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An instance of Neanderthal mobility dynamics: a lithological approach to the flint assemblage from stratigraphic unit VIII of El Salt rockshelter (Alcoi, eastern Iberia)

Alejandro Mayor[a,*], Santiago Sossa-Ríos[b], F. Javier Molina[c], Leopoldo Pérez[b,d], Bertila Galván[e], Carolina Mallol[e,f], Cristo M. Hernández[e,f]

[a] Àrea de Prehistòria, Departament de Prehistòria, Arqueologia, Història Antiga, Filologia Llatina i Filologia Grega, Facultat de Filosofia i Lletres, Universitat d'Alacant, Sant Vicent del Raspeig, Spain

[b] Àrea de Prehistòria, Departament de Prehistòria, Arqueologia i Història Antiga, Facultat de Geografia i Història, Universitat de València, València, Spain

[c] Freelance Researcher

[d] Institut Català de Paleoecologia Humana i Evolució Social, Tarragona, Spain

[e] Área de Prehistoria, Unidad de Docencia e Investigación de Prehistoria, Arqueología e Historia Antigua, Departamento de Geografía e Historia, Facultad de Humanidades, Universidad de La Laguna, San Cristóbal de La Laguna, Spain

[f] Archaeological Micromorphology and Biomarkers Laboratory, Instituto Universitario de Bio-Orgánica Antonio González, Universidad de La Laguna, San Cristóbal de La Laguna, Spain

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ABSTRACT

The relationship between hunter-gatherer group mobility and lithic raw material procurement strategies is central to the study of Neanderthal productive behaviours. In this framework, determination of flint procurement sources through lithological analysis is key to infer Neanderthal group mobility patterns. El Salt rockshelter (Alcoi, Alacant, eastern Iberia) features different nearby flint sources, including primary outcrops and secondary deposits containing flint. In this study, we sourced the stratigraphic unit VIII archaeological flint assemblage based on identification of geogenic and postgenetic lithological traits. Our results indicate that flint procurement at El Salt during the stratigraphic unit VIII Neanderthal occupations was mainly linked to Pleistocene secondary deposits along the upper and middle courses of Serpis river. The artefacts were made predominantly on alluvially reworked nodules of different flint types. Connecting these procurement areas with their corresponding knapping products reveals a direct relationship between flint-source distance and degree of technical intervention, and defines a hypothetically unidirectional series of rivershore itineraries of procurement.

1. Introduction

Population mobility is a central issue in behavioural and economic studies on ancient hunter-gatherers. One of the most analysed data inferences for mobility is the lithic raw material availability in the territory and suitability for knapping or use (cf. Bleed, 1986; Morrow, 1996a, 1996b; Kuhn, 1991, 1994; Shott, 1986). The link between raw material knapping-related quality, and operational sequences and technical procedures is translated into distinguishable procurement and management strategies. This is a critical part of wider studies on mobility patterns and technological processes of Neanderthal groups (cf. Vaquero and Romagnoli, 2017; Wallace and Shea, 2006).

A very representative lithic raw material found within the Eurasian Neanderthal archaeological contexts is flint. The almost quincuagenarian development of geochemical techniques and methods has favoured generating more accurate definitions and enclosements of characteristics and origins of this siliceous raw material primary outcrops (cf. Delvigne et al., 2019b; e.g. Beller et al., 2020; Hussein and Abd el-Rahman, 2019; Moreau et al., 2018; Sánchez et al., 2019), and thus helped to improve our comprehension of flint sources.

This kind of analysis is the most cutting-edge in terms of technical and methodological innovation. However, geochemistry does not usually permit identifying secondary deposits in which the flint might have been resedimented. These deposits can be located very far away from the formation areas (cf. Fernandes and Raynal, 2006). Therefore, recognising the provenance of archaeological flint needs other approaches

* Corresponding author.
E-mail address: alejandro.mayor@ua.es (A. Mayor).

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that make possible characterising the signs of postgenetic alterations occurring on it after the release. These shall be used as tracers in order to distinguish potential locations of resedimentation in which hunter-gatherer groups could have caught the raw material.

Surveying and geolocating primary outcrops and resedimentation deposits, macroscopic and petrographic characterisation, and comparison between archaeological record and lithological collection have proved to be important data sources to adduce the matters treated here (e.g. Blasco et al., 2018; Cánovas et al., 2018; Fano et al., 2016; Fernandes et al., 2006; Fernandes et al., 2019; Herrero et al., 2021; Molina and Belmonte, 2018; Molina et al., 2011, 2018, 2019; Tarriño, 2017; Tufféry et al., 2018). In some cases (e.g. Molina et al., 2016; Ramacciotti et al., 2019), geochemical inferences on provisioning dynamics were even previously defined by macroscopic analyses of the flint petrological traits.

Specifying within this framework into the El Salt rockshelter (Alcoi, Alacant, eastern Iberia) as a case study, the main differential geogenic and postgenetic features of the flints appearing in the Serpis valley were recognised and described through comparison between collected samples and archaeological finds (cf. Molina, 2015, 2016; Molina et al., 2010, 2014, 2015, 2016; Figs. S1–S31; vid. Supplementary materials). These petroarchaeological analyses established the foremost characteristics for the various flint types, always keeping in mind the distinct physical–chemical transformations that flint suffers all along its itinerant history (*sensv* Fernandes and Raynal, 2006). This is because it is precisely this evolutionary chain which enables recognising the secondary contexts where flint was resedimented after being released from the formation rock. Consequently, it allows identifying sourcing areas by observing natural postgenetic alterations. This point is significant since procurement of flint found in secondary deposits by Neanderthals seems to have been very frequent (e.g. Avni et al., 2021; Delvigne et al., 2019b; Fernandes et al., 2007; Mihailović et al., 2021; Minet et al., 2021; Molina, 2016; Rusch et al., 2019).

In this paper, we aim to analyse flint types, cortical and natural surfaces, neocortical formations and postgenetic macroscopic alterations in order to define procurement areas and thus broad flint-resourcing strategies for Neanderthal groups imbricated within the archaeological palimpsest of the El Salt stratigraphic unit (i.e. SU) VIII. Additionally, we intend to associate these petrological data with basic technical information (i.e. metric measurements, presence or absence of cortical surfaces, and types of products and raw material masses), since inferences on the relationship between raw material and mobility are subjected to matters such as, for instance, on-site or off-site flaking, raw material mass transportation, or configuration degree of input nodules (e.g. Picin and Carbonell, 2016; Romagnoli et al., 2016; Spinapolice, 2012): in short, the way in which raw material was managed within the territory. Ultimately, this information will be cross-checked with other proxies related to resourcing (i.e. non-siliceous lithological, archaeobotanical and archaeozoological data) resulting from other studies already done on El Salt (i.e. Pérez, 2019; Pérez et al., 2017; Vidal et al., 2018) in order to draw a picture of the mobility dynamics performed by these Neanderthal groups.

2. Overview of El Salt and surrounding silicifications

El Salt rockshelter (Fig. 1) is located inside the Villa Vicenta public estate. This is set within the locality of Cases del Salt, which is placed in the Riquer Alt rural part of the Alcoi municipality, headtown of the L'Alcoià county and belonging to the Valencian province of Alacant. It is situated at 680 m above sea level, within the southern foothills of Mariola mountain range and at the base of a 38m-high Palaeocene limestone wall, which is covered by a tuff formation related to a Pleistocene lacustrine environment and overlaps an Oligocene conglomeratic deposit due to a fault.

The current archaeological excavations, ongoing since 1986 and only interrupted in 1999 and 2020, have exposed a 6.3m-thick stratigraphic sequence comprising thirteen SUs, (cf. Galván et al., 2014a). SUs I to IV are Holocene deposits and SUs V to XII are Upper Pleistocene containing Neanderthal record. SU XIII is an alternating succession of Upper Pleistocene tuffaceous crusts and sandy layers located at the bottom of the sequence. It has been surveyed over 1m^2 to ca. 1.5m deep, but has not provided any archaeological record. Chronometric dating frames the sequence between 60.7±8.9ky BP for XII and 45.2±3.4ky BP for V (cf. Galván et al., 2014b).

The El Salt nearby environment is assembled around the Serpis[1] river headwaters, which also comprise the Polop, Barxell[2], Molinar, Penàguila[3], Agres, Uxola and Benissaidó[4] riverbeds, as well as many brooks, ravines and other subsidiary watercourses deriving into Serpis river from Mariola, El Menejador, La Serreta, La Filosa, L'Albureca, Benicadell, Onil[5], La Serrella and Almudaina mountain ranges (Fig. 2). As above-mentioned (vid. 1), geological surveys and petrological studies carried through within the Alcoian valleys have provided a clear view of how siliceous resources distribute out of El Salt surrounding landscape (cf. Molina, 2015; vid. Supplementary materials for further information; Fig. S32).

In this sense, it is possible to find flint within numerous Oligocene and Miocene conglomerates associated with marine activity that eroded Upper Cretaceous and Eocene silicifications. These conglomerates were likewise partially disintegrated by Pleistocene alluvial and colluvial processes as a consequence of fluvial erosion, gelifraction or weathering. Pleistocene erosion was also responsible for partially dismantling Palaeocene, Miocene and Pliocene lime and marl formations comprising primary silicifications. This is why Oligocene and Miocene conglomerates and Pleistocene deposits are the main sources of flint in secondary position. Upper Cretaceous, Palaeocene, Eocene, Miocene and Pliocene primary and subprimary outcrops can also be found within Mariola, El Menejador, Almudaina and La Serreta mountain ranges (Table 1). Lastly, Holocene erosions and anthropogenic alterations have modified and sometimes dismantled a number of deposits containing secondary-positioned flint. Even if these processes do not have implications for Neanderthal lithic procurement strategies, they do affect the record integrity and oftentimes stand in the way of recognising or correlating distinct deposits.

2.1. Overview of stratigraphic unit VIII

This SU was originally described and defined by sedimentological sequencing on archaeological profiles (cf. Fumanal, 1994; for biostratigraphic analysis, cf. Guillem, 1995). It was extensively excavated during seven field seasons (i.e. 1996–2003, except for 1999) over a ca. 36m^2 area. Some materials were recovered in a test pit performed in 2008. Micromorphological analyses applied on profiles verified its consistency as an independent SU within the sequence. In addition, it is chronometrically framed (cf. Galván et al., 2014b) between the thermoluminescence (TL) dating of 49.2±4.8ky BP for the bottom of SU VII, and that of 52.3±4.6ky BP for SU Xb.

Eight sedimentary facies were recognised within the inner area (i.e. close to the travertine wall base) during the excavation process, and were named alphabetically from VIIIa to VIIIh. However, the outer area of the excavation surface was characterised by a homogeneous sedimentary matrix of brown silt, sandier at some points and sometimes nearing orange hues, so identifying sedimentary facies was not possible.

This 30cm average-thick SU VIII allowed gathering up ca. seven

[1] Also known as Alcoi.
[2] Also known as Riquer.
[3] Also known as Frainós.
[4] The Benissaidó river has often been wrongly called Cint. This frequent mistake is due to the name of the ravine through which it runs, named as El Cint (also but only colloquially known as El Cinc, El Sinc or El Zinc).
[5] Also known as Biar or as El Reconco.

Fig. 1. (**a**) Geographic location of El Salt; (**b**) picture taken from El Castellar height displaying the immediate surroundings of El Salt, whose position is signed with the red arrow; (**c**) archaeological profile displaying the whole Pleistocene stratigraphic sequence, in which unit VIII has been approximately highlighted with a red rectangle; (**d**) general picture of the site, in which the lower excavation area has been marked using a red rectangle.

