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Vegetation and plant exploitation at Mentesh Tepe (Azerbaijan), 6th–3rd millennium BC initial results of the archaeobotanical study

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ABSTRACT

The study of several types of botanical remains from the site of Mentesh Tepe, Azerbaijan, has provided the first data on the vegetation cover and the exploitation and use of plant resources from the Neolithic to the Early Bronze Age in this part of the Kura River Basin. Riparian woodlands constitute the main fuel source throughout the occupational sequence. However, wood was also exploited in relatively open woodlands characterised by the presence of a dozen shrub and tree species, among them oak, hornbeam, buckthorn, wayfaring-tree, maple and lime. Most seed and fruit remains correspond either to crops, such as cereals (barley, wheat) and pulses (lentil, grass pea), or to weeds and ruderal plants. The analysis of phytoliths shows that cereals were treated (de-husked) on-site. Very few fruits were found in the botanical record.

1. Introduction

The Caucasus region, situated between the Black and Caspian Seas, encompasses almost 600 000 km^2 on the border between Europe and Asia. Due to a contrasted relief, with the presence of several high mountain chains, and its location at the meeting point between different climatic and biogeographic systems, this region hosts an exceptional biodiversity with numerous endemic plant and animal species (Myers et al., 2000). From a phytogeographical point of view, the southern part of the Caucasus – or Transcaucasia – is located on the boundary between two main floristic units: the Euro-Siberian region to the north and the Irano-Turanian region to the south (Zohary, 1973). The present day territories of Azerbaijan, Georgia and Armenia have long been recognised as one of the Asian centres for crop diversity (Vavilov, 1926/1992) as well as for hosting the wild ancestors of many plants that were domesticated in south-west Asia in the past (Gabrielian and Zohary, 2004). This region was potentially, therefore, the scene of ancient plant domestication and diversification, involving both perennial plants (mainly fruit trees) and annual crops (cereals, pulses etc.).

Despite being of interest from both a plant geographical and palaeo-agronomical point of view, to date the southern Caucasus has been the subject of relatively few systematic archaeobotanical studies. Early works, published in the 1970s and 1980s, are rather limited in scope and are not sufficiently linked to the archaeological contexts from which the studied plant remains were retrieved (Lisytsyna and Prischepenko, 1977; Gorgidze and Rusishvili, 1984; Yanushevich and RusishviliSh, 1984). Recently, several more extensive studies have been published and allow the scientific community to study in greater detail questions of ancient plant husbandry (Wasylikowa et al., 1991; Gandilyan, 1998; Badalyan et al., 2007; Connor and Sagona, 2007; Badalyan et al., 2008; Hovsepyan and Willcox, 2008; Badalyan et al., 2010; Hovsepyan, 2010, 2011a, 2011b, 2013; Ristvet et al., 2011; Areshian et al., 2012; Decaix, 2012; Guliyev and Nishiaki, 2012; Kalantaryan et al., 2012; Wilkinson et al., 2012; Kakhiani et al., 2013; Messager et al., 2015). However, these studies only concern certain parts of Transcaucasia and cover a very small portion of the long and rich occupational history of this region. To date, most studies have focused almost exclusively on the analysis of seed

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remains, while studies of other types of archaeobotanical remains, such as charcoal and phytoliths, remain rare for this part of South-West Asia. In the present paper, we aim to reconstruct the vegetation cover and the plant husbandry activities at the site of Mentesh Tepe, from the 6th to the 3rd millennium BC, by combining the analysis of botanical macroremains (seeds, fruits, wood) and phytoliths.

Using this multidisciplinary approach, several research issues can be addressed: What was the nature of plant formations in the environs of the site in the past? Did they differ much from the vegetation that we observe in the area today? Did they change over time as a result of human activities and/or climatic change? Which wild resources were exploited and from where? What plants were cultivated and how? And what can we say about the treatment and use of plant resources within the prehistoric village?

2. The site of Mentesh Tepe

Mentesh Tepe, in the Tovuz district of western Azerbaijan, is situated approximately 1 km from the Zeyem Cay, one of the left bank tributaries of the Kura River. The foothills of the Lesser Caucasus mountain chain are located less than 10 km to the south (Fig. 1). The site was first surveyed in the 1960s and dated to the Chalcolithic period (Narimanov, 1987). In the 1970s the mound was partly destroyed by levelling prior to the planting of a vineyard. A survey carried out in 2007 showed, however, that structural remains were still relatively well preserved under the surface. Since 2008 six excavation campaigns have been undertaken at Mentesh Tepe, under the direction of B. Lyonnet (UMR 7192–CNRS) and F. Guliyev (Institute of Archaeology and Ethnology, Baku). These excavations have revealed a succession of occupational phases spanning a period of almost 3500 years, from the Neolithic to the Early Bronze Age (Lyonnet et al., 2012).

The first occupation is dated to the first half of the 6th millennium BC and is characterised by a village of circular houses related to the Shulaveri-Shomu culture. The associated material culture includes, for example, obsidian and bone tools as well as pottery with vegetal temper. The second period of occupation identified at the mound belongs to the Chalcolithic period with an early phase dated to the first half of the 5th millennium BC. Unfortunately, no architectural remains are securely associated with this phase that, in general, appears to be poorly represented on the site. After a short hiatus in occupation, a second phase of Chalcolithic occupation (2nd half of the 5th mill. BC) is characterised by rectangular mud-brick houses and a rich and varied material culture. The last period is attributed to the Early Bronze Age and covers different phases that are mainly represented by funerary architecture. A collective burial under a *kurgan* is attributed to Phase I of the Kura-Araxes (KA) culture (2nd half of the 4th millennium BC). Several individual burials, pits and hearths belong to Phase II (1st half of the 3rd millennium BC) and another kurgan burial as well as pits are linked to the third phase, i.e. the Martkopi phase of the Early Kurgan culture (*c.* 2400 BC).

3. Present-day vegetation

Mentesh Tepe is situated at the northern edge of the modern village of Ashagi Ayibli and is surrounded by habitations, gardens and dirt roads. Wheat, potatoes and corn are cultivated in open fields; fruit trees and grape vines are grown in orchards. Animal herding is also important with sheep grazing taking place in open areas to the north of the site. While the vegetation around the site is highly shaped by human activities and consists, to a large extent, of cultivated and ruderal elements, better-preserved formations are to be found at some distance, in particular on the slopes and on higher altitudes of the Lesser Caucasus.

Open shrublands, locally called *shibliak*, develop on dry slopes at lower altitudes. They are dominated by Christ's thorn (*Paliurus spina-christi*) which is found growing in association with Pallasii buckthorn (*Rhamnus pallasii*), wild plum (*Prunus divaricata*), hackberry (*Celtis glabrata*), maple (*Acer ibericum*) and other shrub species. At higher altitudes, between 800 and 1300 m, the *shibliak* vegetation transforms into open woodlands where juniper (*Juniperus* spp.), oak (*Quercus* spp.) and pistachio (*Pistacia atlantica*) grow together with wayfaring-tree (*Viburnum lantana*), wild apple (*Malus orientalis*), wild pear (*Pyrus salicifolia*), buckthorn (*R. pallasii*), *Sorbus* spp., hackberry (*Celtis* spp.), pomegranate (*Punica granatum*) and hornbeam (*Carpinus* ssp.) (Gabrielian and Fragman-Sapir, 2008).

