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Quartzite procurement in conglomerates and deposits: Geoarchaeological characterization of potential catchment areas in the central part of the Cantabrian Region, Spain

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Abstract

Raw material characterization in Paleolithic archaeology has widened our knowledge of Middle Paleolithic societies. Procurement of raw material, specifically flint, has allowed the tracing of the mobility of both stones and people, as well as selective processes to obtain specific types or even extraction activities. The analysis of quartzite has also developed in recent years, providing an opportunity to better understand prehistoric societies. This study characterizes the procurement strategies implemented by Middle Paleolithic people in the mountainous region of the Picos de Europa. To this end, we present a comprehensive characterization of potential catchment areas: massive outcrops, conglomerates, and river deposits. The exploitation of quartzite at the sites of El Habario and El Arteu allows us to understand the territorial management of this mountainous area through the combination of selective processes and mobility mechanisms in lower and middle altitudes. These perspectives enable us to view the mountainous region not as a barrier but as an environmental mosaic managed by Middle Paleolithic groups. This study shows strategies that bring together direct and embedded procurement based on both intensive and extensive searches. These discourses are more closely related to the daily life of people than those only considering the mobility of people and objects.

KEYWORDS

Cantabrian Region, field survey, Middle Paleolithic, petrology, quartzite, raw material procurement

1 | INTRODUCTION

The understanding of raw material procurement strategies adopted by human societies has been a recurrent topic in archaeology, especially since the 1950s. This study demonstrates the complexity of raw material procurement by human societies, especially during the Neolithic (Dixon et al., 1968). Procurement through mining mechanisms (Sieveking et al., 1972; Singer & Ericson, 1977) and human transportation of raw material associated with direct mobility or trading systems (Clark, 1965; Dixon et al., 1968) were the most explored topics. In addition, this pioneering research opened new lines of investigation due to the application of a broad spectrum of geoscience disciplines to characterize the rocks processed by humans and their potential catchment areas (Durrani et al., 1970; Kowalski et al., 1972). The technical and theoretical progress made by these studies widened the perspectives of other researchers in later decades (e.g., Luedtke, 1979; Roebroeks, 1988; Tarriño, 2006; Turq, 1996).

As a result, at the beginning of the new millennium, raw material procurement studies have become an important source of data for understanding the economy of prehistoric societies and human mobility patterns. Numerous maps of dots and arrows illustrating the European continent have been drawn, which connect flint formations and archaeological sites in different Paleolithic frameworks (e.g., Fiers et al., 2019; Gurova et al., 2016; Moreau et al., 2016; Sánchez de la Torre et al., 2017; Tarriño et al., 2015). These studies, based on flint sourcing, also provide information connected with flint procurement strategies and mobility circuits. Moreover, together with other proxies of analysis such as Geographic Information System (GIS), technological characterization of the lithics, or use-wear analysis, flint sourcing provides interesting data about prehistoric territoriality and technological management of resources (e.g., Arrizabalaga et al., 2014; Herrero-Alonso et al., 2020; Prieto et al., 2016; Turq et al., 2013, 2017).

Most of these studies are based on the premise of direct procurement of raw material at primary strata by quarrying or, more reasonably, by gathering detached blocks around the flint stratum. These procurement strategies are generally associated with high-cost, direct, and curated procurement as opposed to an embedded or neutral model of procurement, linked to the catchment of non-flint rocks and/or low-quality flint from secondary deposits (Bamforth, 2006; Binford, 1979; Brantingham, 2003; Gould, 1978). During the last few decades, research that has addressed the study of non-primary potential catchment areas from geoarchaeological perspectives has widened the spectrum of procurement mechanisms carried out by prehistoric societies. These processes are related to the identification of raw material and selection mechanisms, drawing a more complex picture of this type of procurement (e.g., Daffara et al., 2019; P. Fernandes et al., 2008; Roy et al., 2017). Finally, an additional procurement strategy documented at Paleolithic contexts is based on quarrying or mining for specific raw material (e.g., Baena Preysler et al., 2011; Barkai & Gopher, 2009; Prieto, Yusta, Pastoors, et al., 2019).

Quartzite, the second most-often utilized raw material in the Cantabrian Paleolithic, has only been systematically analyzed in the last few years (Blomme et al., 2012; Cnudde et al., 2013; Dalpra & Pitblado, 2016; Pedergnana et al., 2017; Prieto, Yusta, & Arrizabalaga, 2019; Prieto et al., 2020; Soto et al., 2020; Veldeman et al., 2012). These studies define and characterize quartzite from geoarchaeological perspectives, including both metamorphic and sedimentary siliceous rocks, thus expanding the range of raw material studied by archaeologists. In addition, the characterization of quartzite, together with an insight into quartzite procurement strategies, is improving our understanding of the economic patterns of prehistoric populations. This is especially relevant in areas such as the Cantabrian Region, where quartzite was associated with simple and embedded procurement, generally from secondary deposits (Álvarez-Alonso et al., 2013; Sarabia, 2000).

The main goal of this study is to show the procurement strategies followed by Middle Paleolithic groups in the Deva and Cares Valleys. To this end, the geoarchaeological characterization of potential catchment areas where quartzite could be acquired is described. These areas include primary outcrops, secondary position outcrops or conglomerates, and Quaternary unconsolidated deposits. We also describe and characterize the quartzite in these contexts using macroscopic, stereoscopic, petrographic, and geochemical methods, following the approaches proposed by our team (Prieto, Yusta, & Arrizabalaga, 2019; Prieto et al., 2020). The procurement mechanism involved in the archaeological sites of El Habario and El Arteu will be described through the characterization of their quartzite remains and the analysis of their cortexes. Finally, the proposed models and perspectives in the understanding of lithic procurement will be described. Hopefully, the latter could surpass the simplistic and dual relationship created by the terms "direct" and "embedded" procurement to see more complex systems of raw material acquisition, management, and distribution mechanisms.

2 | MATERIALS

The research area is located in the Cantabrian Region, northwestern part of Iberia, southwestern Europe. From a geographic perspective, this region combines relief associated with coastal and mountain landforms. The first is related to the Cantabrian Sea and the Atlantic Ocean, which delimit the northern and western limits of the area. The second to the Cantabrian Mountain Range, the western prolongation of the Pyrenees. These two landforms, together with glaciation and active fluvial systems, in particular, create multiple geomorphologies such as high-altitude mountains, cliffs, gorges, talus slopes, plateaus, and closed or open valleys in a wide range of altitudes that vary more than 2500 m (Alonso et al., 2007). The Deva and the Cares valleys are situated in the central part of the region, and they are also characterized by high variability of geomorphological units (Figure 1).

From a geological standpoint, the research area is characterized by its complexity caused by the existence of two main geological domains. The first is the eastern part of the Cantabrian Zone, which

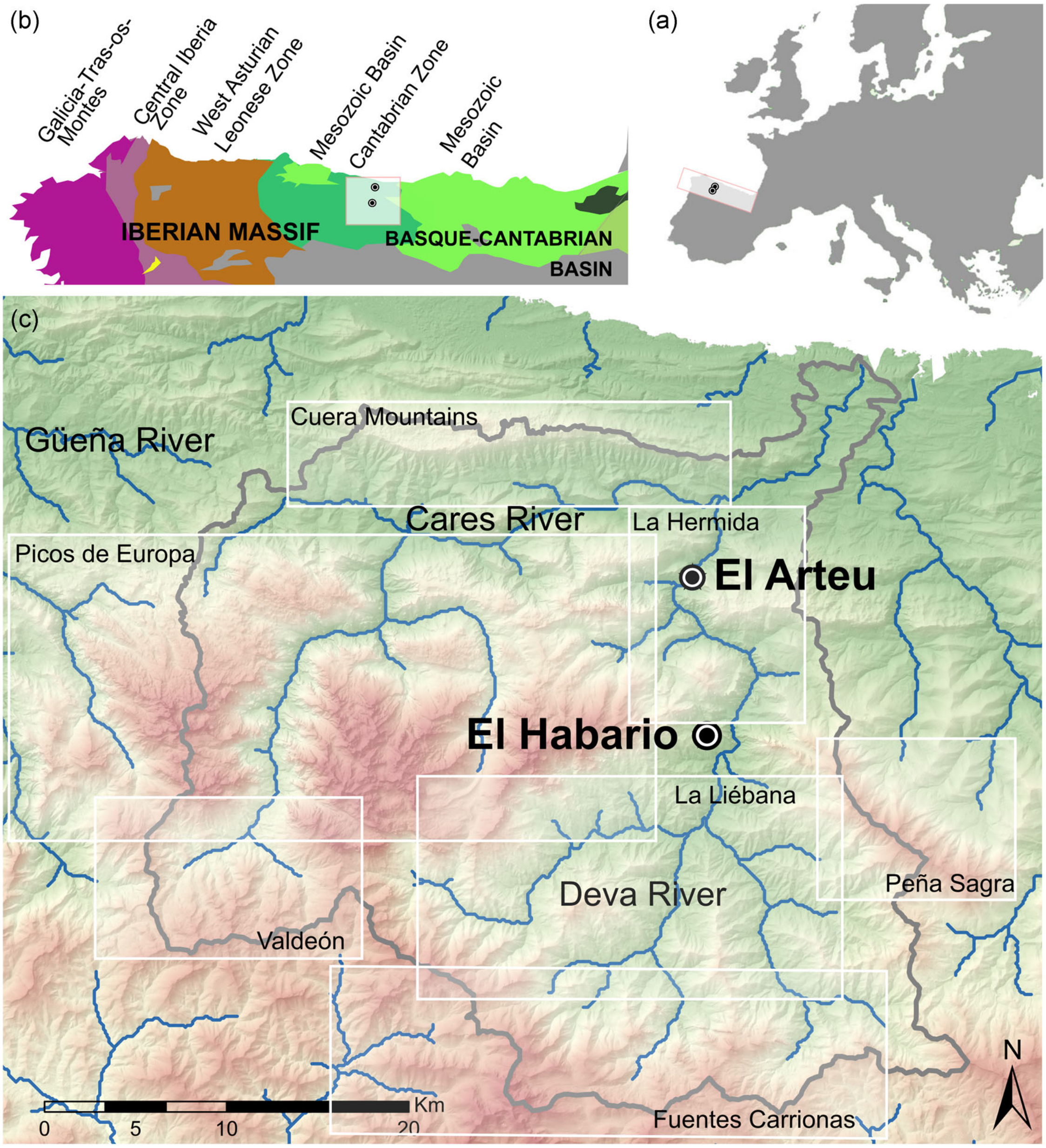

FIGURE 1 (a) The map of Europe showing the location of the research area. (b) A general overview of the north of Spain displaying the main geological zones based on the 1:1,000,000 geological map (Álvaro et al., 1994). (c) The research area showing the location of the analyzed sites and the areas mentioned in the text [Color figure can be viewed at wileyonlinelibrary.com]

is mainly composed of Carboniferous materials. Two main provinces can be distinguished in the eastern Cantabrian Zone: the Pisuerga-Carrión Province to the south and the Picos de Europa and Ponga province to the West and North (Figure 1). Both provinces also contain Cambrian, Ordovician, Silurian, and Devonian strata (Bastida, 2004). The second area is the western end of the Basque-Cantabrian Basin, which is dominated by sedimentary Mesozoic material and small relicts of Cenozoic material (Barnolas & Pujalte, 2004). Neogene and Quaternary deposits are represented in both areas. This situation leads to significant lithological variability, including (a) old massive siliceous outcrops, related to Ordovician and Cambrian series; (b) Carboniferous sequence with alternations of limestones, shales, conglomerates, and siliciclastic material; (c) massive Carboniferous and Cretaceous calcareous series; and (d) recent unconsolidated Quaternary deposits.

