
Between the flake and the blade: Associated systems of production at Riparo Tagliente (Veneto, northern Italy)

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Abstract:

The Riparo Tagliente site (Verona, Italy) shows three macro phases in which high technological variability can be observed. The aim of this study is to evaluate the specific role of the Middle Paleolithic blade production within this variability. Preliminary results show a complex scenario in which the role of the blade is strictly linked with flake production through mixed reduction systems.

Two different approaches were used for analysing the lithic assemblages from the site. The first analysis focused on the identification of the reduction systems by determining the techniques, methods and concepts underlying the entire *chaîne opératoire*. The second approach concentrated on analysing blade production in order to identify its variability.

Evidence of blade technology from the Middle Pleistocene (MIS 8-6) has been found in northern Europe (France, Belgium). Later, during MIS 5 blades can be found over a larger area, this time also including north-western Germany and the central-southern part of France. A third period (MIS 4-3) marks the appearance of laminar production in southern Europe, including in the Italian peninsula. Based on the present state of research these three phases appear to be on-and-off events without clear evolutionary continuity.

By repositioning the sequence of Riparo Tagliente within the Italian context we can observe that at the end of the Mousterian period the technological patterns differ greatly, with laminar production being one of its most evident expressions. The origin of this fragmentation is questionable.

Keywords: blades; Riparo Tagliente; Middle Paleolithic; Levallois; reduction systems



1. Introduction

By simplifying what is produced through lithic production, we can identify three possible categories of products: flakes and blades, both produced by knapping operations (*débitage*), and shaped tools (hand axes, choppers), the result of shaping operations (*façonnage*). If shaping operations involve a conceptual modelling structure of a block of raw material, the dichotomy flake-blade is, at the macroscopic scale, a double variant of the same theme, which entails the separation of a piece from its original volume. The Middle Paleolithic marks the emergence and development of a variety of knapping methods aimed at producing predetermined blanks within which the blade occupies a not-yet defined role.

This paper addresses the issue of the technological complexity that characterizes Middle Paleolithic reduction systems and investigates the role of elongated products within the Neanderthal techno-cultural baggage. In addition to Levallois production, the sequence of Riparo Tagliente shows the use of various reduction systems aimed at obtaining a mixture of flake and blade blanks. Because of this a comparison of the morpho-technical characteristics of Levallois and non-Levallois elongated products was carried out.

1.1. The blade phenomenon in the Middle Paleolithic

From a global point of view, blade production dates back to the Middle Pleistocene. The first evidence of blade production was found in Africa at two sites, Kathu Pan (Wilkins & Chazan 2012) and Kapturin (Johnson & McBrearty 2010), both approximately 500,000 years old (Figure 1).

The Amudian complex in the Middle East is the second oldest evidence of blade production and dates back to MIS 9 and MIS 8 (Mercier & Valladas 2003; Barkai *et al.* 2005).

Subsequently, in a second phase (MIS 7-6), the expansion and differentiation of blade production over a larger area took place, which included the internal part of Syria and the southern area of the Caucasus. This second phase gave rise to several other lithic industries known by various names: the Hummalian (Le Tensorer 2005; Richter *et al.* 2011), Pre-Aurignacian (Bordes 1977), Hayonim (Meignen 2011), and Djrchula-Koudaro industries (Meignen & Tushabramishvili 2006; 2010).

The third and final phase is that of the well-known case of the northern European blade production observed at several sites dating back to MIS 8 and MIS 7 (Révillion 1995).

By contrast, there is no evidence of blade tool production in Asia, at least during the Middle Pleistocene (Boëda *et al.* 2013; Li & Bodin 2013; Peng *et al.* 2014). The easternmost assemblages containing volumetric blade technology have been documented at Khonako in Tadjikistan and date back to around 170 ka (Schäfer & Ranov 1998; Schäfer *et al.* 1998; 2003).

All of these industries have in common the presence of blades, but differ strongly in the rest of their productions (Meignen 1994; 2007).

In short, during the Middle Pleistocene at least three blade production epicentres differentiated in space and time can be observed. As far as we know these spatial, chronological and technological differences suggest a convergence phenomenon (Figure 1).

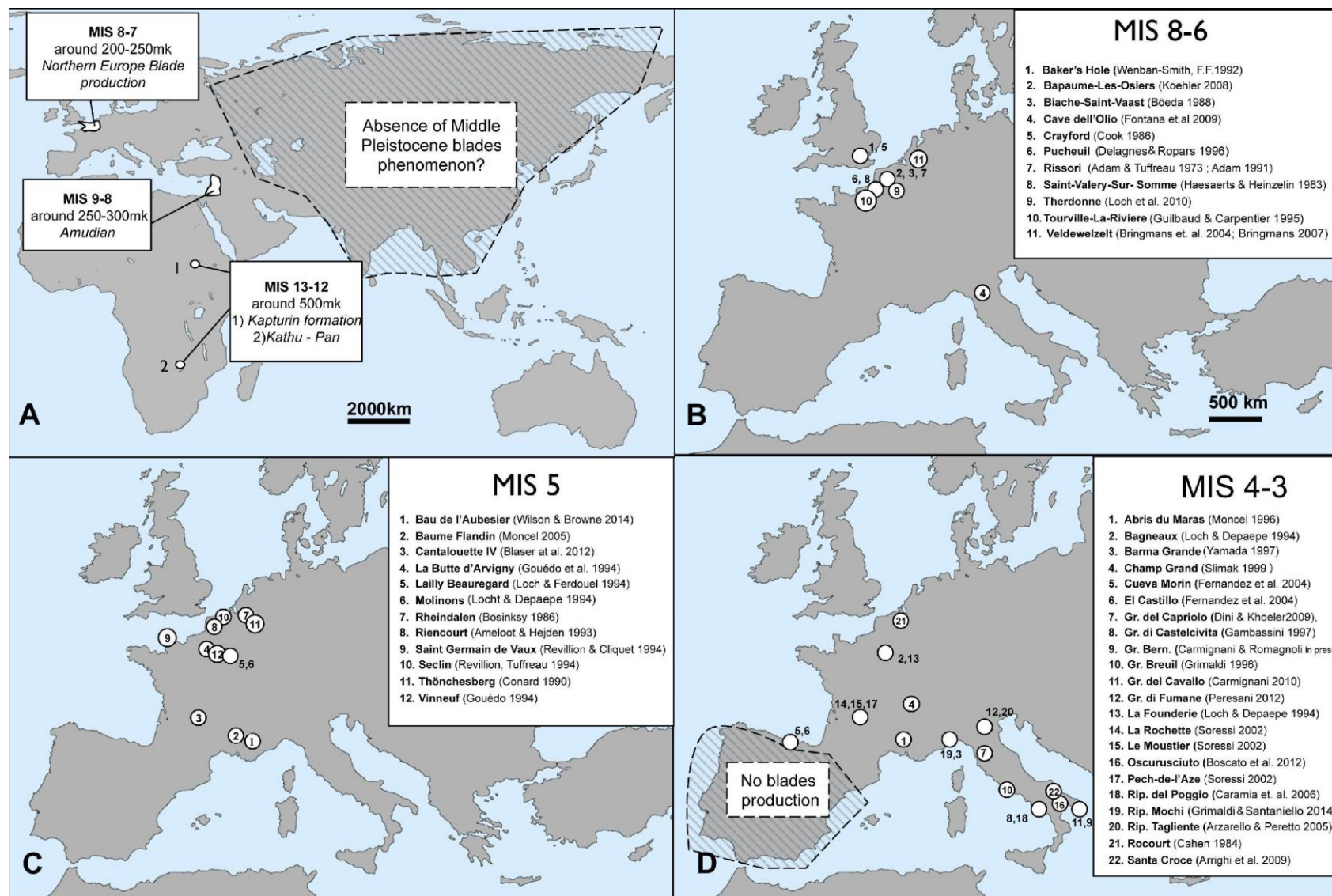


Figure 1. (A) Blade production during the Middle Pleistocene. (B, C, D) - Main sites with blade production in Western Europe during the Middle and Upper Pleistocene (MIS 8-3). (Adapted blank maps from Free Software Foundation (FSF), GNU General Public License).

We will now focus our attention on the European continent, where, as was already noted, the earliest evidence of laminar production dates back to MIS 8 and MIS 7 and is found in northern Europe. The reduction systems used were either volumetric, such as those of Saint-Valéry-sur-Somme (Heinzelin & Haesaerts 1983), Bapaume-les Osiers (Koehler 2008) and Therdonne (Locht *et al.* 2010) in France, Rissori (Adam 1991; Adam & Tuffreau 1973) in Belgium, or followed a Levallois concept, as noted at the site of Biache-Saint-Vaast in northern France (Böeda 1988) (Figure 1). We know these productions continued throughout MIS 7, but there is a lack of archaeological evidence for the glacial peak that was MIS 6. Further east, the sites of Kabazi, Molodova, and Kolorevo show blade production starting in MIS 7 (Chabai & Sitlivyj 1994; Chabai *et al.* 2004).

During MIS 5 blade production becomes, once again, abundant in northern Europe as exemplified by the French and Belgian sites of Riencourt lès-Bapaume (Ameloot-Van der Heijden 1993; Goval & Hérisson 2006), Saint-Germain-des-Vaux (Cliquet 1992; Révillion & Cliquet 1994), Seclin (Révillion & Tuffreau 1994), Bettencourt-Saint-Ouen (Loch 2002), Blangy-Tronville (Depaepe *et al.* 1999), and Rocourt (Otte 1994a).

At the same time, blade production also spread over a wider area including northeast Germany (Tönchesberg (Conard 1990) and Wallertheim sites (Conard & Adler 1997)) and central and southern France (Angé (Locht *et al.* 2008), Vinneuf (Gouédo 1994), Baume Flandin (Moncel 2005; Moncel *et al.* 2008) and Cantalouette 4 sites (Blaser *et al.* 2012)) (Figure 1).

In all of the above sites blades were rarely the predominant tool types, but instead co-existed with various other reduction systems (Levallois, Discoid, etc.) as well as with a number of shaping systems such as those noted at the sites of Bapaume-les Osiers (Koehler 2008) and Vinneuf (Gouédo 1994) in France. In the MTA B industries, the association of blade reduction systems with hand axe is also well documented (Soressi 2002; 2005).

The variability of the blade reduction systems used does not allow for these to be grouped based on a common denominator. Knapping can begin with the preparation of a crested blade or by exploiting the natural convexity of the raw material. Both unidirectional or bidirectional methods are applied for directing the removals. Exploitation can be applied to the narrow surface by means of a rotating or semi-rotating rhythm ('volumetric *latu sensu*') or to a configured large surface ('Levallois concept').

There is still ongoing debate concerning the origin of these production systems. Some authors have suggested that blade production could be an opportunist method leading to the optimisation of the use of the raw materials, which may have motivated the production of elongated removals (Conard 1990). However, this may not necessarily be the case in areas rich in raw materials, where these productions are equally present. Furthermore, the use of different raw material geometric structures such as pebbles, nodules, core-flakes or slabs does not appear to have been hindered or limited the production of blades. Other authors have suggested a relationship between blade production and environmental crises (Otte 1994b). However, the duration of the blade phenomenon and the diffusion in areas that differ greatly from one another suggest that it is impossible to provide a single explanation for it.

This phenomenon only appeared in southern Europe at a later stage. Blades first appear in the south of France in MIS 5, as in the site of Cantalouette 4 (Blaser *et al.* 2012), but become more widespread during MIS 4 and MIS 3 such as in the site of Abris du Maras (Moncel 1996) and Champ Grand (Slimak 1999) (Fig 1).

