Research Article

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New Evidence from Galeria da Cisterna (Almonda) and Gruta do Caldeirão on the Phasing of Central Portugal's Early Neolithic

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Abstract: Funerary usage of Galeria da Cisterna (Almonda) and Gruta do Caldeirão began at the onset of the Neolithic and continued until Early Medieval times. At Cisterna, the thin Holocene deposit was unstratified; at Caldeirão, the stratigraphic sequence underwent post-depositional disturbance. Using radiocarbon dating, typological considerations, spatial distribution patterns, and physical anthropological data, these palimpsests can be disentangled to a significant extent. At both sites, the earliest depositions fall in the *c*. 5250–5500 cal BC interval and are associated with large numbers of beads. Wares extensively decorated with shell and comb impressions are likely to belong in this phase. Another style of decoration – shell impressions forming bands below the rim and garlands between prehension knobs – probably dates to a slightly later time. Burial continued at both sites through the *c*. 5000–5250 cal BC time range, but which decorative styles were then in fashion remains difficult to ascertain; it is likely that the irregular arrangements of shell impressions seen in some Cisterna vessels are among them. At Caldeirão, non-Cardial impressed and incised wares date to *c*. 4500–5000 cal BC, while undecorated wares are associated with human bone samples demonstrating two different periods of burial during the *c*. 3500–4000 cal BC interval. Most if not all of the nine Cardial individuals directly dated at the two sites died coevally with the more recent of the Mesolithic interments found in the shell-midden sites of the Tagus estuary.

Keywords: cardial, epicardial, radiocarbon, burial, cave

1 Introduction

The Cardial culture is the archaeological proxy for early farming in the western Mediterranean. Fifty years ago, Jean Guilaine's review of museum collections showed that this culture had reached as far as Iberia's Atlantic façade; the proof came from vessels or sherds bearing the diagnostic decoration that Guilaine was able to identify among the finds made at a number of Portuguese cave and open-air sites excavated in the nineteenth century or the first half of the twentieth (Guilaine & Veiga Ferreira, 1970).

One such cave site was the Galeria da Cisterna, a passage located *c*. 5 m above the spring of the Almonda river (Torres Novas), a tributary of the Tagus (Figures 1 and 2). Here, surface collection coupled

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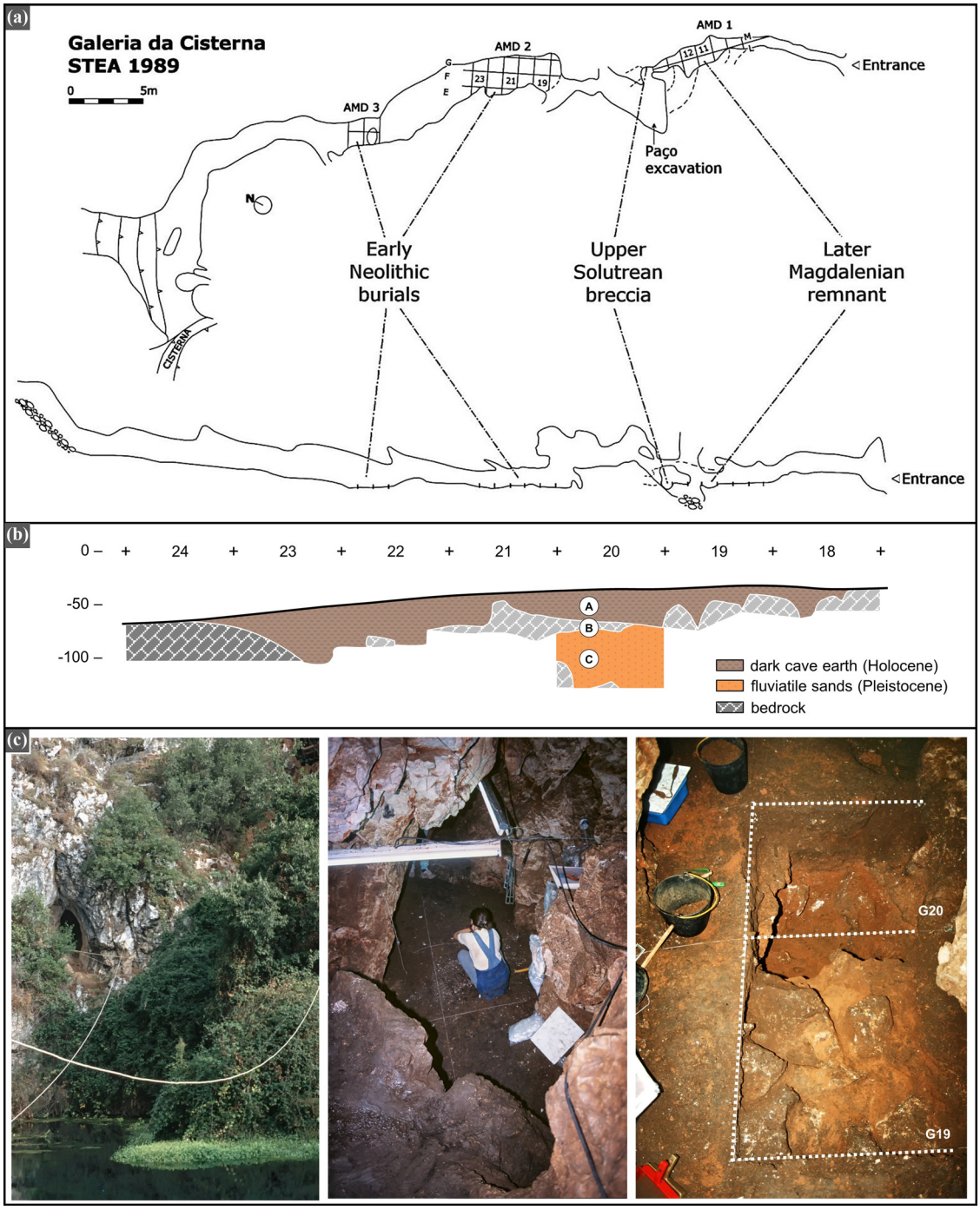

Figure 1: Galeria da Cisterna. Excavation and stratigraphy. (a) Plan and cross-section of the passage, archaeological zones, and 1988–1989 excavation grid. (b) Stratigraphic profile along the *F* > *G* axis of zone AMD2 (elevations in cm below datum). (c) Entrance to the passage (left), overview of zone AMD2 prior to excavation (centre), and the basal fluviatile sands of layer C, exposed (in G19), or excavated (down to bedrock, in G20) (right).

with limited archaeological excavation had been carried out between 1937 and 1942 (Paço, Vaultier, & Zbyszewski, 1947). In 1988–1989, I explored zone AMD2 of the site, which had been spared by the previous excavations and yielded evidence of funerary usage in the Early Neolithic as well as in later pre- and proto-historic times (Zilhão, Maurício, & Souto, 1991; Zilhão, Maurício, & Souto, 1993). This work was carried out as my 1979–1988 exploration of Gruta do Caldeirão (Tomar) – a cave site located *c.* 40 km north–east of the Almonda spring – was coming to an end. Opening onto a side valley of the Nabão river, a sub-tributary of the

Figure 2: Galeria da Cisterna. The Holocene context in zones AMD2 and AMD3. (a) Pottery and beads (the white scale bars associated with each item or group of items represent 1 cm). 1. Perforated red deer canine and bone bead imitation; 2. perforated shells (*Theodoxus fluviatilis*); 3. teardrop beads (*Glycymeris* sp.); 4 and 5. sperm-whale ivory buttons; 6. stamped pot; and 7–11. impressed ceramics (1–3, 7–11: Early Neolithic; 4 and 5. Bell Beaker; 6. Iron Age). (b) The human bone remains providing the MNI for the Cardial burials (not to scale).

Tagus, Caldeirão features a Palaeolithic sequence overlain by a thick Holocene deposit containing a record of nearly continuous funerary usage from the Early Neolithic onwards (Zilhão, 1992, 1993) (Figures 3–7).

