EVIDENCE OF A NEANDERTHAL-MADE QUARTZ-BASED TECHNOLOGY AT NAVALMAÍLLO ROCKSHELTER (PINILLA DEL VALLE, MADRID REGION, SPAIN)

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The present work describes a preliminary study of a primarily quartz-based Mousterian lithic assemblage deposited about 75,000 years ago by Neanderthals in Navalmaíllo rockshelter (Pinilla del Valle, Madrid, Spain). Although archaeological assemblages dominated by quartz are not common in the central Iberian Peninsula, they are more common in peripheral areas such as Catalonia and Galicia. As documented in other European sites, the abundance of quartz led to its becoming the main raw material used in tool-making in the area, even though it seems to be more difficult to knap than other, more homogeneous types of rock that fracture conchoidally. Moreover, the cores found at the Navalmaíllo site appear to have been intentionally worked to a very small size, a finding also reported for other European assemblages of similar age. The other raw materials found at the site include chert, quartzite, porphyry, rock crystal, and sandstone, all of which appear to have been worked in the same manner as the quartz. The scarcity or quality of raw materials is not the reason for this behavior.

NAVALMAÍLLO ROCKSHELTER, A MOUSTERIAN SITE AT PINILLA DEL VALLE in the Madrid region of central Spain (Figure 1), was discovered in 2002. It lies at an elevation of 1,100 m, some 100 m from the Camino Cave site (Arsuaga et al. 2012).

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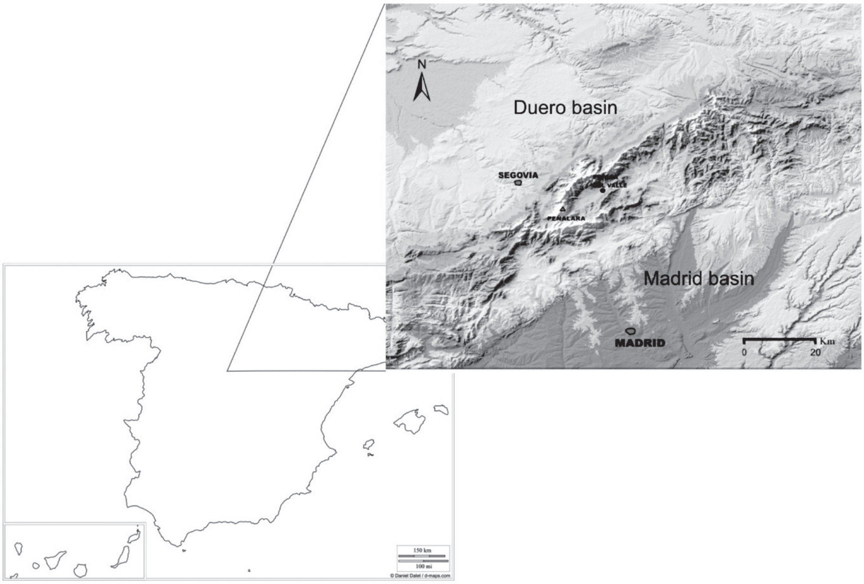

Figure 1. Location of the Pinilla del Valle sites in the high-elevation Lozoya Valley (Sierra de Guadarrama, central Spain) (modified from Pérez-González et al. 2010).

Over time the shelter was completely buried by sediments (Figure 2). Our work describes a preliminary study of the site's lithic industry, thus paving the way for the archaeological work necessary for its complete scientific interpretation. We focus on quartz technology, which has received increased interest in recent years, particularly as concerns sites where this material was preferentially used (e.g., Driscoll 2011a, 2011b; Lombera-Hermida et al. 2011; Mourre 1993–1994, 1996; Tallavaara et al. 2010). This study contributes to the growing body of evidence for Neanderthal adaptive flexibility, in contrast to earlier characterizations of the cultural limitations of this (sub)species.

In 2003, an examination of the site revealed a number of stratigraphic layers (Pérez-González et al. 2010). In 2004 these layers were confirmed to have been formed under the shelter of what was once a rocky ledge. Subsequent excavation suggested that this ledge covered an area of some 300 m^2. These dimensions were confirmed by geophysical surveys in 2006 (Análisis y Gestión del Subsuelo S.L. [AGS] 2006; Pérez-González et al. 2010).

The most characteristic feature of the lithic sample at Navalmaíllo is that the artifacts are mostly made of quartz (commonly called "milky quartz"). Chert and other good raw materials, such as quartzites—found in river terraces—are relatively abundant in the central Iberian Peninsula, where Navalmaíllo rockshelter is located. Quartz cobbles are also common locally, but this material was usually avoided during the Middle Paleolithic period. The few exceptions are always in rockshelters or caves. The best known are Jarama VI cave (Guadalajara), where quartz and rock crystal (clear quartz) dominate the Mousterian sample (Adán et al. 1995; García Valero 2000), and Peña Capón rockshelter (Muriel, Guadalajara)

Figure 2. Recent view of Navalmaíllo rockshelter
(photo by Pinilla del Valle Research Team).

(Alcolea et al. 1997; García-Valero 2000). The latter site has only a few lithic artifacts, and quartz is preferred over other raw materials.

Mourre (1996) and Jaubert (1997) indicate that quartz is used whenever available, despite the presence of other materials of better quality. However, at some European sites, such as Payre (dated to MIS 7 and 5 [Moncel et al. 2008; Lombera-Hermida et al. 2011]) in the central part of the Rhône Valley, the locally abundant quartz appears to have been less used than semi-local chert. At that site, the sources of the chert are at distances of 8–50 km.

Unlike what is common in the central peninsula, in peripheral zones the numerous sites similar in age to Navalmaíllo reveal the predominant use of quartz: for example, in Catalonia at Cueva 120 (La Garrotxa, Girona) level G (57.3% quartz materials; Alcalde et al. 1991); Avellaners and Diable Coix (Comarca de la Selva, Girona) (77% and 91%, respectively; Mora and Carbonell 1987); Arbreda (Serinyà, Girona) level H-43 (58%; Bracco 1997; Mora 1984); in Extremadura at Maltravieso (Complejo Kárstico del Calerizo Cacereño, Cáceres; somewhat older than the occupation at Navalmaíllo, but also Mode 3), Sala de los Huesos (84.6%; Peña 2008), and finally, in Galicia at Cova Eirós (Lugo) (88.8%; Lazuen et al. 2011). At all these sites quartz is available locally.