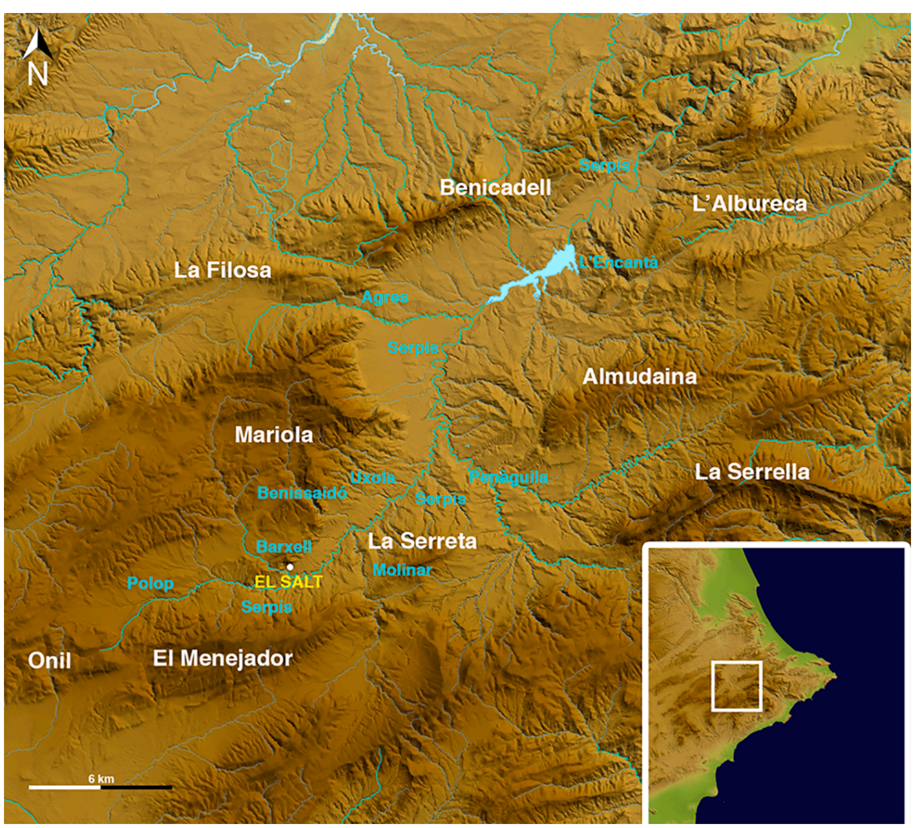

Fig. 2. Map displaying the main toponyms written in the paper. Mountain-range names are black, and river and ravine (i.e. L'Encantà) names are blue.

Table 1
Contextual geological data of formation and resedimentation processes of flint types appearing in this paper (cf. Molina, 2015).

FLINT TYPE NAME	FORMATION		RESEDIMENTATION			
			Palaeogene-Neogene		Quaternary	
	Series – stage	*Environment*	*Series – stage*	*Erosive process*	*Series – stage*	*Erosive process*
Mariola	Upper Cretaceous – Maastrichtian	High-bottom platform	Oligocene – Rupelian-Chattian	Marine detrital	Pleistocene – Gelasian-Upper Pleistocene	Alluvial and/or colluvial
Font Roja	Palaeocene – Selandian-Thanetian	Parareefal restrict platform	–	–	Pleistocene – Gelasian-Upper Pleistocene	Alluvial and/or colluvial
Beniaia	Eocene – Ypresian	Reefal	Miocene – Serravallian	Marine detrital	Pleistocene – Gelasian-Upper Pleistocene	Alluvial and/or colluvial
Serreta	Eocene – Ypresian	Parareefal restrict platform	Oligocene-Miocene – Rupelian-Aquitanian	Marine detrital	Pleistocene – Gelasian-Upper Pleistocene	Alluvial and/or colluvial
Polop	Miocene – Serravallian-Tortonian	Internal platform	–	–	Pleistocene – Gelasian-Upper Pleistocene	Alluvial and/or colluvial
Catamarruc	Miocene-Pliocene – Tortonian-Piacenzian	Continental lacustrine	–	–	Pleistocene – Gelasian-Upper Pleistocene	Alluvial and/or colluvial

hundred faunal remains, eight combustion structures and more than a thousand lithic products (Table 2). Together with the magnetic susceptibility and soil organic carbon low rates (cf. Galván et al., 2014b), this relatively exiguous material assemblage points to the fact that SU VIII is more related, in terms of human impact, to the V-VII sequence segment rather than to the IX-XII section, which comprises a considerably higher degree of ancient anthropogenic input.

SU VIII has been published as a part of the above-mentioned sedimentological and biostratigraphic studies (i.e. Fumanal, 1994; Guillem, 1995), just as an implicit part of general data syntheses associated to interpretation of territorial management and prehistorical insights (i.e. Galván et al., 2001b, 2006a, 2006b). Furthermore, some summarised SU VIII data have appeared as within El Salt overview publications (i.e. Galván, 2000; Galván et al., 2001a, 2014a) as indirectly within papers whose topic was unrelated to this SU, such as chronometric sequencing (i.e. Galván et al., 2014b). Faunal and botanical assemblages from this SU have also been published from palaeoecological and palaeoeconomic perspectives (cf. Pérez et al., 2017; Vidal et al., 2018). Nevertheless, this is the first paper exclusively focusing on some aspect of SU VIII.

3. Materials and methods

SU VIII comprises more than a thousand lithic specimens, from which 931 are georeferenced flint elements. The remaining flint record has no precise spatial information and has been ruled out, because they are mostly millimetric and thus potentially non-diagnostic for this approach.

From the whole studied assemblage, 217 (i.e. 23.31%) burnt flint specimens were discarded from the recognition of alterations due to the fact that heat-marks might hide or modify postgenetic features. Moreover, 81 (i.e. 8.70%) from these heated elements resulted undiagnosed also during the flint-type identification due to a high degree of thermal alteration concealing the geogenic traits (cf. Dorta et al., 2010). This is why 850 (i.e. 91.30%) elements have been included within the flint-type results (Table 3) and 714 (i.e. 76.69%) have been analysed in order to recognise alterations that happened on flint (Tables 4–6). Furthermore, 39 (i.e. 4.59% out of 850) elements have been ruled out from the metric procedure (Figs. 4 and 5), since they were significantly fractured or fragmented.

Table 2
The flint assemblage of the stratigraphic unit VIII by support types. Those considered fragments have not been recognised either as flakes or as cores. In the text, it is indicated that more than a thousand flint remains were recovered. The data incongruity between the text and this table is due to the fact that the non-georeferenced millimetric remains have not been counted.

FLINT ASSEMBLAGE OF STRATIGRAPHIC UNIT VIII	
Flakes	767
Cores	127
Fragments	37
TOTAL	**931**

Table 3
Numbers and proportions of identified flint types.

FLINT TYPE	NUMBER OF SPECIMENS	PROPORTION (%)
Mariola	193	20.73
Font Roja	3	0.32
Beniaia	381	40.93
Serreta	266	28.57
Polop	5	0.54
Catamarruc	2	0.21
Undiagnosed	81	8.70
TOTAL	**931**	**100**

The aforesaid assemblage has been subjected to the following lithological analysis. It is fundamented on macroscopic observation of flint physical traits (cf. Machado et al., 2013, 2017; Molina et al., 2010), such as grain size (i.e. fine, medium and coarse), texture (i.e. soft and rough), cortex thickness, hue and shape, colour spectrum, presence or absence of recrystallisations, subcortical and endocortical halos, frequency of internal fractures, inclusions (e.g. fossils, carbonates, quartzites), and quantification of some of these characteristics (vid. Supplementary materials). To do so, we have observed the lithic assemblage as *de visv* as well as using a Novex® AR-Zoom 64.210 and a Leica Microsystems® MS5 stereomicroscopes in the cases for which macroscopic observation fell short. Direct comparison with geological samples was also performed. By these means, main geogenic features of flint (i.e. genetic polarity) can be recognised, as defined in previous petrological studies carried out within the territorial frame (cf. Molina, 2015).

The same macroscopic procedure has served for identifying and defining physicochemical postgenetic processes occurring on flint (i.e. secondary polarity). In this sense, recognisable alterations which we have worked with are:

- *Neocortex and patina formation*: neocortex is the result of a desilicification process that happened on flint (cf. Van Nest, 1985). Patinas are distinguished here from neocortex since they represent the initial stage of a neocortical formation. We only have considered those patinas produced before technical intervention.
- *Character of cortex and neocortex*: country-rock cortex and neocortical formations may be partially removed by erosive processes. In this sense, heterogeneous or homogeneous cortical and neocortical surfaces can inform about resedimentation happening after their formation has occurred (cf. Molina, 2015). In this sense, heterogeneity stands here for coexistence of cortical and neocortical surfaces,

Table 4
Numbers and proportions of flint elements conserving cortical surfaces, and approximate percentages of cortex present on them. Elements presenting a high degree of thermal alteration have been discarded from this table.

FLINT TYPE	NUMBER OF SPECIMENS/CORTICAL SPECIMENS	PROPORTION OF CORTICAL SPECIMENS (%)	NUMBER OF SPECIMENS BY APPROXIMATE PERCENTAGE OF CORTICAL SURFACE				
			>0–25	>25–50	>50–75	>75–<100	100
Mariola	165/123	78.85	56	28	26	11	2
Font Roja	3/1	33.33	0	1	0	0	0
Beniaia	323/202	62.54	117	59	12	11	3
Serreta	216/156	72.22	98	33	18	7	0
Polop	5/0	0.00	0	0	0	0	0
Catamarruc	2/2	100	0	2	0	0	0
TOTAL	**714/484**	**67.79**	**271**	**123**	**56**	**29**	**5**

Table 5
Numbers of cortex types and signs of postgenetic processes on flint. Permeation and patina fields also comprise elements with no cortical surface. In the case of rolling and crashing stigmata, the rolling stigmata are posterior to the crashing ones in all cases.

FLINT TYPE	CORTEX TYPE					NUMBER OF SPECIMENS DISPLAYING SIGNS OF POSTGENETIC PROCESSES				
	Original cortex			Neocortex	Non-cortical natural surface	Patina	Rolling stigmata	Crashing stigmata	Rolling and crashing stigmata	Permeation
	Homogeneous	*Heterogeneous*	*Indeterminate*							
Mariola	10	8	2	101	2	77	18	40	60	27
Font Roja	1	0	0	0	0	0	0	0	1	0
Beniaia	12	12	5	168	5	99	65	63	60	34
Serreta	0	7	0	146	3	81	47	43	62	30
Polop	0	0	0	0	5	0	1	1	0	0
Catamarruc	2	0	0	0	0	2	1	0	0	0
TOTAL	**25**	**27**	**7**	**415**	**15**	**259**	**132**	**147**	**183**	**91**

Table 6
Number of flakes and cores. Cores are divided by the original nodule format.

FLINT TYPE	FLAKES	CORES BY ORIGINAL NODULE		
		Block	Cobble	Indeterminate
Mariola	141	4	20	0
Font Roja	3	0	0	0
Beniaia	266	5	44	8
Serreta	182	0	34	0
Polop	3	1	1	0
Catamarruc	2	0	0	0
TOTAL	**598**	**10**	**98**	**8**

whereas homogeneity corresponds to the presence of the original cortex surface alone.

- *Permeation*: absorption of mineral or organic substances into siliceous matter or into cortical and subcortical parts. These are related to the presence of flint within water environments during resedimentation (cf. Molina, 2016).
- *Rolling stigmata*: polishing, abrasion, round-shaping and rounded crash-marks. The roundedness allows us to distinguish between blocks and cobbles.
- *Crashing stigmata*: sharp fractures, natural hit-marks and partial loss of cortex and/or neocortex.

Mineral surface impregnations are also macroscopically visible alterations related to natural postgenetic processes, but their formation origins can be so varied and relatively fast that they result undiagnosed for the matters treated here. Flint surface carbonations, for example, can be often associated to some colluvial deposits recorded in the surrounding territory (cf. Molina, 2015), but they also might be related to postgenetic processes befalling flint within the El Salt deposit.

Additionally, width, length, thickness and weight of every flint element have been measured. In the case of cores, length and width have been replaced for a major axis and another one being transversal to the former. Also, a statistical approach has been used in order to establish the reliability of some assertions related to the relationship between distances and other factors: a chi-squared distribution (cf. Prokhorov, 1994) has been applied using the free software PAST, version 4.03 (Hammer et al., 2001).

In short, with this lithological characterisation of the SU VIII flint assemblage, we have obtained critical data for inferring Neanderthal broad mobility patterning in this territory.

4. Results

The results will be next exposed, chronologically ordered by geological series of formation.

