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Carrying rocks: Hoarding behaviour in the Gravettian occupation of Cova Gran de Santa Linya (SE Pyrenees)

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A B S T R A C T

Lithic resources can be accumulated to form caches or hoards as an effective subsistence strategy in response to times of stress. Hoarding behaviour is the manifestation of foresighted mechanisms, and is one of the common and also little known strategies among forager groups. In this paper, we present the evidence of such behaviour: a deposit of raw material recovered from level 497C of the Cova Gran de Santa Linya (SE Pyrenees).

The lithic hoard is made up of 27 chalcedony nodules that have been tested at the site and exhibit great variability in terms of size and shape. The geostatistical analysis applied to the accumulations of raw materials identified has allowed us to determine spatial relationships between different categories in the archaeological record, such as nodules and cores, and has yielded insight into the use of chalcedony in specific areas of the occupation.

The archaeological data suggest that this stockpile of raw material functioned as small-scale storage, constituting one of the few references about hoarding behaviour during the Palaeolithic, and the first time it has been exhaustively described in the Gravettian on the Iberian Peninsula. The lithic hoard from the Cova Gran allows us to investigate the role played by raw material hoards in the planning of subsistence activities and the organisation of human occupations.

1. Caching behaviour and hoarding behaviour as an example of small-scale storage

Mobility plays an important role in all forager adaptations, resource procurement and in the hunter-gatherer lifestyle (Eder, 1984; Shott, 1986; Kuhn, 1989; Brantingham, 2006; Kuhn et al., 2016). The procurement of natural resources, and their availability in the environment, are key considerations in the analysis of the occupational and organisational dynamics of a site (Binford, 1980; Binford 1982; Münzel, 2002; Calvo and Arrizabalaga, 2020; Kuhn, 2020). Animal and plant resources are essential to reach daily energetic requirements and are subject to marked seasonality (Speth, 1990; Foley, 1997; Aranguren et al. 2015; Aubry et al., 2015; Hamilton et al., 2016; Rufí et al., 2019). Lithic raw materials may also be affected by environmental constrains (accumulation of snow or ice) which may prevent temporarily the resource procurement. However, stone tools are non-perishable materials, which are less affected by seasonality when they are available in the landscape (Kelly, 1983, but see Moreau et al., 2021). This strategic attribute implies that they can be acquired along recurring routes or at provisioning points within regional mobility circuits (Geneste, 1991, *sensu* Kuhn, 1992), as their collection does not imply their immediate use, as is the case with other organic resources (Beyries and Cattin, 2015; Jacquier and Naudinot, 2015; Dibble et al., 2016). Likewise, the provisioning of lithic resources may be the primary purpose of a movement out of the site, or it may be an indirect objective as part of broad-spectrum movements for the purpose of specific activities (Kelly, 1983). These dynamics give rise to processes of resource procurement, transport and accumulation motivated by the social or techno-economic

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decisions involved in resource management (Barton and Riel-Salvatore, 2014).

When raw materials are collected but are not part of immediate production goals, it implies that these resources have been transported and intended for storage for deferred consumption (Hurst, 2006; Franco et al., 2018). This series of decisions has been encompassed with the concepts of the cache or hoard, which have been characterised depending on the type of storage and the attributes of the artefacts stored (Astruc et al., 2003). This curational or foraging behaviour (*sensu* Binford, 1979; Nelson, 1991) intrinsically involves a series of technical, organisational, economic and social decisions, which can lead to the emergence of hoarding behaviour. It demonstrates the ability to anticipate, plan and organise subsistence strategies and human dynamics through raw material reserves.

The practice of storage constitutes an insurance strategy to reduce risk and to establish resource control over time (Rowley-Cowny et al., 2004). Storing tends to be a subsistence and organizational behaviour with low archaeological visibility at Palaeolithic sites, and can be associated with long- or short-term strategies (Hurst, 2006; Cunningham, 2011). Long-term large-scale storage has been perceived as more significant than short-term small-scale storage in the development of social complexity, because it allows a better comprehension of long-term planning strategies. This idea has led to an underrepresentation of the role that small-scale storage may have in the subsistence of hunter-gatherer societies (Cunningham, 2011).

Storing strategies denote the anticipation and foresight of future needs (Bamforth, 1986) and the development of mechanisms to ensure success in the event of unforeseen situations. This behaviour provides information about economic, social and cultural aspects at an intergroup scale, and has been included within the concept of caching behaviour (Street et al., 1999; Gurioli et al., 2005; Hurst, 2018).

Caching behaviour refers to caches or accumulations of artefacts with a high technical or cultural value (large blades, flakes, retouched tools, preformed cores). Cached artefacts are prepared for immediate use and are particularly useful in situations of stress. The importance of these materials lies in their temporality, as they can be used in the short, medium or long term, can be modified or recycled, and serve for a wide range of activities (Barkai et al., 2015; Jacquier and Naudinot, 2015; Romagnoli, 2015; Clark et al., 2017). Consequently, cached artefacts play an important role in subsistence strategies and in the temporal control of resources, mobility and landscape use by constituting manufactured tool deposits (Kornfeld et al., 1990, Peresani, 2009).

On the other hand, hoarding behaviour encompasses the storage of pieces with a high potential for transformation (tested cores, nodules) (Bertola et al., 1997, Carter, 2007) which provide flexibility in tool manufacturing. The concept of hoard has sometimes been used as a synonym for cache (Bamforth et al., 2004) although unlike cached artefacts, these have not been preformed or modified to fulfil a specific function.

Such artefacts make it possible to carry out reduction sequences to obtain whatever end product is sought, and can also be modified for use as tools (Almeida et al., 2009; Wojtczak, 2015; Mathias and Bourguignon, 2020). These artefacts would have acted as a type of *insurance gear* (Binford, 1979), allowing the groups that accumulated them to take on situations of risk or stress and to effectively meet a wide range of needs (Ballenger, 1996). Whereas, caches are related to *personal gear,* in that they comprise concrete types of items for predictable or specific purposes (Bamforth and Woodman, 2004).

Caching and hoarding behaviours share common patterns in terms of meaning, but they differ in the materials stored, and thus have relevance in curational behaviour, mobility and social/spatial organisation (Shott, 1996). Both are aimed at building a stockpile for medium or long-term consumption and could be linked to logistical supply points (Conneller and Schadla-Hall, 2003).

Hoards, caches or small-scale storages are inconspicuous in the archaeological record because they can be consumed or left unrecovered due to their strategic or logistical locations in the vicinity of areas of human occupation. Examples of storage vary in nature and composition, and it is difficult to characterise which extrasomatic elements (Haidle and Schlaudt, 2020; O'Brien and Bentley, 2020) give rise to the technical-organisational and techno-economic responses entrenched in caching or hoarding behaviour.

This paper presents the results of the techno-morphological and geospatial analysis of the set of chalcedony nodules recovered from the gravettian occupations of the Cova Gran de Santa Linya (South Eastern Pyrenees) (Fig. 1) and the implications of those results for the significance of such raw material accumulations within the sphere of hoarding behaviour. Furthermore, this assemblage has allowed us to introduce new assessments of the provisioning strategies and techno-economic decisions involved in mobility related to the management of lithic resources by forager groups in the northern Iberian Peninsula.

2. Archaeological setting

The Cova Gran de Santa Linya is a rock shelter with a surface area of approximately 2000 m^2 located in an enclosed valley in the SE Pyrenees, close to the Noguera-Pallaresa river basin. Fieldwork in Cova Gran since 2002 has revealed an archaeo-stratigraphic sequence spanning from the Middle Palaeolithic to Late Prehistory (Mora et al., 2011; Mora et al., 2014a; Mora et al., 2014b).

Level 497C is part of the archaeo-stratigraphic sequence belonging to the early Upper Palaeolithic and is separated at the base and at the top by sterile strata. The analysis of the archaeological fabrics has shown the integrity of the archaeological assemblage with little post-depositional alteration (Benito-Calvo et al., 2009). This level, dated by 14C AMS radiocarbon at 26220 ± 220 BP (31260–30580 cal. BP) and by thermoluminescence at 22,922 ± 777 BP, has been taxonomically ascribed to the Gravettian technocomplex (Roy-Sunyer et al., 2013; Sánchez-Martínez et al., 2020) (Fig. 2).

The level covers a surface area of 45 m^2 in which the coordinates have been recorded for 2784 remains, including 2369 lithic remains. The faunal remains (282) have been identified as an assemblage made up of rabbits (*Oryctolagus cunniculus*), deer (*Cervus elaphus*), large bovids (*Bos/Bison spp.*) and goats (*Capra pyrenaica*) (Samper Carro, 2014). In addition, 24 marine gastropods have been recovered, attributed to the species *Columbella rustica*, *Trivia* spp. and *Nassarius pygmaea*, and possibly used as ornaments.

The tool assemblage has been analysed in detail in previous studies (Sánchez-Martínez et al., 2020). The lithic technology exhibited here is characterised by core reduction strategies directed at the production of elongated pieces from prismatic cores. The cores are morpho-technically homogeneous, and evidence attention paid to the lateral and distal convexities of their surfaces. The primary knapping objective are blades in a wide variety of sizes and degrees of standardisation. Cortical flakes are related to core trimming and preparation stages to yield shapes suitable for subsequent knapping. Some macro-flakes and curated tools comprise an assemblage of imported items that may have functioned as a type of toolkit. The retouched tools point to a common background, with notable burins and pieces with abrupt retouch, indicating the low presence of armatures.

3. Methods

The recovery techniques used during fieldwork aimed to maximise the contextual resolution of the archaeological record. The archaeological levels were excavated following archaeostratigraphic criteria and slopes. All remains were recovered using the methodological framework for Palaeolithic sites (Mora et al., 2010; Martínez-Moreno et al., 2011; Mora et al., 2014a; Mora et al., 2014b; Roda Gilabert et al., 2014).

