C. R. Palevol 12 (2013) 211–221

Contents lists available at SciVerse ScienceDirect

Comptes Rendus Palevol

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Human palaeontology and prehistory

Blades, bladelets and flakes: A case of variability in tool design at the dawn of the Middle–Upper Palaeolithic transition in Italy

Lames, lamelles et éclats : un cas de variabilité dans la réalisation de l'outillage à l'aube de la transition Paléolithique moyen–supérieur en Italie

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ARTICLE INFO

Article history:
Received 1st December 2012
Accepted after revision 9 April 2013
Available online 13 June 2013

Presented by Yves Coppens

Keywords:
Middle Paleolithic
Behaviour
Levallois
MIS3
Italy

Mots clés :
Paléolithique moyen
Comportement
Levallois
MIS3
Italie

ABSTRACT

Neanderthals left diverse sets of cultural evidence just before the Middle–Upper Palaeolithic transition in Europe. Within this evidence, the production of lithic implements plays a key role in detecting possible affiliations (or lack thereof) with the techno-complexes that occurred during the few millennia before the large-scale spread of the Proto-Aurignacian. This crucial phase has also been recorded in the North of Italy, where around 44–45 ky cal BP, the last Neanderthals were still using the Levallois knapping technique, in common with the technology adopted at several sites in the central Mediterranean region. A similar picture is seen at the Grotta di Fumane, which provides the evidence presented in this paper. The production technology employed produced different levels of variability with respect to the production of blades, sometimes pointed, and the use of recurrent centripetal flaking at the end of the reduction sequence, in addition to bladelet and Discoidal volumetric structures. This variability does not outweigh the dominant tendency towards the use of elongated Levallois blanks and other by-products for shaping into basic retouched tools such as simple or convergent scrapers and points. A break from this apparently well-rooted use of the unipolar Levallois method is recorded in the Uluzzian where, instead, flakes and cores were made using the centripetal modality.

RÉSUMÉ

Les Néanderthaliens ont laissé diverses séries de preuves de culture, juste avant la transition Paléolithique moyen–Paléolithique supérieur en Europe. Parmi ces preuves, la production d'objets lithiques joue un rôle clé dans la détection d'affiliations possibles (ou d'absence d'affiliation) avec les techno-complexes trouvés durant les quelques millénaires avant l'expansion à grande échelle du Proto-Aurignacien. La phase cruciale a été enregistrée au Nord de l'Italie où, aux alentours de 44–45 ka cal BP, les derniers Néanderthaliens utilisaient encore la technique de débitage Levallois, en même temps que la technique adoptée sur différents sites de la région méditerranéenne centrale, en particulier à la Grotta di Fumane, qui fournit la preuve présentée dans cet article. La technique de production utilisée a pour conséquence différents niveaux de variabilité en ce qui concerne la production de lames quelquefois pointues et l'usage d'un écaillage centripète récurrent à la fin de la séquence de réduction, outre les structures volumétriques Discoïdes et lamellaires. Cette variabilité ne l'emporte pas sur la tendance à l'utilisation d'ébauches de taille Levallois allongées et autres

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http://dx.doi.org/10.1016/j.crpv.2013.02.005

sous-produits pour fabriquer des objets retouchés, tels que grattoirs et pointes simples ou convergents. Une interruption de cet usage, apparemment bien rodé, de la méthode unipolaire Levallois est enregistrée dans l'Uluzzien, où des éclats et nucléus ont été confectionnés en utilisant la modalité centripète, à la place de la précédente.

1. Foreword

Research on human behaviour around the Middle–Upper Palaeolithic transition in Europe involves several different scientific domains, each of which provides, at various levels, its contribution in detecting the bio-cultural distance between Neanderthals and Anatomically Modern Humans (Harrold, 2009; Lalueza-Fox et al., 2011; Van Andel and Davies, 2003). Within these fields, a first-order role in the investigation of cognition, skill, handedness and economic strategies in terms of landscape ecology is performed by the study of lithic tool design and the organization of lithic tool production (Bird and O'Connell, 2006; Kuhn, 1994; Uomini, 2011). Across the interval considered, the examination of lithic techno-complexes has permitted us to discover substantial differences between the final Mousterian period, the transitional complexes and the full affirmation of the Aurignacian period.

As in other European regions, the MP–UP transition was a multi-faceted period in the Italian peninsula, where substantial change occurred across many aspects of human behaviour and material culture (Boscato and Crezzini, 2012; Broglio and Gurioli, 2004; D'Errico et al., 2012; Kuhn and Bietti, 2000; Mussi, 2001; Peresani, 2011; Ronchitelli et al., 2009). This has encouraged dispute, even if not strongly supported by data, over the presumed taxonomic coherence or lack thereof of some techno-complexes (Bietti and Negrino, 2007; Gioia, 1990; Riel-Salvatore, 2009), and over enhancing models of mobility and settlement dynamics (Riel-Salvatore and Barton, 2004). The recent attribution of the Uluzzian techno-complex to the first spread of AMH (Benazzi et al., 2011) seems to indicate an earlier replacement of Neanderthals by AMH (Moroni et al., in press). This, in turn, leads to new implications in the comparison of cognition and behaviour between the two species. Our attention should then be focused on the last behavioural expressions of the autochthonous population. The comparison between such expressions assumes a greater importance in cases where the temporal distance is short.

In North-East Italy, some known sequences (Grotta di Fumane, Riparo Tagliente, Grotta di San Bernardino, Riparo del Broion, Grotta del Rio Secco) might permit this kind of evaluation, but the lack of chronometric data or the scarcity of artefacts could be an obstacle to their eventual value in addressing the issue. One case of a short time horizon occurs at Grotta di Fumane, where the presence of a finely stratified sequence comprising a recently-analysed group of layers, A5, A5+A6, A6 (to be referred to as A5–A6 from here forwards), offers ample evidence of Neanderthal technical expressions, so much so as to become the object of the present study. This cave, on the southern fringe of the Venetian Pre-Alps, has been systematically excavated since 1988 and owes its importance to the 12 m thick Late Pleistocene stratigraphic sequence (Martini et al., 2001) which includes the MP–UP transition spanning the final Mousterian, the Uluzzian and the Aurignacian periods (Broglio et al., 2005, 2009; Higham et al., 2009; Peresani, 2008; Peresani et al., 2008, 2011).

2. The A5–A6 complex and its cultural content

The stratigraphic complex of the layers A5–A6 covers 58 m^2 at the cave entrance and has been excavated in many different sectors since 1988 and more extensively from 2006 to 2008. It is sandwiched between the Uluzzian layer A4 above and the sterile layer A7 below. This finely layered sedimentary succession made of frost-shattered breccia, Aeolian silt and sands is markedly different in the density and number of anthropogenic signatures (bones, with signs of anthropic modification, hearths, flint flakes) as a consequence of changes in settlement dynamics. A thin, flat charcoal layer (A5) overlies a loose stony layer with loamy fine fraction (A5+A6). Below, a dark layer (A6) is recognizable over the whole excavated zone, with constant dense indications of anthropogenic activity. Combustion structures are plentiful in A6 and there are a smaller number in A5 and A5+A6 (Peresani et al., 2011). The chronometric refinement offered by the ^{14}C data puts A5 at 43.6–43.2 ky BP and the boundary with the Uluzzian layer A4 above at 43.6–43.0 ky BP (Higham et al., 2009). Red-deer, ungulate and some carnivore bones all bear signs of cultural modification (Peresani et al., 2011).

