**Supplementary Table 1: Compilation of AMS radiocarbon data published for Late Middle Palaeolithic levels of archaeological sites in Iberian caves and rock shelters.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  | **14C yr BP**  | **std. dev.** | **Cal yr BP; 95.4%-interval** |  |  |  |  |  |  |
|  |  |  |  | **from** | **to** |  |  |  |  |  |  |
| Abric Romani | NzA-2312 | 43500 | 1200 | 49589 | 45005 | charcoal |  | B | MO | Vaquero, 1997; Carbonell et al., 2000 | LMP before ~42 ka cal BP |
|  | NzA-2313 | 40600 | 900 | 45858 | 42805 | charcoal |  | D | MO | ditto |
|  | OxA-12025 | 39060 | 350 | 43467 | 42390 | charcoal | AF | B | MO | Camps and Higham, 2012 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Antón, Cueva | OxA-20882 | 31070 | 170 | 35370 | 34606 | charcoal | ZR | I-k  | MO | Zilhao et al., 2016 | LMP between ~35.5 and ~37 ka cal BP, but layer I-k yielded low number of artefacts  |
|  | OxA-26346 | 31790 | 270 | 36259 | 35077 | charcoal | XR | I-k top  | MO | ditto |
|  | OxA-22625 | 32330 | 250 | 36860 | 35635 | charcoal | XR | I-k base  | MO | ditto |
|  | OxA-22019 c | 32390 | 280 | 37129 | 35611 | charcoal | XR | II-a  | AS | ditto | Ages providing terminus post quem are overlapping  |
|  | OxA-20881 c | 31150 | 170 | 35455 | 34666 | charcoal | ZR | II-b  | AS | ditto |
|  | OxA-21244 c | 32890 | 200 | 37731 | 36319 | charcoal | XR | II-b  | AS | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Arbreda | AA-3777 | 34100 | 750 | 40345 | 36570 | charcoal | ABA | I | MO | Soler Subils et al., 2008 | Timing of LMP is unclear, because of high variability of dating results and overlap with dates for Proto-Aurignacian level H. Dates on bone tend to be younger than dates on charcoal. Independent age control is needed. |
|  | AA-3776 | 39400 | 1400 | 46400 | 41416 | charcoal | ABA | I | MO | ditto |
|  | AA-3778 | 41400 | 1600 | 48813 | 42682 | charcoal | ABA | I | MO | ditto |
|  | OxA-19994 | 38350 | 400 | 43017 | 41926 | charcoal  | XR | I | MO | Maroto et al., 2012 |
|  | OxA-3731 | 44560 | 2400 | ... | 44947d | bone | AI | I | MO | Soler Subils et al., 2008 |
|  | OxA-21663e | 32100 | 450 | 37331 | 34990 | bone | AF\* | I | MO | Wood et al., 2014 |
|  | OxA-21703e | 32300 | 450 | 37710 | 35220 | bone | AF\* | I | MO | ditto |
|  | OxA-21704 | 39200 | 1000 | 45029 | 41825 | bone | AF\* | I | MO | ditto |
|  | OxA-21702 | 44400 | 1900 | ... | 45310d | bone | AF\* | I | MO | ditto |
|  | OxA-21662 | 37300 | 800 | 42968 | 40353 | bone | AF\* | I | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Arrillor | OxA-21986f | 44900 | 2100 | ... | 45488d | bone | AF | Lmc | MO | Higham et al, 2014 | LMP before ~45 ka cal BP.  |
|  | OxA-22654 | <46800 |  |  |  | bone | AF | Lamc | MO | ditto |
|  | OxA-22655f | 45600 | 2300 | ... | 45779d | bone | AF | Lamc | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Beneito, Cova | Gif-TAN-89229 | 25750 | 410 | 30830 | 29038 | charcoal |  | D3 | MO | Iturbe and Cortell, 1987, 1992; Zilhão, 2006 | Large scatter of data placing the LMP to in between 29 and 48 ka cal BP. Inconsistencies in stratigraphy likely (cf. Zilhão, 2006) |
|  | GifA-89283  | 30160 | 680 | 35692 | 32946 | charcoal |  | D1 | MO | ditto |
|  | AA-1387  | 38800 | 1900 | 47860 | 40060 | charcoal |  | D1 | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Boquete de Zafarraya | OxA-8411 | 26300 | 440 | 31160 | 29540 | tooth  | AG | D, UE, (Z6d) | MO | Barroso Ruíz, de Lumley, 2006; Zilhão, 2006 | Although lots of effort has been spent to date the LMP at Boquete, its timing remains unclear. Recent chronological studies suggest MO occupation before ~33.65 ka cal BP (Michel et al., 2013) or before ~46 ka cal BP (Wood et al., 2013) |
|  | OxA-8024 | 30200 | 460 | 35111 | 33531 | tooth  | AG | D, UD, (Z4d) | MO | ditto |
|  | OxA-8999 | 33300 | 1200 | 40654 | 35105 | bone | AG | D, UE, (Z8b) | MO | Michel et al., 2013 |
|  | OxA-9000 | 30650 | 650 | 36052 | 33650 | bone | AG | D/E, UF, (Z69b) | MO | ditto |
|  | OxA-9001 | 36700 | 1400 | 43959 | 38647 | charcoal | ZR | D, UE (199) | MO | ditto |
|  | OxA-9002 | 34600 | 800 | 41114 | 37162 | charcoal | ZR | D, UE (217) | MO | ditto |
|  | OxA-23198 | >46700 |  |  |  | bone | AF | D, UE, (Z8os) | MO | Wood et al., 2013 |
|  | OxA-26440 | >46700 |  |  |  | bone | AF\* | D, UE, (Z8os) | MO | ditto |
|  | OxA-21810 | 46300 | 2500 | ... | 46036d | bone | AF | D, UE (ZAF2) | MO | ditto |
|  | OxA-21813 | >49300 |  |  |  | bone | AF\* | D/E, UF (ZAF7) | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Boja, Abrigo de la | VERA-5899 | 46500 | +2400/-1800 | ..d | …d | charcoal |  | OH22/2013-384 | MO | Zilhão et al., 2017 | LMP before ~44 ka cal BP |
|  | VERA-5900 | 46900 | +2400/-1800 | ..d | …d | charcoal |  | OH22/2013-330 | MO | ditto |  |
|  | VERA-5899 | 46500 | +2400/-1800 | ..d | …d | charcoal |  | OH23/2013-258 | MO | ditto |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Caldeirão, Gruta do | OxA-1941 | 27600 | 600 | 33189 | 30749 | bone  | AC | K top | MO | Zilhão, 2001 | Samples OxA-5521 and OxA-8670 are probably not reliable due to poor collagen yields (Wood et al., 2013). Timing of LMP still unclear. |
|  | OxA-5521 | 23040 | 340 | 27835 | 26560 | bone  | AI | K base (K5) | MO | ditto |
|  | OxA-8670 | 25220 | 200 | 29782 | 28777 | boneg | RR | K | MO | Zilhão, 2006 |
|  |  |  |  |  |  |  |  |  |  |  |  |

