Quartzite procurement not only in fluvial deposits: Raw material characterisation of the lithic assemblage from level XXII-R at El Esquilleu, Cantabrian Region, Spain

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Abstract:

The consideration of quartzite as a secondary raw material has relegated in-depth research of this raw material in favour of other rocks such as flint or obsidian. The latter two are the most researched raw materials because of the information derived from their study: long-distance transport of rocks and mobility of people. In contrast, information obtained from research into a wide range of rocks defined as quartzite generally supported near-site procurement areas mainly related to secondary river deposits. This has influenced the poverty of research on the second most-often used raw material during the Palaeolithic. To overcome this narrow perspective, it is necessary to put quartzite in the centre of the debate as a raw material, using an inductive proposal based on geoarchaeological methodologies.

This issue is approached by the application of a multi-scalar methodology that combines thin section analysis, stereomicroscope observation, and X-ray Fluorescence compositional analysis of the quartzite from Level-XXII-R at El Esquilleu. Potential areas where quartzite could be procured, especially river beaches, are also characterised here. The results show complex mechanisms of quartzite acquisition based on intensive and selective searching, not only in proximate river deposits, but also in more distant fluvial deposits and conglomerate formations. Finally, in combination with techno-typological criteria, complex mechanisms of exploitation are proposed. These depended on each quartzite type, which promoted not only lithological but also technological variability. All these data open new perspectives for the characterisation of the second best represented raw material in Europe, as well as for understanding acquisition mechanisms in fluvial deposits and conglomerate formations.

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1. Introduction

1.1. Raw material variability at Middle Palaeolithic assemblages

Variability has been one of the most common terms to define lithic assemblages in the last twenty years of research on the Iberian Middle Palaeolithic frameworks (*e.g.*, Carrión *et al.* 2008; Eixea *et al.* 2020; Navazo & Díez 2008; Rios-Garaizar *et al.* 2015; Romagnoli *et al*. 2018). The technological and typological characterisation of classic and new sequences, following different proxies of analysis, suggest different technical variability and behaviours that go beyond the classical geographic and chronological axes that articulate (Pre)historical interpretations (*e.g.*, Baena Preysler *et al.* 2021; Carrión *et al.* 2008; 2013; Maillo 2007; Rios-Garaizar 2017; Romagnoli *et al.* 2018; Santamaría 2012: 1276-1289; Vaquero & Romagnoli 2017). Geographic, temporal and social fragmentation of the reduction sequences (Baena Preysler *et al.* 2019; Straus 2005; Turq *et al.* 2013), technological adaptations to specific climatic conditions (Baena Preysler *et al.* 2021; Delagnes & Rendu 2011), the relevance of versatility phenomena in determined circumstances (Romagnoli *et al.* 2018; Vaquero & Romagnoli 2017), or even resilience practices (Baena Preysler & Torres Navas 2019; Bradtmöller *et al.* 2017; Rios-Garaizar & García 2015; Rios-Garaizar 2017;) are a few of the multiple ideas that explain this technological variability, not only in Iberia, but also in other parts of Europe.

The geographic distribution and availability of rock potentially used as raw material (*e.g.*, Fernandes *et al.* 2008; Gómez de Soler *et al.* 2020; Prieto *et al.* 2021b; Turq *et al.* 2017;), the format in which the rocks appear in potential catchment areas (Prieto 2018: 151-230; Roy *et al.* 2017; Villeneuve *et al.* 2019) and the knapping and use properties of each lithology, type or variety (Cuartero *et al.* 2015; Daffara *et al.* 2018; Pedergnana *et al.* 2017; Prieto *et al*. 2019b) do not only create lithological variability within and among lithic assemblages but, also influence the aforementioned techno-typological variability. Although basic and primary lithological descriptions of lithic assemblages from the Cantabrian Region had been given since the initial research in the region, solid geoarchaeological methodologies were not applied until the late twentieth century (Sarabia 1999; Tarriño 1998). These pioneer studies, and the proliferous research lines they opened, focused on the characterisation of flint, have determined the source areas of raw materials, while also establishing the physical characteristics of the rock and its behaviour in reduction and use (*e.g.*, Calvo 2019; García-Rojas 2014: Herrero-Alonso *et al.* 2020; Perales 2015; Perales & Prieto 2015; Rios-Garaizar 2020; Tarriño *et al.* 2013; 2015).

Despite being the second most-often used lithic raw material in the Cantabrian Region, quartzite has not received the same methodological attention as flint (Prieto *et al.* 2021a). This omission generates a severe loss of information that biases raw material research through three interrelated axes: a) geographically because the distribution of geological strata causes a loss of information in the western part of the Cantabrian Region, where quartzite is the best-represented raw material, b) a chronological axis, that discriminates raw material research in favour of the Upper Palaeolithic, when flint is the best represented raw material; and c) a interpretative axis that over represents the narratives created by flint studies (Prieto 2020).

This research tries to overcome this situation through the application of a novel methodology to understand quartzite in archaeological contexts (Prieto 2018: 37-150; Prieto *et al*. 2019a; 2020a). The raw material in the assemblage from Level XXII-R at El Esquilleu will be described, especially focusing on quartzite, on its types and varieties (Prieto *et al*.

2019b; 2020) but also its cortical surfaces (Fernandes & Raynal 2006; Prieto *et al*. 2021b; Turq 2005). The most relevant techno-typological features will also be presented to interpret knapping processes and how they were applied to different quartzite types or even single nodules. This information is contextualised with information obtained by surveying in the Deva, Cares and Güeña basins (Cantabria, Castilla y León and Asturias, Spain), specifically searching at potential catchment areas of quartzite (Prieto *et al.* 2021b). The relationships between lower and middle altitudes will be outlined as the determining factors producing particular technical adaptations to specific lithotopes and lithotypes in conglomerates (on plateaus) and (closed and open) river valleys. The relationship between the different approaches applied to the same assemblage allows us to propose the catchment areas and land-use, to inferring past mobility, and allow us to understand how different types of relief were used to enable better economic and social use of the environment.

1.2. The site of El Esquilleu and Level XXII-R

The cave of El Esquilleu is located in the Picos de Europa (Cantabria, Spain) in the northern façade of the Iberian Peninsula (Figure 1). It is located in an area of steep relief, very close to the River Deva, on the western side of La Hermida Gorge. Excavations in Esquilleu began in 1997 in search of Mousterian occupations in this peripheral area. Two perpendicular trenches (14 m^2) were opened as the fieldwork culminated in 2006 with the establishment of a complete stratigraphic and geoarchaeological sequence with 41 archaeological levels without hiatus (Baena Preysler & Carrión 2014). The sequence reached a depth of about 4.2 m, but manual drilling carried out at the bottom of the trench indicated the existence of more than one meter of deposits below.

The Esquilleu series emerged as one of the most complete archaeological sequences, with dates that comprise MIS 4, and even beyond MIS2, around 30 ka BP. Initially, the sequence dating was clearly coherent, except for the results from Levels 6 and 19. The geoarchaeological analysis of the layers and the sequence were presented in a specific publication (Jordá *et al.* 2008). In addition, the sequence at El Esquilleu was analysed by micromorphology (Mallol *et al.* 2010). Level XXII is located in the middle unit, in the so-called ESQ-C (70–90 cm), which comprises the interval between levels ESQ-30 and ESQ-12 (Baena Preysler *et al.* 2021; Jordá *et al.* 2008). It is formed by a succession of thin dark levels (10YR2/2, 7.5YR2/0), consisting of sands with different proportions of silts and clays. Available radiocarbon (OxA-20321 > 59600 BP, on charcoal sample treated by ABA) and luminescence (Mad3299 = 51,034±5114 BP and Mad3300 = 53,4915114 BP, both on burnt clays) dates of level-XXI put level XXII beyond the 50,000 cal. BP. Level-XXII-R, a red coloured homogeneous sublevel is the sample analysed here.

Ibex is the main species in the faunal assemblage from this level, followed by chamois, with a clear absence of deer, bovids and carnivores. However, remains of smaller animals such as ibex and chamois predominate throughout the entire sequence.

The existence of discrete events, with the dominance of particular technological concepts (mainly Quina, discoid or Levallois) (Moncel *et al.* 2014), suggests the persistence of long periods of occupancy with specific changes in the course of the sequence (Baena Preysler *et al.* 2012; 2021). Level XXII-R is inscribed in a wider part of the sequence with a dominance of discoid production and a residual presence of Levallois and Quina debitage. The two latter (Levallois and Quina) appear in the upper part of the sequence. General technological and raw material distribution of the layer XXII is shown in Tables 1 and 2.

Lithic and faunal remains are closely correlated with geological events throughout the complete sequence. Human occupation decreases in the lower levels, until the ephemeral human presence documented in the final part of the sequence.

