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Middle Magdalenian human occupation at Coímbre Cave, Zone A (Asturias, northern Iberia)

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ABSTRACT

This paper presents the results of the interdisciplinary study of level Co.A.3 in Zone A of Coímbre Cave (Peñamellera Alta, Asturias, northern Iberian Peninsula), corresponding to a human occupation attributed to the Middle Magdalenian. Despite the limited extent of the excavation, the stratigraphic integrity, contextual coherence, and volume of recovered materials allow for meaningful comparisons with other sectors of the site, particularly Zone B. Flint provenance analysis reveals a marked eastern orientation in raw material procurement, suggesting long-distance acquisition networks or exchange systems, in contrast to the low representation of western sources despite their geographic proximity. The zooarchaeological study indicates a subsistence strategy focused primarily on ibex and red deer, with evidence of systematic processing and a broad age range among the hunted individuals. Spatial modelling through cost-distance analysis defines a restricted catchment area of 57.96 km^2, shaped by the rugged topography between the Sierra del Cuera and the Picos de Europa, and suggests predominantly east–west mobility patterns along the Cares River. Finally, AMS radiocarbon dates confirm the presence of a chronological hiatus between the Lower and Middle Magdalenian occupations, consistent across both excavated areas. Altogether, these findings provide new insights into settlement dynamics, mobility strategies, and regional interaction patterns during the Middle Magdalenian, supporting the hypothesis of a cultural and territorial reconfiguration in the Cantabrian region at the onset of this phase.

1. Introduction

Coímbre Cave is located in Besnes (Peñamellera Alta, Asturias, northern Iberia). Its UTM coordinates are: X 363,165; Y 4,798,482; Z 145, Zone 30 (Datum ETRS 89) (Fig. 1). From a physiographic standpoint, the site is situated in the middle-to-lower course of the Cares Valley, in the central-western sector of the Cantabrian region, an area among the most mountainous in the region. The cave lies on the northern edge of the central-eastern massif of the Picos de Europa, where the highest peaks reach up to 2,600 m in elevation. The Coímbre karst system opens on the southwestern slope of Mount Pendendo (529 m), in the small valley formed by the Besnes River, approximately 800 m before it flows into the Cares River.

The excavations at Coímbre Cave took place between 2008 and 2012, resulting in a comprehensive monograph focused on Zone B of the cave (Álvarez-Alonso and Yravedra, 2017). Before the fieldwork began in 2008 and given the large dimensions of the cave's Entrance Chamber, a general grid was established based on a Cartesian coordinate system, and from this framework, the chamber was divided into four sectors. This subdivision allowed for the identification of areas where the main sedimentary deposits with archaeological content were preserved, and although these appeared stratigraphically disconnected, they were nonetheless designated as Zone A and Zone B (Álvarez-Alonso et al., 2009). This division was based on several factors: first, the large size of the cave's Entrance Chamber; and second, the sediment extraction carried out in the central area of the chamber during the 1940 s, which removed a significant portion of the site in that sector and led to the perception that the entire archaeological deposit had been disturbed –a

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notion that began to change with the onset of our investigations (Álvarez-Alonso and Yravedra, 2017a)-. Finally, the separation between Zones A and B was due to significant rockfalls and a steep difference in elevation of approximately 10 m between Zone B and the excavation area in Zone A (Figs. 2 and 3).

As previously mentioned, the research focused on Zone B, where five successive excavation campaigns were carried out (Álvarez-Alonso and Yravedra, 2017a, 2024; Álvarez Alonso et al., 2009, 2011, 2013b, 2016, 2020). However, during the 2008 and 2010 campaigns, a test excavation was also carried out in Zone A with the aim of assessing the condition of the site in this sector and identifying its stratigraphic sequence (Álvarez Alonso *et al.*, 2009). To this end, a 2 × 2 m area (squares L/M−9/10) was initially cleared, although the presence of several large blocks forced a reduction of the excavation area to approximately 1 m^2. The final excavated surface was located in squares L-9 and M−9, with dimensions of approximately 1.33 × 0.66 m (Fig. 4).

This test excavation made it possible to preliminarily identify a stratigraphic sequence composed of four layers. In any case, only the upper part of the deposit in Zone A has been excavated to date, so the full depth of the sedimentary fill remains unknown. The discovery of a site with significant richness and abundance of materials in Zone B directed the focus of our research efforts at Coímbre almost entirely toward this sector, leaving the study of Zone A in the background. We have recently completed the analysis of the Level Co.A.3 materials recovered from squares L9 and M9 in Zone A, and we have also carried out AMS radiocarbon dating, which places this context within the Middle Magdalenian.

Within the Cantabrian Region, Middle Magdalenian occupations have been linked to changes in mobility, raw-material networks and osseous traditions. This contribution provides a compact, level-by-level report of Co.A.3 integrating lithic technology and provenance, zooarchaeology and taphonomy, osseous artefacts, spatial analysis and AMS dating, and it explicitly compares Zone A with Zone B and nearby sites.

Fig. 2. Entrance Hall of Coímbre Cave. In the foreground, the excavation of Zone A.

Our goals are to (1) describe the technological and typological composition of the Co.A.3 assemblage; (2) determine flint provenance and evaluate mobility/procurement within a site-catchment framework; (3) characterize taxonomic composition, mortality structure and taphonomic signatures of the fauna; (4) document the osseous industry; and (5) discuss the implications for Middle Magdalenian settlement and

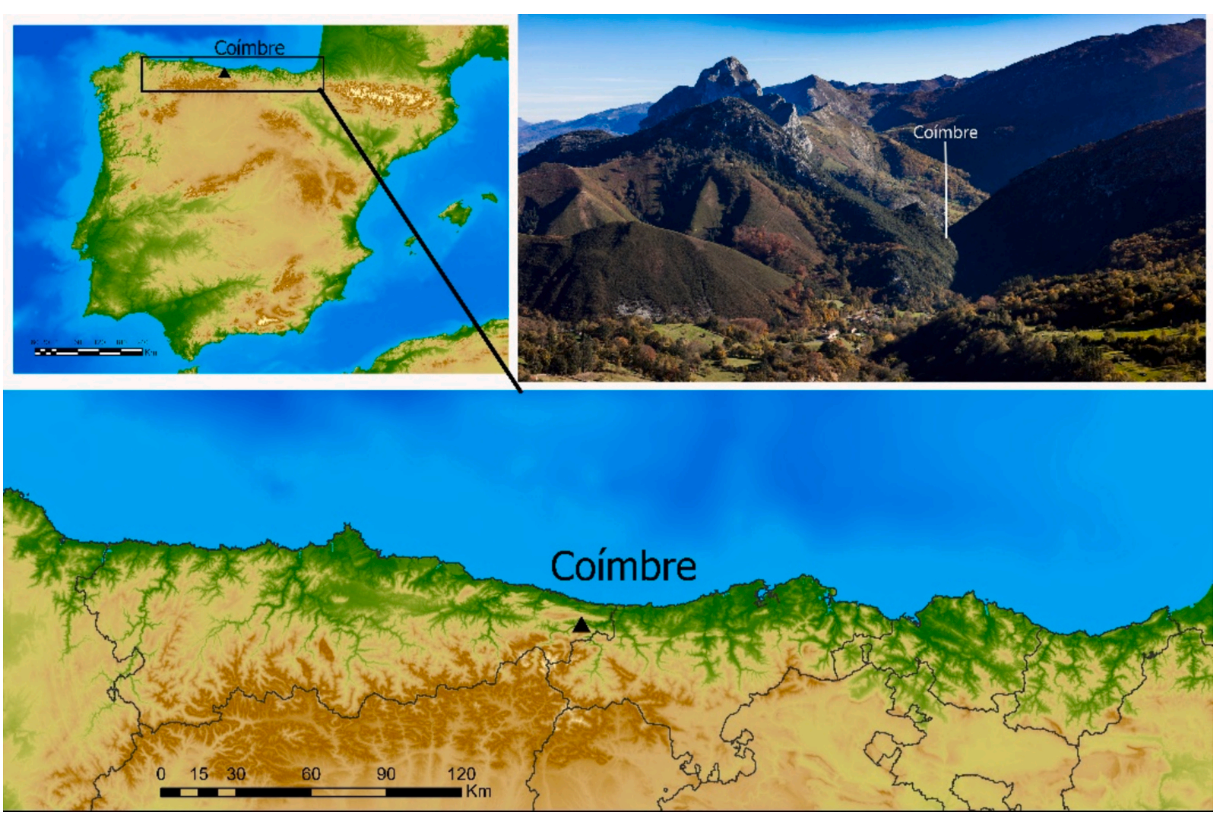

Fig. 1. Location of Coímbre cave. Photograph of Coímbre surroundings by K. Llamas ©FMCMP).