This final phase of Middle Paleolithic blade production is also comparable to the lithic industries observed in central Europe such as the Bohunician (Svoboda & Skrdla 1995; Skrdla 2003).

In short, we can observe how the oldest expressions of the laminar phenomenon occurred within the northern borders for a long time (MIS 8-6) while the southern regions were still dominated by the production of flakes (Figure 1).

As far as the Italian peninsula is concerned, current studies report the first evidence of blade production in the final phases of the Middle Paleolithic, more specifically in MIS 4 and in the first part of MIS 3 (Figure 1). The geographic distribution of both non-Levallois and Levallois blade production does not appear to be linked to a specific area or environment. In fact these productions can be found all throughout the Italian peninsula.

Non-Levallois productions were found in the Apulia region at the sites of Santa Croce (Arrighi *et al.* 2009) and Grotta del Cavallo (Carmignani 2010); in Lazio at Grotta Breuil (Grimaldi 1996); in Molise at Grotta Reali (Arzarello *et al.* 2004; Peretto 2012); in Veneto at Fumane (Peresani 2012); and in Liguria at Grotta di San Francesco (Tavoso 1988) and Madonna dell'Arma (Cauche 2007; Cauche & Lebègue 2008).

At the same time Levallois blade production is well represented both in northern Italy at Riparo Mochi (Grimaldi & Santaniello 2014; Yamada 2004) and Barma Grande (Yamada 1997) and in the south at Riparo del Poggio (Caramia & Gambassini 2006), Grotta di Castelcivita (Gambassini 1997) and Oscuruscuto (Boscato *et al.* 2011; De Stefani *et al.* 2012).

The only exception to this late appearance in the Italian peninsula is the site of Cave dell'Olio (Fontana *et al.* 2009; Fontana *et al.* 2013). This site is, at the present, the only one dating back to MIS 9, representing the only proof of blade production in the Italian Peninsula during the Middle Pleistocene.

While it is now certain that blades were produced during the Middle Paleolithic, the production of bladelets, obtained by means of an independent reduction system, is less evident and occurred just in the final phases of the Mousterian period. Some bladelets production has been noted at the sites of El Castillo and Cueva Morin in northern Spain (Maíllo Fernández 2001; Maíllo-Fernández *et al.* 2004), at Champ Grand (Slimak & Lucas 2005) and Combe Grenal in France (Faivre 2012), Fumane (Peresani *et al.* 2013) and Grotta del Cavallo in Italy (Carmignani 2010) and Balver Höhle in Germany (Pastoors & Tafelmaier 2010).

Some geographic areas, such as the Balkans and Greece, and the Iberian Peninsula, do not seem to be influenced by this phenomenon, both during its earliest and more recent phases, completing the fragmentary and irregular overview that emerges from the data in our possession.

Although this absence can be attributed to a lack of research, especially for the Balkan region and Greece, this is certainly not the case for the Iberian Peninsula for which there is a much larger amount of available data.

The Riparo Tagliente site, which is presented in this paper, is part of the last phase of the Middle Paleolithic blade phenomenon and shows an articulated techno-cultural repertoire consisting of mixed flake and blade reduction systems.

2. Materials and methods

2.1. The site of Riparo Tagliente

Riparo Tagliente is a rock shelter located in the Veneto region in northern Italy (Figure 2). It was first excavated in the 1960s by the *Museo Civico di Storia Naturale di Verona* (Pasa & Mezzena 1964; Zorzi 1962; Zorzi & Mezzena 1963) and subsequently in collaboration with the University of Ferrara (Bartolomei *et al.* 1982; 1984). The Mousterian collection under examination here comes from these excavations. Research at the site is still ongoing currently under the direction of Federica Fontana from the University of Ferrara. Sediment,

macrofaunal, microfaunal and pollen analyses date the Mousterian sequence between MIS 4 and the beginning of MIS 3 (Arzarello *et al.* 2007; Cattani & Renault-Miskovsky 1989; Thun-Hohenstein & Peretto 2005). The stratigraphy, excavated by artificial layer, is composed of a Mousterian sequence and an Epigravettian sequence separated by erosion. The 1960s excavation procedures, which paid much attention to sedimentary details, have enabled us to determine light patterns of internal evolution of the lithic industry.



Figure 2. (A, B, C) Maps showing the position of Riparo Tagliente; (D) view of Riparo Tagliente (from Arzarello 2003).

The Mousterian sequences have been found in two different locations known as ‘Internal shelter’ and ‘External shelter’ (Figure 3). The Internal shelter comprises 18 layers (52 to 34) and extends over 8 m² while the External shelter comprises 13 layers (46 to 34) and a larger surface area (16m²).

2.2. Sorting procedure and methodology

In Medieval times the shelter has been used as a refuge. These occupations caused a partial destruction and reshuffle of the deposits on a quite large area both for the Epigravettian layers as well as for the Mousterian’s ones.

For these reasons a preliminary check of the material and stratigraphy has been focused on eliminating the squares and the layers considered not reliable. After the check we have considered as being reliable just four squares coming from the Internal shelter (Q 614, 615, 634, 635) and four squares coming from the External shelter (Q 5, 6, 8, 9) (Figure 3). In the same way the layers 34 and 35, have been as well excluded from our analysis because of the

presence of contamination coming from the Epigravettian layers. After the sampling, our analysis has been concentrated on the layers going from 52 to 36 on an area of 9 m². We have selected all flakes (complete or broken) bigger than 15 mm. All cores, core fragments, tools, tool fragments and all blades and blade fragments are selected regardless of their size. The distribution of the material across the sequence show different concentration of the material that has been possible to group in three macro phases called Lower layers, Intermediate layers and Upper layers (Figure 3). Five layers show a high density of stone artefacts (more than 200 pieces). Three layers contain less than 5 pieces and can therefore be considered as sterile (Figure 3).

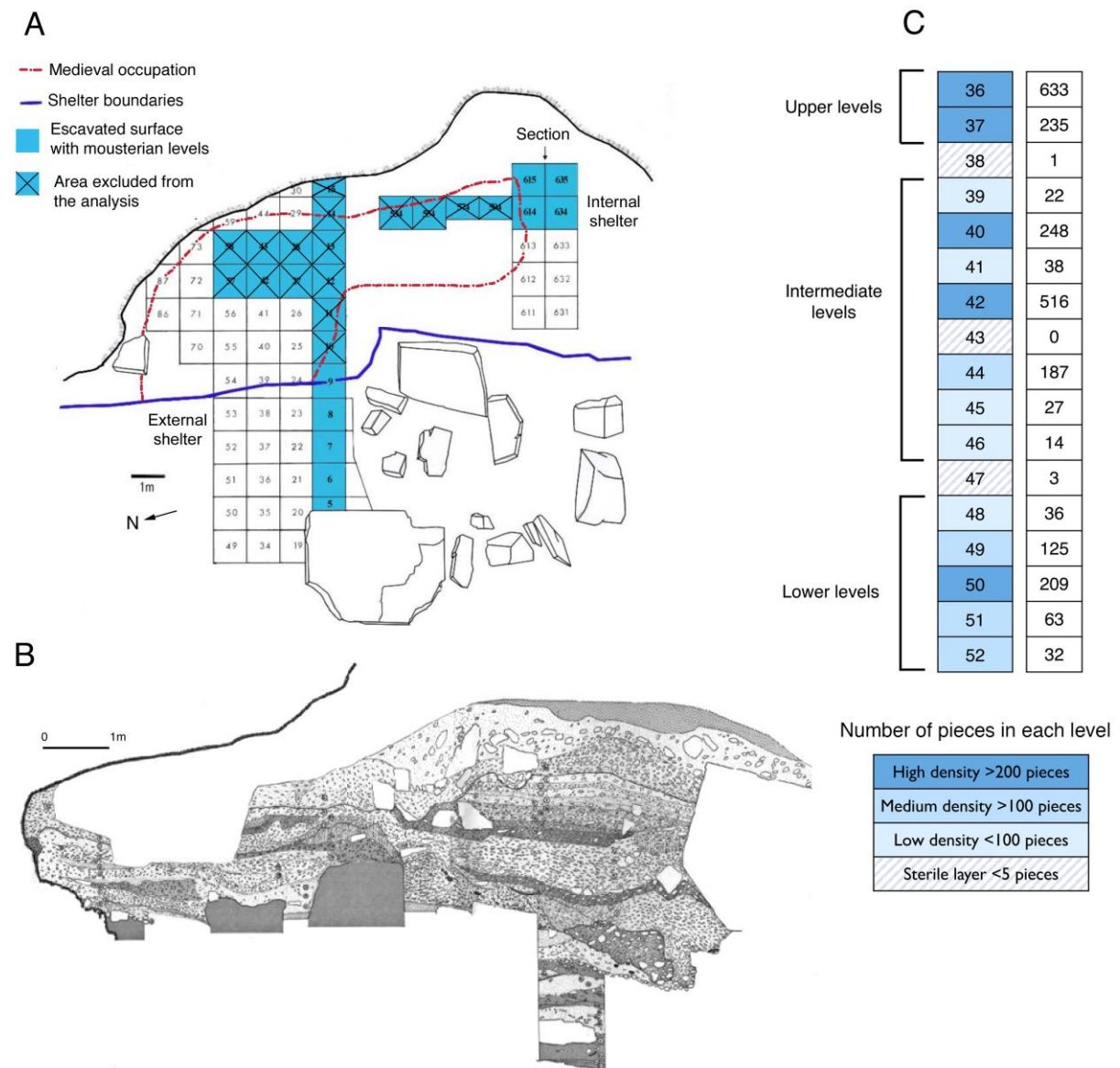


Figure 3. (A) Plan showing the excavation areas (Modified after Bartolomei *et al.* 1982). (B) Stratigraphic section between squares 5/15 and 505/515, and layers 43 to 31 (Modified after Arzarello 2003). (C) Lithic industry distributions across the sequence.

The lithic products of Riparo Tagliente were analysed using a technological approach. The knapping system analysis follows the same principles as those of the *chaîne opératoire* analysis, which is supported by the quantitative presentation of technological categories (Inizan *et al.* 1995). The definition suggested by Boëda (1994) was adopted for the Levallois

concept. Given the absence of the refitting reconstruction of the reduction sequences we used the mental refitting method (Pelegrin 1995). The techniques were identified according to experimental studies carried out by Pelegrin (1991; 2000). Volumetric and Levallois blade productions were distinguished by means of volumetric structure analyses (Boëda 1990). In terms of the Discoid production, we used the definition put forward by Boëda (1993; 1991) as well as also taking in consideration broader criteria (Peresani 1998; Slimak 2003). Diacritical analyses were applied to cores and blanks as a means to reconstruct the chronological order of the scars (Dauvois 1976).

3. Results

3.1. Lithic technology

Our database contains a total of 2315 *débitage* removals and 75 cores. The raw material used is good quality flint from local sources (<5 km). The flint was collected mainly in secondary position in the form of pebbles and to a smaller extent in primary position as roundish nodules (Arzarello *et al.* 2007). Production mainly comprised flakes and to a lesser extent blades (Table 1).