4.1. Upper Cretaceous flint: Mariola type

The Mariola flint type is the third one in terms of numbers within the assemblage (n193: 20.73%; Figs. S1–S6; Table 3). From this raw material group, 141 flakes and 24 cores have allowed us to gather postgenetic information (Fig. 5). 123 out of 165 studied elements present cortical surfaces (Table 5). This cortical assemblage is characterised by low proportions of conserved cortex (Table 4). There is a predominance of the elements conserving the lesser amount of cortical surface, even if they do not exceed the percent halfway. From this point, the greater is the amount of cortex, the lower is the number of elements displaying it (Table 4). The most of them (n101: 82.11%) exclusively possess neocortical formations. From those presenting the original cortex, 8 have been considered heterogeneous, which implies coexistence of both original cortex and neocortex, only 10 show homogeneous original cortex surfaces and 2 have not been determined (Table 5). Analysis of cortical surfaces (Table 6) also has enabled us to note that 4 cores are made on blocks, whereas the remaining 20 are carried out on cobbles. Table 5.

In regards to the presence of signs of postgenetic processes, rolling stigmata predominate (Table 5): 18 specimens display signs of roundedness or abrasion, while other 60 present rolling stigmata altering

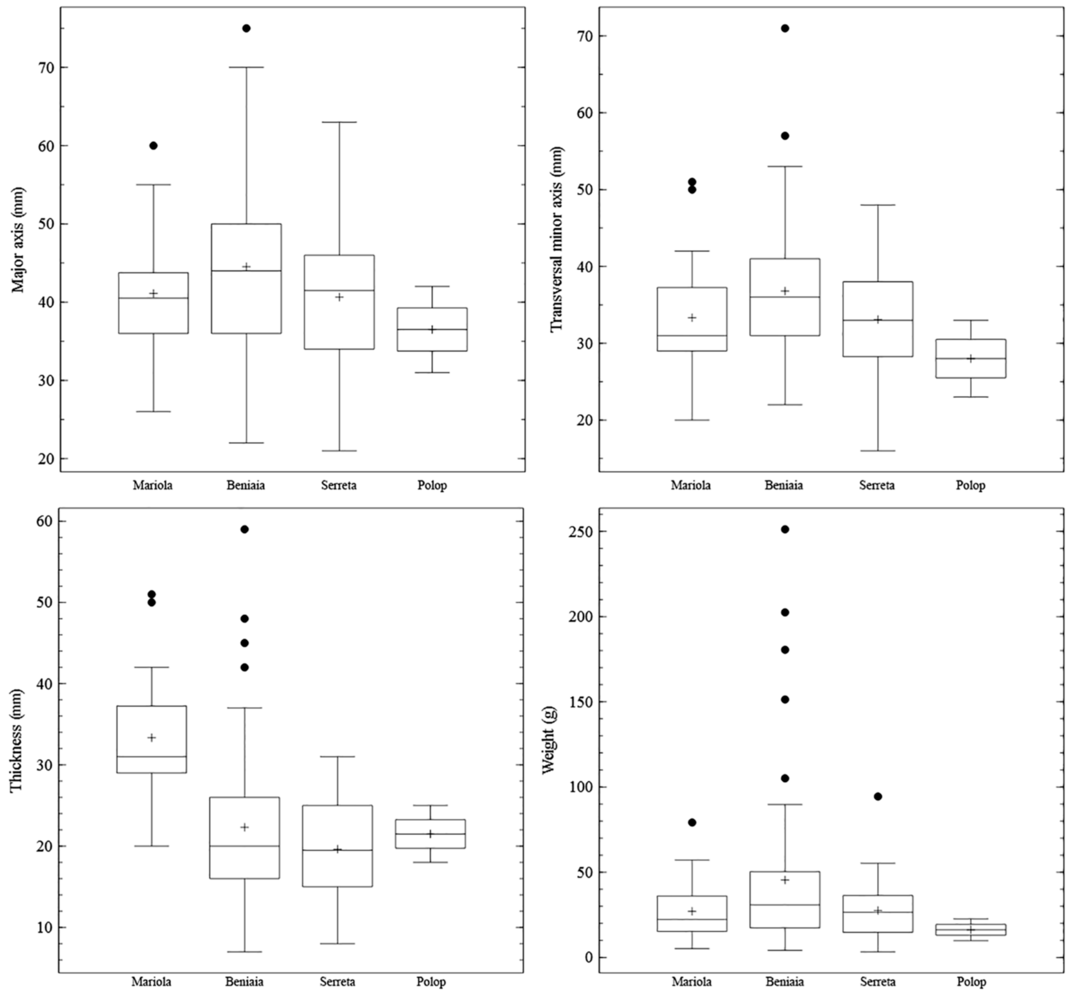

Fig. 3. Box-whisker diagrams showing major axis, transversal minor axis, thickness and weight of cores by flint type.

previous crash-marks. 77 Mariola elements present patinations formed prior to the technical intervention, while other 27 show either mineral or organic permeations (Table 5).

4.2. Palaeocene flint: Font Roja type

This is one of the scarcest types of flint in the assemblage (n3: 0.32%; Figs. S7–S10; Table 2). Two elements are flakes lacking cortex and not indicative of any sign of postgenetic processes, so they result undiagnosed (Fig. 6). The third flake displays cortical mass: a homogeneous orangish cortex showing rounded crashing stigmata.

4.3. Eocene flints: Beniaia and Serreta types

The Eocene flints are the most abundant within the assemblage (n647: 69.50%). In this case, the Beniaia type (n381: 40.93%; Figs. S21–S26) predominates over the Serreta flint (n266: 28.57%; Figs. S11–S20; Table 3).

From the Beniaia assemblage (Fig. 7), 266 flakes and 57 cores (Table 6) allow us to recognise marks of postgenetic processes that occurred on flint. From these, 202 specimens display either cortical or natural surfaces. In this cortical assemblage, the elements having a lesser amount of cortex (i.e. >0–25%) are predominant (Table 4). From this point, it can be observed a decrease of numbers to the ones conserving the greatest amount of cortical surface (i.e. 100%), which are the scarcest ones (Table 4). Neocortical formations are the main type of cortical surface for the Beniaia assemblage (n168: 83.17%). From the 29 Beniaia elements keeping the original cortex, 12 also have neocortical formations, while only 12 display homogeneous original cortex and 5 are undetermined (Table 5). The cores of this assemblage have enabled us to see that the most of them were made on cobbles (n46: 50.87%) and the remaining ones on blocks, except for 5 Beniaia cores carried out on an undetermined format (Table 6). Regarding signs of postgenetic processes occurring on the Beniaia assemblage, rolling stigmata are predominant (n125: 67.55%) over the signs of crashing. Permeations and patinas are present within the record in percentages similar to those of other major types of flint (Table 5): the patina formations predominate over the permeations.

In regards to the case of the Serreta type (Fig. 8), there are 182 flakes and 34 cores that permit us to observe the result of postgenetic processes. 156 Serreta elements display cortical surfaces (Table 5). Those that conserve the lesser amount of cortical surface are predominant (Table 4), and the numbers of elements having more cortex tend to decrease to the absolute absence of elements with a 100% (Table 4). Neocortex is the most abundant type of cortical surface in the Serreta assemblage (n146: 95.42%). From those elements conserving original cortex, 7 have heterogeneous cortical-neocortical formations, whereas specimens displaying homogeneous original cortex do not exist in the case of Serreta (Table 5). The cores of this assemblage have enabled us to identify that all of them were made on cobbles (Table 6). In relation to signs of postgenetic processes happening on the Serreta assemblage, rolling stigmata are predominant (n109: 71.71%) over the crash-marks. Like in the case of the Beniaia assemblage, permeations and patinas are present within the record in similar percentages (Table 5): the patinas

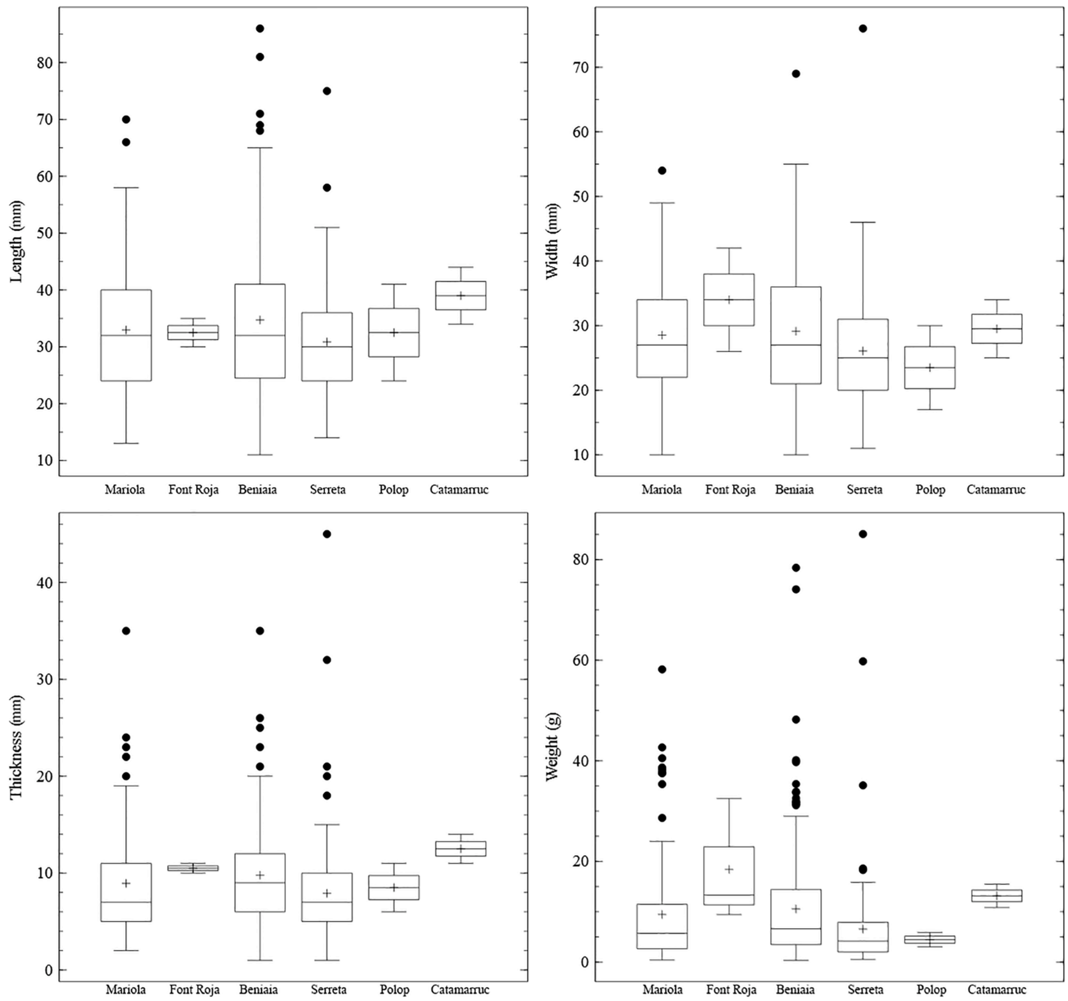

Fig. 4. Box-whisker diagrams showing length, width, thickness and weight of flakes by flint type.

are predominant over the permeations.

4.4. Miocene and miopliocene flints: polop and catamarruc types

Alongside the Font Roja type (vid. Palaeocene flint: Font Roja type), these flints are a minor part of the assemblage (n7: 0.81%; Table 3). Catamarruc type (n2: 0.23%; Figs. S29–S31) is more scarcely represented than Polop flint (n5: 0.58%; Figs. S27 and S28).

Regarding the Polop specimens (Fig. 9), four out of five display natural surfaces without cortex, which is due to its extremely powdery character (cf. Molina, 2015). One of these also shows crash-marks, while another displays polishing signs.

Both of the two Catamarruc flakes (Fig. 10) conserve homogeneous cortical surfaces, and patina formation produced before the flakes were extracted. One of these has signs of cortical roundedness.

