Unravelling the burin-core dichotomy: Historiographic and technological data to develop a new analytical framework for the study of on-edge artefacts

Javier Sánchez-Martínez [1,2], Xavier Roda Gilabert [1,3], Jorge Martínez-Moreno [1]

1. Departament de Prehistòria. Facultat de Filosofia i Lletres, C/de la fortuna s/n. Universitat Autònoma de Barcelona. 08193 Bellaterra, Spain. Email: Sánchez-Martínez: javier.sanchez.martinez@uab.cat; Roda Gilabert: Javier.roda@uab.cat; Martínez Moreno: Jorge.Martínez@uab.cat
2. Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour (ICArEHB), Universidade do Algarve, Pav. K3 8005-139 Faro, Portugal.
3. CASEs - Culture, Archaeology and Socio-Ecological Dynamics group. Universitat Pompeu Fabra. Departament d'Humanitats. Mercè Rodoreda building, Ramon Trias Fargas, 25-27 08005 Barcelona, Spain.

Abstract:

Burins are flexible tools that have been analysed from different perspectives, showing a wide range of technical diversity. The interpretation of this morphotype has oscillated between two dichotomies: form-function and core-tool. In this paper, we analyse the historiographical trajectory of the burin from a typological, technological, and functional perspective to develop a methodological and analytical framework for the study of this morphotype. Likewise, this work aims to propose technical attributes for the study of burins and burin-cores in order to broaden our knowledge about on-edge core reduction strategies. To this end, we have combined historiographical research on burins and burin-cores together with a general overview of the technical attributes of these artefacts in the units 6P and 7P from Cova Gran de Santa Linya.

The analysis of the refits and technical attributes on the lithic assemblage show different degrees of complexity in the configuration and reduction of burin-like artefacts. Simple burins are configured on a fracture, a plane or a previous removal and do not usually record notches or lateral retouch. On the other hand, we recovered more complex artefacts that belong to the technical sphere of cores. Qualitative and quantitative data allowed understanding the technical actions involved in the reduction of the lateral edges of the flakes by 1) identifying core management actions through retouching (shaping); 2) understanding the actions for the opening of the knapping surfaces (burin facets) from the edge, 3) exploring the technical actions involved in the lateral and volumetric reduction of flakes. 4) reconstructing the knapping sequences associated with this knapping method aimed at obtaining homogeneous bladelets through different reduction phases on the edge of flakes.

As a result, we aim to visualise the role of on-edge cores in the technical organisation of the Palaeolithic occupations and extend our knowledge of the technical behaviour of Upper Palaeolithic groups. Likewise, through this case study we address some of the constraints in the study of Upper Palaeolithic lithic assemblages and allow us to visualise how interpretative biases in the analysis of artefacts may remove expressions of human behaviour in past societies. By limiting these preconceptions, we could fill in some gaps in the interpretation of the archaeological record.

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1. Introduction

The application of specific analytical approaches to the study of stone tools (technological, typological, and functional) may change our perception of lithic assemblages. This problem is not new (Dibble *et al.* 2016; Plisson 2006; Vaquero & Romagnoli 2018) and has been part of the dichotomy between burins and cores over the past decades (de Araujo Igreja *et al.* 2006).

Burins have a long historiographic tradition in which their wide technical and morphological diversity has been highlighted. Two of the first types to be defined are the burin on truncation "*le burin latéral est obtenu par l'enlèvement au bord du grattoir d'un lamelle parallèle à la direction de la lame*" (Bardon *et al.* 1903: 165) ("*the lateral burin is obtained by detaching a bladelet from the side of an end-scraper parallel to the direction of the blade*"), and the dihedral burin: "*burin classique du Magdalenien; le plus simple de tous. [...] Le biseau, placé à l'extremité de la lame, est formé par deux faces qui se rejoingnent en un angle dièdre assez aigu, l'arête est perpendiculaire au plan de la lame*" (Bardon *et al.* 1910) ("*classic Magdalenian burin; the simplest of all. [...] The bevel, placed at the end of the blade, is formed by two faces that meet at an acute dihedral angle; the edge is perpendicular to the plane of the blade")*, whose representation in the *Late Glacial Maximum* (LGM) assemblages fitted in with the emergence of new activities such as the manufacture of bone tools, art, and engravings. All these attributes are linked to the emergence of modern behaviour. For this reason, the burin became a structural artefact within the Upper Palaeolithic tool-kit and its general acceptance as a tool-type quickly fitted into the construction of the discipline and cultural taxonomies (Arrizabalaga 1994; see references in Dujardin 2005: 25-320; Cattin, 2006; Klaric 2007; de la Peña Alonso 2009).

This paper aims to be a historiographical summary of the typo-technological analyses on burins. Thus, we focus on the historiography of burins within the construction of prehistoric archaeology and provide an analytical framework for studying burin-cores and on-edge reduction methods. Following this, we aim to characterise the technical actions involved in the manufacture of burin-cores (Le Brun-Ricalens & Brou 2003), as well as analyse their technological differences with burins. To explore this, we have compiled qualitative data from previous publications combined with technical information collected during the preliminary study of the reduction sequences of burin-cores from the Magdalenian occupations of the Cova Gran de Santa Linya (Mora *et al.* 2011; Sánchez-Martínez *et al.* 2022). To analyse the object of study we have used the 6W rhetorical formula (Herrscher 2009), whose application has been tested in fields such as medicine, education, or engineering (*e.g.*, Deng & Ruan 2008; Vanasse *et al.* 2018; Zhang & Huang 2013). Through this procedural approach we explore cause-effect relationships and analyse the burin-burin-core dichotomy from a multidimensional perspective based on "who", "what", "where", "when", "why", "how" questions (Figure 1).

Who refers to burins, which are fundamental artefacts in the composition of Upper Palaeolithic assemblages since the construction of Prehistoric Archaeology as a discipline.

When refers to the long historiographic trajectory of burins along more than 100 years and its last review with the volume "Burins préhistorique: formes, fonctionnements et fonctions" (de Araujo Igreja et al. (Eds.) 2006).

What refers to the different perspectives applied to the study of burins, covering technological, typological, and functional aspects.

Where refers to the information collected from the study of the Magdalenian occupations of Cova Gran de Santa Linya (Sánchez-Martínez *et al*. 2022), which are a good reference to address the burin and burin-core dichotomy.

Why refers to the constraints identified in the study of burins from a technological perspective and the interpretational biases surrounding on-edge reduction methods.

How refers to the methodological approach proposed in this article and the importance of providing new analytical baselines to understand research on burins and on-edge reduction sequences.

Along this contribution, we elaborate an analytical framework that can be used as a starting point for ongoing studies applied to Upper Palaeolithic archaeological materials.

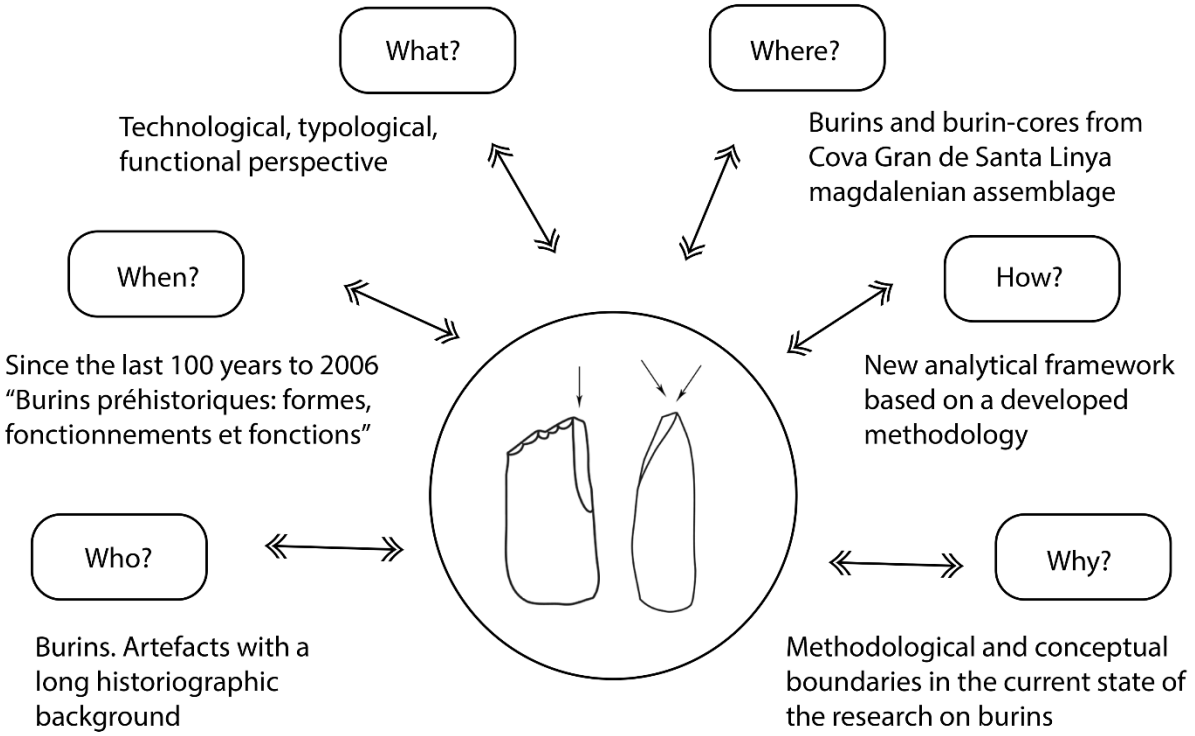

Figure 1. The 6 W's model applied to the study of on-edge or burin-core assemblages.
Figura 1. Modelo de las 6 W's aplicado al estudio de los conjuntos de núcleos sobre borde o núcleos-buril.