Table 1. Riparo Tagliente. Frequencies of *débitage* classes and cores

	Lower layers from 52 to 47		Intermediate layers from 46 to 39		Upper layers from 38 to 36	
	no.	%	no.	%	no.	%
Levallois centripetal flakes	20	4.3	90	8.6	36	4.1
Levallois unidirectional flakes	22	4.7	36	3.4	16	1.8
Levallois orthogonal flakes	0	-	1	0.1	1	0.1
Levallois convergent flakes	1	0.2	7	0.7	4	0.5
Levallois flakes with a back	4	0.9	15	1.4	2	0.2
Centripetal flakes	51	10.9	96	9.1	74	8.5
Unidirectional flakes	48	10.3	83	7.9	26	3.0
Bidirectional flakes	4	0.9	10	1.0	2	0.2
Orthogonal flakes	0	-	11	1.0	3	0.3
Sub-convergent flakes	5	1.1	14	1.3	5	0.6
Convergent flakes	3	0.6	7	0.7	1	0.1
Debordant flakes (unspecified)	11	2.4	21	2.0	7	0.8
Debordant flakes (centripetal)	4	0.9	16	1.5	7	0.8
Debordant flakes (unidirectional)	4	0.9	7	0.7	0	-
Debordant flakes (bidirectional)	0	-	7	0.7	0	-
Pseudolevallois points	0	-	2	0.2	4	0.5
Kombewa 1st generation	9	1.9	17	1.6	5	0.6
Kombewa 2nd generation	5	1.1	14	1.3	5	0.6
Levallois blades	3	0.6	18	1.7	7	0.8
Non Levallois blades	28	6.0	56	5.3	48	5.5
Crested blade	1	0.2	0	-	0	-
Cortical flakes	79	16.9	186	17.7	180	20.7
Striking platform flakes	11	2.4	5	0.5	6	0.7
Unspecified flakes	57	12.2	123	11.7	170	19.5
Undetermined fragments >15 mm	73	15.6	165	15.7	256	29.4
Cores	25	5.3	45	4.3	5	0.6
Total	468	100.0	1052	100.0	870	100.0

Hard hammer direct percussion was the only technique used in all the reduction systems. The abundance of cortical flakes proves that the initial stage of knapping activities was carried out at the site (Table 1).

In terms of the knapping products, all the layers show a high degree of homogeneity as shown by the large number of Levallois flakes derived from centripetal and unidirectional methods (Table 1). Generic unidirectional and centripetal flakes are numerous. Unidirectional flakes, the number of which falls in the upper layers, represent the only element of discontinuity across the sequence. Blade production is distributed in similar percentages throughout the sequence and is composed of both Levallois and non-Levallois blades (Table 1). Production also includes convergent, orthogonal, bidirectional and Kombewa flakes that are present in small numbers throughout the sequence. The apparent homogeneity observed when analysing the knapping products will be partially invalidated when we turn our attention to the analysis of the cores.

3.1.1. Lower layer reduction systems

The Lower layers contain 468 lithic pieces of which 25 are cores. As is the case with the end product, the cores indicate that the Levallois is the main reduction system, which is predominantly expressed in the centripetal method and secondarily in the unidirectional method (Figure 4). The purpose of using the Levallois unidirectional system was to produce mostly flakes. Few blades are associated with this system.

The second most adopted system is based on the exploitation of cortical thick flakes by means of the Kombewa system (Table 2). The exploitation can be limited to a singular detachment or to a short sequence of detachments (Figure 5). The preparation of the cores is limited to a partial correction of the lateral convexities of the flaking surface.

Table 2. Riparo Tagliente. Core types.

	Lower layers					Intermediate layers					Upper layers
	t52	t50	t49	t48	total	t46	t44	t42	t40	total	t36 (total)
Levallois centripetal	-	3	3	-	6	-	-	16	-	16	3
Levallois unidirectional	-	1	-	1	2	-	-	3	-	3	-
Levallois bidirectional	-	-	-	-	-	-	-	1	1	2	-
Levallois preferential	-	-	-	-	-	-	1	5	-	6	1
Levallois initialized	-	-	-	-	-	-	-	3	-	3	-
Discoid	1	1	-	-	2	1	-	1	-	2	-
SSDA	-	1	2	-	3	1	-	2	-	3	-
Kombewa (single removal)	-	1	3	-	4	-	-	-	-	-	-
Kombewa (multiple removal)	-	2	1	-	3	-	-	-	-	-	-
Semi pyramidal	-	-	2	-	2	-	-	-	-	-	-
Unidirectional Type 1	-	1	1	-	2	-	-	-	-	-	-
Unidirectional Type 2	-	-	-	-	-	1	-	6	1	8	1
Bidirectional	1	-	-	-	1	-	-	2	-	2	-
Total	2	10	12	1	25	3	1	39	2	45	5

Two cores show a unidirectional reduction system composed of two different exploitation yet interconnected phases, which we termed Unidirectional Type 1 (Figure 6). The first phase exploits the larger surface of the volume through a short unidirectional sequence and has two complementary functions: to produce quadrangular, slightly elongated flakes and to reduce the thickness of the adjacent surface, which will be exploited by a second unidirectional sequence (second phase). The exploitation of the thinner side of the volume, already reduced in thickness during the first sequence, allows for the production of small

blades (Figure 6). The configuration of cores is limited to a partial preparation of the lateral convexities carried out by means of a series of orthogonally-oriented detachments with regard to the main flaking direction. An isolated core shows a bidirectional exploitation starting from two opposite striking platforms. The variability of the production systems in this unit is also composed of two Discoid cores and two sub-pyramidal cores. The sub-pyramidal cores are aimed at producing thick convergent flakes (Figure 5). Four cores follow a reduction system based on the exploitation of orthogonal alternated surfaces that can be associated with a SSDA system (Forestier 1993) or with an opportunistic method, *sensu* Arzarello (2003).

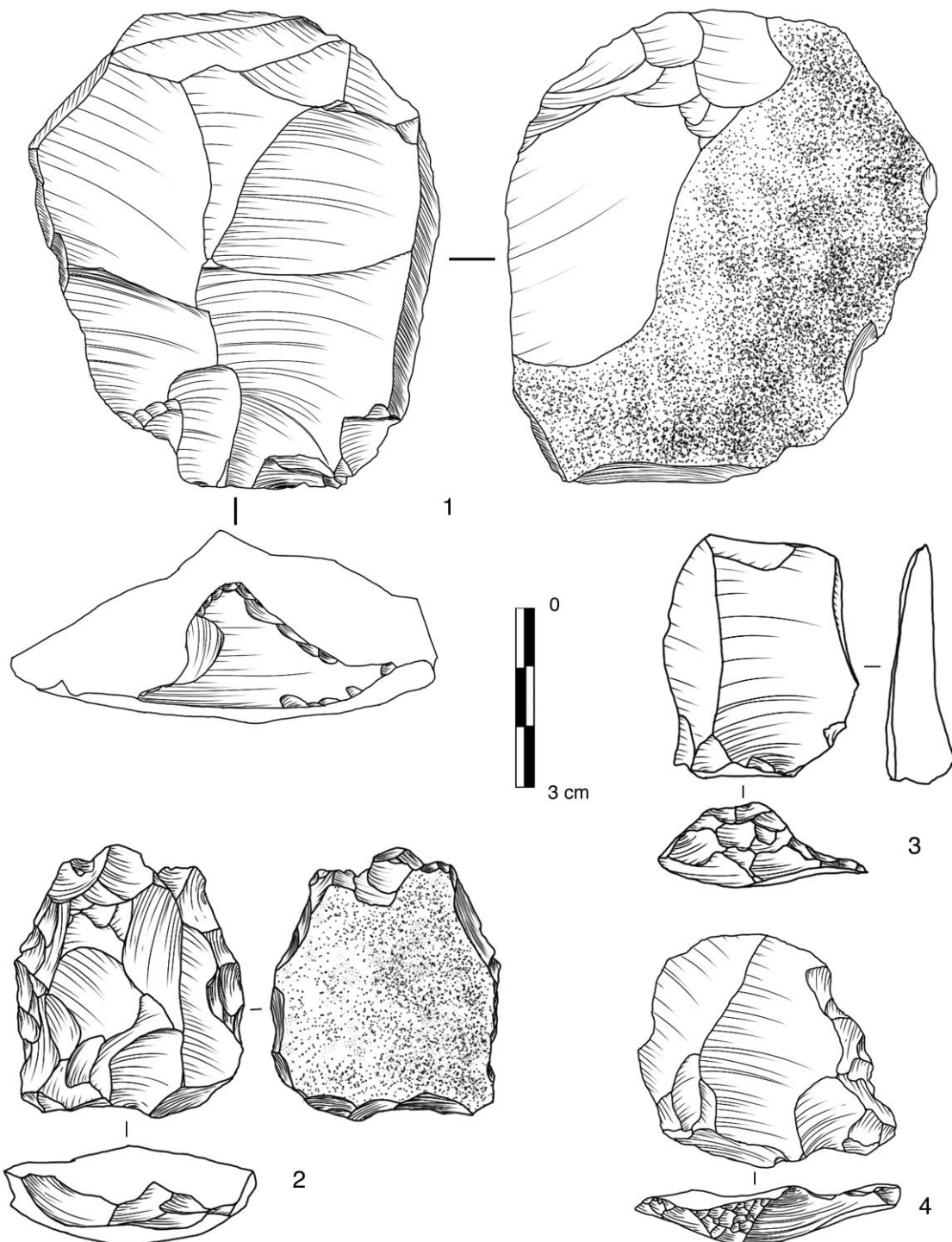


Figure 4. Riparo Tagliente. Lithic industries from the Lower Layers. (1) Levallois unidirectional core; (2) Levallois centripetal core; (3) Levallois unidirectional flake; (4) Levallois centripetal flake.

