An offprint from

ISLAND ARCHAEOLOGY AND THE ORIGINS OF SEAFARING IN THE EASTERN MEDITERRANEAN

Proceedings of the Wenner Gren Workshop held at Reggio Calabria on October 19-21, 2012

In memory of John D. Evans

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TEMPORAL PLACEMENT AND CONTEXT OF CYPRO-PPNA ACTIVITY ON CYPRUS

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Abstract

This short chapter has three main aims. The first is to review and establish the dates of the recently recognized Cypro-PPNA period on Cyprus from the current evidence associated with this phase at the settlements of Ayia Varvara Asprokremnos (hereafter AVA) and Ayios Tychonas Klimonas (hereafter Klimonas). The second aim is to compare this time horizon on Cyprus with the recent re-assessment of the evidence for the dating of the Pre-Pottery Neolithic A in the Levant (Blockley and Pinhasi, 2011). Thirdly, the chapter will consider how the dating of the Cypriot late Epipalaeolithic and Cypro-PPNA periods on Cyprus positions these two phases of human activity in terms of climate in a more general sense and especially with respect to the cold event known as the Younger Dryas.

Key words: Radiocarbon dating, Pre-Pottery Neolithic A, Asprokremnos, Klimonas, Aetokremnos, Levant, Younger Dryas

ONLY 14C DATES ON CHARCOAL SAMPLES WILL BE CONSIDERED HERE

Considerable effort has gone into trying to obtain radiocarbon dates on bone or tooth samples for the earliest currently known sites on Cyprus. However, in no case where ages have been obtained do the results appear to offer robust, reliable, age estimates, and in most cases the dates reported are clearly incorrect (Fig. 1:parts A and B). In addition, dates or potential dates on marine shells or snail shells may be regarded as less reliable given the uncertain marine 14C reservoir offsets for the period or the potential in the calcareous areas of Cyprus for incorporation of dead carbon from the surrounding geology, as discussed in the case of the Levant by Blockley and Pinhasi (2011:101). Instead, only dates on charcoal samples appear to offer reliable and appropriate ages. In contrast, as shown in Figure 1, only 15% of the dates on samples of bones or tooth (or fractions of a given sample) at any point within their 1SD ranges lie within the maximum extents of the 1SD ranges of the 14C dates on charcoal samples. Moreover, the bone/tooth data exhibit a much larger spread and lack of consistency – with, in 54% of cases, the mid-point ages lying more than 1000 14C years from the limits of the 1SD ranges from the charcoal dates for the same site or even the same context at a given site. In two other unpublished cases known to me suites of bone samples for Akrotiri Aetokremnos (courtesy of Alan Simmons, including both pig and bird bone samples) and also AVA (the present author, comprising pig bone samples selected by Paul Croft) have, after initial screening at the Oxford Radiocarbon Accelerator Unit, been deemed entirely unsuitable for reliable 14C dating (less than 1% Nitrogen and negligible or even zero collagen yields; Thomas Higham, personal communication). Thus, for our present purposes, only 14C dates from charcoal samples will be considered here.
THE TIMEFRAME FOR THE CYPRO PPNA

