Wood charcoal from Santorini (Thera): new evidence for climate, vegetation and timber imports in the Aegean Bronze Age

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Wood charcoal from stratified layers at Akrotiri is helping to map the ecology of the island of Santorini before the volcanic eruption in the second millennium BC which brought Bronze Age settlement to an end. Far from being treeless like today, the island had a relatively moist and cool climate with diverse vegetation including open oak woodland. Olive cultivation can be traced back to the Early Bronze Age. Cedar, yew and beech were also imported from Lebanon, Cyprus and Anatolia as artefacts, or for building.

Keywords: Bronze Age, Cyclades, Aegean, Santorini, Thera, archaeobotany, charcoal analysis

Bronze Age climate in the Aegean

Palaeoclimatic reconstructions for the Bronze Age Aegean based on pollen analytical investigations from several sites in mainland Greece (Bottema 1974, 1982, 1990) have suggested climate conditions drier than at present, with a reversal to a wetter climate favouring woodland expansion and arboriculture (including the intensive cultivation of olive trees) occurring only towards the end of the Bronze Age and the beginning of the historical periods (c. 3200/2700 uncal. BP, c.1500/1100 cal. BC). More recent pollen analyses from Crete have refined this general model, indicating contrasting patterns of vegetation change with the Greek mainland, with the former providing evidence for a much earlier onset of olive management/cultivation back to the Final Neolithic (Moody *et al*. 1996), which is even earlier than the classic case for Early Bronze Age olive domestication made by Colin Renfrew (Renfrew 1972). The same datasets have also suggested an overall slow pace of aridification for the southern Aegean, which was not complete until the Middle Bronze Age (early second millennium BC) (Moody *et al*. 1996).

These models for the nature and timing of vegetation and climate changes in the prehistoric Aegean have important implications for theories concerning the economic base of Bronze Age societies, being directly related to key parameters such as the environmental setting of prehistoric agriculture in this region and local variation in economic production (for useful reviews see Hansen 1988, Halstead 1994). However, more precise reconstructions of local

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vegetation catchments based on pollen evidence and the extrapolation from these of climate patterns and the impact of human activities on the landscape have been hindered by the scarcity and poor preservation of pollen-bearing sediments in the Aegean (especially near settlement sites) and their low chronological resolution (Bottema 1994: 46-48).

The systematic study of suitable plant macrofossil assemblages (i.e. stratified wood charcoal macro-remains) from archaeological sites of this period should allow the investigation of the local vegetation settings at a spatial and temporal scale congruent with that of the prehistoric human settlement, thus overcoming to some extent the dating limitations and low spatial resolution of pollen sequences (for recent examples of this methodology in the Eastern Mediterranean see Asouti & Hather 2001; Asouti 2003, in press). The microscopic analysis of stratified wood charcoal assemblages from one of the most eminent Bronze Age island settlements in the Aegean, Akrotiri on Thera, has furnished important preliminary results about the vegetation resources locally available prior to the second millennium volcanic eruption, revealing signs of a moister climate, a wooded landscape, early olive cultivation and a wide spectrum of economic activities, including trade links with more distant places.

Bronze Age and modern landscapes of Santorini

A major feature of the island complex of Santorini (Thera) is the submerged caldera created by the 'Minoan' volcanic eruption dated to the mid-second millennium BC (for a detailed discussion of the dating debate see Manning 1999) (Figure 1a). A substantial contribution to our knowledge of the late prehistoric geomorphological environment of Santorini has emerged from the systematic study of volcanic deposits and landforms associated with the

Figure 1a. Map showing the modern configuration of the island complex of Santorini'

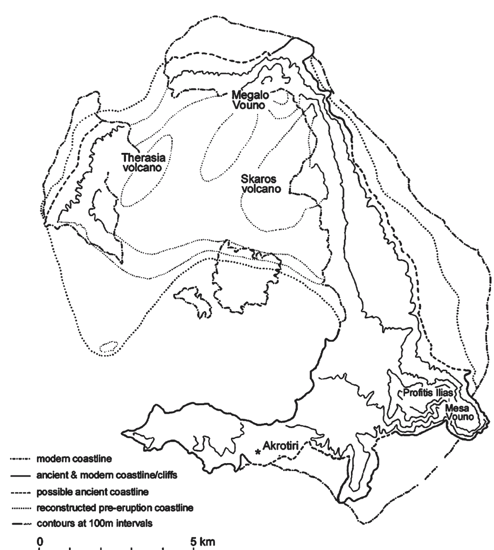

Figure 1b. Reconstructed late Bronze Age configuration based on the geomorphological data (redrawn after Aston & Hardy 1990; for alternative reconstructions see Friedrich 2000).

