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A chronological reassessment of *Panicum miliaceum* and *Triticum spelta* at Crasto de Palheiros (Murça, Northeast of Portugal) during the first millennium BCE

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Abstract Two AMS dates are published here, one on *Panicum miliaceum* (broomcorn millet) and another on *Triticum spelta*. The first confirms that *Panicum* cultivation at Crasto de Palheiros occurred only during the Iron Age, remaining unconfirmed its possible Late Bronze Age origins. The second provides the first direct dating of this wheat species at this archaeological site. Attention to post-depositional processes and sample infiltration has led to a contextual reassessment of previously published dates from nearly two decades ago, particularly those of *Panicum miliaceum*, warranting a more detailed publication of these and other related contexts. Given the difficulty in recovering broomcorn millet grains without employing bulk sediment sampling, this study revisits the significance of storage and consumption of both this cereal and *Triticum spelta* within the agro-pastoral economy of Crasto de Palheiros.

Keywords: Crasto de Palheiros; Iron Age; Archaeobotany; *Panicum miliaceum*; *Triticum spelta;* pastoralism

Resumo Publicam-se duas datações por AMS, uma realizada a partir de *Panicum miliaceum* (milho miúdo) e outra a partir de *Triticum spelta*. A primeira vem confirmar que os cultivos de *Panicum* se realizaram no Crasto de Palheiros somente durante a Idade do Ferro, estando por confirmar se terão começado no Bronze Final. A segunda expõe pela primeira vez uma datação direta sobre este tipo de trigo neste sítio arqueológico. A atenção dada aos fenómenos pós-deposicionais e de infiltração destas amostras conduziu a uma reavaliação contextual das restantes datações publicadas há perto de duas décadas, particularmente as de *Panicum miliaceum*, sendo motivo para a publicação mais pormenorizada dos contextos destas e de algumas das restantes. Em consequência da dificuldade de obter sementes de milho miúdo a não ser que se usem recolhas de sedimento íntegro, é reavaliada a importância do armazenamento e consumo deste cereal e do *Triticum spelta*, no contexto da economia agro-pastoril do Crasto de Palheiros.

Palavras-chave: Crasto de Palheiros; Idade do Ferro; Arqueobotânica; *Panicum miliaceum; Triticum spelta*; pastorícia

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1. Introduction

The main objective of this paper is to clarify the absolute chronology of two cereals recovered from Crasto de Palheiros – *Panicum miliaceum* and *Triticum spelta* – through direct AMS radiocarbon dating.

Panicum miliaceum grains were recovered from a Chalcolithic layer and initially published with a chronology placed in the 3rd millennium BCE (Chalcolithic) (FIGUEIRAL, 2008: 86, Quadro 4), based on conventional 14C dating of charred wood from the same stratigraphic layer [2b]. However, subsequent research at other sites with identified caryopses has failed to confirm such an early chronology, both across the Iberian Peninsula and specifically in its northern and northwestern regions. In these late regions, the earliest evidence dates from the mid-2nd millennium BCE onwards: Middle Bronze Age at Sola IIb (Braga, Lower Minho) (BETTENCOURT *et al.*, 2007), Late Bronze Age in Cantabria/Asturias (GONZÁLEZ-RABANAL *et al.,* 2022), Bronze Age-Iron Age transition at As Laias (Ourense, Galicia) (TERESO *et al.,* 2013), and various Iron Age settlements ("castros") (SEABRA *et al.,* 2018).

This accumulating evidence has prompted several scholars to advocate for reconsidering early chronologies obtained indirectly from sites subject to prolonged occupations, as is the case with Crasto de Palheiros (TERESO *et al.,* 2016; TEIRA BRIÓN, 2019). Currently, the data point to the introduction of this crop in the north of the Iberian Peninsula during the 2nd millennium BCE (TEIRA BRIÓN, 2019; GONZÁLEZ-RABANAL *et al.,* 2022), and it is now generally accepted that its dissemination, whilst dependent on both economic and cultural systems, was relatively rapid.

In 2017, a small excavation in the Upper Northern Platform of the Upper Enclosure of Crasto de Palheiros was carried out. This unpublished excavation yielded the AMS ^{14}C direct date from *Triticum spelta* at this site. In fact, *Triticum spelta* presents a similar case to *Panicum miliaceum*, appearing in layers containing Chalcolithic archaeological material and, consequently, being attributed to a comparable initial chronology. To date, published archaeobotanical studies have clearly identified *Triticum spelta* only in Iron Age contexts – e.g. 4th–3rd centuries BCE at Castrovite (REY CASTIÑEIRA *et al.,* 2011). However, chronological doubts remain regarding samples of *Triticum spelta* and *Panicum miliaceum* identified in Late Bronze Age contexts in Crasto de Palheiros. Both cereals would require direct dating for confirmation.

2. The Crasto de Palheiros archaeological site: an overview

Crasto de Palheiros (Murça, Portugal) – Lat. 41.402909 N, Long. -7.380212 W; 590 m above sea level – is classified as a Site of Public Interest[(1)] (Figs. 1 and 2). Continuous excavations were carried out at the site between 1995 and 2003, with results published across various partial studies, which were subsequently synthesised in the 2008 monographic study (SANCHES, 2008). Further research: a) examined consumption patterns (both daily and calendrical) by integrating faunal remains and plant macro-remains (SANCHES, 2016); b) expanded the carpological knowledge of Enclosure L (Iron Age) (LEITE, 2017) by analysing storage functions of individual residential units (huts) within Enclosure L based on seed diversity and quantity (LEITE *et al.*, 2018).

