

Bladelet production, core reduction strategies, and efficiency of core configuration at the Middle Palaeolithic site Balver Höhle (North Rhine Westphalia, Germany)

Lamellenproduktion, Strategien der Kernzerlegung und Effizienz der Kerngestaltung an der mittelpaläolithischen Fundstelle Balver Höhle (Nordrhein Westfalen, Deutschland)

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ABSTRACT - In past years, the significance of bladelet production has become more and more important within the discussion about the transition from the Middle to the Upper Palaeolithic. The diversity of methods to produce bladelets is on the one hand used to identify chrono-cultural units and on the other hand to expose diachronic relations. However, the presence of blade and bladelet cores within Middle Palaeolithic assemblages can also be considered as evidence for the stable standard of technological knowledge. Within all horizons of the Balver Höhle (North Rhine Westphalia, Germany) numerous unidirectional bladelet cores were identified. They are embedded within a broad spectrum of core reduction strategies. Given configurations were used for bladelet production either ad hoc or with little preparation. In our opinion, such an approach should be seen as opportunistic.

By analysing the efficiency of the configuration of the reduction surfaces (of cores) it is possible to determine the efficiency of working processes in lithic production. In the case of the Balver Höhle the degree of efficiency seems to increase from the lowest to the upper horizon. For the future, correlations of the results of the efficiency analysis with ecological data may offer the possibility to reconstruct interactions between climatic conditions and the degree of efficiency of working processes in lithic production.

ZUSAMMENFASSUNG - In den letzten Jahren hat die Bedeutung der Lamellenproduktion in der Diskussion um den Übergang vom Mittel- zum Jungpaläolithikum zugenommen. Die Diversität der Methoden ihrer Produktion dient einerseits der Differenzierung chrono-kultureller Einheiten, andererseits der Darlegung von diachronen Bezügen. Das Vorkommen von Klinge- und Lamellenkernen in mittelpaläolithischem Kontext kann aber auch als Hinweis für den ausgeglichenen Stand technologischen Wissens gewertet werden. In allen Horizonten der Balver Höhle kommen mehrfach unidirektionale Lamellenkerne vor. Diese sind eingebettet in ein breites Spektrum der Grundformproduktion. Bestehende Gegebenheiten wurden entweder ad hoc oder mit wenig Präparation für die Lamellenproduktion genutzt. Diese Vorgehensweise spricht dafür, solche Lamellenkerne als opportunistisch abgebaute Kerne anzusehen.

Die Analyse der Effizienz der Gestaltung der Abbaufächen der Kerne erlaubt es, die Ökonomie von Arbeitsprozessen in der Steinbearbeitung zu untersuchen. Es deutet sich an, dass innerhalb der Balver Sequenz der Grad an Effizienz in der Kerngestaltung von den älteren zu den jüngeren Schichten hin ansteigt. Eine Korrelation der Ergebnisse der Effizienzanalyse mit Umweltdaten könnte in Zukunft Aussagen zum Zusammenspiel zwischen Klimabedingungen und der Ökonomisierung von Arbeitsprozessen in der Steinbearbeitung ermöglichen.

KEYWORDS - Middle Palaeolithic, core configuration, bladelet production, efficiency
Mittelpaläolithikum, Kerngestaltung, Lamellenproduktion, Effizienz

Introduction

The phenomenon of blade and bladelet production within Middle Palaeolithic assemblages is not a novelty.

Today, we know of numerous sites in Europe, the Near East, and Africa, where diverse strategies for the production of blades and bladelets were observed besides classic Middle Palaeolithic core reduction strategies (Bosinski 1966; Conard 1992; Révillion & Tuffreau 1994; Conard et al. 1995; Bar-Yosef & Kuhn 1999; Sáenz de Buruaga 2005; Maíllo Fernández et al.

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2004; Slimak & Lucas 2005; Fiedler 2009; Pastoors 2009). These sites date to a period that reaches from the end of MIS 6 to MIS 3 and thus covers most of the Middle Palaeolithic.

There is still a lively discussion about the significance of this observation, because blades and bladelets are traditionally closely linked to the Upper Palaeolithic and thus traditionally with anatomically modern *Homo sapiens*. Today many researchers agree that this relation between technological behaviour and biology cannot be made.

An opposing view has lately been proposed by Cabrera Valdés, Maíllo and others (Cabrera Valdés et al. 2006; Bernaldo de Quirós & Maíllo Fernández 2009). The fact that bladelet cores occur continuously from late Middle to early Upper Palaeolithic in Cantabria led them to establish the so-called welcoming hypothesis. In their opinion, "modern humans needed the help and knowledge of the Neanderthals in order to survive in the new European world. They were in dire need of information to locate raw materials, to hunt unfamiliar animals such as bison, reindeer and mammoth, or to find and take advantage away of the edible and other useful vegetables found in the forest. Modern humans also had to use their technical knowledge, similar in part to their own, in order to optimize their use of these resources" (Cabrera Valdés et al. 2006, 461–462).

In our opinion, this hypothesis has to be questioned, given the fact that the production of blades and bladelets was part of the conceptual reservoir (Weißmüller 1995) throughout the entire Middle Palaeolithic period. Rather, the occurrence of blade and bladelet cores in Middle Palaeolithic contexts, for example in Salzgitter Lebenstedt, should be seen as evidence for the required standard of technological knowledge during the entire Middle Palaeolithic (Pastoors 2009).

The question that has yet not been satisfyingly answered is why bladelets were produced (Slimak & Lucas 2005), although we can conclude that bladelets were not as important as in Upper Palaeolithic times. Middle Palaeolithic hunter and gatherers were not that interested in bladelets as blanks (Pastoors 2009). A bladelet was only one blank among several others. This view is supported by the less standardised mode of bladelet production and contrasts highly with the serial production of bladelets in the early and middle Upper Palaeolithic.

In his work on the Balver Höhle (North Rhine Westphalia, Germany), an important site for the development of the Keilmessergruppen, Günther (Günther 1964, 89; *ibid.* 80) mentioned a few prismatic cores within horizons Balve II and Balve IV. At that time archaeologists did not focus on the technological variability within lithic production systems. Günther focussed on taphonomic analysis of the site and a typological interpretation of the retouched tools; cores played a minor role (Günther

1964). Jöris simply announced a publication of an analysis of the lithic production system (Jöris 1993). Therefore it was absolutely essential to reconsider the lithic material of the Balver Höhle, and to analyse it with respect to the different applied methods of lithic production.

In the following, results will be presented and discussed against the background of bladelet production within the European Middle Palaeolithic.

Geographic setting and dating

The Balver Höhle is located in a Devonian limestone ridge in the Hönne valley, nearly 50 km southeast of Dortmund in North Rhine Westphalia (Fig. 1). The huge entrance opens to the northwest and leads to a simple cave of around 70 m in length. Since 1830, the phosphate rich cave sediments have been mined intensively for agricultural purposes (Günther 1964). Unfortunately, little is known about the archaeological potential of the destroyed fill from this period. The least poorly-preserved lower levels were partly excavated by Bahnschulte in 1939 and later by Günther in 1959. Since 2002 new investigations are underway under the direction of Baales (LWL -

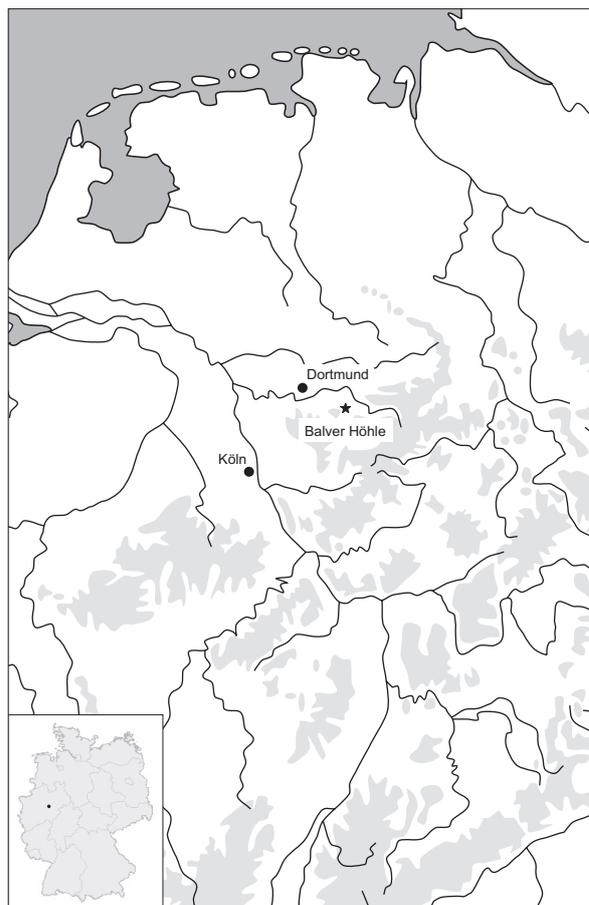


Fig. 1. Geographic location of the site Balver Höhle.