(Álvarez-Alonso and Yravedra, 2017a. Photograph by K. Llamas ©FMCMP)

Fig. 3. Plan of the Entrance Hall of Coímbre Cave, showing the location of the two excavation areas (modified from Álvarez-Alonso and Yravedra, 2017a).

Fig. 4. Excavation of Zone A (2010 field season).

connectivity in the central-western Cantabrian Region.

2. Methods

The analysis of the lithic assemblage has been approached from the perspective of the *chaîne opératoire*, understood as a theoretical and methodological framework for studying technical production sequences (Leroi-Gourhan, 1964; Lemonnier, 1976; Pelegrin et al., 1988). For the characterization of the different blanks and the technological analysis of the various categories of knapped products, the methodological approaches of Bernaldo de Quirós et al. (1981), Geneste (1991), and Merino (1994) have been followed. Regarding the description and analysis of retouched blanks, the classical criteria established for the Upper Palaeolithic by Sonneville-Bordes and Perrot (1956) have been considered, with particular emphasis on the typological system developed by Laplace (1972).

The analysis of lithic raw materials has focused exclusively on describing and determining the provenance of the flint. To this end, a protocol based on previously developed classification proposals was followed (e.g., Tarriño, 2006; Tarriño et al., 2007a, 2015, 2016; Tarriño and Terradas, 2013; Herrero-Alonso, 2018; Herrero-Alonso et al., 2021). The study was supported by a lithotheque that includes the main flint types used during Prehistory across the Cantabrian Zone, the Cantabrian Range, the Basque-Cantabrian Basin, and the western Pyrenees. The methodology employed combines direct observation (*de visu*) with the analysis of external textures under a stereoscopic microscope, following an approach already applied in previous studies (e.g., Martín-Jarque et al., 2022, 2024). First, direct observation records characteristics such as colour, gloss, transparency, texture, and the presence of cortex on the analysed remains were recorded. Second, the composition of the quartz matrix and the different inclusions −both mineral (detrital quartz, carbonates, sulphates, and oxides) and organic (bioclasts) inclusions- were identified microscopically. In the Cantabrian context this protocol has repeatedly shown high discriminatory power and reproducibility, including for Alba radiolarite, Las Portillas, Monte Picota and Flysch flints. Geochemical characterization could be an excellent complement in targeted cases (e.g., for unresolved varieties), but falls outside the aims and scope of this level-focused report and it's not necessary in this case.

The zooarchaeological analysis of level Co.A.3 at the Coímbre site has focused on taxonomic identification, the determination of mortality patterns, the quantification of remains, and a preliminary taphonomic assessment. The faunal assemblage exhibits a high degree of fragmentation, and no complete elements have been identified that would allow for reliable biometric estimations. The faunal study includes all remains recovered from Level Co.A.3 in squares L-9 and M−9 (n = 1,688, including identified and indeterminate fragments). All sediments from these units were wet-sieved (water-sieved) through a 2 mm mesh, and the residues were subsequently hand-sorted in the laboratory.

The taxonomic identification of the faunal assemblage was carried out following the criteria proposed by Lavocat (1966), Pales and Lambert (1971), Schmid (1972), and Hilson (1992). For more specific cases, Fernández (2001) was consulted to differentiate between Iberian ibex (*Capra*), chamois (*Rupicapra*), and roe deer (*Capreolus*), while Prumel (1988) was used to distinguish between large bovids and cervids in particular contexts. Additionally, reference osteological material housed at the Department of Prehistory, Ancient History, and

Archaeology of the Complutense University of Madrid was employed. Given the high degree of fragmentation of the assemblage, many remains could not be taxonomically identified. However, some fragments were tentatively assigned to broad body-size categories: large-sized animals (e.g., aurochs, horse, or bison), medium-sized (e.g., red deer or wild ass), and small-sized (e.g., Iberian ibex, chamois, or roe deer).

For the calculation of the Number of Remains (NR), both taxonomically identifiable and indeterminate elements were included. The Minimum Number of Individuals (MNI) was estimated based on the most frequently represented anatomical element, taking into account lateralization and incorporating age and sex criteria following the methodology proposed by Brain (1969).

Given that this study presents a preliminary analysis, mortality patterns were assessed through dental eruption and epiphyseal fusion, allowing a broad classification of individuals into adults, juveniles, and infants. Taphonomic examination was carried out under magnification (10×, 15×, and 20 ×), and, given the generally good preservation of the assemblage, emphasis was placed on recording biologically induced modifications, particularly those linked to human activity (thermal alterations, cut marks, percussion marks). Whenever possible, modifications attributable to carnivore activity were also identified and documented.

To carry out the spatial analysis and delimit the catchment area of Coímbre Cave, a cost-distance analysis was performed using the ArcGIS platform. For this purpose, the ASTER DEM digital elevation model was used, with a spatial resolution of 25 m across the general dataset (Andrés-Herrero et al., 2017a, 2017b). Subsequently, Tobler's algorithm (Tobler, 1993) was applied to transform terrain slope values and calculate movement costs (Wheatley and Gillings, 2002; Becker, 2012; Herzog, 2014).

In an initial phase, an isochrone corresponding to a 4-hour one-way journey from the cave was generated, considered the maximum reasonable limit for a daily foraging expedition. This estimate is based on ethnographic and archaeological proposals that establish an 8-hour round-trip range of daily mobility as a suitable value for resource procurement activities from a base camp (Kelly, 1995; Uthmeier et al., 2008). The methodology is inspired by the classic Site Catchment Analysis model developed by Vita-Finzi and Higgs (1970) and its subsequent refinements. Once the catchment area was defined using the 4-hour isochrone, successive concentric isochrones at the same time interval were generated in order to carry out a density and distance analysis of the flint outcrops.

3. Chronostratigraphic sequence

The preliminary stratigraphic sequence comprises four layers, corresponding exclusively to the uppermost portion of the sedimentary deposit (Fig. 5). Contrary to initial assumptions of widespread disturbance, it has been confirmed that such alteration is limited to the occupations associated with the Upper Magdalenian, which, moreover, are well represented in Zone B. (Álvarez-Alonso et al., 2013; Álvarez-Alonso and Yravedra, 2017a).

Fig. 5. Stratigraphy of Zone A.