The results of the 2017 campaign were highly significant. However, they required (i) a review of the ceramic studies of the Upper Enclosure (although to date only those of the Upper North Platform have been partially published (PÉREZ IGLESIAS, 2018)), and (ii) a reanalysis of

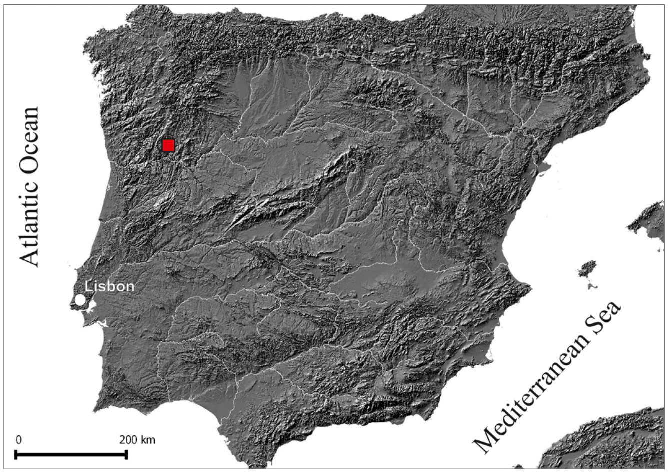

Fig. 1. Crasto de Palheiros in the Iberian Peninsula.
Fig. 1. Crasto de Palheiros na Península Ibérica.

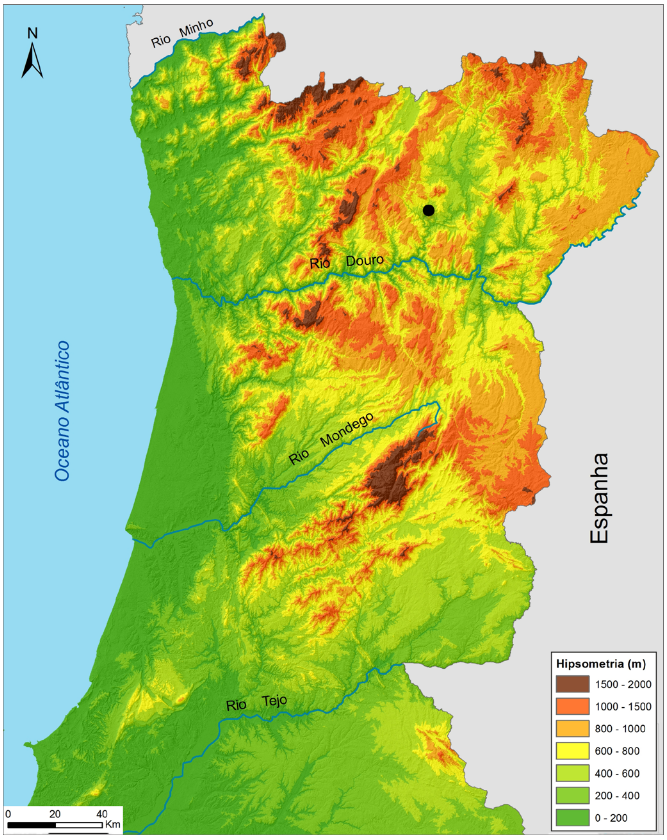

Fig. 2. Crasto de Palheiros, in the Eastern Trás-os-Montes province, East of the Marão-Padrela mountain range (Mediterranean biogeographical region), is marked (black dot) on the hypsometric and hydrographic map of Northern and Central Portugal (©Marta Araújo, modified).
Fig. 2. Crasto de Palheiros em Trás-os-Montes Oriental, a leste do alinhamento montanhoso Marão-Padrela (região biogeográfica "mediterrânica"), marcado (ponto a negro) sobre o mapa hipsométrico e hidrográfico do norte e cento de Portugal (©Marta Araújo, modificado).

(1) Portaria nº 406/2010, *Diário da República*, 2ª série, nº 114 de 15-06-2010.

the stratigraphic sequences in each area of Crasto. These studies confirmed distinct Late Bronze Age occupation in some areas of the Upper Platform, particularly in the eastern sector, which had not been clearly identified previously (Sanches, 2025). Through these studies it also became evident that the entire Upper Enclosure appeared to have contained systematic residential structures during the Iron Age; however, due to erosion and the collapse of both the Iron Age wall and the Chalcolithic rock structures (stone embankments) that supported the slopes, these residential structures remain only partially preserved in areas immediately adjacent to rocky outcrops (Fig. 3).

In summary, Crasto de Palheiros has been occupied since the first quarter of the third millennium cal BC, during which time its inhabitants transformed the natural quartzite crest into a monumentalised hill (phase I) (Sanches, 2016). This was accomplished through the construction of durable architecture – including embankments, walls, and stone barriers –which created a system of continuous and staggered platforms, often positioned in areas sheltered by rocky outcrops.