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| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Galería de las Estatuas | Beta-247626  | >45000 |  |  |  | bone |  | GE-1 LU1 | MO | Arsuaga et al., 2017 | LMP before ~45 ka cal BP.  |
|  | OxA-21523  | 43500 | 1800 | … | 45055d | bone | AF | GE-1 LU1 | MO | ditto |  |
|  | Beta-247627  | >45000 |  |  |  | bone |  | GE-1 LU2 | MO | ditto |  |
|  | OxA-21524  | >45600 |  |  |  | bone | AF | GE-1 LU2 | MO | ditto |  |
|  | Beta-247628  | >45000 |  |  |  | bone |  | GE-1 LU3 | MO | ditto |  |
|  | OxA-21525  | 44000 | 1900 | … | 44992d | bone | AF | GE-1 LU3 | MO | ditto |  |
|  | OxA-24563  | 44200 | 2000 | … | 44669d | bone | AF | GE-2 LU1b | MO | ditto |  |
|  | OxA-24564  | >46300 |  |  |  | bone | AF | GE-2 LU2 | MO | ditto |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Castillo,El | GifA-89144 | 39300 | 1900 | 48261 | 40664 | charcoal |  | 20 (B2) | MO | Soto-Barreiro, 2003; Zilhão, 2006 | LMP before ~40.7 ka cal BP, if all datings are considered reliable. Bone dating with ultrafiltration yielded ages larger than 49.8 ka cal BP |
|  | GifA-92506 | 43300 | 2900 | ... | 43567d | charcoal |  | 20 (B2) | MO | Zilhão, 2006 |
|  | OxA-22204 | 48700 | 3400 | ... | 49844d | bone | AF\* | 20C | MO | Wood et al., in press |
|  | OxA-22205 | 49400 | 3700 | ... | 49875d | bone | AF\* | 20C | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Conde (Forno), Cueva del | Beta-224302 | 29750 | 300 | 34480 | 33379 | bone |  | N20A | MO | Uzquiano Ollero et al., 2008 | Due to large scatter of dates, timing of the LMP is still unclear. Independent age control desirable.  |
|  | Beta-230416 | 37710 | 470 | 42718 | 41391 | charcoal  |  | N20A | MO | ditto |
|  | Beta-210572 | 38250 | 390 | 42940 | 41875 | bone |  | N20A | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Cova Gran  | Beta-224299 | 38640 | 440 | 43281 | 42047 | charcoal | AAA | 1B | MO  | Martínez-Moreno et al., 2010 | The sample from the uppermost LMP level 1B yielded a higher radiocarbon age than those from underlying levels 1C and 1D. Timing of the LMP unclear. |
|  | Beta-195430 | 32000 | 300 | 36521 | 35198 | charcoal | AAA | 1C | MO  | ditto |
|  | Beta-187423 | 32180 | 430 | 37415 | 35105 | charcoal | AAA | 1D | MO  | ditto |
|  | Beta-207575 | 32260 | 490 | 37774 | 35110 | charcoal | AAA | 1D | MO  | ditto |
|  | Beta-195431 | 33090 | 350 | 38327 | 36362 | charcoal | AAA | 1D | MO  | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Covalejos  | GrA-33811 | 43050 | 750 | 48157 | 45005 | tooth | L | I | MO  | Maroto et al., 2012 | One date only. |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Cuco, El | OxA-27196  | 42350 | 700 | 47211 | 44471 | Shell  | OX | X  |  | Gutierrez-Zugasti et al., in press | Cultural attribution of lithics was re-evaluated and new datings were presented, placing the sequence into the LMP, dated to before ~44.5 ka cal BP. |
|  | OxA-27115  | 46200 | 650 | ... | 48328d | Shell  | OX | X  |  | ditto |
|  | Beta-382681  | >43,500  |  |  |  | Shell  |  | XII  | MO | ditto |
|  | OxA-30851  | 46400 | 800 | ... | 48227d | Shell  | OX | XIII  | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  |  |  |  |  |  |  |  |  |
| Ermitons, Cueva de los | OxA-3725 | 33190 | 600 | 38886 | 36026 | bone |  | IV | MO  | Maroto, 1993; Zilhão, 2006 | The new dating study suggests an earlier time of MO occupation probably before ~43 ka cal BP.  |
|  | GrA-33813 | 40580 | 550 | 45167 | 43182 | tooth  | L | IV | MO  | Maroto et al., 2012 |
|  | GrA-33814 | >45000 |  |  |  | bone  | L | IV | MO  | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Esquilleu, Cueva del | AA-29664 | 12050 | 130 | 14264 | 13563 | bone |  | III | MO | Zilhão, 2006; Jordá Pardo et al., 2008 | Although ultrafiltration has been employed, bone from level III gave very young 14C ages. The same applies for charcoal from levels IV and V, but these samples were run with a mild pretreatment only and it is uncertain, if all contaminants were eliminated. From level VI downwards, the majority of samples date the MO occupation to before ~42.5 ka cal BP. Since a lot of scatter remains, the timing of the uppermost LMP at Esquilleu is still unclear.  |
|  | OxA-19967 | 19300 | 100 | 23546 | 22950 | bone  | AF | III | MO | Maroto et al., 2012 |
|  | OxA-19968 | 19310 | 80 | 23528 | 22984 | bone | AF | III | MO | ditto |
|  | OxA-19246 | 20810 | 110 | 25446 | 24637 | bone | AF | III B | MO | ditto |
|  | GrA-35064 | 22840 | 280 | 27636 | 26505 | charcoal | A | IV | MO | ditto |
|  | GrA-35065  | 30250 | 500 | 35286 | 33508 | charcoal | A | V | MO | ditto |
|  | AA-37883 | 34380 | 670 | 40539 | 37068 | charcoal |  | VI | MO | Zilhão, 2006; Jordá Pardo et al., 2008 |
|  | GrA-33816 | 40110 | 500 | 44690 | 42924 | charcoal | ABA | VI | MO | Maroto et al., 2012 |
|  | OxA-19965f | 43700 | 1400 | 49885 | 45135 | bone | AF | VI | MO | ditto |
|  | OxA-19966f | 44100 | 1300 | 49948 | 45602 | bone | AF | VI | MO | ditto |
|  | AA-37882 | 36500 | 830 | 42471 | 39524 | charcoal |  | XIf | MO | Zilhão, 2006; Jordá Pardo et al., 2008 |
|  | Beta-149320 | 39000 | 300 | 43325 | 42415 | charcoal |  | XIII | MO | ditto |
|  | OxA-20318 | 53400 | 1300 | 56647 | 51095 | charcoal | XR | XVII | MO | Maroto et al., 2012 |
|  | OxA-20319 | >58600 |  |  |  | charcoal | XR | XVII | MO | ditto |
|  | OxA-X-2297-31 | 49400 | 1300 | 52647 | 47095 | charcoal | XR | XVII | MO | ditto |
|  | OxA-20320 | 52600 | 1200 | 55529 | 50459 | charcoal | XR | XVII | MO | ditto |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Fuentes de San Cristobal | OxA-8589 | 27200 | 1000 | 33735 | 29465 | charcoal | RR | O | ? | Zilhão, 2006 | The first set of samples stems from levels O and P with uncertain cultural attribution (Zilhão, 2006; Maroto et al., 2012). The dating study by Maroto et al. (2012) yielded ages older than ~41 ka cal BP for the typologically well constrained levels E and F.  |
|  | OxA-8524 | 36050 | 550 | 41755 | 39575 | charcoal | RR | O | ? | ditto |
|  | OxA-8590 | 36000 | 1900 | 45026 | 36567 | charcoal | RR | P | MO? | ditto |
|  | OxA-19145 | 38650 | 600 | 43663 | 41860 | charcoal | ZR | E | MO | Maroto et al., 2012 |
|  | GrA-33817 | 39290 | 490 | 44024 | 42399 | charcoal | ZR | F | MO | ditto |
|  | GrA-33904 | 37330 | 490 | 42531 | 41018 | charcoal | ZR | F | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |

