A Radiocarbon-Based Chronology for the Chalcolithic through Middle Bronze Age of Cyprus (as of AD 2012)

Stuart W. Manning

Introduction

In a study forming an Appendix to the synthesis of Cypriot prehistory by A. B. Knapp1, I offered an approximate radiocarbon-based chronology for the entire of Cypriot prehistory from the Late Epipalaeolithic to the Late Bronze Age based on the radiocarbon data to hand in 2011.2 This large-scale model necessarily did not focus on any specific periods nor sites, and at most hoped to define approximately the starts and ends of the main cultural phases3. In the present study, I employ almost the same data as in Manning (2013a), but focus this new analysis specifically on the Chalcolithic through Middle Bronze Age (MBA = Middle Cypriot, or MC) periods on Cyprus. This study allows some consideration of a couple of key sites, and also takes the opportunity to correct and improve/change a few details in the Manning (2013a) study with more appropriate and detailed modelling – especially with regard to the key Early Cypriot (EC) to MC site of Marki Alonia. The reason to focus on the Chalcolithic to MC periods is because they have been the focus of much fieldwork and analysis in Cypriot prehistory over recent decades4, and are also the periods during which Cyprus first starts to become relevant to the trade and so to wider archaeological chronology of the surrounding eastern Mediterranean. It therefore appears useful to try to place this period into a relatively resolved absolute chronological framework.

Data and Methods

The radiocarbon data employed in this study are as listed in the Manning (2013a) study for the Chalcolithic, through MBA (i.e. the data from Kition and Mylopotaka Early Chalcolithic through Episkopi Phaneromeni in Manning 2013a: Sub-Appendix),5 along with the data from the earlier Late Cypriot (LC) period from Maroni Vounres and Politiko Phorades, plus two dates from Early Prehistoric (late EC to earlier MC) Ambelikou Aletri6 which were inadvertently missed out in the Manning (2013a) study. In all 179 data were employed in the main study (see Fig. 1). The data set employed represents as of mid-2012 those radiocarbon data published and known to the author and deriving from archaeological contexts stated to be of Chalcolithic through initial MBA archaeological date7. Since there is no good overlap or connection really between the available late Ceramic Neolithic radiocarbon dates from Cyprus and those from the Chalcolithic sites on Cyprus8, I start this study simply with the Chalcolithic data – accordingly the definition of the start of the overall Chalcolithic period on the early side is not really constrained in this analysis (and so I end up using the date for the start of the Early Chalcolithic from the Manning 2013a study where the Neolithic data are taken into account). There is at present a lack of radiocarbon data closely related to the late/ final Middle Cypriot – we have just a few dates on long-lived sample material which set various and less than clear terminus post quem ranges (and four new radiocarbon dates on bone from tombs

1 Knapp 2013.
2 Manning 2013.
3 Although in the accompanying Supporting Online Materials – <www.cambridge.org/9780521725375> – there is some additional focus on the Late Epipalaeolithic through initial Ceramic MBA periods, including data appearing only in 2011 and in 2012 after the Appendix had been written.
5 I note that Kallaras Aynisi is spelt ‘Ayouis’ in Manning 2013a.
6 Hilsenrath 1981, 422.
7 Two as yet unpublished (at the time I write) sets of data, from Erimi Lamin Tsa Pyrgos and Politiko Triviwa were subsequently considered as additional elements, see text below Section 1 and Figures 9-11 and the End-Note. Postscript: see further in Manning 2013b.
8 See Manning 2013a.
...it is rare for a model based on a uniform distribution to be importantly wrong.19 The periods of time before, between, and after the dating groupings are quantified in the text, as in Frankel and Webb.12 Questions may also be asked for example about the period of time within groups or between events - some such duration or span findings are reported below. The Boundaries for the start (a date range from or after) and end (a date range before or to) of Phases (site or overall cultural period) or site Sequences are the key quantified outcomes from the analyses. All Phases and Sequences are delimited by Boundaries in the model.

Any such dating model has some outliers which need to be excluded (with the data potentially being outliers from normal reasons, ranging from incorrect stratigraphic/cultural association including possible re-used old wood or contamination/dissolution, through to laboratory problems in pre-treatment or measurement, or other errors). In this case I found that three data (BM-1385R, GU-2966 and Oxa-9972 - the data marked with * in Fig. 1) had to be removed even to get the model to run successfully at all (see above). Outlier analysis as described by Frankel15 was not employed, as it proved impossible to run a model of this complexity/size on a Boundary "End of Prehistoric Bronze Age", i.e. end of MC III. This assumption is based on several good archeological linkages for Middle Cypriot III (MC III) and Middle Cypriot II (MC II) with one site or phase sequence placed in the first period (for the Early-Middle Cypriot part to continue this example), and a second in the second period (in the Late Cypriot in this example). The following dating model employed for Models 1-4 is illustrated in Fig. 2.

