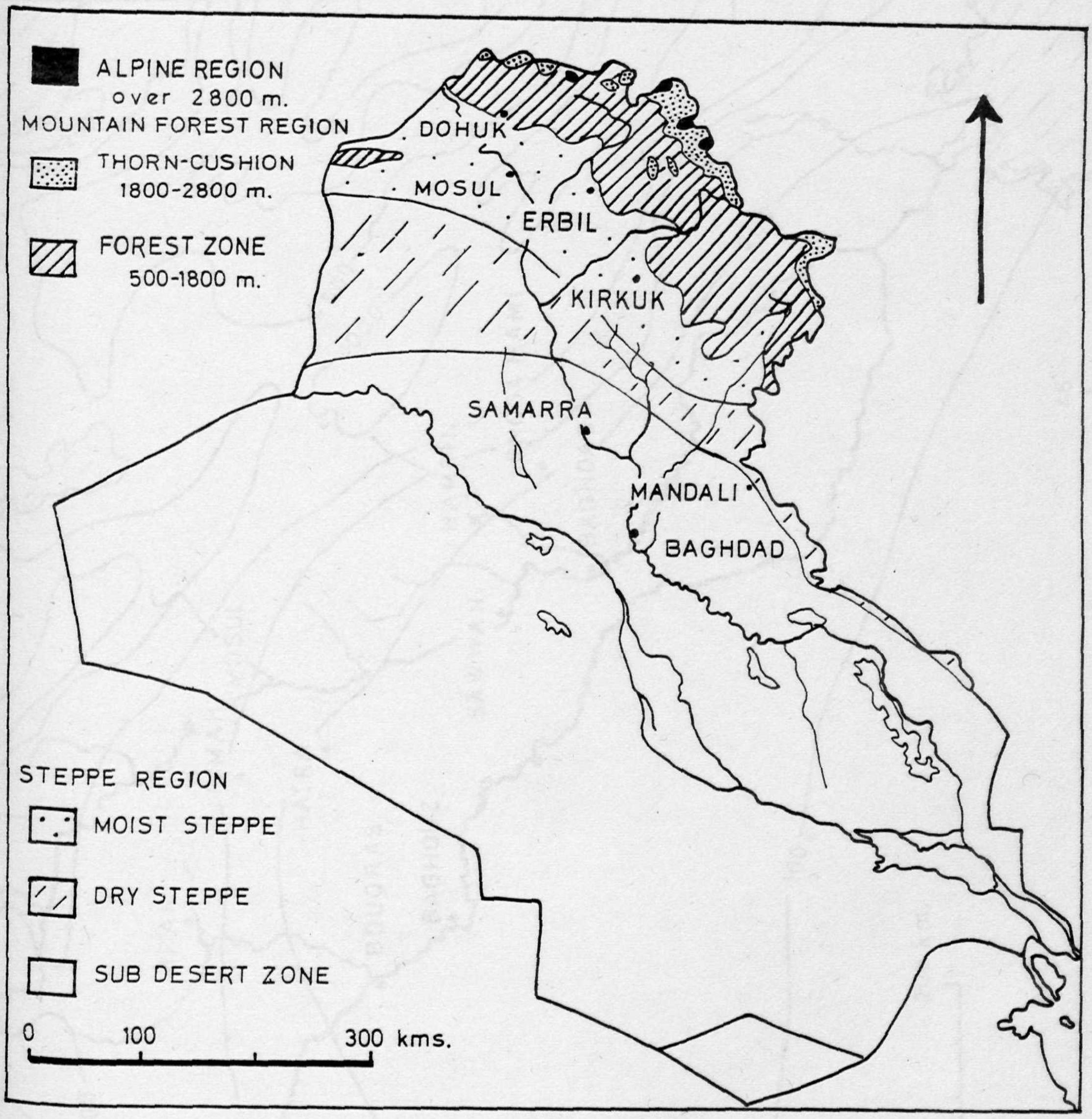

Fig. 18.6 Map of Iraq showing zones of vegetation in what is believed to have been their natural state or climax, after Guest and Al-Rawi 1966, Fig. 15.

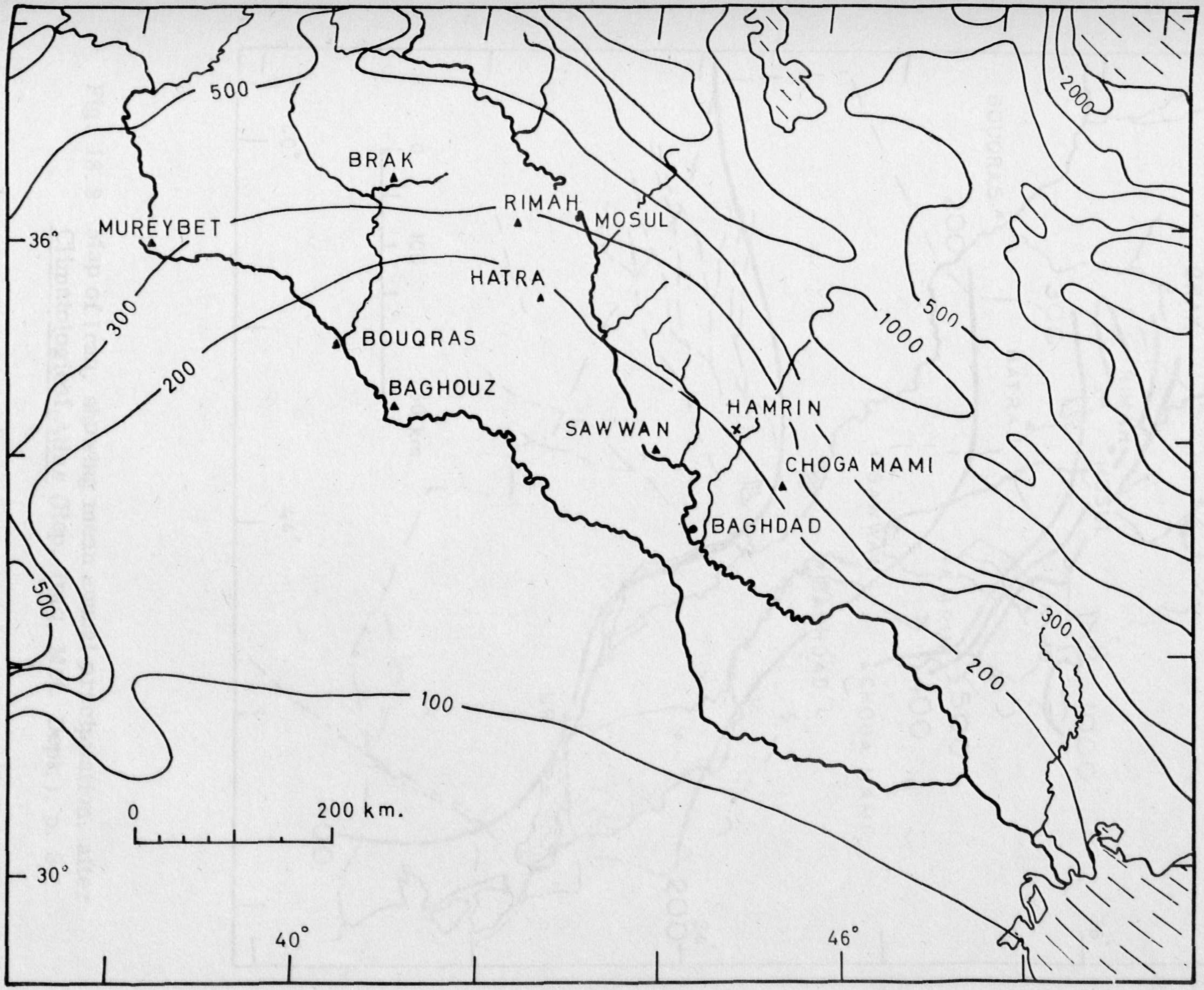

Fig. 18.7 Map of Mesopotamia showing rainfall isohyets, after Baly and Tushingham 1971, map 6.

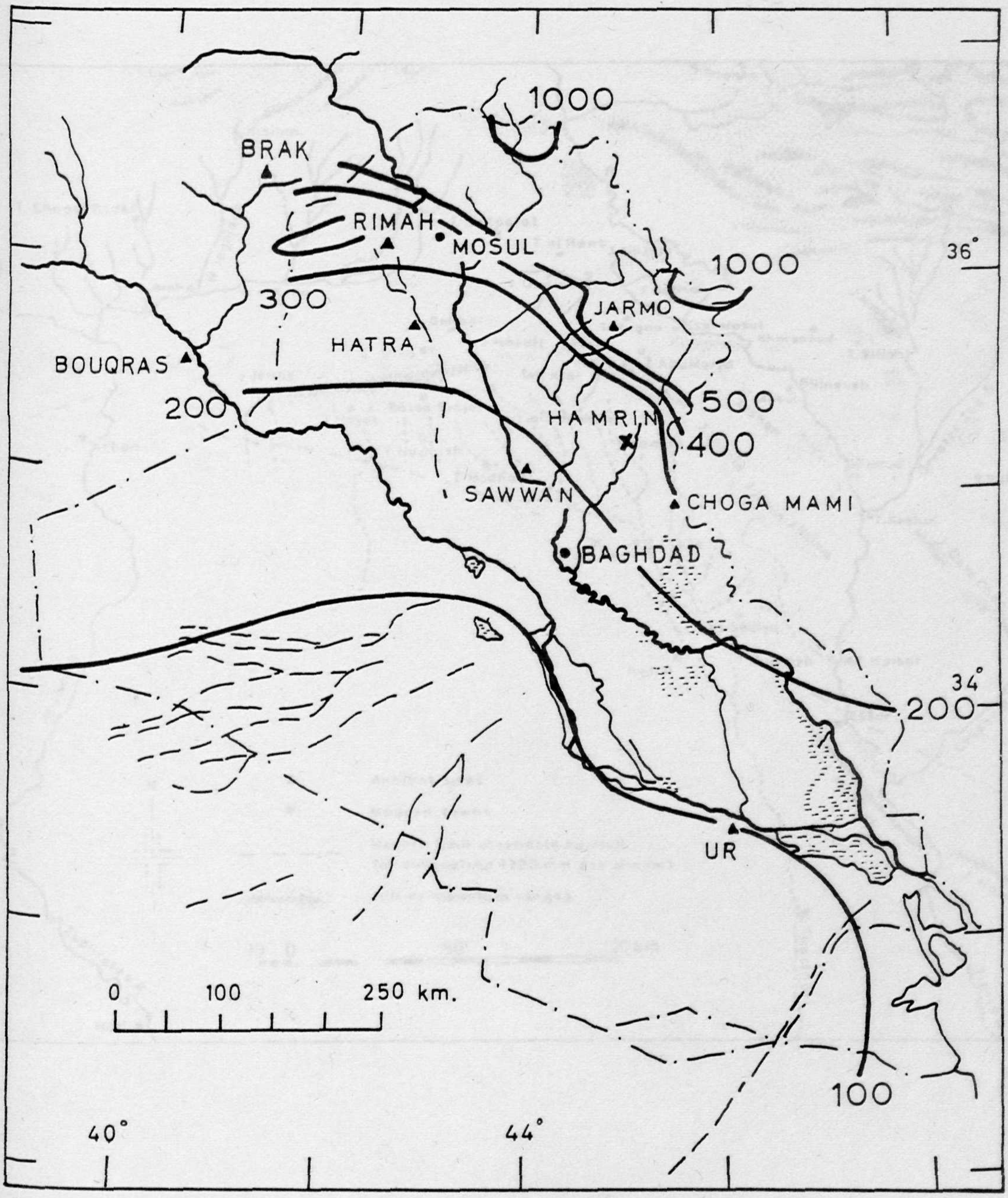

Fig. 18.8 Map of Iraq, showing mean annual precipitation, after Climatological Atlas (Rep. Iraq, Met. Dept.), p. 8.

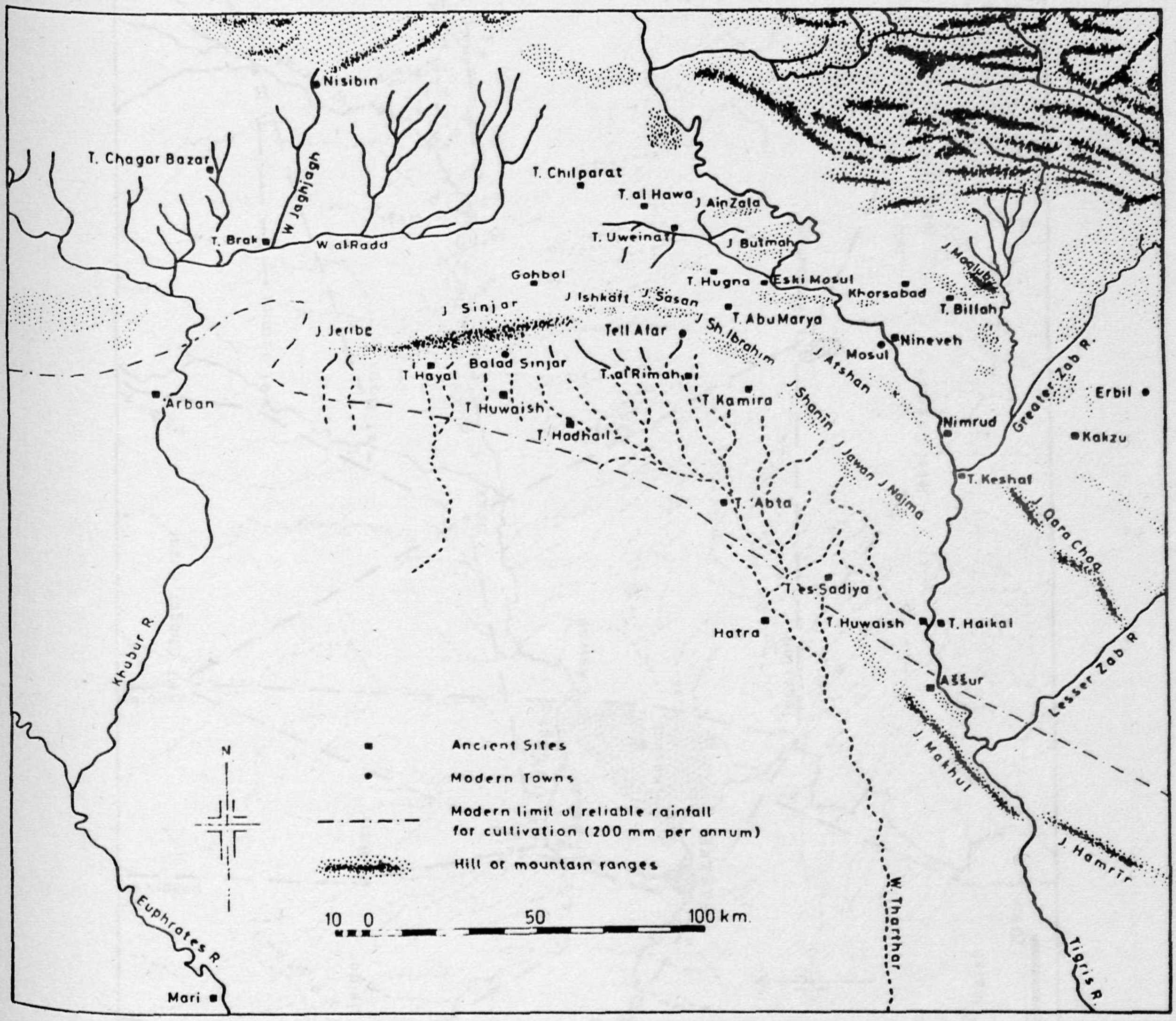

Fig. 18.9 Map showing topography of northern Iraq and historical sites, after D. Oates, 1968, Fig. 2.

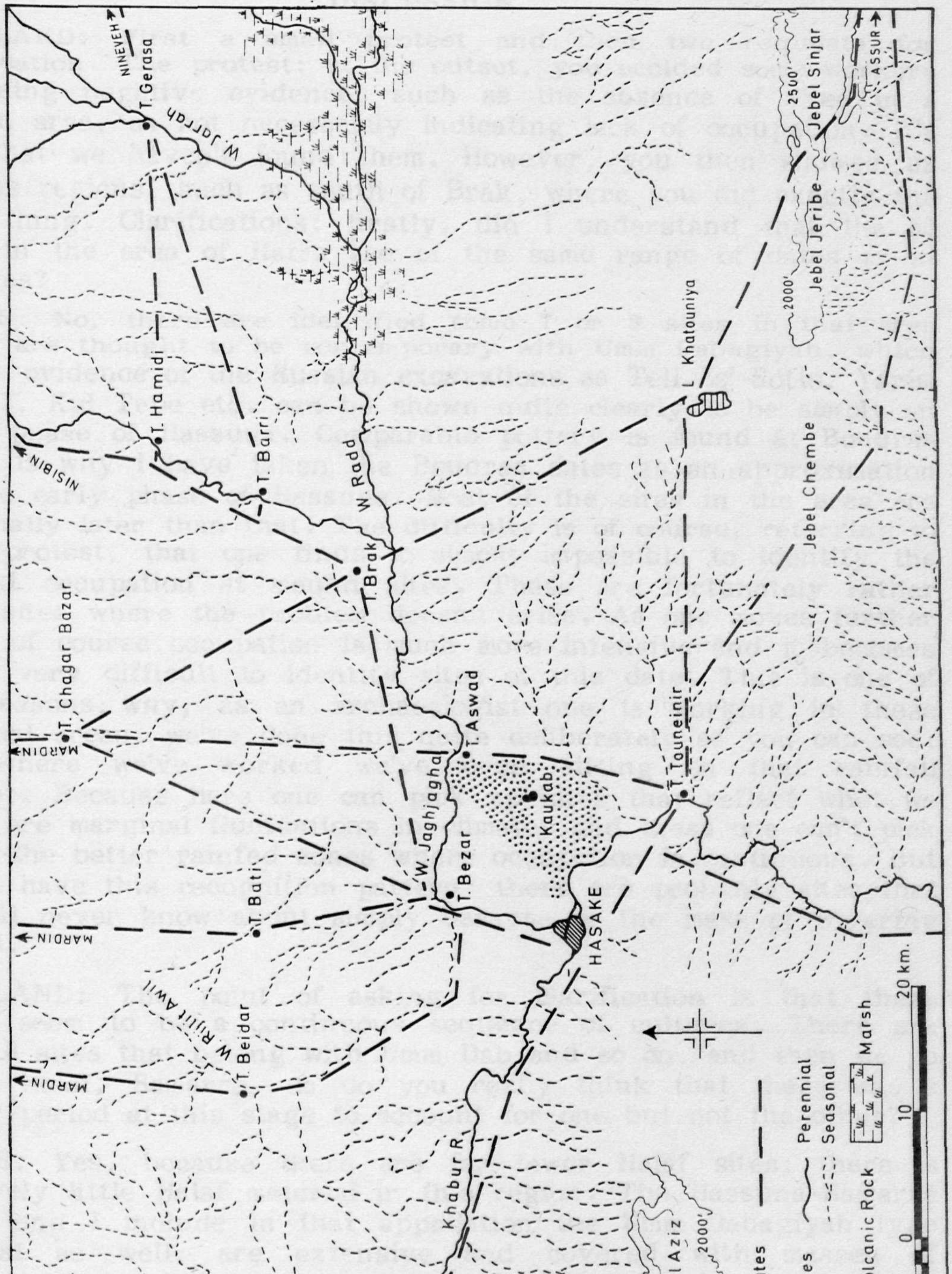

Fig. 18.10 Map of the upper Khabur basin, northeastern Syria, after D. Oates 1977, Pl. IV.

DISCUSSION

COPELAND: First a small protest and then two requests for clarification. The protest: at the outset, you scolded some workers for using negative evidence, such as the absence of sites in a certain area, as not necessarily indicating lack of occupation. It's just that we haven't found them. However, you then showed us various regions, such as south of Brak, where you did exactly the same thing. Clarifications: firstly, did I understand that the 50 sites in the area of Hatra are of the same range of dates as at Bouqras?

OATES: No, there are identified some 7 or 8 sites in that area which are thought to be contemporary with Umm Dabagiyah, which on the evidence of the Russian excavations as Tell Es'-Sotto, Yarim Tepe 1, Kul Tepe etc. can be shown quite clearly to be simply an early phase of Hassuna. Comparable pottery is found at Bouqras which is why I have taken the Bouqras dates as an approximation to this early phase of Hassuna. Most of the sites in the area are marginally later than that. The difficulty is of course, referring to your protest, that one finds it almost impossible to identify the earliest occupation at mound sites. These are fortunately rather small sites where the problem doesn't arise. As one moves further north of course occupation is much more intensive and it becomes very, very difficult to identify sites of this date. This is one of the reasons why, as an archaeologist one is working in these marginal areas, we've done this quite deliberately as you can see; everywhere we've worked we've been sitting on that rainfall isohyet. Because here one can pick up sites that reflect what we think are marginal fluctuations in climate, and these one can't pick up in the better rainfed zones where occupation is continuous. But we do have this recognition pattern: there are probably sites that we will never know about simply because of the mass of covering debris.

COPELAND: The point of asking for clarification is that there would seem to be a continuous sequence of cultures. There are these 8 sites that belong with Umm Dab and so on, and then we go on to Halaf, Samarra, so do you really think that there was a wetter period at this stage to account for one but not the other?

OATES: Yes, because there are far fewer Halaf sites; there is relatively little Halaf material in this region. The Hassuna-Samarra sites, and I include in that appellation the Umm Dabagiyah type material as well, are extensive and covered with masses of archaeological debris, there are masses of sherds of this date. One rarely finds Halaf material. One also finds a little Ubaid material. But generally speaking there is not the same sort of evidence for occupation in this area and I think it's a tailing off, to the point where by the Uruk period there are only two sites and they may be there for rather special reasons. So that yes, I would argue that the climate is deteriorating. The difficulty is that even the most minor fluctuation in rainfall pattern affects an area like this in a rather major way and there are probably periods of tens, or perhaps 50 or 100 years, where a minor fluctuation would have made possible reoccupation or agriculture. I've given you a sweep of dates from 6400 to 5000 for these early sites, but what we don't know, and archaeologically this is impossible to determine, is whether there were short phases within that almost 1500 year span, where occupation was impossible. One would assume that this is probably so. All we can do is give you the gross picture. But certainly the gross picture is for a rather impressive level of evidence for settlement in that time range and increasingly less as one gets later. Again I must emphasise that one doesn't know to what extent this reflects degradation of the steppe, certainly I would argue quite strongly for cultivation around Umm Dab in the period that I'm talking about.

COPELAND: The second point of clarification: the region north of Chagar Bazar. I wasn't sure whether you said that the first occupation there that we know about is the Halaf.

OATES: The first occupation that we know about in any extensive way. It's arguable whether there are Neolithic materials there earlier than that. Certainly there are dark-burnished sherds.

COPELAND: I could mention the famous Alt-Monochrom deep at Tell Agab and possibly something aceramic earlier than that at Tell Fakhariyah. So I think there was probably continuous occupation of this part at least from the start of PPNB.

OATES: Continuous occupation along the rainshadow of the mountains doesn't bother me, one would expect that; what I've been trying to look at, and giving the Halaf evidence as a contrast, is the extension of that occupation further south into regions that are today rather marginal. I think in the past one can see fluctuations, for example the very considerable extension in the 4th millennium, that probably indicates some climatic amelioration at that time, and then the retraction to essentially today's levels in the 2nd millennium. I issued the warnings as I began and I've gone along to play the game myself. I was asked to examine the archaeological evidence and that's the best one can do with it I think.

BROOKES: I'm just wondering what the present state of Northern Mesopotamian archaeological thinking is on the potential for geomorphological modification, masking of sites, destruction of sites. Has anyone been in there investigating those things or do you get a feeling that environmental conditions are not the way they were when the sites were occupied?

OATES: I think probably you are quite right. We have had geomorphologists on the excavation with us, e.g. at Tell al Rimah. But there wasn't the sort of wadi pattern that was informative from their point of view. Certainly there has been alluviation, but this does not mask sites to the extent that it does in the southern alluvium where one has a very considerable problem in this respect. At Brak for example I would assume that we probably have at least 8 metres of deposit below the plain at that point. This is the normal sort of pattern, but it's nothing like the depth of deposition that one finds in the south. But it's not an ideal area for people interested in this sort of thing. It's one of the interesting things about Brak that this is next to Nineveh, the major site in northern Mesopotamia. It's as large as the mound at Nineveh. Nineveh goes up on through the late Assyrian/Parthian/

Sassanian periods. Brak, however, comes to an end in 1200 BC and it's quite clear at Brak that after 2000 BC (in historical dates) the site was not important. The line of settlement at that point, and I think this is probably something to do with a minor climatic fluctuation, moves to the north along that line of tells that I indicated. And the same pattern exists south of Jebel Sinjar.

BAR YOSEF: I would like to comment on your opening remarks which I found very interesting, particularly the use of settlement patterns by archaeologists. I believe that one should distinguish between two kinds of settlement patterns. One which is related to the hunter-gatherer way of life and which is directly influenced, as we can see from the ethnographic evidence, by geomorphological and climatological changes, and on the other hand the one from historical periods. I believe that when you have the onset of the establishment of chiefdoms, and of city states, you get on the deserts 'supported societies' like the Bedouin, and their distribution might be directly influenced by the amount of material goods, money etc. which can be given to them, that they can obtain from their supporters, either city-states, chiefdoms, or states. Therefore one should be very careful to separate settlement pattern types for archaeological sites, between let's say everything which is before 10000 or 8000 bp, before the establishment of agricultural societies, and everything which comes in later periods. The example you gave from the Saudi Arabian so-called 'late Neolithic' recently studies by Tixier in Qatar is a good example for what might be 'Bedouin' societies getting goods from Mesopotamia, either by caravans or by sea navigation. Perhaps we should mention also the contacts that took place at that time with India, with the Indus Valley. This material perhaps can be used to infer climatic changes, but with much more caution than any kind of material which comes from the preceding periods. When we come to discuss the climatic changes of later periods, which means from let's say the 4th millennium onwards, the use of in-depth geomorphological work is essential. Because from that time and on into as late as Byzantine times, broader commercial considerations can control site location and abandonment. Only the environmental evidence, the kind we have seen from Greece for example from Paepe's work, can contribute secure data about climatic changes.

OATES: I couldn't agree with you more. One of the difficulties in Mesopotamia is that we virtually never find evidence of hunters and collectors on the alluvial plain because of problems of alluviation. And you may remember that I did remark that political considerations might well be a factor in prehistoric times as well. One can only speculate about this. Agreement also on geomorphological studies, but in the absence of these I've done the best that I can. I rule out at present caravan contact between Saudi Arabia and Mesopotamia; it seems to me that the marine orientation of these sites is fairly persuasive. Also we know that along the Wadi al Batin which is the main route from that area into southern Mesopotamia, there are no archaeological materials to be found, and certainly no Ubaid pottery. I know that this was Masry's idea, and he and I disagree about this, although certainly the pottery that we have examined comes from Mesopotamia. I can't see the Bedouin carrying large quantities of pottery back to Saudi

Arabia, presents for the wife and kiddies or something like that, and it seems to me to make much more sense, particularly in relation to the visible pattern of settlement at that time (and there are only 4 large mound sites) that this was some maritime contact. I know this is perhaps an extreme point of view but I'm persuaded of it myself.

UERPMANN: I agree that one has to separate the distribution of hunter-gatherer sites from farmer sites, but I don't agree that the former are more useful for inferring climatic factors, because hunter-gatherers live wherever there are animals, and in the Middle East there are no major areas where there are no animals for such exploitation. Hunter-gatherers could range over the whole of the area without major distinctions between their economy, whereas early farmers were much more dependent on climatological considerations in the area and their sites are those that can really give some idea about the distribution of climate. So it's the period from the beginning of agriculture to the beginning of irrigation where you can best use settlement patterns for climatic investigations.

OATES: I would argue that in Northern Mesopotamia you can continue to use these sites after irrigation because it's only in the south that irrigation is a relevant factor.

ENVIRONMENTAL AND ARCHAEOLOGICAL EVIDENCE FOR CLIMATIC CHANGE IN THE SOUTHERN LEVANT

Paul Goldberg and Ofer Bar-Yosef
(Institute of Archaeology,
The Hebrew University of Jerusalem, Israel)

Preliminary Remarks

Archaeological and geological evidence for environmental change in the Southern Levant, as elsewhere, are necessarily interwoven, a feature that arises from the symbiotic relationships between archaeological sites and their sedimentary traps. On the one hand, the lithic assemblages, organic and inorganic remains (bones and charcoal) and locations of sites through time provide temporal control as well as regional information about environments. On the other, geological study of associated sediments supplies data pertaining to site-specific environments, which when integrated in space and time provide a regional picture of environmental and climatic change.

Regional studies were the main tool through which a large body of geographically distributed data was accumulated during the last decade in the Southern Levant. In a north-south cross section these include the studies made in the Fazael-Salibiya Basin in the lower Jordan Valley, the Nahal Besor/Fara area in the northern Negev, the Nahal Zin/Avdat and Har Harif areas in the Negev Highlands, the Negev Archaeological Rescue Project in the western Negev, the Qadesh Barnea in easternmost Sinai and Gebel Maghara in northern Sinai (Bar-Yosef et al., 1974; Schuldrenrein and Goldberg, in press; Price-Williams, 1975; Marks, 1976, 1977; N. Goring-Morris, personal communication; Goldberg, in preparation; and Bar-Yosef and Phillips, 1977). A large number of sites were located, many were excavated and several provided clusters of radiometric dates. In perhaps a slightly exaggerated way one may state that the Late Pleistocene /Early Holocene chronological and cultural framework is now mainly based on the evidence collected through the studies of these areas.

The use of archaeological data for making climatic inferences involves several assumptions concerning both the nature of prehistoric remains and the past patterns of human behaviour. The model used in deciphering the archaeological data presented here is based on recent studies of today's hunter-gatherers' modes of life (Lee and DeVore, 1968; Bicchieri, 1972). These studies have shown that as a rule a group of hunter-gatherers lives below the carrying capacity of their territory. The degree of their nomadism is dictated by the nature of their preferred sources of subsistence. In arid zones this equilibrium is quite delicate but during lean years they will move into the lusher territories and will be accepted by their neighbours. This type of general movement, of abandoning the desertic areas during successive droughts and expanding back during rainy years should be expressed in the archaeological record.

The Southern Levant, dominated by Mediterranean and arid climate regimes, would be an ideal region to observe such past movements. The expansion of hunter-gatherers into the deserts under favourable climatic conditions would be exhibited in the number of sites and their distance from permanent water sources, the latter being manifested by travertines, water-logged sediments, etc. The dry periods will be those with no or rather scarce archaeological data. In other words, it is suggested that the number and distribution of prehistoric sites in the Near Eastern deserts is a direct reflection of climatic conditions.

The following assumptions are necessary in order to facilitate the interpretations of the archaeological record presented in this paper.

1. The behaviour of past hunter-gatherers in semi-desertic areas was basically similar to those living today under current conditions.
2. The numbers and densities of prehistoric occurrences in desertic areas are taken as an indication for climatic improvement whereas the decrease or absence of evidence is interpreted as the result of increasing aridity. This would have been a questionable assumption a decade ago when much of the prehistory of the Central and Southern Negev, Sinai and the Jordan Valley regions was unknown.

Geological evidence of environmental change is manifest in a variety of ways. These include both the types and styles of sedimentation, such as fluvial gravels, silts and sands, aeolian sands and silts, lacustrine silts and clays, and associated features represented by gleying and travertines. Goldberg (in press) has recently summarized the data from several archaeo-sedimentary sequences from the Sinai, Negev and Jordan Valley areas and concluded that as a first approximation fluvial and lacustrine deposition took place during periods wetter than today, whereas dry intervals, like the present, are typified by erosion; colluviation was interpreted to result from aridification whereby vegetation cover was reduced and landscape surfaces became unstable (Table 1).

When the dated archaeological sequences of the Southern Levant are combined with those of the North which are more sparsely radiocarbon dated, the resulting identifiable archaeological entities (or cultures) can be used as a reasonably secure means of dating various geological deposits such as alluvium or dunes (Copeland and Vita-Finzi, 1978). Environmental change as represented by periods of infilling or erosion can be dated in every region using both radiocarbon and archaeological dating, assuming that the spatial distance between sites does not exceed 50 to 100 km; the proximity of the studied regions is essential for maintaining archaeological continuity.

Below we present the evidence based on a series of time slices that we believe conform to natural archaeologic and stratigraphic subdivisions. By such a presentation we hope to convey a sense of continuity through time. In Table 1 we summarize most of the geological evidence that is discussed below (for greater detail, see Goldberg, in press.)

A 30,000 to c. 22,000 B. P. (Upper Palaeolithic, Fig. 19. 1)

This period is well represented by water-laid sediments in the Sinai and Negev regions. In Gebel Maghara this is shown by former aeolian sands and silts reworked by tributary wadis (Goldberg, 1977). In Qadesh Barnea (Goldberg, in press; in preparation), fluvial clays and silts grade upwards to silty sands and dune sands; the lower half is extensively gleyed and stained by root marks. In the Nahal Zin/Avdat area, fluvial sandy silts give way to later colluvial clays (Goldberg, 1976; Yair et al., 1980). The palaeoenvironmental inference from all these localities is a wetter climate at the beginning of the interval with increased aridity toward the end (c. 25,000-22,000 B. P.).

Archaeological data from these and other localities are well represented. In Wadi Sudr (western Sinai), in Gebel Maghara (the Lagaman sites; Bar-Yosef and Phillips, 1977) and Nahal Zin (sites Boker A, BE; Marks, 1976, 1977), the sites generally consist of small occurrences of highly specialised blade/bladelet industries, all situated within valleys; these types of sites are as yet unknown from the plateaux. Nevertheless, the fact that most are embedded in either fluviatile silts, or sands underscores the proximity of these sites to water sources.

Upper Palaeolithic assemblages with a higher content of flakes (and therefore related by most scholars to the Levantine Aurignacian) were found on the plateaux above wadi beds near Avdat (sites D 27, D 22 etc. - Marks, 1976, 1977) and Wadi Sudr (U. Baruch, personal cummunication). Since these are still undated and they are not geologically in situ, their palaeoenvironmental significance remains unclear.

B c. 22,000 to 18,000 B. P. (Late Upper Palaeolithic, Fig. 19. 1)

This period is very poorly represented in both the geological and archaeological record. In the desert regions, with the possible exception of the Wadi Feiran sequence (Issar and Eckstein, 1969; Nir, 1970), no geological deposits have as yet been found. Some prehistoric sites, e.g., the "late Upper Palaeolithic" site of Ein Aqev East (D-34 - Ferring, in Marks, 1977) probably fit within this interval although this assessment is far from being universally accepted.

In the North, "late" Upper Palaeolithic sites that possibly belong here are somewhat more numerous although no less problematic. In Wadi Fazael, localized colluvial deposits yielded three in situ sites: Fazael IX, X, and XI (N. Goring-Morris, personal communication). Other possible candidates within this time-unit are Nahal Ein Gev I (Bar-Yosef, 1978), El-Khiam X, IX (Echegaray, 1964) and El Wad C (Garrod and Bate, 1937). In any case, the lack of geological deposits of this age, the degradational mode of the wadis and the paucity of sites in the Sinai and Negev, as well as in the North, strongly suggests that this was a markedly arid interval.

C 18,000 to 14,500 B. P. (Early Epi-Palaeolithic, Fig.19. 2)

This early part of the Epi-Palaeolithic is represented by the Kebaran industry, dated to about 18,000 to 14,000 B. P. (Bar-Yosef, in press a, b). Kebaran assemblages are distributed in the Lebanese mountains (Hours, 1976) and down in the Galilee-Judean Hills (Bar-Yosef, in press a, b). In addition, there are a large number of rich occurrences, some of which include architectural remains, in the northern coastal plain (e.g., Nahal Hadera V - Saxon et al., 1978) and the Jordan Valley (Ein Gev I - Bar-Yosef, 1970; Arensburg and Bar-Yosef, 1974; and Fazael - Bar-Yosef et al., 1974). These sites tend to be embedded in sands and alluvial silts and clays that point to a narrow band of wetter climate in the north-central part of Israel in contrast to the cold and drier climate to the north and south (cf. Butzer, 1978). Aridity in the south is manifest by the lack of sedimentation at this time and the virtual absence of sites from most of the Negev and Sinai, although recently a few surface scatters of one of the Kebaran facies have been recorded in the western Negev, near Nahal Nizzana (N. Goring-Morris, personal communication).

D 14,500 to 10,500 B.P. (Later Epi-Palaeolithic, Figs. 19.3 & 4)

This represents a continuation of the microlithic industries and includes the Geometric Kebaran, Mushabian, Natufian, Harifian and Khiamian (Bar-Yosef, in press a, b). In the first half of this interval the distribution of sites indicates a distinct period of climatic amelioration of predominantly wetter conditions but with perhaps minor fluctuations. For example, sites of the Geometric Kebaran cultural complex are small and occur everywhere both on plateaux and in wadi situations from Lebanon to the Suez and Wadi Feiran in southern Sinai. In Wadi Feiran, for example, small sites have been located stratigraphically close to the top of the massive fine-grained fluvio-lacustrine sediments that locally attain thicknesses of up to 50 m. Similarly, in northern Sinai (Gebel Maghara - Bar-Yosef and Phillips, 1977) these sites are found associated with lacustrine deposits and a widespread, well-developed palaeosol which is partly contemporaneous with occupation.

An essentially coeval archaeological entity named the Mushabian, which clearly displays North African technological affinities, is distributed from northern Sinai into the Negev (Bar-Yosef and Phillips, 1977; Valla et al., 1979) and it appears that the climatic improvement enabled more human contact at the close of the Pleistocene than previously. Finally, in the north, in Wadi Fazael, several Geometric Kebaran sites occur within both colluvium and fluviatile clays and sands (Bar-Yosef et al., 1974).

Later cultures such as the Negev Kebaran of Harif Phase and of Helwan Phase have a slightly more restricted distribution although site sizes are roughly comparable with early Epi-Palaeolithic ones. Such a distribution might reflect an increase in aridity around 12,000 to 11,000 yrs B.P. At this time in the northern region (Galilee and Judean Hills) lower Natufian base camps were established (Bar-Yosef, in press a, b). It was not until 11,000 B.P. that such sites are found in the Negev Highlands (Marks 1976, 1977).

Geological information for this later part is minimal. In the Fazael area, the early Natufian is found within colluvium which relates to increased aridity (Bar-Yosef et al., 1974); in the adjacent Salibiya basin, the recently exposed Lisan marls were undergoing extensive erosion at this time, presumably a function of the retreat of the lake as well as a general drying out of the climate (Schuldenrein and Goldberg, in press).

E 10,500 to 8,000 B.P. (Neolithic, Fig. 19.5)

The socio-economic change that was brought by the Natufian culture culminated in the dichotomy between incipient farming societies such as the Sultanian (Pre Pottery Neolithic A) of Jericho, Nahal Oren, Netiv Hagdud, Gilgal I, etc., and cultures of hunters and gatherers such as the Harifian (Bar-Yosef, in press a, b). From c. 10,500 B.P. the coexistence of farming communities and hunter-gatherers is well established in the southern Levant. Thus, the behaviour of Neolithic bands in desertic areas can be interpreted on the same basis as their Palaeolithic ancestors.

The overall picture of the Neolithic period (from 10,000 to 7,000 B.P.) shows several fluctuations in the distribution of sites. The traditional PPNA phase is probably rather shorter in time than generally held and lasted only about 500 to 800 years. Large village sites are known from this period (recently relegated to the Sultanian culture - Crowfoot-Payne, 1976; Bar-Yosef, in press a, b), as well as in the later Neolithic ones. Both show that continuous deposition was taking place on the alluvial fans, a phenomenon interpreted as being a result of wetter conditions and a better distribution of annual rains. The presence of travertines and sediment gleying associated with the Neolithic in the Gilgal area would support this view (Schuldenrein and Goldberg, in press). Thus the building of walls and terrace walls by the inhabitants of Jericho and Beidha (Kenyon, 1960; Kirkbride, 1966; Bar-Yosef, 1980) is seen as an attempt to prevent the flooding and silting up of their sites.

Both desertic sequences of Neolithic sites and the excavated ones in the Jordan Valley indicate interruptions of archaeological deposition at various points during the Pre Pottery Neolithic B sequence (e.g., Beisamoun, Munhatta, Tell 'Eli, etc.). Most of the Sinai PPNB sites are presumably contemporary with the sequence of Beidha and therefore, are believed to date to the Seventh Millennium B.C. (9000 to 8000 B.P.). Large Neolithic communities existed during the Seventh Millennium B.C. within the Mediterranean zone while the smaller sites (up to 1000 m^2) in the deserts practised basically hunting with additional use of vegetal food stuffs.

F 8,000 to 5,500 B.P. (Neolithic and Chalcolithic)

The events during the Sixth Millennium B.C. are as yet controversial. The temporal gap in most sites between the Pre Pottery and Pottery Neolithic levels was correctly given a socio-economic meaning but wrongly estimated as to duration (1000 to 1500 years - Perrot, 1968; Moore, 1973). The transition to pit dwellings in both the Jordan Valley and the coastal plain is correlated with the onset of the Atlantic Period, presumably wet and humid as shown by the pollen record (Horowitz, 1971) and fluvial/colluvial deposition in the Fazael/Salibiya area (Schuldenrein and Goldberg, in press). The presence of sites of this millennium in desertic areas such as Qadesh Barnea and the Uvda Valley (near Eilat) is good evidence for a continuation of basically a similar settlement pattern. Moreover, the increase in the number of sites during the Fifth and Fourth Millennia B.C. in the deserts of Sinai and the Negev corroborates accumulating data from Chalcolithic sites over all of Israel (Gophna, 1979; Kozloff, 1972/3).

In every valley more Chalcolithic sites are discovered every year. Those, either of the Wadi Rabah Phase or of the Ghassulian (or their contemporaries) are most often buried in silts indicating large scale alluvial and colluvial deposition. Small or large villages sites turn up in the alluvial deposits of the Jezreel Valleys, the northern Negev, and wadis descending from the Judean Hills. These wet conditions prevailed also during the period of the Early Bronze I (5,500-5,000 B. P.)

G 5,500 B. P. to the Present (Bronze Age and Historical Periods)

The transition into what can be defined as "Today's" arid climate took place during the Early Bronze II and III periods (5,000 to 4,400 B. P.). Thus, in all likelihood, increasing desiccation was responsible for the collapse of city-states such as Arad (around 4,600 B. P.) in southern Judea, due to the destruction of their agricultural resources (barley, olives, goats, etc.). The northward shift of the climatic and vegetational belts in the southern Levant during the Third Millennium B.C. was recorded both in the archaeological remains, the written records and perhaps triggered the collapse of certain political systems and the establishment of new ones.

An additional wet spell can be recognized with the distribution of Middle Bronze I sites all over the Negev and Sinai (4,200-4,000 B. P.). However, for the following Second and Third Millennia B. C. the climate record is as yet unclear both on geological and archaeological grounds. The use of archaeological evidence for this interval is made rather complex since this is the period of the rise and fall of the Egyptian Empire, the build up of new political entities, etc. Furthermore, the Bedouin groups of this period were basically dependent on the adjacent powerful states and city-states. Therefore, before we can separate natural from human influences on the distribution of archaeological sites, much more field work will be needed.

Finally, a relatively widespread phenomenon deserves mention though its climatic significance is uncertain. In much of northeastern Sinai and the northwestern Negev widespread deposits of fluvatile silts occur. These are particularly prominent and well exposed in the Qadesh Barnea area where they are at least 4 m thick (Goldberg, in press; in preparation). Charcoal from two localities about 5 km apart yielded radiocarbon dates of 665 ± 115 B. P. (QC-491) and 1755 ± 105 B. P. (QC-492) clearly an historical age. Some 30 km to the north the same silts occur with Byzantine check dams that are built on top of as well as block the silt behind them.