Abb. 1. Lage des Fundortes Balver Höhle.

Archäologie für Westfalen). All of these investigations have provided a sequence of several Middle Palaeolithic horizons; each attributed to the Keil-

messergruppen (Bosinski 1967, 2008; Günther 1964; Jöris 1992; Jöris 1993).

The major difficulty is to correlate the results of

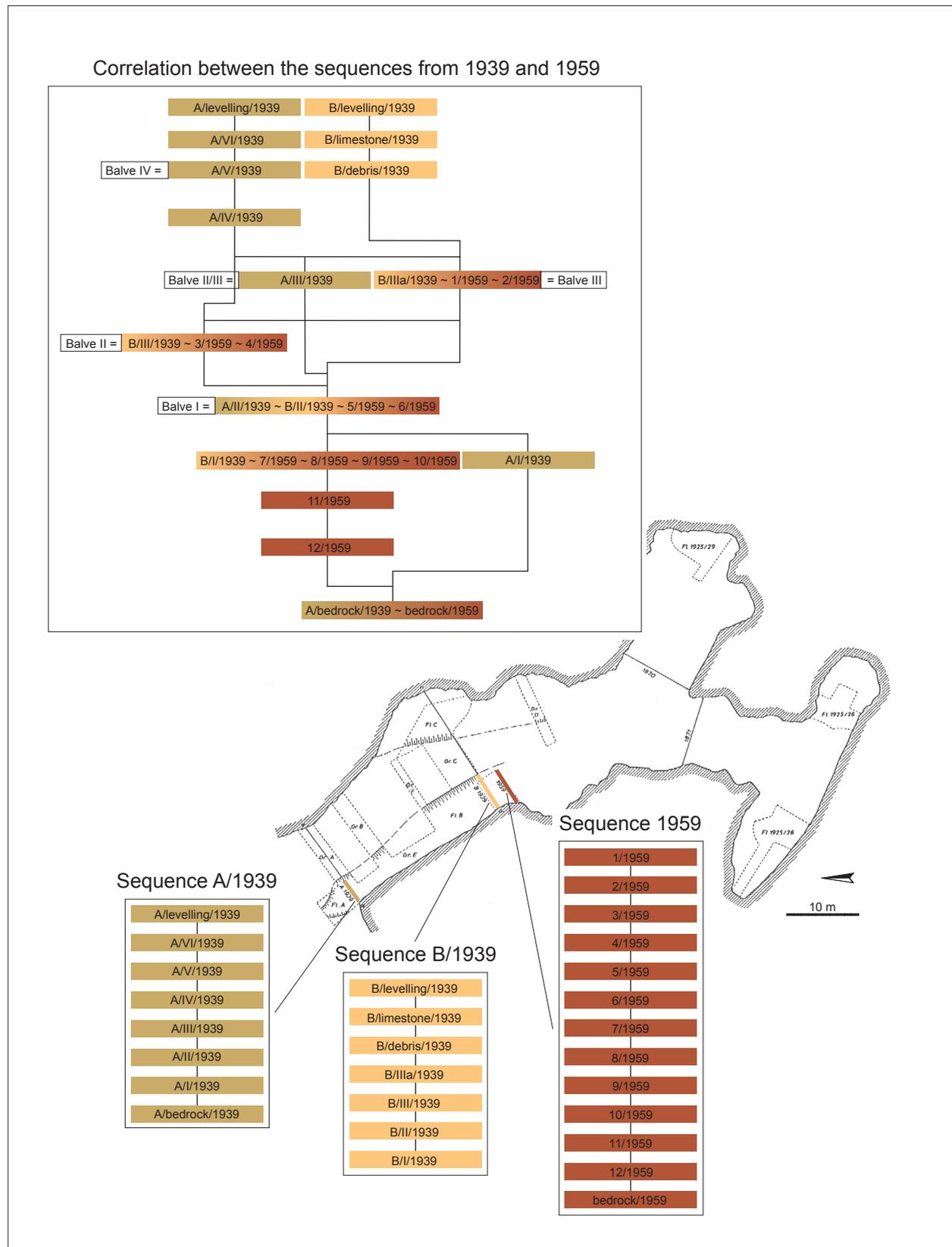


Fig. 2. Balver Höhle: Correlation between the complex stratigraphies of the different excavations.

Abb. 2. Balver Höhle: Korrelation der komplexen Stratigraphien der verschiedenen Ausgrabungen.

the different archaeological excavations. Günther has done important work to clarify the situation. The following correlation, depicted by the Harris Matrix below (Fig. 2), is based on his results (Günther 1964).

The assemblages of the different layers of the numerous excavation areas were subsumed within five horizons (Balve I, Balve II, Balve II/III, Balve III und Balve IV). The oldest horizon Balve I contains the archaeological material of layer 1959/6 (upper part), layer 1959/5, A/II and layer B/II. The following horizon Balve II comprises the assemblages of layer B/III/1939, B/III fine/1939 and layer 4/1959. Horizon Balve II/III includes the archaeological remains of the so-called Stoßzahnschicht (A/III/1939), which was discovered at the entrance. From a stratigraphical point of view, this layer can be solely placed between horizon Balve I and Balve IV. Layers B/IIIa/1939, 2/1959 and 1/1959/ lower part belong to horizon Balve III. Horizons Balve I to Balve III have been classified as Micoquian because of the presence of bifacial surface shaping (Günther 1964).

The assemblages of layers A/V lower part/1939 and A/IIa/1939 are part of the most recent horizon Balve IV, which hitherto has been classified as Mousterian, because of the quasi absence of bifacially surface-shaped artefacts (Günther 1964). Günther interpreted the 15 bifacially-worked artefacts discovered within this horizon as foreign elements, following the idea that Mousterian and Micoquian assemblages are mutually exclusive. Therefore he grouped those artefacts together as Balve IVa (opposing view: Richter 1997; Uthmeier 2004). Based on the archaeological material of horizon Balve IV, Bosinski defined the Mousterian type Balve IV (Bosinski 1967).

In contrast to that, Richter classifies all horizons of the Balver Höhle as belonging to what he called Mousterian with a Micoquian option (M.M.O.) (Richter 1997). On the basis of his work on the layer G stratigraphic complex (G-Komplex) of the Sesselfels-grotte, he discussed a model, defining conventional Mousterian and conventional Micoquian assemblages as functional occurrences.

Up to now, no absolute dates are available for the Balver sequence. The chronological interpretation

rests predominantly upon a sediment-analysis (Günther 1964, 59) linked with typological aspects of the lithic artefacts. Basically there are two opposing models that provide a different interpretation of the chronology of the Balver sequence.

On the one hand there are those (Günther 1964, 39; Bosinski 1967; Jöris 1992; Jöris 1993) who favour a long chronology with the Balver sequence beginning within the last Interglacial. According to Günther, layer 1959/6 can be connected with a phase of temperate climate, which Jöris would like to correlate with the Eemian Interglacial (Günther 1964, 50; Jöris 1992, 8). Of particular importance is layer A/IV/1939. Günther and Jöris parallel this sterile horizon, which contains a large amount of frost-debris, with the first glacial maximum of the last glacial complex. It separates the two horizons Balve II and Balve III from Balve IV (Günther 1964, 52; Jöris 1992, 8).

Richter advances an oppositional view. According to him, the first human activities at the Balver Höhle should be dated after the first glacial maximum of the last glacial complex, at least where horizon Balve II/III is concerned (Richter 1997, 245). Weißmüller also proposed a younger age for the Balver stratigraphy (Weißmüller 1995, 245 ff). He criticised Jöris's correlation of "the clay accumulation horizon, in which the oldest Micoquian (Balve I and Balve II) occurs, with the Eemian" and concludes that this point of view was only based "on the assumed age for the major layer of the Bockstein", which Weißmüller also calls into question (Weißmüller 1995, 245 ff). In his opinion, the lowest clay accumulation should be equated with the Eemian (layer 11/1959; series II, samples 2 und 3 see Günther 1964; Jöris 1992). Similar to the archaeological situation of the Sesselfels-grotte horizon (G-Komplex), Balve III would then be attributed to an Interstadial at the beginning of MIS 3 (Weißmüller 1995, 246).

