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Neanderthal mobile toolkit in short-term occupations at Teixoneres Cave (Moia, Spain)

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ABSTRACT

Hunter–gatherers have a nomadic lifestyle and move frequently on the landscape based on the seasonal distribution of resources. During these displacements, carrying capacities are limited, and the composition of the transported gear is generally planned ahead of the activity to perform. During the Pleistocene, prehistoric hunter–gatherers faced similar difficulties in exploiting the territory and employed different strategies for coping with their subsistence needs and the possible shortage of stone tools. The understanding of how these behaviors developed diachronically is pivotal for the reconstruction of the human trajectories of land use in different environments, orographic settings, and climates. Thus far, the identification of the mobile toolkit has been related to blanks produced with allochthonous rocks, whereas the recognition of the transported artefacts knapped in local and semi-local raw materials encounters more difficulties because of the possible association with the lithic production conducted at the site. In this paper, we present the mobile toolkit of sub-unit IIIb and IIIa of Teixoneres Cave, a Middle Paleolithic site where a clear differentiation between *in-situ* knapping activities in local quartz and the import of stone tools in other raw materials is documented. The analysis of these latter assemblages reveals that the bulk of the toolkit is composed of knapping by-products and that the number of curated artefacts, Levallois flakes, and cores is significantly lower. Results show that the main strategy of transport at Teixoneres Cave was a combination of hunting and cutting tools aiming toward a generalized set of gears instead of narrowing the equipment to few specialized items. These new data highlight the plasticity of Neanderthals' technological organization in the western Mediterranean.

1. Introduction

Studies on the lifestyle of modern hunter–gatherers have provided pivotal insights into the human land use and strategies applied for the acquisition of resources (Binford, 1978; Binford, 1982; Kelly, 1983, 1995). Climatic and ecological settings are two of the main causes influencing the productivity of the environment and therefore the mobility and dispersal of foragers groups. Generally, in territories with relatively scarce biotic resources, hunter–gatherers tend to move frequently, whereas in plentiful environments, they are less mobile and tend to camp near ecotones, where resources from several habitats can be gathered at the same time (Binford, 2001; Kelly, 1995). These two types of settlements reflect different amounts of investment and planning in the technological strategies, as indicated by Binford (1977, 1979) in the concept of curation. Curation requires an investment for future use, as the artefacts are produced in advance of anticipated use. This strategy can cope with the possible shortage of tools during the completion of specific tasks or when the exploitation of high seasonal resources prompts for a greater organization of the activities (Binford, 1979). At the other end of the spectrum is expedience, which refers to the opportunistic production of tools, as needs arise with the artefacts used and discarded in one place. In high-mobility contexts, the strategy of artefact curation and the preparation of the toolkit in advance of the foraging foray is a better strategy for hunter–gatherers that could not

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predict when and where they would need it (Binford, 1979, 1980). Conversely, in low-mobility contexts, the uncertainty of biotic and abiotic resources is reduced, and a strategy of expediency is favored because artefacts are made on a needs basis (Binford, 1979, 1980).

In the last 50 years, these concepts have been largely used and rephrased by Paleolithic archaeologists because of their applicability to understand the patterns of prehistoric technological organization, human mobility, and land use (Bamforth, 1986; Kelly, 1983, 1988; Kuhn, 1992, 1994; 1995; Nelson, 1991; Shott, 1986, 1996; Torrence, 1983). After Binford's (1979) primary association between curated technologies and the features of artefact transport, efficiency, and maintenance, others scholars enlarged the original formulation by adding other characteristics, such as the possibility to be hafted (Hayden, 1993), repaired (Gamble, 1986), recycled, or designed for multi-functionality (Bamforth, 1986). However, the ambiguity of the definition of curation also yielded some criticisms because it was unclear whether Binford (1979) referred to stone tools, assemblages, or technologies in general (Nash, 1996; Odell, 1996; Shott, 1996) and what were the relations to other variables (e.g., availability of raw materials, distribution of resources, time–stress, degree of tool reduction) in encouraging hunter–gatherers to adopt curation instead of expedience (Andrefsky, 1994, 2009; Bamforth, 1991; Bleed, 1986; Kuhn, 1992; Nelson, 1991; Roebroeks, et al., 1988; Torrence, 1983; Vaquero and Romagnoli, 2018). To some extent, curation can also be interpreted as the degree of utility of a particular technology or artefact. An extreme example is that a single flake can be curated when the point of maximum utility is reached for the activity performed (Shott, 1996; Shott and Scott, 1995).

During the Pleistocene, hominins developed different strategies for raw material management and lithic production for coping with the daily need of cutting tools (Boëda, et al., 1990; Féblot-Augustins, 1997; Féblot-Augustins, 2009; Kuhn, 1992; Le Brun-Ricalens and Otte, 2014). The understanding of these processes, particularly how prehistoric hunter–gatherers organized their technology when moving in the landscape or disperse in other territories, is critical for unveiling the trajectories of human adaptation to shortages of lithic gears and the behavioral reactions to different orographic settings, environmental changes, and climatic fluctuations. Identifying the transported lithic artefacts in the archaeological record is not an easy task. These lithic artefacts have been commonly associated with blanks produced with allochthonous rocks or curated tools (Féblot-Augustins, 1997; Geneste, 1988; Porraz, 2009; Turq, et al., 2013). As the transport cost of raw material rises as the travel distance increases, archaic humans could have balanced the effort of carriage by removing the cortex, configuring the cores, or choosing to carry only specific blanks (e.g., Levallois flakes, bifaces) (Metcalfe and Barlow, 1992). In high-mobility contexts, the number of lithic items in allochthonous raw materials (> 20 km) is generally lower than the number of artefacts knapped in local sources, and flakes, transported over long distances, show evidence of re-sharpening more frequently than stone tools produced from the neighboring outcrops (Geneste, 1988). These re-sharpening events could have also contributed to the changing morphology of the blanks over time, thus increasing their shape variability (Dibble, 1987, 1995).

In foraging systems, hunter–gatherers are always equipped with personal gears. A main issue in the identification of the toolkit composition is the recognition of the transported artefacts knapped in local and semi-local raw materials. As their number in the assemblages are larger than the allochthonous rocks, and their cutting edges do not display recurrent re-sharpening events because of their transport over a reduced area, the artefacts of the mobile toolkit in local and semi-local raw materials can be mistaken for by-products of the lithic production conducted at the site. This problem hampers our comprehension of the variability of the prehistoric toolkits in the short mobility range that could have been composed of artefacts from different raw materials at different stages of reduction. This paper aims to discuss this issue by presenting new results from the technological analysis of the late Middle Paleolithic industries at Teixoneres Cave (Moià, Spain). In these assemblages, a clear differentiation between *in-situ* knapping activities and the import of stone tools at the site is documented (Picin et al., 2020; Rosell et al., 2017; Talamo et al., 2016). Whereas quartz pebbles, which were gathered from the nearby stream, were reduced by bipolar and *tranche de saucisson* (sausage slice) methods, the other portion of the lithic collections is composed of isolated artefacts made mainly from chert and other rocks (metamorphic, sedimentary, and igneous), distributed in a radius of 15 km and with little evidence of reduction at the site. These new evidence from Teixoneres Cave aims to shed light on the variability of the mobile toolkit, providing new examples for the understanding of Neanderthals' technological organization in the western Mediterranean.

1.1. Mobile toolkit: Concepts and variability

During the Pleistocene, the diet of archaic humans was mostly based on meat (Fiorenza, et al., 2015; Hublin and Richards, 2009; Jaouen et al., 2019), a behavior that could have been prone to shortfalls and, consequently, to subsistence risk. In this perspective, lithic technologies played a major role in reducing the probabilities of failing and in enhancing the spectrum of food supply (Bamforth and Bleed, 1997; Bousman, 1993; Torrence, 1989). However, lithic productions can also be susceptible to possible shortages (e.g., deficiency of raw material), making the equilibrium of the foragers' sustenance precarious under stressful conditions (e.g., climate change, faunal turnover). Among prehistoric hunter–gatherers, carrying capacities were limited, and the coping with the potential demand for stone tools could have been solved by keeping individuals equipped with various implements (provision of individuals), supplying the place of the activity with a stockpile of raw materials (provision of places), or producing artefacts when the need arises (provisioning of activities) (Kuhn, 1992, 2004). For mobile groups, this planning strategy in the management of the stone resources equates to a form of risk minimization (Kuhn, 1992).

Thus far, the investigation on prehistoric toolkits has been generally associated with retouched artefacts knapped in allochthonous raw materials and with particular attention to handaxes and Clovis points (Andrefsky, 1994; Beck, et al., 2002; Jennings, et al., 2010; Jeske, 1992; Kelly, 1988; Kelly and Todd, 1988; Wiśniewski, et al., 2019). These items are extremely versatile because they have a long use-life, can be utilized as cutting tools and cores, and can easily be resharpened when blunted (Kelly, 1988). Other studies referred to retouch intensity in stone tools as evidence that the artefact had been transported frequently across the territory (Andrefsky, 2006; Blades, 2003; Dibble, 1995; Hiscock and Attenbrow, 2003). In the Middle Paleolithic, among bifaces and asymmetrical (*Keilmesser*) bifacial knives (Jöris, 2006; Soressi, 2004), Quina scrapers are stone tools designed for frequent sharpening events in high-mobility contexts (Hiscock, et al., 2009; Lebègue and Meignen, 2014). Other works on the Middle Paleolithic record suggested that Levallois cores and Levallois by-products (e.g., flakes, blades, points) were the items carried farther on the landscape (Geneste, 1988; Henry, 1995; Hovers, 2009; Moncel, et al., 2014; Picin and Carbonell, 2016; Roebroeks, 1988; Turq, et al., 2017) because of their features that were more appealing during longer forays (Brantingham and Kuhn, 2001; Eren and Lycett, 2012; Picin and Vaquero, 2016). Conversely, simpler technologies (e.g., discoid, orthogonal, globular) reflected a more expedient approach and a broader utilization in low mobility areas (Wallace and Shea, 2006). Levallois and Mousterian points were also proposed to have been transported more frequently than other tools because they were considered to be the main components of the Neanderthals' hunting kits (Rios-Garaizar, 2016; Rots, 2013; Sharon and Oron, 2014; Shea, 2006; Yaroshevich, et al., 2016). A recent synthesis of the Mousterian subsistence and technological strategies in Western France found that Quina and discoid methods are related more to high-mobility patterns for the acquisition of migrating large ungulates. The applicability of the knapping methods to different types of stones facilitated their use during long displacements. Conversely, laminar and Levallois technologies are more dependent on better-quality chert nodules, implying a reduced mobility and an enlargement of the faunal spectra (Delagnes and Rendu, 2011).