Level Co.A.1 (25–35 cm). Corresponds to the apex of the debris cone at the lowest part of the Entrance Chamber, resulting from sediment removal activities. This level is composed of a matrix of dark brown, highly organic sediment, containing numerous clasts along with faunal remains and lithic industry. It represents a completely disturbed layer, the product of the dismantling of the upper part of the site, which corresponds to the Upper Magdalenian occupations. This level is subdivided into Co.A.1a and Co.A.1b: –Co.A.1a consists of approximately 20 cm of deposit, characterised by numerous highly heterogeneous limestone clasts, some reaching up to 40 cm in size (mostly matrix-supported), with abundant faunal remains and lithic artefacts. This sublevel is completely chaotic, resulting from intense disturbance processes affecting this part of the site.–Co.A.1b measures around 15 cm in thickness and is primarily composed of an accumulation of heterogeneous limestone clasts, predominantly clast-supported. Like Co.A.1a, it is in a secondary position and lacks cohesion.

Level **Co.A.2** (15–20 cm). This level consists of a highly plastic, light brown clayey matrix containing faunal remains and lithic artefacts and exhibits clear evidence of disturbance. It reflects the superficial alteration of the immediately underlying deposit. At its base, a blackish layer −formed through intensive trampling- marks the original ground surface disturbed during the sediment extraction activities of the 1940 s. This layer effectively delineates the boundary between the disturbed upper deposits and the intact archaeological sequence below.

Level **Co.A.3** (10–15 cm). It consists of a light brown clayey matrix containing lithic artefacts, abundant faunal remains, and bone industry remains. The sedimentary matrix is identical to that of the overlying level, suggesting that both belong to the same sedimentary unit, divided into an upper disturbed portion and a lower intact one. This represents the first undisturbed level of the sequence and is associated with the Middle Magdalenian.

Level **Co.A.4**. (0–8 cm visible). This level is composed of a greyish clayey matrix with a higher organic content than the preceding layer. It contains lithic artefacts, faunal remains, and bone industry remains, and is attributed to the Lower Magdalenian. The test excavation was halted within this level before reaching its base.

Two bone samples from Levels Co.A.3 and Co.A.4 were analysed for collagen radiocarbon dating (C14-AMS) at the CIRAM laboratory in Bordeaux, and both samples exhibited good collagen preservation. The results are presented in the following table:

Both radiocarbon dates have been calibrated using OxCal 4.4 and the IntCal20 calibration curve (Reimer et al., 2020), yielding the following results: 16,889–16,413 cal BP (CIRAM-12805) and 18,278–18,059 cal BP (CIRAM-12804) (Table 1).

The CIRAM-12805 date fully matches the chronological range established for Level Co.B.2 (Middle Magdalenian) in Zone B, while the CIRAM-12804 date, although consistent with the Lower Magdalenian occupation of Zone B, is notably more recent than the general chronological framework provided by Level Co.B.4 (Lower Magdalenian) (Álvarez-Alonso and Jordá Pardo, 2017). In both cases, these dates contribute to broadening the chronological spectrum of human occupation at Coímbre Cave, confirming continuous occupation during the Middle Magdalenian and reinforcing the occupational hiatus previously identified in Zone B, which is likewise observed in Zone A. This last consideration suggests that Coímbre Cave shows no evidence of human occupation over an extended period, which can likely, though with some nuances, be placed between 18,000 and 17,200 cal BP. The same temporal hiatus between the Lower and Middle Magdalenian occupations has been observed in both Zone B and Zone A, suggesting that the gap previously identified in Zone B −and discussed in earlier studies- now appears to reflect a genuine absence of human presence, especially as we

Table 1
C14-AMS Radiocarbon Dates from Zone A of Coímbre.

Level	Lab. code	Sample	Radiocarbon age	SD (2σ)	C/N	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
Co.A.3	CIRAM-12805	Bone (*Cervus elaphus*)	13,736	53	3.3	−20.97	4.13
Co.A.4	CIRAM-12804	Bone (*Cervus elaphus*)	14,869	52	3.2	−21.16	4.5

now have reliable data from Zone A as well (Álvarez-Alonso and Yravedra, 2017b, 2024:117).

4. Results

4.1. Zooarchaeological analysis

The zooarchaeological analysis has led to the identification of a total of 1,688 faunal remains within the examined assemblage: 313 are taxonomically identified (18.5 %) and 1,375 are indeterminate (81.5 %), consistent with heavy fragmentation but good cortical preservation. The documented species include the horse (*Equus* sp.), representatives of the genus *Bos/Bison*, red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), Pyrenean chamois (*Rupicapra pyrenaica*), and Iberian ibex (*Capra pyrenaica*). Among identified remains, Iberian ibex (*Capra pyrenaica*) and red deer (*Cervus elaphus*) dominate (49 % and 45 % of identified NR, respectively) (Table 2).

This trend is also reflected in the values of the Minimum Number of Individuals (MNI), with ibex accounting for 43 % of the estimated individuals, while red deer represents 21.4 % (Table 2). In contrast, other species such as bovids, equids, Pyrenean chamois, and roe deer show a markedly lower representation, each limited to a single individual (Table 2), suggesting a marginal contribution in comparison to the two dominant taxa. Skeletal-part representation indicates dominance of long-bone shaft fragments with scarce axial elements; this pattern accords with on-site butchery and marrow/grease extraction rather than secondary water transport.

Regarding mortality patterns, the data from level Co.A.3 indicates a clear predominance of adult individuals among both ibex and red deer (Table 3). Nevertheless, remains of juvenile and infant individuals have also been identified in both species, suggesting the exploitation of a broad age range within the herd or wild population, possibly linked to specific hunting or management strategies.

As shown in Table 2, a substantial portion of the faunal assemblage consists of taxonomically indeterminate remains, accounting for over 80 % of the total recorded. This high proportion of unidentifiable fragments is attributable to the significant degree of fragmentation observed in the sample from level Co.A.3. Nevertheless, despite this fragmentation, the overall state of preservation of the bone remains is remarkably good, which has enabled the documentation of a considerable number of taphonomic modifications across the assemblage.

Table 2
Taxonomic profiles based on NR and MNI. See Methods for the definition of large, medium, and small-sized animals. %* indicates the percentage representation among taxonomically identified fauna. “Indet.” = Indeterminate.

Level Co.A.3	NR	%	%*	MNI	%
Equus ferus	3	0,2	1	1	7,1
Bos / Bison	8	0,5	2,6	1	7,1
Capra pyrenaica	153	9,1	49	6	42,9
Rupicapra pyrenaica	6	0,4	1,9	1	7,1
Cervus elaphus	140	8,3	45	3	21,4
Capreolus capreolus	2	0,1	0,6	1	7,1
Oryctolagus cuniculus	1	0,1	0,3	1	7,1
Indet. Large size	31	1,8			
Indet. Medium size	52	3,1			
Indet. Small size	915	54,2			
Indet.	377	22,3			
Total	**1688**	**100**	**100**	**14**	**100**

Table 3
MNI and Age-at-Death Patterns for Coímbre Zone A (A: Adult, J: Juvenile, I: Infant).

Level Co.A.3	MNI A/J/I	MNI
Equus ferus	1	1
Bos / Bison	1	1
Capra pyrenaica	4/1/1	6
Rupicapra pyrenaica	1	1
Cervus elaphus	2/1/0	3
Capreolus capreolus	1	1
Oryctolagus cuniculus	1	1

In terms of surface preservation, most of the remains exhibit well-preserved cortical surfaces, with minimal evidence of surface cracking due to weathering and no signs of abrasion or rounding caused by water action. This suggests that the assemblage was not subjected to significant redepositional or post-depositional transport processes following its primary accumulation.

About biotic modifications, evidence of tooth marks attributable to carnivores or other trophic agents has been recorded in only a small number of cases (Table 4), indicating a low incidence of such agents in the modification of the faunal assemblage. In contrast, anthropogenic modifications are clearly predominant and are expressed in the form of cut marks, percussion marks, and traces of thermal alteration, reflecting an active human role in the processing and modification of the remains. Table 5..