Mixed forests have a wide distribution in the southern Caucasus between altitudes of 550 m–2300 m. Several species of oak, such as *Quercus iberica* or *Quercus robur*, characterise the lower altitudinal

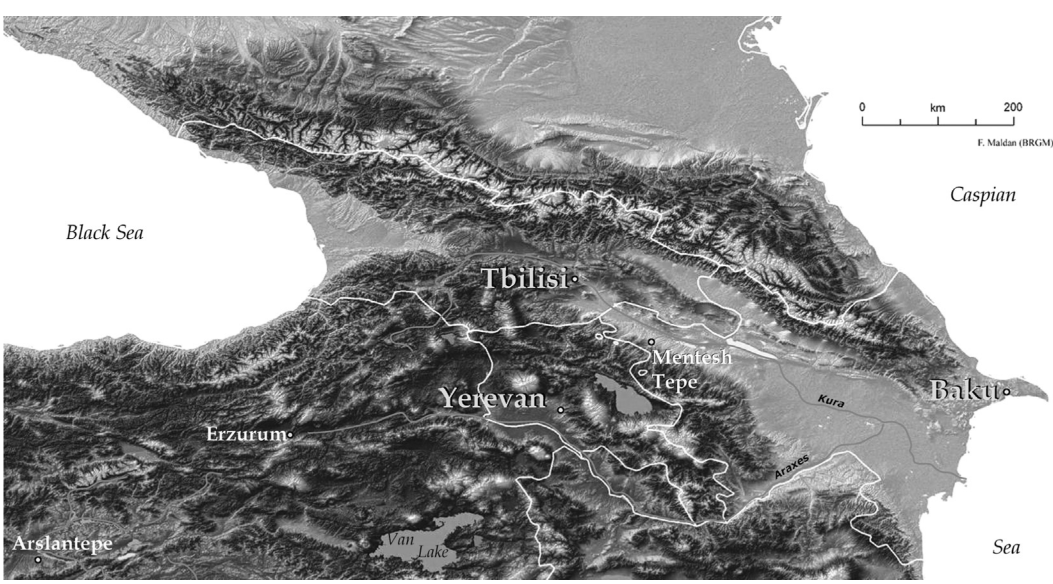

Fig. 1. Map showing the location of Mentesh Tepe.

belts (under 1400 m). Higher altitudes are characterised by the presence of *Quercus macranthera*, associated with yew (*Taxus baccata*), hornbeam (*Carpinus* spp.), *Sorbus* spp., maple (*Acer* spp.) and lime (*Tilia* spp.) Other frequently found trees at higher altitudes are dogwood (*Cornus mas*) and birch (*Betula* spp.) (Gabrielian and Fragman-Sapir, 2008).

Finally, along rivers on the lower alluvial plain, riparian forests develop with the main elements belonging to the willow (or Salicaceae) family such as *Salix excelsa*, *Populus tremula*, *Populus nigra* and, along the Araxes River, *Populus euphratica*. Tamarisk (*Tamarix ramosissima*) is also well represented in this habitat. Other hygrophilous species that can be found along the rivers are alder (*Alnus glutinosa*) and climbers like ivy (*Hedera helix*) and wild grape (*Vitis vinifera* subsp. *sylvestris*). On the higher parts of the alluvial plain, hardwood forest predominates featuring pedunculate oak (*Q. robur*), elm (*Ulmus laevis* and *Ulmus minor*) and ash (*Fraxinus rotundifolius*) (Bohn et al., 2003; Gabrielian and Fragman-Sapir, 2008).

4. Material and methods

Sampling for archaeobotanical remains was carried out during the excavations conducted at Mentesh Tepe between 2008 and 2013. This paper focuses on evidence from domestic structures: no archaeobotanical data from funerary structures will be presented.

Sediment samples containing charred macro-remains were collected from various Neolithic and Chalcolithic contexts, preferentially with a high ash content, such as pits, hearths and occupational layers. For the Early Bronze Age period, only the fill from one pit has been considered in this study (structure 190). Charred macro-botanical remains were extracted from the archaeological sediments using the flotation method, with a sieve mesh size of 0.5 mm. A total of 1060 l of sediment were floated. Sizes of the sediment samples range between 0.1 l and almost 200 l. The sorted light fraction, after drying, represents 3305.5 ml.

Within the laboratory, charcoal fragments were fractioned manually for anatomical observation along three wood sections (Schweingruber, 1990; Chabal, 1997). Sizes of charcoal fragments studied range between 0.5 cm and 2 cm. The fragments were studied under an optical reflected-light microscope (×50–×1000) and identified using reference collections of modern temperate, Mediterranean and Near Eastern woods as well as descriptions in wood anatomy atlases (Schweingruber, 1990; Parsa Pajouh et al., 2001; Benkova and Schweingruber, 2004; Schweingruber et al., 2011). Taxa were identified as precisely as possible, most often to the genus level, but in some cases it was not possible to distinguish between two different taxa, for example between willow (*Salix*) and poplar (*Populus*) in the willow (Salicaceae) family or between *Paliurus* and *Ziziphus* in the buckthorn (Rhamnaceae) family. Difficulties in botanical identification are most often due to similarities in the cellular structure between two closely related species. Sometimes the general state of preservation can also have an influence on the degree of precision that can be obtained. Whenever a new taxon was identified in an archaeological sample from Mentesh Tepe, a further 50 charcoal pieces from the same sample were examined in order to increase the chances of discovering the entire spectrum of wood species used at the site (Salavert et al., 2014).

Seeds and fruit remains were identified with the help of a binocular microscope allowing ×10 magnification. As was the case for the charcoal study, a reference collection of Near Eastern seeds and comparison atlases were used for the identification of archaeological samples (Berggren, 1981; Jacomet, 2006; Nesbitt and Goddard, 2006; Cappers et al., 2009, 2012; Neef et al., 2012; Cappers and Bekker, 2013).

Samples used to extract phytolith assemblages were collected from two different profiles:

- The entire section of Structure 336, a large Neolithic pit dated by 14C radiometric dating (SacA 31997/Gif-12993 and SacA 31998/Gif-12994) to the first half of the 6th millennium BC (5838–5671 and 5784–5636 cal. BC respectively), allowing a diachronic perspective of the phytolith composition of assemblages;
- The northern excavation baulk, where four different structures were concerned, one of which dates to the Neolithic, two to the Chalcolithic and one to the Early Bronze Age.

Phytoliths were extracted from sediment samples using HCl and H_2O_2 baths, sieving, clay removal and densimetric separation (Lentfer and Boyd, 1998). After cleaning, the residue was suspended in glycerine, mounted on slides and observed under a microscope at 600× magnification. Each phytolith was classified according to its morphology, following several systems (Twiss et al., 1969; Mulholland, 1989; Fredlund and Tieszen, 1994) and the International Code for Phytolith Nomenclature (ICPN Working Group et al., 2005). Based on the existing literature, the phytoliths were classified into 12 different categories (Table 1, see Messager et al., 2010a): (1) elongate, (2) elongate dendritic, (3) acicular, (4) bulliform, (5) rondel and trapeziform short cells, (6) sinuate trapeziform, (7) bilobate, (8) saddle, (9) Papillae, (10) cylindric sulcate, (11) globular, (12) point-hair. Phytolith assemblages were calculated as a percentage of the sum of classified phytoliths. Silica skeletons, corresponding to fragments of silicified Poaceae epidermis, were also identified and counted. This group is divided into silica skeletons from inflorescences and silica skeletons from grass leaves and stems (Fig. 2).

At this stage of the excavation, it is not yet possible to attribute the archaeobotanical samples to a specific phase within the Neolithic, Chalcolithic or Early Bronze Age. Therefore, the results presented below are expressed in terms of the main periods without taking into account variations between occupational phases.

