



## Research Article

# The use of local fibres for textiles at Neolithic Çatalhöyük

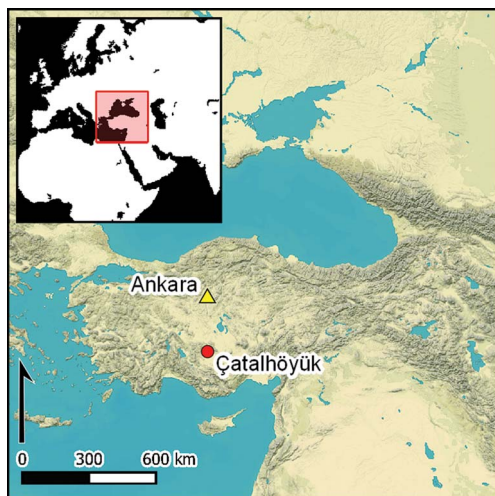
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Woven textiles from Çatalhöyük in southern Anatolia are among the earliest-known examples of weaving in the Near East and Europe. Studies of material excavated in the 1960s identified the fibres as flax. New scanning electron microscope analysis, however, shows these fibres—and others from more recent excavations at the site—to be made from locally sourced oak bast. This result is consistent with the near absence of flax seeds at Çatalhöyük, and suggests there was no need for the importation of fibres from elsewhere; it also questions the date at which domesticated flax was first used for fibres. These findings shed new light on early textile production in the Neolithic, suggesting that tree bast played a more significant role than previously recognised.

Keywords: Çatalhöyük, Turkey, Neolithic, SEM analysis, textiles, plant fibres

## Introduction

Because of their generally poor preservation, relatively little is known about early textiles and cordage, or the materials from which they were made. The identification of fibres recovered from the Neolithic settlement of Çatalhöyük in southern Anatolia, for example, has long been a matter of contention, with the same material identified by different specialists as either flax or as wool. The possibility of other fibres, however, has been neglected. Recently, awareness of the use of tree bast fibres for making string, netting and textiles has increased; such fibres are now well documented from a number of prehistoric contexts in Europe (Rast-Eicher 2005, 2018). Cordage and string were usually made of tree bast, mostly of willow, oak or lime, but lime bast was also used for woven textiles (Rast-Eicher & Dietrich 2015). Depending on the location of the bast layers within the bark, tree bast fibres farthest from the bark can be very fine and their morphology can resemble that of flax fibres, with, for

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example, similar diameters. This new knowledge has made it important to (re)investigate the textiles and fibres recovered from Çatalhöyük. Recent discussions about these fibres and others from early sites in the Near East, such as Wadi Murabba'at and Nahal Hemar in Israel, have focused on flax, and specifically on whether it was domesticated or traded (Fuller *et al.* 2014; Bar-Yosef 2020; Shamir & Rast-Eicher 2020). The use of tree basts, which involves a *chaîne opératoire* that is somewhat different from that of flax, has not previously been considered as tree bast is not reliant on cultivation or animal husbandry.

## Çatalhöyük

The archaeological site of Çatalhöyük consists of two mounds: Çatalhöyük East, which is Neolithic, and Çatalhöyük West, which dates largely to the Chalcolithic period. During the Neolithic a tributary of the Çarşamba River ran between the two mounds and created a system of channels and islands with different landscape types (Ayala & Wainwright 2020). The site as a whole is very large (about 13ha); there are nearly 21m of deposits representing some 1150 years of continuous occupation by a complex society with a rich material culture (including wall paintings, figurines, graves with skeletal remains, stratified occupation in houses, and early ceramics).

The first excavations were undertaken between 1961 and 1965 (Mellaart 1967). In 1993 excavations were resumed, first at the eastern mound by the Çatalhöyük Research Project, directed by Ian Hodder, and later at the western mound (Hodder 2014; Hodder & Kutlu 2021; [www.catalhoyuk.com](http://www.catalhoyuk.com)). During both excavation campaigns, numerous objects fashioned from perishable materials were discovered, including cordage, basketry, matting and textiles. These textiles and cords were used in burials to wrap the deceased in a flexed position; baskets were also used in burials, particularly to contain babies, but also in other contexts; mats were used as floor coverings (Helbæk 1963).

### *The age of the Çatalhöyük textiles*

The textiles found during the Mellaart excavations derive from Level E VI A/B, originally dated to between 6200 and 5800 BC (Mellaart 1964: 116). With advances in radiocarbon-dating methods, Bayesian modelling now dates the start of the Çatalhöyük East site to *c.* 7100 cal BC (Bayliss *et al.* 2015; Hodder & Kutlu 2021). Four habitation phases can now be defined: early (7100–6700 cal BC), middle (6700–6500 cal BC), late (6500–6300 cal BC) and a final phase (6300–5950 cal BC). This represents both a correction and a refinement of previously published dates (Cessford *et al.* 2005; Hodder 2014). The textile finds from the Mellaart and Hodder excavations all derive from the middle phase (Hodder & Kutlu 2021: tab. 1.2) between 6700 and 6500 cal BC, a narrower time span than previously suggested (6700–6300 cal BC; Bayliss & Tung 2017; Rast-Eicher & Bender Jørgensen 2018).