Following the end of the third millennium cal BC, the monumentalised hill was apparently abandoned for about a millennium until the beginning of the 9th century cal BC. The site was probably revegetated naturally (trees and/or shrubs) and potentially used for subsistence activities (hunting, gathering, or agriculture), although this remains unconfirmed by archaeological evidence. Between the 9th century and the mid/late 6th-early 5th centuries, during the Late Bronze Age (phase II), the spatial dispersion (and discontinuity) of the occupied areas and the thickness of their strata suggest that the settlement lasted for only a short time, possibly as a multi-year mobile settlement (Sanches, 2025). The three ^{14}C dates corresponding to this phase are: CSIC-1319, CSIC-1282 and Ua 22217. The last of these (774-418 cal BC), despite its wide interval, seems to establish the transition to the Iron Age (Table 1). The successive occupations throughout the Late Bronze Age would have embedded within regional communities both a sense of place for settlement and collective references of group identity and memory, constituting structural elements that underpinned the deliberately permanent reoccupation established during the Iron Age (phase III). Consequently, the foundation of the Iron Age settlement (phase III) is dated between 500 and 400 BCE in all lower areas (platforms and embankments), with dates Ua-22219 (747-364 cal BC) and Ua-22218 (736-382 cal BC) from the Eastern Embankment, associated with the most archaic Iron Age pottery. This settlement appears to have persisted for approximately 500-600 years, from c. 500-550 BCE to 80-130 CE (Sanches & Pinto, 2008: 49-52) (Fig. 3), and, where preserved, is evidenced by subcircular (more rarely, subquadrangular) residential huts built with perishable materials (wood and earth/clay) (Sanches & Pinto, 2006).

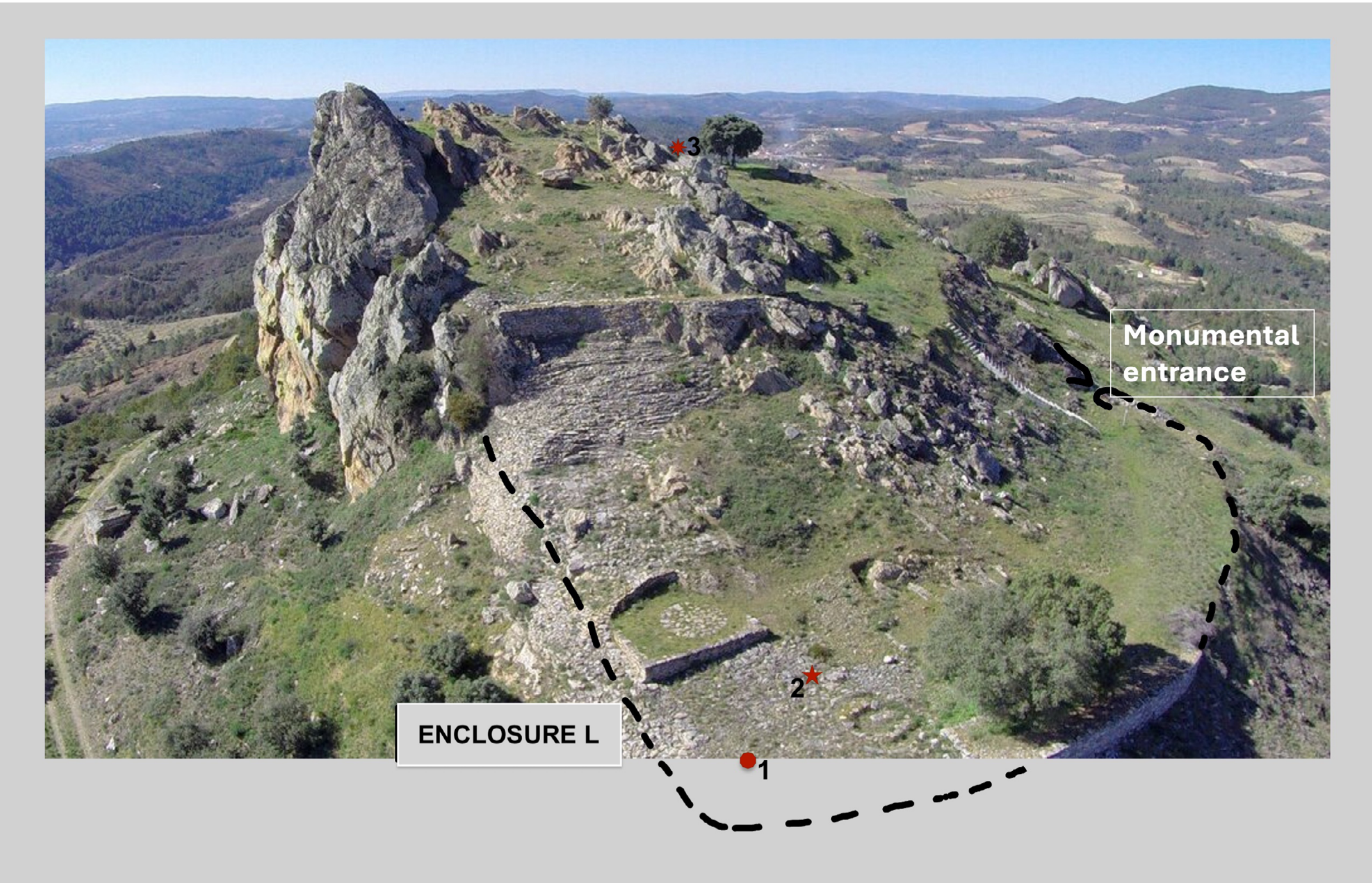

Fig. 3. Crasto viewed from the East. Enclosure L is demarcated with its monumental entrance. 1 and 2- *Panicum miliaceum* samples: 1 - Residential unit 1 (Hut 1/U. Hab. 1); 2 - Residential unit 2 (Hut 2 /U. Hab. 2) and its samples. 3 - *Triticum spelta* sample in the Upper Enclosure (Upper Northern Platform) (Photo by the Municipality of Murça, modified).