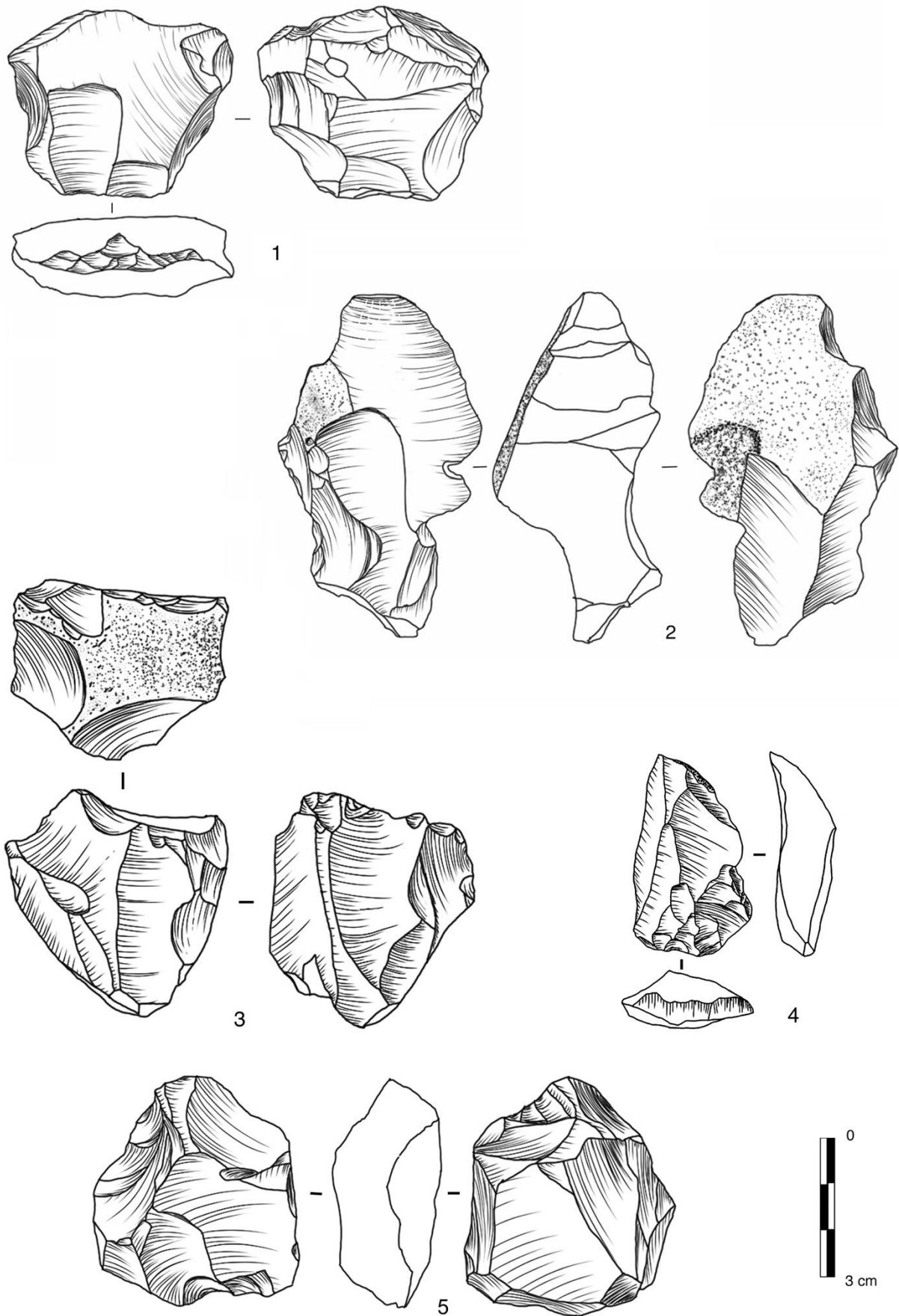


Figure 5. Riparo Tagliente. Lithic industries from the Lower Layers. (1, 2) Kombewa cores; (3) Half-pyramidal core; (4) Convergent flake; (5) Discoid core.

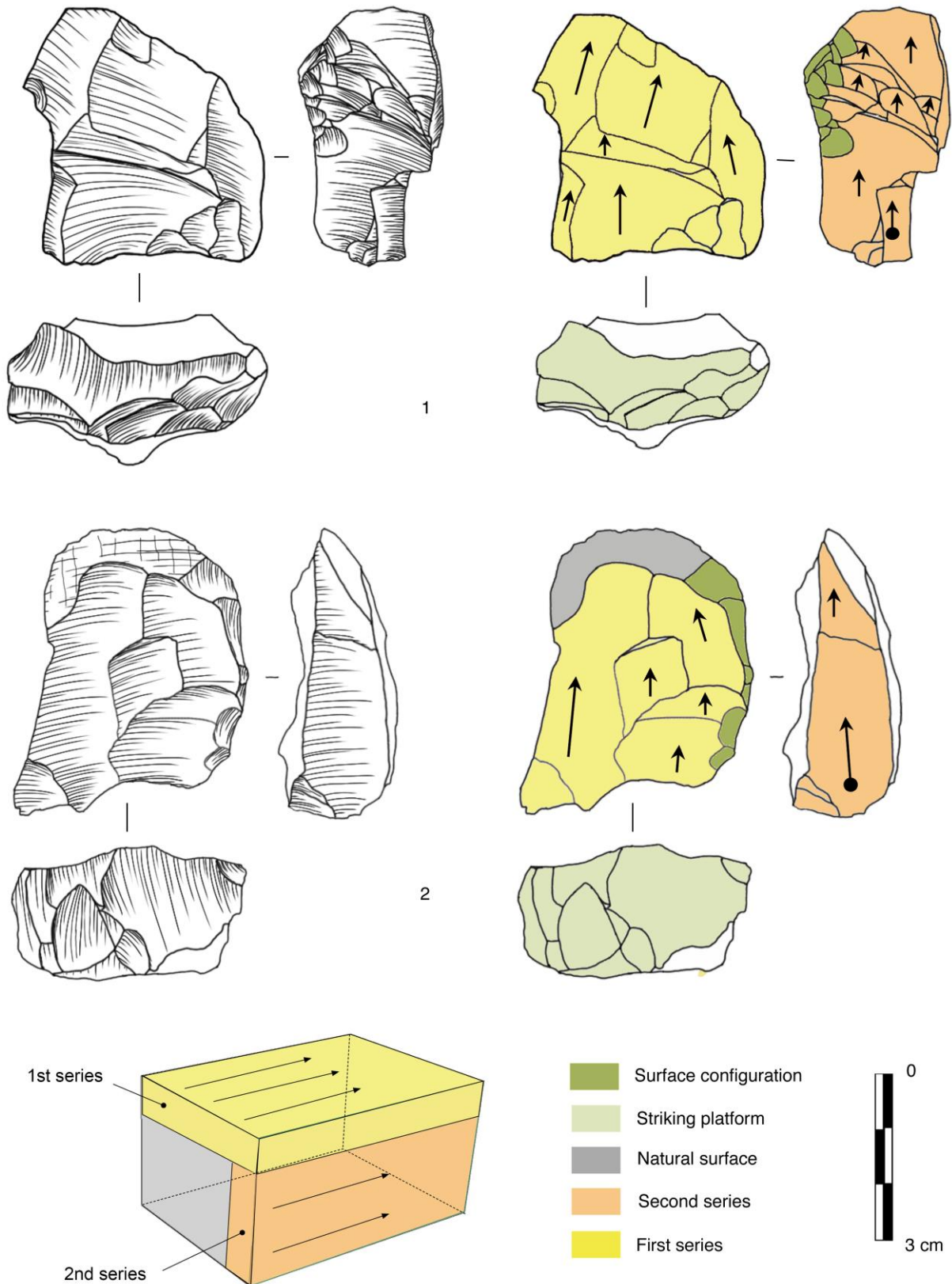


Figure 6. Riparo Tagliente. Lithic industries from the Lower Layers. Unidirectional system Type 1 cores.

3.1.2. Intermediate layers reduction systems

The Intermediate layers of Riparo Tagliente show some elements of continuity with the Lower layers such as the persistence of the Discoid and SSDA systems. The centripetal

Levallois continues to be the predominant reduction system, however, the plasticity of the Levallois concept finds greater variability here than it does in the Lower layers. The centripetal and unidirectional methods are supported by a bidirectional exploitation while the use of the preferential method, totally absent in the Lower layers, is well represented here (Figure 7).

No Kombewa cores were noted in the Intermediate layers. The presence of Kombewa flakes in these layers could indicate the export of the cores outside the site or they could derive from other flaking operations such as the configuration of a Levallois surface based on the exploitation of the ventral face of a flake. The absence of pyramidal and unidirectional system type 1 methods is a further element of divergence compared to the Lower layers.

In the Intermediate layers the most common production system consists of a unidirectional system which tends to develop around the edge of the core following a semi-rotating rhythm (Unidirectional core type 2) (Figure 7). There is no or minimal flaking surface preparation. The maintenance of the core convexities is evident in some debordant blades and plunging laminar blanks. The end products consist of elongated thick blanks.

3.1.3. Upper layer reduction systems

The lack of cores roughly sums up the reduction systems in the Upper layers. However, based on the end products, we can see a certain continuity with the Intermediate and Lower layers represented by a large number of Levallois flakes. As for the Intermediate layers, the Levallois concept shows great variability expressed in the convergent, unidirectional and bidirectional methods (Figure 8). The unidirectional semi-rotating system (Unidirectional Type 2) is only observed in one core.

3.2. Retouched pieces

Three different categories were established in order to study the retouched pieces. Each of these categories corresponds to the number of transformation degrees undergone by the blanks: low, medium and high degrees (Figure 9).

The low degree describes a marginal retouch of the perimeter of the piece, which does not modify the cutting edge nor the morphology of the pieces in any way. The medium degree consists of a retouch that modifies the morphology of the cutting edges, but not the structure of the piece.

The high degree refers to the structural modification of the blanks, which completely or partially transforms their original morphology.

Transformation through retouching can be noted in all layers. The Lower layers show the highest percentage of transformation while the lowest percentages are observed in the Intermediate and Upper layers (Table 3).

The retouching phase shows different degrees of transformation in terms of the *débitage* classes. Besides a few rare exceptions, high levels of transformation are mainly observed in the cortical and generic flakes found in all three layer groups (Table 4). On the other hand, Levallois flakes only show slight modifications just like in the blade production (Figure 9).

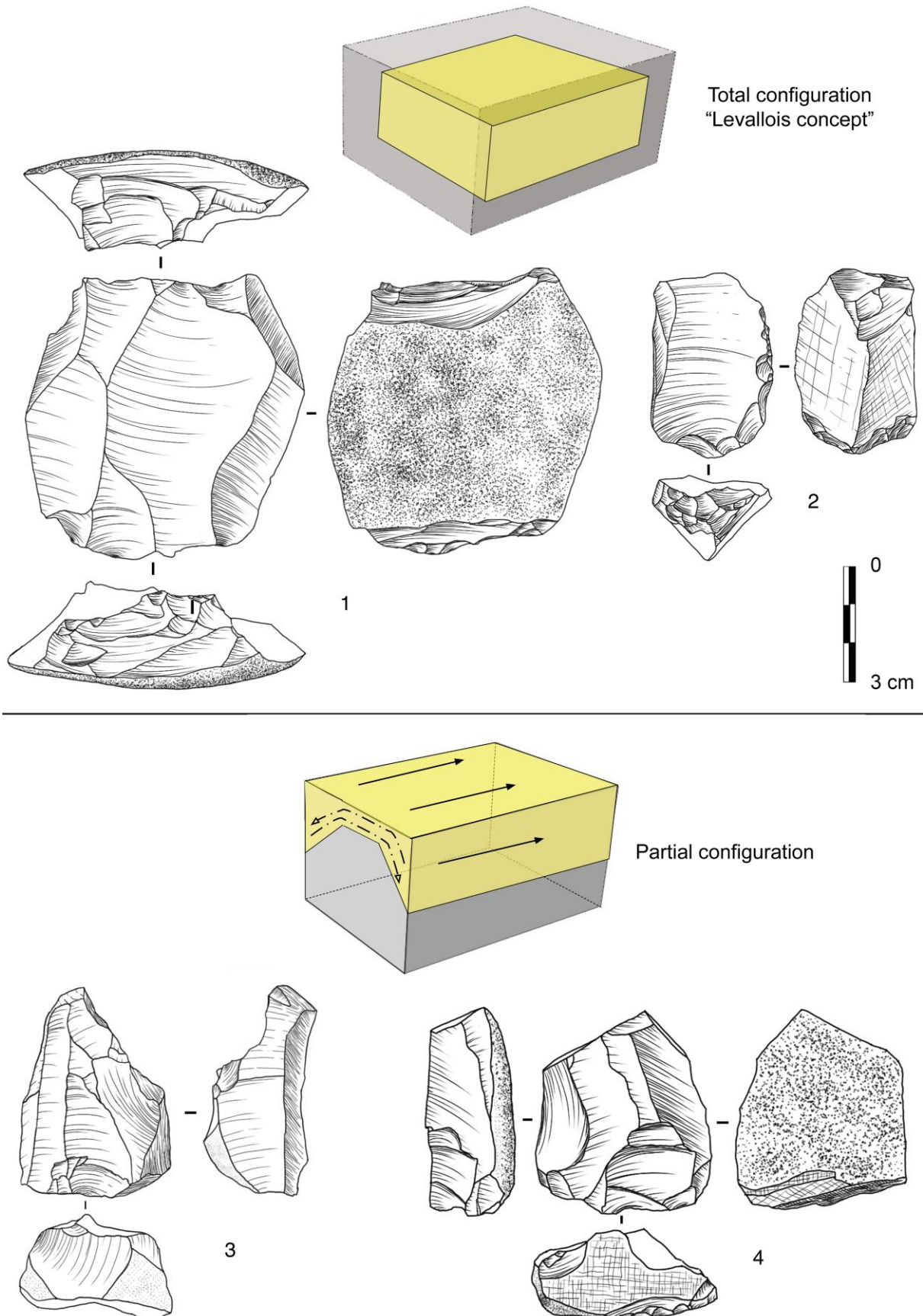


Figure 7. Riparo Tagliente. Lithic industries from the Intermediate Layers. (1) Levallois bidirectional core; (2) Levallois preferential core; (3, 4) Unidirectional system type 2 cores.