2. Burins: a long discussion between shape and function

In the early years of Palaeolithic archaeology, different types of burins were defined based on their morphology and manufacture (Bardon *et al.* 1903, 1906, 1910). This phase served to provide a conceptual framework for the study of these artefacts and to detect changes in the composition of retouched assemblages throughout the Upper Palaeolithic. During the second half of the 20th century, several classifications were proposed with the aim of reducing their variability (Demars & Laurent 2003: 50-75; Laplace 1972: 130-133; Sonneville-Bordes & Perrot 1956), which had been overestimated because of regional, stylistic, technical, and morphological variations (Brézillon 1977) (Table 1).

Most of the burin types were defined in the first half of the 20th century (see supplementary information Table s1). During this period, researchers provided different names based on regional and morphotechnical variations on burins, resulting in a wide diversity of types, some of them equivalent between each other. This practice resulted on the classification and organisation of burins and the compilation of the different terms applied to these artefacts (Figure 2).

Table 1. Main typological compilations for Upper Palaeolithic retouched tools by chronological order and number of burin types identified in each work.
Tabla 1. Principales compilaciones tipológicas para útiles retocados del Paleolítico superior por orden cronológico y número de buriles identificado en cada trabajo.

Compilation reference	Year	Types of burins
Sonneville-Bordes and Perrot	1954	18
Laplace	1972	7
Brézillon	1977	89
Demars and Laurent	2003	13

Although the term burin carries an implicit functional attribution (Plisson 2006), the definition and graphic representation of some burins in the typological lists open a possible interpretation of these tools as cores. This is indicated in the dihedral burin definition suggested by Sonneville-Bordes and Perrot (1956): "*burin formé par l'intersection d'un angle dièdre de deux enlèvements ou* ***groupes d'enlèvements****, dits coup de burin*" ("*burin formed by the intersection of a dihedral angle of two removals or* ***groups of removals****, known as a burin spall*"). This concept encompasses the idea of creating a platform that later serves to obtain elongated pieces, emphasising the productive nature of burins. Tixier (1963: 27), who stated that truncations and crested blades are part of the technical genesis of laminar knapping productions, developed this idea. However, other authors consider that crested bladelets are aimed at maintaining the bevel, which is considered one of the main active parts of burins (Cattin 2006). In addition, the burin was considered a type of retouch (Sonneville-Bordes & Perrot 1956) and a knapping technique (Cattin 2006) (*technique du coup de burin / burin spall technique*) (Cochrane *et al.* 2013; Inizan *et al.* 1995; Tixier *et al.* 1980: 84-87, Vaughan 1985). This conceptual and technical diversity reflects the complex nature of burins, the definition of which is shrouded in typological, technological, and functional biases. These issues, among others, have been addressed in the collective work *Burins préhistoriques: formes, fonctionnements, fonctions* (de Araujo Igreja *et al.* 2006) and present the goal of this article: the technological and methodological framework for the study of burin-cores.

2.1. Structure and evolution of terms in Lithic Analysis)

The terms (categories of analysis) used in lithic technology reflect humankind's thoughts and ways of expressing ideas (Brézillon 1977: 43-44). Concepts used in lithic analysis undergo an evolution from an initial descriptive phase to a final phase, in which the concept itself gathers the most relevant information about the artefact. These descriptive and reductionist tendencies are born with the aim of simplifying language and analysis, but they feed back and empty the concepts of meaning (*e.g.*, the use of the term burin automatically according to its morphology) (Table 2).

2.2. Burins as tool types (typological perspective)

Burins are classic tools in Upper Palaeolithic assemblages and have a wide chronological and geographical extension. These artefacts have been classified based on their techno-morphological characteristics and the orientation of their facets, resulting in a diversity of types related to the technical and regional variability of the lithic assemblages. However, these classifications were not able to capture the multi-functionality of some types of burins-burin-cores (Barton *et al.* 1996; Tomásková 2005), which is one of their main features.

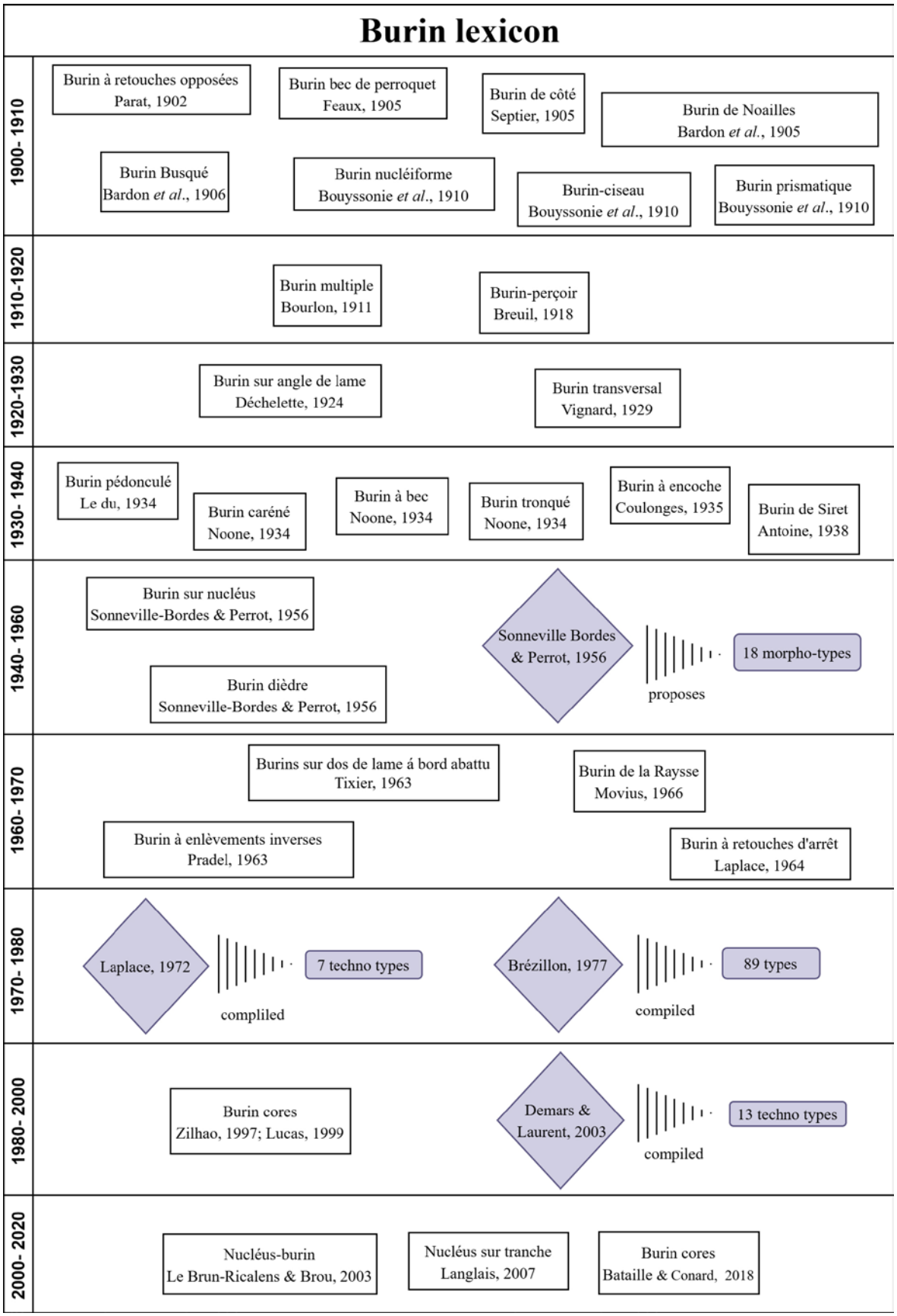

Figure 2. Burin lexicon by author and date of publication and the most remarkable burin compilations (in grey). Note no new type of burin has been defined since the emergence of burin-cores.
Figura 2: Lexicón de buriles por autor y fecha de publicación y las compilaciones de buriles más relevantes (en gris). Resaltar que no se ha definido ningún tipo nuevo de buril desde la aparición de los núcleos-buril.