While it is reasonably clear that these silts represent original aeolian silts (loess) that were later stripped from the slopes and reworked by small and large wadis alike, the problem remains whether this deposition is related to climate or some cultural practice such as clearing, farming, etc. As yet we do not have any solution to this problem and can only refer the reader to Vita-Finzi's (1969) discussion of what he calls the "Historical Fill."

Concluding Remarks

A decade ago the synthesis outlined above would not have been possible. Since that time, however, the avalanche of information from new excavations and geological field work has increased our overall understanding of Late

Quaternary palaeoenvironments and climatic changes in the Southern Levant to the level where we feel that our first approximation is a reasonable one. In addition, in spite of the youthfulness of the data, it is evident that for our region at least, environmental reconstructions inferred from sedimentation/erosion patterns and landscape changes vary concordantly with the distribution of archaeological sites through space and time. We hope that this synthesis will serve as a basis for future testing and research.

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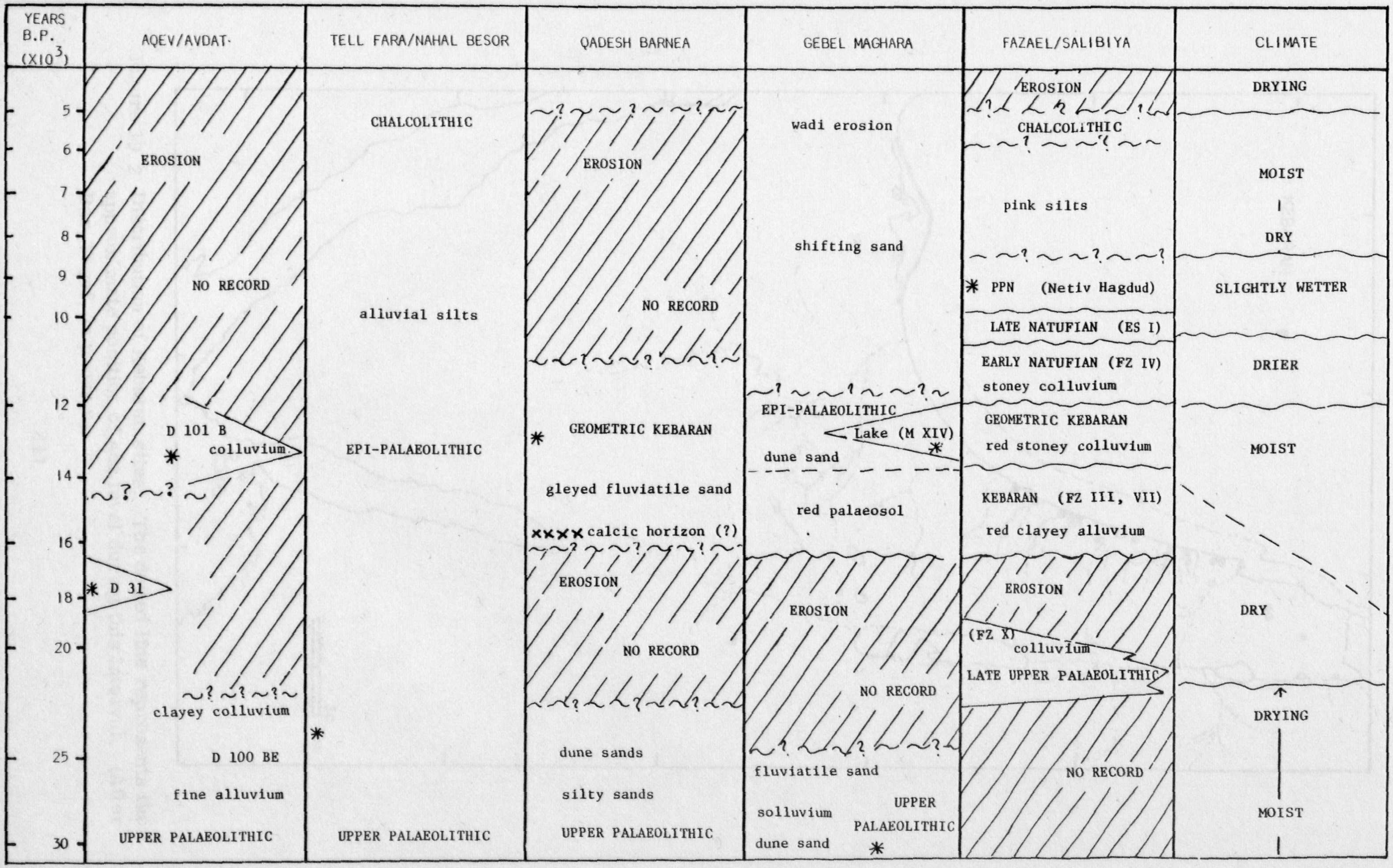


Table 1 Late Quaternary stratigraphic sequences from the Southern Levant and inferred palaeo climates.

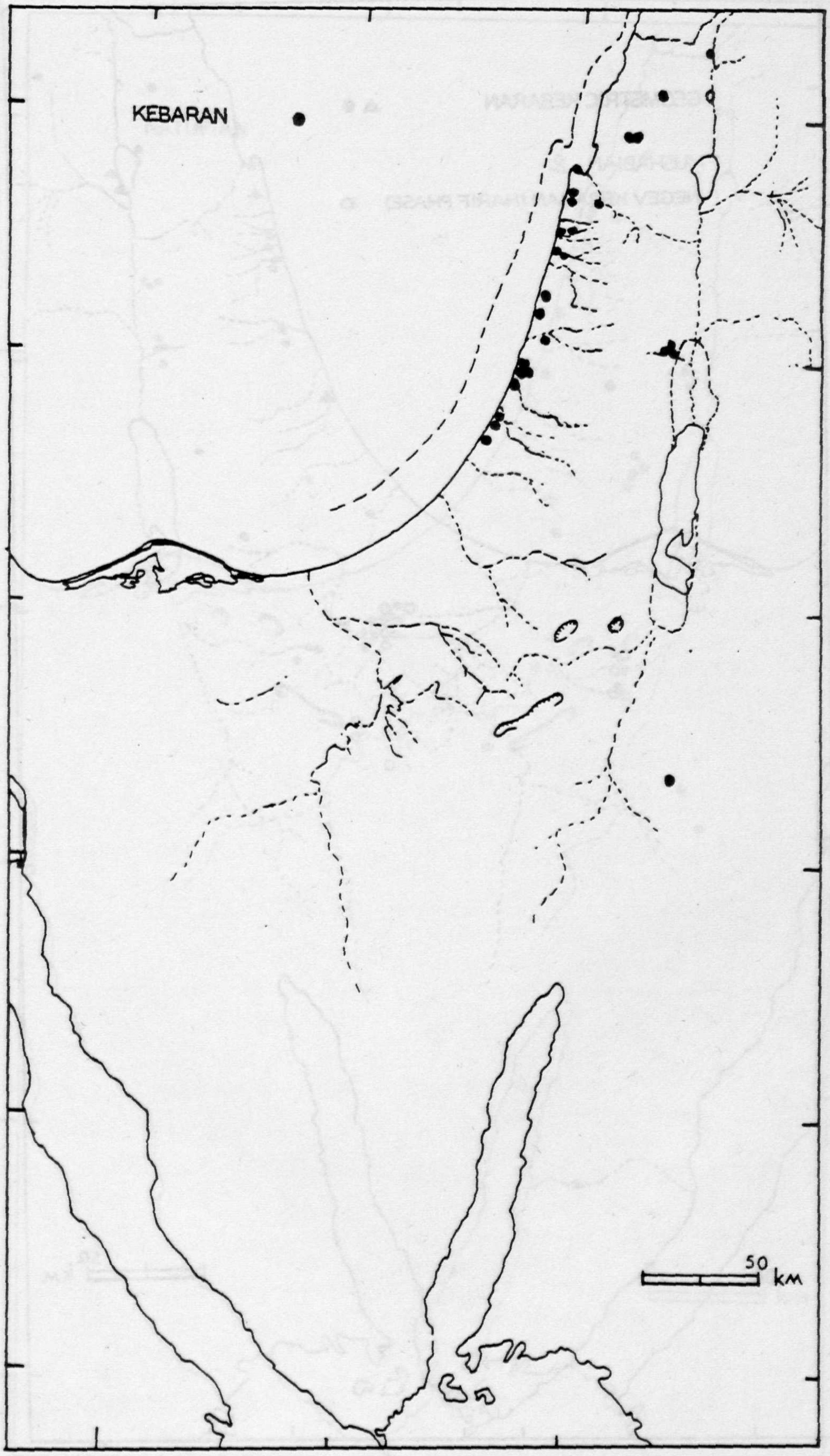


Figure 19.2 Distribution of Kebaran sites. The dotted line represents the approximate position of sea level during this interval. (After Bar-Yosef, in press a).

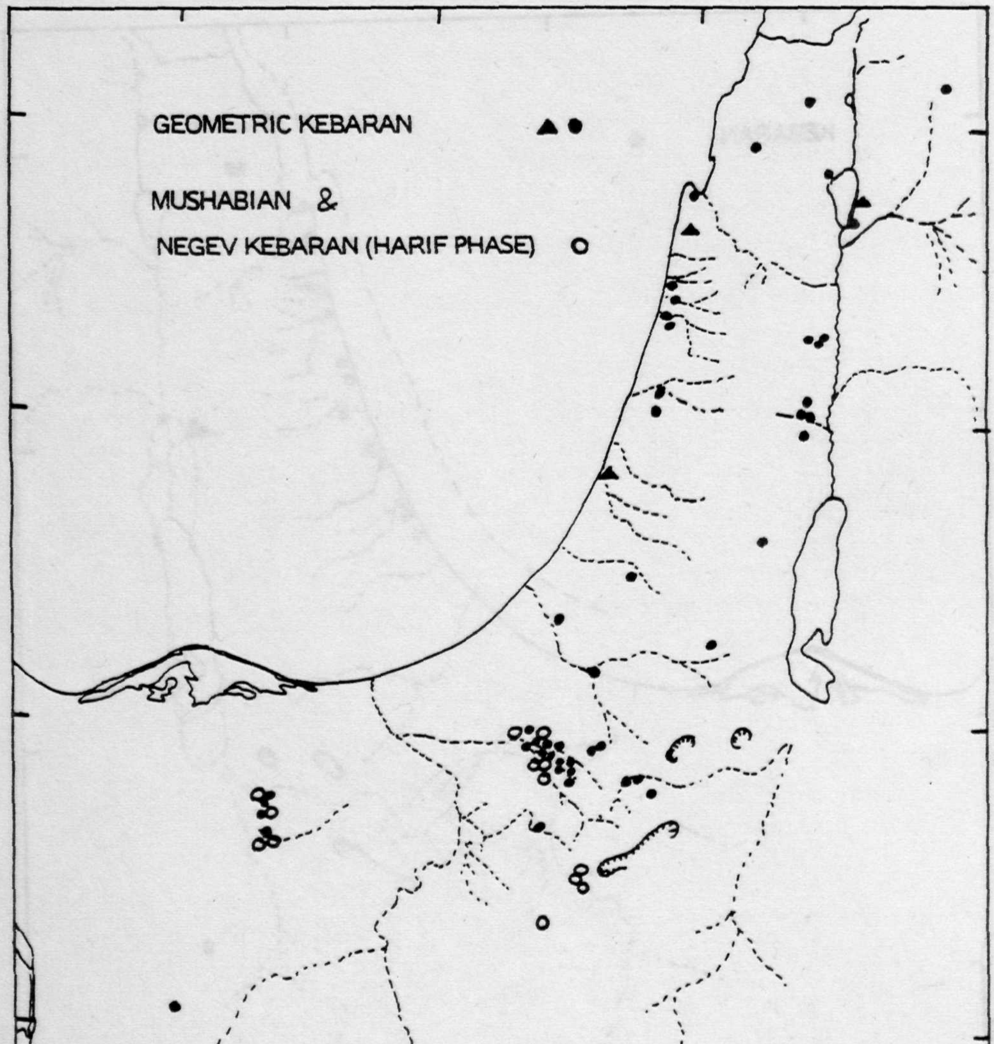


Figure 19.3 Distribution of Geometric Kebaran, Mushabian and Negev Kebaran sites (14,500-12,500 B.P.). (After Bar-Yosef, in press a).

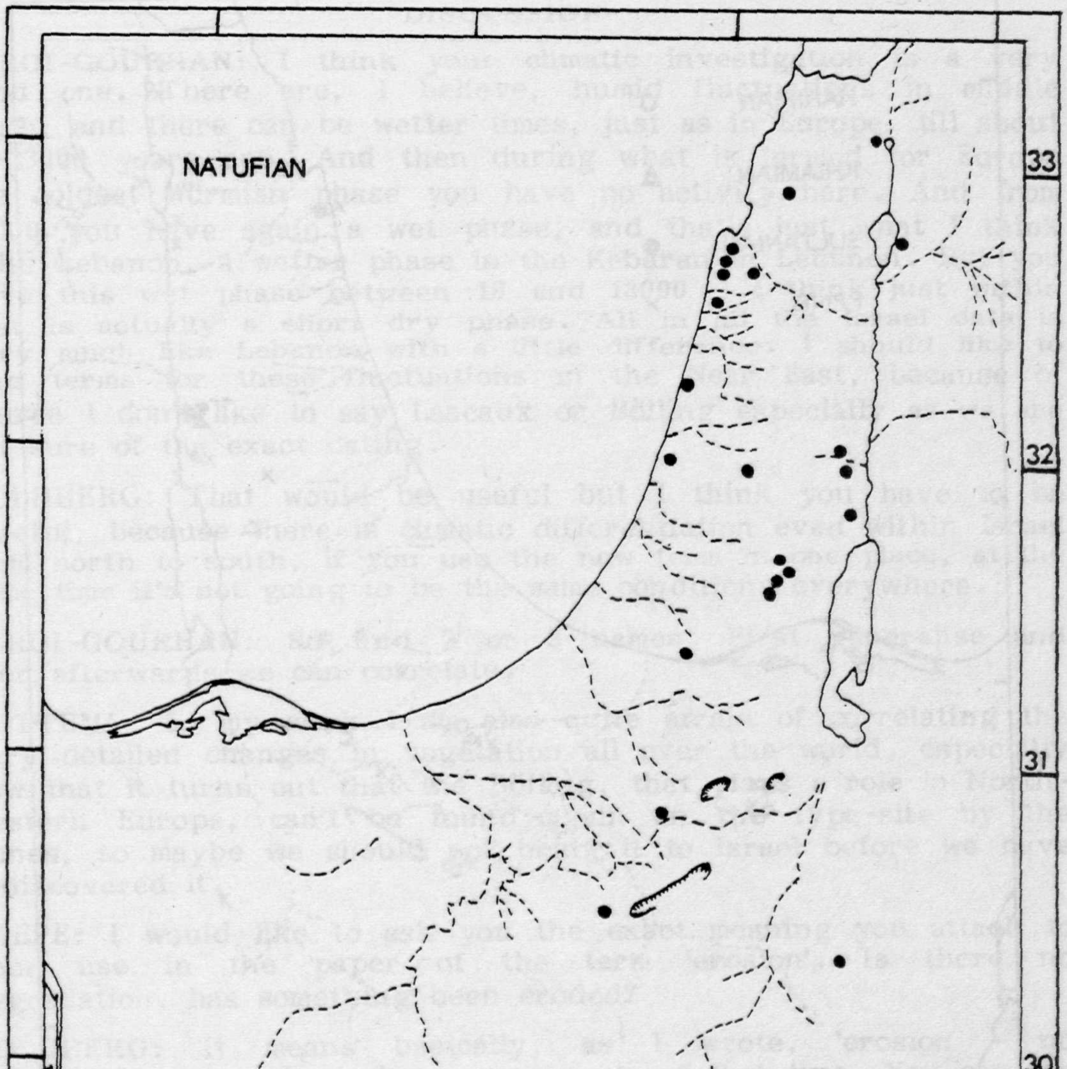


Figure 19.4 Distribution of Natufian sites (12,500–10,500 B.P.) (After Bar-Yosef, in press a).

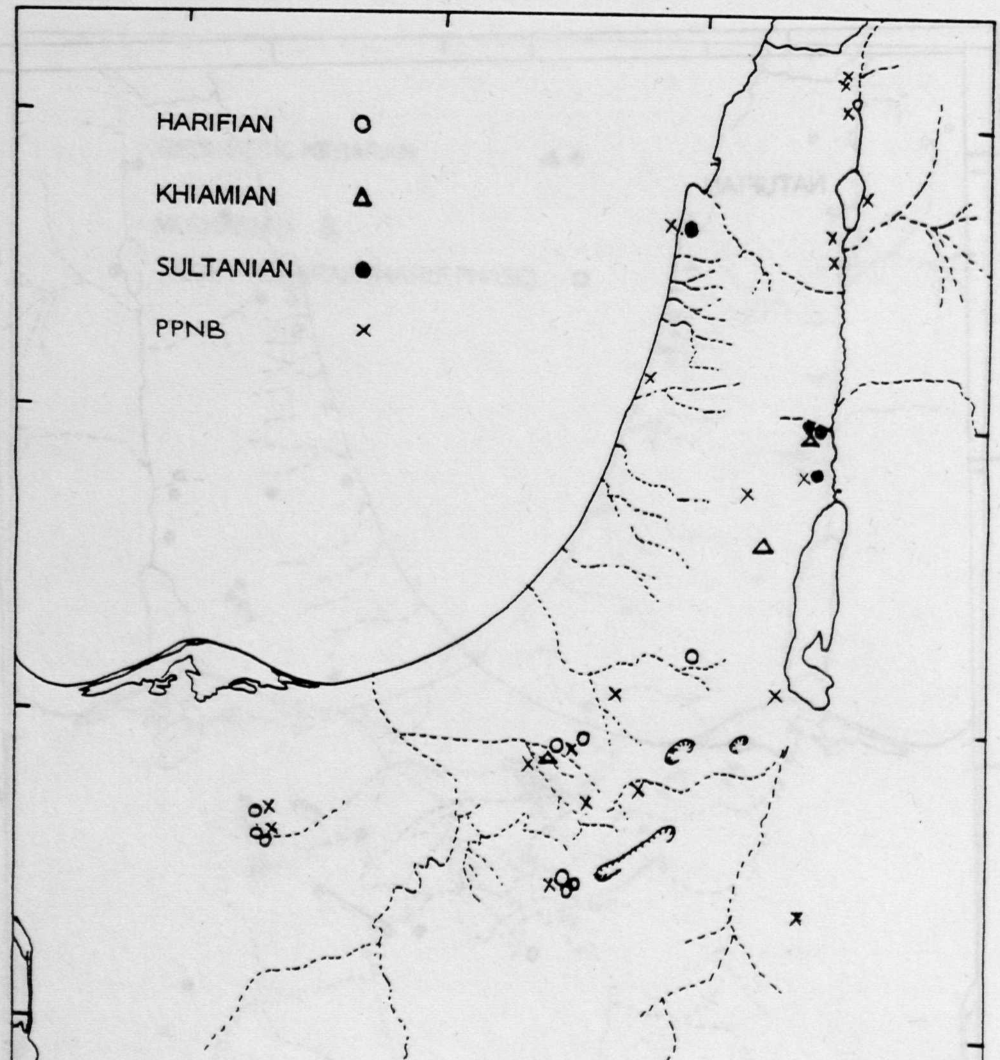


Figure 19.5 Distribution of Neolithic sites (10,500-8,000 B.P.) (After Bar-Yosef, in press a).

DISCUSSION

LEROI-GOURHAN: I think your climatic investigation is a very good one. There are, I believe, humid fluctuations in middle Würm, and there can be wetter times, just as in Europe, till about 24-23000 years ago. And then during what is termed for Europe the coldest Würmian phase you have no activity here. And from 18000 you have again a wet phase, and that's just what I think suits Lebanon, a wetter phase in the Kebaran in Lebanon. But you have this wet phase between 18 and 13000 - I think just within that is actually a short dry phase. All in all the Israel data is very much like Lebanon with a little difference. I should like to find terms for these fluctuations in the Near East, because of course I don't like to say Lascaux or Bölling especially as we are not sure of the exact dating.

GOLDBERG: That would be useful but I think you have to be careful, because there is climatic differentiation even within Israel from north to south, if you use the new term in one place, at the same time it's not going to be the same conditions everywhere.

LEROI-GOURHAN: So find 2 or 3 names. First generalise and then afterwards we can correlate.

BOTTEMA: In my work I am also quite afraid of correlating the very detailed changes in vegetation all over the world, especially now that it turns out that the Bölling, that plays a role in North-Western Europe, can't be found again on the type-site by the Danes, so maybe we should not bring it to Israel before we have rediscovered it.

PAEPE: I would like to ask you the exact meaning you attach to your use in the paper of the term 'erosion'. Is there no aggradation, has something been eroded?

GOLDBERG: It means basically, as I wrote, 'erosion - no record'. It means there are no sediments of that time. You can see in various places, say Middle Palaeolithic here, overlain by Upper Palaeolithic there and we know probably that there's about 30000 years missing between the two of them. So here I assume that the material was eroded, i.e. there could have been sediment put there but there might not have been - we just don't really know. So it's a mixture of both.

BROOKES: Can you see an erosional contact?

GOLDBERG: Yes, it's very sharp.

PAEPE: But does this contact cover the whole time span? That's really my question.

GOLDBERG: Well you can't tell. What if it's been eroded downstream? An extreme case would be that all the Mousterian or the Middle Palaeolithic was eroded away. All we can know is the topmost part that got eroded. So usually I tend to put question marks at the bottom contact because I don't know when erosion started, but I can tell you when it ended because I know that the system above it marks cessation of erosion and renewed deposition.

WHITNEY: What kind of environmental change do you envision for the carbonate soil? How much wetter?

GOLDBERG: Under today's conditions of about 60 -90 mm, you'd never get a soil like that ever, you could sit there and look at it for 100000 years and you wouldn't see it change. I suspect to get something like the soil you have 2 choices: either a long time span with slightly more wetness, or a shorter time span and having conditions a lot wetter. And you can't really sort out the two. But just on my own estimate I would assume something like 3 -400 mm of rain. A lot, but this happens to fit pretty nicely with some independent evidence. Our botanists have come up with the same estimate based on relict floras in the area. They say you need something like 300 400 mm of rain to establish such a floral picture. That's quite a change.

BAR YOSEF: One comment about the early Holocene sites. If we are talking about Early or Late Natufian and Early Neolithic sites, this is where you see a realistic shift in settlement pattern. This is not differential site loss due to erosion, because even where a site is eroded and the flints are carried away, when you look at the local gravels the flint doesn't disappear - you can even identify rolled pieces. So where we don't find sites even in erosion sediments, we look for them in some other place. For example if you take Har Harif which is about 10 - 15 km away from Qadesh Barnea, here you have Late Natufian sites very well preserved in the deposits, including C14 dates. If you go to the Western Negev, which is also about 10 km or 15 km away from Qadesh Barnea, only in a more northwards direction, you have Early Natufian sites. It's a matter primarily of shifting settlement patterns from one area to another. That's the reason why our plan was from the first to work every region to a fine detail, and each region will be within a distance of 40 - 50 km away from the rest.

ROBERTS: Questions and comments about two of your areas: first Gebel Maghara - the lake bed environment. Am I right in thinking that they were Kebaran sites in question and not related lithostratigraphically to the lake beds?

GOLDBERG: No, they are Geometric Kebaran and they interfinger with the lake beds.

BAR YOSEF: There are about 14 - 15 C14 dates for these sites.

ROBERTS: Apart from the interbedding, have you unambiguous evidence for the deposits being lacustrine, and I mean by that geochemistry, molluscs, diatoms, ostracods.

GOLDBERG: No, I don't. There aren't any.

ROBERTS: To come onto the second area, that's the Salibiya area in the Jordan valley. I'm afraid I find the evidence that you're presenting particularly for the Lisan sequence a bit thin and the lake level curve that you've put in hard to swallow. I'll give you some pieces of evidence: the last C14 date that I know of for the upper part of the Lisan Beds is 15 -16000 years bp, not Early Natufian. Indeed there is a C14 date for gastropods of fluviatile origin interbedded with Lisan Beds showing that lake levels were already fluctuating at 17000, so that clearly lake levels were already beginning to go up and down pretty radically by then. The other thing which I find hard to swallow is the idea that the lake somehow went up again in Neolithic times. A travertine isn't necessarily a lake bed and I would have thought if it went up that high then Jericho would be under water.

GOLDBERG: A couple of comments in reply. Firstly, as you noticed, I did draw fluctuations on the curve for that late glacial time. Secondly, previous work on the Dead Sea has been a little bit here and a little bit there, with no really concerted effort ever to come up with a reconstruction that would interest a Quaternary specialist, rather than someone who is interested in geochemistry or some other sub-speciality. As you know a Quaternary scholar looks at deposits a lot differently from even a sedimentologist, a different set of glasses are on compared to someone who works in the Cretaceous. Another problem with the dates is this. If you look at where the deposit has been dated, it's never really clear where you are, altitudinally or elevationally. And it's clear that if you want to construct a curve of lake level, that is height versus time, it's nice to know the elevation that the dates came from and this has never really been adequately published. The report will say 2 or 3 metres below the top of such and such, but you never really know where the top of such and such is. So until that's straightened out and the dates are really confirmed, with precision, as to time and space it's going to be hard to use such dates one to one. The point we're trying to make, and obviously we wouldn't push it too far, is the fact that you don't find any sites between the Geometric Kebaran and Early Natufian in that whole area is somewhat fishy. Even though every square inch of it has been walked over, and including the sedimentary traps where the stratigraphy is clear enough (there are gullies and so on). If there were something there you'd find it, and there isn't. Next, the travertines, your last point: these are quite widespread, and in this particular area I would find it strange that there'd be no connection between a large let's say 'aquifer nappe' or some kind of watertable, and the connection with the lake. It would seem reasonable to me that if you do find these travertines occurring over large areas with water dripping out of the substrate, that means the groundwater table was higher. The fact that you don't find any of these things anywhere in the early Natufian and the fact that you don't find them in sites associated with the Chalcolithic suggests to me pretty strongly that they are somehow tied to the Neolithic.

ROBERTS: Is this site actually above Jericho, altitudinally?

GOLDBERG: Yes.

ROBERTS: Clearly if you've got occupation at Jericho in PPNB and in all the other relevant periods you can't have a lake covering the site.

GOLDBERG: I didn't infer that the lake covered the site, I just said that the groundwater was higher there, which I assume was connected to the regional groundwatertable, which was, in turn probably connected to the lake. So I think indirectly you can make a case that the lake was higher, but it doesn't tell you where the lake was, and we never put on the graph where the lake was. I just said relatively high or relatively low.

BINTLIFF: If I could just go back to that interesting point about the erosion, with your alternation of phases of activity (accumulation) and then this erosion. Going through the sequence, what happens to the material that's being eroded, where does it go to, where is it redeposited? Perhaps you could illuminate this?

GOLDBERG: I think a large part of it is extremely difficult to trace. Certain areas are inaccessible, in other words it's very difficult in this part of the world to check a whole watershed. I also have to admit I've never been to every place downstream from the locations that you saw. But I suspect that because some of these systems are quite long, it just gets deposited downstream somewhere, but where exactly I don't know. I suppose with Nahal Zin, right below where the sites occur, the system widens out quite a bit, and there's probably a lot more seepage, so here a lot of the material that gets eroded probably gets blown out all over the wadi. And the same sort of thing happens with Qadesh Barnea; it just gets washed out, the northern foreland of Sinai is quite broad and the gradient more or less shallow. For the Jordan Valley it is quite hard to tell because the material ends up in the Jordan river which is inaccessible. For Gebel Maghara it's carried out into the Plain of Sinai through the exit of the anticline.

VAN ANDEL: On the problem of where the eroded material goes - this often turns out to be something of a non-problem. I've struggled with it in my own area in Greece. It turns out that when you estimate how much material you might have eroding and then you look at the area you can spread it over, there's not always that much for you to have to worry about. I was also glad to hear you adopt a rather 'laid back' attitude about calcareous concretions in soils. I think they have been placed there by the Lord to keep us modest about our interpretative abilities. You find them in lots and lots of places and they seldom make any sense. I have a number to study, they're all over the Peloponnese, Late Pleistocene, very abundant and very massive. The you find younger soils and I have some that are 5000 years old, in rainfall up to 300 mm, and they don't show any concretions whatsoever, in the same area where their older brothers are thick with it. I think that some more soil work on these concretions would be helpful, but right now any interpretation in terms of rainfall creating them or not is a dicey business.

GOLDBERG: Generally I agree with you, but I think if you look at present day soil conditions the best you'll find is a fleck of carbonate 2 mm across on whatever surface you look at of recent origin. And our concretions are very similar to soils developed in sandy stuff on the coastal plain of Israel near Tel Aviv, which gets about 500 mm. I don't want to stick my neck out too far on how much rain you need, but there's no question you need more water to produce them, and a fair amount more.

PREHISTORIC SETTLEMENT PATTERNS IN THE LEVANT, IN RELATION TO ENVIRONMENTAL CONDITIONS

Francis Hours
(C.N.R.S., Maison de l'Orient méditerranéen, Lyon, France)

Pour étudier la repartition des sites dans le Levant septentrional, il a été nécessaire de dresser un certain nombre de cartes, qui retracent l'évolution du peuplement dans la région. Elles représentent chacune une étape culturelle, caractérisée par des attributs comme l'architecture ou l'équipement technique, dont les limites dans le temps sont fixées par les dates de 14 C disponibles (données ici en B.P., avec demi-vie courte de Libby, non calibrées). Autour des sites bien datés, on a regroupé, époque par époque, les sites dont le matériel était suffisamment décrit pour qu'on puisse en identifier la civilisation.

L'établissement de ces cartes est le résultat d'un travail mené en commun depuis cinq ans par O. Aurenche, J. Cauvin, M.C. Cauvin, L. Copeland, F. Hours et P. Sanlaville. En ce qui concerne le Levant septentrional seulement (sud de la Turquie, Syrie et Liban), on a dépouillé les résultats d'environ 35 prospections publiées (voir carte 2) et utilisé les renseignements oraux qu'un long séjour sur le terrain a permis d'obtenir. La localisation des 820 points situés sur les cartes de répartition repose sur un nombre de références trop considérable pour qu'on puisse les mentionner dans cette prépublication. De plus, certaines prospections anciennes doivent être interprétées à la lumière de ce qu'on connaît aujourd'hui. Les choix qui en résultent, si on devait les justifier ici, demanderaient de longues explications, qui ne pourraient pas trouver leur place dans le cadre d' une communication aussi courte.

De même, la carte des domaines bio-géographiques actuels (carte 1), qui sont une des bases dont on dispose pour essayer de retrouver l'environnement passé a été spécialement préparée par Paul Sanlaville, et suppose également le dépouillement d'un nombre de documents non négligeable.

Tout cela explique qu'on ne trouvera ici que les résultats d'un travail de synthèse, dont les références paraîtront éventuellement dans la publication définitive.

Ces résultats sont exposés sous la forme d'un bref commentaire des différentes cartes, ces dernières constituant le document essentiel.

CARTE 1. Domaines biogéographiques

En dehors de la disposition en arc de cercle bien connue que la carte met en évidence, on doit noter que la limite méridionale théorique des cultures sèches (le Croissant céréalier) peut avoir des extensions vers le sud, soit le long des vallées (Euphrate, Balikh, Khabour), soit dans l'enfilade des "montagnes de la zone steppique" (Anti-Liban, Qalamoun, Dorsale palmyrénienne, Jabal Bichri, Jabal Abd el Aziz, Jabal Sinjar), soit dans des niches écologiques trop peu étendues pour figurer sur une carte à si petite échelle (dépressions ou oasis comme Palmyre et El Kowm).

CARTE 2. Prospections effectuées en Syrie et au Liban

Ces prospections ne recouvrent pas tout le territoire, et sont d'inégales valeurs. Néanmoins, la côte, les grandes vallées et le piedmont du Taurus sont suffisamment couverts pour que cela donne une idée du peuplement entre 20,000 et 5,600 B.P., encore qu'une étude systématique des régions situées entre l'Euphrate, le Balikh, le Khabour et ses affluents apporterait sans doute des données nouvelles.

CARTE 3. Les sites de 20,000 à 14,000 B.P.

10 sites en 6,000 ans, soit un site pour 600 ans. Les sites israéliens ne sont pas comptés, et le moyen utilisé pour effectuer des comparaisons entre les périodes est assez rudimentaire. Cependant, cela peut donner une vague idée des mouvements de population.

La fin du paléolithique supérieur est marquée dans le Levant septentrional, comme d'ailleurs plus au sud, par une industrie à dominante microlithique: le Kébarien, qui commence peut-être un peu après 20,000 B.P., et se termine vers 14,000 B.P. La région semble alors peu peuplée. A l'exception du Nahr el Homr sur l'Euphrate, les sites se concentrent plutôt en bordure des massifs montagneux, Liban et Anti-Liban.

CARTE 4. Les sites entre 14,000 et 12,000 B.P.
14 sites en 2,000 ans, soit un site pour 142 ans.

Durant ses 2,000 ans, la Syrie et le Liban, comme Israel et peut-être aussi le Zagros, sont occupés par des populations utilisant des géométriques. Localement, cette civilisation a reçu le nom de Kébarien géométrique. On peut y reconnaître des faciès variés, dont l'existence est sans doute facilitée par l'isolement géographique des groupes humains. Tout en restant faible, le peuplement augmente de façon significative, et s'étend vers l'intérieur, en particulier le long des montagnes de la zone steppique occidentale. C'est à cette époque qu'apparaissent les premiers indices d'un changement dans le genre de vie: cabanes construites, sépultures, mobilier lourd.

CARTE 5. Les sites de 12,000 à 10,300 B.P.
16 sites en 1,700 ans, soit un site pour 106 ans.

La civilisation qui domine dans le Levant est le Natoufien. Cette fin du pleistocène, considérée comme aride, voit une légère augmentation du nombre des sites, qui semblent avoir représenté parfois de véritables villages: Sables de Beyrouth, Saaidé II dans la Beqaa, Abu Hureyra et Mureybet sur l'Euphrate. Le peuplement reste cependant du même ordre que dans la période précédente. La répartition des sites, souvent en rapport avec la présence de l'eau, reflète ce que l'on connaît par ailleurs de l'aridité de la période.

CARTE 6. Les sites de 10,300 à 9,600 B.P.
10 sites en 700 ans, soit un site pour 70 ans.

Vers 10,300 B.P., l'outillage change: les faucilles se multiplient, les pointes de flèches apparaissent. En même temps, les premiers indices d'agriculture se manifestent. Cela correspond au Protonéolithique et au P.P.N.A. de Jéricho. Avec la conquête de territoires nouveaux, comme la vallée du Queiq, la population semble continuer a s'accroître. Mais le phénomène serait sans doute inversé si on pouvait isoler tous les sites existant seulement entre 10,300 et 10,000 B.P., qui ont déjà un outillage différent de celui du Natoufien, mais dont le genre de vie ne semble pas encore avoir changé par rapport à ce dernier. Ce sont les plus nombreux, et la population paraît régresser à partir de 10,000.

Il est tentant de mettre le passage de l'économie de prédation à l'économie de production en rapport avec les variations de climat du début de l'holocène, mais ces rapports ne sont pas évidents. D'autre part, sauf à Nachcharini dans l'Anti-Liban, les montagnes semblent vides, ce qui peut s'interpréter comme une recherche des terres arables.

CARTE 7. Les sites de 9,600 à 8,600 B.P.

6 sites en 1,000 ans, soit un site pour 166 ans.

Aux environs de 9,600 B.P., l'outillage change à nouveau, ainsi que l'architecture. Les cabanes de plan rectangulaire et à murs rectilignes remplacent les huttes rondes. En Palestine, à Jéricho et à Beidha, cela correspond au début du P.P.N.B. En Syrie, cela se traduit par une dimunution sensible du nombre des sites, ce qui prolonge le mouvement amorcé dans la période précédente.

Le phénomène reste à expliquer, mais on doit constater que les rapports entre les débuts de l'économie de production et les mouvements de population ne sont pas ce qu'on pourrait attendre.

CARTE 8. Les sites de 8,600 à 8,000 B.P.

53 sites en 600 ans, soit un site pour 11 ans (en comprenant les 36 sites portés sur la carte 8 bis).

L'outillage lithique ne change guère et, de ce point de vue, on se trouve toujours en présence du P.P.N.B. Mais sur l'Euphrate à Bouqras la céramique apparaît, de même qu'en Anatolie à Çatal Hüyük. Le site de Ras Shamra est occupé pour la première fois. La haute vallée de l'Oronte, dans la Beqaa libanaise et jusqu'à Homs en Syrie, voit se multiplier les traces d'une industrie de petites dimensions, connaissant faucille et tête de flèche à pédoncule: le "Néolithique des Pasteurs". Elle est placée à cette date, de façon un peu conjecturale (carte 8 bis).

Meme si l'on ne tient pas compte du Néolithique des Pasteurs, le population est en augmentation.

CARTE 9. Les sites de 9,600 à 8,000 B.P.

Récapitulation des cartes 7 et 8, plus les sites qu'on ne peut pas placer dans le temps de façon plus précise, mais qui sont certainement à leur place en 7 ou en 8.

92 sites en 1,600 ans, soit un site pour 17 ans (en comprenant le Néolithique des Pasteurs, carte 8 bis).

Si on ne dispose que de la typologie sommaire de l'industrie lithique pour apprécier la date d'un site, il est impossible de préciser si on se trouve dans les débuts ou à la fin de ce qu'on appelle le "Néolithique Précéramique B". Cela explique qu'on ait regroupé sur cette carte 9 tous les sites attribués à cette phase culturelle.

Les fluctuations du mouvement de la population en sont un peu estompées, et il en résulte l'impression d'une augmentation continue du nombre des sites, en même temps que celle d'une certaine colonisation de la steppe. Les villages semblent s'aventurer en dehors de ce qui constitue de nos jours le biotope favorable aux céréales. Est-ce dû à des changements de climat?

CARTE 10. Les sites de 8,000 à 7,600 B.P.

30 sites en 400 ans, soit un site pour 13 ans.

Cela correspond à la généralisation de la céramique, présente désormais partout. A partir de cette époque, les renseignements publiés par la plupart des archéologues ne concerneront plus que cela. C'est d'ailleurs un critère commode, car la céramique n'est pas uniforme. Sur la côte, depuis la Cilicie jusqu'à Byblos, et à l'intérieur jusqu'à l'Euphrate, on rencontre une céramique non peinte lustrée, dont la pâte est de couleur plutôt sombre, à dégraissant minéral (Amuq A). Sur le haut Khabour également, la ceramique est lustrée, sombre et non peinte, mais est épaisse et le dégraissant est végétal (Altmonochrom). A El Kowm, sans doute en relation avec ce qui se passe à l'est, elle est de couleur claire, à décor peint en rouge. Que ce soit à El Kowm ou sur la côte libanaise, la céramique s'accompagne d'une "vaisselle blanche" de chaux ou de plâtre. Les montagnes de la zone steppique occidentale marquent la frontière entre céramique peinte et non peinte.

Il y a donc des traditions techniques qui différencient plusieurs groupes.

Par ailleurs, le schéma de répartition des sites ne change guère.

CARTE 11. Les sites de 7,600 à 7,000 B.P.

49 sites en 600 ans, soit un site pour 12 ans.

L'équipement domestique, sur la côte, ne change guère. Cependant, des modifications dans le décor de la céramique permettent de distinguer l'Amuq A de l'Amuq B. Le trait le plus frappant est la transformation qui s'opère dans l'implantation des sites. Le sud est pratiquement déserté, tandis que les collines de piedmont du Taurus se peuplent. Reste à savoir si cela est dû à un changement dans les conditions de l'environnement.

Sur le plan culturel, on assiste aux premiers contacts entre les entités définies par leur céramique. L'influence anatolienne se fait sentir en Cilicie, et pénètre timidement jusque dans le Queiq. La céramique de Halaf, à ses débuts sur le Khabour, se rencontre jusque sur le Balikh. La vaisselle blanche pénètre dans l'Amuq.

CARTE 12. Les sites de 8,000 à 7,000 B.P.

Récapitulation des cartes 10 et 11, plus les sites qu'on ne peut attribuer de façon précise au début ou à la fin du VI° millénaire B.C., mais qui sont sûrement en activité à cette époque.

95 sites en 1,000 ans, soit un site pour 10 ans.

Il arrive que les renseignements fournis soient trop vagues pour qu'on puisse rattacher un site à l'Amuq A ou à l'Amuq B. C'est pourquoi on a regroupé tout ce qui concerne le néolithique céramique pré Halaf sur la carte 12. Comme pour la récapitulation du P.P.N.B. (carte 9), des nuances sont ainsi évacuées, notamment le moment de la conquête du piedmont taurique entre 7,600 et 7,000 B.P. Mais cela permet de mieux percevoir les zones de peuplement: la Cilicie, l'Amuq, la côte syro-libanaise, la Beqaa, la vallée du Queiq et le Khabour. Les oasis: Damas, Palmyre, El Kowm semblent avoir perdu de leur importance.

Il semble que, durant ce millénaire, les populations désormais dépendantes de l'agriculture pour la plus grande partie de leur subsistance recherchent des terres arables dans les vallées et les bassins alimentés par des rivières de débit moyen. Les grands fleuves comme l'Euphrate ou les régions moins humides comme les oasis paraissent moins attractifs.

CARTE 13. Les sites de 7,000 à 6,500 B.P.

184 sites en 500 ans, soit un site pour 3 ans.

On assiste à une veritable explosion démographique: c'est la période la plus peuplée du Levant septentrional avant la "révolution urbaine". Mais le schéma de répartition des sites ne varie guère: ils restent groupés dans les bassins et les vallées dépendant de rivières moyennes. Il est très vraisemblable que l'image fournie par les renseignements dont on dispose aujourd'hui serait modifiée si on connaissait mieux ce qui se passe alors sur les affluents orientaux du Khabour.

La conquête des pentes du Taurus se poursuit, et certaines grottes sont réoccupees (indice de transhumance?).

Sur le plan culturel, deux ensembles se distinguent assez nettement. Au nord, sur les collines qui bordent le Taurus, la civilisation de Halaf s'étend a l'ouest jusqu'à l'Amuq, et même de façon atténuée jusqu'en Cilicie. Cependant cette dernière région commence à basculer dans l'orbite anatolienne. La dernière trace méridionale de céramique halafienne se trouve sur les bords de l'Oronte, dans un petit tell en bordure du lac de Homs (Arjoun). Par contre, le Liban échappe à l'emprise de Halaf. Sur la côte, la céramique non peinte persiste seule, avec un outillage lithique un peu différent, comportant en particulier des haches à taillant rond poli, qui permettent de rattacher a cette époque les nombreux ateliers de débitage qu'on trouve en Beqaa et en Galilée.

CARTE 14. Les sites de 6,500 à 6,100 B.P.

71 sites en 400 ans, soit un site pour 5 ans.

L'occupation de l'espace marque un temps d'arrêt. Les pentes du Taurus se vident. Ailleurs, les régions habitées restent les mêmes, mais les villages sont moins nombreux (sauf dans le bassin de Jabboul?).

Dans le nord, la civilisation de Ubaid, née 1,500 plus tôt en Mésopotamie méridionale, se fait sentir jusque dans l'Amuq et à Ras Shamra, tandis que la Cilicie participe à l'évolution de la céramique du bassin de Konya. Au sud, le néolithique de Byblos arrive à son terme, avec un outillage lithique rénové, caractérisé par de grands ciseaux à taillant droit, qui va durer longtemps.

CARTE 15. Les sites de 6,100 à 5,600 B.P.

54 sites en 500 ans, soit un site pour 9 ans.

Par rapport à la période halafienne, le retrait de population reste sensible. Les aires d'occupation donnent l'impression de se refermer sur elles-mêmes. Avec quelques nuances originales, la Cilicie fait maintenant complètement partie du domaine anatolien. A Byblos et sur la côte libanaise règne un chalcolithique très particulier, différent de l'Amuq E, à Ras Shamra et dans la région d' Antioche. Sur le Balikh, on ressent encore l'influence de Ubaid.