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| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Gorham’s Cave  | Beta-196785 | 26070 | 360 | 30963 | 29488 | charcoal | ABA | IV | MO? | Finlayson et al., 2006 | The young radiocarbon dates reported by Finlayson et al. (2016) for level IV have been subject to strong debate concerning sedimentological cultural attribution of finds, and pretreatment technique. Previous studies suggested that MO occupation at Gorham's cave date back to before ~33.7 ka cal BP (OxA-8541), which acc. to Zilhão (2006), stems from the uppermost securely Middle Palaeolithic levels (CON 19 and 18). Except of OxA-7979, all other dates for these and underlying levels were older than ~43.8 ka cal BP.  |
|  | Beta-185344 | 27020 | 480 | 32197 | 30205 | charcoal | ABA | IV | MO? | ditto |
|  | Beta-196784 | 28360 | 480 | 33515 | 31335 | charcoal | ABA | IV | MO? | ditto |
|  | OxA-10230 | 32330 | 390 | 37552 | 35370 | charcoal | RR | IV | MO | Pettitt et al., 2000; Zilhão, 2006 |
|  | OxA-10295 | 34600 | 900 | 41263 | 36942 | charcoal  | RR | trench 7 | MO | ditto |
|  | OxA-7857 | 32280 | 420 | 37573 | 35246 | charcoal | RR | CON 16 | MO | ditto |
|  | OxA-205 | 47900 | 2100 | ... | 49893d | charcoal |  | CON 18 | MO | ditto |
|  | OxA-7979 | 23800 | 600 | 29343 | 26965 | charcoal | RR | CON 18 | MO | ditto |
|  | OxA-7791 | 42200 | 1100 | 48313 | 43701 | charcoal | RR | CON 18  | MO | ditto |
|  | OxA-8541 | 31900 | 1400 | 39994 | 33688 | charcoal | RR | CON 19 | MO | ditto |
|  | OxA-8542 | 42800 | 2100 | ... | 43786d | charcoal  | RR | CON 19 | MO | ditto |
|  | OxA-8525 | 43800 | 1300 | 49838 | 45280 | charcoal | RR | CON 19 | MO | ditto |
|  | OxA-8526 | 46700 | 1900 | ... | 49637d | charcoal | RR | CON 19 | MO | ditto |
|  | OxA-6075 | 45300 | 1700 | ... | 46139d | charcoal  | ZR | CON 22 | MO | ditto |
|  | OxA-7790  | 51700 | 3300 | ... | 49963d | charcoal  | RR | CON 22d | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Güelga, Abrigo de la | Beta-172343 | 32460 | 440 | 37935 | 35464 | bone | CE | 1 (D int.) | CH? | Menéndez Fernández et al., 2005 | The presumably Châtelperronian levels 1, 2 (interior), 4a and 4b (exterior), were originally dated to between 32.5 to 37.9 ka cal BP. A bone from level 2 has been recently dated to 41.4 to 46.5 ka cal BP. The MO occupation took place before 45.5 ka cal BP. Age underestimation of the Beta-samples is likely. |
|  | Beta-172344 | 30210 | 340 | 34833 | 33725 | bone | CE | 2 (D int.) | CH? | ditto |
|  | Beta-172345 | 29950 | 310 | 34622 | 33576 | bone | CE | 4a (D ext.) | CH? | ditto |
|  | Beta-186766 | 29020 | 260 | 33800 | 32518 | bone | CE | 4b (D ext.) | CH? | ditto |
|  | COL2014 | 37429 | 302 | 42324 | 41399 | bone | CE | 2 (D int.) | CH? | Menéndez et al., 2014 |
|  | OxA-27958 | 40300 | 1200 | 46461 | 42273 | bone | AF | 2 (D int.) | CH? | Higham et al., 2014 |
|  | OxA-20122 | 47400 | 2700 | ... | 49734d | bone | AF | 4b (D ext.) | MO | Quesada López, Menéndez Fernández, 2009 |
|  | OxA-20124 | 48500 | 3500 | ... | 49814d | bone | AF | 4b (D ext.) | MO | ditto |
|  | OxA-19244f | 43700 | 800 | 48989 | 45498 | bone | AF | 9 (D int.) | MO | ditto |
|  | OxA-19245f | 44300 | 1200 | 49950 | 45854 | bone | AF | 9 (D int.)  | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |

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| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Higueral de, Sierra Valleja, Cueva del | OxA-12270 | 20780 | 80 | 25355 | 24665 | charcoal  | ZR | V | MP | Jennings et al., 2009 | Several inconsistencies exist between 14C and luminescence dating results. For example the uppermost 14C sample is very young and much younger than the OSL age estimates for overlying layer IV. More dates are necessary to define the timing of the LMP at this site.  |
|  | OxA-12362 | 32840 | 210 | 37687 | 36265 | charcoal  | ZR | VI | MP | ditto |
|  | OxA-12271 | 33950 | 200 | 38911 | 37905 | charcoal  | ZR | VII | MP | ditto |
|  | OxA-12272 | 37220 | 290 | 42178 | 41255 | charcoal  | ZR | VII | MP | ditto |
|  | OxA-13280 | 52400 | 2100 | 59080 | 48804 | charcoal  | RR | VIII | MP | ditto |
|  | OxA-13279 | 56800 | 2900 | 69191 | 52141 | charcoal  | RR | VIII | MP | ditto |
|  | OxA-13417 | >42900 |  |  |  | charcoal  | ZR | VIII | MP | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Jarama VI  | Beta-56640 | 23380 | 500 | 28590 | 26605 | charcoal |  | JVI.1 | MO | Jordá et al., 2007 | New radiocarbon ages and luminescence age estimates fort he seuence at Jarama strongly suggests that the previous Beta 14C ages age underestimated the time of occupation (cf. Wood et al. 2013, Kehl et al. 2013). The MO occupation most probably ended before 50 ka cal BP.  |
|  | Beta-56639 | 32600 | 1860 | 41956 | 33750 | charcoal |  | JVI.2 | MO | ditto |
|  | Beta-56638 | 29500 | 2700 | 43915 | 29049 | charcoal |  | JVI.3 | MO | ditto |
|  | OxA-21714 | >50200 |  |  |  | bone | AF | JVI.1 | MO | Wood et al. 2013 |
|  | OxA-X-2310-22 | 49400 | 3700 | ... | 49875d | bone | AF | JVI.2.2 | MO | ditto |
|  | OxA-X-2290-56 | >47000 |  |  |  | bone | AF | JVI.3 | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Labeko Koba | Ua-3034 | 26575 | 505 | 31449 | 29602 | bone |  | IX upper | ? | Arrizabalaga, 2000 | Level IX is represented by very poor assemblages. The Châtelperronian occupation at labeko Koba probably occurred before 40.5 ka cal BP |
|  | Ua-3325 | 29750 | 700 | 35339 | 32214 | bone |  | IX upper | ? | ditto |
|  | Ua-3324 | 34215 | 1265 | 41635 | 36049 | bone |  | IX lower | CH | ditto |
|  | OxA-22563 | 37800 | 900 | 43665 | 40637 | bone | AF | IX lower | CH | Wood et al., 2014 |
|  | OxA-22562  | 38100 | 900 | 43990 | 41010 | bone | AF | IX lower | CH | ditto |
|  | OxA-22561 | 38000 | 900 | 43890 | 40886 | bone | AF | IX lower | CH | ditto |
|  | OxA-22560 | 37400 | 800 | 43046 | 40446 | bone | AF | IX lower | CH | ditto |
|  | OxA-22564 | 37900 | 900 | 43782 | 40762 | bone | AF\* | IX lower | Pre-CH | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Lezetxiki | OxA-22021 | 29250 | 320 | 34045 | 32681 | bone  | AF | III | AU/MO | Maroto et al., 2012 | Level III represents a mixed assemblage. Datings are either between 32.7 and 39.4 ka cal BP (expected for Aurignacian) or > 46.5 ka (Mousterian) |
|  | OxA-21838 | 30830 | 380 | 35567 | 34078 | bone  | AF | III | AU/MO | ditto |
|  | OxA-21837 | 34550 | 100 | 39416 | 38675 | bone | AF | III | AU/MO | ditto |
|  | OxA-21715 | >46500 |  |  |  | bone | AF | III | AU/MO | ditto |
|  | OxA-22627 | >46700 |  |  |  | bone | AF | III | AU/MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Los Casares | COL4208.1.1 | 39494 | 850 | 44899 | 42175 | charcoal | AAA | c | MO | Alcaraz-Castaño et al., 2017 | One radiocarbon date only but backed by terminus post quem from layer d |