These pieces of evidence point out that the lithic reduction and human mobility are dynamic systems and that the personal gear carried on the landscape could have changed through time based on different variables (e.g., environment, climate, cultural traditions). This variability, documented during the Middle Paleolithic, is somehow in contrast with the previous ethnographic observations that the mobile toolkits tend to be more specialized in highly seasonal environments and generalized in temperate habitats, where resources are less scattered and the faunal communities do not migrate (Binford, 1978; Oswalt, 1976; Torrence, 2001). Conversely, Neanderthals are flexible in their choice of lithic items to carry on the landscape (Delagnes and Rendu, 2011; Picin, 2016; Picin and Carbonell, 2016; Turq et al., 2013; Vaquero et al., 2012; Picin, 2020). This behavioral plasticity is also recorded during periods of subsistence stress, when the visits to carnivore dens for exploiting meat, fat, and warm pelts are accompanied by curated and expedient artefacts (Airvaux, et al., 2012; Brugal and Jaubert, 1991; Charles, 1997; Romandini, et al., 2018; Talamo, et al., 2014). Recently, digging sticks have been found in several Middle Paleolithic sites (Aranguren, et al., 2018; Carbonell and Castro-Curel, 1992; Castro-Curel and Carbonell, 1995; Rios-Garaizar, et al., 2018), broadening the possibility that Mousterian toolkits could have been composed of different subsistants, as shown in the ethnography by Oswalt (1976).

2. Materials and method

2.1. Teixoneres Cave

Teixoneres Cave is located northeast of the Iberian Peninsula at 760 m a.s.l. near the town of Moià, 50 km north of Barcelona (Fig. 1). The natural shelter is part of the karstic system called Toll Caves that developed on sedimentary material in the margin of the Central Catalan depression, which includes another cave (Toll Cave) and an aven (l'Avenc del Bassot). The caves are located on the fluvial terraces created by the Mal stream in the Neogene limestones of the Collsuspina Formation. The sites were discovered during the speleological explorations of the karstic systems at the end of the 1940s, and several archaeological excavations were performed in the following years, unveiling rich Pleistocene and Holocene sequences (Castellví, 1974; Serra et al., 1957; Donner and Kurten 1958). Since 2003, a new project is exploring Toll Cave and Teixoneres Cave. This latter is excavated in extension over a surface of 250 m^2.

The stratigraphic sequence of Teixoneres Cave is composed of three main large deposits sealed by a stalagmitic crust dated to approximately 16 ky BP (Tissoux, et al., 2006). The upper deposit contains units II and III, which are radiocarbon dated from 44,840–33,060 cal. BP (68.2%) and from > 51,000–44,210 cal. BP (68.2%), respectively (Talamo, et al., 2016). This sequence is located over another stalagmitic layer dated between 98 and 100 ky BP (Tissoux, et al., 2006), which separates the upper and middle sets. The upper units II and III are the most studied archaeological assemblages. Their faunal record shows a high diversity of ungulates, such as red deer (*Cervus elaphus*), horse (*Equus ferus*), aurochs (*Bos primiginius*), wild ass (*Equus hydruntinus*), roe deer (*Capreolus capreolus*), wild goat (*Capra pyrenaica*), chamois (*Rupicapra pyrenaica*), wild boar (*Sus scrofa*), woolly rhino (*Coelodonta antiquitatis*), woolly mammoth (*Mammuthus primigenius*), and lagomorpha such as rabbit (*Oryctolagus cuniculus*) and hare (*Lepus* sp.) (Álvarez-Lao, et al., 2017; Rosell, et al., 2017). Human remains are represented by three deciduous teeth corresponding to at least two different individuals younger than 7 years old and a molar of an adult. Even though the presence of Neanderthals is recurrent at the site, the activities of carnivores are common in all the stratigraphic units [e.g., cave bear (*Ursus spelaeus*), hyena (*Crocuta crocuta*), wolf (*Canis lupus*), fox (*Vulpes vulpes*), lynx (*Lynx spelaea*), and badger (*Meles meles*)], and hyenas are the most active predators (Rosell, et al., 2017). According to the spatial distribution of the finds, the items associated with the carnivore den activities are mainly clustered in the inner parts of the cave, and the anthropogenic items (i.e., lithics and bones with cut marks) are mainly clustered in the main entrance. Some small and thin hearths have been excavated in this area as well, suggesting that short-term domestic activities were also conducted at the site.

Preliminary surveys on the raw material distribution in the region indicate that the formations with chert are located at about 10–15 km from the site in Triassic deposits of the Lower Muschelkalk facies running in a northeast–southwest axis (Mangado and Nadal, 2001). In this area, nodules of chert, limestone, hornfels, and quartzite are found in primary and secondary positions in the Llobregat valley and its fluvial terraces, in the Congost valley, and at the bottom of the Montseny Massif. At about 8 km south from the cave, sources of quartz and chert in the secondary context are found at Sant Quirze, and chert outcrops in the secondary context are found at Coll Can Tripeta situated at about 15 km northwest of the site (Mangado and Nadal, 2001). Nodules of jasper are found at Morrot (Barcelona), and flint sources of the "Gasteropoda-dolomite type" and "Oolithic type" are still unknown (Mangado, et al., 2006). Within the vicinity of the cave, cobbles of quartzite, sandstone, and quartz can be gathered in the secondary context in the nearby Mal stream. Provenance studies on the raw materials uncovered in the archaeological levels are still underway. In the current study, the lithic materials are discriminated solely based on their macroscopic features.

2.2. Methodological approach in the lithic analysis

This study aims to identify the transported toolkit and is restricted to the lithic materials produced in metamorphic, sedimentary, and igneous rocks. The lithic assemblages are initially distinguished by the raw material units defined according to stone macroscopic features, including type of cortex, color, grain size, and texture (Roebroeks, 1988). Then, the different raw material groups are analyzed following the *chaîne opératoire* approach, a methodological framework that defines the reconstruction of the various processes of flake production from the procurement of raw materials through the phases of manufacture and utilization until final discard (Boëda, 2013; Inizian, et al., 1992; Pelegrin, et al., 1988). Following this methodological scheme, lithic production is examined from a techno-economic perspective, documenting the patterns of nodule/artefact transport and/or reduction at the site. According to the principle of economic zonation (Binford, 1982; Geneste, 1988), in this study, the distribution of the raw material sources on the landscape are divided into local (< 5 km), semi-local (5–20 km), and allochthonous (> 20 km).

The analysis of the core assemblage is performed by identifying the number of flaking surfaces, the presence or absence of the hierarchical preparation of the core volume, the angle between the flaking surface and the striking platform, and the direction of the flakes detached. The Levallois and discoid technology is identified following the criteria defined by Boëda (1993, 2013), and the intermediate core morphologies, which are characterized by the hierarchization of the flaking surface and core configuration with secant fracture planes, are considered hierarchized and discriminated based on the direction of the detachments (e.g., unidirectional, bidirectional, or centripetal) (Picin, 2018; Vaquero and Carbonell, 2003).

The study of the flake assemblage is performed by analyzing the presence (cortex > 50% = cortical flake; cortex < 50% = semi-cortical flake) or absence of the cortex, the number and direction of the detachments on the dorsal face, the angle and the type of striking platform, the flaking axis, the presence of knapping accidents (e.g., overshot and hinged removal, siret fracture), and the retouch. Retouched tools are distinguished following Bordes' (1961) typological

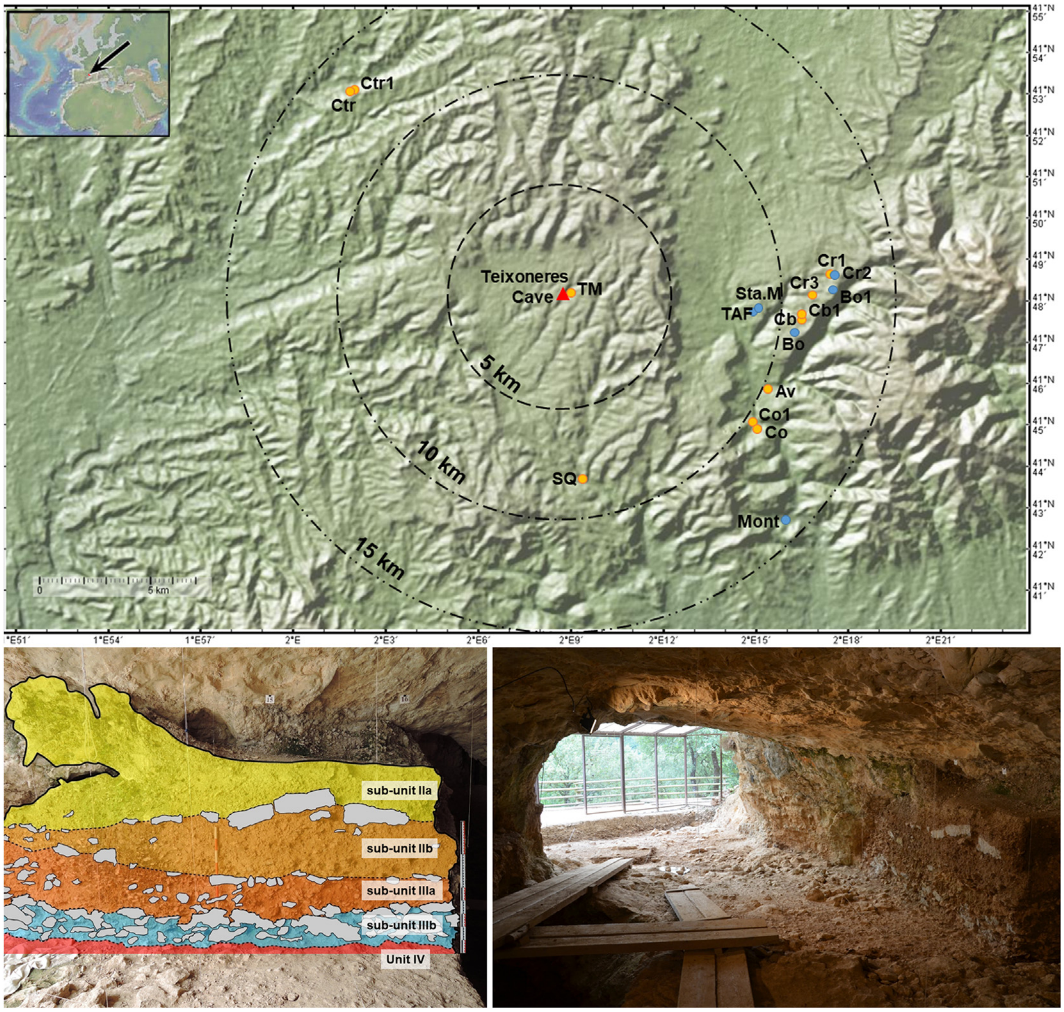

Fig. 1. Stratigraphic sequence, general overview and geographical location of Teixoneres Cave, and raw material outcrops. Legend: Raw materials in primary position: Montamany (Mont), Torrent de l'Afrau (TAF), Sta. Madrona (Sta. M.), Boix (Bo, Bo1), Can Rovira (Cr2); Raw materials in secondary position: Coll Can Tripeta (Ctr, Ctr1), Torrent Mal (TM), Sant Quirze (SQ), Can Oller (Co, Co1), Avenco (Av), Can Brull (Cb, Cb1), Can Rovira (Cr1, Cr3).