A plot showing the individual calibrated calendar age ranges for all the currently published Cypro-PPNA $^{14}$C dates on charcoal is shown in Figure 2. We see immediately that all 19 dates fall within a relatively short and well defined period (between 9198 Cal BC to 8569 Cal BC at 95.4% probability). The same data (used in Fig. 2) are then reordered in Figure 3 to show: (i) stratigraphic sequences where known – thus among the AVA dates those from Trench 6 Context 130 (the sealed bottom fill of a small pit, with this pit equal to Context 126 cutting into bedrock) clearly pre-date those from Trench 6 Contexts 99, 101 and 105 (a sediment horizon and two lithic lenses above Context 116, the upper fill of Context 126 and the sealing fill of Context 130), and, at Klimonas, there are two building phases, and it is held that two of the 11 $^{14}$C dates (samples numbers 7 and 8 in Vigne et al., 2012:table 1, where they are called Muse31/SacA 25300 and...
Fig. 1B. The $^{14}$C data shown in Figure 1A for the Epipalaeolithic and Cypro-PPNA in more detail (with error bars at 2SD this time) but excluding the dates on bone reported in Simmons (1999) – thus only apatite/bone/tooth samples reported in AD 2009 or since are shown here. We see that although up to 3 (of 16 – so 19%) of the dates on apatite/bone/tooth could yield ages compatible (within 2SD limits) with some or more of the data on charcoal samples, nonetheless, the vast majority (81%) do not, and moreover, they exhibit a wide spread – hence these data are not used in this study.
Fig. 2. Plot showing the individual (non-modelled) calibrated age probabilities, and 68.2% and 95.4% most likely calendar age ranges (upper and lower lines under each distribution respectively), for the 14C dates on charcoal samples currently available from Cypro-PPNA contexts at AVA (n = 8) and Klimonas (n = 11). For sources of data see the caption to Figure 1A above. Data from OxCal (Bronk Ramsey, 2009a) and IntCal09 (Reimer et al., 2009) with curve resolution set at 5.
Fig. 3. The data shown in Figure 2 but re-arranged to reflect: (i) the stratigraphic sequence where known (thus, for AVA the dates from Trench 6 Context 130 pre-date those from Trench 6 Contexts 99, 101 and 105; and for Klimonas, there are two recognized building phases and two of the dates are stated to derive from the second, subsequent phase: Vigne et al., 2012: SI page 4); and (ii) otherwise an ordering by 14C age (oldest to most recent)
The reason for the (small) dating ambiguity for some of the $^{14}$C ages is illustrated in Figure 4. A plateau in the radiocarbon calibration curve, which runs from the late 92nd to 89th centuries CalBC, is progressively more and more caught by those $^{14}$C data with values older than about 9500 $^{14}$C years BP, whereas it is avoided by dates that fall at about 9480 $^{14}$C years BP. The available Cypro-PPNA radiocarbon data offer quite a precisely defined age range in terms of a $^{14}$C years BP estimate: the total range of midpoint ages in the 19 date set is only 9590-9432 $^{14}$C years BP (a spread of 158 years). Indeed, within stated measurement errors, the 19 $^{14}$C dates could all be combined together – not actually an appropriate strategy (but just to highlight their similarity) – consistent with the hypothesis of all representing estimates of the same real $^{14}$C age within 95% confidence limits (weighted average 9492 ± 11 BP, passing a Chi-squared test at df18

![Fig. 4](image-url)

**Fig. 4.** The individual calibrated age probabilities (the black flattened histograms) for each of the 19 data on charcoal samples from AVA and Klimonas, as shown in Figures 2 and 3, now plotted (where they lie) against the IntCal09 $^{14}$C calibration curve. Here we see that one group of the data – bracketed and labeled as 1 – intersect both with the late 10th millennium Cal BC (approximate range indicated and labeled as A) and also in the earlier 9th millennium Cal BC, whereas another group with slightly later $^{14}$C ages just miss this ambiguity and intersect only with a range in the earlier 9th millennium BC – bracketed and labeled as 2 (with approximate calibrated calendar age range indicated as B). For further comments on this figure, see the text.
with $t = 20.5 < 28.9$, following Ward and Wilson, 1978). However, the relevant specific part of the radiocarbon calibration curve (the history of past natural variations in atmospheric $^{14}C$ levels) creates a wider calendar spread because of the plateau (Fig. 4), which catches the $^{14}C$ data around and older than about 9500 $^{14}C$ years BP.