|  | U/Th, S3 | 48052 | 187 |  |  | calcite |  | d0 | AS | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Mirón, El  | GX-27112 | 41280 | 1120 | 47269 | 42951 | charcoal |  | W10 (130) | MP | Straus et al., 2002 | One radiocarbon date only  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Morín, Cueva  | GrA-33823 | 29380 | 260 | 34038 | 32975 | charcoal |  | 10 | CH | Maroto et al., 2012 | Timing of CH is still unclear. The MO probably dates to >44 ka cal BP  |
|  | GifA-92263 | 36590 | 770 | 42432 | 39734 | charcoal |  | 10 | CH | Zilhão, 2006 |
|  | OxA-19083 | 41800 | 450 | 46022 | 44406 | charcoal | ZR | 11 | MO | Maroto et al., 2012 |
|  | OxA-19459f | 43600 | 600 | 48343 | 45648 | charcoal | XR | 11 | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Moros de Gabasa | Gr-12809 | 46500 | 4400 | ... | 48661d | charcoal |  | e | MO | Blasco et al., 1996; Montes et al., 2001 | One radiocarbon date only  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Oliveira, Gruta da  | GrA-10200 | 31900 | 200 | 36255 | 35325 | boneg |  | 8 | MO | Zilhão, 2001 | 14C on burnt bone is unreliable, but data are in broad agreement with independent age control (Hoffmann, 2013). It remains unclear, if level 8 documents one of the latest occupation by Mousterian culture |
|  | OxA-8671 | 32740 | 420 | 38205 | 35880 | boneg | RR | 8 | MO | ditto |
|  | GrA-9760 | 38390 | 480 | 43169 | 41855 | boneg |  | 9 | MO | ditto |
|  | Beta-111967 | 40420 | 1220 | 46658 | 42323 | boneg |  | 9 | MO | ditto |
|  | OxA-8672 | 42900 | 120 | 46510 | 45640 | boneg  | RR | 11 | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Sima de las Palomas  | OxA-10666 | 34450 | 600 | 40514 | 37459 | bone | ZR | 2e | MO | Zilhão, 2006 | 14C on burnt bone is unreliable. U series and luminescence dates for the site are in broad agreement with 14C. More data needed. |
|  | OxA-15423 | 35030 | 270 | 40230 | 38888 | boneg  | ZR | 2l | MO | Walker et al., 2008 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Roca dels Bous | Ua-21494 | 16515 | 145 | 20300 | 19559 | bone |  | N 10 | MO | Martínez-Moreno et al., 2006 | The two Ua ages are the youngest recorded for the Mousterian of this compilation. It is highly likely that they are erroneous. |
|  | Ua-21493 | 18110 | 170 | 22379 | 21524 | bone |  | R3 | MO | ditto |
|  | AA-6481 | 38800 | 1200 | 45286 | 41234 | charcoal |  | R3 | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Sopeña, Abrigo de  | GrA-39761 | 35500 | 650 | 41459 | 38784 | bone  | L | XII | MO | Maroto et al., 2012 | One radiocarbon date only  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Name of site** | **Lab code** | **Convent.age**  | **Calibrated age**  | **Material** | **Treat-ment a** | **Layer/****sample** | **Culture b** | **References** | **Comment** |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Valiña, A  | GrA-3014  | 31600 | 250 | 36072 | 34936 | bone |  | III | MO | Zilhão, 2006 | One radiocarbon date only  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Viña, La  | GifA-99231 | 37700 | 590 | 42901 | 41198 | charcoal |  | XIII basal | MO | Fortea Pérez, 2001 | Most datings suggest occupation before 48 ka BP. Sample GifA 95550 from the interface of Mousterian and AU layer was excluded. |
| Viña, La  | GifA-99230 | 48100 | 1600 | ... | 49945d | charcoal |  | XIII basal | MO | ditto |
| Viña, La  | OxA-19144 | >59300 |  |  |  | charcoal | ZR | XIII basal | MO | Wood et al., 2014 |
| Viña, La  | OxA-19196 | >62000 |  |  |  | charcoal | XR | XIII basal | MO | ditto |
|  |  |  |  |  |  |  |  |  |  |  |  |