5. Results and interpretations

5.1. Results of the charcoal analysis

The analysis of 1402 charcoal fragments from Mentesh Tepe has allowed the identification of 19 ligneous taxa (Figs. 3 and 4). Although the study of charcoal fragments reflects a human choice, it nevertheless allows us to reconstruct the palaeoenvironment of the site, even if this reconstitution has its limits (Chabal, 1997). The taxa are presented below, together with their ecological requirements, in advance of a wider discussion on the past vegetation formations that can be identified from the environs of the site and their possible changes through time.

Trees belonging to the Salicaceae family (Fig. 3c) – poplar (*Populus*) or willow (*Salix*) – as well as elm (*Ulmus*) constitute the main taxa identified for all of the studied periods. These two taxa represent more than 66% of the total charcoal assemblage. Although the anatomical structure of elm is close to the anatomy of hackberry or zelkova, it appears that in this case we are dealing with elm (homogeneous rays, absence of storied parenchyma).

Other taxa are more or less significant depending on the period. Thus, hoarwithy (*Viburnum*) and hornbeam (*Carpinus*, Fig. 3b) are relatively well represented during the Neolithic period (9.7% and 7.1% of the identified charcoal fragments respectively), whereas maple (*Acer*, Fig. 3a) and ash (*Fraxinus*) are more frequent in the Chalcolithic period (9.9% and 8.9% respectively).

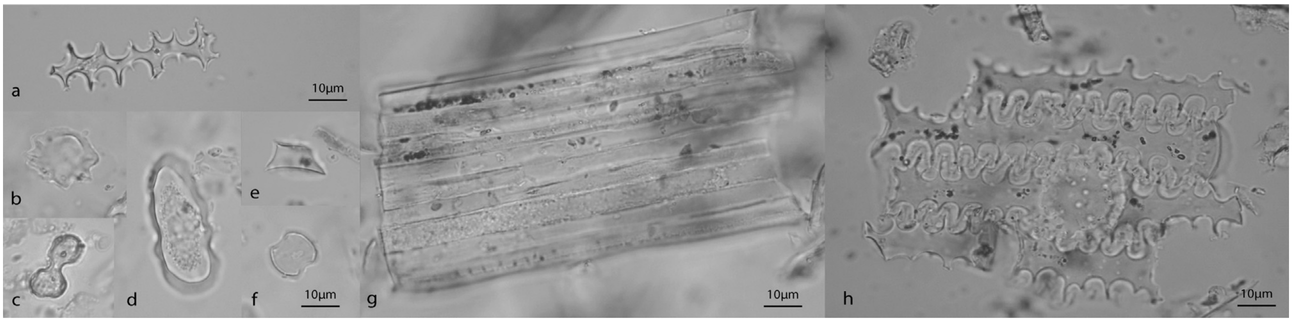

Fig. 2. Phytoliths identified in Mentesh Tepe: a. elongate dendritic, b. papillae, c. bilobate, d. sinuate trapeziform, e. rondel, f. saddle, g. silica skeleton from grass leaves and stems, h. silica skeleton from grass inflorescences (composed of dendritic cells).

However, most of identified taxa are represented by less than 5% of the charcoal fragments. This is the case for tamarisk (*Tamarix*), Russian olive (*Elaeagnus angustifolia*), reed (cf *Phragmites*), grapevine (*Vitis vinifera*, Fig. 3d), buckthorn (*Rhamnus*), trees from the Rosaceae family (Maloideae and Prunoideae), elder (*Sambucus*), probably Christ's thorn (*Paliurus* or *Ziziphus*), juniper (*Juniperus*), dogwood (*Cornus*), oak (*Quercus*) and lime (*Tilia*).

According to the ecological requirements of the identified taxa, at least two different vegetation types seem to have been exploited for fuel during the occupation of Mentesh Tepe. An overwhelming majority of the charred wood fragments belongs to hygrophilous taxa that would have grown near water. Poplar/willow, elm, tamarisk, ash, Russian olive, reeds and grapevine are all elements of the gallery forests and represent between 79% and 90% of the identified charcoals, depending on the period.

The other taxa identified from the site are more difficult to situate within a precise plant formation as many of them could grow in hardwood alluvial forests, *shibliak* formations and in relatively open woodlands. Some trees, such as hornbeam, maple and lime, could even have been exploited in deciduous forests (Bohn et al. 2003; Gabrielian and Fragman-Sapir, 2008).

The inhabitants of Mentesh Tepe primarily exploited wood resources from the gallery forest, that probably grew close to the site, and secondarily turned to shrub- and woodlands on higher ground, perhaps even in the foothills of the Lesser Caucasus. In general, the vegetation cover around the site in the past appears to have been richer in woody species – shrubs, trees and lianas – than it is today.

Table 1
Phytolith morphotypes (following ICPN Working Group et al., 2005) identified in Mentesh Tepe, with their taxonomic attributions and the corresponding literature.

Morphotypes	Main taxonomic attribution	Bibliography
Elongate	Poaceae	Twiss et al., 1969 (elongate)
Elongate dendritic	Poaceae	Ball et al., 1996 (dendriform)
Acicular	Poaceae	Twiss et al., 1969 (point-shaped)
Bulliform (cuneiform & parallelepipedal)	Poaceae	Twiss et al., 1969 (fan-shaped)
Papillae	Poaceae	Rosen, 1992 (papillae)
Rondel & trapeziform short cells	Poaceae, Pooideae	Fredlund and Tieszen, 1994 (keeled, conical, pyramidal)
Sinuate trapeziform	Poaceae, Pooideae	Mulholland, 1989 (sinuate)
Bilobate	Poaceae, Panicoideae/ Arundinoideae	Brown, 1984 (bilobate)
Saddle	Chloridoideae	Mulholland, 1989 (saddle)
Cylindric sulcate	cf Dicotyledonous	Strömberg, 2002 (tracheid)
Globular	cf Dicotyledonous	Runge, 1999 (spherical)
Point-hair	No taxonomic value	Pearsall, 2000 (hair cell)

Even though many of the identified taxa are present throughout the occupational sequence, there are differences from one period to the other. While the taxonomic diversity is highest for the Chalcolithic it should be kept in mind that this period is also represented by the highest number of studied fragments (734 *versus* 334 for the Neolithic and 334 for the Early Bronze Age). The importance of hornbeam and hoarwithy in the Neolithic may suggest a more wooded environment. Inversely, the increase in maple and Christ's thorn in the Early Bronze Age could be an indication of the development of drier *shibliak* formations caused by increasing anthropogenic impact. The absence in this period of several woodland taxa, such as hornbeam, dogwood, oak, buckthorn, lime and hoarwithy also seems to be significant and may indicate a depletion of forests and the opening up of the immediate surroundings during the last period of occupation. However, the rather broad ecological requirements of many of the taxa, together with the difficulty in pushing the identifications beyond the genus level, do not allow us, at this stage, to confirm these hypotheses.

The presence of juniper wood is of particular interest as this taxon was used to build the roof of the funerary chamber of the *kurgan* associated with the Martkopi culture.

5.2. Results of the analysis of seed and fruit remains

Almost 16 000 remains of seeds and fruits have been studied from Mentesh Tepe and these have allowed the identification of cultivated and wild taxa (Table 2). Among the crops, cereals are by far the most frequently encountered plants, in the form of both grain and chaff remains (glumes, rachis segments). Three main taxa can be identified: barley (*Hordeum vulgare*, Fig. 5b), emmer wheat (*Triticum dicoccum*) and a naked wheat type (*Triticum aestivum/durum*, Fig. 5a). When sufficiently well preserved, the barley grains present longitudinal scars on their sides, indicating hulled barley, the inner glumes of which remain attached to the grain even after threshing.

Emmer wheat grains are flat on the ventral side and convex on the dorsal side. Some rachis segments may be attributed to hulled wheat but their level of preservation does not allow them to be identified as such with certainty. As no einkorn grains (*Triticum monococcum*) were found, we surmise that they could belong to the emmer wheat type.