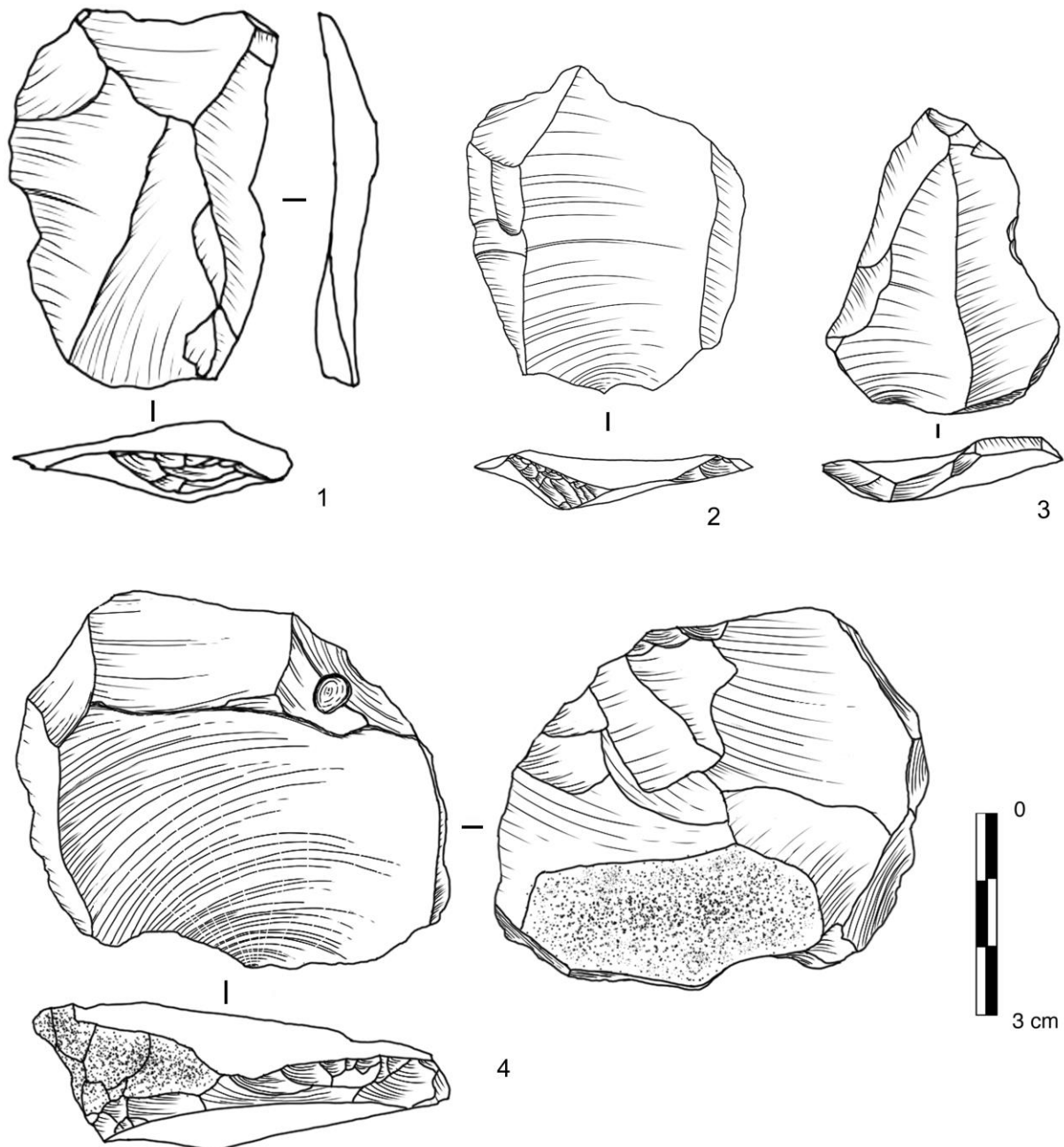


Figure 8. Riparo Tagliente. Lithic industries from the Upper Layers. (1) Levallois centripetal flake; (2) Levallois unidirectional flake; (3) Levallois convergent flake; (4) Levallois preferential core.

Table 3. Riparo Tagliente. Frequencies of retouched and unretouched pieces.

	Lower layers		Intermediate layers		Upper layers	
	no.	%	no.	%	no.	%
Unretouched	293	79,2	706	83,8	513	86,1
Retouched	77	20,8	136	16,2	83	13,9
Total	370	100	842	100	596	100

Table 4. Riparo Tagliente. Comparison between degree of retouch and *débitage* types. Abbreviations: U - unretouched; L - low retouch; M - medium retouch; H - high retouch.

	Lower layers				Intermediate layers				Upper layers			
	U	L	M	H	U	L	M	H	U	L	M	H
Levallois flakes	28	17	2	0	122	18	9	0	52	4	3	0
Centripetal flakes	34	2	12	3	86	9	1	0	66	4	2	2
Unidirectional flakes	35	6	7	0	65	8	7	3	22	1	2	1
Bidirectional flakes	3	1	0	0	8	1	1	0	2	0	0	0
Orthogonal flakes	0	0	0	0	9	1	1	0	3	0	0	0
Sub-convergent flakes	5	0	0	0	11	3	0	0	3	1	0	1
Convergent flakes	3	0	0	0	6	0	0	1	1	0	0	0
Debordant flakes	19	0	0	0	44	3	1	3	0	0	0	1
Pseudo-levallois	0	0	0	0	1	1	0	0	3	0	1	0
Kombewa	14	0	0	0	29	2	0	0	9	1	0	0
Levallois blades	1	1	1	0	13	2	3	0	6	1	0	0
Non Levallois blades	25	0	3	0	43	10	3	0	43	3	2	0
Crested blades	1	0	0	0	0	0	0	0	0	0	0	0
Striking platform flakes	11	0	0	0	5	0	0	0	6	0	0	0
Cortical flakes	69	1	6	3	158	9	10	9	146	7	11	16
Unspecific flakes	45	2	5	5	106	4	7	6	151	4	3	12
Total	293	30	36	11	706	71	43	22	513	26	24	33

3.3. Blade tools across the sequence

Blade production is similar throughout the sequence with a slight increase in percentages in the Upper layers (Table 5). The blades can be described as being well preserved. Proximal fragments are the most numerous (Table 6).

Within the sequence different production systems can produce elongated blanks, both deriving from the unidirectional and bidirectional Levallois systems as well as from unidirectional non-Levallois systems (Unidirectional Type 1 and 2). Therefore the main aim of the study was to verify whether this variability was due to a predetermined intention to produce differentiated tools by using different reduction systems or whether this was only the result of opportunistic behaviour.

By observing the morphological characteristics of the blades and those of experimental representatives it was possible to distinguish two main blades categories: Levallois blades and non-Levallois blades. The blade fragments which could not be attributed to a specific category and blades with mixed characteristics that could have pertained to any category were placed in a third category termed 'undefined blades'.

The parameters taken into consideration when defining these categories were: types of platform, knapping surface angles, cutting edge angles, transversal cross-section, longitudinal profile, length-width ratio and width-thickness ratio.

Most of the blades fell in the 'undefined blade' category (Table 6). Levallois blades and non-Levallois blades are found in all layers in similar frequencies. From a morphometric point of view there is certain overlapping between the non-Levallois and Levallois productions in as far as the length-width ratio is concerned (Figure 10).

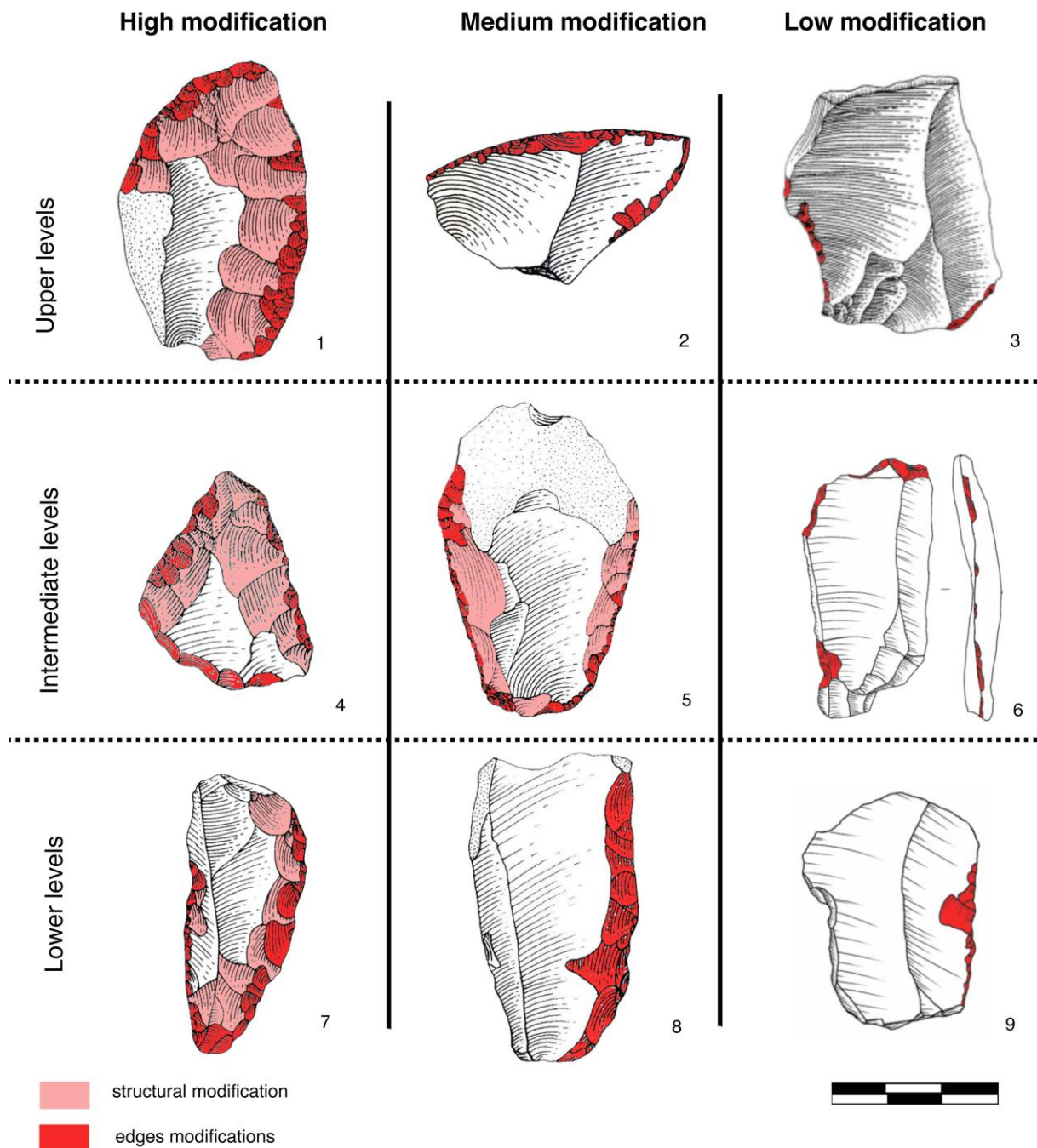


Figure 9. Riparo Tagliente retouched pieces. (1, 5) Scrapers on cortical flakes; (4,7) Convergent scrapers on undefined flakes; (2, 3) Levallois retouched flakes; (6, 8, 9) Unidirectional retouched flakes. (Drawings 1-3 and 4,5,7,8 modified after Arzarello 2003). The scale bar is 3 cm wide (3 sections of 1 cm each).