GEOGRAPHIC AND GEOLOGICAL CONTEXT

Navalmaíllo rockshelter is in the center of the high Lozoya Valley, a cul de sac in which the valley bottom never exceeds an elevation of 1,200 m asl. The surrounding mountains run northeast-southwest and reach heights of more than

2,000 m. At 2,428 m, Pico de Peñalara is the highest in this eastern sector of Spain's Sistema Central mountain range, which is composed of orthogneisses, leucogranites, adamelites, granitoids, migmatites, and to a lesser degree, schists and quartzites (Arenas Martín et al. 1991; Bellido et al. 1991; García Cacho and Aparicio Yagüe 1987). Numerous dykes of igneous rocks, such as aplite, porphyry, pegmatite, and quartz, are also present. All of these rocks formed between the Proterozoic and Carboniferous periods, when the main Variscan deformation occurred (Vera 2004).

The cul de sac conserves Mesozoic deposits. The lowest are marine-influenced continental deposits of sands with layers of quartz gravels. The uppermost are marine sediments of carbonates with marls, some reaching 35 m in thickness. During the Pleistocene, endokarstic and exokarstic morphologies developed in the latter sediments, and it is among these that Navalmaíllo rockshelter was formed.

The Alpine Orogeny (which occurred from the late Mesozoic to the Cenozoic) determined the current topographic configuration of the area, leading to the uplift of Spain's central mountain chain and the formation of tectonic depressions such as the Lozoya Valley, where carbonate rocks of the Late Cretaceous and continental detrital deposits of the Early Tertiary have been preserved from erosion.

Quaternary sedimentation in the area is mainly seen in the low-lying areas of fluvial origin, on terraces and in alluvial fans (Pérez González et al 2010) , and in places above 1,700 m with glacial cirques and accumulations of moraine material from the Late Pleistocene (Palacios et al. 2012; Pedraza 1994; Pedraza et al. 2003).

GEOLOGY OF THE NAVALMAILLO ROCKSHELTER

Navalmaíllo rockshelter was formed by fluvial action that eroded Late Cretaceous dolomite outcrops, and today it lies some 8 m above the Arroyo de Lontanar (Figure 3). The stratigraphic sequence from top to bottom consists of an Ap horizon (10YR 5/2) some 0.20–0.40 m thick and at least two colluvium stages of dolomitic clasts within a silt-sand matrix (7.5 YR 6/3) up to 1 m thick. Below these layers is a bed with large blocks of dolomite that have fallen from the shelter's roof. Some of these blocks are more than 1 m in height. Surrounding them is clay (level D) that was originally part of the underlying level F, a bed up to 0.85 m thick composed of clay-sand (10YR 4/3) and carbonate clasts with a long axis of up to 0.35 m. In the portion of the rockshelter being anayzed here, levels D and F are contiguous. Level F has been dated by thermoluminescence on burned sediments to between 71,685 ± 5.082 (MAD-4262) and 77,230 ± 6.016 (MAD-3767) years old by the TL Lab at the Autonomous University of Madrid (Arsuaga et al. 2011). Under level F are at least 2 m of allochthonous fluvial facies of siliceous gravel and sands deposited by the Arroyo de Navalmaíllo (Figure 3), which drains Variscan gneisses before flowing into the Lozoya River. When the rockshelter's roof fell, materials from the F bed, including archaeological remains, filled in the spaces between the blocks. Level F contains lithic and faunal remains in situ. Level E is a clayey bed with very altered clasts restricted to a small part of the rockshelter. Although lithic and osseous materials are moderately abundant in level E, they will not be included in this analysis.