The sites of El Arteu and El Habario are situated in the central part of the research area. We selected these sites because their assemblages are almost fully composed of quartzite and the high intravariability of this rock, as pointed out by previous research (Prieto, Yusta, & Arrizabalaga, 2019; Prieto et al., 2020). Both assemblages have been attributed chrono-culturally to the Mousterian, with discoidal reduction methods. They appear to form a network of sites together with El Esquilleu rock shelter (Baena Preysler et al., 2005, 2012; Carrión, 2002; Carrión et al., 2008).

El Arteu is situated in a small rock shelter (originally a cave) in a rugged high-mountain area near the Deva and its confluence with the River Cares (*X* = 368.247, *Y* = 4.793.505; 30T ETRS-89). The site is located in the Barcaliente Formation (Colmero et al., 2002). This formation is part of the eastern zone of the Picos de Europa Province, mainly characterized by massive Carboniferous limestones. The lithological composition, Variscan and Alpine orogenies, and the later fluvial, glacial, gravitational, and karstic erosion have generated sharp relief with slopes over 2000 m in height. Cliffs, ravines, talus slopes, glacial moraines, caves, and deep gorges are the most important geomorphological features in the area surrounding El Arteu. The most prominent landform is the Hermida Gorge, a narrow canyon created by the Deva River in a north–south direction. Moreover, the Middle Cambrian to Early Ordovician Barrios Formation crosses the massive limestone strata in an east–west direction to the south of El Arteu site, creating less steep geography. The lithic assemblage here analyzed is composed of 255 artifacts that were collected after they had fallen from a section, but they display industrial coherence. They were attributed to a single phase within the Mousterian.

The site of El Habario is an open-air site in a mountainous area, close to Carboniferous conglomerate bedrock units (*X* = 368.973, *Y* = 4.784.861; 30T ETRS-1989). This site is situated in a small colluvial unit of unconsolidated sediments on the top of the Remoña Formation, and it is mainly composed of noncarbonate material. El Habario is in the area called the Liébana Valley, characterized by less stepped mountains and open valleys created by the River Deva and its tributaries, and the Quiviesa and Buyón rivers. This river system erodes material from the Peña Sagra and the Peña Labra ranges to the east, Sierras Albas and the Sierra de las Orpinas to the south, and the Sierra Mediana and the Picos de Europa massif to the west. The river system deposits the material in this open valley, bottlenecked to the north by the abovementioned Hermida Gorge. We have analyzed the unit El Habario B. The lithic assemblage was attributed to a single phase within the Mousterian, and it is composed of 467 artifacts.

3 | METHODS

The methodology applied combines different approaches such as the analysis of the available geology and geography through GIS, geological field surveys, stereoscopic characterization, and thin-section petrography.

GIS analysis was performed to integrate the available geographical and geological information, and also to improve the geological field survey. The analysis was grounded on the digital elevation model, as well as on other resources provided by the Spanish National Institute of Geography (IGN, 2017) and, especially, the geological maps from the Geological Institute of Spain (IGME), MAGNA 1:50,000 and GEODE series (Merino-Tomé et al., 2016). From these, we have selected locations of massive strata of highly siliceous rocks, conglomerate formations, and secondary deposits. Finally, and to determine the most favorable areas of transit and the cost of moving from the archaeological sites to each potential catchment areas, we generated cost maps and calculated the cost distance from each site to the nearest geological stratum or geological deposit, following the proposals of Prieto et al. (2016) and Sánchez et al. (2016).

The field surveys took into account the three different geological environments where quartzite could be found. The lithological variability of massive outcrops and their facies are described, and the strata above and below the main outcrop (also conglomerates) are characterized. The bedding and jointing of the primary strata were analyzed to understand better how weathering mechanisms modify the rock and the size and morphologies of rock fragments detached from the outcrops and conglomerates. The composition and compactness of the conglomerate cements were described together with the feasibility of rock extraction from them. In this context, the way rock cobbles are distributed in the matrix/cement and the quantity of matrix/cement are also analyzed. While in the field, a first classification of the rocks was performed, examining their main lithological characteristics, and later at the laboratory and specifically with regard to the quarzitic rocks, petrogenetic types and grain size variety were studied. At least, one block or one piece of each type and variety of quartzite described in the field was sampled for in-depth description in the laboratory. Finally, the most representative quartzite types were sampled for thin sections. In conglomerates and unconsolidated deposits, the lithologies and types and varieties of quartzite were quantified, following a similar method as Roy et al. (2017). The minimum quantity of rocks characterized at each survey point (henceforth SP) in the field was 100. The rocks were also classified according to external morphology and size. In unconsolidated deposits, we took into consideration whether they were colluvial or fluvial deposits. In these contexts, we describe smaller than 3-cm pebbles by their main lithology.

The characterization and classification of quartzite in field surveys and the assemblages are based on a multiscalar approach that combines macroscopic descriptions, stereomicroscopic surface characterization at different magnifications (×10–20, ×50, and ×250), and thin-section petrographic description of the selected sample. Thin sections were described on the basis of the methods proposed by Prieto, Yusta, and Arrizabalaga (2019). All thin sections were produced and analyzed in the Sample Preparation Laboratory (Department of Mineralogy and Petrology, University of the Basque Country-UPV/EHU, Spain). Thin sections were analyzed using a Nikon Eclipse LV100N POL microscope. Photomicrographs were taken with a Nikon D90 camera adapted to the microscope.

The characterization of the thin sections considered the texture and packing of each section, the diagnostic quartz grain features, their quantity, metric of size, shape and orientation of quartz grains, the matrix and cement of the section, and the presence of non-quartz minerals. These data were applied to classify each section to a petrogenetic type: For sedimentary quartzites, clastic fabric with matrix or cement quartzarenite (MA), clastic quartzarenite (CA), syntaxially overgrown orthoquartzite (OO), and sutured grain orthoquartzite (SO), and for truly metamorphic quartzites, another three types depending on the textural changes on quartz grains: bulging recrystallized quartzite (BQ), subgrain rotation recrystallized quartzite (RQ), and grain boundary migration recrystallized quartzite (MQ) (Bastida, 1982; Howard, 2005; Prieto, Yusta, & Arrizabalaga, 2019; Skolnick, 1965).

Stereomicroscopic characterization of noncortical surfaces used the protocol established by Prieto et al. (2020). This proposed a multifocus observation of qualitative criteria such as luster, microcracks, texture, packing, quartz grain features, quartz grain size (mean and distribution), bedding, foliation, and primary mineral and mineral alterations. The association of most of these features classified each quartzite in the seven petrogenetic types previously described. Finally, each quartzite was characterized by its grain size mean value also describing nonquartz minerals.

Finally, the cortical areas of the quartzite were characterized by adapting the proposal made by P. Fernandes et al. (2007) and P. Fernandes and Raynal (2006) for this rock. We have described the texture of cortical surfaces as coarse-grained, fine-grained, fine, or soapy surfaces. The presence or absence of mineral precipitates and their mineralogy was analyzed. Some features were also identified, such as rootless imprints, lithophagous marks, or voids generated as a consequence of a meteoric alteration in soils or water sources. Impact cracks, caused by the collision of stones in watercourses, were also recorded. Finally, the color of these surfaces was classified. These data were applied to relate the features with specific sources.

4 | RESULTS

4.1 | Analysis of potential catchment areas

A total of 111 locations (SPs) were analyzed during our surveys (Figure 2). Some SPs are in the Sella and Güeña valleys to the west and others in the Nansa valley to the east. Table 1 summarizes the information from the 102 points systematically analyzed. The other nine SPs are colluvial deposits with quartzite blocks (Supporting Information Files S1–S3).

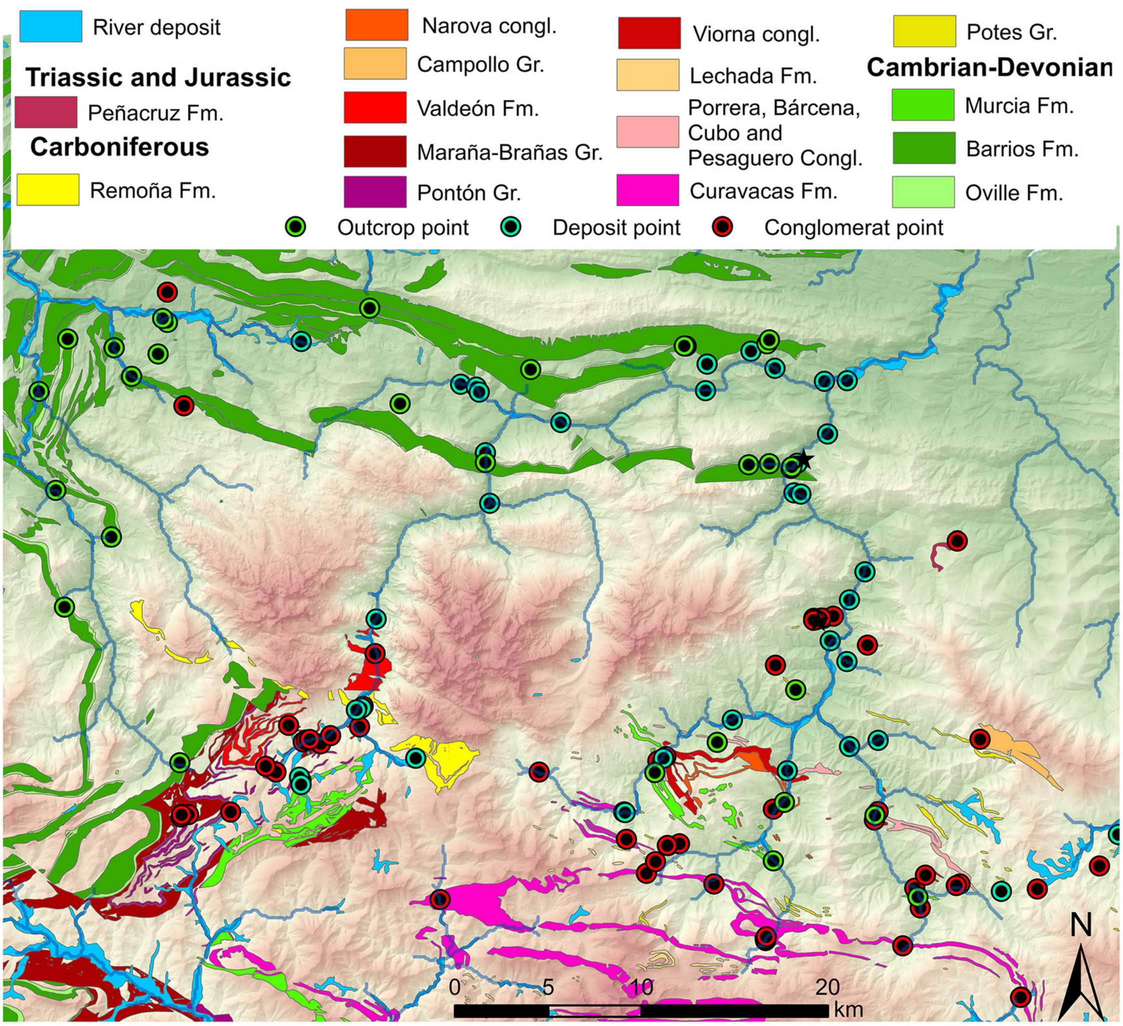

FIGURE 2 Geological strata surveyed based on MAGNA 1:50,000 series. Fm., formation; Gr., group [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 A summary of formations analyzed