A few extra decisions, choices or elaborations were made. First, the treatment of the Markar Alosa sequence is revised versus Manning 2013a: OZA-340 is placed in site phase D-I following Frankel and Webb12 and the absence of mention of

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5 Frankel. 2010. with missing citation.
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An obvious question is why did I choose to exclude at agreement values of less than 15? This was simply an arbitrary choice by me on the basis that they were around 25%, or less, of the threshold satisfactory value of 60. It seemed to indicate substantive versus minor outliers. Note: such identification as an outlier is in terms of the combination of the individual 14C dates and the Model and therefore the separate site Sequences and (where present) the Phases within these. Thus if a site has relatively constrained data within its Phase or Sequence, a date can seem to be a clear outlier in terms of the OxCal analysis and the Agreement values even if this is not dramatically evident in looking at Fig. 1; and, in contrast, if a Phase or Sequence widely ranging data then these data may pass as acceptable because the test on acceptability is very wide in such a case (e.g. Lembaka Lakhtous Period 1). If a date has a very large measurement error, then this can mean it remains apparently consistent, whereas dates with smaller measurement error can— if they vary from their constituent grouping— more quickly be flagged as apparent outliers. Model 2 had typical Amold values around 22.5 ± 0.10 and Beaverton values of 23.9 ± 0.10. For the next incremental analysis, the 5 dates with individual Agreement values <35 in Model 2 were excluded (see Model description below) to form Model 3. Model 3 achieved an Amold value around 31.4 ± 0.10 and a Beaverton value around 49.3 ± 0.10. The first incremental analysis excluded then the 5 dates with individual OxCal Agreement values <50 in Model 3 (see Model description) to form Model 4. Model 4 achieved satisfactory Amold and Beaverton values of respectively around 74 and 71.1 (Note: every run of such a model produces slightly different outcomes; typical values based on several runs are stated in this study.)

**Model 1**

The Run File for this model is set out in the Appendix. It employs all dates except three (BM-1835R, GU-2966, and Oxa-9972) from the total dataset of 122 dates (see Fig. 1). Note: the // annotation in that Run File shows that this information is not employed in the model. I ran successfully but offers very poor overall OxCal agreement values of (typically) Amold 0.5 and Beaverton of 0.6. This is because there are a significant individual dates with very low agreement values (10 dates typically yield individual agreement values of less than 15). Dates in Model 1 = 119, dates excluded = 3.

**Model 2**

As Model 1 but excluding the 10 most extreme apparent outlier dating in Model 1 on the basis of those dates with individual agreement index values more than 15 (Oxa-2964, GU-2967, AA-1049, BM-2526, GU-2426, GU-2157, BM-1353, P-2980, KN-4462 and Oxa-9932). The choice of the individual agreement values of less than the 10% in the Run File in the Appendix. Thus there is nothing necessarily wrong with the laboratory's dates in such cases— just this would be taken as a hint that the growth of the relevant tree-rings—contemporary with the archaeological context in which it was found (the so-called old wood problem). In terms of sites, there is also evidence representations of outliers in some cases (6 of the 12 sites have no outliers). In particular, 7 of the 13 (54%) worst outliers (those excluded in Model 1 and Model 2) are from just one site: Kissenera Moshipa. Those dates come from four different laboratories: AA (Arizona), BM, GU and Oxa. Thus one would have to suggest that perhaps more than the laboratory issues are likely involved here. The value of these samples has again been entirely arbitrary and chosen as 50% of the 60 threshold value. The OxCal agreement values improve again compared to Model 2, with typical values of Amold 51 and Beaverton 49.3. Dates in Model 3 = 104, dates excluded = 18.

**Model 3**

As Model 2 but excluding further data which regularly yielded the lowest individual OxCal agreement values of less than 30 in runs of Model 2: BM-2278, WK-166434, OZA-3354, Oxa-9817 and OX-18221. The value of these samples has again been entirely arbitrary and chosen as 50% of the 60 threshold value. The OxCal agreement values improve again compared to Model 2, with typical values of Amold 51 and Beaverton 49.3. Dates in Model 3 = 104, dates excluded = 18.

**Model 4**

As Model 3 but excluding further data which regularly yielded the lowest individual agreement values in runs of Model 3 (less than OxCal individual agreement values of 50): GU-2166, BM-2535, Oxa-2962, OZA-279U2 and OZB-162. As for Models 2–3, this was an arbitrary choice of exclusion level. The OxCal agreement values are of interest to consider again compared to Model 3, and now pass the approximate satisfactory threshold value of 60 with typical values of Amold 74 and Beaverton 71.1. Dates in Model 4 = 99, dates excluded = 23 (or 18.9% of the original dataset). The outcomes from Model 4 are shown in Fig. 3–6. The distribution of the dates identified as outliers is not even in terms of sites or laboratories, nor in terms of the date that the samples were run at those laboratories. Of those laboratories providing more than 10 dates in the 122 dataset we can observe that the percentages deemed outliers by Model 4 vary from 38% for GU (Gloucester University) to 19% for BM (British Museum) to 15% for Oxa, and 14.5% for OX (Antares AMS Facility, Muns, Australia).