The assemblage was analysed using a combination of morpho-technical criteria, the raw material unit (RMU) classification system

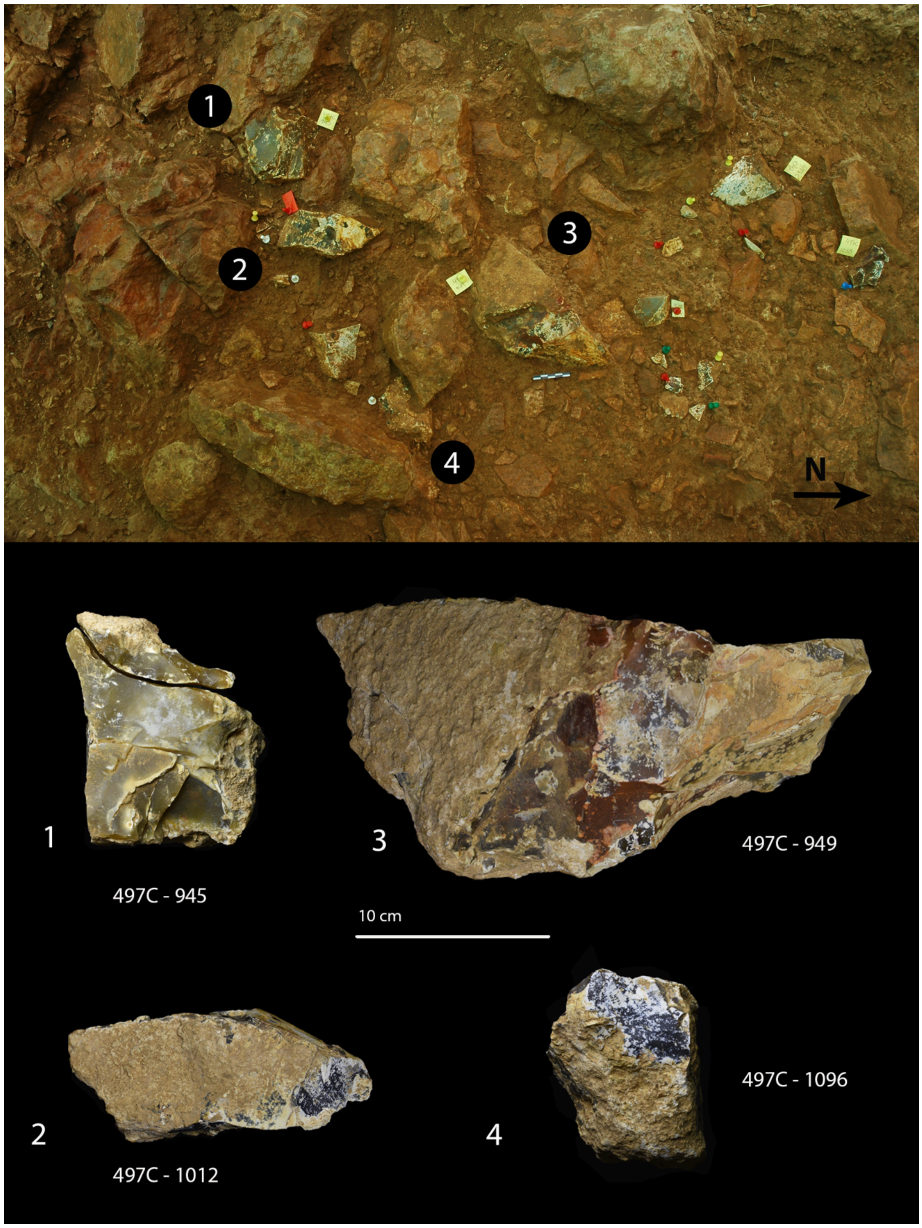


Fig. 1. Top: Plan view of an accumulation of tested nodules during the excavation of the lithic hoard. Bottom: View of four nodules contained in the lithic hoard. (1) RMU-G nodule. (2) RMU-M nodule (3–4) RMU-A nodules (Authorship: J. Sánchez-Martínez).

and statistical and geospatial analyses. The lithic materials were analysed based on a techno-typological approach (Tixier et al., 1980; Tixier, 1984; Pelegrin, 1986; Inizan et al., 1995; Andrefsky, 2008). As a starting point, materials attributed to tested nodules were identified and separated from the cores. The cores were then analysed by means of a reduction sequence analysis (Pelegrin, 1985; Karlin, 1991; Martínez-Moreno et al., 2019; Sánchez-Martínez et al., 2020). The nodules were categorised and contextualised from studies on lithic operative chains (Pelegrin et al., 1988; Geneste, 1991; Karlin and Bodu, 1991; Soressi et al., 2011). Nodules were differentiated from the cores in accordance with the current technological attributes proposed by Peresani (2006), including the analysis of tested surfaces, knapping platforms and selected supports. We have avoided the concept *manuport* (Leakey, 1966), currently used and debated in African Plio-Pleistocene Archaeology, when referring to nodules as we consider the Cova Gran lithic hoard have broader implications in terms of foresight, planning and complexity (Potts, 1991; de la Torre and Mora, 2005; Benito-Calvo and de la Torre, 2011).

We applied statistic tests to evaluate the configuration of the assemblage data set. The Mann-Whitney *U* test allows to detect significant differences between independent variables in the core and nodule assemblages. The Mann-Whitney is a non-parametric test of the null hypotheses that assesses the probability that two variables are equal (Fay and Proschan, 2010). Principal component analysis (PCA) was performed using length, width, thickness and weight as variables to represent the typometric differences between the cores and nodules. Typometric and statistical analyses were performed using XLSTAT statistical software.

In parallel to the techno-typological study, the materials were classified in accordance with the reconstruction of RMU. From the original conceptualization of this units (Roebroeks, 1988) we have isolated raw material groups in order to reach the maximum analytical resolution.

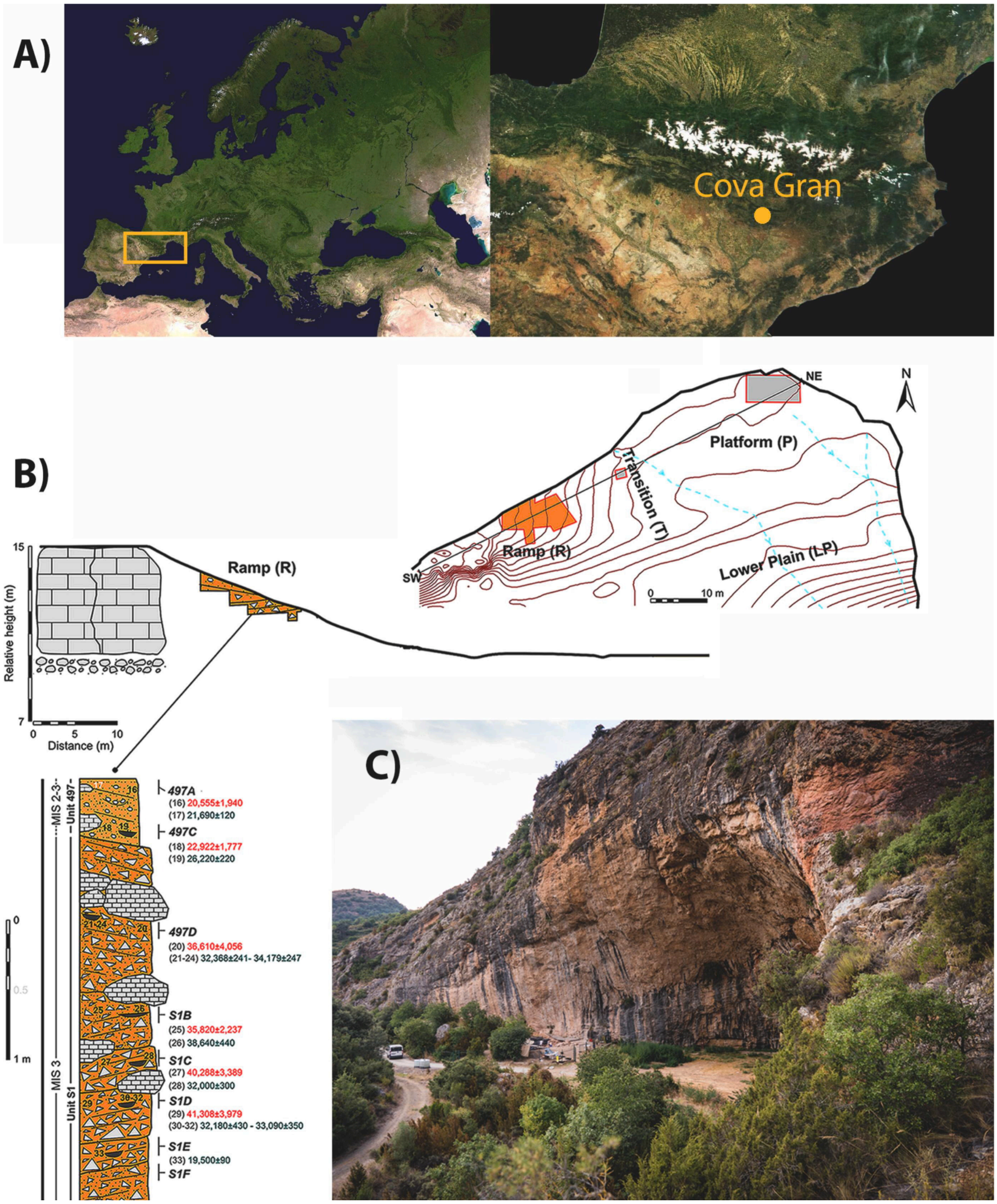


Fig. 2. (A) Geographic location of Cova Gran de Santa Linya. (B) Archaeostratigraphic sequence of Ramp sector, including datings and geological information. (C) Front view of Cova Gran (modified from Mora et al., 2011).

Thus, RMU consist of groupings of materials that share the same macroscopic petrographic features (Roy-Sunyer, 2016).

The lithic artefacts from level 497C were projected on a plane and cross-sectional views (NS and EW) were obtained with the ArcGIS10 geographic information system (ESRI, 2017) to assess the horizontal continuity and vertical dispersion of this level. The spatial distribution of the RMUs identified by means of XY projections was then determined, and hotspot analysis was used for geostatistical processing (Getis and Ord, 1992). This method detects clusters based on a quantitative variable and the spatial relationship, in terms of continuity and discontinuity, between objects, yielding a statistical significance (90–99%) for each group detected. It allows us to distinguish intentional concentrations from those of natural or random origin as well as to identify differences in raw material use at the spatial level within the occupation (Mora et al., 2020).