mid-second millennium BC eruption. According to these studies, Bronze Age Santorini comprised a highly complex volcanic landscape: a pre-existing submerged caldera (corresponding to an older eruption at c.18000 BP) occupied its southern half, whilst the northern half consisted of overlapping shield volcanoes and composite cones (Heiken *et al.* 1990) (Figure 1b). Based on these reconstructions it is plausible to infer that the pre-eruption Bronze Age landscape of Santorini comprised very diverse landforms including volcanic slopes and cones, sheltered bays and beaches and more exposed limestone peaks. Furthermore, estimations of the maximum height attained by the volcanic cone of Santorini before the eruption (c.350-500/600m; cf. Pilcher & Friedrich 1980; Heiken & McCoy 1984; Aston & Hardy 1990) have led some scholars to conclude that, although overall conditions could have been slightly more favourable for plant growth than today (given also the substantial period that had elapsed since the previous eruption at c.18000 BP allowing soil development) the island could not have supported substantial tree and shrub vegetation due to the absence of peaks high enough to attract rainfall trapped in clouds and fog (Rackham 1990).

The pre-eruption evidence reported to date from the Bronze Age settlement of Akrotiri includes olive stones and the charcoal remains of vine (*Vitis*), possibly oak (*Quercus*), pine (*Pinus*) and tamarisk (*Tamarix*) alongside the casts of reeds (*Arundo donax*) and the remains of tree roots spotted under buried soil horizons (Friedrich *et al.* 1990; see also Grove & Rackham 2001: 321). Charred seed remains have indicated the presence in the later phases of the settlement of cultivated crops such as barley (*Hordeum vulgare*), fig (*Ficus carica*), almond (*Amygdalus* sp.) and several pulses (including fava beans, lentil, chickpea and lupin) (cf. Friedrich *et al.* 1990; Sarpaki 1990; Friedrich 2000).

At present, Santorini is almost completely devoid of tree and shrub vegetation with the exception of pines, cypresses and a few olive trees that occur mostly on the limestone outcrops of Profitis Ilias, the highest peak of the island (566m a.s.l.). Otherwise, cultivated carobs (*Ceratonia siliqua*) and vines (*Vitis vinifera*) are the sole higher woody plants that manage to flourish in the island's arid environment with an average annual rainfall of c.380mm

The wood charcoal evidence

In December 2000, at the invitation of the director of the Akrotiri excavations, Professor Christos Doumas, and the archaeobotanist responsible for the material, Dr. Anaya Sarpaki, the present author undertook a short assessment in the field of the wood charcoal macro-remains retrieved from stratified archaeological deposits excavated in the process of digging shafts for the supports for the new shelter of the excavations. Given the limited period of field study, it was decided to concentrate on stratified samples retrieved from one of the deepest excavated shafts (63A). In order to maximise information on sample composition, both the flots and the heavy residues (non floating fractions) were examined (i.e., all fragments >2mm; fragments <2mm were considered too small for secure identification). The results of the analysis, expressed as absolute and percentage fragment counts, are summarised by archaeological phase in Table 1 (phasing has been based on the pottery and other artefacts as reported in the excavation diaries). Full anatomical descriptions of the identified taxa are given in Table 2 (see also Figures 2, 3).

Table 1. Summary absolute and percentage fragment counts of charcoal remains arranged by taxon (genus and/or species). Samples have been provisionally grouped into periods (Early Bronze Age, Middle Bronze Age and Late Bronze Age) according to the artefactual evidence from each sampled layer (reported in the excavation diaries) (percentages have been calculated after the exclusion of unidentifiable fragments from the sums, i.e. values represent percentages of identified fragments; N=number of samples examined)

	EBA (late 4th-3rd millennium BC) N=5	%	MBA (early 2nd millennium BC) N=11	%	LBA (up to mid-2nd millennium BC) N=7	%
Pinus (pine)	48	36.4	93	17.8	9	7.0
Cedrus libani (cedar)			14	2.7		
Cupressaceae (cypress/ juniper)	10	7.6	29	5.6	9	7.0
Taxus baccata (yew)			61	11.7		
Olea (olive)	57	43.2	221	42.3	87	68.0
Punica granatum (pomegranate)	1	0.8	4	0.8	2	1.6
Arbutus (strawberry-tree)			7	1.3	3	2.3
Maloideae (pears/hawthorns)	1	0.8				
Quercus deciduous (oak)	4	3.0	56	10.7	7	5.5
Quercus evergreen (oak)	2	1.5	10	1.9	5	3.9
Fagus (beech)			2	0.4		
cf. Rhamnus (buckthorn)			9	1.7		
cf. Tamarix (tamarisk)	2	1.5	8	1.5		
cf. Capparis (caper)					4	3.1
Lonicera (honeysuckle)			1	0.2	1	0.8
Fabaceae (legume undershrubs)	6	4.6	1	0.2	1	0.8
Lamiaceae (mint family)	1	0.8	5	1.0		
Poaceae (reeds?)			1	0.2		
Indet.	119		315		106	
Total	251	100	837	100	234	100
Total (-Indet.)	132		522		128	

