The Early Bronze Age Chronology of Troy (Periods I–III): Pottery Seriation, Radiocarbon Dating and the Gap

Bernhard Weninger,[1] *Donald Easton*[2]

Abstract: Detailed re-analysis of N=76 previously published ^{14}C-ages from Early Bronze Age (EBA) Troy (northwestern Anatolia) provides an absolute chronology for periods I–III with dating precision ± 30 yrs (68% confidence). As shown by pottery seriation (Correspondence Analysis: CA) of Blegen vessel shapes for periods I–V, there are indications for an extended (multi-phase) gap in the EBA-sequence between periods III and IV. A similar gap can be recognized in the ^{14}C-dates from Troy IV and V. As it appears, following desertion at the end of Troy III around 2150 calBC, the site was abandoned for some (estimated) 100–200 years. However, we were unable to identify the gap in the pottery data of Schliemann. The possibility of a break in the Troy EBA-sequence deserves further studies.

Keywords: Turkey, northwestern Anatolia, Troy, Early Bronze Age, radiocarbon, chronology

In this paper we present a re-analysis of Early Bronze Age (EBA) radiocarbon dates from Troy (periods I–III), all of which have been previously published.[3] The large majority of these dates derive from the very earliest years of the excavation,[4] that is, from a phase of archaeological research long before it was possible to use the ^{14}C-AMS-technology for dating of small (milligram-sized) samples, e.g. short-lived animal bone and grain. All available ^{14}C-dates were measured by ß-decay counting, for which large amounts of carbon (typically: many grams) were required. In consequence, the ^{14}C-database consists almost entirely of measurements made on archaeological charcoals. This non-ideal sample selection immediately complicates the analysis by introducing samples which may be significantly older than the deposits they appear to date. Furthermore, although some large numbers of ^{14}C-ages are available for Troy IV and V,[5] the present studies are restricted to the periods Troy I–III. The reasons for this decision will be described below.

Radiocarbon Database

The radiocarbon database for Troy I–III is assembled in Appendix, Tab. A. It contains a total number of 76 ^{14}C-ages. For each dated sample we provide the following information: Laboratory code (*Lab Code,* to be used in the following as sample identifier), architectural *phase*, dated *material*, excavation unit (*Behälter Nr.,* according to the Tübingen documentation system), conventional ^{14}C-age [BP], and metric coordinates to identify the spot at which each sample was found (stratigraphic depth: *height, x, y*). The majority of this data is taken from Korfmann and Kromer.[6] An important exception is a change in the stratigraphic position of the charred wooden-beam from Quadrat D5 (*Beh.Nr.* D5.365; Appendix, Tab. A, Nos. 60–68) that was initially attributed to Troy

1 Institut für Ur- und Frühgeschichte, Universität zu Köln, Germany; email: b.weninger@uni-koeln.de.
2 12, Weltje Road, London W6 9TG; email: donaldfeaston@hotmail.com.
3 Korfmann – Kromer 1993; Sazcı 2001; Ünlüsoy 2010.
4 Korfmann – Kromer 1993.
5 Blum 2012.
6 Korfmann – Kromer 1993.

Ib/c,[7] but which more likely belongs to Troy Id or to a later phase of Troy I.[8] Further information as to the stratigraphic position and architectural dating is based on Sazcı and Ünlüsoy.[9] Missing values, and in particular the stratigraphic depths for samples Appendix, Tab. A, Nos. 15–32 from the Pinnacle were kindly provided by Sinan Ünlüsoy, using the primary excavation documents (*Tagebücher*) that are stored in the Institute of Prehistory at the University of Tübingen. The large majority (82%) of ^{14}C-ages were measured at the Heidelberg Radiocarbon Laboratory (Lab Code Hd: Bernd Kromer). Further laboratories participating in the ^{14}C-dating project are Berlin (Bln: Jochen Görsdorf) and Köln (KN: Jürgen Freundlich). As mentioned above, the radiocarbon ages under study in the present paper were all measured by (large sample) ß-decay counting.

The radiocarbon database (Appendix, Tab. A) contains a supplementary column (on the far right) which is headed by 'model age' calBC (68%). This specific column provides a documentation of dating results we have obtained in the present paper for each individual sample. Strictly speaking, these results should not be referenced as *calibrated ages* (we use this terminology only for simplification), but rather as *modelled calibrated ages*. This is because these results were obtained, not by single-age calibration, but by stratigraphic-statistical modelling. The model-analysis was performed using stratigraphic data subsets, as shown below in Fig. 1.

Time-Scales and Data Notation

All absolute dates given in this paper are based on tree-ring calibrated ^{14}C-ages, with results referenced to the calendric scale time [calBC] (yrs before Christ). Conventional ^{14}C-ages are given on the ^{14}C-scale with units [BP]. When addressing the ^{14}C-ages, we always provide the measured (uncalibrated) ^{14}C-age value (e.g. 3797 ± 25 BP) in combination with its Laboratory code/sample identifier (Hd-20174). A typical notation is therefore Hd-20174 (3797 ± 25 BP). This citation corresponds to recommendations of the radiocarbon community.[10] It can be extended to cover calibrated ages, in which case we use the notation: Hd-20174: 3797 ± 25 BP (2230 ± 40 calBC). This specific notation does not conform to international agreement. Normally, the '±'-symbol is reserved for Gaussian-shaped probability distributions. We nevertheless use it, quite pragmatically, to replace the otherwise unreadably long list of alternative calendric-scale intervals, with their equally complex interval-internal mixture of logically exclusive [either/or] and logically inclusive [both/and] readings, the assigned 'probability' values of which do not add up to 100% anyway.[11]

Technically, what we refer to as calibrated ^{14}C-ages (with 'median' and '±' values) are based on the *shortest* interval that covers 95% of the total area of the calibrated probability, optimised in direction of the calendric time-scale (e.g. for Hd-20174: 2330–2130 calBC). The centre half of this interval is taken to define the calibrated '±' value. The centre of the interval defines the calibrated 'median'. This simple procedure works acceptably for the majority of archaeological ^{14}C-ages available today, which have $\sigma \geq 25$ BP. For increasingly Gaussian-shaped distributions, it produces results that converge to the normal definition of 'median' and of '±' (68% confidence). In particular, since the median values are defined so that they sensitively lock into the middle of what the observer recognises as *wiggles/plateaus* of the calibration curve, this notation corresponds in *ideal* manner to the non-commutative algebra and corresponding quantum probability theory that is so characteristic for all ^{14}C-ages.[12]

7 Korfmann – Kromer 1993, 157.
8 Easton – Weninger in preparation.
9 Sazcı 2001; Ünlüsoy 2010.
10 Most recently: Reimer et al. 2013.
11 Weninger et al. 2011.
12 Weninger et al. 2011.

Dörpfeld	Blegen	Korfmann	Ünlüsoy (2010)	Radiocarbon Data Sets Under Study in this Paper
	TROIA III	not studied		Historical Set (Tab. A, Nos. 1–13) Not analysed
TROIA III	IIg	(Phase 44)	Troia III	
	IIf	(Phase 42)		
TROIA II	IIe	(Phase 41)	IIc3	Pinnacle E4/5
	IId	(Phase 40)	IIc2	
II.3	IIc	Iu (Phase 39)	IIc1	
		It (Phase 38)	IIb4	
II.2		Is (Phase 37)	IIb3	Troia IIa1 – Troia III (end) (Tab. A, Nos. 15–32, 33–39)
		Ir (Phase 36)	IIb2	
		Iq (Phase 35)	IIb1	
	IIb	Ip (Phase 34)	IIa2	
II.1	IIa	Io (Phase 33)	IIa1	
TROIA I		In (Phase 32)	In	
		Im (Phase 31)	Im	Phases Il–Im not 14C-dated
		Il (Phase 30)	Il	
	(Ik)	(Ik)	(Ik)	'Phase Ik' excluded from age-models
	Ij	Ij	Ij	
	Ii	Ii	Ii	
	Ih	Ih	Ih	
	Ig	Ig	Ig	
	If	If	If	Troia Ia–Ij (Tab. A, Nos. 69–74, 40–59)
	Ie	Ie	Ie	
	Id	Id	Id	Troia Id Beam (Tab. A, Nos. 60–68)
	Ic	Ic	Ic	
	Ib	Ib	Ib	
	Ia	Ia	Ia	Troia Ia (Nos. 69-74)
				'Older than Ia' (Tab. A, Nos. 75-76) Not analysed

Fig. 1 Periodization of Early Bronze Age Troy (periods I–III) according to Dörpfeld (1902), Blegen et al. (1950; 1951), Korfmann (1999), and Ünlüsoy (2010). The vertical lines (Fig. 1, right) indicate the architectural time-spans covered by the separately analysed (floating) ^{14}C-data subsets.

Methods

All radiocarbon determinations were age-calibrated by employing the INTCAL13-database,[13] which is integrated into the CalPal-software we use here for ^{14}C-age calibration.[14] As discussed below, the ^{14}C-analysis is strictly (technically) speaking not based directly on INTCAL13-data,

13 Reimer et al. 2013.

14 Weninger – Jöris 2008.

but rather on a spline-representation of the calibration curve that uses INTCAL13-data as support points. We use this spline to produce a continuous (annual-spaced) calibration curve through the discontinuous (5-yr spaced) INTCAL13-data. Although of relatively minor importance, we nevertheless report on the error-analytical implications of this approach (cf. below). CalPal further incorporates a database that contains the primary raw-data used in construction of INTCAL13. For all laboratories that participated in the construction of INTCAL13, in CalPal-software the laboratory raw-data can be selected, either to produce a calibration curve, or else simply to project the laboratory raw-data onto the specific calibration curve under study. In the present paper we apply this projection to the INTCAL13-data sets called SET 1 (Belfast), SET 2 (Seattle) and SET 5 (Pretoria), which are the components relevant to our studies. Before continuing, we would like to emphasise our gratitude to all researchers involved in calibration curve construction[15] and, in particular, to the authors of the extremely useful INTCAL13-database available online at the Belfast home-site[16] from which we have obtained these specific (and other) laboratory data sets.

Periodization of EBA-Troy

Over the course of the last 130 years, the nomenclature used to describe the stratigraphy at Troy in terms of architecture and material culture has become increasingly complex. In the present paper we make use of the nomenclature shown in Fig. 1. This periodization has the following historical background. As a result of his initial excavations, Heinrich Schliemann was able to identify a threefold number of 'Cities' or '*Schichten'* (i.e. layers) which he called First, Second and Third *Schicht*. His architect Wilhelm Dörpfeld then provided further subdivisions, called Troy II.1, II.2 and II.3. These are defined mainly by the threefold extension of the Troy II fortification system.[17] As a result of excavations undertaken in 1932–1938 for the University of Cincinnati, Carl Blegen and his team were able to refine Dörpfeld's periodization by the introduction of sub-phases (written with small letters e.g. Troy I a, b, c; Troy IIa–IIg, etc.[18]

The intention was not only to establish a more detailed architectural framework, but also to define a sequence of architectural/stratigraphic units that could be used on-site to synchronise, by pottery comparisons, the large number of 'floating' local stratigraphic sequences that had survived the partially destructive earlier excavations. To this end, Blegen and his team-members are quite particular in emphasizing that certain pottery assemblages represent finds (collected in baskets) from 'certified' or 'safely attributed' architectural phases. However, since the envisaged certification was not always possible (e.g. for clearly reworked deposits), as an alternative to leaving these finds undocumented, the Cincinnati team introduced a number of broader designations in order to describe the position of each pottery assemblage, with as much detail as possible. With reference to profiles and deep soundings, this concept led to descriptions such as 'Upper/Middle/Lower'. With the same intention, the Cincinnati team introduced a number of subperiods (e.g. Troy I Early with phases Ia–c; Middle (d–f) and Late (g–k). Although this broader subdivision is widely used even today, and is indeed convenient, we have refrained from applying it to the ^{14}C-data, for reasons described below.

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15 Reimer et al. 2013.

16 <http://intcal.qub.ac.uk/intcal13/> (last accessed 28.02.2014).

17 Dörpfeld 1902.

18 Blegen et al. 1950.

^{14}C-Dating of EBA-Troy: General Approach

The general dating strategy used in the present paper is to independently analyse the different 'floating' sub-sets of ^{14}C-data and finally combine the results to achieve a continuous ^{14}C-chronology for Troy I–III. Obviously, prior to this analysis, we must first optimize the ^{14}C-dating on the sample level, and to this end each sample must be attributed as precisely as possible to some specific stratigraphic or architectural unit. Simultaneously, the dating results must also be optimized in terms of the pre-established stratigraphic/architectural periodization. As it appears, the targeted highest possible *joint* (^{14}C-radiometric and stratigraphic/architectural) dating precision can presently be obtained only by referencing the results to the *mixed* nomenclature shown in Fig. 1. Closer inspection of Fig. 1, however, shows that the specific periodization proposed by Ünlüsoy[19] not only covers Blegen's subdivision for Troy I (phases Ia–Ij), with Ik representing a levelling phase prior to the construction of the first Troy II fortification wall; it also allows for three previously unknown phases of Troy I (called phase 30–32 by Korfmann, or alternatively 'Blegen Il–In' by Ünlüsoy). In particular, Ünlüsoy introduces a more refined architectural sequence for Troy II, which allows for the introduction of five new phases (IIb1–IIb4) in the transition from Early Troy II to Middle Troy II. Hence, by using his nomenclature, we can back-reference all published ^{14}C-ages to all previous periodizations, including those of Dörpfeld and Blegen, and in particular those of Korfmann.

Prior to the ^{14}C-analysis, we have undertaken efforts to maintain control over the ^{14}C-sample sequence. To this aim, the present studies include a re-analysis of results achieved by seriation of the EBA-pottery.[20]

^{14}C-Dating at EBA-Troy: Limitations of Single-Date-Analysis

What first complicates the ^{14}C-analysis, following this decision, is that the majority of available ^{14}C-dates, when calibrated individually, actually provide only limited support for the targeted high-resolution chronology. This is due to the extremely wiggly character of the ^{14}C-age calibration curve in the time-window under study. The indeed quite devastating impact of the shape of the calibration curve on the precision (and accuracy) of the individually calibrated ^{14}C-ages is illustrated in Fig. 2 for the overall time-window 3100–1900 calBC.

The two vertical lines at 2820 and 2630 calBC and corresponding horizontal line at 4100 BP demonstrate that two samples of quite different calendric age (for example 2820 and 2630 calBC) may have the same ^{14}C-age (4100 BP). Allowing for the finite dating precision of real ^{14}C-measurements (even for the high-precision measurement Hd-20174: 3797 ± 25 BP), the folding properties of the calibration curve lead to an extreme widening (and age-distortion) of the initially Gaussian-shaped ^{14}C-dating probability distribution. In consequence, it is impossible to use single calibrated ^{14}C-ages to precisely date any one of the architectural phases for Troy I–III.

The existence of such difficulties becomes all the more apparent, when we take a closer look at the structure of the calibration curve. We illustrate this for the presently recommended calibration data set INTCAL13 (Fig. 3), noting that in this section of the Holocene the INTCAL13-data set is identical to the previous datasets underlying INTCAL09 and INTCAL04. With minimal variations (max 10 yrs) this also applies to the corresponding CalPal-splines. As mentioned above, for technical reasons it is necessary to run a continuous (1-yr spaced) spline-curve through the given (5-yr spaced) INTCAL-data. However, as shown in Fig. 3, the CalPal-generated curve does not perfectly reproduce the INTCAL-data. Although the deviations are generally small (~ 10 yrs), at certain points (e.g. ~ 2460 calBC) the CalPal-spline does show

19 Ünlüsoy 2010.
20 Weninger 2002.

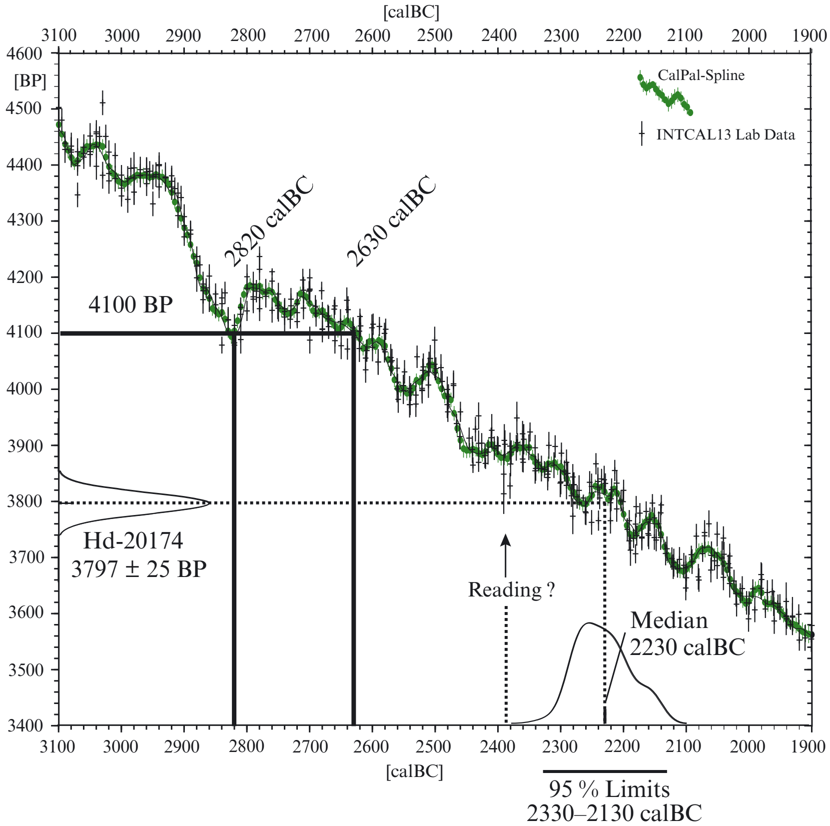

Fig. 2 High-precision ^{14}C-age calibration curve (Reimer et al. 2013) in the time-window 3100–1900 calBC. The CalPal-spline is built from 5-yr spaced INTCAL13-data (shown but not visible). The graph also shows the lab-data of Belfast, Seattle and Pretoria (error bars with ± 1 σ length). The calibration procedure is illustrated for Hd-20174: 3797 ± 25 BP (2230 ± 50 calBC).

larger variations (max. 20 yrs) from INTCAL, and these variations occur on both scales (^{14}C and calendric). Technical difficulties with similar magnitude (some few decades) can also be observed, when the INTCAL13-data is itself compared with the underlying laboratory raw-data (Fig. 3). Since it is technically hardly possible to presently achieve yet higher precision, in the present paper we make allowance for such variability by three complementary approaches, two of which are analytical and one is graphical. First, for single ^{14}C-ages, an additional error of σ = 10 BP is added (squared) to the given standard deviation. Second, for wiggle-matching studies, an additional error of σ = 10 BP is added to the CalPal-spline during Monte Carlo simulation. Third, and this is an optional graphic procedure, it is possible to show the tree-ring calibration *curve (*as wiggly line) in context with the laboratory raw-data (± 1 σ data bars). This graphic approach is especially useful, since it enables visual evaluation of the age-position obtained for the archaeological ^{14}C-data, in comparison to the laboratory raw-data. As is well-known, there are certain age-intervals (e.g. ~1180 and ~1330 calBC) for which the INTCAL04 calibration curve appears to be over-smoothed.[21] Irrespective of whether these particular wiggles are confirmed in future, or not, in the analysis of archaeological ^{14}C-data it is advisable at least to allow for the possibility that the (real-world) calibration curve does not necessarily reflect the exact amplitude and frequency of the atmospheric ^{14}C-variations. However, for the (large: multi-ring) charcoal samples under study in the present paper, we may reasonably expect some in-built smoothing

[21] Weninger – Jung 2009.

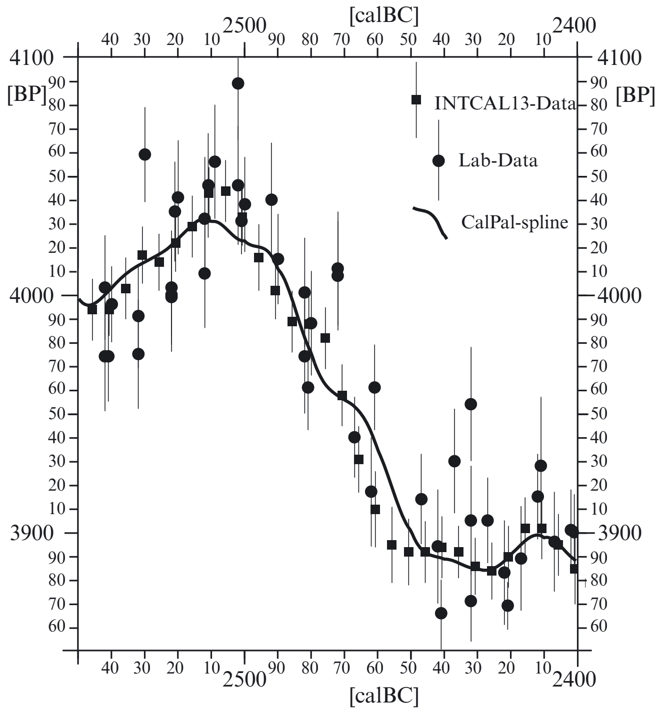

Fig. 3 Zoom into the ^{14}C-age calibration curve (Reimer et al. 2009) in the time-window 2550–2400 calBC (3850–4100 BP). INTCAL13 5-yr-spaced support points are shown as square dots with error bars (± 1 σ). Underlying Lab-data of Belfast, Seattle and Pretoria are shown as circular dots with error bars (± 1 σ). The spline-representation of the ^{14}C-age calibration curve generated by CalPal from INTCAL13 support points is shown as a continuous line.