### *Textile fibres at Çatalhöyük*

The first textiles at Çatalhöyük were discovered in 1962 and excavated by palaeoethnobotanist Hans Helbæk (Helbæk 1963). Helbæk emphasised that he was not a textile expert and refrained from describing the textiles in detail except for the fibres. He stated that all the

textiles, apart from one piece of a string, were made from animal fibres, probably wool (Helbæk 1963: 43–44). In 1963, the textile historian Harold Burnham examined the textiles and accepted Helbæk's fibre identifications (Burnham 1965), but wool specialist Michael Ryder did not and concluded that some of the textiles were made of flax (Ryder 1965). Textile specialist Gillian Vogelsang-Eastwood later confirmed Ryder's identification of plant-based fibres, probably flax (Vogelsang-Eastwood 1988). In 2013 textile remains were discovered in Building 52 and determined to have been made from domesticated flax (Hodder 2013; Fuller *et al.* 2014).

Mellaart remained convinced that the textile fibres from Çatalhöyük were wool (Mellaart 1967: 219). The arguments in favour of his position included the presence of nitrogen in the fibres, the absence of flax seeds at the site and the finds of sheep bones and rams' skulls (Burnham 1965: 170, quoting Mellaart 1962: 56, 1964: 57, 66, 73). Recent excavations (Bogaard *et al.* 2013: 98 & 128, 2017: 3, tab. 3; Filipović 2014: 57 & 59) have recovered only a very small quantity of flax seeds, confirming their scarcity. According to Bogaard *et al.* (2013), linseeds are absent from the mid- to later Neolithic layers, but are present in small quantities in the earlier Neolithic sequence. Filipović (2014: tab. 4.5) lists 13 seeds of *Linum* species in total.

The basketry and matting recovered during the Hodder excavations have been examined by Willeke Wendrich and Philippa Ryan (Wendrich 2005; Wendrich & Ryan 2012), and Antoinette Rast-Eicher and Lise Bender Jørgensen have analysed the textiles and cordage (Bender Jørgensen & Rast-Eicher 2017; Rast-Eicher & Bender Jørgensen 2018; Bender Jørgensen *et al.* 2021).

## **Textile production in the Neolithic**

Plant fibres were used for a multitude of purposes in the Neolithic period, including the production of thin, flexible fabrics using techniques such as twining and weaving. Threads for such fabrics were made by splicing (Leuzinger & Rast-Eicher 2011; Gleba & Harris 2018), rather than by retting and spinning as in later periods. Instead, strips of fibres were joined end to end, with the ends overlapping; these strips were then rolled together by hand to produce a yarn, and two such yarns were plied together. Fine threads from the Neolithic period in Europe and the Near East are always plied. The technique probably derives from early string-production methods using tree bast. Twining is a very important technique in the Neolithic period, and is used to produce flexible fabrics (Schick 1988; Alfaro 2012); weaving marks a further development of this earlier technique (Bender Jørgensen *et al.* 2021). All woven textiles from the Neolithic are made in simple tabby or plain weave.

## **Fibre analysis: materials and methods**

Seventeen textiles (woven and twined) and 14 threads/strings made of plant fibres were recorded from the Neolithic layers in the East Mound of Çatalhöyük (Bender Jørgensen *et al.* 2021). A small number of samples was selected for fibre analysis on site (export restrictions limited the number; Table 1). One sample was taken from a coiled basket (no. 20465) to analyse the stitching; the coils are mineralised and material identification was based on

Table 1. Catalhöyük textile samples dated to the Neolithic period (6700–6500 cal BC).

Cat. sample/no. for SEM	Ref.	Technique	Building/layer	Fibre
Sample 2; SEM18/13	20465	Coiled basketry	Space 489	Mostly preserved as silicified structure/ phytoliths; stitching: <b>Gramineae leaf</b>
Sample 4; SEM18/10	30511, s4	Cordage	Building 52	Charred; plant fibre: <b>oak bast</b>
Sample 9; SEM18/3	17457 X10	Woven; tabby	Building 49	Mineralised; poorly preserved, with conservation product; fibre diam. 7–15µm: <b>plant fibre</b>
Sample 11; SEM17/229	30503 s8 (s6-9)	Woven; tabby	Building 52	Charred; badly preserved, cross-section with hollow fibres, remains of ray: <b>oak bast</b>
Sample 15; SEM17/230. Sample 16; SEM18/11	22661 s5	Net? tassel?	Building 131	Charred; plant fibre with large lumen, dense fibre bundles, evidence of rays, different diam.: <b>tree bast fibre?</b>
Leiden sample; SEM 17/209	1963 textile from skull	Woven; tabby	Mellaart VI A/B	Charred; polygonal fibres, some thick and crossing nodes, large lumen: <b>unclear (tree bast?)</b>

their siliceous remains (Table 1, sample 2; Wendrich & Ryan 2012). Four samples were taken from cordage or textiles (Table 1, samples 4, 9, 15 and 11). In addition, a sample was taken from a textile fragment from the Mellaart excavations, now stored at the Textile Research Centre in Leiden (Table 1, last line); the box containing this fragment was labelled ‘Textile from skull, lower layer VI’. As this sample is dated ‘summer 1963’ it may derive from the textile found in Room E VI,1 (Mellaart 1964: 93; pl. XXIVa–b, 1967: pl. 94). The samples were mostly charred; when a house burnt down, the plant material in the graves beneath the floors was ‘baked’, preserving the textiles.

