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ORIGINAL PAPER

Lost in the mountains? The Cova del Sardo and the Neolithisation of the Southern Central Pyrenees (fifth-third mill. cal BC)

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Abstract
In this paper, we present the results of the analysis of the Cova del Sardo flaked stone assemblage, a rock shelter located at 1.790 m a.s.l. in the Central Pyrenees. An integrated analysis of the lithic record, from a petrological, technological, and functional point of view, has been realised. The daily life activities carried out at the site have been reconstructed and a diachronic reading of the data has been finalised. An interpretation in terms of territorial and economic organisation of the prehistoric group is advanced. A mixed farming economy is suggested, even if herding and pasture exploitation could have locally played an important role. The analysis of lithic raw materials indicates that the groups followed a south-north mobility, as most of exploited cherts are from southern sources (Ebro valley and pre-Pyrenean ranges). Finally, the Cova del Sardo is discussed within a broader framework, taking into account the Neolithisation process of the Southern Central Pyrenees.

Keywords Mountain archaeology · Neolithic · Lithic raw materials · Use-wear analysis · Marginal environments

Introduction

The human adaptation to the so-called marginal environments has been one of the most discussed topics in Archaeology during the last decades. In this context, the term 'marginal' has been used mainly to design lands with a poor production capacity; this label has been, thus, associated with very different landscapes such as alpine areas, deserts, rain forests and flood or tidal plains. Nevertheless, there is not a clear definition of what a marginal environment actually is, from the fact that land productivity varies according to the type of land use. As K. Walsh et al. (2006: 437) pointed out, landscapes that are often labelled as marginal are those that 'are perceived today as economically marginal and therefore unattractive to earlier societies as well'.

European mountains, such as the Alps or the Pyrenees, have been often defined as marginal areas, poorly suitable for human life. Here, some of the main constraints to productivity were considered to be the abrupt topography, the steepness of terrain, the difficult accessibility, the extensive forest coverage, the presence of unproductive rocky slopes, the harsh climatic conditions, the poor infrastructure level, the low population pressure, etc. (Gassiot et al. 2016). However, most of those criteria are established on the basis of current productive models, whilst their applicability to ancient economic systems has not yet been demonstrated. Moreover, during the last decades, the palaeoclimatological and palaeoecological researches carried out in the European mountainous zones have demonstrated that climate and vegetation have strongly changed after the last glacial maximum and, therefore, the biophysical setting should not to be taken for granted. Climate oscillations have been recorded all along the Holocene, affecting seasonality and mean annual temperatures (Hausmann et al. 2002; Pèlachs et al. 2011; Catalan et al. 2013 amongst others). Vegetation dynamics related to both natural and anthropic factors have been observed thanks

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to the analysis of pollen, plant macrofossil and charcoal records (see for example Joannin et al. 2013; Gassiot et al. 2012; Gassiot et al. 2014, Galop et al. 2013; Pérez-Díaz et al. 2015; Thöle et al. 2015).

Archaeologists, from their side, have carried out an intensive work of surveying and cataloguing of the vestiges located in high-altitude areas; several projects have been carried out in the most important European mountains (Curdy 2007; Walsh et al. 2007; Della Casa 2013; Rendu et al. 2013; Gassiot et al. 2016). These projects show that the scarcity of documented archaeological vestiges in mountainous areas was not a consequence of past settlement strategies, but of a generalised lack of interest of the archaeologists toward high-altitude zones.

The implementation of systematic survey programmes during the last 20 years has radically changed this situation. Today, subalpine and alpine zones appear as dynamic landscapes in which past populations have carried out a diversity of practices, from Prehistory to Modern times. Nevertheless, there is still much work to do. Surveys allowed highlighting the archaeological potential of those 'marginal' areas, whilst palaeoenvironmental research has been capable of identifying trends in climate and vegetation and their mutual relations with human activities; despite that, there is still a lack of models about the economic and social organisation of those groups. Hunting, pastoralism, mining, wood production and crop cultivation are all activities that played a role in shaping the mountainous landscape, pushing human populations to occupy and exploit high altitude spaces. But how were those practices carried out? What was their relative importance in each historical period? How and how much adopted economic system changed through time? To explore these issues, a more detailed level of analysis is required. That is why, during the recent years, surface surveying has been often combined with extensive stratigraphic excavations. Excavations allow a deeper comprehension of the each site and of its occupation sequence, granting the recovery of a variety of evidences (i.e. structures, artefacts, bioarchaeological remains) that can provide information on the everyday life of the inhabitants, their social organisation, their economic behaviour, their cultural habits and so on.

In this paper, we present the result of an integrated analysis of the lithic materials recovered from the Cova del Sardo, a rock shelter located in the Southern Central Pyrenees at 1.790 m a.s.l. (Gassiot et al. 2014). The site, with an occupation sequence ranging from Neolithic Age to Modern times, represents one of the most important sources of information on the mid-Holocene environmental and human dynamics in the area. In this context, the study of the flaked stone assemblage recovered from the prehistoric deposit has provided precious data for reconstructing economic and social aspects related to the group technological organisation, daily activities, economy and mobility.

Materials and methods

The Cova del Sardo: the geographical framework and the occupation sequence

Cova del Sardo de Boí is one of the highest archaeological sites that have been fully excavated in the Iberian Peninsula. Apart from the altitude, the peculiarity of this site is the long stratigraphic sequence, which attests to eight different preserved phases of human occupation, for a period of more than 7000 years. The site is located in the NW of Catalonia, in the Sant Nicolau Valley, within the National Park of Aiguestortes and Estany de Sant Maurici. More specifically, the site is situated at an altitude of 1.790 m a.s.l., about 60 m above the Sant Nicolau riverbed (Fig. 1). The rock shelter opens on the southern slope of a huge granite massif; the cavity was excavated into the massif by glacial erosion at the end of the Last Glacial Maximum. It measures 9.0 × 3.0 × 1.3 m, with an inner area of about 20 m^2 that has been progressively covered with eroded materials. The archaeological deposit has a depth between 30 and 80 cm depending on the areas.

After its discovery in the 2004, excavation campaigns took place between 2006 and 2008, investigating the entire inner area and part of the external terrace, for a ca. 60 m^2 total area. Five different phases of prehistoric occupation have been ascertained. The first archaeological evidence of human occupation at the rock shelter comes from phase 9, dated to ca. 5600–5400 cal BC. Human presence is attested by a pit-hearth with a small number of lithic materials associated with (Gassiot et al. 2014). This stage seems to show an early and short occupation of the site, probably related to a single episode. After a more than five-century hiatus, during the fifth millennium cal BC, human presence is attested by a number of contexts dated to between ca. 4800 and 4350 cal BC (phase 8). During this phase, the human settlement occupied both the shelter's inner and external areas. Hearths and other combustion structures have been identified. Lithic materials, not abundant, are associated with rare ceramic fragments. At the beginning of the fourth millennium, the cave was settled once again with a series of occupations dated to between ca. 4000 and 3400 cal BC (phase 7). The main archaeological evidences display an array of fire pits located inside the rock shelter, whilst the external terrace seems to have been little frequented. Fragments of pottery, characterised by plastic decorations, lithic remains and highly fragmented and burnt faunal remains were recovered. Toward the end of the millennium, between ca. 3350 and 3000 cal BC, a new phase of occupation took place, namely, phase 6. The presence of numerous large pieces of a burnt tree stump suggests the existence of some type of vegetable roofing that covered the cave entrance (Gassiot et al. 2017: 87). In the inner area, human traces are almost absent. The last prehistoric occupation of the cave (i.e. phase 5), dated between ca. 2900 and 2500 cal BC, seems to follow the same

Fig. 1 **a** View of the Sant Nicolau Valley. **b** View of the Cova del Sardo during its excavation

pattern as the one documented for phase 7, with a series of human occupations organised around a large fire pit situated in the central sector of the cave.