4. Characterising a raw material hoard

4.1. Raw material units (RMU)

Garumnian chalcedony is the most widely used raw material in the lithic assemblage (98%) from the level 497C, and at Cova Gran de Santa Linya site, as well as at other archaeological sites of the south-eastern Pre-Pyrenees (Roy-Sunyer et al., 2013). Garumnian chalcedony is characterised by its heterogeneous colouring and textures, both inter- and intra-nodule, resulting in a large number of lithologies. This diversity makes its geostatistical analysis difficult, as it presents several varieties or subgroups of raw materials with few implements. To solve this problem, the recovered artefacts were grouped by raw material units (RMUs) based on petrographic criteria, resulting in five main groups (RMU-A, RMU-AA, RMU-J, RMU-G and RMU-M) whose macroscopic characterisation had been previously established according to attributes such as colour, texture or impurities (Mora et al., 2020).

This method of analysis was also applied to the nodules tested to determine the varieties brought into to the deposit, their spatial distribution, and any possible differences in their use. Among the nodules, the predominant RMUs were RMU A with nine implements (36%) and RMU J with seven implements (28%), while the prevalence of implements in group RMU G, with five (20%), and group RMU M, with four (16%), was lower (SI Table 1). No nodules were recovered from RMU-AA. Given the abundance of chalcedony outcrops in the vicinity of the site, we assume that most of these nodules came from the local environment (<5 km) (Roy-Sunyer, 2016), which allows us to better understand the technoeconomic and transport decisions involved in the formation of the hoard.

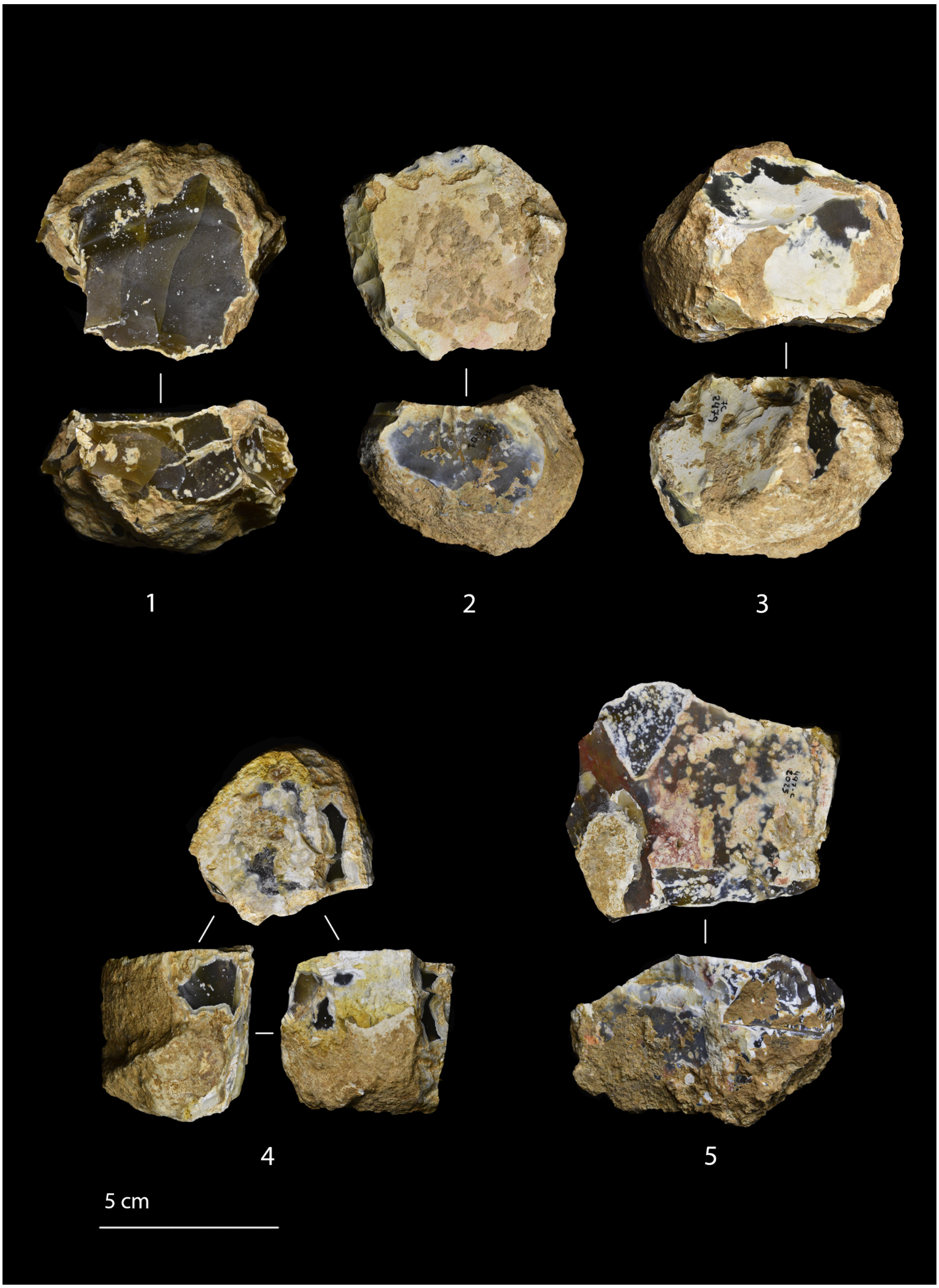


Fig. 3. Small nodules recovered from the lithic hoard. (1–4) Sub-rounded nodules. (5) Sub-angular nodule (Authorship: J. Sánchez-Martínez).

4.2. Technological and morphometrical assessments

The nodules recovered vary in size and weight. Smaller individual pieces are generally sub-rounded nodules (10), while larger nodules have angular and fragmented morphologies (17) (Figs. 3–5). The nodules have cortical surfaces, isolated removals and broad surfaces that have not been systematically knapped. All the nodules have test removals on some of their surfaces, which have been knapped from a natural surface (22) or from a previous removal (5) as striking platform. These actions point to testing activities for the purpose of assessing the quality and mechanical properties of the raw material and its suitability for knapping (Brantingham et al., 2000; Braun et al., 2009; Romagnoli et al., 2016).

Testing activities are usually carried out at the provisioning site to avoid carrying low quality raw materials to the site (Peresani, 2006). To verify this, systematic refittings were performed in the hoarded lithic assemblage (Fig. 6), and showed that some of the the nodules were tested at the site after transport. This indicates that there were no selection criteria for what was brought to the site, thus the decision made as to which pieces would be knapped is took on this place. In parallel, inspection of the surfaces of the nodules has not yielded any evidence of thrusting/resting percussion macro-traces that would link them to production activities (Caricola et al., 2018).

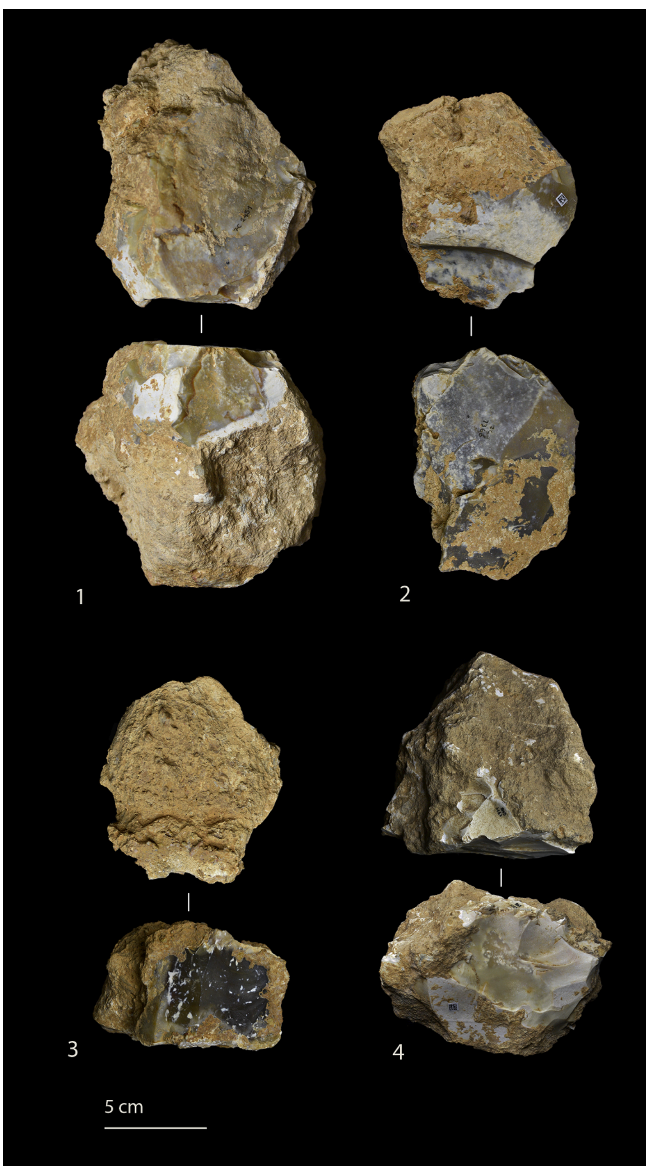


Fig. 4. Tested nodules from the lithic hoard. (1–2) Nodules showing a single test removal. (3–4) Nodules showing more than two test removals (Authorship: J. Sánchez-Martínez).