(decadal scale) of the calibration curve.[22] In this case the possible existence of such unresolved wiggles is unlikely to be significant for the ^{14}C-ages at Troy.

Closer inspection of Fig. 2 shows that, around 2400 calBC, a number of high-precision measurements are (seemingly) not well-represented by the INTCAL13-curve. Indeed, as indicated by the vertical dashed line (headed with an arrow), there could exist an older reading ~ 2400 calBC for Hd-20174 (3797 ± 25 BP) that is not covered by the given distribution of calibrated ages. From the perspective of carbon-cycle modelling, short-lived (grain) samples are indeed capable of recording atmospheric ^{14}C-variations at a higher frequency than is possible with long-lived charcoal. However, in this specific case, we judge that the older reading is not a real option, since such extremely high-frequency atmospheric ^{14}C-variability does not appear possible due to the growth width of 10 rings in the relevant sample.

For the time-window under study (~3100–1900 calBC), the radiocarbon laboratories participating in construction of INTCAL13 are Seattle, Belfast and Pretoria. The accuracy and precision of the measurements provided by these laboratories is under direct quality control by the INTCAL group[23] and therefore beyond reasonable doubt. Due to their regular participation in the Interlaboratory Comparison Projects organised by the ^{14}C-Community,[24] this further applies in particular to the Heidelberg laboratory that has measured the large majority of archaeological ^{14}C-ages, but also to Köln and Berlin.

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22 Mook 1983.

23 E.g. Reimer et al. 2009; Reimer et al. 2013.

24 Most recently: Scott et al. 2010.

Gaussian Monte Carlo Wiggle Matching (GMCWM)

In the analysis, and applied to all data subsets, we have used the method called Gaussian Monte Carlo Wiggle Matching (GMCWM). In general terms, the application of GMCWM requires *prior* construction of an archaeological age model, in which each sample is distinguished on the calendric time-scale from its immediate (or far away) stratigraphic neighbour. This time-separation can be achieved, either on an ordinal scale (*younger/older*), or else by specifying a certain age distance. Whereas for trees this distance is readily available by direct ring-counting, for samples that derive from a complex tell-stratigraphy the construction of an adequate sequence of distances is not only more demanding, but as such immediately more error-prone. In consequence, when studying the properties of ^{14}C-dates from tell-sites, additional emphasis must be placed on the error analysis.

Basically, the approach taken in GMWCM is to systematically (step-by-step) expand the time-span covered by the sample sequence on the calendric time-scale in order to identify the best-fitting position of the ^{14}C-ages on the calibration curve.[25] In this respect GMCWM is quite similar to the well-known method of dendrochronological wiggle matching, except that the algorithms have been generalised to allow for the calendric-scale expansion. GMWCM is also, to some extent, similar to Bayesian Sequencing (BS) in that – if only in its most elementary application – BS assumes what is called a *uniform prior*, whereas in GMWCM we speak of a *linear age model*. In terms of error-management, the specific concept underlying GMCWM is that it is possible to distinguish between basically three different types of dating errors, which can readily be quantified according to their different sources. For samples from archaeological sites, such as Troy, the main three error sources are: Type 1 (calendric scale): potential secondary deposition or misallocation of samples, Type 2 (^{14}C-scale): errors associated with the archaeological ^{14}C-ages, and Type 3 (both scales): errors in construction of the calibration curve. Since all these error types can be taken into account by GMCWM, in the following we call them 'basic' or 'fundamental'. Notwithstanding how large (or small) these 'basic' errors are, they can at least in principle be quantified. This does not immediately apply to the 'old-wood' effect. This (fourth) error type requires additional attention (cf. below).

To begin, we may reasonably assume that the three 'basic' errors are uncorrelated, such that they can be independently quantified. For this purpose, in their technical implementation in CalPal-software, the GMWCM algorithm uses a set of three independently running (Gaussian-steering) random number generators. These are used in a Monte Carlo procedure to simultaneously allow for errors that occur (1) on the calendric time-scale, (2) on the ^{14}C-scale, and (3) on the calibration curve (which interconnects these two scales). For the data under study here, the calendric-scale (i.e. stratigraphic: Type 1) errors are typically set to a Gaussian distribution with 1σ width of ± 30 yrs (68% confidence). The first random number generator is then used to provide a large number of age-models, in which the sample sequence is not only incrementally expanded, but during each expansion step the initially entered sample order is changed, over and over again, up to (max) 10,000 times. Such wide errors (which have an overall width of ~ 120 yrs at 95% confidence) should allow for the majority of sample misallocations, including potential switching of samples between phases.

Although typically much smaller than the stratigraphic errors, further allowance is made for (Type 3) errors that occur in calibration curve construction. The corresponding Gaussian is set to ± 10 BP (68%), and the calibration curve spline is rebuilt dynamically (again 1–10,000 times) during run-time by applying the third random number generator. Finally, the ^{14}C-scale errors (again of Type 2) are dynamically simulated by applying the third (Gaussian-steering) random number generator to the dating errors given by the respective laboratories for each individual archaeological ^{14}C-age.

25 Benz et al. 2012.

Let us now turn to the question, how to combine this Monte Carlo method with the (pre-established) architectural periodization as well as with the (given) archaeological ^{14}C-data.

In age-modelling, the solution we apply is to construct an artificial (relative, but linear) metric 'time-scale', onto which the architectural-phase position of each dated sample is projected. For convenience, this time-scale is constructed from old to young, with the 'begin' of the oldest phase assigned a value 0 (rel-yrs). Each phase is taken to be 100 time-units long. Having defined this basic scale (e.g. begin Troy Ia = 0, end Troy Ij = 1000 time-units), intermediate sample positions are then given intermediate values. These values can be varied, slightly, to avoid graphic overlap of the error bars. The advantage of this procedure is that it can also be applied to double-phase samples (e.g. Iab or Igh) for which the exact phase-assignation is not known. For future reference, and in particular for future control purposes (as well as for analysis by alternative methods), in the Appendix (Tabs. C, D, E, F, G) we provide an exact documentation of all age-models used in the present paper. Note that we do not provide explicit numerical age-models for the ^{14}C-ages with database Nos. 3–13, nor for Nos. 75–76 (Appendix, Tab. A), which were excluded from the present studies.

Why not use the Method of Bayesing Sequencing ?

At this point the reader may reasonably ask: *Instead of developing such complicated numeric age models and applying GMWCM, why not use the method of Bayesian Sequencing (BS), for which all you need to know is the older/younger sequence of samples?* There are a number of reasons for this. To begin, already under ideal testing conditions, BS has been shown to optimise the dating precision, but only at the cost of a reduction in dating accuracy.[26] From a wider mathematical view-point, this is because BS is based on classical probability algebra, which is not applicable to ^{14}C-data.[27] A direct consequence of what we call *radiocarbon quantum theory* is that, although BS in many cases does produce seemingly satisfactory results, even the experienced user may encounter difficulties in recognising the true extent of the analytical errors. We think this applies to the studies (for example) by Sevink et al.;[28] at any rate, definitely problematic are the application of BS to the (for whatever reason) *inverted* grave sequence of the Varna cemetery,[29] and the misinterpretation of the parallel dating of samples on calibration curve plateaus as a cultural overlap of the Tiszapolgár and Bodrokerestúr cultures.[30] This second case requires further methodological attention. Given that a certain (assumed known) number of archaeological time units (say 20 Linearbandkeramik [LBK] house-phases) are uniformly distributed over a plateau (or otherwise wiggly section) of the calibration curve and given that the wiggly-plateau has a length of some 400–500 yrs (as is the case for the LBK), then the BS-method will indeed provide an average LBK phase-length of 20–25 yrs. Unfortunately (for the user), this result is not a *wonderful confirmation of the power of the BS-algorithm,* as has been stated in the early BS-literature. It is trivial. Indeed, it is true as well. But there are more truth values than just Aristotelian true and false. The result is *misleadingly* true. Namely, the same result can be achieved for the LBK-chronology (both by BS and by GMWCM) if the sample order is exactly inverted. [Or any other order is chosen. Please try it out. This applies to the majority of published BS-studies].

In general terms, to enable the BS algorithm (and this applies equally to GMWCM), to reconstruct the *true* (in a probabilistic sense) sequence of sample ages, exactly this *true* sequence must be entered as a *prior*.[31] Now, what we may also expect, but what is equally problematic, is that the closer the *prior* (alias *age-model*) corresponds to the actual sample sequence, the better

26 Steier – Rom 2000.
27 Weninger et al. 2011.
28 Sevink et al. 2010, cf. Jung 2013, 239.
29 Higham et al. 2007, cf. Krauß et al. 2014.
30 Razky – Siklósi 2013.
31 Benz et al. 2012.

the results will be (idem for *worse*). Unfortunately, due to the increasingly strong impact of lock-in (quantisation) effects with increasing measuring precision, BS can only be expected to work properly for coarser chronologies. For these, the application of BS (or GMWCM) may not necessarily be worthwhile.

Anyway, and even recognizing that (specifically) the BS-method does work properly under certain conditions, as has been demonstrated many times over, it cannot be applied to the present data. In Bayesian terminology, for the Troy charcoals it is simply not possible to define the correct *prior* probability distribution, which would be a necessary condition for BS to produce reliable dating results,[32] for the following reason.

Normally, the approach taken in Bayesian Sequencing would be to use the known (*older/younger*) sample order (the so-called *prior),* in order to calculate a chronologically more refined *posterior probability distribution for the calibrated ages.* Unfortunately, simply by providing the dated charcoals with a reliable sequence (e.g. stratigraphic order) does not automatically mean that this sequence will accurately reflect the (charcoal-internal) order of the actually dated growth-rings. Indeed, for any given (both small and large) charcoal samples, the two sequences are quite likely to have little in common. Namely, in the (very useful) terminology of Patrick Ashmore, archaeological charcoals do not represent *single entities*.[33] Nor should we look on them as if they were simply *objects,* for which a unique order in time is pre-established. A more realistic view would be to call them *complex temporal structures.* Whatever name is chosen (and later we call them wild animals, to be tamed), even assuming that the *object sequence* could be reliably established (in terms of *younger/older)* and further even assuming that this *object sequence* corresponded perfectly to the architectural periodization under study, the problem remains that the calendric-scale reliability of the sequence is immediately counteracted by the 'old-wood' effect.

Getting to Grips with Radiocarbon Determinations on Charcoal

As is well-known, radiocarbon determinations on charred wood can only provide a *terminus post quem* for the targeted event (e.g. fire destruction). The problem hereby is the existence of a plethora of different 'old-wood' effects. To begin, and perhaps most obvious, the dated (inner) tree-rings are unlikely to cover the targeted cutting year. We may call this the *primary 'old-wood'* effect. It has a biological background. In addition, the wood used in any specific house construction may (or may not) have been recycled from an earlier building. This may cause a *secondary 'old-wood'* effect, which has its background in the human use of wood/charcoal. We must also allow for the additive impact of such biological and taphonomic processes. This is best-illustrated by considering the life-history of a wooden beam used in the construction of a large house. To begin, the dated charcoal will surely be older than the cutting year of the tree. However, due to the cylindrical geometry of all trees, and assuming equal ring-widths for a standard tree with 100 growth-rings, we can calculate that the tree has its centre of gravity (in terms of charcoal weight) at around ring 70 (counted from old to young). Hence, when large numbers of large charcoal samples are under study, it appears justified to expect an average 'inner ring' effect which is some 30 years older than the targeted cutting year. This can be generalised to cover trees with more, or less, rings. In any case, the 'inner ring' effect will amount to some 30% of the total number of rings.

Perhaps the most intricate of 'old-wood' effects, however, is a different type of 'old-wood' effect that is due to the life-span of the building under study. We may base this expectation on the inevitable fact that the remaining charcoal will have only been produced, and therefore conserved, following some fire-event. Note that the burning event itself does not produce any measurable change in the ^{14}C-age of the sample (at least not for charcoal; bones can be different). Furthermore, the firing

32 Bronk Ramsey 2000.
33 Ashmore 1999.

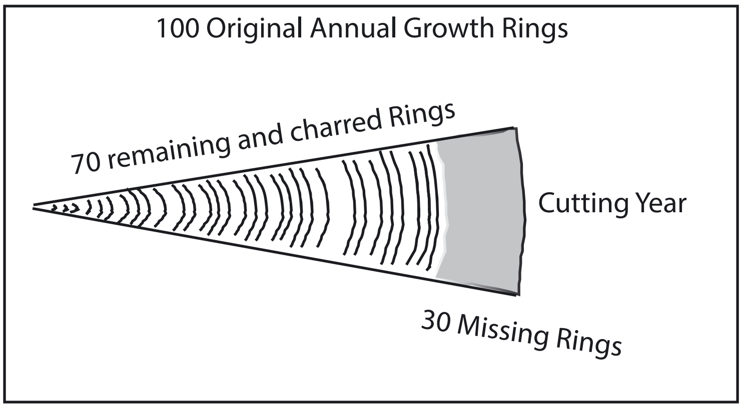


Fig. 4 Troy standard tree.

event will most likely (indeed quite inevitably) have occurred at the very end of the life-span of the building under study. These arguments put together, given that a specific charcoal sample is *known* to derive from the burning of a large building, we may therefore expect the larger 'old-wood' effect to represent the life-span of the building. For example, if the house under study had a life-span of, say, 50 years, and conservatively assuming the house had been built using wooden beams from relatively small trees (e.g. 100 rings), then the combined age offset (30 + 50 = 80 yrs) will inevitably have its larger component not in the 'inner ring' effect (in this case 100 rings × 30% = 30 yrs), but rather in the much longer time lapse of 50 yrs between the cutting year of the tree and its later burning. Unfortunately, the dating error associated with this combination of biological and of life-span properties of charcoal samples is not only large, but – worse – highly asymmetric.

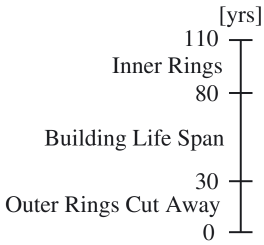
At this point in the discussion we now recognise that the Gaussian error model implemented in GMWCM, as described above, is quite incapable of describing the real-world sampling situation at Troy. Due to the strong bias of the Troy-EBA database on charcoal, the Gaussian error model is dangerously incomplete. Put differently, if we nevertheless (and despite these known restrictions) do actually use the GMCWM method in the present paper, we must at least develop some kind of strategy to make allowance for the age-offsets to be expected for the 'old-wood' effect. As an illustration of the 'old-wood' effect, we now introduce the notion that the dated charcoals derive from what we call a 'Troy Standard Tree' (Fig. 4).

For illustration purposes this picture of a 100-year old tree (Fig. 4) is included in the legend in many of the ^{14}C-graphs. Although we could have used the same picture to emphasise that some quite specific date looks very much as if it were measured on a truly (very) 'old-wood' sample, we have avoided attaching this icon to any of the individual ^{14}C-data bars. Otherwise the ^{14}C-graphs would have been be smothered by the many 'Standard Tree' labels.

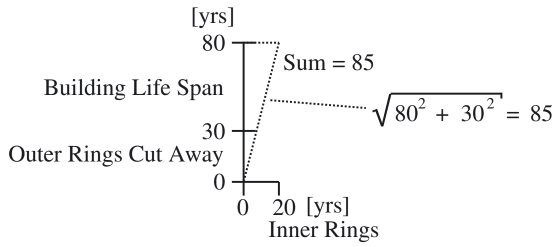
Quantitative Error Analysis

As mentioned above, due to the strong bias of the present Troy ^{14}C-database towards charcoal samples, it is not possible to construct a useful *prior* (or any other kind of age-model) that can adequately mirror, simultaneously, all of the many different types of 'old-wood' effect. What would be clearly necessary would be a detailed dendrochronological analysis of all dated charcoals, in combination with estimates of the time-spans of all the different buildings. But for that the available data is quite insufficient. Hence the question arises, how to account for the 'old-wood' effect in quantitative terms? To begin, it is not even clear how to recognise which of the ^{14}C-ages are really affected, and by what amount, by the 'old-wood' . Perhaps the correction factor is different for each sample, for different phases, or even systematically for the different periods? Further, how can we possibly differentiate between 'old-wood' samples on the one hand, and the statisti-

Error Mechanism	Depth-Error [cm]	Context [different Units]	Systematic [yrs]	Gaussian [yrs]
Daily Nivellement	± 1 cm	---	---	± 1 yr
Square Nivellement	± 1 cm	---	---	± 1 yr
Phase-Internal	---	± 0.5 phase	---	± 10 yrs
Wood Outer Rings Cut Away	---	+ 30 rings	+ 30 yrs and/or	± 20 yrs
Building Life Span	---	+ 50 yrs	+ 50 yrs and/or	± 20 yrs
Wood Inner Rings	---	+ 30 rings	+ 30 yrs and/or	± 20 yrs
Terracing Operations	+ 40 cm	+ 60 yrs	+ 60 yrs	?
Not-Flat Stratigraphy	± 30 cm	---	---	± 30yrs



[Old wood effect]
(Model 1: Additive)



[Old wood effect]
(Model 2: Additive/Gaussian)

Tab. 1 Quantitative estimates of modelling errors.

cally quite normal (or extreme) spread of the ^{14}C-ages, on the other? To illustrate this problem, in Tab. 1 we have assembled a number of error-estimates for the different mechanisms to be allowed for in statistical modelling.

As indicated in Tab. 1, the (unknown) building life-span is likely to be the largest of all 'old-wood errors', but only in combination with the equally (if not larger) impact of the *a priori* also largely unknown terracing operations. Such terracing, indeed any kind of stratigraphic sample reworking, will have a potentially devastating impact on the integrity of any ^{14}C-based age-model. In face of this problem, what we finally decided to do is to take out of the ^{14}C-analysis the (really) obvious outliers (of course following their documentation) and simply fit the remaining charcoal-dates to the calibration curve. This decision opens the path for testing by comparison.

Multiple Testing Programme

In running this case-control program what we have basically done is to apply the GMCWM-method under different study conditions and then compare the results. For all data sub-sets (Fig. 1) it is possible to apply (Test 1) a uniform (architectural) phase-model. If only applicable to the Troy II–III data, as an alternative approach it is possible (Test 2) to assume a linear increase in the height of the tell, i.e. a uniform (stratigraphic) age-depth model. This double test was unfortunately not applicable to the Troy I sequence, due to its strongly sloping stratigraphy in the central and northern parts of Schliemann's north–south trench. Such linearity test would require projection of the recorded depths of the Troy I samples onto a vertical line through the relevant layers, which was beyond the scope of the present paper. Hence, to avoid being blinded by untested GMWCM-results, for Troy I we have compared (Test 3) the results obtained from the analysis of the sequence of all phases (Ia–Ij) with the age obtained independently for phase Id by dendro-wiggle matching of the beam (Behälter D5.365). In a next step (Tests 4/5), only applicable to the Troy II–III data subset, we have compared the results of two different age-models (age-depth and age-phase). Finally (Test 5), the results obtained in Tests 4/5 were critically evaluated by comparison with the results obtained from single-age calibration of the short-lived sample from phase IIIa (Hd-20174: 3797 ± 25 BP, 2230 ± calBC). As it turned out (see below), the critical point prior to the final combination of results achieved for Troy I and for Troy II–II was the – clearly – unrealistic overlap (by some 50 yrs) of both chronologies. Nevertheless, and allowing both for this overlap and for other (partly terminological) problems that only became apparent during the testing exercise, the results were altogether acceptable. In statistical terms, the ^{14}C-chronology has a precision in the order of ± 30 yrs (68% confidence).

Naturally, even after all the number-crunching necessary in modelling, the resulting ^{14}C-chronology will still be charcoal-based. But then, at least, we will have at our disposal an archaeologically criticised and statistically optimised impression of what we call the *best position* of each ^{14}C-dated charcoal sample on the calibration curve. Allowing for the final 'old-wood' correction, for convenience chosen as 50 yrs, we estimate that the overall dating precision (Troy I–III) is in the order of ± 30 yrs (68% confidence).