After each occupational phase, a period of abandonment visibly occurred at the rock shelter. The longest interval is between phase 9 and phase 8, which displays an 800-year gap. Moreover, the model points out the existence of different patterns of site occupation. This is particular evident between phases 8–7, for which a higher number of samples are available. Whilst phase 8 appears to have been a short but relatively continuous occupation, phase 7 seems to have been characterised by a discontinuous settlement pattern taking place over a longer period of time (Gassiot et al. 2014).

The flaked stone assemblage: methods of analysis

Different analytical techniques have been integrated for the study of the lithic record (i.e. analysis of raw material procurement, analysis of lithic production processes and analysis of use-wear traces; see Inizan et al. 1999; Terradas 2001; Marreiros et al. 2015 for a general description of each method). A stereoscopic binocular microscope (Leica MZ16A, × 5–× 60) has been employed for a first assessment of the petrographic and techno-functional aspects. Once the different lithologies represented within the assemblage have been grouped, thin sections from each group have been realised; a transmitted light microscope (Leica DM2500P, × 50–× 500) has been used to confirm the textural and micropalaeontological characters observed macroscopically. A more detailed description of the lithic raw materials is provided in Mazzucco et al. (2013a). Lithics showing edges or areas possibly employed for working tasks have been analysed through a reflected light microscope (Leica DM2500M, × 50–× 400). A more detailed description of the wear patterns can be found in Mazzucco (2014).

Results

Raw material sources and their techno-economic management

The lithic assemblage recovered from the prehistoric contexts of Cova del Sardo (phases 5–8) is constituted by 368 items. Lithics were mostly recovered directly from the excavation; only small flakes and debris greater than 1 mm were recovered through dry sieving. The sediment, except for modern or disturbed units, has been indeed sieved on site through a 0.5-mm mesh sieve. In addition, 10 L of sediment for each 100 has been sampled for flotation. Therefore, the recovered assemblage can be regarded as representative of the lithic resources exploited at the site. The low number of lithic items should be attributed neither to the methods of excavation adopted nor to other biases in the archaeological record. It should be interpreted as a result of behaviours performed by the inhabitants of the site, a consequence of the technological organisation, settlement pattern and mobility strategies adopted.

The Sant Nicolau Valley is constituted by two main geological formations: on the northern side, one finds the Palaeozoic rocks of the Maladeta Massif, whilst the southern slope is characterised by Devonian and Silurian metamorphic formations, mainly constituted by calcareous and volcanic rocks. In this geological setting, good-quality knappable rocks are absent; the main lithologies that can be exploited locally are granite, slate, schist, porphyry and hornfels. All of these rocks can be easily gathered along the Sant Nicolau riverbed located 60 m away from Cova del Sardo and that probably represented the nearest catchment area for the groups that inhabited the site (LOC—Fig. 2 (a)). Rocks gathered from the local environment show an opportunistic exploitation, without or with little core preparation. Porphyries appear to have mainly been employed for producing elongated flakes of 19–29 × 13–20 × 5–8 mm on average. Slate materials were mainly exploited for the production of flat, tabular blanks. Hyaline quartz, quartzite, schist and granite were only marginally exploited and are represented by a low number of specimens, mainly debris or fragmentary flakes (Table 1). The few tools identified were used for domestic activities, probably tasks of brief duration: a few flakes on porphyry were employed for cutting soft materials, whilst one other, a rectangular flake, was used as wedge, possibly for bone fracturing and/or marrow extraction as already suggested for similar tools from Palaeolithic to Mesolithic contexts (Fig. 3 (a)) (Gibaja et al. 2007).

The nearest outcrops of fine-grained rocks are located at about 20–30 km from the site, in Late Hercynian volcanic strata in which greenish rhyolites with a fine texture can be found (RHY—Fig. 2 (b)). Rhyolite appears to have been exploited to produce elongated flakes; the presence in phase 7 of a polyhedral core with two opposite striking surfaces and elongated negatives confirms this hypothesis. However, only few debris and wastes have been recovered on site, whilst no tools have been identified, this suggesting that rhyolite blanks were mainly used, transported and discarded elsewhere. Rhyolite is not homogenously exploited during the various occupational phases (Table 1).

At a few kilometres of distance, chert nodules can be gathered from the Cretaceous carbonate formations of the pre-Pyrenean ranges (CRE—Fig. 2 (c)). It is a dark, black to grey coloured, solid chert with abundant fossiliferous inclusions, mainly composed of marine foraminifera, sponge spicules and calcispheres. Those materials are often highly jointed and not very suitable for knapping; they are, indeed, little documented in all of the analysed phases (Table 1). Artefacts on this chert type mainly correspond to flakes, core-rejuvenation and other wastes of knapping activities. Their dimension is small, between 13–9 × 11–5 × 3–2 mm, in all the phases. The absence of cortical elements suggests the transportation of small preforms, which were knapped on site. However, the scarcity of finished blanks and tools indicates that at least part of the produced items were later transported and discarded outside of the site. Only three tools have been recovered: two trapeze backed tools, respectively, from phases 7 and 6 and a small flake used as wedge, as well from phase 6. One of the geometric tools shows a burin-like fracture on the tip demonstrating its use as projectile point (Fig. 3 (b)).

Further south, at 40–60 km from the Cova del Sardo, cherts of higher quality can be found amongst the Upper Cretaceous/ Palaeocene carbonate units of the Marginal Sierras (PAL—Fig. 2 (c)). Those materials have tonalities from white to grey, occasionally with reddish shades; they are characterised by a compact cryptocrystalline matrix with rare lacustrine fossiliferous inclusions. They are suitable for most of blade-knapping techniques, and they represent the main raw material throughout the occupation sequence (Table 1). Blades on this chert are abundant; they are knapped through indirect percussion technique; averagely, they measure 52–35 × 15–12 × 4–2 mm. Nevertheless, because the extreme scarcity of core trimming elements and other by-products, it seems plausible that the great majority of blades were transported to Cova del Sardo already flaked; only few of them might have been flaked on site, as documented by the presence of few debris and cortical flakes; after that, cores were possibly transported to other places for further use and so discarded elsewhere. This behaviour would explain the absence of core of Upper Cretaceous/ Palaeocene cherts at the site. Moreover, it is possible that a part of the debris derives from tool retouching and maintenance activities and not from core reduction; for example, the local production of geometric tools is documented by the presence of an unfinished trapezoidal backed tool from phase 7.

From a functional point of view, tools on this type of chert are mainly used for gathering and processing plants. Blades are used intensively, often with multiple active edges. The main tasks are related to harvesting non-ligneous plants, like weeds or grasses (Fig. 3 (c)); occasionally, concave or slightly concave edges are used for scarping motions, in relation to wood- or plant-fibres working. Backed tools, both segments and trapezoidal forms, are realised as well with these chert types; they are mainly shaped by direct abrupt retouch and, in one case, by a bifacial flat retouch (i.e. *doble bisel*, from phase 8). The fractures identified on their edges and tips indicate a use as projectile tips or side elements (Fig. 3 (d)). Other tasks, such as butchering or dry-hide scraping have been detected only on few implements.