Anthropogenic evidence is abundant (Table 4): cut marks = 362 (21.4 %), percussion = 122 (7.2 %), thermal alterations = 440 (26.1 %), whereas carnivore tooth marks are scarce (1.2 %). Importantly, the proportion of cut-marked remains by taxon supports systematic processing: ibex 31/153 = 20.3 %, red deer 48/140 = 34.3 %, *Bos/Bison* 2/8 = 25 %, *Equus* 2/3 = 66.7 % (small samples for minor taxa). These values substantiate intensive butchery of the main game and marrow/grease exploitation consistent with the percussion evidence. We therefore tone down our earlier seasonal wording and now state that while recurrent hunting is clear, seasonality cannot be demonstrated with the present indicators.

Seasonality proxies (e.g., incremental dentine, antler growth stage) were not available for Co.A.3.

Table 4
Summary of principal bone modifications. CM: Cut Marks; PM: Percussion Marks; TM: Tooth Marks; Th.M: Thermal Marks.

Level Co.A.3	
Equus ferus	2
Bos taurus	2
Cervus elaphus	48
Capra pyrenaica	31
Rupicapra pyrenaica	1
Oryctolagus cuniculus	1
Indet. Large size	1
Indet. Medium size	10
Indet. Small size	236
Indet.	30

Table 5
Taxa showing cut marks.

Level Co.A.3		
	NR	**%**
Burned	487	28,9
CM	362	21,4
PM	122	7,2
TM	20	1,2
Th.M	440	26,1
Total	**1688**	

4.2. Lithic industry and raw materials analysis

Level 3 of Coímbre A is composed of a lithic assemblage of 978 pieces, of which 656 (67 %) are microdebris smaller than 10 × 10 mm, while the fraction larger than 10x10 mm represents 33 % (n = 322). Among the larger pieces, 34 are retouched artefacts, accounting for 10.55 % of the remains exceeding 10 × 10 mm. Within microdebris, 67.83 % are made of flint, while 30.64 % are made of quartzite.

The high proportion of microdebris, together with the significant presence of retouched artefacts among the larger fraction, suggests that Level 3 represents an *in-situ* knapping and tool maintenance area. The predominance of flint within the microdebris indicates a deliberate selection of high-quality raw materials for tool production activities.

The lithic assemblage larger than 1 × 1 cm from Level Co.A.3 of Coímbre A consists of 322 remains and knapping products. Two main groups of raw materials have been identified: flint and quartzite. Flint is the most abundant material, with 175 pieces (54.34 %), followed by quartzite with 137 pieces (42.54 %). Additionally, 6 pieces of quartz/crystal rock (1.8 %) and 5 of lutite (1.5 %) have been recorded. Overall, there is a clear predominance of flint over quartzite (34.56 %), following a pattern like that observed in Level Co.B.2 −also attributed to the Middle Magdalenian and excavated in Zone B of the same cave- where quartzite accounted for 40.94 % of the assemblage (Álvarez-Alonso et al., 2017).

Flint was selected for laminar production (31 blades/bladelets and 10 backed bladelets) as well as for the majority of the retouched tools (73.52 %; n = 25). Additionally, all five documented cores are made of flint, suggesting the *in-situ* exploitation of this high-quality resource. Quartzite, on the other hand, accounts for most of the knapping debris (small flakes and simple flakes), indicating the development of flake-based reduction sequences on this material, likely aimed at producing cutting edges (Maté et al., 2017; Yravedra et al., 2019).

Regarding the retouched tools, a total of 34 pieces have been documented, although in general the assemblage is not highly diagnostic. It can be divided into two main typological groups: a substrate group (n = 10), which includes 4 endscrapers, 3 retouched flakes, 2 notched pieces, and 1 denticulated piece; and an Upper Palaeolithic typological group, dominated by backed pieces, including 10 backed bladelets and 1 simple backed piece, as well as 5 end-scrapers, 4 burins, 1 retouched blade, and 1 truncation. Within this second group, 75 % of the artefacts are made of flint. In addition to these two major groups, 2 splintered pieces have been recorded, a type commonly found in Magdalenian contexts of the Upper Palaeolithic.

In summary, the lithic assemblage from Level Co.A.3 of Coímbre A reflects a technological organization centered on the exploitation of flint for laminar production and tool manufacture, alongside the use of quartzite for the development of flake-based reduction sequences aimed at obtaining cutting edges. The typological composition of the retouched tools shows a balance between substrate forms and typical Upper Palaeolithic implements, with a marked predominance of flint among the latter. However, due to the restricted excavation area, broader interpretations regarding knapping strategies remain limited, and aspects such as the high proportion of primary debitage relative to the small number of cores cannot be fully assessed without a more comprehensive spatial analysis of the site.

For comparative and contextual purposes within the same cave (different zone), Level 2 in Coímbre B (Co.B.2) shows 2,899 lithic, and the great majority of which (73.1 %) are microdebitage. Only 2.8 % correspond to retouched artefacts (10.5 % if microdebitage is excluded). Flint predominates (58 %) over quartzite (41 %), this being the only level in the sequence with such a ratio. A substantial portion of the flint comes from distant areas (Piloña, Kurtzia), indicating medium- to long-distance connections, although 45 % of the raw materials are local.

Production focuses on flakes (n = 409) and laminar products (n = 139, almost all in flint), with a high degree of prior preparation of blanks, reflected in the low frequency of cortex. Unidirectional removals predominate and striking platforms are plain.

A total of 82 retouched blanks were documented, mostly in flint and on blade blanks. Burins (34 %) and backed bladelets (23 %) stand out, followed by sidescrapers, denticulates, borers/perforators and end-scrapers in lower proportions (Álvaez-Alonso et al., 2017). The abundance of burins and backed pieces places this assemblage within the dynamics of the Cantabrian Middle Magdalenian, albeit with particularities that suggest functional differences with respect to sites such as La Viña or Las Caldas.

4.2.1. Raw materials analysis

The provenance study of the flint was conducted on the entirety of the recovered elements. The flint type was successfully identified in 151 pieces > 10x10 mm (86.28 %), distinguishing nine different varieties: Alba radiolarite, Las Portillas chert, Fito chert, Piloña flint, Monte Picota flint, Flysch flint, Treviño flint, Urbasa flint, and Salies-de-Béarn flint (Figs. 6 and 7).

Alba radiolarite is the most abundant raw material, with 45 pieces (28.1 %). Its prominence is due to its wide geographical distribution across the Cantabrian Zone. It was formed during the Visean (Lower Carboniferous) in deep marine basin environments and outcrops in the middle and upper members of the Alba Formation (Wagner et al., 1971). Although its archaeological presence had been known since the late twentieth century, Alba radiolarite −characterised by its parallel, often highly regular lamination and the presence of radiolarians- was formally described in recent studies based on geological and archaeological materials (Herrero-Alonso, 2018; Herrero-Alonso et al., 2021).

Las Portillas chert is fairly well represented, with 22 pieces (13.8 %). It forms in a very specific area of the Cantabrian Zone, near Espinama (Cantabria), in shallow marine platform environments dating to the Famennian–Tournaisian transition (Late Devonian–Early Carboniferous); apart from an early study (Raven, 1983), its characterization has only been undertaken in recent years (Herrero-Alonso, 2018; Herrero-Alonso et al., 2021). Las Portillas chert is characterised by its very homogeneous matrix, an intense vitreous luster, and the frequent presence of detrital accessory minerals (quartz, tourmaline, zircon, etc.). This raw material is located to the south of the central massif of the Picos de Europa, in the Deva Valley. It is therefore likely that its procurement was secondary, from the alluvial deposits of the Deva River, where the Cares River flows into it.