Table 2. Example of the diagram of the evolution of terms proposed by Brézillon (1977). The definition of Noailles burin on Demars & Laurent (2003) has been adopted for phase 0. Phases 1-4 have been modified from the original publication to clarify this case.
Tabla 2. Ejemplo de diagrama de evolución de los términos propuesto por Brézillon (1977). Se ha adoptado la definición del buril de Noailles de Demars & Laurent (2003) para la fase 0. Las fases 1-4 se han modificado de la publicación original para ilustrar este caso.

Reduction phase	Description
Phase 0	Burin on a small flake with a retouched truncation from which a minuscule burin stroke is raised, stopped by a notch and generating a very narrow burin (2 mm). This burin is often multiple
Phase 1	Burin on oblique truncation of the Noailles type from a given site
Phase 2	Burin of the Noailles type
Phase 3	Noailles Burin
Phase 4	Noailles

The techno-typo-functional dichotomy in burin-cores is similar to the one addressed in other carinated tools (*e.g.*, carinated-nucleiform scraper and burins) (de Araujo Igreja *et al.* 2006; Demars 1982; Klaric 2002; Le Brun-Ricalens *et al*. 2005), whose analytical approach has evolved because of the application of a technological perspective. Therefore, the dissociation of these artefacts from their unique tool-type nature is possible by their incorporation in technological and operational chains approaches (Aubry *et al.* 1995; Le Brun-Ricalens 2005).

2.3. Burins as tools (functional perspective)

Burins have been historiographically considered as tools (Plisson 2006). From functional studies, these artefacts have encompassed a greater number of activities that link them as fundamental objects for understanding the socio-organisational sphere of prehistoric societies. The functionality of burins includes the execution of engravings and incisions on hard (portable and cave art) and soft materials (wood, bone, antler), as well as other actions such as scraping, grooving, sharpening, or drilling (Anderson *et al.* 1993; Barton *et al.* 1996; Calvo *et al.* 2019; Gassin & Gibaja 2016; Janny *et al.* 2006; Longo & Skakun 2008: 3-20; Semenov 1981: 131-133; Venditti *et al.* 2016). Furthermore, other functional studies mentioned that burin facets are adaptations for hafting (Gassin *et al.* 2006; Keeley 1982; Santaniello & Grimaldi 2021; Semenov 1981: 184-185; Taipale & Rots 2020; Tixier 1958), that they are related to the configuration of projectiles (Tixier 1966) or that truncations are active parts used for different purposes (Hilbert *et al.* 2018). Additionally, it has been argued that pieces with burinations are related to impacts (Dinnis *et al.* 2009; Fischer *et al.* 1984; Pargeter 2011), amplifying the functional range of these tools as projectiles. These technical and functional options, among others, indicate the wide techno-functional field of these pieces (Barton *et al.* 1996; Tomásková 2005).

2.4. Burins as cores (technological perspective)

In the last decades, different authors have pointed to a complementary role of burins as cores (among others Almeida 2001; Aubry *et al.* 1995; Bataille & Conard 2018; Le Brun-Ricalens & Brou 2003; Leplongeon & Goring-Morris 2018; Leroi-Gourhan 1988:166-168; Lucas 1999; Olive 1988; Soriano 1998; Zwyns *et al.* 2012). This proposal coincides with the characterisation of on-edge knapping strategies in Upper Palaeolithic contexts. (Aubry *et al.* 1997; Bodu *et al.* 2007; Falcucci & Peresani 2018; Langlais 2007: 54-55; Sánchez-Martínez *et al.* 2022; Zilhao 1997).

In the description of the dihedral burin proposed in the work of Sonneville-Bordes and Perrot (1956), which is a reference for the typological classification of Upper Palaeolithic assemblages in Southwestern Europe, it is noted that burins are tools with a bevel obtained by detaching a group of removals called burin spalls. The intention of obtaining groups of removals (bladelets) has been also identified in the Vachons, Raysse and Busqué types, technologically re-evaluated as burin-cores (Brou & Le Brun-Ricalens 2006; Flas *et al.* 2006; Klaric *et al.* 2002; Pesesse & Michel 2006; Pottier 2006). The mentioned works contributed to characterise the technical actions involved in on-edge knapping methods and their derived blanks (de Araujo Igreja & Pesesse 2006; Brou & Le Brun-Ricalens 2006), providing examples of how the technological perspective must be integrated within typo-functional approaches. In this line, our research promotes the view of burin-cores as multifunctional pieces that cover different activities throughout their transformative phases (Audouze *et al.* 1981; Arrighi *et al.* 2006; Barton *et al.* 1996; Cahen 1980; Janny *et al.* 2006).

3. Archaeological setting

Cova Gran de Santa Linya is a rock shelter located in the northeast of the Iberian Peninsula, in the southeastern foothills of the Pyrenees. This site provides evidence of human occupations during the last 50k years and informs about variations in the technical behaviour of hunter-gatherer groups during the Upper Palaeolithic (Benito-Calvo *et al.* 2009; Mora *et al.* 2011). In this paper we analyse the burin technology of levels 6P and 7P, located in test pit EA, on the inner platform of the rock shelter (Platform, P) (Mora *et al.* 2011; Sánchez-Martínez *et al.* 2022). The unit in which levels 6P and 7P are located consists of clastic, coarsely stratified breccias, composed of clasts and subangular limestone blocks with a sparse orange sandy-loamy matrix. The 14C AMS radiocarbon dates for level 6P (14,520±60 BP and 15,120±70) and level 7P (15,280±60 and 16,800±80) place this sequence in the Lower Magdalenian chronometric range. The archaeological remains recovered in this part of the sequence raised technological and analytical questions to understand technological trends in on-edge knapping strategies (Sánchez-Martínez 2022). Thus, burins (54), burin-cores (85) and technological blanks associated with on-edge knapping strategies (792) were used as reference to conduct this work (see Supplementary Information Table S2, Table S3 and Table S4).

4. Methods: Burin-core technical attributes

The lithic materials were analysed based on a techno-typological approach (Andrefsky 2008; Inizan *et al.* 1995; Pelegrin 1986; Tixier 1984; Tixier *et al.* 1980) and contextualised from studies on lithic *chaîne opératoires* (Geneste 1991; Karlin *et al.* 1991; Pelegrin *et al.* 1988; Soressi & Geneste 2011). We perform the analysis of cores and reduction sequences based on previous works in laminar technology (Falcucci & Peresani 2018; Karlin 1991; Le Brun-Ricalens *et al.* 2005; Langlais *et al* 2010; Naudinot *et al.* 2017; Pelegrin 1985, 1995; Pigeot 1987: 21-56; Ploux *et al.* 1991; Roussel *et al.* 2016; Sánchez-Martínez *et al.* 2022). Burins and burin-cores were analysed following the current technological framework for the study of on-edge knapping strategies (de Araujo Igreja *et al.* 2006; Bataille & Conard 2018; Langlais 2007: 54-55; Le Brun-Ricalens & Brou 2003; Zilhao 1997;) as well as their variability (Sánchez-Martínez *et al*. 2022). The concepts burin-core and on-edge core are used indistinctly along this article. For the study of crested bladelets and their variability (1st and 2nd phase, and burin tablet) we have followed specialised works focused on the technical attributes of that pieces (Le Brun-Ricalens & Brou 2003). The lithic analysis has been done following the general methodology presented in previous studies on the Upper Palaeolithic

assemblages in Cova Gran de Santa Linya (Sánchez-Martínez 2022; Sánchez-Martínez *et al.* 2021).