list, and pointed artefacts are discriminated into the following: a) Mousterian point: a triangular/subtriangular blank with a pointed end produced by retouching on both sides, b) point: a triangular/subtriangular blank with a pointed end produced by retouching on one side, and c) convergent tool: a triangular/subtriangular blank with the long axis relatively oblique to the flaking axis and a pointed end produced by retouching on one side. Denticulates and notched tools are analyzed according to Picin et al. (2011). The intensity of the retouch is measured using the modified version of Kuhn's (1990a) geometric index of unifacial reduction (GIUR) (Hiscock and Attenbrow, 2003). The average of three ratios between the height of retouch ("t") and the flake thickness in the same orientation ("T"), following the formula [(t1/T1 + t2/T2 + t3/T3/)/3], provides a value between 0 and 1 that estimates the proportion of the original mass removed from the blank through unifacial retouching. In denticulates, the GIUR is calculated on the concavities, and the average is performed at times on two ratios between the height of retouch ("t") and the flake thickness in the same orientation ("T"). In notched tools, the GIUR is calculated by multiplying the sine of the angle of retouch (*a*) by the extension of the retouch scar (D) with the maximum thickness at the center of the blank (T) using the formula [sin *a* (D)/T] (Kuhn, 1990b).

3. Results

3.1. Sub-unit IIIb

The lithic assemblage of the sub-unit IIIb is composed of 3314 lithic artefacts. Among these items, 1950 are quartz (59%), mostly knapped at the site, and the remaining 1364 stone artefacts are produced on other raw materials (41%). In this latter collection, chert (73%) is the most common, whereas quartzite (11%), hornfels (6%), limestone (6%), and other rocks are documented the least (Fig. 2). The analysis of the core assemblage indicates that that the use of the Levallois technology is limited only to chert artefacts and that the use of hierarchized configuration of the core volume is recorded in chert and hornfels (Table 1). The Levallois recurrent unidirectional core is an exhausted and small artefact characterized by an overshoot removal and two smaller detachments on the lateral side. Similarly, the second Levallois recurrent centripetal core arrived at the site already exhausted, and the refitted pieces show different stages of re-utilization (Fig. 3 n. 2). After a knapping accident, a portion of the core was removed, and the fracture was used as a new striking platform for continuing the Levallois production. A second knapping accident broke another portion of the artefact, and then the core was discarded (Fig. 3 n. 2). The hierarchized cores in chert and hornefels show similar technical expedients with the preparation of the striking platforms and a centripetal exploitation of the flaking surfaces (Fig. 3 n. 1, 3). Similar to the Levallois artefacts,

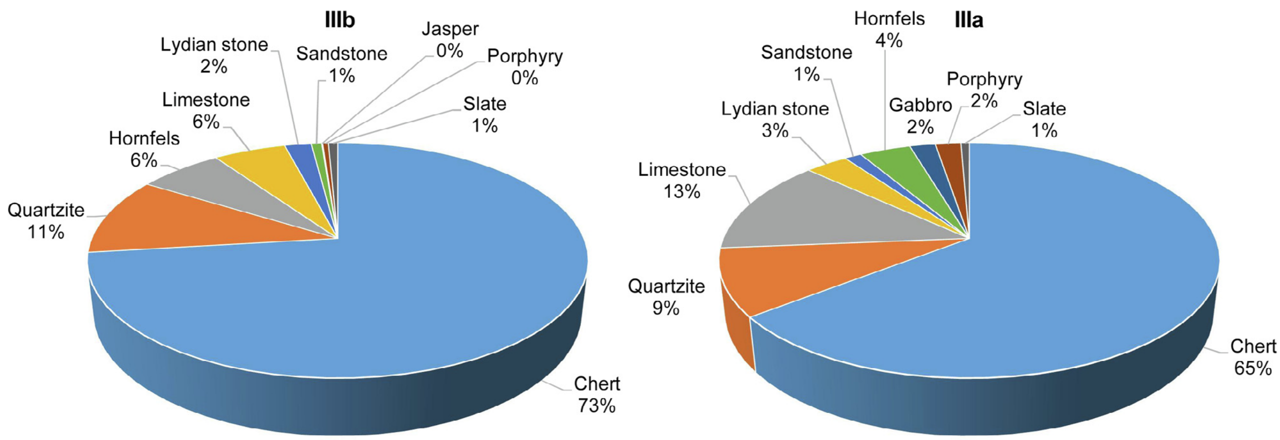

Fig. 2. Percentages of raw materials of sub-unit IIIb and IIIa considered in this study.

lithic production is aimed at small flakes smaller than 3 cm. The remaining chert cores show the broader use of a simpler method as unidirectional, centripetal, or bidirectional (Table 1). These artefacts are reduced opportunistically. A striking example is a small and broken chert blank in which the fracture is used as a new striking platform for the detachment of two small flakes (Fig. 3 n. 5–7). In the assemblage of the other raw materials, a semi-cortical flake is produced from a portion of a limestone pebble, and three quartzite cores attest the use of the centripetal method. In one core, a centripetal flake is refitted (Fig. 3 n. 4).

In the assemblage, the discovery of a small amount of core-on-flakes shows a change in the function of some flakes from the cutting tools to the source for blanks (Table 1), corroborating a technical behavior of the ramification of the lithic production (Bourguignon, et al., 2004; McPherron, 2009). Cortical elements are the preferred blanks for core-on-flake in chert (55.5%), quartzite, and limestone. The striking platforms are prepared by truncating one or two proximal sides of the flake, detaching up to four flakes from the ventral surface. The blanks produced are small with a mean size of 12.4 ± 2.2 mm.

The study on the flake collection reveals the presence of artefacts from different phases of reduction (Table 2). However, refitting analysis highlights only two examples of refitted fragments in chert, three examples of knapping refitting between the flakes in chert, and one refitting of a centripetal flake with the core in quartzite. These data indicate that the knapping activities at the site using chert and metamorphic rocks are rare. A broad comparison of the frequencies of complete flakes by stage of reduction shows that the phase of decortication is underrepresented in chert, quartzite, and hornfels, absent in sandstone and slate, and common in limestone and lydian stone (Fig. 4). The predetermined by-products, such as Levallois flakes or other commonly transported blanks, as core–edge removal flakes and pseudo-Levallois points are documented in lesser frequencies than, for example, ordinary flakes or the by-products of the preparation of the striking platform (Table 2, Fig. 3 n. 8–9). In lydian stone, porphyry, sandstone, or slate raw materials, the artefacts comprise mostly isolated objects that are transported at the site after different knapping events (Fig. 3 n. 10).

In the high-mobility context, the size of the transported artefacts affects the portability of the lithic toolkit (Kuhn, 1992). Therefore, to reveal the characteristics of these transported objects, the metric features of the complete flakes are analyzed (Fig. 5). The comparison of the length distribution indicates that the bulk of the flake assemblage is less than or equal to 30 mm and that few longer blanks are documented in the chert raw material (Fig. 5). The flakes are also small in quartzite, and some blanks are > 30 mm in limestone and hornfels. However, a detailed analysis of the length size by reduction stage indicates that the median values of the cortical flakes are generally larger than those of the non-cortical flakes (Fig. 6), and the chert artefacts have median values smaller than those of quartzite and limestone (Fig. 6). A statistical comparison reveals a significant difference in the median values of the flake length between chert and quartzite (cortical flakes: Mann–Whitney test, $p = 0.0186$; non-cortical flakes: Mann–Whitney test, $p = 0.0035$) and between chert and limestone (cortical flakes: Mann–Whitney test, $p = 0.0387$; non-cortical flakes: Mann–Whitney test, $p = 0.0002$). Conversely, no difference is recorded in the median flake length values between quartzite and limestone (cortical flakes: Mann–Whitney test, $p = 0.5147$; non-cortical flakes: Mann–Whitney, $p = 0.1598$). The flake length shows a significant correlation with weight values in chert ($n = 333$, $r = 0.9015$, $p \leq 0.0001$), quartzite ($n = 62$, $r = 0.9321$, $p \leq 0.0001$), limestone ($n = 35$, $r = 0.7495$, $p \leq 0.0001$), and hornfels ($n = 44$, $r = 0.8230$, $p \leq 0.0001$). However, a comparison between the assemblages reveals that, by similar length values, quartzite and hornfels flakes are weightier than chert and limestone flakes (Fig. 7). Moreover, the linear regression model indicates that the differences between the slopes are extremely significant ($F = 22.3326$, $DFn = 3$, $DFd = 466$, $p \geq 0.0001$). Levallois flakes in

Table 1
Total number and percentage of the core assemblage of sub-unit IIIb of Teixoneres Cave.