Both the Early (c.3200-2000 cal. BC) and the Late Bronze Age (for the purpose of this study its lower end is set at the time of the volcanic eruption, i.e. mid-second millennium BC) are very much under-represented compared to the Middle Bronze Age (early second millennium BC). Yet, despite the somewhat unbalanced nature of the dataset, the results of the analysis have nevertheless provided a very rich charcoal assemblage. Olive (*Olea*) is by far the best-represented taxon, on average accounting for approximately 50 per cent of sample composition, followed by pine (*Pinus*) with an average value of 20 per cent. Given that the sampled deposits comprised exclusively fill layers containing scattered charcoal and not 'specialised', short-lived contexts (e.g. hearths) which are likely to represent isolated events (cf. Chabal *et al.* 1999), these frequency values suggest that olive and pine were probably the species most intensively exploited for fuel in prehistoric times. The same appears to be the case with *Cupressaceae* (cypress and/or juniper; a more precise identification was hindered by the small size of the examined charcoal fragments).

Table 2. Detailed anatomical descriptions of the tree and shrub taxa found in the Akrotiri charcoal assemblages (Key to captions – TS: Transverse Section, RLS: Radial Longitudinal Section, TLS: Tangential Longitudinal Section)
The charcoal specimens were examined under a high power, Olympus BHMJ epi-illuminating microscope, at magnifications of x50, x100, x200 and x500. Identifications were made in the field using wood anatomical descriptions and microphotographs available in Fahn *et al.* (1986) and Schweingruber (1990), and were later checked by comparison to charred specimens and thin sections of fresh wood from the A. C. Western wood reference collection held at the Institute of Archaeology, University College London. Rare and/or more problematic taxa were also examined in greater detail under the SEM (Scanning Electron Microscope) at the Institute of Archaeology. No indeterminate taxa (i.e., identifiable fragments for which a botanical determination was not possible to obtain) were encountered in the assemblage, the only factor limiting identification being the small size of the charcoal fragments (the number of specimens >4 and <5mm was in the range of 1-5 for each sample).

Taxa	Wood anatomical descriptions
Pinus (halepensis/ brutia type)	TS: early – latewood transition abrupt, latewood part relatively short. Resin canals present; RLS: Ray tracheids present, occasionally with conspicuously dentate walls. Ray parenchyma cells with pinoid pits. Crossfields with 1-2(3) pits; TLS: Resin canals present. Rays 7-8 cells high, occasionally higher (up to 15 cells)
Cedrus libani	TS: early – latewood transition mostly gradual, latewood part relatively short. Traumatic resin canals occasionally present in tangential rows at the ring boundary; RLS: Tracheids bearing mostly uniseriate pits with scalloped tori (Fig. 3), the latter particularly visible in the earlywood. Ray tracheids present, uniseriate, thin-walled, with irregular borders. Ray parenchyma cells thick-walled, with taxodioid pits in the earlywood and mostly piceoid pits in the latewood. Crossfields with 1-4 pits; TLS: Resin canals present (TLS surface too narrow for a reliable estimation of ray height)
Cupressaceae	TS: early – latewood transition gradual, latewood part short. Resin canals absent; RLS: Tracheid pits uniseriate. Ray tracheids absent. Transverse ray walls rather thick, smooth. Tangential walls smooth, occasionally nodular. Ray parenchyma with cypressoid pits. Crossfields with 1-2(3) pits; TLS: (TLS surface too narrow for a reliable estimation of ray height)
Taxus baccata	TS: early-latewood transition gradual, earlywood cells thick-walled. Resin canals absent; RLS: Tracheid pits uniseriate. Conspicuous helical thickenings on tracheid walls. Rays pits cypressoid. Ray tracheids absent; TLS: (TLS surface too narrow for a reliable estimation of ray height)
Olea	TS: Wood diffuse porous, growth rings mostly indistinct. Pores thick-walled, arranged in short radial multiples of 2-4(5), sometimes in clusters, occasionally solitary, dense. Parenchyma frequent, paratracheal-vasicentric, occasionally confluent; RLS: Perforation plates simple. Rays heterogeneous, with a central proportion of strongly procumbent cells and 1-2(3) rows of square and/or upright marginal cells. Inter-vessel and ray-vessel pits numerous, alternate, rounded, small. Libriform fibres present. Gummy deposits occasionally present; TLS: Rays uni- to bi(3)-seriate up to 10(12) cells high (uniseriate rays rare, short)
Punica granatum	TS: Wood diffuse porous, growth rings mostly indistinct, when present undulating. Pores solitary, in short radial multiples of 2(3-4) or clusters. Parenchyma infrequent; RLS: Perforation plates simple. Rays conspicuously heterogeneous, with a short central portion of procumbent cells and numerous rows of square and upright marginal cells. Inter-vessel and vessel-ray pits vestured, alternate. Libriform fibres present, septate. Gummy deposits present; TLS: Rays uni- to biseriate

