

Human adaptive responses to abrupt climate change during the Late Pleistocene



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Introduction

Here we present new data on human adaptive responses across the Middle-Upper Paleolithic transition from Lapa do Picareiro. The sequence includes almost 2m of deposits dated between 40 ka cal BP, claimed by Higham et al. (2014) to mark the end of the Mousterian, and 30 ka cal BP, the latest occurrence argued by Finlayson et al. (2006) for southern Iberia. Our excavation of Lapa do Picareiro has revealed at least one post-40 ka cal BP Middle Paleolithic occupation, dated 36.3-38.5 ka cal BP, with three more unattributed archaeological levels between it and an Upper Paleolithic layer dated, 30.9-31.3 ka cal BP. These results support models of late Neanderthal survival in southern Iberia.

- Lapa do Picareiro is a limestone cavern located 570 m a.s.l., on the west-facing slope of Serra de Aire, a karst mountain north of the Tagus River valley in west-central Portugal (Fig. 1).
- The cave is approximately 10x15 m and situated in a larger bedrock depression of roughly 25x30 m (Fig. 2).
- We have excavated a 10.6 m deep section with 36 Pleistocene-aged strata (E-NN), almost all of which contain archaeological and/or paleoecological remains that increase in richness towards the back of the cave.

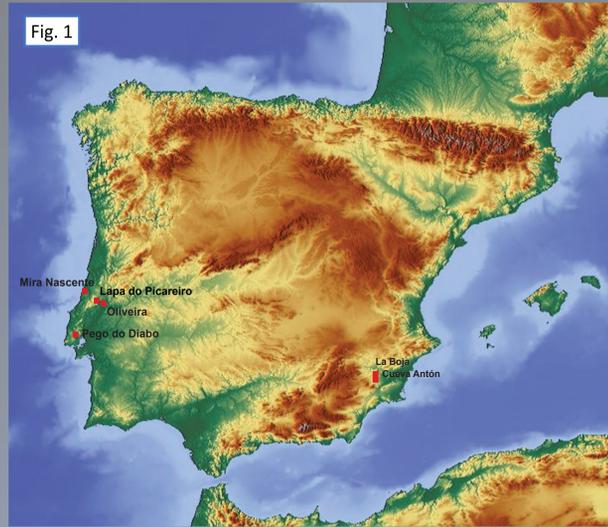


Fig. 2: Views from outside and inside of Lapa do Picareiro



Dating and Stratigraphy

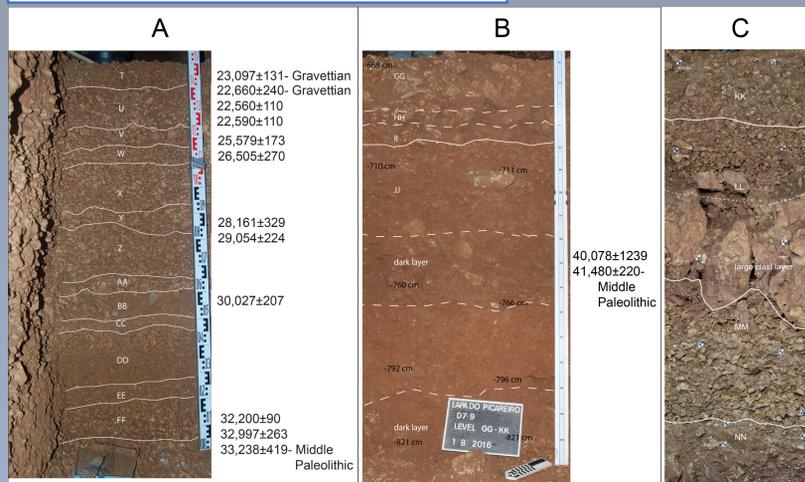
Table 1: Radiocarbon dates for the Middle-Upper Paleolithic transition at Lapa do Picareiro