The lithic industries yielded groups of flint flaked artefacts, with highest frequency in A6 and lowest in A5, with a total of around 6,000 with a module (length + breadth) ≥ 4 cm. Several flint types were exploited, albeit with varying frequency. At a first glance at their texture, structure, colour and the morphology of the exterior surface, the flints were obtained from the Late Jurassic to Middle Eocene carbonatic formations in the western Lessini Mountains. Maiolica and Scaglia Rossa (Cretaceous) have the highest frequencies, but high frequencies are also shown by the Tertiary carbonatic sandstones, Scaglia Variegata (Cretaceous) and its varieties, while there are lower frequencies from oolitic limestone (Jurassic) and other formations of Tertiary age. These lithic assemblages show the variety of raw materials exploited in this region, where provisioning may have occurred at a range of 5–10 km from the site. Flint is also contained in loose coarse stream or fluvial gravels, slope-waste deposits, and soils: for this reason, they became a major resource to be exploited close to the cave. There was also very occasional exploitation of old patinated artefacts collected as potential cores from elsewhere. Indeed, flaking was

Table 1
General count of samples, with Levallois end-products and by-product (see Table 2 for expanded list), bladelets, Discoid flakes and Pseudo-Levallois points, other flakes (Kombewa-type flakes, pieces indeterminable due to invasive retouching), indeterminable fragmentary flakes, indeterminable proximal fragments of flake, Levallois, bladelet and other types of cores, indeterminable fragmentary cores. Note that A5 count includes pieces from layer A5+A6 (see explanation in the text).
Tableau 1
Décompte général de l'échantillon : produits finis et sous-produits Levallois (voir Tableau 2 pour une liste exhaustive), lamelles, éclats discoïdes et pointes pseudo-Levallois, autres éclats (éclats de type Kombewa, pièces indéterminables en raison de la retouche envahissante), éclats fragmentaires indéterminables, fragments proximaux d'éclat indéterminables, lamelles Levallois et autres types de nucléus, nucléus fragmentaires indéterminables. À noter que les décomptes de l'A5 incluent les pièces du niveau A5+A6 (cf. explication dans le texte).

	A5		A6	
	n	%	*n*	%
Flakes				
Levallois end-product	101	14.0	132	14.5
Levallois by-product	310	42.8	375	41.0
Bladelet	9	1.2	8	0.9
Discoid flake	7	1.0	10	1.1
Other flake	33	4.6	39	4.3
Indeterminable fragmentary flakes	194	26.8	248	27.1
Indeterminable proximal fragments of flake	53	7.3	65	7.1
Cores				
Levallois	6	0.8	18	2.0
Bladelet	1	0.1	2	0.2
Discoid	1	0.1	4	0.4
Other	7	1.0	8	0.9
Indeterminable fragmentary cores	2	0.3	5	0.5
Total	724	100.0	914	100.0

performed on every type of raw material, regardless of its mechanical properties or the manner in which the flint was introduced into the production-manufacture system.

3. Materials and methods

The artefacts analyzed in the present study amount to a total of 1629 with a module ≥ 4 cm (Table 1). Given to the quantity of lithics recovered during recent fieldwork, this number can be considered a reliable representative sample of such population (Centi, 2008–2009; Di Taranto, 2009–2010). Studies in progress on the rest of the assemblage confirm the technological variability identified at this first step. They show fresh surfaces over all faces and retouched edges, although natural modifications ranging from the marginal to the invasive of the unmodified and retouched edges affect 6–8% of the total assemblage. The spatial distribution of these alterations, based on the degree of edge modification, becomes denser progressively towards the inner cave.

To reconstruct the reduction sequences, morpho-technical and morpho-metric analyses were carried out on the cores and the completed blanks, which are the most significant by-products (in terms of their technological role), as well as some refitted pieces. As concerns the Levallois method, the conceptual and analytical approaches of the present study have been inspired by the work of E. Boëda (1994) and have also taken in consideration broader criteria for defining Levallois predetermined products (Grimaldi, 1996; Guette, 2002), previously used in the context of this region (Peresani, 2001, 2012). Technological descriptions of both major and minor lithic production sequences and the key typological features of retouched blanks are given below.

Table 2
Tabulation of Levallois by-products, end-products and cores. Note that A5 count includes pieces from layer A5+A6 (see explanation in the text).
Tableau 2
Tableau des sous-produits, produits finis et nucléus Levallois. À noter que les décomptes en A5 incluent les pièces du niveau A5+A6 (cf. explication dans le texte).

Levallois products	A5		A6	
	n	%	*n*	%
By-products				
Cortical flake	116	27.8	121	23.3
Platform renewal	36	8.6	49	9.5
Predetermining flake	114	27.4	144	27.8
Core repairing	17	4.1	13	2.5
Flaking accident	27	6.5	48	9.3
End-products				
Unipolar	64	15.4	78	15.0
Centripetal	24	5.8	40	7.7
Indeterminable	9	2.2	9	1.7
Cores				
Unipolar	1	0.2	4	0.8
Centripetal	2	0.5	3	0.6
Other[a]	4	1.0	5	1.0
Indeterminable fragmentary cores	2	0.5	4	0.8
Total	416	100.0	518	100.0

[a] Levallois cores with orthogonal pattern, cores-on-flake, cores with double flaked face.

4. Blades and flakes: Levallois production

Almost all stages of the Levallois reduction sequence are represented here by the flakes which are mostly the results of the initial shaping of the cores, and the maintenance and re-preparation of Levallois cores (predetermining flakes, core-edge removal flakes, platform renewal, core repairing), designed to eliminate imperfections and accidents (Table 2). Cortical flakes are fairly flat and elongated, resulting from the exploitation of cobbles using the unipolar modality, following parallel planes. Over 200 Levallois end-products reflect the technical aims that were envisaged at initial reduction, and pursued throughout the whole process of exploitation, and also provide good evidence for recognizing options and ways of predetermining shape and size.

Levallois production concerns a main reduction sequence managed through the unipolar recurrent method, but also involves branching out and other levels of variability: one example is the modification to exploit cortical flake-cores and a second case is the procedure to change from unipolar to centripetal towards the final phase of core exploitation. In addition, technological variants and various predetermining devices have been identified within a given modality.