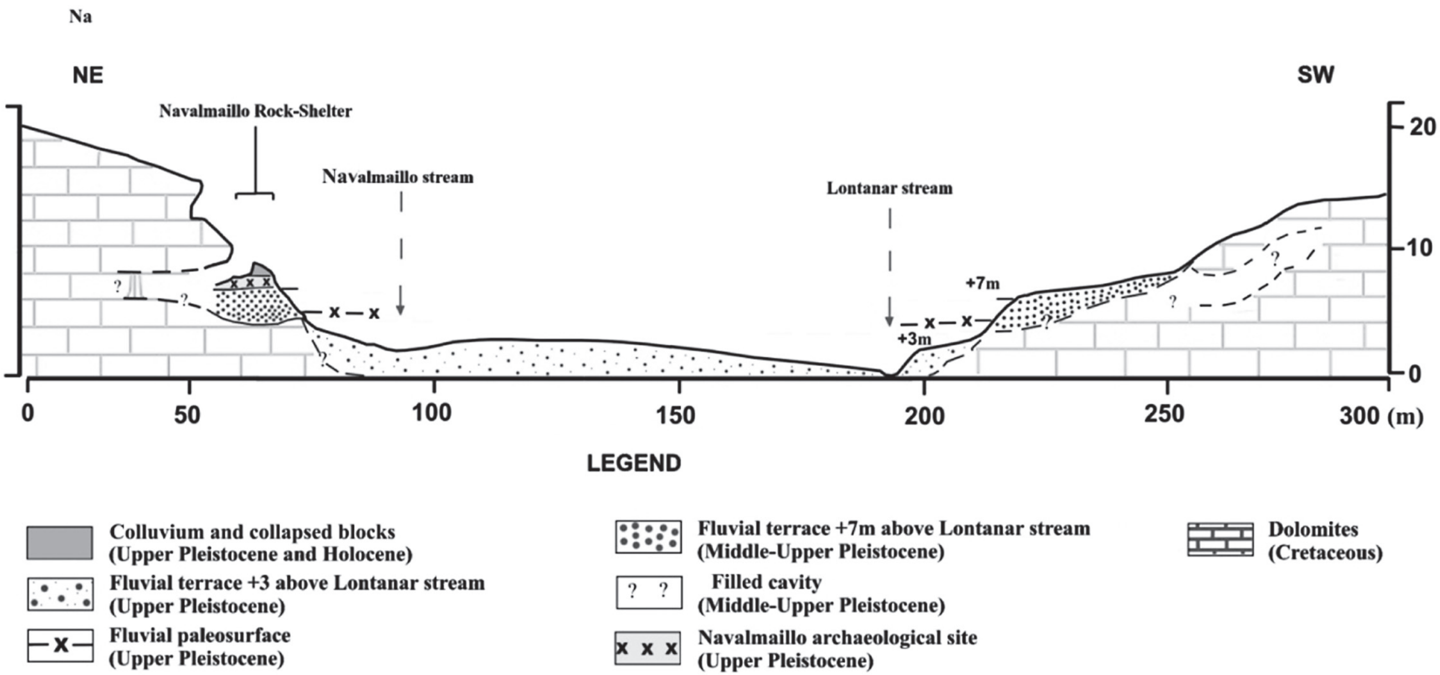

Figure 3. Geomorphological cross-section (NE–SW) of the Arroyo de Navalmaíllo and Arroyo de Lontanar valleys. The relationship between the terraces and deposits in the rockshelter, including the Neanderthal occupation, can be seen (modified from Pérez-González et al. 2010).

THE FAUNAL REMAINS

The macrofaunal assemblage of levels D and F thus far includes some 2,000 fossil remains, of which 614 (30%) have been analyzed (Huguet et al. 2010). Among these, only 11% have been identified anatomically and taxonomically (Table 1). The majority are from medium-size to large adult animals. Taphonomic analysis shows them to have a high degree of green fracturing. Some 30 bone fragments bear cut marks, and 47 show traces of burning in hearths or other fires (Huguet et al. 2010).

THE LITHIC INDUSTRY IN LEVELS D AND F

As of 2008, 6,262 lithic objects had been recovered from levels D and F (Table 2). Fifteen different types of raw material were represented, although just six

Table 1. Mammal remains at Navalmaíllo (modified from Arsuaga et al.2011)

Artiodactyla	
Cervus elaphus	Red deer
Dama dama	Fallow deer
Bos primigenius	Aurochs
Perissodactyla	
Equus ferus	Horse
Stephanorhinus hemitoechus	Narrow-nosed rhinoceros
Carnivora	
Vulpes vulpes	Red fox
Mustela cf. *nivalis*	European common weasel
Rodentia	
Arvicola cf. *sapidus*	Southwestern water vole
Microtus arvalis	Common vole
Microtus agrestis	Field vole
Microtus cabrerae	Cabrera's vole
Microtus gr. *duodecimcostatus*	Mediterranean pine vole
Pliomys lenki	Lenki's vole
Apodemus sylvaticus	Wood mouse
Allocricetus bursae	Hamster
Eliomys quercinus	Garden dormouse
Castor fiber	Beaver
Soricomorpha	
Sorex gr. *araneus*	Common shrew
Talpa europea	European mole
Lagomorpha	
Oryctolagus cuniculus	Rabbit

Table 2. Tool type (*n*) by lithic material type at Navalmaíllo rockshelter (levels D and F)

	Quartz	Chert	Quartzite	Porphyry	Rock crystal	Sandstone	Other
Pebbles	2		1			3	13
Hammerstones	4		1	1			5
Fractured pebbles	9		2	4			11
Pebble cores	215	14	5	5	1	1	10
Flakes exploited as cores	34	10	1		1		1
Pebble tools	11						
Retouched flakes	358	73	15	10	13	2	7
Whole flakes	1462	274	54	46	18	20	61
Broken (nearly complete) flakes	1069	103	36	24	12	4	41
Flake fragments	308	47	11	5	9	6	8
Fragments (debris)	1295	114	4	10	14	6	187

(quartz, chert, quartzite, porphyry, rock crystal, and sandstone) make up 90% of the total. Indeed, 77% of the artifacts are made of quartz, the most commonly used material. The most common technological category recorded was that of simple flakes (84%).

The raw materials used in the lithic industry were collected from nearby gravel deposits that originated from the fluvial networks of the Arroyos de Navalmaíllo and Lontanar, and the Lozoya River. The first two have small drainage basins (0.24 km² and 3.05 km², respectively; Figure 4). Angular and subangular pieces of gneiss and quartz (pebble-sized: 4–64 mm) are transported in the Arroyo de Navalmaíllo, but also cobbles in the Arroyo de Lontanar. The Lozoya River carries rounded and subrounded gravel containing porphyry, metamorphic quartzites, and granitoids, the average dimensions of which are cobble-size (64–256 mm). No chert is present in any of these fluvial networks, nor has any been found in the Cretaceous carbonate facies around the site. It may, however, have come from Cretaceous and Miocene outcrops in the Duero Basin to the north and/or from the Madrid Basin to the south (Figure 1). Whether it is Cretaceous or Tertiary in origin is yet to be determined.

Evidence for Complete, In Situ Chaînes Operatoires

Cores, simple flakes, retouched flakes, and fragments of quartz, chert, quartzite, porphyry, rock crystal, and sandstone have all been found (Table 2 and Figure 5). The large amount of knapping debris, along with other evidence (discussed throughout the paper), suggests that most of the raw materials were worked at the shelter.