Unfortunately, we cannot immediately start off with ^{14}C-age modelling, say by plonking the dates into an algorithm and seeing what comes out. As stated above, such is the increasingly widespread misuse of the otherwise highly advanced and useful method of Bayesian Sequencing. The use of BS would have been nice, but the data under study here are not. Similar to wild animals in a circus, they first require some fair amount of taming. In support of this maybe curious judgement, we may cite the excavator of the Pinnacle, who states quite frankly that he cannot make sense of the ^{14}C-ages obtained for the Pinnacle E4/5, except that they are *clearly* wrong, at any rate unacceptably old.[34] Well, we think we can make sense of them, but that remains to be demonstrated. In historical perspective, it is interesting to observe that similar statements were made about the acceptability of ^{14}C-ages, the moment the very first stratified ^{14}C-ages became available for the southeast European tell-sites, and that is some 40 years ago. At that time the dates were criticised for not *clearly* following the archaeological stratigraphy. The solution, as we now know, is that ^{14}C-dates should indeed follow the stratigraphy, but simultaneously the wiggles of the ^{14}C-age calibration curve, as well as a variety of taphonomic processes.

Today, and *prior* to the ^{14}C-analysis in the sense of an analytical *conditio sine qua non*, what is first required is to establish that the architectural stratigraphy of EBA-Troy does not contain temporal breaks (what we call 'gaps'), at least to any extent beyond the visibility of the ^{14}C-data to be analysed. With this specific question in mind, we now turn to the pottery analysis. The overall aim of the following studies is to quantify the size of potential gaps in the stratigraphic sequence at Troy. As already discussed, the existence of such gaps would *not* necessarily inhibit the envisaged ^{14}C-modelling studies; this depends on their temporal extent (and visibility cf. below), which must be quantified.

Pottery Seriation and Stratigraphic Analysis

In a previous study, a database that covers the 'complete' Cincinnati pottery shape inventory of Troy I–V was established.[35] That database contains a total of 14,917 reconstructed pots, all clas-

34 Mansfeld 2001, 203.
35 Weninger 2002.

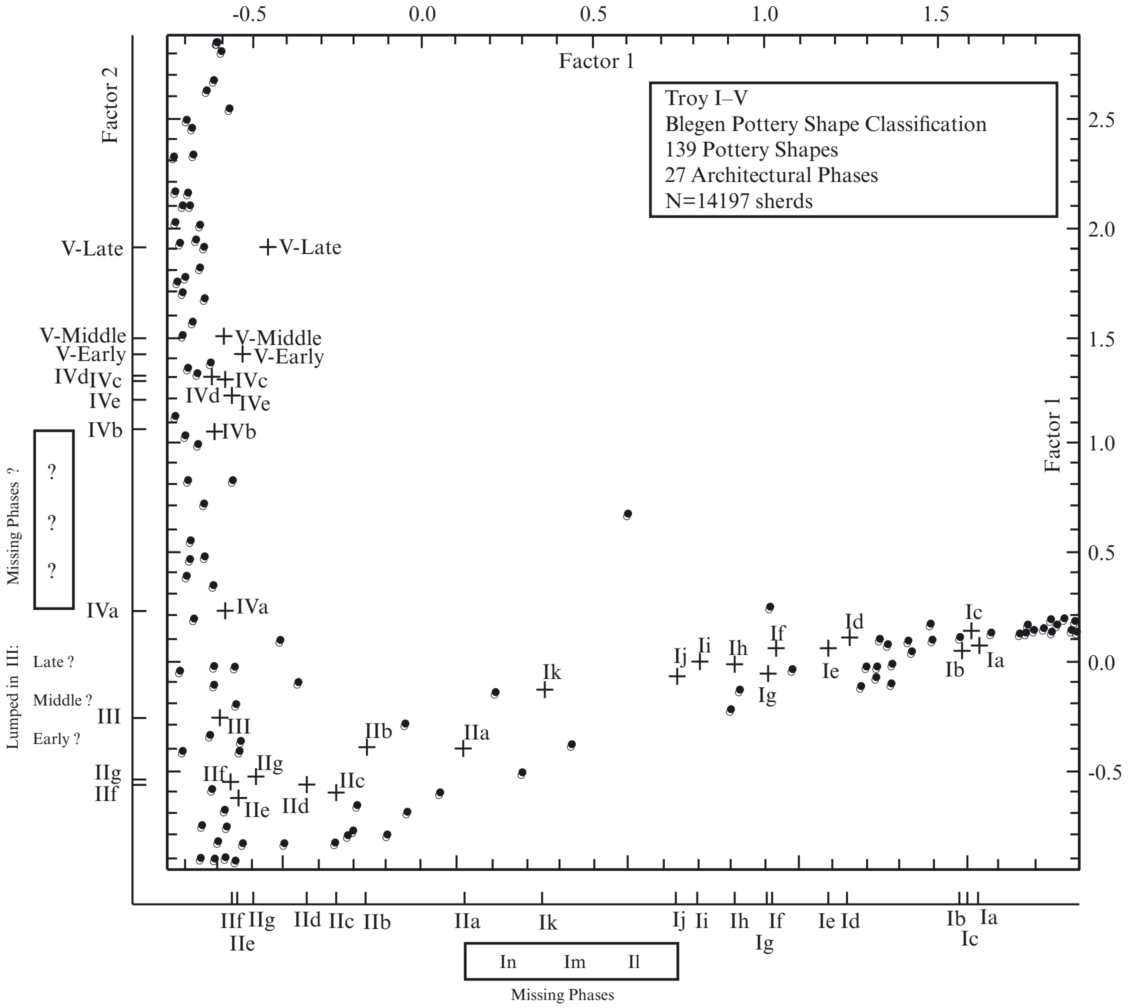


Fig. 5 Correspondence analysis applied to pottery shapes for Troy (periods I–V), classified according to Blegen et al. (1950; 1951; 1953). Graph based on data assembled in Weninger (1995). CA-scores for Blegen phases (shown as crosses) are projected onto Factor 1 (Troy I–II) or onto Factor 2 (Troy III–V). Small dots show CA-scores (i.e. central values) for pottery shapes. There are indications for a gap with three missing phases between Ij and IIa (shown on Factor 1) and for another gap with missing phases between III and IV (shown on Factor 2).

sified according to the Cincinnati pottery shape system.[36] Using Correspondence Analysis (CA) as seriation method, it was shown possible to use the Blegen pottery inventory assemblages to reconstruct the EBA architectural stratigraphy, albeit with a quantifiable dating precision. The dating precision achieved by CA for Blegen's material is of the order ± 1 settlement phase, which translates to a dating error of ± 50 yrs (68% confidence). Previously, we had no satisfactory explanation either for the conspicuous bend in the CA-diagram around the time of Troy IIg/III, nor did we understand the cause of the rather void region in the seriation between Troy III and Troy IV (Fig. 5). The central topic of the following section is a re-interpretation of this seriation, which we have undertaken to incorporate the new excavation results achieved by Manfred Korfmann and his team.

Next to the generally acknowledged existence of a terminological error in Blegen's periodization, there is another interesting observation by Easton,[37] namely, that there appear to be

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36 Blegen et al. 1950; Blegen et al. 1951.

37 Easton 1976, tab. 1.

some phases missing (he proposed two) in the transition from Late Troy I to Early Troy II (i.e. in between Troy Ij and Troy IIa). At this very position, practically the same number of phases (three) were later identified by excavation.[38] The existence of these phases was also forecasted by pottery seriation. In Fig. 5, we have redrawn the original CA-diagram (dated to Sep. 1986) on which this forecasting was based. As noted by Weninger,[39] the CA-results clearly pointed to the existence of a substantial number (3–5) of new architectural phases between Late Troy I and Early Troy II, which were unknown to the Cincinnati team. In combination with Easton's forecasting, and now that Korfmann has identified by excavation the forecasted number of phases, we are presently confident that the CA-results are confluent, for Troy I–II. This is useful to know, since we can now confidently analyse the ^{14}C-dates from Troy I–II, for which a gap-free linear interpolation is necessary.

As can also be taken from Fig. 5, however, not only is there a gap in the CA-diagram between Ij and IIa, but quite apparently again between III and IVa. Then follows the largest of all gaps, that is between IVa and IVb. The next following phases of Troy IV and V fall nicely into sequence.

Before proceeding, we must add a cautionary note. To be sure, independently, the CA-method cannot prove the existence of settlement gaps. This is only possible by excavation. Gaps of any type are caused by lack of data. We can, of course, classify them, just as we classify pottery. The most elementary classification is to differentiate between two fundamentally different and logically exclusive types of gap. All gaps of what we call 'Type 1' are caused by lack of excavation of existing deposits. All gaps of 'Type 2' are due to non-existing deposits. Despite their clear and distinct definition, in any given case (and in particular for disturbed deposits), it is actually not at all easy to decide whether a gap exists, or not. Obviously, it is impossible to excavate non-existing *deposits*. A more demanding (structural) question is to decide whether it is possible, or not, to excavate non-existing *phases.* This is because we find deposits, but define phases. Although maybe curious, this is the very problem we must address, in order to understand the cause of the CA-gap between Troy III and Troy IV.

Sometimes a historical perspective can be useful in scientific discourse. Above we noted that the CA-seriation shown in Fig. 5 was established in 1986, that is some 16 years before its publication.[40] Back in 1986, the relevant author (B. Weninger) had not yet visited the site of Troy and, indeed, the CA-analysis of the Blegen material was initially not even directed at obtaining a pottery-based chronology for the EBA at Troy. Instead, my intention was to critically test the proposal put forward by Peter Stehli and Andreas Zimmermann (at that time my teachers at the Institute of Prehistory, University of Frankfurt/M.) that the CA-method was capable of producing a high-resolution pottery chronology for the early Neolithic Linearbandkeramik (LBK) culture. Quite simply, *a priori*, I did not believe them. Obviously, the underlying method needed testing. Now, for empirical testing and hence under realistic conditions, it is necessary to find a pottery database which has an independent time-scale. Further, the independent (non-pottery) time-scale to be used in the CA-test should be as long and as precise as possible. And, of course, the test had to be interesting. Now, back in 1986, the controversies between the followers of the traditional chronology of the European Neolithic and Bronze Age and the new calibrated ^{14}C-chronology were at a climax. A central site within this discussion was Troy. So, I went to the library, took out the Blegen volumes, sat down for some months to produce a pottery database for the EBA, ran a CA-seriation, and concluded my teachers were correct. At Troy, the dating resolution of the CA-method is ± 1 phase and this applies, as far as I could judge at that time, to all phases of Troy I–V. Apparently, the precision of pottery dating was indeed sufficient to help solve the dating

38 Korfmann 1999, fig. 6; Korfmann 2000, fig. 6.
39 Weninger 2002, 1051.
40 Weninger, 2002.

controversy, that amounted to a difference of ~1000 years between the conflicting high- and low chronologies for the European Neolithic.[41]

However, there is one important condition. With life-spans of many hundreds of years for typical vessel shapes, the condition is that pottery dating must be based on statistical procedures, not on single vessel comparisons. The next thing I did was to test the seemingly natural hope that a refined pottery classification will automatically lead to an increase in the precision of pottery dating. For this I made use of the refined (i.e. carefully re-classified) EBA-Troy pottery classification that Podzuweit[42] had developed, also based on Blegen's publications. For the re-classified Blegen material of Troy I, the expected (enhanced) chronological sensitivity is confirmed by CA. But for Troy II–V the opposite is the case. In both cases, moreover, since the refinement of the classification could only be achieved based on the relatively few pictures that Blegen had been able to publish, following re-classification there is very little remaining data. This may be useful for long-distance comparisons. But the refined classification is definitely quite insufficient for site-internal synchronization. Finally, following these studies, I gave up trying to prove the validity *either* of the low (pottery-based) *or* of the high ^{14}C-chronology. For me, the highest dating resolution could quite obviously be achieved only by combining the different types of dating methods (CA and ^{14}C), not by putting them in contra-position.

What had not occurred to me in these earlier papers, and even up to recently, was that under certain conditions the achieved 'highly precise' CA dating at Troy can actually be highly misleading. At Troy, and acknowledging that other sites may be different, the exact methodological fix-point for the results to become misleading is when the dating is transferred from the (ordinal) architectural scale to the (metric) calendric time-scale. This transfer process, that makes phases into years (e.g. ± 1 CA-phase ~ ± 50 yrs), is only valid for a gap-free sequence.

What Makes a Gap?

Now, a gap is not simply a Gap, and in a tell-site such as Troy there are sure to be many gaps, and probably an infinite number, depending on how close we look. Fortunately, looking at all the many gaps, there is a natural limit to the number we can sensibly talk about. As in ^{14}C-analysis, the only gaps worth talking about are the ones with a length beyond the established statistical dating limits. At Troy, these limits are in the range of ± 1 architectural phase. Using the CA-method, we could be able to discern temporal gaps, but significantly only if their length is longer than 3 standard deviations (i.e. three phases or more). In other words, assuming that the gap under study is shorter than ~ 150 years (i.e. 3σ), it will be difficult if not impossible to recognize its existence. If longer than ~ 150 years? Well, then, we may have a chance to see it. Ultimately, what we can recognise as a gap depends on how realistic the corresponding error-analysis is.

With these limitations in mind, let us now take a closer look at the structure of the CA-diagram (Fig. 5). When projected onto Factor 1, we observe that the CA-scores are in correct stratigraphic order for the large majority of phases of Troy I and Troy II. One particular concern is Troy IIe, for which the seriation provides a seemingly wrong date between IIg and IIf (on Factor 1), but which is also very close to III (on both Factors). However, making allowance for the limited amount of material available from IIe, this dating is quite acceptable. First, the architectural structures (buildings IIM and IIN) assigned to IIe (Ünlüsoy: IIc3) are indeed likely to be at least broadly contemporary with Megarons IIA and IIB. This was concluded both by Easton and by Unlüsöy.[43]

[41] E.g. Renfrew, 1971.

[42] Podzuweit 1979.

[43] Easton 2002, 307; Unlüsöy 2011, plan 12; Easton 2014, note 540.

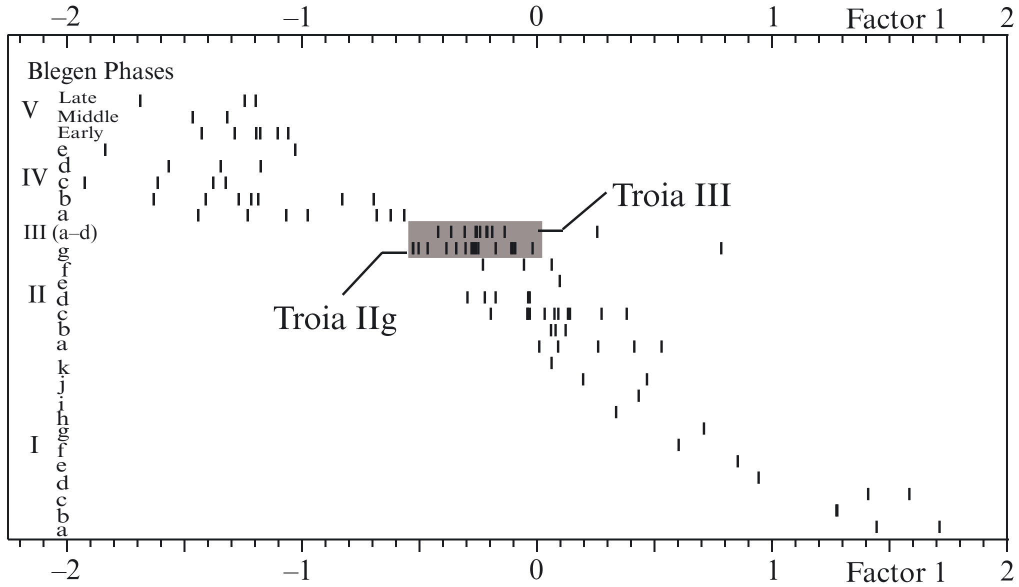

Fig. 6 Zoom into Fig. 5 (above) with rotation of the CA-diagram by 45º to illustrate that Blegen pottery shapes from IIg and III are virtually indistinguishable, using only statistical procedures.

Second, not only does the available pottery from IIe derive from a quite small (3 m^2) section, but the CA-dating of this phase is based on a mere 35 sherds (from 5 vessel shapes).[44]

At this point it is worth emphasising how satisfactory the CA-results are, despite such material limitations. The real question to ponder, therefore, is not the cause of the seemingly wrong pottery dating of IIe (which is statistically correct). Instead, we may wonder how can it be possible that the CA-method is capable of such reliable dates, even when based on a handful of default-type Troy II sherds? The answer is that the CA-method analyses the complete pottery assemblage, simultaneously for the entire site, to reconstruct the overall pottery sequence, but only from the specific perspective of what is found together. The alternative dating method would be to take every single pottery find, analyse all the finds, but only one after another. Whichever of these two approaches we favour, both have their advantages and disadvantages, depending on application. From the dating perspective, however, the problem of applying single-vessel procedures is very similar to that of analysing radiocarbon dates. If based on graphically stacking the separate calendar-age intervals, one above the other for each single measurement, all that essentially happens is that we reinforce the already known calendric interval, over and over again. Now, since every now and then an outlier will occur, inevitably, the targeted interval will get wider and wider, the more dates that are entered. This seemingly contra-intuitive property of archaeological ^{14}C-dates was first described by James Ottaway, who concluded that he would not allow application of any such method to any kind of data for which he was responsible.[45] The solution, and which does not only apply to archaeological ^{14}C-dates, is that we can only obtain access to the information otherwise hidden in the increasingly large database by changing the analytical method (today we use the method of archaeological wiggle-matching). Interestingly, a similar restriction applies to pottery dating. Again, the solution is not (only) to add more data but to change the dating method. Otherwise, the larger the set of individual pottery synchronisms, the more outliers will appear, and the more difficult a conclusion becomes. What we may conclude, now that we are using the CA-method for pottery-based chronological analysis, is that the given (Blegen-classified) CA-

44 Blegen et al. 1950, 301; Weninger 2002, 1049, Appendix II.

45 Ottaway 1983.

sequence is essentially 'gap-free' (within the 3σ limits of observability defined above), all the way from the beginning of Troy I to the end of Troy III, but not necessarily beyond.

To further address the question what causes the CA-gap between Troy III and IV, let us now rotate the CA-diagram and zoom into the relevant section (Fig. 6). The reason for this may not be immediately clear. By rotating the diagram, we achieve a reconstruction of the overall sequence of architectural phases for Troy I–V. Unfortunately, the advantage of this approach is immediately counteracted by a loss of dating precision for certain periods. By CA-rotation, we may optimise the dating precision either for phases on Factor 1 (periods Troy I–III), or else for phases on Factor 2 (periods Troy III–V), but not simultaneously for all phases of all periods. Having tried out all possible rotations, with the aim of identifying that one specific rotation which optimizes the phase-sequence in the vicinity of Late Troy II/III, we come to the following conclusion. Whatever rotation is selected, the result is always the same: the material from these phases appears to be identical (at any rate in statistical terms). This interesting property of the CA-diagram is illustrated in Fig. 6. If only demonstrated here for one specific rotation, (and hopefully the reader will nevertheless accept the following argument), the almost complete overlap of Blegen's pottery assemblages for phases IIg and III can be observed for all possible rotations of the CA coordinate system.

Indeed, this is no new result. As is known from detailed CA-studies by Frirdich[46] it is very difficult to differentiate between the pottery inventories of Late Troy II and Troy III, not only using the Blegen pottery classification but also by fabric analysis. One of her most important results[47] is that basically only Troy II and III are represented on the Pinnacle E4/5, and not the entire Troy II–V-sequence as was later proposed by the excavator.[48] Her results were confirmed by Pavúk,[49] who undertook a detailled reconstruction of the height of the different pinnacles along the NS-section of EBA-Troy. Apparently, Mansfeld[50] had not taken into account the existence of a major terminological discrepancy between Dörpfeld's and Blegen's periodizations, such that Blegen's Troy III is Dörpfeld's Troy IV, and Blegen's Troy IV+V are Dörpfeld's Troy V.[51] To this the complementary information can be added, namely, that it is impossible to close the CA-gap between III and IV, simply by rotating the CA-diagram.

To this last point we return to the autobiographical section (cf. above). In contrast to all other phases of Troy I–V, back in 1986, when first constructing the Blegen pottery-shape database, we had found it impossible to separate into different phases (Troy IIIa–d) the material that Blegen had excavated from Troy III, simply by reading the text.[52] Namely, in contrast to all other EBA-periods, the pottery finds from Troy III are catalogued according to rooms and houses, but not by phases.[53] In consequence, what is called 'Troy III' in the CA-diagram in actual fact represents the material from altogether four phases, but which is lumped together. Based on previous efforts to better resolve the pottery dating in the region of the CA-bend (i.e. between II and III), we also know that the change from Factor 1 to Factor 2 is not due to the properties of the Troy IV/V-material, as might be expected. What we observe is that the switch from Factor 1 to Factor 2 is a fundamental property of the total pottery assemblage, such that the switch occurs immediately, the moment the database contains even only one excavation unit that follows stratigraphically upon Troy III.[54] Put differently, if we accept the general consensus that Troy V dates to the Middle Bronze Age (e.g. due to the occurrence of red-cross bowls), due to the strong clustering of the respective CA-scores, (Fig. 5), then this must surely also apply culturally, if not chronologically, to Troy IV.