The GU data, in particular, stand out as apparently less reliable (and this is not surprising since the GU and also BM - samples were all run several decades apart and not on the same old wood charcoal). The use of "old wood" which is too old for their first contexts (Oxa-9972, OXA-9932, Oxa-9817) and so placed in the "Stray old or recycled wood" or "Likely of tree-rings or wood reduplicated in some way" Phases in the Run File for Models 3 and 4. Thus there is nothing necessarily wrong with the laboratory's dates in such cases—just this would be taken as a hint that the growth of the relevant tree-rings—contemporary with the archaeological context in which it was found (the so-called old wood problem). In terms of sites, there is also evidence representations of outliers in some cases (6 of the 12 sites have no outliers). In particular, 7 of the 13 (54%) worst outliers (those excluded in Model 1 and Model 2) are from just one site: Kissenera Moshipa. Those dates come from four different laboratories: AA (Arizona), BM, GU and Oxa. Thus one would have to suggest that perhaps more than the laboratory issues are likely involved here. The value of these samples has again been entirely arbitrary and chosen as 50% of the 60 threshold value. The OxCal agreement values improve again compared to Model 2, with typical values of Amold 51 and Beaverton 49.3. Dates in Model 3 = 104, dates excluded = 18.

The identification of outliers in the process described above is, at stated, subjective and enforced by computational limitations—although it appears a reasonable approach and approximation. However, it seems important to consider a couple of the key sites in isolation and with other analysis in OxCal to compare which dates are identified by both explicit and formal approach as outliers for these sites. I choose Kissenera Moshipa, identified as somewhat problematic above, and Marki Alonii, the key EMC-C site, on the two sites for such extra consideration. The "General" outlier model of Bronk Ramsey has been employed.

1 The Kissenera Moshipa model when run in isolation finds 9 data to be outliers with Posteriors of 0.019, 0.004, 0.001, 0.0002, 0.0001, 0.053, 0.0001, 0.0001 and 0.0001. This is the scenario that shows the presence of some old wood charcoal (including modern wood) and recycled wood charcoal plausible. It is a candidate for an interpretation of the Chalcolithic outlier model of Bronk Ramsey 2009b.

2 Bronk Ramsey 2009b.

3 Bronk Ramsey 2009b.

4 Bronk Ramsey 2009b.
Results
Table 1 lists typical outcomes at both 68.2% and 95.4% probability for the Modelled data results (calibrated age ranges in years BC) for the starts and ends of the Periods and Phases (the Boundaries) and somc other events for Models 1a and 4 and some calculated spans for Models 1a and 4. Look at Table 3 in Fig. 3-7, we see that in general the outcomes are fairly similar (indicating relatively robust findings); only a few cases show any substantial differences; in particular the dates for the transitions of Kissonerga Mosphila Periods 2 to 3A and 3B to 3B, and Lembka Lakkous Periods 1 to 2 and for the End of Period 2. Here we may note the impact of excluding several clearly outlying data and/or relatively small datasets and the difference even one exclusion may therefore make. We further see that the Early through Middle Chalcolithic represents a large period of time (around 1200-1300 years: see footnote 33 below, Fig. 7, and the Manning 2013a study) with relatively sparse data for the earlier part of this span, that the Late Chalcolithic is a relatively brief time horizon and is well defined, and that the EC to MC period has one reasonably well defined site sequence (Marki Alona) covering most of this phase (EC to MCII) and then several other sets which offer generally compatible data.

Two additional sites
New radiocarbon dates are already available subsequence to those listed in Mangahy or the Appen
dix here. One set of new data which can be briefly considered based on preliminary information come from Erini Lamon Ton Poradov (as taken in ad
dence of publication) from the conference paper of Scri6 Calabrohncto et al. 26. An analysis of the site dates in terms of the archaeological sequence is shown in Fig. 10. Two dates (Ch-uu391 and Ch-uu392) on charcoal from Phase B (Early Chalco
lithic III-Middle Chalcolithic II) contexts offer data in keeping with this approximate cultural associa
tion versus other sites. Two dates on bone from Tomb 230 § (T321,1 and T321,1,0) placed in Phase A and dated Middle Chalcolithic II to Late Chalcolithic I appear to belong to the MC II/I11 phase of this range. But another date on bone (T322,2) from this tomb offers a date where more of the dating probability lies after 1550 BC and so would seem best associated (from the radiocarbon date along) with the Late Chalcolithic I phase of the Phase A range (see Fig. 10). However, the problem in that Tomb 230 is reported inhumation, thus the bones (and this individual and burial) should belong to either the MC II/III phase or the LC I phase, and not both. This implies some possible problematic attribution to the archaeological as
sociations or the laboratory work for one or two of these dates. I arbitrarily place Tomb 230 in the MC period in radiocarbon terms (Fig. 12) based on the two versions one 14C dates available at this time, and the MCII phase is thus something of an archa
eological outlier pending further resolution. Two further dates from early Chalcolithic (one from Tomb 328, also placed in Phase I (MC II/III-LC I), one (T322,1) offers a Late Bronze Age date (calibrated age range of 1411-1396 BC at 68.2% probability), but is late for LC I, and the other (T232,3) yielded a date in the 4th century BC and so is entirely irrelevant to the Bronze Age context.

