

Neanderthals of Porto Selvaggio in southern Italy: lithic industry of Grotta Torre dell'Alto (Nardò, Lecce)

FILOMENA RANALDO,^{1,2}  DARIO MASSAFRA¹ and KEIKO KITAGAWA^{3*} 

¹Museo della Preistoria di Nardò, Piazza Sant'Antonio, Nardò, Lecce, 73048, Italy

²Dipartimento di Scienze Fisiche, della Terra e dell'ambiente, Unità di Ricerca di Preistoria e Antropologia, Università degli Studi di Siena, via Laterina 8, Siena, 53100, Italy

³Institute of Prehistory, Early History and Medieval Archaeology, University of Tübingen, Burgsteige 11, Tübingen, 72070, Germany

Received 25 October 2020; Revised 31 August 2021; Accepted 8 September 2021

ABSTRACT: Porto Selvaggio in southern Italy is where the Uluzzian culture was first identified and documented, providing key insights into the transition from the Middle to the Upper Paleolithic. The area has also yielded evidence for continuous occupations by Neanderthals spanning between Marine Isotope Stage (MIS) 5 and 3. Situated in the Natural Regional Park of Porto Selvaggio, different sites were excavated by Borzatti von Löwenstern in the 1960 and 1970s. As one of the initiatives in the research program of the Museo della Preistoria di Nardò, we have revisited the artifact assemblages from these caves. Based on the lithic analysis of production sequences, we document the development of Levallois and laminar methods before MIS 3 when this form of reduction sequence presumably dominated in the region according to the previous research. The review of the lithic assemblages is combined with the contextualization of chronostratigraphy and paleoenvironmental study in the region to consider the possible role that this region had for Neanderthals during unfavorable climatic conditions.

© 2021 The Authors *Journal of Quaternary Science* Published by John Wiley & Sons Ltd.

KEYWORDS: Interglacial period; laminar technique; Levallois technique; Neanderthals; southern Italy

Introduction

Well-known for the transitional Uluzzian culture, Porto Selvaggio, which lies close to the town of Nardò in southern Italy, has produced one of the richest Paleolithic archives that provide insights into the behaviors of hominins within the Mediterranean landscape from the Middle to the Upper Paleolithic. The area has been subject of archaeological investigations from the 1960s and there are ongoing excavations and recent research from multiple research groups.

This work is part of a broader interdisciplinary project to expand our knowledge on the local Paleolithic sites by re-examining the archaeological finds, which are housed at the Museo della Preistoria di Nardò (MPN) using modern techniques. The project is also a result of collaboration with the Parco Naturale Regionale di Portoselvaggio e Palude del Capitano and made possible with the permits granted by the Soprintendenza Archeologia Belle Arti e Paesaggio of the Province of Brindisi and Lecce. The objective of the present study is to understand the cultural behavior of the archaic humans as well as the relationship between humans and the environment in the Mediterranean by studying the lithic assemblages and reconstructing the technical systems, which were adapted by Neanderthals from Marine Isotope Stage (MIS) 5 to 3 in southern Italy.

Previous studies concerning the human evolution and past settlement patterns on the Italian peninsula have been synthesized in an analytical model, which was proposed by Palma di Cesnola (2001). Based on this model, the first occupations of Neanderthals in the Salento region occurred at least by the

Interglacial–Eemian (MIS 5e) around 110 ka. The oldest evidence of humans in Porto Selvaggio is present at Grotta Torre dell'Alto (Borzatti von Löwenstern, 1966; Borzatti von Löwenstern and Magaldi, 1967), Grotta M. Bernardini (Borzatti von Löwenstern, 1970, 1971) and Capelvenere (Borzatti von Löwenstern, 1961; Giusti, 1979, 1980; Patriarchi, 1980) (Fig. 1).

It is important to revisit this model, which was initially proposed by Palma di Cesnola and Borzatti von Löwenstern, and to pose new research questions as we gain insights from recent research from Porto Selvaggio including Grotta del Cavallo (Giaccio *et al.*, 2008; Carmignani, 2010; Benazzi *et al.*, 2011; D'Errico *et al.*, 2012; Romagnoli, 2012; Ranaldo, 2017; Ranaldo *et al.*, 2017a,b; Sarti *et al.*, 2017; Moroni *et al.*, 2018; Zanchetta *et al.*, 2018; Sarti and Martini, 2020) as well as outside of the Park such as at Grotta Romanelli (Sardella *et al.*, 2018). These lines of evidence enable us to enhance our knowledge of the local prehistory and consider the possible role that southern Europe played in the settlement dynamics of archaic humans.

This study will focus on lithics from Grotta Torre dell'Alto (GTA), which has yielded one of the oldest Paleolithic occupations in the region, by providing a general overview and preliminary results. Technological analysis of the lithics from the layers E and D suggest two scenarios: (i) the emergence of the Levallois and laminar techniques has a deeper history in Porto Selvaggio of southern Italy (Palma di Cesnola, 2001) or (ii) layers E and D are contemporaneous with other Mousterian technocomplexes of the Middle Paleolithic from nearby sites.

Background

In the Middle Paleolithic, the occupation of Neanderthals in the Mediterranean basin corresponds to a phase when the populations reached their maximum geographic expansion

*Correspondence: Keiko Kitagawa, as above.

E-mail: keiko.kitagawa@uni-tuebingen.de

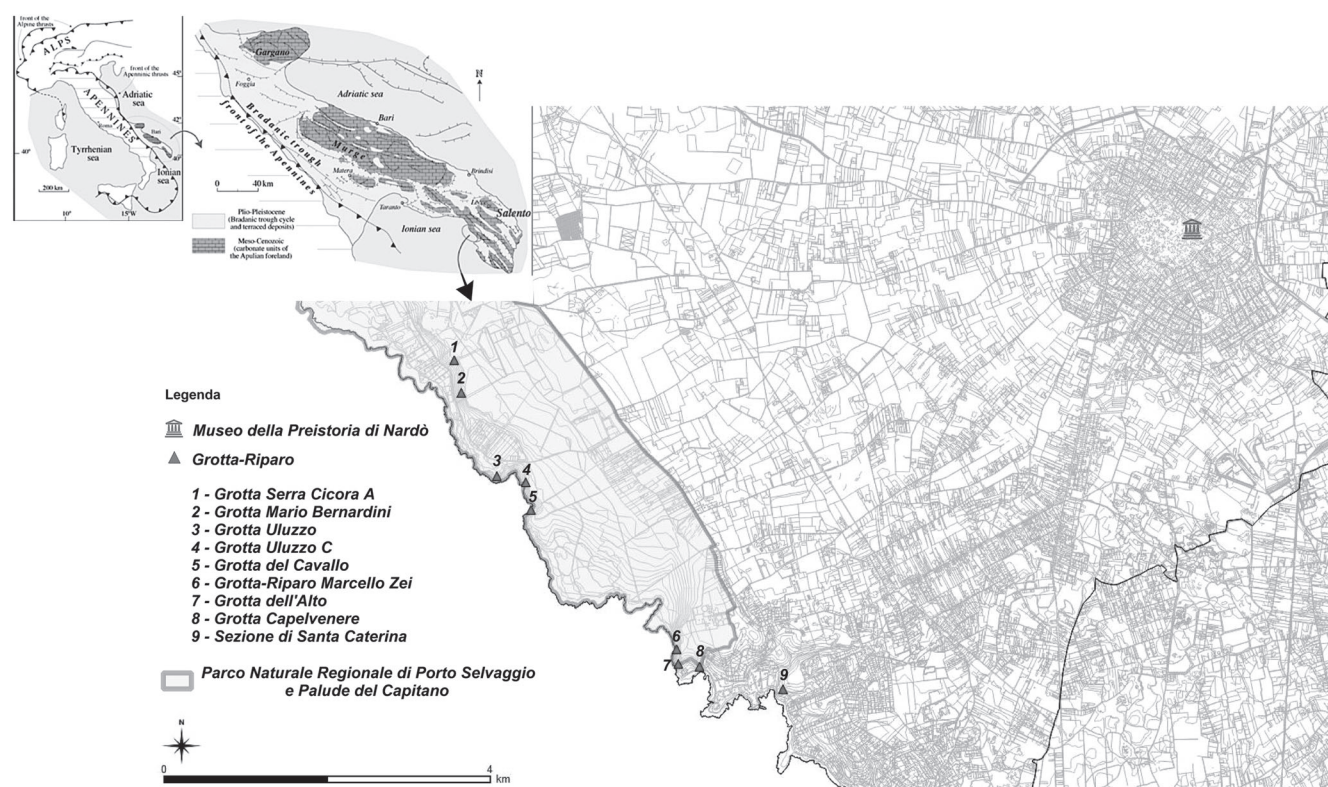


Figure 1. Map of Paleolithic sites in the Parco Naturale Regionale di Portoselvaggio e Palude del Capitano (Nardò, Lecce – southern Italy).