In the laboratory, the samples were mounted on aluminium stubs, which were then sputtered with gold (about 20nm). They were analysed with a scanning electron microscope (SEM) (Zeiss EVO 50, 15KV; SEM of the University of Bern, Switzerland, Institute of Geography, Oeschger Centre, analyses by A. Rast-Eicher). The results were compared with previous findings of plant bast fibres (Rast-Eicher & Dietrich 2015; Rast-Eicher 2016a & b).

The identification of archaeological plant fibres is challenging. The main diagnostic feature shared by bast fibres (both flax and tree) is the presence of nodes, but there are important differences between the families. A range of characteristics must be checked: fibre diameter, the presence or absence of epidermis or rays with a clear morphology, the presence and form of crystals and stomata cells, the form of the fibres in cross-section, the form and diameter of the lumen (inner canal of fibre) and the twist of the cuticula. Flax has no rays and no large, perforated vessels. To enhance comparisons, modern reference material (both fresh and experimentally charred) was also prepared. Cross-sections were made with a microtome (HM 355S Thermo Fisher Scientific) and photographed with a Leica DM 5000B photomicroscope (Botanical Institute of the University Potsdam, Germany; preparations and photographs by Barbara Schmitz and Sabine Karg).

## Results

The sample taken from the stitching of a basket (sample 2) is made of grass blades (*Gramineae* sp.; Figure 1). The cordage (sample 4) from Building 52 (30511-s4), found wrapped around the legs of infant 30511-s6 (the same infant that yielded textile sample 11, see below), is oak tree bast (*Quercus* sp.) (Figure 2a). A large vessel with partly perforated cell walls, characteristic of oak, is visible on the right of the image; fibres and single-row rays can be seen on the left (crystals missing; empty cells visible). The fibres seen in cross-section are hollow (5–7µm diameter) (Figure 2b).

Oak bast was also identified in sample 11 (30503 s6-9), taken from a tabby-woven textile recovered with an infant in the same building (Building 52) as sample 4 (Figure 3). Twined and woven textiles are flexible objects and need well-prepared fibres. Threads from the Çatalhöyük textiles were spliced, with the fibres used as strips. This is why the remains of epidermis, or, as in sample 11, the remains of a large vessel, are still visible (Figure 4a).

The textile (30503 s6-9; sample 11) was found in the thorax region of infant 30511-s6 (which had also yielded sample 4, the cordage 30511-s4 wrapped around the legs). The perforated vessel seen on the right side of the image of sample 11 (Figure 4a) appears as a small, crunched-up fragment. Both this sample and sample 4 show a large lumen in the cross-section (Figure 4b). Sample 11 is the same textile that Fuller *et al.* (2014) identified as made from domesticated flax. In order to confirm our identification, the morphological characteristics were compared with those of modern material (Figure 5). The perforation of the

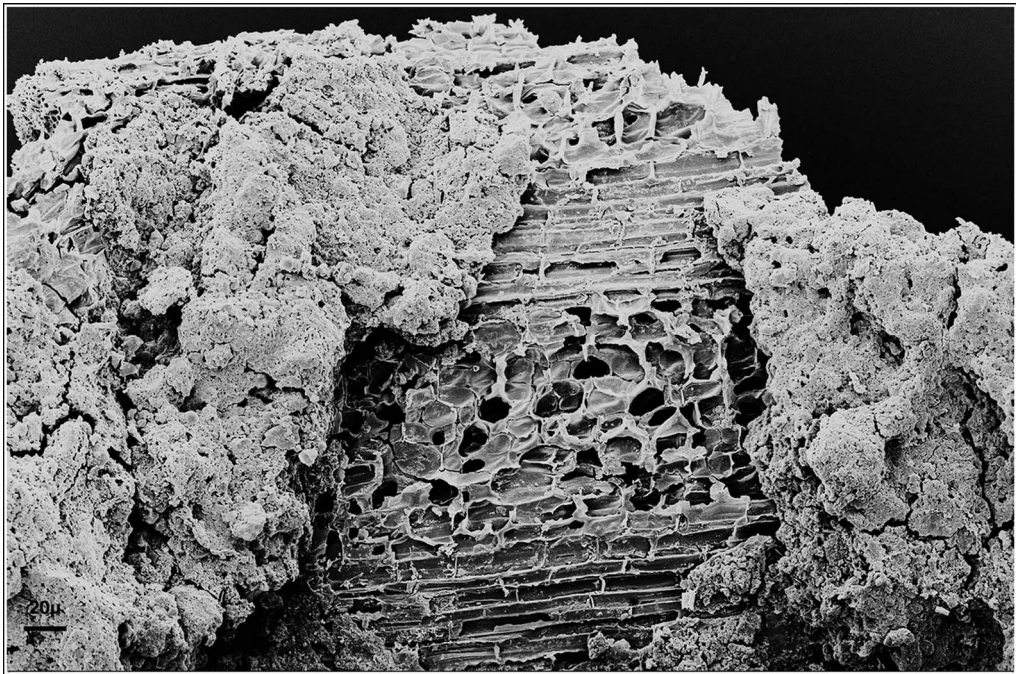


Figure 1. Çatalhöyük 20465: grass fibres used in the stitching of coiled basketry. Photograph: A. Rast-Eicher.