Context	Formation	∑ Survey points	∑ Lab	∑ Thin section	Petrogenetic types MA	CA	OO	SO	BQ	RQ	Period	Epoch	Age
D	Deva river	12	63	4	4	3	1	1	-	-	Quaternary	Holocene	
	Cares River	13	52	1	4	3	2	2	2	-		Pleistoce	
Conglomerate	Remoña	4	16	4	3	-	3	3	3	-	Carboniferous	Pennsylvanian	Gzhelian
	Campollo	3	13	4	4	3	2	-	-	-			Kasimovian
	Valdeón	4	24	6	4	3	4	3	1	1			
	Maraña-Brañas	1	4	1	-	-	4	4	1	-			
	Pontón	8	21	4	4	3	3	2	1	1			
	Viorna	3	6	2	4	2	1	-	-	-			
	Lechada	2	15	1	4	2	3	1	-	-			Moscovian
	Porrera	5	18	1	4	2	2	-	1	-			
	Curavacas	14	78	20	4	3	3	1	-	-			
	Potes	6	23	4	4	3	3	1	1	-			Bashkirian
Outcrop	Potes	1	13	1	4	-	-	-	-	-	Carboniferous	Pennsylvanian	Gzhelian
	Mogrovejo	2			4	-	-	-	-	-			Kasimovian
	Viorna	1			4	-	-	-	-	-			Moscovian
	Cavandi	4			4	-	-	-	-	-			
	Murcia	3	8	1	4	-	-	-	-	-	Devonian	Upper	Fammenian
	Barrios	15 + 2	58	2	4	3	1	-	-	-	Cambrian-Silurean	Series 3-Llandovery	Guzhangian-Rhuddanian

Note: In the columns for Petrogenetic types, the frequency of each rock type is shown using the following numeric codes: 4 when frequency is > 30%; 3 for 10%–30%; 2 for 2%–10%; and 1 when frequencies < 2% are found.

Abbreviations: BQ, bulging recrystallized quartzite; CA, clastic quartzarenite; MA, matrix or cemented quartzarenite; OO, syntaxially overgrown orthoquartzite; RQ, subgrain rotation recrystallized quartzite; SO, suturated grain orthoquartzite.

4.2 | Massive outcrop formations

Starting with the *Barrios Formation*, its base is dated in the Cambrian and the last accumulation is dated in the Middle Ordovician. The thickness is variable, ranging from a few meters up to 1020 m. The visibility of the Barrios Formation is variable too; however, it is associated with gentle or intermediate relief. In the research area, the formation crops out to the north and to the west (Supporting Information File S4). In the former, it crops out in successive massive strata, parallel to the coastline, whereas in the eastern area, as a succession of outcrops on a north–south alignment. This sedimentary formation was deposited in delta plain environments (Aramburu et al., 1992, 2004). Bedding is observable at almost all SPs. Despite some authors pointing toward a lateral increase in grain size from east to west (Aramburu et al., 1992, 2004), we only observed general heterogeneity in the quartz framework, associated with medium and coarse sizes. The formation was clearly modified by the thin-skinned tectonism generated by the Variscan orogeny and its reactivation during the Alpine orogenesis. Folds, faults, and joints in different directions appear along the outcrops. A high-intensity joint system with more than three planes modifies the formation, and it is generally filled by iron and manganese oxide patinas and/or secondary quartz (Figure 3a). Mechanical weathering on these joints creates orthogonal and angular fragments of rock around outcrops. Lithologically, the Barrios outcrops are composed of quartzarenite (MA and CA) with some shaley strata (linked to the underlying Oville Formation) and a few relicts of OO orthoquartzite (Figure 4c). All these quartzite types are white with small darker or reddish areas as a consequence of iron and manganese oxides.

The *Murcia Formation* is chronostratigraphically dated between the Frasnian and the Famennian in the Upper Devonian. This formation crops out in the Pisuerga-Carrión Province and its thickness ranges from 60 to 200 m. It is mainly formed by siliciclastic material, creating a sandstone/quartzite and shale alternation (Figure 3b). The quartzite strata are MA of a variable grain size and morphologies, always associated with medium and coarse sizes (Figure 4a). A clayey and siliceous matrix and carbonate cements fill the space between the quartz grain framework. Clear bedding is not observed. These data agree with previous studies suggesting that the formation was created under marine sedimentary conditions, as a consequence of either turbidity currents or under platform conditions (Aramburu et al., 2004; Rodríguez-Fernández, 1992). Folds, faults, and joints in different directions are observed in the formation in a more than three directional joint system. They are always filled with silica and occasionally with iron oxides. The first compound does not promote differential erosion, making a more compact outcrop than the

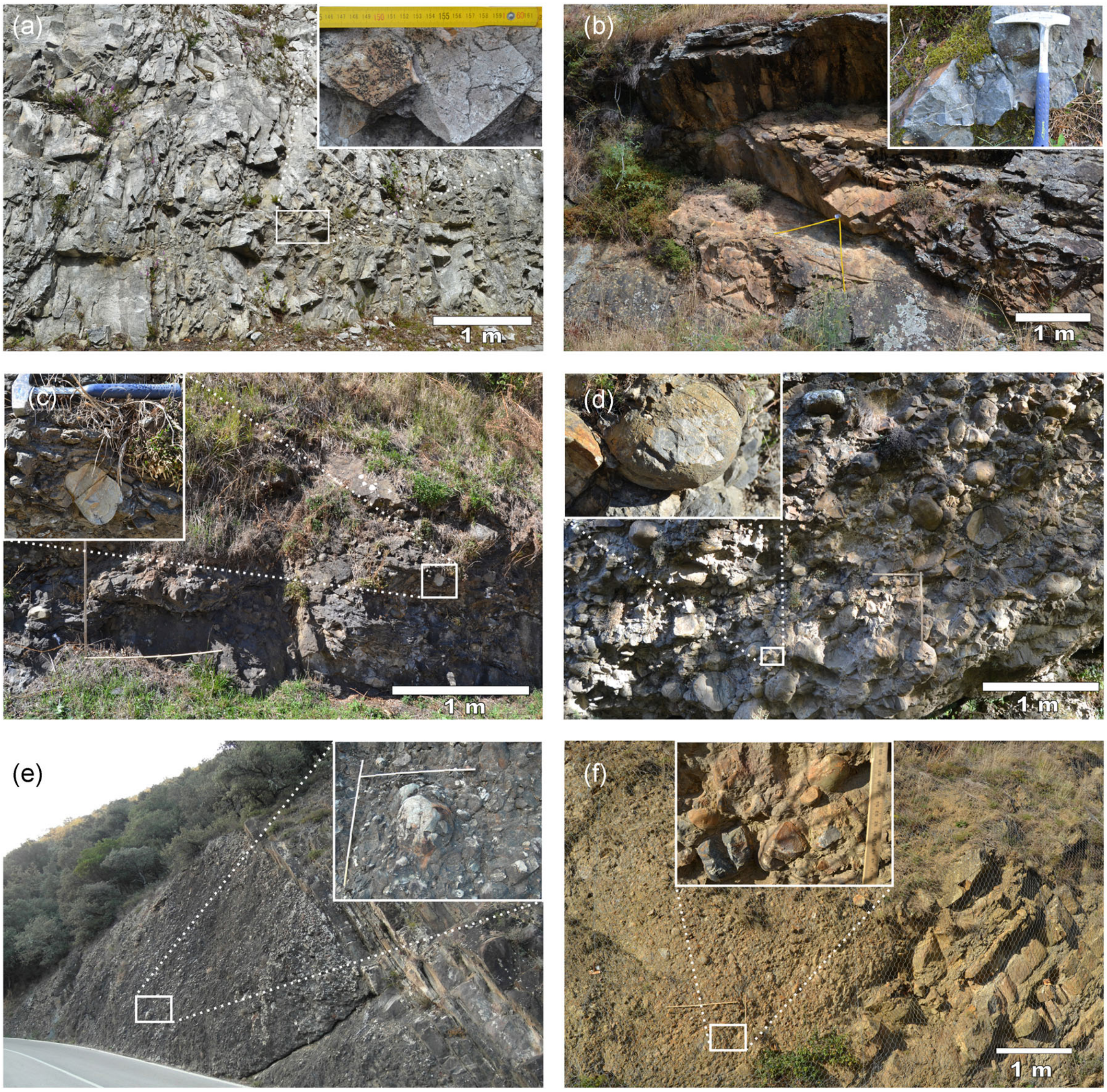

FIGURE 3 Surveyed formations and detailed pictures: (a) Barrios formation, (b) Murcia formation, (c) conglomerates from the Potes formation, (d) Curavacas conglomerate, (e) Pesaguero polymictic conglomerate, (f) Lechada conglomerate [Color figure can be viewed at wileyonlinelibrary.com]

previous Barrios Formation. In this case, orthogonal blocks with sharp edges are found around the outcrops.

Another four siliciclastic strata were analyzed. They are a part of the *Potes*, *Mogrovejo*, *Viorna*, and *Cavandi Formations*, which show alternations of limestones, shales, graywacke, conglomerates, and other siliciclastic materials. They were created during the Pennsylvanian Carboniferous, and they are representative of the heterogeneous conditions of this area due to the Variscan orogenesis and the formation of small sedimentary basins (Fernández et al., 2004; Pastor-Galán et al., 2014). Lithologically, these sandstone strata can be classified as MA quartzarenite with a heterogeneous distribution of quartz grain sizes (with the medium-coarse grain size generally predominating) and a large presence of non-quartz minerals such as iron oxides, mica, and non-identified black and heavy minerals. They are submature–immature sandstones. SP analysis confirms the lack of metamorphic processes or strong diagenetic cementation processes that create a highly compact material (Supporting Information Files S1–S4).

4.3 | Conglomerate formations

The conglomerates analyzed belong to formations consisting of a succession of sandstone, limestone, shale, and conglomerate strata.