Fito chert is a rarely used raw material, represented by 5 pieces (3.1 %). It outcrops at the headwaters of the Ponga River, a tributary of the Sella, within carbonate facies of Podolskian/Myachkovian age (Upper Carboniferous), formed during a transition from a prograding delta to a subsiding platform. References to silicifications within this geological formation are very scarce (Bahamonde, 1989), and its first formal description has only been provided recently (Herrero-Alonso, 2018; Herrero-Alonso et al., 2021). Fito chert is characterised by a lenticular lamination with frequent bioclasts and idiomorphic dolomite crystals, which give it a distinctive brownish to blackish coloration.

The use of Piloña flint, represented by 9 pieces (5.6 %), is relatively limited considering its high degree of mobility within the Asturian region. It originally forms in the Santonian limestones (Upper Cretaceous) in outer marine platform environments within the Piloña Valley, a

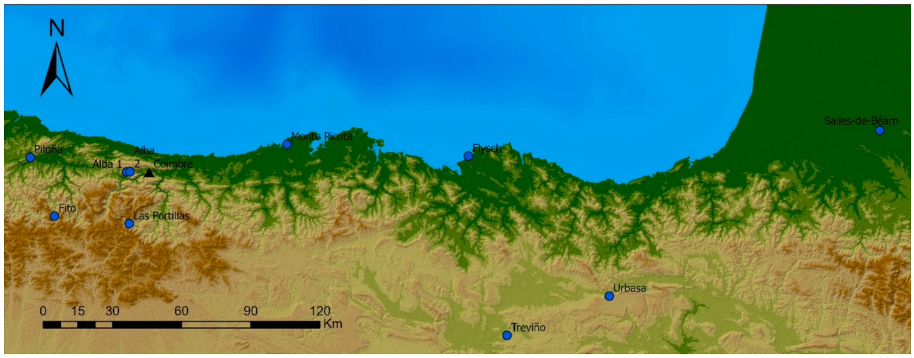

Fig. 6. Location of Flint Outcrops.

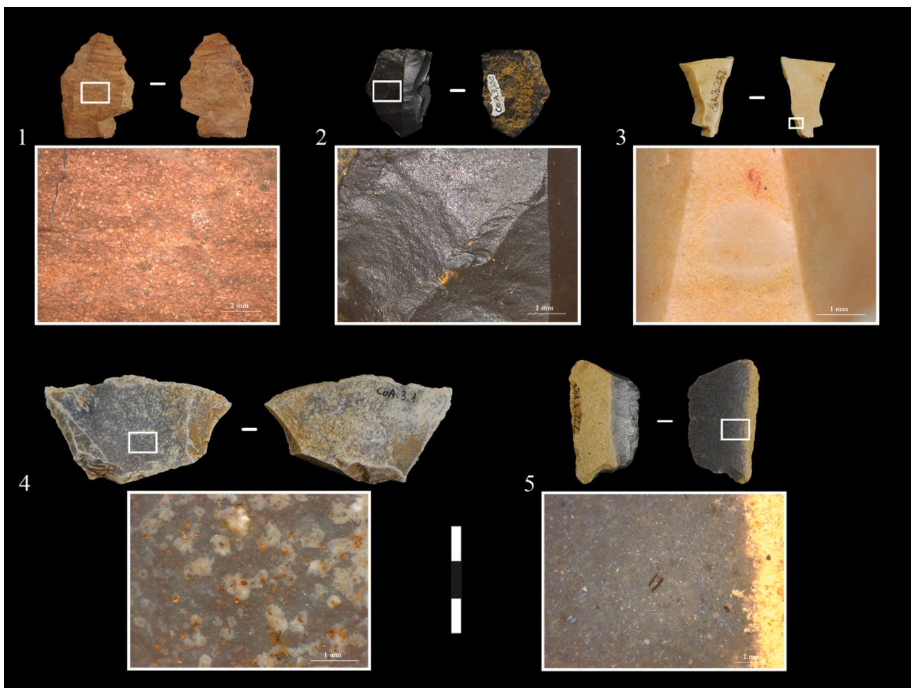

Fig. 7. Samples of the best-represented flint types from Level Co.A.3 of Coímbre A. 1. Alba radiolarite: laminated texture, more or less regular in some areas, with abundant radiolarian inclusions. 2. Las Portillas chert: homogeneous texture with a characteristic vitreous luster and dispersed inclusions of detrital quartz. 3. Piloña flint: patinated micro-cryptocrystalline texture with a benthic foraminifer (*Lacazina* genus). 4. Monte Picota flint: chalcedonic composition texture with a granular-type patination and multiple inclusions of idiomorphic dolomite crystals. 5. Flysch flint: bioclastic texture composed of abundant longitudinal sections of sponge spicules, showing significant signs of marine abrasion.

tributary of the Sella River. However, the flint used appears in a secondary position within Eocene–Oligocene continental conglomerates, such as the Posada puddingstone, in the Oviedo Basin (Asturias). Described just over a decade ago (Tarriño et al., 2013), Piloña flint is characterised by a micro-cryptocrystalline matrix with a high content of detrital quartz and the presence of benthic foraminifera of the genus *Lacazina*.

Monte Picota flint is well represented, with 27 pieces (16.9 %), and originates from silicifications formed in an inner marine platform environment during the Maastrichtian (Upper Cretaceous), outcropping in the Santillana–San Román syncline near Monte Picota, along the coast west of the Bay of Santander (Cantabria); its formal description has only been undertaken recently (Herrero-Alonso, 2018). Monte Picota flint is characterised by a chalcedonic matrix containing abundant microgeodes and fractures cemented with fibrous quartz and megaquartz, as well as the common presence of idiomorphic dolomite crystals.

Flysch flint, represented by 37 pieces (23.1 %), is one of the most frequently used raw materials at Level Co.A.3. It derives from turbiditic geological formations deposited in deep marine environments at the base of slopes connecting continental shelves with pelagic ocean floors. Among the various defined varieties associated with outcrops on both sides of the Pyrenees, only the Kurtzia Flysch variety—dated to the Cenomanian–Santonian (Upper Cretaceous) and described from the coastal area near Barrika (Bizkaia, Basque Country) (Tarriño, 2006)—has been securely identified in Coímbre A. This variety is distinguished by its characteristic turbiditic lamination and a high content of sponge spicules, features that are key for its archaeological recognition.

Treviño flint is a very scarcely represented raw material, with 4 pieces (2.5 %). It formed in lacustrine-palustrine environments of the Miranda-Treviño Depression, associated with the Aquitanian (Miocene), and occurs in the hills of the Sierra de Araico and its northern extension into the Cucho-Busto Mountains (between the provinces of Álava, in Basque Country, and Burgos, in Castile and León) (Tarriño, 2006). Treviño flint is characterised by the presence of fossils typical of continental environments, such as gastropods, ostracods, and pedotubules.

The use of Urbasa flint is merely testimonial, represented by a single piece (0.6 %). This material outcrops in the karst of the Sierra de Urbasa (Navarre) (Tarriño et al., 2007b) and corresponds to nodular silicifications formed in outer marine platform environments. Its dating to the Middle Thanetian (Paleocene) has been established through the analysis of benthic foraminifera, such as discocyclinids (*Discocyclina seunesi*) and nummulitids (*Nummulites heberti*) (Baceta, 1996). In addition to the high content of foraminifera and other bioclasts, a distinctive feature of Urbasa flint is the presence of incipient microdolomitization.

Salies-de-Béarn flint has a marginal representation within the assemblage, with a single piece (0.6 %). This raw material forms within a carbonate series of Campanian age (Upper Cretaceous), exposed in the Peyrehorade anticline near the town of Orthez (Pyrénées-Atlantiques, France), and is associated with a deep marine basin (Normand, 2002). Salies-de-Béarn flint is distinguished by bioturbations rich in carbonate relics, which confer a zoned appearance to its outer surface, complemented by the frequent presence of planktonic foraminifera of the genus *Globigerina*.

