Charcoal Analysis

Methodological Approaches, Palaeoecological Results and Wood Uses

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Evidence for ancient forest cover and deforestation from charcoal analysis of ten archaeological sites on the Euphrates

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Abstract
Identifications of charcoal from ten sites along the Euphrates provide evidence for the presence of tree species which are rare or absent in the area today. This difference, between the charcoal evidence and modern day vegetation is seen to result from extensive deforestation. Evidence from forest remnants in isolated areas which provide information about vegetation history is discussed in the light of charcoal analysis. Although up to 20 taxa have been identified from these sites, three characteristic tree taxa, deciduous oak, *Pistacia* and *Amygdalus*, are given special attention because they are considered to be good markers.

Key-words: *Charcoal, Euphrates, Deforestation, Vegetation history*

Résumé
Les identifications de charbons de dix sites sur les rives de l'Euphrate ont montré la présence d'arbres, rares ou absents actuellement dans la région. Ces différences entre les indices anthracologiques et la végétation moderne sont interprétées comme les résultats d'une déforestation. Les indices de reliquats de forêts dans les régions isolées qui fournissent également des informations sur l'histoire de la végétation sont examinés en relation avec les données anthracologiques. Plus de 20 taxons ont été identifiés, mais seuls trois taxons chêne f. c. *Pistacia* et *Amygdalus* sont traités ici parce qu'ils sont considérés comme de bons marqueurs.

Mots-clés : *Charbons de bois, Euphrate, déforestation, histoire de la végétation, chêne, pistachier, amandier.*

Introduction

Degradation of the vegetation in the Near and Middle East is well known to field botanists who have frequently remarked on how several millennia of over-grazing and wood exploitation has severely diminished the forests. For example Zohary (1973, 653) wrote "thousands of miles of bare rocky hillside testify to the extreme ruination of the landscape....scattered single trees found far from woodland show how radical the destruction of the forest was". He goes on to say that "...man has introduced floristic and distribution changes that in their magnitude exceed by far those caused by Pleistocene climatic changes".

Deforestation is particularly severe in the Near East because regeneration is made difficult due to the aridity and more importantly, constant grazing, which kills off freshly germinated seedlings. Thus in areas where climatic conditions are severe with maximum pressure from herds, regeneration may not occur at all.

Botanists working on the contemporary vegetation were the first to comment on the deforestation. They noted isolated relic stands of trees in inaccessible areas and these were interpreted as the remains of extensive forests which had existed in the past. However the true extent of past forest cover and the chronological sequence of the destruction can only be evaluated by interpreting the results from analysis of fossil material.

While pollen diagrams obtained from lake sediments have provided evidence of vegetation history, sites where anaerobic conditions permit good pollen preservation are rare and limited to the higher rainfall and more mountainous areas such as the Anatolian highlands and the Zagros, or the Mediterranean regions. Further, accurate dates are not always available from these lake deposits. (Despite these areas of south-eastern Anatolia and inland Syria.) Most of these areas are devoid of trees today, but are within the areas of potential forest or forest steppe (Zohary, 1973).

Charcoal from archaeological sites provides a record of wood exploitation within a chronological framework even if sequences are incomplete. Unlike pollen data archaeological wood charcoal does not directly reflect the vegetation cover, it only provides information concerning the taxa used. Most charcoal comes from fuel for which there is less selection than for building timber. Fuel is generally collected from the nearest resources, thus the charcoal assemblages, to a greater extent, reflect the availability within the site catchment area. It is highly probable that for domestic fire wood availability played the most important role in terms of the choice of wood gathered; thus wood will be collected from the trees or shrubs nearest to the site, regardless of other factors such as combustibility.

In regions of the world where wood was readily available such as forested regions of northern Europe or the Mediterranean basin it has been rightly assumed that in the majority of cases charred wood found on archaeological sites represents locally available timber which was gathered not far from the sites and was essentially autochthonous. However in regions where local wood was scarce it may have been collected farther afield, and imported, or driftwood may have been used; thus finds may be allotochonous.