Core configuration

Following Bar-Yosef and van Peer, we understand our work as a typological sorting of cores with technological descriptions of processes involved in core configuration (Bar-Yosef & van Peer 2009). Blanks themselves were not analysed because of their

horizon	Levallois				discoidal (%)	blade/ bladelet			Kom-bewa (%)	Type Pucueil (%)	opportunistic (%)	total
	preferential (%)	recurrent centripetal (%)	recurrent unidirectional (%)	recurrent bidirectional (%)		uni-directional (%)	bi-directional (%)					
Balve IV	2.2	7.2	3.6		5.8	15.8	0.7	0.7	10.8	2.2	51.1	139
Balve III		23.8	7.1	2.4	11.9	16.7			26.2		11.9	42
Balve II/III		11.8	5.9		17.6	41.2			5.9	5.9	11.8	17
Balve II	7.1	11.2	10.2	2.0	14.3	11.2	1.0		6.1	1.0	35.7	98
Balve I			66.7			33.3						3

Fig. 3. Balver Höhle: Relative portion of the different core reduction strategies.

Abb. 3. Balver Höhle: Relativer Anteil der verschiedenen Strategien der Grundformproduktion.

unequal documentation during the excavation history of the Balver Höhle. Drawings were made of all bladelet cores that were identified within the different, analysed collections. In addition to that for each horizon examples of the conceptual and methodological reservoirs are given.

Technological terms and definitions adhere mainly to the work of Boëda, Geneste and Meignen (Boëda 1990; Boëda 1994; Boëda et al. 1991; Delagnes & Meignen 2006; Révillion & Tuffreau 1994) and Delagnes for the unidirectional Le Pucueil-type flake method (Delagnes 1993).

In the course of our research we studied the collections of the Sauerland-Museum des Hochsauerlandkreises at Arnsberg, the LWL-Museum für Archäologie at Herne and the archive of the LWL Archäologie für Westfalen at Münster. A problem arose with the artefacts of horizon Balve III at Herne, where a distinction of the findings from the entrance (Balve II/III) and inner cave (Balve III) has not been made. That is why the cores of this collection (n=40) are excluded from our analysis.

A total of 304 cores from all five horizons were studied with most cores belonging to horizons Balve II and Balve IV (Fig. 3). This distribution correlates with the overall picture of artefact frequencies (Günther 1964, 121ff).

For the most part, lithic raw material for stone knapping is of local origin. Flinty slate is dominant with more than 90% within all assemblages, followed by Greywacke with percentages between 3% and 8%

(Günther 1964, 101). Outcrops of primary raw material are abundant in the immediate surroundings of the site and in addition to that, flinty slate and Greywacke constitute the two of the main components of the gravel from the small river Hönne. Flint artefacts are rare and regularly take up less than 1% within the respective assemblages. In the course of our research we classified the raw material concerning its quality into micro-grained, fine-grained and coarse-grained. For the most part micro-grained raw material of good quality was used. Raw material usage remains constant through the different horizons. A correlation between raw material quality and specific reduction concepts could not be drawn. Only in Balve II two cores of coarse-grained raw material were reduced following the discoid concept.

Within all horizons except Balve I, a broad range of different core reduction concepts and methods was identified (Fig. 3). Besides unidirectional bladelet methods, the recurrent Levallois methods (unidirectional, bidirectional and centripetal), the discoidal method, the Kombewa method and opportunistically-reduced cores were observed. The unidirectional Le Pucueil-type flake method, which is quite similar to the unidirectional bladelet one, is only absent in Balve II. Despite this homogeneity, each horizon is characterised by a specific frequency of concepts and methods. However, with only three cores in Balve I, conclusions cannot be drawn without difficulties. Opportunistically-reduced cores are predominant in Balve II (35.7%) and within Balve II/III unidirectional

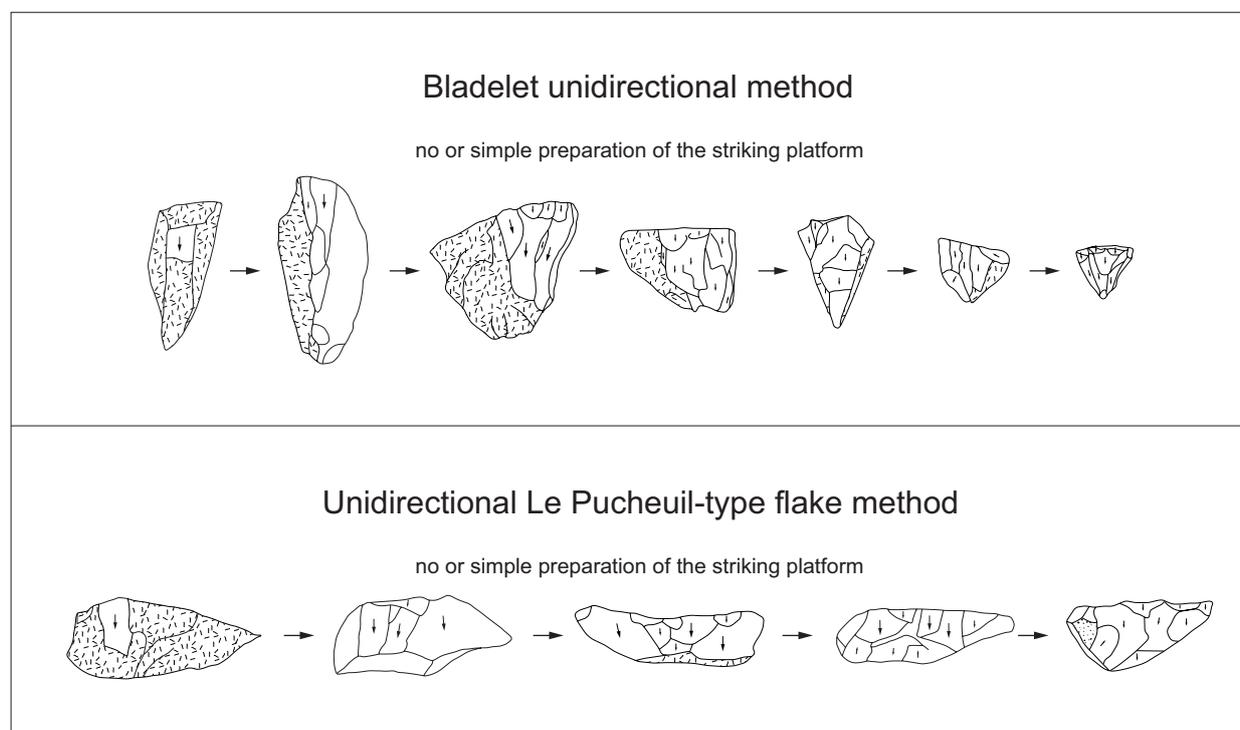


Fig. 4. Balver Höhle: Schema of core configuration. Bladelet unidirectional and unidirectional Le Pucueil-type.

Abb. 4. Balver Höhle: Schema der Kerngestaltung. Unidirektionale Lamellenkerne und unidirektionale Abschlagkerne Typ Le Pucueil.

bladelet cores dominate (41.2%). Balve III yielded nearly as many cores of the Levallois recurrent centripetal type (23.8%) as those of the Kombewa method (26.2%). Within Balve IV, opportunistically-reduced cores account for the largest part (51.1%). We do not interpret this heterogeneous distribution as cultural-chronological distinctions, but rather as evidence for functional differences or individual knapping preferences. These strategies of lithic reduction are too close. The spectrum within all horizons comprises the majority of known concepts and methods for lithic production (Delagnes & Meignen 2006).

Bladelet production

Besides the 47 cores from all studied horizons of the Balver Höhle that were reduced following the unidirectional bladelet method, only one single core represents the bidirectional bladelet method (Fig. 4, Fig. 6, Fig. 7, Fig. 8, Fig. 9 and Fig. 10). In the course of our analysis we include even very early stages of the core reduction in our counting. Most parts of all cores are covered with natural surfaces or negatives resulting from previous removal stages of unknown type. The back of the cores remain unprepared. Only some cores show a simple preparation of the striking platform; in most cases natural flat surfaces were used to strike the intended end products. The distal and lateral convexities of the exploitation surface were ensured by natural, unmodified surfaces with conver-

gent shoulders. During the bladelet production, the lateral convexity was maintained by oblique struck predetermined bladelets.

Within Balve III, the distal convexity was also realised by preparation from the distal part of the cores.

In Balve II/III, the ventral face of a blank was immediately used as striking platform and in horizon IV the lateral convexity was also prepared from the shoulder (Fig. 10: 1).

In all, we observe a very simple use of given configurations, which were either ad hoc or with little preparation used for bladelet production.

Within each of the horizons Balve I, Balve II and Balve IV, one single blade core was discovered, whereas only the one from Balve I shows a reduction following the unidirectional method. The two others revealed the bidirectional method. The fact that, from a technological point of view, these three cores cannot be distinguished from the bladelet cores demonstrates that the classification is of metric and not of conceptual quality.

