Radiocarbon Dating Results for the Early Upper Paleolithic of Klissoura 1 Cave

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This chapter reports the results of an extensive program of radiocarbon dating on the Middle and early upper Paleolithic at Klissoura 1 Cave. Klissoura Cave contains the longest and most complete sequence of Middle and early Upper Paleolithic archaeological horizons in Greece, and one of the longest sequences in southern Europe. Radiometric dating results from the site are of considerable interest with respect to transition from Middle to Upper Paleolithic in southern Europe, as well as for understanding the chronology of the Aurignacian in the region.

Table 1 shows results for 29 radiocarbon samples collected from the Upper and Middle Paleolithic layers at Klissoura 1 Cave. All but two of the reported dates were obtained on charcoal, or material identified in the field as charcoal. In some cases the charcoal samples could actually be assigned to a genus or family of tree (Ntinou, this volume). The exceptions are two samples of land snail shell from layer 6a.

A large series of dates on soil carbonates, reported in an earlier publication (Koumouzelis *et al*., 2001a: tab. 1), is not presented here. The carbonate dates are consistently more recent than the dates obtained from snail shell or charcoal from the same levels. The nature and origin of the carbonates dated is not entirely clear. The majority of the calcareous material in Klissoura consists of ash and some quantities of limestone clastic material from the walls of the cave (Karkanas, this volume), so the carbonates presumably derive from calcitic ash. Micromorphological studies have shown that re-crystallization of ash is generally minimal at Klissoura but does vary locally. Stable isotope analyses of the dated carbonate samples does suggest that there was some re-crystallization of the samples dated. Values for $\delta^{13}C$ vary from -26.4 to -14.66 (‰PDB), and $\delta^{18}O$ vales range from -15.99 to -4.54 (‰PDB) (Koumouzelis *et al*., 2001b). Two published isotopic analyses of modern ash samples gave -22.37 and -24.54 $\delta^{13}C$ (‰PDB) and -16.44 and – 17.33 $\delta^{18}O$ (‰PDB) respectively (Karkanas *et al*., 2007; Shahack Gross, *et al*. 2008). Such low values are expected during the process of ash formation and are comparable to those for more extensively studied lime mortar, which absorbs CO_2 from the atmosphere in a similar way. Geogenic calcite, coming directly from limestone or chemically precipitated, would shift the original ash values higher. The reported values from Klissoura do show such a trend, implying that some re-crystallization has occurred, and/or that there has been mixing with some clastic calcite. However, because the amount of re-crystallization or mixing cannot be evaluated, the ages of the carbonate samples can be only considered rough minimum age estimates.

Table 1 also contains ”calibrated” radiocarbon ages generated using the CalPal online program, and calibrated according to the CalPal2007HULU curve (May, 2009), which is based in large part on results of Fairbanks *et al*., (2005). These calibrated ages use the correct half-life of ^{14}C of 5730 years ,radiocarbon ages are calculated using the Libby half-life of 5568 years), and account for changes in the ^{14}C activity of the atmosphere through time. In the absence of a universally accepted calibration curve for the period before 26,000 BP, and in the face of continuing uncertainties about severe fluctuations in atmospheric ^{14}C in the period between 30,000 and 40,000 years ago (Beck *et al*., 2001, Conard and Bolus 2003, Fairbanks *et al*., 2005, Giaccio *et al*., 2006; but compare Higham *et al*., 2009), the calibrated results should be treated with caution. They are useful as estimates of the true age of samples, but close comparisons with other age estimates, especially those produced using other calibration curves, may be misleading. Thus, discussions below refer to uncorrected radiocarbon ages unless otherwise noted.