Oligocene-Miocene formations containing large nodules of cherts are situated at a distance between 80 and 100 km from the site, in the Central and Eastern sectors of the Ebro Valley (LOM—Fig. 2 (d)). Those materials, with colours ranging from beige to dark brown, are characterised by a cryptocrystalline matrix rich in inclusions, amongst which metal oxides, macroquartz grains, and lacustrine micro-fossils. Those chert types are one of the most used lithologies in the NE of the Peninsula during the entire Prehistory due to their homogeneity and the large size of the nodules (Ortega et al. 2017). Amongst the artefacts from the Ebro Basin two main types of blade products can be distinguished: small narrow blades (30–20 × 12–10 × 3–2 mm) and larger blades (85–70 × 20–15 × 4–3 mm). Considering the presence of few characteristic core-trimming elements (a crested blade and a core-rejuvenation flake), it is plausible that some knapping activities took place on site. Small preformed cores were probably taken to Cova del Sardo for the

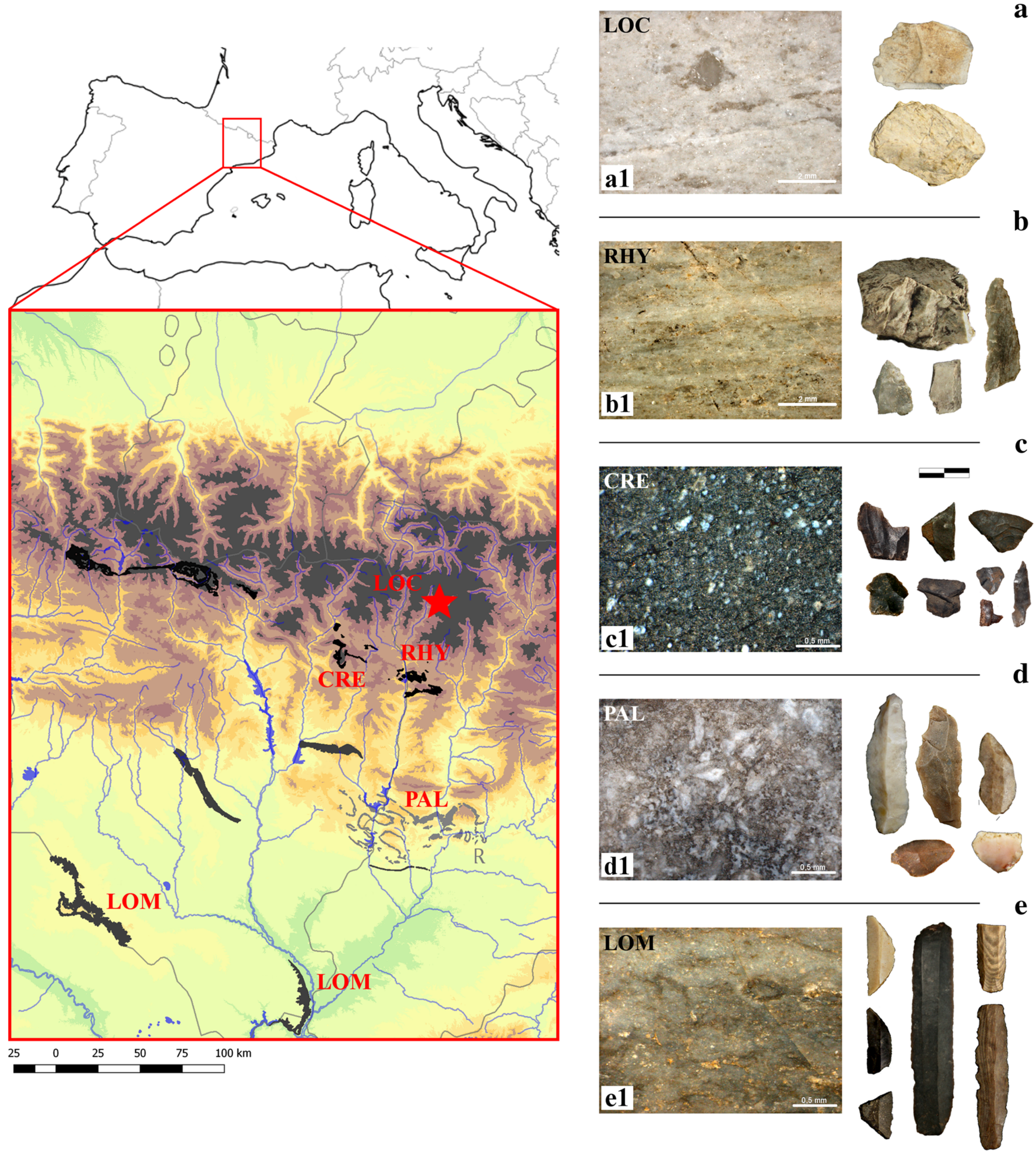


Fig. 2 Localisation of the Cova del Sardo in the Southern Central Pyrenees. Exploited geological formations are indicated in the map: Lacustrine Eocene-Miocene cherts (LOM), Upper Cretaceous marine cherts (CRE), Upper Cretaceous/Palaeocene cherts (PAL), rhyolites (RHY), and local rocks (LOC). On the right column, archaeological materials are shown: (a) flakes made of porphyry; (b) a core and flakes made of rhyolite; (c) flakes made of Upper Cretaceous marine cherts; (d) blades and flakes made of Upper Cretaceous/Palaeocene cherts; (e) blades and geometric tools made of Lacustrine Eocene-Miocene cherts. Macroscopic photos of the materials: (a1) Porphyry, quartz phenocrysts, × 10 magnification; (b1) rhyolite macroscopic aspect, × 7 magnification; (c1) Marine foraminifera and spicule at × 8; (d1) Lenticular shaped gypsum pseudomorphs at × 10 magnification; (e1) Ostracods and a transversal section of a Charophyte algae at × 10 magnification

production of small blades/bladelets and flakes at least during phases 5–7; the presence of two exhausted core with dorsal flake removal scars confirms such a hypothesis. However, the large majority of products were transported to the site already flaked (Mazzucco and Clemente 2013), as finished blanks or hafted tools. The predominant percussion technique is indirect percussion, even if pressure flaking is also documented.

On a functional level, the management of the Ebro valley chert types appears quite similar to what observed for the Upper Cretaceous/Palaeocene. Most of the blade blanks are used for activities related to plant working tasks: herbaceous plant harvesting (Fig. 4 (a, b)) and, in lesser extent, plant/wood processing (Fig. 4 (d)). Amongst the tools used for harvesting activities, a few, especially from phase 5, show the typical gloss produced by cereal

Table 1. Lithic assemblage technological characterization for each occupational phase