The analysis of burin-cores is aimed at characterising their manufacture process from a broad perspective encompassing the concepts of operational chain and tool life history (Andrefsky 2008, 2009) combining litho-techno-typo-functional data of the analysed assemblages. And thus, establishing a solid theoretical and analytical basis for the study of on-edge knapping methods. The refits on the lithic assemblage revealed the obtention of elongated blanks from the edge of flakes, providing new elements of discussion to discern whether burins refer to the technical sphere of the cores. Considering the multipurpose nature of the burins, technical variables have been quantified based on the attributes of the cores to understand the technical aspects involved in the reduction sequence (Sánchez-Martínez *et al.* 2022). This data allowed us to propose a technical baseline to distinguish burin-cores from burins, as well as between preferential burin-cores (BCP) and equivalent burin-cores (BCE). In this way, we establish normative and facultative criteria to discriminate the diagnostic attributes for these artefacts.

4.1. Discriminant criteria between burins and burin-cores

Technical attributes were recorded based on previous analyses of burins, burin-cores, and artefacts derived from on-edge knapping strategies. The diagnostic pieces are burin bladelets, 1st order crested bladelets, 2nd order crested bladelets, and burin tablets (Le Brun-Ricalens & Brou 2003; Le Brun-Ricalens *et al.* 2006; Pesesse & Michel 2006).

Crested bladelets and burin tablets are only obtained from burin-core methods. The crested bladelets are generally thin, elongated and triangular or quadrangular in cross-section. They can be fully retouched (first order) or with the retouch in the distal part (second order) as they belong to the second core removal. Other authors consider the first order removals the ones with triangular cross-section (the so-called burin spalls) and the second order removals those with quadrangular cross-section (also called burin bladelets) (Gameiro 2007). After the crested bladelets, the consecutive elongated blanks obtained are burin bladelets. In most cases, these products are characterised by having a natural backed edge coming from the ventral face of the blank. This attribute is unique to burin-core methods. New burin facets are formed with the extraction of burin bladelets from the lateral edge of a blank, which can play a dual role of either core platform or knapping surface. The width of burin facets will be related to the thickness of the blank reduced.

BCP and BCE share technical attributes because of the technical convergence presented in on-edge reduction methods. However, there are some attributes that gather specific information to distinguish between preferential and equivalent types (Table 3 and 4). BCP are hierarchical cores organised on a main platform and a knapping surface, whereas in BCE the knapping surfaces (facets) are alternatively exploited playing complementary roles during reduction. In addition, the burin angle varies between BCP (75-90º) and BCE (60º or less) due to how the reduction is organised. Progression is another informative attribute used to distinguish between BCP (frontal, linear consecutive, and linear alternating) and BCE (mostly frontal). That may be explained because in preferential sub-types there is higher variability in the organisation of the knapping rhythm, whereas in the equivalent non-hierarchical subtype, the reduction is conducted frontally, without turning the core.

The attributes mentioned here help to understand the technical actions involved in on-edge reduction methods, and specifically to distinguish the preferential and equivalent sub-categories of burin cores. These same attributes, applied to cores, can be applied as a methodological basis for distinguishing when a piece is in the tool sphere (burin) or in the core sphere (burin-core) (Table 5).

Table 3. Technical attributes in preferential burin-cores (BCP). Attributes have been compiled and created from previous and current works in on-edge reduction sequences. Normative attributes (N), Facultative attributes (F). References: [1] Le Brun-Ricalens & Brou (2003) [2] Le Brun-Ricalens *et al.*, (2006 and reference therein) [3] Zwyns (2012) [4] Bataille & Conard (2018) [5] Pesesse (2006) [6] de Araujo & Pesesse (2006).
Tabla 3. Atributos técnicos en núcleos-buril preferenciales. Los atributos se han definido a partir de trabajos previos y actuales sobre secuencias de reducción sobre borde. Atributos normativos (N), Atributos facultativos (F). Referencias: [1] Le Brun-Ricalens & Brou (2003) [2] Le Brun-Ricalens *et al.*, (2006 y citas en el texto) [3] Zwyns (2012) [4] Bataille & Conard (2018) [5] Pesesse (2006) [6] de Araujo & Pesesse (2006).

Attributes	**Description**	**Presence**
Recurrence [1,2,5,6] (Debitage and core maintenance)	Repetition of technical actions in the management of the core and blanks derived from this type	N
N= Removals [1,2,3,4]	Knapping surface with elongated removals (3 or more removals)	N
Progression [1,2,4,5] (Debitage rhythm)	Order in which the removals follow each other during reduction. Also called debitage rhythm. It can be linear consecutive, linear alternating or frontal (occasional)	N
Volumetric reduction [1,2,5,6]	Mass lost during the reduction sequence. If the initial volume of the blank cannot be reconstructed, the reduction will be significant.	N
Hierarchization	The core is hierarchised. There is a preferential platform and knapping surface	N
Refittings [1,2,5,6]	Reconstruction of debitage series (crested and burin bladelets) and phases of core maintenance (burin tablets)	F
Bevel angle [2,6]	Angular relationship between platform and knapping surface around 75-90º	F
Shaping (crested bladelets) [1,2,5,6]	Configuration of the distal convexity by lateral retouch (notch optional)	F
	The distal convexity assists of the creation of the platform and the knapping surface	F

As some of these attributes can be found in burins and cores, it is necessary to underline qualitatively and quantitatively, which attributes allow discriminating both categories from a technological perspective.

The criteria that may help in the recognition of burin-cores are recurrence, number of removals (greater than 3), progression (linear consecutive or linear alternating), and volumetric reduction. The recurrence in debitage and maintenance actions informs about the composition of a technical behaviour aimed at managing core volumes in a homogeneous way through time. The number of removals is directly related to the intentionality for reducing a given volume of the blank, which is an indicator linked with cores. Occasionally, the progression, also called debitage rhythm, may give rise to semi-circumferential burin cores, equivalent to the classic burin Busqué and Vachons types as well as other carinated tools. This is because as core reduction becomes more advanced, a lateral convexity must be generated to favour the obtention of laminar extractions. The volumetric reduction marks the mass lost during knapping. Burin-like artefacts allow an easy recognition of their initial volume because they are made on blanks. For that reason, depending on the volume loss it can be inferred how intense the reduction is, becoming a useful indicator to distinguish burins from burin-cores.

Table 4. Technical attributes in equivalent burin-cores (BCE). Attributes have been compiled and created from previous and current works in on-edge reduction sequences. Normative attributes (N) Facultative attributes (F). References: [1] Le Brun-Ricalens & Brou (2003) [2] Le Brun-Ricalens *et al.*, (2006 and reference therein) [3] Zwyns (2012) [4] Bataille & Conard (2018) [5] Pesesse (2006) [6] de Araujo & Pesesse (2006).
Table 4. Atributos técnicos en núcleos-buril equivalentes. Los atributos se han definido a partir de trabajos previos y actuales sobre secuencias de reducción sobre borde. Atributos normativos (N), Atributos facultativos (F). Referencias: [1] Le Brun-Ricalens & Brou (2003) [2] Le Brun-Ricalens *et al.*, (2006 y citas en el texto) [3] Zwyns (2012) [4] Bataille & Conard (2018) [5] Pesesse (2006) [6] de Araujo & Pesesse (2006).

Attributes	**Description**	**Presence**
Recurrence [1,2, 5, 6] (Debitage and core maintenance)	Repetition of technical actions in the management of the core and blanks derived from a given knapping method	N
N= Removals [1,2,3,4]	Knapping surface with elongated removals (3 or more removals)	N
Progression [1,2,4,5] (Debitage rhythm)	Order in which the removals follow each other during reduction. Also called debitage rhythm. It is generally frontal	N
Volumetric reduction [1,2,5,6]	Mass lost during the reduction sequence. If the initial volume of the blank cannot be reconstructed, the reduction will be significant.	N
Hierarchization [6]	The surfaces of the core are not hierarchical. Both are exploited alternatively	N
Refittings [1,2,5,6]	Reconstruction of debitage series and phases of core maintenance. Dorso-ventral refittings are habitual because of the frontal progression of debitage	F
Bevel angle [2,6]	Angular relationship between knapping surfaces (facets) lower than 60º	N
Shaping (crested bladelets) [1,2,5,6]	Configuration of the distal convexity by lateral retouch (notch optional)	F
	The distal convexity allows the creation of the knapping surfaces (facets)	F

Other attributes, such as the hierarchization, or the angle of the bevel, are not relevant to differentiate burin from cores, although they are relevant in on-edge methods to distinguish between preferential (BCP) and equivalent (BCE) subcategories of burin-cores. Finally, the refits on the lithic assemblage help with the qualitative and quantitative observation of all the technical attributes mentioned before, as they allow the reconstruction of the lost mass, and then provide a better picture about the knapping sequence. In this specific case, refittings were essential to deepen the burin-core dichotomy and to discriminate between on-edge sub-categories.