(Condemi and Weniger, 2011). According to the chronology proposed by Palma di Cesnola and Borzatti von Löwenstern, the first evidence of Neanderthals in Salento coincides with the development of the so-called evolved Tayacian technocomplex, which is found in the lower layers of GTA (Palma di Cesnola, 2001). However, this model does not exclude the possibility of Neanderthal occupations before MIS 5e as archaeological and sedimentological records were possibly destroyed due to erosive processes during the Interglacial period. This is supported by the assemblages from Layer A' of GTA, which is probably a remnant of deposits that pre-dates the Interglacial period, and Grotta-Riparo Marcello Zei (Dantoni and Nardi, 1980; Palma di Cesnola, 2001) that is under investigation for radiometric dating. Furthermore, researchers consider layer N in Grotta del Cavallo to be younger than layers E–D of GTA (Palma di Cesnola, 2001; Sarti and Martini, 2020) and recent dating to 116 ± 0.7 and 117 ± 0.7 ka obtained from the speleothems of layer N (Zanchetta *et al.*, 2020) makes the lower horizons of GTA potentially older than MIS 5. New data from Grotta Romanelli (Sardella *et al.*, 2018, 2019) and Grotta Mario Bernardini, which revealed occupations that pre-date MIS 4, can help clarify the true antiquity of human occupations in southern Italy (Palma di Cesnola, 2001).

Archaeologists have also recovered Neanderthal remains from Lamalunga Cave in Murge which date to 172 ± 15 to 130.1 ± 1.9 ka (Lari *et al.*, 2015), demonstrating that archaic humans were present on the Apulian peninsula before MIS 5e. This points to continuous occupation of Neanderthals at least by 130.1 ± 1.9 ka in southern Italy (Palma di Cesnola, 2001; Ronchitelli *et al.*, 2009; Calattini and Carmignani, 2017; Martini *et al.*, 2017; Rinaldo *et al.*, 2017a).

Environment

Paleoenvironmental records are critical in understanding the context in which Neanderthals occupied and exploited local

resources. Recent paleoenvironmental records of Italy help us gain a granular picture of the climate and vegetation in the Late Pleistocene (Combourieu-Nebout *et al.*, 2015; Columbu *et al.*, 2020). Pending radiometric dating, Palma di Cesnola (2001) has argued that the faunal signatures of layers F–C of GTA indicate dry temperate climate trending toward higher temperatures over time (Palma di Cesnola, 2001) based on the analyses of Borzatti von Löwenstern (Borzatti von Löwenstern, 1966; Borzatti von Löwenstern and Magaldi, 1967). This interpretation differs from observations made in recent studies (Allen *et al.*, 2000; Oppo *et al.*, 2006; Brauer *et al.*, 2007; Combourieu-Nebout *et al.*, 2015; Tzedakis *et al.*, 2018; Columbu *et al.*, 2020) and is in need of re-evaluation. Additional study of avifauna and microfauna as well as the stable isotopic study of animal remains will generate more data to reconstruct an accurate picture of the past climate and to better understand the different ecological zones of Porto Selvaggio, especially in the surrounding areas and areas along the past coast line.

Grotta Torre dell'Alto: chronostratigraphic context

The landscape in the area is generally characterized by calcareous slopes overlooking the Ionian Sea. A concentration of archaeological sites attests to a continued presence of Middle Paleolithic settlements, which date at least to MIS 5e (e.g. Grotta del Cavallo) (Palma di Cesnola, 2001; Zanchetta *et al.*, 2020).

GTA, one of the most important Pleistocene sites along the coast, is located in the Mesozoic limestone of the Neretina coast (Largaiolli *et al.*, 1969; Bossio *et al.*, 2006), roughly 35 m asl. It was excavated by Borzatti von Löwenstern between 1961 and 1967 (Fig. 2). Although renewed attempts at radiometric dating are underway, archaeologists have suggested that this cave has yielded one of the oldest cultural horizons in the Salento region (Palma di Cesnola, 2001). The



Figure 2. Location of Grotta Torre dell'Alto (Nardò, Lecce – southern Italy). Photo taken by Sergio Fai. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

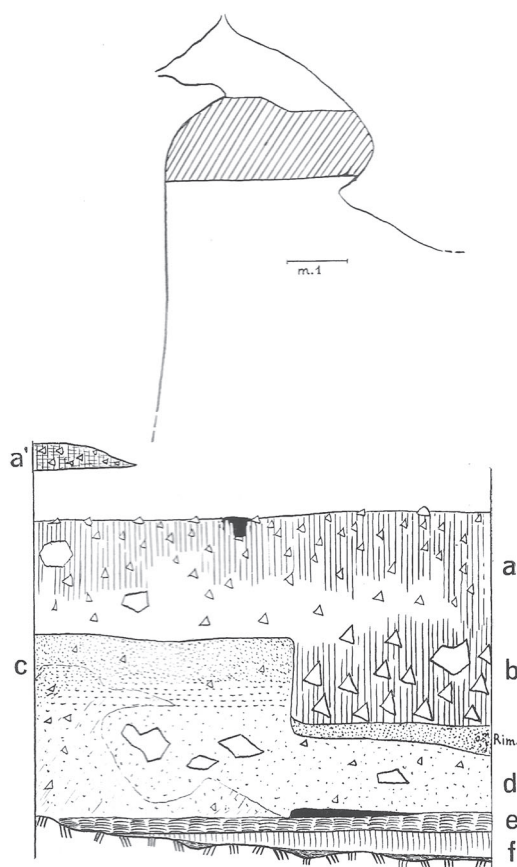


Figure 3. Plan and section of the excavation of Grotta Torre dell'Alto (modified from Borzatti von Löwenstern, 1966).

excavations have identified fine layers of sediment (layer A'), whose remnants are found in forms of concretions on the wall of the cave. In the 1960s, this layer was interpreted by Borzatti von Löwenstern (1966) as deposits that can be assigned to the Final Riss period (MIS 6), which later eroded away. The accumulation of sediments then resumed with subsequent climatic deterioration during the Wurm II (MIS 4) period.

A hiatus resulting from karstic erosion has been recorded between layer C and layer B/A, which is attributed to the final stages of the Glacial Period. In the most upper horizons, several burials dating to the Iron Age have been recorded (Borzatti von Löwenstern, 1966) (Fig. 3).

The lowest horizons of GTA, layers E and D, are comparable to other sites in the region of Salento. Situated at 33 m asl, Grotta M Bernardini is close to the coast and has yielded a sequence that continues from the Middle Paleolithic through to the beginning of the Upper Paleolithic. The horizon at the base of the cave appears to correlate with the lower layers of GTA according to Borzatti von Löwenstern (1971), who studied both sites between 1964 and 1970, and Palma di Cesnola (2001). They drew a similar conclusion for Grotta di Capelvenere that is located close to GTA. Borzatti von Löwenstern documented the stratigraphic horizons with disturbances, which possibly place the layers between the Interglacial period MIS 5e to Interstadial periods including MIS 3 (Giusti, 1980; Patriarchi, 1980).

The sedimentological matrix of layer E consists of brown sandy soil while the matrix of layer D consists of sandy, brownish-brown soil. The excavation area was located at the entrance and extended over 7 m², reaching the base at a depth of ~2 m. The excavation cut through the central part of the deposit and left a large portion outside the shelter intact. A hearth was documented in the upper horizon of layer E.

After decades of research, it became clear that these sites, especially GTA, have the potential to inform us of the past strategies and the use of territory by Neanderthals. However, this is limited by the absence of absolute dating, faunal studies accompanied by taphonomic analysis and in-depth study of lithic assemblages that demonstrate technological systems and behaviors. This study will address one of these limitations through a study of lithics that combines the reconstruction of operational schemes, technical characteristics of the lithic reduction and tools as well as the evolution of technical behaviors over time.