Since, only the directly dated sheep bones from the open-air locality of Lapiás de Lameiras (Sintra) have added fresh evidence on Central Portugal's earliest farming communities (Davis, Gabriel, & Simões, 2018). Those bones are demonstrative of a Cardial-age occupation, but the associated material culture has yet to be published. Thirty years on, Cisterna and Caldeirão therefore remain the only modernly excavated

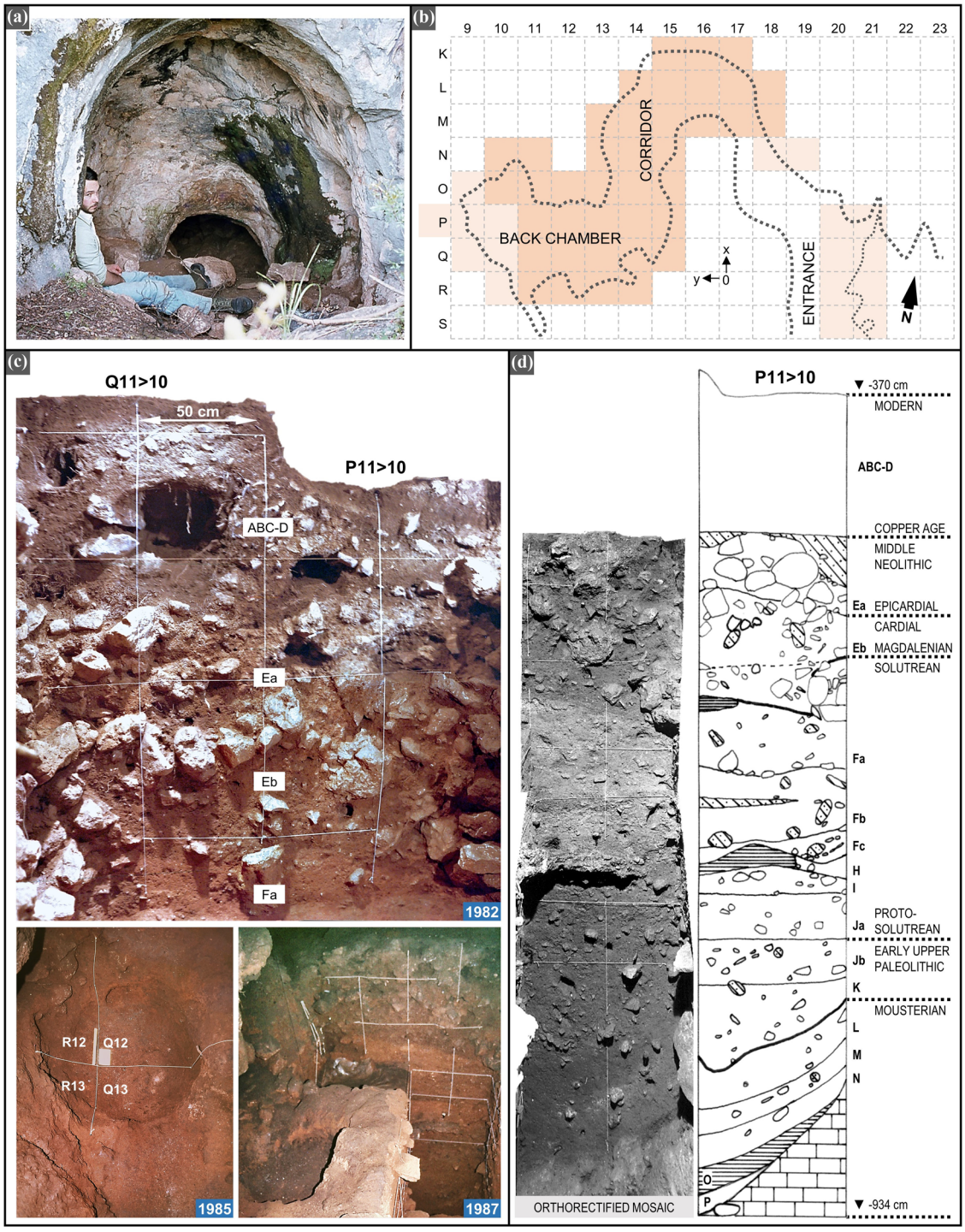

Figure 3: Gruta do Caldeirão. Excavation and stratigraphy. (a) The entrance to the cave in 1980, at the beginning of the second field season. (b) Outline of cave walls at the surface of the sedimentary deposit and excavation grid (in darker shade, those in which the Neolithic was excavated). (c) Stratigraphy and post-depositional disturbance in the upper part of the sedimentary fill (top); note the large subsurface hollows in layer ABC-D (badger burrows) and a comparable feature in squares Q-R/12-13, which was filled with a mix of Neolithic and Magdalenian material and penetrated deeply into the underlying Solutrean sequence (bottom). (d) The reference profile at the end of the 1988 field season (elevations in cm below datum).

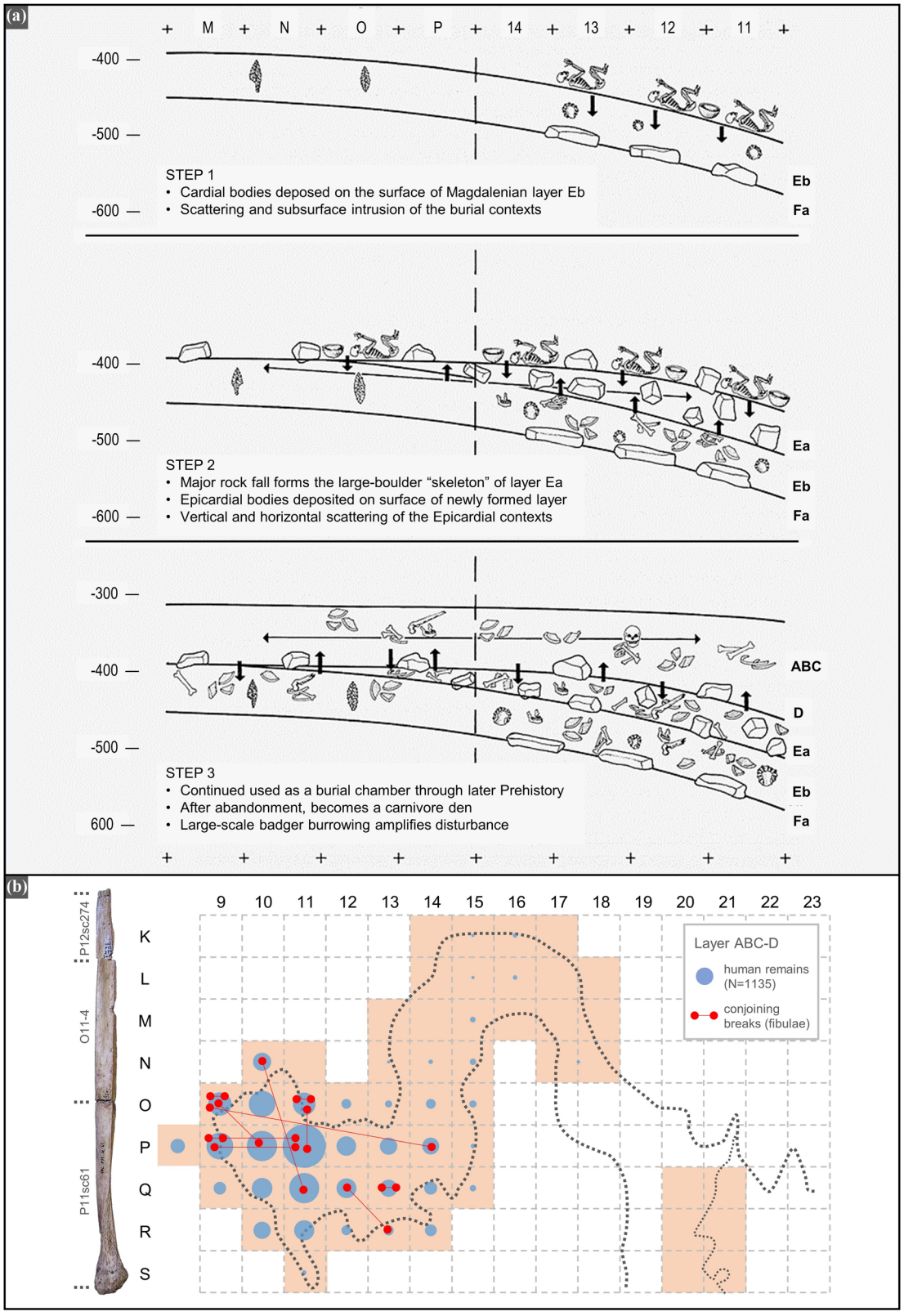

Figure 4: Gruta do Caldeirão. Excavation and stratigraphy. (a) Site formation process of the Holocene sequence inferred from stratigraphy, refitting and spatial distributions (after Zilhão, 1992, Figure 3.11). (b) Bubble plot of human osteological remains from layer ABC-D and links conjoining the broken human fibulae therein retrieved.