Thus, it would seem there are two possibilities to consider. The first is that, in reality, all the dates do reflect – at either site or else taking them together (in the areas of the two sites excavated so far) – a relatively short (e.g., on a scale of just one or two centuries) activity period for the Cypro-PPNA, and that the plateau in the $^{14}C$ calibration curve is misleading us in offering a somewhat wider possible calendar age range for some dates. The key proviso to note here is, of course, that chronological inferences are being made with respect to two sites excavated only over a limited area so far. In the case of sites on the mainland of PPNA age, the excavations are commonly much larger in size than those carried out to date at AVA and Klimonas. The second possibility is that this first and most economical hypothesis is incorrect; instead, an earlier aspect of the Cypro-PPNA is partly represented in these data, indicating perhaps a longer overall period (or periods) of activity at these two sites, which may become more obvious as further excavations are conducted at them and more $^{14}C$ dates obtained.

As the next step, I turn to Bayesian chronological modelling of the radiocarbon and archaeological data (Bayliss, 2009), using OxCal (Bronk Ramsey, 1995, 2009a) and the General outlier model of Bronk Ramsey (2009b) as well as the IntCal09 (Reimer et al., 2009) radiocarbon calibration dataset. It is worth noting that, by convention, OxCal terms (such as Phase, Sequence, Boundary) will capitalized in this chapter. I consider models initially for each site separately, and then an integrated model with a Sequence combining the substantive suites of radiocarbon dates available at present from Cyprus on charcoal samples from the Epipalaeolithic site of Akrotiri Aetokremnos (hereafter Aetokremnos), from the Cypro-PPNA (AVA and Klimonas) and from the initial Cypro-PPNB (called Early Phase A at the site of Paraklesia Shillourokambos (hereafter Shillourokambos). The data from each of the three groupings is taken in the model to be a single uniform Phase (with the available data regarded as a random sample between the respective start and end of Phase Boundaries for each site grouping). This uniform probability model, apart from being cautious (as explained by Bayliss et al., 2011:58-59, “...it is rare for a model based on a uniform distribution to be importantly wrong”), is appropriate here since the charcoal samples in question come from a variety of contexts at each site and there is no reason to assume that the samples or contexts are coeval, or otherwise other than some form of random selection from the overall period of activity represented at each site for the respective technoculture period or periods. The only grouping where the assumptions behind the model may not be met, when it comes to statistical analysis, is in the case of Aetokremnos, as we shall see below.