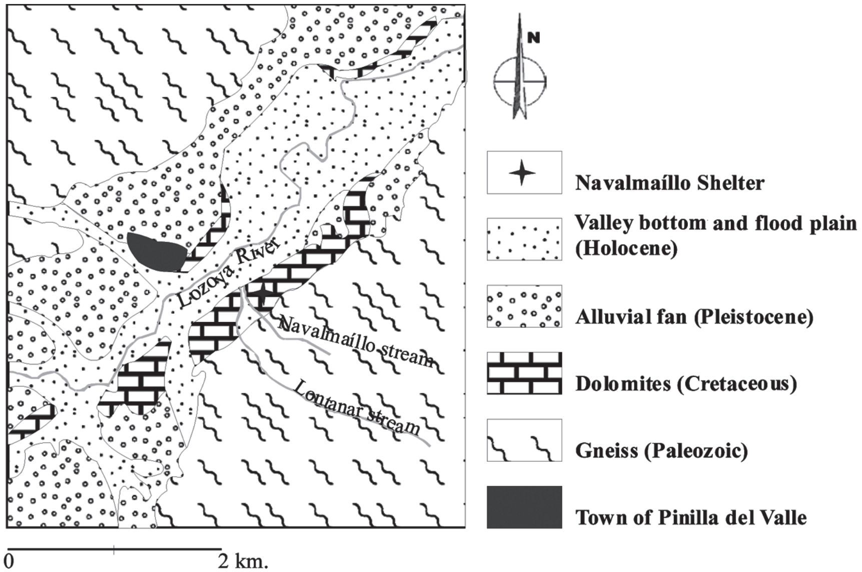

Figure 4. Geology and fluvial network around Navalmaíllo rockshelter.

The production rate associated with each raw material (Table 3) was estimated from the direct relationship between the number of cores used to produce flakes and the number of flakes actually produced (ratio 1) and the relationship between the number of cores plus retouched pebble tools plus retouched flakes (all considered production blanks) and the number of products, including simple flakes, debris, and shaped flakes (ratio 2). Unidentifiable and broken elements were excluded from this analysis. Ratio 1 distinguishes between worked cores and products. In this ratio, retouched flakes fall into the category of products, although when they are being retouched, small flakes are produced. However, few simple flakes are usually produced during this process. Ratio 2 better describes the relationship between all the worked objects present, a consequence of retouched flakes being considered both cores and products. However, their reduced potential for further flake production relative to that of the true cores may bias the final ratio. The actual production rate for each material probably lies between those described by ratios 1 and 2.

Table 3 shows that sandstone has the highest production ratio according to both calculation methods. However, only one sandstone core and two retouched flakes were found, resulting in the high ratios. In addition, no cortical sandstone flakes have been found, suggesting that the initial stages of knapping occurred elsewhere. It is also possible that such evidence may be found in areas yet to be excavated.

Rock crystal and chert both had higher production rates for ratio 1 than for ratio 2. The production rate suggested by ratio 2 for rock crystal was, in fact, the lowest for all the raw materials. These results show that both raw materials, especially rock crystal, were highly prized and were chosen for making retouched tools (Table 4).

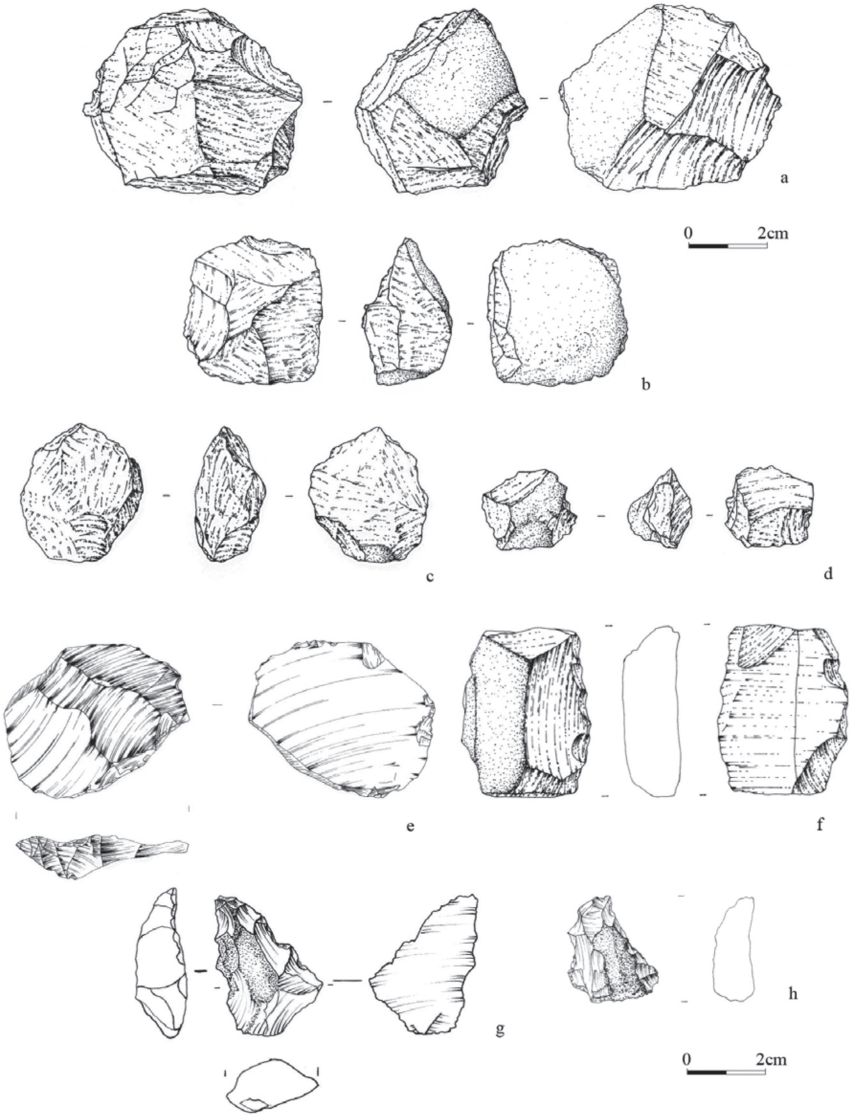

Figure 5. (a) Trifacial quartz core, (b) Centripetal unifacial quartz core, (c) Centripetal bifacial quartz core, (d) “Micro-core” from Navalmaíllo, level F, (e) Levallois flake, (f) Sandstone denticulate, (g) Chert denticulate point, (h) Retouched chert flake (drawings by B. Márquez).