Burins and burin-cores share technical actions in their configuration, such as the creation of platforms, knapping surfaces (or burin facets) and to control the length of the removals by retouching the edge. This technical convergence may result in a combination of attributes that difficult the diagnosis between on-edge cores and burins. For this reason, we establish that burin-cores should meet at least 3 of the 8 criteria presented here.

Table 5. Burin and burin-core discriminant attributes. Comparison between technical attributes of burin and burin-cores. References: [1] Le Brun-Ricalens & Brou (2003) [2] Le Brun-Ricalens *et al.,* (2006 and reference therein) [3] Zwyns *et al.* (2012) [4] Bataille & Conard (2018) [5] Pesesse & Michel (2006) [6] de Araujo & Pesesse (2006).

Tabla 5. Comparación entre atributos técnicos de buriles y de núcleos-buril. Referencias: [1] Le Brun-Ricalens & Brou (2003) [2] Le Brun-Ricalens *et al.*, (2006 y citas en el texto) [3] Zwyns *et al*. (2012) [4] Bataille & Conard (2018) [5] Pesesse & Michel (2006) [6] de Araujo & Pesesse (2006).

Category	**Burin**	**On-edge core**
Graphic representation		
Recurrence [1,2, 5, 6] (Debitage and maintenance)	No	Yes
N= Removals [1,2,3,4]	2 or less removals	3 or more removals
Progression [1,2,4,5] (Debitage rhythm)	Frontal	Frontal, linear consecutive, linear alternated
Volumetric reduction [1,2,5,6]	Low	Intense
Hierarchisation	Not significant	Not significant
Refittings [1,2,5,6]	Short sequences	Long sequences
Bevel angle [2,6]	Not significant	Not significant
Shaping [1,2,5,6](crested bladelets)	Occasional	Abundant

5. Results: On-edge operative chain and technological insights

A combination of qualitative and historiographic research applied to burins, burin-cores, and on-edge reduction methods, together with the technological analysis and refittings of the Magdalenian lithic assemblage of Cova Gran de Santa Linya was conducted to explore some of the constraints in the study of Upper Palaeolithic classical interpretations. Based on the data collected through this study we propose the standard operational and technical sequence of the burin-core reduction and its implications for understanding on-edge technology (Table 6 and Figure 3).

Burin-cores are generally organised on thick blanks which are transformed by a combination of lateral retouch and notches conducting the initial shaping of the artefacts (Figure 3, step 1). This shaping process is aimed at maintaining the distal convexity to ensure success in the following step, which consists of the creation of the first facet by detaching the retouched edge of the blank (Figure 3, step 2). The new surface created through the detachment of a crested bladelet may drive the organisation of preferential burin-core (Figure 3, step 3) or may be used as a platform to create the second facet (Figure 3, step 4). At this point, the blank with two facets may be reduced following two different schemes: The first, uses the first facet as a platform and the second facet as a knapping surface, giving rise to a preferential burin-core (Figure 3, step 5). The second uses both facets alternatively as a platform and knapping surface, resulting in a non-hierarchical burin-core (Figure 3, step 6).

From this scheme, we have observed how the organisation of edge reduction methods and the configuration of burin-cores is based on specific and recurrent technical actions. Following this, it could be suggested that the stages (reduction phases) in the burin-core operational chain may correspond to specific types of burins identified in classic Upper Palaeolithic typology (Table 7). This implies understanding lithic reduction as a non-linear process where different transformative stages are overlapped.

Table 6. Summary scheme of the main technical actions in the reduction of burin cores. The phases below have been proposed based on the technological analysis of the units 6P and 7P from Cova Gran de Santa Linya.
Tabla 6. Esquema resumen de las principales acciones técnicas en la reducción de los núcleos-buril. Las fases en la parte inferior se han propuesto a partir del análisis tecnológico de las unidades 6P y 7P de Cova Gran de Santa Linya.

Reduction phase	Description
Phase 1	Lateral retouching, truncation, or notch creation
Phase 2	First facet opening + preferential reduction on truncation
Phase 3	Second facet opening + preferential reduction on previous surface
Phase 4	Alternant reduction on non-hierarchised surfaces

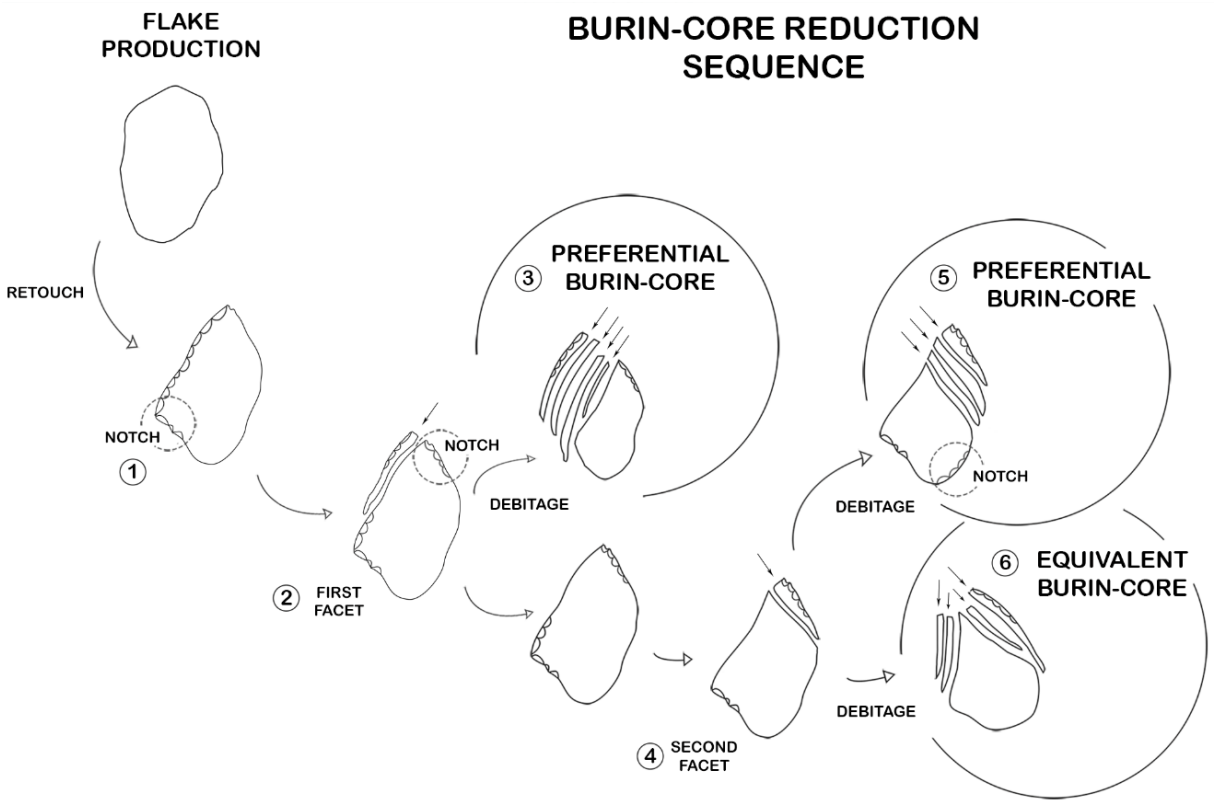

Figure 3. Operational scheme for the reduction sequences of burin-cores. Each step is marked with sequential numbers and their direction by arrows. The subcategories preferential and equivalent of burin-cores (BCP and BCE) are surrounded by circles.
Figura 3: Esquema operacional para las secuencias de reducción de núcleos-buril. Cada paso está marcado por un número secuencial y su dirección con flechas. Las subcategorías de núcleo-buril preferencial y equivalente (BCP and BCE) están rodeadas por círculos.

Table 7. Burin-core reduction phases and their correspondence with the burins from the typological lists of Sonneville-Bordes & Perrot (1956) and Laplace (1972).
Tabla 7. Fases de reducción de los núcleos-buril y su correspondencia con los buriles de las listas tipológicas de Sonneville-Bordes & Perrot (1956) y Laplace (1972).