Among the bladelet cores from Balve III, a unique combination of tool and core was found (Fig. 5). The flat and plain base of a biconvex hand axe was used as a striking platform to produce several bladelets on the edge. Existing convexities were used without preparation. The lateral convexity was maintained by obliquely struck predetermined bladelets. A single negative, providing a flat surface, was used as a striking platform. Interference between negatives of surface

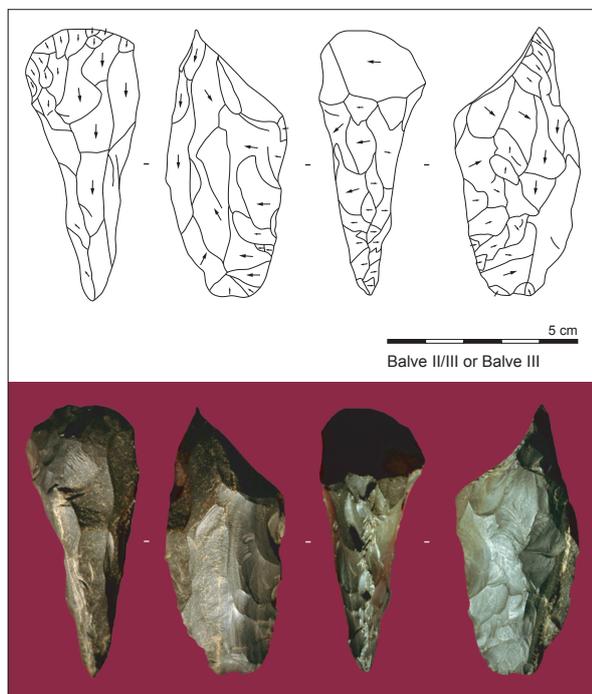


Fig. 5. Balve II/III or Balve III: Core configuration. Bladelet unidirectional core on biconvexe handaxe.

Abb. 5. Balve II/III oder Balve III: Kerngestaltung. Unidirektionaler Lamellenkern an bikonvexem Faustkeil.

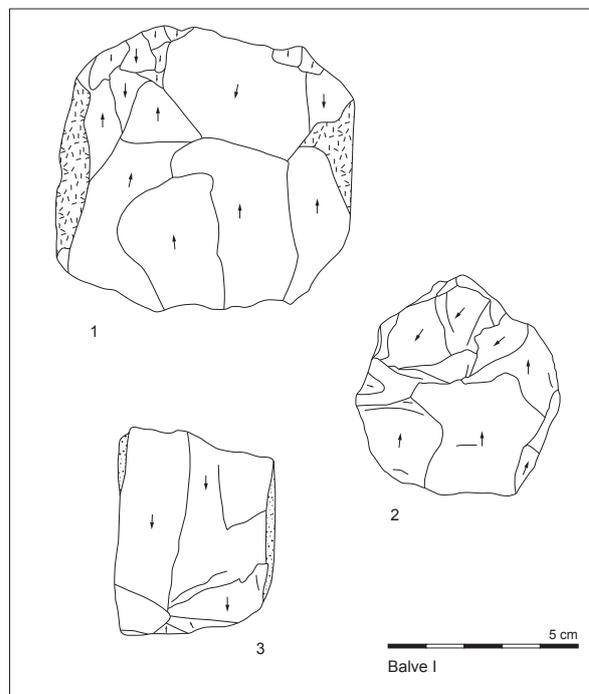


Fig. 6. Balve I: Core configuration. Levallois recurrent unidirectional (1-2) and blade unidirectional (3).

Abb. 6. Balve I: Kerngestaltung. Levallois recurrent unidirektionaler (1-2) und unidirektionaler Klingenkern (3).

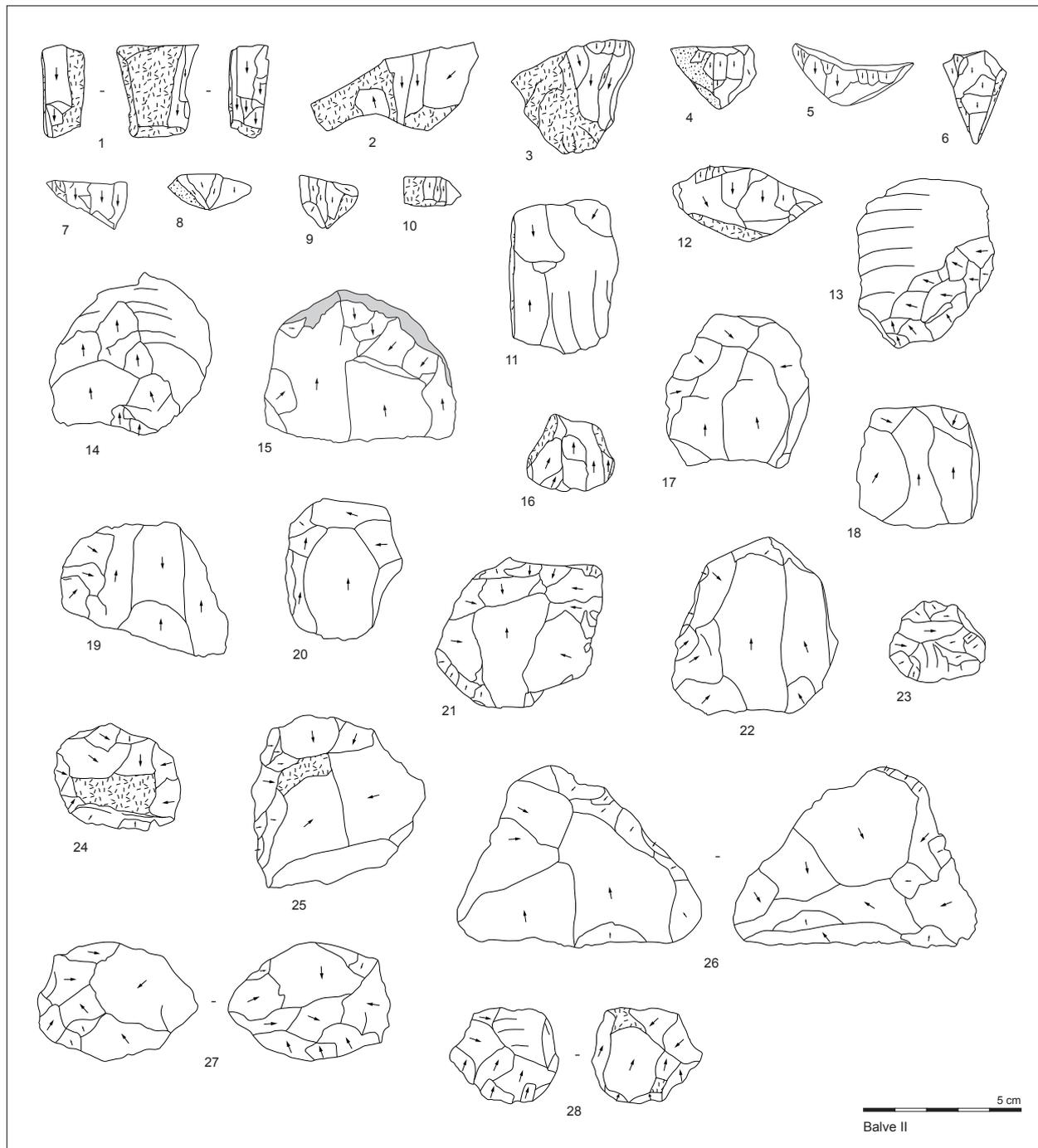


Fig. 7. Balve II: Core configuration. Bladelet unidirectional (1-10), blade unidirectional (11), unidirectional Le Pucueil-type (12), Kombewa (13-14), Levallois recurrent unidirectional (15-18), Levallois recurrent bidirectional (19), Levallois preferential unidirectional (20-22), Levallois recurrent centripetal (23-25) and Discoidal (26-28) - (grey shading = retouch).

Abb. 7. Balve II: Kerngestaltung. Unidirektionale Lamellenkerne (1-10), unidirektionaler Klingenkern (11), unidirektionaler Abschlagkern Typ Le Pucueil (12), Kombewa (13-14), Levallois recurrent unidirectional (15-18), Levallois recurrent bidirectional (19), Levallois preferential unidirectional (20-22), Levallois recurrent centripetal (23-25) und Diskoide (26-28) - (grau schattiert = Retusche).

shaping of the hand axe and débitage prove the simultaneous working process. The exact biography of the piece has not yet been reconstructed. The object shows substantial similarities with an artefact from the late Middle Palaeolithic site of Salzgitter Lebenstedt (Pastoors 2009).

Another piece of the collection of the Sauerland-Museums at Arnsberg combines a tool and core

function (Fig. 9: 20). On the distal working edge of a Pradnik-knife, bladelet negatives orthogonal to the intersection of the upper and lower surfaces can be observed. However these negatives do not create a new working edge. Therefore, a reworking purpose can be excluded. This artefact clearly demonstrates the double function of the distal thinning of Pradnik-knife and the Kostienki or Nahr Ibrahim thinning

(Slimak & Lucas 2005): Sharpening of the working edge and/or débitage of bladelets.

