THE DEBATE ON AEGEAN HIGH AND LOW CHRONOLOGIES: AN OVERVIEW THROUGH EGYPT

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Abstract

One of the most important problems which affect the reconstruction of the Aegean Late Bronze Age (LBA), and its significance in the Mediterranean world, is the absolute chronology of the Minoan LM I-II periods, and, in turn, the absolute dating of the mature LM I A Theran eruption, and their relationships with the Egyptian and Cypriote relative chronologies. Since the last three decades, the traditional chronology has been challenged by radiocarbon results obtained from a few key sites, which, during the late 1990's seemed to be confirmed by several other dating techniques. In turn, an impressive amount of new data, often supporting the traditional view, has been obtained from the (re)analysis of the Aegean, Cypriote and Egyptian assemblages, which have yielded good evidence for their chronological correlation. As a consequence, the archaeologists face with an impasse, given that none of the two parts involved in the debate can rely upon conclusive arguments, or be confident of the outcome. However, a slightly modified version of the traditional "Low" chronology might be put forward, maintaining both archaeological and radiocarbon evidence. It is interesting to point out that the radiocarbon results, when individually calibrated, do not seem homogeneous enough to justify a shift of some 120 calendar years in the traditional chronology.

1. Introduction

The debate on the absolute chronology of LM I-II Crete dates back to more than three decades ago (see, for instance, Kemp and Merillees 1980). More new evidence has been achieved since then, allowing scholars to formulate new chronological hypotheses that are opposite to the interpretative evidence.

In particular, a great number of new radiocarbon determinations has been obtained, leading some authors to hypothesise a new chronology, based on high-quality datasets, otherwise called Aegean High Chronology (AHC) (Manning 1999; 2005; 2006; 2007; Manning *et al*. 2001; 2002a; 2002b; 2003; 2006; Bronk-Ramsey *et al*. 2004).

During the 1990's this radiocarbon chronology seemed to be confirmed by independent proxy-data among which are 1) anomalous growth peaks in the Bristlecone, Belfast, and Hohenheim tree ring sequences (Manning 1999; Manning *et al*. 2001; 2002a), and 2) volcanic activity-related acidity spikes, and glass sherds horizons in the Greenland ice cores (Zielinsky *et al*. 1994; Clausen *et al*. 1997; Manning 1999; Hammer 2000; Hammer *et al*. 2003).

As a consequence, a date of 1645-1625 cal BC for the Theran eruption has been suggested and it is still used by many authors (Manning 1999; 2005; 2006; 2007; Manning *et al*. 2001; 2002a; 2003; 2006; Duhoux 2003; Bronk-Ramsey *et al*. 2004; Kieser 2005). This implies a shift of some 100 years in the LM I-II absolute chronology (Bietak 2003; 2004; 2007; Bietak and Hein 2001; Bietak and Hoeflmayer 2007; Bronk-Ramsey *et al.* 2004; Manning 1999, 2006, 2007; Manning *et al.* 2001; 2002a; 2002b; 2003; 2006; Warren 2006; Wiener 2001; 2003; 2006; 2007a; 2007b; 2008).

Nevertheless, many things have changed since then. First of all, it has been demonstrated that the glass sherds from the above 1645 horizon, do not belong to the Theran eruption (Keenan 2003; Wiener 2003), and bear more resemblance with the Aniakchak late Holocene eruption chemical composition (Pearce *et al*. 2007). Then, a shift of 22 years (Manning *et al*. 2001; Manning 2006) of the Ana-

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tolian dendrochronological sequence, whose correlation is still discussed (James 2002; 2006; Keenan 2004; 2006), has definitely rejected any relationship between the 1645 cal BC horizon and Thera, leaving only radiocarbon to support the AHC (Wiener 2001; 2003; 2006; 2007a; 2007b; Manning 2005; 2006; 2007).

In the meantime, a new high-quality, independent dataset (*fig*. 3, a, b, c, d) obtained from an olive tree branch buried by the eruption – thus a singleton – (Friedrich *et al*. 2006) has fixed the most probable eruption time-range to 1627-1600 cal BC, with a very low possibility for a date within the first decades of the XVI century cal BC. Furthermore, many more data have been obtained also from several archaeological contexts, which have yielded strong evidence to correlate more and more strictly the Egyptian and Minoan chronologies, very often via Cyprus (see contributions in Bietak 2000; 2003b; Bietak and Czerny 2007). These contexts, together with some criticism on the methodology applied to the interpretation of the radiocarbon data (Porter 2005a; 2005b; Keenan 2006; Wiener 2003; 2006; 2007a; 2007b; 2008), have cast some doubt on the reliability of the AHC.

2. The Problem

If we accept that the XVIII dynasty Egyptian chronology is well-based, as suggested by Kitchen (1982; 2000; 2007) and Krauss (2003; 2007), and as possibly confirmed by astrochronology (Brein 2000; Firneis 2000; Firneis *et al*. 2003), the absolute dates cannot be shifted by more than a very short time-span (a generation, more or less). As a consequence, the beginning of Ahmose's reign is to be fixed around 1539 cal BC, following Kitchen (2007). On the other hand, a unilateral shift of the standard Aegean chronology, leaving Egyptian chronology apart, seems unlikely, because of the cross-dating elements considered below, as pointed out by Bietak (2003b; 2004; 2007), Wiener (2003; 2006; 2007a; 2007b) and Warren (2006).