Continued

Table 2. (continued)

Taxa	Wood anatomical descriptions
Arbutus	TS: Wood diffuse porous, growth rings distinct. Pores mostly angular, solitary, in short radial multiples (2-3) or clustered, numerous. Parenchyma mostly apotracheal, occasionally paratracheal (infrequent); RLS: Perforation plates simple. Rays heterogeneous, with a central portion of strongly procumbent cells and one row of upright marginal cells. Inter-vessel pits and vessel-ray pits with slit-like apertures. Fibre tracheids with bordered pits and (infrequent) septate fibres present. Conspicuous helical thickenings present on vessel members and fibre tracheids; TLS: Rays bi- to 3(4)-seriate
Maloideae	TS: Wood diffuse porous. Growth rings distinct. Pores solitary; RLS: Perforation plates simple. Rays homogeneous to slightly heterogeneous with one row of square marginal cells. Fibre-tracheids present. Helical thickenings present on vessel members and tracheids. Vessel-ray pits simple rounded, enlarged; TLS: Rays mostly biseriate
Quercus (type 1 – deciduous)	TS: Wood ring porous, growth rings narrow, distinct. Early wood pores solitary, arranged in a single row, large. Latewood pores solitary, in dendritic to radially oblique arrangement. Broad multiseriate rays conspicuous; RLS: Perforation plates simple. Rays homogeneous. Libriform fibres and vasicentric tracheids present. Vasicentric tracheids abundant, forming the greater part of ground tissue. Apertures of vessel-ray pits simple, enlarged, round to horizontally elongate; TLS: Rays uni- and multiseriate, the latter very broad (>15 cells)
Quercus (type 2 – evergreen)	TS: Wood diffuse porous, pores solitary, in dendritic arrangement; RLS: Perforation plates simple. Rays homogeneous. Libriform fibres and vasicentric tracheids present. Vasicentric tracheids abundant, forming the greater part of ground tissue. Apertures of vessel-ray pits simple, enlarged, round to horizontally elongate; TLS: Rays uni- and multiseriate, the latter very broad (>15 cells)
Fagus	TS: Wood diffuse to semi-ring porous. Growth rings distinct. Pores numerous, in clusters and radial multiples in earlywood, solitary in latewood. Rays sometimes very large, distended along the ring boundary; RLS: Perforation plates simple and scalariform (bars >15). Rays homogeneous. Apertures of vessel-ray pits oval, enlarged, horizontal. Inter-vessel pits opposite to alternate. All transitions present from pits to perforations. Fibre tracheids very frequent, compose the greater part of the ground tissue; TLS: Rays uniseriate to multiseriate (the latter very high)
cf. Tamarix	TS: Wood ring porous. Early wood pores large, solitary. Latewood pores very small, infrequent, predominantly solitary and in clusters/multiples of 2. Large rays visible in TS; RLS, TLS indeterminate due to salt encrustations
cf. Capparis	TS: Wood diffuse to semi-ring porous. Growth rings indistinct. Early wood pores large, solitary or in radial multiples of 2, latewood pores smaller, mostly in clusters; RLS: Indeterminate due to mineral encrustations. TLS: Rays 4- to 7-seriate, spindle-shaped with occasional sheath cells
Lonicera	TS: Wood diffuse to semi-ring porous. Pores solitary. Growth rings distinct; RLS: Perforation plates simple. Rays conspicuously heterogeneous with multiple rows of square and upright cells and few central procumbent cells. Ray-vessel pits slightly enlarged. Inter-vessel pits alternate to opposite, rounded, with slit-like apertures. Fibre tracheids form the greater part of ground tissue. Vessels and fibre tracheids with fine helical thickenings; TLS: Rays uni- to bi(3)-seriate

Continued

Table 2. (continued)

Taxa	Wood anatomical descriptions
Fabaceae	TS: Wood diffuse to semi-ring porous. Pores in oblique to dendritic arrangement. Parenchyma paratracheal and apotracheal banded (tangential bands); RLS: Perforation plates simple. Rays homogeneous to heterogeneous, the latter with a central portion of weakly procumbent cells and a few rows of square marginal cells. Inter-vessel pits vestured. Helical thickenings very conspicuous. Vessel members and parenchyma storied; TLS: Rays bi- to 3-seriate, storied
Lamiaceae	TS: Wood diffuse to semi-ring porous. Pores small, in clusters, solitary and in radial multiples of two, usually in tangential arrangement; RLS: Perforation plates simple. Rays heterogeneous, composed of numerous rows of square and upright cells. Vascular tracheids and libriform fibres present. Helical thickenings occasionally present on vessel members. Abundant salt encrustations; TLS: Rays uni- to bi(3)-seriate
Poaceae	Monocotyledonous wood. Vascular bundles surrounded by sclerenchyma sheaths. Metaxylem vessels 2, large. 1-2 protoxylem vessels, thick-walled. The examined specimens were very fragmentary and brittle, probably the result of thermal degradation