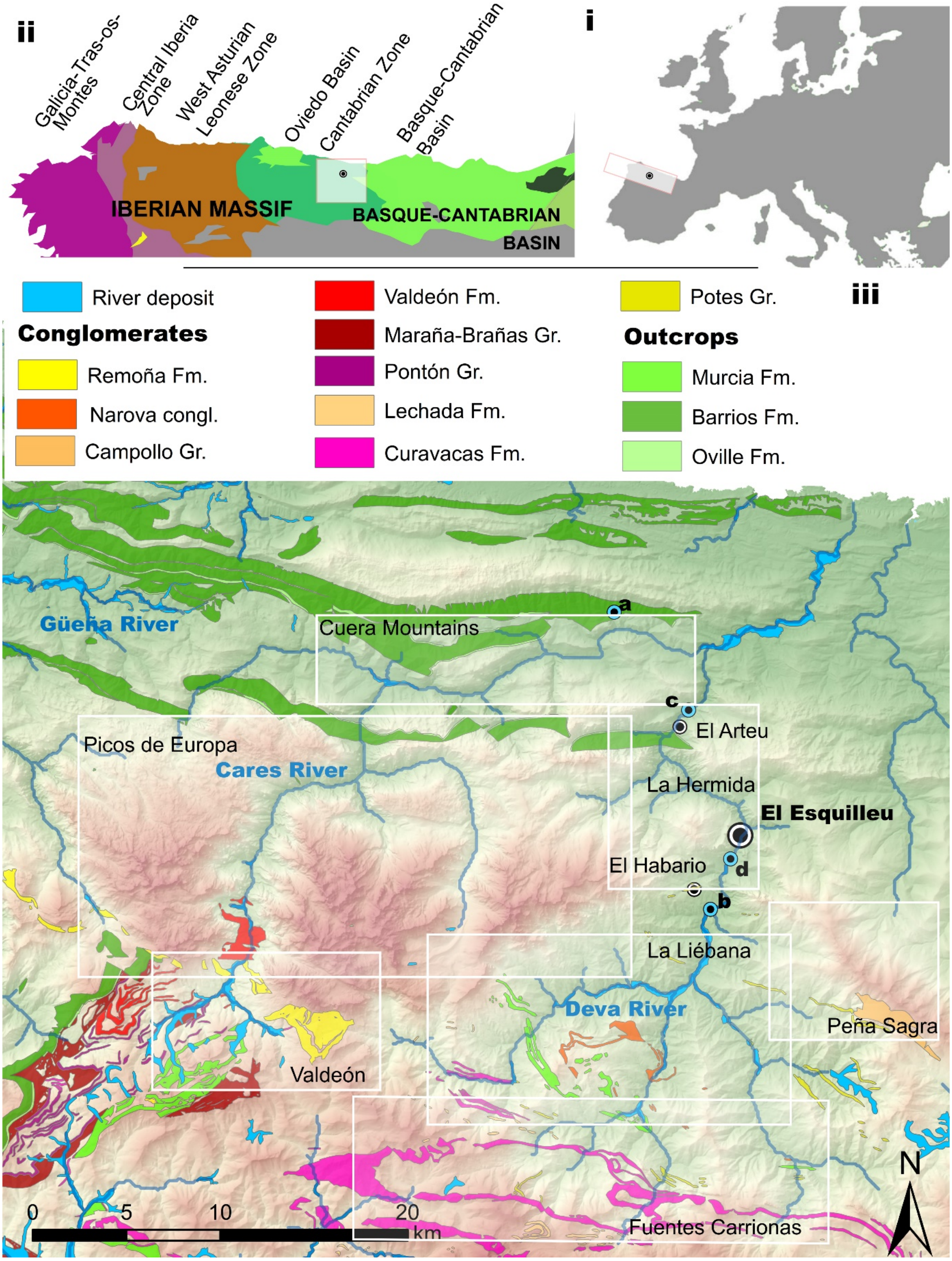

Figure 1. i) The map of Europe showing the location of the research area and the site of El Esquilleu; ii) Most relevant ii) general overview of the north of Spain displaying the main geological zones based on the 1:1,000,000 geological map (Álvaro *et al*. 1994). iii) Geologic map and colour legend representing the research area, the site of El Esquilleu and the other two sites mentioned in the discussion. The geological formations discussed on text (see references therein) are detailed, also river deposits in blue and the location of some sampling sites (a, b, c, d in Figure 4). Main rivers are expressed, also the most relevant zones discussed in the text.

Table 1. Description of the lithic assemblages of Level XXII. Technological categories are presented. N = total number

	Flakes		Flake fragments		Cores		Core fragments		Retouched tools		Knapping fragments		Hammer-stone		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
Lvl- XXII	2264	45.1	1173	23.4	58	1.2	40	0.8	259	5.2	1170	23.3	55	1.1	5019

Table 2. Description of the lithic assemblages of Level XXII. Raw materials described for the complete level XXII and the sample taken from the sublevel XXII-R (J-10). N = total number

	Quartzite & sandstone		Flint, chert & radioralite		Lutite		Limestone		Quartz		Undet.		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Lvl-XXII	4211	83.9	507	0.1	15	0.3	5	0.1	256	5.1	25	0.5	5019	
J-10	684	86.5	39	0.0	8	1.0	0	0.0	40	5.1	1	0.1	791	15.7

2. Methods and materials

The methodology applied is based on a multi-scalar approach that combines Geographic Information System (GIS) analysis, geological field surveys, techno-typological descriptions, stereoscopic observations, thin section petrography and geochemical characterisation.

GIS analysis was performed to integrate the available geographic and geological information, improve the field geological survey (*e.g.*, Herrero-Alonso *et al*. 2018; Prieto *et al*. 2021b; Roy *et al*. 2017) and understand human mobility (García-Rojas *et al*. 2017, based on Llobera 2000 and López Romero 2005; Prieto *et al*. 2016; Sánchez *et al*. 2016). The analysis was grounded on the digital elevation model, as well as on other resources provided by the Spanish National Institute of Geography (IGN 2020) and, especially, the geological maps from the Geological Institute of Spain (IGME), MAGNA 1:50,000 and GEODE series (Merino-Tomé *et al*. 2016). The software used were ArcGIS 10.2 and QGIS (QGIS Development Team 2021). The field considered the three different geological environments where quartzite could be found: outcrops, conglomerates, and secondary deposits (*e.g.*, river beaches). The lithologies, quartzite types and varieties and their morphologies were described at each survey point (Prieto *et al*. 2019a; 2020; Roy *et al.* 2017).

Thin section and X-ray Fluorescence analysis followed the proposal in Prieto *et al*. (2019a). The data acquired were applied to classify each section into seven petrogenetic types already proposed: clastic fabric with matrix or non-quartz cement quartz arenite (MA), clastic quartz arenite (CA), syntaxially overgrown orthoquartzite (OO), sutured grain orthoquartzite (SO), bulging recrystallized quartzite (BQ), subgrain rotation recrystallized quartzite (RQ) and grain boundary migration recrystallized quartzite (MQ) (Prieto *et al*. 2019a). All thin sections were produced and analysed in the Sample Preparation Laboratory (Department of Mineralogy and Petrology, University of the Basque Country-UPV/EHU, Spain). Thin sections were analysed using a Nikon Eclipse LV100N POL microscope. Photomicrographs were taken with a Nikon D90 camera adapted to the microscope. The semiquantitative chemical composition of the lithics was determined by wavelength dispersive X-ray fluorescence (WDXRF) using a PANalytical Axios Advanced PW4400 XRF spectrometer (4Kw Rh anode SST-Max X-ray tube) at the SGIker Facilities (UPV/EHU). After being cut for thin sections, the 17 fresh cuts were directly placed in 20 mm-diameter sample holders. They were measured with 3 Kw excitation power using PANalytical's Omnian standardless analysis software. The analysed sections were ≈300mm^2, except for some very small debitage pieces (100mm^2).

Non-cortical surface characterisation was performed using stereoscope microscopy and following the protocol stablished by Prieto *et al*. (2020). This was based on four different scales of observation. The first one is based on naked-eye description. The second one, uses two ×10 and ×20 hand magnifiers, a stereomicroscope and the Dino-Lite digital microscope to the same magnifications. The third scale employs ×50 magnification provided by the Dino-Lite digital microscope and by stereomicroscopes. The fourth applies ×250 magnification with the first instrument. Most of the pieces were photographed in a flat position to ×50 and ×250 magnification to create a library of reference pictures. We preferentially used Dino-Lite model AD7013MZT with polarized light to eliminate most of the surface lustre. The microscope was handled with the MS35B vertical stand. We used the software Dino-Capture 2.0. The stereomicroscope used was the Nikon SMZ800, with up to ×120 magnification. The association of most features classified each quartzite into the petrogenetic types, but also characterised the grain-size mean value and the non-quartz minerals. The cortical areas were characterized by adapting the proposal made by Fernandes *et al.* (2007) and Fernandes and Raynal (2006). These data were applied to relate the features with specific and potential raw material sources.

Techno-typological analysis was based on Analytical Typology (Laplace 1972), specifically by the application of the latest proposals (Fernández-Eraso & García-Rojas 2013; García-Rojas 2010; 2014: chapter 4) and synthesised by our team (Prieto *et al*. 2020). Metric characterisation was achieved through the weight, following the proposal of Tarriño (2015).

This approach was applied to a sample from the Level-XXII assemblage in the excavated area (4 square metres), specifically to the Square J-10 of the sublevel XXII-R. With the exception of hammerstones, every lithic piece (coordinated ones and those recovered after sieving) was analysed, up to a total of 791 items (684 quartzites). The selection corresponds with the 15.7% of the total assemblage of Level-XXII and consists of a representative sample in technological but especially raw material distribution from sublevel XXII-R (Tables 1 and 2).

From 684 quartzites, nine specimens were selected for thin section petrography and six for XRF analysis (Figure 2). The selection prioritised the internal variability in the orthoquartzite group (n=490), the best represented and the most variable group in this assemblage. It is relevant to acknowledge this research was part of a broader project, the PhD of the first author (Prieto 2018), and the selection of these specimens was done after the characterisation of the seven petrogenetic types previously described, first in the sites of El Habario and El Arteu and later, through the field geological surveys. The BQ type was easily recognised at El Esquilleu thanks to the properties observed through non-destructive methods of the two main varieties, mainly characterised at El Habario and El Arteu (Prieto *et al*. 2019b; 2020). The RQ and MQ types, due to the small quantity and size (relevant for thin section petrography) of them were sampled in the layer XIII (analysed in the aforementioned PhD) thanks to the high number of specimens characterised through non-destructive techniques. Since techniques used (thin section petrography and X-Ray Fluorescence) are destructive, the strategy used (also based on non-destructive techniques) allowed us to gain information with a minimal destruction.

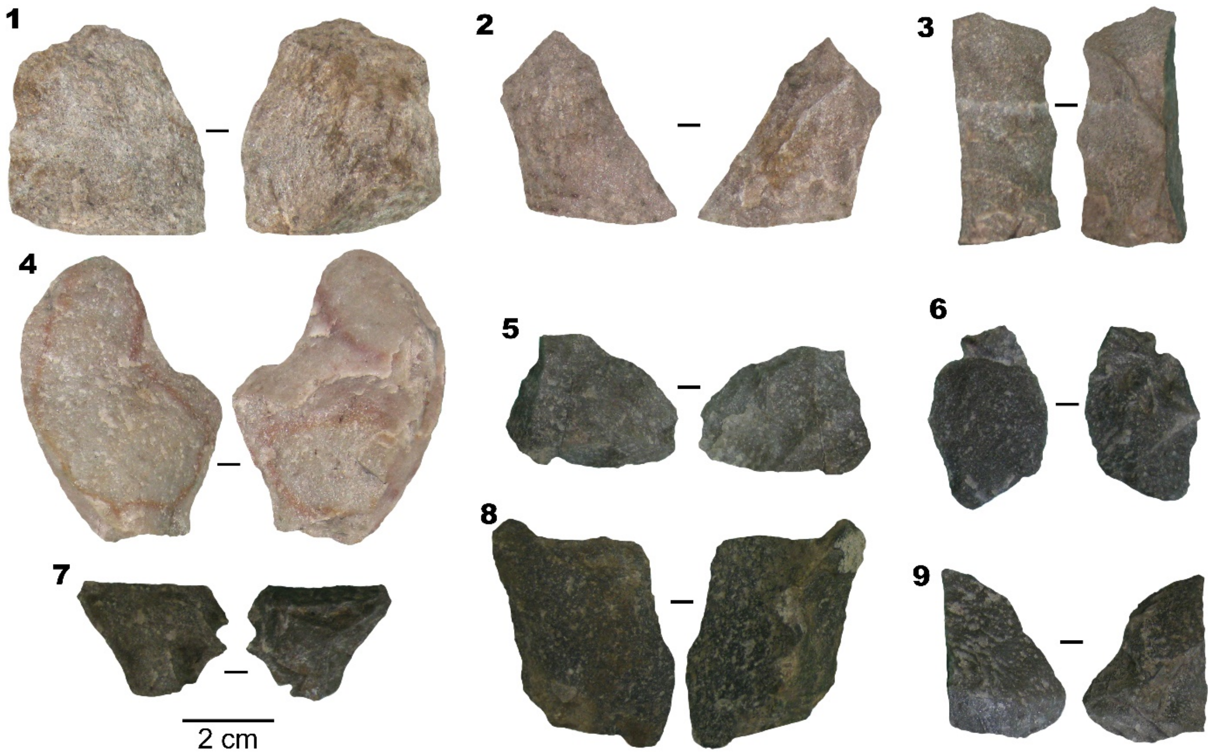

Figure 2. Quartzites selected to make thin section and X-ray fluorescence (marked with an asterisk) from the Level XXII-R. 1) ES-263*: CA type; 2) ES-283: OO type; 3) ES-255*: OO type; 4) ES-245*: OO type; 5) ES-293: OO type; 6) ES-246: SO type; 7) ES-314: SO type; 8) ES-328*: SO type; 9) ES-265*: SO type.