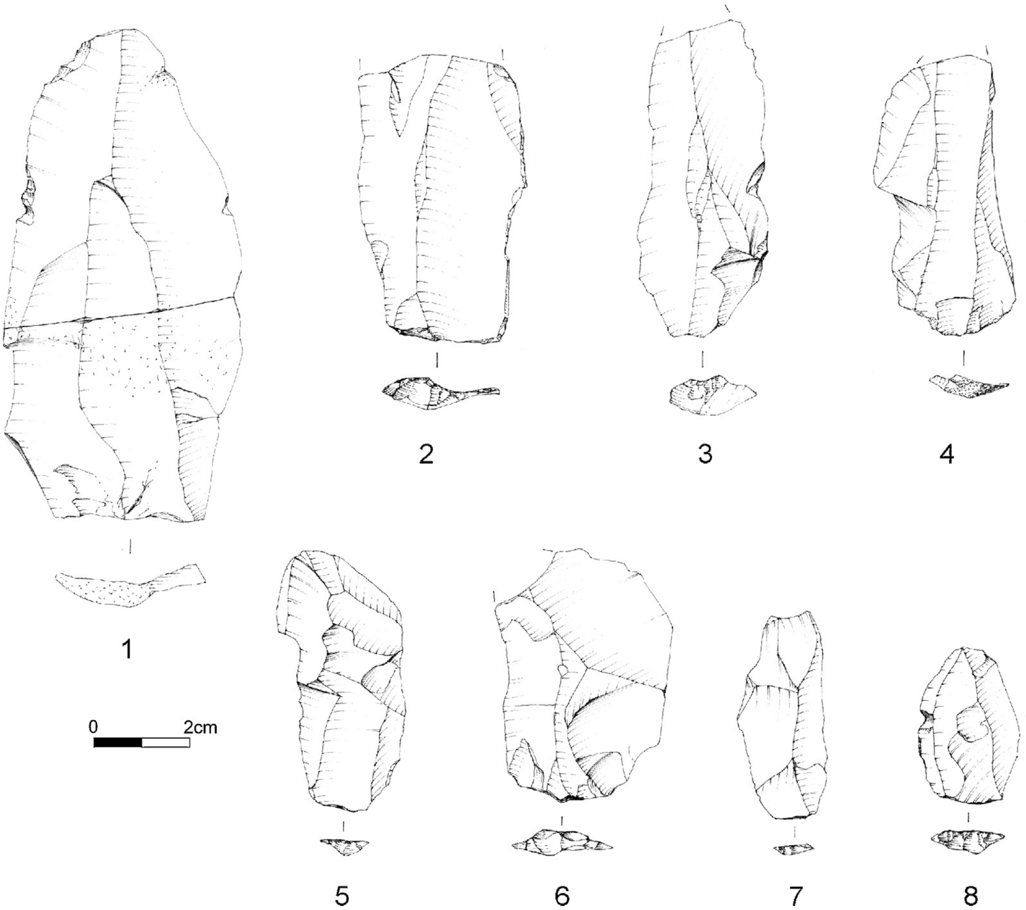

Fig. 1. Levallois blades from layers A5 (3, 4), A5+A6 (7), A6 (1, 2, 5, 6, 8). Pieces 5 and 6 show traces of serial detachments with angled orientation with respect to the former flake axis.

Fig. 1. Lames Levallois provenant des niveaux A5 (3, 4), A5+A6 (7), A6 (1, 2, 5, 6, 8). Les pièces 5 et 6 portent des traces d'enlèvements en série, avec une orientation différente par rapport à l'axe antérieur de l'éclat.

Drawings S. Muratori.

4.1. Blade making: unipolar flaking and variants

Artefacts ascribed to this aim are the most numerous and record all the steps of the reduction sequence through to the final discarding of the cores.

4.1.1. Initial stage

Due to the lack of unknapped or semi-worked cobbles and of cores discarded during the initial stage of exploitation, this operational stage has been reconstructed from the examination of numerous cortical flakes. Most of the complete or partly complete flakes longer than 4 cm are covered with cortex from 20% to 100%, or have lateral cortex. Butts are mostly plain or naturally flat, although faceted, dihedral and punctiform types increase more and more as cortex reduces. The features of these blanks show that their natural dorsal faces are from regularly convex nodules or flat fractured surfaces that are arranged in a regular morphology, sometimes refined by detaching a natural abrupt side parallel to the flaking axis. In addition, they are much longer than wide, giving a markedly elongated blank-shape. Moreover, these first flakes are provided with thin, long and regular edges.

From these features, it is possible to infer which criteria led to the selection of the raw materials: nodules showing exterior convexities and plaquettes and blocks with exterior fractures arranged to shape lateral and distal convexities that suited the requirements of predetermination. From the outset, production started from a plain, rather than faceted or dihedral platform, and was executed so as to exploit the natural convexities or the deliberately shaped form of the block after the removal of the longest ridges. A different device involved detaching flakes obliquely or perpendicularly to the main axis of the blank.

4.1.2. Main production and predetermination

Following the preceding phase, the end-products demonstrate that this mode of exploitation was used to optimize the core volume until the unipolar modality was replaced or stopped. Once this was done, allowing the avoidance of complex and expensive decortication and shaping of the peripheral convexities, the basic rules of

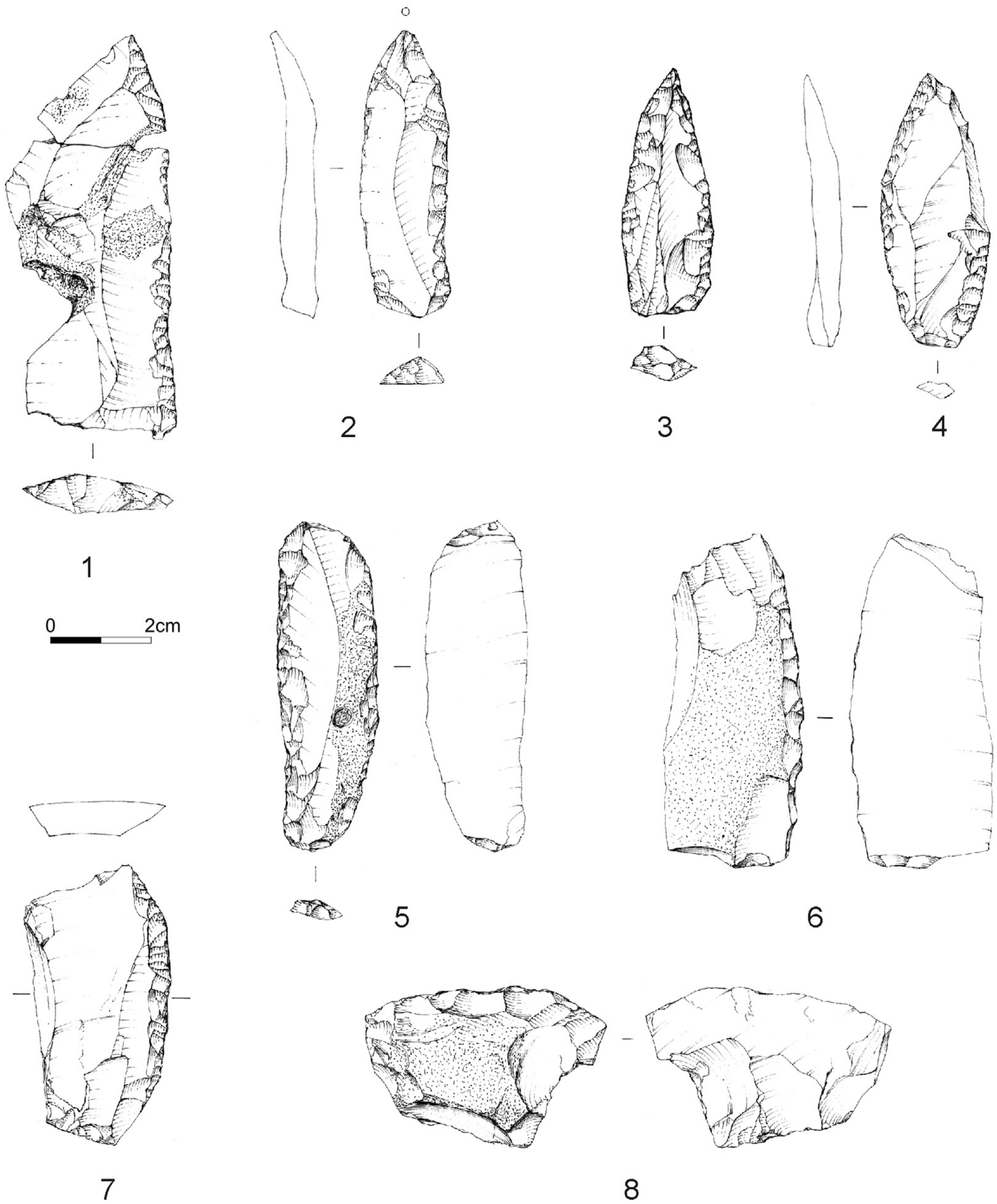

Fig. 2. Tools on Levallois blades and on flakes from layers A5 (2, 3), A5+A6 (1, 5), A6 (4, 6–8): side-scrapers (1, 7), side-scapers on bi-truncated cortical blade (5, 6), points (2–4); transverse scraper on thinned cortical flake (8).