Figures 5 and 6 show the AVA and Klimonas data analysed within in their respective site models. For AVA, we have an overall period of culture-technological time, Cypro-PPNA, which we can define as a Phase, within which we have one Sequence in Trench 6 where Context 130 predates Contexts 99, 101, and 105 (which have no clear sequence relationship to each other), and then another Context, 426, from another area of the site to the north associated with structure F300, which could sit anywhere within the Cypro-PPNA period at the site. The model resolves the Trench 6 sequence in favour of the common, earlier 89th to 87th century CalBC range (see Figure 4 and its discussion above) at the most likely 68.2% probability level (see Fig. 5). However, it leaves Context 426 as much less clearly defined, since there are no constraints on these data within the site model – hence the very poorly defined start and end Boundaries for Context 426 (Fig. 5). And, in turn, Context 426 may possibly lie either around the same region, or else it possibly represents earlier activity late in the 10th millennium CalBC (the modelled calibrated ages ranges for the two AVA Context 426 dates in Fig. 5 at 95.4% probability are 9135-8969 CalBC (50%) and 8946-8761 CalBC (45.4%) for VERA-5811W and 9150-8791 CalBC for VERA-5811_2). The evidence available from the AVA site at present does not, by itself, allow resolution of this question. However, as seen below, if one considers the Cypro-PPNA data altogether as
Fig. 5. AVA charcoal dataset modelled as a site Cypro-PPNA Phase, with two main elements: (i) a Phase comprising Context 426 associated with structure F300 and (ii) from a separate area of the site to the south and thus potentially overlapping (or not) a Sequence from Trench 6 where Context 130 appears to be the oldest element in this area and stratigraphically pre-dates the set of contexts comprising Contexts 99, 101 and 105. No date is an outlier. The individual calibrated age probabilities in light grey are as in Figures 2-3; the modelled age ranges (much smaller) are in darker grey and the 68.2% and 95.4% most likely age ranges for the modelled probability distributions are indicated by the upper and lower lines respectively under each probability distribution. The start and end Boundaries for the Phase (regarding Context 426) and Sequence (regarding Trench 6) are shown as well as the transition Boundary covering the end of Context 130 to the start of Contexts 99, 101 and 105. To the right, details are shown for the overall start and end Boundaries for the Trench 6 Sequence. The calculated span of time for the entire Trench 6 Sequence is 0 to 140 calendar years at 68.2% probability and 0 to 390 calendar years at 95.4% probability, which indicates a relatively short overall period of time represented by the Trench 6 dates. There is some in-built age for a charcoal sample. The species dated are only known for two of the samples (*Pistacia* sp. for the two VERA dates); however, given the likely species involved, there is no reason to assume, typically, more than a few decades of offset, and, as suggested in Manning et al., (2010:698) and discussed in Manning (2013:489-491), an allowance of around 0-50 ± 50 years should typically more than cover most such circumstances. This would suggest human activity in the Trench 6 area from around the end of the 89th century CalBC or the start of the 88th century CalBC, and certainly no later than the end of the 88th century CalBC. Data from OxCal (Bronk Ramsey, 2009a) and IntCal09 (Reimer et al., 2009) with curve resolution set at 5. Note that each run of such a model yields slightly varying outputs, typical values are shown.
a Phase within the greater late Epipalaeolithic to initial Cypro-PPNB Sequence, then this seeks to place all the Cypro-PPNA data, including AVA Context 426, as not starting until during the 90th/89th century BC (most likely 95.4% and 68.2% probability ranges respectively; see Fig. 8 below and Table 1). Even allowing for a little in-built age in the charcoal samples (see the caption to Fig. 5), the Trench 6 data appear to define a relatively short overall period of Cypro-PPNA activity on Cyprus. The calculated span of time for the entire represented Klimonas Sequence is 0 to 105 calendar years at 68.2% probability and 0 to 296 calendar years at 95.4% probability. There is some in-built age for a charcoal sample. The species dated are *Pistacia* sp., *Quercus* sp. and *Prunus* sp. (Vigne et al., 2012:table 1). In the case of lower elevation southern Cyprus, there is no reason to assume (typically) more than a few decades of offset, and, as suggested in Manning (2013:489-491) an allowance of 0-50 ± 50 years should typically more than cover most such circumstances. Data obtained from OxCal (Bronk Ramsey, 2009a) and IntCal09 (Reimer et al., 2009) with curve resolution set at 5. Note that each run of such a model yields slightly varying outputs, typical values are shown.