Materials and methods

We present the preliminary results from the lithic assemblages of layer E and the lower layer of D at GTA (Table 1). The upper

Table 1. Lithic assemblages

Layer	Cores	Retouched	Unretouched	Total
E	1	103	12	116
D	4	395	17	412

Table 2. Number of analyzed lithic pieces

Layer	Spits	<i>n</i>	%
E	e	7	6.03
	11	106	91.37
	B11	2	1.72
	11-B9	1	0.86
Total		116	100
D	10	86	20.87
	B10	20	4.85
	9	275	66.74
	B9	31	7.72
Total		412	100
Total E + D		528	

Table 3. Raw material

Raw material	Layer E	%	Layer D	%
Blocks of limestone	42	36.2	128	31
Pebbles of limestone	3	2.5	23	19.8
Dolomite	27	23.2	91	22
Lastrine	8	6.8	45	10.9
Local nodule flint	15	12.9	48	11.6
Exogenous pebbles flint	17	14.6	65	15.7
Exogenous pebbles jasper	2	1.7	3	0.7
Exogenous flint	2	1.7	4	0.9
Ind.	0	0	5	1.2
Total	116	100	412	100

levels of layer D were excluded from this study because their stratigraphic context is not as reliable as the lower level. A part of the collection is housed in the warehouses of the local Soprintendenza and mostly consists of flakes and fragments that remain to be studied. While this will be integrated with future studies, we will focus on the assemblage that is housed at the MPN. The method involves reconstructing the technical system of production, raw materials, core reduction stages, tool typology and production variability (Bagolini, 1968; Boëda, 1990, 1994, 2013; Geneste, 1991; Inizan *et al.*, 1996). To this end, the following information was recorded: raw material, lithic type, presence and relative abundance of cortex, patina and other alterations, degree of completeness, orientation of artifacts, direction of dorsal removal, additional data related to the percussive technique, characteristics of butts and ventral faces, morphology of the cross-section, location of retouches, macroscopic traces and the presence of organic residues. For the cores, the reduction sequence as well as the management techniques were considered with regard to the raw material. The studied sample includes 116 artifacts from layer E and 412 artifacts from the lower levels of layer D. Due to the rare presence of cores, the reconstruction of blank production is based primarily on the technical characteristics of the tools and flakes. While we present the results according to each stratigraphic unit D and E, individual spits are also considered (Table 2).

Results

In both layer D and E, most of the lithic raw materials came from the immediate vicinity of the site. They consist of limestone in the form of blocks and pebbles, as well as *lastrine* slabs (local siliceous limestone that forms in plaques), dolomite, and flint in the form of nodules and slabs. All raw materials are available in the local Cretaceous strata of the region (Mastrogiacomo *et al.*, 2012). Flint and jasper were used rarely and were probably collected in secondary deposits. Today, they are available in the form of pebbles in ancient riverbeds west of Taranto (Bentivenga *et al.*, 2004) (Table 3).

Only 4.3% ($n = 24$) of the analyzed materials have abraded surfaces. Two types of patination are documented, indicating that 2.8% ($n = 15$) of the lithics were refashioned and reused. Thermal alteration is present on 4.7% ($n = 25$) of the lithics. In layer E, 27.5% ($n = 33$) of the tools and flakes retain cortexes, 20.7% ($n = 24$) are local raw materials and 6.9% ($n = 8$) are non-local materials. In layer D, 31% ($n = 128$) of the lithics retain cortexes, 25.7% ($n = 106$) are local raw materials and 5.3% ($n = 22$) are non-local materials. In both layers, size dimensions of the tools vary considerably (Figs. 4 and 5). Layers E and D also produced 14.6% ($n = 18$) and 18.4% ($n = 76$) fragmented artifacts, respectively, and refit studies have not yielded any results.

Most of the tools show retouches amounting to 89.3% ($n = 104$) of retouched artifacts in layer E and 95.9% ($n = 395$) of retouched artifacts in layer D in total (Table 3). In both layers, management flakes for blank preparation, cortical flakes or flakes resulting from platform preparation were present. Retouching, which occurred in the form of direct or reverse retouches, greatly modified the morphology of the artifacts.

Layer E (Table 4)

A single remain of an exhausted core is attributed to the unipolar production of small, elongated flakes. In total, 23.3% ($n = 27$) of the tools have thick dorsal edges with steep angles, which are cortical, non-retouched or retouched and 40.1% ($n = 46$) exhibited retouches on the distal transversal edge. Also, 27.6% ($n = 32$) of the artifacts are obtained through a recurrent unipolar Levallois method (Fig. 6.1, 2, 3). Roughly 5.1% ($n = 6$) of the non-local pebbles (flint) were used for this purpose while 28.4% ($n = 33$) were made from local raw

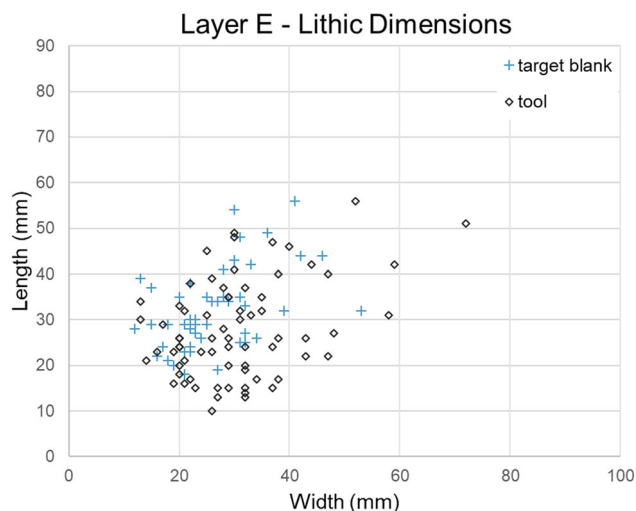


Figure 4. Layer E – dimensions of lithic artifacts. *Width is on the x-axis and length is on the y-axis. [Color figure can be viewed at wileyonlinelibrary.com]

materials. The technical characteristics of the tools and management flakes show that the knappers obtained short quadrangular and elongated flakes with convergent removal. These products are quite thin with faceted or dihedral butts and edges that are transformed by light retouches. By contrast, more invasive retouch was used to create points and to transform flakes and débordant flakes, which resulted from the preparation and maintenance of the striking platforms.

In total, 21.5% ($n = 25$) of the artifacts were made with the unipolar method aimed at producing short and thick tools on the local raw materials, namely dolomite (12%) and limestone (9.4%). In knapping the primary nodules, makers exploited the natural edges or natural dihedral shapes, which then resulted in the extraction of short flakes with uniform or elongated shape. These flakes exhibit natural backs, straight ventral profiles and wide smooth butts (Fig. 6.6). The strategy for producing these artifacts involved preparation through managing the striking platform and maintaining the steep angle of the flaked surface on the lateral dorsal edge, instead of altering the entire shape of the core. These tools were then frequently modified by localized retouches on the transversal edge.

In total, 7.7% ($n = 9$) of the lithics were obtained from the local lastrine slabs. The natural blank was laterally adjusted to isolate a straight or convex cutting edge, which is obtained by retouches (Fig. 6.5) and knappers selected blanks with a maximum thickness of 15 mm. Thicker slabs were used as cores to extract short flakes that are evident from the debitage plane, which is parallel to the natural flaking planes of the blocks.

In total, 5.1% ($n = 6$) of the artifacts consist of small blades and elongated flakes obtained through laminar volumetric production (Fig. 6.4). In the absence of cores, the reduction sequence is again deduced from the negative scars, which are present on the tools and technical flakes. Finally, 2.6% ($n = 3$) of the artifacts are obtained from small pebbles of flint or radiolarites, which were halved and then modified through direct or bifacial retouches to obtain straight cutting edges.

Layer D (Table 4)

The assemblage of layer D includes two lamellar cores and two discoidal cores, all of which are exhausted extensively. Retouched tools, often on the transversal edge, account for 94.9% ($n = 391$) of the artifacts, and 17% ($n = 70$) of the blanks show natural or retouched backs.