Raw-materials		Technological classes					Total	
		Core	Flake	Blade	Waste	Core trimm.		
Lacustrine Eocene-Miocene (LOM)	Σ	1	3	8	1	3	**16**	**PHASE 5**
	%	*1,3%*	*3,8%*	*10,0%*	*1,3%*	*3,8%*	***20,0%***	
Upper-Cretaceous/Palaeocene cherts (PAL)	Σ	1	1	9	6	4	**21**	
	%	*1,3%*	*1,3%*	*11,3%*	*7,5%*	*5,0%*	***26,3%***	
Upper-Cretaceous marine cherts (CRE)	Σ	-	-	-	2	1	**3**	
	%	-	-	-	*2,5%*	*1,3%*	***3,8%***	
Rhyolite (RHY)	Σ	-	4	-	6	2	**12**	
	%	-	*5,0%*	-	*7,5%*	*2,5%*	***15,0%***	
Local rocks (LOC)	Σ	1	5	-	10	-	**16**	
	%	*1,3%*	*6,2%*	-	*12,5%*	-	***20,0%***	
Cherts indeterminate (CIN)	Σ	-	2	6	4	-	**12**	
	%	-	*2,5%*	*7,5%*	*5,0%*	-	***15,0%***	
Total	Σ	**3**	**15**	**23**	**29**	**10**	**80**	
	%	***3,7%***	***18,7%***	***28,8%***	***36,3%***	***12,5%***	***100%***	
Lacustrine Eocene-Miocene (LOM)	Σ	-	-	3	2	-	**5**	**PHASE 6**
	%	-	-	*3,3%*	*2,2%*	-	***5,6%***	
Upper-Cretaceous/Palaeocene cherts (PAL)	Σ	-	4	5	11	2	**22**	
	%	-	*4,4%*	*5,6%*	*12,2%*	*2,2%*	***24,4%***	
Upper-Cretaceous marine cherts (CRE)	Σ	-	2	1	2	3	**8**	
	%	-	*2,2%*	*1,1%*	*2,2%*	*3,3%*	***8,9%***	
Local rocks (LOC)	Σ	1	19	-	16	3	**39**	
	%	*1,1%*	*21,1%*	-	*17,8%*	*3,3%*	***43,3%***	
Cherts indeterminate (CIN)	Σ	-	4	-	10	2	**16**	
	%	-	*4,4%*	-	*11,1%*	*2,2%*	***17,8%***	
Total	Σ	**1**	**29**	**9**	**41**	**10**	**90**	
	%	***1,1%***	***32,2%***	***10,0%***	***45,6%***	***11,1%***	***100%***	
Lacustrine Eocene-Miocene (LOM)	Σ	1	2	13	3	1	**21**	**PHASE 7**
	%	*0,7%*	*1,4%*	*9,3%*	*2,1%*	*0,7%*	***15,0%***	
Upper-Cretaceous/Palaeocene cherts (PAL)	Σ	-	3	9	5	2	**19**	
	%	-	*2,1%*	*6,4%*	*3,6%*	*1,4%*	***13,6%***	
Upper-Cretaceous marine cherts (CRE)	Σ	-	-	1	7	-	**7**	
	%	-	-	*0,7%*	*5,0%*	-	***5,0%***	
Rhyolite (RHY)	Σ	1	3	1	18	-	**23**	
	%	*0,7%*	*2,1%*	*0,7%*	*12,9%*	-	***16,4%***	
Local rocks (LOC)	Σ	-	19	2	30	-	**51**	
	%	-	*13,6%*	*1,4%*	*21,4%*	-	***36,4%***	
Cherts indeterminate (CIN)	Σ	-	5	2	11	1	**19**	
	%	-	*3,6%*	*1,4%*	*7,9%*	*0,7%*	***13,6%***	
Total	Σ	**2**	**32**	**28**	**74**	**4**	**140**	
	%	***1,4%***	***22,9%***	***20,0%***	***52,9%***	***2,9%***	***100%***	
Lacustrine Eocene-Miocene (LOM)	Σ		3	4	1	1	**9**	**PHASE 8**
	%		*5,2%*	*6,9%*	*1,7%*	*1,7%*	***15,5%***	
Upper-Cretaceous/Palaeocene cherts (PAL)	Σ		-	6	-	-	**6**	
	%		-	*10,3%*	-	-	***10,3%***	
Upper-Cretaceous marine cherts (CRE)	Σ		-	-	1	-	**1**	
	%		-	-	*1,7%*	-	***1,7%***	
Local rocks (LOC)	Σ		17	-	12	-	**29**	
	%		*29,3%*	-	*20,7%*	-	***50,0%***	
Cherts indeterminate (CIN)	Σ		3	-	10	-	**13**	
	%		*5,2%*	-	*17,2%*	-	***22,4%***	
Total	Σ		**23**	**10**	**24**	**1**	**58**	
	%		***39,7%***	***17,2%***	***41,4%***	***1,7%***	***100%***	

In bold are indicated the line and the column totals, while in italics the percentages for each phase

reaping (Fig. 4 (a)); however, it is possible that the harvesting did not took place locally, in the surroundings of the site, but at some distance from the Cova del Sardo. The sickle blades would have been later transported to the site and there retooled for other tasks, such as soft animal substance working (Fig. 4 (b)). On the group of blades from phase 5, such a succession of uses is particularly striking because of the presence of edge-resharpening scars that allows a clearer reading of the 'use-wear stratigraphy' (Fig. 4 (c)). The transportation (even over considerable distances) and retooling of sickle blades is a typical behaviour during Neolithic period in the NE

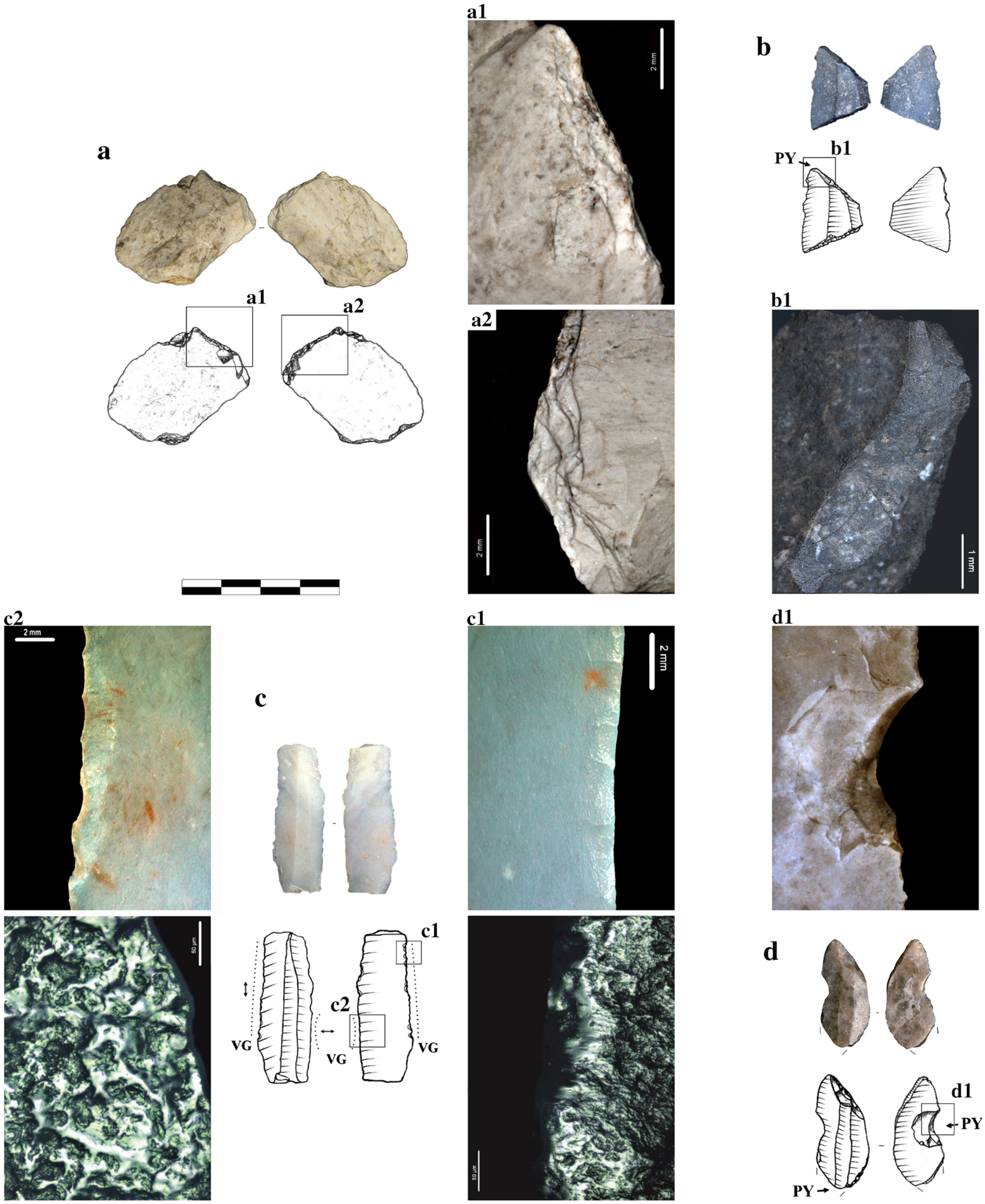


Fig. 3 Selection of use-wear from the Cova del Sardo. (a) Phase 7—flake on porphyry used as wedge, a1–2: bifacial macroscopic fractures on both edges. (b) Phase 7—backed trapezoidal tool used as projectile tip, b1: burin-like fracture. (c) Phase 7—blade made of Upper Cretaceous/Palaeocene chert used on both edges, c1: scraping plant/wood; c2: cutting vegetal substance. (d) Phase 8—backed tool made of Upper Cretaceous/Palaeocene chert used as projectile tip, d1: bending-step fracture

(Gibaja 2009; Rojo et al. 2013), which indicate that sickle inserts and other harvesting tools were artefacts with a long use-life, eventually moving along with peoples and/or adapted to new tasks.