L'élément neuf est que, à Byblos comme dans l'Amuq et à Ras Shamra, l'usage du cuivre fondu et forgé est attesté avec consistance pour la première fois.

CARTE 16. Les sites de 6,500 à 5,600 B.P.

Récapitulation des cartes 14 et 15, plus les sites qu'on ne peut pas placer avec certitude dans l'une ou l'autre phase, mais qui datent surement de cette période.

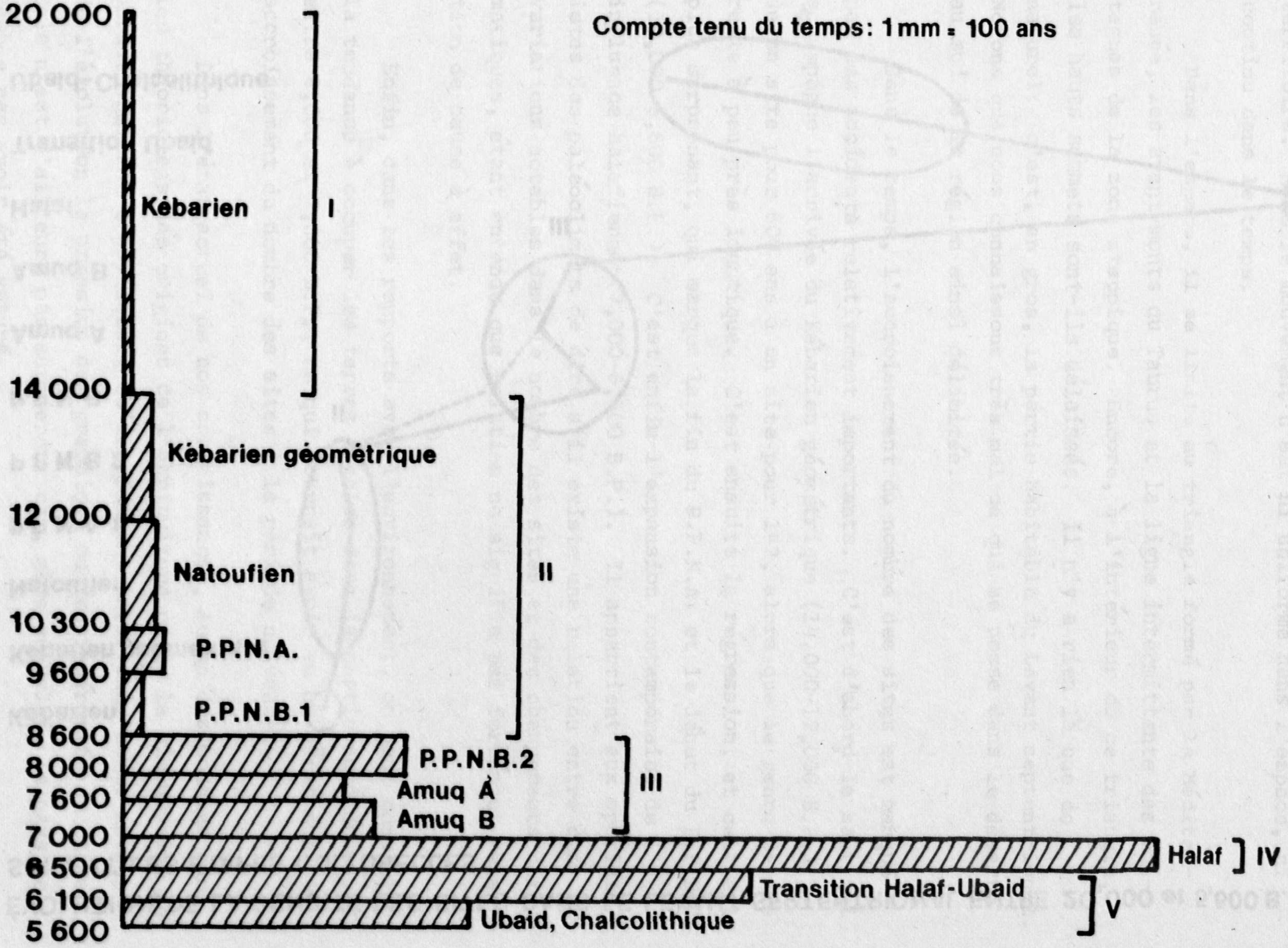
148 sites en 900 ans, soit un site pour 6 ans.

Bien que cette synthèse des sites attribuables à ces 900 ans donne naturellement un nombre d'établissements plus élevé que la somme des cartes 14 et 15, la tendance au retrait par rapportà Halaf reste perceptible.

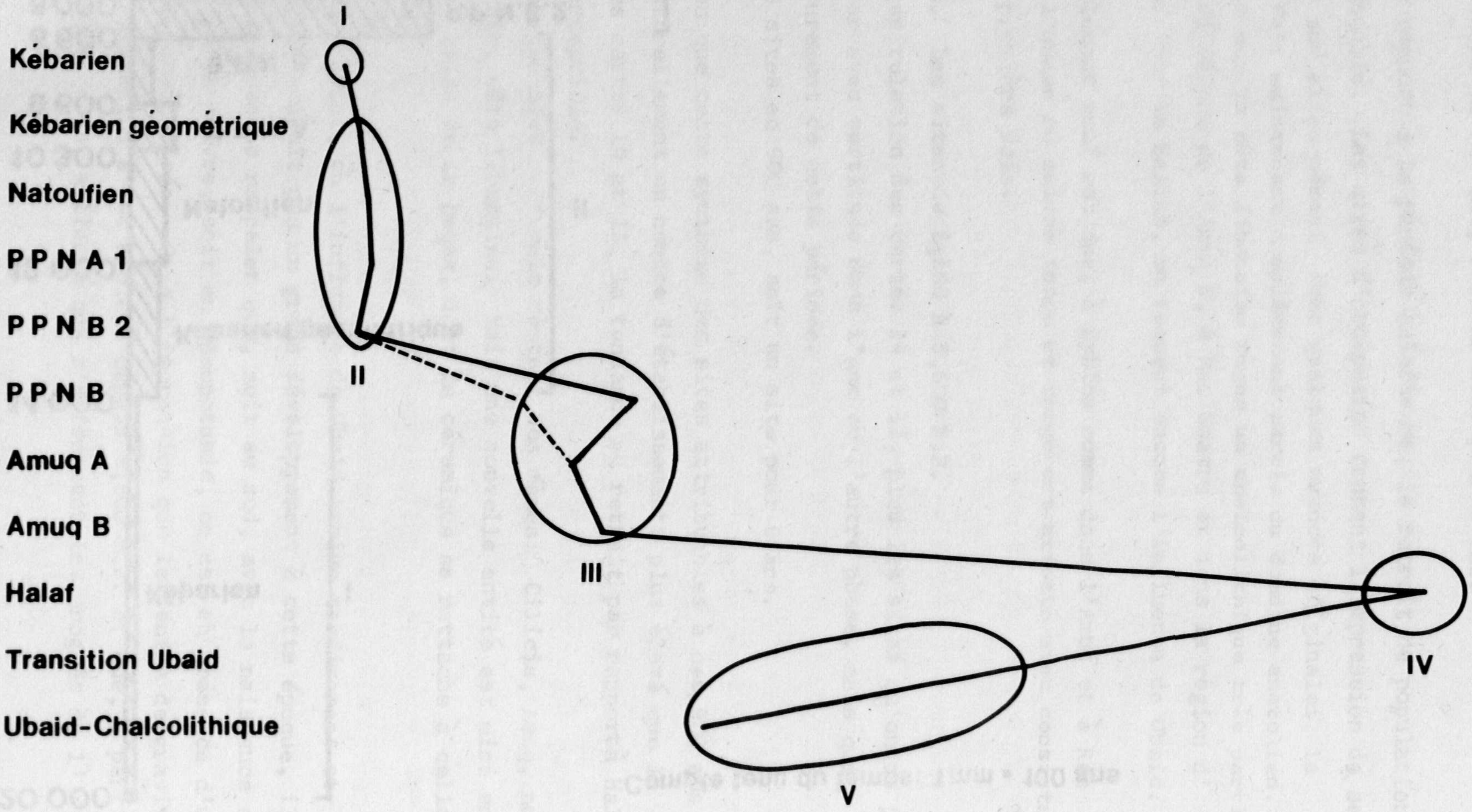
Les ensembles culturels restent les mêmes: Cilicie, Amuq, nord de la Syrie, côte libanaise. Mais une nouvelle entité est mise en évidence, celle de la Beqaa, dont la céramique se rattache à celle de Palestine.

Si le Levant, où l'influence de Ubaid arrive tardivement et atténuée, ne connaît pas un grand développement à cette époque, il faut en revanche se rappeler que, soit au sud, avec la naissance de l'industrie du cuivre, soit en Mésopotamie, on est en présence d'une expansion caractérisée. On a l'impression que le centre de gravité de la civilisation s'est déplacé depuis 6,500 B.P. et que, à partir de ce moment, c'est ailleurs que s'effectuent les progrès de l' humanité.

EVOLUTION DE LA DENSITE DES SITES DANS LEVANT SEPTENTRIONAL ENTRE 20,000 ET 5,600 B.P.



ÉVOLUTION DE LA DENSITÉ DES SITES DANS LE LEVANT SEPTENTRIONAL ENTRE 20,000 et 5,600 B.P. SUIVANT LES ÉTAPES CULTURELLES



CONCLUSION

Le phénomène le plus apparent qui ressort de l'analyse de répartition des sites en Syrie et au Liban est l'accroissement du nombre des installations, et la prise de possession progressive du territoire. Mais le mouvement n'est ni uniforme dans l'espace, ni continu dans le temps.

Dans l'espace, il se limite au triangle formé par la Méditerranée, les avant-monts du Taurus et la ligne intermittente des montagnes de la zone steppique. Encore, à l'intérieur de ce triangle, les hauts sommets sont-ils délaissés. Il n'y a rien là que de naturel: c'est, en gros, la partie habitable du Levant septentrional. Notons que nous connaissons très mal ce qui se passe dans le désert, au sud de la région ainsi délimitée.

Dans le temps, l'accroissement du nombre des sites est marqué par des accidents relativement importants. C'est d'abord le saut qui accompagne l'arrivée du Kébarien géométrique (14,000-12,000 B.P.): de un site pour 600 ans à un site pour 142, alors que le genre de vie reste à peu près identique. C'est ensuite la régression, et cela est plus surprenant, qui marque la fin du P.P.N.A. et le début du P.P.N.B. (10,000-8,600 B.P.). C'est enfin l'expansion contemporaine de l' influence halafienne (7,000-6,500 B.P.). Il appartient aux spécialistes des paléoclimats de dire s'il existe une relation entre ces variations notables dans le nombre des sites et des changements climatiques, étant entendu que relation ne signifie pas forcément relation de cause à effet.

Enfin, dans les rapports avec l'environnement, on peut constater la tendance à occuper les terres arables dans la partie nord du pays entre 8,000 et 7,000 B.P., ce qui pourrait avoir eu un effet sur l' accroissement du nombre des sites à la période suivante.

Dans l'état actuel de nos connaissances, aucun des modèles par les théoriciens des origines de l'agriculture ou de la vie urbaine ne paraît vraiment s'appliquer, qu'ils fassent intervenir comme moteur de l'évolution la pression démographique ou les impératifs du climat. Cela n'est d'ailleurs pas surprenant car, même au Halaf, le pays ne semble pas avoir été saturé.

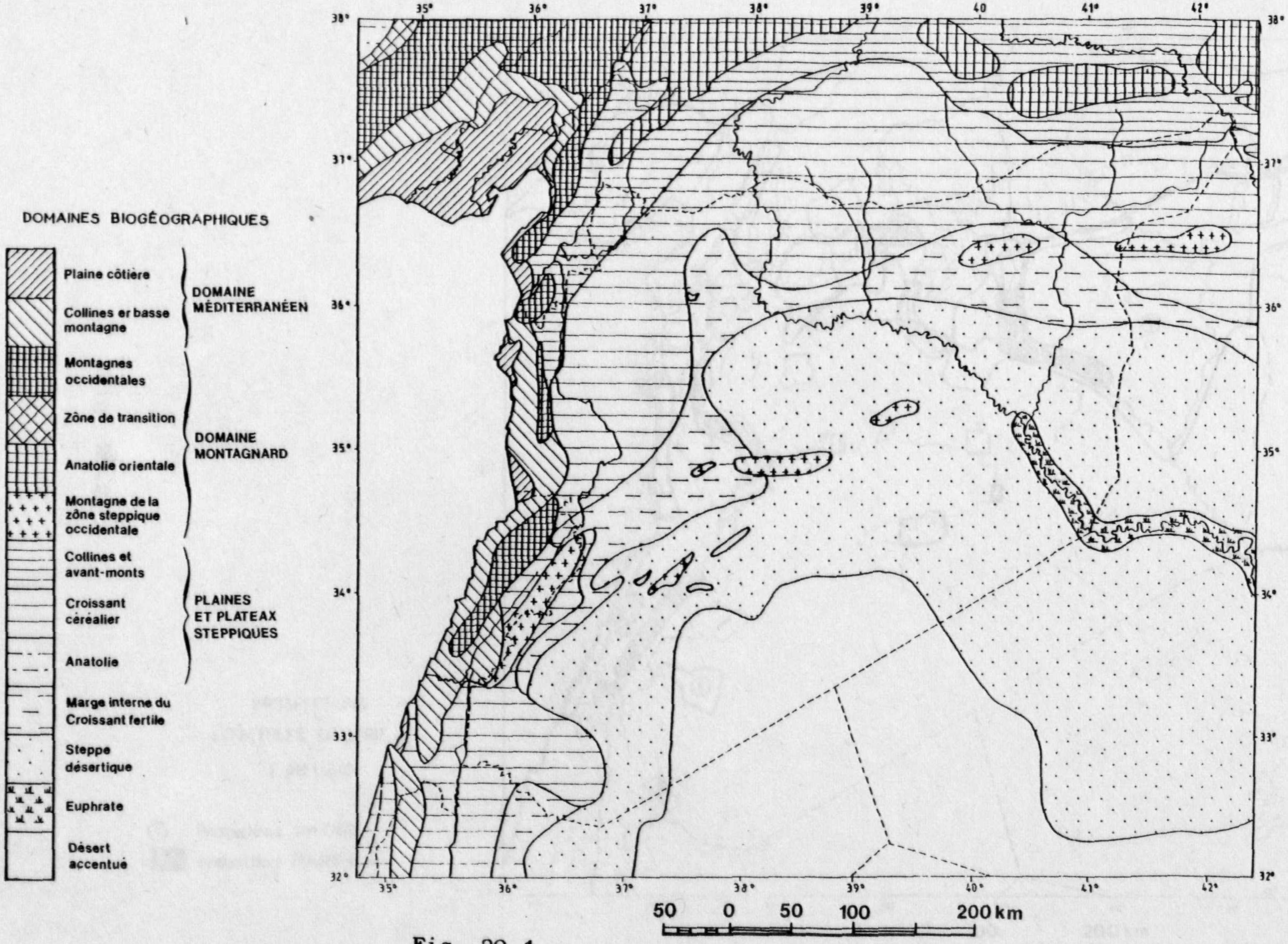

DOMAINES BIOGÉOGRAPHIQUES
Plaine côtière
Collines er basse montagne
DOMAINE MÉDITERRANÉEN
Montagnes occidentales
Zône de transition
Anatolie orientale
DOMAINE MONTAGNARD
Montagne de la zône steppique occidentale
Collines et avant-monts
Croissant céréalier
Anatolie
PLAINES ET PLATEAUX STEPPIQUES
Marge interne du Croissant fertile
Steppe désertique
Euphrate
Désert accentué
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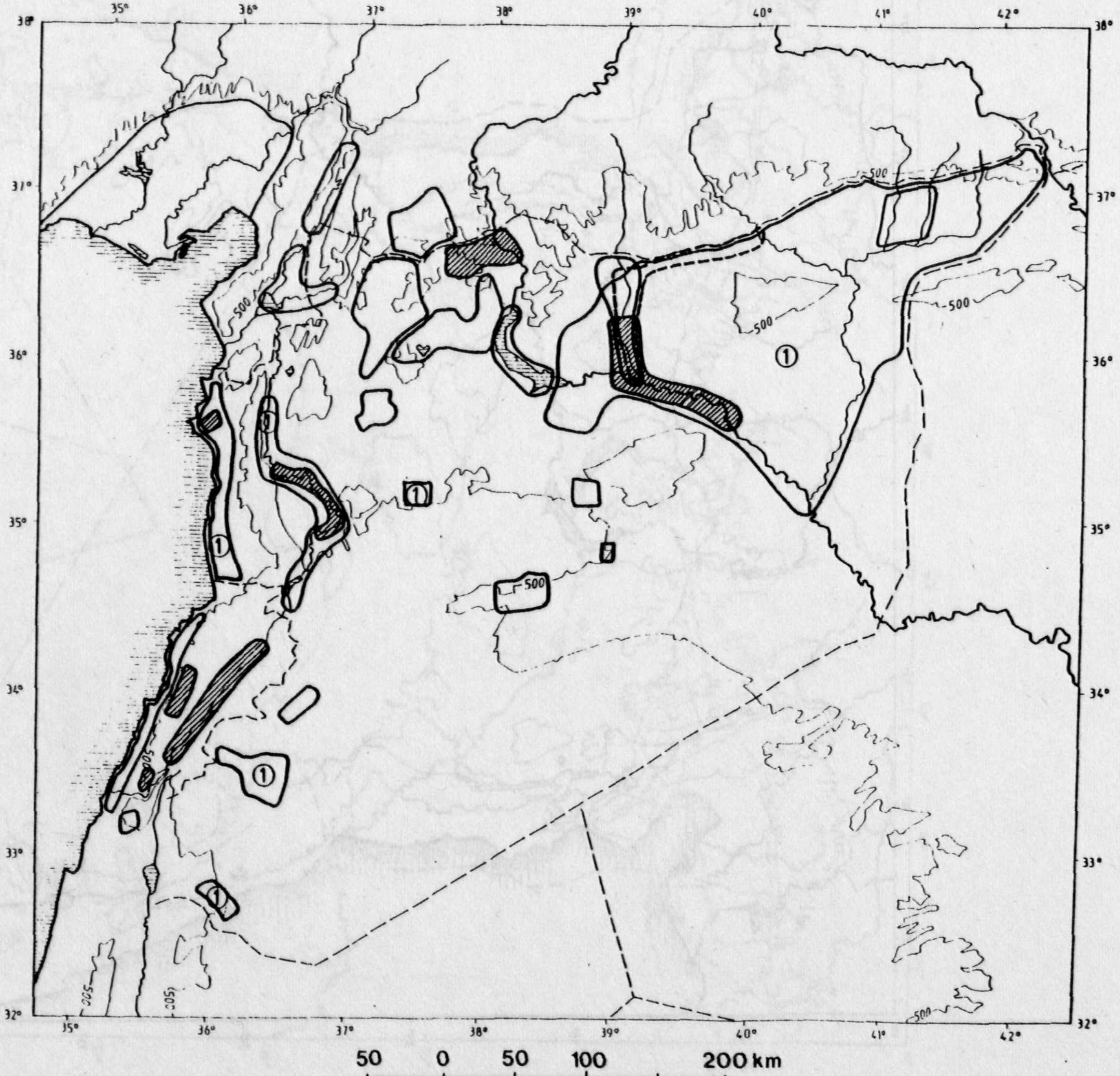
Fig. 20.1

Fig. 20.2



PROSPECTIONS
EFFECTUÉES EN SYRIE
ET AU LIBAN

① Prospections *van LIERE*
▨ Prospections *HOURS et al.*

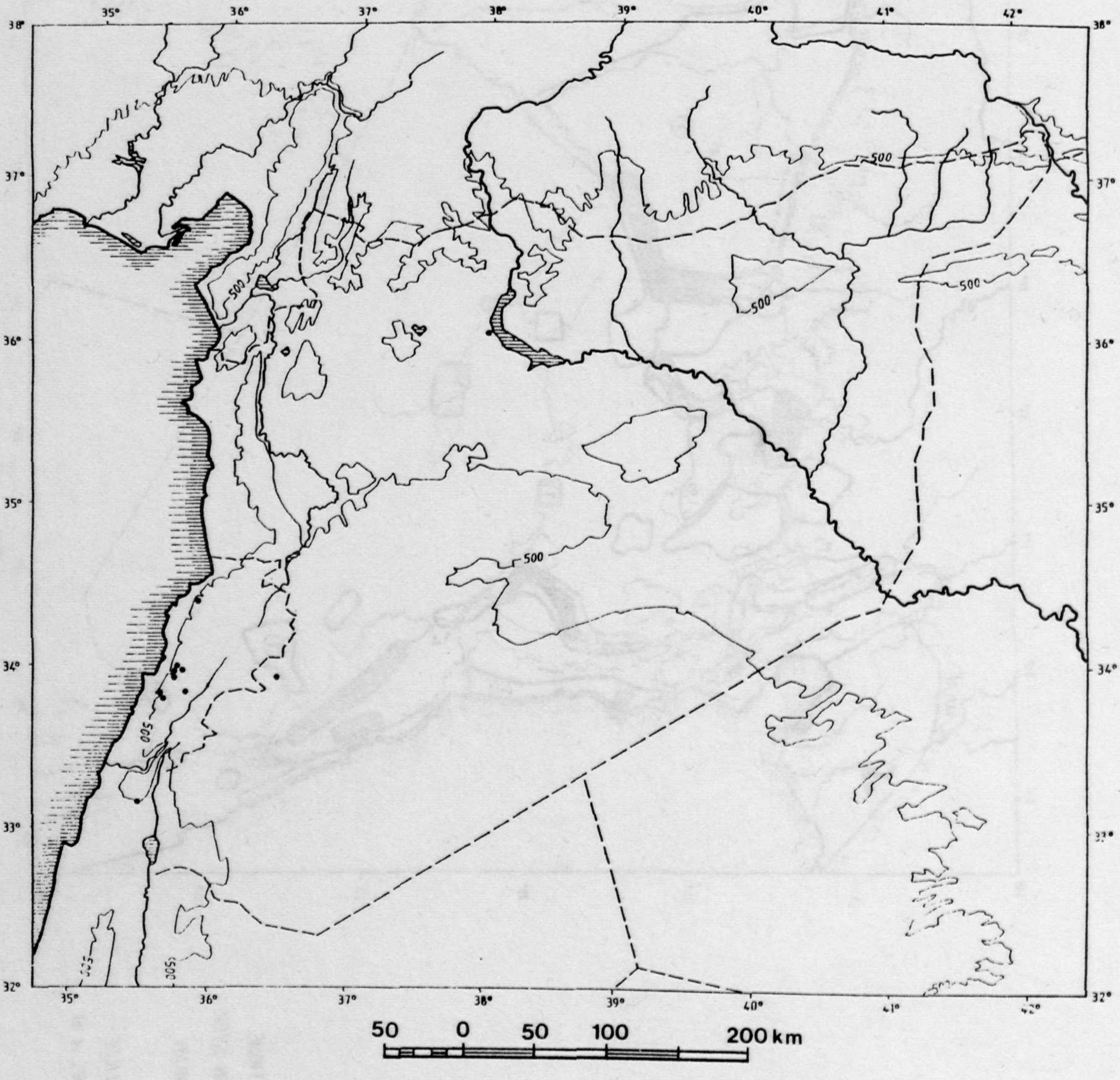


Fig. 20.3

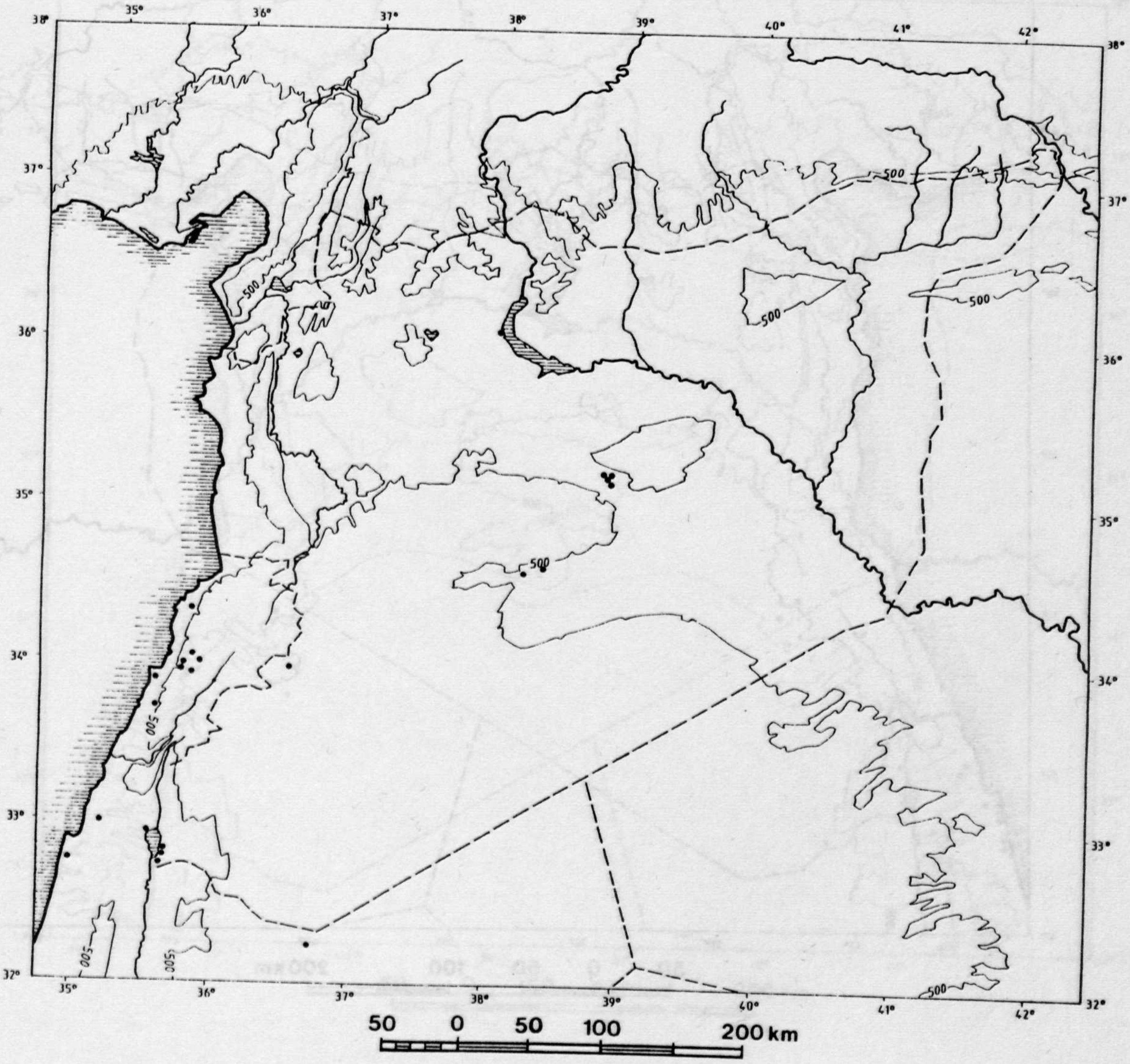


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Fig. 20.4

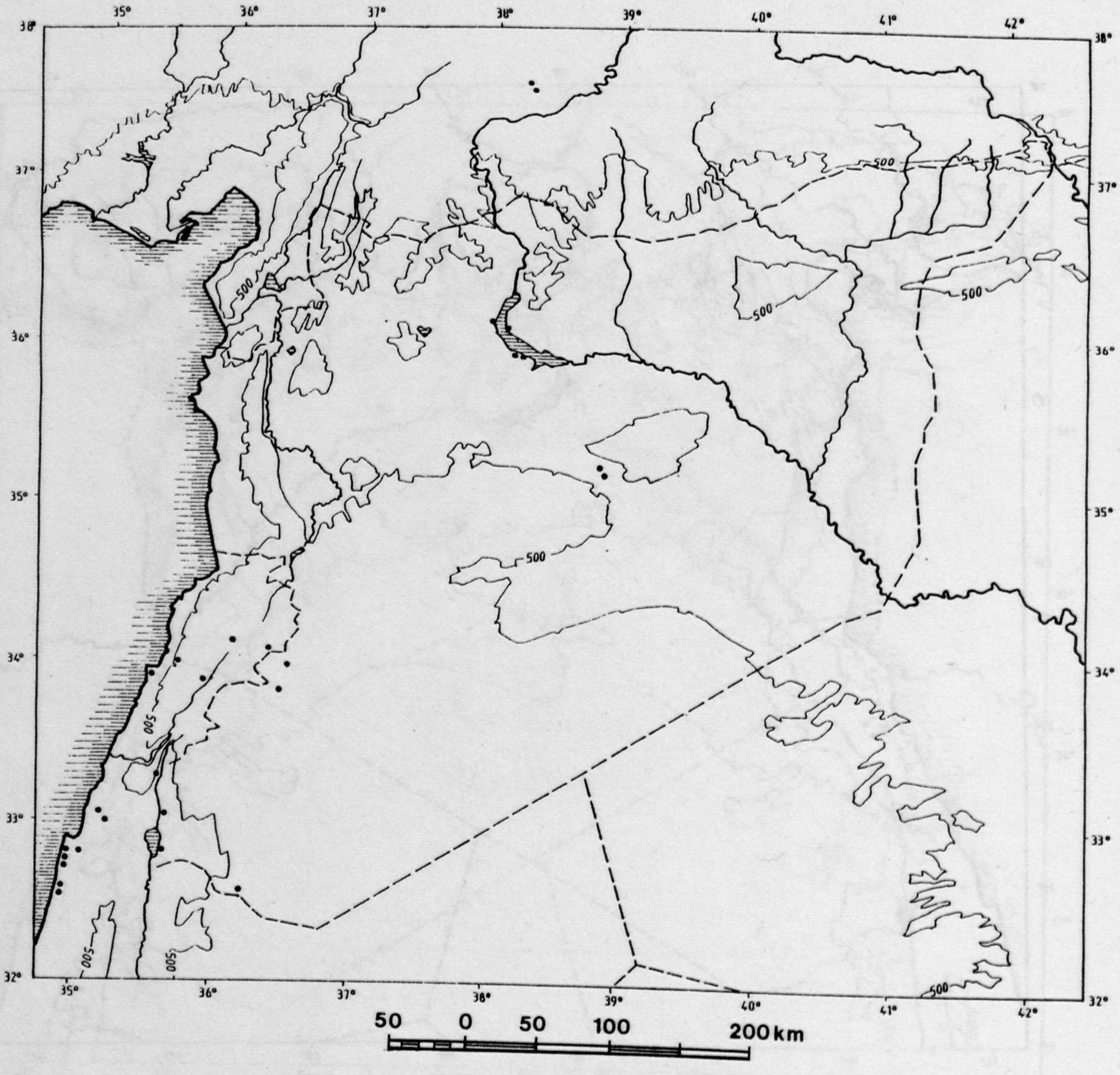


Fig.20.5

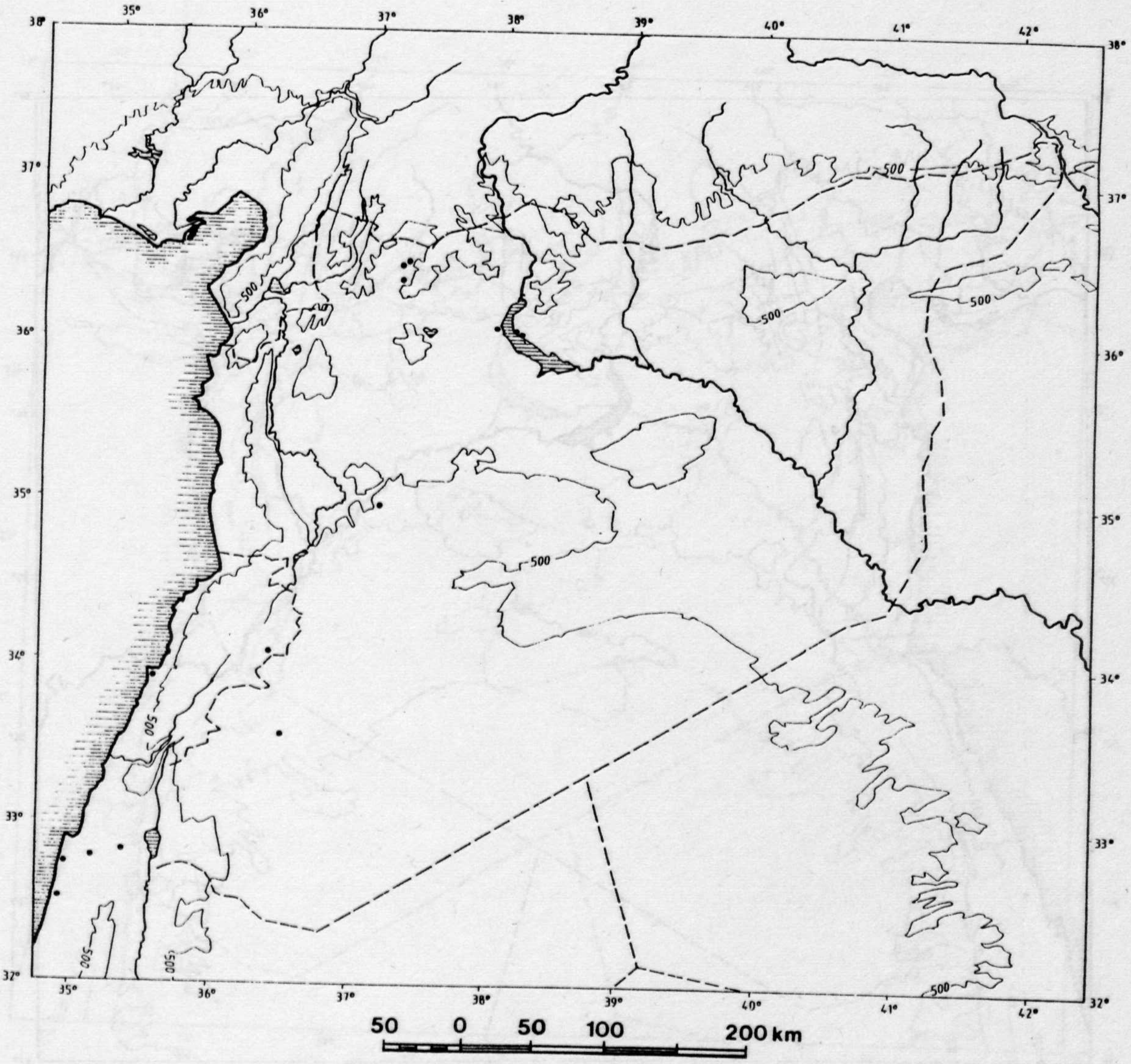
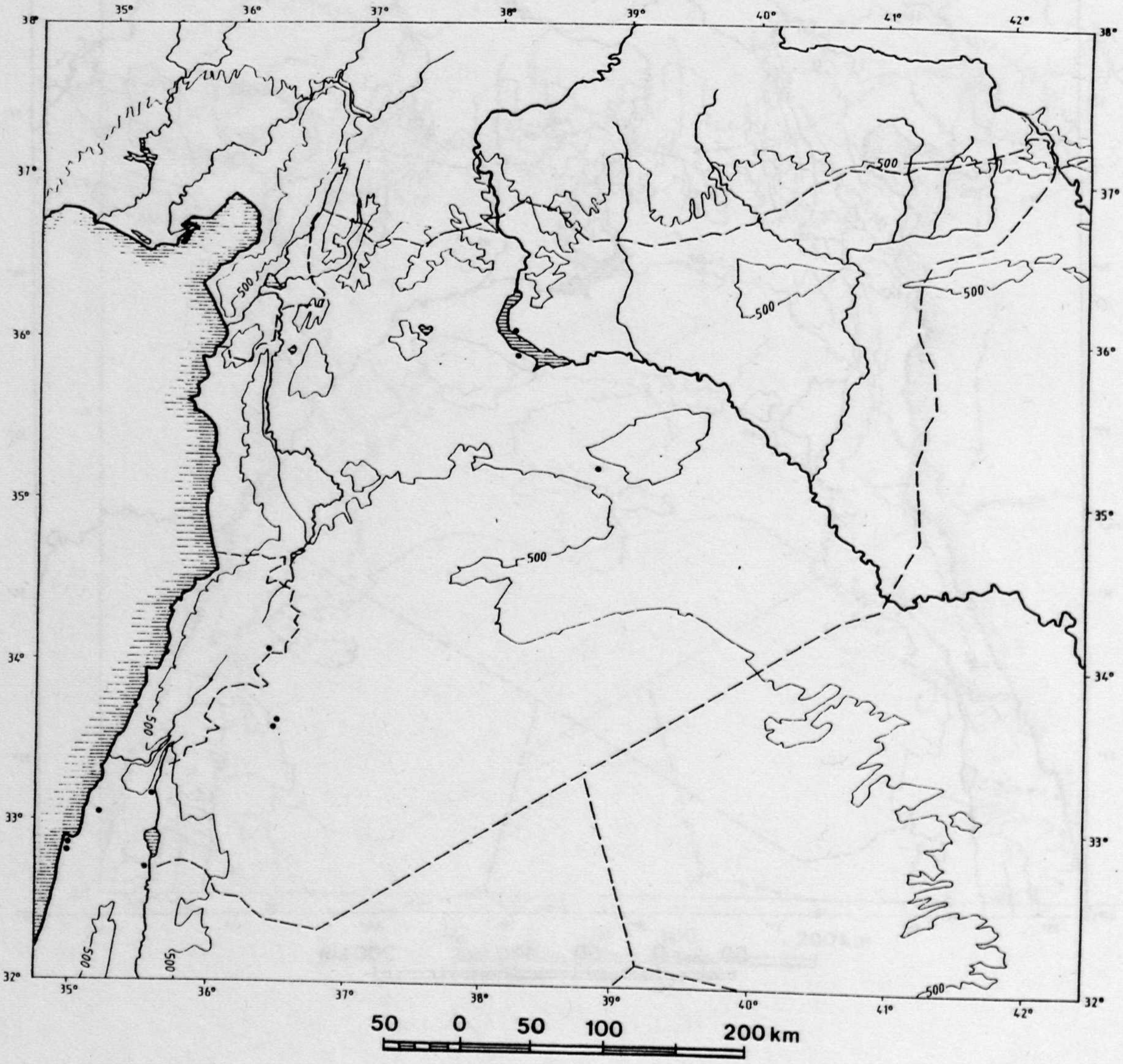


Fig.20.6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34°
33°
32°
500
500
500
500
500
500
500
500
50
0
50
100
200 km

Fig. 20.7

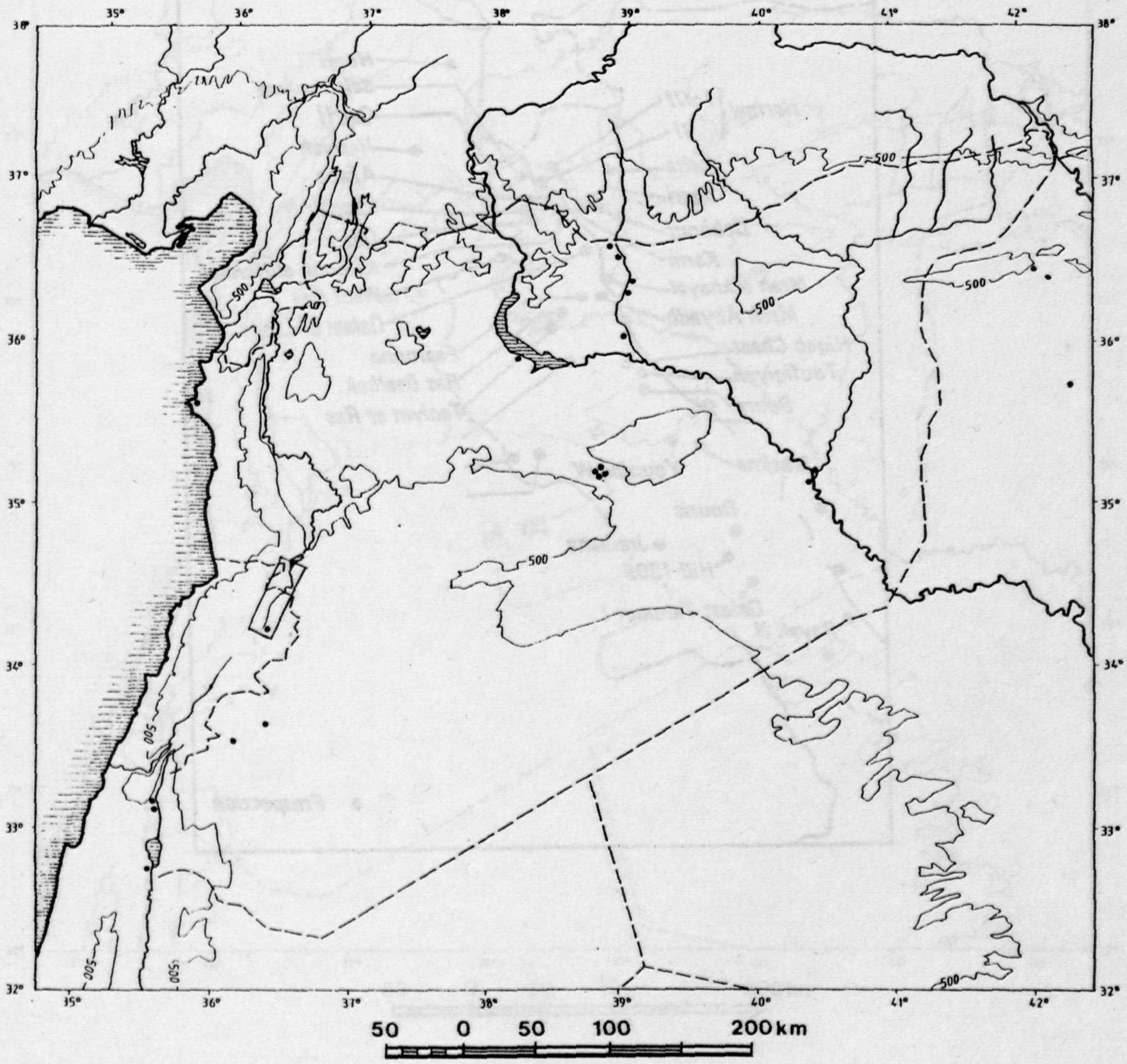

Fig. 20.8

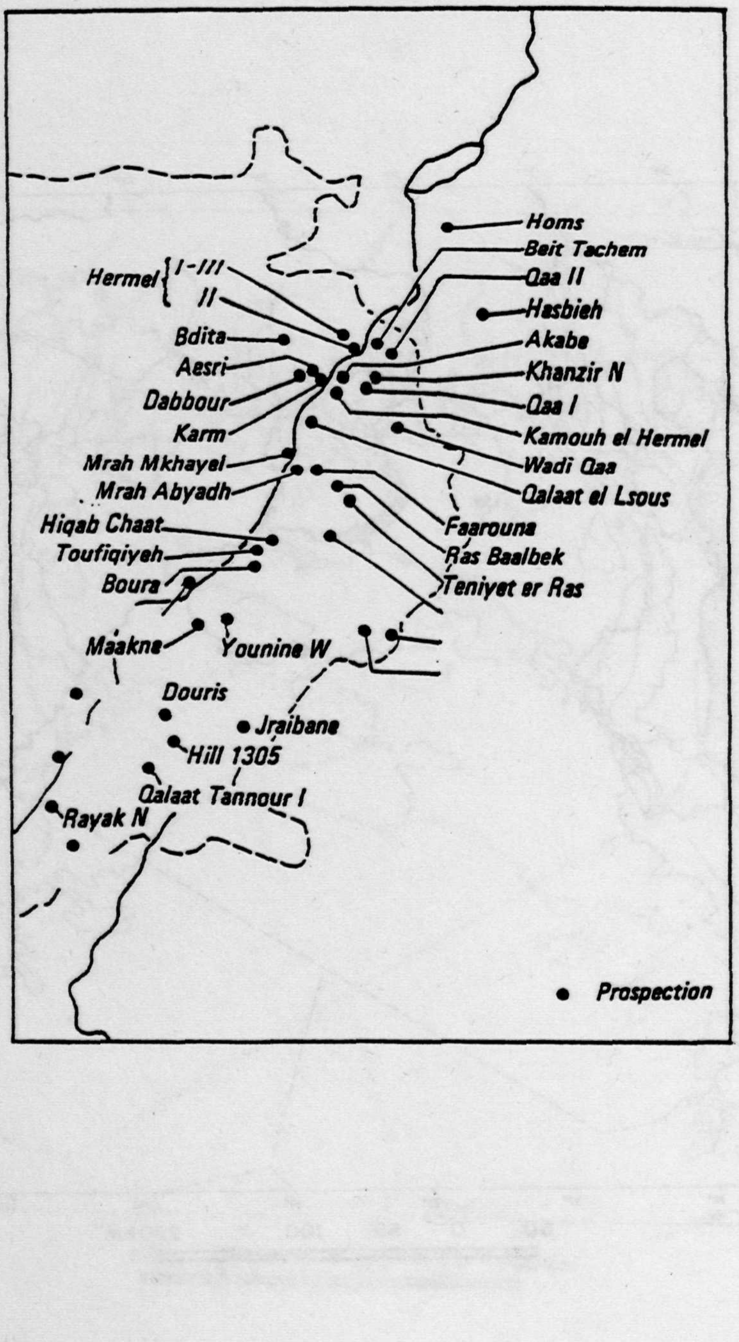
Homs
Beit Tachem
Qaa II
Hasbieh
Akabe
Khanzir N
Qaa I
Kamouh el Hermel
Wadi Qaa
Qalaat el Lsous
Hermel { I-III
II
Bdita
Aesri
Dabbour
Karm
Mrah Mkhayel
Mrah Abyadh
Hiqab Chaat
Toufiqiyeh
Boura
Faarouna
Ras Baalbek
Teniyet er Ras
Maakne
Younine W
Douris
Jraibane
Hill 1305
Qalaat Tannour I
Rayak N
● Prospection