Grains of naked wheat are rather short and roughly rectangular in shape. The distinction between bread wheat (*Triticum aestivum*) and hard wheat (*Triticum durum*) can mainly be made through the study of rachis fragments. Unfortunately, in this case, the level of preservation of the remains has meant that this has not been possible.

Lentil (*Lens culinaris*, Fig. 5c) and grass pea (*Lathyrus sativus*) have been identified among the pulses. Poor preservation of some

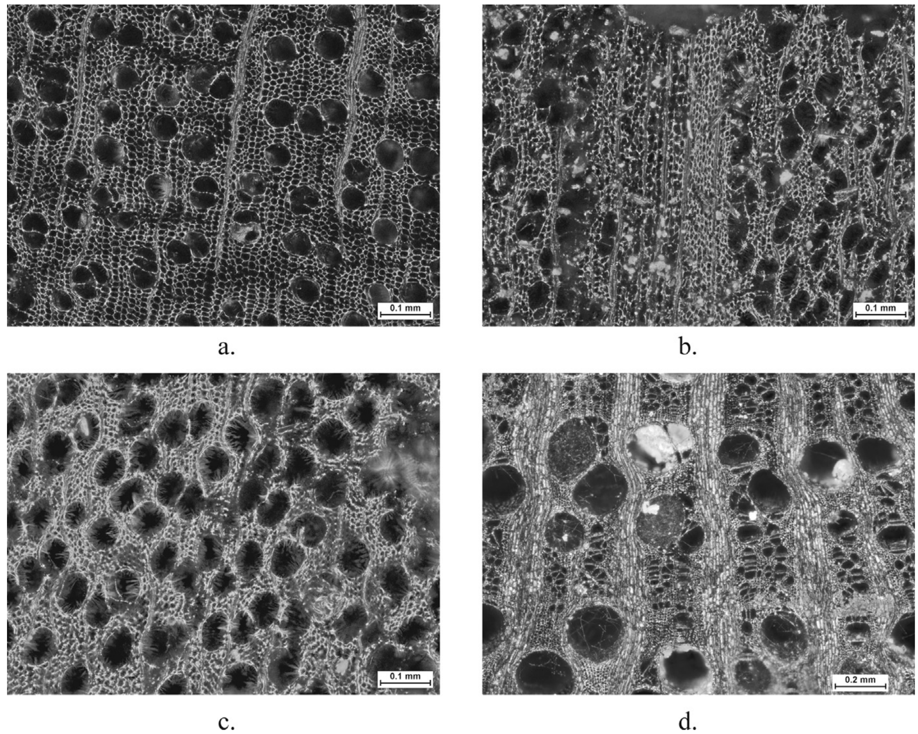

Fig. 3. Transversal sections of some wood taxa identified in Mentesh Tepe: a. *Acer*, b. *Carpinus*, c. *Populus/Salix*, d. *Vitis vinifera*.

seeds and in particular the disappearance of the diagnostic *hilum* (scar of attachment point of the seed to the pod) prevent the precise identification of many spherical pulses (here named *Pisum/Vicia*).

The presence of flax (*Linum usitatissimum*, Fig. 5d) is attested, but this plant is probably underrepresented in the archaeobotanical record because of charring, leading to the bursting of the oily seeds (Cappers and Neef, 2012). Flax could have been used to produce textiles using the stem fibres or edible oil extracted from the seeds (Zohary et al., 2012).

Three fruit tree species have been identified in the samples: caper (*Capparis*), hackberry (*Celtis*) and grape (*Vitis vinifera*). However, they represent less than 1% of the total identified remains.

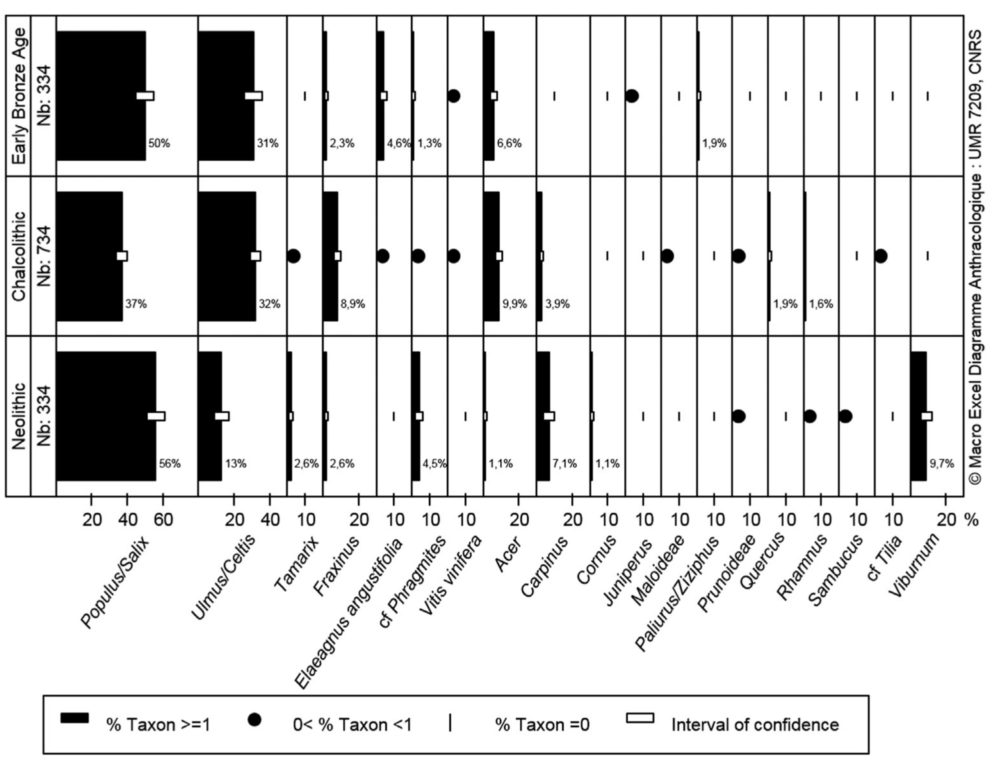

Fig. 4. Charcoal assemblages from Mentesh Tepe. Nb: number of charcoal fragments.