1) The first pivot in the traditional chronological network lies in the Cypriot imports of the end of the MBA, when Tell el Yahudiya ware, manufactured during the last decades of the XVII century at Tell el Dab'a, or in its neighbourhood, was exported to MC III Cyprus, as supported by the grave goods from Arpera Tomb Ia, and Toumba tou Skourou Tomb V (Eriksson 2001; 2003). This shows that in Cyprus the end of MBA took place later than the XVII century (considering the time needed to develop a local Ty production), or roughly around that time.
2) The following LC I A was partly (LC I A2) contemporary with LM I A in Crete, and the Egyptian XVIII dynasty, as shown by the assemblages from Palaepaphos-Teratsoudhia Tomb 104, where an Ahmose-inscribed vessel was found together with LM I A and Cypriot WS I wares (Eriksson 2001; 2003). Given that the XVIII dynasty began not earlier than 1540, the imported items from the Aegean assemblages, like the NM 829 and NM 592 reworked jars from Mycenae SG, show that LH I/LM I A continued at least to the last decades of the XVI century (Warren 2006). Furthermore, the Cypriot LC I A2-B contexts with LM I A ware found in association with Egyptian *Mechak* razors of Tuthmosis III age (Toumba tou Skourou and Agia Irini; Eriksson 2003), seem to indicate that it continued until the beginning of the XV century, although the presence of such items in older contexts cannot be excluded at the moment. Another very important argument that links the Theran eruption to the XVIII dynasty is represented by two famous imported vessels from Akrotiri: the reworked Egyptian alabastron Akr*1800, and the now-lost WS I cup from Goceix's excavations (Merillees 2001; Wiener 2001; 2003). The first is an example of the transition between S.I.P. type alabastra and New Kingdom specimens, with mixed characteristics. It was probably damaged during its use, and undoubtedly reshaped into a Minoan vessel (Merillees 2001). This means that it was quite "old" when it was buried, suggesting that the eruption took place, at the earliest, somewhat after the end of the S.I.P. The latter is a classical example of WS I ware, datable at least some two-three generations after the first WS productions, according to Merillees's analysis. A discussion on the chronological importance of this Cypriot class of pottery, and the contemporary BR and RLWM wares, the most serious argument in favour of the standard chronology, will follow in the next paragraph.
3) The Cypriot PWS-WS, RLWM and PBR-BR contemporaneous sequences (Åström 2001; Eriksson 2001; 2003), allow us to suggest a network between Egypt, Crete and Cyprus during the XVI-XV centuries, which is pinpointed by the interrelated chronologies of subsequent Amar-

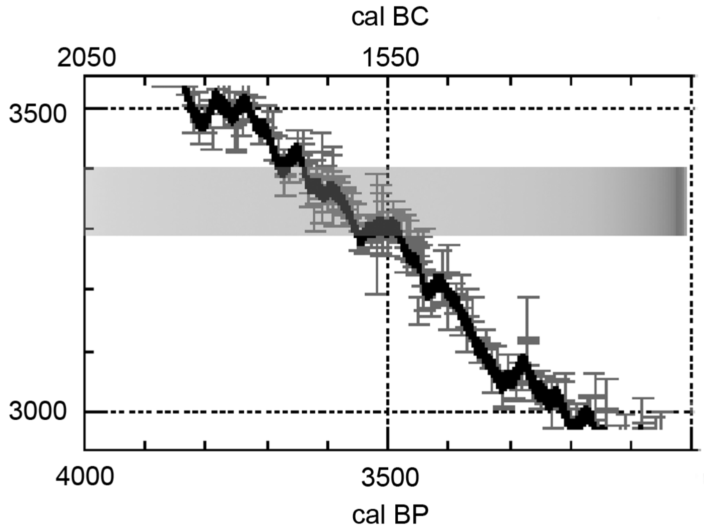


fig. 1 - IntCal 04 calibration curve 3500-3000 uncal BP, showing the "plateau" leading to a (long-range) ambiguous calibration (Reimer *et al*. 2004, modified by the author. The relevant time-span for the Thera eruption is highlighted).

na period. The sequence of the imported items seems to be almost identical whenever produced in Cyprus, and exported to Egypt and the Levant. The sites of Ashkelon, Tell el Ajjul and Tell el Dab'a have yielded comparable sequences, which closely link the PWS-WS development to the historical absolute chronology (see various contributions in Bietak 2000; 2003a; Karageorghis 2001; Bietak and Czerny 2007).

Thus we can state that WS never makes its appearance outside Cyprus before the beginning of the LBA, except for a doubtful example from Tell el Ajjul (Bergoffen 2001). During later periods, it is often attested from reliable stratigraphic sequences (Bergoffen 2001; 2003; Bietak and Hein 2001; Cadogan *et al*. 2001; Fischer 2001; 2003; Wiener 2001; Bietak 2003b), which systematically recall the same development already known from Cyprus. This suggests that a significant delay between its first production and its (hypothetical) later export is unlikely. PWS wares, typical of LC I A1, come from Tell el Dab'a and Ajjul not before the final MBA phases (Tell el Dab'a phase D/2), in a period that cannot be dated earlier than 1-2 generations before the conquest of Avaris by Ahmose (Bietak 1999; 2003b; Bietak and Hein 2001; Aston 2003; 2007). In Cyprus, LC I A1 is a period for which no links are demonstrated with the LM I A, since LM I A ware starts to make its appearance only in the subsequent LC I A2 (Eriksson 2001; 2003). Typical Cypriot exports of this latter phase are WS I and BR I wares, which are so widely distributed in the Eastern Mediterranean that no doubt can be cast on their chronological reliability (Merillees 2001).