Fig. 20.8 bis

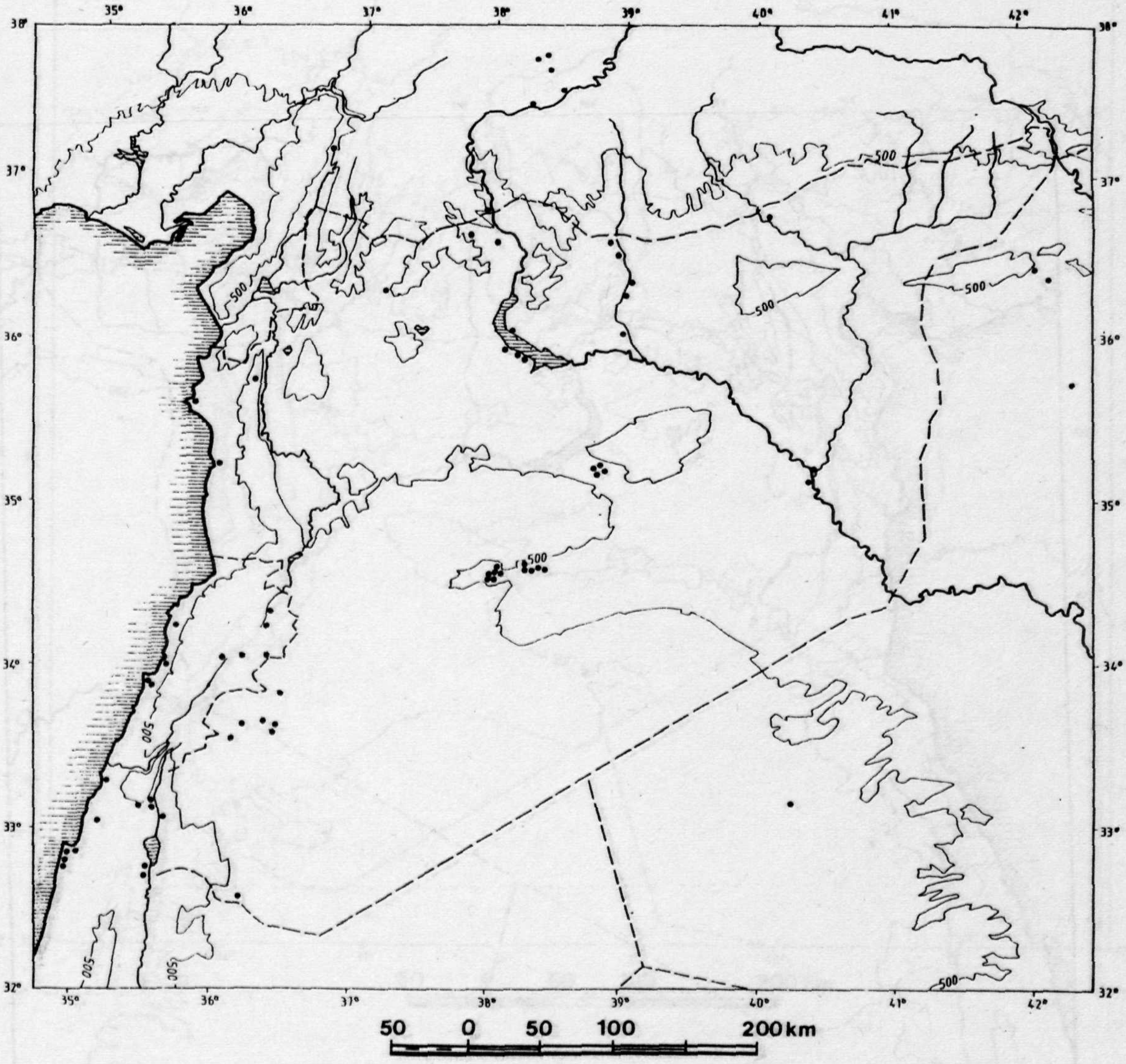

Fig. 20.9

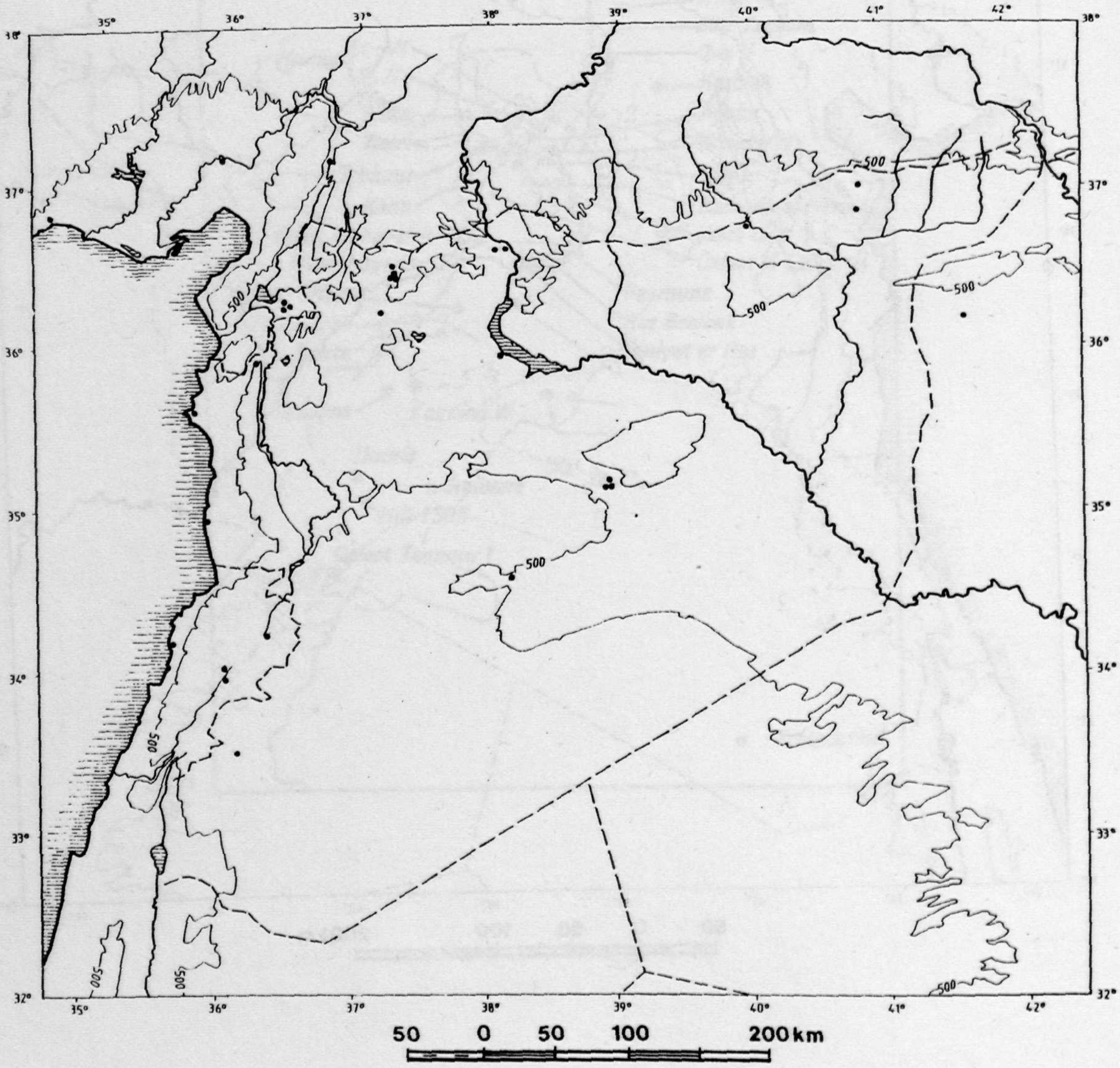

Fig. 20.10

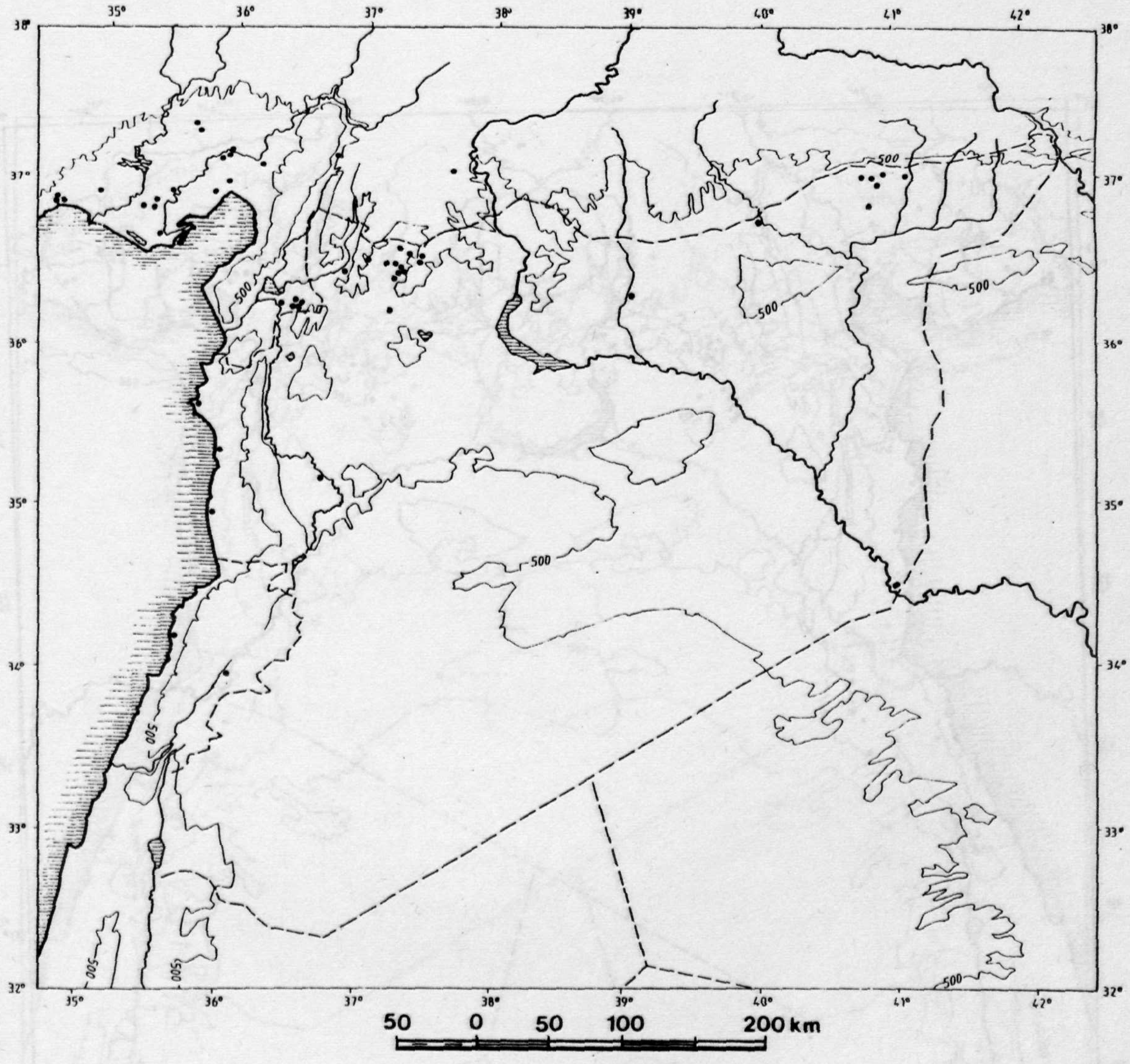

Fig. 20.11

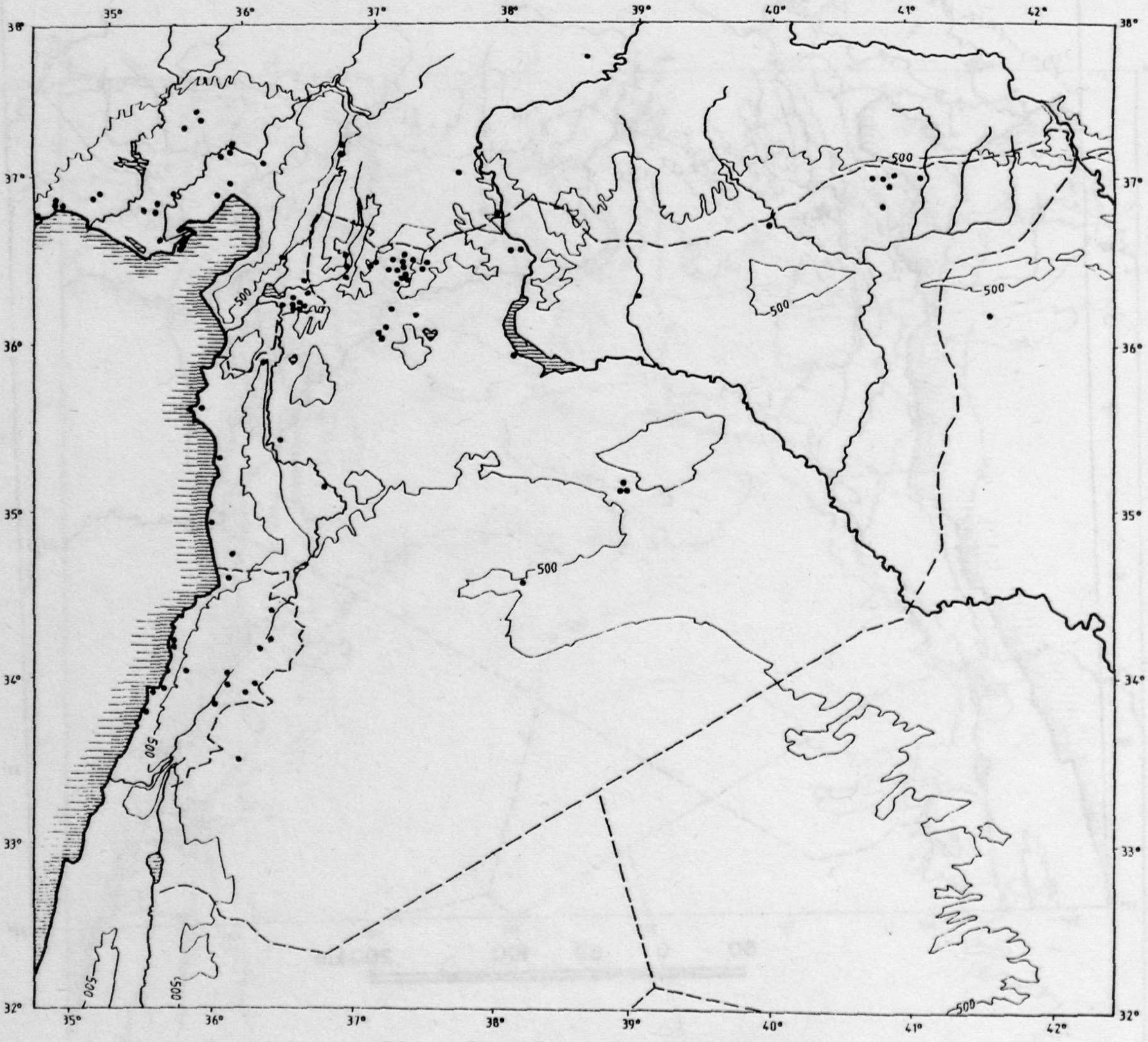

Fig. 20.12

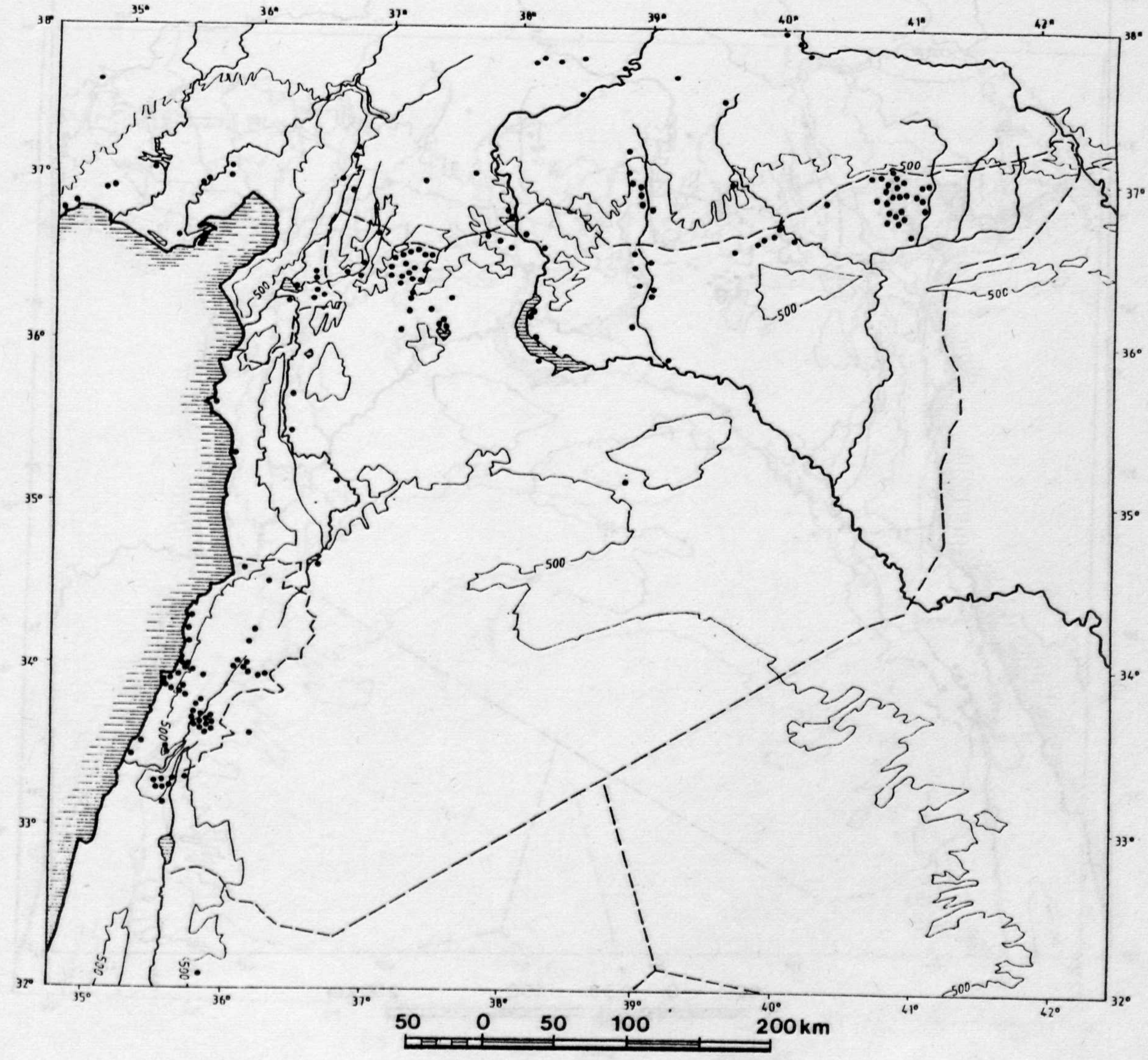

Fig. 20.13

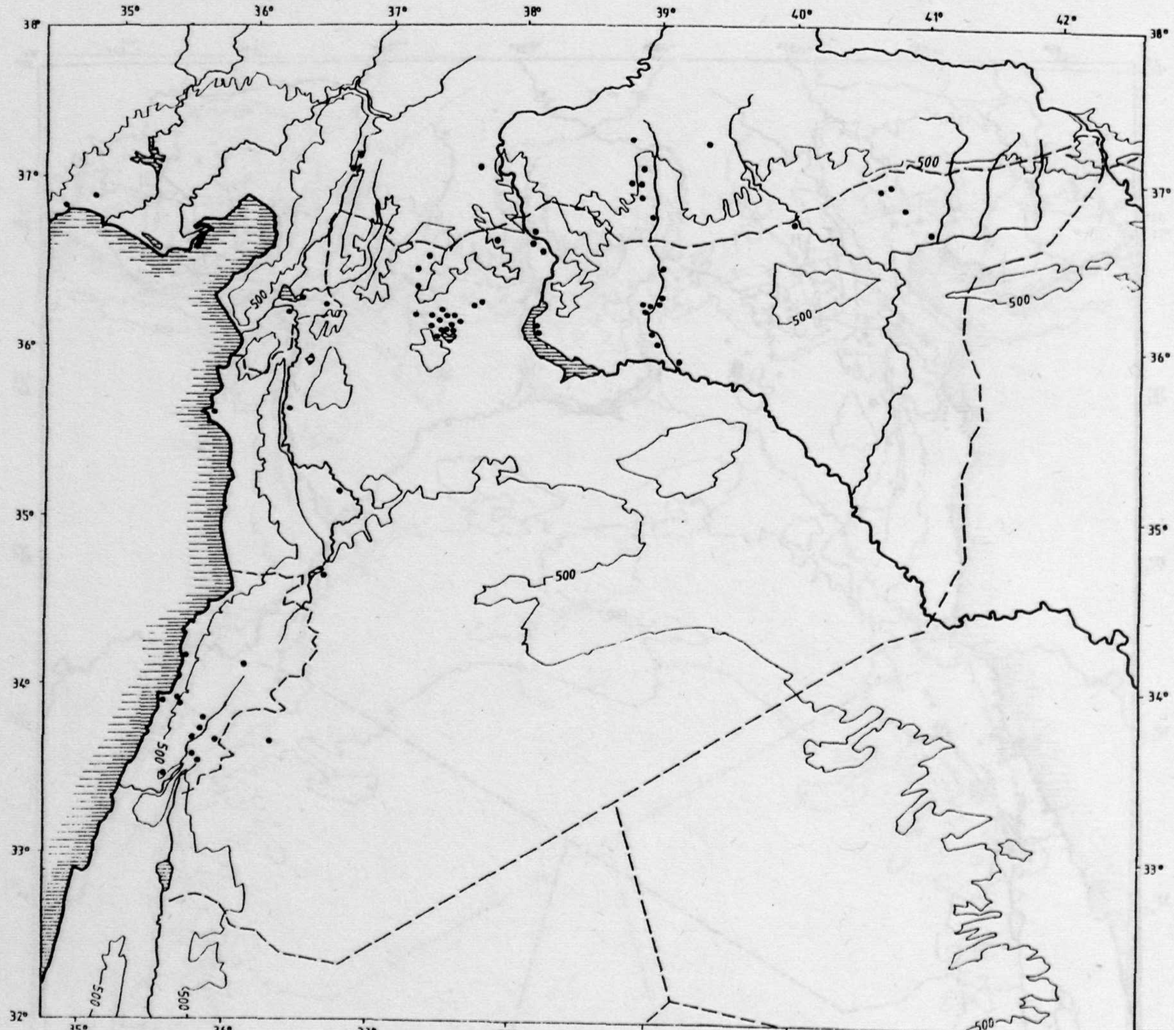

Fig. 20.14

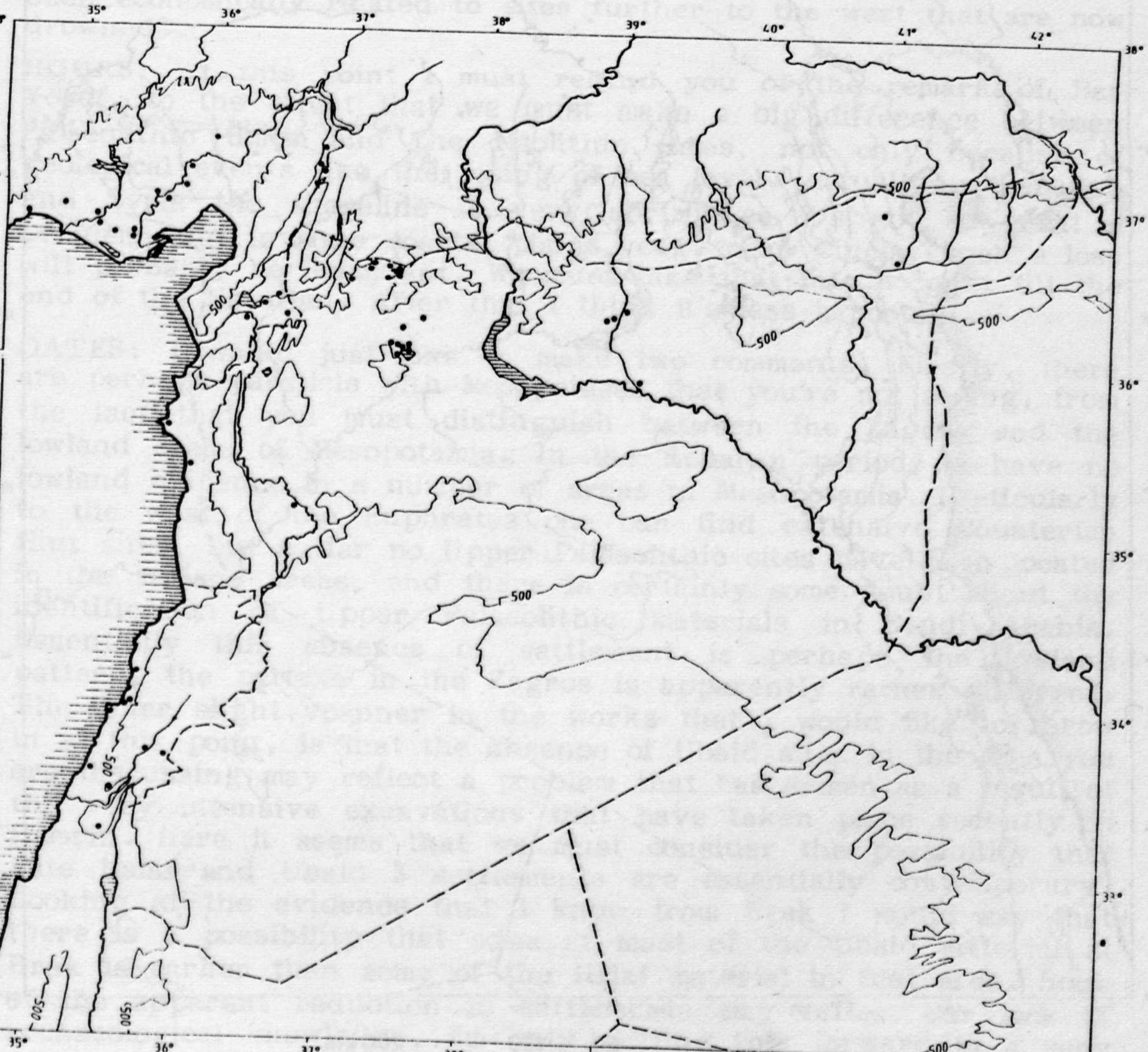

Fig. 20.15

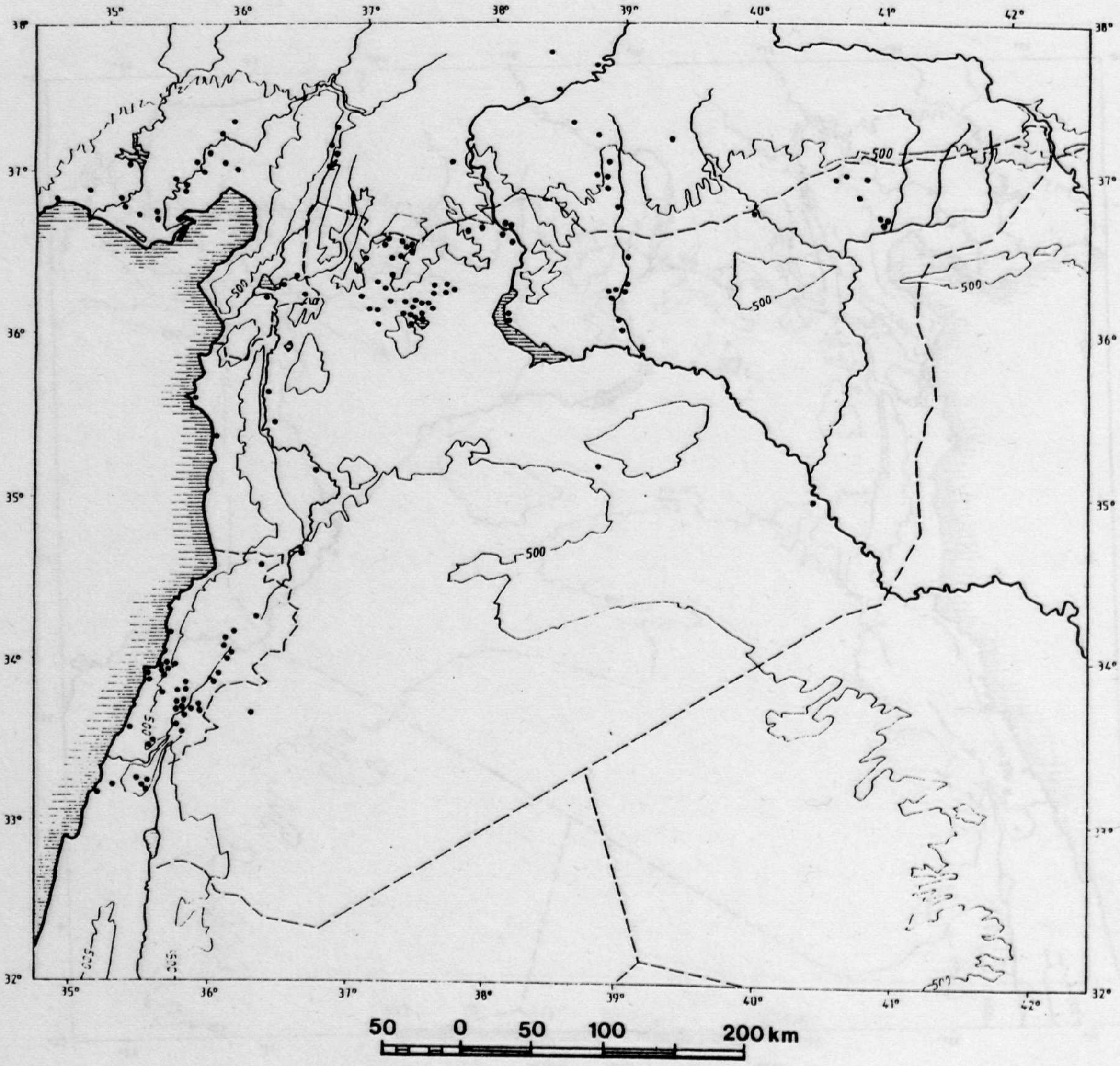

Fig. 20.16

DISCUSSION

BROOKES: I wondered how you felt about the importance of the coastal orientation of prehistoric economy before about 6000 bp, because you have been missing that record entirely because of sea level change. I know your final comments said this is all we have to go on, but if you're making economic inferences from the distribution of sites that presently lie near the coast of - let's say - 8000/9000 bp and prior to that, then they could very well have been economically related to sites further to the west that are now drowned.

HOURS: At this point I must remind you of the remark of Bar Yosef. to the effect that we must make a big difference between Palaeolithic times and the Neolithic times, not only because of geological events like the rising of sea level. Actually in Lebanon and Syria the shoreline is very abrupt so it's not so great a problem, but in some coastal plains, e.g. near Cilicia, such a loss will probably be important. We must take that into account till the end of the Natufian. After that I think it's less important.

OATES: I would just like to make two comments. Firstly, there are perhaps parallels with Mesopotamia that you're not seeing, from the fact that you must distinguish between the Zagros and the lowland areas of Mesopotamia. In the Kebaran period we have no lowland evidence in a number of areas in Mesopotamia. Particularly to the west of the Euphrates one can find extensive Mousterian flint sites, but so far no Upper Palaeolithic sites have been located in the lowland areas, and there is certainly some doubt about the identification of Upper Palaeolithic materials in Saudi Arabia. Essentially this absence of settlement is perhaps the lowland pattern, the pattern in the Zagros is apparently rather different. The other slight spanner in the works that I would like to throw in at this point, is that the absence of Ubaid sites in the area you are discussing may reflect a problem that has arisen as a result of the very intensive excavations that have taken place recently in Hamrin. Here it seems that we must consider the possibility that Late Halaf and Ubaid 3 settlements are essentially contemporary. Looking at the evidence that I know from Brak I would say that there is a possibility that some at least of the Ubaid material at Brak is earlier than some of the Halaf material in that area. Some of the apparent reduction in settlements may reflect our lack of archaeological knowledge. I'm only putting this forward in a very tentative way, but it may prove in the end that we're going to have to lump together a number of types of site that we now separate for apparent cultural reasons, as spatial phenomena rather than chronological phenomena and this may alter the patterns of the settlement data for this particular period.

HOURS: Yes. Certainly for the Ubaid period the data are not very accurate.

PAEPE: I remember from Mesopotamia and my own experience at Tell e-Der, that after the occupation of the plain there has been a very important lowering of this plain, a lowering in the topography. I don't know if this was erosion or whether this plain was flooded - but what happened to the occupation of the plain? I mean, what is the meaning of the distribution of settlement in such a plain if we don't know exactly what has been happening with regard to long term floodplain drainage and erosion cycles? This is a very big question which I can't answer with regard to Tell e-Der.

HOURS: Yes. But you must remember that Syria is not Mesopotamia! We don't have such big plains in Syria as in Mesopotamia. Except for that of the Euphrates. From Hit and downstream we do see a big plain but if it is in the natural state it's clearly absolutely not suitable for any kind of settlement because of the floods, because of meanders, marshes, and so on. And we didn't find any sites, nor have any others, of your kind of tells inside the floodplain. With our floodplain-associated sites, very often the first terrace is mostly from the last glaciation, and a lot of sites are on this terrace or higher up. Just at the edge of the floodplain but not inside. So I don't think much settlement has disappeared by erosion or flooding in that way. For Syria only the Euphrates offers some possible scope for your theory. The Orontes, Litani, Nahal Kabir, Kara Su and so on are small rivers, and all the tells here are very well preserved, only suffering minor erosion.

OATES: This is true of northern Mesopotamia as well, we are dealing with rivers that actually flow within terraces that confine their flooding, as is the situation in Syria. And it is still the situation in Mesopotamia itself, in Iraq, down to below the site of Tell es Sawwan, which is on the terrace. But I think one must be very careful in interpreting these apparent flooding data from archaeological sites as Professor Paepe's, which are not represented at other sites, particularly in the alleged "flood", at Ur. There is a small site called Tell Al Ubaid which happens to be the typesite for this culture that we're discussing. This lies on the plain 4 km from Ur. It's not a high mound site and it lies below the flood debris in absolute elevation, and this small site wasn't flooded at the time.

VAN ANDEL: I am very impressed by the effort and usefulness of such a compilation. But so often I have heard the words "This is not a very good data set but it is the best we have, so let's use it". It's my firm conviction that some data sets are just not good enough to show any more than the fact that they're incomplete and that we should do more work before we use them. And I suspect that at least for parts of this data set, for substantial parts the data set is only good enough to spur us on to more effort, but not good enough to draw any socio-economic, political, environmental or climatological conclusions.

HOURS: Well after that I think I have to be silent.

ROBERTS: Well despite that, it does seem to me that there's one interesting trend that comes out for at least Syria-Lebanon, and that is the comparison between numbers of archaeological sites and the domestication of plants and animals. We've been pushing back the domestication of individual species, not just in PPNB and PPNA, and in certain cases back to the Natufian or earlier. But there doesn't seem to be any record of that in a massive change in settlement. The first appearance of domestic wheat, barley, sheep/ goat, cattle, is not reflected apparently in an immediate increase in Syria and Lebanon in site numbers. Instead this seems to come at a rather later stage. Perhaps this may have been due not to the innovation but to a phase of adoption, and perhaps this data which obviously is only at a preliminary stage, and much more is required, is maybe pointing us in the direction of a division between those two, a division between innovation and adoption.

HOURS: You're perfectly right. This is a little surprising, for me at least, but it is one of the conclusion we have come to. And your distinction between invention and adoption is certainly a good one I think. One thing it's possible to see, and when we have full agriculture, at the end of the PPNB, is a trend towards occupation of good arable soils in the bottom of valleys. At that time we have seemingly a conscious selection of such resources.

UERPMANN: I think you've got to be very careful with statements about 'domestication'. It is a process which did not happen in one day and, not even in one year, not even in one hundred years. We known now that first there was some sort of pre-cultivation and then finally cultivation, and then much later people came to domesticate animals. The increase in population which is definitely shown here between phase PPNB1 and PPNB2 shows that the discovery of effective animal domestication of sheep and goat did lead to a tremendous spread of human beings in that area, an increase in population density. It is in my view only with the completion of the whole process of domestication with the domestication of animals, that allowed this increase. It was not the beginning of the process, it was the end of the process, that allowed for overall population takeoff.

HOURS: Surely the process began with the PPNA, PPNB2 is clearly the end of the process?

CLUTTON-BROCK: These maps reflect the number of sites and not the number of people in the sites, and we know that the actual sites increased considerably in size from the Natufian through to the PPNB.

VAN ZEIST: Père Hours was complaining that he had hoped to obtain some information about climatic history to explain the distribution of his prehistoric sites, but the data got so confused that according to him it didn't make any sense. It may be a small comfort to him when I tell him that we may be able to explain the fact that between 8000 and 7000 bp you see a concentration of sites towards the north. Those are all early agricultural sites, so they depend on precipitation for plant-growing and we know from adjacent parts of Turkey, from south-western Turkey and also from central Turkey that it was more or less about 8000 bp that in the pollen diagrams there are very distinct indications for an increase in humidity. The humidity had not reached its maximum, but from that time humidity increased, implying that this area, the foothill of the Taurus mountains, became inhabitable for farmers.

OATES: May I just add to that that this is precisely the period that I was talking about where you have an extension of settlements well south of the present rainfall isohyet in the Hatra area, and these are contemporary sites.

COPELAND: I would just like to add on the same subject that this is not the case for the area of the so-called Palestinian Hiatus, which is a contemporary phenomenon. Can you somehow explain this?

VAN ZEIST: No, we cannot explain it, we must accept it as it is. Bottema and I tried to emphasize that at least according to the pollen record there is no general tendency valid for the whole of southwest Asia towards a drier or moister climate. You see very marked regional differences and what we now hope is that climatologists will be able to provide us with some clues, not to explain them necessarily yet, but to give some clues how that could happen. I'm not surprised now that in the southern part of the area of this conference you've got a drier climate in the early postglacial times whereas more towards the north in Turkey it became moister. That is what the palynological evidence indicates and also the distribution of sites in the southern Levant at least suggests a moister climate in Late Palaeolithic and maybe early Neolithic times.

Holozän-Geologie und Archäologie

Gedanken und Fragen zur Korrelation der Resultate zweier Wissenschaften

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Burchard Brentjes

In einer Zeit, die den Wert interdisziplinärer Forschungen hochschätzt, sollten auch zwei Wissenschaften zusammenfinden, die über weite Strecken die gleichen Zeiten und Regionen bearbeiten. Ich begrüße daher die Aufforderung des Veranstalters, zum dem Problem Stellung zu nehmen, inwieweit dies jetzt schon möglich ist und muß gestehen, daß die Fragen eigentlich erst im Verlauf der Arbeit an diesem Referat gewachsen sind und allmählich die Grundlagen berühren. Jedoch hoffe ich, daß die hier aufgeworfenen Probleme uns in der Zusammenarbeit voranbringen, da ich für die Archäologen sagen kann, daß wir die Ergebnisse der Holozängeologie brauchen, aber oft nicht ihre innere Problematik kennen, d.h. nicht ihre Relativität, da wir selbst in der Regel nur sehr relative Aussagen machen können, auch wenn diese in der Literatur (und auch im Selbstverständnis manches Archäologen) häufig recht absolut formuliert sind. Mir geht es jedenfalls so mit vielen holozängeologischen Studien, deren Daten umso lieber zur Grundlage eigener Arbeiten genommen werden, je absoluter sie ausgesprochen worden sind. Nur ergibt mitunter der Vergleich, daß es in der Holozängeologie nicht anders ist als in der Archäologie, daß Hypothesen in den Veröffentlichungen und als vollgültige Thesen niedergelegt werden, ohne daß ihre Voraussetzungen genannt werden, d.h. ohne daß sie vor allem dem Fachfremden überprüfbar sind, so daß Fehlurteile m.E. zur Zeit nahezu unvermeidbar sind, speziell wenn die Resultate der einen Disziplin von Vertretern der anderen genutzt werden. Auf

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Martin-Luther-Universität, Sektion Orient- und Altertumswissenschaften, Halle/S, DDR

einige dieser möglichen Fehlerquellen möchte ich im letzten Teil dieses Beitrages verweisen und durch die Formulierung von Fragen an die Holozängeologen zu einer eindeutigen Verwendbarkeit ihrer Arbeiten durch die Archäologen beitragen. Jedoch sollen in den Hauptteilen positive Aussagen versucht werden, die hoffentlich nicht durch die soeben geäußerten Zweifel allzusehr relativiert werden. Sie erfolgen vorwiegend für den mir vertrauteren Bereich des Orients, in dessen Archäologie bereits häufig geologische Erkenntnisse berücksichtigt werden.

I. Sind holozängeologische und archäologische Daten verknüpfbar?

1. Holozängeologie und Archäologie

Die Frage einer Korrelation geologischer und archäologischer Daten kann m.E. positiv entschieden werden, auch wenn die Geologie zu den sogenannten exakten Wissenschaften gezählt wird und die Archäologie zu den Gesellschaftswissenschaften. Im englischen Sprachbereich gilt der Unterschied ja zwischen science und social sciences, und die englische Literatur der siebziger Jahre prägte ein wortreicher Streit, ob nicht die Archäologie überhaupt zur "science" zu rechnen sei, da sie so viele Naturwissenschaften treibe, eine Auseinandersetzung in der M.E.L. Mallowan zu der sarkastischen Formulierung kam, daß ein Holzbein noch keinen alten Matrosen zum Baum gemacht habe (1). Die Holozängeologie ist primär Geschichte der Umwelt des Menschen seit der Eiszeit. Die Archäologie (dieses Zeitabschnittes) dient der Erfassung der Geschichte des Menschen in dieser Umwelt, seine Auseinandersetzung mit dieser Umwelt, seine Anpassung und Bewältigung dieser Umwelt. Die Bedeutung der Holozängeologie für die Rekonstruktion des historischen Ablaufes wird umso größer, je deutlicher wir die Dürftigkeit unserer derzeitigen Information mit archäologischen Mitteln erkennen. Ihre Ergebnisse sind umso unentbehrlicher, je klarer wird, daß der zur Diskussion stehende Zeitraum zwischen 14 000 v.u.Z. und der geologischen Gegenwart die Zeit gewaltiger Wandlungen in der menschlichen Gesellschaft war. Es war die Zeit des Übergangs von dem weltweiten, Millionen von Jahren anhaltenden Stadium der Jäger und Sammler zur Klassengesellschaft auf zuerst agrarischer Basis und in den letzten Jahrhunderten auch industrieller Grundlage, ein Übergang, dessen Ablauf nur in sehr allgemeinen Zügen erfaßbar und mit archäologischen Mitteln nur zum Teil belegbar ist, liegen doch der Archäologie nur die Reste menschlichen Handelns vor und davon auch nur jene, die gefunden worden sind.