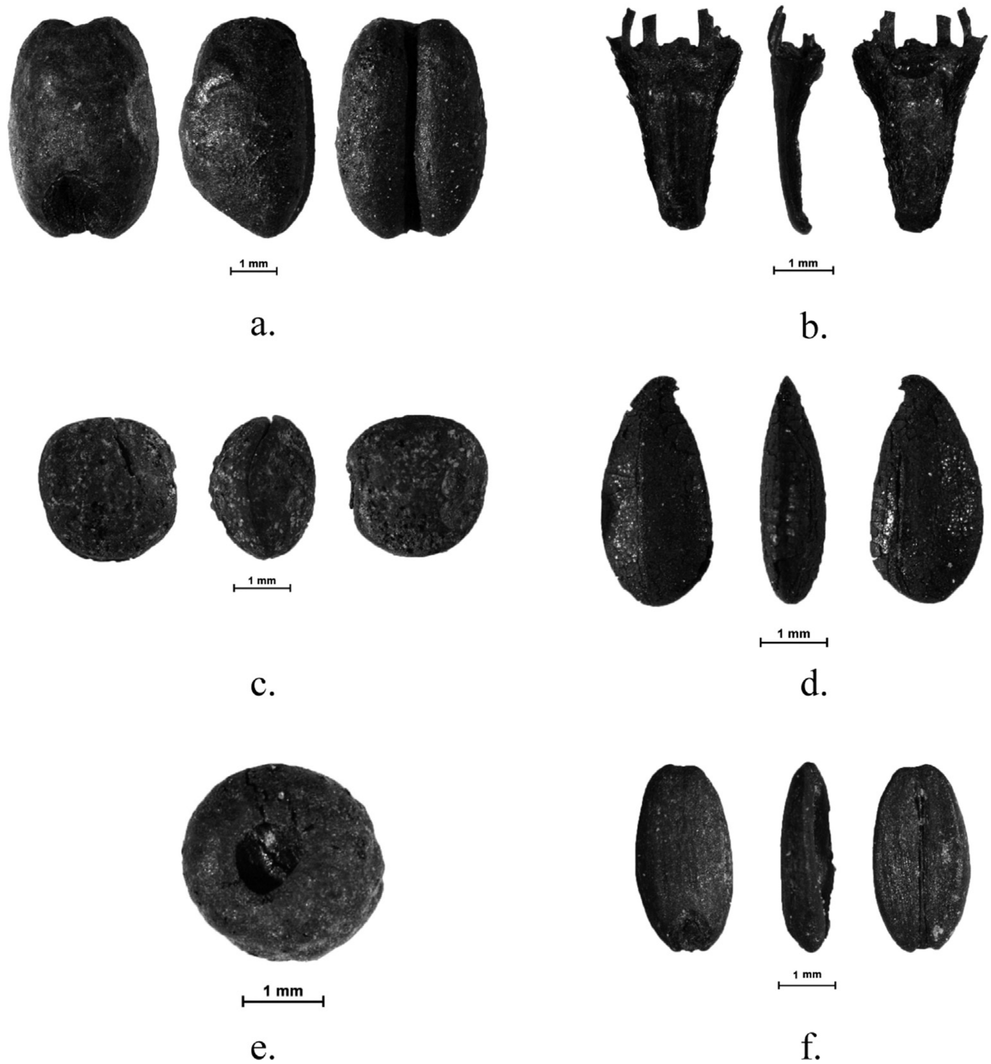

Fig. 5. Seeds identified in Mentesh Tepe a. *Triticum aestivum/durum* grain, b. *Hordeum vulgare* rachis segment, c. *Lens culinaris*, d. *Linum usitatissimum*, e. *Galium* sp., f. *Aegilops* sp. grain.

Wild herbaceous plants identified from the Mentesh Tepe samples could come from various habitats. Most of them are probably arable weeds growing in the fields (Willcox, 2012). This may the case, for example, for the goat-face grasses (*Aegilops*, Fig. 5f), brome grasses (*Bromus*), wild barley (*Hordeum spontaneum*), milkvetch (*Astragalus*), medick (*Medicago*), plants from the fenugreek family (various species of *Trigonella*, *Trigonella astroites*), heliotrope (*Heliotropium*), cowherb (*Vaccaria*), bugleweed (*Ajuga*), horned poppy (*Glaucium*), mallow (*Malva*), storksbills (*Erodium*), plants from the Chenopodiaceae family, and pheasant's-eye (*Adonis*). A second group is composed of potential ruderal plants, some of which also occur in the previous group: storksbills (*Erodium*), heliotrope (*Heliotropium*) and knotgrass (*Polygonum*). Many seeds of the spurge genus (*Euphorbia*) were also found in our samples, but we presume that they are probably modern, as they were not charred.

Plants from the Boraginaceae family are also attested (*Anchusa*, *Buglossoides arvensis/sibthorpianum*, *Heliotropium*, *Lithospermum* cf *officinale* and *Rochelia*) and represent more than 6% of all the remains. Apart from heliotrope seeds which are almost all carbonised, the plants from the Boraginaceae family may be overrepresented due to the biomineralisation process (Messager et al., 2010b).

Seeds of bedstraw (*Galium*, Fig. 5e) have been found. They may represent weeds but this plant could also have been be used to flavour food, to prepare certain drinks and vinegar or for medicinal uses. Flowers of species such as *Galium mollugo* can also be used for dyeing (Rivera et al., 2011).

If we compare the seed and fruit assemblages from the three main occupational periods, the following differences can be highlighted:

Samples attributed to the Neolithic are mainly dominated by cereals that represent more than 80% of the identified remains. Among these cereals, barley is the most frequent type, even though wheat grains are also present with naked wheat and emmer recorded in similar proportions. Rachis segments and glumes represent less than 4% of the remains of cereals identified. Lentil is the only identified pulse for this period. One grape seed was identified from a Neolithic sample, but it is not yet possible to determine if it belongs to the wild *V. vinifera* subsp. *sylvestris* or to the cultivated *V. vinifera* subsp. *vinifera* type.

The Chalcolithic period is the most important in terms of the number of samples studied. Among the cereals, emmer decreases to the advantage of barley. Naked wheat is still present in the same proportions as observed for the previous period. Rachises represent around 6% of the cereal remains. Pulses are more diversified, with

Table 2
Results of the seed and fruit analysis. Neo, Chalco and EBA, correspond respectively to Neolithic, Chalcolithic, Early Bronze Age.

Period			Neo	Chalco	EBA	Total
Number of samples studied			14	40	2	56
Cereals	Hulled barley grain	*Hordeum vulgare*, hulled caryopsis	41	2	16	59
	Barley, asymmetrical grain	*Hordeum vulgare*, asymmetrical caryopsis	9	37	7	53
	Barley grain	*Hordeum vulgare*, caryopsis	207	779	25	1011
	Barley chaff	*Hordeum vulgare*, rachis segments	3	131	203	337
	Emmer grain	*Triticum dicoccum*, caryopsis	86	37	25	148
	Emmer chaff	Hulled wheat, rachis segments	6	0	23	29
	Emmer chaff	Hulled wheat, glumes	8	0	0	8
	Naked wheat grain	*Triticum aestivum/durum*, caryopsis	57	127	24	208
	Naked wheat chaff	*Triticum aestivum/durum*, rachis segments	3	45	178	226
	Wheat grain	*Triticum* sp., caryopsis	67	60	10	137
	Wheat chaff	*Triticum* sp., rachis segments	0	0	2	2
	Wheat chaff	*Triticum* sp., glumes	2	4	1	7
	Undeterminated cereal grain	*Cerealia*, caryopsis	1034	2132	185	3351
	Undeterminated cereal chaff	*Cerealia*, rachis segments	39	43	595	677
	Total cereals		1562	3397	1294	6253
Pulses	Lens	*Lens culinaris*	33	146	0	179
	Pea/Vetch	*Pisum/Vicia* type	0	24	0	24
	Grass pea	*Lathyrus* sp.	0	7	0	7
	Undeterminated cultivated pulses	Cultivated *Fabaceae*	0	27	0	27
	Total pulses		33	204	0	237
Oil/textile plant	Flax	*Linum usitatissimum*	0	82	0	82
	Total oil/textile plant		0	82	0	82
Fruits	Caper	*Capparis* sp.	0	2	0	2
	Grape pips	*Vitis vinifera*, pips	1	6	1	8
	Hackberry	*Celtis* sp.	0	7	0	7
	Total fruits		1	15	1	17
Wild *Poaceae*	Goat-face grasses grain	*Aegilops* spp., caryopsis	0	257	3	260
	Goat-face grasses chaff	*Aegilops* sp., rachis segments	0	48	0	48
	Brome grasses grain	*Bromus* sp., caryopsis	1	18	168	187
	Wild barley grain	*Hordeum spontaneum*, caryopsis	22	8	3	33
	Wild barley chaff	Wild *Hordeum* sp., rachis segments	1	6	0	7
	Bristle grasses grain	*Setaria* sp., caryopsis	0	2	84	86
	Panicoids grain	*Panicoideae*, caryopsis	0	4	0	4
	Undeterminated *Poaceae* grain	*Poaceae*, caryopsis	50	1316	86	1452
	Total wild *Poaceae*		74	1659	344	2077
Wild *Fabaceae*	Milkvetch	*Astragalus* sp.	3	27	0	30
	Alfafa	*Medicago* sp.	5	1	0	6
		Trigonella astroites	0	1	0	1
	Fenugreek	*Trigonella* sp.	1	13	0	14
	Undeterminated wild *Fabaceae*	Wild *Fabaceae*	7	27	0	34
	Total wild *Fabaceae*		16	69	0	85
Other wild plants	Pheasant's eye	*Adonis* sp.	16	28	0	44
	Bugleweed	*Ajuga* sp.	0	13	0	13
	Alkanet	*Anchusa* sp.	0	15	1	16
	Wormwood	*Artemisia* sp.	0	30	1	31
	Daisy family	*Asteraceae*	0	20	1	21
	Borage family	*Boraginaceae*	1	26	7	34
	Cabbage family	*Brassicaceae*	0	38	0	38
	Corn gromwell	*Buglossoides arvensis/sibthorpianum*	13	501	2	516
	Pink family	*Caryophyllaceae*	1	128	0	129
	Goosefoot	*Chenopodium album*	0	2	0	2
	Goosefoot family	*Chenopodiaceae*	1	766	299	1066
	Dodder	*Cuscuta* sp.	0	19	0	19
	Sedges family	*Cyperaceae*	0	2	3	5
	Sedges family or knotweed family	*Cyperaceae/Polygonaceae*	1	3	7	11
	Storksbills	cf *Erodium* sp.	0	1	0	1
	Spurges	*Euphorbia* sp.	0	1288	0	1288
	Fumewort	*Fumaria* sp.	0	4	0	4
	Bedstraw	*Galium* spp.	0	100	7	107
	Horned poppy	*Glaucium* sp.	0	3	0	3
	Heliotrope	*Heliotropium* sp.	56	358	3	417
	Common gromwell	*Lithospermum* cf *officinale*	0	29	0	29
	Mallow	*Malva* sp.	0	7	0	7
	Knotgrass	*Polygonum*	0	3	0	3
	Knotweed family	*Polygonaceae*	0	11	13	24
		Rochelia sp.	0	2	0	2
	Club-rush	*Scirpus* sp.	0	5	93	98
	German knotweed	*Scleranthus annuus*	0	21	0	21
	Sparrow weed	*Thymelaea* sp.	0	6	0	6
	Total other wild plants		89	3429	437	3955
		Undeterminated	447	2013	688	3148
		Stem	1	15	3	19
		Undeterminated tuber	0	1	0	1
Total			2223	10 884	2767	15 874