Flakes and bladelets on Ebro valley chert types are occasionally used for working animal substance (Fig. 4 (e)), wood working or other tasks on both soft and hard materials. Projectile tools on Ebro chert types are present as well and are mainly segments shaped through direct abrupt retouch.

Others materials, difficult to classify into the above-mentioned groups, are likely to be exogenous; therefore, their sources are to be sought outside of the Pyrenean range.

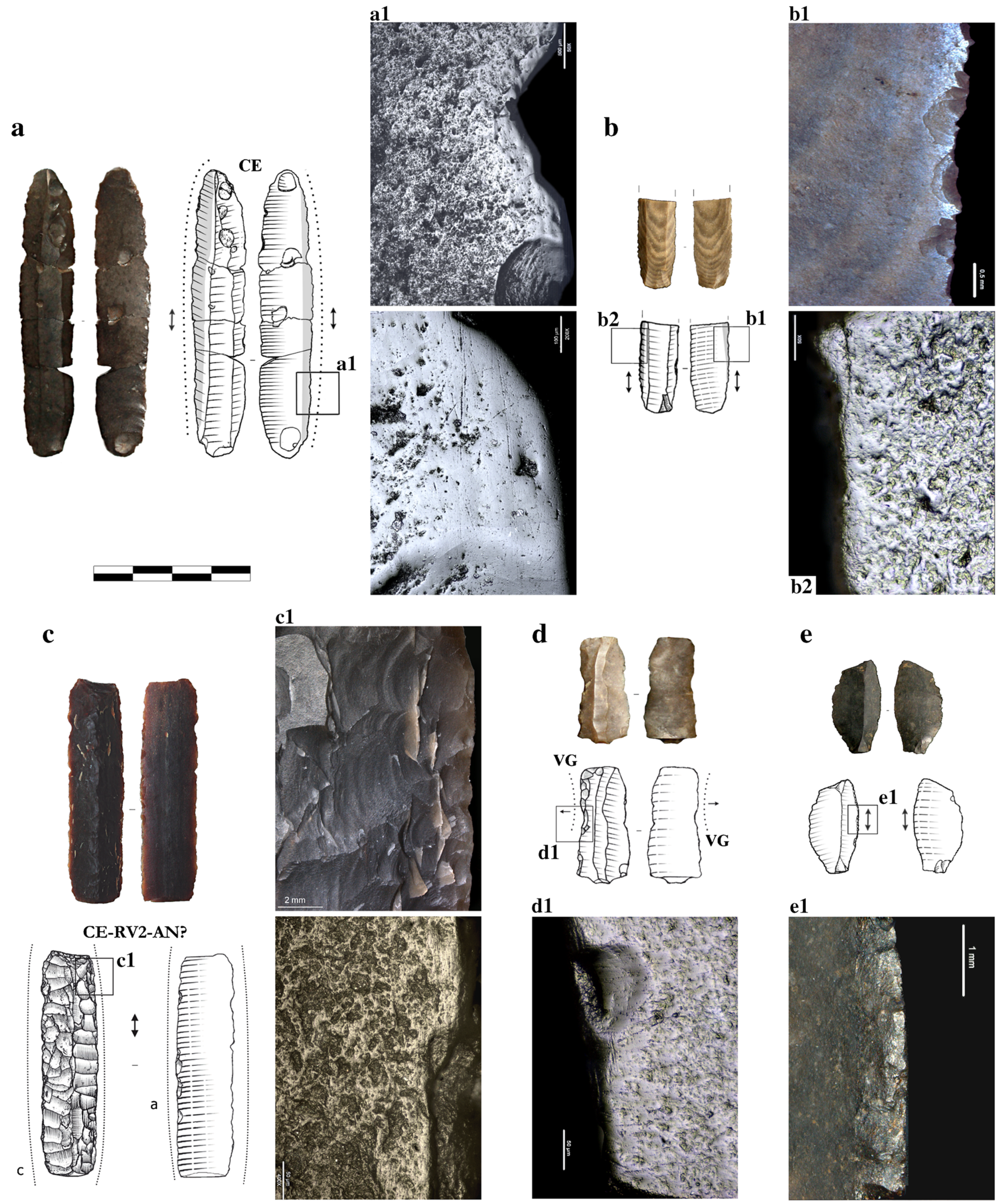


Fig. 4 Selection of use-wear from the Cova del Sardo. (a) Phase 7—blade made of Lacustrine Eocene-Miocene cherts used as crop-reaping knife, a1: well-developed cereal polish. (b) Phase 8—bladelets made of Lacustrine Eocene-Miocene cherts used as sickle insert, b1: marginal plant polishes. (c) Phase 5—blade made of Upper Cretaceous/Palaeocene chert used as crop-reaping knife, later resharpened and retooled for cutting animal substances, c1: resharpened edge, with abrasive polishes. (d) Blade made of Upper Cretaceous/Palaeocene chert used for scraping plants, d1: transversal plant polish. (e) Flake made of Upper Cretaceous/Palaeocene chert used for scraping plants used for cutting soft animal substances

Amongst them, we can cite a foliated point from phase 6 that is realised on a tabular chert type and, later, used as projectile tip (Fig. 5 (a)). Tabular cherts with such features are typical of the Aude-Roussillon region (Vaquer and Vergély 2006). Similar materials are also known from Chalcolithic/Bronze Age sites in the Lower Ebro valley (Royo Guillen 2014). Finally, heavily burned, crackled or altered materials, on which it was impossible to read the petrographic and micropalaeontological features, have been classified as indeterminable materials.

Discussion

From tools to peoples: mobility patterns and daily activities

The information provided by the provenance and techno-functional analyses has turned out to be crucial for figuring out the management strategies of lithic resources at Cova Sardo; however, the analysis of procurement strategies also gives us important information for reconstructing some aspects of the prehistoric landscape and people's mobility.

Gathered data on the exploited raw material sources suggests that the groups that occupied the Cova del Sardo between the fifth and the third millennium developed their economic activities over an area of approximately 1.400 m^2 (taking into account its minimum extension), from the Ebro Valley plains to the highest peaks of the Axial Pyrenees. According to the raw materials origins, mobility patterns seem to have mainly followed a south-north direction, whilst a westward movement of objects and artefacts appears extremely reduced (Mazzucco et al. 2013a). The catchment area was substantially the same during the entire occupation sequence, with only slight variations in the exploitation of one lithologies or another.