The *Potes Group* is in the oldest formation, and it crops out in the southeast of the research area as successive thin and discontinuous layers arranged in a northwest–southeast direction. Its visibility is reduced to road cuts, natural cliffs, or steep flanks. Bedding structures are common in most of the SPs; moreover, joints are infrequent and not substantial. The matrix between quartzite pebbles is clayey

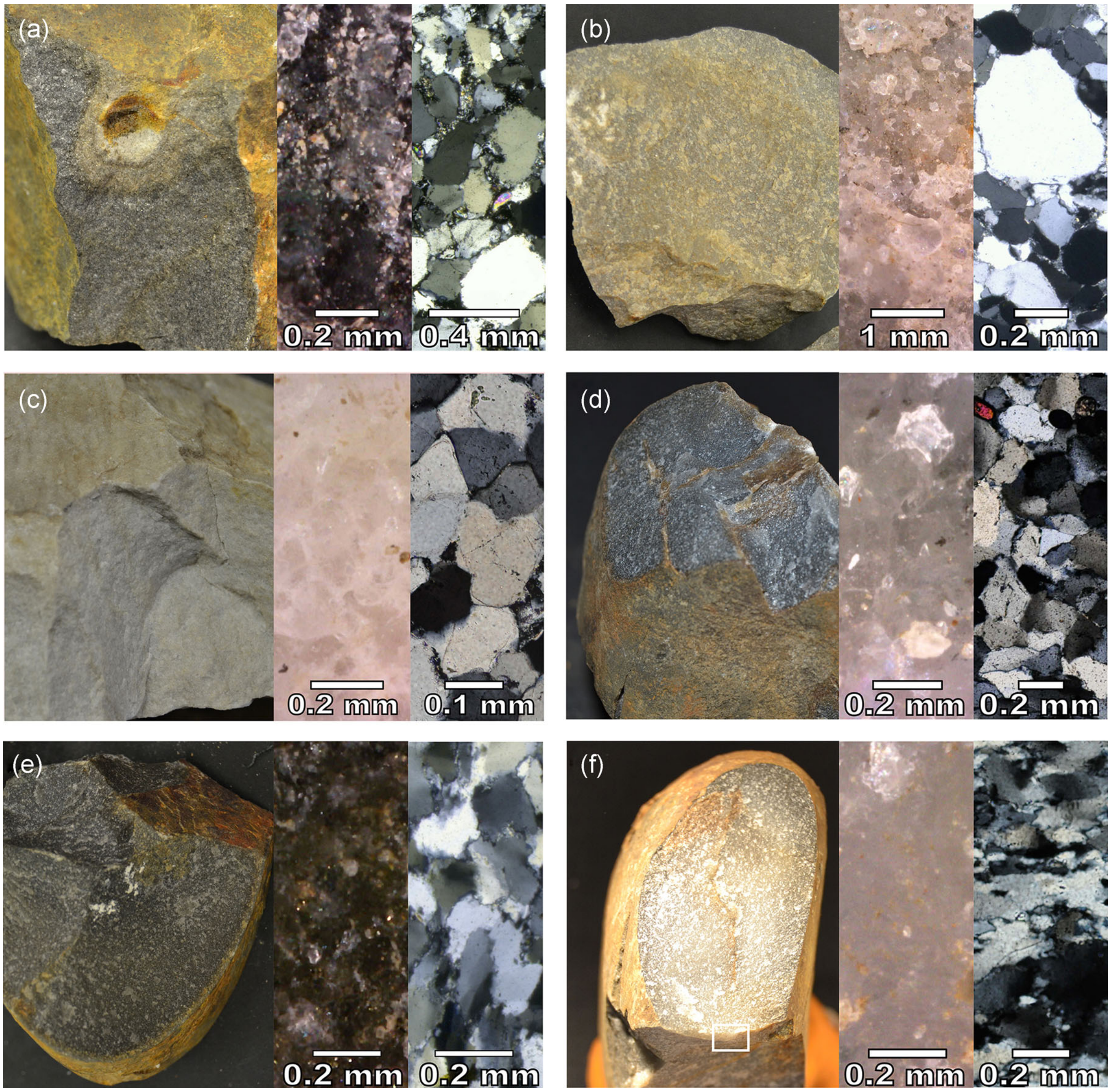

FIGURE 4 Representative examples of the described petrogenetic types, showing hand specimen, binocular stereoscope, and petrographic microscope micrographs: (a) MA quartzarenite from Murcia formation, (b) MA quartzarenite from the Curavacas formation, (c) OO orthoquartzite from the Barrios formation, (d) SO orthoquartzite from the Valdeón formation, (e) BQ quartzite from the Remoña formation, and (f) RQ quartzite from the Pontón formation. BQ, bulging recrystallized quartzite; MA, matrix or cemented quartzarenite; OO, syntaxially overgrown orthoquartzite; RQ, subgrain rotation recrystallized quartzite; SO, suturated grain orthoquartzite [Color figure can be viewed at wileyonlinelibrary.com]

with iron oxides that confer a brown hue to the external parts (Supporting Information File S5). This cement facilitates rock extraction in an isolated to tangential packing (Figure 3c). These features agree with the data given by Fernández et al. (2004) and Rodríguez-Fernández et al. (2003) who relate this formation with a heterogeneous sedimentary condition (from turbidity to fan-delta deposits) in different basins during the Variscan orogenesis. There is great variability among the rocks coming from the conglomerates based on the general lithologies with sandstone, lutite, and quartzite. The latter are mainly formed by MA and CA types and secondarily by OO orthoquartzites. SO and BQ quartzites are restricted to negligible proportions. Most of the clasts are spherical pebbles, except for the MA quartzarenite, sandstone, and lutite, which are more flat (Supporting Information File S6). Cortical surfaces are fine-grained, with iron oxide patination.

The *Curavacas conglomerate* is chronostratigraphy dated to the Moscovian. Its thickness is greater than 1000 m. It crops out to the south of the research area, especially in La Liébana and Fuentes Carrionas. In general, this conglomerate follows a west–east direction. The conglomerate was formed by four different subaerial facies of sea fan (Fernández et al., 2004; Heredia, Alonso, et al., 2003; Heredia, Rodríguez-Fernández, et al. 2003; Rodríguez-Fernández et al., 2003). According to the properties of joints and bedding, they are clearly heterogeneous, but they are more homogeneous when it comes to cement color and composition, cortical color, packing (isolated to tangential), and feasibility of rock extraction. The cement consists of siliceous material, making the color gray and in some areas brown due to iron oxide patina. The cement is abundant and it complicates the extraction of the clasts due to its compactness (Figure 3d). Lithology includes limestone, lutite, quartzarenite, and orthoquartzite; the first three are predominant. MA is the best-represented quartzite, followed by CA and OO types, with <5% each (Figure 4b). Finally, SO orthoquartzite is represented in negligible proportions. Cortical areas are mainly fine-grained, gray and brown in color, which preserve small relicts of cement. The external morphologies of clasts are spherical; however, tabular formats could be linked to MA and lutite.

The *conglomerates of Porrera, Bárcena, Cubo, and Pesaguero* consist of polygenic and polymictic conglomerates formed contemporarily to the Curavacas one. They are located at La Liébana, in a northwest–southeast direction. Visibility and thickness are different in each conglomerate, ranging from more than 100 to 10 m (Fernández et al., 2004; Heredia, Rodríguez-Fernández, et al., 2003; Rodríguez-Fernández et al., 2003). Except for bedding (not easily recognizable), they are very heterogeneous in terms of cement composition (siliceous, clayey, or carbonated) and color, feasibility of rock extraction, joint system intensity, directional systems, filler minerals, and also packing (Figure 3e). The lithology is quite variable, but the best-represented categories are limestone (in some SPs, only rock), shale, and MA quartzarenite. CA and OO are represented in a few SPs in small proportions. We found one BQ-type pebble.

The conglomerates from the *Lechada Formation* extend across the south of our research area, but they are only visible at La Liébana and Fuentes Carrionas. Their visibility is restricted, except for the areas where they are cut through by any landform. They are arranged into small, thin, and discontinuous strata among the Curavacas conglomerates, generally with a northwest–southeast orientation. The conglomerate cement is siliceous/clayey, brown in color, and allows for easy rock extraction (Figure 3f). However, the strata are jointed at each SP (Supporting Information File S4). CA quartzarenite and limestone are the best-represented lithologies. OO orthoquartzite is well represented and SO appears with a lower frequency. They are generally spherical pebbles, and their cortex textures are fine-grained with brownish/reddish iron oxides derived from the conglomerate cement.

The *Viorna Conglomerate* is the last conglomerate from the Middle Pennsylvanian. It is at the base of the alternation with the sandstone formations described above. The polymictic conglomerate was created in the sea talus as a turbidity deposit of grain flow (Rodríguez-Fernández et al., 2003), and it is situated in the central area of La Liébana zone. The visibility of the conglomerate varies between the western and eastern areas, depending on the thickness (75 m in the west to 10 m in the east), the position of the formation, and the erosion of surrounding material. According to bedding and the cement composition (carbonate or clayey), the formation is heterogeneous, but it is more homogeneous when it comes to joints impacting the conglomerates, the lithologies present, and the feasibility of extracting rocks (Figure 5a). The best-represented lithology is limestone, followed by lutite, generally tabular and more flat than quarzitic rocks. The latter are mainly represented by the MA type, even though CA and OO appear. Cortical areas are grainy, fine, or coarse with relicts of carbonates and/or clays.

The *Pontón Group* belongs to the first formation generated during the Upper Pennsylvanian. It was created in an intermediate sedimentary basin filled with massive clastic subaquatic and fan-delta sediments (Fernández et al., 2004; Heredia, Rodríguez-Fernández, et al., 2003). This sedimentation process generated a sequence more than 1000-m thick; however, conglomeratic layers are thinner than 10 m and appear as small, thin, and discontinuous layers in a southwest–northeast direction in the Valdeón zone (Supporting Information File S7). They are relatively homogeneous according to the bedding and joint properties (Figure 5b). In contrast, based on the cement properties, they are relatively heterogeneous (clayey or siliceous), even though the presence of iron oxides in the cement is constant. The feasibility of rock extraction clearly differs from one conglomerate to another, but it is always possible. Although lutite and limestone are found, the most representative lithology is quartzite with MA, CA, and OO types well represented, and also SO type at almost every SP (Supporting Information File S8). BQ and RQ are represented at some SP, even though always in small proportions (Figure 4f). Clasts are spherical and cortical surfaces are fine or coarse-grained with the presence of iron oxides. Quartzite is jointed.

The conglomerates from *Maraña-Brañas Formations* are scarce in the research area, and they consist of thin and almost nonvisible relicts in bigger alternations of shale, sandstone, and calcareous breccia and olistoliths (Heredia, Rodríguez-Fernández, et al., 2003). The conglomerates are not individualized inside the formations in the regional geology map, and they are situated in the Valdeón area. The matrix of this conglomerate is argillaceous, facilitating rock extraction in its tangential packing (Figure 5c). In addition to quartzite, limestone is also represented. Types OO and SO are well represented; also, the BQ type is present but in negligible proportions. Cortical surfaces are thin and fine-grained with clayey material (generally with pyrites).

The conglomerates in the *Valdeón Formation* (a succession of sandstone, shale, lutite, conglomerate, and coal strata) were created under subaerial fan conditions in the final filling of a synorogenic basin (Heredia, Rodríguez-Fernández, et al., 2003; Julivert & Navarro, 2003). They appear as thin and successive layers, generally in a southwest–northeast direction extending across the Valdeón area. These conglomerates are recognizable in the field in contemporary road cuts or in the relief generated by the differential erosion of the other strata in the formation. In general, bedding is not recognizable and most of the SPs have joints in three planes filled with siliceous and ferruginous material. Cement is clayey and its quantity is variable, creating tangential to complete packing (Figure 5d). Lutite and limestone are well represented, generally as tabular pebbles, whereas quartzites are more spherical. MA is the best-represented type, followed by OO and CA types. SO is

FIGURE 5 Surveyed formations and their detailed pictures: (a) Viorna conglomerate, (b) conglomerate from the Pontón formation, (c) conglomerate from the Maraña-Brañas formations, (d) conglomerate from the Valdeón formation. (e) Conglomerate from the Campollo formation and (f) conglomerate from the Remoña formation [Color figure can be viewed at wileyonlinelibrary.com]

represented in some SPs as BQ and RQ types (Figure 4d), and the latter two in smaller proportions. Cortex is fine-grained and iron oxides and other clayey components adhere to the surfaces.