Table 3. Production ratios by raw material

	Ratio 1. Excluding shaped tools as production blanks and products	Ratio 2. Including shaped tools as production blanks and products
Quartz	1:16	1:7.2
Chert	1:22.4	1:6.3
Quartzite	1:17.5	1:5.7
Porphyry	1:17	1:6.3
Rock crystal	1:26.5	1:4.4
Sandstone	1:36	1:12.6

Table 4. Percentages of simple and retouched flakes by raw material

	Quartz	Chert	Rock crystal
Simple flakes	80.8	73	52.6
Retouched flakes	19.2	27	47.4

The Production Process

To elucidate the production process at the site, the following factors were examined: (1) the knapping methods used; (2) the stages at which the cores were abandoned (with the initial stage being that at which the core retains part of its cortical layer; the middle stage as that at which knapping appears to have reached an intermediate point; and the final stage as that at which at least some or indeed most of the core's surface exhibits negative scars similar in size to the core's dimensions); (3) the mean measurements of the cores in relation to the size of their original blocks, taking the largest product as indicative of this latter size; (4) the mean dimensions of the simple flakes, which provides a clue to the size below which a simple flake cannot be used as a tool, and (5) the size of the largest flake in relation to the size of the core, plus the minimum dimensions of the original block from which it came.

The main techniques employed at the site were unifacial and bifacial knapping, combined with centripetal, unipolar-longitudinal, orthogonal, Levallois, and discoid techniques (Tables 5 and 6). Rock crystal and chert cores were those most often knapped in a bifacial-centripetal manner.

Table 5. Knapping technique (numbers of cores) by raw material type

	Quartz	Chert	Quartzite	Porphyry	Rock crystal	Sandstone	Other
Bifacial	100	14	6	2	1	1	5
Multifacial	15	2					
Trifacial	17	1					
Unifacial	97	5		2	1		4

Table 6. Core type by material type

	Quartz	Chert	Quartzite	Porphyry	Rock crystal	Other
Centripetal	74	4		1	1	3
Discoidal	17	2	1			
Levallois	3		1			
Massive	30		1	1		1
Orthogonal	34	5	1			1
Pyramidal	8					1
Other	45	6	2	2	1	2

Table 7 indicates that the two rock crystal cores were discarded only in the late stages of working (100%). Most of the chert cores (86.3%) were also abandoned in the late stages of their use. This again suggests that chert and rock crystal were highly prized raw materials.

The mean dimensions of the rock crystal cores is 20 × 13 × 5 mm (length, width, and thickness, respectively), and the mean dimensions of the complete flakes of rock crystal ($n = 29$) are 15 × 15 × 6 mm. The largest, a retouched flake, measured 38 × 25 × 8 mm, which indicates the size of the original core from which it was produced. On the other hand, the mean dimensions of the chert cores ($n = 17$ were 29 × 26 × 15 mm, with the mean flake size ($n = 251$) being 16 × 16 × 5 mm. The largest, also a retouched flake, measured 64 × 46 × 15 mm. These findings indicate that chert cores were brought to the shelter after having been partially worked elsewhere.

Some 62% of the quartz cores ($n = 211$) were also abandoned in the last stages of working, the rest being abandoned at the initial or middle stages. Their mean length, width, and thickness are 41 mm, 33 mm, and 24 mm, respectively, with 20 × 18 × 8 mm being the mean measures of the complete simple flakes ($n = 1{,}392$).

The majority of the 376 simple and retouched quartz flakes exhibiting cortical butts may have been produced from the 97 unifacial cores (those that normally yield such flakes). The production rate (as determined by ratio 1) of these unifacial quartz cores was 1:2.6. The largest simple flake and retouched tool were some 65 mm long. These dimensions suggest that the quartz was selected from the Arroyo de Lontanar, where blocks of such dimensions are available today.

As shown in Table 8, 52% of the quartz flakes were between 10 and 20 mm long, and 12% were less than 10 mm. This is consistent with the size of the negative scars visible on the cores. The smallest retouched piece of the entire assemblage was a quartz denticulate measuring 10 × 12 × 4 mm. In fact, 38 retouched pieces were less than 20 mm long, and three of them were less than 15 mm. Quartz is a locally very abundant material and its cores were therefore quite disposable. However, the knappers still extracted some very small flakes.

Two of the quartzite cores ($n = 6$) were also abandoned during the final stages of exploitation, but the other three were abandoned in the initial stages—the largest percentage of such abandonment. Why such good material was so

Table 7. Lithic assemblage characteristics by material type

		Quartz	Chert	Quartzite	Porphyry	Rock Crystal	Sandstone
Stage of core abandonment (%)†							
	Final	61.5	86.3	33	—	100 (n = 2)	—
	Middle	34.3	13.6	17	100 (n = 4)	—	100 (n = 1)
	Initial	4.2	0	50	—	—	—
Dominant knapping methods		Unifacial + Bifacial Centripetal Orthogonal Unipolar longitudinal	Bifacial Orthogonal Centripetal	Bifacial Unipolar longitudinal Levallois Discoid	Bifacial + Unifacial Unipolar longitudinal Centripetal	Unifacial + Bifacial Centripetal	Bifacial Unipolar longitudinal
Products (cortex)							
	Noncortical (%)	52	86.9	50	64	n = 15	n = 4
	Cortical (%)	2.3	0	2	1	0	0
	Some cortex (%)	46	17	48	34	n = 9	n = 9
Flakebutts (platforms)							
	Plain(%)	93.2	85	96.4	93.3	84	87.5
	Linear (%)	2.5	9.4	2.4	5	8	8.3
	Punctiform (%)	4.2	5.4	1.2	1.6	8	4.1
	Unifaceted (%)	42	43	38	31	52	39
	Bifaceted (%)		20		28		
	Multifaceted (%)				21		
	Nonfaceted (cortical) (%)	40	22	29			35
Flakes: Ventral face							
Bulb of percussion	Marked (%)	23.2	53	41	40	39	28.5
	Diffuse (%)	76.7	47	59	60	61	71.4
Morphology	Plain (%)	41	34	39	32.3	45	63
	Sinuous (%)	26.3	26.5	25.5	31	24	—
	Concave (%)	14.7	16	16.3	12.6	17.2	18.5
	Convex (%)	17.9	23.6	19.3	24	13.7	18.5