46 Frirdich 1997.
47 Frirdich 1997, figs. 9–10.
48 Mansfeld 2001.
49 Pavúk 2010, fig. 11.
50 Mansfeld 2001.
51 I.e. the so-called Easton's Law: Blegen=Dörpfeld-1: Easton 2000, 78–79; Jablonka 2000, 103.
52 Blegen et al. 1951, 37–97.
53 Blegen et al. 1951, 37–97.
54 Weninger 2002.

Putting all this information together, we come to the following conclusions. First, the CA-gap between Troy III and Troy IVa is probably due to the lumping together of the material from altogether four Troy III Blegen phases into 'Troy III'. As indicated in Fig. 5, by interpolation we may therefore fill the III–IVa CA-gap by allowing for the (known) existence not of one, but of four Troy III phases. This first gap-component is purely artificial. It is an artefact of the manner in which we initially constructed the pottery database for Troy III. Allowing for this, what remains to be explained is why the CA-seriation places the material from IVa so close to that of Troy III. The same question, but formulated the other way around, is, why does the seriation produce such a strong separation between the material of Troy IVa and that of the following Troy IV phases? The solution we propose is that there exists a real settlement break between Troy III and Troy IV, which amounts to some (at least) three phases. The CA-score for Troy IVa is being pulled so strongly towards Troy III, we propose, because some large amounts of the IVa pottery finds actually do derive from Troy III, but were re-deposited during the very first rebuilding activities following an abandonment of the site at the end of Troy III. Interestingly, the ^{14}C-dates assigned to Troy IV show very much the same properties. As can be taken from the ^{14}C-diagrams published by Kromer et al.[55] and which were further studied by Blum,[56] essentially all ^{14}C-ages assigned to Troy IV have calibrated ages that overlap (indeed entirely) with available (and altogether satisfactory) dates for Troy III. From these same diagrams, it further appears that the ^{14}C-dates assigned to Troy V are separated by some 100–200 years from Troy IV. Even allowing for the 'old-wood' effect, the dates from Troy IV and V do point in the same direction.

But how long could the III–IV gap be, supposing it exists? As *Gedankenexperiment*, we may calibrate its (unknown) length by reference to the (known) length of the I–II gap in the CA-diagram (Fig. 5). As it appears, between Troy periods III and IV there are some 3–4 missing architectural phases. Hence, we conclude, the gap has a length in the order of 100–200 years. This estimate agrees well with a chronological gap shown by the ^{14}C-data.[57] Although we judge that the coincidence of missing phases and of obviously strongly reworked ^{14}C-samples is indeed telling, this alone does not resolve the problem whether there exists a real settlement break at Troy, or not. Namely, in terms of the gap-classification introduced above, the III–IV gap could either be of Type 1 (lack of excavation) or else of Type 2 (settlement break).

Not least Wilhelm Dörpfeld supplies arguments that *could* be interpreted in the same manner. Looking back at his excavations 1870–1894, partly undertaken together with Heinrich Schliemann (up to 1890), he writes:

> "Die Zerstörung der III. Ansiedlung ist bei weitem nicht so gründlich gewesen, wie die der II. Burg. Sicherlich war es keine grosse allgemeine Feuersbrunst, die das Dorf vernichtete. Zwar sind in manchen Häusern deutliche Brandspuren gefunden worden, sie waren aber nicht allgemein wie bei der II. Schicht. Da die Hausmauern trotz ihrer geringen Stärke bei der Ausgrabung meist noch 1–1,5m hoch aufrecht standen, so möchte man am liebsten vermuten, dass das Dorf aus irgendeinem Grund von seinen Bewohnern verlassen wurde und dann allmählich verfiel. Die Dächer und Oberteile der Wände stürzten zusammen, füllten die Zimmer bis zu einer gewissen Höhe an und schützten so die stehengebliebenen Unterteile der Mauern vor gänzlichem Verfall. Einige Zeit später wurde ein neues Dorf errichtet, die IV. Schicht. Von den Häusern der älteren Ansiedelung kann damals nichts mehr sichtbar gewesen sein, weil sonst die zerstörten Mauern wieder reparirt oder als Fundament für die neuen Häuser benutzt worden wären."[58]

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55 Kromer et al. 2003, fig. 5.
56 Blum 2012, fig.107.
57 Kromer et al. 2003, fig. 5; Blum 2012 fig.107.
58 Dörpfeld 1902, 102.

Unfortunately these observations are not relevant to the present Gap question. For when Dörpfeld talks about the end of his '*III. Ansiedlung*' we must understand him to mean the end of Blegen's Troy II (i.e. Blegen IIg) – although, since there was some irregularity across the mound, at least some of what Dörpfeld calls '*Schicht III*' may have been a part of what Blegen later calls 'period III'. Perhaps more clearly formulated, most of what Dörpfeld calls '*Schicht IV*' later became Troy III.[59] Hence, we cannot use Dörpfeld's observations, however intriguing they may appear, as independent (eye-witness) testimony that the postulated III/IV gap in the Blegen-referenced CA-diagram (Fig. 5) really does indicate a temporal break in the architectural sequence.

Concluding this chapter, Fig. 7 illustrates that the gap-question cannot either be resolved by analysis of the *amounts* of pottery excavated by Blegen for the different periods. What this diagram does demonstrate is that, closely corresponding to the phase-wise strongly varying number of excavated sherds, Blegen was able to define a higher (or lower) number of different pottery shapes. But that is not unexpected. Neither is it of particular help to know that Blegen excavated a comparatively large amount of material (both sherds and shapes) from Troy III. This is an artefact of our lumping of the material from four phases into one. More important is what the diagram does not show: there is no indication for any lack of material from any of the Troy IV phases, nor for that matter from Troy V. Hence, we conclude (and this is not trivial), there is enough material evidence to demonstrate the existence of all five periods (I–V) at Troy. But, as with the non-existence of a major gap in the sequence, and in particular between III and IV, this can neither be proven nor discounted by simply counting sherds and shapes. Whatever is correct, even the possibility that 'the Gap' exists, immediately enforces a truncation of the ^{14}C-analysis using the GMWCM-method, at the end of Blegen Troy III.

Seriation of Pottery Data Derived from Schliemann's Records (1870–1873 Seasons)

To further address the cause of the III–IV gap, we have undertaken complementary CA-studies, based on pottery data reconstructed from the Schliemann material by Easton.[60] As is well-known, the relevant layers were largely removed from the mound by Heinrich Schliemann already during his highly destructive excavations 1870–1873, and for which only limited documentation is available. The idea is to see how far the pottery distribution proposed for the spread of Schliemann 'Units' across the periods I–V may (or may not) be consistent with the expectations derived from the Blegen excavations. The pottery contents of the Schliemann 'Units' are given in Appendix, Tab. B. This database contains altogether 63 'Units' that were derived from Schliemann's notebooks and publications.[61] In this study, the units were first dated according to the reconstructed stratigraphic depths, as described by Easton.[62] The material was already 'Blegenized', i.e. shape-classified according to Blegen's pottery shape system, and has been entered into the Blegen-seriation. The pottery database takes into account not just presence and absence of the different types, but also frequency of occurrence. It is important to note that, *qua method*, it is only possible to include in the joint seriation the Schliemann material for which the same shapes were noted by Blegen.

Not unexpectedly, a number of Schliemann units immediately turned out to be outliers, and we have removed these from the seriation. This applies in particular to shape C30 which introduces a large distortion of the CA-diagram. As shown in Fig. 8, the Schliemann units spread across the same span as the Blegen units.

[59] Easton 2014, 297.
[60] Easton 2002.
[61] 1870 to 1873 seasons – the sources are detailed in Easton 2002.
[62] Easton 2002.

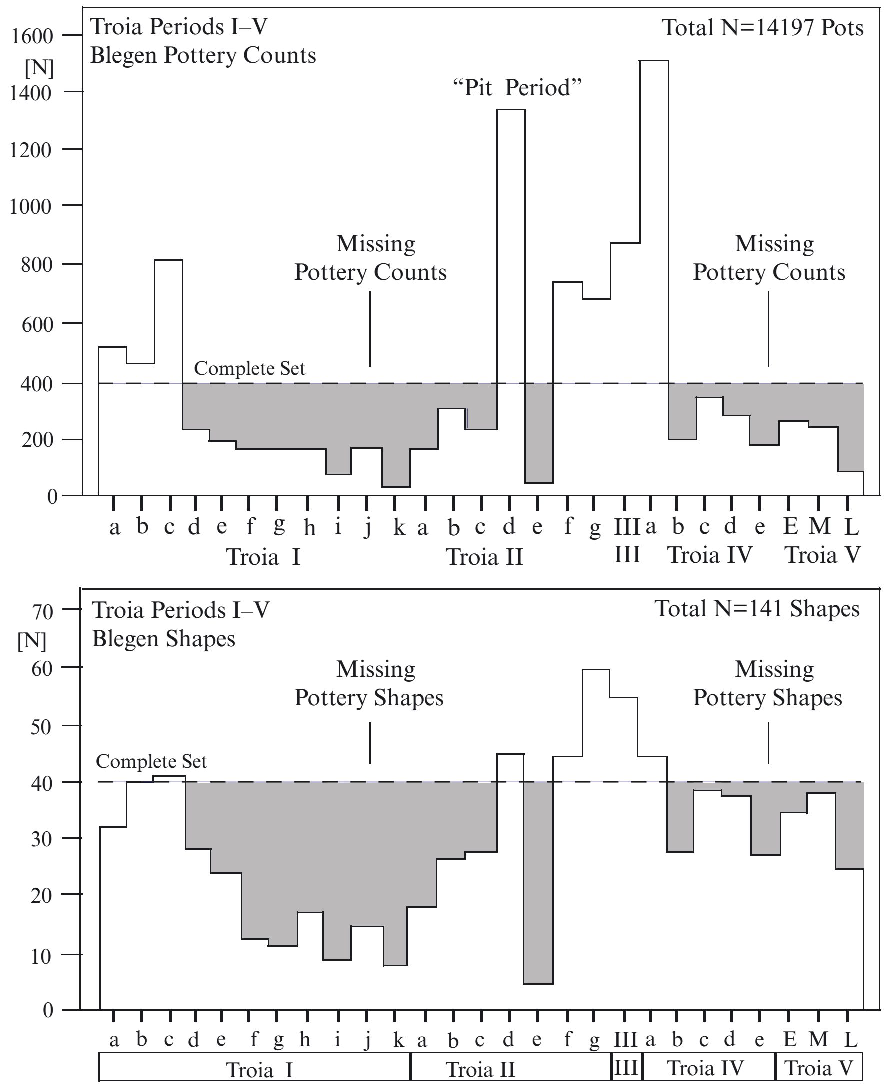

Fig. 7 Quantities of pottery for Troy periods I–V reconstructed from Blegen et al. (1950; 1951). Upper: pottery (sherd-based) counts referenced to Blegen phases. Lower: pottery (shape-based) counts referenced to Blegen phase. Data: Weninger (1995).

Naturally, due to their lower stratigraphic integrity, the Schliemann units show much less distinction between Troy IIg/III and Troy IV/V than was previously apparent in Blegen's units (Fig. 4). A sceptic might take this wider spread of the Schliemann deposits as confirmation of his hopeless unreliability as an excavator. But other explanations are available. As it appears, the Schliemann material succeeds in bridging the conspicuous gap between III and IV which exists in the CA-chart of the Blegen material (Fig. 4). This bridging of the gap is no doubt due to the much greater extent of Schliemann's excavations in the strata of II, III and IV and especially in his 'Burnt City'. However, we must be cautious in all details of this interpretation, since we do not yet know how precise the CA-dating of the Schliemann material actually is. In particular, we cannot yet exclude the possibility of a settlement hiatus between III and IV, which Schliemann himself would surely not have recognised.

To answer this question, let us take a closer look at the data. It contains a large number (N=14) of units (i.e. 14/63 = 22%) that consist of only two shapes. For such limited amounts of material we cannot expect a particularly precise dating. Further units were demonstrably affected by the presence of pottery shapes occurring either earlier, or later, than was observed by Blegen. Such younger/older CA-readings are, of course, not necessarily wrong. But this does probably account

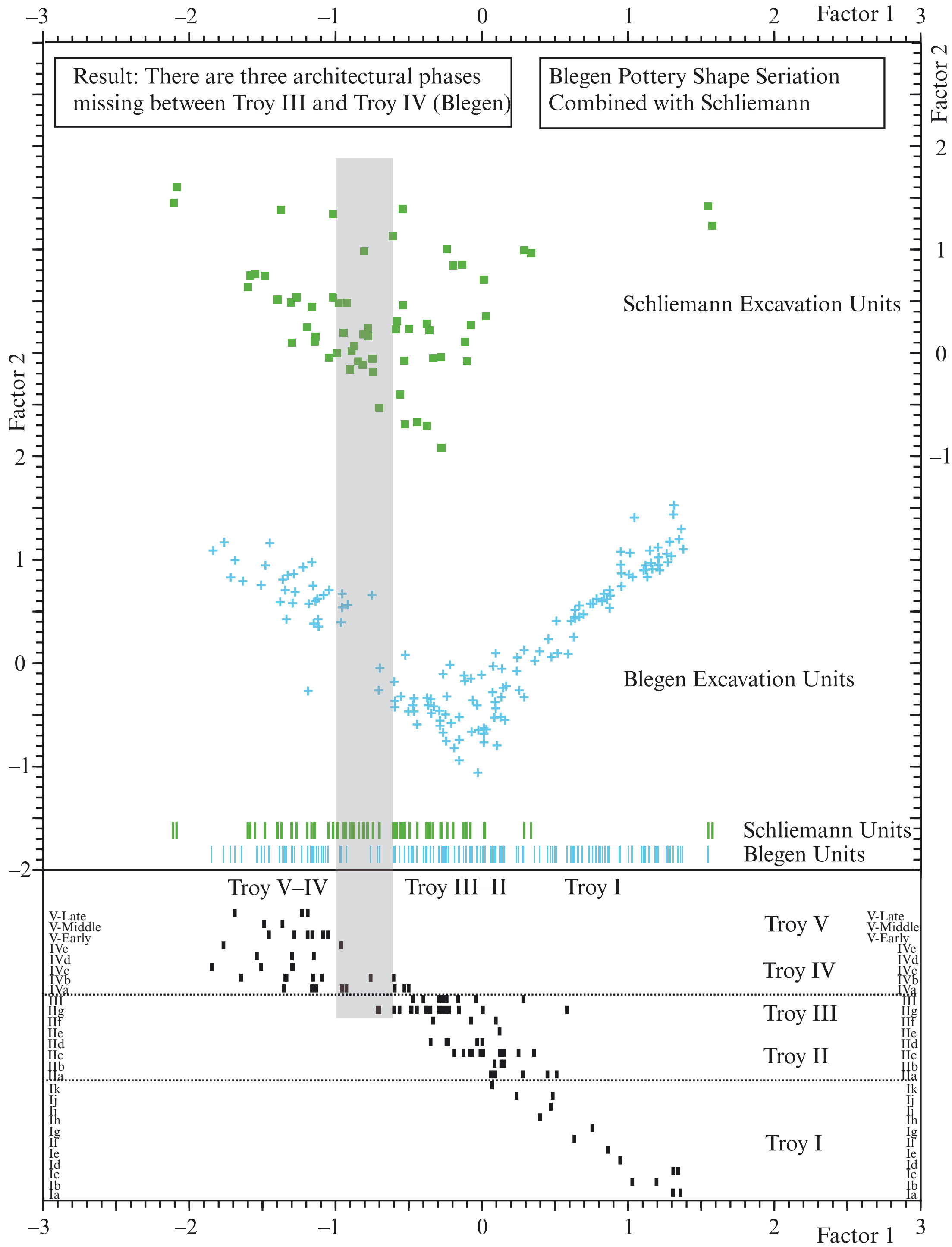

Fig. 8 Correspondence analysis applied to the joint Blegen and Schliemann pottery shape database for Troy periods I–V. CA-rotation by 45º. The graph (upper) shows CA-scores for Blegen and Schliemann excavation units. The graph (lower) shows the CA-scores for Blegen's phase-certified excavation units. At first look the Schliemann units appear to fill the gap between III and IV. Their position in the CA-graph is consistent with their stratigraphic position, but the quality of the Schliemann excavations and the small size of the units may make them less reliable than Blegen's (see text).

for the extreme position of Units 120 and 20 which appear to date 'younger than Troy V' (i.e. beyond the limits of the CA). The point here is that, since the Blegen data used in CA replicate the chronological distributions which Blegen observed, we had no choice but to judge the Schliemann data against those same distributions. Further inspection of the relevant units shows that Unit 20 belongs to period IV, which is acceptable (allowing for finite CA-dating errors). Curiously, Unit 120 was expected to date to Troy II, such that the CA-dating to Troy IV or V is unacceptable, despite the fact that Unit 120 contains quite a large number of shapes (N=8) and pots (N=11). This specific dating discrepancy is probably explained, however, by the fact that the unit includes a theriomorphic vase (classified as D29) and a beak-spouted jug (classified as B20) both of which shapes have exclusively late distributions in Blegen.

Although the exercise to some degree yielded a positive verdict on the proposed distribution of the Schliemann material, its value is obviously limited, in two respects. First, Schliemann did not systematically quantify his finds as Blegen generally did. Thus a comparison based simply on presence and absence, not on relative frequency, might have been deemed more preferable. Although we have tested the combined seriation for such effects – which do not appear to significantly impact the results – we must nevertheless acknowledge that at many points the Schliemann corpus extends the chronological distribution of pottery shapes beyond that defined by Blegen. In conclusion, although promising for further studies, for the moment we must regard the Schliemann data as neutral and inconclusive in regards to the Gap question.

Radiocarbon Age Modelling

Troy Ia, Single-Phase Model (Appendix, Tab. C)

Turning now to the ^{14}C-studies, we begin by calculating an up-dated age estimate for Troy Ia. The new results are shown in Fig. 9. They are based on the hypothesis that, since the six available Troy Ia ^{14}C-ages are all assigned to the same phase, it is quite likely they will have approximately the same age. Of course, as mentioned above, we must allow for the fact that their exact position within phase Ia remains unknown, just as the dated charcoals all have an unknown number of inner growth rings. In the Monte Carlo modelling process, consequently, we have applied a random shuffling error of ± 30 yrs (i.e. ± 30 rings) to all samples. This error should be sufficient to cover both effects (i.e. phase-internal age differences and inner rings), but it does require further testing. Unfortunately, as can be taken from Fig. 9, the probability distribution of the 'best-fitting' GMWCM-model shows the existence of two alternative dates, namely at ~ 2880 calBC (with the highest probability) and at ~ 2760 calBC (with only slightly lower probability).

Actually, it would be possible to force a decision between these two alternative dates, simply by choosing an error smaller than ± 30 yrs for the Gaussian random sample shuffling. For example, by selecting ± 10 yrs, the relative probability for the older reading increases significantly. Quite apparently, the younger readings are due to the shape to the calibration curve, which shows an upwards directed wiggle for calendric ages ~ 2780 calBC. This wiggle catches the younger ^{14}C-ages all the more, the wider the random shuffling is chosen. Nevertheless, before deciding on which of these two dates is to be preferred, let us have a look at the results obtained for the extended Troy I sequence.

Troy Ia–Ij, Multiple-Phase Model (Appendix, Tab. D)

Whereas for Troy Ia all samples derive from the same phase, when extending the age-model to cover the total number of ten Troy I phases (Ia–Ij), the error-model must now allow for the finite (but unknown) time-span of the different phases. Hence, in contrast to the single-phase model, it is not possible to reduce the random shuffling error (below, say ± 30 yrs), even for explorative purposes. Fig. 10 shows the results obtained under the assumption that all Troy I phases have an equal length. Although the best-fitting positions achieved for samples assigned, in particular, to the younger phases Ie to Ii are not all entirely satisfactory, what does appear to be significant is that the Troy Ia dating to ~ 2880 calBC is confirmed. Quite apparently, when combined with the sequence of younger samples, *qua method* a unique reading is obtained for the Troy Ia samples.

