NICCOLÒ MAZZUCCO

The Human Occupation of the Southern Central Pyrenees in the Sixth-Third Millennia cal BC:

a Traceological Analysis of Flaked Stone Assemblages

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Director:
Dr. Ignacio Clemente-Conte

Co-Director:
Dr. Juan Francisco Gibaja Bao

Tutor:
Dra. Maria Saña Seguí

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1. Introduction

1.1. Research Framework

1.1.1. A Brief Retrospective on the Pyrenean Archaeology

The investigative approach to mountain areas has radically changed within the European Archaeology over the last twenty years. For a long time, indeed, many of the European mountains had been considered marginal places, where the human presence was limited to occasional forays or migrations. In addition, mountains were considered peripheral compared to the historical and social processes that were contemporarily taking place at lower altitudes. According to this perspective, the archaeology of mountain zones has mainly been based on indirect sources, thus extrapolating data from the historiography or ethnography of the past century. Until the beginning of the new millennium, the predominant view regarded mountains as isolated spaces where human life was strongly conditioned by a hostile environment, being then often described as primitive and underdeveloped contexts (Della Casa & Walsh 2007; Gassiot et al. 2014).

About the Central Pyrenees, the first theories about the ancient occupation of mountain areas were elaborated during the twenties and thirties of the last century. These theories are known as *Cultura Pirenaica* and *Cultura Megalítica*, according to the concepts coined by Bosch Gimpera and his student L. Pericot respectively (Pericot 1925; Bosch Gimpera 1944; Pericot 1950). These two terms were quite successful amongst archaeologists and ethnographers and the idea of the existence of a 'Pyrenean culture' persisted until few decades ago.

In this context, the archaeology of the Pyrenees has almost exclusively been based on the study of megalithic phenomena. Megalithism is one of the aspects that have drawn much attention within the Iberian Archaeology since the mid-nineteenth century (Basch 1942, 1944; VV.AA. 1987). The origin and meaning of such monuments were mainly investigated following an ethnic/culturalist approach; their appearance was explicated in terms of migration and colonization processes, generally associating such evidence with ahistorical pastoral transhumant practices (Jimenez 2006 and references therein).

However, apart from this theoretical perspective, the empirical basis was extremely poor. As already stated, the main archaeological findings were megalithic sites and, moreover, surface finds, mostly ceramic vessels or macrolithic tools. Therefore, the main theories were largely constructed on aprioristic beliefs and not on the analysis and interpretation of archaeological data.

This situation well persisted until the seventies of the last century, when a number of systematic surveys and excavations of large caves started to be carried out. Amongst the main archaeological works of that period, one can mention the research led by V. Baldellou of the Museo Provincial of Huesca in Aragon: the excavation of Cueva de Chaves started in 1974-75; that of Espluga de la Puyascada in 1975; the surveys at Cueva del Forcón in 1976, and the surveys at Cueva de la Miranda in 1975-76. Other works in the region were undertaken by I. Barandiarán with the surveys at Huerto Raso in 1969 and, in the western area of the Pyrenees, in Navarra, at Cueva de Zatoya in 1975-76 (for a general overview over the prehistory of Huesca region see Baldellou 1990).

In Catalonia, excavations were carried out at Cova Colomera by J. de la Vega in 1973, at Cova del Parco by J. Maluquer de Motes from 1974 until 1986, and at Balma del Gai by M. Llongueras and J. Guilaine between 1977 and 1978. In the same area, M. Cura, J. Padrò and their collaborators collected surface materials dated to prehistoric times at the sites of Valldany and Espluga Negra (for a review of research in the Segre-Montsec area see Maluquer de Motes 1988; for a general overview of the Neolithic research in Catalonia see Pié 1991; for Palaeolithic research see Estévez & Vila 2006).

With regard to the French Pyrenees, several archaeological excavations were undertaken as early as the 19th century, mainly in connection with the interest in Palaeolithic art and material culture. This is the case of Grotte du Mas-d'Azil in the Pyrénées ariégeoises that was investigated by Édouard Piette from 1880 to 1890 and, later, by Henri Breuil from 1901 to 1902. Édouard Piette also excavated several other caves in Piedmont, amongst which Grotte de l'Éléphant at Gourdan (Haute-Garonne) from 1871 to 1875, Grotte d'Espalungue at Saint -Michel d'Arudy (Pyrénées-Atlantiques), and Grotte de Lortet (Hautes-Pyrénées) from 1873 to 1874. Another site that was excavated in that period is Grotte du Gargas, specifically by Félix Régnault from 1884 to 1887 and, later, by H. Breuil and É. Cartailhac from 1911 to 1913. In addition, the excavation of Grotte du Tourasse at Saint-Martory (Haute-Garonne) can be mentioned, which was carried out by Gabriel de Mortillet from 1891 to 1892, and also the researches of Félix Garrigou at Grotte du la Vache at Alliat and Grotte de Niaux (Ariège) in 1866 (for a more detailed reconstruction of early French archaeology see Groenen 1994).

However, most of these researches focused on the peripheral areas of the Pyrenees and only rarely archaeological works were carried out in the inner mountain area. Excavations at higher altitudes gradually began from the seventies, as for example at Balma de Montbolò at *ca.* 600 m.a.s.l. (Pyrénées-Orientales), Abri Jean-Cross on the Corbières Mountain at *ca.* 600 m.a.s.l., and Roc du Dourgne in the Aude Valley at *ca.* 700 m.a.s.l., all of them under the direction of J. Guilaine and his collaborators. Later, beginning from 1979, the same research group undertook the excavation of Balma Margineda in Andorra at *ca.* 900 m.a.s.l (Guilaine et al. 1974, 1979, 1993; Guilaine & Martzluff 1995).

In the Cerdanya, some of the first archaeological excavations over large areas were conducted by P. Campmajó at the sites of Llo (*ca.* 1.600 m.a.s.l.) and L'Avellanosa (*ca.* 1.550 m.a.s.l.), both spanning the Neolithic and Bronze Age. In 1976 J. Rovira started the excavation of the Cova d'Anes (Prullans, Bellver de Cerdanya) (for an overview of the archaeological researches in Cerdanya see Mercadal 2009).

The first congress that was specifically dedicated to the archaeology of the Pyrenees was actually organized in the seventies: the *Col·loqui Internacional d'Arqueologia de Puigcerdà*. The first edition goes back to 1974 and relied on the participation of some of the most influencing scholars of that time, such as J. Guilaine, P. Campmajó, J. Vaquer, J. Padró, J. Rovira, J. Maluquer de Motes, and M. Cura. Congresses dedicated to the Pyrenees had also taken place previously, although they did not specifically revolve around archaeological topics, such as the *Congreso Internacional de Estudios Pirenaicos*, the editions of which were organized by the Instituto de Estudios Pirenaicos de Zaragoza since 1950.

In 1979, in Pau (Pyrénées-Atlantiques), the *Groupe Archéologique des Pyrénées Occidentales* (GAPO) was founded, which has represented a reference point for the archaeological researches in southern Aquitania, from Palaeolithic to Medieval times. Its publications, the *Cahiers du Groupe Archéologique des Pyrénées Occidentales* were issued from 1981 until 1991, later changing its name in *Archéologie des Pyrénées Occidentales et des Landes*.

This scenario attests to an increased and renewed interest in the history and prehistory of the Pyrenees. As from about the seventies and throughout the eighties and nineties, scholars' investigations have moved from specific subjects (e.g. Palaeolithic art, Megalithic phenomena, *etc.*) towards a more general reconstruction of human occupations in the mountain areas. Systematic excavations of large sites gradually took place, along with more consistent field surveys. Nevertheless, apart from a few exceptions, the prevailing approach was still based on a culturalist perspective, namely, identifying and characterizing cultural entities on the basis of the typological analysis of the material record (mostly lithics or ceramics); the understanding of the socio-economic organization of these communities and their relationship with the mountain environment still had a marginal role.

Moreover, it is remarkable that the large majority of archaeological works were carried out in the outer parts of the mountains, generally situated below 1.000 m.a.s.l. Until recently, the only investigated sites located at higher altitudes were Espluga de la Puyascada (1.320 m.a.s.l.) (Baldellou 1985), the site of L'Avellanosa (*ca.* 1.550 m.a.s.l.) (Campmajo & Guilaine 1971), and Llo in Cerdagne (*ca.* 1.600 m.a.s.l.) (Campmajo 1983).

The reasons for such a scenario are quite clear: the valley bottoms and piedmont areas are the most accessible and so it is logistically easier to manage a survey or an excavation there. Not secondarily, the external mountain ranges were also the most populated areas, where more public works and infrastructure projects were carried out —thus facilitating the discovery of archaeological sites. Valley bottoms are also better known, from an archaeological point of view, thanks to the activity of local historians and scholars as well as because of the numerous clandestine excavations. Actually, most of the archaeological works of that time followed reports from amateur archaeologists rather than being programmatic or systematic researches. On the contrary, archaeologists almost completely ignored the high-altitude areas; these were considered to be pristine landscapes in the past as well in the present, scarcely affected by human dynamics. The only exception was the transhumant practice; however, transhumance was often seen as an unchanging and marginal activity with little impact on the environment, which had not gone through significant changes as if it was 'frozen in time' (Jimenez 2006).

It was at the end of the last century that the Pyrenean Archaeology changed direction. The turning point was the establishment of two new guidelines in the archaeology of mountain areas: 1) a more intensive and systematic survey of high-altitude areas; 2) a conclusive implementation of palaeoenvironmental and palaeoecological analyses, for either archaeological or lake/peat-bog sequences.

The first relevant works are probably the researches of C. Rendu and her collaborators in the Endveig Mountain located in the French Cerdagne (Rendu et al. 1995, 1996; Davasse et al. 1997; Galop 2000; Rendu 2003). C. Rendu and her team succeeded in ascertaining the presence of long-term human occupations in the subalpine and alpine regions since Neolithic times; moreover, they demonstrated the influence of human presence on the shaping of the alpine landscape. The project included a combination of archaeological data —obtained through extensive survey and stratigraphic excavations— with palynological and anthracological data, on both local and regional scale. Similar researches also took place in the Ariège region for the study of the long-term forest history and the impact of metallurgy, including the combination of phytogeography, palynology, anthracology, history, and archaeology (Bonhôte & Vernet 1988; Davasse & Galop 1989, Davasse et al. 1997).

Such projects exported to the Pyrenees a research model that had already been tested in the Alps, where surveys and excavations were underway since the early seventies, mainly due to the large amount of evidence of hunter-gatherer occupations above 2.000 m.a.s.l. (among others, Bintz & Desbrosse 1979; Bagolini & Broglio 1985; Fedele 1986; Bagolini & Dalmieri 1987). Since the nineties, the archaeological excavations of Late Palaeolithic and Mesolithic sites have been integrated by palaeoenvironmental studies, thus framing the archaeological data within the relevant landscape and climate dynamics. This multi-disciplinary approach has allowed a better reconstruction of the settlement strategies and the man-mountain relationship (Alciati et al. 1994; Fedele & Wick 1996; Orombelli & Ravazzi 1996; Walsh & Mocci 2003).

Apart from producing new and innovative results, such approaches have been extremely stimulating for other scholars too, who began to carry out more and more investigations with similar perspectives in other areas of the Pyrenees. As a result, since the first decade of the twenty-first century, several new projects have been set up in Andorra (Palet et al. 2006; Ejarque 2010; Ejarque et al. 2010), in the Pyrénées-Atlantiques in south-western France (Galop 2000, 2006; Galop et al. 2007, 2013; Rendu et al. 2013), in the Basque country in north-western Spain (Galop et al. 2001; Mazier et al. 2009; Cugny et al. 2010), and in the Catalan Pyrenees in north-eastern Spain (Gassiot et al. 2010a, 2010b, 2012b, 2014; Pèlachs et al. 2011; Catalan et al. 2001, 2013).

Even if the studied areas represent only a small portion compared to the extension of the Pyrenees, the amount and quality of data have grown exponentially during the last decade. The archaeological works are filling in the gaps in information that has hitherto been a strong limit to any historical reconstruction of the Pyrenees and surrounding regions. One of the main objectives of these projects was actually to provide an empirical basis for the study of the Pyrenean Mountains, whose archaeological reconstructions have too often been based on ahistorical biases and preconceptions. Moreover, in the light of the progressive abandonment —and the ensuing low levels of industrialization— of this region during the last fifty years, the Axial Pyrenees have turned out to be an ideal area for the study of climatic and landscape dynamics and man-environment interactions during the last 10,000 years.

1.1.2. Trends and Problems in Pyrenean Archaeology

If one considers the evolution of Pyrenean archaeology during the last ten years, it is quite clear that most of the developed projects have turned their attention to the high-altitude areas, from 1.600-1.700 m.a.s.l. up to the highest peaks at ca. 3,000 m.a.s.l. According to this, such researches should be defined as 'High-Altitude Archaeology' rather than 'Pyrenean Archaeology', since one of the trending topics is the human adaptation to high altitudes and the consequent interactions with landscape and climate. The reconstruction of Pyrenees' human population as a whole (and of the social dynamics connected with that) can be considered an important, although secondary, topic.

Apart from definitions, such a point should be taken into account when one evaluates how the most recent discoveries of the so-called 'High-Altitude Archaeology' have been accepted by the rest of the scientific community. A slight separation probably exists between the works carried out in the sub-alpine and alpine areas and the investigations at lower altitudes. Actually, at least in the Iberian Peninsula, there is little dialogue between 'traditional' and 'High-Altitude Archaeology', generally limited to precise quotations; there is so far no real integration between the two disciplines. High-Altitude Archaeology's discoveries are often not included (at least not yet) in the regional papers about the evolution of the prehistoric societies in the NW-N-NE of the Peninsula (see Rojo et al. 2012a and the various regional articles therein). This situation is probably consequent on the different methods applied and, in particular, on the different objectives of the two 'branches'. Indeed, clear differences exist about the type of archaeological evidence studied by these disciplines.

Mountain zones are traditionally considered poor in terms of archaeological findings, especially if compared to the sites located at lower altitudes, where archaeological deposits are richer, at least about artefacts. It is not by chance that the main datasets relevant to high-altitude areas are based on surface prospections and palaeoecological surveys; material records are extremely scanty or even absent. In this respect, one has also to consider that, in mountain areas, excavations are generally limited to stratigraphic surveys of a few square metres; they rarely cover extensive areas and this actually prevents from recovering large archaeological assemblages. However, the shortage of material records is also due to a combination of other variables that do not depend on the excavation techniques adopted. Many factors are determining in preserving archaeological materials; among those, the type and characteristics of the materials/artefacts, the geographical context in which the site is located, the settlement pattern (open-air, cave, burials, etc.), its position, its sedimentary history, etc.

In general, one may assert that the higher a site is located, the more the topographical, physical and logistic difficulties are for the transportation of large quantities of objects and artefacts, especially for raw materials and productions exogenous to the area. This can then explain the generally poor evidence of archaeological records in the mountain areas.

Such 'material scarcity' is probably one of the reasons that have brought mountain archaeologists to adopt different strategies for the study of human activity. The extraordinary proliferation and improvement of palaeoecological and paleoenvironmental studies of mountain contexts during the last ten years may also be seen in this light. In some part of the Pyrenean chain, for example, the study of the human peopling has been tackled almost exclusively on the basis of palaeoecological analysis (mainly pollen data, but not only), while the archaeological dataset is either absent, marginal or only employed as a reference (see, for instance Cugny et al. 2011, Riera & Turu 2011 or Rius et al. 2012). Moreover, as it is extremely time-consuming and often logistically complicated, also requiring large teams to run the surveys, systematic prospections have only been carried out in some specific geographic or administrative districts, whereas the large majority of the Pyrenees can still be regarded as a virgin, not-studied, area.

On the contrary, most of the archaeological researches carried out at lower altitudes have based their interpretation on a sound archaeological dataset grounded on decennial excavations of large deposits, usually over extensive areas. The material record is generally abundant (even if these contexts too are subject to the aforesaid preservation conditions), and is commonly studied in depth in terms of typological and technological patterns. In these cases, palaeoecological analyses are often subsidiary to the archaeological researches, being mainly intended to provide a sort of environmental background of the site or, eventually, confirm the presence of anthropic traces. Prospection works, apart from a few exceptions (see for example Montes & Domingo 2001-2002; Montes et al. 2000, 2003; Alcalde et al. 2008, Alcalde & Saña 2009; Oms et al. 2009), are generally absent or limited to the surroundings of the sites, whilst a deep and diachronic archaeological knowledge of the area, in which the site is located, is generally lacking. Moreover, even if some prospections works have been carried out, in the most cases they were focused toward the identification of new archaeological deposits or the revision of old excavations, but only rarely gave raise to new proposals and models on prehistoric landscape exploitation and settlement patterns.

Such different approaches, even if partially constrained by environmental or practical situations, have brought about a sort of separation between the two fields. On the one hand, high-altitude sites are often considered controversial and scarcely reliable by archaeologists. As a matter of fact, the shortage of materials often makes it difficult to put forward any interpretation of the sites following the traditional chronological/cultural classification; moreover, the small size of the excavated areas often prevents from achieving a clear understanding of the stratigraphic sequence. On the other hand, researches at high-altitude areas, given the logistical difficulties and the little prospects in terms of material findings, often relegate the archaeological works to the background, in favour of more detailed paleoenvironmental and palaeoecological analyses. In addition, the archaeological evidence is often used only to confirm the presence of human groups in certain areas during a certain period and is not always integrated with the discussion of the data. More attention towards the general social and historical context would probably be necessary for a better understanding of both landscape and human dynamics in high-altitude areas.

Recent projects carried out in the National Park of Aigüestortes i Estany de Sant Maurici, in the Central Catalan Pyrenees, have shown that a real integration of these approaches allows a better reconstruction of human interactions with the landscape to be achieved (Gassiot et al. 2012b, 2014; Catalan et al. 2013). The archaeological reconstruction should then comprise systematic prospections, full-site excavations, analysis of the material record, and a detailed analysis of the archaeological deposits; all these data should be integrated within a small-scale study of the landscape evolution through archaeological sites and soils, also in the light of the environmental and climatic evolution emerging from lacustrine and peat-bog sediments of the region. Finally, the data obtained should be integrated within a broader cultural and geographical context, since 'no man is an island', nor are archaeological sites, either in mountains or plains.

1.1.3. Objectives and Materials of This Work

The main purpose of this work is to contribute to the understanding of how human populations occupied the mountain spaces of the Southern Central Pyrenees between the sixth and the third millennium cal BC, an epoch that coincides, in the NE of the Iberian Peninsula, with great social changes, which are traditionally labelled as 'Neolithic'. Compared to the scenario described in the previous paragraphs, this work turns out to be somewhat 'cross-the-board', as it aims at combining some of the different approaches that have contributed to the historical and archaeological reconstructions of the Pyrenees during the last thirty years. Such an integration is accomplished on different levels, from a geographical and methodological point of view.

First, from a geographical perspective, I shall include in this analysis different environmental contexts, with altitudes between *ca.* 600 and 1.800 m.a.s.l., thus considering alpine, subalpine and upper and lower mountain zones. Within this setting, I shall focus on four archaeological sites located in different geological, topographical and vegetation contexts.

The selected sites differ from one other for several reasons: because of their geographical position, their excavation history, and their physical characteristics. I have included old excavations located at lower altitudes —traditionally considered as reference sites for the establishment of regional chrono-cultural sequences— as well as small caves situated at higher altitudes, which have been recently excavated and have yielded a relatively poor amount of material record. I shall thus integrate a varied archaeological record, as a result of diverse, but complementary, researches.

From a methodological point of view, this work will mainly deal with the analysis of artefacts and, more precisely, flaked stone assemblages. Stone or lithic tools traditionally represent one of the 'index fossils' in prehistoric research. However, this analysis will mainly focus on a socio-economic classification of the lithic record, brushing aside the traditional techno-typological approaches that have so far represented the dominant approach for the study of stone tools, at least in the Pyrenean area.

Finally, I shall try to integrate this data within a broader context and the interpretation will rely on both archaeological evidence and palaeoecological/paleoenvironmental outcomes, also taking into account the discoveries and advances made during the last thirty years in both lower and upper parts of the Pyrenean mountains.

I am aware of the magnitude of the problem and that the topic is too wide-ranging, in both geographical and chronological terms, to be tackled only by the study of lithic collections coming from a few archaeological sites. Nonetheless, I am confident these analyses can give new insights into the economic and settlement organization of the human groups that inhabited the Pyrenees during the Middle Holocene. Indeed, the lithic record shows some interesting features that have so far drawn little attention within the Pyrenean archaeology:

i. lithics represent one of the most common category of finds in prehistoric deposits; their ubiquity and good preservation allow for the establishment of comparison between different assemblages and so between different sites;

ii. since they are rocks, they can be analysed in terms of petrographic features; their geological provenance can thus be ascertained and traced. To this point, lithics represent a spatial marker and the investigation of them may provide insights into the land frequented by human groups and also the mobility of these;

iii. as 'artefacts', lithics are products of specific craft activities that can be characterized from a technological point of view. This analysis will provide information about the strategies of mineral-resources management, their ways and places of production, their maintenance and transportation;

iv. as 'tools', lithics are employed in different production processes. The traceological analysis of their surfaces and edges allows one to distinguish the type of processes in which they were used; it will then be possible to reconstruct some of the tasks and actions prehistoric groups performed and thus put forward a functional interpretation of the various sites.

To sum up, this work mainly aims at reconstructing the ways lithic resources were exploited at different sites of the Southern Central Pyrenees between the sixth and the third millennium cal BC. A socio-economic approximation of the material record will bring to highlight the variability between sites located in different altitudinal and environmental contexts and identify possible settlement- and resource-exploitation patterns. By integrating the achieved data within a broader economic and environmental context, it will be possible to contribute to the understanding of how the prehistoric groups organized themselves in mountain environments.

Finally, it has to be stressed that this thesis is not an independent work, but collaborates with different research projects related to the prehistory of the Pyrenees and surrounding areas. Amongst the main projects, which have contributed with archaeological materials or other data sources, the following can be mentioned:

2002-2007: *La vida prehistórica a l'alta muntanya del Pallars Sobirà: de la cacera a la transhmància (9.000-50 cal ANE)* (AGAUR - *Agència de Gestió d'Ajuts Universitaris i de Recerca, Generalitat de Catalunya, Institut d'Estudis Il·lerdencs* - Dr. Ermengol Gassiot, UAB);

2006-2008: *Arqueologia de l'Alta Muntanya Pirinenca. Ocupació humana i canvi climàtic al llarg de* *l'Holocè* (AGAUR - *Agència de Gestió d'Ajuts Universitaris i de Recerca, Generalitat de Catalunya*, Spain - Dr. Ermengol Gassiot, UAB);

2008-2012: *Origins and spread of agriculture in the south-western Mediterranean region* (European Research Council Advanced Grants - Dr. Leonor Peña-Chocarro)

2008-2011: *Los Caminos del Neolítico* (I+D+i project of *Ministerio de Ciencia e Innovación* - Dr. Manul Rojo Guerra, UVA).

2009-2012: *Interacción entre clima y ocupación humana en la configuración del paisaje vegetal del Parque Nacional de Aigüestortes i Estany de Sant Maurici a lo largo de los últimos 15.000 años* (I+D project of *Ministerio de Medio Ambiente y Medio Rural y Marino*, Spain - Jordi Catalan Aguilà, CSIC-CEAB);

2010-2013: *Aproximación a las primeras comunidades neolíticas del NE peninsular a través de sus prácticas funerarias* (I+D project *of Ministerio de Ciencia e Innovación*, Spain - Juan Francisco Gibaja Bao, CSIC-IMF).

1.2. Area of the Study

1.2.1. General Characters

In this chapter I will provide a general description of the Pyrenees, of their limits, their divisions and their main geological and topographical features. More extensive and complete descriptions can be found in Solé i Sabarís (1951) for both geographical and ethnographical aspects, while Barnolas & Pujalte (2004) resume the main geological features.

The Pyrenees is a range of mountains that separates the Iberian Peninsula from the rest of the continental Europe. Their orogeny took place during the Palaeozoic, around 350 Ma, when Laurussia and Gondwana supercontinents collided. Such tectonic activity caused the formation of a complex set of reliefs, among which a proto-Pyrenean mountain chain. A second orogeny occurred at the end of the Mesozoic. During this phase the Iberian plate start moving under the European plate, gradually sinking into its mantle. This phenomenon leads to folding and thrusting processes, with rocks of lower stratigraphic position that were pushed up, over higher strata. As result the huge massifs that actually constitute the Pyrenees were formed.

Pyrenees extends for about 435 km from the Bay of Biscay to the Mediterranean Sea in a west-northwest, east-southeast direction. Their width across varies between 65 km in their western part, to a maximum of 150 km in their central sector. On a transversal plane, Pyrenees may be divided into three sectors: the Western (or Atlantic), the Central and the Eastern (or Mediterranean) Pyrenees. From an administrative point of view, more or less they correspond to (from west to east): the Basque Country (province of Gipuzko), Navarra, Aragon (Huesca province) and Catalonia (provinces of Lleida, Barcelona, Girona).

The highest peak is represented by the Aneto (3.404 m.a.s.l.), located in the middle of Maladeta Massif, in the central sector of the Pyrenees. Maladeta Massif with altitudes comprised between 2.700 and 3.400 meters, represents, together with the Posets Massif, the highest and larger massif of the entire mountain. Toward west, in the Basque country, Pyrenees descend gradually, forming a range of moderates heights, while on the eastern side Pyrenees descend quite abruptly, passing from the Canigó Mountain (2.785 m.a.s.l.) to the Mediterranean sea in only 50 km.

Pyrenees are bounded in the north by a major thrust wedge, called the North Pyrenean Frontal Thrust (NPFT), while their southern limit is called the South Pyrenean Frontal Thrust (SPFT).

On a longitudinal plane Pyrenees is traditionally divided into five structural zones, which are (Fig. 1.1):

i. *Axial Pyrenees*: occupies the central and inner zone of the Pyrenees; it is essentially made up of Palaeozoic and pre-Palaeozoic formations; belonging to an ancient Hercynian massif, mainly formed of primary rocks such as granite and gneiss.

ii. *pre-Pyrenees*: it is series of mountain ranges extended both on the northern and southern side of the chain. Mainly consist of Mesozoic and Tertiary formations. On the French side, also called the North Pyrenean zone, the slopes descend rather abruptly; on the contrary, on the Iberian side, the South Pyrenean zone, pre-Pyrenees form a large and complex system of mountain ranges, running both in a west-east and north-south direction. Spanish pre-Pyrenees are mainly constituted by limestone formations, characterized by abrupt reliefs and gorges alternated by loamy depressions.

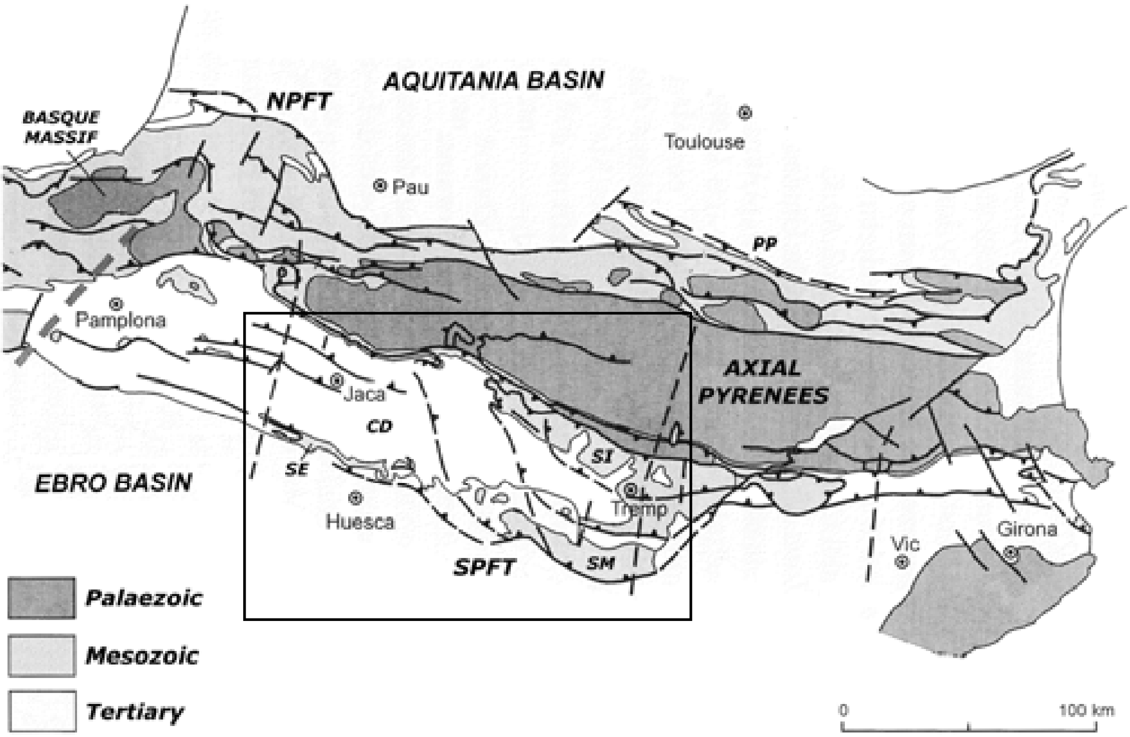

Fig. 1.1. Schematic structure of the Pyrenees, modified from Barnolas & Pujalte (2004: 235). NPFT - North Pyrenean Frontal Thrust; SPFT - South Pyrenean Frontal Thrust; SI: *Sierras Interiores*; PP: *Petites Pyrénées;* SE*: Sierras Exteriores;* SM*: Sierras Marginales; CD: Central Depression.* The square indicates the area of the study.

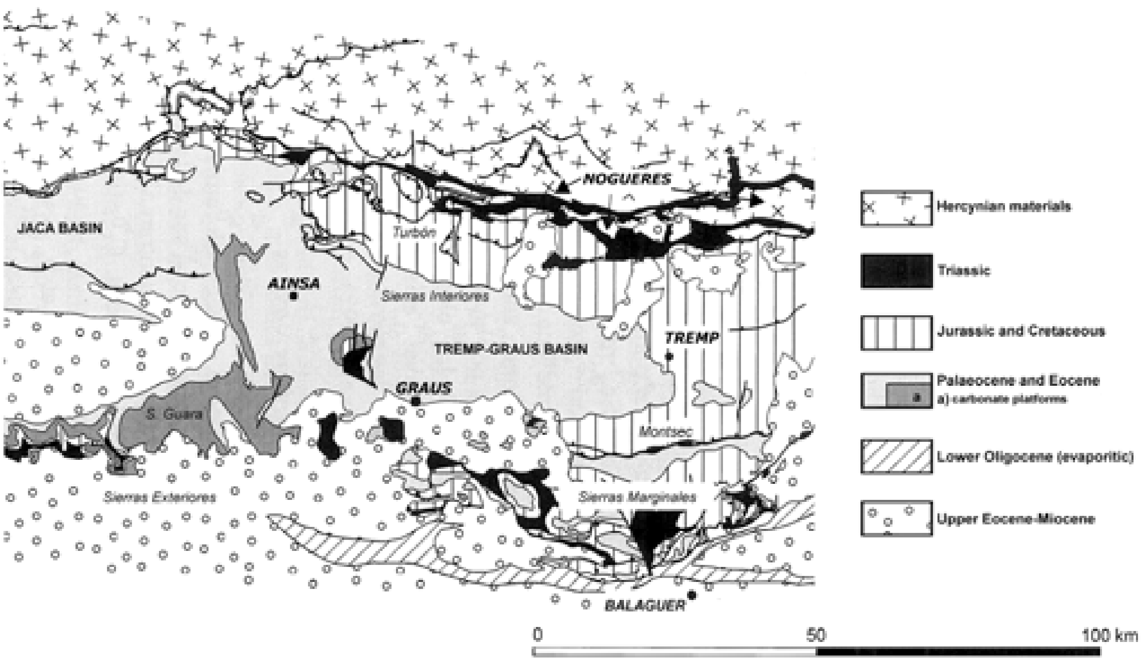

Fig. 1.2. Schematic geologic structure of the Central Pyrenees, zoom of the studied area. Modified from Barnolas & Pujalte (2004: 235).

The South Pyrenean zone can be further divided in:

⇒ *Interiors ranges or Sierras Interiores (SI):* they are a system of reliefs adjacent to the Hercynian Pyrenees, with massifs and peaks around 2.400-2.000, such as Peña Tendeñera (2.850 m.a.s.l.), Peña Collarada (2.963 m.a.s.l.), Peña Montañesa (2.295 m.a.s.l.), Cotiella (2.910 m.a.s.l.), Turbón (2.492 m.a.s.l.), Cadí (2.642 m.a.s.l.) and Pedraforca (2.493 m.a.s.l.). They mainly consist of Mesozoic and Eocene sedimentary sequences.

⇒ *Marginal/Exteriors ranges or Sierras Exteriores/Marginales (SE and SM)*: they represent the most external reliefs of the Pyrenees. They run for about 125 km in east-west direction. Highest altitudes are represented by the Leyre range (1.371 m.a.s.l.) in Navarra, Loarre (1.864 m.a.s.l.) and Guara (1.864 m.a.s.l.) in Aragon, and Montsec (1.693 m.a.s.l.) in Catalonia. They are, much like the Sierras Interiores, formed from Mesozoic-Eocene sedimentary successions, although with a more reduced thickness, of about 900 m.

⇒ *Depressión Media Prepirenaica or Central Depression (CD):* it runs between the External and Interiors ranges; it is constituted by a series of long and narrow loamy depressions with altitudes around 600-800 m.a.s.l., among them: the Cuenca de Pamplona in Navarra, Cuenca de Jaca and Canal de Berdún in Aragón and the Tremp-Graus Basin in Catalonia.

⇒ *Ebro Basin*: it is a large sedimentary basin of triangular shape with W-E orientation that rest directly on the Hercynian basement. This depression is mainly drained by the Ebro River and corresponds to a tertiary sedimentary basin constituted by Eocene deposits.

The North Pyrenean zone can be divided in:

⇒ *North Pyrenean zone or Sierras Interiores*: it is characterized by a series massifs, between Lourdes and Perpignan, commonly known as North Pyrenean massifs, among which: Gourette (2.613 m.a.s.l.), Arbizon (2.831 m.a.s.l.), Barousse (2.102 m.a.s.l.), Bessède (2.676 m.a.s.l.), Saint Barthélémy o Tabe (2.368 m.s.l.m), etc. Moreover, several minor reliefs are present in the northern Basque country. In respect to the South Pyrenean zone, the Northern zone it is quite narrow, averagely only about 10 km wide, even if can widen up to 40 km. Most of the sedimentary package of the North Pyrenean Zone is formed by Mesozoic (Jurassic and Cretaceous) rocks. In contrast with the Sub Pyrenean Zone, the North Pyrenean Zone contains hardly any Paleogene.

⇒ *Petites Pyrénées (PP)*: they represent the northern limit of the North Pyrenean zone; they are the homologous of the Spanish Sierras, even if with a much reduced extension. They are mainly constituted of Upper Cretaceous and Eocene formations.

⇒ *Aquitania Basin*: it is a large Mesozoic and Cenozoic sedimentary basin. It was formed on a Variscan basement which was peneplained during the Permian and started subsiding in the early Triassic. The basement is covered in the Parentis Basin and in the Sub Pyrenean Basin.

1.2.2. The Southern Central Pyrenees

1.2.2.1. Geographical Framework

The area of study considered in this work corresponds to a wide geographical space, approximately comprised between the Alcanadre River —in the Sierra de Guara, part of the Sierra Exteriores— and the Nogueras Rivers —in the Central Catalan Pyrenees. This area is defined as Southern Central Pyrenees, a large territory with an extension of more than 8.000 km^2. From an administrative point of view, from west to east, it includes the Hoya de Huesca, Somontano de Barbastro, Sobrarbe, Cinca Medio, la Litera the Ribargoza (all of them part of the Huesca province) and the Noguera, Pallars Jussá, Alta Ribagorça, Vall d'Aran, Pallars Subirá, Alto Urgell (all of them part of the Lleida province) and Andorra (Fig. 1.3, 1.5).

This large area is characterized by a strong topographical and altitudinal gradient, passing from the 200-300 m.a.s.l. of the Ebro Basin to the 3.000 m.a.s.l. of the Axial Pyrenees, which in the Central sector form a huge block of mountains that represent the highest range of the entire Pyrenees. All along this gradient one can see different environments: 1) the alpine landscape characterized by seasonal grasslands located over 2.300 m.a.s.l. until the top of the mountains (where there is enough soil and insolation) approximately around 2.800 m.a.s.l.; 2) a mixed-coniferous forests in the subalpine stage between 2.300-1600 m.a.s.l., dominated by mountains pines over 2.000 m.a.s.l. and eventually alternated with grazing areas; 3) a Mediterranean mixed deciduous forest in the mountain stage, between 1.600 and 800 m.a.s.l., quite degraded and with an extensive secondary vegetation dominated by shrubland formations; 4) a highly anthropized landscapes of floodplains, mainly dominated by cultivated fields or abandoned areas.

Actual climate in the Pyrenean region displays an oceanic influence in the west, becoming more Mediterranean toward the east. The Axial Pyrenees is mainly characterized by an Atlantic climate, with cold winters, mild summers and high rainfall throughout the year. Annual precipitations overcome the 1000 mm/yr., while temperatures during winter are between -4 ºC and 2 ºC and during summer between 13 ºC and 18 ºC. The pre-Pyrenees are mainly characterized by a Mediterranean climate, with annual precipitations that oscillate between 500-800 mm/yr., while temperatures between 3 ºC-5 ºC during winter and 18 ºC-24 ºC during summer. An Atlantic influences is also present, but mainly toward the western valleys of the Aragon's pre-Pyrenees. Further south, the Ebro basin is mainly characterized by a Continental-Mediterranean climate, with low rainfall (300-350 mm/yr.), high insolation and high evapotranspiration (between 1000-1500 mm/yr.) and the prevalence of strong, dry north-westerly winds. Since it is enclosed by various mountain systems —the Pyrenean (to the north), Iberian Cordillera (to the southwest) and the Catalonian mountains (to the east)— Ebro basin's climate adopts continental traits: aridity, deficit of rain, drying winds, high insolation, elevated nocturnal radiation and strong annual and daily thermal oscillations. The resulting climate can be defined as semi-arid Mediterranean.

This environmental setting makes of the Southern Central Pyrenees one of the most interesting context for studying the human dynamics of mountain occupation; such altitudinal gradient implies not only a strong variation in climatic and vegetation patterns, but also in the type of resources and their availability.

From a geographical point of view, the main communication routes between the Ebro Basin and Pyrenees are represented by the Ebro tributaries that from the reliefs of the Axial Pyrenees and of pre-Pyrenees descend almost parallel toward the Ebro Basin. The main

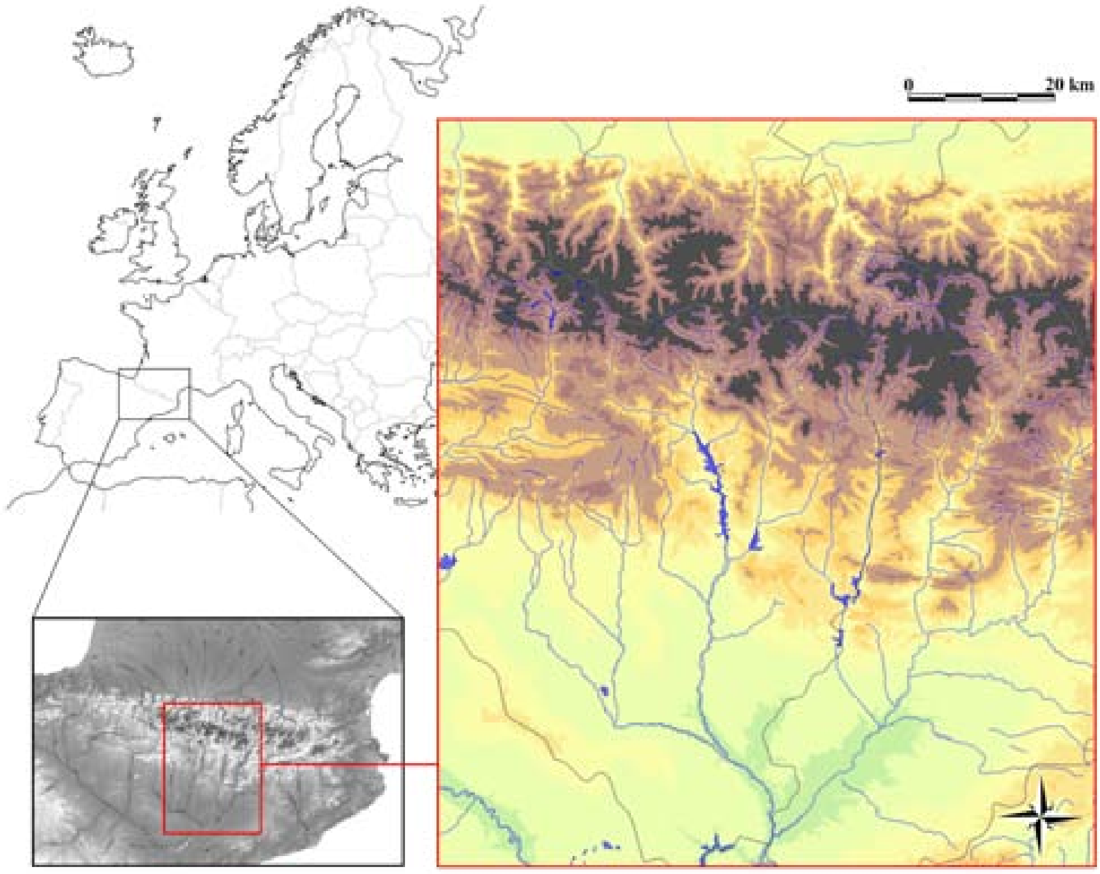

Fig.1.3. Geographical framework. In red is indicated the area of the study.

rivers of the area, from west to east, are: Alcanadre, Vero, Cinca, Ésera, Isábena, Noguera Ribagorçana, Noguera Pallaresa and Segre, among which the Cinca-Segre represent the main tributaries. Indeed, the Segre and, in lesser extent, the Cinca represent the widest and more accessible valleys, respectively connecting the eastern and the western sector of the Southern Central Pyrenees with the plain areas, while the Isábena, Ésera and the Nogueras are characterized by more narrow valleys, forming canyons and gorges when passing through the limestone formations of the pre-Pyrenean Sierras. Pre-Pyrenees traditionally represented the mayor obstacle to human mobility in the Spanish Pyrenees, especially on the west-east axis, between adjacent valleys. In this sense is remarkable that, historically, the main economic practices have been developed on a longitudinal (north-south) and not transversal (west-east) axis (Comas d'Argemir 1995; Benlloch 2002).

Among the various geographical features in the region, one can distinguish some elements especially relevant in relation to the studied area and the selected sites (Fig. 1.5):

⇒ Sierra the Guara: it is part of the Sierras Exteriores of Aragon, which represent the frontal part of the Pyrenean fold and thrust belt. Sierras Exteriores run for about 125 km in west-east direction, parallel to the Axial Pyrenees. Those ranges are mainly characterized by sediments of Triassic, Upper Cretaceous, Tertiary and Eocene period. The Sierra de Guara is located in the eastern sector of the Sierras Interiores, 25 km north from the city of Huesca; Sierras de Guara extends between the Guatizalema and Alcanadre Rivers. It reaches altitudes of 2.077 m.a.s.l. with the Tozal o Pico di Guara.

⇒ Sierra Ferrera: it is part of the Sierras Interiores system; is a WNW-trending mountain range that bounds the Axial Pyrenees to the south. It runs between the Cinca and the Ésera river, and it is part of the Cotiella massif. It is mainly composed of limestone (in the upper sedimentary sequence), and marls (in the lower formations). The highest peak is called Peña Montañesa (2.295 m.a.s.l.).

⇒ El Turbón: it is a massif located in the Huesca's Pre-Pyrenees. It is about 6 km long and it is aligned N-S. It is mainly composed by limestone and marl formations. The Isábena River flows on the eastern side, separating El Turbón massif from the Sierra de Sis. Highest altitude is of 2.492 m.a.s.l.

⇒ Sierra de Sis: is a 28 km long mountain range of the Pre-Pyrenees that runs in N-S direction. Is located between the valleys of Isábena and Noguera Ribagorçana rivers. It is mainly formed by Eocene-Oligocene materials. The highest summits of the range are the Pico de l'Amorriador (1.791 m.a.s.l.) and Puialto (1.782 m.a.s.l.).

⇒ Serra de San Gervàs: it represents the main range among the reliefs of the Sierras Interiores that run between the Noguera Ribagorçana and Pallaresa rivers. It is mainly constituted of Upper Cretaceous formations of limestone and marls. The main peak is the Pala del Teller (1.890 m.a.s.l.).

⇒ Sierra del Montsec: it is constituted by a series of calcareous mountains that run east to west for about 40 km. Is located in the provinces of Huesca and Lleida. It is divided into three main massifs by three of the most important rivers of the Catalonian Pyrenees: the river Segre in the eastern sector, the Noguera Pallaresa in the middle and, to the west, the Noguera Ribagorçana. It is composed of a thick layer of Upper Cretaceous limestone, followed by Lower and Middle Eocene conglomerates, sandstones and shale. The highest mountain, the Santalís peak, is located in the central massif at 1.678 m.a.s.l.

⇒ Sierra del Castillo de Laguarres: part of the Sierras Exteriores, it runs between the Embalse de Barasona and the Noguera Ribagorçana, in the province of Huesca. It is composed of Paleogene formations, mainly conglomerates and sandstone. The highest peak is the Pico de Laguarres (1.100 m.a.s.l.).

⇒ Besiberri: it is a mountain massif located in the central area of the Axial Pyrenees, located at the western limit of the Aigüestortes i Estany de Sant Maurici National Park. The main summits of the massif are the Comaloforno (3.029 m.a.s.l.), Besiberri Sud (3.024 m.a.s.l.), Besiberri Nord (3.008 m.a.s.l.) and Besiberri del Mig (2.995 m.a.s.l.).

⇒ Aneto: it is the highest mountain of the Pyrenees, 3.404 m.a.s.l. It is located the Posets-Maladeta Natural Park, near the town of Benasque, Huesca province. It forms the southernmost part of the Maladeta massif. It consists of Palaeozoic formations of a granitic nature and Mesozoic materials. Its northern slope holds the largest glacier of the Pyrenees.

⇒ Ainsa basin: it is a foreland sedimentary basin part of the South Pyrenean foreland basin along with the Jaca and Tremp-Graus basins. The separation of the three basins took place during Eocene, due to the development of the Mediano and Boltaña Anticlines. It presents reduced dimensions of about 25 x 40 km. Basin-fill materials are mainly constituted by marls and limestone of Upper Cretaceous and Palaeocene periods.

⇒ Tremp-Graus basin: it is a E-W foreland sedimentary basin located between the Sierras Interiores and the Montsec range. It is made of a syncline of Cretaceous and Palaeocene units, with basin-fill materials of Eocene age. The basin is about 20 km wide and almost 100 km long. Lithologies vary, from north to south, from marine (marls and turbidites) to continental materials (conglomerates and sandstone). In the Noguera Ribagorçana and Isábena basins marls predominates, while in the western sector, in the Ésera basin conglomerate prevails.

1.2.2.2. Climatic and Vegetation Evolution during Early-Middle Holocene

In this paragraph I will provide a brief and general description of the changes occurred both on a climatic and vegetation level in the Central Pyrenees; however without entering in a detailed description of the different regions, considering the wideness and the environmental diversity of the studied area. Moreover, both climatic and vegetation evolution are extremely complex phenomena that could vary notably even on a small-scale, for example between the northern and southern slope of a same valley, or between two adjacent valleys. So, I will only describe some general trends for the analysed period, aware of the limits of such reconstruction.

At the broadest scale, Holocene is considered a period of relative climate stability, in contrast to the high variability observed during the last glacial period, occurred in the previous 60 ka yrs. (Fletcher et al. 2009). However, over the last decades, many paleoclimatic studies have highlighted the climate fluctuations of the last glacial interval, as well characterized by global abrupt changes, could events and climatic oscillations (Mayewski et al. 2004), that have been also evidenced in the study area (González-Sampériz et al. 2006).

The Early Holocene (around *ca.* 9500 to 5000 cal BC) is a period characterized by colder climatic conditions (González-Sampériz et al. 2006; Morellón et al. 2008; Pèlachs et al. 2011). Precipitations were probably slightly higher in respect to the actual moment, at least at the end of the Younger Dryas; however a strong geographical variability between plain and mountain areas has been evidenced (Davis & Stevenson 2007; Morellón et al. 2008; Catalan et al. 2013). The vegetation cover of NE Spain during the Early Holocene also reflects humid conditions. In the Pyrenees and pre-Pyrenees, from about 9500 cal BC, vegetation passes from mountain steppe to a forested coverage (González-Sampériz et al. 2005; (Pèlachs et al. 2011; Catalán et al. 2013). Around 8000 cal BC the existence of arboreal mass is registered above the 2.200 m.a.s.l. (Miras et al. 2007; Pélachs et al. 2007; Cunill et al. 2013). The lowlands of the Central Ebro Basin were probably characterized by Mediterranean forest formations (coniferous and evergreen *Quercus*), even if scarce steppe land proportions were probably present (González-Sampériz et al. 2005).

A first severe climate disruption has been worldwide registered around *ca.* 6300 to 5700 cal BC. The so-called '8.2 ka yr. cal BP event', a short cooling moment of two or three centuries (Berger & Guilaine 2009), belongs to this interval. Such cold-event is considered producing a widespread decreasing of the arboreal masses, with a lowering of the treeline at

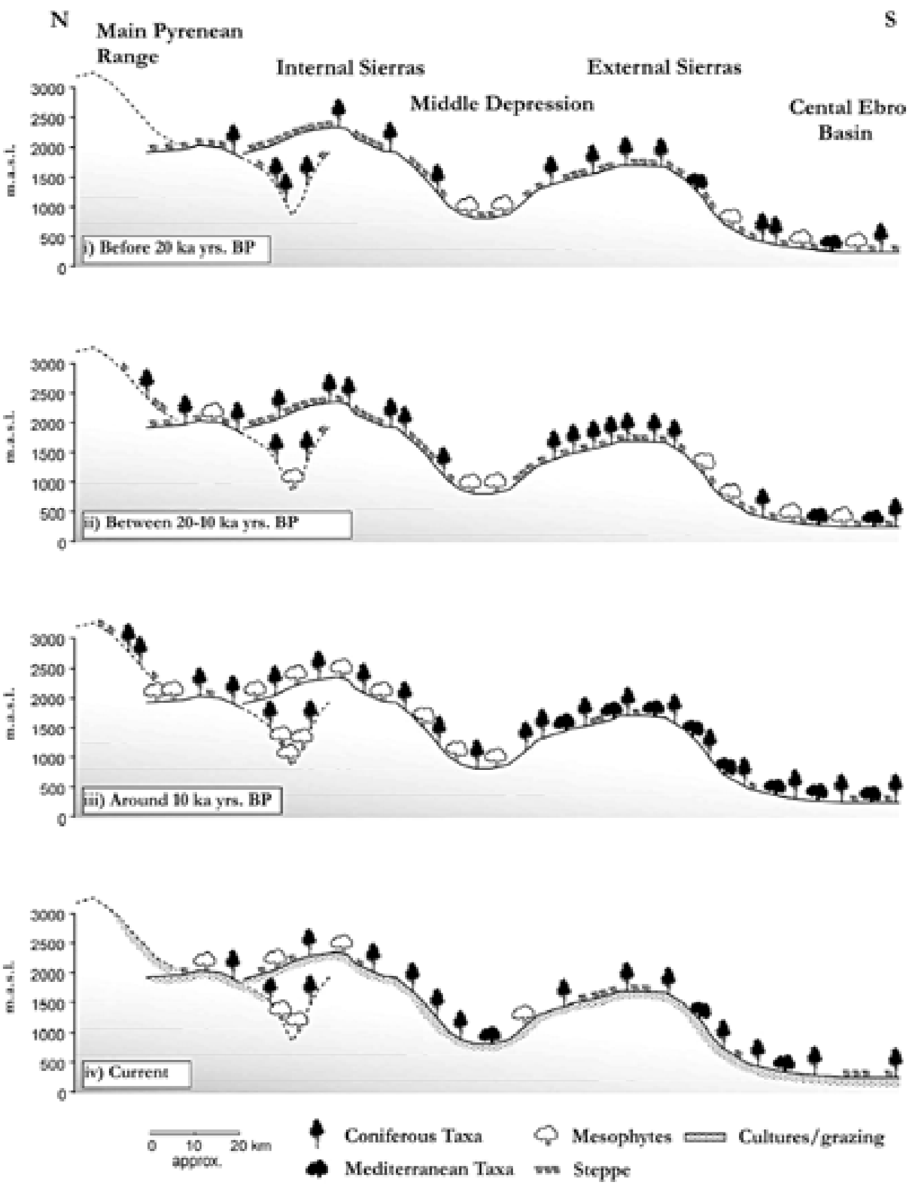

Fig.1.4. Hypothetical reconstruction of a vegetation transect between the Pyrenees and the Central Ebro Valley: (i) before 20 ka yrs. BP, (ii) between 20-10 ka yrs. BP; (iii) around 10 ka yrs. BP and (iv) currently (present formations). Modified from González-Sampériz et al. (2005).

higher altitudes and a period of increasing aridity at lower altitudes. In the Central Ebro valley a decrease in forest formation (*Juniperus*, *Betula*, *Corylus*, deciduous *Quercus* and other mesophytes) is detected in association with the 8200-yrs event, along with an increase in fire frequency (González-Sampériz et al. 2006; Davis & Stevenson 2007; González-Sampériz et al. 2008). After the 5600 cal BC, fire peaks have been also detected in the Axial Pyrenees, along with an increase in *Poaceae*. However, in the mountains the arboreal biomass remained at relatively high levels, suggesting that such fires consisted mainly in small opening of the forest (Miras et al. 2007; Cunill et al. 2013). Until the end of the Early Holocene, vegetation is mainly characterized by a deciduous forest in the valleys bottom and subalpine stages, while at alpine altitudes is gradually occupied by *Pinus*, with contributions of deciduous and evergreen *Quercus* together with *Corylus* and *Betula* (Catalan et al. 2013; Pérez-Obiol et al. 2012).

During Middle Holocene (*ca.* 5000 - 2000 cal BC), in most of the NE the Iberian Peninsula, a shift toward drier climate conditions and an increase in seasonality is detected (Pélachs et al. 2011; Catalán et al. 2013). In the Ebro Basin, sedimentary and palynological records shows the establishment of arid conditions, with a clear evidence of steppe herbs like *Artemisia* or *Chenopodiaceae* landscape, alongside a residual presence of coniferous forests. In particular, an increasing aridity is observed in the Central Ebro Basin, in the Los Monegros area, where desiccation phenomena and the formation of the playa lakes are attested (Sancho et al. 2011). In the Pyrenean area, this phase corresponds to the establishment of an *Abies* forest at the subalpine stage, between 1.700 to 2.000 m.a.s.l., along with the appearance of *Fagus* at the same altitudes (from *ca.* 3200 cal BC) (Pélachs et al. 2007). Moreover, between *ca.* 4500-4000 cal BC are dated the first signs of anthropic impact over the landscape, in form of fires in the valleys bottom that probably correspond to clearances of forested areas (Galop et al. 2002; 2013). Throughout Middle Holocene *Pinus* percentages decrease and the increase of *Poaceae* becomes more important, along with an increasing of fire events in the mountainous ranges of both Axial Pyrenees and Pyrenees. This landscape dynamic involves a general increase of human pressure on all Pyrenees areas (Galop 2006). From this moment onward, the human pressure over the environment will be constant, becoming the main factor in the shaping of the landscape.

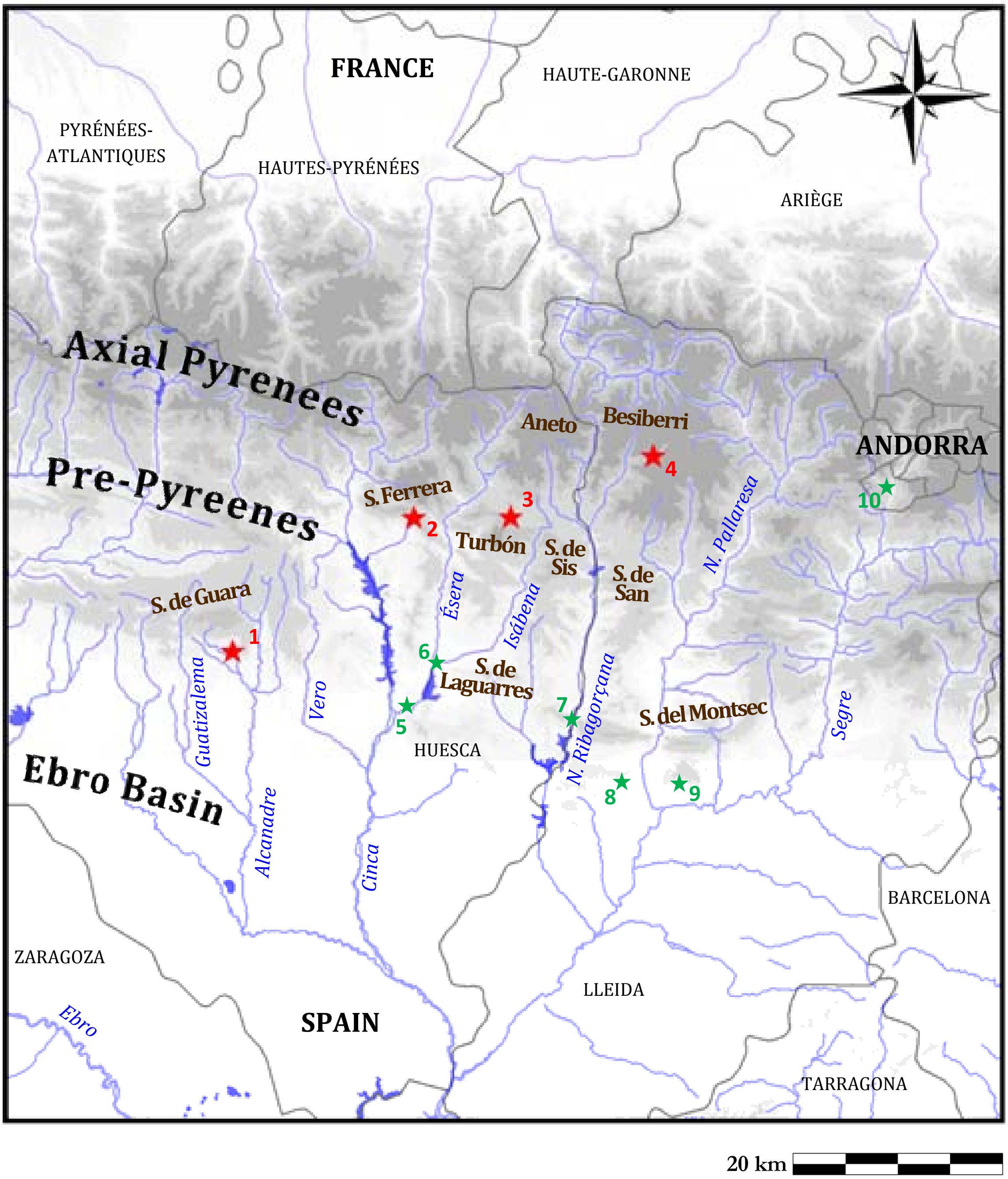

Fig.1.5. Geographical framework of the study-area. The red stars indicates the selected sites, from west to east: 1) Cueva de Chaves, 2) Espluga de la Puyascada, 3) Cova de Els Trocs; 4) Cova del Sardo. In green are indicated the other sites cited in the text, from west to east: 5) Cueva del Moro de Olvena, 6) Forcas II, 7) Cova Colomera, 8) Cova Gran, 9) Cova del Parco, 10) Bauma Margineda; In blue are indicated the rivers, from west to east: Ebro, Guatizalema, Alcanadre, Vero, Cinca, Ésera, Isábena, Noguera Ribagorçana, Noguera Pallaresa, Segre. In brown the main mountain ranges, from west to east: Sierra de Guara, Sierra Ferrera, Sierra del Castillo de Laguarres, Turbón, Sierra de Sis, Aneto, Besiberri, Sierra de San Gervàs, Sierra del Montsec. In black are indicated the states and provinces.

1.3. Archaeological Contexts

1.3.1. Site Selection

As I already explicated in the previous paragraphs, the main objective of this thesis is to contribute to the understanding of the human occupation of the Pyrenees through a socio-economic approximation of the lithic assemblages. To this, given the time constraints which come with an integrated analysis of the lithic record, I need a sample of sites at the same time reduced and diversified: a sample that allows us to cover a wide geographical and chronological framework.

One of the main objectives of this work was to compare contexts located at different altitudes and in different environmental conditions, to approximate the variability in the settlement patterns in mountain areas. During the last decades, the number of excavated contexts in the area has certainly grown; however, the majority of them are located in the exterior ranges of the Pyrenees. Indeed, while there is certain abundance of sites in the Sierras Exteriores and in the Sierras Marginales, the interior reliefs have been only superficial surveyed and few sites have been extensively excavated. This situation implies that, while I could choose between a variety of contexts for the lower altitudes, for the mountain and subalpine areas I almost had no choice, being the number of excavated sites in those area extremely reduced.

Moreover, for what concern older excavations (e.g. Cueva de Chaves and Espluga de la Puyascada) their analysis has been mainly oriented toward a chrono-cultural interpretation, thus defining their cultural attribution and their relationship with other Neolithic sites of the region and of the Catalan and Valencian coasts (Baldellou 1989, 1994). Economic aspects were also discussed, however, while the study of the faunal assemblage provided detailed information about herds composition and management, the other economic activities were scarcely characterized, recognized exclusively on the basis of the occurrence or non-occurrence of certain category of artefacts (e.g. mills, blades with lustres, adzes, etc.) or considering the actual soil potential (Baldellou 1987; Rodanés & Ramón 1995). With this work I also aspire to contribute to a more solid and detailed interpretation of the economic organization of such contexts.

1.3.1.1. Lower Altitudes

At the present day, open-air sites dated to Neolithic period have not been discovered in the Southern Central Pyrenees. This bias is probably due to the superficial character of the archaeological surveys realized and, more in general, to the scarceness of large-scale public works and construction projects in the studied area. Some authors suggest that possibly the dispersed character and the small dimensions of these first settlements made their detection more difficult (Oms et al. 2013). Consequently, cave sites represent the only type of available evidence for the study of the human occupation in the Central Pyrenees.

At lower altitudes, the caves that have been more or less systematically excavated, are no more than six. Among the most notorious are the Cueva de Chaves, the Peña de las Forcas II, the Cueva del Moro de Olvena, the Cova Gran de Santa Linya, the Cova del Parco and the Cova Colomera. All of these sites are cavities of large dimensions located in the external sierras of the Pyrenees. However, not all of them are easily accessible. Cueva de Chaves, Cova Gran, Forcas II and Cova del Parco, are easily accessible sites, facing plain areas or large valleys; on the contrary, the Cova Colomera and, in lesser extent, the Cueva del Moro de Olvena are located in canyons or abrupt valleys and so their access is way more complicated.

Among these sites, the Cueva de Chaves undoubtedly represented the most attractive context for a detailed study of the lithic assemblage, for several reasons:

⇒ it is one of the most important referent for the chrono-cultural sequence of the NE of the Iberian Peninsula;

⇒ a good number of radiocarbon dates are available and all of them appear coherent with their stratigraphic position;

⇒ lithic materials are well preserved and, at a macroscopic examination, did not show significant alterations;

⇒ an extensive study of the techno-typological characters of the industry was already available;

⇒ the archaeological materials is varied and abundant, allowing and integration between traceological data and other classes of material;

⇒ an extensive interpretation of the site, as well an hypothesis of its functionality, was already formulated;

⇒ materials were accessible and available for the study.

If one looks to the other caves excavated in the Sierras Exteriores and Marginales it appears clear that only few of them match such requirements.

Forcas II, for example, it is an interesting context, but its 'chrono-cultural' definition, as well its functional orientation, is still debated. Some scholar suggested that the Meso-Neolithic transition levels (level V) may represent a palimpsest (Bernabeu et al. 1999; Martínez-Moreno et al. 2006). Even this explication cannot be taken 'a priori' for granted, one has to remark certain discordance[1] between the radiocarbon dates obtained on the wood-charcoals samples and the results obtained on faunal bone samples proceeding from the same levels (levels V and VI) (Utrilla & Mazo 2007; Utrilla et al. 2009). Without further entering in the debate, all of this information makes Forcas II a controversial context, not apt, at least for the moment, to establish a comparison between lower and mid/high-altitudes occupations.

Similar considerations can be made for the Cueva del Moro del Olvena. At the time when the first archaeological campaigns took place, in the early '80s, an important part of the archaeological deposit was already removed by clandestine interventions. In the superior chambers most of the archaeological levels were almost completely disturbed. Intact Neolithic horizons, dated to Early Neolithic, appeared only in a small residual area, however, "*con insuficiente extensión como para permitirnos la obtención de datos que tuvieran la solvencia mínimamente indispensable a la hora de sonsacar conclusiones más o menos fiables*" using Baldellou's own words[2] (1995: 47). In the lower chambers the deposits was something more intact, even if as well affected by extensive clandestine excavations. Disturbed occupations dated to the

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1 A more detailed discussion of the Forcas II radiocarbon dates will be made in the Chap. 7, Par. 7.3.1.1.

2 Proposed translation: "with an insufficient extension to provide enough data to draw out more or less reliable conclusions" (Baldellou 1995: 47).

Bronze Age were detected over a large surface, while Late Neolithic levels were identified in one sector of the cavity, partially mixed with the Bronze Age materials. All of this makes of the Cueva del Moro de Olvena a difficult context for the reconstruction of the settlement and subsistence strategies in the Pyrenean area and, thus, I opted to exclude it from the study.

For what concern the other cavities located in the Catalan Sierras Marginales, their study resulted also problematic for different reasons. Cova del Parco, for example, was extensively excavated during the course of the '70s, however without a proper stratigraphic control. This fact precludes the analysis of most of the excavated collections. Recently a residual pit has been excavated with modern methodologies (Petit 1996), however, lithic materials from the new excavations are extremely scarce, representing a partial sample.

During the '70s and the '80s archaeological excavations have been undertaken at the Cova Colomera; also in this case the research lacked of a detailed stratigraphy and modern methodologies. However in the Colomera cave, differently from the Cova del Parco, a large part of the archaeological levels were still intact. Recent investigations, over an total surface area of about 40 m^2, has been recently undertaken by Oms et al. (2008, 2013). Unfortunately the lithic materials were not available for the study as other scholars were already analysing the assemblage.

Finally, archaeological excavations have been undertaken, since the 2004, at the Cova Gran de Santa Linya, although the first results have been published only recently (Mora et al. 2011; Polo Díaz et al. 2014). The cave has an enormous extension, about 2500 m^2, and until now only a small portion of the surface has been excavated. In the northern sector, various Neolithic levels have been discovered, revealing the presence of both pen-deposits and domestic structures. However, the sedimentary dynamics of the deposit appear extremely complex, being affected by intense anthropogenic sedimentary disturbances that result in the mixing and redisposition of archaeological sediments and materials. Future excavations will be probably shed light on the modalities of occupation of the cavity; however the research on the Cova Gran is still in an early phase.

1.3.1.2. Mountain Altitudes

The number of excavated sites in the mountain areas of the Pyrenees is extremely reduced. Until few years ago the only site known at higher altitudes (1.314 m.a.s.l.) was the Espluga de la Puyascada. The site was partially excavated during the course of one single campaign for a total surface of about 15 m^2. Despite the site potential, the research was interrupted: the topographical constraints and the difficult access to the cave made the excavation logistically complicated (Baldellou 1987).

Further east, in Andorra, is located one of the most notorious site of the Pyrenees, the Balma Margineda (970 m.a.s.l.). The site has been partially excavated in the '60s by J. Maluquer that mainly excavated the Neolithic levels for a surface of approximately 14 m^2, corresponding to the central sector of the rock-shelter (Maluquer de Motes 1962). During the '80s, new excavations have been undertaken by J. Guilaine and his collaborators, investigating the entire stratigraphic sequence for a surface of about 26 m^2. However, the Neolithic levels were largely disturbed by the Maluquer excavations and only residual sectors have been excavated by Guilaine & Martzluff (1995).

Finally, the third site is the Cova de Els Trocs, located at *ca.* 1.500 m.a.s.l. in the Ribagorza region. Excavations campaigns took place during 2009-2012 and new levels are still in course of excavation. Actually about 40 m^2 have been excavated, revealing the existence of a stratigraphic sequence that covers the entire Neolithic (Rojo et al. 2012b; 2014).

All of these three sites show some similar characteristics. They are relatively large cavities or rock-shelters located at mountain altitudes, however no far away from the valleys bottom of the lower mountain zones. At first, my intention was to include all of these three sites within the work; finally, I had to exclude the Balma Margineda from the study. The state of preservation of the lithic surfaces was indeed not suitable for a microscopic examination, giving the presence of mechanical abrasions and a strong 'soil lustre' in almost the entirety of the assemblage. Thus, considering also the reduced extension of the modern excavations, I decided to omit this site from the current work, as scarcely comparable with the other analysed sites. The results of the study of the Balma Margineda lithic materials will be maybe published apart in the future. However, on the basis of a preliminary observation of the lithic assemblage, it seem clear that the Balma Margineda fundamentally respond to the same model observed in the other Pyrenean sites, with a quite reduced lithic assemblage, composed of both siliceous and non-siliceous rocks, with chert materials mainly proceeding from exogenous source.

1.3.1.3. Subalpine and Alpine Altitudes

Subalpine and alpine areas have been ignored from archaeological researches, until the 2000s. As result, is not surprising that the number of excavated sites is still very scarce. Most of the archaeological interventions are limited to prospections and stratigraphic surveys, normally of reduced extension. In the area of study most of the data proceed from the researches carried out in the National Park of Aigüestortes i Estany de Sant Maurici (Gassiot et al. 2014). Ten years of research in subalpine and alpine zones of the Central Pyrenees have led to the discovery of several prehistoric sites, of which several have been excavated completely. Among them the most relevant is probably represented by the Cova del Sardo de Boí, a rock-shelter located at *ca.* 1.800 m.a.s.l., with a stratigraphy from Early to Final Neolithic/Chalcolithic, with also Roman, Medieval and Modern occupations. The lithic assemblages from all the prehistoric phases of the Sardo cave have been included in this thesis.

Other sites, surveyed and excavated in the Aigüestortes i Estany de Sant Maurici National Park, such as the Abric del Estany de la Coveta, have been also discussed in this work, however they have not specifically analysed given the absence of lithic materials among their archaeological record, for the period in analysis.

1.3.2. Chronological Framework

This work embraces a wide chronological period, from Early 'Cardial' Neolithic to Final Neolithic/Chalcolithic period[3]. In other terms, it starts from the appearance of the first agro-pastoral communities in the Pyrenean area, around the half of the sixth millennium, following their dynamics and development, until the end of the third millennium, which coincide with the beginning of the Bronze Age. Considering the extension of this period, I will not only appeal to the data obtained from the case-study sites, but I will integrate my

[3] A detailed discussion of the chronological framework will be made at the end of this work, in Chap. 7, Par. 7.3.

reconstruction with the information proceeding from other sites of the region.

Both the beginning and the end of this period are marked by major changes, even if still little understood by archaeologists. The Late Mesolithic period is considered fundamentally a moment of 'vacuum', at least in the study-area. In the Southern Central Pyrenees there is a hiatus of almost 500 yrs. between the last hunter-gatherers and the first agro-pastoral communities (Morales & Oms 2012). Late Mesolithic occupations, in the area, are testified only by few controversial archaeological evidences. The sites distribution pattern, seem to suggest that in the Iberian Peninsula, Late Mesolithic populations were concentrated only in few specific geographical contexts, such the Valencian Façade, the Ebro Valley, the Basque Country, the Cantabrian Façade and central and southern Portuguese coast. Meanwhile, vast areas such the Southern Pyrenees, the Central Spain, the Andalusian or the Galician coasts, appear scarcely populated. This setting is mainly explicated as a response to climatic and demographic dynamics. Indeed, the emerging of coastal adaptations probably resulted in a change of the settlement and mobility strategies (Berger & Guilaine 2009; Fernández-López de Pablo & Gómez-Puch 2009; Fernández-López de Pablo & Jochim 2010).

To the other extreme, the transition to Bronze Age is marked as well by changes in the economic and social organization. Nevertheless, the limit between the Chalcolithic and Early Bronze Age is not a well-defined boundary. Traditionally Bronze Age has been mainly associated with the appearance of metallurgic productions. Alternatively, its beginnings have been described in relation with the appearance of specific index fossils (e.g. metal daggers, ceramic vessels, e.g. carinated pottery and plastic decorations) (Maya 1997; Soriano 2010). Only recently has been evidenced the occurrence of changes in the settlement patterns both in the mountain and plain areas. For example, the establishment of open-air settlements characterized by very large areas occupied by silos (also called *campos de hoyos*) is retained as one of the most characteristic feature of the Early Bronze Age in the NE of the Iberian Peninsula (Martín 2003; Soriano 2010). On the contrary, in the subalpine and alpine areas, a change of the settlement pattern is mainly deduced starting from an 'absence of habitats'. Indeed, a switch from small rock-shelters and caves toward larger open-air occupations has been hypothesized, but still few archaeological evidences have been encountered, given the difficulty of detecting such contexts only through superficial surveys. Until now, at higher altitudes Bronze Age materials are documented exclusively by the presence of disperse findings, mainly associated to burials practices (Gassiot et al. 2014; Garcia et al. 2014).

Between these two extremes, Late Mesolithic and Bronze Age, I will focus my attention on the establishment of the first agro-pastoral communities in the Southern Central Pyrenees and their modalities of exploitation of the mountain spaces.

2. THEORY & METHODS

2.1. Theoretical Framework

2.1.1. Lithic Materials and Prehistoric Societies

"Why are we studying lithic collections?"

This apparently simple question has already been asked and answered in the past in a variety of ways, giving rise to different schools and academic trains of thought. In this brief paragraph, the purpose is neither to make a review of the different positions, nor to propose new answers or theories. The aim is mainly to clarify which theoretical framework this work is abode by; in addition, it wants to show the objectives and purposes that have brought to analyse the lithic collections.

When one speaks of 'lithic materials', one refers to all those objects that are made of stone. In this work, I shall mainly focus on siliceous rocks; however, the word lithics comprises all possible lithologies exploited by human populations. A large variety of objects of different morphology, nature and function falls into this category.

The first distinction that can be made amongst lithic materials is between "*bienes de consumo de origen mineral directos o indirectos*"[1] (Clemente 1997a: 11). The first are constituted of all those lithic items that are produced for direct consumption (such those artefacts that mainly fulfil a communicative function, as beads, statues, etc.); the second ones refer to all those lithic objects produced to be integrated in further production processes (all those artefacts that are commonly defined as 'tools'). In this work, I shall focus on the last category, namely, tools or objects of mineral origin for indirect consumption.

This is anyway a very broad category as, within archaeological lithic assemblages not only finished goods and instruments are found, but also their production wastes and residues. Following an integrated methodology developed at the Milà i Fontanals Institution of the Spanish National Research Council during the eighties and nineties (Vila 1981, 1987; Terradas 1995, 2001; Clemente 1997a; Gibaja 2003), this work concerns both types of remains (products and waste materials), since both of them may give information about past production processes; on the one hand, lithic waste materials show how the production of lithic items took place, thus helping us understand which procurement and management strategies and also techniques were adopted for supplying and transforming raw materials; on the other hand, lithic objects give information about their further use in other production processes (Fig. 2.1).

When (indirect) lithic materials from an archaeological context are here mentioned, they therefore refer to a varied and diverse assemblage of archaeological finds made of stone, which represent the material remains of past production processes. From this perspective, the reason that has led me to analyse such assemblages is the possibility of obtaining information about socio-economic structures that produced and used them in order to ensure their own reproduction (Pié & Vila 1992). Lithics, far from being simple stones, are in fact 'social products', that is, outcomes of human work which, at the same time, participated in the social production, being employed as tools capable of transforming (working) other resources. Therefore, they can be considered historical sources, which may contribute to the

[1] Proposed translation: "Goods of mineral origin for direct or indirect consumption".

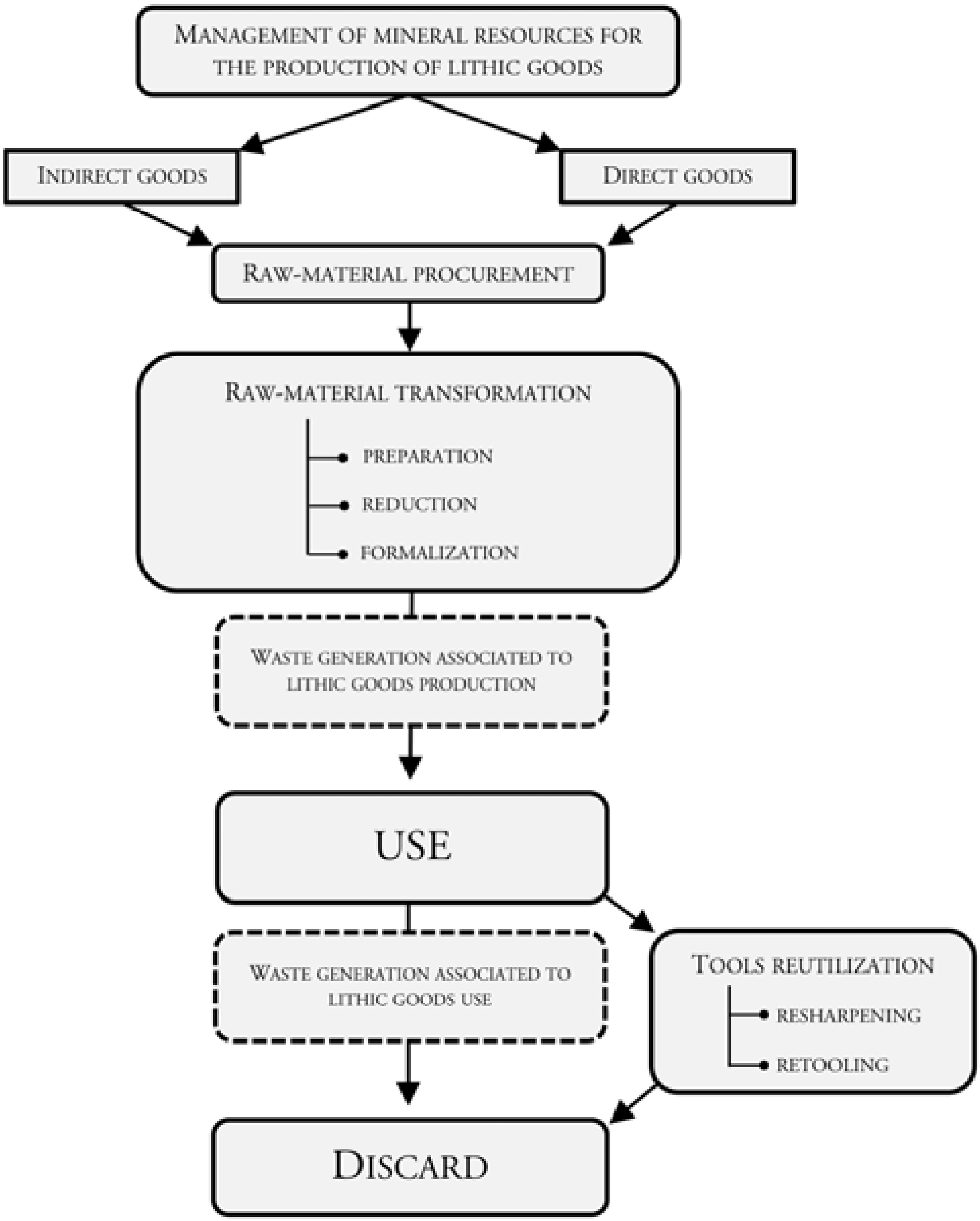

Fig. 2.1. Methodological framework: schematic representation of the lithic materials management and production in archaeological contexts. Modified from Clemente (1997a: 12).

scientific reconstruction of the organization and development of a certain society.

This type of theoretical-methodological framework can be regarded as part of a Social Archaeology, this being intended as the discipline that deals with the study of human beings starting from the analysis of their social activity's material remains (Estévez et al. 1984; Vila & Estévez 1989). In this respect, lithic analysis is not accounted as a methodology for the identification of 'styles' or 'cultures', nor of 'techniques' or 'technical behaviours' (which could also be investigated, although without being the objective of the study); on the contrary, lithic technology is seen as a supporting implement for the reconstruction of production processes, which represent the material and economic bases of a society (Pié & Vila 1992).

2.2. Methodological Framework

2.2.1. A Brief Introduction

Since the trailblazing works of Semenov, resumed by the publication of his "Prehistoric Technology" in 1964 (Semenov 1964), the study of the ancient technological systems has gradually become a more holistic approach, integrating different disciplines and methodologies, in order to achieve as comprehensive a reconstruction as possible, from the raw-material selection, supply, and transformation to the introduction, manufacturing, use, and management of instruments.

Although this dissertation mainly concerns siliceous chipped stone assemblages, it is important to remark that such a methodology can be applied to any type of lithic materials (either chipped or macrolithic industries of different lithologies), as also to other types of raw materials, for example shells (Cristiani et al. 2005; Lammers 2008; Mansur & Clemente 2009; Cuenca 2013), faunal bones (d'Errico 1993; Maigrot 1997; Cristiani 2004; Gijn 2007; Mozota 2012), or wood (López et al. 2012).

In summary, one can divides this analytical method into three main parts:

i. analysis of raw-material procurement (detecting provenance);

ii. analysis of lithic production processes (techno-morphological analysis);

iii. analysis of functional patterns (traceological analysis).

These three clusters constitute the basic 'core' of this study and by these the data relevant to prehistoric subsistence strategies has been collected. Additional methods are also often applied for further analyses of the archaeological record, amongst which one can certainly mentions the intra-site spatial analysis; this often makes it possible to ascertain the existence at the site of areas associated with specific production processes. However, at this stage of the work, I shall not apply any spatial analysis to the archaeological research.

The basic concept of this approach, as defined by Pié & Vila (1992), Clemente (1997a), and Terradas (2001), as well proposed by other authors such as Perlès & Vaughan (1983) Binder & Gassin (1988), Binder et al. (1990), is that none of those analytical techniques expresses all its potential if implemented individually, whilst the objective is to contribute to a holistic reconstruction of the modes of production. As a result, the objective here is not a mere description of the lithic materials exploited by a certain prehistoric population, by characterizing their physical and mechanical features or the changes they underwent because of anthropic or human agents. Quite the contrary, it is to understand why these materials were collected, how they were transformed, and what role they had in the development of the subsistence economic activities.

Accordingly, I try to apply an integrated approach to the analysis of the lithic materials, characterizing them from a petrological, technological and functional point of view. I am aware of the fact that this work is not balanced in terms of efforts devoted to each of the three disciplines. The analysis is mostly directed at a functional interpretation of the lithic assemblages as this is the main objective of the research here concerned. As a result, the traceological analysis represents the main body of this work. In the text, a greater attention is turned to the use-wear analysis and interpretation and to the functional reconstruction of each investigated site.

Nonetheless, I consider necessary to extent the research focus to provenance and technological analyses too, although in more general terms. Actually, it is not possible to reconstruct the functional features of a certain assemblage or site properly without understanding the relevant strategies in terms of raw-material and technological management. Moreover, some of the research topics that are here explored require a comprehensive overview of the technological organization and procurement patterns.

Once obtained the 'raw data' by the analysis of the lithic collections, this can be set in the relevant database and, afterwards, the statistical study can be set out, in order to prove their consistency and significance. Finally, an important part of the work is represented by the integration of the data coming from lithic analyses with other sources of information derived from other disciplines such as archaeozoology, archaeobotany, paleoecology, ceramic analysis, micromorphological information, etc.

2.2.2. Provenance Analysis

The characterization and classification of the exploited raw-materials (lithic or not) represent a fundamental step in the study of the prehistoric technology. Several guides and manuals has been published such as Sieveking & Hart (1986) and Luedtke (1992). In this work I will mainly follow the research line designed by Vila (1987), Terradas (1995, 1998, 2001) and Terradas et al. (1991).

One of the basic concepts of this perspective that I like to repeat, is that 'raw-material sources' are for definition a social construct. Stones and rocks naturally exist, but they become a raw-material only when they are socially recognized as such and, consequently, they are integrated as part of the productive process to provide goods of various nature (Terradas 2001).

Without entering in the discussion of which are the criteria adopted by a certain population in the selection of one or another raw-material, neither of the possible strategies for their procurement (both themes have been abundantly discussed, for some examples see Binford 1980; Ramos Millán 1987; Terradas 2001; Wilson 2007; Andrefsky 1994a, 1994b, 2009) in this paragraph I'd like to draw out schematically the methodology followed in this study. One can distinguish three main steps of analysis:

i. Identification and petrologic characterization of the lithic raw-materials represented in the studied assemblage:

   ⇒ the first step of the analysis has been the classification of the lithic assemblage in preliminary groups on the basis of the petrographic characters of the rocks (micro-paleontological, mineralogical and textural features) through the use of a stereoscopic microscope (Leica MZ16A, 5X-40X). Photography have been taken with a Leica IC3D camera;

   ⇒ once defined the various groups, samples for the realization of thin-sections have been chosen from each group. In this work, thin-sections have been mainly employed for distinguish and characterize siliceous rocks, while no-siliceous rocks were generally classified macroscopically. In the case of large group of materials, I selected more than one sample to confirm the homogeneity and the consistency of the aggrupation; on the contrary, in the case of very small assemblages I opted for a non-destructive analysis, limiting the analysis to the macroscopic observation of the lithic surfaces;

⇒ each one of the thin-section has been analysed with a petrographic-microscope (Leica DM2500P, 50X-400X). Photographs have been taken with a Leica DFC420 camera. During this phase my main concern was: 1) the confirmation of the textural, mineralogical and micro-paleontological characteristics of the rocks; 2) the identification of the depositional environments in which the rocks were formed; 3) the identification of possible index-fossils to identify specific geologic periods (such as calcispheres, ostracods, foraminifera, etc.). Such taxonomic classification, however, has been realized at 'class-rank', without entering in the distinctions of orders, families or genus. The recognition of the fossiliferous content has been made following the criteria described by Flugel & Munnecke (2010). All the thin-sections have been realized at the Laboratori de Preparació de Làmines Primes of the Universitat Autònoma de Barcelona, thanks to the founding of the OCUPA project[2] (Catalan et al. 2013).

ii. Identification and localization of geological outcrops containing materials of similar petrographic characters in the area of study:

⇒ a major part of this work has been realized thanks to the aid of the of the database and the reference collections of the Lithotecha of Siliceous Rocks of Catalonia (LitoCAT) of the Institució Milà i Fontanals[3] (CSIC-IMF) in Barcelona (Terradas et al. 2012) which collections cover most of Catalonia and part of Aragon;

⇒ a second part of this study has been based on the analysis of the reference geological bibliography, first of all to understand the geological characters of the area and, successively, to identify which formations possibly contain lithologies with similar characteristics to the ones observed in the archaeological record;

⇒ finally, specific surveys have been realized for some lithologies that were not previously identified among the LitoCAT collections;

iii. Comparisons and results confirmation:

⇒ in this phase I proceed with the comparison between the archaeological materials, the LitoCAT collections and the materials collected on the field, in order to evaluate similarities and differences between the samples. The result of

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[2] In particular, I thank Dr. Ermengol Gassiot, who is the advisor for the archaeological part of the OCUPA project;

[3] In particular, I thank Dr. Xavier Terradas and David Ortega for introducing me to the procurement analysis and for allow me to make use of the LitoCAT collections and of the geographical information associated.

> this comparison allowed establishing which formations have been possibly exploited by prehistoric communities, thus contributing to the understanding of the procurement strategies and of the technological organization adopted in the various analysed contexts.

In any case, is to remember that the analysis of the raw-materials carried out in this work has been oriented toward the research questions previously formulated; the main objective was not to define the exact outcrops exploited by prehistoric populations, nor to distinguish all the exploitable lithologies in the area; rather to identify macro-areas of raw-material procurement and to create a background for the interpretation of the technological system. In this sense, the study has been facilitated by the existence of number works dedicated to the prehistoric exploitation of siliceous rocks in the Pyrenean area (Terradas 1995; Mangado 1998; Ortega 2002; Mangado et al. 2007; Simonnet 2007; Tarriño et al. 2007; Mangado et al. 2012; Sunyer et al. 2013; Sanchez et al. 2014). Those scholars already characterized and classified some of the most relevant formations.

2.2.3. Techno-morphological Analysis

Once defined the raw-materials exploited in each site, their area of provenance and their physical and mechanical characteristics, my attention has been directed toward the understanding of the modalities in which the various rocks have been exploited in each one of the analysed sites.

My main questions in respect to the lithic assemblage can be summed as following: to which type of knapping scars the lithic materials recovered in the archaeological deposit under analysis correspond? Do they represent the objective of the productions or do they are waste materials? Which type of products prehistoric flint-knappers were seeking? There is any difference in the management of the various types of raw-materials exploited? Are the production realized entirely on site or parts of the knapping sequence are missing?

In the realization of the analysis I mainly followed the methodology, the terminology and the classification described by Inizan et al. (1999). However, is to remember that the study has been directed to provide a general background for the understanding of the lithic productions and their modalities of integration inside other productive processes; thus several aspects related to lithic technology have been only marginally discussed or left aside. Indeed, my objective is not to define the lithic reduction techniques and strategies adopted in the Neolithic period, but more simply to approximate the lithic production processes that took place in the analysed sites. For that reason, I leave many aspects of the lithic production untreated. For example, I do not attempt to make any *remontage*, nor to reconstruct the exact type of knapping technique adopted (e.g. direct or indirect percussion debitage, pressure debitage, *etc.*).

The analytical work mainly consisted of three phases:

i. a first reading of the lithic materials is made in order to assess their position within the knapping sequence; to determine whether it represent a product, a waste materials or a characteristic flakes;

ii. a second level of inference is made to define the interdependence between the artefacts; we analyse the presence or absence of certain technological products and their relative frequencies for each raw-material;

iii. a third level implicates the analysis of the formalized or retouched artefacts. The analysis of the retouched implements has been made following the typological classes established by Laplace (1964); however I classified the artefacts only on the rank of 'groups' without entering in the description of the 'primary types', not being a detailed typological classification one of the objectives of this work.

Finally, one has to cite the existence of several works that have been contributing to the characterization of the lithic production of the Middle Holocene in the NE of the Iberian Peninsula. For what concern Neolithic period some of the most relevant works are represented by Cava's research on the Cueva de Chaves (Cava 2000) —which however mainly focus on typological aspects— and the works of Terradas & Gibaja (2001; 2002), Palomo (2012) and Borrell (2008) on the Catalonian lithic assemblages, embracing a period from early to final Neolithic/Chalcolithic.

2.2.4. Traceological Analysis

2.2.4.1. A Brief Digression on the Discipline Definition

Often the terms 'traceology', 'microwear', 'use-wear' or 'functional' analysis are used as synonymous. However each one of them has specific implications about the focus and the objectives followed in the study of the archaeological assemblages.

So far as I know, one the first uses of the term 'Microwear analysis' or 'Microwear studies' was in Lawrence Keeley's works (1973, 1974). The same definition has been later employed by several other western researchers such as Tringham et al. (1974), Keeley and Newcomer (1977), Newcomer et al. (1986), Cook and Dumont (1987), only to cite a bunch of them. At least originally, the use of this terminology was associated to the employment of high magnification and an incident light microscope, empathizing the importance of the 'micro-traces' as the most diagnostic elements for interpreting lithic tools functionality, following a methodology that later would have been defined as 'high-power approach'.

The terminology 'use-wear' analysis was introduced in 1977 with the First Conference on Lithic Use-Wear (Hayden 1979), fundamentally coexisting with the term microwear. 'Use-wear analysis' was later utilized by George Odell in several of his works (Odell & Odell-Vereecken 1980; Odell 1994), probably to equally embrace in the definition both micro-traces and macro-traces, and in particular edge-damages that represented the base of his 'low-power approach'.

Both terms, 'Microwear' and 'Use-wear', however define the discipline through the definition of the objects the study (the wears) and not its goal or purpose (the function). For that reason, in the same CLUW Conference, Tringham and Faulkner proposed an all-encompassing definition: «Functional Analysis» (Hayden 1979: 61). This terminology is probably become the most common term in romance-speaking Europe (even if not exclusively), for example among French (*analyse fonctionnelle*) (Plisson 1985; Beyries 1987), Spanish (*análisis funcional)* (Vila 1984; Clemente et al. 2002) and Italian researches (*analisi funzionale*) (Longo et al. 2001). With the use of the term 'functional analysis' scholars are specifying that the goal of their researches is the reconstruction of prehistoric tools function, that is the manner of tool's employment and the identification of the tasks carried out with their surfaces/edges.

In any cases, still today, the three terminologies, despite their conceptual differences are often employed as synonymous terms, or more simply, as similar ways of referring to the

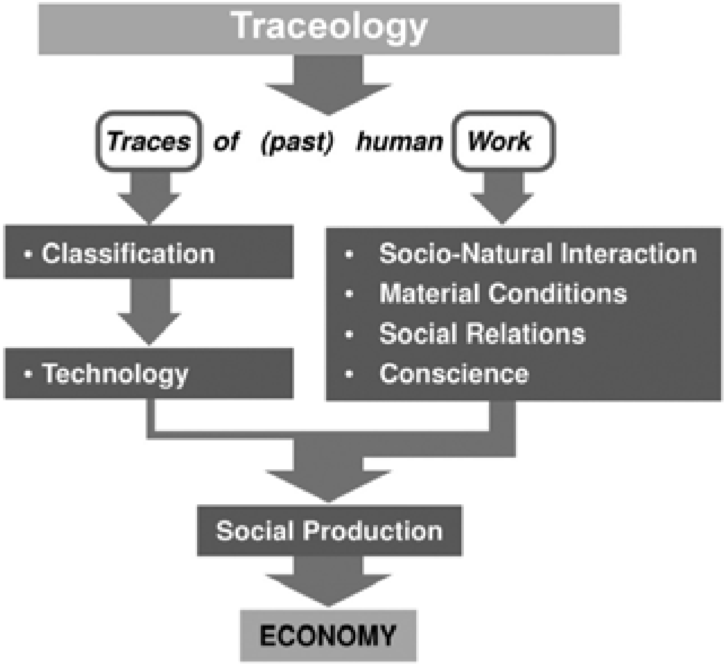

Fig. 2.2. Methodological framework: schematic representation of the Traceology theoretical implications. Modified from Risch (2008: 323).

same scientific discipline.

However, if one goes to their origin of discipline the original term was the neologism 'Traceology'. Semenov defined it as «the study of artefacts' productive functions and modes of use by traces of wear preserved on their surfaces» (cited and traduced by Levitt 1979: 27). In Semenov's view Traceology was intended as an analytical method for the identification and interpretation of the traces of wear, use and of manufacture observed on the prehistoric tools; the aim of the discipline was the reconstruction of the ancient techniques and technologies, which represent the basis of economic production and consequently of the social organization (Anderson et al. 2005). In my view, the interesting point is that Semenov's definition is the only one that overcomes the concept of 'function', to embrace the concept of 'production'. In this is sense, Traceology not only study the use or the function of prehistoric implements —in other words how prehistoric tools were integrated into diverse productive processes— but also analyses their manufacturing, maintenance and management, embracing a broader range of behaviours. Indeed, Semenov never discriminated between manufacturing or technological-wears and use-wears, considering all of them expression of specific production processes.

In this work I will maintain the term 'Traceological analysis' as I consider that is the one that best reflects the aim of the present study. Following the suggestion of R. Risch, one can define that the object of the study of Traceology is «human work, while its empirical references are the traces visible on all objects that have been manipulated by people» (2008: 520) (Fig. 2.2). The aim of the discipline, is thus the reconstruction of the productive processes carried out by prehistoric groups, thus participating in the understanding of how past societies organized themselves and their economy.

2.2.4.2. Methods of Analysis

During the last thirty years, the traceological approach to the study of the lithic industries has been defined and updated by the works of several authors (even if each one with different objectives and theoretical frameworks): Odell (1977), Keeley (1980), Anderson-Gerfaud (1981), Vaughan (1981, 1985), Plisson (1985), Beyries (1987), Gijn (1989), Moss (1983), González & Ibáñez (1994), Gassin (1996), Clemente (1997a), Rots (2005), Gibaja (2003) only to cite some of the most notorious works.

The discipline has today a well-established method shared by most of the analysts. The development of new techniques and methodologies has been a constant during the history of Traceology, since the pioneer works of Semenov, through the application of both low- and high-power approaches, until the employment, in more recent years, of software-based analysis, 3D-scanning techniques, residues analysis, *etc*. For a detailed 'state of art' of the discipline, one should look at the works of Cook & Dumont (1987), Yerkes (1993), Donahue (1994) Marreiros et al. (2014). However, apart from the methodological improvements that occur along with the appearance of new techniques and analytical tools, one can fundamentally divides the traceological work in three main steps:

i. a first evaluation of the conservation of the archaeological assemblage is done through stereoscopic microscopy (in my case Leica MZ16A, 5X-40X or Leica M80). A sample of artefacts is observed, in order to identify the presence of eventual post-depositional alterations and, thus, to evaluate the feasibility of the analysis and the possible levels of interpretation;

ii. once defined the state of conservation of the industry, a detailed analysis of each single artefact is undertaken. The first step of the analysis involves the employment of stereoscopic microscope (Leica MZ16A or Leica M80) with observation between 5X-40X. The analysis of edges and surfaces is mainly directed to the identification of possible actives zones (PUAs - Possibly Used Areas) (Gijn 1989). Moreover, the observation of such macroscopic traces not only allow the determination of the PUAs, but also allows a first level of inference; it is already possible to formulate hypotheses about the hardness of the worked materials (soft, medium, hard) and about the type of movement performed (longitudinal, transversal, circular, vertical, impact). The analysis of macro traces is also important for the recognition of possible hafted parts, for the recognition of transported implements and for the identification of post-depositional and post-excavation modifications. Several works of reference are available for the study of the so called 'macro-traces' among which one can cites Tringham et al. (1974), Odell & Odell-Vereecken (1980), González & Ibáñez (1994). The categories considered in this study have been mainly taken from these works, classifying the macro-traces on the basis of semi-qualitative variables. Three main classes of macro-wears have been recognized:

   ⇒ macro-fractures: edge-damage or edge-scarring is classified on the basis of its invasiveness (*absent*, *lightly, medium or strongly damaged edges*), location (*ventral face, dorsal face, bifacial*), position (*distal, proximal, mesial, entire edge*) of their pattern of distribution (*isolated, continues, overlapping, single scar, chaotic*) and on the basis of the preferential morphology of the fracture-termination (*feather, step, hinge or snap fractures*). The general morphology of the edge is recorded (*straight, undulated, concave, convex, denticulate*), as well the presence/absence of voluntary retouches.

⇒ edge-roundings: edge roundings are classified on the basis of their invasiveness (*absent, marginal, medium, pronounced*).

⇒ lustres, patinas, bright and friction spots: the presence of macroscopic patinas, lustres and of all types of bright surfaces is also registered, considering their position (*ventral, dorsal, bifacial*) and distribution (*marginal, invasive, all over the surfaces*).

iii. when possible used areas (PUAs) or other modified zones are detected, the artefacts is submitted to a detailed microscopic analysis of the surfaces through the employment of reflected-light microscopy (metallographic microscope) (in my case Leica DM2500M, 50X-400X or Olympus BH2). The objective of this analysis is, first of all, to prove the nature of the previously identified PUAs. If PUAs are actually used we call it AUAs (Actually Used areas) (Gijn 1989). Proved the consistency of the traces, the analysis is directed toward the interpretation of the micro-features, such as strias and polishes, through the observation of their characteristics. For the definition of the semi-qualitative variables employed for micro-wears classification one can refers to several works among which Plisson (1985), Gijn (1989) and González & Ibáñez (1994) and Gassin (1996)[4]. Thus, micro-traces have been recorded following these variables:

⇒ Distribution: this variable represent the way in which the polished zone is distributed over the lithic surfaces (normally distribution is evaluated at magnification of 50X-100X). Borrowing some categories from Gijn (1989) one can defines it as: *isolated spots, streak of polish, marginal band, extended polish, very extended, covering*;

⇒ Texture: this variable represent the grade of linkage of the polished zone (it is evaluated at magnification of 200X). Following the classification proposed by Plisson (1985) and González & Ibáñez (1994) one can defines it as: *compact, closed, half-closed, open*.

⇒ Topography: this variable represent the aspect of the polished zone (it is evaluated at magnification of 200X). Following González & Ibáñez (1994) one can defines it as: *flat, rough, domed*;

⇒ Invasiveness: this variable represent the extension of the polish over the edge surface (it is evaluated at magnification of 50X): *low* (less than 25% of the edge's surface), *medium* (between 25-50%), *high* (more than 50%);

iv. Once the artefacts has been analysed and described both on a macroscopic and

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[4] Among the other works that I followed for specific types of traces/alterations:

⇒ for the analysis of all the fire/thermal alterations (both macro- and microscopic) I followed the criteria proposed by Clemente (1995, 1997b);

⇒ for the description of chemical alterations I mainly followed the works of Gutiérrez et al. (1988), Plisson & Mauger (1988) and Gijn (1989);

⇒ for the analysis of impact/projectile traces I mainly followed the works of Fischer et al. (1984), Domingo (2005), Gibaja & Palomo (2004); Cristiani et al. (2010); Petillón et al. (2012).

⇒ the so-called 'RV2' traces has been defined following the work of Clemente & Gibaja (1998).

⇒ Hafting traces have been recognized and analysed mainly following the work of Rots (2005, 2010).

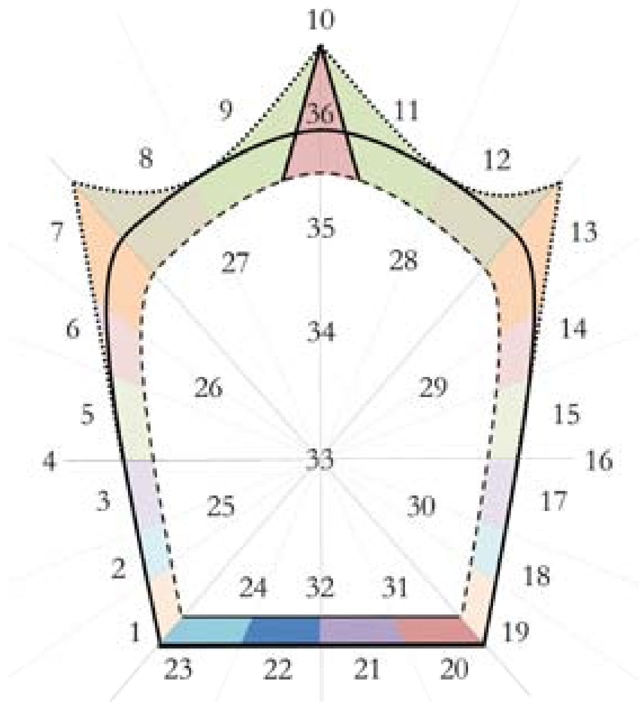

Fig. 2.3. System of Polar Coordinates for the registration of the different types of wears.

microscopic level, a global interpretation of the observed traces is advanced. I decided to employ variables capable to describe not only use-wear traces, but also the types of traces resulting from 'non-functional' activities, such as hafting traces, transportation traces or alterations, which could be equally described as any other modification of the lithic surfaces/edges. The location of wear-traces is registered in the database utilizing a System of Polar Coordinates (modified from Gijn 1989) (Fig. 2.3), to indicate the exact position and extension of the observed features (both macro- and micro-traces).

⇒ The type of wears has been classified following the criteria proposed by Gyria (2004) which include both use, manufacturing and management wears: *use-wears*, *technological wears*; *non-utilitarian wears (e.g. hafting and transportation traces)*; *alterations*. A last category, *residues,* has been created to group the macro- and microscopic residues observed on the lithic surfaces. However, residues have been only superficially mentioned, if easy recognizable and relevant to the interpretation of the tool, as we are not specifically working on that theme.

⇒ The interpretation of the contact material is given using three levels of confidence, depending on the interpretability and conservation of the wear (1 - *hardness*: soft, medium, hard; 2 - *substance*: animal, vegetal, mineral, metallic; 3 - *material*: meat, meat/bone, fish, hide, fresh hide, dry hide, bone/antler, indeterminate herbaceous plants, dry herbaceous plants, fresh herbaceous plants, herbaceous plants with abrasive component, soft woody plants, hard wood, clay, pottery, soil, etc.).

⇒ The kinematic of the movement is described as following: *cutting/sawing, scraping,* *planning, graving, boring, pounding, projectile, hafting, transportation, alteration.*

⇒ Depending on which level the interpretation is made it is considered *possibly* (PO) (if only the hardness is determined), *probably* (PR) (if both the hardness and the type of substance are determined) and *certain* (SG) (when traces are fully interpretable).

⇒ A final category is established to define the relationship of the traces with other traces. The relationship between traces is defined as: *adjacent traces*, *overlapping traces*, *partially overlapping traces*; *isolated traces*.

v. Photographs have been taken systematically both macroscopically and microscopically at different magnification. In the case in which archaeological materials have been studied at the Milà i Fontanals Institution (CSIC-IMF), photographs have been realized with a Leica IC3D camera for the stereoscopic microscope and with a Leica DFC420C for the reflected-light microscope, with the aid of Leica Image Manager Software to mount together the different photos. In the case of lithic assemblages that have been studied elsewhere (e.g. museum collections) has been used a Canon 450D camera and photos have been processed with the software Helicon Focus v. 4.62.

vi. Experimental references of both macro- and micro-traces have been taken from the Traceotecha of the Institució Milà i Fontanals (CSIC-IMF) in Barcelona, where more than a thousand of experiments on different materials and with different rock-types are conserved. New experimental works have been also realized to resolve specific archaeological questions, but they will later described (*cfr.* Chap. 2, par 2.3.).

vii. Cleaning procedures have been applied previously to the analysis of the archaeological materials. I followed the indications published by Plisson & Mauger (1988), Gijn (1989) and Bouwman (2011):

⇒ All the materials have been washed with water after the excavations works to wash away the sediment superficially attached to the surfaces. This first phase has been realized directly on the excavation and, thus, I did not personally control this part of the procedure.

⇒ Previously to each microscopic observation 95% ethanol has been employed for a superficial cleaning. Ethanol is applied on the surface with a cotton bud that is changed after each use. The aim is to remove the superficial grease and the dust which derives from the conservation and handling of the artefacts.

⇒ Chemical cleaning has been realized to remove concretions, sediments, greasy patinas or other dirty substances that are not removed with a superficial cleaning. To remove greases and other organic materials ultrasonic cleaning for 30 minute with 10% Oxygen Peroxide solution is employed. This protocol allows cleaning the lithic surfaces without destroying use-wears, even if in this case the eventual organic residues would be lost. Acid cleaning is employed to remove calcareous concretions and other inorganic residues, such as spots of sediment or other incrustations. In this case, ultrasonic cleaning for 15 minute with a 5% Hcl solution is employed. At this concentration, and for such time interval, no damage is reported on the polishes. Alkaline cleaning is never employed as potentially dangerous for the preservation of all the silica-based polishes.

2.2.5. Data Registration

All the data of this study have been collected following the methodology of analysis explicated in the previous paragraphs. To organize the information systematically, a relational database has been built with the software Microsoft Access. All the variables considered relevant for this study have been organized on six different tables: site, us, lithic, area, traces, wear. Each table has a relation of one-to-many, from the table *site* to the table *wear*:

i. *site*: this table collects all the basic information about each archaeological context. I considered the site name, cultural affiliation, chronology, typology (e.g. cave, open-air, rock-shelter, etc.) and its geographical position expressed in coordinates UTM Huso30 ED50;

ii. *us*: this table collects all the basilar information about the stratigraphic unit from which the lithic artefact proceeds. The US is mainly classified on the basis of its typology (pit, hearth, pavement, occupational layer, etc.) and the type of sedimentary matrix that constitutes it;

iii. *lithic*: this table collects all the information about the lithic artefacts: their reference code, measurements, integrity, petrological classification, technological classification, typology and, eventually, the presence of macroscopic alterations (patinas, lustres, fire effects, etc.);

iv. *area*: this table collects all the data about the area in which traces are observed: its localization, position, length, shape, morphology, technological classification (retouched, resharpened, polished area, fractured edge, natural knapped edge, natural surface, etc.) and angle;

v. *traces*: this table collects the information about the observed traces: their interpretation, the classification of the contact material (hardness, substance, material), the type of movement that produced them, their interpretability, the existence of relation with other traces in the same area, their degree of conservation and eventually the presence of alterations;

vi. *wear*: this table collect all the information about the wears (both macroscopic and microscopic) that constitute the use-wear traces. Selected variables are: wear type, position, locational, distribution, invasiveness, termination (in the case of edge-fractures) and texture and topography (in the case of micro-wears). Moreover in the table is reported the (eventual) relation between the various wears if referred to the same tool.

2.2.6. Data Statistical Treatment

Once collected data have been ordinated and described, I proceeded with the application of statistic tests to prove their significance and consistency. I selected few well-known techniques for which there is abundant theoretical and empirical literature, as well several examples of archaeological applications. All the statistics chosen have been applied systematically to all the studied sites, with only little variation depending on the specifics of each lithic assemblage. Significance tests have been realized mainly on a intra-site level, while multivariate and cluster analyses have been realized on a inter-site level to compare data between the various contexts.

All the operations and tests have been realized with the software IBM SPSS Statistic v. 21. The analysis and interpretation of the data has been mainly based on IBM SPSS Statistics Guide to Data Analysis (Norusis 2011) and Pérez's SPSS manual for Multivariate analysis (2004), while a review of the various statistical techniques and their application from an archaeological perspective have been taken from Shennan (1992), Baxter (2003) and Drennan (2009).

i. *Standard deviation, variance, mean, median:* basic statistics can be used when one needs to evaluate the distribution of a certain variable, especially for metric variables such as length, width and thickness. For example, the average measurements of each class of tools (e.g. sickle blades, hide scrapers on flake, *etc.*) have been estimated considering median and variance as best representing the measures of central tendency.

ii. χ^2: Pearson chi-square test is a statistic used to discover if there is a relationship between two categorical variables. Pearson's test is only one of the many type of chi-squared tests (e.g. Yates, likelihood-ratio, *etc.*) which can be fundamentally defined as statistical procedures of which results are evaluated by reference to the chi-squared distribution. In practice, given a crosstab with two variables, the chi-square test provides a method for testing the association between the row and column variables. The null hypothesis H_0 assumes that there is no association between the variables (in other words, one variable does not vary according to the other variable), while the alternative hypothesis H_a claims that some association does exist. One of the 'limits' related to the application of the chi-square test is that the alternative hypothesis (H_a) does not specify the type of association nor its intensity, but only indicates a probability for the association to exist. Moreover, the chi-square test is affected by the size of the employed sample. One of the chi-square basic requirement is of a minimum cell expectation of 5 (at least for the 80% of the cells); this constraint is not always satisfied by my data, as often I have to deal with contingency tables with sparsely populated cells. This limit can be eluded grouping variables into larger categories with a greater number of items. For samples large enough, chi-square represent a rapid and quick method to analyse the distribution of two variables and explore the existence of significance associations. I mainly employed this test to explore the distribution of data from technological and raw-material analysis among a set of archaeological phases, as well their mutual relationship.

iii. *Correspondence Analysis (CA):* Correspondence Analysis is a statistical test that allows examining the relationship between two nominal variables in a multidimensional space. It computes row and column frequencies and produces plots based on the scores. Categories that are similar to each other appear close to each other in the plot. In this way, it is easy to see which categories of a variable are similar to each other or which categories of the two variables are related. The distance between the variables is computed using the chi-square distance, thus one of the requirements of this test is that analysed data satisfy the chi-square requirements (expected value>5). For what concern the normalization procedure, exist several methods; in my case I employed the default method proposed by SPSS software: symmetric normalization, which is the most useful method when examining differences or similarities between rows and columns. I applied this statistic to the analysis of the raw-materials distribution among the different occupational phases studied in this work, with the objective of highlighting associations between sites and lithologies.

iv. *Cluster Hierarchical Analysis (HCA)*: Cluster Hierarchical is an exploratory tool designed to reveal natural groupings (or clusters) within a data set. Is one of the most common approaches in archaeology as it allow to categorize data, to separate them and thus ordinate them. The idea of the test is that cases that are strongly similar to each other, in terms of their values for a number of variables, wind up in the same groups, while those that are more different from each other join in different clusters. In this sense — seeking structures in the relationships among cases characterized by a number of variables— HCA is quite similar to CA. However, in this case, one of the main advantages of Cluster analysis is that cells with value zero are as well considered valid data and represented in the diagram. In fact, I employed Clustering analysis to compare the type and frequency of the economic activities carried out in each site/phase. Thus, the absence of a certain economic activity is considered as well a relevant data and not a null value. I applied different clustering method and measures depending on the data considered in the analysis. At first, starting with a reduced sample, I applied the Single Linkage Clustering (or Nearest neighbour). With this method the distance between two clusters is defined as the smallest distance between two cases in different clusters. That means that at every step, the distance between two clusters is taken to be the distance between their two closest members. Single-Linkage represents the simplest approach, but often it is very useful to identify the presence of outliers (i.e. *outlier* is an observation that lies an abnormal distance from other values in a random population). In fact, as the single linkage algorithm is based on minimum distances, it tends to form few large clusters with the other clusters containing only one or few objects each, while the other methods tend to avoid single-element clusters. In this first test, expecting the existence of single-element cluster, I decided to apply this method. In the second step, enlarging the sample with new data, I run the Ward's procedure, to confirm the precedent classification and to test the number of clusters. In this approach the means for all variables are processed and, then, for each case, the squared Euclidean distance to the cluster means is calculated. At each step, the two clusters that merge are those that result in the smallest increase in the overall sum of the squared within-cluster distance. In this case, expecting somewhat equally sized clusters and being the outliers absorbed with the adding of new data, I opted for Ward's method. After Ward method, the last step of the so-called 'three-step clustering' procedure is the *K-means* method. This test serve to prove the stability of the clusters previously obtained. The number of clusters (*k*) is, indeed, provided as an input parameter at the beginning of the analysis. The objective of the *k-means* is to verify whether there is a change in the clusters centres or not, with a re-assignations of objects between the various groups. If the initial partitioning of the objects in the first step of the *k*-means procedure is retained, it means that was not possible to reduce the overall within-cluster variation. This result provides evidences of the clusters stability and reliability.

v. *One-way ANOVA*: Analysis of variance, or ANOVA, is a linear modelling method employed to evaluate the relationship among fields. It tests whether the mean values vary across certain categories of a certain input. ANOVA test compares the explained variance (caused by the input fields) with the unexplained variance (caused by the error source). If the ratio of explained variance to unexplained variance is high, the means are statistically different. In my case, I employed the one-way ANOVA test to determine which classifying variables are significantly different between the clusters identified with the Ward's method. *F* statistics establish if there is or not a difference between means and whether if any of these mean differences are significant. Using this test, one can understand which variables contribute the most to the solution obtained through HCA.

vi. *Tukey post-hoc*: also known as Tukey range test or Tukey method is a statistic used in conjunction with ANOVA to find which means are significantly different from each other. In fact, post-hoc are designed for situations in which one has already obtained a significant omnibus *F*-test and an additional exploration of the differences among means is needed. Tukey post-hoc provides specific information on which means are significantly different from each other. In my case, I employed Tukey post-hoc to evaluate the contribution of the significant variables to each one of the cluster identified.

2.2.7. Maps and Geographic Information

Maps of the area of study have been generated to resume graphically the data and to provide a geographical framework for their interpretation. All the maps have been realized employing MiraMon v7.1 GIS software. Raw-maps have been taken from the following sources:

i. MiraMon Map Collections - www.creaf.uab.es/miramon

ii. ICC vissir (Institut Cartogràfic i Geològic de Catalunya) - www.icc.cat/vissir3

iii. Aragon SITAR (Sistema de información territorial de Aragón) - sitar.aragon.es

iv. EOSDIS (Earth Observing System Data and Information System) - earthdata.nasa.gov

The base for the geographical map employed is ASTER Digital Elevation Model V002. For the geological map has been employed the IGME 5000 - European Geological Map 1:5.000.000 scale. Specific geological formations have been selected from the Aragon Geological Map 1:400.000 and the Catalonian Geological Maps 1:300.000, provided by the Lithotecha of Siliceous Rocks of Catalonia (LitoCAT).

2.2.8. Radiocarbon Chronology

One of the main objectives of this work is to contribute to the understanding of the human dynamics in the Pyrenees between the VI-III millennium calBC. However, working with a large chronological interval of more than three millennia of duration I will need to interpret the data from a diachronic point of view. Thus, ^{14}C information represents a key-element for this research, as radiocarbon chronology gives a temporal dimension to the data gathered from the study of the lithic record.

For each site and for each phase of occupation I will carefully consider the chronological framework. All the available radiocarbon dates have been recalibrated using the software OxCal v4.2 (Bronk Ramsey 2009) and the most recent calibration curve, IntCal13 (Reimer et al. 2013). Moreover, in the case of multi-stratified sites with multiple dates, I adopt a Bayesian approach to the interpretation of the archaeological chronologies. OxCal software offers the possibilities to create different models to analyse ^{14}C data. The base principle of those models is that, although the calibration of the radiocarbon dates accurately estimates the calendar dates of the samples, it is the archaeological event (e.g. a structure, a layer, a phase, etc.) associated with those samples that allow building a reference chronology. Bayesian techniques provide an instrument to combine an absolute dating evidence —the calendar date of a ^{14}C sample— with relative dating evidence —the stratigraphic relationships between samples (e.g. one layer is older than one other) (Buck et al. 1991, 1992, 1996; Bayliss 2009).

Thus, for example, when constructing a Bayesian model for a certain site, ^{14}C dates are organized following the stratigraphic sequence of the same site. All the available dates are separated among a number of bounded phases as described by the excavators or by the site's Harris Matrix. The software OxCal v.4.2 presents three types of relationships between phases: Phases (or Sequences) can be Contiguous, Sequential or Overlapping, depending whether exist a hiatus or certain continuity between them.

Once the data have been introduced, OxCal recalculates the probability density functions for each date using the stratigraphic information. Thus, the program calculates the probability distributions of each calibrated radiocarbon date and then attempts to reconcile these distributions with the relative ages of the samples, by repeatedly sampling each distribution using an algorithm of the Markov chain Monte Carlo method (Metropolis-Hastings algorithm) (Bronk Ramsey 1995, 2009; Bronk Ramsey & Lee 2013). This process produces a 'posterior probability distribution' for each sample, which occupies only part of the 'prior probability distribution'. The 'prior' distribution is the probability distribution of the ^{14}C-calendar age calibration before the relative age information (e.g. archaeological/ stratigraphic data) is taken into account. The 'posterior' distribution is the ^{14}C probability distribution after that the relative age observations have been taken in account. This posterior distribution is compared to the prior distribution and an Index of Agreement (^{A}) is calculated. Such index gives a measure of the agreement between the two distributions. If the posterior distribution is situated in a high probability region of the prior distribution, the index of agreement is high (90, 100 or more). If the index of agreement falls below 60% the date should be questioned. A very low-agreement index can indicates that a certain date is a statistical outlier, but it also may indicate that the sample material was intrusive or affected by an 'old-wood effect'. A model agreement index (^{A}Model) is also calculated, to see if the model is acceptable as whole. OxCal program is also able to calculate probability distributions for events that have not been dated directly, such as the beginning and end of a certain phase or sequence, or the transition period between two phases.

Apart from working at site level, ^{14}C dates represent a fundamental source of information to work on broader spatial frameworks, to integrate and analyze larger set of dates. One of the main techniques adopted for the analysis of large set of radiocarbon data is the use of Summed Probability plots (Williams 2012). This method generally requires large dataset of dataset of ^{14}C dates. Some authors claimed that a minimum of 780 radiocarbon dates were required to produce robust summed probability age distributions (Michczynska & Pazdur 2004). However, the size of the sample also depends on the size of the analyzed region. In the case of the Pyrenees, the sample is much more reduced as the analyzed region (the central-eastern Pyrenees) represents a small geographical ambit and it presents a quite scarce number of archaeological sites. The Summed Probability Plot can be done also with a reduced set of dates; however, its interpretation should very cautious. Indeed, despite the limits imposed by the sample size, radiocarbon Summed Probability plots represent a useful instrument to analyze ^{14}C dates and, possibly, to detect trends and dynamics also with reduced data set.

OxCal program allows to easily plot together radiocarbon dates through the 'Sum' command. When Summed Probability plots are generated, on the Y axis is visible a scale of the probabilities, which indicates the maximum and minimum probability density values for each time intervals, while on the X axis is reported the time-scale..

Moreover, OxCal offers a useful instrument to reduce the noise given by the repeated dating of a same event (e.g. the same structure, the same occupational phase, the same layer, the same individuals, etc.): the 'Combine' function. In any case, it is important to remember that the combination of dates should only be carried out if there is good reason to assume that the events being dated all occurred within a short span of time.

Once produced the plots, one can employs the *K*-means algorithm to partitioning the plot into several smaller intervals. To decide the number of clusters to detect, at first I analyzed visually the summed probability plot, trying to highlights relevant intervals of discontinuity and peaks. After, I simplified the plot, collecting uniquely the median values for each calibrated range, in order to apply the *K*-means statistic. Later, to prove the clusters detected, I run a Discriminant analysis with the maximum and minimum values for each calibrated range considered in the previous test. This approach clearly represent a simplistic approach to the analysis of ^{14}C-hisograms, however considering that my aim is exclusively descriptive, I considered it adequate. Indeed, my purpose is to divide the period —which covers more than 3000 yrs.— in smaller chronological intervals, to more easily handle the data and to describe the human dynamics in the area 'step by step'. However, I am aware that such intervals do not represent fixed periods, but are likely to change with the addition of new ^{14}C dates or simple changing the sample of dates. The use of median values to build ^{14}C-histograms has been already described by several authors, among which Geyh & Maret (1982) and Weninger et al. (2011).

2.3. Experimental Works

As already told in the previous paragraphs, the main experimental references for this work have been constituted by the numerous dissertations and thesis on use-wear analysis published in the last thirty years. Most of these works, many of them pioneer in their respective field of research, provided of a detailed experimental apparatus where the different types of use-wear traces are minutely described and presented. Moreover, I had the possibility of constantly comparing my functional interpretations with the Traceotecha of the Milà i Fontanals Institution.

However, even if experimental and methodological issues are not the objectives of this thesis, I realized some punctual experimentation to solve some of the problematic that emerged during the study and that have not extensively or sufficiently treated by other scholars. Most of the realized experiments had an exploratory character, not pretending to cover the entire variability of the analysed phenomena; however they do represented an important step for the construction of a more detailed and updated interpretative framework. Moreover, with these experiments I contributed to enlarge the knowledge on some aspect of detail related to lithic tools alterations, maintenance and use. More precisely, in this work I focused my attention on three aspects that appeared particularly relevant for the interpretation of the lithic assemblages in study:

i. the effects of post-depositional agents on the conservation of surfaces and use-wears;

ii. the presence of modification induced by transportation practices;

iii. the presence of traces (both on macro and micro scale) possibly associated to working tasks on clay/ceramic.

Each one of this three issues appeared relevant for the current work and, even if all of these themes have been already debated in some extent from other researchers, they have been only partially resolved and specific analysis were necessary to adapt them to the specifics of this case-study.

2.3.1. Chert Taphonomical Alterations: Preliminary Experiments*

The study of post-depositional alterations of chert is an important issue in microwear analysis. It not only provides a reference for a correct interpretation of use-wear traces to distinguish human from natural modifications, but it also offers a record of some of the processes that affected the lithic assemblage during deposition and paedogenesis. However, even if a number of scholars have been trying to deepen the comprehension of the mechanisms responsible for the alteration of prehistoric chert artifacts (Shackley 1974;

* This work has been preliminary published in the proceedings of the 3rd International Congress of Experimental Archaeology (Banyoles, 17-19 October). I am thankful with the authors that collaborated in the original version of the paper: Mazzucco, N., Trenti F., Gibaja F., Clemente I. 2013a. Chert taphonomical alterations: preliminary experiments. In: *Experimentación en arqueología. Estudio y difusión del pasado*, Palomo, A., Piqué, R. & Terradas, X. (eds.) Sèrie Monogràfica del MAC, 25(1-2). Girona: Museo de Arqueologia de Catalunya, pp.269-277.

Rottlander 1975; Keeley 1980; Vaughan 1981; Levi Sala 1986; Plisson 1983, 1985; Gutierrez et al. 1988; Howard 2002; Burroni et al. 2002), post-depositional modifications remain a controversial issue in use-wear research.

Nevertheless, researchers admit that most of the archaeological assemblages were to some extent affected by some kind of post-depositional alteration. Moreover, not only the chert material itself, but also the use-wears (Gijn 1986; Plisson & Mauger 1988) and the residues conserved on lithic surfaces (Langejans 2010), are strongly influenced and could be potentially destroyed by the action of taphonomic processes.

During the study of the archaeological material comprised in this work, I identify a number of features that suggested the influence of some disturbing agents over the assemblage. Among those:

i. the presence of extensive patinas (Fig. 2.3.1, *a-b*);

ii. the presence of rounded surfaces (Fig. 2.3.1, *c-d*);

iii. the pronounced roughness of some of the use-polishes observed on the edges of the tools (Fig. 2.3.1, *e*);

iv. the presence of unknown or unspecific alterations (Fig. 2.3.1, *f)*.

All those features were usually classified as post-depositional modifications, but no explication about the processes that produced them is generally given. They are collected under ambiguous terms as "alteration", "sheen", "patina" or "lustre" that often assumed different significances, overlapping each other.

The objective of this experimental program is to investigate which effects have been produced by post-depositional processes on the analysed assemblages. My aim is to classify the observed alterations on the basis of the phenomena that produced them. In this way, I will obtain additional information on the depositional environments of the studied sites. Moreover, I will provide a refined interpretation of the prehistoric implements, being capable to discern more clearly which wears were produced by human actions and which modifications were possibly produced by natural agents.

2.3.1.1. Experimental Procedure

A series of samples were prepared in order to investigate some of the alterations detected among the analysed lithic assemblages. Chert samples were collected from the same sedimentary depositional environment of most of the archaeological specimens, which outcrops are located in the Central Ebro Valley. This raw material, of a dark-brown coloration, is characterized by a cryptocrystalline matrix, occasionally banded (called Liesegang rings), with the presence of charophyte stems and oogonies (Mangado et al. 2007). Analysis of chert samples through X-ray Powder Diffraction (XRD) indicates a relevant percentage of no-silica materials, mostly carbonate elements (Tab. 2.3.1)

Among the chert samples I used both fresh, unused samples, and some fragments of previously used instruments. This latter elements are characterized by the presence on their surfaces of use-wear polishes derived form the work of plant/wood materials. My aim was to prove whether acid or alkaline environments also affected micropolishes or not, and if yes to which extent.

In this preliminary experiment I only selected those traces that derive from the work of

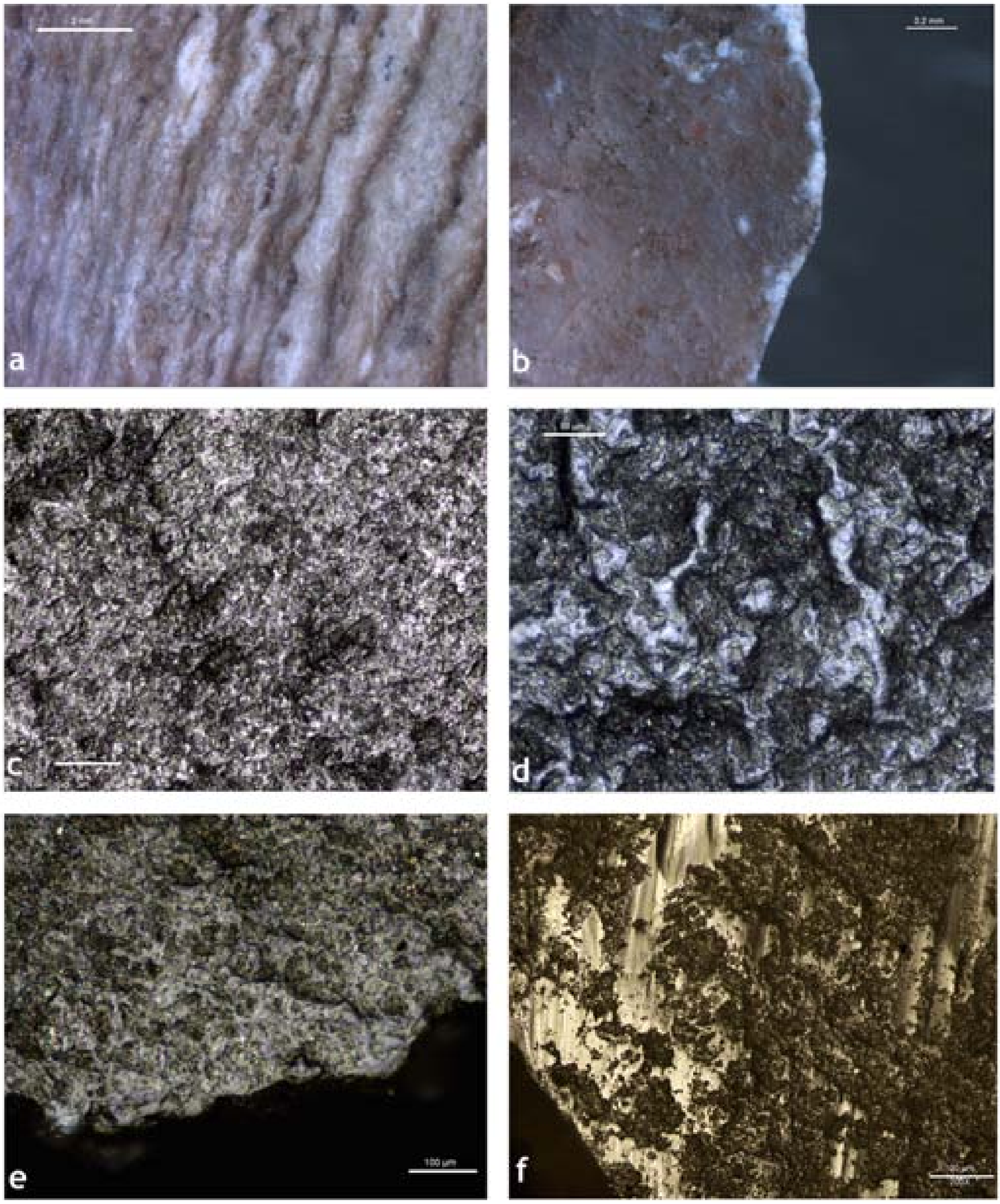

Fig. 2.3.1. Example of alterations detected on the archaeological assemblages. *a*) Stereoscopic image of white-yellow patina. 8x magnification; *b*) Stereoscopic image of white patina spots on the edge of a tool. 15X magnification; *c*) Moderate lustre. See how the rounding mainly affects the highest point of the topography, while depressions and craters remain unaltered. 400X magnification; *d*) Strong lustre. See how the rounding mainly affects the highest point of the topography, while depressions and craters remain unaltered. 400X magnification; *e*) Altered plant polish. Silica gel is partially dissolved, characterized by craters and roughness. 200X magnification; *f*) Unspecific polish of unknown origin. 200X magnification.

Oxide	%
SiO2	88.48
Al2O3	0.28
Fe2O3	0.78
MnO	0.01
MgO	0.14
CaO	4.65
Na2O	0.08
K2O	0.05
TiO2	0.02
SrO	0.02

Tab. 2.3.1. Composition of the chert samples obtained through X-ray Powder Diffraction (XRD). Laboratory ALS Global (Canada). Courtesy of the Lithotecha of Siliceous Rocks of Catalonia (LitoCAT), of the Milà i Fontanals Institució (CSIC-IMF). Modified from Mazzucco et al. (2013a).

vegetal substance, such as fresh grasses or wood, as they are the most represented in the archaeological contexts in study. However, in the future this type of experimentation should be extended to other class of polishes/traces.

Two different classes of experiments were realized to reproduce both 1) mechanical and 2) chemical post-depositional surface alterations.

1. Mechanical alterations are mainly produced on chert surfaces by soil physical forces. The intensity of those forces depends on a great number of factors, as the specific soil structure, the amount of water in soil, the amount and the type of organic matter, the presence of specific oxides, the type of vegetation, the effect of other natural agents as wind, ice, snow, etc. For the moment, this experimental program will be focused on the replication of the effects of soil mechanical forces on lithic surfaces, through the employment of a tumbling machine. Similar experiments, even if they are a simplistic approximation of the natural processes, have been already realized by use-wear analysts (Plisson 1985; Levi-Sala 1986; Plisson & Mauger 1988; Clemente 1997a) and represent a useful instrument to reproduce some of the types of post-depositional modifications.

I decided to replicate a 'tumbler experimentation' as previous studies were realized on different types of chert and soils. To approximate at best the conditions of the analysed archaeological contexts, I used the same type sediment that was deposited in the archaeological layers, mainly characterized by loess with the diffuse presence of gravels and charcoals. No water has been added to the sediment, as I was interested in isolating mechanical stress from potential chemical agents. Nevertheless, I am consciousness that water has a great archaeological relevance as it surely affected the deposit.

Ten different samples of chert, both unused and used samples, were put in the machine for different time intervals, from 8 hours up to 90 hours of tumbling. The used machine is a QT-6 tumbler with 2.7 kg of capacity and a tumbling speed of about 50 rpm. Those parameters are similar to those utilized by Levi-Sala (1986) in her experimental program. After tumbling, all the samples have been cleaned in an ultrasonic tank with a 30% H_2O_2 solution for 15 minutes, in order to remove any possible greasy lustre. A proper cleaning of the experimental tools is fundamental for the analysis and the comparison of the micro-wears.

2. Chemical alterations are all those types of modifications that involve a changing in the chemical composition of the chert samples. There are many possible factors in archaeological soils capable of producing a variation in the chemical composition of the flint artifacts. Among those, many authors have pointed out the influence of soil pH in chert alteration and use-wear conservation (Plisson 1985; Gijn 1986; Burroni et al. 2002).

Both alkaline and acid environments are usual in archaeological layers. Alkaline condition are common for shell-rich soils, for pyroclastic layers of volcanic ash and for layers rich of ashes from ancient hearths, especially where wood, peat and/or cow-dug had been used as a fuel (Braadbaart et al. 2009). Otherwise, soil acidity is often caused by high rainfalls, plant root activities, soil bacteria and decomposition processes of organic matter (Sparks 2002).

There are few experimental works that tried to replicate systematically the actions of chemical agents on archaeological artifacts. I mainly followed the method proposed by Plisson (1983) and Plisson and Mauger (1988). To reproduce effects of both alkaline and acid environments, four different solutions were prepared. In order to maximize the reaction both strongly alkaline and ultra-acid attacks were tested: 1 Mol and 0.5 Mol of NaOH and 12 Mol and 0.5 Mol of Hcl solutions. Samples were immerged in the solutions and stored in laboratory conditions, for time intervals of 6 hours at a temperature of 60°C. After reaction pieces have been washed with water. A thin section of each altered sample has been realized in order to evaluate the extension of the reaction.

However, to check the reproducibility of the experiments under conditions comparable with the archaeological depositional environment, two weaker solutions where tested. One acid solution of 0.1 Mol CH_3COOH and an alkaline solution made of natural wood pine ashes. I utilized wood ashes as they are a distinctive and common element of many archaeological layers. Moreover, ash naturally contains all the elements, like calcium (~30% of the ash), potassium (~15%), sodium ions (~1%) and other metal ions as magnesium (~7%), necessary to produce the alkali-silica reaction (Misra et al. 1993).

2.3.1.2. Results

2.3.1.2.1. Mechanical Alterations

These experiments confirm the observations already made by other scholars, suggesting that soils forces are capable of producing strong modifications on the chert samples.

Resulting wear mainly consist of a pronounced rounding of all the micro-topographic high points of the surfaces. A first rounding appears already after 15-25 hours of tumbling, especially on the edges and on the ridges of the tool (Fig. 2.3.2, *a-b*). Already after 30-40 hours almost the entire surface is affected, even if the polishing is still not pronounced (Fig. 2.3.2, *c*). After 50-60 hours the topography already appears completely smoothed (Fig. 2.3.2, *d*). Under the microscope rounded spots have a rough appearance, characterized by holes and craters (Fig. 2.3.2, *e*). Only the highest points of the surface appear affected, while craters still preserve the raw material natural colour and brightness. At this stage of development, flint appears shiny even at the naked eye, with a bright lustre completely covering the tool.

Tumbling machine also produced on chert surfaces a number of 'bright spots' (Levi-Sala 1986). Those spots are never extensive and limited only to the edges and ridges of the tools (Fig. 2.3.2, *f*). Elongated striations were almost absents, maybe depending on the low percentage of gravel present in the sediment.

In literature has been proposed various models for the formation of this type of wears. Both chemical (Hurst & Kelly 1961; Rottländer 1975; Howard 2002) and mechanical

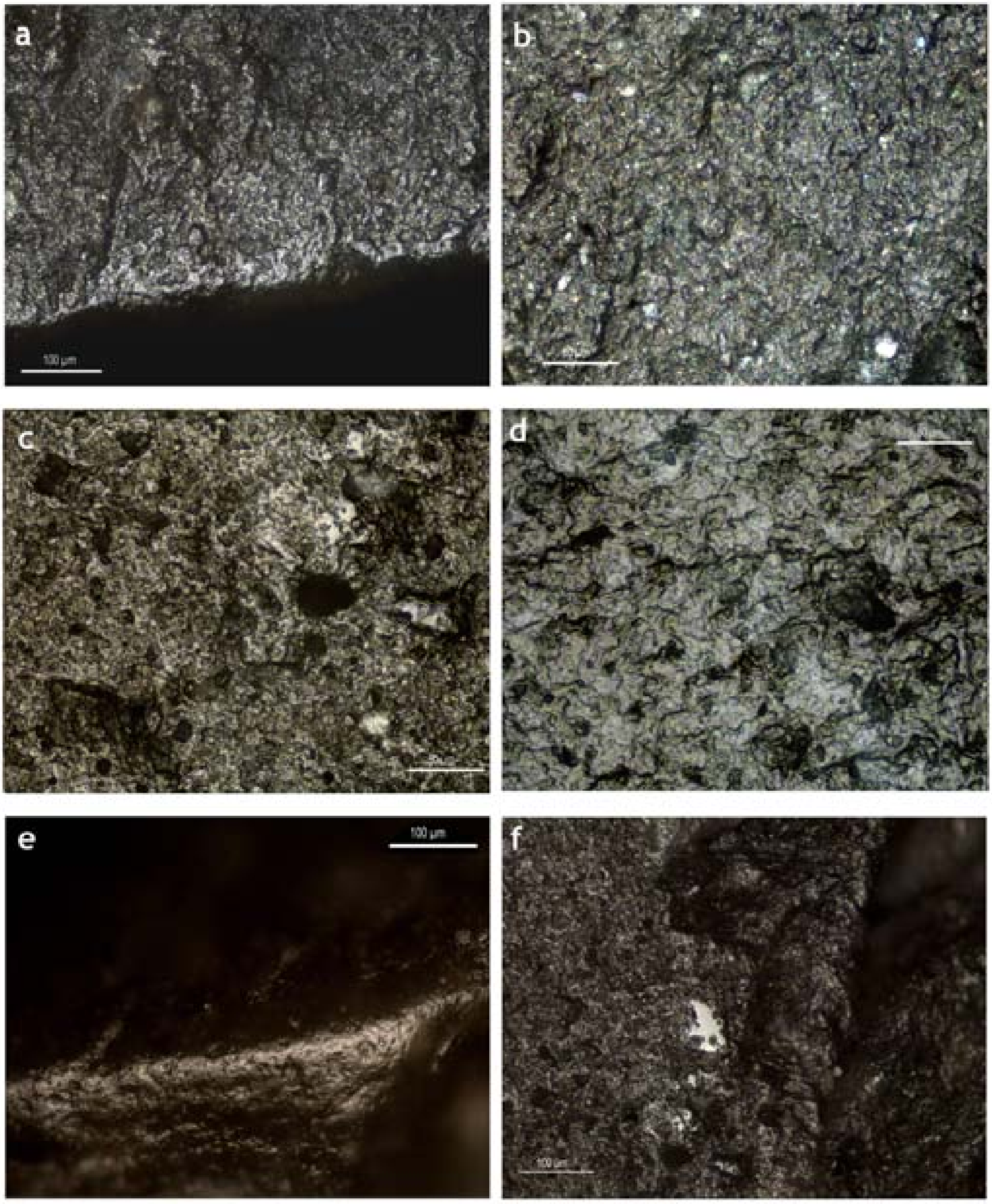

Fig. 2.3.2. Mechanical alterations. *a*) Edge rounding produced by tumbling machine after 25 hours of motion. 400X magnification; *b*) Slight lustre caused by 25 hours of tumbling. 400X magnification. *c*) Surface rounding caused by 40 hours of tumbling. 400X magnification; *d*) Pronounced surface rounding caused by 60 hours of tumbling. 400X magnification; *e*) Edge rounding produced by 60 hours of tumbling. See the rough appearance of the polish. 200X magnification; *f*) Isolated friction spot produced after 50 hours of tumbling. 200X magnification.

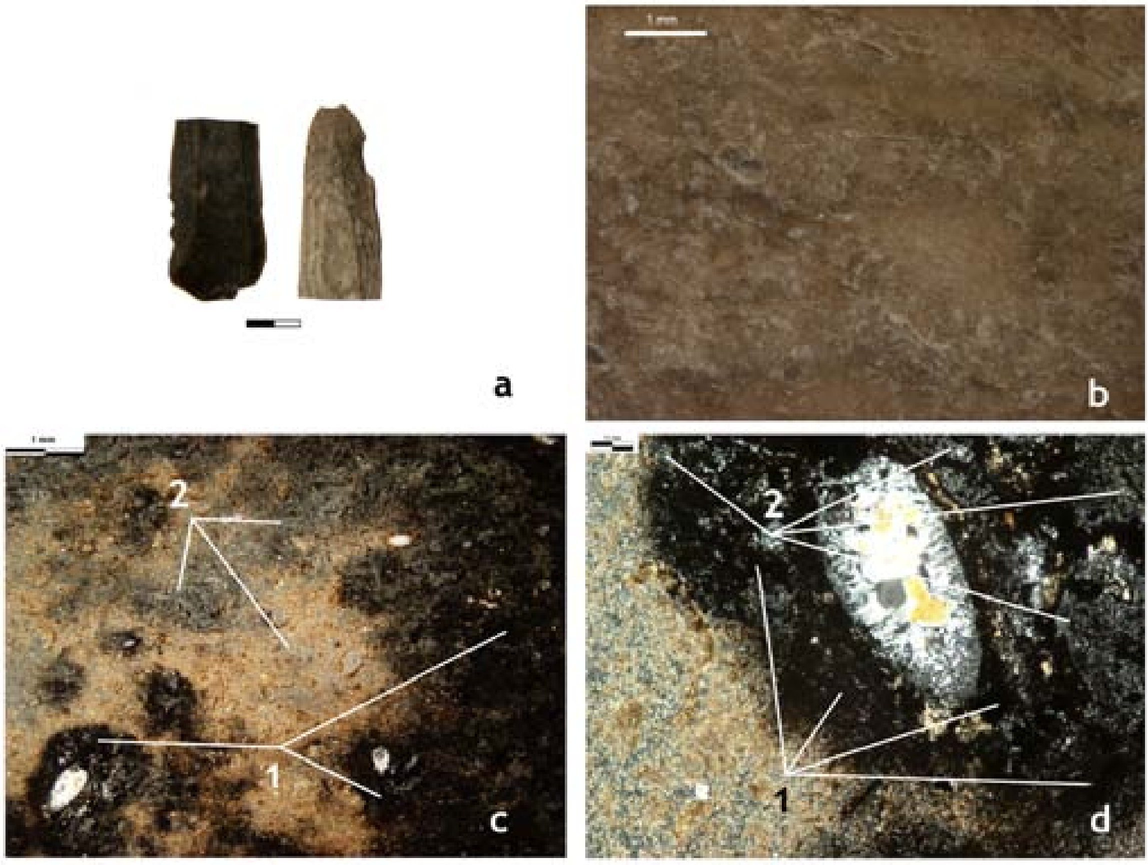

Fig. 2.3.3. Thin section of chert sample altered by acid solution. *a*) chert sample. 1. Unaltered. 2. Altered; *b*) White-yellow patina produced by acid solution. 2X magnification. *c*) Acid alteration affects carbonate components; 1. Carbonate elements, naturally of a beige-brown colour, when dissolved appears of a darker coloration; 2. The aspect of the microcrystalline silica in the background appears unchanged. 2X magnification; *d*) Detail of the same thin section; 1. Dissolved carbonate elements. 2. Unaltered silica. 10X magnification.

processes (Levi-Sala 1986) have been indicated as responsible for their formation. However is possible that with the various terms 'gloss patination', 'glossy sheen', 'glazing'; 'soil sheen', 'surface sheen', etc., I are referring to a number of different phenomena of widely varying origin.

In this experimentation these types of wears seem to have been produced mainly by mechanical forces, even if probably there are other minor agents involved that I am not capable to detect.

2.3.1.2.2. Chemical Alterations

Observed reactions can be divided in two main groups, acid and alkaline solutions.

Acid solutions. Acids react with chert impurities as carbonates, oxides, clays and organic matter located among the quartz and chalcedony grains. At low pH, carbonates solubility grew (Limbrey 1975; Luedtke 1992), thus, acids attack calcite elements, for example remains of bioclasts (radiolars, bivalves, foraminifers) and other carbonate elements incorporated within silica matrix. In this case, acids (Hcl or CH_3COOH) when invade the chert porous

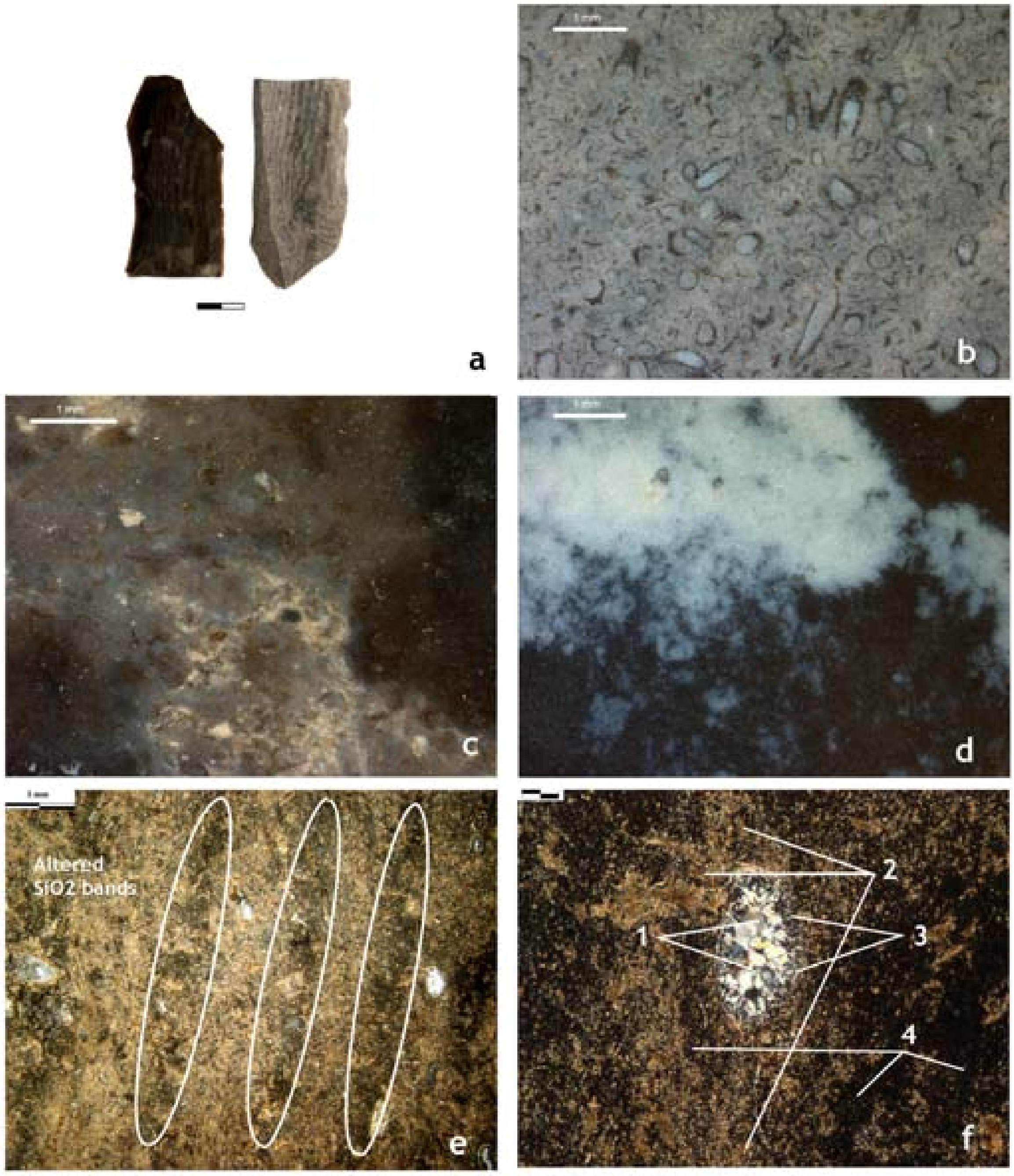

Fig. 2.3.4. Thin section of alkaline altered chert. *a*) Chert sample: 1. Unaltered. 2. Altered; *b*) Fully developed white-grey patina. 2X magnification; *c-d*) White spots produced by alkaline solution. 2X magnification; *e*) Bands of altered SiO_2. 2X magnification; *f*) Detail of the same thin section. 10X magnification. 1. Unaltered macro quartz; 2. Unaltered carbonate elements; 3. Partially dissolved chalcedony; 4. Dissolved silica layer;

matrix, reacts with calcium oxide (CaO) producing compounds as calcium chloride, or calcium acetate, and water. This reaction produce a white-yellow patina over the surfaces, as the chert turns of a clearer colour than the natural tone (Fig. 2.3.3, *a-b*). Reaction times depend on a number of factors, as the concentration of the acid solution, the temperature, the amount of calcite elements and their surface area, etc. However, a light patina on the flint surface appears after about 30 minutes with a 3 Mol Hcl solution. In thin section is possible to appreciate that, while SiO_2 and micro quartz grains remain unvaried, carbonates are dissolved. Altered areas appear darker than the natural colour (brown-beige) of calcite (Fig. 2.3.3, *c-d*).

Use-wears derived from plant/wood materials do not show any modification after the immersion in acid solutions. These type of traces are probably mainly constituted by layers of amorphous silica (Anderson-Gerfaud 1981; Fullagar 1991) and, thus, they are scarcely affected to acid aggression, at least for the concentrations and time intervals experimented.

Alkaline solutions. Alkalis react with SiO_2 matrix. The alkali-silica reaction (ASR) is well studied in material sciences. It occurs between alkaline compounds and cryptocrystalline or amorphous silica. More in details it requires the presence of hydroxyls (OH), alkali metals (K, Na, Mg), calcium ions (Ca) and water. Simplifying, the hydroxyls ions provoke the destruction of the atomic bonds of the siliceous compounds, then the alkali ions, reacting with the new soluble silica complexes, $Si(OH)_4$, form a silica-gel that exchanges ions with calcium elements, gradually solidify upon them (Prezzi et al. 1997). This reaction only occurs between alkali and reactive siliceous aggregate. Opal, which has a very disorder structure, is the most reactive form of silica; chalcedony and microcrystalline quartz have an intermediate reactivity, while quartz α, having an ordered structure, is scarcely reactive (Knauth 1994, Bulteel et al. 2004). The precipitation of the silica gel the lithic surfaces, starts when the solution in which the chert is immersed becomes saturated with respect to silica, leading to the formation of a white-grey patina (Hurst & Kelly 1961). This type of patina at first is visible only in some isolated spots, then attacks the edges and finally expands to the entire surface (Fig. 2.3.4, *a-d)*. The rapidity of reactions varies on the concentration of the solution. A first patina appears already after 24h with 0.5 Mol NaoH solution. However, it is interesting that also in a solution of pine ashes – with concentrations similar to those that could be encountered in an archaeological layer – a slight patina gradually covered the surface after 270h of immersion at 60˚C, forming and increasing over time (Fig. 2.3.4, *b-d*). In the thin section is possible to see how the alteration principally attacks areas of mayor structural inhomogeneity in which starts the dissolution of amorphous silica. Alkaline alteration mainly affects microcrystalline and fibrous silica (Fig. 2.3.4, *e-f)*, while do not affect microcrystalline silica (Fig. 2.3.4, *f)*.

Use-wears derived from plant/wood materials also suffer strong alterations as a consequence of the immersion in alkaline solution at 40˚C for different time intervals (Fig. 2.3.6). The dissolution of the amorphous silica deposited on the lithic surface appears extremely rapid also in this condition. When a fragment employed on plant or wood materials is immerged in an 'ash solution' at natural temperature I observe a gradual but increasing dissolution, already after 24 hours of immersion at 40˚C. After 270 hours of immersion however, I observe certain stabilization of the wears and also after 320 hours the polishes did not seem to lose much more material.

Even if only preliminary, this experimentation appears extremely interesting, not only in relation to issues of wear conservation, but more in general in relation to polishes composition and formation processes.

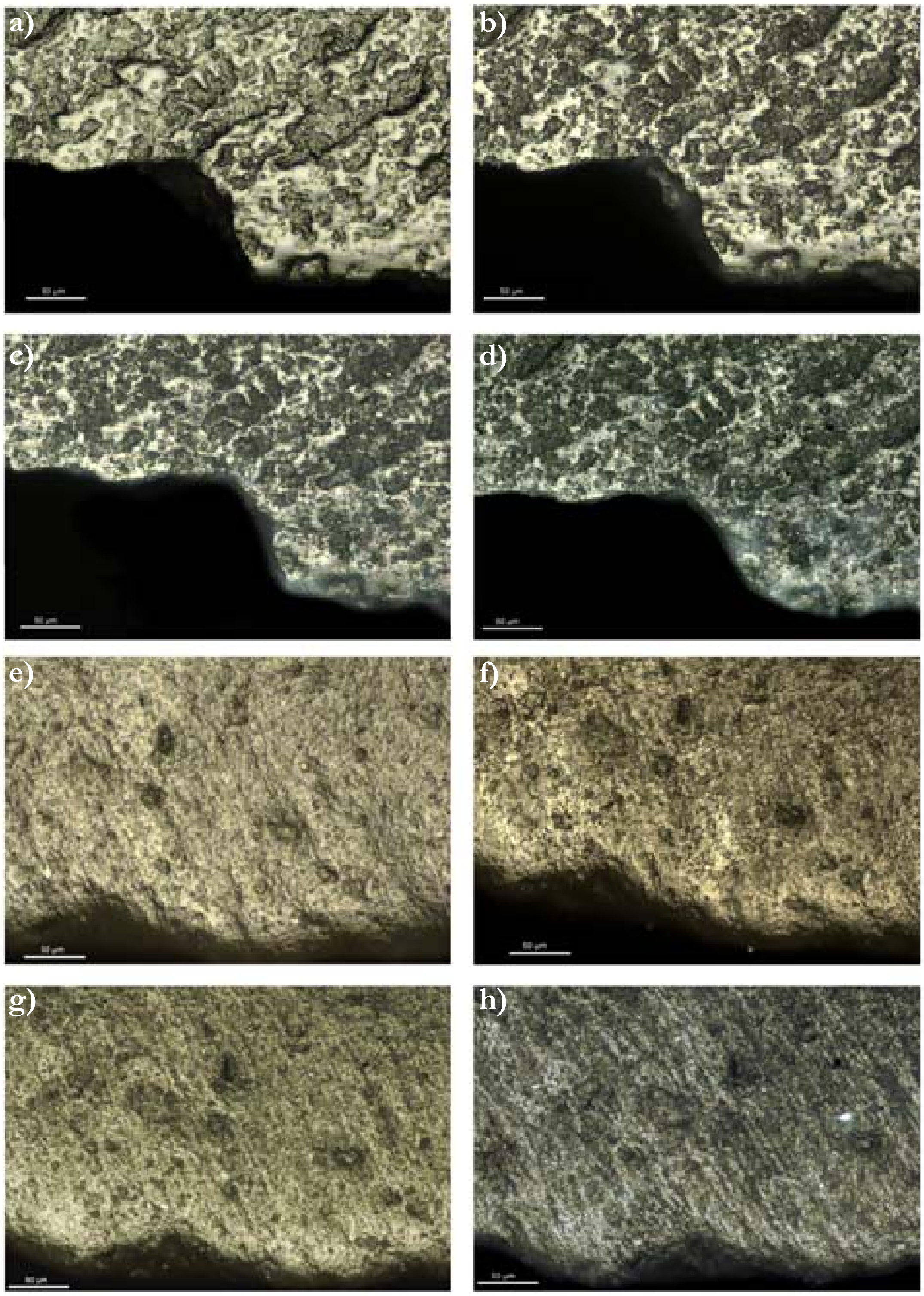

Fig. 2.3.5. Chemical alteration of use-wear polishes: *a*) Polish produced by the cutting of fresh grasses, after 25'. 400X magnification; *b*) The same polish after the immersion in a ash solution (pH 12) for 72 hours at 40ºC, 400X magnification; *c*) Same as before, after 168 hours; d) Same as before, after 240 hours; *e*) Polish produced by the scraping of dry pine-wood, after 20', 400X magnification; *f*) The same polish after the immersion in a ash solution (pH 12) for 48 hours at 40ºC, 400x magnification; *g*) Same as before, after 120 hours; *h*) Same as before, after 144 hours.

Without entering in the debated of about the polish formation process, I would like to point out some relevant reflection. Following the idea of Kamminga (1979), I believe that polishes are created in a different way depending on the type and chemical composition of the contact materials. For instance, polishes created by plants are mainly an additive process, involving the deposition of a layer of amorphous silica gel, while other categories of traces are mainly abrasive, as for example hide-working. Tribological model both for additive and abrasive wear has been recently proposed also for various contact materials (Astruc et al. 2003).

If one looks to the use-wears employed in this experimentation, one can notes some relevant differences. In the first case I immerged in the ash solution a fragment of a tool employed for cutting fresh grasses. The original trace was a very smooth and fluid polish with domed topography and closed texture (Fig. 2.3.5, *a*). After 240h, alkaline alteration led to a gradual solution of the silica layer deposited in the surface, with an evident opening of the texture and losing of the smooth aspect. Resulting polish has a rougher aspect and the bright 'polished' spots are now mainly concentrated on the highest point of the surface (Fig. 2.3.4, *b-d*). The abrasive component in this case seems almost uninfluential or, anyway, covers a minor role.

The second trace that I analysed, is a polish produced by the scraping of a dry wood (*Pine*). The original trace was characterized by the presence of striations, however also spots of bright polish were visible on the very edge of the tool (Fig. 2.3.5, *e*). With the immersion in the alkaline solution the 'additive' component is gradually lost, with the dissolution of the silica gel, while the abrasive elements (i.e strias) are now more clearly visible on the surface, suggesting an abrasion of microcrystalline matrix of the chert itself (Fig. 2.3.5, *f-h*). In this case, the pine-wood trace appears to be produced by both components, additive and abrasive.

2.3.1.3. Final Remarks

This experimental program was not intended to resolve any of the many unsolved questions about post-depositional modifications, that is beyond authors' competence. Taphonomical alterations remain a controversial issue for the number and complexity of variables implicated. More detailed analysis will be necessary to properly understand which mechanisms are responsible and to what extent. However, this experimentation permitted to obtain additional information regarding the post-depositional alterations, creating a first reference collection for the recognition of wears and modification produced by natural agents.

Moreover, despite being a preliminary experimentations, these results suggest that not only chert materials, but also use-wears are strongly affected by taphonomic alterations. There are many agents in nature capable of producing a degradation of the use-wear traces, and thus analysts should carefully consider depositional environments and their possible influence on archaeological artefacts before giving a functional interpretation of the assemblage. Further works, employing additional techniques (e.g. confocal microscope, GC-MS), will probably allow understanding more in detail the mechanics of the alteration processes; for example it would be interesting to quantify the addition and dissolution of material from the lithic surfaces and from the polishes when immersed in alkaline or acid solutions. This type of experiments would also contribute to the understanding of the polish formation process itself.

2.3.2. Lithic Tools Transportation: New Experimental Data**

The transportation of lithic tools has been an important issue in prehistoric studies. It has been mainly discussed as related to the 'curation' debate. In 1973 Lewis Binford defined a 'curated tool' as an instrument that has been manufactured and transported from one site to another in anticipation of future needs (Binford 1973). When Binford first developed the curation concept, he was interested in the study of the site formation process. He was analysing the Nunamiut Eskimo technology, focusing on the way in which they conceived different types of gear as appropriate to carry on trips of differing purpose, distance and duration. Even if later the curation concept assumed other significances, both linked to tool efficiency, tool recycling, tool maintenance and tool functionality, at first 'curated tools' were mainly conceived as a corollary of mobility (Andrefsky 1991).

In this context, transportation was considered a practice subsumed by curation. Tools were transported to one site to another to perform specific activities at the new locations, as well as a form of precaution, in the eventuality of the insurgence of unexpected needs (Shott 1996a). Moreover, transportation was considered a relevant behaviour as implicates a selection. Considering the constraints associated with mobility and transport loads, the transportation of stone implements requires prehistoric individuals to operate a selection over the lithic assemblages, favoring some tools over others (Shott 1996b, Close 1996).

In microwear studies, the analysis of the effects of the transportation of lithic tools has often passed unperceived. Published researches on the so-called 'bagwear' have been mainly developed in order to investigate 'non-use wears' (wears caused by external agents, unrelated to the use or management of the tool) as post-excavation damage produced by the archaeological recovery and storage of the findings (Odell & Odell-Vereecken 1980, Lewenstein 1981, Plisson 1985, Luedtke 1986, Gutierrez et al. 1988).

Until now, most efforts were mainly focused on a methodological level to create an experimental reference in order to distinguish 'use-wears' (wears produced by the use of the tool) from 'treatment wears' and 'non-utilitarian wear1' (wears caused by actions linked with the production, management or maintenance of the tool, but not directly caused by use; e.g. hafting, prehension, manufacture or transportation wears) (Rots 2010). On the contrary, few studies have considered prehistoric transportation as a relevant action capable of producing substantial changes on lithic tools (for a first the recognition of transport traces see Gyria 2004).