Reduction phase	Reduction scheme (Figure 4)	Sonneville-Bordes and Perrot (1956)	Laplace (1972)
Phase 1	1	Racloir latéro-transversale	R1
Phase 2	2	Burin sur troncature	B12, B22, B23
Phase 3	4	Burin dièdre d'angle	B32
Phase 4	6	Burin dièdre	B31

The model proposed here highlights two main claims. First, the construction of tool typologies is based on the repetition of artefacts over time and space. Variations in the composition of retouched tools indicate changes in human behaviour and socio-chrono-cultural organisation. However, this static perception derived from the study of fossil-directors, is not always consistent with the transformative phases that lithic material undergoes, as indicated by the reconstruction of operational chains (Karlin *et al.* 1991). Consequently, a more dynamic view of the reduction process of lithic assemblages is needed, as we proposed for the study of on-edge artefacts, accepting its duality between tools and cores. At the same time, the capacity to vary production goals by incorporating specific technical decisions reflects a complex organisation of knapping activities and a consolidated technical behaviour. This operational chain suggests burin-cores are artefacts that admit variation within the application of reduction schemes, which remark their transformative value. This characteristic can be linked with the idea of flexibility introduced in some functional studies with regard to burins (Arrighi *et al.* 2006; de Araujo Igreja *et al.* 2006 and references therein).

6. Discussion: Misconceptions and conceptual constraints

The first approximation to this issue was previously described in the analysis of core reduction sequences during the Magdalenian (Sánchez-Martínez *et al.* 2022). Here, a distinction was made between semi-circumferential and burin-core methods, and the main technical features of each group are described. Refittings on the lithic assemblage indicate a recurrence in the choice of on-edge reduction methods and allow exploring whether these pieces are burins or cores (Figure 4). To shed some light into this question, we expose different insights to evaluate their role as burin, as cores, or as both.

If they are burins, it should be assumed refittings refer to a continuous process of bevel rejuvenation by means of the detachment of burin spalls, and that all the technical actions identified are aimed at controlling the angle of the piece and the morphology of the burin facets (Cattin 2006). In turn, if the burin bladelets correspond to resharpening processes (Arrizabalaga 1991; De Bie 2006; Leroi-Gourhan & Brézillon 1972), they should record usewear related to the last activity carried out, which is an issue that has been occasionally confirmed by functional analysis (Ibáñez & González Urquijo 2006). This perspective is the most classical one, as it has been part of the construction of the discipline and has helped to understand the emergence of complex elements of human behaviour such as engravings and bone technology.

If they are cores, it is assumed that the burin bladelets are integrated into a debitage sequence and that, the technical actions identified during the reduction are aimed at controlling the convexities of the core, as well as generating surfaces from which to obtain regular, elongated, and narrow supports (Le Brun-Ricalens & Brou 2003). It should be also assumed that burin spalls and bladelets are sought blanks in the technical organisation of the site that could be either used or not used. This perspective has been incorporated into scientific research in the last decades and it allows for amplifying the technical sphere of blanks as cores, to obtain elongated blanks from their edges.

If they are both, it should be accepted the multiple nature of these artefacts, which work as cores and tools simultaneously (Almeida 2001; Arrighi *et al.* 2006; Hays & Lucas 2000). The organization of a series of debitage does not preclude that in intermediate processes these pieces can be used for different purposes. Nor can it be excluded that these pieces are cores at an initial stage and that they are used in scraping, engraving, or drilling activities in their final phase. In this sense, some authors have proposed that burins (and specifically the burination) are the result of a process of mass loss in which burin spalls are obtained (Barton *et al.* 1996),

which would explain their multifunctionality. However, although we have tried to answer some questions with the development of an analytical methodology, new questions arise. Does the functional phase of the burin occur when the core is exhausted? Is it possible to distinguish between an initial reduction phase or a burin without a functional contextualisation?

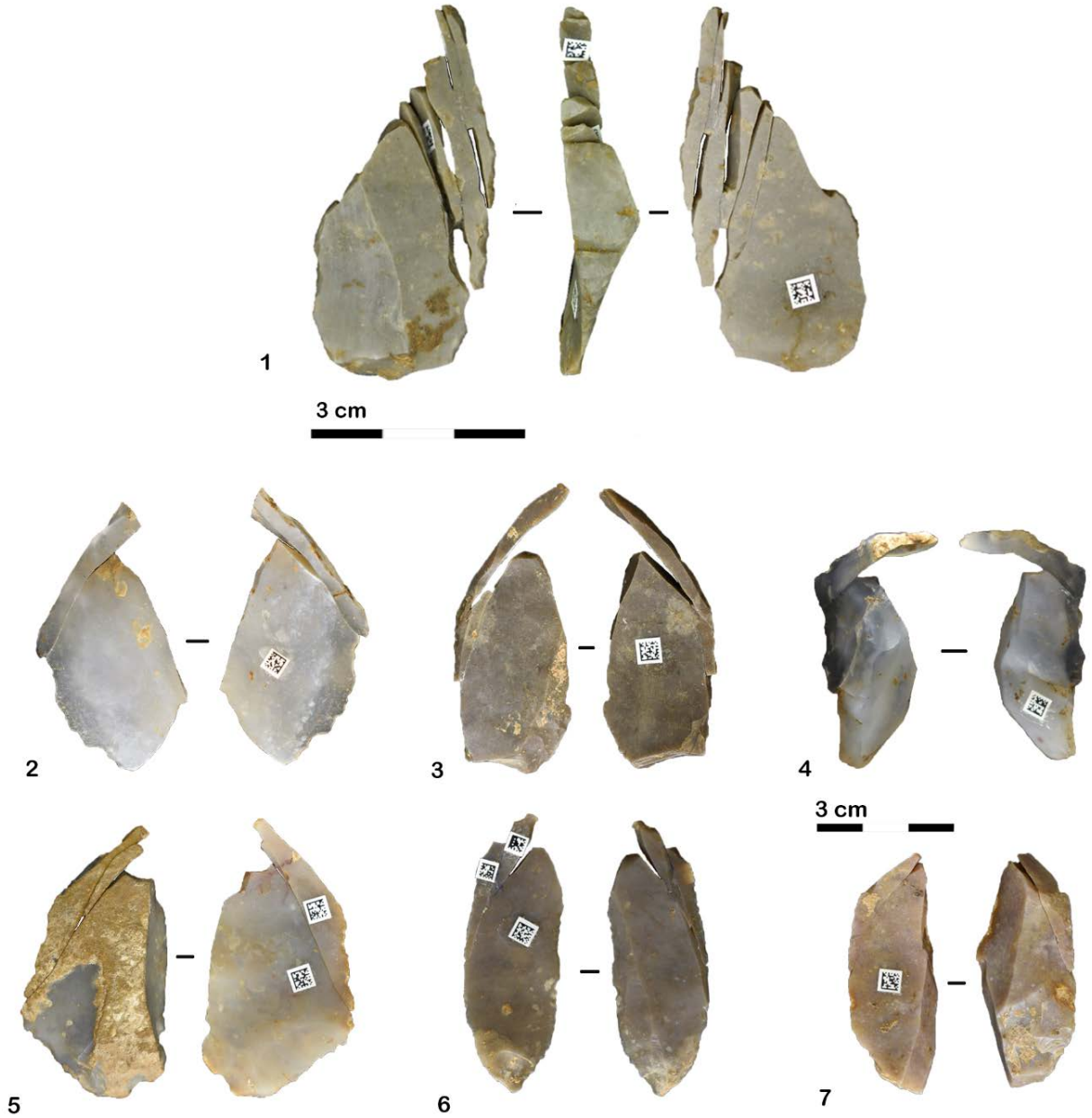

Figure 4: Burin.cores from the Magdalenian units 6P and 7P from Cova Gran de Santa Linya: (1) Refitted preferential burin-core, (2-7) Short sequence refitted burin-cores.
Figura 4. Núcleos buril procedentes de las unidades magdalenienses 6P y 7P de Cova Gran de Santa Linya: (1) Remontaje de un núcleo-buril preferencial, (2-7) Núcleos-buril con secuencias cortas remontadas.

The variability in burins and burin-cores is wide. This is due to the flexibility in terms of tool efficiency that these artefacts have (Sánchez-Martínez *et al.* 2022). The concept of flexibility is central to understanding the technical convergence in tool manufacturing and that are therefore responding to different functions (Duches *et al.* 2018) (Figure 5).

The technological and functional data on burin assemblages has indicated the multipurpose nature of these tools, which is given by their flexibility both in the

manufacturing processes and in their capacity to adapt to different activities. The initial configuration of the artefact and its initial purpose may change, modifying the morphology of the piece and adapting it to a new technical-functional process. The reconstruction of this series of processes is encompassed within the concept of tool-life (Andrefsky 2009; Efrati *et al.* 2022; Shott 2003).