Holozängeologie und Archäologie fließen zudem in Teilbereichen zusammen, da im Prozeß der agrarischen Erschließung (und teilweisen Zerstörung) der vorgefundenen Landschaft anthropogene Oberflächenformen entstehen - von der Entwicklung über die Agrarlandschaft zur "man-made desert", der durch unkontrollierte menschliche Eingriffe verwüsteten Umwelt.

2. Die Sahelkatastrophe als Lehrbeispiel

Mittel- und Westeuropa geben mit ihren relativ stabilen Umweltbedingungen der letzten Jahrhunderte kaum Anstöße zum Überdenken der Abhängigkeit des Menschen von seiner Umwelt, da selbst die spürbaren kurzfristigen Klimaschwankungen der letzten Jahrzehnte, wie der Wechsel harter und milder Winter, den Städter und auch den Bauern Europas nur bedingt berühren. Die Ökologie ist eigentlich in der Öffentlichkeit vorrangig eine durch die Umweltzerstörung industrieller Art aufgeworfene Frage, deren aktuelle Bedeutung ich nicht leugne, die aber für die uns interessierenden Zeiten keine Rolle spielt. Jedoch hat zumindest vorübergehend eine Umweltkatastrophe in Afrika die Abhängigkeit vorindustrieller Gesellschaften von an sich relativ geringen Klimaschwankungen in erschreckendem Maß gezeigt, die Sahelkatastrophe, die selbst die UNO beschäftigte.

Kurt Waldheim erklärte am 21. Februar 1974: "Es besteht die Gefahr, daß in weniger als 50 Jahren durch das Vorrücken der Wüste drei oder vier Länder Afrikas von der Landkarte wegradiert sein werden" (2). Ein internationales Forschungsprogramm entwarf auf der Konferenz von Nairobi 1977 (3) ein schreckliches Bild der "Desertification" Afrikas im schon geringfügigen Schwanken der klimatischen Voraussetzungen, die der Mensch nicht selten durch Mißachtung der Naturabläufe zur Katastrophe führte.

Die Sahelkatastrophe ist natürlich primär ein Problem der betroffenen Völker, aber sie ist auch das Lehrbeispiel für die unauflösliche Verbindung menschlicher Geschichte und der Umweltsentwicklung, bzw. der sie erfassenden Wissenschaften, der Archäologie und der Holozängeologie. Gewiß ist die Sahelzone ein extremer Fall, aber gerade daher sind die hier gewonnenen Lehren für die Korrelation von Archäologie und Holozängeologie so aussagereich. Daher sei hier ein Resumée gezogen.

Unter der Sahelzone verstehen wir den Raum südlich der Sahara, die einen jährlichen Regenfall von 100-350 mm erhält, und die damit die Hirtenregion darstellt. 80 bis 90 % der Regenmenge verdunstet in kurzer Zeit.

Die südwärts liegende Zone mit 350-600 mm Regen teilen sich Hirten und Bauern auf der Basis der jeweiligen Machtverhältnisse. Bis zum Eindringen der Kolonialarmeen mit Maschinengewehren und Kampfflugzeugen waren die Nomaden im Vorteil, beherrschten ihre mobilen Reiterheere die Region bis zum Waldland, aber seitdem drangen die Bauern und Hirten nach Norden vor. Allein von 1940 bis 1970 schoben sie die Ackerbaugrenze um 200 km nach Norden, vom 15. bis zum 18. Breitengrad. Nomade und Bauer können unter den gleichen Bedingungen in der halbariden Zone leben - eine Warnung vor allzu einfachen Schlüssen in der Geschichte - die in den mich interessierenden Regionen Nordafrikas, Vorder- und Zentralasien über die Jahrtausende hin vom Gegensatz "Bauer und Nomade" beherrscht wird. Die Vielzahl der Nomadenbewegungen bestimmt scheinbar den Rhythmus der Geschichte jener Regionen, so daß schon vor 600 Jahren Ibn Chaldun im Kampf der Beduinen gegen die Ansässigen die Grundlagen der Geschichte sah.

Im Mechanismus der Nomadenbewegungen, in der sie bewegenden Gesetzmäßigkeit, spielt die Schwankung des Klimas eine wesentliche Rolle, aber nicht die allein bestimmende, wie gerade am Sahel-Beispiel deutlich wird, denn in der halbariden Steppenregion führen auch geringfügige Schwankungen trotz aller Anpassung der Menschen zu tiefgehenden Veränderungen.

Howard Brabyn (s.2,S.5) schreibt: "Verhältnismäßig geringe Schwankungen der jährlichen Regenmenge können gewaltige Auswirkungen haben und ganze Gebiete verändern. Als 1941/42 in einen 340 000 km^2 umfassenden Zone Mauretaniens weniger als 100 mm Regen fiel, verwandelte sich der ganze Landstrich (ein Drittel der Gesamtoberfläche) in unwirtliche Wüste. Zehn Jahre später, als wieder über 100 mm Regen fiel, konnten die Nomaden im gleichen Gebiet ihre Herden weiden... Im Laufe des letzten Jahrzehnts dehnte sich auch die Sahara unablässig gegen Süden aus - etwa 150 km weit ist die frühere Trockensteppe nun zur Wüste geworden." Wie weit diese letztere Wandlung noch kurzfristig zu nennen ist, gehört bereits zu den Fragen an den Holozängeologen, auf die zurückzukommen ist. Das Ergebnis und die mehrfache Wiederkehr der Katastrophe allein in diesem Jahrhundert lassen Fragen hinsichtlich der früheren Nomadenbenbewegungen stellen.

Nördlich des 15. Breitengrades haben sich im "Verlauf der Jahre 1972/1973 die Umweltbedingungen derart verschlechtert, daß das Vieh fast völlig verschwunden und der landwirtschaftliche Ertrag gleich Null geworden ist. Hunger hat die Bevölkerung vertrieben. Zwischen dem 15. und 13. Breitengrad ist das Wasser an der Oberfläche verschwunden und damit auch die Wechselkulturen und die

Zuchtmöglichkeiten, der Landwirt kann nicht mehr damit rechnen, seine Versorgung mit Lebensmitteln und Geld sicherzustellen...." resumiert Jacques Bugnicourt (4). "Was sich nun ereignet hat, ist das Sterben, das Verschwinden dieser natürlichen Umwelt, Vegetation und Wasser sind verschwunden, die Herden sind tot und viele Menschen mit ihnen. Die Nomaden "entflohen der Hölle" in ein unbekanntes Schicksal... Immer neue Wellen von Tuareg, Arabern, Peule, Wodaabe, Songhai, Djerma und Haoussa zogen in den südlichen Sahel" - wobei "der größte Teil mehr als 500 km zurückgelegt hat." (s.4, S.12-13). War dies nun ein Nomadensturm, den nur die moderne militärische Überlegenheit der Ansässigen zu einer Katastrophe für die Nomaden werden ließ? Ein Blick zurück zeigt ähnliche Katastrophen 1913, 1931/1932 und 1937. Die Hungersnot von 1942 ist den Nomaden als "Wanda waasu" - "Vergiß Deine Frau" in schrecklicher Erinnerung geblieben. Deutlich wird auch, daß die Zerschlagung der Tuaregs 1916/1917 durch die Franzosen den Nomaden nicht einmal die Hilfe eigener sozialer Strukturen ließ.

Die Studien der Unesco ergaben zudem, daß die Katastrophe der sechziger und siebziger Jahre in der Sahel durch eine Reihe unsachgemäßer Entwicklungsprojekte zumindest verschärft wurde. Daher ist es erforderlich, als dritte Wissenschaft in die interdisziplinäre Kooperation die Agrargeographie einzubeziehen, da die Landwirtschaft jene Produktion ist, in deren Folgen und Voraussetzungen sich Archäologie und Holozängeologie am ehesten treffen. Als Beispiel hierfür möge der Irak dienen.

3. Agrarstruktur und Klima

Die Abhängigkeit der Lebensverhältnisse und der Produktion ist nicht auf die Hirtengesellschaften der semiariden Zone beschränkt. Die Produktion der Ackerbauer ist nicht weniger vom Klima und den anderen Umweltbedingungen abhängig, vielleicht sogar noch weitgehender, so daß mögliche Schlußfolgerungen von holozängeologischen Befunden auf den Ablauf der Geschichte hier noch differenzierter gezogen werden müssen. Als Exempel sei die Untersuchung E. Wirths (5) über die Agrarregionen des Irak genannt. Wirth unterschied sieben Zonen, vermutlich sind es noch zu wenig, um die Relation zwischen Ackerbau und Umwelt voll zu erfassen - das Sumpfland des Südens, die Stromoase am mittleren Euphrat, die Alluvialebene, die Regenfeldbauzonen, die "Schlechten Länder" (badlands) am Bergrand, die Kalksteinketten und das Kulturland am Dschebel Sindschar. Die regionale Gliederung des Zweistromlandes und seiner Randzonen ist auch die der Siedlungszonen unter klimatischen Verhältnissen, die der Gegenwart entsprechen. Die Stromoase des südlichen Euphrattals war das alte Sumer, die Regenfeldbaugebiete und das Sindschargebiet die Grundlage des neuassyrischen Reiches.

An die Sahelzone und die südlich angrenzende Ackerbauregion Afrikas erinnert eine Zone zwischen Vollwüste und sicherem Regenfeldbau... In diesem 200 bis 400 km breiten Übergangssaum zwischen Vollwüste und Gebieten mit sicherem, krisenfesten Regenfeldbau liegt die größte Tat des syrischen und irakischen Agrarlandes" (s.5, S.8). Auch die Bewässerungsoasen sind mit Regenfeldbauzonen umgeben, wie die Flußauen. Im Unterschied zur Sahel fällt hier Winterregen (mit geringer Verdunstung), so daß der Winter nicht arid ist. So ergibt sich eine Anbaufähigkeit bis zur 200 mm-Regengrenze (in Nordafrika 300 mm und in Südafrika 250 mm) und zum Teil sogar ausserhalb der 200 mm-Zone ein 'Dellenackerbau', bei dem der von den Hügeln ablaufende Regen die Täler dem Gerstenanbau öffnet. Sie sind die Grundlage des begrenzten Feldbaus der Nomaden und Halbnomaden, deren Hauptregion in diesem Jahrhundert die Zone zwischen 150 bis 200 mm war.

Die Abhängigkeit der Vorherrschaft von Nomaden oder Bauern in diesem Zwischenraum zeigt die Geschichte der

letzten Jahrhunderte. Seit 1800, 1870 und 1914, d.h. jeweils mit der Festigung der Staatsmacht, wurden die Nomaden zurückgedrängt. Die Analyse der Agrarstrukturen fehlt zumeist in historischen Studien. So übersieht man zumeist, daß eine Großraumbewässerung erst südlich von Baghdad möglich ist, da die oberirakischen Stromoasen 30 bis 100 m tief eingegraben sind und der Nordirak "weniger von den Bewässerungsmöglichkeiten als vom Klima - vor allem von den Niederschlägen abhängig ist, so daß die legendäre "asiatische" (oder altorientalische) Produktionsweise, die auf dem Bewässerungsackerbau beruht haben soll, für Assyrien völlig abwegig ist.
"... Zwischen Tigris und den ersten kurdischen Bergketten..... (liegt) ein breiter Streifen Landes...., der auch in Trockenjahren noch genügend Niederschlag empfängt, um einen lohnenden Regenfeldbau zu erlauben.... Diese fruchtbaren Ackerebenen sind der Kernraum der assyrischen Staatsbildungen gewesen, und eben hier liegen auch die Ruinen fast aller berühmten assyrischen Königspaläste" (s.5, S. 39/40).

Hier zieht der Agrargeograph bereits (berechtigte) archäologische Schlußfolgerungen.

Jede Agrarregion hat ihr spezifisches Gesicht, das die historischen Möglichkeiten bestimmt. So ist das Sumpfland des Südens eine Region intensiven Gerstenbaus mit reicher Viehhaltung. Die Stromoase am Euphrat ist (heute) ein Reisbaugebiet mit Büffelhaltung und die Alluvialebene ein Feldbaugebiet mit Weizen, Gerste, Rind und Esel. Die Regenfeldbaugebiete bauen Wintergetreide an und halten Schafe und Ziegen. Die Bergregionen leben von Gartenbau und Weidewirtschaft mit Maulesel und Ziege. Jede dieser Wirtschaftsformen hat unterschiedliche Produktivitätsgrenzen und dementsprechend Maximalgrenzen der Bevölkerungskonzentration in einem gegebenen Territorium.

Ein weiteres Agrarfolgeproblem holozängeologischen Charakters nennt Wirth gleichfalls, bereits unter Verweis auf archäologische Konsequenzen mit der Versalzung agrarisch-genutzter Flächen im Bewässerungsbereich. Er nennt ca. 60% der Flächen an Euphrat und Tigris versalzen (s.5, S.97), wobei ca. ein Viertel der Felder erst in den letzten Jahren aufgegeben werden mußten. Besonders die Eindeichung nun hochliegender Flüsse hat durch Sickerwasser zur Versalzung der Aulandschaften geführt.

Wirth verweist auf vier ältere Verzalzungshorizonte - ein Problem, das ebenfalls noch im Folgenden aufgegriffen werden soll. Es sind die Etappen 2400 bis 1700 v.u.Z., 1300 bis 900 v.u.Z. und ab 1100 u.Z. (im Diyala-Gebiet). Das wellenweise Auftreten von Versalzungsperioden stellt die Frage nach der Stabilität der genannten Agrarzonen, die schon für sich für die Archäologie und die Holozängeologie unterschiedliche Aufgaben stellen, bzw. historische Schlußfolgerungen erlauben. Die Eigenarten der erwähnten Agrarzonen werden sowohl durch die örtlichen Voraussetzungen wie von den regionalen Klimata bestimmt - und deren Veränderungen müssen in der zur Erörterung stehenden Periode in den einzelnen Regionen von unterschiedlichen Konsequenzen gewesen sein. Die von der Archäologie an die Holozängeologie zu stellende Frage betrifft diese Folgen als Voraussetzungen für historische Vorgänge, bzw. die Konsequenzen von Produktionsvorgängen für die Umwelt.

II. Meeresspiegelschwankungen und ihre möglichen Effekte auf die Besiedlung

Eine in den letzten Jahren viel diskutierte Frage ist die Auswirkung postglazialer Meeresspiegelschwankungen auf die Siedlungsgeschichte. Ihre Verifizierung erweist sich als überaus kompliziert, da vorwiegend die damit verbundenen Fragen der Klimaveränderung und der Regenfallmengen in ihrer gegenseitigen Abhängigkeit kaum eindeutig zu beantworten sind. Zwar scheint festzustehen, daß Temperaturanstieg und Meeres -transgression eng verbunden sind, aber die gleichfalls mit der nacheiszeitlichen Erwärmung verbundenen Veränderungen der Regenfallmengen und Regenfallzonen lassen sich weit schwerer erfassen, obwohl sie außerhalb der Küstenzonen offenbar von beträchtlich größerem Einfluß waren als die Meeresspiegelschwankungen. Verwiesen sei nur auf die nach Hahn und Huntington gegebenen Daten W. Samolins (6) für New South Wales (6) nach denen bei 20 Zoll Regen im Jahr auf 1 Quadratmeile über 600 Schafe gehalten werden können, bei 13 Zoll noch über 100 Schafe und bei 10 Zoll nur noch 1 Schaf ausreichend Nahrung findet.

Ein derartiges Schwanken, das höchstens bei längerer Dauer als Trockenhorizont holozängeologisch faßbar sein dürfte, muß auch bei kurzfristigem Auftreten verheerende Folgen für die Besiedlung haben, d.h. daß auch relativ unbedeutende Klimaveränderungen bereits archäologische Wirkung zeigen - ohne daß die Ursachen dokumentierbar sein müssen.

Relativ einfach ist die Korrelation der Meeresspiegelschwankungen mit archäologisch faßbaren Siedlungen in Fällen alter Küstenlinien (unter Voraussetzung seismischer 'Ruhe'), wie z.B. im Falle der Funde von Hajji Muhammad-Ware und Obed-Keramik in ehemaligen Küstenplätzen an einer heute ca. 50-60 km im Landesinneren liegenden Küstenlinie Nordsaudiarabiens (7).

In der Auswertung der Meeresspiegelschwankungen sind eine Reihe von Schwankungskurven gezeichnet worden, deren relative Richtigkeit hier erst einmal vorausgesetzt sei. Ters (8) verglich ihre Ergebnisse mit denen Mörners und Fairbridges, und eine Tabelle P. Kasslers (9) anhand der "Meteor"-Resultate im Persischen Golf stimmt so weitgehend mit den drei genannten Kurven überein, daß man als Außenstehender die Realität dieser Schwankungen und ihrer Zeitfolgen akzeptieren muß, falls man nicht als Skeptiker eine gegenseitige Abhängigkeit an-nehmen will. Letztere Bedenken möchte ich ausschalten, wohl aber bleiben Fragen nach der jeweils verwandten Chronologie, da für eine Heranziehung holozängeologischer Resultate zur Interpretation archäologischer Befunde die gleichen Datierungssysteme zugrunde gelegt werden müssen. Alle vier genannten Kurven verlocken geradezu zum Vergleich mit den Auf und Ab der Siedlungs- und Staatengeschichte vor allem Mesopotamiens, wenn nur die Daten gesichert wären. Hierbei verweise ich nur auf den letzten Versuch J. Mellaarts die historische Chronologie des Alten Orients anhand der korrigierten C^{14}-Daten zu ändern (10) - ein Versuch, den ich für die mit Schriftquellen überprüfbaren Etappen zwar für überspitzt halte, für die "prähistorischen" Phasen jedoch weitgehend mit eignen Auffassungen übereinstimmt. Da es hierbei um Datenveränderungen von einem Umfang bis zu 1200 Jahren (für die Zeit um 3000 v.u.Z.) geht, sind die Vergleiche mit den Daten der Holozängeologen schwierig. Ich setze im weiteren voraus, daß die von der Geologie hier verwandten Daten dem C^{14}-Datengerüst nach Libby entsprechen, das den meisten archäologischen Arbeiten der siebziger Jahre noch zugrundeliegt - und versuche zu einem Vergleich beider Zahlenfolgen zu kommen, wobei ich auf den in der Archäologie übliche Bezugspunkt (Christi Geburt) umrechne.

Ters gibt für die französische Atlantikküste sieben Transgressionen und sechs Regressionen zwischen 6250 v.u.Z. und der Gegenwart an (s.8, S.114). Nach ihrer Tabelle geht ein rascher Anstieg seit 8000 v.u.Z. bis 6250 voraus. Es folgt eine Regression, die noch vor 6000 wieder von einem Anstieg abgelöst wird. Zwei von einer kurzen Transgression unterbrochene Regressionen leiten um die Mitte des 6. Jahrtausends v.u.Z. zu einem ersten Hochstand (bei ca. -8m) (jeweils auf NN bezogen), von dem es einen Rückfall auf fast -16 m und ein langsames Aufschwingen gibt. Langsam ansteigende Hochstände verzeichnet sie um 4000 v.u.Z. (unter -4 m), um 1200 v.u.Z. (um -3m), mit zwei Zwischenhochs vor und nach 2000 v.u.Z. und einem Zwischenhoch um 800 v.u.Z., dem ein Maximalstand um 200 v.u.Z., ein zweiter um 300 nach Christi, ein dritter um 1000 und ein vierter nach 1200 gefolgt seien.

Kassler gibt gleichfalls ab 8000 v.u.Z. einen raschen Anstieg bis gegen 7000 v.u.Z. mit ca. -15 m an, einen Rückgang um 6000 v.u.Z. unter -20 m, einen Anstieg mit zwei (oder drei) Regressionen bis 3800 v.u.Z. mit +1-2 m (über NN), einen schrittweise Abfall im 3. Jahrtausend v.u.Z. bis -2 m 3 m um 2400 v.u.Z., einen Wiederanstieg auf +2 m um 1800 v.u.Z., eine etappenweisen Abfall bis 1000 v.u.Z., einen Aufschwung über NN noch vor 0 und zwei Tiefstände (um 500-600 und 1200-1400) mit einem Hochstand (ca. 800-1000) an. Trotz gewisser Differenzen liegen die grundsätzlichen Übereinstimmungen offen zu Tage, so daß zumindest für unmittelbar betroffene Regionen die Frage gestellt werden darf, wie sich diese Veränderungen in der archäologisch erfaßbaren Siedlungsgeschichte widerspiegeln. Ich schließe hier noch absichtlich die direkten Auswirkungen des postglazialen Temperaturanstiegs aus - und möchte als Beispiel das südmesopotamisch-chusistanische Tiefland nehmen, das von Meeresspiegelschwankungen unmittelbar betroffen worden sein muß. Nützel hat in mehreren Studien (11) gründliche Analysen der Frühzeitphasen geliefert, wenn auch etwas zu wenig die sozialökonomischen Änderungen in dieser Zeit berücksichtigt (12). Jedoch kann man m. E. über seine Arbeit beim Vergleich der Meeresspiegelschwankungen und der Besiedlung Südmesopotamiens herausgehen.

Nach unserem derzeitigen Wissen begann die Besiedlung des südmesopotamischen Tieflandes im 6. Jahrtausend v.u.Z., jene Etappe, in der der Meeresspiegelanstieg die -20 m Marke überstieg und rasch voranschritt. Um 5000 v.u.Z. lag der Meeresspiegel 17 m unter dem NN, so daß eventuelle Flußrandsiedlungen in einer Tiefe von 10-15 m unter dem

Flußschotter gesucht werden müßten, d.h. unauffindbar sind, falls es sie gegeben hat. Es setzte eine Aufschotterung ein, die allmählich die tiefeingeschnittene Flußebene (die wir nicht kennen) ausfüllte. In dieser Zeit erfolgte die Besiedlung des Südens, wie zur Zeit anhand des Fundmaterials aus Eridu (13) zu erschließen ist. Nützel hat die im 6. Jahrtausend v.u.Z. erfolgende Besiedlung auf das Atlantikum zurückgeführt und einen ansteigenden Regenfall postuliert, der einen Regenfeldackerbau in Südmesopotamien erlaubt habe. Der Beweis dürfte für die ersten Jahrhunderte dieser Etappe schwer zu erbringen sein.

Mir erscheint es wahrscheinlicher, daß ein Ackerbau in der Zeit nach den Hochwasserperioden in den Flußtälern geübt wurde, während die Siedlungen (wie z.B. Eridu und Obed) auf hochgelegenen Stellen außerhalb der Überschwemmungszonen angelegt wurden.

Für das 4. Jahrtausend v.u.Z. kann man sich hingegen Nützels Thesen voll anschließen. Der Anstieg des Meeresspiegels erreichte in dieser Zeit sein Maximum von +3 m über NN, so daß weite Teile des Südens überflutet waren und die Stauwirkung des Meeresspiegels die Flüsse auffächerte, (Nützel schreibt "verwildert") (s.11b, Abb.4). Ein engmaschiges Netz von Wasserläufen gab eine gute Grundlage für eine Flußrandbewässerung, die die Grundlage der sumerischen Staatsbildungen seit der Obedzeit war. Hochstand des Meeres schob die Küstenlinie an der Südwestküste des Golfes bis zu 60 km landeinwärts, so daß die Anlegestellen von Schiffen der Hajji Mohammad- und der Obed-Periode mit Keramiken dieser südmesopotamischen Kulturen tief im Inland liegen (s.7).

Den Abfall des Meeresspiegels bis hin zur zweiten Hälfte des 3. Jahrtausends v.u.Z. begleitete die Periode der Ausbildung der sumerischen Stadtstaaten, deren ökonomische Grundlage die immer wichtiger werdende Großbewässerung war, da wir letztlich sumerischen Stadtstaat und Bewässerungsprovinz gleichsetzen können. Das

Einschneiden der Flüsse muß zur fortschreitenden Austrocknung der Ebene geführt haben, die die Menschen durch immer größere Bewässerungswerke aufzuhalten suchten. In der Übergangsphase von der Uruk-Jemdet-Nasr-Zeit zur Frühdynastischen Zeit vollzog sich nach Mc Adams und Nissen (14) ein Umbruch in der Siedlungsform und Staatsorganisation, der durchaus eine Anpassung an diese natürlichen Veränderungen darstellen kann. Sie geben für den Raum um Uruk folgende Daten an:

	Dörfer	Städte	Städtische Zentren	Großstädte
Späte Urukzeit	112	10	1	
Jemdet Nasr u. Frühdyn.Zeit I	124	20	2	1
Frühdyn.Zeit II und III	17	6	8	2

Der Tiefpunkt des Meeres um 2400 v.u.Z. war die Zeit des Zusammenbruchs des südmesopotamischen Staatensystems, gegen die sich die im nördlichen Tiefland ansässigen Akkaderdurchsetzten. Dem Wiederanstieg des Meeres gegen Ende des 3. und zu Beginn des 2. Jahrtausends v.u.Z. (mit bis +2 m über NN) sah die neue Blüte der Sumerer des Südens, die neusumerische Zeit, in der ein intensiver Ackerbau blühte, der weit über die alten Stadtstaatgrenzen hinausgriff.

Diese Phase von 2400 bis 1700 v.u.Z. nennen Jacobsen und McAdams (15) die Phase der intensivsten Versalzung Mesopotamiens, d.h. einer Zeit intensiven Bewässerungsackerbaus, dem ein neuer Zusammenbruch folgte.

Im zweiten Viertel des 2. Jahrtausends v.u.Z. fällt der Süden erneut in der Entwicklung zurück. Babylon übernahm für kurze Zeit die Vormacht und verfiel dann gleichfalls, so daß um 1400 v.u.Z. das Tiefland unter ariden Bedingungen ökonomisch und kulturell nahezu unbedeutend wurde. Der Wiederanstieg des Meeres um 1200 v.u.Z. fiel zeitlich mit der Blüte des kurzfristigen Reiches des "Meerlandes" zusammen, eine Phase erneuter Versalzung der Agrarzonen (s.15).

Mir scheint die Übereinstimmung von Meeresspiegelschwankung und Kulturentwicklung in Südmesopotamien seit dem Beginn des 4. Jahrtausends v.u.Z. evident zu sein. Nun sind die Etappen des Auf und Ab in der Ackerbauentwicklung nicht auf Südmesopotamien beschränkt - und deutliche Intervalle in der Besiedlung der Steppenräume können unmittelbar nicht von den Meeresspiegelschwankungen abhängen, wohl aber von Temperatur- und besonders Regenfallschwankungen, die ähnlich wie der Meeresspiegel von den Klimaänderungen der Nacheiszeit abhängen.

III. Meeresspiegelschwankungen, Temperatur- und Regenfalländerungen

Die Erwärmung der Nacheiszeit äußerte sich in vielen Formen, von denen die eine in ihren Wirkungen auf Südmesopotamien untersucht wurde. Ein Ausgreifen über die engen Küstenzonen zeigt, daß auch die anderen Formen des Klimawechsels bei der Korrelation von Holozängeologie und Archäologie zu berücksichtigen sind. Das in diesem Zusammenhang stehende Problem ist nun inwieweit ihre jeweilige geologisch-feststellbare Spuren mit den weltweit deutlich verbundenen Meeresspiegelschwankungen verknüpftwerden können.

Ložek und Jäger (16) haben aus der Analyse des Wechsels von "Sedimentlagen und begrabenen Böden" auf Synchronismen zu den Transgressionen geschlossen: "Nach Aussage dieser Befunde waren die Meeresvorstöße (Transgressionsphasen) im nordwest-mitteleuropäischen Küstengebiet zeitgleich mit relativ feuchten Phasen der klimatischen Entwicklung im mitteleuropäischen Binnenland, Phasen des Stillstandes oder gar der Rückläufigkeit im nacheiszeitlichen Meeresspiegelanstieg dagegen verbunden mit relativ kontinentalem Klima im Inneren des Kontinents" (s.16, S.145).

Jäger hat seine bodenkundlichen Forschungen mehrfach mit archäologischen Befunden zu verbinden gesucht (17). "Vom Endneolithikum ab wird im übrigen der Wechsel fundfreier Sedimentationsphasen und funddatierter Trockenphasen in seiner weiträumigen Synchronität überschaubarer. Zu den ersteren gehören folgende Perioden: 1. Schnurkeramik, 2. Hügelgräberbronzezeit, 3. Mittlere Früheisenzeit, 4. Mittellatène. Auf Lücke damit stehen als trocken ausgewiesene Zeitabschnitte der Bodenbildung: 1. Glockenbecher/Aunjetitz, 2. Urnenfelderbronzezeit (BD - Beginn HC), 3. Endhallstatt nebst Frühlatène (Ende HD - LA), 4. Spätlatène bis frühe römische Kaiserzeit mit der augusteischen Periode" (s. 17, S.671).

Dieser Wechsel in Zahlen umgesetzt würde Feuchtphasen um 2000 v.u.Z. (der neusumerischen Zeit Mesopotamiens), im zweiten Viertel des 2. Jahrtausends v.u.Z. (der altbabylonischen Zeit), dem 8.-7. Jahrhundert v.u.Z. (der neuassyrischen Zeit) und der Epoche um die Zeitenwende (der Partherzeit) ergeben, d.h. eine relative Übereinstimmung zwischen der südmesopotamischen Entwicklung und der mitteleuropäischen Folge. Liegt dieses an der Küstennähe beider Regionen?

L.N. Gumilev (18) hat in einem mehrteiligen Artikel einen im Detail anzuzweifelnden Vergleich von fünf Regionen gegebenen und den Weg der Zyklone mit aufgezeichnet. Gumilev sieht im Zug der Zyklone die Grundlage des Regenfalls, wobei ein Gegensatz zwischen der bei nördlichen Zyklonen trockenen und bei südlichen Zyklonen feuchten Zone Eurasiens und humiden Zone Europas, in dem die Zyklone entgegengesetzt wirken sollen.

Der am Ende der Betrachtung der mesopotamischen Entwicklung genannte Widerspruch, daß die Wirkungen der Meeresspiegelschwankungen auf Südmesopotamien analogen Verhältnissen in Nordmesopotamien entsprechen, ließe sich dann nach Gumilevs Vergleichen aus einer relativen

Übereinstimmung von Erwärmung und Meeresspiegelanstieg erklären. Nützel (s. 11d, Fig.1) hat nach Bohrkernen eine Klimakurve für den Nahen Osten gezeichnet, die aus einem Tief um 14 000 v.u.Z. mit mehr als -6^0 unter heutigem Klima bis um 9000 v.u.Z. auf -2^0 ansteigt, wieder um 8000 v.u.Z. auf -3^0 abfällt. Um 7000 v.u.Z. steigt danach die Temperatur an, um gegen 4000 v.u.Z. $+3^0$ (über heutigem Klima) zu erreichen und fällt dann allmählich ab, bis sie dann im 2. Jahrtausend v.u.Z. unser gegenwärtiges Klima erreichte. Leider bricht dann die Dokumentation ab.

Nach Van Zeists Zeribar-Forschungen und anderen Autoren (19) lag das Hochland Vorderasiens bis ca. 12000 v.u.Z. unter extremer Trockenheit und polarer Kälte. Noch bis 8000 v.u.Z. sind nur wenige Bäume in aridem Klima nachweisbar und erst um 4000 seien die gegenwärtigen Verhältnisse erreicht -

Jahrhdt.	Zyklone	Aride Zone Westeurasien	Feuchtes Osteur.	Europa	China	Vorderasien
XXXIV-XXV	Nordweg	Trocken Äneolith.	Trocken Afanasjewo	Steig. Feuchtigkeit Neolith.	Feucht Yang Shao	Feucht Altes Reich
XXIV-XXII	Nordweg	Trocken	Trocken	Feucht	"Weltweite Flut" (1)	
XXII-XXI	Mittel	Trocken Katakomben Gräber	Trocken	Feucht Bronze (1)	Sink. Feuchtigkeit Lungshan	Sink. " Akkad-Sumer
XX-XIII	Süd	Feucht Balkengräber	Feucht Andronovo	Trocken Fatjanovo	Trocken Shang	Tr. Neues Reich Assyrer

Jahrhdt.	Zyklone	Aride Zone Westeurasien	Feuchtes Osteur.	Europa	China	Vorderasien
XX-XIII	Süd	Feucht Balkengräber	Feucht Andronovo	Trocken Fatjanovo	Trocken Shang	Trocken Neues Reich Assyrer
XII	Süd	Feucht	Feucht Zug der Hunnen nach Norden	Trocken	Trocken Fall der Shang	Trocken Unterg. der Hethiter
XI-IX	Nord	Sinkende Feuchtig. keit Kimmerier	Sinkende Feuchtigkeit Karasuk	Wechselnde Feuchtigkeit Hallstatt	Trocken Dschou	Trocken jüdische Wanderung
VIII-V	Mittel	Trocken Skythen	Trocken Pazyryk	Feucht Iberer	Trocken Fall d. Dschou	Trocken Assyrer Perser Meder
IV	Süd	Feucht Sarmaten	Feucht Jüetschi	Trocken Kelten	Trocken Kämpf. Reiche	Trocken Alexanderzug
III	Süd	Feucht Sarmaten	Feucht Hunnenzug	Trocken Kelten	Trocken Tsin-Reich	Trocken Hellenismus
II-I	Mittel	Trockenwerdend Sarmaten	Trockenwerdend Krise der Hunnen	Feucht. werdend	Feucht. werdend Han	Feuchter werdend römische Republik

(1) - zweifelhaft

und nach 3000 v.u.Z. ist die fortschreitende Austrocknung erneut deutlich.

Legt man nun die Analogie der Entwicklung in Vorderasien und Europa zugrunde, so könnte der historische Ablauf in Nordmesopotamien und in den Steppen der syrisch-arabischen Ebenen mit der Klimaentwicklung folgendermaßen verknüpft werden.

Das Vordringen der monochromen Keramikkulturen im 6. Jahrtausend v.u.Z. in die Sindscharregion und die südwärts angrenzende Steppenzone, der Hassuna-Kultur, ist offenbar mit dem Klimawechsel im 6. Jahrtausend v.u.Z. verbunden (vergleiche hierzu J. Oates, Referat 18 S.366) (20). Der Anstieg des Regenfalls kann nicht beträchtlich gewesen sein, da kaum die heutigen Siedlungsräume überschritten wurden. Das "Atlantikum" (von 5500 bis 3000 v.u.Z.) brachte auch dem Nordteil des Irak und Syriens, der Regenfeldzone reichere Niederschläge. Sie waren eine der Voraussetzungen der "Buntkeramik"-Kulturen. Das Trockenwerden im 3. Jahrtausend v.u.Z. trieb die Nomaden gegen die Stromtäler, ein Prozeß, der sich im 2. Jahrtausend v.u.Z. zweimal wiederholte. Verheerend war vor allem die Trockenphase des späten 2. Jahrtausends v.u.Z., in der selbst Assyrien zugrundeging und Babylonien verfiel. Die Aramäerwanderung fiel wohl kaum zufällig mit der "Seevölkerwanderung" aus Osteuropa zusammen. Die Reorganisation des neuassyrischen Staates im 9. Jahrhundert v.u.Z., wie seine Ablösung durch Neubabylon hatten in Feuchtphasen ihre natürliche Grundlagen.

Die Untersuchungen in anderen Regionen bestätigen das sich ergebende Bild. So reichten die Auswirkungen der Wärmezeit des Atlantikums bis zu den Neusibirischen Inseln, auf denen Birken wuchsen (21). In Nordchina und in der Mongolai kamen Büffel und Bambusratte vor - und selbst Torfmoore entstanden in der Mongolei (22). Eine zweite Wärmezeit Sibiriens ist für das 1. Jahrtausend u.Z. nachweisbar, in der die Jakuten nach Norden vordrangen. Ausführliche Studien liegen auch für Mittelasien und den Nordiran vor, die dort drei Trockenzeiten für 1. das frühe 2. Jahrtausend v.u.Z., 2. die zweite Hälfte des 1. Jahrtausends v.u.Z. bis in die ersten Jahrhunderte unserer Ära und 3. für das 14. bis 16. Jahrhundert belegen (23). Sie sind die Voraussetzungen des Nordostwärtsvordringens der Ackerbaukulturen der Steppen Eurasiens. Die zweite Etappe der Trockenheit ist die Grundlage der Nomadisierung der Steppenbewohner. Bei Asterabad im Iran (24) ist die Trockenphase des 2. Jahrtausends durch die Lösslager kenntlich, die 10 m Stärke erreichen und in deren unterem Drittel die schwarzgraue Ware des späten 3. Jahrtausends v.u.Z. eingelagert sind.

Ehlers will den "Höhepunkt des trockenkalten Subboreals in Nordpersien auf die Zeit zwischen 1500 und 800 v.Chr. einsetzen, eine Datierung, die sich zwanglos in die Grenzen des europäischen Subboreals einfügen läßt"(25). Gestützt auf Deshayes und Crawford gibt er eine Folge von Feuchtigkeit bis 4500 v.u.Z., dann 1000 Jahre Trockenzeit, eine Feuchtzeit von 3500-1800 v.u.Z., eine Trockenperiode bis 600 v.u.Z. und eine Feuchtzeit bis 300 u.Z., Beobachtungen, die der Siedlungsfolge entsprechen.

Nach mündlicher Information Agrawals auf einer Tagung in Aarhus sind für Indien drei Folgen belegbar. Einmal ist die +3 m Transgression am 3000 v.u.Z. festzustellen und zum anderen sind dies in Kaschmir und in Radjastan Höhepunkte einer Feuchtzeit. Sarma (26) möchte die Entwicklung der Harappa-Zeit in die Etappe des eustatischen Meerhochstandes um 2000 v.u.Z. setzen. Er verweist dabei auf die heutige Lage der Harappa-Häfen, die weit landeinwärts liegen, so Suktagen 30 Meilen, Sotkako 8 Meilen und Balakot 12 Meilen. Falls diese Lage nicht ein Ergebnis tektonischer Hebungen ist, muß in der Tat diese Phase der Harappa-Kultur der mesopotamischen Ur III-Dynastie zeitlich gleichgesetzt werden.

Der Zug der Indoarier nach Indien könnte dann als Resultat der Austrocknung Turkmeniens im 2. Jahrtausend v.u.Z. gesehen werden. Auch wenn man unterschiedliche Datierungsmethoden mit als mögliche Quellen auftretender Widersprüche einberechnet und die Tatsache sehr verschiedenen Forschungsstandes berücksichtigt, bleibt eine deutliche zeitliche und regionale Asymetrie der Klimawirkungen auf die Siedlungsgeschichte.

In Kaukasien und Transkaukasien verfolgt u.a. Sajadjan (27), der zur Feststellung kam: "Die Transgressionsperioden des Sevan und die starke Bewaldung seines Beckens fielen mit feuchtkühlen klimatischen Phasen zusammen, während die Regressionen mit einer Verringerung der Feuchtigkeit einhergingen. Diese Schwankungen decken sich gut mit den Vorgängen in den angrenzenden Gebieten und sogar im globalen Maßstab. Die nacheiszeitlichen Transgressionen des Schwarzen Meeres (insgesamt) mit dem Einfluß des Weltozeans verbunden und sind mit den flandrischen Schichten des Mittelmeeres vergleichbar. Für die letzten 6000-7000 Jahre ist eine genaue Analogie in der Entwicklung dieser Transgression für das Schwarze Meer, das Mittelmeer und den Weltozean zu beobachten... Hingegen entwickelten sich die Wasserstandsschwankungen des abgeschlossenen Kaspisees asynchron... Interesaant ist, daß dem Rhythmus der nacheiszeitlichen Transgressionen des Sevan die Transgressionen des Kaspisees und die Regressionen des Schwarzen Meeres sowie das Auftreten von Gletschern und eine stärkere Bewaldung des Großen und Kleinen Kaukasus entsprechen" (s.27, S.32-33).

Diese Feststellungen treffen offenbar auf den Persischen Golf, auf Westeuropa, Indien usw. zu, an deren Küsten analoge Vorgänge abliefen, während die Binnenzonen (s. Gumilevs Tabelle) nach den Bahnen der Zyklone wechselnde Feuchtigkeitsmengen aufwiesen. Hierbei scheinen die Zugbahnen in weiten Kurven über die Nordhalbkugel zu verlaufen, nicht in geraden Linien. Der Interpretation der unterschiedlichen Zonen klimatischen Einwirkens auf die

Lebensführung der Menschen wird man auf Flohn (28) zurückgreifen können, nach dem die relativ stabilen Klimazonen sich im Prozeß des Abschmelzens der Eisschilde relativ spät herausbildeten. Flohn nennt zwischen jüngerer Dryas (8400 v.u.Z.) und Peron-Transgression (2800 v.u.Z.) einen Meeresspiegelanstieg von 42 m, der ein schnelles Abtauen voraussetzt und einen jähen Wechsel der Zyklonenzonen einschließt. Jedoch muß einschränkend gerade für die Umbruchszeit die Skepsis Büdels ernst genommen werden, daß uns nur das gegenwärtige Zirkulationsmodell (und auch dieses nur in großen Zügen) wirklich bekannt ist (29).

Der Umbruch zwischen den Klimazonen der Vereisungszeiten und dem Atlantikum ist als allgemeine Erscheinung nicht zu bezweifeln, nur seine konkreten Ergebnisse je Region stehen zur Erörterung. Nach den vorderasiatischen Daten wäre (bei Libby-Daten) dieser Umbruch im 6. Jahrtausend v.u.Z. erfolgt - und bildet die Grundlage der agrarischen Erschließung des Tieflandes (nach korrigierten Daten wären ca. 1000-1200 Jahre hinzuzuzählen).

IV. Die Entwicklung in Nordafrika

In Nordafrika haben in den letzten Jahren zahlreiche holozängeologische Forschungen stattgefunden, deren Resultate oft zur Interpretation der Sahara-Siedlungsgeschichte herangezogen worden sind. Sie geben ein relativ einheitliches Bild, m.E. im allgemeinen in das vom Fairbridge (30) nach Büdel (s.29) und Flohn (s.28) gezeichnete Bild passen. Genannt sei in erster Linie Butzer (31), der für das Niltal zu folgenden Phasen kam:

1. 16000-5000 v.u.Z. Trocken
2. 5000-2350 v.u.Z. Feucht mit Etappen
   a) um 3600 v.u.Z. Zurücktreten der Savannenfauna
   b) zwischen 2800 und 2600 v.u.Z. Verschwinden der Savannenfauna
3. 2350-500 v.u.Z. Arid

4. 500 v.u.Z.-300 u.Z. Höhere Wasserführung des Nils
5. 300-800 u.Z. Trockenzeit mit äolischen Ablagerungen (s.31, S.115)

Sein nicht unbestrittenes Schema steht zum Teil im Widerspruch zu den Befunden in anderen Regionen, ein Widerspruch, der wieder auf eine Asymmetrie weisen könnte. So gibt Michel (32) für den Tschadsee erstens eine Transgression zwischen 9600 v.u.Z. und zweitens eine Regression zwischen 5000 und 4500 v.u.Z.

Pachur (33) differenziert die Angaben über den Tschadsee folgendermaßen:

1. Transgression um 12000 v.u.Z.
2. Regression
3. neue Transgression zwischen 5500 und 4500 v.u.Z.
4. Regression bis 2000 v.u.Z.
5. Transgression 1500 v.u.Z.