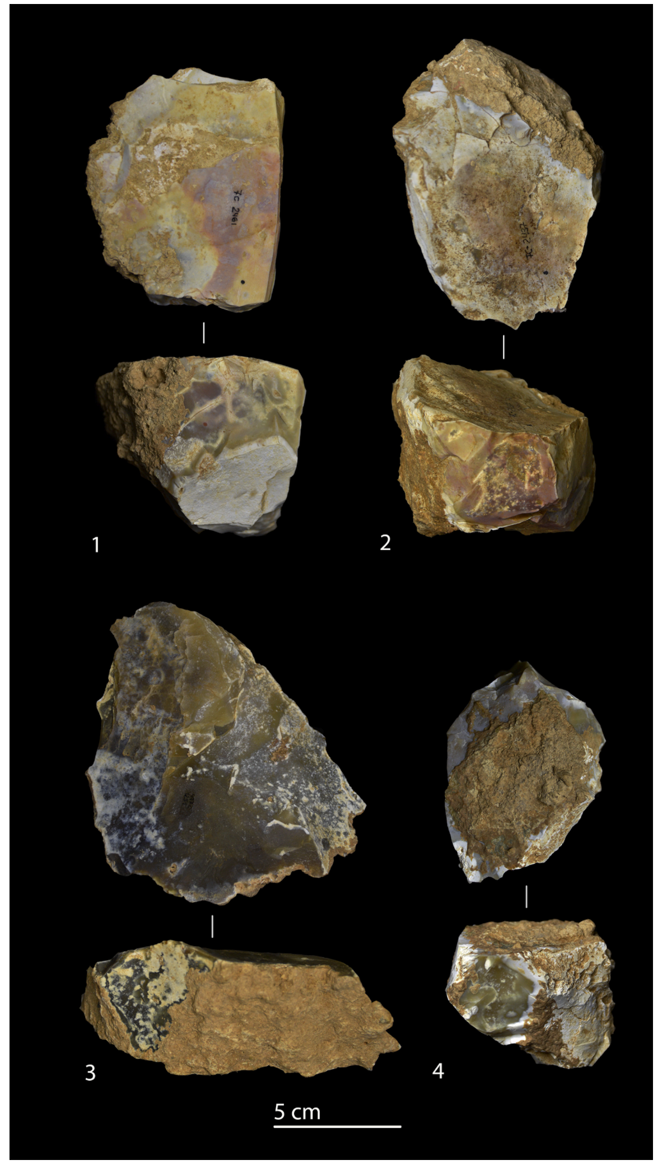


Fig. 5. Tested nodules from the lithic hoard. All artefacts contain a single test removal (Authorship: J. Sánchez-Martínez).

From a technological perspective, the cores and nodules differ both in the organisation of the removals and in their morpho-technical characteristics (Table 1). The nodules exhibit extensive cortical surfaces or neocortex remains. The removals derived from the testing actions appear isolated and non-hierarchical, which indicates that they were not intentionally shaped. These indicators show that the purpose of testing activities is not to obtain specific knapping products, but rather to check the flake suitability and quality of the nodules. Thus, the fact that the items were not knapped may refer to a broad range of technical and organizational decisions.

The cores were preformed following standardised prismatic morphologies that favour blade knapping. The core surfaces are hierarchical, showing medium and advanced degrees of exploitation. They are formed with one or two knapping platforms created from a plane or removal, generating an acute angle between the knapping platform and the knapping surface. The lateral convexity of the knapping surface is

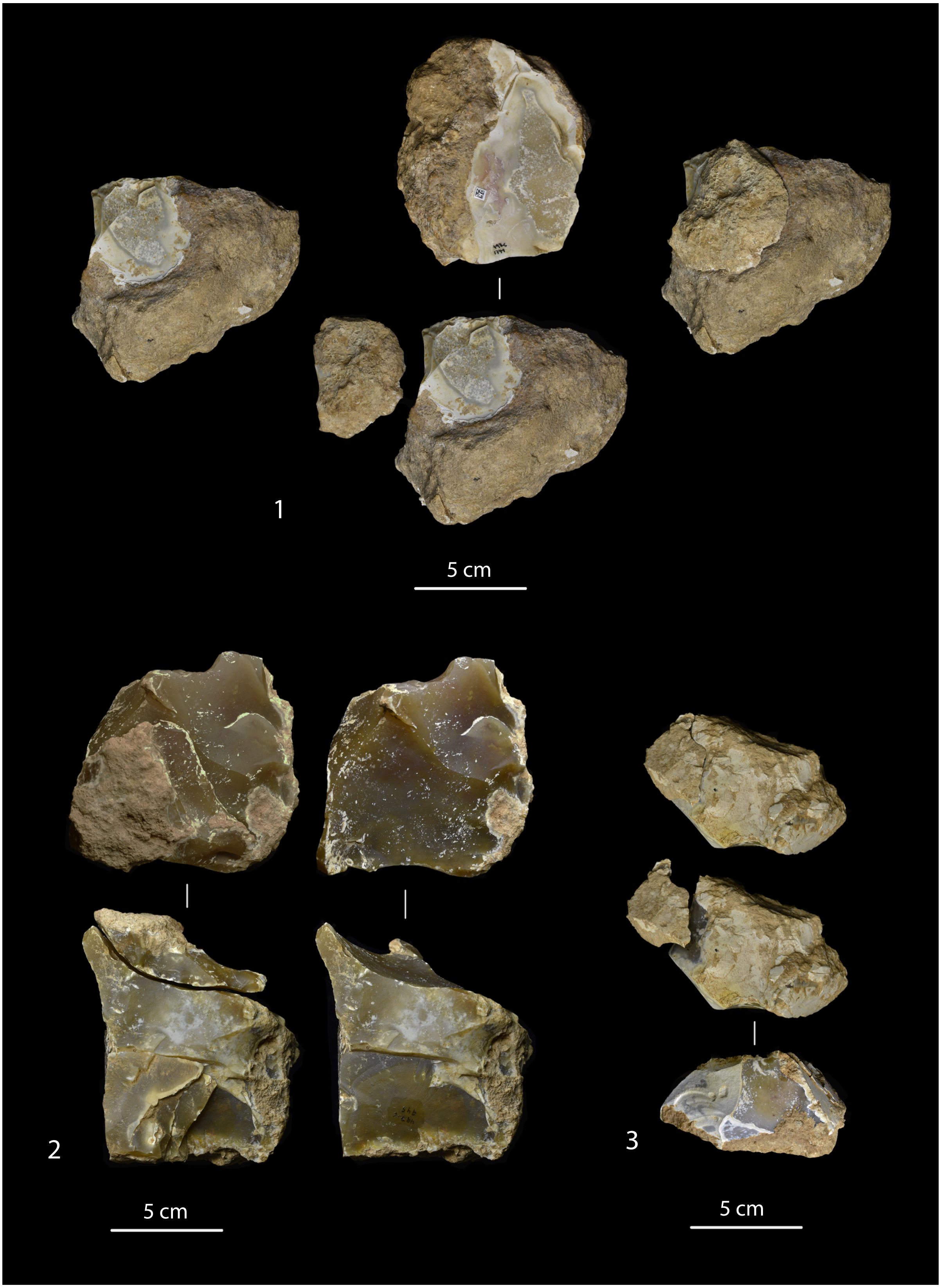


Fig. 6. Refitted tested nodules from the lithic hoard. (1 and 3) Nodule refitting with cortical flake (2) non-cortical flake refitted (Authorship: J. Sánchez-Martínez).

maintained following a *semi-tournant* method, making it easier to obtain a series of blades. These criteria have made it possible to identify 27 tested nodules and 13 cores.

Mann-Whitney *U* test combined with PCA was used to determine statistical differences in the core and nodule assemblages (SI). The Mann-Whitney *U* test revealed significant differences between the weight of cores and nodules ($p = 0.028$), while the length ($p = 0.11$), width ($p = 0.106$) and thickness ($p = 0.209$) variables were non-

Table 1
Technological criteria discriminating between cores and nodules and products derived from volumetric reduction.

Category	Technological criteria	Blanks	∑
Tested nodules	Artefacts with isolated removals in their surfaces and not formatted	Cortical flakes	27
Cores	Hierarchical and formatted artefacts with one single platform or two. Clear relation between the striking platform and the knapping surface, which show at least three core removals. Characterized by 'sémi-tournant' laminar systems and an angular relation between the striking platform and the knapping surface of 60–70° (Sánchez-Martínez et al., 2020)	Elongated blanks (blades and bladelets). Ocassionaly flakes w/o cortex	13

significant (SI Table 5). The principal component analysis (PCA) performed on the variables length, width, thickness and weight recorded a confidence of 90.91% between PC1 (81.59%) and PC2 (9.32%) (SI Table 2 and Fig. 1). The contributions of the cosines were revised by eliminating the implements not represented in the PC1 and PC2 factors (SI Table 4). A close correlation was found in the conjunction of the length and weight variables, while the squared ratio of width and thickness to weight suggests that they are relatively independent variables (SI Table 3 and Fig. 2). The PCA identified two clusters located above and below the mean value of the variables analysed, and both clusters are made up of nodules and cores, so it is not possible to separate the two populations (Fig. 7). This indicates that cores and nodules vary in a similar way, constituting relatively homogeneous groups at the morphometric level.

Cores and nodules behave similarly morphometrically, but there are differences in how their surfaces were handled. The values of the lengths and widths of the removals from the cores and tested nodules were taken in order to determine whether there are any morphometric differences in the supports obtained (Fig. 8). In the cores, a total of 54 removals were documented (avg 4.15 removals per core), while in the nodules we counted 48 removals (avg 1.7 removals per nodule). The core removals are generally elongated and narrow with a blade-like tendency, while those derived from nodule testing actions are wider and correspond mostly to cortical flakes.

These results underscore the involvement of reduction strategies in obtaining desired products and speak of two distinct technical behaviours involved in the formation of the archaeological record. On the one hand, the cores point to the decision-making involved in the organisation of blade knapping characterised in level 497C; on the other hand, the nodules indicate the creation of a flexible stockpile of raw material with a view to deferred consumption.

4.3. Spatial analysis

The spatial distribution of the lithic material has been analysed by means of horizontal (XY) and vertical (XZ and YZ) plots to evaluate the homogeneity of archaeological level 497C (Simonetti 2013; Mora et al., 2020). This analysis has resulted in the identification of two higher density areas located to the south (SA) and north (NA) of the excavated area. The vertical plots reflect a homogeneous vertical dispersion of the assemblage, all located in the same stratigraphic position (Fig. 9).

The RMUs (RMU-A, RMU-AA, RMU-G, RMU-J and RMU-M) were projected in plan view jointly and individually, which allowed us to analyse whether the spatial patterns of these groups are similar or different to the general trend. At the geostatistical level (hotspot analysis), the projections of all of the RMUs yielded significant values for the two clusters located in the north and south of the occupation, coinciding with the two areas previously identified (Fig. 10).