3. Results

3.1. Potential raw material sources

The field surveys allowed us to classify quartzites from 16 geological formations where these rocks could have been collected by prehistoric societies. Six correspond to massive bedrock formations while the other ten are conglomerate formations (Prieto *et al.* 2021b: table 2). In general, in the massive outcrop formations, the direct and intensive exploitation of visible strata would have been easy due to the broad extension and visibility in the study area (Prieto *et al*. 2021b: 495). Moreover, raw material potentially exploited is constrained to MA quartzarenite. The CA and OO types could only be exploited in small areas and proportions from the Barrios Formation (Figure 1) (Prieto *et al*. 2021b: 495-496 and supplementary file 1). In conglomerate strata, rocks could be obtained easily through collection or extraction (Carrión & Baena 1999). However, the extraction is more difficult in the Curavacas and especially in the Campollo Formations (Prieto *et al*. 2021b: 497-499 and supplementary file 2). The dispersion of conglomerates in the area is limited and their visibility is restricted (except for the Curavacas, Campollo, Viorna and Narova Formations and Groups) (Prieto *et al.* 2021b: supplementary files 2 and 5-8) and mainly to the south (Figure 1). Quartzarenites could be acquired in most conglomerates due to its wide representation (Figure 3D). The intense exploitation of OO orthoquartzites only would have been geographically restricted to some conglomerate formations (Remoña, Valdeón, Lechada, Potes and some strata of Curavacas Formations) and it would have required selective mechanisms. SO, BQ and RQ types would have been restricted to a few small conglomerate outcrops in the Valdeón area and the small Remoña conglomerates in the Liébana area (Figure 1). Selective mechanisms would have been required to obtain these types. These siliceous formations have been described in a greater detail elsewhere (Prieto 2018: 151-230 and supplementary information I-VII; Prieto *et al*. 2021b).

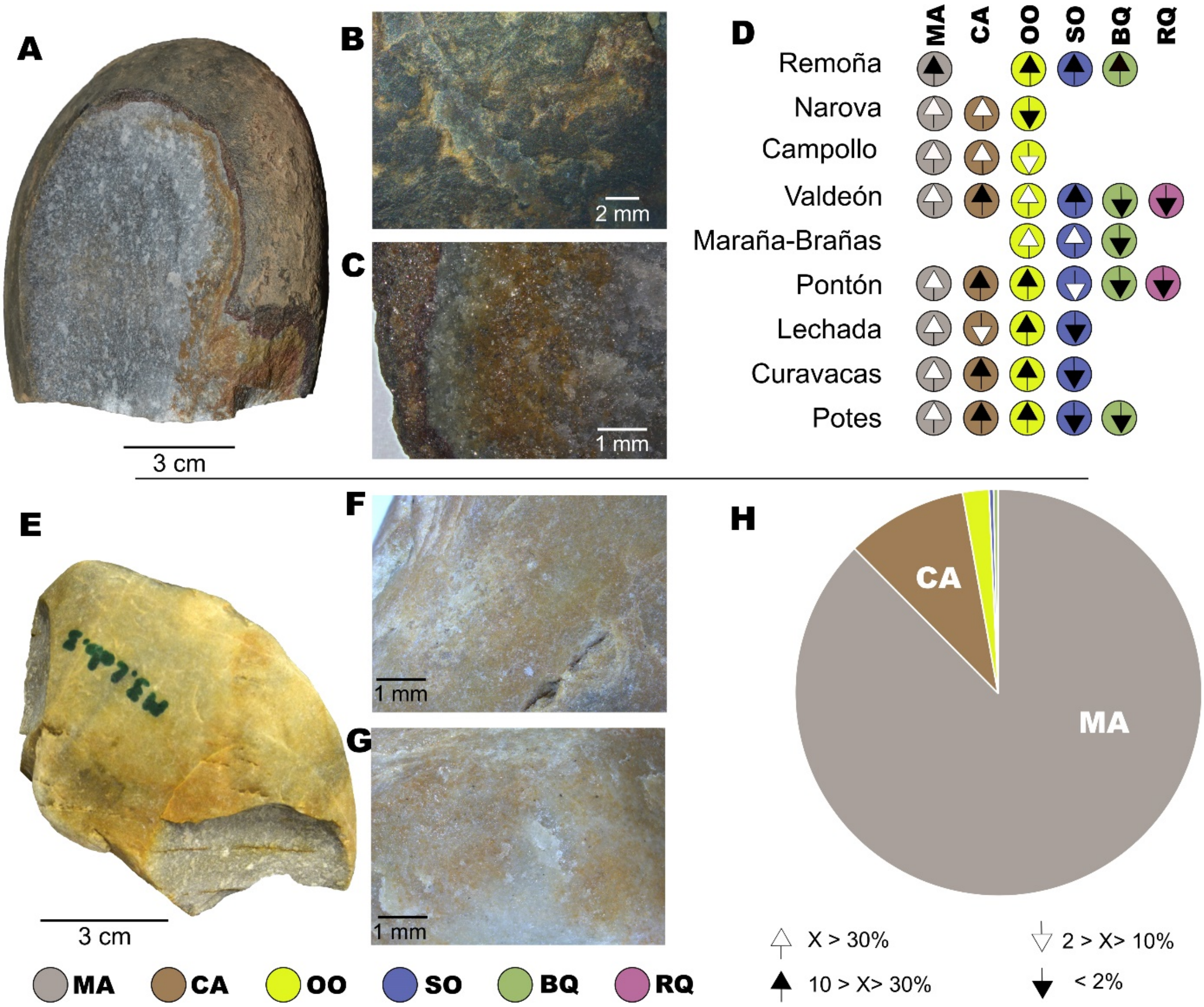

Figure 3. Quartzites derived from a conglomerate (Remoña Formation) and fluvial deposits (near the site of El Esquilleu). The first is a SO type and the second an OO orthoquartzite (A and E). Different textures are observable. The first is rougher than the second, mainly due to cement, making the outer cortical areas darker. Details of representative cortical surfaces: B) conglomerate cement (dark with iron oxides and pyrite) adhered to the neo-cortical surface (black and thin). C) Inner area of the SO orthoquartzite. From left to right, the weathered area of the quartzite (neo-cortex) in contact with the conglomerate cement; the inner area of the quartzite with iron oxides and pyrite crystals inner rim following external morphology of the pebble. The inner area of the quartzite is less weathered. F) Cortical area of the quartzite displaying impact cracks caused by rock impacts in water courses. See also the void generated by water highlighted by the joint system. G) Plain and polished surface of the cortex (soapy texture). D) Representation of the types of quartzite in interesting conglomerate strata. H) Pie chart of quartzites in fluvial deposits, based on Prieto *et al*. 2021b). Arrows pointing up and down indicate relative percentage of each petrological type.

The analysis of secondary sources of raw material suggests that intensive quartzite acquisition would have not been reliable due to the scarcity of this lithology. This is especially relevant for other types than MA (Figure 3). (Detailed information in Prieto *et al*. 2021b: 500 and supplementary files 3 and 9). The availability of CA and OO would have been limited and selective mechanisms must have been applied to acquire them. The gathering of SO, BQ and RQ types is possible, but their proportions are negligible. The lithologies in each river beach are conditioned by the strata immediately eroded by the river system. Moreover, these deposits also contain distant lithologies associated with highly eroded surfaces and spherical morphologies. The survey points located on secondary deposits revealed lithological differences. Siliciclastic materials on beaches are associated with the south of the research area (Pisuerga Carrión Unit), but also with the Barrios Formation strata.

Quartzarenites and OO type (the last one in a small proportion) are related to massive outcrops, while the SO type and quartzites are linked to the aforementioned conglomerates where these are embedded.

Fluvial deposits situated in the headwater of the rivers are generally more ephemeral and smaller. The stones appear as tabular pebbles or clasts and erosion on neo-cortex is not well developed (Figure 4a). In contrast, in non-stepped relief, river beaches consist of big accumulations of rocks, generally in the form of spherical or flattened pebbles with highly-eroded neo-cortex. In the Hermida Gorge, lithologies only derived from conglomerates are scarce, despite the presence of fragments of conglomerates (Figure 4b). The OO type is better represented, especially after the river passes through the Barrios strata (Figure 1c). Moreover, the proportion is low when compared with quartzarenites (Prieto *et al*. 2021b: supplementary file 3). The latter appears in smaller proportion than limestone, the predominant bedrock in this zone. The beaches in this area are variable and smaller where the Gorge is more abrupt (Figure 4c). In contrast, where the relief is less stepped because of the presence of siliciclastic bedrock (*i.e.*, Barrios strata and the Lebeña Formations), beaches are larger (Figure 4d).

Figure 4. River beaches and banks from Deva and Cares Basin. A) La Candaliega Stream (high proportion of quartzarenites, as flatten, tabular pebbles or clasts). B) Deva beach river (quartzarenites, lutites and limestone as tabular, flatten or rounded pebbles, also a conglomerate fragment from the Campollo Group). C) Broader Deva beach river on the Lebeña bedrock (rounded, flatten and tabular pebbles made of limestones, quartzarenites and lutites). D) Small beach on the Devariver (Limestones and quartzarenites as tabular pebbles and clasts).

3.2. Petrological characterisation of the lithic assemblage

Quartzites are the most common rock types, in a proportion of 86%, followed by quartz, flints and cherts, and lutite (Table 1). Focusing on the former, seven petrogenetic types are represented. Orthoquartzite is the best represented group, over 71% (Table 3). Quartzarenite and quartzite groups are underrepresented. Four main varieties were identified: the OO type with medium grain size in both homogeneous and heterogeneous distribution, and the SO type associated with fine grain size, again, in both homogeneous and heterogeneous distribution.

The best represented non-quartz minerals are iron oxides, followed by non-identified black minerals, mica and manganese oxides. Only the latter is associated with SO and BQ types. Pyrite and feldspar are more scarcely represented. The former is related to RQ and MQ types and the latter to quartzarenites. Supplementary File 1 a-c shows detailed petrographic characterisation data and images according to Prieto *et al*. (2019a). Supplementary File 2 contains the X-Ray Fluorescence raw data.

Table 3. Frequency table of petrological features identified in El Esquilleu Level-XXIIR based on binocular characterisation. Columns are petrogenetic types and rows contain the characteristics of grains according to size, classified by distribution and size itself. Percentage inner columns represent the proportion of determined quartz grain size variety regarding each type. Percentages in the total raw refer to the percentage of each type in the full assemblage.

		Petrogenetic type																
		MA		**CA**		**OO**		**SO**		**BQ**		**RQ**		**MQ**		**Unknow**		**Total**
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**N**
Homogeneous and one mode distribution	Fine grain	3	6	4	9	29	9	55	30	22	42	13	76	4	67			130
	Medium grain			7	16	166	54	30	17	11	21	2	12	1	17	2	9	219
	Coarse grain							4	2									4
Heterogeneous and two modes distribution	Fine grain			4	9	8	3	44	24	13	25	1	6			2	9	72
	Medium grain	4	8			1	0	4	2					1	17	3	14	13
	Coarse grain									1	2					2	9	3
Heterogeneous distribution	Fine grain	3	6	3	7	1	0	6	3	1	2							14
	Medium grain	24	45	14	32	97	31	27	15	2	4	1	6					165
	Coarse grain	19	36	12	27	7	2	11	6	2	4							51
Unknown																13	59	13
	Total	**53**	**8**	**44**	**6**	**309**	**45**	**181**	**26**	**52**	**8**	**17**	**2**	**6**	**1**	**22**	**3**	**684**

MA quartzarenites are characterised by its dull lustre and small quantity of microcracks. Texture is saccharoid or grainy and packing range between floating or punctual (Figure 5). Quartz grain features are variable, but they display ruffled and irregular limits generated by the matrix effect. Quartz grain sizes are in the medium and coarse categories, although finer and more homogeneous varieties also appear. Every mineral described in the collection is represented in this type, which is the most variable one. These are also variable in terms of colours (white, brown, and reddish varieties). Bedding is observable in some lithics. White varieties are related to the MA from Barrios or Cavandi Formations, while dark and brown to Murcia or Carboniferous sandstone strata. Most conglomerate formations also contain this type.