5. Discussion

We can translate these results into different types of geological deposits. They had been previously recognised and described by the aforementioned petroarchaeological studies performed in the territory (vid. 1 and 2; cf. Molina, 2015), but also geolocated through systematic surveying (Fig. 11). These data will serve for situating potential provisioning areas exploited by Neanderthal groups during the formation of SU VIII. Furthermore, knowing these areas and combining them with basic technical information (Figs. 4 and 5; Tables 4 and 6) will be used for gathering data on selection of siliceous raw materials and nodule formats. Thus, it will serve also for trying to identify and describe the technoeconomic processes that permit characterising the starting point of the operational chain that Neanderthal groups carried out within the Serpis valley.

5.1. Translating geogenic and postgenetic data into potential provisioning areas

Observation of geogenic features present on flint (i.e. those regarding the genetic polarity or formation environment; vid. 3) has allowed us to establish a relation between the different types within the assemblage (Table 4). According to this, Beniaia is the predominant one, followed in this order by Serreta, Mariola and the minor types (i.e. Polop, Font Roja and Catamarruc, respectively).

Studying this genetic polarity is very significant since it permits to specify the geological origin of these flints and thus to relate the specimens to formation environments, and to geolocated primary outcrops. It is also the starting point from which we can begin to associate signs of postgenetic processes seen on these siliceous elements to particular deposits of resedimentation, whose locations are known as well.

In this sense and regarding natural crashing stigmata (vid. 3), we can observe that they are abundant but not predominant in the three major types of flint (Table 5). These stigmata are natural sharp edges not necessarily related to internal fractures, and non-anthropogenic hitmarks, both due to gravitational effects occurring in hillside colluvial deposits and fluvial erosion produced next to the country-rock. Although the mentioned processes might have happened in different places

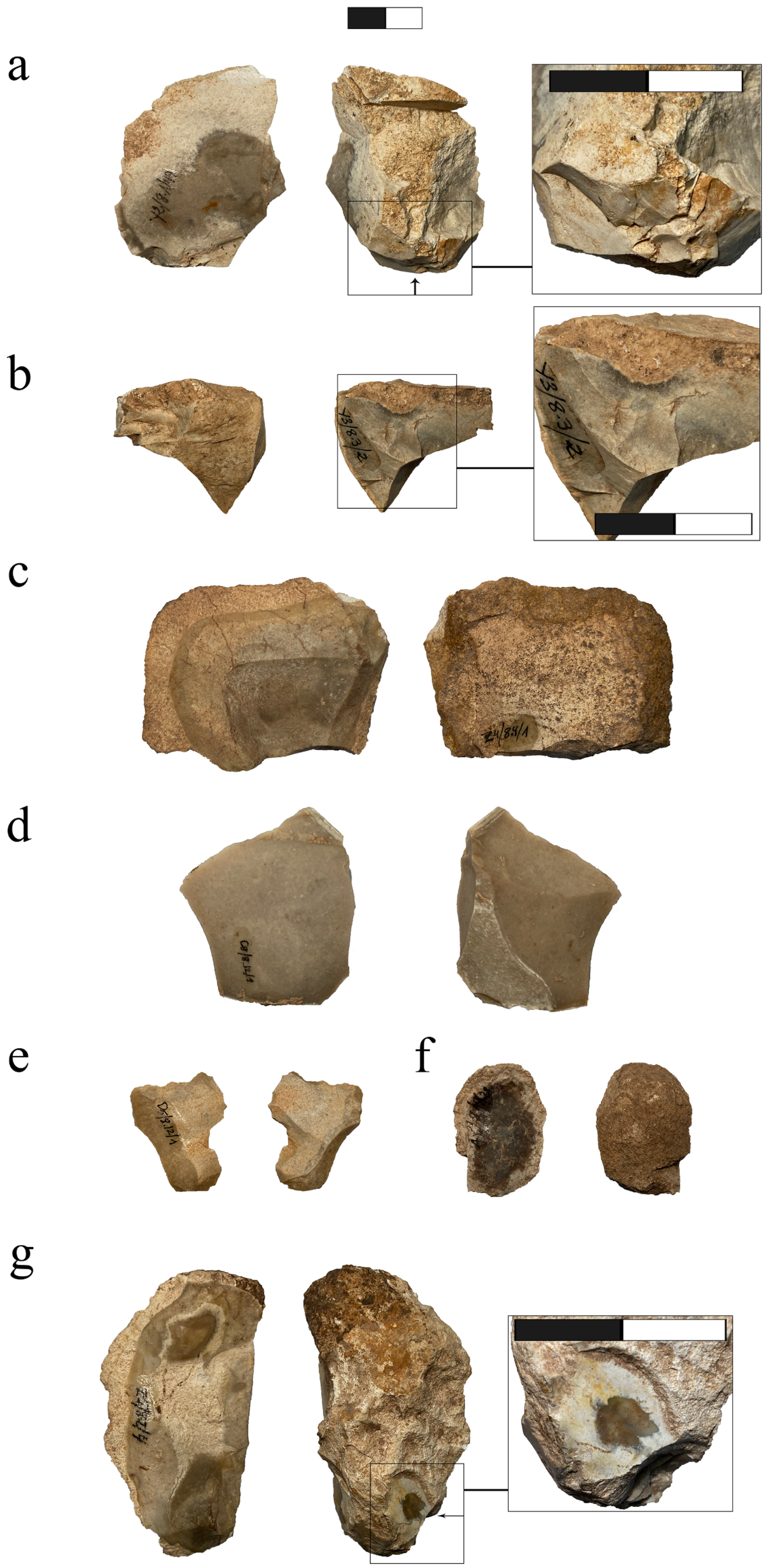

Fig. 5. Seven examples of elements made on Mariola flint. **a**: flake with combined cortical and neocortical formations in surface and natural hitting marks. **b**: core fragment displaying a subcortical blackish permeation, probably produced either by organic matter or by manganese oxide. **c**: flake with original cortex. **d**: flake with a relict of a technically unaltered patinated surface. **e**: flake displaying different stages of surface patina formation. **f**: cortical flake with rolling stigmata due to Oligocene erosive processes. **g**: cortical flake with natural hitting marks and patina formation.

Fig. 6. The three elements made on Font Roja flint. **Upper left**: flake fragmented due to an internal fracture of the original nodule. **Upper right**: flake with no cortical surface. **Lower left**: cortical flake with a slight carbonation on its dorsal face. **Lower right**: detailed picture of the cortex belonging to the single Font Roja cortical flake and displaying natural hit-marks.

depending on each flint type (cf. Molina, 2015).

Concerning Mariola and Serreta flints in particular, this had to occur within the context of the Serpis river headwaters. All the Pleistocene colluvial deposits where these two types can be found are located here (cf. Molina, 2015), within the foothills of Mariola, Almudaina and La Serreta mountain ranges.

In the specific case of Mariola flint (Fig. 12; cf. Molina et al., 2010), Pleistocene colluvial deposits containing it are distributed, from west to east, amongst the Barxell river upstream (i.e. ≲5km from El Salt), Orents ridge (i.e. the easternmost part of Mariola mountain range; i.e. ≲2.5km), an area situated in the Mariola northeastern foothills (i.e. ≳5 and ≲7.5km), and Baix ridge (i.e. the westernmost part of Almudaina mountain range; i.e. ≳7.5 and ≲10km). In regards to Serreta flint (Fig. 11; cf. Molina et al., 2010), these colluvia are gathered, again from west to east, among Orents ridge (i.e. ≲2.5 km from El Salt), the La Serreta northwestern foothills (i.e. ≳2.5 and ≲4km), and Baix ridge (i.e. ≳7.5 and ≲10km).

The case of Beniaia flint is different (cf. Molina, 2015), since Pleistocene colluvial deposits containing it are located far northeast, within a mountainous area whose basins stream into the Serpis middle course (Fig. 11). This space is located at ca. 20 km from El Salt. However, there are also Pleistocene colluvial deposits comprising Beniaia flint located in Orents (i.e. ≲2.5km) and Baix ridges (i.e. ≳7.5 and ≲10km), although only one of this kind has been recognised within each, and the presence of Beniaia within these contexts is exceptional.

Furthermore, the relationship between crashing stigmata and patina formations is a significant proxy to support the presence of these flints within colluvial deposits at the moment of being taken by Neanderthals in this territory. Firstly, we must indicate the inexistence of patina formed in the deposit of El Salt, since we have not noticed its formation prior to the technical intervention in any case, not only for the SU VIII, but also for the other studied assemblages (cf. Molina, 2015; Machado and Pérez, 2016; Machado et al., 2017).

Flint being exposed within open hillside deposits appears to be more susceptible to form patina than within other contexts of resedimentation (e.g. Glauberman and Thorson, 2012; Molina et al., 2015, 2016; Pawlikowski and Wasilewski, 2002). On this matter and including here those specimens with rolling stigmata posterior to those caused by crashing, 48 Mariola specimens counting on crash-marks also display patina formation, whereas 55 of this kind of Serreta elements and 66 objects on Beniaia flint do (Table 5). These numbers mean, in the case of Mariola and Beniaia, more than a third of the specimens with patina formations and, regarding Serreta flint, three quarters of all patinated elements. In addition, the case of Serreta flint has been studied deeply (cf. Molina, 2015) and we know that patina formation on this type of flint is especially frequent on these elements when they resedimented in Pleistocene colluvial deposits around La Serreta mountain range (Fig. 11).

With regard to rolling stigmata (vid. 3), we have observed that they are predominant in every major type of flint (Table 5). Here, we take into account those elements exclusively displaying rolling stigmata as well as those presenting both rolling and crashing stigmata. This is because roll-marks overlap crashing stigmata in all cases.

Mariola flint in alluvial contexts related to river environments (Fig. 11) can be found in the upper and middle courses of Serpis river. Specifically, Pleistocene alluvial deposits containing Mariola flint have been identified within the headwaters of Barxell river (i.e. ≳1 and ≲3km from El Salt), some fluvial terraces south of Orents ridge (i.e. ≳1 and ≲2.5km), and other terraces southeast, east and northeast of the easternmost part of Mariola mountain range (i.e. ≳7.5 and ≲10km). Mariola flint can be also found within alluvial contexts beyond the indicated areas, but no element here shows the stigmata that would be related to the middle and lower courses of the Serpis river (cf. Molina, 2015).

The case of Serreta flint is more variable (Fig. 11), due to the fact that Pleistocene alluvia comprising it are located all along the Serpis river course to its mouth. Notwithstanding, almost the entire Serreta assemblage here displaying rolling stigmata related to fluvial processes are characterised by low degrees of polishing and roundedness, and conserve observable crashing stigmata, even though these are altered by the former. Mineral or organic permeations are relatively scarce (Table 5) and are associated with the subcortical areas. This relation of