Using the individualised geostatistical analyses of the RMUs, we were able to analyse the contribution of each raw material group to the overall distribution. The results show that RMU-A and RMU-J form two or more clusters of materials that are continuously distributed throughout the excavated area, in both cases with a higher significance in the northern area (NA). This distribution differs from RMU-G, RMU-AA and RMU-M, whose significance is situated in the southern zone. That is, the spaces occupied by the types of chalcedony are statistically different at 95% confidence, suggesting that the use of chalcedony in the space is the result of intentional actions and not attributable to possible alterations caused by natural processes (Benito-Calvo et al., 2009)

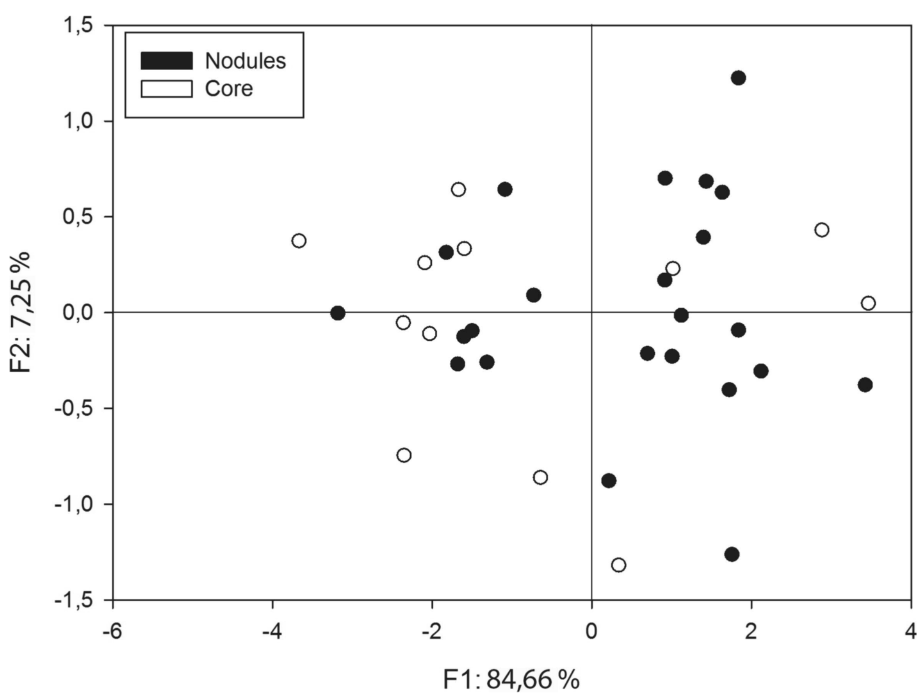


Fig. 7. PCA of nodules that comprise the hoard (black dots) and cores (white dots) from archaeological level 497C (Authorship: R. Mora).

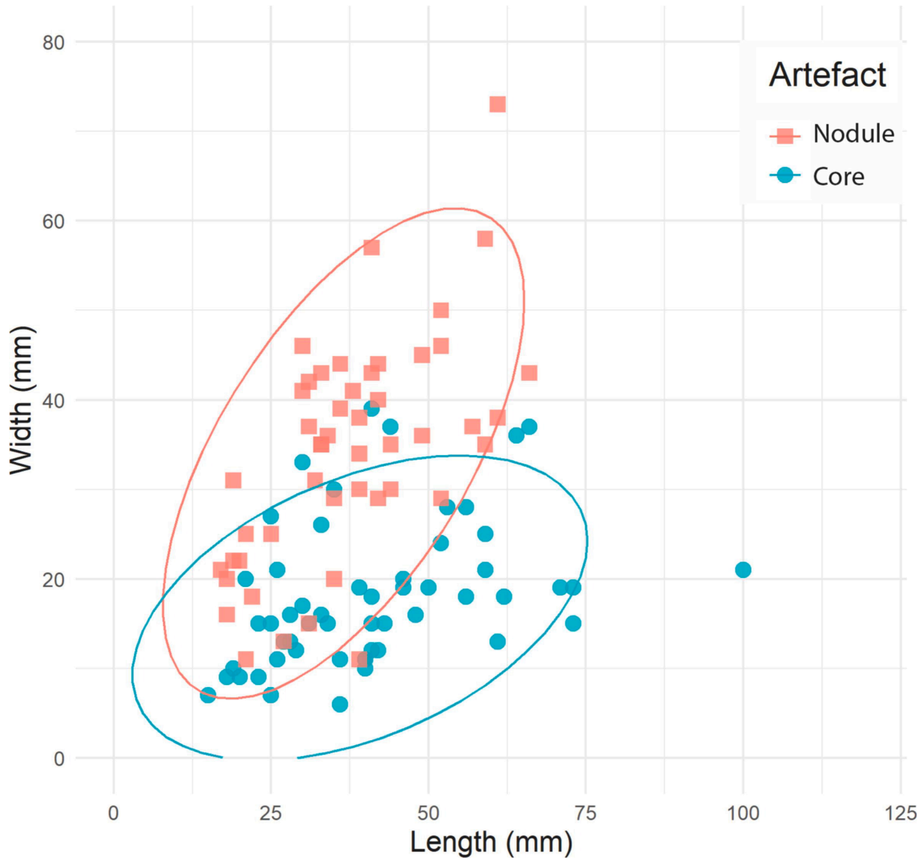


Fig. 8. Scatter plot representing length (X) and width (Y) measurements from core removals (blue) and tested nodule removals (red). 95% confidence intervals have been included in both data sets (Authorship: J. Sánchez-Martínez). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

This analysis applied to specific technological groups enabled us to determine whether their spatial distribution follows a pattern or if, in contrast, their horizontal dispersion is random. In the case of the nodules, 19 of the 27 identified are located in the northern zone of the occupation and are clustered in a space measuring 4 m^2. In the southern zone, six of the eight nodules identified are located in an area measuring 1 m^2 (Fig. 11). Most of the cores were recovered from the southern zone (8), while fewer were found in the northern zone (5). The large amount of debris found in the southern zone could be related to a knapping area, which is consistent with the spatial position of the cores.

The spatial distribution analysis of these categories reflects the same areas of density of materials observed geostatistically to the north and south of the excavated surface in the RMU study. Most of the nodules, as well as the materials from RMU-A and RMU-J, are clustered in the northern zone. Meanwhile, most of the cores associated with knapping activities and the presence of the RMU-AA, RMU-G and RMU-M are located in the southern zone. This differentiated use of space indicates that a distinction of a technical-organisational nature was made in the spatial organisation of level 497C.

5. Discussion

5.1. Spatial assessments and formation process of level 497C

Spatial analyses have been pivotal in reconstructing the hunter-gatherer lifestyle at Palaeolithic sites. They have been able to establish close intra-site connections between activities and have reinforced the integrity of the archaeological record (Almeida et al., 2009; Chacón et al., 2012; de las Heras et al., 2012; Nigst and Antl-Weiser, 2012; Martínez-Moreno et al., 2016). This has been thoroughly discussed through the study of short-term occupations and high-resolution contexts in archaeology (Pettitt, 1997; Porraz, 2009; Malinsky-Buller et al., 2011; Reynolds et al., 2019), which have contributed to assessments of the role of time in the interpretation of human occupations (Bright et al., 2002; Bailey, 2007a; Bailey, 2007b; Holdaway et al., 2008; Roda Gilabert et al., 2016; Perreault, 2018; Romagnoli et al., 2018a; Romagnoli et al., 2018b).

The time perspective applied to the archaeological record has been used to detect synchronic and diachronic events in short- and long-term occupations (Cascalheira and Picin, 2020). Using technological, geostatistical and spatial data, we were able to formulate different possible scenarios for the temporal development of the events that can be distinguished in level 497C. Level 497C illustrates how artefacts concentrated in specific areas could point to different occupation models, depending on the time-perspective and the contextual resolution given to the archaeological surface. We combined RMU analysis with technological data to characterise the temporal events that occur in this unit. Spatial analysis has highlighted the specific location of certain RMUs and geostatistical data reaffirmed the significance of the artefact dispersion. This very specific distribution may offer a guideline for distinguishing between events within human occupations (Malinsky-Buller et al., 2011; Mora et al., 2020).

Thus, we suggest different plausible scenarios to explain the archaeological formation process of this level. If level 497C constitutes a single occupation, then the artefact density plots observed in the north and south part of the occupation are synchronic (see Figs. 9 and 10). An analysis of the distribution of nodules and cores suggests that the two areas may be complementary to one another. So, knapping and tool-manufacturing activities were clustered in the southern area, which is associated with most of the recovered cores and RMU-G, RMU-M and