The CA implements are characterised by its dull luster, an almost absence of quartz micro-cracks, the granular texture, and the tangential packing (Figure 5). Quartz grain limits are plain, either angular or rounded, and some are modified due to small quantities of cement. Quartz grain sizes are variable but associated with medium and coarse sizes and heterogeneous distributions. Colour is also variable, as are the non-quartz minerals identified. The white variety is associated with white micas, feldspars, undetermined black minerals and iron oxides. Manganese oxides and pyrite crystals are connected with black varieties. There is also a wide spectrum of brownish CA quartzarenites. The thin section of Sample ES-263 indicates the sedimentary nature of this type, as shown by the clastic texture, the tangential packing, the presence of classic quartz grains and a small proportion of siliceous matrix and carbonated cement (Supplementary File 1). XRF data certify that silica content is smaller when compared with other types, and Al_2O_3 and Fe_2O_3 contents are higher (Supplementary File 2).

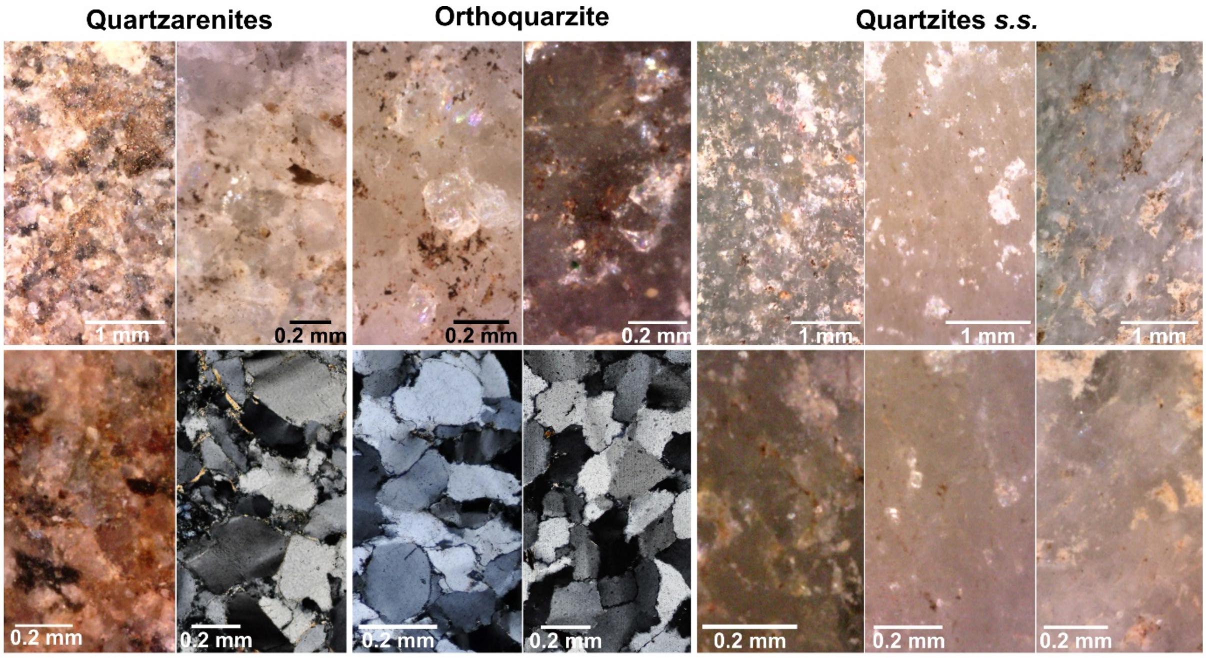

Figure 5. Photomicrographs of quartzite surfaces and thin sections at different magnifications for the seven quartzite types at El Esquilleu Level XXII-R: From left to right: ES-318, an MA type; ES-263, a CA type; ES-245, a OO type; ES-246, an SO type; ES-331, an BQ type; ES-R242, an RQ type; ES-R093, an MQ type.

The OO implements are characterised by its brighter but still low or medium intensity luster, the higher quantity of microcracks, compact but grainy texture, complete packing and, by rounded quartz grain limits surrounded by the halo of quartz overgrowth (Figure 5). The best represented grain sizes varieties are fine-medium with homogeneous distribution and medium-coarse with heterogeneous distribution. There are also other two colour and mineral varieties, the grey-white one (majority), associated with white mica, black and heavy non-identified minerals and iron oxides, and the dark one, with manganese and iron oxides, also with pyrite. Thin sections are characterised by complete packing in a clastic texture with quartz grain overgrowths that make concave-convex limits. Quartz grain sizes differ between the samples ES-255 and ES-283, associated with very fine sands and coarse silt, and the others, related to the fine sand category (Supplementary File 1). Clay minerals are common in all four samples, also mica, rutile and zircon. Although SiO_2 concentration is lower in Sample ES-255 (94%), this component is more common (≈ 97%) than in the previous type (94%) (Supplementary File 2). The higher content of clays between grains explains the smaller concentration of SiO_2. The potential source strata of the lighter colour variety in the area are in the more deformed bands in the outcrops of the Barrios Formations, as well as in the Carboniferous conglomerates and river deposits, although the darker variety is exclusive to the last two.

The SO implements differ from the previous type because luster intensity is higher, the texture is finer (but still grainy) and the packing is suturated, creating flat and ruffled grain boundaries (Figure 5). Thin section petrography characterises these orthoquartzites by the stylolithic joints in quartz grain, the suturated packing and the increase in undulate extinction on section. Three samples have grains preferentially oriented, although they are not easy to observe by non-destructive techniques. In addition, some samples have Böhm lamellae and others, a few recrystallised grains. The two quartz grain size varieties suggest that one is related to fine grains (majority) while the other to bigger grains. Despite the presence of different minerals in the analysed samples and their identification on the surfaces, we do not observe clear associations between them, or with their (also variable) colours. Pyrite crystals are frequent (Supplementary File 1). The potential sources in the research area of this type are restricted to the conglomerates at Lechada, Maraña-Brañas, Pontón, Potes, Remoña and Valdeón and fluvial deposits.

The BQ quartzites in this assemblage are characterised by their fine texture, suturated packing, flat and ruffled limits of quartz grains (when they are identified). The luster is more intense than in the previous type and foliation is obvious in most of the samples (Figure 5). Most of the BQ assemblage has quartz grain sizes around the fine category, although coarser grain sizes are represented too. In this case, colour and mineral identification point to the presence of three varieties. The first is characterised by the presence of iron oxides, white micas and black and non-identified minerals, as well as pyrite. These quartzites are grey or brown and they are well represented. The other two varieties are: the black one associated with manganese oxides; and the white one, associated with white micas. This type could be acquired in the conglomerates at Remoña, Valdeón, Pontón, Maraña-Brañas Pesaguero and Potes and the river beaches.

The RQ type has a soapy texture, absence of quartz grain boundaries (mainly) and few suturated borders (Figure 5). The intensity of the luster is high and vitreous, and micro-cracks are much more limited than in the previous three types. Foliation structures were detected on few surfaces. Due to the small quantity of RQ quartzites, grain size varieties were not detected. While some black varieties are related with manganese oxides, the sample is too small to establish correlation. RQ quartzites could only be found in the research area in the Pontón and Valdeón conglomerates and in the Cares river fluvial beaches.

The MQ type is also characterised by a soapy texture, but in this case, the surfaces are even more translucent than in the previous type and the grains are not recognisable (Figure 5). The luster is high and micro-cracks are variable. The small quantity of this quartzite in the assemblage prevents the determination of grain size or colour varieties, but the pieces are associated with fine or medium sizes and white or white-grey colours with few non-quartz minerals. Our survey in the research area did not identify the presence of this type.

Cortical surfaces are represented on 19% of the complete assemblage (Figure 6). On flint (1), radiolarite (1), and quartz (2), only a few pieces preserve those surfaces, but on quartzite (144) and lutite (2) is better represented. Focusing on quartzite, cortex is better represented on the RQ, CA and MA types than on the others, especially MQ and BQ types. Cortical areas derived from conglomerates are represented on 15% of the lithics which preserve these areas. These neo-cortex are characterised by the presence of cement, recognisable as red iron oxides or dark silica precipitates derives by the cement or the matrix of the conglomerates. Voids are filled by this cement and impact cracks are hinder by the latter. Neo-cortex is generally thin and darker in colour, coating also inner areas nearest to the outer zones. It is associated with the presence of pyrite microcrystals and their alterations due to the cement of conglomerates. Cortical areas derived from fluvial or alluvial sources are better represented (76%) and are characterised by fine or soapy textures with impact cracks and voids. Cement is almost absent and the inner part is much more weathered, creating thicker neo-cortical areas (especially on quartzarenites). The cortex type distribution is significantly different between types, especially when quartzites and the SO type are compared with the quartzarenites and the OO type χ^2 (6, n = 130) = 44.721, p < .001 (Figure 6). We did not identify evidence of cortex or neo-cortex from exposed or weathered massive strata of quartzites.

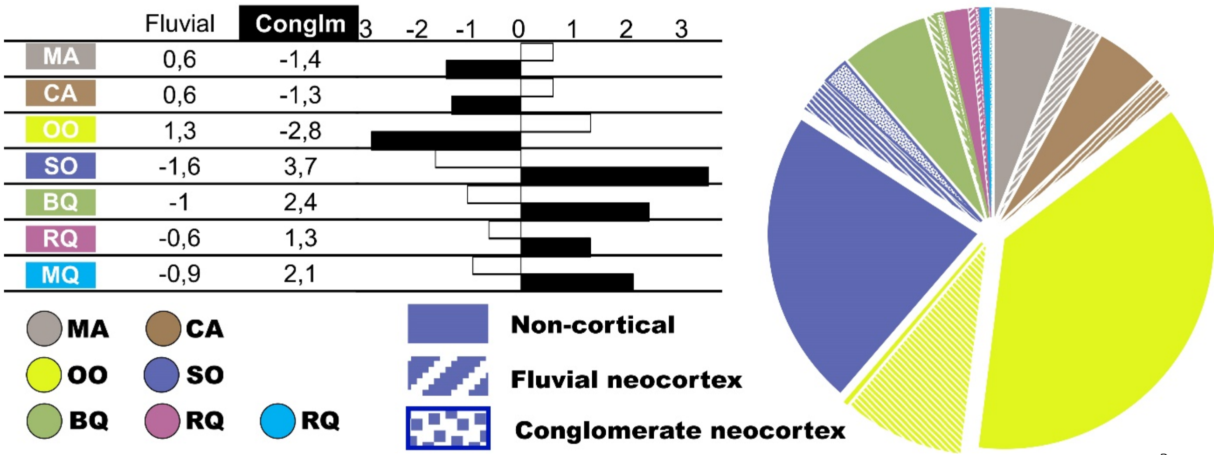

Figure 6. Preservation of cortical surfaces in Esquilleu Level XXII-R. On the left, standardise residues of χ^2 test of quartzites. On the right, pie chart representing the distribution of quartzites and cortex associated.