Both WS I and BR I wares make their appearance at Tell el Dab'a not earlier than during phase C/3, well into the XVIII dynasty (most likely during the reigns of Hatshepsut and Thutmosis III; Bietak and Hein 2001; Bietak 2000; 2003b; 2004). They are known, from contemporary phases, also from Lachish, Ashkelon and Ajjul (Bergoffen 2001; Merillees 2001; Fischer 2001; 2003; Wiener 2001; 2003; Warren 2006), and are followed by the subsequent WS II and BR II imports around the middle of the XV century (Tell el Dab'a phase C/2; Bietak and Hein 2001; Bietak 2003b; 2004).

The close relationships between the above Cypriote WS and BR sequence and Egypt, the interconnections between LC I A2 and LM I A, and the occurrence of Egyptian artefacts in both LH I Greece and Thera, would demonstrate that no independent shift of the Aegean LM I chronology is acceptable, unless we think that WS I lasted some 120-160 years, during which 1) WS I was produced (and exported, as it is known, but only to Akrotiri), without any stylistic change, some 100 years before the peak of its export, and 2) the entire ceramic sequence, including its formative and transition-al phases, was continuously produced following the same manufacturing technique and decorative styles for generations (Wiener 2001, 2003; 2007a; 2007b; 2008).

According to Manning (2007) the Tell el Dab'a sequence, which represents the entire Cypriot development in detail, shows a few gaps marked by the overlap of a few ceramic classes, which coexisted in Cyprus for much longer than it is shown at Tell el Dab'a. PWS and WS I, for instance: in Cyprus they overlap during the entire LC I A2, and the beginning of LC I B, when PWS was dismissed. Although this fact can be observed also at Tell el Dab'a, there it seems to have lasted for a very short period (Manning 2007). At this latter site, in fact, LC I A1 corresponds to phase D/1, LC I A2 to phase C/3, and LC I B to phase C/2, and Thutmosis III reign. WS II and BR II make their appearance at Tell el Dab'a during Thutmosis III reign, and this shortens the chronology of LC I A 2-LC I B pottery to some 75-50 years. Even though we accept that the LC I A2 sequence shown at Tell el Dab'a is partially incomplete, in any case it would not correspond to the 100 years shift represented by a XVII century cal BC date for Theran eruption. On the other hand, even considering the small flexibility admitted by Bietak (2004; Bietak and Hein 2001) one might also try to "smooth" the problem, and elongate the LC I A2 period (of some 20 years?), as seen from Tell el Dab'a, with almost no consequence for the traditional chronology.

3. Discussion

To sum up, there are a few arguments that would invite to some caution to the acceptance of the high chronology: 1) the currently available network is based on the distribution of several, widespread specific items, coming from different, independent contexts, which give shape to a coherent scenario; 2) if we accept a calendric date as high as 1600, for the Theran eruption (which implies that LM I A ended before 1570 cal BC, or even earlier), this would require an alternative reconstruction of the archaeological network, which seems to be unlikely, the more our knowledge of Cypriote imports/exports improves, even if some degree of regional variability has been recognized in Cyprus (Manning *et al*. 2002b); 3) the gap between archaeological and radiocarbon chronology seems difficult to reassess (Bietak 2003b), and it is still highly debated.

According to the available data, three possibilities can be put forward:

1. The archaeological reconstruction is unreliable, and the eruption did take place somewhat around the end of the S.I.P., or even earlier. According to the available archaeological data this seems unacceptable, and new elements, which support a revision of the above archaeological network, are necessary to propose an alternative reconstruction, although an attempt in this sense has been made by Manning *et al.* (2002 b);
2. Both archaeological reconstructions and radiocarbon data are reliable. In this second case the problem could arise from the interpretation of the radiocarbon dates. For the late LM I A, the radiocarbon determinations from Thera often suggest that the eruption took place during the XVI century: more precisely, all the ^{14}C dates older than 3330 uncal BP point to an high chronology (with the eruption occurring in the XVII century BC), those falling between 3330 and 3310 uncal BP (with the eruption occurring in the XVII as well as in the XVI century BC) speak in favour of both an high and a low chronology, whilst the radiocarbon dates from 3310 uncal BP downwards (see, for instance, Eastwood *et al*. 2002) (*fig*. 4 a-b) point to a lower one, with the eruption occurring during the XVI century BC, as also pointed out by Manning (2006). Among the 28 radiocarbon results from Akrotiri published by Manning *et al*. (2006), 25, once (individually) calibrated at 2 sigma, suggest an eruption date as late as the middle of the XVI century, and 19 could also allow a date more recent than 1530 cal BC (Table 1). Only once they are combined by the use of sequenced analysis, which incorporate stratigraphic information, the uncertainty is much reduced (Bronk-Ramsey *et al*. 2004; Manning *et al.* 2002a; 2003; 2006; Manning 2005; 2006; 2007).
An intermediate chronology, that has been referred to as "compromise early" or "modified low" (see, for instance, Wiener 2003; 2007b; Bietak 2004; Manning 2005; 2007; Warren 2006), with the eruption occurring somewhat around 1580-1520 cal BC, would be acceptable, discarding neither the archaeological evidence, nor the radiocarbon datasets. Nevertheless it is to be remembered that this is a merely speculative point of view: neither the available archaeological evi-

dence, nor the radiocarbon assays support the reliability of this "mid" chronology. It is just a compromise that would work with both arguments (Wiener 2003; Warren 2006; Manning 2006; 2007). It is also interesting to note that a volcanic horizon in Dye-3, dated to 1525-1524 cal BC, perhaps corresponding to tree ring anomalies attested in several regions, might be connected with the Theran eruption (Wiener 2006; 2008). Thus, if we accept the traditional chronological framework without discarding the radiocarbon evidence, a slightly modified version of the Standard Aegean Chronology might be proposed as follows (see for example Warren 2006):

a. LM I A = 1600-1510/1500 cal BC
b. LM I B = 1510/1500-1440 cal BC
c. LM II = 1440-1400 cal BC