Gasse (34) gibt aus der Afar-Region

1. eine Transgression um 8000 v.u.Z. (von 10000 bis 7500 v.u.Z.)
2. eine Regression ab 6000 v.u.Z.
3. eine Transgression zwischen 500 v.u.Z. und 600 u.Z. und
4. eine begrenzte neuzeitliche Transgression.

Dieser Befund paßt eher zu Butzers Nildaten als die Tschad-Folge, die besser zum Bild der Sahara stimmt.

Jäckel (35) bietet für die Zentralsahara (Tibesti, nach dem Flußsystem Bardagné-Aragé) eine sehr stark gegliederte Kurve:

1. 14000-12500 v.u.Z. erste Feuchtphase
2. 12500-12000 v.u.Z. Trockenstadium
3. 12000-11000 v.u.Z. Feuchtzeit
4. 11000-10800 v.u.Z. Trockenphase
5. 10800- 9500 v.u.Z. Feuchtphase
6. 9500- 9200 v.u.Z. Trockenzeit
7. 9200-8850 v.u.Z. Feuchtzeit
8. 8850- 8700 v.u.Z. Schwankend
9. 8700- 8400 v.u.Z. Feuchtzeit
10. 8400-8300 v.u.Z. Schwankend

11. 8300- 8100 v.u.Z. Trockenzeit
12. 8100- 7150 v.u.Z. intensivste Feuchtzeit, kaltfeucht, ab
7200 v.u.Z. Erwärmung
13. 7150- 7000 v.u.Z. Trockenzeit
14. 6650- 6100 v.u.Z. intensive Feuchtphase (mit trockener Zwischenetappe von 150 Jahren)
15. 6100- 5100 v.u.Z. Trockenzeit mit intensiver Abtragung (und bis 4000 v.u.Z.)
16. 4000- 3100 v.u.Z. neue Feuchtzeit, warmfeucht
17. 3100- 2100 v.u.Z. Aridität heutiger Prägung
18. 2100- 1300 v.u.Z. Feuchtphase übergehend in Aridisierung
19. in Phasen, davon zwischen 800-300 v.u.Z. eine relative Feuchtphase

Jäckel interpretiert seine überaus detaillierte Kurve in dem Sinn, daß die Feuchtzeit ab 14000-6000 v.u.Z. von Norden her bestimmt war und ab 12000 v.u.Z. von Süden her ein Vordringen tropischer Luftmassen vorlag, so daß beide Tendenzen sich im Tibesti überschnitten.

Er folgt dabei offenbar der These Büdels (29), der zwei Pluvialtypen der Sahara erkannte. Auch Flohn (s.28) unterschied polare Pluviale mit äquatorial ausgreifenden Winterregen von tropischen Pluvialen mit tropischen Sommerregen und nordwärts verschobenen Subtrophenhochs. Er verweist auf eine asymmetrische Vereisung beider Pole, die bei früherer (oder späterer?) Südvereisung den meteorologischen Äquator nordwärts verschieben würde.

Flohn verweist auch bereits darauf, daß schon eine Erhöhung der "mittleren Regenmenge um vielleicht 100 mm" ausreicht, um tiefgreifende Folgen für Vegetation, Tierwelt und Hydrologie" zu bewirken. Diese Folgen untersuchten Gabriel (36), Taute (37) und andere Autoren. So war nach Taute (s.37, S.58) die Sahara zwischen 2800 und 17000 v.u.Z. Siedlungsleer - (zu trocken).

Am Rande des Niltals blühte von 13000-10000 v.u.Z. die Qadan-Kultur mit Getreideernte und Verarbeitung des

Getreides (38). Sie entspricht den frühen postglazialen Feuchtzeiten.

Die Feuchtphasen des 7. Jahrtausends v.u.Z. entsprechen die ersten Spuren eines Ackerbaus im Hoggar, in Amekni (mit 6100+80 v.u.Z.), denen gleichalte keramische Kulturen im Acacus-Gebirge, und in Tibesti entsprechen (39). Kuper unterschiedet eine südliche und eine nördliche Variante - die südliche scheint auf einer Sahel-Wirtschaft mit Hirse und Fischerei zu beruhen, eine Gruppe, die Sutton als "African aqualithic" zu definieren trachtete (40) und aus der Südzone Westafrikas ableitete.

Der Feuchtzeit des 4. Jahrtausends v.u.Z. entspricht die "Rinderzeit", die Glanzzeit der Saharafelskunst.

Der feuchten Phase zwischen 2100 und 1300 v.u.Z. ist die sogenannte "Pferdephase" der Felsmalerei zuzuordnen, wie die Etappe von 800 bis 300 v.u.Z. die Garamantenkultur ermöglichte.

Auch die Entwicklung Altägyptens stand unter dem Einfluß der Klimaschwankungen in Nordafrika. Die Trockenphase ab 6100 v.u.Z. scheint die Stämme der Sahara u.a. gegen das Niltal gedrängt zu haben, das sie als frühe Ackerbauern in neuer Weise zu nutzen verstanden. Es entwickelte sich das ägyptische Ackerbauzentrum, das im 4. Jahrtausend weit über das Niltal auszugreifen verstand, aber vom Ende des 4. Jahrtausends v.u.Z. auf das Flußtal begrenzt war, in dem sich das Pharaonenreich entwickelte, während die Saharakulturen regelrecht "austrockneten". Die Asymmetrie der nordafrikanischen Entwicklung zu der Vorderasiens ist offenkundig. Der nordafrikanischen Trockenphase von 6100-5100 (bzw. 4000) v.u.Z. steht das Atlantikum und der Meereshochstand als Grundlage der sumerischen Entwicklung gegenüber. Der Trockenphase des 2. Jahrtausends v.u.Z. in Vorderasien steht eine Feuchtphase gegenüber usw. (Jedoch könnten hier bereits unterschiedliche C^{14}-Chronologien das Bild total verfälschen). Erklärbar wäre dieser Unterschied anhand des Zirkulationsmodells Fairbridges (41), nach dem die "südlichen Pluviale"

Vorstöße des S.W.-Monsuns in nichtglazialer Zeit seien, in denen Vorderasien kontinentale (trockene) Winde erhalten würde, während "glaziale" Verhältnisse Vorderasiens Mittelmeerregen und Afrika trockene Winde mit Dünenbildung bringen würden. Demnach befinden wir uns immer noch im Übergang vom glazialen zum nichtglazialen Klima mit Schwankungen, wobei die Sahara-Feuchtphasen (südlicher Prägung) Vorstöße nichtglazialen Charakters wären. Im Ausgreifen über weitere Regionen gerät man immer mehr in den Bereich der Hypothese und in Gefahr, Parallelen zu sehen, die eventuell zu weit gehen (42). Die Problematik der Korrelation holozängeologischer und archäologischer Daten aus verschiedenen Regionen zeigt u.a. der Beitrag J. Oates (s.Anm.20) mit ihren Daten für Ostarabien und den Golf, die nicht ohne weiteres mit der Entwicklung Mesopotamiens in Einklang zu bringen sind. Vielleicht hat Bintliff (43) mit seiner Vermutung Recht, daß die Zyklone, die der Sahara Regen brachten, nach der Levante und Arabien übergriffen. Er verweist dabei auf Lambs These einer länger anhaltenden Vereisung Nordamerikas (im Verhältnis zu Europa), die natürlich zu einem anderen Verlauf der Luftmassen, der Zyklonbahnen, geführt haben müssen. Eventuell ist dies die Erklärung für die "Anomalien" des Regenfalls im vorderasiatisch-nordafrikanischen Holozän. Hierfür sprechen auch die Angaben Goldbergs und Bar-Yosefs (44), die für die Südlevante fundierte Perioden so datieren, daß sie mit den Sahara-"Pluvialen" übereinstimmen würden.

Ein Widerspruch scheint noch zu bestehen zwischen den Pollendiagrammen W. van Zeists (45) und den paläozoologisch gewonnenen Angaben S. Bökönyis (46). Letzterer weist z.B. für Tepe Asiab im Westiran für das Ende des 8. Jahrtausends v.u.Z. ein Vorherrschen von Waldfauna nach - van Zeist gibt für den Zeribar-See noch eine weitgehend baumlose Steppe an. Vielleicht wirken hier bereits die Unterschiede der zugrundeliegenden Datierungsmethoden verwirrend.

V. Probleme und Fragen

Im vorstehenden Text wurden in der Literatur vorgefundene Daten und Angaben prinzipiell akzeptiert, da viele Voraussetzungen einer kritischeren Aneignung nicht gegeben sind. Zwar dürfte sich die allgemeine Abhängigkeit menschlicher Siedlungstätigkeit in der Nacheiszeit von der Umweltsentwicklung bestätigt haben - und blieb auch die Rückwirkung des Menschen auf die Umwelt hier ausgespart - so ist doch die Erklärung siedlungsgeographischer konkreter Vorgänge mit holozängeologischen Erkenntnissen noch an eine Reihe von Voraussetzungen geknüpft, die bisher nur zum Teil erfüllt werden.

Daraus ergeben sich

1. Probleme allgemeiner Art:
   a) Es fehlt trotz Fairbridges u.a. ein befriedigendes Modell der Luftmassenzirkulation (und der Regenverteilung) in der Nacheiszeit und die Erklärung der Wandlungen.
   b) Die chronologischen Daten vieler Holozängeologen lassen nicht erkennen, wie sie gewonnen sind, worauf sie beruhen und welches Stadium z.B. einer Klimaschwankung sie beschreiben.
   c) Über die Asymmetrie der Klimaentwicklung der Regionen und Zonen liegen nur völlig unzureichende Hypothesen vor.
   d) Die Auswirkungen von Klimaveränderungen auf die jeweilige soziale Gemeinschaft müssen sehr differenziert werden, trotz aller oben gegebenen Verallgemeinerungen.
   e) Das gegenwärtige Bild der Entwicklungsgeschichte, das die Archäologie zeichnet, entspricht in seiner Relativität (Unvollständigkeit) dem Forschungsstand der Holozängeologie.
2. Einige regionale Probleme (aus der Vielzahl vorhandener):
   a) Es fehlt ein befriedigendes Bild von der Entwicklung der Niederschläge in Vorderasien, das auch nur annähernd der hier zitierten Tibesti-Folge Jäckels entspräche.

b) Die Veränderungen der Niederschläge der euroasiatischen Steppen bedürfen weiterer Überprüfungen.

c) Genauere Studien zur Reaktion der unterschiedlichen Produktionstypen auf klimatische Veränderungen selbst geringer Intensität und kurzer Dauer müssten angefertigt werden.

3. Daher wird vorgeschlagen, im Rahmen der INQUA zu einem internationalen Programm der Korrelation der holozängeologischen und archäologischen Resultate in Nordafrika, Vorderasien, Europa, Indien und Zentralasien zu kommen. Dazu müßten:
   a) ein einheitliches Datensystem festgelegt,
   b) ein gleichartiges Beschreibungssystem und
   c) ein Kartierungsschema gefunden werden.

Anmerkungen

1. Der Streit um die "New Archaeology" Binfords hat zweifellos manche anregende neue Studie hervorgebracht, wenn auch die Anhänger der unterdessen recht weit aufgefächerten Binford-Schule zum Teil mehr versprochen als gehalten haben. Zu den fruchtbarsten Serien zählen die "Studies in Archaeology" der Academic Press(New York-London) mit Arbeiten wie K.V. Flannery (Ed.) "The early mesoamerican village" oder F.Wendorf und R. Schild, Prehistory of the Nile Valley.
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PALAEOCLIMATIC MODELLING OF ENVIRONMENTAL CHANGES IN THE EAST MEDITERRANEAN REGION SINCE THE LAST GLACIATION

John L. Bintliff
(Undergraduate School of Studies in Archaeological Sciences,
University of Bradford, U. K.)

Taking the very long time-span being considered by this conference as a whole, c. 20,000 b.p. to the present-day, one is most struck by the discontinuous nature of detailed information available on possible climatic fluctuations. Those periods about which we possess most climatic data and theories have generally been the focus of intensive research precisely because it was considered that climatic changes were significant then, and hence we are at risk of circular arguments. But the overall effect of such a data-base is to necessitate a greater concentration at the present time on specific phases of the past for which the evidence is best available, filling the often lengthy intervening periods with theoretical suggestions about the dominant climatic mode.

Given that even the best-researched periods are rarely unambiguous in the data they offer for a particular climatic pattern, it may seem very premature to attempt to model the prevailing climate of the Eastern Mediterranean region, period by period, especially for the less well-known stages of the past. However, there has been a very significant shift in recent decades within the discipline of Climatology, a shift away from the highly detailed, particularising approach to regional climates, with its emphasis on unique combinations of topography and surface pressure systems, and on to a far more powerful analysis in which the fundamental source of dominant surface weather systems is to be sought in largescale airmass and circulation dynamics in the upper atmosphere. This approach rests on the fundamental link between the development and steering of surface weather and wind systems, and the general atmospheric circulation and the flow of the circumpolar vortex (the broadly latitudinal flow of dominant winds concentric around the poles): "the circumpolar vortex of broadly upper westerly winds.. constitutes the main flow of the atmosphere, and controls the development and steering of the surface weather systems" (Lamb 1978a, 121); "One gets the impression at this stage of research on the subject that the most fundamental aspects of the climatic variations which we can observe are (1) changes of global mean temperature near the surface of the earth, particularly..over equatorial and tropical..and over the highest northern latitudes.. (2) Changes of the wind circulation over the middle latitudes of both hemispheres. The changes to these items appear to be significantly linked with each other and probably explain most other aspects of the climatic regime.. It may be sufficient in some connexions to use the variations of the wind circulation, and of the temperatures and total extent of the Arctic ice, as indirect indicators of the variations of the global regime" (Lamb 1978b, 183).

The major wind systems under analysis in such an approach are such as the upper Westerly system, affecting both Europe and the Mediterranean latitudes, and therefore of sufficient amplitude that the possibility exists of interpolating from indications in widely separate localities the overall climatic pattern for regions of sub-continental size. Moreover, the pattern of the dominant upper circulation features is then also inferrable from discrete but consistent indications of surface weather and pressure systems on the strength of their significant distributional characteristics. Such an overall approach has been most notably applied by Professor Hubert Lamb in his extensive publications on Climatic History:

> "in the Northern hemisphere..the main wind current aloft is a single great vortex of more or less westerly winds blowing round the low pressure centre over the polar regions in each hemisphere — the circumpolar vortex. This wind system which we find through a great depth of the atmosphere between about 2 km and 20 km above the Earth's surface is, in fact, the main flow.. As the upper winds circle the Earth, they pass from regions of weak to regions of strong pressure gradients.. The temporary disequilibrium between the forces acting upon the air causes some departures from strict flow along the pressure lines.. This is the origin of those shifts of mass which create the anticyclones and cyclones..of the surface weather map. These familiar features develop and decay in response to changes in the upper wind pattern over them and are carried along with the general direction of the massive flow of the mainstream of the upper winds" (Lamb 1975a, 123).
>
> "If we examine the changes of climate in the past..we find evidence of ..changes of overall warmth, paralleled by changes in the prevailing intensity and shifts of latitude of the main features of the wind circulation" (Lamb 1975a, 134). "the global integrity of the atmospheric circulation is such that no one region is independent of the rest of the world climatically. Data from North America are pertinent to European climatic reconstruction" (Bryson et al. 1974, 49). "the mean conditions of successive climatic regimes..may be derived by considering the atmospheric circulation characteristics that would be in equilibrium with the environmental conditions prevailing" (Lamb 1975b, 169).
>
> "Since physical constraints exist that tie together the regional circulation patterns of the atmosphere into a coherent whole, we have a powerful tool for testing the validity of a proposed pattern with evidence from regions quite distinct from the one for which the analogue was chosen" (Bryson et al. 1974, 47).
>
> "These plots are for a particular location, but, considering the integrity of the hemispheric circulation pattern, the postglacial climatic changes indicated here must have been associated with changes over large parts of the world" (Bryson 1974).

A characteristic feature of Prof. Lamb's studies of past climate are maps, (or rather, physically-realistic speculations), representing each major era of the late Pleistocene and Holocene, at a sub-continental level, and showing estimations for major circulation patterns and pressure gradients.

These considerations encourage the modelling of climate for past eras in the E. Mediterranean, even when it relies apparently overmuch on data from selected areas within that wider region, or is visibly propped up by reference to data available for adjacent regions (such as temperate Europe or North Africa). Underlying this attempt therefore, and those incorporated into it from published work by previous scholars, is that concept fundamental to Lamb's oeuvre, that major climatic fluctuations (secular changes of climate), in one region of the globe are believed to be correlated with predictable fluctuations in contiguous regions, due to the strong interdependence of the major features of the Earth's climate and the large scale on which the underlying circulation features operate. A second major concept in Lamb's approach, that is invaluable for palaeoclimatic reconstructions, is the building of models for changing secular climatic patterns on the basis of analogous recent short-term fluctuations. This 'Uniformitarian' concept argues that recent analogues are available for virtually all past climatic modes, with allowance being made for degree and duration.[1]

The foregoing points are especially relevant to the study of climatic change in the E. Mediterranean. For almost all of this region, the availability of wild game and plants, the successful maturing of cultivated cereals and tree fruits, and of pasture for domestic animals, all are dependent on the winter-season incursion of upper westerly steered cyclonic stormtracks, (especially from the west and northwest), coupled with the parallel retreat of the summer-dominant subtropical arid pressure systems (predominantly high pressure) towards the equator. These displaced troughs in the upper westerlies also bring rain to winter-season Northern Europe, just as the expanded Azores subtropical anticyclone is responsible for prolonged periods of warm, dry weather in North-West European summers.

Essentially there would seem good reason for establishing a palaeoclimatic model linking unusually wet and cold winters in Northern Europe with a similar tendency in South (Mediterranean) Europe and the Levant, and a corresponding correlation between Mediterranean winter rainfall decline and a decrease in Europe north of the Alps. This MODEL ONE envisages a simple northward or southward displacement of present-day circulation patterns. It is one of the key climatic changes isolated by Lamb:

> "regional climatic histories. . seem generally understandable in terms of latitude shifts of the main features of the global wind circulation" (Lamb 1977, 400).

Its operation can be seen vividly in the significant fluctuations of this century:

> "The main climatic feature of this century in the northeast sector of the Atlantic Ocean was an intensification of the westerlies, resulting in a prolonged northward migration of wind and pressure belts. This

> culminated in the mid 1930's. After the 1930s there was an accelerated weakening of the westerlies and an associated southwards shift of these belts" (Lamb and Dickson 1975, 142).

This model may also be appropriate for past glacial eras, and Holocene mini-glacial eras (such as the Medieval to Early Modern 'Little Ice Age', c. 1550-1850 A.D.), during which it is believed that an expansion occurred towards the equator from both the poles of the subpolar cold and dry pressure systems, associated with the likewise equatorward displacement of the temperate rain-bearing westerly depression system and subtropical arid, high pressure systems:

> "It is by now fairly clear that at the glacial climax, and in the relatively cold epoch of the Little Ice Age..there was a zone of strengthened circulation associated with the sharpened thermal gradient between the colder Arctic and the lower middle latitudes" (Lamb 1978b, 184).

A complicating factor arises if we consider another source of precipitation, that of the equatorial rains (primarily the monsoons). At present such rain affects only the southernmost area of the Middle East, and even there only where relief is significant. But if, as seems likely, there have been periods in the past, especially that of the supposed climax of warmth and ice-melt during the Atlantic era (c. 5500-3500 b.c.), when the circumpolar vortex of broadly latitudinal climatic zones contracted towards the poles, then it would be quite appropriate for the monsoon/equatorial rains not only to have an effective influence further north in the E. Mediterranean and Saharan Africa, but to operate there also irrespectively of local relief. This is an important corollary of Model One, a northern movement of the monsoon.

MODEL TWO relates to the strength of the zonal circulation of the upper atmosphere. It has been argued (cf. Lamb 1977, 1979), that the vigour of the Earth's circulation is correlated with the existence of marked contrasts between low latitude heat surplus and high latitude heat deficit (hence the concentration of atmospheric disturbances due to mixing of cold and warm air, in middle latitudes). The efficient running of this heat engine is therefore at its maximum when both equatorial insolation and polar ice development are well balanced. During the climax of glacial eras and the maximum warming of interglacials, it is argued that one or the other tendency would gain the upper hand, tending to produce a marked decline in circulation vigour.[2] Under ideal conditions (e.g. the early decades of this century rather than in the present climatically abnormal period), there is an apparent tendency for the strong equator-polar heat contrast to create a vigorous flow of airmasses between them, that is converted by effects such as the Earth's rotation into a broadly latitudinal or 'zonal' flow. A decline in this heat exchange vigour would weaken the zonal flow (west to east in the Northern hemisphere, hence the 'upper westerlies'), and encourage a strong development of meridional flow, that is north-south airmass exchanges. This disruption of the smooth passage round the hemispheres of important zonal features such as the rain-bearing westerly winds, would be a greatly-accentuated version of lesser interruptions and deviations that are always found in these windstreams. At all times the upper westerly flow is disturbed by recurrent or semi-permanent wave-like meanders. These arise as a consequence of the relative disposition of land and ocean masses, variations in physical relief, a 'balancing' of wave disturbances in different segments of each hemisphere, and the relative distribution of regions of intense warmth and cold (e.g., ice-sheets). Under 'ideal' conditions, a powerful zonal flow is interrupted by 3-4 low amplitude waves per hemisphere, but under conditions of sluggish flow these can increase to 5-6 high amplitude waves. The meanders themselves represent diversions of airflow around relatively static pressure systems such as expanded belts of warm high pressure, or polar cold pressure (which can be the direct cause of the sluggish flow in the first place), or physical barriers as noted above. The larger the diversions, the greater the scope for meridional exchanges in the place of westerly flow. This results in the areas concerned being subject either to the relatively static extreme climates or to mobile airmasses from unaccustomed directions and with a tendency to notable divergence from previous zonal flow character (warmer from the south, colder from the north, in the case of the Northern hemisphere). These situations of highly disturbed flow are termed 'blocked', and it is an important feature of such patterns that major shifts can occur on a season-by-season, or longer term basis, in the location of the blocking warm, subtropical or cold, polar anticyclones and hence the areas where the disturbed flow is concentrated. Severe drought may be followed by remarkable flooding in the same region, under such a regime, on a short term basis. But if there exists a long term tendency for the circulation anomaly to increase or decrease, one may predict whether a given region will tend to return to a more zonal flow of weather conditions or will come into the more permanent sphere of static pressure systems:

> "regional climatic histories.. seem generally understandable in terms of latitudinal shifts of the main features of the global wind circulation .. Some differences in the course and timing of the climatic changes in different longitudes are, however, known to have affected middle and higher latitudes. These presumably mark differences in the placing and amplitude of the waves in the upper westerlies" (Lamb 1977, 400). "The colder Arctic in the last 15 years or so has been accompanied by an intensified thermal contrast around the perimeter of the region of cooling. This may be the reason for anomalies in the distribution of prevailing atmospheric pressure and winds, which up to mid- 1974 produced an anomalous frequency of anticyclones in the zone between 40^oN and 70^o N — so-called blocking anticyclones, which greatly reduced the frequency of the prevailing westerly winds in the middle latitudes and accounted for prolonged spells of drought, and of wetness and flooding, in middle latitudes in different sectors at different times, particularly since 1968.. This regime.. was accompanied by climatic stress of a severe kind also in low latitudes, while middle latitudes of the southern hemisphere have experienced alternating spells of drought and wetness, warmth and cold much like corresponding parts of the northern hemisphere" (Lamb 1975a, 138).[7]

Overall, the extent of global ice seems to have increased by around 12% from 1967-1972, and this is closely associated with a predictable shift of the equatorial rainbelt towards the equator. But as Lamb's precipitation maps show (Lamb 1977, Figs. 18.34 and 18.35), the middle latitudes have been subjected to all the variability of a blocking system, with strong contrasts from the 60's to the 70's in the regions of drought and floods, warmth and cold anomalies within the Mediterranean latitude.

The implications of this for Mediterranean latitude climates during periods of known expansion of subtropical or polar anticyclones are clear, and will be pursued in application later in this paper. But it will be obvious that a particular complication arises in the correct identification of the ultimate cause of surface effects indicating a 'blocked' circulation. They may originate from an unusual increase in equatorial warming or cooling, i.e. can be indicative of either mini-glacial or climax warming phases.

MODEL THREE (and note that all of these models may be applicable at the same point in time) considers the possible effects of an out-of-phase relationship between the north and south hemisphere circulation. Some palaeoclimatologists have even argued that it has been the norm, within the Holocene and the late Pleistocene, for warming and cooling tendencies to have been out-of-phase in the short term (i.e. one to several centuries) on either side of the equator, but in-phase on longer time-scales (such as the one to several thousand year cycles of climatic phases defined by the classic pollen zonation of Northwest Europe). A notable exception to this rule existed with the universal Little Ice Age.[3]

A commonly-accepted practical effect of this imbalance might be a shift in the average position of the meteorological equator, i.e. the dividing line between the broadly zonal circulation systems extending in a mirror-fashion polewards from the equator, the ITCZ or Intertropical Convergence Zone. Such an effect might either reinforce or tend to negate the general climatic tendency for each hemisphere in its effect on low latitudes, (and here the Sahara region is frequently cited, cf. Rognon and Williams 1977), but could extend into lower-middle latitudes such as the Mediterranean and Middle East region in more extreme cases. Thus in a cold period in the northern hemisphere, the climatic belts might broadly move south, with a tendency for the arid Sahara to migrate south into the savannah zone; but if the southern hemisphere ice cap was far more extended than the Arctic, the pressure for displacement from the south to the equator would outweigh these effects by shifting the ITCZ northwards, allowing equatorial rains to persist in the south Sahara fringes and creating a compressed Sahara desert zone.

One further specialised effect, MODEL FOUR, can be proposed, especially when considering situations such as Model Three, where unusual proximity of the normally remote westerly and equatorial rain systems is created, or with Model Two, where meridional flow might likewise bring into proximity these two rainfall sources. On the analogy with present day processes, though feeble in magnitude and significance now, it has been suggested that interactions might take place between these two systems, especially at changeover seasons such as spring and autumn, such as to bring rainfall to intermediate regions such as the Central Sahara, normally deprived by their distance from either source from major precipitation (cf. Sudan-Sahal depressions, and the suggestions of Flohn and Nicholson 1979, and Rognon and Williams 1977).

In the remainder of this paper, I shall discuss the broad lines of the environmental, archaeological and historical evidence relating to major climatic fluctuations in the E. Mediterranean region, from a mature phase of the last Ice Age up to the last few centuries of relative warming. This long period is treated in terms of the major subdivisions widely recognised as reflecting significant secular climatic changes.

MIDDLE TO LATE WÜRM, UNTIL c. 20,000 b.p.

In very general terms, the period from early Würm to about 40/30,000 b.p. provides evidence for a climate cooler and moister than now in the E. Mediterranean, from palynology, pedology, geomorphology and archaeology. Between then and the climax of the glacial not long after 20,000 b.c., there is similar source material for a cold and dry climate over much of the region (Farrand 1979).

Our most detailed data stems from the Levant, especially the southern Levant. The distribution of Mousterian sites, palynology, the accumulation of travertines and gravels, the formation of 'hamra' soils, and extensive areas of marshes and lakes in present-day arid depressions, have argued strongly for the early to mid Würm cool, moist climate (Price-Williams 1973; Bar-Yosef 1974; Marks 1975; Horowitz 1975; Huckriede 1968; Brunnacker 1977, 1978; Copeland 1980). But with the sparser finds of Upper Palaeolithic culture, its site distribution, palynology, geomorphology (e.g. the deposition of loess), and the decline in the extent of moist depressions, suggest a clear reduction in precipitation (Price-Williams 1973; Marks 1975; Ronen 1975; Garrard 1977; Henry 1976). On the other hand, palynology in northern Israel has seemed to argue for continuously moist conditions throughout this period (Horowitz 1971). A further anomaly exists in the fluctuating levels of the Dead Sea in its giant late Pleistocene form of Lake Lisan. Peak high levels around 70-60,000 and 18-15,000 b.p. are highpoints within a generally high lake between 70 and 15,000 b.p. (Bull 1979).

However, in the last few years, detail and greater complexity has been added to this general scheme. Goldberg (1977, 1980) argues that the moist phase is associated with an early Mousterian in the Levant, c. 70-60,000 b.p.; a dry phase then ensues till c. 45,000 b.p., covering late Mousterian times; from 45-25/20,000 b.p. a further moist phase is associated with transitional Mousterian/Upper Palaeolithic and early Upper Palaeolithic culture; dryness then follows. The data stems from geomorphology, palynology, isotope studies and archaeological fieldwork (cf. also Hietala 1980; Marks 1980a, b; Gilead 1980; Bar-Yosef 1980; Lamb 1977, p. 352). The 'loess' is now seen as deposited in the long late Mousterian arid phase, to be redeposited by alluvial/colluvial activity in the succeeding moist phase. But it is still clear that the climate was drier in Upper compared to Middle Palaeolithic times, though not as arid as today, and there is still visible a strong trend to greater aridity through the period 30-20,000 b.p. In northern Israel, a similar variability has been detected (Farrand 1978; Jelinek 1980), but it seems likely that relief and other microenvironmental factors, together with undetermined advantages in terms of access to rainfall (cf. Farrand 1979), allowed a less arid environment to prevail throughout this period than to the south (cf. Gilead 1980). A recent restudy of the N. Israel pollen evidence does moreover demonstrate that here, too, there is a notable drying tendency through the period 30-20,000 b.p. (Van Zeist and Bottema 1980).

Data from Syria and Lebanon also indicate a peak of moist conditions (and cold) in early to mid Würm, above Holocene values, followed by fluctuations of drier/somewhat moist climate. But here the drier tendency seems to begin from around 30,000 b.p. and continue till near the end of the glacial era, if moderated locally by altitude in comparison to the low-lying regions of the south Levant (Leroi-Gourhan 1973 a, b; van Zeist and Niklewski 1970).

For Turkey we have little data until the latter part of this period, when palynology presents a picture of moist/dry but generally cool climate (Van Zeist and Bottema 1977) in the inland uplands, comparable to Syria,and also to Greece. For Greece, lengthy periods of woodlands, formerly interpreted as interglacial, now interstadial spectra, fit into similar prolonged phases of cool, moist climate within the early to mid glacial elsewhere in the E. Mediterranean, preceded by evidence for a more arid and cold early Würm, and also followed after c. 30,000 b.p. by evidence of cold and dry conditions. However, as with the north Levant, the high relief favoured tree refuges even into the most arid late glacial era (Bottema 1974; Van Zeist and Bottema 1977). But it may be noted that the climax glacial woodlands of south Europe were notably lower in density than their interglacial equivalents, in contrast to the reverse situation for the Levant, and testifying to the greater contrast brought to the more southerly region by glacial cooling.

Iran offers a unique picture of pronounced dryness, already present in the Zagros Mountains by mid Würm, a feature that becomes even more extreme by the period 30-20,000 b.p. (Van Zeist and Bottema 1977).

Numerous so-called 'pluvial' lakes can be dated with varying degrees of certainty to the last glacial throughout the E. Mediterranean region, but where precision is available their main development seems to occur at the end of the 30-20,000 b.p. period and the first half of the next 10,000 years, and will be discussed below. The south Levant lakes are exceptional, especially Lake Lisan (high throughout Würm, though it also has its maximum in the next phase to be dealt with), and this may relate to the more extreme climatic shifts this region seems to have undergone. A similarly widespread phenomenon are massive colluvial formations found in all the countries of the E. Mediterranean, and designated the 'Older Fill' by Vita-Finzi (1969a, 1976). His numerous studies of this formation provide dates clustering between c. 40,000 and 10,000 b.p., broadly correlating with the later cold, dry rather than early - mid cool, moist divisions of the last glacial. For this reason he argues for massive frost shattering and brief but intense precipitation as responsible (cf. Butzer 1978).

In the Arabian peninsula there is clear evidence for much greater precipitation than at present in the latter part of the last glacial. The chief evidence stems from fossil lakes, dated between 36-17,000 b.p., but with a maximum development 30-20,000 b.p. (McClure 1976); there are also sinter formations and palaeosols, and some archaeological evidence (Al-Sayari 1978).

Possible Interpretation

The orthodox view is well-expressed by Lamb:

> "Probably the early stages of each glacial period brought a general increase in rainfall in the lower middle latitudes (e.g. the Mediterranean), while the seas were still warm but cyclonic activity was increasing in those latitudes.. In the later stages of each ice age much less water vapour could be taken up into the atmosphere from the

> colder seas, and in most latitudes the amount precipitated must have decreased.. Lakes in Africa and elsewhere could nevertheless be maintained at much higher levels than now because of reduced evaporation.. in the cooler air and under cloudy skies. The same factors no doubt helped maintain the greatly expanded Caspian Sea and the deep ice age lakes (Lake Bonneville and Lahonton and others) in the now arid regions in the western United States" (Lamb 1977, 329).

This is therefore a straightforward application of Model One. An even more specific application is neatly illustrated in diagram form by Bottema (1974, 168), who makes the important point that the upland regions will show more a change of species rather than woodland cover in the early moist phase in comparison to Mediterranean lowlands, which will experience dramatically more precipitation than present-day. In the late dry phase the abnormally well vegetated lowlands will degenerate to a cool, dry open environment while in the uplands there will be at least some woodland refuges due to the moisture attraction of the relief.

It seems very reasonable to see the flourishing of the south Levant deserts as a direct response to the displacement of the upper westerly storm-tracks to a more southerly position, combined with notably lower evaporation from insolation decline in that latitude; the same would hold for the flourishing woodland and lakes of the north Levant countries. The general trend to late glacial aridity is also very marked except for the Arabian peninsula, and Lake Lisan. The latter example does however fit into a broad group of climax glacial 'pluvial' lakes throughout the E. Mediterranean, ranging from Ioannina and Copais in Greece (Ioannina: Vita-Finzi 1978, Higgs 1978, but see Bottema 1974; Copais: Schmid 1965), through Turkey (Eisma 1978; Farrand 1979) to Iran (Farrand 1979; Krinsley 1970). The coincidence of their rise with palynological indications for pronounced cold and aridity, most notably at Zeribar in the Zagros, has prompted the view that minimal evaporation in extreme glacial cold was responsible, without elaborating on the nature of the necessary precipitation required to then remain unevaporated in these depressions (cf. Butzer 1978). Farrand, however, questions the sufficiency of such a model, and raises the concept of precipitation increase (1979). This expedient does create difficulties with the palynological evidence for extreme dryness. A possible further clue seems to be available in the widespread 'Older Fill' of Vita-Finzi, for it does seem to have been laid down throughout the latter part of the last glaciation, and is well evidenced (and dated) in many regions of Iran (Vita-Finzi 1969b, 1975; Brookes 1977). The truly massive proportions of this formation throughout the Mediterranean demand powerful erosive forces at work, well beyond frost and gravity, and there seems little doubt that considerable precipitation was involved. Vita-Finzi's suggestion that the rainfall regime responsible would have been exceptionally concentrated, would perhaps explain the presence of the 'pluvial' lakes, whilst yet inhibiting woodland development. That such an explanation is a plausible one is supported by the fact that Older Fill seems to have been deposited well into Boreal times in Iran, where woodland recovery seems also to have been equally long delayed (Van Zeist and Bottema 1977; such a regime is proposed tentatively for the early Holocene in Iran by Van Zeist, 1969).

Useful comparisons may be made with known developments in North Africa. At least from middle Würm times to c. 30,000 b.p., Africa north of the Sahara shows unmistakeable evidence from geomorphology and palynology for increased rainfall and evaporation decrease compared to today. This is generally ascribed to the increased displacement of cyclonic tracks into the region, and indeed isotope studies point convincingly to such a source for the moisture surpluses involved (Rognon and Williams 1977; Rognon 1979), as do careful geomorphological studies in Egypt (Butzer 1978; cf. Haynes 1977). The Central Sahara is at this stage still relatively unaffected, whilst the south edge of the Sahara runs contrary to expectation of Model One, in presenting no retreat of the equatorial/monsoon rains towards the equator, but increased humidity, with notably high lake levels. Rognon and Williams postulate a Model Three situation till 30,000 b.p., arguing that the Antarctic ice advance was more pronounced than that of the Arctic (cf. Hecht 1979), thus pushing the ITCZ to the north of its present range, maintaining the previous south Saharan rainfall in position and enhancing its effect with a lower evaporation due to lower insolation. The argument is of importance to the identification of the rainfall source for the Arabian lakes of this phase. One might have expected them to reflect the general southward shift of the westerly stormtracks, although at this stage the other indicators for the main flow are somewhat to the north. A displacement of the ITCZ and pronounced decline in evaporation now offers an alternative explanation.

From c. 30,000-20,000 b.c. a distinct change in climatic indicators is traced for North Africa. In Egypt local rainfall all but disappears, but high Nile Floods argue for high precipitation upstream throughout the late glacial climax (Butzer 1978). Rognon and Williams (1977) record a partial desiccation north-east of the Sahara, and to its south, but a distinct moist phase in the central and north-west Sahara, at a time of a pronounced push of 'Arctic' ice sheets across north Europe, and hence a return of the ITCZ more to its recent position of latitude. This leads them to set up a model of blocked circulation (of Model Two type), which rests on the well-attested fact that in climax Würm a major temperature anomaly lay in the north-east Atlantic, a zone of static cold, dry air lying above an extremely cold area of ocean (and/or ice, cf. Lamb 1977). This feature would tend to block the weak westerly flow now displaced to lower middle latitudes, forcing it south round the obstacle, from whence it would be steered north-eastwards along a powerful pressure gradient on the lee side of the obstacle. The resultant flow would create cold and dry conditions in the north-west Mediterranean and north-east Africa, a moist central Sahara and north-west Sahara; then the stormtracks depart to the north-east, attracting after them the other features of the once zonal circulation—the subtropical arid, high pressure zone, which would now occupy north-east Africa (e.g. Egypt), and the zone of equatorial/monsoon rains, which would continue to be abnormally expanded into Arabia. The continuance of the very moist indicators in Arabia might thereby be explained, as would the creation of high Nile floods.

That cyclonic precipitation did in fact press deep into the central Saharan latitude can also be seen from studies of offshore sediments in the Atlantic Sahara region (Diester-Haass 1977), whilst the concept of a dichotomy between the cold, dry, north-west Mediterranean and a cool, moist zone to the east receives some support from the recent work on palaeotemperatures along the Mediterranean axis from ocean cores (Rognon 1979), which show much warmer ocean temperatures for the eastern Mediterranean compared to the west.

Of major interest in the data summarised for the period, above, is the growing evidence of more than one phase of moist, cool followed by cold, dry conditions. This is most clearly seen in the south Levant, but also occurs with the Greek pollen data, with fluctuations too in North Africa. The initial phase in earliest Würm might simply be explained as a shift of stormtracks southwards, with plentiful moisture from the still mild ocean temperatures. Then from early to mid Würm, the seas cool and precipitation is reduced. But did the cyclones shift further south at this stage? As yet there is no indication that they did, although data for this period is rarely well-preserved and very difficult to date with precision. The return of cool, moist conditions in mid Würm has been described as an Interstadial, covering the late Mousterian transition to upper Palaeolithic and the early part of the latter period. Certainly in north-west Europe this is a clear amelioration of conditions (the Upton Warren Interstadial Complex, cf. Lamb, 1977). But in the Mediterranean an Interstadial cannot mean a significant tendency towards Interglacial climate of semi-arid 'Mediterranean' type, rather it is to be seen as a transposition of north European temperate climate into the Mediterranean area.

Finally we have then a return of very severe dryness and ocean cooling at the end of this period, this time with a clear push further south of the cyclonic stormtracks into the central Saharan latitude.

It still seems likely that the ice sheets were little affected by the mid-Würm amelioration, although landsurfaces beyond them were greatly warmed by the increased insolation. This combination of observations explains the situation of the continuing confinement of the stormtracks to lower-middle latitudes, although the rainfall content was improved due to the warmer oceans. A further problem concerns the subtropical belt of high pressure, that normally separates the equatorial rainbelt and that affected by the upper westerly stormtracks. In the period till 30,000 b.p., this seems to be compressed, in place. along the axis of the central Sahara, and presumably somewhere in north Arabia. But from then to 20.000 b.c., Rognon and Williams (1977) would have the stormtracks sweeping into the north Levant, and the subtropical arid, high pressure belt taking over the south Levant. Although less moist than early Mousterian times, the south Levant data still suggest a climate moister than now, however, which would seem to rule out this suggestion. Where now, is the arid zone, if in Arabia the monsoon extension is still creating lakes and other similar features? Again somewhere compressed between these two rainfall systems? Certainly in the Sahara, Rognon and Williams are suggesting a minimal belt of high pressure between the central Saharan cyclonic and the south Saharan monsoon system. Is there a conceivable weather pattern that accounts for south Saharan moistness as equatorial rain, but with the westerly stormtracks running across the central Sahara on into the Nile headwaters and then into Arabia, and yet somehow creating notable rainfall in north-west Africa and the Levant? Certainly such an extreme range of cyclonic rainfall cover is suggested by the transitional glacial/Holocene period evidence later, when rainfall expands again throughout the Mediterranean and yet still seems to be active in the central Sahara and the south Levant. Given the slow recovery of the monsoon rains in the late glacial period (see below), despite proven rapid global warming preceding actual ice-sheet withdrawal, it is curious that they survived into this near glacial climax period, a circumstance that would favour the cyclonic hypothesis.

Lastly, in Iran, despite considerable altitudinal variation, we seem to see cyclonic rainfall drastically cut off from access except perhaps as extreme confined seasonal downpours. Van Zeist and Bottema have raised the possibility of a shift in the direction of cyclonic tracks in the E. Mediterranean (1977) so as to reduce the access to Iran yet maintain flow to the Levant, and one might also propose some possible factor involving changes in the wavelength of meanders in the upper westerlies to achieve this flow pattern (Model Two). Modern analogues might be highly illuminating for this interesting situation.

20,000 - 10,000 b.p.

From the end of the previous ten thousand years (from around 23,000 b.p.), till around 16,000 b.p., the overall indications from the E. Mediterranean are of the most extreme dryness and cold, a situation paralleled both to the north into continental Eurasia, and to the south in terms of Intertropical aridity . From c. 15-10,000 b.p. there are fluctuations, with phases of improvements in warmth and moisture in the E. Mediterranean, but although the dates for these fluctuations often coincide from region to region, few of them are universally effective over the entire zone.

Once again, the fullest information stems from the Levant (in the form of palynology, sedimentology, archaeology, and the study of snail and rodent fauna). The greater detail here reveals perhaps predictable local variability for climatic manifestations. Till very recently, site surveys had suggested that the end-glacial witnessed first the Kebaran culture, with its Geometric Kebaran successor, confined to spring source locations and associated with very arid conditions, followed by the vigorous and expansive Natufian culture associated with much more humid conditions (Henry 1976). Previous to the Kebaran a further dry interval had followed the early Upper Palaeolithic (Goldberg 1977). Rather contradictory evidence came from the continuing moist indicators of pollen from north Israel (Horowitz 1971). Likewise, the great Lake Lisan brought its high levels of Würm to a peak around 16-13,000 b.c. (Bull 1979)—although a wide range of alternative earlier or later dates than this have been published—then sank dramatically.