3.3. Techno-typological characterisation

The most frequent technological category is knapping products, followed by chunks (material modified by humans without features to classify them as cores or knapping product) and cores. Cores are made on quartzite, flint and quartz and they are relatively more abundant on the latter two lithologies. Except for lutite, only represented by knapping products, there are chunks in every raw material, suggesting knapping processes of these lithologies in the site (especially when chunks are small in size). Focusing on quartzites, technological products are differently distributed among petrogenetic types (χ^2 (12, n = 662) = 28.211, p = .005). There are no cores in RQ and MQ types and chunks in these types are scarce. In addition, the latter category is not represented in the BQ type (Table 4). Moreover, cores are more abundant in the CA, SO and BQ types than in others. Chunks are overrepresented in the MA and MQ types. Cortex is better represented on cores (43%) rather than on chunks (32%) and, especially, on knapping products (19%).

Table 4. Main technological category distribution of each raw material. The % columns are the percentage of each raw material in relation to each technological category, while % rel. is the percentage of each technological category in relation to each type.

	Technological order										
	Cores			Knapping product			Chunk			Total	
	∑	%	% rel	∑	%	% rel	∑	%	% rel	∑	%
MA	1	4.8	1.9	43	7.1	81.1	9	16.7	17	53	7.7
CA	2	9.5	4.5	39	6.4	88.6	3	5.6	6.8	44	6.4
OO	2	9.5	0.6	287	47.1	92.9	20	37	6.5	309	45.2
SO	10	47.6	5.5	158	25.9	87.3	13	24.1	7.2	181	26.5
BQ	4	19	7.7	48	7.9	92.3	0	0	0	52	7.6
RQ	0	0	0	16	2.6	94.1	1	1.9	5.9	17	2.5
MQ	0	0	0	5	0.8	83.3	1	1.9	16.7	6	0.9
Undetermined	2	9.5	9.1	13	2.1	59.1	7	13	31.8	22	3.2
Total	**21**	**3.1**		**609**	**89**		**54**	**7.9**		**684**	

Regarding cores, cores on flakes are the best represented and are characterised by the small occurrence of percussion platforms and flacking surfaces, generally not more than one. They are better associated with SO and BQ types (also flint and quartz), pointing into ramified strategies associated to high quality raw materials. Irregular cores are associated with the SO type, and they do not show hierarchical extractions, generally displaying more than two percussion surfaces and more than two flacking surfaces. Discoidal and Levallois cores are similarly represented. The first configured on quartz, quartzarenite and orthoquartzite, while the second only on the last group. This can be determined by the properties of different raw materials or quartzite types. Finally, a prismatic core was made on quartz (Supplementary File 3). Cortical areas are better represented on discoidal cores than on others, especially cores on flakes. The cortex type distribution follows the general tendency.

Out of the 679 knapping products, there are nine core preparation or rejuvenation products. They were made on OO and SO orthoquartzites, also on flint and quartz. Blanks display more negative extractions on flint, quartz and radiolarite rather than on lutite and quartzite (Supplementary File 4), suggesting differential exploitation degree on each raw material. Although there are no clear differences between types in the latter raw material, RQ and MQ types always have one or more scars. This situation is different when comparing the types with the remaining cortical surfaces, in which a clear gradation from broader to narrower preservation of cortex is observed from the quartzarenites to the quartzites *s.s.* (Supplementary File 5).

Retouch is only observed on 53 artefacts in the assemblage. Of these, six have two different primary types of retouch. Retouch is significantly better represented on flint and quartz than on other raw materials (χ^2 (4, n = 791) = 25.030, $p < .001$). On quartzites, small differences are observed when it is compared by petrogenetic types because BQ, SO and RQ types are retouched more than others. Most of the artefacts were retouched through the simple mode and following sidescraper morphothemes. Endscrapers are scarce and only configured on quartz and radiolarite. Denticulates are made on flint and orthoquartzites and the only point is made on RQ quartzite. Splintered pieces are configured on the OO type (supplementary files 6). Despite sidescrapers are overrepresented and the small number of pieces analysed, determined quartzite types guided latter modifications.

The weight distribution between raw material indicates that quartz (M = 3.7 g) and quartzites (M = 3.4g) are heavier than radiolarite (M = 1.5 g), flints (M = 2.2 g) and lutite (M = 2.9 g). Although Kruskal-Wallis test did not unveil statistical differences between petrogenetic types, (χ^2 (6) = 11.906, p = 0.064), quartzarenites (M = 5.1g) are heavier than orthoquartzites (M = 3.4 g) and quartzites (M = 2.7 g). This is more obvious when categories are compared by petrogenetic types (Figure 7). Small differences arise in cores, especially when comparing the discoidal cores (M = 39.9 g) with irregular (M = 13.6 g), Levallois (M = 11.3 g), and, of course, cores on flake (M = 6.0 g). The formers are generally made on quartzarenites.

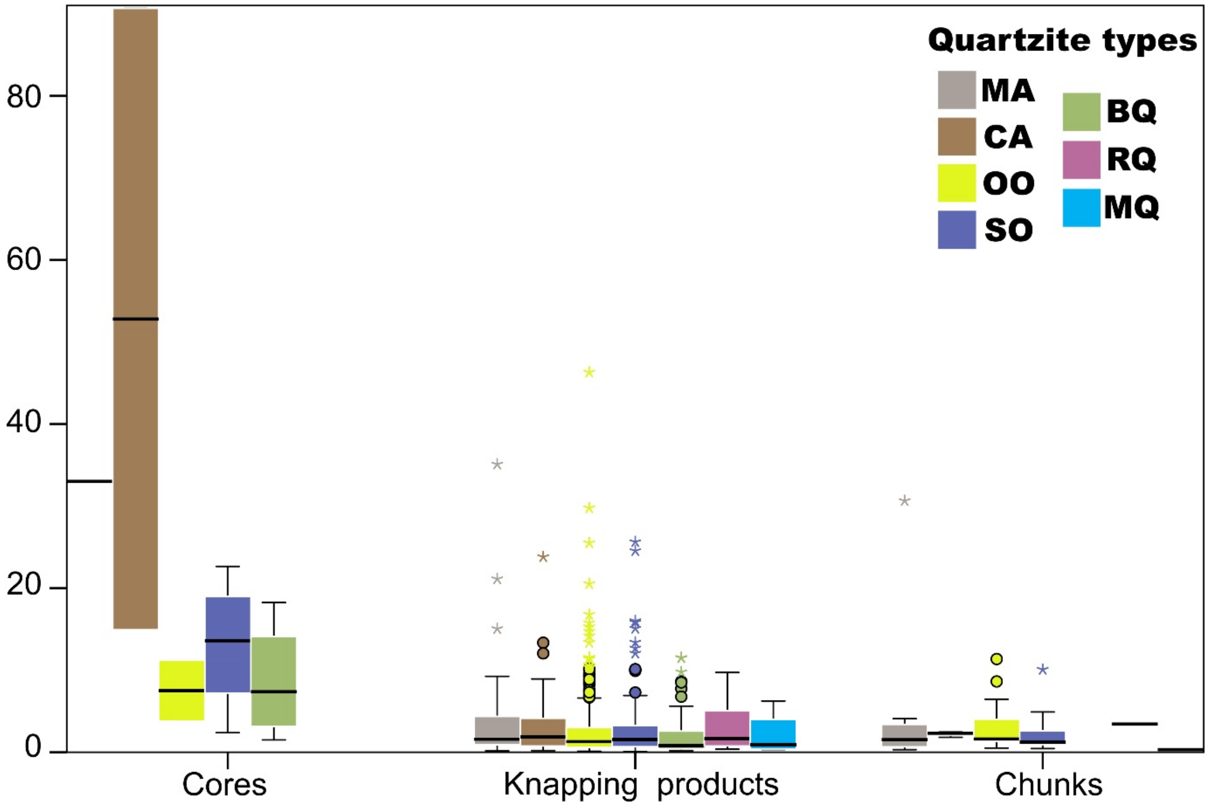

Figure 7. Boxplot with the distribution of weight in grams of quartzite remains grouped first by technological order and by raw material in the chart on the left, and by petrogenetic type in the chart on the right.

Finally, the weight of the lithics with cortex differs between those derived from fluvial sources (*M* = 5.36 g) and from conglomerates (M = 4.5 g). This is reinforced when they are classified by petrogenetic type (Figure 8a). It is also remarkable that lithics which preserve cortical areas are heavier in the BQ, SO, and even OO types than on the quartzarenite group. The weight distribution of blanks differs between those without or with small cortical areas and those with broader cortex. This is clearer in quartzarenite than in others (Figure 8c). In addition, it is noteworthy that most of the blanks with complete or almost complete cortical dorsal surfaces are thinner than those with less extensive cortical zones (Figure 8b; *e.g.*, numbers 4 (OO), and 8 (SO) from Figure 2).