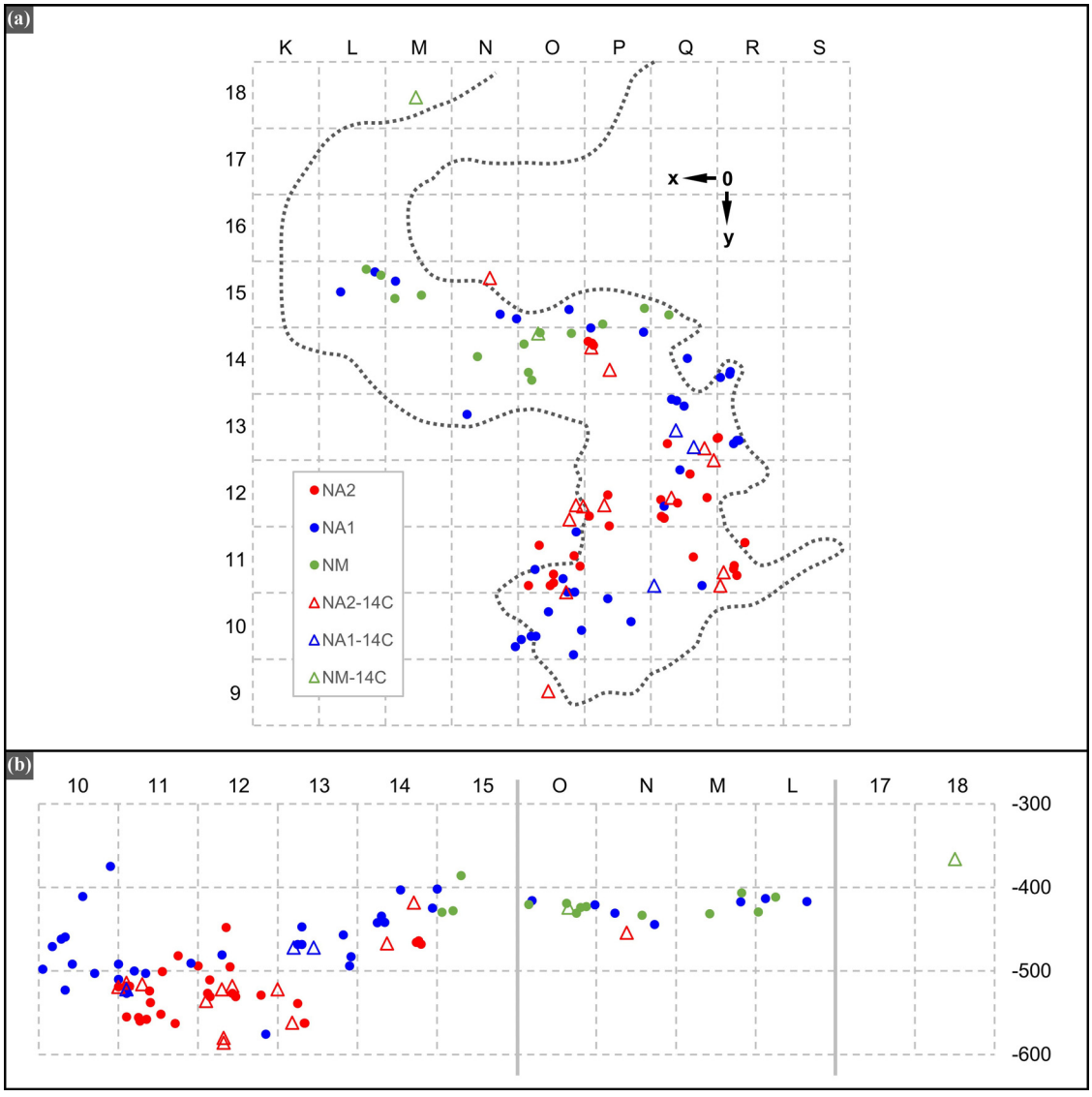

Figure 5: Gruta do Caldeirão. Spatial distribution of Neolithic diagnostics and associated radiocarbon-dated samples. (a) Horizontal scatter plot. (b) Vertical projection along the axis of the passage (elevations in cm below datum). NA2 = Cardial; NA1 = Epicardial; NM = Middle Neolithic.

sites upon which the culture-stratigraphy of western Iberia's earliest Neolithic can rest. Here, I report on recently acquired evidence concerning both caves and conclude with implications for the understanding of the Mesolithic–Neolithic transition in this part of the world.

2 Sites

Nowadays, Cisterna functions as a rarely activated overflow spring. Most of the floor is bedrock, but shallow sediment infills existed in places. Remnant fluviatile sands of Pleistocene age containing the remains of beaver formed the base of the stratigraphic sequences in zones AMD1 and AMD2, which were capped by a dark, Holocene cave earth deposit. In zone AMD1, an eroded breccia of Late Magdalenian age containing stone tools and animal and human remains was found in the intermediate position (Trinkaus, Bailey, Davis, & Zilhão, 2011). In zone AMD2, a dense bat bone lens (layer B), denoting a prolonged hiatus in

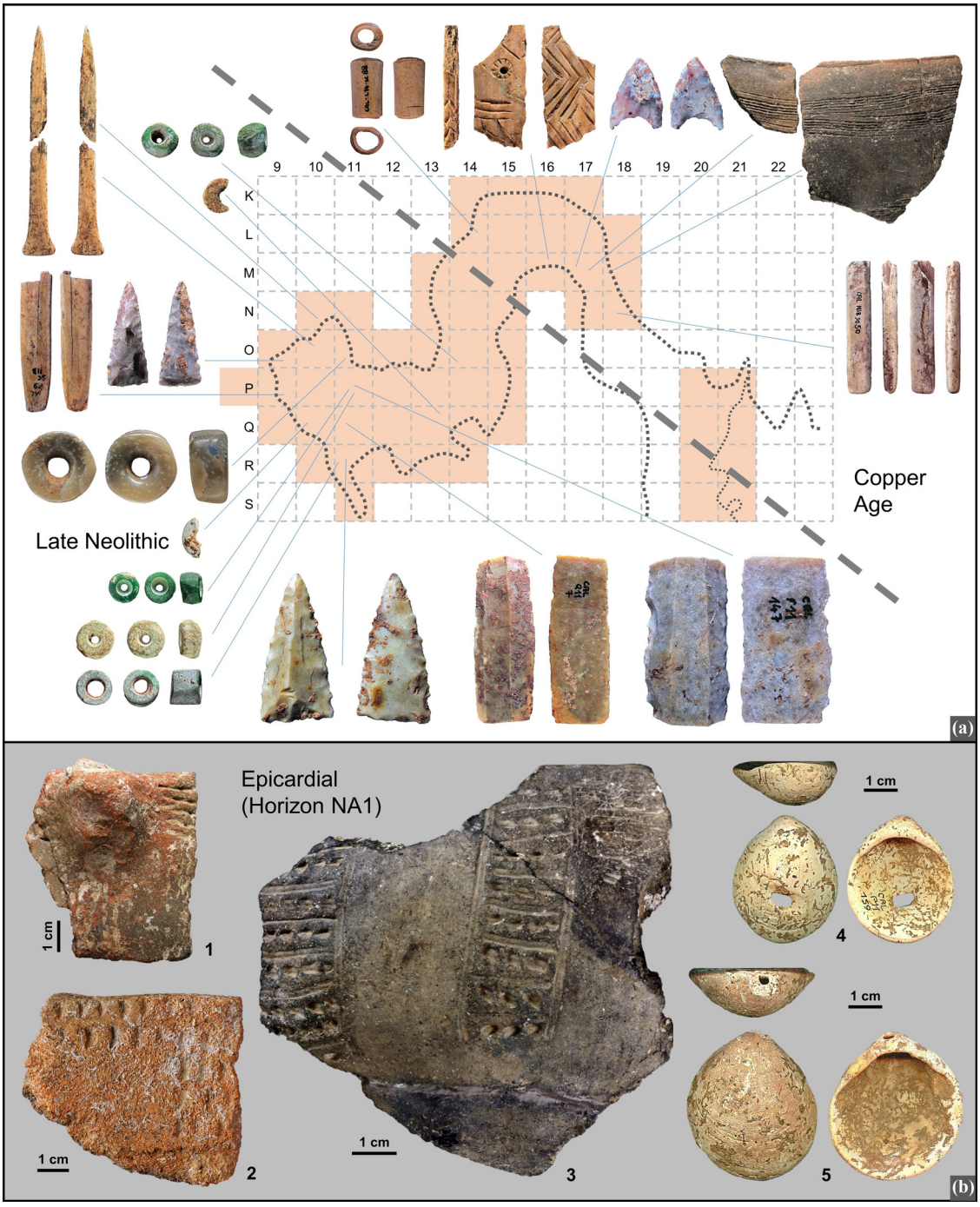

Figure 6: Gruta do Caldeirão. The post-Cardial Neolithic contexts. (a) Distribution of Late Neolithic and Copper Age diagnostics (not to scale); note the preservation of spatial structure despite the significant post-depositional disturbance (Late Neolithic finds in the Back Chamber, Copper Age ones between Corridor and Entrance). (b) Impressed wares and body ornaments from the NA1 horizon. 1. Vessel 2; 2. Vessel 5; 3. Vessel 3; 4 and 5. Perforated *Glycymeris glycymeris* valves.

sedimentation, separated the fluviatile sands (layer C) from the archaeological deposit (layer A), which spilled onto zone AMD3 (Figure 1).