Flake production

Bladelet production at the Balver Höhle is embedded in each horizon into different methods of surface conception, including Levallois recurrent uni-, bidirectional and centripetal methods (Fig. 3). Furthermore discoid cores and opportunistically-reduced cores such as Kombewa ones are common. Interestingly, the Levallois preferential method is only present in Balve II and Balve IV. Levallois cores comprise 12.9% (n=18) in Balve IV, 33.3% (n=14) in Balve III, 36.4% (n=8) in Balve II/III and 30.6% (n=30) in Balve II. The number of cores in Balve I is too small for meaningful analyses (3 cores). This underlines the different importance of core configuration in the Balve horizons. Nevertheless, the majority of the cores are opportunistically-reduced ones. Within the assemblage of the Balver Höhle, we understand opportunistically-reduced cores to include bladelet and blade ones, as well as the unidirectional Le Pucueil-type, Kombewa ones, and cores that show a flexible handling of the lithic material, without the application of a distinguishable method. In total we recognised 81.3% (n=113) in Balve IV, 54.8% (n=23) in Balve III, 50.0% (n=11) in Balve II/III and 55.1% (n=54) in Balve II. Generally, natural

surfaces are integrated into the conceptual preparation of all cores.

The lithic production systems of the different horizons will be described together or separated dependent on their similarities in the specific application of the different concepts.

Levallois recurrent methods

The Levallois recurrent unidirectional method was observed in each horizon of the Balver Höhle, though its realisation appears heterogeneous.

Balve I: The two cores that are configured according to the Levallois recurrent unidirectional method in Balve I show natural surfaces with single negatives on the lower side of the core, or a completely prepared lower surface, which serves as striking platform for the preparation of the reduction surface (Fig. 6: 1 and 2). Distal preparation and lateral éclats débordants establish the required convexities on the reduction surface. The striking surface is smoothly prepared.

Balve II: As in Balve I, the lower sides of the cores are characterised by the presence of natural surfaces with single negatives or a completely prepared surface, serving as a striking platform for the preparation of the upper side (Fig. 7: 15-18). The required convexity of the reduction surface is established by preparation from the distal end as well as from lateral, via éclats débordants or centripetal flaking. The confi-

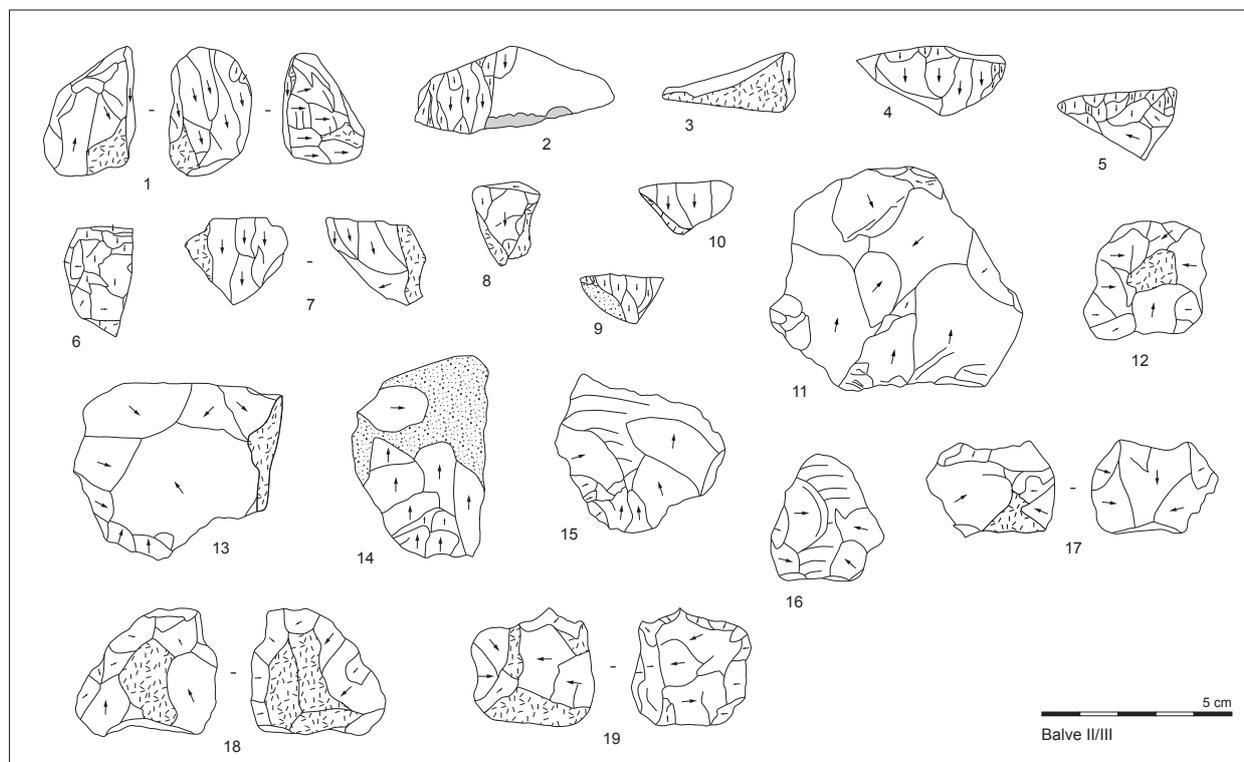


Fig. 8. Balve II/III: Core configuration. Bladelet unidirectional (1-10), Levallois recurrent centripetal (11-13), Levallois recurrent unidirectional (14), Kombewa (15-16) and Discoidal (17-19) - (grey shading = retouch).

Abb. 8. Balve II/III: Kerngestaltung. Unidirektionale Lamellenkerne (1-10), Levallois recurrent centripetal (11-13), Levallois recurrent unidirectional (14), Kombewa (15-16) und Diskoide (17-19) - (grau schattiert = Retusche).

guration of the striking platform does not follow a single pattern. Either natural surfaces or a single negative were used, or a smooth or rough preparation can be recognised.

Balve II/III: In this horizon, only one single core was observed, following the Levallois recurrent unidirectional method (Fig. 8: 14). The dorsal surface of a flake was used as reduction face. For ensuring the distal convexity, a natural surface was integrated in the configuration of the core. Éclats débordants maintain the lateral convexities. A single negative serves as the striking platform.

Balve III: Similarly to Balve I and Balve II, cores show natural surfaces with single negatives on the lower side or a fully-prepared surface that serves as striking platform to establish the convexities on the upper side (Fig. 9: 8 and 9). On the one hand, the distal convexities are realised by preparation from the lateral edges and on the other hand by absorbing old negatives. Éclats débordants and preparation from the lateral edges ensure the lateral convexity. The striking platform was only roughly prepared.

Balve IV: The lower sides of the cores of Balve IV are formed by joint planes (Fig. 10: 29-31). The distal