3. The archaeological reconstruction is correct, and the radiocarbon dates are affected by some alteration/contamination effect. It is to be remembered that many different issues can affect the radiocarbon results: regional variability in the IntCal04 calibration curve is a problem, as pointed out by the authors of the curve, which is in fact an average for the Northern Hemisphere temperate zones, where growing season is estimated to be around April-October (Reimer *et al*. 2004; Reimer, pers. comm. 2008), and doubts have been cast on the reliability of the calibration, when used for dating events in short timespans – decadal measurements being subjected to all the possible errors/contamination (not least intra and inter year variations) of the single dates (Wiener 2003; 2007a; 2007b; 2008) – and on the use of summed probabilities for defining start and end dates of each event (Michczynski 2004). As pointed out by Manning (2005), the gap between the two chronological hypotheses in question is of some 20-30 radiocarbon years, which is roughly the best precision currently available for AMS dating. With such an uncertainty even small offsets and variations could face us with an impasse (Manning 2005) (*fig*. 1).

Furthermore, geophysical and atmospheric conditions may produce very significant shifts in radiocarbon dating, the so-called reservoir effects, which include the contamination caused by small amounts of ^{14}C deficient carbon from different sources has ground water, volcanic venting or deep sea water up-welling (Wiener 2007a): for example, an up-welling of old deep marine waters, beginning after the end of the Sapropel 1 episode, has been suggested by Keenan (2002). Such an effect, albeit far from demonstrated (see Siani *et al*. 2001), might explain slightly older dates in areas downwind from the Mediterranean (or, at least, downwind from the up-welling zone), possibly relevant as a shift of only 20 radiocarbon years would be enough to undermine measurement's reliability in determining an high or a low eruption date within its tighter range. It is to be noted that the radiocarbon results from Tell el Dab'a (whose publication is awaited, see Bietak and Hoeflmayer 2007) seem to reflect the same offset hypothesized for the Aegean (Bietak and Hoeflmayer 2007; Bruins 2007), which, if true, might be a strong argument in favour of a widespread ^{14}C alteration. Solar activity may also play a significant role, as sunspots cycles, for example, can significantly affect radiocarbon dating (Knox and McFadgen 2004; and Mauquoy *et al*. 2004), albeit such an effect would be expected to be picked up also in the tree-rings used for the calibration curve (Knox and McFadgen 2004). No less important, the inter-year differences in the growing seasons of measured plants may produce slightly older dates, for example in Egypt, where the growing season is December - February, or younger dates, for example in Turkey, where the growing season is early spring (Wiener 2003; 2007a; 2007b; 2008; Ouda 2006).

4. Conclusion

It is interesting to point out that radiocarbon dates favouring a low chronology have been obtained from samples collected from sites supposedly out of the limit reached by the above-mentioned hypothetical contamination, amongst which is Gölhisar in Turkey (Eastwood *et al*. 2002) (*fig*. 4 a-b). More recently, tsunami deposits from Palaikastro (Crete) have yielded new non-univocal (for our dating purpose) radiocarbon dates (Bruins *et al*. 2008). The most stratigraphically reliable of them support both an high and a low chronology (*fig*. 2 a-b): two results from cattle bone samples are 3310±35 uncal BP (GrA-30336), and 3390±35 uncal BP (GrA-30339). These results were also confirmed by other measurements from marine shells. However this example shows how far we are from an univocal and acceptable radiocarbon chronology for the Theran eruption, given that radiocarbon dating provides just a probable time-range for the

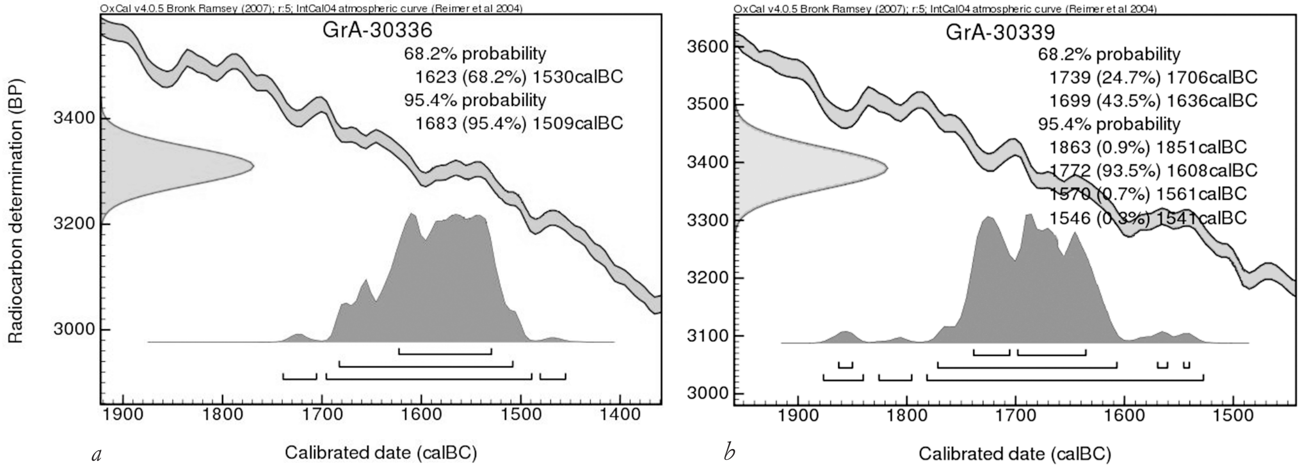


fig. 2 - Calibration of two dates for the Theran Tsunami, from Palaikastro (Bruins *et al*. 2008) according to OxCal 4.0.