Level	Lab number	Sample material	¹⁴ C age	cal BP range ^a (2-sigma)	δ ¹³ C (‰)	%C	C:N
Gravettian							
V	Wk-31353	bone ^b	25,579±173	30,320-29,254	-20.2	44.27	3.31
W	Wk-30539	bone	26,505±270	31,164-30,184	-19.4	42.3	3.2
X	UGAMS-23723	charcoal	27,230±80	31,331-30,996	-24.2		
Unknown							
Y	Wk-41389	bone	28,430±210	33,041-31,633	-19.0	41.04	3.29
Z	Wk-30538	bone	28,161±329	32,984-31,307	-19.6	43.5	3.3
	Wk-32280	bone	29,054±224	33,769-32,690	-19.4	43.48	3.24
BB	Wk-32281	bone	30,027±207	34,512-33,745	-19.4	42.93	3.24
Middle Paleolithic							
FF	Wk-32219	bone	32,997±263	38,086-36,355	-19.3	43.02	3.25
	Wk-41259	charcoal	33,238 ±419	38,524-36,381	n/a		
	UGAMS-20479	charcoal	32,200±90	36,355-35,800	-24.0	57.04	
GG	Wk-41258	bone	32,063 ±336	36,726-35,173	-19.0	38.74	3.44
JJ	Wk-28844	bone	40,078±1239	46,381-42,094	-19.9	39.53	3.4
	UGAMS-07769	charcoal	41,480±220	45,420-44,451	-25.1	55.54	

^a Calibrated in OxCal software using IntCal13 calibration curve (Reimer et al., 2013).

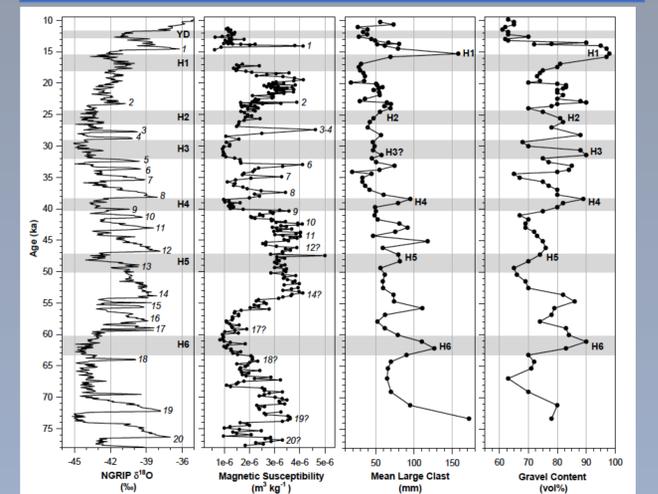
^b Bone samples pretreated with ultrafiltration method (Talamo & Richards, 2011).

Fig. 3: Stratigraphic profiles representing the MIS 4-2 interval



- The cave fill is primarily composed of limestone éboulis derived from roof spalling, and muddy fine sediment derived from weathered soil infiltrating through bedrock joints and crevices.
- The sequence contains no major erosional unconformities.
- Picareiro also has several layers with thin and thick lenses of dark sediments (B) associated with human activity.

Fig. 4: Matching the Picareiro sedimentary record to the Greenland ice cores



- Sedimentological parameters show good agreement with paleoclimate records over the radiocarbon-dated section.
- The cold-arid climate of Heinrich stadials is represented by coarse clast beds with little fine sediment.
- The mild climate of Greenland interstadials corresponds with muddy beds with sharp peaks in magnetic susceptibility.

Archaeology



The earlier Upper Paleolithic levels (V-X, dated 29.2-31.3 ka cal BP) contain lithic artifacts with Gravettian affinities, further supported by the radiocarbon dates (Tab. 1).

- Level W contains a quartzite flake assemblage with a few retouched chert pieces (Fig. 5&6). The large fauna include red deer and ibex.
- In level X, we have excavated a single combustion feature with a few associated retouched and simple chert flakes (Fig. 7).