Some flint pieces could not be assigned to a precise provenance due to various processes that hinder effective identification. On the one hand, alterations to the external appearance of the matrix –such as burning, whitish patinas, the formation of microfractures, color changes, or increased porosity- compromise the reading of diagnostic features; however, altered flints represent only 3 pieces (1.9 %). On the other hand, in some cases, identification is limited by the small size of the observable surface or the absence of clear discriminating traits, affecting 15 pieces classified as indeterminate flints.

Although a definitive determination was not possible, a preliminary descriptive approach has been made for the indeterminate flints. It is likely that most of these pieces belong to the same type of flint, characterised by a fairly opaque, blackish matrix with a matte luster and abundant inclusions of detrital minerals and idiomorphic dolomite crystals. These remains most likely correspond to the Las Portillas chert, previously identified at Coímbre A.

4.3. Bone industry

Within the small excavated area of Level Co.A.3, three sagaies—one with a forked base and two double-pointed—as well as a plano-convex rod have been recovered (Fig. 8). These artefacts are consistent with the cultural context of the Middle Magdalenian. As in Zone B, the bone industry is exceptionally well preserved, and a high density of such materials has also been documented in this sector of the site, mirroring the pattern previously observed in that area (Álvarez-Alonso, 2017).

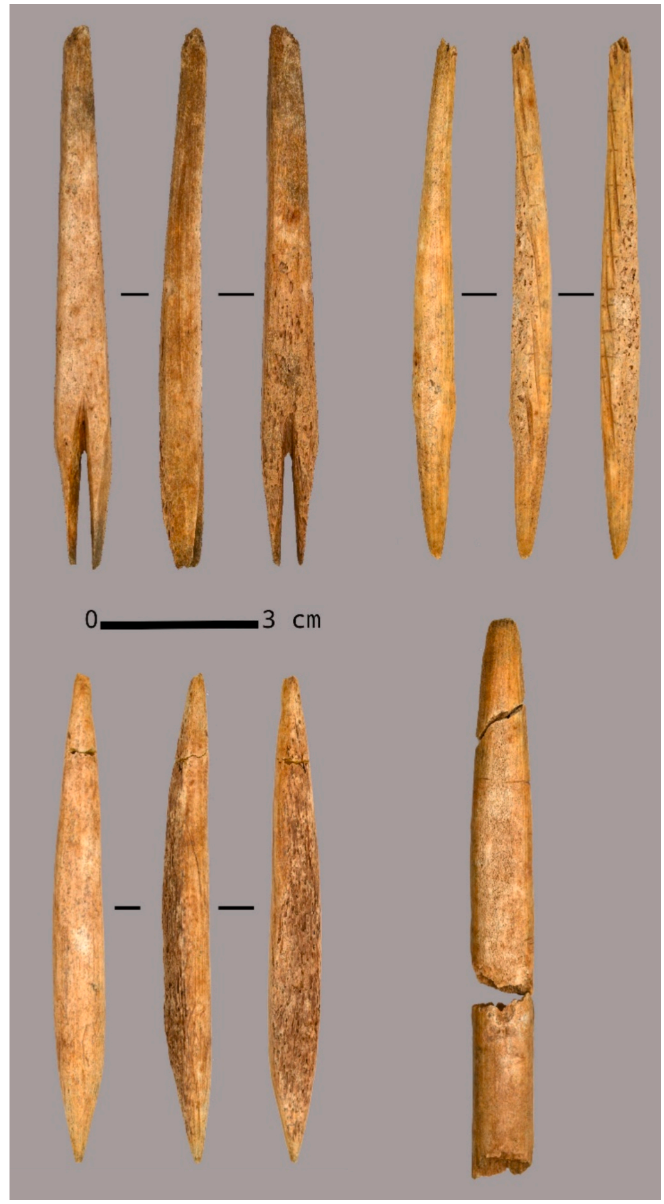

Fig. 8. . Bone industry from Level Co.A.3, Middle Magdalenian of Zone A, Coímbre Cave.

4.4. Spatial analysis

With regard to spatial analysis, an area of approximately 57.96 km^2 was defined as the Coímbre catchment area, whose boundaries closely reflect the topographic confinement between the Sierra del Cuera and the initial escarpments of the Picos de Europa. This operational spatial unit provides a quantifiable framework for evaluating the economy and mobility of the hunter-gatherer groups that occupied Coímbre Cave (Fig. 9). The small size of the catchment area—six times smaller than that of sites located in more open valleys, such as the Nalón Valley (further west in the Cantabrian region)—suggests local provisioning strategies and predominantly east–west movements along the Cares River, whereas north–south axes would have involved a higher energy cost (Andrés-Herrero et al., 2017a, 2017b).

Based on the boundaries defined by this catchment area, an analysis of the provenance of the lithic raw materials was carried out. This analysis considered the existence of both primary and secondary contexts, among which the alluvial deposits of the Cares River and its tributaries are particularly noteworthy (Álvarez-Alonso et al., 2013a; Fernández Sánchez, 2016). Within these secondary contexts, and within the limits of the catchment area, deposits containing quartzites, radiolarites from the Alba Formation, and chert have been identified. Additionally, a primary outcrop of radiolarite from the same formation is located within this area, along with several conglomerate deposits rich in quartzites.

The analysis of lithic pieces larger than 10x10 mm (n = 322) reveals that 56.52 % correspond to quartzites and radiolarites from the Alba Formation. These raw materials are considered local, as their sources are located within the boundaries defined by the Coímbre catchment area (Andrés-Herrero et al., 2017a, 2017b). The remaining 43.48 % are composed of various types of flint. Within this group, 4.34 %—specifically Piloña flint and Fito chert—originate from an area to the west of the catchment zone, namely the Sella Valley. In contrast, 28.57 % of the total lithic assemblage (including flints from Monte Picota, Flysch, Treviño, Urbasa, and Salies-de-Béarn) comes from areas located to the east of the catchment. In other words, among the non-local raw materials—defined as those sourced from outside the catchment area and totalling 106 pieces—86.79 % originate from eastern regions, while only 13.2 % come from the west.

This distribution is clearly illustrated in the kernel analysis (Fig. 10) and in Table 6, which present the travel time costs, in hours, from

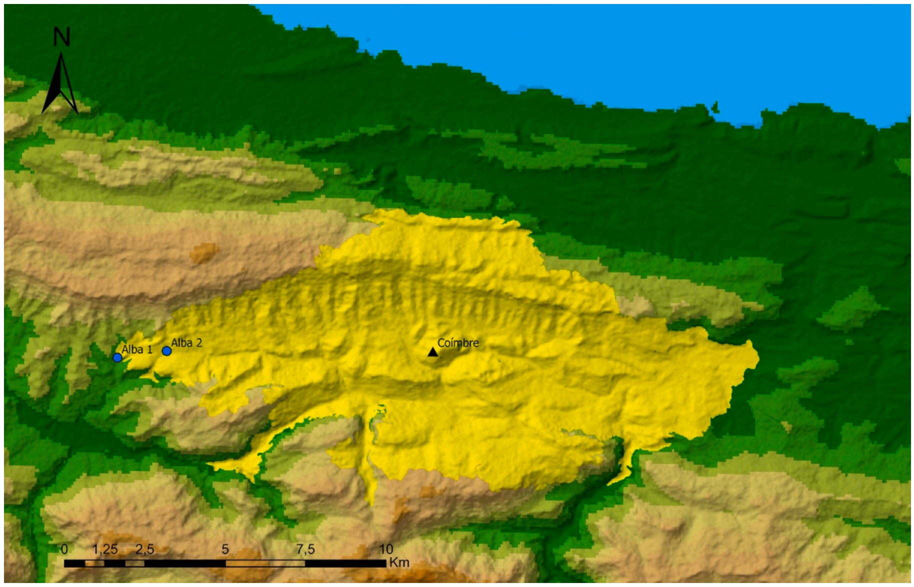

Fig. 9. . Coímbre Cave catchment area.