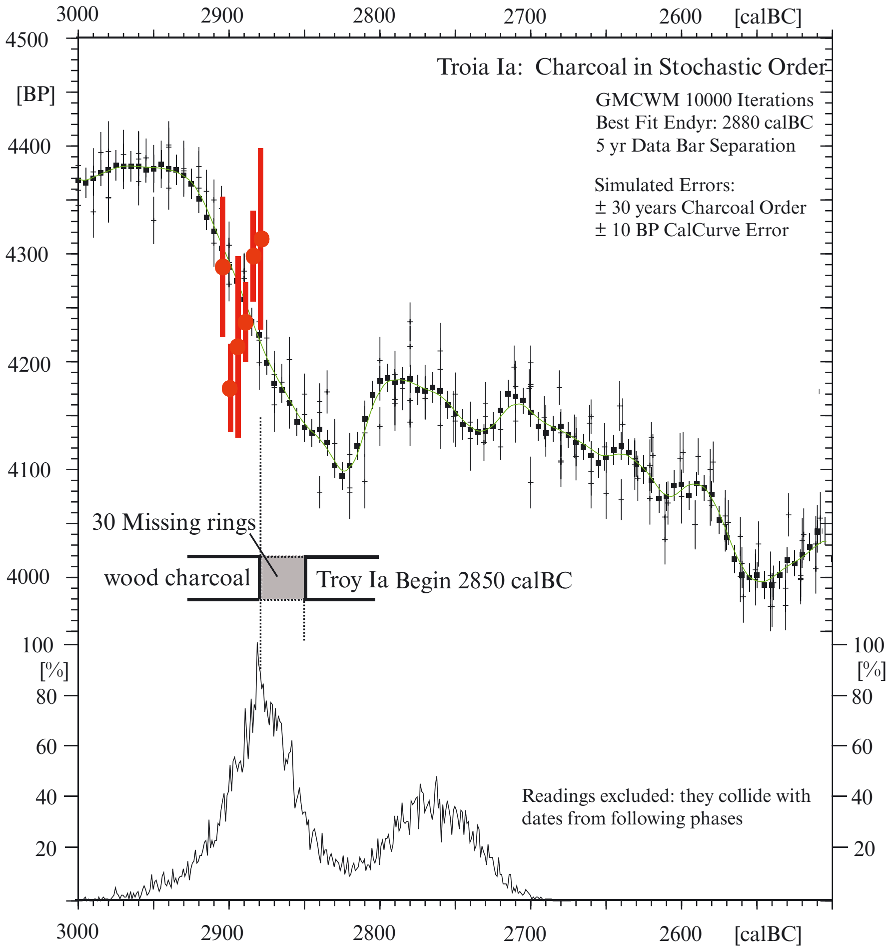

Fig. 9 Troy Ia. Results of GMWCM using Single phase model (Age-model: Tab. C, Appendix).

As such, we gain confidence that the older reading for Troy Ia is indeed correct. However, this does not necessarily imply that the assumed equal phase-length model is equally valid for the following phases.

Looking at the younger end of the Troy I sequence, it is interesting that the two samples (No. 40 and 41: Hd-16810, Hd-16832) from phase Ij do actually appear to derive from the wiggle around 2510 calBC. Both ^{14}C-measurements, although positioned at some (unacceptable) distance *above* the INTCAL13-calibration curve, have ^{14}C-ages that are closer to the limits we may expect if the amplitude of the INTCAL13-curve around 2520 calBC could be set, say, some ~50 BP higher. But, as can be judged from the spread of the laboratory raw-data in this region of the calibration curve, this appears unlikely. Anyway, taken at face value, both of these samples could just as well represent 'old-wood' that is ~ 100 years (or more) older. Less understandable, in statistical terms, are the positions *beneath* the calibration curve obtained for samples Nos. 45 and 47 (Hd-13862, Hd-13848), which could either be due to stratigraphic misalignment or else due to extreme ^{14}C-values.

Model Testing: Troy Id, Beam (Appendix, Tab. E)

Having confirmed the modelled date of ~ 2880 calBC for Troy Ia, let us now test the results of the uniform multiple-phase model itself. If this model is correct, we may expect a date between 2800 and 2760 calBC (i.e. ~ 2780 calBC) for phase Id (Fig. 10). The following test is based on a series of 10 high-precision ^{14}C-measurements obtained by the Heidelberg laboratory on a large charred beam (Beh.D5.365) that was found, apparently in-situ, in Square D5, at the eastern edge

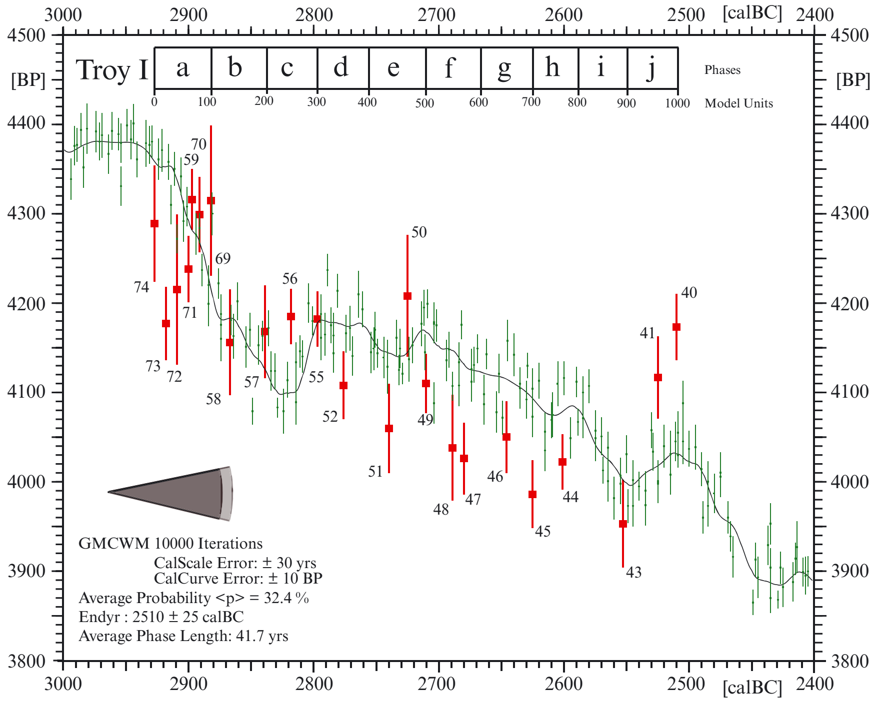

Fig. 10 Troy Ia-Ij. GMWCM-results for multiple-phase model (Age-model: Tab. D, Appendix).

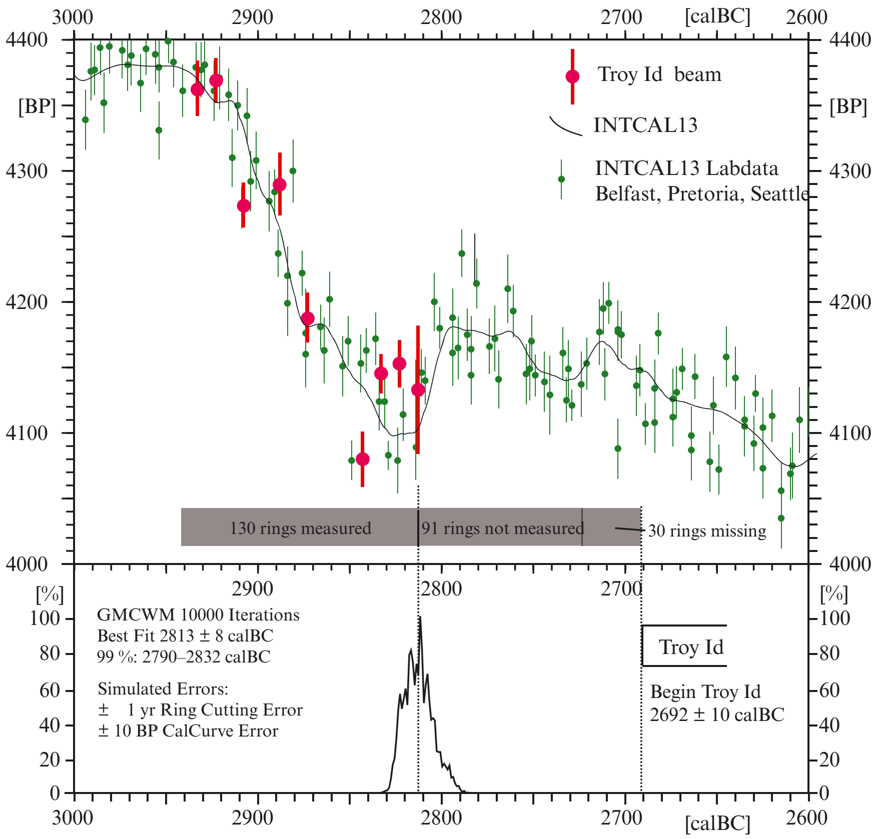

Fig. 11 Troy Id beam. Results of dendrochronological wiggle matching (Data: Korfmann – Kromer 1993, 155) (Age-model: Tab. E, Appendix).

of the Schliemann Graben. Originally, this beam was assigned to Troy I b/c,[63] but its stratigraphic position is more likely to be Troy Id or even later in Troy I.[64] The following discussion is based on the assumption that Troy Id is the correct assignment for the beam.

As shown by dendrochronological analysis, the beam had 226 growth rings, of which only 130 rings were large enough for ^{14}C-measurement. According to the communication from Peter Kuniholm to Manfred Korfmann (dated 18.08.1990) and which is cited by Korfmann and Kromer,[65] the "badly deteriorated condition of the exterior rings made them unsuitable for radiocarbon analysis". Kuniholm writes further: "Thus the final date for the felling of the tree will be the wiggle-matched date plus 91 plus ?? missing rings". As to these question marks, Kuniholm proposes that ~ 30 yrs should be allowed for to account for the missing bark and/or sapwood (German *Splintholz*). Hence, in Fig. 11, having achieved a dendrochronology-based wiggle-match best fit of 2813 ± 8 calBC (rounded: 2813 ± 10 calBC) for the youngest measured sample, we have adjusted the date for the deposition of the beam in Middle or Late Troy I to 2813 minus (91+30 yrs) = 2692 ± 10 calBC. This result is in near-perfect agreement with the result 2699 ± 15 calBC obtained by Korfmann and Kromer.[66]

Looking back at the ^{14}C-results for Troy I (Fig. 10), and comparing the phase-modelled age of Troy Id (2800 ± 30 calBC) with the surely more precise dendrochronological wiggle-matching age (2692 ± 10 calBC) (Fig. 11), it immediately becomes apparent that the phase-modelled results are more-or-less exactly 100 years too old. This age-difference, although obviously large and at any rate not covered by the combined error, is disappointing but not unexpected. It makes us aware, once again, of the many dangers involved in construction of archaeological age-models that are based on the uncritical analysis of charcoal samples. Despite all cautionary measures, perhaps we are still underestimating the impact of the 'old-wood' effect? Notwithstanding this is a real possibility, on the one hand, the offset can *itself* hardly be explained by the exceptional size of the Troy Id beam which has 226 (measured) growth rings. This is because we have corrected the dendro-wiggle-matched date for the 'old-wood' effect, in order to get as close as possible to the actual cutting year of the beam. Hence, this age is *qua method* not dependent on the size of the tree. On the other hand, we cannot exclude that the beam is indeed *double* exceptional, in comparison to the other Troy Ia–Ij charcoals. Beyond its unusual size, it may well represent one of the rare cases where the outer growth rings are conserved. Ultimately, it is impossible to decide which of the two dates is correct. Indeed, perhaps both are correct (or wrong). The only remaining question is, then, how to combine the different dating results? Obviously, we should not simply use the offset of 100 yrs as a correction factor, to be applied to all phases. It may be an extreme value. Instead, but this is looking ahead, in the combined ^{14}C-chronology (Fig. 16) we finally applied a 50-yr 'old-wood' correction to the entire sequence (Troy I–III).

To the same question, it is informative to take a brief look at previously obtained results. According to Weninger (1995), based on an assumed uniform 50-yr phase model for Troy I, the beginning of Troy Ia was dated to 2920 calBC. The end of Troy I (defined as Ii) was dated to 2420 calBC. Similar results were obtained by Manning.[67] In comparison, the present studies indicate that the average Troy I phase length is likely to be somewhat shorter (43 yrs) than was previously established (50 yrs). The difference, although seemingly small (~ 14%), does add up to some 70 yrs at the end of Troy, due to its many phases.

Before taking a closer look at the ^{14}C-dates that are available for the transition from Troy I to Troy II, it is informative to hear what Manfred Korfmann thinks about this question. He comments on the continuity problem as follows: "Several further building phases in the area of Late Troy I to

63 Korfmann – Kromer 1993, 155.
64 Easton – Weninger in preparation.
65 Korfmann – Kromer 1993, 155.
66 Korfmann – Kromer 1993, 155.
67 Manning 1997.

Troy IIc were revealed in addition to those known to Blegen. This jumble of countless walls and parts of walls was extremely difficult to untangle".[68] As it turns out, since the dating results are better than expected (under such prospects), it appears that the necessary untangling of walls, and definition of phases, was altogether quite successful. Plans of the different phases are provided by Unlüsöy.[69] The results of modelling the Troy II–III dates are described in the following.

Troy II–III, Multiple-Phase Model (Appendix, Tab. F)

Similar to the approach taken in modelling the ^{14}C-ages for Troy Ia–Ij, for the next younger data set (Troy II–III) we first apply a uniform phase model. In addition, and which was not possible for Troy I (due to the strongly sloping stratigraphy), it was possible to test the Troy II–III phase model using an age-depth model (see below). For purposes of comparison, the results of the two models are shown together in Fig. 12. Both models are in good agreement concerning both the *beginning of Troy* II (with phase IIa1 dated to ~2550 calBC) as well as the *end of Troy III* (with the youngest Troy III Pinnacle Schicht S6 dated to ~2200 calBC).

Due to its importance for the ^{14}C-analysis, in Fig. 13 we provide a stratigraphic section through the Pinnacle, onto which the ^{14}C-dates for Schichten S13, S12, S9, S7, S6, and S3 are projected.[70] Note that we use here the phasing terminology of Frirdich.[71] Based in particular on studies by Pavúk,[72] we may be reasonably confident that the Pinnacle contains layers mainly of Troy II–III. As indicated (Fig. 13, top), Troy IV is also represented in the Pinnacle, but only in the uppermost layers (S1–S5). These layers, for which ^{14}C-ages are not available, have an extremely small area (< 1m²). More important is that the Pinnacle provides a more-or-less continuous sequence of stratified ^{14}C-ages, documented under conditions that could have been termed ideal if only short-lived samples (e.g. animal bones) had been dated. Even for the given charcoal dates, however, the Pinnacle provides us with some welcome control over the modelling results, both in stratigraphic terms and in terms of periodization/phasing.

Moving from lower to higher in Fig. 13, the heavily burnt Schicht S12 at the lowest levels of the Pinnacle represents the destruction by fire of Megarons IIA and IIB. Both buildings were constructed in Blegen IIc/Ünlüsoy IIc1. The stratigraphically lowest ^{14}C-ages are from burnt wooden beams either from the roof construction of Megaron IIA (Hd-14561) or from the Parastade of Megaron IIB (Hd-14572, Hd-14573, Hd-14008).[73] There is no special need to clarify the ^{14}C-results for Hd-14573, Hd-14008, Hd-14561), since it is obvious these measurements are indicative of the 'old-wood' effect, in all its glory.

The next higher level in the Pinnacle (Schicht S11), and which is also heavily burnt, corresponds to Blegen's IIg. Since the two destruction layers S11 and S12 are difficult to separate elsewhere on the site, many researchers, including Blegen, did not recognise the existence of these two consecutive fire destruction episodes (S12 and S11). Moving again higher, Blegen's Troy III is represented in S10–S3 (^{14}C-ages are available for Schichten S9, S7, S6). Finally, at the very top of the Pinnacle, Blegen's Troy IV is represented in Schichten S1–S5 (^{14}C-age Hd-12099 is available for S3).

Mansfeld correctly shows Blegen's Troy IId and IIe as subphases within his lowest bundle of deposits, Pinnacle S12.[74] In our judgement, they are best interpreted as representing subphases of IIc, during which the large central Megarons continued to exist, although with many alterations to

68 Korfmann 2000, 5–7, fig. 5.
69 Unlüsöy 2010, vol. II.
70 Cf. Tab. 4, Tab. G, Appendix.
71 Frirdich 1997.
72 Pavúk 2010.
73 Mansfeld, 2001, Appendix III, 266.
74 Mansfeld 2001, figs. 12–13; cf. figs. 1, 51.

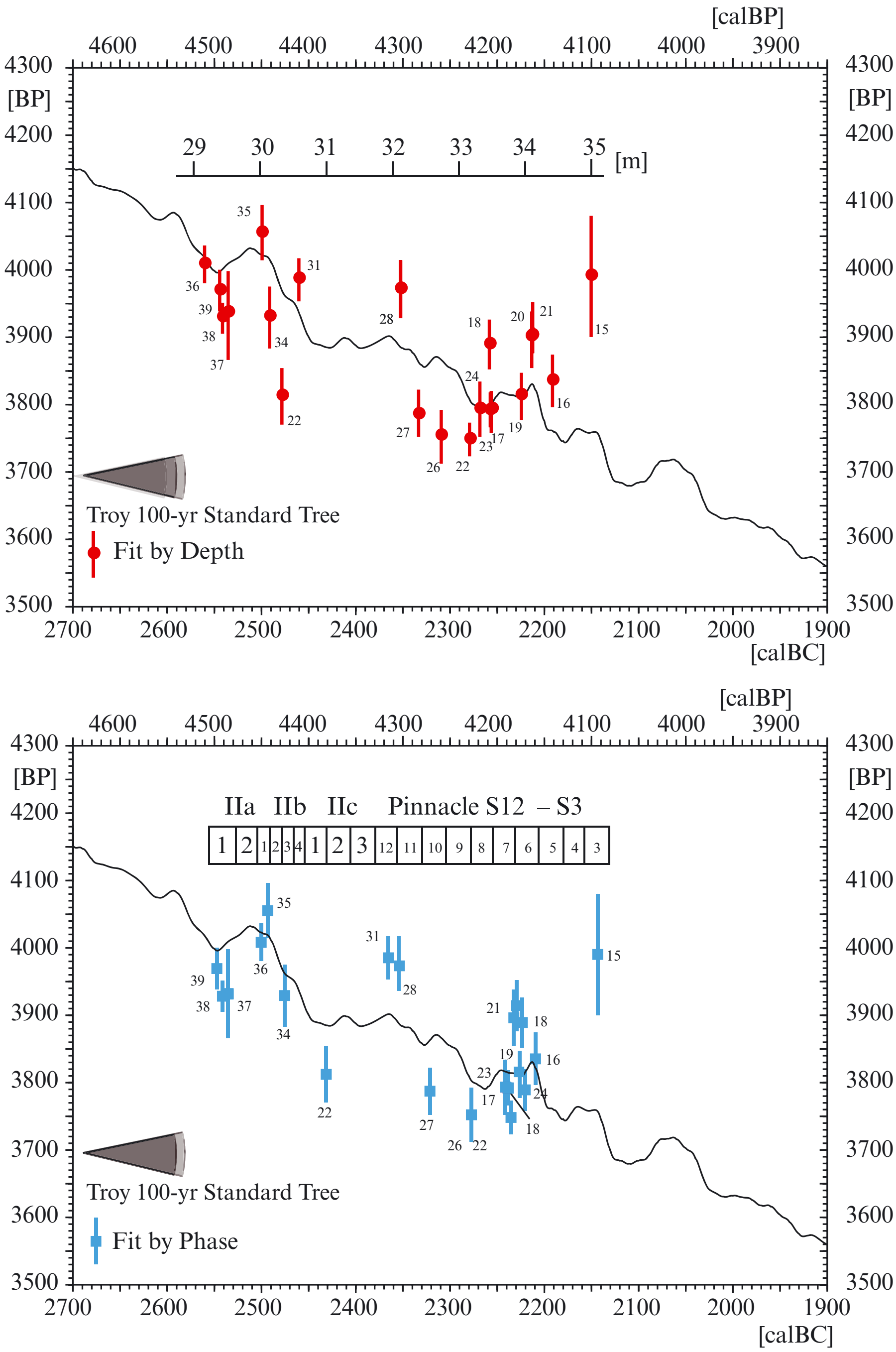

Fig. 12 Comparison of modelling results for Troy II–III, using a linear age-depth model (Upper. Model: Tab. G, Appendix) in comparison to a uniform phase-model (Lower: Model: Tab. F, Appendix). For convenience in ^{14}C-phase-modelling, Phases IIc1–c3 are taken as consecutive, despite the fact that elements of these phases are known to be parallel (cf. text).

the buildings around them.[75] This same phase (Blegen IIc, Ünlüsoy IIc1) witnessed not only the construction of the two central buildings (Megaron IIA and IIB), but also the strengthening and an expansion of the fortifications (Dörpfeld's fortification IIb), the construction of large gates (Gate FM with ramp, Gate FO with superstructure), and the construction of the Temenos with Gate IIC.