	Chert	%	Hornfels	%	Limestone	%	Quartzite	%	Total	%
Levallois rec. uni.	1	2.7							1	2.1
Levallois rec. centr.	1	2.7							1	2.1
Hierarchized centr.	2	5.4	2	100					4	8.5
Discoid	1	2.7							1	2.1
Unidirectional	5	13.5			1	50			6	12.8
Bidirectional	1	2.7							1	2.1
Centripetal	2	5.4					3	50	5	10.6
Core-on-flake	9	24.3			1	50	2	33.3	12	25.5
Core fragments	15	40.5					1	16.7	16	34
Total	37	100	2	100	2	100	6	100	47	100

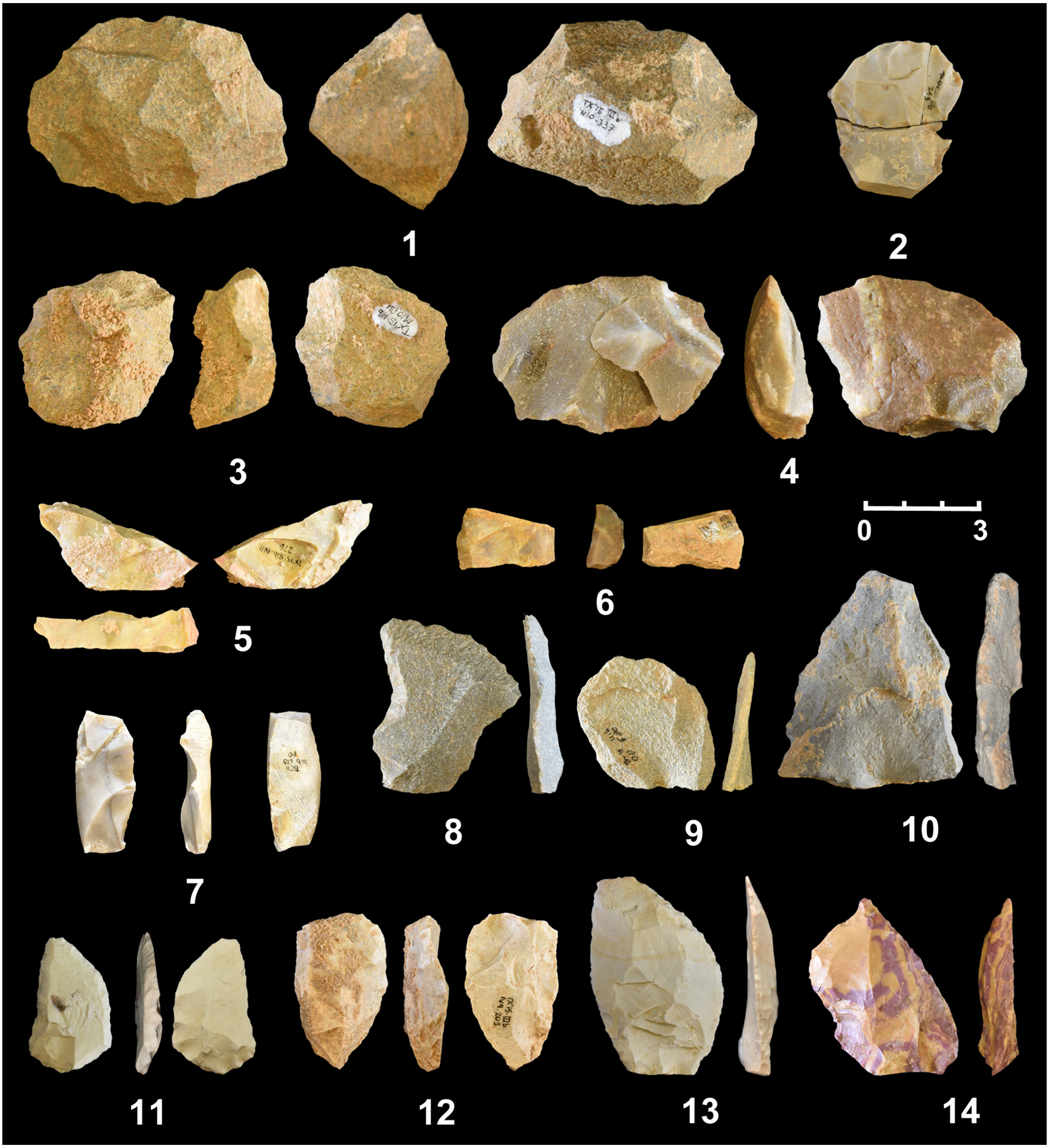

Fig. 3. Lithic material from sub-unit IIIb of Teixoneres Cave. 1, 3) hierarchized centripetal core in hornfels; 2) refitted Levallois centripetal core in chert; 4) refitting of a flake and a centripetal core in quartzite; 5–7) unidirectional core on fragment in chert; 8) Levallois flake in quartzite; 9) Levallois flake in hornfels; 10) convergent unidirectional flake in limestone; 11, 13) Mousterian point in chert; 12) demi-Quina scraper in chert; 14) scraper in jasper.

the different raw materials have similar median length sizes (Kruskal–Wallis test: $p = 0.9884$), and the comparison of the relation between the length and the weight indicates that the samples in other raw materials reenter in the variability of the Levallois blanks in chert (Fig. 8).

The assemblage of retouched tools is composed of scrapers, convergent tools, and denticulates (Table 3, Fig. 3 n. 11–14). The technical behavior of re-sharpening the cutting edges is common in chert artefacts but rare in quartzite and in other raw materials (Table 3). This pattern is also supported by the discovery of some flakes of retouch in chert. However, these types of items are absent in the assemblages of the other rocks. Cortical elements (51.2%) and core–edge removal flakes (12.1%) are preferred as blanks for scrapers in chert. These tools have larger length values (mean = 37.89 ± 11.05 mm) than the *débitage* items (mean = 22.91 ± 10.51 mm), although their size remains small. The calculation of the GIUR indicates similar values in the

Table 2
Total number and percentage of the flake assemblage of sub-unit IIIb of Teixoneres Cave.

	Chert	%	Quartzite	%	Limestone	%	Hornfels	%	Lydian stone	%	Porphyry	%	Sandstone	%	Slate	%	Total	%
Cortical flake (> 50%)	6	0.7	2	1.5	2	2.7											10	0.8
Cortical flake (< 50%)	28	3.2	5	3.8	9	12.3	3	3.5	2	7.7					1	10	48	4
Natur. core–edge flake	19	2.2	3	2.3	4	5.5	1	1.2									27	2.2
Trim. strik. platform	58	6.6	8	6.2	5	6.8	13	15.1			1	16.7	1	11.1	2	20	88	7.3
Ordinary flake	79	9	18	13.8	3	4.1	9	10.5	2	7.7			1	11.1	1	10	113	9.3
Predeter. Lev. flake	14	1.6	6	4.6			6	7									26	2.1
Levallois rec. unid.	16	1.8	3	2.3	2	2.7	1	1.2					2	22.2			24	2
Levallois rec. centr.	13	1.5	2	1.5	2	2.7	1	1.2									18	1.5
Levallois point	1	0.1															1	0.1
Core edge rem. flake	27	3.1	4	3.1	3	4.1	1	1.2									35	2.9
Dos limite flake	10	1.1	3	2.3					1	3.8							14	1.2
Pseudo-Lev. point	15	1.7	7	5.4			3	3.5	1	3.8					1	10	27	2.2
Unidirectional flake	9	1	3	2.3	2	2.7	4	4.7	1	3.8							19	1.6
Bidirectional							1	1.2					1	11.1			2	0.2
Orthogonal	2	0.2															2	0.2
Centripetal	18	2.1			2	2.7	1	1.2									21	1.7
Kombewa-type flake	7	0.8			1	1.4	1	1.2									9	0.7
Re-shaping flak. surf.	18	2.1	1	0.8	1	1.4											20	1.6
Translation strik. platf.	1	0.1					3	3.5									4	0.3
Knapping accident	56	6.4	10	7.7	3	4.1	5	5.8									74	6.1
Retouch flake	15	1.7															15	1.2
Frag. with cortex	59	6.8	5	3.8	12	16.4	2	2.3	5	19.2	5	83.3			2	20	90	7.4
Frag. without cortex	327	37.5	46	35.4	20	27.4	31	36	13	50			3	33.3	3	30	443	36.5
Chips	75	8.6	4	3.1	2	2.7			1	3.8			1	11.1			83	6.8
Total	873	100	130	100	73	100	86	100	26	100	6	100	9	100	10	100	1213	100

scrapers between chert (GIUR index: 0.51 ± 0.17) and jasper (GIUR index: 0.55), and the artefact in quartzite is more resharpened (GIUR index: 0.87). Note that two scrapers in the chert assemblage have the retouch types Quina and demi-Quina, respectively (Fig. 3 n. 12). Before discard, the latter stone tool undergoes an ulterior reduction, and two flakes are detached from the ventral side of the cutting edge (Fig. 3). The thinning of the ventral surface, which is probably used for a better handling of the tool during the actions of cutting, is present in five scrapers, and in most of them, the bulb is removed.

Convergent tools, points, and Mousterian points are shaped principally in chert flakes (Fig. 3 n. 11, 13), and only three examples in quartzite are recorded (Table 3). Blanks knapped during different stages of reduction are used for their manufacture without any particular preference, and Levallois flakes are documented only in two convergent tools in chert. The lengths of the Mousterian points (mean = 32.4 ± 7.4 mm) and points (mean = 33.88 ± 11.96 mm) in chert are slightly smaller than those of the convergent tools (mean = 43.09 ± 10.41 mm), and no significant differences are recorded between their median values (Kruskal–Wallis test: p = 0.3039). The comparison between the length and weight of the scrapers and pointed artefacts shows that they share the same dimensional variability and that only one Mousterian point exhibits a lower weight value (Fig. 9). Conversely, the quartzite stone tools have larger weight values, although they are included in the range of chert items (Fig. 9).

In the assemblage of retouched tools, several denticulates and notched tools are also found. The artefacts in chert show a preference for notched tools characterized by a single concavity (1Ns: simple notch) and denticulates with two or more than three concavities (Table 3). The quartzite raw material is documented to have a complex notched tool (1Nc) characterized by a concavity produced by contiguous removals and few denticulates. In other raw materials, the production of these types of stone tools is sparse (Table 3). The use of cortical elements is common in chert (49%), quartzite (50%), and hornfels. The length values of the notched tools and denticulates in chert (mean: 35.06 ± 11.8 mm) and quartzite (mean: 38.47 ± 9.1 mm) are slighter larger than those of the pointed artefacts and similar to those of scrapers. The comparison of the length and weight shows a separation between the denticulates in chert and between the denticulates and the notched tools in metamorphic rocks (Fig. 10). The calculation of the intensity of retouch shows analogous values for denticulates in chert

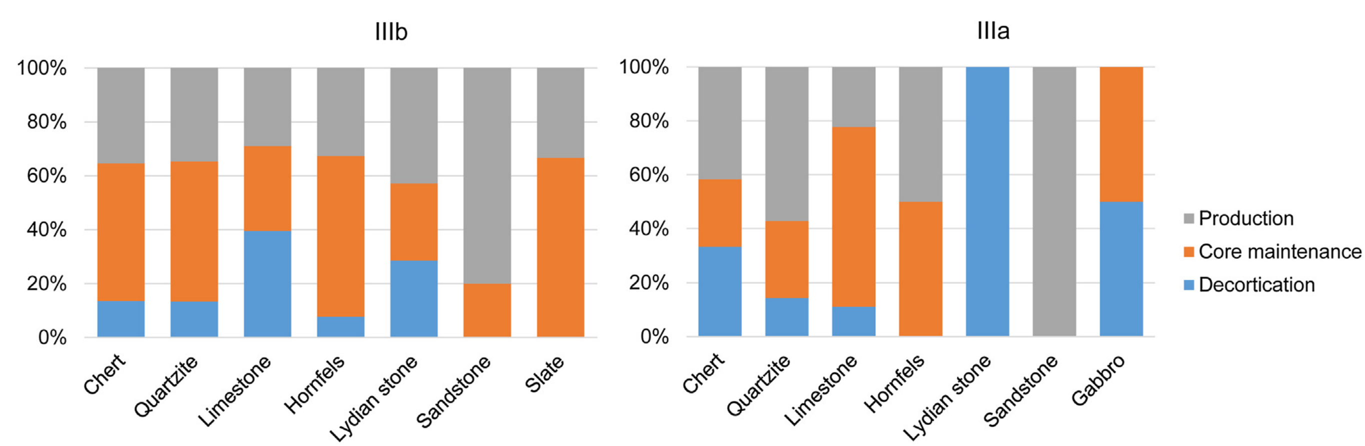

Fig. 4. Comparison of the frequencies of complete flakes by the knapping stages in the different raw materials of sub-unit IIIb and IIIa.