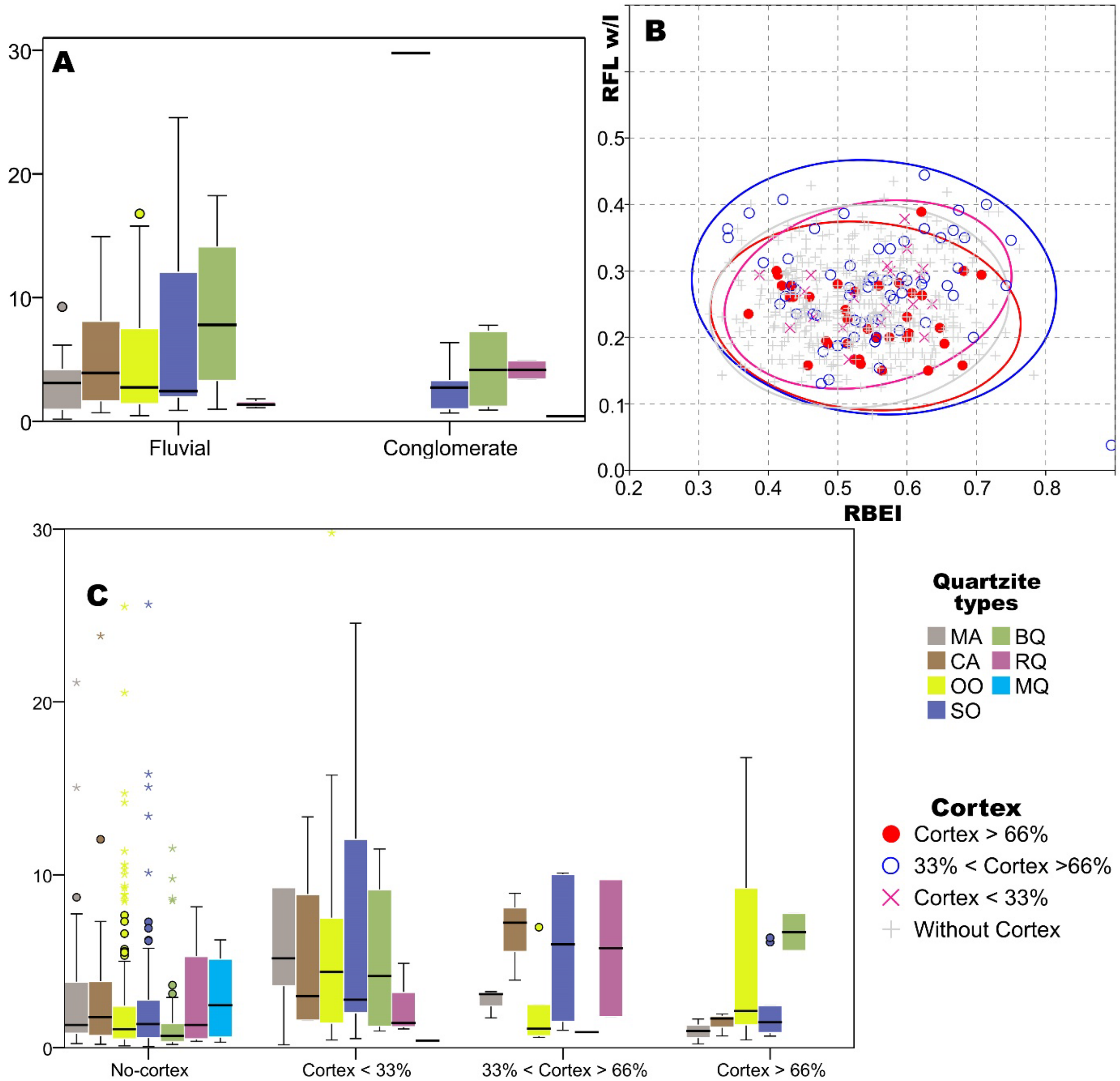

Figure 8. A) Boxplot with the distribution of weight in grams of quartzite with cortical areas grouped by cortex type and by quartzite types. B) Scatter plot of RFLw or RFLl, (Flatness Index) and RBEI (Elongation index) for blanks according to the quantity of cortex on them. Ellipses represent 95% of cases. C) Boxplot showing the distribution of weight in grams of quartzites grouped by cortex preservation and by quartzite types.

4. Discussion

4.1. Management of quartzite as a factor to understand technological and lithological variability in El Esquilleu Level XXII-R

The results suggest high variability of technological products, especially when they are compared with the types of quartzites and other raw materials (Figure 9). Complete and long reduction sequences were represented on orthoquartzites. Moreover, the different preservation of cortex, the weight distribution or the intensity of retouch suggested that the SO type was exploited much more intensively than the OO type. In addition, the small quantity of cores on the latter type and the size and morphology of cortical flakes reinforces the different managements between types. Therefore, the OO type could be introduced in the site as knapping products detached from the cores on the procurement areas, while the SO type was introduced in the site as cores. The high presence of cores on flakes on the SO hint into ramified process of production and geographically fragmented on a good quality raw material as seen in other places such as Amalda VII or the upper layers of Axlor with flints from Treviño, Flysch or Urbasa (*e.g.*, Rios-Garaizar 2010; Rios-Garaizar *et al*. 2015).

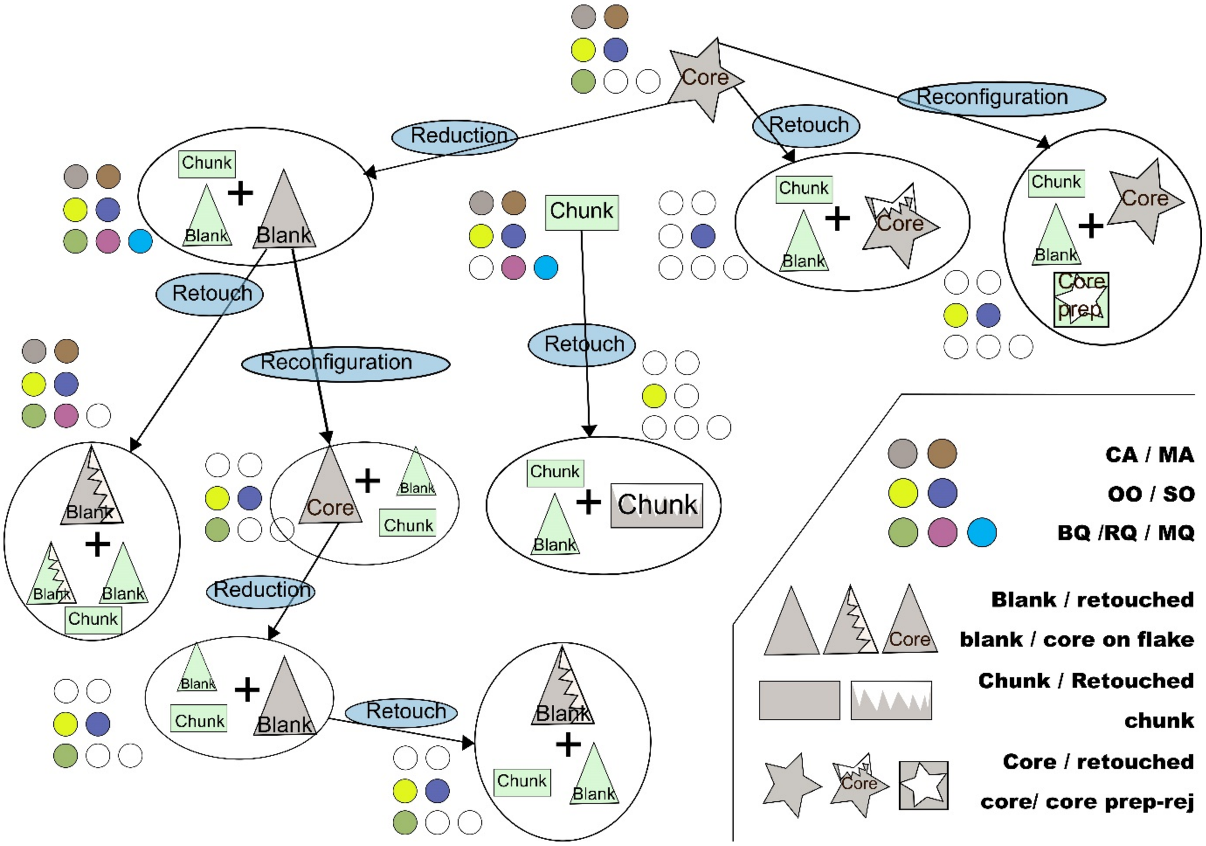

Figure 9. Schematic and basic reduction sequence derived from the analysis of the Level XXII-R from El Esquilleu. Highlighted in colours and associated to each process are the types of quartzites represented.

The absence of core preparation or rejuvenation products, the higher variability of blanks, and the lack of standardisation on the few cores in the quartzarenite group point to expedient knapping behaviours, probably related to the extraction of big flakes in the initial steps of the reduction sequence in and outside the site. The absence of core on flakes on both types (MA and CA types) – especially when this is compared with SO type, flint or quartz – does not suggest ramified productions. Therefore, the quartzarenites were introduced, used, and amortised in form of broader blanks. The small proportion of retouch, the weight distribution, the broad cortical areas, and the small quantity of negative scars suggest that quartzarenites were not intensively exploited at the site. In addition, and as revealed by mineral and grain size heterogeneity, input into the site could have been in the form of big flakes derived from multiple pebbles or Raw Material Units (RMU) (Roebroeks 1988: 29). The physical features of these quartzarenites conditioned the knapping of the material.

Finally, the quartzite group is characterised by fragmented management in the last steps of the reduction sequence which favoured the intensive exploitation of the material. Cores (mainly cores on flakes) are limited to the BQ type and their features and weight suggest intensive exploitation, and a possible existence of ramified in an optimal, suitable but scarce raw material. Similar behaviours were also observed in other levels from El Esquilleu, despite the characterisation of quartzites was done through macroscopic and interpretative raw material criteria (Baena Preysler *et al*. 2021; Cuartero *et al*. 2015) The small quantity of items, the representation of retouch on the artefacts and the weight distribution supports this interpretation. This group, but especially the RQ and the MQ types suggest conservative management of non-abundant lithic masses, slightly knapped and re-sharpened.

The comparison between these patterns with those documented at the site of El Habario and El Arteu (Prieto *et al*. 2020) suggests different management of quartzite as consequence of the different roles of each site. At El Habario, the initial transformation of the OO, but especially SO and BQ into suitable raw material was obvious. This was pointed out by the high quantity of cores, the knapping products with high broad cortical areas derived from conglomerates and the representation of core preparation or rejuvenation products in the aforementioned types (Prieto *et al*. 2020: 15-17 and 19). Those types are well represented in the Remoña formation conglomerates, which are adjacent to the site. In El Esquilleu XXII-R, this behaviour is only revealed by the OO and maybe the SO type, but these stocks seem to be amortised at the site. The use of MA and CA types point to a similar use as at El Arteu (expeditive resource), but the input of more varieties and higher proportions (therefore, RMU) suggest a more stable and probably longer habitat at El Esquilleu (level XXII) than at El Arteu. The higher quantity of BQ and MQ types at the last site underpin previously proposed site functionality: a hunting post (and probably short-term occupation) where raw material stocks and probably toolkits were transported from a central place to be amortised in the acquisition of resources in this area (Baena Preysler *et al.* 2005).

Differential management of raw material in the Iberian Middle Palaeolithic has been broadly documented (*e.g.,* Carrión 2002: 1100-1018; Eixea *et al.* 2016; Maillo 2007; Rios-Garaizar 2005). Moreover, differential management depending on types or varieties of a specific type of rock was not frequent and, except for the few examples in which flint (*e.g.*, Eixea *et al*. 2020; Gómez de Soler 2020; Rios-Garaizar 2020; Romagnoli *et al.* 2018; Santamaría 2012: chapters 6 and 7) or quartzite (Prieto 2018: 533-548; Prieto *et al*. 2019b; Prieto *et al*. 2020) types were established through solid geoarchaeological approaches, such differences were only based on interpretative criteria derived by the knapping quality or even grain size, the latter without precise determination of grain size distributions (*e.g.*, Baena Preysler *et al.* 2021; Cuartero *et al.* 2015; de Lombera-Hermida *et al.* 2020). These studies hint that either raw material was an important factor to produce specific reduction sequences (mainly those with higher requirements such as Levallois or laminar production) or Middle Palaeolithic people adapted specific reduction sequences to particular raw materials. It is relevant to mention that in other cases, raw material quality plays a secondary role, other aspects being occupation patterns (as discussed previously or in Abric Romaní (Gómez de Soler *et al.* 2020; Romagnoli *et al.* 2016; 2018), mobility strategies (*e.g.*, Gómez de Soler 2020; Rios-Garaizar 2020), land use (Prieto *et al.* 2020) or even other (still) under-discussed factors (Eixea *et al*. 2020). These proposals were also debated in other parts of Europe pointing to raw material management as an important factor to understand lithic variability in Middle Palaeolithic contexts, proposing also new hypothesis to understand the way of life of the inhabitants of Europe 50,000 years ago (Prieto *et al*. 2019b; Turq *et al*. 2013; Villeneuve *et al*. 2019).

4.2. Quartzite procurement at El Esquilleu, Level XXII-R

The data show that quartzites, but also other raw materials, were mainly obtained on river beaches. However, procurement also took place in conglomerates formations (Figure 10).