Fig. 3. Crasto visto de Leste. Marca-se o Recinto L com a sua entrada monumental. 1 e 2- amostras de *Panicum miliaceum*: 1 - Unidade habitacional 1 (U. Hab. 1); 2 - Unidade habitacional 2 (U. Hab. 2) e suas amostras. 3 - Amostra de *Triticum spelta* no Recinto Superior (Plataforma Superior Leste) (Foto do Município de Murça, modificada).

3. Collection Methods

Systematic sampling of macroremains from all undisturbed stratigraphic layers and settlement structures was the standard protocol throughout all excavation campaigns. This represented a considerable undertaking, given both the extensive area excavated and the significant stratigraphic depth of certain sectors. The absence of on-site water supply and flotation facilities necessitated less accurated sampling strategies, which influenced the results to an extent that remains imprecise, as previously noted in other publications (Leite, 2017: 62, 86; Leite *et al.*, 2018: 51).

From each square and stratigraphic unit – identified during excavation as layer or Lx, but referred to here as u.e.(2) for clarity – 10 litres of sediment were collected and dry-sieved through a 4/5 mm mesh. Subsequently, laboratory processing involved water flotation through a 2 mm or 1 mm sieve. For well-delimited deposits – such as combustion structures and postholes – where sediment volume varied, samples bypassed dry-sieving and underwent direct flotation, typically using a 1 mm mesh. In areas where basketry containers were potentially present, particularly near Iron Age 'fire' features, additional bulk sediment samples (1-2 litres, unsieved) were collected.

The analysis of samples must therefore account for these methodological limitations particularly regarding identification statistics, since carpological and anthracological studies by Figueiral (2008) and Leite (2017) unequivocally demonstrate the presence of macroremains of varying sizes. Some specimens were so small that their recovery was only possible by collecting sediment in bulk and then flotation in fine-mesh sieves.

The Iron Age occupation yielded substantial samples in both quantity and volume. Following archaeobotanist Isabel Figueiral's protocol, macroremains were processed as follows: after shade-drying, a 0.5-litre subsample was randomly collected from each sample (blind collection) for anthracological and carpological analysis. According to Figueiral (personal information), the volume of macroremains identified per sample was sufficient to provide a comprehensive anthracological characterisation of the site.

These samples derive primarily from the eastern area of the site. Sedimentary disturbances in the northern sector resulted in significantly fewer samples being collected, and only a small portion of these were subsequently analysed. Consequently, further carpological studies are needed to better understand the functional differences between various settlement areas.

To partially address this analytical gap, Margarida Leite subsequently completed the carpological analysis of Enclosure L's northern zone, thereby enhancing our understanding of the functional areas within this precinct (Leite, 2017; Leite *et al.*, 2018). Nevertheless, most samples collected during the 2017 excavation of the Upper Enclosure remain unanalysed. These samples bypassed dry sieving and went directly to water flotation. Although the sampling strategy followed established spatial and stratigraphic protocols, the exclusive use of 1 mm mesh water flotation for these samples is expected to yield both greater floristic diversity and more precise statistical evaluation compared to previous methods.

4. The New Cereal Dates

4.1. *Panicum miliaceum* from Enclosure L (Eastern Lower Platform)

The *Panicum miliaceum* sample selected for direct dating has the reference UET-97-125 (X11) and was identified by Isabel Figueiral (2008: 86, Table 4). This sample was collected from square X11, specifically from the upper 10 cm of stratigraphic unit [2b] (Figs. 3 and 4). It forms part of a group of three samples that yielded *Panicum miliaceum*, from the same stratigraphic unit (u.e.) and topographical context [2b]: UET-97-109 (W9) and UET-98-104 (X10-11). However, the third sample (UET-98-104), which was collected in 1998, was recorded under a different stratigraphic u.e. designation [41.3]. Thus, all three samples were thus recovered from a Chalcolithic context, designated as either [2b] or [41.3].

From a spatial perspective, the three samples were recovered from beneath the clay and earth compacted floor of an Iron Age residential unit (Hut 1/U Hab. 1). Although this floor [1b] exhibits evidence of modifications and prolonged use – ultimately culminating in a fire that devastated the structure – the stratigraphic sequence reveals two intermediate strata, [25] and [2a], located between the lower level [2b] (from which the samples were collected) and the base of the dwelling unit's clay floor [1b] (Fig. 4).

Stratigraphic layer u.e. [25], dated by ^{14}C and ceramic assemblages from the Late Bronze Age (CSIC 1282) (Table 1), constitutes a spatially discontinuous sedimentary deposit, which may therefore correspond to distinct occupations within this period. Stratigraphic layer u.e. [2a] comprises an imbricated arrangement of blocks and sediments (forming a protective 'armour') which, within this sector of the Eastern Lower Platform, served to intentionally seal the underlying Chalcolithic occupation [2b] (Fig. 4), dated from the second quarter of the 3rd millennium BCE (CSIC-1617) (Sanches, 2008: 45, Table 2).