lentil, grass pea and a pea/vetch type all occurring. Grape pips and hackberry are attested. Caper is also present and could have been eaten, as is still the case today. The fruit, when it is ripe, can be consumed raw or as a condiment and the flower buds can be used as a seasoning. The seeds can also be used to produce oil (Rivera et al., 2003, 2011). Flax was identified in several samples along with cereal and pulse remains, but also with arable weeds.

During the Early Bronze Age, barley decreases, to the advantage of naked wheat. Rachises and glumes are the most frequent cereal remains as they represent more than 77% of the assemblage. No pulses have been identified from this period. Grapevine is still the sole fruit identified.

5.3. Results of the phytolith analysis

5.3.1. Structure 336

Phytoliths of the Poaceae family are over-represented throughout the entire sequence of deposits stratified in Pit 336 (Fig. 6). They are dominated by the subfamily Pooideae, represented by the "rondel" and "trapeziform" (ranging from 10 to 51%) and "sinuate trapeziform" (1–10%) forms (Twiss et al., 1969; Fredlund and Tieszen, 1994).

The "elongate dendritic" phytolith (Fig. 2) is very common in the assemblages (more than 30% in every sample). This form derives from inflorescences (glume, palaea and lemma) of domesticated or wild grasses. Its abundance can be explained by the bringing of whole spikelets to the site for storage or processing. Since domesticated cereals (Poaceae) are selected for their abundant grains (and husks as a consequence), they produce many dendritic phytoliths. Moreover, this part of the plant also corresponds to the nutritive part, which is the element most subject to harvesting. These facts explain why this class of phytolith is especially abundant in archaeological sites in which cereals have been processed (Berlin et al., 2003; Portillo and Albert, 2011). The frequent occurrence of "papillae" (Fig. 6), a form of phytolith produced in chaff, confirms this result.

Another interesting point is the occurrence of fragmented epidermis from Poaceae plants, represented by the "silica skeleton" morphotype. The fragments are absent in the samples from the top and the bottom of the pit, but are well-recorded (up to 15%) in the middle part of the pit section. They represent the remains of Poaceae plants (most probably cereals) that were threshed. An accumulation of threshing remains in the middle part of Structure 336 can, therefore, be suggested. Apart from sample 413-1 (containing only inflorescence silica skeletons), the silica skeletons identified in this pit are composed of a mix of inflorescence-, leaf- and stem fragments (Fig. 6).

5.3.2. North section

In this profile, four structures were studied (Fig. 7): a Neolithic house, two Chalcolithic houses and an Early Bronze Age pit. In all of these structures, the Poaceae family, and especially the Pooideae subfamily (represented by "rondel" and "sinuate trapeziform" forms), predominates. Nonetheless, certain differences in composition between the different structures identified in the north profile should be highlighted.