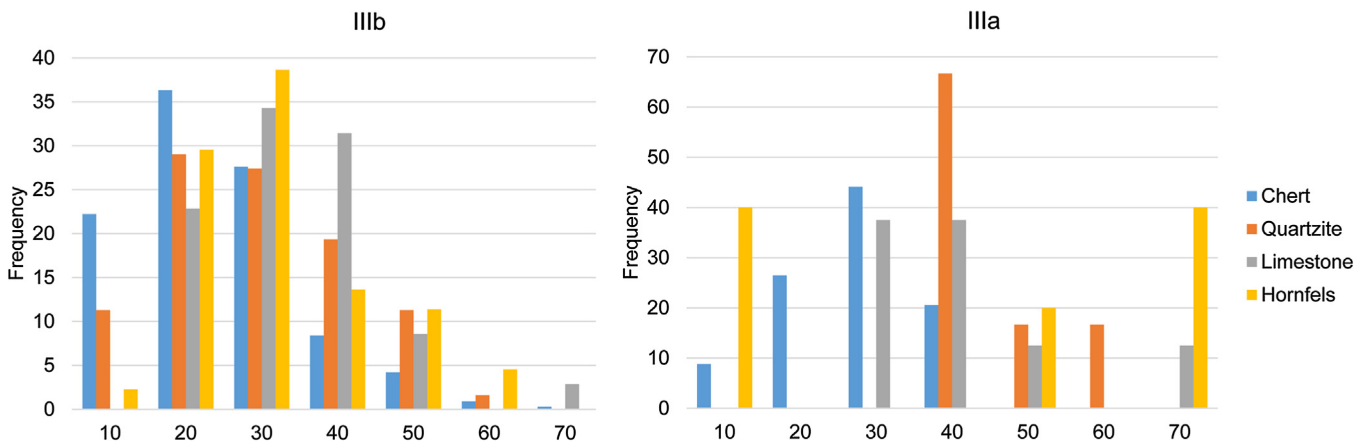

Fig. 5. Histogram of comparison between complete flakes in different raw material by length intervals (mm) of sub-unit IIIb and IIIa of Teixoneres Cave.

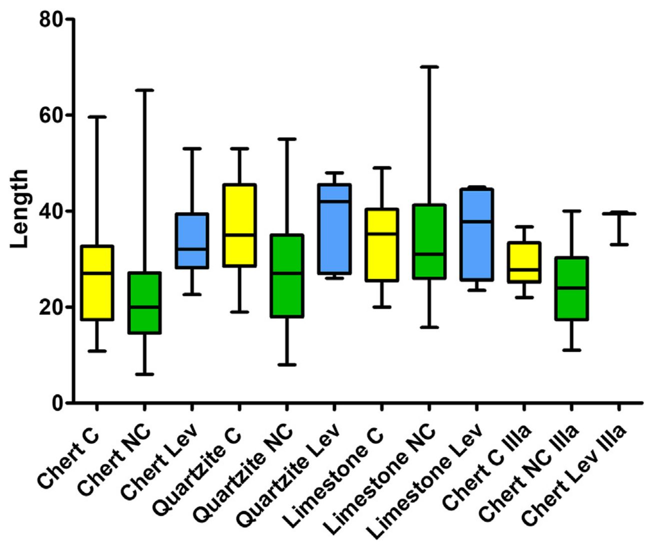

Fig. 6. Comparison between cortical flakes (C), no-cortical flakes (NC) and Levallois flakes in different raw materials from sub-unit IIIb, and chert from sub-unit IIIa of Teixoneres Cave.

(GIUR index: 0.74 ± 0.13), quartzite (GIUR index: 0.71 ± 0.15), and lydian stone (GIUR index: 0.8) and smaller values in sandstone (GIUR index: 0.56 ± 0.19) and hornfels (GIUR index: 0.67). The notched tools in chert (GIUR index: 0.83 ± 0.13) and quartzite (GIUR index: 0.94) also have comparable results with denticulates, and the limestone simple notch has lower values (GIUR index: 0.37).

3.2. Sub-unit IIIa

The lithic assemblage of the sub-unit IIIa is composed of 500 artefacts, among 348 items are in quartz (69%) mostly knapped at the sites, and the remaining 152 stone tools are knapped in different raw materials. In this latter collection, the use of chert (65%) is recurrent and that of quartzite (9%), limestone (13%), hornfels (4%), and other rocks is recorded in lesser frequency (Fig. 2). The analysis reveals a small amount of cores, and Levallois technology is documented in two examples (Table 4). The Levallois recurrent centripetal core in chert is an exhausted artefact exhibited on the flaking surface in the production of four flakes smaller than 20 mm. The latter one removes a thicker portion of the striking platform, and then the core is discarded. The other Levallois core is also exhausted and characterized by the use of the preferential modality for the production of a flake smaller than 30 mm (Fig. 11 n. 1). The other artefacts include two core-on-flakes on the cortical elements (Table 4 Fig. 11 n. 5). In both examples, the striking platforms are prepared by truncating a proximal side of the flake, and the ventral reductions are removed by the bulbs. The blanks produced are small with a mean size of 17.6 ± 5.5 mm.

The study on the flake assemblage shows a high fragmentation of the operative chains with few artefacts by technological phases (Table 5, Fig. 11 n. 2–4, 7–11, 14), and no refittings have been found thus far. The comparison of the frequencies of the complete flakes by stage of reduction shows that, in quartzite and limestone, the phase of decortication is underrepresented at the beginning of nodule reduction, and the cortical elements are common in chert (Fig. 4). The transport of

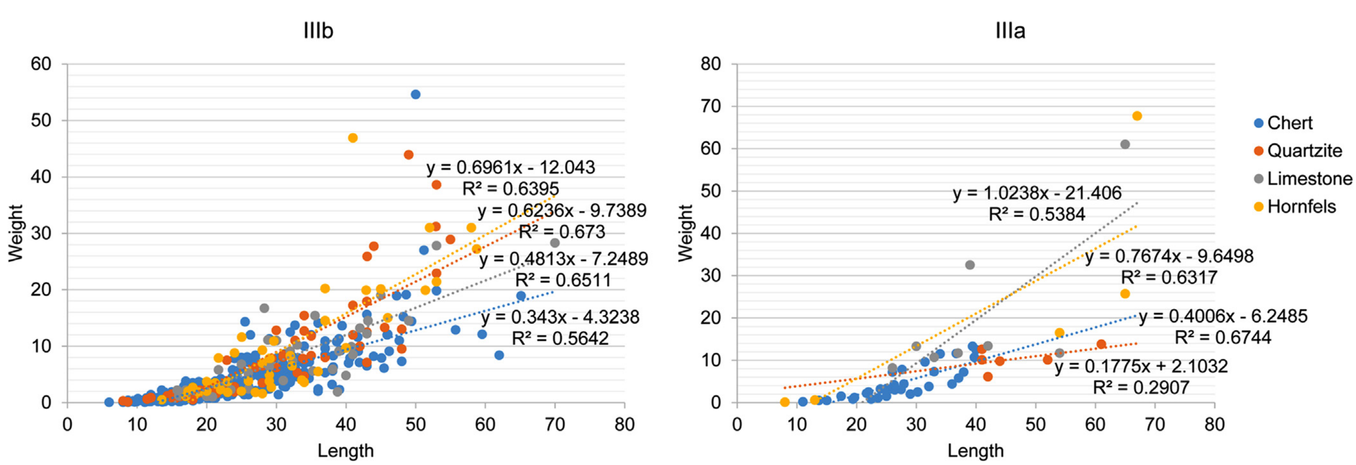

Fig. 7. Plot of the relation between the length (mm) and the weight (gr) of complete flakes in different raw materials from sub-unit IIIb and IIIa of Teixoneres Cave.

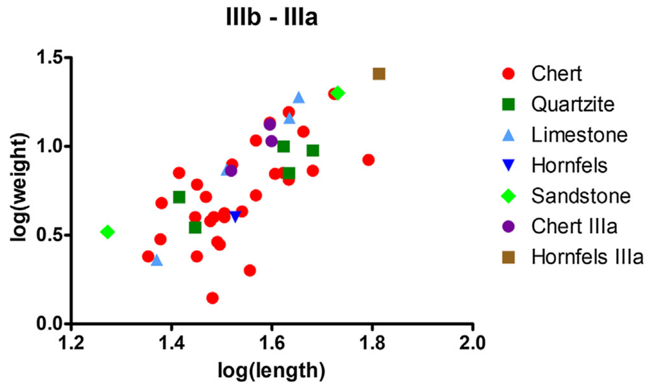

Fig. 8. Log transformation plot of weight and length of Levallois flakes of sub-unit IIIb and IIIa of Teixoneres Cave.

knapping by-products is common in chert, quartzite, and hornfels, whereas only a few isolated examples are recorded in the other rocks (Table 5). The fragmented character of the flake assemblage is evident by comparing the length of complete flakes (Fig. 5). Small flakes are frequent in chert and hornfels, although the latter also records the longest artefacts of the assemblage. In the quartzite collection, blanks are > 40 mm, and the bulk of the flakes is 30–40 mm in limestone (Fig. 5). The comparison of the median values of the length of unbroken flakes in chert shows that the cortical elements are larger than the non-cortical blanks (Fig. 6), and no significant differences are found in the chert flakes of sub-unit IIIb (cortical flakes: Mann–Whitney test, $p = 0.3642$; non-cortical flakes: Mann–Whitney, $p = 0.1772$). The flake length shows a significant correlation with weight value in chert ($n = 34$, $r = 0.8821$, $p \leq 0.0001$) and hornfels ($n = 5$, $r = 1$, $p = 0.0167$) but not in quartzite ($n = 6$, $r = 0.2206$, $p = 0.6583$) and limestone ($n = 8$, $r = 0.6826$, $p = 0.6584$). The linear regression model reveals that, by similar length values, the limestone and hornfels artefacts are weightier than the chert and quartzite artefacts (Fig. 7), although the difference between the slopes is not significant ($F = 2.59402$, $DFn = 3$, $Dfd = 45$, $p = 0.06417$). The Levallois flakes in chert have similar sizes with the Levallois blanks of sub-unit IIIb, and the only example for hornfels has larger values (Fig. 8).