Radiocarbon ages from Klissoura 1 Cave includes dates obtained from four different laboratories, using both conventional and AMS counting methods, and two different techniques of pre-treatment: ABA (acid/base/acid) treatment, and the more stringent ABOX technique. The ABOX method involves wet oxidation and step-heating of samples. The ABOX method, developed by Bird and colleagues (Bird *et al*., 1999) eliminates a substantially larger percentage of recent contaminants from the sample than conventional ABA treatment and promises more accurate and older age estimates from very old samples with low residual ^{14}C. In addition, the ABOX samples were processed on an ultra-clean vacuum line dedicated to very old ^{14}C samples with low residual activity, which reduces potential problems associated with cross-contamination between samples (Pigati *et al*., 2007).

Age estimates from layers IIIe-g, and IV, which represent the Middle and early Aurignacian are relatively consistent. They show a generally monotonic trend of increasing age, from 31-34 ^{14}C kyrs BP in layer IIIe-g to 32-33 ^{14}C kyrs BP in layer IV (figures 1 and 2). The entire Aurignacian sequence appears to have been created between roughly 31,000 and 33,000 ^{14}C kyrs BP, corresponding with an interval of roughly 35,000-37,500 calibrated yrs BP.

As is typical of any large group of radiocarbon ages from the early Upper Paleolithic, there are some anomalies in the dates for the Aurignacian at Klissoura 1. One specimen from layer IIIe-g (Gd7892), dated using conventional counting methods, yielded an unexpectedly early age estimate (34,700 ± 1600). We note that this date has a very large uncertainty (σ=1600), and overlaps with ranges for other estimates from layers IIIe-g and IV at the 2σ confidence level.

Four radiocarbon dates obtained from layers III", III', IIIe-g, and IV are anomalously young. One of these samples (GD9688) was identified as having critically low carbon weights in the lab and another one was contaminated by fungi (RTT 4788); the age estimates are therefore suspect (Karkanas, personal communication, 2009). However, there is no evidence that the other anomalous dates from layers III' and III" (Gd 15349, Gd 15351) were based on problematic samples. We speculate that these unexpectedly recent ages represent small fragments of charcoal incorporated from more recent deposits. The Upper Paleolithic layers at Klissoura 1 Cave are dominated by anthropogenic formation processes (Karkanas, this voume). Numerous shallow hearths and some pits were excavated by the inhabitants of the cave, and some localized bioturbation is apparent (Karkanas, this volume). Processes such as these could have displaced some charcoal fragments. Layer 6a is a case in point. The material from this layer, originally identified as Aurignacian, was determined to be in secondary position. The presence of radiocarbon samples with ages ranging from 22,370 ± 270 to 29,150 ± 340 in layer 6a undoubtedly reflects a mixing of materials from different deposits by anthropogenic processes.

Layer V contains the early Upper Paleolithic assemblages with splintered pieces, backed crescents and other geometric forms, originally identified as Uluzzian. The age of this assemblage is of considerable interest with respect to understanding the timing of the Middle-Upper Paleolithic transition in Greece and southern Europe. This is the only stratigraphically sealed EUP assemblages with geometrics known outside of Italy, and one of very few assemblages situated outside the southern extreme the Italian peninsula. Understanding its chronological relationship to similar assemblages in Italy therefore is important to reconstructing the history and distribution of so-called “transitional” assemblages in southern Europe, and ultimately in assessing behavioral evolution at the interface between later Middle and early Upper Paleolithic.

Unfortunately, the radiocarbon results provide ambiguous estimates for the age of layer V. Four of the five ^{14}C ages from this layer (including two minimum age determinations) are anomalously young, in the range of 30-32 KY. These age estimates actually represent a reversal in the otherwise well-behaved Upper Paleolithic sequence, as they are younger than ages obtained from the overlying layer IV and are more in line with estimates from layer IIIe-g. The fifth date from layer V is much older (^{14}C kyrs). However, this sample was not obtained during the excavation, but was collected while placing TL dosimeters in the site. It is derived from an area where layer V pinches out, so that layers IV and VI are in direct contact a short distance away. Thus, the precise stratigraphic origin of this sample remains somewhat uncertain. The age of this sample is also similar to two ABOX dates from layer VI, at the contact between the Middle and Upper Paleolithic sequences.