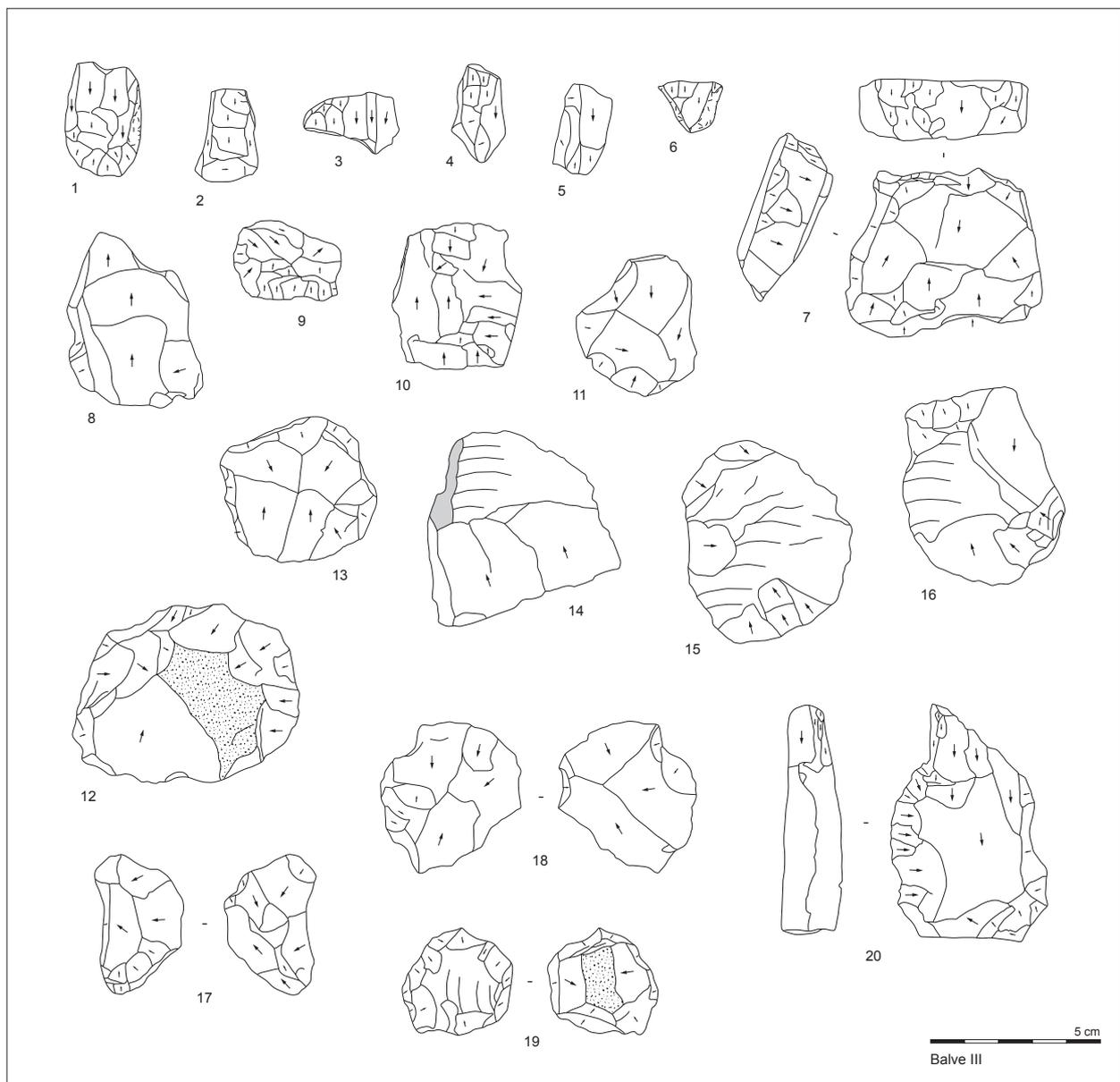


Fig. 9. Balve III: Core configuration. Bladelet unidirectional (1-6), unidirectional Le Pucheuil-type (7), Levallois recurrent unidirectional (8-9), Levallois recurrent bidirectional (10), Levallois recurrent centripetal (11-13), Kombewa (14-16), Discoidal (17-19) and unidirectional bladelet core on Pradnikknife (20) - (grey shading = retouch).

Abb. 9. Balve III: Kerngestaltung. Unidirektionale Lamellenkerne (1-6), unidirektionaler Abschlagkern Typ Le Pucheuil (7), Levallois recurrent unidirectional (8-9), Levallois recurrent bidirectional (10), Levallois recurrent centripetal (11-13), Kombewa (14-16), Diskoide (17-19) und unidirektionale Lamellenkern an Pradnikmesser (20) - (grau schattiert = Retusche).

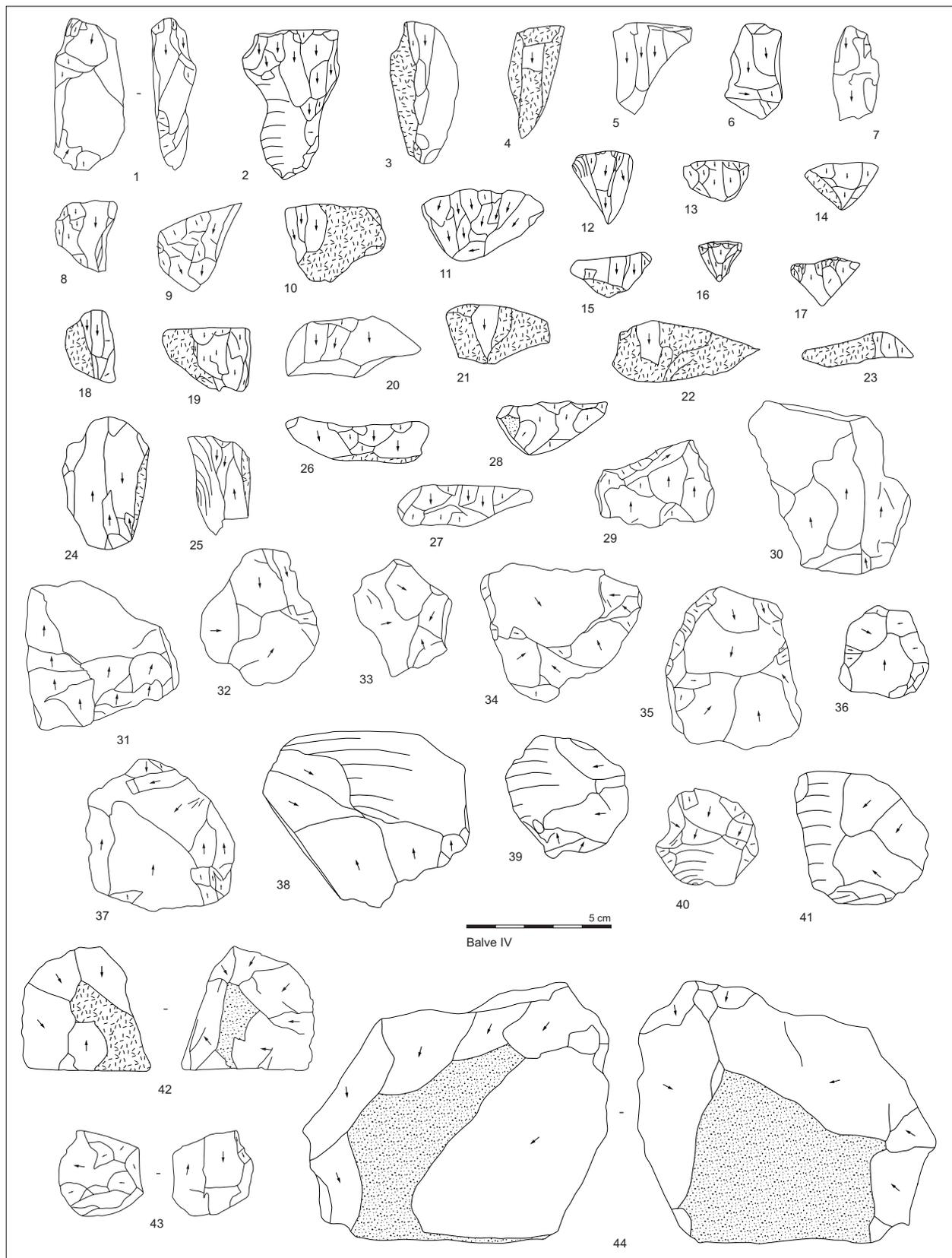


Fig. 10. Balve IV: Core configuration. Bladelet unidirectional (1-23), blade bidirectional (24-25), unidirectional Le Pucueil-type (26-28), Levallois recurrent unidirectional (29-31), Levallois recurrent centripetal (32-35), Levallois preferential unidirectional (36-37), Kombewa (38-41) and Discoidal (42-44).

Abb. 10. Balve IV: Kerngestaltung. Unidirektionale Lamellenkerne (1-23), bidirektionale Klingenkern (24-25), unidirektionale Abschlagkerne Typ Le Pucueil (26-28), Levallois recurrent unidirectional (29-31), Levallois recurrent centripetal (32-35), Levallois preferential unidirectional (36-37), Kombewa (38-41) und Diskoide (42-44).

convexity was prepared from the distal end or ensured by integrating old negatives. The lateral convexity was realised differently: With the help of éclats débordants, by preparation from the lateral edges and by integrating natural joint planes. No effort was made to prepare the striking platform. Either unprepared surfaces or single, large negatives were used.

Only three cores attest an exploitation following the Levallois recurrent bidirectional method. Two of the cores belong to Balve II and one to Balve III.

Balve II: One core shows a completely prepared lower surface (Fig. 7: 19). The second core is characterised by the presence of natural plane surfaces with single preparation on the lower side. The distal convexity of the reduction surface was established by preparation from the lateral and the distal edges, whereas the lateral convexity of the reduction surface was realised either by preparation from lateral, by opposing end-products or by éclats débordants. The striking platforms show a smooth and rough preparation, although in some cases no preparation was observed.

Balve III: The only Levallois recurrent bidirectional core of this horizon shows natural surfaces on the lower side (Fig. 9: 10). The distal convexity of the reduction surface is ensured by lateral preparation as well as by the contre bulbe of opposing negatives. In addition to that, the lateral convexity is established by preparation from the lateral edges and by éclats débordants. A rough preparation of the striking platform can be observed.