Fig. 2. Outils sur lames et éclats Levallois, issus des couches A5 (2, 3), A5+A6 (1, 5), A6 (4, 6–8) : racloirs latéraux (1, 7), racloirs latéraux sur lame corticale bitronquée (5, 6), pointes (2, 4) ; racloir transversal sur éclat cortical aminci (8)

Drawings S. Muratori.

Levallois predetermination were followed, although the need for skills in core maintenance were reduced to a minimum.

Overall, the method involved production of short recurrent series of elongated and pointed blanks (Figs. 1 and 2) struck from a single striking platform and rarely from a second opposed one, which in most cases was faceted or kept flat. Detachments were arranged to the right or left, in direct or alternate sequence with the first struck across the centre of the core surface. Lateral convexities were reshaped by core-edge removal flakes, Levallois core-edge removal flakes or a series of angled unipolar blades detached from an expanded striking platform. This platform was adjoined to that used in the first series, so that their ridges converged. Therefore, the sequence of production produced two groups of scars on the core surface, which partially overlapped each other towards the distal end to shape one of two lateral convexities. In contrast, the distal convexity was shaped by a combination of scars with driving-ridges, but also by detaching one flake or a

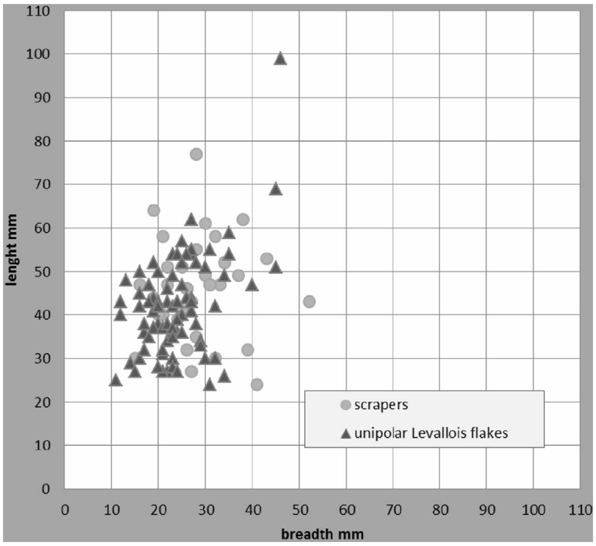

Fig. 3. Size values of unipolar Levallois blades and simple + double scrapers.

Fig. 3. Valeurs dimensionnelles des lames unipolaires Levallois et des racloirs latéraux et bilatéraux.

series of sharp, moderately invasive flakes in an opposed or oblique direction to the Levallois flaking axis, or by using the warped surface from plunged core-edge removal flakes. Therefore, predetermination only required minor actions such as detaching a few predetermining flakes, which economised on raw material in the maintenance of the convexities. Other preparatory actions may have affected the proximal zone of the flaking surface when problematic irregularities were removed or the ergonomic outline of the planned Levallois blank was improved. These blades mostly range between 24 and 70 mm in length with a maximum of 99 mm (av. 42.1 mm) and from 11 to 46 mm in breadth (av. 24.0 mm), but most of the breadth values fall between 15 and 29 mm (Fig. 3). The elongation index is 2.1, as calculated for a total of 45 blades greater than 4 mm in length.

The scarcity of Levallois flakes, core-edge removal flakes and other artefacts perpendicular or opposed to the flaking axis, suggests that the creation of new striking platforms on core zones not adjoined to the main platform was rare. In such cases, the production of a series of short, unipolar, stocky flakes – alternating with some core maintenance – was made possible through the detachment of core-edge removal flakes from the opposed platform or the lateral sides at 90° from the platform used for the last predetermined removal. Maintenance of convexities was reduced to a minimum and mainly achieved through the role played by core-edge removal flakes.

4.2. *Flake making: centripetal flaking*

This method was only used towards the end of unipolar reduction sequences. Among the reasons worth considering for this change are:

- core reduction. The progressive reduction that the unipolar core underwent led to either a restriction in the size of end-products or a compromise in their morpho-technical features, especially their edges and size ratios;
- unipolar variation. The flake axis switching from unipolar to orthogonal made the core assume outlines close to centripetal;
- flaking accidents. Among the flakes struck for removing hinged scars it is possible to note that orthogonal and multidirectional patterns clearly prevailed over other forms. The axis of the repairing flake crossed at a variable angle the axis of the hinged scar, sometimes sub-parallel to the lip, but more obliquely after a new platform was adopted or an adjoined platform enlarged.

Thin centripetal flakes display a polygonal or fan-like outline when the core-edge was partially removed. Detachment occurs clockwise or cross-crossed and core volumes were poorly maintained. The same holds for the convexities, whose maintenance was extremely limited and sometimes occurred between two end-products or as a short series of flakes. Nevertheless, the combination of core-edge removals with centripetal flakes was seemingly uninterrupted and led to high number of blanks per core, but a low degree of metric and morpho-technical standardization for functional edges. Flakes are small, not exceeding 40 mm in length.

From the reconstruction of the core operational schemes and examination of these flakes, it has been possible to infer that platforms were carefully prepared, and extended around almost the whole perimeter. Production stopped as a result of the volume reduction as much as the usual flaking accidents such as hinging or plunging. None of the cores were discarded due to incipient fractures, voids or other elements that would reveal poorly selected raw material.

4.3. *Levallois flakes from flake-cores*

Numerous flakes were produced from the exploitation of by-products. The procedure required the removal of the bulb by means of a single lateral blow or the shaping of the peripheral region to facilitate uni- or bi-polar exploitation. In this latter case, the predetermination, as shown by fairly complex operational schemes, was systematic with one or more scars being adjacent to the original bulb and the driving ridge between them. This morpho-technical layout, completed by the trimming of the core-flake platform, shares similar technical criteria with the Levallois concept (Dauvois, 1981). Exploiting a plane parallel to that which divides the dorsal and ventral core-flake faces allowed the extraction of thin, invasive blanks.

5. Bladelets from laminar volumetric concept

The assemblage also contains evidence of bladelet production, through the exploitation of cortical ridges, as demonstrated by two refitted pieces (Fig. 4), and of four bladelet cores-on-flake.

A core (fig. 4 n. 6) was exploited on the dorsal face of a large, possibly laminar, flake. At least ten bladelet