It is difficult to neatly reconcile the available radiometric information on the age of layer V Stratigraphic observations by Karkanas (this volume) show that the Aurignacian layer IV clearly truncates the underlying layers at the back of the sheltered area, including layers V, VI and VII. There is a marked erosional contact between layer IV and layer VII. Although layer IV truncates layer V as well, the processes of sedimentation and site formation in layer V are more similar to the overlying Aurignacian sequence than to the Middle Paleolithic layers. Karkanas concludes that the hiatus between layers V and IV is “relatively minor” compared with the interval represented by the erosional contact at the top of the Middle Paleolithic sequence. Layer VI meanwhile is interpreted as representing a mixture of materials from layers VII and V, probably a Middle Paleolithic deposit reworked during a subsequent early Upper Paleolithic occupation.

Layer V itself is comparatively thin, and certainly does not represent an accumulation of ~10,000 years (the approximate span between the earliest and latest ages). The two finite determinations of around of ~30-31 ^{14}C kyrs, and the two infinite (> 31^{14}C kyrs) ages provide nothing more than minimum age estimates for layer V.

Two alternate scenarios can be suggested. One is that the oldest set of age estimates—including the sample yielding the date of 40,100±740 ^{14}C yrs reported to be from layer V and the two dates of 40,920±580 and 41, 480±810 ^{14}C yrs from layer VI, pertain to the earliest Upper Paleolithic occupation of Klissoura 1 Cave. If so, then there is a chronological gap of 6-7000 years between layer V and both the Middle Paleolithic of layer VII and the Aurignacian of layer IV. The second interpretation is that the three dates in excess of 40 ^{14}C kyrs BP from layers V and VI actually represent fragments of charcoal reworked from the most recent Middle Paleolithic deposits at the top of layer VII. In this scenario, the age of the archaeological assemblages within layer V is constrained to between approximately 33 ^{14}C kyrs (layer IV) and 40 ^{14}C kyrs.

Tephrachronology may be the best tool for resolving questions about the age of layer V at Klissoura. There is a concentration of micro-tephra fragments between layers V and VI (Dustin White, personal communication, March 2010). Chemical analyses of the glass shards is ongoing as of this writing. However, if these prove to represent the widespread Campanian Ignimbrite or Y5 tephra (Giaccio *et al*., 2006; Pyle *et al*., 2006; Thunell *et al*., 1979), then the layer V deposits are clearly older than 39.3 ky. This would in turn suggest that the early dates from layers V and VI probably do relate to first Upper Paleolithic occupations of the cave, and that there is a significant time gap between layers V and IV.

Four radiocarbon ages were also obtained from clear Middle Paleolithic contexts at Klissoura 1. These range from 48,990±1,770 in layer VII, to 62,290±3,930. All four of these ages were obtained using the ABOX pretreatment technique. These results are encouraging in that they show the potential of the technique to produce reliable radiocarbon age estimates for Middle and early Upper Paleolithic samples older than 50 kyrs. They are also among the first reliably finite radiocarbon dates obtained from Middle Paleolithic layers in Greece.

Evaluation of ABOX results

The application of ABOX pre-treatment to the Middle and Upper Paleolithic wood charcoal samples from Klissoura 1 cave is relatively novel. The ABOX technique had not been widely applied to Paleolithic sites in Eurasia until very recently (e.g., Higham *et al*. 2009; Kuhn *et al*., 2009; Peresani *et al*., 2008). Results from Klissoura are encouraging in many respects, even if ABOX radiocarbon dating has not succeeded in resolving all of the problems associated with the chronology of the Middle-Upper Paleolithic transition and the earliest Upper Paleolithic in Eurasia.