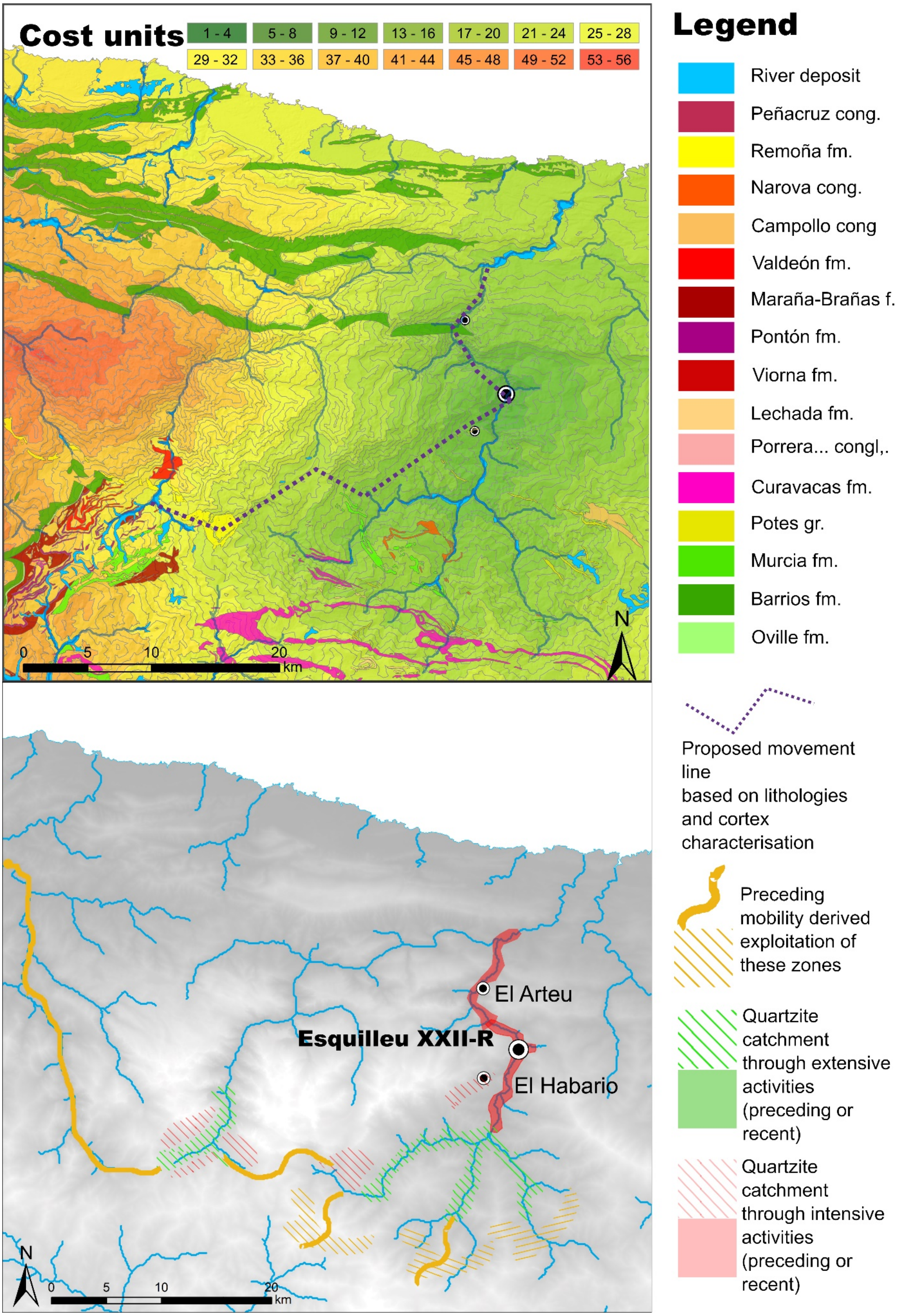

Figure 10. Cost map to strata where interesting quartzite could be acquired on the research area (on the left). Quartzite procurement areas map (on the right).

The direct acquisition in the river was carried out by applying a raw material selective mechanism. On river beaches, the proportion of lithologies selected is low, except for MA quartzarenites. They can easily be collected, but a small selection effort must have been made to obtain varieties which allow a minimum knapping control (like those described at the site). As shown by the number of MA on the level, together with their different grain size and colour-mineral varieties, they were knapped on the fluvial beaches to finally select and transport the most interesting blanks. These were taken to the site and amortised there. It is important to note that El Esquilleu is quite near to an area susceptible to form beaches or banks in which this and other types (CA, OO, SO and BQ) where represented in similar formats (spherical or flatten) to those observed in the assemblage (Figure 1). The CA type, despite its smaller proportion in fluvial areas was also procured in similar conditions despite the presence of few cores. The OO type was mainly acquired in these deposits but intensive searching and selection were required. Nodules, and probably blanks were taken to the site and, then cortical weathered areas were probably removed. These processes could have been made, not only on the adjacent beaches, but on longer circuits (especially after the Deva and Cares rivers erode the Barrios strata) in an economic mechanism which exploited the area in search of different vegetal and faunal resources associated to riverine environments (Uzquiano *et al.* 2012; Yravedra & Gómez-Castanedo 2014; Yravedra & Uzquiano 2013). The entrance of the cave of several RMUs of all these types suggest either a long habitat stability inserted in a residential model, as proposed by Baena *et al*. (2012), in which several individual episodes of acquisition were accumulated in El Esquilleu; or a long or short habitat stability where group procurement was carried out in near fluvial beaches, as proposed in other contexts (*e.g.*, Romagnoli *et al.* 2018). It should be added that a very small proportion of this type was also acquired on conglomerates, possibly as a secondary product in areas where other types, *i.e.*, SO and available quartzite types are the main focus of exploitation (Prieto *et al*. 2020; 2021b).

The acquisition of other types suggests greater importance of procurement from conglomerates. Some suggestions can be proposed to understand how they were procured. The SO orthoquartzite assemblage suggests that they were procured similarly from conglomerates and on river beaches. The latter were probably in the River Deva, but also at the headwater of the Cares, where this type is more abundant. In the first area, the raw material must be selected, and its procurement is related more to mobility or the exploitation of these areas to acquire other resources, rather than to planned procurement of this type. In the second area, its acquisition was more intentional and planned. This idea connects with the acquisition of this type (but also the quartzite group) in conglomerates.

The metamorphic quartzites were mainly procured on the conglomerates and the distant river beaches, especially in the area suggested above, the headwater of the River Cares. The conglomerates with *s.s.* quartzites and the SO, therefore, became important landmarks on the economic routes that allowed Middle Palaeolithic populations to manage and inhabit this region. We consider two different hypotheses to understand these data. The first relates the procurement of these quartzites and SO type in conglomerates with a broad residential mobility in which these products were transported to different locations following a conservative use of the raw material. In this case, the conglomerates and their surrounded areas where successively exploited probably alternating these zones with riverine ones reinforcing the high mobility in the area as proposed by other proxies of analysis at the site (Baena Preysler *et al*. 2013; Carrión *et al*. 2008) or in other Iberian Palaeolithic contexts (*e.g.*, Abric Romaní Level P and Oa: Gómez de Soler *et al*. 2020). The second hypothesis suggests a more complex behave that articulate, through a logistic model, different biotopes and being the site of El Esquilleu a central camp where resources from different ecosystems were put together. Still, this explanation given to the central part of the sequence (Baena Preysler *et al*.

2013; Carrión *et al*. 2008), does not fully agree with the data discussed in previous paragraphs, neither with previous research. Finally, it should be noted that the RQ type was not found in the research area, and therefore it must have been procured elsewhere, reinforcing the residential (and high) mobility practice by inhabitant of El Esquilleu.

All in all, these hypotheses point to a different management of resources that articulated two types of terrain (Figure 11). The first was based on the use of middle altitude plateaus, where the conglomerates crop out (Prieto 2018: 528-548; Prieto *et al*. 2019b; 2020; 2021b). These areas were important to acquire raw material, but also to easily move between different valleys in the region, as shown by the cost map (Figure 10a). The other resources, more intensively explored in this research, were based on a fluvial exploitation mechanism, where beaches played an important role in the long-term habitats which intensively exploited these biotopes (Baena Preysler *et al.* 2021, also in Roy *et al*. 2017). The latter is shown by the geoarchaeological analysis of lithic assemblages from Esquilleu Level-XXII-R and the potential catchment area of quartzites, mainly conglomerates and fluvial deposits. Faunal and anthracological analysis also point to a similar conclusion in which local resources were intensively used at the site in level-XXII (Baena Preysler *et al.* 2021; Yravedra & Gómez-Castanedo 2014; Yravedra & Uzquiano 2013).

5. Conclusions

The main goal of this paper was to explore how raw materials, in particular quartzites, contribute to the lithic variability in Cantabrian Middle Palaeolithic contexts, but also to understanding the reasons behind this. To do so, a transdisciplinary and multiscalar geoarchaeological methodology was successfully applied to the quartzite assemblage of the Level XXII-R of El Esquilleu cave.

The data here exposed suggests that raw material, and quartzite, in particular, constitutes an important vector in the promotion of lithic variability in this Mousterian assemblage. The different quartzite types described in the level-XXII, also in the research area, are varied because of the different formative processes involved in their petrogenesis (from pure sedimentary process to complex metamorphic ones), but also due to the origin of the properties of the former sediments. Besides, the long geologic history of this material dated at least from the Cambrian (~500 Ma), contributes to the aforementioned variability because of the different geological contexts where this rock could be procured by prehistoric populations (outcrops, conglomerates and secondary deposits). Behind this lithological variability in the assemblage, complex and varied procurement and management strategies were practised by the inhabitants of the cave. The firsts are related to procurement in near (mainly) and far fluvial deposits, on the one hand, and also in middle and far conglomerate formations, on the other. The catchment in river deposits was probably done through several episodes of group or individual procurements based on intensive searching of determined quartzites together with other activities carried out in riverine areas. The procurement on conglomerates was done in preceding moments to the occupation of the site, probably integrated into residential mobility along with or through the Deva, Cares and other Cantabrian valleys. The varied and complex management strategies point into a) the exploitation and fast amortisation of local and more abundant lithic resources (MA, CA and partially OO types) for expedient tasks in non-exhaustive or weak exploitation; b) the intensive exploitation of non-local and less abundant quartzites (partial OO, SO and quartzite group) in geographical and temporal fragmented reduction sequences (probably ramified); and, c) a technical and typological adaptation to determined quartzite types and varieties.