Cores that show exploitation following the Levallois recurrent centripetal method were found in all horizons (except Balve I) of the Balver Höhle (Fig. 7: 23-25, Fig. 8: 11-13, Fig. 9: 11-13 and Fig. 10: 32-35). This concept was applied in a very similar way: The lower side of the core was covered by natural surfaces supplemented by single or complete preparation. The distal as well as the lateral convexity of the reduction surface is ensured by centripetal end-products. The striking platform is smoothly or roughly prepared. Variations of this basic method are present in each horizon. Within Balve II and Balve IV, plane joint surfaces cover the lower side of the cores. Within Balve II/III, a second reduction surface constitutes the lower side of the core. Natural surfaces are integrated within the configuration of the distal convexity of the reduction surface within Balve II/III and Balve III (Fig. 8: 12 and Fig. 9: 12). In addition to that, a secondary lateral preparation realising the lateral convexity can be observed within Balve II (Fig. 7: 23) and a single negative served as striking platform within Balve II/III.

Levallois preferential method

Interestingly, cores following the Levallois preferential method were only found within Balve II and Balve IV (Fig. 7: 20-22 and Fig. 10: 36-37). The lower surfaces of the cores are generally prepared completely; apart

from that covered by natural surfaces or sporadically prepared. The distal convexity is realised by lateral preparation. Whereas within the assemblage of Balve II, the preparation was additionally performed from the distal edges; within Balve IV, the natural convexity of a given surface was used. The preparation from the lateral edges ensured the lateral convexity. Similar to the organisation of the distal convexity, a natural surface was integrated in the configuration of the lateral convexity within Balve IV. Striking platforms show a rough preparation; in addition to that, no preparation or only one single negative serving as striking platform was observed within Balve II.

Discoidal method

Discoidal cores are characterised by the presence of two opposing reduction surfaces. Unifacial discoidal cores, as described by Duran at the site of Arbreda (Duran 2006), have been classified here as Levallois recurrent centripetal cores, because of the clear differentiation between reduction surface and lower surface of the cores. Within Balve II/III, remains of natural surfaces are still visible on the cores; they were integrated within the conceptual configuration of the cores (Fig. 8: 17-19).

The distal as well as the lateral convexities were ensured by centripetal end-products and by making use of natural surfaces. No effort was made to prepare the striking platform; generally a single negative was considered sufficient. Only within Balve II and Balve III was the striking platform roughly prepared (Fig. 7: 26-28 and Fig. 9: 17-19).

Within the assemblages of Balve II/III and Balve IV, a few discoidal cores were documented that possess a plane surface on one edge (Fig. 8: 17-19 and Fig. 10: 42-44). They resemble discoidal cores from El Castillo and Cueva Morín, which were configured in a similar way (Cabrera Valdés et al. 2006).

Opportunistic methods

Besides the unidirectional bladelet and blade methods, two other core reduction strategies that make ad hoc use of naturally-given conditions were documented within the different horizons of the Balver Höhle and classified as opportunistic (Fig. 3, Fig. 7: 12, Fig. 9: 7 and Fig. 10: 26-28). Those include the unidirectional Le Pucueil-type flake method and the Kombewa one.

The cores exploited following the unidirectional Le Pucueil-type flake method are based on the utilisation of edges of more or less thick raw pieces (maximum of 20 mm). The lower surfaces of the cores are either covered by old negatives or naturally planar surfaces. The end-products were manufactured almost perpendicular to the striking platform. Whereas the lateral convexity is ensured by sloping end products, the preparation of the distal convexity is of no importance because of the shortness of the reduction surface. In addition to that no effort was

made to prepare the striking platform. The ventral face of a flake or, as in Balve II, a single negative was used.

All in all, in contrast to the unidirectional bladelet method of the Balver Höhle two convergent surfaces were not used as the reduction surface, but an isolated, straight edge (Fig. 4). This is very similar to a backed retouch. This procedure consequently leads to the production of quadratic, short-broad flakes.

The Kombewa cores do not show specific characteristics (Fig. 7: 13-14, Fig. 8: 15-16, Fig. 9: 14-16 and Fig. 10: 38-41). Only within Balve II was the distal convexity of the reduction surface additionally prepared from the distal end, and the lateral convexity from the lateral edges. In all horizons, natural surfaces served as striking platforms; one single negative was used in Balve II and Balve IV; rough preparation was documented among the cores of Balve III and Balve IV and smooth preparation was only observed within Balve III.

Although the cultural-chronological classification of the different Balver horizons is not our main focus, it seems necessary to comment on the proposals published by Richter whereby core reduction strategies are of substantial importance in his argument (Richter 1997). At first it has to be noted, that the different horizons of the Balver Höhle are indeed comparable to those of the G-Komplex of the Sesselfelsgrötte. As the different inventories of the Sesselfelsgrötte the different lithic assemblages of the Balver Höhle contain four principal components: Bifacial tools, microlithic tools, Upper Palaeolithic tools, standard Mousterian tools (Richter 2001, 209) and can therefore be classified as Mousterian with Micoquian option (M.M.O.) (Richter 1997; 2001). In addition to that Richter argues, that the Balver stratigraphy displays the succession of M.M.O. - A (older Mousterian with a Micoquian option) and M.M.O. - B (younger Mousterian with a Micoquian option) (Richter 1997, 244). Therefore Balve II/III is classified as M.M.O. - A1 and Balve IV as M.M.O. - B3. „If the difference between Balve-IIIa/Günther [here Balve II/III: our annotation] and Balve-IIIb/Günther [here Balve III: our annotation], indicated by the different mode of preparation of the striking platform, resulted from an alternation between an exploitation following a non-Levallois strategy and a Levallois recurrent centripetal method, even a sequence of M.M.O. - A1 - M.M.O. - A2 or - B1 would be proven“ (Richter 1997, 244). For us the classification as M.M.O.-A seems to be problematic. This phase is characterised by the application of the Quina concept, which, however, was not identified in one of the different Balver horizons (Richter 1997, 243). According to our results we cannot approve the classification of horizon Balve IV as M.M.O. - B3; besides the Levallois recurrent centripetal method, other Levallois methods were recognised. If a correlation between the different horizons of the Balver Höhle was intended, all horizons would be

classified as either M.M.O. - B1 or M.M.O. - B2 (see Richter 1997, 243).

Efficiency of the core configuration

The discussion about the determination of the economic value of the different core reduction strategies has a long tradition, and is held on different levels. On the one hand, some argue that the value can be deduced from the degree of schematisation of the working processes. It concerns the production of blanks as well as their subsequent processing to retouched tools (Hering & Kraft 1932; Feustel 1985). On the other hand, the degree of exploitation of a given raw material volume is considered. In addition to that, the amount of waste products, and the number of intended end-products are seen as indicators as well (Brantingham & Kuhn 2001; Pasda 1998; Uthmeier 2004), as also the cumulative length of the produced sharp edges of the blanks (Leroi-Gourhan 1964; 1988).

The cost-benefit ratio is of special importance in evaluating the efficiency. This ratio serves as a parameter to calculate the efficiency of the core configuration. We can talk of efficiency if given costs benefits are maximised or if given benefit costs are minimised. It is a measurement of cost-effectiveness, a cost-benefit relation. The methods applied so far lead towards this direction (Brantingham & Kuhn 2001; Pasda 1998; Uthmeier 2004), thereby varying only slightly in their methodological approach. Basically, the blanks are classified and quantified; cores are not taken into account.

Thereby Brantingham and Kuhn's approach serves as a basis "the sum of the amount of waste in preparing one or more striking platforms and the primary reduction surface" (Brantingham & Kuhn 2001, 752). The ultimate phase of blank production is not considered. In addition to that, the shape of the raw nodule influences the effort that has to be invested in the preparation of the core. Bulky raw nodules need more intensive preparation than fluvial gravels.

Although the method of Pasda includes the phase of blank production, flakes are in principle assigned to the preparation phase (Pasda 1998); cores are ignored.

Uthmeier distinguishes between predetermined and predeterminant preparational flakes and the predetermined end-products (Uthmeier 2004). With the help of a so-called extraction-analysis, he calculates the efficiency of the blank production phase. Similar to the method applied by Pasda, cores are excluded. This seems to be problematic, because especially the Upper Palaeolithic end-products are likely to be taken away or to be transformed. That is why, in our opinion, the cores should be the focus of interest. Rightly one has to admit that by concentrating on the cores, the absolute number of blanks

core reduction strategie	end-product		end-product		preparation		n
	exploiting convexity		holding up convexity		providing convexity		
	μ (%)	σ	μ (%)	σ	μ (%)	σ	
unidirectional bladelet	15.3	26.9	72.6	29.5	12.1	17.2	75
unidirectional flake method type	25.0	29.9	59.5	31.6	15.6	16.9	42
Le Pucueil							
discoidal with flat base	1.1	4.4	78	19.5	21	18.7	17
discoidal	1.6	11.1	73.9	16.9	24.5	15.7	46
Levallois recurrent centripetal	1.6	7.1	64.1	22.2	34.4	20.1	173
Levallois recurrent bidirectional	22.1	19.8	42.1	27.5	35.7	25.1	10
Levallois recurrent unidirectional	26.2	18.5	22.6	25.7	51.3	26.5	54
Levallois preferentiel	14.9	7.5	0.8	2.9	84.6	7.3	27

Fig. 11. Different Middle Palaeolithic sites: Relative amount of different negative types on the reduction surfaces of divers core reduction strategies; (μ = mean, σ = standard deviation).