Other Mediterranean elements present in the charcoal assemblage include deciduous and evergreen oak (*Quercus* spp.). Anatomically, only the distinction between deciduous and evergreen oaks can be drawn securely, since it is impossible to tell the difference between individual species on the basis of their anatomy alone (Schweingruber 1990: 401). The main deciduous oaks of the southern Aegean are *Quercus macrolepis* and *Q. pubescens*, both shallow-rooted trees usually confined to water-retaining soils with good root penetration (Grove & Rackham 2001: 54). The ecology of prickly-oak (*Q. coccifera*) and holm-oak (*Q. ilex*), the evergreen oaks characteristic of the southern Aegean area, is well known from various studies (cf. Rackham & Moody 1996; Turland *et al.* 1993; Grove & Rackham 2001). Prickly-oak is a very versatile species, able to withstand a variety of soil substrata (including hard limestone) and abounds in maquis and open, "savanna"-like vegetation. Holm-oak is more moisture demanding and is usually associated with higher woodland. Both species can grow to high trees in the absence of browsing. They produce high-quality fuel, and are able to survive repeated woodcutting and fire through vegetative propagation.

Also present in the charcoal assemblage (albeit more sporadically) are a number of trees and shrubs associated with Mediterranean maquis woodland and scrub, such as pomegranate (*Punica granatum*), strawberry-tree (*Arbutus*), honeysuckle (*Lonicera*) and Maloideae (sub-family of the *Rosaceae*). Pomegranate (see also Figure 3) is reported in the literature as an endemic of south-west Asia, particularly the southern Caspian coastline, and is thought to have been naturalised in the Mediterranean region after its introduction from further east (Zohary & Hopf 2000: 170-171; Blondel & Aronson 1999: 226). It represents one of the earliest cultivated fruit trees in the region, with archaeobotanical finds from early Bronze Age Jericho and Arad, and late Bronze Age Hala Sultan Tekke (Cyprus) and Tiryns (Zohary & Hopf 2000: 171). Its presence in the Santorini charcoal assemblage serves as a *terminus ante quem* for its introduction in the Aegean. It is possible that pomegranates were cultivated in Akrotiri, perhaps as planted trees in gardens.