Layer A of Cisterna was completely excavated, with total water sieving of the sediment, in the course of two field seasons. Initial testing was carried out using arbitrary spit subdivisions, but the practice was abandoned, and the layer removed as a single package, once it became clear that we were dealing with a

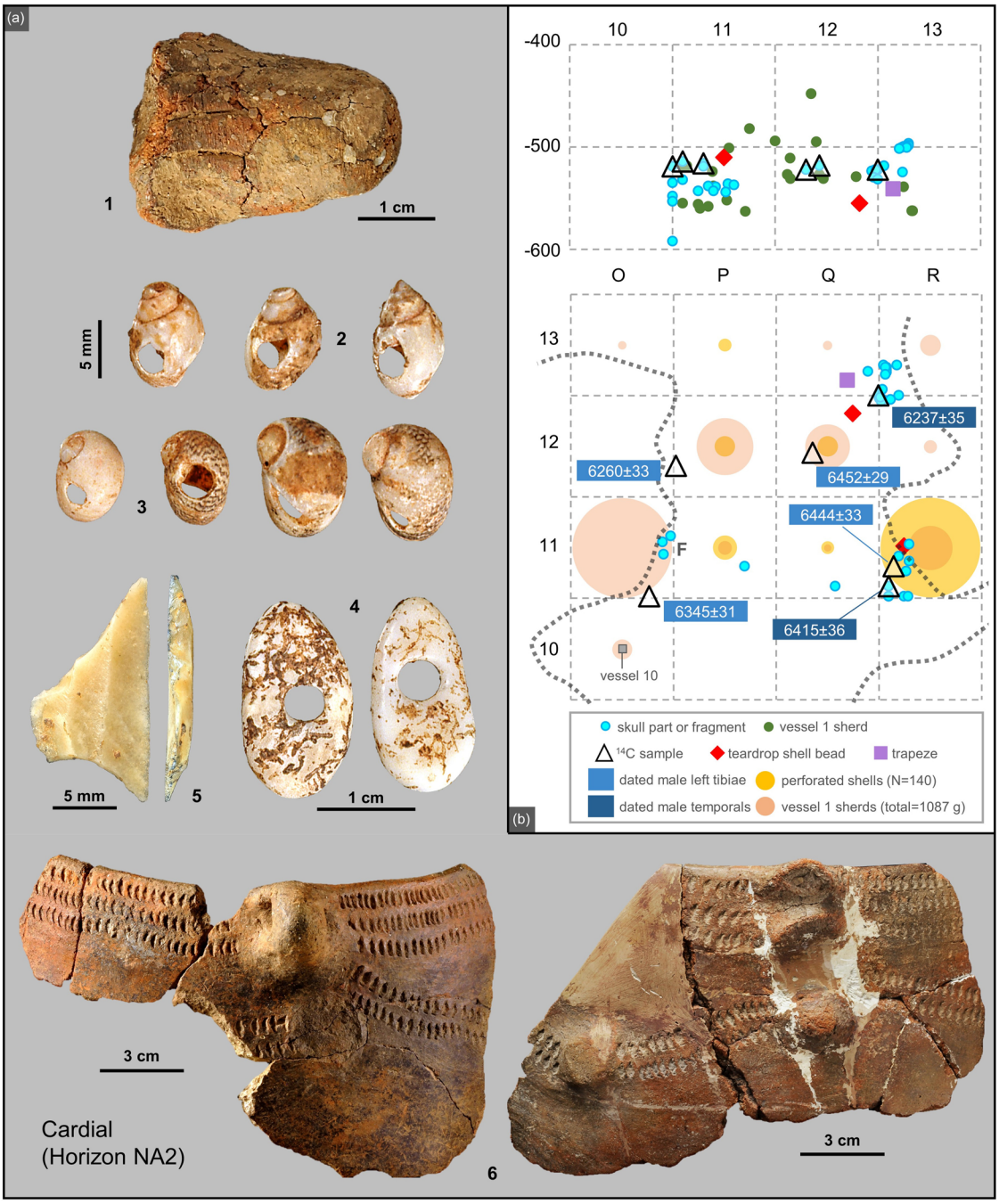

Figure 7: Gruta do Caldeirão. The Cardial context. (a) Artefacts from the NA2 horizon. 1. Vessel 10; 2. perforated *Hynia pfeifferi*; 3. perforated *Theodoxus fluviatilis*; 4. teardrop *Glycymeris* sp. beads; 5. flint trapeze; and 6. two sets of conjoined sherds from Vessel 1. (b) Spatial distributions. Only the dated human bone samples providing the MNI have been plotted. The bubble graphs represent the distribution per square of Vessel 1 sherds (by weight; total = 1,087 g) and perforated gastropod shells (by number; total = 140). The position of the undated female mandible (denoted by the letter F) is indicated. The positions of the single Vessel 10 sherd in O10 and the teardrop bead in R11 are approximate. Note the similar elevation of the dated, large size skeletal remains (corresponding to the surface of layer Eb, i.e. the cave floor atop which the bodies were laid down), and the significant vertical displacement of the smaller items. Elevations in cm below datum.

<40 cm-thick unstratified and homogenised palimpsest. Typological considerations enabled the rich artefact assemblage to be sorted out into its different components (Figure 2a): Early Neolithic (Zilhão, 2009;

Zilhão & Carvalho, 2011; Table 1), Bell Beaker and Bronze Age (Martins et al., 2015; Zilhão, 2016), and Iron Age and Roman (Martins et al., 2015; Tente & Lourenço, 2016).

Magdalenian layer Eb caps the Palaeolithic sequence of Caldeirão (Figure 3). A hiatus in sedimentation followed, and so it was atop a Pleistocene cave floor that people of the Cardial culture deposed the bodies of their dead. Eventually, these funerary contexts were dispersed by processes of syn- and post-depositional disturbance. As a result, the skeletal remains and associated material culture offerings intruded the underlying deposit, where they intermingled with the lithics of the Magdalenian and with the associated faunal remains (which differed markedly in typology, taxonomic composition, and degree of fossilisation). In the Back Chamber (squares N-R/8-12 and P-R/13-15), sedimentation resumed with the accumulation of layer Ea, a sandy matrix éboulis containing a funerary context with Epicardial ceramics. The post-depositional disturbance of this context scattered it onto the Corridor (squares K-O/13-18), where elements thereof were found in layer Eb, mixed with likewise-intruded human remains and undecorated ceramics representing funerary usage of this part of the cave during the Middle Neolithic. The sequence was capped by a 1.5 m-thick organic cave earth deposit (layer ABC-D) devoid of internal stratification and containing abundant human remains, pottery, and other artefacts spanning the Late Neolithic to Early Medieval time range (Zilhão, 1992, 1993).

Tree roots and carnivores were the main agents of disturbance in operation at Caldeirão (note, well-apparent in the stratigraphic profile illustrated in Figure 3c, the still-hollow tunnels and chambers made by the badger, which could be followed across the excavated extent of layer ABC-D of both Corridor and Back Chamber). As a consequence, elements belonging to each of the different human occupation episodes recorded in layers ABC-D, Ea, and Eb were displaced from their original locus of deposition, and this in all directions, horizontally as well as vertically, upward as well as downward (Figure 4a).

However, as illustrated by the conjoining of broken human fibulae from layer ABC-D (Figure 4b), enough of the original spatial structure survived to allow for reliable, albeit partial and limited reconstruction of Caldeirão's original contexts of deposition, and especially so in the case of the Neolithic material (Table 1). First, based on the diagnostic ceramics retrieved in layers Eb and Ea, three archaeological horizons were defined: NM (Middle Neolithic), NA1 (Epicardial), and NA2 (Cardial). Based on the distribution of sherds that conjoined or that, based on decoration and fabric, could be unambiguously attributed to a single vessel, the spatial envelope of each horizon was then delimited. Finally, the skeletal remains of humans and domesticated animals, the stone tools, and the objects of personal ornamentation retrieved within such spatial envelopes were assigned to the corresponding horizon.

Table 1: Neolithic ceramics from Galeria da Cisterna and Gruta do Caldeirão

	Cisterna (after Zilhão & Carvalho, 2011)		Caldeirão (after Zilhão, 1992)	
Decorative style	**Vessels (*N*)**	**Sherds (*N*)**	**Vessels (*N*)**	**Sherds (*N*)**
Late Neolithic/Copper Age	—	—	1	3
Middle Neolithic	—	—	5	22
Epicardial	13	96	12	61
Cardial	27[a]	160[a]	3	37
TOTAL	40	256	21	123

[a] Includes two vessels, totalling 71 sherds, with dense, comb, or shell impressions extensively covering the body from rim to base, defining possible anthropomorphic motifs, and associated with large handles (Phase 3 of the Valencia sequence, following Bernabeu, Gómez, Molina, & García, 2011).

Following the same logic, it was also possible to partially reconstruct, from finds retrieved in layer ABC-D or at its disturbed interface with underlying units, two other Caldeirão find horizons: Late Neolithic and Copper Age. Note that four green rock (muscovite and variscite) beads previously assigned to horizon NA1 (Zilhão, 1992, pp. 109–110) are now considered to belong in the Late Neolithic context. This is because

(a) two were found in burrowed areas of layers Ea and Eb, (b) another came from the interface between layers ABC-D and Ea, (c) layer ABC-D yielded similar finds, and (d) recent surveys of the evidence suggest that, in Iberia, variscite beads are no earlier than the fourth millennium cal BC (Odriozola et al., 2016). Such a chronology is consistent with the types of bone pins, arrowheads, and flint knives that the green rock beads were spatially associated with.

Illustration of key artefacts, together with their spatial distributions and that of the associated dating samples, is provided in Figures 5–7.

3 Dating

Table 2 lists all the radiocarbon determinations currently available for the Holocene deposits of Cisterna. The dates on beads of tooth and bone (OxA-9287, 9288) were intended to assess contemporaneity with the Cardial context from Cova de l'Or (Valencia, Spain). The hypothesis, suggested by the style of decoration seen in Cisterna's Vessels 1 and 3 (Figure 2a, no. 10), was supported by the dating results (Zilhão, 2001). The other samples were intended at assessing the time spans represented by the different components that could be differentiated in the palimpsested assemblages from zones AMD2 and AMD3. To do so, samples were selected using (a) a Minimum Number of Individuals (MNI) approach, applied to sheep/goat astragali and human right foot first phalanges (Martins et al., 2015) and (b) spatial proximity to Cardial sherds, applied to human bones retrieved from the base of layer A in those G-row squares where the excavation had used spit subdivisions.