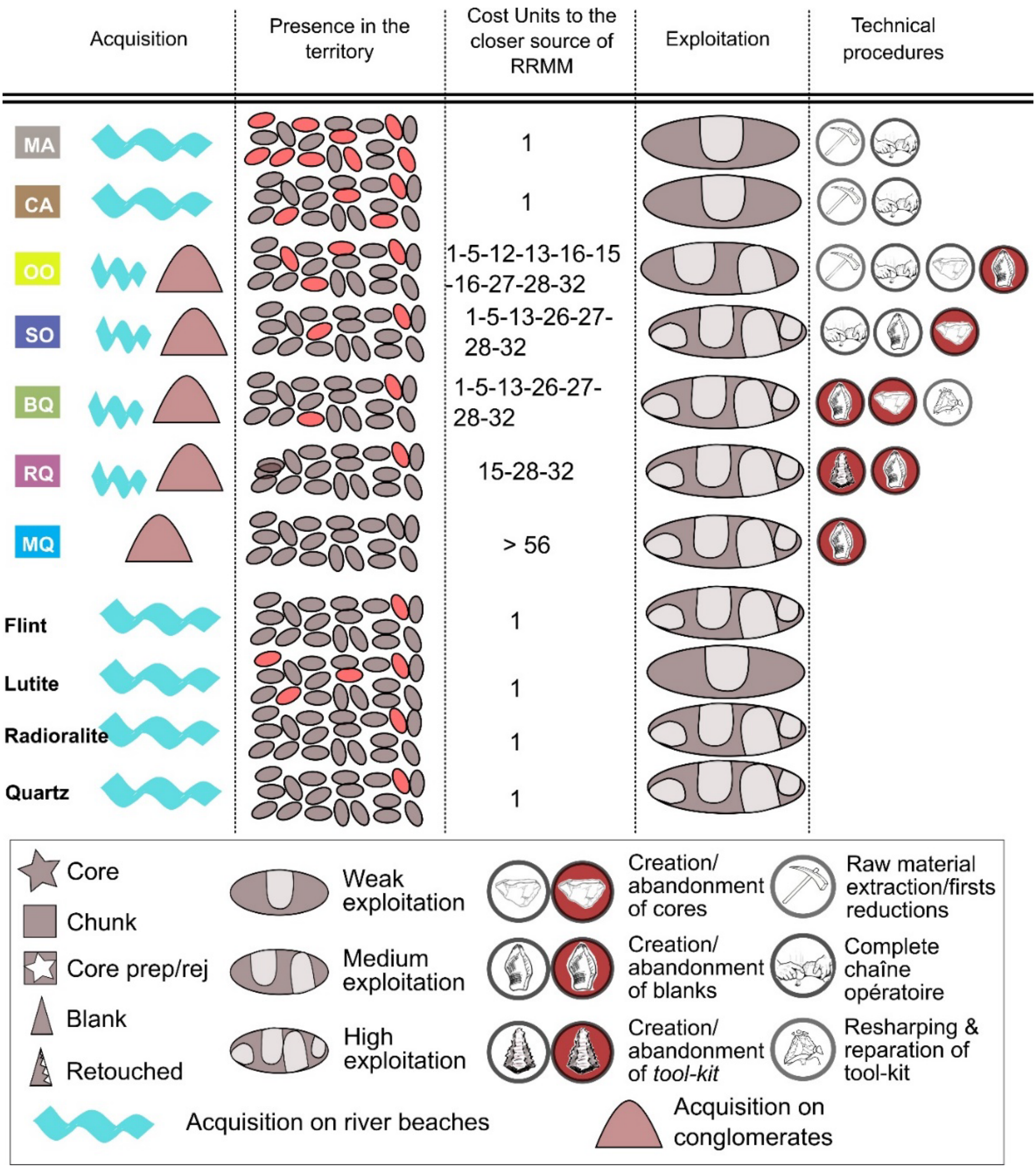

Figure 11. Systematic management strategies followed by human populations who inhabited El Esquilleu in the timeframe of Layer XXII-R, grouped by raw material and petrogenetic types

Behind these procurement and management strategies, broader concepts such as land use, habitat duration, mobility strategies or even personal decisions have been suggested. All of them, through a behavioural scope, are unveiling variable human adaptations on the natural and social environment, understating the economic and social behaves of the inhabitant of Picos de Europa 50,000 years ago (Vaquero 2013). These data were discussed with other research from Middle Palaeolithic contexts from the Iberian Peninsula where quartzite (*i.e.*, Baena Preysler *et al.* 2013; Cuartero *et al*. 2015; Prieto *et al.* 2019b; 2020; 2021b; Roy *et al.* 2017) and flint or chert (*e.g.*, Gómez de Soler *et al*. 2020; Rios-Garaizar *et al.* 2015; Romagnoli *et al*. 2018) types were identified and related with raw material procurement or management strategies. The data here shown and the perspective this study tacked contribute to the knowledge of raw material economy in the Cantabrian Region through a bottom-up approach, as an example that could not be extrapolated to the whole, but which shows how researching on the so-called “second rate raw materials” could promote richer and more complex hypothesis to understand raw material economy than those previously proposed (Prieto *et al*. 2021a; 2021b).

Still, the application of other proxies of analysis, such as the spatial relationships between artefacts (*e.g.*, Vaquero *et al*. 2019), refitting analysis (*e.g.*, Mayor *et al*. 2020; Romagnoli & Vaquero 2019), more complex technological approaches (*e.g.*, Cuartero *et al*. 2015; Eixea *et al*. 2017), use-wear analysis (*e.g.*, Pedergnana *et al*. 2017) or the study of other raw materials such as the cherts or flints (*e.g.*, Herrero-Alonso *et al*. 2021; Santamaría 2012: 1280-1284), quartz (*e.g.*, de Lombera-Hermida & Rodríguez-Rellán 2016) or lutite (*e.g.*, Fernández-Eraso *et al*. 2017) to this lithic assemblage will promote more varied and sophisticated knowledge about lithic variability in this layer and the explanations behind it.

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Data accessibility statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary files.

List of supplementary files

Supplementary file 1
“Prieto et al. - Supplementary file 1.pdf”
Thin section description of selected samples. Non-quartz mineral identified on thin section description of selected samples. Grain size, morphology and orientation descriptions.

Supplementary file 2
“Prieto et al. - Supplementary file 2.pdf”
X-ray fluorescence of selected samples.

Supplementary file 3
“Prieto et al. - Supplementary file 3.pdf”
Frequency table of types of cores identified in El Esquilleu XXII-R grouped by petrogenetic types of quartzite. Columns are the types of cores.

Supplementary file 4
“Prieto et al. - Supplementary file 4.pdf”
Frequency table and its representation through a bar chart using the percentage of each blank category (determined by the quantity of scars on dorsal surface) according to each raw material.

Supplementary file 5
"Prieto et al. - Supplementary file 5.pdf"
Frequency table and its representation through a bar chart using the percentage of each blank category (determined by the quantity of scars on dorsal surface) according to each petrogenetic type of quartzite.

Supplementary file 6
"Prieto et al. - Supplementary file 6.pdf"
Frequency table and its representation through a bar chart using the percentage of each blank category (determined by extension of cortex on dorsal surfaces) taking into account each petrogenetic type of quartzite.

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El aprovisionamiento de las cuarcitas no es solo en depósitos fluviales: Caracterización de las materias primas líticas del Nivel XXII-R de El Esquilleu, Región Cantábrica, España

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Resumen:

La cuarcita se ha considerado como una materia prima secundaria en muchos contextos arqueológicos, retrasando su investigación en profundidad a favor de otros recursos líticos, principalmente el sílex y la obsidiana. El estudio de estos dos recursos y especialmente su transporte a larga distancia, ha favorecido el desarrollo de trabajos desde perspectivas geoarqueológicas, así como su relevancia cuantitativa en contextos arqueológicos y el propio devenir historiográfico de la arqueología prehistórica. Por el contrario, la información derivada del estudio del amplio espectro de rocas clasificadas como cuarcitas en la literatura arqueológica, propone aprovisionamientos a menor distancia y en contextos secundarios, principalmente en playas fluviales cercanas a los yacimientos. Esta situación ha generado la infrarrepresentación de trabajos centrados en el estudio de la cuarcita, encerrando los comportamientos humanos que se infieren a hipótesis circulares y, generalmente, redundantes y unidireccionales. Para romper esta lógica, consideramos que es imprescindible colocar a la cuarcita en el centro del debate y entenderla como materia prima lítica utilizada por las comunidades prehistóricas mediante propuestas inductivas basadas en sólidas metodologías geoarqueológicas.

El trabajo que aquí presentamos es una muestra de la aplicación de una propuesta multifocal y geoarqueológica a la industria lítica del Nivel XXII-R de El Esquilleu (Musteriense) y en el que se combina el análisis petrográfico de láminas delgadas, la observación con lupa binocular de las superficies de la cuarcita y sus zonas corticales y el análisis composicional mediante Fluorescencia de rayos X. Además, cada implemento lítico se ha descrito tecno-tipológicamente aplicando los desarrollos más recientes de la Tipología Analítica. El análisis de las potenciales fuentes de materia prima en el entorno de Picos de Europa (Valles del Deva, Cares y Güeña) se ha realizado mediante prospección geoarqueológica. Mostramos los resultados obtenidos de la caracterización de afloramientos de roca cuarcítica y conglomerados que la contienen, si bien centramos la investigación en caracterizar en detalle los depósitos fluviales secundarios cercanos y lejanos al yacimiento.

Como estamos comprobando en otros contextos arqueológicos de la zona y otras partes del mundo, existe una amplia variedad de tipos cuarcíticos, formados no sólo bajo condiciones de metamorfismo -cuarcitas s.s. (sensu stricto)-, también bajo condiciones sedimentarias y con evidencias de deformación -ortocuarcitas-, y también otras rocas sedimentarias clásticas no deformadas -cuarzo-arenitas-. De forma general, los comportamientos técnicos observados muestran una compleja y versátil gestión del material cuarcítico en el que se produjo una explotación rápida, expeditiva y no exhaustiva de los tipos MA, CA (cuarzo-arenitas) y parcialmente del tipo OO (aunque en este tipo se desarrollan cadenas operativas completas), junto con una gestión más intensa, compleja y conservadora de las de las cuarcitas SO (también completa) y el grupo de las cuarcitas s.s., que son amortizadas en el sitio. El estudio en detalle de la roca y la superficie del córtex revela que la mayoría de los implementos líticos provienen de playas fluviales cercanas al Esquilleu, si bien la presencia de determinadas litologías y córtex asociados a afloramientos de conglomerados más lejanos también nos hablan de una adquisición en la zona sur-occidental de los valles del Deva y Cares, en contextos geográficos diferentes (zonas amesetadas a media altura que favorecen los tránsitos humanos). La selección de las ortocuarcitas y cuarcitas s.s. en ambos contextos es clara y, debido a la baja presencia de determinados tipos en contextos fluviales, se siguieron mecanismos de selección intensivos, también una adquisición recurrente realizada por múltiples individuos o en grupo y, ocasionalmente, otra más versátil. La movilidad que articuló los distintos ambientes fue también variada, aunque se basa en la corta y media distancia en dirección Norte-Sur y que permitió a los grupos paleolíticos moverse, pero también explotar diferentes biotopos del valle del Deva. La movilidad Este-Oeste fue también relevante, especialmente en el sur de la zona de estudio, uniendo los valles del Deva y del Cares. A pesar de que existe una movilidad a mayor escala, esta fue reducida, como muestra la presencia de algunos tipos y variedades no encontradas en los trabajos de prospección en estos valles.

La comparación de los resultados e hipótesis planteadas con otros contextos europeos, nos han permitido entender la variabilidad y la versatilidad de los comportamientos que las neandertales pusieron en práctica para adaptarse al entorno natural y social de los Picos de Europa hace 50.000 años. Consideramos que este trabajo contribuye al conocimiento de las materias primas prehistóricas de la Región Cantábrica mediante un enfoque *bottom-up* y ejemplificando cómo la investigación en las otras materias primas líticas puede promover hipótesis más ricas y complejas en torno a la economía prehistórica.

Palabras clave: Paleolítico medio; aprovisionamiento de materias primas líticas; tecnología lítica; cuarcita; variabilidad; prospección geoarqueológica, petrografía, estero microscopía.