One of the potential benefits of the ABOX technique is its potential for providing more accurate age estimates by removing more recent carbon contamination from samples than other techniques. This technical innovation promises to push the limits of radiocarbon dating significantly beyond the 50kyrs boundary. To evaluate the degree of improvement using the ABOX technique, one sample from layer III' was split into two aliquots: one was subject to ABOX pretreatment and the other to standard ABA treatment. ,This was the only sample large enough to be treated in this manner). The ABOX-treated fraction (AA 73821) provided an age estimate 31,460±210 ^{14}C yrs, whereas the fraction that underwent standard ABA pre-treatment yielded an age of 30,274±182 ^{14}C yrs.

A recent paper (Higham *et al*., 2009) details an experiment with a larger number of dates from Middle and Early Upper Paleolithic layers at the site of Grotta Fumane in northern Italy. The authors report a consistent "improvement" in ABOX-treated fractions of split radiocarbon sample. Their Aurignacian samples, which are slightly older than the one obtained from Klissoura, show similar discrepancies in ages (1000-3000 years) for the split samples. The greatest discrepancies, 5000-7000 years, occur in the Middle Paleolithic layers. This is a clear demonstration of the so-called "black hole" in radiocarbon dating, where as little as 1% contamination with recent carbon can shift age estimates for even infinite-aged samples to between 35 and 40 kyrs (Pigati *et al*., 2007). The fact that finite dates as early as 62kyrs were obtained from the Middle Paleolithic layers at Klissoura is a testament to the efficacy of the ABOX method in reducing contamination to << 1.0%.

Although the results from split samples from Klissoura and Fumane show the improvement in age estimates from ABOX pre-treatment, it is important to note that the age estimates for the other ABOX samples from Klissoura are not consistently older than dates on *associated* samples from layers III' and IIIe-g pre-treated using the conventional method (table 1). This result is not unexpected. As the results from Middle Paleolithic layers at Klissoura and Fumane show, the effect of more stringent sample pretreatment is most pronounced in the oldest samples. In other words, the degree of "improvement" in the comparatively recent (< 35 kyrs) ABOX-treated samples may not exceed the dispersal of ages or the two-sigma ranges for dates from a particular stratigraphic unit.

Finally, we note that fewer than half of the 23 samples selected for ABOX processing, and none of the samples from layer V, actually survived the pre-treatment process. Interestingly, however, all of the samples subject to ABOX pretreatment had previously been identified as wood charcoal based on microscopic features such as cell structure—in most cases it was even possible to assign a charcoal sample to a particular genus (Ntinou, this volume). Sample destruction by pretreatment may therefore be evidence of *in situ* diagenetic alteration of graphite (Cohen-Ofri *et al*., 2006) in which the crystalline structure is altered while the macro-structure is preserved.

Comparisons to other sites

Table 2 presents a series of radiocarbon ages from selected early Upper Paleolithic sites in southern and south-central Europe. No other dated Upper Paleolithic materials from Greece is comparable to the Klissoura 1. The so-called Initial Upper Paleolithic at Lakonis Cave differs significantly from both the Aurignacian and the Uluzzian at Klissoura 1 in terms of its technological and typological features. The same is true of the more recent Upper Paleolithic from Theopetra Cave. Sites in Italy and Bulgaria provide a better comparative basis, both in terms of the techno-typological characteristics of the assemblages and their chronology.

Generally speaking, the time span represented by the dates from the Aurignacian layers at Klissoura (27-33 KA) is consistent with the ages of Aurignacian levels at Bacho Kiro and Temnata Caves in Bulgaria. The sample of dates from Klissoura layer IV in particular fits well with results from the two Bulgarian sites. The Klissoura Aurignacian sequence as a whole appears to post-date the proto-Aurignacian from Italy, southern France, and Austria (table 2). The proto-Aurignacian is generally considered the earliest form of Aurignacian in southern Europe (e.g., Teyssandier, 2006). It is characterized by systematic production of numerous large, straight bladelets, which are often further modified with fine, marginal retouch. Retouched bladelets are scarce in the Klissoura Aurignacian, which is instead dominated by carenated elements, retouched flakes and blade tools. These techno-typological characteristics are more indicative of local variants of classic or late Aurignacian. Thus, it is not surprising that these levels post-date proto-Aurignacian layers elsewhere in southern Europe.