In all, nine of the Cisterna results fall in the time range of the Early Neolithic. Statistical comparison shows that they form two clusters whose 1σ ranges do not overlap. The earlier cluster spans the 5238–5478 cal BC interval (2σ) and includes one human bone sample, the G21-1764 radius. The later cluster spans the 5073–5358 cal BC interval and includes five human bone samples: three mandible fragments of adult individuals, a foot phalange, and a juvenile metatarsal. These results demonstrate body deposition in at least two occasions, of minimally one person in the first and of minimally four in the second. The MNI for the Cardial burials of Cisterna is therefore five, those represented by the samples illustrated in Figure 2b. Of these, we know from aDNA analysis that the later cluster includes at least one male (represented by the G21-631 mandible) and one female (represented by the F19-385 phalange) (Olalde et al., 2015).

A chronological framework for the Caldeirão sequence was initially produced 35 years ago, in the early days of accelerator mass spectrometry dating (Zilhão, 1992, 1993) (Table 3). That dating project's rationale was to assess the age of the Early Neolithic occupation of the site and, in the process, the integrity of the taphonomy-based assemblies of skeletal remains, stone tools, and ornaments assigned to the ceramics-defined NM, NA1, and NA2 find horizons (Figures 6b and 7a). The reconstructions passed the test, as the samples yielded results consistent with the Cardial for horizon NA2 (OxA-1033, 1034, 1035), the Epicardial for horizon NA1 (OxA-1036, 1037; TO-350), and the Middle Neolithic for horizon NM (TO-349). Additionally, sample TO-351 showed that two Visigoth iron buckles (one of armour, another of bridle) found in layer ABC-D of squares P10 and P11 related to funerary usage of the place in Early Medieval times. It could also be concluded that the statistically earlier conventional charcoal result previously obtained for layer Eb (6870 ± 210 BP; ICEN-296) represented a natural component of the deposit unrelated to the site's Early Neolithic occupation.

Table 3 also includes new results contributed by ongoing paleonutrition and paleogenetics projects (Carvalho, 2018; Linscott, personal communication; Allentoft, personal communication). The sampling targets were as follows: (a) the four adult male left tibiae from horizon NA2; (b) cranial fragments from layers ABC-D and Eb bearing a preserved petrous; and (c) small elements of the skeleton (teeth, phalanges, metacarpals, and metatarsals) judged to be *in situ* within the Magdalenian and Solutrean levels (to make sure they were not Neolithic intrusions), or, conversely, found in layer ABC-D, but suspected, due to their degree of fossilisation, of having been upwardly displaced from the Magdalenian or the Solutrean (a few reworked lithic diagnostics of which having been retrieved alongside; Matias, Aubry, & Zilhão, 2019).

Table 2: Radiocarbon ages for the Holocene archaeology of Galeria da Cisterna (Almonda karst system)

Sample	Spit	Layer	Description	Lab #	Age BP	Period	cal BC 1σ	cal BC 2σ	Observations
F22-696	—	A	*Ovis* (likely), right astragalus	OxA-27982	2129 ± 27	Iron Age/Roman	59–196	52–344	Ultrafiltration
Underwater	—	—	Wooden shaft of iron spear	Beta-124199	2270 ± 40	Iron Age	231–394	204–400	—
G19-419	A1	A	*Capra* (likely), right astragalus (cut-marked)	OxA-27983	3310 ± 28	Bronze Age	1537–1612	1505–1665	Ultrafiltration
G21-556	A2	A	*Capra*, right astragalus	OxA-27984	3354 ± 28		1546–1688	1539–1736	Ultrafiltration
G18-129	A1	A	*Ovis aries*, right astragalus (cut-marked)	OxA-X-2515-17	3378 ± 32		1621–1734	1543–1746	Ultrafiltration
G19-785	A2	A	Human first phalanx, right foot	OxA-28856	3774 ± 28	Bell Beaker	2141–2279	2055–2291	Ultrafiltration
G21-1765	A4	A	Human first phalanx, right foot	OxA-28858	3819 ± 29		2202–2334	2143–2435	Ultrafiltration
G18-187	A1	A	Human first phalanx, right foot	OxA-28857	3836 ± 29		2205–2342	2153–2455	Ultrafiltration
F23-90	—	A	Human first phalanx, right foot	OxA-28859	3847 ± 29		2208–2400	2203–2455	Ultrafiltration
G21-1762	A4	A	Human rib	S-EVA-25635	3865 ± 17		2290–2436	2212–2457	Ultrafiltration
G21-1079	A3	A	Human fifth metatarsal	S-EVA-27410	3872 ± 19		2295–2448	2239–2459	Ultrafiltration
G21-1080	A3	A	Human mandibular fragment	Wk-38575	6253 ± 30	Cardial	5209–5304	5073–5310	Ultrafiltration
G21-1871	A4	A	*Cervus elaphus*, metatarsal	S-EVA-25634	6261 ± 20		5214–5299	5134–5310	Ultrafiltration
G20-1030	B2	A	Human mandible	Wk-38574	6270 ± 30		5214–5303	5084–5318	Ultrafiltration
F19-385	—	A	Human first phalanx, right foot	OxA-28855	6280 ± 34		5216–5305	5083–5327	Ultrafiltration; female (aDNA)
G21-1081	A3	A	Human fifth metatarsal, right foot (juvenile)	Wk-38576	6312 ± 31		5219–5317	5215–5358	Ultrafiltration
G21-631	A2	A	Human mandible	S-EVA-27412	6319 ± 22		5222–5317	5216–5358	Ultrafiltration; male (aDNA)
G21-1764	A4	A	Human radius, diaphysis	S-EVA-27411	6380 ± 21		5321–5369	5232–5468	Ultrafiltration
G21-2278	A4	A	*Cervus elaphus*, canine (pierced)	OxA-9288	6445 ± 45		5376–5473	5325–5478	—
F19-52	—	A	Bone bead in shape of red deer canine	OxA-9287	6445 ± 45		5376–5473	5325–5478	—

Table 3: Radiocarbon ages for the Holocene archaeology of Gruta do Caldeirão

Sample	Spit	Layer	Phase	Description	Lab #	Age BP	Period	cal AD 1σ	cal AD 2σ	Observations
P11sc375	7a	ABC-D	—	Human left temporal	UBA-40089	1213 ± 27	Islamic	774–877	706–887	Ultrafiltration
P13-32	North	ABC-D	—	Human right temporal	UBA-40090	1258 ± 31		680–818	669–875	Ultrafiltration
					Average	1232 ± 20		706–869	690–880	Same individual (aDNA)
P11-73	5a	ABC-D	—	Human left temporal	UBA-40091	1313 ± 26	Visigothic/Islamic	663–772	657–773	Ultrafiltration
P11-112	7a	ABC-D	—	Human rib fragment	TO-351	1420 ± 50	Visigothic			—
					TO-351a	1490 ± 70				Repeat measurement
					Average	1444 ± 41		597–647	428–656	
Sample	**Spit**	**Layer**	**Phase**	**Description**	**Lab #**	**Age BP**	**Period**	**cal BC 1σ**	**cal BC 2σ**	**Description**
M18sc36	E1	Eb-indif	NM	Human metatarsal, proximal	OxA-35145	4770 ± 32	Middle Neolithic	3528–3629	3386–3638	Ultrafiltration
O14-78	E1	Eb-sup	NM	Human rib fragment	TO-349	4940 ± 70		3645–3784	3542–3946	—
Q11-88	E	Eb-indif	NA1	Human rib fragment	TO-350	5810 ± 70	Epicardial	4551–4725	4494–4834	—
Q13-62	E1.2	Ea	NA1	*Bos taurus*, second phalanx	OxA-1036	5870 ± 80		4615–4838	4540–4939	—
Q13-66	E1.2	Ea	NA1	*Bos taurus*, phalanx	OxA-1037	5970 ± 120		4712–5006	4555–5208	—
O12-50	E5	Eb-indif	NA2-A	Human rib, fragment	OxA-1033	6130 ± 90	Cardial	4954–5209	4836–5303	—
Q13-99	E5	Eb-indif	NA2	*Ovis aries*, second phalanx	OxA-1034	6230 ± 80		5059–5303	4958–5368	—
Q12-186	E6	Eb-indif	NA2-A	Human left temporal[a]	UBA-40087	6237 ± 35		5079–5300	5063–5306	Ultrafiltration
N15-68	E2	Eb–inf	NA2-A	Human metatarsal	OxA-35146	6242 ± 35		5084–5301	5066–5307	Ultrafiltration
P12-151	E7	Eb-indif	NA2-A	Human left tibia[b]	Wk-38579	6260 ± 33		5211–5304	5073–5314	Ultrafiltration
P14-44	E1	Ea	NA2	*Ovis aries*, metatarsal	OxA-1035	6330 ± 80		5214–5462	5072–5474	—
P11sc174	E	Eb-indif	NA2-B	Human left tibia[b]	Wk-38577	6345 ± 31		5228–5362	5217–5462	Ultrafiltration; conjoins with O11-74
P12-251	F11	Fb	NA2-B	Human manual middle phalanx 2–4[c]	OxA-37728	6350 ± 34		5231–5365	5219–5464	Ultrafiltration
O9sc97	ABC1	ABC-D	NA2-B	Human metacarpal	OxA-35147	6368 ± 34		5307–5458	5221–5469	Ultrafiltration
O12-57	F3	Fb	NA2-B	Human left metacarpal 4[c]	OxA-37729	6374 ± 34		5310–5459	5224–5469	Ultrafiltration
R11-8	E2	Eb-indif	NA2-C	Human right temporal[a]	UBA-40088	6415 ± 36		5333–5471	5320–5473	Ultrafiltration
R11-7	E2	Eb-indif	NA2-C	Human left tibia[b]	Wk-38580	6444 ± 33		5377–5473	5332–5477	Ultrafiltration
Q12-181	E6	Eb-indif	NA2-C	Human left tibia[b]	Wk-38578	6452 ± 29		5381–5473	5364–5477	Ultrafiltration
P14-84	E4	Eb-indif	NA2	Charcoal	ICEN-296	6870 ± 210	Pre-Neolithic	5572–5982	5383–6215	Conventional