Table 7 continued—

		Quartz	Chert	Quartzite	Porphyry	Rock Crystal	Sandstone
Flakes: Dorsal face							
	Noncortical (%)	69.3	86.7	66.3	74.6	65.5	81
	Cortical (%)	6.1	0.7	8.6	2.6	—	3.8
	Predominantly noncortical (%)	15.7	9.2	17.3	13.3	24.1	7.6
	Predominantly cortical (%)	8.7	3.3	7.7	9.3	10.3	7.6
Number of scars	2 (%)	27	19	23	18	28	38
	3 (%)	32	34	37	29	43	43
Flake Morphology							
	Trapezoid (%)	23.6	21	20.8	27.5		
	Triangular (%)	14.7				18.1 ($n = 4$)	
	Rectangular (%)		13.4			27.2 ($n = 7$)	
	Oval (%) / Quadrangular (%)			20.8 / —	22.5 / —	18.1 ($n = 4$)	29.4 ($n = 8$) / 23.5 ($n = 6$)
Percentage of flakes that are retouched tools		12.6	17.2	15	13.3	33.3	6.6
Shaped tools							
	Denticulates (%)	39	53	40 ($n = 6$)	100 ($n = 6$)	54.5 ($n = 6$)	
	Sidescrapers (%)	12	15	33.3 ($n = 5$)		9.1 ($n = 1$)	
	Notches (%)	20	11	6.6 ($n = 1$)		18.2 ($n = 2$)	
	Endscrapers (%)	3.4				9.1 ($n = 1$)	
	Points (%)	3.4 ($n = 11$)	9.3 ($n = 6$)	6.6 ($n = 1$)			
	Marginal retouch (%)	18.5					
Shaped quadrants							
	≤ 1Q	64	50	41.7 ($n = 7$)	11.1 ($n = 1$)	54.5 ($n = 6$)	
	2Q	29	32	33.3 ($n = 5$)	88.8 ($n = 6$)	36.3 ($n = 4$)	
	≥ 3Q	7	18	11.1 ($n = 1$)		9.1 ($n = 1$)	

† absolute frequency (n) is reported when n ~10 or less

Table 8. Percentages of simple whole flakes larger than 20 mm, between 20 and 10 mm, and smaller than 10 mm in maximum dimension

	Quartz	Chert	Quartzite	Porphyry	Rock crystal	Sandstone
	(*n* = 1,392)	(*n* = 251)	(*n* = 54)	(*n* = 46)	(*n* = 18)	(*n* = 20)
> 20 mm	36.6	22.5	94.5	86	22.4	80
20–10 mm	51.4	66	5.5	11	66.6	15
< 10 mm	12	11.5	0	3	11	5

commonly abandoned remains to be explained, although they might have been discarded as raw material reserves for future visits to the site. The mean length, width, and thickness of the quartzite cores were 54 mm, 39 mm, and 29 mm, respectively, and all exhibited evidence of bifacial knapping. The simple quartzite flakes (*n* = 54 have mean dimensions of 35 mm in length, 31 mm in width, and 12 mm in thickness. Only 5.5% of the simple flakes are between 10 and 20 mm in maximum dimension, which would appear to be consistent with the size of the cores abandoned in the initial stages of production. The largest piece of quartzite is 60 × 57 × 34 mm.

The porphyry (*n* = 4) and sandstone (*n* = 1) cores were abandoned at a mid stage of exploitation. The porphyry cores have mean dimensions (length, width, and thickness) of 79 mm, 60 mm, and 37 mm, while the flakes average 32 × 33 × 11 mm. Finally, the sandstone core measures 64 × 43 × 33 mm, and the simple and/or retouched flakes of sandstone have a mean length, width, and thickness of 29 × 28 × 10 mm.

Use of Percussion Tools and Anvils in the Working of Materials

The lack of any clear traces of soft-hammer percussion is notable, although stone hammers, which average 30 × 25 × 20 mm, were almost certainly used in tool-making. A large number of percussion marks that correspond to bipolar knapping on an anvil were identified on tools and cores of all materials. These are particularly visible on the quartz artifacts, especially in the middle of the cores and along certain flake edges in the form of small chippings and notching.

Double bulbs of percussion or presence of battering on two edges is also frequent on bipolar flakes.

The bipolar knapping technique (i.e., knapping with an anvil) appears to have been used to work cores to make longitudinal unipolar, centripetal, and even discoidal knapped products. A 197 × 145 × 109 mm piece of porphyry may have been used as an anvil (Figure 6).

Working small cores via the bipolar knapping technique is the best method for making small tools (Prous and Alonso 1990) since the core is easily held in place when striking it. This technique is ideal for working small quartz cores (Mourre 2004; Vergès and Ollé 2011) since it helps prevent the uncontrollable fracturing to which this material is subject (see Mourre 1996) and increases ease of handling. A detailed study of bipolar knapping at Navalmaíllo is in progress.