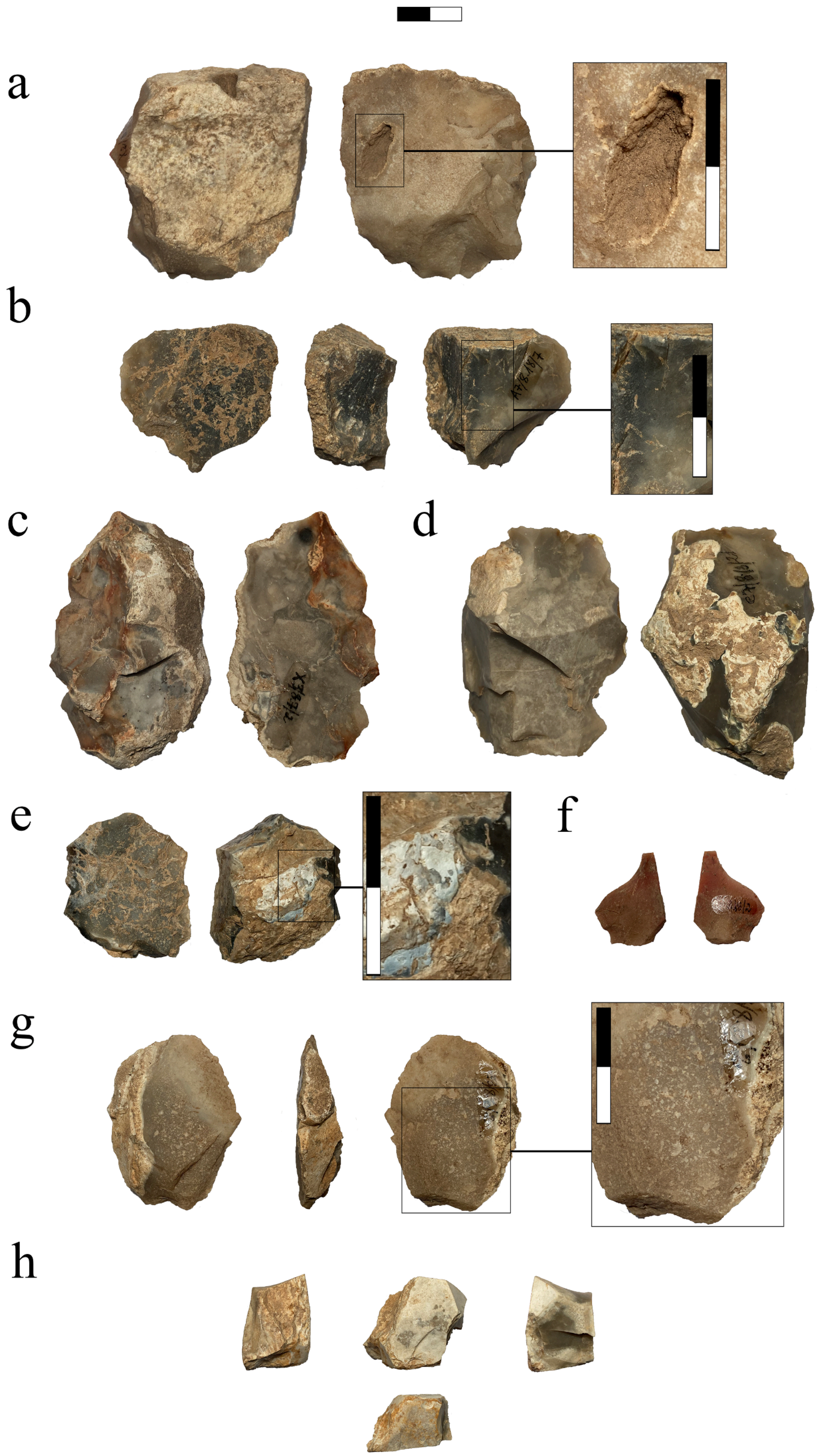

Fig. 7. Eight examples of elements made on Beniaia flint. **a**: cortical flake displaying recrystallisation. **b**: core containing an invasive subcortical blackish permeation, produced either by organic matter or by manganese oxide. **c**: flake with original cortex and reddish permeations, probably produced by iron oxide. **d**: core displaying neocortical surfaces. **e**: core displaying neocortical formation eroded by crashing stigmata and patina on the crashing marks. **f**: heated flake conserving observable geogenic features. **g**: flake displaying neocortical surface and multiple recrystallisations. **h**: fragmented core displaying original cortex, neocortex and patina, as well as a surface orangish impregnation, probably derived from iron oxide.

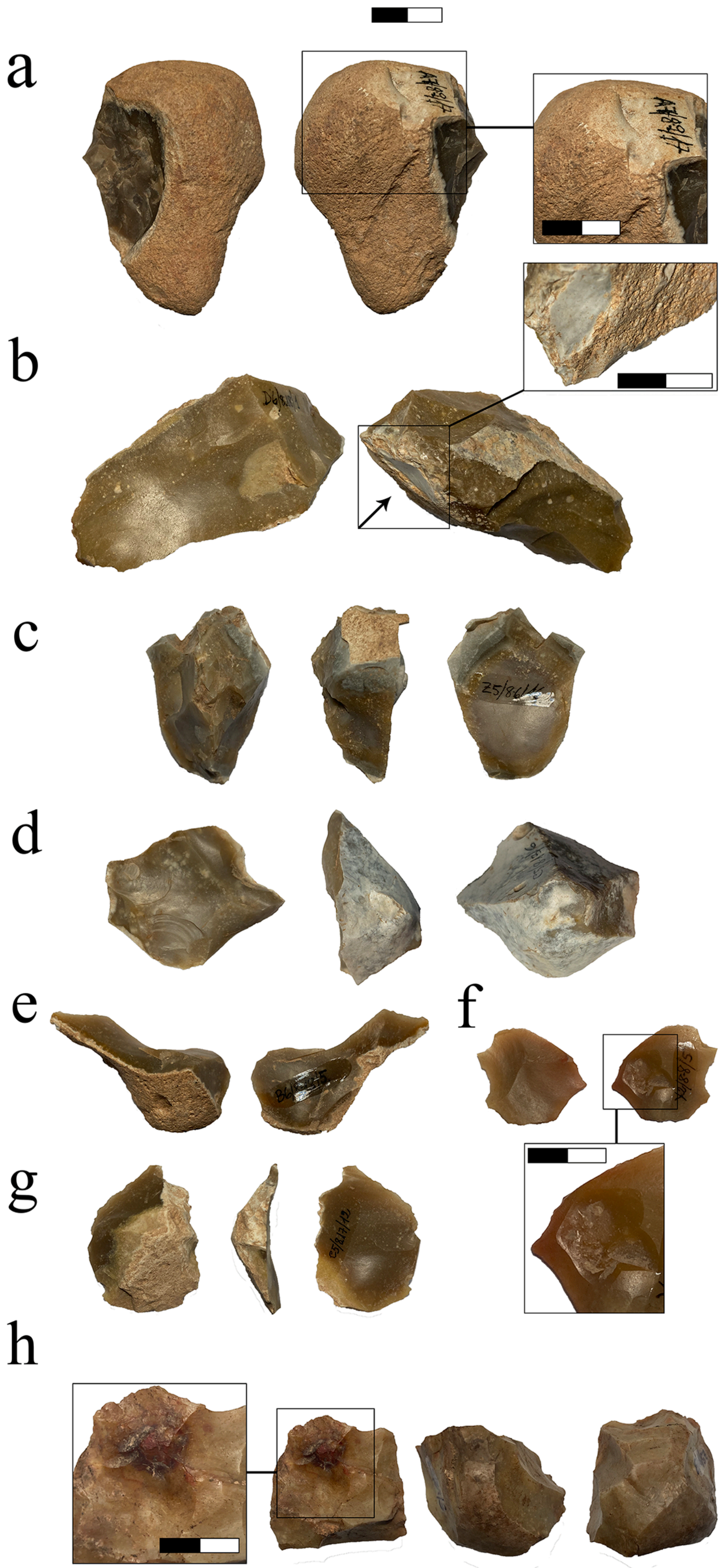

Fig. 8. Eight examples of elements made on Serreta flint. **a**: core made on a cobble covered by a neocortex with signs of heavy abrasion related to Oligocene erosion, and displaying rounded and patinated crashing stigmata. **b**: flake displaying a neocortex with signs of two different episodes of crashing (i.e. patinated vs. non-patinated), and natural surface roundedness. **c**: neocortical flake made on a rare variety of Serreta coming from Onil mountain range, and displaying signs of alluvial processes linked to the upper course of Serpis river. **d**: core displaying a crashed, patinated and polished surface linked to the ending of Serpis upper course. **e**: flake displaying a neocortex with abrasion and signs of posterior crashing stigmata. **f**: heated flake with diagnostic geogenic features, but undiagnosed regarding secondary polarity. **g**: flake with crashing marks on the cortical surface. **h**: core with a polished natural surface and a deep reddish permeation, probably produced by iron oxide.

Fig. 9. The five elements made on Polop flint. A flake (**upper left**) and two cores (**upper right** and **central left**) with no sign of any postgenetic process, and two flakes displaying rolling stigmata (**lower left**) and crashing signs (**lower right**).

stigmata is connected to the results of fluvial action within the uppermost course of Serpis river (cf. Molina, 2015), in a distance range comprised between $\gtrsim$1 and $\lesssim$20km from El Salt down the stream.

Some elements do not fulfil these features: their neocortical surfaces present a high degree of polishing, with or without loss of cortex, and deep permeations. These characteristics in Serreta flint are signs of the resedimentation of these elements within the Serpis midcourse beginning (i.e. $\gtrsim$20 and $\lesssim$25km from El Salt; cf. Molina, 2015)[6]. Nevertheless, they correspond to ca. 3% of the Serreta assemblage.

The catchment of this little part of the Serreta assemblage might be geographically connected to the Beniaia flint provisioning areas. Eocene primary deposits, as well as Oligocene and Miocene conglomerates and Pleistocene colluvia containing Beniaia flint are located within a mountainous area mentioned in previous pages (Fig. 11). Alluvial deposits comprising Beniaia also have been identified here, especially related to the course of L'Encantà[7] ravine, which is born not far east from Cantacuc ridge (i.e. the northernmost part of Almudaina mountain range), goes down north through Cantalar ridge (i.e. the southwesternmost part of L'Albureca mountain range) and discharges into the end of the Serpis river upper course.

As in the case of cores as in that of flakes, the Beniaia flint assemblage possesses the largest measures. The formats for producing these big flakes (i.e. $\gtrsim$7 and $\lesssim$9cm-long, and $\gtrsim$5 and $\lesssim$7cm-wide; Fig. 3) necessarily had to be collected within L'Encantà ravine, since it is the only place where Beniaia nodules surpass 9cm and reach even 15cm in their major axis (cf. Molina, 2015). Although they are a minor part of the assemblage, since most of the Beniaia elements have smaller measures (i.e. for flakes, the average length is 3.5cm and the average width is 2.9cm; Fig. 4). This does not imply perforce that their original nodules were not picked in the same area as the bigger specimens, but the size is not a geographically diagnostic datum for them, since nodules can reach at most 9cm in their major axis within the middle course of Serpis river.

Alluvial deposits in the end of the Serpis upper course and the beginning of its midcourse contain a high degree of minerally or organically permeated nodules, but the most of them appear to be originated in Holocene contexts (cf. Molina, 2015). Pleistocene mineral and organic permeations are not too common and not too invasive in the fluvial terraces of this area. Here and nowadays, Beniaia flint is scarcer than Serreta, even if its primary outcrops are closer than those in which the latter was formed. Most of the Beniaia assemblage displaying rolling stigmata present in SU VIII has probably been taken from here (i.e. $\gtrsim$25 and $\lesssim$35km from El Salt; Fig. 11), since they present round-shaped neocortical surfaces, subcortical permeations, even if not too abundant, and rounded natural crash-marks (e.g. Fig. 7).

There are some cases in which rolling stigmata are cortex abrasion combined with a very noticeable cortical roundedness and without any mineral or organic permeation. This kind of marks is related to marine detrital processes and has to be associated to the Oligocene conglomerates existing in the territory (cf. Molina, 2015). However, these stigmata are almost always overlapped by posterior crashing and/or rolling stigmata.

Ultimately and regarding the representatively minor types (i.e. Polop, Font Roja and Catamarruc), they reveal different areas where they could have been taken by Neanderthal groups of SU VIII.

In this sense, there are Miocene primary outcrops of Polop flint

[6] Deep permeations could be also the result of a prolonged stay within a fluvial terrace located in the upper course (cf. Molina 2015).

[7] Also known as L'Encantada ravine.

Fig. 10. The two flakes made on Catamarruc flint. These flakes show different types of original cortex for the case of the Catamarruc flint and formation of superficial patina.

within the Polop river upper course and the easternmost part of Mariola mountain range, and Pleistocene alluvial and colluvial deposits, even if scarcely due to Holocene erosion, nearby these areas (Fig. 11). As commented before, the powdery character of the Polop type cortex usually does not allow to observe signs of postgenetic alterations on it, since it disintegrates (vid. 4.4). Notwithstanding this, two specimens display rolling and crashing stigmata, respectively. Anyhow, all the Polop assemblage could have been gathered in a range of ≲4km upstream from El Salt and ≲12km downstream.

Continuing with Font Roja flint and taking into account its underrepresentation in this assemblage, all of it seems to have been collected in the proximities of its primary outcrops (Fig. 11), which go from the headwaters of Polop river (i.e. ≳3 and ≲7km from El Salt), in the form of Pleistocene colluvial deposits, to an area located south to Orents ridge (i.e. ≳1 and ≲3km), in the form of Pleistocene fluvial deposits. Only one of the Font Roja specimens shows signs of postgenetic alterations, certainly related to the Serpis-associated Pleistocene alluvia located the furthest as possible from the primary outcrops for this type of flint (ca. 3km downstream from El Salt).