2.3.2.1. Experimental Procedure

The experimental program was designed and realized during a field work in the Central Pyrenees, inside the National Park of Aigüestortes i Estany of Saint Maurici, during 2009-2010 campaigns. Aims of this experimentation were to:

** This work has been recently published on the proceedings of the 3rd International Congress of Experimental Archaeology (Banyoles, 17-19 October). I am thankful with the author that collaborated in the paper: Mazzucco, N. & Clemente, I. 2012. Lithic tools transportation: new experimental data. In: *Experimentación en arqueología. Estudio y difusión del pasado*, Palomo, A., Piqué, R. & Terradas, X. (eds.) Sèrie Monogràfica del MAC, Girona, 2013: 235-243.

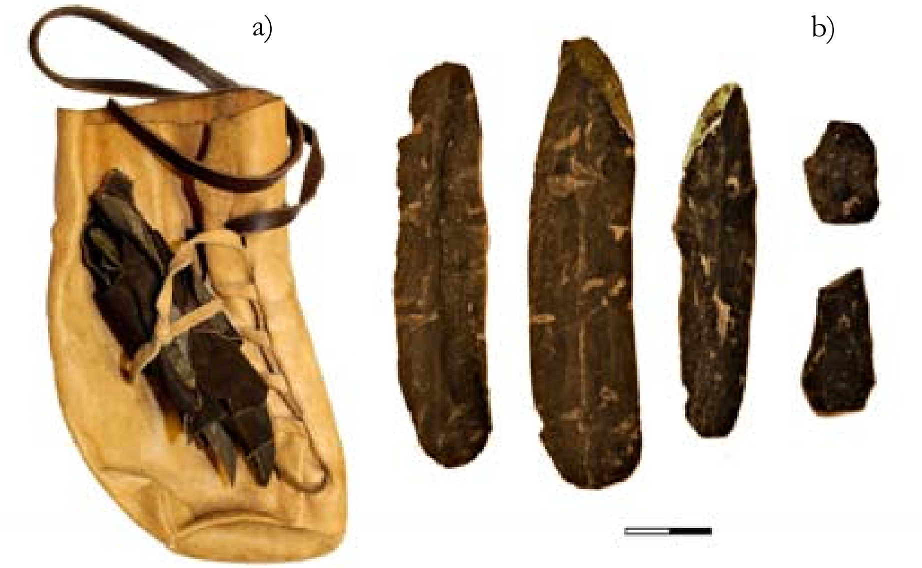

Fig. 2.3.6. *a*) Leather bag with the flint implements tied together (transportation mode D); b) Some of the transported tools.

i. Prove the efficiency of different modalities of transportation;

ii. Individualize which types of wear transportation produces on flint implements;

iii. Evaluate if those wears are distinguishable from other types of wear;

iv. Analyse which effects transportation could have on previous use-wear traces;

Transportation was executed in a way which is plausible for prehistoric conditions. Most of the authors agree that prehistoric implements were possibly transported between sites using a leather bag, as it has been also attested ethnographically (Oldfield 1865, Balicki 1970, Kamminga 1982, Plisson 1985). Organizing the experimental practice, I followed part of the methodology already proposed and published by Rots (2010). Three different modes of transportation were tested experimentally. In each case a single person transported some freshly knapped blade together with some previously used instruments under the following circumstances: A) in a loose hanging leather bag; B) in a loose hanging leather bag, with each implement individually rolled in a leather wrapping; C) and tied together by a leather string in a loose hanging leather bag; D) in a loose hanging leather bag, with each implement individually rolled in a leather wrapping and tied together by a leather string (Fig. 2.3.6, *a*).

Transported artifacts were blades and flakes produced from the same chert types recognized in the archaeological assemblages, the Ebro Valley cherts (Fig. 2.3.6, *b*). These materials have been intensively exploited during the entire Neolithic period in the NE of Iberian Peninsula, representing the best-quality raw-material for the production of blades, which generally represent tools with a long use-life, more likely to have been transported from one location to another during prehistoric times. Moreover, raw-material sourcing analysis indicates that such materials were moved over considerable distances (Mazzucco et al. 2013b; Rojo et al. 2014).

Thirty elements were transported, of which 8 elements were previously used for cutting a soft vegetal substances, mainly wild grasses of various type. I decided to introduce this variable into the experimentation as most of the blade scrapers, analysed from the archaeological contexts included in this work, present traces associated to herbaceous plant harvesting. Experimental tools have been used for a variety of actions and tasks in to order to produce polishes resembling the archaeological specimens: cutting wild grasses, cutting aquatic plants and cutting meadow. The main objective was to create a layer of silica gel on the tool surfaces (i.e. polishes) and successively observe which type of modifications occurred during transportation. Artifacts have been transported for different time intervals, from a minimum of 8 hours (1 day) to a maximum of 180 hours (22 days).

2.3.2.2. Results

2.3.2.2.1. Type of Wears

I distinguished five main types of alterations that could occur with transportation practices: 1) edge-damage; 2) striations; 3) abrasions; 4) surface sheen; 5) polishes. The two last points briefly examine the modifications produced by transportation on previous use-wears (6) and the influence of the transport duration on the development of the wears (7).

1) Edge-damage occurs mainly as a consequence of the mutual contact between flint implements within the bag. All the transported edges have been in some degree affected by transportation-damage, even after few hours of transportation. However, the size and invasiveness of the fractures vary notably from one transport mode to another. When instruments are not tied together, as in mode A and mode B, movement during transportation is greater and could produce deep notches and extensive fractures along the edges (Fig. 2.3.7, *a-b*). Otherwise, in mode C and mode D, edge-damage is reduced and fractures are generally smaller than 2 mm (Fig. 2.3.7, *c-d*). Even if fractures could occur in patches of certain regularity, the overall damage produced by transportation is easily distinguishable. Scars are generally irregular both in morphology and directionality. Their distribution over the edges is discontinuous and random. In this sense, scarring caused by transport resemble more post-depositional damage than use-damage.

2) Striations are a consequence of the contact between flint implements within the bag. They occur mainly in modes A and C, while in mode B and D the presence of the leather wrap partially protects implements from mutual contact. Striations produced by transportation do not show a clear directionality and distribution. They could be isolated on the surfaces, as well concentrated in little spots (Fig. 2.3.7, *e-f*). Generally, they are easily distinguishable from wears produced by use or hafting. Otherwise, they resemble striations produced by contact with mineral substances, as rubble or brash present in soils.

3) The friction between flint implements could produce extensive abrasions on the surfaces. Those wears are comparable to 'polish G' described by Moss (1987) or the 'bright spots' described by Gijn (1989). Abrasion spots occur randomly on the surfaces, even if they frequently appear in the most exposed areas, such as the extremities, the edges and the bulb. They could reach a diameter of about 2 mm and, under an incident light, they are often visible at the naked-eye. Such features, caused by an intense friction between the flint surfaces, mainly occur in mode C, where tools are constantly in mutual contact, and even if movements are reduced, as implements are tied

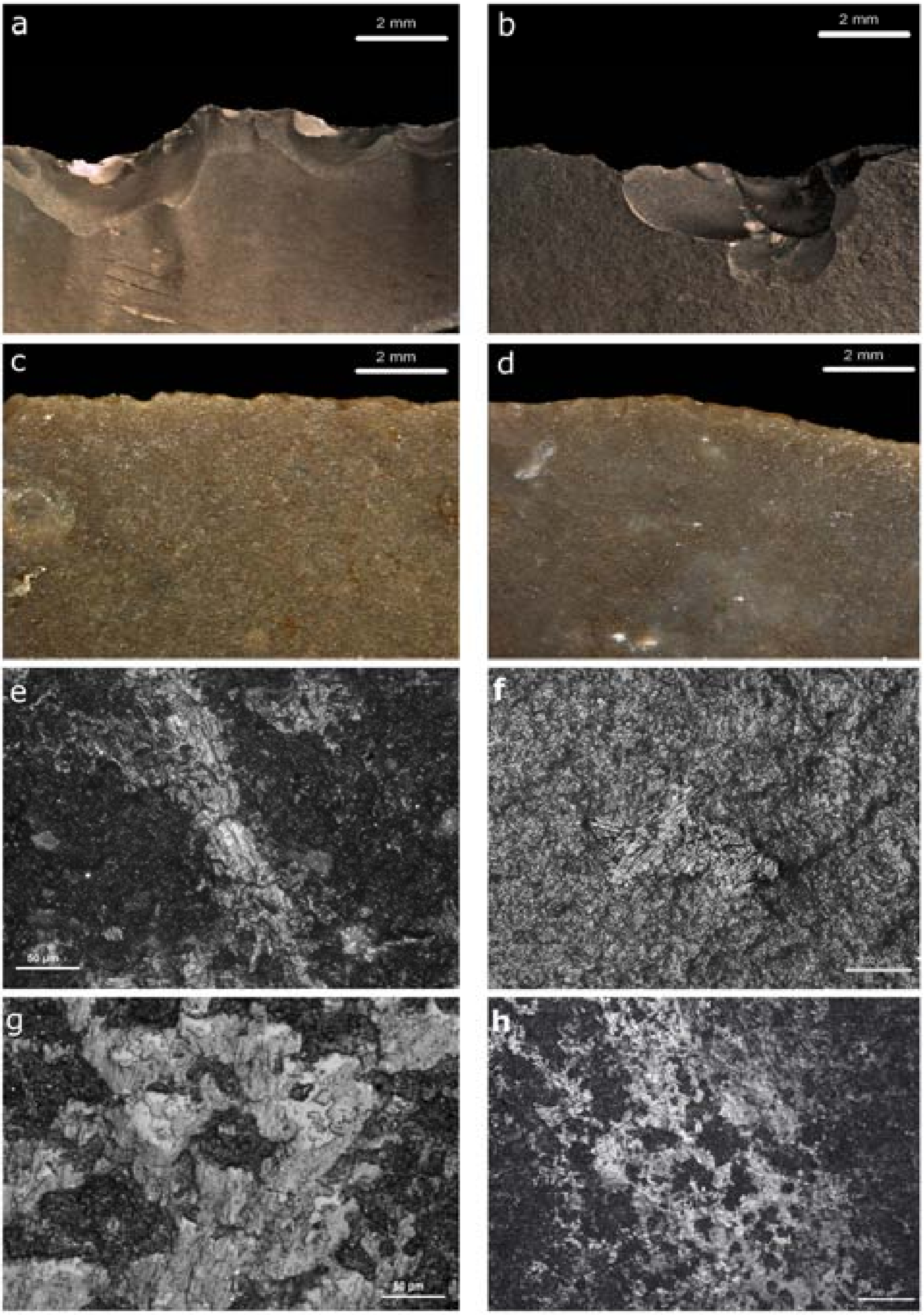

Fig. 2.3.7. *a-b*) Invasive edge-damage produced in modes A-B (8X and 10X magnification); *c-d*) Light edge-damage produced in mode D-C (8X magnification); *e*) Striation produced by transportation (400X magnification); *f*) Scratches produced by transportation (200X magnification); *g-h*) Friction spots at different magnifications (400X and 100X magnification).

together, friction between them is high (Fig. 2.3.7, *g-h*). In mode A and mode B contact between implements is more discontinuous, occasional, and is more likely to produce scarring than abrasions. Finally, mode D also produces spots of 'polish G', but they are mainly caused by the friction between the leather wrapping and the lithic surfaces, because of the pressure exerted by the leather string that holds together the pieces.

4) One of the most characteristic wear caused by transportation is the formation of a macroscopic visible gloss all over the tool (Rots 2010). However, this surface sheen (Fig. 2.3.8, *a*) could not be considered a proper 'wear', as do not produce any real modification of the flint surfaces. The gloss is probably a greasy layer deposited on the surface as a consequence of the contact with the leather bag. To prove the consistency of this layer I immerged the implements in a H_2O_2 30% solution, for various time intervals (10, 30, 60, 120 minutes). After one hour of immersion, the gloss completely disappears, proving that is a thin layer of organic substances. After cleaning only those friction-spots produced by mechanical forces are visible on the surface (Fig. 2.3.8, *b*). I consider this "greasy sheen" very difficult to recognize in archaeological materials as similar glosses could be produced by other natural agents, e.g. soil.

5) Polishes are mainly the result of the contact between flint and the leather bag or the leather wraps. Hide-like polishes are mainly produced in transportation mode D, where leather and implements are tied together. In this case, the friction between the leather string and the flint surfaces causes a certain rounding of the ridges and of the edges, sometimes associated to tiny striations. Those kinds of wears can be distinguished from use-wear as they are isolated on the surface and limited to small portions of the tools not necessarily connected to use or hafting (Fig. 2.3.8, *c-d*). In other transportation modes, where leather and tools are not tied together, the contact is too weak and discontinuous to produce polishes. Finally, the friction between flint implements could produce polishes. I recognized, on the very edge of the tools, some flat and bright spots with tiny striations that resemble polishes caused by the contact with hard materials (Fig. 2.3.8, *e*).

6) Previous use-wears develop a series of modifications after being transported. Scarring is the most evident alteration of the used edges. In fact, during transport a series of small fractures are often produced all over the used area, interrupting the polish and revealing the original flint surface (Fig. 2.3.8, *f-g*). Transportation also produces striations overlapping with the underneath polish. Both elongated striations and tiny scratches are visible in mode A, B and C (Fig. 2.3.8, *h*). In transportation mode D modifications are limited and hardly detectable as the leather wrap protect edges from wear phenomena.

7) The amount of wears seems to increase in a linear manner over time. The longer the instruments were transported, the higher the number of stripes and bright spots, more intense the gloss on the surface and the scarring of the edges. Edge-damage and striations are the first alterations to be produced, as a first contact between tool surfaces is produced when implements are mounted together inside the bag. Polishes and abrasions develop gradually during transportation as friction between the surface is produced during movements. In mode A and B well-developed transportation wears are produced already after 10 hours of transportation, while in mode C and D at least 30 or 40 hours of transport are required. However it is difficult to properly estimate

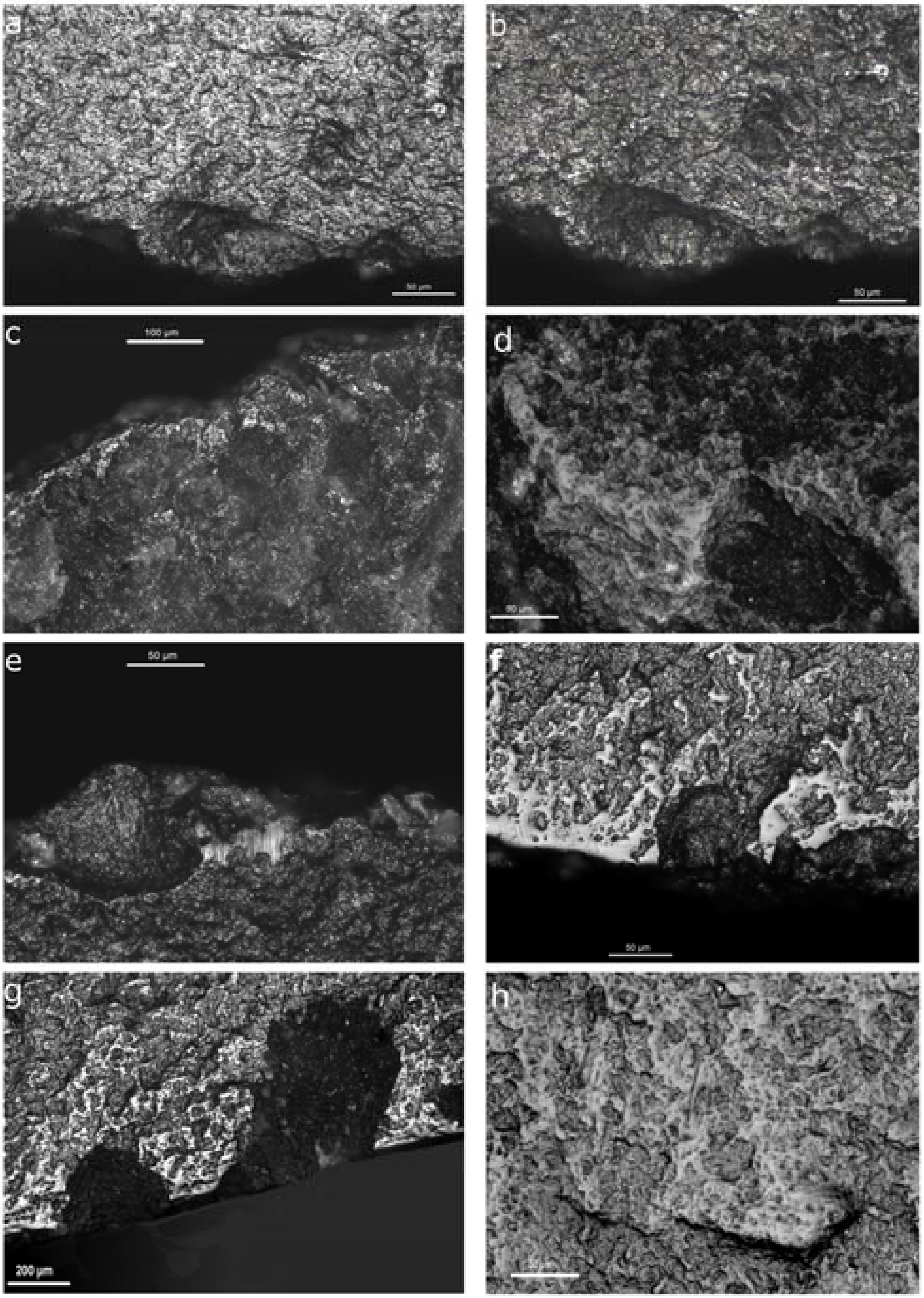

Fig. 2.3.8. *a*) Gloss produced by transportation (400X magnification); *b*) Same surface after H_2O_2 treatment (400X magnification); *c-d*) Polishes caused by the contact with the leather wrapping (200x and 400x magnification); *e*) Polish spot that resemble contact with hard material (400X magnification); *f-g*) Transport-scars interrupting plant polish (400X and 100X magnification); *h*) Scratches overlapping plant polishes (400X magnification).

how the time affects transportation wears production, as traces are not intentionally produced on the flint surface, but casually - and their degree of development could vary notably from one tool to another depending on the movements and the stress that suffered.

2.3.2.2.2. Modes of Transportation

On the basis of this experimentation I consider that the only reliable modes for transporting lithic tools are modes C and D. If one assumes that the main concern in the long-distance transportation of stone tools is the preservation of the cutting-edge from accidental damage, then only the presence of a leather string holding together the implements against the stress and the motion caused by transport, represent a valid response. In the other modes (mode A and B) transportation could destroy the potentially functional edges. Even the presence of a leather wrap inside the bag (mode B) is not sufficient to prevent edge-damage, as during the trip the stone implements tend to move from their original position, losing the protection of the leather and possibly crashing into each other.

However, this experimentation does not pretend to reproduce all the possible ways in which prehistoric transportation could have occurred. For the archaeological case in analysis I cannot make reference to any specific ethnographic source. So, I based the experimentation on the basis of data and results previously published by other authors and on the basis of my common sense. This consideration, does not implicate that this experimental practice reproduces correctly prehistoric modes of transporting lithic tools; I simply tried to reproduce some plausible ways to do it, assessing which of these are reliable and which are not.

2.3.2.3. Final Remarks

As already stated by other authors (Odell & Odell-Vereecken 1980, Rots 2010), transportation produces quite different wears, mostly in terms of distribution and recurrence, from hafting and use-wear traces. However, scholars rarely wondered if it is possible to distinguish such wears from other sort of modifications, as post-depositional or post-excavation damage. Indeed, all of these wears involve similar physical forces (as compressive stress and sliding contact between siliceous materials, friction with organic matter, etc.). Moreover, both transportation, post-depositional or post-excavation alterations, are involuntary, not deliberately produced by humans, as happen in use-wears, where the contact between the tool and the worked material is intentionally sought. Thus, is not surprising that the result will be a set of broadly comparable kinds of wear phenomena. In particular, post-excavation damage (e.g. the storage of lithic materials all together in a plastic bag) completely mimics, and consequently cancel, prehistoric transportation wears.

In my view, the main relevant difference between transportation traces and other post-depositional modifications is the absence of an extensive rounding all over the lithic surfaces. Erosion natural forces, because of the size of the soil particles, can lead to changes at a microscopic level, polishing and rounding down to the most microscopic high-points of the lithic surfaces. Transportation does not produce such extensive rounding, as the contact between the lithic implements, the wrap, the string and the bag, is always limited to some specific points, never involving the entire surface.

In this sense, assuming that the modalities that I adopted for transporting lithic tools are plausible for prehistoric conditions, my experimentation has permitted to advance in the understanding of the type of wears that transportation practices can produce on chert surfaces. On the basis of the distribution pattern of the wears and on the basis of the concurrence of two or more types of the previously described traces (edge-damage, striations, bright friction spots, hide-like polishes, alteration of pre-existence use-wears, absence of extensive rounding) it may be possible to determine if a lithic tool has been or not transported.

However, I still consider the detection of transportation wears a controversial issue. Even if use- and transportation-wears can be confidently distinguished, both post-depositional and post-excavation alterations can largely overlap those traces. In my view, prehistoric transportation could be confidently detected on flint tools through microscopic analysis only on well-preserved materials. Moreover, the microscopic analysis of wears should be integrated by other sources of information. Important data about prehistoric transportation directly from the archaeological context. Indeed, the analysis of the procurement and reduction strategies of the lithic materials could offer important indications in that sense. It is fundamental, more than ever for the interpretation of transportation modes, to integrate functional data in the overall context.

2.3.3. Tools for Ceramic Production and Maintenance: a Preliminary Experimental Approach

During the last decades, traceological analysis revealed how lithic tools participated in a variety of economic processes among agro-pastoral communities. Stone implements were used in a huge variety of crafting processes associated to the production of artefacts of different raw-materials and for different purposes.

Among the goods manufactured through the employment of lithic instrument one can certainly include pottery vessels. The use of pebbles and no-chipped rocks as smoothers has been observed both ethnographically and archaeologically (Rodríguez Rodríguez et al. 2004; Clemente et al. 2008). However, not only macrolithic tools were employed for the production of ceramic vessels, but also chipped stone tools, as suggested by the works of Gassin (1996) and Torchy & Gassin (2011) for the Chassey Neolithic of Southern France, Jardón-Giner & Jadin (2008) for the LBK in Belgium, Gijn (1989) for Dutch LBK, only to cite some European settings.

The experimental works published by Gijn (1989) and Gassin (1993) probably represent the best references for the experimentation with chipped stone tools for the production/finishing of pottery vessels. Both experimentations were mainly focused toward scraping and planning activities on fresh and dry clay.

A. van Gijn mainly focused her experimentation on semi-dry, dry clay. Tools were used mainly with scraping motions, while boring tools have been realized only briefly and almost no wears were produced. The scrapers were used both on tempered and untempered clay. The resulting wears were described as following: «The polish was distributed in a wide band, had a rough and matt texture, a corrugated topography, and a directionality perpendicular to the edge. In six instances the polish was very bright. In the cases with quartz- or chamotte-tempered clay, deep, long, and wide striations developed» (Gijn 1989: 47).

The works of Gassin both focused on fresh clay and semi-dry tempered clay, trying to reproduce different tasks within the processes of vessels production: from the thinning of the vessel's walls and lips (semi-dry clay) to their polishing (dry clay). The nature of the resulting traces was broadly comparable with the results obtained by Gijn (1989). Macroscopically employed tools were characterized by a lustre visible at the naked-eye, a strong edge-rounding and a marginal edge-damage; microscopically, by a well-developed polish (heavily striated), with a compact or closed texture and a topography that vary from smooth to rough depending on the movement and on the state of the worked clay. Gassin also identified differences in the distribution of the traces between the two faces of the tool, between the contact face and the opposite one.

During the study of the lithic collections from several Neolithic contexts located in the Pyrenees —which is presented in this volume— I identified several traces possibly related to pottery working. Some of them strongly resemble the experimental wears obtained by Gijn (1989) and Gassin (1993), however some others traces differs substantially from their results. The latter can be divided in two main groups:

i. Traces associated to the scraping/planning of some type of mineral abrasive material. Those wears partially resemble the traces produced by Gijn (1989) and Gassin (1993), at least on a macroscopic level, both presenting strong edge-roundings, superficial lustres, a very marginal scarring; however, on a microscopic level they differ from such traces presenting a stronger abrasive component. Indeed, polishes appear more striated and abraded; the smooth and matt spots are much more reduced in extension, often showing a rougher appearance. Such traces could be produced by the working of ceramic materials in a slightly drier state in respect to what experienced by A. van Gijn and B. Gassin.

ii. Traces associated to the drilling of some type of resistant abrasive materials. Those type of traces have been observed only on a specific category of tools: borers. As already stated above, A. van Gijn only a makes a quick reference to the use of borers for repairing baked pottery, as the tools were used briefly and no traces or edge-roundings were produced. In his experimentations, B. Gassin do not makes any reference to the experimental boring of baked pottery. However, several borers with very abrasive traces have been documented at the sites of Vila-Giribaldi and Pirou by Torchy & Gassin (2011) and the authors hypothesize their employment in pottery repairing activities.

To prove the nature of the observed traces I decided to realize a brief experimental program, mainly focusing on these two types of traces: 1) the working of dry pottery and 2) the drilling of baked pottery. However, this experimentation should be considered only as preliminary as a much more extended works should be run out to further prove the possible employments of lithic tools in ceramic production and maintenance.

2.3.3.1. Experimental Procedure

2.3.3.1.1. Ceramic Preparation

The clay paste for the experiments has been prepared following the general characters described for Early Neolithic potteries of Aragon's and Catalonian contexts (Gallart & López 1988; Ramón 2006; Clop 2011).

For the experiments I realized two different vessels, two small pots both realized with the coil technique. I used industrial clay mixed respectively with: 1) grinded quartz and 2) chamotte. In the case of quartz-tempered clay the tempering materials was rather large, with

		Contact Material		
		Semi-Dry tempered clay	Dry tempered clay	Backed vessels
Motion	Longitudinal	20'	15', 25'	
	Transversal	25'	15'x3, 25', 30'	
	Boring			15', 15', 25', 15'x2,

Tab. 2.3.3. Resume of the performed experiments. The total number of experiment realized is of 14. I respectively used 5 borers (of which one fro two times) and eight flakes/blades (of which one used on both edges).

grain-size between 0,1 and 1,25 mm. In the case of chamotte-tempered clay the size of the grains was something smaller, between 0,1-0,5 mm.

I called it semi-dry or *verte* pottery, when the clay material was still humid, approximately from 6 to 12 hours after the vessel production. In this case, the waste produced while working the clay was still plastic and still was possible to agglomerate clay particles between them. I called dry pottery after more of 12 hours of drying. In this case the waste materials have a consistency like dust, with very fine particles that is impossible to agglomerate without the adding of water.

For what concern baked pottery I did not run an experimental program on ceramic baking. For drilling activities I used two archaeological ceramic fragments, proceeding from the Els Trocs cave, recovered from a superficial disturbed layer and, thus, were excluded from the archaeological assemblage[1]. The fragments employed (both undecorated, formless fragments) presented the same characteristic of the ceramic materials proceeding from the underlying Neolithic levels. Given this premise, such fragments represented the best opportunity to reproduce experimentally the traces observed on the archaeological assemblage.

All the experimental tools have been cleaned after use with a solution of water and soap and, successively, with alcohol just before the microscopic observation.

2.3.3.1.2. Performed Tasks

2.3.3.1.2.1. Ceramic Production

In his experimental work Gassin (1993) defines a series of tasks in which could be used lithic tools in relation to ceramic vessels production. He identified the following operations:

i. *'amincir le paros'* - thinning the vessel's walls (semi-dry clay);

ii. *'biseauter ou tronquer la lèvre'* - to bevel or cut the vessel's lips (dry or semi-dry clay);

iii. *'lissage des surface'* - smoothening of the vessel's walls (semi-dry clay);

iv. *'polissage des surfaces'* - polishing of the vessel's walls (dry clay):

[1] I am thankful to Prof. Manuel Rojo Guerra, one of the directors of the Els Trocs excavation, for let me using the ceramic fragments proceeding from a disturbed, superficial strata.

v. *'décor des surfaces'* - surface decoration.

As already mentioned above, B. Gassin (1993: 194) mainly realized his experiments with *verte* clay. He define the *verte* or semi-dry state as: «*au moment où la pâte a acquis, par le séchage, suffisamment de fermeté pour ne pas se déformer sous la pression de l'outil, mais où elle est encore assez humide et souple pour permettre la formation de copeaux réguliers*»[2]. However, this definition leaves space to certain variability within the degree of dryness of the clay pasta. The same author in his paper distinguishes between different degrees of dryness within the worked clay: '*argille plus plastique*' and '*argille plus ferme*'[3].

In this experimentation, to explore the differences between different state of dryness I realized few experiments on a '*verte'* clay, and then a series of experiments on a drier clay (Tab. 2.3.3.). As already stated above, being difficult to express the difference in terms of humidity or dryness, I mainly differentiated the two stages (semi-dry and dry) in terms of the type of waste produced during use.

To carry out the experiments I employed eight tools. All the tools were realized on chert types proceeding from the Ebro valley. This is the main raw-material exploited in the prehistoric sites analysed in this work. In three cases I realized a previous retouching of the edge to regularize it or to make it more obtuse. The remaining tools were used unretouched. All the tools were handled by hand.

2.3.3.1.2.2. Ceramic Repairing

Four borers have been manufactured employing a chert type proceeding from the Ebro Basin, the same chert-type of most the specimens recovered in the archaeological contexts. The tip has been retouched through direct abrupt retouch, occasionally flattening the point with an inverse flat retouch, as observed on the archaeological borers. However, in one case I did not retouched the tip. I employed a naturally pointed flake to see its effectiveness, as well to observe the type of scars produced on the edge by the drilling motion.

Drilling movements have been realized without any haft. In only one case I employed a small of piece of leather to handle the tool without being hurt. The time of use of each tools have been approximately of 15-20 minutes, the time necessary to perform a complete perforation. In only one case I used the same borer (without any resharpening or successive retouching) for two perforations. Moreover, during the work I observed that the addition of a little quantity of water on the drilling spots considerably favours the perforation of the ceramic surface, making it softer and easier to drill. However, in two cases I drilled the ceramic completely dry.

2.3.3.2. Results

2.3.3.2.2. Ceramic Production

The first two experiments that I realized were practiced about eight hours after the production of the vessels. The clay was still humid, but resistant and rigid enough not to be

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[2] Translation: «the moment in which the clay, after drying, is firmly enough not to be deformed by the pressure of the tool, but it is still moist and supple enough to allow the formation of regular chips».

[3] Translation: '*argille plus plastique*' - more plastic and humid clay; '*argille plus ferme*' - drier clay;

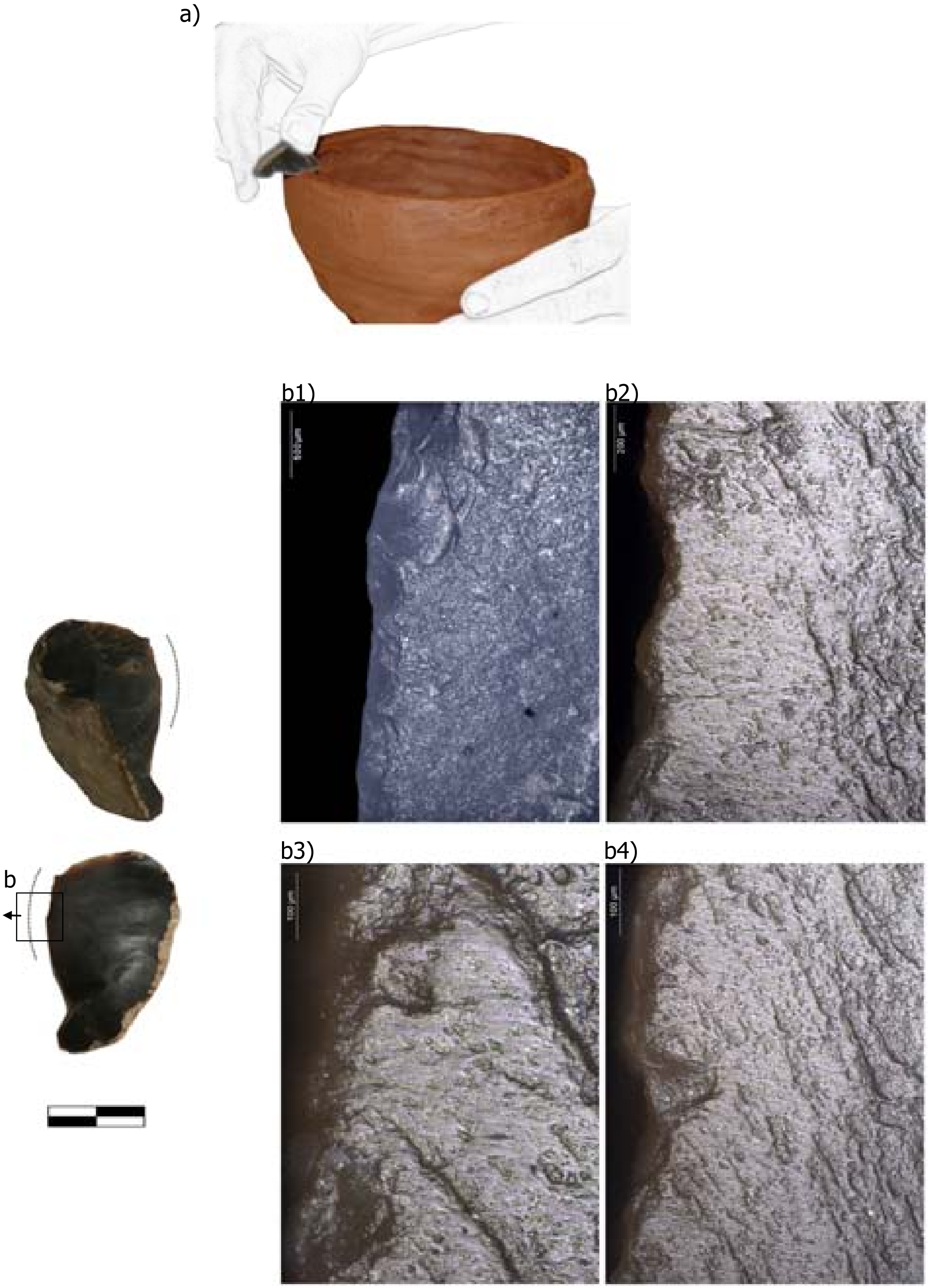

Fig. 2.3.9. *a*) Schematic representation of the performed action: thinning the vessel's lips, 25 minutes. *b*) Edge used for thinning the vessel's lips. Chamotte-tempered ceramic in semi-dry state; *b1*) edge-scarring, 50X; *b2*) Same side, 200X. Smooth band of compact matt polish characterized by transversal striations. Note the strong rounding of the edge, completely abraded; *b3-4*) Details of the same area, 200X.

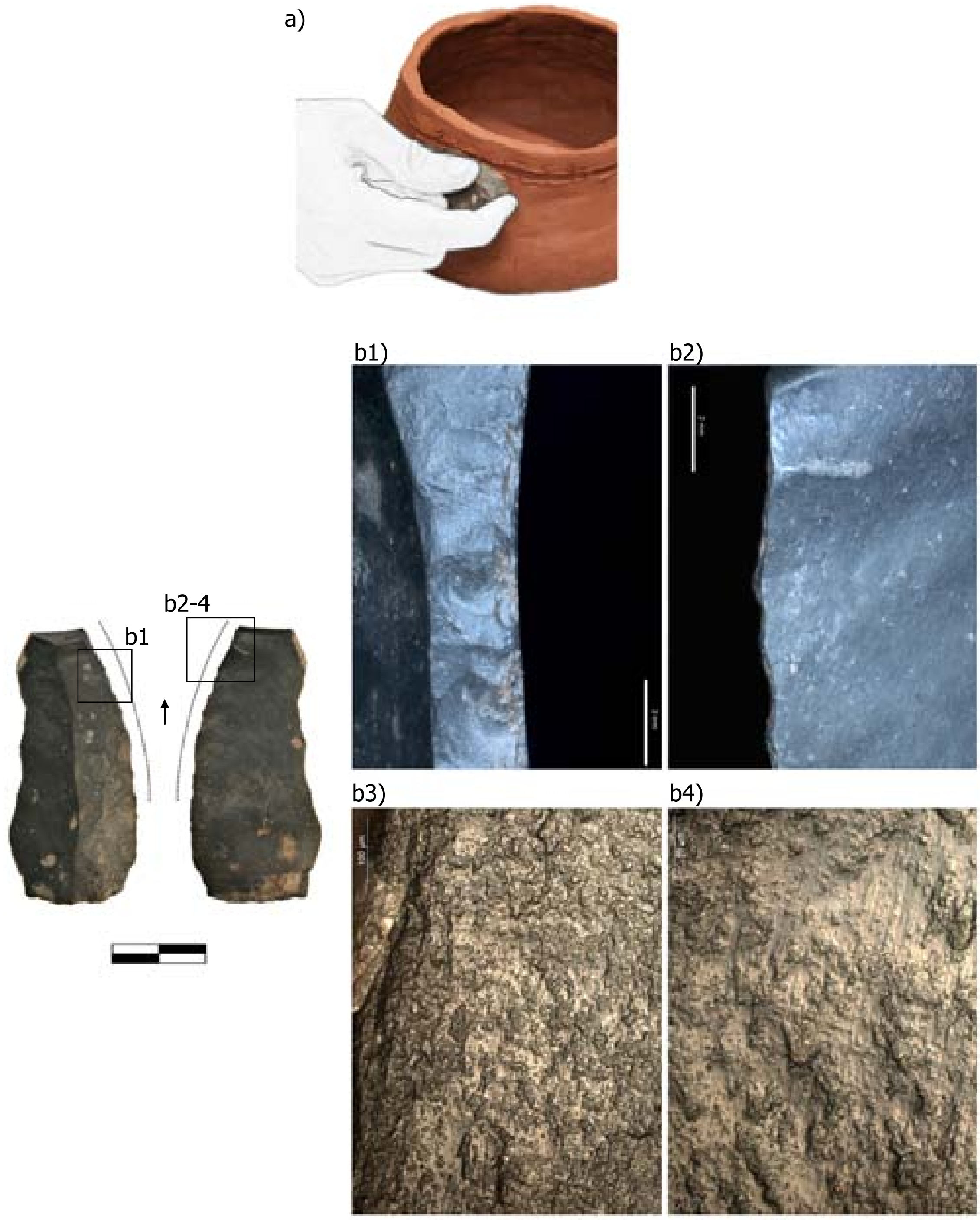

Fig. 2.3.10. *a*) Schematic representation of the performed action: graving the vessel's walls, 15 minutes. *b*) Edge used for graving/decorating the vessel's walls. Quartz-tempered ceramic in semi-dry state; *b1*) retouched edge, 10X. Note the strong rounding; *b2*) Same side, ventral face, 10X. Note the presence of a marginal lustre; *b3*) Spots of smooth bright polish with longitudinal directionality. The edge of the tools is strongly abraded, and part of the polish destroyed, 200X; *b4*) Spots of smooth bright polish in the distal portion of the edge, 400X.

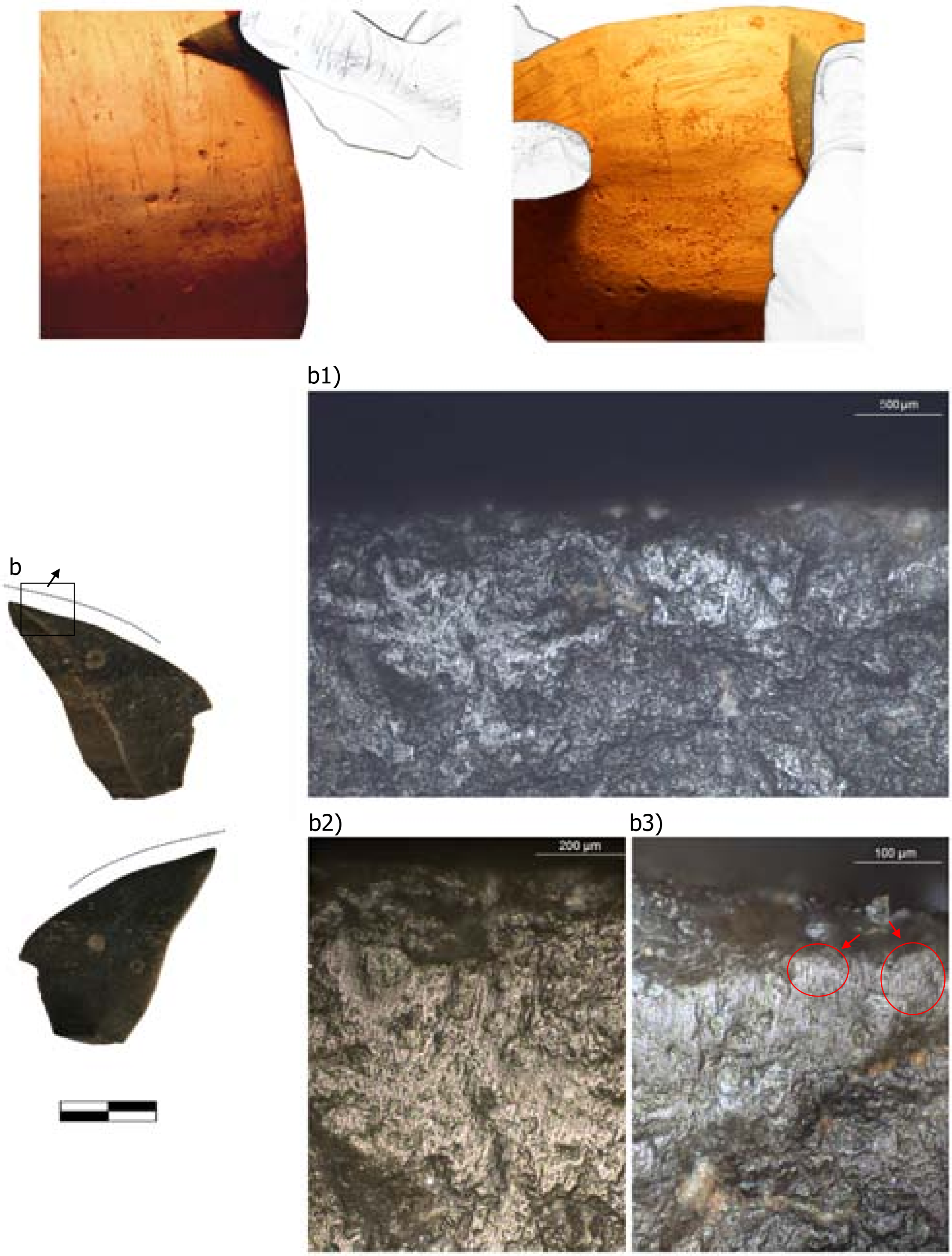

Fig. 2.3.11. *a1-2*) Schematic representation of the performed actions: thinning and polishing the vessel's walls, 20 minutes. *b*) Edge used for smoothening/polishing the vessel's walls with transversal directionality. Chamotte-tempered ceramic in dry state; *b1*) Unretouched active edge, 50X. Note the strong rounding and the presence of overlapping abrasions on the very edge; *b2*) Same side, dorsal face (contact face), 100X. Abrasive rough polish characterized by dense striations with transversal orientation; *b3*) Same face, other point of the edge, 200X. Rough polish with striations. Note the occasional presence of flat, bright spot of polish (red arrows).

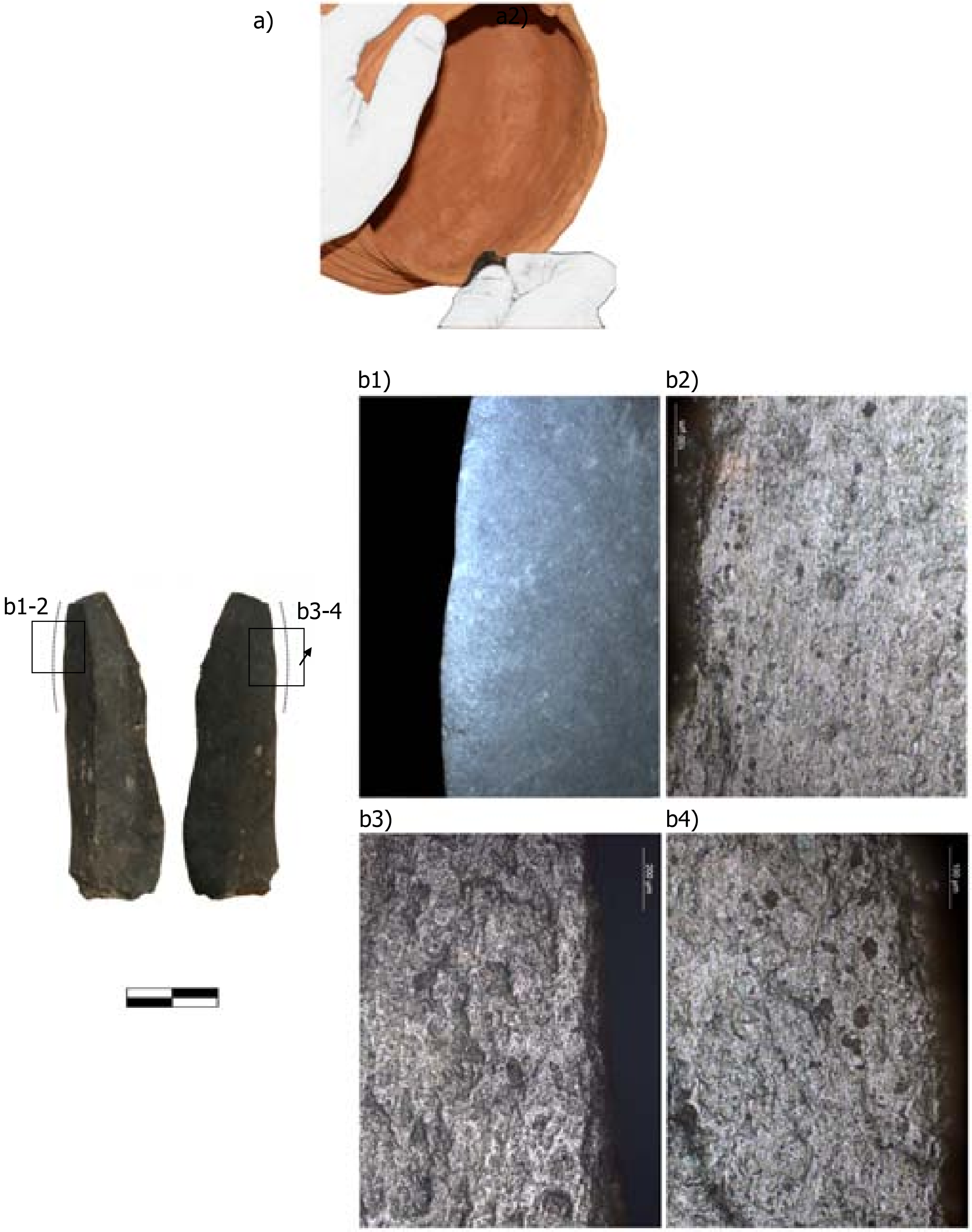

Fig. 2.3.12. *a1-2*) Schematic representation of the performed actions: thinning and smoothening the vessel's lips, 25 minutes. *b*) Edge used for thinning/smoothening the vessel's lips with diagonal/longitudinal directionality. Quartz-tempered ceramic in dry state; *b1*) Unretouched active edge, 10X. Note the presence of superficial lustres; *b2*) Same side, dorsal face, 200X. Abrasive rough polish characterized by dense striations; *b3*) Ventral face (contact face), 100X. Rough marginal polish with diagonal striations. Note the occasional presence of flat, bright spot of polish (red arrows); *b4*) Detail of the same area, 200X

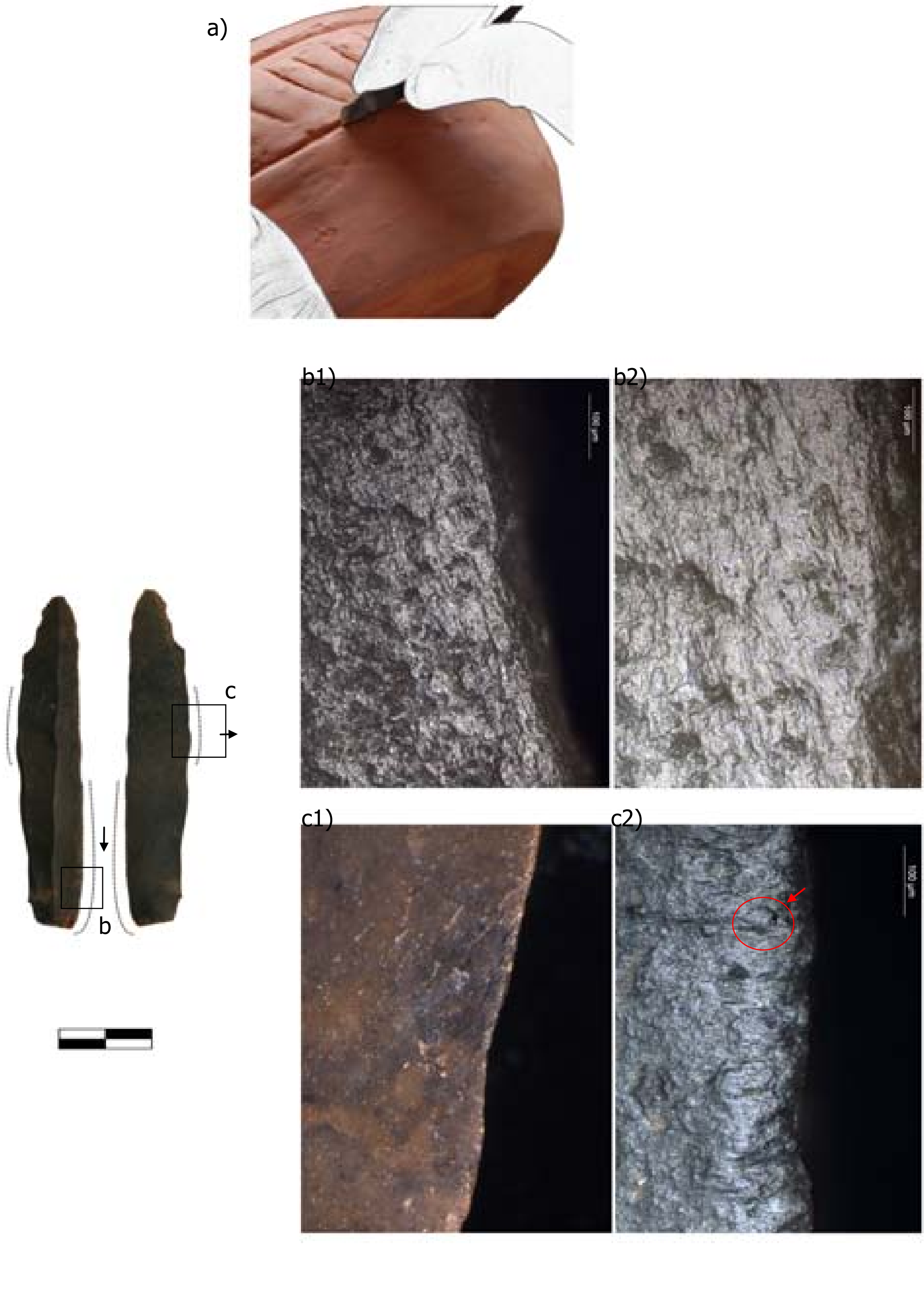

Fig. 2.3.13. *a1-2*) Schematic representation of one of the performed actions: *a*) graving/decorating the vessel's walls, 15 minutes. *b*) Edge used for graving/decorating the vessel's walls. Chamotte-tempered ceramic in dry state; *b1*) Retouched active edge, 100X. Note the strong rounding and the presence of parallel abrasions on the very edge; *b2*) Same side, 200X. Abrasive rough polish characterized by dense striations and strong edge-rounding; *c*) Edge used for thinning the vessel's lips. Chamotte-tempered ceramic in dry state; *c1*) Unretouched active edge, 10X; *c2*) Rough polish with transversal striations, 200X. Note the occasional presence of flat, bright spot of polish (red arrow).

deformed by the pressure of the tool. In this case I expected traces quite similar to the obtained by Gijn (1989) and Gassin (1993).

The first tool has been used with transversal motion for thinning the vessel's walls and lips. The used edge was unretouched, with an angle of 40°. The resulting wears are: a pronounced edge-rounding, a marginal lustre over the active zone —especially on the contact face, the ventral one— and a marginal scarring, with feather-termination fractures distributed continuously on both faces. Microscopically wears strongly resemble to the traces published by Gijn (1989) and Gassin (1993). The polish shows a clear transversal directionality, with the presence of many striations of different size and deepness, however it also shows large spots of a compact and matt polish (Fig. 2.3.9., *a-b*).

The second tool used on semi-dray clay is a blade employed to perform a linear decoration —graving the vessel's walls. The blank have been previously retouched to obtain a step and regular edge. The resulting wears present almost the same features as before, except for the directionality, which in this case is clearly longitudinal. After the use, the retouch scars appeared strongly rounded, however only few spots of polish have been identified on the dorsal face. This was mainly due to the continuous abrasion that suffered the edge that leads to the partial destruction the same use-wear traces that were forming on it (Fig. 2.3.10., *a-b*).

After those experiments, I realized the same tasks but in drier conditions. A series of tools have been used to further thinning and smoothening the vessels' lips and walls. On a macroscopic level resulting wears were quite similar: strong edge rounding, a marginal lustre (which perhaps is developed more rapidly than with semi-dry clay), and a marginal micro-scarring, almost unperceivable at the naked-eye. However, at higher magnifications several differences are observable. The smooth and matt spots of polish that were produced working semi-dry o green clay are now leaving space to a rougher polish characterized by a dense series of abrasions and strias. Occasionally some spots of more compact and smooth polish are still visible. Moreover, bright friction spots characterized by chaotic striations are also observed. These are probably produced by the friction with some larger grain of mineral (Fig. 2.3.11.). The number and length of the striations appears greater in longitudinal/ diagonal movements in respect to transversal ones (Fig. 2.3.12 and Fig. 2.3.13). A longitudinal/diagonal orientation could be also result from the activity of lips thinning a smoothing (Fig. 2.3.12); however, it also depends from the way in which the tool is handled and the portion of the edge used.

2.3.3.2.2. Ceramic Repairing

Five perforations have been realized and lithic borers appeared an appropriate tool for this task (Fig. 2.3.16). Baked pottery is very hard material and thus is necessary great pressure on the instrument to perform a complete perforation. For this reason, the previous retouching of the tip is a fundamental step, as an unretouched tool —even if characterized by a thick pointed extremity— suffers a continuous fracturing of the tip that impede the correct performing of the activity.

Edge-fracturing occurs also on retouched tools, however in this case the scarring is marginal and limited to the edges and the ridges of the point. However, the feature that characterizes this type of tools is the strong edge-rounding. The borers loss their tip almost immediately when the first pressure against the ceramic walls is exerted. Then, only a minor scarring occurs; on the contrary a continuous abrasion of the lithic surfaces is produced for the entire duration of the movement (Fig. 2.3.14, *a1-b1*; Fig. 2.3.15, *a1*). Rounding is more pronounced and generalized when water is added to ceramic, while with dry ceramic there is

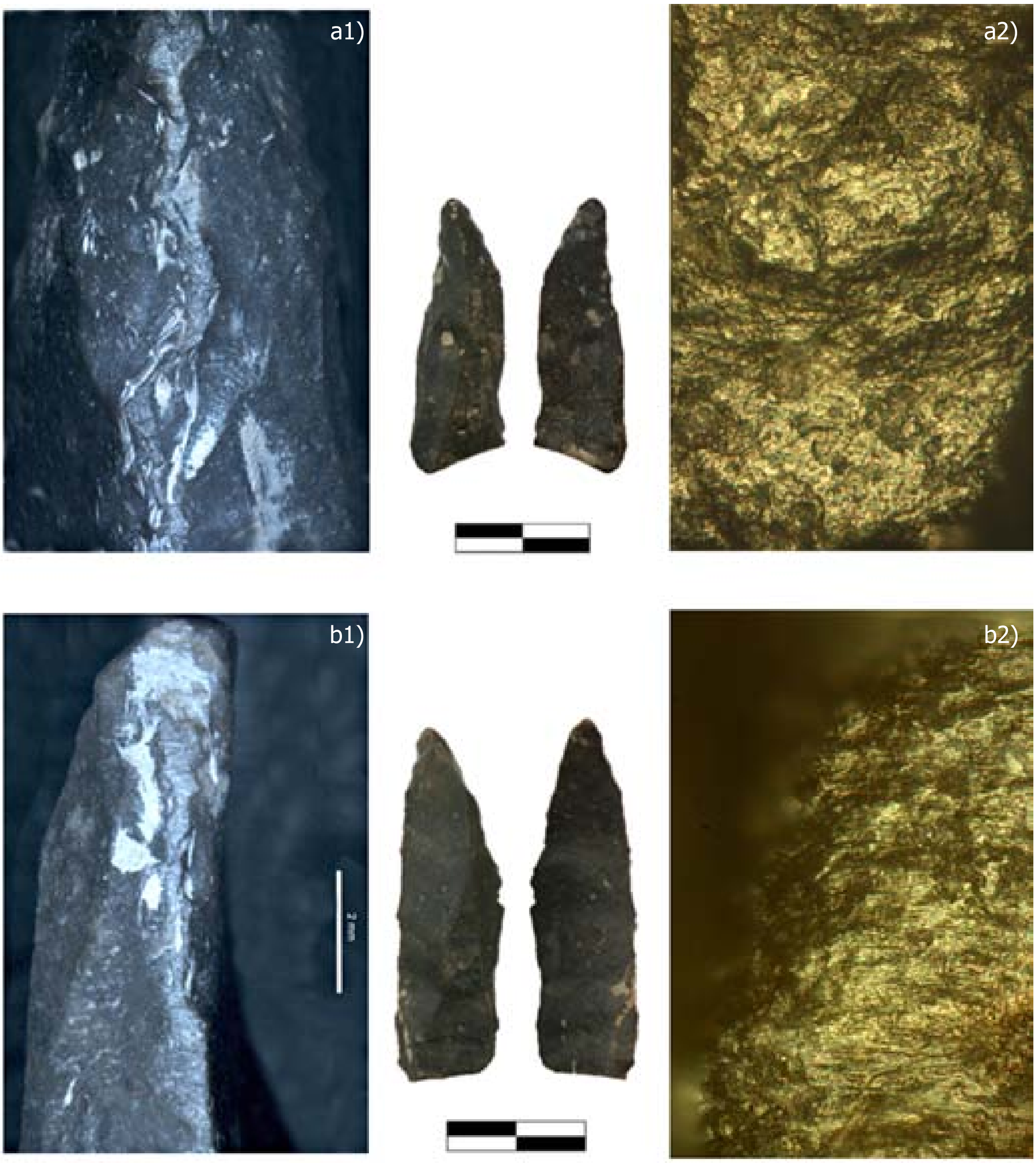

Fig. 2.3.14. *a*) Drilling pottery 20'. Tool employed for one perforation with the addition of water. *a1*) Macro-traces: all the point is characterized by a strong rounding of the lateral ridges, 15X; *a2*) Micro-traces: a rough polish is diffuse all along the rounded edge, with the presence of strias and tiny flat spots of compact polish, 200X. *b*) Drilling pottery 40'. Tool employed for two perforations with the addition of water. *b1*) Macro-traces: all the point is characterized by a strong rounding of the lateral ridges, 15X; *b2*) A rough polish diffuse all along the rounded edge, with the presence of many parallel striations, 200X.

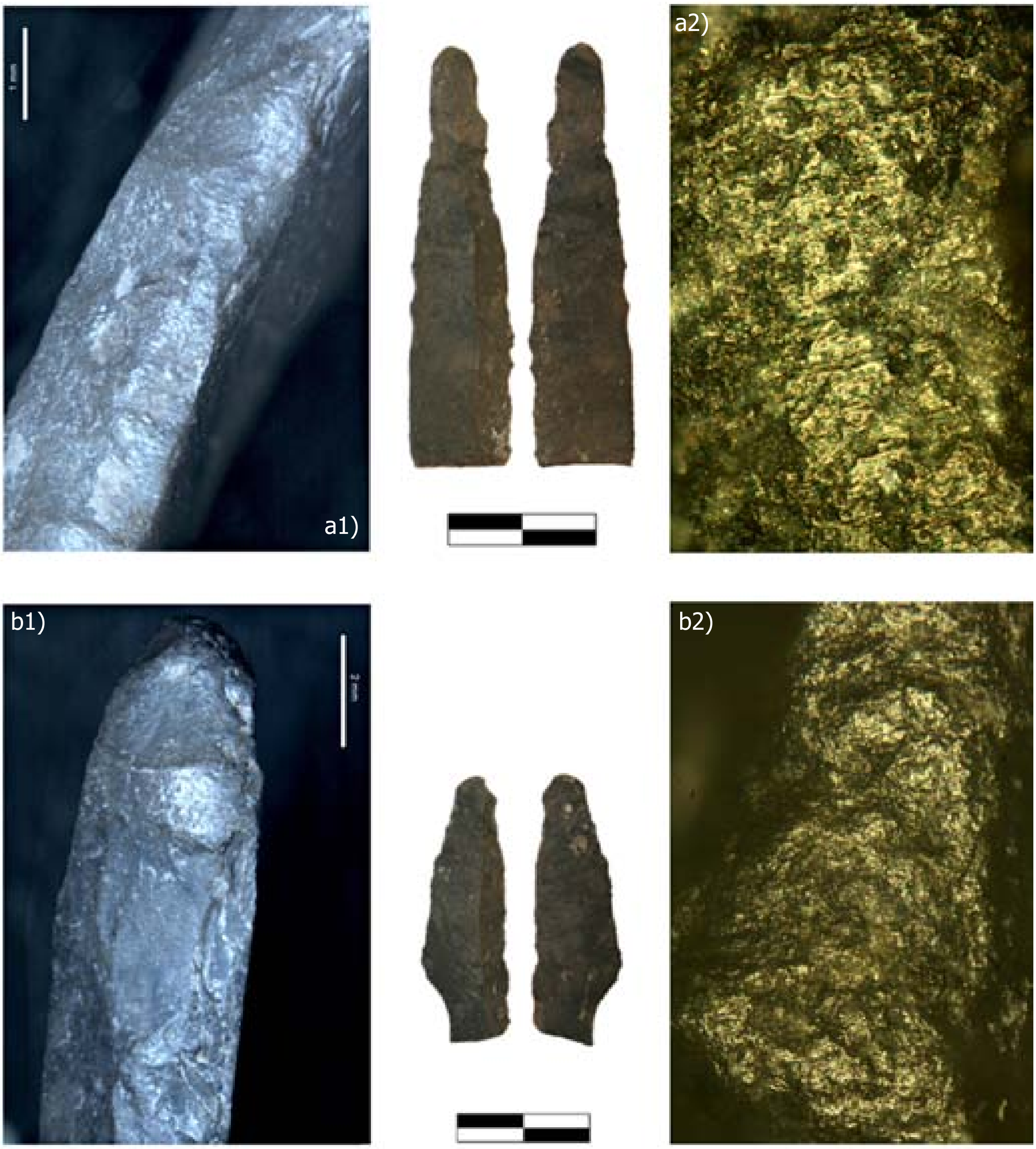

Fig. 2.3.15. *a*) Drilling pottery 15'. Tool employed for one perforation with the addition of water; *a1*) Macro-traces: the tip is characterized by a very strong rounding. In particular the two side of the tip show an abrupt rounded edge, 20X; *a2*) A rough polish diffuse all along the rounded edge, with the presence of tiny strias and flat spots produced by the contact with mineral grains. *b*) Drilling pottery 20'. Tool employed for one perforations on dry ceramic. *b1*) Macro-traces: the point is characterized by a mayor scarring. Only few contact-points developed a more intense rounding, 20X; *b2*) Rough uncharacteristic polish spreads all over the tip, 200X. Note the presence of tiny rounded spots.

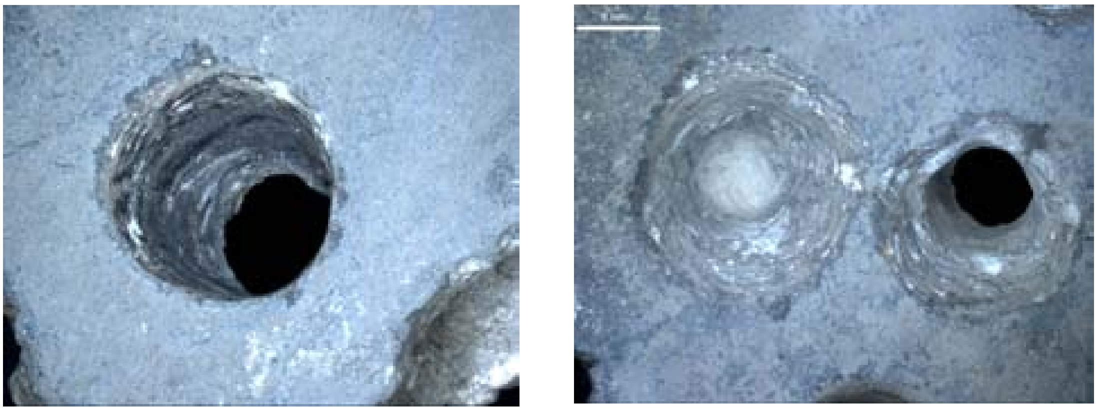

Fig. 2.3.16. Three experimental perforations on pottery fragments. Note the presence of parallel strias within the hole, following the drilling movement.

a major fracturing of the edges and the rounding is limited only to few spots (Fig. 2.3.15, *b1*).

On a microscopic level one can observes two main types of wears. First of all, a general lustring of the surface is produced all over the point. Bright points are visible all over the surfaces, however they are clearly distinguishable only at high magnifications (400X or more). This is a very uncharacteristic polish (Fig. 2.3.15, *b2*), quite difficult to distinguish from other wears. On the contrary, on the most rounded areas of the tip, where a mayor contact with the pottery occurred, more developed traces are visible. Such polishes are characterized by an open texture, a rough aspect and the presence of many strias with orientation perpendicular to the point, following the direction of the drilling movement. Traces are more abundant when water is added to ceramic, while with dry ceramic polishes and strias are limited to few spots. Tiny, compact bright spots, produced by the friction with mineral grains, are also visible.

2.3.3.3. Discussion

From the experiments realized, it resulted clear that the dryness of the worked clay/ pottery has a great influence on the resulting use-wear. Fullagar (1991) already pointed out that water is a fundamental factor in use-wear formation and thus this consideration it is not surprising. In both the experiments realized —drilling baked pottery and working dry/semi-dry clay— I saw that the humidity of the worked material (that is the quantity of water) is a discriminating factor in traces development; it affects the polish extension and its aspect.

For what concern baked pottery, one can affirms that the use of lithic borers represent an appropriate tools for drilling motions; such tools are likely to have been employed for this type of repairing activities during the past. The presence of several heavily rounded borers among the studied assemblages, as well of several ceramic fragments with marks of perforations comparable to the ones obtained experimentally (*cfr*. Chap. 3, par 3.4.2.1.3.1. and Chap. 5., par 5.4.2.1.3.), seems to confirm this hypothesis.

For what regard the other traces related to pottery working, the situation is slightly more complicated. With this preliminary experimentation I have been able to reproduce different types of wears related both to semi-dry and dry clay working. Clear differences between the

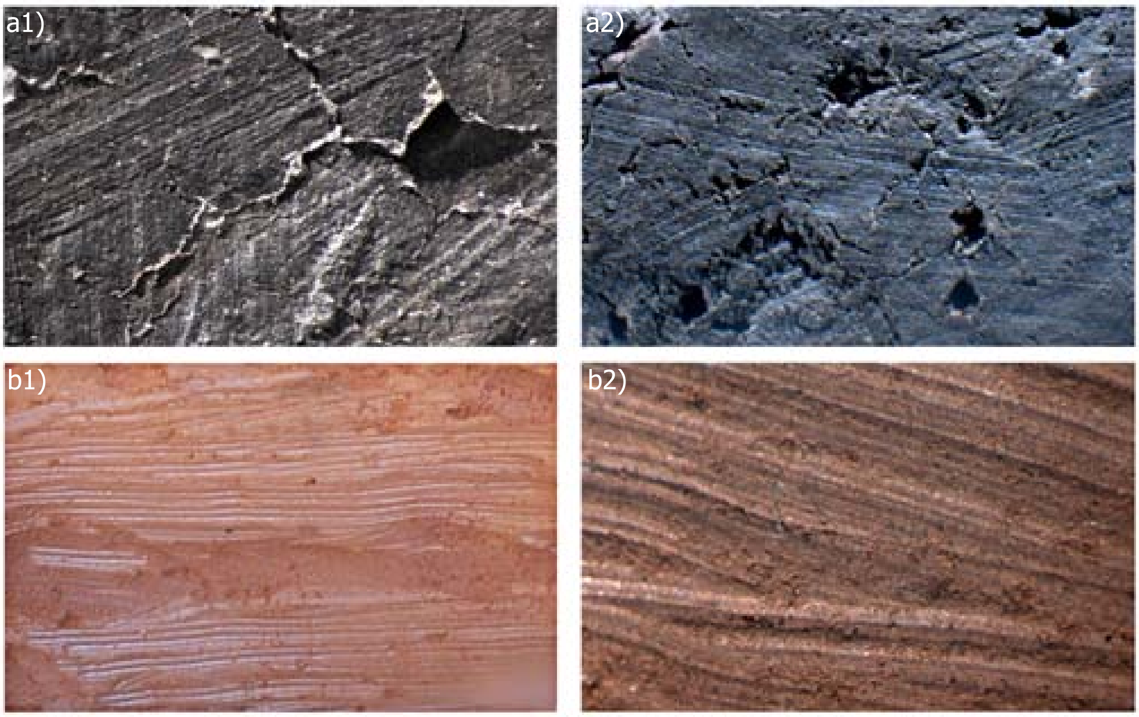

Fig. 2.3.17. Photos of archaeological and experimental marks on ceramic surfaces. *a1-2*) two ceramic fragments from Els Trocs cave characterized by linear marks; *b1-2)*: marks produced experimentally on dry clay by the smoothing of the surfaces with a lithic tool.

two type of traces are visible. However, their archaeological relevance is still difficult to assess.

The experimental traces resemble pretty much the traces observed on the archaeological samples (Fig. 2.3.18), even if not always there is a perfect coincidence between the experimental and the archaeological wears. Indeed, a wide variety of micro-wears patterns have been highlighted and certain variability is observable from wear to wear, especially in the quantity of strias, in the extension of the polish and in the occurrence of pits and craters. Probably several factors influence the use-wears formation, not only the clay dryness. The quantity, the size and the type of tempered materials also appears to play a major role. In this sense, is certainly necessary to carry out a broader experimentation, using more types of ceramic pastes with a mayor variety of tempering materials. On the basis of the obtained results, it seems that fine-grained tempering materials are capable of producing more extensive wears, while coarse materials are more destructive, often removing the use-wear polishes. Moreover, it should be also considered the possible effect of taphonomical agents on the archaeological use-wears, which can lead to certain degradation the traces (*cfr*. Chap. 2, Par. 2.31.). These phenomena should be taken in account as well at the moment of comparing experimental with archaeological polishes.

Concluding, this experimental work suggest that the use of lithic tools both for thinning or polishing the pottery vessels could be functional also with dry clay. When dry, clay surfaces are more resistant to deformation and thus it results more easy to proceed to their finishing and smoothing without removing an excessive quantity of material. Moreover, the vessel itself is more handy, being less fragile and more stable.

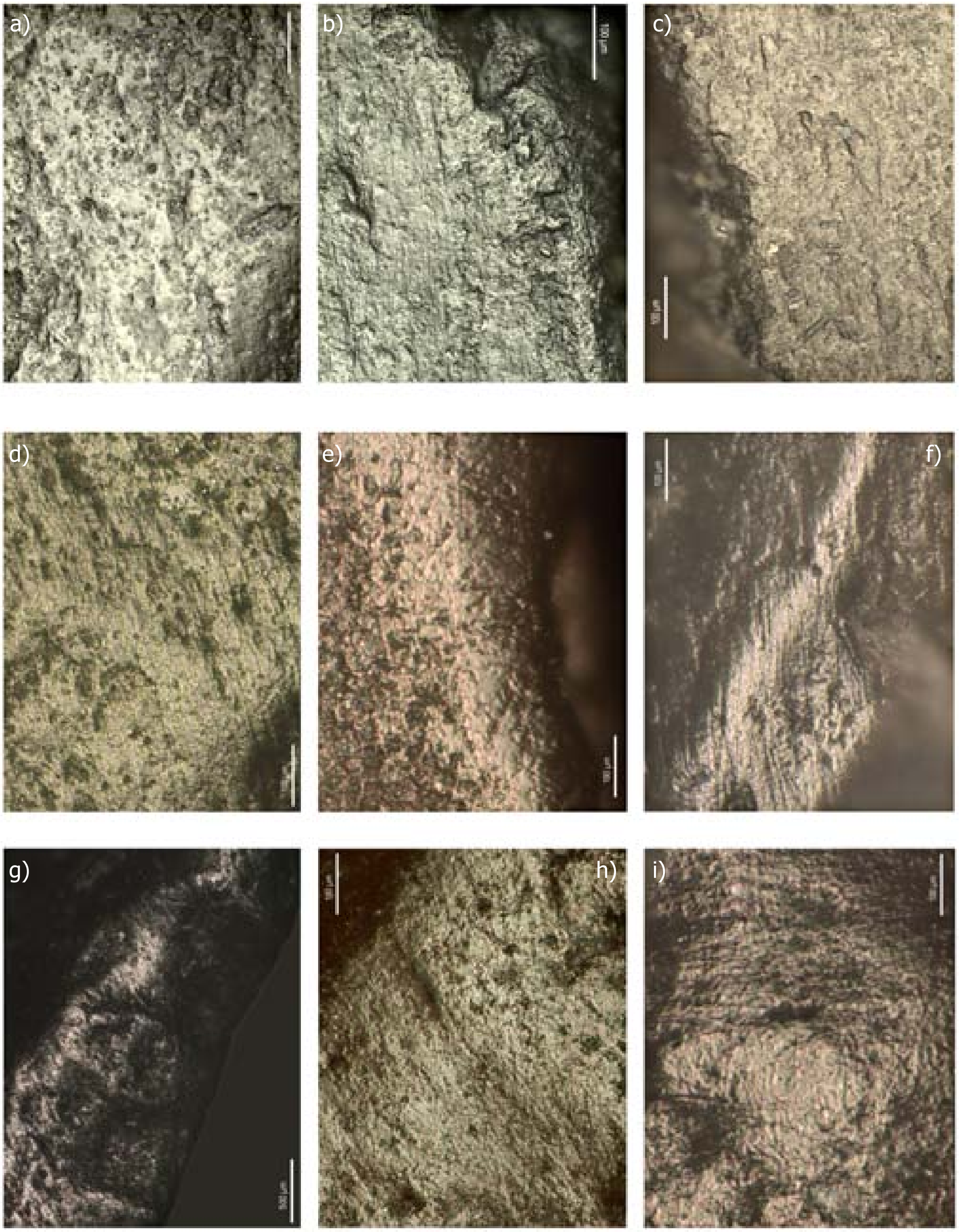

Fig. 2.3.18. Archaeological materials. Traces attributed to the work of some type of abrasive mineral material, possibly semi-dry/dry clay. *a-b*) Cova del Els Trocs-phaseIII; *d*) Espluga de la Puyascada-levelE.II; *e-i*) Cueva de Chaves-level1.b.

The identification, on some archaeological fragments proceeding from the Els Trocs cave, of several linear marks that seem made by a sharp edge (Fig. 2.3.17, *a*), suggests that also chipped stone tools were occasionally use to smooth or regularize the ceramic surfaces. Such marks resemble pretty much the type of streaks left by lithic tools on dry ceramic (Fig. 2.3.17, *b*). Both marks are characterized by parallel strias of different deepness and width. Experimentally, such irregularities are produced by the irregularities that characterize the lithic edge itself, which is never perfectly plane or homogeneous. However, a much more detailed study —which was not the objective of this work— should be carried out to confirm this hypothesis.

3. Cueva de Chaves

3.1. Introduction

Cueva de Chaves de Bastarás is one of the most important sites for the Iberian Neolithic Age. Since the first publication (Baldellou & Castán 1985; Baldellou 1985b), this cave had a primary role in the construction of explanatory models about the diffusion and development of a production economy in the Ebro Basin and, more in general, in the NE of the Peninsula.

The excavation of Cueva de Chaves probably represented the first systematic research project on the Neolithization of Aragón. The promising results of the archaeological excavations at Chaves favoured the development of an intensive research activity over the entire region. During about two decades, almost fifteen sites were investigated thanks to the works of the Museo Provincial de Huesca and the Universidad de Zaragoza (e.g. Espluga de la Puyascada, Cueva del Forcón, Cueva del Moro de Olvena, Abrigo de Forcas II, Abrigo de Huerto Raso, Cueva Pacencia, Paco Pons, Samitiel, Riols, Abrigo de Ángel, Abigo del Pontet, *etc.*) (Alday et al. 2012a).

In this scenario, Cueva de Chaves has represented the reference point for elaborating the main theories on the Neolithization of the area since the early years of its excavation (Baldellou 1987b; 1989; 1994; Baldellou & Utrilla 1999). Along with the Valencian sites of Cueva de l'Or or Cueva Cendres, Chaves became one of the paradigmatic sites of the Iberian Neolithic Age, representing the full development of the Neolithic *modus vivendi*, from both an economic and ideological/symbolic point of view (Utrilla & Baldellou 2001-2002; Alday et al. 2012a).

However, even if the cultural, symbolic, and funerary aspects of the cave have been object of several investigations (Baldellou & Rodanés 1990; Utrilla & Baldellou 2001-2002; Utrilla 2002; Utrilla et al. 2008), the economic organization of the site has scarcely been studied. Until now, the main set of data has been provided by Castaños (2004), with the study of the archaeozoological assemblage, and López-García & López Sáez (2000), with the study of the pollen sequence. One of the aims of these studies was to ascertain the 'production' character of Cueva de Chaves' economic organization or, in other words, demonstrate the presence of domesticated species, that is, the fundamental element of the 'Neolithic package'. However, even if the faunal assemblage was rich and indicative of a well -established pastoral economy, cereal cultivation has not clearly been demonstrated, at least for the earliest phase of occupation. In fact, except for a silo (Zapata et al. 2008), no thorough anthracological or carpological studies have so far been carried out for the site.

Despite its richness, the material record has mainly been described from a typological and technological point of view (Gallart & López 1988; Cava 2000; de la Fuente 2001; Ramón 2006). There is still a poor knowledge of the production and domestic activities which were carried out at the site.

My aim is to achieve a socio-economic approximation of the lithic record from Level I.b, thus reconstructing the economic processes in which the chipped stone materials were involved. So far, traceological analyses have only been accomplished for a small sample, by selecting specific typological classes (Domingo 2009). This study is then integrating the available information on the site function and improving the understanding of the economic organization of the first agro-pastoral communities in the Central Pyrenees.

3.2. General Information

3.2.1. Geographical Framework

The coordinates of Cueva de Chaves are: X: 735391 and Y: 4675860 (ETRS89 UTM30). The site is located in the NE of the Iberian Peninsula, in the autonomous community of Aragón, about 30 km north-east of the town of Huesca, near the small village of Casbas de Huesca. The cave entrance is situated at 663 m.a.s.l., on the southern slope of the Sierra de Guara Mountain. Sierra de Guara is a range that belongs to the Sierras Exteriores system, which is the southernmost mountain chain of the Aragón pre-Pyrenees. Its highest peak is Pico de Guara (2,077 m.a.s.l.).

The Sierras Exteriores extend in a west-east direction for about 125 km, parallel to the Axial Pyrenees, which are located about 60 km north of the site (Fig. 3.1, *a*; *cfr*. Chap. 1, Par. 1.2.). The Sierras Exteriores are characterized by a strong environmental gradient between the northern and southern slope. Actually, the western sector's climate is influenced by the continental Axial zone and so it is characterized by colder and humid conditions. The vegetal coverage is here dominated by oaks, in particular *Quercus faginea* and *Quercus cerrioides*. The southern slope mostly shows a Mediterranean influence. The climate is warmer and drier and the vegetation is almost exclusively characterized by shrubby taxa such as *Juniperus*, *Genista*, and *Echinospartum*. The arboreal cover is limited to residual zones of angiosperms and coniferous trees (*Quercus, Fagus*, and *Pinus)* (Baldellou & Castán 1985; Baldellou 1990).

The main river of the region is Alcanadre, which runs about 5 km east of Cueva de Chaves. However, the area is characterized by the seasonal presence of several streams. Other rivers of the region are Alcanadre's tributaries, amongst which Mascún, Flumen, and Guatizalema (Fig. 3.1, *b*).

The cave is oriented west-southwest. The maximum width is about 60 metres and the height about 12 metres. Its maximum length is ca. 225 metres, although the main chamber does not measure more than 110 metres. In addition, there are secondary tunnels that penetrate the mountain for another 50 metres (Fig. 3.2, *b*). The site is extremely sunny, characterized by good climatic conditions; the daylight reaches a large part of the cave, with a surface area of about 500 m^2.

3.2.2. Archaeological Researches

Presence of archaeological remains inside the cave was reported as early as the beginning of the 20th century. However, systematic survey works began only during the sixties with the Grupo de Investigación Espeleológica (G.I.E.) of the Peña Guara Hiking Club.

The first archaeological excavation started in 1974-75, which was organized by the Museo Provincial de Huesca and led by Dr. Vicente Baldellou, director of the museum. During this first investigation, four stratigraphic surveys (Cat.1, Cat.2, Cat.3, Cat.4) were carried out at the cave entrance and an area of 15 m^2 was dug out (Fig. 3.2, *b*).

The excavation consisted of artificial cuts, each about 5-10 cm deep. Later, the artificial levels were grouped into four archaeological phases. Apart from the surface layer, a Bronze-Age occupation and two Neolithic contexts were identified (Baldellou 1985b).

Given the great potential of the archaeological deposit, a series of new excavation campaigns was accomplished between 1984 and 1992, thanks to the collaboration between the Museo de Huesca and the Universidad de Zaragoza (Baldellou & Utrilla 1986; 1991a,

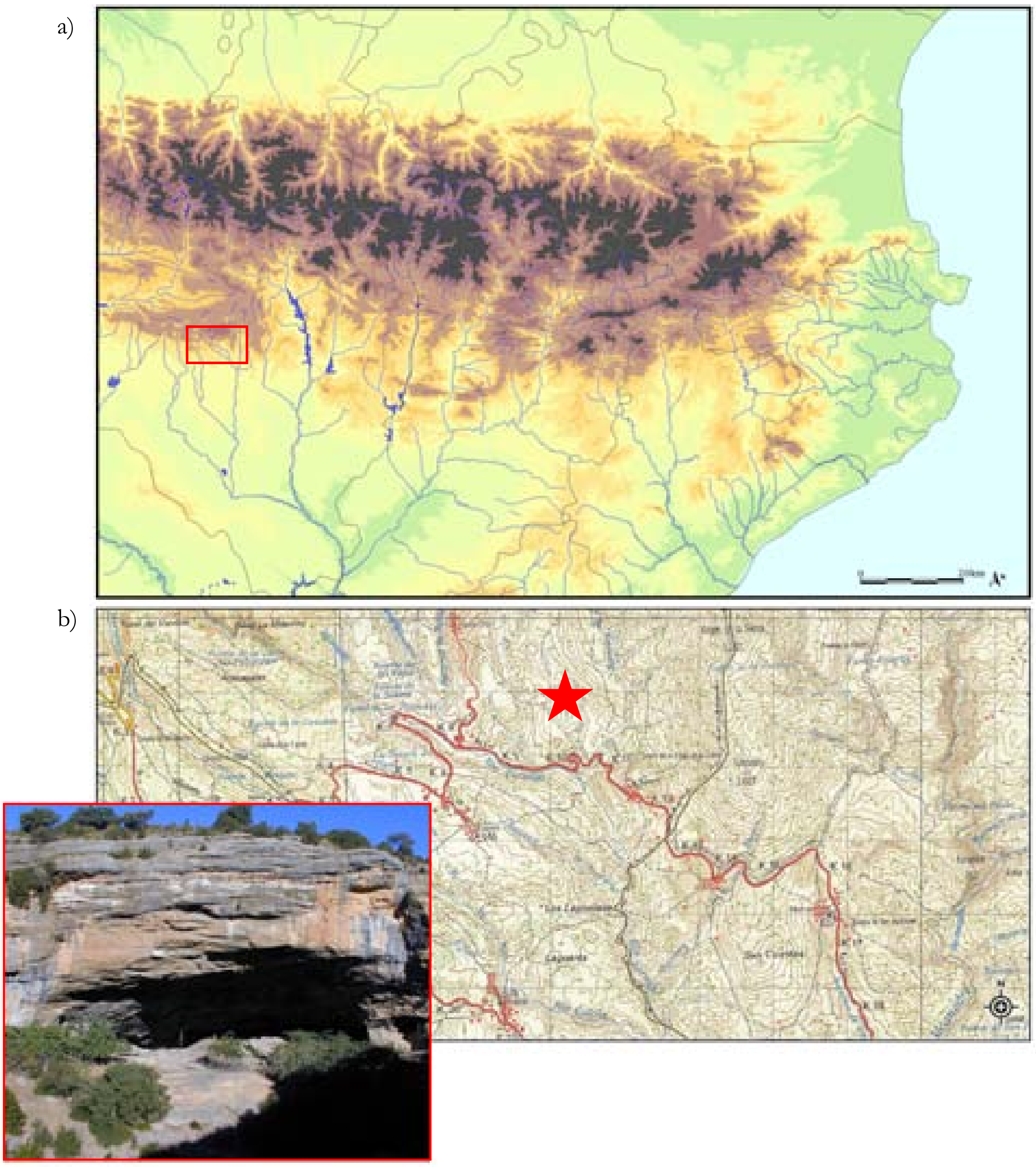

Fig. 3.1. *a*) Geographical framework of the site; *b*) Site location on 1:50.000 map. The red star indicates the exact position of the Cueva de Chaves; *c*) Photo of the cavity entrance.

1991b, 1991c, 1992; Utrilla & Baldellou 1991, 1994). The main purpose was to extend the excavation towards the inner area of the cave, in order to obtain new data about the prehistoric occupation of the site. During this decade, an area of approximately 90 m² was excavated. The research was mainly focused on the inner area of the cave, about 40 metres from the cave's entrance (Fig. 3.2, *b*). Two additional stratigraphic surveys were carried out in the central area of the cave, where a burial was discovered (Fig. 3.2, *b*).

Aside from the Neolithic contexts, the extension and stratigraphy of which was confirmed, two new anthropic layers were ascertained, which dated back to the Palaeolithic Age, specifically to the Solutrean and Magdalenian period respectively (Fig. 3.3; 3.4; 3.5). These levels were separated from the Holocene occupations by a layer of calcareous

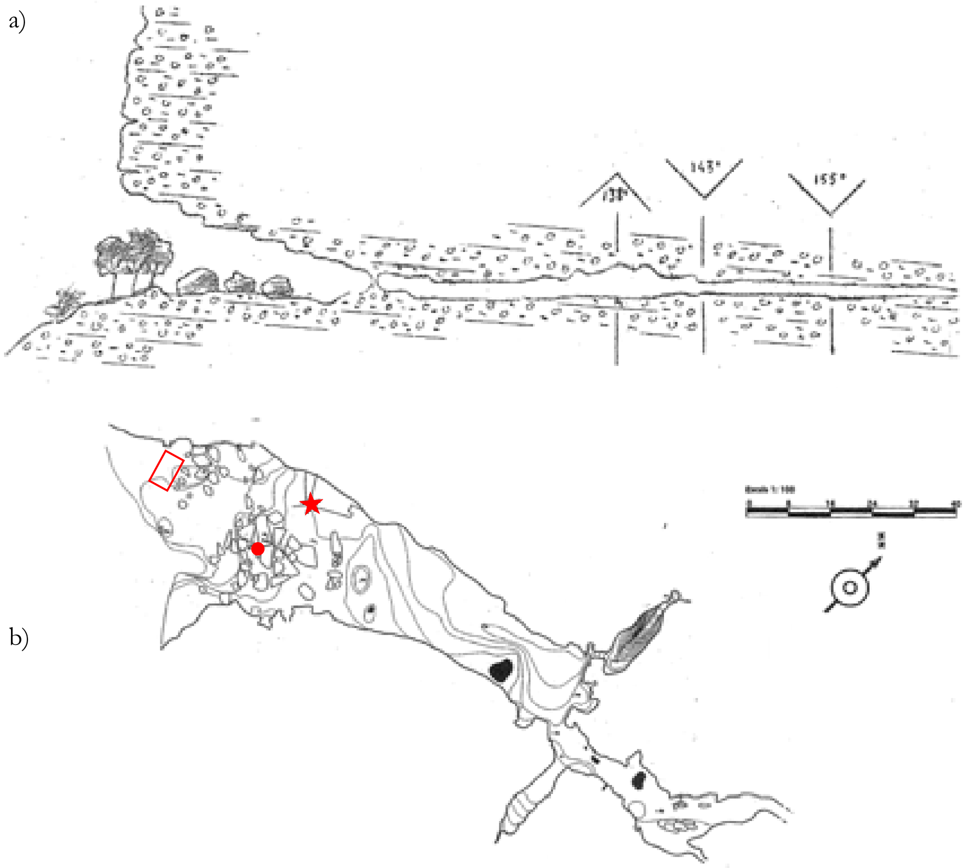

Fig. 3.2. *a*) Section of the Cueva de Chaves. Modified from Abad 1970; *b*) Topographic plan of the Cueva de Chaves. Modified by Baldellou & Utrilla 2001-2002. The red square indicates the area of the 1974-75 surveys; the red star indicates the area of the 1984-1992 excavations; the red point the area where the burial was discovered.

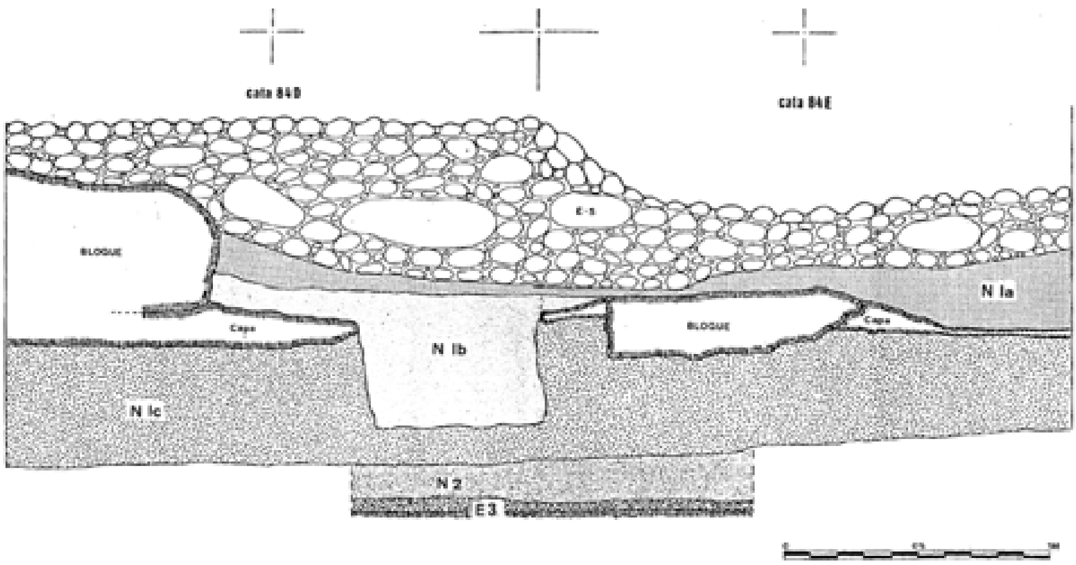

Fig. 3.3. Stratigraphical section of the 84D and 84E squares, from the 1984 excavations. Modified from Baldellou 1985.

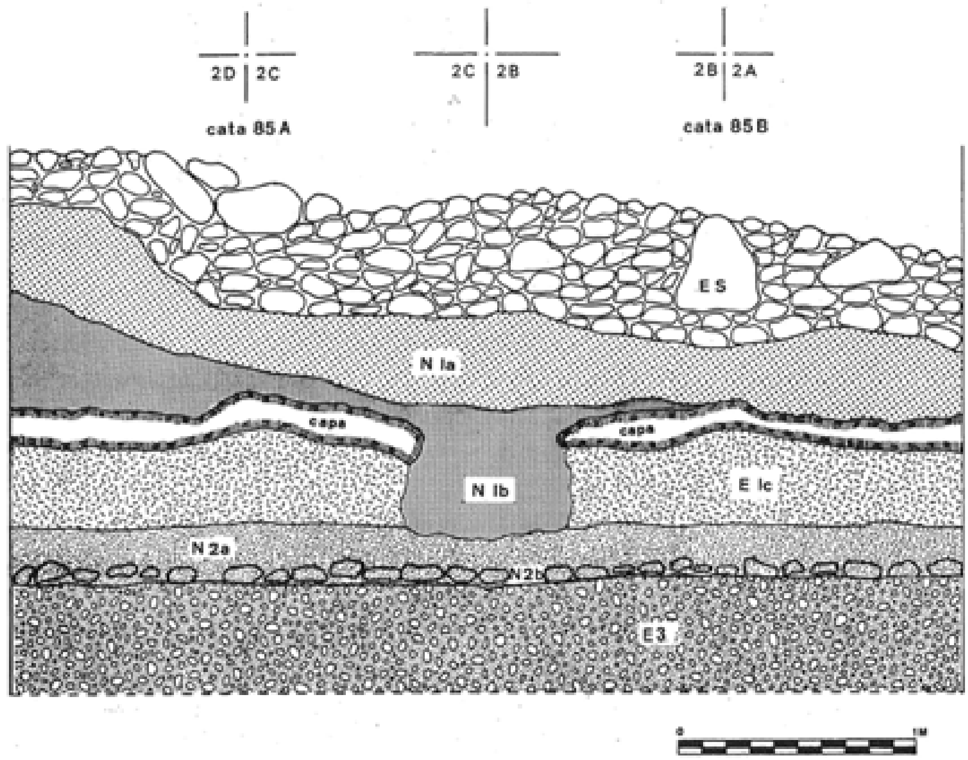

Fig. 3.4. Stratigraphical section of the 85A and 85B squares, from the 1985 excavations. Modified from Baldellou & Utrilla 1991a.

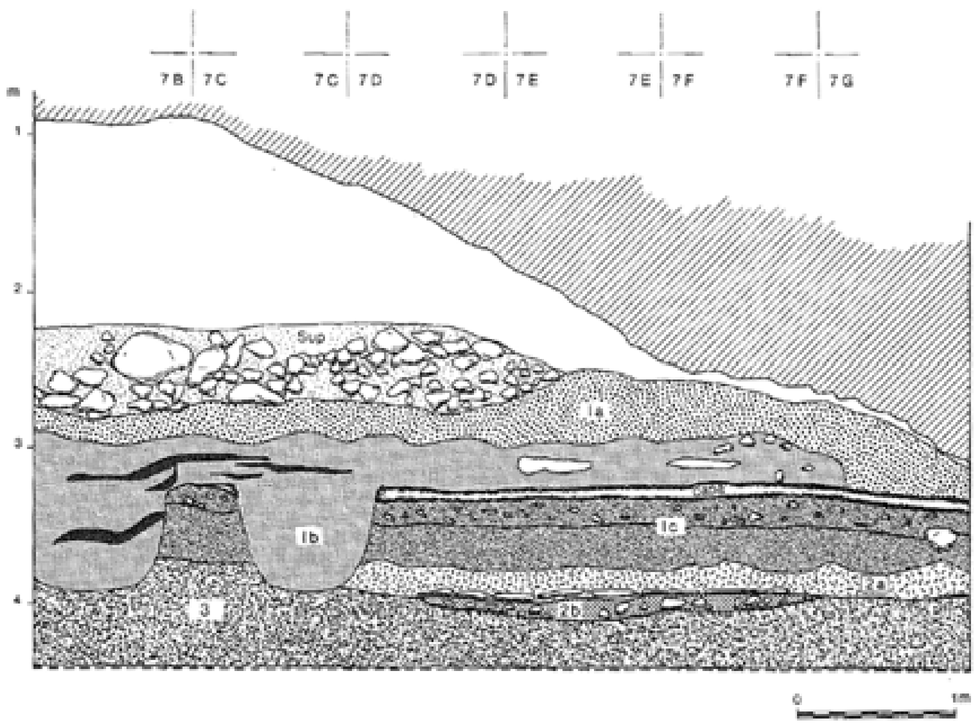

Fig. 3.5. Stratigraphical section of the trench 7, square from 7B to 7G, from the 1989 excavations. Modified from Baldellou & Utrilla 1991c.

concretions, which had sealed the archaeological deposit. The excavation was coordinated by Dr. Vicente Baldellou, who directed the excavation of the Neolithic contexts, and Prof. Pilar Utrilla of the Universidad de Zaragoza, who led the excavation of the Palaeolithic deposit. The excavation area was divided by a grid system, featured by square units of 2 x 2 metres (Utrilla & Baldellou 2008).

The burial discovered in the central area of the cave (Fig. 3.2, *b*), was attributed to the second Neolithic Level (Ia or IIa), an epicardial Early Neolithic epoch. The burial was located at about 50 metres from the domestic area of the cave. The individual was an adult male buried in fetal position and covered by a tumulus of small pebbles. The skeleton worn a bone ring in his middle finger; ceramic shards and lithic fragments were found all over the mound (Baldellou & Utrilla 1986; Utrilla et al 1998).

In 1998, after an interruption of five years, new excavations were carried out extending the research towards the cave entrance. In this sector, an area with many storage-pits was discovered. However, the results of this excavation are still largely unpublished.

In 2007, the site was completely destroyed by unauthorized works. The entire area of the cave, about 3000 m^2, was excavated by mechanical diggers, thus destroying the whole Holocene deposit.

3.2.2.1. The Excavation of the Level I.b

The first data about the Neolithic occupations of the cave was obtained during the 1974-75 works. An about 20-30 cm deep layer, characterized by the presence of Cardium Ware, was detected under the cave entrance (Baldellou 1985a). This level was originally called N.IIb, in order to distinguish it from the upper level N.IIa. Both contexts were ascribed to the Neolithic Age; specifically, the lower one to the Cardial Neolithic period and the upper one to an Epicardial phase.

During the excavations of the eighties and nineties, the research focused on the inner area of the cave. In 1984, an area of 16 m^2 was investigated in the southwestern sector of the cave. In squares 84D and 84E, the first Neolithic pits (Pits *A* and *B*) were brought to light (Fig. 3.3), which were found in Layer II.b (now called I.b), situated in the underlying calcareous stratum. During the campaign of the following year, in 1985, the excavation was extended by the survey of two new squares (85A and 85B). Another structure (Pit *C*) was identified (Fig. 3.4). The majority of lithic, ceramic, and bone materials was recovered in the sediment filling the pit (Baldellou 1987). In 1986, two new squares were dug out (86A and 86B), in order to complete the excavation of Pit *B*: according to the great amount of ash and charcoal, the structure was interpreted as a large pit-hearth. On the other hand, the other two pits, *A* and *C*, did not show any clear function, possibly being silos for clay extraction, storage silos, or rubbish pits (or all of them) (Baldellou & Utrilla 1991a) (Fig. 3.6).

During the 1987 campaign, the area of the excavation was extended in both directions, towards northwest and east, in total 5 m^2. Three new negative features were identified, one small pit (Pit *D)* and two larger structures, Pits *E* and *F*, with a diameter of more than one metre (Fig. 3.5; 3.6) (Baldellou & Utrilla 1991b).

In 1988, the excavation of a pit went on, which had been found in the northern corner of the investigated area, namely, Pit *G* (Fig. 3.6). Initially, the pit was thought to be a burial as it was covered by a large stone of 64 cm in length. However, underneath this, only pebbles of the same type of those encountered in the other burial were found and no human remains. The excavators hypothesize that the pit had already been excavated by some clandestine diggers, who may have taken away all archaeological materials, including human remains.

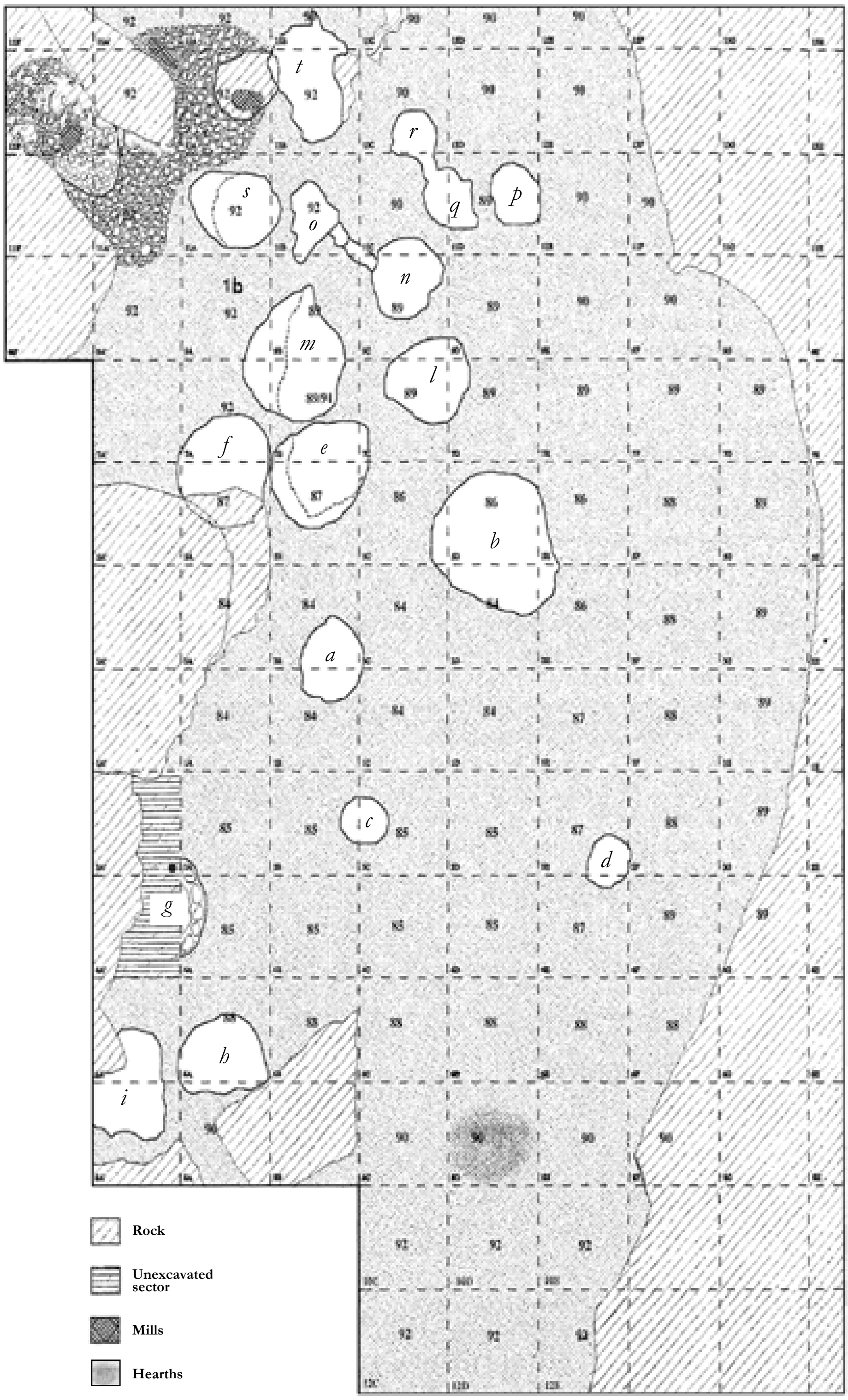

Fig. 3.6. Topographical plan of the Cueva de Chaves 1984-1992 excavations. Modified from Utrilla & Baldellou 1998. With letters from "*a*" to "*t*" are indicated the negative structures (pit-hearths; burials; storage-pits, etc.) identified during the excavation. The numbers in the middle of the squares indicate the year of excavation, from '84 to '92.

The excavation was then extended towards the inner part of the cave by opening new trenches, which measured in total 11 m². Two new pits were discovered (Pits *H* and *I*), both extremely rich in archaeological materials (Utrilla & Baldellou 1991c).

In the next year, in 1989, two new trenches (9 and 11) were opened in the southernmost part of the excavation and several new features were discovered. The largest structure, Pit *F*, had previously been partially excavated, during the campaign of 1987. This pit, with an almost three-metre diameter, was characterized by stone plates placed against the walls of the pit, thus forming a slab-lined structure. Other excavated features were several round-shaped pits, which yielded a great quantity of ceramic fragments and bone materials (Pits *L, N, Q, P*) (Fig. 3.5) (Baldellou & Utrilla 1991d).

During the 1990 campaign, a new trench was opened in the northernmost sector of the excavation (Trench 8), where a large elliptical hearth was discovered (Fig. 3.6). Works also went on in the southern sector, with the excavation of Trenches 9, 11, and 13. Amongst the main identified structures, there are two communicating pits (Pits *R* and *Q*), which are connected with each other by a hole dug between them.

In 1991, the excavation of Pit *M* was completed, which was very large, almost 70 cm deep, and had been dug into the calcareous crust and the underlying Magdalenian layers. The pit was very rich in archaeological finds, both animal and lithic materials, amongst which also ornaments and movable pieces of art were found.

During the 1992 campaign, the excavation was enlarged and another 16 m² were investigated in both southern (Trenches 9-11-13-15) and northern area (Trenches 10-12). In Sectors 11A-A', 13A-A', 13B-B', 15A, and 15B, a large structure was discovered, characterized by an extended stone floor (Fig. 3.6). This area was the richest in terms of remains. The great quantity of ash and charcoal has suggested that this place was used as a combustion area; however, it has also been hypothesized that the stone pavement may have been the base of a hut or a building of the kind. Because of a large boulder fallen from the ceiling of the cave, the structure has only been partially excavated. In addition, three new structures have been discovered (Pits *O*, *S*, and *T*) (Utrilla & Baldellou 2001-2002).

After a five-year interruption, new excavations were undertaken from 1998 until the year 2007, when the deposit was destroyed. New trenches were mainly opened in the area facing the cave entrance, specifically Trenches 13, 15, and 17, while another small area was excavated in the northern sector (Square 14); however, the relevant data is still unpublished (Baldellou et al. 2012).

3.2.3. Detailed Stratigraphy

N. S: This superficial level is composed of grey/brown sediments mixed with sheep/goat dung accumulated during recent penning practices. Besides, the entire surface is characterized by the presence of many stones and blocks of different size. The layer depth varies between 20 and 150 centimetres. Together with modern and medieval materials, ceramic shards with plastic decorations dating to the Bronze Age have been recovered.

N. I: This level has been detected exclusively in the area of the 1974-75 excavation, near the cave entrance. The layer is composed of a brown-grey silty sediment. The number of rocks and stones is lower than in the surface layer. In some sectors, it has been divided into three different horizons (Ia, Ib, Ic). It has a depth ranging from 20 and 50 centimetres. The archaeological materials recovered from this have been attributed to the Bronze Age (Baldellou 1985a), although some authors put forward that it may belong to the Late Neolithic period (Cava 2000).

N. I.a: This layer is characterized by silty sediments of brown colour and is rich in ash and charcoal. Its thickness ranges between 10 centimetres, in areas where it has been disturbed by the falling of stones from the ceiling of the cave, and 50 centimetres. A good number of hearths and anthropic structures, such as pits and silos, has been identified. The archaeological material is abundant. It has been ascribed to the Epicardial phase.

N. I.a2: This level has been recognized only in some sectors (Trench A', Sectors 6-8-10). The excavators think that it represents an intermediate layer between N. I.a and N. I.b. However, such an interpretation is questioned (Cava 2000) and this context may be considered as part of the upper layer, that is N. I.a.

N. I.b: This layer is characterized by silty sediments extremely rich in ashes and other by-products of combustion activities. It is distinguished from the upper layer I.a for a major compactness of the sediment and a minor quantity of stones/rocks. It presents a thickness that varies from 10 cm to 80 cm in correspondence of negative structures such as silos/pits. The level is characterized by more than fifteen negative evidences, among which pit-hearths, storage pits and other structures of unknown functionality. It is attributed to an Early Neolithic with Cardial Ware.

N. C: This layer is a calcareous crust, on which the Neolithic occupation took place. It is natural.

N. I.c: This layer is a natural layer characterized by clayey sediments. Archaeological remains are only occasionally present and do not refer to any clear cultural/chronological context. During the campaign of 1988, it has been preliminary subdivided into two horizons, namely, N. I.c1 and N. I.c2, later grouped together.

N. II.a: It is a silty layer rich in ash and charcoal, with fire-altered sediments. Archaeological materials are attributed to the Magdalenian period.

N. II.b: This layer differs from the upper one, N. II.a, because of the presence of a layer of stone/rocks at the bottom of the stratum. However, it is attributed to the same cultural and chronological horizon.

N. III: This layer is composed of clayey sediments of brown/yellow colour, with abundant detrital materials of fluvial origin. It represents the basic natural layer.

3.2.4. Radiocarbon Chronology

The Neolithic occupations of Cueva de Chaves have been dated by 16 radiocarbon dates (11 for Level I.b; 5 for Level I.a) (Tab. 3.1). Such dates have already been published in several articles and excavation reports (Baldellou 1985b, 1987b; Baldellou & Utrilla 1991a; Utrilla et al. 2008; Baldellou et al. 2012) (Tab. 3.1). The excavators state that all the relevant samples for the dating have been taken from well defined contexts, mainly combustion structures and hearths. However, only in rare cases the context of sampling has been precisely described in the publications. Therefore, the exact provenance of the samples is generally unknown. As a

Ref. Lab	Layer	Sample	BP	±	Cal BC 1σ	%	Cal BC 2σ	%	Cal BP 2σ (whole range)
GrN-12685	I.b	C	6770	70	5724-5627	68.2	5803-5551	95.4	7752-7500
GrN-12683	I.b	C	6650	80	5552-5486	68.2	5708-5478	95.4	7657-7427
GrA-38022	I.b	F	6580	35	5552-5486	68.2	5614-5586 5570-5478	13.2 82.2	7563-7427
GrA-34258	I.b	C	6530	40	5530-5473	68.2	5609-5592 5564-5463 5445-5419 5410-5381	2.6 84.0 3.5 5.3	7558-7330
GrN-13604	I.b	C	6490	40	5489-5463 5447-5418 5411-5380	26.6 18.2 23.4	5527-5367	95.4	7476-7316
UCIAMS-66317	I.b	F	6470	25	5479-5465 5442-5423 5407-5383	20.6 17.9 29.6	5482-5375	95.4	7431-7324
CSIC-378	I.b	C	6460	40	5483-5363	68.2	5551-5307	95.4	7500-7256
GrA-34257	I.b	C	6410	70	5467-5401 5390-5356	45.4 22.8	5472-5322	95.4	7421-7271
GrA-28341	I.b	B	6380	40	5464-5445 5420-5410 5381-5315	10.6 5.1 52.5	5471-5304	95.4	7420-7253
GrA-34256	I.b	C	6335	40	5367-5295 5249-5231	59.2 9.0	5464-5444 5422-5409 5381-5218	3.3 1.8 90.3	7413-7167
GrN-13605	I.b	C	6330	70	5374-5220	68.2	5475-5206 5162-5137 5129-5120 5107-5080	91.7 1.6 0.6 1.5	7424-7029
GrN-13602	I.b	C	6330	90	5464-5443 5423-5408 5382-5217	5.6 3.6 58.9	5479-5197 5179-5064	83.6 11.8	7428-7013
GrN-13603	I.a	C	6260	100	5326-5195 5180-5062	40.1 28.1	5469-4994	95.4	7418-6943
GrA-26912	I.a	C	6230	45	5297-5207 5162-5137 5129-5120 5106-5100 5095-5080	45.7 10.1 3.6 2.4 6.3	5308-5190 5185-5057	51.7 43.7	7257-7006
CSIC-379	I.a	HH	6230	70	5299-5205 5167-5076	36.4 31.8	5340-4999	95.4	7289-6948
CSIC-381	I.a	C	6120	70	5207-5146 5138-5127 5122-5094 5081-4977 4970-4964	19.2 3.1 7.9 36.3 1.6	5281-5276 5226-4846	0.3 95.1	7230-6795

Tab. 3.1. ^{14}C Dates from Cueva de Chaves, level 1b (Baldellou et al. 2012). Calibrated dates, both BC and BP, have been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013). Dates calBP are expressed indicating the whole range of 2σ (95.4). C: Charcoal; F: Bone of domestic fauna; HH: Human bone.

consequence, one has to deal with the two levels regarding them as a more or less homogeneous context. Considering the extension of the excavated area, a higher number of dates from hearths and silos would have allowed a better understanding of the occupational dynamics, possibly ascertaining the existence of different sub-phases within each level.

Amongst the collected samples, wood charcoal prevails. There are only four 'short-lived' samples; three from bone materials (one human bone, CSIC-379, and two bone samples from *Ovis aries*, GrA38022 and UCIAMS66317), and one from a charred hazelnut (GrA28341). Looking at Tab. 3.1, it is evident that the most ancient samples, coming from charred wood and collected during the first excavations in the eighties and nineties, show a greater standard deviation compared to the more recent dates. However, all dates show a certain homogeneity, since they belong to the same chronological interval and are consistent in terms of material culture.

The two phases are fundamentally contiguous. During the excavation, sedimentological discontinuity in the layers has not been detected. The two phases have been separated on the basis of slight changes in the sedimentological composition of the layers as for example a greater compactness of sediment or the presence of a higher/lower percentage of rocks and pebbles. In addition, differences have been observed in terms of ceramic artefacts' composition between Level I.a and Level I.b (Baldellou 2011).

In Table 3.1, I have reported the dates of Cueva de Chaves recalibrated by software OxCal v. 4.2.3 (Bronk Ramsey 2009), using the most recent calibration curve IntCal13 (Reimer et al. 2013). Furthermore, in order to prove the consistency of the various dates with each phase, I have implemented a Bayesian Model based on software OxCal v. 4.2.3 (*cfr.* Chap. 2, Par. 2.2.8). Considering the absence of a clear layer of discontinuity between I.b and I.a, I have opted for Bounded Contiguous Phases. In the first test, I have included all the dates relevant to each phase. The resulting model shows a good agreement index (^{A}Model=87.7). However, the first date (GrN-12685 - 6770±70), based on charcoal sample, displays a very low agreement with Phase I.b (44.6%). Actually, this chronology appears too old for the Early Neolithic Age in the NE of the Peninsula. Such an early date may be due to the sample being an old wood. Therefore, given the low agreement, it is better to exclude it from the model.

The new model, calculated without the first dating outcome (excluding GrN-12685), shows a higher agreement (^{A}Model=100.2; ^{A}Overall=102.7). The model indicates that the first phase, Layer I.b, approximately began between 5540 and 5478 cal BC (with a probability of 68.2%), or between 5608 and 5463 cal BC (with a probability of 91.4%) (Boundary 1) (Fig. 3.7). Within Phase I.b, there is a series of dates that are regularly distributed over time. This pattern may indicate an occupation of the cave taking place regularly; however, the absence of a detailed stratigraphic analysis and micromorphological studies prevents from making any further consideration about that.

The transition between the two phases is established around 5351-5276 cal BC (1σ) and 5421-5233 cal BC (2σ) (Boundary Transition 1/2). During the successive phase, I.a, dates appear homogenously distributed over a time span ranging between 5306 and 5157 (68.2%) or 5368 and 5093 (95.4%) (Tab 3.1). However, it is to remark that their standard deviation is generally higher, 70 and 100 years. The final moment of this phase is dated to between 5282 and 5094 cal BC (68.2%) and between 5300 and 4941 cal BC (2σ) (Boundary 2). In conclusion, by revising the calibration of 2σ, the Neolithic occupations of Cueva de Chaves cover a maximum period of ca. 700 years, with Layer I.b covering ca. 300 years and Layer I.a ca. 330 years at the most. The two phases appear contiguous as it is not possible to ascertain any significant abandonment of the cave.

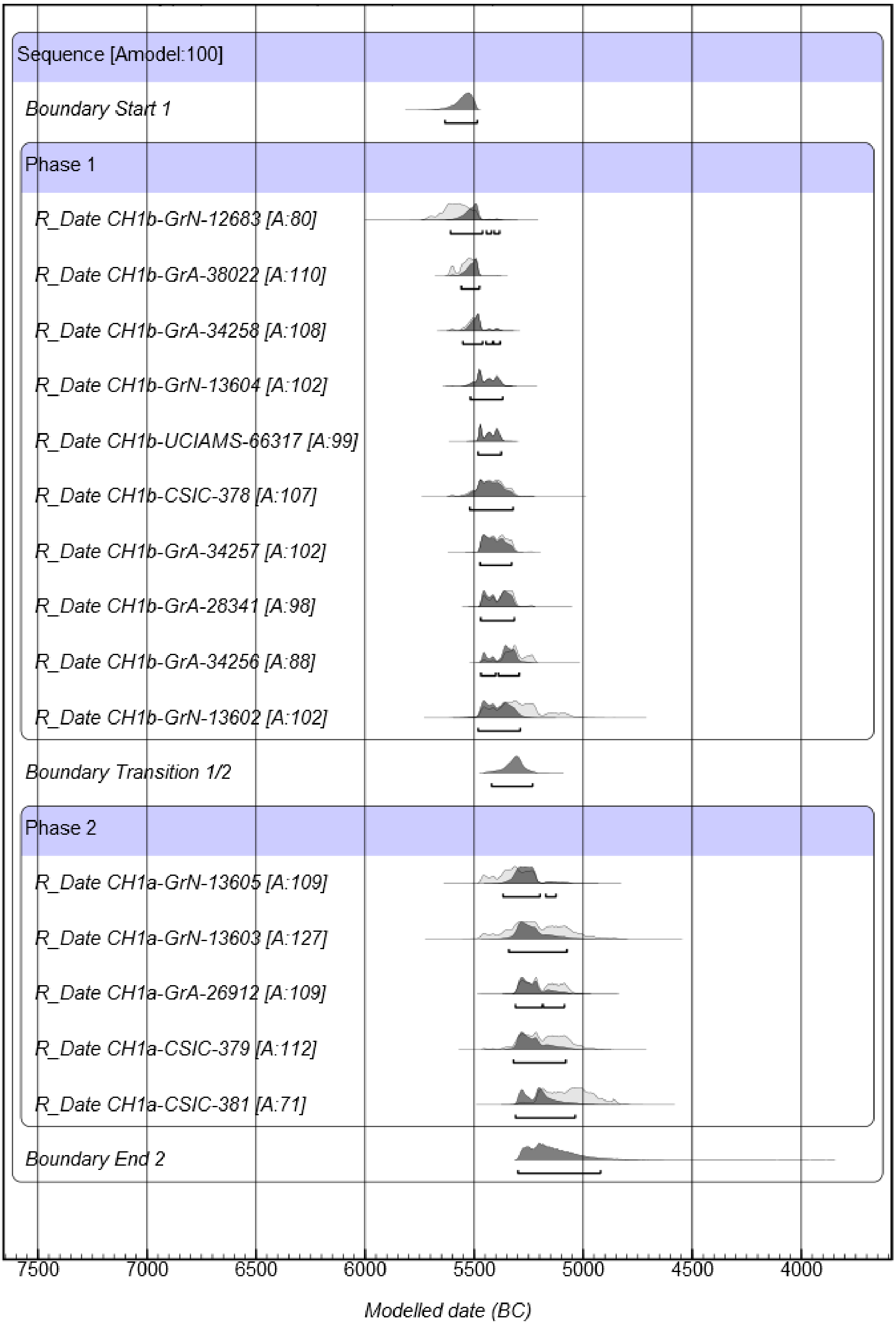

Fig. 3.7. Model of Sequential Phases. Multiple plot of ^{14}C Dates from the Cueva de Chaves, level 1b (yrsBC). Model has been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013). The first date GrN12685 has been excluded from the model.

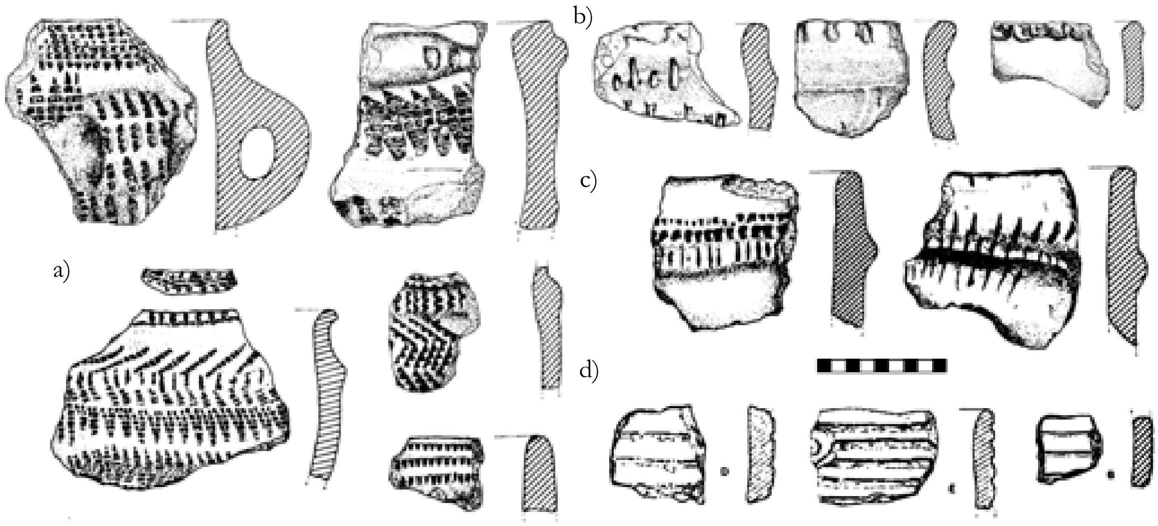

Fig. 3.8. Selection of materials from the ceramic assemblage of the Cueva de Chaves, N. I.b, excavation 1974-75 (Baldellou 1985): *a*) Cardium decorated shreds; *b*) Impressed (with instrument) decorations; *c*) Plastic decorations; *d*) Incised decorations. Modified from Baldellou (1985).

3.3. Materials

3.3.1. Ceramic Assemblage

Cueva de Chaves has yielded a great quantity of pottery, specifically more than 11,000 shards (considering the 1984-2007 excavations), 6,039 from I.b and 5,167 from I.a (Sánchez et al. forthcoming). However, this assemblage has only been partially studied. The materials coming from the 1974-75 surveys have been preliminary published by Baldellou (1985a). Petrographic analysis was carried out by Gallart & López (1988); however, only a small sample of materials recovered from two squares (85A and 85B) was considered. A more extensive study was successively developed by Ramón (2006), who included almost 8,000 fragments. Recently, a synthesis of the assemblage's main characteristics has been published by Baldellou (2011).

Pottery is extremely varied, in terms of both vessels' types and pastes. Amongst the most recurrent shapes, there are sub-hemispherical and globular bowls with various types of loops. From a decorative point of view, undecorated fragments largely prevail (80%) compared to the decorated ones (20%). Amongst decorative motifs, impressed decoration is the most common pattern (56%), followed by plastic decorations (33%) and incised decorations (11%). Amongst those impressed, 'decorations with Cardium' represent the most recurrent motifs as they feature in almost 70% of the group. Other types of decoration are 'decorations with tool' and 'engravings and grooves' (Baldellou 2011) (Fig. 3.8).

In conclusion, the ceramic assemblage of Cueva de Chaves represents a reference point for defining the Cardial manufactures in the NE of the Iberian Peninsula at the end of the sixth millennium cal BC. Its evolution from Layer I.b to I.a is consistent with the dynamics observed in other sites of the Pyrenean region (Cueva del Moro de Olvena; Cova Colomera, Cova de Els Trocs) and, more generally, with the Catalan and Valencian pottery manufactures (Blasco et al. 2005; Alday et al. 2012a; Gibaja & Clop 2012; Oms et al. 2012).

3.3.2. Archaeozoological Assemblage

The study of the archaeozoological assemblage of Cueva de Chaves came out by a two-step publication. The materials of the 1974-75 excavations were published in the book issued for the site (Castaños 1985). Later, the materials of the 1984-1992 excavations were separately published still by Castaños (2004). In this latter publication, about 20,000 faunal remains were studied, of which 12,754 were determined fragments, specifically 8,122 from Layer I.b and 4,632 from Layer I.a. A recent recount of faunal remains, including those from the most recent excavation until 2007 (Sánchez forthcoming), has resulted in 48,464 fragments (33,064 from I.b and 15,400 from I.a), considering both determined and undetermined fragments. Such a large assemblage is probably unique in the whole Iberian Peninsula and represents a reference point for the Iberian Neolithic Age.

Available data from Castaños (2004) indicates a clear predominance of domesticated species (63.2% NR) over the wild ones (36.8% NR). Amongst domestic animals, *Ovis/Capra* clearly prevails (51.6%), followed by *Sus domesticus* (8.8%) and *Bos Taurus* (2.4%). Amongst wild ungulates (which represent 11.9% as a whole), *Cervus elaphus* dominates (8.2%), followed by *Capra pyrenaica* (1,5%) *Sus ferus* (1.3%), *Capreolus capreolus* (0.7%), *Bos primigenius* (0.1%), and *Equus ferus* (0.1%). Amongst the other attested species, there are several types of carnivores, even if represented by a small quantity of remains (2.2%) (*Meles meles*, *Vulpes vulpes, Ursus arctos*, *Felis silvesitris*, *Lynx pardina*). However, some of these species are probably intrusive, that is, not taken to the place by humans, but brought by other animals or naturally deceased inside the cave (Castaños 2004).

Finally, one has to remark the abundance of the European rabbit, *Oryctolacus cuniculus*, which alone represents 22.1% of the faunal assemblage, second only to *Ovis/Capra*. However, in this case too, such an abundance is only to a limited extent due to human action. Most of the remains were probably transported to the cave by other carnivores or belonged to animals that independently died there, according to the good state of preservation of the long bones (Castaños 2004).

3.3.3. Other Materials

At Cueva de Chaves, apart from the abundant faunal and ceramic record, a great variety of artefacts was recovered: bone artefacts, macrolithic tools, mills and grinding tools, polished tools, mobile artworks, etc. The studies of most of these categories are still underway and only preliminarily published.

Polished tools: the polished-tool industry of Cueva de Chaves is made up of 139 elements, of which 76 come from Level I.b and 63 from Level 63 I.a. There are mainly axes of different shape and size. On the one hand, I have ascertained the presence of small, 3-4 cm wide, implements of sub-rectangular shape; on the other hand, there are larger elements of trapezoidal shape, which measure more than 10 cm in length. However, a detailed study of the assemblage does not exist.

Macrolithic industry: Cueva de Chaves has yielded several different macrolithic tools. Three mills were recovered in Level I.b, all of them concentrated in the stone-pavement area. In addition, over four hundred pebbles with evident signs of human modification have been recovered. 119 of them show traces of ochre (85 in I.b and 34 in I.a), forming decorative motifs and patterns with 'chaotic' dots.

Bone industry: : Bone implements amount to 152 elements (Sánchez et al. 2013). A detailed study from a techno-typological point of view has only been carried out for the materials of the 1984-98 campaigns, specifically 77 items. However, in this work, the bone implements of Levels I.b-I.a are dealt with as a homogeneous assemblage. The prevalent types are punches (93.5%), followed by needles (3.9%), spatulas (1.3%), and pointed flakes (1.3%).

Shells tools and Ornaments: Ornaments are abundant at Chaves. In Layer I.b, 64 elements have been recovered, while other 31 come from Layer I.a. Several types of beads have been recognized, made out of stones, bones, teeth, and shells. Amongst the shells, one finds bivalves such as *cardium* and *pectin*, drilled *Columbellas*, and fragments of *Dentalium*. Some of these elements appear to have been used as tool for scraping mineral substances, probably fresh clay (I. Clemente, pers. comm.). In addition, in Layer I.a, several variscite beads were found, originally coming from the Catalan littoral zone (Baldellou et al. 2012).

3.3.4. Lithic Assemblage

3.3.4.1. General Considerations

The lithic industry of Cueva de Chaves is quite rich. 2,486 lithic materials come from Level I.b, including all the pieces recovered during the campaigns 1984-2007, just before the destruction of the deposit. One can add to this collection 175 elements, which were recovered during the surveys of the seventies, thus reaching a total number of 2,661 lithic finds. This count includes all chipped stone materials, both siliceous and non-siliceous, such as quartz and hyaline quartz, even if the latter represents a low percentage of the assemblage. A large part of these materials is still unpublished, although a significant number of them was studied and published by A. Cava (2000), including all the campaigns between 1984 and 1990. The majority of these materials directly comes from the floors relevant to the settled cave, from hearths and combustion areas, and, to a lesser extent, from storage and refuse pits. A recent study on the spatial distribution of Cueva de Chaves' remains has pointed out the existence of two main areas of lithics concentration. The first one is around the hearth placed on the stone floor at the centre of the stone floor (Bands 11-15); the second one in Bands 10-12, situated in the inner sector of the excavation.

The sample selected for the analysis consists of 1,774 elements (71.3% of the entire assemblage), and corresponds to all the materials recovered during the 1984-1992 excavations. All of these materials come from the main inhabited area of the site, where the majority of domestic structures was identified. On the contrary, the last archaeological campaigns (1998-2007) turned to the investigation of a storage area, the excavation of which, however, has remained unfished (Baldellou 2012).

The study of the lithic materials took place in the Museo Arqueológico Provincial de Huesca. Most of the materials were clustered according to year of excavation and, successively, squares or bands. The only materials excluded from the sample were those elements, the identification code of which were illegible or absent, being without any spatial or stratigraphic reference. The scarcity of elements smaller than 5 mm in width (such as debris and other waste materials) among the studied assemblage suggests that only dry sieving was carried out at the site, while the mesh holes were probably 5 mm wide or larger. It is also remarkable that archaeobotanical materials such as seeds or charred grains are almost absent at Cueva de Chaves, this also suggesting that no wet-sieving of the archaeological sediment were carried out.

All the same, the studied sample can be considered exhaustive and representative of the economic activities that took place inside the cave or, at least, in the excavated area of the site. They are also a sufficient sample for the reconstruction of the strategies in terms of lithic -resources management and exploitation.

3.3.4.2. Typological Aspects

A detailed analysis of Cueva de Chaves' lithic assemblage was accomplished by A. Cava (2000). Her study mainly focused on typological aspects and, secondarily, on technological and functional determinations. The materials recovered during the 1974-75 surveys were preliminarily published with the first monographic work on Cueva de Chaves (Cava 1985). Later, all the materials collected in the 1984-1990 excavations came out with a more detailed analysis in a specific publication. I am mainly referring to this latter work for any aspect related to the typological composition of Cueva de Chaves' lithic industry, although the analysed sample includes some materials which were not studied by Ana Cava.

The published assemblage (Cava 2000) consisted of 22 cores, 47 core resharpening elements, 4 burin strokes, and 1,064 knapping products, for a total number of 1,137 lithic artefacts. Amongst them, retouched implements amount to 439 and correspond to 477 primary types. The typological analysis was carried out following Fortea's typological list (1973). The main structural features identified by A. Cava were the following: a preponderance of *Diversos* (53%) (*Raederas* -D3 49.3%; *Piezas Esquirladas* -D1 2.7%; *Piezas Apuntadas* -D5 1.0%), followed by *Muescas y Denticulados* MD (15.5%), *Geometricos* -G (9.2%), *Truncaduras* -FR (7.5%), *Perforadores* -P (5.5%); *Raspadores* -R (4.0%); *Laminitas de dorso* -lba (2.5%); *Piezas con retoque abrupto* -LBA (2.1%); *Microburiles* -M (1.0%); *Buriles* -B (0.4%).

The most represented class in Level I.b is the group of *Diversos*, in particular blade and flake scrapers (D3). However, as already noticed by the same author (Cava 2008: 85), this category is largely constituted by tools that show pseudo-retouches and not by intentional retouches (*n.* 235; 53.3% of the retouched items). This fact emphasizes the scarce significance of this category, which, although often displaying high percentages, is not really representative either in terms of quantity of retouched pieces or specific tools attested in the assemblage. Actually, excluding these materials, the number of 'real' retouched implements at Chaves would drop by almost half. Other aspects that should be remarked from a structural and stylistic point of view are:

i. the low percentage of endscrapers;

ii. the low percentage of borers;

iii. the almost complete absence of burins;

iv. the relative abundance of denticulate tools, both on flake and blade blanks, often characterized by invasive bifacial retouches;

v. a low percentage of geometric tools: 12 segments; 17 trapezoids, and 12 triangles. Segments are mainly retouched by *doble bisel* (bifacial flat retouch). Trapezoids are characterized by asymmetric shapes, manufactured by the microburin technique, with abrupt or simple retouch. Triangles are represented by isosceles shapes with simple retouch. Size is standardized: on average 20 mm long and 10 mm wide.

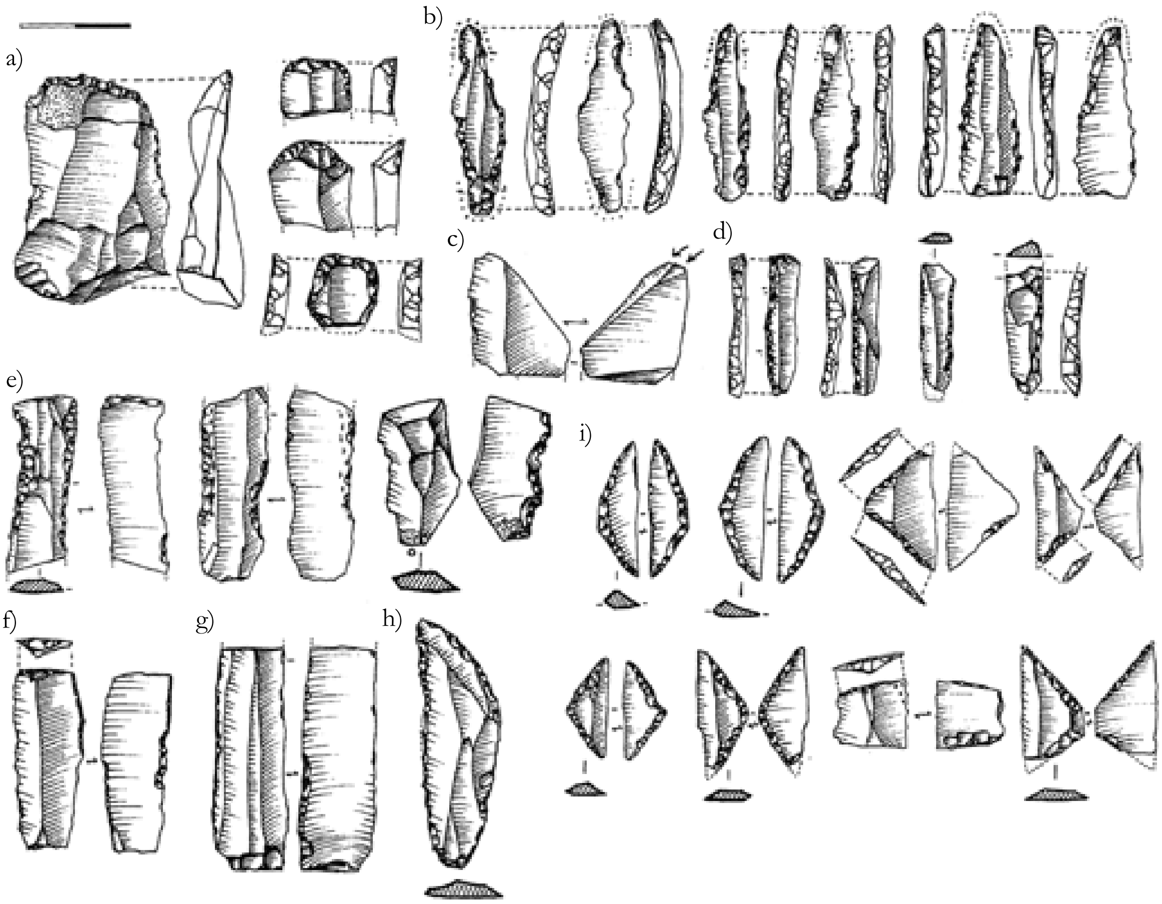

Fig. 3.9. Main typological groups identified among the Cueva de Chaves lithic assemblage. Draws modified from A. Cava (2000); *a*) endscrapers; *b*) borers; *c*) burin; *d*) backed tools; *e*) denticulate tools; *f)* truncated blade; *g*) blade scraper; *h*) pointed tool; *i*) geometric tools.

3.3.4.3. Raw-materials Procurement

Cueva de Chaves is located in the exterior ranges of the Pyrenees, facing the Ebro Basin. The cave opens into the Sierra de Guara, the geological history and composition of which have been described by Puigdefabregas (1975) and, more recently, by Samso et al. (1994). It is mainly composed of marine limestone of Eocene Epoch, in particular, of the Lutetian stage. No evidence of any chert outcrops in this area has so far been reported.

The nearest outcrop of chert rocks is represented by the lacustrine deposits of the so-called '*Calizas de Peraltilla*' formed in the Lower Oligocene Epoch (Alvárez Sierra et al. 1987), at about 10-15 km from the site. The Peraltilla Formation is located west of Barbastro and represents the western extension of the Castelltallat (Anadón et al. 1989) or Serra Llarga Formation (Mangado et al. 2007), which is located in the municipalities of Algerri, Alfarràs, and Castelló de Farfany (Fig. 3.10). Nodules in primary position of 5-30 cm in length are available in such formations. It is a good-quality, homogeneous material with a thin grey/white calcareous cortex and a microcrystalline matrix of brownish or blackish colour. It is generally compact, only occasionally characterized by a layered aspect (Liesegang rings).

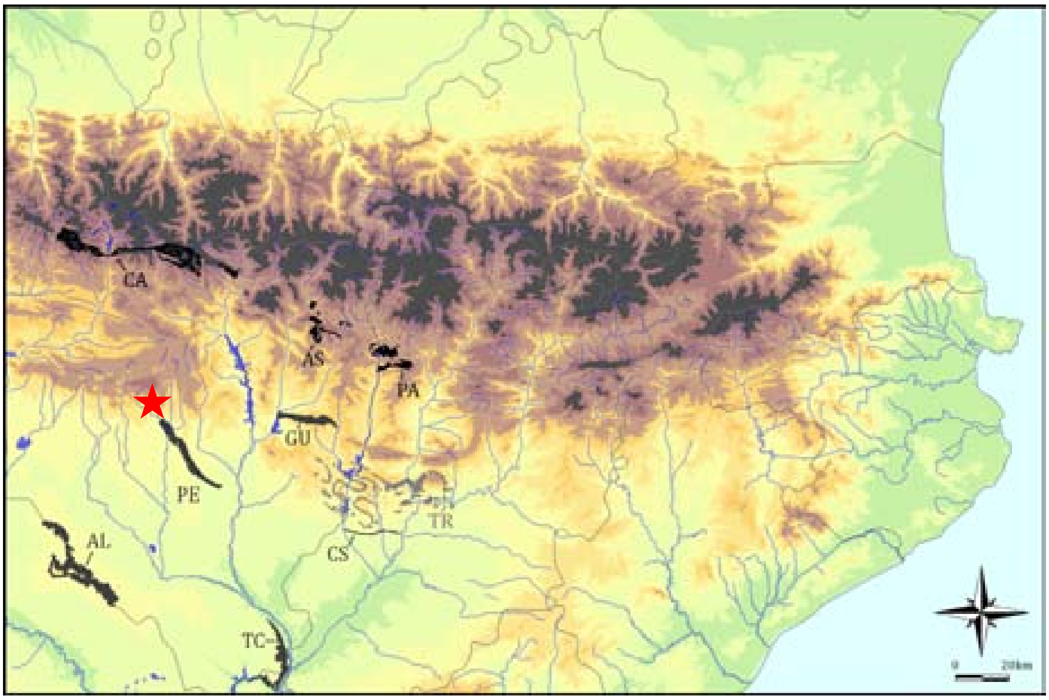

Fig. 3.10. Digital Terrain Model with the principal formations containing chert in the region. Map realized with software Miramon v7.1h. The red star indicates the Cueva de Chaves. CA: frm. Calizas de las carenas altas; AS: frm. Agua Salenz; PA: frm. Pardina; TR: frm. Tremp; GU: frm. Guarga; CS: frm. Castelltallat; PE: frm. Peraltilla; AL: frm. Alcubierre; TC: frm. Torrent de Cinca.

PHASE		Cherts				Other rocks				TOT
		LOM	EVP	MEC	IND	Qrz	Rhy	Gra	Hya	
I.b	N	1216	139	34	342	3	1	2	34	1774
	%	*68,5*	*7,8*	*1,9*	*19,3*	*0,2*	*0,1*	*1*	*1,9*	*100*

Tab. 3.2. Raw-materials composition of the Cueva de Chaves lithic assemblage. *Ind*: Indeterminable chert materials. *Cherts*: LOM: Lacustrine Oligocene-Miocene chert; EVP: Upper Cretaceous-Palaeocene Evaporitic chert; MEC: Eocene-Cretaceous Marine chert; IND: Indeterminable chert materials. *Other rocks* – Qrz: Quartzite; Rhy: Rhyolite; Gra: Granite; Hya: Hyaline Quartz;

Microscopically, it is distinctive for the presence of transverse and longitudinal sections of *Charophyte algae* and Ostracods (Fig. 3.11, *a-f)*. Materials of identical characteristics are also available in the lacustrine formations of the central sector of the Ebro Basin, such as the Alcubierre (Arenas & Pardo 1999) and Torrent de Cinca Formations (Luzón et al. 2002). This type of chert is the most abundant amongst Level I.b lithic materials. Lacustrine Oligocene-Miocene cherts represent almost 70% of the assemblage and more than 85% of the determined lithologies (Tab. 3.2).

A second group is represented by a chert of white/grey colour, only occasionally with reddish shades. This lithology constitutes less than 10% of the assemblage (Tab. 3.2). Macroscopically, it appears compact, translucent, with a coarse or medium-grained texture. The presence of iron oxides is quite characteristic. Microscopically, it is characterized by a mosaic microquartz textures, length-fast chalcedony, and inclusions of macroquartz. These

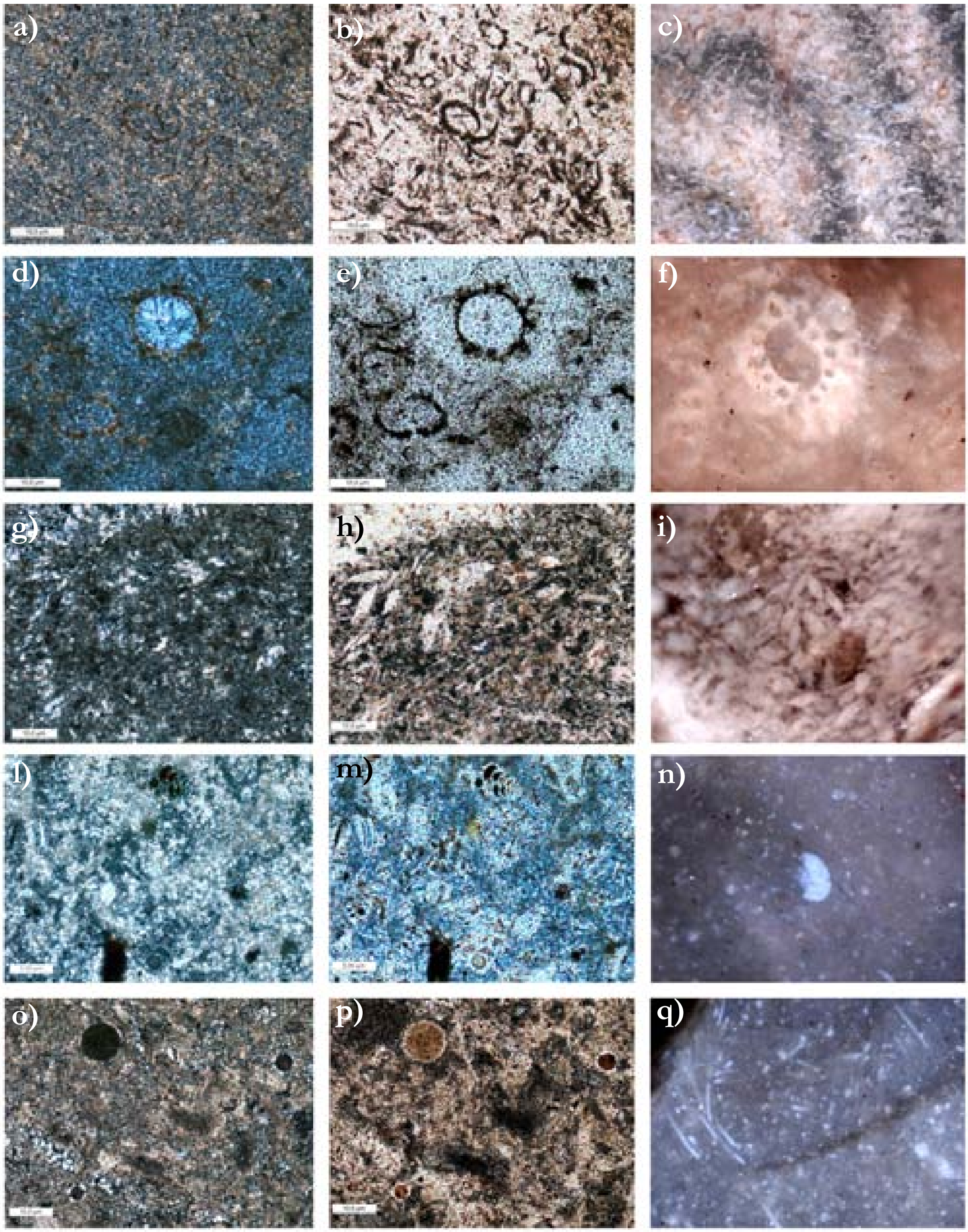

Fig. 3.11. Micro- and macroscopic photographs of chert types from the Cueva de Chaves assemblage. A-F) Oligocene-Miocene Lacustrine cherts: *a-b)* Thin section view under microscope, plan-polarized light and crossed polarizer view (50X), fragments of ostracods and of *Charophyte algae*; *c)* Fragments of ostracods at 10X magnification; *d-e)* Thin section view (same as before), transversal section of a *Charophyte algae* filled of macro quartz; *f) Charophyte algae* at 10X magnification. G-I) Evaporitic Upper Cretaceous-Palaeocene cherts: *g-h)* Thin section view (same as before), lenticular shaped gypsum pseudomorphs; *i)* Lenticular shaped gypsum at 10X magnification. L-Q) Cretaceous Marine cherts: *l-m)* Thin section view (same as before) (100X), marine foraminifera and fragments of sponge spicule; *n)* Marine foraminifera at 10X magnification; *o-p)* Thin section view (same as before), calcispheres and veins filled with macro quartz; *q)* Calcispheres and sponge spicule at 10X magnification.

cherts are distinctive for the presence of lenticular pseudomorphs of gypsum and, occasionally, transverse and longitudinal sections of charophyte algae (Fig. 3.11, *g-i*). However, the fossiliferous record is generally scarce. Cherts of this type, originated in a continental hypersaline environment, are known in the region, specifically in the Garumnian limestone of the Pyrenean foothills. Various chert outcrops of this type were identified in the Carrodilla and Montsec Mountain Ranges, as part of the so-called Tremp Formation (López-Martínez et al. 2006; Sanchez & Mangado 2013; Sanchez et al. 2014), located between 40 and 150 km from the site. No near outcrops have hitherto been detected; however, further prospecting should be carried out in order to investigate their possible presence further west.

A third chert type is a dark material with blackish and bluish shades. This material is represented by a small number of specimens (Tab. 3.2). Macroscopically, they appear quite homogeneous, solid, and with a fine-grained texture. Their main characteristic is the presence of abundant fossiliferous inclusions, specifically sponge spicules, calcispheres, and marine foraminifera. In addition, dolomite crystals and veins with chalcedony or macro-quartz filling are also common (Fig. 3.11, *l-q*). Rocks with similar materials are known in the Upper Cretaceous formations near the Turbón Massif (Agua-Salenz Formation) (Garrido-Megías & Ríos 1972) and in the Sopeira Basin (Pardina Formations) (Caus et al. 1997). It is also possible that some fragments of Eocene chert types are mixed with this group. Indeed, similar cherts (blackish and with abundant marine foraminifera) feature in the limestone formations of the Monte Perdido unit (Van Lunsen 1970). Macroscopically, both types are quite similar and only a detailed microscopic identification of the micro-palaeontological record makes a distinction possible.

The other lithologies appear to have only marginally been exploited at Cueva de Chaves, at least for flaking activities. Among them, hyaline quartz is the only rock that was regularly knapped at the site. Veins of hyaline quartz are abundant in the Axial Pyrenees; however, it is also possible that such materials were collected from secondary deposits at lower altitudes. Other rocks like granite, rhyolite, or quartzite were only occasionally flaked (Tab. 3.2).

3.3.4.4. Technological Management

All the phases of lithic production are represented at Cueva de Chaves, from core preparation to core reduction and tools formatting (Tab. 3.3). From a technological point of view, one can point out some remarkable features of the lithic assemblage:

i. a high percentage of cortical elements (27.4%);

ii. a limited number of cores (2.6%);

iii. a remarkable presence of characteristic core-trimming elements (4.1%);

iv. a low number of debris (2.0%);

v. a scarce presence of flake/blade-resharpening elements (0.3%);

vi. a high laminarity index (Ll) (55.3%).

As already mentioned before (*cfr*. Chap. 3. Par. 3.3.4.1), the low percentage of debris should be ascribed to the sieving techniques adopted during the excavations. Indeed, there are several elements that clearly indicate that flaking activities were carried out on site. The high percentage of cortical elements —in numerous cases completely covered with cortex (*n*. 22; 1.2%)—, the good number of cores and core fragments (*n*. 46; 2.6%) at different stages of exploitation —from exhausted elements to little exploited cores—, and the presence of

PHASE		Flake	Blade	Core	Débris	Characteristic waste products	Ind	TOT
I.b	N	1016	593	46	36	73	10	1774
	%	57,3%	33,4%	2,6%	2,0%	4,1%	0,6%	100%

Tab. 3.3. Technological composition of the Cueva de Chaves. Technological lexicon has been taken from Inizan et al. 1999. *Ind.* indicates indeterminable elements.

core-maintenance and resharpening elements —such as tablets or debitage rejuvenation flakes (*n.* 73; 4.1%)— are all elements that bear evidence of on-site lithic production, from the initial operations of blocks preparation to the last phases of the debitage.

The main objectives of the production were the laminar blanks (*n.* 593; 33.4%). Active cores have mainly a prismatic or, to a lesser extent, pyramidal shape. Generally, only one percussion plane was exploited, with parallel extractions (Fig. 3.12). If one exclusively considers the chert materials, there is only one group of blades. Their width ranges between 10 and 14 mm and their thickness between 2 and 4 mm on average. In all cases, standard deviation and variance are reduced, this suggesting a quite standardized production. A greater variability is observed for their length, with a larger range in terms of mean value. The interquartile range is between 27 and 51 mm.

About flakes, as expected, one can observe a greater variety of shapes and dimensions. Blanks are generally wider and thicker, measuring 16-30 x 12-25 x 3-7 mm. Elongated/ laminar flakes were only occasionally produced. Hyaline quartz was also used for the production of blade blanks, although of more reduced dimension. Hyaline quartz bladelets measure 12-21 x 4-7 x 1-3 mm on average. Several cores and knapping by-products are also attested at the site, suggesting a local production.

In order to ascertain whether there was any variation in the exploitation of the different types of raw materials, I carried out a chi-square test cross-tabulating the 'raw_material' and 'blank_type' variables. Raw materials were grouped in four main categories («Oligocene-Miocene lacustrine cherts», «Evaporitic Upper Cretaceous-Palaeocene cherts», «Marine Eocene-Cretaceous cherts», «Hyaline Quartz»), excluding the indeterminable elements; blank types were clustered in three main categories, grouping all cores and knapping wastes and by-products within a single category («blade», «flake», «waste»).

The result of the test rejects the null hypothesis (χ^2: 22.467; df: 6; *P*: 0.001). The exploitation of both continental chert types (Oligocene-Miocene and Upper Cretaceous-Palaeocene cherts) was strongly oriented towards blade production. In both groups, blades represent over 30% of the assemblage. On the contrary, Pyrenean marine cherts and Hyaline quartz characterize a greater number of flakes and waste materials, whereas blades represent 14-17%. However, this difference is probably due to the lower quality of these latter lithologies and not to the adoption of a different exploitation strategy. The production still aimed at obtaining blades; however, since these materials were less-homogeneous (Eocene-Cretaceous Marine cherts) or implied a different flaking method (Hyaline quartz), the number of by-products was higher. As a result, one can realize that flaking activities at Cueva de Chaves were fundamentally homogeneous and oriented towards the production of laminar blanks. Flakes were then mainly produced as a result of core preparation and maintenance activities and did not represent the original purpose of the lithic production.

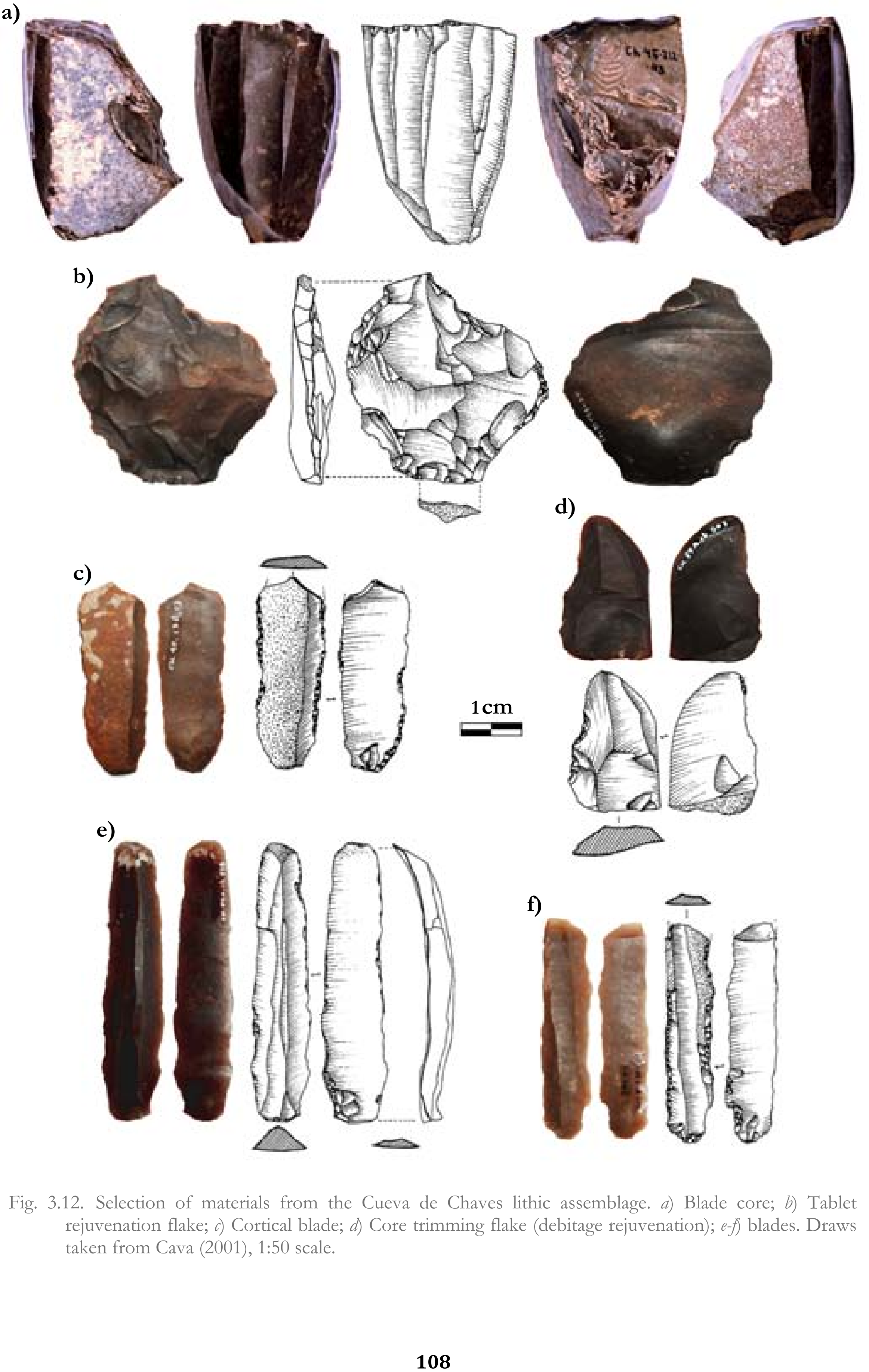

Fig. 3.12. Selection of materials from the Cueva de Chaves lithic assemblage. *a*) Blade core; *b*) Tablet rejuvenation flake; *c*) Cortical blade; *d*) Core trimming flake (debitage rejuvenation); *e-f*) blades. Draws taken from Cava (2001), 1:50 scale.

3.4. Traceological Analysis

3.4.1. Material Conservation

The lithic collections from Cueva de Chaves are conserved at the Museo Arqueológico Provincial de Huesca. The materials are kept in boxes, corresponding to the subdivision of the levels (I.a, I.b, I.c, …, *etc.*), each containing plastic bags corresponding to specific excavation campaigns and years (1984, 1985, 1986, …, *etc.*). In addition, each bag includes several smaller bags, which refer to the groups of lithic materials according to their square or area of provenance.

Every find is provided with a single identification number written on the lithic surface with enamel and lacquer. The identification number displays the year of excavation, the relevant level, square, or area of recovery and, occasionally, its height. The identification number itself is written at the end (e.g. CH90.1b.9E-F.156.30).

Macroscopically observed, lithic materials appear well preserved. Taphonomic alterations and post-excavation damages are present, although only on a part of the finds. Finally, unanalysable elements amount to about one quarter of the whole lithic assemblage (*n.* 447; 23.5%).

3.4.1.1. Mechanical Alterations

As stated before, the lithic materials are not individually kept in plastic bags, but several implements, from the same square or area, are often grouped together. This conservation method is not suitable for preserving their lithic surface as the materials constantly touch one another, this producing a mechanical stress that can result in scarring the edges and/or smoothening the surfaces. Numerous experimental works have demonstrated the damages brought about by such a conservation method. Specifically, the phenomenon known as 'bagwear' is associated with these bags containing various artefacts all together, which actually cause abrasions and wear of the lithic implements (Odell & Odell-Vereecken 1980, Lewenstein 1981, Plisson 1985, Luedtke 1986, Gutiérrez, González & Ibáñez 1988, Mazzucco & Clemente 2013). The main modifications induced by the contact between lithic items are edge-fractures, striations, and polished spots (Fig. 3.13, *a-b*). Moreover, this type of wear can easily be confused with traces left by other actions like hafting or tools transportation and even with some use-wear marks caused, for example, by butchering.

Apart from post-excavation damages, a group of implements is characterized by the presence of soil lustre and other mechanical alterations induced by soil mechanical forces. This is one of the most typical alterations affecting the archaeological collections (Levi-Sala 1986). Such modifications are mainly consequent on artefacts lying in a sedimentary deposit for a long period of time and being exposed to digenetic phenomena (*cfr*. Chap. 2, Par 2.3.1). The degree of alteration can dramatically vary from one piece to another; indeed, such agents do not have a uniform effect on the finds. In Cueva de Chaves' assemblage, I have recognized different stages of material alteration, from slight lustres that have exclusively affected the microtopographic highpoints (Fig. 3.13, *c-d*), to an evident polishing on the whole surface of the lithic tool (Fig. 3.13, *e-f*). On the implements with a marked lustre, use-wear traces are generally poorly preserved or completely vanished. In most of the cases, I had to exclude these elements from the study.

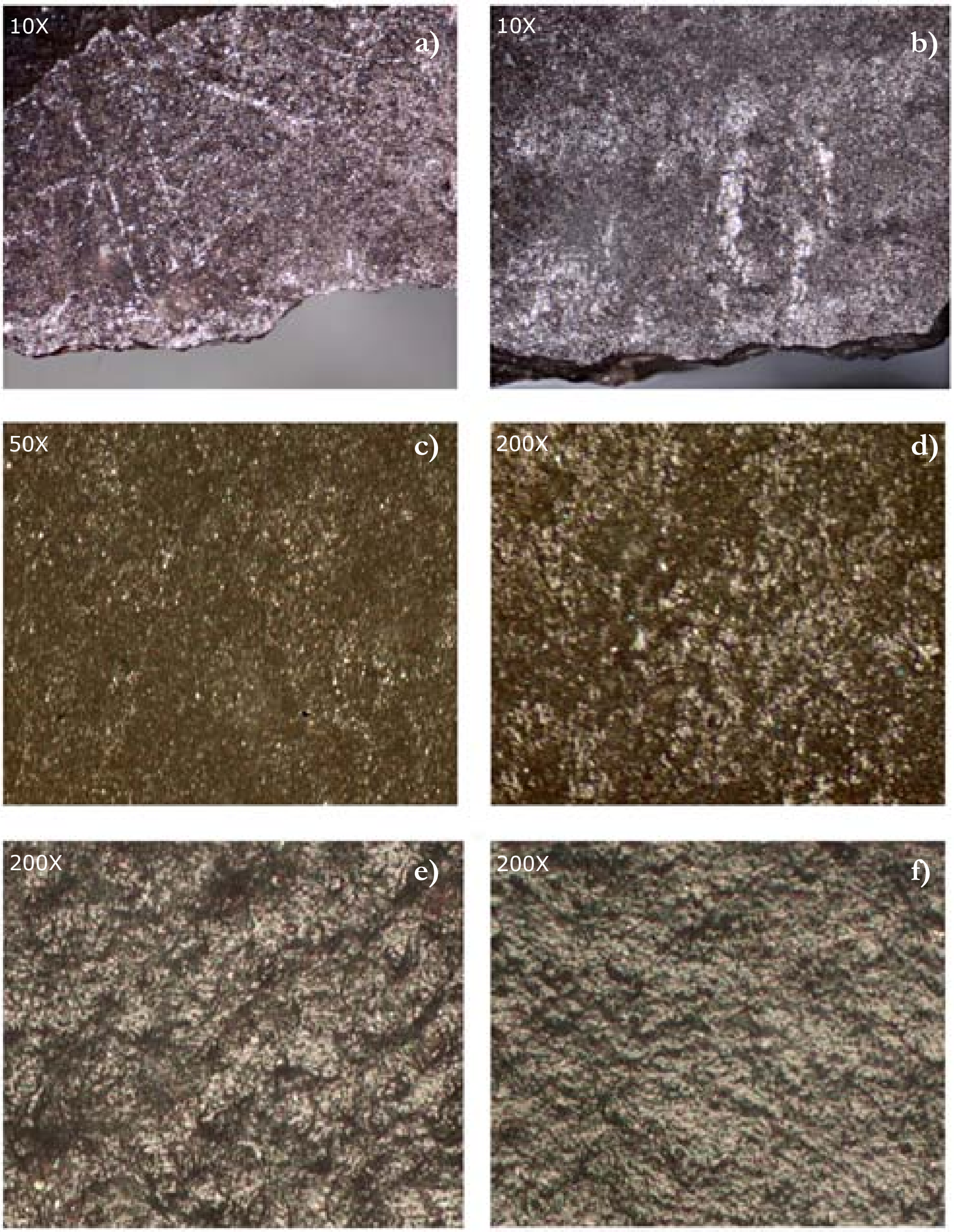

Fig. 3.13. Some example of the mechanical alterations observed among the Cueva de Chaves assemblage. *a-b*) post-excavation damage; abrasions and strias with chaotic directionality produced by the mutual friction between lithic implements (10X magnification); *c-f)* Microscopic view of soil lustres at different stages of development, from slight lustres (*c-d*) to a stronger polishing of the surfaces (*e-f*), (50X and 200X magnification).