The conglomerates from the *Campollo Group* (in the Peña Sagra area) and the Narova conglomerate (a big conglomerate situated in the middle of La Liébana) are inserted in a shale, sandstone, conglomerate, and limestone succession. They were created under sedimentary and synorogenic conditions related to underwater and high-density grains and mudflow (Heredia, Rodríguez-Fernández, et al., 2003; Rodríguez-Fernández et al., 2003). The conglomerates are easy to recognize due to their thickness (sometimes more than 130 m). They are heterogeneous in their bedding, presence of joints (in general not highly impacted), and especially in cement composition, varying between argillaceous (with carbonates), carbonated, or highly indurated siliceous (Figure 5e). The quantity of cement is smaller as compared with other conglomerates, creating tangential, or even complete packing. The best-represented lithologies are lutite, limestone, sandstone, and quartzite. The latter is mainly represented by MA quartzarenites, even though CA and OO could be present. The external morphologies are more tabular for MA and non-quarzitic lithologies, whereas CA and OO are more spherical. Cortical textures range from fine-grained to fine due to the different conglomerate cements.

The last conglomerate presented in detail is the *Remoña conglomerate*, a part of another succession of shale, sandstone, and conglomerate with an approximate thickness of 900 m. It was created in a foreland basin system, in the filling area of a basin created in the surroundings of the Picos de Europa orogeny (Heredia, Rodríguez-Fernández, et al., 2003; Rodríguez-Fernández et al., 2003). The conglomerates from the Remoña Group are small, thin, and discontinuous layers with poor prominence. They extend to the south and southeast of the area surrounding the Picos de Europa mountain range. They are homogeneous, showing bedding structures, absence of joints, and presence of argillaceous cement. The latter allows for easy-to-medium rock extraction (Figure 5f). Cement composition gives the embedded clasts a reddish and/or black color and a thin coating of clayey cement (usually with pyrites). The main framework of pebble packing is isolated or tangential. The best-represented lithology is quartzite, followed by lutite. The OO type is the most abundant type, followed by SO and BQ types (Figure 4e). The MA type is represented and, together with lutite, it is more flat and more angular. Contrarily, spherical pebbles are associated with the orthoquartzites and quartzites.

4.4 | River deposits

River beach deposits consist of the accumulation of unconsolidated sediments from bedrock outcrops and other unconsolidated deposits or as a consequence of weathering and erosion by watercourses. The river beach deposits in the Deva and the Cares basins form a diverse source of raw material, owing to the heterogeneous lithology of the basin and transport by these active rivers (Supporting Information File S9). The strata eroded by these determine the primary lithologies present in each river beach, even though distant lithologies also appear occasionally. The morphologies of the most frequent lithologies are tabular pebbles conditioned by their arrangement in the original formations (Figures 6b and 6c). In contrast, the morphology of the distant and less frequent lithologies is always rounded.

In the *River Deva*, the most frequent lithologies are limestone, lutite, and quartzarenite, with higher percentages of the former. Regarding the diversity of quartzarenites, the MA type is predominant. The source area of this type extends widely across the Liébana and Fuentes Carrionas areas, comprising the siliciclastic outcrops of Potes, Mogrovejo, Viorna, and Murcia, as well as the Barrios Formation in the Hermida Gorge. The presence of CA and OO types is scarce. When present, they always form <2% of the SP. Their source areas are the slightly deformed zones of the Barrios outcrops or the rocks derived from conglomerates in the southern zone. Finally, the negligible presence of the SO type is related to the aforementioned conglomerates (Figure 6a).

In the river beach deposits of the *Cares basin*, the most frequent lithologies are limestone, quartzite, and lutite. Focusing on the quartzites, the most frequent type is the MA one (>90%). This type is probably derived from the Barrios, Murcia, Pontón, and Valdeón Formations. Besides the former, which appears parallel to the coast alignment once the river crosses the Picos de Europa, all these bedrocks are situated in the Valdeón area. The Barrios Formation can also be responsible for the introduction of small percentages of CA and OO types in the river system. The conglomerates from the Valdeón area, which contain the CA, OO, SO, and BQ types, can also be the sources of these varieties in the Cares basin. The quantity of the CA and OO types is moderate in this area, and the presence of SO and BQ types is residual. The quantity of these types gradually decreases once the River Cares starts eroding other strata, especially the Valdeteja and Picos de Europa limestone formations (Figure 6a).

In both rivers, the cortex of the quartzites is similar, generally represented by a soapy or fine texture, especially on more deformed or metamorphosed types. Fine-grained or even coarse-grained textures are described in some MA, CA, and OO types, and they could be associated with their proximate massive outcrops. The neocortex is, as in previous cases, not well developed. The most noteworthy feature of the cortex is the presence of impact cracks caused by collision with other stones. The presence of voids on the cortical surfaces is also apparent, especially in the quartzarenites and OO types. Lithophagous marks and rootless imprints are represented on these surfaces. In general, there is no mineral precipitation on the cortex. The color of the surface is similar to the inner color of the quartzite, even though it is generally lighter or pale.

4.5 | Quartzite assemblages at El Habario and El Arteu

The first assemblage analyzed was recovered in the excavation of *El Habario-B* (Carrión & Baena Preysler, 1999, 2005). Most of the rocks were weathered, which modified their colors into brownish or reddish hues, especially in cases of the lighter varieties. The seven proposed petrogenetic types were identified in the quarzitic artifacts (n = 467) from El Habario (for detailed petrographic analysis and binocular characterization, see Prieto, Yusta, & Arrizabalaga, 2019; Prieto et al., 2020). Metamorphic quartzite is the best-represented group, owing to the high quantity of the BQ petrogenetic type. Orthoquartzite is the second-best represented group, and both OO and SO types are similarly represented. Quartzarenite is under-represented. Regarding quartzite types and size varieties, nine preferential varieties are associated with OO, SO, and BQ types and fine and medium grain sizes (Prieto, Yusta, & Arrizabalaga, 2019; Prieto et al., 2020).

Cortical areas are represented on 57.2% of the quartzites (N = 271). Regarding the types of cortex, 14% of the assemblage could not be characterized due to the absence of diagnostic features. None of the cortex identified could be interpreted as evidence of direct extraction from a massive outcrop. Conglomerate cortex is the most frequent type, representing 82% of the lithic implements with cortical areas. They are characterized by the presence of cement made of dark and red iron oxides or (in small occurrence) made of siliceous material. The cement covers voids. Some linear grooves, probably related to glacial erosion, are represented. Cortex is generally thin, especially on deformed and metamorphic types, giving a darker color and coating the inner areas nearest to the cortex. In thin section, it is associated with clayey minerals, iron oxides and, especially, pyrites. Cortex from fluvial sources is scarce, represented by 4% of cortical surfaces. It is only defined on the OO, SO, and BQ types. This type of cortex is characterized by the presence of soapy surfaces, and especially by the high quantity of impact cracks not covered by the cement. The representation of types of cortex by types of quartzite is shown in Figure 7a.

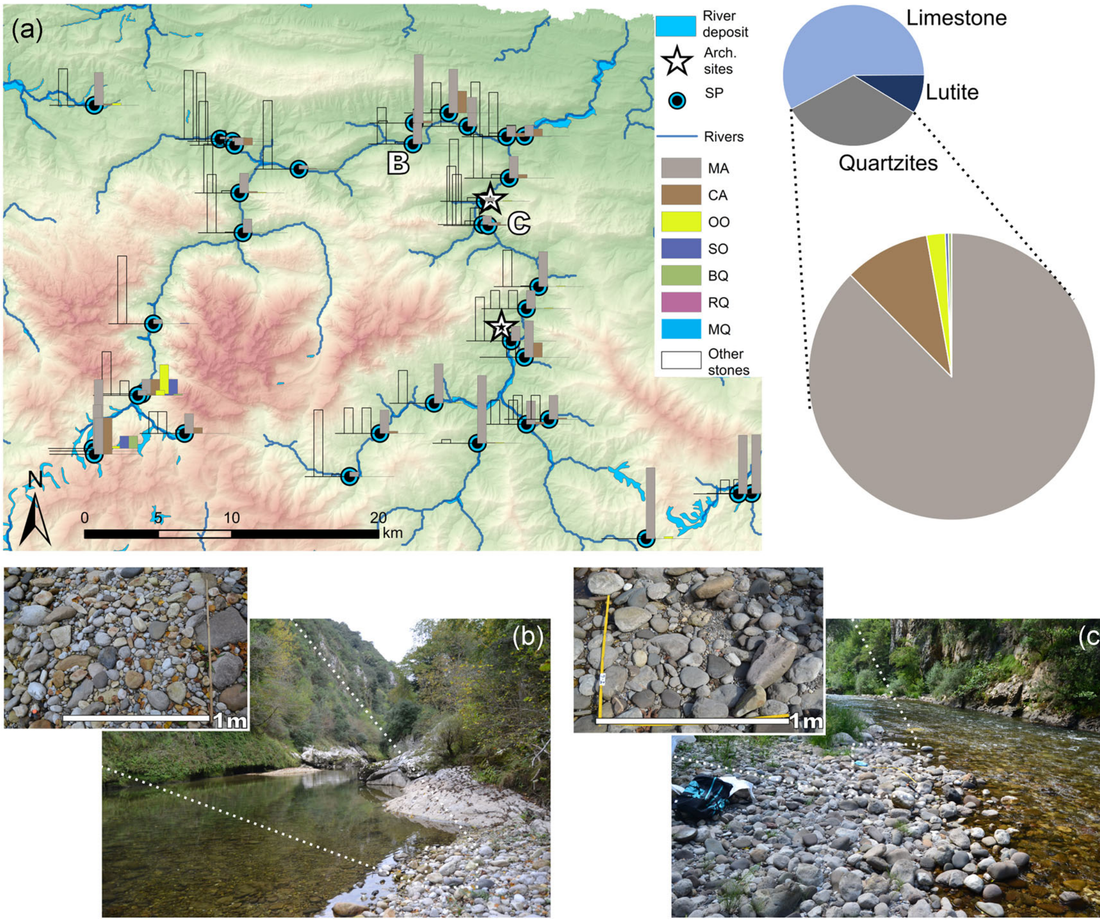

FIGURE 6 Representation of lithologies in fluvial sources. (a) The map of the area with the percentage of main lithologies and quartzite grouped by petrogenetic types. General lithological variability and representation of quartzite types through the pie charts. (b) Cares River beach and detail of a 1-m survey square. (c) Cares River beach and detail of a 1-m survey square. BQ, bulging recrystallized quartzite; CA, clastic quartzarenite; MA, matrix or cemented quartzarenite; MQ, Grain boundary migration recrystallised quartzite; OO, syntaxially overgrown orthoquartzite; RQ, subgrain rotation recrystallized quartzite; SO, suturated grain orthoquartzite [Color figure can be viewed at wileyonlinelibrary.com]