Another new set of four 14C dates comes from Politiko Troulida (I thank Steve Falconer and Pat Fall for kindly sending these data in advance of publication). The calibrated probability distributions and 68.2% and 95.4% probability ranges for these are illustrated in Fig. 11. These dates all lie between the 22nd to 20th or 19th centuries BC within their 95.4% probability ranges, consistent with material culture associa
tions of late early Chalcolithic to early Middle Chalcolithic, and in keeping with the 14C dates in Fig. 1 and Fig. 7 and 9 for the other sites around this cultural horizon.

We can consider the data in Model 4 re-run to include these additional data. Thus I include the four Politiko Troulida data, and the Erini Lamon Ton Poradov sequence of the two EC II/III-I/II dates and then two what I interpret as MC II/ III dates, in the EC-MC (Prehistoric Bronze Age) Phase (and I leave out the remainder of the Erini Lamon Ton Poradov data as not related to post MC, or apparently are a little problematic in the case of date T232,2, see above). The revised EC to MC sequence is shown in Fig. 12 and a revised version of Table 1 relevant to the EC-MC period is shown in Table 2; the span of time represented for the entire EC-MC (or Prehistoric Bronze Age), revised version of Table 1 (in Table 2, esp. see 629-796 calendar years at 68.2% probability, and 554-871 calendar years at 95.4% probability).

A comparison of the re-run data in Fig. 12 ver
sus the previous Model 4 data (Table 2) indicates most ranges are little changed and especially the most likely 68.2% ranges or the mean and standard devia
tion (75%) of the distributions.

Discussion
Steel27 offered approximate dates of:

- Chalcolithic c. 4000-2500 BC
- Phila c. 2500-2350 BC
- Early Cypriot c. 2400-2000 BC
- Middle Cypriot c. 2200-1700 BC


The dates I now propose from the re-run ver
dition of Model 4 (with the extra data added as in
Fig. 12 and Table 2), using the mean and standard deviation (75%) of the relevant probability distributions as a best guide are:

- Early to Middle Chalcolithic
  - c. 4000/3900 BC to 2709 ± 48 BC
- Late Chalcolithic
  - c. 2667 ± 47 BC to 2518 ± 49 BC
- Phila (Marki)
  - c. 2277 ± 57 BC to 2183 ± 31 BC
- Early Cypriot
  - c. 2183 ± 31 BC to 2092 ± 37 BC
- Middle Cypriot
  - c. 2092 ± 37 BC to 1685 ± 32 BC

1. Since there is no earlier constraint on the date for the start of the Early Chalcolithic period in this study, and the few early dates available vary quite substantially, the date in the Model for the Start of the Early Chalcolithic period (e.g. 4702 ± 212 BC from Table 1) is not reliable, nor appropriate. In particular, we are not considering the body of Ceramic Neolithic data. These lie in the 5th millen
nium BC, and among the latter defend and more re
cent data, these run from the mid into the later 5th millenni
m BC and suggest a temporal transition between the Ceramic Neolithic and the Early Chalcolithic somewhere around 4100-4200 BC (Manning 2013a). The few appa
rently later dates for these four dates in Model 4 (see from Kalyvas Trotta, one date from Kissonerga Mosphila Pe
riod 3, and two dates from Lembka Lakkous Period 1) either are old/residual samples or are misplaced or sex ab
crant (Manning 2013a). I therefore use c. 4000/3900 BC as the start for the Early Chalcolithic here from Manning 2013a.

We see that the new radiocarbon-based chro
nology for EC to MC Cyprus in this study offers dates relatively consistent with the standard previous scheme. This is not to suggest the dates for the MC period were already based on assessments of the radiocarbon evidence. The main difference is a little bit of precision with more better data. In particular, we can test our model better define the Late Chalcolithic transition in light of the tight set of data from Politiko Kokkonouros (placed as late Mid
dle Chalcolithic, after Kissonerga Mosphila Middle Chalcolithic and before Kissonerga Mosphila Late Chalcolithic),28, and also the EC to earlier MC pha
es, thanks to the Marki Alona data sequence.

The duration of the Early to Middle Chalcolithic periods is calculated at around 1200-1300 calen
dary years (revising the model outcomes in this pa
ticu instead of the Neolithic data in Manning 2013a see footnote 29, and Fig. 7). The Early through Middle Chalcolithic is a long period of time. Most of our better dated evidence at present relates only to the final few centuries in the earlier 3rd millennium BC. In particular, the good set of dates (all but one sample) short-lived samples from the late Middle Chalcolithic occupation at Politiko Kokkonouros provide tight dates both for this site, and for defining the start of the subsequent period.

The short-lived site occupation (as dated) of around ca. 50-55 calendar years (rounding outcomes in Tables 1 and 2 and the Model 4 re-run) lies between about 2183±45 BC and 2709±48 BC (Middle to early). The Late Chalcolithic is revealed as a relatively brief and concentrated period: 105±60 calendar years in the Model 4 re-run (and even shorter in the original Model 1: see Table 1). In Manning 2013a I suggested dates of 2700±2600 to 2500±2400 BC, here I revise slightly to 2700±2650 to 2500 BC.