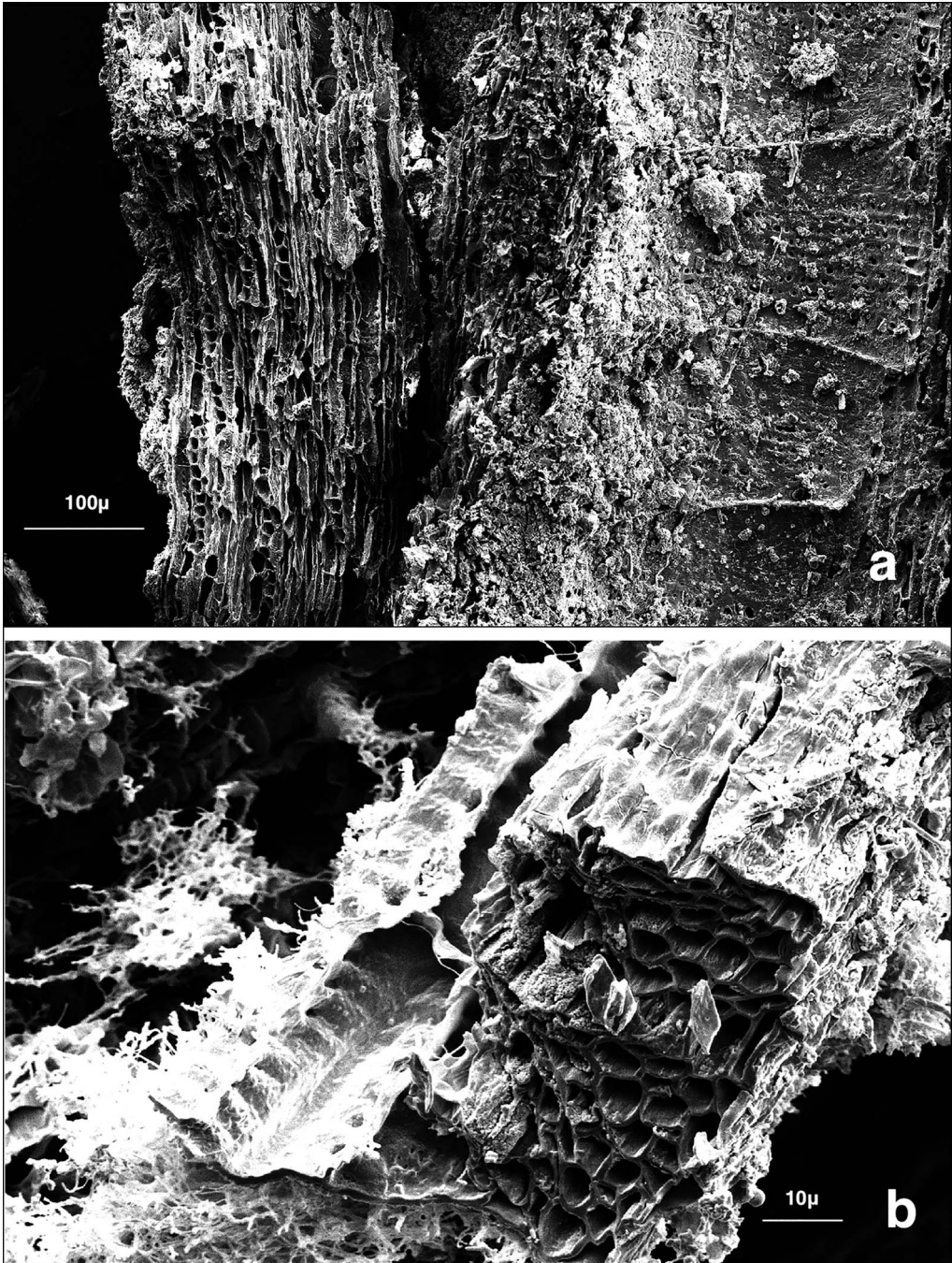


Figure 2. Çatalhöyük 30511-s4. Cordage: a) remains of oak bast with fibres and a large perforated vessel; b) cross-section with thick cell walls. Photographs: A. Rast-Eicher.



Figure 3. Çatalhöyük 30503: tabby-woven fragment. Photograph: A. Rast-Eicher.

vessels seen in the fibres from Çatalhöyük are consistent with oak bast (Figure 5a); the cross section of wild flax shows a small lumen (as also seen in domesticated flax; see the dot in the centre of Figure 5b); the oak bast has a large lumen (large black space on Figure 5c)—an important diagnostic indicator for distinguishing flax from oak bast.