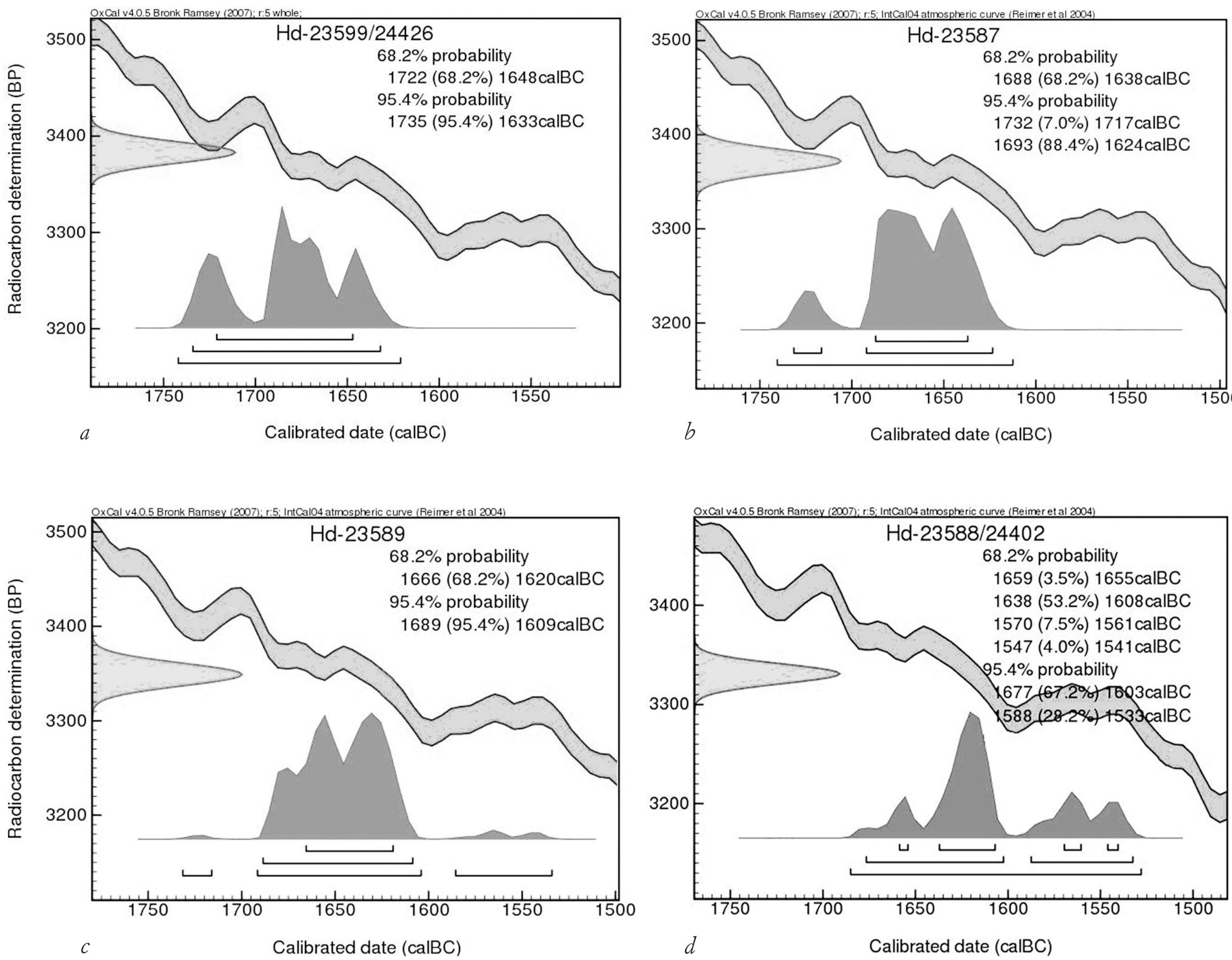
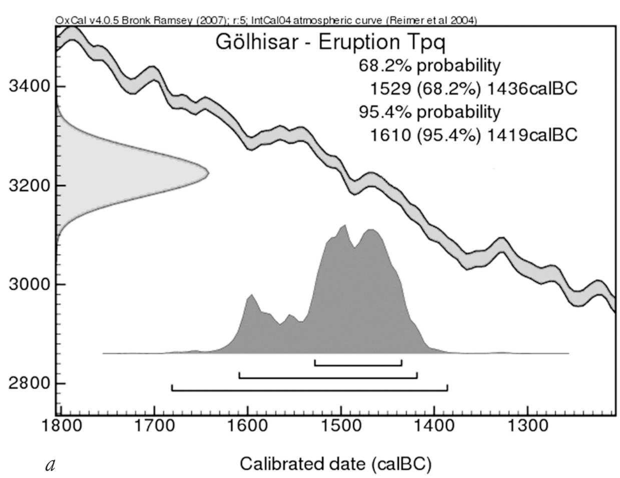


fig. 3 - Individual calibration of the four dates from the olive tree branch found near Akrotiri (Friedirch *et al*. 2006) according to OxCal 4.0.

eruption, which is too broad for our expectations (Table 1).