The transition (temporal - I am not entering into discus
tion of cultural issues here)29 between the Late Chalcolithic and the Early Cypriot (EBA or Prehis
toric Bronze Age) is placed somewhere (rounded) between ca. 2500 BC (Protopalatial) and ca. 2450 BC (start of the EC). Our refined chronology for the EC to MC phases largely comes from Marki Alona, where there is a detailed site sequence and a majority of dates on short-lived samples. This suggests (from the overall model) dates for the Phila phase (or facies, etc.) at Marki from 2277±57 BC (Model 4 re-run, or 2325±59 BC (What happened between 2325 BC and 2450 BC (above) and ca. 2500 BC is not clear from existing evidence. Two of the Source Gamma dates, OZB-161, OZB-162, offered calibrated ages in the 25th-24th cent. 

27 Manning 2013a.
28 Scri6 Calabrohncto et al. 2012. On the site, see Bombicheti.
29 Falaner - Fall 2013, tab. 1.
we should allow that it perhaps continues into the 18th century, perhaps even to about 1750 BC. The earlier of the MC II-III data (2 of 3 dates) on bone from Ermiou Laroni Tou Porohou indicate a date in the late 17th century BC (1828±52 BC), and perhaps may also date MC II. I do not discuss here the topic of whether the MC III should exist as a separate chronological phase or should be combined into a MC III-LC IA phase at the start of the Protohistoric Bronze Age, with 'MC' ending with MC II.

The date for the end of the overall Middle Cypriot period (including MC III) is as noted above in Section 2 as problematic from the available evidence. We lack any clear MC III dates (and the very reality of aspects of this period — as a distinct archaeological entity — is unclear). In Models 1-4, I employed a terminus post quem for the end of MC from Merrillies of 1705 BC or a terminus ante quem for the start of the LC period as the accession of Ahamu after Merrillies. Without the terminus post quem, the Model 4 re-run would end the MC period somewhat earlier: 1819-1674 BC (68.2% probability) or 1863-1654 BC (95.4% probability) or 1739±68 BC (±1σ). This reflects the lack of MC III evidence and it is a more 18th century BC terminus ante quem for the end of MC II (see above). With the terminus post quem we get dates from 1691±10 BC (Model 1) to 1658±32 BC (Model 4 re-run) for the end of MC or the start of the Late Bronze Age in turn should begin around or just after these dates. If the numbers are rounded into approximate terms, I close by proposing the following dates on present evidence:

Start    End
Early Chalcolithic    4200±3900 BC    2700 BC
Middle Chalcolithic    2700 (±4650) BC    2500 BC
Late Chalcolithic    2500-2400 BC    2200 BC
Philia    2200 BC    2100-2050 BC
Early Cypriot    2100/2050 BC    1800 BC (to ca. 1750 BC)
Middle Cypriot I-II    1690-1650 BC
End MC/Start LC

These dates are the same or very similar to those in Manning 2013a with just a few minor differences.35 I have commented on the slight reworking of the Late Chalcolithic and initial Prehistoric Bronze Age dates above (text and footnote 36). The other difference relates to the later MC period. In this study I end MC II 1800-1750 BC (a revision and improvement) — whereas Manning 2013a ended the overall Prehistoric Bronze Age 1692±1650 BC. In this study I do not try to date MC III, only the point when the MC (as usually approximately defined) ends, and LC begins, at about 1690-1650 BC.

End-Note

Such a listing of all ‘published’ radiocarbon dates is always incomplete, whether the author inadvertently misses some dates in a published paper or book, or because of new publications appearing after this listing was assembled (to give just one example: the Manning 2013a listing for the period covered in this paper ended up somehow dropping out two dates from Ambelokhi, Alami, and slightly misdating the Marki phasing regarding a few dates). However, the dataset employed in this paper is relatively large and thus hopefully fairly representative (even if not complete). The collection of radiocarbon data was assembled in mid-2011 for the study of Manning 2013a, and these data were also employed for various slides shown at the Berlin Workshop from which this paper and volume derives in September 2011. The author is not aware of much published data appearing between then and completing this paper. Among new unpublished data I have been employed belatedly are: (i) four new radiocarbon dates to come from the EC-MC site of Politiko Troulla offering calibrated ages variously in the 22nd-21st centuries BC (and so as expected) which are discussed in Section 5 above and shown in Fig. 11 from Falconer and Fall27; and (ii) a set of radiocarbon data from Ermiou Laroni Tou Porohou — these dates were presented at a conference by Sturt Calabrese et al. and were published in the proceedings volume (after submission of this paper) — which are discussed in Section 5 above and shown in Fig. 10. Finally I am aware of new Chalcolithic radiocarbon data to come from Souskiou Laona (the Scottish Universities Environmental Research Centre, SUEREC, Radiocarbon Dating Laboratory website lists a project entitled ‘Radiocarbon Dating the Dental Remains from the Prehistoric Souskiou-Laona Cemetery in Cyprus’) — but these data are not available at the time of writing (Edgar Peltenburg, pers. comm., July 2012). Postscript: for some updates and further bibliography regarding some of the topics mentioned in this End-Note, see now Manning 2013b.