Present day vegetation and forest remnants

The area covered by this study includes two potential vegetation zones of the Irano-Turanian region which have been defined by the presence of isolated relic formations. The distribution of tree species in this area is strongly influenced by altitude. Thus one can distinguish a northerly high altitude zone (above 750 m a.s.l.) dominated by *Quercus brantii*. Here this species is at the extreme west of its distribution which extends east as far as the Zagros mountains. This zone also contains *Q. boisseri* which has a more

Mediterranean distribution. *Quercus brantii* is the most xeric of the deciduous oaks, penetrating further into the arid steppes than any other species of oak. In addition within this zone there are Mediterranean incursions in climatically favourable areas marked by the presence of *Quercus calliprinos*. However pollen analyses and charcoal studies clearly show that the evergreen oak expansion occurred in the mid to late Holocene (Willcox, 1999; Baruch, 1990; Baruch and Bottema, 1999; Jahns, 1990).

The second major zone is found at a lower altitude to the south (less than 900 m a.s.l.). It is dominated by *Pistacia atlantica* and *Amygdalus* spp. This is a forest steppe association with very open woodlands which today only exists in restricted areas. The best preserved example of this zone is to be found on the Jebel Abdul Aziz in north-east Syria between 700 and 850 m a.s.l. Apart from *Amygdalus* other members of the Rosaceae family are frequent components of both these vegetation zones, and include *Crataegus monogyna*, *C. syriaca*, *Pyrus syriaca*, *Prunus spinosa* and *P. microcarpa*. These species are difficult to identify precisely from wood charcoal and are not good markers. Below this zone one finds the true steppe dominated by short-lived annuals, and perennials such as *Artemisia*, various chenopods such as *Noaea mucronata* and grasses such as *Stipa*.

From the point of view of charcoal analysis three taxa, *Pistacia* sp., *Amygdalus* sp. and *Quercus* (deciduous oak) are good markers and are readily identified in the wood charcoal from archaeological sites. The presence/absence of these three taxa allows identification of the vegetation zones for the area concerned.

Archaeological sites

The archaeological sites discussed here range from the Natufian at Abu Hureyra in the extreme south to Middle Ages for the late samples from the Asvan area. Early

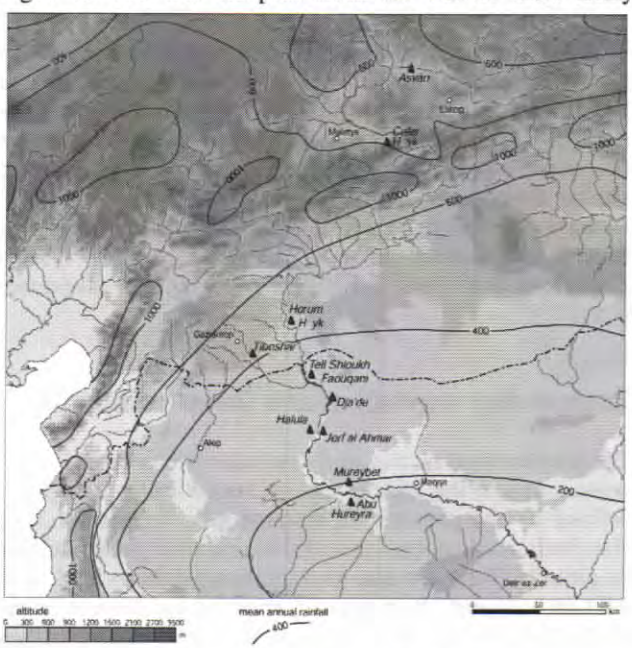

Figure 1: Site location map with contours and isohytes.

Site	Period	Country	Deciduous oak	*Pistacia*	*Amygdalus*
Abu Hureyra	Natufian	Syria	x	x	x
Asvan	Bronze/ Chalco	Turkey	xx	x	x
Cafer Höyük	PPNB	Turkey	xx	x	x
Can Hassan III	Neolithic	Turkey	x	x	x
Dja'dé	Early PPNB	Syria	x	x	x
Halula	Middle PPNB	Syria	x	x	x
Horum Hoyuk	Bronze / Chalco	Turkey	xx	x	x
Jerf al Ahmar	PPNA	Syria	x	x	xx
Mureybet	PPNA	Syria	x	x	x
Tell Shioukh Faouqani	Bronze Age	Syria	x	x	x
Tilbeshar	Bronze /Chalco	Turkey	xx	x	x

Table 1: Three characteristic taxa for ten sites on the Euphrates. Oak is more abundant at sites in Turkey while *Pistacia*/*Amygdalus* are more abundant on sites in Syria. Abundant = dominant taxa in the majority of samples.