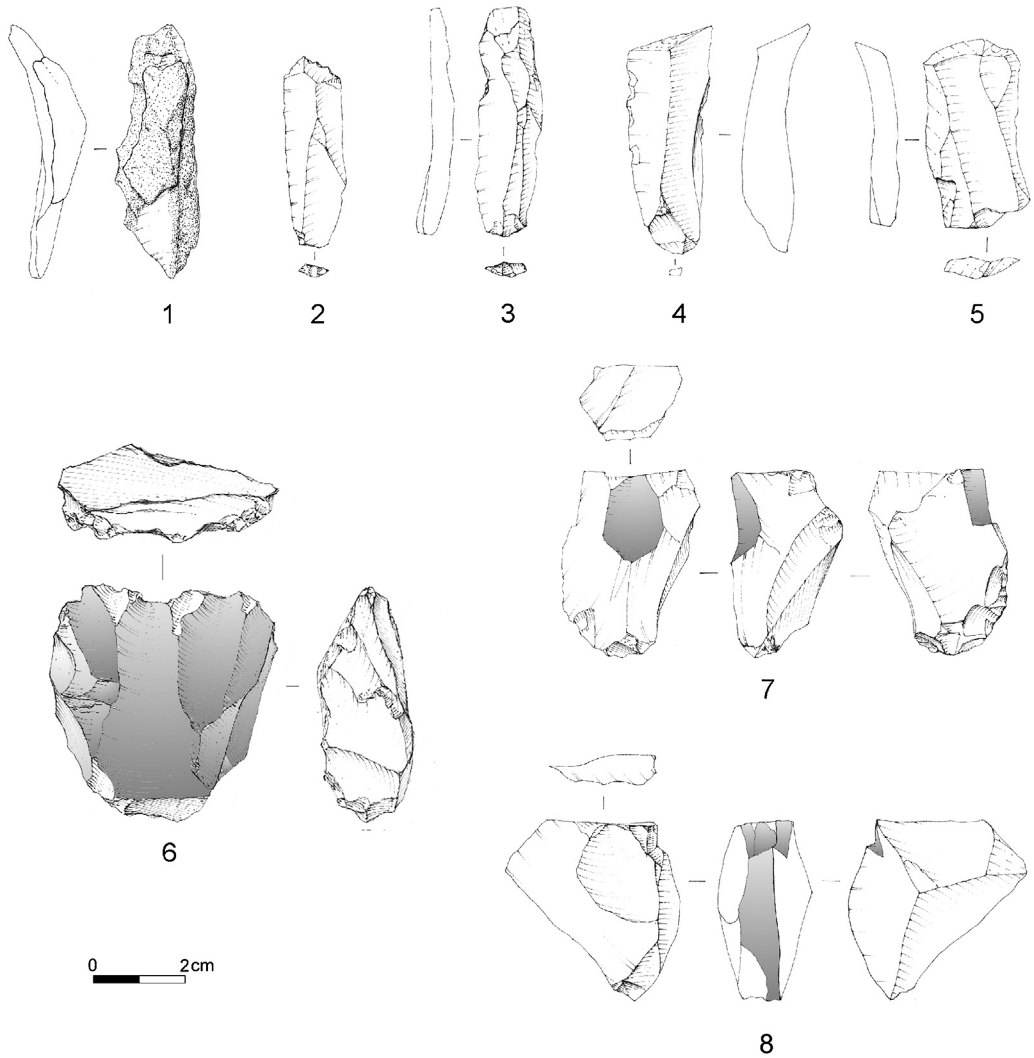

Fig. 4. Bladelet production: refitted cortical bladelets (1), primary products (2–3), lateral bladelet (4), large bladelet (5), cores-on-flake (6–8).

Fig. 4. Production lamellaire : lamelles corticales remontées (1), produits de première qualité (2–3), lamelle de flanc (4), lamelle large (5), nucléus sur éclat (6–8).

Drawings S. Muratori 1–5, 7–8, G. Almerigogna 6.

scars originate from a single striking platform made on a truncation at the middle of the blank. Some of these are overshot, some are hinged and parallel: all testify the frontal reduction of the original volume. The distal parts of several other laminar detachments are visible along the left side and testify to an earlier exploitation of the flake. A few final elements are related to the maintenance of the striking platform.

A second core (fig. 4 n. 7) was exploited on two faces (A and B). The first phase saw the preparation of a striking platform and the initial exploitation (face A) of a partially prepared ridge formed by the intersection of the ventral and dorsal faces of the original flake. The scars of three bladelets are visible: the first runs along the crest and the others hinge at the same height. The next phase saw the rejuvenation of the striking platform by means of two detachments and the production of one further bladelet (also hinged) from a brute ridge adjacent to the earlier one (face B). This ridge has an obtuse angle (about 120°) and is formed by the intersection of the dorsal face and the negative scars of a crest shaped on the back.

A third core (fig. 4 n. 8) has one platform, the creation of which involved the removal of the butt from the original flake. A ridge formed by the intersection of the dorsal and ventral faces was used to remove a bladelet, followed by a series of hinged detachments. The sequence ends with an attempt to widen the flaking face. Tiny flake removals are related to the maintenance of the distal convexity of the core face.

The last core is on a cortical flake that has been shaped into a transverse scraper. The butt was removed to create a striking platform. As in the preceding cases there was also exploitation of an unprepared edge made from the intersection between the ventral and dorsal faces. Here, two bladelets were produced. The core is of similar size to the cases described above.

The bladelets have flat (five), punctiform (four), and faceted (two) butts, with marked bulbs ascribable to direct percussion with a stone hammer. The sagittal profile is straight or slightly convex and its section ranges from triangular to polygonal. Edges show straight and regular outlines and remain unretouched. The elongation index as calculated on eight pieces is 2.8.

6. Flakes from other volumetric concepts

Evidence of discoid production is provided by cores and flakes relating to various stages of the reduction sequence: cortex removal/initial shaping (four), centripetal (seven) or tangential flake removal (core-edge removal flakes and pseudo-Levallois points (six)), change in core orientation (one axial crest flake). Some refitting provides evidence of *in situ* reduction. These flaking products are, for the most part, whole with fresh edges, considerable thickness (average 1.3 cm), quadrangular form and slight elongation. The butts are almost always flat and tilted. The percussion technique was direct with a hard hammer. Two flakes, one cortical and one centripetal, were respectively transformed into a denticulate and a double scraper. The cores are centripetal and heavily reduced: four out of five are below 3.5 cm in length.

The assemblage also contains cores which have been modified to provide a series of edges, used for recurrent production of small multidirectional and bidirectional flakes, alternating between two faces or with a short series from a single face. A hard hammer was used for percussion. The identification of the products from this procedure was difficult due to their rarity and the small size of the flakes.

7. Retouched tool design

Retouched tools are mostly scrapers, while the others are points (four), notches (one), denticulates (seven) and a few retouched flakes. Simple scrapers (49) prevail over double (six), convergent (six) and transverse types (five). Generally, tools have been mainly shaped on Levallois blanks and of these, more on unipolar than centripetal flakes (Table 3). Other blanks are cortical and, incidentally, various by-products arising from the Levallois core exploitation: predetermining, core repairing, platform renewal or flakes from accidents. Finally, the blank type of a very few scrapers and denticulates has not been determined due to the invasiveness of the retouching.

Scrapers have been made from different types of flakes: simple scrapers using cortical flakes, mainly from the initial decortication, and from unipolar recurrent flakes; a small number are recorded on naturally backed predetermining flakes and, occasionally, on various blanks detached in core maintenance, Kombewa-type flakes, but also flakes from accidents. Similar to simple scrapers, cortical and Levallois flakes were mainly used as blanks for convergent and transverse tools. The retouch is simple, moderately invasive, with less marginal or strongly invasive interventions. Four scrapers were thinned on the dorsal or ventral face. Concerning the other tools, it has been shown that Levallois semi-cortical blades and flakes were used for making pointed items; notches and denticulates were made on quite thick, even cortical flakes, but also on recycled broken flakes, discoidal flakes and various by-products; two pieces are thinned on the ventral face; the thinning of unretouched blanks involved cortical, Levallois, Kombewa-type and platform trimming flakes.

Contrary to these trends, the few tools with marginal, partial or discontinuous retouching have been shaped on second choice blanks such as predetermining flakes, occasionally cortical flakes and two recycled pieces.