The age of layer V is of course more difficult to assess. Dates for Uluzzian assemblages in Italy in table 2 provide an interesting perspective on the possible age of layer V at Klissoura. Published radiometric ages for the Italian Uluzzian sites vary between roughly 29 and 36.5 ^{14}C kyrs BP. If the dates of 40-41.5 KY from layers V and VI actually belong to the first Upper Paleolithic occupation at Klissoura, and if the microtephras between layers IV and V prove to belong the Campanian Ignimbrite/Y5 eruption, then this assemblage would predate the earliest Uluzzian from Grotta del Cavallo in southern Italy and from layer A4 at Grotta Fumane, the Uluzzian site closest to Klissoura, by several thousand years. However, this discrepancy may also be more apparent than real. The published radiocarbon dates from the southern Italian Uluzzian sites were obtained using conventional pretreatment of charcoal, or from dating of carbonized bone, (Riel-Salvatore, 2007:94). Although the dating of apatite from burned bone is considered an acceptable procedure, it is subject to effects of contamination with recent atmospheric carbon associated with secondary calcites (Surovell, 2000). In other words, almost all of the dates in table 2 should be considered minimum age estimates, liable to being pushed back in time as new methodologies are applied. Even the recent dates from Grotta di Fumane (Higham *et al*., 2009; Peresani *et al*., 2008) are being reevaluated (M. Peresani, personal communication, 10/2009).

On the other hand, we cannot at present exclude the possibility that the charcoal samples from layers V and VI dating to > 40 ^{14}C kyrs actually belong to the terminal Middle Paleolithic at Klissoura, and that the microtephras at the top of layer V refer to a later eruption. In this case, we can be certain only that layer V predates layer IV, which yielded radiocarbon ages between 32,400±600 and 33,150±120 ^{14}C yrs BP. This hypothesis could place the age of layer V within the range of the recently reported results from layer A4 at Grotta Fumane, where three samples provided consistent age estimates between 33,150±350 and 33,700 ±600 ^{14}C yrs BP. At least some of the ages recently obtained for the Uluzzian at Grotta del Cavallo (table 2, Riel-Salvatore 2007) in southern-most Italy are substantially older. This interpretation could support a hypothesis of an early development of the Uluzzian in the south of the Italian peninsula, followed by an expansion into northern Italy and eventually Greece (e.g. Peresani 2008). However, evaluation of this or any other scenario must await application of more stringent and accurate dating, including methodologies such as ABOX pretreatment of charcoal and ultra-filtration of bone, as well as tephrachronological analyses, to as many sites as possible. Otherwise, we run the risk of comparing dates with fundamentally dissimilar levels of reliability and precision.

Summary

Radiocarbon results from the Klissoura Cave 1 sequence have greatly expanded the number of dates available for the early Upper Paleolithic in Greece With the exception of a few anomalously young determinations, the age estimates for the Aurignacian layers (IIIe-g and IV) are very consistent with dates from other classic or late Aurignacian sites in the Balkans region. In contrast, it has been remarkably difficult to arrive at a secure estimate for the age of layer V. The unique Uluzzian assemblage in layer V may date to more than 40 ^{14}C kyrs, seemingly much earlier than any comparable assemblage. This would have important implications for the origins and possible dispersal of early Upper Paleolithic assemblages with backed geometrics. More secure age estimates may come from ongoing analyses of microtephras from Klissoura.