The radiocarbon chronology suggests that the eruption took place between the XVII and XVI centuries cal BC, probably not in the XV, although this point is still debated. Such a wide time-span is not surprising, given that radiocarbon dating alone (in absence of an independent test) can rarely be employed for the definition of short time-ranges. The statistical approach used for its shortening is supposed to produce exclusively exploratory values, sometimes perhaps misrepresented as objective data – with the exception of the wiggle-matching of the olive branch measured by Friedrich *et al*. (2006), which is nonetheless subject to the uncertainties of the calibration curve. Furthermore, this wiggle-matching may be influenced also by problems connected with ring counting. Counting error has been estimated by Friedrich *et al*. (2006), but it has been shown that plants can fail to produce annual ring for one or more growing seasons when influenced by local climatic conditions, but also, although this is uncertain, by arboricultural works (Wiener 2008). Furthermore, it is noticeable that a difference of only a few dozen ^{14}C years, which is difficult to ascertain from a scientific point of view (given the absence of an independent test with other arguments, apart from historical chronology), could significantly mislead our interpretation of the radiocarbon results, not least because the difference in ^{14}C years between the two chronologies is very small (*fig*. 1). Such a shift of a few dozen radiocarbon years is possible, as admitted by Manning *et al*. (2002a), and Manning (2005), as we are operating close to the current precision limit of AMS dating (24-32 ^{14}C yrs, Manning 2005). Even if a better-defined calibration curve will be obtained, from the dendro-dated wood in the Aegean Dating Project, local variability would still be a great deal (see, for example, Bruins 1995; and Bruins and Van der Plicht 2003), in an attempt to individuate such a small, although very important, alteration effect.

As a consequence, it might be more constructive to rely on sequence analysis of radiocarbon determinations with caution, when they contrast with an otherwise well-established and coherent chronological reconstruction. More data are necessary for a conclusive remark on radiocarbon reliability for the later part of the II millennium cal BC in the Eastern Mediterranean. New information, at least regarding the eruption date, has long been awaited from the Greenland ice cores volcanic, activity-related, acidity peaks (Zielinsky *et al*. 1994; Clausen *et al*. 1997; Vinther *et al*. 2006), but this is now no more certain. The Theran eruption may also never be recognised in the Greenland Ice Cores as, at least by now, any persuasive conclusion based on trace elements analysis seems impossible (Wiener pers. comm. 2008). Anyway, if this impasse will be overcome, valid candidates (apart from the XVII century horizons proposed following the AHC) could be the 1524 cal BC peak in the Dye-3 sequence (Wiener 2006; 2008), the major events at 1569 (Dye3)-1566 (GRIP), or at 1463 cal BC (in Dye3, Zielinsky *et al*. 1994; Clausen *et al*. 1997), but also minor XVI century evidences in the GISP2 sequence, which,



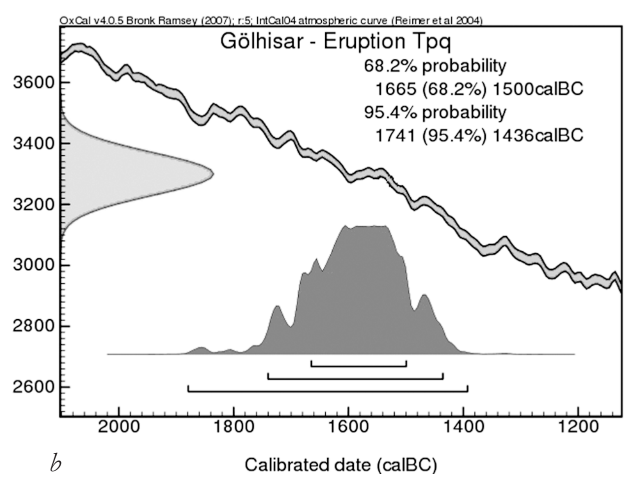


fig. 4 - Calibration of two dates from Gölhisar published by Eastwood *et al*. (2002) according to OxCal 4.0. The two samples came from a geoarchaeological layer which was covered by a consecutive deposit containing tephra from the Thera eruption, and give thus a *terminus post quem* for the eruption date.