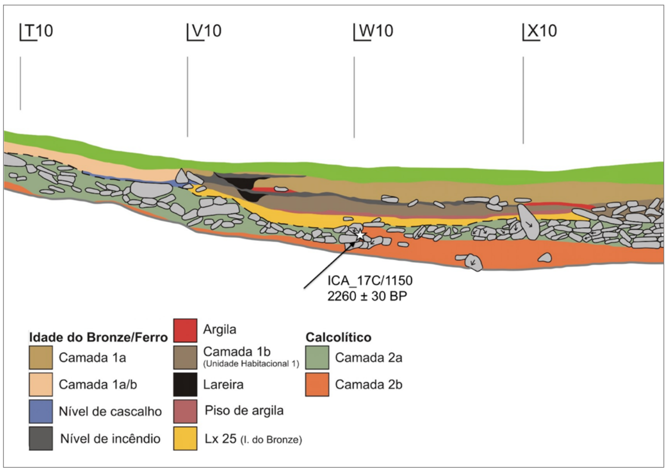

Fig. 4. West-east stratigraphic section across Residential Unit 1 (Hut 1/U Hab. 1). The grid is 2 m^2. The star shows the stratigraphic position of sample ICA 17C/1150 (*Triticum miliaceum*). It is represented in horizontal projection.

Fig. 4. Corte estratigráfico Oeste-Este sobre a Unidade Habitacional 1 (U. Hab. 1). A quadrícula é de 2 m^2. A estrela indica a posição estratigráfica da amostra ICA 17C/1150 (*Triticum miliaceum*) e está representada em projeção horizontal.

(2) Portuguese abbrev. for 'stratigraphic unit'.

Table 1. Radiocarbon ^{14}C dates from Crasto de Palheiros covering the 1st millennium BCE (2σ calibration). First column on the left: III (e.g. PIL III; TEN III) refers to contexts stratigraphically and/or archaeographically related to the Iron Age (phase III); In bold: new 14C dates (*Panicum miliaceum* and *Triticum spelta*). Column 6: "Wood selection" indicates samples in which short-lived plant elements were selected for 14C dating.

Quadro 1. Datações radiocarbono para o Crasto de Palheiros, cobrindo o 1º milénio AC (calibração a 2σ). Primeira coluna da esquerda: III (por ex. PIL III; TEN III) refere-se aos contextos relacionados estratigraficamente e/ou arqueograficamente com a Idade do Ferro (fase III); Em negrito: datações inéditas de *Panicum miliaceum* e *Triticum spelta*. Sexta coluna: "Wood seletion" indica as amostras em que se selecionaram elementos vegetais de vida curta para datação.

Ref.	BP	±	2σ calibration	Context	Charred material
PSL II (CSIC-1319)	2682	27	900-802 BC (95.4%)	[7]	Cereals & Wood
PIL II (CSIC-1282)	2686	43	919-792 BC (95.4%)	[25]	Wood
TEN II (Ua-22217)	2480	45	774-458 BC (92.0%) 440-418 BC (3.4%)	[28.1]	AMS/Wood seletion (1)
TEL III (Ua-22219)	2365	45	747-688 BC (7.0%) 666-643 BC (3.1%) **565-364 BC (85.4%)**	[133] bulk sample	AMS/Wood seletion (1)
TEL III (Ua-22218)	2370	40	736-694 BC (5.3%) 664-648 BC (2.5%) **547-382 BC (87.7%)**	[140/133] bulk sample	AMS/Wood seletion (1)
PIN III (CSIC-1962)	2371	36	725-705 BC (2.6%) 663-651 BC (1.7%) 545-386 BC (91.1%)	[79] Hearth	Wood seletion (1)
PIL III (Ua-18527)	2195	50	387-107 BC (95.4%)	[87]	AMS/Wood seletion (1)
PIL III (CSIC-1219)	2260	47	402-336 BC (33.2%) **328-198 BC (62.3%)**	[37]	wood
TEL III (Ua-19117)	2225	40	**389-194 BC (93.9%)** 186-178 BC (1.6%)	[128]	AMS/Wood seletion (1)
PIN III (CSIC-1961)	2208	37	381-174 BC (95.4%)	[73.2]	Wood seletion (1)
PIL III (ICA_17C/1150)	2260	30	394-348 BC (36.3%) 312-206 BC (59.2%)	[2b]*	AMS/ Panicum miliaceum
PIN III (CSIC-1406)	2284	26	401-352 BC (60.4%) 288-226 BC (33.6%) 220-210 BC (1.5%)	[2b]*	
PSL III (CSIC-1217)	2258	48	402-197 BC (95.4%)	[1/2] top	Cereals & Wood
TEN III (Ua-22882)	2110	45	351-290 BC (10.0%) 226-222 BC (0.2%) **210-31 BC (82.3%)** 18-8 AD (3.0%)	[20.4]	AMS/Wood seletion (1)
PSL III (CSIC-1281)	2116	40	350BC (9.5%) 304BC **208BC (84.7%)** 38BC 12BC (1.3%) 2AD	[0/1]	
PSN III (ICA-17C/1133)	2050	30	159BC-26 AD (95.4%)	Structure 10_ bulk sample	AMS/Triticum spelta
PSN III (Sac-1972)	1990	45	102-66 BC (3.4%) **60-131 AD (90.7%)** 141-158 AD (1.0%) 192-200 AD (0.4%)	[30]	
PSN III (Ua-22883)	2000	45	146-140 BC (0.4%) 108-127 AD (95.0%)	[30]	Unidentified cereals similar to wheat/ barley
PSN III (CSIC-1691)	1922	29	26-208 AD (95.4%)	[7]	Cereals & Wood
PIL III (CSIC-1215)	1959	47	44-204 AD (95.4%)	Hearth 4	Cereals & Wood
PIL III (CSIC-1320)	1979	32	42-120 AD (95.4%)	Hearth 1	Unidentified cereals similar to wheat/ barley
PIL III_P m_ (CSIC-1805)	1982	30	**43-87 AD (84.6%)** 92-118 AD (10.9%)	[31] hand-collected	Agglomerate of Panicum miliaceum
PIL III_P m_ (CSIC-1404)	1951	26	36-14 BC (3.0%) **4-130 AD (91.4%)** 144-155 AD (1.0%)	[31] [31] hand-collected	Agglomerate of Panicum miliaceum
PIL III (CSIC-1405)	2014	26	88-80 BC (1.0%) 54-76 AD (94.4%)	[1b/31]	
PIL III (CSIC-1403)	1954	26	38-12 BC (3.9%) **3-129 AD (91.6%)**	[1b/31]	
PIL III_P m_ (CSIC-1279)	2045	35	**160BC (91.8%) 31AD** 40-60 AD (3.7%)	[1b/31] [31] hand-collected	Agglomerate of Panicum miliaceum
TEL III (Sac-1971)	1980	50	94-74 BC (2.0%) 56-204 AD (93.4%)	[142.1]	
PIN III (Sac-1970)	2020	45	151-130 BC (2.7%) **121BC (88.5%) 86AD** 93-118 AD (4.3%)	[131.2/16]	Wood seletion (1)
PIN III (Sac-1973)	1980	50	94-74 BC (2.0%) **56-204 AD (93.4%)**	[62]	Wood seletion (1)