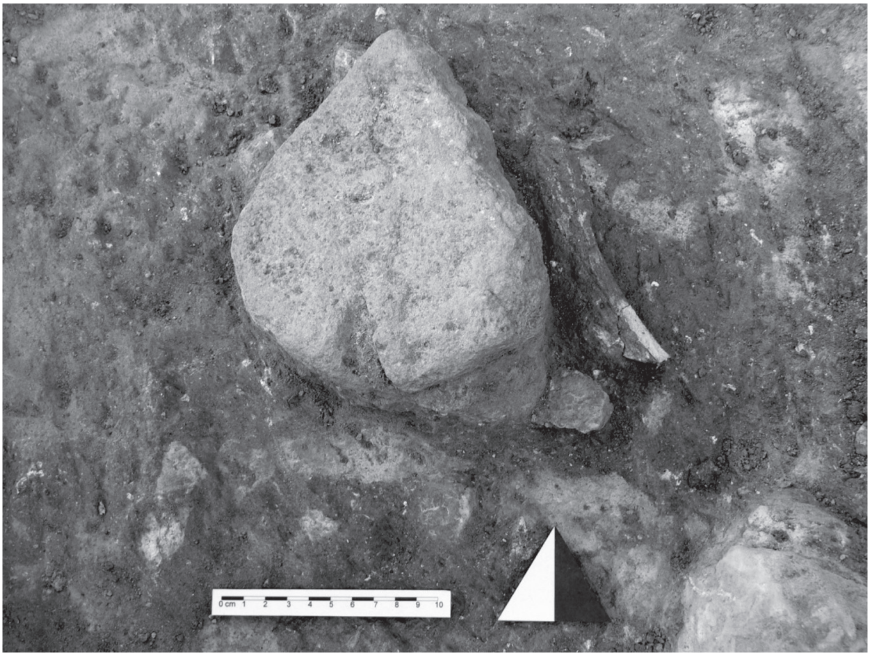

Figure 6. Close-up of the porphyry anvil from level F
(photo by Pinilla del Valle Research Team).

Products of Knapping

The products made by knapping the different raw materials show similar characteristics. For each raw material, some 50–87% of the final products are entirely noncortical (Table 9). Entirely cortical products were seen only for quartz and quartzite (and porphyry), and then, only some 2% were of this type.

Most of the flakes exhibit noncortical butts (71–96% depending on the raw material) (Table 9). Some 41% of these flakes are unifaceted and have flat butts (83–96%). The greatest quantities of bifaceted and multifaceted butts are seen for chert and porphyry products. The quartz, quartzite, and sandstone products usually show small ventral bulbs. Half of the porphyry and rock crystal products

Table 9. Presence of cortex on flake butts by material type.

	Quartz	Chert	Quartzite	Porphyry	Rock crystal	Sandstone	Limestone	Other
Cortical	376	4	22	11	2	6	1	11
Predominantly cortical	35	3	4		1			1
Noncortical	1040	191	58	53	21	17		35
Predominantly noncortical	33	3	2					

had well-marked ventral bulbs, and half did not. For the chert products, however, clear ventral bulbs were very common. Since all the tools produced at the shelter appear to have been worked in the same way, the existence of a ventral bulb depends on the physical properties of each raw material rather than variation in knapping techniques.

Once again, chert is the material in which cortical dorsal faces are most often seen.

A single characteristic normally differentiates flakes that were selected for retouching from those that were not: size. Usually only the largest were selected for retouching, irrespective of any other characteristic or property of the raw material in question. The exception is quartzite, the simple and retouched flakes of which are about the same size, although the latter show more cortex.

Retouched Flakes

With the exception of rock crystal and sandstone, the percentage of simple flakes selected for retouching is similar for all materials: quartz = 11%, chert = 14%, quartzite = 13%, porphyry = 12%, rock crystal = 25%, and sandstone = 6%. This suggests that the rock crystal was highly prized for making retouched instruments while sandstone was much less preferred.

Denticulates are the most common retouched tool for all materials (39% for quartz rising to 100% for porphyry). Notched tools and scrapers are the next most common type. Some 63% of the scrapers are made of quartzite, which might be explained by the strength of this material. The majority of rock crystal and chert tools (i.e., tools made from the most highly prized raw materials) are denticulates. One possible scraper was made from bone.

The largest of the simple flakes were chosen for retouching, except for those made from quartzite and porphyry. No other characteristic of the flakes appears to have been involved in this choice. Some 8.1% of the retouched flakes were less than 20 mm in length; the smallest was a quartz denticulate measuring 10 × 12 × 4 mm.

The intensity of the retouching process was only low to medium, irrespective of the raw material. This is evident in (1) the number of retouch series on the cutting edge of the tools (e.g., one series for modifying the dorsal surface and one for modifying the ventral surface, or a later series superimposed over an earlier one) and (2) the number of quadrants (all tools were divided into four equal quadrants) showing signs of retouching. Only 3% of the tools exhibited two series of retouch; the rest had only one. The number of quadrants with retouched cutting edges varied from material to material. The quartz and sandstone tools returned the smallest numbers; indeed, some 64% only showed one partially retouched quadrant. The chert tools exhibited one partially retouched quadrant (50%) or two (32%) or even three fully retouched quadrants (18%) (i.e., 3/4 of the tool's cutting edge had been retouched). Some 54% of the quartzite and rock crystal tools had one partially retouched quadrant, around 36% had two fully retouched quadrants, and the remainder showed three or more partially/fully retouched quadrants. Some 90% of the porphyry tools had two whole retouched quadrants.

DISCUSSION

Up until the Final Upper Paleolithic, what is called "microlithism" is still a matter of debate. Rust (1950) and Burdukiewicz and Ronen (2003a) consider microliths to be those flakes or tools that cannot easily be held in the hand. Bagolini (1968) considers 4 cm to be the size below which flakes or other products of knapping can be considered microliths.

As reported in other European sites of approximately the same age, in Navalmaíllo some of the cores had been worked to a very small size; their products were therefore small as well. This fact is well-known at Lower Paleolithic sites such as Vértesszöllös (Hungary) (Vértes 1965), Bilzingsleben and Schöningen (Germany) (Brühl 2003; Gramsch 1979; Thieme 2003), and in Italy at Isernia (Longo et al. 1997; Peretto 1994), Grotta Paglicci (Ollé et al. 1998), and Monte Poggiolo (Vergès et al. 1998), to name only the best known cases. The artifacts are quite similar regardless of their geographical location, which could indicate similar environments and similar adaptations to those environments or constraints owing to raw material quality or availability (Kuhn 1991). In some cases (e.g., Bilzingsleben) the fabrication of small tools seems to have been related to particular subsistence strategies (Brühl 2003). Perhaps the existence of similar wooded environments led to the production of small lithic elements being hafted onto shafts of wood (Burdukiewicz and Ronen 2003a, 2003b).