Neolithic sites include Jerf el Ahmar, Mureybet, Dja'de, Halula and Cafer Höyük. Bronze Age sites include Tell Shioukh Faouquâni, Tilbeshar and Horum Höyük. The area defined by these sites has a climate which forms a gradation from the north-west to the south-east. Thus in the extreme south the average annual rainfall is 200 mm at Abu Hureyra, and in the extreme north it is 450 mm at Asvan (fig. 1).

The sites in question are found in areas which today are totally denuded and devoid of the three key species; yet these species represented by equivalent taxa (*Quercus*, *Pistacia* sp. and *Amygdalus*), have been shown to be present in abundance from charcoal identified at all the sites (tabl. 1). The ligneous vegetation in proximity to the sites today consists of a few spiny shrubs, riverine species and plantations of poplars and fruit trees.

Results

By comparing the distribution the presence the three species in the past with their availability in relation to the sites today, it is possible to assess ancient vegetation cover. In order to do this we will start by looking at the more northerly sites, which occur in what botanists consider to be areas of potential oak forest under present-day climatic conditions with a rainfall of more than 400 mm per annum. Then we will look at sites farther south where climatic conditions become progressively more arid as rainfall drops to below 250 mm and summer temperatures increase considerably. Here the vegetation becomes more xeric and more susceptible to over-exploitation.

Starting in the north four sites ranging from Chalcolithic to Medieval in the Asvan region are situated overlooking the flood plain of the Murat, a tributary of the Euphrates. Given the relatively high annual rainfall of between 400 and 450 mm the area could potentially support oak forests. The vegetation in the area today is extremely degraded with only a few spiny shrubs such as *Crataegus monogyna*, *Lycium*, and *Paliurus spina christi* growing locally around the sites. Deciduous oak charcoal was found from all periods at high

frequencies (Willcox, 1974). Oak is now very rare in the region. A small damaged stand still existed in 1973 at about nine kilometres from Asvan, but at a considerably higher altitude. Asvan is situated at about 750 m a.s.l. and the oak trees were found at between 1100 and 1200 m a.s.l. This relic formation occurred on a north-facing slope and in 1973 had not been exploited for some time. It covered less than a hectare. Given that there is good evidence for long-term exploitation of oak in the region during several millennia it is inconceivable that this small area of forest could have withstood this kind of long-term exploitation. Thus it appears that oak forests had a much wider distribution in the past and were progressively degraded. In practice it was not possible to trace the degradation over time from the archaeobotanical data. But it was demonstrated that when the site was first occupied the area would have been dominated by deciduous oaks with the assemblage of lesser species such as *Celtis*, *Pistacia*, *Acer* and *Juniperus*. The trees nearest the sites would have been the first to be exploited and then deforestation progressively expanded as the inhabitants were forced to gather their wood farther and farther from the settlement. In the late Medieval period there is evidence of imported wood with the presence of pine, which with willow and poplar began to replace the oak.

Eighty kilometres further south from Asvan charcoal was recovered from the ninth millennium BP (non cal.) neolithic site of Cafer Höyük which is situated on the Euphrates north-east of Malatya (Willcox, 1991). Rainfall is lower than at Asvan and year-round temperature somewhat higher. Only eleven taxa were definitely identified. Willow and poplar combined make up about 50% of the charcoal. Deciduous oak charcoal made up about 35% indicating that oak was a frequently used fuel. Given that oaks almost always are dominants they no doubt formed an important component in the local vegetation. No oaks occur locally in the region today but again this site is well within the potential range of deciduous oak forest. While *Pistacia* and *Amygdalus* were rare at Asvan, these two taxa are more common at Cafer Höyük, which probably reflects its more southerly position and lower altitude compared to the Asvan sites. Riverine species such as poplar, willow and plane would have been locally available on the banks of the Euphrates. Thus the evidence from this site shows that the post-glacial treeless steppe (van Zeist and Bottema, 1982),was colonised by oaks before the ninth millennium BP.

As we move further south we enter a less continental climate, where today Mediterranean species can penetrate from the west, notably the evergreen oak *Quercus calliprinos*. The distribution of the evergreen oak extends from the Mediterranean but does not occur much further east than Gazintape, some 15 km north of which we leave behind the last evergreen oaks. Further south at lower altitudes conditions become hotter and drier. The banks of the Euphrates and the Sajour (a western tributary of the Euphrates) provide a habitat for a rich riverine vegetation. This area is agriculturally rich with extensive dry farming of cereals and pistachio production on a large scale. During the Bronze Age these rich lands were also extensively exploited judging from the high density of archaeological sites of this period in the area.