The assemblage of retouched tools is composed mostly of scrapers, pointed artefacts, and denticulates in chert, whereas isolated objects are recorded in other raw materials (Table 6, Fig. 11 n.6, 12, 13, 15). The preferred blanks for the re-sharpening of the cutting edges are cortical (38%) and *débordant* (23.8%) elements. In the chert assemblage, the stone tools (mean = 37.89 ± 11.05 mm) have larger mean length values than the *débitage* flakes (mean = 22.05 ± 10.15 mm). The comparison of the length versus the weight values shows that most of the retouched tools of the sub-unit IIIa reenters in the size variability of chert scrapers and chert points and that the quartzite Mousterian point and the lydian stone convergent tool have larger values (Fig. 9). The calculation of the GIUR of scrapers in chert (GIUR index: 0.47 ± 0.33) indicates lower values in comparison with the retouched tools of sub-unit IIIb. In the collection of pointed artefacts, only one Levallois flake in sandstone is transformed into a Mousterian point, and no clear pattern is observed in the selection of blanks in the remaining pointed tools. Denticulates are documented only in chert, and most of them are characterized by two concavities and inverse retouching (Table 6).

4. Discussion

The analysis of the lithic collection of sub-units IIIb and IIIa at Teixoneres Cave reveals new insight into the composition of artefacts transported by Neanderthals during their foraging activities in the surrounding areas of the Moianès plateau. The study reveals the use of lithic sources scattered at a semi-local distance from the site (5–15 km) with a clear preference for chert nodules (Table 1–6). The comparison of the raw material units and the reconstruction of the technical behaviors point out that these transported artefacts are isolated pieces, or by-products of operative chains carried out elsewhere in the landscape. The technological reconstruction indicates that the bulk of the toolkits is composed of flakes produced during the different stages of the knapping process, and the typically transported by-products (e.g., Levallois flakes, pseudo-Levallois points) are underrepresented in comparison with ordinary flakes or blanks in the management of core convexities (Tables 2 and 5). As the occupational horizons of sub-unit IIIb and IIIa are interpreted as palimpsests of the recurrent short-term occupations (Rosell, et al., 2017; Sánchez-Hernández, et al., 2014; Talamo, et al., 2016), the diversity of technological categories found in the lithic series points out that Neanderthals were highly flexible in the selection of blanks to be transported on the way to Teixoneres Cave. This behavioral plasticity is also supported by the near-absence of flake refittings, suggesting that, beyond a few examples, majority of the chert artefacts were not knapped at the site but voluntarily carried to satisfy the possible need for cutting edges all the way through the forays. During the displacements to the cave, Levallois and hierarchized cores were rarely transported, and small artefacts, reduced using simple methods (e.g., unidirectional, bidirectional, centripetal), were preferred (Tables 1 and 3). Although Levallois flakes are present in both assemblages (Tables 2 and 4), the discovery of several expedient cores points out that, at times, ordinary flakes produced from small chunks or pebbles were sufficient in fulfilling the butchering or other domestic tasks. Therefore, Neanderthals moving around the Moianès plateau appeared to be occasionally interested in flakes with particular technical features (e.g., Levallois flake, pseudo-Levallois point) and relied

Table 3
Total number and percentage of the retouched tools assemblage of sub-unit IIIb of Teixoneres Cave.

	Chert	%	Quartzite	%	Limestone	%	Hornfels	%	Lydian stone	%	Jasper	%	Sandstone	%	Total	%
Scraper	37	42.5	1	10							1	100			39	37.5
Double scraper	1	1.1													1	1
Point	8	9.2	2	20											10	9.6
Mousterian point	14	16.1	1	10											15	14.4
Convergent tool	2	2.3													2	1.9
1Ns	4	4.6			1	100									5	4.8
1Nc			1	10											1	1
2 N			1	10			1	100							2	1.9
1N1n	6	6.9	1	10											7	6.7
1 N-1n	1	1.1													1	1
1N2n	2	2.3							1	50					3	2.9
1 N-2n													1	50	1	1
Nc	7	8	3	30									1	50	11	10.6
Fragment	5	5.7							1	50					6	5.8
Total	87	100	10	100	1	100	1	100	2	100	1	100	2	100	104	100

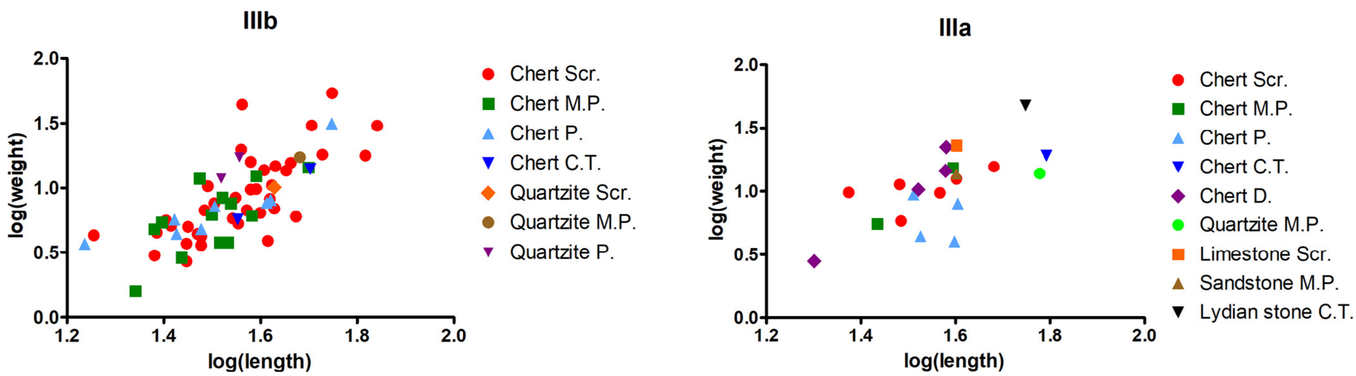

Fig. 9. Log transformation plot of weight and length of scrapers (Scr.), Mousterian points (M.P.), points (P.), and convergent tools (C.T.) in different raw material of sub-unit IIIb and IIIa of Teixoneres Cave.

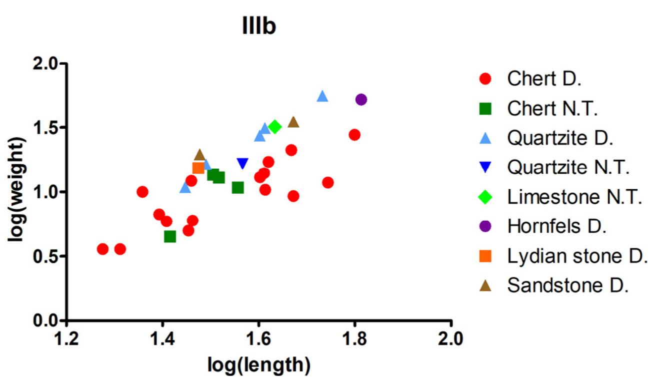

Fig. 10. Log transformation plot of weight and length of denticulates (D.) and notched tools (N.T.) of sub-unit IIIb of Teixoneres Cave.

on blanks with different morphologies. This behavior can be correlated with the relative short distance from the place of foray to the site. For longer displacements, Neanderthals could have applied different strategies and included in the toolkits larger flakes and stone tools (Delagnes and Rendu, 2011; Picin and Carbonell, 2016; Turq, et al., 2017; Turq, et al., 2013; Vaquero, 2011).

Another common characteristic of both core assemblages is the production of small blanks, generally shorter than 30 mm (Fig. 5). Although the dimension of the chert nodules found in the primary and secondary deposits are generally small (Mangado, et al., 2006), the application of centripetal methods, the recycling of short fragments, or the prolongation of knapping activities on broken items shows a sharp tendency to produce short blanks. In other Middle Paleolithic contexts, the reduced sizes of the chert pebbles were contrasted with the use of uni- and bidirectional core reduction strategies to maximize the exploitation of the flaking surfaces (Grimaldi, 1998; Kuhn, 1995; Picin, 2016). Therefore, the maintenance of technical behaviors related to the production of small flakes with limited possibilities of being resharpened implies the relative abundance in the territory of other rocks suitable for knapping that could be used in case of shortage of cutting edges. The isolated artifacts in lydian stone, porphyry, sandstone, gabbro, or slate would reenter in this dynamics, opportunistically enlarging the spectrum of raw materials when the particular need arises. A similar condition can be suggested for the blanks in quartzite, limestone, and hornfels, although their amount in the assemblages is larger (Tables 1–8). In fact, even if the cobbles of these raw materials can be found in the nearby Mal stream, the high fragmentations of the operative chains and the absence of refitting suggest that they were knapped elsewhere in the landscape and not *in situ*. Conversely, the complete reduction sequences were accomplished only with quartz pebbles, which are abundant in the Mal stream, and were transported at the site in their natural form and not configured (Picin et al., 2020).

The analysis of the lithic assemblages of sub-units IIIb and IIIa indicates the use of mixed strategies. The transport of small flakes and cores in chert, which is characterized by a high rate of portability, was complemented by larger artefacts in quartzite, limestone, and hornfels, thus assuring a higher degree of durability (Figs. 6–7). However, these latter flakes were occasionally resharpened, and only chert blanks show a recurrent modification of the cutting edges (Tables 3–6). Generally, cortical elements are mostly used for scrapers and denticulates, but only a few of them show an extensive transformation of the original volume, such as bulb thinning or high rates of retouch reduction. This suggests that the artefacts had a short lifetime use and were not transported for long time in the landscape. The presence of several pointed artefacts (Tables 3 and 6), which are a type of stone tool that is uncommon in Southwestern Europe, should be noted in retouched tools. Beyond the few examples in Cantabria (Lazuén, 2012) and at Abrigo de la Quebrada in the Iberian Levant (Eixea et al., 2015), the Mousterian toolkit in the Iberian Peninsula is generally dominated by denticulates, scrapers, and flakes (Picin, et al., 2011; Rios-Garaizar, 2017; Torre, et al., 2013). This evidence raises the possibility that the Neanderthals in these regions hafted pointed flakes or relied on wooden spears for their hunting activities (Picin, 2012). A broad comparison with the other stone tools of sub-units IIIb and IIIa reveals that, in terms of length and weight, the Mousterian points and convergent tools are clustered in the lower range of the variability of cutting tools (Fig. 9). This result emphasizes that a certain selection was made for blanks assigned for the production of points. Further studies on use–wear analysis can determine whether some of these pointed artefacts had been hafted in wooden implements

Table 4
Total number and percentage of the core assemblage of sub-unit IIIa of Teixoneres Cave.