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Figure captions

Figure 1: Radiocarbon ages from Klissoura 1 Cave. Horizontal bars = 1 sigma. Light gray hollow symbols denote problematic samples or minimum age estimates.

Figure 2: Calibrated radiocarbon ages from Klissoura 1 Cave. Horizontal bars = 1 sigma. Light gray hollow symbols denote problematic samples or minimum age estimates. (Note that the CalPal program does not provide calibrated ages beyond 50,000 radiocarbon years. Therefore the samples from layers XVII and XXc are plotted in the same position as in Figure 1).

material	lab	sample no.	method	pre-treatment	Layer	raw ^{14}C age	1s	CalPal ^{14}C age	sigma
C	Gd	11546	conventional	ABA	6a	22370	270	26974	611
S	Gd	7994	conventional		6a	23800	400	28732	511
S	Gd	7996	conventional		6a	27200	500	31901	435
C*	RTT	4793	AMS	ABA	6a upper	28600	350	33058	506
C*	RTT	4792	AMS	ABA	6a upper	29150	340	33577	400
C	Gd	15349	conventional	ABA	III'	23000	540	27566	690
C	AA	73821	AMS	ABOX	III'	31460	210	35381	416
C	Gd	15351	conventional	ABA	III"	24820	520	28583	675
C*	RTT	4788+	AMS	ABA	IIIe'	22270	160	26884	579
C*	RTT	4786	AMS	ABA	IIIg	30925	420	35052	444
C	Gd	7893	conventional	ABA	IIIg	31400	1000	35979	1250
C	AA	73817	AMS	ABOX	IIIe-g	31630	250	35548	472
C	Gd	7892	conventional	ABA	IIIe-g	34700	1600	39141	1869
C	Gd	9688+	conventional	ABA	IV	22500	1000	26889	1253
C	GdA	228	conventional	ABA	IV	31150	480	35232	506
C	Gd	10562	conventional	ABA	IV	32400	600	36920	980
C*	AA	75629	AMS	ABOX	IV/V	32690	110	37225	644
C*	AA	75628	AMS	ABOX	IV/V	33150	120	37655	613
C*	RTT	4790	AMS	ABA	V upper	29660	360	33914	373
C*	RTT	4791	AMS	ABA	V upper	30774	410	34957	438
C	Gd	10714	conventional	ABA	V	>30800	.	>34930	.
C	Gd	10715	conventional	ABA	V	>31100	.	>35098	.
C	Gif	99168	AMS	ABA	V	40100	740	43841	764
C*	AA	73819	AMS	ABOX	VI	40920	580	44433	841
C*	AA	73818	AMS	ABOX	VI	41480	810	44990	934
C*	AA	73820	AMS	ABOX	VII	48990	1770	53637	3135
C*	AA	75630	AMS	ABOX	XVIII	56140	1450	NA	.
C*	AA	75631	AMS	ABOX	XVIII	62290	3930	NA	.
C*	AA	75632	AMS	ABOX	XXc	60250	2700	NA	.

Table 1: Radiocarbon dates on charcoal and shell from Klissoura 1 Cave.
Key: Material: C= carbon, S= land snail; samples marked with * were identified as wood charcoal. Sample no.: samples marked with + showed very low carbon content, unreliable results. Pre-treatment: ABA= standard acid/base/acid; ABOX= step-heated wet oxidation. Laboratory abbreviations: AA = Arizona/NSF (USA); Gd= Gliwice (Poland); Gif = Gif sur Yvette (France); RTT= Weizmann Institute of Science (Israel).