We must acknowledge that, although not observed during excavation, these *Panicum miliaceum* grains would have percolated through the coarser sediments of the upper stratigraphic units – [1b] or [1a] – where they were also identified in substantial quantities within the area corresponding to residential unit 1(Hut 1/U. Hab. 1), specifically in squares T/V11 and X10 (Figueiral, 2008: 94, Table 10). The small size of these caryopses would have facilitated their infiltration into underlying layers, a process likely exacerbated by the architectural modifications and continued use of this hut.

Given these considerations, it is now essential to verify through direct dating by 14C whether the two *Panicum miliaceum* samples collected from u.e. [25] – one from square W9 and another from V10 (Figueiral, 2008: 91, Table 8-B) – might also result from similar post-depositional infiltration. This context, which also contains *Triticum spelta*, is dated to the Late Bronze Age (phase II) through both absolute chronology (CSIC-1282) and ceramic assemblages (Pinto, 2019), although Table 8-B (Figueiral, 2008: 91) is erroneously labelled as "Phase III-1/early occupation". However, given the horizontal discontinuity and limited thickness of these strata, along with the apparent continuity between late Bronze Age and early Iron Age occupations, some of these contexts may actually date to the later Late Bronze Age occupation (c. 6th-5th centuries BCE).

Within Enclosure L, several small agglomerates of *Panicum miliaceum* were recovered directly from fire contexts, three of which were ^{14}C dated using conventional methods (Fig. 3 and 6). The sample from square V10, still located within the spatial boundaries of residential unit 1 (Hut 1), formed part of the carbonised sediments accumulated during fire event [31] and corresponds to date CSIC 1279. The second and third samples were likewise collected from the fire context within residential unit 2 (Hut 2/U. Hab. 2), which is adjacent to Hut 1. Sample CSIC 1404 derives from square T12 [31], whilst sample CSIC 1405 was collected from square V12 [31], as illustrated in Fig. 5. In summary, these four dated samples of *Panicum miliaceum* were recovered from residential units within Enclosure L – two from Hut 1 and two from Hut 2 – and are associated with Crasto's Iron Age occupation (Fig. 7 and Table 1).

Thus, the ^{14}C dates of *Panicum miliaceum* suggest that cultivation of this crop commenced by the late 4th - early 3rd centuries BCE and continued until the abandonment of the settlement in the 1st-2nd centuries CE.

4.2. *Triticum spelta* in the Upper Enclosure: Northern Upper Platform

Within this sector of the settlement, Iron Age occupation strata are poorly preserved, the platform having become inclined towards the exterior. The only preserved deposits are those where settlement structures were deeply embedded within the Chalcolithic stone "armour", or where rocky outcrops defined the embankment structure, as exemplified by this sample (Fig. 3 and 6).

A 3.5-litre bulk sediment sample was recovered from u.e. [2] in square 48/20, within a burnt well-delimitated earth context. The caryopses were selected for dating following their identification as *Triticum spelta* by archaeobotanist João Tereso. Stratigraphic layer/u.e. [2] and [3] are contemporaneous and associated with settlement structures within a discontinuous sedimentary layer containing Iron Age ceramics. The sample yielded a date of 2050±30 BP (159 BC-26 AD cal 2σ) (Fig. 6, ICA_17C/1133 in Table I and Fig. 7).

Based on this sample, we can confidently infer the cultivation of *T. spelta* from the mid-2nd century BCE onwards, although this cereal was likely already part of earlier Late Bronze Age/Iron Age agricultural systems in Crasto de Palheiros. However, clarification of this issue would require direct dating of this cereal from earlier contexts of this archaeological site.

Fig. 5. Residential Unit 2 (Hut 2 /U. Hab. 2) during excavation, showing its subcircular outline. Stars mark the collection points of *Triticum miliaceum* samples.