Acknowledgements

I thank Felix Hofmayer for organizing the Berlin workshop and for making it such an enjoyable event.

Postscript (March 2014)

Some time has transpired between the preparation of the analyses in this mid-2011, the writing and submission of the final paper (August to start September 2012), and the production of this volume (expected to occur in spring 2014). A subsequent study (prepared is early 2013) on some of the relevant time period by this author has already been (with exemplary speed) published (Manning 2013b). Readers should therefore also refer to this study, and to other bibliography cited there, which appeared after August 2012.

35 Manning 2013a, table 2. The lom similar results in results between this study (see also Manning 2013b) and the Manning 211 study, despite correct/incorrect/changing a few of the details in the Manning 2013a model (regarding especially the EC-MC period), illustrates the general robustness of such models. Furthermore, the apparent there are reasonable com-
36 Falconer – Fall 2013a; table 1;
37 Sturt Calabrese et al. 2012.
In terms of radiocarbon, the major change since this work was prepared and submitted is the publication of the subsequent IntCal13 radiocarbon calibration dataset and curve. Fig. 13 illustrates the differences between IntCal09 (as employed in this paper) versus IntCal13 for the time period 4000-1500 BC. In the period 4000-1700 BC there are only tiny changes and thus the analyses and date ranges cited in this paper using IntCal09 will vary only by negligible amounts if re-run employing IntCal13. Hence they remain valid and approximately correct. In the period from ca. 1750 to 1500 BC there are slightly larger changes (although still small). A re-run of Model 1 (as in the Appendix) with IntCal13 nonetheless sees only a very small change to the date for the final Boundary; End Prehistoric Bronze Age: 1705–1688 BC at 68.2% probability (same upper limit and a +2 years change on the lower limit versus Table 1 left-hand-side), 1705–1675 BC at 95.4% probability (same upper limits at a +5 years change on the lower limit versus Table 1 left-hand-side) and with the \( \mu \) as 1693±8 BC (versus 1691±10 BC in Table 1 left-hand-side).

\( ^{43} \) Kromer et al. 2010.

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Table 1. Calibrated Calendar Age ranges BC at 68.2% probability and 95.4% probability for the starts and ends of site Sequences and Phases (only sites with 2 or more 14C dates are shown) and some other events and queries from Models 1–4 (for Model 4, see Figures 3–6) for the period of focus in this study from the Chalcolithic through to the end of the Middle Bronze Age/EarlyIron Age period. Typical values shown are – repeated runs loosely defined/constrained groups show more variation, and well-defined/constrained groups (e.g., Polniki Kokkinotamos) show negligible variation. For the TQF (of 1720 BC) for a point still in MC, and the TQF for the start of the LC before the ascension of Ahmose, see text. *Note: regarding the necessary revi

Table 2. Revised Calibrated Calendar Age ranges BC at 68.2% probability and 95.4% probability for the Early Cypriot to Middle Cypriot period (Prehistoric Bronze Age) for the starts and ends of site Sequences and Phases (only sites with 2 or more 14C dates are shown) and some other queries from a re-run of Model 4 adding extra Phases (Steps 1–3). In addition to Table 1, NA = Not Applicable – no data in the original Model 4.
Fig. 1 The 122 radiocarbon dates employed initially in this study and in the OxCal Rom File in the Appendix (data from Manning 2013a). There is a single date “space” between each of the Phase groupings. The three dates marked with the * are deemed extreme outliers and were excluded to enable Model 1 to run. The data in grey (n=13 in total) are excluded as outliers (in terms of their Phase grouping and the model) in Model 2 on the (arbitrary) basis of their typical individual OxCal Agreement index values being <15 (versus the satisfactory value of 60).

Fig. 2 Schematic representation of the groupings used in the OxCal model (Model 1 – see Appendix).
Fig. 3. Continued plot of Model 1 outcomes – for details, see caption to Figure 3.

Fig. 4. The modelled (dark shaded histograms) versus non-modelled (light shaded histograms) calibrated calendar age probability distributions from Model 4 (continued in Figures 4–6). The 68.2% probability range for the modelled distributions are indicated by the lines under each plotted distribution. The A values are the individual OxCal agreement values (satisfactory threshold is ca. 60). The extent of overlap between the modelled and non-modelled distributions determines whether a satisfactory A value is achieved. The structure of the model is also indicated – note especially that within each of the main cultural periods (e.g. Early–Middle Chalcolithic, Late Chalcolithic, Prehistoric Bronze Age or EC–MC) that the different site sequences are independent and can overlap (or not) as the radiocarbon data indicate. The only expectation of continuous Phases are within site stratigraphic sequences; thus the five successive Phases at Marki, or Phase I before Phase II at Sotiri Kanninosdha, and so on.
Fig. 5 Continued plot of Model 4 outcomes – for details, see caption to Figure 3.