Table 5. Riparo Tagliente - Frequencies of blades and flakes. Cores and undetermined fragments are excluded from the count.

	Lower layers		Intermediate layers		Upper layers	
	no.	%	no.	%	no.	%
Flakes	337	91,6	768	91,2	541	90,8
Blades	31	8,4	74	8,8	55	9,2
Total	368	100	842	100	596	100

Table 6. Riparo Tagliente. Blade classes and distinction between fragmented and whole pieces.

	Layers	Lower layers	Intermediate layers	Upper layers	Total
Undefined blades	Whole	14	17	18	49
	Apex absent	0	1	0	1
	Platform absent	0	1	1	2
	Distal fragment	2	1	9	12
	Mesial fragment	0	4	2	6
	Proximal fragment	6	8	3	17
	Partial total	22	32	33	87
Volumetric blades	Whole	5	16	5	26
	Apex absent	0	1	1	2
	Platform absent	1	1	0	2
	Distal fragment	0	1	1	2
	Mesial fragment	0	0	1	1
	Proximal fragment	0	5	7	12
	Partial total	6	24	15	45
Levallois blades	Whole	2	13	3	18
	Apex absent	1	2	0	3
	Platform absent	0	0	1	1
	Distal fragment	0	1	1	2
	Mesial fragment	0	0	0	0
	Proximal fragment	0	2	2	4
	Partial total	3	18	7	28
Total	31	74	55	160	

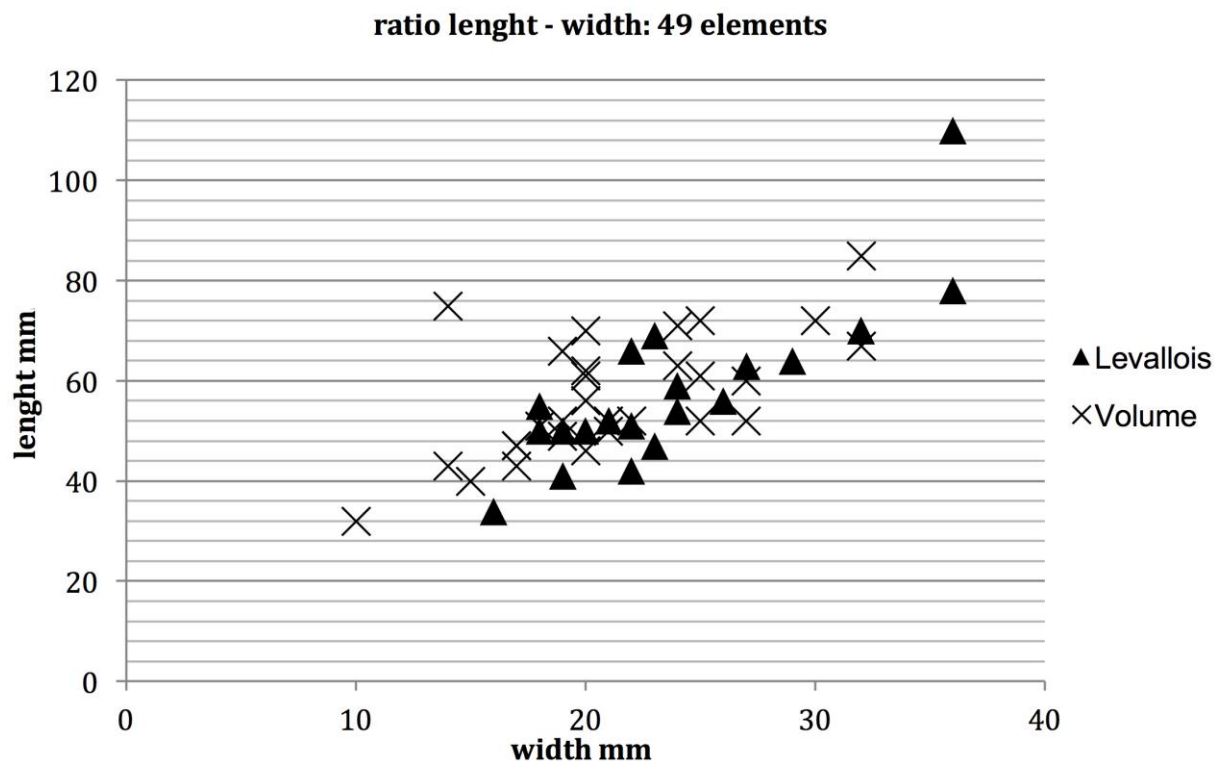


Figure 10. Riparo Tagliente. Levallois and Non-Levallois blade length-width ratios.

Conversely a significant difference is evident in their width-thickness ratios (Figure 11). This difference is also noticeable when we compare the angle of the cutting edges. In the Levallois blades the opening of the angles are concentrated between 10° and 35° , while the non-Levallois blades show wider angles of the cutting edges, ranging between 35° and 55° (Figure 12).

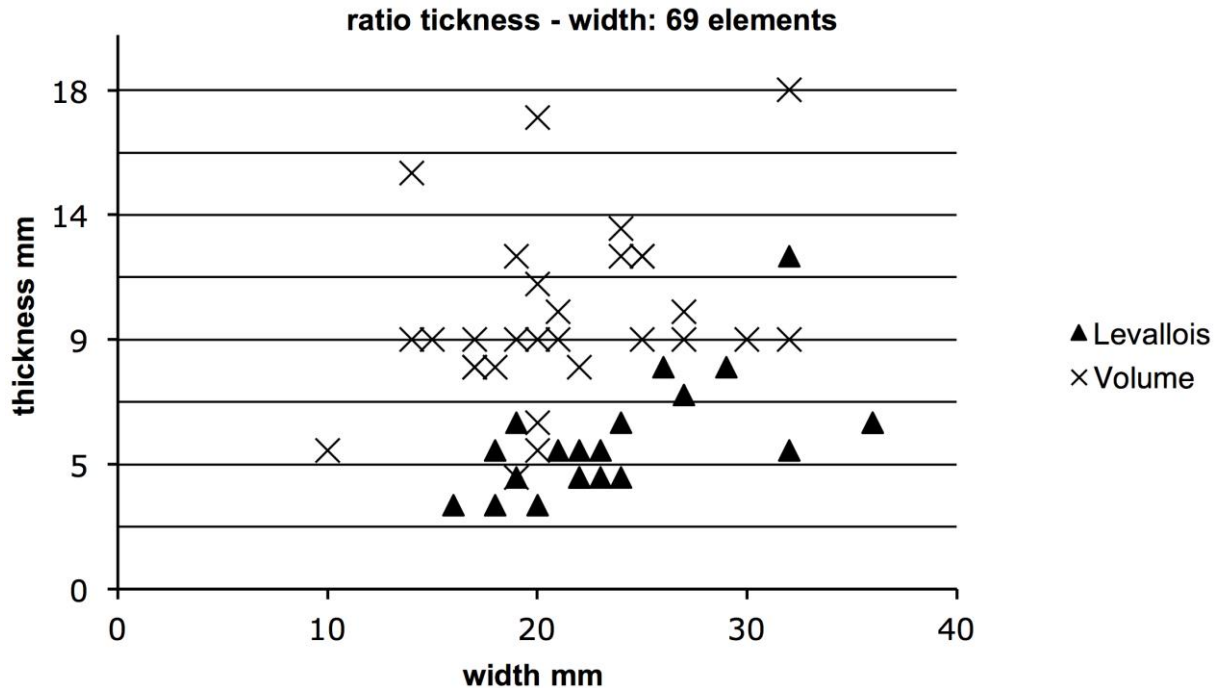


Figure 11. Riparo Tagliente. Levallois and Non-Levallois blade thickness-width ratios.

Both for the Levallois and non-Levallois productions, six techno-functional categories were observed, all based on the morphological structure and the organization of the cutting and non-cutting edges (Figure 13). Only completely intact blades were analysed; minimally fractured pieces were also excluded.

In general, we can observe how blade production at Riparo Tagliente focused on the production of objects with differentiated techno-functional characteristics rather than the making of a mono-tool (Figure 14).

By comparing the classes of blade we can see how blades with a peripheral cutting edge (S1 Type) are attributed mainly to Levallois blades. On the contrary, debordant blades (S3, S4 type) are more frequent among the Non-Levallois blades. Convergent blades (P1 type, P2 type) are rare in both categories (Table 7). The undefined blade category does not show any specific tendency except for the scarce presence of convergent blades, as was the case in the Levallois and non-Levallois blades.