[a] Male, based on aDNA (Allentoft, personal communication). [b] Male, based on morphology (Jackes & Lubell, 1992). [c] Male, based on aDNA (Lalueza, personal communication).

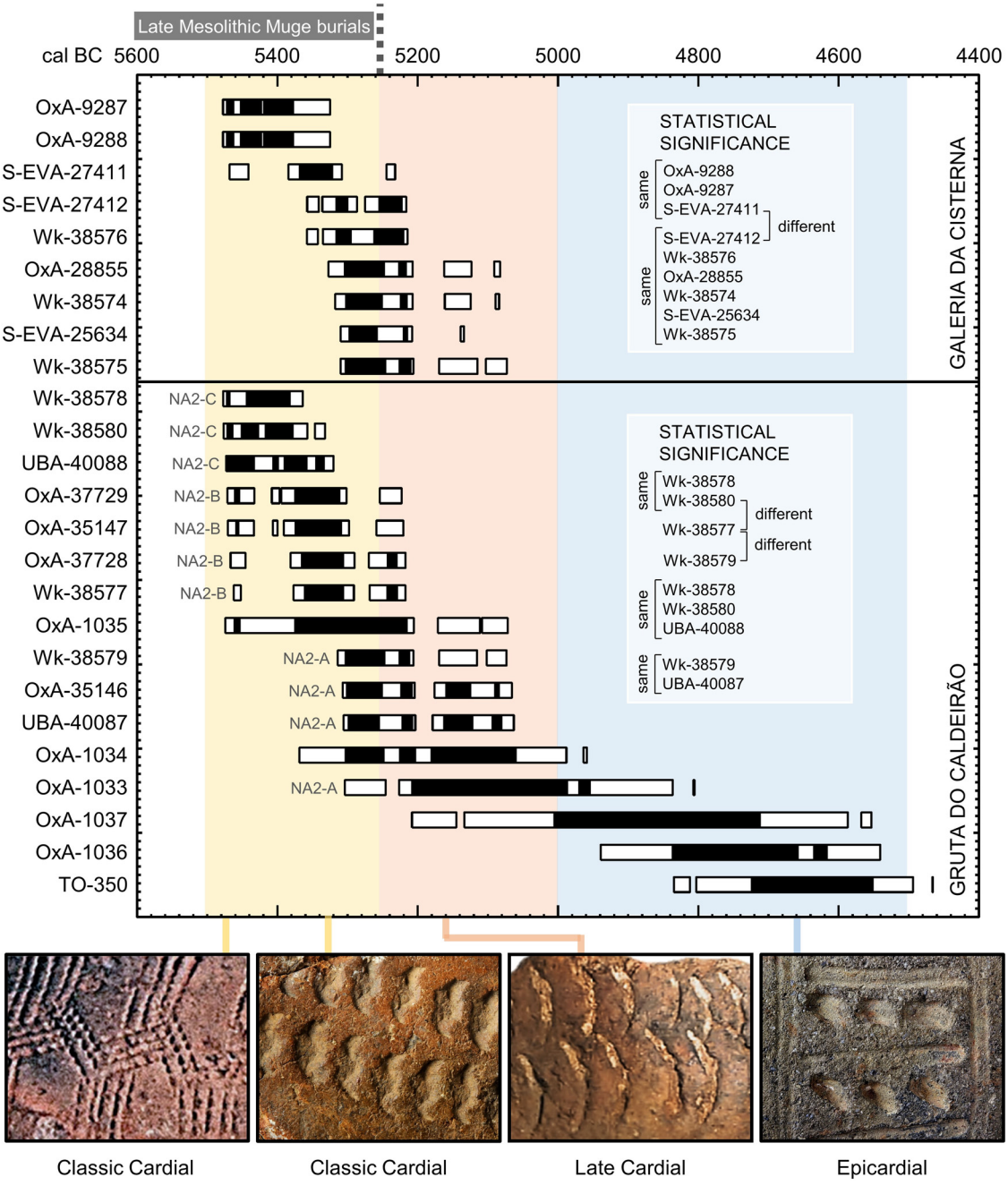

Figure 8: Calibrated radiocarbon ages and periodisation of the Early Neolithic in Central Portugal. Calibration used the IntCal20 Northern Hemisphere curve in Calib 8.1 for Windows (Reimer et al., 2020; Stuiver & Reimer, 1993). The directly dated human bones based on which the funerary activity of horizon NA2 times could be phased are labelled accordingly. The upper chronological boundary of Mesolithic burial activity at Muge is taken from Peyroteo-Stjerna (2020).

The new Caldeirão results add four bone remains previously thought to be *in situ* Palaeolithic finds to the tally of horizons NA2 (three) and NM (one). They also raise to three the MNI of layer ABC-D's Early Medieval (Visigoth or Islamic) burials. More to our point here, they significantly improve the temporal resolution of the site's Cardial phase. Collectively considered, the overall results allow partition of NA2 into two phases whose chronological boundaries coincide with those defined by the Cisterna set (Figure 8): *c.* 5250–5500 cal BC, for which, given what we know of the chronology of the Early Neolithic in southern France and Spain

(e.g. Bernabeu et al., 2011; Manen et al., 2019), the "Classic Cardial" label is appropriate; and *c.* 5000–5250 cal BC, for which a "Late Cardial" label will be used here.

Statistical comparison further shows that the four individuals represented by the dated tibiae entered Caldeirão on at least three separate occasions and that the site's two dated temporals, even though representing opposite sides of the braincase, are not from the same person. The radiocarbon age of the right temporal from R11 (6415 ± 36 BP, UBA-40088) is consistent with either the first or the second occasion, but its spatial proximity to the tibia from the same square (6444 ± 33 BP; Wk-38580) suggests the first. The radiocarbon age of the left temporal from Q12 (6237 ± 35 BP, UBA-40087) is consistent with the age of the tibia from P12 (6260 ± 33 BP, Wk-38579), which represents the third occasion. The other NA2 dates are consistent with such a periodisation into three phases of burial activity: from more recent to earliest, NA2-A, NA2-B, and NA2-C (Table 3; Figure 8).

A corollary of the Caldeirão dating pattern is that the skeletal remains of Cardial people found therein were laid down over an extended period, ruling out interpretations of the site as a communal burial ground. Rather, the pattern suggests spaced-out funerary usage, leading to intermittent accumulation, over the generations, of the bodies of a few selected individuals, one at a time.

4 Burial

The MNI for the skeletal remains in horizon NA2 of Caldeirão is five: the four adult male left tibiae that were dated plus the mandible and dentition of a young adult female (Jackes & Lubell, 1992). The assemblage also includes the lower left deciduous incisor of a 7-month-old infant (inventory number P12sc662). This tooth, however, will not be considered here. It came from the very base of layer Eb and bears the matrix of red silty sands characteristic of the immediately underlying Solutrean layer (Fa); it is therefore quite likely that it represents either décapage error or upward displacement (note, in Figure 3c, the large burrow in adjacent square Q12, which penetrates >40 cm into layers Fa and Fb).

In the monographic publication of the Neolithic of Caldeirão, I argued that, notwithstanding the disturbance, the layout of the burial space could be gleaned from the distribution of the archaeological remains forming the NA2 horizon (Zilhão, 1992, pp. 74–77, Figure 4.14). Based on the interpretation of the artefacts as grave goods and the assumption that the clusters of skull bones denoted the original emplacement of the bodies, the following associations were proposed: of Vessel 1 (Figure 7a, no. 6) with the female, which would have been laid down against the north wall in squares O/11-12; of the teardrop *Glycymeris* shell beads (Figure 7a, no. 4) and the trapeze (Figure 7a, no. 5) (and perhaps three other microliths as well) with the male laid down against the south wall in squares Q-R/12-13; and of the concentration of over 100 perforated shells of *Theodoxus fluviatilis* and *Hinia pfeifferi* (Figure 7a, nos 2 and 3) with another male laid down in adjacent square R11. The new dating results are broadly consistent with this model, as is the sexing via aDNA of some of the dated samples: the O12-57 metacarpal, the P12-251 phalanx, and the two temporals, Q12-186 and R11-8, all of which are of male individuals (Table 3; Figure 7b). For instance, as the two dated temporals are of different radiocarbon ages, the hypothesis stands unrefuted that the two clusters of cranial material found against the south wall of the Back Chamber represent at least two different individuals laid down in different spots and at different times.