8. Discussion

The lithic industry found in the A5–A6 complex provides a large data set to allow inferences to be made about the final Levallois assemblage and other types of products. The aim of extracting elongated Levallois convergent blanks with symmetrical and highly functional lateral edges is also highlighted by the incidence of retouching, which is higher among these flakes – and even on those from the initial decortication/production phase – than for others. The use of the unipolar method towards the end of the reduction sequence shows that these technical aims were constantly pursued, in accordance with a procedure that had been well-integrated into the system of production. This might explain why in the course of some sequences there was technical variation, which involved reduction through a series of blows in oblique and, at times, perpendicular directions relative to the former series. The aim of this method was clearly to reduce the impact caused by expensive re-preparations of core convexities. The turning to the centripetal method when the reduction sequence ended, but before core discard, implies minor reshaping of the surfaces to control the volume of the raw material at the same time as extracting more predetermined blanks, despite being less morphologically normalized than unipolar blanks. This production decision was influenced by two factors: the first being a change in the criterion of the main aim of yielding blades, not shorter than a given length. The second relates to optimizing resources by possibly changing production technique because of the qualitative deficiencies of some flint types, thereby reducing the risk of accidents and facilitating re-preparations.

Making a comparison of the Levallois technology between A5–A6 and the chronologically closest layers at Fumane, there is a greater similarity with A11, A10V and A10I: unipolar reduction focuses on blades with more constrained morpho-metric calibres, although differences have been observed. The modality in A11 combines bidirectional and orthogonal patterns until core deactivation, whereas in A5–A6, there is lateral expansion of the trimmed striking platforms for the striking of convergent blade series. Again, in the final step of the reduction sequence this "widened" unipolar pattern is replaced by the centripetal procedure, up to final deactivation (Peresani, 2012).

This Late Mousterian sequence at Fumane broadly fits other evidence in the North Adriatic region where Final Mousterian practice is based on the Levallois recurrent unipolar modality (Peresani, 1996). At the final steps of the

Table 3
Tabulation with number of retouched tools made on cortical flake, Levallois end-products and by-products.
Tableau 3
Tableau reportant le nombre d'outils retouchés obtenus sur éclats corticaux, produits finis et sous-produits Levallois.

	A5				A6			
	Scr.	Marg. r.	Other	Total	Scr.	Marg. r.	Other	Total
Cortical flake > 50%	3		2	5 (11.4)	2			2 (4.0)
Cortical flake < 50%	5		1	6 (13.6)	5	1		6 (12.0)
Platform renewal					1			1 (2.0)
Predetermining flake	3			3 (6.8)	6	1	3	10 (20.0)
Core repairing					1	1		2 (4.0)
Flaking accident					2			2 (4.0)
Lev. unipolar	5	2	2	9 (20.5)	8	1		9 (18.0)
Lev. centripetal	1			1 (2.3)				
Lev. indeterminable	2			2 (4.5)	3			3 (6.0)
Fragment	6	1	3	10 (22.7)	6	2	1	9 (18.0)
Other	7		1	8 (18.2)	3	1	2	6 (12.0)
Total	32	3	9	44	37	7	6	50
%	72.7	6.8	20.5	100.0	74.5	13.7	11.8	100.0

Lev.: Levallois; Scr.: scrapers; Marg. r.: flakes with marginal retouch; "Other" includes points, denticulates, and composite denticulate-scraper tools; "Other" in the row of the flaking products includes flakes different from above and indeterminable blanks due to invasive retouching. Note that A5 count includes pieces from layer A5+A6 (see explanation in the text).

reduction sequence, the unipolar modality may have been replaced by the centripetal to extract the last, small flakes. Tools are scrapers and points largely made from the Levallois blades. Similar situations can be seen across the Italian peninsula, where blades and elongated flakes, flat and with thin converging margins, have been noted at various sites, such as Castelvicita in Campania (Gambassini, 1997) and Riparo l'Oscurusciuto layer 1 (43.8–42.2 ky BP), where the laminar Levallois production seems to be employed in the making of scrapers (Boscato et al., 2011).

Blade and bladelet volumetric production is little represented in respect to the Levallois at Oscurusciuto, but at Grotta del Cavallo, a lamellar industry is noted in the sectors FIII–II, developed through the production of local flint plaquettes (Carmignani, 2010). Other lamellar production evidence has been, at times, identified to date at Riparo Tagliente, where a specific flint type was used in blade production from level 37 upwards (Arzarello and Peretto, 2005); at San Francesco on the Ligurian coast (Bietti and Negrino, 2007); at Grotta Breuil on the Latium Coast; and at Grotta Reali, again in the South of Italy (Peretto, 2012). There is no chronometric evidence for the lithic assemblage found in a single layer at San Francesco, which contains many Upper Palaeolithic tools like truncated and retouched blades made on blades produced by the exploitation of three different types of cores: prismatic, recurrent Levallois and prismatic with lateral crest (Tavoso, 1988). Although the assemblage from the most recent layers at Grotta Breuil shares a group of features with other local Mousterian assemblages, it shows that, there, the laminar flaking method used unipolar cores made from small pebbles with no relation to the appearance of Upper Palaeolithic tools (Rossetti and Zanzi, 1990). At Grotta Reali, the Mousterian sequence yields evidence of blade production in layer 5, based on the recurrent Levallois method (mostly unipolar) and on the detachment of blades/bladelets from prismatic unipolar cores. In the light of this variability, the features and the variety of the retouched tools do not differ from a typical Mousterian profile comprised of scrapers and denticulates. This assemblage dates between 44.5 and 39.4 ky BP (Peretto, 2012), falling in a wide temporal interval which sees the Final Mousterian replaced by the Uluzzian and the Proto-Aurignacian in the South of the Peninsula (Moroni et al., in press). More data are also required to set the chronological position of the assemblage found in the second stratigraphic complex (layers 2abc and 2β/2γ), where blade production comparable to layer 5 is also recorded (Peretto, 2012). The hypothesis claiming cultural persistence at Grotta Reali needs further chronometric confirmation for two reasons: the radiocarbon age of layer 2γ (40.3–37.2 ky BP), which brackets a time range containing the start of the Aurignacian in the South of the Peninsula (at least from 40.4 ky BP) and the lack of Campanian Ignimbrite across the sedimentary succession (Giaccio et al., 2008).

Returning to Fumane, a break with this apparently deep-rooted use of the unipolar Levallois method is recorded in the oldest Uluzzian layer A4 where, rather, flakes and cores were made using the centripetal instead of the unipolar recurrent modality. Levallois blades and laminar flakes are therefore sporadic and polygonal or fan-shaped flakes of variable sizes feature in the lithic assemblage, in addition to other flakes issuing from other poorly curated methods, the incidence of which increases at the top of the Uluzzian sequence. As well as side-scrapers and points, the retouched tools include backed knives, splintered pieces and one end-scraper. There are very few denticulates and marginally retouched points on Levallois flake. The backed knives are on thin flakes, which can also be cortical, with the back either straight or convex. The frequency of splintered pieces in A3 is double that in A4. The shapes vary, as do the thicknesses (Peresani, 2012).

9. Conclusion

During the Final Mousterian, in the North of Italy, the Levallois method continues to enjoy a role of primary importance, although based on the standardization of laminar production with careful control of the technical parameters. Blades spread as a general phenomenon in the Levallois techno-complexes in the Old World and in many cases are associated with Upper Paleolithic formal tools. In fact, the effort devoted to producing elongated flakes/blades appears as a feature that is shared across many European regions in the interval between 50 and 40 ky BP. In southern Caucasus, in Georgia, unipolar Levallois reductions mark levels 10 to 5 dated between 50 and 39 ky BP at the site of Ortvadle Klde (Adler et al., 2006) and produce suitable blanks for making simple or convergent scrapers. In the Crimea the Micoquian was replaced by the western Crimean Mousterian, whose industries are concentrated on laminar products and elongated points, obtained through Levallois and volumetric methods and transformed into simple scrapers or into unifacial foliated points (Chabai, 2000). In the Middle Danube area, a similar discontinuity marks the replacement of Micoquian with the techno-complexes with blades and points like the Bohunician (Škrdla, 2003) and the Bachokirian (Kozłowski, 1979; Teyssandier, 2006), founded on the use of uni- and bipolar Levallois and blade volumetric methods. In the South-East of France, the production of elongated flakes and normed points using the same system was noted in the Neronian, where scholars have identified a pattern of blade/point and another of bladelet/micropoint (Slimak, 2007) that do not find a point of comparison in the context of the classical Middle Paleolithic industries.