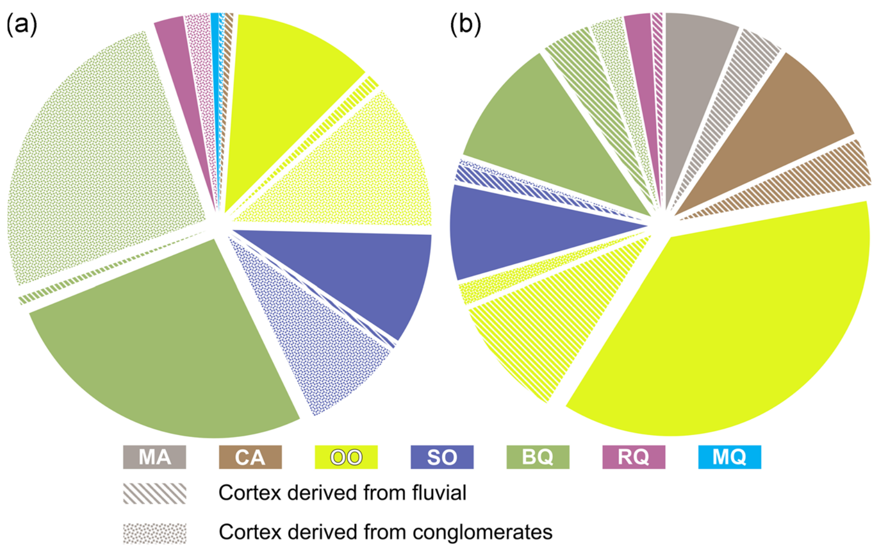

FIGURE 7 A pie chart representing the quartzite distribution grouped by petrogenetic types and cortex types at the assemblage of (a) El Habario and (b) El Arteu. BQ, bulging recrystallized quartzite; CA, clastic quartzarenite; MA, matrix or cemented quartzarenite; MQ, grain boundary migration recrystallised quartzite; OO, syntaxially overgrown orthoquartzite; RQ, subgrain rotation recrystallized quartzite; SO, suturated grain orthoquartzite [Color figure can be viewed at wileyonlinelibrary.com]

The in-depth techno-typological characterization of this assemblage (Prieto et al., 2020) and its interpretation through a basic reduction sequence proposed different management strategies, depending on each type of quartzite (Figure 8). Complete reduction sequences were performed in the SO, BQ, and the OO type. In contrast, only partial processes were followed at the site in the quartzarenite group and the RQ and MQ types. In the latter two types, these processes were related to the last steps of reduction sequences. The degree of exploitation differs between the highly exploited SO type and quartzite group when they are compared with the quartzarenite group. Despite its broad representation, the OO type was not as intensively exploited as the others (Prieto et al., 2020). The small quantity of artifacts with fluvial cortex does not allow clear differences to be established in its representation between the different technological categories. Moreover, the absence of chunks with this cortex type and its higher representation on core on flakes could be indicative of differential raw material management, depending on the area where they were acquired, and also that raw material was transported as blanks or retouched artifacts rather than proper (on block) cores (Figure 8).

The second archaeological assemblage is the complete collection recovered at *El Arteu* site (Baena Preysler et al., 2005; Carrión, 2002; Carrión et al., 2008). Some pieces have recent fractures, and also carbonate and clay patinas on lithic surfaces. Others have altered surfaces due to water erosion. Six petrogenetic types have been identified in the quarzitic artifacts (*n* = 237) from El Arteu (for detailed petrographic analysis and binocular characterization, see Prieto, Yusta, & Arrizabalaga, 2019; Prieto et al., 2020). Sedimentary orthoquartzite (47%) is the most represented group, and quartzarenite (21%) is the second most frequent one. Finally, the group of metamorphic quartzite is the least frequent (19%). We identified six preferential grain size varieties: three belong to OO type, one with fine size and homogeneous distribution, and another two medium-sized varieties with homogeneous and heterogeneous distributions. Another two varieties are BQ and SO types with fine grain size and homogeneous distribution. The last one is the CA type with heterogeneous distribution and medium quartz grain sizes (Prieto, Yusta, & Arrizabalaga, 2019; Prieto et al., 2020).

The cortical characterization of this assemblage clearly differs from the previous one. Cortical areas are restricted to 35% of the pieces (*n* = 84). Twenty-one percent of the assemblage could not be characterized due to the absence of diagnostic features. Cortex from fluvial sources (62%) is the best-represented type. The most relevant features are the fine or soapy texture, the presence of impact cracks, and the presence of lighter surfaces. Weathering processes from the cortical areas to the inner part of the quartzite are clear, especially in quartzarenites. Conglomerate cortex is only represented in 4% of the cortical areas. It is characterized by the presence of cement, which

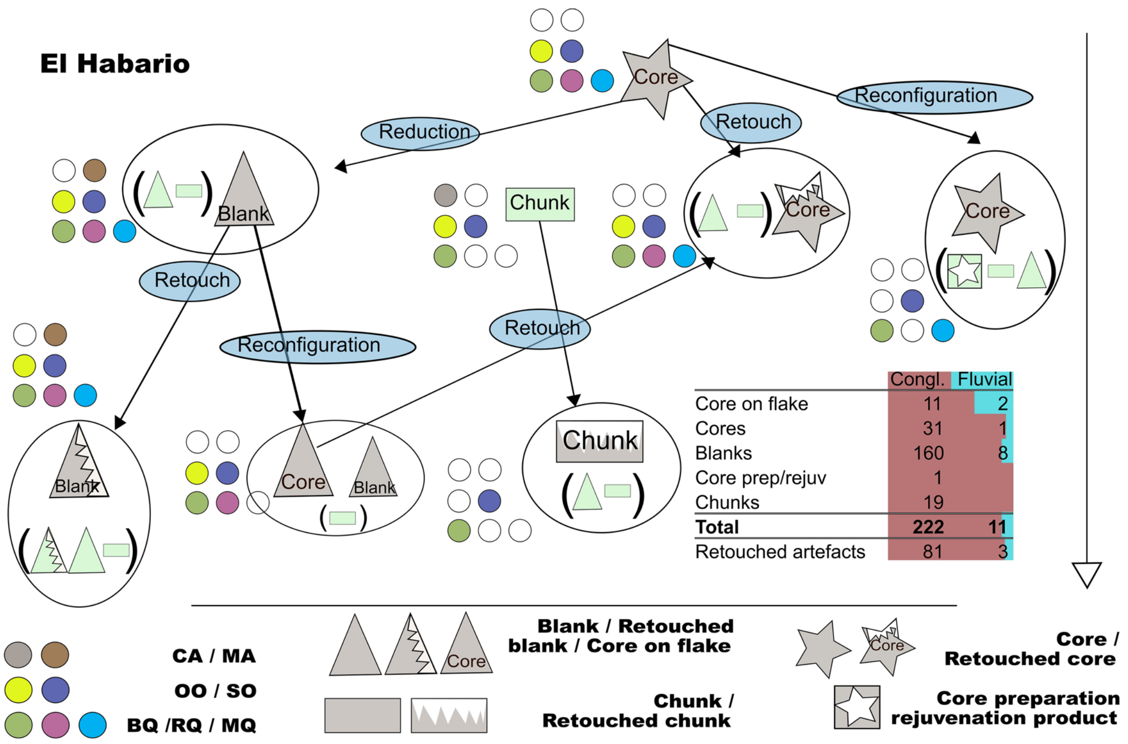

FIGURE 8 A schematic and basic reduction sequence at El Habario-B, based on Prieto et al. (2020). The types of quartzite represented are highlighted in colors and associated with each process. Icons in green are byproducts. The association between types of cortex and basic technological categories is shown in the table. BQ, bulging recrystallized quartzite; CA, clastic quartzarenite; MA, matrix or cemented quartzarenite; MQ, grain boundary migration recrystallised quartzite; OO, syntaxially overgrown orthoquartzite; RQ, subgrain rotation recrystallized quartzite; SO, suturated grain orthoquartzite [Color figure can be viewed at wileyonlinelibrary.com]

creates a rougher touch and covers some visible voids. Cement compositions are related to clays and iron oxides. As in the previous assemblage, the massive outcrop cortex was not recognized (Figure 7b).

The management strategies differ between petrogenetic types, as noted by the techno-typological analysis (Prieto et al., 2020) and the reduction sequence inferred in Figure 9. In this case, complete reduction sequences were restrained to the quartzarenites and the OO orthoquartzites. The fragmented reduction sequences of the SO, especially the quartzite group, suggest they were knapped in advanced or even final stages of the reduction sequences. The analysis of cores, dorsal scars on blanks, the weight distribution, and the presence of retouch reveals that orthoquartzite and quartzite were heavily exploited (Prieto et al., 2020). Due to the small number of items with the cortex, the relationship between the type of cortex and the main techno-typological features must be nuanced. The cortex derived from conglomerates is more abundant on certain categories such as core preparation/rejuvenation products or retouched artifacts, whereas fluvial cortex is associated with cores and chunks. These data suggest that quartzite stocks from conglomerates could be transported as blanks rather than as cores (Figure 9). Moreover, and as pointed out by the in-depth techno-typological analysis, the cortex is scarcer on cores than on other products (Prieto et al., 2020).

5 | DISCUSSION

5.1 | The rock cycle and its consequences for human life: Potential raw material procurement strategies in the Deva and Cares basins

The outcrop formations analyzed reflect, through the grain size and morphological features, the dynamics of erosion and sedimentation of quartz grains. The Barrios Formation is the result of a delta plain environment (Aramburu et al., 1992, 2004), observable in the moderately sorted and well-rounded sediment. In turn, the Murcia Formation is the consequence of a marine and sedimentary turbidity process (Aramburu et al., 2004; Rodríguez-Fernández et al., 2003), evidenced by heterogeneous size and morphology of quartz grains and the major presence of matrix in the samples. A similar heterogeneous distribution of quartz grains is observable in the four Carboniferous outcrops (Rodríguez-Fernández et al., 2003). The scarcity of deformed petrogenetic types and the absence of the metamorphic group in these formations are evidence of the low degree of metamorphism in this area (Bastida, 1982, 2004).

The conglomerates show a greater complexity, determined by successive sedimentary, transport, and sometimes deformation processes. Thus, the formations where conglomerates were inserted are alternations of sandstone, shale, (sometimes limestone), and conglomerate. These heterogeneous successions reflect the variable sedimentary basin

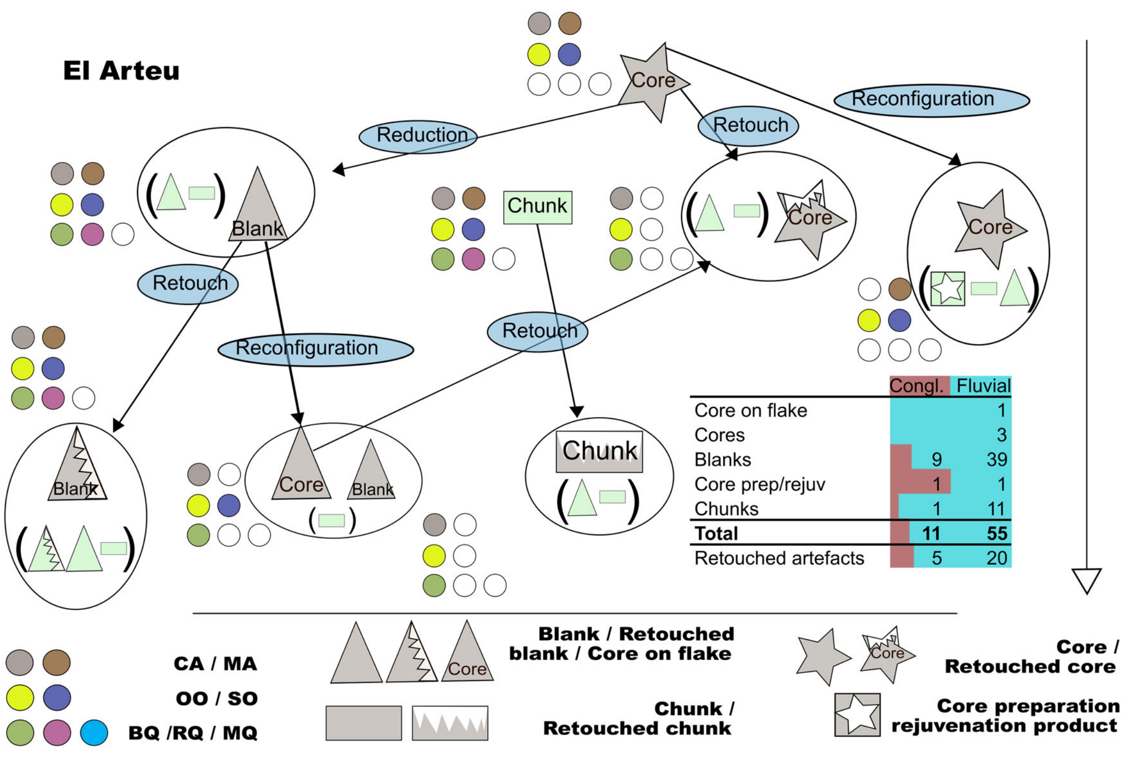

FIGURE 9 A schematic and basic reduction sequence at El Arteu, based on Prieto et al. (2020). The types of quartzite represented are highlighted in colors and associated with each process. Icons in green are byproducts. The association between types of cortex and basic technological categories is shown in the table. BQ, bulging recrystallized quartzite; CA, clastic quartzarenite; MA, matrix or cemented quartzarenite; MQ, grain boundary migration recrystallised quartzite; OO, syntaxially overgrown orthoquartzite; RQ, subgrain rotation recrystallized quartzite; SO, suturated grain orthoquartzite [Color figure can be viewed at wileyonlinelibrary.com]