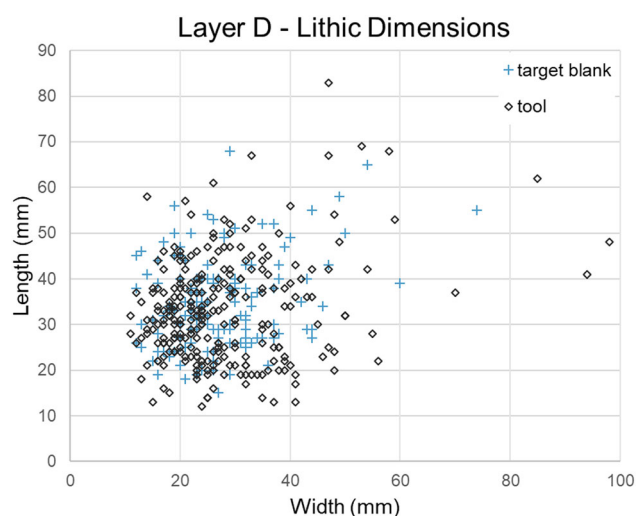


Figure 5. Layer D – dimensions of lithic artifacts. *Width is on the x-axis and length is on the y-axis. [Color figure can be viewed at wileyonlinelibrary.com]

Table 4. Identified blank types

Production method	Layer E	%	Layer D	%
Indeterminate	11	9.48	55	13.34
Ind. cortical flakes	26	22.41	93	22.57
Levallois				
Generic flakes	0	0	39	9.46
Sub-square flakes	3	2.58	12	2.91
Sub-triangular flakes	4	3.44	6	1.45
Elongated flakes	7	6.03	28	6.79
Management flakes	12	10.34	18	4.36
Management striking platform flakes	6	5.17	14	3.39
Total	32	27.56	117	28.36
Unipolar				
Generic flakes	2	1.72	1	0.24
Sub-square flakes	7	6.03	0	0
Elongated flakes	3	2.58	0	0
Management flakes	12	10.34	2	0.48
Cores	1	0.86	0	0
Total	25	21.53	5	0.72
Discoid				
Generic flakes	0	0	10	2.42
Sub-square flakes	0	0	9	2.18
Sub-triangular flakes	0	0	7	1.69
Elongated flakes	0	0	1	0.24
Partial debordant flakes	0	0	3	0.72
Cores	0	0	2	0.48
Total	0	0	32	7.73
Transformation of 'lastrine slabs'				
Cortical flakes	2	1.72	2	0.48
Generic flakes	2	1.72	3	0.72
Sub-square flakes	3	2.58	9	2.18
Sub-triangular flakes	0	0	3	0.72
Total	7	6.02	17	4.1
Parallel debitage of the surface of 'lastrine slabs'				
Cortical flakes	1	0.86	9	2.18
Generic flakes	0	0	6	1.45
Elongated flakes	0	0	2	0.48
Management flakes	1	0.86	1	0.24
Total	2	1.72	18	4.35
Laminar				
Cortical flakes	1	0.86	5	1.19
Generic flakes	0	0	2	0.48
Blades	2	1.72	11	2.66
Elongated flakes	0	0	3	0.72
Crests	0	0	2	0.48
Management flakes	3	2.58	2	0.48
Cores	0	0	2	0.48
Total	6	5.16	27	6.49
'Double-ventral'				
Cortical flakes	0	0	6	1.45
Management striking platform flakes	0	0	1	0.24
Sub-square flakes	0	0	6	1.45
Sub-triangular flakes	0	0	6	1.45
Elongated flakes	0	0	6	1.45
Total	0	0	25	6.04
'Dihedral-ventral'				
Generic flakes	0	0	1	0.24
Elongated flakes	0	0	1	0.24
Total	0	0	2	0.48
Bipolar technique on anvil				
Cortical flakes	0	0	4	0.95
Generic flakes	2	1.72	8	1.91
Total	2	1.72	12	2.86
Debitage large blocks				
Cortical flakes	0	0	2	0.48
Management flakes	0	0	1	0.24

(Continued)

Table 4. (Continued)

Production method	Layer E	%	Layer D	%
Sub-square flakes	0	0	1	0.24
Total	0	0	4	0.96
Retouched small pebbles (with cortex)	3	2.58	7	1.67
Façonnage on flakes				
Elongated flakes	1	0.86	0	0
Management flakes	1	0.86	0	0
Total	2	1.72	0	0

The occasional presence of artifacts with double ventral faces indicates that the cores were possibly obtained from large flakes of local limestone or nodular flint and were knapped using discoidal and Levallois methods. Some decortication flakes cannot be attributed to a specific reduction method.

In addition, there are some large flakes made from limestone, which resulted from fragmenting large blocks. Some have double ventral faces with a dihedral shape. By contrast, some productions of flake with a double ventral

face were aimed at obtaining a biconvex section or transformed into a core for thick and dihedral-sided points (6%) and flakes.

The unipolar Levallois débitage is found on 28.4% ($n = 117$) of the artifacts (Fig. 7). The large variability reflects the diversity of the raw materials exploited by the knappers. For instance, the limestone was mainly used to create larger artifacts. In general, the decortication process shows unipolar extractions. The knappers managed the lateral convexity through the detachment of débordant and pseudo-Levallois flakes. The butts are often faceted or dihedral. The forms of flake also show variability, including elongated flakes, short flakes and triangular flakes. They served as blanks for side-scrapers with convex or straight edges and fine points. Many flakes for platform management were subsequently transformed into transverse scrapers by deep and direct retouching of the distal edge. Some elongated limestone blanks, by contrast, were transformed through thinning of the ventral face and bifacial retouches.

In total, 7.7% ($n = 32$) of the tools are produced by discoidal reduction (Fig. 8). They consist of thick flakes with a quadrangular or triangular shape and variable dimensions. Many blanks and tools were obtained from the local limestone blocks. Also, 8.5% ($n = 35$) of the analyzed artifacts were made from local *lastrine* slabs. With this material, knappers aimed at producing straight or convex edges and exploited the lateral edges of the blanks to obtain artifacts with a quadrangular or triangular shape (Fig. 10.2). The thickness of these blanks is a recurring technical trait that was probably important to the knappers. For the thicker blocks, the débitage plane of the flakes was often parallel to the natural plane of the raw material.

The laminar method quantitatively is of a marginal role. It represents 6.5% ($n = 27$) of the entire assemblage, but was used for the production of artifacts with specific traits: small blades with straight edges and a poorly convex ventral profile (Fig. 9). The débitage surface shows unipolar removal, and convexity is managed by convergent removal. The exogenous raw material, which consists mostly of small radiolarite pebbles, was selected and carefully modified with direct or bifacial retouches to obtain small scrapers (Fig. 10.1). Some lithics in the assemblage also attest to bipolar striking on an anvil (2.9%) although they remain rare.

As already mentioned, the production of flakes with double ventral faces was aimed at producing scrapers with a biconvex section and bifacial retouches. These artifacts were largely made of limestone except for one small flint artifact. Thick points were also obtained from core flakes, and in this case, double-ventral flake removal served as a useful technique to obtain triangular points (Fig. 10.3).

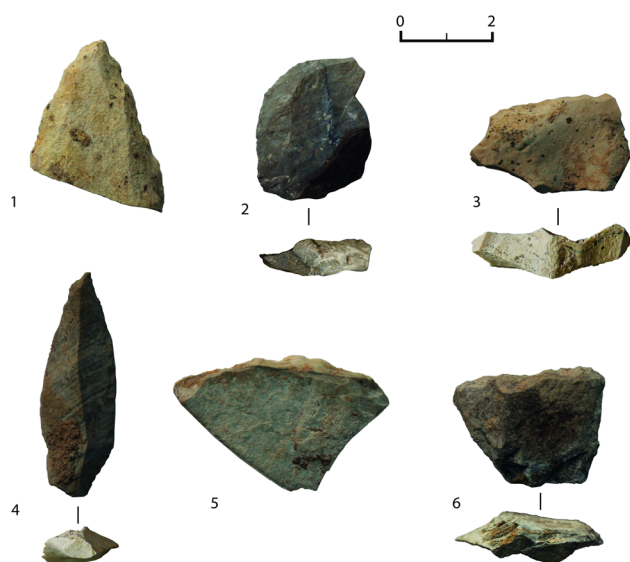


Figure 6. Layer E: 1, sub-triangular flake; 2, generic flake by Levallois débitage; 3, striking platform flake; 4, blade; 5, slabs; 6, sub-square flake by unipolar débitage. [Color figure can be viewed at wileyonlinelibrary.com]

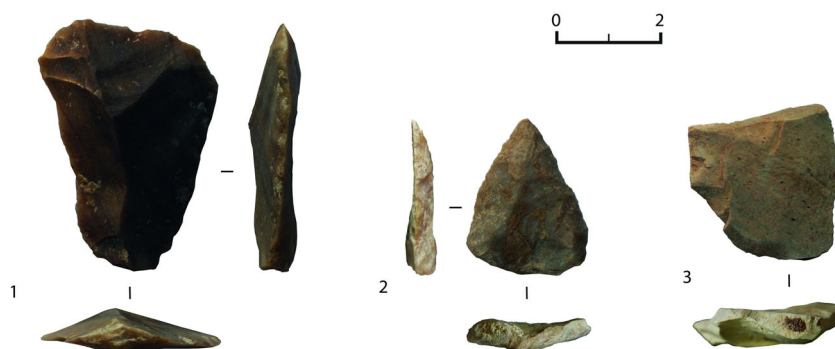


Figure 7. Layer D: 1, generic flake; 2, sub-triangular flake; 3, sub-square flake by Levallois débitage. [Color figure can be viewed at wileyonlinelibrary.com]

Discussion and conclusion

The reconstruction of the technical system involved in the lithic production confirms some of the interpretations proposed by Borzatti von Löwenstern for the lower part of the stratigraphic sequence and allows us to better understand the territorial organization and techno-cultural evolution of the archaic human groups on the Salento peninsula. Spinapolice (2012, 2018) highlighted the presence of Levallois débitage and exogenous raw material in some levels of layer D. Our study of the lithics from layer E and the lower levels of D supports this interpretation.