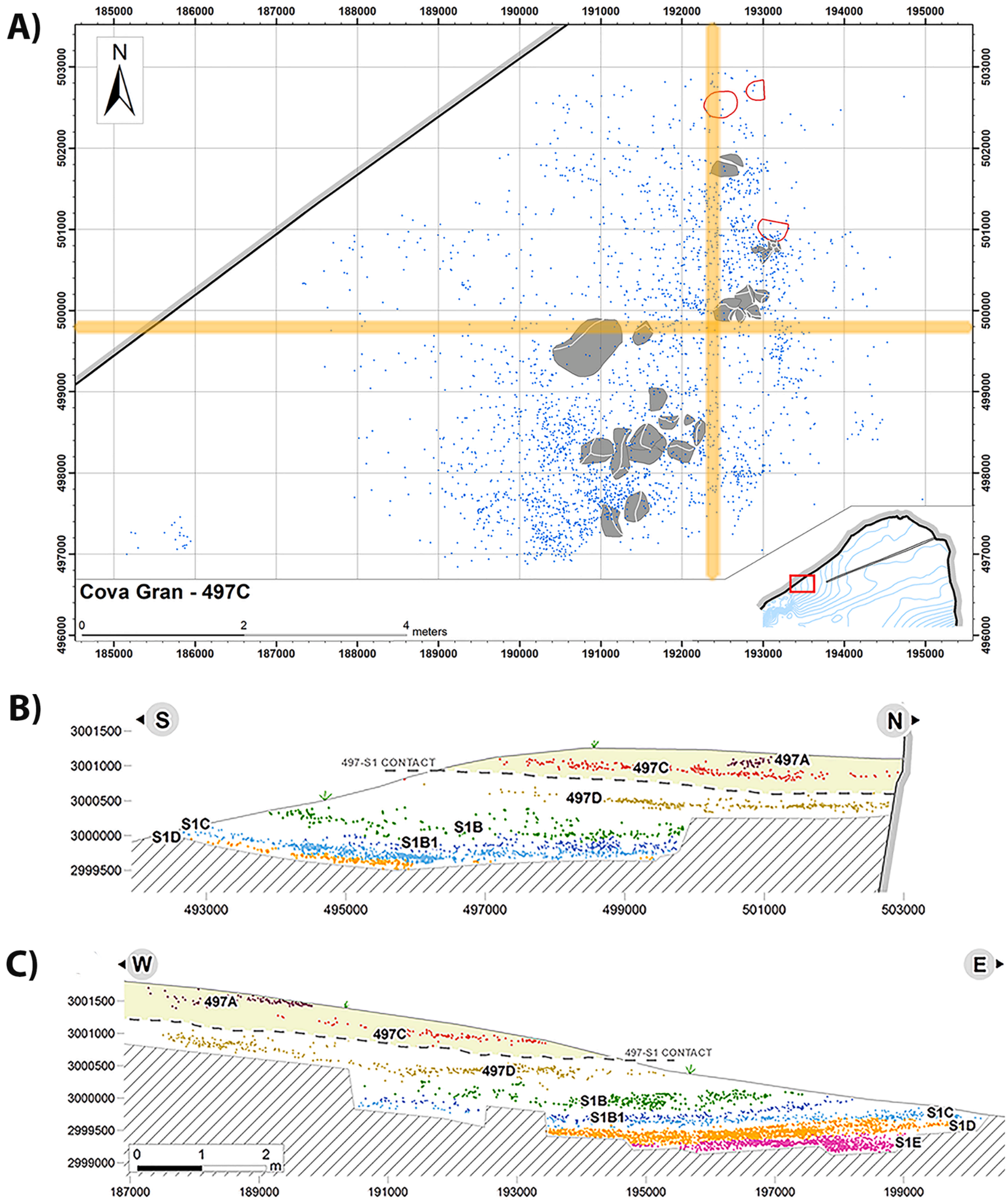


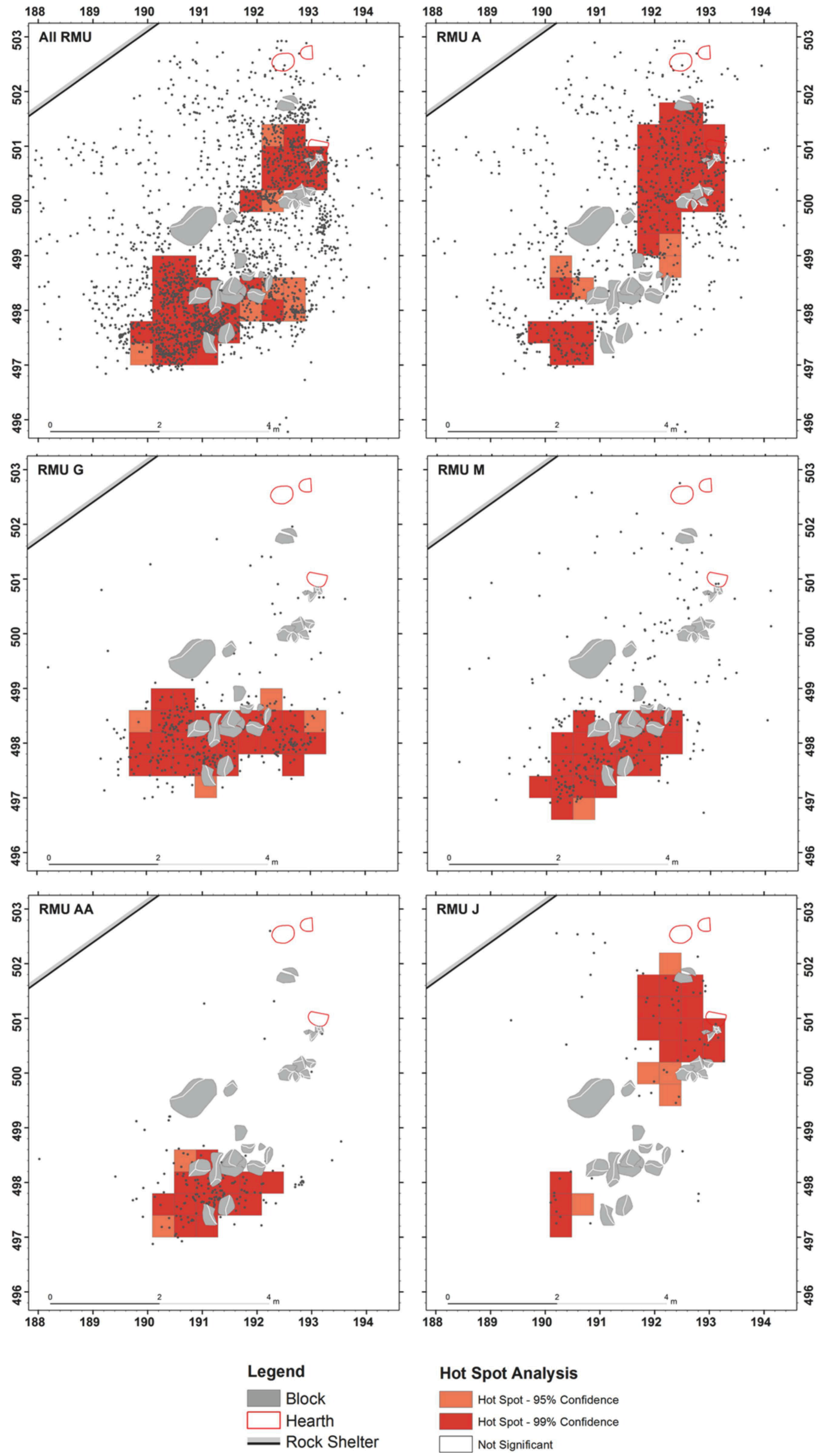
Fig. 9. A) General plan of 497C archaeological unit. Yellow frames: 20 cm. Yellow frame values represent Z values in relation to the baseline of the archaeological sequence. B) North-south 20-cm-thick vertical plot and C) East-west 20-cm-thick vertical plot following the maximum slope of level 497C (red dots). Dots represent coordinated artefacts (including lithics, bones and charcoals) recovered from different Upper Palaeolithic (497A, 497C and 497D) and Middle Palaeolithic levels (S1B, S1B1, S1C, S1D and S1E) (modified from Mora et al., 2018). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

RMU-AA, which are characterised by their quality and flake suitability. In the northern area we find the hoard of chalcedony nodules, one of the most representative geostatistical attributes in this level, as well as specialised artefacts such as a group of macro-flakes (see Sánchez-Martínez, 2020). This hypothesis may be reinforced by the spatial distribution of refitted materials, which indicates two main clusters of pieces with a low dispersion rate (See SI Fig. 3).

The location of the nodules in a different place than the cores could indicate different intra-site activities. Nodules act as raw material stock, while cores are linked to knapping activities. We propose that the hoarded nodules are linked to the cores, as both categories play complementary functional and spatial roles. Consequently, the northern and southern zones would have originated from a single event. This scenario could explain why some RMUs are more present in nodules (e.g. RMU-J) or in cores (e.g. RMU-G), as the raw material varieties most suitable for knapping would be selected first (Table 2).

However, the possibility that level 497C is a palimpsest resulting from an undetermined number of occupations cannot be ruled out. Such causal relationships may be involved in the formation of the archaeological level (Bailey, 2007a; Bailey, 2007b; Malinsky-Buller et al., 2011). One possible indicator used in the differentiation of temporal events are combustion structures (Henry, 2012), even in situations in which the horizontal resolution of the archaeological level does not clearly show anteriority-posteriority relationships between structures (Nakazawa, 2007; Martínez-Moreno et al., 2016).

The spatial distribution study of the raw materials described in this



(caption on next page)

Fig. 10. Spatial hotspot clustering of the 5 RMU. (a) The entire surface, (b) RMU-A, (c) RMU-G, (d) RMU-M, (e) RMU-AA, (f) RMU-J. Statistically significant hotspot using Getis-Ord Gi* statistics, confidence areas of 95% (orange squares) and 99% (red squares). Archaeological coordinates are positioned (grey dots) (Authorship: R. Mora). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

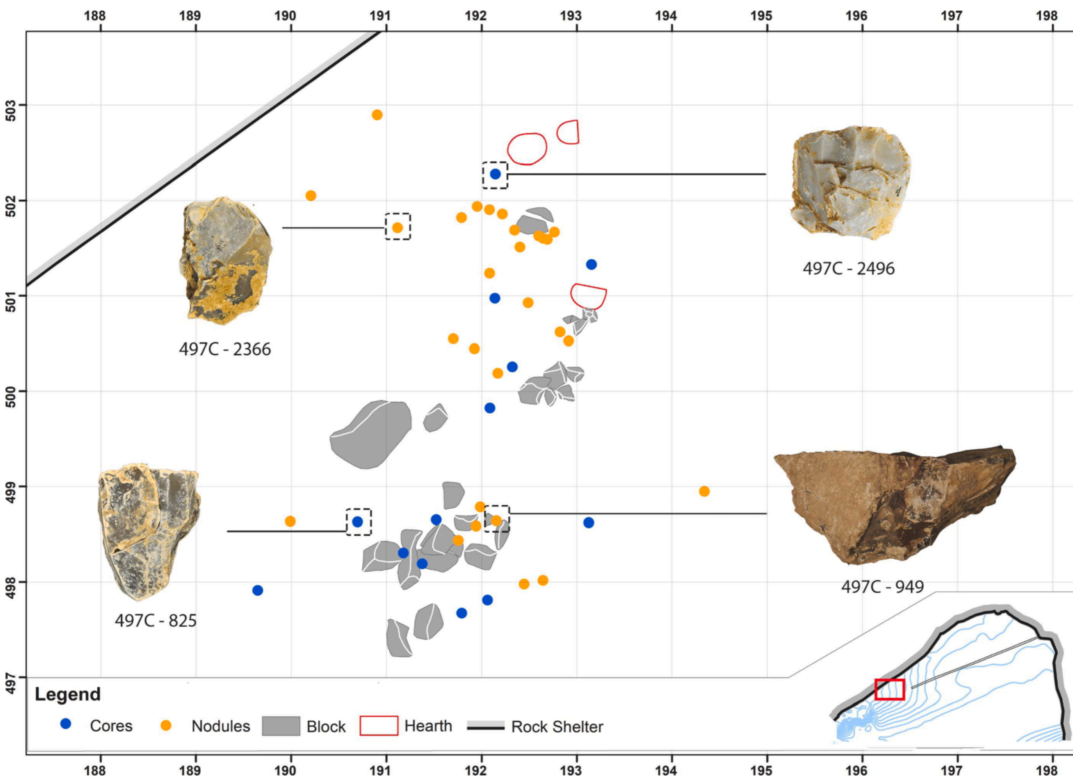


Fig. 11. Spatial distribution of nodules (orange) and cores (blue) from level 497C. Notice how most of the cores are clustered in the southern sector and most of the nodules in the northern sector of the excavated surface (Authorship: J. Sánchez-Martínez). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2
List of sites exhibiting storage behaviour in Europe during the Upper Palaeolithic and Early Mesolithic. A = Armatures, B = Blade, C = Core, F = Flake, MF = Macro-flake, N = Nodule, P = Preform, RT = Retouched tool, SF = Shapeless fragment, TN = Tested nodule, O = Other, / = w/o precise information, * = doubtful context.