The most recent data present an overall impression of moister intervals from Kebaran though to Natufian, but visible effects are discontinuous over the landscape. There are alluvial deposits, with indications from associated pollen of greater woodland than now, indicating rainfall rise from 17-10,000 b.c. around the Dead Sea (Bar-Yosef 1974; Schuldenrein 1980). However these authors consider the Lisan Lake to have shrunk before this phase, preferring an older date for its demise than offered above, and indeed Bar-Yosef has suggested that aridity and tectonic activity dried up the lake, then, after a further phase of dryness, the wet Kebaran environment came into being in the Lower Jordan Valley (Bar-Yosef 1975). Horowitz has also raised tectonic faulting as a prime cause of the Lake Lisan decline (1975). However, support for a temporal overlap between the high final Lisan sediments and Kebaran alluvia stems from work by Vita-Finzi (Vita-Finzi and Copeland 1978) who pointedly underlines this coincidence. It is certainly anomalous that the Kebaran finds are closely associted with the high level (-180 m) of Lisan, before its fall to much lower levels associated with Natufian occupation (-240 m) (Schuldenrein 1980). In Sinai there is evidence for moister conditions 15-12, 500 b. c. (Goldberg 1980), and the same paper now advocates more widespread indications of precipitation improvement from c. 14, 000 b. c. with Kebaran associations. From north Palestine and the Lebanon-Syria region there are palynological indications of a moist interval 15-14, 000 b. c., and then after dryness returns, a further moist phase 12-11, 000 b. c. (Leroi-Gourhan 1973 a, b, 1978), then dry again, with Kebaran associations (cf. Cauvin M.-C. 1980).

It is clear that a major reason why dispute has arisen over the link between rainfall rise in the end-glacial and the height of Lake Lisan, is the range of dates available for the demise of the lake, running between 18 and 11 000 b. c. (Vita-Finzi and Copeland 1978; Bull 1979). Given the generally high levels throughout Würm, and the proven incidence of phases of higher rainfall after the shrinkage of Lisan, it would seem that the key element may have been minimal evaporation at the Würm climax, together with tectonic instability. With the exception of Arabia the other major 'pluvial' lakes of the E. Mediterranean also associate with the aridity climax.

Despite localised hints of rainfall rise from c. 17, 000 b. c., it still seems a widely supported belief that the real breakthrough in moisture rise is seen with the expansion of Geometric Kebaran sites throughout the Levant c. 12, 500 b. c. to 10, 000 b. c., preparing the way for the even more notable Natufian flourishing (Henry 1980; Aurenche 1980; Bar-Yosef 1980). Evidence of palaeosols seems to support this view (Brunnacker 1977). Furthermore, a restudy of the N. Israel palynology, finds indications of dry steppe from 22-12, 000 b. c. then forest recovery (Van Zeist and Bottema 1980).

These regular fluctuations continue after Geometric Kebaran times. There are indications of an intervening dry phase c. 10, 500-10, 000 b. c. before the moist early Natufian phase of the tenth millennium b. c. (Henry 1980; Leroi-Gourhan 1978; Goldberg 1980), seen most dramatically (though we must allow for the tectonic factors) in the massive incision of Lisan deposits between Kebaran and Natufian occupations of the Dead Sea littoral (Schuldenrein 1980). General agreement is visible on a notably less moist late Natufian from c. 9000 b. c., although many presentday arid habitats are settled now for the first time (Leroi-Gourhan 1978; Moore 1978) and the evidence immediately around the Dead Sea suggests no significant moist phase between Kebaran and Pre-Pottery Neolithic (Schuldenrein 1980; Vita-Finzi and Copeland 1978). Particularly in the south Levant, the indications for these moist interludes argue for greater humidity than at the present time (Tchernov 1980; Henry 1980; Leroi-Gourhan 1978).

Given this large body of evidence, it is remarkable that papers can still be written about Natufian and Pre-Pottery Neolithic times in the Levant, that make no allowance for climatic change, although even minor changes in precipitation and evaporation must have been crucial to many of the settlements concerned (Miller 1980). Indeed, it is this very body of evidence providing undeniable proof for considerable variability in rainfall and evaporation in the Near East, which has reopened controversy over the role of end-glacial climatic change as a forcing factor in the origins of agriculture. Gordon Childe's 'oasis theory', of a pluvial Near East reduced to presentday levels of aridity by the arrival of Holocene climate, creating a concentration of human subsistence effort on the now confined stands of wild plants and leading to their artificial encouragement i. e. domestication, has generally been and still is being, written off as a viable explanation for this crucial stage in human development (cf. Butzer 1975, 1978). But there is growing evidence that the widespread Natufian culture was associated with wild cereals, both reacting to the changing distribution of the steppe habitat. It has recently been suggested that the shift to a much drier environment in late Natufian times created problems for human groups with a now restricted subsistence habitat, encouraging them to manipulate these wild plants they had come to derive important dietary supplies from—hence the commencement of intensive interference leading to actual removal of wild cereals from their habitat (Henry 1976, 1980; Aurenche 1980). However, Moore prefers to see the expansion of the steppe habitat at the end-glacial with wild cereals associated, as spur enough for both the connected Natufian expansion and the desire to experiment with crop control on the highly nutritious grasses (Moore 1978, 1979).

There would seem to be good reason to link the flourising of Natufian and related cultures, with evidence for much larger settlements than previously, more permanent home bases, perhaps greater social complexity, with the creation of an unusually favourable environment in the Levant, including a wider distribution than previously or afterwards of wild cereals and a varied steppe flora and fauna. The late Natufian deterioration of this habitat cannot have been without major significance in food procurement strategies, and it seems most likely that this was linked to greater control over key resources at risk such as the cereals. But we are left with the question as to why such a sequence had not occurred before in the natural habitat of the cereals, under the recurrent climatic stresses that the semi-arid regions have been exposed to in both glacial and interglacial eras. The equation seems unfinished, even if some elements are securely in place. Nor is it clear how the now-acknowledged preceding settlement expansion and climatic amelioration of Geometric Kebaran times relates to the rise of the Natufian phenomenon and its significant advances.

We have already noted that there are significant parallels between the south Levant and the Syria-Lebanon evidence for this overall period and its recurrent fluctuations. Perhaps importantly, the pollen evidence suggests that the major time of climatic amelioration was 10-9, 000 b. c. contemporary to Natufian flourishing (Van Zeist and Bottema 1980).

But further north we seem to enter a very different climatic sphere at this time (Bottema 1978; Van Zeist and Bottema 1977). After the five millennia or so of notable cold and arid conditions which it shares with the regions to the south (on palynology), there are fluctuations in the pollen spectra which are indeed of comparable magnitude and timing to those noted already from the Levant. But they reflect fluctuations in warmth rather than precipitation. Rainfall does not recover sufficiently throughout lowland south Europe and Turkey until Holocene times proper, i. e. from the Preboreal period, often later. Bottema has shown how this backwardness is distinct not only from the humid fluctuations of the Levant, but also from the south European mountains, which follow changes in north-west Europe — with open woodland recovery during the milder ameliorations of the period 15-10, 000 b. c. The earlier part of this period, the climax glacial, witnesses high 'pluvial'lakes in Turkey and Greece, as also in Iran and the Levant (Vita-Finzi 1978; Schmid 1965; Farrand 1979; Krinsley 1970). The most recent confirmation of this pattern comes from pluvial lake Konya, dated c. 21,-15, 000 b. c. (Roberts et al. 1979). The range of time for these lakes does seem to correspond most reasonably, as indicated earlier, with minimum evaporation, whilst at the same time offering evidence for continuing precipitation, probably in a very concentrated form. The suggested continuing deposition of Vita-Finzi's Older Fill through this period provides further support for brief but powerful precipitation in the northern lands of the E. Mediterranean. The prolonged life of 'pluvial' lake Zeribar (c. 20-12, 000 b. c.) seems to fit the remarkably delayed recovery of woodland in Iran, and the abnormally lengthened time span of the Older Fill there (see above).

In Arabia, the 'pluvial' lakes are in decline after c. 18, 000 b. c. and gone by 15, 000 b. c. (McClure 1976). The evidence for climatic change in isotopic studies from Red Sea and Aden cores is difficult to interpret, given the poor resolution of the dates available, and the unclear source of the precipitation involved. However, it is possible to suggest that they register a moist then drier climate broadly in parallel to the same sequence on the adjacent Arabian peninsula (Deuser 1976; Schoeli 1978).

Possible Interpretation: It may be appropriate to introduce the climatic data available for North Africa over this period. The regime observed for the previous period continues till around 16, 000 b. c., with humid indicators present in the central and north Sahara and the southeast of the region (Nile headwaters). The Nile is high from 22-16, 000 b. c. (Butzer 1975), but local cyclonic rainfall is at a minimum in Egypt over the same period. After 15, 000 b. c. the climate changes and the Nile floods decrease at the same time as local rainfall in Egypt recovers; the latter will continue to be well-evidenced until c. 6500 b. c. with a dry interlude c. 9500 b. c. The central Sahara and the area of North Africa north of the Sahara exhibits general evidence for moister climate, and warmth too, from this turning point until the Preboreal period c. 8000 b. c., but the data from north of the Sahara in detail seem to show both localised increased rainfall compared to now and also more widespread signs of aridity compared to the presentday (Rognon and Williams 1977; Jäkel 1977; Rognon 1979). Rognon and Williams suggest that the cyclonic depressions now have a very wide range and less effective cover over the area and deep into the central Sahara.

In interpreting the first half of this time interval, we may repeat our suggestions for the latter part of the previous period; with climax cold in both hemispheres, rainfall was everywhere at a minimum. Cyclonic depressions seem to have survived along the central Saharan axis and either across into the Nile headwaters and Arabia (to create the 'pluvial' features of the latter and high Nile floods), or veered northeast into the Levant. Their presence in the Levant is not well attested and there are difficulties in accounting for the Nile and Arabian phenomena in terms of a monsoon survival (given the otherwise Intertropical aridity). The generally low state of archaeological evidence suits the severe habitat conditions implied. With the changes noticeable everywhere after c. 15,000 b.c. human cultures seem revitalised, and vegetation, game and fluvial activity reflect the revival of rainfall throughout the region from the central Sahara up into the north Levant. Beyond here, however, the phases of greater warmth are more evident that any major increase in rainfall. In Arabia and the Nile headwaters, precipitation decreases and undoubtedly evaporation increases, as also in the adjacent oceans.

The period from 15-10,000 b.c. is well-known from northwest European studies as a period of striking changes of climate, with a sequence of warming phases interrupted by glacier advances. The most notable warming interludes are those of the Bolling (c. 11,000 b.c.) and Allerod (c. 10,000 b.c.). It seems that although temperatures could be as high or higher than present, the ice sheets remained extended until major wasting occurred from the Preboreal period, and the main axis of pressure contrasts will have remained also in lower middle latitudes. Advances of woodland from mountain refuges in Europe north of the Alps, and in mountainous southern Europe, were then primarily due to greater warmth and a slight moisture increase rather than a return to temperate latitudes of the main flow of the upper westerlies. This conclusion is borne out by Bottema's (1978) and Farrand's (1979) distinction between the northern and southern portions of the E. Mediterranean region at this time, with the implication that the now reviving stormtracks were still broadly confined to lower middle latitudes. Certainly the rainfall into the central Sahara is still of cyclonic origin (Rognon and Williams 1977). But the Levant evidence does indicate a significant increase in the strength of the depression tracks in that latitude. The slow decline of the North Atlantic sea ice,and the fact that even when retreating the melting ice would continue to refrigerate the north-east Atlantic throughout this period, must have slowed down the disappearance of the strong pressure anomaly over the ocean border to the Atlantic coast of South Europe and North Africa. Combined with increasing insolation over the equator from the warming globe, the pressure gradient at the Mediterranean latitude must have increased still further, producing the Levant humid phases.

But to improve conditions so radically in the south Levant deserts, and to desiccate Arabia and the Nile headwaters, we could be dealing with a cyclonic flow distorted to the north-east, but not running at the central Saharan latitude into Arabia (our alternative models for the earlier half of this period). The evidence seems to suggest a flow of increased rainfall often running through the region of the central/north Sahara, Egypt and on into the Levant, with regions to north and south being warmer than before but not significantly more humid. One additional element needs to be allowed for, the precocious warming of the Antarctic ice sheets (Rognon and Williams 1977); on Model Three we might expect a 'pull' of climatic zones southwards, which might perhaps relate to the possible retraction of monsoonal rainfall from Arabia and the Nile headwaters, and the flow of cyclonic rainfall through the south Levant deserts. The subtropical, arid high pressure zone would now occupy the south Sahara and Arabia. The more 'zonal' cyclonic flow in the Mediterranean may be related in some way to the decline of the north-east Atlantic temperature minimum as the Atlantic warmed up over this period and hence less distorted steering of rainfall took place in a north-easterly direction. Whatever course the cyclones took, Iran continued to be remote from all but the briefest and most violent rainfall, as has been seen from geomorphology and palynology. A recent analogue for its particular late glacial climate may be worth seeking for. Rognon (1979) feels that the stormtracks are beginning to shift away from Africa north of the Sahara, but at present there does not seem to be evidence for them advancing into Provence and the rest of the north Mediterranean. But clearly the rainfall is weaker in the north 'temperate' part of Africa, and yet still effective deep into the central Sahara. Some climatic model accounting for such a distribution, and for the concentration visible of greater precipitation in the south Levant and Egypt, is called for at a more elaborate level than that I have so far proposed.

THE EARLY HOLOCENE: PREBOREAL AND BOREAL c. 8300-5500 b.c.

Once again, perhaps our most detailed information stems from the Levant. After the drier conditions indicated for late Natufian times, c. 9000 to 8000 b.c., a revival of moist environmental and settlement indicators is associated with the PPNA culture and related groups, during the 8th millennium b.c., on pollen, geomorphic activity and archaeological traces in presentday arid areas. But the distribution of PPNA sites is far more confined than Natufian, especially in the southern deserts (Harifian facies). Nonetheless it is still considered that PPNA climate in the Levant was moister than at present. (Bar-Yosef 1975, 1980; Goldberg 1980; Tchernov 1980; Aurenche 1980).

In some localities the PPNA is the first since the Kebaran to produce major fluvial activity, e.g. parts of the lower Jordan valley (Schuldenrein 1980; Vita-Finzi and Copeland 1978). The 7th millennium b.c. period of the PPNB culture is widely evidenced as a period of increasing desiccation, leading into an apparent climax of arid severity in the 6th millennium b.c., when the poverty of human occupation throughout the Levant has earned it the title of 'Hiatus palestinienne' (Aurenche 1980). However, it is still true that PPNB period sites are significant in the southern deserts, and hence their frequency in the Syrian desert (Cauvin, J. 1980) cannot be used without environmental support to argue a local moist period. What of the latter is available seems to indicate that PPNB southern deserts were approaching modern levels of aridity (Tchernov 1980).

To the north, in Syria and Lebanon, similar fluctuations are recorded in palynology and settlement studies (Leroi-Gourhan 1978). But if we take more continuous palynological evidence, a wider overall underlying trend seems detectable. The recent restudy of Lake Huleh in northern Israel shows a very interesting early recovery of woodland, contemporary to the Geometric

Kebaran expansion and moist phase, and a maintenance of this high humidity from c. 12-8000 b.c. ; there then ensues increasing aridity, a decline from 70% arboreal pollen to 40% and a shift to vegetation more suited to a warm climate, as today's (Van Zeist and Bottema 1980). Further north in Syria the major recovery of humid woodland in later, 9-8000 b.c., changing by 6000 b.c. to modern aridity levels (Van Zeist and Bottema 1980). Individual site pollen studies confirm this pronounced northern moist phase, with sites associated with moist depressions, and conditions gradually declining throughout the 7th millennium b.c. (Leroi-Gourhan 1978; Van Zeist 1977; De Contenson 1980). But a more significant and less interrupted moist phase than in the south Levant could be postulated (cf. for the geomorphology, Besancon 1980).

The evidence as it stands at present, seems to suggest a gradual shift of higher than present rainfall, from the south to the north Levant from 12,000 to 6500 b.c., then its departure for higher latitudes.

Considerable interest has always been attached, since their initial discovery, to the larger settled communities of this period, which lie in present-day environments too dry to support the populations inferred, using a farming economy. The most spectacular example is PPNA Jericho, but sites such as Beidha show that such locations could be occupied even in the PPNB period. The phenomenon is most notable on the fringe of the steppe habitat of Mediterranean climate, where it meets the desert climate of Sahara type, with the sites frequently significantly beyond the threshold into the desert zone, i.e. beyond the level of rainfall necessary, consistently, every year, to ensure dry-farmed cereal crops (2-300 mm, cf. Oates and Oates 1976). This desert border series of sites is found around the curve of the Fertile Crescent, from Jordan Jericho through the Syrian desert (Mureybat and Abu Hureyra), to the Mesopotamian Plain, and the sites concerned belong to the period of PPNA and B, and in the case of the Mesopotamian Plain can even run into the 'Hiatus' millennium from 6000 b.c. (Oates and Oates 1976). Various explanations have been put forward to account for these anomalies (cf. Mellaart 1975), often accepting the problem of local agricultural support by postulating regional exchange functions, or a reliance on hunting/herding gazelle and other animals. Oates and Oates (1976) maintain that a slight increase in rainfall would be insufficient to make dry-farming viable for some of these sites, and Miller (1980), while intent on demonstrating the possibilities of irrigation agriculture from available spring sources, effectively demolishes most of the claimed irrigation systems for this period. At sites such as Bouqras, contemporary to PPNB, a compromise is proposed, with limited crop support based on simple irrigation, and a major support from extensive grazing (Akkermans 1980). A rather similar approach may have been adopted at Abu Hureyra (Moore 1979). However the numerous tells of the 6th millennium in the arid Mesopotamian Plain (Oates and Oates 1976) seem to imply a more favourable climate than now, since they cannot all have existed as trading posts or settlements of specialised hunters. On the other hand, except for the excavated site of Umm Dabagiyah, most of these may belong to the latter part of the 6th millennium, when there is reason to suggest an overall moisture improvement in the northern part of the E. Mediterranean (see below). Nonetheless, the presence of quantities of cereals at many of these Near Eastern desert sites is not easily explained by a cereals' trade for communities at this level of complexity. A final proposal might be to take up the suggestion of Van Zeist (1969) that the rainfall was no less in quantity than today, but its seasonal distribution was different, favouring cereal growth but inhibiting woodland and developed fluvial and pedological features on the landscape.

The environmental picture from the northern part of the E. Mediterranean continues to have a slightly separate character from the south, and is relatively uniform. With the beginning of this period, or the Preboreal, woodland begins a notable recovery in Greece and parts of Turkey, but in the more remote inland regions of Turkey and in Iran this recovery is slight. Even the more favoured areas develop open rather than closed woodland, and it is not till the Atlantic period for them, and Subboreal or even Subatlantic for the less favoured areas, that climax woodland is established (Van Zeist and Bottema 1977, 1980; Bottema 1978). Apart from palynology, there is very little complementary evidence from either the other environmental indicators or archaeology, except in Iran. Dates here for the Older Fill (Vita-Finzi 1969b, 1975; Brookes 1977) suggest it was being deposited until the end of this period, which, as noted above, agrees with the pollen evidence for a continuance of extremely concentrated precipitation conditions. The faunal evidence discussed by Bökönyi (1976, 1978), arguing increasing aridity from the 9th to the 4th millennium b. c., is very difficult to relate to the pollen evidence, and it is not clear if the trend away from the 'Older Fill' regime to a more evenly spread rainfall regime is compatible with these faunal inferences.

Additional information comes from cores from the Persian Gulf (Diester-Haass 1973) which record the varying input of terrigenous sediment into the Persian Gulf from the Tigris-Euphrates and other major rivers draining the uplands fringing the Mesopotamian Plain. In theory the overall rise and fall of this 'wet' indicator should correspond to increased precipitation in these highlands, which would probably be from the westerly stormtracks. The cores are not closely dated, but the sequence begins c. 7000 b. c. with 'dry' indications, changing to 'wetter' input. For various reasons the most likely date for the arrival of greater rainfall in the Turkey-Iran uplands would be Atlantic times or later (see below), which would agree with greater or more effective rainfall arrival dates deduced from palynology. A further Iranian study is that by Kirkby (1977) of the Deh Luran Plain. A major alluviation episode from c. 6500 to 1500 b. c. is recorded, which the author interprets as reflecting upland erosion in the increasingly arid postglacial climate. A drier upland environment sees a reduced vegetation mat, greater erosion, river incision and transport of eroded material down into the lowlands, where it accumulates as alluvium. A moister climate after 1500 b. c. would encourage a better scrub cover and cut off the source of sediment.

The total data from Iran is inconsistent, but it might be feasible to attempt a reconciliation of the varying sources of information. Can we see a shift from the Older Fill geomorphic regime, to that of Kirkby's during the Boreal era, coinciding with greater aridity in the lowlands (cf. the settlement discussion above), greater effective precipitation in the highlands of Iran (cf. the palynology, and with a different view of the causes of Kirkby's upland changes in geomorphology)? Is the 6500-1500 b. c. high sediment supply to the Deh Luran Plain comparable to the increased terrigenous supply to the Persian Gulf in Diester-Haass' core data? Is the shift from cool, brief but violent rainfall, climate to one of hot but more extended rainfall reflected in Bökönyi's faunal shifts during the same period?

In Arabia, the younger generation of lakes has been shown by McClure (1976) to occur between 7-4000 b. c., and is associated with a little-known indigenous aceramic culture and a shortlived expansion of Mesopotamian Ubaid culture into the area (Al-Sayari 1978; Oates 1976; Masry 1978).

Possible Interpretation:

The Preboreal has been taken to mark the beginning of the Holocene in north-west Europe, the time when the Scandinavian ice sheets made their first uninterrupted retreat of this interglacial. Concomitant changes would be a shift north of the climatic zones (Model One), bringing the warm, dry subtropical high pressure belts back into the ambit of the Mediterranean latitude, and reconstituting the strongest thermal gradient and hence the belt of most frequent cyclonic depressions in temperate latitudes. One would therefore expect a Mediterranean-latitude climate to gradually shift towards present-day semi-arid conditions, as the stormtracks became increasingly remote (Lamb 1977). In the long-term, such a development may be detected in the south Levant, with its remarkable end-glacial/earliest Holocene moist phases followed by rapidly increasing aridity. The apparent shift of such moistness towards the north Levant in the earliest Holocene, may also agree with this model, but if we move into Greece, Turkey and Iran the model seems far too simple for the complexities of the data. Rather than demonstrate (on the palynology primarily). a rise in moist indicators with the Preboreal, followed by a decline through the warmest eras (Boreal, Atlantic), as the stormtracks passed ever further to the north, these regions seem rather to record a gradual improvement in precipitation from Preboreal right into the Subatlantic (Van Zeist and Bottema 1978, 1980).

The explanation for this phenomenon may be sought in Professor Lamb's researches (1977). It is well-known that the American ice sheets were several millennia behind the European in the timing of the major Holocene retreat (cf. Hecht 1979). It has plausibly been argued that this anomaly highly distorted the flow of the upper westerly winds and their associated cyclonic disturbances round the northern hemisphere. The westerlies were diverted south by the blocking effect of the ice sheets, to veer northeastwards across the Atlantic well north of their present position (Model Two). North-west Europe benefitted from a conpensatory expansion of the Azores subtropical anticyclone, producing notably warm and dry climate. Thus the stormtracks would have switched from a position in the south Levant (end glacial/earliest Holocene), to one well north of their presentday range, without a gradual shift across the intervening latitudes. From the pollen data it seems that the diverted flow was nonetheless a moister environment for the woodland of Greece and the more accessible parts of Turkey than the previous regime, but full development of climax woodland throughout the northern E. Mediterranean, it seems, required a return to an unblocked and more zonal flow, which should have occurred with the waning of the American ice sheets by Atlantic times. Paradoxically then, the supposed warm peak period of the present interglacial, the Atlantic phase, when one might have expected cyclonic rainfall to be concentrated further north than its present distribution, was a more favourable period for penetration of northern rainfall into the Mediterranean than preceding millennia. The gradual shift south of the stormtracks from later Atlantic times, parallels the probable readvance of the ice sheets, and hence the continual improvement of woodlands in the northern zone of our study region.

Equally satisfactory as a model is the simple application of Model One to the younger generation of Arabian lakes, An expansion of monsoonal rainfall into the Arabian peninsula over this period would neatly parallel the suspected retreat of the European ice sheets, and imply a northward push of the subtropical arid zone—hence the problems of the south Levant? Allowing for dating difficulties, moist indicators in cores from the Aden Gulf and the Red Sea could reflect the same monsoon expansion (Olausson 1969; Deuser 1976; Schoeli 1978), and the recovery and expansion of the equatorial/ monsoon rains in the south border of the Sahara has been described by Rognon and Williams (1977).

However, with westerly stormtracks diverted to the far north of Europe, and impinging only marginally into the northern part of the E. Mediterranean, one should not expect any further moist episodes in the southern part of the region except within the possible sphere of monsoonal expansion. Yet for PPNB times in the Levant, and in the Mesopotamian Plain at this time and on into the 6th millennium b. c., (admittedly now a time of apparent settlement hiatus in the Levant), there must have been sufficient rainfall to grow grain and pasture animals in a fashion not much different from the present day. Analogy with the evidence from North Africa may again assist in our interpretation. Here a moist phase c. 9-8000 b. c. is attested on geomorphic and other environmental evidence (Rognon and Williams 1977), and in the central Sahara heightened rainfall continues till 6-7000 b. c. with dry intervals (Jäkel 1977). In the more 'temperate' northern margin to the Sahara, a further moist phase is claimed from c. 6500-5000 b. c. (Rognon and Williams 1977). Associated with the latter humid phase in the far north is the Capsian culture, extremely dense in well-studied districts, and if not associated with an environment far removed from that of today, yet seemingly a moister habitat on geomorphology and palynology (Lubell 1976; Grébénart 1978). In Egypt local winter rains persist until c. 6500 b. c. (Butzer 1975, 1978), and in the Libyan Desert moister conditions are indicated from geomorphology and archaeology, between 6500-4000 b. c. (although eroding aquifers may also be involved) (Haynes 1977).

Lamb has suggested (1977) that in periods with a greatly expanded Azores anticyclone, blocking over western Europe may produce striking meridional flow to the east, creating zones of very variable and strongly contrasted climate in the Mediterranean (cf. for example his reconstructions of stormtrack patterns during the early Medieval Warm Phase). This follows our Model Two. To account for the coexistence during this period of extreme expansion of the subtropical anticyclones in the northern hemisphere, of areas of pronounced aridity and above present day humidity in similar latitude, might we suggest the operation of such a system of 'bitrack depressions'.[4] They would seem to be dominant for some considerable time in each inferred position, but shifts within the period c. 8300-5500 b. c. in longitude are indicated also. An additional factor may then be introduced, interactions between the abnormally expanded monsoon and equatorial rain during this period, and these meridional cyclonic zones—as in our Model Four, and most appropriate for central Saharan moist phases. If this hypothesis be considered a reasonable one by climatologists, it might be modelled in further detail to compare with the historically supported shifts in longitude of similar troughs and ridges in Europe over the last 1000 years (Lamb 1977).

ATLANTIC PERIOD, c. 5500-3500 b. c.

Beginning with the Levant evidence, we find a gradual resettlement of the region after the preceding environmental decline that had culminated in the 6th millennium settlement hiatus.[5] Late Neolithic sites are still rare, from the 5th millennium b. c. (Moore 1973, 1978) and limited in distribution, but may be common in the very arid Azraq Basin (Garrard 1977). In the latter part of the period we have a much more notable development that seems to indicate a humid phase in the south Levant. Chalcolithic and Early Bronze Age 1 settlement (c. 4000-3500 b. c. on into the 3rd millennium b. c.) is exceptionally extensive, notably in the Negev and Sinai deserts, and here there is good reason to suggest fully agricultural communities (Moore 1973; Price-Williams 1973). Moreover, there is pollen evidence from the south for milder and moister climate (Horowitz 1974), and as yet it has not been suggested that agriculture was dry farming with the aid of elaborate run-off systems as with later cultures of the southern deserts (Evenari 1971), except with the Jordan settlement of Jawa (Miller 1980). Furthermore, there is fluvial evidence for improved precipitation, with wadis in the Dead Sea area building up an alluvial terrace that could be Chalcolithic and of later date (Vita-Finzi and Copeland 1978). The Dead Sea itself, if we can rule out major cooling leading to reduced evaporation for this period, also seems to exhibit higher levels at the end of this period and on into the Subboreal (c. 3500-2300 b. c. , Crown 1972), suitably matching the settlement expansion in the southern deserts, (although one hesitates to take such evidence at face value given the complexity already revealed in interpreting such high lake levels).

From north Israel pollen evidence, Horowitz (1975) has suggested a straight parallel development with the pollen phases of north-west Europe, arguing that a period of moister climate indicated in the pollen from mid-Holocene times would be parallel to the classic Atlantic period climate. There are obvious difficulties climatologically, in predicting such a development for the Levant, and it is notable that his additional supportive evidence is that of moister indications associated with the Chalcolithic expansion in the south from c. 4000 b. c. It is therefore possible that although much of the Atlantic period was dry and not a major improvement on the Hiatus Period, the latter part of the phase witnessed precipitation notably above present-day levels. Most significantly, the recent restudy of the north Israel pollen record finds the Atlantic period broadly reflecting a climate comparable to today, but this in itself might be slightly unexpected if we are correct in assuming that the climatic zones were somewhat north of their present position (Van Zeist and Bottema 1980).

In Lebanon and Syria the general picture from palynology is comparable to the present day semi-arid climate (Leroi-Gourhan 1973), with hints of a brief moist phase c. 3000 b. c. But an improved climate in comparison to the preceding arid peak, possibly greater rainfall than today, may be indicated by deposition of a major Euphrates terrace between c. 5500-3800 b. c. (Besançon 1980). The notable abandonment of sites in the marginal steppe-desert zone, that had reached its climax in the 6th millennium b. c. (Moore 1979), is not without its survivors such as Bouqras, and the numerous sites of Hassuna affinity in the dry Mesopotamian steppe margins (Oates 1973; Oates and Oates 1976). Did these survivors adapt to extreme conditions, or was the arid climax concentrated in certain regions, with contiguous zones enjoying sufficient rainfall? Also here though, there is evidence from the Khabur basin of a notable expansion of settlement into modern desert areas c. 3500 b. c. and possibly on through the second millennium (Oates and Oates 1976).

From the evidence from southern Mesopotamia, we have already seen that the Persian Gulf cores (Diester-Haass 1973) may indicate precipitation increase from the Atlantic or later Boreal period, and possibly this may be linked to the Deh Luran aggradation of similar age (Kirkby 1977), and to the major revival of woodland that palynology places in Atlantic times (Van Zeist and Bottema 1977).

From the palynology of Turkey and Greece, as noted earlier, the trend seems to be of continued precipitation increase from the preceding period. In Greece climax woodland is evidenced by the end of the Atlantic, but in Turkey, although woodland advances significantly in all but the most interior inaccessible localities, climax woodland occurs only in Subboreal or even Subatlantic times (Van Zeist and Bottema 1977, 1980). That Iran (Zeribar) recovers its full woodland during this period, while the remoter areas of Turkey such as Lake Van lag behind, has led Van Zeist to suggest that a change in the prevailing winds may be involved, with westerly winds bringing rainfall into the Zagros but the Van region requiring south-westerlies for rainfall access.

In Arabia the first half of this period sees continuing 'pluvial' developments, then drying up of these depressions after c. 4000 b. c. (McClure 1976). The associated local culture and the Ubaid involvement seem to be linked to the improved local conditions for as long as they last (see earlier), and in the Red Sea (Deuser 1976; Schoeli 1978), we may be able to detect (though the chronology is very complex) a moist phase at this time which could reflect the monsoonal expansion.

Possible Interpretation:

With the melting of the great American ice-sheets, the distorted Boreal regime of Europe ceased, and the upper westerlies would probably course in a much more 'zonal' or latitudinal flow through temperate latitudes. Though more northerly than at the present day, owing to an hypothesized contracted circumpolar vortex and shrunken Arctic polar cap, the westerly stormtracks would encroach on the Mediterranean area in a similar fashion to the present day, if less deeply to the south, yet equally strongly (Lamb 1977; Starkel 1977).

It is considered by Lamb that cyclonic depressions could now penetrate much deeper into Eurasia (1977) and this must be seen as significant for the development of climax woodland in Iran, held up hitherto by rainfall not warmth, and the associated possible shifts in geomorphic regime indicated above. The stronger and effectively more southerly flow is seen most clearly in the continuing improvement of woodland in south Europe and Turkey. But for the south Levant, this more 'modern' rainfall regime must have been more unsatisfactory than the climax of the proposed 'bitrack' rainfall that may have been responsible for the PPNA humid phase, though obviously an improvement on the 6th millennium Hiatus Period.

Comparison with North Africa is illuminating. After the Capsian moist phase, which may have arisen from a 'bitrack' rainfall, possibly with trans-Saharan depressions of Model Four kind, there are indications of aridity, followed by the Neolithic moist phase of c. 4500/4000-3000 b. c. (Rognon and Williams 1977; Jäkel 1977; Lubell 1976), based primarily on geomorphic and archaeological data for the central Sahara and the 'temperate' margin of the Sahara. Isotopic studies have confirmed that the rainfall responsible for the Capsian and Neolithic humid phases is from westerly stormtracks (Rognon 1979), and in the Atlantic Sahara region there is a development of lakes during the overall period 6-2000 b. c. (Petit-Maire 1977). In Egypt, local cyclonic rainfall from winter stormtracks is recorded from the 5th and 4th millennia b. c. (Butzer 1978). In the south Sahara region, high humidity through this period may be associated with the expanded monsoon/equatorial rains, in parallel with the postulated contracted circumpolar vortex, and the same cause accounts for the continued 'mini-pluvial' phase in Arabia. In the latter region the moist phase is over by c. 4000 b. c., but elsewhere there are indications that total monsoon retraction did not occur till c. 2000 b. c. (Butzer 1978).

The bunching of 'humid climate' indicators in the entire region from North Africa through the south Levant and into Syria, around 4-3000 b. c., may reveal a major period of heightened southward displacement of the winter depressions, rather than blocking disturbances due to the subtropical Azores anticyclone being slightly more expanded than at present. Such an inference from Mediterranean data cannot be divorced from the known vicissitudes of climate in north-west Europe and elsewhere in later Atlantic times. On the scale of the northern hemisphere there are in fact very notable glacier advances dated to this precise time interval (Hecht 1979; Porter 1979), and widespread environmental hints of a cool phase—the Piora oscillation (Lamb 1977; La Marche 1974; Röthlisberger 1979). Such wider indications might in fact argue for a minor southward displacement of the climatic belts (Model One), which best accords with the very wide range of humid markers in lower middle latitudes at this time. Perhaps the premature (?) decline of the monsoon in Arabia at the same time may be linked to this general displacement, although the humid phase in the central Sahara might have required not only more southerly stormtracks than today but interactions of Model Four type across the Sahara with expanded equatorial/monsoon rains. However, to make the situation even more complex there is evidence for the Antarctic being in a cold expansive phase between 6-2000 b. c. (Lorius 1979) which would perhaps tend to displace the ITCZ to the north together with the monsoon/equatorial belt. This would account for some late indications for such a rainfall expansion from the south (Butzer 1978).

SUBBOREAL PERIOD c. 3500-1000/750 b. c.

In the literature for this period from north-west Europe, there is a clear difficulty in interpreting the environmental indicators in climatic terms. A similar difficulty from variety of indicators characterises the E. Mediterranean region, and may in fact be characteristic for a particular regime of blocked and predictably variable weather.

In the Levant, the first half of the period represents the main phase of expansion into the southern deserts and generally an advance in settlement, as noted earlier. We have the same period and effects in North Africa and Syria. There is evidence for this humid phase lasting till the latter part of the third millennium in the Negev (Price-Williams 1973) and the Khabur basin (Oates and Oates 1976). Likewise the Jordan alluvial phase described by Vita-Finzi and Copeland (1978) from probably Chacolithic times in commencement, has a date of 2000 b. c. in its upper levels. The Dead Sea may have been higher from 3500-2300 b. c. (Crown 1972) and therefore cooler or in a moister catchment, or both. In fact there is some evidence from studies off the Israeli coast (Magaritz 1973) for cooler sea temperatures between 3000 and 1000 b. c.

Price-Williams (1973) suggests that the Middle and Late Bronze Age, and Iron Age occupations of the south Levant deserts, were not primarily agricultural, but concerned with trade routes and defence, although Evenari has argued for the MBA at least being partly agricultural in character and the first to have applied run-off systems on a large scale (1971). But it does seem as if there was a clear decline in land use in the region through the second millennium b. c. and beyond. Just north of the Negev, a study of wood charcoal from archaeological sites (Liphschitz 1979) distinguishes between the Late Bronze Age and the Iron Age, giving a shift from more Mediterranean to more Saharan vegetation c. 1200 b. c., with thus the earlier period being moister than now (or merely cooler?). However, no allowance was made for the importation of wood from varying distances. In Syria, despite possible fluctuations noted above, pollen spectra furnish a semi-arid climate comparable to today (Bottema 1977).

Moving into the northern region, we find as with the preceding period a continued improvement in moisture recorded by increasingly full or climax woodland conditions. In Turkey pollen diagrams show climax woodland achieved by the end of this period, and in Greece the climax was reached in the latter part of the Atlantic (Van Zeist and Bottema 1977, 1980; Bottema 1978). Some possible wider implications might be drawn from the Persian Gulf core data, which could be read to indicate a dry early, and moister late Subboreal, reflecting upland precipitation around the Mesopotamian Plain (Diester-Haass 1973). The change from aggradation to incision in the Deh Luran section of that plain (Kirkby 1977) is taken by that author to suggest a moister climate, with greater vegetation mat and reduced run-off, possibly correlating with the Gulf indications.

In Arabia, present day arid conditions are already established, and the indications from Red Sea isotope studies are appropriately dry, although the data for the Gulf of Aden could be read to show fluctuations of dry to moister conditions (Deuser 1976; Schoeli 1978; Olausson 1969).

Possible Interpretation:

In north-west Europe, after the Piora decline, forests regained ground, but in the latter part of the period, especially after 1500 b. c., they decline in altitude and yield to peat growth and podsolisation (Lamb 1977, 416). Although there are indications of greater warmth, comparable to Boreal times (hence the term Subboreal), there are also clear recurrent fluctuations, especially of rainfall such that: "More variable, and presumably more meridional, circulation patterns than in Atlantic times seem an obvious interpretation" (op. cit. 373). Underlying this pattern, for Lamb, would be blocking situations arising from a weakened circulation. In the earlier half of the period he ascribes this to extreme retreat of the ice sheets and northern advance of the belts of climate, but for the latter period there is sufficient evidence from glacier advance and treeline depression, and supportive environmental indicators, for an overall shift of climatic belts south again as a prelude to the Subatlantic climate. (For northern hemisphere glacier advances see Hecht (1979) between 1500-500 b. c. ; advances between 1000-800 b. c. on a worldwide scale see Porter (1979); in the Swiss Alps a climate decline on pollen and glacier stratigraphy, see May (1979), 14-1300 and 9-300 b. c. ; for a cooler climate between 1500-1150 and 8-700 b. c. on European oak density studies see Röthlisberger (1979); in the White Mts. of California treering studies show climate decline c. 1300 b. c. after La Marche (1974)).

The implications for the Mediterranean latitude are not clearcut. One might expect after the Piora fluctuation onwards in time, a marked variability at different longitudes of the Mediterranean (Model Two) with unusually dry zones adjacent to unusually wet zones, and a generally expanded subtropical anticyclone belt interrupted by 'bitrack' depressions steered round them. In the latter half of the period, however, a general advance of the depression belt further south into the Mediterranean winter might be expected, and a retreat of the monsoons.

In the Levant and inland Syria the indications of a cooler and moister climate occur in the earlier part of the Subboreal, perhaps as a continuation of the Piora conditions. This is difficult to relate to the north European stituation, unless we assume a 'bitrack' concentrated in the south-east Mediterranean. Seemingly the later shift of the depression belt on a broad front into the Mediterranean, as predicted above, had no significant effect on this area. The indications of precipitation increase in the Mesopotamian Plain's mountainous hinterlands are perhaps significantly concentrated in the latter half of the period, coincident with the suggested rainfall increase throughout the Mediterranean (Model One).

In the rest of the northern part of the region, the continued rise of woodland is recorded, seemingly reflecting a continued rise in moisture. Whereas this is reasonable for the latter part of the period with its supposed increase in rainfall, the earlier Subboreal might have been supposed to be associated with a dry interval, unless 'bitrack' conditions favoured the regions where palynology has been concentrated. There does seem to be a problem here with an overall early Subboreal interpreted as a major northward shift of the location of winter rainfall, and at present the north-east Mediterranean data is more consistent with a continual southward shift of cyclonic depressions from Subboreal into Subatlantic times, with minor moves in the opposite direction that do not seem to be registered in the woodland record.

Such a conclusion would also be consistent with the evidence from the Nile headwaters and the south Sahara, with the monsoon in serious decline, as with the equatorial rains (Rognon and Williams 1977). Although the general retreat of the monsoon to present levels of northward migration is seen as occurring by 2000 b. c. (Rognon and Williams 1977; Butzer 1978), this may not be merely a reflection of an early Subboreal with a generally contracted northern hemisphere circumpolar vortex; for as noted above, there is Antarctic cooling that may have created an ITCZ displacement northwards from 6-2000 b. c. Certainly the decline of the monsoon is recorded by the continual fall in Nile levels in Egypt during the 3rd millennium b. c. and again after some recovery in the latter part of the 2nd millennium b. c. The serious political implications of this decline for the prime subsistence basis of Egyptian civilisation have been excitingly explored by Barbara Bell (1971, 1975). Likewise the decline of the monsoon, especially from c. 2000 b. c., has been plausibly linked to the collapse of the Indus civilisation of north-west India and west Pakistan (cf. McGhee 1979).

Particular attention has been paid by climatologists, historians and archaeologists, to the possible role of climatic fluctuations in precipitating the collapse of the Mycenaean and Hittite civilisations c. 1200 b. c. The initial drought hypothesis of Carpenter (1966) was given support from research by Bryson, Lamb and others into modern parallels for a mosaic of drought and normal rainfall over the E. Mediterranean as postulated by Carpenter from historical and archaeological evidence (Lamb 1967; Bryson 1974; Lamb 1977). Such a pattern was not uncommon this century and was primarily a consequence, in its short-term manifestations, of the distribution of relief in the region. However, the continued operation of such a climatic pattern over a matter of centuries to enforce the post-civilisational collapse of the Dark Ages, was tentatively ascribed in one paper to a blocking regime across the westerlies created by a southward displacement of the north hemisphere climatic belts (Bryson 1974; but this interpretation is denied by his co-author Lamb, pers. comm.). In any case the climatologists have shown that Carpenter's initial drought theory assumed a general warm climate with subtropical aridity extending further north after a retreating winter rainfall belt, whereas in fact the mosaic of wet and dry areas is most plausibly, on present analogues, due to an expanded polar high that blocks winter rainfall from a smooth progression through the E. Mediterranean. Archaeological objections have been raised to the reality of the mosaic pattern, in terms of settlement continuities and discontinuities (Dickinson 1974), which have more weight than the apparent absence of change in Aegean woodlands (Wright 1968). The latter data give no evidence for any perturbations of climate in this or the Subatlantic period, contrary to very clear indications from historical and geomorphic data. One must conclude that at the level of fluctuations within the major Holocene periods, woodland evidence is only notably sensitive in marginal environments e.g. desert margins of the south Levant, upper treeline margins in northern Europe. In the intermediate situation, such as the north-east Mediterranean, the lesser-scale changes may be insufficient to disturb established woodland. As we have seen, there is in fact evidence for climatic decline in the northern hemisphere from 1500 b.c. onwards, which could be appropriate for the blocking situation discussed by Bryson and Lamb. The resolution of the discussion must await detailed information to clarify these opposing claims, but it may be difficult to find environmental data in the E. Mediterranean sensitive enough to the correct chronological scale and locally varying effects involved. Perhaps new historical sources may appear to resolve the issue.

SUBATLANTIC PERIOD c. 750 b.c. - 20th century

The general environmental and archaeological evidence from the Levant is of a climate comparable to the present day, less extreme in either cold/moist or hot/dry conditions than earlier phases such as the Copper Age or Hiatus period. However, it is not always clear whether the development of human cultural skills and initiative is sufficient an explanation for the perseverance of settlement and agriculture in areas of minimal rainfall such as the Negev, or that a habitat was milder owing to a minor climatic oscillation.