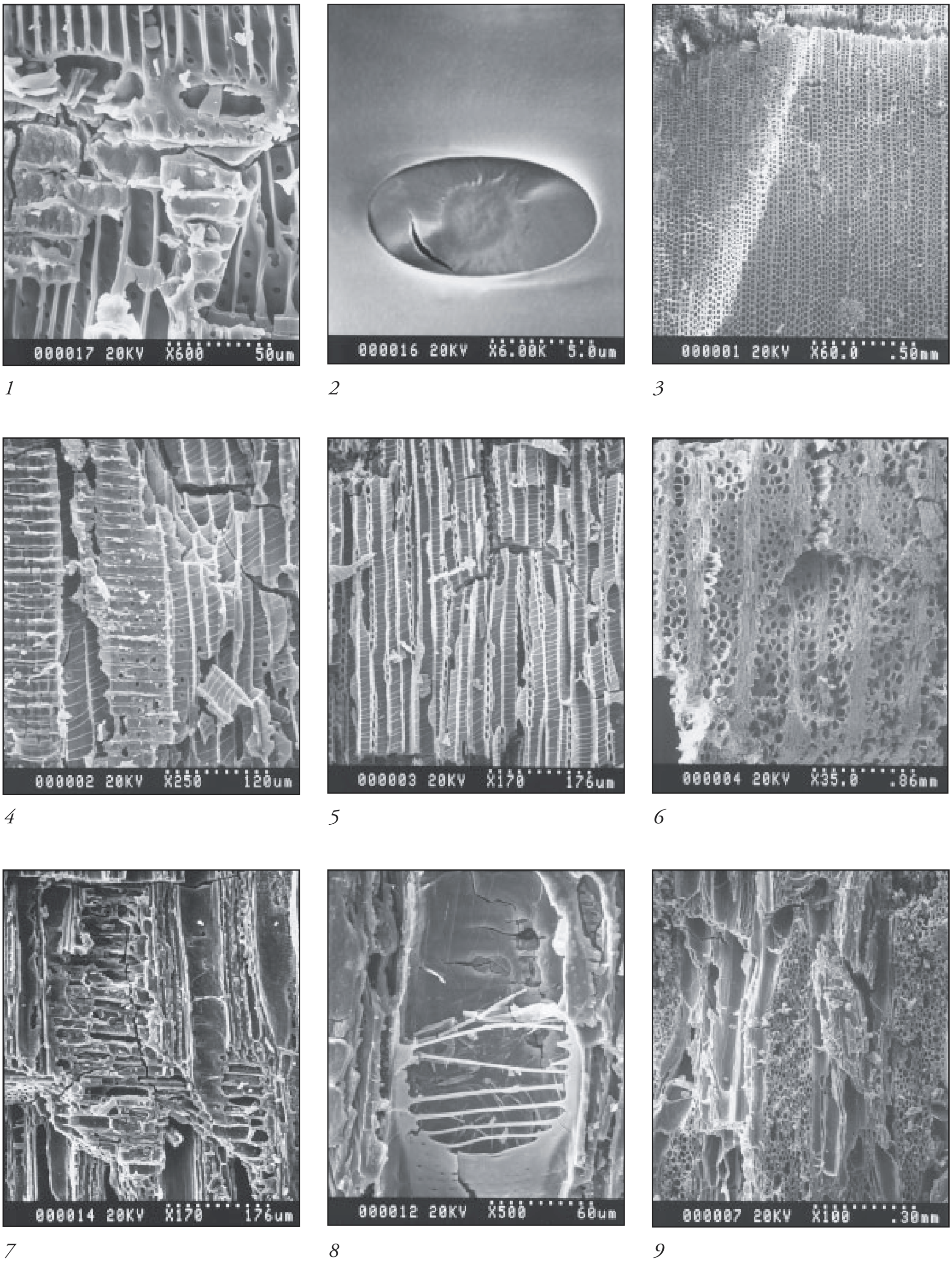

Figure 2. Scanning electron microphotographs of charred wood from Santorini: 1. Cedar (Cedrus libani) – Radial Longitudinal Section; 2. Cedar – Detail of RLS showing tracheid pit with scalloped torus; 3. Yew (Taxus baccata) – Transverse Section; 4. Yew – RLS showing tracheids with helical thickenings; 5. Yew – Tangential Longitudinal Section; 6. Beech (Fagus sp.) TS showing large, distended rays; 7. Beech – RLS showing homogeneous rays; 8. Beech – RLS showing scalariform perforation plate; 9. Beech – TLS showing large multiseriate rays

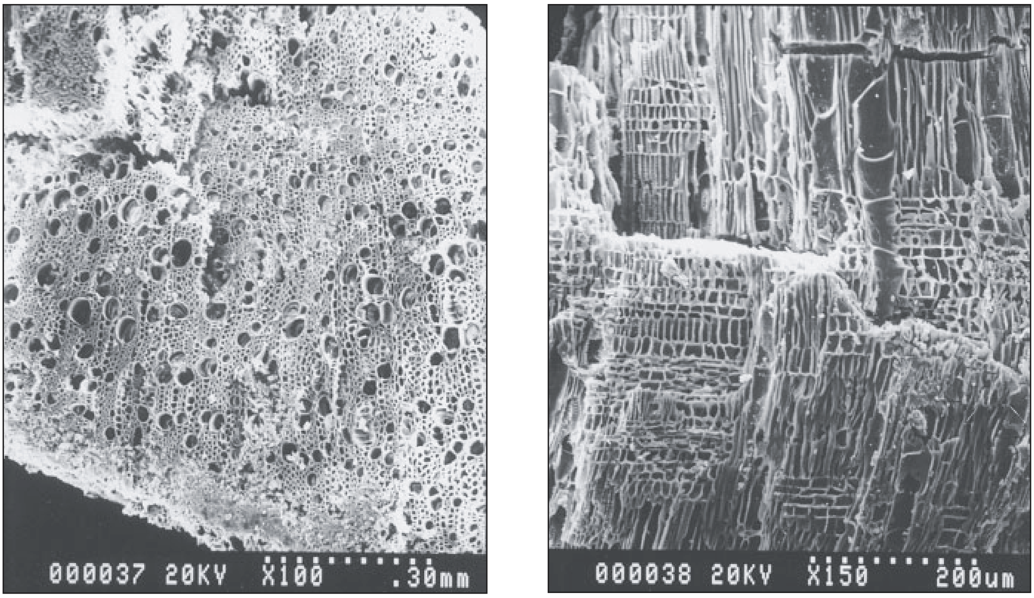

Figure 3. Scanning electron microphotographs of charred wood from Santorini: Pomegranate (Punica granatum): *left – Transverse Section; right Radial Longitudinal Section showing rays with multiple rows of square and upright cells.*

Strawberry-tree (*Arbutus*) and honeysuckle (*Lonicera*) can be associated with maquis vegetation, growing on middle and low-altitude calcareous soils (Rackham & Moody 1996; Turland *et al.* 1993). It is not possible to distinguish anatomically the different genera of Maloideae (Schweingruber 1990: 617). On ecological grounds, they may equally represent hawthorn (*Crataegus*), a tree associated in this region with scrub "savanna" woodland, or wild pear (*Pyrus amygdaliformis*) one of the most drought-resistant open woodland trees currently encountered in the southern Aegean (Rackham 1990; Turland *et al.* 1993).