Fig. 6 Continued plot (to end) of Model 4 outcomes – for details, see caption to Figure 3.
Fig. 7. Comparisons of the means and standard deviations (s standard) of the calibrated calendar age probability distributions for the named (along bottom, x-axis) Boundaries from Models 1 and 4 (see Table 1 for data). The data largely overlap (s similar and relatively robust findings whether with, or without, outing data) – exceptions are discussed in the text. Note: the dating model employed in this paper starts with the Early Chalcolithic data, and these are therefore not constrained in the older (or earlier) direction. In fact, there are a number of Ceramic Neolithic calibrated BC dates which lie in the 5th millennium BC, and especially in the mid-5th to late 5th millennium BC (Manning 2013a). This (overlapping) time range is indicated in the figure by the cross-hatched box. Hence, the few apparently 5th millennium BC Early Chalcolithic dates are problematic. Considering the overall Neolithic to Chalcolithic datasets available, the Manning (2013a) finds the Ceramic Neolithic as ending around 4100/4200 BC and the Early Chalcolithic as starting around 4000/3900 BC (Manning 2013a).

Late Chalcolithic
Prehistoric Bronze Age
Early to Middle Cypriot

Model 1
Model 4

Approximate range of Ceramic Neolithic calibrated radiocarbon data: see Manning (2013)

Table 1: Modelled dates for the Early Chalcolithic (BC)

<table>
<thead>
<tr>
<th>Date</th>
<th>Model 1</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date 1</td>
<td>4000 BC</td>
<td>4100 BC</td>
</tr>
<tr>
<td>Date 2</td>
<td>3900 BC</td>
<td>4000 BC</td>
</tr>
<tr>
<td>Date 3</td>
<td>3800 BC</td>
<td>3900 BC</td>
</tr>
<tr>
<td>Date 4</td>
<td>3700 BC</td>
<td>3800 BC</td>
</tr>
<tr>
<td>Date 5</td>
<td>3600 BC</td>
<td>3700 BC</td>
</tr>
</tbody>
</table>

Fig. 8. Outlier analysis of the Kissonerga-Mosphilia site sequence in isolation. Employing the OxCal “General” outlier analysis model (Bronk Ramsey 2009b), the Ox values list the calculated Posterior vs. Prior (5 = threshold value) for each date, with those cases shown in bold identified as outliers (Posterior value > Prior value). The A values are the individual OxCal agreement values (credibility threshold is ca. 60). The model as shown – because of the numerous outliers – has a poor A model value of 4 and (Amber) value of 4.5. The high, shaded histograms are the calibrated age probability distributions for each date in isolation (no model), and the dark shaded histograms are the modelled probability distributions with the model. The extent of overlap between the modelled and non-modelled distributions determines whether a satisfactory A value is achieved. The lines under each of the models demonstrate the 95.4% probability range.
Fig. 10 Erini Larnici Tou Paredos radiocarbon dates and sequence analysis (based on preliminary information) — see text. The modelled sequence is shown on the left (with the 68.2% probability calibrated calendar age ranges for the modelled distributions indicated under each) and a detail for Tomb 364 is shown on the right (the light grey shaded histograms show the non-modelled calibrated probability distribution, the dark grey shaded histograms show the modelled probability distribution) with the 68.2% and 95.4% probability ranges indicated.

The table below shows the radiocarbon dates for the Erini Larnici Tou Paredos site.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date (Cal BC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta 3269</td>
<td>2080-2050 BC</td>
</tr>
<tr>
<td>Beta 3268</td>
<td>2080-2050 BC</td>
</tr>
<tr>
<td>Beta 3267</td>
<td>2080-2050 BC</td>
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<td>Beta 3230</td>
<td>2080-2050 BC</td>
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<tr>
<td>Beta 3229</td>
<td>2080-2050 BC</td>
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</tbody>
</table>

Fig. 9 Outlier analysis of the Marki Alonii site sequence in isolation. Otherwise see caption to Figure 8 for explanation.

The graph shows the distribution of radiocarbon dates for the Marki Alonii site. The X-axis represents the calibrated calendar age (BC), and the Y-axis represents the probability density. The shaded areas indicate the 68.2% and 95.4% confidence intervals.
Fig. 11 Calibrated calendar age probability distributions for the four 14C dates from Politiko Triandha from Falconer and Fall (2013: Table 1) (with no modelling). The lines under each histogram indicate the 68.2% and 95.4% probability ranges respectively.

Fig. 12 Dating outcomes for the Early Cypriot to Middle Cypriot period (Prehistoric Bronze Age) from Model 4 re-run adding data from Politiko Triandha (4 dates) and Errmu Larnax Tom P64006 (4 dates – see text). The 68.2% ranges for the modelled probability distributions (dark grey shaded histograms) are indicated under each distribution.
Abstract

This contribution presents an approximate radiocarbon-based chronology for Chalcolithic through Middle Bronze Age Cyprus considering several sites, including the key Early Cypriot to Middle Cypriot site of Marki Alonia. The Chalcolithic to Middle Cypriot periods are of considerable interest since during this time Cyprus first starts to become relevant to the trade and therefore also to the archaeological chronologies of the surrounding east Mediterranean. Therefore it seems to be useful to place this period into a relatively resolved absolute chronological timeframe.