<table>
<thead>
<tr>
<th>Element</th>
<th>68.2% Probability CalBC or calendar years (for Interval/ Span)</th>
<th>95.4% Probability CalBC or calendar years (for Interval/ Span)</th>
<th>μ ± σ CalBC or calendar years (for Interval/ Span)</th>
<th>μ ± σ CalBC adjusted 50±50 calendar years for in-built age allowance</th>
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</thead>
<tbody>
<tr>
<td>Aetokremnos Boundary Start</td>
<td>11659-10697</td>
<td>12056-10616</td>
<td>11315 ± 556</td>
<td>11265 ± 558</td>
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<tr>
<td>Aetokremnos Boundary End</td>
<td>10094-9658</td>
<td>10343-9147</td>
<td>9817 ± 329</td>
<td>9767 ± 333</td>
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<tr>
<td>Interval Duration Aetokremnos</td>
<td>805-1940</td>
<td>441-2667</td>
<td>1497 ± 657</td>
<td></td>
</tr>
<tr>
<td>Interval Between Aetokremnos and Cypro-PPNA</td>
<td>755-1247</td>
<td>227-1437</td>
<td>937 ± 342</td>
<td></td>
</tr>
<tr>
<td>Cypro-PPNA Boundary Start</td>
<td>8898-8781</td>
<td>9097-8764</td>
<td>8880 ± 103</td>
<td>8830 ± 114</td>
</tr>
<tr>
<td>AVA Context 426 Boundary Start</td>
<td>8858-8776</td>
<td>8989-8757</td>
<td>8843 ± 68</td>
<td>8793 ± 84</td>
</tr>
<tr>
<td>AVA Context 426 Boundary End</td>
<td>8823-8755</td>
<td>8907-8697</td>
<td>8794 ± 51</td>
<td>8744 ± 71</td>
</tr>
<tr>
<td>AVA Trench 6 Context 130 Boundary Start</td>
<td>8811-8762</td>
<td>8856-8746</td>
<td>8746 ± 30</td>
<td>8696 ± 58</td>
</tr>
<tr>
<td>Interval Duration AVA Context 426</td>
<td>0-55</td>
<td>0-179</td>
<td>49 ± 63</td>
<td></td>
</tr>
<tr>
<td>AVA Trench 6 End of Context 130 to Start Contexts 99, 101, 105</td>
<td>8878-8751</td>
<td>8808-8732</td>
<td>8770 ± 19</td>
<td>8720 ± 53</td>
</tr>
<tr>
<td>Interval Duration AVA Trench 6 Context 130</td>
<td>0-31</td>
<td>0-90</td>
<td>25 ± 31</td>
<td></td>
</tr>
<tr>
<td>AVA Trench 6 Contexts 99, 101, 105 Boundary End</td>
<td>8871-8731</td>
<td>8799-8692</td>
<td>8748 ± 28</td>
<td>8698 ± 57</td>
</tr>
<tr>
<td>Span Duration AVA Trench 6 Contexts</td>
<td>0-58</td>
<td>0-135</td>
<td>46 ± 44</td>
<td></td>
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<tr>
<td>Klimonas Phase 1 Boundary Start</td>
<td>8811-8772</td>
<td>8840-8759</td>
<td>8796 ± 21</td>
<td>8746 ± 54</td>
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<td>Klimonas Transition Phase 1 to Phase 2 Boundary</td>
<td>8794-8761</td>
<td>8810-8741</td>
<td>8776 ± 17</td>
<td>8726 ± 53</td>
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<tr>
<td>Interval Duration Klimonas First Phase</td>
<td>0-26</td>
<td>0-77</td>
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<td>Klimonas Phase 2 Boundary End</td>
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<td>8806-8696</td>
<td>8757 ± 29</td>
<td>8707 ± 58</td>
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<td>Interval Duration Klimonas Second Phase</td>
<td>0-24</td>
<td>0-71</td>
<td>19 ± 24</td>
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<td>Span Duration Klimonas Cypro-PPNA</td>
<td>0-49</td>
<td>0-118</td>
<td>39 ± 38</td>
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<tr>
<td>Cypro-PPNA Boundary End</td>
<td>8776-8690</td>
<td>8795-8572</td>
<td>8709 ± 61</td>
<td>8659 ± 79</td>
</tr>
<tr>
<td>Span Duration Cypro-PPNA (=Span AVA + Klimonas Cypro-PPNA)</td>
<td>3-128</td>
<td>0-284</td>
<td>107 ± 86</td>
<td></td>
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<tr>
<td>Interval Between Cypro-PPNA and initial Cypro-PPNB</td>
<td>236-412</td>
<td>108-455</td>
<td>296 ± 91</td>
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</tr>
<tr>
<td>Shillourokambos Early Phase A Boundary Start</td>
<td>8452-8319</td>
<td>8553-8303</td>
<td>8413 ± 71</td>
<td>8363 ± 87</td>
</tr>
</tbody>
</table>