The woven textile from Building 49 (sample 9, 17457 X10) was made of spliced fibre bundles, which were not easily visible and probably covered by conservation products. No further details could be discerned, so that ‘plant fibres’ remains the appropriate identification. Samples 15 and 16 were obtained from a net or tassels of a textile found in Building 131. The threads are three-ply and made with large fibre strips. The cross-section shows substantial differences in the fibre diameters, thick-walled fibres with a very large lumen, but not as large as those seen with the oak bast fibres (Figure 6). The large bast strip shows an unusually large lumen for flax. The Leiden sample shows thick cell walls and a sizeable lumen—not as large as those from the samples identified as oak bast (samples 4 and 11), but larger than is usual in flax (Figure 7). No other morphological details, such as epidermis or rays, are visible: the determination is therefore unclear.

## Discussion

Early textiles made of plant fibres are rarely preserved in archaeological layers. In the Southern Levant, strings made of grasses (monocotyledons) have been identified at Ohalo II, a hunter-gatherer camp dated to 19 300 BP (Nadel *et al.* 1994). From the Early Neolithic period onwards, preserved twined textiles are reported from sites dated to the ninth and/or eighth

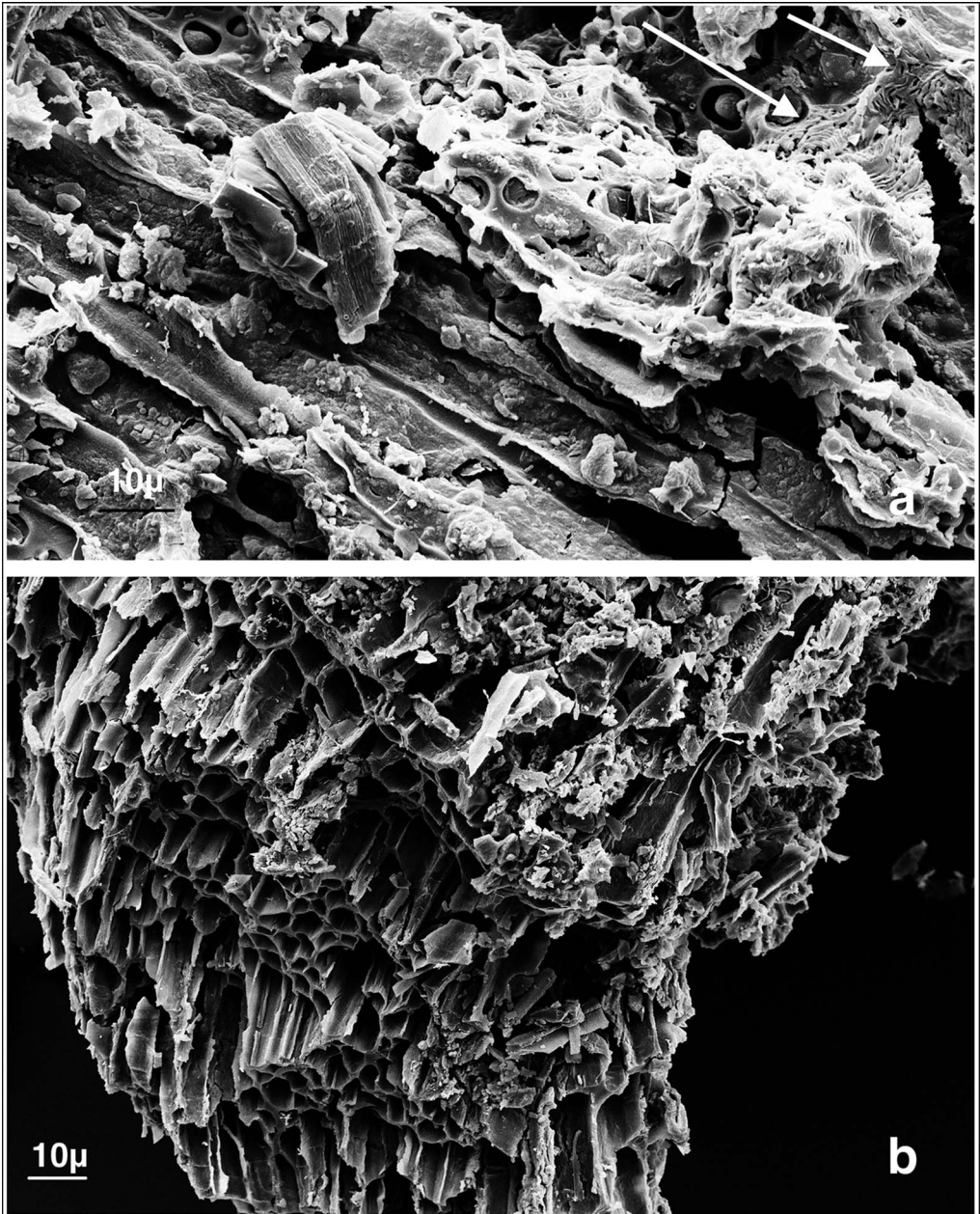


Figure 4. Çatalhöyük 30503-s8 (s6-9). Woven textile: a) fibres of oak bast with the remains of a perforated vessel (white arrows); b) cross-section with thick fibre walls and large lumen. Photographs: A. Rast-Eicher.

millennium cal BC, such as Tell Aswad and Tell Halula in Syria, Nahal Hemar in Israel and Çayönü in Turkey. These are all reported as certainly or possibly made of flax (Schick 1988; Vogelsang-Eastwood 1993; Stordeur *et al.* 2010; Alfaro 2012).