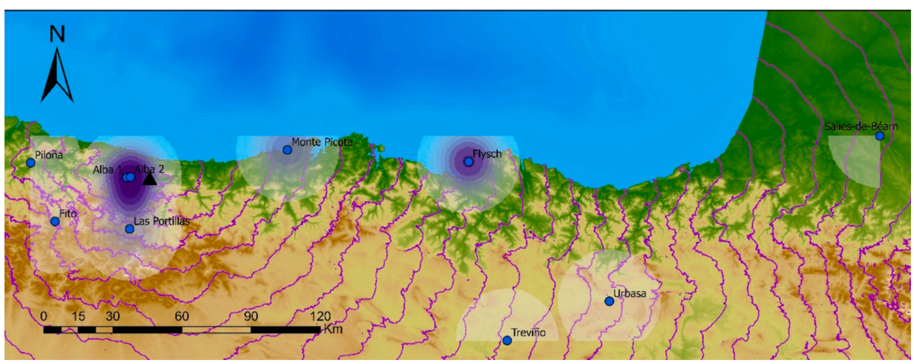

Fig. 10. . Kernel density analysis based on the provenance of the identified flints.

Table 6
Comparison of distances and representation among the different flint types.

	Travel time from Coímbre	Proximity ranking	% Representation of flint
Alba	3 h, 30 *m*	**1°**	1° (28,1)
Las Portillas	13 h	**2°**	4° (13,8)
Piloña	17 h, 30 *m*	**3°**	5° (5,6)
Monte Picota	17 h, 30 *m*	**4°**	3° (16,9)
Fito	23 h	**5°**	6° (3,1)
Flysch	42 h, 15 *m*	**6°**	2° (23,1)
Treviño	52 h	**7°**	7° (2,5)
Urbasa	62 h	**8°**	8° (0,6)
Salies-de-Béarn	94 h	**9°**	9° (0,6)

Coímbre to the various outcrops. It is important to emphasize that these values should not be interpreted in absolute terms, but rather as an analytical tool for establishing relative comparisons between different provisioning points.

In summary, the analysis of raw material mobility suggests a greater degree of connectivity with the central and eastern areas of the Cantabrian region—such as the Pas, Asón, and Deba River valleys—compared to the Sella River Valley and other more western areas. The study of flint provenance from Level Co.A.3 provides a preliminary framework for understanding the patterns of mobility and territorial provisioning practiced by the human groups that inhabited the cave during the Middle Magdalenian. The diversity observed in the sources of raw materials, including both relatively nearby resources (Alba radiolarite, Las Portillas chert) and those from more distant areas (Fito chert, Piloña flint, Monte Picota flint, Flysch flint, Treviño flint, or Salies-de-Béarn flint), points to a mixed resource acquisition model. Within this framework, direct logistical procurement strategies likely coexisted with forms of exchange or seasonal mobility operating across broader geographic ranges (e.g., Martín Jarque et al., 2023).

The presence of relatively distant outcrops with significant representation—such as Flysch flint or Monte Picota flint—stands out, especially when compared to the notably lower frequencies of materials from closer sources, such as Fito chert or Piloña flint. This disparity appears to reflect a greater representation of raw materials from eastern sources as opposed to those from the west, regardless of the relative quality or proximity of the outcrops. Consequently, the procurement or presence of materials from the Sella Basin, despite its geographical closeness to the cave, is comparatively less significant than that of raw materials originating from more distant eastern areas. Although not conclusive, this trend suggests a preferential orientation of contacts and movements toward the east—an aspect that warrants further investigation and may align with the changes observed in local settlement patterns between the Lower and Middle Magdalenian.

5. Discussion

The Level Co.A.3 signal dovetails with Middle Magdalenian patterns observed in Coímbre Zone B and in nearby Cantabrian sites, combining a flint-oriented laminar toolkit with strong evidence of carcass processing and a compact catchment constrained by the Cuera–Picos topography. The east-weighted provenance of non-local flints (vs. the relatively modest western signal) suggests preferential connectivity along the Pas–Asón–Deba corridors, consistent with broader proposals of intensified inter-regional links during the Middle Magdalenian. In this framework, Coímbre provides a focused, level-specific snapshot that complements the larger Zone B sequence and helps refine the timing of the Lower/Middle Magdalenian hiatus at the site.

The Middle Magdalenian along the Cantabrian Coast is dated to roughly ca. 17,000–15,500 cal BP, coinciding with the cold phases of the Late Glacial; two successive subphases are recognized: an archaic or early phase (~17.0–16.5 ka cal BP) and an evolved phase (~16.5–15.5 ka cal BP) (Corchón, 2005; Álvarez-Alonso, 2006-2007; Langlais et al., 2016). The early phase falls within the peak cold of GS-2 (Greenland Stadial 2), a very cold and humid period evidenced, for example, by the presence of cold-climate fauna represented in the portable art from these levels (Corchón, 1995). Toward the evolved phase (after ~ 16.5 ka cal BP) a slight climatic improvement is observed within still humid conditions, a prelude to the interstadial amelioration that will characterize the Upper Magdalenian. Chronologically, Middle Magdalenian levels in the Cantabrian region correlate with GS-2, immediately before the onset of the Bølling–Allerød interstadial (Straus and González Morales, 2012; Corchón, 2005; Álvarez-Alonso, 2006-2007). The available calibrated radiocarbon dates confirm this framework, placing the principal Cantabrian Middle Magdalenian sites between 17,000 and 15,500 cal BP (e.g., Las Caldas levels IX–VI: 17–15.8 ka cal BP; La Viña level IV: 16.6–15.5 ka cal BP) (Álvarez-Alonso, 2014).

As for the lithic industry of the Cantabrian Middle Magdalenian, it shows a notable typological balance, with endscrapers and burins in similar proportions (with a slight predominance of burins), alongside a strong microlithic component. Compared with earlier phases, small-size blade production becomes more pronounced, and backed bladelets constitute the most abundant tool group, especially in the later stages of the period. For example, in level IV of La Viña (Asturias) backed bladelets account for more than half of the lithic toolkit (53 %), and toward the end of the Middle Magdalenian they reach up to 30 % at Las Caldas (Asturias) (Fortea, 1990; Corchón, 1995; Utrilla, 1981; Corchón et al., 2005; Álvarez-Alonso, 2014). Another notable feature is the preference for high-quality flint as raw material, even in areas (western Asturias) where this resource is scarce; this suggests long-distance provisioning networks or greater group mobility to obtain non-local flint (Corchón and Rivero, 2008; Langlais et al., 2016). From a technological perspective, blade production continues but trends toward smaller sizes, evidencing a progressive microlithization of the lithic toolkit as the Late Glacial advances.

By contrast, the osseous industry of the Middle Magdalenian is particularly rich and varied, with proto-harpoons and abundant single-bevel–based points standing out. In a more evolved phase, fork-based points appear, which constitute a true index fossil of this period (Corchón, 1983; Utrilla, 1981) and have been documented at numerous Cantabrian sites of this phase, such as Las Caldas and La Viña in Asturias (Nalón basin), Llonín and Coímbre A in eastern Asturias (Cares basin), among others—persisting into the beginning of the Upper Magdalenian (Álvarez-Alonso, 2014; Straus and González Morales, 2012). Alongside these points there are also double-bevel points, bipointed points (sometimes with longitudinal grooves), as well as other osseous implements: rods with flat–convex section, perforated batons (bâtons de commandement), spear-throwers (propulseurs), spatulas, and awls, reflecting a broad technical–functional repertoire.