[75] Ünlüsoy 2010.

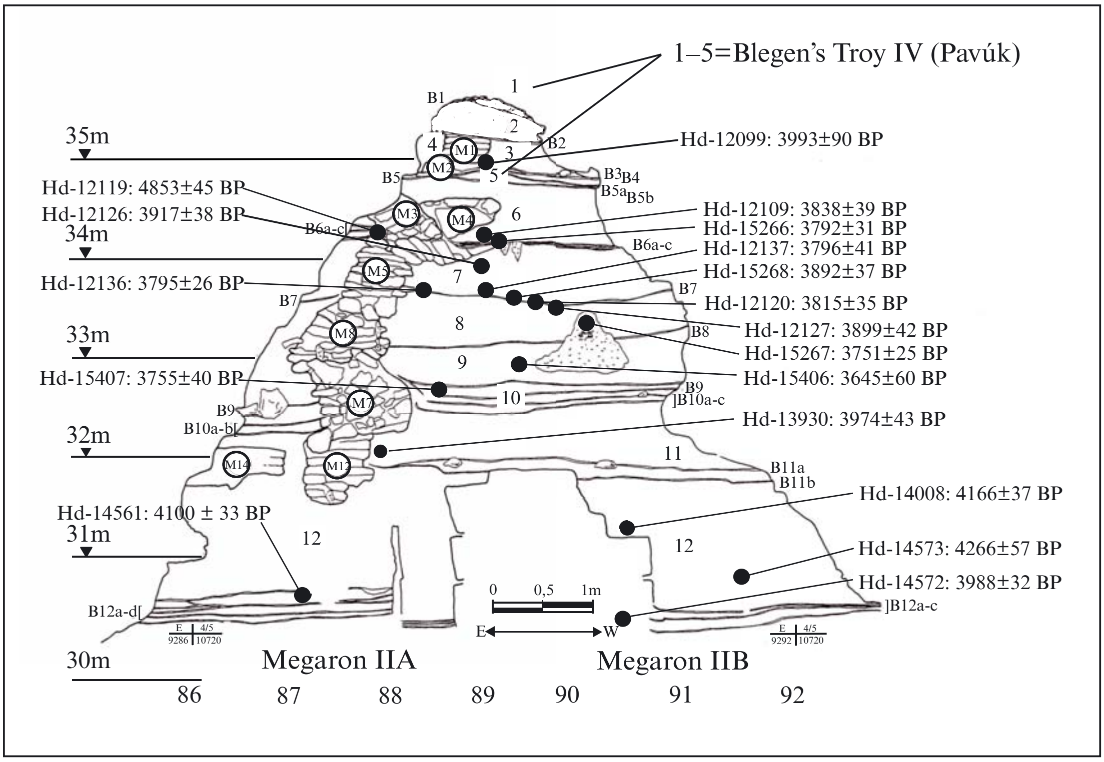

Fig. 13 Pinnacle E4/5 (E–W Profile) excavated by Mansfeld (2001), with projection of ^{14}C-ages (Tab. A, Nos.15–26) according to site coordinates provided by Korfmann – Kromer, 1993). The phases are named here *Schichten* (S12–S1) according to the terminology of Frirdich (1997). As indicated, the highest Schichten (S1–S5) most likely correspond to Blegen's Troy IV (Pavúk 2010). According to archaeozoological analysis by Hans-Peter Uerpmann (referenced in Mansfeld 2001, 162) the hyena den dug into Schichten S8 and S9 (shown with dotted outline) is indicative for a settlement abandonment of unknown length. The B=Boden numbers follow those in Mansfeld's section drawing, but recoded according to the terminology of Frirdich (1997).

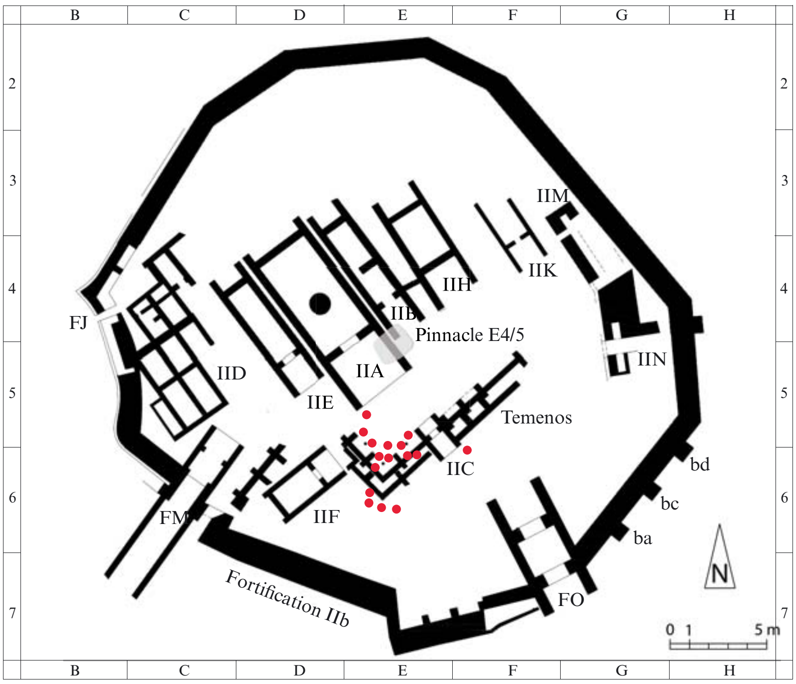

Fig. 14 Plan of Troy Phase IIc (redrawn from Ünlüsoy 2010, 12), with location of major architectural units, including Pinnacle E4/5 (shaded outline) and the position of pits from Phase IId ('Pit Period': Blegen et al. 1950, pt. 2, pl. 457).

With all these major components put together, the plan of IIc (Fig. 14) provides a vivid impression of architectural monumentality and economic wealth at Troy, during this period. Indeed, to the present day the central Megaron IIA at Troy remains the largest building in the EBA of western and central Anatolia.[76]

Of special importance in ^{14}C-age modelling, contrary to Blegen's conclusion the evidence now attests that Megaron IIA was in continued use during Blegen IIc–d–e (Ünlüsoy, IIc1–c3), but was burnt at the same time as the colonnade and courtyard.[77]

Consequently, in ^{14}C-age modelling it is necessary to allow for the extended lifespan of the central architectural complex. As a pragmatic solution, instead of correctly placing phases IIc1–c3 (partly) parallel to each other in time, for convenience we have allowed for their additive timespan by assuming they are consecutive and of equal timespan. This decision opens the path for numerical ^{14}C-age processing.

As stated above, for the Troy II–III sequence we obtain essentially identical *corner* dates for the beginning of Troy II and for the end of Troy III, for both age-models (Fig. 12). What remains to be studied is the statistical stability of intermediate dates.

Troy II–III, Age-Depth Model (Appendix, Tab. G)

To maintain control over the Troy II–III age-depth model (Fig. 12, upper), let us have a closer look at the underlying assumptions. In comparison to the phase-model, which is based on an ordinal scale (i.e. one phase after the other), the age-depth model is based on a metric scale. The specific assumption we wish to check is, how precisely does each centimetre of stratigraphic growth represent one and the same time-span? This time-span is initially unknown. The task we therefore present to the GMWCM-algorithm is to find the best-fitting position of the ^{14}C-ages on the calibration curve, in relation to their stratigraphic depth. Using the GMWCM-method, this task is achieved by stepwise expansion of the sequence, until an optimal growth value [cm/yr] is achieved. In archaeological terms the assumption is that, within error limits to be established, the overall stratigraphy of Troy II in any one phase is horizontal, with gradual but always upward directed growth due to the accumulation of deposits. Obviously, prior already to the ^{14}C-analysis, the validity of this assumption needs to checked. It is not that we *believe* in the validity of this assumption, or not. Much simpler, the aim of checking is to quantify the numeric errors to be entered into the GMWCM-algorithm.

As can be taken from Fig. 15, the central stratigraphy of the site has corner values of ~ 29.5m for Troy IIa1, at the lower end, and of ~ 35.0m for the end of Troy III (Pinnacle Schicht S3) at the higher end of the graph. The growth rate between these two ends is indeed to some extent linear, as required for age-depth modelling. However, the graph shows two quite conspicuous steps, the first and largest of which (> 1.5m) dates to Pinnacle Schicht S12, the second dates to Pinnacle Schicht S7. The first step at c. 31–32m reflects the large accumulation of burnt debris that is associated with the collapse of Megaron IIA and Megaron IIB at the end of the IIc–d–e sequence (in Blegen's terms). This was a very severe conflagration and a major incident in the site's history. The step at c. 33.20–34.20 does coincide with another severe burning in the course of Troy III (Pinnacle S7). However, both the two lowest as well as some of the higher samples in this step come from pits dug down from the next younger Schicht S6a into these deposits. Hence, if only for this second step, the vertical spread of sample heights is not only caused by fire-destruction. As in the case with the linear growth model, it is also interesting to observe that, for essentially all the many (!) phases in between these steps, the site does appear to be gradually developing upwards. A quick estimate would be that it takes some 500 years for Troy to grow some 5m. This value (i.e. 1cm/yr) is no way unusual. Similar values (± 30%) can be obtained

76 Bachhuber 2009, 7.

77 Easton 2000, 78–79.

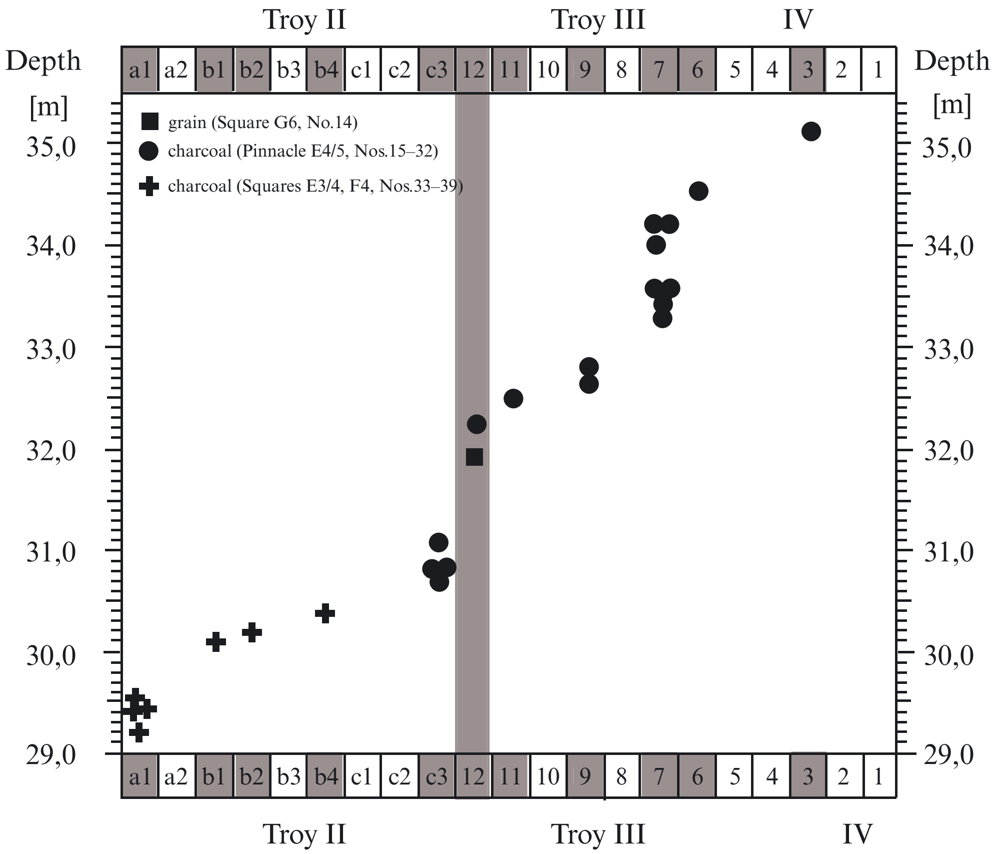

Fig. 15 Phase-depth relation for ^{14}C-dated samples from Troy II–III.

for tell-sites all over the Near East and southeast Europe and, as it appears, the range of values is only a minor function of construction material (stone and/or clay). These notions remain to be documented. What is important, for present purposes, is that the growth-rate error, to be entered into the GMCWM-algorithm is in the order of ± 30cm (see Fig. 15). When translated to calendric ages, the resulting error of ± 30 yrs coincides perfectly with the value we have been using all the time in phase-modelling (above), but which was up to now not well-established.

We are now in a position to critically compare the results achieved for Troy II–III by the two different methods (Fig. 12). As already mentioned above, essentially identical ages are achieved for the *corner ages* of the sequences (i.e. for the beginning of II and the end of III). But what about the ages for the intermediate samples? For these samples, the maximal deviation is for date No. 31, for which an age-model difference of 97 yrs is achieved [2464 calBC (*phase*) minus 2367 calBC (*depth*)]. Otherwise, the results of the two models are quite similar. The main difference is that, in the phase model (Fig. 12, lower), the sample positions are slightly (by a few decades) closer together than in the depth model (Fig. 12, upper). From a statistical viewpoint, this is acceptable. To maintain compatibility with the phase-modelling for Troy I, in the final combined chronology (Fig. 16) we decided also to base the Troy II–III component on the phase model.

Model Testing: Hd-20174: Final Test

Purposely, we have not included Hd-20174: 3797 ± 25 BP (2230 ±50 calBC) in any of the models. Hd-20174 is quite singular in that the ^{14}C-measurement was performed on the only short-lived (grain) sample in the entire data-set. Consequently, it is possible to use this date for final control purposes. Hd-20174 was taken from the inside of a burnt wooden construction found standing on the floor of Megaron 1 (Square G6, Beh. G6.1056). Photographic documentation of Megaron 1 is provided by Sazcı and Ünlüsoy.[78] According to Sazcı,[79] the sample can be attributed to Blegen IIIa (i.e. the earliest phase of Blegen's period III, if only in the sense that the sample represents the burning of Megaron 1 at some – unknown – time following its construction). When transferred to the Pinnacle, therefore, we may expect Hd-20174 to have a calendric age that is compatible with the end of Schicht S10. For this comparison to be valid, however, due allowance is to be made for the 'old-wood' effect.

Combined ^{14}C-Chronology

All that is now necessary is to combine the age-models achieved for the different floating data sub-sets, that is for Troy Ia–Ij (Fig. 10), the Beam Id (Fig. 11), and for Troy II–III (Fig. 12, lower). The combined ^{14}C-chronology is shown in Fig. 16 (upper).

Remembering that all these components were obtained for charcoals, Fig. 16 (lower) shows the chronology as it would appear when a systematic shift of 50 yrs (younger) is applied to all phases. This shift is necessary to allow for the (estimated) 'old-wood' effect. In the corrected ^{14}C-chronology, due allowance is also made for the three Late I–Early II phases (Il, Im, and In). These three phases are not covered by the age-models. We show this corrected chronology in Fig. 16 (lower), despite all necessary phase-interpolations. It is the chronology to be preferred for synchronisms with other Anatolian EBA-sites, and in particular when long-distance synchronisms between Troy and sites with historical dates (e.g. in Mesopotamia) are requested.

Purposely *not* shown in the Final Age Model (Fig. 16, lower) is the chronological position of Hd-20174, which is the only presently available ^{14}C-age that was measured on a short-lived

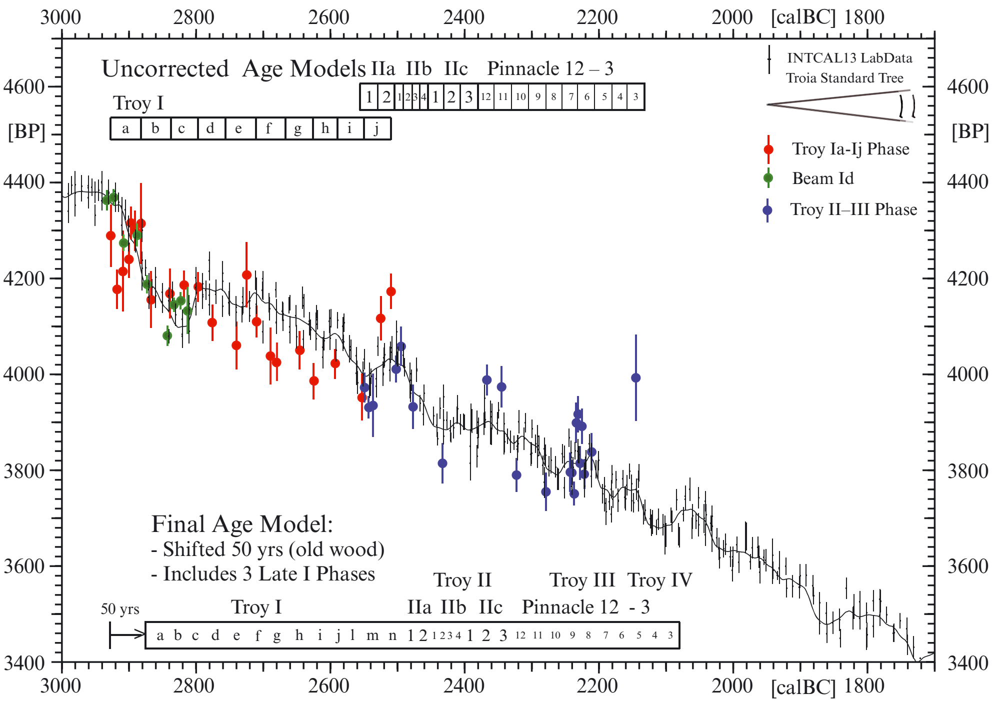

Fig. 16 Combined stratigraphic succession of ^{14}C-ages (Data: Tab. A, Appendix) for Early Bronze Age Troy (periods I–III). The figure combines the ^{14}C-age sequence according to different age models for initially floating ^{14}C-data subsets (Fig. 1).

[78] Sazcı 2001; Ünlüsoy 2010.

[79] Sazcı 2001, 384.

sample. According to the forecasting (in the previous section), the age obtained for Hd-20174 (3797 ± 25 BP: 2230 ± 50 calBC) by single-date-analysis should (hopefully) be synchronous with the age obtained for the end of Pinnacle Schicht S10. As can be taken from Fig. 16 (lower), and when inserting a date of 2230 ± 30 calBC for Pinnacle Schicht S10, this is indeed the case.

Conclusions

To summarise, we have developed a stratigraphic age model for EBA-Troy (periods I–III) that incorporates N=76 published ^{14}C-ages (Appendix, Tab. A). The main results of our studies are shown in Fig. 16. We provide here two variants of the same ^{14}C-based chronology, that is (1) a chronology that is uncorrected for the 'old-wood' effect (Fig. 16 upper) and (2), the same chronology but which is systematically shifted by 50 yrs to the younger, and which incorporates three ^{14}C-undated architectural phases between Late Troy I and Early Troy II (Fig. 16 lower). It is to be emphasised that, in the construction of both chronologies, we found it impossible to attribute any of the ^{14}C-dated charcoal samples to the calendric time-scale, more precisely than with a (minimum) error of ± 30 yrs (68% confidence). A further (and significant) reduction in dating errors should be possible, we judge, if in the future a more extensive series of radiocarbon ages on short-lived samples (e.g. animal bone, shell, charred grain) becomes available.

In our judgement, the following three observations are of particular interest: 1. the chronological results shown in Fig. 16, although derived from complex modelling, are in good agreement with the results for Troy II–III obtained from critical single-date analysis by Ünlüsoy;[80] 2. the chronological results shown in Fig. 16, although obtained on such complex entities as are archaeological charcoals, finally required leaving away *only* six ^{14}C-measurements as *outliers* (Hd-14008, Hd-14573, Hd-13633, Hd-14561, Hd-13619, Hd-13931 cf. Appendix Tab. A); 3. as discussed in detail here, there are indications for the existence of a gap (in the sense of a real settlement hiatus) of 100–200 yrs in length between the end of Troy III and the beginning of Troy IV. This possibility (Fig. 5), although presently not confirmed by the combined Blegen and Schliemann pottery seriation (Fig. 8), requires further attention.

Acknowledgements: We gratefully acknowledge the support by Peter Jablonka (Tübingen) during many excavation campaigns at Troy and thank him for his thoughtful and constructive review of the present paper. Remaining errors are of course ours, to be quantified.

80 Ünlüsoy 2010, 172–178, pl. 120.