Table 1. Modelled calibrated age ranges for selected elements from the data plotted in Figures 8 and 9. Start Boundaries are dates “from” or “after which” for each Phase. End Boundaries are dates “to” or “by which” for each Phase (μ ± σ = means plus or minus 1 standard deviation)
activity in this area of the site, starting probably (in round numbers) around ca. 8800 CalBC and no later than ca. 8700 CalBC, and ending, before 8600 CalBC (at 68.2% probability) and certainly before 8500 CalBC (95.4% probability).

Figure 6 shows the Klimonas site Sequence for the 14C dates currently available on charcoal samples. The data are consistent with, and indicate, a relatively short period of activity. Even allowing for a little in-built age in the charcoal samples, the dates suggest an overall period of activity starting no later than during the 88th century CalBC and ending in the later 88th to mid 87th century Cal BC. The calculated span of time for the entire Klimonas Sequence is only 0-105 calendar years (at 68.2% probability) and 0 to 296 calendar years (at 95.4% probability), indicating a relatively brief overall period of activity from the data to hand. There is little to no difference between the 14C dates from the early phase structure at Klimonas and the later phase structure, which likewise points toward a short overall period of activity at the site according to the model. On the other hand, it is worth recalling here that only a limited area of the site has been excavated so far.

To broaden the context when its comes to chronological inferences on the basis of what is currently known of the Cypro-PPNA on Cyprus and to consider how this may further constrain the available Cypro-PPNA data (in particular, whether or not it affects the two alternative dates obtained in the case of Context 426 at A V A), it is now useful to consider the data for the time before and the time after the Cypro-PPNA: that is, the late Epipalaeolithic site of Aetokremnos and the initial Cypro-PPNB site of Shillourokambos (Early Phase A).

The Aetokremnos data on charcoal samples (seven of them were run before 1990) are less than satisfactory in terms of current ideas with regard to radiocarbon dating – with 4 of the 8 determinations having very large measurement errors (from 230 to 300 14C years). In short, the 8 dates are spread over a considerable span of time, and it is unclear whether they all belong to the same phase of activity or to two or more different phases of activity. When these data are run as a Phase using no outlier model, the resulting calibrated calendar age ranges cover an interval of time that has a length of one or two millennia (and perhaps even extends towards a third millennium), looking at the 68.2% probability range and especially the 95.4% range. As shown in Figure 7, the end Boundary for the phase likely lies somewhere around 10084-9660 CalBC (68.2% probability) or from 10217 to 9115 CalBC (95.4% probability range). Only the far extremity of this end Boundary potentially reaches the earliest of the available Cypro-PPNA dates. This suggests that there is, in all likelihood, some intervening period of time at least between the currently attested late Epipalaeolithic at Aetokremnos (whatever appropriate span or spans of human activity should be recognized for this period) and the subsequent Cypro-PPNA at either A V A or Klimonas. In the case of those dates for Aetokremnos run more than 20 years ago, some would hold that the sources of error in the determinations are more than simply those concerned with instrumental counting error (the optimistic working assumption behind the statistical treatments in the Bayesian chronological model used here, which may be appropriate for high-quality recent AMS dates but not for poor-quality determinations obtained years ago). In effect, the part of the current analysis (based on the “old” dates for Aetokremnos) should be viewed as an exercise that is heuristic in character.