3.4.1.2. Chemical Alterations

The available information on Cueva de Chaves' archaeological deposit, from a micromorphological and sedimentological point of view, is quite scarce. Level I.b is simply described as a silty layer characterized by the presence of large spots of ash and charcoal. With this information, it is quite difficult to estimate to what extent taphonomic agents have affected the archaeological finds.

Soil acidity is probably to exclude. The faunal remains' state of preservation is good. Moreover, among the lithic assemblage, no signs of acid-induced alterations or patinas have been detected.

On the other hand, several alkaline alterations have been observed. Amongst them, there are two main types: macroscopic patinas and microscopic alterations of use-wear polishes.

Patinas mainly consist of white or grey spots, which have probably formed on the lithic surfaces because of the process of silica dissolution (*cfr*. Chap. 2, Par, 2.3.1.). At an early stage, the patina is composed of isolated whitish spots, spread all over the lithic surface. When the alteration was more intense, white spots have become larger, forming more or less continuous stripes, especially along the edges of the tools (Fig. 3.14, *a*). Actually, 'white patinas' have formed when the spots covered almost the whole flake (Fig. 3.14, *b*).

About the microscopic alteration of use-wear polishes, this is mainly caused by a process of abrasion and decay of micropolishes. This type of alteration is more evident on traces produced by working vegetable substances, which are largely composed of amorphous silica. Actually, the solubility of silica-gel is higher in alkaline solutions. On a microscopic level, such a dissolution is evident for the formation of non-polished areas (*cfr*. Chap. 2, Fig. 2.3.5.) (Fig. 3.14, *c-f*). The resulting polish is thus characterized by spots and a rougher aspect, as a consequence of silica dissolution (Mazzucco et al. 2013a). In most of the cases, polishes can still be analysed; however, when they are excessively deteriorated, it is no more possible to determine the exact type of material worked by the artefact concerned.

3.4.2. Level I.b

The traceological analysis has been carried out on 1,774 elements. About a quarter of them could not be analysed because of being too altered or fragmentary (*n.* 447; 25.2%). About a half of the assemblage did not show any trace (*n.* 983; 55.4%). Finally, tools characterized by use-wear or non-utilitarian traces amount to about one fifth of the analysed sample (*n.* 344; 19.4%).

Among the analysed tools, 86.3% (*n.* 297) show only one area of use, 13.1% (*n.* 45) two active zones, while 0.6% (*n.* 2) three active zones, for a total of 393 AUAs (Actually Used Areas). Almost all of those zones (*n.* 383) have been associated to 'use-wear' traces, while the remaining ones (*n.* 7) have been referred to 'non-utilitarian traces', such as hafting traces, residues, *etc.* Such a low frequency of non-utilitarian traces can largely be ascribed to the effects of taphonomic and post-excavation alterations that well resemble this type of traceological evidence. In terms of interpretation, 61.5% (*n.* 242) of the used areas have made a clear interpretation of the wear possible (SG); in 13.5% of the cases (*n.* 53), the interpretation has been considered probable (PR); finally, in 24.2% of them (*n.* 95), the interpretation has been considered doubtful (PO) (Tab. 3.4).

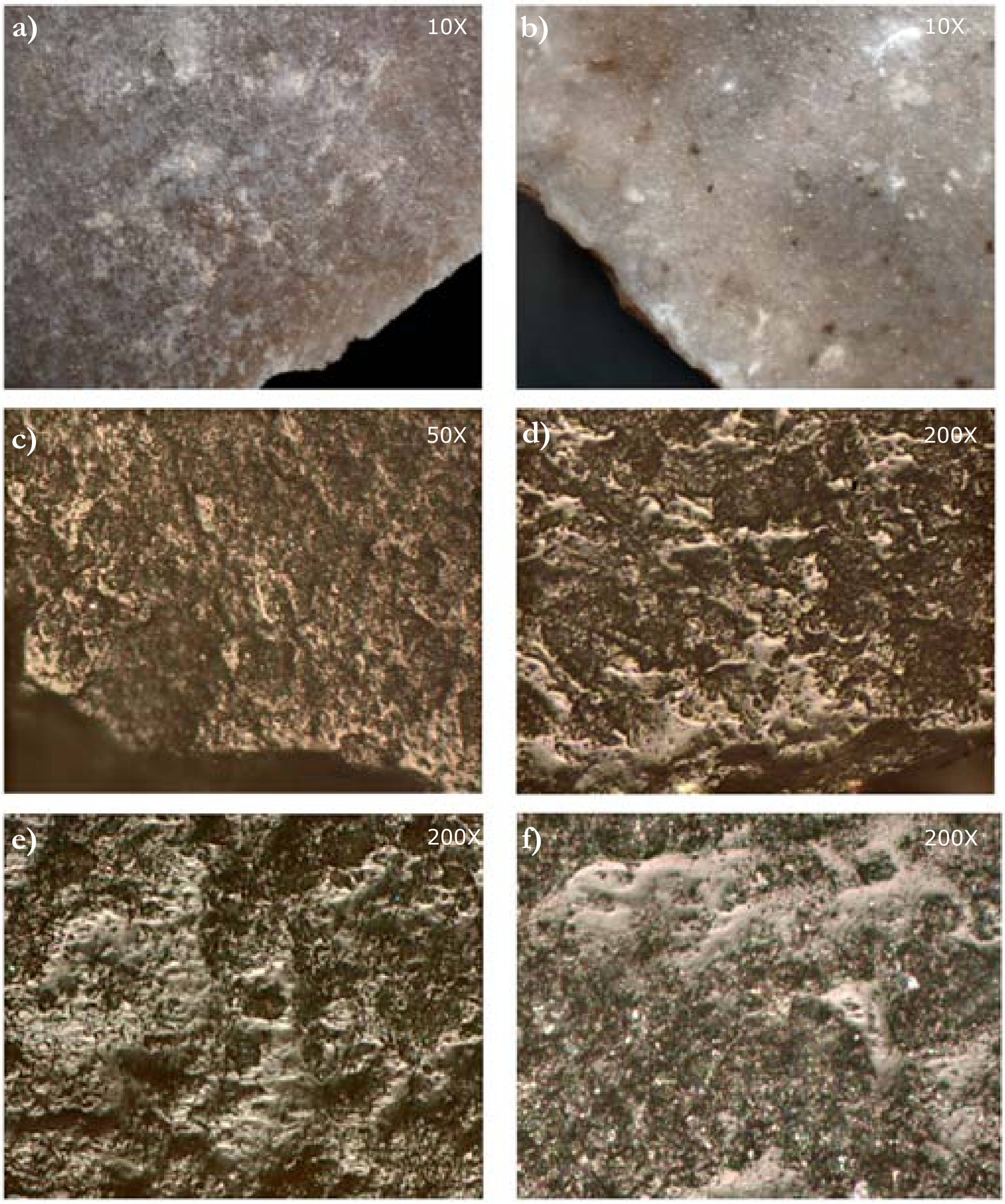

Fig. 3.14. Some example of the chemical alterations observed among the Cueva de Chaves lithic assemblage. *a -b)* Macroscopic view of alkaline patinas at different stage of development, 10X magnification. In the first image the original chert surface is still visible underneath the white spots. In the second one, the lithic surface is completely covered by the whitish patina; *c-f)* Degraded polishes. Original polishes were probably produced by the working of soft vegetal substances. The partial dissolution of the silica -gel led to a lost of volume, with the formation of craters and blank spots. Polishes now appears rougher and degraded. 50X and 200X magnifications.

3.4.2.1. Use-Wears

3.4.2.1.1. Vegetal Substances

Amongst the observed use-wears, the traces produced by vegetable-substance working represent the largest group (*n.* 119; 34.6%; *n.* 141 AUAs; 36.8%) (Tab. 3.5). A large variety of tools and actions related to different production processes has been included in this category. Amongst them, the working of non-ligneous plants prevails (*n.* 121 AUAs; 31.6%). One can further divide this category into several classes, depending on the type and state of the worked plants, as well as on the preservation of the wear: indeterminable non-ligneous plants (*n.* 58; 15.1%); dry herbaceous plants or cereals (*n.* 23; 6.0%); fresh herbaceous plants (*n.* 24; 6.2%); herbaceous plants with an abrasive component (RV2 traces) (*n.* 16; 4.2%). Woody plants are represented by a smaller group (*n.* 9; 2.3%).

The last category is represented by indeterminable vegetable materials (*n.* 11; 2.9%), and includes all those traces related to the working of vegetable substances characterized by a poorly preserved traces.

For working this type of material, blade blanks were preferred (*n.* 105), while only one quarter of the assemblage is represented by flakes (*n.* 36). One has to add to these a burin stroke with traces of previous use on vegetable matters (*n.* 1). In terms of type of movement, longitudinal actions prevail (*n.* 116) on the transverse ones (*n.* 25) (Tab. 3.6).

3.4.2.1.1.1. Herbaceous Plants

The tools associated with the harvesting of *dry herbaceous plants or cereals* were all made on laminar blanks. From a dimensional and technological point of view, they appear quite standardized, with dimensions between 10 and 14 mm in width and between 3 and 4 mm in thickness on average. The length is more difficult to estimate, all elements being fragmentary. The tools were not intentionally broken before employing them and distal/proximal fractures occurred after their use. The most complete elements are between 45 and 50 mm in length (Fig. 3.15).

The so-called 'cereal gloss' is generally visible to the naked-eye. Its distribution is generally parallel or slightly transverse to the edge, forming an angle of about 10°-15° with the border. The micropolish shows the characteristic features of the cereal gloss, with a flat topography and a compact texture, along with the presence of pits and comet-tail strias (Fig. 3.15-3.18).

Tools' state of fragmentation suggests that all of them were discarded at the end of their use-life. It is highly probable that the cultivation fields were located at a certain distance from Cueva de Chaves and that sickles were carried back to the site only for being refitted or repaired. This behaviour might have brought about the abandonment of exhausted blades within the cave area. According to this, I have identified two tools that were retooled on site after being employed as sickle inserts, in order to produce borers (Fig. 3.18, *a*), and a resharpening flake with traces of previous use still as sickle (Fig. 3.18, *b*). The production of borers with used sickle blades has also been observed in several other sites of the Central and Northern Iberian Peninsula, such as San Pau del Camp in Catalonia and Revilla del Campo in Soria (Gibaja 2009).

Sickle blades were never retouched on the active edge. Only in one case, a simple resharpening retouch is present, which must have occurred later than the first use of the tool (Fig. 3.16, *a*). On the other hand, the opposite edge was occasionally retouched for attaching the blade to the handle (Fig. 3.16, *a*; 3.17*, a*).

Methods of hafting the sickle blades at Chaves are difficult to define, considering the

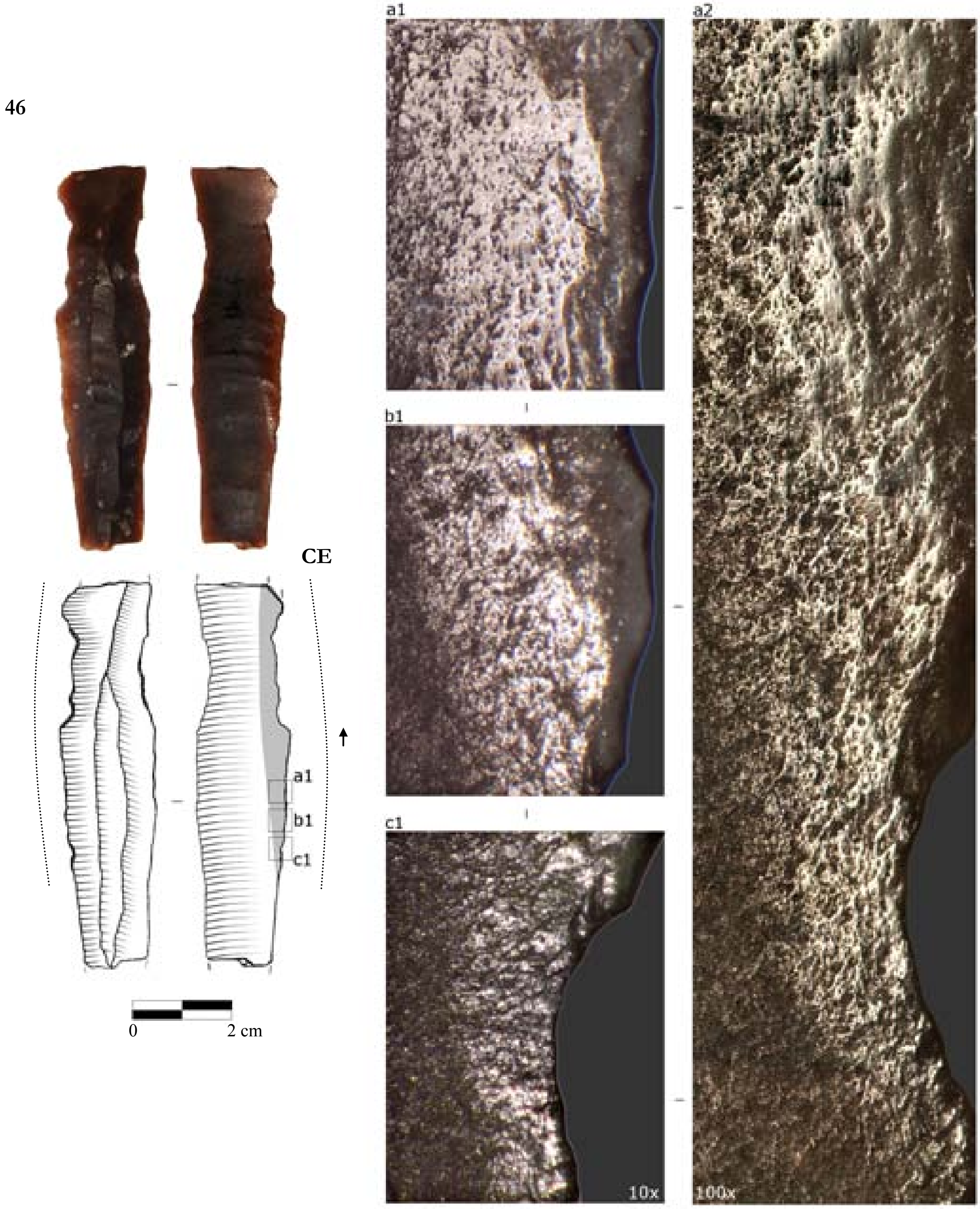

Fig. 3.15. Use-wears from the Cueva de Chaves, level 1.b. **46-** Tool used for harvesting herbaceous plants, probably cereal; *a1-c1)* Macroscopic views of the edge showing 'cereal lustre' with slightly diagonal orientation (10X, ventral face); *a2*) Microscopic view of the polish: band of compact polish produced from harvesting herbaceous plants, 100X.

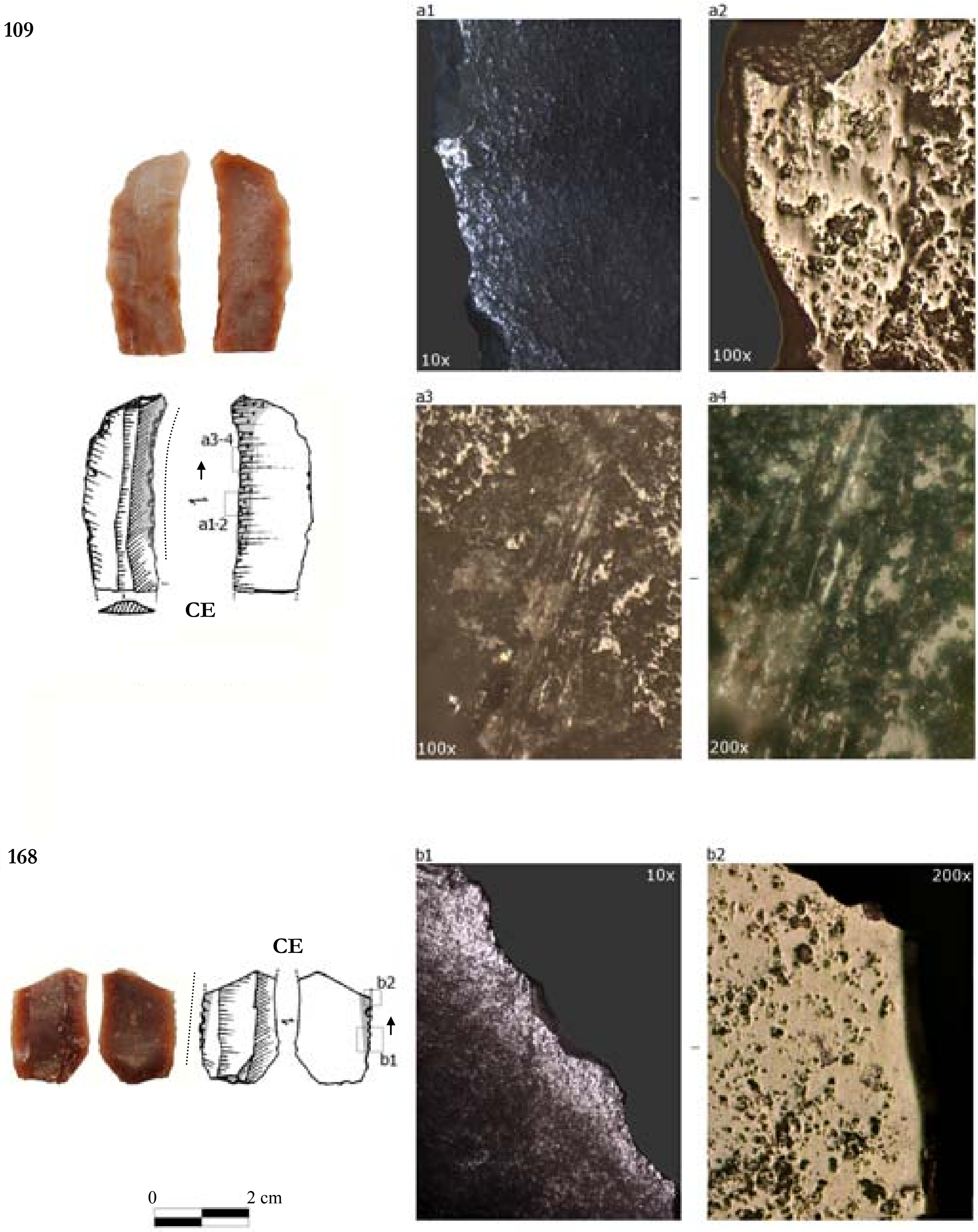

Fig. 3.16. Use-wears from the Cueva de Chaves, level 1.b. **109-** Tool used for harvesting herbaceous plants, probably cereal; *a1)* Macroscopic view of the edge showing 'cereal lustre'. The edge is characterized by the presence of resharpening retouches (10X, ventral face); *a2*) Microscopic view of the polish: band of compact polish produced from harvesting herbaceous plants, 100X; *a3-4*) Microscopic view of a plant silica body stuck on the tool's active edge (100Xand 200X). **168-** Tool used for harvesting herbaceous plants, probably cereal; *b1)* Macroscopic view of the edge showing 'cereal lustre', with a slight diagonal orientation (10X, ventral face); *b2)* Compact cereal polish, at 200X.

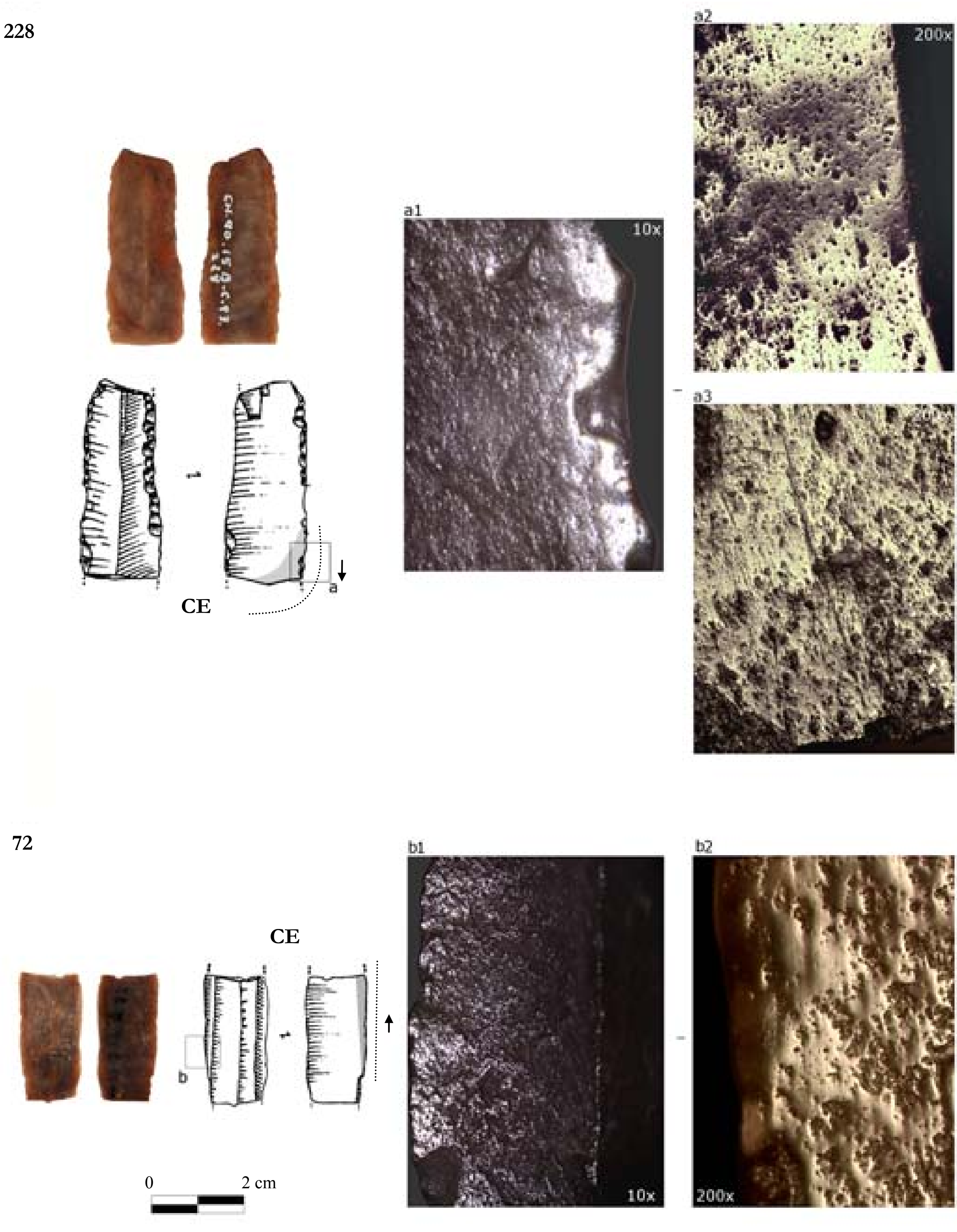

Fig. 3.17. Use-wears from the Cueva de Chaves, level 1.b. **228-** Tool used for harvesting herbaceous plants, probably cereal; *a1)* Macroscopic view of the edge showing 'cereal lustre' (10X). The lustre has a very diagonal distribution and it is interrupted by the proximal fracture; *a2-a3*) Microscopic view of the polish. Note how the proximal fracture interrupt the polish, 200X; **72-** Tool used for harvesting herbaceous plants, probably cereal; *b1)* Macroscopic view of the edge showing 'cereal lustre', with a parallel, marginal distribution (10X, dorsal face); *b2)* Cereal/plant polish, at 200X.

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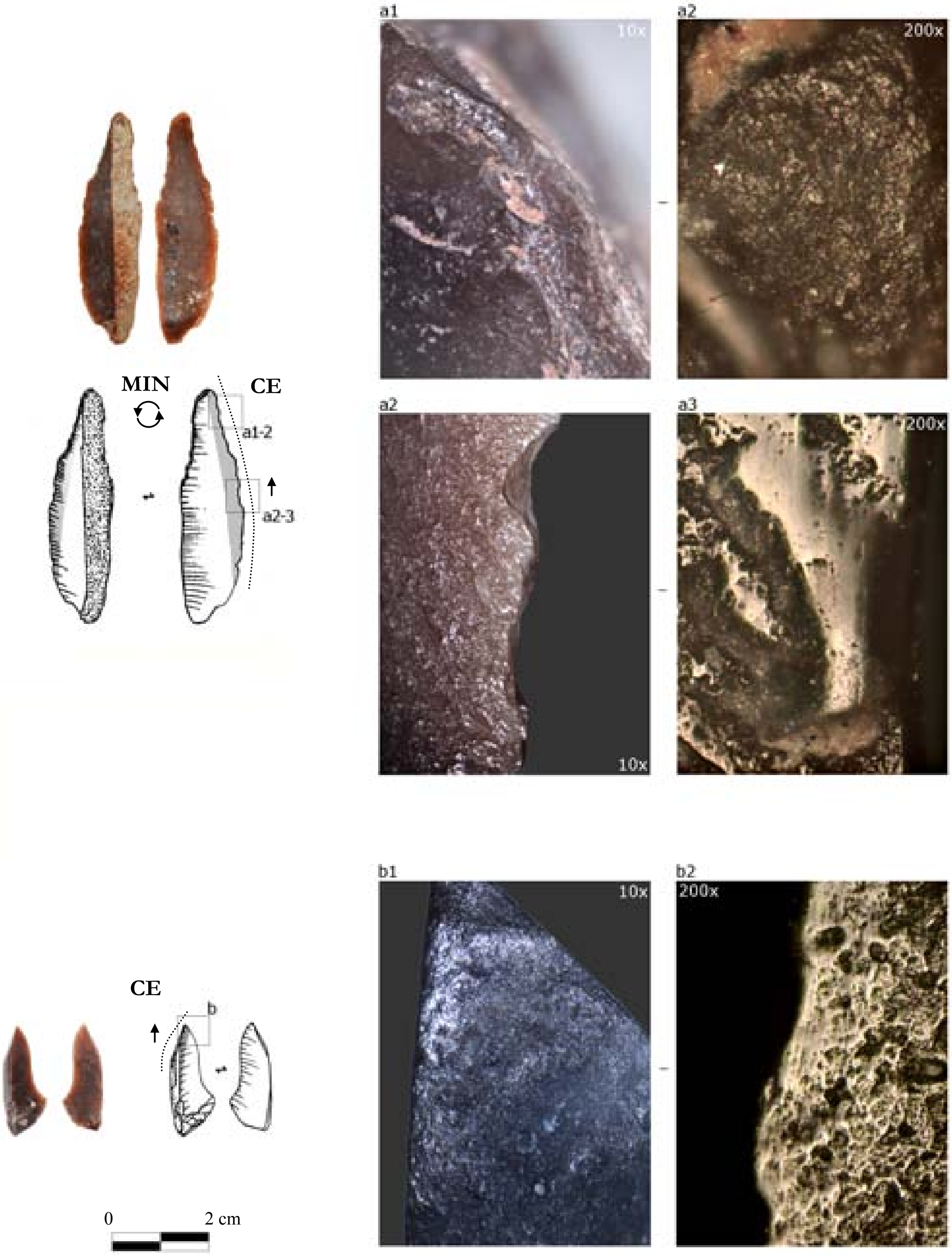

Fig. 3.18. Use-wears from the Cueva de Chaves, level 1.b. **68-** Tool used for harvesting herbaceous plants and later retooled to drill mineral –abrasive– materials; *a1*) Macroscopic view of the point of the borer with overlapping step scars. Note the pronounced rounding of the ridges, 10X; *a2)* Microscopic view of the mineral polish on the point, 200X; *a3*) View of the edge showing a residual 'cereal lustre', 10X; *a4*) Microscopic view of the cereal polish, at 200X. **5-** Rejuvenation flake of a tool used for harvesting herbaceous plants, probably cereal; *b1)* Macroscopic view of the edge showing 'cereal lustre' on the dorsal ridge (10X). *b2*) Microscopic view of the cereal/plant polish.

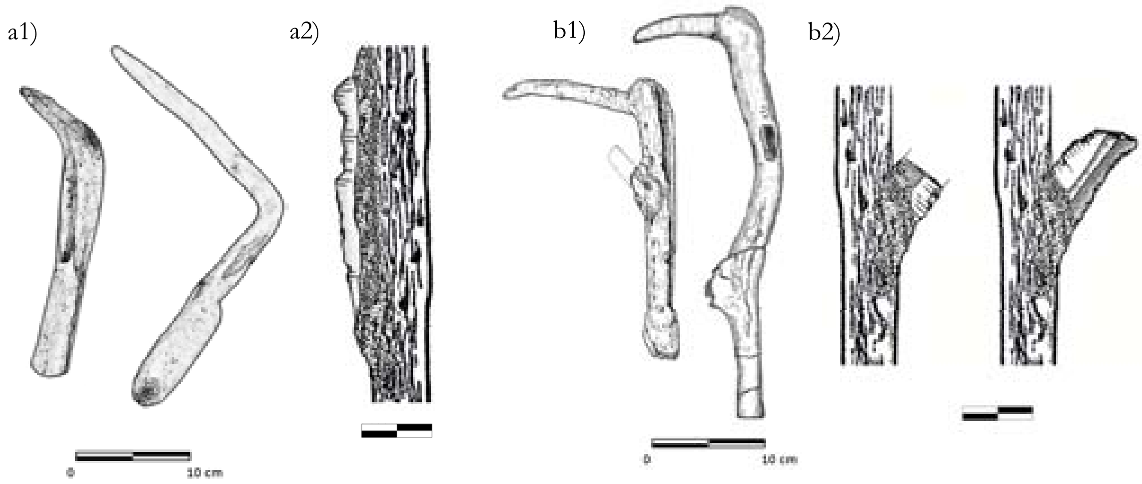

Fig. 3.19. Hypothetical reconstruction of the sickle blades recovered at the Cueva de Chaves: *a1)* Sickles with parallel insertion from La Draga settlement. Draws modified from Bosch et al. (2006); *a2*) Hypothetical hafting mode of the sickle blade *n*. 46 from the Cueva de Chaves; *b1*) Sickles with single diagonal insertion from Costamar (Flor et al. 2012) and La Draga site (Bosch et al. 2006); *b2*) hafting mode of the sickle blades *n*. 109 and 288 from the Cueva de Chaves.

fragmentarity of the blanks. However, the size of the tools and the orientation of lustres seem to recall the type of sickles used in Languedoc-Roussillon (Gassin et al. 2008) and along the Catalan Coast (Ibáñez et al. 2008; Gibaja 2002) during the sixth-fifth millennium cal BC. This type of blades was probably hafted individually (or in pair) parallel to the handle, forming an edge of about 5-8 mm; wooden sickles of this type have been recovered at the lacustrine settlement of La Draga in Catalonia (Bosch et al. 2006: fig. 204; Palomo et al. 2011). However, amongst Cueva de Chaves' assemblage, there are only two elements that clearly do not match this hafting pattern (Fig. 3.16, *a*; 3.17, *a*). In those cases, the cereal gloss has a much more oblique distribution, forming an angle of about 30° with the edge. Moreover, the hafted part of both blades appears quite long, with a range of 1-3 cm. This type of insertion may correspond to the type of sickles with transversal branch and a single flint blade inserted diagonally, like those recovered at La Draga (Bosch et al. 2006: fig 203) and Costamar in the Valencia Coast (Flors et al. 2012).

The traces associated with the working of *herbaceous plants with an abrasive component* have mainly been defined on the basis of the work by Clemente & Gibaja (1998). These type of traces may have been produced by several economic processes which involved two main elements: 1) soft vegetable materials —mostly herbaceous plants— and 2) abrasive elements such as soil and sediment particles. Activities that could imply the contact of lithic tools with these two elements were for example: 1) the cutting of grasses or straw to ground level; 2) the separation of the ears from the straw if carried out on the ground; 3) the cutting of sods or of part of the meadow (Gijn 1988). All of these tasks had an important economic role as the obtained materials could be used in a variety of production processes. Straws and grasses could be used as fuel, as construction materials for houses, roofs, bedding, and drainage systems, and for craft activities like basketry, or as fodder for animals, *etc.* (Zapata et al. 2004: 295-311; Gijn 2010: 84-91).

In all cases, the characteristics of these traces derived from a combination of plant polishes and abrasive elements. In fact, during the cutting movement, the contact with the

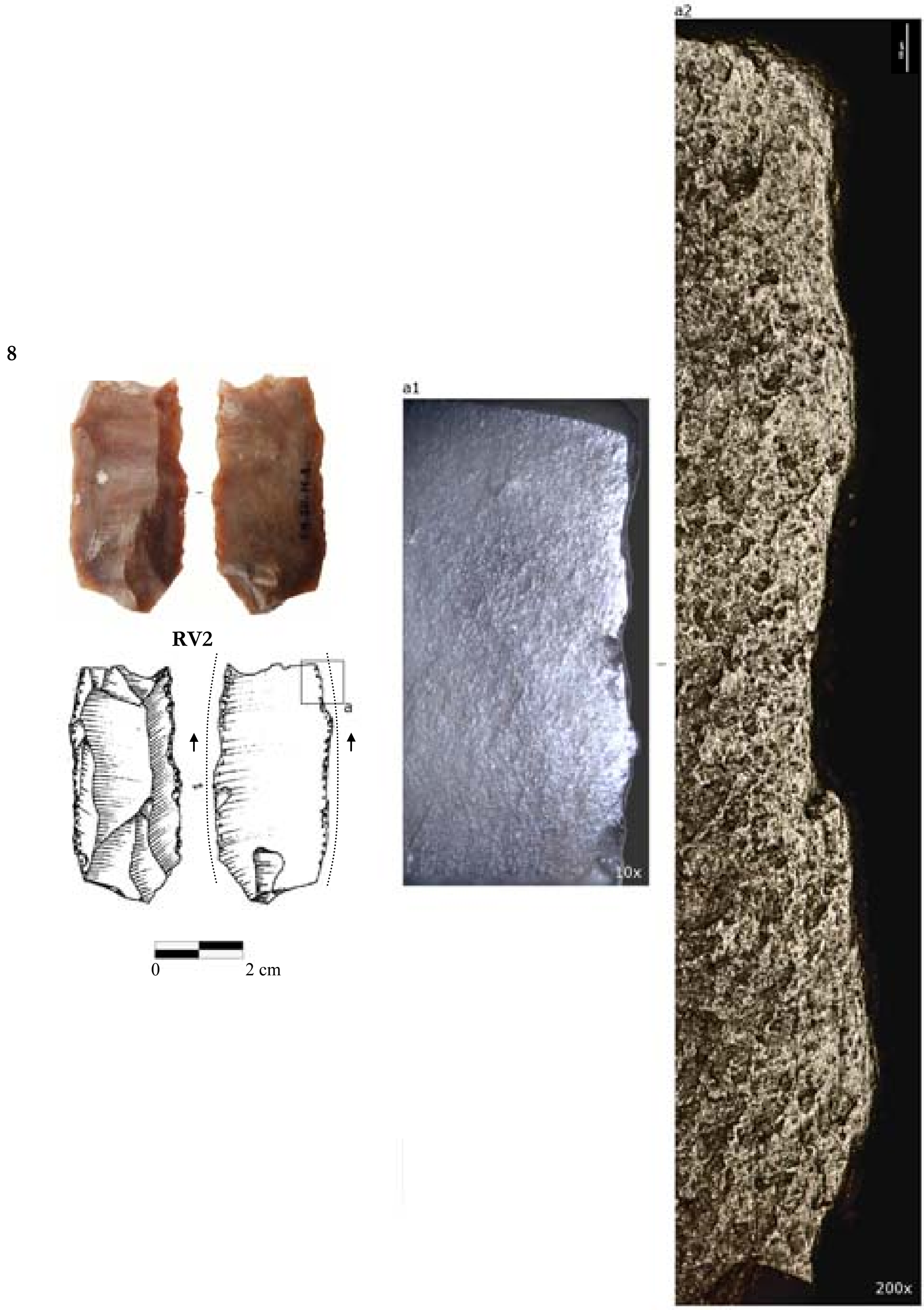

Fig. 3.20. Use-wears from the Cueva de Chaves, level 1.b. **8-** Tool showing traces of herbaceous plants with a strong abrasive component, employed on both sides: *a1*) Macroscopic view the active edge with a rounded and polished appearance, 10X; *a2*) Collage of microscopic photo of the so-called 'RV2' polishes, at 200X.

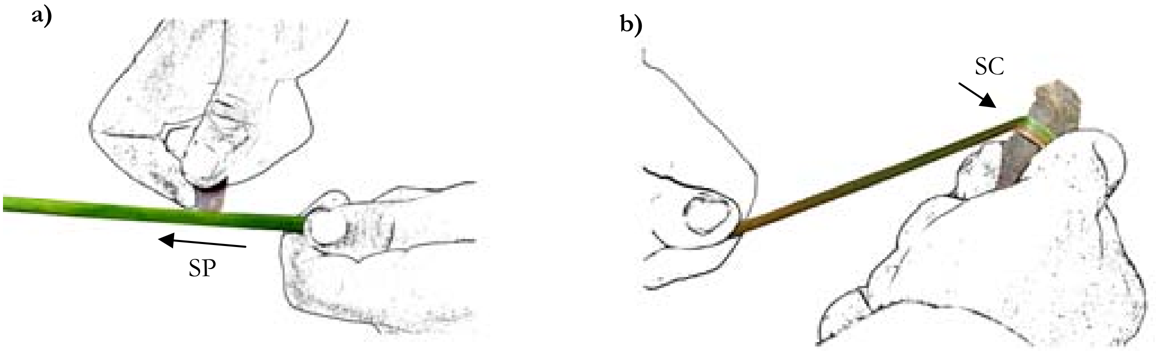

Fig. 3.21. Basketry tasks: *a*) vegetal fibres splitting (SP); *b*) vegetal fibres scraping (SC). Experimentation realized with *Juncus*-type plants. The arrows indicate the directionality of the movement.

plants originated a silica-gel layer on the lithic edges, which was constantly scratched and abraded by the soil particles trapped on the tool's surfaces. At Cueva de Chaves, tools showing this type of traces are mainly represented by laminar blanks with dimensions between 35 and 50 mm in length and between 10 and 16 mm in width (Fig. 3.20). As a result of abrasion, the active edge shows a marked rounding and the surface is extensively polished (Fig. 3.20, *a1*). Microscopically, the lithic surfaces are characterized by a rough polishing, with many strias featured by a longitudinal directionality, and, occasionally, residual spots of smooth and fluid plant polish (Fig. 3.20, *a2*). In three cases, both edges of the tool have been used, while the remaining tool shows only one edge being used.

The traces relevant to working *fresh herbaceous plants* are characterized by a smoother aspect, with a fluid and undulating polish distributed in stripes along the active edge. Only a small number of those tools has been employed for activities performed by a longitudinal movement (*n.* 5) (Fig. 3.22), whereas the majority of them attests to a scraping movement (*n.* 19) (Fig. 3.23) (see Tab. 3.6 at the end of the chapter).

Tools employed for cutting fresh plants were very thin and short blades, measuring 29-41 x 10-16 x 2-3 mm (Fig, 3.22, *a-c*). The traces are always marginal, forming a bright streak on the very edge of the tool, not penetrating the surface. This pattern seems to suggest a short and non-intensive use. Microscopically, the polish is very smooth, with a convex and undulating shape, mainly affecting the highpoints of the chert topography. This type of use may be ascribed to short activities relevant to wild-plants gathering and also to the splitting of vegetable fibres, in order to prepare them for basketry (Fig. 3.21, *a*) (Gijn 2010).

Tools employed for scraping soft vegetable substances can also be related to basketry activities (Fig. 3.21, *b*). Within this category, I have ascertained the presence of both blades (*n.* 15) and flakes (*n.* 9). Used blanks show sharp, unretouched edges with angles between 25° and 30° (Fig. 23, *a*), or obtuse angles between 35° and 45°, often retouched in order to create a notch (Fig. 23, *b-c*). Traces are always limited to a small portion of the edge, 1.5-2 cm maximum; polishes show a clear transverse directionality, with a very smooth aspect, a domed topography, and a compact texture.

In the category of *non-ligneous indeterminable plants* all those traces fall that are characterized by a poor preservation and a low-level development. In those cases, it is not possible to advance a detailed interpretation of the use-wear. However, in most of the cases, it is still possible to recognize the type of worked material and the directionality of the movement. I am referring to traces that appear deteriorated or affected by some taphonomic agent. Only a

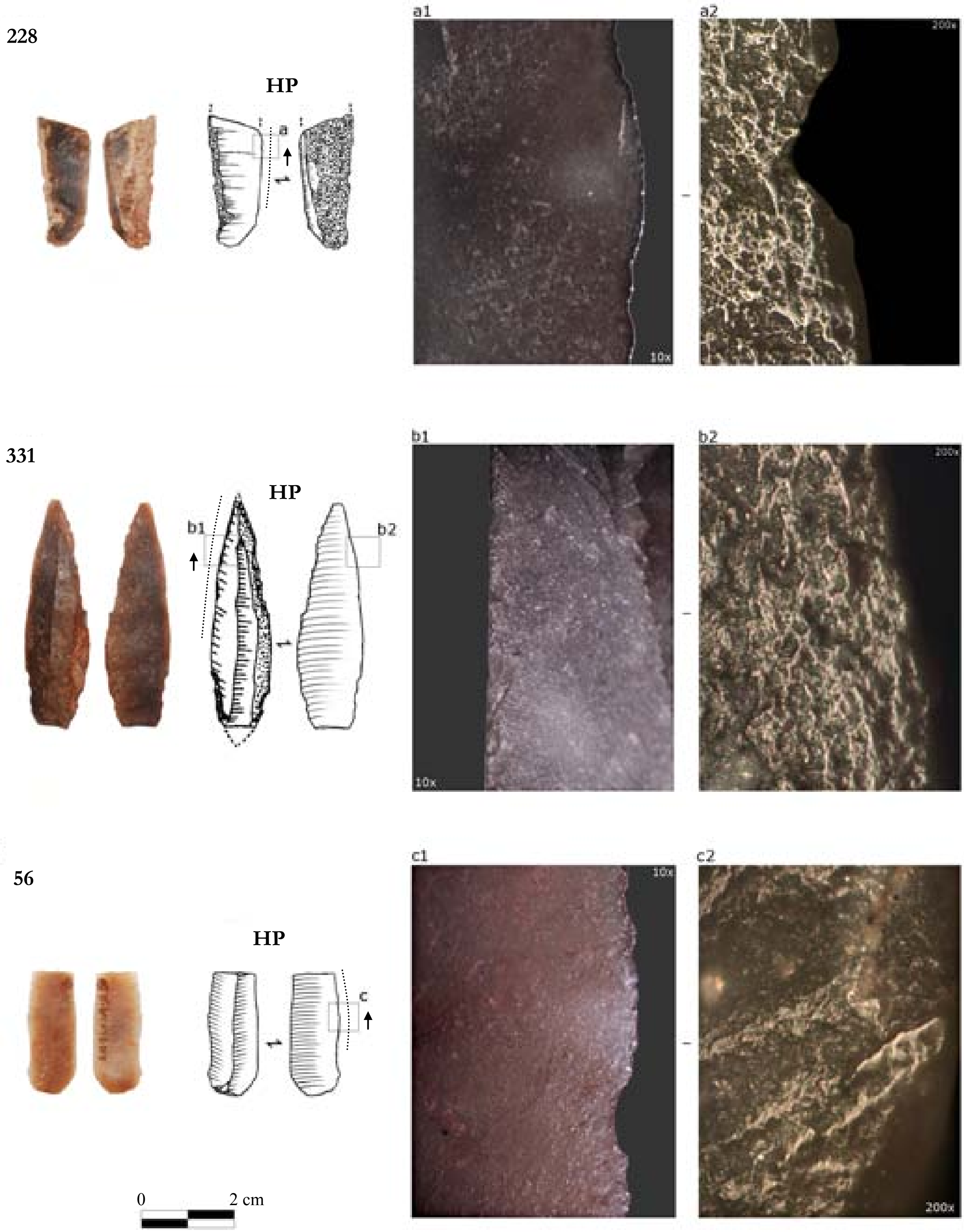

Fig. 3.22. Use-wears from the Cueva de Chaves, level 1.b. **228-** Tool showing traces of herbaceous plants cutting; *a1*) Macroscopic view the active edge, a very marginal band of polish is visible, 10X; *a2*) Marginal plant polish, 200X. **331-** Tool showing traces of herbaceous plants cutting; *b1*) Macroscopic view the active edge, moderate edge-scarring, 10X; *b2*) Marginal plant polish, partially altered. **56-** Tool showing traces of herbaceous plants cutting; *c1*) Macroscopic view the active edge, bright spot of polish are visible, 10X; *c2*) Marginal plant polish with longitudinal directionality.

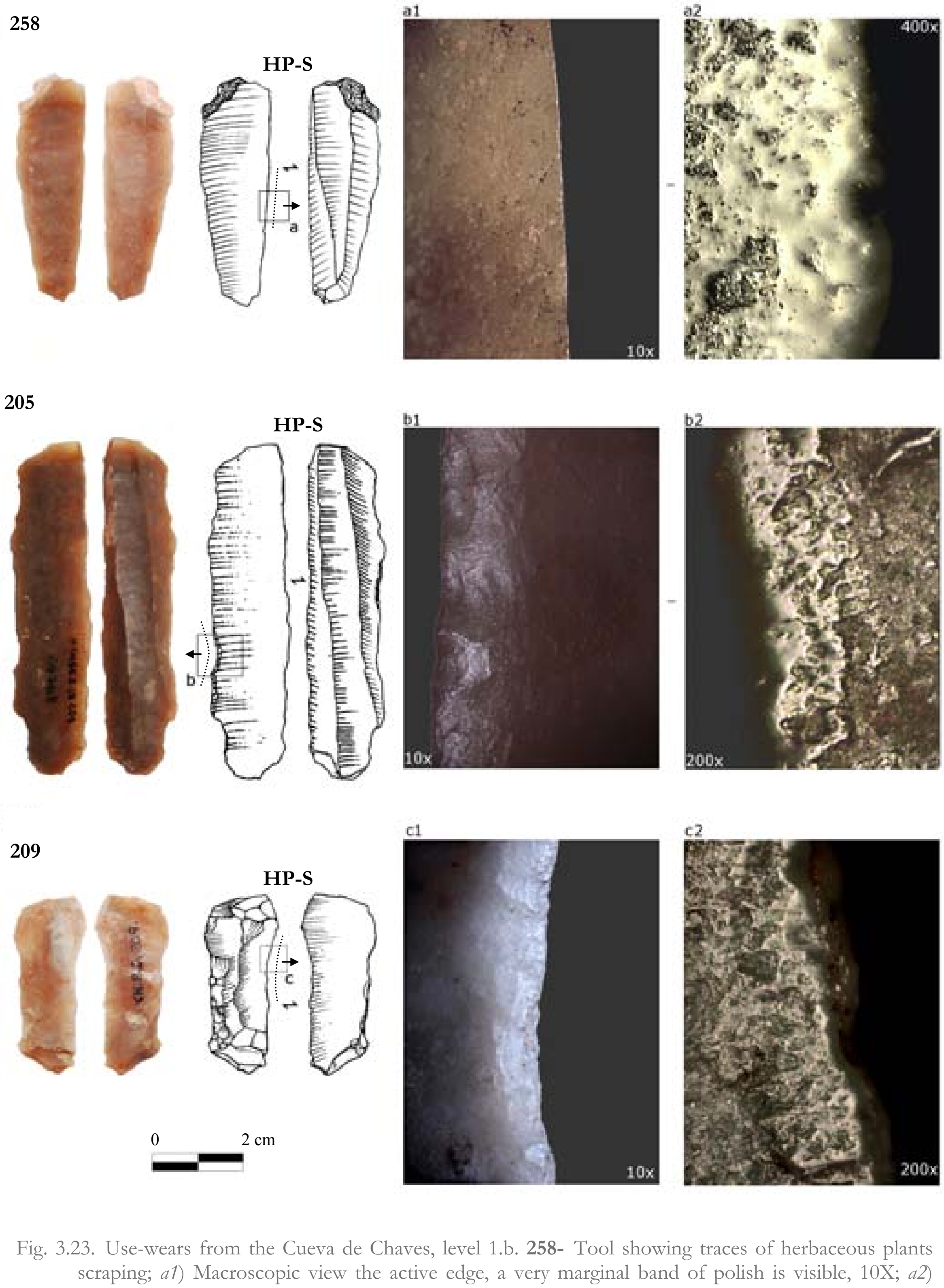

Fig. 3.23. Use-wears from the Cueva de Chaves, level 1.b. **258-** Tool showing traces of herbaceous plants scraping; *a1*) Macroscopic view the active edge, a very marginal band of polish is visible, 10X; *a2*) Polish from scraping fresh plants, 400X. **205-** Tool showing traces of herbaceous plants scraping; *b1*) Macroscopic view the retouched edge, 10X; *b2*) Polish from scraping fresh plants, 200X. **209-** Tool showing traces of herbaceous plants scraping; *c1*) Macroscopic view the retouched edge, 10X; *c2*) Marginal plant polish with transversal directionality.

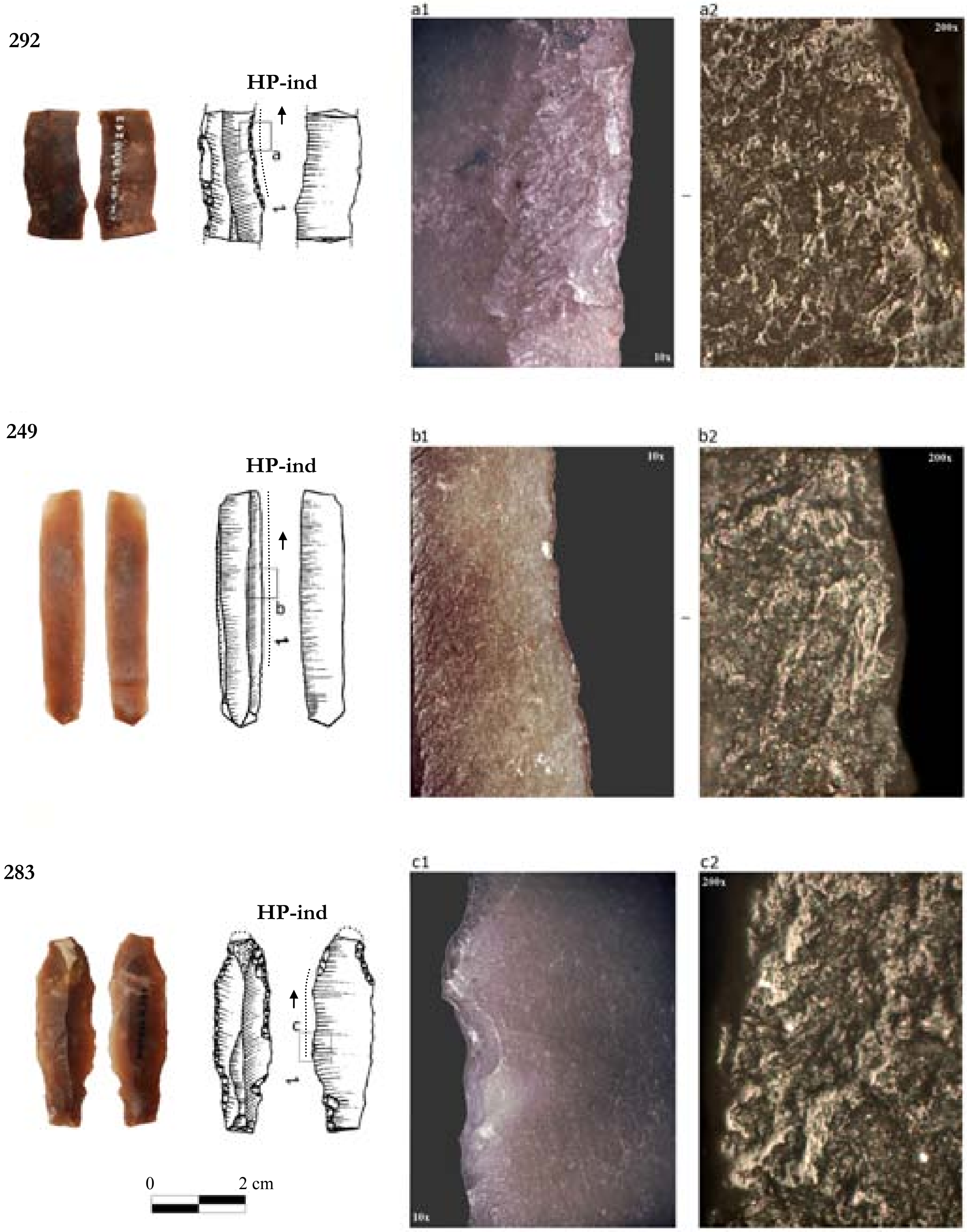

Fig. 3.24. Use-wears from the Cueva de Chaves, level 1.b. **292-** Tool showing traces of indeterminable herbaceous plants; *a1*) Macroscopic view the active edge, 10X; *a2*) Altered plant polish. Only residual spots are visible, while large parts of the trace appears dissolved, 200X. **249-** Tool showing traces of indeterminable herbaceous plants cutting; *b1*) Macroscopic view the retouched edge, 10X; *b2*) Altered plant polish, 200X. **209-** Tool showing traces of indeterminable herbaceous plants cutting; *c1*) Macroscopic view the retouched edge, 10X; *c2*) Altered plant polish.

few residual spots of the original polishes are still recognizable on the lithic surfaces; however, their texture and aspect appear partially changed (Fig. 3.24, *a-c*). For this elements, it is not possible to discern whether they were used for harvesting cereals, cutting straw to ground level, or scraping fresh fibres.

Most of these tools are blades (*n.* 48), with sizes between 34 and 47 mm in length and between 11 and 15 mm in width, thus fundamentally matching the same type of blanks employed for the above-mentioned activities. They are generally unretouched; the edge-scarring visible on the edges corresponds to a slight edge-fracturing and not to an intentional retouching. The use of flakes and core trimming elements was limited (*n.* 8). They were all employed for activities performed by a longitudinal movement (*n.* 56), except for two implements that were used by a transverse one.

In summary, amongst the tools associated with herbaceous-plants processing (*n.* 100), activities carried out by a longitudinal movement prevail. These mainly concerned laminar blanks (*n.* 83) (39-49 x 11-15 x 2-4 mm), whilst the number of flakes is smaller (*n.* 17) (34-44 x 14-18 x 3-5 mm). Transverse movement has been ascertained for a greater variety of blanks, both blades (*n.* 13) (43-53 x 12-15 x 3-5 mm) and flakes (*n.* 8) (37-45 x 15-27 x 4-6 mm), which also include two thicker elements and two core rejuvenation flakes (43-47 x 21-31 x 7-9 mm) (Tab 3.6, 3.7).

3.4.2.1.1.2. Woody Plants

The elements associated with the working of *woody plants* represent quite a small assemblage (*n.* 9; 2.3% of the total number of use-wears). For wood-working activities, flakes were preferred (*n.* 8) to blades (*n.* 2). The selected blanks appear not very elaborate, generally unretouched. Cortical flakes and core rejuvenation flakes prevail (Fig. 3.25, *a-b*). Only in one case, I have observed the use of a formatted blank, with a continuous retouch on both edges, in order to form a pointed tool (Fig. 3.25, *c*). Traces associated with transverse movements prevail (*n.* 6), whereas only four elements, amongst which the two aforesaid blades, were employed for longitudinal actions (*n.* 4) (Tab. 3.6, 3.7). Actives are characterized by a pronounced rounding often connected with a series of wide, invasive bending fractures. The microscopic view of use-wears suggests that the working of woods of different hardness, from soft woody plants to harder woods, originated the characteristic bevel-like polishes (Fig. 3.25, *a-c*) (Gassin et al. 2013).

In general terms, the working of wood materials seems to have had a marginal role within the flaked stone assemblage of Cueva de Chaves. Lithic tools were probably employed for accomplishing specific tasks relevant to wooden-artefacts manufacturing, such as finishing or resharpening. It is highly probable that also other types of instruments were used in these craft activities, especially for all the phases of raw-materials preparation, reduction, and configuration. However, a detailed study of the polished and macrolithic tools from Cueva de Chaves is still missing.

3.4.2.1.1.3. Indeterminable Vegetal Substances

A number of lithic instruments shows traces of *indeterminable vegetal substances.* Such tools are characterized by a poor preservation of micropolishes and so it is difficult to discern whether the type of worked substance was a ligneous or non-ligneous plant. In general, only residual spots of the vegetal polishes are visible. Probably both chemical and mechanical alterations have produced a deterioration of use-wears and their original distribution and

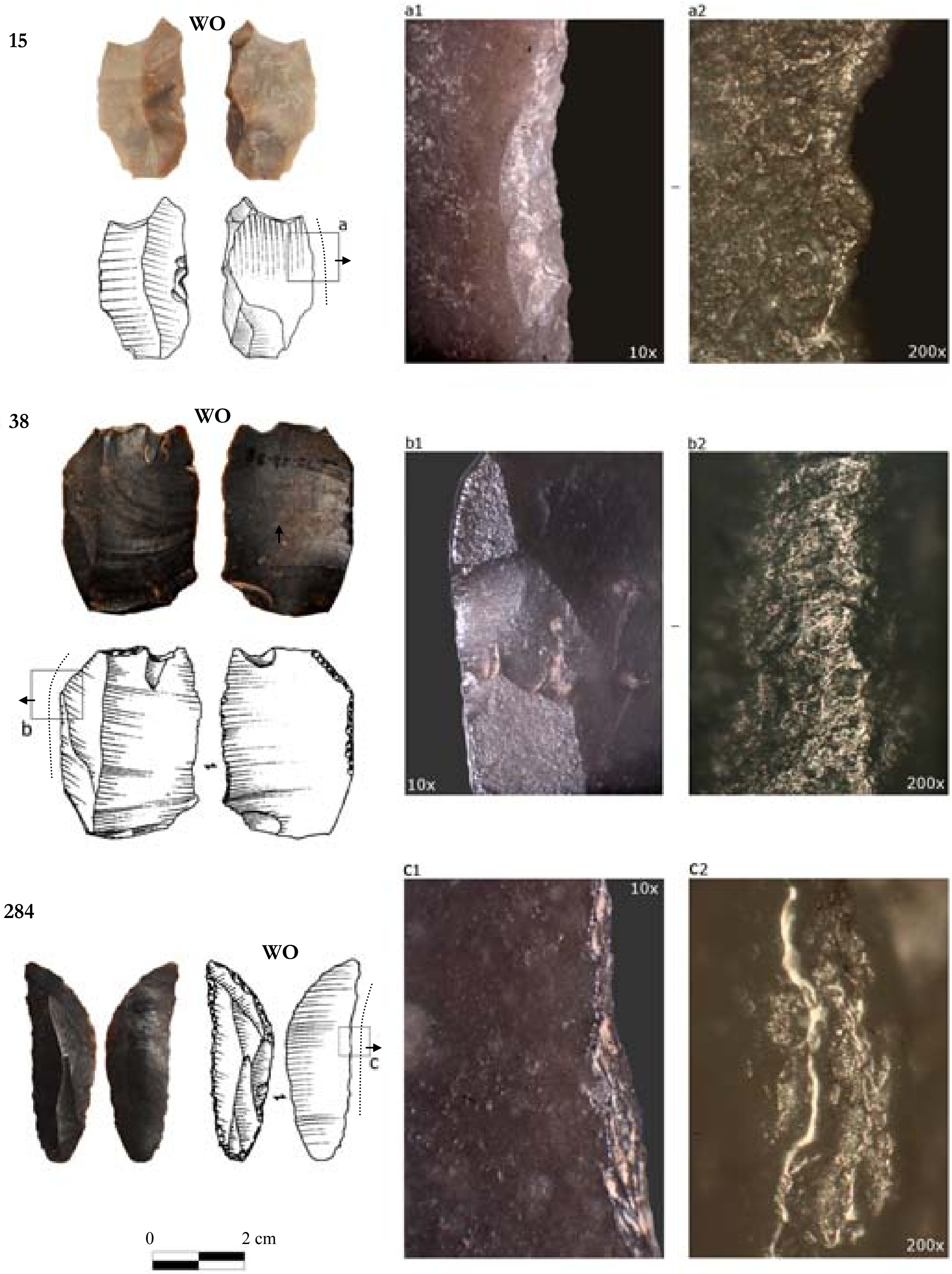

Fig. 3.25. Use-wears from the Cueva de Chaves, level 1.b. **15-** Tool showing traces of wood working; *a1*) Macroscopic view the edge-scarring, 10X; *a2*) Spots of wood polish with transversal directionality, 200X. **38-** Tool showing traces of wood working; *b1*) Macroscopic view the active zone, see the pronounced rounding 10X; *b2*) Transversal wood polish on the very edge, 200X. **284-** Tool showing traces of wood working; *c1*) Macroscopic view, 10X; *c2*) Bevel-like wood polish, 200X.

texture are therefore not distinguishable anymore. Given the presence of post-depositional alterations, their interpretation remains uncertain.

Amongst those instruments, blades prevail (*n.* 7), followed by a limited number of flakes (*n.* 4). In both cases, the used blanks show the same typometric and morphological criteria that have been observed for the previous functional classes. The movement is generally longitudinal, even if sometimes it is hard to recognize its directionality, since surfaces are poorly preserved.

3.4.2.1.2. Animal Substances

The tools associated with the working of animal substances represent the second largest group amongst the Cueva de Chaves lithic assemblage (*n.* 86; 25.0%) (*n.* 98 AUAs; 25.6%). In this cluster, hide-working prevails (*n.* 58; 15.1%), followed by slaughter and butchering activities (*n.* 22; 5.7%), and by all those related to the working of hard animal substances (bone or antler) (*n.* 18; 4.7%) (Tag. 3.5).

The employment of flakes and knapping by-products prevails (*n.* 66) over the use of laminar blanks (*n.* 31). Amongst the performed movements, the transverse ones are slightly more common (*n.* 50) than the longitudinal ones (*n.* 44), while drilling movement features in a much smaller number of artefacts (*n.* 4) (see Tab. 3.6; Tab. 3.7 at the end of the chapter).

3.4.2.1.2.1. Skin/Hide

Hide working activities are attested to at Cueva de Chaves by a variety of tools and 'movements'. I have identified four main classes of tools involved in the operations relevant to hide working: 1) endscrapers with a convex or subrectilinear retouched front (Fig. 3.26); 2) rejuvenation flakes and other knapping by-products (Fig. 3.27); 3) little formatted unretouched blades (Fig. 3.28); 4) retouched borers (Fig. 3.29, *c*).

Endscrapers (*n.* 19) were mainly made on large blanks with size between 20 and 30 mm in width and between 6 and 11 mm in thickness; length is always over 30 mm, even if in most cases endscrapers are fractured. All of those instruments were made on large and compact core-preparation or debitage-rejuvenation flakes. The retouched front is generally convex or slightly convex and the action was performed by placing the distal edge over the material and working it by a transverse movement. Generally, the action appears carried out almost with a straight angle in respect to the worked surface. The edge is moderately rounded, occasionally with some overlapping micro-fractures on the dorsal face. The micropolish is distributed in marginal bands over the working zone, often affecting the upper face (generally the dorsal face) (Fig. 3.26, *c1*). Traces show a very greasy and rough aspect, characterized by craters, pits and occasionally strias (Fig. 3.26, *a-c*). This type of traces is generally associated with the first stages of hide working, are also known as 'skinning' and 'fleshing' (Keeley 1980: 49; Beyries & Rots 2008; Gijn 2010: 79). Such an activity was mainly related to the of removing animal fat, muscles, and all adipose tissues (Plisson 1985: 46-48; Calvo 2004: 140-153).

Depending on the type of the adopted hide-processing technique, lithic endscrapers could also be used for the hide 'dehairing' phase. This type of activity is also called 'wet-scraping' by scholars, namely, a method of hide processing where the scraper was used for both fleshing and dehairing and is generally associated with deerskin-working techniques, at least amongst the Plains Indian groups (Schultz 1992; Wiederhold 2004). By this technique, the tools is used to remove both the hair and the grain layer of the hide, which is previously soaked in water, in order to loosen the hair. Bases such as lye from wood ashes, ochre, or

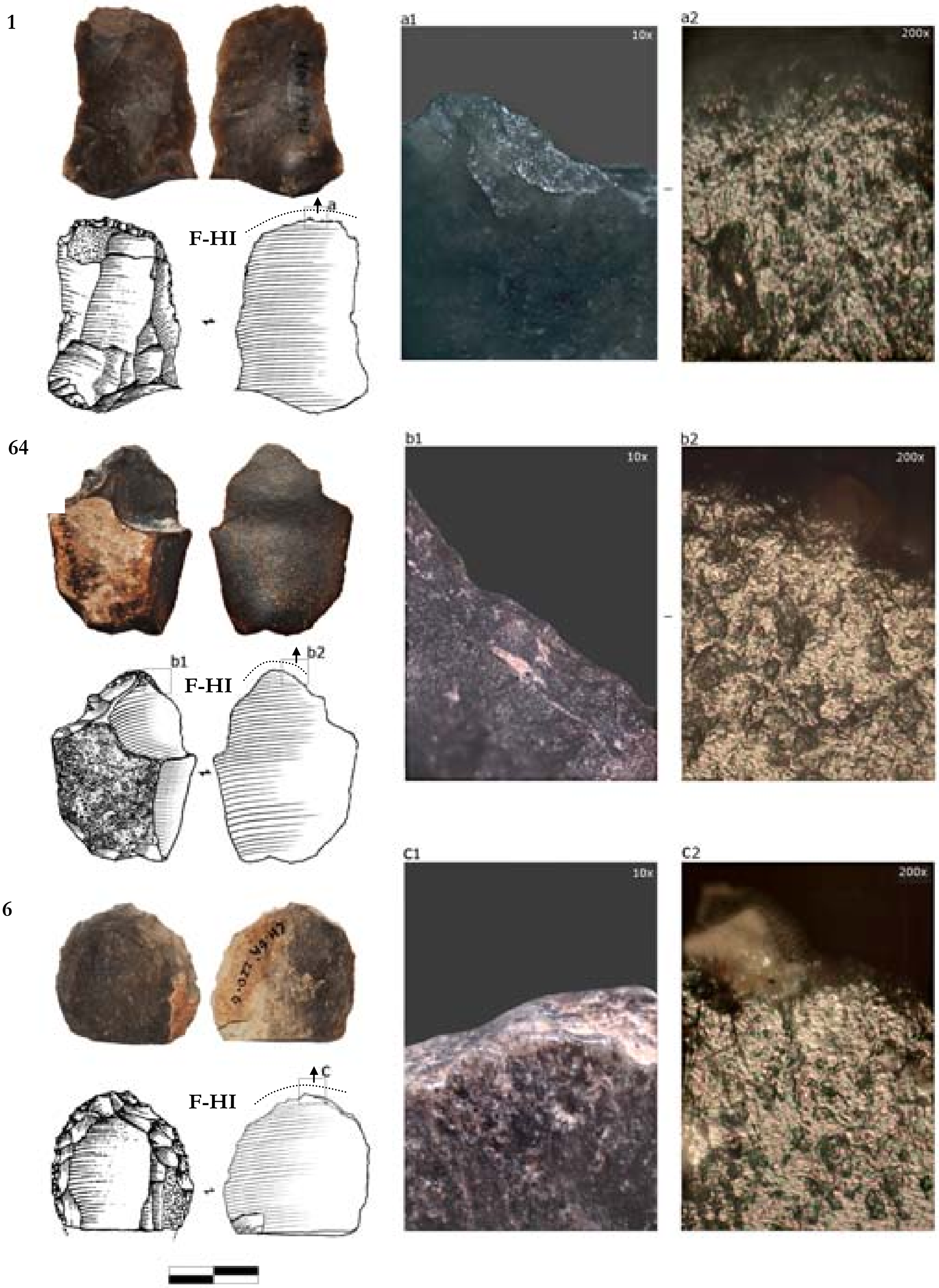

Fig. 3.26. Use-wears from the Cueva de Chaves, level 1.b. **1-** Tool showing traces of hide working; *a1*) Macroscopic view, 10X; *a2*) Greasy and rough polish with a mineral component, 200X. **64-** Tool showing traces of hide working; *b1*) Macroscopic view of the edge-resharpening, 10X; *b2*) Greasy and rough polish, 200X. **6-** Tool showing traces of hide working; *c1*) Macroscopic view, see the edge-rounding and the ochre residues, 10X; *c2*) Greasy and rough polish with a mineral component, 200X.

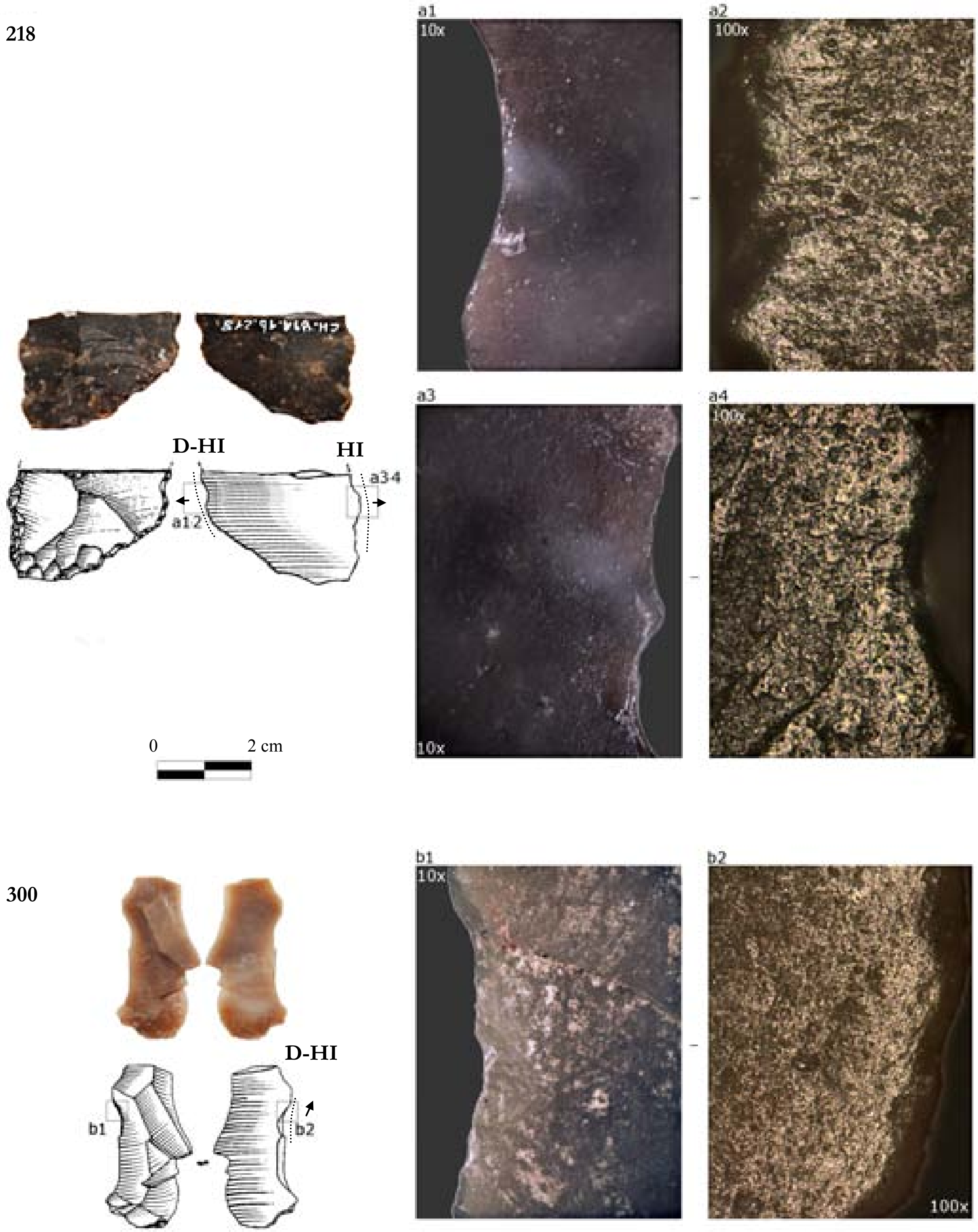

Fig. 3.27. Use-wears from the Cueva de Chaves, level 1.b. **215-** Tool showing traces of hide working on both sides; *a1-a3*) Macroscopic view the used edges, 10X; *a2-a4*) Rough hide polish with transversal directionality. In one case the worked matter is probably dry hide. **300-** Tool showing traces of hide working; *b1*) Macroscopic view the active zone, 10X; *b2*) Dry-hide polish with longitudinal/diagonal directionality, 200X.

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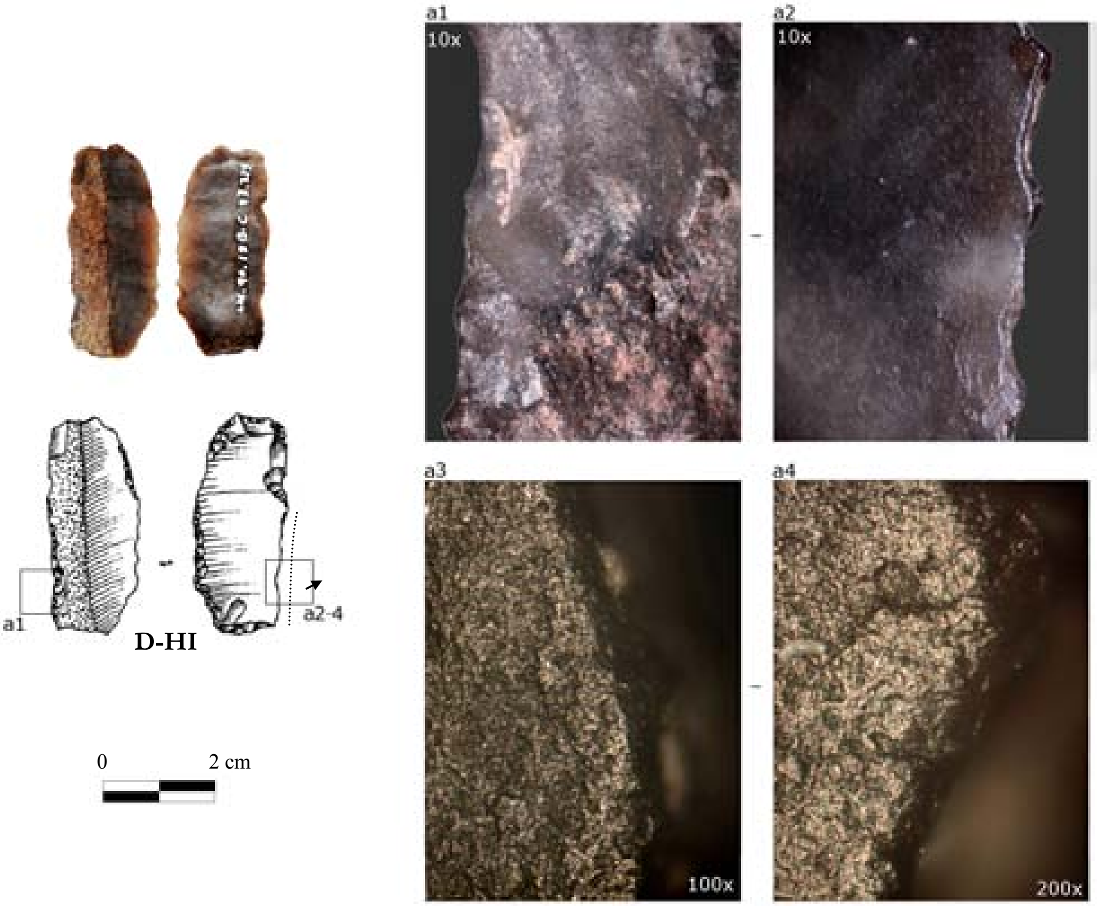

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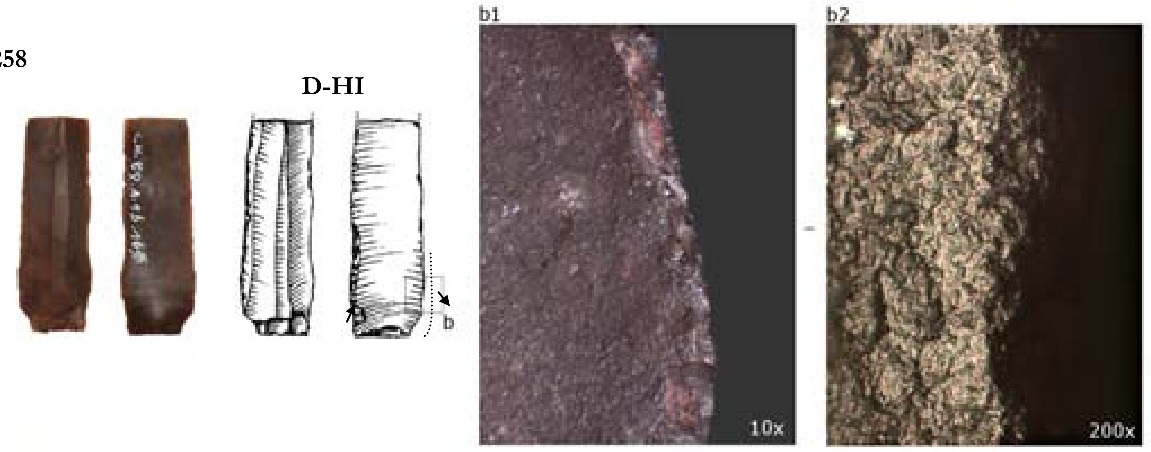

Fig. 3.28. Use-wears from the Cueva de Chaves, level 1.b. **229-** Tool showing traces of hide working; *a1-a2*) Macroscopic view , ventral and dorsal faces, 10X. The edge shows a pronounced rounding; *a3-a4*) Two photos at different magnification of the same spot. Rough polish produced by the contact with dry-hide, 100X and 200X. **258-** Tool showing traces of hide working; *b1*) Macroscopic view the active zone, 10X. The edge appears slightly rounded; *b2*) Dry-hide polish, 200X.

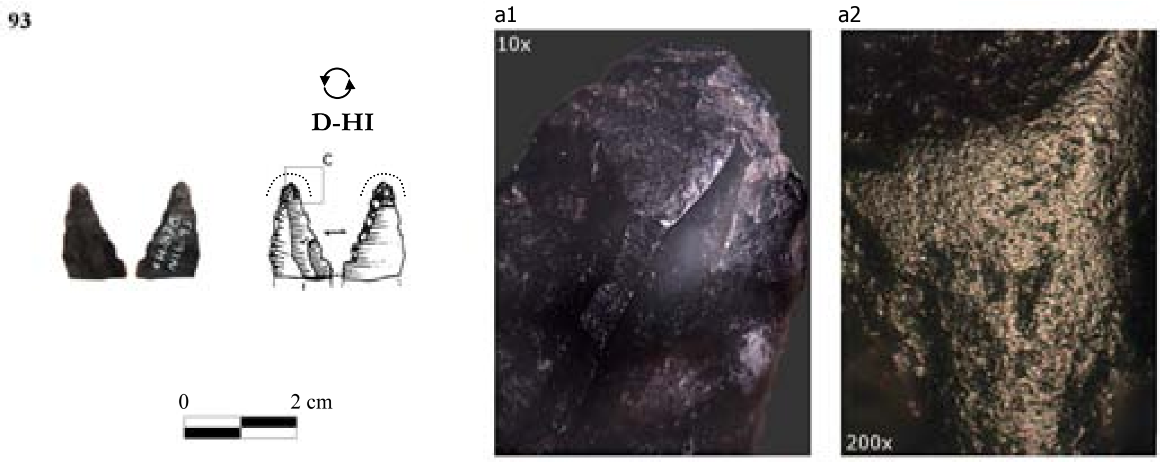

Fig. 3.29. Use-wears from the Cueva de Chaves, level 1.b. **93-** Tool used for boring hide; *a1)* Macroscopic view, 10X. The dorsal ridge appears rounded; *a2*) Rough polish probably produced by the contact with leather/dry hide. 200X.

lime are also helpful additions in the wet-scraping technique (Wiederhold 2004, Rifkin 2011). However, there are other instances in which dehairing is mainly carried out by chemical actions and tools are only marginally employed (Calvo 2004).

It is remarkable that Cueva de Chaves's scrapers show the presence of several strias and abrasions over the polished surfaces, a fact that suggests the addition of some mineral additives to the animal skins (Fig. 3.26, *a2, c2*). Moreover, reddish spots of ochre are also visible on the surface of the instruments (Fig. 3.26, *b1, c1*). The presence of ochre as mineral additive has been suggested for a variety of tasks relevant to the hide-working process, amongst which the above-mentioned skinning and fleshing phases, in which ochre could act as an abrasive agent. However, ochre may have also been added for later processes such as 'pseudo-tanning', where it acted as a protective agent (Calvo 2004). In sum, one can assume that Cueva de Chaves's endscrapers were mainly used in the first stages of hide-working process; tools appear quite standardized in terms of both shape and size; finally, retouch was regularly preformed before employing the tools.

The second group of tools related to hide-working activities is characterized by both flakes and blades. Amongst flakes, there is a huge number of knapping by-products (*n.* 25), mainly debitage rejuvenation flakes. However, compared to the previous tools, these are little formatted and generally have smaller dimensions, on average 15-22 mm in length, 16-24 mm in width, and 2-6 mm in thickness (Fig. 3.27). Within this group, several blades are also found (*n.* 11), which measure 28-46 x 13-16 x 3-4 mm (Fig. 3.28). The used edges are generally unretouched. The active zone is mainly represented by small parts of the edge, mainly associated with the working of dry hide performed by both transverse and longitudinal/diagonal movement. Often active zones are represented by the distal or proximal parts of the tool, thus employing the angular part formed by the long and short sides. The edge is always markedly rounded, occasionally in connection with marginal fractures. The micropolishes have a dull and rough aspect with a more invasive distribution along the edge (Fig. 3.27, 3.28). Striations are often present (Fig. 3.27, *a2*, *b2*). It is plausible that many of these tools were employed for cutting tanned leather while making clothes, containers, shoes, strings, or other leather artefacts (Plisson 1985: 49). However, it is also possible that some of them, especially the largest flakes, were employed for dry-scraping activities connected with the phases of hide 'thinning', 'softening' and 'loosening' (Fig. 3.27, *a*) (Beyries & Rots 2008; Gijn 2010: 81). These tasks were generally carried out when the animal skin was dry, after being skinned and stripped of its flesh. Hide softening, in particular, was mainly related to the operations of hide stripping and graining, in order to remove the rough spots and smooth out the whole surface (Ibáñez et al. 2002: 89; Wiederhold 2004: 30). However, these actions can be also performed with macrolithic tools, such as pebbles and stones, which are abundant at Cueva de Chaves.

Finally, two elements, made on blade blanks, were used as borers (*n.* 2). Both tools have distal fractures. The tips are shaped by abrupt retouch on the dorsal face, with a flat retouch on the ventral face for flattening the tool. The edges and ridges appear slightly rounded (Fig. 3.29, *a1*), while, microscopically, an extensive rough polish is visible on the dorsal ridge (Fig. 3.29, *a2*). It is possible that such tools served the purpose of perforating leather while making clothes or containers.

In conclusion, on can assume that the selection of blanks largely depended on the type of activity to carry out. Tools used for scraping rawhides were mainly made on thick and resistant blanks, which were characterized by a large retouched front with angles between 70° and 90°. On the contrary, tools employed in the following phases (i.e. dry-hide scraping; leather-craft processes) show thinner edges, generally unretouched, with angles between 30° and 50°. In those cases, the active zone was generally a small part of the edge, which performed a transverse or diagonal/longitudinal movement.

3.4.2.1.2.2. Hard animal substances

Amongst the tools associated with the *working of hard animal materials*, both blades (*n.* 9) and flakes (*n.* 9) were in use. The latter are represented by large platform- and debitage-rejuvenation flakes (*n.* 5) (28-48 x 18-24 x 6-10 mm) as well as by small flakes (*n.* 3) (23-27 x 13-10 x 2-5 mm). The former ones show dimensions which are on average between 36 and 39 mm in length, between 11 and 13 mm in width, and between 3 and 4 mm in thickness.

Transverse movement was connected with bone/antler scraping (Fig. 3.30, *a-c*), whilst the longitudinal one featured in bone/antler engraving or sawing (Fig. 3.31, *a-b*). It has not been possible to identify a specific tool morphology for either activity, since no specific movement has been associated with the use of blades, large rejuvenating flakes, or smaller knapping by-products. The main criterion in the selection of blanks seems to have been the thickness of the used edge: most of the active zones present obtuse angles, between 60° and 80°, at times shaped by a previous, intentional retouch, in order to make them more resistant to fracture. Use-wears are distributed along the long edges; in only three cases both sides were used. Traces are characterized by overlapping step-bending fractures. Microscopically, edge-scarring is associated with a compact micropolish, distributed in narrow bands along the used edge (Fig. 3.30, 3.31). Occasionally, the preservation of the polish has been affected by taphonomic agents, probably because of soil mechanical abrasion. However, traces are generally recognizable for both their position and distribution. Moreover, in many cases, one can notice the characteristic striations and microfractures of the so-called bone 'bevel' (Fig. 3.30, *a2-c2*) (Vaughan 1981: 140-141; Moss 1983: 92; Plisson 1985: 55; Clemente 1997a: 56).

In conclusion, this array of instruments is mainly associated to the working of animal bones and antlers through a variety of actions, such as scraping, sawing, engraving, and drilling. This tools were probably employed for manufacturing (sawing and engraving movements?) and maintaining or resharpening (scraping activities?) bone and antler tools. As

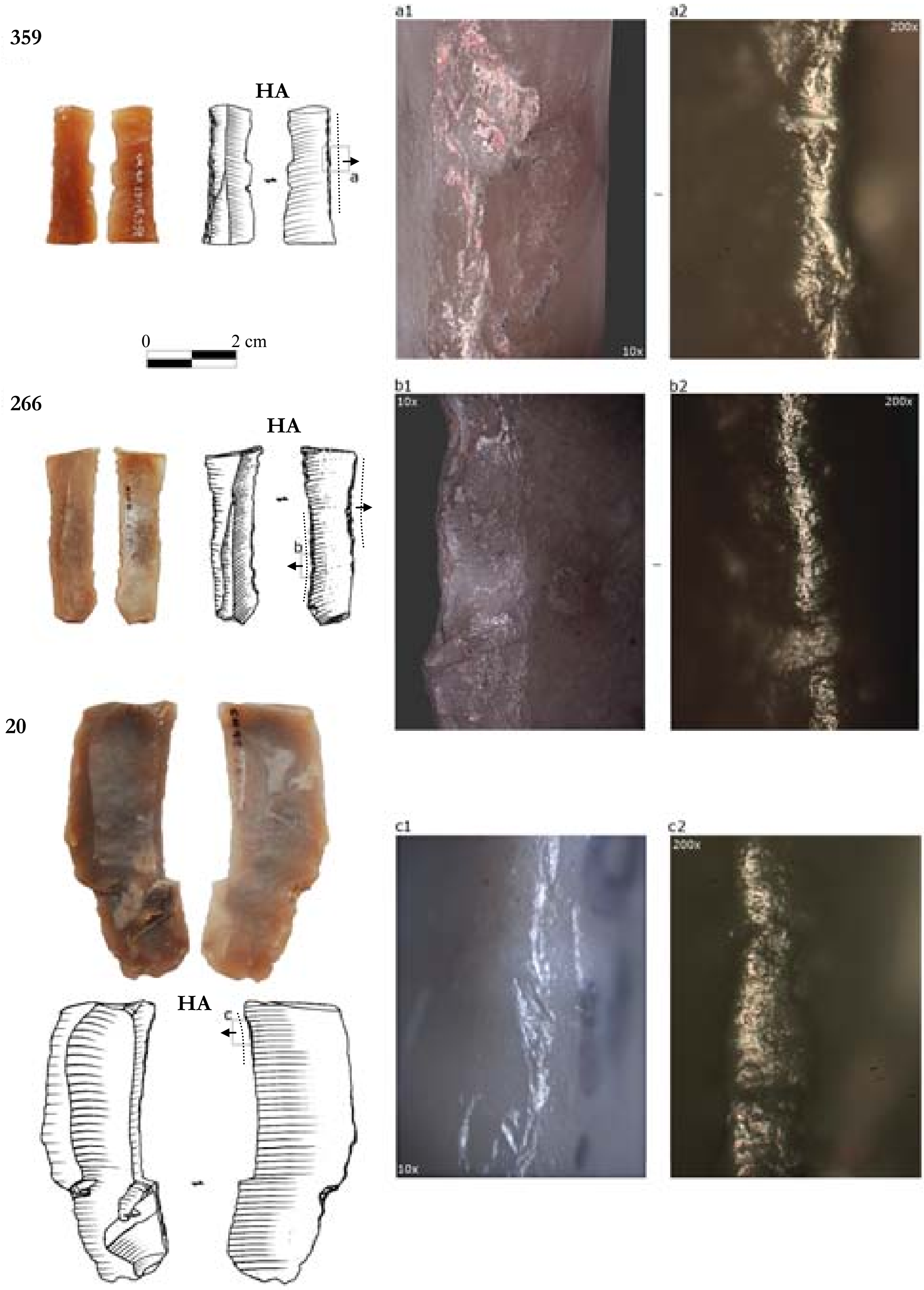

Fig. 3.30. Use-wears from the Cueva de Chaves, level 1.b. **359-** Tool used for working hard animal substances; *a1)* Macroscopic view, 10X. Bifacial edge-scarring; *a2*) Bone/antler bevel, 200X. See the microfracturing of the polish and the linear abrasions. **266-** Tool used for working hard animal substances used on both sides; *b1*) Macroscopic view, overlapping step-termination bending fractures, 10X; *b2*) Bone/antler bevel partially altered, 200X. **20-** Tool used for working hard animal substances; *c1*) Macroscopic view, 10X. Bifacial edge-scarring; *c2*) Bone/antler bevel with strias and abrasions, 200X.

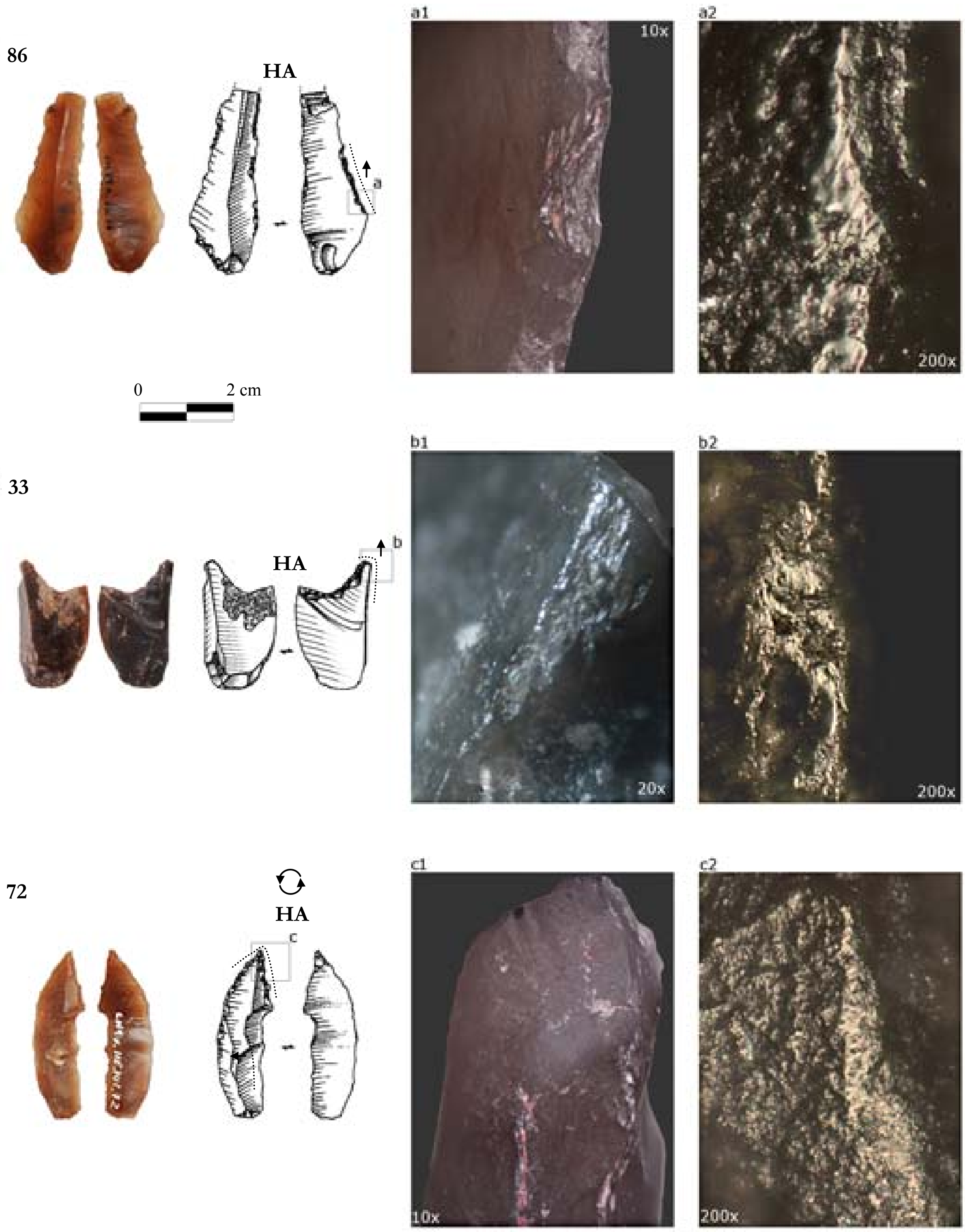

Fig. 3.31. Use-wears from the Cueva de Chaves, level 1.b. **86-** Tool used for sawing/cutting hard animal substances; *a1)* Macroscopic view, 10X, edge scarring with overlapping step-termination fractures; *a2*) Smooth bone polish spots with longitudinal directionality, 200X. **33-** Tool used for engraving bone/antler materials; *b1)* Macroscopic view, 10X. Edge-rounding associated to overlapping fractures; *b2)* Spots of bone polish with longitudinal directionality, 200X. **72-** Tool used for drilling bone/antler materials; *c1)* Macroscopic view, 10X; The edge is scarcely rounded. *c2)* Spots of bone polish on the dorsal ridge, 200X

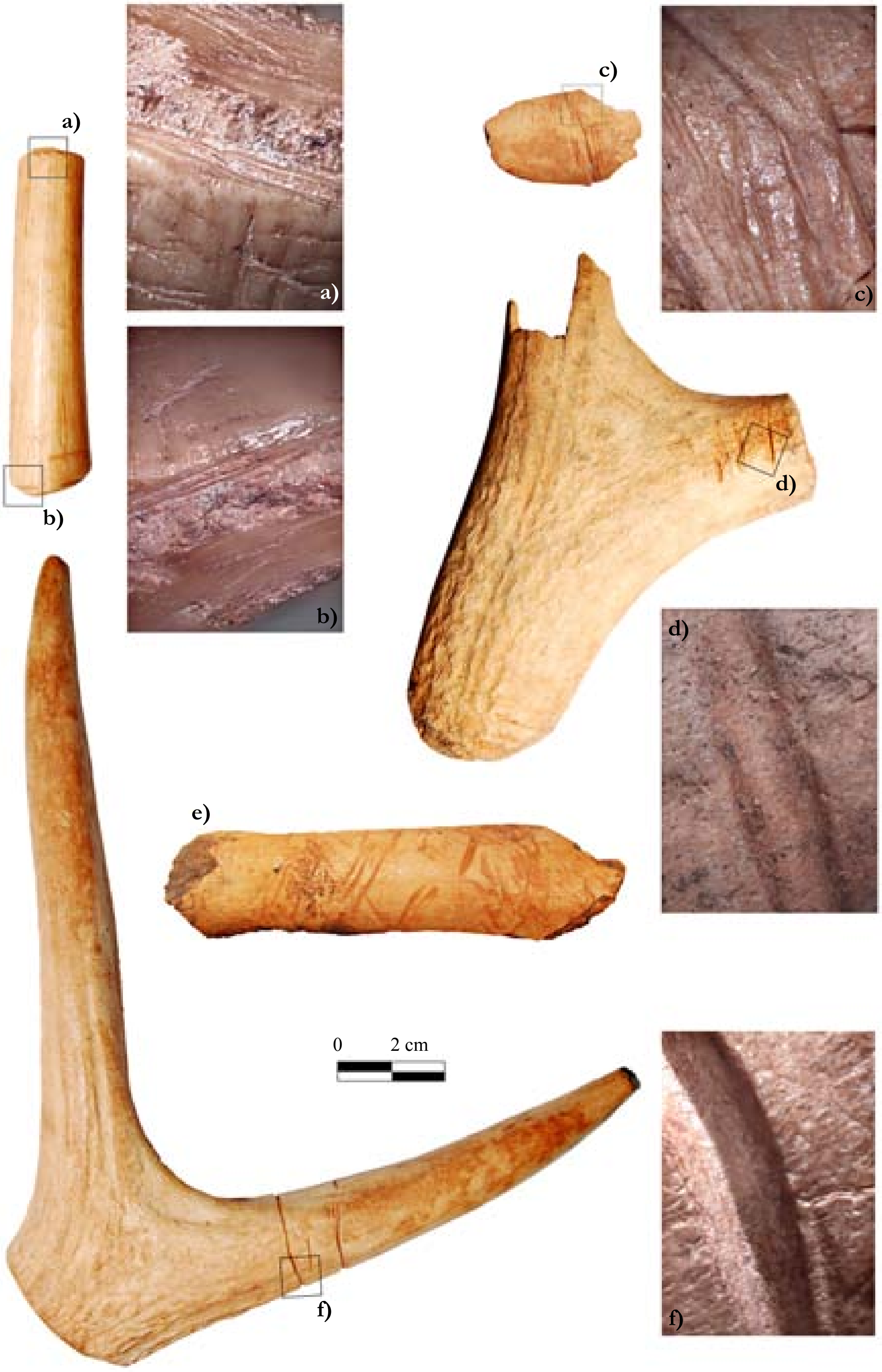

Fig. 3.32. By-products of antler/bone artefacts production from the Cueva de Chaves, level 1.b; *a-b*) Fragments of antler with cut marks on both the extremities, probably to favour its fracture, photos 10X; *c*) Fragments of a bone with cut marks, photo 10X; *d*) Fragment of an antler with various cut marks directed to the fracturing of the point, photo 10X; *e*) Fragments of a bone with possible cut marks from carnivore tooth, note the differences with the other cut marks; *f*) Fragment of antler with various cut marks directed to the fracturing of the point, photo 10X.

Fig. 3.33. Bone and antler industry from the Cueva de Chaves, level 1.b. *a*) Bone punches from the level 1.b. *b*) Bone, teeth, shell and antler artefacts that present voluntary perforations: *b1*) drilled teeth, *b2*) rib pendants, *b3*) antler beads, *b4*) shell beads.

described in a previous paragraph (*cfr.* Chap. 3, Par. 3.3.3.), the bone industry of Cueva de Chaves is rich and abundant, especially about bone punches (Fig. 3.33, *a*). In addition, marks of cuts possibly produced by lithic tools have been recognized on several by-products of both antler and, to a lesser extent, bone (Fig. 3.32).

Apart from punches and spatulas, bone and antler items were also employed for beads and ornaments production. In this respect, the presence of three tools is remarkable —three borers made on blades and shaped by abrupt retouch—, which must have been employed for drilling some type of hard animal substance, either bone or antler. A moderate rounding of the tip and distal ridges can be noticed, being associated with the presence of some 'bone/antler polish spots' having a smoother appearance (Fig. 3.31, *c2*) (see Yerkes 1983 for experimental traces of bone-drilling). Such tools are likely to be related with the production of antler beads and other bone ornaments (i.e. drilled ribs probably used as pendant), which have been documented at Cueva de Chaves (Fig. 3.33, *b*).

3.4.2.1.2.3. Soft Animal Substances

Traces related to *slaughter and butchering activities* and, more in general, to the working of soft animal substances, should probably be considered as underrepresented in the analysed assemblage. The presence of soil lustres, even if slight, makes it more difficult to recognize such type of traces. Use-wears produced by the cutting of animal skin, flesh, and tissues are generally characterized by a marginal edge-scarring and a rough and greasy lustre, which, in

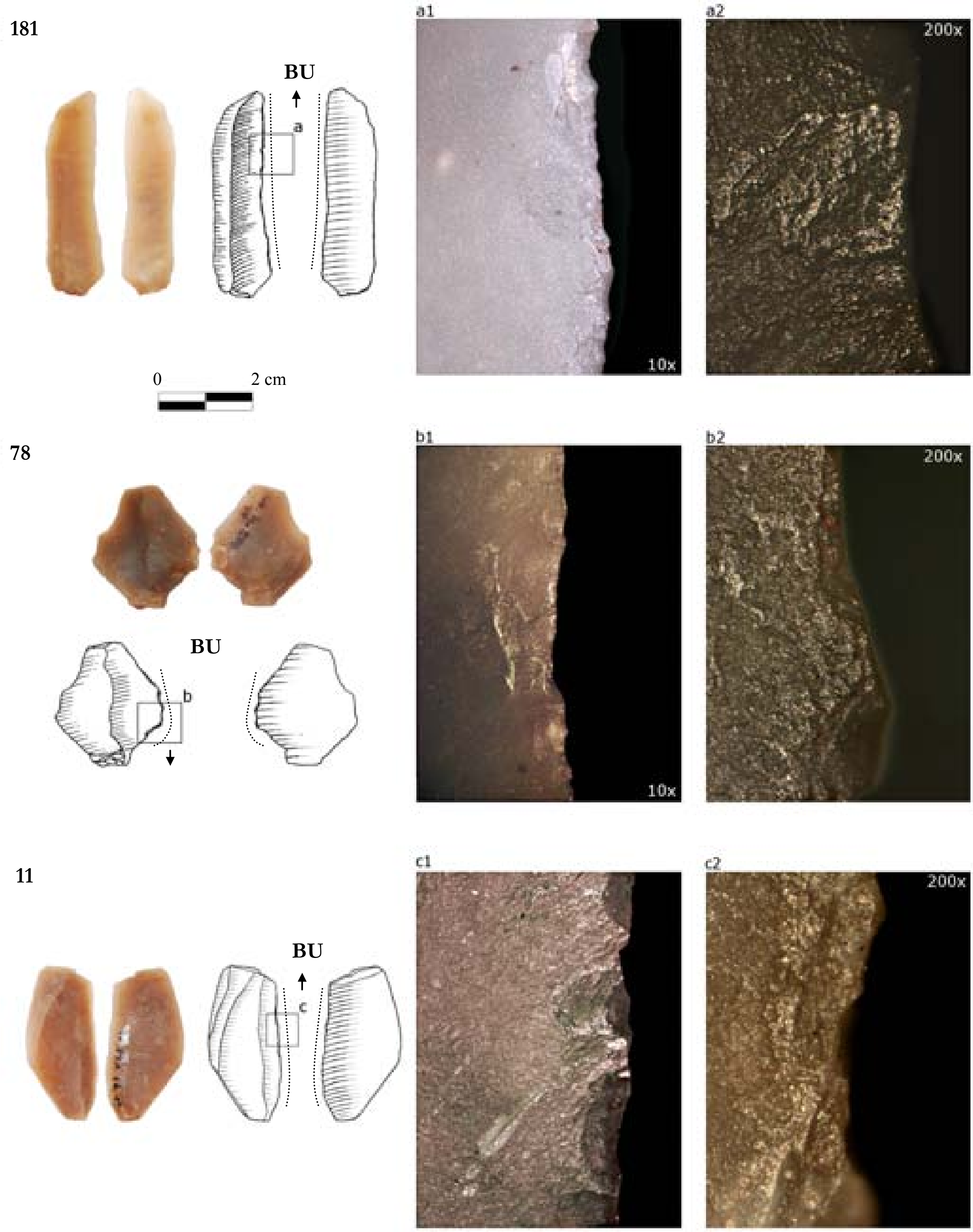

Fig. 3.34. Use-wears from the Cueva de Chaves, level 1.b. **181-** Tool used for butchering activities; *a1)* Macroscopic view, 10X. Edge scarring with a combination of scalar and step-termination fractures; *a2*) Greasy and rough polish with open texture and irregular distribution, 200X. **78-** Tool used for butchering activities; *b1)* Macroscopic view, 10X. Series of marginal fractures; *b2)* Greasy and rough polish with open texture, and occasional spots of contact with bone/hard materials, 200X. **11-** Tool used for butchering activities; *c1)* Macroscopic view, 10X; Feather termination and snap fractures; *c2)* Greasy and rough polish with marginal distribution, 200X

many instances, can be easily covered by post-depositional factors.

Amongst the elements attributed to this functional category, flakes prevail (*n.* 13) (Fig. 3.34, *b-c*), with dimensions ranging between 21 and 30 mm in length, 22 and 26 mm in width, and 4 and 6 mm in thickness. Laminar blanks (*n.* 8) are mainly attested to by bladelets with dimensions that range between 28 and 36 mm in length, 9 and 11 mm in width, 2 and 3 mm in thickness on average (Fig. 3.34, *a*). In both cases, tools were little formatted, mainly used for performing longitudinal (*n.* 17) and, to a lesser extent, transverse movements (*n.* 5).

Most of the observed traces are related to the processing of animal carcasses. The main features observed macro- and microscopically are: 1) a marginal edge fracturing with a combination of 'half-moon' fractures and step-terminating bending fractures produced by the occasional contact with the skeletal parts (Fig. 3.34, *a1-c1*); 2) a slight edge rounding; 3) polishes with a patchy texture, irregularly distributed along the edges, occasionally showing spots of bone polish (Gijn 1989: 43; Vaughan 1981: 162) (Fig. 3.34, *a2-c2*).

Slaughter and butchering processes probably represented an important economic activity at Cueva de Chaves. The faunal assemblage recovered in Level 1.b is extremely abundant (*cfr.* Chap 3, Par 3.3.2.). Unfortunately, P. Castaños, in his analysis of the remains from Level 1.b (2004), has paid little attention to the type of slaughter strategies adopted by Chaves' inhabitants and has not reported any presence of cutmarks on the animal bones. The anatomical representation of the main species recovered at Cueva de Chaves (sheep/goat, cattle, and pigs, which together amount to 60% of the assemblage) suggests that animals were entirely processed at the site, as only a few differences have been detected between the various anatomical portions (head, trunk, limbs). Only red deer carcasses were probably taken to the site partially processed, given the prevalence of limb portions (almost 70%) over heads and trunks. However, the sample of remains is relatively small; therefore, no definitive assumptions can be made.

In conclusion, the butchering activities were probably took place on site, mainly employing specific tools such as poorly-finished bladelets or small flakes. The selected blanks have acute and sharp edges, which were suitable for cutting soft substances like meat or animal tissues. Their use was not generally long-lasting; edge resharpening was not common for this type of instruments that were probably discarded quite soon after use.

3.4.2.1.3. Mineral Substances

Activities associated with the working of mineral substances represent about one sixth of the analysed sample (*n.* 51; 14,8%) (*n.* 58 AUAs; 15.1%). Amongst the identified materials, indeterminable mineral substances prevail (*n.* 40 AUAs; 10,4%), followed by the traces ascribed to pottery manufacturing (*n.* 18 AUAs; 4.7%) (Tab. 3.5).

Flakes and knapping by-products prevail (*n.* 29) over blades (*n.* 22). In addition, amongst the tools in use, the presence of two cores (*n.* 2) and four rejuvenation flakes (*n.* 4) is noteworthy. In terms of performed movements, drilling prevails (*n.* 20), followed by longitudinal/diagonal (*n.* 19) and transverse movements (*n.* 17), and, finally, by pounding/grinding (*n.* 2) (Tab. 3.6; Tab. 3.7).

3.4.2.1.3.1. Clay/Pottery

At Cueva de Chaves, most of the tools with traces attributed to soft/medium-resistant mineral substances processing are related to *clay/pottery working activities*. The employment of flaked stone tools in ceramics manufacturing has been reported by Gassin (1993) and Torchy

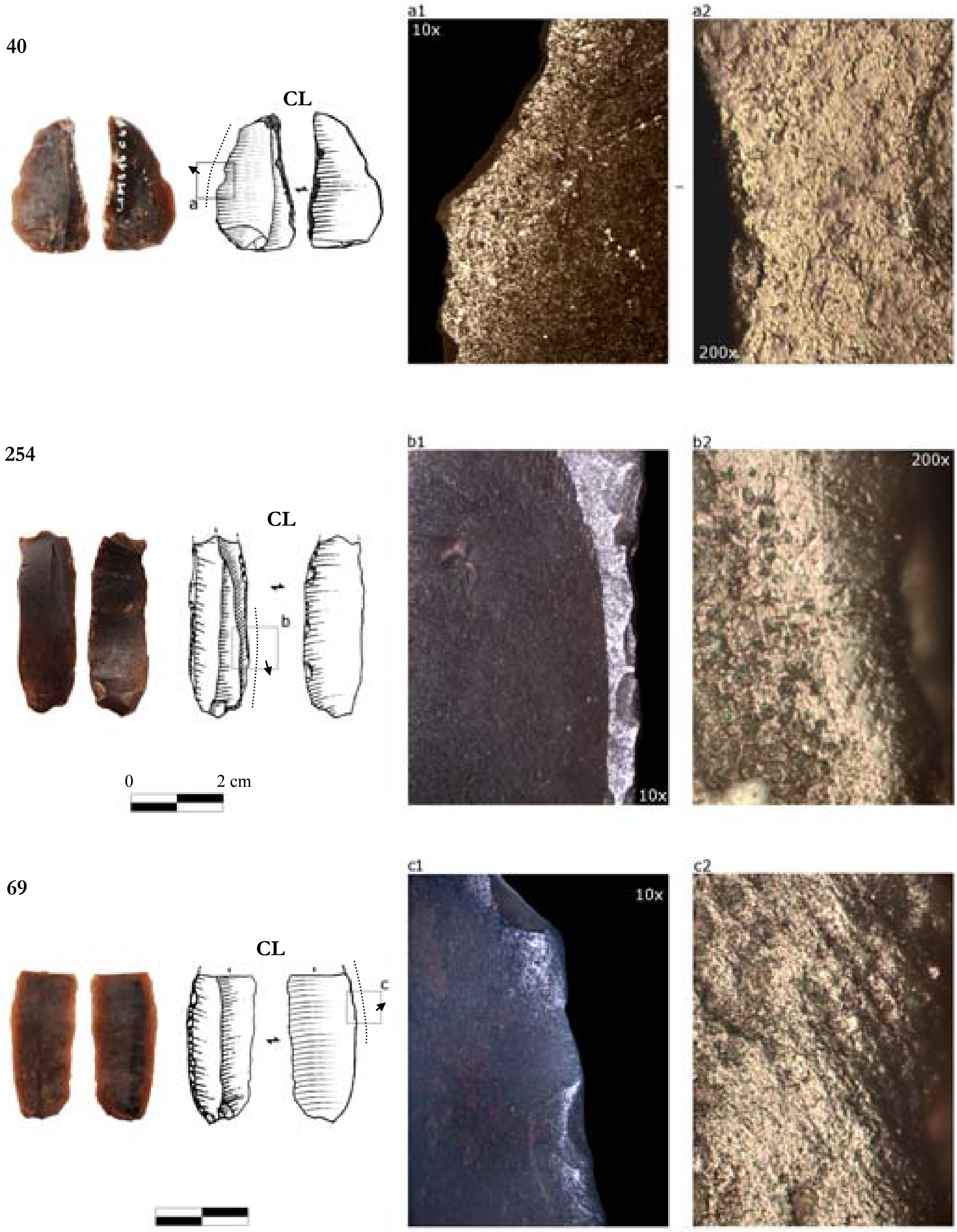

Fig. 3.35. Use-wears from the Cueva de Chaves, level 1.b. **40-** Tool used for semi-dry clay scraping; *a1)* Macroscopic view, 10X. A band of lustre and mineral strias are visible; *a2*) Compact smooth polish with chaotic striations. The edge is marginally abraded, 200X. **254-** Tool used for semi-dry clay engraving; *b1)* Macroscopic view, 10X. The edge is rounded and lustred; *b2)* Compact spots of a smooth polish associated to strias and abrasive elements, 200X. **69-** Tool used for dry clay scraping; *c1)* Macroscopic view, 10X. Marginal lustre; *c2)* Rough polish densely striated, 200X.

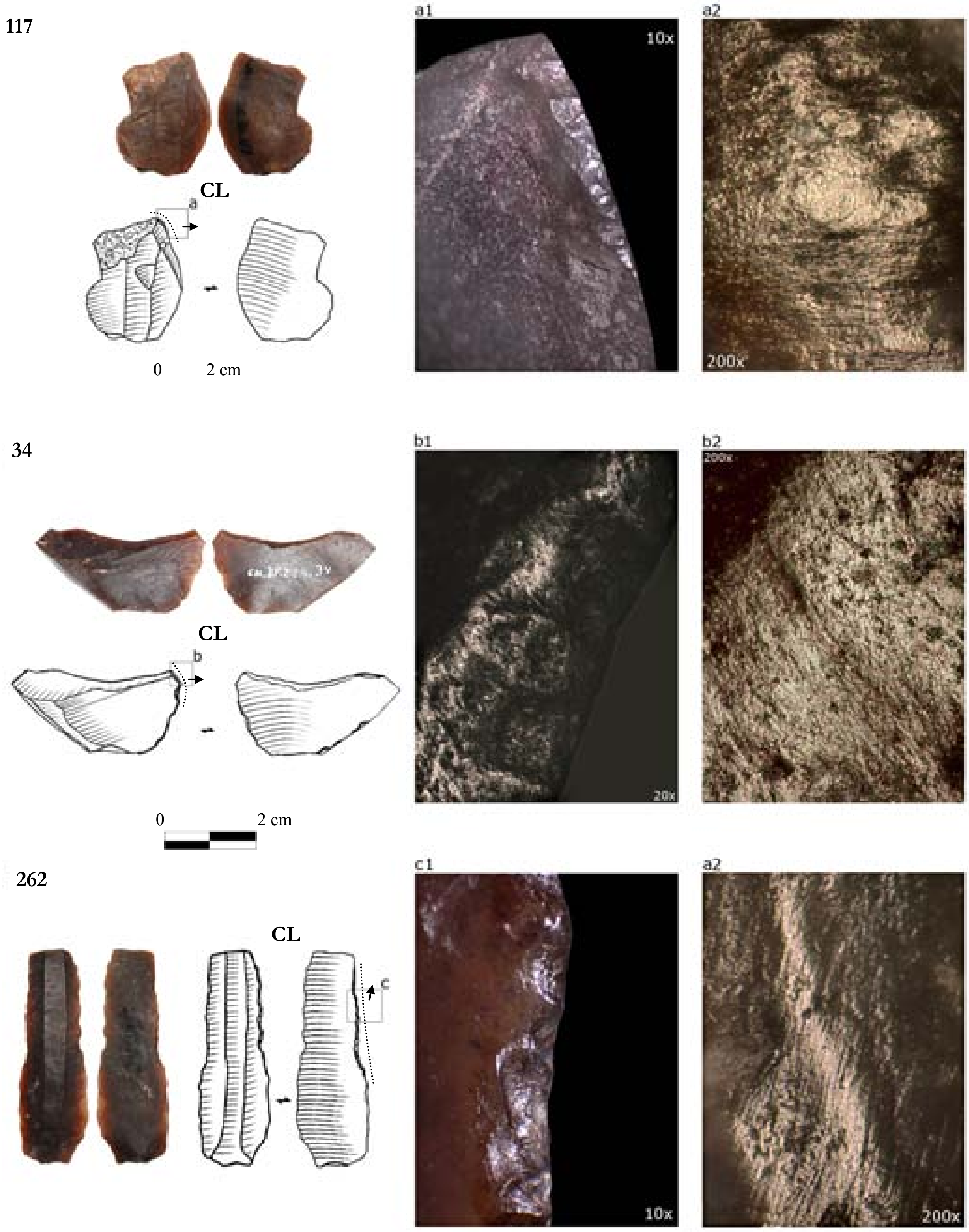

Fig. 3.36. Use-wears from the Cueva de Chaves, level 1.b. **117-** Tool used for dry clay scraping; *a1)* Macroscopic view, 10X. Pronounced edge rounding; *a2*) Rough polish densely striated with residual spots of smooth and compact appearance, 200X. **34-** Tool used for dry clay scraping; *b1)* Macroscopic view, 10X. Pronounced edge rounding; *b2)* Rough polish densely striated with residual spots of smooth and compact appearance (same as before), 200X. **262-** Tool used for dry clay engraving/decorating; *c1)* Macroscopic view, 10X; Pronounced rounding on a retouched edge; *c2)* Rough polish densely striated with longitudinal orientation, 200X.

Fig. 3.37. *a)* Use-wears from the Cueva de Chaves, level 1.b. **296-** Tool used for drilling ceramic materials; *a1)* Macroscopic view, 10X. The tip is strongly rounded; *a2*) Spots of mineral polish on the point, 200X. See the association of strias and bright flat spots of polish. *b*) Fragments of ceramic materials with perforations from the Cueva de Chaves, level 1.b. Scale 1:50; *b1*) Unfinished perforations, 10X; *b2*) Complete perforation. See the presence of concentric strias within the perforation.

& Gassin (2010) about the Neolithic Chassey Culture of southern France, Jardón-Giner & Jadin (2008) for the LBK in Belgium, and Gijn (1989) for Dutch LBK, only to mention some European contexts.

These types of traces have already been described by several authors and the experimental works of Gijn (1989) and Gassin (1993) probably represent the best references. Their experimentations mainly focused on scraping/planning fresh or semi-dry clay. The resulting traces are characterized by the following features: on a macroscopic level: 1) the presence of a marked edge rounding; 2) the presence of evident lustre on the active zone, also visible to the naked eye, and 3) a low or moderate edge-fracturing occurrence, with small bending fractures of regular shape. On a microscopic level, use-wear polishes are characterized by: 1) compact matt polish spots distributed in bands or stains over the used edge; 2) abundant abrasive elements, especially narrow and elongated striations.

Within this category, however, I have observed a certain variability depending on the number of strias and abrasive elements and, to a lesser extent, on the development of the polish. Recent experimental works —already described in a previous paragraph (*cfr.* Chap. 2, Par. 2.3.3.)— confirm that several variables can influence the wear-formation pattern, as already observed by Gassin (1993), too. Apart from working time, type of tempering material used and granulometry of this —all factors that have a considerable influence on wear formation—, one of the most affecting variables is the humidity level of the worked clay (fresh, semi-dry, or dry).

In general terms, one can say that the more humid and fresher the clay is, the flatter and smoother the polish appears; vice versa, the drier the clay, the higher the number of striations and abrasions on the surfaces. Such differences in the state of worked clay are connected with the different types of tasks that can be carried out with the lithic tools. When the tempered clay is still wet (semi-dry or green), it is more malleable and so it is easier to remove materials from the vessel. At this stage, a lithic flake can be used for «thinning» the walls and rims, thus taking away the excess clay. However, being still fresh, clay can still change shape or be modified; therefore, only a little pressure can be exerted on the vessel, in order to prevent warping. On the contrary, when the tempered clay is completely dry, its structure is more resistant and stable. Although with dry clay it is more complicated to remove materials from the vessels, other tasks can be performed, like 'smoothing' and 'polishing' walls and rims or 'engraving' and 'decorating' surfaces.

At Cueva de Chaves, I have identified both types of wear: from smooth polishes characterized by flat, compact spots (Fig. 3.35, *a-b*), to rougher and heavily striated polishes (Fig. 3.34, *c*; 3.35 *a-c*). Both flakes (*n.* 11) and blades (*n.* 5) were used. In addition, I have also identified a burin stroke with traces of previous use for scraping clay.

Flakes are mainly represented by small implements, on average between 24 and 28 mm in length, between 15 and 15 mm in width, and between 4 and 8 mm in thickness. They appear poorly formatted, with unretouched edges. Only a small part of the tool was usually employed, probably for thinning or smoothing the walls or rims of the vessels. Indeed, the movement must generally have been transverse. The edge usually appears markedly rounded and a bright lustre is visible to the naked eye. Both smoother (Fig. 3.35, *a*) and rougher striated polishes (Fig. 3.36, *a-b*) have been observed, probably in relation to different phases of pottery manufacturing, when the clay was characterized by different degrees of dryness, as previously described.

Blade blanks also have quite small dimensions, on average between 30 and 34 mm in length, between 12 and 14 mm in width, and between 2 and 3 mm in thickness. The edge was generally unprepared (Fig. 3.35, *a-c*), although a previous retouch has also been ascertained (Fig. 3.36, *c*). The performed activities mainly show a longitudinal directionally, even if often with a diagonal or slightly diagonal orientation. Such movements could correspond to a variety of actions for retouching/smoothing the vessels. Furthermore, the presence of a large amount of reddish residues on the tools' surfaces is remarkable, which seems to support the hypothesis of being employed for working clay/pottery.

Finally, two borers with traces of drilling activities over ceramic materials have been observed. In this case, perforations were made after firing pottery, probably for repairing broken vessels. Borers display markedly rounded tips, characterized by spots of mineral polishes. The presence of perforations is a typical element of Cueva de Chaves' ceramic assemblage. In her study, N. Ramón (2006: 165) has identified perforations in 20% of the ceramic fragments, mainly as decorative motif, but also repair. Post-firing perforations carried out by lithic materials are actually easily distinguishable from the decorative ones. They generally have a conical shape and present concentric striations on the inner surfaces; on the contrary, perforations made on fresh clay are generally pipe-shaped, with smoother surfaces, often producing a bump or burr on the opposite side. Both finished and unfinished perforations have been ascertained, which have a diameter that matches the width of the borers' tips, that is, between 1 and 1.5 mm (Fig. 3.37).

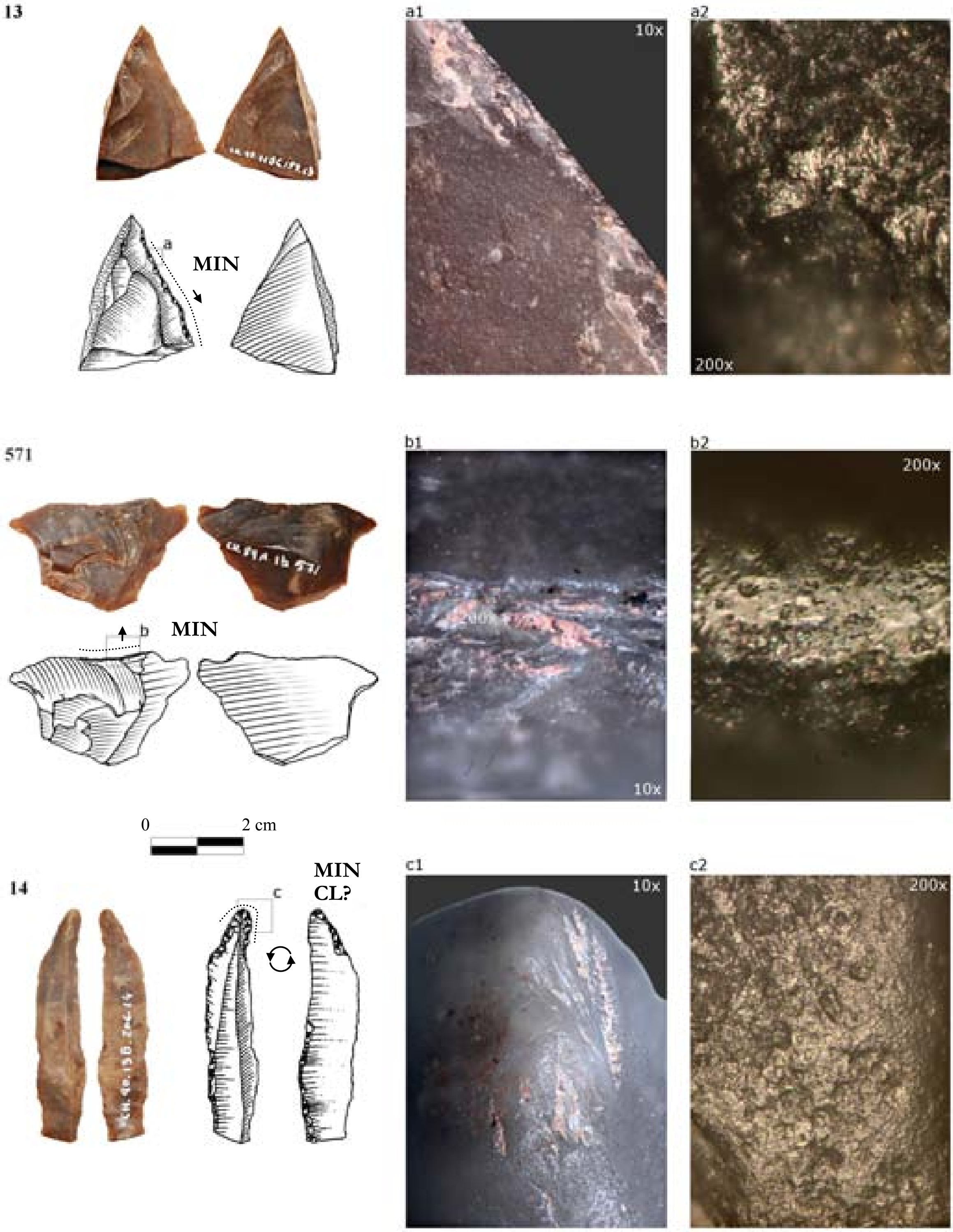

Fig. 3.38. Use-wears from the Cueva de Chaves, level 1.b. **13-** Tool used for working (engraving?) a resistant mineral substance; *a1*) Macroscopic view, 10X. The edge is damaged and rounded; *a2*) bright spots of mineral polish with longitudinal strias. **27-** Tool used for working soft/medium mineral substances; *b1*) Edge-scarring produced by a transversal motion, 10X. Abundant mineral residues; *b2*) Smooth mineral polish, 200X. **14-** Tool used for drilling a mineral (abrasive) substance; *c1)* Macroscopic view, 10X. The tip is heavily rounded; *c2*) Extensive rough polish of an unspecific abrasive mineral material (ceramic?), 200X.

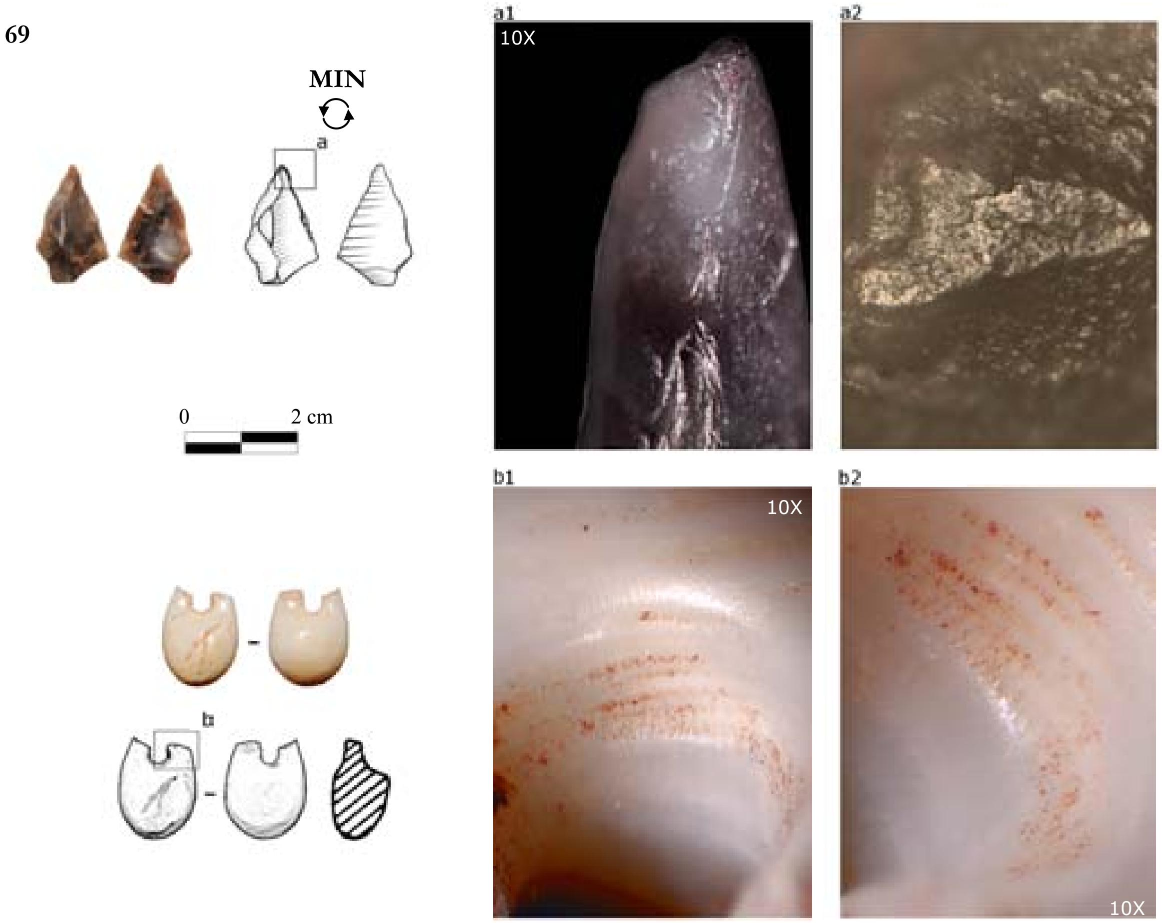

Fig. 3.39. *a)* Use-wears from the Cueva de Chaves, level 1.b. **69-** *a1*) Macroscopic view, 10X. The tip presents series of overlapping fractures and it is only marginally rounded; *a2*) dull spots of polishes on the high points of the surfaces. *b*) Drilled red deer canine; *b1-b2)* Macroscopic view, 10X. Two photos with different angle. The strias within the perforation appear to have been produced by some type of hard and sharp tool, such as a lithic borer.

3.4.2.1.3.2. Indeterminable Mineral Substance

The category of *indeterminable mineral substances* includes all those traces relevant to use-wears produced by mineral substances. However, in those cases, it has not been possible to ascertain the specific type of the material worked by them. This may be due to a lack of experimentation, but also to the poor preservation or development of the use-wears.

Several types of mineral materials of diverse nature fall in this category, amongst which one can mention: soft stones, ochre, teeth, shells, *etc*. I have mainly distinguished the 'contact' materials on the basis of their hardness: soft/medium mineral substances (*n.* 24) and hard mineral substances (*n.* 18). The prevailing action results to have been drilling (*n.* 18), followed by transverse (*n.* 13), longitudinal (*n.* 9), and pounding movements (*n.* 2).

Drilling tools were mainly made out of blade blanks (*n.* 12) (Fig. 3.18, *a*; 3.38, *c*), although also some borers on flake are present (*n.* 6) (Fig. 3.39, *a*). Borers are generally quite narrow and elongated, with dimensions ranging between 32 and 42 mm in length, 9 and 11 mm in width, and 3 and 5 mm in thickness. The presence of a great variety of materials with perforations amongst Cueva de Chaves' assemblage suggests that borers were employed in several processes, not only related to ceramics repairing, but also to beads and ornaments production. Shell, tooth, and stone pendants have actually been recovered at Chaves, which, in some cases, show signs of having been drilled by some sharp and pointed tool (Fig. 3.39 *a*).

Experimental works with microdrills have been carried out by Yerkes (1983), Peter (1989), and Taborin (1991) on stone, shell, and tooth materials. Their distinction is not always clear as such traces often present similar characteristics. Amongst Chaves's assemblage, I have observed very abrasive materials, which have caused a marked rounding of the tip (Fig. 3.18, *a*; 3.38, *c*), as well as more resistant substances that have brought about dull spots of polishes on the high points of the surfaces (Fig. 3.39, *b*). However, a detailed experimentation is still missing.

The activities related to the scraping and engraving of mineral materials also show a considerable variability in terms of type of worked material. I have observed traces produced by resistant materials (Fig. 3.39, *a*) as well as by soft/medium mineral substances (Fig. 3.39, *b*). However, in most of the cases, the exact type of worked matter remains unknown.

Used tools were mainly made on flake (*n.* 12) (28-40 x 20-42 x 4-10 mm), generally unretouched and little elaborate. Blades represent a smaller group (*n.* 5) (41-55 x 11-13 x 4 mm); in addition, I have also ascertained the presence of two cores used for grinding/ pounding activities.

3.4.2.1.4. Projectile Elements

Projectile tools are represented by a group of geometric tools which show traces of being used as points of *arrows or other weapons* (*n.* 27; 7.8%) (*n.* 27 AUAs; 7.0%). Amongst the ascertained typologies, segments prevail (*n.* 11), followed by trapezoids (*n.* 7), triangles (*n.* 6), and three elements of uncertain classification. Tools have a quite standardized size, measuring 16-22 x 7-11 x 1-3 mm. Most of them were made on blade blank, except for two implements —the long edge of which has a curvy outline— that, possibly, were made on flake. Amongst the tools that present impact traces, only a part of them (*n.* 15) display clear, diagnostic impact wears, while the rest of the group shows much more uncertain evidence. Traces are always concentrated on one of the tips, with an orientation that is parallel or slightly diagonal to the axis of the tool. The extension of impact-fractures is generally limited, between 1 and 5 mm in length. Overlapping bending/step fractures prevail (Fig. 3.40, *a-c*), often bifacial (Fig. 3.40, *b*) and with the presence of tiny spinoff microfractures (Fig. 3.40, *a*). Only in one case, I have detected the presence of MLITs (Fisher et al. 1984) (Fig. 3.40, *a*). In addition, also invasive burin-like fractures have been identified (Fig. 3.40, *d*). There are no significant differences, in terms of function, between the diverse typologies which were employed (segments, trapezoids, and triangles). It is to remember that I have detected a greater number of traces on the most elongated and narrowest tools than on the largest ones, characterized by a sub-rectangular shape; however, this may also be consequent on the greater fragility of the former, more breakable, morphologies rather than on a specific functional behaviour.

Residues of resin or bitumen have not been identified. It is thus difficult to reconstruct the exact way of hafting geometric tools. However, on the basis of the directionality of most of the observed fractures, microliths appear to have been used as points or lateral barbs. Moreover, considering that most of the implements are almost complete and that the fractures show a reduced extension, it is highly probable that a large part of the instrument

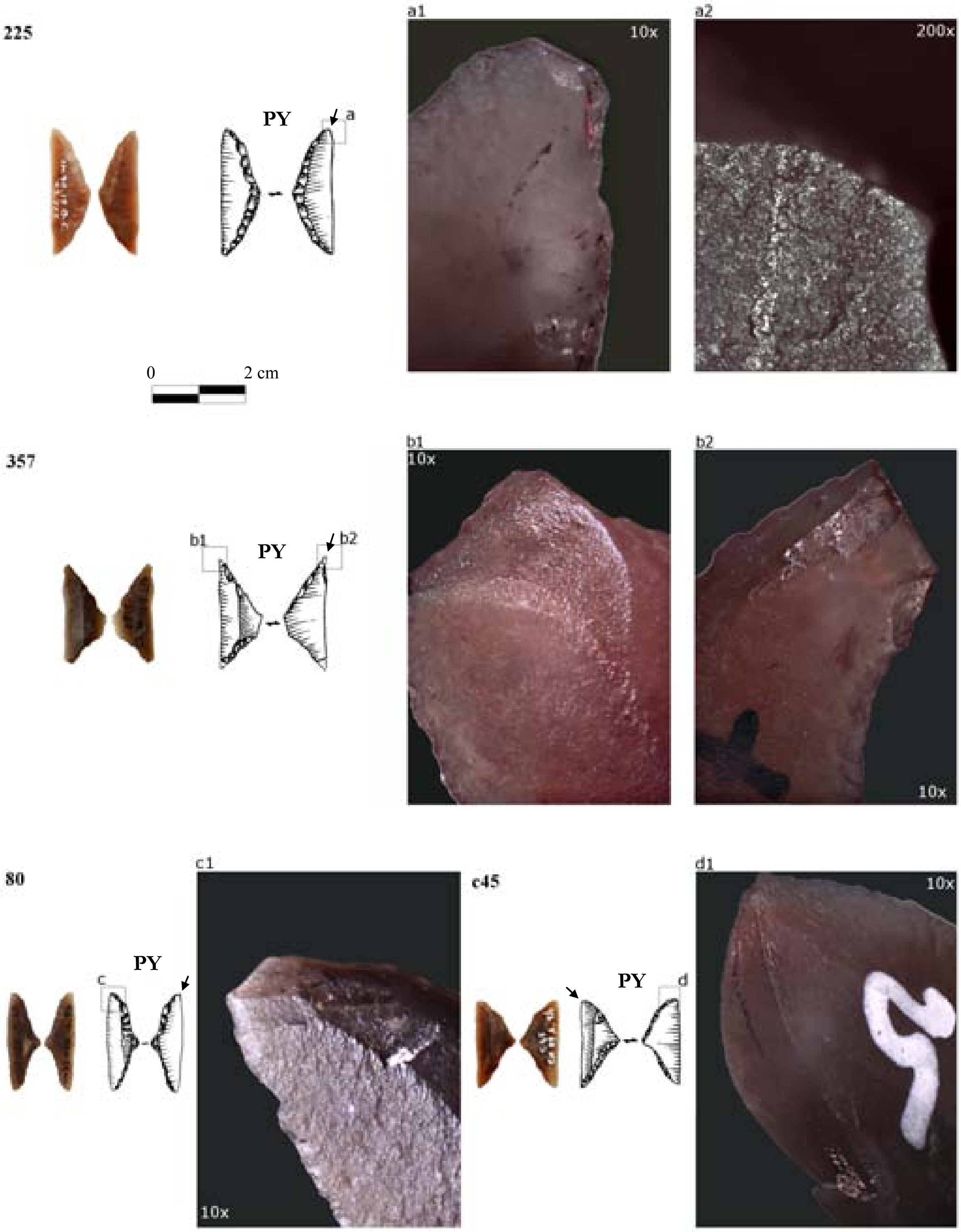

Fig. 3.40. Use-wears from the Cueva de Chaves, level 1.b. **225-** Tool used as projectile tip; *a1*) Macroscopic view, 10X. Overlapping bending fracture; *a2*) Impact strias on the ventral face, 200X. **357-** Tool used as projectile tip; *b1*) Elongated bending fractures on the dorsal face, 10X; *b2*) Overlapping bending fractures with spin-off on the opposite face. **80-** Tool used as projectile tip; *c1*) Overlapping bending fractures, 10X; **c45-** Tool used as projectile tip; *d1*) Extensive Burin-like fracture, 10X.

was covered with and protected by resin/bitumen and that only the tip was left uncovered.

According to faunal data, it seems that hunting activities at Cueva de Chaves were mainly oriented towards wild ungulates such as *Cervus elaphus*, *Capra pyrenaica, Capreolus capreolus*, and *Sus ferus* (Castaños 2004). Red deer remains are the most abundant, with a minimum number (NMI) of 13 individuals, while Iberian wild goats amount to 11, roe deers to 6, and wild boars also to 13. All those species are characteristic of the environment surrounding the site (i.e. open woodland), especially towards north, where the Sierra de Guara mountain system is situated. Hunting activities had an economic importance not only in terms of meat procurement, but also for gathering raw materials (i.e. antler or hide). However, it definitely represented a secondary/marginal activity at Chaves.

In previous studies on Chave's microliths' function (Domingo 2009, 2012), it has been proposed that geometric tools were used not only for hunting activities, but also for other tasks like, for instance, cutting non-ligneous plants. However, those uses have only sporadically been detected. Indeed, this behaviour is generally quite unusual at Neolithic sites of the Western Mediterranean area. One can mention only few places where microliths were allegedly used for boring leather or cutting vegetable substances, such as Vale Pincel (I. Clemente, pers. comm.) in Portugal, or Su Coloru in Sardinia (Mazzucco et al. 2012). In most of the cases, these tasks were mainly connected with an occasional retooling of the microliths for other works and they must never have represented a systematic or continuous behaviour.

3.4.2.1.5. Indeterminable Substances

This category gathers together all those tools the interpretation of which remains uncertain (*n.* 58; 16.9%) (*n.* 59 AUAs; 15.4%). The relevant evidence has mainly been interpreted on the basis of macroscopic traces, given the scarce preservation of the surfaces. I subdivided the worked materials into three main categories based on their hardness: soft substances (*n.* 20), medium-resistant materials (*n.* 21), and hard materials (*n.* 18).

Soft materials have been worked by both flakes (*n.* 9) (27-41 x 16-30 x 5-9 mm) and blades (*n.* 11) (32-39 x 11.5-14.5 x 3.5-4.5 mm). In both cases, selected blanks present sharp edges, between 25° and 35°, and are generally unretouched. Macro-traces are mainly characterized by marginal scarring, with an array of semi-lunar-shaped feather-termination fractures (Fig. 3.41, *a*). Amongst those instruments, I have also included two bladelets of hyaline quartz. Possibly, a large part of those tools was employed for working soft animal substance; however, given the little development of the traces and the poor preservation of the surfaces, it is not possible to advance any clear interpretation.

Medium-resistant substances were worked by a variety of blanks. Flake blanks slightly prevail (*n.* 12) over blades (*n.* 9); active edges were either retouched or unretouched depending on the type of activity. From a cinematic point of view, I have recognized both transverse (*n.* 8) and longitudinal movements (*n.* 8), along with a group of drilling tools (*n.* 6). Edge fractures are characterized by a combination of feather-termination and step-termination fractures (Fig. 3.41, *b*). In addition, one of the most diagnostic elements for this category is edge rounding. The rounded parts only feature in small areas of the tools; they are thus associated with an intentional use of the instruments and not with the action of some taphonomic agent (Fig. 3.41, *c-d*). Rounding is generally indicative of the contact with an abrasive material that must have brought about a constant polishing of the active zone. Materials of this type are, for example, hide and leather, vegetable matters such dry woods and ligneous plants, or mineral materials like clay, *etc.* However, the scarce preservation of the microtraces has not allowed a detailed classification of the wears to be carried out. Amongst the detected tools,

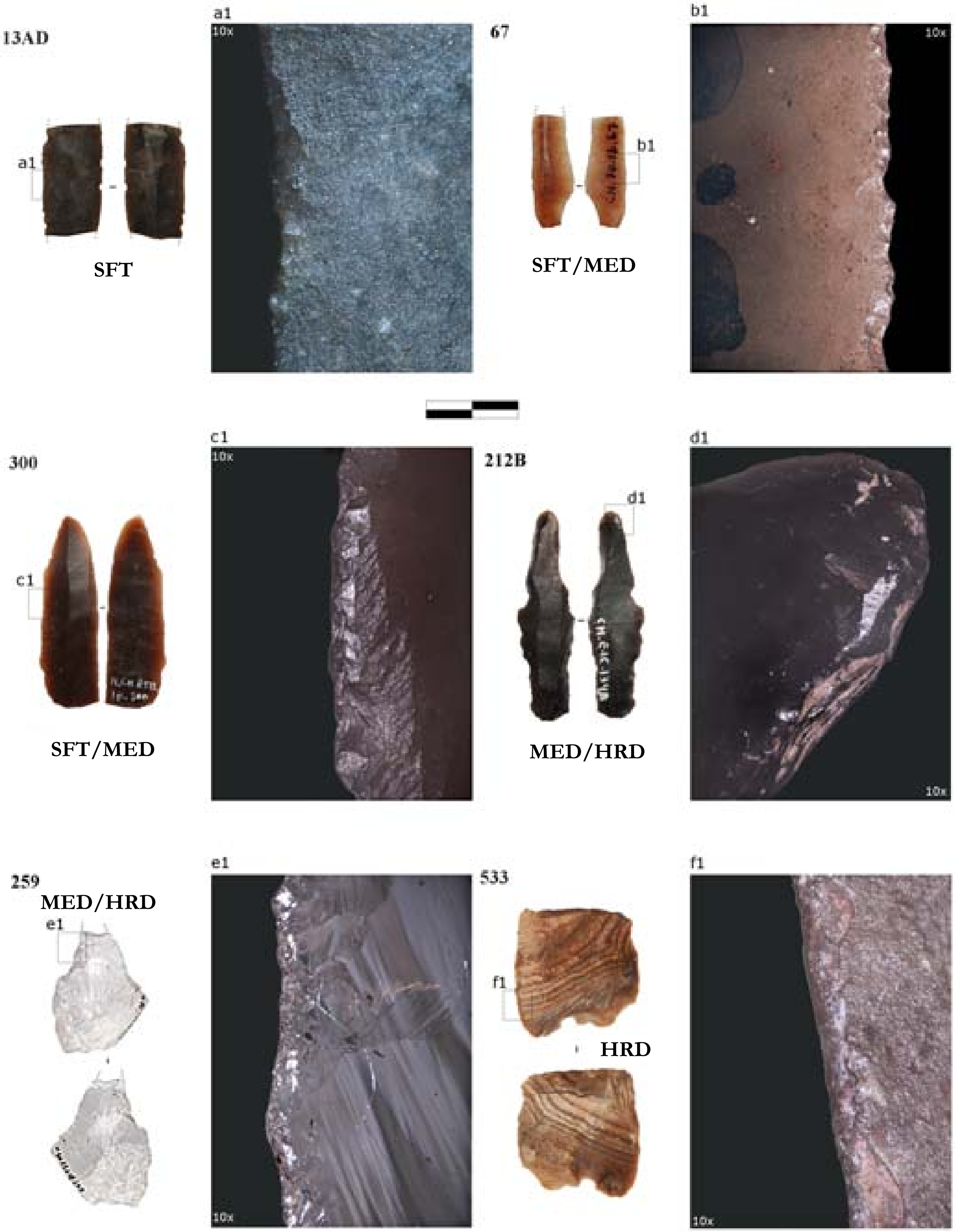

Fig. 3.41. Use-wears from the Cueva de Chaves, level 1.b. **225-** Tool used as projectile tip; *a1*) Macroscopic view, 10X. Overlapping bending fracture; *a2*) Impact strias on the ventral face, 200X. **357-** Tool used as projectile tip; *b1*) Elongated bending fractures on the dorsal face, 10X; *b2*) Overlapping bending fractures with spin-off on the opposite face. **80-** Tool used as projectile tip; *c1*) Overlapping bending fractures, 10X; **c45-** Tool used as projectile tip; *d1*) Extensive Burin-like fracture, 10X.

the presence of a possible borer on hyaline quartz is remarkable. It is a flake with converging edges, distally broken. Both sides show a series of overlapping fractures (Fig. 3.41, *e*).

Hard or resistant materials have mainly been worked by blades (*n.* 9) (30-41 x 10-18 x 3-4 mm), flakes (*n.* 7) (30-38 x 19-25 x 7-10 mm), and two thick tools (*n.* 2) (40-56 x 60-67 x 24-37) (Fig. 3.41, *f*). Transverse movement prevails (*n.* 14) over the longitudinal one (*n.* 2); in addition, two tools show traces of percussion/grinding (*n.* 2). The hardness of the worked materials has mainly been inferred from the type of edge fracture observed on the active zones. Overlapping bending fractures are recurrent, especially with step- and hinge-terminating fractures. This type of traces can be produced by a variety of resistant materials such as bone/antler, hard woods, and hard mineral materials. About pounding movements, in both cases, the used tool is an exhausted core retooled and used as grinder or hammer. The type of worked material remains unknown.

3.4.2.2. Non-utilitarian Wears

Non-utilitarian wears (e.g. hafting, transportation, technological wears, *etc.*) are poorly represented at Cueva Chaves. Indeed, post-depositional and post-excavation alterations have at times affected their preservation, thus making it difficult to recognize them. The only non-utilitarian wear which I have detected is that associated with traces possibly related to hafting tools (*n.* 8; 2.3%). Hafting wears are mainly represented by bright spots of polish caused by the friction between tool and handle. Such spots are often associated with edge rounding and/or striations. These types of traces are often located on the high points of lithic surfaces, such as dorsal ridges, and on the percussion bulb, on the ventral face. Indirect information on ways of hafting tools also comes from the distribution of use-wears and edge fractures. This is the case with sickle blades, endscrapers, or borers.

Other types of non-utilitarian wears, such as transportation wears, have not been detected, a fact that is probably due to the presence of post-excavation wears that actually resemble the ones here concerned.

3.5. Discussion

The use-wear analysis of a large sample of lithic implements from Cueva de Chaves' Level 1.b has brought to ascertain a variety of production processes carried out inside the cave or in its surroundings. It has been possible to advance a reconstruction of the lithic production sequence, type of tools that were produced, and their functional destination (Tab. 3.7). All this data has contributed to the reconstruction of site function and economic activities carried out at Chaves.

Obtained results indicate that almost the entire lithic production took place inside the cave. The main raw material, a good-quality chert, the outcrops of which are located a few kilometres from the site, was probably taken to the site in form of unmodified nodules. The large presence of fully-cortical elements suggests that core-preparation phases took place at the site. The exploitation of other lithologies available in the region, within a range of about 10-50 km, was marginal. However, the objective of the lithic production was always the same, irrespective of the chert material that was flaked, namely, obtaining narrow and thin blades. Sizes are 26-46 x 10-14 x 2-4 mm on average, however longer blades up to 90 mm in length have been recovered as well. Cores show a prevalence of blade making; cores at different stages of exploitation have been found, from elements with still largely exploitable surfaces with a debitage of over 70 mm in length, to almost exhausted cores with a flaking-front of 30-20 mm in length. The abundance of tablets and other core-rejuvenation flakes indicates that all the phases of core reduction and maintenance took place on site.

In a functional respect, one can stress on some considerable aspects. Most of the blade blanks were employed to work vegetable substances and, in particular, for cutting herbaceous plants. Within this category, several activities are grouped, amongst which agricultural works like cereal harvesting practices. The number of sickle blades is not very high if one compares Chaves with other sites of the same time situated in the NE of the Iberian Peninsula, such as for example La Draga (Gibaja 2010). However, it is highly probable that sickles were brought to the cave exclusively for their maintenance. Most of the recovered sickle blades are fragmentary, probably discarded while resharpening the sickles, being the used blades replaced by new ones. This behaviour appears consistent with the existence of cultivation fields at a certain distance from the site. Sickles would have been taken back to the site only occasionally for their maintenance, therefore their number is probably underrepresented at the site. A similar scenario is suggested by pollen analysis. Cereal pollen was not detected in Level I.b, so indicating that cultivation fields were settled at a considerable distance from the settlement (Lopéz-García 1992; Lopéz-García & López-Sáez 2000; López-Sáez et al. 2006).

Plant materials appear to have been gathered for several uses, not exclusively for food producing. The presence of tools associated with cutting plants to ground level indicates that not only inflorescences, but also straws were collected. In addition, several blades appear to be associated to wild grasses cutting, generally gathered when still green, differently from cereals. Straw and grasses could be used for basketry, as building materials for huts or roofing structures, as combustible for ignition, or for creating bedding and draining floors. The presence of compacted layers of plant remains in caves and rock-shelters has been documented in several Neolithic sites of the Western Mediterranean area, not only in relation to animal stables. In many cases, wild herbaceous plants appear to have intentionally been gathered and used as both combustible and bedding/construction materials (Juan et al. 1996; Angelucci et al. 2009; Lancelotti et al. 2013). About plants gathered for fodder production, there is not enough data to support such a hypothesis. Fodder production has been proposed for the site of Arene Candide, in Liguria, aiming at providing alternative and additional sources for animal feed (Maggi & Nisbet 2000). All the same, at Arene Candide, fodder usually appears to have been foliage and brushwood and not straws or grasses. Micro-morphological analyses of Arene Candide sediments and coprolites support this hypothesis, showing that a significant part of animal fodder derived from thin branches, twigs, and leaves (Macphail et al. 1997). In this case, the use of lithic tools is of little help since trees and shrubs were probably directly and spontaneously grazed by livestock (Papanastasis et al. 2006).

The rest of the blades were employed for diverse manufacturing processes, amongst them: ceramic production, leather working, bone/antler working, and butchering activities. However, for none of these processes blades were the only tools used; also flakes with edges of similar thickness were largely employed. Actually, edge thickness and morphology (e.g. thin rectilinear edges, sharp parts, tips, *etc.*) seem to have been the main criteria in the selection of blanks. Retouching was often applied to shape the active part before its use, in order to obtain the desired angle or strengthen the edge.

An exception is represented by projectile inserts, which were almost exclusively made out of blade blanks. Geometric tools were used as arrowheads or lateral barbs. They probably account for hunting practices. The most attested game species at Chaves are wild ungulates, amongst which red deer, wild goat, roe deer, and wild boar. However, hunting probably represented a marginal activity at Cueva de Chaves. One can hypothesize the existence of a foraging strategy with unspecialized, occasional hunting of the main species available in the surroundings of the site.

The other tools that were mainly made on blade blanks are borers; also specimens out of flakes have been recognized; however, they represent a lower percentage. Borers, which are one of the most representative types of Early Neolithic lithic assemblages (Cava 2000), featured in diverse production processes. Several tools were used to make holes into the walls of broken vessels, presumably for repairing them. Besides, borers were also used to drill bones, antler and teeth, suggesting their employment in ornaments and beads manufacturing. Finally, hide perforation has been recognized too, probably in relation to leather craft, for producing either clothes or bags.

Flakes were used in a variety of domestic and craft activities. They were mainly knapping by-products; indeed, at Chaves, no flake-oriented production has emerged. Debitage and platform rejuvenation flakes were intensively used, as well as cortical and, to a lesser extent, elongated flakes. Their dimensions vary from very thick and large tools to small thin flakes. They were generally used for one activity only, with just one active edge. They were rarely retouched or resharpened and so they can be considered disposable tools.

Amongst the activities in which flakes were employed, those related to animal substances prevail: butchering activities, rawhide and hide working and, to a lesser extent, bone and antler working. Larger flakes mainly served the purpose of making rawhide: endscrapers were made on thick-core trimming elements, frontally retouched to form a thick front for scraping green skin. Smaller flakes show a greater variability, having being used for both cutting and scraping, with a wider range of forms and shapes. Besides, flake tools were also availed of in many other craft activities, amongst which vegetable substances gathering and processing —either non-ligneous or ligneous plants—, ceramic vessels manufacturing and repairing, as well as for working other indeterminable materials.

The functional analysis of the lithic assemblage has revealed the existence of a domestic space characterized by a great diversity of economic processes. Activities related to food procurement, processing, and probably storing were practised inside the cave and in its surroundings, as well as manufacturing processes for the production and maintenance of tools, vessels, and ornaments. Production processes appears to have been composed of several phases of tasks and operations: from the obtaining of raw-material to its preparation and further elaboration and, finally, maintenance and repairing activities. A large part of these phases was probably carried out inside the cave, except for raw-material procurement that, in most cases, took place outside the site.

One can take as example the production cycle associated to domestic animal resources. Cueva de Chaves is characterized by an abundant faunal assemblage, which attests the existence of large domestic flocks: the estimated minimum number of individuals indicates the existence of 120 sheep/goats, 41 domestic pigs, and 14 cattle. Pollen analysis indicates a certain deterioration of the environment around the site, with a strong decrease in arboreal pollen and the appearance of taxa associated with human activity. The appearance of *Asphodelus albus* indicates the use of fire by people to open grassland areas, while the presence of *Plantago lanceolata* is another well-known anthropogenic indicator favoured by extensive grazing (Lopéz-García 1992; Lopéz-García & López-Sáez 2000; López-Sáez et al. 2006). All of this data suggests that pastoral practices were carried out, at least in part, in the surroundings of the site.

Slaughter activities took place entirely within the site. The ascertained kill-off pattern, with a high proportion of young individuals, suggests that husbandry was mainly oriented towards meat production, even if possibly also other by-products were exploited (Castaños 2004). Lithic tools featured in butchering activities, for meat extraction and preparation. Moreover, animals were skinned and their skins stripped of flesh and scraped. Finished leather was cut, perforated, and, later, possibly worked for making clothes, containers, strings, *etc*. Similarly, also bone and other hard animal materials were exploited for the production of tools (e.g. bone punches) and ornaments (bone beads or other pendants).

A similar production cycle probably took place for vegetable materials, too. Grasses, straw, and seeds were collected outside in the cultivation fields and then brought to the cave. In case of cereals, straw were successively trashed to strip the ears off the stalks. While cereal grains were alternatively consumed and stored, grasses and straw could be used as combustible or building materials.

In conclusion, this data confirms that the inhabitants of Cueva de Chaves practised a varied production economy, focused on the exploitation of both animal and vegetable resources. Both of them were gathered as food resources and, at the same time, they provided raw materials for manufacturing and crafting processes. As a whole, the economic model adopted at Chaves appears to have been a mixed, largely self-sufficient, economy based on the exploitation of a variety of resources that were procured or produced locally.

3.6. Final Remarks

Cueva de Chaves has often been mentioned in literature as one of the most paradigmatic Neolithic sites of the Iberian Peninsula (Jiménez-Guijarro 2010: 76). The size of the cave, the abundance and variety of the archaeological record, the presence of burials and artworks, all are factors that have contributed to create the image of Chaves being a prototype of «Neolithic» stable settlement (Baldellou 1987: 39; 1994: 36; Utrilla 1998: 184).

Nevertheless, in spite of the undeniable importance of the site, little attention has been paid to the settlement's economic organization. Until now, many assumptions on the type of activities carried out inside the cave have not relied on empirical data. Only some aspects have been studied in detail (e.g. pollen analysis; faunal remains; geometric-tools' function), while other questions have only been superficially or preliminarily addressed.

The objective of this study was to propose a general reconstruction of the activities carried out at the site by the analysis of chipped stone assemblages. Use-wear analysis has allowed tasks and activities to be ascertained, which could not otherwise have emerged from the archaeological records. Moreover, it has resulted in proving a wide range of economic activities, which involved different types of resources and materials.

The assumptions and observations made in previous studies of the site have largely been confirmed by this analysis. Cueva de Chaves appears to have been a self-sufficient settlement, whose economy was based on the exploitation of a variety of biotic and abiotic resources. Food was produced by both animal and vegetable farming, whilst several craft processes were carried out within the site. The manufacture of goods seems to have been varied and unspecialized and it was probably mainly oriented towards a domestic consumption. This reconstruction of the production processes carried out at Cueva de Chaves sheds new light on the site's technological and economic organization, thus bringing empirical data to the discussion on what may feature in a 'Neolithic economy' or a 'Neolithic site'.

PHASE		SG	PR	PO	TOT
1.b	**N.**	242	53	95	390
	% phase	*61,5%*	*13,5%*	*24,2%*	*100,0%*

Tab. 3.4. Interpretability of both the use-wears and non-utilitarian traces identified among the Cueva de Chaves lithic assemblage. SG: clear use, traces are fully interpretable; PR: probable use, traces are partially interpretable; PO: possible use, the interpretation is considered dubious.

PHASE		Herbaceous plants	Woody plants	Vegetal ind.	Hide	Soft/medium animal sub.	Hard Animal sub.	Clay/ceramic	Mineral sub. Ind.	Ind. Sub.	Projectile	TOT.
1.b	N.	121	9	11	58	22	18	18	40	59	27	383
	%	*31,6*	*2,3*	*2,9*	*15,1*	*5,7*	*4,7*	*4,7*	*10,4*	*15,4*	*7,0*	*100*

Tab. 3.5. Composition of use-wear traces identified among the Cueva de Chaves lithic assemblage. *Ind.* is an abbreviation for 'indeterminable'.

		HP	WP	VG	BU	HI	BA	CC	MI	PY	IS	TOT
	N	101	6	9	17	18	9	10	9	0	29	208
LO	*% Mov*	*48,6%*	*2,9%*	*4,3%*	*8,2%*	*8,7%*	*4,3%*	*4,8%*	*4,3%*	*0,0%*	*13,9%*	*100,0%*
	% Mat	*83,5%*	*66,7%*	*81,8%*	*77,3%*	*31,0%*	*50,0%*	*55,6%*	*22,5%*	*0,0%*	*49,2%*	*54,3%*
	N	20	3	2	5	38	7	6	11	0	22	114
TR	*% Mov*	*17,5%*	*2,6%*	*1,8%*	*4,4%*	*33,3%*	*6,1%*	*5,3%*	*9,6%*	*0,0%*	*19,3%*	*100,0%*
	% Mat	*16,5%*	*33,3%*	*18,2%*	*22,7%*	*65,5%*	*38,9%*	*33,3%*	*27,5%*	*0,0%*	*37,3%*	*29,8%*
	N	0	0	0	0	0	0	0	2	0	2	4
PO/GR	*% Mov*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*50,0%*	*0,0%*	*50,0%*	*100,0%*
	% Mat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*5,0%*	*0,0%*	*3,4%*	*1,0%*
	N	0	0	0	0	0	0	0	0	27	0	27
IMP	*% Mov*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*100,0%*	*0,0%*	*100,0%*
	% Mat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*100,0%*	*0,0%*	*7,0%*
	N	0	0	0	0	2	2	2	18	0	6	30
CIRC	*% Mov*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*6,7%*	*6,7%*	*6,7%*	*60,0%*	*0,0%*	*20,0%*	*100,0%*
	% Mat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*3,4%*	*11,1%*	*11,1%*	*45,0%*	*0,0%*	*10,2%*	*7,8%*
Tot	N	121	9	11	22	58	18	18	40	27	59	383
	% Mov	*31,6%*	*2,3%*	*2,9%*	*5,7%*	*15,1%*	*4,7%*	*4,7%*	*10,4%*	*7,0%*	*15,4%*	*100,0%*

Tab. 3.6. Cross-tab between *Movement* and *Worked Materials*. LO: Longitudinal movement; TR: Transversal movement; PO/GR: Pounding/Grinding movement; IMP: Projectile impact; CIRC: Drilling movement; *Mov* is the abbreviation for *Movement*. *Mat* is the abbreviation for *Worked Material;* HP: Herbaceous plants; WP: Woody plants; VG: Indeterminable Vegetal substances; BU: Soft Animal Substances; HI: Hide; BA: Bone/Antler materials; CC: Clay/ceramic; MI: Indeterminable Mineral Substances; PY: Projectile tools; IS: Indeterminable Substances.