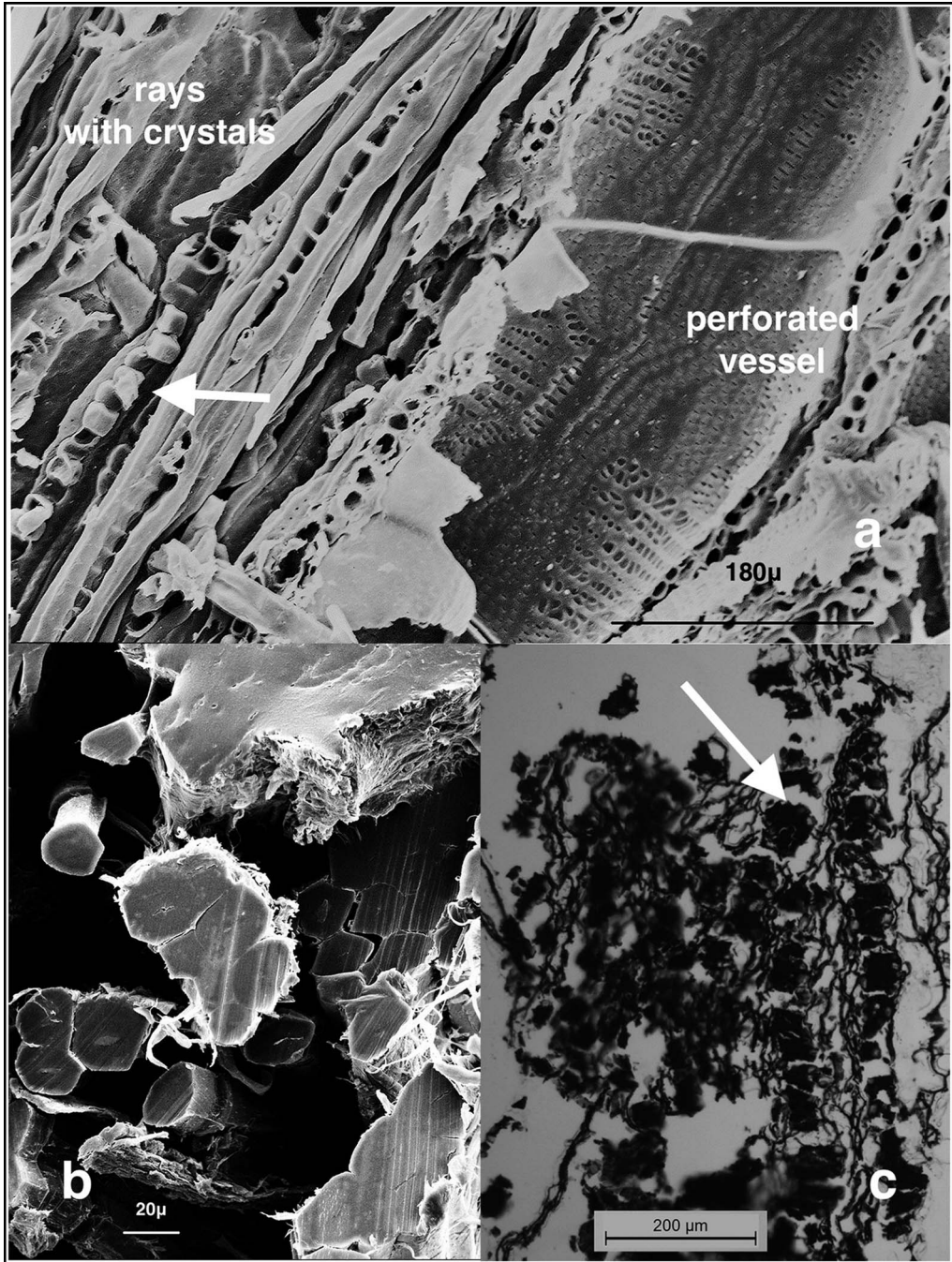


Figure 5. Comparative material: a) oak bast; b) cross-section of *Linum bienne*, charred; c) cross-section of oak bast, charred, with large lumen of fibres (arrow). Photographs a–b: A. Rast-Eicher; photograph c: B. Schmitz & S. Karg.



Figure 6. Çatalhöyük 22661-s5 from Building 131: thick-walled plant fibres with relatively large lumen. Photograph: A. Rast-Eicher.