a Codes for technocomplexes: MO, Mousterian; MP, Middle Paleolithic; CH, Châtelperronian; AU, Aurignacian; AS, Archaeologically sterile.

b Codes for laboratorypretreatment: AAA, acid-acid-acid; ABA, acid-base-acid; AF, collagene extract with ultrafiltration (Brock et al., 2010); AF\*,ditto with additional solvent treatment; RR, AAA treatment for carbonised residues (Brock et al., 2010); ZR, ABA (Brock et al., 2010); XR, ABOx-SC (Brock et al., 2010); L, bone collagene extraction (Maroto et al., 2012); AI and AC, as indicated in https://c14.arch.ox.ac.uk/database/db.php; A, acid only (for small delicate samples); CE, collagen extract; OX, dating of shells in vacuo with phosphoric acid (Brock et al., 2010).

c Samples providing terminus post quem for overlying layer.

d Denotes a calibrated date which may extend beyond the limit of the calibration curve (IntCal13).

e Measured on the same bone, and identified as statistical outliers by Bayesian modelling (Wood et al., 2014).

f Datings included in the pdf of ages suggested to represent the end of the LMP in Cantabrian Spain (Higham et al., 2014)

g Radiocarbon dating of burnt bone samples is suspected to be unreliable (Wood et al., 2013)

**References:**

Alcaraz-Castaño, M., Alcolea-González, J., Kehl, M., Albert, R.-M., Baena-Preysler, J., Balbín-Behrmann, R. de, Cuartero, F., Cuenca-Bescós, G., Jiménez-Barredo, F., López-Sáez, J.-A., Piqué, R., Rodríguez-Antón, D., Yravedra, J., Weniger, G.-C., 2017. A context for the last Neandertals of interior Iberia: Los Casares cave revisited. *PLoS ONE* 12, e0180823.

Arrizabalaga, Á., 2000. El yacimiento arqueológico de Labeko Koba (Arrasate, País Vasco). Entorno. Crónica de las investigaciones. Estratigrafía y estructuras. Cronología absoluta. In: Arrizabalaga, Á., Altuna, J. (Eds.), Labeko Koba (País Vasco). Hienas y humanos en los albores del Paleolítico superior. *Munibe*, vol. 52. Sociedad de Ciencias Naturals Aranzadi, San Sebastián, pp. 15−72.

Arsuaga, J.L., Gómez-Olivencia, A., Sala, N., Martínez-Pillado, V., Pablos, A., Bonmatí, A., Pantoja-Pérez, A., Lira-Garrido, J., Alcázar de Velasco, Almudena, Ortega, A.I., Cuenca-Bescós, G., García, N., Aranburu, A., Ruiz-Zapata, B., José Gil-García, M., Rodríguez-Álvarez, X.P., Ollé, A., Mosquera, M., 2017. Evidence of paleoecological changes and Mousterian occupations at the Galería de las Estatuas site, Sierra de Atapuerca, northern Iberian plateau, Spain. *Quaternary Research* 88, 345-367.

Barroso Ruíz, C., de Lumley, H., 2006. La Grotte du Boquete de Zafarraya (Malaga, Andalousie), Vol. IeIII. Junta de Andalucía, Consejería de Cultura, Sevilla.

Blasco, M.F., Montes, L., Utrilla, P., 1996. Deux modèles de strategie occupationelle dans le Moustérien Tardif de la vallée de l’Ebre: les grottes de Pena Miel et Gabasa. In: Carbonell, E., Vaquero, M. (Eds.), *The Last Neandertals, The First Anatomically Modern Humans*. Universitat Rovira i Virgili, Tarragona, pp. 289−313.

Camps, M., Higham, T., 2012. Chronology of the Middle to Upper Palaeolithic transition at Abric Romaní, Catalunya. *Journal of Human Evolution* 62, 89−103.

Carbonell, E., Vaquero, M., Maroto, J., Rando, J., Mallol, C., 2000. A geographic perspective on the Middle to Upper Paleolithic transition in the Iberian Peninsula. In: Bar-Yosef, O., Pilbeam, D. (Eds.), *The Geography of Neandertals and Modern Humans in Europe and the Greater Mediterranean*. Peabody Museum Bulletin 8. Harvard University, Cambridge, pp. 5−34.

Finlayson, C., Giles Pacheco, F., Rodríguez-Vidal, J., Fa, D.A., Gutierrez López, J.M., Santiago Pérez, A., Finlayson, G., Allueé, E., Baena Preysler, J., Cáceres, I., Carrión, J.S., Fernández Jalvo, Y., Gleed-Owen, C.P., Jimenez Espejo, F., López, P., López Sáez, J.A., Riquelme Cantal, J.A., Sánchez Marco, A., Giles Guzman, F., Brown, K., Fuentes, N., Valarino, C.A., Villalpando, A., Stringer, C.B., Martinez Ruiz, F., Sakamoto, T., 2006. Late survival of Neanderthals at the southernmost extreme of Europe. *Nature* 443, 850−853.

Fortea Pérez, J., 2001. El Paleolitico superior en Galicia y Asturias (1996e2000). In: *Le Paléolithique Supérieur Européen. Bilan Quinquennal* 1996-2001. Commission VIIIeXIVe Congrès UISPP (Liège, 2e8 Septembre 2001). ERAUL (Études et recherches archéologiques de l’Université de Liège), vol. 97. Université de Liège, Liège, pp. 149−160.