In the Cantabrian region, several reference sites define the Middle Magdalenian by virtue of their robust stratigraphies and characteristic finds—for example, Las Caldas (Asturias), notable for its extraordinary corpus of portable art belonging to the Middle Magdalenian, or the rockshelter of La Viña (Asturias), where level IV, subdivided into lower and upper sublevels, spans both subphases of the Middle Magdalenian (Fortea, 1990; Álvarez-Alonso, 2014). In eastern Asturias, Llonín Cave has also yielded well-defined Middle Magdalenian levels, together with other contexts assigned to this technocomplex in the western Cantabrian zone such as La Paloma and Tito Bustillo (Álvarez-Alonso 2014).

Farther toward the center and east of the region, in Cantabria and the Basque Country, we find equally key sites such as El Juyo and Rascaño (Cantabria), which provided some of the earliest indications of Middle Magdalenian occupations in excavations from the mid-20th century (González Echegaray 1960; González Echegaray and Barandiarán 1981). In the Basque Country, sites such as Isturitz (France) and Ermittia (Gipuzkoa) are culturally connected with the Pyrenean sphere, contributing stylistic evidence that acts as a "hinge" between Cantabrian and Franco-Pyrenean traditions (Bahn, 1984; Utrilla, 1996). Moreover, at the southeastern end of the Cantabrian region, the site of Abauntz (Navarre) has yielded Middle Magdalenian materials whose decorative motifs have served to establish a clear connection between the two ends of the Cantabrian region and the Pyrenean area (Bahn, 1984; Utrilla, 1996; Duarte et al., 2012; Straus and Langlais, 2020).

The Level Co.A.3 faunal assemblage from Coímbre Cave is dominated by Iberian ibex and red deer, reflecting a subsistence focus on these two ungulates and intensive on-site carcass processing. This aligns with broader Middle Magdalenian patterns in the Cantabrian region, where red deer and ibex together constituted the chief game animals. At central Asturian sites like La Viña and Las Caldas, red deer typically predominates in the Magdalenian fauna (often accompanied by horse and large bovids), while ibex remains are present in smaller proportions (Corchón et al., 2016). By contrast, more montane or interior cave sites such as Coímbre and El Rascaño exhibit a stronger emphasis on ibex hunting – Rascaño has long been noted as a specialized Capra kill site in a rocky setting (González Ehegaray and Barandiarán, 1981). Mortality profiles at Coímbre show a predominance of adult prey but with juveniles and infants also taken, a broad age-range exploitation that is comparable to patterns reported at other Middle Magdalenian sites (suggesting opportunistic hunting of whole herds rather than selective targeting of prime adults). The dominance of long limb-shaft fragments over axial parts at Coímbre further corroborates an on-site butchery and transport strategy focused on high-utility carcass portions, a pattern echoed at other base camps in the region. Finally, the Middle Magdalenian occupations at El Mirón Cave (eastern Cantabria) illustrate a broad-spectrum subsistence and site-use strategy that complements the pattern seen at Coímbre (Straus and González Morales, 2012). In summary, when viewed against contemporaneous sites like La Viña, Las Caldas, Rascaño, and El Mirón, the Coímbre Level Co.A.3 fauna fits within a regional subsistence framework characterized by the hunting of red deer and ibex, intensive carcass exploitation (butchery, marrow extraction, low carnivore access), and occasional cultural uses of animal remains, while also reflecting adaptive responses to local topography and resource availability (e.g. ibex in mountainous zones versus cervids in lowland contexts).

In sum, the Cantabrian Middle Magdalenian forms part of the Franco-Cantabrian cultural sphere and presents strong links with the traditions of southwest France and the Pyrenean zone (Utrilla, 1996; Álvarez-Alonso, 2014). Unlike the Lower Magdalenian, which has a more local character in the Cantabrian area, in the Middle Magdalenian contacts intensify with Pyrenean and Aquitanian (SW France) Magdalenian groups, as reflected in artistic–symbolic convergences and in the exchange of exogenous goods (raw materials, ornaments) (Straus and González Morales, 2012). For example, certain elements of portable and symbolic art appear in Cantabria as clear imports from the Pyrenean orbit: this is the case of contours découpés (bone cut-outs representing heads of goats, deer, or other animals) documented at Las Caldas and La Viña, whose style and technique clearly have a Pyrenean origin (Corchón, 2005). Likewise, rodetes (perforated bone discs with a possible ornamental or symbolic function) emerge for the first time in Cantabrian contexts during the archaic Middle Magdalenian—recorded at Las Caldas, La Viña, Llonín, and Coímbre—and are interpreted as cultural borrowings from the Pyrenean area. These shared artistic and technological innovations indicate close interaction within the so-called Franco-Cantabrian Magdalenian world.

6. Conclusions

The archaeological assemblage from Level Co.A.3 of Coímbre Cave provides a coherent and well-preserved snapshot of Middle Magdalenian occupation in the Cantabrian region. The lithic industry is characterised by a strong emphasis on flint for blade and backed tool production, complemented by quartzite-based flake reduction strategies—pointing to a dual technological approach adapted to raw material availability and quality. The osseous industry, though recovered from a limited excavation area, includes diagnostic artefacts such as sagaies and a plano-convex rod, reinforcing its cultural attribution. The faunal assemblage reflects a subsistence economy centred on ibex and red deer, with evidence with evidence for recurrent carcass processing; seasonality cannot be demonstrated with the present indicators.

This synthesis provides the basis for a broader interpretative reflection on the significance of Level Co.A.3, particularly in relation to the data from Zone B and the wider Magdalenian sequence at Coímbre Cave. Despite being a small-scale excavation, the volume of recovered materials is considerable. Moreover, these data allow for a meaningful comparison with the results obtained from Zone B of Coímbre, which are fully comparable to those recorded in Zone A (Álvarez-Alonso et al., 2017; Álvarez-Alonso and Jordá Pardo, 2017; Yravedra et al., 2017). In summary, Level Co.A.3 corresponds to a human occupation assigned to the Middle Magdalenian. Based on the evidence from both excavated areas of the site, it can be observed that the Middle Magdalenian occupations developed in close continuity with those of the Upper Magdalenian, following a significant hiatus in occupation relative to the earlier phases represented by the Lower Magdalenian (Álvarez-Alonso and Yravedra, 2017b, 2024). This discontinuity may reflect a shift in settlement patterns, particularly affecting the more interior or mountainous areas of the central-western Cantabrian region, coinciding with the emergence of the Middle Magdalenian—a technocomplex with Pyrenean cultural roots.

In this context, it is worth considering whether Coímbre Cave represents a meaningful example of the potential cultural, social, and territorial shifts associated with the emergence of the Middle Magdalenian. This issue, the subject of ongoing debate, has led to the proposal of a bipartite division of the Magdalenian: on one hand, an early Magdalenian (archaic and lower), and on the other, an advanced Magdalenian (middle and upper). This framework has had significant interpretive implications for the Cantabrian region, where a division of the Magdalenian into two major groupings has been suggested (Álvarez-Alonso, 2014; Corchón, 2005; González Sainz and González Urquijo, 2004; González Sainz and Utrilla, 2005).

Author statement

All authors have contributed equally to the research and the preparation of the article.

CRediT authorship contribution statement

David Álvarez-Alonso: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **María de Andrés-Herrero:** Writing – review & editing, Resources, Methodology, Investigation. **Verónica Estaca Gómez:** Writing – review & editing, Resources, Methodology, Investigation. **Sergio Martín Jarque:** Writing – review & editing, Resources, Methodology, Investigation. **José Yravedra Sainz de los Terreros:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation.

Data availability

No data was used for the research described in the article.

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