Catamarruc flint is the least represented in the assemblage. It has its origins in the same area of Beniaia flint, where also Pleistocene colluvial deposits containing it can be found (Fig. 11). It follows the same itinerary of Beniaia flint through L'Encantà ravine and can also be situated in the beginning of the Serpis middle course (i.e. ≳20 and ≲25km from El Salt). Only one out of the two Catamarruc specimens presents rolling stigmata, probably associated with the beginning of the Serpis midcourse.

The next step is to follow the map that we have made using the combination of geogenic and postgenetic information on flint and the geolocated deposits containing it. According to this, the Neanderthal groups that occupied El Salt during the formation of SU VIII would have gathered the siliceous raw materials within the frame of the Serpis upper and middle courses (Fig. 12). They would have given preference to the Beniaia flint type uncontained within Pleistocene alluvial deposits, most likely located in fluvial terraces, since they appear to be the commonest water environment comprising flint in the upper and middle courses of Serpis river.

The presence of flints like Font Roja, Polop and, particularly, Mariola and Serreta without significant rolling stigmata allows us to indicate that provisioning of these was carried out almost exclusively in the upper course (Fig. 12). Thus, these Neanderthal groups moved for flint within a range of nearly 7 km upstream Barxell and Polop rivers, and an approximate maximum of 35 km downstream Serpis river, also preferring fluvial terraces to slope deposits.

Utilisation of fluvial networks as flint-resourcing itineraries has been widely observed in other studied territories with Neanderthal presence, such as that of the valley of Rhône river, in southeastern France, counting on archaeological sites like, for instance, Les Pêcheurs (Berrias-

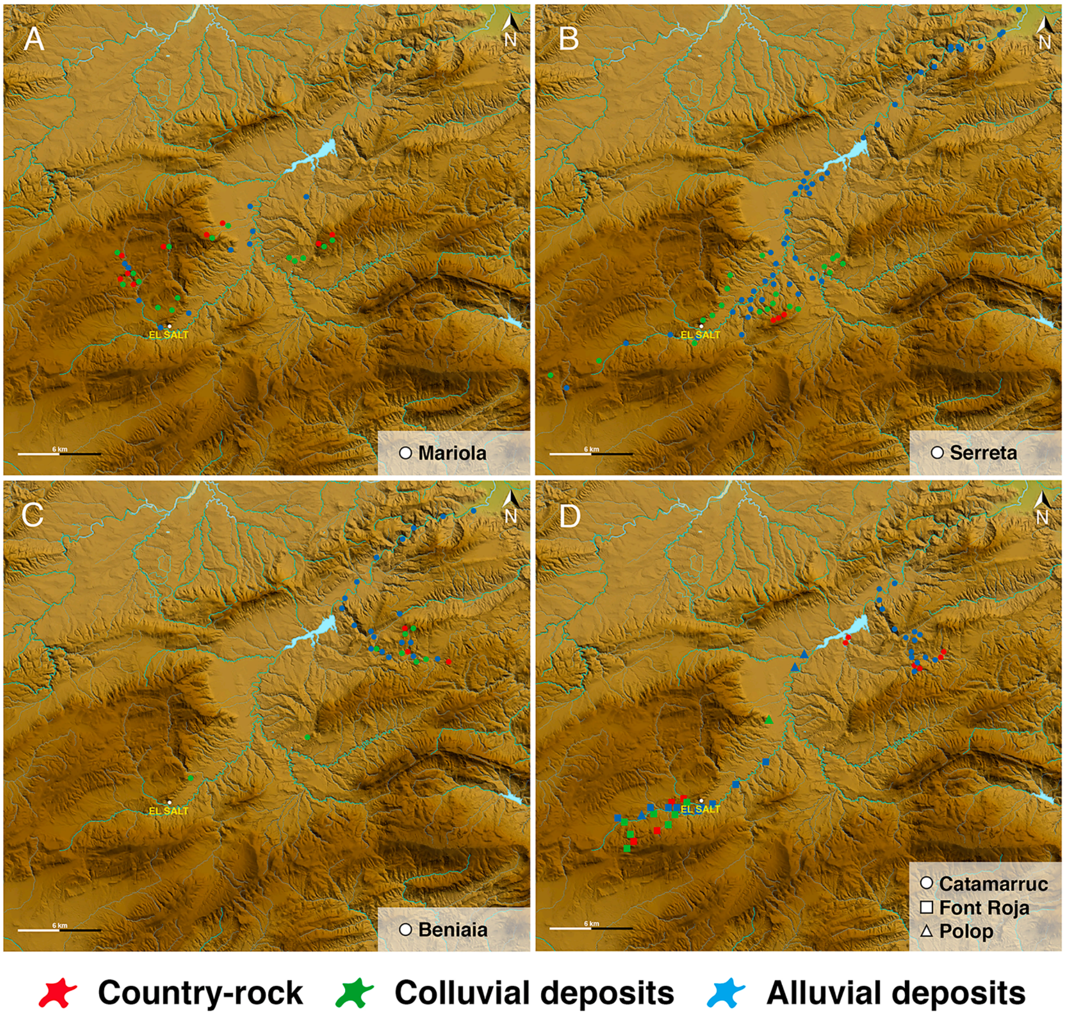

Fig. 11. Map displaying the distribution of the identified Pleistocene alluvial and colluvial deposits containing Mariola (**a**), Serreta (**b**), Beniaia (**c**) and representatively minor flints (**d**) in the upper and middle courses of Serpis river. Toponyms mentioned in the text in **a**: **1**: Barxell river headwaters; **2**: Orents ridge; **3**: easternmost part of Mariola mountain range; **4**: Baix ridge. In **b**: **1**: Orents ridge; **2**: easternmost part of Mariola mountain range; **3**: La Serreta mountain range; **4**: Baix ridge. In **c**: **1**: Cantacuc ridge; **2**: Cantalar ridge; **3**: L'Encantà ravine. In **d**: **1**: Polop river headwaters; **2**: Orents ridge; **3**: L'Encantà ravine; **4**: Cantalar ridge.

et-Casteljau, Ardèche) (cf. Fernandes et al., 2008), Le Maras (Saint-Martin-d'Ardèche, Ardèche) (cf. Fernandes et al., 2008) and Payre (Rompon, Ardèche) (cf. Moncel and Fernandes, 2008) rockshelters, or Les Barasses II (Balazuc, Ardèche) (cf. Blasco et al., 2018) and Moula-Guercy (Soyons, Ardèche) (cf. Defleur, 2015) caves. In these cases, fluvial ramifications seem to be the main focus of flint provisioning dynamics (cf. Delvigne et al., 2019b).

Different examples of raw material provisioning in alluvial deposits involved in fluvial pathways could be the upper valley of Loire river, in southern-central France, with archaeological sites such as, for instance, Le Rond-de-Saint-Arcons rockshelter (Saint-Arcons-d'Allier, Haute-Loire), Sainte-Anne I cave (Polignac, Haute-Loire) and Vallée cave (Solignac-sur-Loire, Haute-Loire) (cf. Fernandes et al., 2008), and the valley of Vinalopó river, in southeastern Iberia, where sites containing Neanderthal record such as El Cochino (Villena, Alacant) (cf. Molina, 2015) and Els Calderons caves (La Romana, Alacant) (cf. Torregrosa et al., 2018), or Les Oliveres III rockshelter (Santa Pola, Alacant) (cf. Molina et al., 2019) can be found.

Other cases, such as SUs M, O and P of Romaní rockshelter (Capellades, Barcelona, northeastern Iberia) (cf. Gómez et al., 2020b) or several SUs of La Quebrada rockshelter (Chelva, València, eastern Iberia) (cf. Eixea et al., 2016), do not coincide apparently with this alluvium-related resourcing scheme because of different reasons.

In the former case, even if fluvial terraces do not appear to be the most exploited due to the virtual absence of alluvial stigmata on the record, Neanderthal group mobility across the riverdale pathways seems to be verified owing to distribution of raw material primary and non-alluvial resedimentation deposits. This is supported by the severe scarcity of flint within the alluvial deposits located in the nearby territory (cf. Gómez et al., 2020b).

The second case could be a significant example of how not working with the concept of the flint itinerant history (*sensv* Fernandes and Raynal, 2006) might make any raw-material approach becoming incomplete in terms of human mobility and provisioning dynamics. In La Quebrada, siliceous raw materials have been studied as macroscopically as by means of geochemical procedures (cf. Eixea et al., 2011; Eixea et al., 2016; Prudêncio et al., 2016; Roldán et al., 2015). It has allowed identifying the primary provenance of the so-called local flint record, but not the environments of flint resedimentation and thus either the resourcing areas where it was potentially gathered.

Approaches that aim to recognise primary outcrops and formation environments are very useful in order to know what and how is the siliceous raw material that was knapped by these populations. However, studying also the signs of postgenetic alterations that occurred on flint after its release can allow us to formulate questions and provide answers on where they were moving about, what and how they were selecting and transporting, or even why they were doing it. In this sense, the next epigraphs shall try to do precisely this: raising doubts and suggesting

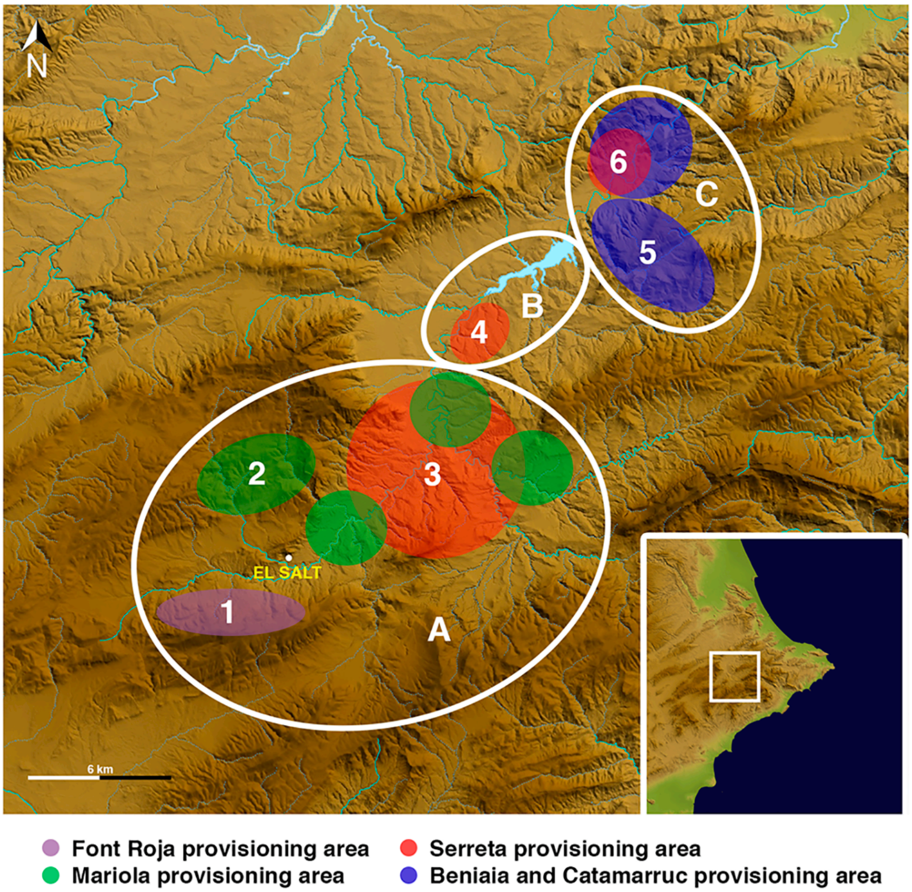

Fig. 12. Map displaying the potential provisioning areas in the upper and middle courses of Serpis river. **a**: headwaters and upper course in a range of ≳1 to ≲10 km from El Salt, containing (**1**) Font Roja with minor Polop presence, (**2**) Mariola and (**3**) mixed Mariola and Serreta sourcing areas. **b**: the upper course ending in a range of ≳7.5 to ≲18 km, comprising (**4**) combined Serreta and Polop sourcing areas, with less presence of Mariola flint. **c**: the middle course beginning in a range of ≳20 to ≲35 km, including (**5**) Beniaia and Catamarruc, and (**6**) common Beniaia and Serreta and, in fewer numbers, Catamarruc and Mariola sourcing areas.

hypotheses on Neanderthal resourcing-related mobility and flint management.