	Chert	%	Hornfels	%	Limestone	%	Porphyry	%	Total	%
Lev. preferential			1	100					1	12.5
Lev. rec. centr.	1	20							1	12.5
Centripetal	1	20							1	12.5
Core-on-flake	1	20			1	100	1	100	3	37.5
Core fragments	2	40							2	25
Total	5	100	1	100	1	100	1	100	8	100

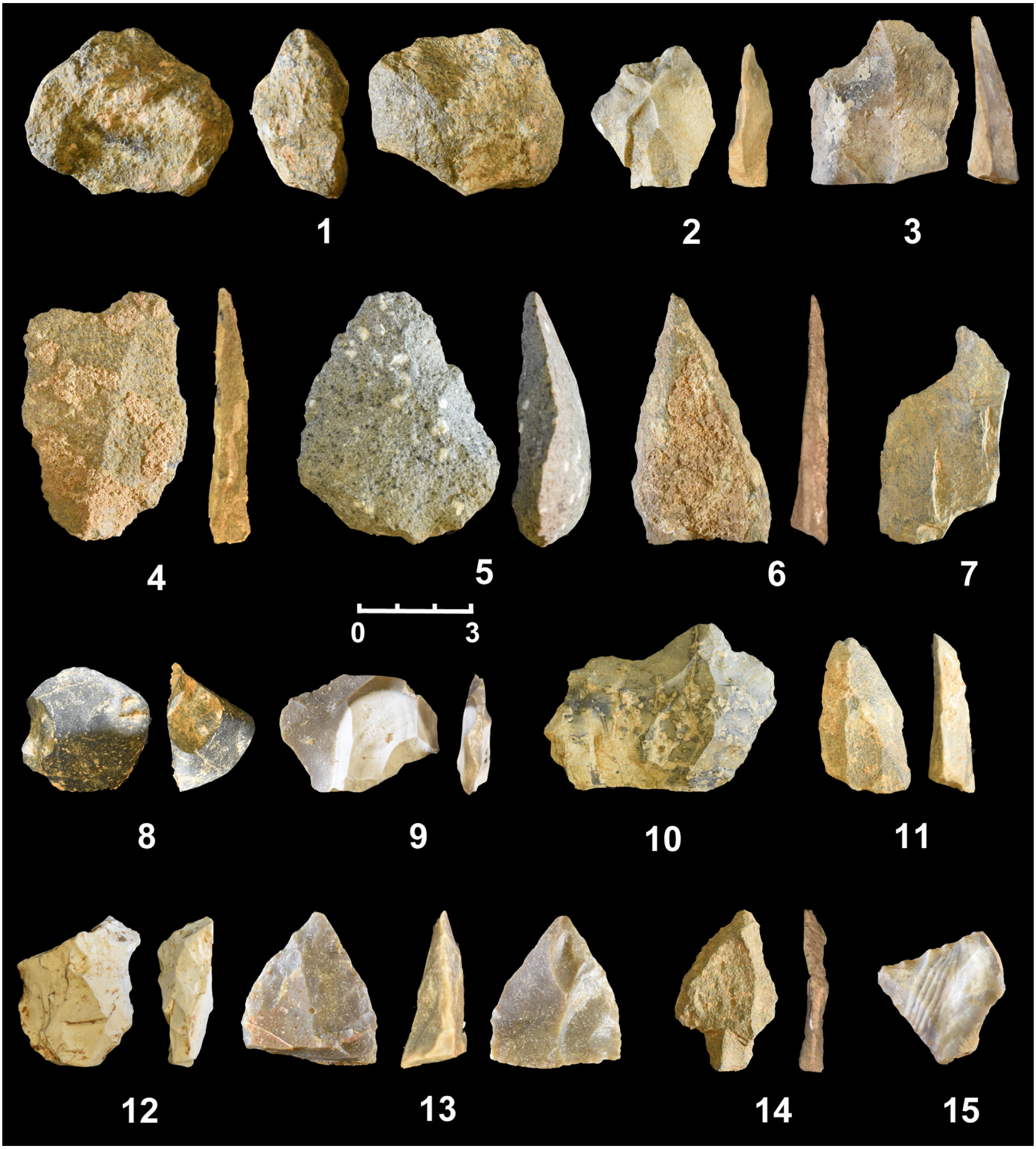

Fig. 11. Lithic material from sub-unit IIIa of Teixoneres Cave. 1) Levallois preferential core in hornfels; 2–3) Levallois flakes in chert; 4) Levallois flake in hornfels; 5) core-on-flake in porphyry; 6) Mousterian point in hornfels; 7) core–edge removal flake in hornfels; 8) cortical flake in lydian stone; 9) flake in chert; 10) flake in limestone; 11) convergent unidirectional flake in quartzite; 12) double scraper in chert; 13) Mousterian point in chert; 14) point in hornfels; 15) convergent tool in chert.

or if the tip fractures could be related to the impact scars from hunting activities.

The transport capacities of hunter–gatherers are limited, and their mobile toolkit reflects a combination of portability, durability, and efficiency (Binford, 1979; Kuhn, 1994; Shott, 1996). In the ethnographic context, the carrying constraints are generally solved by transporting lightweight and multifunctional tools to be used in a wide range of tasks (Binford, 1979; Shott, 1986). This strategy has been documented in groups of different environments during residential displacements, whereas in logistical forays, the search for specific resources promotes the transport for more specialized tools (Binford, 1980; Kelly, 1995). In the latter case, the portability and durability of the toolkit can decrease in favor of enhancing efficiency for the planned task, as the activity is provisory and performed in the neighborhood of the base camp

Table 5
Total number and percentage of the flake assemblage of sub-unit IIIa of Teixoneres Cave.

IIIa	Chert	%	Quartzite	%	Limestone	%	Hornfels	%	Lydian stone	%	Gabbro	%	Porphyry	%	Sandstone	%	Slate	%	Total	%
Cortical flake (> 50%)	1	1.3			1	5.6			1	25	1	33.3							4	3.3
Cortical flake (< 50%)	9	12	1	7.7															10	8.2
Natur. core–edge flake	2	2.7																	2	1.6
Trim. strik. platf.	2	2.7			2	11.1													4	3.3
Ordinary flake	8	10.7	4	30.8	1	5.6	1	20											14	11.5
Predeter. Lev. flake	1	1.3																	1	0.8
Lev. rec. unidire.							1	20											1	0.8
Lev. rec. bidire.	2	2.7																	2	1.6
Lev. rec. centr.	1	1.3																	1	0.8
Core-edge rem. flake	3	4			2	11.1	2	40					1	50					8	6.6
Unidirectional flake	1	1.3			1	5.6													2	1.6
Centripetal flake	3	4													1	100			4	3.3
Re-shaping flak. surf.	1	1.3	1	7.7	1	5.6													3	2.5
Knapping accident	2	2.7	1	7.7	1	5.6					1	33.3							5	4.1
Frag. with cortex	5	6.7	2	15.4	4	22.2			3	75									14	11.5
Frag. without cortex	32	42.7	4	30.8	5	27.8	1	20			1	33.3	1	50			1	100	45	36.9
Debris	2	2.7																	2	1.6
Total	75	100	13	100	18	100	5	100	4	100	3	100	2	100	1	100	1	100	122	100

(Binford, 1978, 1980; Kelly, 1995; Oswalt, 1976). In a computational model, Kuhn (1994) demonstrated that small flakes have higher values of utility/mass ratio, and, in terms of portability, a toolkit composed of several retouched tools and small flakes is more efficient than carrying a core of equivalent mass. Therefore, the analysis of the transported artefacts of sub-units IIIb and IIIa of Teixoneres Cave is similar to the evidence recorded in ethnography and in Kuhn's (1994) model. Studies on the seasonality of ungulates teeth indicate recurrent short-term occupations during summer and winter in sub-unit IIIb and a succession of seasonal short-term occupations all year round in sub-unit IIIa (Sánchez-Hernández, et al., 2014). During these cyclical movements, Neanderthals moved to Teixoneres Cave carrying lightweight toolkits with a few flakes and stone tools. This behavior implies that Neanderthals not only had good knowledge of the seasonal availability of animal resources in the area (Rosell, et al., 2017; Rufà, et al., 2014) but also of the abundance of quartz pebbles in the nearby Mal stream. Although quartz has lower knapping properties than chert or metamorphic rocks, the repeated exploitation of this raw material at the site during short stays highlights the broad behavioral plasticity of Neanderthals in land use and management.

4.1. Mobile toolkit in the carnivore and residential contexts

Archaeological data on the Eurasian Middle Paleolithic records indicate that Neanderthals were highly mobile, moving their residential base on the landscape frequently and settling in different locations (e.g., riverbanks, lakeshores, foothills, mountainous ranges) based on the distribution of resources. During these displacements in the territory, Neanderthals accomplished different tasks (e.g., hunting, bivouac, resting, gear retooling), and the composition of the transported artefacts varied in relation to the activity to be performed, the foraging radius, the availability of raw material sources, and the duration of the settlement (Delagnes and Rendu, 2011; Roebroeks, 1988; Turq, et al., 2017; Turq, et al., 2013). At Teixoneres Cave, Neanderthals arrived at the site after hunting, carrying the appendicular portions of the ungulates richest in meat and marrow and a lightweight toolkit comprising heterogeneous artefacts (Rosell, et al., 2010; Rosell, et al., 2017; Talamo, et al., 2016). Once at the site, the domestic activities were performed around hearths, and local quartz pebbles were knapped *in situ* to provide fresh cutting edges to slice the meat and extract the marrow (Picin et al., 2020; Rosell et al., 2017; Talamo et al., 2016; Rosell et al., 2010). The mobile toolkit transported at the site is a combination of hunting tools (e.g., Mousterian points, convergent tools) and cutting artefacts (e.g., flakes, scrapers) used during the primary butchery of the chased preys. This variety of lithic artefacts is common in kill sites such as Nahal Mahanayeem Outlet (Israel), where hunting and butchering tools were discarded after the processing of aurochs (*Bos primigenius*) (Sharon, 2018; Sharon and Oron, 2014), or in hunting camps such as Biache Saint-Vaast (France), where a broad spectrum of animals (e.g., aurochs, bears, rhino, elephant, red deer, and horse) was processed, curated tools (e.g., Mousterian points, scrapers) were imported, and high-quality chert pebbles were exploited (Auguste, 1995; Hérisson, 2012).