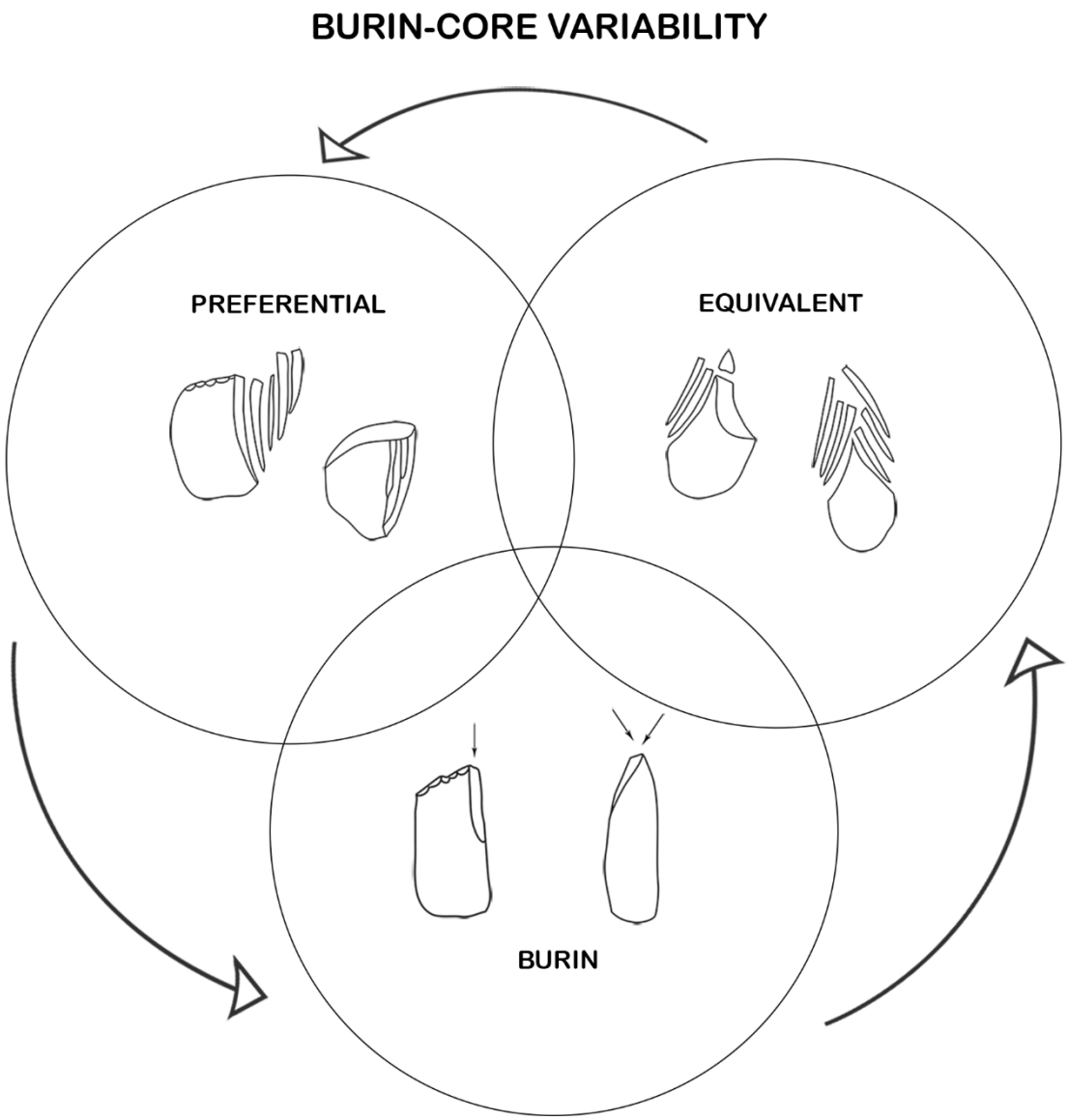

Figure 5. Technical convergence between preferential burin-cores, equivalent burin-cores and burins.
Figura 5. Convergencia técnica entre núcleos-buril preferenciales, núcleos-buril equivalentes y buriles.

Alternatively, the way in which categories were defined in lithic studies may generate inconsistencies in the analysis of lithic assemblages. Some conceptual limits arise from the dichotomy between functionality and technology, from the use of terms that have not been revised over the years, or from the evolution of research itself (Dibble *et al.* 2016 and references therein).

Carinated tools are useful to illustrate this issue because they have received different denominations based on technological, typological, or functional approaches (Aubry *et al.* 1995; de Araujo Igreja *et al.* 2006; Le Brun-Ricalens *et al.* 2006). Some of these examples indicate how technological analyses are conditioned by interpretative biases (Le Brun-Ricalens & Brou 2003) which pose a problem in establishing the foundations of the discipline

(Dibble *et al.* 2016; Reynolds & Riede 2019; Shea 2014). To evaluate this, we revised the main typological list of burins (Brézillon 1977; Demars & Laurent, 2003; Sonneville-Bordes & Perrot 1956), and we organized the types of burins following their description according to Laplace's typology (1972) (see supplementary information Table s1 and supplementary file 2). We also included in this classification the burin-cores to visualize their recurrence in the "burin assemblages" (see supplementary information Table s1 and Figure 6).

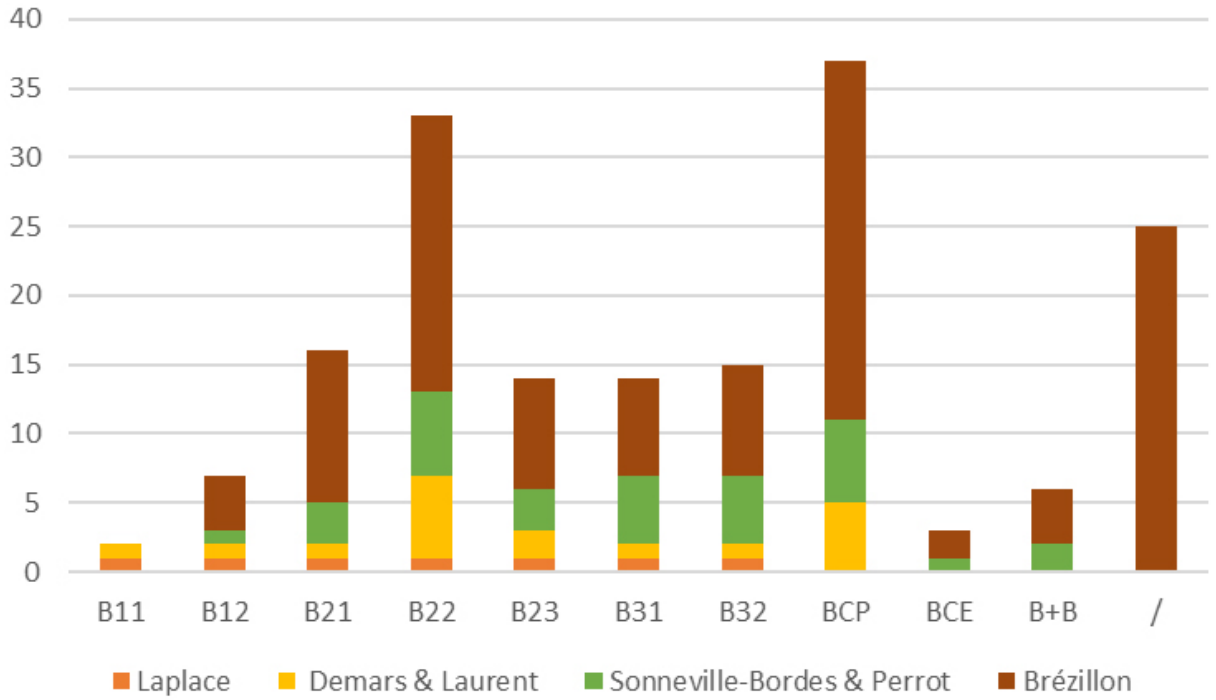

Figure 6. Correlation of the burin types documented in the list of Sonneville-Bordes & Perrot (1956), Brézillon (1977) and Demars & Laurent (2003) adapted to the analytical typology of G. Laplace (1972). Preferential burin-core (BCP) and equivalent burin-core (BCE) have been added to the graph, as well as the category of double burin (B+B), and undefined (/). Note that some types of burin may belong to several analytical categories.
Figura 6. Correlación de los tipos de buril documentados en la lista de Sonneville-Bordes & Perrot (1956), Brézillon (1977) y Demars & Laurent (2003) adaptados a la tipología analítica de G. Laplace (1972). Los núcleos-buril preferenciales (BCP) y los núcleos-buril equivalentes (BCE) se han añadido al gráfico, así como la categoría de buril doble (B+B) e indefinidos (/). Nótese que algunos tipos de buril podrían pertenecer a varias categorías analíticas.