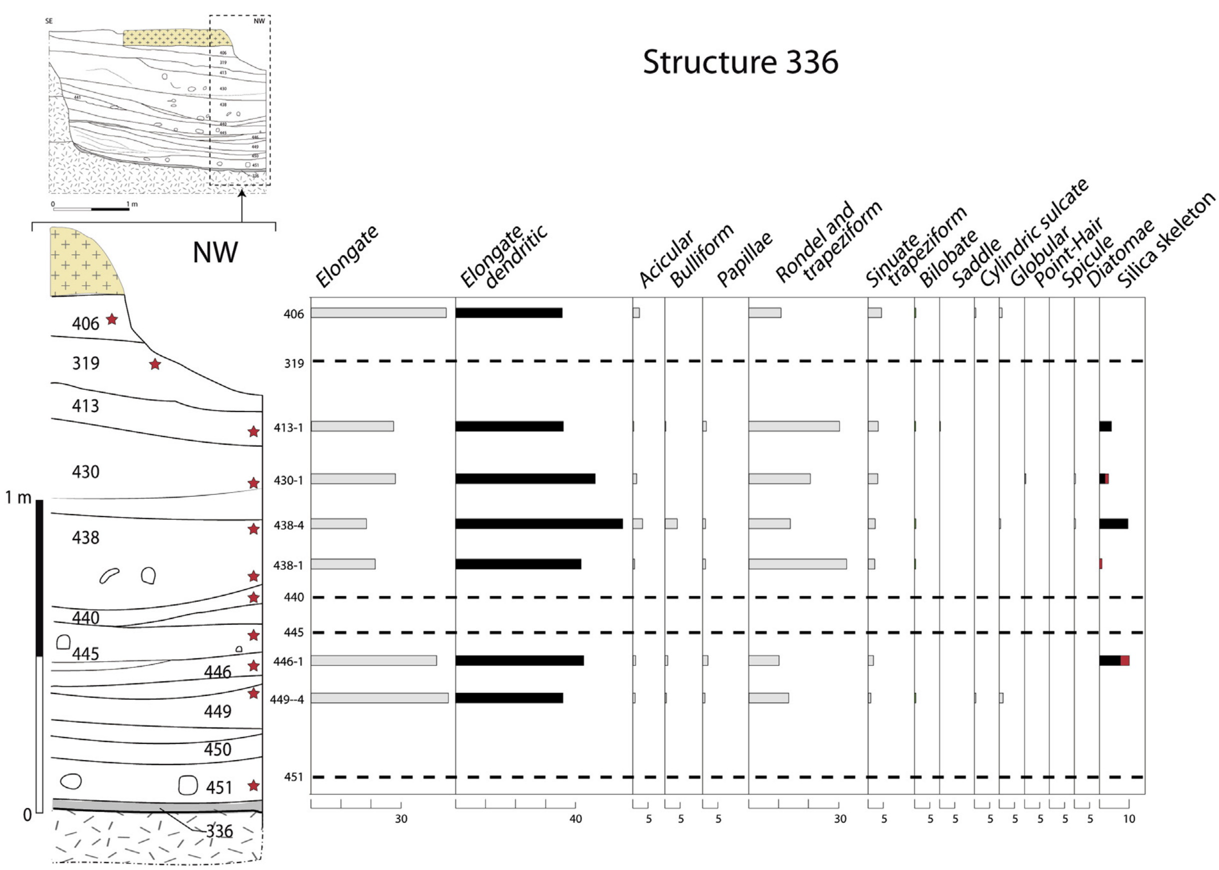

Fig. 6. Phytolith assemblages (%) from structure 336 (Neolithic pit). Red stars correspond to samples. In the silica skeleton histograms, the black part corresponds to silica skeleton from grass inflorescences and the red part corresponds to silica skeleton from grass leaves and stems. The dotted lines represent samples which did not yield enough phytoliths (451, 445, 440, 319). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

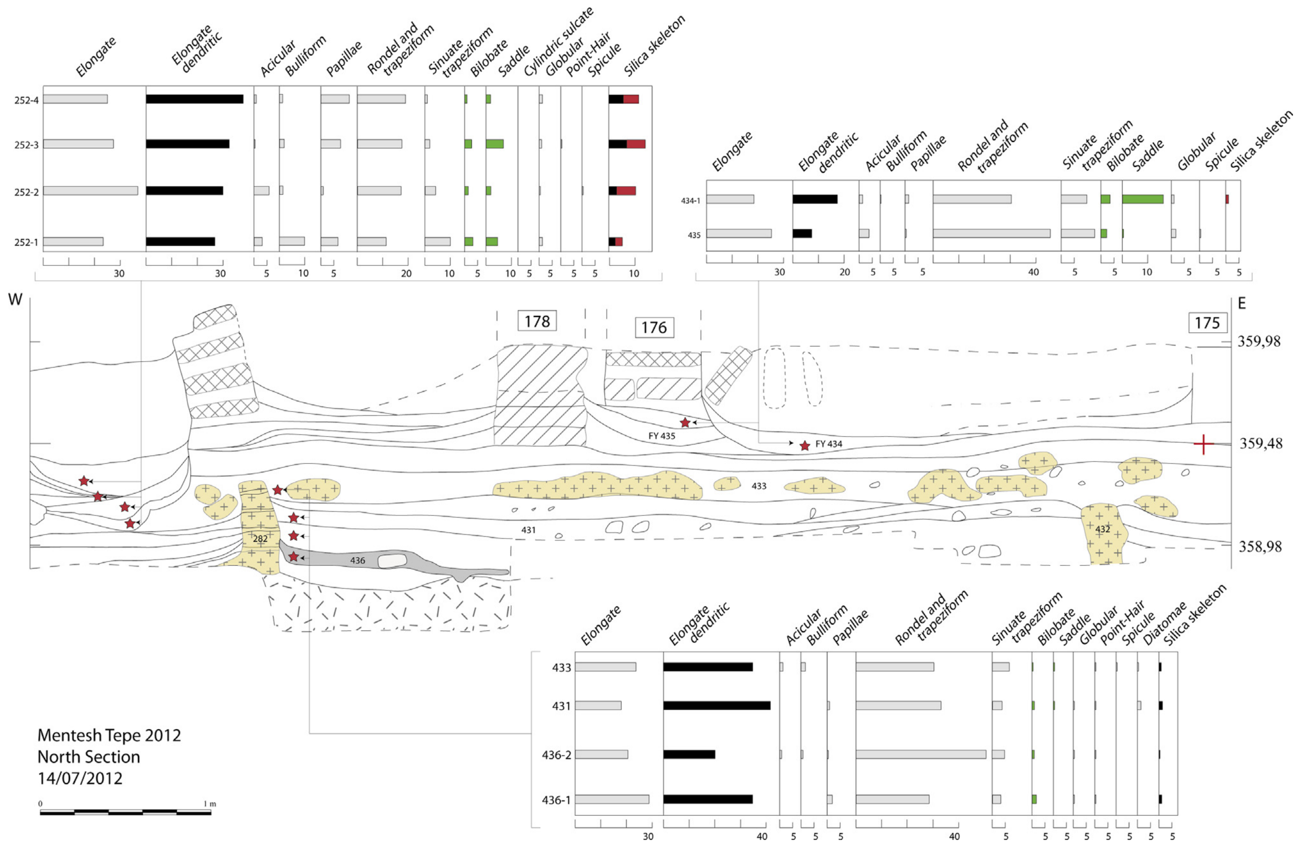

Fig. 7. Phytolith assemblages (%) from the various structures occurring in the North section of the excavation. Red stars correspond to samples. In the silica skeleton histograms, the black part corresponds to silica skeleton from grass inflorescences and the red part corresponds to silica skeleton from grass leaves and stems. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

In the Neolithic house, the phytolith assemblages are quite similar to the assemblages from Structure 336, except for the Poaceae epidermis ("silica skeletons") values (0–1.5%). These fragments of epidermis seem to be less frequent in the Neolithic house than in Pit 336 (also dated to the Neolithic period). Moreover, they are only composed of inflorescence epidermis (Fig. 7).

In the two Chalcolithic houses, the subfamily Pooideae is still predominant, but the "bilobate" and "saddle" phytolith classes reveal the occurrence of other subfamilies: Panicoïdeae, Arundinoïdeae or Chloridoïdeae. In these houses, the values for the "elongate dendritic" classes are the lowest produced in this study (7–17%). Fragments of Poaceae epidermis ("silica skeletons") are virtually absent from these samples, revealing that the signal for cereal processing is very low in the Chalcolithic houses.

In the Early Bronze Age pit, the "rondel and trapeziform" (11–19%) as well as the "sinuate trapeziform" (1–10%) values are lower than in the other structures studied. The "bilobate" (1–3%) and "saddle" (2–7%) forms are frequent. As is the case for the Chalcolithic houses, they attest to the significant occurrence of subfamilies other than Pooideae. In this pit, the "elongate dendritic" form and the "silica skeletons" (mix of inflorescence-, leaf- and stem fragments) are well-recorded, indicating an accumulation of cereal threshing remains.

6. Discussion

6.1. Evolution of the environment

The riparian forest was the main area in which the inhabitants of Mentesh Tepe collected wood, regardless of the period concerned. This can be explained by the fact that it was situated closer to the site than other forested areas. Its dominance could also be due to the quality of wood present there, which can easily be cut and used for fuel, construction works, basketry, tools etc. In general, lands adjoining rivers represent an attractive and rich area for fishing, hunting, grazing and wood exploitation. As no burned buildings or traces of wildfire were identified on the site, we can assume that charcoal remains result from the use of wood, directly or indirectly, as fuel. While most of the trees identified through the charcoal study, such as elm, ash tree or hornbeam, are considered to be good sources of fuel, they may also have been used for other purposes: tool production, basketry, and production of fibres or dyeing materials (Rameau and Dumé, 2008).