Fig. 5. Unidade Habitacional 2. (U. Hab. 2) quando em escavação, observando-se o seu contorno subcircular. As estrelas marcam o local de recolha das amostras de *Triticum miliaceum*.

Fig. 6. The arrow indicates the location where the concentrated sample of *Triticum spelta* – ICA 17C/1133 – was recovered.

Fig. 6. A seta indica o local aonde foi recolhida a amostra concentrada de *Triticum spelta* – ICA 17C/1133.

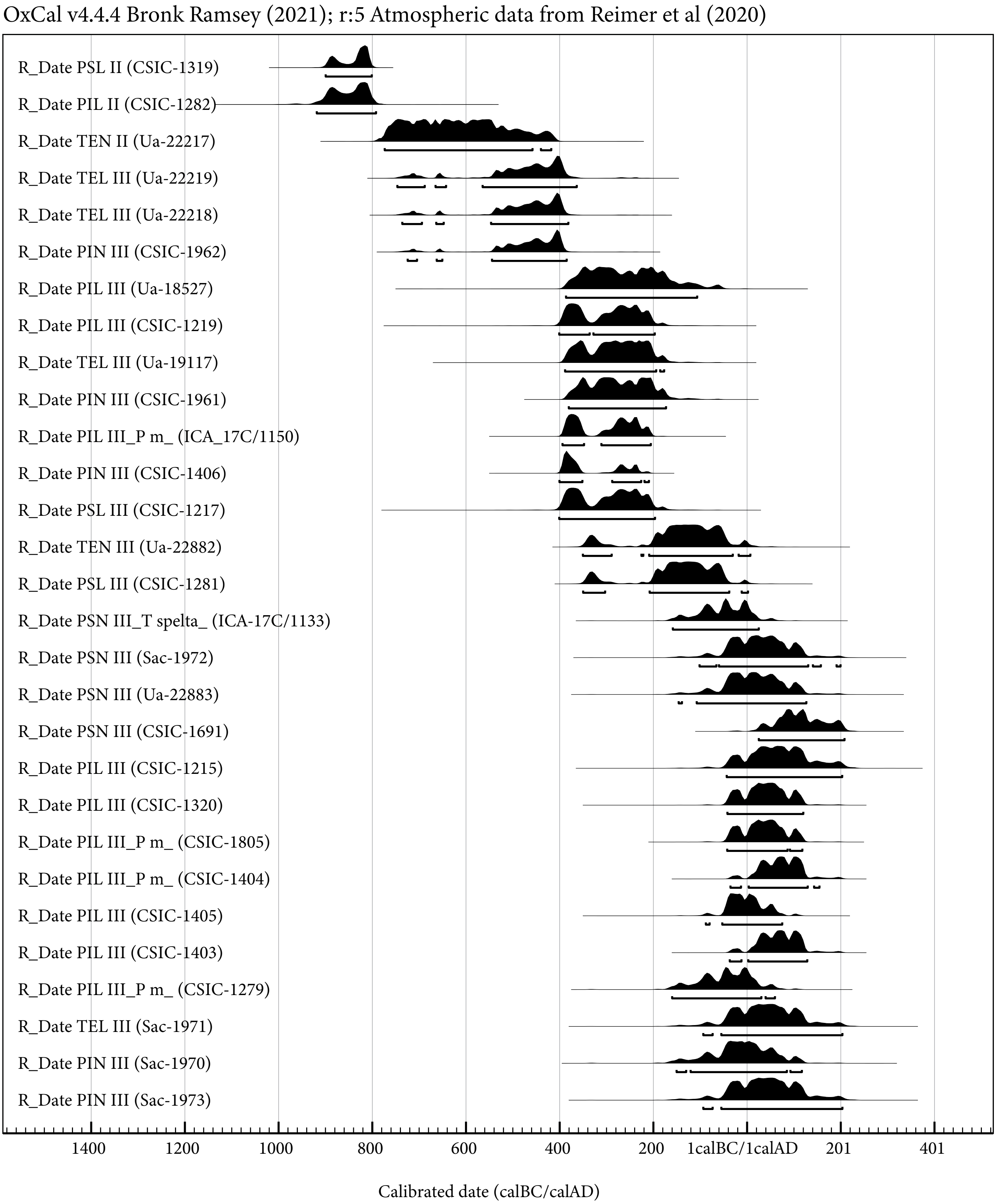

Fig. 7. Radiocarbon dates from Crasto de Palheiros (OxCal v4.4.2; IntCal20 curve; Reimer *et al.,* 2020).

Fig. 7. Datas de radiocarbono do Crasto de Palheiros (OxCal v4.4.2; IntCal20; Reimer *et al.,* 2020).

5. Discussion and conclusions

Crasto de Palheiros is situated in the transitional area between Atlantic and Mediterranean bioclimatic regions (Fig. 2). Previous analyses of interregional connections reflected in material culture have emphasised this 'hybrid' character, showing influences from both the Meseta/Beira Interior and the northwestern littoral region of the Iberian Peninsula (Sanches & Pinto, 2008; Sanches, 2016; Pinto, 2019). This bioclimatic position and cultural context help to contextualise and better understand the direct dating that motivated this study.

Significantly, Crasto de Palheiros was cited as the only site in the Iberian Peninsula where *Panicum miliaceum* had been recovered from Chalcolithic contexts (e.g. González-Rabanal *et al.,* 2022), an exceptional claim that motivated direct dating, as we have previously stated.