Nevertheless, the lack at Fumane of the co-presence of Levallois technology and Upper Paleolithic tools (as seen in this Europe-wide spectrum of industries), clearly marks out the complex A5–A6 and highlights the replacement with Uluzzian technology. This replacement might be considered abrupt, similar to that at the other aforementioned Italian sites, but the complementary use of other methods like the bladelet making seen at Fumane as well as at Grotta del Cavallo and Grotta Reali, seems to record a deviation from the homogeneity typically expressed in the Mousterian Levallois industries of this period.

Acknowledgments

Research at Fumane is carried out by the University of Ferrara as part of a long-term project supported by the Superintendent for Archaeological Heritage of Veneto, the Comunità Montana of Lessinia, the Fumane Municipality, the Venetian Region, the Cariverona Foundation and many other institutional and private supporters. The authors are grateful to Craig Alexander and Nicholas Ashton for improvements made to the English version of the manuscript and to two anonymous reviewers for constructive suggestions.

References

Adler, D., Belfer-Cohen, A., Bar-Yosef, O., 2006. Between a rock and a hard place: Neanderthal – Modern Human interaction in the southern Caucasus. In: Conard, N. (Ed.), When Neanderthals and Modem Humans met, International Workshop. Tübingen Publications in Prehistory, Verlag, Tübingen, pp. 165–187.

Arzarello, M., Peretto, C., 2005. Nouvelles données sur les caractéristiques et révolution techno-économique de l'industrie moustérienne de Riparo Tagliente (Verona, Italie). In: Molines, N., Moncel, M.-H., Monnier, J.-L. (Eds.), Données récentes sur les modalités de peuplement et sur le cadre chronostratigraphique, géologique et paléogéographique des industries du Paléolithique inférieur et moyen en Europe. BAR Interntional Series 1364, Archaeopress, Oxford, pp. 281–289.

Benazzi, S., Douka, K., Fornai, C., Bauer, C.C., Kullmer, O., Svoboda, J., Pap, I., Mallegni, F., Bayle, P., Coquerelle, M., Condemi, S., Ronchitelli, A., Harvati, K., Weber, K.W., 2011. Early dispersal of modem humans in Europe and implications for Neanderthal behaviour. Nature 479, 525–528.

Bietti, A., Negrino, F., 2007. "Transitional" industries from Neandertals to Anatomically Modem Humans in continental Italy: present state of knowledge. In: Riel-Salvatore, J., Clark, G.A. (Eds.), "Transitional" Upper Paleolithic Industries: new questions, new methods. BAR International Series 1620, Archaeopress, Oxford, pp. 41–60.

Bird, D.W., O'Connell, J.F., 2006. Behavioral ecology and archaeology. J. Archaeol. Res. 14, 143–188.

Boëda, E., 1994. Le Concept Levallois : variabilité des méthodes. Monographies Centre Rercherches Archéologiques 9. CNRS, 280 p.

Boscato, P., Crezzini, J., 2012. Middle-Upper Palaeolithic transition in southern Italy: Uluzzian macromammals from Grotta del Cavallo (Apulia). Quat. Int. 252, 90–98.

Boscato, P., Gambassini, P., Ranaldo, F., Ronchitelli, A., 2011. Management of Palaeoenvironmental Resources and Raw materials Exploitation at the Middle Palaeolithic Site of Oscurusciuto (Ginosa, TA, southern Italy): Units 1 and 4. In: Conard, N.J., Richter, J. (Eds.), Neanderthal Lifeways, Subsistence and Technology: One Hundred Fifty Years of Neanderthal Study, Vertebrate Paleobiology and Paleoanthropology. Springer, Berlin/Heidelberg, pp. 87–98.

Broglio, A., Gurioli, F., 2004. Le comportement symbolique des premiers Hommes modernes : les données de la Grotte de Fumane (Pré-Alpes vénitiennes). Actes de Colloque international de Liège. La Spiritualité, U.I.S.P.P., VIII Commission – Paléolithique supérieur, ERAUL 106, pp. 97–102.

Broglio, A., Bertola, S., De Stefani, M., Marini, D., Lemorini, C., Rossetti, P., 2005. La production lamellaire et les armatures lamellaires de l'Aurignacien ancien de la Grotte de Fumane (Monts Lessini, Vénétie). In: Le Brun-Ricalens, F. (Ed.), Productions lamellaires attribuées à l'Aurignacien, Luxembourg. Musée National d'Histoire et d'Art, pp. 415–436.

Broglio, A., De Stefani, M., Gurioli, F., Pallecchi, P., Giachi, G., Higham, Th., Brock, F., 2009. L'art aurignacien dans la décoration de la Grotte de Fumane. Anthropologie 113, 753–761.

Carmignani, L., 2010. L'industria litica del livello FIIIe di Grotta del Cavallo (Nardò, Lecce). Osservazioni su una produzione lamino–lamellare in un contesto del Musteriano finale. Origini XXXII, Nuova Serie 4, 7–26.

Centi, L., 2008–2009. L'ultimo Levallois: tecno-economia della produzione litica e organizzazione spaziale nel complesso A5-A6 (50.000 anni BP) di Grotta di Fumane (Verona). Studio di due varietà selcifere, Thesis of bachelor, Università di Ferrara, Ferrara, 153 p.

Chabai, V.P., 2000. The evolution of the western Crimean Mousterian industry. In: Orschiedt, J., Weniger, G.C. (Eds.), Neanderthals and Modern Humans–Discussing the transition: Central and Eastem Europe from 50,000-30,000 B. P., Wissenschaftliche Schriften des Neanderthal Museums 2. Neanderthal Museum, Mettmann, pp. 196–211.

Dauvois, M., 1981. De la simultanéité des concepts Kombewa et Levallois dans l'Acheuléen du Maghreb et du Sahara nord-occidental. In: Roubet, C., Hugot, H., Souville, G. (Eds.), Préhistoire Africaine. Éditions A.D.P.F, Paris, pp. 313–321.

D'Errico, F., Borgia, V., Ronchitelli, A., 2012. Uluzzian bone technology and its implications for the origin of behavioural modernity. Quat. Int. 259, 59–71.

Di Taranto, E., 2009–2010. L'ultimo Levallois. Tecno-economia e organizzazione spaziale della produzione litica nel complesso A5-A6 (45-44 Ka BP) della Grotta di Fumane (Verona). Studio della Scaglia Rossa, Facoltà di Scienze MM.FF.NN., Master's degree in Prehistoric Science.

Gambassini, P., 1997. Il Paleolitico di Castelcivita. Culture e ambiente. Electa, Napoli, 159 p.

Giaccio, B., Isaia, R., Fedele, F.G., Di Canzio, E., Hoffecker, J., Ronchitelli, A., Sinitsyn, A.A., Anikovich, M., Lisitsyn, S.N., Popov, V.V., 2008. The Campanian Ignimbrite and Codola tephra layers: two temporal/stratigraphic markers for the Early Upper Palaeolithic in southern Italy and eastern Europe. J. Volcanol. Geothermal Res. 177, 208–226.

Gioia, P., 1990. An aspect of the transition between Middle and Upper Palaeolithic in Italy: the Uluzzian. In: Farizy, C. (Ed.), Paléolithique moyen récent et Paléolithique supérieur ancien en Europe. Mémoires Musée Préhistoire Île-de-France 3, Musée de Préhistoire, Nemours, pp. 241–245.