		HP	WP	VG	BU	HI	BA	CC	MI	PY	IS	TOT
Blade	N	15	1	1	9	14	4	5	6	6	18	79
	% Blank	*19,0%*	*1,3%*	*1,3%*	*11,4%*	*17,7%*	*5,1%*	*6,3%*	*7,6%*	*7,6%*	*22,8%*	*100,0*
	% Mat	*12,4%*	*11,1%*	*9,1%*	*40,9%*	*24,1%*	*22,2%*	*27,8%*	*15,0%*	*22,2%*	*30,5%*	*20,6%*
Flake	N	94	3	8	9	13	9	5	17	21	29	208
	% Blank	*45,2%*	*1,4%*	*3,8%*	*4,3%*	*6,3%*	*4,3%*	*2,4%*	*8,2%*	*10,1%*	*13,9%*	*100,0*
	% Mat	*77,7%*	*33,3%*	*72,7%*	*40,9%*	*22,4%*	*50,0%*	*27,8%*	*42,5%*	*77,8%*	*49,2%*	*54,3%*
Core Trim.	N	11	5	2	4	31	5	7	12	0	12	89
	% Blank	*12,4%*	*5,6%*	*2,2%*	*4,5%*	*34,8%*	*5,6%*	*7,9%*	*13,5%*	*0,0%*	*13,5%*	*100,0*
	% Mat	*9,1%*	*55,6%*	*18,2%*	*18,2%*	*53,4%*	*27,8%*	*38,9%*	*30,0%*	*0,0%*	*20,3%*	*23,2%*
Other	N	1	0	0	0	0	0	1	5	0	0	7
	% Blank	*14,3%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*14,3%*	*71,4%*	*0,0%*	*0,0%*	*100,0*
	% Mat	*0,8%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*5,6%*	*12,5%*	*0,0%*	*0,0%*	*1,8%*
Tot	N	121	9	11	22	58	18	18	40	27	59	383
	% Blank	*31,6%*	*2,3%*	*2,9%*	*5,7%*	*15,1%*	*4,7%*	*4,7%*	*10,4%*	*7,0%*	*15,4%*	*100,0*

Tab. 3.7. Cross-tab between *Blank type* and *Worked Materials*. Within the category of «Other» are included cores and rejuvenation flakes. *Mat* is the abbreviation for *Worked Material;* HP: Herbaceous plants; WP: Woody plants; VG: Indeterminable Vegetal substances; BU: Soft Animal Substances; HI: Hide; BA: Bone/Antler materials; CC: Clay/ceramic; MI: Indeterminable Mineral Substances; PY: Projectile tools; IS: Indeterminable Substances.

4. ESPLUGA DE LA PUYASCADA

4.1. Introduction

Although the archaeological site of Espluga de la Puyascada was only partially excavated during a short campaign in 1975, this cave can be considered one of the most significant sites in the Aragonese Pyrenees. Until ten years ago, the site was thought to be the highest cave with archaeological layers dating back to Neolithic Age. Moreover, it was one of the few sites with an intact stratified deposit. The majority of sites in the area, between the Cinca and Ésera Rivers, where Neolithic materials have been found, are mainly known because of surface findings, as at Cueva de la Miranda (Baldellou & Barrill 1981-1982), Cueva de las Brujas, and Cueva de Las Campanas (Montes 1983; Utrilla & Ramon 1992; Utrilla & Mazo 1994), or deposits badly disturbed by clandestine excavations, as at Cueva del Forcón (Baldellou 1985c) and Cueva del Moro de Olvena (Baldellou & Utrilla 1995). The only exception in the region is Abrigo de Forcas II (Utrilla & Mazo 2007), which is anyway located further south, at the bottom of the Ésera Valley at 480 m.a.s.l. Other stratified deposits with reliable stratigraphic sequences are only situated in the area of the Sierra de Guara, where several caves going back to Neolithic Age have been excavated or surveyed, like Cueva de Chaves (Baldellou 1985b), Cueva Paciencia, Abrigo de Paco Pons, and Abrigo de Huerto Raso (Baldellou 1991; Montes et al. 2000, 2003; Montes & Domingo 2001-2002).

Considering this scenario, Espluga de la Puyascada, located in the Sierras Interiores at an altitude of 1.300 metres, can reasonably be regarded as one of the most important mountain sites of the Southern Pyrenees. The settlement has been a reference point for the study on occupation of mountain areas; it has provided information on the economic organization and material culture of the first agro-pastoral communities that inhabited the highest ranges of the pre-Pyrenees during the fifth millennium cal BC. Only recently, with the discovery of new sites at mid- and high-altitudes and with the ongoing excavations of Cova de Els Trocs —in the municipality of Bisaurri in the Ribagorza (Rojo et al. 2014)— and Cueva de Coro Trasito —in the municipality of Tella-Sin in the Sobrarbe (Clemente et al. in press)—, the knowledge of the first groups that exploited the mountain and subalpine zones of the pre-Pyrenees has expanded.

4.2. General Information

4.2.1. Geographical Framework

Espluga de la Puyascada, also known as Espluga Escala, is located in the northeast of the Iberian Peninsula, in the region of Aragon, province of Huesca. It is situated in the municipality of La Fueva, a few kilometres away from the town of San Juan de Toledo, in the Sobrarbe district. Site coordinates (UTM31 ED50) are: X 771.955, Y 4.706.080 (Fig. 4.1).

The cave has formed in a limestone massif called Sierra Ferrera, which extends in a NW-E direction from the Cinca Valley to the Ésera Valley. This range is part of the Sierras Interiores system, which runs parallel to the Axial Pyrenees and reaches considerable heights, over 2,000 metres in the central and western sectors. The cave entrance is located at 1.314 m.a.s.l., formed in a limestone massif characterized by steep slopes and sheer cliffs.

The cave is large and consists of a broad chamber, almost completely opened to the

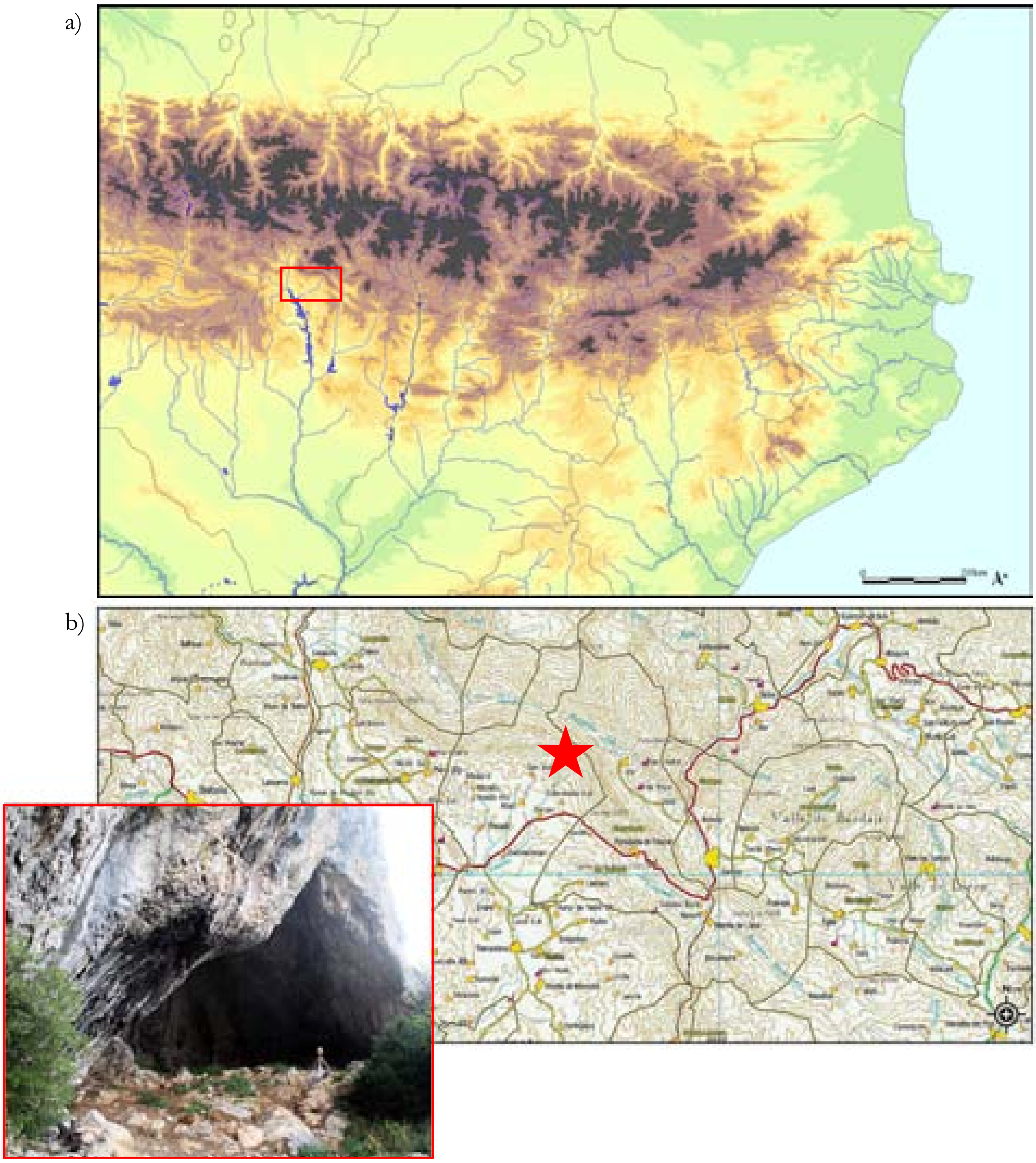

Fig. 4.1 *a*) Geographical framework of the site; *b*) Site location on 1:50.000 map. The red star indicates the exact position of the Espluga de la Puyascada; *c*) Photo of the cave entrance.

outside, which is 25 metres long and 19.5 metres wide. The cave opening is very high, about 10 metres at the entrance and 8.5 metres in the central part. The cave extends along a small passage that is situated in the north-eastern area of it and that is about 5 metres long (Baldellou 1987a) (Fig. 4.2).

Local climate is today influenced by both Atlantic Ocean and Mediterranean Sea, with annual mean temperatures around 10-12°C, about 3-4°C during the winter season and 21-22°C during summer. Average yearly precipitation is about 1.000 mm/year. Present-day vegetation is mainly dominated by shrubs (mostly *Echinospartum horridum V.*), with some scattered forested areas mainly characterized by oaks (*Quercus cerroides* and *Buxus sempervirens*) and, secondarily, pines (*Pinus sylvestris*) (Gómez García 1986).

4.2.2. Archaeological Researches

Espluga de la Puyascada was discovered by Anchel Conte, a local professor and historian, during the early years of the seventies. The only archaeological campaign carried out at the site took place during summer 1975, under the supervision of Dr. Vicente Baldellou, from the Museo Arqueológico Provincial de Huesca. During this excavation, four trial surveys were carried out, covering an area of approximately 16 m², three inside the chamber (C.1, C.3, C.4) and one under the cave entrance (C.2), although the latter did not yield any archaeological materials.

The context was excavated by artificial cuts, each 5 to 10 cm thick, which were later grouped together in sedimentary macro-units. Although the stratigraphic sequence was not homogeneous in the different surveys, three main levels were distinguished (Fig. 4.3).

The first phase can be generically dated to the fifth millennium cal BC. Archaeological materials are relative abundant, especially in the surveys inside the cave (C.3 and C.4). The presence of Impressed and Incised Ware is particularly significant (*cerámica a impresiones e incisiones*), whilst Cardial Ware was not found. During the excavation, some combustion areas were recognized, which were characterized by charcoal, thermally-altered sediments, and ash layers, whereas no clear structures or hearths were identified. Bone-industry materials were abundant and remarkably well-preserved, whilst lithic objects were at quite low numbers and not characteristic from a typological point of view (Baldellou 1987a).

The second phase is dated towards the end of the fourth millennium. However, it has only been documented on the basis of a very poor layer, which has yielded a few ceramic fragments possibly belonging to Chalcolithic period, with decorations that appear to have been influenced by the Bell-Beaker culture (Baldellou 1987a). This layer has only been detected in one of the four surveys (C.3), perhaps corresponding to a short occupation of the cave.

The third phase substantially corresponds to the modern occupation of the cave, mainly associated with animal stabling. Here, historical remains are mixed with archaeological materials.

4.2.3. Detailed Stratigraphy

E.S - Surface level, mainly formed by remains of modern practices of penning sheep and goats. This level was documented in all surveys. Mixed archaeological material was occasionally found. Its depth varied between 13 and 30 cm.

E.1 - Silty grey-brown layer, characterized by abundant ash and charcoal. It has been recognized only in the central sector of the main chamber, in Survey C.3. The deposit was sloping and it was sub-divided into two strata based on the different amount of organic remains. It was between 50 and 110 cm thick. The few archaeological remains apparently referred to a Bell-Beaker occupation.

E.2 - Silty dark brown layer, characterized by the presence of abundant ashes and charcoal. In some areas, spots of fire-altered sediments were identified. The presence of many stones of different size was probably due to an ancient collapse of the overhanging ledge. This level was detected in Surveys C.1, C.3, and C.4. In some sectors, it has been sub-divided into different strata (E.2a and E.2b) depending on the distribution of

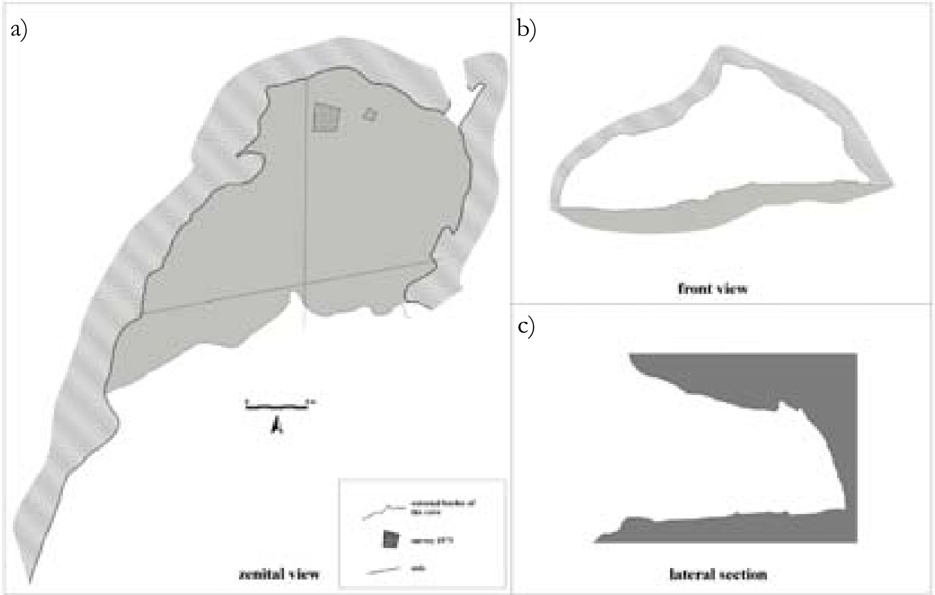

Fig. 4.2. Plan of the Espluga de la Puyascada realized by the Grup d'Arqueologia d'Alta Muntanya (GAAM-UAB); a) zenital, b) front and c) lateral view.

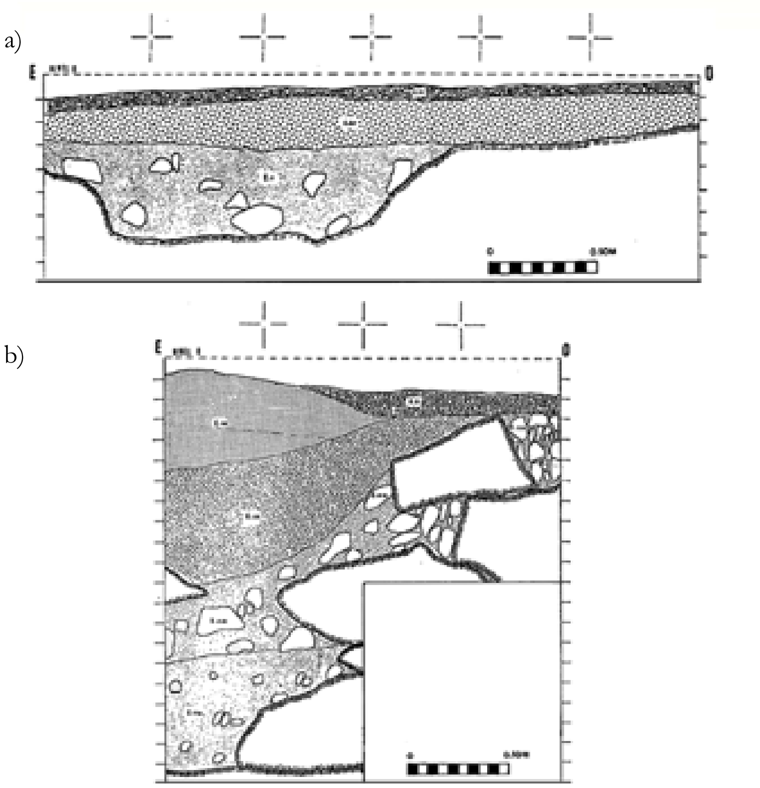

Fig. 4.3. Stratigraphic section of the surveys: *a*) C4 and *b*) C3. Modified from Baldellou (1987a).

stones and their size. Its maximum thickness varies between 60 and 110 cm. This layer contained a large number of archaeological remains belonging to a Neolithic phase with Impressed and Incised pottery. Other finds were a rich bone assemblage (mainly punches, but also a spoon and a spatula) and ornaments such as beads and bone rings (Fig. 4.6).

4.2.4. Radiocarbon Chronology

The radiocarbon chronology of the occupations of Espluga de la Puyascada was determined by three dates. The first sample, charcoal, was taken from Level E.1, in Survey C.3, while the other two charcoals came from Level E.2, from Survey C.1 and C.3 respectively. The results of the radiocarbon analysis have already been published by Baldellou (1987a). Here, I present the radiocarbon dates recalibrated with the OxCal 4.2.3v software (Bronk Ramsey 2009), using the IntCal13 calibration curve (Reimer et al. 2013) (Tab. 4.1).

The outcomes show that the cave was occupied in the course of the fifth millennium cal BC and, later, a second phase occurred at the end of the fourth millennium cal BC. The first phase has been ascertained by two dates coming from Survey C.1 and C.3 respectively. The oldest one, from Survey C.1, indicates that the cave was occupied during the first half of the fifth millennium, between 4981 and 4687 cal BC (95.4%), while the second, from Survey C.3, shows an interval between 4557 and 4323 cal BC (93.9%). At the moment, considering the scarcity of the stratigraphic data and the limited extension of the still preliminary archaeological excavation, it is difficult to determine whether these two chronological intervals represent a single, prolonged occupation or two distinct phases. Additional radiocarbon dating seems to be necessary for verifying the consistence and duration of human occupation during the fifth millennium. Moreover, there is no detailed information on the spatial and stratigraphic location of the two radiocarbon samples, nor has been established a direct stratigraphic relation between the two surveys. Given the preliminary nature of the excavation and the homogeneity of the ceramic typologies recovered in the three surveys, it seems reasonable, at this stage of research, to consider Level E.2 as a homogeneous context going back to a final phase of the Early Neolithic/early Middle Neolithic Age.

Tab. 4.1. ^{14}C Dates from Espluga de la Puyascada (Baldellou 1987a). Calibrated dates, both BC and BP, have been realized with OxCal software v4.2.2 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013).

Ref. Lab.	Layer	Sample	BP	±	Cal BC (68.2%)	%	Cal BC (95.4%)	%	Cal BP (68.2%) (whole range)
CSIC-383	C3 – E.1	Charcoal	4560	80	3490-3471 3373-3265 3241-3104	4.3 27.5 36.4	3619-3611 3521-3020	0.4 95.0	5439-5053
CSIC-384	C3 – E. 2	Charcoal	5580	70	4465-4349	68.2	4578-4574 4557-4323 4288-4268	0.2 93.9 1.3	6414-6298
CSIC-382	C1 – E.2	Charcoal	5930	60	4893-4889 4884-4869 4849-4724	1.3 5.4 61.6	4981-4687	95.4	6842-6673

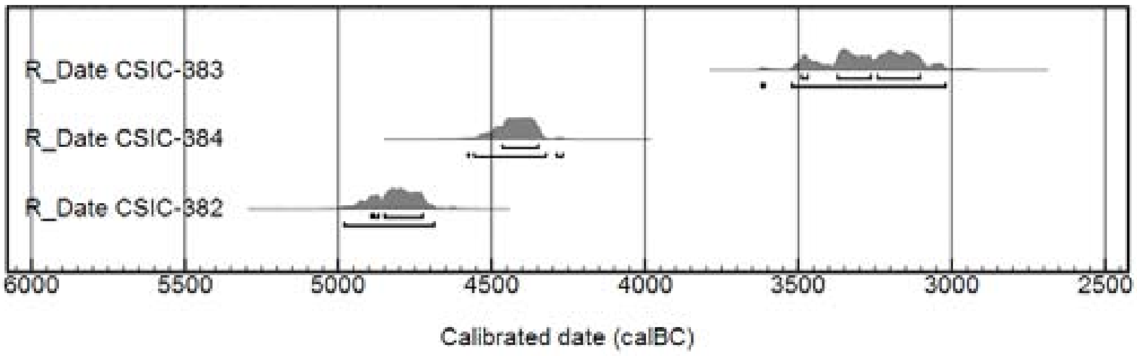

Fig. 4.4. Multiple plot of ^{14}C Dates from the Espluga de la Puyascada (yrs. BC). Calibrated dates have been realized with OxCal software v4.2.3 Bronk Ramsey (2009); Atmospheric data from Reimer et al (2013).

About the second phase of occupation, stratigraphic and archaeological data is even fainter. The chronological interval obtained from the 14C sample indicates, with a 95% probability, that this charcoal goes back to 3521-3020 cal BC. This interval appears too ancient for the types of archaeological material found in Layer E.1, since the Bell-Beaker culture is traditionally attested in the NE of the Iberian Peninsula around 2600-2500 cal BC (Bernabeu 1984; Gusi & Lujan 2012). However, the supposed ceramic materials characterized by Bell-Beaker linear decorations are extremely fragmentary and so, also taking into account the scarcity of remains associated with this facies in the region (Baldellou & Moreno 1986), their interpretation requires some caution. The radiocarbon data should not be blindly trusted either, but questioned; however, it cannot be just refuted, even though it does not match the (poor and fragmentary) archaeological record. Future excavation works might perhaps shed some light on this problem.

4.3. Materials

4.3.1. Ceramic Assemblage

Espluga de la Puyascada presents a relatively abundant ceramic record, considering the limited extent of the surveys. The assemblage has been studied by Baldellou (1987a) and later by Ramón (2006).

The materials from Level E.1 are extremely scarce and mainly composed of undecorated shards, while there are only three diagnostic decorated fragments, which apparently recall Bell-Baker traditions.

Materials from Level E.2 amount to 1,929, of which 1,139 come from Survey C.3, 493 from Survey C.3, and 199 from Survey C.1. Among them, the largest group is composed of undecorated fragments (71.2%), whilst decorated fragments represent a low percentage of the sample (8.7%). The represented typologies are extremely various. There are open globular and elliptical shapes, such as pots and bowls, and closed vessels like jars or bottles, of both large and small size.

Amongst decorations, the presence of some typical motifs of the period is significant, like bands of horizontal lines combined (above or below) with arrays of impressed points mainly of rectangular or circular shape (Fig. 4.5, *a-d)* (Rojo et al. 2013). Amongst the decorated

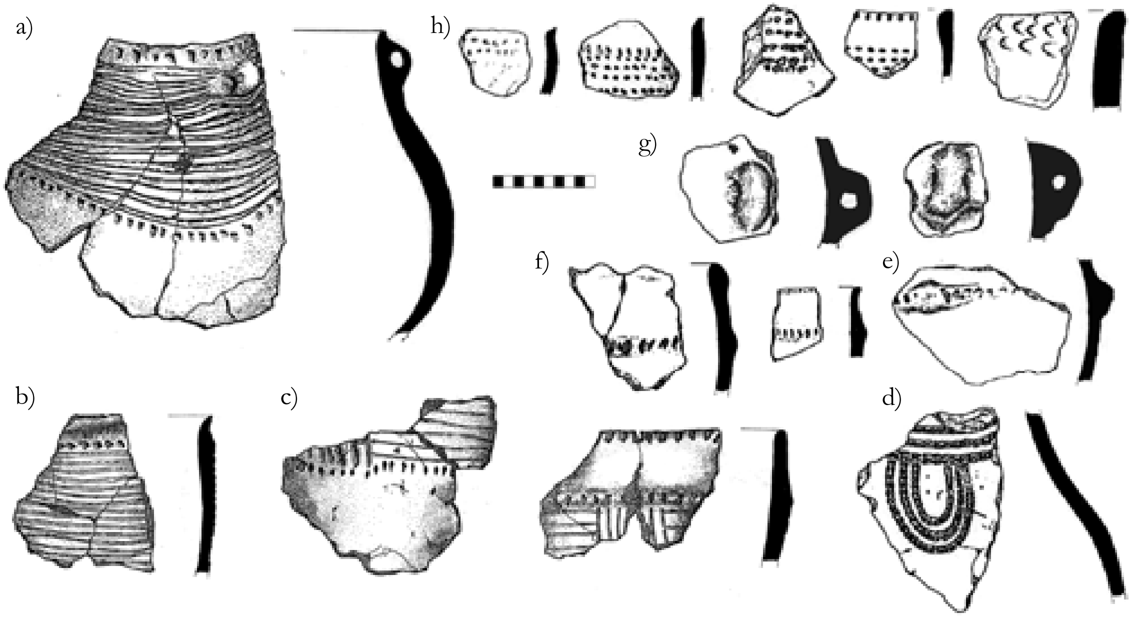

Fig. 4.5. Ceramic assemblage from the Espluga de la Puyascada, level E.2. Modified from Baldellou (1987a): *a -d*) lineal decorations associated to impressions; *e*) *pitorro; f*) incised decorations; *g*) plastic decorations; *h*) impressed decorations: impressions with instrument.

assemblage, impressed decorations prevail, especially those carried out by an instrument (61.4%) (Fig. 4.5, *h*), followed by plastic (15.7%) (Fig. 4.5, *g*) and incised decorations (11.5%) (Fig. 4.5, *f*), whilst Cardial decorative patterns are completely absent. Amongst plastic decorations, especially the presence of two fragments of *pitorros* is significant, which are motifs typical of the Valencian and Andalusian Early Neolithic Age (Fig. 4.5, *e*) (Ramón 2006).

4.3.2. Archaeozoological Assemblage

The faunal assemblage of Espluga de la Puyascada has been studied by Castaños (1987). The determinate fragments amount to 58 in Level E.1, attesting to a minimum number of 10 individuals, and 307 in Level E.2., which refer to a minimum number of 22 individuals. In this paragraph, I only focus on the Neolithic assemblage; therefore, Level E.1 is not considered in this study.

The data available at the moment indicates a clear prevalence of domestic species, dominated by ovicaprids (*Ovis aries*/*Capra hircus*) that represent 61.6% of the sample, followed by cattle (*Bos taurus*) (21.7%) and suids (*Sus scrofa*) (11.7%). All species are attested by cranial and post-cranial remains, with a prevalence of mandibular and dental remains. Estimated ages indicate the prevalence of young individuals.

Wild species are represented by low percentages, with fragments of red deer (*Cervus elaphus*) (4.2%) and roe deer (*Capreolus capreolus*) (1.3%). Red deer is attested by both cranial and postcranial remains, while roe deer has only left a complete right antler.

Considering the limited extent of the excavations, these results should be regarded as preliminary, since the percentages and the ratio of the various species could certainly vary

Fig. 4.6. Archaeological materials of the Espluga del Puyascada. *a*) Bone ring; *b*) Perforated shells; *c*) Edible Cockles (*Cerastoderma edule*); *d*) Bone spoon; *e*) Bone spatula; *f*) Bone punch; *g*) Lacustrine Oligocene-Miocene flint type; *h*) Marine Cretaceous chert type; *i*) Blond flint type; *j*) Evaporitic Upper Cretaceous -Palaeocene Continental flint type; *k*) hornfels axe.

even to a significant extent by enlarging the sample. All the same, the prevalence of sheep/goat amongst domestic species seems remarkable, as also the low numbers of wild animals (Castaños 1987).

4.3.3. Other materials

Apart from ceramic and faunal assemblages, a wide variety of finds has been recovered during the excavation of Espluga de la Puyascada, amongst which polished instruments, macrolithic tools, ornaments, malacological remains, and bone/antler-industry products (Fig. 4.6). The majority of these materials have only been preliminarily published and no detailed study is so far available (Baldellou 1987a). However, it is possible to point out some important aspects.

Bone/antler industry: After the ceramic record, bone tools represent the most abundant materials. The assemblage is mainly composed of punches (*n.* 9), spatulas (*n.* 2), one spoon (*n.* 1), and one worked fragment of wild boar's canine tooth (*n.* 1).

Polished tools: Adzes and axes, most of them made of hornfels, amount to 8 implements, of which the two largest ones, around 6-7 x 3-4 x 2-3 mm, are not completely polished; besides, five smaller, completely polished tools have a trapezoidal or oval shape and measure 2-4 x 1.5-3 x 0.7-1.2 mm. Finally, there is a very small axe measuring 1.8 x 0.8 x 0.3 mm, with a rectangular/oval shape and probably made out of sillimanite.

Macrolithic assemblage: The macrolithic assemblage exclusively attests a fragment of granite mill and one of a millstone, both coming from Survey C.4.

Ornaments and others: : Some ornaments were also found: two discoid shell beads with central hole and three pendants, two of which made of shell and one of tooth. Finally, the presence of two shell fragments is to remark, one of which belongs to a *Cerastoderma edule*. Both of them appear to have been used to scrape clay (Mazzucco et al. 2014a).

4.3.4. Lithic assemblage

4.3.4.1. General Aspects

The lithic assemblage from Espluga de la Puyascada is extremely small since only one element —an unretouched blade— from Level E.1 and 38 finds from Level E.2 have been recovered. The materials from both levels have been published by Baldellou (1987a: 22). In the study here concerned, I only consider the lithic objects from the Neolithic horizons (Level E.2).

The first aspect to point out is the absence of debris and, more generally, of micro-sized lithic items. This is probably due to the excavation and sieving techniques adopted during the field works of the seventies. In fact, only dry sieving carried out by sifters with square mesh of at least 5 mm probably took place on site, this preventing from recovering the smallest materials.

Moreover, giving the limited extension of the surveys, one should consider this study as a first step towards an understanding of lithic resources-management strategies, which can offer some interesting research points, to be anyway considered as preliminarily and partial since data can change rapidly when the studied sample is enlarged. The analysis carried out in

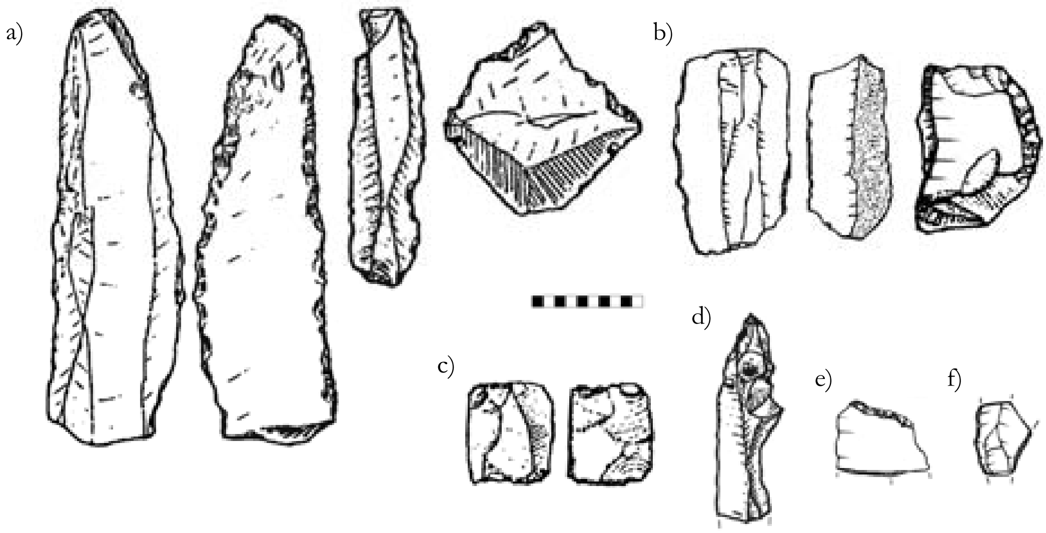

Fig. 4.7. Typological classification of the lithic assemblage of the Espluga de la Puyascada. Modified from Baldellou (1987): *a*) denticulate tools; *b*) scrapers; *c*) *écaillé* tool; *d*) borer; *e*) truncated tools; *f)* backed tool.

PHASE		T	L	R	D	Bc	E	Ind	TOT
E.2	N	1	4	2	4	1	1	1	14
	%	*7,1*	*28,6*	*14,4*	*28,6*	*7,1*	*7,1*	*7,1*	*100*

Tab. 4.2. Typological classification (essential structure from Laplace 1964) of the lithic materials of the Espluga de la Puyascada. T: Truncated tools; L: Blade scrapers; R Flake scrapers; D: Denticulate tools; E: Écaillé; Bc: Borers; Ind: Indeterminate tools.

this work is then expected to be integrated by futures studies, when the excavations will be tackled as a whole. For the moment, it is not possible to draw any definitive conclusion.

4.3.4.2. Typological aspects

Espluga de la Puyascada' lithic assemblage has always been considered as a poor and uncharacteristic industry (Baldellou 1987a: 22). Retouched implements are rare and often characterized by pseudo-retouches produced by resharpening or consequent on the use of the object and not due to an intentional retouching of the edges. Considering the scarcity of elements, I can only make some general points about the identified categories of tools and their stylistic aspects (Tab. 4.2).

The most represented class is the Substrate, amongst which Denticulate tools (D) prevail (*n.* 4; 28,6%) (Fig. 4.7, *a*). Within this group, I have highlighted the presence of two denticulate blades and two denticulate scrapers on flake blanks. However, retouches are, in these cases, mainly results of resharpening and retooling processes and not of a previous configuration of the tool. The other tools are mainly blades, characterized by edge damages that can be ascribed to infra-marginal retouches (L) (*n.* 4; 28,6%), besides two scrapers on flakes (R) (*n.* 2; 14,4%), which were only roughly retouched (Fig. 4.7, *b*).

One item can be ascribed to the category of *Écaillé* pieces (*n.* 1; 7,1%); however, also in this case, edge scarring was produced by use rather than intentional retouching. The tool is a quadrangular flake characterized by two opposite edges (proximal and distal), with a succession of overlapping bifacial fractures (Fig. 4.7, *c*).
One of the few elements showing an intentional retouch is a borer (Bc) (*n.* 1; 7.1%), which is a heavily burnt piece, in which the point was configured by a bilateral and bifacial retouch that is abrupt on the dorsal face and flat and invasive on the ventral one (Fig. 4.7, *d).*
Amongst the abrupt retouched implements, one can emphasize the presence of a distal fragment of a truncated blade, which is characterized by an inverse marginal retouch on the distal edge (T) (*n.* 1; 7.1%) (Fig. 4.7, *e*).

Finally, a previous publication has pointed out the presence of a fragment shaped by abrupt retouching, which may be a geometric tool (Fig. 4.7, *f)* (Baldellou 1987a). Given the fragmentary nature of the blank, it is not possible to establish whether the tool is really a geometric. However, in my view, the presence of two opposite, convergent retouched edges makes such an interpretation not probable; alternatively, it may be interpreted as a fragment of borer.

4.3.4.3. Raw materials procurement

The analysis of the lithic raw materials exploited at Espluga de la Puyascada has been accomplished by a macroscopic non-destructive observation only, giving the low number of specimens recovered during the excavation. I have included in this work only the materials coming from Level E.2 (Tab. 4.3).

All the examined materials are siliceous stones. The large majority of them are allochthonous and just a low percentage can be considered of local provenance. Local materials are exclusively represented by two fragments (n. 2; 5.3%). Specifically, it is a dark-colour chert with black to dark-grey shades (Fig. 4.8, *a1-2*). This material is characterized by the presence of marine foraminifera, amongst which one can distinguish sponge spicules. Several types of marine chert are known in the region in the Cretaceous and Eocene formations of the Axial Pyrenees and pre-Pyrenees. One of them, the nearest one, is located at about 15 kilometres from the site, in the Armeña district. It is a limestone stratum dated to the Upper Cretaceous period and characterized by abundant chert nodules containing spicules and foraminifera like the Lacazina species (Garrido-Megías & Ríos 1972). Further west, marine chert types are situated in the Añisclo Canyon, at about 10 kilometres from Puyascada. However, in this case, it is an Eocene chert, distinguished by the presence of Alveolina and Nummulites (Van Lunsen 1970; Mazo and Cuchí 1992). The same unit is also known as *Calizas de las cornisas altas* (Ríos-Aragüés 1980). Macroscopically, both chert types are extremely similar and only a microscopic identification of the micro-palaeontological record makes a distinction possible. Moreover, both types are jointed rocks, characterized by cracks and fissures, this being not suitable for producing blades. This may explain why they were so rarely employed in the archaeological sites of the period concerned. The sample from Puyascada consists of just two pieces, the exact provenance of which cannot be ascertained because of the absence of diagnostic fossils —at least by a macroscopic observation of the surfaces. However, they can be considered of local provenance.

A second group, a white-grey translucent chert, is characterized by the presence of pseudo-morphs of gypsum crystals and iron oxides (n. 6; 15.8%) (Fig. 4.8, *b1-2*). Cherts of this type are known in the region amongst the continental units of high-salinity lacustrine environments of Upper Cretaceous-Palaeocene Age, specifically in the Tremp-Graus Basin

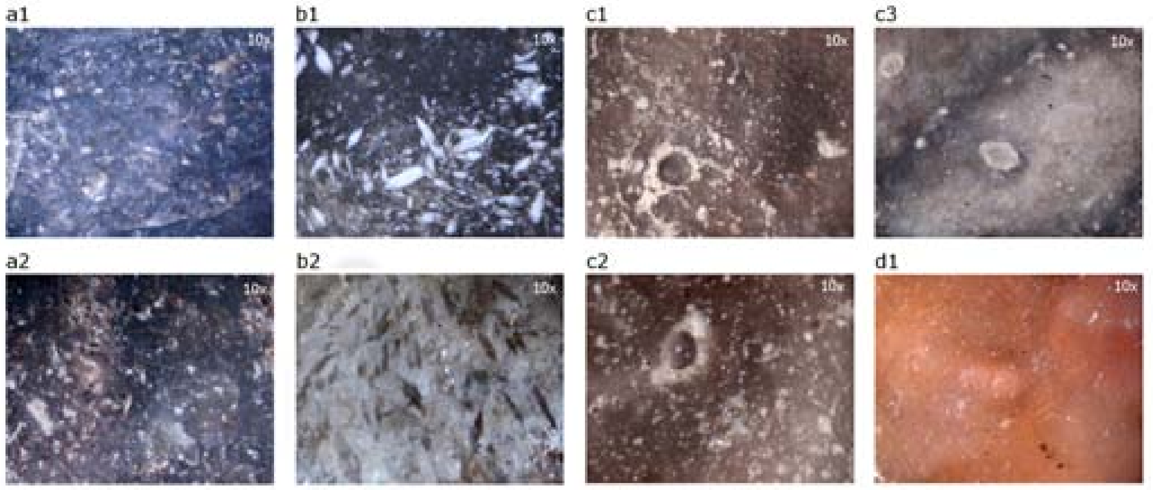

Fig. 4.8. Macroscopic photos at 10x magnification of the lithic materials of the Espluga de la Puyascada: *a1-2*) Marine cherts with benthic foraminifera and sponge spicule; *b-1-2*) Evaporitic chert with pseudo-morphs after lenticular crystals of gypsum; *c1-2*) Lacustrine cherts with ostracods and oogonies and stems of charophyceae algae; *d1*) Massive orange/blond fine-grained chert.

PHASE		Chert				TOT
		LOM	**EVP**	**MEC**	**IND**	
E.2	**N**	28	6	2	2	38
	%	*73,7*	*15,8*	*5,3*	*5,3*	*100*

Tab. 4.3. Raw material composition of the Espluga de la Puyascada lithic assemblage. LOM: Oligocene-Miocene lacustrine chert; EVP: Evaporitic Upper Cretaceous-Palaeocene cherts; MEC: Eocene-Cretaceous Marine cherts; IND: Indeterminate chert materials.

in the Pre-Pyrenees, in the provinces of Lerida and Huesca. Outcrops of the same formation are also known further west, in the localities of Serraduy and Campo, in the Ésera and Isábena Valleys, about 20 km far from the site (Rosell et al. 2001; López-Martínez et al. 2006); however, for these latter units the presence of chert nodules has not been confirmed.

The largest group (n. 28; 73.7%) is represented by a brown/beige/black chert which can be distinguished for the presence of Oogonia fragments and stems of Charophyceae algae (Fig. 4.8, *c1-3*). Chert of this type is well-known in the region and can be found in the carbonate lacustrine formations of Oligocene and Miocene Age in the central and eastern sectors of the Ebro River Basin (Anadón et al. 1989; Pardo et al. 2004). It is a good quality chert, available in large nodules, the diameter of which ranges from 20 cm to more than 1 m. The nearest outcrops of this type of chert are located about 80 kilometres far from the cave in the Casteltallat (Lleida) and Peraltilla (Huesca) Formations. This type of chert is also known, amongst Spanish archaeologists, as *Silex negro de Sierra Larga* or *Silex marrón de los Monegros* (Sunyer et al. 2013); however, they actually refer to the same lithology. On the basis of current data, it is not possible to distinguish any subgroups amongst the Ebro cherts as they are microscopically identical.

The last flint type, represented by a single item (*n.* 1; 2,6%), probably comes from a more

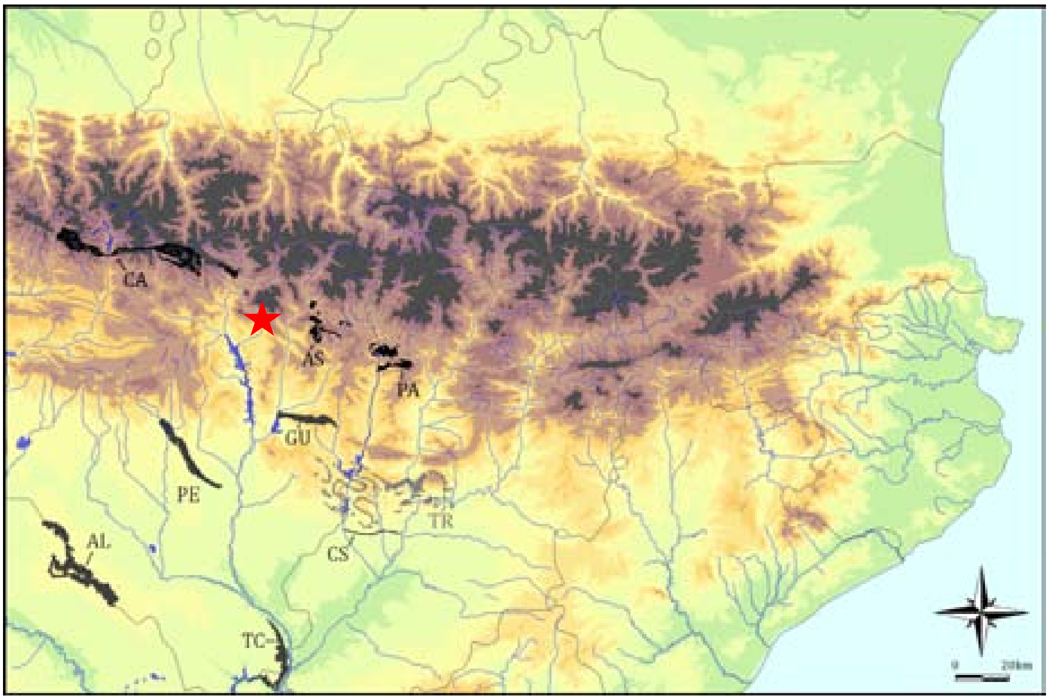

Fig. 4.9. Digital Terrain Model with the principal formations containing chert in the region. Map realized with software Miramon v7.1h. The red star indicates the Espluga de la Puyascada. CA: frm. Calizas de las carenas altas; AS: frm. Agua Salenz; PA: frm. Pardina; TR: frm. Tremp; GU: frm. Guarga; CS: frm. Castelltallat; PE: frm. Peraltilla; AL: frm. Alcubierre; TC: frm. Torrent de Cinca.

distant source, outside the region. It is a fragment of a solid translucent chert, of orange-beige colour, extremely homogeneous, and fine-grained, which can be compared with the so-called 'honey flint' or *silex blond* (Fig. 4.8, *d1*). The source of this material has long been debated by different researchers, although one of the most plausible hypotheses suggests that it may come from the Lower Cretaceous formations situated in Provence (Binder 1998, 2002; Blet 2000).

Finally, one last element —heavily burnt and cracked— has not been attributed to any of the previous groups and its provenance remains indeterminate. Given the low number of specimens and the presence of just one phase of occupation, I have not carried out any statistical test.

4.3.4.4. Technological management

From a technological point of view, considering the scarcity of remains, one can only point out some general features of the assemblage, whilst it is not possible to recognize any specific production sequence (Tab. 4.4).

A first aspect to remark is the strong prevalence of laminar products (*n.* 26; 68,4%). Such blades were mainly produced with chert types from the Ebro Valley, while the other lithologies appear to have marginally been employed. The presence of two cores and a resharpening tablet of this lithology, together with a higher frequency of artefacts with cortex, suggest that at least a part of the knapping activity was performed on site. Blades dimensions range between 11 and 17 mm in width and between 3 and 5 mm in thickness,

PHASE		Flake	Blade	Core	Characteristic waste products	TOT
N.2	**N**	8	26	2	3	38
	%	*18,4*	*68,4*	*5,3*	*7,9*	*100*

Tab. 4.4. Technological composition of the Espluga de la Puyascada lithic assemblage. Lexicon has been taken by Inizan et al. 1999.

while their length can only be estimated for a complete blade that measures 67 mm. Given the scarcity of materials, it is impossible to ascertain which part of the production was carried out on site and which outside the site. It is plausible that preformed cores were transported to the site for making small blades and flakes, while larger blanks were probably taken to the settlemet already shaped.

Flakes (*n.* 7; 18,4%) and other knapping by-products (*n.* 3; 7,9%) represent a smaller group. They were mainly the result of maintenance and rejuvenation of the striking platform and removal surfaces. They are generally quite thick, with irregular shapes, and measure 33-44 x 17-30 x 6-9 mm. In this case, both lacustrine Ebro cherts and Upper Cretaceous-Palaeocene evaporitic cherts are represented. Also in this case, the scarcity of the sample has not allowed any statistical analysis of the data to be accomplished.

Finally, two cores of roundish shape (*n.* 2; 5,3%), both made out of Ebro chert types, have been recovered. Their size is 48 x 41 x 38 and 25 x 28 x 18 mm respectively. In both cases, I have observed the presence of laminar removal, with two opposite striking surfaces. They are not exhausted elements and could be further exploited; however, they both appear to have been retooled as instruments and no longer used as cores.

4.4. Traceological Analysis

4.4.1. Material Conservation

The study of Espluga de la Puyascada's materials has been carried out at the Museo Arqueológico Provincial de Huesca. The lithic materials were partially exposed in the Museum and partially conserved in the warehouses of the museum.

By a macroscopic observation, the objects show a good state of preservation, despite the presence of some surface lustres, probably caused by post-depositional soil conditions. Such alterations consist of a slight smoothening of the microtopographic high-points and are recognizable thanks to a diffuse sheen on the lithic implements. However, this type of alteration, at this stage of development, is no significant obstacle to the use-wear analysis of the archaeological materials (Mazzucco et al. 2013a).

Chemical alterations have also affected the assemblage. Such type of alteration mainly produces a deterioration of micro-polishes, especially of those traces characterized by a higher content of amorphous silica. However, it is a marginal alteration that has only affected a small number of tools.

Another type of modification detected on part of the assemblage has been brought about by thermal alterations. The effects of fire have been observed on eight implements; however, only on one of them fire has caused severe cracks and fissures, along with a change of the macroscopic aspect and a patination of surfaces. Post-excavation modifications are also present, but they are mostly removable elements, such glues and varnishes.

Since they are old collections, materials have already been cleaned of sediments and other macroscopic impurities. Surfaces have been cleaned with alcohol before being analysed microscopically. In conclusion, out of the 38 elements that compose the assemblage, 26 implements were selected for the 'high-power' microscopic analysis. Amongst the remaining lithics, 8 implements did not show any active zone, while the other 4 were too altered to be analysed.

4.4.2. Level E.2.

More than half of the lithic assemblage from Espluga de la Puyascada shows traces of being intentionally used or modified by human actions (*n.* 26; 68.4%). Such a sample corresponds to 45 active zones (AUAs), most of which can be classified as actual 'use-wear traces' (*n.* 43; 97.7%). Amongst the latter, 11 implements are characterized by one active zone only, 13 implements by two active zones, and 2 elements by three active zones. For a summary of identified actions and worked materials, see Tab. 4.6 and Tab. 4.7.

One implement is characterized by the presence of 'non-utilitarian traces', more specifically due to transportation (*n.* 1; 2.6%). Finally, on one implement organic residues have been detected (*n.* 1; 2.6%).

In terms of outcomes, in 58.1% of the cases, it has been possible to achieve a complete interpretation of the use-wears (SG); in 27.9% of the cases, I have only determined the type of worked substances without identifying the exact material (e.g. vegetal, animal, or mineral substances) (PR); finally, in 14% of this assemblage, I have determined the hardness of the worked material (e.g. soft, medium, hard, etc.) (PO) (Tab. 4.5).

PHASE		SG	PR	PO	TOT
N.2	**N.**	25	12	6	43
	% tot	*58,1*	*27,9*	*14*	*100*

Tab. 4.5. Interpretability of the use-wear traces identified among the Espluga de la Puyascada assemblage. SG: clear use, traces are fully interpretable; PR: probable use, traces are partially interpretable; PO: possible use, the interpretation is considered dubious. Numbers and percentages are referred to active zones (AUAs).

PHASE		Herbaceous plants	Vegetal ind.	Soft/medium animal sub.	Hide	Bone/antler	Mineral substances	Soft ind.	Hard ind.	TOT.
N.2	**N.**	12	1	9	2	5	3	5	6	43
	%	*27,9*	*2,3*	*20,9*	*4,7*	*11,6*	*7,0*	*11,6*	*14,0*	*100*

Tab. 4.6. Composition of the use-wear traces identified among the Espluga de la Puyascada lithic assemblage. *Ind.* Is an abbreviation for 'indeterminable materials'. Numbers and percentages are referred to active zones (AUAs).

MOV	MAT							
	VG		**AN**			**MI**	**IND**	
	HP	*W/P*	*SA*	*B/A*	*H*		*SO*	*HA*
LO	12	-	9	-	1	-	5	-
TR	-	1	-	5	1	2	-	1
BO	-	-	-	-		1	-	-
PO/GR	-	-	-	-		-	-	5

Tab. 4.7. Cross-tab between the actions and the worked material, level E.2. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO/GR: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; W/P: Other indeterminate plants/ Ligneous plants; AN: Animal substances; SA: Soft animal substances; B/A: Bone/Antler; HI: Hide; MI: Mineral substances; IND: Indeterminate substances; SO: Soft indeterminate substances; HA: Hard indeterminate materials.

4.4.2.1. Use-wear

4.4.2.1.1. Vegetal Substances

Tools related to the working of vegetable substances represent the largest group of the analysed sample (*n.* 8; 31.0%) (*n.* 13 AUAs; 30.2%). Within this category, the majority of the implements are associated with longitudinally-moving actions, connected with harvesting *no-ligneous plant materials* (*n.* 7; 26.9%) (*n.* 12 AUAs; 27.9%) (Tab. 4.6.). In this group, one can distinguish three main classes of wear: traces associated with harvesting herbaceous plants; wears caused by cutting plant materials with a strong abrasive component; finally, wears associated with the working of indeterminate herbaceous plants.

Traces ascribed to *harvesting herbaceous plants* are documented by the presence of a wide medial blade fragment measuring (34) x 19 x 4 mm. The blank was made out of a chert type coming from the Ebro Valley and employed on both sides for cutting herbaceous plants (*n.* 1; 3.8%) (*n.* 2 AUAs; 4.6%). The polishes have not formed a compact and flat layer of silica gel, but show a scattered distribution, characterized by a mosaic of spots of polish and empty areas. The polish texture is smooth, with an undulating distribution that mainly affects the high points of the topography (Fig. 4.10, *a*). Polishes of this type, with a 'wet', flowing look, are usually attributed to the harvest of fresh plants such as reeds and grasses (Gijn 1989: 40; Ibáñez et al. 2013).

Tools associated with the *cutting of plants with a strong abrasive component*, the-so called 'RV2 traces' (Clemente & Gibaja 1998), are two, resulting in four active zones (*n.* 2; 7.7%) (*n.* 4 AUAs; 9.3%). They are both fragmentary, unretouched blanks characterized by the presence of a cortical surface. Dimensions are (27) x 13 x 4 and (30) x 17 x 6 mm respectively. Use-wears are distributed all along the long edges, which are characterized by a rough aspect and by the presence of linear abrasion marks (Fig. 4.10, *b* and Fig. 4.11, *a*). Traces of this type are generally attributed to the cutting of plants or grasses to ground level, which brings about an intensive contact between lithic surfaces and soil particles.

Wears attributed to *indeterminate herbaceous plants* have been identified on four implements corresponding to six active zones (*n.* 4; 15.4%) (*n.* 6 AUAs; 13.9%). Within this category, I have grouped together all those tools whose traces have been disturbed by some alterations, either intentional or unintentional. Among those, two tools —corresponding to three active zones— present traces affected by taphonomic alterations. Both elements are blades, a distal and a proximal fragment, with dimensions of (21) x 8 x 2 and (23) x 19 x 6 mm respectively. Micro-wears are not homogenously distributed, appearing in isolated spots poorly linked with one another, probably because of the dissolution of part of the silica gel. However, plant polishes, with a smooth and undulating aspect, are still recognizable (Fig. 4.11, *b*). Given the presence of a marginal scarring associated with a moderate edge rounding, both tools appear to have been employed for non-ligneous, soft plant materials, although it is not possible to ascertain the type of worked plant.

The remaining two elements are tools which were at first used for cutting herbaceous plants and later reused for other activities. In this case, the later employment partially abraded and disturbed the previous wears, this making their interpretation definitely more complicated. The first is a very wide and large blade measuring (84) x 27 x 44 mm, with a broken proximal end, which was extensively resharpened on both sides (Fig. 4.12). The residual polish is only preserved on the proximal part of the left edge (Fig. 4.12, *d)*. In this case, traces appear quite developed, with spots of flat and smooth polishes that may be attributed to residual spots of 'sickle-gloss'. However, use-wears have been affected too much by the second use to ascertain the type of performed activity precisely.

The last implement is also a heavily resharpened blade, with residual spots of the original polishes on both edges. The blank is a narrow blade of (52) x 12 x 4 mm, with one cortical side and fractured at its distal end. In this case, use-wears recall especially 'RV2' traces, since they are characterized by many abrasions and linear striations (Fig. 4.13, *a1-2*). However, taking into account the tool having been used in a second activity for hard animal materials, it is difficult to ascertain whether such abrasions were produced by use or retooling.

Finally, one tool has been attributed to *indeterminate vegetal substances* (*n.* 1; 3.8%) (*n.* 1 AUAs; 2.3%) (Tab. 4.6.). It is a fragment of a flake made out of the local marine chert type, with quite small dimensions, that is, (21) x 17 x 7 mm. The active zone is characterized by the presence of an array of large bending scars probably caused by use. Traces seem to suggest the working of some vegetable material, probably some soft/medium woody plant (Fig. 4.13, *b1-2*). Polishes show a very flowing look and a transverse/diagonal movement, thus attesting some type of scraping/planning activity. However, the surface is too altered and the flint itself is characterized by a bright lustre that disturbs the microscopic observation.

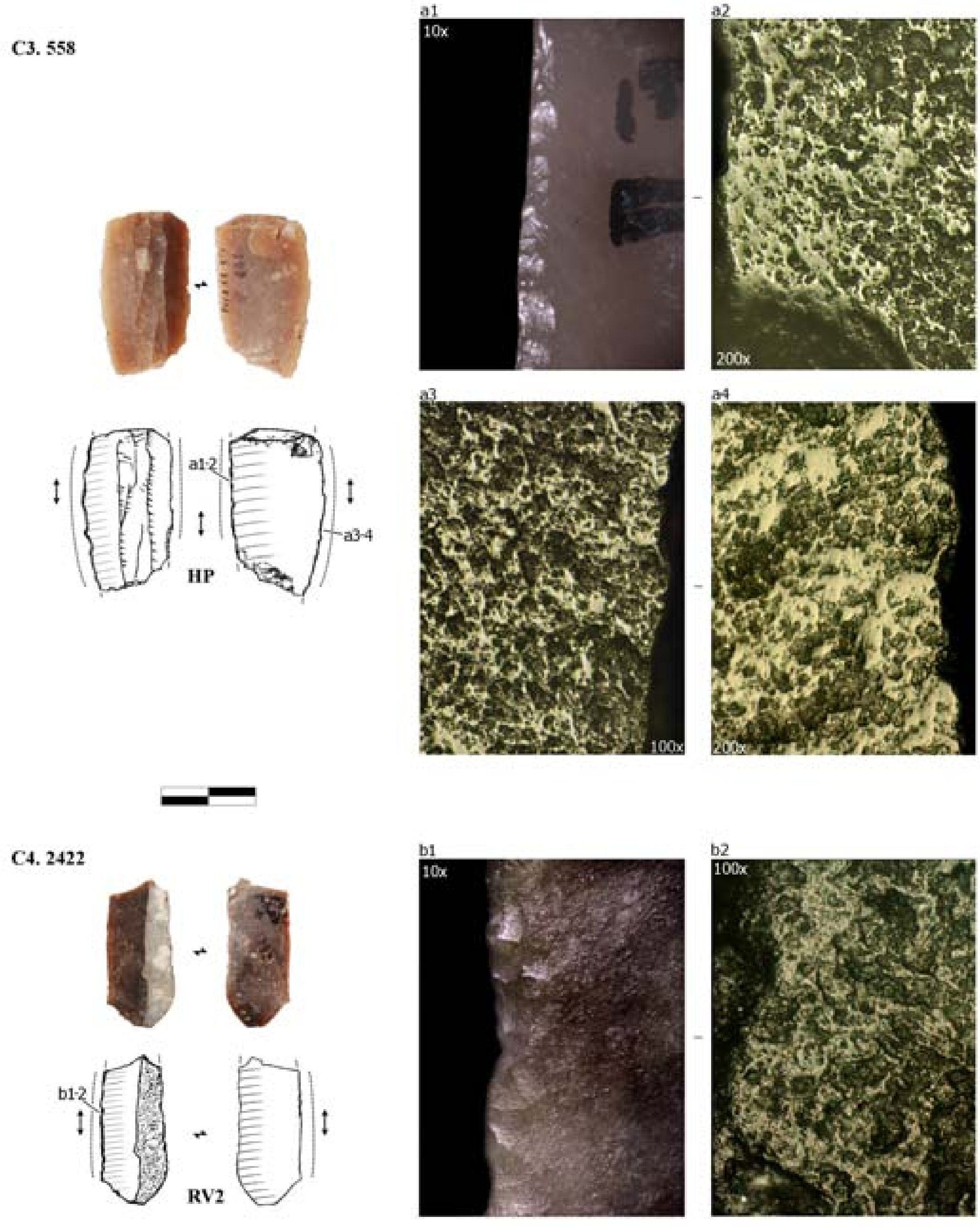

Fig. 4.10. Use-wears from the Espluga de la Puyascada. **C3.558-** Tool use for harvesting herbaceous plants on both edges; *a1-2*) Left ventral side, macro- and micro-traces; *a3-4*) Right ventral side, images at different magnification of the same spot. **C4.2422-** Tool used for harvesting plants at the ground level; *b1-2*) Right dorsal side, macro- and micro-traces of RV2 wear type.

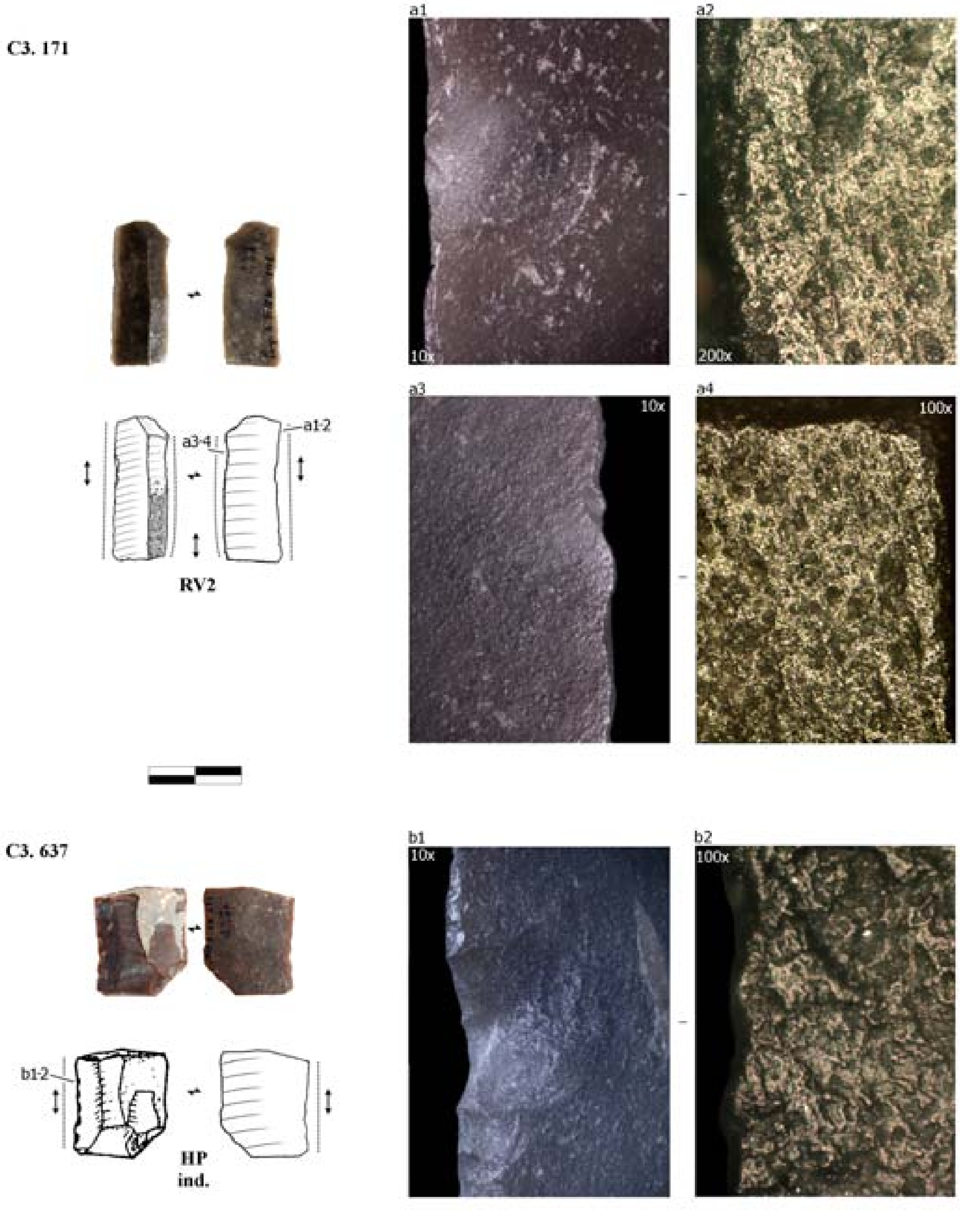

Fig. 4.11. Use-wears from the Espluga de la Puyascada. **C3.171-** Tool used for harvesting plants at the ground level on both edges; *a1-2*) Left ventral side, macro- and micro-traces of Rv2 wear type; *a3-4*) Right ventral side, macro- and micro-traces of RV2 wear type. Note the abrasions and striations over the polish. **C3.637-** Tool used for cutting indeterminate herbaceous plants; *b1-2*) macro- and micro-traces of an indeterminable plant polish.

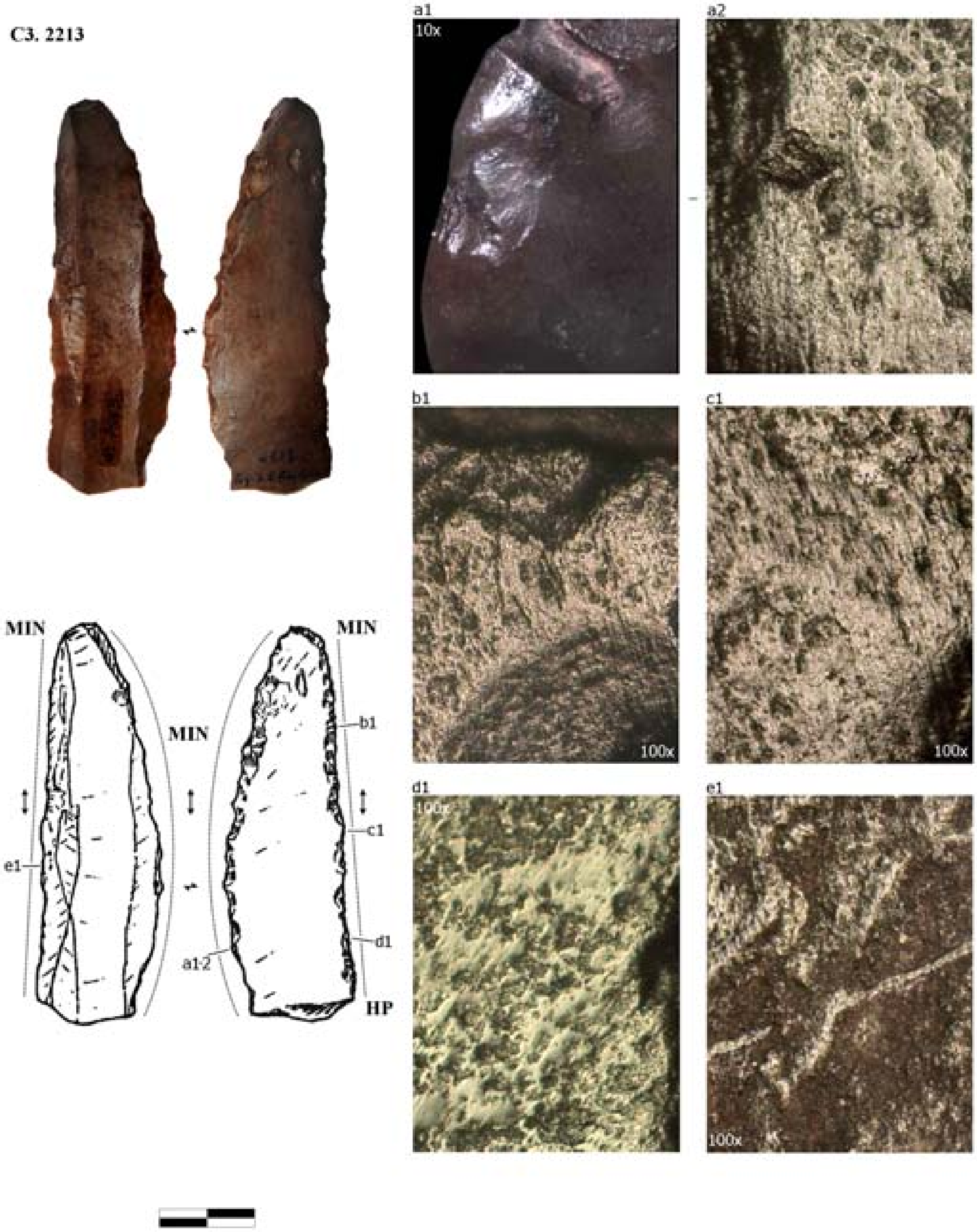

Fig. 4.12. Use-wears from the Espluga de la Puyascada. **C3.2213-** Tool with multiple uses, at first for cutting plants and, successively, for working mineral abrasive substances; *a1-2*) Right ventral side, macro- and micro- traces of working a very abrasive substance, probably semi-dry ceramic; *b1-c1*) Same wears on the other side. Note the density of fine striations with oblique/longitudinal directionality; *d1*) Residual spot of plant polish; *e1*) Possible transportation wear. Note how the striation is underneath the mineral polish.

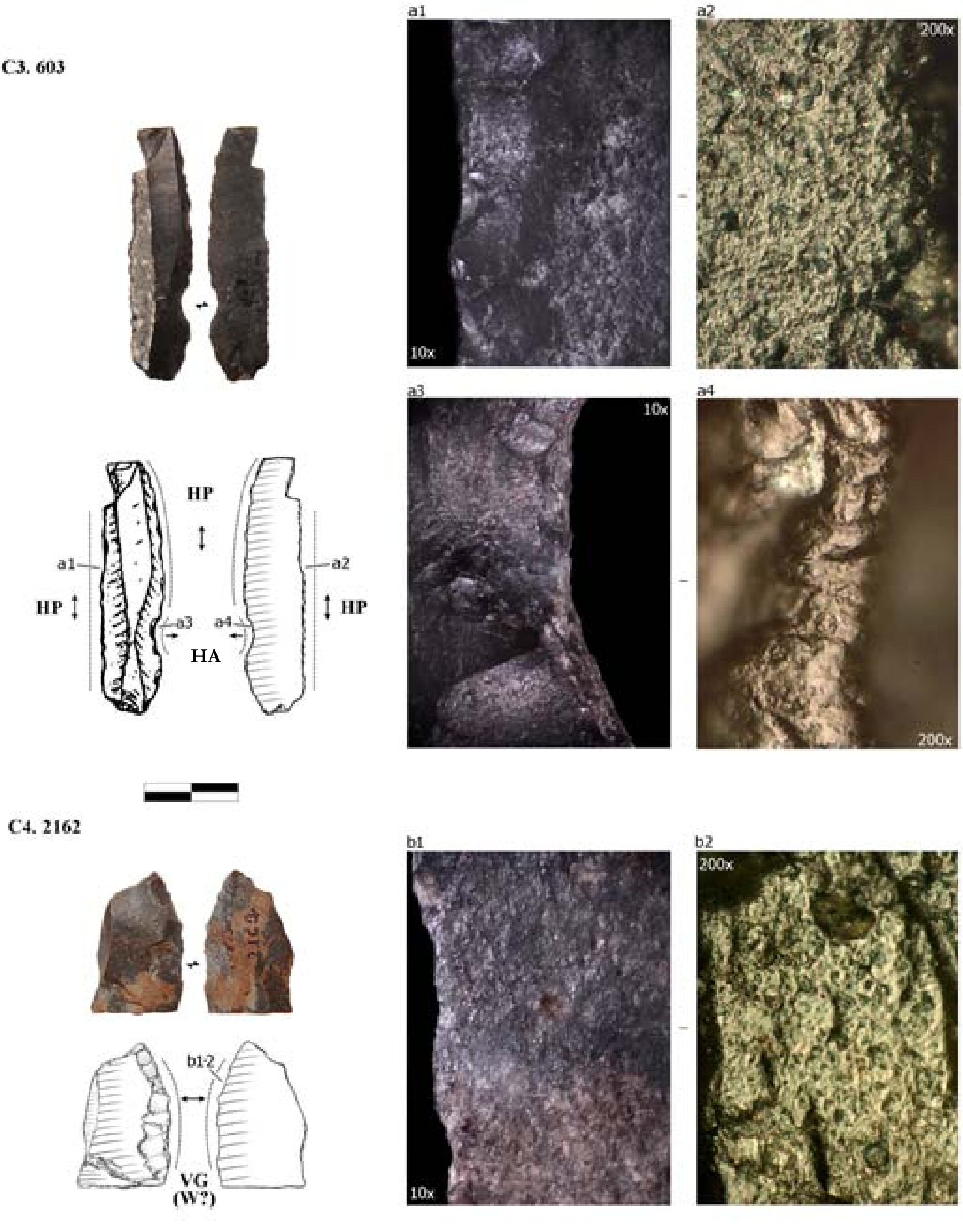

Fig. 4.13. Use-wears from the Espluga de la Puyascada. **C3.603-** Tool with multiple uses, at first for cutting plants and, successively, for working hard-animal materials; *a1*) Right dorsal side, resharpening edge; *a2*) Residual plant polishes; *a3-4*) Notch realized for working hard-animal materials. Note the presence of cracks and striations typical of bone/antler polishes. **C4.2162-** Tool used to scrape vegetal material, probably a woody plant; *b1-2*) Left ventral side, macro- and micro-traces. The polishes are degraded and partially altered.

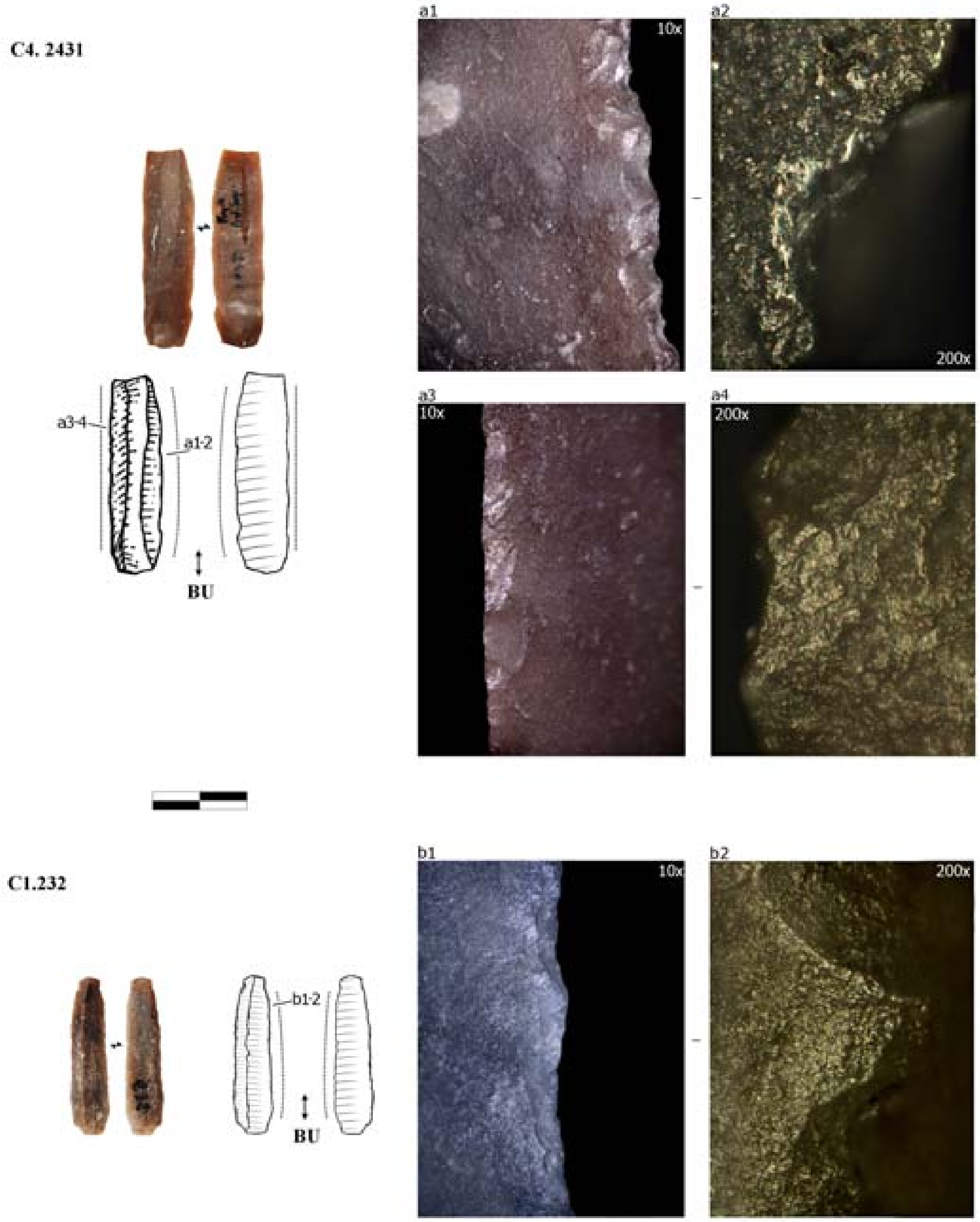

Fig. 4.14. Use-wears from the Espluga de la Puyascada. **C4.2431-** Tool used to work soft animal substances on both sides; *a1-2*) Association of edge scarring with spots of polish produced by the contact with hard material, probably bone; *a2-3*) Macro- and micro-traces produced by contact of soft animal matter. Note the presence of a greasy diffuse polish. **C1.232-** Tool used to work soft animal substances, probably butchering; *b1*) Macroscopic view of the edge-scarring, 10X; *b2*) Microscopic view of the edge, with a greasy polish, 200X.

4.4.2.1.2. Animal Substances

A high number of tools associated with the working of animal substance have been recovered (*n.* 11; 42.3%) (*n.* 16 AUAs; 37.2%). Among them, the largest group is referred to the working of *soft/medium animal substance* (*n.* 6; 23.1%) (*n.* 9; AUAs; 20.9%) (Tab. 4.6). There are 5 blades, which measure 32-51 x 9-12 x 2-3 mm, and one elongated flake of 43 x 13 x 6 mm. None of them is retouched, indicating a rough blank preparation. The ascertained traces are mainly a succession of marginal scars, edge rounding, dull greasy polishes distributed all along the active edge, and isolated spots caused by contact with hard materials such as bone (Vaughan 1985: 38; Gijn 1989: 44; González & Ibáñez 1994: 126) (Fig. 4.14, *a, b*; Fig. 4.15, *a*). The movement performed in the works was always longitudinal, or slightly oblique, this suggesting the use of these tools in butchering activities while processing animal carcasses. The presence at Espluga de la Puyascada of a relatively abundant faunal assemblage that includes both cranial and post-cranial remains confirms that slaughter took place at the site, mainly in relation to the killing of domestic animals, especially goats/sheep, but also cattle and suids.

Tools associated with *hard animal materials*, such as bone or antler, amount to 4 implements corresponding to five active edges (*n.* 4; 15.4%) (*n.* 5 AUAs; 11.6%) (Tab. 4.6). Among them, there is one flake of 23 x 31 x 8 mm and three blades, all fragmentary, which measure (50)-(58) x 10-14 x 4 mm on average. Edges are generally very rounded, characterized by the typical polish bevel, with smooth and bright bands characterized by tiny and transverse scratches and cracks (Plisson 1985: 55; Gijn 1989: 32; González & Ibáñez 1994: 119-130) (Fig. 4.14, *a2-3*; Fig. 4.15, *b-c*). In one case, the edge was retouched for creating a notch on it (it had previously been used for cutting vegetable matter), probably in order to increase stability during the scraping activity (Fig. 4.14, *a3-4*). This type of practice has also been observed at other Neolithic sites in Catalonia (Gibaja 2009) as well as southern Iberia (Clemente & García 2008). Considering the abundant bone assemblage recovered, mostly consisting of punches and spatulas, it is reasonable to assume that such implements were used in the processes of maintaining, finishing, or resharpening some of those bone instruments.

Finally, one tool has been employed for *processing hide*, probably dry hide (*n.* 1; 3.8%) (*n.* 2 AUAs; 4.6%) (Tab. 4.6). The blank was used on both sides; however, traces are only found on small areas of the edges: specifically, on the proximal part of the right side, for a transverse-movement activity, and on the distal part of the left side for performing a longitudinal movement. In both cases, I have observed the presence of a markedly rounded edge; in addition, longitudinal action has been associated with evident micro-scarring of the edge. The polishes have a rough texture, forming a compact band along the edge (Fig. 4.16, *a*). In conclusion, the observed traces seem to bear evidence of scraping/cutting some dry-skin or leather artefacts, perhaps in relation to some repair or finishing activity.

4.4.2.1.3. Mineral Substances

Tools associated with mineral substances amount to two instruments, corresponding to three active zones (*n.* 2; 7.7%) (*n.* 3 AUAs; 7.0%) (Tab. 4.6).
One of them is a large blade that measures (84) x 27 x 44 mm, which had previously been used for cutting plants and later resharpened and used on both side for working some *dry abrasive mineral material*, probably clay (dry-clay?) (*cfr.* Chap. 2, Par. 2.3.3.). I have observed a longitudinal movement on both edges, with a very abrasive and striated polish. Edges are

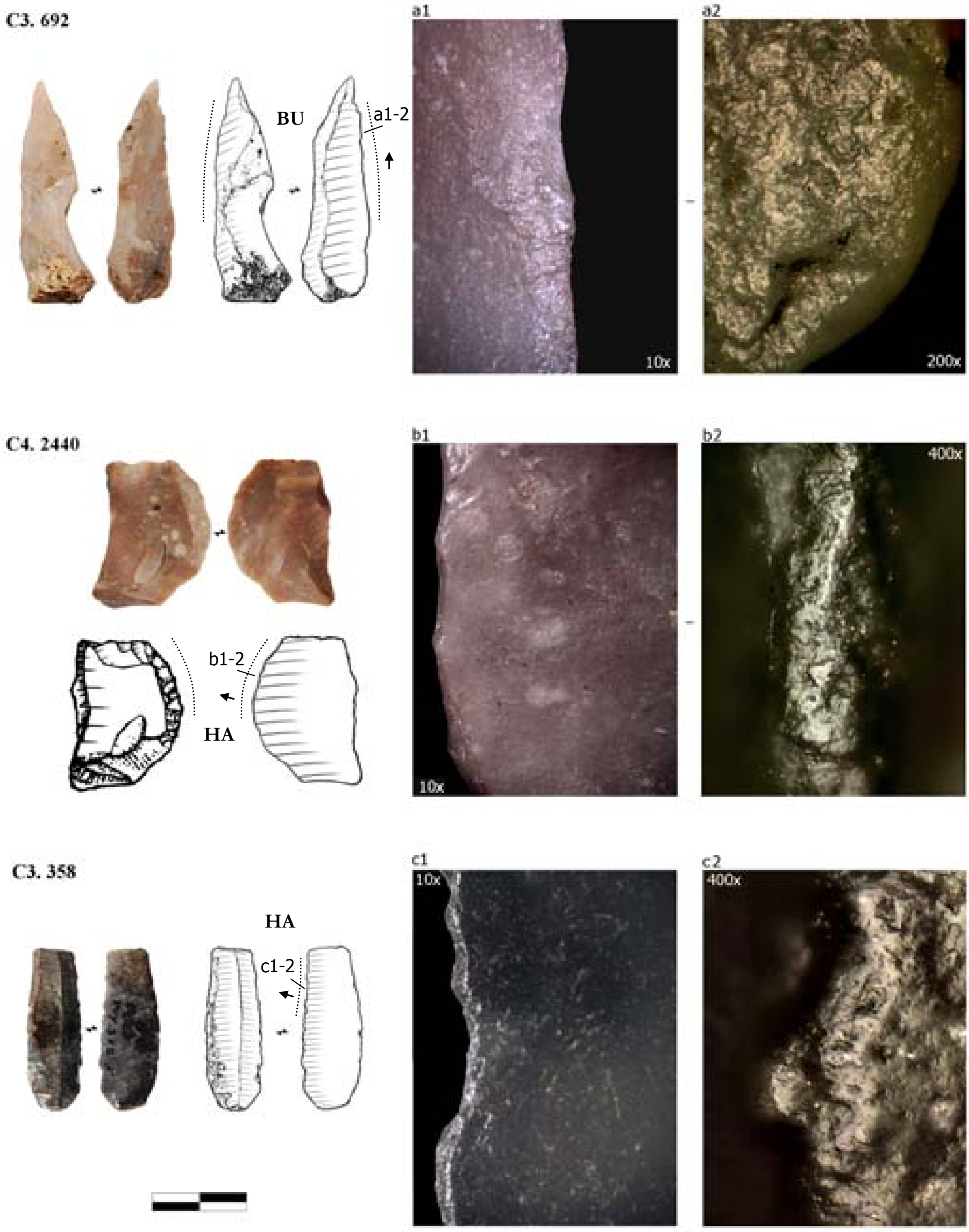

Fig. 4.15. Use-wears from the Espluga de la Puyascada. **C3.692-** Tool used to work soft animal substances; *a1 -2*) Macro- and micro-traces, observe the association of edge rounding and a greasy superficial polish. **C4.2440-** Flake used to scrape hard-animal materials; *b1-2*) Ventral left side, macro- and micro-traces. Note the association of a rounded abrupt edge with a bevel-like polish. **C3.358-** Blade used to scrape hard-animal materials; *c1*) Ventral left side, Macroscopic view, 10X; *c2*) Microscopic view. The edge appear rounded and characterized by a bevel-like polish (partially altered).

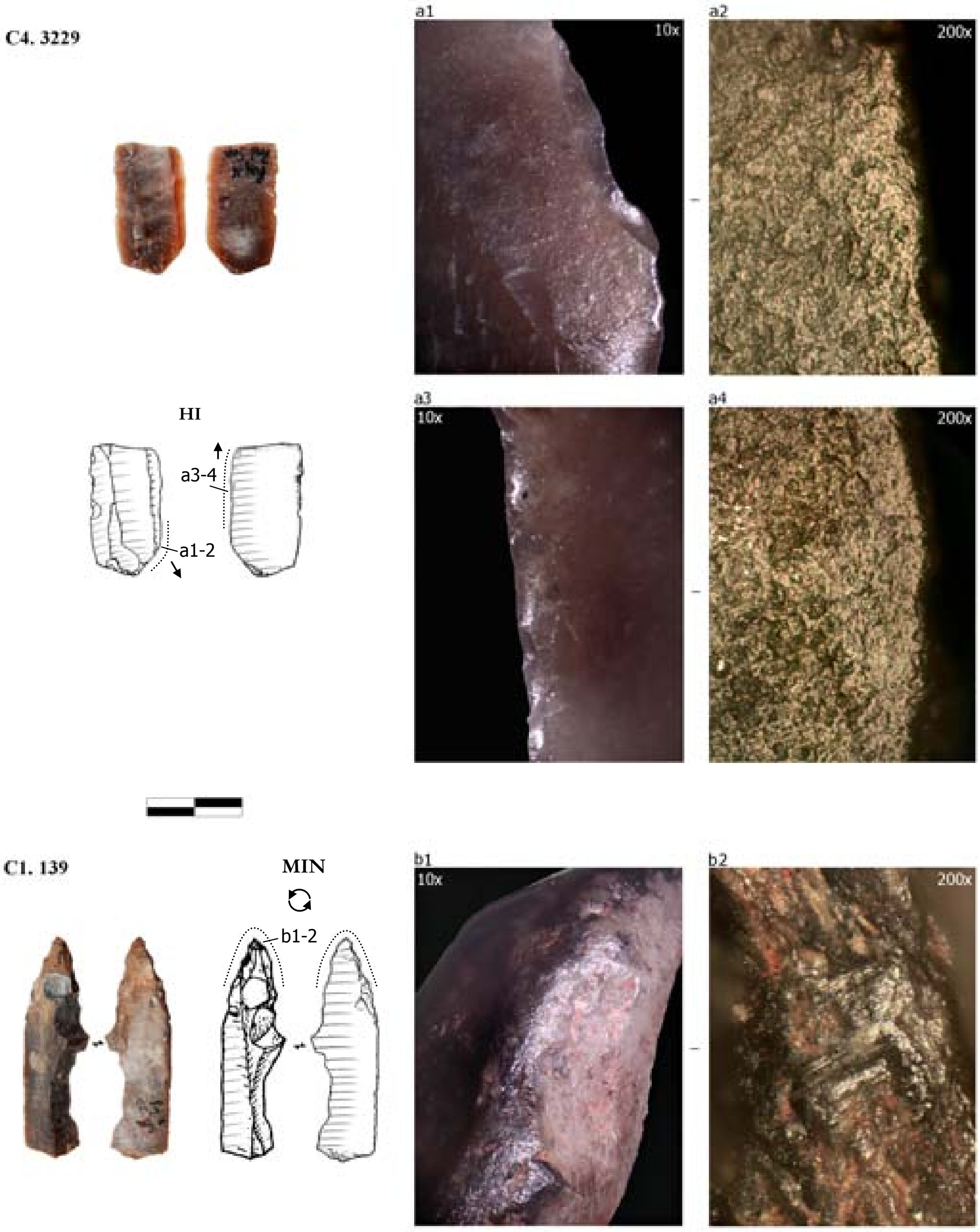

Fig. 4.16. Use-wears from the Espluga de la Puyascada. **C4.3229-** Tool used to work hide, probably dry hide on both sides; *a1-2*) Macro- and micro-traces, scraping movement. Observe the association of the pronounced edge rounding with a rough polish. *a2-3*) Macro- and micro-traces, longitudinal movement. Edge fractures with longitudinal orientation associated to rough polishes. **C1.139-** Borer used to drill a mineral substance, probably ceramic; *b1-2*) Macro- and micro-traces, rounded tip of the borer. Note the presence of striations and reddish residues.

strongly rounded and a matte lustre is visible along the margins (Fig. 4.12, *a-c*).

The second instrument is a borer that shows traces of being used for perforating some mineral abrasive materials. This tool, made on a laminar blank of (47) x 14 x 4 mm, was configured by a bifacial retouch, abrupt on the dorsal face and flat, invasive on the ventral one. Traces are characterized by a heavy edge rounding all around the point, a diffuse glossy polish, and a few spots with both transverse and longitudinal striations (Fig. 4.16, *b1-2*). Traces of this type can be associated with the boring of ceramic materials, mainly connected with the repair of broken vessels (*cfr.* Chap. 2, Par. 2.3.3.). Actually, this type of tool, with a triangular tip that is about 4-6 mm wide and progressively increasing up to 1 cm, appears too large to perform only 2-3 mm-wide perforations as the ones observed on the shell and tooth beads recovered at Espluga de la Puyascada. In this light, the use on ceramic materials appears to be the most plausible.

4.4.2.1.4. Indeterminate materials

This category includes all those tools for which, despite the recognized intentional use, it has not been possible to determine the type of worked material. In these cases, I have classified the contact materials on the basis of their hardness: materials of soft-medium hardness (*n.* 3; 11.5%) (*n.* 5 AUAs; 11.6%) and resistant or hard materials (*n.* 4; 15.4%) (*n.* 6 AUAs; 14.0%) (Tab. 4.6). Functional determination has mainly relied on macro-wear patterns, being micro-traces absent or scarcely visible.

Tools associated with *soft materials* are three blades measuring (40)-(56) x 13-14 x 3 mm. Macro-traces mainly consist of unbroken series of small scalar fractures combined with a light edge-rounding (Fig. 4.17, *a1-2*). Such traces could be produced by working a variety of soft materials, either animal or vegetable, especially if activities were not prolonged. However, considering that post-depositional alterations can definitely resemble this type of evidence and being micro-traces absent, the interpretation of these tools remains uncertain.

Among the implements associated with the working of *indeterminate hard materials*, there are two cores and two flakes. Cores, measuring 48 x 41 x 38 and 25 x 28 x 18 mm respectively, present traces of being employed for pounding/grinding activities. In both cases, both distal and proximal face of the core was used; the wear pattern has resulted in micro-fractures of the ridges, which give a spherical shape to the cores (Fig. 4.17, *c1-2*). About the flakes, these are two core rejuvenation elements. One of them is a thin flake of 39 x 40 x 9 mm, characterized by a succession of overlapping step-terminating fractures on a very abrupt edge, probably in relation to working some resistant materials. The other one is a quadrangular flake of 17 x 20 x 4 mm, characterized by two opposite edges with a series of overlapping invasive, bifacial fractures, probably caused by using the tool as a wedge (Fig. 4.17, *b1-2*). Tools of this type are typical of the Meso-Neolithic background of the Iberian Peninsula (Gibaja et al. 2006, 2007). However, no clear micro-traces have been detected, therefore such an interpretation cannot be verified.

4.4.2.2. Non-utilitarian traces

4.4.2.2.1. Transportation traces

Only one implement shows non-utilitarian traces. The tool is a large blade used for two different activities: specifically, the first for harvesting vegetables and the second for working mineral substances (Fig. 4.12, *e1*). According to the morphology and dimensions of the blank, it seems unlikely that the blade was produced at the site. My hypothesis is that this tool

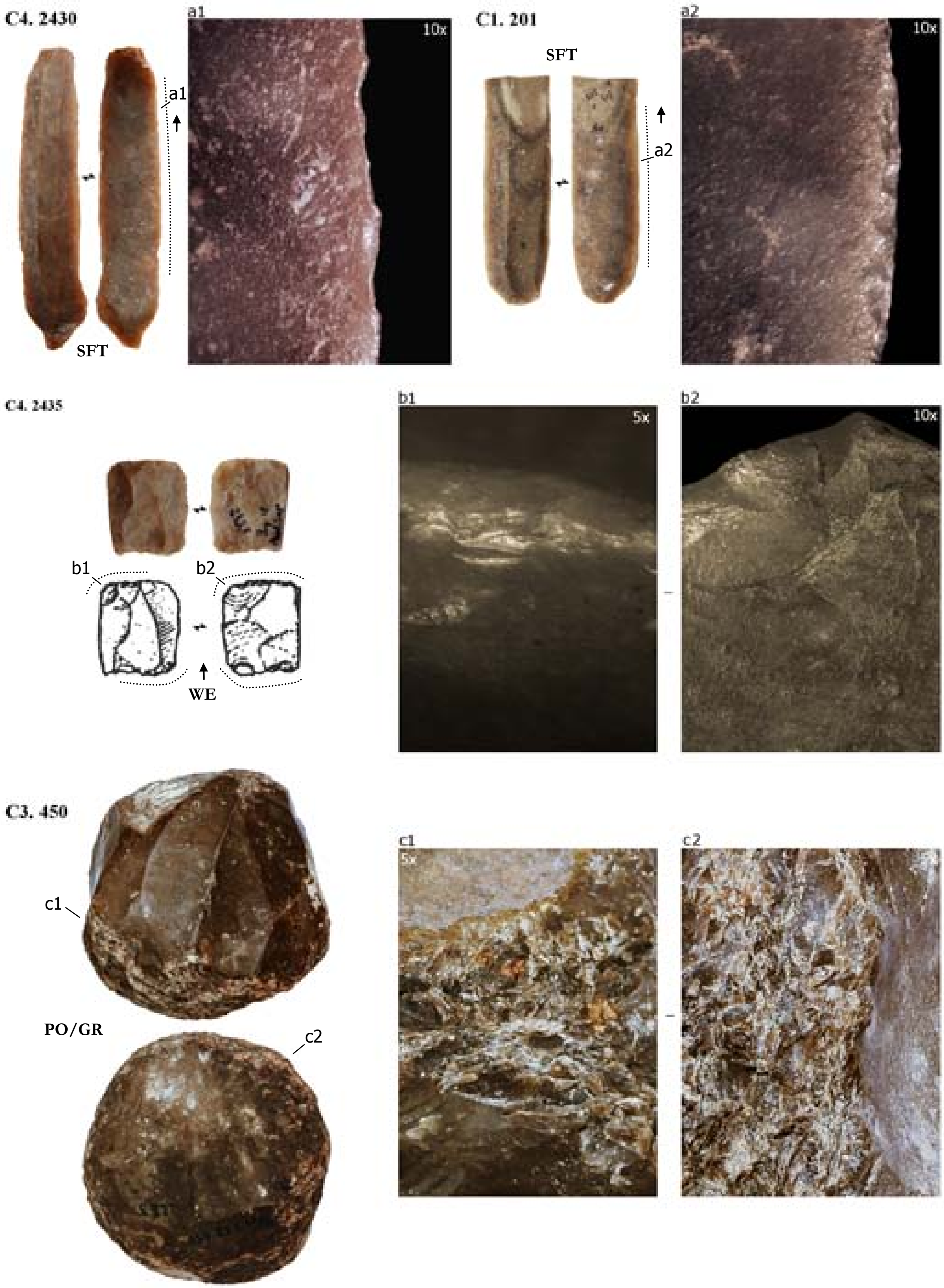

Fig. 4.17. Use-wears from the Espluga de la Puyascada. **C4.2430** and **C1.201-** Blades used for cutting soft indeterminate materials; *a1-2*) Macro-traces. **C4.2435-** Tool used as wedge; *b1-2*) Macro-traces. Note the bifacial scarring of both proximal and distal edges. **C3.450-** Core used for pounding/grinding activities on both faces; *c1-2*) Macroscopic views, 5X.

was made and used outside the site and, later, taken to Espluga de la Puyascada, where it was resharpened and used for other activities. A confirmation of this hypothesis may come from the observation of a long striation underneath the mineral polish. This type of long strias is one of the most characteristic wears produced by the transportation of lithics tools, especially if tools were carried in a bag or other containers together with other lithic items (Mazzucco & Clemente 2013). It is generally very difficult to distinguish such types of wear from post-depositional wears; however, in this case, being the striation clearly interrupted and overlapped by the use-polish, it seems clear that it was produced before discarding the tool. If this interpretation is correct, this type of tool, characterized by a long use-life, as it was transported, resharpened, and retooled, would represent a perfect example of Binford's curated tools (Binford 1973: 215; Shott 1996: 261).

4.4.2.3. Residues

The only residue that I have observed macro- and microscopically (and possibly related to use), consists of some reddish spots on the tip of a borer that was employed for drilling mineral materials. More specifically, such traces have been left by repairing some broken pottery vessels. The presence of these reddish spots may be ceramic residues themselves (Fig. 4.16, *b1*). However, since no specific analysis of their chemical and mineralogical composition is available, this interpretation remains hypothetical.

4.5. Discussion

The Neolithic levels of Espluga de la Puyascada attest to a long human occupation during the entire course of the fifth millennium cal BC. Available data does not allow more specific times of occupation of the site to be ascertained. It is to remark that, considering the settlement pattern (a large and open rock-shelter) and its geographical position (mid-altitude site, located on an abrupt and steep elevation), it is more likely that the site was not occupied continuously for such a long period of time, but it went through a series of episodic frequentations of different duration. This appears to have been the most plausible scenario, also comparing Espluga de la Puyascada with other sites of the region that show similar characteristics (e.g. Balma Margineda - Guilaine & Martlzuff 1995; Cova Els Trocs - Rojo et al. 2014). However, both archaeological and chronological data is still too scarce to advance a clear reconstruction of the site and its function and new excavations are certainly needed to put forward more detailed hypotheses.

The excavators themselves have initially used great caution while interpreting the site because of partial and preliminary data (Baldellou, 1981, 1987a, 1987b, 1994). Their work mostly focused on a general chrono-cultural interpretation of the deposit, mainly based on ceramic materials and radiocarbon dates. The result was the attribution of Puyascada to the so-called Epicardial or Final Cardial phase (Baldellou 1981), an interpretation that has substantially been confirmed in more recent works with similar purposes (Manen 2002; Manen & Sabatier 2003; Oms et al. 2012).

On the contrary, the socio-economic aspects of the site have been little discussed. The interpretation of these has hitherto mainly relied on the outcomes of archaeozoological studies (Castaños 1987). P. Castaños has evidenced, in his work, the highest percentage of domestic animals, especially sheep/goat species, compared to wild ones, which appear to have been at low numbers at the site; however, he has clearly remarked the partial and preliminary nature of his observations.

The relative abundance of domestic animals has also been compared to the scarcity of remains attesting to agricultural activities. Baldellou points out that Espluga de la Puyascada witnesses «*una forma de vida pecuaria*»[1] (Baldellou 1981: 85), characterized by «*una actividad pastoril más enraizada y de mayor entidad*»[2] (Baldellou, 1994: 59), where agriculture probably represented a complementary or secondary practice.

A broader and more detailed analysis of the current geographical and topographical context, in which Puyascada is located, has been accomplished by Ramón and Rodanés (1995), who have emphasized:

i. the altitude of the site;
ii. the abrupt topography of its surroundings, which represents a strong limit for long-distance movements;
iii. the local environmental conditions unsuitable for agricultural activities;
iv. the favourable conditions for seasonal herding activities;

Following the same line of research, Baldellou & Utrilla (1999) proposed, some years later, a land-occupation model for the Ésera Valley based on a complementarity between sites, wherewith they have put forward a mobility between settlements located in the valley bottom (such as Cueva del Moro del Olvena), more strictly associated with an agricultural system, and sites located near possible pasture areas, like Puyascada, also hypothesizing some intermediary settlements.

However, all of these considerations are based exclusively on conjectures and additional empirical data is needed to support such hypotheses. Palaeoenvironmental works for the area do not exist and such models are based on the present-day landscape and its current or historical exploitation; similarly, the economic orientation of the site is exclusively deduced from the presence/absence of specific categories of artefacts (i.e. sickle blades, mills, etc.), which, however, have not undergone any techno-functional study aimed at ascertaining their actual use.

The latter is the purpose of the present work instead. The lithic industry has only preliminarily and superficially been studied by a typological point of view, regarding it as a very small and uncharacteristic assemblage Baldellou (1987a). My analysis has proved that, although it is a partial sample, the lithic industry of Puyascada offers some interesting data about the economic orientation of the site.

The low number of specimens does not allow any complete reconstruction of the technological processes carried out at the site to be achieved; however, on the basis of the record available at the moment, it seems that the majority of materials were transported from distant sources, mainly from the chert formations of the Ebro Valley. Locally, knapping activities must have been limited to the production of small blades, while the largest implements were more likely flaked elsewhere. In addition, the employment of non-exhausted cores for pounding and grinding activities suggests a little exploitation of raw material. Probably, at Puyascada, the main knapping activities were related to tools maintenance and configuration and only marginally to core reduction.

In terms of function, most of the blade blanks were destined to plant-reaping activities.

[1] Proposed translation: "a pastoral way of life".
[2] Proposed translation: "a well-established pastoral activity of greater relevance".

Extensive cereal-induced polishes are not represented amongst the observed use-wears, this suggesting that most of the plants were harvested for non-alimentary purposes. The use of wild grasses to build bedding areas and pavements has recently been documented in the nearby Els Trocs Cave (Lancelotti et al. 2014). In addition, stalks and grasses could also be gathered for different purposes such as providing fuel, medicinal plants, etc. Not even the presence of a mill fragment and a grindstone at Puyascada implies that agricultural works took place locally. More likely, cereal grains were transported to the cave as food resources, as is documented at Els Trocs Cave (Lancelotti et al. 2013) and Cova del Sardo de Boí (Gassiot et al. 2014), which go back to roughly the same time.

The main production activity appears to have been the processing of animal carcasses. The percentage of instruments associated with butchering activities is proportionally significant. Moreover, this type of traces should be considered underrepresented in the assemblage, since they have been covered or affected by post-depositional agents. This data matches the information provided by the archaeozoological study that indicates that domestic animals were slaughtered at the site.

On the contrary, the other activities inferred from the micro-wear analysis mainly refer to isolated tasks related to the maintenance and repair of specific categories of objects. Among these, one can mention leather and wood artefacts. Also pottery vessels were probably repaired at the site, but, in this latter case, it is possible that also some stages of the production process took place locally. The presence of a blade and a half-shell with traces of ceramics scraping may indeed indicate that other phases of pottery manufacturing were carried out on site, such as the finishing and smoothing of vessels.

In the case of bone/antler artefacts, it is difficult to ascertain whether the tools were produced locally or outside the site. The bone industry is quite abundant and varied; however, the traces observed on the lithic tools mainly seem to refer to short works for finishing or resharpening them. Moreover, the absence of intensive activities (i.e. bone and antler sawing) seems to support the idea of maintenance only. However, taking into account the biased sample, it is not possible to make any definitive points; the analysis of a larger sample of materials is necessary for confirming these observations and verifying whether or not those artefacts were produced locally.

4.6. Final remarks

The data provided by the use-wear analysis of the lithic assemblage of the Espluga de la Puyascada seems in accord with the hypothesis of a specialization toward pastoral practices at the site, as previously advanced by Ramón and Rodanés (1995) and by Baldellou & Utrilla (1999). Neither agricultural activities, nor manufacturing processes composed of a number of different working phases have been observed through use-wear analysis. Indeed, working process are mainly represented by discontinuous and isolated tasks of artefact maintenance.

However, consider the Espluga de la Puyascada as merely a shelter for pastoral groups during their migration toward summer pastures, would be as well too simplistic. It is not possible to consider the site only as a pass-through shelter; more likely it should be considered as a seasonal occupation, focused on a reduced set of economic practices. Indeed, the presence of a large variety of instruments (as bone, lithic and shell tools), the presence of ornaments and of a relatively abundant ceramic record are all elements that point out toward a certain stability of the human occupation.

About the pastoral orientation of the site, this is mainly is mainly documented by the practice of slaughtering and butchering activities; while the proximity to pasture areas should be investigated by means of palaeoecological analysis, as their presence cannot be taken for granted on the basis of parallelism with historical and current times.

Finally, one must stresses that as long as new excavations will be not realized, enlarging the excavated area and integrating archaeological record with paleoenvironmental data, it will be not possible to obtain a more complete and reliable image of the site.

5. COVA DE ELS TROCS

5.1. Introduction

The recent excavation of Cova de Els Trocs has represented one of the most considerable discoveries for the study on the rise of agro-pastoral societies in the NE of the Iberian Peninsula (Rojo et al. 2012b). The importance of this site is due to several factors; first of all, the early chronology of the settlement. In the surroundings of the cave, several dolmens and other megalithic structures are known, but all of those remains are dated to later periods, namely, Final Neolithic, Chalcolithic, or Bronze Age (Utrilla & Ramón 1992; Rojo et al. 2014). On the contrary, Els Trocs Cave presents a stratigraphic record that, on the basis of the numerous absolute dates, covers almost 3000 years, specifically from an early Cardial Neolithic phase to the Final Neolithic Age. Secondly, the location of the site is particularly interesting considering its altitude. Actually, the cave is one of the highest prehistoric sites of the region and the entire Pyrenees. Moreover, the cave itself is interesting for its particular microclimatic conditions; the inner chamber is characterized by low temperatures all year round and it is constantly humid because of water infiltrations. These conditions have favoured a good preservation of both inorganic and organic materials. All these factors make Els Trocs Cave a fundamental site for understanding the human dynamics in the Central Pyrenees during the Middle Holocene.

5.2. General Information

5.2.1. Geographical Framework

Cova de Esl Trocs is located in the NE of Aragon, about 5 km from the village of Abella, in the Ribagorça region, which belongs to the municipality of Bisaurri. Site coordinates (U.T.M. 31N) are: X 298.198, Y 4.702.955 (Fig. 5.1, *a-b*).

The cave is located at an altitude of 1.564 m.a.s.l. on the southern slope of a limestone massif called 'Els Trocs', which is situated a few hundred metres far from the Barranco de las Cogulas, a secondary tributary of the Ésera River. The cave entrance, about 1.8 m high and 2.2 m wide, is south-southeast oriented and gets the light during most of the day. However, the interior is dark and humid; the down-sloping entrance tunnel has a strong inclination and the sunlight never reaches the inner chamber. This latter is formed by a single room of about 90 m², 15 m long and 5.6 m wide in its central part (Fig. 5.1, *c*).

Local climate is influenced by both Atlantic Ocean and Mediterranean Sea, with temperatures ranging between -8°C during the winter season and 26°C in summer. Mean annual precipitation is about 800 mm/year. In the surroundings of the cave, vegetation is mainly characterized by *Echinospartum horridum*, an endemic spiny shrub rarely taller than 40 cm, *Buxus sempervirens*, and some residual areas of *Pinus sylvestris*.

5.2.2 Archaeological Researches

The site has been discovered in 2007, during a field survey directed by Héctor Arcusa, on the basis of information given by a local inhabitant, D. José San Martín. During that

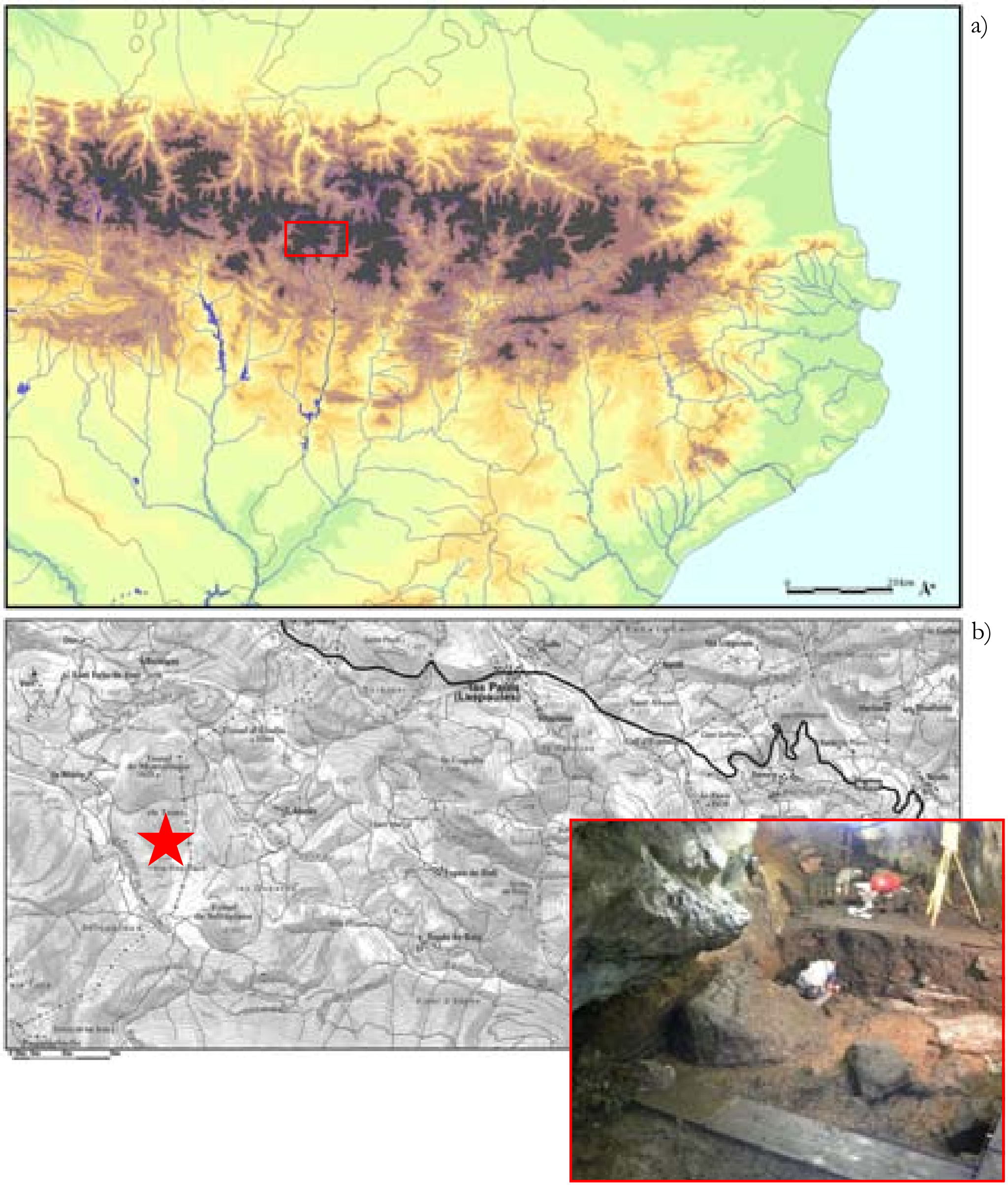

Fig. 5.1. a) Geographical framework of the site; b) Site location on 1:50.000 map. The red star indicates the exact position of the Cova de Els Trocs; c) Photo of the excavation area.

campaign, in collaboration with a group of palaeontologists, a first survey of the cave was carried out. In 2009, a preliminary excavation confirmed the archaeological potential of the site and, between 2010 and 2012, extensive campaigns took place under the direction of Prof. Manuel Rojo Guerra of the Universidad de Valladolid and Ignacio Royo Gullién of the Dirección General del Patrimonio of the Government of Aragon.

During the excavation campaign of 2009-2010, an area of about 19 m^2, in the central sector of the cave, was dug out. The excavation adopted the Harris Matrix method. Until now, a total number of 68 contexts have been identified (Fig. 5.2).

According to chronological and stratigraphic data, the archaeological deposit can be divided into four main phases (Fig. 5.2). However, it is to remark that each phase is composed of different and recurrent frequentations and it does not show a continuous or homogeneous occupation.

The first phase is dated to the last third of the sixth millennium cal BC. Amongst the identified structures, the presence of a large drainage floor is to highlight, which was built with ceramic and stone fragments; in addition, various pits and hearths have been found.

After about five hundred-year hiatus, a second phase of occupation took place, which is dated to the second half of the fifth millennium cal BC. With regard to this phase, another drainage floor has been detected, which was built with stones and pebbles; besides, numerous hearths and other combustion areas have been recorded.

Finally, a third phase, dated to between the first third of the fourth and the first half of the third millennium cal BC, is characterized by the presence of a large hearth and two pits that were probably connected with some type of funerary practice.

The last period of occupation is documented by a surface layer with mixed archaeological materials of Neolithic, Roman, and Modern Age.

Archaeological finds are extremely abundant in all phases, especially ceramics and faunal remains. Besides bone and lithic instruments, also the presence of ornamental objects is remarkable, such as beads and other pendants, which were made out of stone, shell, and tooth. Finally, one has to remember the exceptional preservation of the organic matter inside the cave, due to the low temperatures and the high humidity.

5.2.3. Detailed Stratigraphy

Phase 4 (Trocs IV): corresponds to the most recent human occupation of the site. No radiocarbon dates are available for this phase, which is characterized by mixed materials belonging to prehistoric, Roman, and modern time. It is only composed of one surface layer (US 0).

Phase 3 (Trocs III): it goes back to between the first third of the fourth millennium cal BC and the beginning of third millennium cal BC. It is relevant to the last Neolithic occupation of the cave. The main stratigraphic unit (US 1) is an almost half a metre-deep clay layer. One can here observe various different structures, amongst which: chaotic heaps of stones (US 3, 4, 7, 31) —that probably represent remains of disturbed hearths— and well-preserved hearths (US 40, 43, 47, 48). Along with this evidence, two large pit-holes have been found (US 38 and 69), which can be interpreted as ritual-funerary depositions, according to the presence of a large quantity of human and animal bones. At the end of this phase, some collapses probably occurred in the cave (US 37). Archaeological materials are abundant.

Phase 2 (Trocs II): dated to the second half of the fifth millennium cal BC. This phase of occupation is characterized by the presence of a possible drainage floor made of hard-packed stones (US 10) (Fig. 5.3, *b*). This was built on a natural clay layer (US 14), quite poor in terms of archaeological materials, which had probably previously been levelled in order to arrange the room as dwelling. Various habitation structures have been ascertained in connection with those layers, like a number of hearths located in the southern sector of the excavation (US 40-43-47-48, 49-55-59, 51, 75, 77). Amongst them, the main structure is a large circular-elliptical stone-built hearth, with a diameter of more than 1 metre, situated in the central sector of the cave (US 8-9-11-12). Another evidence is represented by accumulations of ashes and charcoal (US 29),

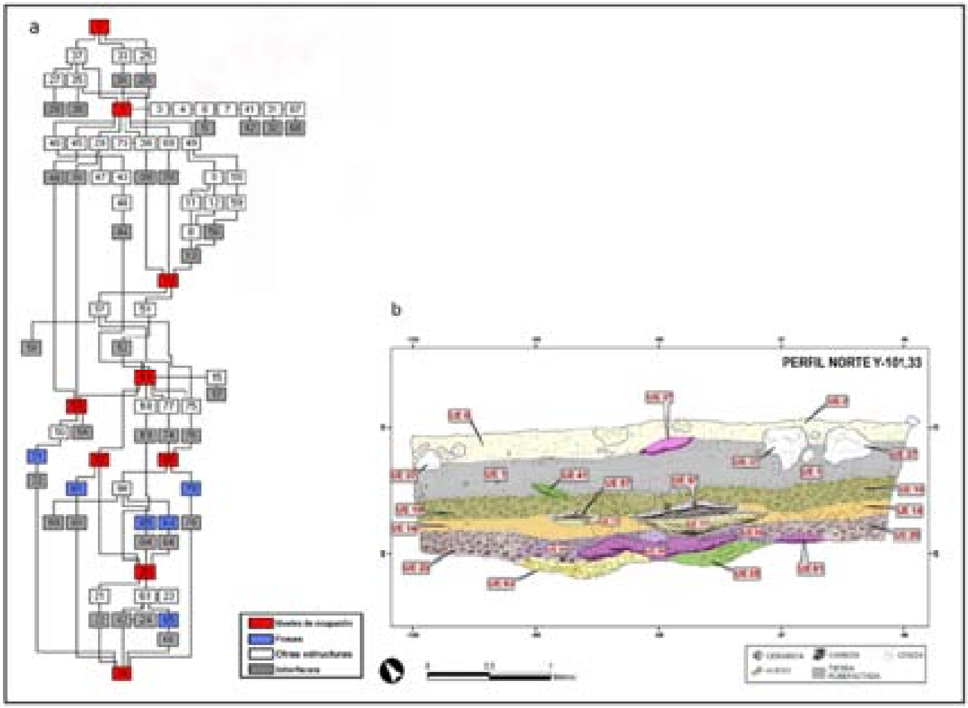

Fig. 5.2. *a)* Harris Matrix of the Cova de Els Trocs, phases I-III. In red are marked the occupational levels; in blue the pits and the other negative structures; the grey squares represent interface surfaces; in white all the other structures. *b)* Stratigraphic cross-section of the North side of the excavation. Modified from Rojo et al. 2014.

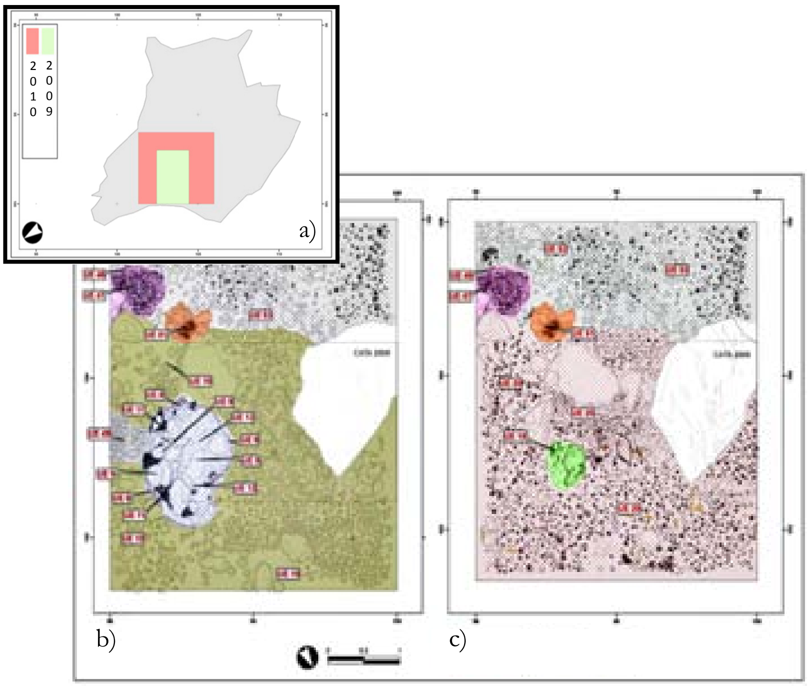

Fig. 5.3. *a)* View of the cave surface. In green the surface excavated in the 2009; in red the surface excavated in the 2010; the part excavated in 2012 is missing. Two plans of Cova de Els Trocs, modified from Rojo et al. (2014); *b)* Plan of the stone pavement (US 10) and of the associated structures; *c)* Plan of the ceramic/stone pavement (US 20 & 53) and of the associated structures.

probably brought about by cleaning/burning compact layers of straw and hay used as bedding materials (Angelucci et al. 2009; Lancelotti et al. 2014); '*fumiers*' layers (accumulation of dung and plant remains produced by stabled domestic livestock) have been recognized only in a small area of the excavation, in the NE corner of the cave (US 57). Faunal and ceramic materials are abundant.

Phase 1 (Trocs I): dated to the last third of the sixth millennium cal BC. The first evidence of human presence inside the cave is shown by a few fragments of animal and ceramic materials; they were recovered directly from the clayish sediment that formed the natural soil of the cave (US 16). This context is interpreted as a very 'preliminary' and short occupation. Some features have been ascertained in the layers above it: two pit-holes dug into the substrate of the cave (US 65 & 71) and remains of two hearths (US 50 & 61). Later, a large pavement of hard-packed stones and crushed potsherds was built (US 105-53-20) (Fig. 5.3, *c*). A number of large pits (dug into the pavement and the underlying layers) (US 64-63 & 84-85) and several hearths (US 90 & 18) have been associated with these features. All this evidence attests to the main occupation of the cave, which has yielded a large quantity of faunal and ceramic materials. The finds recovered in the filling sediment of one of the pits are of particular interest (US 64-63); specifically, a large number of skeletal remains which include a frontal cranial bone of a human infant and the foetal remains of an ovicaprine.

5.2.4. Radiocarbon Chronology

The stratigraphic sequence at Cueva de Els Trocs has been integrated by twenty-nine radiocarbon dates (Rojo et al. 2014). 'Short-lived' samples were selected for the dating, such as charred grains or human and faunal bones. All calibrations were carried out by OxCal software 4.2.3v (Bronk & Ramsey 2009), using IntCal13 calibration curve (Reimer et al. 2013). In addition, all dating samples came from well-defined stratigraphic contexts, such as hearths, pits, or drainage floors. Radiocarbon dates were carried out by two different laboratories that have obtained the same results.

A phase-model composed of three sequential phases has been built to verify the agreement between the various radiocarbon dates. This type of model has brought to combine '*a priori*' information, represented in this case by the stratigraphic position of ^{14}C samples, and the sample's calendar ages calculated by OxCal software (*cfr.* Chap. 2, Par. 2.2.8.). The resulting model (Fig. 5.4) shows a strong general agreement ($^{A}97.7$). A high agreement index is obtained when posterior distributions of the samples, as calculated by the model, are situated in a high-probability area of the prior distributions. This means that all radiocarbon dates are consistent with the respective phases.

The first phase of occupation (Trocs I) began around 5400-5240 cal BC (2σ) and ended toward 5070-4880 cal BC (2σ), thus lasting for about 300-600 years. According to radiocarbon dating, it is possible to distinguish at least two intervals: in the first one, all the dates coming from human-bone samples are grouped together, which range between 5400 and 5070 cal BC (1σ), while the second group includes all the dates obtained from charred grains and faunal remains, which refer to the time between 5080 and 4880 cal BC (2σ) (Tab. 5.1; Fig. 5.3). However, the human bones are not directly representative of the age of the archaeological structures and their use. In fact, their presence can be related to habits of bones exhumation and circulation, therefore to be regarded as a sort of 'relics' as the excavators themselves have pointed out (Rojo et al. 2014). If one considers exclusively the

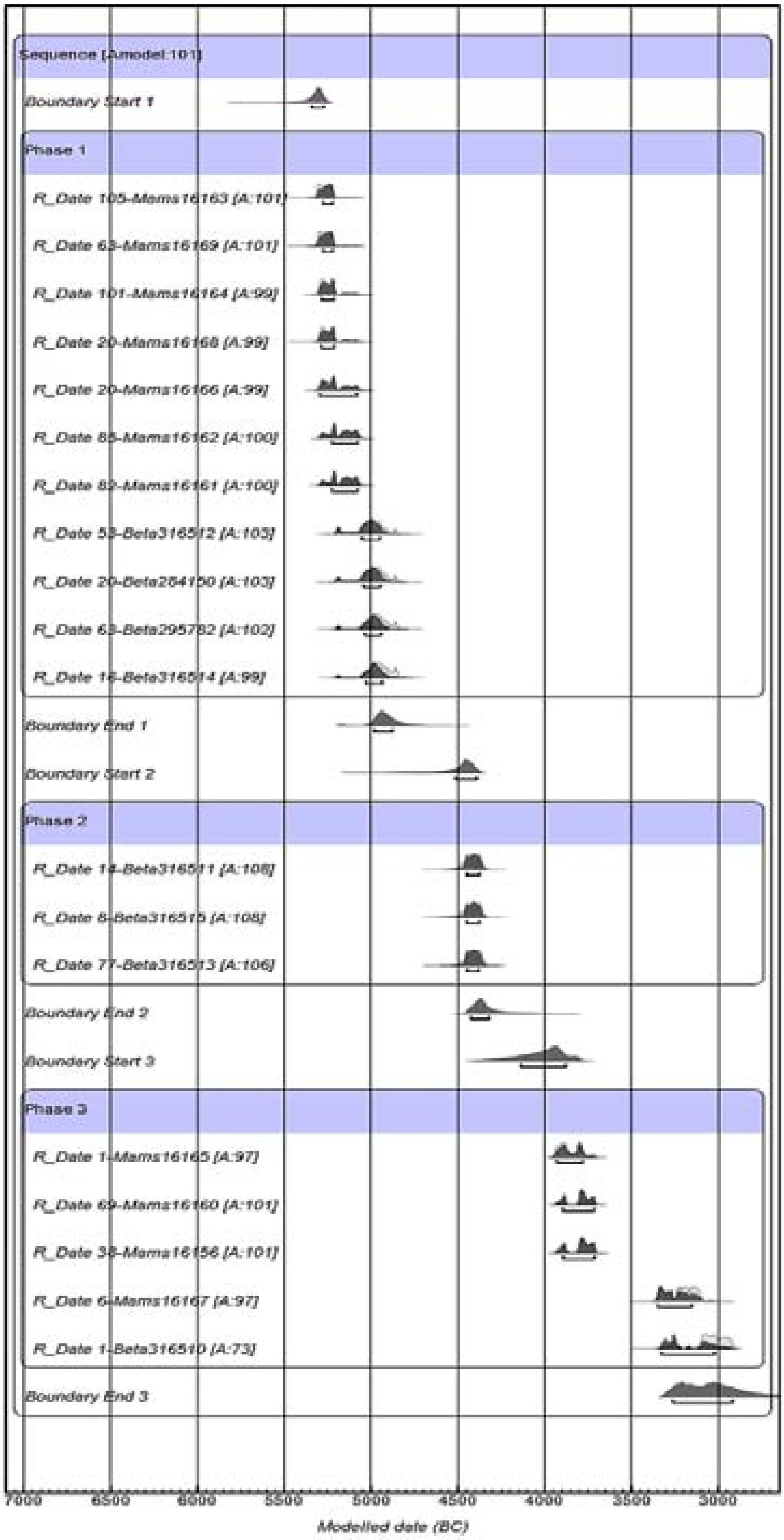

Fig. 5.4. Model of Sequential Phases. Multiple plot of ^{14}C Dates from the Cova de Els Trocs (yrsBC). Model has been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013).

Ref. Lab.	Layer	Sample	BP	±	Cal BC (68.2%)	%	Cal BC (95.4%)	%	Cal BP (95.4%)
Mams-16163	US 105	Human bone	6285	25	5276-5221	68.2	5408-5240	95.4	7265-7165
Mams-16163	US 63	Human bone	6280	25	5276-5221	68.2	5306-5216	95.4	7260-7165
Mams-16164	US 101	Human bone	6249	25	5288-5244 5233-5214	45.1 23.1	5307-5206 5163-5138 5129-5120 5094-5080	90.1 2.7 1.0 1.7	7260-7025
Mams-16168	US 20	Human bone	6249	28	5288-5240 5235-5214	45.4 22.8	5306-5206 5164-5119 5105-5079	85.7 6.0 3.7	7260-7025
Mams-16166	US 20	Human bone	6234	28	5296-5207 5145-5139 5091-5082	62.5 2.2 3.6	5301-5202 5172-5072	65.3 30.1	7255-7020
Mams-16162	US 85	Human bone	6218	24	5226-5204 5168-5077	18.4 49.8	5292-5199 5177-5068	38.6 56.8	7245-7015
Mams-16161	US 82	Human bone	6217	25	5225-5204 5167-5077	17.2 51.0	5292-5199 5178-5066	36.8 58.6	7245-7010
Beta-316512	US 53	Seed	6080	40	5051-4949	68.2	5208-5148 5135-5129 5121-5101 5080-4906	10.9 0.4 1.5 82.5	7155-6795
Beta-284150	US 20	Seed	6070	40	5043-4947	68.2	5208-5158 5119-5108 5079-4895	8.0 0.6 86.8	7155-6790
Beta-295782	US 63	Faunal bone	6060	40	5038-4942	68.2	5206-5169 5073-4886 4864-4857	8.0 0.6 86.8	7145-6790
Beta-316514	US 16	Seed	6050	40	5031-4936	68.2	5203-5176 5066-4882 4866-4856	4.0 90.6 0.8	7140-6785

Tab. 5.1. ^{14}C Dates from Cova de Els Trocs, phase I (Rojo et al. 2014). Calibrated dates, both BC and BP, have been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013). Dates calBP are expressed indicating the whole range at the 1σ (68.2).

dates provided by faunal or charred remains, one can realize that the various structures must have been of roughly the same time as all of them belong to a span of only 100 years. This data suggests that most of the dated archaeological structures relevant to the first phase of occupation have formed in a relatively short period, a fact that indicates a quite continuous occupation or frequentation of the cave.

The second phase of occupation (Trocs II) is clearly separated from the previous one as it began almost 500 years later. The boundary between TrocsI and TrocsII is established by the model between 4700 and 4360 cal BC (2σ) (Tab. 5.2; Fig. 5.3). The three available dates, all of them from charred-seed samples recovered from a hearth and the drainage floor, are extremely homogeneous as they display the same chronological interval, that is, between 4480 and 4350 cal BC (2σ). A single occupation then seems to emerge.

The last prehistoric occupation (Trocs III) began after at least 200 years. It covers almost

Ref. Lab.	Layer	Sample	BP	±	Cal BC (68,2%)	%	Cal BC (95,4%)	%	Cal BP (95,4%)
Beta-316511	US 14	Seed	5590	40	4448-4438 4433-4375	9.0 59.2	4482-4479 4473-4354	0.5 94.9	6445-6295
Beta-316515	US 8	Seed	5590	40	4448-4439 4433-4375	8.6 59.6	4482-4479 4474-4354	0.4 95.0	6445-6295
Beta-316513	US77	Seed	5580	40	4446-4380	68.2	4466-4350	95.4	6440-6295

Tab. 5.2. [14]C Dates from Cova de Els Trocs, phase II (Rojo et al. 2014). Calibrated dates, both BC and BP, have been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013). Dates calBP are expressed indicating the whole range at the 1σ (68.2).

Ref. Lab.	Layer	Sample	BP	±	Cal BC (68,2%)	%	Cal BC (95,4%)	%	Cal BP (95,4%)
Mams-16165	US 1	Human bone	5035	23	3930-3873 3811-3780	41.9 26.3	3943-3765	95.4	5895-5895
Mams-16160	US 69	Human bone	5008	23	3895-3881 3801-3759 3742-3714	9.3 42.1 16.8	3931-3876 3807-3709	22.9 72.5	5885-5655
Mams-16156	US 38	Human bone	5005	27	3893-3884 3800-3752 3745-3713	5.4 41.6 21.2	3936-3871 3812-3705	21.9 73.5	5890-5655
Mams-16167	US 6	Human bone	4512	25	3348-3265 3238-3177 3157-3153	40.6 26.3 1.3	3353-3263 3246-3106	43.8 51.6	5300-5045
Beta-316510	US 1	Seed	4410	40	3327-3237 3097-3021	42.3 25.9	3336-3215 3181-3159 3118-2926	48.3 3.0 44.1	5275-4860

Tab. 5.3. [14]C Dates from Cova de Els Trocs, phase III (Rojo et al. 2014). Calibrated dates, both BC and BP, have been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013). Dates calBP are expressed indicating the whole range at the 1σ (68.2).

one millennium, from 3945-3765 cal BC (2σ) to 3340-2925 cal BC (2σ). Within this large interval, one can distinguish two main moments: the first ranges between approximately 3900 and 3700 cal BC, while the second between approximately 3350 and 2900 cal BC (Tab. 5.3; Fig. 5.3). This fact may suggest the existence of different phases of occupation; however, the dating of the human bone samples should be carefully evaluated. Actually, those bones were not recovered in anatomical connexion, but they were scattered all over the cave. Two of them come from a pit, together with faunal remains, and may be related to a ritual deposition (Rojo et al. 2014); the remaining samples have been found mixed up in habitation layers. Since these materials were in secondary position, they are probably not the best sample for dating this occupation. The other sample, a charred seed recovered from the occupation layer US.1, has provided a date for this settlement of between 3340 and 2925 (2σ) cal BC.

In general, one can note that the samples from animal materials and charred seeds are more homogeneous, whilst human bones have resulted in wider chronological spans. If one excludes the latter from the model, the intervals for each phase of occupation are the following:

i. *Trocs I*: 5210-4855 cal BC (95.4%);

ii. *Trocs II*: 4485-4345 cal BC (95.4%);

iii. *Trocs III*: 3340-2925 cal BC (95.4%);

These intervals appear to be the most reliable for reconstructing the occupation period at the cave, since they have been obtained from samples directly connected with habitation structures/layers and so it is less likely that they have been disturbed, removed, or reused.

5.3. Materials

5.3.1. Ceramic Assemblage

Cova de Els Trocs presents an extremely abundant ceramic record of over 24.000 fragments, considering all the materials recovered during the excavation campaigns of 2009-2012. The assemblage is currently being studied by Prof. Manuel Rojo of the Universidad de Valladolid and his collaborators. All of the data dealt with in this chapter has been taken from the recently published results (Rojo et al. 2014).

If one looks at the distribution of the materials in the four occupational phases, one can observe that a great part of the ceramic assemblage belongs to Trocs I. 14.625 fragments have been recovered from the first phase (60% of the total), while 4.740 elements (19%) come from Trocs II and 3.563 fragments (15%) from Trocs III. The last phase, Trocs IV, has yielded only 1.481 items (6%). It is evident that a great disproportion exists between the three phases, with a gradual decrease from the older to the most recent phases. To this point, it is important to take into account that a considerable part of Trocs I assemblage was found in 'secondary context'. Indeed, several ceramic finds have been recovered from the large floor that covers the entire area of the cave (US 105-53-20). This pavement was built of superimposing layers of stones and potsherds. However, it is plausible that most of this pottery was at first used as vessels and only later, after breaking and/or being abandoned, was employed as 'construction material' for a draining floor.

If one compares Els Trocs with the other archaeological contexts of the region, one can note that, apart from Trocs I which has yielded an extraordinary number of fragments, the other phases show quantities of finds similar to other sites such as Cueva de Chaves (6.039 from Level I.b and 5.177 from Level I.a, both extending over an area of about 90 m^2), Espluga de la Puyascada (1.929 fragments from an excavated area of about 15 m^2), and Cueva del Moro del Olvena (2.450 shards collected from the surface layer). Moreover, it is to remark that, in most of those contexts (apart from Cueva Chaves), the excavated areas are much smaller than Cova de Els Trocs.

According to the analyses carried out so far (Rojo et al. 2014), Els Trocs' assemblage is dominated by open globular shapes such as pots and bowls, which represent about 80% of the collection (Fig. 5.5, *a*), while closed shapes, such as jars or bottles and large storing vessels, show very low percentages in all phases (Fig. 5.5, *b*).

In terms of decoration, the assemblage from Els Trocs displays the same characteristics observed at other sites of the region, with a predominance of impressed pottery (around 50% of the assemblage) (Fig. 5.5, *c-d*), followed by incised, grooved, and plastic decorations (Fig. 5.5, *e-f*). The presence of 'Cardial' and 'Boquique' decorations, both typical of that period, is particularly remarkable as it indicates that the manufactures of Els Trocs were somehow connected with the pottery of the same time produced in the NE of the Peninsula (Rojo et al. 2014; Blasco et al. 2005).

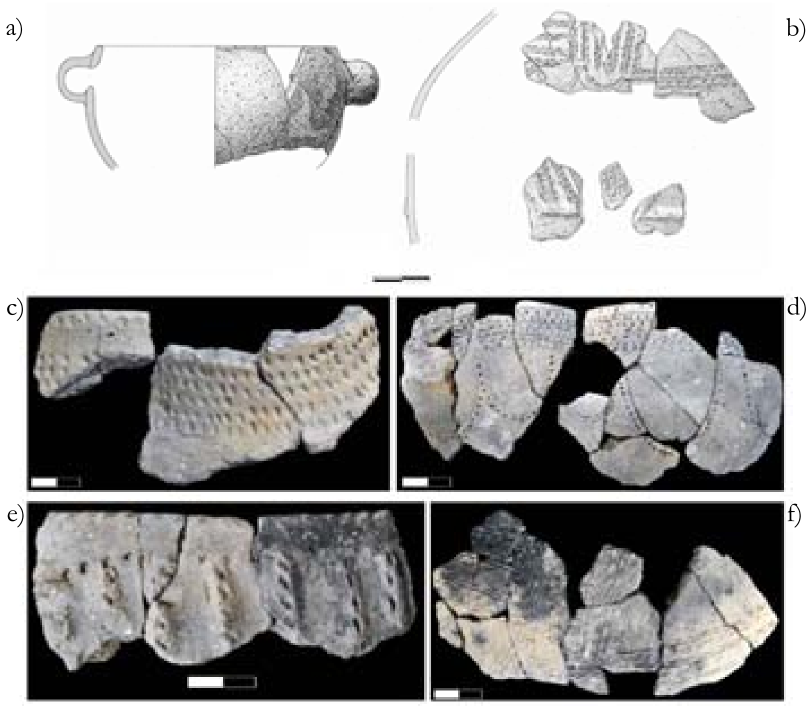

Fig. 5.5. Ceramic assemblage from the Cova de Els Trocs. Modified from Rojo et al. (2014); *a-b)* An example of the type of vessels recovered during the 2009-2010 excavations campaigns, scale 1:4; *c-f)* Selection of decorative motifs from the Cova de Els Trocs ceramic assemblage.

5.3.2. Archaeozoological Assemblage

The faunal assemblage of Els Trocs Cave is being studied by Marta Moreno of the Centre for Human and Social Sciences (CCHS) of the Consejo Superior de Investigación Cientificas. The published results of this analysis are still preliminary (Rojo et al. 2014). The published assemblage includes all the animal finds recovered during the 2009-2011 excavations, for a total of 14,661, 3,879 of which are determinate fragments.

Currently available data indicates a clear predominance of domesticated species, especially of *Caprinae* that represent about 80% of the collection (Trocs I - 81%; Trocs II - 86%, Trocs III - 78%). The ratio between sheep and goat is always between 25:1 - 6:1 this suggesting that the flocks were mainly composed of sheep and only to a lesser extent of goats. The other domestic species are at low numbers: *Bos taurus* around 6% (Trocs I - 8%; Trocs II - 3%; Trocs III - 7%) and *Sus sp.* around 11% (Trocs I - 9%; Trocs II - 9%; Trocs III - 13%). Wild species are represented by very low percentages in all phases, which are never higher than 1% of the whole sample: *Lepus europaeus* 1%, *Capreolus capreolus* and *Cervus elaphus* 0.1%, while *Vulpes vulpes* and *Ursus arctos* represent around 0.3%, although these latter species are often intrusive in cave contexts.

In conclusion, the faunal spectrum of Els Trocs Cave seems to match a model characteristic of many other cave-sites of the period; a clear orientation towards sheep/goat farming can be assumed, whereas cattle, suids, and wild animals represented a minor component (Castaños 2004).

5.3.3. Other Materials

Apart from the ceramic and animal assemblage, during the excavation of Cova de Els Trocs, various archaeological finds were recovered, like polished instruments, macrolithic tools, beads and other ornaments, malacological materials, and bone/antler-industry items. However, the large majority of these materials are still being studied and the relevant results are unpublished.

At this preliminary stage, one can note that mills and polished tools are quite rare as only a few of them have been recovered from each phase; the number of bone-industry objects is slightly higher, not over thirty examples per phase anyway. The same is true for beads and other pendants, around twenty items yielded from each phase.

5.3.4. Lithic Assemblage

5.3.4.1. General Aspects

Considering the materials recovered during the 2009-2012 excavations, Cova de Els Trocs' lithic assemblage amounts to 297 elements. 111 of them belong to the first occupational phase (Trocs I), 85 to the second one (Trocs II), and 101 to the third and last phase of occupation (Trocs III). Another 33 lithic items have been recovered in the surface level (Trocs IV), out of a clear stratigraphic context; therefore, they have been excluded from this study. In addition, it has been impossible to attribute any of them to one of the previous occupations, being the entire assemblage extremely homogenous from a petrological, technological, and typological point of view.

This sample of materials represents the total number of chipped stone elements recovered at Els Trocs Cave. The flotation of sediments has been carried out on site and all materials, even millimetre-sized scars and debris, have been recovered.

Lithic objects have been singularly stored in plastic bags, in order to protect the materials from post-excavation damages. The entire assemblage has been studied in PreTech laboratories of the Milà i Fontanals Institution of the CSIC of Barcelona.

As previously stated, the excavation works have not been concluded yet. An area of about 36 m^2 has so far been investigated, namely, the central sector of the cave (Fig. 5.3). Approximately 50 m^2 remain unexcavated. However, it seems plausible that the main habitation areas of the site have been investigated. In fact, looking at the provenance of materials, it is evident that lithics do not have a ubiquitous distribution; the main concentrations of lithics are associated with the arranged habitation floors (US 53, 14, 20, 29) and hearths (US 1). These structures presumably attest to the areas where most of the human activities took place. Although excavations are not complete yet and other lithic materials will probably be recovered during next campaigns, one can thus consider the analysed assemblage as a good starting point for the reconstruction of the ways of managing and using lithic resources at Els Trocs Cave.

5.3.4.2. Typological aspects

From a typological point of view, Cova de Els Trocs' lithic assemblage is scarce and uncharacteristic. The assemblage is composed of only 8 cores and 49 retouched implements. The proportion between retouched and unretouched elements is similar in every phase, with

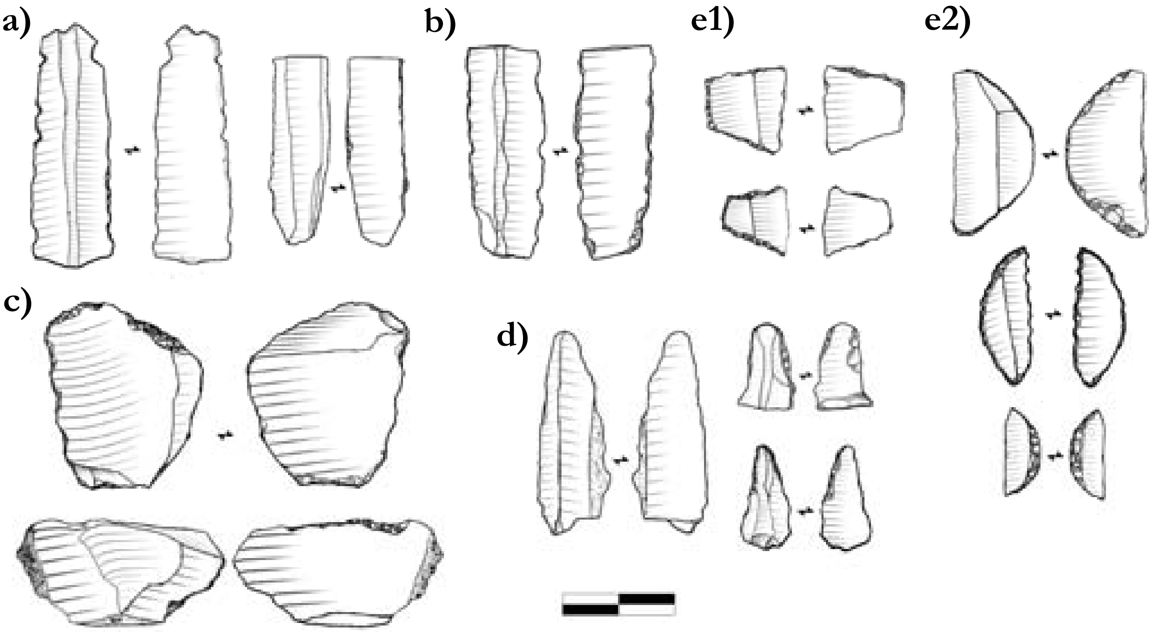

Fig. 5.6. Some of the main typological groups identified among the Cova de Els Trocs assemblage (phases I-III): *a*) blade scrapers; *b*) denticulate blade; *c*) flake scrapers; *d*) borers; *e*) geometric tools, *e1*) trapezes; *e2*) segments.

PHASE		T	Gm	B	L	R	D	E	Bc	LD-PD-DT	TOT
3	N	3	1	-	2	3	2	-	3	-	14
	%	21,4%	7,1%	-	14,3%	21,4%	14,3%	-	21,4%	-	100%
2	N	3	1	-	5	2	-	1	2	1	15
	%	20%	6,6%	-	33,3%	13,3%	-	6,6%	13,3%	6,6%	100%
1	N	1	7	1	3	2	1	-	6	-	21
	%	4,8%	33,3%	4,8	14,3%	9,5%	4,8%	-	28,6	-	100%
TOT	N	7	9	1	9	7	3	1	11	1	50
	%	14%	18%	2,0	18%	14%	6%	2%	22%	2%	100%

Tab. 5.4. Typological classification of the lithic assemblage of the Cova de Els Trocs. Based on the Laplace typological list (Laplace 1964). T: Truncated tools; Gm: Geometric tools; B: Burins; L: Blade scrapers; R: Flake scrapers; D: Denticulated tools; E: *Écaillé* tools; Bc: Borers; LD-PD-DT: backed tools.

the latter representing always more than 80% of the assemblage. Considering the scarcity of retouched elements, I can only make some general considerations on the technical and stylistic aspects of the main categories of identified tools.

In general terms, one can remark that the three phases show industries with similar characteristics from both a typological and structural point of view. About Trocs I, retouched tools amount to 21 elements (18.9%): among those, geometric tools (Gm) and borers (Bc) prevail, followed by blade scrapers (L) and flake scrapers (R). The other typological groups as burins (B), truncated (T), and denticulated (D) each consist of just one element (Tab. 5.4). Apart from geometrics and borers, the majority of instruments are characterized by marginal and discontinuous retouches, in many cases pseudo-retouches caused by use and not by an intentional edge retouching. However, in order to follow homogeneous criteria, I have included those elements in the class of marginal blade/flake scrapers (L/R), as occurred for the other lithic collections (i.e. Espluga de la Puyascada and Cueva de Chaves), where edge damages have also been considered as retouches (*cfr*. Chap. 3, Par. 3.3.4.2.). Geometric tools are mainly characterized by segments, shaped by a marginal flat retouch (both bifacial and unifacial), and trapezoids with an abrupt or semi abrupt retouch. In terms of size, they are microlithic or hypermicrolithic as they measure 21-15 x 13 -9 x 3-2 mm. Amongst borers, distal fragments prevail; the tips are generally shaped by both inverse and direct bilateral retouch. In four cases, borers are made on flake and, in two cases, on blade blanks. Most of the elements show quite small dimensions, with narrow blanks ranging between 8 and 13 mm in width and 3 and 5 mm in thickness.

About the second phase of occupation, Trocs II, retouched tools amount to 14 elements (16.5%). The main group is represented by blade scrapers (L), followed by borers (Bc), truncated (T), and flake scrapers (R). The other groups, like *écaillé* (E), geometric microliths (Gm), and baked tools (LD-PD-DT), are composed of just one element (Tab. 5.4). Among blade scrapers, the most representative tool is a mesial fragment showing an invasive simple retouch on the dorsal side; all other pieces are characterized by marginal and irregular retouches. Both truncations and flake scrapers are also scarcely formatted. Amongst borers, the most representative element is a distal fragment of a narrow and flat borer (11 mm wide x 4 mm thick), extremely rounded, with a bifacial marginal step-retouch on both edges of the tip; the other borer of the assemblage is a lateral borer on flake, characterized by a superficial and marginal retouch.

Finally, the third phase of occupation, Trocs III, is characterized by 14 retouched implements (14.3%). The main typological groups are: borers (Bc), truncated (T), flake scrapers (R), denticulated (D), geometric tools (Gm), and blade scrapers (L) (Tab 5.4). In this level too, the most representative groups are borers and geometric implements, while the other categories are characterized by poorly formatted tools. All borers are fragmentary: one is a proximal fragment, while the others are distal elements. In all cases, the edges of the tip are shaped by an invasive simple retouch. The only geometric tool present in this phase is a sub-rectangular isosceles trapezoid characterized by a bifacial flat invasive retouch.

Concluding one can remark some relevant aspects:

i. the general scarcity of retouched implements;
ii. the presence of geometric microliths (trapezoids and segments) and borers as the most characteristic classes of retouched tools (Fig. 5.6, *d-e*);
iii. the prevalence of marginal and pseudo-retouches amongst the basic categories (especially blade scrapers and denticulate tools) (Fig. 5.6, *a-c*);
iv. the absence of endscrapers.

5.3.4.3. Raw materials procurement

The communities that inhabited the Els Trocs cave exploited raw-materials of different nature and diverse provenance. The assemblage can be fundamentally divided in two parts: chert materials and no-chert materials. The latter represent less than 10% of the assemblage, mainly consisting of quartz and hyaline quartz, while other rocks such as granite, sandstone and quartzite cover minimum percentages (Tab. 5.5). All these lithologies are easily available in the local environment, from the streams and the rivers that flows from the Axial Pyrenees,

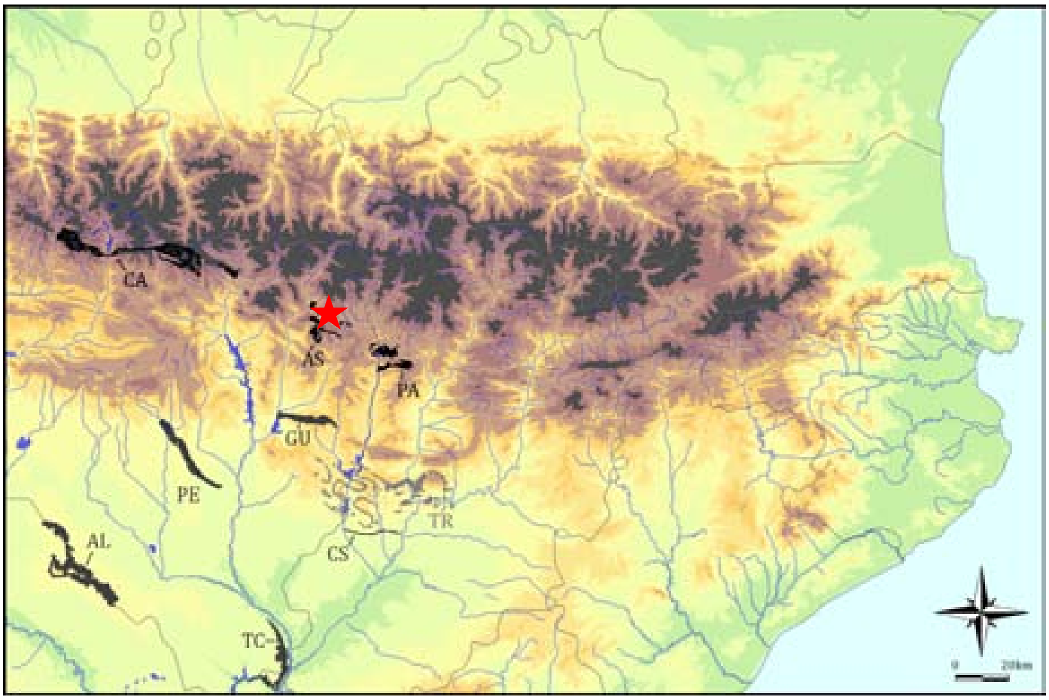

Fig. 5.7. Digital Terrain Model with the principal formations containing chert in the region. Map realized with software Miramon v7.1h. The red star indicates the Cova de Els Trocs. CA: frm. Calizas de las carenas altas; AS: frm. Agua Salenz; PA: frm. Pardina; TR: frm. Tremp; GU: frm. Guarga; CS: frm. Castelltallat; PE: frm. Peraltilla; AL: frm. Alcubierre; TC: frm. Torrent de Cinca.

PHASE		Other rocks					Cherts			Ind	TOT
		Qua	**Hya**	**Qrz**	**Gra**	**Sdt**	**LOM**	**EVP**	**MEC**		
3	**N**	1	4	2	-	-	28	7	46	13	101
	%	*1,0%*	*4,0%*	*2,0%*	-	-	*27,7%*	*6,9%*	*45,5%*	*12,9%*	*100%*
2	**N**	-	-	-	1	-	27	5	34	18	85
	%	-	-	-	*1,0%*	-	*31,8%*	*5,9%*	*40,0%*	*21,3%*	*100%*
1	**N**	2	8	1	-	1	46	3	44	6	111
	%	*1,8%*	*7,2%*	*1,2%*	-	*0,9%*	*41,4%*	*2,7%*	*39,6%*	*5,4%*	*100%*
TOT		3	12	3	1	1	101	15	124	36	297
		1,0%	*4,0%*	*1,0%*	*0,3%*	*0,3%*	*34,0%*	*5,1%*	*41,8%*	*21,1%*	*100%*

Tab. 5.5. Raw-materials composition of the Cova de Els Trocs lithic assemblage. *Other rocks* - Qua: Quartz; Hya: Hyaline Quartz; Qrz: Quartzite; Gra: Granite; Sdt: Sandstone. *Cherts* - LOM: Lacustrine Oligocene-Miocene chert; EVP: Evaporitic Upper Cretaceous-Palaeocene chert; MEC: Cretaceous Marine chert; Ind: Indeterminable materials.

in a radius of about 5-10 kilometres from the site.

Chert materials represent the majority of the lithic assemblage. Within this group, I distinguished two main subgroups: local chert formations and regional chert formations.

Local chert formations represent the main source of raw materials for the production of lithic tools. Indeed, they always are the most abundant group: 39% in Trocs I, 40% in Trocs II and 45% Trocs III. This type of chert is characterized by dark colorations (from black to grey tonalities), a massive aspect and an abundant fossiliferous content including sponge spicules, radiolarian and other foraminifera of diverse nature (Fig. 5.8, *a-f)*. Cherts of these characteristics are typical of shallow-marine carbonate platforms; formations of this type are available in the immediate surroundings of the cave, such as the Agua Salenz formation, dated to the Coniacian-Santonian period (Barnolas 2009: 28-29).

Among no-local chert materials prevails a group of brown cherts (with tonalities from black to beige) of massive texture, occasionally with a layered structure (Liesegang rings). The micropaleontological record is abundant, mainly constituted of Charophyte stems, Ostracods and, occasionally, gastropods (Fig. 5.8, *l-q*). In the region similar types of chert are well-known in the Miocene lacustrine carbonate formations of the northern sector of the Ebro Basin, which outcrops are located at about 80 km of distance from the site. The nearest outcrops are situated in Peraltilla (Frm. Peraltilla) in the province of Huesca, and in Alfarràs and Algerri (Frm. Castelltallat), in the province of Lleida (Anadón et al. 1989). However, cherts of similar characteristics, indistinguishable by a petrological point of view, are also available in the calcareous formations of Alcubierre (Arenas & Pardo 1999) and Torrent de Cinca (Luzón et al. 2002), in the central part of the Ebro Depression, at about 100-120 km from the site. Given their similarity, until now there are no clear criteria to distinguish between the various Ebro Basin chert formations and, thus, it is impossible to determine the exact provenance of the archaeological materials.

Another lithology represented in the site, even if with low frequencies, is a chert of bright tonalities (from white to grey to reddish colours) of massive texture, characterized by the presence of fibrous, length-slow, spherulitic quartzite. Other distinctive characters of this material are the scarcity of microfossils and the diffuse presence of grains of iron oxides (Fig. 5.8, *g-i*). Those materials are attributed to the Late Cretaceous-Early Palaeocene (Maastrichtiense a Daniense) lacustrine deposits of the Tremp-Grauss Basin, usually called Tremp Formation or Tremp Group, at about 40-60 km from the site (López Martínez et al. 2006).

Among the indeterminable materials, I grouped together all those lithologies of doubtful interpretation. A large part is composed of heavily burned, cracked or chemically altered elements for which is impossible to recognize the petrological and mineralogical characteristics. However, there is also a small group of chert that shares some similar characteristics, forming a homogeneous and distinctive group within the indeterminable materials: they are characterized by a cryptocrystalline, massive, matrix, a yellow-reddish coloration, the presence of iron oxides and other indeterminable bodies of dark coloration. This group, even if scarcely exploited at the site, represents an exogenous chert type of unknown provenance.

A series of chi-square tests has been carried out to investigate the distribution of the different lithologies through the occupational sequence of the Els Trocs cave. Indeterminable elements have been excluded from the sample. The work hypothesis is that exist a differential distribution of the lithic materials among the three phases of occupation.

In the first case I grouped all the materials on the basis of their provenance area («Axial Pyrenees», «pre-Pyrenees», «Ebro Basin»). However, the result of this test, giving a low *p*-value, substantially indicated that the materials are equally distributed among the three occupational phases (χ^2: 8.269; df: 4; *P*: 0.082). A second test has been realized grouping the materials on the basis of their availability («local material», «no-local materials»). Also in this case the results confirmed the null-hypothesis (χ^2: 1,320; df: 2; *P*: 0,517). Finally, a third test has been realized grouping the materials on the basis of their petrographic proprieties («siliceous material», «no-siliceous materials»). Even in this case the result indicated a low correlation between the analysed variables (χ^2: 1.320; df: 2; *P*: 0.517).

Concluding, in all the tests the values for the observed and the expected frequencies are

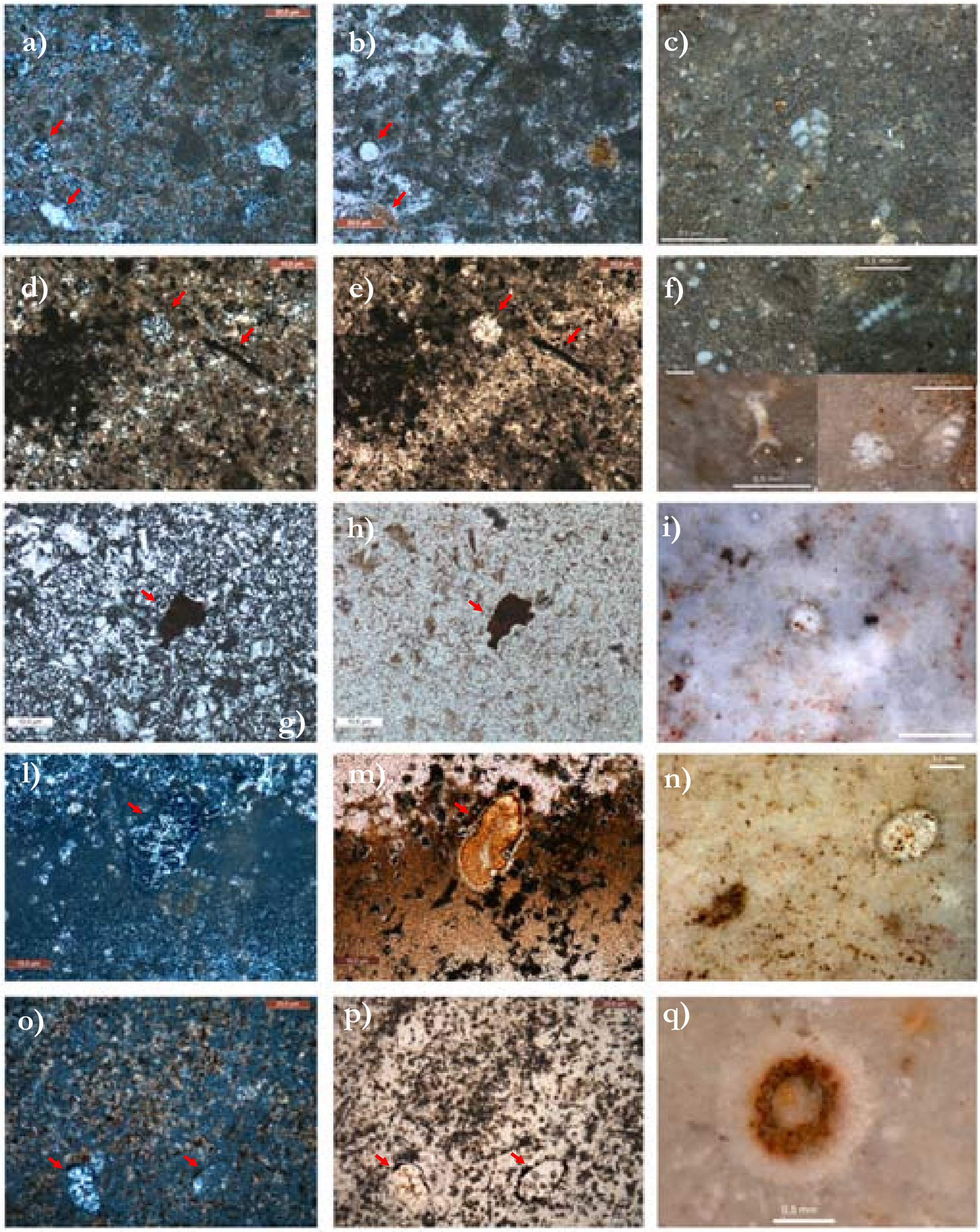

Fig. 5.8. Macro- and microscopic photographs of the main chert types from the Cova de Els Trocs (phases I-III). A-F) Cretaceous Marine cherts: *a-b)* Thin section view under microscope, plan-polarized light and crossed polariser view (100X). Calcisphere and marine foraminifera; *c)* Marine planktonic foraminifera, 25X magnification; *d-e)* Thin section view (same as before) (50X). Calcisphere and sponge spicule; *f)* Details: radiolarian, calcisphere, sponges and other planktonic foraminifera. G-I) Evaporitic Upper Cretaceous-Palaeocene chert type: *g-h)* Thin section view (same as before). Microquartz and chalcedony. Iron oxide, (50X); *i)* Charophyte algae at 10X. L-Q) Oligocene-Miocene Lacustrine cherts: *l-m)* Thin section view (same as before), Ostracod; *n)* Ostracod at 15X magnification; *o-p)* Thin section view (same as before) (100X), Ostracods filled by macroquartz crystals; *q)* Charophyte algae at 20X.

similar, showing no significant differences. This fact points out toward the existence of a homogeneous distribution of the different lithologies for each occupational phase. If one look to the data, one observes that chert materials are always dominant and among them the pre-Pyrenean chert types always prevails; in particular local chert types prevail in all the phases, marking a slight tendency toward an increase, from 39.6% in Trocs I to 45.5% in Trocs III. On the contrary, chert materials from the Ebro valley appear diminishing (from 41.4% to 27.7% of the assemblage) (Tab. 5.5).

5.3.4.4. Technological Management

The lithic industry of Els Trocs Cave is characterized by some general features that can be summarized as follows:

i. low degree of cortical elements (27.4%);
ii. low frequency of cores (2.7%);
iii. scarce presence of characteristic waste products (9.8%);
iv. high frequency of debris (22.6%);
v. moderate laminarity index (39.2%);

All these aspects are common to the three occupational contexts. Indeed, if one looks at the distribution of the different knapping products, one can observe that they are equally distributed amongst the various phases. A chi-square was carried out to test this hypothesis. The materials were divided into three classes, where cores, characteristic trimming elements, and debris were put together in one group («waste»), while the other products were kept separate («blade» and «flake»). The resulting *p*-value (χ^2: 3.099; df: 4; *P*: 0.541) confirmed the null-hypothesis of a homogeneous distribution. In addition, about the knapping strategies applied to the different raw materials, one can highlight some considerable differences.