The dated adult male tibia from R11, which defines burial phase NA2-C, is one of the south wall individuals. This square also yielded a diagnostically male left innominate, and the dated male temporal from the same square is likely to belong to the same individual. In this case, the radiocarbon results strengthen the interpretation that the close spatial association of the remains with the *Theodoxus* and *Hinia* beads from that square means that the latter are this person's grave goods.

The more recent temporal from the Q-R/12 corner represents a second south wall male – perhaps the same individual whose tibia was found against the opposite wall, is of statistically identical radiocarbon age, and defines burial phase NA2-A. This tibia comes from square P12 and a diagnostically male pelvis was found alongside, broken in four fragments retrieved from O12 and P12. A metatarsal from square N15, *c.* 4 m

away (Figure 5), is of the same radiocarbon age (6242 ± 35 BP, OxA-35146). These four bones may well belong to the same skeleton. If so, burial phase NA2-A would have been affected by more widespread scattering than the preceding ones, implying that assigning grave goods on the basis of spatial proximity is in this case more problematic. For instance, even though not refuted, the hypothesis is weakened that the teardrop beads and geometric microliths from Q-R/12-13 are associated with this male (alternatively, these items could relate to the second adult male from burial phase NA2-C, defined by a tibia from Q12 because, with available evidence, we cannot exclude that cranial remains of this second adult male are included in the adjacent Q-R/12-13 cluster). On the other hand, if the remains of the NA2-A individual are widely scattered in the area around the angle between Corridor and Back Chamber, then the possibility exists that the three thick undecorated body sherds that define Vessel 15, all retrieved in that area (square P14), belong in his set of grave goods.

No grounds exist to question the association between Vessel 1 and the O11 female mandible found against the north wall in close association with most of the vessel's sherds (Figure 7b). The mandible is undated, but the male tibia defining burial phase NA2-B was found nearby (in two conjoined fragments from O11 and P11), and so were the male metcarpal and the male phalanx that intruded the underlying Solutrean deposit, all three of which are of indistinguishable radiocarbon age (Table 3; Figure 8). If this NA2-B individual also had accompanying grave goods, two association scenarios are conceivable: (a) given where the tibia was found, it could represent a male deposed alongside the O11 female, in which case Vessel 1 could be a shared offering; (b) both his cranium and grave goods lie in the unexcavated parts of layer Eb (rows 8–9 and squares P-R/10). If the former, we would be dealing with a double burial, perhaps that of a couple, and an exception to the one-at-a-time rule inferred from the dating evidence. If the latter, Vessel 10, represented in the NA2 assemblage by a single fragment from adjacent square O10 – a decorated handle with a fabric similar to Vessel 1 (Barnett, 1992; Figure 7a, no. 1) – could, like the tibia, stand for the spilling onto the excavated area of a largely unexplored burial context preserved against the unexcavated bottom end of the Back Chamber. This latter hypothesis is supported by the fact that the fourth dated human bone that is definitional of phase NA2-B – the O9sc97 metacarpal (Table 3) comes from square O9.

5 Phasing

The shell ornaments from horizon NA2 of Caldeirão (Figure 7a, nos 2–4) are associated with individuals from the earliest burial phase, NA2-C. Statistically identical ages were obtained for the directly dated tooth and bone pendants from Cisterna (Figure 2, no. 1), whose large assemblage of shell ornaments (Figure 2, nos 2 and 3) – over 200 whole, perforated shells of small gastropods (mostly *Theodoxus fluviatilis*), and over 40 teardrop beads (mostly cut from valves of *Glycymeris* sp., but also of *Unio* sp. and even of *Sepia officinalis* cuttlebone) (Zilhão, 2009) – is typological akin to those from horizon NA2 of Caldeirão. Bringing together the evidence from the two sites, we can conclude that shell beads, pierced red deer canines, and bone beads imitating their shape are characteristic of the Cardial from the onset.

No ceramic vessels could be directly associated with Caldeirão's NA2-C individuals. Their bodies may have been laid out with none or, as is possibly the case with the adult male from NA2-B, such ceramics may await discovery in the site's unexcavated area. However, the type of decoration seen in Cisterna's Vessels 1 and 2 – dense, comb, or shell impressions extensively covering the body from rim to base, associated with large handles, and sometimes defining anthropomorphic motifs (Figure 2a, no. 10) – is characteristic of the very start of the Classic Cardial of the regional sequence of Valencia (Spain) (Bernabeu et al., 2011). Based on correlation with that sequence, I have suggested that Vessel 1 of Cisterna stood for a phase of the Portuguese Cardial preceding that represented by Vessel 1 of Caldeirão (Zilhão, 2009), which is decorated in a style characterised by shell impressions forming bands below the rim and garlands between prehension knobs (Figure 7a, no. 6). Put another way, my hypothesis was that, in Bernabeu et al. (2011) terms, Vessel 1 of Cisterna and Vessel 1 of Caldeirão belonged in the Portuguese equivalents of Phase 3 and Phase 4 of Valencia's Classic Cardial, respectively.

The Valencia correlation is consistent with assignment of Vessel 1 of Caldeirão to this site's burial phase NA2-B, and with assignment of Vessel 1 of Cisterna to the material culture package represented by the shell and bone beads that define both sites' earliest moments of funerary activity – at Caldeirão, burial phase NA2-C. These inferences find additional support in the spatial patterning displayed by the human bone dates for horizon NA2 of Caldeirão, which suggests that depositions become more recent as one moves clockwise from square R11 along the walls of the Back Chamber. The pattern is apparent in Figure 7b and further strengthened by consideration of the smaller elements of the skeleton whose age is statistically the same as the NA2-B tibia's, all of which come from north wall grid units (O9, O12, P12; Table 3). It is unlikely, therefore, that Vessel 1 and the female it presumably is associated with belong in the earliest burial phase, NA2-C (whose dated remains are all found along the north wall), or in the latest, NA2-A (whose dated remains are all found farther outward).

Excavation of the bottom end of the Back Chamber is planned and will provide a test of these conclusions. Pending the outcome, whether the differentiation of burial phases NA2-C and NA2-B of Caldeirão has wider significance and translates into a chronological subdivision of Central Portugal's Classic Cardial must remain an open issue. With current evidence, the parsimonious interpretation, which Figure 8 retains, is that the two styles – Cisterna's "extensive comb impressions," and Caldeirão's "bands and garlands of shell impressions" – were broadly coeval in the region.

The timespan of the Epicardial as defined by horizon NA1 of Caldeirão is unrepresented among Cisterna's 18 dates on animal and human bone samples. The reasoning above associates the dated human radius from Cisterna with Vessels 1 and 2, and with the site's shell and bone bead assemblage. The age of the other four individuals represented by the dated remains illustrated in Figure 2b is consistent with assignment to either the Classic Cardial or the Late Cardial. These must therefore be the chronological phases to which belong a significant proportion (if not all) of the site's other 38 Early Neolithic decorated vessels. Vessel 28 (Figure 2, no. 9), featuring a narrow band of large, irregular cardial impressions disposed in two rows immediately below the rim would be consistent with the Late Cardial, while Vessel 5 (Figure 2, no. 11) is relatively close to Vessel 1 of Caldeirão and, stylistically, amenable to inclusion in the Classic Cardial. Vessel 8 (Figure 2, no. 7) is the best candidate to represent a possible Epicardial phase that radiocarbon dating failed to detect; in Table 1, however, a dozen of other vessels decorated with a range of non-Cardial impressions, incisions, and grooves are conservatively assigned to that phase as well.

6 Conclusion

Based on Cisterna and Caldeirão, the Cardial people of Central Portugal used caves for funerary purposes. Bodies were laid down one at a time, over several generations, reflecting that only a few selected individuals received this type of treatment. The associated grave goods include personal ornaments, geometric microliths, and ceramic vessels. The direct dating of sexed and aged human remains allows for the differentiation of three burial phases within the NA2 find horizon of Caldeirão. Combining the evidence from both sites, the hypothesis can be advanced, but not demonstrated, that the earliest two burial phases are associated with Classic Cardial impressed wares and the latest with Late Cardial ones.

The existence of a pre-Cardial phase of Ligurian-style affinities has been suggested for Valencia; impressed groove wares would be the index fossil of this phase (Bernabeu, Molina, Esquembre, Ramón, & Boronat, 2009). However, as shown by Martins et al. (2015), the associated radiocarbon dates are statistically indistinguishable from the Classic Cardial's, and so such wares might be diagnostic of the latter's earliest stages rather than of a separate cultural tradition. The evidence from Cisterna is consistent with Martins et al.'s interpretation, as the impressed groove technique is represented therein (by Vessel 4, counted as Epicardial in Table 1; Figure 2a, no. 8) but none of the dates obtained for the site fall in the time range of the Ligurian *Impressa*.