To explore variations in the distribution of the raw materials and of the types of products amongst the four occupational phases, chi-square tests have been carried out following the approach by Beasley and Schumacker (1995). A test has been carried out grouping raw materials on the basis of type of rocks and of their region of region of provenance: 'local materials' (LOC), 'pre-Pyrenees' (CRE + PAL + RHY) and 'Ebro Basin' (LOM), whilst excluding all those materials of uncertain provenance (CIM) (Table 1). The result disproves the null hypothesis of a homogeneous distribution (χ^2 28,486; df 6; P 0.000). Post-hoc tests indicate that significant P values are related with a greater presence (76.5%) of exogenous rocks during phase 5; vice versa, during phase 8, one can observe as exogenous materials only representing the 35.6%, with local rocks the 64.4%. Phases 6–7 can be situated somewhat in between, with phase 7 resembling to phase 5 with 57.9% of exogenous materials, and phase 6 to phase 8, with 52.7% of local rocks. Such difference might be related to the different formative process of the various occupations: Phases 6–8 might represent two single episodes of rock shelter occupation, not much extended in time, whilst phases 5–7 are constituted by a series of repeated episodes of occupations over a larger span of time. If we hypothesise that each time that the rock shelter was occupied some exogenous tools were transported, used and then discarded there, thus it is reasonable to expect a greater number of exogenous rocks from phases 5 to 7.

Nevertheless, the quantity of materials for each phase is very small, especially if compared to the sites of the same period located at lower altitudes (Mazzucco et al. 2015; Mazzucco and Gibaja 2016), and thus some caution is required whilst interpreting such percentages. The assemblage represents the outcome of a few on-site knapping episodes and of the abandonment of a small number of transported tools; therefore, more than informing about a systematic strategy of raw materials exploitation, it provides data about sporadic or occasional events of tools use and abandonment.

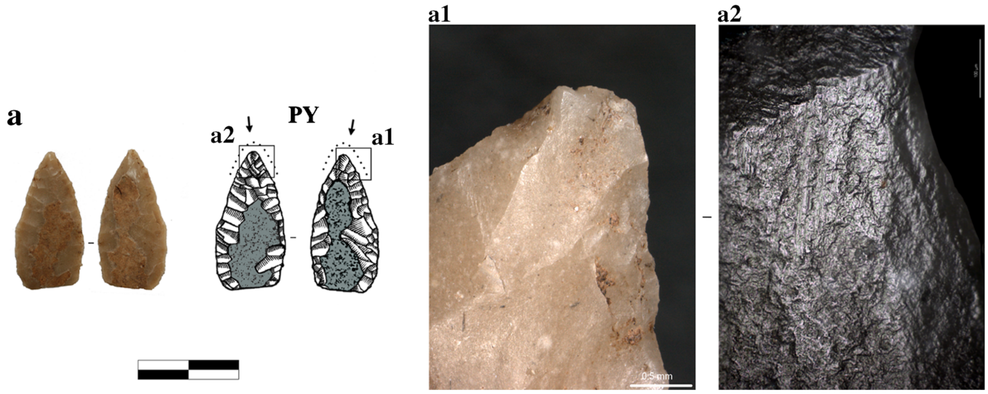
Raw materials were transported to the site as part of the individual toolkit of the site inhabitants. Preformed cores, unretouched blanks and hafted tools are, indeed, easy-to-carry objects and did not represent a heavy or bulky load if transported in small quantities. They were everyday artefacts, parts of the Neolithic personal gear, namely, items that everyone would have normally taken along during a trip or a travel. They were finally discarded at the Cova del Sardo because they were worn-out; indeed, they are often broken and fire-cracked, being dumped as wastes of repairing and maintenance activities. Their procurement and transportation were not the result of a single-purpose oriented strategy, but they were gathered and transported whilst engaging into other subsistence activities (i.e. embedded procurement, Binford 1979). Alternatively, local rocks were exploited when lacking of better quality materials because they were easily available in the site surroundings. They were used for manufacturing disposable tools, employed for tasks of short duration, often without any previous tool-retouching or tool-configuration.

Following this reasoning, it is not surprising that exogenous gears show a longer 'use-life' than tools on local rocks. They were more intensively retouched and used, exploiting all the available edges; in addition, they had often already been used and hafted before their arrival at the site, where they were recycled for other purposes. This pattern is somewhat similar to the one observed for caves and rock shelters of the Chassey of Southern France, where imported tools generally show a major degree of utilisation (and of curation) in respect to the ones produced locally, with a dichotomy between tools showing a 'long' or 'short' management strategy (Gassin et al. 2010).

On a functional level, the activities identified can be classified in three main categories: (1) tasks related to the working of vegetal matters, (2) tasks related to the processing of soft animal substances and (3) tasks related to the reparation and refitting of projectile weapons. All of these activities are typical of domestic settings; they correspond to brief tasks related to the maintenance of other artefacts or tools (i.e. repairing broken arrows), to food-preparation activities or to the upkeep of the dwelling space. Evidence of structured production processes is absent and all the tasks have been carried out on a sporadic basis.

Given the low number of specimens, it is difficult to ascertain relevant differences between one phase and another; moreover, only the quantity of tools recovered varies, not their functional management (Fig. 6; Table 2). An increasing number of tools related to crop-harvesting activities are visible

Fig. 5 Tool from phase 6—foliated point made of a tabular chert type of indeterminate origin, possibly from Southern France. a1, impact fracture; a2, microscopic striations produced by the impact



during Late Neolithic-phase 5, which might be related to an extension of the cultivation practices toward the mountainous zones. Despite that, most of those tools were retooled at the Cova del Sardo for other tasks and, thus, their first use as harvesting inserts could not be directly associated with local cultivation practices. In this sense, carpological remains of cereals are extremely rare at the site: only two charred cereal grains have been recovered, one of naked barley (*Hordeum vulgare* L. var. *nudum* Hook. f.) from phase 8 and one of wheat (*Triticum aestivum/durum/turgidum*) from phase 6. The presence of crop-harvesting blades and charred grains testify that the group that occupied the rock shelter practised agriculture to some extent; cereal fields were perhaps not located so high, but site inhabitants harvested and consumed cereals. Charred seeds may have been taken to the Sardo as provisions, whilst sickle tools were transported for being retooled for other tasks. At this stage of research, this appears to be the most reasonable hypothesis, also in the light of the data from other sites of the region (i.e. Balma Margineda, Marinval 1995; Els Trocs, Lancelotti et al. 2014). Els Trocs cave, in particular, has been recently studied in detail by analysing plant macro- and micro-remains. The outcomes of phytolith analyses have demonstrated that, despite that grains of cultivated cereals were encountered in the archaeological deposit, no secondary crop-processing activity (e.g. de-husking) took place on site. Therefore, the presence of wheat and barley grains is interpreted as a consequence of transporting provisions from more permanent settlements as dietary supplements. However, the distance of such 'hypothetic' locations is still unknown and difficult to approximate. Cultivation fields were maybe located at lower altitudes, or, maybe they were not far away from those caves. In this sense, evidence from other Pyrenean sites, namely Coro Trasito, seems to point out the possibility of the practice of agriculture at ca. 1.500 m a.s.l. since 5200 cal BC (mils, storage pits, an abundant number of charred cereal grains, on-site cereal pollen) (Clemente et al. 2016). Future researchers might shed light whether small-scale cultivation took place at mountain altitudes or not since Neolithic and which their relevance within the overall economic organisation. For example, the intermittent presence of *Cerealia*-type pollen in peat bogs and lakes records (e.g. Bassa Nera, Burg lake and Madriu valley records) between ca. 3500 and 3000 cal BC might be evidence of some cereal-based agriculture in altitude areas, at least since Final Neolithic (Pèlachs et al. 2007, 2011; Miras et al. 2010; Harfouche 2015; Garcés-Pastor et al. 2017).