Grimaldi, S., 1996. Mousterian reduction sequences in central Italy. In: Bietti, A., Grimaldi, S. (Eds.), Reduction Processes (chaînes opératoires) in the European Mousterian, 4. Quaternaria Nova, pp. 279–310.

Guette, C., 2002. Révision critique du concept de débitage Levallois à travers l'étude du gisement moustérien de Saint-Vaast-la-Hougue/le Fort (chantiers I-III et II, niveaux inférieurs) (Manche, Franche). Bull. Soc. Prehist. Fr. 99 (2), 237–248.

Harrold, F.B., 2009. Historical Perspectives on the European Transition from Middle to Upper Paleolithic. In: Camps, M., Chauhan, P.R. (Eds.), Sourcebook of Paleolithic transitions: methods, theories and interpretations. Springer, New York, pp. 283–299.

Higham, T., Brock, F., Peresani, M., Broglio, A., Wood, R., Douka, K., 2009. Problems with radiocarbon dating the Middle to Upper Palaeolthic transition in Italy. Quat. Sci. Rev. 28, 1257–1267.

Kozłowski, J.K., 1979. Le Bachokiri : la plus ancienne industrie du Paléolithique supérieur en Europe. Quelques remarques à propos de la position stratigraphique et taxonomique des outillages de la couche 11 de la grotte Bacho Kiro. Prace Archeologiczne 28, 77–99.

Lalueza-Fox, C., Thomas, M., Gilbert, P., 2011. Paleogenomics of archaic hominins. Curr. Biol. 21, 1002–1009.

Kuhn, S.L., 1994. A formal approach to the design and assembly of mobile toolkits. Am. Antiquity 59 (3), 426–442.

Kuhn, S.L., Bietti, A., 2000. The late Middle and early Upper Paleolithic in Italy. In: Bar-Yosef, O., Pilbeam, D. (Eds.), The Geography of Neandertals and Modern Humans in Europe and the Greater Mediterranean, Peabody Museum Bullettin 8. Peabody Museum Press, Cambridge MA, pp. 49–72.

Martini, M., Sibilia, M., Croci, S., Cremaschi, M., 2001. Thermoluminescence (TL) dating of burnt flints: problems, perspectives and some examples of application. J. Cult. Herit. 2, 179–190.

Moroni, A., Boscato, P., Ronchitelli, A., in press. What roots for the Uluzzian? Modern behaviour in central-southern Italy and hypotheses on AMH dispersal routes, http://dx.doi.org/10.1016/j.quaint.2012.10.051. Quat. Int.

Mussi, M., 2001. Earliest Italy. An overview of the Italian Paleolithic and Mesolithic. Kluwer, New York, 399 p.

Peresani, M., 1996. The Levallois reduction strategy at the Cave of San Bernardino (Northern Italy). In: Bietti, A., Grimaldi, S. (Eds.), Reduction Processes (chaînes opératoires) in the European Mousterian, 5. Quaternaria Nova, pp. 205–236.

Peresani, M., 2001. Méthodes, objectifs et flexibilité d'un système de production Levallois dans le Nord de l'Italie. Anthropologie 105, 351–368.

Peresani, M., 2008. A new cultural frontier for the last Neanderthals: the Uluzzian in northern Italy. Curr. Anthropol. 49 (4), 725–731.

Peresani, M., 2011. The end of the Middle Palaeolithic in the Italian Alps. An overview on Neandertal land-use, subsistence and technology. In: Conard, N.J., Richter, J. (Eds.), Neanderthal Lifeways, Subsistence and Technology: One Hundred Fifty Years of Neanderthal Study, Vertebrate Paleobiology and Paleoanthropology. Springer, Berlin/Heidelberg, pp. 249–259.

Peresani, M., 2012. Fifty thousand years of flint knapping and tool shaping across the Mousterian and Uluzzian sequence of Fumane Cave. Quat. Int. 247, 125–150.

Peresani, M., Cremaschi, M., Ferraro, F., Falguères, C., Bahain, J., Gruppioni, G., Sibilia, E., Quarta, G., Calcagnile, L., Dolo, J.-M., 2008. Age of the final Middle Paleolithic and Uluzzian levels at Fumane Cave, northern Italy using ^{14}C, ESR, $^{230}Th/^{238}U$, and thermoluminescence methods. J. Arch. Sci. 35, 2986–2996.

Peresani, M., Chravzez, J., Danti, A., De March, M., Duches, R., Gurioli, F., Muratori, S., Romandini, M., Tagliacozzo, A., Trombino, L., 2011. Fire-places, frequentations and the environmental setting of the final Mousterian at Fumane Cave: a report from the 2006–2008 research. Quartär 58, 131–151.

Peretto, C. (Ed.), 2012. L'insediamento musteriano di Grotta Reali. Rocchetta a Volturno, Molise, Italia, Museologia Scientifica e Naturalistica,. Annali Università Ferrara 8/2, 164 p.

Riel-Salvatore, J., 2009. What is a Transitional industry? The Uluzzian of southern Italy as a case study. In: Camps, M., Chauhan, P.R. (Eds.), Sourcebook of Paleolithic transitions: methods, theories and interpretations. Springer, New York, pp. 377–396.

Riel-Salvatore, J., Barton, C.M., 2004. Late Pleistocene technology, economic behavior and land-use dynamics in southern Italy. Am. Antiquity 69, 257–274.

Ronchitelli, A., Boscato, P., Gambassini, P., 2009. Gli ultimi neandertaliani in Italia: aspetti culturali. In: Facchini, F., Belcastro, G.M. (Eds.), La lunga storia di Neandertal. Biologia e comportamento. Jaca Book, Milano, pp. 227–257.

Rossetti, P., Zanzi, G., 1990. Technological approach to reduction sequences of the lithic industry from Grotta Breuil. In: Bietti, A., Manzi, G. (Eds.), The fossil man of Monte Circeo. Fifty years of studies on the Neandertals in Latium, 1. Quaternaria Nova, pp. 351–365.

Škrdla, P., 2003. Bohunician technology: a refitting approach. In: Svoboda, J., BarYosef, O. (Eds.), Strànskà Skàla: Origins of the Upper Paleolithic in the Brno Basin, American School of Prehistoric Research Bulletin 47, Dolni Véstonice Studies 10. Peabody Museum Press, Cambridge MA, pp. 19–151.

Slimak, L., 2007. Le Néronien et la structure historique du basculement du Paléolithique moyen au Paléolithique supérieur en France méditerranéenne. C.R. Palevol 6, 301–309.

Uomini, N.T., 2011. Handedness in Neanderthals. In: Conard, N.J., Richter, J. (Eds.), Neanderthal lifeways, subsistence and technology. One hundred fifty years of Neanderthal Study, Vertebrate Paleobiology and Paleoanthropology Series. Springer, Berlin, Heidelberg, pp. 139–156.

Tavoso, A., 1988. L'outillage du gisement de San Francesco a San Remo (Ligurie, Italie) : nouvel examen. In: Kozłowski, J.K. (Ed.), L'Homme de Néandertal 8. La Mutation. ERAUL 36, Liège, pp. 193–210.

Teyssandier, N., 2006. Questioning the First Aurignacian: mono- or multi-cultural phenomenon during the formation of the Upper Paleolithic in central Europe and the Balkans. Anthropologie 44 (1), 9–29.

Van Andel, T.H., Davies, W., 2003. Neanderthals and modem humans in the European landscape during the last glaciation: archaeological results of the Stage 3 Project. McDonald Institute for Archaeological Research monographs, Cambridge, 265 p.