Lab. Number	Material	Species	Uncalibrated radiocarbon date BP	Calibrated BC date at 1 sigma (68.2%)	Calibrated BC date at 2 sigmas (95.4%)
Akrotiri, VDL (Manning *et al*. 2006)					
OxA-11817	Carbonised seeds	*Lathyrus* sp.	3348 ± 31	1689 (62.2%) 1608 1570 (3.7%) 1561 1546 (1.9%) 1541	1735 (5.2%) 1714 1694 (90.2%) 1531
OxA-11818	Carbonised seeds	*Hordeum* sp.	3367 ± 33	1728 (4.6%) 1721 1691 (63.6%) 1620	1744 (87.8%) 1605 1579 (7.6%) 1536
OxA-11820	Carbonised seeds	*Hordeum* sp.	3400 ± 31	1742 (68.2%) 1666	1862 (0.9%) 1853 1771 (94.5%) 1617
OxA-11869	Carbonised seeds	*Hordeum* sp.	3336 ± 34	1683 (51.5%) 1606 1574 (9.3%) 1558 1551 (7.4%) 1538	1730 (2.1%) 1719 1692 (93.3%) 1525
OxA-12175	Carbonised seeds	*Hordeum* sp.	3318 ± 28	1631 (22.5%) 1601 1593 (45.7%) 1532	1681 (95.4%) 1524
OxA-1548	Charcoal	*Lathyrus* sp.	3335 ± 60	1687 (41.0%) 1601 1593 (27.2%) 1532	1756 (94.2%) 1492 1478 (1.2%) 1459
OxA-1549	Charcoal	*Lathyrus* sp.	3460 ± 80	1888 (68.2%) 1687	2012 (0.6%) 2000 1978 (92.7%) 1606 1576 (2.1%) 1537
OxA-1550	Charcoal	*Lathyrus* sp.	3395 ± 65	1862 (2.6%) 1851 1772 (65,.%) 1611	1880 (8.0%) 1838 1831 (87.4%) 1529
OxA-1552	Charcoal	*Lathyrus* sp.	3390 ± 65	1861 (1.6%) 1853 1771 (65.5%) 1608 1568 (1.1%) 1563	1879 (7.1%) 1838 1831 (88.3%) 1526
OxA-1553	Charcoal	*Lathyrus* sp.	3340 ± 65	1690 (68.2%) 1530	1866 (1.1%) 1849 1774 (92.7%) 1491 1480 (1.6%) 1456
OxA-1554	Charcoal	*Lathyrus* sp.	3280 ± 65	1632 (65.3%) 1494 1473 (2.9%) 1464	1762 (1.4%) 1718 1692 (94.0%) 1430
OxA-1555	Charcoal	*Lathyrus* sp.	3245 ± 65	1608 (15.8%) 1570 1561 (52.4%) 1448	1682 (95.4%) 1411
OxA-1556	Carbonised seeds	*Hordeum* sp.	3415 ± 70	1871 (7.8%) 1846 1812 (2.4%) 1803 1776 (58.1%) 1626	1891 (95.4%) 1530
K-5352	Pulses	–	3310 ± 65	1668 (68.2%) 1516	1741 (95.4%) 1451
K-5353	Pulses	–	3430 ± 90	1879 (11.1%) 1839 1829 (57.1%) 1633	1961 (95.4%) 1513
K-3228	Pulses	–	3340 ± 55	1688 (43.8%) 1603 1589 (24.4%) 1534	1753 (95.4%) 1497
K-4255	Charred twig	*Tamarix* sp.	3380 ± 60	1750 (64.8%) 1608 1570 (2.3%) 1561 1546 (1.1%) 1541	1877 (4.2%) 1842 1822 (2.6%) 1797 1781 (88.1%) 1521
VERA-6795	Peas	*Pisum sativum*	3360 ± 60	1739 (11.7%) 1707 1697 (43.5%) 1606 1576 (13.0%) 1536	1871 (2.1%) 1846 1811 (0.5%) 1804 1776 (92.8%) 1500
VERA-5519	Grains	–	3490 ± 80	1915 (63.0%) 1735 1714 (5.2%) 1694	2027 (95.4%) 1621
VERA-7967	Grains	–	3140 ± 70	1498 (57.7%) 1371 1346 (10.5%) 1316	1606 (2.1%) 1573 1559 (0.5%) 1550 1539 (91.6%) 1257 1230 (1.3%) 1216

Lab. Number	Material	Species	Uncalibrated radiocarbon date BP	Calibrated BC date at 1 sigma (68.2%)	Calibrated BC date at 2 sigmas (95.4%)
Akrotiri, mature LM I A (samples divided between Oxford and Wien - Manning *et al*. 2006; Bronk Ramsey *et al*. 2004)					
OxA-12170	Carbonised seeds	*Lathyrus* sp.	3336 ± 28	1682 (56.4%) 1607 1572 (7.1%) 1560 1548 (4.7%) 1540	1690 (95.4%) 1528
VERA-2757	Carbonised seeds	*Lathyrus* sp.	3315 ± 31	1627 (20.6%) 1600 1594 (47.6%) 1532	1682 (95.4%) 1520
-repetition	Carbonised seeds	*Lathyrus* sp.	3390 ± 32	1738 (28.8%) 1708 1697 (30.7%) 1661 1654 (11.7%) 1638	1770 (95.4%) 1609
OxA-12171	Carbonised seeds	*Hordeum* sp.	3372 ± 28	1727 (4.2%) 1721 1691 (64.0%) 1627	1745 (93.9%) 1608 1570 (1.0%) 1561 1546 (0.5%) 1541
VERA-2758	Carbonised seeds	*Hordeum* sp.	3339 ± 28	1684 (60.4%) 1608 1570 (5.1%) 1561 1546 (2.7%) 1541	1691 (95.4%) 1528
-repetition	Carbonised seeds	*Hordeum* sp.	3322 ± 32	1658 (1.3%) 1655 1636 (25.2%) 1602 1592 (41.6%) 1532	1687 (95.4%) 1522
OxA-12172	Carbonised seeds	*Hordeum* sp.	3321 ± 32	1636 (25.2%) 1601 1593 (43.1%) 1532	1686 (95.4%) 1521
VERA-2756	Carbonised seeds	*Hordeum* sp.	3317 ± 28	1623 (21.2%) 1605 1581 (47.0%) 1536	1664 (2.7%) 1652 1641 (92.7%) 1526
OxA-10312	Charcoal	*Tamarix* sp.	3293 ± 27	1608 (68.2%) 1530	1632 (95.4%) 1501
VERA-2748	Charcoal	*Tamarix* sp.	3319 ± 28	1631 (23.1%) 1602 1592 (45.1%) 1532	1681 (95.4%) 1525
OxA-10313	Charcoal	*Tamarix* sp.	3353 ± 27	1681 (68.2%) 1616	1736 (6.1%) 1712 1695 (76.1%) 1603 1589 (13.1%) 1534
VERA-2749	Charcoal	*Tamarix* sp.	3335 ± 33	1682 (51.1%) 1606 1574 (9.5%) 1558 1551 (7.6%) 1538	1728 (1.3%) 1720 1691 (94.1%) 1525
OxA-10314	Charcoal	*Tamarix* sp.	3330 ± 27	1663 (8.3%) 1651 1641 (31.9%) 1605 1577 (28.1%) 1536	1686 (95.4%) 1525
VERA-2750	Charcoal	*Tamarix* sp.	3325 ± 28	1658 (1.8%) 1655 1637 (27.4%) 1604 1588 (39.0%) 1534	1685 (95.4%) 1527
OxA-10315	Charcoal	*Olea europaea*	3449 ± 39	1874 (16.3%) 1844 1815 (7.0%) 1800 1778 (29.9%) 1730 1719 (15.0%) 1692	1885 (95.4%) 1667
VERA-2743	Charcoal	*Olea europaea*	3413 ± 28	1750 (68.2%) 1682	1866 (2.8%) 1849 1774 (92.6%) 1629
OxA-10316	Charcoal	*Olea europaea*	3342 ± 38	1687 (53.8%) 1606 1574 (8.0%) 1558 1551 (6.4%) 1538	1737 (5.7%) 1712 1695 (89.7%) 1525
VERA-2744	Charcoal	*Olea europaea*	3427 ± 31	1771 (68.2%) 1686	1877 (10.0%) 1841 1822 (4.4%) 1797 1781 (81.0%) 1635