Appendix Tab. A

No.	LabCode		Phase	Material	*Behälter Nr.*	^{14}C-Age [BP]	Height [m]	Y	X	Model Age calBC (68%)
1	Hd-13823		nd	charcoal	D7.33	3829 ± 33	31.32	78.50	67.50	nd
2	Hd-14022		nd	charcoal	D7.146	3890 ± 33	27.91	78.20	72.30	nd
3	KN-131		III ?	charcoal	---	3750 ± 95	nd	nd	nd	*2038 ± 40*
4	Bln-1235		--	short	Inv.No.9493	3665 ± 60	nd	nd	nd	*2062 ± 40*
5	Bln-1234		--	pees	Inv.No.9483	3635 ± 60	nd	nd	nd	*2086 ± 40*
6	Bln-1239		III ?	charcoal	Inv.No.9482	3845 ± 70	nd	nd	nd	*2110 ± 40*
7	Bln-1237		--	pees	Inv.No.9481	3730 ±100	nd	nd	nd	*2134 ± 40*
8	Bln-1238		--	charcoal	Inv.No.9480	3710 ± 80	nd	nd	nd	*2158 ± 40*
9	Bln-1106		III	seeds	Inv.No.9479	3900 ± 90	nd	nd	nd	*2182 ± 40*
10	Bln-1310		--	charcoal	Inv.No.9475	3760 ± 60	nd	nd	nd	2206 ± 40
11	Bln-1236		--	charcoal	Inv.No.9475	3700 ±100	nd	nd	nd	*2230 ± 40*
12	Bln-1129		IIg ?	peas	Inv.No.9474	3800 ± 60	nd	nd	nd	*2254 ± 40*
13	Bln-1132		IIg ?	peas	Inv.No.9474	3735 ± 60	nd	nd	nd	*2278 ± 40*
14	Hd-20174		IIIa	seeds	*G6.1056*	*3797 ± 25*	*31.94*	*93.30*	*94.80*	2230 ± 50
15	Hd-12099	S-3	IV	charcoal	E4/5.17+20	3993 ± 90	35.03	88.60	19.80	2145 ± 30
16	Hd-12109	S-6	III	charcoal	E4/5.31	3838 ± 39	34.44	88.89	20.35	2211 ± 30
17	Hd-15266	S-7	III	charcoal	E4/5.122	3792 ± 31	33.50	88.95	18.90	2222 ± 30
18	Hd-15268	S-7	III	charcoal	E4/5.112	3892 ± 37	33.50	88.95	18.90	2225 ± 30
19	Hd-12120	S-7	III	charcoal	E4/5.67	3815 ± 35	33.97	89.25	20.30	2228 ± 30
20	Hd-12126	S-7	III	charcoal	E4/5.68	3917 ± 38	34.14	89.25	20.30	2231 ± 30
21	Hd-12127	S-7	III	charcoal	E4/5.71	3899 ± 42	34.13	90.35	19.97	2234 ± 30
22	Hd-15267	S-7	III	charcoal	E4/5.178	3751 ± 25	33.19	88.09	19.92	2237 ± 30
23	Hd-12136	S-7	III	charcoal	E4/5.92	3795 ± 26	33.50	88.20	20.00	2240 ± 30
24	Hd-12137	S-7	III	charcoal	E4/5.93	3796 ± 41	33.55	89.30	19.70	2243 ± 30
25	Hd-15406	S-9	III	charcoal	E4/5.140	3645 ± 60	32.58	89.70	22.10	2030 ± 90
26	Hd-15407	S-9	III	charcoal	E4/5.162	3755 ± 40	32.76	88.45	20.67	2279 ± 30
27	Hd-15408	S-11		charcoal	E4/5.170	3790 ± 35	32.42	87.77	21.70	2323 ± 30
28	Hd-13930	S-12		charcoal	E4/5.307	3974 ± 43	32.15	87.50	21.50	2345 ± 30
29	Hd-14008	S-12		charcoal	E4/5.393	4166 ± 37	31.00	90.50	20.00	outlier
30	Hd-14573	S-12		charcoal	E4/5.580	4266 ± 57	30.75	91.55	19.90	outlier
31	Hd-14572	S-12		charcoal	E4/5.584	3988 ± 32	30.62	90.27	20.04	2367 ± 30
32	Hd-14561	S-12		charcoal	E4/5.551	4100 ± 33	30.79	86.75	19.20	outlier
33	Hd-16733		IIb4?	charcoal	E4.660	3815 ± 42	30.37	86.00	36.00	2433 ± 30
34	Hd-16734		IIb2	charcoal	E4.701	3932 ± 46	30.18	88.00	36.50	2477 ± 30
35	Hd-16735		IIb1	charcoal	E4.639	4058 ± 41	30.07	85.00	31.00	2495 ± 30
36	Hd-17664		IIb1	charcoal	E3.39	4011 ± 28	29.19	87.50	49.00	2502 ± 30
37	Hd-19823		**IIa1**	charcoal	F4.67	**3935 ± 66**	29.55	07.00	29.20	2537 ± 30
38	Hd-19822		**IIa1**	charcoal	F4.68	3931 ± 23	29.46	07.50	29.20	2543 ± 30
39	Hd-20040		**IIa1**	charcoal	F4.69	3972 ± 31	29.42	08.00	29.40	2549 ± 30
40	Hd-16810		Ij	charcoal	D3.278	4173 ± 37	24.30	74.00	47.50	2510 ± 30
41	Hd-16832		Ij	charcoal	D3.266	4117 ± 46	24.13	75.50	48.30	2525 ± 30
42	Hd-13633		Ii	charcoal	D2.82	4228 ± 45	24.44	79.50	61.25	outlier
43	Hd-13813		Ii	charcoal	D2.275	3954 ± 49	23.90	74.50	63.80	2553 ± 30

No.	LabCode	Phase	Material	*Behälter Nr.*	^{14}C-Age [BP]	Height [m]	Y	X	Model Age calBC (68%)
44	Hd-13812	Igh	charcoal	D2.236	4022 ± 31	24.27	66.75	62.45	2600 ± 30
45	Hd-13862	Igh	charcoal	D2.196	3986 ± 38	22.92	73.70	68.70	2625 ± 30
46	Hd-13850	Ig	charcoal	D3.190	4050 ± 40	24.00	71.45	58.75	2646 ± 30
47	Hd-13848	If	charcoal	D3.105	4026 ± 40	23.77	69.00	59.00	2680 ± 30
48	Hd-13801	If	charcoal	D3.105	4038 ± 59	23.77	69.00	59.00	2689 ± 30
49	Hd-13384	Ief	charcoal	C3.164	4110 ± 33	24.25	55.35	58.25	2710 ± 30
50	Hd-13852	Ie	charcoal	D3.138	4208 ± 68	23.51	68.50	58.50	2725 ± 30
51	Hd-13851	Ie	charcoal	D3.167	4060 ± 50	23.47	68.30	58.20	2740 ± 30
52	Hd-13618	Icd	charcoal	C3.223	4108 ± 38	23.50	54.50	57.65	2776 ± 30
53	Hd-13619	Icd	charcoal	C3.223	4288 ± 37	23.50	54.50	57.65	outlier
54	Hd-13931	Icd	charcoal	D4.215	3786 ± 55	28.32	77.12	24.22	outlier
55	Hd-13751	Icd	charcoal	C3.201	4182 ± 31	23.87	55.10	57.00	2797 ± 30
56	Hd-13929	Icd	charcoal	D4.379	4185 ± 31	28.38	77.60	23.72	2818 ± 30
57	Hd-11906	Ibc	charcoal	D4.14	4168 ± 52	26.46	74.40	31.00	2839 ± 30
58	Hd-12059	Iab	charcoal	D4.118	4156 ± 59	26.50	60.75	24.25	2867 ± 30
59	Hd-11935	Iab	charcoal	D4.38	4316 ± 34	26.30	75.45	24.20	2897 ± 30
Beam (*pinus brutia,* 226 rings), Beh.D5.365. 'Id' means: *Begin Id (or younger), with ~121 not-dated outer rings.*									
60	Hd-14706	'Id'	charcoal	1051-1060	4133 ± 49	27.47	78.0	18.0	2813 ± 10
61	Hd-14614	--	charcoal	1041-1050	4153 ± 18	27.47	78.0	18.0	2823 ± 10
62	Hd-15023	--	charcoal	1031-1040	4145 ± 15	27.47	78.0	18.0	2833 ± 10
63	Hd-14698	--	charcoal	1021-1030	4080 ± 21	27.47	78.0	18.0	2843 ± 10
64	Hd-14686	--	charcoal	991-1010	4188 ± 19	27.47	78.0	18.0	2873 ± 10
65	Hd-14937	--	charcoal	976-985	4290 ± 24	27.47	78.0	18.0	2888 ± 10
66	Hd-14672	--	charcoal	956-965	4274 ± 17	27.47	78.0	18.0	2908 ± 10
67	Hd-15095	--	charcoal	941-950	4369 ± 17	27.47	78.0	18.0	2923 ± 10
68	Hd-14615	--	charcoal	931-940	4363 ± 21	27.47	78.0	18.0	2933 ± 10
69	Hd-11945	Ia	charcoal	D4.46	4315 ± 84	26.00	75.30	24.12	2882 ± 30
70	Hd-11917	Ia	charcoal	D4.35	4299 ± 42	25.58	74.10	32.45	2891 ± 30
71	Hd-11944	Ia	charcoal	D4.50	4238 ± 37	25.62	75.20	24.20	2900 ± 30
72	Hd-12058	Ia	charcoal	D3.43	4215 ± 84	24.53	61.00	40.60	2909 ± 30
73	Hd-12061	Ia	charcoal	D4.136	4177 ± 41	25.93	60.60	24.30	2918 ± 30
74	Hd-12060	Ia	charcoal	D4.129	4289 ± 65	26.02	60.65	24.30	2927 ± 30
75	Hd-14223	Pre-I	charcoal	D5.457	4271 ± 45	25.49	75.75	9.50	--
76	Hd-14222	Pre-I	charcoal	D5.443	4568 ± 47	25.52	74.30	9.30	--

Appendix Tab. A Early Bronze Age ^{14}C-Dates (Troy I–III). ^{14}C-data from Korfmann – Kromer (1993), Sazcı (2001) and Ünlüsoy (2010). Calendric ages in the far right column are based on architectural-phase modelling (Tabs. C–F), see text. These ages do not account for the age-distorting impact of the 'old-wood' effect. Ages provided for Hd-20174 and Hd-15406 – set *italic* – were derived from single-age calibration. They were used for model testing. For methodological reasons it is not possible to derive weighted averages from calibrated ^{14}C-ages with '±' notation (Chapter 3).

Abbreviations: (1) LabCodes: Hd (Heidelberg), Bln(Berlin), KN(Köln). (2) nd: not defined) (3). S-1 to S-12: Pinnacle notation by *Schichten*, according to Frirdich (1997).

Appendix Tab. B

Unit Nr	Text Unit	Text Page	Troy Period	Blegenized Pottery Inventory																
UNIT 5	NE.v.4–5	p97	II–III	NoTypes	NoPots	%-Tot	C10	D14											
				2	2	0.01	1	1											
UNIT 7	NP.i.10	p110	II	NoTypes	NoPots	%-Tot	B3	C34	C39	D33									
				4	4	0.03	1	1	1	1									
UNIT 9	NP.ii.4	p115	V	NoTypes	NoPots	%-Tot	A33	C28	D13										
				3	3	0.02	1	1	1										
UNIT 11	NP.ii.6	p115f	III	NoTypes	NoPots	%-Tot	B15	C35	D13										
				3	3	0.02	1	1	1										
UNIT 12	NP.ii.7	p116	II	NoTypes	NoPots	%-Tot	A39	A41	B8	B17	C28	C34	C35	C39	D29				
				9	9	0.06	1	1	1	1	1	1	1	1	1				
UNIT 13	NP.ii.9	p117	I–II	NoTypes	NoPots	%-Tot	B1	B20	D1										
				3	3	0.02	1	1	1										
UNIT 16	NP.iv.2	p121	III	NoTypes	NoPots	%-Tot	A12	B20	B24	C32	D8	D24							
				6	6	0.04	1	1	1	1	1	1							
UNIT 17	NP.iv.3	p122f	II	NoTypes	NoPots	%-Tot	B3	B15	C28	C35	D13	D15	D31						
				7	7	0.05	1	1	1	1	1	1	1						
UNIT 18	NP.iv.4	p125	I–II	NoTypes	NoPots	%-Tot	B15	C1	C35	D3									
				4	4	0.03	1	1	1	1									
UNIT 20	NP.v.2	p127	IV	NoTypes	NoPots	%-Tot	A8	B3	B24										
				3	3	0.02	1	1	1										
UNIT 22	NP.v.4a	p128f	II	NoTypes	NoPots	%-Tot	C28	C34	D30										
				3	3	0.02	1	1	1										
UNIT 23	NP.v.4b	p128f	II	NoTypes	NoPots	%-Tot	B13	C28											
				2	2	0.01	1	1											
UNIT 25	NP.vii.6a	p131	III	NoTypes	NoPots	%-Tot	B3	C5	C39	D34									
				4	5	0.03	2	1	1	1									
UNIT 27	NP.vii.7a	p132	II	NoTypes	NoPots	%-Tot	A	C28	D7	D33									
				4	4	0.03	1	1	1	1									
UNIT 28	NP.vii.7b	p132	II	NoTypes	NoPots	%-Tot	B5	C34											
				2	2	0.01	1	1											
UNIT 31	NP.viii.2	p135f	V	NoTypes	NoPots	%-Tot	B21	B22	C5										
				3	3	0.02	1	1	1										
UNIT 38	NS/n.ii.5	p145f	III–IV	NoTypes	NoPots	%-Tot	A45	B20	B21	C32	C35	C39	D3	D7	D8	D13			
				10	10	0.06	1	1	1	1	1	1	1	1	1	1			
UNIT 39	NS/n.ii.6	p147	II	NoTypes	NoPots	%-Tot	A45	B24	C28	C32	C39	D7	D8						
				7	8	0.05	2	1	1	1	1	1	1						
UNIT 44	NS/n.iii.7	p153f	IV	NoTypes	NoPots	%-Tot	B13	C28	D26										
				3	3	0.02	1	1	1										
UNIT 45	NS/n.iii.10	p155	III	NoTypes	NoPots	%-Tot	A2	A33	A43	B3	B17	C28	D13	D33					
				8	8	0.05	1	1	1	1	1	1	1	1					
UNIT 46	NS/n.iii.11	p156	II	NoTypes	NoPots	%-Tot	A39	A45	B3	B6	B17	C5	C28	D3	D13	D29			
				10	15	0.10	1	3	2	1	1	1	3	1	1	1			
UNIT 48	NS/n.iii.11	p157	II	NoTypes	NoPots	%-Tot	A2	B3	B18	C27	C28	D1	D13						
				7	9	0.06	1	1	1	1	2	1	2						
UNIT 49	NS/n.iii.12	p160	II	NoTypes	NoPots	%-Tot	A39	B3	B17	C10	C27	C28	C39						
				7	12	0.08	1	1	1	1	1	1	6						
UNIT 50	NS/n.iii.15	p163	I–II	NoTypes	NoPots	%-Tot	A12	A26	C28	C35	D8	D15							
				6	6	0.04	1	1	1	1	1	1							
UNIT 51	NS/n.iii.17	p164	I	NoTypes	NoPots	%-Tot	A7	D24											
				2	2	0.01	1	1											
UNIT 53	NS/n.v.4a	p168f	IV	NoTypes	NoPots	%-Tot	B3	C7	C28	D30									
				4	4	0.03	1	1	1	1									
UNIT 54	NS/n.v.4b	p169	IV	NoTypes	NoPots	%-Tot	A33	A39	A43	B5	B15	C35							
				6	6	0.04	1	1	1	1	1	1							
UNIT 55	NS/n.v.5	p170	III	NoTypes	NoPots	%-Tot	A45	B3											
				2	3	0.02	2	1											
UNIT 56	NS/n.v.6a	p171	II	NoTypes	NoPots	%-Tot	A33	A43	A45	B3	C10	C19	D3						
				7	8	0.05	1	1	1	2	1	1	1						
UNIT 57	NS/n.v.6b	p171f	II	NoTypes	NoPots	%-Tot	A2	C28	D33										
				3	3	0.02	1	1	1										
UNIT 58	NS/n.v.7	p173	I	NoTypes	NoPots	%-Tot	A31	D11											
				2	2	0.01	1	1											
UNIT 66	NS/s.iii.9	p187f	IV	NoTypes	NoPots	%-Tot	A2	A33	A45	B3	B17	C25	C29	C35	C36	D1	D3	D8	D13
				13	21	0.14	1	5	3	1	1	1	1	2	1	1	1	1	2
UNIT 67	NS/c.i.5	p194f	V	NoTypes	NoPots	%-Tot	A33	A45	C8	D13	D31								
				5	7	0.05	2	2	1	1	1								

Unit Nr	**Text Unit**	**Text Page**	**Troy Period**	**Blegenized Pottery Inventory**			
UNIT 68	NS/c.i.6	p195f	IV	NoTypes 8	NoPots 15	%-Tot 0.10	A33 A39 A45 B9 C19 C28 D13 D14 2 1 4 1 1 4 1 1
UNIT 69	NS/c.i.7	p198f	III	NoTypes 9	NoPots 10	%-Tot 0.06	B3 B6 B20 C22 C28 C39 D7 D29 D33 2 1 1 1 1 1 1 1 1
UNIT 70	NS/c.i.8	p201f	II	NoTypes 10	NoPots 11	%-Tot 0.07	A2 A39 B6 B18 C6 C10 C11 C21 C25 C35 1 2 1 1 1 1 1 1 1 1
UNIT 71	NS/c.11a	p204	II	NoTypes 3	NoPots 3	%-Tot 0.02	A2 C25 C28 1 1 1
UNIT 72	NS/c.i.11b	p205	II	NoTypes 5	NoPots 5	%-Tot 0.03	A1 A39 A45 C25 D29 1 1 1 1 1
UNIT 73	NS/c.i.14	p207	I	NoTypes 4	NoPots 4	%-Tot 0.03	A12 B1 C25 C28 1 1 1 1
UNIT 75	NS/c.ii.6	p209	IV	NoTypes 2	NoPots 2	%-Tot 0.01	A39 D33 1 1
UNIT 76	NS/c.ii.7	p209	III	NoTypes 2	NoPots 2	%-Tot 0.01	A45 D7 1 1
UNIT 77	NS/c.ii.8	p210f	II	NoTypes 6	NoPots 6	%-Tot 0.04	A2 A39 B15 C1 C27 D29 1 1 1 1 1 1
UNIT 86	EW.ii.5	p229	IV–V	NoTypes 4	NoPots 5	%-Tot 0.03	A44 B24 C35 D15 1 1 1 2
UNIT 87	EW.iii.3	p233	III	NoTypes 9	NoPots 11	%-Tot 0.07	A16 B3 B4 B5 B20 C10 C35 D2 D7 2 1 1 1 1 1 2 1 1
UNIT 88	EW.iii.4	p234f	II	NoTypes 7	NoPots 12	%-Tot 0.08	A2 A30 A45 B3 B18 C7 C11 6 1 1 1 1 1 1
UNIT 89	EW.iv	p236f	II	NoTypes 11	NoPots 12	%-Tot 0.08	A43 B4 B8 B9 C1 C7 C13 C19 D7 D13 D31 1 2 1 1 1 1 1 1 1 1 1
UNIT 94	EW.v.9	p242ff	II 20	NoTypes 29	NoPots 0.19	%-Tot 6	A2 A37 A39 A45 B3 B4 B18 C1 C5 C10 C13 C28 C32 C34 C35 D2 1 2 1 2 1 1 1 1 2 1 2 1 1 1 1 D13 D14 D24 D33 1 1 1 1
UNIT 97	NW.iii.6	p259	II	NoTypes 2	NoPots 2	%-Tot 0.01	A45 D29 1 1
UNIT 100	WA.iii.6	p272	IV–V	NoTypes 2	NoPots 2	%-Tot 0.01	A20 C21 1 1
UNIT 103	WA.iv.7a	p276	IV	NoTypes 2	NoPots 2	%-Tot 0.01	C28 D1 1 1
UNIT 105	WA.iv.7c	p276	IV	NoTypes 2	NoPots 2	%-Tot 0.01	B20 C13 1 1
UNIT 106	WA.iv.8	p278	III	NoTypes 4	NoPots 6	%-Tot 0.04	A16 A39 A45 C27 2 1 2 1
UNIT 107	WA.iv.9a	p279	II	NoTypes 2	NoPots 2	%-Tot 0.01	D13 D34 1 1
UNIT 108	WA.iv.9b	p279f	II	NoTypes 5	NoPots 5	%-Tot 0.03	A16 B5 B17 C10 C27 1 1 1 1 1
UNIT 110	WA.iv.9d	p280	II	NoTypes 2	NoPots 2	%-Tot 0.01	A2 C35 1 1
UNIT 113	WA.v.3	p284	IV	NoTypes 3	NoPots 3	%-Tot 0.02	B7 C32 D13 1 1 1
UNIT 114	WA.v.4	p285f	III	NoTypes 8	NoPots 12	%-Tot 0.08	A7 B3 B4 C5 C6 C19 C28 C35 1 1 1 2 1 1 3 2
UNIT 115	WA.v.7a	p288f	II	NoTypes 6	NoPots 9	%-Tot 0.06	B9 B15 B24 C25 C32 D13 1 1 1 1 2 3
UNIT 116	WA.v.7b	p288f	II	NoTypes 3	NoPots 6	%-Tot 0.04	C5 C7 C28 3 1 2
UNIT 117	WA.v.7c	p288f	II	NoTypes 2	NoPots 2	%-Tot 0.01	B13 C10 1 1
UNIT 118	WA.vi.4	p294	IV	NoTypes 3	NoPots 3	%-Tot 0.02	B9 B17 C12 1 1 1
UNIT 119	WA.vi.5	p295	III	NoTypes 8	NoPots 8	%-Tot 0.05	A39 B1 B13 B15 C32 D15 D31 D32 1 1 1 1 1 1 1 1
UNIT 120	WA.vi.8	p301ff	II	NoTypes 8	NoPots 11	%-Tot 0.07	B6 B20 C5 C32 D8 D26 D28 D29 1 1 2 1 2 2 1 1

Appendix Tab. B Blegenised pottery data from Schliemann (seasons of 1870–1873). Early Bronze Age pottery finds reconstructed from figures recorded by Schliemann in notebooks and publications (sources detailed in Easton 2002), and referenced to the pottery shape classification system of Blegen et al. (1950; 1951). The database contains 62 text units (named UNIT 5 ... UNIT 120). For each unit we provide the most probable *stratigraphic dating* (e.g. *I–II*=Troy I–II) as reconstructed by Easton (2002).The table includes all units for which at least two pot shapes can be referenced to Blegen et al. (1950; 1951).