A few charcoal fragments have been identified as *Fabaceae* shrubs (woody legumes) and *Lmiaceae* (mint family). Due to their small size it was not possible to obtain more precise identifications. They most likely represent undershrubs growing in patches of garigue scrub (cf. Rackham & Moody 1996: 113-114). Their very erratic presence in the charcoal record could be explained as the result of their small size, which may be responsible for their poor preservation due to high rates of charcoal loss when burnt.

Some charcoal specimens have been tentatively identified as tamarisk (*Tamarix*), caper (*Capparis*) and buckthorn (*Rhamnus*). Although these fragments were also poorly preserved, it is likely that all three taxa are represented in the charcoal assemblage. Buckthorn and caper are compatible with garigue scrub (caper can also grow on rocky surfaces and cliffs), whilst tamarisk could have occurred in halophytic communities growing on marshes and streams close to sea level (cf. Turland *et al.* 1993). Both tamarisk and Poaceae (the latter likely to represent reeds) have been previously identified in Santorini (see above).

Perhaps the most striking feature of the assemblage was the recovery of charcoal fragments belonging to cedar (*Cedrus libani*), yew (*Taxus baccata*) and beech (*Fagus*) (Figure 2). Presently, none of these trees occurs naturally in the southern Aegean. On the basis of modern ecology and the available palaeobotanical evidence it seems reasonable to infer that all three species were imported to Akrotiri. Cedar has a very localised distribution which includes the subalpine (1500-2000/2200m) slopes of the Taurus range in Anatolia and the Lebanon range in the Levant (*Cedrus libani*; the cedar of Lebanon), whilst two subspecies (*C. libani* ssp. *brevifolia* and *C. libani* ssp. *atlantica*; nomenclature follows Davis *et al*. 1965: 72) are known from the Cypriot highlands and the Atlas mountains in northern Africa respectively (ibid.). Yew and beech are more mesic species. Today beech does not occur south of Thessaly, whilst yew is found in the high-altitude coniferous forests of mainland Greece (Sfikas 1995: 56). The available pollen evidence confirms that these species were not present in southern Greece during later prehistoric times, with the exception of beech for which there are some records from central Greece (Allen 1997), the southern Peloponnese (Kraft *et al*. 1980; Bottema 1990) and Crete (Bottema 1980). Its low frequencies in the Cretan pollen diagrams had been previously interpreted as the result of long-distance transport (Bottema 1980). However, the occurrence of beech in more recently published diagrams from western Crete accords with evidence indicating the presence in this region during the first half of the Holocene of several mesic tree species such as alder, lime, hornbeam, elm and birch (although it seems rather unlikely that beech could have grown on Santorini itself, given its low altitude). This evidence has been interpreted as indicative of moister conditions prevailing in this area, with a reversal to more arid conditions from the mid/late Bronze Age (MBA/LBA) onwards (Moody *et al.* 1996; for a general summary see Grove & Rackham 2001: 55, 144-145).

Discussion: Bronze Age vegetation, timber trade and related activities

Previously proposed patterns of Bronze Age vegetation for the island of Santorini (cf. Rackham 1990) suffered from a lack of direct evidence and had to rely instead on observations of modern vegetation, geomorphological reconstructions and extrapolated rainfall patterns. The first systematically collected evidence from charcoal macro-remains associated with stratified archaeological deposits (including fifteen taxa believed to have grown locally) indicates that Bronze Age Santorini (unlike modern) was far from treeless.

The wood charcoal macro-remains suggest a highly variable vegetation cover for the island of Santorini prior to the volcanic eruption of the second millennium BC. The available evidence indicates the presence locally of pine forest and/or woodland. In general, pine and olive would appear to represent the main firewood resources exploited by the prehistoric inhabitants of Akrotiri. However, the overall poor preservation and high fragmentation of charcoal macro-remains do not allow a more precise estimation of the intensity of firewood consumption and the potential contribution of dung fuel as has been suggested elsewhere (cf. Rackham 1978: 758).