A model integrating these (rather poorly defined) Epipalaeolithic 14C data, the Cypro-PPNA 14C data, and the set of 14C data from initial Cypro-PPNB from Shillourokambos (Early Phase A), when they are run using the General outlier model (Bronk Ramsey, 2009b), is shown in Figures 8 and 9 (details of the main elements are given in Table 1). The striking feature is that the currently available data indicate that the attested Cypro-PPNA period would begin by or after about 8830 ± 114 CalBC, and it would end by or before about 8659 ± 79 Cal BC, according to the model (see Table 1).
The Cypro-PPNA period currently lies separate from the late Epipalaeolithic at Aetokremnos: that is, broadly around a millennium later (and at least more than 227/755 calendar years at 95.4% and 68.2% probability respectively; $\mu \pm \sigma = 937 \pm 342$ calendar years). Even if (i) the more recently run (but solitary) Oxford AMS date for a charcoal sample from Aetokremnos is regarded as a more appropriate and higher-resolution age estimate than the other data (see below), and (ii) the two Context 426 dates at AVA correctly indicate late 10th millennium CalBC activity at the site, then an interval over 600 calendar years is indicated between the respective 95.4% probability age ranges. The end of the attested Cypro-PPNA period seems to lie before the earliest so far attested Cypro-PPNB at Shillourokambos (Early Phase A) by an interval of, $\mu \pm \sigma$, 296 ± 91 calendar years, with a minimum gap of 108 or 236 years (looking at the 95.4% and 68.2% probability ranges respectively). The available Cypro-PPNB $^{14}$C dates from other sites do not
Fig. 8. Overall model (with General outlier model: Bronk Ramsey, 2009b) integrating the Epipalaeolithic $^{14}$C data on charcoal samples from Aetokremnos (poorly defined), the Cypro-PPNA $^{14}$C data in Figures 2 through 6 above,
offer any earlier range (Manning, 2013). It seems likely that if this gap is to be closed by work in the future that the relevant data will come from finds of later Cypro-PPNA age or else from those of transitional Cypro-PPNA/PPNB age.

COMPARISON WITH THE PPNA IN THE LEVANT

The recent reassessment of the dating of the PPNA period in the Levant, after removal of sample materials likely to include large in-built ages and some chronometric hygiene considerations, produced an estimate for the start of the PPNA period at 11777-11420 CalBP (Blockley and Pinhasi, 2011) or 9828-9471 CalBC, while the end Boundary for the overall period lies in the later 8th millennium CalBC (or more specifically 7496-7103 CalBC). One can then say, based on the limited evidence currently available on Cyprus (only two sites and both of them excavated on a rather small scale) that the PPNA on the mainland began at least several centuries (ca. 315 calendar years minimum, if we use the AVA Context 426 dates) to likely ca. 700 to 800 years (and no more than about a millennium) before the Cypro-PPNA period. The Aetokremnos late Epipalaeolithic appears to begin during the late Natufian (the end of the Epipalaeolithic) of the Levant and to end likely around 500+ years after the apparent end of the Late Natufian in the Levant, as placed in the analysis by Blockley and Pinhasi (2011), and indeed to within a couple of centuries of – or even to overlap with – the time-span of the initial PPNA in the Levant (Fig. 10).