Appendix Tab. C

No.	Lab Code	Phase	^{14}C-Age [BP]	Model Input [yrs]	Model Output [calBC]
69	Hd-11945	Ia	4315 ± 84 BP	0 ± 30	2880 ± 30
70	Hd-11917	Ia	4299 ± 42 BP	5 ± 30	2885 ± 30
71	Hd-11944	Ia	4238 ± 37 BP	10 ± 30	2890 ± 30
72	Hd-12058	Ia	4215 ± 84 BP	15 ± 30	2895 ± 30
73	Hd-12061	Ia	4177 ± 41 BP	20 ± 30	2900 ± 30
74	Hd-12060	Ia	4289 ± 65 BP	25 ± 30	2905 ± 30

Tab. C Troy Ia. Single Phase Age Model (Fig. 9)

Appendix Tab. D

No.	Lab Code	Phase	^{14}C-Age [BP]	Model Input Units [rel]	Model Output [calBC]
40	Hd-16810	Ij	4173 ± 37 BP	967	2510
41	Hd-16832	Ij	4117 ± 46 BP	933	2525
43	Hd-13813	Ii	3953 ± 49 BP	867	2553
44	Hd-13812	Igh	4022 ± 31 BP	775	2593
45	Hd-13862	Igh	3986 ± 38 BP	700	2625
46	Hd-13850	Ig	4050 ± 40 BP	650	2646
47	Hd-13848	If	4026 ± 40 BP	570	2680
48	Hd-13801	If	4038 ± 59 BP	550	2689
49	Hd-13384	Ief	4110 ± 33 BP	500	2710
50	Hd-13852	Ie	4208 ± 68 BP	467	2725
51	Hd-13851	Ie	4060 ± 50 BP	433	2740
52	Hd-13618	Icd	4108 ± 38 BP	350	2776
55	Hd-13751	Icd	4182 ± 31 BP	300	2797
56	Hd-13929	Icd	4185 ± 31 BP	250	2818
57	Hd-11906	Ibc	4168 ± 52 BP	200	2839
58	Hd-12059	Iab	4156 ± 59 BP	134	2867
69	Hd-11945	Ia	4315 ± 84 BP	100	2882
70	Hd-11917	Ia	4299 ± 42 BP	80	2891
59	Hd-11935	Iab	4316 ± 34 BP	66	2897
71	Hd-11944	Ia	4238 ± 37 BP	60	2900
72	Hd-12058	Ia	4215 ± 84 BP	40	2909
73	Hd-12061	Ia	4177 ± 41 BP	20	2918
74	Hd-12060	Ia	4289 ± 65 BP	0	2927

Tab. D Troy Ia–Ij. Uniform Phase Model (Fig. 10)

Appendix Tab. E

No.	Lab.Code	^{14}C-Age [BP]	RingNo. Center	RingNo. (10 rings)	Model Output [calBC]
60	Hd-14706	4133 ± 49	1055	1051–1060	2813 ± 10
61	Hd-14614	4153 ± 18	1045	1041–1050	2823 ± 10
62	Hd-15023	4145 ± 15	1035	1031–1040	2833 ± 10
63	Hd-14698	4080 ± 21	1025	1021–1030	2843 ± 10
64	Hd-14686	4188 ± 19	995	991–1000	2873 ± 10
65	Hd-14937	4290 ± 24	980	976–985	2888 ± 10
66	Hd-14672	4274 ± 17	960	956– 965	2908 ± 10
67	Hd-15095	4369 ± 17	945	941– 950	2923 ± 10
68	Hd-14615	4363 ± 21	935	931– 940	2933 ± 10

Tab. E Troy Id or later, Beam. Dendrochronological Wiggle Matching (Fig. 11)

Appendix Tab. F

No.	Lab Code	Phase	^{14}C-Age [BP]	Model Input Units [rel]	Model Output [calBC]
15	Hd-12099	S-3	3993 ± 90 BP	3150	2145
16	Hd-12109	S-6	3838 ± 39 BP	2850	2211
17	Hd-15266	S-7	3792 ± 31 BP	2800	2222
18	Hd-15268	S-7	3892 ± 37 BP	2787	2225
19	Hd-12120	S-7	3815 ± 35 BP	2775	2228
20	Hd-12126	S-7	3917 ± 38 BP	2762	2231
21	Hd-12127	S-7	3899 ± 42 BP	2750	2234
22	Hd-15267	S-7	3751 ± 25 BP	2737	2237
23	Hd-12136	S-7	3795 ± 26 BP	2725	2240
24	Hd-12137	S-7	3796 ± 41 BP	2712	2243
26	Hd-15407	S-9	3755 ± 40 BP	2550	2279
27	Hd-15408	S-12	3790 ± 35 BP	2350	2323
28	Hd-13930	S-12	3974 ± 43 BP	2250	2345
31	Hd-14572	IIc3	3988 ± 32 BP	2150	2367
33	Hd-16733	IIb4	3815 ± 42 BP	1850	2433
34	Hd-16734	IIb2	3932 ± 46 BP	1650	2477
35	Hd-16735	IIb1	4058 ± 41 BP	1567	2495
36	Hd-17664	IIb1	4011 ± 28 BP	1533	2502
37	Hd-19823	IIa1	3935 ± 66 BP	1375	2537
38	Hd-19822	IIa1	3931 ± 23 BP	1350	2543
39	Hd-20040	IIa1	3972 ± 31 BP	1325	2549

Tab. F Troy II–III, Uniform Phase Model (Fig. 12, Lower)

Appendix Tab. G

No.	Lab Code	Phase	^{14}C-Age [BP]	Model Input [m]	Model Output [calBC]
15	Hd-12099	S-3	3993 ± 90 BP	35.03	2150
16	Hd-12109	S-6	3838 ± 39 BP	34.44	2192
20	Hd-12126	S-7	3917 ± 38 BP	34.14	2213
21	Hd-12127	S-7	3899 ± 42 BP	34.13	2214
19	Hd-12120	S-7	3815 ± 35 BP	33.97	2225
17	Hd-15266	S-7	3792 ± 31 BP	33.51	2258
23	Hd-12136	S-7	3795 ± 26 BP	33.50	2259
18	Hd-15268	S-7	3892 ± 37 BP	33.49	2260
24	Hd-12137	S-7	3796 ± 41 BP	33.35	2270
22	Hd-15267	S-9	3751 ± 25 BP	33.19	2281
26	Hd-15407	S-9	3755 ± 40 BP	32.76	2312
27	Hd-15408	S-12	3790 ± 35 BP	32.42	2336
28	Hd-13930	S-12	3974 ± 43 BP	32.15	2355
31	Hd-14572	IIb4?	3988 ± 32 BP	30.62	2464
22	Hd-16733	IIb2	3815 ± 42 BP	30.37	2482
34	Hd-16734	IIb1	3932 ± 46 BP	30.18	2495
35	Hd-16735	IIa1	4058 ± 41 BP	30.07	2503
37	Hd-19823	IIa1	3935 ± 66 BP	29.55	2540
38	Hd-19822	IIa1	3931 ± 23 BP	29.46	2546
39	Hd-20040	IIa1	3972 ± 31 BP	29.42	2549
36	Hd-17664	IIb1	4011 ± 28 BP	29.19	2565

Tab. G Troy II–III. Linear Age-Depth Model (Fig. 12, Upper)

References

Ashmore 1999
P. Ashmore, Single entity dating, Mémoires de la société préhistorique française, 1999, 26, 65–71.

Bachhuber 2009
C. Bachhuber, The treasure deposits of Troy. Rethinking crisis and agency on the Early Bronze Age citadel, Anatolian Studies 59, 2009, 1–18.

Benz et al. 2012
M. Benz – A. Coşkun – I. Hajdas – K. Deckers – S. Riehl – K. A. Alt – B. Weninger –V . Özkaya, Methodological implications of new radiocarbon dates from the Early Holocene site of Körtik Tepe, Southeast Anatolia, Radiocarbon 54, 3–4, 2012, 291–304.

Blegen et al. 1950
C. W. Blegen – J. L. Caskey – M. Rawson – J. Sperling, Troy I. General Introduction. The First and Second Settlements (Princeton 1950).

Blegen et al. 1951
C. W. Blegen – J. L. Caskey – M. Rawson – J. Sperling, Troy II. The Third, Fourth, and Fifth Settlements (New Jersey 1951).

Blum 2012
S. W. E. Blum, Die ausgehende frühe und die beginnende mittlere Bronzezeit in Troia. Archäologische Untersuchungen zu ausgewählten Fundkomplexen der Perioden Troia IV und Troia V, Studia Troica Monographien 4, 2 vols., (Darmstadt 2012).

Bronk Ramsey 2000
C. Bronk Ramsey, Comment on the use of Bayesian statistics for ^{14}C dates of chronologically ordered samples. A critical analysis, Radiocarbon 42, 2, 2000, 199–202.

Bronk Ramsey 2009
C. Bronk Ramsey, Bayesian analysis of radiocarbon dates, Radiocarbon 51, 1, 2009, 337–360.

Dörpfeld 1902
W. Dörpfeld, Troja und Ilion. Ergebnisse der Ausgrabungen in den vorhistorischen und historischen Schichten von Ilion, 1870–1894 (Athens 1902).

Easton 1976
D. F. Easton, Towards a chronology for the Anatolian Early Bronze Age, Anatolian Studies 26, 1976, 145–173.

Easton 2000
D. F. Easton, Schliemann's "burnt city", Studia Troica 10, 2000, 78–83.

Easton 2002
D. F. Easton, Schliemann´s excavations at Troy, 1870 – 1873, Studia Troica Monographien 2 (Mainz 2002).

Easton – Weninger, in preparation
D. F. Easton – B. Weninger, On the dating of Troy II–V (in preparation).

Easton 2014
D. F. Easton, The first excavations at Troy: Brunton, Calvert and Schliemann, in: E. Pernicka – C. B. Rose – P. Jablonka (eds.), Troia 1988–2008: Grabungen und Forschung 1. Forschungsgeschichte, Methoden und Landschaft. Studia Troica Monographien 5 (Darmstadt 2014) 32–103.

Frirdich 1997
C. Frirdich, Pinnacle E4/5 – Die Keramik der Periode II im Vergleich, Studia Troica 7, 1997, 111–258.

Heaton et al. 2009
T. J. Heaton – P. G. Blackwell – C. E. Buck, A Bayesian approach to the estimation of radiocarbon calibration curves. The INTCAL09 methodology, Radiocarbon 51, 4, 2009, 1151–1164.

Higham et al. 2007
T. Higham – J. Chapman – V. Slavchev – B. Gaydarska – N. Honch – Y. Yordanov – B. Dimitrova, New perspectives on the Varna cemetery (Bulgaria). AMS dates and social implications, Antiquity 81, 313, 2007, 640–654.

Jablonka 2000
P. Jablonka, Computergestützte Rekonstruktion und Darstellung der Stratigraphie von Troia, Studia Troica 10, 2000, 99–122.

Jung 2013
R. Jung, The time around 1600 B.C. in southern Italy. New powers, new contacts and new conflicts in: H. Meller – F. Bertemes – H.-R. Bork – R. Risch (eds.), Cultural change in the shadow of the Thera-eruption? 4. Mitteldeutscher Archäologentag vom 14. bis 16. Oktober 2011 in Halle (Saale), Tagungen des Landesmuseums für Vorgeschichte Halle 9 (Halle/Saale) 235–251.

Korfmann 1999
M. Korfmann, Troia – Ausgrabungen 1998, Studia Troica 9, 1999, 7–9.

Korfmann 2000
M. Korfmann, Troia – Ausgrabungen 1999, Studia Troica 10, 2000, 5–7.

Korfmann – Kromer 1993
M. Korfmann – B. Kromer, Demircihüyük, Beşik-Tepe, Troia. Eine Zwischenbilanz zur Chronologie dreier Orte in Westanatolien, Studia Troica 3, 1993, 135–171.

Krauß et al. 2014
R. Krauß – S. Zäuner – E. Pernicka, Statistical and anthropological analysis of the Varna necropolis, in: H. Meller – E. Pernicka – R. Risch (eds.), Metalle der Macht – Frühes Gold und Silber. 6. Mitteldeutscher Archäologentag vom 17. bis 19. Oktober 2013 in Halle (Saale), Tagungen des Landesmuseum für Vorgeschichte Halle 11, 2 (Halle 2014) 371–387.

Kromer et al. 2003
B. Kromer – M. Korfmann – P. Jablonka, Heidelberg radiocarbon dates for Troia I to VIII and Kumtepe, in: G. A. Wagner – E. Pernicka – H. P. Uerpmann (eds.), Troia and the Troad. Scientific Approaches, Natural Science in Archaeology (Berlin, Heidelberg 2003) 43–54.

Manning 1997
S. W. Manning, Troy, Radiocarbon, and the chronology of the northeast Aegean in the Early Bronze Age, in: C. Doumas – V. La Rosa (eds.), Η Πολιόχνη και η Πρώιμη Εποχή του Χαλκού στο Αιγαίο / Poliochni e l'antica età del bronzo nell'Egeo settentrionale (Athens 1997) 498–520.

Mansfeld 2001
G. Mansfeld, Die Kontroll-Ausgrabung des "Pinnacle E4/5" im Zentrum der Burg von Troia, Studia Troica 11, 2001, 51–308.

Mook 1983
W. G. Mook, ^{14}C calibration curves depending on sample time width, in: W. G. Mook – H. T. Waterbolk (eds.), Proceedings of the First International Symposium ^{14}C and Archaeology, Groningen, PACT Publication 8 (Strasbourg 1983) 517–525.

Ottaway 1983
J. H. Ottaway, A biologist's thoughts on radiocarbon dating, in: B. S. Ottaway (ed.), Archaeology, Dendrochronology and the Radiocarbon Calibration Curve (Edinburgh 1983) 64–73.

Pavúk 2010
P. Pavúk, Pottery processing at Troy. Typology, stratigraphy and correspondence analysis. How do they work together?, in: B. Horejs – R. Jung – P. Pavúk (eds.), Analysing Pottery. Processing, Classification, Publication, Studia Archaeologica et Medievalia 10 (Bratislava 2010) 73–98.

Podzuweit 1979
C. Podzuweit, Trojanische Gefäßformen der Frühbronzezeit in Anatolien, der Ägäis und angrenzenden Gebieten. Ein Beitrag zur vergleichenden Stratigraphie (Mainz 1979) 249.

Razky – Siklósi 2013
P. Razky – Z. Siklósi, Reconsideration of the Copper Age chronology of the eastern Carpathian Basin. A Bayesian approach, Antiquity 87, 2013, 555–573.

Reimer et al. 2009
P. J. Reimer – M. G. L. Baillie – E. Bard – A. Bayliss – J. W. Beck – P. G. Blackwell – C. Bronk Ramsey – C. E. Buck – G. S. Burr – R. L. Edwards – M. Friedrich – P. M. Grootes – T. P. Guilderson – I. Hajdas – T. J. Heaton – A. G. Hogg – K. A. Hughen – K. F. Kaiser – B. Kromer – F. G. McCormac – S. W. Manning – R. W. Reimer – A.A. Richards – J. R. Southon – S. Talamo – C. S. M. Turney – J. van der Plicht – C. E. Weyhenmeyer, IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP, Radiocarbon 51, 2009, 1111–1150.

Reimer et al. 2013
P. J. Reimer – E. Bard – A. Bayliss – J. W. Beck – P. G. Blackwell – C. Bronk Ramsey – C. E. Buck – H. Cheng – R. L. Edwards – M. Friedrich – P. M. Grootes – T. P. Guilderson – H. Haflidason – I. Hajdas – C. Hatté – T. J. Heaton – D. L. Hoffmann – A. G. Hogg – K. A. Hughen – K. F. Kaiser – B. Kromer – S. W. Manning – M. Niu – R. W. Reimer – D. A. Richards – E. M. Scott – J. R. Southon – R. A. Staff – C. S. M. Turney – J. van der Plicht, INTCAL13 and Marine INTCAL13 Radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55, 4, 2013, 1869–1887.

Renfrew 1971
C. Renfrew, Sitagroi, Radiocarbon and prehistory of south-east Europe, Antiquity 45, 1971, 275–276.

Sazcı 2001
G. Sazcı, Gebäude mit vermutlich kultischer Funktion. Das Megaron in Quadrat G6, in: Archäologisches Landesmuseum Baden-Württemberg et al. (eds.), Troia – Traum und Wirklichkeit. Exhibition Catalogue (Stuttgart 2001) 384–390.

Scott et al. 2010
E. M. Scott – G. T. Cook – P. Naysmith, The fifth international Radiocarbon intercomparison (VIRI). An assessment of laboratory performance in stage 3, Radiocarbon 52, 2–3, 2010, 859–865.

Sevink et al. 2011
J. Sevink – M. J. van Bergen – J. van der Plicht – H. Feiken – C. Anastasia – A. Huizinga, Robust date for the Bronze Age Avellino eruption (Somma-Vesuvius): 3945 ± 10 calBC, Quaternary Science Reviews 30, 9, 2011, 1035–1046.

Steier – Rom 2000
P. Steier – W. Rom, The use of Bayesian statistics for ^{14}C dates of chronologically ordered samples. A critical analysis, Radiocarbon 42, 2, 183–198.

Ünlüsoy 2010
S. Ünlüsoy, Die Stratigraphie der Burg von Troy II, PhD thesis, Eberhard-Karls-University (Tübingen 2010).

Weninger 1995
B. Weninger, Stratified ^{14}C dates and ceramic chronologies. Case studies for the Early Bronze Age at Troy (Turkey) and Ezero (Bulgaria), Radiocarbon 37, 1995, 443–456.

Weninger 2002
B. Weninger, Pottery Seriation dating at Troy in the Early Bronze Age, based on the Cincinnati Classification System, in: R. Aslan – S. Blum – G. Kastl – F. Schweizer – D. Thumm (eds.), Mauerschau. Festschrift für Manfred Korfmann I (Remshalden-Grunbach 2002) 1035–1062.

Weninger – Jöris 2008
B. Weninger – O. Jöris, A ^{14}C age calibration curve for the last 60ka. The Greenland-Hulu U/Th timescale and its impact on understanding the Middle to Upper Paleolithic transition in western Eurasia, in: D. S. Adler – O. Jöris (eds.), Setting the record straight: Toward a systematic chronological understanding of the Middle to Upper Paleolithic boundary in Eurasia, Journal of Human Evolution 55, 5, 2008, 772–781.

Weninger – Jung 2009
B. Weninger – R. Jung, Absolute chronology of the end of the Aegean Bronze Age, in: S. Deger-Jalkotzy – A. E. Bächle (eds.), LH IIIC Chronology and Synchronisms III. LH IIIC Late and the Transition to the Early Iron Age. Proceedings of the International Workshop Held at the Austrian Academy of Sciences at Vienna, February 23rd and 24th, 2007, Veröffentlichungen der Mykenischen Kommission 30 (Vienna 2009) 373–416.

Weninger et al. 2011
B. Weninger – K. Edinborough – L. Clare – L. Jöris, Concepts of probability in radiocarbon analysis, Documenta Praehistorica 38, 2011, 1–20.