In Middle Paleolithic samples from Tata (Hungary) (MIS 5) (Moncel 2003a), most of the tools recovered are under 3 cm in length; just as at Navalmaíllo, this cannot be explained by any lack of availability of raw material nor by the size or quality of the original cobbles. The same is true for the Taubachian (Valoch 1984) of the Central European sites of Kulna (layer 11) and Předmosti II (layers 9 and 8) (Moncel 2003b; Moncel and Neruda 2000); for the so-called Pontinian sites of central-western Italy (Kuhn 1995) and Grotta di San Bernardino in the north (Leonardi and Broglio 1962; Bagolini 1968); for Pech de l'Azé, Grotte des Ramandils (Moles and Boutié 2009), and L'Arago (layer C) in southern France (Byrne 2004; Peña 2008); for Roca dels Bous, Estret de Tragó (Casanova et al. 2009), and Cova Eirós (layer 3) (Lazuén et al. 2011) in northeastern Spain; and for El Hundidero (layers 1, 2, 3 and 4) in central Spain (Navazo et al. 2011).

As just noted, Cova Eirós (Lugo), Roca dels Bous, and Estret de Tragó (Lleida) in the Iberian Peninsula have lithic samples with microlithic tendencies. Quartz is the main raw material at Cova Eirós, but quartzites and flint are the preferred materials at Roca dels Bous (final MIS3) (Layer 10: 68% made on flint and 32% on metamorphic rocks, and layer 12: 15% flint vs. 85% metamorphics [Mora et al. 2008]).

Flint is the preferred material (around 85%) to be intensively exploited at Estret de Tragó, layer UA3 (MIS5) (Casanova et al. 2009; Castañeda and Mora 1999). The same phenomenon is observed in its upper layer (MIS 3), and in Roca dels Bous layer 10 (MIS 3). A "cultural" (i.e., idiosyncratic or stylistic) explanation for this behavior is proposed by the authors.

The Micromousterian "Asinipodian" facies (Bordes 1975, 1978) at the Pech de l'Azé site is one of the best known cases for Middle Paleolithic small tools (found in level IV). However, differences are apparent between the cores of Pech de l'Azé and those of Navalmaíllo, where the percentages of cores between 30 and 40 mm and less than 30 mm in diameter are 58% and 28%, respectively. At the former site, small Levallois cores have been found, whereas at the latter the discoidal technique predominated, even when working chert. Nevertheless, at both sites the intention was to make small tools. The purposeful production of small tools has also been recorded at several other sites in Central Europe (Moncel and Neruda 2000).

If these small pieces were indeed intentionally made, questions of what they were used for, and how they were used, must follow. As a result of their size, some were probably fixed to handles, while others were most likely used directly in the hand. Despite the growing literature on the use of handles by Neanderthals (and indeed even earlier hominids) (Mania and Mania 2003; Thieme 2003), morphological studies have shown that Neanderthal hands were better designed for holding stone tools directly than for holding tools with oblique handles (Niewoehner 2001). Nonetheless, the similarities in the thumbs of *Homo sapiens sapiens* and Neanderthals has led to the conclusion that both could make fairly sophisticated tools and were capable of making and using any tool of the Middle Paleolithic repertoire (Churchill 2001; Niewoehner 2001; Niewoehner et al. 2003).

Use-wear analysis can provide information on the handling of small tools and their functions. However, before any such analysis can be undertaken, it is vital that the artifacts in question have been identified as tools rather than simply as pieces of debris. At Navalmaíllo, all the lithic remains recovered at the excavation have been stored separately, preventing any use-wear marks from being damaged through contact with other pieces ("drawer retouch"), which certainly does occur if pieces are stored together. At other sites, non-retouched and small tools/debris have all been stored together, making use-wear analysis difficult or impossible (Shea 2006).

Research on use and hafting traces of ancient microliths has only just begun. Use-wear analysis on Bilzingsleben materials began with Gramsch (1979). Since then, others have analyzed the small tools from Bilzingsleben that appear to have been used for working organic materials, such as wood (Mania and Mania 2003; Steguweit 2001, 2003), antler, and bone (Steguweit 2001, 2003).

Based on the very small size of the lithic reduction products, differentiating between intentionally produced flakes and debris can be difficult, even after use-wear analysis, particularly when an object has been used only for a short period, giving little time for evidence of use to appear (Dibble and McPherron 2006). However, even after a short period of use, linear marks representing the kinetics of use are usually present; this at least shows whether a tool has been used. Preliminary use-wear analyses made possible by storing finds individually to avoid their damage revealed that the small tools from the Navalmaíllo rockshelter do show traces of use. If further samples show the same, this, along with the variety of raw materials found at the site, would suggest that the Neanderthal people who occupied it followed a "microlithic-like" tradition of tool-making, and that they used the tools they made in their daily lives.

CONCLUSIONS

Neanderthals were able to adapt to many European and West Asian environments during the Middle Pleistocene. This problem-solving capacity is manifest in the wide variation in Mousterian lithic assemblages, the study of which has become a major area of research into the technical and cultural capacities of Neanderthal societies.

Quartz was the most commonly used raw material in tool-making at Navalmaíllo. The use of quartz to make tools at Middle Paleolithic sites of the central Iberian Peninsula is unusual because of the abundance of other raw materials traditionally considered to be better for knapping. There are only few sites where quartz is predominant, and Navalmaíllo is one of them.

With the possible exception of chert and sandstone tools, the *chaînes operatoires* involved in tool production at the site appear to have been largely unbroken. Despite the local abundance and quality of quartz, many of the cores and tools made of this material discovered at the site are very small, as indeed are those of the other raw materials, such as chert, rock crystal, and quartzite. This suggests that small tools were intentionally made from all these raw materials. In addition, all these materials appear to have been processed using the same techniques. Therefore, these small pieces were intentionally made. What they were used for will hopefully be known after use-wear analyses, although they were probably both used by hand and also fixed to handles. A cultural explanation of this behavior can be proposed in the sense that the Neanderthal groups that occupied the Navalmaíllo rockshelter may have followed a "microlithic-like" tradition of tool-making.

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