Although the lithic assemblages in our sample derive from a limited excavation area, all phases of the production are documented. The raw material data indicate selective use of raw materials, such as radiolarite pebbles, which were

exploited to produce specific types of tools. According to the current lithological distribution, radiolarites were available in secondary deposits which lie ~100 km from the Neretina coast (Bentivenga *et al.*, 2004). Currently, it is not possible to verify whether this material was also available in a closer radius during the Paleolithic, but the occasional use of non-local raw material indicates that the Neanderthals' territory extended over a considerable area and points to the scale of their mobility (Fig. 11). This pattern is also observed in the later Middle Paleolithic and Upper Paleolithic phases (Ranaldo, 2017; Trenti *et al.*, 2017; Spinapolice, 2018). Evidence from layer E, however, demonstrates that the behavior and mobility of Neanderthals are comparable to those of later Neanderthals and modern humans possibly by the Interglacial period, if not earlier (Ranaldo, 2017; Ranaldo *et al.*, 2017b; Trenti *et al.*, 2017; Spinapolice, 2018; Sarti and Martini, 2020).

Looking at the use of non-local raw materials, knappers selected the nodules on the basis of size of the pebbles in both layers: large blocks were used for Levallois production, while smaller raw materials were knapped using other methods. The use of local limestones, which originate from the Neretina coast, demonstrates that the knappers selected those with larger dimensions for the production of tools. In layer D, artifacts made from limestone were produced using both Levallois and discoidal methods. Knappers produced scrapers and retouched points with bifacial removal using the Levallois method or by exploiting the ventral convexity of the large flakes to obtain the biconvex cross-section from the limestone blocks.

Borzatti von Löwenstern (1966) argued for the antiquity of these assemblages based on the typological traits and technical features, including the presence of dihedral shapes on the ventral face of the artifacts (Figs. 12 and 13). The dihedral form is related to the exploitation of flakes that was obtained from flake cores, which resulted in typical Quinson traits, something that Borzatti von Löwenstern also highlighted.

When we compare the production strategies over time, the Levallois and laminar reduction methods were used in both layer E and D (Table 5). The former method was used to obtain thin and less-elongated tools and the latter method resulted in laminar tools. While some of the shorter and thicker tools in layer E were produced through orthogonal unipolar reduction, comparable tools were produced by a discoidal method and bipolar anvil technique in layer D. This is a significant

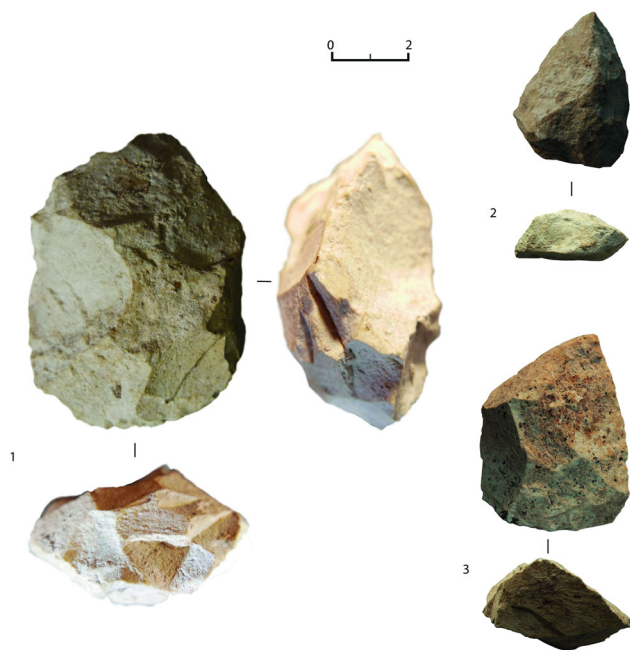


Figure 8. Layer D: 1, discoid core; 2, sub-triangular flake; 3, débordant flake by discoid débitage. [Color figure can be viewed at wileyonlinelibrary.com]

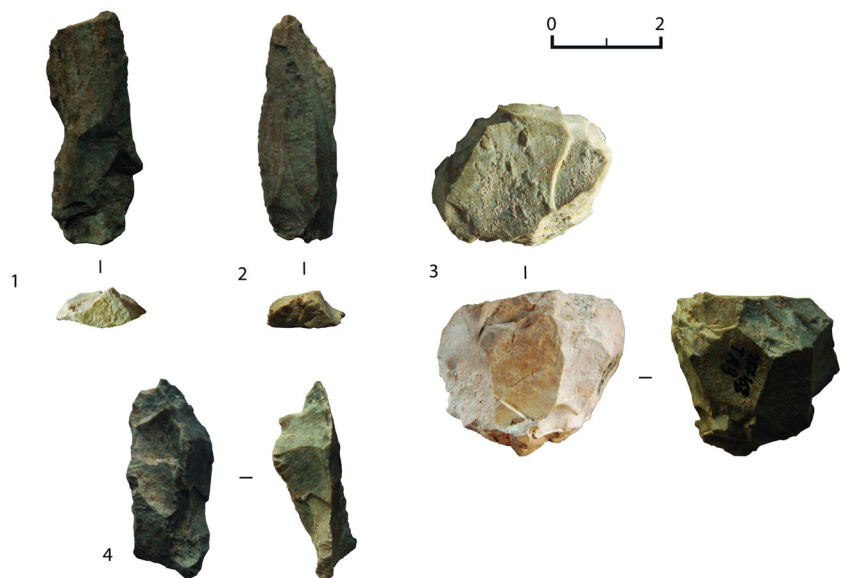


Figure 9. Layer D: 1, 2, blades; 3, laminar core; 4, crest. [Color figure can be viewed at wileyonlinelibrary.com]

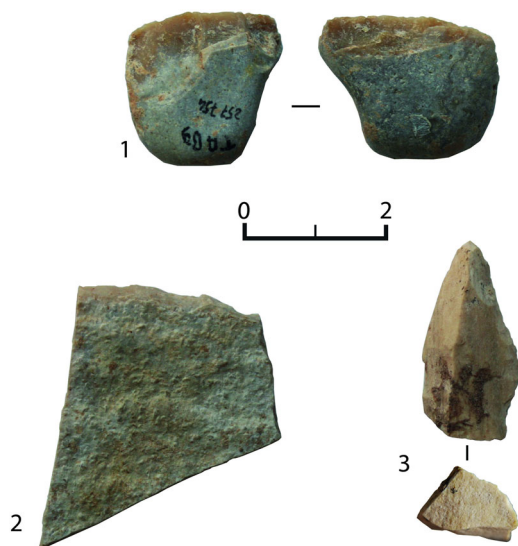


Figure 10. Layer D: 1, small pebble; 2, slabs; 3, double-ventral points. [Color figure can be viewed at wileyonlinelibrary.com]