Much of the olive wood utilised in Akrotiri could have derived from the regular pruning of cultivated olive trees. This was almost certainly the case for the late Bronze Age phases of the settlement as there is supportive evidence from the archaeobotanical remains (Sarpaki pers. comm.; for taphonomic explanations of the low visibility of olive stones in domestic contexts in Akrotiri see Sarpaki 1992). In the present study it has not been possible to substantiate a hypothesis for the systematic pruning of olive trees based on the anatomy of the analysed fragments (e.g. through the recurrent presence of 'degenerate' growth rings, cf. Rackham 1972 or, alternatively, the size of terminal rings preserved in twig and round-wood) due to the small size of the examined charcoal specimens. Certainly, the frequency of occurrence of olive charcoal throughout the examined sequence would seem to suggest that olive trees (wild and/or domesticated) were regularly harvested for firewood, an activity that is likely to have taken place in association with the seasonal harvesting of the olive crop. The fact that olive charcoals appear in large proportions from the earliest examined samples (EBA) might also indicate that olive trees were exploited for their fuel and fruit from an early period in the history of the settlement. Such a pattern would in turn seem to suggest that, in agreement with Renfrew's original thesis (Renfrew 1972) and contrary to what has been proposed by Runnels & Hansen (1986) and Hansen (1988), olive cultivation (not necessarily implying domestication) had begun in the Cyclades by the EBA. This is consonant with the even earlier date for Crete (above; Moody *et al.* 1996) and casts doubt on earlier postulations for a strictly palatial context of Bronze Age olive oil production (cf. Hamilakis 1996). Clearly, more evidence is needed (particularly from the ongoing analysis of seed material from the EBA/MBA phases at Akrotiri) to test further the validity of this hypothesis.

In addition, the definite presence of both deciduous and evergreen oak alongside many typical Mediterranean elements such as juniper/cypress, strawberry-tree, wild pears, pomegranate (possibly cultivated) and honeysuckle suggests the co-occurrence of patches of maquis woodland (however "degraded" by browsing and/or woodcutting), garigue and deciduous open oak woodland. That some kind of "forest" may have existed on the island had been previously indicated by the finds of a troglodytic beetle species (*Troglorhynchus* cf. *anophthalmus*), which lives in thick leaf litter and damp environments, from Late Bronze Age domestic contexts in Akrotiri (Panagiotakopulu 2000: 62-63). The likely occurrence of reeds and tamarisk further points to the existence of more localised waterside vegetation that could have grown at the edges of streams and marshes.

Concerning prehistoric activities such as trade and manufacture, there is now firm evidence to demonstrate the importing of high-quality timber and/or finished wooden objects (cedar, yew and beech) from elsewhere. Possible direct sources for these species include the Lebanon range, Cyprus and the southern coast of Anatolia (cedar; also identified from sites in Crete cf. Rackham 1978: 759) and mainland Greece and/or Crete (yew, beech). Both cedar and yew were widely revered in antiquity for their qualities as construction timber and carpentry wood respectively (the latter also being the case with beech; cf. Meiggs 1982). Particularly for cedar, there is at present sufficient direct evidence to consolidate its status as one of the principal trade items in the Eastern Mediterranean during the MBA and the LBA, mainly on the coastal route from Lebanon to Egypt as suggested by finds of imported cedar wood in Egypt (Gale *et al.* 2000; Pulak 2001) and at the Levantine sites of Tel Nami, Tel Ifshar, Kabri and Lachish (Lev-Yadun *et al.* 1996).

Further integration of the archaeobotanical evidence with the artefactual assemblages retrieved from the recent excavations is necessary for defining with greater precision the origins of such imported goods at Akrotiri. Nevertheless, it is interesting to note the occurrence at Tel Nami of stored fava beans (*Lathyrus clymenum*), an Aegean pulse crop best known from Santorini (found in storage contexts in the West House of Akrotiri) (Sarpaki 1990; Kislev *et al.* 1993). In addition, other activities such as the feeding of silkworms and the production of silk, previously indicated in Akrotiri by the occurrence of a lepidopterous cocoon but otherwise questioned in the absence of evidence for the existence locally of suitable tree species (cypress, juniper, deciduous oak; cf. Panagiotakopulu *et al.* 1997) could be now re-addressed in the light of the charcoal data.

Future analyses of wood charcoal assemblages from a greater number of settlement sites in both mainland Greece and the islands would help substantially in elucidating local vegetation environments and regional variation in climate patterns during the Bronze Age. For Santorini in particular a preliminary hypothesis, open to further investigation through the examination of a larger charcoal assemblage, would posit a moister (and perhaps cooler too) climate during this period on the island, with an average annual precipitation substantially higher (possibly in the range of c.600mm) than at present. A systematic investigation of paleosols and buried land surfaces still preserved in Santorini is also required, in order to obtain direct evidence on the types of soils likely to have sustained different vegetation communities in the past. The limited studies available have indicated the presence of well-developed soils able to sustain higher vegetation and presumably more amenable to plough cultivation (cf. Limbrey 1990).

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