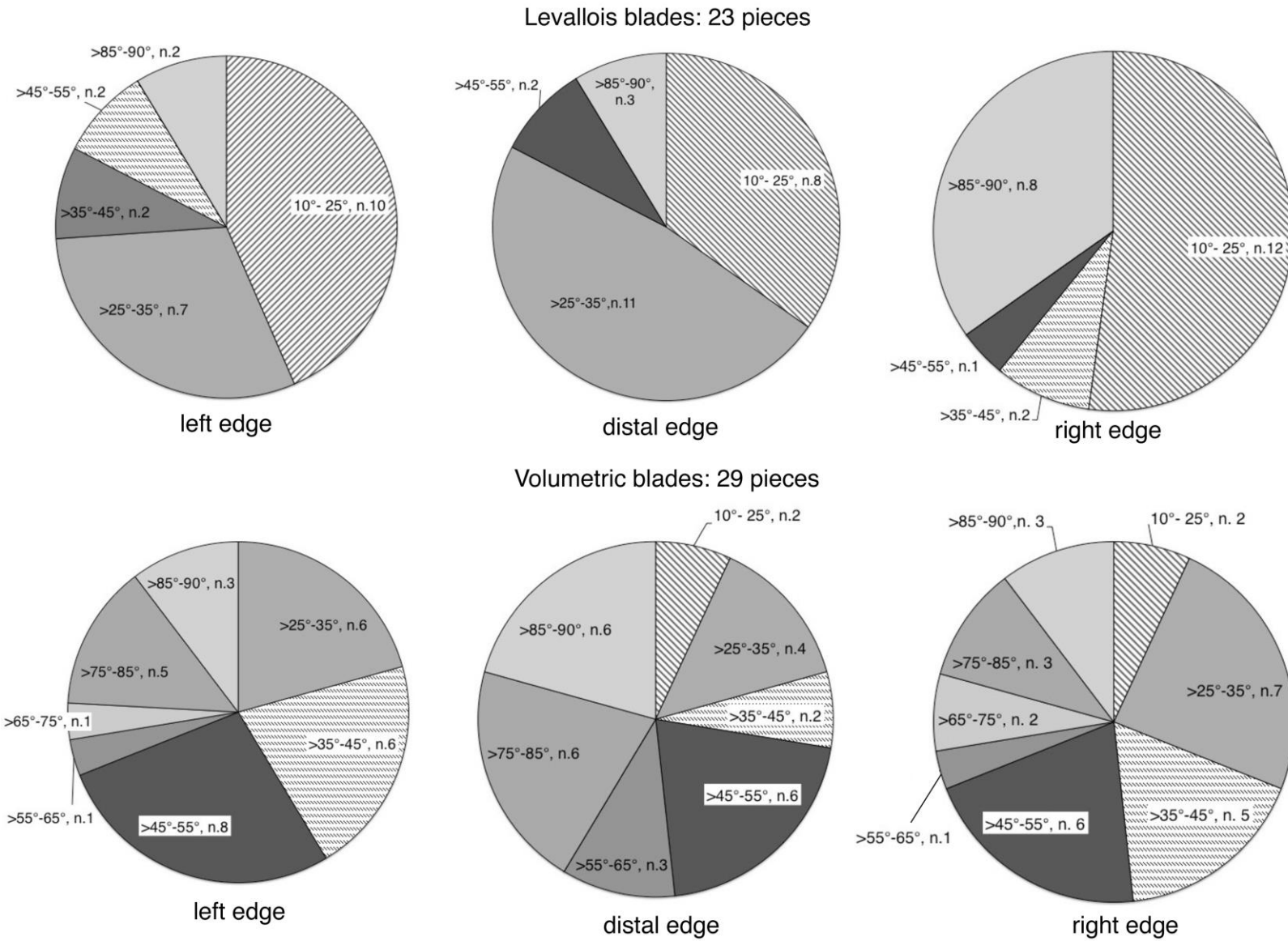


Figure 12. Riparo Tagliente. Cutting edge angle degrees of Levallois and Non-Levallois blades.

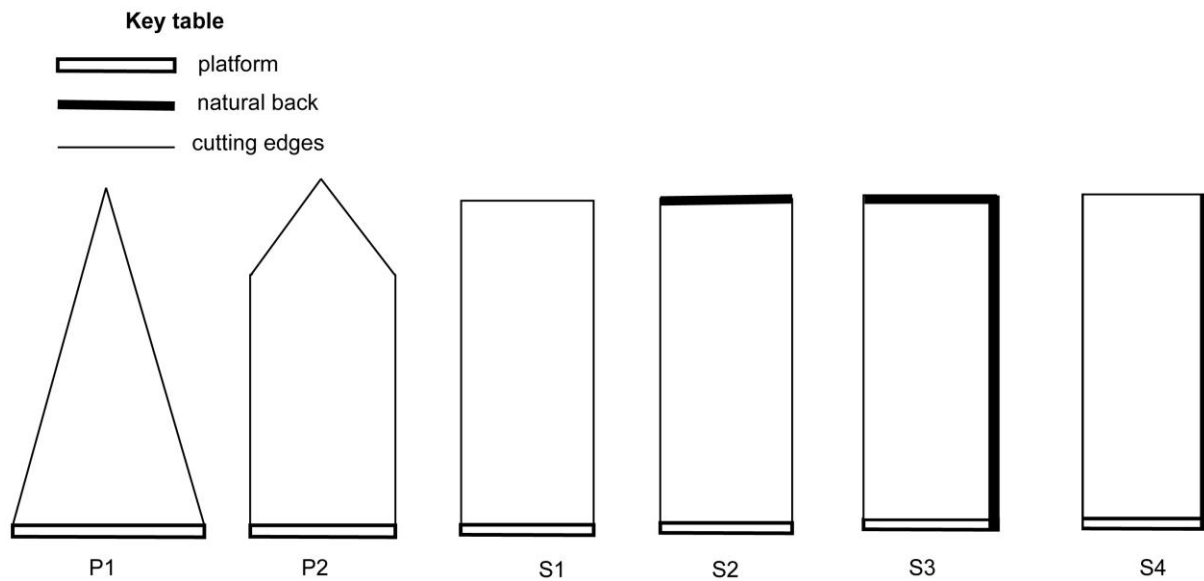


Figure 13. Riparo Tagliente. Blade types.

Table 7. Riparo Tagliente. Blade types.

		Lower layers	Intermediate layers	Upper layers
Undefined blades	P1 type (convergent edges)	1	-	3
	P2 type (parallel edges)	-	3	2
	S1 pheriferal cutting edge	3	4	6
	S2 parallel cutting edge	6	5	2
	S3 single cutting edge	3	3	3
	S4 orthogonal cutting edge	1	2	2
	Partial total	14	17	18
Volumetric blades	P1 type (convergent edges)	1	-	-
	P2 type (parallel edges)	1	2	2
	S1 pheriferal cutting edge	-	3	-
	S2 parallel cutting edge	-	5	1
	S3 single cutting edge	-	2	-
	S4 orthogonal cutting edge	3	4	2
	Partial total	5	16	5
Levallois blades	P1 type (convergent edges)	-	-	1
	P2 type (parallel edges)	-	3	-
	S1 pheriferal cutting edge	1	7	2
	S2 parallel cutting edge	1	-	-
	S3 single cutting edge	-	3	-
	S4 orthogonal cutting edge	-	-	-
	Partial total	2	13	3
Total	21	43	27	

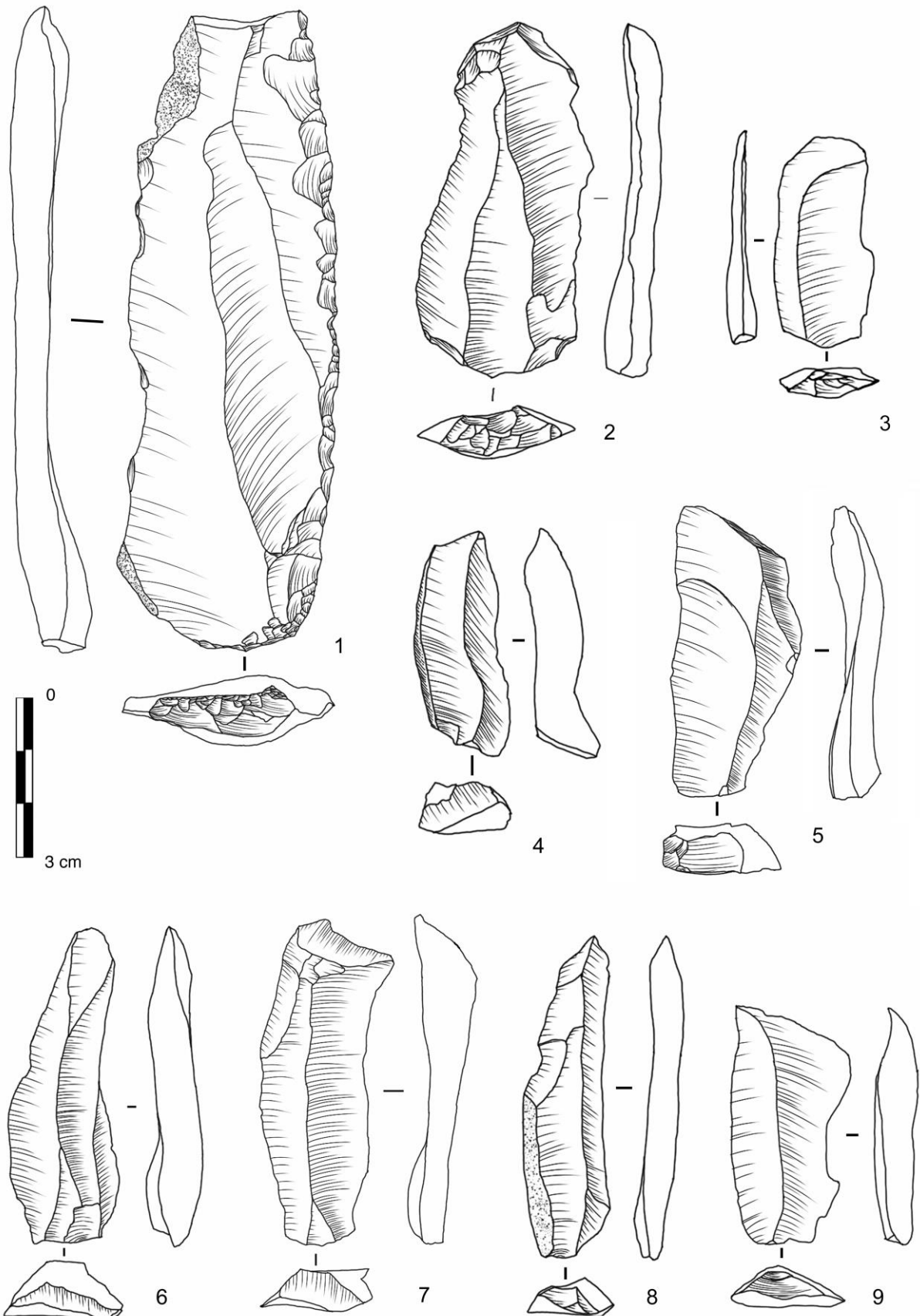


Figure 14. Blade production at Riparo Tagliente. (1) 'S1 type' Levallois blade from the Lower layers; (2) 'S2 type' Levallois blade from the Intermediate layers; (3) 'S1 type' Levallois elongated flake from the Upper layers; (4) 'S4 type' non-Levallois blade from the Lower layers; (5) 'S3 type' non-Levallois blade from the Intermediate layers; (6, 7) 'S1 type' non-Levallois blades from the Upper layers; (8) 'P1 and P2 type' non-Levallois blades from the Upper layers.

4. Discussion and conclusion

Despite the apparent substantial homogeneity of the Riparo Tagliente sequence, some differences can be observed in the reduction systems used. The main characteristics, common to the whole sequence, are the use of the Levallois concept and the production of elongated blanks. Other common features such as the presence, even though sporadic, of the Discoid and SSDA systems are shared by the Lower and Intermediate layers. This homogeneity, which is evident in the end-products, masks the presence of some differences, these mainly visible in the cores.

The greatest variability in the reduction systems used can be observed in the Lower layers (Figure 15). In the Intermediate and Upper layers, the fall in the number of reduction systems is replaced by an increase of the variability of the Levallois concept, which is expressed by means of the centripetal method as well as the convergent, bidirectional and preferential methods (Figure 15).