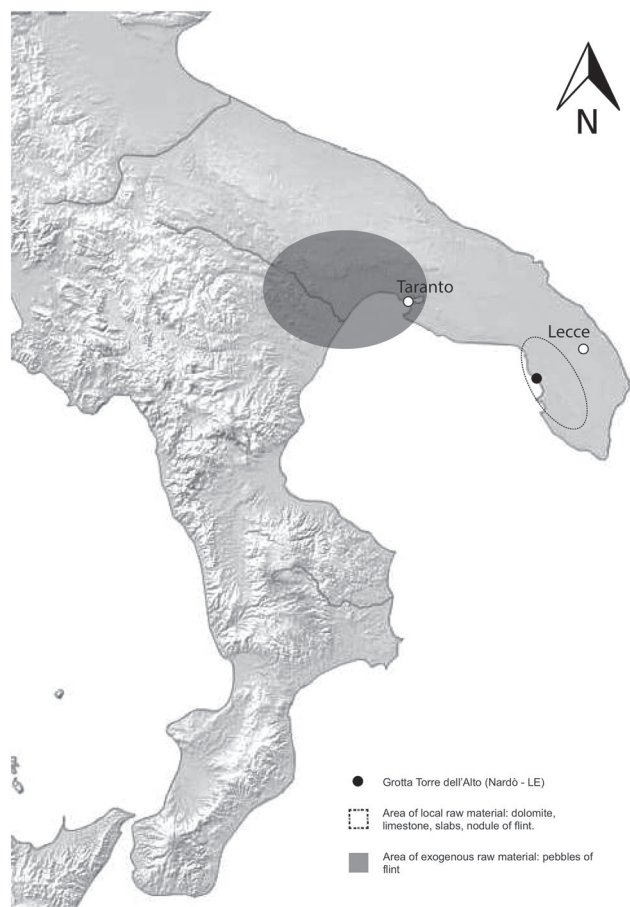


Figure 11. Distribution map of local and non-local lithic raw material.

difference, which hints at multiple occupational sequences with different technological repertoires and potentially different use of the territories over time (Raffestin, 1983, 1984; Turco, 1988; Magnaghi, 2001; Massafra, 2018). This hypothesis will be tested in the future using other lines of evidence including radiometric dating, paleoenvironmental reconstruction and faunal studies.

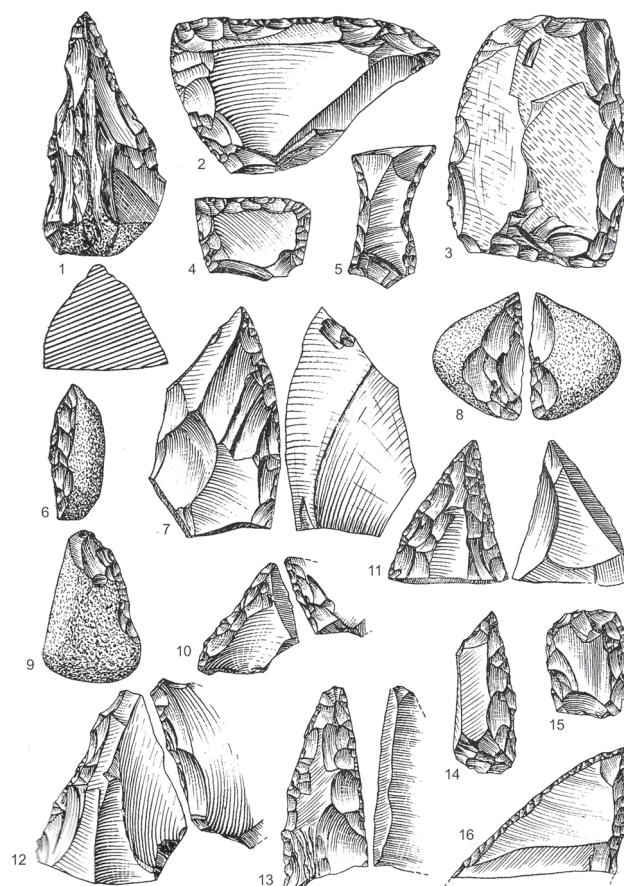


Figure 12. Tools from layer E (modified from Borzatti von Löwenstern, 1966). 1, 10–14, 16, points; 2, déjeté scraper; 3, 6, 7, 9, convex side-scrapers; 4, straight double scraper; 5, concave double scraper; 8, straight side-scraper.

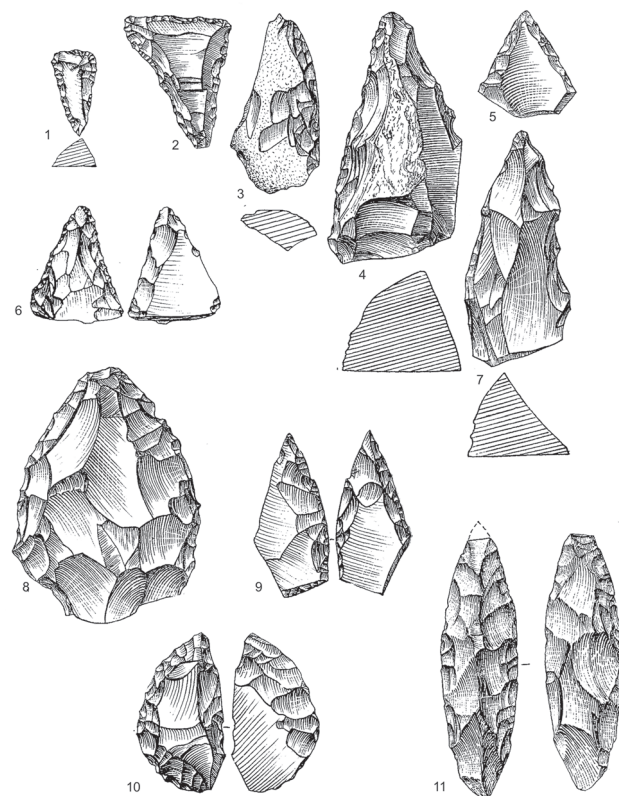


Figure 13. Tools from layer D (modified from Borzatti von Löwenstern, 1966). Layer E (modified from Borzatti von Löwenstern, 1966; Borzatti von Löwenstern and Magaldi, 1967). 1, end scraper; 2, déjeté scraper; 3, convex side-scraper; 4–11, points.

Table 5. Approach to the production

	Unipolar recurrent Levallois	Laminar	Unipolar	Discoid	Retouched lastrines	Bipolar technique on anvil	Dihedral- ventral	Double- ventral	Small pebbles
Layer E	X	X	X		X				X
Layer D	X	X		X	X	X	X	X	X

Table 6. Formal lithic tools from Borzatti von Lowenstern and Magaldi (1967) (*modified*)

Tools	Layer E (%)	Layer D (%)
Straight side-scrapers	10.3	10.7
Convex side-scrapers	23.9	29.2
Concave side-scrapers	4.3	4.7
Sinuuous side-scrapers	1.7	7.7
Straight double scrapers	3.4	0.4
Straight-convex double scrapers	0.8	2.1
Concave-convex double scrapers		0.9
Convex double scrapers		1.9
Concave double scrapers		0.1
Straight-concave double scrapers		0.4
Sinuuous-convex double scrapers		0.3
Scrapers with bifacial retouch	0.8	2.2
Transversal scrapers	10.3	7.5
Déjeté scrapers	4.3	4.4
Planes		0.5
Points	18.8	10
Bifacial points	5.1	3.1
Limaces		0.2
Denticulates	8.6	6.2
Total	117	1044

The technological study of lithic artifacts broadly allows us to question the chronological framework of these stratigraphic units and the nature of the technocomplexes from the lower layers. Previous studies have focused on the link between typology and culture that was interpreted as the evolved Tayacian industry (Palma di Cesnola, 2001) due to the presence of denticulates, transverse scrapers, carinated tools and Tayac points (*sensu* Bordes, 1961) (Table 6). From the technological point of view, Palma di Cesnola (2001) highlighted the absence of Levallois technique and the presence of the 'Quinson technique'. In contrast, this study demonstrates the presence of various débitage methods including the systematic production of thinner tools and blades. This enables us to reconsider the technocomplex and material culture within a broader geographic framework. The coexistence of Levallois and laminar technology was probably a response to specific technological needs (Boëda, 2013).

Levallois and laminar methods were initially known in Salento and the neighboring areas during the later phases of MIS 3 (Carmignani, 2010; Boscato *et al.*, 2011; Marciani *et al.*, 2016; Rinaldo *et al.*, 2017a; Sarti and Martini, 2020), but based on our evidence and the new studies, we can extend their presence back to as early as MIS 5e in the Mediterranean basin, if not earlier. This points to two possible hypotheses: (i) the techniques existed in the Salento region before MIS 3 in contrast to what has been proposed from the previous studies or (ii) the chronological framework of the site needs reconsideration to account for the emergence of these techniques. In either case, we need to revisit the interpretive frameworks and models that were developed by the seminal work of Palma di Cesnola and Borzatti von Löwenstern to

better understand the technological behavior and settlement patterns of Neanderthals. Analysis of the GTA lithic assemblages and future studies can contribute to this topic, adding to the discussion of technological evolution in this region.