Materials from the pre-Pyrenean chert formations are the most numerous in the studied sample. As already said above, the majority of those chert materials are attributed to the Agua Salenz Formations, the outcrops of which are located a few kilometres from the site. This chert can be considered a low-quality material, specifically in the light of a strong presence of fault-related joints that made it scarcely suitable for knapping. Knapping products, in fact, are mainly flakes, while blades display lower percentages. The relative abundance of cores, debris, and characteristic manufacturing waste —such as platform-rejuvenation elements— indicates that most of the core-reduction process took place *in situ*. Amongst cores, one can remark the presence of exhausted elements of 15 x 17 x 17 mm (Fig. 5.9) as well as larger cores of about 40 x 21-40 x 21-33 mm (Fig. 5.9). Both alternate and opposed striking platforms are represented. The presence of complete blanks of similar length seems to confirm the existence of removal surfaces of maximum 40-50 mm in length (Fig. 5.9). On the contrary, negatives of laminar removal are almost absent. However, on the basis of the blanks recovered in the cave, it seems plausible that a local production of laminar elements of reduced dimensions (13-19 x 11-17 x 3 mm) was carried out on site (Fig. 5.9). Formal tools for these chert types are scarce and mainly consist of borers and geometric elements.

The remaining chert coming from the pre-Pyrenean formations is attributed to the Tremp formation. Those materials are mainly represented by blades measuring 29-39 x 11-15 x 4-3 mm on average. Flakes are rarer, mainly fragmentary elements. More generally, the absence of cores and the scarcity of trimming elements seem to indicate that Tremp materials were

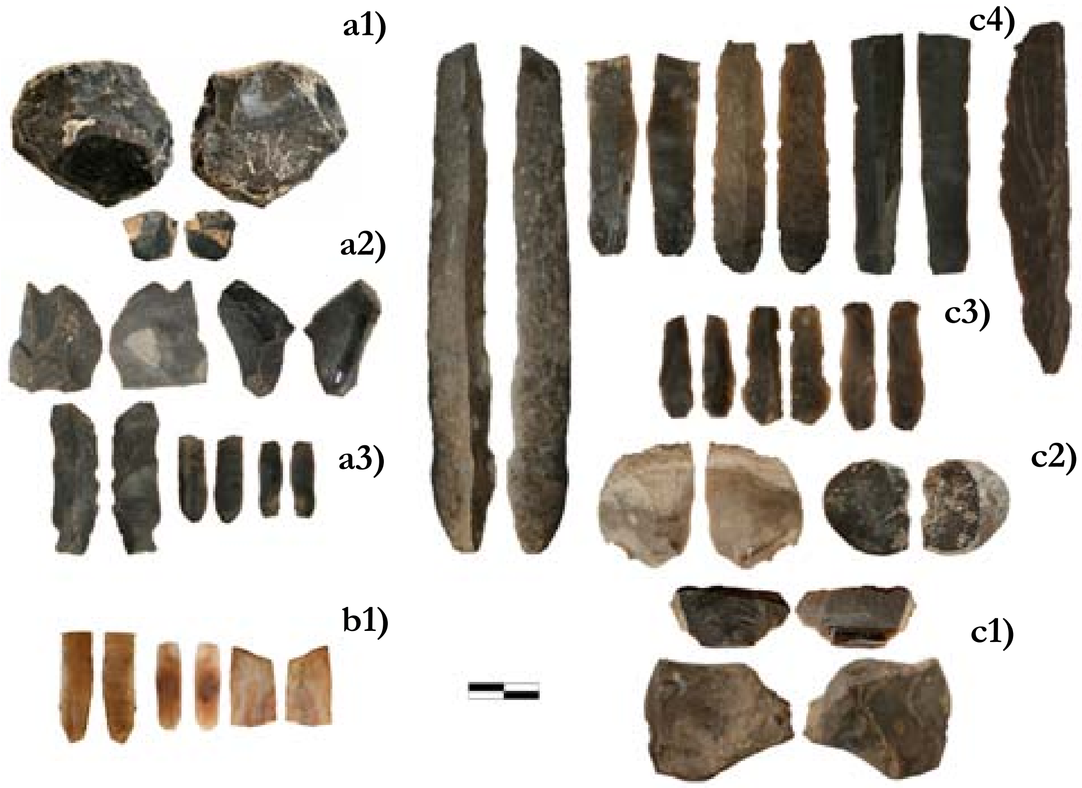

Fig. 5.9. Selection of materials from the Cova de Els Trocs lithic assemblage (phases I-III). A) Cretaceous Marine chert type; *a1*) cores; a2) core trimming elements; a3) blades and bladelets. B) Evaporitic Upper Cretaceous-Palaeocene chert type; *b1*) blades and bladelets. C) Oligocene-Miocene Lacustrine chert type: *c1*) cores; c2) core trimming elements; c3) bladelets and small blades; c4) larger blades. Scale 1:50.

PHASE		Flake	Blade	Core	Débris	Characteristic waste products	Other	Ind	TOT
3	N	36	21	2	30	11	-	1	101
	%	35,6%	20,8%	2,0%	29,7%	10,9%	-	1,0%	100%
2	N	33	24	1	20	6	1	-	85
	%	38,8%	28,2%	1,2%	23,5%	7,1%	1,2%	-	100%
1	N	46	29	5	17	12	1	1	111
	%	41,4%	26,1%	4,5%	15,3%	10,8%	0,9%	0,9%	100%
TOT	N	115	74	8	67	29	2	2	297
	%	38,7%	24,9%	2,7%	22,6%	9,8%	0,7%	0,7%	100%

Tab. 5.6. Technological composition of the Cova de Els Trocs assemblage. *Ind.* indicates indeterminable blanks. *Other* indicates other categories such as fragment of pebbles, fragments of polished implements, tools on tabular blanks, etc. Technological lexicon has been taken from Inizan et al. (1999).

not knapped at the site, but only occasionally transported there in form of blades or bladelets.

Cherts coming from the Ebro Basin represent the second largest group of materials at Els Trocs Cave. In this case, one can distinguish two main productions: on the one hand, I have observed the presence of large laminar blanks measuring 60-75 x 11-15 x 3-4 mm, presumably produced outside the site, while, on the other hand, I have recognized a local production of blades and bladelets of reduced size (17-27 x 9-14 x 3-4 mm) (Fig. 5.9). The scarcity of cores and waste materials suggests that only a part of the lithic production took place *in situ*, whilst the majority of blade blanks were probably taken to the cave already flaked. Amongst the transported materials, a long blade of 150 x 19 x 7 mm stands out, recovered in Trocs III Phase, which was probably made by indirect percussion (Fig. 5.9). Blades of that type recall a well-known production of large laminar implements widespread all over the NE of the Iberian Peninsula beginning from the very period around 3500 cal BC and commonly made out of Ebro chert types (Gibaja et al. 2009). About flakes, they mainly represent core-preparation and debitage-rejuvenation elements, whereas no flake-oriented production has been detected.

On the contrary, the other lithologies were knapped almost exclusively for the production of flakes. Only rock crystal appears to have been exploited for the production of blades, although it is anecdotal evidence considering the scarcity of remains.

In order to test the statistical significance of the observations, I carried out a chi-square crossing the variables about the different lithologies («non-siliceous rocks», «Ebro-Basin cherts», «Pyrenean cherts», «Indeterminable cherts») and the various classes of products («blade», «flake», «waste»). The resulting *p*-value (χ^2: 28.665; df: 6; *P*: 0.000) rejected the null-hypothesis of a homogeneous distribution of the values; specific production processes are then associated with each class of lithic products.

5.4. Traceological Analysis

5.4.1. Material Conservation

Els Trocs' lithic materials were separated and catalogued as early as during the excavation. Each element has been superficially cleaned with water and individually stored in a plastic bag, in order to avoid any type of post-excavation damage. Each bag reports the inventory number of the find and the relative stratigraphic and context information.

Most of the data relevant to the sedimentary sequence at Els Trocs Cave, such as soil micromorphology and sediment analysis, is still unpublished or being processed; the knowledge about the taphonomic processes concerning the cave and its sediments is still limited; therefore, such considerations should be regarded as preliminary. However, according to current data, the deposit must have been well-preserved. Taphonomic processes, such as water percolation, appear to have been limited and did not alter the stratigraphic contexts significantly.

As a result, the lithic assemblage seems well preserved: no evident damages or alterations, such as glossy or coloured patinas have affected the lithic surfaces. Moreover, during the analysis of the assemblage, I have noticed a good preservation of both the organic and inorganic residues deposited on the chert surfaces because of hafting or use. Mechanical alterations that commonly affect lithic assemblages, as rounding of ridges and/or surfaces, are almost absent. The micro-topography of flint materials appears scarcely affected by processes of mechanical weathering (Fig. 5.9, *a-b*), this confirming the relative stability of the archaeological deposit. In this respect, it is important to remark that the cave is characterized by a stable microclimate, with humid conditions and temperatures ranging between 6 and 8 ° C all year long, a situation that has favoured the preservation of archaeological materials (Rojo et al. 2014).

However, other types of alteration have been identified. Most of them can be classified as chemical weathering (Mazzucco et al. 2013a). Those alterations imply a change in the chemical composition of lithic materials or of the use-wears/residues deposited on their surfaces.

5.4.1.1. Chemical Alterations

As already said, because of the lack of detailed information on the Els Trocs deposit, I can only make some general points on the observed alterations and their possible shaping agents. One of the most characteristic aspects of many stratigraphic contexts described by the excavators (Rojo et al. 2014) is the presence of several layers rich in ashes and charcoal, that is, remains of the various hearths and burning/cleaning activities practised by the inhabitants of the cave. More in details, this evidence comes from:

i. *Hearths*: found all over the cave in all three phases; so far, about twenty different combustion structures of diverse nature have been detected, from well-defined pit-hearths to large shapeless spots of ashes. Moreover, ashes and charcoal appear mixed-up and scattered in the sediments of the various occupational layers associated with the hearths, this being due to the reuse and cleaning of the same combustion areas.

ii. *Pavements and large accumulations of combustion waste materials*: such evidence has been found associated with the second phase of occupation (Trocs II). Those areas are interpreted as a result of burnt straw used for building drainages or insulating floors.

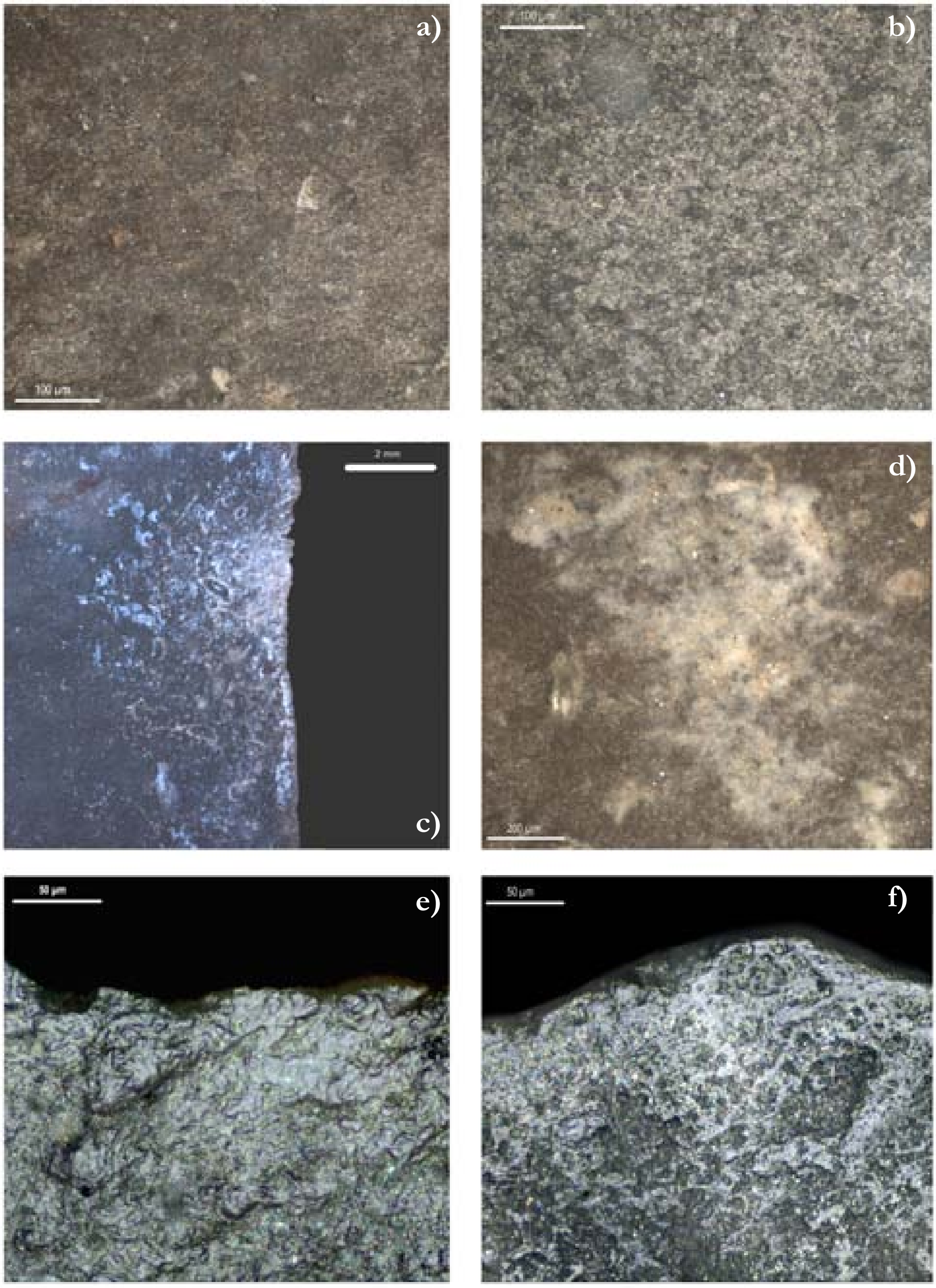

Fig. 5.10. Some example of the alterations observed among the Cova de Els Trocs lithic assemblage: A-B) some examples of the surface preservation at Els Trocs: *a*) very slight soil lustre, 200X; *b*) moderate soil lustre, 200X. C-D) Example of chemical alterations at Els Trocs, white spots on the edges and surfaces of the tools; *c*) Macroscopic view, 15X; *d*) Microscopic view of a white spots, at 200X; E-F) Chemical alterations of use-wears, 50X. Degraded micro-polishes, with rough aspect and the diffuse presence of craters and other small cavities formed due the dissolution of part of the silica-gel.

iii. *Fumiers*: characteristic features which consist of alternating burnt and unburnt dung layers ('ash-rubefaction couplets') (Wattez et al. 1990; Angelucci et al. 2009; Carrancho et al. 2012). A fumier has been identified in Trocs II Phase.

In all these structures —characterized by a lot of burnt waste—, very large quantities of archaeological materials have been recovered. Although a detailed analysis of the sediments is still unavailable, soils containing abundant ashes and charcoal are generally characterized by high alkalinity, a factor that could affect the preservation of certain types of archaeological materials. Recent experimental studies have proved that both chert materials and certain types of use-wear can be affected by alkaline agents, which bring about the dissolution of the silica matrix or the silica-gel deposited on the flint surfaces (Mazzucco et al. 2013a; *cfr*. Chap. 2, Par. 2.3.1). In the case of Els Trocs' materials, I have mainly observed those types of alterations on tools related to plant-working activities. Micro-polishes appeared degraded, with a rough aspect and the widespread presence of 'craters' and other small cavities caused by the dissolution of part of the silica-gel (Fig. 5.9, *e-f)*. Macroscopically, those types of alterations are very difficult to detect, even if small spots of white patina are sometimes visible, which could be related to a precipitation of the dissolved silica on the surfaces (Fig. 5.9, *c-d*). However, alterations of such type characterize only some particular types of use-wears and do not prevent the analysis of these .

5.4.2. Trocs I

The lithic assemblage from the first phase of occupation at Els Trocs Cave is made of 111 elements. Almost half of them display traces of being intentionally used or modified by human actions (*n.* 54; 48.6%). A large majority of this sample (*n.* 39; 35.1% of the total assemblage —corresponding to 49 AUAs), present actual 'use-wear traces'. 30 implements of these were employed exclusively for one single activity, 8 elements show two active zones, while 1 item is characterized by 3 different active zones.

A smaller part of the assemblage attests to 'non-utilitarian traces' (e.g. transportation traces) (*n.* 3; 2.7% —corresponding to 4 wear zones); finally, a high number of tools have revealed the presence of macroscopic residues (*n.* 11; 9.9%).

In terms of interpretation, in 61.2% of the cases, it has been possible to provide a complete explanation of the use-wears, whilst, in the remaining cases, the use has been defined as probable (22.4%) or possible (16.3%) (Tab. 5.7).

5.4.2.1. Use-Wears

5.4.2.1.1. Vegetal Substances

Tools related to the working of vegetable substances represent the most numerous group of the analysed sample (*n.* 11; 28.2%) (*n.* 14 AUAs; 28.6%). Within this category, the majority of implements are associated with longitudinal actions connected with harvesting *non-ligneous plant materials* (*n.* 10; 25.6%) (*n.* 13 AUAs; 26.5%) (see Tab. 5.10 at the end of the chapter). Based on preservation of micro-polishes, I have distinguished two different groups: *indeterminable herbaceous plants* (*n.* 8 AUAs; 16.3%) and *fresh herbaceous plants* (*n.* 5 AUAs; 10.2%). In the former group, all those elements are grouped together, the traces of which have been modified to some extent by taphonomic alterations. As already stated above, the sediments from Els Trocs Cave are characterized by a variety of agents that can bring about a deterioration of silica-gel. In those cases, it is not always possible to determine the characteristics of the worked materials (Fig. 5.11-5.12). On the contrary, the tools of the second group show a better preservation of wears, while the textural and distribution patterns can be more clearly interpreted. Polishes are characterized by a 'wet' and flowing look (Gijn, 1990: 49), with a 'dome-shaped' distribution that adapts to the chert's micro-topography (Fig. 5.13, *a-b*). This type of traces is commonly attributed to harvesting of fresh plants such as reed grasses. It is true that also green cereals can produce similar traces (Ibañez et al. 2013); however, in my opinion, this is not the case with Els Trocs Cave since no remains of crop processing have been detected at the cave (Lancelotti et al. 2014).

From a petrological and technological point of view, all those tools show common features. First of all, they all were made out of exogenous raw materials, especially cherts coming from the Ebro-Basin Oligocene-Miocene formations (Fig. 5.11, *a*; Fig 5.11, *a*; Fig. 5.13, *a-b*) and —only one specimen— a chert attributed to the Tremp formation (Fig. 5.12, *b*). Secondly, all are blades. It is difficult to ascertain the dimensions of the blanks as all tools are fragmentary; however, one can distinguish two main classes: 1) larger elements (with lengths that probably reached 80 mm), quite narrow (widths range between 13 and 16 mm) and flat (thickness between 3 and 4 mm) (Fig 5.10-5.11); 2) implements that, although fragmentary, appear to attest to a smaller pattern (length between 20 and 40 mm, width between 10 and 11 mm, and thickness between 2 and 3 mm) (Fig. 5.13, *a-b*). The first group probably refers to an exogenous production –items transported to the site already flaked–, while the second one may represents a local production.

It is interesting that, on the larger implements, one can observe the presence of extensive glossy spots and striations that recall the experimental traces produced by carrying the lithic tools (Fig. 5.11, *a3-4*; Fig. 5.12, *a4*) (Mazzucco & Clemente 2013; *cfr*. Chap. 2, Par. 2.3.2.). Those features can be explicated as a result of mechanical friction between the implements during transportation. The fact that the tools' surfaces, edges, and ridges show a fresh, unaltered appearance (with no rounding or shiny lustres), suggests that those modifications were not caused by natural agents, e.g. soil movements, but by anthropic actions.

Finally, it is important to remark that micro-polishes, even the well-preserved ones, are always marginal and do not penetrate the surface more than 1-1.5 mm; plant polishes never appear compact and flat, as typically occurs in cereal-harvesting traces instead. This fact suggests a limited use of the tool that well supports the idea of such artefacts having being employed for sawing plants for non-food purposes. Cereal harvesting is generally associated with an intensive and prolonged use; the long duration of this activity is actually the main factor which brings to extensive 'sickle glosses'. In this case, all tools seem to attest to short activities related to the gathering of plant materials for different purposes, but not necessarily connected with agricultural practices.

Alternatively, marginal traces may have been caused by a very invasive hafting, with the tool inserted deep into the handle. However, this type of hafting would differ from the hafting patterns adopted in the NE of the Iberian Peninsula for sickle blades (Gibaja 2002; Ibáñez et al. 2008), which usually resulted in only one edge hidden and not beyond the dorsal ridge. However, some variability is possible from one blade to another.

Amongst vegetable substances, I have also observed the presence of a tool that may be related to *wood-working activities* (*n.* 1; 2.6%) (*n.* 1 AUA; 2.0%) (Fig. 5.13, *c*). It is a core-trimming element, a rejuvenation flake of the removal surface, which was later employed to scrape some soft ligneous plants using its distal edge. Both diagnostic macro- and micro-traces have been observed: spots of smooth plant-polishes associated with bifacial step-termination scars that indicate a transverse movement into a material of medium hardness

14263

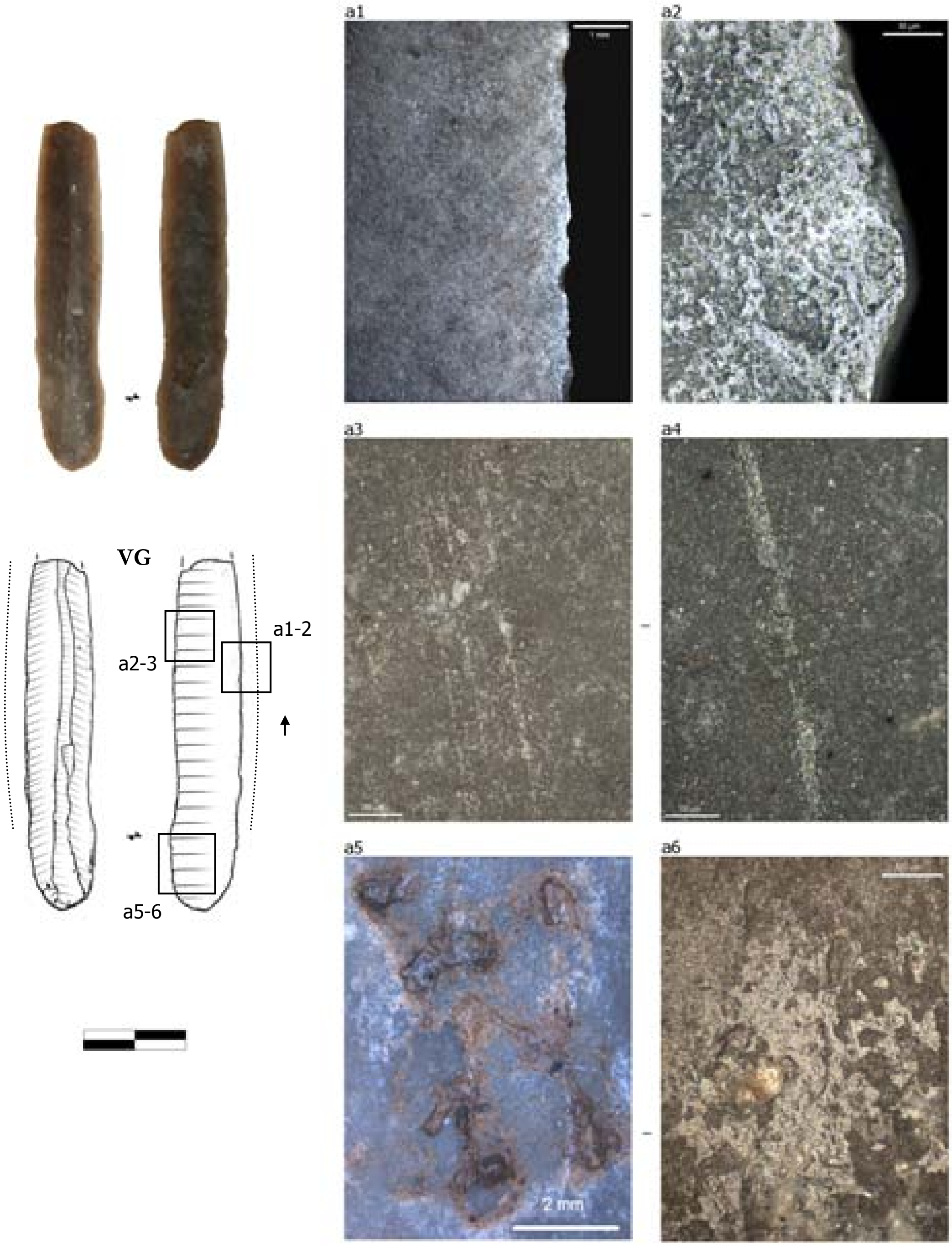

Fig. 5.11. Use-wears from the Cova de Els Trocs, phase I. **14263-** Tool used for harvesting herbaceous plants, probably; *a1-b1)* Macro and microscopic views of use-wears: *a1*) ventral face, 8X. Slight marginal lustre; *b1*) Marginal plant polish, partially altered, 200X; *a3-4*) Microscopic views of possible transport strias, 200X and 100X; *a5-6*) Residues; *a5*) Resin or bitumen residue at 15X; a6) Detail of the residue at 200X. See the greasy and roundish appearance.

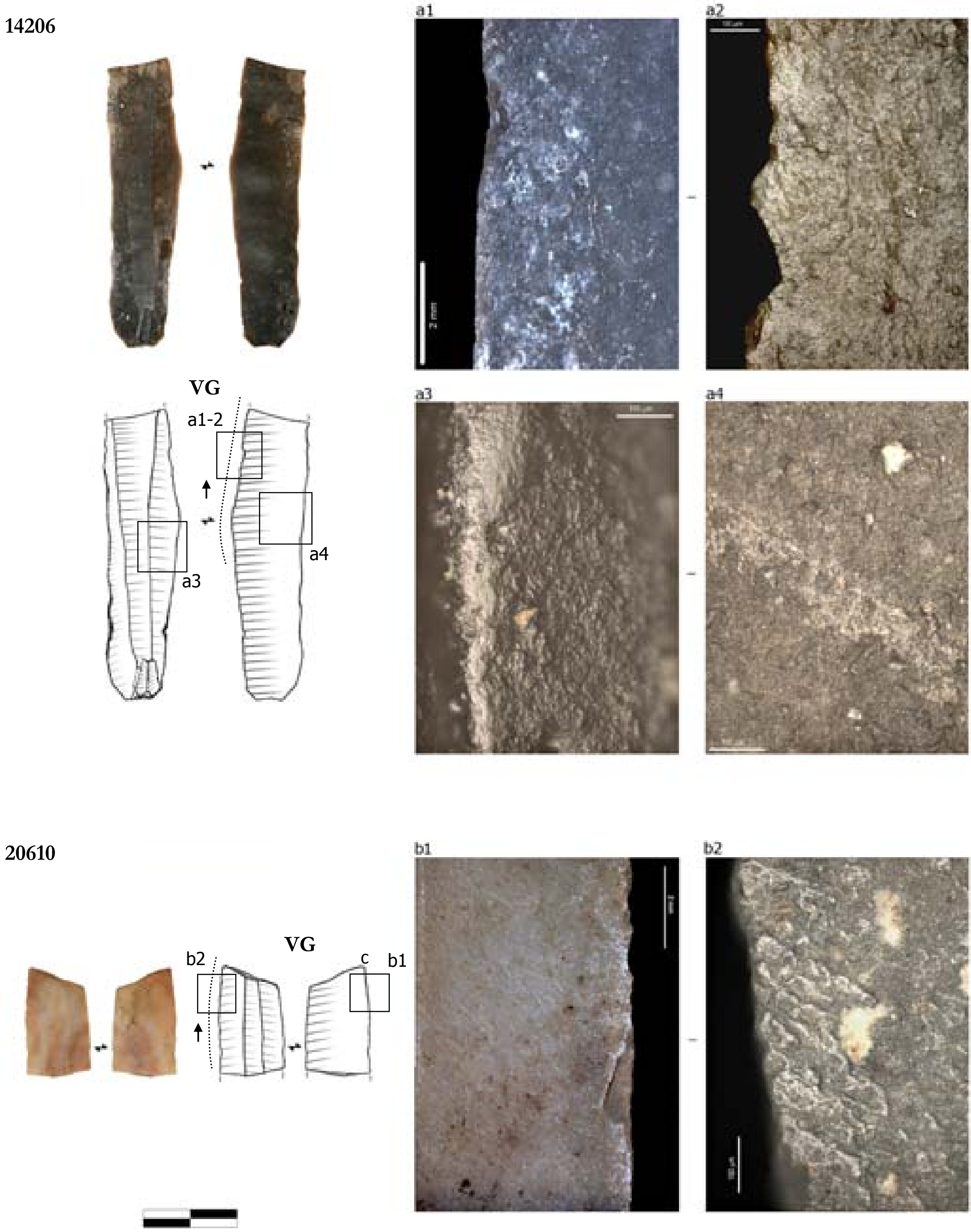

Fig. 5.12. Use-wears from the Cova de Els Trocs, Phase I. **14206-** Tool used for cutting soft vegetal materials; *a1-b1)* Macro- and microscopic views of the traces: *a1*) Active zone: the edge present only a marginal scarring, 8X; *a2*) Altered, 200X; *a3-4*) Possible marks of transportation: a3) bright spots on the ridge of the tool; a4) large striation on the ventral surface. **20610-** Tool used for cutting herbaceous plants; *b1-2*) Macro- and microscopic views of the traces: *b1*) Marginal lustre on the ventral face, 10X; b2) Marginal polish on the dorsal face, 200X. Note the domed distribution of the polishes and their smooth appearance. However, traces are slightly altered too.

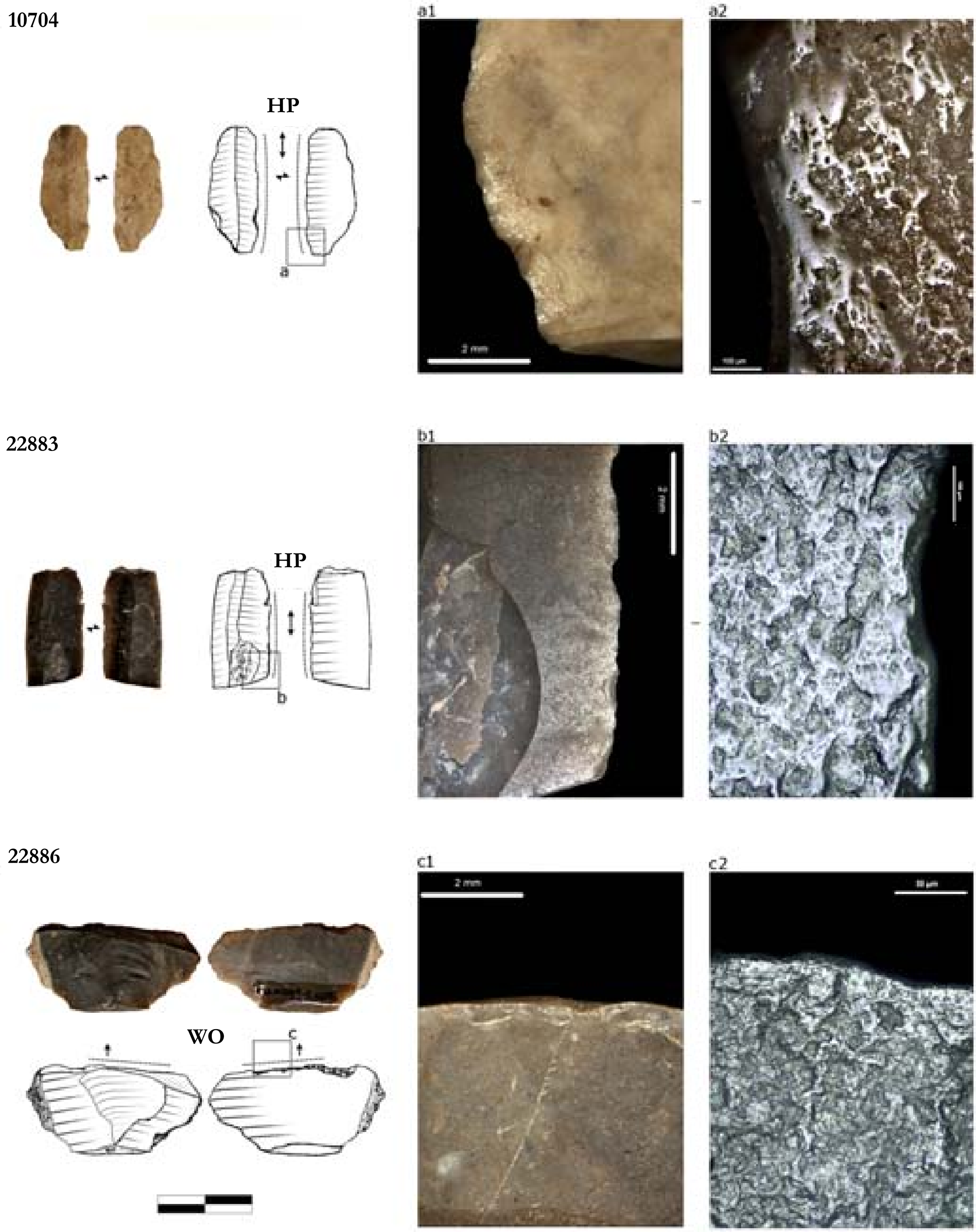

Fig. 5.13. Use-wears from the Cova de Els Trocs, Phase I. **10704-** Tool used for harvesting herbaceous plants; *a1-2)* Macro- and microscopic views of the active zone: *a1*) Macroscopic view, 10X, see the presence of a marginal lustre; *a2*) Smooth and domed plant polish. **22883-** Tool used for harvesting herbaceous plants; *b1-2*) Macro- and microscopic views: *b1*) Marginal lustre, 15X. The tools is heavily burned; *b2*) Smooth and 'wet' plant polish, 200X. **22886-** Tool used for scraping some type of ligneous plant; *c1-2)* Macro- and microscopic views of the active zone; *c1*) marginal step terminating overlapping fractures, 10X; *c2*) Spots of wood polish with transversal directionality, on the very edge of the tool.

(Fig. 5.13, *c1*). However, considering the presence of just one tool, it probably refers to an occasional action and not to a complex working process.

5.4.2.1.2. Animal Substances

Giving the good preservation of lithic surfaces at Els Trocs Cave, I have been able to distinguish a number of different activities related to animal substances (*n.* 10; 20.5%) (*n.* 12 AUAs; 20.4%).

Among those, traces associated with *slaughter and butchering activities* prevail (*n.* 9; 23.1%) (*n.* 10 AUAs; 20.4%). Both flakes and blades were employed. Flake size ranges from large core-trimming elements (36-44 x 17-23 x 5-7 mm) (Fig. 5.14, *a-b;* Fig. 5.15*, c*) to small flakes (22 x 9 x 2 mm) (Fig. 5.15, *c*). Blades are usually of small-medium size (29-33 x 10-12 x 3 mm), always unretouched and poorly formatted (Fig. 5.14, *a-b*). Most of these blanks are probably the result of local flaking activities, although, in some cases, it is difficult to ascertain the exact standard dimensions because of high fragmentation.

The recognized traces mainly show macroscopic edge scarring and rounding. Polishes are always marginal, scarcely developed, with a dispersed distribution pattern, and with a greasy and rough appearance (Fig. 5.14-5.15) (Gijn 1989: 44; González & Ibáñez 1994: 126). Both scraping and cutting have been documented, probably in relation to different movements and activities, such as skinning, boning, meat cutting, *etc.*

Only one tool is associated with the *working of hard animal matters* (*n.* 1; 2.5%) (*n.* 2 AUAs; 4.1%). It is a rejuvenation flake of the removal surface measuring 36 x 27 x 6 mm. The tool shows the presence of two different active zones, both associated with hard animal substances: one for sawing and the other for scraping. In both cases, edge scarring is evident and micro-polishes show a clear directionality, with compact spots characterized by tiny striations and cracks (Fig. 5.15, *c*). However, the tool appears to have been employed just for a short time as the traces do not form a homogeneous and continuous band on the edge. Moreover, considering the presence of only one element, the working of bone/antler should be regarded as a marginal or occasional activity at Els Trocs Cave.

The faunal record recovered from Trocs I Phase is extremely large (1,062 determinate fragments), this attesting to the importance of slaughter activities in the cave economy. Those activities were especially oriented towards domestic ovicaprids that represent 80% of the entire assemblage. Moreover, the kill-off pattern indicates a prevalence of infant (0-6 month-old) and young individuals (1-2 year-old), suggesting that slaughter activities were concentrated in certain periods of the year, in relation to a specialized meat production. In this respect, Trocs I may be considered a 'producer site', where massive slaughter of young animals took place (Bréhard et al. 2009). This data well matches the presence of a relatively abundant number of tools associated with slaughter and butchering practices. However, the archaeozoological analyses are still preliminary (Rojo et al. 2014); therefore, one has to take such interpretations with caution.

5.4.2.1.3. Mineral Substances

Tools associated with mineral substances amount to seven instruments (*n.* 7; 17.9%) (*n.* 7 AUAs; 14.3%). All of these instruments are borers (Fig. 5.17, *a-c*), except for one geometric tool reused as borer (Fig. 5.16, *a*). They are all fragmentary: five elements are distal fragments, characterized by a narrow tip shaped by steep retouch (both bifacial and alternate retouches), while two implements are mesial fragments with only a small portion of the retouched edge

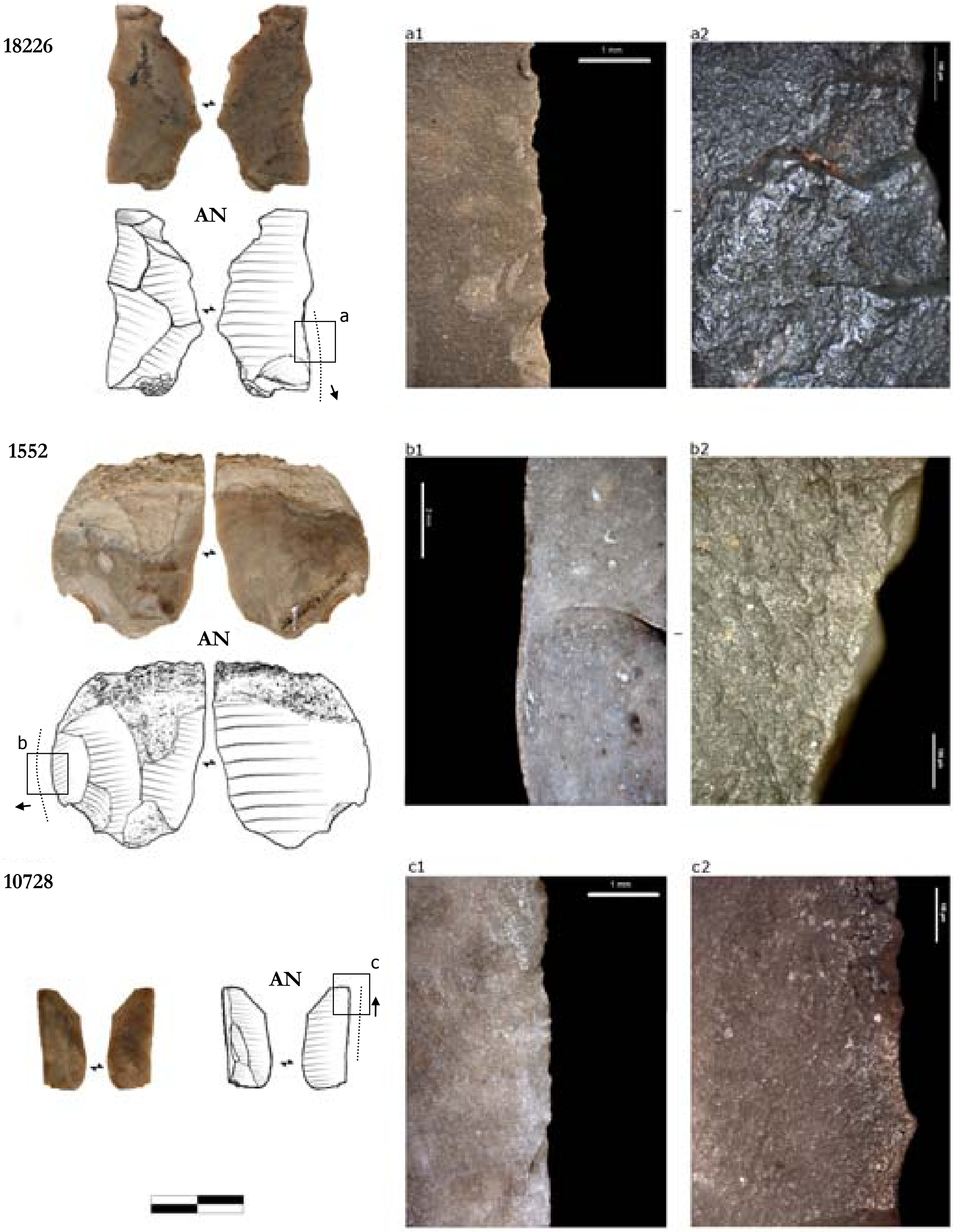

Fig. 5.14. Use-wears from the Cova de Els Trocs, Phase I. **18226-** Tool used for cutting soft animal substances. *a1*) Macroscopic view, 10X; *a2*) Microscopic view, 200X. Greasy polish with open distribution. **1552-** Tool used for scraping soft substance; *b1*) Marginal edge scarring and rounding, 15X; *b2*) Marginal band of polish on the active edge, 200X. **10728-** Tool used for cutting soft animal substances; *c1*) Macroscopic view, 10X. Series of marginal fractures with longitudinal orientation, 15X. Observe the presence of strias produced by the contact with hard animal materials *c2*) Marginal 'weal' polish associated to marginal rounding, 200X.

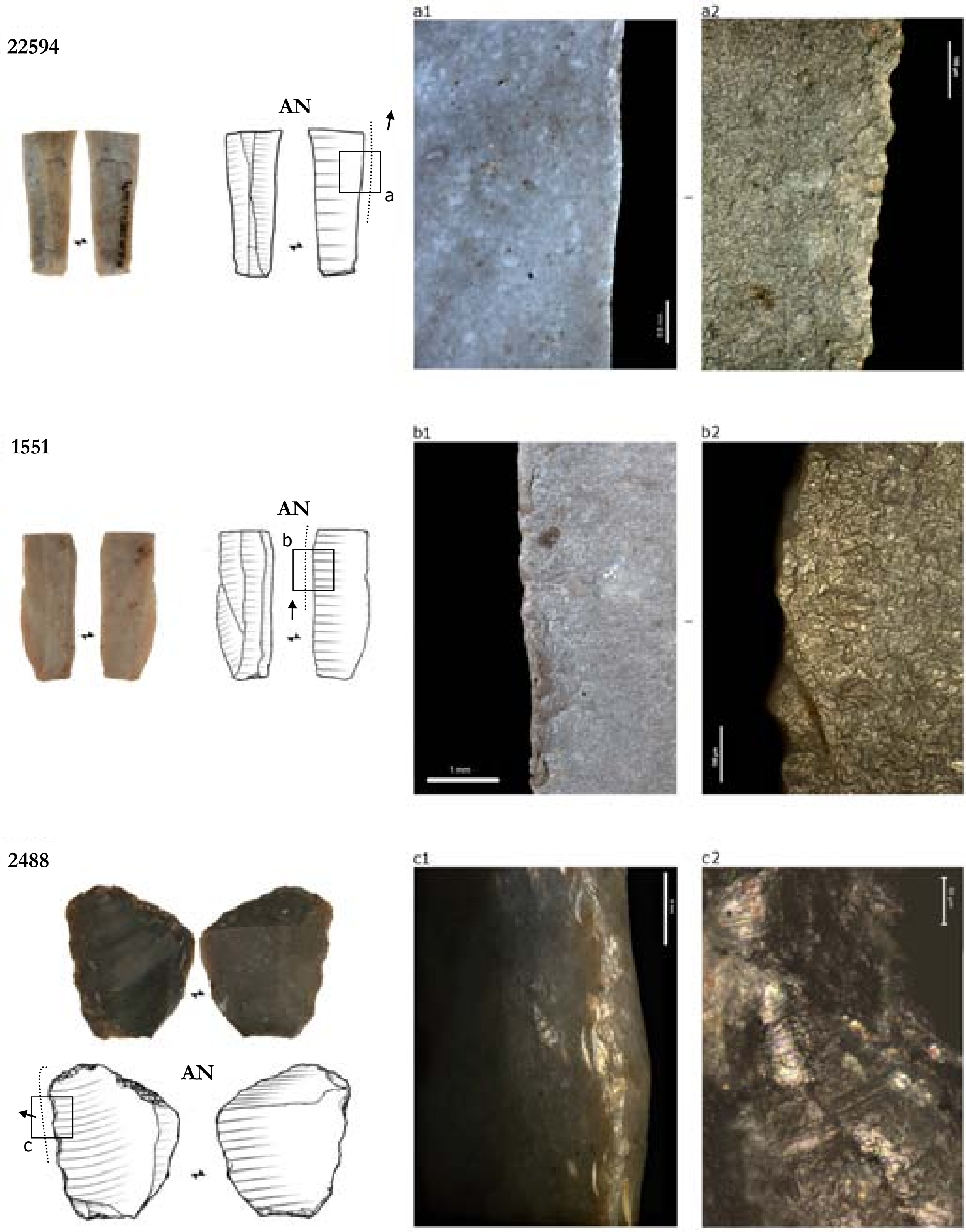

Fig. 5.15. Use-wears from the Cova de Els Trocs, Phase I. **22594-** Tool used for cutting soft animal substances; *a1*) Marginal edge-scarring and edge-rounding, 10X; *a2*) Marginal greasy polish with spots of contact with hard material, 200X. **1551-** Tool used for cutting soft animal substances; *b1*) Edge scarring with scalar feather fractures, 15X; *b2*) Edge-rounding and greasy polish, 200X. **2488-** Tool used for working soft animal substances/hard animal materials; *c1*) Bifacial overlapping step terminating fractures; 20X; *c2*) Polish produced by the contact with hard animal material, probably bone. 400X.

35881

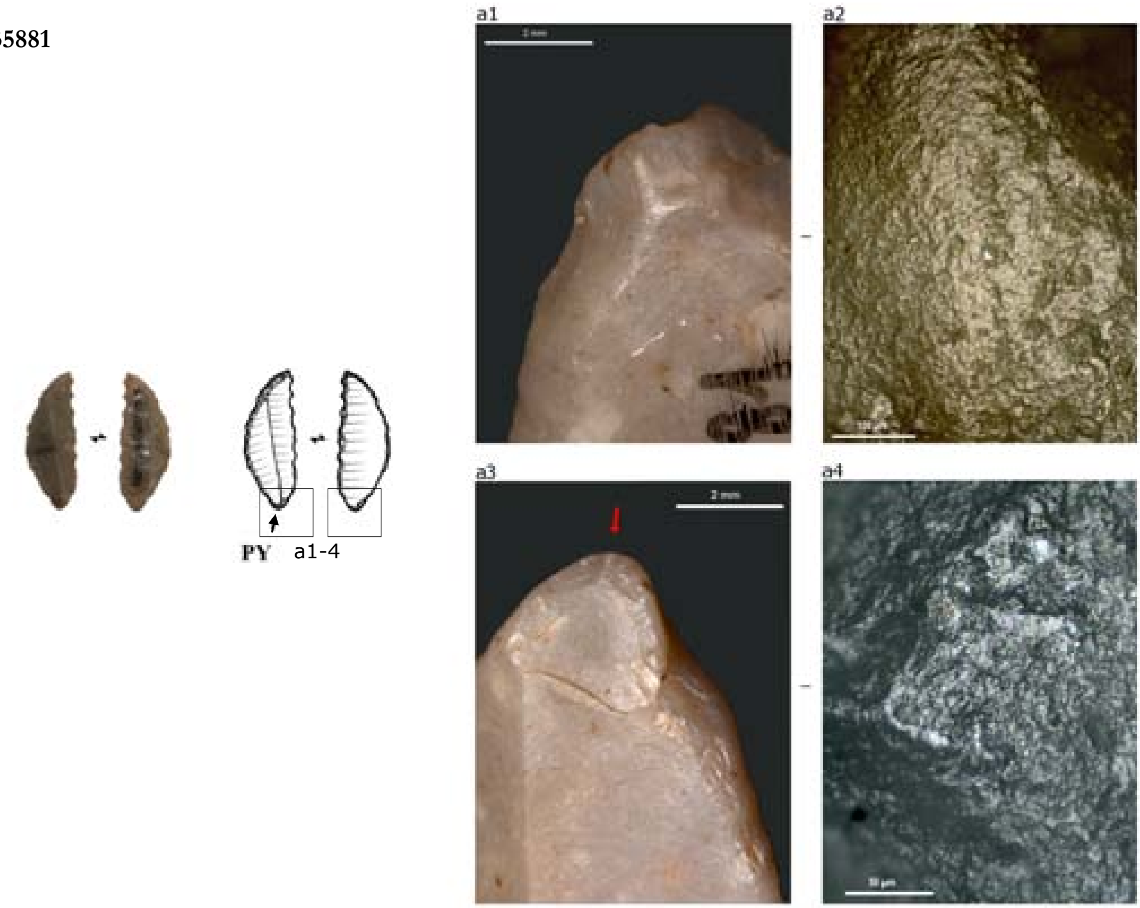

Fig. 5.16. Use-wears from the Cova de Els Trocs, Phase I. **35881-** Geometric tool used as projectile tip and, later, retooled as borer; *a1-2*) Ventral face: *a1*) Stereoscopic view of the rounded tip, 10X; *a2*) Microscopic view, 200X. Bright polish with striations all over the rounded tip; *a2-3*) Dorsal face: *a3*) See the presence of a previous bending-step fracture on the same tip 15X. Also note the presence of small bifacial scars all over the tip produced by the second utilization as borer; *a4*) Bright spots produced by the contact with mineral grains, 400X.

preserved. Tools made on blades are generally narrow and flat (15-20 x 7-9 x 3-3.5 mm) (Fig. 5.16, *a-b*), while borers on flakes appear thicker and wider (20-28 x 7-32 x 7-8 mm) (Fig. 5.17, *c*).

Also by macroscopic observation, the implements appear heavily abraded (Fig. 5.17, *a1, b1, c1;* 5.16, *a1*). Points are flat and rounded, not really suitable for drilling. To this point, it is important to note that extreme rounding is one of the most characteristic wears caused by the contact with mineral substances (Gijn 1989; Torchy & Gassin 2010; *cfr*. Chap. 2, Par. 2.3.3.).

If one looks at the micro-traces, one can observe that all tools have some common features: the aspect of the polishes is generally rough; they are distributed over the entire tool with a significant concentration on the dorsal ridges; striations and other abrasive features are always present. However, the quantity, density, and dimensions of the striations are elements that vary considerably from one tool to another. Some tools appear very striated and abraded, with a density of tiny strias (Fig. 5.17, *a2-b2*), while other implements show more fluid and flat polishes (Fig. 5.16, *c2;* 5.17, *a2-a4*). According to recent experimental data (*cfr*.

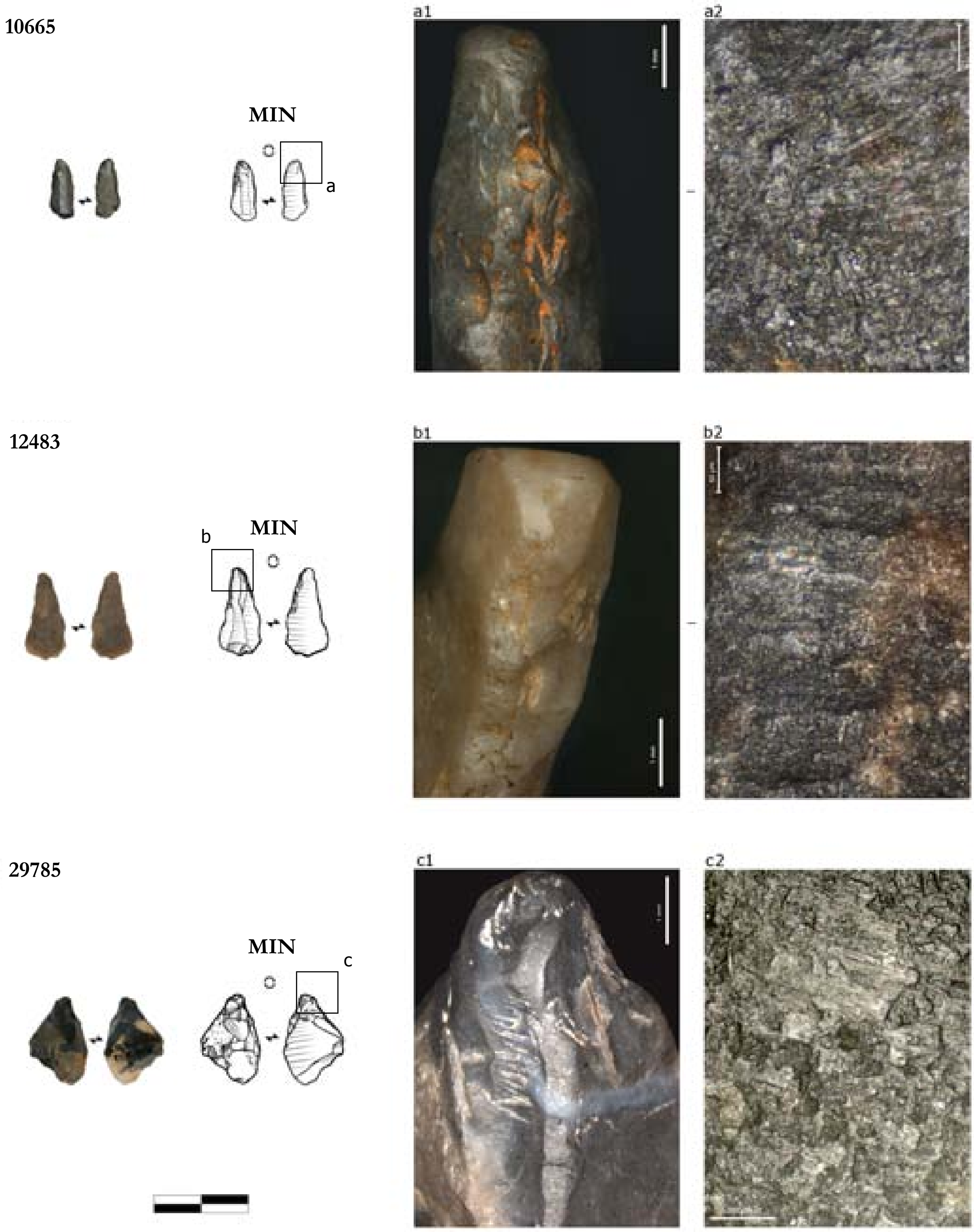

Fig. 5.17. Use-wears from the Cova de Els Trocs, Phase I. **10665-** Tool used for drilling pottery. *a1*) Macroscopic view, 20X. Note the pronounced tip-rounding and the presence of reddish residues; *a2*) Microscopic view, 400X. Chaotic strias produced by the contact with mineral materials. **12483-** Tool used for drilling pottery; *b1*) Pronounced edge rounding, 25X; *b2*) Bright polish with parallel strias, 400X. **28785-** Tool used for drilling pottery; *c1*) Macroscopic view, 20X. Note the pronounced tip-rounding, 20X; *d1*) Compact spots of mineral polish associated to dense striations, 200X

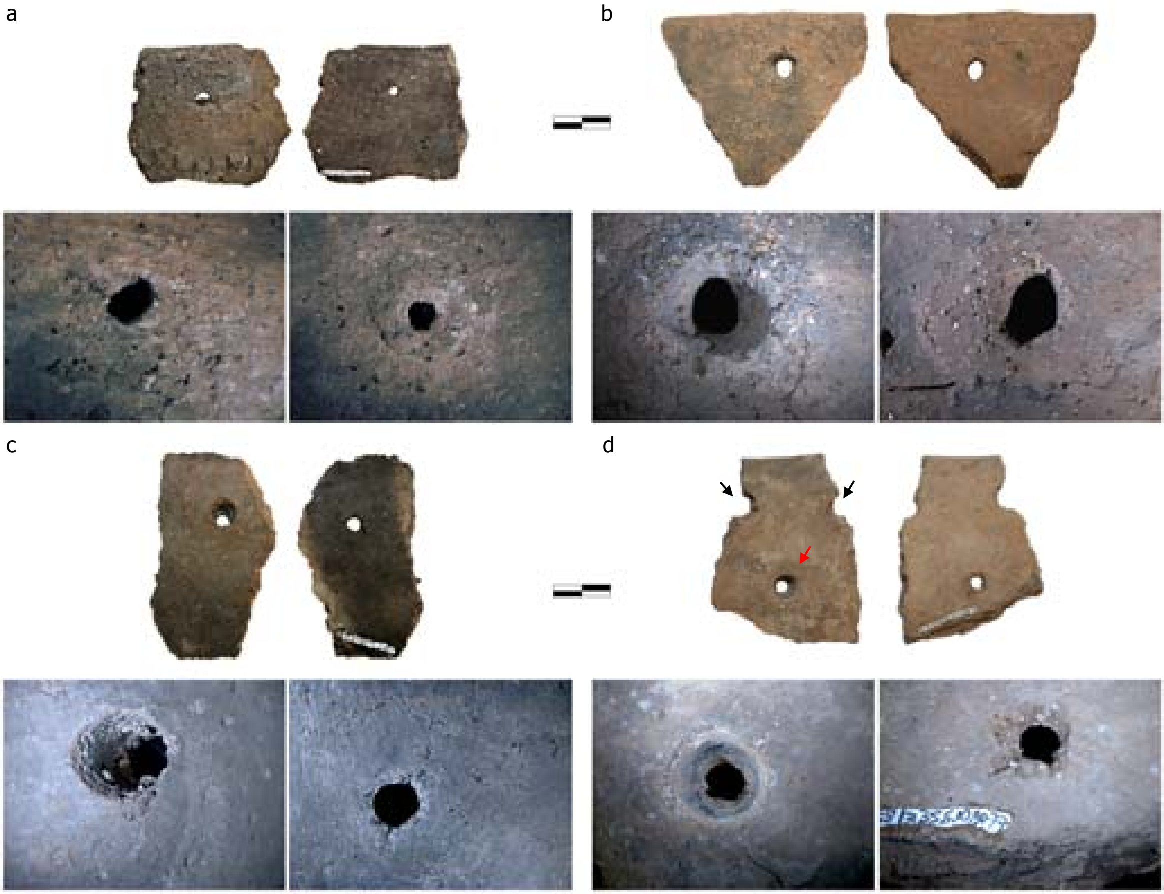

Fig. 5.18. Ceramic fragments with different types of perforations, from the Els Trocs assemblage. For each fragment both exterior and inner walls have been photographed: *a-b*) Perforations probably realized on fresh or green clay. Those perforations have been probably realized by pressuring the clay with a awls or a punch. Note the presence of a bulge in the interior wall; *c-d*) Perforations probably realized with a lithic borer on backed pottery. See the presence of concentric striation within the holes; Holes appears 'cracked' and no bulge is visible. The black arrows indicate decorative perforations (realized when clay was still fresh); the red arrow indicate the repairing perforation (realized after baking).

Chap. 2, Par. 2.3.3.), such differences can mainly be explicated as a result of a variation in the state of the worked matter. Indeed, a dry and abrasive matter tends to produce more striations and just a few polishes, while a wetter abrasive substance usually leaves smoother and flatter traces.

In the case of Els Trocs Cave, the hypothesis is that drilled materials were mainly ceramic vessels. Borers would have been used to drill fragments of broken vessels in order to repair them: the perforations would have served to fasten together the fragments with some kind of rope. In this case, pottery would have been drilled after firing, when it is very dry and resistant. However, it is possible, that occasionally, in order to facilitate the perforation of the vessel by the tool, a little amount of water was poured on the ceramic surface. Experimental works have confirmed such a hypothesis (*cfr.* Chap. 2, Par. 2.3.3.).

It is important to remark that the ceramic assemblage from Cova de Els Trocs is characterized by a high number of fragments with perforations. Some of those perforations were made before firing the vessel. Indeed, if one looks at the internal walls of those holes, one can notice that their surfaces are flat, as if they were produced only by pressing and not drilling the ceramic wall (Fig. 5.18, *a-b*). On the contrary, a high number of perforations show the presence of circular concentric striations (Fig. 5.18, *c-d*). In those cases, only lithic tools appear able to produce such traces. Moreover, while the former perforations are generally located near the edge of the vessel, often with a regular distribution (see the ceramic fragments in Fig. 3.15, *a* and *c*), the latter appear isolated, with an irregular distribution over the ceramic surface, occasionally poorly made. The main hypothesis is that perforations made on fresh clay were decorative motifs or functional elements for suspending the vessel, while post-firing perforations may be ascribed to the repair of broken ware. The former were probably made by means of proper tools (maybe bone or wooden awls), while, for the latter, a lithic borer probably served the purpose.

Other uses, that is, drilling bones, shells, or stone materials, in order to produce beads or other ornamental elements, have not been detected at Els Trocs Cave.

5.4.2.1.4. Projectile Elements

Projectile inserts amount to five elements (*n.* 5; 12.8%) (*n.* 5 AUAs; 10.2%). All of them are geometric tools: three segments and two isosceles trapezoids. However, I have to remark the presence of two additional implements, namely, lunate segments that did not show any traces of use. All of those tools result to have been made on blade blanks (whenever the original blank is determinable), shaped by steep retouch (Fig. 5.16, *a*; 5.18, *a-b*) or flat retouch (Fig. 5.19, *a-b*). The various lithologies appear to have been used for producing them: Ebro chert types prevail, but also Tremp and Agua Salenz cherts were employed. In terms of dimensions, they are always microlithic items, measuring 17-24 x 9-13 x 2-3 mm. Only one element is slightly bigger than the others: it is a segment of 30 x 15 x 3 mm shaped by bifacial flat retouch, a typical morphology of the Iberian Cardial Neolithic period, also called '*segmento de doble bisel*' (Alday 2009; Utrilla et al. 2009).

Detected macro-traces are bending-step fractures (Fig. 5.16, *a3;* 5.19, *a1, a3*), spin-off (Fig. 5.20, *a1*) and burin-like fractures (Fig. 5.18, *b1-c1*). Such traces are always located on one and only one of the two extremities of the microliths, often covering both dorsal and ventral faces. MLITs have been observed on two implements which presented a better preservation of the surfaces (Fig. 5.19, *a2, a4;* Fig. 5.20, *a2*). Such linear streaks start from the edge fractures themselves, with a directionality perpendicular to the axis of the tool, this suggesting that those elements were mainly employed as projectile points.

Recent studies on the faunal assemblage from Els Trocs Cave (Rojo et al. 2014) suggest that wild species had a marginal role in the economy of the site. Hunted animals were mainly roe deer, red deer, and wild boar, in all the cases represented by few bone fragments. This scenario substantially confirms the data emerged from the archaeozoological analyses of other contemporary sites of the region such as Cueva de Chaves in the Sierra de Guara (Castaños 2004), Cova Colomera in the Alta Ribagorça Basin (Oms et al. 2008, 2013), and Bauma Margineda in Andorra (Guilaine & Martzluff 1995). Moreover, similar results have also been obtained at Cova del Mirador in the Sierra de Atapuerca (Martín et al. 2009) and at the lacustrine settlement of La Draga in Catalonia (Saña 2011).

In the context here concerned, the presence and use of microliths do not seem to reflect any systematic and intensive hunting. Quite the contrary, arrowheads and similar tools were probably carried by Neolithic populations as part of their personal gear. It is not a case that most of them were made out of exogenous chert types, a fact that suggests an off-site production. Trapezoids and segments could be used for either defence or occasional hunting.

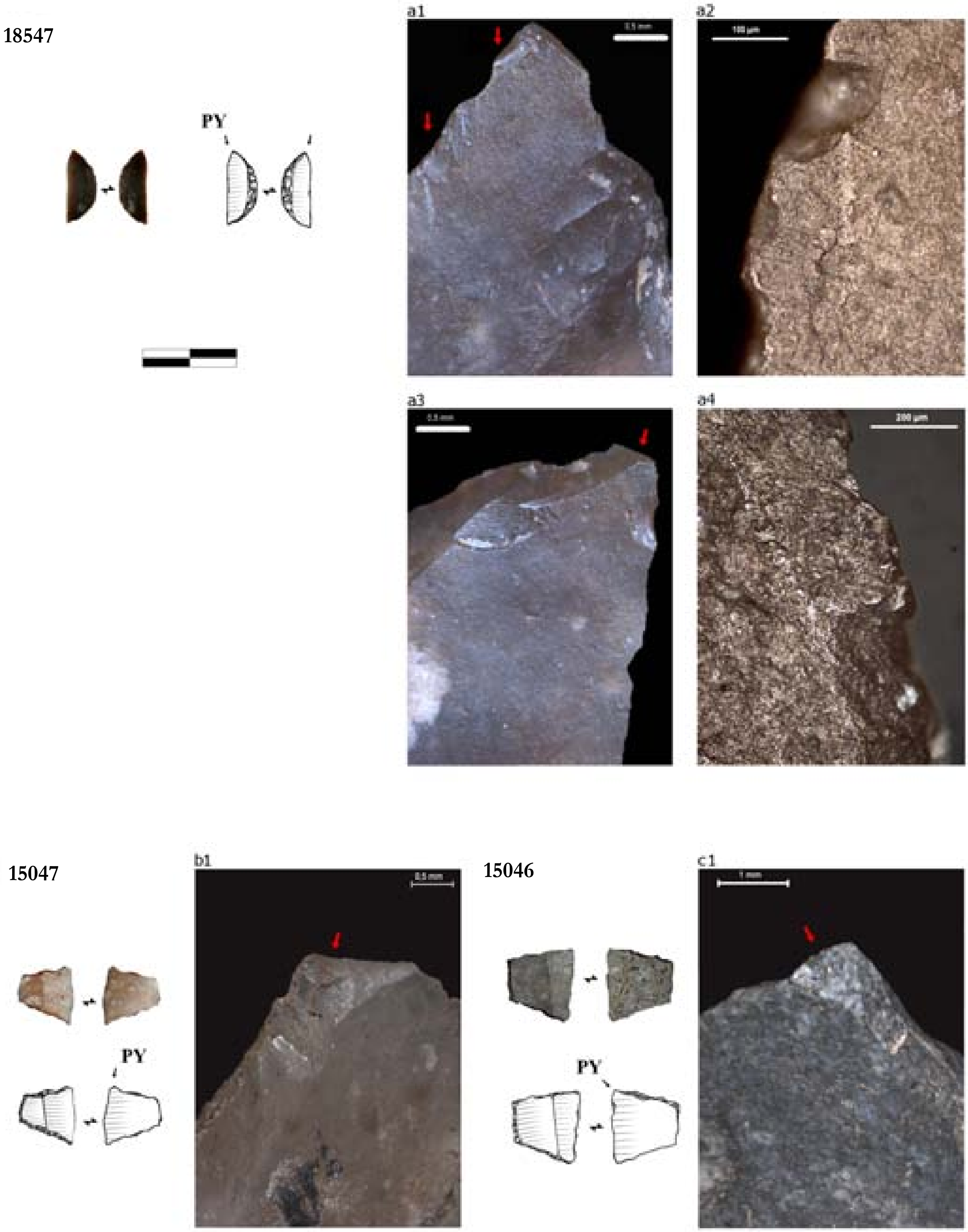

Fig. 5.19. Use-wears from the Cova de Els Trocs, Phase I. **18547-** Tool used as projectile tip; *a1-2*) Ventral face, macro- and microscopic wears: *a1*) Bending-step fractures on the tip, 30X; *a2*) MLIT on the ventral face with parallel orientation in respect to the tool's axis; *a3-4*) Dorsal face: *a3*) Bending-step fractures, 30X; *a4*) MLIT on the dorsal face. **15047-** Tool used as projectile tip; *b1*) Burin-like fracture on of the tip of the tool, 30X. **15046-** Tool used as projectile tip; *c1*) Burin-like fracture on the tip, with diagonal orientation, 15X.

1544

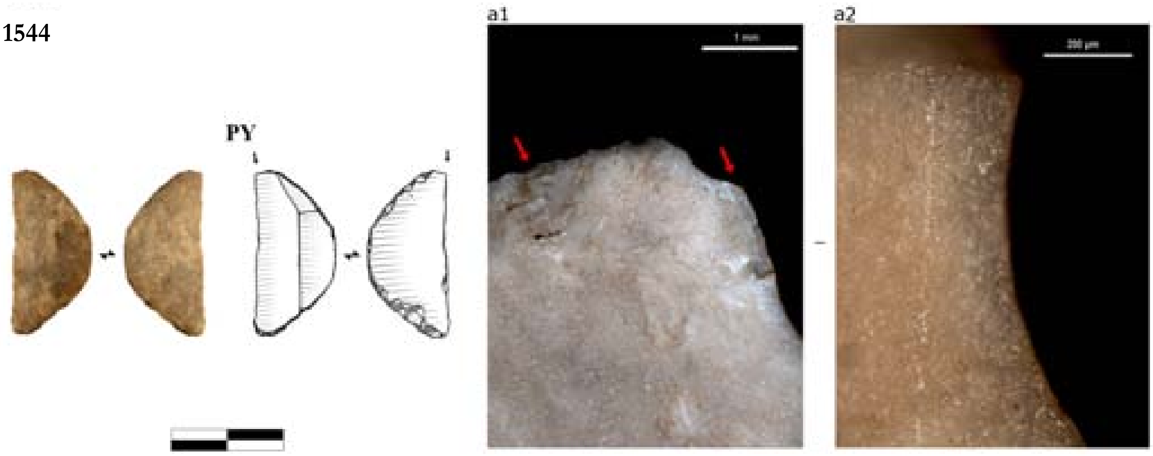

Fig. 5.20. Use-wears from the Cova de Els Trocs, Phase I. **1544-** Tool used as projectile tip. *a1*) Macroscopic view, 15X. Bending overlapping fractures; *a2*) Microscopic view, 100X. MLIT with parallel orientation in respect to the tool's axis.

The faunal record of Els Trocs Cave seems to show a great variety of species that may have been object of an occasional foraging and not necessarily for food. Apart from large ungulates such as *Capreolus capreolus*, *Cervus elaphus*, or *Sus scrofa*, microliths (especially the small trapezoidal shapes) (Unger-Hamilton 1988; Gibaja & Palomo 2004) could be employed for hunting small mammals or even birds.

5.4.2.1.5. Indeterminable Substances

This category includes all those tools for which it has not been possible to determine the worked matter, although an intentional use has been ascertained. In these cases, I have classified the contact materials based on their hardness: materials of soft-medium hardness (*n.* 3; 7.7%) (*n.* 3 AUAs; 6.1%) and resistant or hard materials (*n.* 6; 15.4%) (*n.* 8 AUAs; 16.3%). Functional determinations have mainly derived from macro-wear patterns, being micro-traces absent or poorly visible.

Tools associated with *soft/medium materials* are two blades, both very thin and narrow blanks (32-58 x 9-11 x 2-3 mm), and one flake (45 x 24 x 5 mm). Observed macro-traces mainly consist of a succession of small scalar fractures associated with a limited edge rounding (Fig. 5.21, *a1-b1*). Such traces could be produced by working very soft materials, as meat or animal tissues, especially if activities were not prolonged. However, considering that post-depositional alterations can easily resemble such a type of evidence and being clear micro-traces absent, the interpretation of such tools remains uncertain.

The group of tools associated with *hard materials* includes a variety of different blanks and actions. For example, I have recognized a flake characterized by overlapping step-fractures on both proximal and distal edge and probably used as wedge (*n.* 1; 2.6%) (*n.* 1 AUAs; 2.0%)(Fig. 5.21, *c*). Such a kind of tool was often used for cracking open bones to extract marrow or also in wood-working activities; they are a typical instrument of the Meso-Neolithic inventory (Gibaja et al. 2006, 2007).

Three cores display traces of being employed for pounding/grinding activities (*n.* 3; 7.7%)

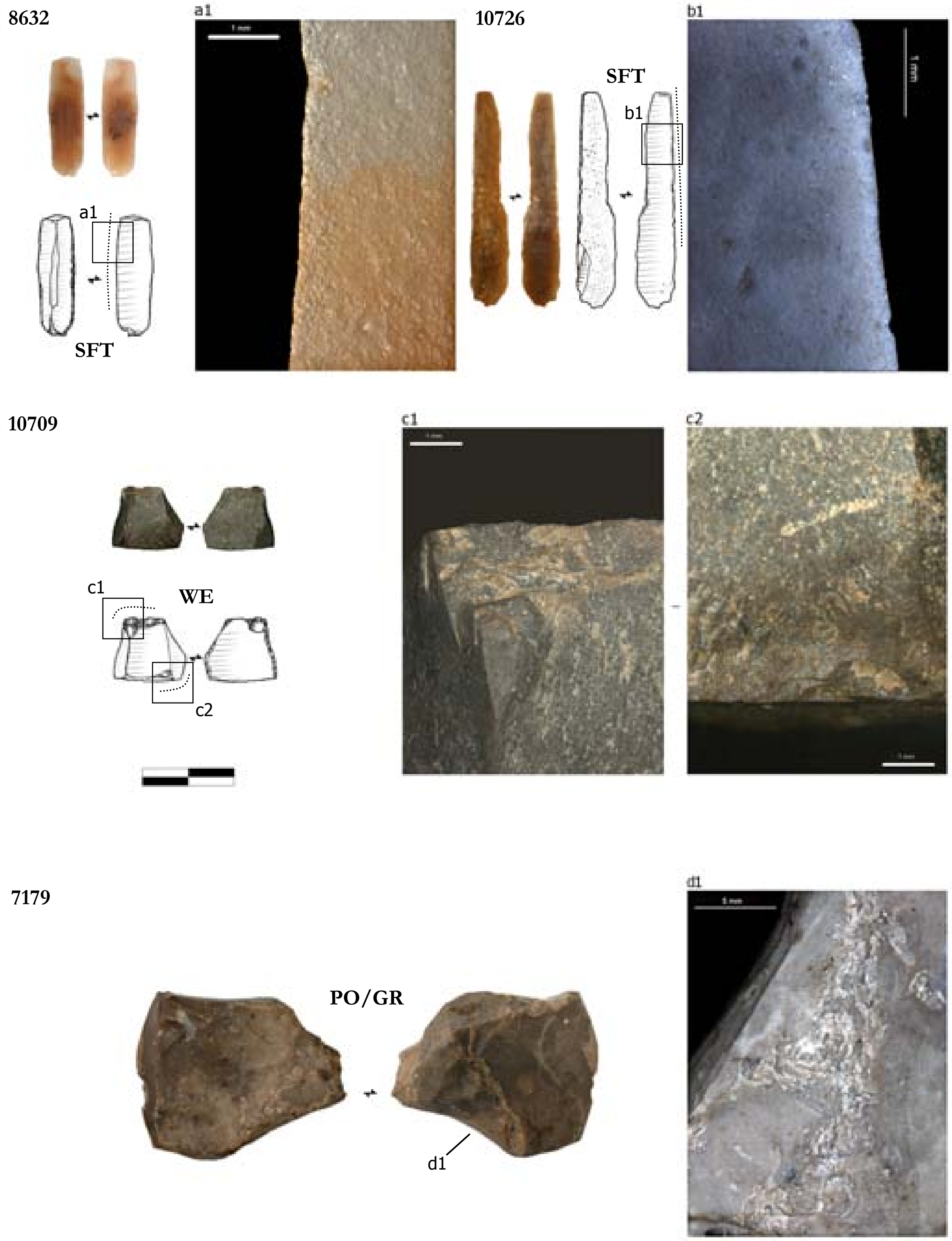

Fig. 5.21. Use-wears from the Cova de Els Trocs, Phase I. **8632-** Tool used for cutting soft indet. substance; *a1*) Marginal edge-scarring associated to slight edge-rounding, 15X. **10726-** Tool used for cutting soft indet. substance; *b1*) Series of scalar feather-terminating fractures, 15X. **10709-** Tool used as wedge; *c1*) Overlapping step-terminating fractures on the distal edge, 20X; *c2*) Fractures on the proximal edge possibly produced by percussion, 20X; **7179-** Core used for pounding grinding activities; *d1*) Cracking and fracturing over the ridges of the core, 10X.

(*n.* 5 AUAs; 10.2%) (Fig. 5.21, *d*). The reuse of exhausted cores for grinding or pounding was also a common behaviour during the Neolithic Age. Such tools can be related to a variety of different activities such as vegetable-fibre processing, mineral-substance crushing, cracking hard animal materials, *etc*. However, the absence of diagnostic wears does not allow any detailed interpretation of their function to be achieved.

Finally, I have ascertained the presence of a retouched flake, possibly used for drilling some indeterminable hard material (*n.* 1; 2.6%) (*n.* 1 AUAs; 2.0%), and one fragment of a polished instrument (*n.* 1; 2.6%) (*n.* 1 AUAs; 2.0%).

5.4.2.2. Non-utilitarian Wears

5.4.2.2.1. Transportation Traces

As already mentioned above (*cfr*. Chap. 5, Par. 5.4.2.1.1.), some tools (*n.* 3) display traces which match those produced by transporting lithic tools in experimental tests. Such traces have only been identified on a particular category of elements; specifically, on long blades made out of exogenous chert types, which probably attest to foreign artefacts taken to the site already flaked.

The good state of preservation of the lithic surfaces made it possible to distinguish transportation traces from those brought about by post-depositional conditions. In fact, lithic surfaces have been scarcely affected by taphonomic processes such as soil weathering. Only a very superficial lustre is visible and, generally, edges and ridges appear fresh without evident rounding.

Observed transport wears are mainly isolated shiny spots (Fig. 5.12, *a3*) and striations (Fig. 5.11, *a3-a4*; Fig. 5.12, *a3*). According to experimentation (*cfr*. Chap. 2, Par. 2.3.2.) (Mazzucco & Clemente 2013), similar traces can be produced by the mutual friction between lithic implements tied together during transportation. Those traces are distributed quite randomly over the surfaces, with no clear directionality. Moreover, it is remarkable that, in the case of the observed shiny spots (Fig. 5.12, *a3*), such wears are located in the distal part of the tools that, on the basis of the use-wear distribution pattern, appears to be the active area. Therefore, the glossy spots do not seem to be related to hafting practices, but other factors probably influenced their formation. Considering the exogenous provenance of the implements, transportation practices represent a reasonable explanation.

5.4.2.3. Residues

Els Trocs Cave is characterized by a good preservation of organic matters as also shown by the large amount of residues on the lithic surfaces. Amongst those, a small group of residues (n. 11) present certain features that indicate that their deposition was not caused by natural processes. First of all, their distribution is not ubiquitous: they are generally more common on certain types of blanks (especially blades) and they are always limited to specific parts of the tools (not the active ones). Secondly, the post-depositional patinas (e.g. whitish or coloured spots), when present, cover lithic surfaces as well as residues, this suggesting that the deposition of residues occurred before discarding the lithic implement (Fig. 5.11, *a5*).

I have distinguished both macroscopic and microscopic residues. The former are macro-spots, often visible to the naked eye, generally characterized by dark-brown colours (Fig. 5.11, *a5*). The latter are microscopic spots with a greasy and roundish appearance (Fig. 5.11, *a6*). In both cases, I have related such evidence to hafting practices, namely, residues of resin or bitumen employed to attach the insert to the haft. Comparison with experimental tools

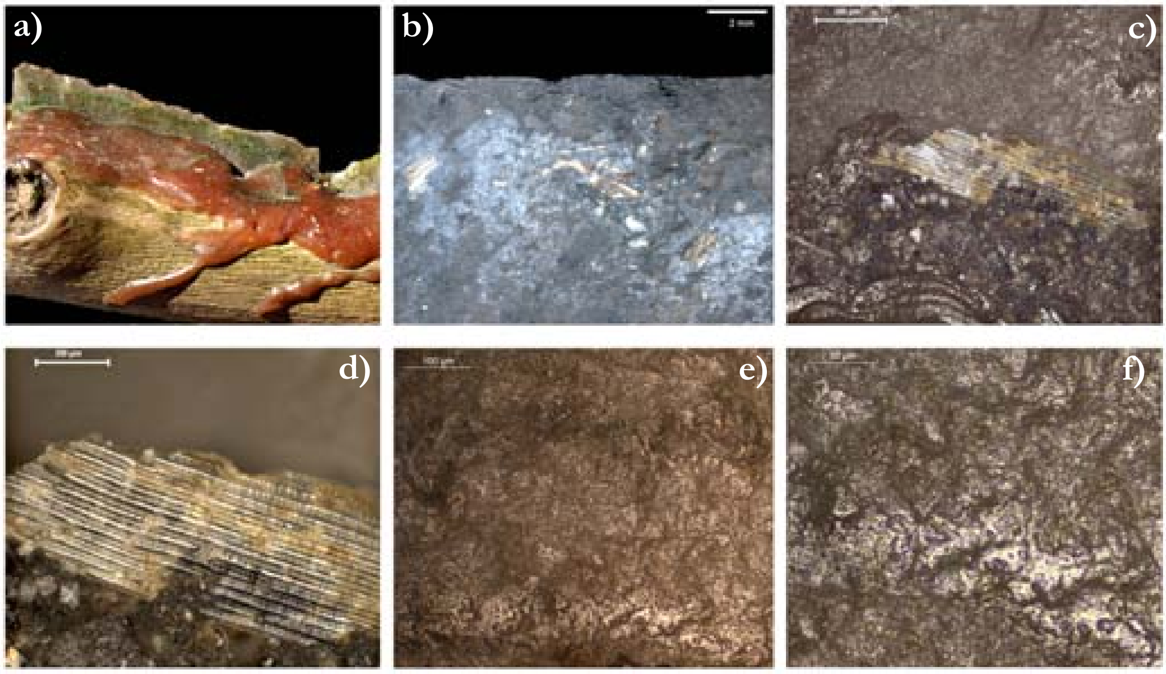

Fig. 5.22. Residues from an experimental tool used for harvesting wild plants: *a*) Lithic tools used for cutting wild plants: see the residues of plants all over the resin and the tool's edge; *b*) Macroscopic view of the edge after a superficial wash with water & soap, 15X; *c-d*) Microscopic view of the resin and the plant residue at 100X and 50X. See how the plant skeleton is attached on the residual resin. *e-f*) Microscopic view of a resin spot, 100X and 50X. See the greasy and roundish appearance.

seems to confirm such an interpretation (Fig. 5.22, *e-f*). Actually, it is quite common that residual resin spots remain stuck to the lithic surfaces. However, this observation should only be considered preliminary and more detailed analyses are necessary to confirm the nature of such residues.

Finally, one can also remark the presence of several reddish residues on the tips of the borers used for drilling ceramic materials (Fig. 5.17, *a-b*). Such residues are probably remains of the pottery itself. However, I am aware that a more detailed analysis should be carried out to confirm such an interpretation.

5.4.2.4. Discussion

The first traces of human presence at the Cova de Els Trocs are dated to between 5050 and 4930 cal BC. During this period of about 100 years, the cave was characterized by several and recurrent occupations that have yielded a variety of archaeological remains. Among those, the main structures are represented by large drainage floors composed of hard-packed stones and crushed potsherds (Fig. 5.5). The construction of such pavements was likely a solution for the high humidity in the cave, which must not actually have been a particularly suitable room for living, considering that temperatures ranged from 6 to 8 °C all year round (Rojo et al. 2014).

Most of the lithic materials and, generally, the majority of the finds at Trocs I come directly from such floors. Actually, if one observes their distribution, 75% of the assemblage has been recovered from the very pottery-stone layers, while 12% has been found in pits and hearths associated with these. Lithic production is essentially featured by two main groups: the local materials, which were more intensively flaked on-site and that result in a small production of flakes and blades, and the exogenous ones, which were in part small preforms taken to the site and flaked there and in part items transported to the site in the form of finished blanks.

In terms of function, the main difference between the two manufactures is that, while local materials were only employed for 'domestic activities' —which likely took place inside the cave, such as butchering or works associated with the maintenance of ceramic vessels—, exogenous materials served a larger number of purposes, amongst which activities that were probably carried out outside the site, such as hunting or herbaceous-plant harvesting. This difference can be explained by interpreting the flaking of local materials as a secondary production, which aimed at integrating the exogenous items, once these were exhausted or destined to other activities. In this respect, it is important to remark that local chert types are of poor quality, therefore not suitable for manufacturing large tools, especially laminar tools, and so the use of them for knapping plausibly required more effort than other more compact chert types did. On the other hand, exogenous materials (mainly Ebro-Basin chert types) were largely availed of to produce 'formal' artefacts, like harvesting tools and projectile inserts. Such instruments generally lasted longer; they were often transported over long-medium distances and employed far away from their production site. They can be considered part of the 'Neolithic personal gear'.

If one looks at Els Trocs' assemblages' range of functions, the main aspect to remark is the scarcity of craft activities. The number of relevant items is very low. Most of the tools were employed for every-day works like butchering practices and those related to keeping the domestic room. There is no evidence at all of any complex manufacturing process. For example, hide working, vegetable-fibre processing, or hard-material working (such as bone and antler) are absent or anecdotal. Even about pottery, the performed activities result to have been connected with vessel repairing only, whereas those relevant to their manufacture and decoration are missing.

If one compares this data with information proceeding from other disciplines, some considerable remarks can be made. The archaeozoological analyses of the Trocs I faunal assemblage suggest that the site was specialized in farming sheep and goats for the production of meat and, secondarily, milk (Rojo et al. 2014). In this respect, the extraordinary abundance of ceramics recovered at the site (especially during Trocs I) may be associated with the storage and preservation of the relevant products. It is important to point out that the cave, as it was characterized by low temperatures and humid conditions, was a natural fridge, an ideal environment for keeping perishable stuffs. Future analyses of residues from potsherds recovered at Els Trocs Cave may confirm such a hypothesis. Recent studies on the faunal assemblage of La Draga, in the NE of Catalunya, in fact, suggested that dairy farming existed in the region as early as the Early Neolithic Age (Tarrús 2008; Saña 2011).

This scenario is substantially confirmed by the analysis of paleoenvironmental samples collected in the surroundings of the site. The study of sedimentary records from the Dolina Selvaplana, situated a few kilometres away from the cave, bears evidence of a strong soil erosion and sediment deposition that occurred around 5600-5300 cal BC, at the same time (or slightly earlier) as the first occupations of the cave. Such phenomena can be associated with anthropogenic fires and forest clearance, which aimed at creating new pasture areas (Uria 2013).

In conclusion, all the data achieved indicates that Trocs I was a settlement specialized in animal farming. Therefore, it is not surprising that craft processes were limited and that the activities, which took place inside the cave, mostly concerned the upkeep of the domestic room. Also the tools associated with harvesting activities give the impression of not being connected with agricultural works. On the contrary, the gathering of plants may speak of a variety of non-food-oriented purposes, such as the creation of bedding layers, these being suggested for numerous caves of the period (Angelucci et al. 2009; Mazzucco et al. 2014; Lancelotti et al. 2014). Cereal seeds may have been transported to the cave from nearby areas or other sites as foodstuffs for integrating the diet, whereas their presence would not necessarily prove cultivation in the areas around the cave. The absence of well-developed sickle tools amongst the finds from Cova de Els Trocs may support such an interpretation.

Finally, hunting can be considered a marginal practice, too. According to the number of domesticated animals slaughtered at the site, wild species must have represented no significant contribution to the diet, so that other, not strictly food-supply-oriented, reasons may have brought to the use of arrowheads.

5.4.3. Trocs II

The lithic assemblage from the second phase of occupation of Els Trocs Cave is comprised of 85 elements. More than one-third of them (*n.* 34; 40%) display traces of being intentionally used or modified by human actions. Use-wear traces have been recognized on 27 tools (31.8% of the whole assemblage), corresponding to 33 active zones. Amongst these, 21 implements show only one active zone, while 6 elements are characterized by two different areas of use. Non-utilitarian traces are absent, while a high number of tools have revealed the presence of macroscopic residues (*n.* 7; 8.2% of the total assemblage).

In terms of interpretation, in 57.6% of the cases, it has been possible to get a full understanding of the use-wears, while, in the remaining cases, the interpretation has been defined as probable (27.3%) or possible (15.2%) (Tab. 5.7).

5.4.3.1. Use-Wears

5.4.3.1.1. Vegetal Substances

Tools related to the working of vegetable substances represent the most numerous group of the analysed sample (*n.* 12; 40.7%) (*n.* 16 AUAs; 4.5%). In this category, the majority of implements are associated with longitudinal-movement actions relevant to harvesting *no-ligneous plant materials* (*n.* 10; 25.6%) (*n.* 13 AUAs; 26.5%) (see Tab. 5.11 at the end of the chapter). In this group, I have ascertained the presence of seven blades and three flakes.

Most of the blade blanks are fragmentary, apart from one implement, a small blade of four centimetres in length. The other dimensions range between 15 and 20 mm in width and 3 and 4 mm in thickness (Fig. 5.24, *b*). All of them were made out of exogenous chert materials, mainly from the Ebro Basin and, in two cases, from the Tremp Basin in the pre-Pyrenees. Blanks result to have been poorly retouched and used without previous modifications. All of them were employed for longitudinal-movement (harvesting) activities. Moreover, three elements were employed on both sides, while the remaining one shows just one active edge.

Observed polishes are always marginal, forming a narrow band along the active edge and gradually disappearing below the surface (Fig. 5.23-5.24). Moreover, the presence of post-depositional alterations has at times made the interpretation of the wear a little complicated. In fact, most of the polishes appear somewhat degraded, with a rough aspect and a patchy texture, with few spots of plant polish still preserved. In some elements, this may also be explicated as a direct consequence of the specific type of use: the employment of the tool for cutting plants to ground level (Fig. 5.23, *b*). In those cases, the observed roughness is due to the abrasive action of the sediment particles rather than to the effects of taphonomic agents. However, the presence of abundant residues of plant materials (i.e. plant skeletons) seems to confirm that such tools came into contact with herbaceous plants. Moreover, those plant skeletons are often associated with spots of resin or bitumen, probably in relation to hafting tools (Fig. 5.23, *a3-4*; Fig. 5.24*, a3-4*). In experimental tests, it is evident that such residues tend to favour the adhesion of the resin present on the haft to the lithic surfaces (Fig. 5.22, *c-d*). Finally, one has to remark the absence of clear and well-developed sickle tools. These tools were probably employed for gathering herbaceous plants, but not in relation to prolonged agricultural activities.

About the three flakes, they appear to have mainly been used for short activities connected with plant working (Fig. 5.25, *a-b*). All of them were employed using only a small

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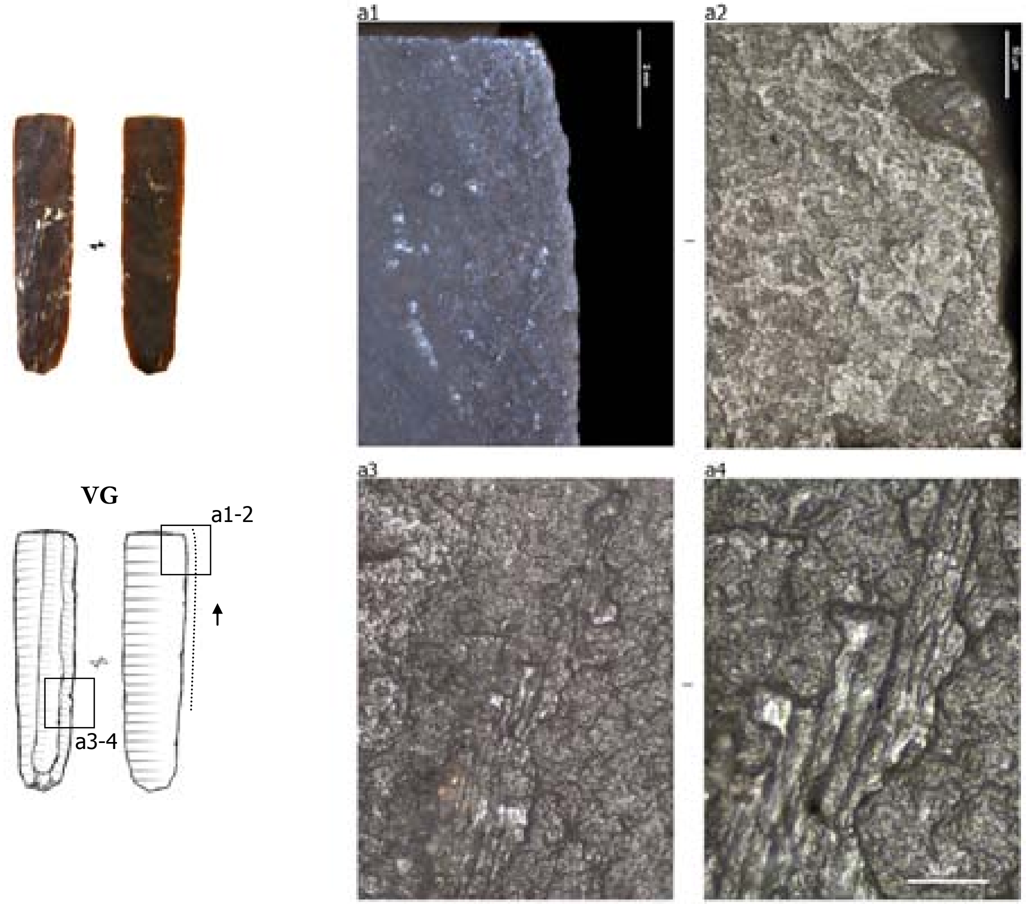

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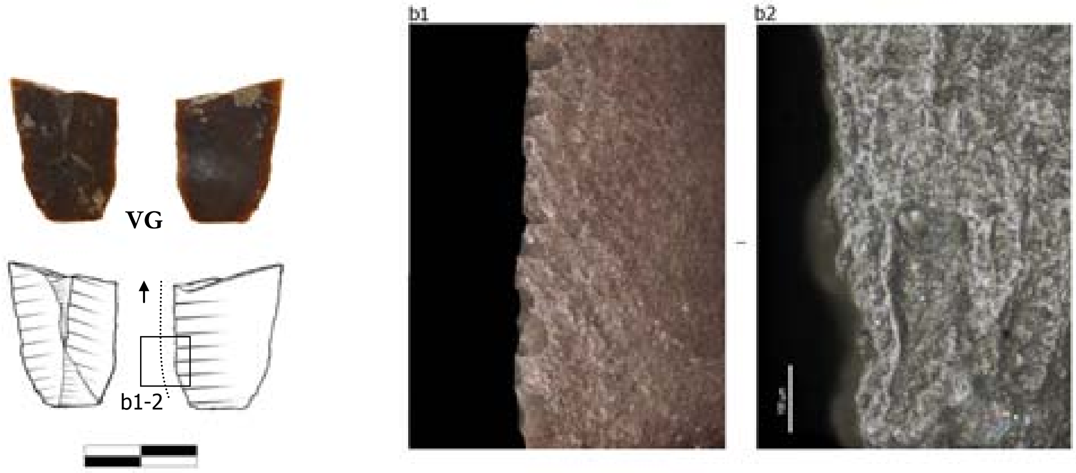


Fig. 5.23. Use-wears from the Cova de Els Trocs, Phase II. **7742-** Tool used for harvesting herbaceous plants, altered polish. *a1*) Macroscopic view, 10X. Slight lustre over the active zone; *a2*) Microscopic view, 200X. Plant polish appears strongly altered; *a3-4*) Plant residue (plant skeleton) attached to the lithic surface, 200X and 400X. **17743-** Tool used for harvesting herbaceous (RV2); *b1*) Marginal edge scarring, 15X; *b2*) Plant polish with abrasive component, 200X.

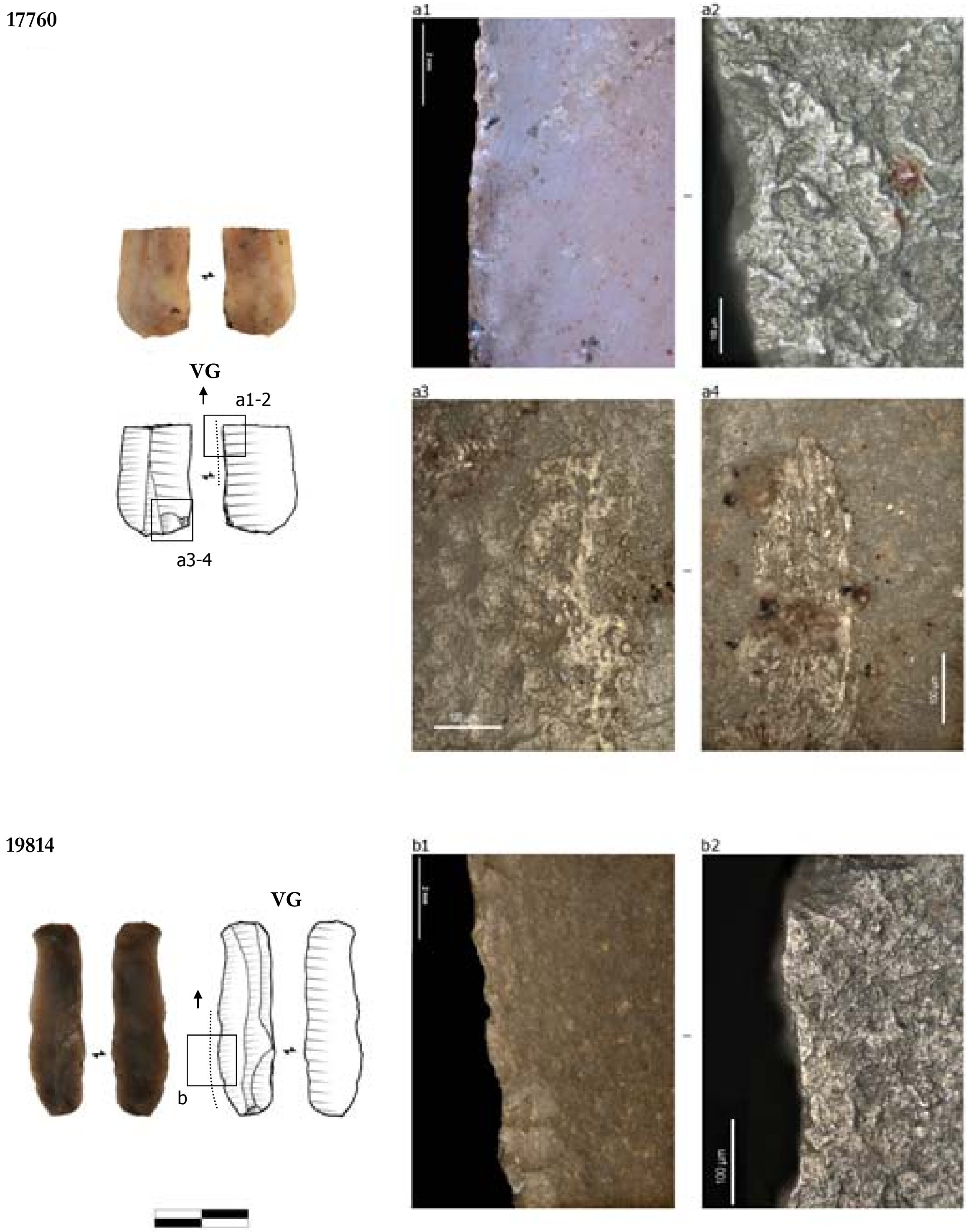


Fig. 5.24. Use-wears from the Cova de Els Trocs, Phase II. **17760-** Tool used for harvesting herbaceous plants, slightly altered polish. *a1*) Macroscopic view, 10X. Marginal edge-scarring; *a2*) Microscopic view, 200X. Smooth spots of plant polish; *a3*) Spot of resin from the haft, 200X. See the greasy and roundish appearance; *a4*) Plant skeleton attached to the tool's surface. **19814-** Tool used for cutting herbaceous plant, altered polish; *b1*) Edge scarring, 15X; *b2*) Residual spots of plant polish on the very edge, 200X.

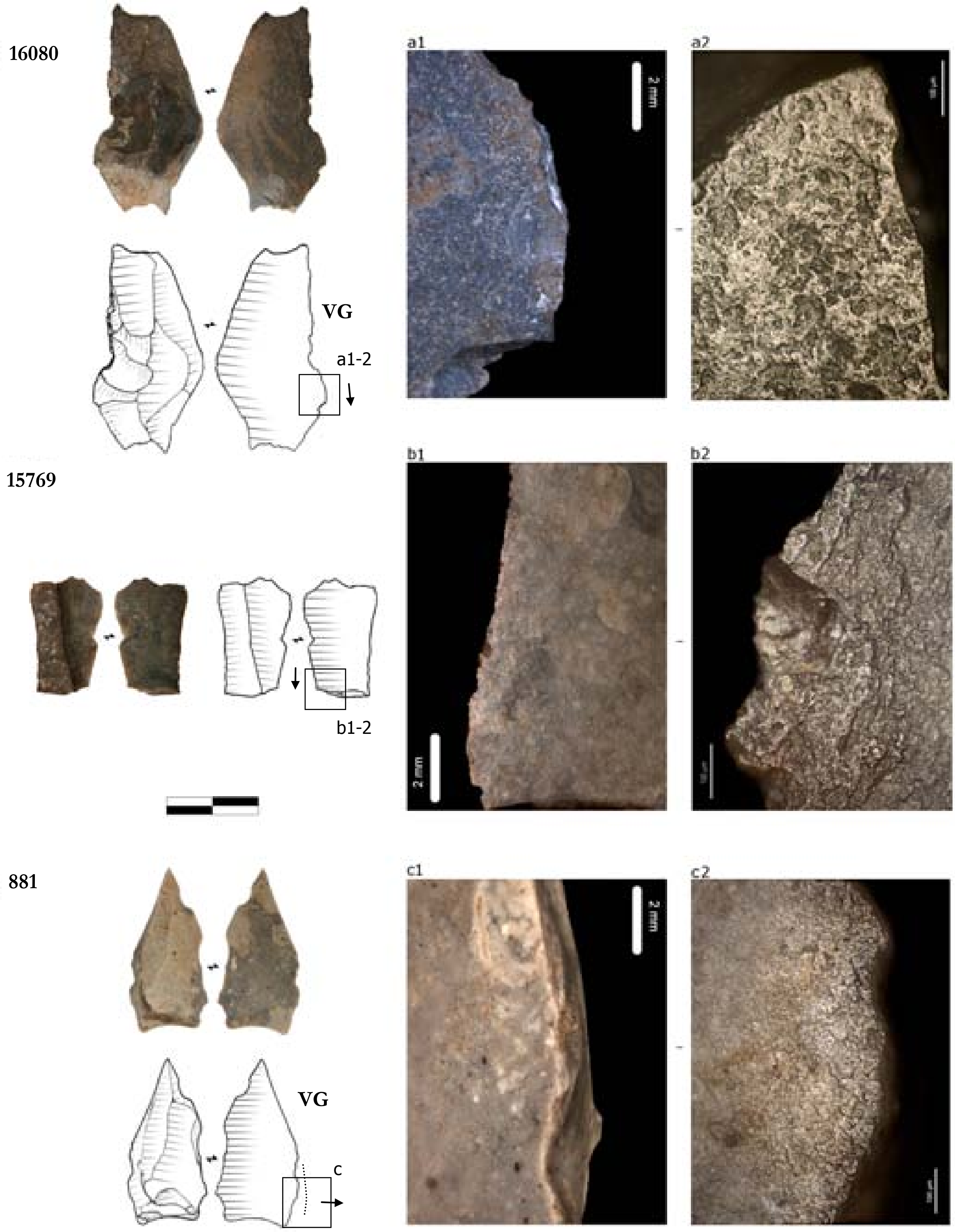


Fig. 5.25. Use-wears from the Cova de Els Trocs, Phase II. **16080-** Tool used for working plants, slightly altered polish. *a1*) Macroscopic view, 10X. Marginal edge-scarring; *a2*) Microscopic view, 200X. Slightly altered plant polish; **15769-** Tool used for cutting vegetal substances; *b1*) Macroscopic view, 10X. The tool is heavily burned and only a residual portion of the active edge is visible; *b2*) Residual spots of plant polish on the very edge, 200X. **881-** Tool used for scraping plants; *c1*) Active edge, 10X; *c2*) Plant/wood polish with transversal directionality.

portion of the edge, usually the distal end. Polishes are reduced in terms of extension and development. Considering this pattern, one possible hypothesis is that such tools were used at some stages of plant processing, possibly in relation to basketry processes.

Three more instruments show traces of having worked *indeterminable vegetable materials* (*n.* 3; 11.1%) (*n.* 3 AUAs; 9.1%). Two of them show traces of having performed transverse movements, specifically for scraping vegetable materials such as herbaceous plants or soft woods (Fig. 5.25, *c*). One last element, characterized by a diffuse white patina all over its surface, shows degraded polishes caused by longitudinal movement to work some kind of vegetable substance. However, the use-wears' poor state of preservation cannot bring to any more detailed interpretation.

5.4.3.1.2. Animal Substances

Tools related to animal substances amount to seven implements (*n.* 7; 25.9%) (*n.* 8 AUAs; 24.2%). All of them were used in *butchering activities*. Both flakes and blades were employed. They are generally small implements: flakes around 27-32 x 21-27 x 6-7 mm and blades, all fragmentary, ranging between 7 and 10 mm in width and around 1-3 mm in thickness. Traces can be related to meat processing and fresh-hide cutting. Tools are characterized by edge rounding, with abrasions and a moderate scarring on the edge; polishes have a rough aspect, showing a dispersed distribution and a patchy texture (Fig. 5.26, *a-c*).

As already noticed for Trocs I, also in the second phase of occupation the faunal record is very abundant and mainly indicates the exploitation of *Caprinae* species, which dominate the animal assemblage as they represent 87% of it. The kill-off pattern shows a slight change compared to Phase I, with a decrease in the ratio of infant individuals (0-6 months old) and an increase in young individuals (8-18 months old). However, the general pattern of exploitation seems to have substantially remained unvaried, having been oriented towards the slaughter of young animals for producing meat (Rojo et al. 2014).

5.4.3.1.3. Mineral Substances

Three tools are associated with the working of mineral substances (*n.* 3; 11.1%) (*n.* 3 AUAs; 9.1%). One of them is a distal fragment of borer, characterized by a heavy rounding of the tip (Fig. 5.27, *a1-b1*). Microscopically, striations due to the contact with mineral material have been observed (Fig. 5.27, *a2-b2*). Probably the borer was used for *repairing pottery*, as already observed for Trocs I. The other two implements show traces associated with the working of *indeterminable mineral substances*, one for cutting and the other for scraping. However, wears are not enough developed to determine the type of worked material.

5.4.3.1.4. Projectile Elements

Only one projectile insert has been identified amongst Trocs II assemblage (*n.* 1; 3.7%) (*n.* 1 AUAs; 3.0%). It is a *doble bisel* segment characterized by the presence of bifacial step-terminating fractures, which suggest the use of it as arrowhead (Fig. 5.27, *b1-2*). A fragment of a possible backed blade has also been identified; however, no diagnostic impact traces have been detected.

Faunal data for Trocs II Phase indicates that wild species did not have an important role in the cave's economy, this fact confirming the same pattern of exploitation observed for Trocs I (Rojo et al. 2014). Hunting then probably represented a marginal and occasional activity.

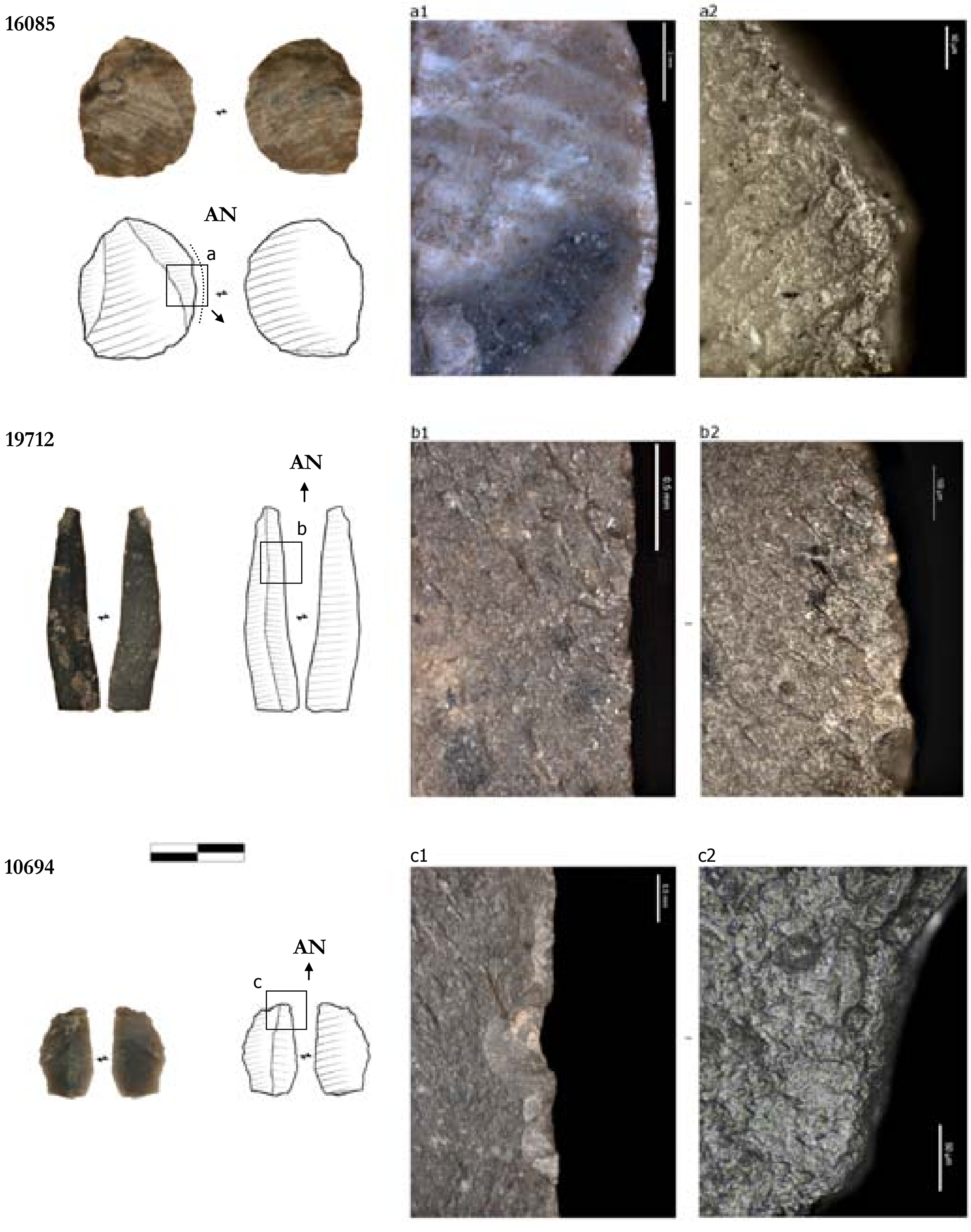


Fig. 5.26. Use-wears from the Cova de Els Trocs, Phase II. **10685-** Tool used for working soft animal substances; *a1*) Macroscopic view, 10X. Scalar fractures associated to edge-rounding; *a2*) Microscopic view, 200X. Rough marginal animal polish; **19712-** Tool used for working soft animal substances; *b1*) Macroscopic view, 10X. Marginal edge scarring, 10X; *b2*) Marginal greasy polish, 200X. **10694-** Tool used working soft animal substances; *c1*) Edge rounding associated to marginal scarring, 30X; *c2*) Rough marginal polish associated to pronounced edge-rounding (fresh hide?), 400X.

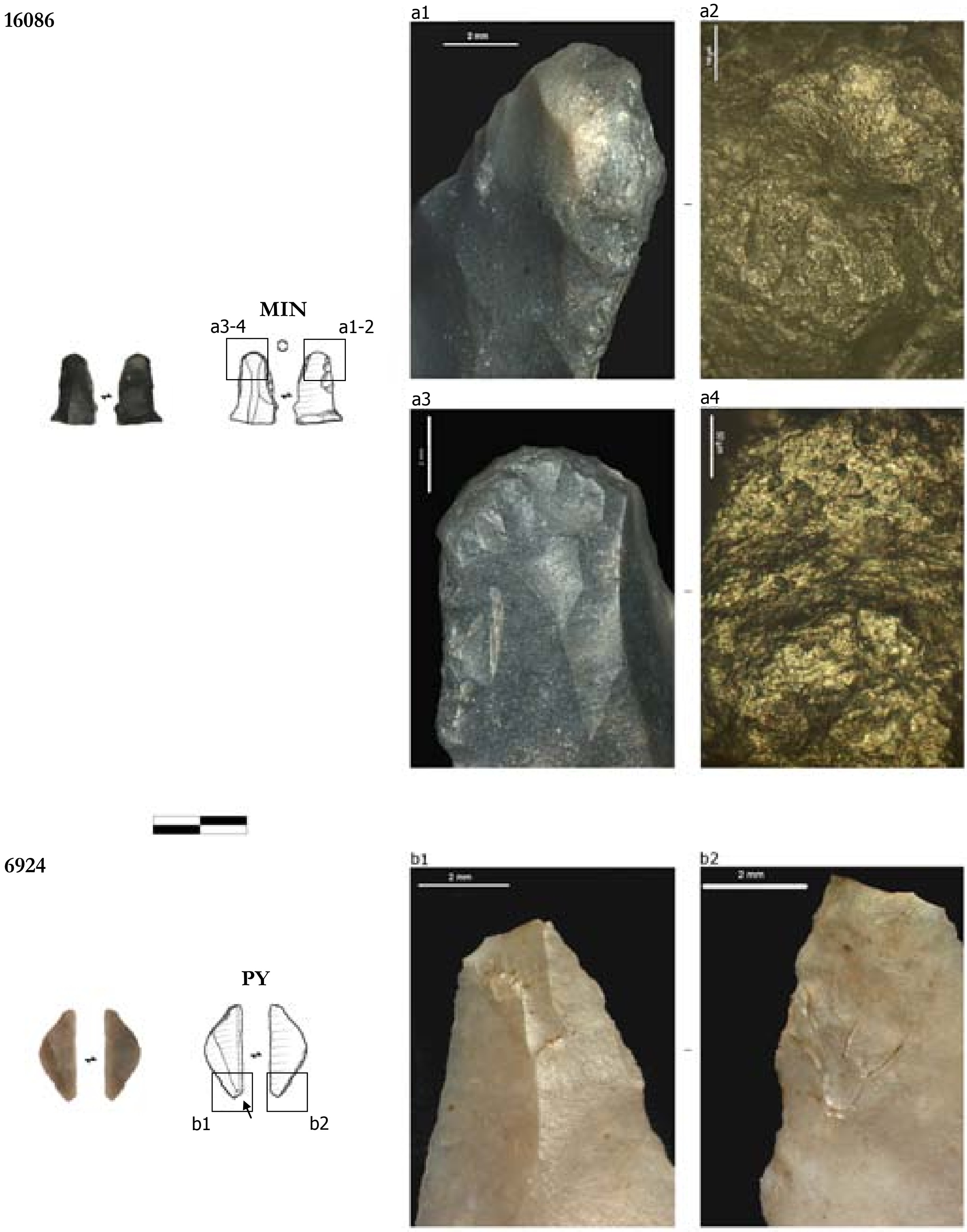


Fig. 5.27. Use-wears from the Cova de Els Trocs, Phase II. **10686-** Tool used for drilling pottery; *a1-2*) Ventral face: *a1*) Macroscopic view, 15X. Pronounced edge-rounding associated to bifacial micro-scarring; *a2*) Microscopic view, 200X. Rough polish all over the tip; *a3-4*) Dorsal face: *a3*) Macroscopic view, 15X. Pronounced edge-rounding; *a4*) Spots of mineral polish, 400X. **6924-** Tool used as projectile tip; *b1*) Dorsal face: burin-like fracture associated to small spin-off fractures, 25X; *b2*) Ventral face: invasive bending fractures, 25X.

5.4.3.1.5. Indeterminable Substances

There are four tools associated with *soft indeterminable materials* (*n.* 4; 14.8%) (*n.* 5 AUAs; 15.1%), specifically, three blades (32-58 x 9-11 x 2-3 mm) and one flake (45 x 24 x 5 mm). Evidence of use is quite poor and uncertain; however, the presence of regular feather-terminating fractures suggests the employment of them for cutting soft substances. Microscopically, no clear polishes have been observed, also because of the presence of glossy alterations all over the lithic surfaces. This is partially due to the natural brightness of the employed chert (i.e. the local marine chert), which makes the recognition of microscopic wears a little complicated, especially for this type of soft materials.

5.4.3.2. Residues

As already pointed out in the previous chapter (*cfr*. Chap. 5, Par. 5.4.3.1.1.), two types of residues have been identified on several implements associated with the working of non-ligneous plants. On the one hand, I have recognized the presence of microscopic spots with a greasy and roundish aspect that I have interpreted as residues of the resin or bitumen used for attaching the lithic implements to the handle (Fig. 5.24, *a3*). On the other hand, I have ascertained the presence of fragments of vegetable materials such as silica skeletons (mainly epidermal cells) (Carnelli et al. 2004) (Fig. 5.23, *a3-a4*; Fig. 5.24, *a4*).

Although a detailed analysis of such residues is not the aim of this study, it is interesting to notice that these two types of evidence mainly appear to be together on harvesting tools. During experimental tests, I have observed that it is very common that, while using harvesting tools, a huge amount of the worked materials remains attached to the lithic surfaces, to the haft, and to the resin itself (Fig. 5.22). It is the very presence of such spots of resin (and their good preservation) that has favoured the preservation of silica bodies on the lithic surfaces.

5.4.3.3. Discussion

After an almost 500-year hiatus, a second occupation of Els Trocs Cave is dated to between 4470 and 4350 cal BC. Archaeological evidence suggests a pattern of occupation similar to that of Trocs I. A floor was built of hard-packed stones and potsherds; several hearths have been discovered on it. In addition, an area for keeping animals has been detected (Lancelotti et al. 2014). This information, together with the data provided by archaeozoological analyses, confirms the use of the cave as seasonal shelter mainly related to husbandry.

However, the occupation of the cave seems to have occurred on a smaller scale compared with the previous phase. No burials or pits have been found; the quantity of ceramic materials drops drastically (from 14.625 to 4.740 fragments), as is also the case with the determined number of faunal remains (Rojo et al. 2014).

Data, obtained from the techno-functional analysis of the lithic assemblage, substantially confirm this scenario. In general, both the procurement strategies and the technological management of different chert materials are the same as those of Trocs I. It is still possible to highlight the existence of two main productions, one based on exogenous materials —mainly from the Ebro Basin— and the other based on local materials from the Marine Cretaceous formations, outcrops of which are found around the site. In both cases, the objective was the production of small blades and bladelets. In this context, since most of the materials are fragmentary, a clear distinction is not possible between imported and locally made blades; however, the basic pattern of lithic-resource exploitation was similar to, if not the same as, that of the previous phase.

The number of tools from Trocs II is anyway significantly lower. Although the performed activities were the same, their frequency appears to have been lower compared with Trocs I. The main activities were connected with the processing of animal substances like meat and fresh hide, gathering of plants, repairing of ceramic vessels, and maintenance of hunting weapons. The latter two seem to have been carried out only occasionally.

With regard to the exploitation of vegetable materials, interesting data come from the study of soil and micro-morphological samples taken at the site (Lancelotti et al. 2014). The relevant results indicate that wild grasses were probably used as non-food resources, specifically for insulating the floor (given the high humidity of the cave), and creating a more comfortable domestic living room. These outcomes substantially confirm my interpretation of the various 'harvesting tools' of the assemblage, which have been identified as related to the gathering of non-ligneous plants, being not associated to agricultural practice. Accordingly, the presence of charred grains of domesticated cereals inside the cave should be interpreted as a result of unprocessed foodstuffs taken to the site from other places. This practice has already been pointed out for the Trocs I and other Neolithic sites located at high altitudes in the Spanish Pyrenees (Gassiot et al. 2014).

In conclusion, the Trocs II assemblages featured in processes of domestic nature, connected with the upkeep of the cave's living room and, occasionally, with the repairing/refit of artefacts, such as ceramic vessels or lithic weapons. The only production activity detected is related to butchering animal carcasses.

5.4.4. Trocs III

Trocs III has yielded a total of 101 lithic elements, of which about one-quarter (*n.* 27; 26.7%) have revealed the presence of use-wears or other modifications caused by using the instrument. Among them, use-wears represent the majority (*n.* 25; 24.7% of the total assemblage), corresponding to 30 active zones. Twenty elements of these attest only one action/activity, while the remaining five implements show the presence of two active zones.

Non-utilitarian traces have been detected on 3 elements (3.0% of the total assemblage), while a considerable number of tools have revealed the presence of macroscopic residues (*n.* 8; 7.9% of the total assemblage).

In terms of interpretation, a complete explanation of the use-wears has been possible in 56.7% of the cases, whilst, in the remaining, the proposed use is probable (26.7%) or possible (16.7%) (Tab. 5.7).

5.4.4.1. Use-Wears

5.4.4.1.1. Vegetal Substances

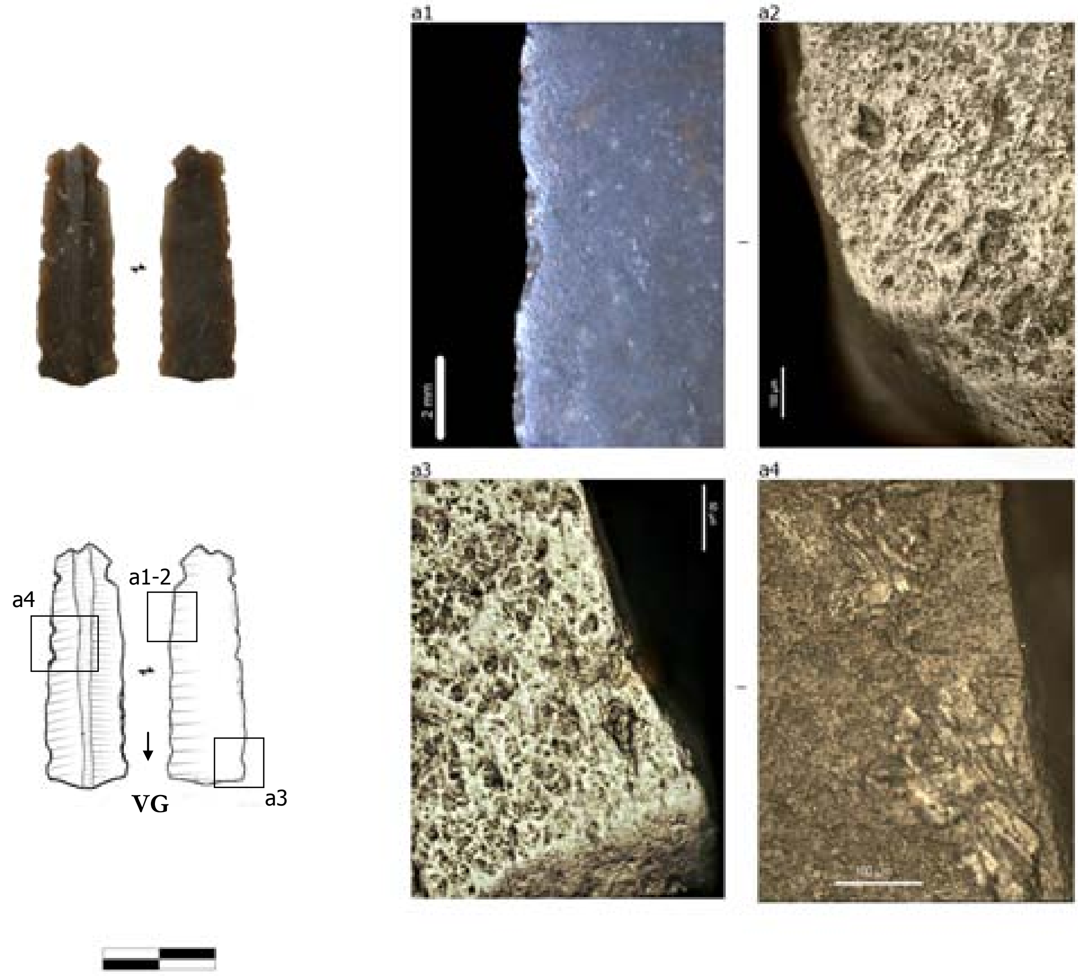
Use-wears associated with the working of vegetable substances represent the most abundant group of the assemblage (*n.* 11; 44%) (*n.* 14 AUAs; 46.7%).

Amongst those, the main group is consists of tools related to the working of *non-ligneous plants* (*n.* 11; AUAs; 36.7%), which show actions performed by longitudinal movement (see Tab. 5.12 at the end of the chapter). All these tools were made on large and narrow blades produced using exogenous chert types, mainly from the Ebro Basin and, secondarily, from the Tremp-Graus Basin. Most of these implements are fragmentary; however, their length appears to have been on average between 60 and 100 mm, their width between 18 and 22, and their thickness between 2 and 6 mm. Given their large size and the scarcity of cores and core-trimming elements in Trocs III, most of these tools were probably transported to the site already flaked, in form of finished unretouched blanks.

The analysis of micropolishes has revealed certain variability in the type of action performed by the various blades. All of them are associated with harvesting of herbaceous plants, however, none of the blades show the typical 'cereal polish', with smooth and flat polishes and glossed surfaces. The majority of tools (*n.* 6 AUAs) are characterized by traces that display a combination of *plant polishes* and *abrasive elements* (e.g. striations, craters, abrasions) (Fig. 5.28, *a-b*). Such a type of polishes strongly resembles the so-called 'RV2' traces (Clemente & Gibaja 1998). These use-wears may have been produced by harvesting plants to ground level, if a constant contact with the soil occurred. A cut of this kind must have been performed when one wanted to gather the whole plant, from stem to inflorescences.

Among these tools, one can remark the presence of a complete blade with absolutely unusual dimensions, that is, 152 mm long, 19 mm wide, and 7 mm thick. Long blades of this kind were typical productions of the final Neolithic period in the NE of the Iberian Peninsula (Gibaja et al. 2008, 2009). Such tools were characterized by a long use-life, being often resharpened and/or retooled. In the blade from Els Trocs, I have ascertained the resharpening of the mesial-distal portion of the active edge (Fig. 5.29, *a3*). Either resharpened or retooled, the performed activity appears to have been related to the cutting of plants to ground level. However, the first use shows a stronger development (Fig. 5.29, *a2*), as polishes are characterized by a higher degree of linkage, whilst the traces observed on

14031



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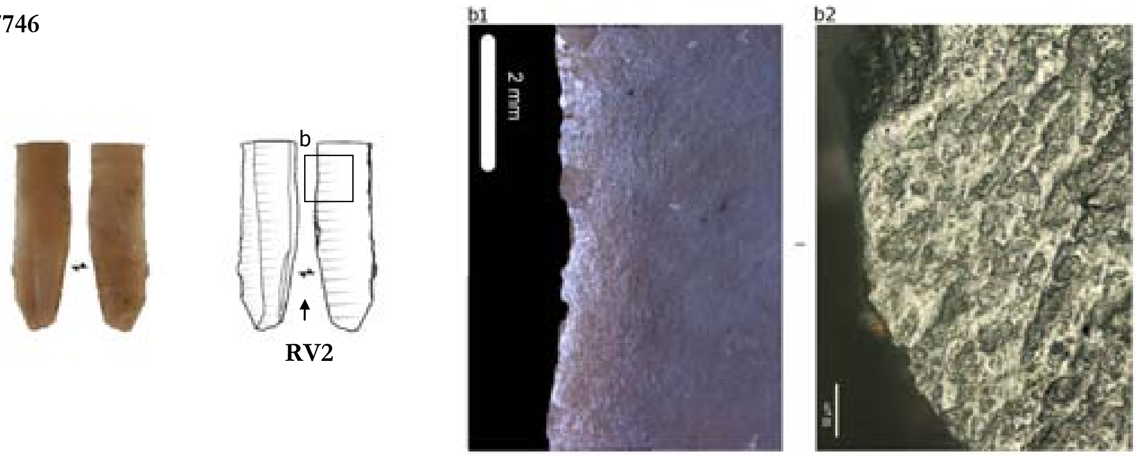


Fig. 5.28. Use-wears from the Cova de Els Trocs, Phase III. **14031-** Tool used for harvesting plant (with abrasive component - RV2); *a1-2*) Ventral face: *a1*) Macroscopic view, 15X. See the presence of a marginal lustre; *a2*) Microscopic view, 200X. Rough polish with striations; *a3*) Ventral face, opposite side, 400X. Detail of RV2 polish; *a4*) Detail of a plant skeleton, 200X. **17746-** Tool used for harvesting plant (with abrasive component - RV2); *b1*) Ventral face: marginal lustre; *b2*) Detail of RV2 polish, 400X.

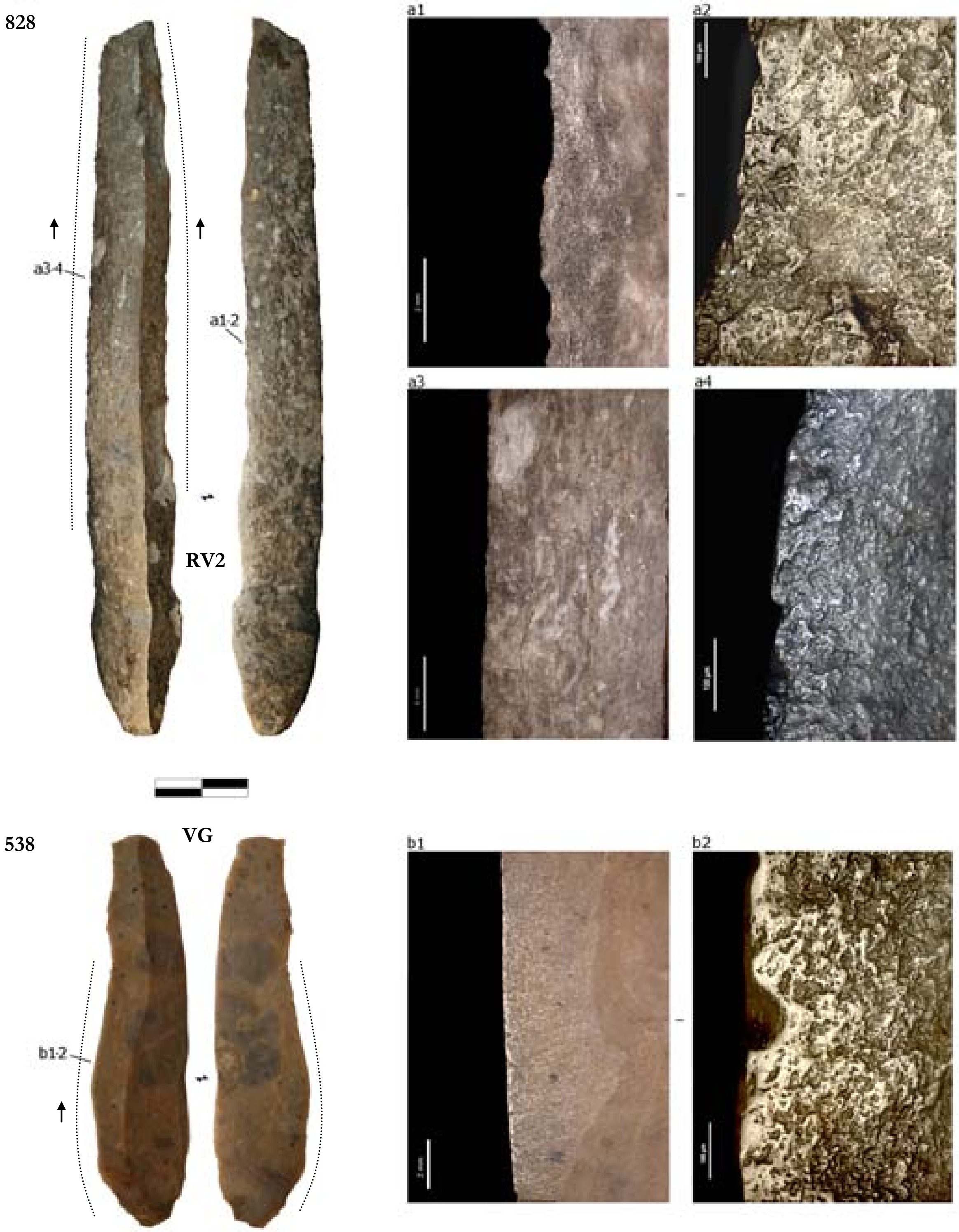


Fig. 5.29. Use-wears from the Cova de Els Trocs, Phase III. **828-** Tool used for harvesting plant (with abrasive component - RV2); *a1-2*) Ventral face: *a1*) Macroscopic view, 15X. Marginal lustre; *a2*) Microscopic view, 200X. Rough polish with striations, RV2; *a3*) Dorsal face, opposite side, 15X. See the presence of resharpening scars; *a4*) Detail of marginal RV2 polish (less developed then the other side), 200X. **538-** Tool used for harvesting plant (fresh plant?); *b1*) Dorsal face: marginal lustre; *b2*) Detail of smooth, fluid, polish with marginal distribution, 200X.

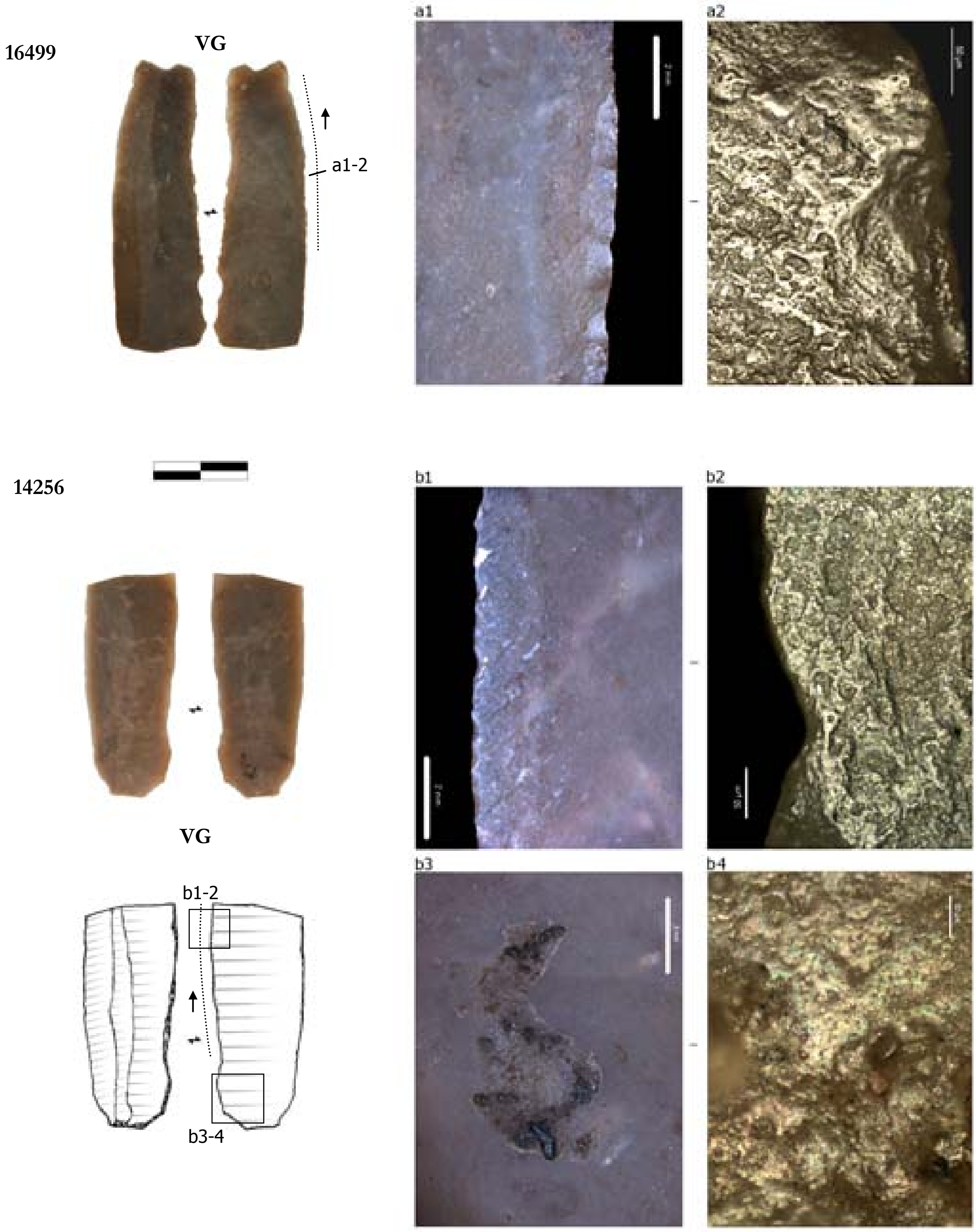


Fig. 5.30. Use-wears from the Cova de Els Trocs, Phase III. **16499-** Tool used for harvesting plant ; *a1-2*) Ventral face: *a1*) Macroscopic view, 15X. Series of scalar fractures associated to slight edge-rounding, 15X; *a2*) Microscopic view, 200X. Smooth plant polish; *a3*) Ventral side, opposite side, 200X. Detail of RV2 polish; *a4*) Detail of a plant skeleton, 200X. **14256-** Tool used for harvesting plant; *b1*) Ventral face: marginal lustre; *b2*) Detail of a marginal plant polish, 400X; *b3*) Macroscopic view of blackish residue, 20X; *b4*) Microscopic view of a residual spot of resin. See the greasy and roundish appearance, 400X.

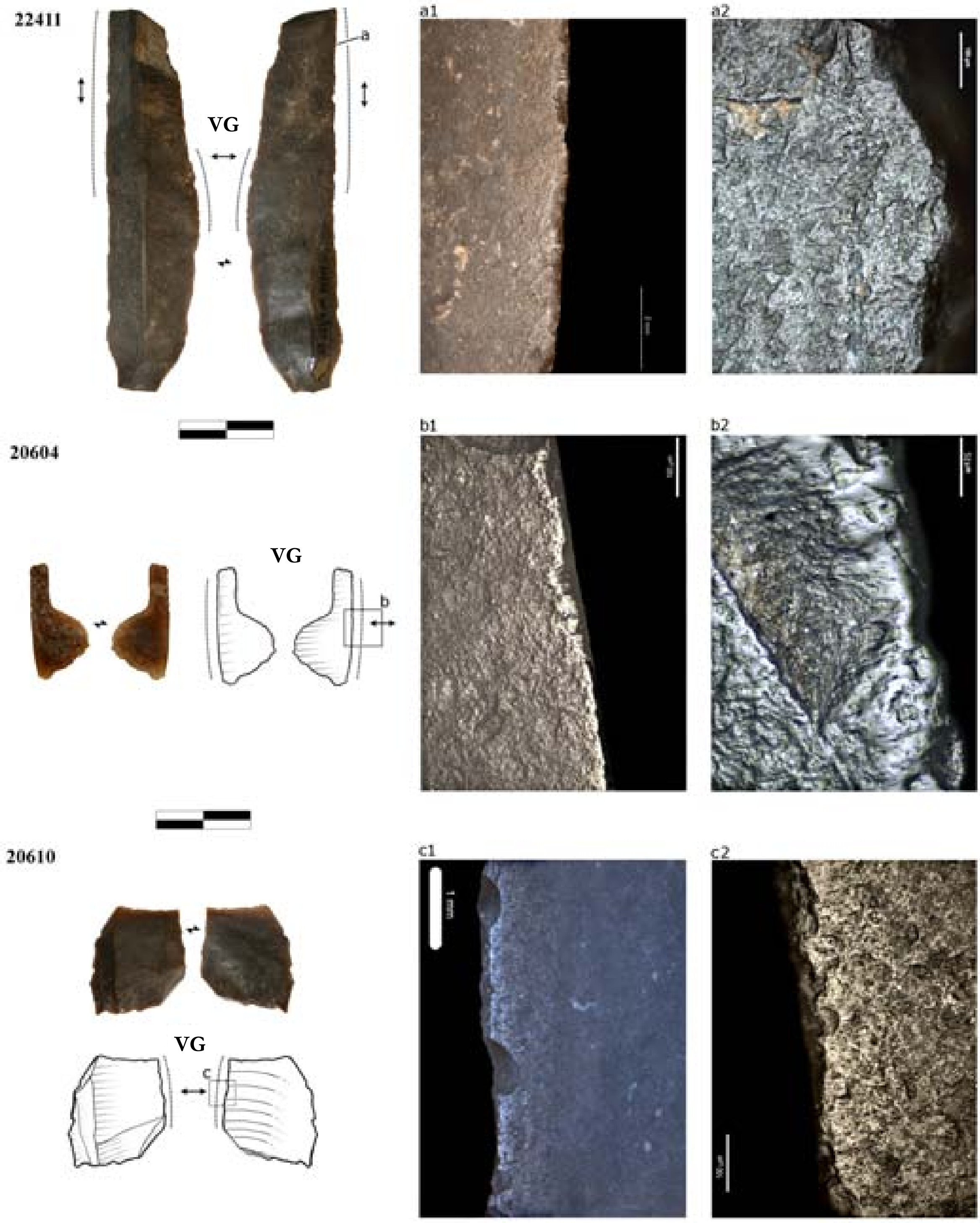


Fig. 5.31. Use-wears from the Cova de Els Trocs, Phase III. **22411-** Tool used for working indeterminable plants; *a1*) Macroscopic view, 15X. Series of scalar fractures associated to edge-rounding, 15X; *a2*) Microscopic view, 200X. Altered plant polish; **20604-** Tool used for scraping plant (woody plant?); *b1*) Band of polish on the very edge, 50X; *b2*) Detail of the same polish, 400X; **20610-** Tool used for scraping plant; *c1*) Macroscopic view, 10X. Marginal lustre; *c2)* Transversal plant polish (slightly altered), 200X.

the resharpened dorsal edge appear less developed (Fig. 5.29, *a4*).

A second category of traces is related to *herbaceous-plant harvesting* (*n.* 2 AUAs). In those cases, polishes appear smoother, scarcely abraded, with a domed or undulating distribution. Their development is generally limited, forming a marginal band on the edge, a fact that suggests a low-intensity use (Fig. 5.28, *b1-2;* Fig. 5.29, *a1-2*). Such traces are typically connected with non-domesticated-plants gathering, while cereal harvesting is attested to by flatter and more extensive polishes, that is, tools used for longer periods of time.

A third cluster is composed of *indeterminable herbaceous plants* (*n.* 3 AUAs). In this category, I have grouped together all those tools whose traces are too scarcely developed or altered too much by some taphonomic agents. These elements are characterized by small edge damages associated with spots of plant polishes (Fig 5.30, *b1-2*). Although it is clear that they were employed for harvesting activities relevant to some kind of soft vegetable substance, polishes are too scarcely developed to determine precisely which type of plants was cut. Moreover, in some cases, the occurrence of post-depositional processes, such as alkaline agents that produce the dissolution of the silica-gel, makes the interpretation of the wears quite difficult.

Finally, three elements are associated with the working of *indeterminable vegetable substances* (*n.* 3 AUAs; 10%). All of them show traces left by transverse-movement actions related to scraping some vegetable matter, although it is difficult to establish if this was a ligneous or non-ligneous woody plant. In these cases, polishes have formed a continuous band on the outer part of the edge of the tool, with a clear transverse directionality (Fig. 5.31, *b-c*). In two cases, the employed blanks are flakes, while the remaining one is a blade. It is to remark that removal was here induced by fire (Fig. 5.31, *b*), this suggesting an intensive exploitation of the raw-material transported to the site. The aforesaid blade was used without being previously retouched and employing the natural edge of the blank characterized by a sharp angle. The other flake is a distal fragment used for scraping vegetable material, specifically on the right edge, which also shows an obtuse angle of 50°-60° (Fig. 5.31, *c*). On this instrument, polishes appear slightly rougher, possibly in relation to some type of alteration (Fig. 5.31, *c2*). Finally, the last element is a blade employed on one side for cutting and, on the opposite one, for scraping; however, in both cases, the preservation of the use-wears is not good enough for ascertaining the worked material precisely (Fig. 5.31, *a1-2*).

5.4.4.1.2. Animal Substances

The working of animal substances is represented by four tools (n. 4 AUAs; 13.3%). All of them are probably related to *butchering activities*.

Blanks are quite reduced in size: flakes measure 30-32 x 18-29 x 6-13 mm, while blades around 7-13 x 3-5 x 2 mm. Observed use-wears are mainly characterized by greasy polishes associated with moderate edge-rounding and scarring (Fig. 5.32, *a-c*). Occasionally, one can observe compact spots of polish associated with a more evident scarring, probably caused by the contact with harder materials like bone (Fig. 5.32, *c1-2*). However, it is to remember that the traces produced by the contact with soft animal substances are always complicated to detect, even when the preservation of surfaces is good.

If one looks at the faunal assemblage from Trocs III, except for slight differences, a scenario similar to that of the previous phases emerges: slaughter activities mainly concerned young sheep/goats, while other domesticated species and wild animals had a marginal role (Rojo et al. 2014).

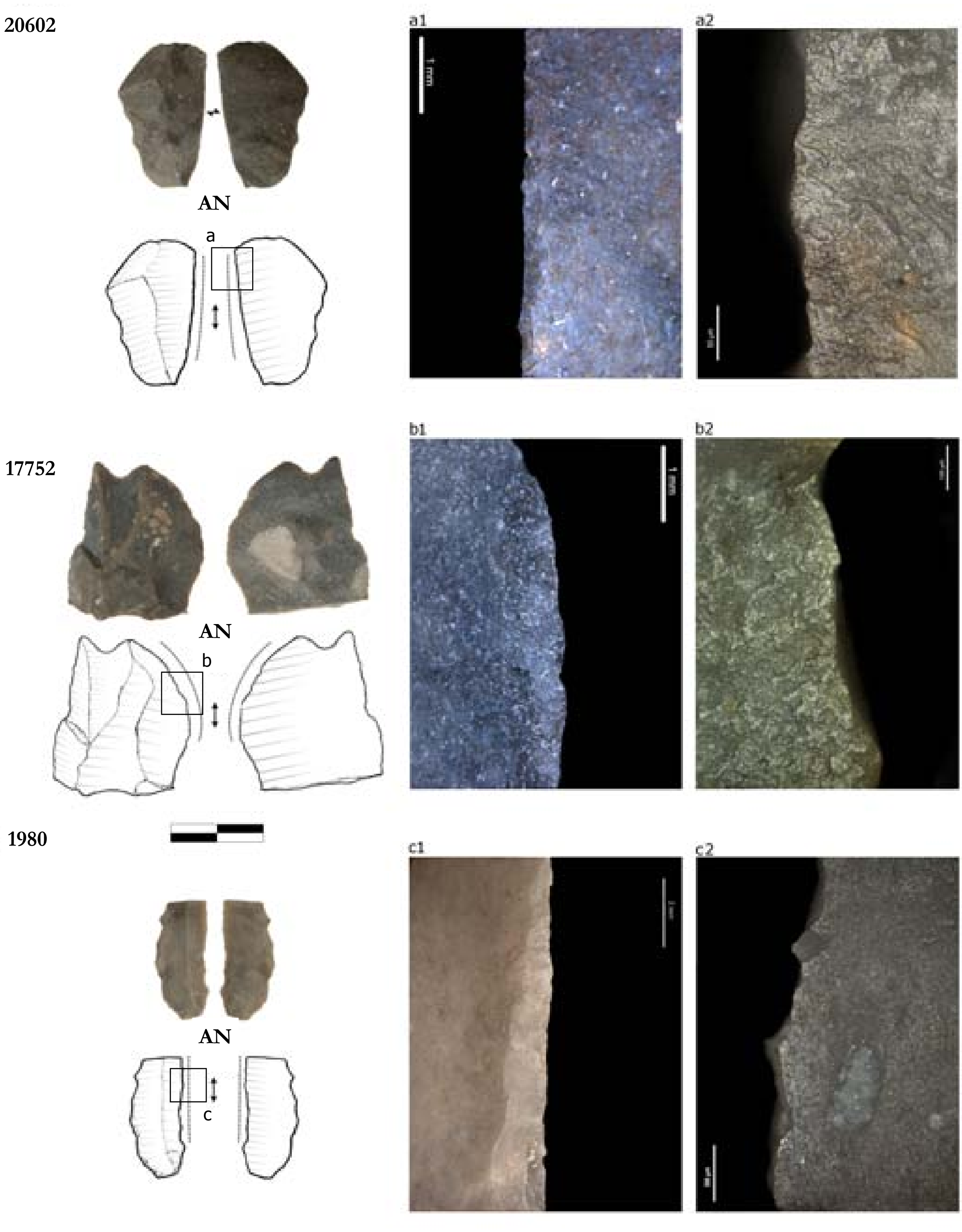


Fig. 5.32. Use-wears from the Cova de Els Trocs, Phase III. **20602-** Tool used for working animal substances; a1) Macroscopic view, 15X. Series of scalar fractures associated to edge-rounding, 15X; *a2*) Microscopic view, 400X. Greasy marginal polish from working animal substances; **17752-** Tool used for working animal substance; *b1*) Flat, invasive feather-terminating scars, 30X; *b2*) Microscopic view, 200X. Greasy polish with spots of contact with hard materials. Note the presence of certain edge-rounding. **1980-** Tool used for working animal substance; *c1*) Detail of use-damage, 10X. Scalar feather-terminating fractures; *c2*) Marginal polish with spots of contact with hard material, 100X.

5.4.4.1.3. Mineral Substances

Mineral substances have been worked with four tools (*n.* 4 AUAs; 13.3%). Three of them are borers —all made out of a local chert type— and the last one is a blade scraper —made out of the Ebro-Valley chert type.

Amongst the borers, one has to emphasize the presence of a tool made on a cortical blade, heavily rounded, and characterized by deep striations (Fig. 5.33, a). This tool was probably used for repairing ceramic materials. Its dimensions (37 x 13 x 6 mm) appear slightly bigger than those of the other borers recovered from Els Trocs, but, probably, only because it is less fragmentary. Indeed, if one considers the dimensions of the tips only, all drilling tools from Els Trocs Cave appear quite standardized, namely, between 3 and 5 mm in width. In addition, it is to take into account that, while being used —as a consequence of continuous scarring and rounding—, the tip tends to get wider.

The two remaining borers were made on flake. Both elements are fragmentary and show less developed traces. In one case, the point is completely broken and only on the right dorsal edge a part of the original retouch is still visible.

Finally, one can point out the presence of one blade associated with the working of clay materials (Fig. 5.33, b). The edge is very rounded, with a very rough and striated polish that extends over the mesial-distal portion of the left side (Fig. 5.33, b). The occurrence of edge abrasions and striations (Fig. 5.33, b3-4) and the presence of extensive friction spots (Fig. 5.33, b2) suggest that the tool was used for working dry or semi-dry clay. This evidence may suggest works relevant to either decorating or, more likely, finishing off some vessels before firing.

5.4.4.1.4. Projectile Elements

The only projectile item (*n.* 1 AUAs; 3.3%) recovered from Trocs III is a large isosceles trapezoid (19 x 20 x4 mm) made on a flake blank and shaped by bifacial flat retouch (Fig. 5.34, *a*). This morphology is quite different from the geometric implements of the previous phases, which were mainly segments or trapezoids made on blades. Moreover, it is interesting to remark that the tool was made out of an exogenous chert type, namely, a reddish coarse-grained chert, which results to have not been used for any other tool and not flaked on site.

In terms of function, the geometric item is characterized by the presence of a burin-like fracture in its distal edge that clearly interrupts the previous retouch (Fig. 5.33, *a1-2*). According to the orientation of the fracture, it seems more likely that the tool was used as a lateral element, like a barb, and not as a transverse point.

5.4.4.1.5. Indeterminable Substances

Tools associated with Indeterminable substances amount to seven implements, of which five are related to the working of *soft substances* (*n.* 5 AUAs; 16.7%), while two show contact with *hard materials* (*n.* 2 AUAs; 6.7%).

Tools associated with soft substances are three blades (44-50 x 12-16 x 1-4 mm) and two flakes (22-32 x 12-31x 4-8 mm). Traces mainly consist of a succession of fractures along the active edge. Scarring is continuous but never invasive, suggesting the contact with a soft material and a longitudinal movement (Fig. 5.34, *b-c*). Polishes and other micro-features are not preserved; therefore, it is not possible to put forward any clear interpretation of the worked material. However, it seems plausible that such tools were used to work soft substances, perhaps in relation to slaughter processes.

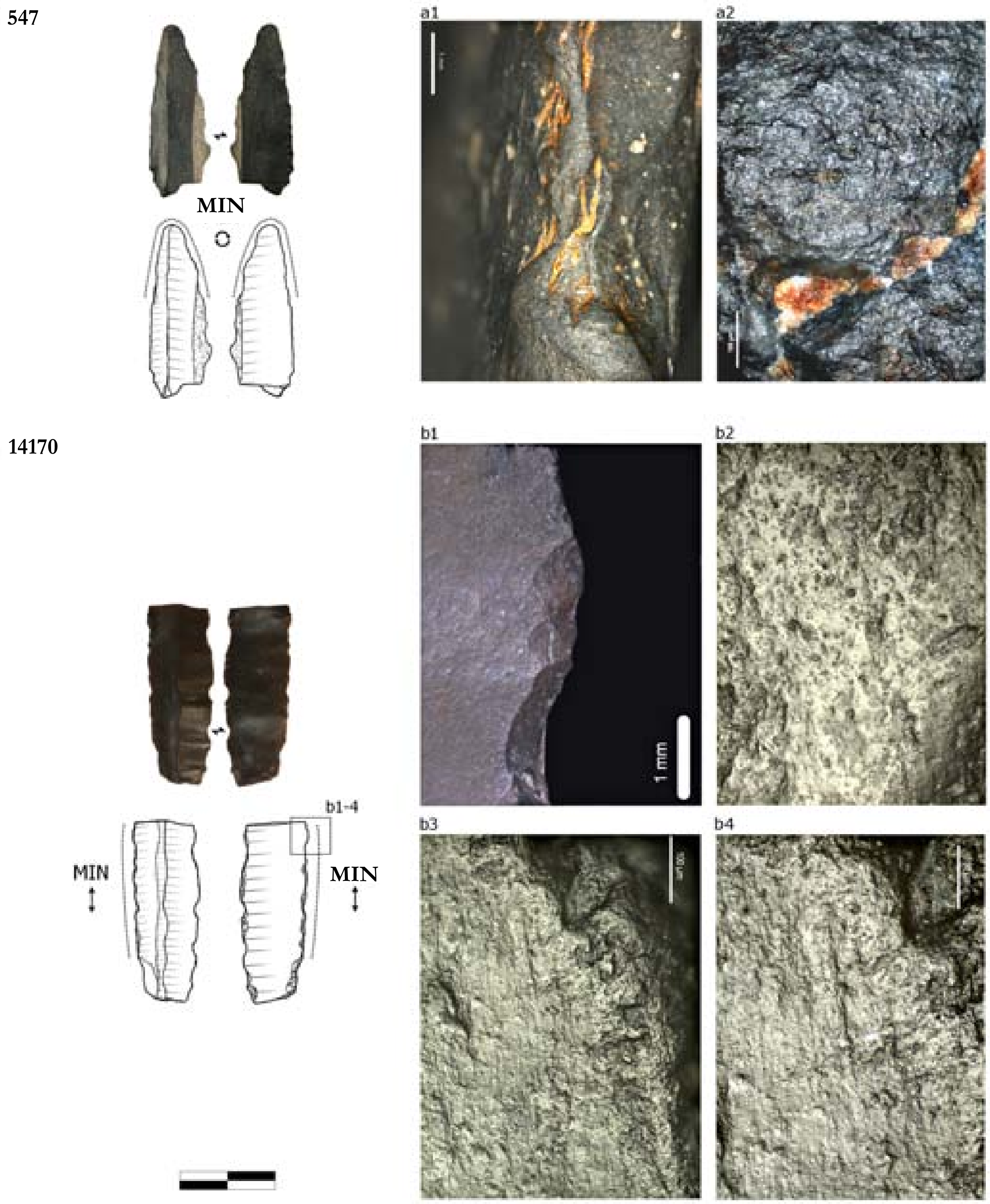


Fig. 5.33. Use-wears from the Cova de Els Trocs, Phase III. **547-** Tool used for boring pottery; *a1*) Macroscopic view, 20X. Strong edge-rounding. Note the presence of reddish residues; *a2*) Microscopic view, 200X. Rough polish all over the tip; **14170-** Tool used for working dry clay; *b1*) Edge-damage and marginal lustre, 15X; *b2*) Bright spots of compact polish produced by the working of clay, 200X; *b3*) Rough, striated polish, 200X. Note the presence of abrasions all over the active edge; *b4*) Detail of the same polish, 400X. Note the presence of chaotic strias, craters and abrasions.

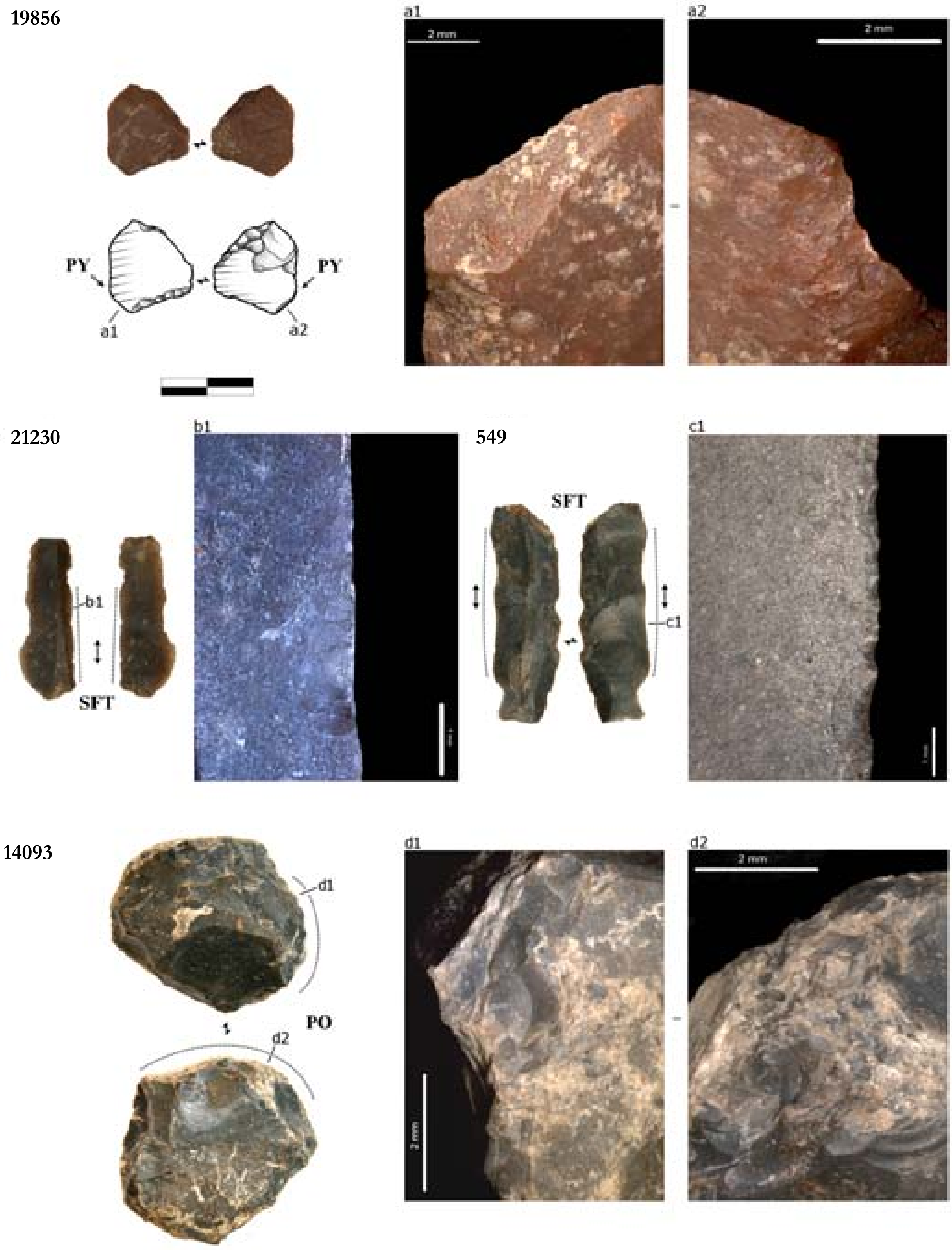


Fig. 5.34. Use-wears from the Cova de Els Trocs, Phase III. **19856-** Tool used as projectile tip; *a1-2*) Macroscopic view, 15X: *a1*) Ventral face. Burin-like impact fracture; *a2*) Dorsal face. See how the impact fracture interrupt the retouch. **21230-** Tool used for working indeterminate soft substances; *b1*) Invasive scalar feather-terminating scars, 15X; **549-** Tool used for working indeterminate soft substances; *c1*) Marginal scalar feather- and step-terminating scars, 15X; *b2*) Detail of the same polish, 400X; **14093-** Core use for pounding/grinding; *d1-2*) Macroscopic view, 30X. Cracks and fractures over the ridges.

Finally, two tools are associated with hard or resistant materials. One of them is a core, made out of the local chert type and reused for pounding/grinding activities. Large macro-fractures and cracks are visible on both sides of the core (Fig. 5.34, *d*). The other tool is a flake characterized, on the distal edge, by a series of invasive bifacial fractures, probably due to employing it as a wedge. However, the poor preservation of the micro-wear does not allow a more detailed interpretation to be put forward.

5.4.4.2. Non-utilitarian Wears

5.4.2.3.2.1. Transportation Wears

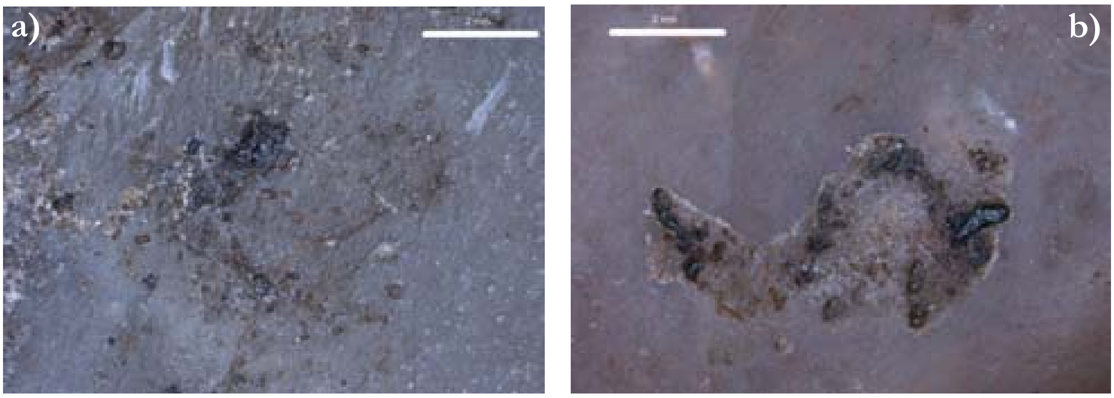
Three elements present traces possibly associated to transportation activities. Among those, particularly relevant is a fragment of a sickle insert. This tool shows the presence of a plant polish, successively altered by some abrasive agent. The margin is characterized by a continuous micro-scarring that largely removed the original used edge. Moreover, on the remaining polish many scratches and abrasions subsequent to the formation of the use-polish are visible. Similar alterations of the use-wears have been observed on transported tools previously employed for plant harvesting activities (Mazzucco & Clemente 2013; *cfr.* Chap. 2, Par. 2.3.2.) suggesting that such elements could have been transported at the Els Trocs after being already used.