Gutiérrez-Zugasti, I., Rios-Garaizar, J., Marín-Arroyo, A.B., Rasines del Río, Pedro, Maroto, J., Jones, J.R., Bailey, G.N., Richards, M.P., in press. A chrono-cultural reassessment of the levels VI–XIV from El Cuco rock-shelter: A new sequence for the Late Middle Paleolithic in the Cantabrian region (northern Iberia). *Quaternary International*, 10.1016/j.quaint.2017.06.059.

Higham, T., Douka, K., Wood, R., Ramsey, C.B., Brock, F., Basell, L., Camps, M., Arrizabalaga, A., Baena, J., Barroso-Ruiz, C., Bergman, C., Boitard, C., Boscato, P., Caparros, M., Conard, N.J., Draily, C., Froment, A., Galvan, B., Gambassini, P., Garcia-Moreno, A., Grimaldi, S., Haesaerts, P., Holt, B., Iriarte-Chiapusso, M.-J., Jelinek, A., Jorda Pardo, Jesus F., Maillo-Fernandez, J.-M., Marom, A., Maroto, J., Menendez, M., Metz, L., Morin, E., Moroni, A., Negrino, F., Panagopoulou, E., Peresani, M., Pirson, S., de la Rasilla, Marco, Riel-Salvatore, J., Ronchitelli, A., Santamaria, D., Semal, P., Slimak, L., Soler, J., Soler, N., Villaluenga, A., Pinhasi, R., Jacobi, R., 2014. The timing and spatiotemporal patterning of Neanderthal disappearance. *Nature* 512, 306−309.

Iturbe, G., Cortell, E., 1987. Las dataciones de Cova Beneito y su interés para el Paleolítico mediterráneo. *Trabajos de Prehistoria* 44, 267−270.

Iturbe, G., Cortell, E., 1992. El Musteriense Final Mediterráneo: nuevas aportaciones. In: Utrilla, P. (Ed.), *Aragón/Litoral Mediterráneo. Intercambios culturales durante la Prehistoria*. Institución Fernando el Católico, Zaragoza, pp. 117−127.

Jennings, R., Giles Pacheco, F., Barton, R.N.E., Collcutt, S.N., Gale, R., Gleed-Owen, C.P., 2009. New dates and palaeoenvironmental evidence for the Middle to Upper Palaeolithic occupation of Higueral de Valleja Cave, southern Spain. *Quaternary Science Reviews* 28, 830−839.

Jordá Pardo, J.F., 2007. The wild river and the last Neanderthals: a palaeoflood in the geoarchaeological record of the Jarama Canyon (Central Range, Guadalajara province, Spain). *Geodinamica Acta* 20, 209−217.

Jordá Pardo, J.F., Baena Preysler, J., Carral González, P., García-Guinea, J., Correcher Delgado, V., de Yravedra, J., 2008. Processos sedimentarios y diagenéticos en el registro arqueológico del yacimiento pleistoceno de la cueva de el Esquilleu (Picos de Europa, Norte de España). *Cuaternario y Geomorfología* 22 (3e4), 31−46.

Maroto, J., 1993. La cueva de los Ermitons (Sales de Llierca, Girona): un yacimiento del Paleolítico Medio final. *Espacio, Espacio, Tiempo y Forma, Serie I, Nueva época. Prehistoria y Arqueología* 6, 13−30.

Maroto, J., Vaquero, M., Arriazabalaga, A., Baena, J., Baquedano, E., Jordá, J.F., Juliá, R., Montes, R., Van Der Plicht, J., Rasines, P., Wood, R., 2012. Current issues in late Middle Palaeolithic chronology: new assessments from Northern Iberia. *Quaternary International* 247, 15−25.

Martínez-Moreno, J., Mora Torcal, R., de La Torre, I., Casanova, J., 2006. La Roca dels Bous en el contexto del Paleolítico Medio final del Noreste de la Península Ibérica. In: Maíllo-Fernández, J.M., Baquedano, E. (Eds.), Miscelánea en Homenaje a Victoria Cabrera. *Zona Arqueológica* 7 (1), pp. 252−263. Madrid.

Martínez-Moreno, J., Mora Torcal, R., de La Torre, I., 2010. The Middle-to-Upper Palaeolithic transition in Cova Gran (Catalunya, Spain) and the extinction of Neanderthals in the Iberian Peninsula. *Journal of Human Evolution* 58, 211−226.

Menéndez Fernández, M., García, E., Quesada López, J.M., 2005. La transición Paleolítico Medio-Paleolítico superior en la Cueva de la Güelga (Cangas de Onís, Asturias). Un avance a su registro. In: Lasheras Corruchaga, J.A., Montes Barquín, R. (Eds.), *Neandertales cantábricos, estado de la cuestión*. Monografías 20 (Museo Nacional y Centro de Investigación de Altamira). Ministerio de Cultura, Santander, pp. 589−617.

Menéndez, M., Weniger, G.-C., Álvarez-Alonso, D., de Andrés-Herrero, M., García, E., Jordá, J. Kehl, M., Rojo, J., Quesada, J.M., Schmidt, I. (2014): La Cueva de la Güelga. Cangas de Onís. Asturias. In Robert Sala Ramos (Ed.) *Pleistocene and Holocene Hunter-Gatherers in Iberia and the Gibraltar Strait: The Current Archaeological Record*. Burgos, 60−63.

Michel, V., Delanghe-Sabatier, D., Bard, E., Barroso Ruiz, C., 2013. U-series, ESR and 14C studies of the fossil remains from the Mousterian levels of Zafarraya Cave (Spain): A revised chronology of Neandertal presence. *Quaternary Geochronology* 15, 20−33.