Site	Location	Period	Level	Date (uncal.)	Method	Adscription	Composition	Reference
Aitzbitarte	Iberia	AU/ MP	Vb base	28010 ± 600 BP	AMS	/	SP (29) N (48)*	Altuna et al., 2012
Cova Gran	Iberia	GR	497C	26220 ± 220 BP	AMS	Hoard	TN (27)	Roy et al., 2013
Grotte du Pape	France	GR	Couche 2D	19700 ± 160 BP	AMS	Dèpot	A (102) and O (93)*	Goutas, 2009
Lapa Do Anecrial	Iberia	GR	Layer 2	23400 ± 170 BP	AMS	Lithic Kit	N(14) C (/)	Almeida et al., 2004; Almeida et al., 2009
Volgu	France	SO	/	/	/	Cache	LP (14)	Aubri et al., 2009
Montgaudier	France	MG	Couche 2	/	/	Cache	P (5)	Bouvier, 1968
La Goulaine	France	MG	/	/	/	Cache	B (c.a 200) O (c.a 200)*	Angevin and Langlais, 2009
Sesselfelsgrotte	Germany	MG	/	/	/	Cache	P (/)	Naber, 1981
Niederbieber	Germany	MG	/	c.a 12.900 BP	Tephra	Cache	MF (2) tested	Baales, 2006
Labastide	France	MG	**	/	/	Cache	B (5)	Angevin and Langlais, 2009
Enlène	France	MG	**	/	/	Cache	B (3)	Angevin and Langlais, 2009
Peña de Estebanvela	Iberia	MG	Unidad III	12360 ± 50 BP		Hoard	TN (/) C (/) F (4)	Cacho et al., 2011
Abrigo de Vergara	Iberia	MG	d	14000 ± 100 BP	AMS	/	N (28)*	Utrilla et al., 2006
Tuc d'Audoubert	France	MG	**	/	/	Cache	B (1)	Angevin and Langlais, 2009
Mas d'Azil	France	AZ	**	/	/	Cache	B (4)	Angevin and Langlais, 2009
Swidry Wielke I,	Poland	EP	/	/	/	Cache	N (/) P (/) MF (/)	Krukowski, 1939, 1976
Grzybowa Gora	Poland	EP	sl	/	/	Cache	N (/) B () C (/)	Krukowski, 1939, 1976
Swidry Mate	Poland	EP	/	/	/	Cache	N (/) P (/) C (/)	Krukowski, 1939, 1976
Val Lastari	Italy	EPG	/	11.390 ± 110 BP	AMS	Hoard	TN (39) N (18) C (1) F (2)	Peresani, 2006, 2009
Palughetto	Italy	EPG	T6	9495 ± 150 BP	AMS	Cache	TN (6)	Peresani, 2006, 2009
Vale of Pickering	UK	LUP/ ME	sl	/	/	Cache	TN (6) N (12)	Conneller and Schadla-Hall, 2003
Ruffey-sur-Seille	France	ME	sl	/	/	Cache	N (22)	Séara et al., 2002
Nizhneye Veretye I	Russia	ME	/	/	/	Cache	C (29)	Séara et al., 2002

article constitutes a strong argument for analysing different scenarios related to time-events. The geostatistical analysis of the RMUs shows the location of raw materials in specific areas (see Fig. 10), indicating that there was not an active flow of materials during human activities that would have taken place in a single event. However, if we assume that contemporaneous activities give rise to heterogeneity in the spatial distribution of the raw materials (Bargalló et al., 2016), then we would have to understand the formation of level 497C as something occurring as the result of more than one event. One might speculate that RMU-J and RMU-A, which are spatially distributed over the entire surface of the archaeological level, were deposited by a first short occupational event. Subsequently, a second occupation was established in the southern zone, and contributed RMU-G, RMU-M and RMU-AA.

Finally, the heterogeneous RMU composition of the hoard could suggest several raw material transport events. In this scenario, the nodules belonging to the southern zone could have been contributed to the deposit at a different time than those present in the northern zone. This would suggest that the hoard formed from non-simultaneous events and that its use may have been delayed in time (Bailey, 2007a; Bailey, 2007b). However, based on the information currently available, we believe that the formation and management of the hoard is linked to a single event. In any case, these models allow us to open up discussions about the temporality of this accumulation and bring us back to the classic problem of the palimpsest in archaeology.

5.2. The role of mobility and raw material procurement in the hoarding behaviour

Carrying flint nodules to the site implies a planning behaviour in terms of raw material management and risk control. The assemblage of chalcedony nodules from level 497C were collected, transported and clustered in specific spaces within the occupation area in view of anticipate future needs and unforeseen situations.

These artefacts were subjected to testing activities, and behave as a morphometrically homogeneous group based on their shared set of attributes. The combination of technological, geostatistical and spatial data has allowed us to characterise this assemblage as a raw material reserve or hoard, which permits to analyse the notion of small-scale storage.

Stone tool assemblages are affected by technical-organisational factors, site functionality and mobility (Binford, 1979; Binford, 1980; Barton and Riel-Salvatore, 2014), which also includes raw material procurement. Generally, raw material acquisition has been discussed in terms of cost-benefit and landscape use models (Barton, 2014; Barton and Riel-Salvatore, 2014; Hamilton et al., 2016; Clark et al., 2017) which have attempted to systematise the range of foraging behaviour in the composition of lithic assemblages and site formation processes. These models have postulated important implications in local source procurement depending on a wide range of variables, such as the distance and accessibility of the outcrop, the weight of transported materials, the carrying capacity, and the route to be followed. The management and organisation of these factors are implicit in the notion of foresight (Monahan, 1998; Morin and Ready, 2013; Clark et al., 2017). Moreover, transport decisions imply planning because of the technological dimension involved in the management of raw materials (Brooks et al., 2018). Thus, depending on how these factors are expressed in the archaeological record, activities would refer to more curated or expedient contexts (Binford, 1979; Lintz and Dockall, 2002).

Following this, Clark and Barton (2017) established the degree of mobility of groups using the incidence of retouching on the pieces and their volume. The smaller the volume a piece has and the more intensely retouched it is, the closer it is to the concept of curated technology, and the more mobile this group would have been. Alternatively, the larger the size of the pieces, the more suitable they are for modification in terms of tool-manufacturing flexibility (Morrow, 1996).

This idea underpins the accumulation of nodules analysed in this paper, as the objective of this stockpile was to cover a wide range of situations in the short, medium or long term. However, if Clark and Barton's predictions are applied to the Cova Gran lithic hoard, contradictions begin to emerge. For example, the absence of retouched materials in the hoard, and its large volume, would indicate that the level had a decidedly residential character, which other proxies have not found to be the most plausible model for level 497C.

The proximity of procurement points to the site is an important factor in terms of transport decisions and raw material management (Close, 1996; Morin and Ready, 2013; Valde-Nowak and Cieśla, 2020). It has been noted that the closer the procurement area to the site, the easier it is to store nodules in the habitat (Kuhn, 1994; Porraz, 2005). This observation fits with the landscape of Cova Gran, where local raw materials are abundant, and could explain why material was accumulated for knapping that was ultimately not undertaken.

However, this argument can be reanalysed from another perspective by proposing the following alternative scenario. The availability of local raw materials makes them simple to provision, reducing the number of movements and the energy cost required (Roy-Sunyer, 2016). Therefore, stockpiling resources would not be necessary because lithic production needs could be covered relatively quickly. In other words, provisioning would be carried out through short and direct displacements based on the group's requirements.

These types of dynamics, predicated on immediate need, can lead to expedient behaviours (Railey, 2010; Vaquero et al., 2018) that cause interruptions or ramifications in the operative chain, resulting in the transport of some of the material out of the site during these displacements (Romagnoli et al., 2018a; Romagnoli et al., 2018b).

Part of these discussions have been outlining decisions that are inherent to small-scale storage and foraging behaviours (Foley, 1987; Kelly, 1995; Cunningham, 2011; Dusseldorp, 2012). We consider these types of small-scale storage strategies to be implicit in the residential mobility characteristic of the forager lifestyle. However, other factors such as territory size, group size, tool duration, and time spent producing and repairing tools are also relevant in the emergence of hoarding behaviour (Peresani, 2009).

In addition, evidence of hoarding behaviour means that the stored nodules were not consumed or that the nodules were only partially exploited/used, and what has been recovered is only the portion of the hoard that has not been exhausted. This may have happened in a single event or may be the result of several time-events. Moreover, the fact that a hoard has been preserved opens the door to observations about the selection of blanks and valuable goods (Lintz and Dockall, 2002), knapping objectives, and the management of non-perishable resources. In relation to this, in the lithic hoard of the Cova Gran, we found that nodules with different characteristics were selected and tested in situ to check their knapping properties. It seems that there were no fixed criteria in the selection of the nodules and that the morphometric differences respond to the heterogeneity of the supports found between outcrops.