Indeed, direct dating of the sample, with its calibration (2σ) - 394-206 cal BC - places it in the initial phase of the Iron Age settlement, as evidenced in the comparative graph in Fig. 7. Given that around 200 BC, and precisely in this area of the settlement, (i) a walled enclosure with a monumental entrance – Enclosure L – was established, and that (ii) five residential units (or huts) dedicated to cereal storage and consumption were grouped in its southern sector at the time of the fire (Leite *et al.*, 2018), we observe that broomcorn millet was part of the crop assemblage that accompanied Crasto's development from its foundation as an Iron Age settlement. Given the percolation process inferred, doubts remain as to whether, in this same area, the *Panicum miliaceum* grains attributed to the Late Bronze Age [u.e. 25] may also have been displaced from their original context.

In any case, the direct dating (conventional method) of three samples in Enclosure L – preserved as agglomerates – is significant, as they were recovered from the fire stratigraphic layer of two adjacent residential units (huts 1 and 2) (Fig. 3). These dates (CSIC-1805, CSIC-1404 and CSIC-1279), when calibrated at 2σ, are statistically similar to other dates associated with the fire event (Fig. 7). Together with four additional dates, they were used to statistically define the timing of this event, which occurred around 80 cal CE (Sanches & Pinto, 2008: 50 and note 19).

Regarding *Triticum spelta*, this wheat variety has been identified across all areas of the Crasto. Even in areas with fewer samples, it appears proportionally more abundant than other cereals (wheat and barley). While documented in strata from the settlement's inception (5th/4th century BC) through to its abandonment, this represents its first direct dating. The calibrated date (2σ) of ICA-17C/1133 – 159 BCE-26 CE (95.4%) – indicates that the occupation of the Upper Enclosure may not predate the 2nd century BCE (Table 1). This timing suggests that the architectural complexification of the Crasto, particularly with the construction of Enclosure L, was part of a comprehensive settlement reorganisation, including the systematic occupation of new areas such as the Upper Platform and the likely construction of a perimeter wall around it. This would have created the Iron Age Upper Enclosure there.

The significance of this wheat cultivation during the Iron Age (and subsequent periods) has been emphasized by various scholars (Figueiral, 2008; Tereso *et al.,* 2013; Tereso *et al.,* 2016; Leite *et al.*, 2018), particularly regarding its adaptability to the depleted and eroded soils of the late 2nd and early 1st millennia BCE, where it maintained viable yields. In its less humid climate compared to the littoral region, Crasto de Palheiros exhibits patterns similar to those observed across the Northwestern Iberian Peninsula – where these crops occur from the Late Bronze-Iron Age transition (6th-5th centuries BCE) (Tereso *et al.* 2013) – with this being the chronology also attributed at Castrovite (Pontevedra) (Rey Castiñeira *et al.,* 2011).

At the Castroeiro settlement (Mondim de Basto), *T. spelta* accompanied the settlement development, having gained dominance as a cultivated crop from the 3rd century BCE onwards (SEABRA, 2015; Seabra *et al.,* 2018). However, unlike the cited *castros*, stone houses were never built at Crasto de Palheiros, a fact that highlights the challenging path ahead in understanding the diverse processes of exchanges/sharing between Late Bronze Age and Iron Age communities in this region.

Returning to broomcorn millet, its value for both human and animal nutrition has been increasingly reassessed in recent years, with evidence showing it became significant from at least the late 2nd millennium BCE (González-Rabanal *et al.,* 2022). Indeed, it is attested from the Late Bronze Age at various Cantabrian archaeological sites, such as El Espinoso cave (1235 and 1099 cal BC) and other contemporaneous sites in that region (González-Rabanal *et al.,* 2022). Similarly, in the northwestern Iberian Peninsula during the Late Bronze Age, the presence of *Panicum miliaceum* is documented at several sites located in Atlantic ecosystems – A Fontenla, Penalva, S. Julião Ia, Ib and Ic, and Castelo de Matos – (Tereso *et al.,* 2016), as well as at sites in Beira Interior – e.g. Vila do Touro (Sabugal) (Tereso *et al.,* 2020) – which are already within a continental Mediterranean ecosystem. This distribution appears to presage a pattern that becomes evident later in the Iron Age: this cereal is systematically recovered whenever appropriate sampling and macroremain collection techniques are employed.

In summary, both broomcorn millet – a spring cereal – and *Triticum spelta* are well-suited to productive diversification based on crop rotation, potentially incorporating fallow periods, and can also be used for animal fodder, as documented in ethnobotanical studies (Moreno-Larrazabal *et al.,* 2015). This productive diversification can be understood as a form of economic intensification, based on careful management of livestock (particularly sheep and goats), whose manure and grazing would have compensated for soil depletion and shallow soil depths. We highlight that *Triticum spelta* was still systematically used in this inland region for young sheep husbandry during the second half of the 20th century (pers. inform. of Francisco Vilariça, now deceased, who was a shepherd throughout his entire life).

Sheep and goat husbandry at Crasto, evidenced by faunal remains recovered from hearths, their peripheries, and other areas within residential units (Sanches, 2016; Figueiral *et al.*, 2017), appears to constitute the predominant form of livestock management. This practice supports the close relationship between cereal cultivation – particularly of *Triticum spelta* and *Panicum miliaceum* – and herd maintenance, with the animal bone remains being preserved in a highly fragmented condition. We believe this evidence points towards a reassessment of the significance of ovicaprine herding as a fundamental economic and socio-political strategy during the second half of the 1st millennium BCE and the first century CE.

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