5.4.4.3. Residues

As for the previous two phases, the main residues observed both macro- and microscopically are related to: 1) possible spots of resin or bitumen used for hafting the tool; 2) silica bodies and other remains of plant materials stuck to the lithic surfaces or to the resin itself.

Residues of the adhesives employed for hafting tools have been observed both macroscopically (stereoscopic microscope) (Fig. 5.30, *b3*) and microscopically (reflected-light microscope) (Fig. 5.30, *b4*). Macroscopically, residues appear as blackish/brownish spots, while, magnified, resin spots are shown to be greasy and roundish surfaces. In the case of two elements of the Els Trocs Cave, FT-IR analysis has been carried out to test further their chemical consistency. I selected two blades from Trocs III (n° 14256 and n° 16499), which show macroscopic residues on the surfaces. Both tools were characterized by spots of possible resin residues (blackish/brownish spots) deposited on their surface. The results of the analysis verified that, apart from the percentages of calcium carbonates and silicates, both samples were characterized by peaks relevant to organic matter, which may be attributed to some resin or bitumen, as microscopically hypothesized (Fig. 5.35). More detailed analyses (such as GC/MS) are needed to ascertain the exact composition of the sample; however, these results are consistent with the FT-IR bitumen spectrum from reference collections or other archaeological specimens (see, for example, Monnier et al. 2013). Moreover, on some samples associated with resin, I have observed the presence of silica bodies that probably represent silica skeletons of plant epidermal cells (Fig. 5.28, *a4*). Once again, it is important to remark that such residues have only been observed on blades connected with vegetable-material harvesting.

Finally, one borer associated with the perforation of ceramic substance shows abundant reddish residues deep in the chert fissures and amidst the retouch scars (Fig. 5.32, *a-b*). They may have been left by the worked material, which, according to the use-wear traces, seems to be pottery; however, a more detailed analysis is required.



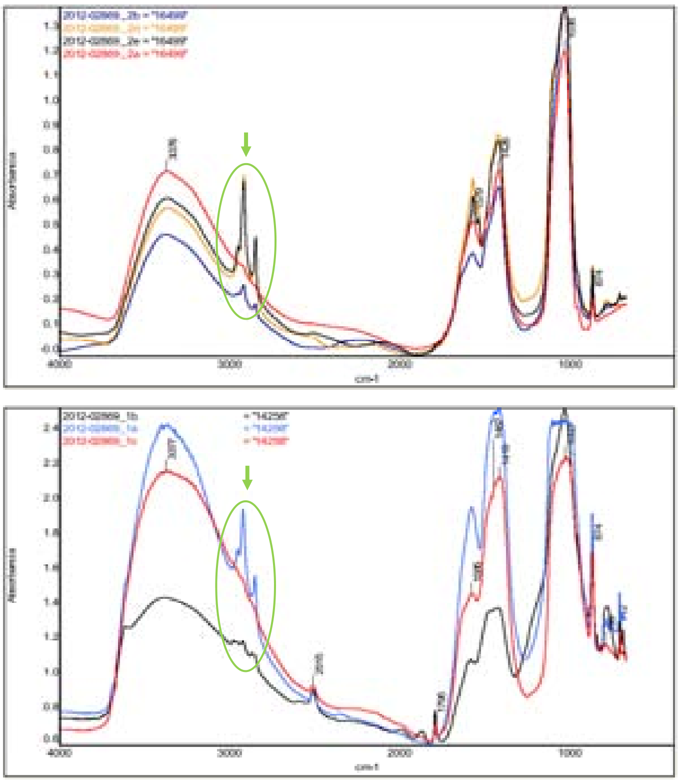


Fig. 5.35. **Above:** Stereo-photos (20X) of the blackish/brownish spots observed on the analysed tools: *a)* tool nº 16499; *b)* tool nº 14256. **On the left:** FT-IR analysis of samples from the selected tools from the Trocs III level. Infrared spectra: *above-* sample from nº 16499 (see Fig. 5.29, *a)*); *below-* sample from nº 14256 (see Fig. 5.29, *b)*). Both spectra present the characteristic bands of the calcium carbonate: 2515, 1795, 1420, 875 and 712 cm-1. A peak is observed around 1000 cm-1, which could correspond to silicates or phosphates. Finally, some zones of the sample show the typical bands of organic matter (3000-2800 cm-1) (the area is marked in green and indicated by an arrow on both spectra). The analysis has been realized by the Unitat d'Anàlisi Molecular (CCiTUB) of the University of Barcelona (UB). The analysis has been funded by the AGRIWESTMED Project.

5.4.4.4. Discussion

The last phase of occupation at Els Trocs Cave covers a period of almost one thousand years, probably corresponding to short and repeated occupations that took place in the course of the fourth millennium. However, if one exclusively considers the charred-grain sample, the chronological span is reduced to last half of the third millennium, from 3340 to 2925 cal BC.

About this time, no pavements or drainage floors have been detected, in contrast to the previous phases; however, a large number of hearths bear evidence of domestic activities. Fireplace features show different states of preservation, from well-preserved fire pits to scattered and isolated ash/charcoal layers, suggesting the maintenance and recondition of domestic floors. Moreover, Trocs III Phase is characterized by the presence of two large pits associated with abundant faunal and human bones, probably attesting to burials/ritual depositions.

Data seem to confirm the same pattern of occupation as in the previous phases. Procurement and reduction strategies were always the same: most of the laminar blanks were transported to the cave already flaked —mainly using Ebro chert types—, while a marine chert was knapped locally for making small-size flakes and blades.

In terms of function, the same lithic-resource management emerges from Trocs I and Trocs II. The largest blades are generally associated with the procurement of vegetable materials, while the other blanks were used for activities related to slaughtering, butchering or ceramics repairing. Something new is represented by the appearance of instruments associated with the scraping of vegetable fibres; this may refer to basketry, rope making, or softwood working. Finally, from a blade with traces of semi-dry clay materials, one may infer that not only repairing activities, but also ceramics-decorating and/or finishing operations took place at the cave.

Nevertheless, in most of the cases, the ascertained activities seem to have been isolated and sporadic, featuring no complex operations for large manufacturing processes. The site still appears economically oriented especially towards animal husbandry and animal-resources exploitation.

If one looks at the data obtained from the archaeozoological analysis of faunal remains from Trocs III, only slight changes distinguish it from the previous phases. Here, the strategy seems based on slaying old animals; however, the general situation recalls the previous one: the predominance of ovicaprids amongst domestic animals and the scarcity of wild species. Therefore, the three phases essentially appear to match one another from a functional/economic point of view.

5.5. Final Remarks

Els Trocs Cave represents a fundamental site for the understanding of human occupation's dynamics in the Central Pyrenees between the sixth and the third millennium cal BC. The area is still poorly understood from an archaeological point of view and only a few Neolithic sites have been properly excavated. A systematic plan of surveys is required, in order to ascertain whether other settlements dating back to this epoch exist in the Ribagorza region or, at lower altitudes, at the bottom valleys of the Isábena and Noguera Ribagorçana Rivers.

However, the excavation of Els Trocs Cave indicates that Neolithic populations occupied the inner elevations of the pre-Pyrenean range as early as from the end of the sixth millennium. Such communities appear to have possessed a well-developed mixed production economy. Domesticated herds, almost exclusively composed of ovicaprids, were driven to the mountain areas, where pastures had probably been artificially created by forest clearance (Uria 2013; Rojo et al. 2014). At the same time, cereal seeds were transported to the site as food stocks, this confirming that these people carried out both agricultural and pastoral activities, even though cultivation did not probably take place in the immediate surroundings of the site (Lancelotti et al. 2014).

Stratigraphic and micro-morphological data suggest that Els Trocs Cave was settled discontinuously and repeatedly, each occupation being short and occurring after long periods of abandonment. This notwithstanding, the settlement pattern appears to have been unchanged through time, thus one may put forward that the site, although occupied for a short period, belongs to a specific model of occupation and exploitation of mountain areas.

The information acquired from the study of the lithic assemblages recovered in the three phases of Els Trocs has provided important elements about the economic activities carried out at the site and about the mobility of these populations. These data basically confirm the specialized character of the site of Els Trocs. I have emphasized the scarcity of production and manufacturing activities; most of the recognized economic processes seem to account for specific works connected with the maintenance of domestic floors or certain categories of objects and artefacts, such as ceramic vessels and arrows. Also the harvest of plants, a largely documented activity at Els Trocs, seems to have been related to the procurement of plants and grasses for non-food purposes, like building drainage floors and bedding layers, instead of proving agricultural practices. The only real production activity that has been ascertained is the slaughter of animals (Tab. 5.8, 5.9).

In this respect, the scarcity of lithic materials should be interpreted as a direct consequence of the specialization of the site in pastoral practices, for which such types of artefacts were not specifically required. Moreover, the absence of hide-working activities suggests that only the slaughter of animals was performed at the cave, whereas no evidence of skin processing has emerged. Only further analyses may prove if milking or dairy-farming activities took place at the cave.

The outcomes of the provenance analysis of lithic raw materials indicate the existence of two different strategies in terms of materials procurement and management: on the one hand, transportation of blanks and, secondarily, cores from the chert formation of the Ebro Valley; on the other hand, a local, subsidiary production has been ascertained, which was based on the exploitation of local marine cherts. These data suggest that the inhabitants of Els Trocs moved across an area that from the Ebro Plain extended to the Sierras Interiores, crossing mountains such as the Macizo del Turbón, the Sierra de la Carrodilla, and Sierra del Montsec, mainly following a South-North direction. This scenario —along with the data produced by archaeozoological studies (Rojo et al. 2014)— seems to confirm that the development of a mobile pastoral economy played a fundamental role in the occupation of the Ribagorza region during the Neolithic Age.

PHASE		SG	PR	PO	TOT
	N.	17	8	5	30
3	***% phase***	*56,7%*	*26,7%*	*16,7%*	*100,0%*
	% tot	*25,8%*	*29,6%*	*27,8%*	*26,8%*
	N.	19	9	5	33
2	***% phase***	*57,6%*	*27,3%*	*15,2%*	*100,0%*
	%tot	*28,8%*	*32,1%*	*27,8%*	*29,5%*
	N.	30	11	8	49
1	***% phase***	*61,2%*	*22,4%*	*16,3%*	*100,0%*
	% tot	*45,5%*	*39,3%*	*44,4%*	*43,8%*
	N.	66	28	18	112
TOT	***% tot***	*59,1%*	*24,5%*	*16,4%*	*100,0%*

Tab. 5.7. Interpretability of the use-wear traces identified among the Cova de Els Trocs lithic assemblage. SG: clear use, traces are fully interpretable; PR: probable use, traces are partially interpretable; PO: possible use, the interpretation is considered dubious.

PHASE		Herbaceous plants	Woody plants	Vegetal ind.	Soft/medium animal sub.	Bone/antler	Mineral substances	Projectile	Soft/medium ind.	Hard ind.	TOT.
3	**N.**	11	-	3	4	-	4	1	5	2	30
	%	*36,7*	-	*10,0*	*13,3*	-	*13,3*	*3,3*	*16,7*	*6,7*	*100*
2	**N.**	13	-	3	8	-	3	1	5	-	33
	%	*39,4*	-	*9,1%*	*24,2*	-	*9,1*	*3,0*	*15,2*	-	*100*
1	**N.**	13	1	-	10	2	7	5	3	8	49
	%	*26,5*	*2,0%*	-	*20,4*	*4,1*	*14,3*	*10,2*	*6,1*	*16,3*	*100*
TOT.	**N.**	37	1	6	22	2	14	7	13	10	112
	%	*33,0*	*0,9*	*5,4*	*19,6*	*1,8*	*12,5*	*6,3*	*11,6*	*8,9*	*100*

Tab. 5.8. Composition of use-wear traces identified among the Cova de Els Trocs lithic assemblage. *Ind.* is an abbreviation for 'indeterminable'.

BLANK		Herbaceous plants	Woody plants	Vegetal indet.	Soft/medium animal sub.	Bone/Antler	Mineral substances	Projectile	Soft indet.	Hard. indet	TOT
	N	0	0	0	0	0	0	0	0	4	4
Core	*% Bl*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*100,0%*	*100,0%*
	% Mat	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*0,0%*	*40,0%*	*3,6%*
	N	4	1	4	11	2	6	2	7	6	43
Flake	*% Bl*	*9,3%*	*2,3%*	*9,3%*	*25,6%*	*4,7%*	*14,0%*	*4,7%*	*16,3%*	*14,0%*	*100,0%*
	% Mat	*10,8%*	*100,0%*	*66,7%*	*50,0%*	*100,0%*	*42,9%*	*28,6%*	*53,8%*	*60,0%*	*38,4%*
	N	33	0	2	11	0	8	5	6	0	65
Blade	*% Bl*	*50,8%*	*0,0%*	*3,1%*	*16,9%*	*0,0%*	*12,3%*	*7,7%*	*9,2%*	*0,0%*	*100,0%*
	% Mat	*89,2%*	*0,0%*	*33,3%*	*50,0%*	*0,0%*	*57,1%*	*71,4%*	*46,2%*	*0,0%*	*58,0%*
	N	37	1	6	22	2	14	7	13	10	112
Tot	*% Bl*	*33,0%*	*0,9%*	*5,4%*	*19,6%*	*1,8%*	*12,5%*	*6,3%*	*11,6%*	*8,9%*	*100,0%*
	% Mat	*100,0%*	*100,0%*	*100,0%*	*100,0%*	*100,0%*	*100,0%*	*100,0%*	*100,0%*	*100,0%*	*100,0%*

Tab. 5.9. Cross-tab between *Blank* type and *Contact Materials*. Waste, Core Trimming Elements have been all grouped within «Flake» category. *Bl.* indicates 'Blank'. *Mat.* indicates 'Material'. *Indet.* is an abbreviation for 'indeterminable'; *Sub.* is an abbreviation for 'substances'

MOV	MAT							
	VG		**AN**		**MI**	**PY**	**IND**	
	HP	*W/P*	*SA*	*B/A*			*SO*	*HA*
LO	13	-	7	1	-	-	3	-
TR	-	1	3	1	-	-	-	-
BO	-	-	-	-	7	-	-	1
PO	-	-	-	-	-	-	-	7
PY	-	-	-	-	-	5	-	-

Tab. 5.10. Cross-tab between the actions and the worked material, Trocs I. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; W/P: Other indeterminable plants/Ligneous plants; AN: Animal substances; SA: Soft animal substances; B/A: Bone/Antler; MI: Mineral substances; PY: Projectile implements; IND: Indeterminable substances; SO: Soft indeterminable substances; HA: Hard indeterminable materials.

MOV	MAT					
	VG		**AN**	**MI**	**PY**	**IND**
	HP	*W/P*	*SA*			*SO*
LO	13	1	8	1	-	5
TR	-	2	-	1	-	-
BO	-	-	-	1	-	-
PO	-	-	-	-	-	-
PY	-	-	-	-	1	-

Tab. 5.11. Cross-tab between the actions and the worked material, Trocs II. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; W/P: Other indeterminable plants/Ligneous plants; AN: Animal substances; SA: Soft animal substances; MI: Mineral substances; PY: Projectile implements; IND: Indeterminable substances; SO: Soft indeterminable substances.

MOV	MAT						
	VG		**AN**	**MI**	**PY**	**IND**	
	HP	*W/P*	*SA*			*SO*	*HA*
LO	11	-	4	1	-	5	-
TR	-	3	-	-	-	-	-
BO	-	-	-	3	-	-	-
PO	-	-	-	-	-	-	2
PY	-	-	-	-	1	-	-

Tab. 5.12. Cross-tab between the actions and the worked material, Trocs II. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; W/P: Other indeterminable plants/Ligneous plants; AN: Animal substances; SA: Soft animal substances; MI: Mineral substances; PY: Projectile implements; IND: Indeterminable substances; SO: Soft indeterminable substances; HA: Hard indeterminable materials.

6. Cova del Sardo de Boí

6.1. Introduction

Cova del Sardo de Boí is one of the highest archaeological sites that have been fully excavated, at least in the Iberian Peninsula. Apart from the altitude, the peculiarity of this site is the exceptional stratigraphic sequence, which attests to eight different preserved phases of human occupation, from the Early Neolithic Age to Modern times, that is, for a period of more than 7000 years, although characterized by several abandonment phases between them.

At the time the excavation of the cave took place, during 2004-2008, the area was practically 'virgin' from an archaeological point of view. No sites were known in the region. A few dolmens and other megalithic structures were known near the municipality of Pont de Sort, although located at much lower altitudes (e.g. Dolmens de la Casa Encantada and Dolmen del Mas Pallares - Senterada, Pallars Jussà, Lleida).

The cave has been excavated with modern methodologies, by a detailed stratigraphic technique. Moreover, several methods and disciplines were integrated for the post-excavation analysis of the recorded artefacts, especially for the faunal remains and the archaeobotanical record. All of this made Cova del Sardo a reference site for the study of the Neolithic period in the NW of Catalonia and, generally, for the study of human dynamics in high-altitude environments.

6.2. General information

6.2.1 Geographical framework

Cova del Sardo de Boí is located in the NW of Catalonia, in the Alta Ribagorça district, province of Lleida. It is situated in the municipality of Boí, about 10 km from the village. Site coordinates are: X 328065, Y 4713369 (UTM31).

The site is a rock-shelter located in the middle of the Sant Nicolau Valley that is part of the National Park of Aiguestortes and Estany de Sant Maurici, a natural reserve that extends over an area of 40,852 hectares in the Central Pyrenees. More specifically, the site is situated at an altitude of 1,790 m.a.s.l., about 60 m above the Sant Nicolau River (Fig. 6.1). The Sant Nicolau is a tributary of the River Noguera de Tor, which in turn is the main tributary of the Noguera Ribagorçana. The valley, about 12 km long, is one of the most important routes of communication between the two Nogueras Valleys, namely, Ribagorçana and Pallaresa.

The rock-shelter has formed on the southern slope of a granite massif called Serrat dels Ginebros, located about 50 m above the Sant Nicolau River and 1 km from Lake Llebreta. Local elevations, ranging between 2,700 and 3,000 m.a.s.l., are part of the granite Maladeta batholith, a huge Precambrian and Palaeozoic bedrock. The cave was excavated into the massif by glacial erosion at the end of the Last Glacial Maximum. This small rock-shelter is 9.0 x 3.0 x 1.3 m, with an area of about 20 m^2 that has been progressively covered with eroded materials. It is south oriented and gets light most of day.

Today, the local climate is characterized by high humidity. The Sant Nicolau Valley is one of the most humid valleys of the Catalan Pyrenees with an annual precipitation of 1100 mm. Average winter temperatures range between -4 ºC and 2 ºC and, during summer, between 13 ˚C and 18 ˚C. Local environment is characterized by a mixed forest of *Pinus uncinata* Miller /

a)

b)

c)

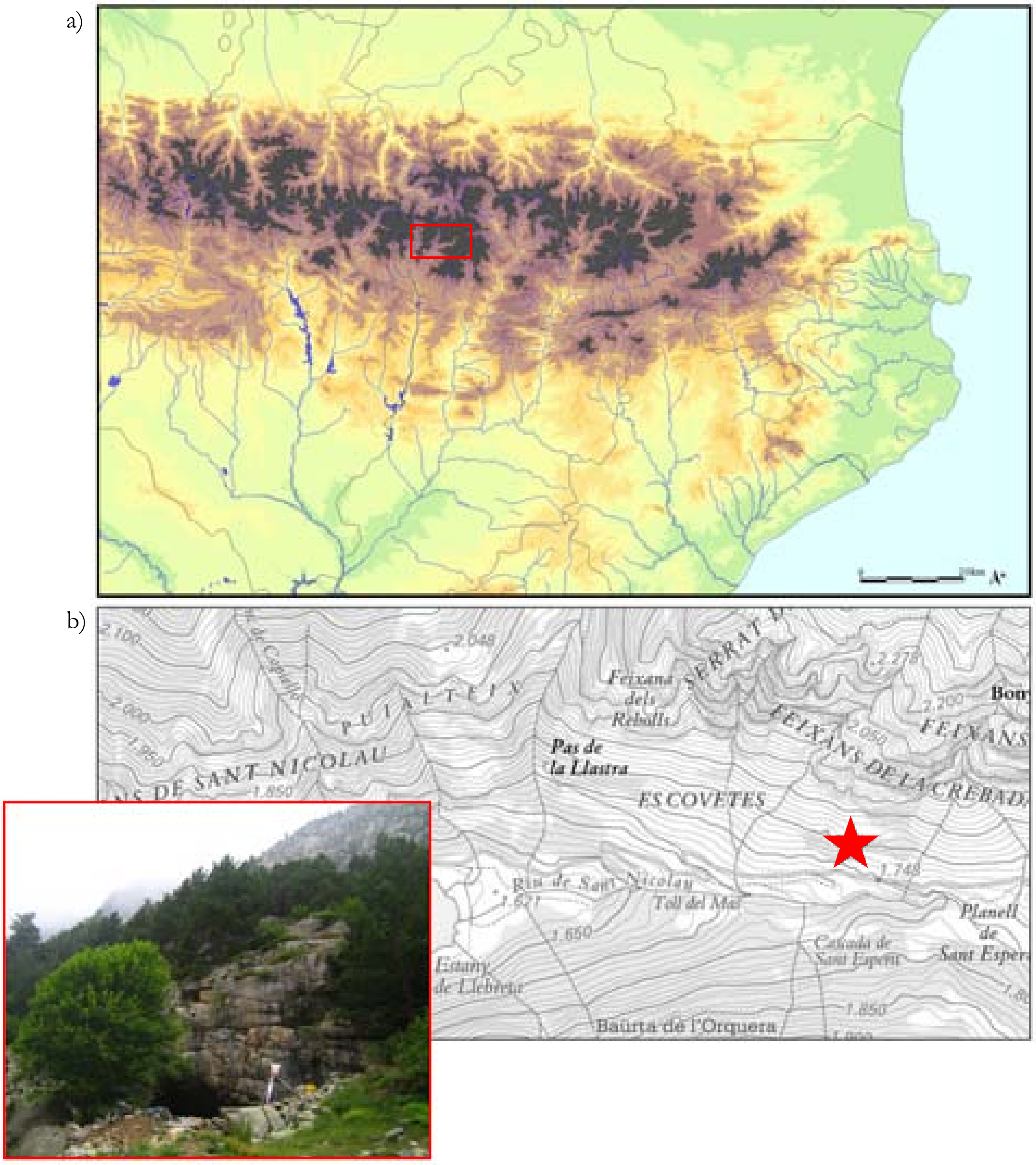


Fig. 6.1. a) Geographical framework of the site; b) Site location on 1:50.000 map. The red star indicates the exact position of the Cova del Sardo de Boí; c) Photo of the rock-shelter.

sylvestris L. and *Abies alba* Mill, with a substantial presence of *Corylus avellana* L. and *Betula pendula* Roth. Open shrubby areas are dominated by *Juniperus communis* L., *Rhododendron ferrugineum* L., and *Sorbus aucuparia* L. However, the northern slope of the valley, in which the cave is located, is actually scarcely covered with vegetation, whereas the riverbanks and Lake Llebreta shores are characterized by a greater biodiversity.

6.2.2 Archaeological researches

The site was discovered during a field survey in 2004. A high number of archaeological remains dating back to different periods, from Neolithic to Medieval and Modern times, were found in the area. One of them was the site of Cova del Sardo. During the same campaign, a first stratigraphic excavation was carried out inside the cave. Charcoal samples were taken for radiocarbon dating. The relevant outcomes indicated the presence of a number of archaeological layers ranging from about 2900 cal BC to 5600 cal BC. Ceramic and lithic materials were also recovered from the survey (Gassiot & Jiménez 2006).

Systematic archaeological excavation, directed by Dr. Ermengol Gassiot Ballbè and Prof. Albert Pèlachs Mañosa of the Universitat Autònoma de Barcelona, took place between 2006 and 2008, investigating the entire inner area and part of the external terrace, for a total area of about 60 m². The methodology followed during the excavation was based on the work of Castro et al (1999). No grid system was used. Topographic plans have been carried out by means of a Sokkia SET3B total station. The different types of archaeological evidence have been identified and classified using a phase and subphase-based system, called '*teoria de conjuntos'* (Castro et al. 1999). This system represents a variant of Harris Stratigraphic Method (Harris 1979), in which each *conjunto*[1] is defined as aggregate of sedimentary and/or structural units that form a homogeneous phase. The single contexts that compose a *conjunto* are called *subconjunto*. Those units can be of different kind (sediments, structures, artefacts, negative actions, *etc.*) and resemble Harris' Stratigraphic Units (U.S.). For example, during the excavation of Cova del Sardo, the *subconjuntos* were classified into two types: 'A' refers to layers, regardless their formation (geological or anthropic), and 'B' to structures, lke post-holes, hearths, walls, pavements, *etc.*

All sediments have been dry-sieved on site, using a 0.5 mm mesh sifter, while samples (about 10 per 100 litres of sediment) have been taken for wet sieving. Finally, sediment samples have been taken from each *subconjuntos* of anthropogenic origin.

Five different phases of occupation have been ascertained. The first archaeological evidence of human occupation at the cave comes from Phase 9, dated to ca. 5600-5400 cal BC. Human presence is attested to by a pit-hearth with a small number of lithic materials associated with that (Gassiot et al. 2010a, 2010b). This stage seems to show an early and short occupation of the site, probably related to a single episode (Fig. 6.2, *a*).

After a more than five-century hiatus, during the fifth millennium cal BC, human presence is attested to 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 inner and external area. Hearths and other combustion structures have been identified. Lithic materials, not abundant, are associated with rare ceramic fragments (Fig. 6.2, *a*).

At the beginning of the fourth millennium, the cave was settled once again with a series of occupations dated to between ca. 4400 and 3400 cal BC (Phase 7). The main archaeological evidence displays an array of fire pits located inside the rock-shelter, while the external terrace seems to have been little frequented. Fragments of pottery, characterized by plastic decorations, lithic remains and highly-fragmented and burnt faunal remains were recovered (Fig. 6.2, *b*).

Toward the end of the millennium, between ca. 3500 and 3000 cal BC, a new phase of occupation took place, namely, Phase 6. The presence of numerous large pieces of a burnt

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[1] In the text I will refer to '*conjuntos'* and '*subconjuntos'* respectively with the terms 'phases' and 'subphases'.

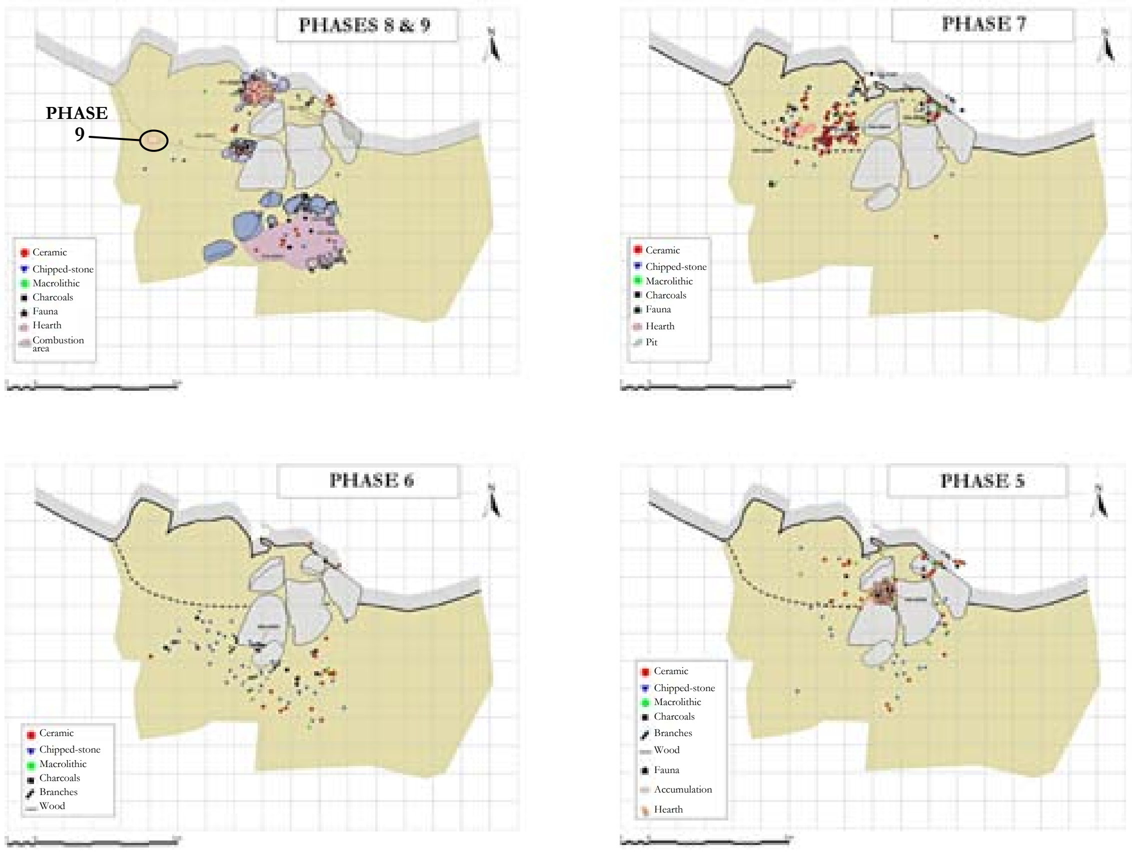

Fig. 6.2. Plan of the Cova del Sardo de Boí. *a*) Phases 9 & 8. Phase 9 correspond exclusively to one pit-hearth, while all the other remains in the plant belong to Phase 8. *b*) Phase 7; *c*) Phase 6; *d*) Phase 5. Modified from Gassiot et al. 2014.

tree stump suggests the existence of some type of vegetable roofing that covered the cave entrance. In the inner area, human traces are almost absent. (Fig. 6.2, *c*).

The last prehistoric occupation of the cave, Phase 5, dated to between ca. 2900 and 2500 cal BC, seems to follow the same pattern as that documented for Phase 7, with a series of human occupations organized around a large fire pit situated in the central sector of the cave (Fig. 6.2, *d*).

6.2.3 Detailed stratigraphy

Phase 1: Surface Layer. Dark-brown organic silt soils with few archaeological materials of modern and contemporary periods.

Phase 2: 16th-18th century cal AD. Dark-brown organic silt soil characterized by the presence of abundant charcoal and remains of three modern hearths. A few archaeological materials: both metallic and lithic artefacts.

Phase 3: 10th-11th century cal AD. Layer composed of brown-grey organic silty sediments. Remains of medieval hearths inside the cave. One has to remark the presence of a granite pebble pavement and the construction of a wall delimiting the outside terrace, probably for stabling livestock. The archaeological materials recovered from this phase are fragments of wheel-thrown pottery and lithic, metallic, and faunal remains.

Phase 5: First half of the third millennium cal BC. Dark-brown and dark organic silty soil with abundant charcoal. Remains of an ancient hearth inside the cave, which was delimited by three large granite stones. Ceramics and lithic materials have mostly been found in the NE corner of the cave, probably because of household upkeep activities.

Subphases: A-5A1. It is a natural layer.

Subphase: A-5A1-est, A-5A1-oest, A-5A2. Domestic layers located in the central sector of the shelter. Few lithic materials have been recovered.

Subphase: A-5B1. Pit-hearth delimited by three large granite stones. The pit is about 20 cm deep.

Subphases: A-5A3. Habitation layer located in the external terrace. Large granite stones chaotically mixed with smaller ones. Both lithic and ceramic materials have been recovered.

Phase 6: Second half of the fourth millennium cal BC. Layer composed of dark organic silty sediments. Archaeological (lithic, ceramic) materials have been recovered only from the exterior area. A high number of large fragments of burnt tree stump suggest the presence of some kind of vegetal roofing covering the rock-shelter entrance. In the inner space, almost no traces of human presence have been found.

Subphases: A-6A1, A-6A2, A-6A4, A-6A9. External terrace: layers lying below A-5A3 Unit. These subphases represent the collapse of the roof structure. Large remains of burnt tree stumps mixed with ashes and few archaeological materials.

Phase 7: First half of the fourth millennium cal BC. One has to remark the presence of hearths and archaeological materials inside the shelter.

Subphase: A-7B2. Pit hearth measuring 60 x 55 x 20 cm. A flat granite stone was used to create a sort of floor. Lithic, faunal, and ceramic materials have been recovered from the hearth.

Subphase: A-7B4. Pit hearth of 29 x 18 x 4.5 cm. Few lithic and faunal remains have been recovered.

Subphase: A-7B6. Irregular pit measuring 80 x 33 x 15 cm, excavated between two granite blocks.

Subphases: A-7A30, A-7A31, A-7A33. Western area of the shelter characterized by brown-yellow silty layers. Habitation area: abundant archaeological remains have been recovered.

Subphases: A-7A8, A-7A8bis, A-7A21, A-7A15. Central area of the cave. Archaeological materials are few.

Subphases: A-7A7, A-7A19, A-7A20, A-7A27. Eastern area of the cave. Brown sediments located between a number of granite blocks, probably caused by maintenance activities. Scattered archaeological materials.

Phase 8: Fifth millennium cal BC. The occupation of the abri took place both inside and outside the cave. Hearths and other combustion areas have been detected. An abundant archaeological record has been recovered.

Subphase: A-8B1. Hearth delimited by stones, with an elliptical shape and measuring 105 x 72 cm. This context emerged from the central sector of the excavation inside the cave.

Subphase: A-8B2. Hearth delimited by stones and measuring 59 x 33 cm. This context was situated in the central sector of the outside excavation.

Subphases: A-8B3. Brown-grey layers related to the building and use of hearths. Lithic and ceramic materials are at low numbers.

Subphases: A-8A4, A-8A6, A-8A3, A-8B4. Layers rich in charcoal and ashes, located in the external terrace (A-8A4, A-8A6). This area is delimited by two parallel alignments of granite stones (A-8A3, A8B4). It has been preliminarily interpreted as a combustion area.

Phase 9: Sixth millennium cal BC. This phase represents the first human occupation of the site. The only archaeological evidence that attests to human presence at the site is a pit hearth (43 x 30 cm) located in the SW area of the excavation. No materials have been found.

6.2.4. Radiocarbon chronology

Cova del Sardo de Boí's stratigraphic sequence is supported by more than twenty radiocarbon dates. For the analysed phases —Phases 9, 8, 7, 6, and 5—, 16 radiocarbon dates are available, obtained from samples coming from reliable sedimentary contexts, such as wood-charred samples recovered directly from hearths and combustion structures. Faunal materials were too deteriorated for radiocarbon dating. All calibrations were carried out by OxCal software 4.2.3 (Bronk Ramsey 2013), using IntCal13 calibration curve (Reimer et al. 2013) (see Tab. 6.1).

Phase 9: This phase has been dated by one ^{14}C Date (Tab. 6.1). The sample comes from the only identified structure: a pit-hearth (A-9B1). The result of the dating, obtained from a charcoal fragment, indicates that the hearth was used between 5565 and 5460 cal BC (75.4%).

Phase 8: This phase has been dated by six ^{14}C Dates (Tab. 6.1). Two of them have been obtained from hearths found inside the shelter (A-8B1, A-8B2) and another from a layer rich in charcoal in the NE area of the cave (A-8A6). The last three samples come from the external terrace (A-8A4). The results indicate that human occupation took place during the first half of the fifth millennium. Radiocarbon dates suggest that both areas (inside and outside) were occupied at the same time at least for a period of about 200 years.

Phase 7: This phase has been dated on the basis of five ^{14}C Dates (Tab. 6.1). The samples for two of them have been taken from pit hearths (A-7B2, A-7B6), while the other ones come from occupational layers (A-7A15, A-7A31, A7A8B). Human occupation took place between the end of the fifth and the first half of the fourth millennium cal BC. During these 700-800 years, the cave seems to have been inhabited in different periods, showing short and repeated occupations.

Phase 6: This phase has been dated on the basis of one ^{14}C Date (Tab. 6.1). The sample has been taken from one of the burnt tree stumps that was probably part of the cave roof. The calibrated date is characterized by two different intervals that display most of the probabilities: the first one between 3375 and 3305 (36%), while the second one between 3240 and 3100 (56%). One can affirm that the collapse/burning of the roof occurred during the second half of the fourth millennium cal BC.

Ref. Lab.	Layer	Sample	BP	±	Cal BC 1σ	%	Cal BC 2σ	%	Cal BP 2σ (whole range)
KIA-37689	A-9B1	Charcoal (*Pinus Sylvestris Nigra*)	6525	45	5545-5465 5400-5390	67.2 1.0	5610-5590 5565-5460 5455-5375	2.7 75.4 17.3	7560-7325
KIA-37690	A-8B1	Charcoal (*Pinus Sylvestris Nigra*)	5850	40	4785-4690	68.2	4785-4690 4800-4600	1.2 94.2	6734-6636
KIA-40878	A-8A4	Charcoal (*Pinus Sylvestris Nigra*)	5715	35	4600-4495	68.2	4685-4635 4620-4460	10.3 85.1	6630-6410
KIA-40817	A-8B2	Charcoal (*Pinus Sylvestris nigra*)	5686	35	4550-4460	68.2	4655-4640 4620-4445	0.6 94.8	6600-6395
KIA-36935	A-8A4	Charcoal (*Pinus Sylvestris Nigra*)	5695	35	4555-4460	68.2	4655-4640 4620-4450	1.4 94.0	6605-6400
KIA-40815	A-8A4	Charcoal (*Pinus Sylvestris Nigra*)	5635	35	4520-4445 4420-4400	58.8 9.4	4540-4365	95.4	6490-6315
KIA-41134	A-8A6	Charcoal (*Pinus Sylvestris Nigra*)	5645	25	4505-4450	68.2	4545-4440 4451-4395 4380-4375	89.5 5.3 0.6	6495-6320
KIA-32340	A-7A31	Charcoal (*Pinus Sylvestris - uncinata*)	5245	40	4225-4205 4155-4130 4070-3980	5.2 10.2 52.8	4230-4195 4175-3970	9.8 85.7	6180-5920
KIA-26248	Survey 2004 talla9	Charcoal (*indet*)	5060	40	3945-3890 3885-3830 3825-3795	28.6 25.3 14.2	3965-3765	95.4	5915-5715
KIA-40816	A-7B6	Charcoal (*Pinus Sylvestris nigra*)	5000	30	3895-3880 3800-3710	4.2 64.0	3940-3865 3815-3700	23.0 72.4	5890-5650
KIA-32342	A-7B2	Charcoal (*Fraxinus excelxsior*)	4945	35	3765-3690 3685-3660	54.0 14.2	3795-3650	95.4	5740-5600
KIA-36394	A-7A8	Charcoal (*Pinus Sylvestris nigra*)	4765	40	3635-3620 3610-3520	9.2 59.1	3645-3505 3430-3301	83.8 11.6	5590-5330
KIA-37691	A-7A15	Charcoal (*Pinus Sylvestris nigra*)	4715	35	3630-3595 3530-3500 3451-3375	18.9 16.0 33.3	3635-3560 3540-3490 3470-3375	30.4 20.6 44.4	5585-5320
KIA-32351	A-6A1	Charcoal (*Pinus Sylvestris/unicnata*)	4555	30	3365-3330 3215-3185 3160-3125	30.2 20.0 18.0	3485-3475 3375-3305 3300-3285 3280-3260 3240-3100	0.6 36.0 1.3 1.5 56.0	5435-5050
KIA-26251	Survey 2004	Charcoal	4210	35	2895-2860 2810-2755 2720-2705	24.3 37.0 6.9	2905-2840 2815-2675	32.2 63.2	4815-4440
KIA-32348	A-5B1	Charcoal (*Pinus Sylvestris/unicnata*)	4090	35	2850-2810 2680-2570	13.2 54.5	2865-2805 2760-2715 2710-2560 2535-2495	19.3 8.5 62.0 5.6	4850-4625

Tab. 6.1. ^{14}C Dates from Cova del Sardo phases 9, 8, 7, 6, 5 (from above to below) (Gassiot & Pèlachs 2010). Calibrated dates, both BC and BP, have been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013). Dates calBP are expressed indicating the whole range of 2σ (95.4).

Phase 5: This phase has been dated on the basis of two ^{14}C Dates (Tab. 6.1). Both samples come from the central hearth (A-5B1). Calibrated dates display the first half of the third millennium cal BC, more precisely between 2900 and 2500 cal BC. Within this range, the first date (KIA-26251) probably indicates an early use of the hearth, which goes back to between ca. 2800 and 2680, while the second date (KIA-32348), which falls within the period between ca. 2710 and 2560 cal BC, bears evidence of a later occupation of the abri. In conclusion, radiocarbon dating confirms that, during Phase 5, the shelter was probably inhabited in different moments, this suggesting a pattern of repeated occupations over *ca*. 300 years

In order to prove the consistency of the different dates with the relevant stratigraphic phases, I carried out a Model of Sequential Phases by OxCal 4.2.3 (Fig. 6.3). Such models were set up by inserting the relative ages of the samples according to the site stratigraphy. Briefly, the program calculated the probability distributions of each ^{14}C dating and then attempted to combine these distributions, called 'posterior', with the relative calendar ages of the samples, called 'prior distribution'. As a result, an agreement index was calculated, which reflected the consistency between the two distributions. If the posterior distribution falls in a high-probability area of the prior distribution, the agreement index is high (sometimes 100 or more). If the agreement index is below 60 (a threshold value), the scientific date is regarded as inconsistent (*cfr*. Chap. 2, Par. 2.2.8).

In this case, I grouped all ^{14}C dates in five contiguous bounded phases that follow one another sequentially in the OxCal model. Phases were modelled without the possibility of temporal overlap between them. In a first attempt, I inserted all available dates for each phase. The resulting model indicated a moderate agreement index (^{A}85.6%). The reason for that low agreement was the presence of a sample that did not match the radiocarbon sequence of its phase. Actually, Sample KIA-37690 from Phase 8 showed an insufficient agreement index (^{A}54%). Its calibration resulted in that being almost 200 years older than the other dates of Phase 8. On the other hand, the other five dates show almost the same time as they fall within an interval of only 180 years, namely, between ca. 4620 and 4440 cal BC. A possible explanation may be that Sample KIA-37690 was affected by the 'old-wood effect' and, accordingly, it showed an older interval than the other samples did. Alternatively —if one assumes it to be true—, it may represents an earlier occupation of the cave. In any case, it was preferable to exclude this date from the model. Excluding KIA-37690, the resulting model gave a higher agreement index (^{A}106.5%).

As a result, I identified the following intervals for each phase of occupation:

Phase 9: 5565-5370 cal BC (95.4%);

Phase 8: 4580-4440 cal BC (95.4%);

Phase 7: 4220-3385 cal BC (95.4%);

Phase 6: 3370-3100 cal BC (95.4%);

Phase 5: 2900-2575 cal BC (95.4%).

After each phase, a period of abandonment visibly occurred at the abri. The longest interval is between Phase 9 and Phase 8, which displays a 800-year gap. Later, the abandonment periods were shorter, on average between 200 and 300 years. Moreover, the model points out the existence of different patterns of occupation. This is particular evident between Phases 8 and 7, for which a higher number of samples are available (Fig. 6.2). While Phase 8 appears to have been a short but continuous occupation, Phase 7 seems to have

Fig. 6.3. Model of Sequential Phases. Multiple plot of ^{14}C Dates from the Cova del Sardo sequence (yrsBC). Model has been realized with OxCal software v4.2.3 Bronk Ramsey (2013); Atmospheric data from Reimer et al (2013). The date KIA-37690 has been excluded from the model.

been characterized by a discontinuous settlement taking place over a longer period of time. However, such differences are discussed in details in the next paragraphs.

6.3. Materials

6.3.1. Ceramic assemblage

The ceramic assemblage from Cova del Sardo is currently being studied by Dr. E. Gassiot and Dr. X. Clop of the Universitat Autònoma de Barcelona. Typological, technological, and petrological analyses are still being carried out; therefore, only preliminary data is available.

The assemblage is small and composed of very fragmentary finds, especially about the prehistoric phases. Decorated fragments are rare; undecorated coarseware prevails. In almost all of the analysed phases, the dominant types are globular pots and hemispherical bowls, generally of small size. In addition, the appearance of large pottery items during Phase 5 is significant, which were possibly storage vessels (Gassiot et al. 2014). However, to draw any further conclusion, one has to wait for more detailed data.

6.3.2. Archaeozoological assemblage

The archaeozoological assemblage recovered from Cova del Sardo has recently been studied by V. Navarrete and M. Saña of the Universitat Autònoma de Barcelona (Navarrete & Saña 2013). The number of remains is extremely low in all of the analysed phases. About the prehistoric phases, from Phase 8 to Phase 5, faunal remains amount to less than 3,000 elements, of which about 500 are determinable remains. Moreover, apart from the low number, archaeozoological materials are characterized by a very poor state of preservation, being extremely fragmentary and heavily altered by fire (Fig 6.4). The identified species/families can be summarized as following:

Phase 9: no faunal remains have been recovered from this phase;

Phase 8: few remains of *Ovis/Capra* and other fragments of indeterminate medium-size mammals;

Phase 7: the assemblage is slightly larger than in the previous phase. Few remains of *Ovis/Capra* and a small group of fragments of indeterminate medium-size mammals;

Phase 6: few remains of *Ovis/Capra* and few fragments of indeterminate medium-size mammals;

Phase 5: few remains of *Capra hircus* and Ovis/Capra (*Caprinae*); the remains are fragments of indeterminate medium-size mammals or indeterminate fragments.

It is evident that the preservation of animal materials is extremely poor. Only 1.5% of the assemblage has been identified in terms of family or species. Such a poor preservation, apart from the possible action of taphonomic agents, is mainly due to materials having been intentionally discarded into the hearths of the cave. Indeed, the authors assert that faunal materials have been intentionally employed as fuel for keeping fire burning. Similar practices were not peculiar to Cova del Sardo, but they have been recognized in other sites of the Iberian Peninsula, too (Navarrete & Saña 2013). Alternatively, or complementarily, their state of preservation can be explicated as a result of an intensive fracturing of bones for extracting

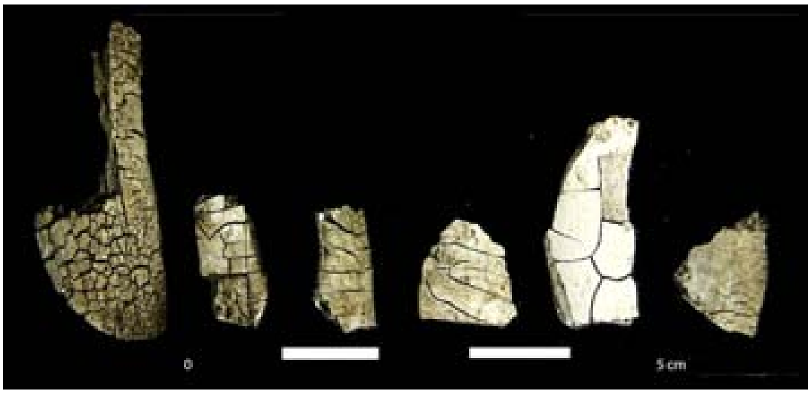

Fig. 6.4. Archaeozoological assemblage of the Cova del Sardo, modified from Navarrette & Saña (2013). Faunal remains are extremely fragmentary and heavily burned.

marrow. Afterwards, remains might have been burned to keep the inhabited area clean and wild animals away.

In addition, there are at least two points that should be remarked. The first one is the general scarcity of faunal remains. The total number of fragments is 2,466, the large majority of which are smaller than 3-4 mm, for a total weight of the assemblage of about 340-350 grams. This indicates a limited extent of slaughter activities practised at the site. Animal-carcass processing/consumption appears to have been extremely rare at Cova del Sardo. The other aspect to remark is the exclusive presence of mammals of medium-size, amongst which only domestic ovicaprids have been determined. Although taxonomic identification is extremely complicated in the light of such a state of preservation and taking into account that other species may have originally featured in the faunal assemblage, it is reasonable to assume that the main species at Cova del Sardo were actually domestic ovicaprids, given their representation along the entire prehistoric sequence.

6.3.3. Other materials

6.3.3.1. Macrolithic assemblage

Apart from chipped lithic industry and ceramic assemblage, during the excavation of Cova del Sardo, several macrolithic elements have also been recovered and conserved (rocks, stones, and pebbles), although the large majority of them do not show any evident modification. All of these materials have been preliminarily analysed with I. Clemente of the Institution Milà i Fontanals of the Consejo Superior de Investigaciones Científicas. No tools have been identified amongst the assemblage, like, for example, mills, hand-mills, or other grinding tools. However, by macroscopic observation, most of the rocks appeared to have been altered by fire. Therefore, one of the hypotheses is that at least some of them were used to retain heat, namely, a sort of 'heating stones'.

6.3.3.2. Macro-charcoals

Amongst the other remains collected from Cova del Sardo, the archaeobotanical ones are some of the best preserved materials. The study of macro-charcoals is currently underway by L. Obea and R. Piqué of the Universitat Autònoma de Barcelona. Some preliminary results have already been published, mainly focusing on the ways of exploiting wood as fuel (Obea et al. 2011). This study suggests the existence of some significant difference in the use of forest resources between the various occupational phases. During the earliest phase, Phase 8, the used taxa were mainly *Pinus sylvestris-nigra*, followed by *Salix/Populus* and *Corylus avellana*. During Phase 7, *Pinus sylvestris-nigra* was still the best represented taxon, but then followed by *Juniperus sp*. This trend continued until the last prehistoric phase (Phase 5). Moreover, some taxa were commonly used in all phases: *Salix/Populus*, *Prunus*, and deciduous *Quercus sp.*

Comparing Sardo Cave to other sites of the NE of the Iberian Peninsula, Obea et al. (2011) assert that altitude is a crucial variable to explain the taxonomic distribution in the archaeological sites. Conifers were the most important in firewood-collection strategies at middle and high altitudes, while deciduous and Mediterranean taxa were mostly used at low-altitude sites

6.3.4. Lithic assemblage

6.3.4.1. General Aspects

The lithic assemblage recovered from the prehistoric contexts of Cova del Sardo (Phases 8-5) is constituted by a low number of implements. The assemblage is composed of 368 items, made out of chert (*n.* 199; 54.1%) as well as of other stone types (*n.* 169; 45.9%), which include both retouched (*n.* 57; 15.5%) and non-retouched (*n.* 311; 84.5%) implements.

Given the long period of settlement at Cova del Sardo, that is, more than 3000 years, although characterized by long gaps and abandonment phases, the lithic industry can actually be considered a small assemblage, especially if compared to the sites of the same time located at lower altitudes, either in Catalonia or Aragon.

Cova del Sardo has been excavated almost completely. Most of the habitable areas of the cave, including not only the inner room, but also the external terrace, have been investigated. Habitation structures, hearths, and numerous occupational layers have been detected and carefully documented. The paucity of materials should therefore be attributed neither to the methods of excavation adopted nor to other biases in the archaeological record.

Taphonomic factors probably had a minimal impact on the preservation of the assemblage. Erosion processes have been documented in the external sectors of the excavation. However, most of the lithic materials were collected around the habitation structures such as fire pits, hearths, combustion areas, and other accumulations of waste and by-products, which represent the best preserved features since they have been scarcely affected by the action of erosion processes (Gassiot 2010).

Consequently, the low number of lithic items should be interpreted as a result of behaviours performed by the inhabitants of the site. Their number, morphology, and dispersion should be interpreted as a consequence of the technological organization, settlement pattern, and mobility strategies adopted; in other words, of the economic organization of such groups.

Sediments have been sieved on site, using both dry- and wet-sieving techniques. Microlithic and other microscopic remains have been recovered, amongst which debris, microlithic tools, micro-charcoals. All the lithic materials abandoned *in situ* have thus probably been recovered during the excavation. Every lithic item has been conserved separately in plastic blags, this favouring a good preservation of surfaces and preventing any type of post-excavation damage.

Fig. 6.5. Main typological groups identified among the Cova del Sardo assemblage. *a-c*) geometric tools; *d*) Foliated point; *e-f)* sickle blades; *g-h*) blade scrapers. Modified by Gassiot et al. 2014.

PHASE		T	Gm	F	P	L	R	D	E	LD-PD-DT	TOT
5	**N**	2	6	2	1	5	5	-	-	1	22
	%	9,1%	27,3%	9,1%	4,5%	22,7%	22,7%	-	-	4,5%	100%
6	**N**	-	1	1	-	2	3	-	-		7
	%	-	14,3%	14,3%	-	28,6%	42,9%	-	-		100%
7	**N**	2	8	-	-	9	2	1	1	-	23
	%	8,7%	34,8%	-	-	39,1%	8,7%	4,3%	4,3%	-	100%
8	**N**	1	2	-	-	2	-	-	-	-	5
	%	20,0%	40,0%	-	-	40,0%-	-	-	-	-	100%
TOT	**N**	5	17	3	1	18	10	1	1	1	57
	%	8,8%	29,8%	5,3%	1,8%	31,6%	17,5%	1,8%	1,8%	1,8%	100%

Tab. 6.2. Typological classification of the lithic assemblage of the Cova del Sardo (1987). Based on Place typological lists (Laplace 1964). T: Truncated tools; Gm: Geometric tools; F: Foliated tools; P: Points; L: Blade scrapers; R: Flake scrapers; D: Denticulated tools; E: *Écaillé* tools; LD-PD-DT: backed tools.

6.3.4.2. Typological aspects

From a typological point of view, Cova del Sardo is characterized by the presence of a high percentage of retouched implements (*n.* 57), which represent 28.9% of the chert assemblage. Considering the four contexts, the typological frame is dominated by the Substrate (*n.* 30; 52.6%), followed by Abrupt-Retouch Instruments (*n.* 23; 40.4%), whereas Foliated and *Écaillé* tools are represented by minimal percentages. Considering the basic situation, blade and flake scrapers are the main typologies, followed by geometric tools (Tab.

6.2). The remaining groups are of little significance in the context as a whole. However, it is to remark that the number of implements is always very low; percentages and typological analysis should therefore be regarded as approximate.

In terms of manufacture, the majority of tools are characterized by partial and marginal retouches, often discontinuous on the edges (Fig. 6.5, *d-h*). Invasive retouches can be observed amongst Phase-5 tools only, which are characterized by overlapping series of edge-resharpening scars, made by impression.

A more accurate manufacturing technique can also be observed for geometric tools. In the first two phases (Phases 8 and 7), segments prevail. They were often made on blades and shaped by unilateral abrupt retouch (Fig. 6.2, *a-b*). About Phases 6-5, it is remarkable that a decrease in the number of segments has been detected, with an increase in trapezoidal and foliated implements (Fig. 6.2, *c-d*). The variability of raw materials and blank types used for producing microlithic tools is also of consequence, especially considering the small sample. However, there was a clear tendency towards the employment of exogenous and extra-regional raw materials for manufacturing geometric tools.

6.3.4.3. Raw materials procurement

The Sant Nicolau Valley is constituted by two main geological formations: on the northern side, one finds the Palaeozoic rocks of the Maladeta Massif, while the southern slope is characterized by Devonian and Silurian-period metamorphic rocks, mainly constituted by calcareous and volcanic rocks. Such a difference is reflected in the Sant Nicolau River bedrock, in which all local lithologies can be easily found, like granite, slate, schist, porphyry, and hornfels. The Sant Nicolau riverbed, which is located 60 metres away from Cova del Sardo, probably represents the nearest catchment area for the prehistoric groups that inhabited the site. In that area, all local lithologies were collected (Fig. 6.8, *i-l*). Amongst them, porphyry clearly prevailed (Fig. 6.6, *p*) followed by slate (Fig. 6.6, *q*), while the remaining rocks are represented by minimal percentages (Tab. 6.3).

Amongst the non-siliceous rocks exploited, the most distant source is represented by Rhyolites (Fig. 6.8, *h*). This magmatic rock is characterized by a green colour, a fine texture, and by the presence of feldspar and quartz phenocrysts. Similar materials are found in the Stephanian-Permian formations of the Malpás Basin, near the locality of Erill Castell, about 20-30 km from the site (Marti 1983) (Fig. 6.6, *l-n*).

Amongst the chert materials transported to Cova del Sardo, I have distinguished three main groups (Fig. 6.6, 6.7; Tab. 6.3). The first one is constituted by a dark, black to grey coloured, solid chert with abundant fossiliferous inclusions mainly composed of marine foraminifera, sponge spicules, and calcispheres (Fig. 6.6, *a-c*). However, only a few fragments of this type have been recognized amongst Cova del Sardo's assemblage (Fig. 6.8, *g*). Similar cherts can be found 30 km south of Cova del Sardo, near the locality of Soperia, in the carbonate facies of the Cenomanian-Turonian period (Cretaceous) that is part of the so-called Pardina formation (Caus et al. 1997) (Fig. 6.7).

The group with a higher number of elements shows a solid light-coloured chert, from white to grey, often with reddish shades (Fig. 6.8, *d-e*). Macroscopically, such materials appear compact and with rare fossiliferous inclusions. Mineral oxide impurities (hematite grains) are also visible. Microscopically, their characteristic is a thick semi-translucent cryptocrystalline matrix with the presence of fibrous, length-slow, spherulitic quartzite and lenticular gypsum pseudomorphs (Fig. 6.6, *d-f)*. The scarce fossiliferous record is composed of charophytic algae and, to a lesser extent, gastropods and ostracods. In the region, chert materials of this

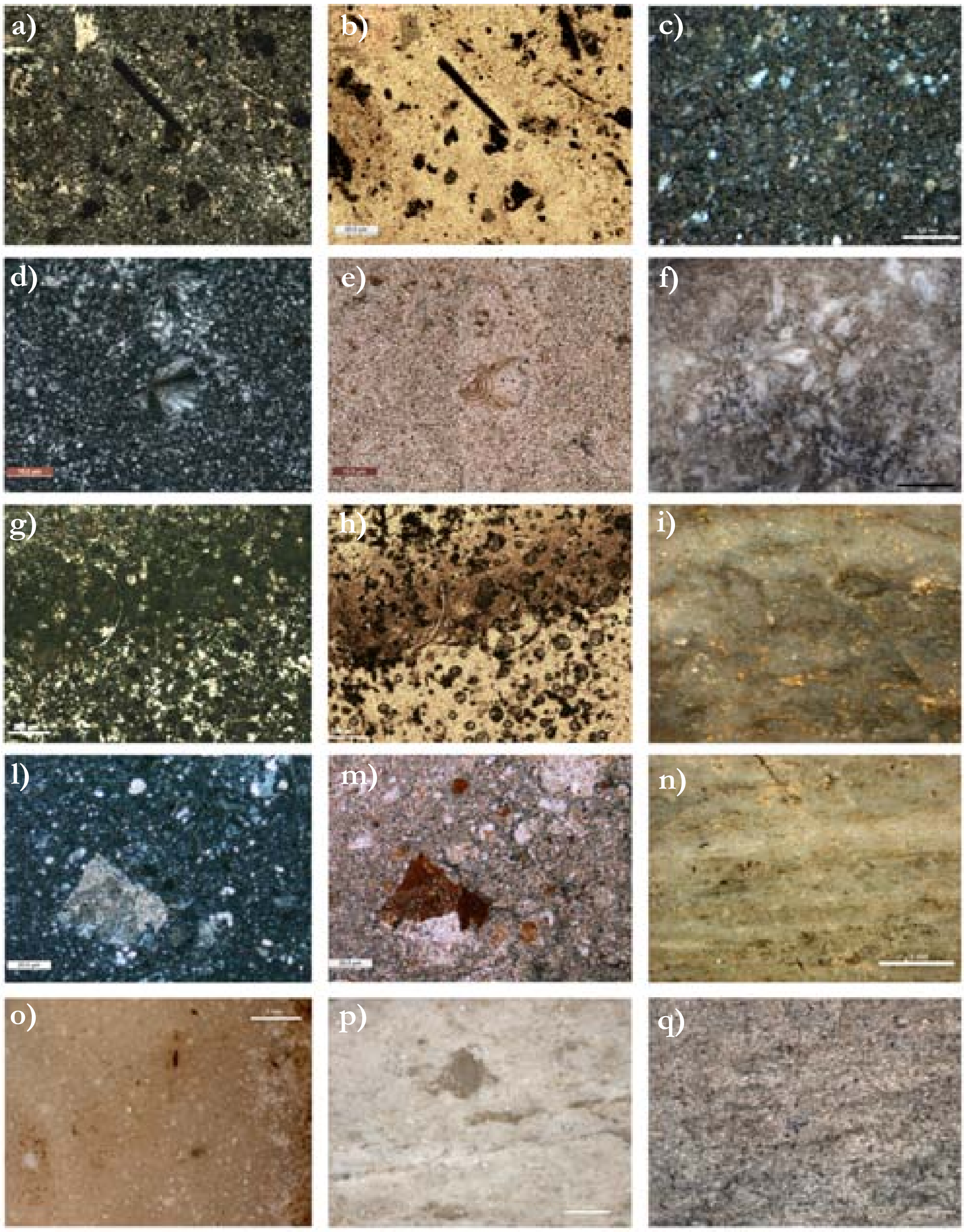

Fig. 6.6. Macro- and macroscopic photographs of the main raw-materials from the Cova del Sardo assemblage. A-C) Cretaceous Marine cherts: *a-b)* Thin section view under microscope, plan-polarized light and crossed polariser view (50X); *c)* Marine foraminifera and spicule at 8x magnification. D-F) Continental chert type: *d-e)* Thin section view (same as before), fibrous, length-slow, chalcedony; *f)* Lenticular shaped gypsum pseudomorphs at 10X magnification. G-I) Oligocene-Miocene Lacustrine cherts: *g-h)* Thin section view (same as before), fragments of ostracods; *i)* Ostracods and a transversal section of a *Charophyte algae* at 10X magnification. L-N) Permo-Carboniferous Rhyolite: *l-m)* Thin section view (same as before), phenocrysts. *n)* rhyolite macroscopic aspect 7X magnification. O-Q) Other rocks, macroscopic view: *o)* Indeterminate tabular chert, 10X; *p)* Porphyry, quartz phenocrysts, 15X; *q)* Slate, macroscopic view, 10X.

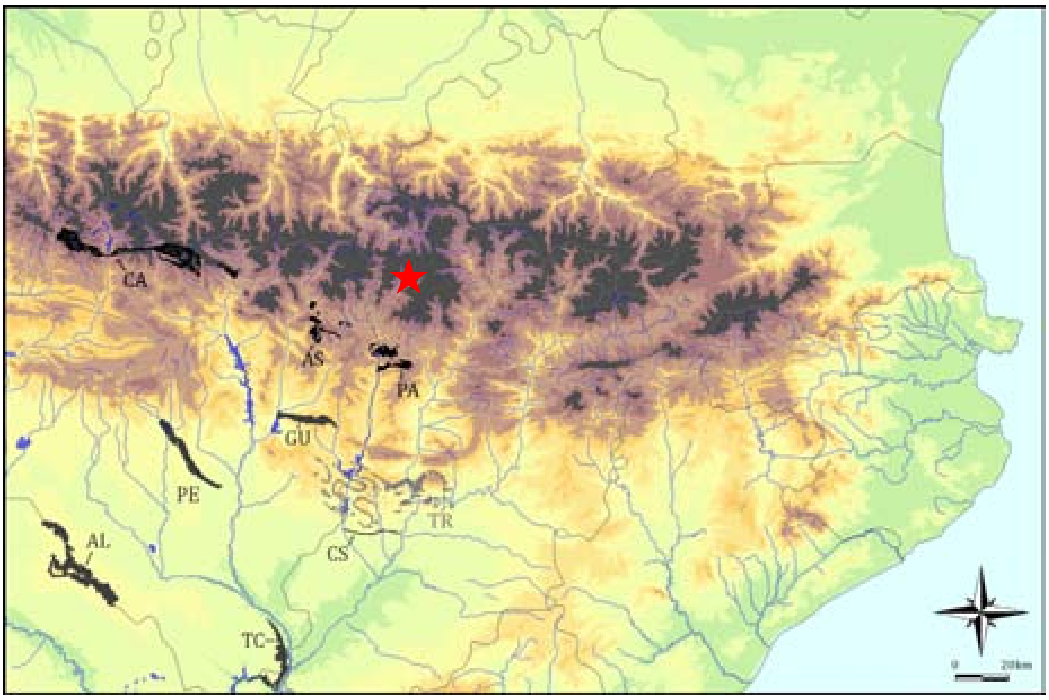

Fig. 6.7. Digital Terrain Model with the principal formations containing chert in the region. Map realized with software Miramon v7.1h. The red star indicates the Cova del Sardo. CA: frm. Calizas de las carenas altas; AS: frm. Agua Salenz; PA: frm. Pardina; TR: frm. Tremp; GU: frm. Guarga; CS: frm. Castelltallat; PE: frm. Peraltilla; AL: frm. Alcubierre; TC: frm. Torrent de Cinca.

PHASE		Other rocks								Cherts			Ind	TOT
		Hfs	Qrz	Hya	Sch	Gra	Sla	Por	Rhy	LOM	EVP	MEC		
5	N	-	-	-	1	-	-	10	12	16	21	3	17	80
	%	-	-	-	1,3%	-	-	12,5%	15,0%	20,0%	26,3%	3,8%	21,3%	100%
6	N	1	5	-	-	1	-	27	-	5	22	8	21	90
	%	1,1%	5,6%	-	-	1,1%	-	30%	-	5,6%	24,4%	8,9%	23,3%	100%
7	N	-	13	1	1	2	8	13	23	22	18	7	32	140
	%	-	9,3%	0,7%	0,7%	1,4%	5,7%	9,3%	16,4%	15,7%	12,9%	5,0%	22,9%	100%
8	N	1	1	-	-	4	9	12	-	9	7	-	15	58
	%	1,7%	1,7%	-	-	6,9%	15,5%	20,7%	-	15,5%	12,1%	-	25,9%	100,0%
TOT	N	2	19	1	2	7	17	62	35	52	68	18	85	368
	%	0,5%	5,2%	0,3%	0,5%	1,9%	4,6%	16,8%	9,5%	14,1%	18,5%	4,9%	23,1%	100%

Tab. 6.3. Raw-materials composition of the Cova del Sardo lithic assemblage. *Other rocks* - Hfs: Hornfels; Qrz: Quartzite; Hya: Hyaline Quartz; Sch: Schist; Gra: Granite; Sla: Slate; Por; Porphyry; Rhy: Rhyolite; *Cherts* - LOM: Lacustrine Oligocene-Miocene chert; EVP: Upper Cretaceous-Palaeocene Evaporitic chert; MEC: Eocene-Cretaceous Marine chert; *Ind*. Indeterminate materials.

type are known in the Upper-Cretaceous-Palaeocene carbonate units (Maastrichtian and Thanetian), which are part of the South Pyrenean Central Unit, known as Tremp Formation or Tremp Group (López-Martínez et al. 2006) (Fig. 6.7). The nearest outcrops are located 40-60 km from the site.

A third group consists of a brown chert type, with colours ranging from beige to dark brown (Fig. 6.8, *a-c*). Macroscopically, it appears compact or characterized by concentric bands (Liesegang rings). Microscopically, it is characterised by a cryptocrystalline matrix rich in inclusions, amongst which metal oxides, macroquartz grains, and carbonate residues. The abundant fossiliferous record is mainly comprised of transverse and longitudinal sections of *charophyte algae*, ostracods, and, occasionally, gastropods (Fig. 6.6, *g-i*). Similar materials have been recovered from the Oligocene and Miocene lacustrine carbonaceous formations of the Central and Eastern Ebro Valley, the outcrops of which are situated at a distance of 80 to 100 km from the site. Some of the nearest sources are situated in the localities of Alfarràs and Algerri (Castelltallat Fm.), in the province of Lledia (Anadón et al. 1989). Other sources have been detected in Peraltilla (Peraltilla Fm.), in the province of Huesca. Further south, chert materials with the same characteristics have been found in Alcubierre (Arenas & Pardo 1999) and Torrent de Cinca Formations (Luzón et al. 2002) (Fig. 6.7).

Finally, the last cluster of materials groups together all indeterminable items. Amongst them, there are chert pieces which have been heavily affected by thermal or taphonomic alterations and chert types represented by a low number of specimens, therefore difficult to classify into specific groups. However, amongst indeterminate materials, the presence of an exogenous chert types is to remark (Fig. 6.8, *o*; Fig. 6.8, *f*). Their sources are to be sought outside of the Pyrenean range, in the northern side of the chain or in the eastern-southern coastal areas.

Collected data allows for the establishment of patterns about the procurement of different raw materials during the various occupational phases. The analysis has been carried out by a Chi-square test, in order to check whether the distribution of the various variables differs significantly from one phase to another.

A first test concerned data grouped on the basis of region of provenance («Axial Pyrenees», «pre-Pyrenees», «Ebro Basin»), excluding all those materials of uncertain provenance. The result indicated a high statistical significance (χ^2: 33.765; df: 6; *P*: 0.000). Local materials coming from the Axial Pyrenees prevailed during Phase 8 (64.3%) and Phase 6 (52.1%). Allochthonous materials, mainly constituted by chipped chert materials, appear to have been less intensively exploited. During Phase 8, Ebro-Basin chert prevailed (21.3%) over pre-Pyrenees cherts (14.3%), which are notably underrepresented. On the other hand, about Phase 6, Ebro lithologies appear to have been little used 6.8%), while pre-Pyrenean cherts are represented by a large assemblage (41.1%), this suggesting a greater exploitation of the sources located at medium distance from the site (Sopeira and Tremp Basin), within 30-60 km.

About Phases 7-5, one can observe opposite dynamics. Both levels show a clear prevalence of allochthonous materials, 64.8% and 80.2% of the assemblage respectively, which mainly come from the Tremp and Ebro Basin, and, to a lesser extent, from the Cretaceous formations of the Soperia Basin. Also rhyolites are present amongst the allochthonous materials —a lithology that is found in the northern sector of the Catalan pre-Pyrenees, in the Malpás Basin, about 30 km from Cova del Sardo. There are no significant differences between the two phases, even if one can notice an increase in the percentages of chert materials, specifically from 47% during Phase 7 to 65% during Phase 5.

A second test has been carried out by grouping all raw materials on the basis of their availability: «local rocks» and «non-local rocks». In this case, I also included in the analysis the indeterminable chert materials, which anyway represent allochthonous sources. The test confirmed a high statistical significance for the analysed sample (χ^2: 19.699; df: 3; *P*: 0.000). The distribution of local and non-local raw materials follows a pattern similar to the one previously observed. Phases 8-6 show a more even balance between local and non-local materials, whilst, in Phases 7-5, exogenous lithologies clearly prevailed, 70% and 83%

Fig. 6.8. Selection of materials from the Cova del Sardo lithic assemblage. A-C) Oligocene-Miocene Lacustrine chert type: *a)* blades; *b)* core; *c)* geometric tools (trapezes and segments); D-E) Evaporiotic Upper Cretaceous-Palaeocene chert type: *d)* blades; *e)* geometric tools (trapezes and segments). The last element on the right of the figure is a geometric tool in course of manufacture; F) Exogenous indeterminate chert types. Blades and a Foliated point.; G) Cretaceous Marine chert type, debris and rejuvenating flakes; H) Rhyolite, cores, flakes and waste materials; I) Porphyry flakes and elongated flakes, debris and a core fragments. L) Slate, tabular flakes.

respectively.

A last test has been carried out by dividing the assemblage on the basis of their petrographic characteristics, specifically «siliceous rocks» and «non-siliceous rocks»; however, in this case, the *P*-value confirmed the null hypothesis as the distribution of the variables did not differ significantly from one phase to another (χ^2: 7.168; df: 3; *P*: 0.067).

I am aware that the sample of materials is quite small and some caution is thus required while interpreting these results; nonetheless, such differences are statistically significant, then the Chi-square test seems to confirm that the strategies of raw-material exploitation varied through time, probably in relation to changes in the settlement pattern (e.g. duration and stability of the occupation, single or recurrent occupations, mobility pattern, *etc.*).

6.3.4.4. Technological management

From a technological point of view, the lithic assemblage of Cova del Sardo is generally characterized by a scarcity of elements related to core-preparation and reduction phases (see. Tab. 6.4). One can highlight the following aspects:

i. a low percentage of core (0.8%);
ii. a low percentage of cortical elements (4.9%);
iii. not very significant presence of debris (24.2%);
iv. a low number of characteristic core trimming elements (4.6%);
v. an high laminarity index (Ll) (40.9%).

The scarcity of cores, core-rejuvenation and preparation flakes, and cortical elements suggests that a large part of the knapping process took place outside of the site. Indeed, the majority of debris belong to local rock types, whereas chert debris and by-products are almost absent.

Non-siliceous rocks show an opportunistic exploitation, probably without or with little core preparation. Porphyries appear to have mainly been employed for producing elongated flakes of 19-29 x 13-20 x 5-8 mm on averarge (Fig. 6.8, *i*). Also rhyolite appears to have been exploited for making elongated flakes; the presence of a polyhedral core with two opposite percussion surfaces and a large dorsal negative indicates the removal of elongated blanks (Fig. 6.8, *h*). However, only few debris and waste materials have been recovered inside the site, this suggesting that rhyolite tools were mainly transported and discarded elsewhere. Slate materials were mainly exploited for the production of flat, tabular blanks (Fig. 6.8, *l*). Hyaline quartz, quartzite, schist, and granite were only marginally exploited and are represented by a low number of specimens.

Cretaceous marine cherts, coming from the Sopeira Basin are little documented in all of the analysed phases. Lithic materials are mainly represented by debris and small core-rejuvenation flakes (Fig. 6.8, *g*). 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.

The Upper Cretaceous-Palaeocene cherts from the Tremp-Graus Basin represent the main source of siliceous materials throughout the occupation sequence. The great majority of blanks, mainly blades, were probably transported to Cova del Sardo already flaked. However, the presence of few debris and cortical flakes suggests that at least a small part of them were produced on site. However, non-exhausted cores were probably transported to other places

PHASE		Flake	Blade	Core	Débris	Characteristic waste products	Other	Indet	TOT
5	N	18	24	-	26	6	1	5	80
	%	22,5%	30,0%	-	32,5%	7,5%	1,3%	6,2%	100%
6	N	29	11	1	30	5	1	13	90
	%	32,2%	12,2%	1,1%	33,3%	5,6%	1,1%	14,4%	100%
7	N	34	27	2	26	4	1	46	140
	%	24,3%	19,3%	1,4%	18,6%	2,9%	0,7%	32,9%	100%
8	N	23	10	-	7	2	-	16	58
	%	39,7%	17,2%	-	12,1%	3,4%	-	27,6%	100%
TOT	N	104	72	3	89	17	3	80	368
	%	28,3%	19,6%	0,8%	24,2%	4,6%	0,8%	21,7%	100%

Tab. 6.4. Technological composition of the Cova del Sardo assemblage. *Indet.* indicates indeterminate blanks. *Other* indicates other categories such as fragment of pebbles, fragments of polished implements, tools on tabular blanks, etc. Technological lexicon has been taken from Inizan et al. 1999.

for further use and so discarded elsewhere. This behaviour would explain the absence of core at the site. Moreover, it is possible that a large part of the debris derives from retouching/maintenance activities and not from flaking activities. For example, the local production of geometric tools is documented by the presence of an unfinished trapezoidal geometric tool (Fig. 6.8, *e*).

The chert materials from the Ebro Basin show a similar situation. Among the assemblage, I have distinguished two main types of products: small narrow blades (30-20 x 12-10 x 3-2 mm) and larger blades (70-85 x 15-20 x 3-4 mm). Considering the presence of few characteristic core-trimming elements (a crested blade and a core-rejuvenation flake), it is plausible that a small part of them were manufactured on site. Small preformed cores were probably taken to Cova del Sardo for the local production of small blades and/or flakes. The presence of one core with a percussion surface and dorsal negatives of flake removal (Fig. 6.8, *b*) seem to confirm this hypothesis. However, the large majority of products were transported to the site already flaked, in form of finished blanks or prepared tools.

In order to verify observations and explore the distribution of lithic remains amongst the various occupational phases, I have carried out a Chi-square test. A first test concerned the lithic remains divided into three main categories («blade», «flake», «waste materials»), grouping all cores, core fragments, debris, and knapping by-products in specific clusters. The result indicated a high statistical significance (χ^2: 20.390; df: 6; *P*: 0.002), disproving the null hypothesis of a homogeneous distribution of the remains. About Phases 8-6, where local lithologies prevailed, there was a prevalence of flake products over blades (54.8%-23.8% during Phase 8 and 37.7%-14.3% during Phase 6 respectively). In addition, in Phase 6, where I have observed a greater exploitation of local and pre-Pyrenean resources, knapping by-products prevailed (48.1%), this suggesting the practice of some on-site knapping and/o retouching activities.

On the contrary, Phase 7 displayed a more even balance between flakes and blades (34.0% -31.9%), whilst, in Phase 5, blades clearly prevailed (23.4%-31.2%). This scenario is consistent with a greater exploitation of good-quality raw materials supplied from distant sources and with the transportation of finished blanks and prepared tools.

A second test took place for exploring the distribution of the various technological categories («blade», «flake», «waste materials») among the various lithological categories

(«Oligocene-Miocene chert», «Upper Cretaceous-Palaeocene chert», «Cretaceous Marine chert», «Rhyolite» «Porphyry» «Other rocks»). The resulting *P*-value confirmed the existence of an association between the two variables ($\chi 2$: 134.340; df: 10; *P*: 0.000). All non-siliceous rocks were characterized by a predominance of flakes and knapping by-products. Among chert materials, Cretaceous Marine cherts were almost exclusively characterized by waste materials (76.5%), while cherts from distance sources were characterized by a predominance of blade blanks. This was particular evident in the case of the Ebro chert types, where blades represent the majority of the sample (64.6%), while flakes and other knapping by-products displayed low percentages (16.7% and 18.8% respectively). For the Tremp chert types, blades represent about half of the sample (49.2%), followed by waste materials (33.8%) and flakes (16.9%).

Finally, the high fragmentarity of the assemblage is to remark (*n.* 277; 75.3%). This data suggests that most of the lithic materials recovered at Cova del Sardo are exhausted implements, at the end of their use-life, broken and discarded. In addition, a significant number of implements also display signs of thermal alterations (*n.* 86; 23.4%), probably caused by them having been thrown near or into fire pits.

6.4. Traceological analysis

6.4.1. Material conservation

During the excavations, all the recovered lithic materials were singularly conserved in plastic bags, thus avoiding any post-excavation damage. However, the microscopic analysis has revealed the existence of other types of alteration caused by various kinds of taphonomic agents. Indeed, given the geographical and physical context of the site, located on a slope characterized by erosion processes, seasonal periods of snow and frost, flow of torrential streams, *etc*., one actually expects the archaeological deposit to have been strongly affected by a wide range of natural agents. Weathering processes of various type, freeze-thaw cycles, percolation of meteoric waters, changes in soil pH, all are phenomena that probably took place cyclically and partially affected the stability of the deposit.

Moreover, during the excavation, episodes of erosion were detected, which brought about cracks and fall of materials from the ceiling of the cave. One of the most considerable episodes is the collapse of large granite blocks during Phase 3, which caused a partial dispersion and fragmentation of archaeological materials in the underlying layers.

However, at Cova del Sardo, post-depositional alterations are no insurmountable obstacle for the functional interpretation of the lithic assemblage. Although a group of elements showed heavy alterations (*n.* 76; 20.8%), which have prevented from analysing them, on the large majority of implements, the preservation of lithic surfaces was sufficiently good for carrying out a traceological investigation.

6.4.1.1. Mechanical alterations

A preliminary micromorphological study of Cova del Sardo's prehistoric contexts indicates that the deposit was relatively stable. Prehistoric levels have not been affected by any strong movement and materials can fundamentally be considered *in situ* (Gassiot 2010). However, minor alterations have been detected. Indeed, the micromorphological analysis suggests that waterflow probably brought about movements of the smaller sediment particles, whilst it was not strong enough to cause heavier debris to shift.

Such a waterflow was probably not an episodic event, but a cyclical phenomenon. Over a period of more than 6000 years, it is likely that water percolation and freeze-thaw cycles has produced a certain alteration of lithic surfaces, which has mainly resulted in a slight smoothening of edges and ridges. Traces of this type have been detected on some of Cova del Sardo's archaeological materials, as for example: superficial soil-lustres (Fig. 6.9, *a-d*), bright spots of different extent (Fig. 6.9, *e-f)*, edge rounding and abrasions (Fig. 6.9, *g-h*.). Such types of wears are visible on different items, from tools to unused and unmodified blanks, this confirming their non-human or non-intentional origin.

On the majority of implements, such alterations are not very evident, at least not preventing the traceological analysis. However, a number of tools have been excluded from the study because of heavy mechanical alterations (*n.* 58; 14.8%). Moreover, in some cases, it is possible that mechanical alterations have modified or disturbed pre-existing traces, especially those typologies of traces that are more easily covered or erased by natural agents. This is the case of all the traces produced by contact with a soft animal substance (butchering, fresh hide scraping, etc.). At Cova del Sardo, such a type of traces should probably be considered underrepresented, compared to other typologies of traces such as use-wear caused by vegetable substances, which are more resistant to mechanical alterations.

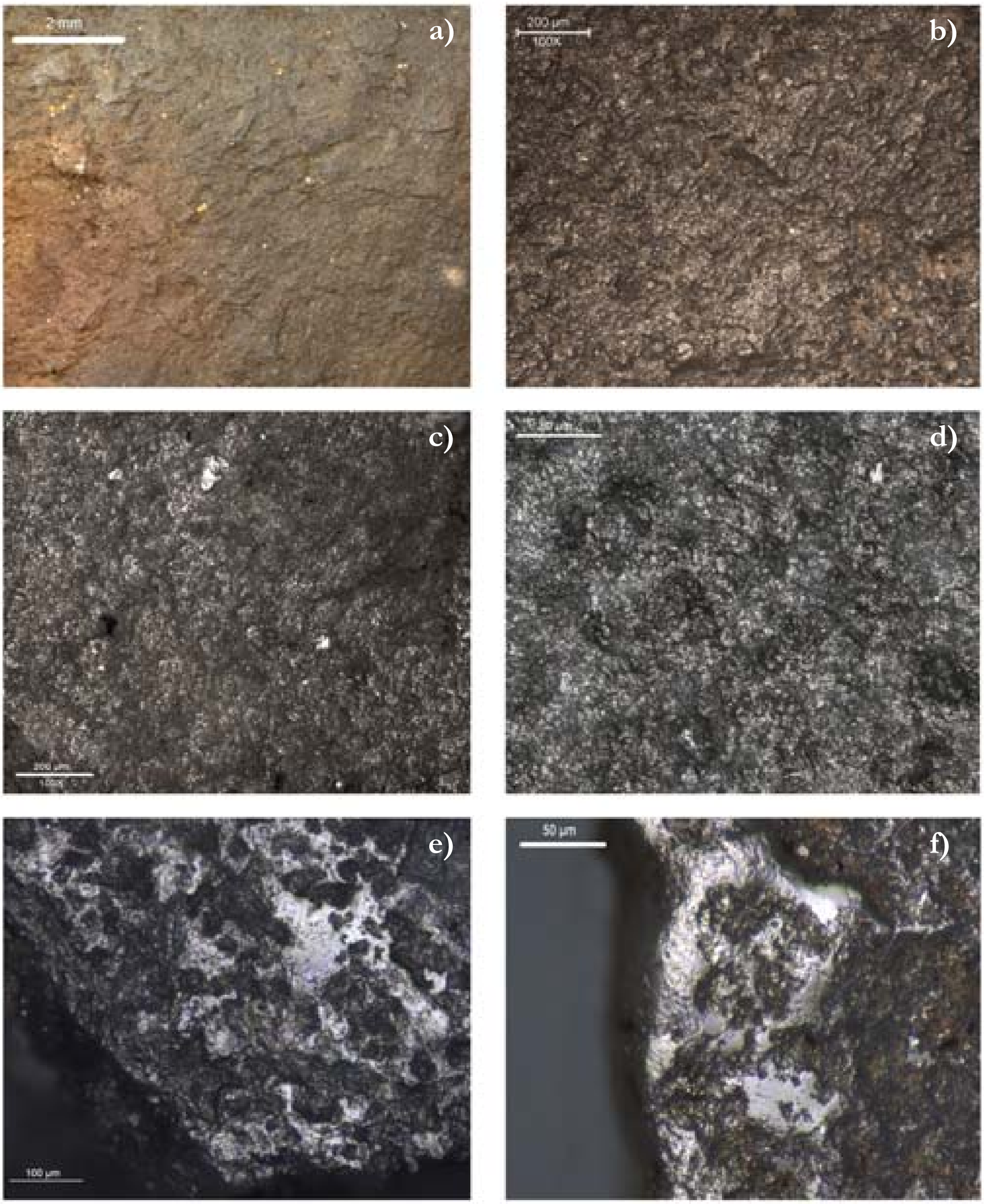

Fig. 6.9. Some example of the mechanical alterations observed among the Cova del Sardo lithic assemblage: *a*) Macroscopic view of a 'soil-lustre'. The surface appears slightly polished and rounded. 8X magnification; *b-c*) Two soil lustres at 100X magnification. The polishing of the lithic surface is slight, and traces are still interpretable. *d*) Same image as before, but at 50X magnification; *e*) Friction spots at 100X; *f*) Edge rounding and friction spots at 50X. The element has been excluded from the analysis as strongly altered.

6.4.1.2. Chemical alterations

During the analysis of Cova del Sardo's assemblage, a number of different alterations have been observed. Among them, a group of tools show alterations that can be related to a change in the chemical composition of the chert material itself (*n.* 26; 7.1%). I have mainly distinguished two types of chemical alterations, acidic and alkaline alterations (*cfr.* Chap. 2, Par. 2.3.1).

Acidic alterations have scarcely affected the assemblage. There are only few elements in which I have recognized some dissolution of chert's carbonate impurities. Macroscopically, such alterations are visible as dissolved carbonates leave pores and empty spaces in the rock. Sometimes, the dissolution of the carbonate component of the chert can also bring about the formation of patinas on the lithic surfaces (Fig. 6.10, *a*).

On the other hand, alkaline alterations mainly affect the siliceous component of rocks as well as of the use-wear traces (Fig. 6.10, *b*). However, while α-quartz and chalcedony need very strong alkaline environments to be dissolved, amorphous silica is easily dissolved also at lower pH. In archaeological contexts, basic pH is often due to the presence of ashes, which contain calcium and potassium and so tend to increase soil alkalinity.

Cova del Sardo is characterized, in almost all of the prehistoric contexts, by a great amount of ashes and charcoals. Moreover, many of the recovered instruments come directly from hearths or surrounding layers, the sediments of which are almost exclusively composed of ashes and other by-products of burning activities. This point is particularly important when one considers the preservation of use-wear polishes. One of the main components of polishes is indeed amorphous silica, especially in the case of polishes produced by vegetable substances, where a layer of amorphous silica has been deposited directly on the lithic surface (Anderson-Gerfaud 1981; Fullagar 1991). Preliminary experiments have proved that ash layers can cause some dissolution of amorphous silica-based polishes also in soil under natural conditions (*cfr.* Chap. 2, Par. 2.3.1.).

A number of 'altered' vegetable polishes have been detected amongst Cova del Sardo's lithic assemblage (Fig. 6.10, *c-f)*. Visually, the dissolution of silica tends to change the fluid and smooth aspect, typical of plant polishes, to a rougher aspect, characterized by a larger number of craters and striations. However, the distribution pattern of polishes remains fundamentally unchanged and, in most of the cases, the traceological interpretation is still possible.

Finally a third group, which can also be regarded as a result of chemical alterations, is that of burnt implements. There are 18 elements (4.9%), which have been excluded from the study because of being heavily burned and characterized by cracks and fissures. Thermal alterations characterize a high number of implements (*n.* 67, 18.4%), since a large part of the industry comes from hearths and combustion areas; however, in most of the cases, fire-induced alterations have not prevented the traceological analysis.

6.4.2. Phase 8

The lithic assemblage recovered from Phase 8 is quite small (*n.* 58). By traceological analysis, I have identified 10 elements that show use-wears produced by an intentional use of the tools (*n.* 11 AUAs). Traces can be clearly interpreted in 5 cases (45,5%) (SG); 3 elements show a probable use (27,8%) (PR) and other 3 elements a possible use (PO) (27,8%) (see Tab. 6.5). For a summary of the activities and movements ascertained, see Tab. 6.8 at the end

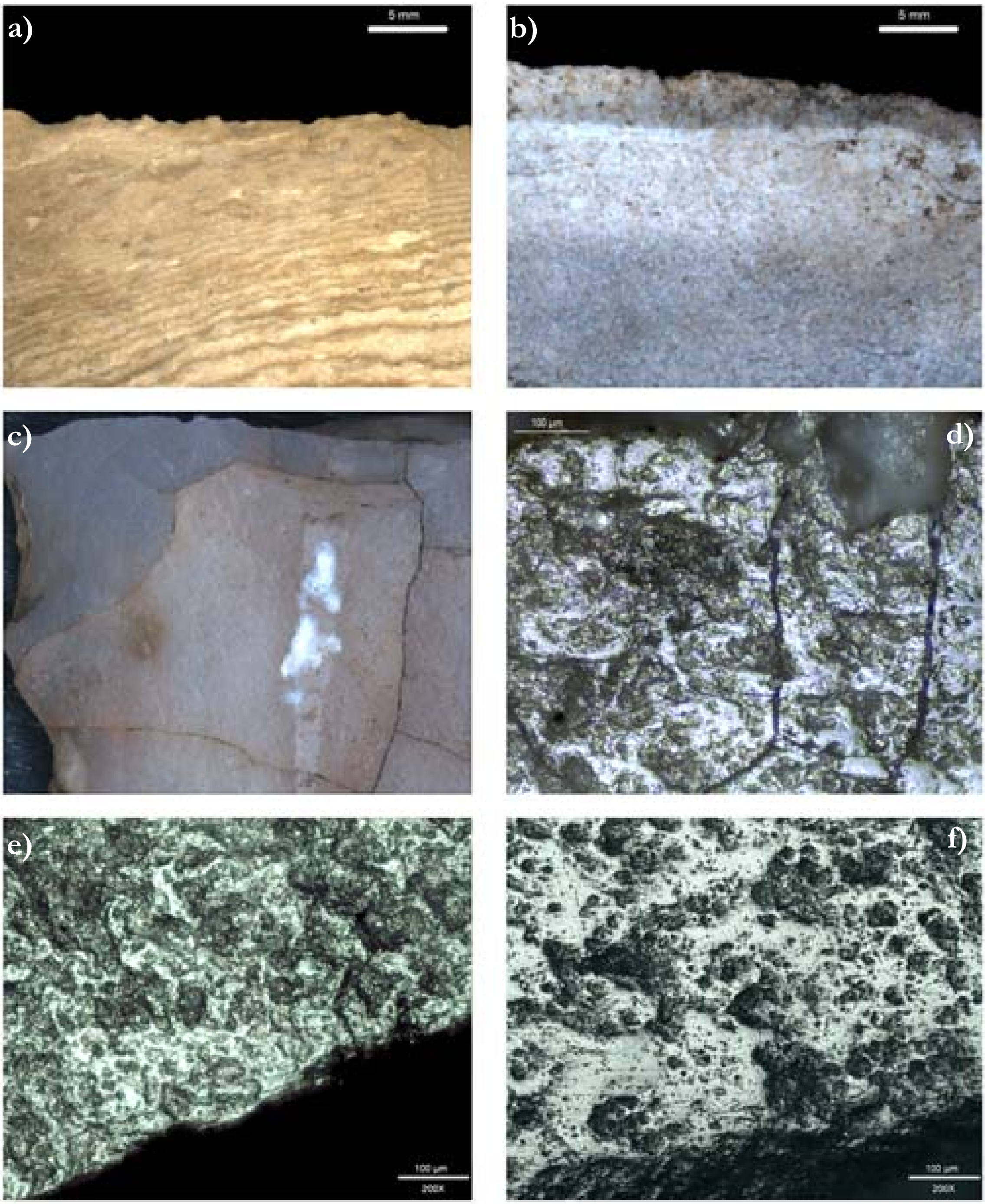

Fig. 6.10. Some example of the mechanical alterations observed among the Cova del Sardo lithic assemblage: *a*) Macroscopic view of an acid patina. 8X magnification; *b*) Macroscopic view of an white/alkaline patina. 8X magnification; *c*) White spots on a burned lithic, probably produced by alkaline environment; *d-e-f)* Plant polish altered by alkaline agents. The partial dissolution of the silica-gel led to lost of volume, with the formation of craters and blank spots. 200X magnification.

of the chapter.

Among non-utilitarian traces, I have identified one possible hafting trace (HF) (Rots 2010) and one transportation trace (TR) (Mazzucco & Clemente 2013).

6.4.2.1. Use-wears

6.4.2.1.1. Vegetal Substances

Amongst the detected use-wears, traces produced by non-ligneous vegetable substances prevail (*n.* 4 AUAs; 36.4%) (Tab. 6.6). I have observed three elements, specifically one bladelet, two blades, and one rejuvenation flake.

The tool that shows a better preservation of the wears is a proximal fragment of a bladelet (21 x 9.5 x 2.5 mm), which was employed for cutting herbaceous plants. Wears are distributed over the right edge. Polishes are well-preserved and also visible to the naked eye. Indeed, one can macroscopically notice the presence of a marginal lustre that resembles to the so-called 'sickle gloss' (Fig. 6.11, *a1, b1*). Microscopically, the polish appears fluid and smooth, with a domed topography and a compact texture (Fig. 6.11, *a2*). About the presence of tiny scratches and abrasions on the extreme part of the tools' edge (Fig. 6.11, *b2*), I would regard them as due to the reuse of the tool for working a soft substance, probably a soft animal substance.

A second blade of larger size (18.5 x 8.5 x 2.5) is characterized by the presence of traces related to the cutting of plant materials in association with a strong abrasive component (Fig. 6.11, *c*). Clemente & Gibaja (1998) described such a wear as produced by the cutting of cereal straws to ground level. In this case, the abrasive component would ensue from the contact with the soil particles that have adhered to the lithic surface. Actually, during the movement, those particles scratch the lithic surfaces and the vegetable polish that is forming over them. However, similar traces can be produced by other activities, too: separation of the ears from the straws, cutting of grasses to ground level, cutting of meadow. Recently carried-out experimental works seem to confirm this hypothesis (Mazzucco et al. 2014).

The remaining two elements also display traces of non-ligneous vegetable substances, probably herbaceous plants; however, their state of preservation is not optimal. Polishes appear degraded and they have probably undergone a mechanical or chemical alteration which has brought about a decrease in the size of the polishes. Their aspect is rougher and the glossy 'polished' spots are mainly concentrated in the topographic highpoints, as observed in experimental tests (Fig. 6.12, *a2*) (*cfr.* Chap. 2, Par. 2.3.1.). However, both distribution patterns and the presence of a clear directionality suggest an intentional use of the tools.

6.4.2.1.2. Animal Substances

Tools associated with working animal substance are only two (*n.* 2 AUAs; 18.2%). The first one is the above-mentioned 'sickle element'. The presence of scratches, abrasions, and microfractures over the utilized edge suggests a reuse of the blade for cutting soft animal substances, probably in relation to slaughter activities (Fig. 6.11, *b2*). The second element is a flake, broken at the distal end, which was probably used on the right edge to cut soft/ medium animal substances (Fig. 6.12, *b1-2*). The edge is rounded and displays scalar/feather fractures. Polishes appear poorly preserved; all the same, some spots of a rough polish with tiny striations suggest the cutting of some type of abrasive matter, maybe leather or hide. However, the poor preservation of the surfaces prevents a clear interpretation of the tool.

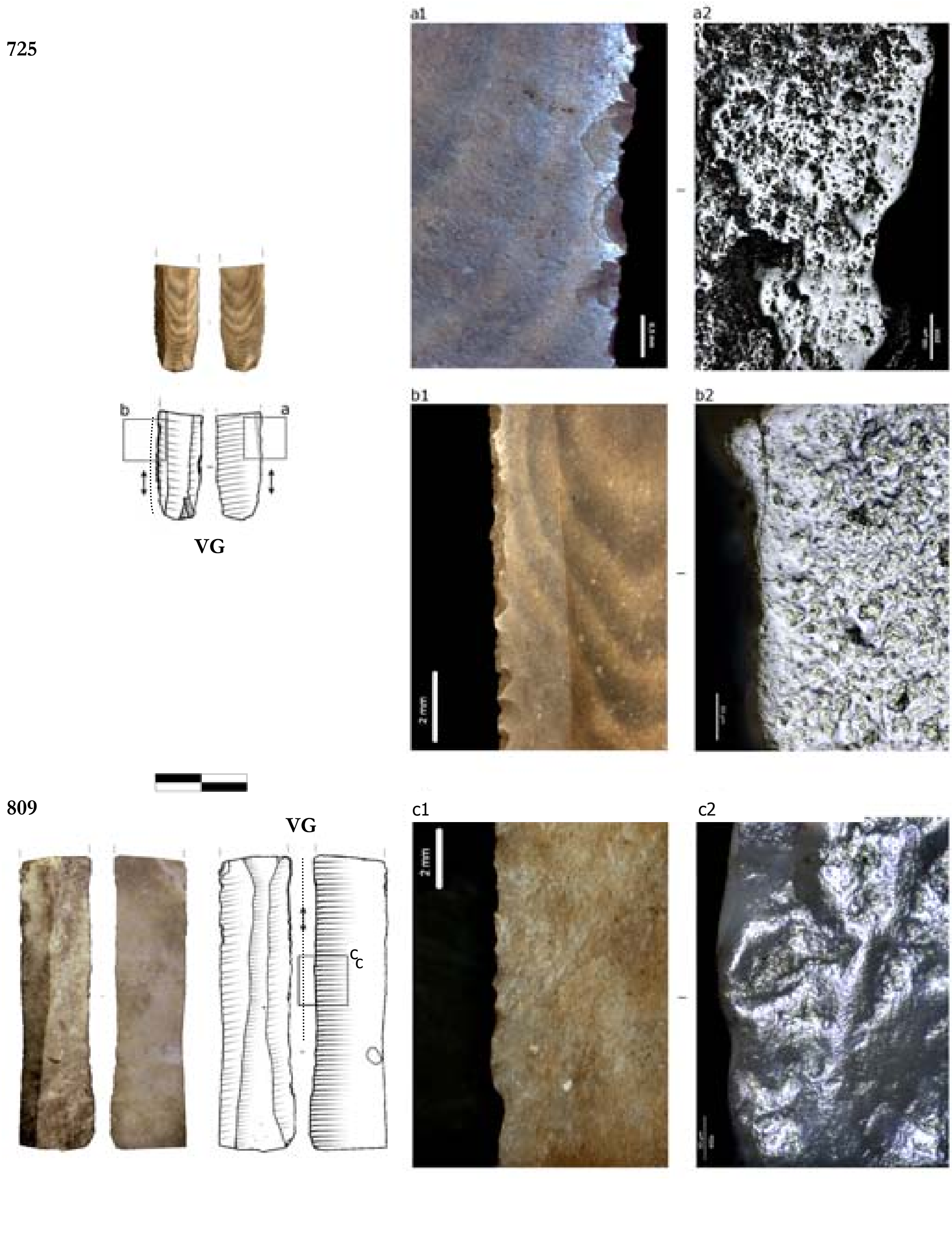

Fig. 6.11. Use-wears from the Cova del Sardo, Phase 8. **725-** Tool used for harvesting herbaceous plants, probably cereal, and later retooled for butchering; *a1-b1)* Macroscopic views of the edge showing 'cereal lustre': *a1*) ventral face, 8X; *b1*) dorsal face, 15X. *a2-b2*) Microscopic views of the polish: *a2*) Compact polish produced from harvesting herbaceous plants, 200X; *b2*) Plant polish after retooling. See the presence of scratches and strias over the margin, 400X. **809-** Tool used for harvesting grasses at the ground level (RV2 polish); *c1-c2*) Macroscopic and microscopic view of the used edge, 10X and 400X.

6.4.2.1.3. Projectile elements

Amongst the assemblage from Phase 8, a geometric tool is present —a segment shaped by abrupt retouch— as well as a fragment of another indeterminate backed tool, probably a trapezoid or a segment (*n.* 2 AUAs; 18.2%).

The first one shows clear signs of having been employed as projectile insert. It presents a burin-like fracture on both edges (Fig. 6.12, *c1*) and also a sequence of invasive overlapping step-terminating bending fractures at the unretouched edge (Fig. 6.12, *d1*). On the basis of the directionality of impact fractures, it seems plausible that the tool was hafted diagonally with respect to the axis of the arrow, probably as arrowhead.

The second element is exclusively represented by a small fragment of triangular shape (Fig. 6.13). It is probably one of the ends of a broken segment. One edge, slightly convex, was shaped by abrupt retouch, while the opposite edge is unretouched, with a rectilinear profile. This is probably a waste material of a broken arrowhead, possibly a small distal/proximal fragment of a microlith that remained trapped inside the wooden haft and that was later discarded at the site. This hypothesis appears to be confirmed by the presence of an impact fracture, which shows a burin-like morphology (Fig. 6.13, *a1-2*).

6.4.2.1.4. Indeterminable substances

This category groups together all those elements that have possibly been used, but whose interpretation remains uncertain (*n.* 3 AUAs; 27.2%). There are several factors that can influence the interpretability of tools, amongst which the effect of post-depositional alterations, the type of raw material employed, or an use for a very short period of time.

Among this group, there is one fragment made out of chert and two flakes of porphyry. Microscopically, surfaces are too altered to recognize any clear wear of use; however, macroscopically, the presence of rounded parts and fractures suggests a possible employment of these tools for working soft/medium-hard substances. The interpretation remains uncertain anyway.

6.4.2.2. Non-utilitarian wears

Among non-utilitarian traces, I have observed the presence of a possible hafting wear and a possible transportation wear. Hafting wears are shown by some glossy spots located on the dorsal ridge of a small blade (Fig. 6.10). The presence of this type of friction spots on ridges and other non-functional portions of the tool is typically associated with hafting (Rots 2010); however, their interpretation is often controversial. Indeed, post-depositional processes can produce traces which resemble this type of wears.

Similar points can be made about transportation traces (Mazzucco & Clemente 2013). Some of the most characteristic wears produced by transportation are extensive friction spots, striations, and marginal edge scarring. Such types of traces have been recognized on the surface of the sickle blade (Fig. 6.11). In addition, it is to take into account that this instrument was probably employed for several activities: at first, it was used for harvesting herbaceous plants and, later (after it broke?), retooled on site for cutting soft animal substances. It is thus plausible that the tools were transported from one site to another. However, given the presence of post-depositional alterations, this interpretation remains uncertain.

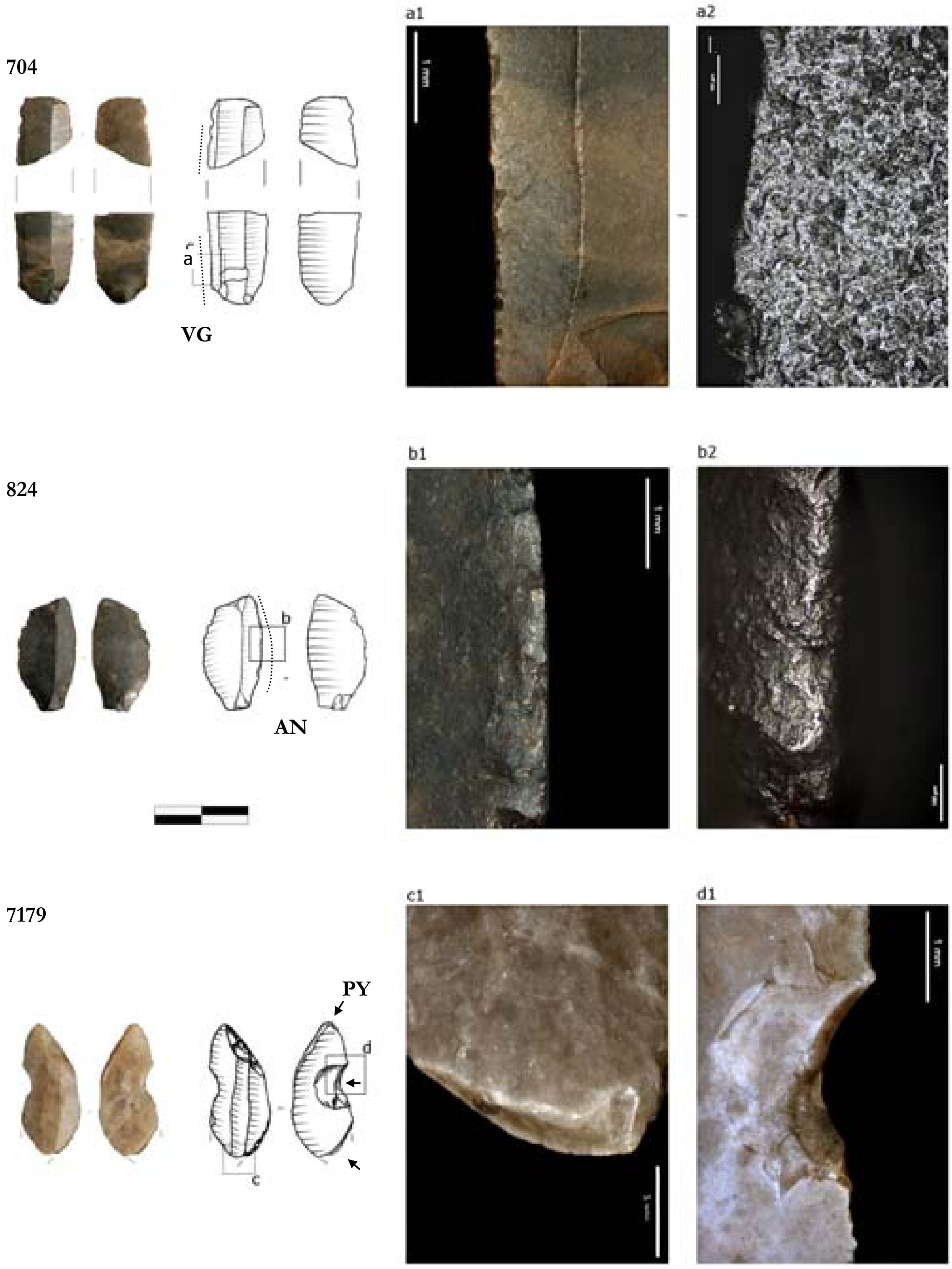

Fig. 6.12. Use-wears from the Cova del Sardo, Phase 8. **704-** Tool used for harvesting herbaceous plants, altered polish. *a1*) Macroscopic view, 10X; *a2*) Microscopic view, 200X. Plant polish appears strongly altered. **824-** Tool used for cutting soft/medium animal substance; *b1*) Edge scarring and rounding, 15X; *b2*) Residual spot of polish, 200X. **7179-** Tool used as projectile insert; *c1*) burin-like stroke, with tiny spin-off fractures, 10X; *d1*) Overlapping bending-step fractures on the unretouched edge, 15X.

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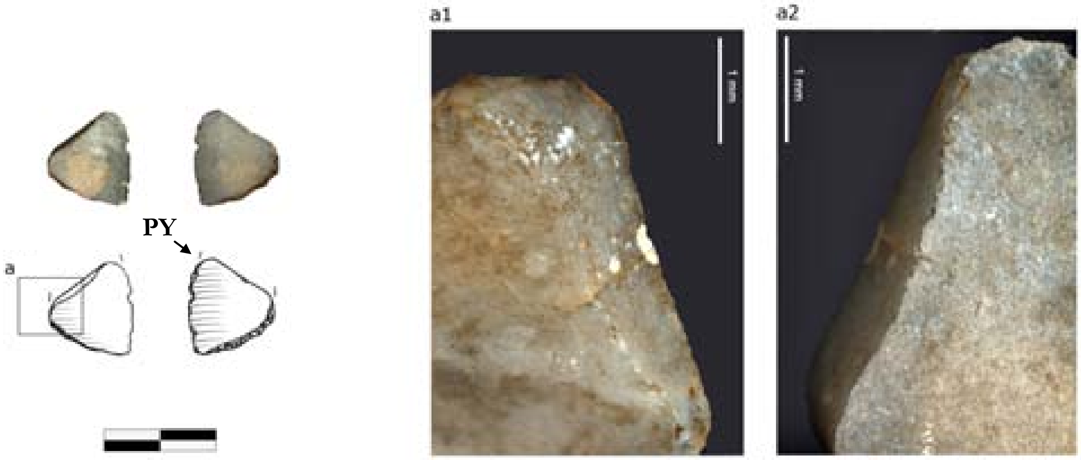

Fig. 6.13. Use-wears from the Cova del Sardo, Phase 8. **870-** Fragment of a tool used as projectile; *a1-2*) Two view of the same burin-like stroke, 15X.

6.4.2.3. Discussion

Phase 8 covers a short time span, specifically a maximum period of *ca.* 150 years between 4580 and 4440 cal BC. For this phase, the site and the surrounding area show a strong evidence of human presence, such as:

i. various archaeological structures both inside and outside the cave, amongst which two pit-hearths and a large burnt area delimited by a stone wall, which were repeatedly used during the human occupation of the site (Gassiot 2010);

ii. the presence of a high percentage of coprophilous fungi spores amongst the non-pollen palynomorphs (NNPs) from the soil samples taken at the Cova del Sardo. Coprophilous fungi confirm a relatively stable human presence inside the cave (Gassiot et al. 2012b).

iii. the existence of an open vegetation in the surroundings of the site, as shown by the reduction in arboreal taxa and the increase in ruderal and shrub species. This change is probably due to a decline of forested areas as caused by more intensive human-related activities, especially grazing;

iv. a remarkable exploitation of local lithic resources, especially porphyries and slates.

This scenario seems to indicate a relatively stable human presence at the site and in the surrounding area, specifically groups of people coming from the South, from the lower and middle course of the Noguera Ribagorçana or Pallaresa Rivers. In fact, the analysis of lithic raw materials shows a supply of chert from the Tremp-Graus and Ebro-Basin formations (Mazzucco *et al.* 2013b).

Accordingly, the Cova del Sardo may have represented the final destination of a migration movement that connected the Ebro Depression and the external mountains of the Pyrenees (e.g. Sierra del Montsec) with the Axial zone. Archaeological and pollen data, indeed, suggest that during this phase only the valley bottom was occupied, while at alpine altitudes anthropic evidence is still absent, at least for the Sant Nicolau Valley (Catalan et al. 2013; Pérez-Obiol et al. 2012).

Grasslands and forests, as detected by the pollen analysis of Cova del Sardo-Phase 8, are to be interpreted in the light of the onset of human activity in the valley bottom. Evidence of herbaceous taxa associated with grazing areas, such as *Galium aparine* subsp. *Aparine,* proves that pastoral activities were practised around the site (Gassiot et al. 2012b). The analysis of faunal remains from Phase 8 also points out the existence of a small flock of sheep/goats, even if slaughter and meat consumption appear to have occurred on a very small scale.

This data is substantially confirmed by the traceological analysis of the lithic assemblage. Despite its poor attestation, the lithic industry gives us some considerable information about activities carried out in the area and, more generally, about the use that prehistoric groups made of the Cova del Sardo shelter.

Lithic materials are mainly discarded items: they are generally broken and fire-cracked, being dumped as wastes of repairing and maintenance activities. Among them, the presence of arrowheads has been ascertained, suggesting that the shelter was used to refit arrows or other hunting tools. However, hunting-related tasks appear to have been performed only occasionally, therefore showing a secondary or complementary activity. Only two microliths have been found, whilst no remains of wild fauna have been recovered within the site deposit (although taphonomical conditions may have affected the preservation of the faunal remains). In addition, no activities related to animal hide or bones processing have been detected, thus suggesting that hunting was occasionally practiced exclusively for meat consumption and not for the obtaining of raw-materials.

Knapping by-products on-site are extremely scarce, especially waste of chert materials. Most of the tools, including the projectiles, appear to have been produced elsewhere and transported to the cave in form of finished instruments. This is also true for harvesting tools. Sickle blades and other tools used for cutting weeds or (meadow) grasses were not manufactured on-site. About sickle inserts, it is even possible that a given tool was first employed far away from the site and then used at the Cova del Sardo exclusively for meat processing.

The find of a carbonized seed of naked barley (*Hordeum vulgare* L. var. *nudum* Hook. f.) indicates that the population that lived in the cave practised agricultural activities to some extent. However, the seed may have been taken from lower altitudes as provisions, since the cereal fields were perhaps not located at high altitudes. At this stage of research, this appears the most reasonable hypothesis, also in the light of the data from other sites of the region (Lancelotti et al. 2014). The preliminary analysis of the phytolith assemblages from Phase 8 confirms the absence of any crop-processing remains (D. Rodríguez-Anton, 2014, pers. comm.). The other tools used for collecting weeds or meadow grasses were possibly related to occasional supply of vegetable materials serving different purposes, as, for example, providing fuel, building materials for creating bedding layers, healing herbs, etc.

Finally, the anecdotal presence of butcher tools indicates an occasional consumption of meat, which well fits the poor evidence of faunal remains.

6.4.3. Phase 7

The assemblage recovered from Phase 7 is the most abundant of the entire sequence (*n.* 140). By traceological analysis, I have identified 27 elements that show use-wears produced by an intentional use of the tools, corresponding to 32 active zones (*n.* 32 AUAs). Of these AUAs, 53.1% have been clearly interpreted (SG); in 28.1% of the cases, the use is probable (PR) and, in 18.8%, possible (PO) (see Tab. 6.5). For a summary of the detected activities and movements, see Tab. 6.9 at the end of the chapter.

On 17 elements, non-utilitarian traces have been recognized, among which 4 possible hafting traces (23.5%) and 13 possible transportation wears (76.5%).

6.4.3.1. Use-wears

6.4.3.1.1. Vegetal Substances

Traces produced by the contact with vegetable substances represent the main group among the analysed assemblage (*n.* 16 AUAs; 50%). A variety of economic activities fall in this category, which are related to the exploitation of vegetable resources for both food and non-food purposes.

Two sickle blades have been identified amongst Phase-7 lithic assemblage (*n.* 2 AUAs; 6.2%). One of them is a long blade, (63) x 15 x 4 mm, broken into several fragments, of which only three parts have been recovered (Fig. 6.14). The fracturing of the tool was probably caused by the collapse of a large granite block from the ceiling of the cave. In addition, the blade is heavily burnt and partially cracked because of fire. However, a still visible well-developed lustre covers the entire left edge, from the margin to the dorsal ridge (Fig. 6.14, *a1-b1*). Microscopically, the polish appears to be the typical 'cereal gloss', with a compact texture and a flat topography, characterized by striations and comet tails (Fig. 6.14, *a2-b2*). Given the good development of the wears, it has also been possible to reconstruct the method applied for hafting this tool; specifically, the blade was hafted parallel to the handle, following a model typical of the Early Neolithic North-East of the Iberian Peninsula between the sixth and the fourth millennium cal BC (Ibáñez et al. 2008; Palomo et al. 2011).

A second element is represented by a mesial fragment, which is also heavily altered by fire, with cracks and fissures. Polishes appear more degraded, as a probable consequence of an alkaline aggression. The tool comes directly from a pit-hearth, the sediments of which were mainly composed of ashes and charcoal. However, it also seems to have been used for harvesting activities (Fig. 6.14, *c1-2*).

Apart from sickle blades, there is a significant group of materials that were used for working different vegetable substances. Five blades (*n.* 5 AUAs; 15.6%) were used to cut non -ligneous plants, more likely weeds or grasses. From a dimensional point of view, all those elements appear quite standardized, measuring (24)-(36) x 14-16 x 3-4 mm. From a traceological point of view, one has to remark the presence of evident post-depositional alterations that have made the interpretation of such tools quite difficult. I have distinguished two main types of traces. The first group is characterized by the presence of smooth polishes, with domed topography and semi-closed distribution, scarcely affected by striations and abrasions. Such traces are mainly concentrated in the margins and gradually vanishing towards the centre of the surface (Fig. 6.15; 6.18, *a*). They are mainly associated with the harvesting of grasses/weeds or other herbaceous plants.

The second group shows rougher polishes, with a more abrasive component, mainly

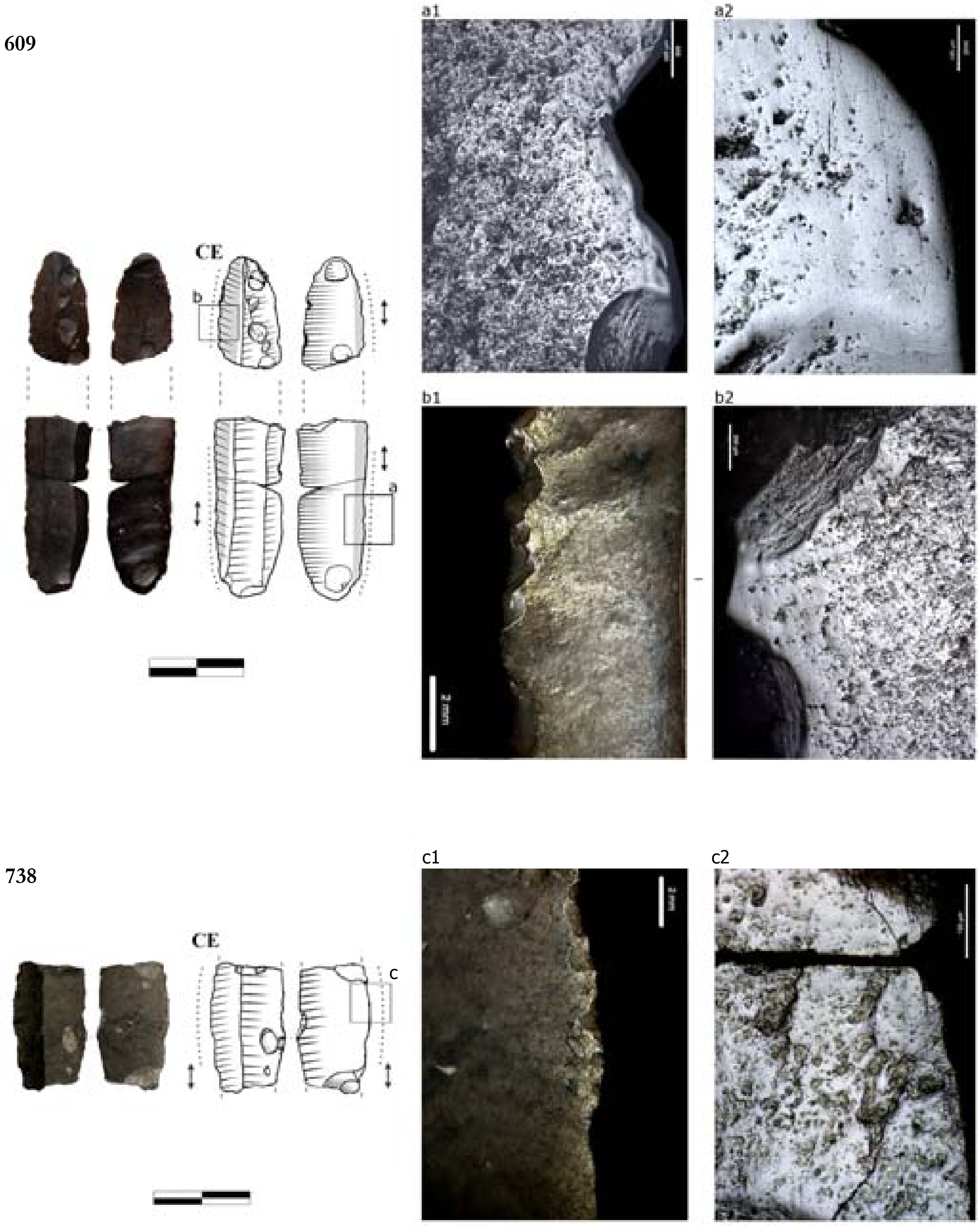

Fig. 6.14. Use-wears from the Cova del Sardo, Phase 7. **609-** Sickle blade; *a1-2*) Left ventral side, 50X and 200x views. Compact, flat cereal polish; *b1-2*) Right dorsal side, 15X and 100X views. The cereal lustre is extremely developed. **738-** Mesial fragment of a sickle blade; *c1-2*) Macro- and micro-traces, 15X and 200X. The tool is heavily burned and cracked.

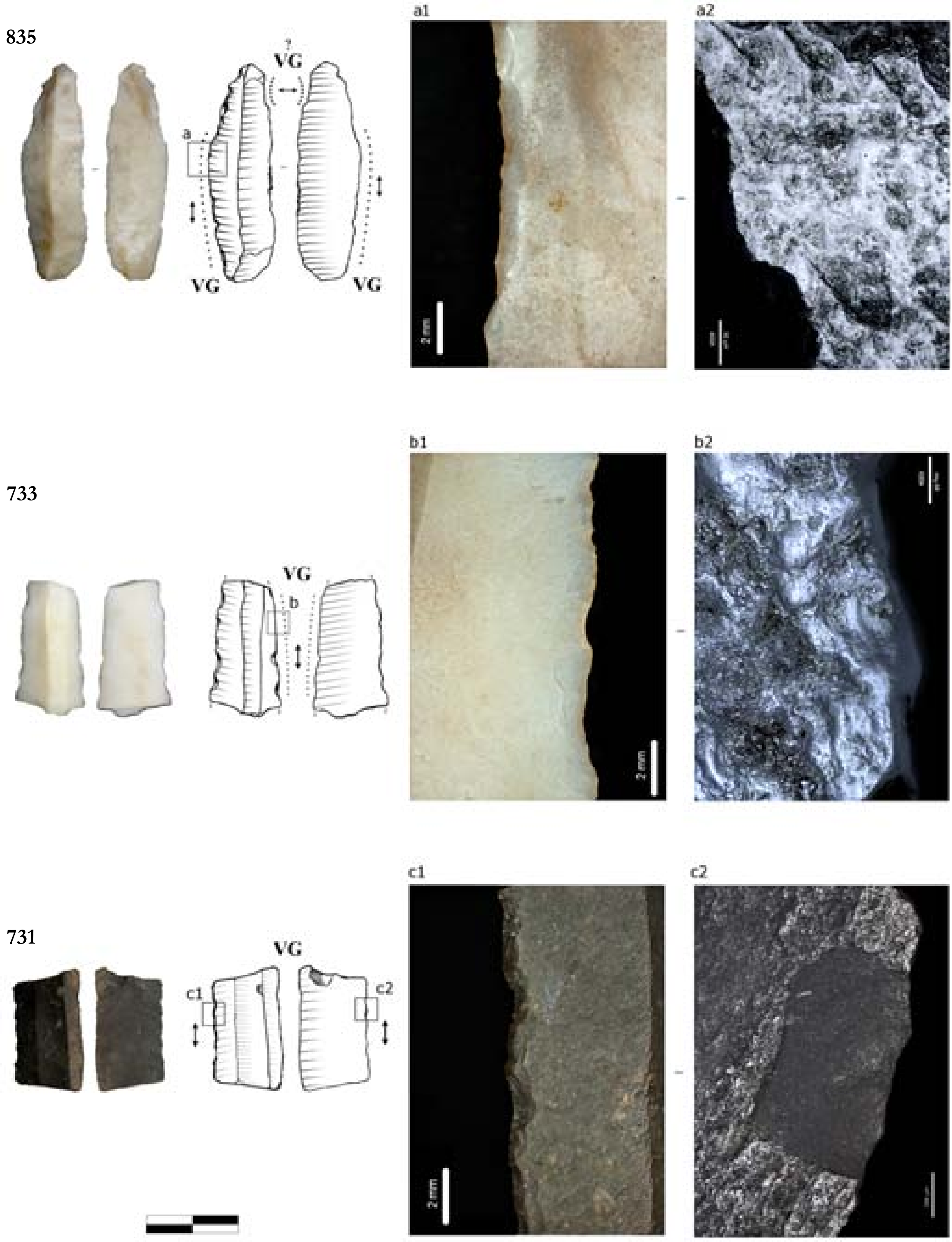

Fig. 6.15. Use-wears from the Cova del Sardo, Phase 7. **835-** Tool used for harvesting herbaceous plants; *a1-2*) Macro and micro-traces, 15X and 400X. The edge and polish appears altered by post-depositional factors. **733-** Tool used for cutting plants; *b1-2*) Macro and micro-traces, 15X and 400X. The polish has a smooth texture and domed topography. Alterations are also present. **731-** Tool used for harvesting herbaceous plants; *c1)* Dorsal view, macro-traces, 15X. Fractures probably represent post-depositional damage; *c2*) Ventral view, micro-traces, 100X. The scars appear posterior to polish formation.

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Fig. 6.16. Use-wears from the Cova del Sardo, Phase 7. **263-** Tool used for harvesting plants; *a1-2*) Right dorsal side, macro- and micro-traces, 15X and 200X. Marginal plant polish with abrasive component; *b1-2*) Possible hafting traces. Blackish residues (bitumen/resin?) on the dorsal ridge associate to friction spots, 400X; *c1-2*) Possible transportation traces. Extensive bright spots in the proximal part of the tool, 200X and 400X.

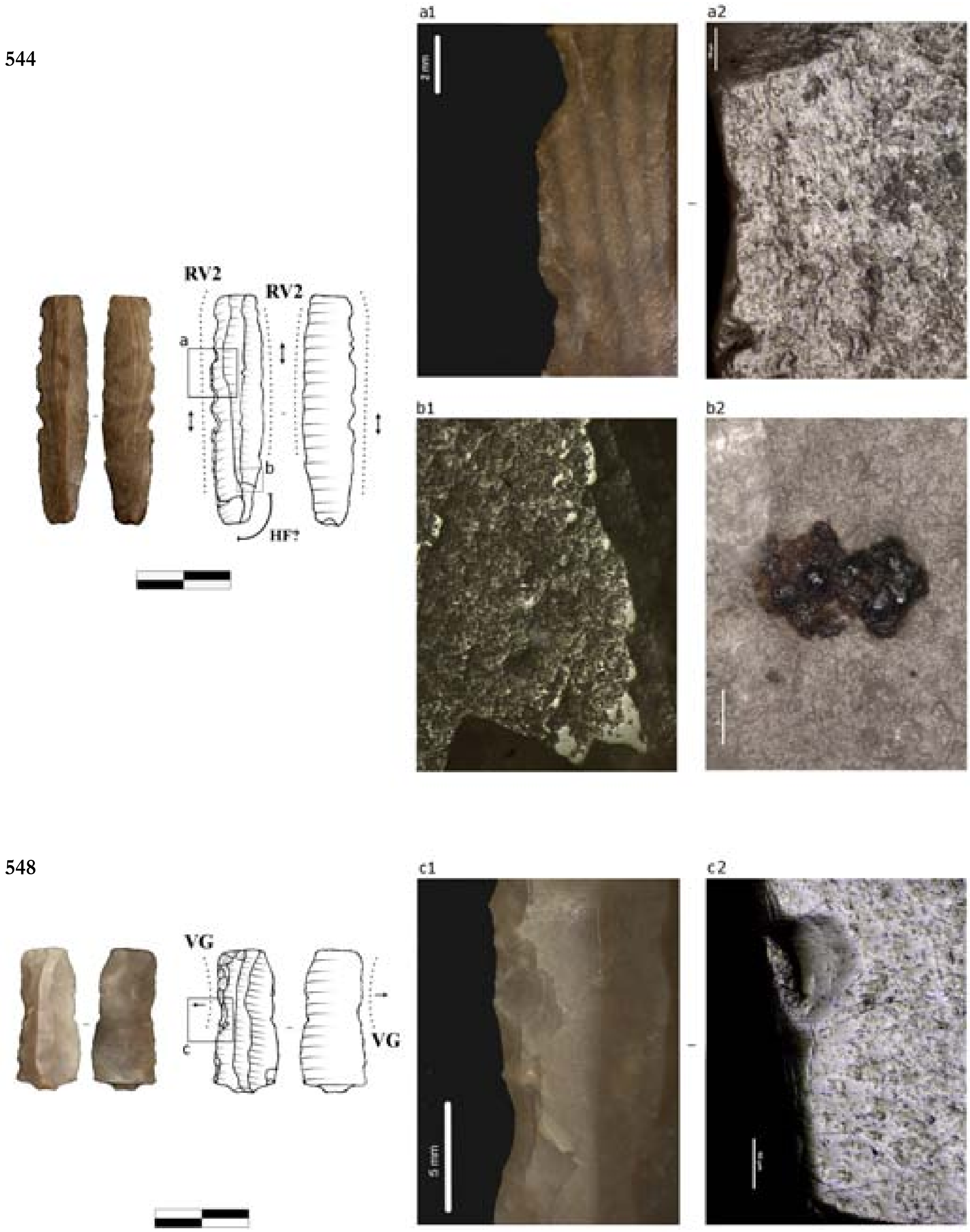

Fig. 6.17. Use-wears from the Cova del Sardo, Phase 7. **544-** Tool used for harvesting herbaceous at the ground level (RV2). *a1-2*) Left dorsal side, macro- and micro-traces, 15X and 200X. Note the presence of a very abrasive plant polish, with longitudinal directionality; *b1-2*) Possible hafting traces. Friction spots associated to blackish residues (bitumen/resin?). **548-** Tool use fro scraping vegetal substance. *c1-2*) Left dorsal side, macro- and micro-traces, 10X and 400X. The polish is slightly altered, however, the transversal orientation is clear.

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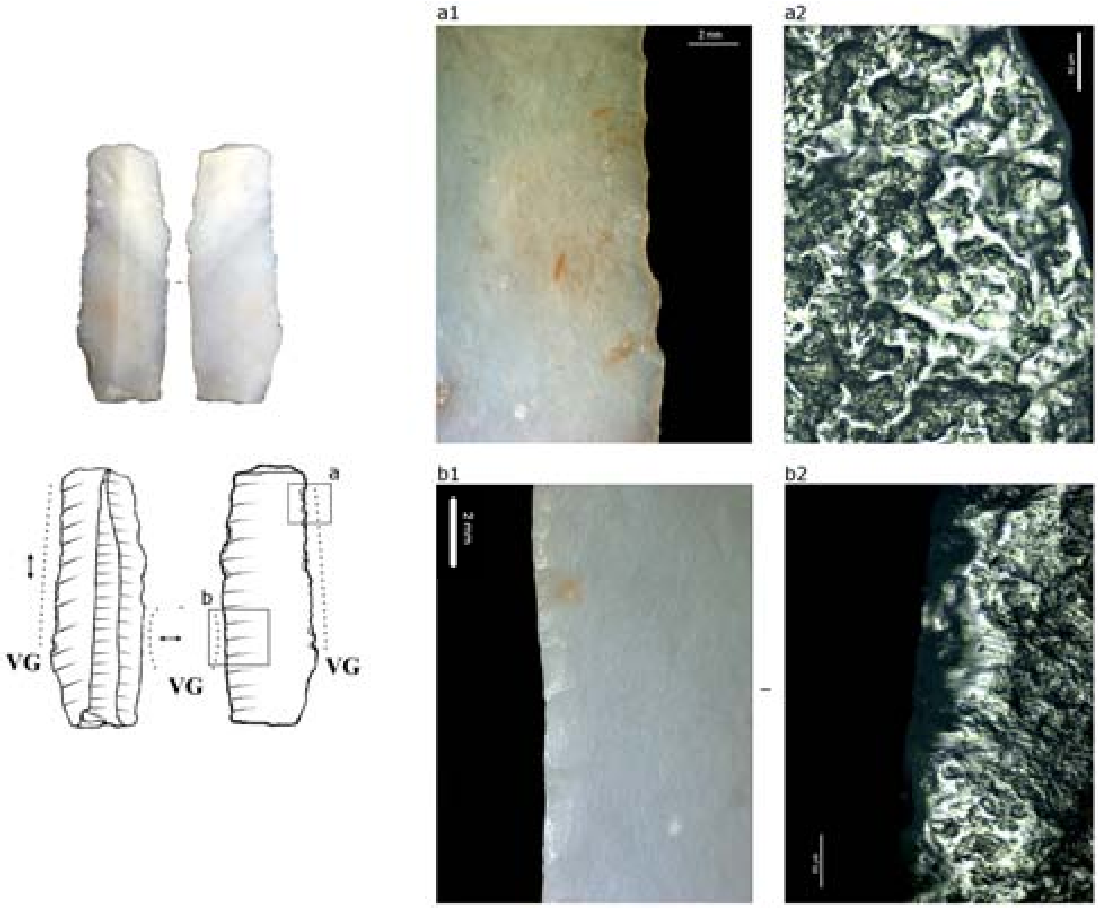

Fig. 6.18. Use-wears from the Cova del Sardo, Phase 7. **872-** Tool used for cutting and scraping plant/wood materials; *a1-2*) Right ventral side, macro- and micro-traces, 15X and 400X. Cutting movement; *b1-2*) Right dorsal side, macro- and micro-traces, 15X and 400X. Scraping movement.

characterized by striations and linear abrasions displaying a parallel directionality. The edge is usually rounded and the distribution of the polish more extensive (Fig. 6.16, *a2*; 6.17, *a2*). In this case, the traces are interpreted as produced by cutting straws or meadow grasses to ground level, in contact with the soil. The way of hafting these tools is difficult to ascertain because of the poor preservation of surfaces.

Finally, there are three elements that were employed to scrape some vegetable substances, either soft wood or perhaps some vegetable fibres (*n.* 4 AUAs; 12.5%). Tools of this type may have been used to prepare arrowheads, as described by Gassin (1993), or scrape some fibres for rope-making or basketry activities, as suggested by experimental tests (Mazzucco et al. 2014). Only small portions of the edge were selected, preferably with concave or slightly concave margins, either retouched or unretouched (Fig. 6.17, *c*; Fig. 6.18).

In the group of indeterminate vegetable materials, all those elements fall (*n.* 5 AUAs; 15,6%) that are characterized by traces of any kind of vegetable substance, for which the specific contact materials remain unknown anyway, because of the presence of post-depositional alterations.

6.4.3.1.2. Animal Substances

Traces of animal substances have been identified only on two implements (*n.* 2 AUAs; 6.3%); however, their preservation is quite poor. One is a flake characterized by scalar fractures on the distal portion of the instrument, combined with a slight edge rounding. The other one is a mesial fragment of a blade, which was possibly employed to cut a soft animal substance (flesh or fresh hide). Nevertheless, in both cases, the interpretation is uncertain, given the presence of post-depositional alterations.

6.4.3.1.3. Projectile elements

From Phase 7, eight geometric tools have been recovered, of which six show impact traces (*n.* 6 AUAs; 18.7%). Amongst the unused geometric tools, the presence of an unfinished geometric implement is to remark. It is a trapezoidal geometric implement, characterized by a sub-rectangular shape and a partial abrupt retouch that partially covers the distal and proximal factures.

Amongst the used projectile inserts, one can observe the presence of both segments and trapezoids. Clear traces of impact are represented by burin-like fracture on the tips (Fig. 6.19, *a, c*) and by overlapping step-terminating bending fractures along the unretouched edge (Fig. 6.19, *b*). It is difficult to ascertain whether they were employed as points or lateral elements. Impacts produced several fractures on tips as well as lateral edges; fractures possibly caused by recoil have also been identified on the hafted portion of the tools, suggesting a very violent impact. The remaining three elements present more uncertain traces, having been heavily altered by fire.

6.4.3.1.4. Indeterminable substances

The contact with indeterminate materials of different hardness has been ascertained on eight elements. Among them, six tools are associated with the working of soft/medium-resistant substances (*n.* 6 AUAs; 18.7%) and two with working hard or resistant matters (*n.* 2 AUAs; 6.3%).

Hard materials are represented by two items, a flake made out of local porphyry and a core of exogenous chert from the Ebro Basin. The former is a large flake probably employed as wedge. The tool is characterized by the presence of a series of overlapping bifacial fractures on the distal edge (Fig. 6.19, *d-e*). Similar traces have been observed experimentally on tools used to work wood or bone/antler materials (Gibaja et al. 2006, 2007). The other one, a flake core strongly altered by fire, presents traces of having been used as grinding or pounding tool. Retooling of cores for pounding/grinding activities is a typical behaviour all over the western Mediterranean area during the Neolithic Age.

Amongst the tools that have been used for working indeterminate soft/medium-hard substances, both siliceous and non-siliceous materials are represented. However, given the poor preservation of the surface, the interpretation of these elements remains uncertain. Amongst them, the presence of a rhyolite flake is remarkable, which was possibly used to scrape some soft material, according to the presence of rounded portions and small fractures. However, such functional interpretation of the tool remains conjectural since the phenocrysts are altered and no micro-traces have been observed.

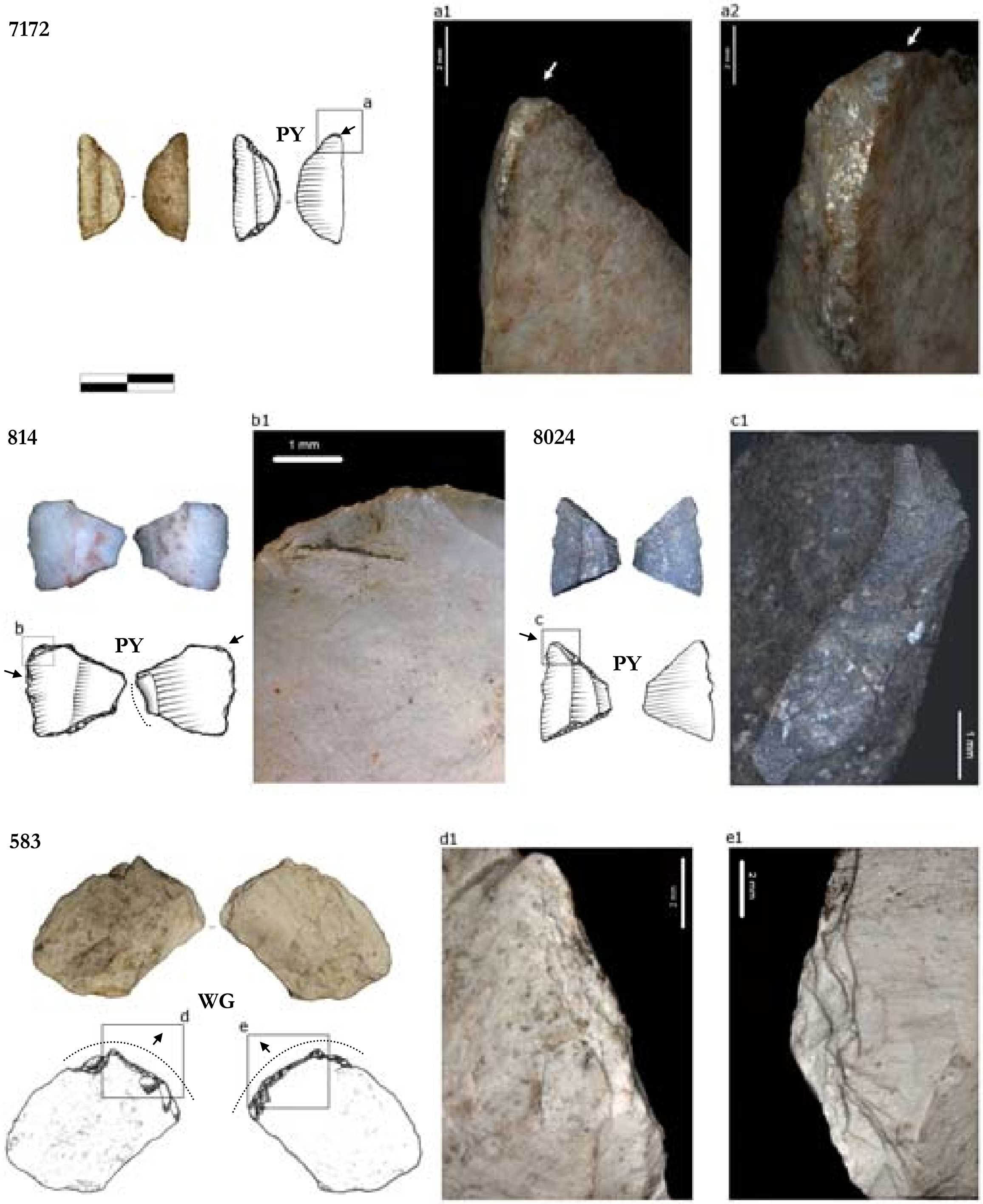

Fig. 6.19. Use-wears from the Cova del Sardo, Phase 7. **7172-** Tool used as projectile insert, segment; *a1-2*) Burin-like stroke on the tip of the tool, 10X and 15X. **814-** Tool used as projectile insert, isosceles trapeze; *b1*) Bending-step fracture on tip of the tool, 15X. **8024-** Tool used as projectile insert, isosceles trapeze; *c1*) Burin-like stroke on the tip of the tool. **583-** Tool used as wedge; *d1-e1*) Bifacial overlapping fractures on the active edge, 15X.

6.4.3.2. Non-utilitarian wears

Possible hafting wears have been detected on four implements (n° 263; n° 609; n° 872; n° 544). This type of traces mainly consists of glossy spots located on the ridges and edges, in non-functional portions of the tool. Hafting wears have only been identified on laminar blanks, whilst, on flakes, this type of traces has not been detected. In addition, in two cases, friction spots have been discovered in association with some blackish stains of resin/bitumen (Fig. 6.16, *b1-2*; Fig. 6.17, *b1-2*). This data seems to confirm the existence of hafting methods at least for blade implements, even if a deeper analysis of the residues would be needed to verify their components.

Apart from hafting traces, I have also ascertained the presence of large friction spots, the extension of which is unusually wide for hafting traces (Fig. 6.16, *c1-2*). Traces show a chaotic directionality and are not associated with any functional zones of the instruments. Such a type of evidence resemble traces caused by transporting lithic implements (Mazzucco & Clemente 2013; *cfr*. Chap 2, Par. 2.3.2.). Considering that most of those blades were not knapped on site, but transported from elsewhere, the presence of transportation-induced modifications of lithic surfaces is not to exclude a priori. However, caution is here required, as I am aware that it is difficult to distinguish transportation traces from other evidence such as hafting or post-depositional alterations.

6.4.3.3. Discussion

Phase 7 covers a long period of more than eight hundred years, between 4220 and 3385 cal BC. According to the chronological and micro-morphological data, this phase has been interpreted as a sequence of short and discontinuous occupations (Gassiot et al. 2012b; 2014).

The study of non-pollen palynomorphs (NNPs) shows a significant percentage of algae during Phase 7, differently from what has been observed for Phase 8, where coprophilous fungi prevailed. The presence of algae in the deposit indicates freshwater flow. This data well fits a pattern of intermittent occupation of the site, with longer periods of abandonment. Furthermore, pollen analysis points out a decrease in human pressure on the bottom of the Sant Nicolau Valley. During Phase 7, in fact, forests were recovering as the values relevant to *Pinus* reach their maximum (Gassiot et al. 2014). This phase also attests the earliest evidence of fire at alpine altitudes around 4200 cal BC, namely, in an area that had rarely been frequented by human populations in previous times.

All of these data show a change in the use of the cave. Cova del Sardo appears to have been occupied for short periods at that time, specifically as a shelter while moving from places at lower altitudes to the alpine pastures. This hypothesis is strengthened by the study of the lithic raw materials. During Phase 7, the exploitation of local lithologies decreased, while the transportation of exogenous materials from pre-Pyrenean and Ebro-Basin areas, increased remarkably. Lithic materials were transported in form of finished tools or, occasionally, small preforms. However, only wastes and broken or exhausted items were left at the Cova del Sardo, while, probably, the other tools and cores were taken elsewhere for further use. This pattern proves the occupation of the cave having been an occasional shelter, whereat tools were refitted and resharpened before moving along (towards alpine areas?).

The main activities documented by traceological analysis are preparation and maintenance of arrows and projectiles, gathering of grasses, weeds and other plants, slaughter of animals, and meat consumption. All of them can be considered domestic activities, related to the management of the living room, tools, and the human group itself. All the same, given the poor evidence of remains, such activities were probably not intensively practised, but only occasionally, thus indicating a pattern of short occupations.

With regard to Phase 7, the gathering of vegetable materials can be associated with a variety of activities, namely for providing fuel, construction materials, healing herbs, or even forage. Only a detailed analysis of the phytolith assemblage from Phase 7 may be helpful to shedding light on the use of such materials. However, my impression is that plants were mainly gathered for non-food purposes. The two fragments of sickle blades recovered were probably employed in the harvest of cereals outside the Sant Nicolau Valley, likely at lower altitudes. As a matter of fact, for these periods, there is no evidence of any agricultural activity near Sardo Cave, nor at higher altitudes. The blades were probably refitted and taken along to carry out other tasks, being then discarded only later. The poor preservation of lithic surfaces does not anyway allow any further use to be ascertained.

Finally, both hunting and butcher tools attest the procurement and consumption of animal resources. The faunal assemblage is poorly preserved; it anyway shows that meat was consumed within the cave. The presence of sheep/goat bears evidence of occasional slaughter of domestic animals; on the contrary, wild species have not been identified. Nevertheless, the large majority of the recovered fragments have been ascribed to 'indeterminate mammals of medium-size', which could refer to either wild or domesticated specimens. However, it is also possible that game was neither processed, nor consumed at the Cova del Sardo, but these occurred on the place where it was killed or near that. In any case, animal resources do not appear to have intensively been exploited; neither slaughter, nor hunting represents the main subsistence activities, having been only occasionally practised. Moreover, aside meat exploitation, was not carried out, on-site, any further processing of the game or of the animal (i.e. skin processing, bone working).

6.4.4. Phase 6

The lithic materials recovered from Phase 6 amount to 90 elements. However, only on nine implements, use-wear traces have been detected (10% of the assemblage), corresponding to ten active zones (*n.* 10 AUAs). Amongst these, four areas have been clearly interpreted (SG) (40%), two shows a probable use (PR) (20%), and two other portions were possibly used (PO) (40%) (see Tab. 6.5). For a summary of detected activities and movements, see Tab. 6.10 at the end of the chapter.

All remaining implements are too altered to be analysed, especially non-siliceous rocks (mainly represented by porphyries), the edges and surfaces of which appear strongly altered and thus difficult to interpret. Non-utilitarian traces have been identified only on one tool, which shows possible hafting traces (*n.* 1); however, their interpretation remains uncertain.

6.4.4.1. Use-wears

6.4.4.1.1. Vegetal Substances

Traces related to the working of vegetable substances amount to three elements, corresponding to four active zones (*n.* 4 AUAs; 40%). Two of them are associated with the harvesting of herbaceous plants, while the other two show traces of contact with woody plants.

Traces of herbaceous plants have been identified exclusively on one tool, used on both edges for cutting grasses or meadow. The tool is a blade made out of a coarse continental evaporitic chert measuring 41 x 11 x 4 mm. The polish is characterized by a strong abrasive component that may have been produced by contact with soil. Abrasions show parallel directionality with respect to the active edges (Fig. 6.20, *b*).

The other two tools appear characterized by traces associated with the working of plants (woody plants?). In both cases, the movement is transverse, probably connected with a scraping activity. Edge scarring is characterized by invasive fractures with hinge and step terminations. The micropolish is not well preserved and, therefore, some caution is needed while interpreting the use-wears. Polishes are distributed over isolated spots with a smooth appearance, suggesting the scraping/planning of some type of resistant woody plant (Fig. 6.20, *d*). In one case, the tool is an elongated flake, a resharpening flake of the core debitage, measuring 45 x 14 x 4 mm; the second one is a blade fragment, laterally retouched and measuring 43 x 15 x 5 mm.

6.4.4.1.2. Animal Substances

There is only one element associated with the working of animal substances (*n.* 1 AUAs; 10%). It is a wide blade of 46 x 20 x 5 mm, made out of coarse evaporitic chert and used on its right edge for processing soft animal substances. Edge rounding is evident and combined with an array of feather scars on the ventral face (Fig. 6.21, *a1*). Polishes have a greasy aspect, patchy texture, and rough topography (Fig. 6.21, *a2*), this also indicating contact with some type of soft animal substances such as flesh or fresh hide.

6.4.4.1.3. Projectile elements

Tools employed for hunting activities represent 20% of the use-wear assemblage (*n.* 2 AUAs; 20%). One is a point shaped by bifacial flat retouch. The tool was made out of a chert

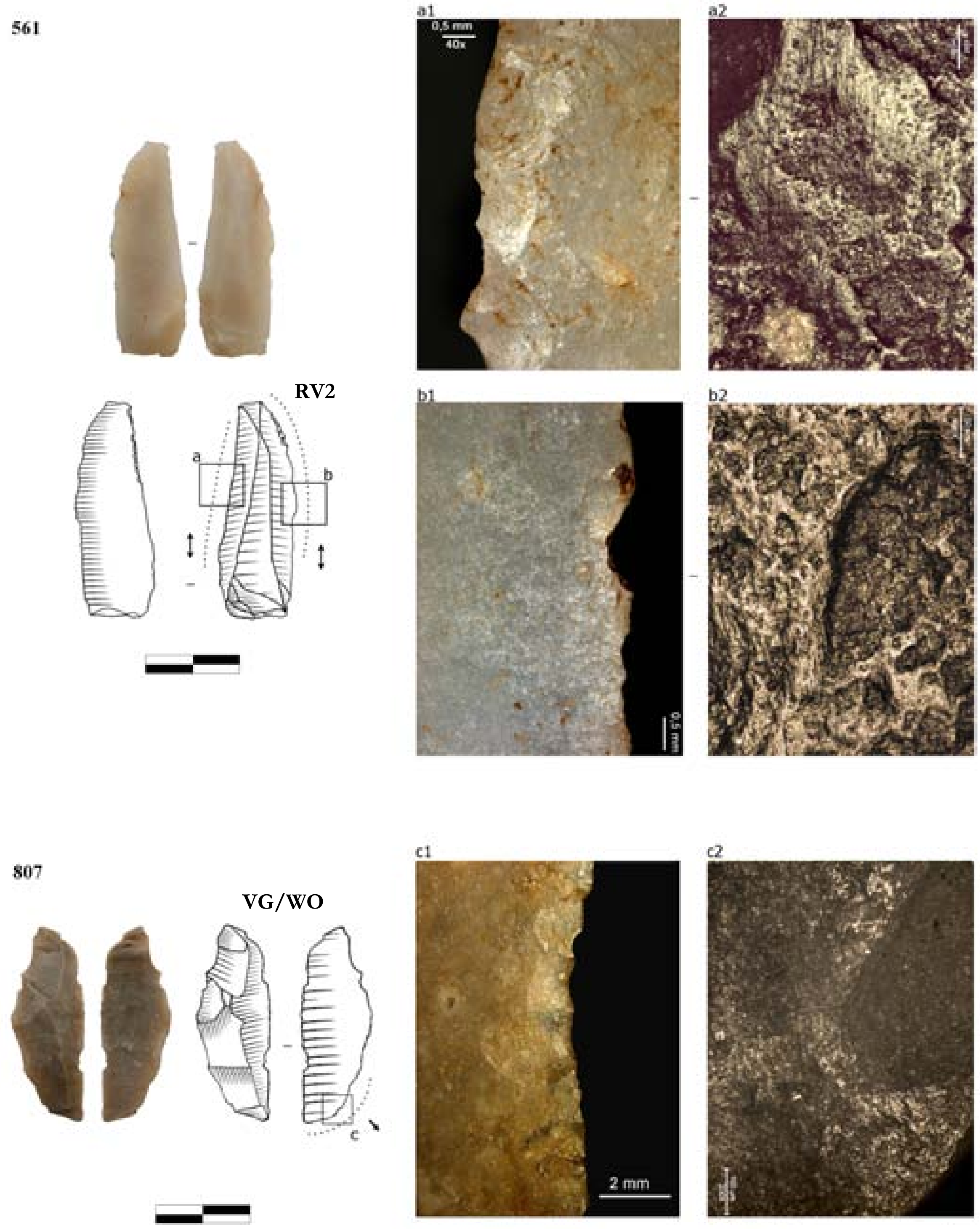

Fig. 6.20. Use-wears from the Cova del Sardo, Phase 6. **561-** Tool used for harvesting herbaceous plants with abrasive component (RV2) on both edges; *a1-2*) Left dorsal side, macro- and micro-traces, 15X and 200X. The polish is characterized by a rough aspect, with dense parallel strias; *b1-2*) Right dorsal side, macro- and micro-traces, 20X and 400X. Same polish at 400X. **807-** Tool possibly used for scraping plant materials (woody plant?); *c1-2*) Left ventral side, macro- and micro-traces, 15X and 400X. Spot of plant polish with transversal orientation, associated to flat bending scars. However, traces are uncertain.

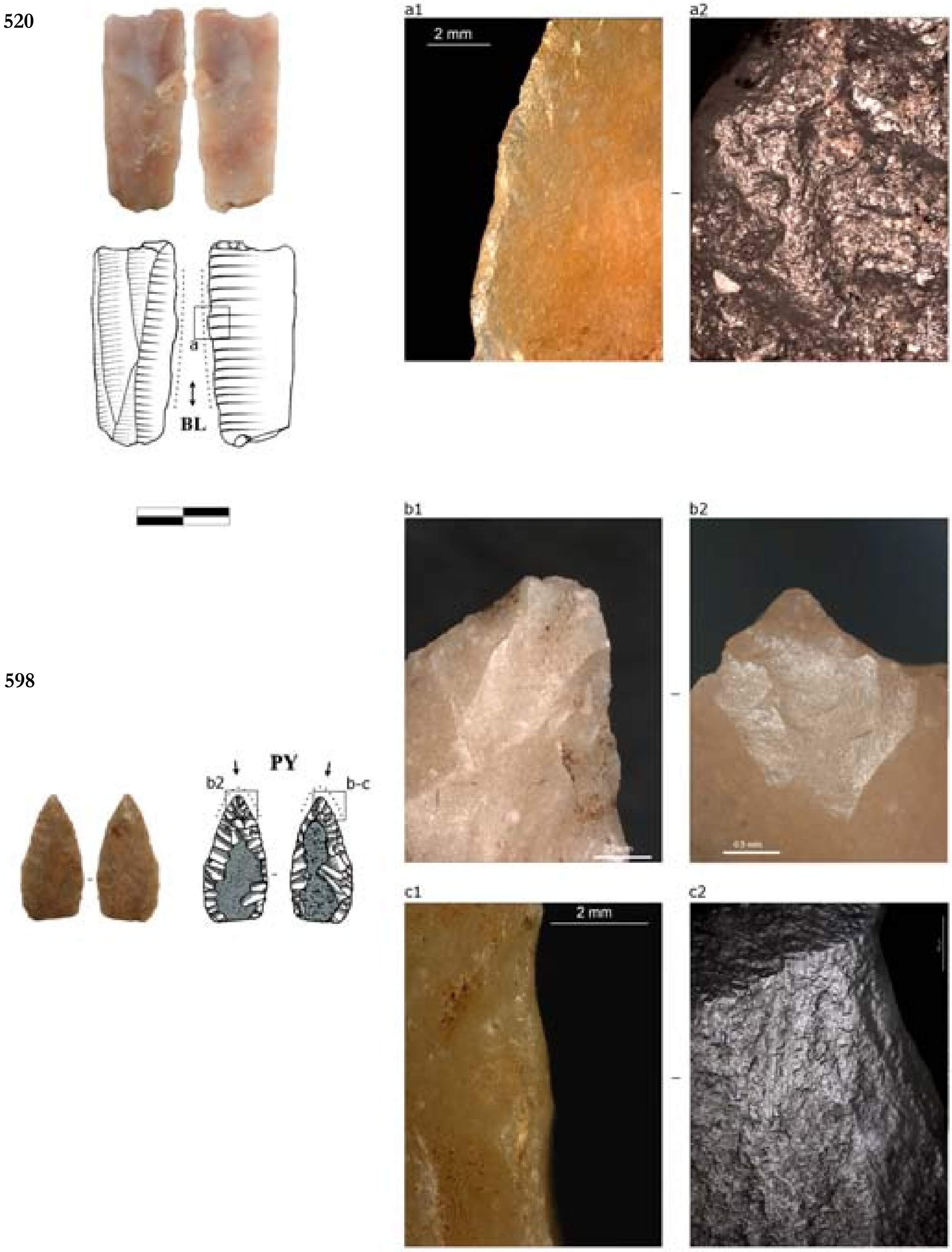

Fig. 6.21. Use-wears from the Cova del Sardo, Phase 6. **520-** Tool used for butchering; *a1-2*) Left ventral side, macro- and micro-traces, 10X and 400X; Edge-rounding it is associated to a greasy, diffuse, polish of rough aspect. **598-** Foliated point used a projectile tip; *b1-2*) Bifacial bending-step fractures on the point, 20X. Overlapping fractures with parallel orientation in respect to the tool axis; *c1-2*) Macro- and micro-traces, 20X and 400X. MILTs indicate the directionality of the impact.

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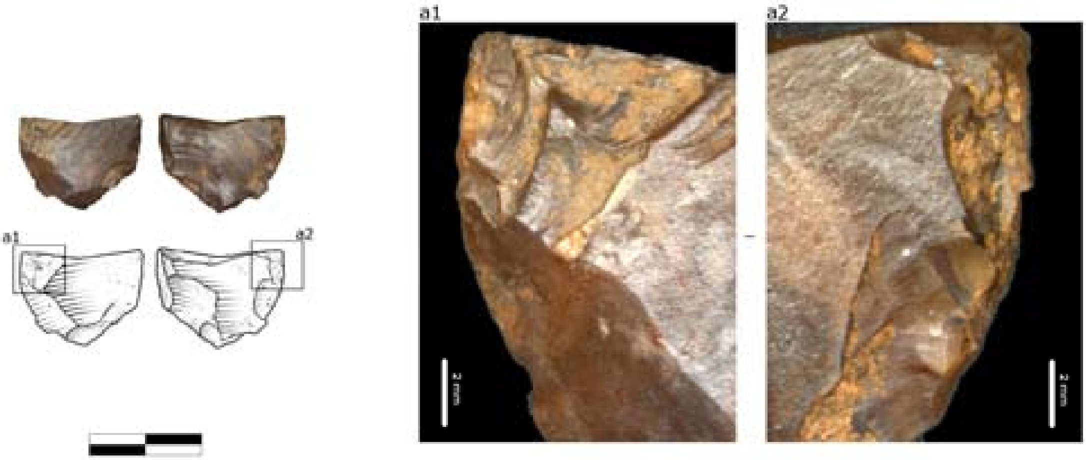

Fig. 6.22. Use-wears from the Cova del Sardo, Phase 6. **665-** Tool used as wedge; *a1-2*) Bifacial overlapping fracture on the active edge;

tablet of exogenous provenance; the morphology of this instrument is characteristic of the Final Neolithic period in the NE of the Iberian Peninsula. On the tip of the point, bifacial invasive step-terminating bending fractures are visible (Fig. 6.21, *b1-2*). In addition, such traces are associated with MILTs (Fischer et al. 1984) and edge rounding that can be observed all over the tip (Fig. 6.21, *c1-2*). The other tool is a geometric one, an isosceles trapezoid, probably produced on flake blank. It is characterized by the presence of burin-like stroke on the distal point.

6.4.4.1.4. Indeterminate substances

I have identified three elements that show a possible employment for working indeterminable substances (*n.* 3 AUAs; 30%). One is a truncated blade, heavily altered by fire, which shows a possible active zone on the right edge. The poor preservation of the surfaces prevents a more detailed interpretation of the wears; however, the tool seems to have worked a soft material. The remaining tools show traces of having being employed as wedges. Both of them are characterized by a series of bifacial overlapping fractures, with hinge or step termination, then indicating the working of resistant material (Fig. 6.22, *a*) like wood or bone/antler, as experimentally suggested by Gibaja et al. (2006, 2007) and de la Peña (2011).

6.4.4.2. Non-utilitarian wears

Amongst the materials from Phase 6, non-utilitarian traces have been identified exclusively on one element. Possible hafting traces have been detected on a blade (n° 561), where glossy spots have been observed on the dorsal ridge of the tool. However, in the absence of residues or other evidence, their interpretation remains uncertain.

6.4.4.3. Discussion

Current data suggest that Phase 6 was occupied during the fourth millennium cal BC, probably in relation to a single episode of occupation. During this phase, the principal archaeological evidence is concentrated in the terrace in front of the cave's entrance. A roofing made of vegetal materials was probably constructed there. The structure was composed of large wood logs aligned to form a sort of porch on the outside. Accordingly, large burnt branches with a length ranging from 10 to 30 cm have been found in the archaeological layers of Phase 6. The radiocarbon dating of them has established a time between 3370 and 3100 cal BC (95.4%), a span that should indicate the period of abandonment of the site. This suspended frame covered an area of approximately 4 m^2, which probably represented the main living room during Phase 6. Most of the ceramic and lithic artefacts have actually been recovered in this sector, whilst almost no remains have been discovered in the inner part of the cave.

The lithic assemblage is small and not connotative. Non-siliceous stone materials represent almost half of the collection, in particular porphyries. Such lithology was probably knapped on-site, according to the presence of debris and other knapping wastes. However, flakes on porphyry do not show any clear sign of use, although this fact may be consequent on the poor preservation of the lithic surfaces. Amongst chert materials, the prevailing lithologies are those from the pre-Pyrenees sources, from the Tremp-Graus Basin and, to a lesser extent, from the Sopeira Basin. In addition, one has to emphasize the presence of a group of indeterminate elements from exogenous sources, which suggest that the communities that inhabited the Cova del Sardo were integrated within over-regional, long-distance, contacts.

The traceological analysis of the lithic assemblage has revealed the presence of a low number of economic processes, mainly represented by sporadic tasks related to the upkeep of the site, probably relevant to the building of the roofing made of vegetal materials. Wedges and other tools used for scraping wood probably served the purpose of preparing the wood logs. Grasses and straws, gathered by using harvesting tools, may also have been availed of for building the vegetal roofing.

The other activities ascertained were mainly connected with the procurement and processing of animal resources. Hunting is attested to by projectiles, while the consumption and processing of animal carcasses are proved by butcher tools. However, the extremely small faunal assemblage suggests that slaughter was practised only rarely. The only determined remains belong to sheep/goat species.

Finally, one should remember the identification of a charred grain of wheat (*Triticum aestivum/durum/turgidum*). In this case too, the preliminary analysis of the phytolith assemblage suggests that crop-processing activities were not carried out at the Cova del Sardo, therefore, cereals must have been taken to the site after being processed elsewhere (D. Rodríguez-Anton, 2014, pers. comm.), as also observed for Phase 8.

In conclusion, the lithic assemblage of Phase 6 reflects a short occupation of the site, characterized by the practice of few economic activities of domestic nature. The main tasks were connected to the upkeep of the site and the supply of food. In this respect, there is no real change in the functionality of the *abri* in comparison with the previous phase of occupation, apart from the different arrangement of the room. During Phase 6, the Cova del Sardo continued to be occasionally occupied within the management of a more general network of settlements. To this point, it is noteworthy that a human occupation, going back to roughly the same period, has been ascertained at a cave located a few metres away from the Cova del Sardo, namely, Cova del Sardo II. This site shows anthropic contexts dating back to between *ca.* 3340 and 3030 cal BC.