In the future, new dating that will help us improve the chronological framework of the region to better understand Neanderthal occupations in southern Italy, given that the lower layers of GTA may be older than the recent dates from Grotta del Cavallo (Sarti and Martini, 2020). In addition to the study of the lithic assemblages discussed in this paper, ongoing zooarchaeological study and geo-sedimentological study will contribute to a more detailed reconstruction of the paleoenvironment and Neanderthals' behavior in this ecological milieu of southern Italy.

Acknowledgements. The authors declare that they have no conflicts of interest. We thank Milena Carvalho and Nuno Bicho for organizing the session in April 2019 and for editing this volume. The study was conducted with the permission of the Ministero della Cultura – Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Brindisi e Lecce; with the support of the Comune di Nardò, of the Ente di Gestione del Parco Naturale Regionale di Portoselvaggio e Palude del Capitano and of Nomos – Servizi per la Cultura del Patrimonio (manager of the Museo della Preistoria di Nardò). We thank Serena Strafella (Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Brindisi e Lecce) for her willingness, Silvia Strafella (Museo Della Preistoria di Nardò) and Francesco Colopi for their support in the management of the archaeological finds. We thank Sergio Fai and Vincenzo Stasolla for providing photography. Final thanks to Edoardo Borzatti von Löwenstern for his research in Porto Selvaggio and to Mino Natalizio, Nicola D'Alessandro and the Gruppo Speleologico Neretino for their dedication. Open Access funding enabled and organized by Projekt DEAL.

Abbreviations. GTA, Grotta Torre dell'Alto; MIS, Marine Isotope Stage.

References

- Allen JRM, Watts WA, Huntley B. 2000. Weichselian palynostratigraphy, palaeovegetation and palaeoenvironment; the record from Lago Grande di Monticchio, southern Italy. *Quaternary International* **73–74**: 91–110. [https://doi.org/10.1016/S1040-6182\(00\)00067-7](https://doi.org/10.1016/S1040-6182(00)00067-7)
- Bagolini B. 1968. Ricerche sulle dimensioni dei manufatti litici preistorici non ritoccati. *Annali dell'Università degli Studi di Ferrara, Sezione XV – Paleontologia Umana e Paleontologia*, 10(1), Università degli Studi: Ferrara; 195–219.
- Benazzi S, Douka K, Fornai C *et al.* 2011. Early dispersal of modern humans in Europe and implications for Neanderthal behaviour. *Nature* **479**: 525–528. <https://doi.org/10.1038/nature10617>
- Bentivenga M, Coltorti M, Prosser G *et al.* 2004. A new interpretation of terraces in the Taranto Gulf: the role of extensional faulting. *Geomorphology* **60**: 383–402. <https://doi.org/10.1016/j.geomorph.2003.10.002>
- Boëda E. 1990. De la surface au volume: analyse des conceptions des débitages Levallois et laminaire. Paléolithique moyen récent et Paléolithique supérieur ancien en Europe. *Actes du colloque international de Nemours, 17–18–19 mai 1989, Mémoires du Musée de préhistoire d'Ile-de-France* **3**: 63–76.
- Boëda E. 1994. *Le concept Levallois: variabilité des méthodes*. Archéo Éditions. Centre National de la Recherche Scientifique: Paris.