conditions in this area during the Carboniferous (Fernández et al., 2004; Rodríguez-Fernández et al., 2003). The heterogeneity of the clasts (based on morphology and size) and conglomerate cement also point toward these environments. Nevertheless, the lithological characterization of the clasts indicates the concurrence of multiple and changeable rock source areas. Some of these come from nearby strata, such as limestone, shale, and MA, CA, or OO types (generally from Barrios, Murcia, or older Carboniferous formations), whereas others originate in more distant strata, as indicated by the presence of other petrogenetic types, such as SO, BQ, or RQ (Figure 10a). The latter three types are associated with the western Precambrian, Silurian, or Devonian outcrops in the Cantabrian (Aramburu et al., 2004; Bastida, 2004; Liñán et al., 2002; Pérez-Estaún, 2004a) and the Western Astur-Leonesa zones in the Iberian Massif (Pérez-Estaún, 2004b). The conglomerate formations of the Curavacas, Porrera, Bárcena, Cubo, Pesaguero, Viorna, Campollo, and Narova only represent the nearest lithologies and types. The Lechada, Pontón, Maraña-Brañas, Valdeón, and Remoña formations also contain orthoquartzites and quartzites from distant source areas. The data point toward a changeable geography and the connection and enclosure of multiple basins (Fernández et al., 2004).

Finally, secondary deposits show active processes of weathering, erosion, transport, and deposition. The weathering processes on siliciclastic massive outcrops mainly alter the joint systems. This situation creates tabular and angular rock fragments in the immediate surroundings of the outcrops. In conglomerate formations, the weathering processes mainly affect the cement, and pebbles are easily released. Finally, fluvial and aeolian forces have also eroded pre-existing elements, creating rounded morphologies. Gravitational, fluvial, and glacial processes transport and deposit the rock fragments, spreading these along the basins. The lithologies of each stratum decrease gradually due to their geographic dispersion.

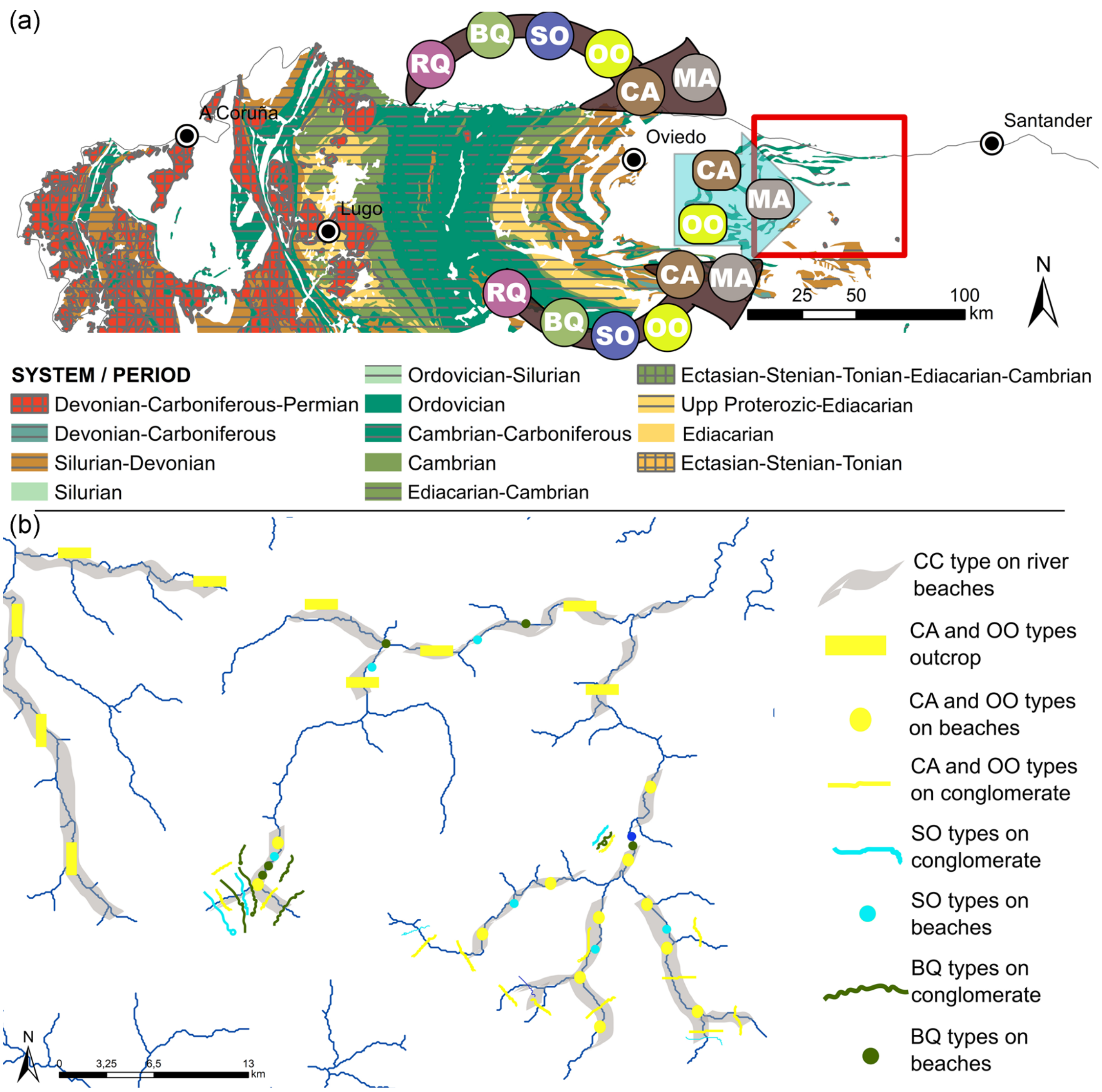

FIGURE 10 (a) The probable source area of the quartzite pebbles embedded in the Carboniferous conglomerates. The map is modified from the 1:1,000,000 geological map of Spain (Álvaro et al., 1994). Unmixed layers created during and after the Carboniferous are not represented. (b) A schematic map showing the available quartzite types in the research area. BQ, bulging recrystallized quartzite; CA, clastic quartzarenite; MA, matrix or cemented quartzarenite; OO, syntaxially overgrown orthoquartzite; RQ, subgrain rotation recrystallized quartzite; SO, sutured grain orthoquartzite [Color figure can be viewed at wileyonlinelibrary.com]

Potential quartzite procurement strategies in these contexts were varied, and they would have been mainly determined by the presence or absence of the petrogenetic types and their features, morphologies, and abundance. Figure 10b synthetically represents the potential areas where different petrogenetic types could be acquired by Middle Paleolithic people.

In the massive outcrops, the direct and intensive exploitation of visible strata would have been easy. The direct collection of rock fragments resulting from the weathered joints would have been possible by hand or using hammers, similar to the gathering of the rock fragments detached from the outcrops. The resulting morphologies of the blanks would have been tabular and relatively angular. Moreover, few lithologies were potentially exploited, and only the MA type and its multiple grain size or matrix/cement varieties could be exploited intensively. Conversely, the acquisition of CA or OO types would have been restricted to small areas or stratum of the Barrios Formation. The selection of specific petrogenetic types, prioritizing homogeneous and certain grain size varieties, could have been done by selective knapping of rock fragments. There would also have been a selection of non-joined or non-weathered areas.

In the mixed strata of conglomerates where quartzite is embedded, the direct and intensive exploitation would have been done using selective mechanisms. The direct extraction of the pebbles would have depended on the cement composition. In those cases where cement is argillaceous, sandy, or carbonated, extraction could have been carried out by direct hand collection. Instead, in the cases where cement is more compact, the extraction must necessarily have involved hammers or other tools. Direct collection of detached fragments would have also been possible in the areas surrounding the conglomerate. The resulting format of the blanks would have been spherical. In most of the conglomerates, the intense exploitation of the quartzarenite group would have been possible without the need for important selective mechanisms. The exhaustive exploitation of the OO type would have been geographically restricted, and it would have required a targeted procurement strategy. The intensive acquisition of SO, BQ, and RQ types would have been restrained to a few small conglomerate outcrops concentrated in the Valdeón area and the small Remoña conglomerate in La Liébana. Its exploitation signifies intentional selection. In other conglomerates, its acquisition would have been reduced to occasional finds. In all conglomerates, a selective mechanism would have been necessary for the procurement of specific types and varieties, as well as for non-weathered or joined pebbles.

In the river beach deposits, intensive quartzite acquisition would not have been reliable due to the scarcity of this lithology. The direct gathering of interesting pebbles would have been easy, but again would be driven by strong and intentional procurement strategies. The morphology of the cores or blanks resulting here would have ranged from tabular to spherical pebbles. The intense acquisition of the MA type would have been possible in this kind of deposit, whereas the exploitation of CA and OO types would have been limited, and selective mechanisms must have been applied. The gathering of SO, BQ, and RQ types is possible, but it would have been related to occasional finds due to the exploitation of river areas, rather than to planned strategies. In the Valdeón area, the exploitation of the latter five types could have been planned due to their more significant quantities.

5.2 | Procurement of quartzite at El Habario and El Arteu: Dialectic exploitation of resources in middle and lower altitudes

This section proposes the quartzite procurement mechanisms employed by Paleolithic people to understand other patterns related to territorial management and human mobility. The representation of quartzite types and cortex characterization suggests different and complementary procurement patterns.