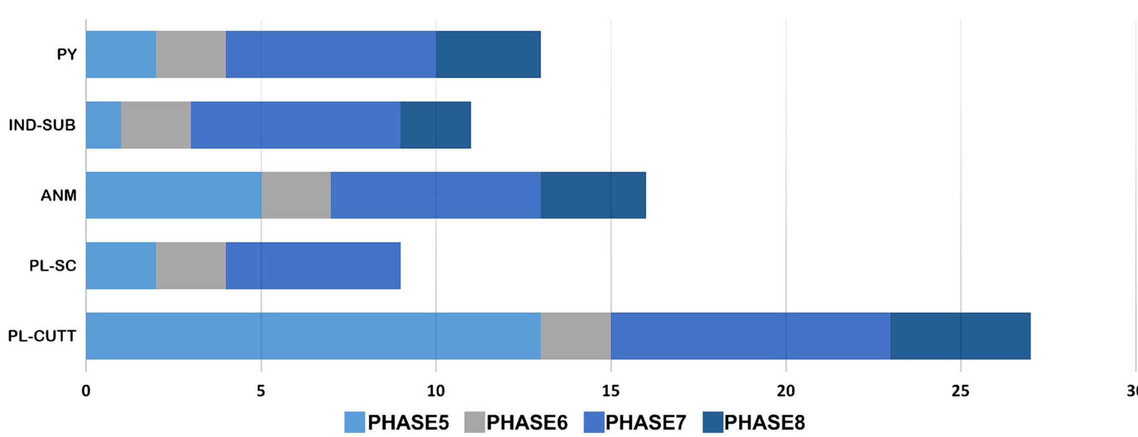


Fig. 6 Graph representing the type of activities (sum of active zones) inferred from the use-wear analysis for each occupational phase (5, 6, 7 and 8). PY projectile implements, IND-SUB indeterminate substances, ANM animal substances, PL-SC plant-scraping activities, PL-CUTT plant-cutting activities

Table 2 Type of activities inferred from the use-wear analysis of the lithic assemblage and the type of raw materials exploited for each occupational phase

Raw materials	Activities (Σ active zones)					Total	
	Plant cutting	Plant scraping	Animal substances working	Indet. substances working	Projectile tools		
Lacustrine Eocene-Miocene (LOM)	11	–	4	–	1	16	Phase 5
Upper Cretaceous/Palaeocene cherts (PAL)	2	1	1	–	1	5	
Cherts indeterminate (CIN)	–	1	–	1	–	2	
Total	*13*	*2*	*5*	*1*	*2*	*23*	
Lacustrine Eocene-Miocene (LOM)	–	–	–	–	1	1	Phase 6
Upper Cretaceous marine cherts (CRE)	–	1	–	1	–	2	
Upper Cretaceous/Palaeocene cherts (PAL)	2	–	2	1	–	5	
Cherts indeterminate (CIN)	–	1	–	–	1	2	
Total	*2*	*2*	*2*	*2*	*2*	*10*	
Lacustrine Eocene-Miocene (LOM)	5	2	4	–	4	15	Phase 7
Upper Cretaceous/Palaeocene cherts (PAL)	3	3	2	–	2	10	
Cherts indeterminate (CIN)	–	–	–	1	–	1	
Local rocks (LOC)	–	–	–	5	–	5	
Total	*8*	*5*	*6*	*6*	*6*	*31*	
Lacustrine Eocene-Miocene (LOM)	3	–	2	–	–	5	Phase 8
Upper Cretaceous/Palaeocene cherts (PAL)	1	–	–	–	3	3	
Cherts indeterminate (CIN)	–	–	–	1	–	1	
Local rocks (LOC)	–	–	1	1	–	3	
Total	*4*	–	*3*	*2*	*3*	*12*	
Lacustrine Eocene-Miocene (LOM)	19	2	10	–	6	37	Total
Upper Cretaceous marine cherts (CRE)	–	1	–	1	1	3	
Upper Cretaceous/Palaeocene cherts (PAL)	8	4	5	1	6	24	
Cherts indeterminate (CIN)	–	2	–	3	–	5	
Local rocks (LOC)	–	–	1	6	–	7	
Total	*27*	*9*	*16*	*11*	*13*	*76*	

Column totals are indicated in Italics

For what regards the other craft activities associated with vegetal matters, they are more discontinuously observed. Vegetal fibres processing and wood-working tasks are attested by few tools; this could be associated to basketry activities, arrow's stick production/refitting as described by Gassin (1996) or to some kind of domestic craft related to a vegetable structure/roofing, as it has been documented in phase 6 (Gassiot et al. 2014).

Hunting practices and slaughtering/butchering activities are documented in all the analysed phases. In both cases, activities were directed toward a local consumption of meat, as also testified from recent residues analysis performed on the Cova del Sardo pottery assemblage (Tarifa 2015). Game was occasionally hunted and processed as food for the site's inhabitants. In addition, no activities related to animal hide or bones processing have been detected, confirming that hunting was directed exclusively to obtain meat and no other raw materials. Macrolithic elements recovered from the deposit that might be used for hide treatment activities were analysed, but none of them showed relevant use-wear; most of them were heated, possibly used as stone-boiling. No remains of wild fauna have been recovered within the site deposit throughout the occupation sequence (although the taphonomic conditions might affected their recognition); despite that, some fragments of domestic *Caprinae* have been detected confirming the occasional slaughtering of sheep/goats (Gassiot et al. 2015).

The Cova del Sardo and the Neolithisation of the Southern Central Pyrenees

The Cova del Sardo testifies the onset of farming societies in the subalpine areas of the Southern Central Pyrenees. On the basis of the gathered data from the lithic record, it is possible to outline a general pattern of site use: over about 3000 years, the rock shelter was repeatedly occupied by small mobile groups. According the data from lithic raw materials, these groups were of southern provenance, probably coming from the pre-Pyrenean valleys or, at most, from the Ebro plains.

They stop at the site were more likely shorts: the material remains of domestic and productive activities are very scarce. On-site knapping episodes were sporadic and limited. Most of the tools were not manufactured on the site, but transported to the Sardo as part of the individual toolkit. The economic processes documented through use-wear analysis support such reconstruction; within the site only, a few domestic tasks were carried out, on an occasional basis; they were not directed to surplus production or food storage, but only to local consumption.

Cova del Sardo's inhabitants were probably engaged in herding practices and used the cavity as a shelter, a sort of 'pasture shed', more or less ephemerally occupied depending on the phase (Gassiot et al. 2014). Palaeoecological and carpological proxies have documented the gradual expansion of herding activities in the area, since about 4600 cal BC (Gassiot et al. 2012). Before then, human activities at subalpine and alpine altitudes were discontinuous and did not have an enduring influence on the natural environment (Pérez-Obiol et al. 2012). Starting from about 3300 cal BC, corresponding with Sardo's phases 5–6, herding activities would become more intense, with an increase in human-induced fire events over 2.000 m a.s.l. and the appearance of new archaeological sites at alpine altitudes (Cunill et al. 2012, Gassiot et al. 2014) (Fig. 7).