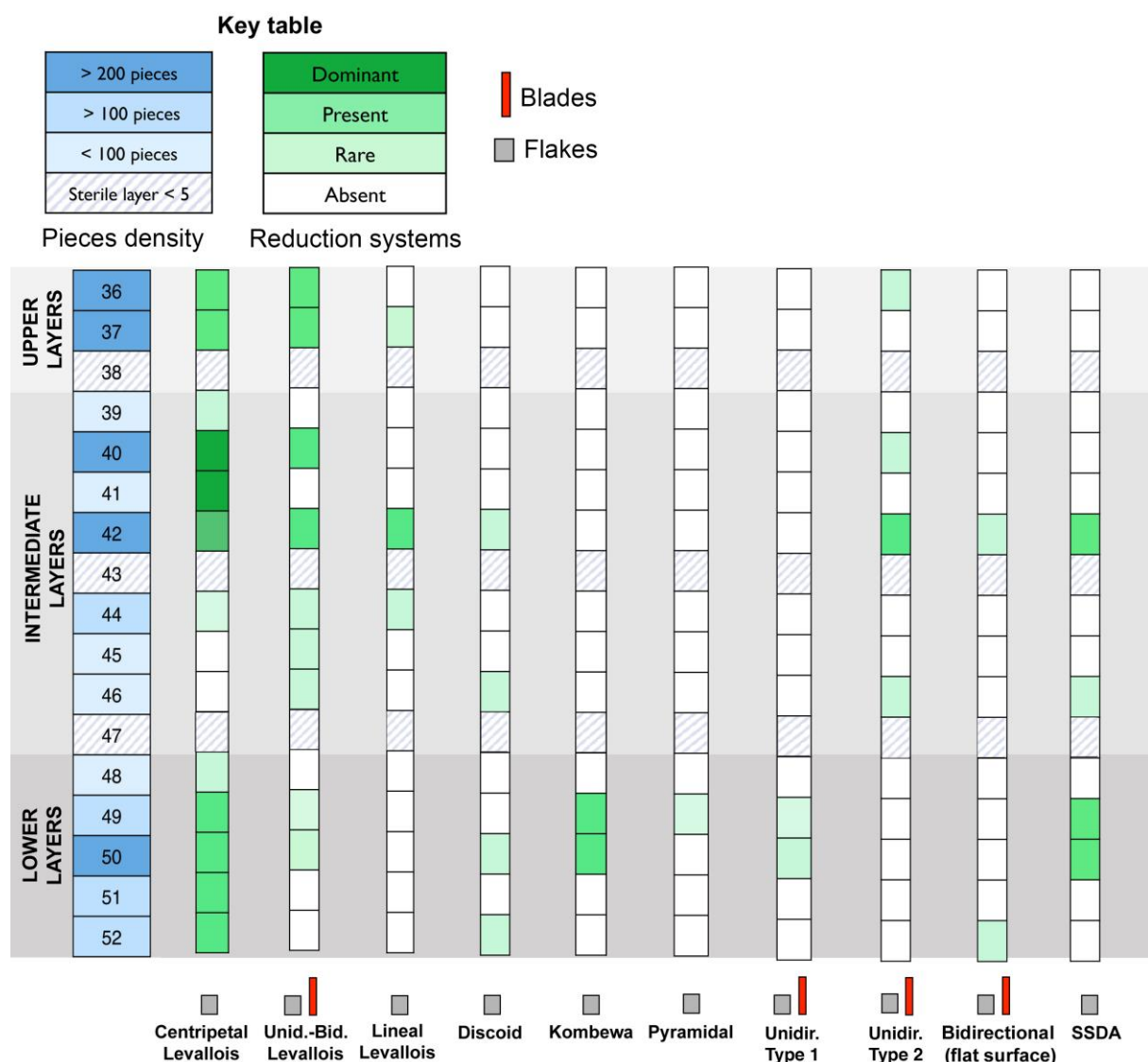


Figure 15. Riparo Tagliente. Frequencies of the reduction systems.

The retouched pieces only reveal minimal modifications of the cutting edges without altering the morphology of the flake nor the blade. Cortical flakes are the most affected and in this case underwent significant modification, while the products deriving from the main

débitage phases were seldom retouched. This can be linked to the anticipation of the variability of the end products for flakes as well as blades already preconceived in the production systems. This aspect emphasizes the substantial difference with the more standardized blade productions of the Upper Paleolithic where differentiation of tools is usually mostly achieved during the retouching phase. Based on our data, at Riparo Tagliente, Levallois and non-Levallois reduction systems coexisted producing elongated blanks, different in their morphological and technological characteristics as a direct result of the different reduction systems used to obtain them. Both reduction systems are aimed at producing blades and flakes rather than blades in a systematic way. This differentiation in production can be observed in the Levallois unidirectional and bidirectional end products as well as in the unidirectional Type 1 reduction system.

By observing the Riparo Tagliente sequence within the context of the Italian peninsula it is therefore possible to make a number of general observations (Figure 16).

The first observation is that the blade phenomenon in the Italian peninsula appeared at some point between MIS 4 and the beginning of MIS 3 and therefore later than in the south of France where blade production is first recorded as early as MIS 5 (Figure 16). The data from Riparo Tagliente fit well within this framework.

The second observation is that, as far as we know, there is no trace of local nor internal evolution. In fact, blade production seems to appear ‘simultaneously’ from north to south in the Italian peninsula and is always associated to other types of reduction systems of which the Levallois is the most common. (Figure 16).

As already noted for the rest of Europe, the production of blades did not entail a particular raw material preference. Blades were made from all types of raw materials (flint, chert, limestone, quartzite) and their different forms (pebbles, nodules, slabs, core flakes). Various reduction systems were used in the production of blades. Blades can be produced exclusively by means of a Levallois concept, as in the cases of Grotta di Castelcivita (Gambassini 1997), Riparo del Poggio (Caramia & Gambassini 2006), Barma Grande (Yamada 1997), and Riparo Mochi (Grimaldi & Santaniello 2014; Yamada 2004), or by ‘volumetric’ reduction systems, as is the case at the sites of Santa Croce (Arrighi et al. 2009), Grotta Reali (Arzarello et al. 2004; Peretto 2012), and Grotta del Cavallo (Carmignani 2010). Occasionally the two systems were used together as has been noted at Riparo dell’Oscurusciuto (Villa *et al.* 2009) and Riparo Tagliente (Arzarello & Peretto 2004; 2005).

In short we can observe how during the MIS 4 and MIS 3 there is widespread production of blades produced by means of original knapping systems or as in the case of the Levallois by a readjustment of this concept oriented towards the production of elongated products.

Given the current state of knowledge there is still much to be learnt concerning the causes of this technological change.

Middle Paleolithic blade productions cannot be considered as monolithic entities.

This ‘non universal’ phenomenon contrasts with other types of production systems such as the Levallois or the Discoid system, with which it coexisted and which contrastingly show a greater geographic diffusion and chronological continuity.

Understanding the role of blade production during Middle Paleolithic requires a systematic approach, which takes into account both the techno-functional aims and the evolution of the reduction systems.

Further research should be carried out on the following two issues:

- Concerning the appearance of blade production, are the diachronic differences noted between northern and southern Europe another case of a convergence phenomenon?
- Can we trace the origins of the Italian peninsula blade phenomenon in the oldest evidence found in southern France?

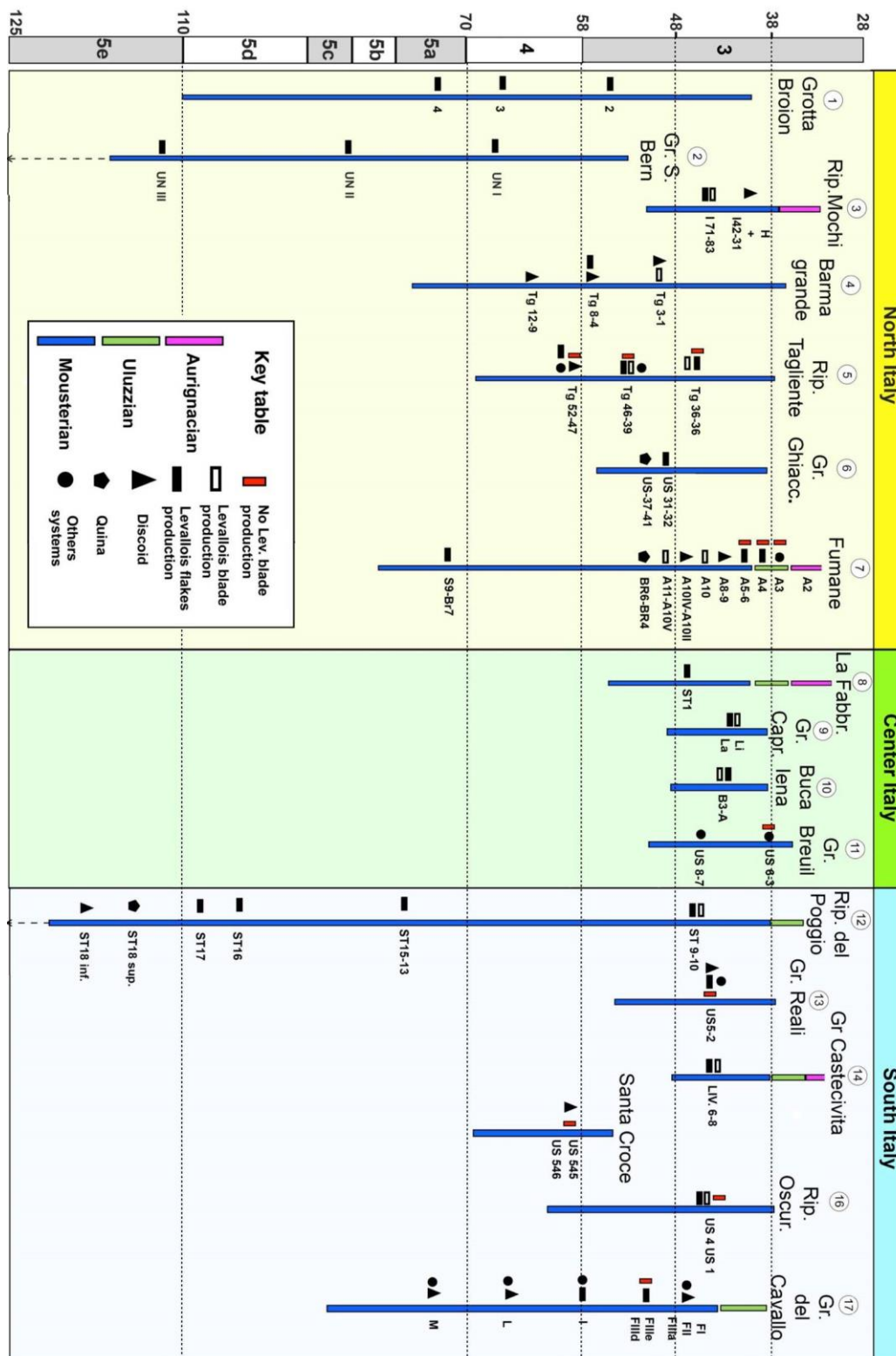


Figure 16. Reduction systems in the main Middle Paleolithic sites from MIS 5 to MIS 3 in the Italian peninsula. (1) Grotta del Broion (Peresani & Porráz 2004); (2) Grotta San Bernardino (Peresani 1995; 1996); (3) Riparo Mochi (Grimaldi & Santaniello 2014; Yamada 2004); (4) Barma Grande (Yamada 1997); (5) Riparo Tagliente (Arzarello & Peretto 2004; 2005); (6) Grotta Ghiacciaia (Bertola *et al.* 1999); (7) Fumane (Peresani 2012); (8) Grotta La Fabbrica (Dini *et al.* 2007); (9) Grotta del Capriolo (Dini & Koehler 2009); (10) Buca della Iena (Dini & Koehler 2009); (11) Grotta Breuil (Lemorini 2000; Grimaldi 1996); (12) Riparo del Poggio (Caramia & Gambassini 2006); (13) Grotta Reali (Peretto 2012); (14) Grotta di Castelcivita (Gambassini 1997); (15) Santa Croce (Arrighi *et al.* 2009); (16) Riparo Oscurusciuto (Boscatto *et al.* 2011); (17) Grotta del Cavallo (Carmignani 2010; Sarti *et al. in press*).

In order to provide answers to both these questions micro and macro regional comparisons of the various blade productions are urgently required in order to understand the blade phenomenon in both its wider and more local geographical context.

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