The southern deserts show little evidence for settlement until the rise of the Nabataeans in the closing centuries b.c. From then until the collapse of Byzantine civilisation in the region in the 6th-7th centuries a.d., and possibly till the 8th-9th centuries a.d. (Evenari 1971) there is a remarkable flourishing of agricultural settlement, tied to the increasingly sophisticated run-off systems carefully investigated by Israeli archaeologists. It cannot merely be claimed that the Arab invasion of these regions was sufficient to create settlement decline, as Dayton (1975) has convincingly shown, especially on present chronology, for in Arabia and Jordan the Islamic period in the longer term saw continuing settlement and considerable irrigation systems constructed, together with settlement advance into marginal areas. Was there a climatic element? Dayton argues that increasing drought marks this change of cultural control, for which there is some historical support in the southern Arabian peninsula with migration of tribes to Tunisia and clear accounts of drought. On the other hand, Goldberg (1980) has drawn attention to considerable deposition of fluvial silts, now in terraces incised up to 4-5 m high, over the Negev and Sinai, associated with C14 dates of 1700 and 600 b.p. and traces of more substantial vegetation than today. While noting the links to Byzantine activity, Goldberg raises the possibility of climatic change, comparing his alluvia with the 'Younger Fill' around the Mediterranean of Vita-Finzi (1969a), broadly dated by the latter from 400-1800 a.d.

But these dates and the evidence of the 'Fill' itself point, if anything, to a change to a much moister climate throughout the Mediterranean (which could be conceivably linked to the Late Roman/Early Byzantine climax of desert occupation), and the decline of the Levant must in fact be associated with cultural discontinuity, even if as seen, there are areas where the Arab encroachment was not economically disastrous. One need only be reminded of the cultural and political gesture of resettlement of the Negev in the late 19th century, and of recent decades (Price-Williams 1973; Evenari 1971), times of no demonstrable precipitation improvement, perhaps rather of decline, to be wary of attributing too much to settlement presence with developed civilisations.

Dayton (1975) fails to distinguish between possible drought in the Levant, under the influence of cyclonic rain, and the Arabian peninsula, under opposing cyclonic and monsoon rain. His best drought evidence seems to be from the monsoon zone and its northern margins. One might perhaps correlate a possible rise in winter rainfall for the south Levant 'Younger Fill' with a monsoon decline to the far south. According to Vita-Finzi (in De Cardi 1975), the Younger Fill is also found in Arabia, but may be purely medieval in date.

The Younger Fill is virtually the only well-attested feature of possible climatic significance in Syria at this time period (Besançon 1980), and its universality and clear indications of erosion/runoff/rainfall causation are more acceptable than localised explanations such as that of Brice (1978), with the alluvial burial of antique Antioch ascribed to earth movements.

In the north of the Eastern Mediterranean, vegetation history shows no significant changes attributed to climate, which would agree with the gradual rise to modern precipitation by the later Subboreal and its overall maintenance to the present day. But the record is increasingly difficult to interpret because of human interference with woodland distribution. More sensitive indicators stem from geomorphic activity. In Iran the historical alluvium or 'Younger Fill' has been well studied (Vita-Finzi 1969b, 1975; Brookes 1977) and conforms to the general time span elsewhere for this formation of c. 400-1800 a.d. or later. But Brookes indicates what could be drier intervals within this long period of supposedly cooler and moister climate.[6] Similar signs may be observable from the Persian Gulf cores (Diester-Haass 1973) in which the Subatlantic is associated with generally moister conditions interrupted by drier intervals. In the Mesopotamian Plain in general, a peak of complex agriculture based on run-off and canal systems is dated to later Roman and early Islamic times (cf. Kirkby 1977), which might perhaps have been aided by the same moister climate indicated by the Younger Fill. In the Iraqi sector, notable flooding of the lower Plain around 600 a.d. might conform, but there is evidence also from historical sources for an unusually warm period c. 1000 a.d. in the same region (Oates and Oates 1976). Finally, ocean cores from the Gulf of Aden cover only the early part of the period, and suggest a dry climate, with no unusual extension of the monsoons (Olausson 1969).

In Turkey, once again, the woodland record offers little apparent sensitivity to changes detectable in river regimes and other geological evidence. The historical Younger Fill is well represented (Vita-Finzi 1969c). There is evidence from glacier development, e.g. from Mt. Ararat, that might record the worldwide climatic cooling of the Little Ice Age (c. 1550-1850 a.d.) (Farrand 1979). The more plentiful historical records now available suggest the following phases of unusual climate or secular changes of climate: after a climate in Roman times comparable to today, higher rainfall is suggested from c. 750-1300 a.d., but with drier intervals associated with frequent droughts (Erinc 1978). Likewise there is unusual wetness in the 15th and 17th centuries a.d., also associated with pronounced drought years (Eisma 1978; Griswold 1979).

In Greece, also, the pollen record provides little indication of climatic fluctuations, and the prime evidence for such stems from the abundant Younger Fill alluvium (Vita-Finzi 1969a; Bintliff 1975, 1977; Dufaure 1976), dated in most exposures from Late Roman to recent times. A number of recent papers critical of the chronology of the Younger Fill (Raphael 1973; Eisma 1964; Davidson 1971, 1976, 1980) may be criticised in their turn for confusing it with earlier colluvial and deltaic deposits (Bintliff 1977, 1981; and for some realisation of this see Eisma 1978).

The best historical evidence for Greece, at least in terms of scholarly accessibility, refers to the period of Classical and Hellenistic Greece, from after 700 to 200 b.c. Careful study of literary sources gives strong evidence for a climate very comparable to the present day during this era (Meigs 1961; Guinis 1976), but rather curiously the assumption is made that therefore the Greek climate has not changed since the Classical period. In fact the prime evidence to disprove that assumption stems from the period of the Younger Fill, later than these carefully studied sources.

Possible Interpretation:

We might first consider the evidence from other parts of the Mediterranean. Little data are available for the period before the Roman Empire, (Lamb 1977, 424), but the Imperial Roman period seems generally to have been one of warmth and precipitation comparable or slightly drier to today. The post-Roman centuries, or Dark Age of the West, has been associated with severe drought in the Byzantine Empire by Carpenter (1966) without adequate evidence, but in Spain there is circumstantial data from which one might deduce seasons of severe drought in the 6th-7th centuries a.d. (Barcelo 1979). On the other hand, in all the lands of the central and west Mediterranean the Younger Fill is well represented (Vita-Finzi 1969a), implying moister and cooler conditions for much of the Dark Ages and medieval era. The apparently contradictory evidence may be reconcilable (see below) and Lamb points out that during the Little Ice Age period the Spanish historical sources clearly indicate frequent juxtapositions of severe drought and flooding seasons (1977, 468). The Mediterranean counterpart to the north European 'Early Medieval Warm era' of c. 900-1200 a.d. is not clearly demonstrable hitherto, except for interludes in deposition of Younger Fill about this time, which may mark drier conditions (cf. for example, Barker 1978; Potter 1979). On the other hand, Lamb has suggested that the Mediterranean continued to benefit from rainfall above recent levels, in some longitudes, during this warming era, because of 'bitrack' depressions, and relates this to indications of more active river flow in Sicily and peat growth in the Azores (1977, 428). The subsequent Little Ice Age is the best documented climatic change over Europe as a whole, during the Holocene, and historical evidence for cold, wet conditions abounds throughout the west and central Mediterranean (often coupled with drought reports, as noted above) (Lamb 1977, 466ff.; Pichard 1979), until the 19th century warming period, and contemporary to the latter part of the Younger Fill.

Historical sources have their obvious weaknesses, although they should assist in the identification of the most extreme years. Nonetheless it is clear from the last two centuries, that individual years of climatic extremity can stand isolated amid a consistent period of different norms. An examination of Weikinn's (1958) historical listing of years of remarkable climate in Europe, not surprisingly offers only a general impression of a greater incidence of more northerly climate in southern Europe, coincident with similar but better attested phases in north-west Europe. Lamb claims a better match but the agreement is patchy (1977, 427). How are we to evaluate for example, the isolated information that in 829 and 1011 there was ice on the Nile (*loc. cit.*)? The former date would fall into the transition from a colder to warmer climate in north-west European terms, and the latter was in fact also a year of severe cold in much of Europe north of the Alps, but within a well-established *warm* era there.

In North Africa, the Nile Flood fluctuations and the inferences concerning the expansion and contraction of monsoon/equatorial rains to be drawn from them, do seem to be in accordance overall with the predictions one might make from the behaviour of the westerly circulation for north-west Europe (Lamb 1977; Brooks 1949): from the 7th century a.d. to *c.* 800, low levels, followed by a rise corresponding to the climatic improvement of the European 'early medieval era'; then a decline *c.* 12-1400 a.d. and *c.* 15-1600 a.d. comparable to the Little Ice Age and its late medieval precursor; even the milder era *c.* 1500 a.d. may be represented by a higher Nile flow. However, from the latter part of the Little Ice Age into the present era, Nile floods are high; but this contrary prediction to north European events may be connected to a displacement of the ITCZ, owing to the delayed decline of the corresponding Little Ice Age in the southern hemisphere (Lamb 1977, 449ff.).

Since the last century, the extensive traces of Roman settlement and agriculture (field systems, irrigation works), throughout North Africa, have inspired theories of climatic decline to account for subsequent abandonments and less intensive land use and settlement (Shaw 1978). The study of classical references to the area seems to have supported such ideas, but makes no allowance e.g. for inherited fossil water (Lamb 1977, 387). On the other hand, it is, as with the south Levant, precisely during the later period of Roman occupation and the subsequent 1400 years in North Africa, that the extensive Younger Fill was being deposited (Vita-Finzi 1969a), which though possibly assisting late Roman agriculture and that of the sub-Roman cities and their cultural successors under Islamic rule, should also have offered an incentive for equally widespread land use till recent times. Once again, climatic change may have been important for the maintenance of an already successful adaptation, but was less powerful than cultural factors in the long-term survival of intensive agriculture. The references of Arab sources to moister than present day climate in North Africa, overlap with the 'early medieval warm era' of north-west Europe, and are seen as further support for a localised 'bitrack' depression series (Lamb 1977, 440ff.). The juxtaposition of humid indicators in literary sources and droughts, for the Little Ice Age period of North Africa, is comparable to the evidence we have seen, both in other parts of the Mediterranean and north of the Alps, for the same phenomenon (Lamb 1977, 469; 1979).

This general survey of the Mediterranean and Near Eastern data for the Subatlantic period does seem to bring out some broad consistencies in climatic trends over the whole region. A climate comparable to the present day, perhaps warmer and drier, predominates until late Roman times, followed by a period up to 1800 a.d. or so, in which abundant evidence exists from historical sources and geomorphic data for greater rainfall, often associated with suggestions of cooler climate but also for severe drought. Less clear is a possible interval of warmer conditions around 1000 a.d.

It is well worth comparing this summary with Lamb's reconstruction of the climatic sequence, based predominantly on north-west European evidence:

> "There was a gradual, fluctuating recovery of warmth and a tendency towards drier climate in Europe over the 1000 years after 600 b.c., particularly after 100 b.c., leading to a period of warmth..around a.d. 400. After some reversion to colder and wetter climates in the next 3-4 centuries, sharply renewed warming from about a.d. 800 led to an important warm epoch which seems to have culminated around a.d. 900-1200 in Greenland and a.d. 11-1300 in Europe. In these few centuries the climates in the countries concerned evidently became briefly nearly as warm as in the post-glacial warmest times.. the Little Ice Age centuries..followed." (1977, 374).

Importantly, for the Little Ice Age, he argues for conditions "when the extent of ice on the Arctic seas and of ice and snow on land seems to have been greater than at any time since the last major glaciation" and with weather features which "indicated a significantly wide range of year to year variability in the Little Ice Age, which seems to have been associated with a reduced frequency of westerly winds in Europe and increases in the frequency of winds from most other directions", producing "alternations of extreme seasons" (Lamb 1979).

In general, Lamb considers the Subatlantic to be marked by a southward shift in the belts of climate, but with pronounced fluctuations of warmth and cold, dryness and moistness, associated with both fluctuations in this zonal shift (Model One), and with the effects of blocking of the westerlies, either by expanded subtropical anticyclones in warming phases, or polar highs in cooling phases (Model Two). Compare for example, his analysis of the Early Medieval Warm Era:

> "All these observations of the medieval period could probably be explained by a circulation pattern in which the northern hemisphere subtropical anticyclones were on the whole displaced somewhat to the north during the time of warm climate in Europe, Greenland and North America. During most of the time the middle latitudes and westerly winds were presumably weaker and less prevalent in latitudes between 40° and 60° N than now or than they became from a.d. 1200-1300 onwards.. While central and northern Europe were enjoying more frequent anticyclonic influence, and rather sluggish W'lies or more variable winds, the Mediterranean zone..may well have experienced more frequent cyclonic activity of various types—e.g. slow moving cut-off cyclones and Khamsin depressions" (cf. our 'bitrack' and 'Sudan-Sahel trans-Sahara depressions) (Lamb 1977, 440).

If one is seeking for confirmatory evidence of northern hemisphere and indeed global cooling, and hence expansion of the circumpolar vortex in the Dark Ages and the later Medieval to Early Modern period, the evidence is impressive (May 1979; La Marche 1974; Porter 1979).

Finally, some further discussion of the interesting phenomenon of the Younger Fill is required. Despite accumulated criticism of this seemingly too simple alluvial formation, the continuing accretion of consistent dates for the fill (cf. recently Roberts 1979), appears to be stimulating a rethink in favour of Vita-Finzi's original dating, allowing for more localised earlier formations (Eisma 1978; Donald Davidson, pers. comm.). Tentative diachronic appearance of the Fill in different latitudes has also led Vita-Finzi to elaborate on his southward cyclonic displacement model, with the most extreme displacement belonging to the time of the Little Ice Age and hence suiting the first clear traces of the Fill in Arabia (Vita-Finzi 1976).

But the origin of the Fill cannot simply be assigned to a southwards stormtrack displacement, for as we have seen, this could be argued to have occurred recurrently throughout the Holocene in the Mediterranean latitudes. This may be an opportunity to seek some middle ground between a purely climatic causation and those who have persistently ascribed the Fill to human erosion. The obvious criticism of the erosion viewpoint, has been the clear evidence from archaeology and history of considerable deforestation and slopewash from agricultural activity, dating well back into the Atlantic period in most countries concerned.

It could be pointed out that it was neglect of intensive field systems in the dramatic collapse of the Western Roman Empire and the parallel serious decline of the Byzantine Empire of the Eastern Mediterranean, that allowed the enormous reserves of penned soil to be washed over and through run-down field walls. Yet the Roman Imperial era was only one of several cyclical phases of intensive land use in the Mediterranean and Near East lands, each of which was followed by field and settlement abandonments on a considerable scale—yet only this final decline is accompanied by such a universal change in fluvial behaviour. Certainly one could argue that the Little Ice Age period was one of the most severe climatic deteriorations of the Holocene, but with less justice for the Dark Age cooling phase.

At the moment, it seems most satisfactory to build an explanatory model which stresses the powerful coincidence of a massive backlog of eroded soil on the Mediterranean hillands—lacking effective enough rainfall to assist their gravity aided fall into river systems,—and in terraced fields, where they were penned from movement into river systems by human barriers, all of this then to be combined with a civilisational collapse in the West, near collapse in the East Mediterranean, and then with a general secular climatic change to a cooler and wetter climate.

What link, if any, could be made between these civilisational declines and the climatic change? Vita-Finzi and I (Vita-Finzi 1969a; Bintliff 1977, 1981), have suggested that the loss of valley fields due to poorly controlled, aggrading rivers, and the decline in warmth that could have had deleterious effects on crops (cf. the frost killing of Provence oranges and olives during the Little Ice Age cited by Lamb 1977, 466; Pichard 1979), must have been significant in the downfall of these two empires. The suggestions of Lamb on pronounced meridional flow and blocking regimes, to be associated with this southward displacement, whilst accounting for apparent contradictions in the Mediterranean evidence for this period, also indicate a further source of problems for human communities, with the unparalleled and unpredictable shifts from year to year of drought and flooding, parching and freezing to cope with.

At the commencement of this paper, we saw how the 1960's and 1970's were generally a period in the world of very variable climate. Some authorities, including Lamb, have characterised the period as one of declining warmth and polar expansion, but the statistical evidence is ambiguous.[7] The local effects for countries of the Mediterranean latitude have been well recorded and exhibit precisely the same juxtaposition of semi-drought and flooding along the east-west axis of the Mediterranean lands, as seems indicated on a much longer time scale for the last two millennia (Lamb 1977, 539 ff.). It seems highly probable that further elaboration of this model, involving longitudinal shifts of waves in the upper westerlies, may assist in the interpretation of regional climatic anomalies in the different countries of the Eastern Mediterranean, which are such a striking feature against the more widespread overall indications consistent with long term secular climatic changes.

NOTES

1. It must be admitted that many climatologists criticise Lamb for constructing general models on rather preliminary and sometimes scanty data. They would argue that we do not yet understand the intricacies of present day climate, so that the theoretical base for the models is likewise weak. One can only reply that such scholarly caution may inhibit any attempts at palaeoclimatic research in the foreseeable future, and that models such as those of Professor Lamb provide working hypotheses to encourage empirical testing. A more serious criticism which could be levelled at this present paper is its necessary reliance on the published sources in palaeoclimatology, and those comprehensible to the layman. These are certainly somewhat outdated in the very rapidly-advancing field of climatic research.
2. This seems very oversimplified to some climatologists, making no allowance, e.g., for the fact that about 50% of heat transport is via the oceans. There are also difficulties in fitting this model to 20th century instrumental data (Dr. T. Wigley, pers. comm.).
3. Although it is widely-recognised in climatology that significant secular shifts in the ITCZ occur, the empirical data for these timescale models in very poor.
4. To follow the useful analogy of Lamb, we might imagine a strong static anticyclone acting like a large rock down the axis of a small stream (the upper Westerlies bringing cyclonic rainfall). The flow of the rainfall might be directed both to north and south of this 'blocking feature',

and if it were to shift up or down stream, this would produce longitudinal shifts in areas receiving much or little rainfall.

5. Bar-Yosef (this volume) is very critical of the so-called 'hiatus' commenting that sites do indeed exist for this period in the Levant, but different in type and location from preceding and succeeding eras. Nonetheless, at least on present evidence, there is a striking reduction in the quantity and quality of human occupation in the area, that could reasonably be associated with a pronounced fluctuation in the environmental conditions favouring dense settlement.

6. Brookes has since modified his interpretation of the recent alluvial formations concerned (this volume, but see the appended discussion).

7. Tom Wigley (pers. comm.) kindly comments that the most recent analysis of the relevant data for the totality of the 60's and 70's can be read to infer a warming tendency in the Northern hemisphere. Since much of this data has been used in previous studies to infer the opposite (even stimulating public fears of a rapid onset of the next Ice Age in the popular press)—the arguments are plainly in the realm of statistical manipulations. However, it is generally recognised that recent years were more in line with the 'warming hypothesis'—a fact publicly supported by Professor Lamb himself (partly to allay public concern!).

8. Papers cited from the abstracts of the 1980 Lyons Symposium on the Prehistory of the Near East are to my knowledge unpublished. A selection of papers from the 1979 Climate and History conference at East Anglia is appearing in '<u>Climate and History</u>', eds. T. M. L. Wigley <u>et al</u>., Cambridge University Press (in press, 1981). The 1978 Tübingen Conference is unpublished, as is the 10th <u>INQUA</u> Congress, 1977.

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DISCUSSION

PAEPE: One of the major problems with such an overview is the link between the different investigators. That is what I learnt from this symposium, that we are all, whether we are archaeologists, climatologists, palynologists, or sedimentologists, looking at the data in different ways. Now in my field, which is mainly palaeopedology, I am very much convinced, that palaeosols never look like modern soils. They are quite different because the landscape on which they developed does not exist now. We have regional variation of soils, the present day geographical variation, but we don't know exactly how this regional variation existed throughout the periods of the Quaternary past. And this is a difficulty. I think we have been witnessing here some strong positions. All these positions probably arise because one or other person is putting more stress on this or that single factor. And this is the advantage of a meeting at this point, that such very sharp positions can be juxtaposed to give a more overall view for some areas. For me when a palynologist says there was woodland here or there is steppe here, I don't know what that was. I try to imagine what a steppe is like in the heart of the Soviet Union, I try to imagine what a steppe would be like in Greece, or a savannah in Somalia. On the other hand, it is also very difficult to read from some gravels what exactly they represent in terms of a river system. A long time ago I tried to follow Lyell - the present is the key to the past - but for me the present day phenomena in various parts of the world are very difficult to categorise precisely. So what I would like to see in such models is the definition of what we are looking for, palaeoclimate. It is a multiple definition I think, for I am sure that palaeoclimate in the various disciplines you are using is quite variably interpreted. It is not a concrete thing, perhaps not even for the meteorologists working or trying to work with it, and it is certainly very difficult for the individual researcher to investigate this.

BOTTEMA: In your paper, you refer to the period of around 30000 in Greece as a cool and moist climate. But I think when you define a climate from palynological information it is rather difficult to say it was cool and moist, because that's rather as if people nowadays were to say when you go to Greece on holiday it is cool and moist, whereas in fact it was not really very wet. Van Zeist avoids this problem by putting quite clearly, it was so and so compared to modern climate, or at that time the pollen record shows a kind of vegetation that's comparable to modern vegetation. And in this particular case when you see the pollen spectra of those diagrams, (and I don't know who interpreted them as Interglacial, I'm sure that neither Van Zeist nor I ever did so,) they point to a very diversified landscape in which both trees and steppe elements were present. At the moment I am of the opinion that when you compare it with a natural type of forest in Greece, (although they have cut everything down,) but when you postulate a natural-looking forest in Greece nowadays, temperature was quite important. It was not I think a cool and moist climate that saw both steppe and forest, but it was a kind of vegetation that had become so dry, that on certain levels you had steppe and on more favourable levels you had forest vegetation. And this situation in which precipitation was quite important enabled both the steppic elements to be there as the forest elements. Do you think that contradicts your interpretation in that part of your paper?

BINTLIFF: No, not really. I wasn't suggesting that you'd thought of these as Interglacial, I was almost quoting your own work in suggesting that these had a later date and were within the last glacial. There had been other earlier suggestions that these related back to Riss-Wurm, these moister conditions. I do say immediately below that the woodlands that are being talked about here were not as favourable in comparison with the Interglacial conditions, rather than suggesting that they are as good as or better than the climax vegetation you would expect in an Interglacial in those areas. I am a little bit worried that you are playing down humidity, because in fact in your paper with Van Zeist humidity is given a lot of importance, particularly in the early Holocene. For we know that the temperature rise could be fairly rapid in the early Holocene, but that this does not relate very clearly to the expansion of woodlands, as a result of the other data - insects and so on which suggest more immediately the changes in temperature.

BOTTEMA: You mean that I have avoided the word humidity, which we so carefully included in our paper to this Congress? When you see the appearence of steppic elements, we can say it was so many degrees of humidity, but as forest is still widespread there was a rather precarious balance of this humidity level that caused these vegetations to appear quite close to each other. The quite regular shifts in the AP/NAP relationship also point to a precarious balance over a short timescale. When you prefer to use the term humidity I agree completely, because up to now we have no indicators that clearly say it was only temperature or only precipitation that controlled these relationships.

BROOKES: In arguing the case of model-building or generalising approaches, any division you might be making between 'lumpers' and 'splitters' is really a false one, because we all start of as 'splitters' and end up as 'lumpers'. Yet, if there is going to be a distinction, I'd much rather be a splitter and feel confident in the interpretation that I have reached in my local region, on the evidence that I have there for it, than feel unconfident about an interpretation reached because I have relied upon analogies drawn from other areas. In my own field area of Iran for instance where certain events have occurred for which I can find no other regional or local explanation, one is really forced to go a little bit outside the area to try and find an analogous phenomenon, but I think to practice that on first principles is really erroneous and we should all try to avoid being philosophical lumpers from the start. You have to set up your own local scheme and explain the phenomena that you have in terms of the local ecosystem, explaining geomorphic events in geomorphic terms, which includes climate but a lot of other things too; the botanical evidence in botanical terms, of which climate is one variable. All the other lines of evidence will have to be interpreted in their own terms within that local ecosystem. Nobody can criticise a worker for erecting a scheme of the interpretation of events that stands up in that local area. The criticism cannot be levelled at that person that they did not consider the global implications of their work. But if you start off looking for those global or hemispheric implications or controls, missing local factors, then of course you are going to get into deep trouble. A lot of people might, in a meeting like this, gather too much confidence in the fact that things are similar in Zululand and California e.g. rather than that the local schemes have to be able to stand on their own.

BINTLIFF: I think it really depends on how optimistic you are that one day everybody will have explained his region and we can all sit together in a room, and say "Well, here is my region, this is what happened, what happened in your region? Ah, the same thing, right", and you begin suddenly, on a map, to show some wide-ranging phenomenon - if such exists - or else to show each area having its own distinctive environmental history. I am not very optimistic that this will happen and in most subjects it doesn't happen, and I think someone must try at all stages of research to look for the wider connections, even if it means that the regional workers go back and say "this link to another region doesn't make sense, I have a better explanation locally". The second point is whether you believe with this school of Palaeoclimatologists, that the major climatic phenomena operate on a very large scale. And that, although perhaps for now or for the foreseeable future, the data from one region are insufficient for definitive statements on past climates, by accumulating data from a number of regions we can detect an overall climatic mode, which can then be related to major models being put forward by palaeoclimatologists. Thirdly, of course one comes to a broader synthesis from one's own region and there are problems within Greece that I've come across and in Turkey where I think some further explanation can be gained by bringing in a much wider region.

PART SIX:

CONCLUDING DISCUSSION

(FINAL INVITED COMMENTS)

FINAL INVITED COMMENTS

BOTTEMA: I will try to recollect some of the important things I have learned in the last few days. Two main points draw my attention. The first point was the aim of the Symposium, to use, among other sources, palynology as a means of reconstructing a past climate, or rather to use palynology to reconstruct the vegetation and to learn from this vegetation something about what happened in the climatical past. Well in fact the information that was gathered, when you see how few palynologists work in such a large area, was not too bad and I think the results are not too discouraging. But on the other hand an important thing remains to be resolved: my second point, that although there are only a few people concerned with this work, they still do not agree about methods and also the way of weighting the results is not at all the same. We learnt from Madame Leroi-Gourhan that terrestrial samples are very poor in pollen compared to lascustrine or peat deposits. I think a lot of people who are interested in this field of work have to think about her important statement, because what is behind the fact that a terrestrial sediment is poor in pollen? I leave it up to those who are interested in this field of work to orientate themselves in this. In the contribution of Mrs Paxton I thought it very interesting that at least some things that we ourselves did not use were discussed. I am thinking here of dividing certain steppe types in future detailed analysis. On the other hand most details of the pollen work in the Near East were already treated exhaustively by Van Zeist and I think that the long list of the relevant bibliography can support further studies for people who are especially interested in this kind of close work. When I return to the aim of the Congress, I must say that it was because in the course of the last 15 years pollen curves that were made for these areas were not easy to connect with each other, that formed the main stimulus for us to start to think that climate maybe was not the same everywhere. In Europe it was commonplace to connect everything, and some people even went so far that Bölling was supposedly found in Bolivia. You have to have some basis to work on, but then it is useful to reconsider the initial model and see whether all these minor fluctuations occur everywhere, and even when they seem to occur are they quite the same? Van Zeist and I experienced difficulties in connecting the various diagrams that we were involved with from Greece to Iran. And finally we decided, although it was already no longer a common method, not to continue to spend our time on connecting things, but to start to think about the things that may not have been the same at each point in time. The main result of our study was the humidity curves, and I hope that climatologists will start looking at them and tell us whether you can do something with them or not.

BAR YOSEF: I strongly believe as an archaeologist, maybe this is a kind of declaration, that after all, people are interested in palaeoclimates because it has something to do with the history of human evolution. And especially significant for these last 20000 years is the fact that we who are sitting in this room are the direct products of the Agricultural Revolution. And one of the crucial questions that has preoccupied research for a long time was how did it happen, and why? And it does seem to me, perhaps because I am a superoptimist, that we are coming closer to giving the answers. I would make a prophecy, although it is said in our sources, that after the destruction of the Second Temple, which took place about 1900 years ago, prophecy was given only to children and idiots. I would consider myself as a combination of the two, and say that perhaps within ten years we are going to have a good answer as to why the first human agglomerations, that we have named Natufian in the Near East, took place, because undoubtedly this was the onset of the Agricultural Revolution from the social point of view. And the question whether this social evolution was influenced by climatic changes I believe is crucial to most of the people who are sitting around in this room. As an archaeologist I would like to say that I strongly agree with all those who say that regional studies are the first basic approach to any of these problems. What it means is that we take an area that is 40 -50 km across, maybe even bigger if we can handle it, if we have enough time, money and people to do it and study it as thoroughly as we can, looking mainly for the residues of the last 20 or 30000 years. This is the kind of work that we have been trying to do for the last ten years in our part of the southern Levant.

Again as an archaeologist I would like to point out that like the other specialists we have difficulties in calibrating our working tools. We witnessed here the discussion about the diet of the bovines, whether they were browsers or grazers. I believe that similar questions can be raised, maybe not so amusing, about some of the archaeological details which we tend to give to those who are non-archaeologists, in the form of maps or numbers of sites and so on. One interesting question is: what is an archaeological site? What is the ting you find there that tells you it should be a dot on one of your maps? I believe that in every regional study one should, after a year or two in the field, define what one calls a 'site', a 'scatter', an 'occurrence', whatever one means by using this term, whether it is ten by ten square metres excavated, deflated or eroded material that is coming from one place or another. The second question concerns the distribution of sites. How do we consider the density of the sites? A site might be a very small one, can be just a station or a transitory camp of hunters who just passed by there and left about 10 arrow heads. But it's very different from a site where you recover about half a million pieces of flint. To give you an example on which we are working recently, two Neolithic sites, PPNB sites, in southern Sinai, both of them 250 sq m in surface area. One of them gave us half a million pieces of flint and the other one only 40000 pieces of flint, so it seems that there is some meaning to this. I hope we will be able to provide you at a future meeting some bone counts to show you that there are differences in this aspect too, which relates to differences in the density of occupation of sites. This of course refers also to tells, the mounds which are so typical of the Near Eastern landscape.

And next, when we are using archaeological material, due to the fact that archaeologists, zoologists as others do tend to have different points of view, sometimes about typology, sometimes about terminology, wouldn't it be the best approach here to use the largest number of radiocarbon dates we can obtain? When Paul Goldberg was speaking nobody asked how our sites were dated, some people would think that the dating was based on the typology of flints, but this is wrong, all the dates that we are dealing with are based on C14 dating, and although it is maybe superfluous here to advocate the use of C14 dates, I think not enough C14 dates from this crucial period are as yet published from the Near East. Many more will help us in resolving some of these gross regional interpretation difficulties. So we don't need to speak only about the Kebaran but we can speak also about certain time units that can cross-cut the whole Near East.

Another point about archaeology I would like to make is the use of the archaeological material for climatic interpretation. I would underline a point I made earlier. From looking at various environments, it is clear to me that when we are dealing with hunters and food-gatherers we are dealing with very mobile or relatively mobile societies which were directly influenced by climatic changes. Of course as Hans Peter Uerpmann was saying, there will be a few animals remaining everywhere even after a number of droughts, but as hunters and gatherers are generally below the level of carrying capacity in a region there is no reason why they will stay in these places. Of course under such circumstances one should expect in oases, where there are some springs in the desert (and there are permanent springs in the deserts) to find in this special spot rather different cultural remains, which means that more time periods will be covered. But here the general picture comes in useful, when you compare one area with another, going from the desert into the more mediterranean or semi-temperate zones. At that point we should look in the record of cultural history: what happened after the period of hunter and food gatherer prevalence over all the Near East? Here we come to the Natufian and one can see obviously, between 12000 bp and 10000 bp quite considerable change, that the sites are not dispersed all around the Near East, and there is a difference in their size. First of all the largest Natufian communities are living only in Irano-Turanian and Mediterranean zones and they are not found all over the Near East. But sometimes contemporary sites are found more dispersed around the Near East, those who remained hunters and food gatherers. When we pass onwards to the PPNA and PPNB we see these farming communities well established in river valleys like the Jordan river, the Euphrates valley and so on, yet at the same time we do continue to find some of their contemporaries living in the desert (but not everywhere). The picture is quite clearly different during the PPNB, (which means the 7th millennium bc or 9000-8000 bp,) when over all the deserts of the Near East and from the little information we are getting from places like Qatar even through the Saudi Arabian deserts, we are finding a large number of PPNB hunter and food gatherer locations. Maybe here we have the original Bedouins herding goats into some of these deserts. Later, it is quite clear that there is a shift northward. I do however object to this famous Palestinian hiatus, because it doesn't exist. There <u>is</u> some kind of stratigraphical gap in some places in the

Jordan Valley. But what is more important is that there is a shift in the settlement pattern and in the character of settlement. Instead of the villages of the PPNB we are getting some kind of either villages or what we call pit dwellings, and other types of site. But these do occur in the Jordan valley, in the hilly zone and especially along the coastal zone and we do find them in the northern part of Sinai, and the fact that there were hardly any C14 dates in the past led many people to identify this hiatus. You do find at that time, around 8000 bp and onwards in the Near East, a shift towards having most of the largest settlements in the northern part of the Levant and much smaller ones in general in the southern part of the Levant. It does seem that some of the earliest evidence for city states perhaps originates in this time period and the dichotomy that exists between the Nile Valley on one hand and the Syrian and Mesopotamian worlds on the other hand might originate in this 6th millennium bc period. But at that time there were still people and sites both in Palestine and in the deserts in Sinai, and 15 different unpublished C14 dates from central Sinai and southern Sinai record this period from excavated sites. By calibrating our archaeological data, defining in every region the size of the sites, the density of the occupation, the length of time of occupation, the general cultural distribution by territories, we should be able to differentiate between at least 3 major steps within the archaeological material, that provides a different kind of relationship between climatic changes and human adaptation: the hunter-gatherers, the early farmers, and the real villages on the way to urban civilisation.

JOAN OATES: I agree essentially with what has just been said by Bar Yosef, but I think I am probably not quite so optimistic, in the sense that I think even within the foreseeable future there will be very great difficulties in establishing interregional correlations. In archaeology we have difficulty enough, within regions, in resolving problems of contemporaneity between archaeological sites, simply because our data base is not adequate for this purpose. I'm not all that optimistic about C14 either, at the moment, because of the discrepancies between various regions in the Near East. I'm thinking particularly of southern Mesopotamia, and Khuzistan, these are environmentally very similar regions, between which there was considerable interaction, and we can identify materials which must be essentially contemporary, but then we have very great discrepancies, in one or two cases up to something of the order of 1000 years, between series of C14 dates from both areas. I think we also have a very major problem in archaeology in assessing site densities. Obviously if one can excavate the sites and establish the ratio of artefactual units per volume of earth one has some sort of meaningful information on which to proceed. But most of the sites we know about of course are not excavated, and given modern financial difficulties are unlikely to be. It's one reason why I have avoided site counts. I felt it was perhaps more useful to provide evidence relating to patterns of settlement that in some way shifted in relation to modern climatic boundaries, and that might therefore have some meaning in terms of climate in the past. I think we would hope that this is the direction in which we are moving in providing the

Quaternary specialist with more reliable archaeological data, but I'm not very optimistic that the next ten years is going to see any great advance in this.

WIGLEY: On the question of southern Arabia, this is difficult because of the dating problems. It seems to me, and other people have said this, that the peak, the glacial maximum, was a time of transition from wet to dry, so that depending on what data you use you could choose the climate of southern Arabia to be wet or dry - and different people have. Rognon, e.g. on his chart, has shown that period, roughly 20-18000, as being a wet period, perhaps explained by a movement north of the Intertropical Convergence Zone. Yet other workers, Nicholson and Flohn, have exactly the opposite and they are able to explain that equally well. If you then try and go back to numerical modelling experiments to back up the physical arguments you find that they contradict each other too. I do know where we go from there, we just collect more and more data and with better and better dating and gradually build up a better picture of what happened. Another factor which has been used in an explanatory sense is the intensity and position of the Subtropical Highs and the general Hadley Cell circulation: this is also related to the possibility of coupling between low latitutde and high latitude circulation which was first, I think, discussed by Flohn. Now once again when we consider the numerical models of the Hadley Cell and the Subtropical High and the general middle-low latitude circulation for 18000 years ago, these numerical models show results which are contrary to what other people have suggested on empirical grounds. One might expect the Hadley Cell at that time to have been contracted and perhaps stronger, perhaps the southern margin not moving as far northwards as it does today, but modelling experiments show very little change in the Hadley Cell, and that applies to almost all modelling experiments. These models are better than our heads are, I think; they do bring together more factors than it's possible to weigh in the mind. This is all really heading towards what Van Andel said about Climatology not really being up to explaining things at the present time and I think we're going together hand in hand. Climatology is advancing while the data-base is advancing, which is the way it ought to be.

Other factors: I think the strength and position of the (thermal) Siberian High is something which is very important as an alternative but not necessarily a better explanation for some of the changes that have occurred. Instead of pulling the Subtropical High up northwards it might be possible merely to develop the Siberian High a little more. Strong ridging of the Siberian High happens today. If you look at individual years or months it's very hard to separate the ridging from this thermal high from highs which might be called dynamic Highs, which are the Subtropical Highs. There's another problem too with pushing the Subtropical High a long way north and that is there are dynamic limitations to the northward extent of the Hadley circulation. So the role of the Siberian High Pressure system, or winter monsoon system, is perhaps quite important. It's also important because that is one way of blocking the migration of cyclones away from the cyclogenesis areas in the Eastern Mediterranean; and not only blocking but changing the relative frequency of cyclone tracks to the north or to the south of this region. In other words, perhaps the frequency with which southerly tracks dominated over northerly tracks has changed in the past and that may be related to the position of the thermal High over the main Asian continent. As you can see there are so many alternative explanations which I think would fit in with the data base that we have now, given the uncertainties in the data base and uncertainties in dating, that one can accommodate a lot of different people more or less independently thinking of different explanations. Then perhaps, with some luck, we can pick out key areas where new data can be used to distinguish between these different explanations. This is really what Rognon is doing, trying to pick out key areas which may be particularly sensitive to distinguish between one hypothesis or the other, and when we do things like that we begin to understand the climate system better. Not only do we understand the past climate system but we also understand the climate of today better. Our understanding there in this region, is really pretty weak, because we don't have particularly good data.

As people presented their data over the last few days I heard a number of points which I found particularly interesting, I'll just mention a couple of these: One of them is the question of short-timescale climatic excursions. In particular I'm talking about the late glacial fluctuations that might have occurred between say 13 and 10000 years ago, identified with names like Bölling, Dryas, Allerod, and so on, in the Western European context. Now these fluctuations were really major fluctuations in Western Europe and I believe they must have had an effect in the Middle East ane Eastern Mediterranean region. Just to show you how important these things were in Western Europe, remember that the change in climate from before to the beginning of the Allerod was about a 6 degree increase in summer temperature and about a 20 degree C increase in winter temperature in a timespan of maybe 1-200 years. These values are based on quantitative interpretations of beetle remains, by Dr. T.C. Atkinson. They are unpublished results but they agree with other people's qualitative results. They represent a very dramatic change and one wonders how it could have happened. I think the reason why we did get such a major change in Western Europe was associated with changes in the extent of sea ice in the North Sea area around England. I think that the boundary conditions for climate changed dramatically and rapidly in both directions about that time. Now if the boundary conditions did change so much, and I think that's the only way you can get such large climate changes in Western Europe, then that must have changed the circulation pattern considerably and those circulation pattern changes must have been felt downstream. The Eastern Mediterranean is not very far downstream. If we identify similar changes here in the Eastern Mediterranean, do you give them the same names, are they the same events? If they're not the same events then what caused the Eastern Mediterranean changes? I think they've got to be the same events.

Then one can go down to even shorter timescale variations and one thing that I thought was interesting was the single flood event (Brookes' paper) that occurred some time between 200 and

1000 ad and which perhaps can be identified with an historical flood that occurred about 640 ad. Just to tie a couple of things together and introduce a new data source I am going to quote from a paper by Gat and Magaritz. These are two isotope geochemists, and they are talking about something that occurred in the Sinai in 1974. "A recent example is the once in a hundred year flood which took place in the Sinai in 1974 and whose origin was traced by both synoptic and isotopic evidence to a freak northward intrusion of a tropical 'monsoonal airmass' into the Mediterranean climate region." This is interesting for two reasons. One is that I think that there is evidence that monsoon airmasses can reach up into this region even today and maybe more commonly at some times in the past. But when these things happened they were very unusual events, it wasn't something that happened every year, maybe every decade or century perhaps. However, I don't think that the monsoon ever had a general influence in the climate of this region.

The other interesting thing is the use of isotopic data. This leads me on to a more general problem, that of the multiplicity of factors which can determine the value of a proxy climate variable. In this region there is no proxy variable giving information about single climate variables, and in particular about temperature alone. Such a variable in Europe is beetle data, because beetles don't really care very much about the rainfall and the presence/absence of many species of Coleoptera depends on temperature alone: annual range and mean annual temperature. If we had data from both beetles and pollen, if the pollen says something about temperature and/or rainfall, you can then tie down the temperature with a variable like beetle presence/absence. This might then allow the rainfall information to be obtained unambiguously from the pollen. It's perhaps not possible to apply such techniques in the Eastern Mediterranean because there are no suitable beetle collections.

My general impression is that the data and the interpretations are very complicated. There seem to be a lot of contradictions, but this is a really promising position to be in because I think it's a general stage that scientific development goes through: a point where everyone is arguing with each other. This prompts workers to collect more and more data and think of more and more ideas, and suddenly the good ideas become obvious; and I think that is the stage that environmental interpretation, palaeo-climatic interpretation in the Middle East has got to now. Perhaps it's a pity that many individual regions are not so readily accessible today as they were recently.

VAN ANDEL: I hope that in our enthusiasm for climate we don't go so far that all archaeological phenomena will be seen as having climatic causes or perhaps climatic consequences. In fact as I think more and more about these things I am more and more inclined to make climatic explanation the last one that I would choose in a sequence of events, mainly because climate so often turns out to be so damned hard to prove.

BINTLIFF: I'm always worried when people say they are going to put things at the bottom of the list when surely we should be trying to integrate the various explanations. One point that I think hasn't really been raised is that all these cultures that we study or environments that we're working in existed with a certain type of climate and we cannot ignore trying to get some information on what that climate was. It seems absurd to forget the climate parameters. Although climate may not have been the crucial forcing factor, as I have pointed out earlier, it nonetheless sets the background conditions for the developments that we are looking at. So I think that all of us who are working on interdisciplinary projects must at least try and make some effort to look at the climatic parameters for these systems.

MOSILMANY: Just one comment on comparing the beetle data and the pollen data. I think the similarity between the pollen curves of Ioannina in Greece and the beetle curves from England are striking, they fit over each other beautifully.

WIGLEY: I wasn't really suggesting connecting beetle curves from England with pollen curves from Greece, I was just thinking of getting beetle data from the Middle East. The similarity you mention is interesting. If you are correct, the beetle data from Western Europe do show major changes in the global circulation pattern. Western Europe is a particularly sensitive area climatically because it's near the Atlantic (which is an important forcing region for global or hemispheric climatic changes). We can therefore expect West European data to give you some idea of general circulation changes. So perhaps if that beetle record is sufficiently smooth then it might tie in well with sufficiently smooth records from this part of the world as well. It's not surprising, but I'm always a little wary about correlating things like that for a couple of reasons. One is that I know that the dating is pretty risky and not particularly reliable and it's so easy to slide dates backwards and forwards a little bit, to make things fit. When one has a smooth curve with a lot of autocorrelation then the statistical significance of patterns that appear similar is low. It's very easy to get patterns which in fact are random and slide them around a little bit to make them fit.

OATES: As an ignorant archaeologist I think one of the most valuable things to be gained from this sort of symposium is simply to discover the difficulties and the limitations of the specialists' data. One listens to these people with such awe and tends at times to accept them without criticism. I think also that the specialists can learn from the archaeologists about the limitations of our own data and vice versa.