Lab. Number	Material	Species	Uncalibrated radiocarbon date BP	Calibrated BC date at 1 sigma (68.2%)	Calibrated BC date at 2 sigmas (95.4%)
OxA-10317	Charcoal	*Olea europaea*	3440 ± 35	1868 (10.7%) 1848 1775 (57.5%) 1690	1881 (95.4%) 1666
VERA-2745	Charcoal	*Olea europaea*	3386 ± 28	1737 (20.6%) 1712 1635 (47.6%) 1636	1747 (95.4%) 1617
OxA-10318	Charcoal	*Olea europaea*	3355 ± 40	1732 (5.6%) 1718 1693 (57.4%) 1608 1570 (3.4%) 1561 1546 (1.8%) 1541	1740 (95.4%) 1530
VERA-2746	Charcoal	*Olea europaea*	3471 ± 28	1877 (25.3%) 1842 1821 (15.8%) 1797 1781 (27.1%) 1745	1884 (91.1%) 1737 1712 (4.3%) 1695
OxA-10319	Charcoal	*Olea europaea*	3424 ± 38	1864 (5.2%) 1850 1773 (63.0%) 1682	1877 (10.8%) 1841 1826 (6.0%) 1796 1783 (78.6%) 1629
VERA-2747	Charcoal	*Olea europaea*	3386 ± 30	1737 (20.3%) 1712 1695 (47.9%) 1636	1753 (95.4%) 1611
Akrotiri, VDL (Friedrich *et al*. 2006)					
Hd-23599/24426	Charcoalized twig – ring 1-13	*Olea europaea*	3383 ± 11	1731 (14.1%) 1719 1692 (42.9%) 1663 1651 (11.3%) 1641	1738 (23.9%) 1710 1695 (71.5%) 1631
Hd-23587	Charcoalized twig – ring 14-37	*Olea europaea*	3372 ± 12	1688 (43.9%) 1660 1654 (24.3%) 1638	1731 (6.1%) 1718 1692 (89.3%) 1625
Hd-23589	Charcoalized twig – ring 38-59	*Olea europaea*	3349 ± 12	1666 (68.2%) 1620	1689 (95.4%) 1609
Hd-23588/24402	Charcoalized twig – ring 60-72	*Olea europaea*	3331 ± 10	1659 (3.5%) 1655 1638 (53.2%) 1608 1570 (7.5%) 1561 1547 (4.0%) 1541	1677 (67.2%) 1603 1588 (28.2%) 1531
Gölhisar, VDL *tpq* (Eastwood *et al*. 2002)					
–	Peat	–	3300 ± 70	1665 (68.2%) 1500	1741 (95.4%) 1436
–	Peat	–	3225 ± 45	1529 (68.2%) 1436	1610 (95.4%) 1419
Palaikastro, Tsunami deposit (Bruins *et al*. 2008)					
GrA-30336	Bone	Cattle	3310 ± 35	1623 (68.2%) 1530	1683 (95.4%) 1509
GrA-30339	Bone	Cattle	3390 ± 35	1739 (24.7%) 1706 1699 (43.5%) 1636	1863 (0.9%) 1851 1772 (93.5%) 1608 1570 (0.7%) 1561 1546 (0.3%) 1541

Table 1 - Radiocarbon dates for the Theran eruption mentioned in the text, individually calibrated against IntCal 04, according to OxCal 4.0 (Bronk-Ramsey 1995; Bronk-Ramsey 2001).

nevertheless, shows a shift of 60 years around 3400 uncal BP, and consequently it is still to be accurately dated (Southon 2004; Vinther *et al*. 2005).

Until one of these horizons will be linked to the Theran eruption beyond any doubt, or another independent chronological test will be available for confirming/discarding the different chronological hypotheses, the debate about the LM I chronology seems hard to reassess in a conclusive way, and, even if radiocarbon evidence is not dismissible, conservativeness seems to be necessary in the chronological reconstructions.

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