- Boëda E. 2013. *Techno-logique & Technologie: Une paléo-histoire des objets lithiques tranchants*. Archéo Éditions. Centre National de la Recherche Scientifique: Paris.
- Bordes F. 1961. *Typologie du Paléolithique ancien et moyen*. Publications del Institut de Préhistoire de l'Université de Bordeaux, Delmas: Bordeaux.
- Borzatti von Löwenstern E. 1961. Un saggio nella Grotta di Capelvenere a S. Caterina (Nardò). *Rivista di scienze preistoriche* **16**: 207–216.
- Borzatti von Löwenstern E. 1966. Alcuni aspetti del Musteriano nel Salento: la grotta-riparo di Torre dell'Alto e la grotta di Uluzzo C. Scavi 1965 e 1966. *Rivista di Scienze Preistoriche* **21**: 203–287.
- Borzatti von Löwenstern E. 1970. Prima campagna di scavi nella grotta Mario Bernardini (Nardò-Lecce). *Rivista di Scienze Preistoriche* **25**: 89–125.
- Borzatti von Löwenstern E. 1971. Seconda campagna di scavi nella grotta 'Mario Bernardini' (Nardò-Lecce). *Rivista di scienze preistoriche* **26**: 31–62.
- Borzatti von Löwenstern E, Magaldi D. 1967. Ultime ricerche nella Grotta dell'Alto (S. Caterina-Nardò). *Rivista di Scienze Preistoriche* **22**: 205–250.
- Boscato P, Gambassini P, Rinaldo F *et al.* 2011. Management of paleoenvironmental resources and exploitation of raw materials at the Middle Paleolithic site of Oscurusciuto (Ginosa, southern Italy): units 1 and 4. In *Neanderthal Lifeways, Subsistence and Technology*, Conard NJ, Richter J (eds). Springer: Dordrecht; 87–96.
- Bossio A, Foresi LM, Margiotta S *et al.* 2006. Stratigrafia neogenico-quaternaria del settore nord-orientale della Provincia di Lecce (con rilevamento geologico alla scala 1: 25.000). *Geologica Romana* **39**: 63–88.
- Brauer A, Allen JR, Mingram J *et al.* 2007. Evidence for last interglacial chronology and environmental change from Southern Europe. *Proceedings of the National Academy of Sciences of the United States of America* **104**: 450–455. <https://doi.org/10.1073/pnas.0603321104>
- Calattini M, Carmignani L. 2017. Aspetti tecnologici e tipologici del Musteriano finale di Grotta delle Mura (Bari). In *Preistoria e Protostoria della Puglia, Studi di Preistoria e Protostoria*, 4, Radina F (ed). Istituto Italiano di Preistoria e Protostoria: Firenze; 159–164.
- Carmignani L. 2010. L'industria litica del livello filile di Grotta del Cavallo (Nardò, Lecce). Osservazioni su una produzione laminolamellare in un contesto del Musteriano Finale. *Origini: Preistoria e protostoria delle civiltà antiche* **32**: 7–26.
- Columbu A, Chiarini V, Spötl C *et al.* 2020. Speleothem record attests to stable environmental conditions during Neanderthal–modern human turnover in southern Italy. *Nature Ecology and Evolution* **4**: 1188–1195. <https://doi.org/10.1038/s41559-020-1243-1>
- Comboureu-Nebout N, Bertini A, Russo-Ermolli E *et al.* 2015. Climate changes in the central Mediterranean and Italian vegetation dynamics since the Pliocene. *Review of Palaeobotany and Palynology* **218**: 127–147. <https://doi.org/10.1016/j.revpalbo.2015.03.001>
- Conde S, Weniger GC (eds). 2011. *Continuity and Discontinuity in the Peopling of Europe*. Springer: Berlin.
- D'Errico F, Borgia V, Ronchitelli A. 2012. Uluzzian bone technology and its implications for the origin of behavioural modernity. *Quaternary International* **259**: 59–71. <https://doi.org/10.1016/j.quaint.2011.03.039>
- Dantoni G, Nardi N. 1980. La Grotta riparo 'Marcello Zei' (Santa Caterina, Nardò). *Studi per l'Ecologia del Quaternario* **2**: 97–119.
- Geneste JM. 1991. Systèmes techniques de production lithique: variations techno-économiques dans les processus de réalisation des outillages paléolithiques. *Techniques and Culture* **17–18**: 3–35.
- Giaccio B, Isaia R, Fedele FG *et al.* 2008. The Campanian Ignimbrite and Codola tephra layers: two temporal/stratigraphic markers for the Early Upper Palaeolithic in southern Italy and eastern Europe. *Journal of Volcanology and Geothermal Research* **177**: 208–226. <https://doi.org/10.1016/j.jvolgeores.2007.10.007>
- Giusti M. 1979. La Grotta di Capelvenere a S. Caterina – Nardò (Campagna di scavo 1974). *Studi per l'Ecologia del Quaternario* **1**: 19–40.
- Giusti M. 1980. La Grotta di Capelvenere a S. Caterina – Nardò (campagna di scavo 1975). *Studi per l'Ecologia del Quaternario* **2**: 77–85.
- Inizan ML, Reduron-Ballinger M, Roche H *et al.* 1996. Technologie de la pierre taillée. *Bulletin de la Société préhistorique française* 141–143.
- Largaiolli T, Martinis B, Mozzi G *et al.* 1969. *Note illustrative della Carta Geologica d'Italia, Foglio 214 Gallipoli*. Servizio Geologico d'Italia, Poligrafica e Cartevalori: Ercolano (Napoli).
- Lari M, Di Vincenzo F, Borsato A *et al.* 2015. The Neanderthal in the karst: first dating, morphometric, and paleogenetic data on the fossil skeleton from Altamura (Italy). *Journal of Human Evolution* **82**: 88–94. <https://doi.org/10.1016/j.jhevol.2015.02.007>
- Magnaghi A. 2001. Una metodologia analitica per la progettazione identitaria del territorio. In *Rappresentare i luoghi: metodi e tecniche*, Magnaghi A (ed). Alinea: Firenze; 13–51.
- Marciani G, Arrighi S, Aureli D *et al.* 2016. Middle Palaeolithic lithic tools: techno-functional and use-wear analysis of target objects from SU 13 at the Oscurusciuto rock shelter, Southern Italy. *Journal of Lithic Studies* **5**. <https://doi.org/10.2218/jls.2745>
- Martini F, Ronchitelli A, Sarti L. 2017. Il Paleolitico e il Mesolitico della Puglia. In *Preistoria e Protostoria della Puglia*, F. Radina (Ed.). Firenze: Istituto italiano di preistoria e protostoria; vol. 4, 25–38.
- Massafa D. 2018. Più conoscenza, più valore: il contributo della ricerca storica allo sviluppo territoriale delle Serre Salentine. Masters Degree Thesis, Università del Salento, Lecce.
- Mastrogiacomo G, Moretti M, Owen G *et al.* 2012. Tectonic triggering of slump sheets in the Upper Cretaceous carbonate succession of the Porto Selvaggio area (Salento peninsula, southern Italy): synsedimentary tectonics in the Apulian Carbonate Platform. *Sedimentary Geology* **269–270**: 15–27. <https://doi.org/10.1016/j.sedgeo.2012.05.001>
- Moroni A, Ronchitelli A, Simona A *et al.* 2018. Grotta del Cavallo [Apulia–Southern Italy]. The Uluzzian in the mirror. *Journal of Anthropological Sciences* **96**: 125–160.
- Oppo DW, McManus JF, Cullen JL. 2006. Evolution and demise of the Last Interglacial warmth in the subpolar North Atlantic. *Quaternary Science Reviews* **25**: 3268–3277. <https://doi.org/10.1016/j.quas.2006.07.006>
- Palma di Cesnola A. 2001. *Il Paleolitico inferiore e medio in Italia*. Museo Fiorentino di Preistoria 'Paolo Graziosi': Firenze.
- Patriarchi C. 1980. Studio sedimentologico e geochimico del paleosuolo della Grotta di Capelvenere (Nardò-Lecce). *Studi per l'Ecologia del Quaternario* **2**: 87–96.
- Raffestin C. 1983. *Pour une géographie du pouvoir*. Edizioni Unicopli: Milano.
- Raffestin C. 1984. Territorializzazione, deterritorializzazione, riteritorializzazione e informazione. In *Regione e regionalizzazione*, Turco A (ed). Angeli: Milano; 69–82.
- Rinaldo F. 2017. L'arco ionico pugliese tra la fine del Paleolitico medio e gli esordi del Paleolitico superiore: problemi e prospettive di ricerca per la ricostruzione dei sistemi antropici. In *Preistoria e Protostoria della Puglia, Studi di Preistoria e Protostoria*, 4, Radina F (ed). Istituto Italiano di Preistoria e Protostoria: Firenze; 169–174.
- Rinaldo F, Boscato P, Moroni A *et al.* 2017a. Riparo dell'Oscurusciuto (Ginosa-TA): la chiusura del ciclo Levallois alla fine del Paleolitico medio. In *Preistoria e Protostoria della Puglia, Studi di Preistoria e Protostoria*, 4, Radina F (ed). Istituto Italiano di Preistoria e Protostoria: Firenze; 169–174.
- Rinaldo F, Klempererová H, Ronchitelli A. 2017b. Evoluzione dei sistemi tecnici nell'Uluzziano di Grotta del Cavallo (Nardò-LE). In *Preistoria e Protostoria della Puglia, Studi di Preistoria e Protostoria*, 4, Radina F (ed). Istituto Italiano di Preistoria e Protostoria: Firenze; 61–67.
- Romagnoli F. 2012. *Risorse litiche e comportamento tecnico dei Neandertaliani: variabilità culturale e adattamento all'ambiente nel Salento. Grotta del Cavallo, strati L-N e Grotta Mario Bernardini strato D'* PhD Thesis, Università Degli Studi di Firenze, Università Rovira i Virgili, Tarragona.
- Ronchitelli A, Boscato P, Gambassini P. 2009. Gli ultimi neandertaliani in Italia: aspetti culturali. In *La lunga storia di neandertal. Biologia e comportamento*, Facchini F, Belcastro G (eds). Jaca Book: Milano; 257–287.
- Sardella R, Iurino DA, Mecozzi B *et al.* 2019. Grotta Romanelli (Lecce, Southern Italy) between past and future: new studies and perspectives for an archaeo-geosite symbol of the Palaeolithic in Europe.

- Geoheritage* **11**: 1413–1432. <https://doi.org/10.1007/s12371-019-00376-z>
- Sardella R, Mazzini I, Giustini F *et al.* 2018. Grotta Romanelli (Southern Italy, Apulia): legacies and issues in excavating a key site for the Pleistocene of the Mediterranean. *Rivista Italiana di Paleontologia e Stratigrafia* **124**: 247–264.
- Sarti L, Martini F (eds). 2020. *Il Musteriano di Grotta del Cavallo nel Salento (scavi 1986–2005)*. Culture e Ambienti, Museo Fiorentino di Preistoria 'Paolo Graziosi': Firenze.
- Sarti L, Romagnoli F, Carmignani L *et al.* 2017. Grotta del Cavallo (scavi Sarti): tradizione e innovazione nella sequenza musteriana sulla base dell'indicatore litico. In *Preistoria e Protostoria della Puglia, Studi di Preistoria e Protostoria*, 4, Radina F (ed). Istituto Italiano di Preistoria e Protostoria: Firenze; 131–138.
- Spinapolice EE. 2012. Raw material economy in Salento (Apulia, Italy): new perspectives on Neanderthal mobility patterns. *Journal of Archaeological Science* **39**: 680–689. <https://doi.org/10.1016/j.jas.2011.10.033>
- Spinapolice EE. 2018. Neanderthal mobility pattern and technological organization in the Salento (Apulia, Italy). In *Palaeolithic Italy. Advanced Studies on Early Human Adaptation in the Apennine Peninsula*, Borgia V, Cristiani E (eds). Sidestone Press: Leiden; 94–124.
- Trenti F, Nannini L, Romagnoli F *et al.* 2017. Grotta del Cavallo: ipotesi di mobilità dei gruppi umani musteriani sulla base dello sfruttamento delle risorse litiche. In *Preistoria e Protostoria della Puglia, Studi di Preistoria e Protostoria*, 4, Radina F (ed). Istituto Italiano di Preistoria e Protostoria: Firenze; 125–129.
- Turco A. 1988. *Verso una teoria geografica della complessità*. Unicopli: Milano.
- Tzedakis PC, Drysdale RN, Margari V *et al.* 2018. Enhanced climate instability in the North Atlantic and southern Europe during the Last Interglacial. *Nature Communications* **9**: 4235. <https://doi.org/10.1038/s41467-018-06683-3>
- Zanchetta G, Bini M, Giaccio B *et al.* 2020. I livelli vulcanoclastici: analisi chimica e considerazioni deposizionali. In *Il Musteriano di Grotta del Cavallo nel Salento (scavi 1986–2005)*. Culture e Ambienti, Sarti L, Martini F (eds). Museo fiorentino di preistoria 'Paolo Graziosi': Firenze; 53–65.
- Zanchetta G, Giaccio B, Bini M *et al.* 2018. Tephrostratigraphy of Grotta del Cavallo, Southern Italy: insights on the chronology of Middle to Upper Palaeolithic transition in the Mediterranean. *Quaternary Science Reviews* **182**: 65–77. <https://doi.org/10.1016/j.quascirev.2017.12.014>