In Central Portugal, the *Impressa* time range is a period during which only Mesolithic hunter–gatherers are documented in the archaeological record. They accumulated the well-known shell-middens of the inner estuary

of the Tagus, near Muge, 45 km downstream from the Almonda spring (as the crow flies), and of the Sado, farther south. Based on the available evidence, I have for long argued that these hunter–gatherer communities had persisted for a few centuries alongside the first farming communities (Zilhão, 1992, 1993, 2000, 2001, 2003). A recent study (Peyroteo-Stjerna, 2020) has added detailed, high-quality radiocarbon evidence that fully corroborates such a coexistence pattern, which, as illustrated in Figure 8, may have lasted for the entire duration of Central Portugal's Classic Cardial – i.e. for up to two and a half centuries (*c.* 5500–5250 cal BC). This overlap highlights the potential of the region for testing models of last hunter–gatherer/early farmer interaction, which the ongoing stable isotope and aDNA analysis of the directly dated Cardial individuals from Cisterna and Caldeirão are expected to shed much light on.

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References

Barnett, W. K. (1992). The physical analysis of early Neolithic impressed pottery from Gruta do Caldeirão. In J. Zilhão (Ed.), *Gruta do Caldeirão. O Neolítico Antigo* (pp. 297–312). Lisboa: Instituto Português do Património Arquitectónico e Arqueológico.

Bernabeu, J., Gómez, O., Molina, L., & García, P. (2011). La cerámica neolítica durante VI milenio cal AC en el Mediterráneo central peninsular. In J. Bernabeu, M. Rojo, & L. Molina (Eds.), *Las primeras producciones cerámicas: El VI milenio cal AC en la Península Ibérica* (pp. 153–178). València: Universitat de València.

Bernabeu, J., Molina, L., Esquembre, M. A., Ramón, J., & Boronat, J. D. (2009). La cerámica impresa mediterránea en el origen del Neolítico de la península Ibérica? In *De Méditerranée et d'ailleurs. Mélanges offerts à Jean Guilaine* (pp. 83–95). Toulouse: Archives d'Écologie Préhistorique.

Carvalho, A. F. (2018). When the Mediterranean met the Atlantic. A socio-economic view on early Neolithic communities in central-southern Portugal. *Quaternary International*, *470*, 472–484. doi: 10.1016/j.quaint.2016.12.045.

Davis, S. J. M., Gabriel, S., & Simões, T. (2018). Animal remains from Neolithic Lameiras, Sintra: The earliest domesticated sheep, goat, cattle and pigs in Portugal and some notes on their evolution. *Archaeofauna*, *27*, 31–172.

Guilaine, J., & Veiga Ferreira, O. V. (1970). Le Néolithique ancien au Portugal. *Bulletin De La Société Préhistorique Française*, *67*, 304–322.

Jackes, M., & Lubell, D. (1992). The early Neolithic human remains from Gruta do Caldeirão. In J. Zilhão (Ed.), *Gruta do Caldeirão. O Neolítico Antigo* (pp. 259–295). Lisboa: Instituto Português do Património Arquitectónico e Arqueológico.

Manen, C., Perrin, T., Guilaine, J., Bouby, L., Bréhard, S., Briois, F., … Vigne, J. D. (2019). The Neolithic transition in the western Mediterranean: A complex and non-linear diffusion process – The radiocarbon record revisited. *Radiocarbon*, *61*(2), 531–571. doi: 10.1017/RDC.2018.98.

Martins, H., Oms, F. X., Pereira, L., Pike, A. W. G., Rowsell, K., & Zilhão, J. (2015). Radiocarbon dating the beginning of the Neolithic in Iberia: New results, new problems. *Journal of Mediterranean Archaeology*, *28*(1), 105–131. doi: 10.1558/jmea.v28i1.27503.

Matias, H., Aubry, T., & Zilhão, J. (2019). Raw-material provenience of the Solutrean diagnostics from Gruta do Caldeirão (Tomar, Portugal). In I. C. Schmidt, J. Cascalheira, N. Bicho, & G. C. Weniger (Eds.), *Human adaptations to the last glacial maximum: The solutrean and its neighbors* (pp. 302–316). Newcastle: Cambridge Scholars Publishing.

Odriozola, C. P., García, R. V., Burbidge, C. I., Boaventura, R., Sousa, A. C., Rodriguez-Ariza, O., ... Dias, M. I. (2016). Distribution and chronological framework for Iberian variscite mining and consumption at Pico Centeno, Encinasola, Spain. *Quaternary Research*, *85*(1), 159–176. doi: 10.1016/j.yqres.2015.11.010.

Olalde, I., Schroeder, H., Sandoval-Velasco, M., Vinner, L., Lobón, I., Ramirez, O., ... Lalueza-Fox, C. (2015). A common genetic origin for early farmers from Mediterranean cardial and Central European LBK cultures. *Molecular Biology and Evolution*, *32*(12), 3132–3142. doi: 10.1093/molbev/msv181.

Paço, A., Vaultier, M., & Zbyszewski, G. (1947). Gruta da Nascente do Rio Almonda. *Trabalhos de Antropologia e Etnologia*, *XI*(1–2), 171–187.

Peyroteo-Stjerna, R. (2020). Chronology of the burial activity of the last hunter-gatherers in the southwestern Iberian Peninsula, Portugal. *Radiocarbon*, *63*(1), 265–299. doi: 10.1017/RDC.2020.100.

Reimer, P. J., Austin, W. E. N., Bard, E., Bayliss, A., Blackwell, P. G., Bronk Ramsey, C., ... Talamo, S. (2020). The IntCal20 northern hemisphere radiocarbon age calibration curve (0–55 cal kBP). *Radiocarbon*, *62*(4), 725–757. doi: 10.1017/RDC.2020.41.

Stuiver, M., & Reimer, P. J. (1993). Extended 14C data base and revised CALIB 3.0 14C age calibration program. *Radiocarbon*, *35*, 215–230.

Tente, C., & Lourenço, S. (2016). A ocupação da Idade do Ferro da Galeria da Cisterna (sistema cársico da nascente do Almonda, Torres Novas). *Revista Portuguesa De Arqueologia*, *19*, 143–154.

Trinkaus, E., Bailey, S., Davis, S. J. M., & Zilhão, J. (2011). Magdalenian human remains from the Galeria da Cisterna (Almonda karstic system, Torres Novas, Portugal). *O Arqueólogo Português*, *V*(1), 395–413.

Zilhão, J. (1992). *Gruta do Caldeirão. O Neolítico Antigo*. Lisboa: Instituto Português do Património Arquitectónico e Arqueológico.

Zilhão, J. (1993). The spread of agro-pastoral economies across Mediterranean Europe: A view from the far west. *Journal of Mediterranean Archaeology*, *6*(1), 5–63. doi: 10.1558/jmea.v6i1.5.

Zilhão, J. (2000). From the Mesolithic to the Neolithic in the Iberian Peninsula. In T. D. Price (Ed.), *Europe's first farmers* (pp. 144–182). Cambridge: Cambridge University Press.

Zilhão, J. (2001). Radiocarbon evidence for maritime pioneer colonization at the origins of farming in west Mediterranean Europe. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(24), 14180–14185. doi: 10.1073/pnas.241522898.

Zilhão, J. (2003). Algumas observações acerca do Mesolítico do interior peninsular e do modelo de passagem ao Neolítico através de colonização pioneira por via marítima. *O Arqueólogo Português*, *IV*(21), 108–118.

Zilhão, J. (2009). The early Neolithic artifact assemblage from the Galeria da Cisterna (Almonda karstic system, Torres Novas, Portugal). In *De Méditerranée et d'ailleurs. Mélanges offerts à Jean Guilaine* (pp. 821–835). Toulouse: Archives d'Écologie Préhistorique.

Zilhão, J. (2016). Beaker people without beaker pots: The Chalcolithic funerary context from the Galeria da Cisterna (Almonda karst system, Torres Novas, Portugal). In *Del neolític a l'edat del bronze en el Mediterrani occidental. Estudis en homenatge a Bernat Martí Oliver* (pp. 379–386). València: Servicio De Investigación Prehistórica.

Zilhão, J., & Carvalho, A. F. (2011). Galeria da Cisterna (rede cárstica da nascente do Almonda). In J. Bernabeu, M. Rojo, & L. Molina (Eds.), *Las primeras producciones cerámicas: El VI milenio cal AC en la Península Ibérica* (pp. 251–254). València: Universitat de València.

Zilhão, J., Maurício, J., & Souto, P. (1991). A Arqueologia da Gruta do Almonda. Resultados das escavações de 1988–1989. In *Actas das IV Jornadas Arqueológicas* (*Lisboa, 1990*) (pp. 161–171). Lisboa: Associação dos Arqueólogos Portugueses.

Zilhão, J., Maurício, J., & Souto, P. (1993). Jazidas arqueológicas do sistema cársico da nascente do Almonda. *Nova Augusta*, *7*, 35–54.