Charcoal from two Bronze Age sites in this area are in the process of being studied by Hugues Pessin for his PhD thesis: Tilbeshar (Kepinski-Lecompte and Ergec, 2000), situated on the Sajour, and Horum Höyük (Marro *et al.* 2000), situated on the banks of the Euphrates. At both sites Chalcolithic and Bronze Age levels were sampled and preliminary studies indicate that oak charcoal is present at very high frequencies. These sites occur in an area with less than 350 mm of rain per annum and are at the very limit of the present-day distribution of *Quercus brantii*. During the June 2000 campaign at Tilbeshar, I made a number of field excursions in this area in order to discover the most southerly stands of *Q. brantii*. Deciduous oak charcoal had already been found at sites in Syria dated to the Natufian, the Neolithic and the Bronze Age. It was therefore of paramount importance to locate the nearest present-day stands of deciduous oak. In 1995 I had extensively surveyed the Syrian side of the frontier and it was clear that deciduous oaks were only to be found in the extreme north-westerly corner of Syria in the regions of higher altitude and rainfall. Mixed Mediterranean forests of *Q. boisseri* and *Q. calliprinos* can be found starting at an altitude of 1000 m north west of Efrine where a combination of cooler conditions and higher rainfall favours their growth. Thus during the June 2000 campaign at Tilbeshar it was a great surprise to find two stations of *Q. brantii* just eighteen kilometres north of Jerablous on the Turkish-Syrian border. The relic stands were found at between 800 and 900 m a.s.l. (fig. 2). To my knowledge they have not been described before and represent the extreme southern limit of *Quercus brantii* in this region. They consisted essentially of *Q. brantii*, but two species of *Amygdalus*, *Crataegus syriaca*, *Prunus microcarpa*, *Celtis tournifortii*, *Rhamnus* sp, *Jasminum* sp., *Rhus sumac* and *Cotinus cogiggia* were also present.

Preliminary studies have demonstrated that Tilbeshar and Horum Höyük have abundant deciduous oak charcoal, and even some acorns were recorded from Horum Höyük. The small surviving stands of oaks in the area appear to represent the last relics of a much more extensive oak forest which has been progressively degraded since the Bronze Age. Given the density of archaeological sites in this area and the very limited amount of oak available today it appears highly probably that oak forests covered much of this area in the past.

Figure 2: A mature specimen of deciduous oak (*Quercus brantii*) in an isolated stand near the turkish village of Akkuyu, 18 km north of the Syrian border. This region is largely deforested but archaeological sites have produced large quantities of oak charcoal indicating that oak forests were far more widespread in the Bronze.

Moving still farther south we leave behind the present-day habitat of *Q. brantii* and move into the treeless steppe zone of northern Syria, dominated in many areas by *Artemisia herba alba* and *Noaea mucronata* (fig. 3). Here the climate again becomes progressively more arid with higher summer temperatures leading to conditions less favourable to tree growth. Away from the Euphrates valley no tree species are to be found. Within the valley and side valleys favourable micro-habitats consisting of inaccessible north-facing cliffs support occasional shrubs of *Pistacia palestina*, *Celtis tournifortii*, *Ficus carica*, *F. palmata*, *Prunus microcarpa*, and *Rhamnus palestina*. These shrubs are extremely rare and their dispersal into these special ecological niches are probably due to migratory birds.

Charcoal from the site of Tell Shioukh Faouquâni near the Turkish-Syrian border is being studied by H. Pessin (see this volume). Here the frequencies of oak charcoal for the Bronze Age are low compared to the riverine species; higher frequencies in the Iron Age may be due to importation for iron smelting. Otherwise the inhabitants relied on local riverine species for fuel.