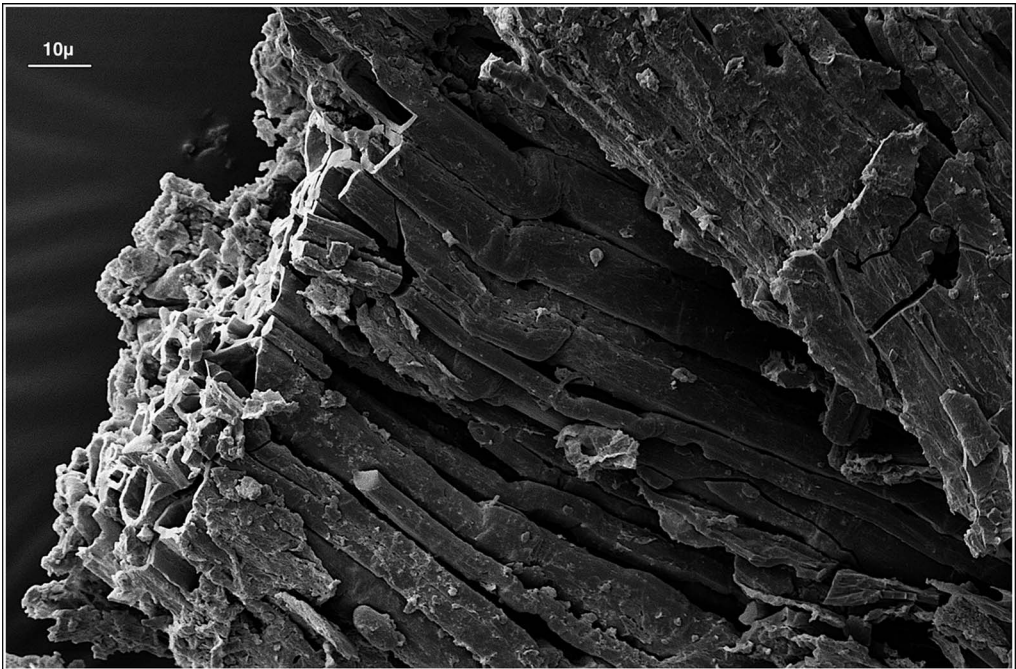


Figure 7. Çatalhöyük sample from Leiden (Mellaart excavation): plant fibre with very large lumen. Photograph: A. Rast-Eicher.

Imprints of woven textiles have been found at Jarmo in Iraq (7000–6000 cal BC) and El Kown 2 in Syria (7100–6000 cal BC); further imprints from Tell Kashkashok in Syria and Telul eth Thalathat and Tell es-Sawwan in Iraq are all dated to the second half or the end of the seventh millennium cal BC (Bender Jørgensen *et al.* 2021 with further references). The textile remains from Çatalhöyük, which belong to its middle phase (6700–6500 cal BC), therefore represent the earliest preserved woven textiles; together with the imprints from Jarmo and El Kown 2, they currently constitute the earliest-known evidence of weaving (Bender Jørgensen *et al.* 2021). The only other preserved woven textile from the seventh millennium BC is from Ulucak Höyük, and dates to 6500–6000 cal BC (Çilingiroğlu 2009). As for the imprints, fibre identification is not possible, and none have been reported at Ulucak Höyük.

Tree bast is often overlooked as the earliest processed plant material; in the search for early fibres, flax has dominated the discussion. A find from Georgia is claimed to represent the earliest use of wild flax for fibre production (Kvavadze *et al.* 2009), but this has been refuted because the fibre diameters are far too large (Bergffjord *et al.* 2010). Another find, also initially thought to be flax, was a fine, S-ply thread used as binding to fix a wooden comb found in Wadi Mubarra'at (Israel, Jordan Valley) and dated to 9500 cal BC (Schick 1995). New analyses of the string clearly show that it was made from fibres of tree bast with the remains of rays visible (Shamir & Rast-Eicher 2020: 34–35). A woven textile from phase X at Ilıpınar (Turkey), dated to 6000 cal BC (Roodenberg & Roodenberg 2008: 6, fig. 14b), can also be added to the list. The fibres display structures untypical of flax, such as the remains of a perforated vessel (perforations and side wall of the vessel), indicating that the textile was made of tree bast (Rast-Eicher 2019).

In Europe wood bast has been identified at several sites. For example, a spindle found in Arbon (Switzerland) wound with lime bast yarn is dated to *c.* 3400 BC (De Capitani *et al.* 2002). The substantial corpus of Neolithic textiles from European 'lake dwellings' includes a large textile with knotted pile, woven from lime bast, found in Zürich (Zürich-Mythenschloss; Rast-Eicher & Dietrich 2015: cat. no. 1001, pls. 106–107) and dated to the Corded Ware period (2750 BC, dendrochronological date). The fibre strips are quite large and fine rays are still visible (Figure 8), although the dimensions of the fibres are similar to those of flax fibres.

The early history of flax domestication is the subject of ongoing research. The progenitor of domesticated flax (*Linum usitatissimum* L.) is *Linum bienne* Mill. (*Linum angustifolium* Huds.; Diederichsen & Hammer 1995). This plant occurs widely in the Near East and Mediterranean area (Zohary *et al.* 2012), where it prefers moist habitats, as in the vicinity of Çatalhöyük (Ayala & Wainwright 2020). Only very few flax seeds have been recovered from the Neolithic layers of the site. In view of their small size, they were identified as most probably deriving from wild flax (Fairbairn *et al.* 2005: 174; Filipović 2014: 35, and personal information from Filipović 18.09.2019). Systematic seed measurements of modern flax varieties and of wild flax point to a clear difference in size (Karg *et al.* 2018). As there is no evidence of domesticated flax at Çatalhöyük, we can advance the hypothesis that wild flax was collected close to the settlement.