Fig. 13 Top: Comparison of IntCal09 (Reimer et al. 2009) versus IntCal13 (Reimer et al. 2013) over the period 4000-1500 BC. Bottom: Difference (\(^{14}C\) years BP) between the midpoint of IntCal09 versus the midpoint of IntCal13 from 4000-1500 BC.
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Appendix: OxCal Run File for Model 1

1. Options
2. Resolution=5
3. iterations=300
4. Plot
5. Sequence ("Cyprus Chal to MBA")
6. Boundary ("Start Chalcolithic")
7. Phase ("Early-Middle Chalcolithic")
8. Sequence ("Mytholokhia")
9. Boundary ("Start Mytholokhia Period 1")
10. Phase ("Mytholokhia Period 2")
11. Phase ("Kissonerga Mytholokhia Period 2")
12. R_Date ("BM-7443 charcoal", 4865, 4851)
13. R_Date ("BM-1475 charcoal", 4815, 644)
14. R_Date ("BM-1539 charcoal", 4790, 840)
15. R_Date ("BM-1537 charcoal", 4765, 550)
16. R_Date ("BM-1545 charcoal", 4740, 50)
17. R_Date ("BM-1474 charcoal", 4645, 50)
18. R_Date ("BM-1476 charcoal", 4650, 50)
19. Boundary ("Mytholokhia Period 2")
20. Phase ("Kissonerga Mytholokhia Period 3")
21. R_Date ("BM-7443 charcoal", 4710, 50)
22. R_Date ("BM-7442 charcoal", 4650, 50)
23. Boundary ("End Mytholokhia Period 3")
24. Sequence ("Kalavasos Ayious")
25. Boundary ("Start Kalavasos Ayious")
26. Phase
27. Phase ("BM-1835 charcoal", 11020, 130)
28. R_Date ("BM-1322 charcoal", 5040, 11)
29. R_Date ("BM-1834 charcoal", 5039, 120)
30. R_Date ("BM-1833 charcoal", 5000, 170)
31. R_Date ("BM-1836 charcoal", 4700, 310)
32. Boundary ("End Kalavasos Ayious")
33. Sequence ("Kalavasos Tenta")
34. Boundary ("Kalavasos Tenta")
35. Phase ("Kalavasos Tenta")
36. R_Date ("P-2780 carbon", 5460, 110)
37. Boundary ("Kissonerga Mosphilia")
38. Boundary ("Start Kissonerga Mosphilia Period 2")
39. Phase ("Period 2 Charcoal")
40. R_Date ("BM-3954 charcoal", 5320, 90)
41. R_Date ("BM-2963 charcoal", 4850, 80)
42. Boundary ("Period 2 Shorter/Short-Lived Samples")
43. R_Date ("BM-2965 Grammiea", 5130, 80)
44. Boundary ("Mosphilia Period 2 to Period 3A")
45. Phase ("Period 3A Charcoal")
46. R_Date ("GU-2967 charcoal", 5540, 113)
47. Phase ("Period 3A Shorter/Short-Lived Samples")
48. R_Date ("AA-16497 Vitserwenna", 4405, 550)
49. R_Date ("AA-16496 Lens", 4285, 60)
50. Boundary ("Mosphilia Period 3 to Period 3B")
51. Phase ("Period 3B Charcoal")
52. R_Date ("BM-2526 Pinus", 4690, 70)
53. R_Date ("BM-2228 Pinus", 4640, 60)
54. R_Date ("BM-2963 charcoal", 4520, 80)
55. R_Date ("BM-2968 Pinus", 4460, 30)
56. R_Date ("BM-2162 Morus", 4300, 80)
57. R_Date ("BM-2164 Morus", 4290, 80)
58. R_Date ("GU-2168 charcoal", 4210, 105)
59. R_Date ("GU-2426 Morus", 3880, 100)
60. Phase ("Period 3B Shorter/Short-Lived Samples")
61. R_Date ("BM-2942 Lens/ Grummiacea", 4370, 70)
62. R_Date ("BM-2961 seed", 4310, 70)
63. Boundary ("Mosphilia Period 3 to Period 3")
64. Phase ("Period 3 charcoal")
Boundary ("End Middle Chalcolithic")

Boundary ("Start Middle Chalcolithic")
Boundary ['End Phorades IIIb']

Sequence ['Transition End Phorades IIb']

Boundary ['End Sequence for Analysis']

Boundary ['Start Phorades']

Phase ['Stray old or recycled wood']

Boundary ['Start Phorades III']

Phase ['Likely older tree-rings or wood but deposited/fused Phase IIIb']

Boundary ['Start LBA = Protohistoric Bronze Age']

Boundary ['End Prehistoric Bronze Age']

Boundary ['End Phaneromeni Charcoal']

Boundary ['End Maroni Vournes 1a Long-Lived LCIA']

Phase ['Long-Lived = Maroni Vournes Phase 1a - LCIA']

Sequence ['Politiko Phorades']

Boundary ['End Maroni Vournes 1a Long-Lived LCIA']

Boundary ['End Maroni Vournes 1a Long-Lived LCIA']
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