Furthermore, in the alpine zone, human occupation has been detected at the Abric de l'Estany de la Coveta, at 2.433 m.a.s.l. Radiocarbon dating shows same chronology (ca. 3340-

3025 cal BC) (Gassiot et al. 2014). This site, a little rock-shelter characterized by a very ephemeral occupation, bears evidence of an increasing human impact on the alpine area, namely pastures. Similar data come from peat-bog and lake sediment cores, which document a marked increasing in human activities at high altitudes as from ca. 3100 cal BC, in relation to forest clearance and grazing by domesticated stock (Galop et al. 2003, 2007; Gassiot et al. 2012b). The human exploitation of the mountain regions was gradually consolidating, with an expansion of pastoral activities into the highest areas of the Axial Pyrenees. Other economic activities, such hunting, appear to have been practised only occasionally, at least in the investigated area.

6.4.5. Phase 5

The lithic assemblage recovered from Phase 5 is quite small (*n.* 80). Only thirteen elements revealed the presence of use-wear traces (*n.* 13; 16.3% of the assemblage). However, most of them have been intensively used and, consequently, active zones amount to twenty-two areas (*n.* 22 AUAs). Fifteen of these are fully interpreted (68.2%) (SG), six show a probable use (27.3%) (PR), and only one zone shows a possible use (4.5%) (PO) (see Tab. 6.5). For a summary of detected activities and movements, see Tab. 6.11 at the end of the chapter.

Non-utilitarian wears, such as hafting or transportation wear, have not been identified. Probably, the intensive use of tools has caused this type of evidence to be covered or removed, so preventing their microscopic recognition.

6.4.5.1. Use-wears

6.4.5.1.1. Vegetal Substances

Traces related to the working of vegetable substances represent the largest group amongst the Phase-5 assemblage (*n.* 14 AUAs; 63.6%). Within this category, RV2 traces (polish of vegetable substances mixed with abrasive components) prevail (*n.* 8 AUAs; 36.4%). In addition, the harvesting of other herbaceous plants, such as cereals (*n.* 2 AUAs; 9.1%), is also attested. Finally, in four cases, it has not been possible to establish the exact type of the gathered plant (*n.* 3 AUAs; 13.6%), while, in one case, a woody plant was probably worked (1 AUAs; 4.5%). All these tools were made on large blades measuring 70-80 x 15-20 x 3-4 mm. They were often used on both edges, in some cases with evident signs of edge resharpening.

Sickle blades are of particular interest (Fig. 6.23, *a-b*). There are two tools clearly employed for agricultural activities. Sickle blades show a well-developed lustre, microscopically characterized by a compact topography and flat surfaces with comet tails and pits/holes. However, on both tools, the use as sickle insert was only the first one of a more complex series of utilizations. The 'cereal lustre' does not cover the active portion of the tool, but only a residual area of the edge; the original active zone has been erased by edge-resharpening scars. Therefore, the cereal polish ends abruptly, being interrupted by resharpening fractures (Fig. 6.23, *a2*; Fig. 6.24, *a2*). On the contrary, successive uses are concentrated in the external portion of the edge, forming well-rounded shapes. The polish, in this case, is much rougher, with semi-closed topography and domed texture, along with the presence of tiny parallel striations (Fig. 6.23, *b-c;* Fig. 6.24, *b*). My hypothesis is that sickle blades were transported to Sardo Cave and later retooled to cut grasses/straw/meadow, this bringing about the formation of RV2 polish.

One of the used sickle blades is a narrow element characterized by an invasive flat retouch made by pressure technique. Such types of tools are characteristic of the Final Neolithic/ Chalcolithic period. Similar artefacts have recently been recovered in the Noguera region, in the pre-Pyrenean area, at Balma de la Sargantana de Renau, not far away from the River Segre (Marcet 1983). Those tools show identical technological and functional managements, with several phases of edge rejuvenation, in this case mainly related to cereal harvesting (J. Gibaja, pers. comm.).

Other blades appear to have been used directly for harvesting grasses/straws to ground level, this time without any previous utilization. This is the case with three large blades used on both edges. Traces are characterized by a very developed polish, with many fine striations

Fig. 6.23. Use-wears from the Cova del Sardo, Phase 5. **383-** Tool used for multiple tasks; *a1-2*) Cereal harvesting, 10X and 200X. The cereal lustre is visible at the naked-eye. Polish is abruptly interrupted from resharpening scars; *b1-2*) Macro- and micro-traces, 10X and 200X. Second use to cut grasses/ meadow in contact with soil. Plant polish mixed with strias. The edge is rounded; *c1-2*) Same traces on the other edge, macro- and micro-traces, 10X and 200X.

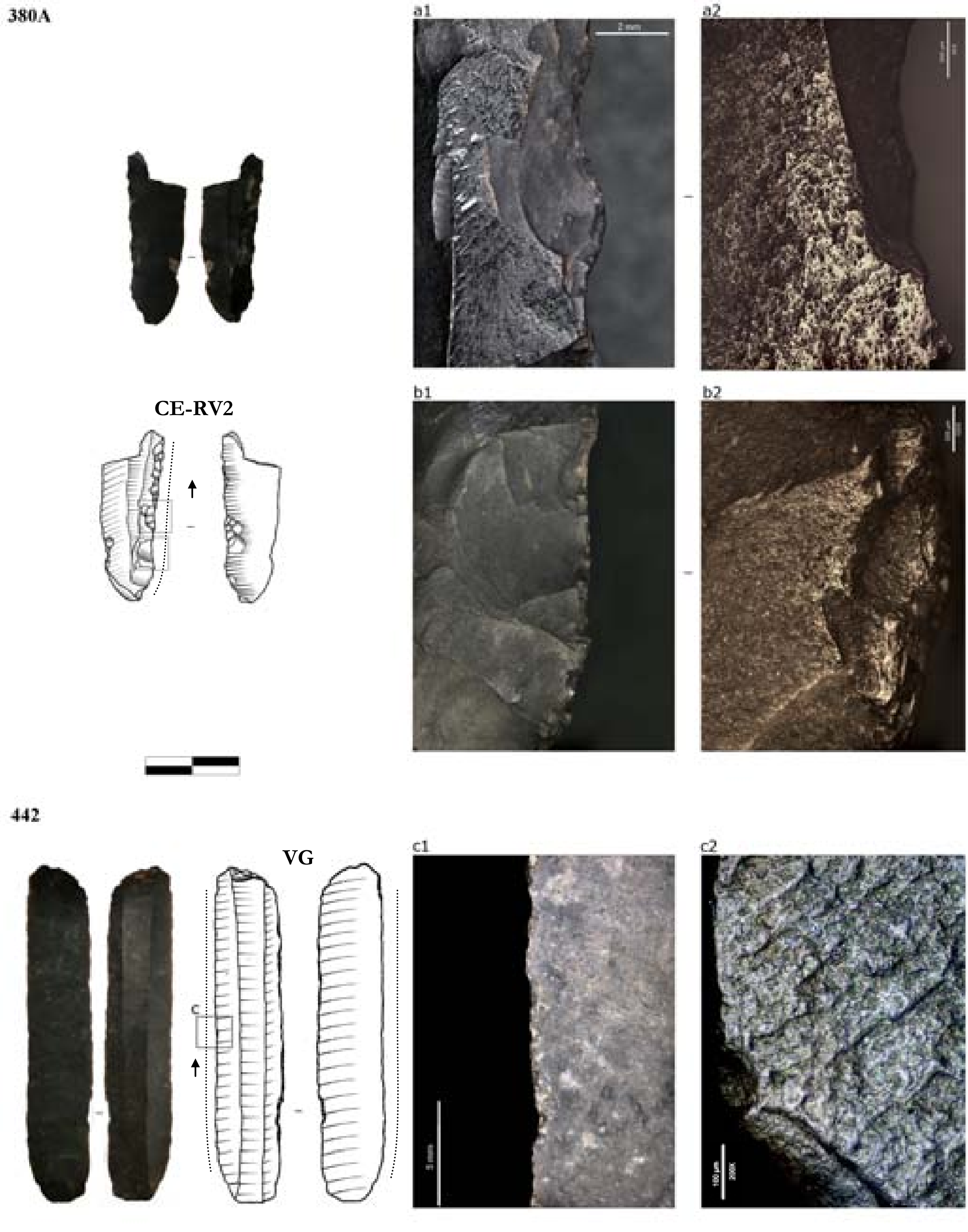

Fig. 6.24. Use-wears from the Cova del Sardo, Phase 5. **380A-** Tool used for multiple task; *a1-2*) Cereal harvesting, 10X and 50X. The cereal lustre is visible at the naked-eye. Polish is abruptly interrupted from resharpening scars; *b1-2*) Second use to cut grasses/meadow in contact with soil, 10X and 100X. Plant polish mixed with strias. The edge appears fresh and rounded. **442-** Tool used for harvesting herbaceous plants; *c1-2*) Left dorsal side, macro- and micro-traces, 8X and 200X. Plant polish appears altered, with a partial loss of volume.

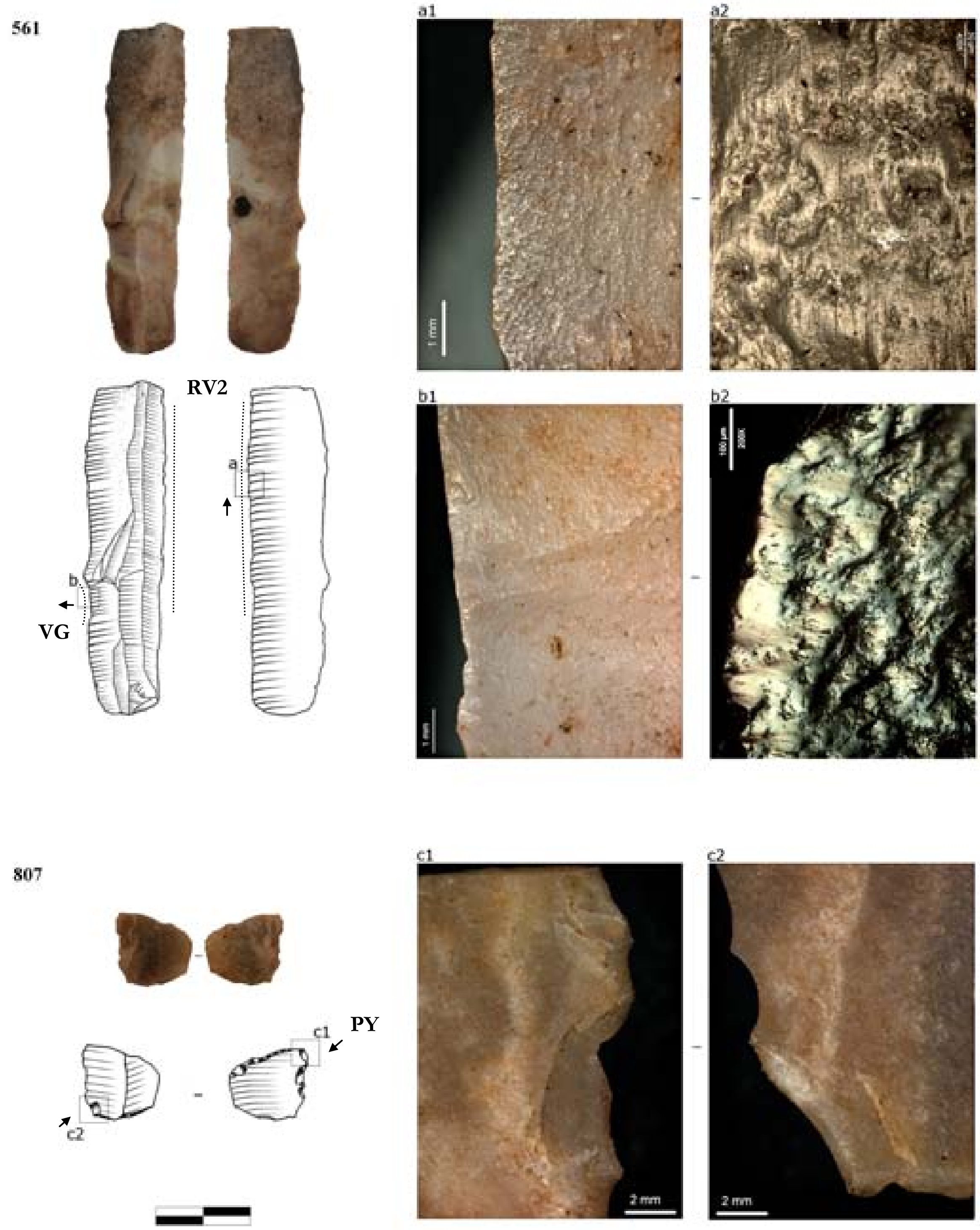

Fig. 6.25. Use-wears from the Cova del Sardo, Phase 5. **561-** Tool used for multiple tasks; *a1-2*) Edge used for cutting plants in contact with soil (RV2). Left ventral side, macro- and micro-traces, 20X and 400X. Polish is characterized by many tiny strias with parallel orientation; *b1-2*) Edge used to scape plant/ wood. Right dorsal side, macro- and micro-traces, 15X and 200X. Polish has a fluid and smooth aspect, with a clear transversal directionality. **807-** Geometric tool used as projectile insert; *c1-2*) Bifacial overlapping bending-step fractures distributed along one tip of the tool, 15X.

that result to be parallel according to the cutting movement. However, in some cases, traces are poorly preserved and only few residual spots of the vegetable polish are visible. Their interpretation remains uncertain (Fig. 6.24, *c1-2*).

In addition, one of these tools has been used on a small portion of the edge for scraping some soft vegetable substance, vegetal fibres, or a woody plant. Traces show a very fluid and smooth polish, with transverse orientation (Fig. 6.25, *b1-2*). Traces of this type can be related to arrow-making processes or basketry production (Gijn 1989; Gassin 1996).

6.4.5.1.2. Animal Substances

There is only one element associated with the working of animal substances (*n.* 1 AUAs; 4.5%). Traces appear to have been produced by contact with a soft/medium-hard material, such as flesh or fresh hide. The tool is a sickle blade that was retooled possibly for butchering activities after having been used for harvesting different types of vegetable matter. However, given the presence of previous utilizations, the interpretation of the wears remains uncertain.

6.4.5.1.3. Projectile elements

In Phase 5, geometric tools amount to six elements. However, only two elements show clear impact traces (*n.* 2 AUAs; 9.1%), while the remaining implements were not used or simply have not developed any diagnostic trace. The used tools are two isosceles trapezoids, both made on blade blanks and shaped by unidirectional abrupt retouch. In one case, the geometric implement has a rectangular/sub-rectangular shape, while the other tool was made on a narrower blank. The presence of step-terminating bending fractures all along the unretouched edges suggests the employment of the tools as projectile points, probably hafted diagonally or transversely with respect to the axis of the arrow (Fig. 6.25, *c*).

6.4.5.1.4. Indeterminate substances

As indeterminate materials, I have classified all those elements that show a poor preservation of the surfaces and, consequently, of the use-wears. Implements possibly associated with the working of soft/medium-resistant substances amount to five (*n.* 5 AUAs; 17.6%). Both flake and blade implements have been used. The recognition of this type of wear has mainly been based on the macroscopic observation of edge scarring and rounding. At least in one case, a blade, it seems likely that the tool was used for working soft animal substances. In the other cases, given the poor preservation of the surface, it has not been possible to achieve any deeper interpretation of the use-wears.

6.4.5.2. Discussion

The last prehistoric occupation of the Cova del Sardo coincides with a period of expansion of the human presence in the National Park of Aigüestortes i Estany de Sant Maurici. An increased number of anthropic occupations have been detected at both subalpine and alpine altitudes with chronologies ranging between *ca.* 3000 and 2300 cal BC. Among them, some rock-shelters, like the Abric del Portarró (2.380 m.a.s.l.), Abric de Obagues de Ratera (2.220 m.a.s.l.), Abric del Lac Major de Saboredo II (2.352 m.a.s.l.), Covetes (1.870 m.a.s.l.), and the Cova de Sarradé (1.980 m.a.s.l.). In addition, an outdoor structure, probably a hut, the Cabana de la Coma d'Escós (2.268 m.a.s.l.) has been dated to this period (Gassiot et al. 2014).

This phenomenon is consistent with a marked fall in the arboreal biomass (resulting in a reduction of *Pinus*) and an expansion of herbaceous taxa associated with open grasslands (*Poaceae*; *Cyperaceae*). Moreover, the increase of shrubs (*Juniperus*) suggests the decline of forests due to anthropic disturbance (Gassiot et al. 2012b).

In this context, the Cova del Sardo seems to have been part of a larger settlement pattern, which was based on the occupation of small caves and other occasional shelters, such as huts and other ephemeral outdoor buildings. Human occupations appear episodic and extremely short, leaving poor material evidence. Such groups were probably characterized by a high mobility, at least on a local scale (within the mountain region), following a pattern of continuous and short-distance movements in relation to herding practices. Indeed, ruderal species (such as *Asteraceae*, *Chenopodiaceae-Amaranthaceae*, *Plantago*, etc.), which are favoured by grazing, were proliferating at both subalpine and alpine altitudes (Pélachs et al. 2007; Gassiot et al. 2012b).

The lithic industry recovered from Phase 5 well fits this scenario. The assemblage is numerically scarce, largely composed of long blades of exogenous provenance (mainly lithologies of the Ebro Basin), which were transported to the site already flaked and finished. In some cases, it is evident that tools have been intensely used and reused for different activities, suggesting that they were availed of for a long time. Knapping at the site was extremely limited and mainly concerned non-siliceous stones (porphyries), whilst chert materials appear to have been flaked there only occasionally.

The main activities were connected with plants and grasses gathering, as observed for the previous phases. The use of tools such as sickle blades does not seem to have been relevant to any of the tasks carried out at Sardo Cave. Cereal harvest probably took place at lower altitudes and sickle blades were resharpened and transported for other uses. Projectile tools are also present amongst the assemblages; however, they only show occasional practices of hunting-weapon refitting/repairing. The faunal assemblage from Phase 5 is very scarce, with a few remains of domestic *Caprinae* species.

In conclusion, Phase 5 seems to confirm the occupation pattern established since Phase 7, with discontinuous and short episodes of occupation of the *abri*. Only domestic and maintenance activities were carried out during that time.

6.5. Final Remarks

The Cova del Sardo is a crucial site for the comprehension of the human dynamics in the Pyrenees between the sixth and the third millennium cal BC. The site is located in the Axial Pyrenees, an area that was completely unknown from an archaeological point of view until a decade ago. Only after almost ten years of surveys and excavations, it has been possible to put forward a reconstruction of the relevant human dynamics during the last 10.000 years (Gassiot et al. 2014).

Within this scenario, the Cova del Sardo is definitely of consequence. A multi-proxy analysis of the cave's archaeological and archaeobotanical record, integrated with palaeoenvironmental and palaeoclimatic data, has allowed to improve the understanding of the site's functionality and, generally, of the patterns of human occupation in the area. This site is one of the few high-altitude settlements that have been fully excavated in the Iberian Peninsula. Furthermore, it shows an incredible stratigraphic sequence, which covers not only the entire Neolithic Age, but also Roman, Medieval and Modern times.

To explain such a recurrent occupation, suffice it to look at the geographical position of the site. The Sant Nicolau Valley is a natural corridor that connects the Noguera Ribagorçana and Noguera de Tor Valleys with an extensive area of pastures (Vall de Llacs; Pletiu d'Aigüestortes; Pletiu d'Estany Llong, etc.). Within a distance of about 5 km from the site, alpine elevations can easily be reached; both water and forest resources are abundant. The site is easily accessible, since it is situated at a few tens of metres from the river and, finally yet importantly, it represents one of the largest natural caves of the region. Indeed, despite its small size, the Cova del Sardo is one of the biggest shelters of the valley, the geology of which is not shaped by karst phenomena. All these elements made Cova del Sardo a suitable place for human occupation (although in a very discontinuous way) over a period of more than 6.000 years.

The data achieved by the analysis of lithic assemblages have considerably contributed to understanding the site and its surroundings. Lithic materials have given information about the mobility patterns and the economic activities that were carried out near or within the site.

In the light of these outcomes and investigations by other colleagues, Cova del Sardo appears to have been a shelter occupied by small human groups mainly dealing with pastoral practices. The site's functionality was likely quite stable through time; however, slight changes can be observed during the occupational sequence. Specifically, the first phase, Phase 8, shows human activities apparently being concentrated in the valley bottom, whilst alpine areas were still scarcely exploited. Pasture areas were probably created in the surroundings of the site and the cave was occupied more continuously. On the contrary, from Phase 7 onwards, one can note a gradual extension of pastoral activities into the grasslands situated above 2.000 m.a.s.l. The site appears to have been settled more episodically and discontinuously at that time, being the shelter part of a large integrated system of settlements.

The economic activities shown by lithic tools are, more or less, the same throughout the sequence. Tools, mainly blades made on exogenous raw materials, were employed in accomplishing domestic tasks mainly related to the maintenance of instruments and the living room (Tab. 6.6, 6.7). Hunting was probably practised only occasionally in the area; however, both animal slaughter and meat consumption appear to have been marginal. Animal resources were only occasionally consumed at the Cova del Sardo. The scarcity of faunal evidence is also indicative of a similar pattern.

The human groups that inhabited the cave also practised agricultural activities. Cereals grains were transported to the site (at least in two of the four phases) and probably consumed as foodstuffs. Farming and harvesting activities probably took place at lower altitudes (it is uncertain at which distance from the settlement). To this point, it is important to remark that the sickle elements recovered at the Cova del Sardo were often retooled and used on-site for other activities, specifically as butcher knives or for gathering wild grasses.

Although data about the season of occupation at the Cova del Sardo are lacking, it is plausible to hypothesize late-spring/summer/early-autumn occupations. Actually, during late autumn and wintertime, alpine pastures were covered with snow, therefore the whole area must have not suitable for farming animals. The analysis of lithic raw materials suggests that those groups moved across a large area, which extended from the Axial Pyrenees to the external ranges of the pre-Pyrenees and to the Ebro Depression, where one could encounter more favourable environmental conditions during cold seasons.

Nevertheless, on the basis of current data, it is impossible to estimate the exact range of mobility of such people. Raw-material supply may have derived from either direct procurement or secondary sources (e.g. trade and exchange); therefore, it is difficult to ascertain whether a long- or short/mid-distance mobility existed. However, it is clear that the economic activities of these groups took place over a wide area, which included a variety of environments that were exploited by them for different resources and purposes.

PHASE		SG	PR	PO	TOT
5	**N.**	15	6	1	22
	% phase	*68,2%*	*27,3%*	*4,5%*	*100,0%*
	% tot	*20,0%*	*8,0%*	*1,3%*	*29,3%*
6	**N.**	4	2	4	10
	% phase	*40,0%*	*20,0%*	*40,0%*	*100,0%*
	%tot	*5,3%*	*2,7%*	*5,3%*	*13,3%*
7	**N.**	17	9	6	32
	% phase	*53,1%*	*28,1%*	*18,8%*	*100,0%*
	% tot	*24,0%*	*12,0%*	*6,7%*	*42,7%*
8	**N.**	5	3	3	11
	% phase	*35,7%*	*14,3%*	*50,0%*	*100,0%*
	% tot	*6,7%*	*5,3%*	*2,7%*	*14,7%*
TOT	**N.**	41	19	15	75
	% tot	*54,6%*	*25,4%*	*20,0%*	*100,0%*

Tab. 6.5. Interpretability of the use-wear traces identified among the Cova del Sardo lithic assemblage. SG: clear use, traces are fully interpretable; PR: probable use, traces are partially interpretable; PO: possible use, the interpretation is considered dubious.

PHASE		Herbaceous plants	Woody plants	Vegetal ind.	Soft/medium animal sub.	Soft/medium ind.	Hard ind.	Projectile	TOT.
5	**N.**	10	1	3	1	5	-	2	22
	%	*45,5*	*4,5*	*13,6*	*4,5*	*22,7*	-	*9,1*	*100%*
6	**N.**	2	2	-	1	1	2	2	10
	%	*20,0*	*20,0*	-	*10,0*	*10,0*	*20,0*	*20,0*	*100%*
7	**N.**	9	2	5	2	6	2	6	32
	%	*28,1*	*6,3*	*15,6*	*6,3*	*18,8*	*6,3*	*18,8*	*100%*
8	**N.**	4	-	-	2	3	-	2	11
	%	*36,4*	-	-	*18,2*	*27,3*	-	*18,2*	*100%*
TOT.	**N.**	25	5	8	6	15	4	12	75
	%	*33,3*	*6,7*	*10,7*	*8,0*	*20,0*	*5,4*	*16,0*	*100%*

Tab. 6.6. Composition of use-wear traces identified among the Cova del Sardo lithic assemblage. *Ind.* is an abbreviation for 'indeterminable'.

BLANK		Herbaceous plants	Woody plants	Vegetal indet.	Soft animal substances	Soft/medium indet.	Hard indet.	Projectile	TOT
	N	24	4	8	5	6	-	9	56
Blade	*% Bl*	*42,9*	*7,1*	*14,3*	*8,9*	*10,7*	-	*16,1*	*100%*
	% Mat	*96,0*	*80,0*	*100*	*83,3*	*37,5*	-	*75,0*	-
	N	1	1	-	1	8	3	2	16
Flake	*% Bl*	*6,3*	*6,3*	-	*6,3*	*50,0*	*18,8*	*12,5*	*100%*
	% Mat	*4,0*	*20,0*	-	*16,7*	*50,0*	*100,0*	*16,7*	-
	N	-	-	-	-	2	-	1	3
Waste	*% Bl*	-	-	-	-	*66,7*	-	*33,3*	*100%*
	% Mat	-	-	-	-	*12,5*	-	*8,3*	-
TOT	N	25	5	8	6	16	3	12	75
	% Mat	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	-

Tab. 6.7. Cross-tab between Blank type and Contact Materials. Within the category of «Waste» are included cores, rejuvenation flakes and tools on plaquette. *Bl.* indicates 'Blank'. *Mat.* indicates 'Material'. *Indet.* is an abbreviation for 'indeterminable'.

MOV	MAT			
	VG	**AN**	**PY**	**IND**
	HP	*SA*		*SO*
LO	4	2	-	3
TR	-	-	-	-
BO	-	-	-	-
PO	-	-	-	-
PY	-	-	1	-

Tab. 6.8. Cross-tab between the actions and the worked material, Phase 8. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; AN: Animal substances; SA: Soft animal substances; PY: Projectile implements; IND: Indeterminate substances; SO: Soft indeterminate substances.

MOV	MAT					
	VG		**AN**	**PY**	**IND**	
	HP	*VG Ind.*	*SA*		*SO*	*HA*
LO	7	3	2	-	4	.
TR	4	2	-	-	2	-
BO	-	-	-	-	-	-
PO	-	-	-	-	-	2
PY	-	-	-	6	-	-

Tab. 6.9. Cross-tab between the actions and the worked material, Phase 7. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; VG ind: Indeterminate Vegetal substances; AN: Animal substances; SA: Soft animal substances; PY: Projectile implements; IND: Indeterminate substances; SO: Soft indeterminate substances; HA: Hard indeterminate substances.

MOV	MAT						
	VG		**AN**	**MI**	**PY**	**IND**	
	HP	*W/P*	*SA*			*SO*	*HA*
LO	11	-	4	1	-	5	-
TR	-	3	-	-	-	-	-
BO	-	-	-	3	-	-	-
PO	-	-	-	-	-	-	2
PY	-	-	-	-	1	-	-

Tab. 6.10. Cross-tab between the actions and the worked material, Phase 6. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; AN: Animal substances; SA: Soft animal substances; PY: Projectile implements; IND: Indeterminate substances; SO: Soft indeterminate substances; HA: Hard indeterminate substances.

MOV	**MAT**				
	VG		**AN**	**PY**	**IND**
	HP	*W/P*	*SA*		*SO*
LO	13	-	1	-	5
TR	-	1	-	-	-
BO	-	-	-	-	-
PO	-	-	-	-	-
PY	-	-	-	2	-

Tab. 6.11. Cross-tab between the actions and the worked material, Phase 5. MOV: action/movement; LO: Longitudinal; TR: Transversal; BO: Boring; PO: Pounding/Grinding; PY: Projectile. MAT: worked material; VG: Vegetal substances; HP: Herbaceous plants; W/P: Woody plant or other indeterminate plant; AN: Animal substances; SA: Soft animal substances; PY: Projectile implements; IND: Indeterminate substances; SO: Soft indeterminate substances.

7. SYNTHESIS

7.1. Technological Organization and Mobility Patterns in the Central Pyrenees in Third-Sixth Millennia cal BC

7.1.1. Defining the Regions: Raw-material Sources and Mobility Patterns

The petrographic characteristics of the lithic collections analysed in this work have allowed for a reconstruction of the type of raw materials exploited by the prehistoric groups that occupied the Central Pyrenees between the sixth and the third millennium. This information has turned out to be crucial especially for figuring out the management strategies of lithic resources at each site, as well as for approaching the organization of economic activities in the relevant mountain areas. For example, it has been possible to distinguish the existence of different lithic production systems, each oriented towards obtaining different typologies of instruments (*cfr.* Chap. 5, Par. 5.3.4.4.). On the other hand, by analysing how the exploitation of different sources has changed over time, it has been possible to point out changes between the various phases of occupation at a certain site (*cfr.* Chap. 6, Par. 6.3.4.4.).

In addition, the analysis of procurement strategies also gives us important information for reconstructing some aspects of the prehistoric landscape and people's mobility. Raw materials, like other natural resources, are culturally recognized elements, which were exploited by human populations due to their value as essential elements for economic and social production processes. Accordingly, once their geographical and geological provenance is ascertained, it is possible to attempt at framing not only the physical context, but also the social space —or 'territory'—, in which the prehistoric populations carried out their activities (Terradas 1998, 2001; Ortega 2002; Mangado 2006). Space is here referred to as a region with no clearly determined or fixed boundaries, rather being a vaguely defined land, some areas of which result to have been known, frequented, or inhabited by prehistoric groups. In this case, such areas are mostly ascertained on the basis of chert outcrops and archaeological sites. Although this evidence is too poor to provide an exhaustive comprehension of the region as a whole, it at least gives some clues about mobility; chert materials are objects —supplies or artefacts— which were moving within a social space, thus they give indirect information about the ways human communities conceived and exploited the surrounding landscape. To this point, not only the provenance of such materials is important, but also the form and the quantity in which they were moved, transported, or exchanged.

The data here concerned has been processed by a Chi-Square Test, in order to ascertain if any significant association existed between the two variables considered («Site_phases» and «Raw_material»). The two variables have been clustered in nine groups (corresponding to the number of the studied phases: «Chaves 1b», «Trocs 1», «Trocs 2», «Trocs 3», «Sardo 8», «Sardo 7», «Sardo 6», «Sardo 5» and «Puyascada E.2») and in four groups (corresponding to the main lithologies observed: «Lacustrine Oligocene-Miocene chert», «Evaporitic Upper Cretaceous-Palaeocene chert», «Marine Eocene-Cretaceous cherts», «Other rocks») respectively, whilst indeterminable chert materials have been excluded from the analysis (Tab.

7.1., see Annex I). The resulting p-value (χ^2: 1434.369; df: 24; *P*: 0.000) indicates that materials are not homogenously distributed amongst the various occupational phases. Furthermore, all chi-square requirements are satisfied since only four cells, representing 8.9% of the sample, show a minimum frequency inferior to 5.

Once it was proved that a significant relationship existed between the two variables, data were overhauled by a Simple Correspondence Analysis (CA) applied to the clusters above mentioned. This implementation has brought to identify two dimensions that explicate up to 99,7% of the variance (94,6% and 5,1% respectively) (Tab. 7.2, Annex I).

If one looks at the contribution of each point to the inertia for each dimension, it clearly emerges that «Cueva de Chaves» is the variable which most contributes to the first factor along with «Lacustrine Oligocene-Miocene cherts», while the decisive items for the second dimension are «Cova del Sardo» and «Other rocks» (Tab. 7.3 and 7.4, Annex I).

The graph of row and column points is useful to summarize data and point out the general locations of row and column points, besides, their relations within each type of point (Fig. 7.1). One can clearly distinguish two groups: on one side of the plot, Cueva the Chaves and «Oligocene-Miocene cherts» are displayed, both isolated from the rest of the items that lie on the other side. This latter group is in turn divided into two groups along the second dimension, namely, all Trocs phases with «Marine cherts» and the Sardo phases with «Other rocks» (which include lithologies such as quartz, quartzite, hyaline quartz, slate, schist, porphyry, rhyolite, etc.). Espluga de la Puyascada lies between the two sites instead, clearly still on the same side of the plot as the other Pyrenean sites.

The first conclusion that one can draw from the analysis of this chart is a marked separation between the mid- and high-altitude Pyrenean sites and Cueva de Chaves, in terms of both amount and type of the exploited raw materials. Moreover, it is possible to observe that each archaeological context is more strictly correlated with the sources of raw materials available in the surroundings of the site. For example, «Other rocks», «Marine Eocene-Cretaceous cherts», «Lacustrine Oligocene-Miocene cherts» represent local resources for Cova del Sardo, the Cova de Els Trocs, and Cueva de Chaves respectively. This pattern of exploitation appears quite obvious, as local raw materials, independently from their quality, represent the closest and most accessible resource, implying little effort for their exploitation.

However, this graph gives only little information about the use of exogenous materials. This is partially a consequence of the strong weight carried by Cueva de Chaves on the first dimension, which brings about a stretching of the graph and compresses the Pyrenean sites into a small area of the plot. For this reason —to explore in detail the distribution of the different raw materials among the Pyrenean sites— a second Correspondence Analysis Test was accomplished, this time excluding Cueva de Chaves from the sample.

As expected, the results are similar to the previous analysis; however, the plots of rows and columns are more squared and not stretched as in the previous one, this allowing a better display of the correlation between the analysed variables.

Data points are distributed over two dimensions that together amount to 95,6% of the total variance (Tab. 7.5, Annex I). On the first dimension, the highest weight is placed by «Other rocks», «Evaporitic Upper Cretaceous-Palaeocene cherts», and «Cova del Sardo»; on the second dimension, by «Lacustrine Oligocene-Miocene cherts» and «Puyascada» (Tab. 7.6 and 7.7, Annex I). Besides, from the scatter diagram (Fig. 7.2), it emerges that both Puyascada and Trocs are clearly separated from Sardo as they lie on a different side of the plot. Such a separation is mainly due to the larger exploitation, at the Cova del Sardo, of non-chert rock types (especially porphyry, rhyolite and slate) and evaporitic chert types, which are poorly attested to in the other two sites. Items are also separated on the vertical axis. For

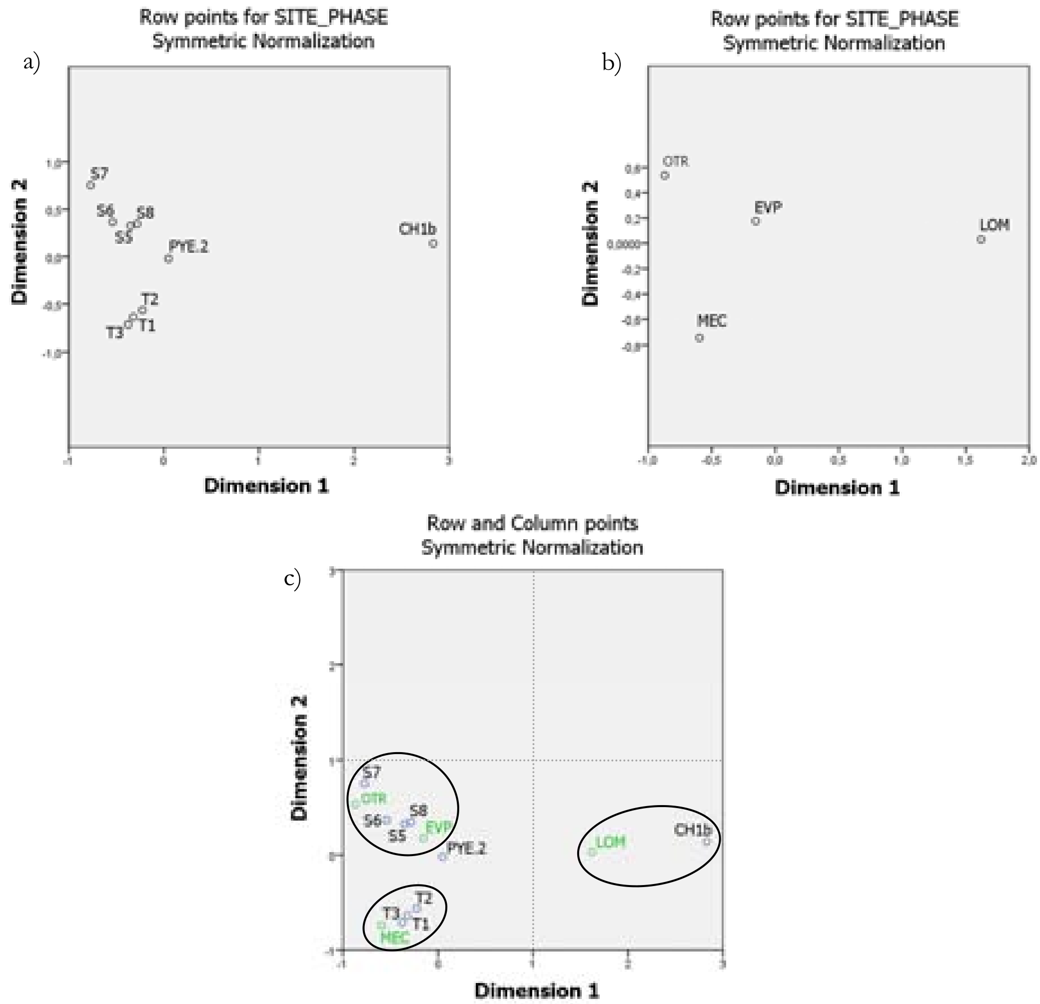

Fig. 7.1. *a*) Scatter diagram of the Simple Correspondence Analysis for the variable SITE_PHASE; *b*) Scatter diagram of the Simple Correspondence Analysis for the variable RAW_MAT; *c*) Scatter diagram of the Simple Correspondence Analysis between the two variables. OTR: Other rocks (quartz, hyaline quartz, quartzite, porphyry, rhyolite, slate, schist, etc.); LOM: Lacustrine Oligocene-Miocene cherts; EVP: Evaporitic Upper Cretaceous-Palaeocene cherts; MEC: Marine Eocene-Cretaceous cherts.

example, while the Puyascada is strongly associated with the Ebro Oligocene-Miocene chert types, Trocs appears to fall in between the Ebro and the Marine cherts, with a certain variability amongst the various phases: Trocs I shows a balanced proportion of both lithologies, whilst Trocs II and, especially, Trocs III show a closer connection with the Marine Eocene-Cretaceous cherts. Also Sardo displays a certain differentiation amongst the various occupational phases; however, a detailed description of such differences has already been made at Chap. 6, Par. 6.3.4.3.

Apart from the exploitation of local raw materials, this test shows that all the Pyrenean sites were characterized by the presence of good-quality exogenous cherts. Indeed, local materials such as non-siliceous stones and marine chert types do not really lend themselves to laminar knapping techniques, hence the necessity of exploiting other types of lithologies

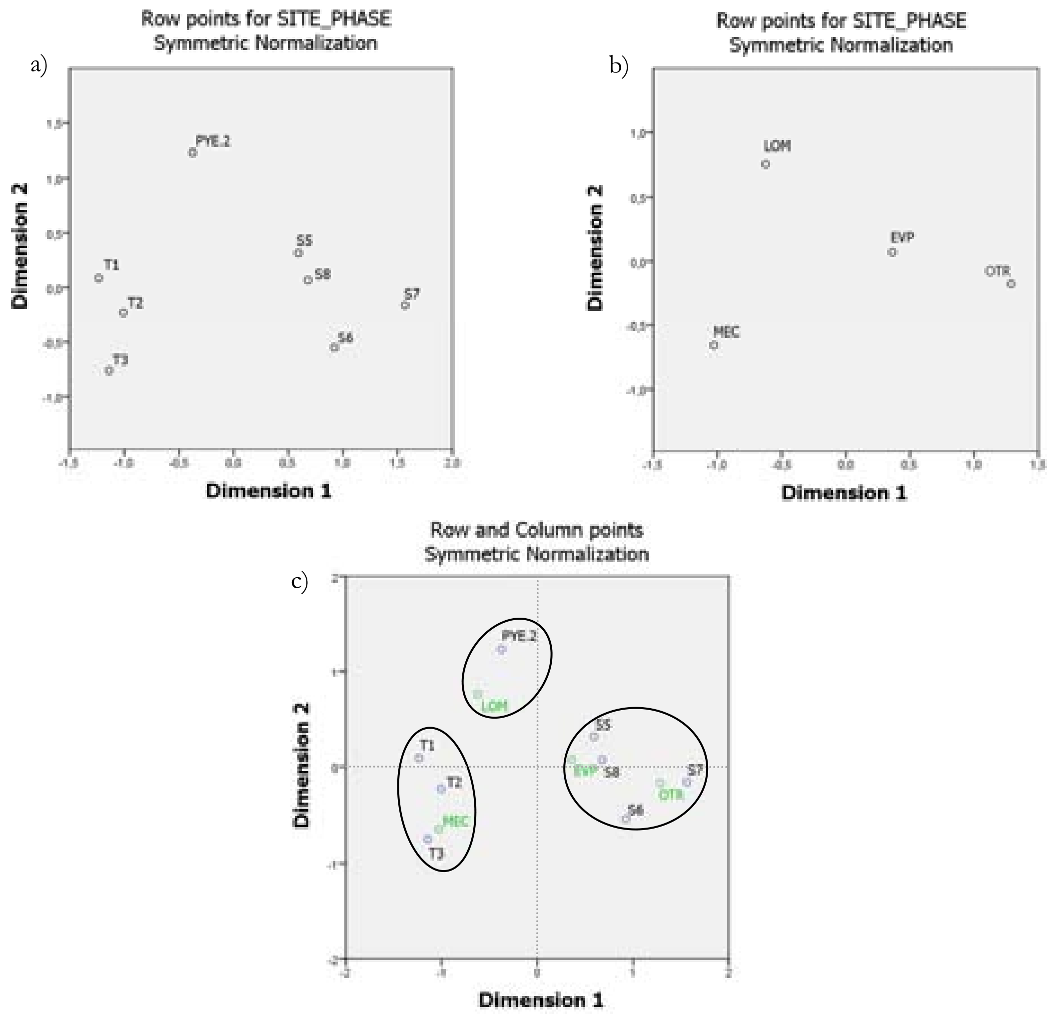

Fig. 7.2. *a*) Scatter diagram of the Simple Correspondence Analysis for the variable SITE_PHASE (Cueva de Chaves excluded); *b*) Scatter diagram of the Simple Correspondence Analysis for the variable RAW_MAT; *c*) Scatter diagram of the Simple Correspondence Analysis between the two variables. OTR: Other rocks (quartz, hyaline quartz, quartzite, porphyry, rhyolite, slate, schist, etc.); LOM: Lacustrine Oligocene-Miocene cherts; EVP: Evaporitic Upper Cretaceous-Palaeocene cherts; MEC: Marine Eocene-Cretaceous cherts.

more suitable for blades production. There are two main types of fine-grained, homogeneous cherts in the region: the Lacustrine Oligocene-Miocene cherts of the Ebro Valley and the Evaporitic Upper Cretaceous-Palaeocene cherts of the Tremp-Graus Basin. However, their exploitation does not appear homogenous: the first were mainly used at the sites of Puyascada and Trocs, while the second are mainly associated with Cova del Sardo. How can such a difference be explained?

Outcrops of Evaporitic Continental cherts have been identified in the area of the Nogueras, in the Montsec range, where decametric nodules are available in primary position (Mangado 1998; Mangado et al. 2007; Mangado et al. 2012). However, similar cherts have also been identified further west in the Carrodilla range (Sánchez & Mangado 2013; Sánchez

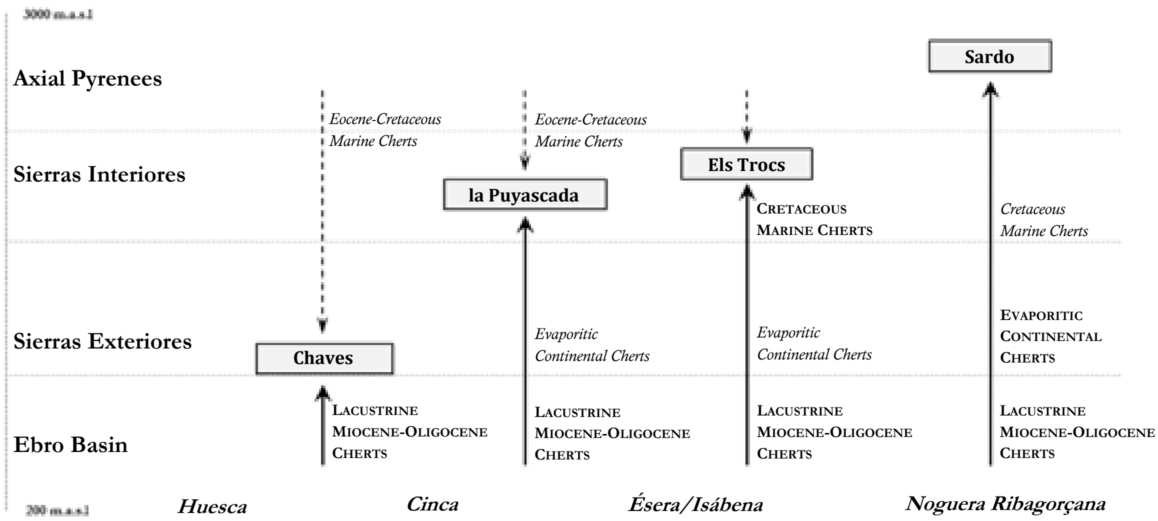

Fig. 7.3. Schematic representation of the chert materials exploited in the analysed region. Black arrows indicates the main lines of procurement, while dotted lines indicate secondary sources. In SMALL CAPITALS are indicated the main lithologies fro each site; in *Italic* are indicated the secondary outcrops for each site. On a vertical plane (Y) are indicated the main geographical formations on S-N axis. On the horizontal plane (X) are indicated the main geographical ambits on a W-E axis.

2014). Their scarce employment at the sites of La Puyascada and Els Trocs is still difficult to figure out. For both sites, evaporitic cherts did represent an accessible resource, given the presence of several outcrops along the course of the Cinca and Isábena Rivers; this notwithstanding, the lacustrine Ebro chert deposits located in the Pyrenean foothills (Castelltallat and Peraltilla frm.) were probably more attractive resources, which were equally accessible, with larger nodules and a homogenous microcrystalline matrix.

About Cova del Sardo, the situation is slightly different. Considering the greater distance of the site from the Ebro Basin, the pre-Pyrenean evaporitic cherts probably represented an important resource for gathering knappable raw materials. In addition, the larger exploitation of this lithology suggests a more intense frequentation of the Nogueras Basin and pre-Pyrenean region (Fig. 7.3).

In sum, the collected data points out the existence of a vast catchment area that from the Ebro Plain reached the Pyrenean mountain ranges. The large majority of materials come from this region, whilst exogenous lithologies are rarely attested and their procurement and transportation result to have been quite discontinuous. Well-known formations such as the *Sílex de Urbasa* —the outcrops of which are located in Navarra and in the western Aragonés pre-Pyrenees (Tarriño et al. 2007)— have not been detected in the analysed region. Similarly, chert materials from the eastern Pyrenees are absent amongst the archaeological assemblages of the Central Pyrenees; however, those materials —being highly jointed rocks, scarcely suitable for flaking— were scarcely exploited during the Neolithic period also at the nearest sites, located in the eastern area of the pre-Pyrenees, and represented a very marginal resource (Mangado et al. 2007).

This scenario is common to the four archaeological contexts and reveals the existence of a strong homogeneity in terms of types and sources of the exploited raw material. The prehistoric groups moved and transported the lithic materials after selecting them on the basis of their quality and the accessibility of their outcrops in relation to the position of the site. Chert types coming from the Ebro-Valley Oligocene-Miocene lacustrine formations represent the most exploited lithologies, since they were employed in all the analysed contexts, although with considerable differences in the proportions and modes of exploitation from one site to another. At the Cueva de Chaves, they represent a local resource, while, in the case of Pyrenean sites, these materials were transported over longer distances, within a range of 80-120 kilometres or even more. The exploitation of Pyrenean lithologies shows a greater variability, depending on several factors. Generally, they represented an important resource only when they were accessible in the surroundings of the site —as a local resource— or, at least, in the same geographical district —e.g. the same drainage basin, as in the case of Cova del Sardo (Fig. 7.3).

To this point, it is noteworthy that a site along the lower course of the Noguera Ribagorçana River, in the Montsec range, shows a pattern of raw-material exploitation which matches the aforesaid model, namely, Cova Colomera (Oms et al. 2008, 2013). Colomera's lithic assemblage has been studied in terms of petrographic analysis by Mangado et al. (2012). Preliminary results have evidenced the presence of a high percentage of cherts from the pre-Pyrenean formation, especially materials from the Tremp-Graus Basin, which can be considered a local resource for the Colomera site, as it is about 1-2 km far from the site. In addition, the lithic assemblage is characterized by a considerable proportion of Ebro-Basin cherts, the outcrops of which are situated 20 km south of the site. This site fundamentally shares the same catchment area with Cova del Sardo, although —since it is located further south— it is characterized by a greater proportion of evaporitic materials.

In conclusion, the gathered data suggests that the groups that occupied the Pyrenees between the sixth and the third millennium developed their economic activities over a large area, which extended from the lower lands of the Ebro Valley and the highest peaks of the Axial Pyrenees. Mobility patterns seem to have mainly followed a south-north direction, whilst an east-west movement of objects and artefacts appears extremely reduced. This pattern is not surprising as the pre-Pyrenean ranges have always hindered human dispersal and interaction between adjacent valleys (Solé i Sabarís 1951; Derruau 1965; Comas d'Argemir 1995; Benlloch 2002). In fact, while on the French side of the Pyrenees, slopes run down quite abruptly, so creating wide and gentle valleys that can easily be passed through, on the Iberian side —especially in Aragon and in Catalonia— the pre-Pyrenees form a large mass of irregular elevations that are characterized by ridges, narrow valleys, gorges, and canyons, the crossing of which is harder and slower. For this reason —also in medieval and modern times— the main pathways of communication were arranged on a north-south direction, which connected the lower lands of the Ebro Basin with the Pyrenean subalpine and alpine zones through the pre-Pyrenean valleys.

The catchment area was substantially the same during the entire period, except for the specific appearance of lithologies imported from other regions. The existence of long-distance contacts is also documented by the presence of marine shells of Mediterranean origin (e.g. *Collumbela rusticae, Cardium sp., Dentalium,* etc.) (Álvarez-Fernández 2008; Baldellou et al. 2012; Rojo et al. 2014), which were recovered since the oldest contexts of occupations at Chaves and Els Trocs Caves. Furthermore, the number of artefacts coming from the surrounding regions, especially from the coastal areas, seems to have increased during the Middle and final Neolithic Age, with the appearance of Can-Tintorer variscite beads in Chaves Level 1.a (Baldellou et al 2012), bone spoons (Pascual Benito 1999) and *silex blond* at la Puyascada (Mazzucco et al. 2013c), *silex en plaquette* of the Aude-Roussillon region at Sardo Phase 6 (Gassiot et al. 2012a; Vaquer & Vergély 2006) and Cova

Colomera (Mangado et al. 2012), long blades (Gibaja et al. 2009) at Els Trocs III. All these artefacts simply confirm that the groups who inhabited the Central Pyrenees —far from being isolated— interacted within a broad network of social and economic relations, sharing technical traditions and a common material culture with the contemporary communities of the north-western Mediterranean areas.

Although more studies are required, in order to define the mobility patterns of these groups more precisely, provenance analysis has turned out to be a first step towards the integration of the data achieved after years of archaeological campaigns in mid- and high-altitude areas within a broader geographical context. This work has tried to answer questions like "from which region or land those groups came", "how extended the area in which they developed their economic activities", "which the range of their movement", and "which their procurement strategies were".

7.1.2. Technological Organization and Lithic-Tool Management

7.1.2.1. Raw-material Selection and Transformation

The previous chapter has dealt with the types of raw materials exploited in each site and the implications in relation to the geographical area and mobility patterns. However, it has not investigated the ways those materials were exploited, how they reached the sites and in which form and amount they were transported or even exchanged. This paragraph mainly focuses on the Pyrenean sites (Espluga de la Puyascada, Cova de Els Trocs, and Cova del Sardo). As previously stated, almost the entire production at Cueva de Chaves can actually be considered 'domestic'. Good-quality raw materials were gathered within a short distance of the site, whereto they were transported almost unmodified or just roughed-out, therefore, the entire lithic production took place *in situ*, specifically all the stages of core reduction and maintenance as well attested to amongst the assemblages. On the other hand, the scenario shown by the Pyrenean site is quite different and so deserves a broader discussion.

As previously stated, raw materials have not the same characteristics and were not exploited for the same type of production. The «Other rocks» group clusters a number of different lithologies, which were flaked to make a variety of different blanks, such as flakes (schist), elongated flakes (rhyolite and porphyry), tabular flakes (slate), and bladelets (hyaline quartz). In turn, chert materials show different characteristics as derived from their petrogenetic process, the depositional environment in which this occurred, and also from their tectonic history. For example, Eocene-Cretaceous Marine cherts have a fine-grained microcrystalline matrix, but they are strongly jointed, therefore they were not a suitable material for laminar knapping techniques. On the contrary, both the Lacustrine Oligocene-Miocene and the Evaporitic Upper Cretaceous-Palaeocene formations provided non-shattering homogenous materials.

This situation clearly emerges from the distribution of the various blank types for each lithology (Tab. 7.8, Annex I). Non-siliceous rocks were exploited almost exclusively for flake production; hyaline quartz crystal was mainly flaked to produce bladelets, even if in small quantities. Upper Cretaceous-Palaeocene Evaporitic and Oligocene-Miocene cherts show a similar —very high— percentage of blades, while Eocene-Cretaceous materials, in the face of a greater proportion of waste and core trimming elements, show a lower percentage of laminar artefacts. These result confirm the observations previously made: a range of different raw-materials were exploited with different purposes on the basis of their

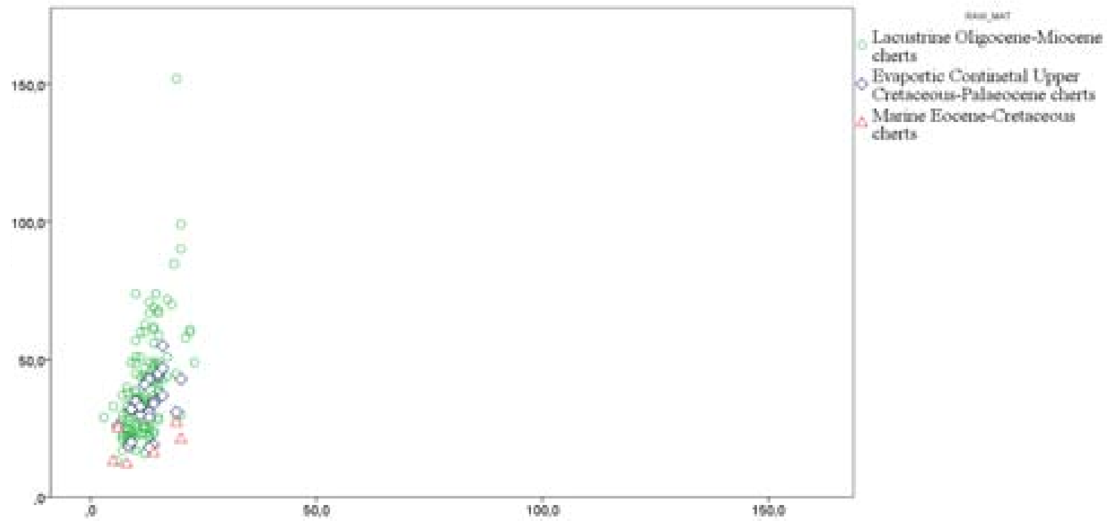

Fig. 7.4. Scatter diagram for length-width measurements of the blades from the main chert lithology exploited in the region. X: length expressed in mm; Y: width expressed in mm. Only complete elements have been used in this analysis.

petrological and mechanical characteristics. Non-shattering homogenous cherts provide good -quality raw-materials for flaking, while the other lithologies offer a more unbalanced ratio between effort and results.

However, it is not only a matter of 'quantity', but also 'of size'. Jointed materials were not only more difficult to knap, but they also produced smaller cores and so smaller objects were obtained. If one looks at the scatter diagram relevant to the length-width measurements of the whole of finished blades for each of the three chert types, it is clear that Marine cherts were mainly oriented towards a bladelet production, while the remaining materials were intended for making larger implements (Fig. 7.4). The scatter diagram also shows that blade's length represents the main difference between the Upper Cretaceous-Palaeocene (pre-Pyrenean) and the Oligocene-Miocene (Ebro valley) cherts: while the first have an average length of 30-39 mm up to a maximum of 50 mm, the second are featured by larger blades, which range on average between 28 and 46 mm, however, with tools that are over 60 mm in length, also reaching 150 mm. Oligocene-Miocene Ebro chert formations represented the best lithic resource available in the region, not only for its homogeneity and its textural features, but also for the larger size of the nodules that made it possible to extract larger blocks of stone.

According to this data, one can conclude that in the Pyrenean area, on the one hand, low-quality materials were in use (which are represented by non-siliceous stones and marine cherts) and, on the other hand, two high-quality chert types, amongst which the lacustrine Ebro chert types were the most exploited and highest-quality raw materials.

If one considers exclusively the Pyrenean sites (Espluga de la Puyascada; Cova de Els Trocs; Cova del Sardo), it emerges that high-standard materials were the most distant exogenous sources, while low-quality stones appear to have been mostly local and supplied from the surroundings or within a 10-15 kilometre-distance of the site.

The percentages of good-quality lithologies (Upper Cretaceous-Palaeocene and Oligocene -Miocene cherts) at the three Pyrenean sites show that blades are always the most represented category, ranging from 43% to 67% of the whole assemblage, while the figures of cores, trimming elements, and waste materials are generally relatively low, around 10%-40% (Tab. 7.9, Annex I).

In some cases, it is possible to hypothesize that non-exhausted cores were transported from site to site for further use and this behaviour would account for the low percentages of cores found. However, core-trimming elements and debris are also scarce in most of the studied contexts. If the absence of debris at Espluga de la Puyascada could be attributed to a non-systematic sediment sieving, in the case of Cova del Sardo and Cova de Els Trocs, the poor evidence of waste materials is not due to the type of sifting technique adopted, thus confirming that on-site knapping of good-quality lithics was actually limited.

Finally, it is important to remark that no large quantity of good-quality raw material was taken to any of those Pyrenean sites as either supplies or stores. The small number of cores that have been recovered should be interpreted as a result of the transportation of a few preforms or small cores and not as a real reserve of knappable materials. In conclusion, the evidence is strong enough to put forward that good-quality exogenous chert materials were carried to the mountain sites mainly in the form of finished blanks, such as unretouched blades or retouched tools; on the contrary, local materials were more expedientially exploited for secondary or subsidiary productions, namely, a sort of 'domestic debitage' (*sensu* Binder & Gassin 1988).

7.1.2.2. Lithic-Tool Transportation and Management

After the ways of procuring and transforming raw materials have been described, it is now possible to make some general observations about how such a pattern of raw-material management interacted within the economic and technological organization.

The first point to emphasize is that raw materials were carried in small amounts and they never were a bulky load. The prehistoric groups that moved to the mountain areas of the Central Pyrenees did not need to elaborate a particular transport strategy, nor adopt a specific technology for conveying lithic resources. Carriage costs were very low as the amount of transported materials was very reduced. Preformed cores, unretouched blanks, and hafted tools were all easy-to-carry objects and did not represent too heavy a load if transported in small quantities. Moreover, this type of materials was basically part of the Neolithic personal gear, namely, items that everyone would have normally taken along during a trip or a travel, even a short-distance one (for a definition of 'personal gear', see Binford 1977, 1979). They were common materials, part of the basic, everyday toolkit of these populations. Their transportation should not be seen as something exceptional, based on '*ad hoc*' strategies, but as a normal behaviour, which did not imply any additional cost or effort.

The only selection that these materials probably underwent was about their size. As previously seen, mainly medium or large laminar blanks were chosen for transportation, also depending on the type of raw material and its possible implementations. At the same time, not too large or heavy cores were also selected for bringing along, probably after being reduced and preformed (with no or just a few waste materials). This pattern appears quite clear if one considers, for example, the finds from Cova de Els Trocs. At least for the periods of Trocs I and Trocs III occupations, it has been possible to ascertain the transportation of larger laminar blanks and the local production of small implements, both on exogenous chert types (*cfr.* Chap. 5, Par. 5.3.4.4.).

In addition, one should probably make a further distinction among the transported objects. Following and adapting Binford's definitions (1979), a large part of the materials to carry can be regarded as *passive gears*, that is, technology that was not being used, but transported for further, either unexpected or scheduled, needs (among them, one can mention the transportation of unretouched/unused blanks and cores). However, a small part of this assemblage was likely composed of *active gears*, namely, tools that were probably employed before or during the trip to the site (among them, one can mention hafted tools such as knifes, sickles, or arrows).

The use-wear analysis has brought to detect several marks and signs of wear that point out a previous use of some of the tools transported to the mountain sites. In some cases, it was possible to observe that traces of a first activity were partially or almost completely covered with those of a second work. This could be done after resharpening the item, but also without modifying its edges, simply using the tool for a new activity. Such a practice is known as 'retooling' (*sensu* Keeley 1982). In some cases, retooling implied a marked 'functional change' in terms of artefact type: examples are sickle blades used for cutting soft animal substances as at Cova del Sardo, sickle blades used for ceramics-related works (e.g. Puyascada), or geometric instruments retooled as borers (e.g. Trocs III). Other times, the shift appears more subtle as occurs about sickle blades which were retooled for cutting wild or meadow grasses (e.g. Cova del Sardo).

Furthermore, the carriage itself of a blank (especially over long distances and for several hours) can bring about signs of wear and damage, which can be recognized under the microscope (for a broader discussion of this issue see Chap. 2, Par. 2.3.2.). By a detailed analysis of the lithic surfaces —also taking into account the overall technological and functional context— it is sometimes possible to hypothesize if an instrument has been transported after or before its first use (Kornfeld et al. 1990; Mazzucco & Clemente 2013). In this respect, it is interesting that all carriage-caused signs of wear and all retooling marks have been identified exclusively on certain types of implements, such as laminar blanks, sickle blades, and geometric tools. This, suggesting that certain categories of blanks or tools were more likely to be transported than others (e.g. flakes or core trimming elements).

In brief, in all three Pyrenean sites, both exogenous and local productions have been ascertained. Local items generally show a short life; they were usually employed for a single activity, often for a short time, without previous retouching or debitage. On the contrary, allochthonous materials show a longer life. They were more intensively retouched and used; moreover, they had often already been used and hafted before their arrival at the site, where they were recycled for other purposes. In other cases, they were intensively employed in the same activity, exploiting all the available edges. This pattern is somewhat similar to the one observed for the Chassey of Southern France, where as well imported tools generally show a major degree of utilization (and of curation) in respect to the ones produced locally, with a dichotomy between tools showing a 'long' or 'short' management (Gassin et al. 2006, 2010).

These considerations are important for understanding the lithic-management strategies and the technological organization; besides, they offer essential clues also for reconstructing the mobility patterns. The existence of allochthonous *active gears* transported from one place to another actually indicates that not only raw materials moved over the mountain areas, but, along with chert materials, also people did, who even used some of these tools during their movements. Lithics were brought along as part of people's 'personal gear' and were finally discarded in the mountains when they were worn-out.

At the moment, it is not possible to ascertain whether this set of artefacts called 'personal gear' was directly collected in the lower plain of the Ebro Valley or at some settlements along the way, in the pre-Pyrenees. Even if I gained a deeper knowledge of the chert outcrops of the region and also of the settlement organization of the pre-Pyrenees, it is difficult to answer such a question, since the area is still largely unknown because of the lack of

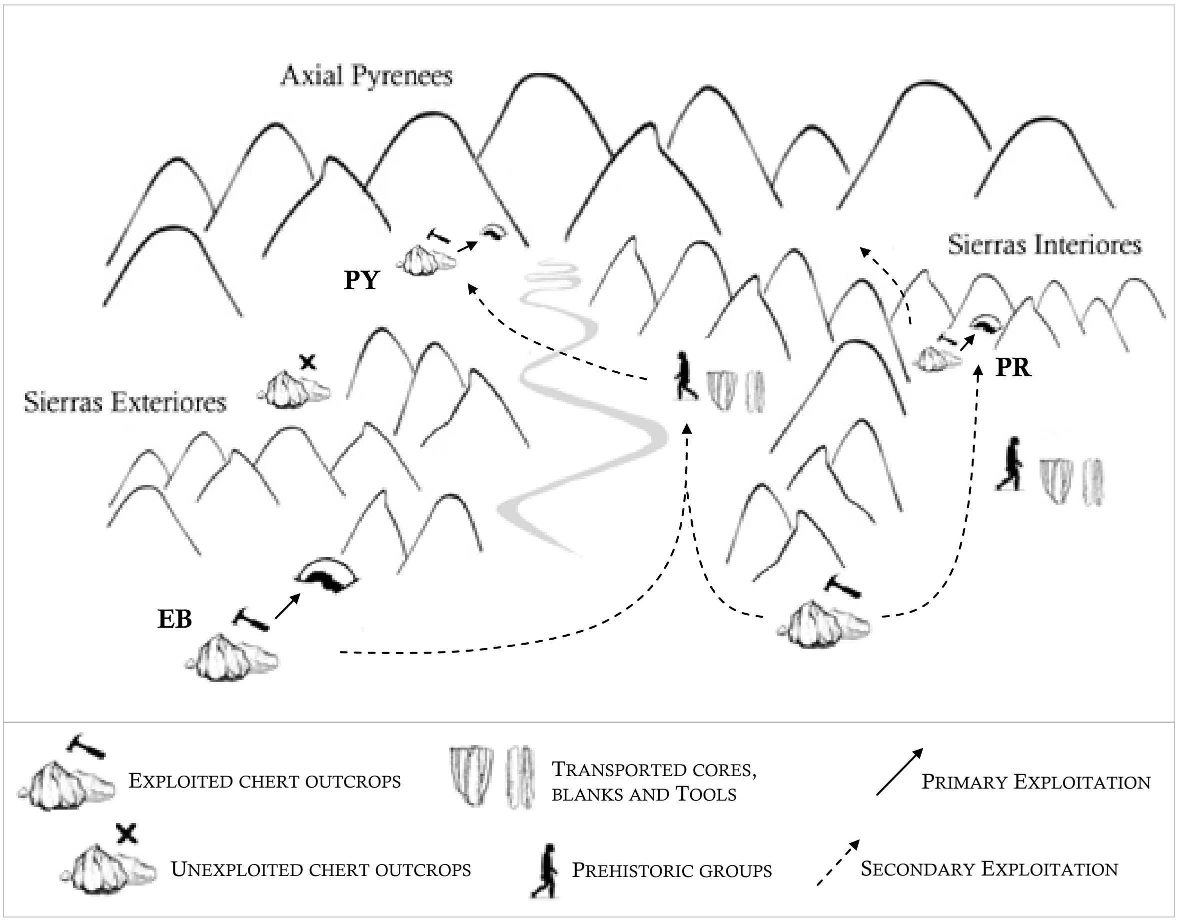

Fig. 7.5. Schematic diagram of chert exploitation in the Pyrenees and mobility patterns. **EB**: Ebro valley high-quality cherts; **PR**: pre-Pyrenean high-quality cherts; **PY**: Pyrenean low-quality rocks (chert and non-siliceous rocks). Each site has a local source of raw-materials; exogenous raw-materials are moved along this territory in form of preformed cores, flaked blanks or tools.

systematic surveys and excavation, especially for what concerns open-air dwelling places.

Nonetheless, a clear point is that procurement and transportation of these materials were not the result of a single-purpose-oriented strategy, but they were integrated within the rest of the economic processes carried out by these prehistoric groups. Local raw materials were exploited because they were easily available, while the exogenous ones were transported in small quantities as part of the individual toolkit. In none of these cases, any additional effort was made to get these resources, all being procured while engaging in other subsistence activities. Furthermore, at least for the Pyrenean sites, it is important to remark the scarcity of lithic materials. If lithic resources had played a central role in the site's economy, one would probably expect to find more evidence of the kind, more on-site knapping activities, the presence of a surplus or reserve of good-quality materials, etc. In the mountain site, lithic artefacts appear to have been a secondary resource instead and their scarcity should be interpreted as a consequence of a specific economic orientation of those settlements.

7.2. Lithic tools and Settlement Organization in the Central Pyrenees

7.2.1. The Application of Cluster Analysis to the Processing of Use-Wear Data

Traceology has been applied to resolve a variety of questions and problems within prehistoric research depending on the focus and the context of the research. From the early works of Semenov (1964) and, later, Keeley (1980) that largely focused on the form/function relationship of prehistoric tools (but not only), traceological studies embraced a wide range of thematic, including technological, economic, social and ideological aspects. Among those, one of the trending topic of use-wears analysis has certainly been 'site function'. Indeed, during the last decades several authors employed traceology to approximate the functionality of an archaeological site (Vaughan 1981; Plisson 1985; Donahue 1988; Gijn 1989; Gassin 1996; Banks 1996; Clemente 1997a; Lemorini 2000; Calvo 2004 only to cite some of them). However, if one looks for studies that extended their analysis from the function of one single site (or occupation) to a group of sites —thus exploring subsistence practices ad settlement organization over a certain territory— one does not observe such abundance.

Some of the most renewed works following this perspective are the research of Odell (1987), Yerkes (1987) and Bamforth (1991) on the hunter-gatherer populations of Northern America. Otherwise, in Europe similar questions have been addressed by Ibáñez & González (1996) for the Final Upper Palaeolithic contexts of the Basque country and by Philibert (1999) for the Mesolithic of the French Pyrenees (also see Calvo et al. 2009 for a general overview on the functionality of the Pyrenean sites during the Late Glacial Maximum). A similar perspective has been recently adopted as well by Crombé & Beugnier (2013) for the Mesolithic of Belgium and the Netherlands.

For Neolithic period, a similar approach has been carried out by Gassin (1999), Gassin et al. (2010) and by Torchy & Gassin (2011) for the Chassey Culture of southern France. These works, in particular, succeeded defining the 'functional status' of a large quantity of contexts, remarking the existence of 'complementarities' between settlements or group of settlements. However, most of these comparisons were based on qualitative considerations about the technological and economic organization of the various sites or, at most, simply comparing percentages of the performed activities. In none of these studies has been run a more complex statistical test to prove the significance of the observed differences and to explore the possible influence of other factors.

One of the main objectives of this work is to advance an economic approximation of the various prehistoric occupations analysed, both singularly and as whole; the aim is to compare the intra-site variability —that is to see if it is possible to appreciate significant variations in the modalities of occupation of a same context— and the inter-sites differences —that means to compare sites located in different environmental and geographical settings.

To homogenize the sample, all the economic processes and the activities inferred through traceological analysis have been grouped into 9 categories, each one of them with a specific functional and economic value (Tab. 7.10). The totality of cases considered in the analysis is of 491 active zones, each one corresponding to one specific activity or task, part of a specific economic process. However, instead of considering a count of the active zones for each functional category, I employed the percentages calculated on the totality of the active zones for each occupation.

The functional categories employed in the analysis has been established on the basis of some of the main traceological works realized on Neolithic assemblages, among which I can cite Gijn (1989), Gassin (1996), Gibaja (2003):

i. (BU) within the category of «slaughtering and butchering activities» I grouped all the traces associated to soft animal substances;

ii. (PWC) all the scraping activities realized on non-ligneous plants and all the working processes realized on wood materials have been grouped together in a single category. I defined such category as «plant-wood crafting activities», including all those crafting processes that involved the processing of some type of vegetal matter, both ligneous and non-ligneous plants;

iii. (HUN) within the category of «hunting activities' I grouped all those tools that show macro- or micro-traces related to projectile impact;

iv. (HA) all the tools associated to the work of «hard animal substances» have been grouped together, including all those lithics associated to the work of bone/antler materials independently from the cinematic involved;

v. (HP) all the activities related to the «harvesting/cutting of herbaceous non-ligneous plants» have been grouped together. Within this category are included both the so-called 'sickle blades' and tools employed for cutting wild grasses. Being often complicated to discern between the two types of materials (domestic cereals and wild grasses) I included all those tools within the same class;

vi. (HI) within the category «hide» I clustered all the activities realized on dry or fresh hide, both scraping, cutting or boring movements;

vii. (MIN) all the tools associated to the working of «mineral materials» have been grouped together independently from the cinematic of the action performed; in this class I included scraping, boring and longitudinal/diagonal movements; however, is to remark that a large percentage of those implements are associated to the work of clay/ceramic;

All those traces that have been classified exclusively on the basis of the hardness of the worked substance (e.g. soft, medium or hard indeterminate materials) have been excluded from the analysis, being generic categories which economic interpretation is often controversial embracing a huge variety of different economic processes. Moreover, usually, indeterminate materials are those of more dubious interpretation, presenting use-wears characterized by a scarcer conservation and a lower degree of reliability.

Previously to run the Cluster Analysis, I realized a Bivariate Correlation with Pearson method. The results showed that neither positive nor negative strong-correlations are present among the observed variables, which is a favourable condition to develop good clusters (Sambandam 2003). I observed only the presence of a negative correlation (at 0.05 level) between the variable MIN and HUN, however all the other variable show no correlations (Tab. 7.11, Annex I).

After that I run a Hierarchical Cluster Analysis test with the Nearest Neighbour or Single Linkage method (for further details on the selection of this statistic test see cap. 2, par. 2.2.6.). The coefficients and the stage of the clustering are reported in the Agglomeration

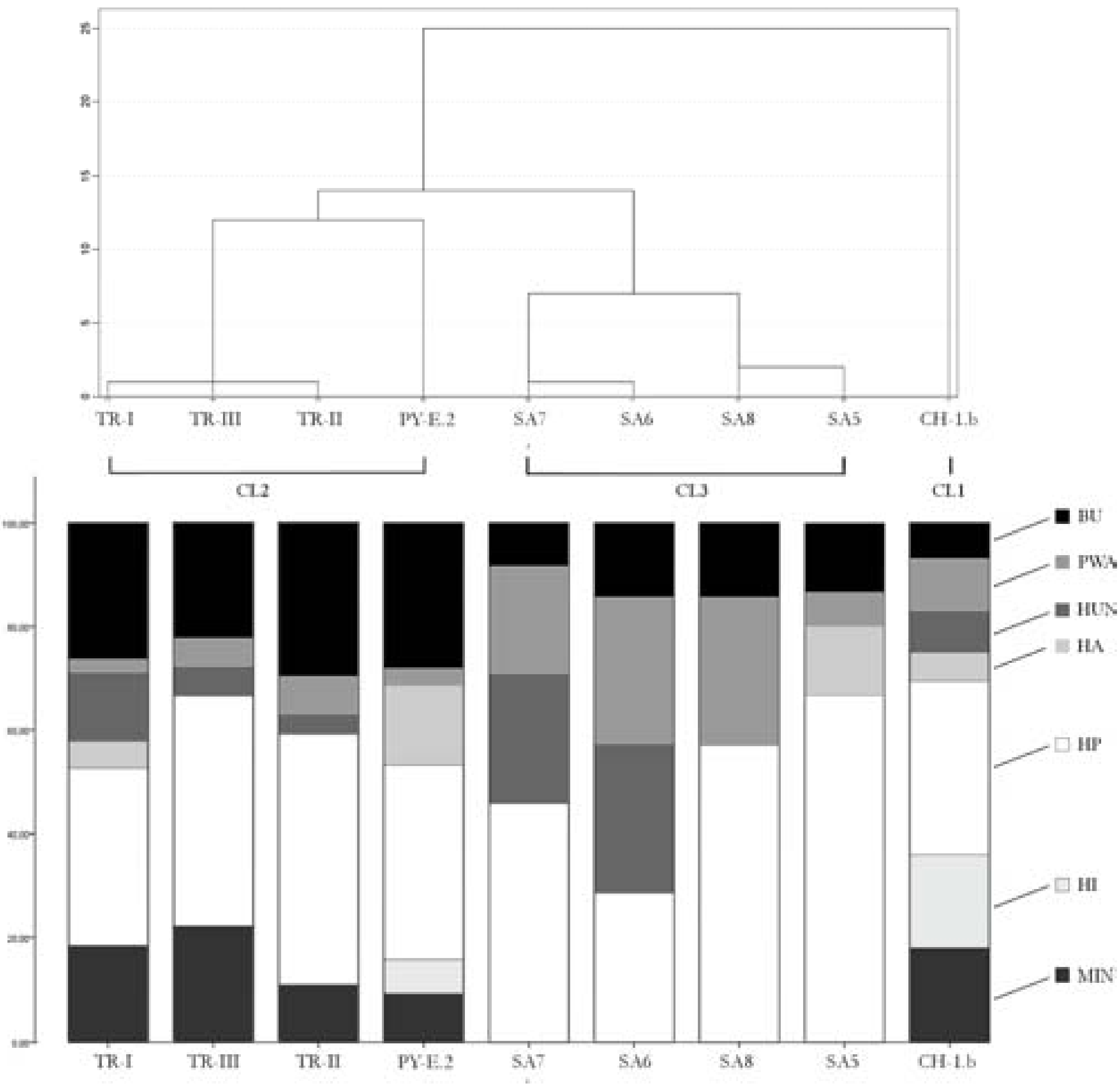

Fig. 7.6. *Above*: Dendrogram using the Single Linkage method (Nearest Neighbour). Rescaled Square Euclidean distance. *TR-I*: Trocs-II; *TR-II*; Trocs2; *TR-III*: Trocs3; *PY-E.2*: Puyascada, level E.2; *SA-6*: Sardo6; *SA-8*: Sardo8; *SA-5*: Sardo5; *CH-1.b*: Chaves, level 1.b. The three cluster are also indicated: CL1, CL3 and CL3. *Below*: Histogram reporting the percentage of each variable for each site/phase. *BUT*: Butchering Activities; *PWC*: Plant-Wood Crafting Activities; *HUN*: Hunting activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

schedule (Tab. 7.13, Annex I). The first aggrupation includes all the Trocs phases; the smallest coefficient of dissimilarity is expressed between Trocs1 and Trocs3 (step 1), followed by the coefficient between Trocs2 and Trocs3 (step 2). These three phases are later clustered with the Puyascada level E.2 (step 5), even if with an higher coefficient of dissimilarity. The second aggrupation is composed by the four Sardo phases. Among them the first cluster is represented by Sardo7 and Sardo6 (step 3), that later is clustered with Sardo5 (step 4). The last phase to be clustered is Sardo8. However this latter aggregation also shows a wider margin of dissimilarity. Finally, the Cueva de Chaves is clustered in the last step with Trocs1 phase. Looking at the distances at which the objects are combined, one can see that the last two steps of aggregation (step 7 and 8) occur at greater distance from the previous, suggesting that the best solution is three a clusters solution (Tab. 7.13, Annex I).

This pattern appears clearer if one looks the dendrogram that resumed graphically the three clusters described (Fig. 7.6). Here, one can appreciate how the Cueva de Chaves form an isolated single-item cluster, being much more different from the other members. In this case the Cueva de Chaves acts like an outlier, a case which deviates much from the other observations. The other two clusters, even if they show some internal differences between phases/sites, can be retained as separated and quite homogeneous.

The mains observation that one can draw from this preliminary analysis are:

i. the multiple occupations of a same site always show less dissimilarity between themselves than not in respect to the other contexts. This indicates certain continuity in the functionality of a same site. This is evident between the Trocs and Puyascada, but also between the various Sardo occupations and the other sites;

ii. sites located in different environmental/geographical settings clearly belong to different clusters: Pyrenean, pre-Pyrenean and Ebro Valley (i.e. Sierras Exteriores) occupations.

However, this first analysis mainly had an exploratory function. Now, that the main clusters has been identified, I decided to run a second Hierarchical Clustering test to prove the consistency of such clusters, this time using the Ward method (Baxter 2003). To avoid the presence of outliers and to enlarge the sample, I added to the analysis three more reference sites for the period in study that presented published, available, traceological data (also see Tab. 7.23, Annex I). All those sites are located in the NE of the Iberia Peninsula and show chronologies comparable with the sites analysed in the work (the chronological framework will be analysed in detail in the next paragraphs, *cfr.* Chap. 7, par. 7.3):

i. La Draga (Banyoles, Girona) (*ca.* 170 m.a.s.l.) - This site is a reference site for the Early Neolithic of the NE of the Iberian Peninsula (sixth-fifth millennium cal BC) (Bosch et al. 2010, 2011). It is a large open-air site located on the shores of lake Banyoles. The site is still under excavation, however large sectors of the settlement have been already investigated. Traceological data has been taken from Gibaja (2000) and Gibaja (2011).

ii. Sant Pau del Camp (Barcelona, Barcelona) (*ca.* 10 m.a.s.l.) - This is another reference site for the Early to Neolithic (Molist et al. 2008). It is a large open-air site with several phases of occupations. The main habitat is dated to an advanced stage of Early Neolithic (fifth millennium cal BC). Traceological data has been taken from Gibaja (1999, 2008) and Borrell & Gibaja (2011).

iii. Ca N'Isach (Palau-saverdera, Girona) (*ca.* 100 m.a.s.l.) - This is one of the few open-air sites dated to Middle Neolithic in the NE of the Iberian Peninsula (fourth millennium cal BC) (Tarrus et al. 1992). It is characterized by several domestic structures. Traceological data has been taken by Gibaja (2005).

Previously to the analysis, I run once again a Bivariate Correlation with Pearson method, to prove if there are any strong positive or negative correlations between the analysed variables. The matrix indicates that no significant correlations are present (Tab. 7.14, Annex, I). Thus, I proceeded with Hierarchical Cluster analysis, employing the Ward method (for further details on the selection of this statistic test see cap. 2, par. 2.2.6.).

The Agglomeration schedule (Table 7.16, Annex I) provides a solution for every possible number of clusters from 1 to 11 (the number of the cases for this test). The first three

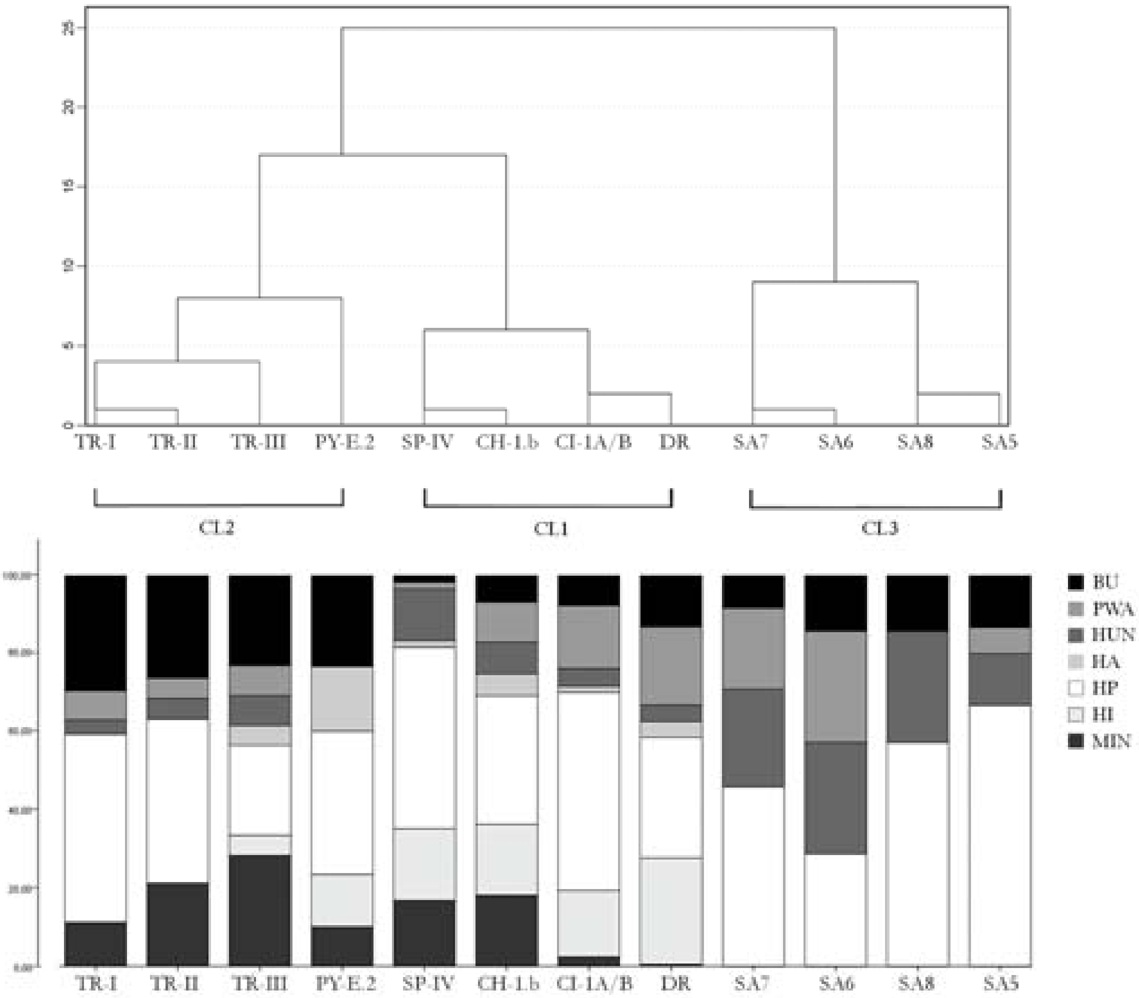

Fig. 7.7. *Above*: Dendrogram using the Ward Method. Rescaled Square Euclidean distance. *TR-I*: Trocs-II; *TR-II*; Trocs2; *TR-III*: Trocs3; *PY-E.2*: Puyascada E.2; *SP-IV*: Sant Pau del Camp, level IV; *CH-1.b*: Chaves1.b; *CI-IA/B*: Ca N'Isach level IA/B; *DR*: La Draga; *SA-7*: Sardo7; *SA-6*: Sardo6; *SA-8*: Sardo8; *SA-5*: Sardo5. The three cluster are also indicated: CL1, CL3 and CL3. *Below*: Histogram reporting the percentage of each variable for each site/phase: *BUT*: Butchering Activities; *PWC*: Plant-Wood Crafting Activities; *HUN*: Hunting activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

clusters are already formed during the first three steps. The first objects to merge together are Trocs II and Trocs III phases (stage1), followed by Sardo7 and Sardo6 (stage2) and by Sant Pau del Camp and Cueva de Chaves (stage3). At the stage 9 all the three clusters are fully merged, but still separated from each other. From this is point onward the combination of an additional object occurs at greater distances, as one can appreciate from the scree plot (Fig. 7.16, Annex I). In this case the break appears clearer in respect to the previous test probably as a consequence of the mayor number of cases. Moreover, the Ward method itself tends to create relatively small numbers of clusters of a similar size.

If one looks to the dendrogram (Fig. 7.7) one can appreciate how the three cluster are clearly separated in the plot, merging together only at greater distances. In this test the first cluster is represented by the low-altitudes sites (CL1 - Cueva de Chaves; La Draga; Sant Pau del Camp; Ca N'Isach), the second by the mountain sites (CL2 - Cova de Els Trocs and La

Puyascada) and the third by the sub-alpine occupations (CL3 - Cova del Sardo). This aggrupation is extremely significant for this case study. Indeed, considering that all the selected variables represent categories of economic activities, the fact that the groups are separated along an altitudinal factor is telling that this factor —altitude— has a great influence in the development and organization of the subsistence and productive processes. Substantially, one can say that as altitude increases, the economic processes in which lithic resources are involved suffer a reduction and/or rarefaction. This explication maybe appears obvious, as it has been already pointed out that with the increasing of the altitude, increase also the distance from the sources of good-quality chert materials. However, as I already stated above, it is not only a matter of distance and resource availability, but all these results had to be interpret as result of a determined economic organization.

To further explore these results I run a one-way ANOVA test that allows calculating the clusters centroids and to compare their differences formally. Indeed, looking at the means of each variable for the three clusters it appears to be some major differences (Table 7.17, Annex I). The one-way ANOVA test serves to prove whether such differences are statistically are significant or not. The results indicate that there are variables that significantly differentiate between the three clusters (Table 7.18, Annex I). Such differences are represented in the ANOVA table through the 'Mean squares' values inter- and intra-groups, the F values and the relative significance levels. The results indicate that «Butchering activities», «Hunting activities» and «Hide working activities» are the most significant variables, with a mayor inter-groups variation. To determine where exactly the differences lie, I run a Tukey post-hoc test, which allow looking at the data for patterns that were not specified a priori (Tab. 7.19, Annex I). The Tukey test reveals that:

i. butchering activities are specifically relevant at the mountain sites (CL2) in respect to other two clusters (CL1 and 3);

ii. hunting activities significantly characterize high-altitude occupations (CL3);

iii. hide working processes are specific of lower altitudes occupations (CL1), while are absent or insignificant in the other two clusters;

iv. activities related to the work of mineral substances characterized mountain sites (CL2) in respect to high-altitude occupations (CL3), but not respect to the first cluster.

At this point the final step of the analysis is to confirm the aggrupation obtained through *k-means* procedure. This is a standard procedure called 'three-step clustering" (*cfr.* Chap. 2, par. 2.2.3.). To do this I employed the centroids already obtained from previous analysis (one -way ANOVA) as input for the *k-means*. This method generates the initial and final cluster centres to prove if there a new partitioning of objects into the three clusters in respect to the Ward method, previously employed. The result of the analysis indicates that initial and final centroids are identical (Tab. 7.20 and 7.21, Annex I). This means that was not possible to reduce the overall within-cluster variation by re-assigning objects to different clusters. In other words, the fact that two different clustering methods yield the same outcomes provides additional evidences of the clusters' stability. In sum, the application of cluster analysis for the processing of use-wear data has been an appropriate method, useful to explore and explicate the assemblage variability. Without the employment of hierarchical and portioning methods it would have been difficult to detect such differences and to describe statistically which factors (or activities) had a mayor influence in differentiating the economic orientation of the analysed occupations.

7.2.2. Confirming the Clusters: Integrating Use-Wear Data with Other Artefactual and Archaeological Categories

After the agglomeration of the various occupations in three different clusters has been ascertained and established, the next and last step of this analysis is the inclusion of other archaeological elements, which can generate additional information about the economic orientation of each of the investigated sites. The main aim of this step is to prove whether the traceological analysis of lithic assemblages has a general validity as economic indicator or not, namely, if it is able to differentiate and characterize the economic orientation of such settlements properly. In this respect, one would not expect the presence of great changes in the resulting dendrogram as the classification based on traceological data should be already capable of distinguishing different site typologies. However, the embedding of new data from other artefacts or material records can help with the understanding of the differences between sites and occupations, revealing the existence of further discriminating factors.

The best option appears to be the comparison of variables with a strong economic significance with one another; for example, by comparing the frequency of macro-botanical remains, especially edible plants, or the presence of ware of diverse shape and function (e.g. cooking pots, storing vessels, etc.). However, in this case, such data is not available for all of the studied sites, because of gaps in the archaeological record or because materials processing is still underway. For example, at Cueva de Chaves, archaeobotanical remains have only partially been gathered since only dry-sieving took place on site. No charred grains or seeds have been collected, except for some hazelnuts recovered from a single pit (Zapata el al. 2003). It is therefore impossible to make a comparison between Cueva de Chaves and the other sites.

Similarly, about the ceramic record, published data is still largely incomplete. The data of ceramic ware's maximum diameters is available only for Sant Pau del Camp (Gómez et al. 2008), La Draga (Bosch et al. 2000; 2011), La Puyascada, and Cueva de Chaves (Ramón 2006), whilst the relevant studies of the assemblages from Els Trocs, Sardo, and Ca N'Isach are still in progress. Moreover, I had to exclude Ca N'Isach from the analysis as faunal materials have not survived at the site and, thus, is not comparable with the other contexts.

In conclusion, considering the available data, I have selected some general categories based on the frequency of certain classes of artefacts or remains (see Tab. 7.23, Annex I). A more detailed study will hopefully be carried out in the future, when the analysis of the material record of the various site will be completed.

i. Artefact Record: artefacts have been recorded in five general categories, according to the overall frequency for each occupation phase:

⇒ LIT: total number of flaked lithic items recovered from each occupational phase;

⇒ CER: total number of ceramic fragments recovered from each occupational phase;

⇒ MO: total number of macrolithic tools (mills, millstones, grindstones, etc.) recovered from each occupational phase;

⇒ POL: total number of polished tools (axes, adzes, etc.) recovered from each occupational phase;

⇒ AD: total number of ornamental artefacts (beads, rings, pendants, etc.) recovered from each occupational phase;

i. Faunal data: remains have been divided into four main categories based on their taxonomic attribution; I have considered the relevant percentages of each species for each occupational phase. In this case, I decided to work with percentages as it (partially) allows representation and conservation issues to be avoided:

⇒ OV: percentage of remains attributed to domestic ovicaprids (*Ovis aries*/*Capra hircus*);

⇒ BO: percentage of remains attributed to domestic cattle (*Bos taurus*);

⇒ SU: percentage of remains attributed to domestic suids (*Sus domesticus*);

⇒ UN: percentage of remains attributed to wild ungulates (*Cervus elaphus; Capra pyrenaica; Capreolus capreolus; Bos primigenius; Equus ferus; Sus ferus*)

The count of artefacts is useful for establishing the size and stability of a specific occupation. Larger and more stable occupations are expected to show a more various and richer artefact assemblage, while short, episodic occupations would presumably be characterized by less and more specialized artefactual records. On the other hand, an evaluation of the faunal remains collected at each site offers direct information about the type of pastoral strategy adopted at that place.

Before carrying out the test, I standardized all values in order to obtain homogeneous variables. Indeed, some categories are represented by frequency and not by percentage as instead occurs in other cases (Tab. 7.22, Annex I).

The result of the Hierarchical Cluster Analysis with Ward's method indicates the same agglomerations as in the previous test, with a three-cluster solution that clearly separates them from one other (Tab. 7.25, Annex I). Sardo Phases still form a specific cluster; Trocs and Puyascada merge together, while Cueva de Chaves is grouped with the other open-air sites, Sant Pau del Camp and La Draga (Fig. 7.8). By comparing these results with the previous test, one can see that there are only minor differences about the order in which the various elements merge together, while the general clustering dynamics remain unvaried.

In order to ascertain how the new variables contribute to the cluster solution, I applied a one-way ANOVA Test (Tab. 7.26, Annex I). About the new variables, I observed that «Macrolithic tools - MO», «Ornaments - AD», «Polished tools - PO», «Sheep/Goat - OV», and «Suids - SU» show significant values for the *F* coefficient, while «Lithics - LIT», «Ceramics - CER», and «Wild Ungulates - UN» seem less important.

By implementing a Tukey Post-Hoc, it is possible to appreciate how these variables contribute to each cluster (7.27a-b, Annex I). One can remark some main aspects that basically confirm the previous observations:

i. the presence of larger assemblages of macrolithic and polished tools is a characteristic of low-altitude sites (CL1), whereas they are scarcely represented in the other two categories;

ii. the same is true for ornaments, which are way more abundant in low-altitude sites (CL1), especially compared with high-altitude occupations (CL3);

iii. on the contrary, it is interesting to note that the presence of a larger assemblage of

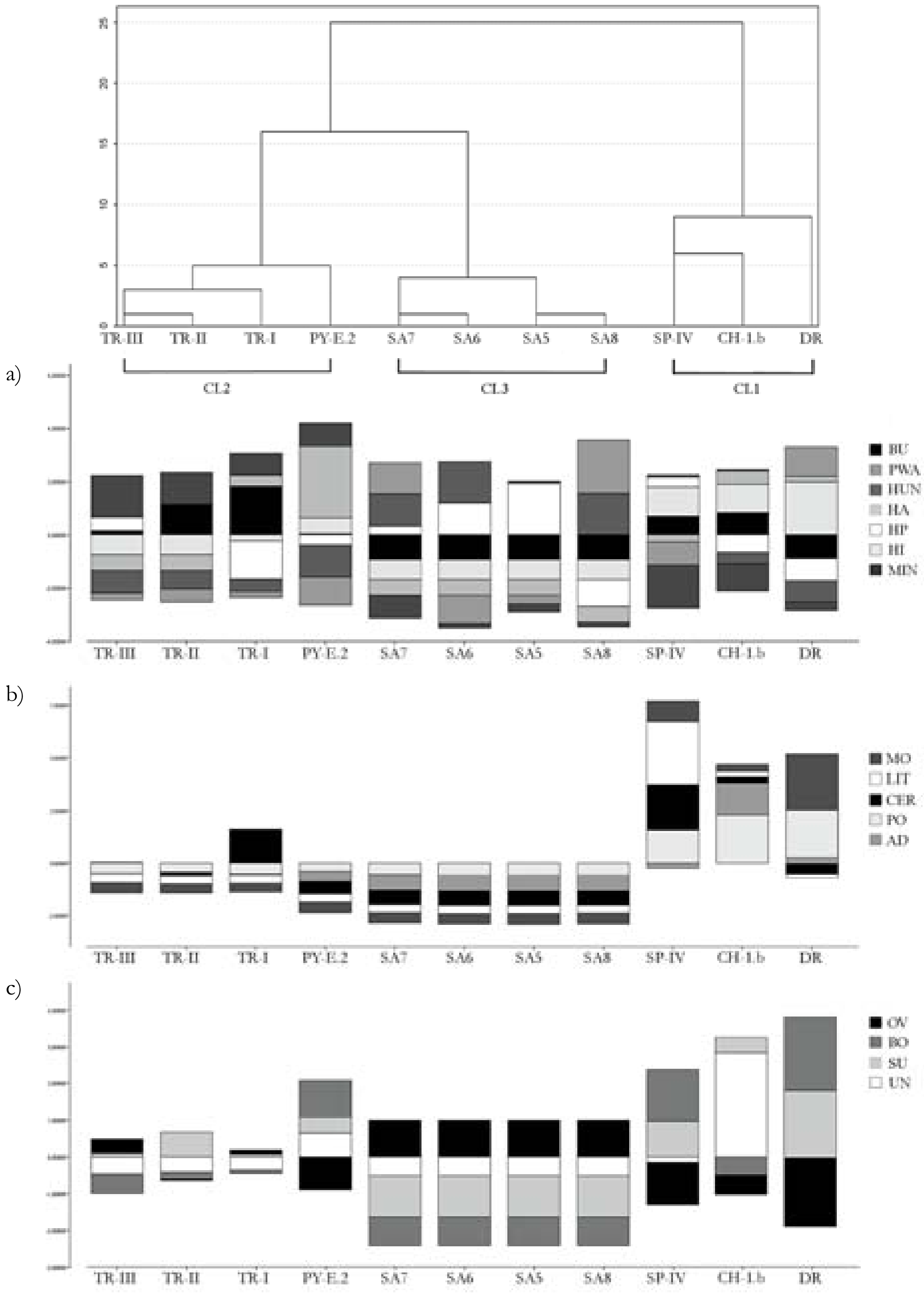

Fig. 7.8. *Above*: Dendrogram using the Ward Method. Rescaled Square Euclidean distance. *TR-III*: Trocs3; *TR-II*; Trocs2; *TR-I*: Trocs-II; *PY-E.2*: Puyascada E.2; *SA-7*: Sardo7; *SA-6*: Sardo6; *SA-5*: Sardo5; *SA-8*: Sardo8; *SP-IV*: Sant Pau del Camp, level IV; *CH-1.b*: Chaves1.b; *DR*: La Draga. The three cluster are also indicated: CL1, CL3 and CL3. *Below*: Histograms reporting the typified values of each variable for each site/phase: *a*) *BUT*: Butchering Activities; *PWC*: Plant-Wood Crafting Activities; *HUN*: Hunting activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances; *b*) *MO*: macrolithic tools; *LIT*: Chipped stone assemblage; *CER*: ceramic assemblage; *PO*: Polished tools; *AD*: ornaments; *c*) *OV*: Sheep/Goat; BO: Cattle; *SU*: Suids; *UN*: Wild Ungulates.

ceramic and lithic materials is not highly distinctive (probably given the high disproportion between assemblages);

iv. about faunal remains, one can see that the presence of specialized flocks consisting exclusively of sheep/goat species is a characteristic of high-altitude occupations (CL 3);

v. the presence of higher percentages of cattle and suids is a distinctive characteristic of low-altitude sites (CL 1);

In conclusion, it is extremely remarkable that, also adding new variables, the agglomerations do not undergo any change. The range of functions reconstructed by the traceological analysis has brought to propose a coherent and sound evaluation of sites' economic orientation. Even if it is necessary to include more sites and analyses in the studied sample, the model that results from this work can be considered a valid and statistically significant one.

On the basis of traceological and archaeological data, it has been possible to distinguish three main categories of sites arranged by altitude: «low-altitude occupations», «mountain occupations», and «high-altitude occupations». These three clusters differ from one another in terms of production organization. In other words, even though one can appreciate such differentiation on a geographical axis —that is altitude— the discriminating factor is a social one, namely, production. Actually, as altitude increases, one can notice a reduction in or drop of the economic processes in which lithic resources were involved. At the same time, one can observe a specialization towards a specific production activity, that is, pastoral practices and, more specifically, ovicaprid breeding (see Fig. 7.9 for a schematic representation of the results).

I am aware that this classification represents only a schematic approximation of the archaeological situation and that such schemes should not be considered too narrowly. This is only a way of arranging the archaeological data, which aims at finding an interpretive key that might bring to create new models and raise new questions for further investigations. Actually, social behaviours rarely follow such inflexible and schematic rules, being more complex and continuously changing through time, often in a subtle way, which is hard to detect from an archaeological point of view. However, the aim of cluster analysis is not to produce everlasting models, but to manage and reduce archaeological variability according to statistical significance.

In conclusion, the difference between the analysed sites/occupations can be summarized as follows:

i. Lower-altitude occupations: these sites were characterized by a diversified mixed economy, in which both pastoral and agricultural processes covered an essential role; production was diversified and focused on the exploitation of different species (both animal and vegetable). Production processes were directed towards obtaining not only food resources, but also a broad range of artefacts. As a consequence, the archaeological record is abundant and various. From a traceological point of view, I have ascertained the presence of a large variety of working activities. Such activities were not isolated, but integrated within structured production processes, which were composed of a high number of different working phases carried out with different instruments. Although it has not always been possible to reconstruct in detail the entire production cycle (since other raw materials were probably used as production implements, apart from chipped stone tools), at least it is possible to realize the existence of a certain complexity and structuration of the economic processes that were carried out. This is true, for example, for all working activities related to the exploitation of animal resources: from the slaughter of animals and processing of their carcasses to the working of derived raw materials such like skin and bone/antler, as well as the use of these for making a variety of artefacts (leather objects, bone/antler tools, ornaments, etc.). Hunting activities are also documented, although they account for a marginal role.

ii. Mountain occupations: these were characterized by a more specialized economic orientation focused on the exploitation of domesticated-animal resources, with a specialization towards sheep/goat species (this pattern is not completely true for the Espluga de la Puyascada; however, is to remark that the Puyascada faunal assemblage is constituted by a scarce number of remains and, therefore, it is not highly indicative of the site's faunal diversity). The faunal record always indicates that the slaughter of young individuals had an important role in those contexts. This is confirmed by the traceological analysis that attests to statistically significant percentages of butchering activities. The rest of the working processes ascertained by the analysis of the lithic assemblage appear to have been more discontinuous, being mainly associated with the repair of specific types of artefacts (mainly ceramic vessels and, to a lesser extent, bone/antler tools), or with the maintenance of the domestic space. The archaeological record is various but not very abundant: only animal and ceramic assemblages are well represented, whilst lithic, macrolithic, bone, and polished tools are scarce. Agricultural activities were not probably practised in the surroundings of the site and cereals were only consumed at the settlement, not produced.

iii. High-altitude occupations: these occupations are characterized by a very poor archaeological record. They are mainly interpreted as occasional shelters, specialized in the exploitation of subalpine and alpine pastures, in relation to sheep/goat breeding. Evidence of production processes is almost absent other than sporadic consumption of domestic animals and, probably, wild game (according to the presence of hunting weapons). Hunting was practised indeed; however, it did not represent any intensive or specialized activity. The rest of the processes detected by traceology account for sporadic works relevant to artefacts resharpening and domestic-space maintenance. The on-site consumption of cereals is attested, but at low percentages. No clear indicators of local cultivation or wheat processing have been noticed, this suggesting that agricultural products were transported as food resources from other areas.

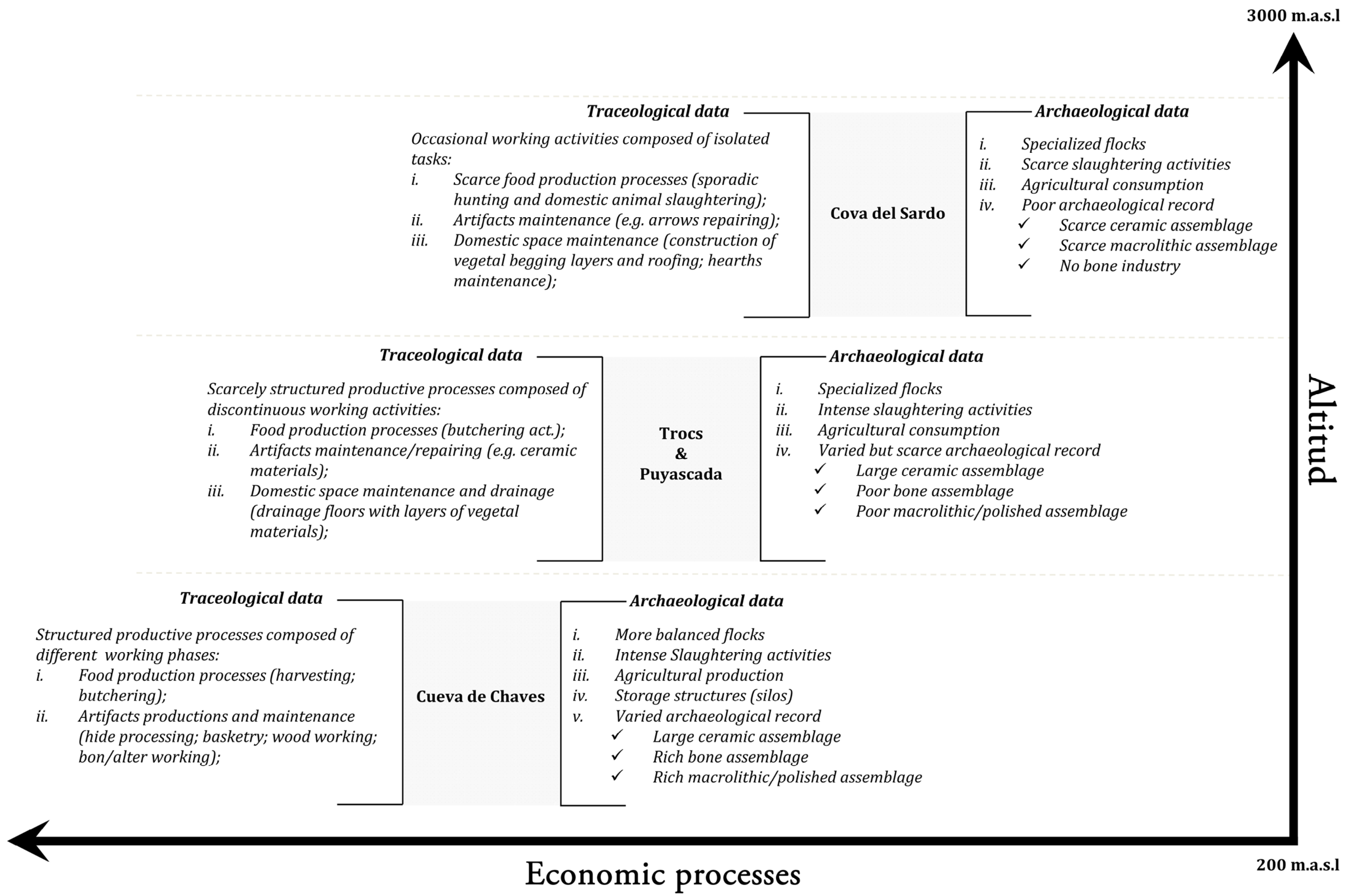

Fig. 7.9. Schematic representation of the variation of the economic processes in respect to the altitudinal factor.

7.2.3. Focusing on Some Production Activities in the Mountain Areas of the Southern Central Pyrenees

7.2.3.1. Agricultural Production or Agricultural-Product Consumption in Mountain Areas?

One of the most interesting questions for prehistoric research in the Central Pyrenees is whether agro-pastoral populations practised or not agricultural activities in mountain and high-mountain areas.

This kind of topic is traditionally a field of archaeobotanical and palaeobotanical studies —disciplines that deal with plant remains from prehistoric soils and archaeological deposits (macro-, micro-botanical and pollen remains.). Recent studies have contributed to this topic from several points of view, exploring data covering a wide chronological span.

Sedimentary- and pollen-analysis outcomes from peat bogs and lakes have demonstrated that, at least during the Middle Ages, cereal cultivation was intensively practised in the Catalan Pyrenees even at alpine altitudes (Ejarque et al. 2010; Pèlachs et al. 2009; Pérez-Obiol et al. 2012). Signs of cereal farming in sub-alpine zones, even though more occasionally and discontinuously, have also been recognized for earlier periods, for example, for the end of the Bronze Age-beginning of Iron Age, from *ca.* 1550 cal BC to 650 cal BC. However, a clear impact of cultivation activities in the valley bottoms has been recorded only from the Roman period, approximately starting in 150 cal BC-50 cal AD (Miras et al. 2007; Pèlachs et al. 2009; Bal et al. 2011; Catalan et al. 2013).

This palaeobotanical data indicates that agriculture in upland zones could have been a reliable and profitable production also in ancient times, especially by exploitation of cold-environment-resistant cereal species, with a short life cycle, such as *Secale cereale*. Nonetheless, it is important to contextualize this information within a broader social and historical context. The research projects carried out in the National Park of Aigüestortes i Estany de Sant Maurici over the last fifteen years have demonstrated that subalpine and alpine zones of the park were characterized by a strong demographic pressure during the Roman and medieval period, as archaeologically documented by the presence of several open-air sites of diverse size and function (Garcia 2014). These sites were characterized by a combination of house and corral structures that indicates the existence of a variety of social frameworks, for either a large population organized in developed villages (Garcia et al. 2013) or small groups forming more isolated and independent dispersed settlements (Garcia 2014).

On the contrary, for the Neolithic Age (sixth-third millennium cal BC), current palaeobotanical data points out a much more discontinuous and episodic occupation of mountain spaces, according to the plausibly much less population pressure compared with Roman and Medieval times. For that period, the presence of markers associated with agricultural practices is extremely exiguous, especially in high-altitude areas (above 1.700 m.a.s.l.), displaying very low percentages of *Cerealia*-type pollen and a few remains of charred grains from the excavated archaeological deposits (Gassiot et al. 2013, 2014). The analysis of samples taken from peat bogs and lakes basically confirms such a scenario: the presence of cereal pollen and charcoal is discontinuous and at relatively low percentages (Pèlachs et al. 2007; Miras et al. 2007; Ejarque et al. 2010; Gassiot et al. 2010a). A slight increase, correlated with drier climatic conditions and a decline in deciduous forests, can only be observed as from 3500 cal BC (Pèlachs et al. 2011); however, the interpretation of this phenomenon is still under discussion and a more detailed data is definitely required to prove the existence of small agricultural practices in mountain areas during the Final Neolithic/Chalcolithic period.

Moreover, although the analysis of human-induced transformations of mountain landscape represents a fundamental step for reconstructing the development of agricultural practices, these studies alone are not sufficient to ascertain whether cultivation was practised or not in mountain areas. Agriculture is a complex system, a mix of social structures, knowledge, know-hows, instruments, and technologies, which, together with the vegetable resources themselves, are required for developing a complete production process.

Recent investigations of several sites located in the NE of the Iberian Peninsula suggest that Neolithic people were experienced farmers, who practised a self-sufficient agriculture since the early stages after their arrival in the Iberian Peninsula (Antolín 2014). Data coming from the lacustrine site of La Draga —whose exceptionally preserved organic materials make it a reference place for the study of Neolithic economy— indicates that approximately 60% of population's food requirements were provided at that site by domesticated plants (Antolín & Buxo 2011; Antolín et al. 2014). Agriculture was neither an 'innovative' activity nor practised in a 'primitive' way, but it appears to have already been well-established; it was based on a variety of species, which were exploited through a system of one-crop permanent fields and by applying specialized knowledge and technologies.

Farming probably relied upon a communal effort, involving a large part of the site's population. Furthermore, it required an effort in terms of manpower and labour hours not only for the activity itself, but also for the construction, preparation, and maintenance of a variety of technologies for harvesting, trashing, processing, and storing products. Accordingly, it is not surprising that the main lithic productions during the Neolithic Age were oriented towards the very manufacturing of blade blanks, amongst which the most regular and elongated items were used for crop harvesting —some examples are the lithic assemblages coming from Early to Final Neolithic sites such as La Draga (Gibaja 2000 & 2011), Plansallosa (Palomo & Gibaja 2001), Sant Pau del Camp (Borrell & Gibaja 2012), Ca N'Isach (Gibaja 2005), and Cueva de Chaves itself (the latter dealt with in this volume, *cfr*. Chap. 4). One can hold that agricultural practices entailed a major commitment in terms of labour, besides specific means of production, and the use of a wide range of biotic and abiotic resources, since they were not a marginal or secondary economic activity, at least in Neolithic Western Mediterranean contexts.

All the same, if this scenario is quite clear for sites located in coastal and plain areas, the situation of mountain areas was almost unknown until recent times. In this respect, an important data comes from a series of rescue excavations carried out in Andorra.

The site of Feixa del Moro was excavated in 1983-1984. It lies at 1.335 m.a.s.l., about 450-550 m above the bottom of Vall del Gran Valira (the altitude of which is around 850 m.a.s.l.). This site attests to dwelling-places and cist burials (Llovera 1986). Within the huts, macrolithic tools related to cereal processing have been recovered. In addition, several ceramic containers were discovered with cereals and hazelnuts (*C. avellana*) (Fortó et al. in press).

Close to Feixa del Moro, at almost the same altitude (1.350 m.a.s.l.), two sites have recently been excavated, Camp del Colomer and Carrer Llinàs 28 (Fortó et al. 2009, in press). Camp del Colomer, in particular, is characterized by structures and material remains that clearly recall agricultural activities: probable storage structures (silos and pits), a great number of large storage vessels, and a correlated number of mills and macrolithic tools (Fig. 7.10). Both Feixa del Moro and Camp del Colomer are dated to the Middle Neolithic Age (second half of the fifth millennium cal BC) and interpreted as stable settlements, either periodically or seasonally occupied.

The archaeobotanical study of Camp del Colomer's assemblage (Antolín 2014) indicates

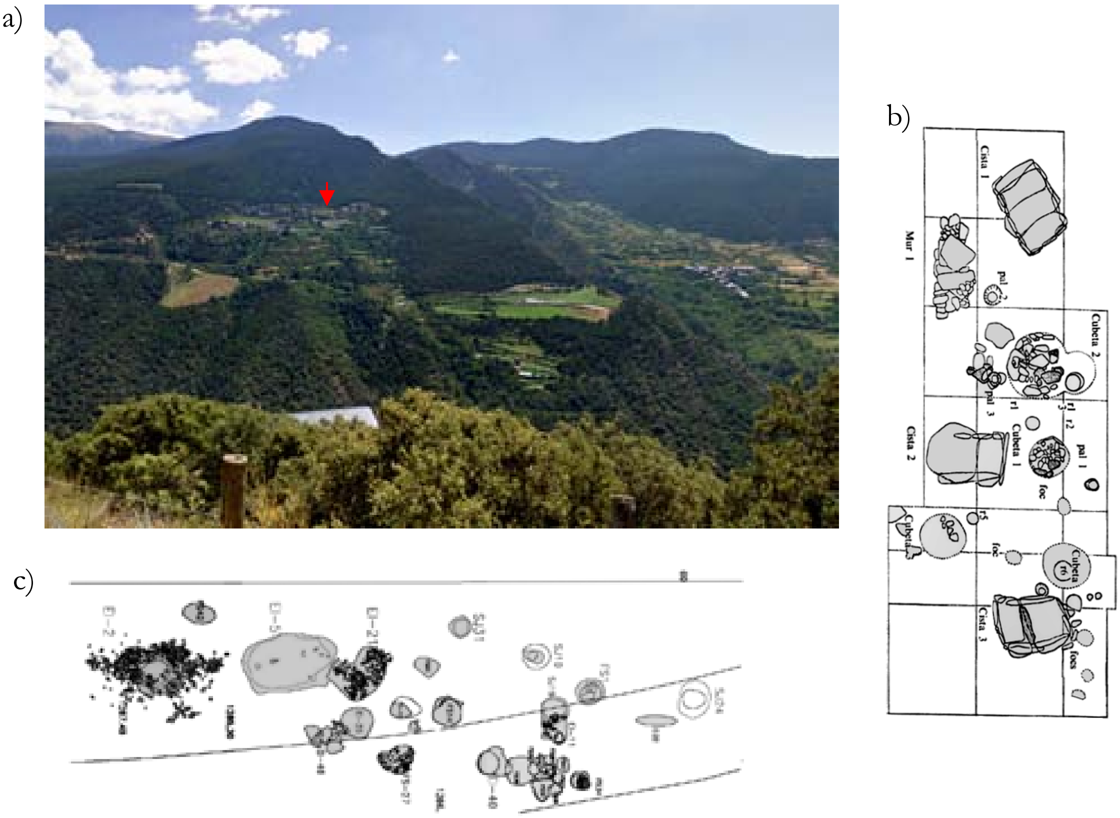

Fig. 7.10. Andorran Neolithic open-air sites. a) View of Juberri (Andorra) from de the Coll de Rep (photo taken form Google Maps): b) Feixa del Moro site plant, modified by Llovera (1985-86); c) Camp del Colomer site topography, modified by Fortó et al. (in press).

that permanent fields were likely maintained at the site, mostly for growing naked barley, which was probably sown in the autumn/winter-time.

All this data points out that agriculture took place in mountain areas at mid-altitudes, at least since the Middle Neolithic Age. Cultivation was practised intensively, with one-crop permanent fields and apparently differing little from farming carried out at lower altitudes. However, it is interesting to remark that such evidence is always associated with residential sites, which consisted in large open-air structures instead of caves or rock-shelters.

Actually, if one looks at the numerous cave sites of Neolithic period located in the mountain and subalpine areas of the Central Pyrenees (at 1.000-1.800 m.a.s.l., such as Balma Margineda, Espluga de la Puyascada, Cova de Els Trocs, or Cova del Sardo), it clearly appears that most of the elements composing such a 'scenario' are missing. There are no storage facilities, no signs of cereal processing, a scarce archaeobotanical record, and last but not least, a small lithic production, which could not meet any intensive harvesting activity.

Most of the Pyrenean cave sites show a pattern of discontinuous and episodic occupations, with a low standard of production processes and a relatively poor material culture, especially those sites located in the upper, sub-alpine and alpine, zones. They likely account for short frequentation by small human groups, mainly in relation to pastoral practices. In such situations, cultivation activities did not probably take place directly in the surroundings of the site, since the social and technical conditions necessary to agricultural activities were lacking.

At those sites, the sporadic presence of grains of domesticated cereals has often been explained as a result of transported processed seeds and not of local cultivation. This is, for example, the case with Balma Margineda (970 m.a.s.l, Andorra) (Marinval 1995) and Els Trocs Cave (1.564 m.a.s.l., Aragon-Ribagorza) (Rojo et al. 2014). The latter site, in particular, has recently been studied in detail by analysing plant macro- and micro-remains. The outcomes of phytolith analyses have demonstrated that, despite the fact that grains of cultivated cereals were encountered in the archaeological deposit, no secondary crop-processing activity took place on site. Therefore, the presence of wheat and barley grains is interpreted as a consequence of transporting provisions from permanent settlements as food supplement (Lancelotti et al. 2014). The same situation has been observed at higher altitudes too, as for example at Cova del Sardo, where only two cereal seeds (Gassiot et al. 2014) and sporadic phytoliths of domestic cereals (Catalan et al. 2013) have been recovered. As well, in the Alps, at the Aulp du Seuil rock-shelter —Middle Neolithic levels— few cereal caryopses have been recovered on-site probably brought from lower altitude, revealing the same be behaviour (Martin et al. 2012).

Amongst the lithic assemblages of those sites, a few sickle elements have been identified during my research. However, the sporadic presence of sickle-blades in Neolithic contexts where agricultural production was absent is no news. Gassin (1991) recorded sickle blades from the Chassey of Grotte de l'Église supérieure in southern France (fifth-fourth millennium cal BC), whereto blades on heated chert were carried after having been used as part of sickles far away from the site, being then reused at the cave for working dry hide. Moreover, the cave is situated in a geographical and geological context that was not very suitable for agricultural activities. The same behaviour has been observed at Cova del Frare, in Catalonia, where several sickle blades have been recovered from the context of an occupation specialized in animal husbandry (Martín & Tarrus 1995; Gibaja 2002). All this data indicates that sickle blades were highly movable tools, likely to be transported, retooled, and discarded even far away from their production site.

The sample here analysed always shows a small number of sickle blades, the interpretation of which is also often controversial. At Els Trocs Cave, no clear sickle blades have been recognized; the majority of blade used for cutting vegetable substances appear to have been associated with plant harvesting for non-food purposes. The size of the polish is always limited, indicating a short-lasting harvesting activity. Moreover, the distributional and textural patterns of wear differ from the canonical 'cereal polishing'. At Espluga de la Puyascada, one can observe almost the same situation. Only one implement appears to have been used for reaping cereals; however, it shows resharpened and retooled elements and was probably taken to the site after many uses. The situation observed at Cova del Sardo is also similar. Few sickle blades have been found amongst the lithic assemblage. One of them may show a reuse for cutting soft materials (possibly animal materials) (*cfr.* Chap. 6, Par. 6.4.2.1.). This type of behaviour (retooling of sickle implements) has been ascertained in numerous sites of the Iberian Peninsula (Gibaja 2009). The other elements are completely burnt and cracked as they were discarded in a fireplace, possibly after having been removed from the handle and replaced with new blanks. A relatively high number of elements have been identified only in Sardo 5 Phase, which goes back to between 2900 and 2500 cal BC. In this context, sickle elements reach 20% of the used tools, with at least three elements that are characterized by a very shiny surface. However, also in this case, tools like sickle inserts do not appear to have been used on site, but far away from Cova del Sardo. In addition, the instruments were intensively resharpened, retooled, and reused for other tasks not related to crop harvesting.

In conclusion, one can assume that the presence of sickle blades is not a marker *per se* of cultivation practices. They suggest that the populations who occupied the Central Pyrenees engaged in agriculture and integrated it within their economy, but it is more likely that cultivated fields were situated near large, open-air settlements, at low- or mid-altitudes. On the contrary, the sub-alpine and alpine zones of the Axial Pyrenees appear to have been frequented only episodically during the Neolithic Age, mainly in relation to animal husbandry and pasture exploitation. It was only at the beginning of the third millennium cal BC that occupations over these areas increased to a certain extent, as inferred from a higher number of documented sites, both caves and open-air structures (although still rare) (Gassiot et al. 2010b). Future studies might ascertain whether this colonization of the alpine zones during the Chalcolithic Age was connected with an expansion of agricultural practices in the high-altitude areas (> 1.600-1.700 m.a.s.l.), whilst, at the moment, data is too fragmentary to support such a hypothesis.

7.2.3.2. Hunting in the Pyrenees during the Neolithic Age: Specialized or Sunday Hunters?

Hunting is one of the activities which are traditionally associated with mountain environments, especially for prehistoric times. Indeed, from the end of the last Ice Age, the occupation of high-altitude areas appears to have been a generalized phenomenon in most of the European mountains, specifically in relation to hunting activities.

On the Alps, for example, the presence of hunter-gatherer groups in the alpine and subalpine zones is clearly attested to by a high number of sites (Bagolini and Dalmieri 1987; Crotti & Pignat 1992; Fedele & Wick 1996; Crotti 1998; Fontana & Guerreschi 2003; Grimaldi & Flor 2009; Bintz & Griggo 2011). Both archaeozoological data (when preserved) and technological management of lithic production indicate a specialization in seasonal hunting practices at high altitudes.

However, as pointed out in a previous chapter (*cfr.* Chap. 1, Par. 1.3.2.), the central and eastern Pyrenees represent a sort of exception compared to the other European mountain ranges, such as the Alps or Caucasus, since high-altitude areas were almost uninhabited until the Neolithic period. In fact, in the NE of the Iberian Peninsula, Mesolithic occupations mainly took place in the outer ranges of the pre-Pyrenees, without penetrating the inner areas, apart from a few exceptions. Amongst them, the best known site is undoubtedly Balma Margineda, which is located in Andorra at 970 m.a.s.l., close to the bottom of the Gran Valira Valley, with an array of contexts dated to between the twelfth and the ninth millennium BC. There, a specialized hunting of alpine ibex has been ascertained, along with an abundant assemblage of microlithic tools with impact marks (Philibert 1999).

More recently, at higher altitudes, the site of Abric del Estany de la Coveta has been excavated, namely, a small rock-shelter situated at 2.433 m.a.s.l., with an episodic occupation going back to the seventh millennium cal BC (Gassiot et al. 2014). However, in this case, the function of the site is not clear at all. There is almost no evidence of hunting practices and only a small flake with butchering marks has been found. It probably accounts for a very short occupation, which likely used the cave as an overnight shelter.

All this data just emphasizes current research's poor knowledge of the occupation of mountain areas in the Central Pyrenees during the Final Palaeolithic-Early Holocene period. There are no traces of human pressure on the mountain environment —apart from some controversial palaeoecological outcomes (Riera & Turu 2011)— and archaeological evidence of hunting in mountain regions is poor, almost absent.

SITES	*Cervus elaphus*		*Capreolus Capreolus*		*Equus ferus*		*Capra Pyreneaica*		*Rubicapra Rubicapra*		*Sus scrofa*		*Bos Primigenius*	
CH 1b	664	8,1	58	0,7	7	0,1	123	1,5	-	-	108	1,3	7	0,1
CH 1a	393	8,4	29	0,8	5	0,1	55	1,2	-	-	46	1	5	0,1
TR 1	6	0,6	2	0,9	-	-	-		-	-	?	?	-	-
TR 2	3	0,3	-	-	-	-	-	-	-	-	?	?	-	-
TR 3	8	0,5	-	-	-	-	-	-	-	-	?	?	-	-
PUY E.II	13	4,2	4	1,3	-	-	-	-	-	-	-	-	-	-
BM C.3	17	?	-	-	-	-	-	-	-	-	?	?	?	?
FO V	222	83,4	17	6,4	-	-	-	-	3	1,1	15	5,6	2	0,7
FO VI	56	52,8	10	9,4	3	2,8	2	1,8	6	5,7	2	1,8	1	0,9
FO VII	3	10	-	-	-	-	-	-	-	-	10	33,3	-	-
DOU C.6	23	3,4	25	3,7	-	-	53	7,9	-	-	52	7,8	15	2,2
DOU C.5	22	2,1	27	2,6	-	-	24	2,3	-	-	65	6,3	41	4,0
ABJ C.2a	106	13,9	38	5,0	1	0,2	?	-	-	-	?	-	?	-
ABJ C.2b	135	14,4	51	5,4	-	-	?	-	-	-	?	-	?	-
ABJ C.2c	54	19,2	17	6,7	-	-	?	-	-	-	?	-	?	-

Tab. 7.2. Remains of wild ungulates in some of the main Neolithic occupations of the Central Pyrenees. Number correspond to the Number of Determinate Remains. Percentages have been calculated on the totality of faunal remains for each site (when reported by the authors). "?" is indicated when the number of determinate remains is not clearly reported from the author, but the presence of the animal is attested anyway. CH 1b-1a: Cueva de Chaves (Castaños 2004); TR 1-3: Cova de Els Trocs (Rojo et al. 2014); PUY E.II: Espluga de la Puyascada (Castaños 1987); BM C.3: Balma Margineda (Geddes 1995); FO V-VII: Forcas II (Utrilla et al. 2009). DOU C.5-C.6: Roc du Dourgne (Geddes 1993); ABJ C.2(a-c): Abri Jean-Cros (Poulain 1979) The Cova del Sardo is excluded from this table as no remains of wild species have been recognized among the assemblage.

A more continuous occupation of Central Pyrenees' subalpine and alpine areas has been ascertained only from the fifth millennium cal BC, which gradually increased until the end of the third millennium cal BC. As seen in previous chapters, the human groups that inhabited the Pyrenees during this period mainly engaged in pastoral practices, which were part of a mixed economy that combined agriculture with a mobile system of animal husbandry. Nonetheless, some evidence of hunting practices has also emerged during this study. In particular, a strong association between hunting activities and high-altitude occupations has been pointed out by the Hierarchical Cluster Analysis described at Chap. 7, Par. 7.2.1. How may one interpret these results? Was hunting intensively practised in the mountain areas of the Pyrenees? If so, can one define any hunting strategy followed by these Neolithic populations?

The first element to consider while evaluating hunting practices during the Neolithic Period is certainly the archaeozoological record. Tab. 7.2 displays the percentages of wild-ungulate remains from some of the main Neolithic sites of the Central Pyrenees between the sixth and the third millennium cal BC.

In Northern Pyrenees, two sites have been considered, both located at mid-altitudes (*ca.* 600-700 m.a.s.l.) in the External ranges of the French Pyrenees: the Roc du Dourgne and Abri Jean Cros. In both sites wild ungulates represent relevant percentages, although clearly in minority in respect to domesticated ones: between 17-25% at the Roc du Dourgne (C.5-6) and between 19-26% at the Abri Jean Cros (C.2a-c). The former is characterized by a wide range of domestic species, among which the Iberian Ibex prevails; the latter appears focused toward red-deer and, in lesser extent, roe-deer hunting.

In Southern Pyrenees wild ungulates reaches at most 10-11% of the whole assemblage in most of the considered sites. The only exception are represented by the Level V and VI of the Forcas Rock-Shelter, in which red-deer represent the main hunted species, between the 50-80% of the assemblage. However, is to remember that the interpretation of Forcas II —Utrilla & Mazo 2007— is still debated and possibly both levels are documenting the occupation by hunter-gatherer groups and not by 'Neolithic' populations.

Leaving aside these considerations, it is nonetheless interesting to remark that the sites located at higher altitudes (e.g. Espluga de la Puyascada, Cova de Els Trocs) show lower percentages of hunted animals compared with occupations at lower elevations, namely in the outer Sierras of the Pyrenees (e.g. Cueva de Chaves, Forcas II, Abri Jean Cros and Roc du Dourgne). Here, the main hunted species were red deer and, to a lesser extent, roe deer and wild boar. However, red deer is the only species that is regularly documented in all sites, reaching considerable percentages at Cueva de Chaves and Abri Jean Cros (and obviously Forcas II). The presence of higher percentages of red deer at lower altitudes could be related to the seasonality of those occupations. Autumn-winter is the very season when cervid's fat accumulation is maximal; this argument has ben used to explicate why some hunter-gatherer populations often focused on deer hunting preferentially on winter ranges (Flueck & Smith-Flueck 2012). On the other hand, one can stress on more stable and larger sites being where the majority of craft activities took place, thus the presence of red deer can be associated with the supply of raw materials, such as antler, which were largely used for making tools, or deer-hide. Alternatively, the focus on the deer-hunting during Neolithic period has been explicated in terms of ideological or symbolic implications (see Whitehouse 1988-89; Vigne 2003; Mikhailova 2006).

Apart from these hypotheses that are at the moment hard to either prove or disprove, is important to remark that the general pattern of hunting practices seems to correspond to a secondary activity among Neolithic groups (thus excluding Forcas II), which was only occasionally practised whatever the purposes were —meat and fat procurement? Raw-materials procurement)? Food supplement? Ideological-symbolic reasons?

Moreover, this scenario seems to confirm that the mountain areas of the Pyrenees were scarcely exploited as hunting territories, and that most of the hunting practices took place at lower altitudes. This result appears in contrast with the outcome of the Hierarchical Cluster Analysis previously described (*cfr.* Chap. 7, Par. 7.2.1.). In such test, the association between hunting activities and high-altitude areas was mainly given by the traceological results obtained for the Cova del Sardo, which is the only site, among the studied contexts, located at high-altitudes. However, I would consider such a data with caution. In fact, the cluster analysis has detected an association between 'high-altitude occupations' and 'hunting activities' not because intensive hunting was practised at Cova del Sardo, but simply because the other economic processes carried out at the site were so scarce and discontinuous that the percentages of hunting reach considerable values. At Cova del Sardo, hunting was not practised more intensively than at Cueva de Chaves or Espluga de la Puyascada; quite the contrary, it is all other activities that are underrepresented.

The type of hunting practised at Cova del Sardo —as well as in the other mountain sites of the Pyrenees— follows a pattern of sporadic hunting, which were marginal compared to other economic sectors. The main purpose of this type of hunting was probably to provide some food supplements for the prehistoric group, who mostly engaged in breeding livestock by exploiting subalpine and alpine pastures. It was only occasionally and not systematically organized, in order to meet temporary needs and/or according to game availability. Therefore, it would be misleading to claim any relation between mountain areas and hunting activities in the Central Pyrenees during the Neolithic Age as little work was taken by both weapons production and game hunting.

Moreover, it is worth considering that in none of the mountain site analysed in this work we observed the presence of activities related to the processing of the animal 'non-meat' resources, such as hide and bone/antler materials. This seem to confirm that the exploitation of wild game was made exclusively to obtain occasional food supplements, while the remaining resources were not exploited. This type of materials appear exploited exclusively at lower altitudes, at more stable site, where a major variety of economic processes were carried out, with a major diversity of artefacts and tools.

Several authors in the past decades have claimed that the occupation of mountain spaces of the Pyrenees by agro-pastoral communities was a process that had its origins in the hunter -gatherers exploitation of mid- and high-altitude regions (Geddes 1983; Pallarés et al. 1997). For those, hunting represents a sort of unbroken tradition between the last Mesolithic and the first Neolithic groups. However, in the light of the most recent discoveries, such theory should be entirely dismissed.

Neolithic hunting camps and stopovers have been detected in the Western Mediterranean at both mid- (e.g. Grotte Lombard - Binder 1991) and high-altitudes (e.g. Aulp du Seuil rock-shelter - Bintz & Pelletier 2000), however this is not the case of the Pyrenees. Here, hunting activities seems mainly practiced at lower altitudes (and generally only marginally), while the mountains areas did not represent a privileged scenario for hunting, rather an occasional location. So far, this hypothesis is also confirmed by the absence of relevant surface collections of flaked artefacts from the archaeological surveys carried out in the Axial Pyrenees (contrarily on what happens in the Alps) and by the very scarce percentages of microlithic tools in high-altitude deposits.

7.3. Human Occupations of Mountain Environments: a Diachronic View

7.3.1. Establishing a Chronological Model for the Human Occupation of the Central Pyrenees between the Sixth and the Third Millennia cal BC

In the previous paragraphs, I have analysed several sites and the related phases of occupation that span more than 3000 years. I have compared various archaeological contexts from an atemporal perspective while investigating their economic organization. However, considering such a long period of time, it seems necessary to approach the matter diachronically as well as evaluate the sites' differences not only in terms of technological and economic variability, but also as a result of specific chronological and occupational dynamics. Radiocarbon dating represents one of the most useful implements in this sense, especially about mountain areas, where the scarcity of artefacts and material records often prevents from putting forward a clear chrono-cultural attribution.

Over the last ten years, the analysis of chronological sequences has largely been used for reconstructing settlement expansion and investigating the patterns of human occupation over a certain area. For the period under question, several works have collected and analysed —by different methods— the radiocarbon-dating outcomes about the Early-Neolithic north-eastern regions of the Peninsula and, more generally, of the Western Mediterranean area (among others, Martín & Mestres 2002; Manen & Sabatier 2003; Bocquet-Appel et al. 2009; Martín et al. 2010; Morales et al. 2010; Oms et al. 2012; Isern et al. 2014).

One of the most common techniques has been the use of joint probability plots of radiocarbon dating (*cfr.* Chap. 2, Par. 2.2.3.). This implementation generally requires a minimum sample of 200-500 radiocarbon dates (Williams 2012), although some authors assert that at least 700-800 dates should be taken in order to produce a sound joint probability chronology distribution (Michczyńska & Pazdur 2004).

For the area here concerned, namely, the Southern Central Pyrenees, available radiocarbon -dates are far too insufficient to reach such a number. To integrate and contextualize this data within a wider geographical and chronological framework, I decided to increase the sample size by including the eastern Pyrenees, specifically both sides of the mountain chain, that is, Spanish and French Pyrenees. ^{14}C data[1, 2, 3] has been collected from several internet databases: 'C14 Catalunya- Database of Catalan Radiocarbon Dates', 'BANADORA- Banque Nationale de Données Radiocarbone', and 'RADON- Radiocarbon dates online 2012'; furthermore, monograph articles have been consulted for each site, in order to understand the archaeological and stratigraphic background.

I reached a number of 156 radiocarbon dates coming from 63 archaeological sites located in the Pyrenees or in the surrounding areas, with chronologies ranging between the sixth and the third millennium cal BC. Within this sample of items, only dates with a standard deviation inferior to 100 years have been selected, as with larger SD the resulting calibrated

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[1] C14 Catalunya - http://www.telearchaeology.org/c14/

[2] RADON - http://radon.ufg.uni-kiel.de

[3] BANADORA - http://www.archeometrie.mom.fr/banadora/

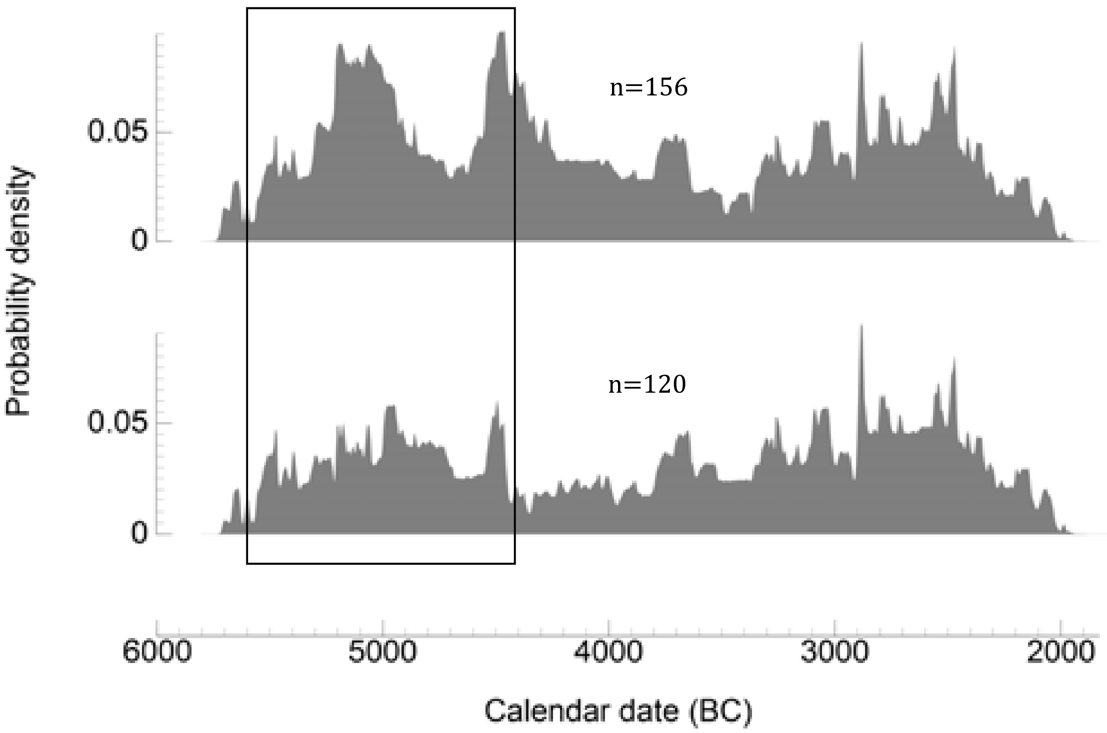

Fig. 7.11. Summed probability plots of radiocarbon data from the Central and Eastern Pyrenees. *Above*: Plot considering 156 radiocarbon dates from 63 archaeological sites. *Below:* Plot considering 120 radiocarbon dates from the same 63 sites, after combining dates relatives to the same occupational event and excluding redundant long-lived samples. The most evident differences between the two plots is evidenced with a black rectangle. Summed probability plots have been realized with OxCal v4.2.3. software (Bronk Ramsey 2013). Atmospheric data from IntCal13 (Reimer et al. 2013).

range would be too wide and so scarcely indicative. The average standard deviation of the selected sample is ±45 years. Of this sample, 95 dates were obtained from charred-wood samples, while the remaining 61 from short-lived samples (faunal bones, human bones or charred seeds). In addition, dolmens and other megalithic structures have been excluded from the analysis, since they require a specific study. I have then focused on habitation sites; the selected contexts are mainly caves or rock-shelters (*n.* 38) and open-air sites (n. 25), amounting in all to 120 archaeological occupations. Amongst the caves, I have included some 'sepulchral cave' too, since, in many cases, the funeral use was not exclusive, but co-existed with other activities of diverse function (storage, habitation, stabling, etc.) (see Gibaja 2004).

Initially, I collected all available dates for each selected context. However, to reduce the noise produced by the repeated dating of the same occupational event, I have combined before calibration —by the OxCal «combine» command— two or more radiocarbon dates of a given site or phase. That occurrence was, in fact, particularly evident for large sites with an array of ^{14}C dates relevant to coeval structures, since this model tends to over-represent a given site within the chart, creating a larger probability aggregation in the curve. Moreover, in the case of large, well-dated sites, which included both long- and short-lived samples, I decided to exclude the long-lived samples to further reduce the redundancy of dates.

After selecting ^{14}C dates, the resulted sample amounts to 120 radiocarbon dates for 63 archaeological sites (see Tab. 7.3.1.1., Annex II). Comparing the two charts, it appears evident

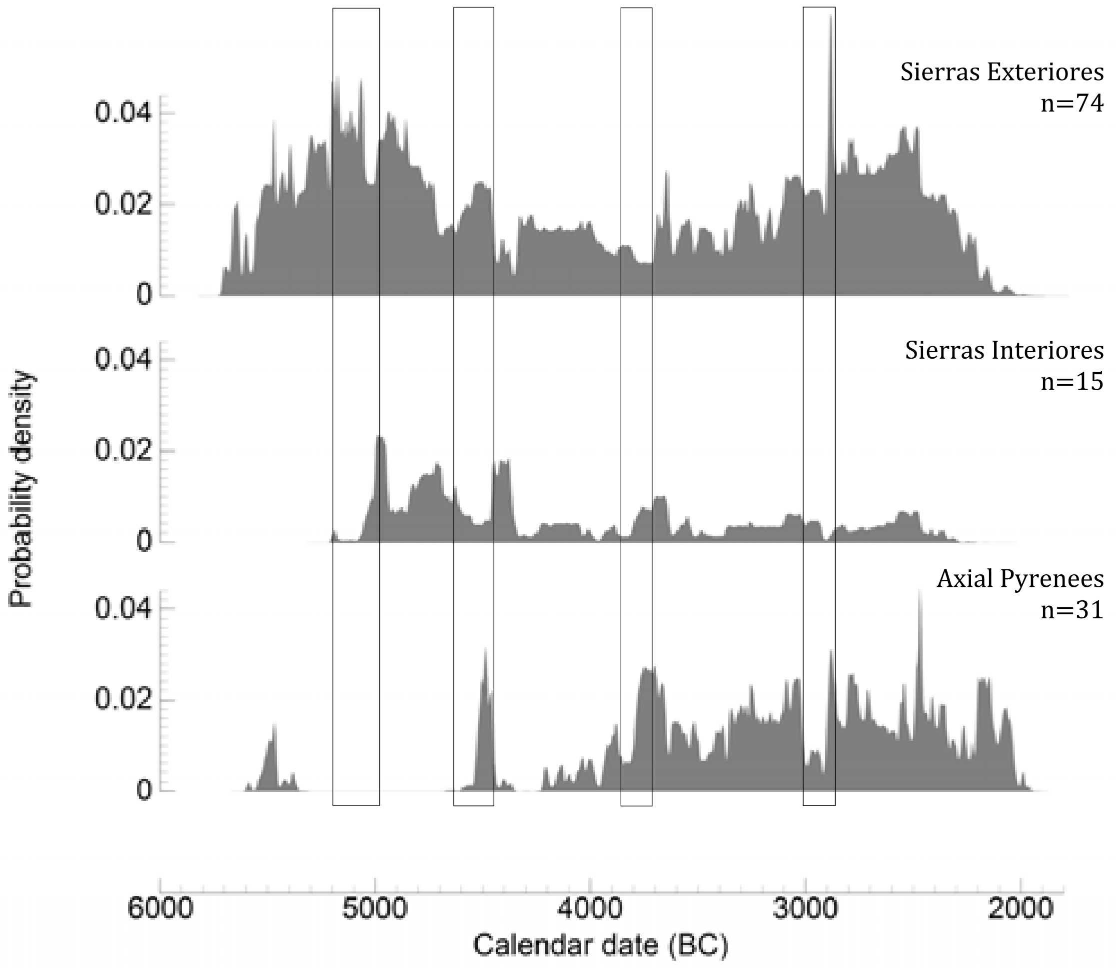

Fig. 7.12. Summed probability plots of 120 radiocarbon data of 63 archaeological sites form the Central and Eastern Pyrenees. The plots are subdivided in three bioregions: Sierras Exteriores (and surroundings areas), Sierras Interiores and Axial Pyrenees. With black rectangles are highlighted areas of the plots where relevant discontinuities or peaks are noticed. Summed probability plots have been realized with OxCal v4.2.3. software (Bronk Ramsey 2013). Atmospheric data from IntCal13 (Reimer et al. 2013).

that a certain noise was produced approximately between 5500 and 4500 cal BC (Fig. 7.11). This was mainly due to the presence of a large set of radiocarbon analyses at sites such like Chaves, La Draga, Font del Ros or Els Trocs I. The second chart seems to give a better representation of the occupational trend, with a much more homogeneous trend.

Despite the reduction of the sample size, the resulting graph is not highly informative for the purposes here concerned. To achieve a more detailed representation of human dynamics in the Pyrenees, I divided the sample into three main bioregions: 1) Sierras Exteriores and surrounding areas; 2) Sierras Interiores; 3) Axial Pyrenees. Unfortunately, the three plots are based on a low number of dates, especially for mountain and high-altitude occupations. However, this chart reflects the real situation of the Pyrenean Archaeology, which has so far provided a low number of excavated and well-dated contexts.

From the three obtained plots (Fig. 7.12), the first aspect that clearly emerges is the existence of a certain graduation between them. The first probability curve —Sierras Exteriores— begins around 5700-5600 cal BC; the curve of the Sierras Interiores starts from

5200-5100 cal BC; the third probability curve, related to the Axial Pyrenees, except for a first peak around 5500 cal BC, starts more continuously only from 4600-4500 cal BC. Moreover, for the axial Pyrenees, the probability is ever-increasing, although slightly, from about 3800 cal BC. Some other interesting correlations come out by comparing the diagrams; for example, a moment of discontinuity, followed by a peak of probability, is observable around 2900 cal BC in both Sierras Exteriores and Axial Pyrenees, along with diminishing probabilities in the Sierras Interiores. Nevertheless, considering the reduced size of the sample, one should not emphasize too much the validity of such patterns as only a larger sample of radiocarbon dates may verify them.

So far I have dealt with a very large temporal scale; however, in order to understand the occupation dynamics of the region, it is necessary to focus on much-reduced chronological spans, after dividing this sequence into smaller segments. By comparing, from a visual point of view, the three joint probability plots, it is possible to identify some areas characterized by peaks or discontinuities (Fig. 7.12.). Such discontinuities seem to divide the chart into five main sections, which can be figured out as follows:

i. *from the beginning of the sequence to 5200-5100 cal BC*: this corresponds to the beginning of the sequence, with a considerable amount of dates featuring only in the Exterior Sierras of the Pyrenees and in the surrounding areas;

ii. *from 5100-5000 to 4650-4500 cal BC*: this corresponds to the first occupation of the Sierras Interiores;

iii. *from 4650/4500 to 3850-3700 cal BC*: this corresponds to the first occupation of the Axial Pyrenees;

iv. *from 3850/3700 to 3000/2850 cal BC*: this corresponds to a moment of a more continuous occupation in the Axial Pyrenees and a slight peak of probability in the Sierras Interiores;

v. *from 3000/2850 cal BC to the end of the sequence*: this corresponds to a continuous occupation in the Axial Pyrenees and in the Sierras Exteriores.

To verify if these time spans correspond to real groups of dates, one can apply a *K*-means with a 5-cluster solution. All 120 calibrated dates represented in the chart (including Combine dates) were embedded in the clusters and analysed by their median as achieved by OxCal (Tab. 7.3.1.2., Annex II). The use of ^{14}C-histograms of medians to explore and simplify plots of radiocarbon dates has been already implemented by other authors (Capuzzo 2014). The result of the *K*-means analysis has largely confirmed the previously ascertained intervals; all clusters fall within the established limits as emerged by the comparison between the three charts as displayed (Tab. 7.3.1.3., Annex II). The clustering procedure has identified five clusters, whose maximum and minimum values are the following:

i. A first cluster composed of 12 dates, with mean values ranging between 5650 and 5180 cal BC.

ii. A second cluster composed of 23 dates, with mean values ranging between 5150 and 4630 cal BC.

iii. A third cluster composed of 19 dates, with mean values ranging between 4570 and 3850 cal BC.

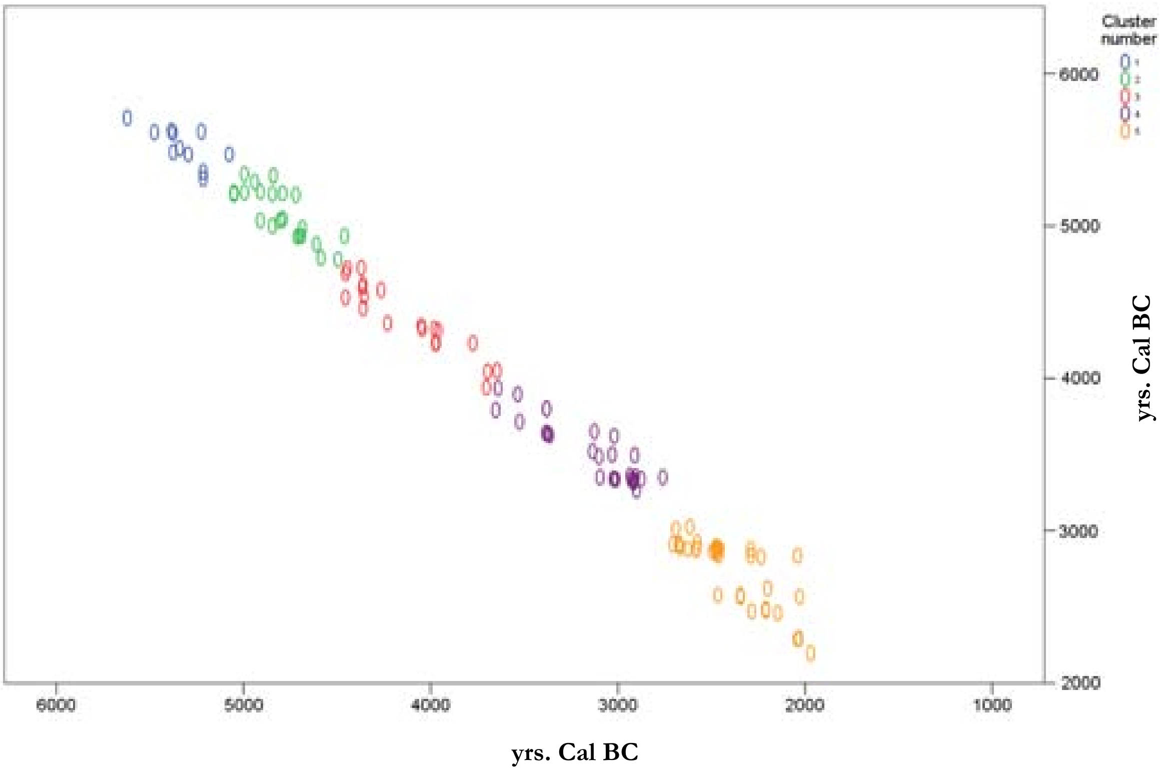

Fig. 7.14. Scatter plot of 14C dates using their maximum and minimum values at 95.4%, separated on the basis of the five clusters identified.

iv. A fourth cluster composed of 31 dates, with mean values ranging between 3770 and 2990 cal BC.

v. A fifth cluster composed of 35 dates, with mean values ranging between 2880 and 2080 cal BC.

A further proof, in terms of stability of the clusters obtained, has come from a discriminant analysis. The use of discriminant analysis is a common practice for verifying the clusters established by a *K*-means test (Peseau & Tudor 1988). In addition, it is generally advisable to applying discriminants by using one or more exogenous variables, so that external data may also corroborate the clustering. In this case, I employed the maximum and minimum values of each single calibration (taking the 95.4% range), in order to verify if the classification of dates matches the one achieved by using mean values.

The result of the test indicates that 99.2% of the objects fall in the cluster previously obtained by *K*-means (Tab. 7.3.1.4. and 7.3.1.5., Annex II). Indeed, only 1 object (situated at the boundary between two clusters) floats across two clusters.

Finally, I also took into account the influence of radiocarbon calibration curves on joint probability plots (Williams 2010). Actually, certain peaks observed in the charts often reflect an expansion of joint probability distributions because of the calibration itself and not a real peak of probability given by the dataset. A standard procedure to 'correct' the diagram, or at least its interpretation, is to embed an array of randomly-generated dates and see whether similar peaks still form along the archaeological sequence. The result confirmed the existence

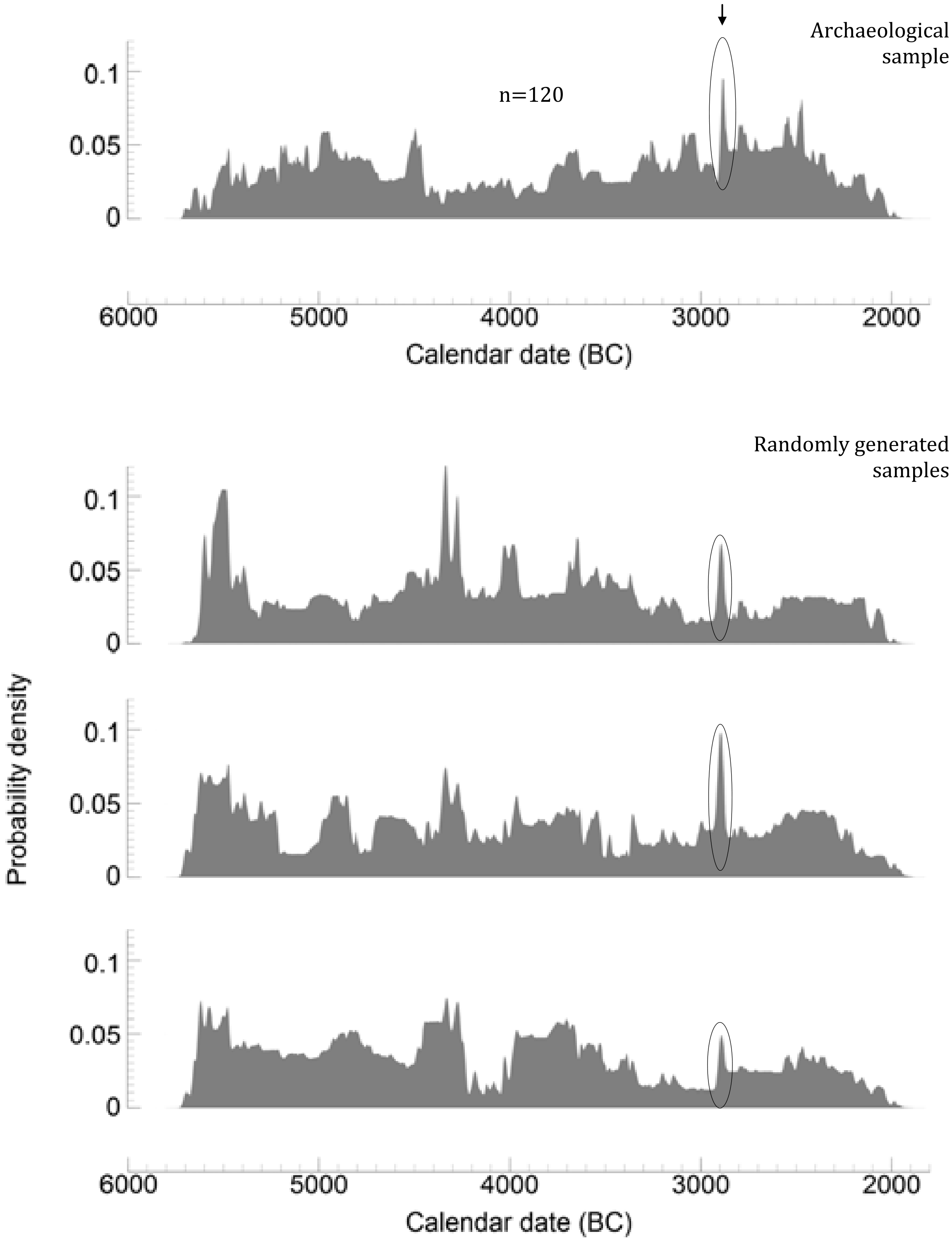

Fig. 7.13. Comparison of the Archaeological summed probability plot (*above*) and three summed probability plots obtained with randomly generated dates (*below*), in both cases with the same number of dates (*n*= 120 dates). The black arrow indicate a peak around 2900 cal BC produced by the calibration process itself. Summed probability plots have been realized with OxCal v4.2.3. software (Bronk Ramsey 2013). Atmospheric data from IntCal13 (Reimer et al. 2013).

of a high narrow peak around 2900 cal BC, which had been brought about the calibration process (Fig. 7.13). Therefore, this peak should not be considered reliable in term of human processes. Moreover, a much slighter peak has been observed around 5500-5480 cal BC; however, it has a much more reduced influence on this archaeological chart and does not distort the dataset conclusively.

Despite the presence of such problems, I decided to maintain the aforesaid intervals identified by *K*-means and discriminant analysis. It is important to remember that the main goal here is to display the data, specifically, highlight some general dynamics in the pattern of human occupation of the Central-Eastern Pyrenees and not define a fixed chronological sequence, nor replace the existent chrono-cultural phases based on the so-called 'traditional chronology'. The clustering procedure depends much on the original sample used and slight variations likely originate while changing the sample size.

Finally, it is important to remark that the traditional chronology does not substantially differ from the phases that have already been ascertained; they are largely comparable with one another and only minor variations can be noticed (Martín & Vaquer 1995; Martín et al. 2010; Oms et al. 2012).

7.3.1.1. 5700-5200 cal BC: The Occupation of the Sierras Exteriores

The first signs of the presence of agro-pastoral communities in the Pyrenean area date back to *ca.* 5650 cal BC. The most ancient evidence is currently represented by the controversial findings from Level V of Peña de las Forcas II, the dating of which, according to the narrowest range, is between 5730 and 5570[4] cal BC. This episode was followed by a new occupation, possibly a short while after, which goes back to between 5725 and 5465 cal BC and is documented in Level VI. According to the excavators' interpretation (Utrilla 2002; Utrilla & Mazo 2007; Utrilla et al. 2009), both phases bear evidence of the early acculturation of a Mesolithic group, whose subsistence was still mainly based on hunting and gathering activities. In fact, no evidence of domesticated species —either animal or vegetal— has been detected in those horizons and radiocarbon dating samples come from wild animal bones. In both contexts, 'Neolithic' materials are featured by a small ceramic assemblage with cardial and impressed decorations, along with the presence of *doble bisel* microlithic tools.

In the light of such information, I would consider such dates with some caution. Information coming from published works on the formation of the deposit, digging process, and relevant archaeological materials is so far too scarce and fragmentary for a proper evaluation of these layers' consistency. Some authors assume that the presence of both ceramics and *doble bisel* geometric microliths may have been brought by post-depositional phenomena, thus such assemblages should be considered a 'palimpsest' (Martínez-Moreno et al. 2006; Oms et al. 2012). Similar situations are well-known about cave occupations in the Iberian Peninsula and have often given rise to debates and discussions amongst scholars (see, for example, Zilhao 2011 and Alday 2011). However, even if uncertain and controversial, the dates from Forcas II cannot be simply excluded from the analysis as they attest the presence of human groups in the first ranges of the Sierras Exteriores at the beginning of the sixth millennium, whatever their economy or cultural affiliation were.

[4] All the dates reported in this paragraph are calibrated at 2σ considering the whole interval (95.4%). Calibrated intervals are available in Tab. 7.3.1.2., Annex II.