MACRO CLIMATE CONTEXT

Figure 10 shows the relationships of the Aetokremnos Epipalaeolithic and the Cypro-PPNA phases (from Table 1) against the date ranges for the Late Natufian and PPNA of the Levant as quantified in the modelling exercise by Blockley and Pinhasi (2011), and then against the δ18O record (temperature proxy) from the GRIP and NGRIP ice-cores on the GICC05 chronology (Rasmussen et al., 2006, 2007). Figure 11 further shows the GRIP and NGRIP ice-core δ18O records versus several other well-known proxy records. All place the Younger-Dryas (Y-D) climate episode in the same calendar year range within measurement errors (with the relatively coarse, low resolution, Soreq Cave δ18O data set appearing – without considering the large dating errors of several hundred years or more, as indicated by Blockley and Pinhasi (2011:fig. 5) – to indicate incorrectly too late a start for the Holocene. It is perhaps worth adding here that the well-known Soreq cave sequence (Bar-Matthews et al., 1999, 2000, 2003) is now superseded by more recent work (see Orland et al., 2012). In the Levant, the Late Natufian, as pointed out by Blockley and Pinhasi (2011:figs 5-6), ends at or around the start of the (cold, dry) early Y-D period, and the PPNA very much commences with the onset of the suddenly warmer and wetter conditions
of the Holocene. The climate linkages for the Cypriot data are less self-evident. As a set, the Aetokremnos dates (again only those on charcoal samples) spread widely from before the Y-D and then across this climatic event. This could suggest that the Aetokremnos activity (at least in part) relates to adaptations to the Y-D climate episode (e.g., Ammerman, 2010). However, one may also observe that the one much more recently measured and higher resolution AMS date from the site on charcoal – OxA-15989 (Simmons and Mandel, 2007) – is also one of the most recent ages in the set and offers a calibrated age range of 10108-9877 CalBC (68.2% probability) and 10174-9806 CalBC (95.4% probability) (respectively 12057-11826 CalBP or 12123-11755 CalBP). As shown in Figure 10, this age range is quite close to the end of the Y-D and the start of the Holocene (now taken to occur at 11703 ± 99 BP (b2k from AD 2000) or 11653 ± 99 CalBP with reference to AD 1950; attributions made by Rasmussen et al., 2006; Blockley et al., 2012:table 1) – and more so if any in-built age is allowed for in the charcoal sample – and very close to, or even within, the range of the start Boundary for the PPNA in the Levant placed at 11778-11435 CalBP by Blockley.
and Pinhasi (2011). Thus, there might be some question mark over whether the Aetokremnos activity is Y-D, or whether instead it is more very late Y-D to onset of the initial Holocene. If one takes the latter position, it means, in turn, that the older series of dates at Aetokremnos is now discounted and no longer seen as being well established. At the Wenner Gren Workshop, several of the participants drew attention to the limitations of the pioneering work at the site done by Simmons, which is fully understandable in the context of such a demanding site and the time when the fieldwork began (in the closing years of the 1980s; for more on the questions raised at the meeting, see other chapters in this issue; for example, in chapter 3, Vigne argues that stratum 4 at Aetokremnos is a natural bone bed and not an archaeological layer; for the responses to this and questions by Simmons, see chapter 9). It is obvious that more reliable dates and ones with higher resolution are called for at Aetokremnos as well as for other late Epipalaeolithic sites.
on Cyprus. It is perhaps worth highlighting that such desired $^{14}$C dates should be either on stratigraphically secure seed samples or charcoal samples, and ideally, in the latter case, on charcoal from species that do not have very long lives, and so are unlikely to include substantial in-built age (compare Blockley and Pinhasi 2011:101-102 with regard to the issue of *Juniperus* spp. samples in the Levant).

The Cypro-PPNA period, as presently dated, falls almost a millennium after the onset of the Holocene, and it occurs firmly within this newly established climate context. As noted previously (Manning *et al.*, 2010:fig. 10), there is some correlation of the timings of the Cypro-PPNA and then earlier Cypro-PPNB (and the OxA date from Aetokremnos) with the reversals/plateaux in the $^{14}$C calibration curve after (as currently known)
gaps in activity during periods of steep slopes in the $^{14}$C calibration curve (reflecting increased $^{14}$C production). In broad terms, the steep slopes (increased $^{14}$C production) would correlate with a quiet sun (reduced total solar irradiance), whereas the reversals/plateaux would correlate with the opposite (that is, increased solar irradiance and changes in oceanic processes linked to this). This might suggest that within the context of the onset of Holocene, and then continuing during the early Holocene itself, that such somewhat warmer/wetter periods were particularly conducive to human activity on Cyprus, and the previous cooler/drier time of the Younger Dryas was less so.

NOTE ON PAPER CHRONOLOGY

This text is as prepared for the Reggio meeting in Autumn 2012 and submitted in Spring 2013. It thus employs IntCal09, and not the subsequently published IntCal13, radiocarbon calibration dataset.

Acknowledgements

I thank my AVA collaborator Carole McCartney. I thank Bernd Kromer for the Hd/ETH dates (see Manning et al., 2010) and Eva Wild for the two new VERA dates. In addition, I wish to thank Albert Ammerman for the terrific hospitality offered by the Altafiumara Hotel, where the Wenner Gren Workshop was held. Thanks are expended to SSHRC, Canada, the College of Arts and Sciences, Cornell, the Department of Classics, Cornell, and the Archaeological Research Unit, University of Cyprus, for support, and I thank the many team members of the EENC project and the AVA excavation. Finally, my appreciation goes to the Department of Antiquities, Cyprus, for the permission to conduct the fieldwork and their assistance.

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