Montes, L., Utrilla, P., Hedges, R., 2001. Le passage Paléolithique moyen e Paléolithique supérieur dans la vallée de l’Ebre (Espagne). Datations radiométrique des grottes de Peña Miel et Gabasa. In: Zilhão, J., Aubry, T., Faustino Carvalho, A. (Eds.), *Les premiers hommes modernes de la Péninsule Ibérique*. Trabalhos de Arqueologia 17. Instituto Português de Arqueologia, Lisbon, pp. 87−102.

Pettitt, P., Bronk Ramsey, C., Hedges, R.E.M., Hodgins, G.W.L., 2000. AMS radiocarbon dating at Oxford and its contribution to issues of the extinction of Neanderthals and the spread of Homo sapiens sapiens across Eurasia. *Nuclear Instruments and Methods in Physics Research B* 172, 751−755.

Quesada López, J.M., Menéndez Fernández, M., 2009. Revisión cronoestratigráfica de la cueva de la Güelga (Narciandi, Asturias). Del Musteriense al Paleolítico superior inicial. *Espacio, Tiempo y Forma, Serie I, Nueva época, Prehistoria y Arqueología* 2, 39−74.

Soler Subils, J., Soler Masferrer, N., Maroto, J., 2008. L’Arbreda’s archaic Aurignacian dates clarified. *Eurasian Prehistory* 5 (2), 45−55.

Soto-Barreiro, M.J., 2003. Cronología radiométrica, ecología y clima del Paleolítico cantábrico. In: Monografías 19 (Museo Nacional y Centro de Investigación de Altamira). Ministerio de Educación Cultura y Deporte, Madrid.

Straus, L.G., González Morales, M.R., Fano Martínez, M.Á., García-Gelabert, M.P., 2002. Last Glacial human settlement in Eastern Cantabria. *Journal of Archaeological Science* 29, 1403−1414.

Uzquiano Ollero, P., Arbizu Senosiain, M., Arsuaga Ferreras, J.L., Adán Álvarez, G.E., Aranburu, A., Iriarte, E., 2008. Datos paleoflorísticos en la cuenca media del Nalón entre 40e32 ka BP: Antracoanálisis de la Cueva del Conde (Santo Adriano, Asturias). *Cuaternario y Geomorfología* 22 (3−4), 121−133.

Vaquero, M., 1997. Tecnologia lítica y comportamiento humano: organización de las actividades y cambio diacronico en el paleolitico medio del Abric Romaní. Ph.D. Thesis, Universitat Rovira i Virgili, Departament d’Història i Història de l’Art, Tarragona, Spain.

Walker, M.J., Gibert, J., López, M.V., Lombardi, A.V., Pérez-Pérez, A., Zapata, J.,Ortega, J., Higham, T.F.G., Pike, A., Schwenninger, J.-L., Zilhão, J., Trinkaus, E., 2008. Late Neanderthals in southeastern Iberia: Sima de las Palomas del Cabezo Gordo, Murcia, Spain. *Proceedings of the National Academy of Science* 105 (52), 20631−20636.

Wood, R.E., Barroso-Ruíz, C., Caparrós, M., Jordá Pardo, J.F., Galván Santos, B., Higham, Thomas F. G., 2013. Radiocarbon dating casts doubt on the late chronology of the Middle to Upper Palaeolithic transition in southern Iberia. *Proceedings of the National Academy of Sciences* 110, 2781−2786.

Wood, R.E., Arrizabalaga, A., Camps, M., Fallon, S., Iriarte-Chiapusso, M.J., Jones, R., Maroto, J., de la Rasilla, M., Santamaría, D., Soler, J., Soler, N., Villaluenga, A., Higham, T.F.G., 2014. The chronology of the earliest Upper Palaeolithic in northern Iberia: New insights from L'Arbreda, Labeko Koba and La Viña. *Journal of Human Evolution* 69, 91−109.

Wood, R.E., Bernaldo de Quirós, F., Maíllo-Fernández, J.-M., Tejero, J.-M., Neira, A., Higham, T., in press. El Castillo (Cantabria, northern Iberia) and the Transitional Aurignacian: Using radiocarbon dating to assess site taphonomy. *Quaternary International*, 10.1016/j.quaint.2016.03.005

Zilhão, J., 2001. Middle Paleolithic settlement patterns in Portugal. In: Conard, N. (Ed.), *Settlement Dynamics of the Middle Paleolithic and Middle Stone Age*. Kerns, Tübingen, pp. 597−608.

Zilhão, J., 2006. Chronostratigraphy of the Middle-to-Upper Paleolithic transition in the Iberian Peninsula. *Pyrenae* 37 (1), 7−84.

Zilhão, J., Ajas, A., Badal, E., Burow, C., Kehl, M., López-Sáez, J.A., Pimenta, C., Preece, R.C., Sanchis, A., Sanz, M., Weniger, G.-C., White, D., Wood, R., Angelucci, D.E., Villaverde, V., Zapata, J., 2016. Cueva Antón: A multi-proxy MIS 3 to MIS 5a paleoenvironmental record for SE Iberia. *Quaternary Science Reviews* 146, 251−273.

Zilhão, J., Anesin, D., Aubry, T., Badal, E., Cabanes, D., Kehl, M., Klasen, N., Lucena, A., Martín-Lerma, I., Martínez, S., Matias, H., Susini, D., Steier, P., Wild, E.M., Angelucci, D.E., Villaverde, V., Zapata, J., 2017. Precise dating of the Middle-to-Upper Paleolithic transition in Murcia (Spain) supports late Neandertal persistence in Iberia. Heliyon 3, e00435.