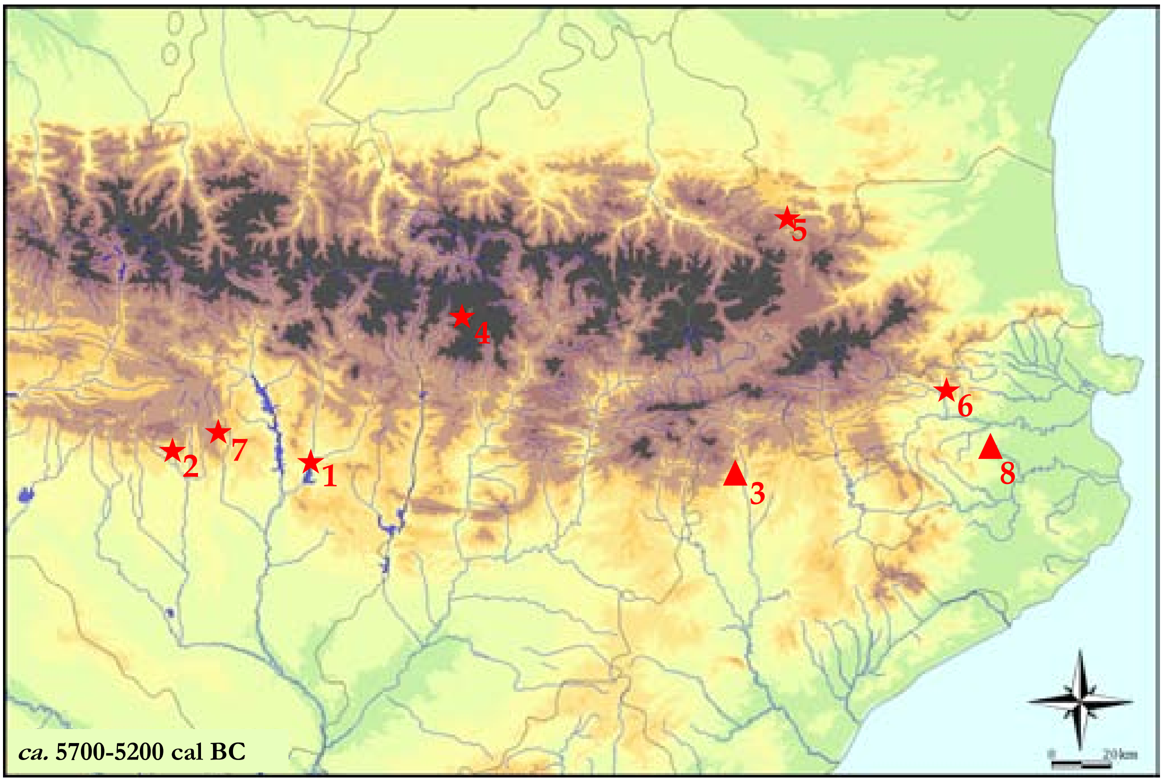

Fig. 7.15. Distribution of the sites between 5700-5200 cal BC. Stars represent cave sites, while triangles open-air settlements. Only dated sites are reported in the map. Site are number in chronological order. 1) Forcas II-V/VI; 2) Cueva de Chaves-1b; 3) Font del Ros-level 64-50; 4) Cova del Sardo-phase9; 5) Roc de Dourgne-C6; 6) Serrat del Pont-III4; 7) Huerto Raso-level2; 8) La Draga-sectorA/level2;

For encountering a context that was clearly associated with an agro-pastoral community, one has to wait until 5615-5475 cal BC, which shows the earliest occupation of Cueva de Chaves (*ca.* 600 m.a.s.l.). Here, human presence is attested almost continuously until 5470-5295 (95.4%) cal BC.

The abundant archaeological record from Chaves-Level 1b bears evidence of the establishment of a production economy based on a variety of biotic and abiotic resources. Pastoral activity was mainly based on sheep/goat farming, while cattle and suids display lower percentages. Amongst hunted species, only red deer seems to have been of some consequence. Agriculture is attested to by the presence of numerous sickle blades, the edges of which show an intensive use for harvesting activities. Mills and hand-mills are also present. The absence of *Cerealia*-type pollen in the diagram relevant to the cave deposit may be ascribed to the existence of cultivation fields at a certain distance from the site, this being a plausible hypothesis, considering the topographical and geographical context in which Chaves is situated. However, the whole surrounding landscape appears to have strongly been affected by anthropic disturbance, possibly in relation to grazing and pastoral activities (*cfr.* Chap. 3, Par. 3.5) (López-García & López-Sáez 2000; López-Sáez et al. 2006).

At Chaves, economic activities were not limited to food production and procurement, but structured production processes took place inside the cave, in relation to foodstuff processing and storing as well as to artefacts manufacturing and maintenance. The traceological analysis of flaked stones as accomplished in this work has demonstrated that the functional range of Cueva de Chaves' materials is similar to that of other stable open-air settlements of the period, such as the site of La Draga, thus confirming the interpretation of the cave being a sort of 'under rock-settlement' (Baldellou et al. 2012).

Near Cueva de Chaves, in the Sierra de Guara, another site has been detected, although with slightly earlier chronologies: Huerto Raso Rock-Shelter (5470-5075 cal BC) (Barandiarán 1976; Baldellou 1991; Montes & Domingo 2001-2002). Little archaeological information is anyway available for this place as the deposit has only been preliminarily surveyed so far.

Apart Cueva de Chaves and Forcas II in the Central Pyrenees, several important sites have been discovered in the eastern sector of the mountain chain. Among those, the above-mentioned La Draga, a lacustrine open-air site located close to the Pyrenean foothill (*ca.* 170 m.a.s.l.), which goes back to between 5310 and 5215 cal BC (Bosch et al. 2000, 2011). Bauma del Serrat del Ponte is located nearby, at the confluence of the Rivers Llierca and Fluvià, and is dated to between 5510 and 5340 cal BC (*ca.* 260 m.a.s.l.) (Alcalde et al. 2005b). Further west, an open-air settlement has been excavated in the Llobregat Valley, namely the site of Font del Ros (680 m.a.s.l.) (Mora et al. 1991), which shows an array of occupations dating to between 5625-5385 and 5355-5215 cal BC. All of these sites were characterized by a full production economy, featured by a mainly hulled-barley- and emmer-based agriculture and a full-range of domesticated animals.

While the outer ranges are characterized by a scattered presence of archaeological sites, there is almost no evidence of human traces in the inner areas of the Pyrenees for this early phase. In the mountain zone (800-1.700 m.a.s.l.), the only evidence of anthropic activity is documented by the palaeoecological survey carried out in the Selvaplana Plain, in Aragon's Ribagorza. There, a micro-charcoal concentration was dated to between 5520 and 5460 cal BC and is probably to refer to human-induced fires for forest clearance (Uria 2013).

At higher altitudes, in the subalpine zone, anthropic evidence is shown by sporadic and short frequentations that have left almost no archaeological trace. A pit-hearth has been recorded at Cova del Sardo, with a radiocarbon dating ranging between 5610 and 5375 cal BC; all the same, the associated archaeological materials are at really low numbers, thus suggesting only an episodic use of the cave (Gassiot et al. 2014).

A similar data is also provided by the study of peat-bogs and lake records. Almost no anthropic disturbance is perceptible in the pollen diagram relevant to Estany Redó (2.240 m.a.s.l.) (Catalán et al. 2001; Gassiot et al. 2012b) or Estany de Burg (1.821 m.a.s.l.) (Pèlachs et al. 2007, 2011), both located in the basin of the Nogueras River. Human activity at high-altitude areas still appears scarce during this early time.

Further east, in the Madriu Valley in Andorra, the analysis of the peat-bog of Bosc dels Estanyols (2.180 m.a.s.l.) indicates that the first signs of human activities may go back to between 6420 and 5850 cal BC (calibration from Miras et al. 2007), as pointed out by a decrease of arboreal taxa between 1.600 and 1.800 m.a.s.l. and the specific appearance of spores of *Sordaria*-type and *Cerealia*-type. However, evidence for this period is still feeble and possibly only refers to an early and short colonization of subalpine zones, which later underwent a rapid abandonment. As a matter of fact, a regeneration of the arboreal vegetation can be observed at Madriu between 5600 and 5300 cal BC (Miras et al. 2007; Ejarque et al. 2010).

During the same time, although at lower altitudes, specifically in the Gran Valira Valley, the occupation of Balma Margineda has been documented (970 m.a.s.l.). However, published radiocarbon dates for this site are quite controversial. The dating of wood-charcoal samples shows a wide standard deviation and so has been excluded from this study. Recently, new calibrated dates obtained from samples of charred hazelnuts have been published, indicating an interval of 5626-5490 cal BC[5]. Such levels bear evidence of the presence of agro-pastoral populations in Andorra in early times. The analysis of the Balma Margineda materials seems to indicate the practice of pastoral activities in the valley, mainly in relation to ovicaprine herds. However, also vestiges of agricultural activities have been retrieved (Guilaine & Martzluff 1995). Judging from the type and quantity of both faunal and lithic remains, hunting seems to have only been a secondary practice.

On the French side, larger occupations are also located at lower altitudes, such as the seaside open-air settlements of Leucate in the coastal region and the cave of Grotte Gazel in the Aude department, with chronologies going back to 5990-5640 cal BC (Manen & Sabatier 2003). On the other hand, in the French Pyrenees, the only discovered sites for such period are Abri de Dourgne, in the Aude Valley (710 m.a.s.l.), with a layer dated to between 5568 and 5310 cal BC (92.4%) (Guilaine et al. 1993), and Abri Jean-Cross[6] (600 m.a.s.l), located on a small plateaux in the western Corbières region (Guilaine et al. 1979). The economic orientation of those sites is more complicated to define, given the scarcity of data and the complexity of the stratigraphic sequences. On the basis of animal remains, both have been interpreted as seasonal occupations, which were mainly connected with animal-husbandry practices and, to a lesser extent, hunting (Geddes 1983). Lithic remains are not very abundant in either of them. Both sites are characterized by a remarkable combination of microlithic tools that are similar —from a techno-typological point of view— to those from Balma Margineda (Barbaza 1993; Guilaine & Manen 2007).

Palaeoecological data seems to support the orientation of those sites towards pastoral exploitation as the first sign of anthropic disturbance in the lower Aude Valley, in the piedmont northern Pyrenees, has been detected from *ca.* 5800 cal BC (Guilaine et al. 1993; Galop 2006; Galop et al. 2013).

In conclusion, between 5700 and 5200 cal BC, the Pyrenees appear to have been scarcely occupied by agro-pastoral populations. The main settlements were located in the outer ranges, facing open and wide valleys and floodplains. In such sites, a variety of domestic structures (e.g. storage facilities, pits, hearths, shed bases, and floors) has been found; at the same time, diverse production processes were carried out in relation to both food-production and artefact-manufacturing. On the contrary, in the inner mountain areas, human presence appears to have been sporadic and discontinuous. Early forays, associated with forest clearance for creating grasslands, have occasionally been recorded; all the same, neither clear occupations nor a systematic exploitation of the environment have been recognized. It has been put forward that, during these early phases, people operated on too small a scale, below a disturbance threshold, to be detectable by pollen analysis (Galop et al. 2013).

7.3.1.2. 5200-4600 cal BC: First Occupation of Mountain Areas

Since approximately 5200 cal BC, a gradual but increasing human pressure can be observed on the Pyrenees and its surrounding areas. Almost all the sites settled in the previous period show an unbroken occupation. Amongst those, Cueva Chaves, whereat the

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[5] For the Balma Margineda site uncalibrated (BP) dates have not been published. Calibrated dates (BC) have been taken from Fortó et al. (in press).

[6] Available radiocarbon dates for the early phases of occupation of the Abri Jean-Cross present a standard deviation too high to be considered in this study: 6540±300 (Gif 218 - level C2); 6600±130 (Gif3575 - level C2b -c); 7160±130 (Gif3576 - level C2a-b-c) (Guilaine et al. 1979).

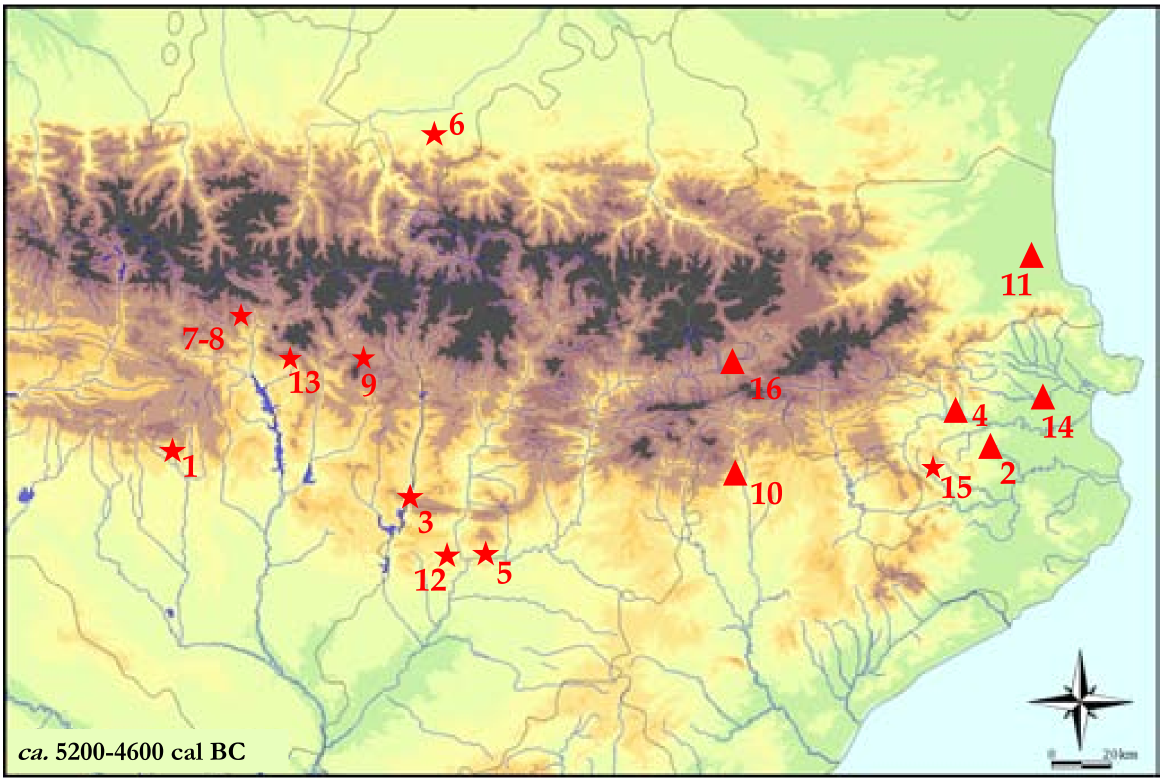

Fig. 7.16. Distribution of the sites between 5200-4600 cal BC. Stars represent cave sites, while triangles open-air settlements. Only dated sites are reported in the map. Site are number in chronological order. 1) Cueva de Chaves-1b; 2) La Draga-sectorsA/B/C/D; 3) Cova Colomera-CV10/E12/13/14; 4) Plansallosa-level1; 5) Roc de Dourgne-C5; 5) Cova del Parco-EE1; 6) Abri de Buholoup-C2; 7-8) Coro Trasito-level3006-3002; 9) Cova de Els Trocs-phaseI; 10) Font del Ros UE33/21/15; 11) Aspre del Paradis-silo5; 12) Cova Gran-E9; 13) Espluga de la Puyascada, level E.2; 14) Mas Bonet; 15) L'Avellaner-C3a; 16) Sanavastre-estr4.

passage between Level 1b and 1a is dated to between 5340 and 4995 cal BC, corresponding to the last Neolithic occupation of the cave, as also Font del Ros (5215-4790 cal BC) (Bordas et al. 1995) and La Draga (with a series of dates ranging between 5300 and 4700 cal BC) (Bosch et al. 2011; Palomo et al. 2014).

Moreover, a considerable number of new sites were occupied, especially in the outer ranges of the chain. In the Nogueras region, in the Central Pyrenees, anthropic contexts have been discovered at Cova del Parco (*ca.* 430 m.a.s.l.) (5290-4940 cal BC) (Petit 1996), facing the Segre River, Cova Colomera in the Montsec range (*ca.* 670 m.a.s.l.) (5210-5050 cal BC) (Oms et al. 2014), and in Cova Gran of Santa Linya's Pit E 9 (*ca.* 380 m.a.s.l.) (5045-4790 cal BC) (Mora et al. 2011; Polo Díaz et al. 2014). For both Cova del Parco and Cova Gran, published data is still too scarce to evaluate the type and the extent of human occupation during this period. More detailed information is available for Cova Colomera, the excavation of which has recently been resumed and new data has been published. The site is characterized by the presence of rich fumier-deposits due to the use of the cave as a *grotte-bergerie*, suggesting the practice of pastoral activities mainly in relation to ovicaprine herds. The presence on-site of grains and rachides of several types of domesticated cereals makes it unclear whether agricultural activities were practised or not locally. However, the presence of by-products of cereal processing points out toward the existence of cultivated fields not faraway from the site (Oms et al. 2008, 2013).

Also Cueva del Moro de Olvena is probably to ascribe to this period, which is situated along the River Ésera in the Aragon's Ribagorza. However, most of the deposit at Moro de Olvena has been disturbed by clandestine excavations, therefore the attribution is not that certain[7] (Utrilla & Baldellou 1996).

In the Mediterranean sector, the presence of agro-pastoral populations is well-documented by an increasing number of contexts. Apart from the sites of La Draga and Font del Ros, one can note the establishment of new open-air settlements such as Plansallosa (5220-4995 cal BC) (Bosch et al. 1999), in the Llierca Valley, l'Aspre del Paradis near the estuary of the River La Têt (5035-4805 and 4935-4690 cal BC) (Manen et al. 2001), and Mas Bonet, in the coastal area (*ca.* 75 m.a.s.l.) (4930-4715 cal BC) (Rosillo et al. 2012).

In addition, several cave sites in the outer elevations were settled for different uses: storage caves and stabling or funerary areas. The same site was often used for different purposes as is the case with Avellaner Cave (4935-4460 cal BC) (Bosch & Tarrus 1990). Many other caves are known for this period, such as Cova s'Espasa, Cova d'en Pau, Cova dels Ermitons, etc.; however, most of them were investigated by old excavations and no radiocarbon dates are available.

On the French side, a Neolithic occupation is documented in the Ariège region, in the piedmont area of the Central French Pyrenees. The site, situated at 310 m.a.s.l., is called Abri de Buholoup and is a small rock-shelter of about 35 m^2, of which approximately 20 m^2 have been excavated, revealing the presence of an anthropic horizon going back to 5225-4910 cal BC (Briois & Vaquer 2009). Despite not many data being published about the site, the excavators interpret the context as formed by short-term occupations connected with the exploitation of a variety of resources: molluscs gathering, fishing, hunting, and animal-husbandry practices.

However, from my point of view, the most interesting data for this period is the establishment of human occupations in the mountainous zones of the interior pre-Pyrenees, namely, an area that has so far been considered to have been frequented only episodically by human groups. The reference site is represented by Cova de Els Trocs (1.540 m.a.s.l.), located in the Ribagorza region, just behind the Turbón massif, with an array of horizons dated to 5035-4910 cal BC (Rojo et al. 2014). This site has already been largely discussed in this work and represents an example of a specialized occupation related to ovicaprine farming and slaughter (*cfr.* Chap. 5). The economic processes ascertained by traceological analysis appear to have been fragmentary and discontinuous and mainly bear evidence of household-maintenance and artefact-repairing activities. Agricultural production was absent at the site and only consumption of cereal provisions occurred at Els Trocs (Lancelotti et al. 2014).

Recently, another site with similar characteristics has been discovered not far from the Cinca Valley: Coro Trasito Rock-Shelter (1.580 m.a.s.l.). The site is located upon a sheer cliff that is part of the Sierras Interiores. It has been only preliminarily surveyed and the publication of most of the data is forthcoming; however, a thick sequence of fumier-deposits and occupational layers has been detected. Amongst them, two different phases refer to the period under question and have been dated to between 5200 and 4600 cal BC (Clemente et al. in press; Clemente pers. comm.).

[7] The most ancient radiocarbon date for the Cueva del Moro de Olvena presents a standard deviation too high to be considered in this model: 6550±130 BP (Baldellou & Utrilla 1985: 255).

Still in Aragon's Sierras Interiores (1.315 m.a.s.l.) and with similar chronologies (4985-4685 cal BC), the large site of Espluga de la Puyascada (4985-4685 cal BC) was surveyed during the seventies by V. Baldellou (1987a). The analysis of the lithic industry carried out in this work suggests a strong similarity to Els Trocs Cave: the main production activities were associated with the exploitation of domesticated flocks (mainly ovicaprine species), while all other processes appear to have been discontinuous and mainly connected with maintenance works. According to current data, cultivation was practised neither at the site nor in its surroundings.

The discovery of the open-air site of Sanavastre is particularly important, which is situated at a mid-altitude, in the Segre Valley (1.080 m.a.s.l.) (4780-4495 cal BC). This site is located in a plain area in Cerdanya and is interpreted as a stable open-air occupation with a mixed economy oriented to both agricultural and pastoral practice (Mercadal et al. 2009).

Palaeoecological data for the period concerned suggests an increasing pressure on the subalpine and alpine zones. In Andorra, in the Madriu Valley, anthropic activity —relevant to both livestock husbandry and early agricultural practises— has been verified in high-altitude zones since 5130 cal BC (Miras et al. 2007; Ejarque et al. 2010). Markers of human activities at high altitudes (2.200-2.300 m.a.s.l.) have been observed in the Nogueras region too, beginning from *ca.* 5300 cal BC, with an increasing evidence of fire, grasses and the appearance of erosion signals. However, such human activities at higher altitudes still appear discontinuous and did not have an enduring influence on the natural environment (Pérez-Obiol et al. 2012).

In conclusion, the interval between 5200 and 4600 is marked by a general increase of human presence in the Sierras Exteriores, along with the establishment of the first occupations in the mountain zones (1.000-1.700 m.a.s.l.). The occupation of mountainous zones appears to have been a gradual process, characterized by the building of both open-air, stable settlements at mid-altitudes and more specialized, seasonal occupations in caves and rock-shelters. Furthermore, human activities have also been detected at higher altitudes, according to the analysis of peat-bog and lake records, although no archaeological site has been identified in such areas. This scenario is very interesting since palaeoecological analysis suggests that the first signs of human disturbance to vegetation systematically occurred a few centuries before the establishment of habitation sites in the mountain and subalpine areas (Galop et al. 2013). Such a situation may be explicated as brought about by early forays of small human groups, who have actually left almost no archaeological traces.

7.3.1.3. 4600-3800 cal BC: Towards the Axial Pyrenees

During this time span, one can fundamentally observe the same dynamics emerged for the previous period. The outer ranges were mainly characterized by large open-air sites, often characterized by a dispersed spatial organization of the dwelling structures, and a well-established mixed farming economy, such La Codella (4720-4445 cal BC) (Alcalde & Saña 2009), Plansallosa (4725-4370 cal BC) (Bosch et al. 1999), La Dou (4615-4360 cal BC) (Alcalde et al. 2012), Ca l'Olaire (4045-3695 cal BC) (Martín et al. 2005), in the eastern pre-

[8] For the Mas Bonet Chassey/Middle Neolithic phases (BP) dates have not been published. Calibrated dates (2σ) have been taken from Rosillo et al. (2010-2011: 54).

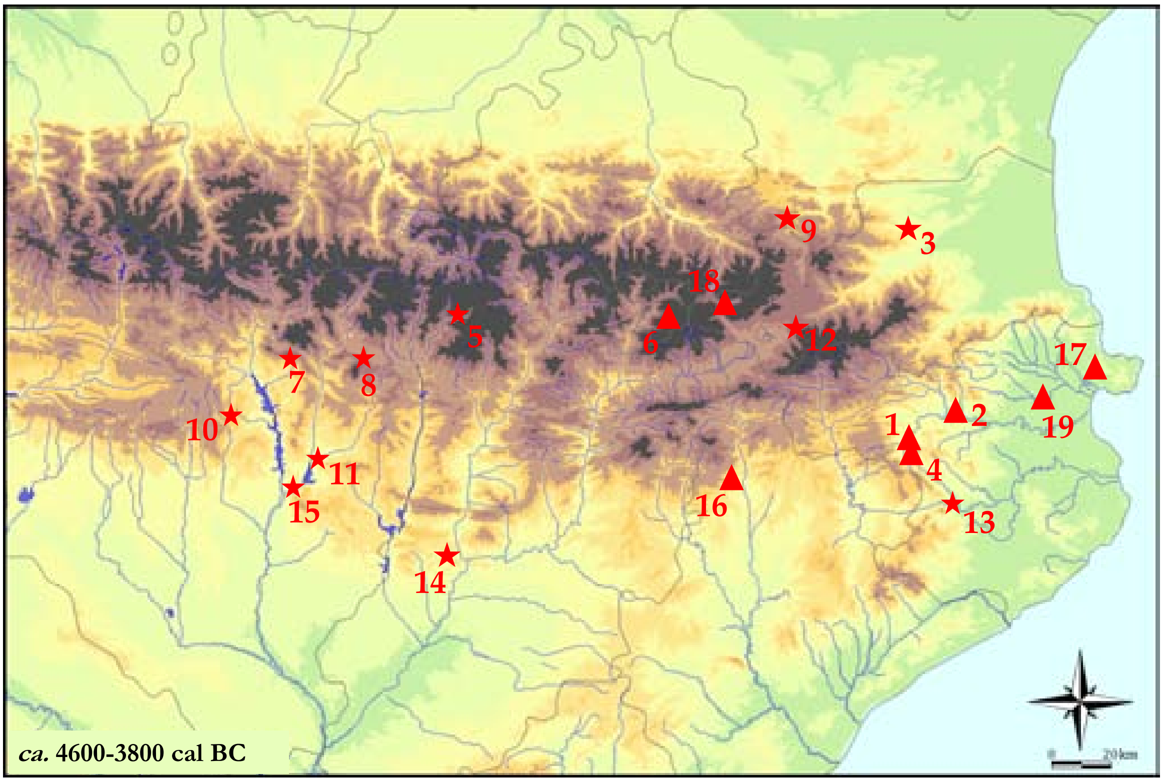

Fig. 7.17. Distribution of the sites between 4600-3800 cal BC. Stars represent cave sites, while triangles open-air settlements. Only dated sites are reported in the map. Site are number in chronological order. 1) La Codella-?; 2) Plansallosa-level2; 3) Grotte de la Caune de la Bélesta-AT13; 4) La Dou-estr.1/2/3; 5) Sardo-phase8-7; 6) Pla de Bacives-M152; 7) Espluga de la Puyascada-levelE.2; 8) Cova de Els Trocs-phaseII; 9) Roc de Dourgne-C5; 10) Cueva Pacencia-subunitI; 11) Peña de las Forcas-levelVIII; 12) Lo Pla del Bach-Inferior level; 13) Cova Pasteral; 14) Cova Gran-H1; 15) Moro de Olvena-c5; 16) Ca l'Oliaire; 17) Ca N'Isach-levelsIa/Ib; 18) Serrat de la Padrilla-C49; 19) Mas Bonet

Pyrenean foothills, and Mas Bonet[8] (4100-3400 cal BC) (Rosillo et al. 2012) and Ca N'Isach (4050-3645 cal BC) (Tarrus et al. 1992) in the coastal area.

Caves and rock-shelters were occupied too, with diverse functions. In the Pyrénées orientales, Grotte de la Caune de Bélesta (390 m.a.s.l.) (4690-4455 cal BC) shows a communal burial place (Claustre et al. 1993); funerary depositions have also been detected at Cova Pasteral, along with domestic-dwelling layers (4315-3960 cal BC) (Bosch 1986). In the Central Spanish Pyrenees, anthropic horizons have been found at Cueva Pacencia (4360-4230 cal BC) (Montes et al. 2000), Peña de la Forcas-Level VIII (4360-4230 cal BC) (Utrilla et al. 2009), Moro de Olvena (4360-4230 cal BC) (Baldellou & Utrilla 1995; Utrilla & Baldellou 1996), and Cova Gran de Santa Linya (Mora et al. 2011), where a hearth has been dated to between 4230 and 3970 cal BC. However, for most of these sites the archaeological evidence associated with radiocarbon dates is still poor and, in some cases, not completely reliable.

In the mountain areas, human presence was gradually expanding to higher zones. At mountain altitudes, sites such as Els Trocs Cave Phase II (4460-4360 cal BC) and Espluga de la Puyascada (4460-4360 cal BC) are characterized by horizons of occupation, which anyway substantially followed the previous pattern. A rock-shelter with similar chronologies has also been detected near the village of Eyne in the Pyrénées-Orientales: Lo Pla del Bach (1.610

m.a.s.l.) (4325-3980 cal BC) (Campmajo & Crabol 1988; Claustre & Mazière 1998).

In addition, new open-air sites have been detected. In Andorra, in the Gran Valira Valley (*ca.* 1.380 m.a.s.l.), a large open-air site has recently been excavated: Camp del Colomer. For this site just preliminary publications have been issued so far and only calibrated dates are available, which approximately range between 4500 and 3900 cal BC[9] (Fortó et al. 2009, in press). The site has revealed the presence of storage buildings like silos and remains of habitation contexts, like shed bases and hearths, thus suggesting a stable occupation. Moreover, the anthracological analysis indicates the establishment of permanent agricultural activities at mountain altitudes. Furthermore, also wild fruits were abundantly collected and processed at the site, especially acorns and hazelnuts (Antolín 2014).

Around 4500 cal BC, one records, for the first time, the presence of habitations located in the subalpine and alpine zones of the Pyrenees. The reference site is Cova de Sardo, a rock-shelter situated at 1.790 m.a.s.l., in the Sant Nicolau Valley, in the Axial Catalan Pyrenees (4530-4455 cal BC). This early phase shows a relatively stable —even though seasonal— occupation, probably in connection with the exploitation of Sant Nicolau Valley's subalpine pastures (Gassiot et al. 2014). Two hearths inside the rock-shelter and a large burnt area in the outer terrace have been documented. Anthracological and pollen data from the site indicates the existence of an open environment in the surroundings of the cave, with ruderal species and marginal scrubs (Gassiot et al. 2012b). The study of lithic-resource management highlights the employment of a high percentage of local, non-siliceous, rocks. The tasks carried out there appear to have mainly been related to maintenance activities. Amongst them, the preparing and refitting of arrows was probably one of the most important; this notwithstanding, hunting should be considered as only occasionally practised. Indeed, faunal materials, at extremely low numbers and very fragmentary, only indicate an episodic killing and consumption of domestic ovicaprines. In addition, also a cereal seed has been recovered at the site, however, it probably speaks of transportation and consumption of food provisions. In my view, current data matches the interpretation of Cova del Sardo having been a sort of 'pasture shed', that is, a shelter mainly occupied during the time when the flocks were put out to pasture in the surrounding areas (*cfr.* Chap. 6, Par. 6.4.2.3.).

After Phase 8, new settlement layers have been ascertained at Cova del Sardo the dating of which ranges between 4230-3975 and 3939-3702 cal BC (Phase 7) (*cfr.* Chap. 6, Par. 6.4.3.3.). This new phase —characterized by a series of regular but discontinuous and brief occupations— marks a slight change in respect to the previous one. A recovering of the forest in the valley bottom is detected, suggesting a decrease in the anthropic pressure, perhaps in relation with the exploitation of areas located at higher altitudes (Gassiot et al. 2014).

Moreover, Cova del Sardo is not the only high-altitude site to have appeared in this period. In the Madriu Valley, at 2.518 m.a.s.l., during the excavation of a small hut of Roman time (fifth-sixth century AD), a subjacent context was detected, which goes back to between 4595 and 4365 cal BC and may attest to an earlier use of the structure during the Neolithic Age (Orengo et al. 2014). Palaeoecological indicators at the near Estany Forcat (*ca.* 2.500 m.a.s.l.) and Bosc dels Estanyols Peat-Bog (*ca.* 2.200 m.a.s.l.), which verify the existence of an open vegetation as early as *ca.* 5200-5050 cal BC (Miras et al. 2007; Ejarque 2010), seem to

[9] Calibrated dates (2σ) have been taken from Fortó et al. (in press).

confirm the presence of human activity in the area.

In conclusion, between *ca.* 4600 and 3800 cal BC, one can observe the establishment of temporary habitations —or shelters— at higher altitudes (1.700-2.600 m.a.s.l.), which were connected with an expansion of pastoral practices towards the subalpine and alpine pastures (e.g. Cova del Sardo, Pleta de les Bacives). However, it is interesting to remark that this phenomenon occurred almost at the same time as the building of the earliest open-air, stable settlements in the mountain zones (800-1.700 m.a.s.l.) (e.g. Sanavastre, Camp del Colomer), a fact that may indicate a gradual penetration of human groups into the Axial Pyrenees, with the contemporary occupation of the valley bottoms and subalpine/alpine pastures. Open-air sites have only been discovered in the eastern sector of the Pyrenees so far; however, I am confident that this scenario has mainly been brought about by partial and/or inaccurate archaeological recording and survey techniques adopted.

Along with this data, one can also observe a continuous human presence in the caves of Sierras Interiores and Sierras Exteriores in the Central Pyrenees, resulting in the occupation of large caves (Els Trocs, Espluga de la Puyascada, Cova Gran), which were characterized by an animal-husbandry-oriented economy. All the same, there is a substantial difference between these sites —which one can define 'stabling sites or sheepfolds'— and the so-called 'pasture shed'. While the first were featured by an intensive on-site slaughter activity and a relatively abundant archaeological record, in the second case, archaeological findings are extremely rare and almost no production activities have been detected. In other words, while 'sheepfold caves' probably acted as seasonal occupations for small human groups, pasture-sheds were probably used as occasional shelters for few individuals engaged in the care of flocks grazing during spring/summer-time.

According to current data, it is clear that pastoral practices gave rise to different types of archaeological sites that have hitherto passed unperceived. The traditional dichotomy between 'open-air' and 'cave' sites is not sufficient per se to explicate the variability of the archaeological record. Many factors influence the site-formation processes, amongst which the type of activities that were carried out at the site, the duration of the occupation, and the geographical context in which the site was located. A detailed analysis of the stratigraphic sequence, material record, and environmental context would therefore be necessary to define the function of the site and its settlement pattern.

7.3.1.4. 3800-3000 cal BC: The Occupation of the Alpine Areas

From about 3800-3700 cal BC, one can note a gradual, but increasing pressure on the alpine areas. Anthropic signs emerge more clearly for this period from both an archaeological and palaeoecological point of view.

In the Aigüestortes i Estany de Sant Maurici National Park, human occupation is well-documented in the subalpine zone with an array of discontinuous settlements at Cova del Sardo Phase 7 and 6 (approximately between 4000 and 3200 cal BC) (Gassiot et al. 2014). Stratigraphic and chronological data indicates a pattern of short and repeated occupations, attesting the use of the cave as occasional shelter. Lithic analysis confirms this interpretation, suggesting maintenance and repairing activities and the absence of structured production processes. Tools show an episodic use that can mostly be referred to the arrangement of the inhabited area, refitting of weapons, and, occasionally, butchering.

As already mentioned, these two phases mark a slight change in the pattern of the *abri*'s occupation. Actually, while, during the previous phase, one observes a pastoral exploitation

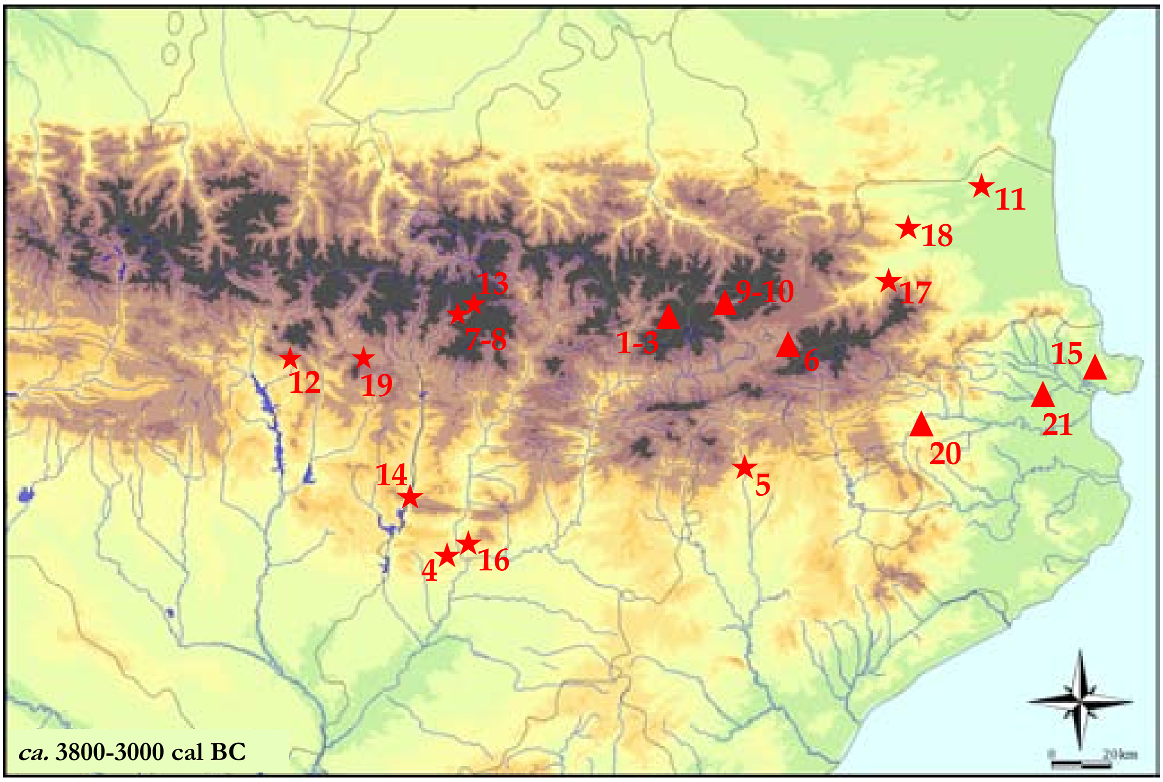

Fig. 7.18. Distribution of the sites between 3800-3000 cal BC. Stars represent cave sites, while triangles open-air settlements. Only dated sites are reported in the map. Site are number in chronological order. 1-3) Pla de Bacives and Els Estany-P008/P169/M085; 4) Cova Gran-level3N; 5) Cova de los Ossos-?; 6) Llo-II; 7) Cova del Sardo-phase7 and phase6; 8) Cova del SardoII; 9-10) Serrat de la Padrilla-C49/C75; 11) Grotte des Bruixes; 12) Espluga de la Puyascada-levelE.1; 13) Abric del Estany de la Coveta; 14) Cova Colomera-levelA; 15) Ca N'Isach-E-19; 16) Forat de la Conqueta-level2; 17) Grotte de la Chance-level0; 18) Caune de Bélesta-us16; 19) Cova de Els Trocs-phaseIII; 20) La Prunera-U.S.2; 21) Mas Bonet.

mainly focused on pastures surrounding the cave, from about 4000-3800 cal BC, the human impact on the subalpine areas of the San Nicolau Valley seems to have gradually been dwindling, with a recovery of forests and a decrease in anthropic disturbance (Gassiot et al. 2012b). This data corresponds with the emergence of a rising human pressure on the alpine regions, whereas the subalpine valleys probably rather became a place that people just passed through. Such an increase in human frequentation of high altitudes is verified by the appearance of archaeological sites over 2.000 m.a.s.l. In the Aigüestortes i Estany de Sant Maurici National Park, the first site to be documented at such heights is the Abric del Estany de la Coveta (3340-3025 cal BC), located at *ca.* 2.430 m.a.s.l. in the upper part of the Peguera River Valley. Human presence is there proved exclusively by a hearth, without any other archaeological material, so suggesting a very short and episodic occupation of the *abri* as an 'overnight' shelter (Gassiot & Jiménez 2008).

Palaeoecological studies also outline a similar scenario. At Estanilles Peat-Bog (*ca.* 2.250 m.a.s.l.), between Noguera de Cardós and Noguera de Vallferrera, not far away from Estany de la Coveta, an increase in grass taxa and a decrease in forest cover is recorded all along the Middle Neolithic period from *ca.* 4600 cal BC. This change occurred along with the first appearance of coprophilous fungi spores and other markers of grazing (Pérez-Obiol et al.

2012).

High-altitude occupations have also been encountered in Cerdagne, where two open-air structures located on Enveig Mountain at *ca.* 2.350 m.a.s.l. have been dated to between 3935-3640 and 3500-3030 cal BC (Hut 75) and between 3650 and 3125 cal BC (Hut 49) respectively (Rendu 2000). Both huts show stratified occupation with layers going back to Modern, Medieval, and Bronze Age. Neolithic chronologies have been obtained from the dating of three large burnt structures at the bottom of the sequences (Rendu 2000). Palaeoecological surveys in the surrounding areas confirm the presence of human activity, attesting a gradual clearance of local lands between *ca.* 3300 and 2900 cal BC, with the appearance of anthropogenic indicators such as Cichorioideae species, *Plantago lanceolata*, and *Artemisia,* along with a decrease in *Pinus* pollen percentages (Rendu et al. 1996).

Neolithic layers were also detected at the site of Llo II, located at *ca.* 1.600 m.a.s.l. in the south-western sector of Languedoc-Roussillon. This site, placed upon a high hill facing a plain area, shows contexts dating back to the Bronze and Middle-Neolithic Age (Chassey Culture), the latter with a chronology ranging from 3800 to 3380 cal BC (Campmajo 1976, 1983). The site is interpreted as a long-lasting seasonal open-air settlement, which was mainly associated with pastoral practices and complementary to occupations located in the valley bottom (at around 1.000-1.200 m.a.s.l.) (Rendu et al. 1996).

A similar scenario is also observed in Andorra, where new open-air sites have been documented at mountain altitudes, which go back to the fifth-fourth millennium cal BC: the site of Feixa del Moro in Juberri (4250-3300 cal BC) (Llovera 1986), characterized by both habitation and funerary structures, and the site of Carrer Llinàs 28, also in Juberri, which is interpreted as a possible workshop for manufacturing polished tools (Fortó et al. in press).

At higher altitudes, in the Andorran valleys of Madriu-Perafita-Claror, the human presence is attested by several open-air structures —both habitations and pastoral enclosures. At Pleta de les Bacives, four different sites have been surveyed and dated to between 3760 and 2935 cal BC (Orengo et al. 2014). Palaeoecological analysis also confirms the increasing anthropic pressure on the area between 4300 and 3500 cal BC. Actually, at Riu dels Orris Fen in the Madriu Valley (2.390 m.a.s.l.), a sharp decline in *Pinus* percentages is registered along with the spread of nitrophilous and ruderal taxa, both elements that indicate a stronger human impact on the alpine pastures (Ejarque et al. 2010). On the contrary, in the northern slope of the valley, at lower altitudes, specifically at Bosc dels Estanyols Peat-Bog (2.180 m.a.s.l.), a moderate recovery of pine woodland has been ascertained. Although grazing-induced pressure on this wooded environment did not fade away completely, the human impact on the subalpine slopes seems to have dwindled. Finally, between *ca.* 3500 and 3000 cal BC, a period of woodland recovery is also recorded at higher altitudes, specifically at Riu dels Orris Fen, thus suggesting a fluctuation in the extent of human activity, which often displays alternating periods of lower and higher anthropic pressure (Ejarque 2010).

The variety of occupations found at lower altitudes seems remarkable. Cave sites probably had different functions as dwelling-places often shared the same room as burials and stables (even if it is also possible that in some cases such occupations were not contemporary, but layers relevant to dwelling-places, burials, and stables follow one another in the stratigraphic sequence). Sheepfold caves with fumier-like deposits have been detected in the outer Sierras and in the Pyrenees forelands, such as at Caune de la Bélesta in the Pyrénées-Orientales region, dated to between 3330 and 2910 cal BC (Brochier et al. 1998; Brochier & Claustre 2000), and Cova Gran de Santa Lynia's Level 3 N in the Montsec chain, with dates ranging from 3700 to 3000 cal BC (Polo Díaz et al. 2014). However, at both sites, stabling episodes do not seem exclusive, but are associated with hearths and other dwelling structures.

Habitation layers have also been documented at Cova de Els Trocs Phase III (3325-2910 cal BC). At Els Trocs, the pattern of cave occupation appears to have been substantially unchanged with respect to the previous phases (Phase I and II): the site was mainly used as a living place —with the presence of several hearths and burnt areas— and may also have had burial/ritual functions. The main activities ascertained by the study of the archaeological record are related to the exploitation and slaughter of domestic ovicaprids, whilst other production processes are poorly attested (*cfr*. Chap. 5, Par. 5.4.4.4.)

Burials and inhumations have been encountered at Balma dels Ossos too (3800-3380 cal BC), in the Berguedà —even though their chronological attributions is still uncertain (Soriano 2013)— and at Forat de la Conqueta (3360-2935 cal BC) (González et al. 2011). Whereas the relevant available information about Espluga de la Puyascada's Level E.1 (Baldellou 1987a), Cova Colomera Phase II (Mangado et al. 2012), and Grotte de la Chance (Lemercier 2010) is still too scarce to advance a clear interpretation of the site and in some cases (i.e. Espluga de la Puyascada) scarcely reliable.

Finally, the presence of open-air settlements is documented in the Mediterranean sector of the Pyrenees and in the coastal area, which go back to around the end of the fourth millennium cal BC. Some of the main sites of that period are La Prunera (3340-2875 cal BC) (Alcalde et al. 2005a), Ca N'Isach's Level Io (3495-2910 cal BC) (Tarrus et al. 1992), and Mas Bonet (3400-2700 cal BC[10]) (Rosillo et al. 2012).

In conclusion, one can observe a consolidation of human presence in the mountainous zones of the Pyrenees between 3800 and 3000 cal BC, with the appearance of new sites in both mountain and alpine areas. In particular, the increase in human-induced fire events over 2.000 metres m.a.s.l. suggests land clearance for creating pastures at altitudes that had been only sporadically exploited in previous times. On the contrary, the subalpine areas of the Central Pyrenees appear to have been less affected by anthropic disturbance at that time, a fact that may be ascribed to a change in pastoral strategies, which then turned to the exploitation of alpine lands, whilst the valley bottoms mostly became just places of transit. However, one has to remark that a certain variability in land-use patterns existed on a small and local scale, therefore, the shown model should be actually only considered as an approximate one.

7.3.1.5. 3000-2100 cal BC: A Greater Impact on Mountain Environment

Towards the end of the fourth millennium, the human presence in the Pyrenean area appears to have been widespread and diversified. Alpine regions were regularly occupied and exploited with an increasing human-induced pressure shown by both archaeological and palaeoecological records. In the area of Aigüestortes i Estany de Sant Maurici National Park, a number of new occupations have been detected from *ca.* 3000 cal BC (Gassiot et al. 2014). Similarly to the situation encountered at Abric del Estany de la Coveta, such sites are characterized by a paucity of material record and poor evidence of structured dwelling-places, thus suggesting a very episodic occupation, which is defined 'overnight shelter'.

Abric del Portarró Rock-Shelter, situated at 2.300 m.a.s.l., has revealed the presence of a

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[10] Radiocarbon dates for the Mas Bonet-Late Neolithic phase are still unpublished. Calibrated dates (2σ) have been taken from Rosillo et al. (2010-2011: 54).

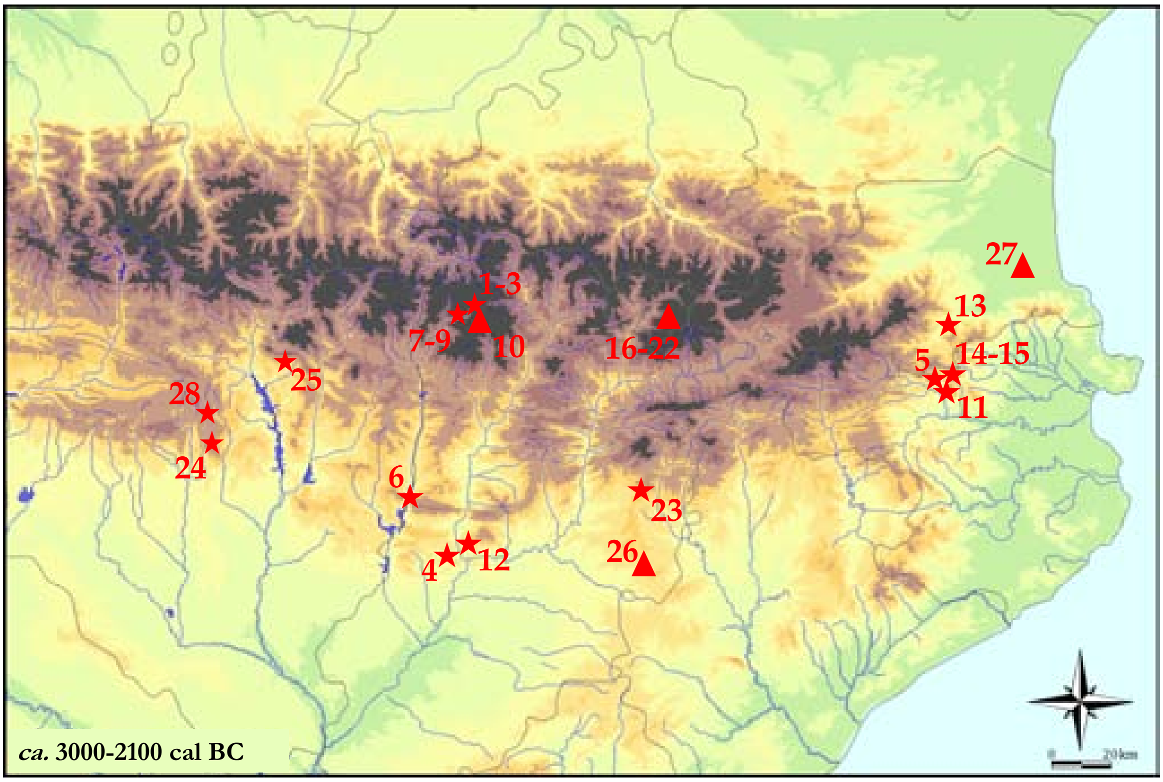

Fig. 7.19. Distribution of the sites between 3000-2100 cal BC. Stars represent cave sites, while triangles open-air settlements. Only dated sites are reported in the map. Site are number in chronological order. 1-4) Abric del Portarró-level3, Obagues de Raetera-level3, Abric del Lac Major de Saboredo-level5; 4) Cova Gran-FumiersT/P; 5) Cova 120-levelII; 6) Cova Colomera-CE8; 7-9) Cova del Sardo-phase5; Cova Serradé-survе1, Covetes-survey1; 10) Coma d'Escos-level4; 11) Bauma del Serrat del Pont-U.S.II/III; 12) Forat de la Conqueta-level1; 13) Balma de Montoboló-sup; 14-15) Cova del Senglar-?, Cova de la Pòlvora-level2; 16-22) Pleta de les Bacives and Els Estanys-P067/M218/M217/M175/M177/M151/M176; 23) Cova de les Portes-levelVI; 24) Cueva Drólica-levela; 25) Cueva del Forcón-sup; 26) Collet de Brics d'Ardèvol-CBA1/CBA2; 27) Cabana de Vigne Canut-?; 28) Cueva de los Cristales-Superficial.

prehistoric occupation dating back to between 3010 and 2690 cal BC, which is characterized by a burnt area associated with a few shards of hand-made pottery. The same pattern has also been found at Obagues de Ratera Rock-Shelter (2.310 m.a.s.l.), where remains of ceramic materials have been yielded from a black carbonaceous layer dated to 2880-2625 cal BC, and Abric de Lac Major de Saboredo (2450 m.a.s.l.), where the dating of wood charcoal has resulted in 2835-2460 cal BC. Finally, also an open-air building, a hut possibly provided with a roof framework, has been documented at Coma d'Espós, situated on the eastern slope of Montorroio Mountain (2.240 m.a.s.l.). There, one of the branches used for the timber work has been dated to 2890-2665 cal BC.

This data agrees with a general increase in anthropic pressure on the high-altitude areas, as observed in the Nogueras region by Pèlachs et al. (2011) and Pérez-Obiol et al. (2012). The analysis of pollen and soil macro- and micro-charcoals indicates a clear impact on the alpine landscape. From 3150 cal BC onwards, the strongest decline in *Pinus* pollen since the beginning of the Holocene has been registered at Estanilles Peat-Bog (2.250 m.a.s.l.). Such a decrease in the arboreal pollen matches a clear increase of herbaceous plants, coprophilous fungi, and shrub taxa, which probably indicate the practice of recurrent fires in order to maintain alpine pastures in the area (Cunill et al. 2012, 2013).

A similar scenario has also been observed in the Madriu-Perafita Valleys, where a growing human presence can be realized throughout the Final Neolithic/Chalcolithic Age (Ejarque 2010). This situation is confirmed by the discovery of a series of open-air structures at altitudes of around 2.500 m.a.s.l., specifically at the site of Els Estanys and at Pleta de les Bacives. At Els Estanys, in the Madriu Valley, four dwelling-places and two walls/enclosures have been dated to between 2470 and 2080 cal BC, while, in the Perafita Valley, a possible anthropic context goes back to 2870-2500 cal BC (Orengo et al. 2014). All of this data seems to underpin the existence of a seasonal occupation of alpine pastures, with the establishment of a small village with stockyards and house structures. In accordance with archaeological data, palaeoenvironmental analyses from the nearby Forcat Lake indicate a pine forest clearance from 2800 cal BC until 1650 cal BC. During that time, almost the whole alpine belt of the Madriu Valley appears to have been completely cleared and replaced with pastures, with a constant and continued pastoral pressure on the environment (Ejarque 2010).

The establishment of new sites emerges at subalpine altitudes, too, in the valley of Sant Nicolau. Two rock-shelters were occupied almost in the same period: Covetes (1.880 m.a.s.l.) (2575-2345 cal BC) and Cova Sarradé (1.910 m.a.s.l.) (2565-2345 cal BC). In addition, Cova del Sardo reflects such a situation, attesting an occupational context that goes back to between 2865 and 2495 (Gassiot et al. 2014). The settlement pattern at Cova del Sardo does not seem to have changed substantially with respect to the previous phases (especially Phase 7-6), this indicating the use of the cave as an occasional shelter, probably during the 'migration' towards the high-mountain areas. For this phase, one has to point out the presence of several large blades made out of exogenous lithic materials coming from the Ebro-Valley chert formations. Such tools were not produced on-site, but were transported to Cova del Sardo already flaked, in form of prepared blanks. This data seems to suggest that the groups who inhabited the Axial Pyrenees were integrated within a much wider geographical context, which included the pre-Pyrenees and the Ebro forelands (Mazzucco et al. 2013b).

At the same time as the human presence consolidated in the Axial Pyrenees, the settlements in the pre-Pyrenees appear to have dropped in number from about 3000 cal BC and Forcón Cave is actually the only site at mid-altitudes known for that period (2835-2290 cal BC). Moreover, this dating is not completely reliable as the analysed sample comes from a disturbed deposit (Baldellou 1985c).

On the contrary, at lower altitudes, in the Sierras Exteriores and in the forelands, the settlement patterns appear to have been fundamentally unchanged, with a mixed occupation model featured by both cave and open-air contexts.

Layers with evidence of dwelling are documented in several caves of the period, amongst which: Cueva de les Portes (2880-2455 cal BC) (Castany et al. 2006), Bauma del Serrat del Pont (with dates ranging between 2920 and 2030 cal BC) (Alcalde et al. 1998), and Cova de la Pòlvora (2865-2470 cal BC) —which was mainly used as storage place (Bosch et al. 1995). More uncertain or partial data has been published for Cueva Drólica (2575-2465 cal BC) (Montes & Martínez-Bea 2006) and Cova Colomera (2915-2675 cal BC) (Oms et al. 2008). About Cova del Senglar (2880-2480 cal BC) (Bosch 1994), Cova 120 (3025-2615 cal BC) (Agustí et al. 1987), Forat de la Conqueta (with a series of dates between 2880 and 2210 cal BC) (González et al. 2011), and Balma de Montboló in the Pyrénées-Orientales region (2895-2475 cal BC) (Guilaine et al. 1974), the relevant occupation seems to have mostly been connected with the practice of collective burials.

Finally, at Cova Gran of Santa Linya, a sequence of fumier deposits have recently been detected in different parts of the cave, which suggest repeated stabling episodes occurred between 3060-2910 and 2875-2580 cal BC (Mora et al. 2011; Polo Díaz et al. 2014). Nevertheless, these results are still preliminary and only further excavations might shed light on the type and intensity of human occupation at the cave.

However, the largest habitation sites of that time appear to have been located in the peripheral area of the Pyrenees, outside the mountain ranges. One of the most interesting contexts is Collet de Brics d'Ardèvol (2828-2235 cal BC) (Castany et al. 1992). The site has been interpreted as a seasonal, open-air settlement, characterized by several habitation structures, mainly large stone-lined hearths. The poor evidence of any sound agricultural production (e.g. absence of silos and large storage vessels) has led the authors to interpret the site as a pastoral winter settlement, strictly associated with the spring-summer exploitation of the near mountain areas of the pre-Pyrenees and Axial Pyrenees.

On the other hand, settlements with a stronger agricultural orientation have been excavated further south in the central and eastern sector of the Ebro Valley, amongst which one can mention Camp del Rector (*ca.* 3000-2900 cal BC) (Font i Piqueras 2005) and Espina C (*ca.* 2900-2500 cal BC) (Teixidó et al. 2009)[11]. These settlements generally extended over large areas, without any defensive structure and with dispersedly-arranged habitation units, mainly identified on the basis of shed bases and a great number of silos/pits (Martín 2003).

In conclusion, the general pattern observed for the Late Neolithic/Chalcolithic period seems to suggest: 1) an increasing pressure on high-altitude areas with the consolidation of human activity in both subalpine and alpine zones, mainly in relation to pasture exploitation; 2) a varied occupation pattern in the Sierras Exteriores, which concerned caves, rock-shelters, and open-air sites (e.g. sheepfold and storage caves; collective burials; seasonal autumn/winter habitations), and 3) the appearance in the plain areas of larger open-air sites characterized by the presence of huts and several silos/pits.

To this point, it is interesting to remark the scarcity of sites in the pre-Pyrenean ranges, a fact that creates a sort of 'gap' between the Ebro Basin and the Axial Pyrenees. Indeed, beginning from the Late Neolithic Age, the whole pre-Pyrenean area mostly seems to attest funerary contexts such as sepulchral caves and megaliths, while habitation sites were decreasing. Such a pattern may indicate a change in the mobility strategies of the agro-pastoral populations: while, during the Early/Middle Neolithic Age, the existence of open-air settlements and sheepfold caves at mountain altitudes (800-1.700 m.a.s.l.) suggests a short- and mid-distance mobility —from the valley bottoms to the alpine peaks (?)—, such distances seem to have increased towards the Chalcolithic Age, a fact that may support the idea of an enhancing mobility from the foreland plains to the Axial Pyrenees. The appearance of open-air sites in the exterior ranges of the Pyrenees that appears strongly oriented toward pastoral exploitation such as Collet de Brics d'Ardèvol (Castany et al. 1992), well fit within this model of a larger mobility. However, given the partial archaeological information and the scarcity of systematic surveys in most of the pre-Pyrenees, all these considerations should only be taken as hypothesis-generating, whereas further confirmations would definitely be required.

[11] Both Camp de Rector and Espina C sites have been included in the text because relevant to the discussion. However, they have been excluded from the map and the radiocarbon plot because located further south. Calibrated dates have been taken from the respective publications (Font i Piqueras 2005; Teixidó et al. 2009).

8. CONCLUSIONS

The knowledge of Pyrenees' prehistoric occupation has improved over the last ten years. From a geographical space that was mainly seen as a barrier to the dispersal and development of human societies, mountain spaces now appear to be fully integrated within the social dynamics of the prehistoric and proto-historic periods.

About the southern Central Pyrenees[1] —according to current data—, their anthropization would not have begun earlier than the sixth millennium cal BC. Pre-existing hunter-gatherer populations only marginally occupied those areas, rarely penetrating into the inner mountainous zones. Until now, only a few Upper Palaeolithic/Mesolithic sites have been detected at higher altitudes and their pattern of land exploitation is still largely unknown.

A marked increase in the process occurred only with the appearance of agro-pastoral communities in the northeast of the Iberian Peninsula, toward the end of the sixth millennium cal BC. At the beginning, the first settlements of these Neolithic communities were mainly located in the outer ranges of the Pyrenees, while scarce traces of human presence have been detected at higher heights. However, a gradual but increasing process of occupation of mid- and high-altitude places began as early as during the first half of the fifth millennium cal BC. In about 500-700 years, both the subalpine and alpine uplands appear to have been settled by human groups, although still showing a scattered distribution, probably characterized by short and discontinuous season-based occupations. This process appears more evident as from the end of the fourth and throughout the third millennium cal BC as a greater number of human settlements have progressively been found.

The economy of those first settlers displays a well-developed production system. The largest habitations witness a mixed farming model, in which agriculture and animal husbandry provided most of food supplies[2]. Craft activities were well-developed and made use of a great variety of both biotic and abiotic raw materials for the production of goods of diverse value and function. Storage facilities and technologies have also been ascertained.

An example of such a settlement pattern is Cueva de Chaves. The analysis of the lithic assemblage presented in this work has confirmed the economic orientation of this occupation that, despite being a cave-site, can be considered a large and stable habitation. A wide range of food-production processes was carried out at the site (e.g. grain harvesting, processing, and storing; animal slaughter and meat processing). In addition, several craft activities were carried out, including structured manufacturing processes characterized by

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[1] I am now referring to the Central Pyrenees as a whole, thus including all regions that extend from the External Sierras to the Axial Pyrenees. Before the seventh millennium cal BC, even if Mesolithic sites are known in the External Sierras, the Axial zone and the mountain elevations were only marginally and episodically affected by human occupations, therefore the word 'anthropization' does not seem to apply.

[2] The scarcity of open-air contexts in the Central Pyrenees is remarkable. For the Middle Neolithic Age, interesting data has recently been obtained from the sites of Sanabastre and Camp del Colomer. However, more detailed information on the economic organization of the first Neolithic settlers is available from the Mediterranean/coastal area. There, a greater number of stable, open-air settlements have been excavated. The resulted data indicates that agriculture was carried out in permanent field with a diversity of crops (mainly naked wheat and barley). Livestock included sheep, goats, pigs, and cattle; their exploitation was mainly oriented towards meat production, although also milk and dairy production has recently been proposed (for more references, see Molist et al. 2003; Gibaja & Clop 2012; Antolín et al. 2014).

several stages such as: the entire cycle of hide- and leather-working, making of beads and ornaments, and the production, finishing, and repairing of pottery vessels.

Nevertheless, while a wide range of economic processes are documented amongst the largest habitations —which were mainly located in the range foothill or, anyway, near the valley bottom—, smaller seasonal occupations appear to have focused on a reduced array of activities. In particular, about sub-alpine and alpine sites, archaeological and palaeoecological data indicates an orientation towards pastoral practices.

Several 'typologies' of sites have been identified in the Central Pyrenees for the time between the sixth and the third millennium cal BC, from stable-caves —often mixed with dwelling layers— to small shelters used as pasture sheds or overnight refuges (both cave and open-air sites), which were often situated at high altitudes (1.700-2.400 m.a.s.l.). Actually, it seems that pastoral practices gave rise to a variability of settlements in terms of size, function, season of occupation, etc., which, however, have often passed unperceived since they are little attractive from an archaeological point of view (e.g. hardly detectable sites; logistic impediments; poor material record; etc.).

Some examples of this type of sites have been dealt with in this work. Cova del Sardo de Boí is a small rock-shelter located at 1.790 m.a.s.l. in the Axial Pyrenees. Four different phases of occupation have been investigated, revealing the existence of a reduced range of economic activities. The site appears to have been occupied mainly seasonally, specifically as a shelter during the exploitation of sub-alpine and alpine pastures for putting livestock out to graze. Only domestic activities have been detected at the site in relation to the maintenance of habitation area and artefacts. Hunting appears to have been practiced only occasionally, mainly intended for meat consumption, whereas no further processing of game was carried out there (e.g. hide-working or meat processing and storing).

The sites of Cova de Els Trocs and Espluga de la Puyascada seem to show a different pattern. Both are located in the uplands (between *ca.* 1.300 and 1.600 m.a.s.l.), specifically in large karstic caves. There, the main production activity was the slaughter of domestic animals (especially young individuals), whilst agriculture was not practised either on site or in the surrounding areas. Activities relevant to artefacts maintenance and finishing have also been documented, especially ceramic-vessels repairing; however, evidence of complex craft activities is absent.

What emerges from this scenario is that the occupation of higher mountain areas appears to have been related to the development of mobile herding strategies. In fact, animal farming played a fundamental role not only for the establishment of settlements, but, more generally, also in shaping the mountain landscape: since the Middle Holocene, the growing anthropic and grazing pressure represented the main factor in terms of vegetation change, with an increase in deforestation and the expansion of alpine grasslands.

Nevertheless, it is important to remark that, in the case of the southern Central Pyrenees, mobile pastoralism does not seem to have represented an alternative to farming, but it was embedded —at least for the period under analysis— in a mixed agro-pastoral economy. There are several elements that witness the mixed nature of such a subsistence model, amongst which the usual presence of agricultural tools and cereal provisions —albeit always in very small quantities— also at mountain and high-altitude sites. Moreover, the expansion towards the inner mountain areas (during the first half of the fifth millennium cal BC) was a gradual process, probably not based on long-lasting and long-distance movements, but more likely on short-lasting mid-distance cyclical migrations. Actually, at the same time as the appearance of the first sites at sub-alpine and alpine altitudes, stable (or semi-stable) open-air villages were established at mountain altitudes, too (900-1.400 m.a.s.l.). This scenario suggests a mobility pattern mainly based on intra-mountain movements between sites located close to the valley bottom and those situated at middle and high mountain altitudes. Empirical data in this respect is still scanty and such an interpretation should be only taken as hypothetical. The main difficulty for a reconstruction is given by the lack of evidence of open-air sites in the southern Central Pyrenees. However, such a scarcity of open-air contexts —which represents the most common pattern of stable habitation during the Neolithic Age— should be ascribed to biased archaeological records caused by the surveys themselves and, above all, to the limited number of rescue or preventive archaeological works in mountain areas[3].

According to current data, there is no certain archaeological evidence that may support the existence of either long-distance pastoral movements[3] or specialized pastoral groups during the Neolithic Age. More likely, one can verify a temporary settlement of at least small groups of people engaged in herding, who were anyway integrated within a larger group/community that relied on a mixed farming economy. A change possibly occurred as from the end of the third millennium, but the relevant data is still so scarce that it does not even deserve a deeper discussion and, moreover, this work has touched upon that period only marginally.

While approaching territorial and economic organization in the southern Central Pyrenees during the Neolithic period, it is important to remember that it has not been possible to ascertain —from an archaeological point of view— any substantial difference in terms of cultural characteristics, technical traditions, resource exploitation, *etc.* between the Pyrenean area and the foreland regions. In brief, no evidence of any isolation or marginalization of the mountain areas has hitherto been detected in relation to the areas located at lower altitudes.

Whenever a sufficient material record has been recovered, the attribution to the same 'culture' has been proposed for both mountain and lower-altitude sites (e.g. cardial, epicardial, postcardial, *etc.*). The material record undoubtedly shows a quantitative reduction from the lower lands to the high-altitude sites; however, from a technological and stylistic point of view, no substantial difference can be observed. The same types of raw materials were exploited in the entire analysed area and were processed by the same techniques. The circulation of lithic raw materials is a good example of such a uniformity. The occurrence of the Ebro-Basin chert types over a large region, which connected the forelands with the Axial Pyrenees, is indicative of the existence of a large geographical interaction and resource sharing. Moreover, the circulation of certain typologies of artefacts during the Neolithic Age, specifically from the Early Neolithic to the Final Neolithic/Chalcolithic times (e.g. sickle blades with parallel insertions, Mediterranean marine shells, variscite beads, bone spoons, fragments of *silex blond,* tools on *plaquette* chert, long-blades, *etc.*) attests to an integration of those Pyrenean groups within a broader social space, which definitely extended beyond the

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3 It is remarkable that the only open-air sites located in the Axial Pyrenees (*ca.* 1.300 m.a.s.l.) have been discovered in Andorra, where several construction projects have been carried out over mountain regions during the last decade, which actually implied large mechanical excavations.

4 In this work, I prefer to avoid the term 'transhumant'. This word has its origins in eighteenth-century Castile, Spain, and refers to the long-distance transhumant routes of *La Mesta*, which represented one of the most developed form of pastoral organizations of Medieval and Modern Europe. In particular, the Mesta pasturage privileges during the fifteenth-seventeenth centuries contributed to the agricultural decay of Spain. Repressive measures against agriculture and enclosures were taken by the Catholic Monarchs to safeguard the Mesta Institution. Thus, the transhumant system in its origins (at least in its etymological origins) was a system strongly opposite to agriculture and sedentary sheep raising. In this sense, I do not consider the term appropriate to define a small-scale mobile herding that appears to have been integrated within a mixed farming system.

Pyrenean boundaries and included plains and coastal areas.

I am not asserting that the north-eastern sector of the Iberian Peninsula represented an homogeneous space —nor were the Pyrenees as a whole— without regionalisms or differences, especially considering the large chronological span embraced by this work. Regional fragmentation and boundaries probably existed and changed over time; however, they did not give rise to substantially different economic models or the currently-available empirical data is anyway too poor to make distinctions between them.

In general terms, I can affirm that no evident breaks have been observed in the southern Central Pyrenees from the Early to the Final Neolithic Age; more or less continuous processes of demographic, economic, and technological development seem to emerge instead. For the entire period, a widespread agro-pastoral economy is attested[5], always marginally integrated by gathering and, to a lesser extent, hunting and fishing (whenever possible). Within this model, a slight variability between sites is accepted as local environmental (type of vegetation, soil potential for agriculture, availability of fresh pastures) and climatic (dry or humid areas) conditions certainly influenced economic practices and their outcomes.

The economic variability, which I have observed between the various archaeological contexts analysed in this work, then does not mark a separation line between sites based on different economic models; quite the contrary, this variability points out the complementarity between different occupations belonging to the same economic system and settlement pattern. Sheepfold caves and pasture sheds appear to have been integrated within a network of larger habitations, which is still largely unknown in the region. However, beginning from the fifth-fourth millennium cal BC, the gradual land clearance and exploitation of high-altitude permanent pastures for feeding livestock as well as the existence of small-groups, within Neolithic communities, (seasonally?) engaged in herding should be assumed as a fact[6] (at east for the area under question). Hopefully, in the near future, with the advance in archaeological practice and the excavation of new sites, it will be possible to discuss more extensively what this may imply in terms of social and territorial organization. Archaeological research in the Central Pyrenees is definitely still in its infancy.

When I started this research, in 2010, the human occupation of the Central Pyrenees was still little understood. Explanatory models had been formulated only on a small, local scale and a wider approach was still missing. The function of many sites, caves, and other shelters located at mid- and high-altitudes represented an open question. If they were occupied for herding, hunting, or other economic activities, it was still largely to demonstrate by empirical data. Moreover, many excavations had just started and the first results were only published during the last year, if not still unpublished. Actually, it is remarkable that an increasing number of works have been published during the last years, which deal with the ways of occupation of the Pyrenean Mountains at different altitudes, from both an archaeological and palaeoecological point of view. In particular, the emergence of mobile pastoral activities

[5] I am not entering the debate about whether Neolithic farming was extensive or intensive, as it is not the objective of this work and it has not been discussed before. Several authors (among others, Boogard 2005, Halstead 2006) have proposed a 'small-scale intensive mixed farming' for European and Mediterranean Neolithic Age. This model has recently been extended to the NE of the Iberian Peninsula, too (Antolín et al. 2014). However, other scholars have suggested the existence of an extensive mixed farming model (Rojo et al. 2008; Alday et al. 2012b). In the case of the southern Pyrenees, data is still too insufficient to discern between them.

[6] Similar results have been obtained by Helmer et al. (2005) and Bréhard et al. 2010 for the Chassey Culture of southern France dating back to between the fifth and the fourth millennium cal BC.

is drawing more and more scholarly attention[7]. With this thesis, I have contributed to this and to other issues from several points of view:

i. The traceological analysis has allowed economic information to be drawn from the lithic record. Chipped stone assemblages have turned out to be a proper tool for the economic interpretation of archaeological contexts, given their ubiquity and their fairly good preservation. Moreover, the study has pointed out the necessity of a thorough sampling for identifying all the different economic processes carried out at each site and the strategies of resource exploitation.

ii. A statistical comparison of the obtained data has been carried out in order to verify the significance of the relevant outcomes. Combining this approach with data coming from other types of artefacts, it has been possible to advance a comprehensive reconstruction of the site function and so to figure out the settlement patterns adopted in the region. Hopefully, enlarging the sample, when more archaeological works will be available for the area concerned, it will be possible to tackle smaller geographical and chronological contexts.

iii. In addition, lithic materials have provided important information on technological organization and mobility patterns. The analysis of lithic raw-material provenance and its technological management has allowed economic activities to be contextualized within a larger geographical and social framework. The analysis of mobility has been a crucial aspect in understanding the ways of mountain-space occupation.

iv. Finally, the diachronic integration of all this data within a chronological and spatial framework has brought to detect —or at least hypothesize— trends in the occupational and socio-economic dynamics. In this respect, the integration of the palaeoenvironmental and palaeoecological dataset has turned out to be essential, which, especially for mountain areas, represents a precious source of information on landscape-exploitation and -management practices carried out by prehistoric groups.

In conclusion, this research brings new and considerable data to the understanding of the human occupation of the Pyrenees. About this region, an integrated approach to lithic materials has never been attempted, at least for the Neolithic period. Enlarging the sample and including new contexts in the study, it will certainly be possible to provide a more detailed data for a further investigation of the variability of human occupations in the area and their economic organization.

I believe that this work makes it clear that the environmental and human history of the Pyrenees cannot be understood without integrating mountains in a broader space, including the forelands and even coastal areas of the Mediterranean Sea and the Atlantic Ocean. The other way round, the explanatory models about how prehistoric societies developed and organized themselves in the Western Mediterranean context cannot ignore mountain areas for their reconstruction, because of these presumably being marginal areas, less suitable for human settlement. An integrative approach should always be carried out and the results of the last ten years of archaeological researches on the Pyrenees confirm it.

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[7] Several works have recently been published directly or indirectly related to Pyrenees and herding practices: Cunill et al. (2013); Oms et al. (2013); Rendu et al. (2013); Gassiot et al. (2014); Orengo et al. (2014); Polo Díaz et al. (2014).

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10. ANNEX I

SITE/PHASE		OTR	LOM	EVP	MEC	TOT
Chaves 1.b	N	42	1218	138	34	1432
	E	163,2	984,0	159,7	125,2	1432,0
	%	*2,9%*	*85,1%*	*9,6%*	*2,4%*	*100,0%*
Trocs 1	N	12	46	3	44	105
	E	12,0	72,1	11,7	9,2	105,0
	%	*11,4%*	*43,8%*	*2,9%*	*41,9%*	*100,0%*
Trocs 2	N	2	27	5	34	68
	E	7,7	46,7	7,6	5,9	68,0
	%	*2,9%*	*39,7%*	*7,4%*	*50,0%*	*100,0%*
Trocs 3	N	7	28	7	46	88
	E	10,0	60,5	9,8	7,7	88,0
	%	*8,0%*	*31,8%*	*8,0%*	*52,3%*	*100,0%*
Sardo 8	N	29	9	7	0	45
	E	5,1	30,9	5,0	3,9	45,0
	%	*64,4%*	*20,0%*	*15,6%*	*0,0%*	*100,0%*
Sardo 7	N	73	22	18	7	120
	E	13,7	82,5	13,4	10,5	120,0
	%	*60,8%*	*18,3%*	*15,0%*	*5,8%*	*100,0%*
Sardo 6	N	39	5	22	8	74
	E	8,4	50,8	8,3	6,5	74,0
	%	*52,7%*	*6,8%*	*29,7%*	*10,8%*	*100,0%*
Sardo 5	N	28	16	21	3	68
	E	7,7	46,7	7,6	5,9	68,0
	%	*41,2%*	*23,5%*	*30,9%*	*4,4%*	*100,0%*
Puyascada E.2	N	0	28	6	2	36
	E	4,1	24,7	4,0	3,1	36,0
	%	*0,0%*	*77,8%*	*16,7%*	*5,6%*	*100,0%*
TOT	N	232	1399	227	178	2477
	%	9,4%	56,5%	9,2%	7,2%	100,0%

Tab. 7.1. Raw materials composition of all the occupational phases considered in this work: *N*: indicates the number of elements for each category; *E*: indicates the attended frequencies for each category; *%*: reports the percentages computed on the row totals. *OTR*: Other rocks; *LOM*: Lacustrine Oligocene-Miocene cherts; *EVP*: Evaporitic Upper Cretaceous-Palaeocene cherts; *MEC*: Marine Cretaceous cherts.

DIMENSION	Singular value	Inertia	Inertia proportions		Confidence		
			Explicated	Accumulated	Standard deviation	Correlation	
						2	3
1	,941	,886	,946	**,946**	,004	-,048	-,013
2	,218	,047	,051	**,997**	,011		,244
3	,054	,003	,003	1,000			
Tot		,936	1,000	1,000			

Tab. 7.2. Simple Correspondence Analysis (CA). Resume table for the analysed variables: «Site_phases» and «Raw_material». The first two dimensions (in red colour) explicate the 99.7% of the variance.

SITE/PHASE	Mass	Factorial weight		Inertia	Contribute				
					from point to dimension		della dimensione all'inerzia del punto		
		1	2		**1**	**2**	**1**	**2**	**Totale**
Trocs1	,100	-,323	-,636	,019	,011	,186	,516	,462	1,000
Trocs2	,100	-,226	-,564	,012	,005	,146	,410	,589	1,000
Trocs3	,100	-,378	-,712	,024	,015	,233	,549	,451	1,000
Sardo5	,100	-,353	**,326**	,015	,013	,049	,789	,156	1,000
Sardo6	,100	-,542	**,367**	,031	,031	,062	,889	,094	1,000
Sardo7	,100	-,774	**,752**	,070	,064	,260	,810	,177	1,000
Sardo8	,100	-,283	**,347**	,010	,009	,055	,731	,254	1,000
Chaves1.b	,100	**2,831**	,139	,755	,851	,009	,999	,001	1,000
PuyaE.2	,100	,048	-,020	,000	,000	,000	,693	,028	1,000
Total	1,000			,936	1,000	1,000			

Tab. 7.3. Simple Correspondence Analysis (CA). Resume table for variable SITE_PHASE. In the red colour the highest values for each dimension.

RAW_MAT	Mass	Factorial weight		Inertia	Contribute				
					from point to dimension		from dimension to point		
		1	2		**1**	**2**	**1**	**2**	Total
OTR	,250	-,871	**,536**	,195	,011	,186	,916	,080	1,000
LOM	,250	**1,621**	,031	,618	,201	,330	1,000	,000	1,000
EVP	,250	-,153	,176	,009	,698	,001	,593	,183	1,000
MEC	,250	-,597	-,743	,114	,006	,036	,736	,263	1,000
Total	1,000			,936	,095	,634			

Tab. 7.4. Simple Correspondence Analysis (CA). Resume table for variable RAW_MAT. In the red colour the highest values for each dimension. *OTR*: Other rocks; *LOM*: Lacustrine Oligocene-Miocene cherts; *EVP*: Evaporitic Upper Cretaceous-Palaeocene cherts; *MEC*: Marine Cretaceous cherts.

DIMENSION	Singular value	Inertia	Inertia proportions		Confidence		
			Explicated	Accumulated	Standard deviation	Correlation	
						2	3
1	,807	,652	,866	**,866**	,006	,240	,273
2	,260	,068	,090	**,956**	,023		-,076
3	,182	,033	,044	1,000	,025		
Total		,753	1,000	1,000			

Tab. 7.5. Simple Correspondence Analysis (CA). Resume table for the analysed variables: «Site_phases» (Cueva de Chaves excluded) and «Raw_material». The first two dimensions (in red colour) explicate the 95.6% of the variance.

SITE/PHASE	Mass	Factorial weight 1	Factorial weight 2	Inertia	Contribute: from point to dimension 1	from point to dimension 2	from dimension to point 1	from dimension to point 2	Total
Trocs1	,100	-1,233	,087	,128	,188	,003	,958	,002	1,000
Trocs2	,100	-1,008	-,230	,083	,126	,020	,982	,016	1,000
Trocs3	,100	-1,137	-,763	,120	,160	,224	,872	,126	1,000
Sardo5	,100	**,590**	,317	,039	,043	,039	,717	,066	1,000
Sardo6	,100	**,920**	-,551	,083	,105	,117	,823	,095	1,000
Sardo7	,100	**1,565**	-,163	,209	,303	,010	,948	,003	1,000
Sardo8	,100	**,677**	,068	,039	,057	,002	,950	,003	1,000
PuyaE.2	,100	-,376	**1,235**	,051	,017	,586	,222	,772	1,000
Total	1,000			,753	1,000	1,000			

Tab. 7.6. Simple Correspondence Analysis (CA). Resume table for variable SITE_PHASE (Cueva de Chaves excluded). In the red colour the highest values for each dimension.

RAW_MAT	Mass	Factorial weight 1	Factorial weight 2	Inertia	Contribute: from point to dimension 1	from point to dimension 2	from dimension to point 1	from dimension to point 2	Total
OTR	,250	**1,286**	-,175	,343	,512	,029	,974	,006	,020
LOM	,250	-,625	**,758**	,119	,121	,553	,664	,315	,021
EVP	,250	**,364**	,072	,051	,041	,005	,530	,007	,463
MEC	,250	-1,026	-,656	,241	,326	,413	,882	,116	,002
Total	1,000			,753	1,000	1,000			

Tab. 7.7. Simple Correspondence Analysis (CA). Resume table for variable RAW_MAT. In the red colour the highest values for each dimension. *OTR*: Other rocks; *LOM*: Lacustrine Oligocene-Miocene cherts; *EVP*: Evaporitic Upper Cretaceous-Palaeocene cherts; *MEC*: Marine Cretaceous cherts.

RAW_MAT		Waste	Flake	Blade	Core trimming elements	Core	TOT
OTR	**N**	51	102	9	5	11	178
	%	28,7%	57,3%	5,1%	2,8%	6,2%	100%
LOM	**N**	37	760	530	37	29	1393
	%	2,7%	54,6%	38,0%	2,7%	2,1%	100%
EVP	**N**	32	104	87	1	1	225
	%	14,2%	46,2%	38,7%	0,4%	0,4%	100%
MEC	**N**	42	73	27	26	8	176
	%	23,9%	41,5%	15,3%	14,8%	4,5%	100%
TOT	**N**	162	1039	653	69	49	1972
	%	8,2%	52,7%	33,1%	3,5%	2,5%	100%

Tab. 7.8. Technological composition for each class of raw-material. Indeterminate lithologies have been excluded from this table. *OTR*: Other rocks; *LOM*: Lacustrine Oligocene-Miocene cherts; *EVP*: Evaporitic Upper Cretaceous-Palaeocene cherts; *MEC*: Marine Cretaceous cherts.

SITE/PHASE		Waste	Flake	Blade	Characteristic core trimming elements	Core	TOT
Trocs 1	N	7	17	21	3	1	49
	%	14,3%	34,7%	42,9%	6,1%	2,0%	100,0 %
Trocs 2	N	3	14	14	1	0	32
	%	9,4%	43,8%	43,8%	3,1%	0,0%	100,0 %
Trocs 3	N	3	16	15	1	0	35
	%	8,6%	45,7%	42,9%	2,9%	0,0%	100,0 %
Sardo 8	N	7	6	18	4	2	37
	%	18,9%	16,2%	48,6%	10,8%	5,4%	100,0 %
Sardo 7	N	10	4	10	0	0	24
	%	41,7%	16,7%	41,7%	0,0%	0,0%	100,0 %
Sardo 6	N	6	6	26	0	1	39
	%	15,4%	15,4%	66,7%	0,0%	2,6%	100,0 %
Sardo 5	N	0	4	10	1	0	15
	%	0,0%	26,7%	66,7%	6,7%	0,0%	100,0 %
Puya E.2	N	0	8	22	2	2	34
	%	0,0%	23,5%	64,7%	5,9%	5,9%	100,0 %
Tot	N	36	75	136	12	6	265
	%	13,6%	28,3%	51,3%	4,5%	2,3%	100,0 %

Tab. 7.9. Technological composition for three Pyrenean sites (Cova de Els Trocs; Cova del Sardo; Espluga de la Puyascada). Cueva de Chaves has been excluded. Only Evaporitic Upper Cretaceous-Palaeocene and Lacustrine Oligocene-Miocene cherts have been considered. All the indeterminate elements have been excluded from this table.

SITES/PHASES	BUT	PWC	HUN	HA	HP	HI	MIN
CH1.b	6,80	10,20	8,00	5,60	33,40	18,00	18,00
TR1	26,30	2,60	13,20	5,30	34,20	0,00	18,40
TR2	29,60	7,40	3,80	0,00	48,10	0,00	11,10
TR3	22,20	5,60	5,60	0,00	44,40	0,00	22,20
PYE.2	28,10	3,10	0,00	15,60	37,50	6,30	9,40
SA8	14,30	0,00	28,60	0,00	57,10	0,00	0,00
SA7	8,30	20,80	25,10	0,00	45,80	0,00	0,00
SA6	14,30	28,50	28,60	0,00	28,60	0,00	0,00
SA5	13,30	6,70	13,30	0,00	66,70	0,00	0,00

Tab. 7.10. Raw data used for Hierarchical Cluster Analysis with Single Linkage method. All the values represent percentages. ACTIVITY - *BUT*: Butchering Activities; *PWC*: Plant-Wood Crafting Activities; *HUN*: Hunting activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances. SITE/PHASES - *CH1.b*: Cueva de Chaves, level 1.b; *TR1*: Cova de Els Trocs I; *TR2*: Cova de Els Trocs II; *TR3*: Cova de Els Trocs III; *PYE.2*: Espluga de la Puyascada, level E.2; *SA8*: Cova del Sardo, phase8; *SA7*: Cova del Sardo, phase7; *SA6*: Cova del Sardo, phase6; *SA5*: Cova del Sardo, phase5.

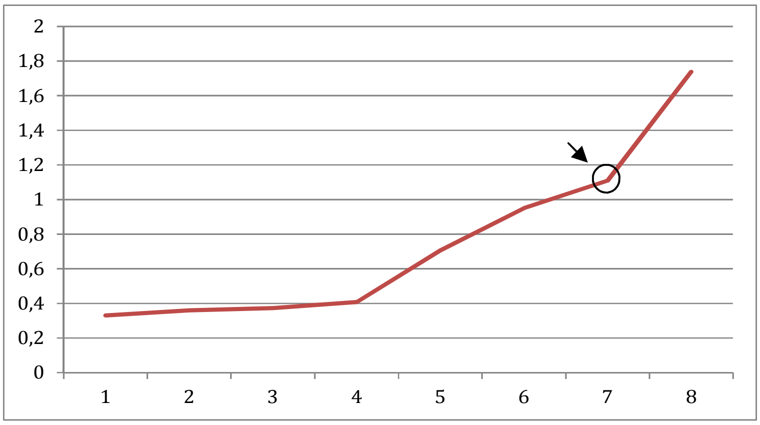
		BUT	PWC	HUN	HA	HP	SK	HI	MIN
	Pearson Corr.	1							
BUT	Sig. (bilteral)								
	N	9							
	Pearson Corr.	-,470	1						
PWC	Sig. (bilateral)	,202							
	N	9	9						
	Pearson Corr.	-,594	,503	1					
HUN	Sig. (bilateral)	,092	,167						
	N	9	9	9					
	Pearson Corr.	,371	-,330	-,552	1				
HA	Sig. (bilateral)	,326	,385	,123					
	N	9	9	9	9				
	Pearson Corr.	,211	-,513	,116	-,436	1			
HP	Sig. (bilateral)	,585	,157	,766	,241				
	N	9	9	9	9	9			
	Pearson Corr.	-,522	,051	-,031	-,072	-,031	1		
SK	Sig. (bilateral)	,150	,896	,938	,853	,937			
	N	9	9	9	9	9	9		
	Pearson Corr.	-,336	-,058	-,367	,493	-,590	,203	1	
HI	Sig. (bilateral)	,376	,883	,331	,178	,094	,601		
	N	9	9	9	9	9	9	9	
	Pearson Corr.	,408	-,409	-,692*	,288	-,275	-,332	,379	1
MIN	Sig. (bilateral)	,275	,275	,039	,452	,473	,383	,314	
	N	9	9	9	9	9	9	9	9

Tab. 7.11. Bivariate Correlation with Pearson method between the selected variables (for Hierarchical Cluster Analysis with Single Linkage method). The * indicates that the correlation is significant at 0.05 level (bilateral). *BUT*: Butchering Activities; *PWC*: Plant-Wood Crafting Activities; *HUN*: Hunting activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

SITE/PHASES	1:CH	2:TR1	3:TR2	4:TR3	5:SA8	6:SA7	7:SA6	8:SA5	9:PY
1:CH1b	,000								
2:TR1	1,837	,000							
3:TR2	2,406	,514	,000						
4:TR3	1,737	,330	,373	,000					
5:SA8	2,928	1,739	1,575	1,917	,000				
6:SA7	2,392	2,099	1,902	2,122	,705	,000			
7:SA6	2,841	2,217	2,262	2,584	1,560	,361	,000		
8:SA5	2,681	1,876	1,110	1,569	,407	,764	1,873	,000	
9:PYE.2	2,008	,950	1,251	1,601	2,945	3,259	3,517	2,543	,000

Tab. 7.12. Matrix of dissimilarities for Hierarchical Cluster Analysis with Single Linkage method. Square Euclidean distance. SITE/PHASES - *CH1.b*: Cueva de Chaves, level 1.b; *TR1*: Cova de Els Trocs I; *TR2*: Cova de Els Trocs II; *TR3*: Cova de Els Trocs III; *PYE.2*: Espluga de la Puyascada, level E.2; *SA8*: Cova del Sardo, phase8; *SA7*: Cova del Sardo, phase7; *SA6*: Cova del Sardo, phase6; *SA5*: Cova del Sardo, phase5.

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	2	4	,330	0	0	3
2	6	7	,361	0	0	5
3	2	3	,373	1	0	6
4	5	8	,407	0	0	5
5	5	6	,705	4	2	7
6	2	9	,950	3	0	7
7	2	5	1,110	6	5	8
8	1	2	1,737	0	7	0



Tab. 7.13. *Above*: Agglomeration Schedule Hierarchical Cluster Analysis with Single Linkage method. The red line indicates the selected cluster breaking point. In the second and third columns (Cluster 1 & Cluster 2) are expressed the objects or combined at each stage; In the central column (Coefficients) are reported the distances at which the merge takes place. *Below*: Scree plot of Coefficients per each cluster. The sharp increase in distance when switching from a one to a two-cluster solution (at stage 4) occurs in almost all analyses and must not be viewed as a reliable indicator for the decision regarding the number of segments. The sharpest increase, also called the 'big jump', occurs after stage 7 (indicated by the arrow).

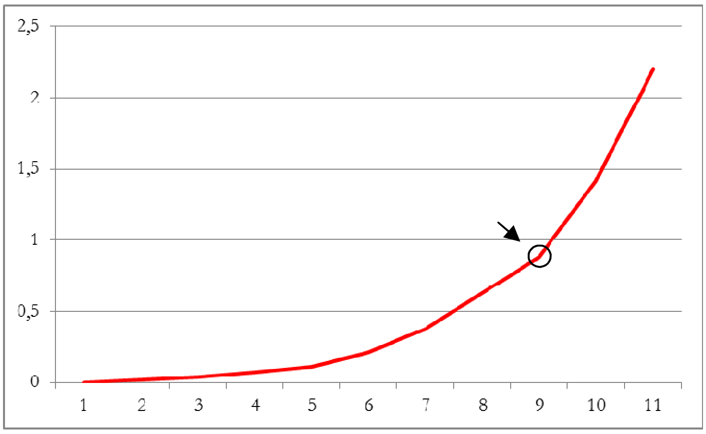
		BUT	PWC	HUN	HA	HP	HI	MIN
BUT	Pearson Corr.	1						
	Sig. (bilateral)							
	N	12						
PWC	Pearson Corr.	-,255	1					
	Sig. (bilateral)	,423						
	N	12	12					
HUN	Pearson Corr.	-,375	,319	1				
	Sig. (bilateral)	,230	,313					
	N	12	12	12				
HA	Pearson Corr.	,191	-,316	-,520	1			
	Sig. (bilateral)	,552	,318	,083				
	N	12	12	12	12			
HP	Pearson Corr.	-,173	-,364	,190	-,412	1		
	Sig. (bilateral)	,591	,244	,553	,183			
	N	12	12	12	12	12		
HI	Pearson Corr.	-,455	,050	-,502	,441	-,323	1	
	Sig. (bilateral)	,137	,878	,096	,151	,305		
	N	12	12	12	12	12	12	
MIN	Pearson Corr.	,322	-,449	-,474	,251	-,456	,065	1
	Sig. (bilateral)	,307	,143	,120	,431	,136	,840	
	N	12	12	12	12	12	12	12

Tab. 7.14. Bivariate Correlation with Pearson method between the selected variables (for Hierarchical Clustering - Ward Method). No correlations at 0.05 level (bilateral) are present among the analysed variables. *BUT*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Indeterminate Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

	1: CI1A/B	2: SPIV	3: DR	4: CH1.b	5: TR1	6: TR2	7: TR3	8: PYE.2	9: SA8	10: SA7	11: SA6	12: SA5
1:CI1A/B	.000											
2:SPIV	.669	.000										
3:DR	.437	1.285	.000									
4:CH1.b	.597	.316	.705	.000								
5:TR1	1.883	1.409	1.997	.754	.000							
6:TR2	1.208	1.660	1.909	1.434	.902	.000						
7:TR3	1.468	1.373	2.159	1.136	.413	.166	.000					
8:PUYE.2	1.680	1.773	1.613	1.117	1.229	1.447	1.489	.000				
9:SA8	1.505	1.364	2.658	1.986	2.444	1.323	1.560	2.690	.000			
10:SA7	.956	1.491	1.748	1.544	2.263	1.520	1.758	3.002	.661	.000		
11:SA6	1.608	2.362	1.884	1.970	2.312	1.962	2.168	3.505	1.427	.289	.000	
12:SA5	.779	1.230	2.062	1.664	2.292	.790	1.173	2.241	.391	.677	1.635	.000

Tab. 7.15. Matrix of dissimilarities. Square Euclidean distance. *CI1A/B*: Ca N'Isach, level 1A/B; *SPIV*: Sant Pau del Camp, level IV; *DR*: La Draga; *CH1.b*: Cueva de Chaves, level 1.b; *TR1*: Cova de Els Trocs I; *TR2*: Cova de Els Trocs II; *TR3*: Cova de Els Trocs III; *PYE.2*: Espluga de la Puyascada, level E.2; *SA8*: Cova del Sardo, phase8; *SA7*: Cova del Sardo, phase7; *SA6*: Cova del Sardo, phase6; *SA5*: Cova del Sardo, phase5.

Stage	**Cluster Combined**		**Coefficients**	**Stage Cluster First Appears**		**Next Stage**
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	6	7	,000	0	0	6
2	10	11	,018	0	0	9
3	2	4	,041	0	0	7
4	9	12	,075	0	0	9
5	1	3	,115	0	0	7
6	5	6	,213	0	1	8
7	1	2	,376	5	3	10
8	5	8	,626	6	0	10
9	9	10	,879	4	2	11
10	1	5	1,413	7	8	11
11	1	9	2,200	10	9	0



Tab. 7.16. *Above*: Agglomeration Schedule Hierarchical Cluster Analysis with Single Linkage method. *Below*: Scree plot of Coefficients per each cluster. The sharpest increase occurs after stage 9 (indicated by the arrow).

Variable / Cluster		N	Media	Std. deviation	Std. error	Minim	Maximum
BUT	1	4	7,345	4,7089	2,3545	1,7	13,2
	2	4	25,589	3,0688	1,5344	23,1	29,6
	3	4	12,550	2,8723	1,4361	8,3	14,3
	Total	12	15,161	8,6660	2,5017	1,7	29,6
PWC	1	4	12,066	8,0339	4,0170	1,7	20,2
	2	4	5,091	3,5628	1,7814	,0	7,7
	3	4	14,000	12,9843	6,4922	,0	28,5
	Total	12	10,386	9,1114	2,6302	,0	28,5
HUN	1	4	7,541	4,2489	2,1244	4,1	13,3
	2	4	4,165	3,2253	1,6127	,0	7,7
	3	4	23,900	7,2567	3,6284	13,3	28,6
	Total	12	11,869	10,1564	2,9319	,0	28,6
HA	1	4	3,232	1,9783	,9892	1,5	5,6
	2	4	5,449	7,8596	3,9298	,0	16,7
	3	4	,000	,0000	,0000	,0	,0
	Total	12	2,894	4,8348	1,3957	,0	16,7
HP	1	4	40,330	9,8682	4,9341	30,9	50,8
	2	4	37,499	10,6975	5,3488	23,1	48,1
	3	4	49,550	16,3716	8,1858	28,6	66,7
	Total	12	42,460	12,6390	3,6486	23,1	66,7
HI	1	4	20,121	4,7325	2,3662	16,9	27,2
	2	4	4,615	6,2947	3,1473	,0	13,3
	3	4	,000	,0000	,0000	,0	,0
	Total	12	8,246	9,8851	2,8536	,0	27,2
MIN	1	4	9,364	9,2922	4,6461	,4	18,1
	2	4	17,592	8,6459	4,3230	10,0	28,2
	3	4	7,345	4,7089	2,3545	1,7	13,2
	Total	4	25,589	3,0688	1,5344	23,1	29,6

Tab. 7.17. Descriptive tables. *BUT*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

		Sum of square	gl	Mean squares	F	Sig.
BUT	**Inter-groups**	706,575	2	353,287	26,602	,000
	Intra-groups	119,525	9	13,281		
	Total	826,099	11			
PWC	**Inter-groups**	175,699	2	87,849	1,072	,382
	Intra-groups	737,493	9	81,944		
	Total	913,192	11			
HUN	**Inter-groups**	891,329	2	445,664	16,483	,001
	Intra-groups	243,346	9	27,038		
	Total	1134,675	11			
HA	**Inter-groups**	60,064	2	30,032	1,372	,302
	Intra-groups	197,063	9	21,896		
	Total	257,128	11			
HP	**Inter-groups**	317,648	2	158,824	,993	,408
	Intra-groups	1439,543	9	159,949		
	Total	1757,191	11			
HI	**Inter-groups**	888,808	2	444,404	21,497	,000
	Intra-groups	186,059	9	20,673		
	Total	1074,867	11			
MIN	**Inter-groups**	619,831	2	309,916	5,771	,024
	Intra-groups	483,291	9	53,699		
	Total	1103,122	11			

Tab. 7.18. One-way ANOVA test. In red the significant values. *BUT*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

Dependent variables	(I) Ward Method	(J) Ward Method	Mean difference (I-J)	Standard Error	Sig.	95% Confidence interval	
						Lower bound	Upper superior
BUT	1	2	-18,2436*	2,5769	,000	-25,438	-11,049
		3	-5,2047	2,5769	,163	-12,399	1,990
	2	1	18,2436*	2,5769	,000	11,049	25,438
		3	13,0389*	2,5769	,002	5,844	20,234
	3	1	5,2047	2,5769	,163	-1,990	12,399
		2	-13,0389*	2,5769	,002	-20,234	-5,844
PWC	1	2	6,9757	6,4009	,543	-10,896	24,847
		3	-1,9336	6,4009	,951	-19,805	15,938
	2	1	-6,9757	6,4009	,543	-24,847	10,896
		3	-8,9093	6,4009	,385	-26,781	8,962
	3	1	1,9336	6,4009	,951	-15,938	19,805
		2	8,9093	6,4009	,385	-8,962	26,781
HUN	1	2	3,3761	3,6769	,643	-6,890	13,642
		3	-16,3591*	3,6769	,004	-26,625	-6,093
	2	1	-3,3761	3,6769	,643	-13,642	6,890
		3	-19,7352*	3,6769	,001	-30,001	-9,469
	3	1	16,3591*	3,6769	,004	6,093	26,625
		2	19,7352*	3,6769	,001	9,469	30,001
HA	1	2	-2,2168	3,3088	,786	-11,455	7,021
		3	3,2320	3,3088	,609	-6,006	12,470
	2	1	2,2168	3,3088	,786	-7,021	11,455
		3	5,4487	3,3088	,277	-3,789	14,687
	3	1	-3,2320	3,3088	,609	-12,470	6,006
		2	-5,4487	3,3088	,277	-14,687	3,789
HP	1	2	2,8312	8,9429	,947	-22,137	27,800
		3	-9,2195	8,9429	,577	-34,188	15,749
	2	1	-2,8312	8,9429	,947	-27,800	22,137
		3	-12,0507	8,9429	,406	-37,019	12,918
	3	1	9,2195	8,9429	,577	-15,749	34,188
		2	12,0507	8,9429	,406	-12,918	37,019
HI	1	2	15,5060*	3,2151	,002	6,530	24,482
		3	20,1214*	3,2151	,000	11,145	29,098
	2	1	-15,5060*	3,2151	,002	-24,482	-6,530
		3	4,6154	3,2151	,364	-4,361	13,592
	3	1	-20,1214*	3,2151	,000	-29,098	-11,145
		2	-4,6154	3,2151	,364	-13,592	4,361
MIN	1	2	-8,2286	5,1817	,299	-22,696	6,239
		3	9,3636	5,1817	,222	-5,104	23,831
	2	1	8,2286	5,1817	,299	-6,239	22,696
		3	17,5922*	5,1817	,020	3,125	32,059
	3	1	-9,3636	5,1817	,222	-23,831	5,104
		2	-17,5922*	5,1817	,020	-32,059	-3,125

Tab. 7.19. Tukey post-hoc test. In red the significant values for the mean differences. The mean difference is significant at 0.05 level. *BUT*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

Initial Cluster Centers

	Clusters		
	1	2	3
BU	7,3	25,6	12,6
PWC	12,1	5,1	14,0
HUN	7,5	4,2	23,9
HA	3,2	5,4	,0
HP	40,3	37,5	49,6
HI	20,1	4,6	,0
MIN	9,4	17,6	,0

Tab. 7.20. *K-means* procedure. Initial cluster centres. *BU*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

Final Cluster Centers

	Clusters		
	1	2	3
BU	7,3	25,6	12,6
PWC	12,1	5,1	14,0
HUN	7,5	4,2	23,9
HA	3,2	5,4	,0
HP	40,3	37,5	49,6
HI	20,1	4,6	,0
MIN	9,4	17,6	,0

Tab. 7.21. *K-means* procedure. Final cluster centres. The centroids are identical to the initial centres. *BU*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances.

P/S	BU	PWC	HUN	HA	HP	HI	MIN	MO	LIT	CER	AD	PO	OV	BO	SU	UN
SP-IV	-1,6	-1,1	0,3	-0,3	0,4	0,7	0,9	1,2	3,3	2,4	-0,1	1,6	-1,1	1,5	1,1	-0,4
CH-1.b	-1,0	-0,1	-0,2	0,5	-0,7	0,7	1,0	0,4	0,3	0,4	1,7	2,3	-0,5	-0,6	0,5	2,0
DR	-0,2	1,1	-0,7	0,2	-0,9	1,5	-0,9	2,9	-0,1	-0,4	2,5	-0,2	-1,9	2,1	2,0	-0,3
TR-1	1,0	-0,4	-0,3	0,4	-1,6	-0,5	2,1	-0,4	-0,4	1,8	0,0	-0,5	0,2	-0,2	0,1	-0,5
PY-E.2	1,1	-1,3	-1,1	2,8	-0,4	0,2	0,2	-0,5	-0,4	-0,6	-0,4	-0,4	-0,9	1,0	0,5	0,2
TR-3	1,4	-0,6	-0,5	-0,6	0,0	-1,0	1,3	-0,4	-0,4	-0,1	0,1	-0,4	0,1	-0,3	0,8	-0,6
TR-2	1,8	-0,4	-0,7	-0,6	0,6	-1,0	0,3	-0,5	-0,4	0,1	0,0	-0,4	0,5	-0,6	0,1	-0,6
SA-7	-0,8	1,2	1,5	-0,6	0,4	-1,0	-0,9	-0,5	-0,4	-0,6	-0,7	-0,5	1,2	-0,9	-1,2	-0,7
SA-5	-0,2	-0,5	0,3	-0,6	2,1	-1,0	-0,9	-0,5	-0,4	-0,7	-0,7	-0,5	1,2	-0,9	-1,2	-0,7
SA-8	0,0	-1,3	1,8	-0,6	1,3	-1,0	-0,9	-0,5	-0,4	-0,7	-0,7	-0,5	1,2	-0,9	-1,2	-0,7
SA-6	0,0	2,1	1,8	-0,6	-1,1	-1,0	-0,9	-0,5	-0,4	-0,7	-0,7	-0,5	1,2	-0,9	-1,2	-0,7

Tab. 7.22. Typified data used for the Cluster Analysis with Ward method. P/S: Studied phases/sites - *SP-IV*: San Pau del Camp-level IV; *CH-1.b*: Cueva de Chaves, level 1.b; *DR*: La Draga; *TR-1*: Cova de Els Trocs, phase I; *PY*: Puyascada, level E.2; *TR-3*: Els Trocs, phase III; *TR-2*: Els Trocs, phase II: *SA-7*: Cova del Sardo, phase7; *SA-5*: Sardo, phase5; *SA-8*: Sardo, phase8; *SA-6*: Sardo, phase6. ACTIVITY - *BU*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances; *MO*: Macrolithic tools; *LIT*: Flaked Stone assemblage; *CER*: Ceramic assemblage; *AD*: ornaments; *PO*: Polished tools; *OV*: Sheep/goat; *BO*: cattle; *SU*: suids; *UN*: wild ungulates.

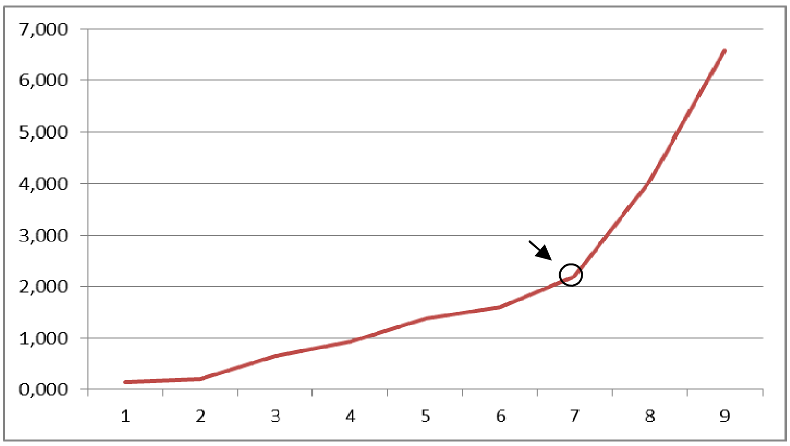
SITES	Lithic Materials (nº)			Ref.	Other artifacts (nº)				Ref.	Faunal Materials (%)				Ref.
	LIT	*SAM*	*AUAs*		*CER*	*MCR*	*POL*	*ORN*		*OV*	*BO*	*SU*	*UG*	
SA-8	39	39	13	cfr. chap. 6	13	-	-	-	Tarifa Mateo 2014	100	0	0	0	Navarrete & Saña 2013
SA-7	58	58	34	cfr. chap. 6	153	-	1	-	Tarifa Mateo 2014	100	0	0	0	Navarrete & Saña 2013
SA-6	140	140	10	cfr. chap. 6	17	-	-	-	Tarifa Mateo 2014	100	0	0	0	Navarrete & Saña 2013
SA-5	90	90	22	cfr. chap. 6	36	-	-	-	Tarifa Mateo 2014	100	0	0	0	Navarrete & Saña 2013
TR-I	83	83	49	cfr. chap. 5	14575	1	2	19	Rojo et al. 2014	82,1	8,1	8,9	0,8	Rojo et al. 2014
TR-II	83	83	32	cfr. chap. 5	4740	0	3	19	Rojo et al. 2014	87,7	2,8	9,1	0,3	Rojo et al. 2014
TR-III	88	88	28	cfr. chap. 5	3563	1	4	20	Rojo et al. 2014	79,0	7,0	13,9	0,5	Rojo et al. 2014
PY-E.2	38	38	43	cfr. chap. 4	628	2	5	8	Baldellou 1987	61,5	21,2	11,7	5,5	Castaños 1987
CH1.b	2486	1774	386	cfr. chap. 3	6039	33	76	64	Baldellou 2012 Ramón 2006 Sanchez et al. in press	69,0	3,2	11,7	15,9	Castaños 2004;
DR	858	601	243	Bosch et al. 2000, 2011	1302	37	9	85	Bosch et al. 2000, 2011	42,1	33,4	22,1	2,3	Saña 2011
SP-IV	12489	77	60	Borrell 2008 Borrell & Gibaja 2011	18115	18	57	14	Gómez et al. 2008 Bofill et al. 2008 Estrada & Nadal 2008	56,3	26,0	15,8	1,7	Colominas et al. 2008
CI-1A/B	393	393	130	Gibaja 2005 Gibaja unpublished	?	?	?	?	-	-	-	-	-	-

Tab. 7.23. Raw-data considered for the Cluster Analysis with Ward method: SITES - *SA-8*: Cova del Sardo, phase8; *SA-7*: Cova del Sardo, phase7; *SA-6*: Cova del Sardo, phase6; *SA-5*: Cova del Sardo, phase5*; TR-1*: Cova de Els Trocs, phase I; *TR-2*: Cova de Els Trocs, phase II; *TR-3*: Cova de Els Trocs, phase III; *PY*: Espluga de la Puyascada, level E.2; *CH-1.b*: Cueva de Chaves, level 1.b; *DR*: La Draga, excavations 1999-2005; San Pau del Camp-level IV; Ca N'Isach-levels 1A -B; LIT: Total number of chipped stone remains; SAM: Sample of lithics selected for use-wear analysis; AUAs: Active Zones Identified through use-wear analysis; CER: Total number of ceramic fragments recovered; MCR: Total number of macrolithic tools recovered; PO: Total number of Polished tools recovered; ORN: Total number of ornaments recovered; OV: Percentage of ovicaprid (sheep/goat) remains; BO: Percentage of cattle remains; SU: Percentage of suid remains; UG: Percentage of wild ungulates remains. In the columns 'Ref' are indicated the works from which data is taken.

	1:SP	2:CH	5:DR	7:TR-1	8:PY	9:TR-3	10:TR-2	11:SA-7	12:SA-5	13:SA-8	14:SA-6
1:SP	,000										
2:CH	22,567	,000									
5:DR	40,588	26,253	,000								
7:TR-1	36,087	20,772	47,122	,000							
8:PY	43,695	26,547	37,014	18,834	,000						
9:TR-3	39,069	21,852	42,522	7,674	17,317	,000					
10:TR-2	44,422	25,760	47,105	11,253	19,449	2,049	,000				
11:SA-7	52,294	32,646	57,993	27,994	37,087	20,350	16,340	,000			
12:SA-5	51,005	35,637	62,825	30,199	31,702	16,072	10,475	6,485	,000		
13:SA-8	51,455	37,215	66,647	29,895	34,009	18,220	13,991	6,279	3,246	,000	
14:SA-6	60,834	36,441	58,735	27,427	41,175	23,802	20,225	3,021	16,237	14,092	,000

Tab. 7.24. Matrix of dissimilarities. Square Euclidean distance. *SP*: San Pau del Camp-level IV; *CH*: Cueva de Chaves, level 1.b; *DR*: La Draga; *TR-1*: Cova de Els Trocs, phase I; *PY*: Puyascada, level E.2; *TR-3*: Els Trocs, phase III; *TR-2*: Els Trocs, phase II: *SA-7*: Cova del Sardo, phase7; *SA-5*: Sardo, phase5; *SA-8*: Sardo, phase8; *SA-6*: Sardo, phase6. .

Stage	**Cluster Combined**		**Coefficients**	**Stage Cluster First Appears**		**Next Stage**
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	5	6	,124	0	0	4
2	7	10	,269	0	0	5
3	8	9	,464	0	0	5
4	3	5	1,111	0	1	6
5	7	8	2,041	2	3	8
6	3	4	3,346	4	0	8
7	1	2	5,611	0	0	9
8	3	7	9,635	6	5	9
9	1	3	15,760	7	8	0



Tab. 7.25. *Above*: Agglomeration Schedule Hierarchical Cluster Analysis with Single Linkage method. The red line indicates the selected cluster breaking point. In the second and third columns (Cluster 1 & Cluster 2) are expressed the objects or combined at each stage; In the central column (Coefficients) are reported the distances at which the merge takes place. *Below*: Scree plot of Coefficients per each cluster. . The sharpest increase, also called the 'big jump', occurs after stage 7 (indicated by the arrow).

		Sum of square	gl	Mean squares	F	Sig.
Z(BUT)	Inter-groups	8.440	2	4.220	21.644	.001
	Intra-groups	1.560	8	.195		
	Total	10.000	10			
Z(PWC)	Inter-groups	1.844	2	.922	.904	.443
	Intra-groups	8.156	8	1.020		
	Total	10.000	10			
Z(HUN)	Inter-groups	7.847	2	3.924	14.579	.002
	Intra-groups	2.153	8	.269		
	Total	10.000	10			
Z(HA)	Inter-groups	2.426	2	1.213	1.281	.329
	Intra-groups	7.574	8	.947		
	Total	10.000	10			
Z(HP)	Inter-groups	2.305	2	1.152	1.198	.351
	Intra-groups	7.695	8	.962		
	Total	10.000	10			
Z(HI)	Inter-groups	8.263	2	4.132	19.030	.001
	Intra-groups	1.737	8	.217		
	Total	10.000	10			
Z(MIN)	Inter-groups	6.046	2	3.023	6.117	.024
	Intra-groups	3.954	8	.494		
	Total	10.000	10			
Z(MO)	Inter-groups	7.219	2	3.610	10.385	.006
	Intra-groups	2.781	8	.348		
	Total	10.000	10			
Z(LIT)	Inter-groups	4.260	2	2.130	2.969	.109
	Intra-groups	5.740	8	.717		
	Total	10.000	10			
Z(CER)	Inter-groups	3.377	2	1.689	2.040	.192
	Intra-groups	6.623	8	.828		
	Total	10.000	10			
Z(AD)	Inter-groups	6.525	2	3.262	7.511	.015
	Intra-groups	3.475	8	.434		
	Total	10.000	10			
Z(POL)	Inter-groups	7.917	2	3.959	15.204	.002
	Intra-groups	2.083	8	.260		
	Total	10.000	10			
Z(OV)	Inter-groups	8.191	2	4.095	18.107	.001
	Intra-groups	1.809	8	.226		
	Total	10.000	10			
Z(BO)	Inter-groups	5.247	2	2.624	4.416	.051
	Intra-groups	4.753	8	.594		
	Total	10.000	10			
Z(SU)	Inter-groups	8.806	2	4.403	29.506	.000
	Intra-groups	1.194	8	.149		
	Total	10.000	10			
Z(UN)	Inter-groups	3.492	2	1.746	2.146	.179
	Intra-groups	6.508	8	.814		
	Total	10.000	10			

Tab. 7.26. One-way ANOVA test. Typified values. In red the significant values. *BU*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances; *MO*: Macrolithic tools; *LIT*: Flaked Stone assemblage; *CER*: Ceramic assemblage; *AD*: ornaments; *PO*: Polished tools; *OV*: Sheep/goat; *BO*: cattle; *SU*: suids; *UN*: wild ungulates.

Dependent variables	(I) Ward Method	(J) Ward Method	Mean difference (I-J)	Std. Error	Sig.	95% Confidence interval Lower bound	
BU Z-value	1	2	-2.09872854*	.33724978	.001	-3.0624010	-1.1350561
		3	-.60819191	.33724978	.229	-1.5718644	.3554806
	2	1	2.09872854*	.33724978	.001	1.1350561	3.0624010
		3	1.49053664*	.31223263	.004	.5983493	2.3827240
	3	1	.60819191	.33724978	.229	-.3554806	1.5718644
		2	-1.49053664*	.31223263	.004	-2.3827240	-.5983493
PWC Z-value	1	2	.59942369	.77118441	.727	-1.6041928	2.8030402
		3	-.35198868	.77118441	.893	-2.5556052	1.8516278
	2	1	-.59942369	.77118441	.727	-2.8030402	1.6041928
		3	-.95141236	.71397803	.418	-2.9915648	1.0887401
	3	1	.35198868	.77118441	.893	-1.8516278	2.5556052
		2	.95141236	.71397803	.418	-1.0887401	2.9915648
HUN Z-value	1	2	.41923066	.39621529	.564	-.7129325	1.5513938
		3	-1.48218326*	.39621529	.014	-2.6143464	-.3500201
	2	1	-.41923066	.39621529	.564	-1.5513938	.7129325
		3	-1.90141392*	.36682408	.002	-2.9495933	-.8532345
	3	1	1.48218326*	.39621529	.014	.3500201	2.6143464
		2	1.90141392*	.36682408	.002	.8532345	2.9495933
HA Z-value	1	2	-.32711674	.74316533	.900	-2.4506703	1.7964368
		3	.75162712	.74316533	.591	-1.3719264	2.8751807
	2	1	.32711674	.74316533	.900	-1.7964368	2.4506703
		3	1.07874386	.68803740	.313	-.8872847	3.0447724
	3	1	-.75162712	.74316533	.591	-2.8751807	1.3719264
		2	-1.07874386	.68803740	.313	-3.0447724	.8872847
HP Z-value	1	2	-.04999424	.74907764	.998	-2.1904419	2.0904534
		3	-.97921290	.74907764	.430	-3.1196606	1.1612348
	2	1	.04999424	.74907764	.998	-2.0904534	2.1904419
		3	-.92921866	.69351114	.414	-2.9108881	1.0524508
	3	1	.97921290	.74907764	.430	-1.1612348	3.1196606
		2	.92921866	.69351114	.414	-1.0524508	2.9108881
HI Z-value	1	2	1.66327011*	.35587156	.004	.6463869	2.6801533
		3	2.12649718*	.35587156	.001	1.1096140	3.1433804
	2	1	-1.66327011*	.35587156	.004	-2.6801533	-.6463869
		3	.46322707	.32947305	.383	-.4782238	1.4046780
	3	1	-2.12649718*	.35587156	.001	-3.1433804	-1.1096140
		2	-.46322707	.32947305	.383	-1.4046780	.4782238
MIN Z-value	1	2	-.57228248	.53692751	.560	-2.1065229	.9619580
		3	1.14089263	.53692751	.146	-.3933478	2.6751331
	2	1	.57228248	.53692751	.560	-.9619580	2.1065229
		3	1.71317510*	.49709828	.021	.2927445	3.1336057
	3	1	-1.14089263	.53692751	.146	-2.6751331	.3933478
		2	-1.71317510*	.49709828	.021	-3.1336057	-.2927445
MO Z-value	1	2	1.79733269*	.45029327	.010	.5106447	3.0840206
		3	1.83978937*	.45029327	.009	.5531014	3.1264773
	2	1	-1.79733269*	.45029327	.010	-3.0840206	-.5106447
		3	.04245668	.41689056	.994	-1.1487849	1.2336982
	3	1	-1.83978937*	.45029327	.009	-3.1264773	-.5531014
		2	-.04245668	.41689056	.994	-1.2336982	1.1487849

Tab. 7.27a. Tukey post-hoc test. Typified values. In red the significant values for the mean differences. The mean difference is significant at 0.05 level. Continues in the following page. *BU*: Butchering Activities; *PWC*: Plant Crafting Activities; *HA*: Animal Hard Materials; *HP*: Harvesting Herbaceous Plants; *HI*: Hide; *MIN*: Mineral substances; *MO*: Macrolithic tools.

LIT Z-value	1	2	1.39986656	.64693615	.138	-.4487175	3.2484506
		3	1.39482325	.64693615	.140	-.4537608	3.2434073
	2	1	-1.39986656	.64693615	.138	-3.2484506	.4487175
		3	-.00504331	.59894649	1.000	-1.7164995	1.7064129
	3	1	-1.39482325	.64693615	.140	-3.2434073	.4537608
		2	.00504331	.59894649	1.000	-1.7064129	1.7164995
CER Z-value	1	2	.41623288	.69492612	.825	-1.5694798	2.4019456
		3	1.33785911	.69492612	.194	-.6478536	3.3235718
	2	1	-.41623288	.69492612	.825	-2.4019456	1.5694798
		3	.92162623	.64337657	.371	-.9167865	2.7600389
	3	1	-1.33785911	.69492612	.194	-3.3235718	.6478536
		2	-.92162623	.64337657	.371	-2.7600389	.9167865
AD Z-value	1	2	1.34302386	.50337705	.066	-.0953480	2.7813957
		3	1.92874792*	.50337705	.012	.4903760	3.3671198
	2	1	-1.34302386	.50337705	.066	-2.7813957	.0953480
		3	.58572406	.46603659	.456	-.7459495	1.9173977
	3	1	-1.92874792*	.50337705	.012	-3.3671198	-.4903760
		2	-.58572406	.46603659	.456	-1.9173977	.7459495
PO Z-value	1	2	1.83961361*	.38971316	.004	.7260300	2.9531972
		3	1.96288669*	.38971316	.003	.8493031	3.0764703
	2	1	-1.83961361*	.38971316	.004	-2.9531972	-.7260300
		3	.12327308	.36080427	.938	-.9077050	1.1542512
	3	1	-1.96288669*	.38971316	.003	-3.0764703	-.8493031
		2	-.12327308	.36080427	.938	-1.1542512	.9077050
OV Z-value	1	2	-1.07225439*	.36322937	.044	-2.1101621	-.0343467
		3	-2.17586338*	.36322937	.001	-3.2137711	-1.1379557
	2	1	1.07225439*	.36322937	.044	.0343467	2.1101621
		3	-1.10360899*	.33628505	.027	-2.0645248	-.1426932
	3	1	2.17586338*	.36322937	.001	1.1379557	3.2137711
		2	1.10360899*	.33628505	.027	.1426932	2.0645248
BO Z-value	1	2	.93123366	.58869765	.307	-.7509371	2.6134044
		3	1.74759000*	.58869765	.042	.0654192	3.4297607
	2	1	-.93123366	.58869765	.307	-2.6134044	.7509371
		3	.81635634	.54502812	.342	-.7410312	2.3737438
	3	1	-1.74759000*	.58869765	.042	-3.4297607	-.0654192
		2	-.81635634	.54502812	.342	-2.3737438	.7410312
SU Z-value	1	2	.75213002	.29503996	.079	-.0909302	1.5951903
		3	2.18438074*	.29503996	.000	1.3413205	3.0274410
	2	1	-.75213002	.29503996	.079	-1.5951903	.0909302
		3	1.43225073*	.27315393	.002	.6517286	2.2127729
	3	1	-2.18438074*	.29503996	.000	-3.0274410	-1.3413205
		2	-1.43225073*	.27315393	.002	-2.2127729	-.6517286
UNG Z-value	1	2	1.02879486	.68888109	.344	-.9396445	2.9972342
		3	1.39964691	.68888109	.167	-.5687924	3.3680863
	2	1	-1.02879486	.68888109	.344	-2.9972342	.9396445
		3	.37085206	.63777996	.834	-1.4515687	2.1932728
	3	1	-1.39964691	.68888109	.167	-3.3680863	.5687924
		2	-.37085206	.63777996	.834	-2.1932728	1.4515687

Tab. 7.27b. Tukey post-hoc test. Typified values. In red the significant values for the mean differences. The mean difference is significant at 0.05 level. Continues from the previous page. *LIT*: Flaked Stone assemblage; *CER*: Ceramic assemblage; *AD*: ornaments; *PO*: Polished tools; *OV*: Sheep/goat; *BO*: cattle; *SU*: suids; *UN*: wild ungulates.

11. ANNEX II

Tab. 7.3.1.1. Archaeological contexts and relative dates cited in the text. Continues in the next 11 pages.

Raw data							cal BC					
SITE	REF	BP	±	SAM	LEV	BIB	1σ			2σ		
Peña de las Forcas II	Beta 247404	6750	40	SH	level V	Utrilla & Mazo 2002	5705	5685	14.6	5730	5615	94.4
							5675	5625	53.6	5585	5570	1.0
Peña de las Forcas II	Beta 247405	6740	40	SH	level VI	Utrilla & Mazo 2002	5705	5690	7.8	5725	5610	91.6
							5675	5620	60.4	5590	5565	3.8
Cueva de Chaves	GrA 38022	6580	35	FA	level 1b	Baldellou et al. 2012	5555	5485	68.2	5615	5585	13.2
										5570	5475	82.2
Font del Ros	AA 16498	6561	56	CA	level 64 50	Bordas et al. 1995	5605	5595	2.4	5625	5465	92.2
							5560	5475	65.8	5440	5425	0.9
										5405	5385	2.3
Cova del Sardo	KIA 37689	6525	45	CA	phase 9	Gassiot et al. 2014	5545	5465	67.2	5610	5590	2.7
							5400	5390	1.0	5565	5460	75.4
										5455	5375	17.3
Cueva de Chaves	UCIAM S66317	6470	25	FA	level 1b	Baldellou et al. 2012	5480	5460	20.6	5485	5375	95.4
							5445	5420	17.9			
							5410	5380	29.6			
Serrat del Pont	Beta 172521	6470	40	FA	level III.4	Alcalde et al. 2002	5480	5460	16.0	5510	5340	95.4
							5450	5375	52.2			
Roc du Dourgne	MC 1104	6470	100	CA	level 6	Guilaine et al. 1993	5515	5335	68.2	5620	5290	93.1
										5265	5225	2.3
Cueva de Chaves	GrA 28341	6380	40	SH	level1b	Baldellou et al. 2012	5465	5445	10.6	5475	5300	95.4
							5420	5405	5.1			
							5385	5310	52.5			
Font del Ros	AA 16502	6370	57	CA	pit E36	Bordas et al. 1995	5470	5435	12.4	5475	5285	87.1
							5425	5405	8.3	5275	5225	8.3
							5385	5305	47.5			
Font del Ros	AA 16501	6307	68	CA	pit E33	Bordas et al. 1995	5365	5215	68.2	5470	5200	85.5
										5170	5070	9.9
Font del Ros	AA 16499	6243	56	CA	pit E15	Bordas et al. 1995	5310	5205	49.7	5325	5045	95.4
							5165	5135	8.1			
							5130	5120	2.9			
							5110	5080	7.4			
Huerto Raso	GrA 21360	6310	60	CA	level II	Montes et al. 2004	5345	5215	68.2	5470	5205	90.5
										5165	5115	2.8
										5110	5075	2.1

La Draga	Beta 278255	6270	40	FA	sector C level I	Palomo et al. 2014	5300	5222	68.2	5325	5205	86.8
										5166	5076	8.6
La Draga	Beta 278252	6270	30	SH	sector D level I	Palomo et al. 2014	5299	5247	54.3	5316	5211	95.4
							5239	5225	13.9			
Cueva de Chaves	GrA 26912	6230	70	HU	level 1a	Baldellou et al. 2012	5300	5200	36.4	5340	4995	95.4
							5170	5075	31.8			
La Draga	Beta 0000	6184	27	FA	sector B level II	Bosch et al. 2011	5210	5200	3.7	5220	5050	95.4
							5175	5070	64.5			
La Draga	Beta 315050	6180	40	SH	sector D level II	Palomo et al. 2014	5215	5195	6.5	5290	5270	1.2
							5180	5065	61.7	5230	5000	94.2
Plansallosa	Beta 74311	6180	60	CA	II	Bosch et al. 1998	5220	5050	68.2	5305	4985	95.4
Cova Colomera	Beta 279478	6180	40	CA	CV10	Oms et al. 2011	5215	5195	6.5	5290	5270	1.2
							5180	5065	61.7	5230	5000	94.2
La Draga	OxA 20233	6179	33	SH	sector B level II	Bosch et al. 2011	5210	5200	4.1	5225	5025	95.4
							5180	5070	64.1			
Cova Colomera	OxA 23634	6170	30	SH	CE14	Oms et al. 2014	5210	5195	4.5	5220	5030	95.4
							5180	5065	63.7			
La Draga	Beta 278256	6170	40	FA	sector B level II	Bosch et al. 2011	5210	5195	6.2	5225	5000	95.4
							5180	5060	62.0			
Cova del Parco	CSIC 281	6170	70	CA	pit EE1	Martín 1998	5220	5025	68.2	5305	4945	95.4
Roc de Dourgne	MC 1102	6170	100	CA	level 5	Guilaine et al. 1993	5290	5265	3.7	5330	4840	95.4
							5230	4990	64.5			
La Draga	OxA 20231	6163	31	SH	sector B level II	Bosch et al. 2011	5210	5090	55.0	5215	5020	95.4
							5085	5055	13.2			
Cova Colomera	Beta2 40551	6150	40	SH	CE13 14	Oms et al. 2011	5210	5145	30.1	5220	4990	95.4
							5140	5090	18.7			
							5085	5040	19.4			
La Draga	OxA 20235	6143	33	SH	str. E 21 level I	Bosch et al. 2011	5210	5160	24.8	5210	5000	95.4
							5140	5125	3.4			
							5120	5090	10.4			
							5085	5020	29.7			
La Draga	Beta 315049	6130	40	SH	sector D level I	Palomo et al. 2014	5207	5162	20.6	5211	4962	95.4
							5136	5130	2.1			
							5120	5107	4.3			
							5080	4997	41.3			
Abri de Buholoup	Ly 1089	6131	54	CA	level 2	Briois & Vaquer 1999	5210	5145	21.9	5225	4930	94.8
							5140	5090	12.1	4925	4910	0.6
							5085	4995	34.2			
Plansallosa	Beta 74313	6130	60	CA	phase I pit I N	Bosch et al. 1998	5210	5145	21.9	5225	4895	94.8
							5140	5090	12.8	4865	4850	0.6
							5085	4995	33.5			

La Draga	OxA 20232	6121	33	SH	sector B level II	Bosch et al. 2011	5205	5165	17.2	5210	4960	95.4
							5080	4990	51.0			
La Draga	Beta 315051	6120	40	SH	sector D level II	Palomo et al. 2014	5225	5195	13.0	5300	5055	95.4
							5180	5065	55.2			
Cova del Parco	GrN 20058	6120	90	CA	pit EE1	Bartolí et al. 1994	5210	4955	68.2	5300	4835	95.4
Coro Trasito	Beta 366546	6080	40	FA	UE 3012	Clemente et al. in press	5050	4939	68.2	5206	5163	6.4
										5118	5109	0.6
										5079	4847	88.4
Cova de Els Trocs	Beta 316512	6080	40	SH	UE53	Rojo et al. 2013	5050	4935	68.2	5210	5160	6.4
										5120	5105	0.6
										5080	4845	88.4
Cova de Els Trocs	Beta 284150	6070	40	SH	UE20	Rojo et al. 2013	5045	4930	68.2	5205	5175	3.3
										5075	4840	92.1
Cova de Els Trocs	Beta 295782	6060	40	FA	UE63	Rojo et al. 2013	5025	4905	68.2	5195	5180	1.3
										5065	4840	94.1
La Draga	HD 15451	6060	40	SH	str. E 3 level I	Bosch et al. 2011	5025	4905	68.2	5195	5180	1.3
										5065	4840	94.1
Font del Ros	AA 16500	6058	79	CA	pit E21	Bordas et al. 1995	5195	5180	1.5	5215	4790	95.4
							5060	4840	66.7			
Cova de Els Trocs	Beta 316514	6050	40	SH	UE16	Rojo et al. 2013	5005	4900	64.2	5060	4835	95.4
							4865	4855	4.0			
Aspre del Paradis	GrA 16273	6030	40	FA	pit 5	Manen et al. 2001	4990	4895	58.3	5035	4825	94.3
							4870	4850	9.9	4815	4805	1.1
Cova Gran	Beta 265982	6020	50	SH	pit E9	Mora et al. 2011	4985	4845	68.2	5045	4790	95.4
Cova Colomera	Beta 248523	6020	50	CA	CE12	Oms et al. 2011	4985	4845	68.2	5045	4790	95.4
La Draga	UBAR 313	6010	70	CA	str. E 56 level I	Bosch et al. 2011	5000	4825	64.2	5205	5175	1.6
							4820	4800	4.0	5070	4720	93.8
Mas Bonet	?	5930	40	CA	phase 1 pit E22	Rossilo et al. 202 2013	4845	4765	56.5	4930	4920	0.9
							4760	4725	11.7	4910	4715	94.5
Espluga Puyascada	CSIC 384	5930	60	CA	level E.2	Baldellou 1983	4895	4865	6.7	4985	4685	95.4
							4850	4720	61.6			
Coro Trasito	Beta 358571	5920	49	CA	UE 3010	Clemente et al. in press	4839	4726	68.2	4934	4702	95.4
Aspre del Paradis	Ly 10069	5915	50	FA	pit 5	Manen et al., 2001	4840	4725	68.2	4935	4920	1.3
										4915	4690	94.1

Plansallosa	OxA 2592	5890	80	CA	phase II pit II	Bosch et al., 1998	4900	4865	5.9	4955	4545	95.4
							4855	4680	60.0			
							4635	4620	2.2			
Plansallosa	Beta 74312	5870	60	CA	phase II	Bosch et al., 1998	4830	4680	68.2	4900	4865	2.9
										4855	4580	91.7
										4570	4555	0.8
Coro Trasito	?	5830	35	SH	UE 3002	Clemente et al. in press	4766	4756	4.0	4788	4590	95.4
							4729	4653	52.2			
							4640	4617	12.0			
L'Avellaner	UBAR 109	5830	100	HU	?	Bosch & Tarrús 1990	4795	4550	68.2	4935	4460	95.4
Sanabastre	UBAR 574	5780	60	CA	E4	Mercadal et al. 2009	4705	4550	68.2	4780	4495	95.4
Caune de la Belesta	Lyon 8626	5720	50	CA	AT13 R64	Claustre et al. 1993	4652	4641	3.9	4690	4458	95.4
							4616	4494	64.3			
La Codella	Beta 221900	5720	60	FA	?	Alcalde et al. 2013	4670	4635	10.1	4720	4445	95.4
							4620	4490	58.1			
Plansallosa	Beta 87965	5720	70	CA	phase II sector E	Bosch et al. 1998	4680	4635	14.2	4725	4440	92.5
							4620	4485	54.0	4425	4395	2.1
										4390	4370	0.8
Cova del Sardo	KIA 40878	5715	35	CA	phase 8	Gassiot et al. 2014	4600	4495	68.2	4685	4635	10.3
										4620	4460	85.1
Cova del Sardo	KIA 40817	5685	35	CA	phase 8	Gassiot et al. 2014	4545	4460	68.2	4655	4640	0.5
										4620	4445	94.9
Cova del Sardo	KIA 41134	5645	25	CA	phase 8	Gassiot et al. 2014	4505	4450	68.2	4545	4440	89.5
										4425	4395	5.3
										4380	4375	0.6
Cova del Sardo	KIA 40815	5635	35	CA	phase 8	Gassiot et al. 2014	4520	4445	58.8	4540	4365	95.4
							4420	4400	9.4			
Pleta de les Bacives	Poz 18807	5660	40	CA	M152	Ejarque 2010	4540	4455	68.2	4595	4435	85.3
										4430	4365	10.1
La Dou	Beta 221903	5660	50	CA	str. 1	Alcalde et al. 2013	4550	4445	64.8	4615	4360	95.4
							4420	4400	3.4			
Caune de la Belesta	Lyon 8625	5620	45	CA	AT13 R55	Claustre et al. 1993	4496	4441	36.2	4538	4358	95.4
							4425	4371	32.0			
Cova de Els Trocs	Beta 316515	5590	40	VC	UE8	Rojo et al. 2013	4455	4365	68.2	4495	4345	95.4
Cova de Els Trocs	Beta 316511	5590	40	VC	UE14	Rojo et al. 2013	4455	4365	68.2	4495	4345	95.4
Cova de Els Trocs	Beta 316513	5580	40	VC	UE77	Rojo et al. 2013	4450	4365	68.2	4490	4345	95.4
Espluga Puyascada	CSIC 382	5580	70	CA	level E.2	Baldellou 1983	4465	4345	68.2	4580	4570	0.2
										4560	4320	93.9
										4290	4265	1.3

La Dou	Beta 221904	5520	50	CA	str. 3	Alcalde et al. 2013	4450	4415	18.6	4465	4315	88.7
							4400	4330	49.6	4300	4260	6.7
La Dou	Beta 221905	5450	50	CA	str. 2	Alcalde et al. 2013	4350	4310	30.6	4450	4415	2.1
										4400	4380	1.0
							4305	4260	37.6	4375	4225	89.1
										4200	4165	2.8
										4090	4080	0.5
Cueva Pacencia	GrA 17665	5445	40	CA	subunitI	Montes et al. 2000	4345	4315	28.2	4360	4230	95.4
							4300	4260	40.0			
Caune de la Belesta	Lyon 3022	5390	60	FA	BLT 83 - VII - F1	Claustre et al. 1993	4335	4228	52.1	4344	4143	75.9
							4201	4169	11.2			
							4127	4121	1.5	4136	4053	19.5
							4091	4080	3.3			
Peòa de las Forcas II	Beta 247406	5340	40	SH	level VIII	Utrilla & Mazo 2002	4255	4220	12.8	4325	4290	6.4
							4210	4155	25.7	4270	4045	89.0
							4135	4065	29.6			
Lo Pla del Bach	GIF 7492	5300	65	CA	N. inf	Campmajo & Crabol 1988	4232	4191	15.8	4321	4292	3.8
							4179	4046	52.4	4266	3981	91.6
Cova del Pasteral	UBAR 101	5270	70	HU	Z-III	Bosch et al. 1990	4230	4195	10.7	4315	4300	1.3
							4170	4035	47.5	4265	3960	94.1
							4025	3990	10.0			
Cova del Sardo	KIA 32340	5254	40	CA	phase 7	Gassiot et al. 2014	4225	4205	7.8	4230	4195	12.1
							4165	4130	14.5	4175	3975	83.3
							4075	3985	45.8			
Cova Gran	Beta 233605	5250	40	CA	EA-2/Hearth H-1	Mora et al. 2011	4225	4205	6.6	4230	4195	11.1
							4160	4130	12.5	4175	3970	84.3
							4070	3980	49.1			
Moro de Olvena	GrN 12117	5160	80	CA	C5	Utrilla & Baldellou 1999	4050	3920	46.7	4230	4195	3.6
							3880	3800	21.5	4175	3775	91.8
Ca l'Oliaire	Beta 147811	5080	80	HU	pit F6	Martín et al. 2002	3965	3790	68.2	4045	3695	95.4
Ca N'Isach	UBAR 164	5060	100	CA	evel 1b - hearth E2	Tarrús et al. 1996	3965	3760	65.9	4050	3645	95.4
							3725	3715	2.3			
Cova del Sardo	KIA 40816	5000	30	CA	phase 7	Gassiot et al. 2014	3895	3880	4.2	3940	3865	23.0
							3800	3710	64.0	3815	3700	72.4
Llo	Gif 6750	4960	70	CA	C5/6	Rendu et al. 1996	3890	3885	1.6	3945	3855	19.5
							3800	3650	66.6	3850	3830	1.9
										3825	3640	74.0

Serratde la Padrilla	Ly 7066	4950	50	CA	c75	Rendu 1994	3775	3660	68.2	3935	3875	7.8
										3810	3640	87.6
Cova del Sardo	KIA 32342	4945	35	CA	phase 7	Gassiot et al. 2014	3765	3690	54.0	3795	3650	95.4
							3685	3660	14.2			
Pleta de les Bacives	Poz 22579	4905	55	CA	P008	Orengo et al. 2014	3760	3742	8.5	3895	3881	1.0
										3800	3631	91.4
							3715	3641	59.7	3578	3574	0.2
										3565	3536	2.8
Cova Gran	Beta 261425	4860	40	CA	Hearth H-6 MN	Mora et al. 2011	3695	3635	68.2	3715	3625	79.3
										3590	3525	16.1
Cova de los Ossos	Beta 147810	4860	70	HU	?	Soriano 2013	3715	3625	47.2	3800	3510	92.7
							3590	3530	21.0	3425	3380	2.7
Llo	Gif 6748	4860	70	CA	C5/6	Rendu et al. 1996	3715	3625	47.2	3800	3510	92.7
							3590	3530	21.0	3425	3380	2.7
Cova Gran	Beta 259272	4780	40	CA	Hearth H-6 MN	Mora et al. 2011	3640	3625	8.7	3650	3510	88.8
							3600	3525	59.5	3425	3380	6.6
Cova Gran	Beta 260863	4750	40	CA	Hearth H-2 MN	Mora et al. 2011	3635	3550	50.4	3640	3495	76.6
							3545	3515	14.4	3440	3375	18.8
							3395	3385	3.3			
Cova del Sardo	KIA 36394	4765	40	CA	phase 7	Gassiot et al. 2014	3635	3620	9.2	3645	3505	83.8
							3610	3520	59.0	3430	3380	11.6
Cova del Sardo	KIA 37691	4715	35	CA	phase 7	Gassiot et al. 2014	3630	3595	18.9	3635	3560	30.4
							3530	3500	16.0	3540	3490	20.6
							3435	3375	33.3	3470	3370	44.4
Grotte des Bruixes	Poz 38059	4680	30	FA	?	Martzluff et al. 2013	3516	3495	15.3	3623	3605	4.6
							3465	3398	46.8	3523	3370	90.8
							3385	3376	6.2			
Serratde la Padrilla	Gif A99606	4680	80	CA	c49	Rendu et al. 1996	3630	3595	9.2	3650	3330	92.1
							3530	3365	59.0	3215	3180	1.7
										3160	3125	1.6
Cova Gran	Beta 262453	4620	40	CA	Hearth H-3 MN	Mora et al. 2011	3500	3435	49.1	3520	3335	92.8
							3380	3355	19.1	3210	3190	1.6
										3155	3135	1.1
Espluga Puyascada	CSIC 383	4560	80	CA	level E.1	Utrilla & Baldellou 1999	3490	3470	4.3	3620	3610	0.4
							3375	3260	27.5	3525	3020	95.0
							3245	3100	36.4			

Cova del Sardo	KIA 32351	4555	30	CA	phase 6	Gassiot et al. 2014	3365	3330	30.2	3485	3475	0.6
							3215	3185	20.0	3375	3305	36.0
										3300	3285	1.3
							3160	3125	18.0	3280	3260	1.5
										3240	3100	56.0
Serratde la Padrilla	Ly 7064	4550	60	CA	c75	Rendu et al. 1996	3370	3310	19.8	3500	3435	7.3
							3295	3285	1.8	3380	3085	86.0
							3275	3265	2.3	3060	3030	2.1
							3240	3105	44.2			
Cova Colomera	OxA 17731	4500	32	SH	Fase 2 - CE9	Mangado et al. 2012	3340	3260	25.3	3350	3095	95.4
							3240	3210	12.7			
							3195	3150	16.9			
							3140	3105	13.3			
Cova Gran	Beta 260862	4490	40	CA	Hearth H-8 MN	Mora et al. 2011	3335	3260	26.9	3355	3085	90.5
							3255	3210	14.5			
							3195	3150	13.8	3065	3025	4.9
							3140	3095	13.1			
Grotte Chance	GIF 7147	4430	90	CA	Niveau 0 - ?	Lermercier 2010	3324	3233	20.9	3352	2906	95.4
							3172	3162	2.2			
							3118	2928	45.1			
Cova Gran	Beta 262455	4410	40	FA	Fumier T-Top	Mora et al. 2011	3095	3005	43.6	3325	3230	13.0
							2990	2930	24.6	3175	3160	1.1
										3120	2910	81.3
Ca N'Isach	UBAR 316	4490	90	CA	vel 1o - hearth E1	Tarrús et al. 1996	3350	3085	64.6	3495	3465	1.9
							3055	3030	3.6	3375	2910	93.5
Estany de la Coveta I	KIA 29816	4475	30	CA	level 3	Gassiot et al. 2014	3330	3215	49.4	3340	3205	54.0
							3180	3155	7.3	3200	3080	34.6
							3125	3095	11.5	3065	3025	6.8
Forat de la Conqueta	UA 34290	4475	60	HU	nivel 1/2	González et al. 2009	3335	3210	38.3	3360	3005	91.3
							3195	3150	11.5			
							3140	3085	13.9	2985	2935	4.1
							3055	3030	4.5			
Cova del Sardo II	KIA 40850	4465	30	CA	phase 1	Gassiot et al. 2014	3330	3215	46.0	3340	3205	50.9
							3175	3160	5.5			
							3120	3085	12.9	3195	3020	44.4
							3050	3035	3.9			
Pleta de les Bacives	Poz 32012	4425	30	CA	P169	Orengo et al. 2014	3263	3246	6.4	3323	3234	16.2
							3101	3011	56.0	3172	3162	1.1
							2978	2966	3.4	3117	2924	78.1
							2951	2943	2.3			

Pleta de les Bacives	Poz 22580	4415	30	CA	P008	Orengo et al. 2014	3095	3010	52.5	3314	3294	1.7
										3287	3274	1.1
							2981	2939	15.7	3266	3238	5.5
										3110	2919	87.1
Cauna de la Belesta	Lyon 8627	4415	45	CA	AT13 R22	Claustre et al. 1993	3262	3253	2.6	3330	3216	19.2
							3098	2928	65.6	3182	3158	2.8
										3125	2914	73.4
Cova de Els Trocs	Beta 316510	4410	40	SH	UE1	Rojo et al. 2013	3095	3005	43.6	3325	3230	13.0
							2990	2930	24.6	3175	3160	1.1
										3120	2910	81.3
Cova Gran	Beta 262456	4380	40	FA	Fumier T-Base	Mora et al. 2011	3080	3070	3.9	3265	3245	1.4
							3025	2920	64.3	3100	2900	94.0
Grotte Chance	GIF 7146	4360	90	CA	Niveau 0 - ?	Lermercier 2010	3265	3241	4.1	3350	2866	93.8
							3104	2887	64.1	2804	2775	1.4
										2770	2764	0.2
La Prunera	Beta 144301	4360	80	CA	Nivel 2	Alcalde et al. 2002	3100	2890	68.2	3340	3205	15.7
										3200	2875	79.7
Abric del Portarró	KIA 28276	4255	40	CA	cata 2 - level 3	Gassiot et al. 2014	2915	2870	58.5	3010	2985	1.0
										2935	2850	67.8
							2805	2775	9.7	2815	2740	21.6
										2730	2690	5.0
Cova Gran	Beta 260860	4250	40	FA	Fumier P-Base	Mora et al. 2011	2915	2870	55.7	2930	2850	63.4
							2805	2775	12.5	2815	2735	25.4
										2730	2680	6.5
Cova Gran	Beta 262454	4220	40	FA	Fumier P-Top	Mora et al. 2011	2900	2860	29.3	2910	2835	37.1
							2810	2755	33.9	2815	2670	58.3
							2720	2705	5.0			
Cova 120	Gif 6925	4240	70	CA	level II	Augustí et al. 1987	2920	2850	29.6	3025	2615	95.4
							2815	2740	26.6			
							2730	2680	12.0			
Cova Colomera	Beta 265439	4230	40	VC	Fase 2 - CE8	Mangado et al. 2012	2905	2860	37.6	2915	2840	44.1
							2810	2755	30.6	2815	2675	51.3
Cova del Sardo	KIA 26251	4210	35	CA	phase 5	Gassiot et al. 2014	2895	2860	24.3	2905	2840	32.2
							2810	2755	37.0	2815	2675	63.2
							2720	2705	6.9			
Serrat del Pont	Beta 90622	4200	70	CA	II.5	Alcade et al. 1997	2895	2840	18.8	2920	2575	95.4
							2815	2675	49.4			
Comad'Escós	KIA 36936	4180	30	CA	str. 2 - level 4	Gassiot et al. 2014	2880	2855	13.6	2890	2830	21.7
							2815	2745	39.9	2820	2665	73.7
							2725	2695	14.8			

Obagues de Raetera	KIA-28280	4160	35	CA	cata 1- level 3	Gassiot et al. 2014	2875	2845	10.6	2880	2625	95.4
							2815	2675	57.6			
Forat de la Conqueta	UA 34289	4140	45	HU	nivel 1/2	González et al. 2009	2870	2830	13.0	2880	2580	95.4
							2825	2800	5.9			
							2775	2770	1.1			
							2765	2630	48.3			
Cova Gran	Beta 261424	4130	40	CA	Hearth H-1 LN	Mora et al. 2011	2865	2805	20.5	2875	2580	95.4
							2760	2715	15.3			
							2710	2625	32.4			
Cova del Senglar	UBAR 57	4100	80	CA	Neolithic level	Mestres et al. 1991	2865	2805	15.7	2880	2480	95.4
							2760	2715	10.5			
							2710	2570	39.7			
							2515	2500	2.3			
Balma de Montbolo	MC 592	4120	90	CA	Galerie sup., zone	Guilaine et al. 1974	2866	2804	17.0	2891	2480	95.4
							2774	2770	1.1			
							2764	2579	50.1			
Serrat del Pont	Beta 64940	4100	90	CA	II.4	Alcade et al. 1997	2865	2805	15.3	2890	2465	95.4
							2760	2565	49.9			
							2515	2500	3.0			
Cova del Sardo	KIA 32348	4090	35	CA	phase 5	Gassiot et al. 2014	2850	2810	13.7	2865	2805	19.3
										2760	2715	8.5
							2680	2570	54.5	2710	2560	62.0
										2535	2495	5.6
Forat de la Conqueta	Beta 243284	4060	35	HU	nivel 1/2	González et al. 2009	2835	2820	4.6	2850	2810	9.3
							2635	2565	44.5	2745	2730	1.1
							2535	2495	19.0	2695	2475	85.0
Cova de La Pólvora	Beta 83126	4060	50	CA	level 2	Bosch et al. 1995	2835	2815	6.2	2865	2805	12.4
							2665	2550	43.6	2760	2715	5.4
							2540	2490	18.3	2710	2470	77.7
Cova de les Portes	UBAR 361	4050	70	CA	nivel VI	Castany et al. 2006	2840	2815	5.7	2880	2455	95.4
							2675	2475	62.5			
Serrat del Pont	Beta 64939	4020	100	CA	III.1	Alcade et al. 1997	2860	2810	7.5	2880	2290	95.4
							2750	2720	3.2			
							2700	2455	56.2			
							2420	2405	1.2			
Abric de Saboredo	Beta 290113	4010	40	CA	cata 1 - level 5	Gassiot et al. 2014	2575	2510	48.2	2835	2820	0.9
							2505	2475	20.0	2635	2460	94.5
Cova Drolica	GrA 33935	4000	35	CA	nivel a	ontes & Martínez 2007-20	2570	2520	46.8	2620	2605	1.5
							2500	2475	21.4	2600	2460	93.9

Cova Drolica	GrA 33936	3975	35	CA	nivel a	ontes & Martínez 2007-20	2570	2520	37.1	2580	2435	89.4
							2500	2465	31.1	2425	2400	2.3
										2380	2345	3.7
Cueva del Forcón	CSIC 384	3980	60	CA	Supercial	Baldellou 1985	2580	2450	59.2	2835	2815	1.4
							2420	2405	3.1	2670	2290	94.0
							2380	2350	5.9			
Covetes	KIA 32341	3960	30	CA	sondeo1	Gassiot et al. 2014	2570	2525	27.3	2575	2510	33.1
							2500	2455	40.9	2505	2395	54.5
										2385	2345	7.8
Collet de Brics d'Ardèvol	UBAR 89	3960	60	CA	CBA1/CBA2	Martín & Mestres 2003	2575	2510	22.6	2830	2820	0.1
							2505	2430	28.2	2630	2285	94.7
							2425	2400	7.0	2250	2235	0.6
							2385	2345	10.3			
Cova Sarradé	KIA 32335	3945	25	CA	sondeo1	Gassiot et al. 2014	2550	2540	3.3	2565	2530	10.8
							2490	2450	44.2			
							2420	2405	7.3	2495	2345	84.6
							2380	2350	13.4			
Vigne Canut	GIF 7337	3930	70	CA	?	Lermercier 2010	2559	2536	5.9	2619	2608	0.6
							2491	2333	55.2	2598	2594	0.2
							2326	2300	7.0	2585	2202	94.6
Forat de la Conqueta	UA 34294	3900	40	HU	nivel 1/2	González et al. 2009	2470	2340	68.2	2485	2275	92.7
										2255	2230	2.1
										2220	2210	0.6
Cuevade los Cristales	GrN 26967	3900	100	HU	Superficial	Montes et al. 2000	2560	2535	2.7	2835	2815	0.6
							2495	2270	55.5	2665	2645	0.5
							2260	2205	10.0	2640	2120	92.0
										2095	2040	2.2
Pleta de les Bacives	Poz 32017	3885	30	CA	M218	Orengo et al. 2014	4540	4455	68.2	4595	4435	85.3
										4430	4365	10.1
Pleta de les Bacives	Poz 284626	3885	35	CA	M175	Orengo et al. 2014	4540	4455	68.2	4595	4435	85.3
										4430	4365	10.1
Serrat del Pont	Beta 69597	3840	90	CA	II.3	Alcade et al. 1997	2460	2200	68.2	2565	2525	2.1
										2500	2030	93.3
Cova Drolica	GrA 25757	3830	45	CA	nivel a	Montes & Martínez 1996	2400	2380	4.7	2460	2195	90.3
							2350	2200	63.5	2175	2145	5.1
Pleta de les Bacives	Poz 32023	3760	35	CA	M217	Orengo et al. 2014	2275	2256	8.9	2289	2120	80.4
							2209	2134	54.7	2095	2041	15.0
							2077	2064	4.6			

Pleta de les Bacives	Poz 32018	3755	35	CA	M177	Orengo et al. 2014	2271	2259	5.1	2287	2117	76.7
							2207	2133	54.1	2099	2039	18.7
							2081	2061	8.9			
Pleta de les Bacives	Poz 18812	3755	35	CA	M151	Orengo et al. 2014	2271	2259	5.1	2287	2117	76.7
							2207	2133	54.1	2099	2039	18.7
							2081	2061	8.9			
Pleta de les Bacives	Poz 28427	3685	30	CA	M176	Orengo et al. 2014	2134	2077	43.4	2194	2176	2.9
							2064	2029	24.8	2145	1972	92.5

Tab. 7.3.1.1. (continues from the first page). Archaeological contexts and relative dates cited in the text. All dates were calibrated with OxCal v.4.2.3 at a range of 1 and 2 sigma (calBC). Atmospheric data from Reimer et al (2013) (IntCal13). SAM: Type of sample: CA - Charcoal; HU - human bone; FA - Faunal bone; SH - Short-lived charred remains.

Date	Max	Min	Me	C	Date	Max	Min	Me	C
CombineForcas	5710	5620	5654	1	CovaOssos-Beta147810	3800	3380	3652	4
Chaves-GrA38022	5615	5475	5528	1	Llo-C5/6-Gif6748	3800	3380	3652	4
FontdelRo-sAA16498	5625	5385	5522	1	CombineCovaGran_1	3640	3385	3572	4
Sardo9-KIA37689	5610	5375	5494	1	Sardo7-KIA36394	3641	3381	3565	4
Dourgne-MC1104	5620	5225	5430	1	Sardo7-KIA37691	3635	3370	3503	4
Chaves-UCIAMS66317	5485	5375	5427	1	SerratPadrilla-C49-A99606	3650	3125	3466	4
SerratdelPont-Beta172521	5510	5340	5426	1	CovaGran-Beta262453	3520	3135	3449	4
CombineCuevaChaves_3	5470	5295	5351	1	Bruixes-Poz38059	3625	3365	3447	4
HuertoRaso-GrA21360	5470	5075	5290	1	Puyascada-CSIC383	3620	3020	3258	4
CombineFont_2	5355	5215	5280	1	SerratPadrilla-C75-Ly7064	3500	3030	3231	4
CombineDraga_1	5310	5215	5264	1	EstanyCovetaI-KIA29816	3340	3025	3223	4
CH1a-GrA26912	5340	4995	5183	1	CovaColomera-OxA17731	3350	3095	3217	4
CombineLaDraga_2	5210	5050	5150	2	SardoII-KIA40850	3340	3020	3216	4
LaDraga-Beta0000	5220	5050	5131	2	Sardo6-KIA32351	3485	3100	3212	4
CombineColomera_1	5210	5050	5130	2	CaN'Isach-UBAR316	3495	2910	3186	4
CombinePlansallosa_1	5220	4995	5115	2	ForatConqueta-UA34290	3360	2935	3182	4
DourgneC5-MC1102	5330	4840	5114	2	CombineCovaGran_2	3335	3010	3152	4
CombineParco_1	5290	4940	5106	2	GrotteChance-GIF-7147	3355	2905	3115	4
Buholoup-C2Ly1089	5225	4910	5078	2	BacivesP169-Poz32012	3325	2920	3059	4
CoroTrasito-Beta366546	5210	4845	4993	2	CaunedeBelesta-Lyon8627	3330	2910	3054	4
CombineTrocsI_2	5035	4910	4973	2	TrocsIII-Beta316510	3325	2910	3042	4
FontdelRos-AA16500	5215	4790	4972	2	BaciveP008-Poz22580	3315	2915	3039	4
CombineLaDraga_3	5000	4845	4934	2	GrotteChance-GIF-7146	3350	2760	3021	4
AspreParadis-GrA16273	5035	4805	4925	2	LaPrunera-Beta144301	3340	2875	3014	4
CovaGran-Beta265982	5045	4790	4914	2	CovaGran-Beta262456	3265	2900	2993	4
Colomera-Beta248523	5045	4790	4914	2	Portarró-KIA28276	3010	2690	2885	5
LaDraga-UBAR313	5205	4720	4906	2	CombineCovaGran_3	2910	2705	2880	5
Puyascada-CSIC384	4985	4685	4810	2	Cova120-Gif6925	3025	2615	2805	5
MasBonet-Notspecified	4930	4715	4804	2	CovaColomera-Beta265439	2915	2675	2803	5
CoroTrasito-Beta358571	4935	4700	4795	2	Sardo5-KIA26251	2905	2675	2790	5
AspreParadis-Ly10069	4935	4690	4789	2	Comad'Escós-KIA36936	2890	2665	2773	5
CombinePlansallosa	4880	4610	4750	2	SerratdelPont-Beta90622	2920	2575	2770	5
CoroTrasito-UE3002	4790	4585	4696	2	ObaguesdeRaetera	2880	2625	2754	5
L'Avellaner-UBAR109	4935	4460	4689	2	ForatConqueta-UA34289	2880	2580	2733	5
Sanabastre-UBAR574	4780	4495	4631	2	CovaGran-Beta261424	2875	2580	2724	5
Codella-Beta221900	4720	4445	4570	3	Montbolo-MC592	2895	2475	2699	5
Plansallosa-Beta879655	4725	4370	4569	3	CovaSenglar-UBAR57	2880	2480	2679	5
CaunedeBelesta-Lyon8626	4690	4455	4567	3	SerratdelPont-Beta64940	2890	2465	2677	5
CombineSaredo8_1	4530	4455	4499	3	Sardo5-KIA32348	2865	2495	2650	5
LaDou-Beta221903	4615	4360	4493	3	LaPólvora-Beta83126	2865	2470	2607	5
Bacives-M152-Poz18807	4595	4365	4488	3	CovadelesPortes-UBAR361	2880	2455	2606	5
CaunedeBelesta-Lyon8625	4540	4355	4448	3	ForatConqueta-Beta24328	2850	2475	2595	5
Puyascada-CSIC-382	4580	4265	4421	3	SerratdelPont-Beta64939	2880	2290	2564	5
CombineTrocsII	4460	4360	4408	3	Saboredo-Beta290113	2835	2460	2533	5
CuevaPacencia-GrA17665	4360	4230	4293	3	CombineCovaDrólica	2575	2465	2528	5
CaunedeBelesta-Lyon3022	4345	4050	4242	3	Forcón-CSIC384	2835	2290	2501	5
ForcasVIII-Beta247406	4325	4045	4171	3	Covetes-KIA32341	2575	2345	2481	5
PlaBach-Gif7492	4325	3980	4136	3	Colletd'Ardèvol-UBAR89	2828	2235	2469	5
Pasteral-UBAR101	4315	3960	4112	3	CovaSarradé-KIA32335	2565	2345	2463	5
Sardo7-KIA32340	4230	3975	4070	3	VigneCanut-GIF7337	2620	2200	2413	5
CovaGran-Beta233605	4230	3970	4061	3	ForatConqueta-UA34294	2485	2210	2385	5
MoroOlvena-GrN12117	4230	3775	3967	3	BacivesM218-Poz32017	2470	2285	2380	5
Cal'Oliaire-Beta147811	4045	3695	3866	3	CuevaCristales-GrN26967	2835	2040	2376	5
CaN'Isach-UBAR164	4050	3645	3854	3	BacivesM175-Poz284626	2475	2210	2376	5
Sardo7-KIA40816	3939	3702	3775	4	SerratdelPont-Beta69597	2565	2030	2300	5
Llo-C5/6-Gif6750	3943	3641	3753	4	CovaDrolica-GrA25757	2460	2145	2288	5
SerratPadrilla-C75-Ly7066	3935	3640	3732	4	BacivesM217-Poz32023	2290	2040	2174	5
Sardo7-KIA32342	3791	3652	3719	4	BacivesM177-Poz32018	2290	2035	2168	5
BacivesP008-Poz22579	3895	3535	3692	4	BacivesM151-Poz18812	2290	2035	2168	5
CovaGran-Beta261425	3715	3525	3653	4	BacivesM176-Poz28427	2195	1970	2080	5

Tab. 7.3.1.2. Data set used for *K*-means and discriminant analysis (120 dates). Maximum (*Max)* and minimum (*Min)* values have been taken considering the 95.4% interval for each single curve. *C*: Cluster number.

Initial Clusters

	Cluster				
	1	2	3	4	5
Median	5654	5114	4567	3447	2080

Stages	Change Cluster Centers				
	1	2	3	4	5
1	156,714	27,850	87,292	148,537	397,536
2	18,286	61,367	85,327	82,264	67,521
3	54,818	49,259	17,781	,000	,000
4	,000	24,611	35,100	,000	,000
5	,000	,000	25,026	15,165	,000
6	,000	,000	23,124	15,756	,000
7	,000	13,330	17,771	,000	,000
8	20,098	10,670	,000	,000	,000
9	,000	,000	,000	,000	,000

Final Clusters

	Cluster				
	1	2	3	4	5
Median	5404	4927	4267	3350	2545

Tab. 7.3.1.2. *K-means* procedure. *Above*: Initial cluster centres. *In the Middle*: Iteration History, changes in cluster centres at each step. Convergence achieved at step 6. *Below*: Final cluster centres.

	Cluster number	**Predicted Group Membership**					Tot
		1	2	3	4	5	
N	1	11	1	0	0	0	12
	2	0	23	0	0	0	23
	3	0	0	19	0	0	19
	4	0	0	0	31	0	31
	5	0	0	0	0	35	35
%	1	91,7	,0	,0	,0	,0	100,0
	2	,0	100,0	,0	,0	,0	100,0
	3	,0	8,0	100,0	,0	,0	100,0
	4	,0	,0	,0	100,0	,0	100,0
	5	,0	,0	,0	,0	100,0	100,0

Tab. 7.3.1.3. Discriminant analysis. Classification Results. The 99.2% of original grouped cases correctly classified.

Wilks's Lambda

Test of function(s)	Wilks's Lambda	Chi-cuadrado	df	Sig.
from 1 to 2	,036	382,397	8	,000
2	,946	6,388	3	,094

Tab. 7.3.1.4. Discriminant analysis. Wilks's Lambda test. The result indicates the significance of the discriminant function. Already at the first test we obtained a highly significant function ($P < .000$).

Legend of the abbreviations used in the images:

CE - Cereal/dry herbaceous plant;

RV2 - Herbaceous plant with an abrasive component;

HP - Indeterminable herbaceous plants;

HP-S - Indeterminable herbaceous plants-scraping;

HP-ind - Indeterminable herbaceous-indeterminate movement;

VG - Indeterminable vegetal substances;

WO - Woody plants;

HI - Hide working;

F-HI - Fresh hide working;

D-HI - Dry hide working;

HA - Hard animal substances (Bone/Antler);

BU - Slaughtering/Butchering activities;

MIN - Mineral substances working;

CL - Clay/Pottery;

PY - Projectile traces;

WE - Tools used as wedge;

PO/GR - Pounding/Grinding activities;

SFT - Soft indeterminable substances;

SFT/MED - Soft/medium indeterminable substances;

HRD/MED - Hard/medium indeterminable substances;

HRD - Hard indeterminable substances.