Moving again farther south to the more arid steppes of northern Syria (fig. 3), the analysis of wood charcoal, charred seeds and fruits at one late Pleistocene and four early Holocene sites situated on the Euphrates have shown that during these periods the *Amygdalus* and *Pistacia* forest steppe association was present in this area (Hillman, 2000; Roitel, 1997; Roitel and Willcox, 2000; Willcox, 1996; Willcox and Fornite, 1999). Oak charcoal was present at all sites but at low frequencies. A rich riverine assemblage made up by far the most important proportion of the charcoal from these sites and consists of *Populus euphratica*, *Salix* sp., *Tamarix* sp., *Fraxinus* sp., *Platanus* sp., *Alnus* sp., and *Vitis sylvestris*. Fruits of another riverine taxa, *Vitex agnus castus* were found at Jerf el Ahmar. It is striking that all but the first three of these taxa have disappeared from the Syrian Euphrates and neither of the forest steppe species occurs in the area.

Figure 3: The valley of the Euphrates today is totally denuded. Only a few remnants of the riverine species remain and unfortunately these are disappearing under lakes formed behind the recently constructed dams.

Figure 4: The Jebel Abdoul Aziz in north-east Syria has a remnant of a forest/steppe association with a species of wild pistachio (*Pistacia atlantica*) and a species of wild almond (*Amygdalus orientalis*). Fruits and charcoal of these two species have been found in abundance on neolithic sites along the Euphrates some 160 kms to the west. This is the nearest living example of this association.

The corroborative evidence from charred fruits further implies that *Pistacia* and *Amygdalus* were gathered locally. As we have seen these two species form a very open forest/steppe. The nearest example today is found on the Jebel Abdul Aziz 160 kilometres to the east (fig. 4). The low density of wood in this association explains the high frequencies of local riverine species. The finds of oak are more problematic. Hillman has suggested that the oaks may have colonised the side valleys in favourable habitats during the cooler, moister Natufian period (Hillman, 2000). Arguments in favour of local oaks include the finds from Halula some four kilometres up a side valley. Also small charred twigs of oak (Roitel, 1997) have been found which do not easily survive the abrasive action of the river as trees float down. Mountain species such as the conifers, which occur for example in the Taurus, have not been found suggesting that the gathering of driftwood was not a regular activity. However the possibility that oak was collected as driftwood must be considered.

Driftwood exists because as rivers cut into their banks and change their courses they undermine trees which then fall into the river. Flow rates recorded on the Euphrates in Syria show clearly that seasonal floods were particularly strong due to the thawing of winter snows in the mountains of Anatolia coinciding with the spring rains. During August, September and November the average flow is between 200 and 300 cubic meters per second while at the peak season during March, April and May the average flow was around 2000 cubic metres per second and could be even double that (Willcox and Roitel, 1998). Thus the availability of driftwood would have been seasonal. Sites situated at some distance from the river, for example Tilbeshar and Halula, would rely less on the river as a source of fuel and timber. In general the lack of mountain species such as the conifers from the Taurus suggests that systematic collection of driftwood was not the general practice. In summary, oak charcoal found at the sites in Syria may have originated 1) from occasional trees, which occupied favourable habitats with deep soils in the side valleys, during moister periods such as

the Younger Dryas, and/or 2) from driftwood brought down from Anatolia. No charred acorns have been found on these sites.

Conclusion

In conclusion, charcoal evidence confirms that both the *Quercus brantii* forests in Turkey and the *Pistacia atlantica/Amygdalus* forests-steppe associations in Syria were much more widespread in the past and that they appear to have extended into lower altitudes. From the archaeological point of view this is important because it shows that when these sites were occupied these areas were more heavily wooded with much richer vegetation compared to the desolate over-grazed steppes that we see today. These habitats may also have been rich in wild cereals and so these results have a bearing on the origins of agriculture. Faunal remains confirm more wooded conditions north of the Syrian frontier during the Bronze Age. At Tilbeshar the principal animals hunted were stag deer and roe deer, whereas further south gazelle and onager, which prefer a more open habitat, were the commonly hunted species for the Neolithic period.

In order to fully understand the vegetation history of this area we need to trace in more detail the chronological advance and retreat of the forests and to determine whether changes are due to climatic or human impact. At present climatic oscillations such as the Younger Dryas are not reflected in the charcoal sequences. Some palaeoenvironmentalists might tempt to interpret these results in terms of climatic change; however, anthropogenic desertification, essentially through over-grazing leads to destruction of the vegetation and increased erosion, which in turn leads to more aeolian activity. In addition, trampling by herds will exaggerate these effects. It is thus cleat that human factors played an important role. The role of climatic change is difficult to assess with the present data.

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