Site	Industry	Layer	raw ^{14}C Age	sigma	CalPal ^{14}C Age	sigma	
Grotta del Cavallo 1	Uluzzian	EIII-2	34900	1900	39193	2084	
Grotta del Cavallo 1	Uluzzian	EIII-3	32300	2700	37202	2851	
Grotta del Cavallo 1	Uluzzian	EIII-4	36510	2300	40582	2246	
Grotta del Cavallo 1	Uluzzian	EIII-5	29063	1500	33498	1286	*
Castelcivita 2	Uluzzian	rsa	32400	650	36897	1019	
Castelcivita 2	Uluzzian	rpi	33300	430	37880	909	
Castelcivita 2	Uluzzian	pie	33200	780	38114	1517	
Fumane Cave 3	Uluzzian	A4II	33150	600	37736	1032	
Fumane Cave 3	Uluzzian	A4II	33300	400	37851	857	
Fumane Cave 3	Uluzzian	A4II	33700	350	36921	1287	
Grotta Paglicci 4	proto-Aurignacian	24Ai	29300	600	33587	555	
Grotta Paglicci 4	proto-Aurignacian	24Bi	34000	900	38940	1508	
Riparo Mochi 5	proto-Aurignacian	G	33400	750	38496	1645	
Riparo Mochi 5	proto-Aurignacian	G	34680	760	39769	1000	
Riparo Mochi 5	proto-Aurignacian	G	34870	800	39831	1020	
Riparo Mochi 5	proto-Aurignacian	G	35700	850	40431	1126	
Riparo Mochi 5	proto-Aurignacian	G base	37400	1	42070	293	
Riparo Bombrini 1	proto-Aurignacian	A1	32580	400	37106	790	
Riparo Bombrini 1	proto-Aurignacian	A1	33090	400	37560	778	
Riparo Bombrini 1	proto-Aurignacian	A2	34200	500	39586	939	
Grotta Paina 6	proto-Aurignacian	9	37900	800	42500	663	
Grotta Paina 6	proto-Aurignacian	9	38600	650	43038	688	
Fumane Cave 3	proto-Aurignacian	A2	32343	404	36870	859	*
Fumane Cave 3	proto-Aurignacian	A2	33672	857	38693	1623	*
Krems Hundsteig 7	proto-Aurignacian		34600	580	39787	901	
Grotte Mandrin 8	proto-Aurignacian		35000	1600	39403	1827	*
Bacho Kiro 9	Aurignacian	6a	29150	950	33417	819	
Bacho Kiro 9	Aurignacian	Base 7	32200	780	36701	1161	
Bacho Kiro 9	Aurignacian	Base 6b	32700	300	37219	710	
Bacho Kiro 9	Aurignacian	6b/8	33300	820	38351	1656	
Temnata 9	Aurignacian	TD-V-3g	>31500		>35400		
Temnata 9	Aurignacian	TD-V-3h	>32200		>32265		
Temnata 9	Aurignacian	TD-I-4	31900	1600	36706	1881	
Temnata 9	Aurignacian	TD-V 4	33000	900	37795	1456	
Lakonis Cave 10	Initial UP	1a	38240	1160	42806	921	
Lakonis Cave 10	Initial UP	1a	44500	2330	48352	2759	
Theopetra Cave 11	Upper Paleolithic	II11	25625	500	30596	617	
Theopetra Cave 11	Upper Paleolithic	II11	25820	270	30858	395	

Table 2: Selected radiocarbon dates from early Upper Paleolithic layers in southern Europe.

Sources: 1 - Riel Salvatore, 2007; 2 - Gambassini, 1997; 3 - Peresani *et al*., 2008; 4 - Gambassini *et al*., 1995; 5 - Hedges *et al*., 1994; 6 - Broglio, 1994; 7 - Kozłowski, 2000; 8 - Slimak, 2008; 9 - Kozłowski, 2006; 10 - Panagopoulou *et al*., 2002-2004; 12 - Karkanas, 2001. (*) Indicates weighted average of several determinations.