In the northeast of the Iberian Peninsula, economic behaviors similar to those recorded at Teixoneres are found in the eastern fringe of the Pyrenees, specifically at the Arbreda Cave (Serinyà, Spain), which is a natural shelter that was used as a hibernation and breeding site by cave bears during winter and occasionally visited by other large carnivores (e.g., hyenas, wolves, leopards) after the human settlements (Lloveras, et al., 2018, 2010; Maroto, et al., 2001). In the late Middle Paleolithic sequence, Neanderthals exploited mostly the local quartz and, in lesser frequency, the metamorphic rocks abundant in the fluvial terraces of Fluvià and Ser Rivers (Duran and Soler, 2006). Although the bulk of the lithic assemblages was gathered at a radius of less than or equal to 5 km, the mobile toolkit was composed of Levallois artefacts, core–edge removal flakes, and cortical elements produced from the flint

Table 6
Total number and percentage of the retouched tools assemblage of sub-unit IIIa of Teixoneres Cave.

	Chert	%	Quartzite	%	Limestone	%	Lydian stone	%	Sandstone	%	Total	%
Scraper	5	27.8			1	100					6	27.3
Double scraper	1	5.6									1	4.5
Point	4	22.2									4	18.2
Mousterian point	2	11.1	1	100					1	100	4	18.2
Convergent tool	1	5.6					1	100			2	9.1
1N1n	2	11.1									2	9.1
1N-2n	1	5.6									1	4.5
Nc	1	5.6									1	4.5
Fragment	1	5.6									1	4.5
Total	18	100	1	100	1	100	1	100	1	100	22	100

formations of Roquefort-des-Corbières (approximately 25 km from the site), d'Attrape Counils (approximately 80 km), and Bages-Sigean (approximately 100 km) in southeastern France (Duran and Soler, 2006). The stone tool collection comprises mostly of scrapers and denticulates. Although convergent tools are absent, Levallois points and flakes with triangular morphologies are common (Duran and Soler, 2006).

In other sites northeast of the Iberian Peninsula, where the Neanderthals' seasonal occupations were spaced out by the visiting of carnivores, the composition of the mobile toolkit varies, but pointed artefacts are generally missing. In the Alta Garrotxa, the Ermitons and 120 Cave were used as hibernation and breeding sites by bears during winter and occasionally settled by Neanderthals as bivouacs (Agustí, et al., 1991; Maroto, et al., 1996). The lithic collections of both caves are small and mostly composed of scrapers and denticulates on chert, originating from the carbonated formations of the Lower Eocene, and on metamorphic rocks, gathered in the nearby Llierca River and its tributaries (Agustí, et al., 1991; Maroto, et al., 1996; Ortega and Maroto, 2001).

In southwestern Pyrenees at Llenes Cave (Erinyá, Spain), carnivore activities by cave bears and hyenas are documented in the deepest areas of the natural shelter, whereas Neanderthals bivouacked mostly near the entrance (Arilla, et al., 2013). The small lithic collection is made of quartzite, chert, hornfels, and quartz collected in the nearby fluvial terraces and Neogene conglomerates, and it mainly includes flakes, knapping by-products, and denticulates (Picin et al., 2020). Similarly, Gabasa Cave (Gabasa, Spain) was occupied by hyenas and bears during winter and settled by Neanderthals in other seasons for hunting red deer and horses (Blasco, 1997; Utrilla, et al., 2010). Although the location of the chert sources is still unknown, the use of ophite and quartzite cobbles, abundant at the bottom of the cave, is low. The lithic assemblages are characterized by configured cores, flakes from different stages of reduction, and scrapers mostly shaped on cortical *débordant* or core–edge removal flakes (Santamaría, et al., 2008).

In other carnivore dens, the Neanderthals' visits were short and opportunistic, leaving few traces of their stay. At Cova del Coll Verdaguer (Coll Verdaguer, Spain), the anthropogenic evidence is attested by a handful of pseudo-Levallois points and core–edge removal flakes. This finding suggests that Neanderthals only took shelter in the cave during their forays in the Garraf Massif (Daura, et al., 2017). Similarly, at Cova del Gegant (Sitges, Spain), Neanderthals built fires in a bone horizon previously deposited by hyenas without leaving any other trace of domestic activities (Sanz, et al., 2017).

In other late Middle Paleolithic Catalan sites, although they are characterized by residential contexts, the patterns of raw material economy and artefact mobility are generally different from those documented at Teixoneres Cave. At Abric Romaní (Capellades, Spain), a rock shelter located at 50 km southwest of the Moianès plateau, limestone, sandstone, and quartz pebbles at the primary and secondary positions are present at a radius of 5 km but are rarely used for knapping activities at some levels. Neanderthals preferred to gather chert pebbles from Tertiary deposits of the Ebro basin located at a different distance from the site [St. Genís formation (≥15–18 km) and Montemaneu formation (≥22–26 km)] (Chacón, et al., 2013; Gómez de Soler, 2016; Vaquero, et al., 2012). Generally, chert nodules were imported at the site as configured cores and reduced using expedient methods, discoid, and Levallois at levels O and E (Bargalló, et al., 2016; Chacón, 2009; Picin and Carbonell, 2016; Vaquero, et al., 2012, 2001). Although the provision of raw materials from these outcrops remained stable throughout the sequence, changes in the composition of the mobile toolkit were recorded at different events of occupations of the same horizon. In thick palimpsests (e.g., level E, J, L, M, and O), prepared chert cores were transported at the site at the beginning of the settlement, but as the volume of lithic artefacts increased after repeated occupations, cores and flakes from previous reduction sequences were reused for producing small blanks, cobble fragments were reutilized as hammerstones, and exhausted cores were recycled in retouched tools (Vaquero, 2011; Vaquero, et al., 2015, 2019). Thus, during the later phases of the occupations, the behavior of raw material provisioning changed, favoring the recycling of the discarded lithic items and the transport of lightweight mobile toolkit (e.g., pseudo-Levallois points, core–edge removal flakes) (Vaquero, 2008; Vaquero, et al., 2012, 2019). Diachronic changes in the transported artefacts are also verified in the far distant Panadella-Montemaneu zone (PAN) source, characterized by chert nodules of best quality and aptitude for knapping. At level O, cores in PAN chert were carried and knapped at the site, whereas at the younger levels M and J, this raw material entered the site as isolated artefacts produced during different reduction stages (Chacon, et al., 2015; Picin and Carbonell, 2016; Vaquero, et al., 2012). These differences in the transported artefacts (cores vs. flakes) between archaeological levels could have been the result of changes in the areas exploited for the foraging activities or in the duration of the settlements (Picin and Carbonell, 2016).

In the southwestern Pyrenees (Noguera, Spain) at Roca del Bous level N10, Neanderthals visited the natural shelter for repeated short-term occupations before moving to other locations (Martínez-Moreno, et al., 2004). Lithic studies found that the local quartzite, which was abundant in the proximity of the site, was used in lesser frequency than chert gathered about 15 km far away (Mora, et al., 2004). During the displacement to the cave, the configured cores in chert were transported to the site and then reduced until exhaustion using the Levallois method (Mora, et al., 2004). The intensive exploitation of the raw material and the production of small flakes are also recorded in quartzite cores even if metamorphic rocks are plenty in the nearby terrace of the Segre River. Similarly to the Abric Romaní, the lithic materials left at the site from previous occupations were recycled afterwards, and cores and flakes were reused for the production of small blanks or retouched tools (Mora, et al., 2004).

5. Conclusion

This study on the lithic assemblages of sub-units IIIb and IIIa of Teixoneres Cave reveals that, during their displacements to the Toll karstic system, Neanderthals transported a wide range of flakes, tools, and cores (Tables 1–6). The excavation in the extension of the archaeological units and the near absence of refitting corroborate the hypothesis that these artefacts were carried to the natural shelter and not produced at the site. This unique circumstance enabled the exploration of the variability of the Neanderthals' toolkit in the high-mobility context in a semi-local environment. Surprisingly, the bulk of the toolkit is composed of knapping by-products and blanks, which are usually interpreted as waste of the lithic production with little utility value; the number of curated artefacts and Levallois flakes is significantly low (Tables 1–6). These data point out that Neanderthals preferred chert nodules for their lithic production, and other raw materials were knapped only during events of shortage to cope with the need for fresh cutting edges. The transport of isolated items in metamorphic, sedimentary, and igneous rocks suggests that, in these situations of demand, the gathering of cobbles was unselective and probably related to their abundance in the vicinity of the location where the activity was carried out.

A broad comparison of ethnographic observations indicates that the toolkit is composed of a combination of hunting and cutting tools, suggesting that the main strategy of transport was aimed at a more generalized set of tools instead of a few specialized items. In comparison with that in other Middle Paleolithic sites in the region, the evidence at Teixoneres Cave is in agreement with other short-term settlements in the carnivore context. Although human occupations are spaced out by those of hyenas and cave bears, the import of flakes and the exploitation of local sources is a recurrent pattern. Conversely, in the residential context, the strategies of raw material management aim to transport chert nodules and configured cores to knap *on-site*.

The findings on the toolkit composition at Teixoneres Cave report the use and the carrying of artefacts that are generally associated with reduction events performed at the natural shelter in the local and semi-local foraging contexts. This result is pivotal for highlighting the Neanderthals' behavioral plasticity in preparing their toolkit in advance of anticipated use. Future works on the microscopic discrimination and association of the raw material types and units of the lithic assemblages with the outcrops can determine the main corridors of movements of Neanderthals to Teixoneres Cave and explain in more detail the composition of personal gear.

CRediT authorship contribution statement

Andrea Picin: Conceptualization, Formal analysis, Investigation, Methodology, Software, Writing - original draft. **M. Gema Chacón:** Formal analysis, Investigation. **Bruno Gómez de Soler:** Formal analysis, Investigation. **Ruth Blasco:** Data curation, Investigation, Funding acquisition, Project administration. **Florent Rivals:** Data curation, Investigation, Funding acquisition, Project administration. **Jordi Rosell:** Data curation, Investigation, Funding acquisition, Project administration.

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