5.2. Neanderthal flint selection and transportation into the site

Defining the provisioning areas in which Neanderthal groups gathered the flint masses that they would work with is a first step. This drawn map allows us to understand where they were moving to or from and a significant part of the environments that they were using to move about. In brief, it permits us to achieve an estimated picture of the territory that they occupied.

Here and according to the presented results, we already know that these Neanderthal groups were managing a territory comprised within a range of 7km upstream and 35km downstream the Serpis valley, and that they appeared to probably prefer rivershores, ravines and brooks as pathways to perform their flint-sourcing itineraries (vid. 5.1). But how they chose the siliceous raw materials that they were going to knap afterwards and how they transported them into the site are questions that are still unanswered in this paper.

In the aim of responding to these, we pay attention to different issues that we consider significant for this matter. For the case of flint selection, we look at abundance or scarcity within the territory, the types of resedimentation deposits and those features that are susceptible of being associated with knapping suitability (e.g. recrystallisations, internal fissures, degree of conchoidal fracture, etc.). As for transporting, we look into sizes and weights of each specimen and the percentages of cortical presence, preliminarily evaluate if there was any off-site flintknapping activity, and cross-check all this information with the distances described before.

5.2.1. Flint selection: gathering riverside cobbles

Beginning with the three representatively minor types of flint, it is important to indicate that their formation deposits were not significantly eroded until Pleistocene, so their presence in the territory outside their primary deposits is relatively low if it is compared with types more represented in the assemblage. In the case of Font Roja, postgenetic fissures generated when the nodules were still inside the country-rock force it to fracture at the moment in which it releases (cf. Molina, 2015). With regard to Polop and Catamarruc, they are the most recent flints in terms of formation (Table 1). This scarce lapse of time that passed from their geogenesis makes them possessing an opaline internal structure that is in process of crystallisation (cf. Molina, 2015). Thus, nodules belonging to these flint types tend to a high fragmentation degree.

These two issues (i.e. rare chance to find them and regular unsuitability for knapping) explain why they are not being picked often by Neanderthal groups. If there is a small amount of them in this assemblage (Table 3), it is probably due to the fact that they share deposits with other flints not presenting these features. This selection is therefore circumstantial, as it has been observed as well in other contexts, such as the SU x of El Salt (cf. Machado et al., 2017; Mayor et al., 2019, 2020) or the SU IV of El Pastor rockshelter (Alcoi, Alacant, eastern Iberia) (cf. Machado et al., 2013; Mayor et al., 2019).

Attending to the three major types of flint and to the predominant secondary deposits where they can be found, we can establish the nodule formats that were selected by these Neanderthal groups: cobbles more or less round-shaped by fluvial action with major axes comprised between 4 and 15cm (cf. Molina, 2015) constitute the commonest kind of original format employed for exploitation (Table 6), mainly belonging to Beniaia flint. But the facts that they are relatively far away from El Salt (Figs. 12 and 13) and that Beniaia flint type predominates over the other two

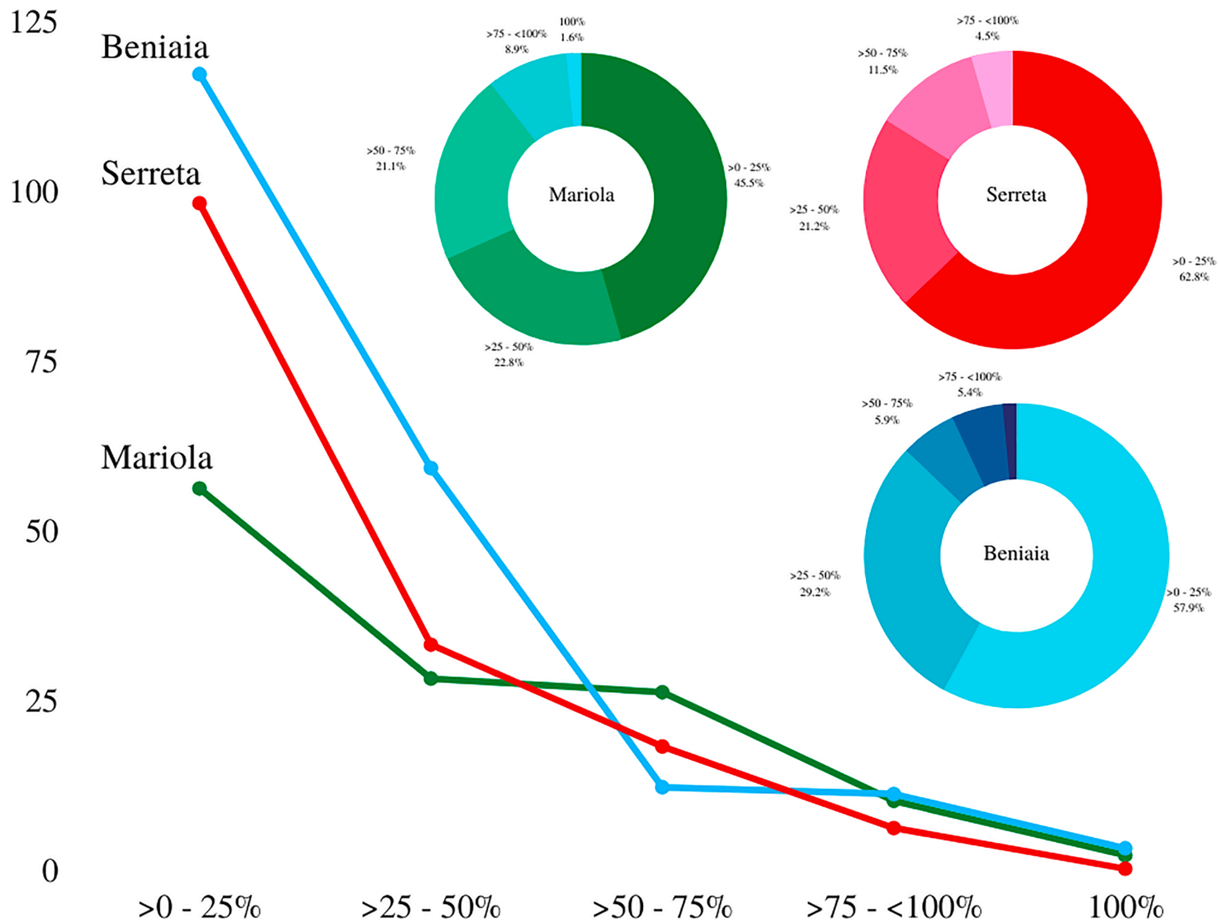

Fig. 13. To the **left**, graph showing the number of elements by representatively major flint type and approximate percentage of cortical surface. To the **right**, three round-charts displaying the percentages of these values by flint type.

(Table 3), being the furthest flint type of all represented in this assemblage, raise questions around why Neanderthals might have given preference to these ahead of others.

In terms of knapping-related quality, Serreta flint is usually the most suitable due to a microcrystalline structure and the almost nonexistent presence of internal fissures, both theoretically permitting an optimal conchoidal fracture (cf. Machado et al., 2019; Mayor et al., 2020). Even if Mariola type also presents a microcrystalline structure, postgenetic tectonic processes occurring in the formation environments foster the appearance of internal fissures, which likewise can cause desilicification processes owing to water infiltrations. Instead, many varieties of Beniaia flint display recrystallisations that increase the material hardness and the chances of knapping accidents due to the formation of internal quartzite geodes (cf. Machado et al., 2013; Mayor et al., 2020; Molina, 2015), albeit other varieties are not that much or at all characterised by this.

Taking into account this information and waiting for technological analyses on this assemblage, it seems unlikely that the leading selection of Beniaia flint cobbles might have responded to technical preferences. In this sense, a feasible hypothesis would be based on the availability of the distinct flint types within the territory.

For the case of some subunits comprised within SU IV of El Pastor, several Serreta flint resedimentation areas would have been fairly inaccessible, possibly due to environmental or geomorphological changes such as a greater profusion of vegetal covering or a decrease of the release of this flint from the country-rock (cf. Molina, 2015). Other examples such as SUs M, O and P of Romaní display a similar scenario in which the nearest siliceous raw materials are less represented than those placed further (i.e. Sant Martí de Tous flint in the case of O and Panadella flint in the case of M and P; cf. Gómez et al., 2020a, 2020b), with no apparent link with technical issues.

SU IV of El Pastor is, in fact, an interesting example for the matters treated here. It is subdivided in several lithostratigraphic units, from which four have been petroarchaeologically studied in depth to date: IVa, IVb, IVc and IVd (cf. Molina, 2015). Whereas IVa and IVb display an overwhelming predominance of Beniaia flint type versus a scarce proportion of Serreta (i.e. IVa, Beniaia: 52% vs. Serreta: 10.4%; IVb, Beniaia: 72.2% vs. Serreta: 9%), IVc and IVd show instead a clear prevalence of Serreta versus a not that short percentage of Beniaia (i.e. IVc, Beniaia: 28.6%-Serreta: 40.8%; IVd, Beniaia: 38.9%-Serreta: 41.2%), keeping Mariola flint as the second in terms of representation. If we cross the chronometric data obtained from the bottom of SU VII of El Salt (cf. Galván et al., 2014b) and from the uppermost part of lithostratigraphic unit IVb of El Pastor (cf. Mallol et al., 2019), we can observe very cautiously that they may belong to a similar broad temporal frame (i.e. bottom of VII, 49.2±4.8ky BP; IVb, 48±5ky BP). This supports provisionally the idea that Serreta flint was less available than in previous moments in the territory, which might have forced the Neanderthal groups to give preference to other types of flint, even if these were not so suitable for knapping.

5.2.2. *Flint transportation: carrying manufactured products*

From the very moment in which the hunter-gatherer collects the raw material mass to when the flint enters into the place that will become an archaeological site, nodules may be technically modified or not for achieving different goals (cf. Turq et al., 2013). There are many archaeological examples of Neanderthal groups manufacturing lithic raw material masses prior to the input into the definitive site in order to, for instance, shape cores prepared to extract products from (e.g. Machado et al., 2017), elaborate portable tools to be reiteratedly used (e.g. Picin et al., 2020) or formerly exploit the nodules in other places (e.g. Vallverdú et al., 2005). Relying on the data presented here, we can infer some issues related to transportation of raw material involved in SU viii.

Regarding aspects related to presence of cortex in the assemblage, the three major types of flint show a greater amount of cortical specimens than non-cortical ones (Table 4). Notwithstanding it, these cortical assemblages display a progressive quantitative reduction from elements possessing lower percentages of cortex surface to those having higher percent data (Fig. 13).

If the nearest flint type (i.e. Mariola; Fig. 5) and the furthest one (i.e. Beniaia; Fig. 7) are compared in terms of potential procurement distances, it can be observed that a feasible association with shorter or greater cortical presence exists. In this sense, the Mariola assemblage, which possesses the largest cortical amount (i.e. 78.67%), shows a lower percentage of elements with the minimal cortical surfaces, whereas the intermediate percent groups are overrepresented if they are contrasted with those belonging to the other two major types. Instead, the Beniaia assemblage, which contains the smallest percentage of cortical elements (i.e. 64.30%), displays a clear predominance of the lower proportions and, after an abrupt decrease in the middle of the intermediate percent groups (i.e. >25–50% and >50–75%; Fig. 13; Table 4), a continual quantitative decline.