At El Habario, the high representation of cortical areas and the overrepresentation of the OO, SO, and BQ types suggest large-scale and active procurement of quartzites in the adjacent Remoña conglomerate. The data reinforce a previous hypothesis that posited that the site was a quarry or a workshop where the initial stages of lithic reduction were carried out (Baena Preysler et al., 2012; Carrión & Baena Preysler, 2005; Manzano et al., 2005; Prieto, Yusta, & Arrizabalaga, 2019). The exploitation of raw material in conglomerates was also suggested in other research in the region (Castanedo, 2001; Herrero-Alonso et al., 2020; Santamaría, 2012). Furthermore, current research demonstrates how these activities were performed through the analysis of an in situ workshop that intensively exploited and transformed the quartzite pebbles into a stock of suitable raw material. The quartzite was extracted by hand from the exposed outcrop or gathered from the immediate surrounding. Non-jointed quartzite pebbles, especially the SO and BQ types, were tested, selected, and knapped, discarding other types and, maybe, jointed zones. The exploitation of the OO type was secondary, as indicated by the different proportions of this type in the assemblage when compared with the conglomerate, reinforcing the hypothesis suggested by the analysis of the technical attributes (Prieto et al., 2020). The representation of RQ and MQ types derived from fluvial sources and conglomerates must be related to the conglomerates from the Valdeón area and other non-researched areas, suggesting procurement strategies related to long-distance mobility of objects and people. Lithics from these types, as well as small quantities of others, are related to preceding, intensive, and direct procurement activities in conglomerates (also from Fuentes Carrionas) and preceding and extensive acquisition events on river beaches. Both procurement strategies are probably indicative of a more sophisticated territorial management that articulated middle altitude plateaus with open and lower river valleys. The COST map helps to visualize the different mobility circuits that converge and cross over these plateaus and the lower and open valleys in La Liébana, Fuentes Carrionas, Peña Sagra, and Valdeón (Figure 11a,c). Finally, these data underpin the hypothesis suggested by the technological characterization in which the high quantity of retouched material (tool kit) and more intensively knapped material previously stocked was discarded and substituted by new stocks (Prieto et al., 2020).

At El Arteu, the smaller representation of cortical areas, the overrepresentation of the OO type, the relative importance of quartzarenite,

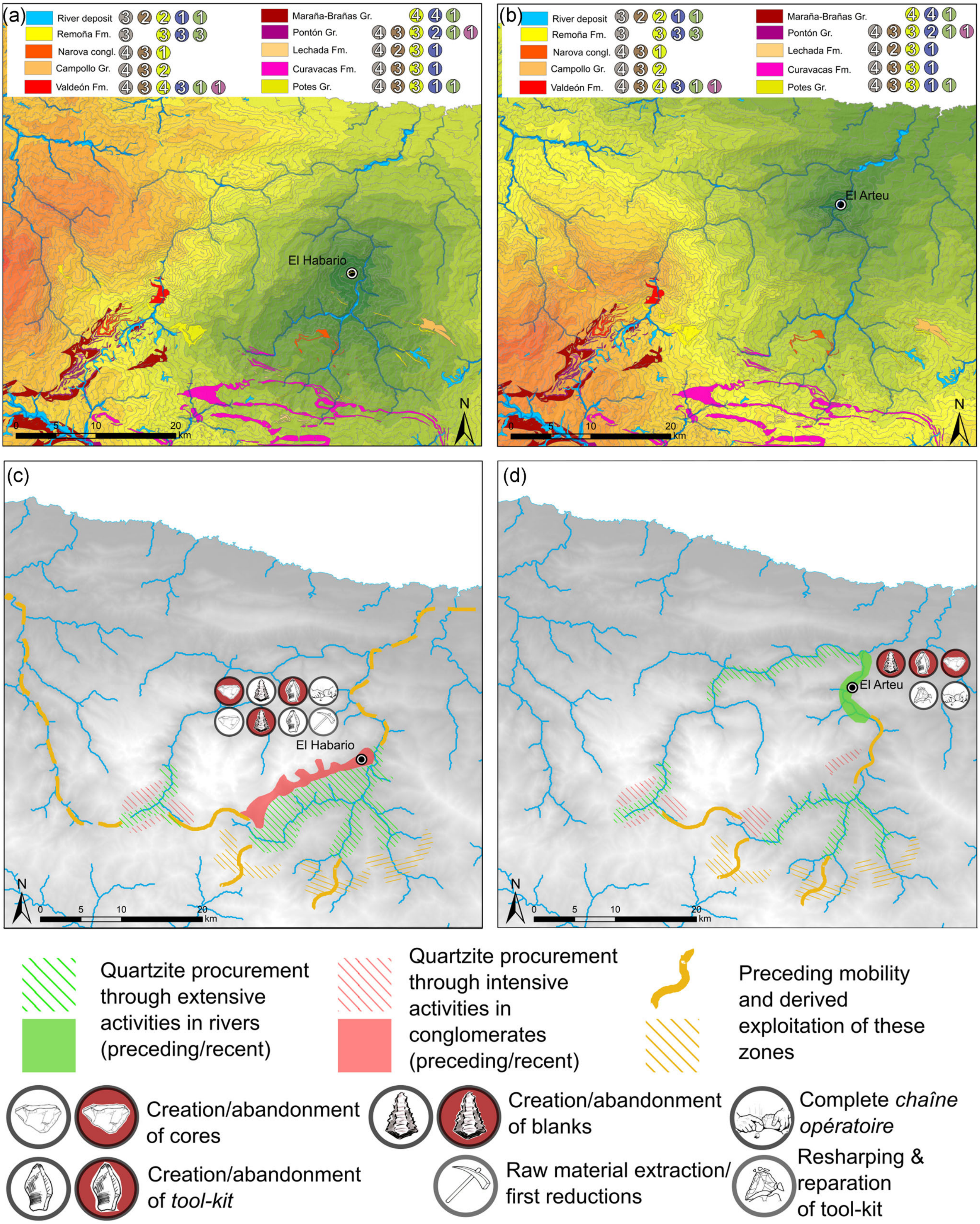

FIGURE 11 Cost maps from (a) El Habario and (b) El Arteu to geological strata where quartzite types are represented. The colored circles in the key represent the lithologies in each geological formation (following the color code of previous figures). Numbers are used to quantify the proportion of each type: 4 when the frequency is >30%; 3 for 10%–30%; 2 for 2%–10%; and 1 when frequencies <2% are found. Quartzite procurement area map of (c) El Habario and (d) El Arteu. Most representative management of raw material according to Prieto et al. (2020) is highlighted [Color figure can be viewed at wileyonlinelibrary.com]

and the importance of fluvial cortex on most of the cortical pieces suggest different procurement strategies. They would be related to the acquisition of quartzite in secondary river deposits and also to a more complex and planned procurement of lithic resources from multiple sources. The first strategy involved immediate and extensive procurement, which was probably linked to other activities in the nearby beach river deposits. This strategy is based on the selection of types and varieties from the fluvial beaches that provide large quantities of MA type and a few of the CA and OO types. It is important to highlight that El Arteu is near a Barrios outcrop alignment (eroded by the River Deva and its tributary the San Esteban river), increasing the proportion of the three types in the proximate fluvial deposits. Other types of quartzite were acquired in these contexts, even though related to fortuitous or occasional supply than a planned one. As suggested by previous research (Prieto et al., 2020), MA, CA, and OO types present complete reduction processes, but quartzarenites were not exploited intensively. The second procurement strategy complements or was complemented by the aforementioned one by the consumption of stocked quartzites. They were obtained in conglomerates or even in other and preceding extensive activities carried out in fluvial sources. As suggested at the proximate site of El Esquilleu, these activities could be related to hunting or gathering of plants and wood (Baena Preysler & Carrión, 2014). Most of the artifacts made on the types SO, BQ, and RQ were derived from this type of procurement, and a few from the OO type. Cortical surfaces and petrogenetic types and varieties suggest that these quartzites were obtained in conglomerates from La Liébana, Valdeón, and probably Fuentes Carrionas. We could not discard the procurement of quartzites from the River Cares due to its proximity and the higher (still negligible) presence of BQ and RQ types (Figure 11b,d). The exploitation intensity, the typological characterization of these quartzites, and the general absence of the first stages of reduction processes reinforce this complex procurement of quartzite on the basis of a conservative and planned management of raw material (Prieto et al., 2020). Moreover, they reinforce the characterization of the site as a hunting post, probably related to hunting activities and associated with the central layers at El Esquilleu (Baena Preysler et al., 2005, 2012).

6 | CONCLUSIONS

In this study, the procurement strategies carried out by Middle Paleolithic groups in the Deva and Cares valleys have been described through the analysis of the quartzite lithic assemblages at El Arteu and El Habario, together with the analysis of the potential procurement areas. This study was based on a multiscalar geoarchaeological approach that combines GIS for the analysis of geological and geographic data, geological field survey to characterize the potential catchment areas, and petrographic–stereomicroscope petrology to describe quartzites from the aforementioned sources and the lithic assemblages. This holistic approach has not been frequent in the scientific literature (Daffara et al., 2019; Fernandes et al., 2007, 2008; Turq, 2005), and this study is the first application to such an understudied raw material as quartzite. The implementation of this methodology in a well-defined research area allows us to propose richer and more complex procurement strategies of raw material than those exclusively described in models that could be termed as "direct" or "embedded" (Bamforth, 2006; Binford, 1979; Brantingham, 2003). Moreover, this discourse is more closely related to the daily life of people as opposed to those only related to long-distance mobility of people and objects. The procurement strategies observed propose complex procedures, combining not only direct and embedded procurement, but also intensive and extensive searching in different places and times and also the different selection and exploitation degrees in specific quarzitic types. These approaches take a step further than previous research in the Cantabrian Region, which has not taken into account the variability of quartzite in the potential catchment zones. Previous studies relate the procurement strategies to simplistic acquisition on secondary river deposits (Álvarez-Alonso et al., 2013; Sarabia, 2000) or even from conglomerates, regarded as a homogeneous raw material source (Castanedo, 2001; Rasilla et al., 2020; Santamaría, 2012).

Furthermore, this study proposes a dispersion of raw material by human groups, not only based on a dot and arrow map but also on more complex mobility (Prieto et al., 2016; Sánchez et al., 2016) and economic settings (García-Rojas et al., 2017; Herrero-Alonso et al., 2020; Rios-Garaizar & García, 2015). The most relevant conclusion considering these terms is that mobility was used to articulate complex economic management of terrain, in which quartzite is one of the multiple resources. The Middle Paleolithic populations who inhabited this area practiced dialectic management and exploitation of a heterogeneous terrain, bringing together lithic resources from lower valleys and middle altitude plateaus, using logistical and/or residential networks, as also suggested by previous researchers in this area (Baena Preysler et al., 2005, 2012) and other parts of the Cantabrian Region (Rios-Garaizar, 2020; Rios-Garaizar & García, 2015). The dialectic exploitation of this heterogeneous terrain allowed Middle Paleolithic societies not only comprehensive management of the environment but also its adaptation to interannual and possibly global climatic changes (Delagnes & Rendu, 2011). Mobility circuits that connect different areas were probably based on short- or medium-range mobility; however, longer circuits also seem to be present, as proposed in other Cantabrian Middle Paleolithic sites (Rios-Garaizar, 2020) or other parts of Europe (e.g., Daffara et al., 2019; Gómez de Soler et al., 2020; Turq et al., 2013, 2017). These longer mobility circuits were not quantitatively important for the dispersion of raw material, but they indicate relationships between the Cantabrian Coast and the northern limit of the Iberian Plateau, as also suggested in the region in other prehistoric frameworks (Herrero-Alonso et al., 2020).

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AUTHOR CONTRIBUTIONS

Alejandro Prieto: Conceptualization; data curation; formal analysis; investigation; methodology; writing-original draft; writing-review & editing. **Iñaki Yusta:** Conceptualization; methodology; supervision; writing-review & editing. **Maite García-Rojas:** Data curation; formal analysis. **Alvaro Arrizabalaga:** Funding acquisition. **Javier Baena Preysler:** Resources; validation; writing-review & editing.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article.

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