These levels are palimpsests of human occupation overprinted by lynx and Eurasian eagle owl activities. They contain a superabundance of small animal remains including rabbit, birds, and microfauna, often in clusters.

Table 2: NISP of large and medium mammals across the Middle-Upper Paleolithic transition

Taxon	W	X	Y	Z	BB	CC	DD	EE	FF	GG	JJ
<i>Cervus elaphus</i>	9	1		5	7		2	1	31	3	33
<i>Capreolus capreolus</i>											
<i>Cervidae</i>					1						
<i>Capra ibex/pyrenaica</i>	13		3	11	11		1	3	2	1	5
<i>Rupicapra rupicapra</i>	1			1	1						
<i>Capridae</i>							1		1		
<i>Sus scrofa</i>								1	1		
Medium ungulate	80	16	13	117	69	3	41	26	60	20	204
<i>Equus caballus</i>	1	1		2							3
<i>Lynx pardinus</i>	6			1			1		2		2
<i>Felis sylvestris</i>											
<i>Canis lupus</i>			2								
<i>Vulpes vulpes</i>											
<i>Oryctolagus cuniculus</i>	89	858	2	78	178	114	156	113	12	18	502
<i>Lepus granatensis</i>	1				1					1	

The section between levels X and FF demonstrates human presence in the cave during the period ~31-36 ka cal BP (Fig. 8). Three archaeological layers (Z, BB, DD) contain non-diagnostic flakes, dispersed charcoal, and modified faunal remains.



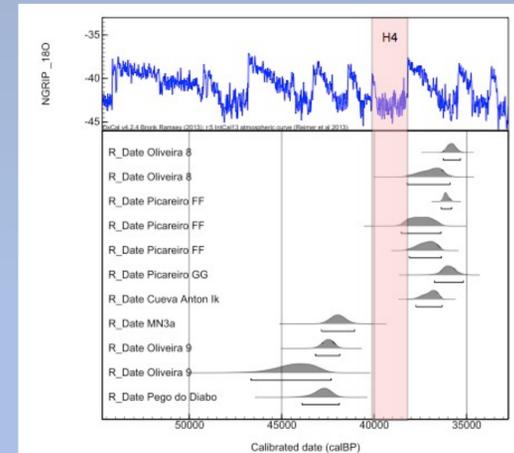
- The latest definitive Middle Paleolithic occupation, level FF (38.5-36.8 ka cal BP) has a diagnostic discoidal core, a sidescraper, and several discoidal flakes (Fig. 8). Numerous ungulate remains, mainly red deer, appear to have been intentionally broken for marrow extraction. MS values indicate the occupation took place during Greenland Interstadial 8.
- Levels GG-II are heavily cemented layers of limestone clasts bracketed by dates from FF and JJ that place their formation during Heinrich Stadial 4.
- Level JJ, dated 42-46 ka cal BP, has possibly three occupation levels containing discoidal flakes, abundant fauna, and charcoal. The fauna include red deer, ibex, horse, lynx and rabbit (Tab. 2). However, these levels lack the superabundant small animal bones found above.

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Conclusions

Fig. 9: Radiocarbon dates from Late Middle Paleolithic sites in Portugal and Spain



- Picareiro is one of three sites in southern Iberia with post-H4 dates for the Middle Paleolithic (Fig.9).
- The radiocarbon dating supports the Ebro Frontier model assertions that the Middle Paleolithic and, by extension, Neanderthals survived H4 and persisted in southern Iberia through GI-8, until ~36 ka cal BP, when GS-8 led to a steep decline in Mediterranean forest (Zilhão et al. 2017).
- The latest Middle Paleolithic and earliest Upper Paleolithic at Picareiro remains an open question that requires further excavation.
- Technological shifts between occupations appear to be adaptive responses to climate and environmental change but a larger artifact sample is necessary to test this idea.

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