The evaluation of burins among the typological lists shows that burins on oblique truncation (B22) and preferential burin-cores (BCP) are the most abundant. In other words, there are different types of burins that belong to the technical sphere of cores, but they are interpreted *per se* as tools, affecting the visibility of on-edge knapping strategies and the conceptualisation of burin-cores (Supplementary Figures S1 and S2). This situation is sensitive, as the technical genesis of these elements has been debated in recent years, accepting their role as cores (Aubri *et al.* 1995; de Araujo Igreja *et al.* 2006: 19-20; Le Brun-Ricalens & Brou 2003; Lucas 1999; Soriano 1998).

On the other hand, some carinated tools are diagnostic artefacts for the chronocultural organisation of the Upper Palaeolithic (*e.g.*, nucleiform scrapers in the Aurignacian and Archaic Magdalenian – Badegulian, among others), being more difficult their re-interpretation due to its historiographic relevance in the construction of the cultural taxonomies. This situation has resulted in these artefacts being used to explain variations in the retouched assemblages and changes in Palaeolithic societies, reducing their visibility for understanding changes in technical behaviour.

For this reason, we believe that the application of a technological perspective to the analysis and interpretation of burins could establish cross-cultural relations to evaluate new evidence of human and technical behaviour on lithic production and socio-organisational tasks.

7. Concluding remarks

A combination of technological and methodological approaches has challenged some of the usual notions linked to the burins as a tool-type, leading to a review of the analytical framework of these artefacts. Refittings allowed identifying the technical actions involved in the reduction of burins aiming at characterising the on-edge technology through the Magdalenian lithic assemblage of Cova Gran de Santa Linya. The preliminary data indicate that some artefacts previously conceived as burins are located in the technological sphere of cores, and thus, should be catalogued as such, placing on-edge knapping strategies as an important technical option in the social-organisation of LGM societies (Sánchez-Martínez *et al.* 2022).

This first approximation to the burin-core dichotomy should be combined with other methodological and analytical approaches to further discussed this issue. In this sense, an exhaustive technological study on the lithic assemblage and the data provided by ongoing use-wear studies will enrich future debates to understand on-edge reduction methods and their role in the socio-technical organisation of human occupations. In parallel, alternative technological approaches applied to other sites or assemblages can add new arguments to analyse and interpret the burin-core technology and show how a flexible methodological approach could amplify our understanding of the Magdalenian technical behaviour.

Additionally, this proposal points out how interpretative biases in the analysis of artefacts may mask the recognition of technical attributes involved in the formation of lithic assemblages. By overcoming these preconceptions, some gaps in the interpretation of Upper Palaeolithic assemblages can be filled in, contributing to visualise aspects of the technical behaviour of hunter-gatherer groups that remain invisible to research.

Data accessibility statement

The authors confirm that the data supporting this study are available as supplementary materials at open access Zenodo repository. DOI: https://doi.org/10.5281/zenodo.14006808

List of supplementary files

Supplementary file 1
“Supplementary Information 1 - Extended materials.pdf”
Document with extended information regarding the burin-core dichotomy and technological information about a case-study in Cova Gran de Santa Linya.

Supplementary file 2
“Supplementary Information 2 - Historiography of burins, lexicon and data base.xlsx”
XLSX file with definitions and descriptions of the types of burins following the main typological lists used for the study of Upper Palaeolithic artefacts.

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Desentrañando la dicotomía núcleo-buril: datos historiográficos y tecnológicos para desarrollar un nuevo marco analítico para el estudio de los artefactos sobre borde

Sánchez-Martínez Javier Sánchez Martínez [1,2], Xavier Roda Gilabert [1,3], Jorge Martínez-Moreno [1]

1. Departament de Prehistòria. Facultat de Filosofia i Lletres, C/de la fortuna s/n. Universitat Autònoma de Barcelona. 08193 Bellaterra, Spain. Email: Sánchez-Martínez: javier.sanchez.martinez@uab.cat.
Email: Sánchez-Martínez: javier.sanchez.martinez@uab.cat; Roda Gilabert: Javier.roda@uab.cat; Martínez Moreno: Jorge.Martínez@uab.cat
2. Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour (ICArEHB), Universidade do Algarve, Pav. K38005-139 Faro, Portugal.
3. CASEs - Culture, Archaeology, and Socio-Ecological Dynamics group. Universitat Pompeu Fabra. Departament d'Humanitats. Fabra. Mercè Rodoreda building, Ramon Trias Fargas, 25-27, 08005 Barcelona, España.

Resumen:

Los buriles son herramientas flexibles que han sido analizadas desde diferentes perspectivas, mostrando una gran diversidad tecno-funcional. La interpretación de este morfotipo ha oscilado entre dos dicotomías: forma/función y núcleo/herramienta. En este trabajo analizamos la trayectoria que el buril ha seguido a lo largo de la investigación arqueológica. Para ello sintetizamos los principales enfoques tipológicos, tecnológicos y funcionales propuestos para el estudio de estos y realizamos una valoración acerca de la dimensión tecnológica de estas piezas. Para analizar el objeto de estudio hemos aplicado la fórmula retórica de las 6W que permite explorar las relaciones causa-efecto y analizar bajo una perspectiva multidimensional la problemática burin/burin-core. El objetivo final es presentar una propuesta metodológica de análisis de los burin-core tras haber valorado los diferentes atributos propuestos para el análisis de estos objetos.

¿Quién? Buriles. Artefactos con un largo historial historiográfico

¿Cuándo? Desde los últimos 100 años hasta 2006 con el volumen “Burins préhistoriques: formes, fonctionnements, fonctions”

¿Qué? Perspectiva tecnológica, tipológica y funcional

¿Dónde? Conjuntos magdalenienses de Cova Gran de Santa Linya

¿Cómo? Nuevo marco analítico basado en la tecnología desarrollada

¿Por qué? Problemas metodológicos y conceptuales en el análisis de los buriles.

El exhaustivo análisis historiográfico realizado en buriles, núcleos-buril y núcleos sobre borde, junto con el análisis de los remontajes y atributos técnicos del conjunto lítico magdaleniense de los niveles 6P y 7P de Cova Gran de Santa Linya, ha permitido contextualizar e ilustrar una problemática presente en la interpretación de conjuntos carenados que siguen la dicotomía núcleo-útil. Asimismo, por medio de este trabajo, se han propuesto una serie de procesos técnicos que estarían involucrados en el desarrollo de las estrategias de talla sobre borde, así como las acciones de acondicionamiento y preparación de los núcleos.

El análisis de los remontajes y atributos técnicos sobre el conjunto lítico muestra diferentes grados de complejidad en la configuración y reducción de los artefactos tipo buril. Los buriles simples

se configuran sobre una fractura, un plano o una extracción previa y no suelen registrar muescas ni retoques laterales. En cambio, recuperamos artefactos más complejos que pertenecen al ámbito técnico de los núcleos sobre borde. Los datos cualitativos y cuantitativos permitieron comprender las acciones técnicas implicadas en la reducción de estas piezas mediante 1) identificar las acciones de preparación de los núcleos por medio de retoque (shaping); 2) comprender las acciones técnicas relacionadas con la apertura de planos de extracción (facetas) desde los bordes laterales; 3) explorar las acciones técnicas implicadas en la reducción lateral y volumétrica de los soportes de talla; 4) reconstruir las secuencias de talla asociadas a este método de talla destinado a obtener productos homogéneos a través de diferentes fases de reducción a partir de los bordes de productos espesos.

Como resultado, pretendemos visualizar el papel de los núcleos sobre borde en la organización técnica de las ocupaciones paleolíticas y ampliar nuestro conocimiento sobre el comportamiento técnico de los grupos del Paleolítico Superior. Asimismo, a través de este estudio de caso abordamos algunas de las limitaciones en el análisis de los conjuntos líticos del Paleolítico Superior y nos permite visualizar cómo los sesgos interpretativos en el análisis de los artefactos pueden borrar u ocultar las expresiones del comportamiento humano en las sociedades del pasado. Limitando la aceptación de conceptos preconcebidos y ampliando nuestra perspectiva y flexibilidad en el estudio de los procesos tecnológicos, podríamos cubrir algunas problemáticas que existen la interpretación del registro arqueológico.

Palabras clave: tecnología lítica; estrategias de reducción; núcleos-buril; historiografía; Cova Gran de Santa Linya