Making woven textiles was probably a small-scale activity, following the hunter-gatherer tradition of exploiting wild plants for their fibres. The raw material was locally available. Tree

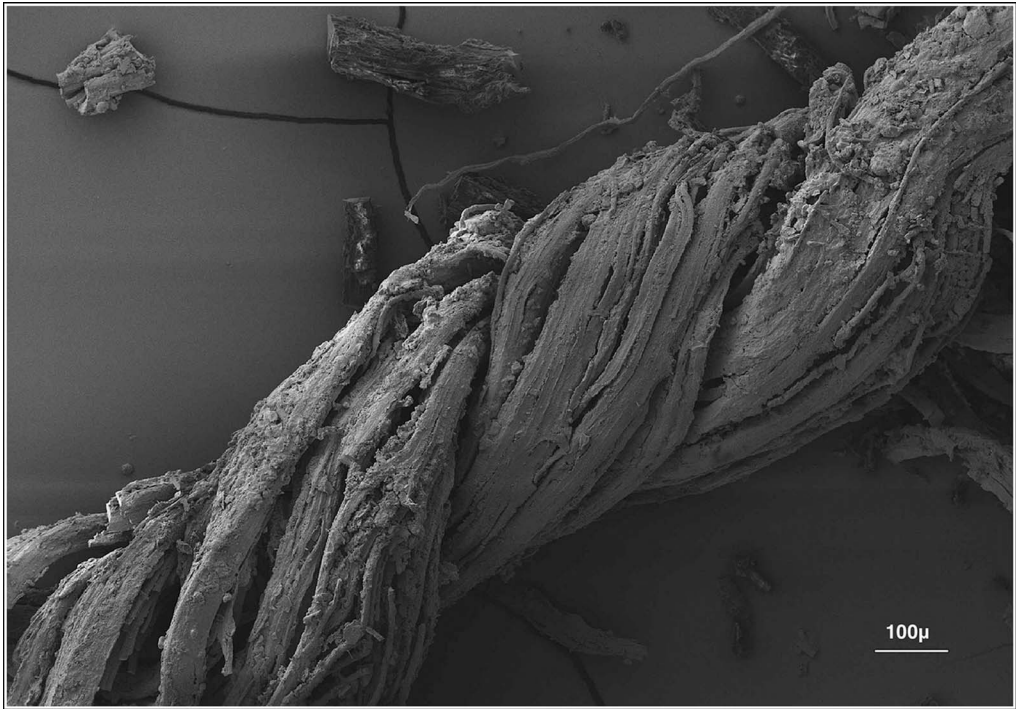


Figure 8. Zürich-Mythen Schloss (Switzerland) 1375. Thread of tabby-woven textile made of lime bast (*Tilia* sp.). Photograph: A. Rast-Eicher.

bast was harvested in spring when the sap was rising within the tree trunks, which facilitates the removal of the bark with the attached bast. This would also be the case with wild flax: the bast strips would have still contained water and are easy to splice when taken from green stems (Leuzinger & Rast-Eicher 2011). Based on the analyses of the phytoliths from the baskets from Çatalhöyük, the grasses (e.g. reed) were also collected in spring (Wolffhagen *et al.* 2020: 101). Analyses of charcoal and worked wood from the site show that oak was the most common wood species used for timber and fuel. Asouti (2005: 240–43 & 248–54) argues that oak grew within 10km of Çatalhöyük and that timbers were floated down the Çarşamba River following woodcutting trips during the spring.

## Conclusions

Our analysis shows that tree bast, in this case from oak, was used to produce the earliest cordage and woven textiles recovered at Çatalhöyük and, indeed, the earliest known in the Neolithic period of the Near East. The textiles excavated in 2013, originally identified and published as ‘flax’, are in fact made from oak bast fibres, and this may well apply to several of the others.

The discovery that several Çatalhöyük textiles, the string from Wadi Murabba’at and the Ilıpınar textile were all made of tree bast fibres demonstrates that this resource played an important role in the early history of textiles and raises new questions regarding the apparent

identification of flax fibres at other early sites. The results show a similar development in the Near East as previously documented for Neolithic Europe, where the use of tree bast fibres was common, even for woven textiles. We may conclude that the inhabitants of Çatalhöyük had a profound knowledge of the fibre properties of bast from oak, and probably other tree species, as well as wild flax. The environmental conditions around the settlement were suitable for harvesting different raw materials close by and there was no need to import textile fibres. Collecting raw material for baskets and textiles would have been part of the inhabitants' activities during the spring, perhaps combined with the procurement of timber. Beyond their significance for Çatalhöyük itself, our results show that the precise identification of the raw materials used to produce fibres for textiles and cordage can throw light on the interpretation of plant domestication and plant use in prehistoric contexts.

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