A change in the exploited vegetation is perceptible through time. During the Neolithic period, even though the river forest constitutes the main area for the collection of wood, the proportion of species characteristic of woodland is relatively significant. For the Chalcolithic period, a similar pattern is observed, but with a small decrease in woodland taxa, and especially in taxa, such as hornbeam, which are characteristic of a denser forest. Finally, during the Early Bronze Age, trees from deciduous forests disappear from the record and taxa characterising open shrub or woodlands increase, although the gallery forest still represents 90% of the charcoal fragments. Thus, from the Neolithic to Early Bronze, the charcoal assemblage reveals a possible decrease in deciduous forest and a focus on wood from more open formations and from the riparian forest.

In the Neolithic period, riparian gallery forest also constitutes the main exploited plant formation at Kamiltepe, in the Mil Plain, Azerbaijan (Decaix, 2012). Likewise, in Aratashen and Aknashen, two Neolithic sites in Armenia, wood collected from the gallery forest dominates the charcoal record (Badalyan et al., 2007, 2010).

For the Chalcolithic period, at Ovçular Tepesi in Nakhchivan, riparian forest is also the woodland type most used for the supply of wood (Berthon et al., 2013). While the vegetation history of the Lesser Caucasus Mountains has recently been reconstructed using continuous pollen sequences (Connor, 2011; Messager et al., 2013; Joannin et al., 2014), there is, as yet, no continuous record for the Middle Kura Basin. It remains difficult, therefore, to decipher the local and the regional components of the vegetation, reconstructed using charcoal assemblages.

6.2. Agricultural practices

On the basis of the analysis of fruits, seeds and phytoliths from Mentesh Tepe, it is clear that crops, in particular cereals, played an important role in the diet from the earliest phases of the Neolithic. From the first occupation, they occur in their domesticated form and the presence, from the beginning, of naked wheat is noteworthy. Indeed, in the Near East, hulled wheats are dominant until the Bronze Age. The importance of barley at Mentesh Tepe is comparable to the situation at other Neolithic sites in the southern Caucasus, for example Aknashen and Aratashen in Armenia or Göytepe and Kamiltepe in Azerbaijan (Hovsepyan and Willcox, 2008; Decaix, 2012; Guliyev and Nishiaki, 2012; Kadowaki et al., 2015).

Another similarity between the Caucasian sites is the rarity and low diversity of edible fruits At Mentesh Tepe only three species have been identified (grape, caper and hackberry). These results are comparable to those obtained, for example, at Aratashen and Aknashen even though two other fruit taxa – *Rubus* and *Eleagnus* – were identified at the latter site (Badalyan et al., 2007; Hovsepyan and Willcox, 2008; Badalyan et al., 2010) or at Areni-1, where grape, hackberry but also plum (*Prunus*) were identified in the Chalcolithic levels (Areshian et al., 2012; Wilkinson et al., 2012; Smith et al., 2014). It should be noted, however, that several of the tree species identified by charcoal analysis bear potentially edible fruits, notably dogwood, buckthorn, Russian olive as well as many species from the Rosaceae family (Prunoideae, Maloideae) (Rameau and Dumé, 2008; Rivera et al., 2011). The paucity of fruit remains may, therefore, reflect differential preservation rather than an actual absence of consumption.

Most of the wild plants identified may have been arable weeds growing in the fields. The presence of dodder (*Cuscuta*) is interesting as it is a parasitic plant that grows particularly on certain wild Fabaceae, such as alfalfa (*Medicago sativa*) or clover (*Trifolium*) for example, and also on flax. Wild Poaceae are well represented for the Chalcolithic and Early Bronze Age: especially goat grasses (*Aegilops*) during the first period and brome grasses (*Bromus*) and bristle grasses (*Setaria*) during the Bronze Age. Among the phytolith assemblages, it is still difficult to identify the proportions of wild and cultivated Poaceae. The main taxonomical group identified by phytoliths, Pooideae, includes the cereal taxa identified by seeds (*Triticum* and *Hordeum*), but also wild grasses, such as *Bromus*. The significant amounts of "bilobate" and "saddle" types recorded in the Chalcolithic and Early Bronze Age structures are more questionable. They could be interpreted as common millet (Panicoideae), but millet seeds are absent from the macro-remains assemblage. The identification of *Setaria* sp. (Arundinoideae) in seed assemblages (84 remains) from Early Bronze Age layers represents a credible key for identifying these phytolith classes. In the Neolithic settlement of Göytepe, located close to the Mentesh site, "bilobate" phytoliths from Panicoideae were also identified but in small amounts (Kadowaki et al., 2015). A few seeds of this subfamily were also identified and attributed to wild plants.

6.3. Cereal processing

Throughout the site, in every structure and in every layer, "dendritic" and "papillae" phytoliths (from inflorescences) are well-recorded. This indicates that the de-husking phase of cereal processing was probably performed within the site during all periods of occupation.

In the large Neolithic pit (called Structure 336), the abundance of "silica skeletons" (Fig. 2), corresponding to fragments of Poaceae epidermis (including leaves, stems and inflorescences), may reflect the accumulation of various threshing by-products, especially in the middle part of the pit deposit. The same pattern is observed in the Early Bronze Age pit (Fig. 7). The phytolith spectra, displaying a lot of dendritic phytoliths and fragmented silicified epidermis, support an interpretation of cereal threshing. Among the macro-remains from the Early Bronze Age pit, chaff is also very abundant, representing more than 77% of the assemblage. The association of phytolith assemblages marked by abundant "silica skeletons" with chaff macro-remains has already been interpreted as a signal of threshing remains accumulated in pits at the Early Bronze Age site of Chobareti (Messager et al., 2015). In Mentesh Tepe, this hypothesis is strengthened by the presence of common arable weeds in seed and fruit assemblages (e.g. Chenopodiaceae, *Galium*, Polygonaceae, *Heliotropium*). The interpretation of botanical assemblages recorded in pit fills remains difficult because pits could have been initially used for cereal storage and then re-used as rubbish dumps. In this case, the phytolith assemblages could also represent dung used as fuel. It has been demonstrated elsewhere that the burning of dung cakes is a plausible pathway for the presence of threshing by-products such as chaff, which was used as fodder (Miller, 1984).

In the houses from the Neolithic and Chalcolithic periods, fragmented epidermis is scarce while dendritic phytoliths are common. These results suggest that cereal grains were probably brought into the dwellings without straw. The scarcity of silica skeletons from leaves and stems in houses supports this hypothesis. The straw elements seem to have been separated from the grain outside the habitation. Cereal grains could have been de-husked inside, or in the vicinity of, houses (i.e. in courtyards), as was recently demonstrated at the neighbouring site of Göytepe where de-husking remains were preserved in a clay bin, associated with a Neolithic building (Kadowaki et al., 2015).

7. Conclusion

This paper, which is the result of a multidisciplinary study, makes an important contribution to our understanding of the social and economic framework of the Southern Caucasus in the Neolithic, Chalcolithic and Early Bronze Age periods. Thanks to the analysis of seeds, fruits, charcoal fragments and phytoliths, a reconstruction of the agricultural practices and local environment has been proposed.

Crops, such as cereals (de-husked on site) and pulses, contributed to the diet of the inhabitants of Mentesh Tepe. In addition, wild fruits were gathered in the nearby riparian forest or in the woodlands which also provided wood in order to complete the agropastoral economy.

Because of its diachronous occupations, Mentesh Tepe is a key site for reconstructing human impact on the environment over time and in understanding the evolution of agricultural practices in this part of western Asia. Future work will build on these preliminary results in order to define in greater detail the agricultural strategies and land uses employed by past societies in the southern Caucasus and to examine the impact of their economies on the development of the environment.

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