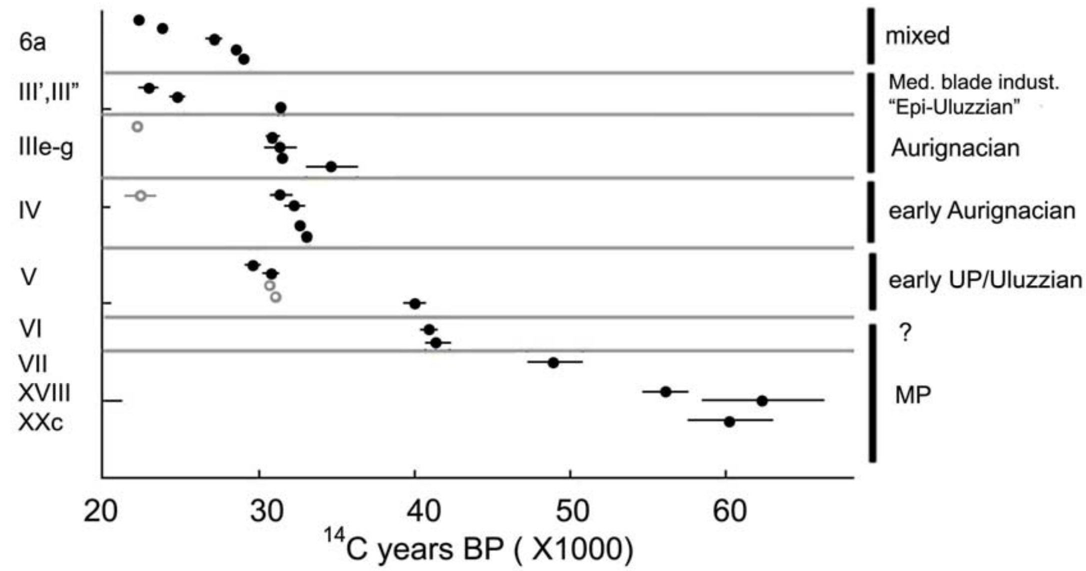

Figure 1

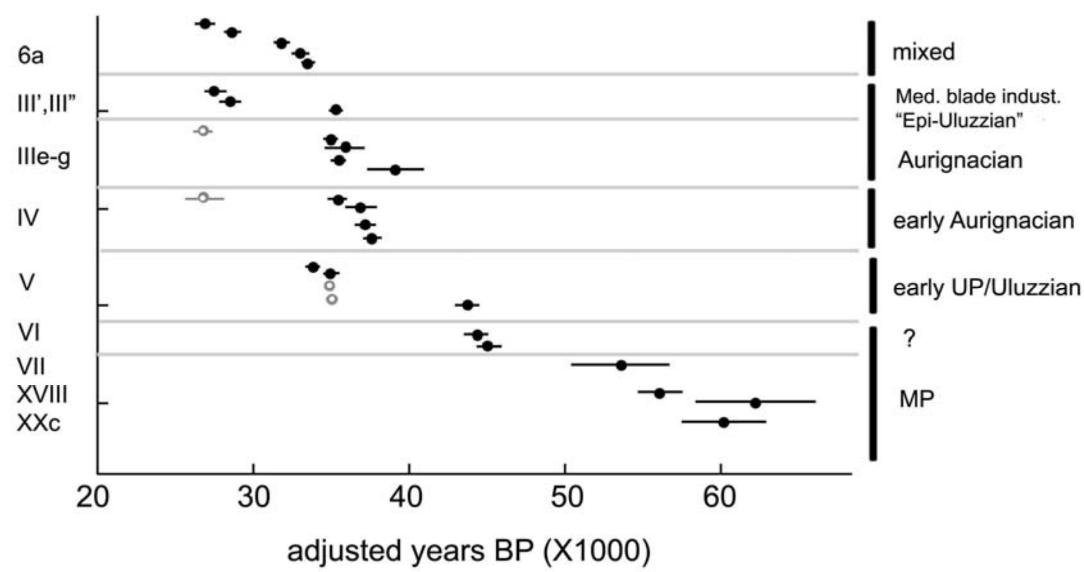

Figure 2