Following this, the Serreta assemblage (Fig. 8) stands as a halfway case between both of the former ones. The cortical proportion stays in a rough midst (i.e. 71.79%) and the corresponding flint elements are gathered within a quantitative reduction from lower to higher cortex-surface percentage that is slightly distinguishable from the others. Whereas it shares with Beniaia the predominance of elements counting on a scarce cortical surface, it has in common with Mariola the softly progressive character of the percent reduction (Fig. 13). We have to put these data in relation with the geographic distribution of Serreta flint (Figs. 12 and 13), which can be found all along the Serpis course and coexisting separately with Mariola and Beniaia in the Pleistocene alluvial deposits that, as we have observed (vid. 5.1), are predominant in this case. It appears then to be an exponential relationship between cortical presence and distance of acquisition: the greater the distance, the lower the cortical percentage in general terms. This assertion has significant statistical support based on the relationship between flint types and cortical percentage groups (i.e. Chi^2: 25.58; critical value: 15.57; probability (no relationship): 0.0012389).

In the case of cross-checking the nodule minimal and maximal sizes in resedimentation deposits and the core measures relating to this assemblage (Fig. 3; for nodule sizes, cf. Molina, 2015), there is no such an exponential relation. The length of major and minor axes and the weights of cores find themselves within similar proportional ranges for Mariola and Serreta, and only the Mariola thickness values stand out, since they are higher than those of Serreta and even Beniaia. As for the Beniaia assemblage, it displays the highest measures and the widest ranges of major and minor axes and weights. It means that the largest and heaviest formats correspond to Beniaia elements, which are also the ones arriving from the furthest away (Fig. 12).

In the absence of the upcoming technological analysis, we might preliminarily state that the flint belonging to this assemblage was put into the site already in the form of manufactured products (i.e. flint elements presenting any technical intervention). There are few signs of *in situ* knapping activity, such as the presence of several hundreds of small debris, and a single refit and some set raw material units[8], but still other predominant aspects such as low percentages of cortical elements, near or full exhaustion of cores, or abundance of single tools point to a usual off-site knapping production. This would be supported by the fact that as the more distantly the nodules have been taken from, the greater technical intervention has been applied on them.

Concerning technical procedures that could have been responsible for generating products displaying cortical surfaces during the whole application, they might blur the relationship between distance magnitude and cortical presence. Following this, we ought to indicate that, generally speaking, the applied technological schemes seem to be similar in all the flint types in this sense[9], since no particularly distinguishing procedure has been observed during the preliminary technical check.

5.3. An instance of Neanderthal mobility dynamics: proposals and constraints

This scenery cannot be totally understood only by considering palaeoenvironmental or geomorphological issues associated with flint disposal (cf. Fernandes et al., 2008; Delvigne et al., 2019a), or by assuming distance as the mere space between one point and another without weighing the spectrum of potential activities carried out during the journeys (cf. Binford, 1977; Binford and O'Connell, 1984; Kelly, 1983). Human behavioural variability should have to be tabled to represent these interactions between Neanderthal groups and source territories. Moreover, this variability of hunter-gatherer behaviours is also imbricated within a complex network of productive and reproductive strategies (cf. Bate and Terrazas, 2002). In this sense, it should be comprehended that procurement of lithic raw materials is only a part of a wider territorial conception (cf. Kelly, 1992), in which availability, accessibility and suitability of other biotic and abiotic supplies play their own roles within a multifunctional mobility context.

A feasible way for reaching a greater comprehension of mobility dynamics would be dissecting the archaeological palimpsest (cf. Mallol and Hernández, 2016) that is the SU viii. By doing so, we might be able to define analytical frameworks comprising assemblages whose temporality is closer to the human timescale (cf. Machado et al., 2011, 2015; Vaquero, 2008; Vaquero and Pastó, 2001). Establishing these might precise the general trends discussed here into a whole potential spectrum of possibilities regarding provisioning features and strategies, and might therefore allow us conceptualising these within the frames of Neanderthal behavioural variability across time and space. Despite this, we have aimed to approach provisioning strategies through the indicators derived from siliceous raw materials as well as from other resources.

In this sense, collating data with other proxies relating to different parts of the archaeological record may lead us to infer more deeply the mobility dynamics of these Neanderthal groups. In the frame of SU viii, vegetal, limestone and faunal assemblages are also the result of the Neanderthal provisioning strategies.

As for the plant resources used for fuel, woodwork or consumption, and conserved as charcoal and seeds, they could have been gathered within a circle range from ca. 50m to 1km from El Salt (cf. Vidal et al., 2018). Regarding the limestone cobbles and pebbles utilised mainly as hammerstones but also unusually as exploitable nodules, they could have been acquired either from the dismantlement remains of the Oligocene conglomerate existing in El Salt or from other Oligocene, Miocene and Pleistocene detrital deposits within the immediate vicinities (cf. Molina, 2015). The presence of these two in the entire territory, as well as the water, make these critical resources not be productive tethers for these Neanderthal groups, since those might have been obtained almost anywhere.

The anthropogenic faunal record is mainly composed of deer (i.e. *Cervus elaphus*), horse (i.e. *Equus ferus*) and goat (i.e. *Capra pyrenaica*), with a minor presence of aurochs (i.e. *Bos primigenius*), chamois (i.e.

[8] These features are provisional until technological analyses have been applied on this assemblage.

[9] *Idem.*

Rupicapra rupicapra) and lynx (i.e. *Lynx* sp.), ordered here after the minimal number of individuals (Table 6). The former three inhabited tight mountain-meadow ecotones, open forests and scrublands of medium–high height, without specific climatic requirements given their eurythermal character (cf. Pérez et al., 2017). Since these environments were most likely spread out over the whole territory, indicators of mobility and transportation would have to be addressed from skeletal representations and nutritional indexes among the ungulates (e.g. Marín et al., 2019, 2020; Moclán et al., 2021; Pérez et al., 2020; Terlato et al., 2019).

So, despite the bias that may exist among deer in their differential conservation by bone density (i.e. 0.55p<0.01; cf. Pérez, 2019) and taking into account that the skeletal profiles are made on the entire unit as a whole, we can see a partial transportation of appendicular and axial elements in medium and large-sized ungulates (Table 7). We can put this in relation to a greater exploitation of marrow and unsaturated grease belonging to the appendicular elements. Only small-sized ungulates (i.e. *Capra pyrenaica*) seem to have a general nutritional utility related to the exposure of the entire carcass (cf. Pérez, 2019). The exceptional presence of a chamois is compatible with longer-distance transportation events, supported by the data on flint transporting, especially if we consider that it is a high-mountain taxon that is very rare in Mediterranean Iberian Neanderthal contexts (cf. Yravedra and Cobo, 2015).

At this moment, we are able to state that the orientation of the journeys recognised from this assemblage responds to movements from northeast to southwest. In addition, the almost complete absence of flints whose gathering would have to be done upstream far beyond El Salt denotes a unidirectional character of these movements. This is supported by the predominance of flints that had to be caught mandatorily northerly from El Salt and also by the possible long-distance transportation of high-mountain animal carcasses, such as the chamois (cf. Pérez et al., 2017). Bearing all this in mind, these groups could have been travelling upriver from at least the mountainous lands in which the Beniaia and Catamarruc types were formed and released (Fig. 11).

We do not have any evidence of raw materials or specific taxa with special environmental requirements that could be diagnostic indicators of provisioning either upstream from El Salt or downstream from the Serpis river midcourse. If we may consider that the absence of material brought from upstream beyond El Salt is a marker of the unidirectionality of the movements, we would also have to take into account the lack of record originating from downstream the initial midcourse as indirect evidence of a possible northern limit of procurement routes. This absent septentrional raw materials would be flint elements with signs of postgenetic processes linked to more advanced stages of the midcourse, to the lower course or even to littoral deposits, as well as flint types that would have to be necessarily obtained at least in the Serpis lower course, such as Marxuquera (cf. Molina et al., 2016).

Additionally, these trips made from northeast to southwest had to be involved in wider mobility dynamics. We see the circumscription to a seemingly delimited territory, as well as the combination of an import of northeastern siliceous resources coexisting with a very local exploitation of botanical, faunal, and other siliceous and calcareous raw materials. However, stating reliably a more complex socioeconomic character of these travels, that is, if they are circular residential moves (cf. Binford, 1980), bidirectional logistical expeditions (cf. Binford, 1980, 1986), a blend of both schemes, or anything like it, is something for which we do not have enough evidence. In spite of this, if we consider the occupation temporal patterning of Neanderthal populations in this region (cf. Leierer et al., 2019; Machado and Pérez, 2016; Machado et al., 2017; Mallol et al., 2019; Mayor et al., 2019, 2020; Molina et al., 2010; Pérez et al., 2015, 2020) and particularly that of the lithostratigraphic units IVa and IVb of El Pastor (cf. Machado et al., 2013, 2019), we could suggest the performance of resourcing fluvial itineraries imbricated within a highly mobile context comprising the upper course and the initial midcourse of Serpis river.

6. Conclusions and prospects

Characterising the SU VIII of El Salt from a petroarchaeological perspective has served for establishing that the Beniaia flint type gathered in Pleistocene alluvial deposits was the raw material that was used the most by these Neanderthal groups, followed by Serreta and Mariola, respectively, which are also found in Pleistocene fluvial terraces. These data correspond to a flint-resourcing territory going from the immediate headwaters of the Serpis river, located at more or less 7km upstream from El Salt, to the beginning of its midcourse, situated at approximately 35km downstream.

These data and the proportions in which different flint types and secondary deposits are distributed, compared to other information regarding selection and transportation, have permitted us to establish that flint provisioning dynamics are broadly fundamented on the acquirement of riverside small-sized (i.e. ≳4 and ≲15cm in the major axis) cobbles and pebbles contained within relatively distant deposits. This would be combined with procurement of nearer block fragments and cobbles coming from both colluvial and alluvial deposits linked to the headwaters of Serpis river. Generally, decortication, core configuration and partial debitage have been made before the definitive input of the flint. The degree of intensity displayed by these technical interventions appear to be widely related to distance.

The provisioning dynamics observed here could be defined as based on fluvial itineraries comprising the upper course and the beginning of the midcourse of Serpis river with a predominant input of northeastern flints coexisting with a local resourcing of siliceous, calcareous and nonlithic raw materials.

The significance of studying the link between natural postgenetic alterations and secondary deposits containing flint must be highlighted. Whilst the constraints, the analysis of postgenetic processes befalling flint might allow the researcher to identify procurement areas,

Table 7
Archaeozoological data on subfamilies and species: number of remains (NR), minimal number of elements (MNE), minimal number of individuals (MNI), and skeletal representation by anatomical groups (cf. Pérez, 2019).

TAXA	NR	MNE	MNI	SKELETAL REPRESENTATION BY ANATOMICAL GROUPS				
				Cranial	Axial	Forelimb	Hindlimb	Extremities
Bovinae	1	1	1	0	0	0	1	0
Bos primigenius	6	6	1	0	0	3	3	0
Caprinae	11	10	1	2	3	2	3	1
Capra pyrenaica	21	19	2	1	0	4	11	5
Rupicapra rupicapra	1	1	1	0	0	0	1	0
Cervinae	10	8	2	4	1	2	3	0
Cervus elaphus	75	52	4	5	2	17	42	9
Equinae	7	7	1	5	2	0	0	0
Equus ferus	16	16	3	4	0	2	8	2
Lynx sp.	1	1	1	0	0	1	0	0
TOTAL	**149**	**121**	**17**	**21**	**8**	**31**	**72**	**17**

resourcing itineraries and thus territorial management for ancient hunter-gatherer populations. However, this is only feasible if there is a previous background of thorough geological prospecting and sampling, and qualitative comparison with the archaeological flint record.

This study will be enhanced by upcoming technological analyses regarding the relationships between raw material and technical strategies, as well as by palimpsest dissection approaches that may enable to discern if these were productive trends of the Neanderthal groups, if they varied across time, or even if they could be fragmented into more specific dynamics during the whole formation period of the SU VIII.

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CRediT authorship contribution statement

Alejandro Mayor: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. **Santiago Sossa-Ríos:** Resources, Writing – original draft, Writing – review & editing. **F. Javier Molina:** Methodology, Resources, Supervision. **Leopoldo J. Pérez:** Resources, Writing – original draft, Writing – review & editing. **Bertila Galván:** Funding acquisition, Project administration, Supervision, Writing – review & editing. **Carolina Mallol:** Funding acquisition, Project administration, Writing – review & editing. **Cristo M. Hernández:** Conceptualization, Investigation, Funding acquisition, Project administration, Supervision, Writing – original draft, 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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