5.3. Hoarding behaviour and its European context

Lithic storage predating MIS 3 has rarely been identified in Europe. In this time period, the two cobble accumulations uncovered in Soucy 1 and Grotte Vaufrey (Geneste, 1985; Rigaud et al., 1988; Lhomme et al., 2000) provided the first references to lithic raw material accumulations. Caching behaviour has been more often identified in sites dating from the beginning of the Last Glacial Maximum (LGM), leading to a diversification of artefacts that make up small- and large-scale storages (see Table 3 and SI Table 6). These storages temporally correspond to the first deposits of specialised tools requiring a high level of technical skill for their manufacture, as seen in the Solutrean cache of 14 laurel-leaf points in Volgu (Aubry et al., 2009). Other examples of caching behaviour are the tested macro-flakes identified at Niederbierer (Baales, 2006), and the stockpiles of large blades from the Magdalenian sites of Labastide,

Table 3
Gravettian sites with documented nodules in the lithic assemblage. TN = tested nodule, N = Nodule, CB = Cobble. One dating has been selected for each level of La Viña.

Site	Level	Date	Calibrated (2 Ω)	Method	Definition	Composition	Σ	Reference
Cova Gran	497C	26220 ± 220	29196–28401	AMS	Hoard	TN	28	Roy-Sunyer et al., 2013
Mirón	128	27.580 ± 210	29924–29211	AMS	/	N	6	González-Morales et al., 2002
La Viña	IX	28360 ± 290	31442–29743	AMS	/	TN	7	Martínez and De la Rasilla, 2002
La Viña	X	28560 ± 300	31764–29925	AMS	/	TN	83	Marín-Arollo et al., 2018
Coímbre	Co.B.6	24410 ± 120	28760–28120	AMS	/	N and CB	27	Álvarez-Alonso et al., 2017
Ametzagaina	Conjunto W	/	/	/	/	N	22	Calvo et al., 2012
Lapa Do Anecrial	Layer 2	23,400 BP	26380–24900	AMS	Lithic Kit	N	14	Almeida et al., 2004; Almeida et al., 2009
Foz de Medal	1098	/	19 200 ± 4630	OSL	/	TN	180	Gaspar et al., 2016

Enlène and Trois-Frères (Simonnet, 1982; Angevin and Langlais, 2009). These elements were also recovered from the La Goulaine cache, interpreted as a “provisional stock” and for which precise contextual information is lacking (Breuil, 1908).

Evidence of hoarding behaviour including preforms, nodules and test-cores have been identified in different sites in Europe. At Lapa Do Anecrial, nodules and some cores interpreted as a lithic toolkit were documented in a Late Gravettian level. At Sesselfelsgrotte, Montgaudier and Tuc d’Audoubert, a series of preforms were found which constitute raw material reserves (Bouvier and Duport, 1968; Naber, 1981). At the Polish sites of Swidry Wielke I, Grzybowa Gora and Swidry Mate and Vale of Pickering, tested preforms and nodules, interpreted as insurance gear, were documented together with formatted flakes and cores, which points to the dual functionality of these reserves (Krukowski, 1939; Krukowski, 1976). Furthermore, at Vale of Pickering, lithic stockpiles are distributed throughout the valley as logistical supply points for raw materials (Conneller and Schadla-Hall, 2003). Tested nodules have been documented on the Iberian Peninsula in unit III of Estebanvela, referring to a raw material hoard (Cacho et al., 2010) and in the alpine sites of Val Lastari and Palughetto. In those sites, the nodules, which were deposited in specific areas, tended to exhibit differential reduction stages (Bertola et al., 1997). Likewise, some of the nodules were fractured in the process of testing for flake suitability, as is the case at Val Lastari (Peresani 2006; Peresani, 2009).

Late Upper Palaeolithic and Mesolithic caches may be useful references for the conceptualisation of hoarding behaviour as a manner of controlling temporal resources on a time–space scale. Evidence of small-scale storage is more common during the Holocene, which has allowed us to better define selection criteria and transformation decisions for the stored artefacts (Cunningham, 2011). The above-described examples constitute the few references to stored lithic artefacts in Palaeolithic and Early Masolithic societies, and have served as a comparative framework for contextualising and characterising the artefacts presented here. However some of these sites report unprecise and fragmented contextual data that hinder the evaluation of the techno-economic responses involved in the formation of this deposits.

The lithic hoard at Cova Gran is made up of a single constituent, as in some of the examples cited above (see Table 3). The chalcedony nodules are located within the habitat, which points to their primary role in daily activities, as is the case at Estebanvela. Generally, these artefacts are located in the immediate vicinity of the habitat or at logistical points outside the site environment. For example, at Val Lastari, the hoard was found about 10 m from the lithic workshops described on the site, while the Vale of Pickering, Grzybowa Gora and Ruffey-sur-Seille, the hoard sites were located at strategic points in the territory. Likewise, the components of the Cova Gran hoard are not as tightly clustered as at Estebanvela, Val Lastari or Vale of Pickering, where the density of artefacts is higher. The Val Lastari and Palughetto hoards have allowed us to relate techno-economic and technological data with the nodules recovered from Cova Gran. In Palughetto, the dimensions of the cores are smaller than those of the nodules, which has allowed us to estimate the volumetric reduction of the supports during the production of blades. At Cova Gran, the morphometric differences between cores and nodules are not statistically significant because both categories contain large, medium and small sizes, which makes it difficult to establish the degree of volumetric reduction produced during knapping.

5.4. *Hoarding behaviour on the Iberian Peninsula: Is it really there?*

Hoarding behaviour has been identified at several sites in Western Europe dating to the Magdalenian and Late Upper Palaeolithic. Small-scale stores have been recovered from chronologically diverse sites, suggesting that the emergence of this type of behaviour primarily responded to techno-economic issues related to the logistical organisation of the human occupations. However, there is no consistent evidence of lithic storage before the LGM. For that reason, Cova Gran de Santa Linya provides key information with which to evaluate the range of hoarding behaviour in south-western Europe during the Early Upper Palaeolithic.

Following the example of level 497C, we have compiled archaeological data from Gravettian sites on the Iberian Peninsula seeking recurrences or common patterns in the archaeological record related to hoarding behaviour. The references that have been found mainly come from sites in the Cantabrian and Atlantic areas (Table 4). In the Cantabrian area, the presence of unknapped flint nodules was documented at Aitzbitarte III (Altuna et al., 2012). In Cueva Morín and in the open-air site of Ametzagaina, raw flint nodules were mentioned as forming part of the lithic assemblages studied (Calvo et al., 2012; Calvo et al., 2016). In the Atlantic area, unknapped nodules appear in Gravettian assemblages from Lapa Do Anecrial, Lagar Velho and the open-air site of Foz do Medal (Almeida et al., 2004; Almeida et al., 2009; Gaspar et al., 2016).

At other sites, artefacts have been documented that need to be better defined in order to obtain more precise data on their role within the occupations. For example, at El Mirón six ‘cortical blocks’ and 32 ‘non-cortical blocks’ were differentiated from the cores of the assemblage (González Morales and Straus, 2012). At Agirremendi, some cobbles and fragments were recorded (Rios-Garaizar et al., 2014), but their raw material or whether they could represent a stockpile was not mentioned, while at Coímbre, unmodified quartzite and flint blocks have been documented (Álvarez-Alonso et al., 2017).

The artefacts mentioned above may indicate that the notion of small-

Table 4
Comparative relationship between the primary and secondary elements of the northern and southern zones of level 497C. The spatial location of RMUs, cores and nodules and the possible role played by the two zones have been considered.

Area	South Area	North Area
Significant elements	Cores	Nodules
Secondary elements	Debris, Knapping activities	Macroflakes, Hearths
RMU	RMU-AA, G y M	RMU-J y A
Rol	Main rol/Knapping area/ Concentration daily activities	Marginal rol/Hoard, raw material stock/Specialized activities

scale storage may be a relevant component within the Gravettian technocomplex. However, more precise contextual information is needed in order to know whether these materials were deliberately accumulated, what the transported material weighted, if they form homogeneous or heterogeneous assemblages, if they underwent any kind of intentional modification or were tested, and in order to evaluate whether they may have played a specific role within these occupations.

6. Conclusions

The Cova Gran de Santa Linya hoard comprises 27 chalcedony nodules and constitutes the largest assemblage of stored artefacts documented in the Early Upper Palaeolithic and one of the few examples of hoarding behaviour in southwestern Europe.

The technological analysis highlights the relevance of this nodule assemblage, as they represent the initial stage to which organize reduction sequences, and the cores, which are the result of such activity. The derived products from both categories have been obtained as a result of different actions (testing and knapping) and inform about the management and use of raw materials within the knapping strategies.

Geostatistical data analysis based on the spatial distribution of artefacts has been pivotal to identify density areas and significant patterns in the location of certain raw materials on the archaeological surface. These locations (north and south), associated to site-specific activities, have been critical in considering plausible scenarios with which to reconstruct the role of time-events in the site formation process.

The study of hoarding/caching behaviour contributes to improving our understanding of the subsistence strategies and adaptive responses involved in the lifestyles of forager groups. Small-scale storages have been mainly detected since the Late Upper Paleolithic, but this element needs to be further explore from a diachronic perspective to analysis the range of paleolithic storing practices. Following this point, we have addressed several examples of lithic assemblages from Iberian Gravettian sites where nodules, cobbles and test-cores have been identified. We consider that these artefacts could point to the stockpiling or hoarding of lithic resources, constituting possible small-scale storages. Systematic studies must be conducted in order to clarify the role played by lithic storages in human occupations and the multiple factors behind the formation of lithic storages. We claim to be cautious when detecting evidences of potential hoards or caches because of the wide range of reasons leading to the presence of accumulated raw materials in the archaeological record.

In this sense, the hoard from the level 497C offers new insights to understand how mobility and foraging behaviour may contribute to the composition of the archaeological record. Moreover, this lithic assemblage provides a unique glimpse into early human planning, foresight and management of lithic resources as well as further identifying social and techno-economic responses related to the storage of potentially valuable goods.

CRediT authorship contribution statement

Javier Sánchez Martínez: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing - original draft, Writing - review & editing. **Rafael Mora Torcal:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Resources, Project administration, Software, Supervision, Visualization, Writing - review & editing. **Jorge Martínez-Moreno:** Funding acquisition, Writing - review & editing. **Xavier Roda Gilabert:** Conceptualization, Writing - review & editing. **Miquel Roy-Sunyer:** Conceptualization, Data curation, Methodology, Software, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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