Despite that some authors have hypothesised the existence of long-distance transhumant routes (Polo Díaz et al. 2014), according to current data, there is no archaeological evidence that might support the existence of specialised pastoral groups, at least during the Early and Middle Neolithic. Though Cova del Sardo testifies the presence of small groups (temporarily?) engaged in herding activities at high-altitudes, those shepherds were integrated into larger communities relaying on farming. High-altitude areas were exploited for pastoral productions on a seasonal scale, more likely following a short-range mobility between valley bottoms and subalpine-alpine zones. In addition to high-altitude pasture sites like Cova del Sardo, the Pleta de les Bacives and Els Estany sites in Andorra (Orengo et al. 2014) or the Serrat de la Padrilla in the French Cerdanya (Rendu et al. 1996), larger caves at lower altitudes were associated to sheep/goat folding and intensive slaughtering activities, all of them integrated within a mixed crop-animal husbandry system. The presence of several cave sites at mountain altitudes (800–1.600 m a.s.l.) in the pre-Pyrenees, such as Balma Margineda (Oms et al. 2016), Espluga de la Puyascada (Mazzucco et al. 2013b), Coro

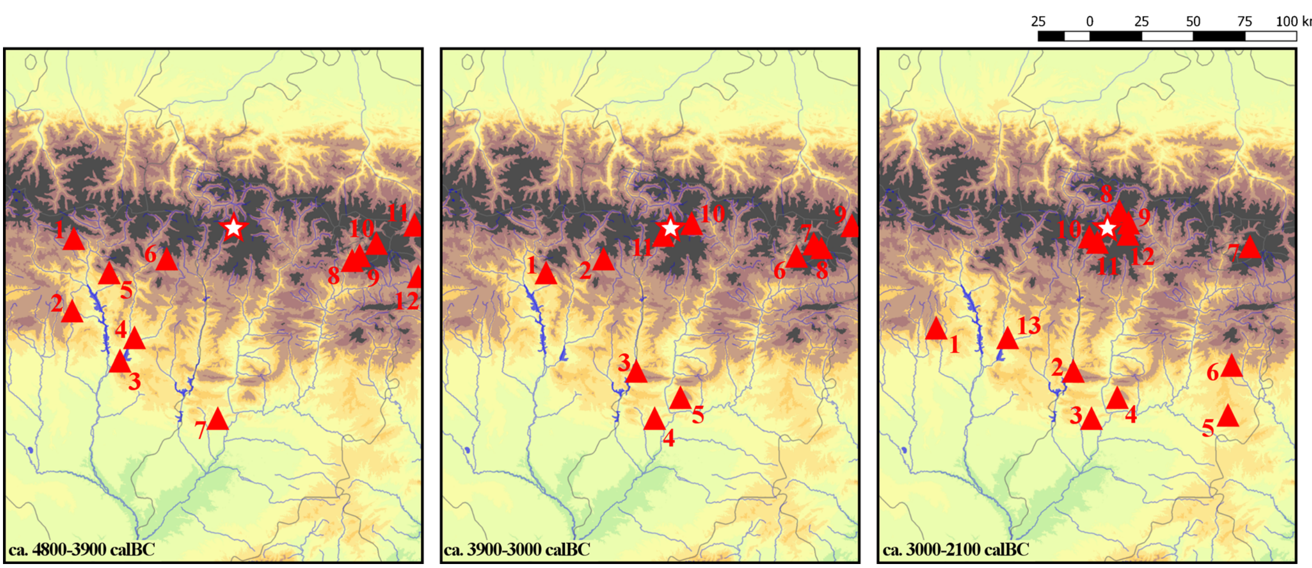


Fig. 7 The Cova del Sardo in the context of the occupation of the Southern Central Pyrenees. **a** ca. 4800–3900 cal BC, corresponding to Sardo phase 8. (1) Coro Trasito-UE3002/3010, (2) Cueva Paciencia-subunit I, (3) Moro de Olvena-c5, (4) Peña de las Forcas-layer VIII, (5) Espluga de la Puyascada-E.2, (6) Els Trocs-phase II, (7) Cova Gran-H1, (8) Balma Margineda-C3a, (9) Camp de Colomers-SJ7/SJ24/FS29/FS15/E12, (10) Pla de les Bacives-M152, (11) Serrat de la Padrilla-C49, (12) Sanavastre-str4. **b** ca. 3900–3000 cal BC, corresponding to Sardo phase 6/7. (1) Espluga de la Puyascada-E.2, (2) Els Trocs-phase III, (3) Cova Colomera-layer A, (4) Cova Gran-layer 3N, (5) Forat de la Conqueta-layer 2, (6) Feixa del Moro-Cist2/3, (7) Pla de les Bacives-M085, (8) Els Estany-P008/P169, (9) Serrat de la Padrilla-C49/C75, (10) Abric de l'Estany de la Coveta-layer3, (11) Cova del SardoII-Survey2004. **c** ca. 3000–2100 cal BC, corresponding to Sardo phase 5. (1) Cova Drólica-layer A, (2) Cova Colomera-CE8, (3) Cova Gran-Fumiers T/P, (4) Forat de la Conqueta-layer 1/2, (5) Collet de Brics d'Ardevol-CBA1-CBA2, (6) Cova de les Portes-layer 6, (7) Els Estanys-M218/M217/M175/M177/M151/M176, (8) Abric del Portarrò-layer 3, (9) Abric del Lac Major de Saboredo-layer 5, (10) Cova Serradé-S1, (11) Covetes-S1, (12) Coma d'Escós-layer 4, (13) Peña de las Forcas-layer 7. Supplementary Table 14C dates from the sites cited in the text

Trasito (Clemente et al. 2014), Cova Colomera (Oms et al. 2015), Els Trocs (Rojo et al. 2013) and Cova Dròlica (Montes and Martínez-Bea 2006), can be interpreted in this perspective: the pastoral production cycle is composed of different stages, giving rise to a diversity of practices and sites (see also Bréhard et al. 2010). However, it is to be remark that all of the above-mentioned sites bear hard evidence of agricultural production/consumption (e.g. cereal harvesting, processing and consumption, grain storage).

The occupation of cavity not only for folding activities, but also for dwelling or burial spaces is documented also at lower altitudes, in the Marginal Sierras of the Pyrenees, as Las Forcas (Utrilla and Mazo 2014), Cova Gran (Mora et al. 2011), Cova del Moro de Olvena (Utrilla and Baldellou 1996) and Cova Paciencia (Montes et al. 2000). Moreover, in the Pyrenean area, the presence of open-air sites with a clear agricultural vocation is attested starting from the beginnings of the fifth millennium cal BC, at the sites of Sanavastre (Mercadal et al. 2009) Camp del Colomer (Fortó and Vidal 2016) and Feixa del Moro (Remolins et al. 2016) suggest the existence of a system of economically complementary landscapes and sites, involving small temporary shelters, large caves and open-air settlements. Sites such as the Cova del Sardo were probably occupied only for short episodes, developing specific economic activities, but people were moving in the mountain space for longer periods, using a variability of settlements in terms of size, function, season of occupation, etc.

A change in the mobility and economic patterns may be possible starting around 3300–3000 cal BC, when a decrease in the number of sites is observed in the pre-Pyrenean area with the abandonment of most the above-cited caves, along with an increasing occupation of the alpine altitudes, as suggested by both archaeological and palaeoenvironmental proxies (Gassiot et al. 2014; Mazzucco 2014). The appearance of large open sites with a clear orientation toward pastoral economy in the peripheral areas of the Pyrenees, such as Collet de Brics d'Ardèvol (Castany et al. 1992), well fits within this model of a larger mobility. However, archaeological information for this period is so partial and fragmentary that all these considerations should be taken solely as hypothesis and further confirmations would definitely be required.

Conclusions

The Cova del Sardo was repeatedly occupied between the fifth and third millennium by groups of mobile herders/farmers of southern provenance. Data from lithic analysis matches the interpretation of the site as a sort of 'pasture shed', that is, a shelter seasonally occupied during the time when the flocks were put out to pasture in the surrounding areas. Hunting was locally practiced to obtain complementary food sources. However, prehistoric groups also consumed cereals and practiced agriculture to some extent. The hypothesis of a local, low-scale, cultivation should be further explored, even if currently there is no conclusive evidence.

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