Abb. 11. Verschiedene mittelpaläolithische Fundstellen: Relativer Anteil der verschiedenen Typen von Negativen auf den Abbaufächen der Kerne verschiedener Strategien der Grundformproduktion; (μ = Mittelwert, σ = Standardabweichung).

cannot be measured; but this is not the intention. An analysis of the exploitation of a given raw material volume in the sense of a maximisation of the outcome

(end-products or sharp edges) does not take place. In fact, the efficiency of the working processes of core configuration is to be analysed. We claim that the

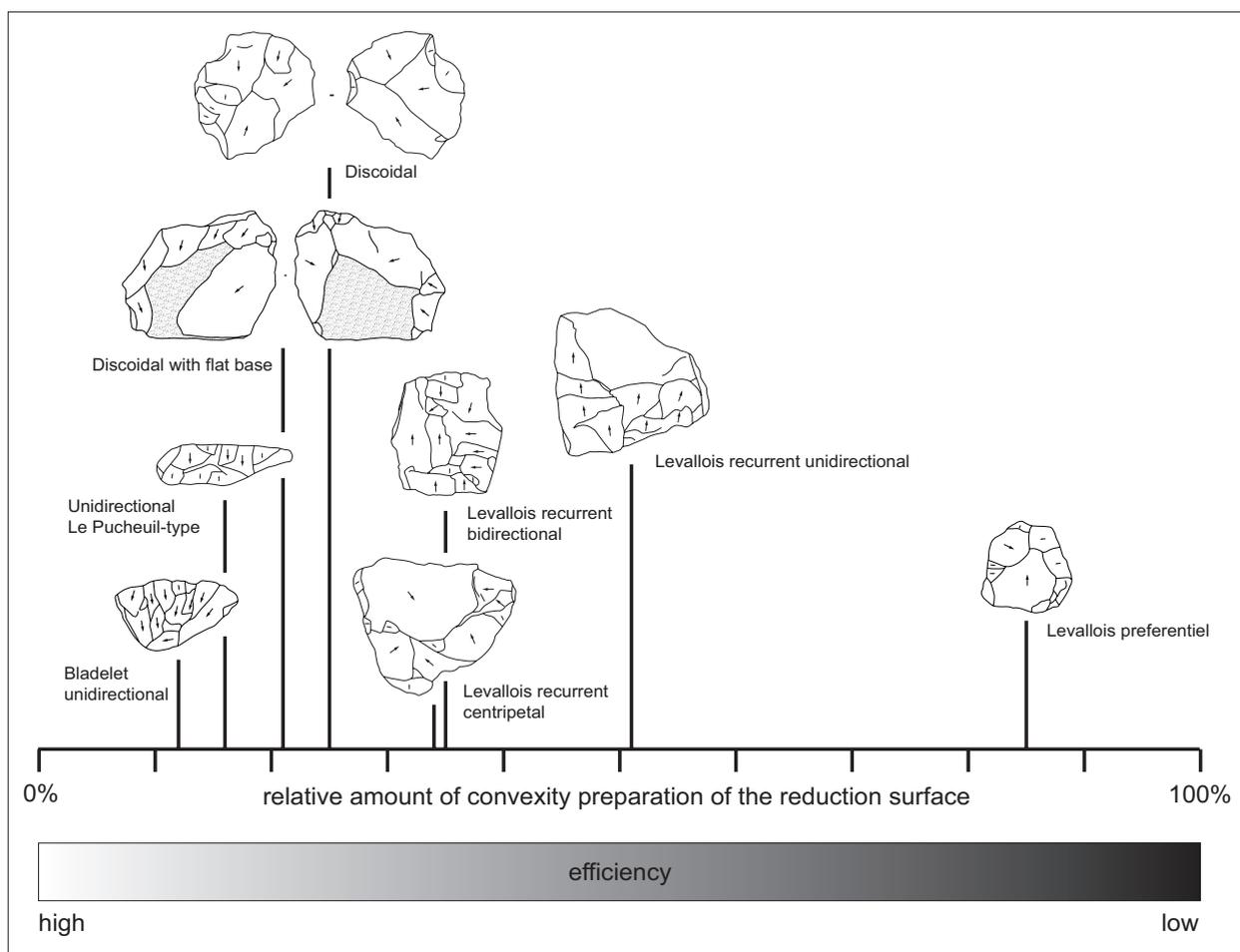


Fig. 12. Different Middle Palaeolithic sites: Efficiency of configuration of the reduction surface of main core reduction strategies.

Abb. 12. Verschiedene mittelpaläolithische Fundstellen: Effizienz der Gestaltung der Abbaufächen bei den wichtigsten Konzepten und Methoden der Grundformproduktion.

degree of efficiency reflects the tenor of how lithic raw material is handled. This tenor however is influenced by external factors, such as general living conditions. It is supposed, that a high pressure to survive assists people in organising working processes more efficiently in all areas and is therefore reflected in stone technology. The reduction surfaces of the cores are of analytic interest. The negatives thereon are divided into preparational flakes that provide convexity (predetermining), end-products that profit from the convexity (predetermined) and end-products that establish convexity (predetermined and predetermining), and then quantified. The degree of efficiency of the working processes, stored in the different reduction surfaces of the cores, can be determined from the relative ratio of the different types of negatives. Thereby the intensity of preparation for establishing the required convexities is seen as a parameter for the efficiency of the working process. The results can be used for diachronic as well as for isochronic analysis of the core reduction strategies.

Within the framework of a project that was funded by the German Science Foundation (DFG), cores from Middle Palaeolithic, transitional and early Upper Palaeolithic industries were analysed following the method described above. The results indicate a broad variety of the degree of efficiency of working processes. A total of 444 cores of the sites of Salzgitter-Lebenstedt (Germany), Balver Höhle/ I - IV (Germany), Cueva Morín/ 13 - 9 (Spain), El Castillo/ 22 - 16 (Spain), Jarama VII/ III - I (Spain), Arbreda/ 39 - 23 (Spain) und Abri Romani/ I - A (Spain) were studied (Tode 1982; Pastoors 2001; Günther 1964; González Echegaray & Freeman 1971; 1973; 1978; Cabrera Valdés 1984; Maíllo Fernández & Baquedano 2006a; 2006b; Zilhão 2006; Soler Masferrer & Maroto 1987; Vaquero 1997). The degree of efficiency of the configuration of the reduction surfaces can be deduced from the relative portion of the preparation for establishing the required convexity. Its percentage varies considerably within the analysed cores from 12% (unidirectional bladelet method) to 85% (Levallois preferential method) (Fig. 11, Fig. 12). It becomes apparent that the methods of surface

conception display a lower degree of efficiency, due to the high effort that has to be invested in the preparation of the reduction surfaces than the methods of volumetric conceptions. This is not surprising; it is rather a proof for the validity of the applied method. The large separation between the Levallois preferential method and the other core reduction strategies is astonishingly pronounced (Fig. 12). The Levallois recurrent methods are placed between the volumetric concepts (unidirectional bladelet, unidirectional Le Pucueil-type flake method and discoidal) and the Levallois preferential method. The observation that the discoidal method displays a high degree of efficiency allows the analysis of the changes in the economisation of working processes of stone technology, not only at the transition from the Middle to the Upper Palaeolithic, but also during the entire Middle Palaeolithic.

A comparison of the values for the discoidal, Levallois recurrent unidirectional, Levallois recurrent centripetal and unidirectional bladelet core reduction strategies of the different horizons of the Balver Höhle with the results of the general analysis displays a higher degree of efficiency for the discoidal and Levallois recurrent unidirectional methods at the Balver Höhle (Fig. 13). A similar degree of efficiency can be observed with the Levallois recurrent centripetal and the unidirectional bladelet method.

A diachronic analysis shows a change from a lower degree of efficiency in Balve II towards a high degree of efficiency in Balve IV (Fig. 13) with no change in the selected raw material. This overall tendency in the horizons of the Balver Höhle is also reflected within the different discoidal, Levallois recurrent centripetal and unidirectional core reduction strategies. Only the cores that follow the unidirectional bladelet method display another picture. Within Balve II, the degree of efficiency is very high and declines to a level that remains consistent in the overlying horizons. By comparison, both discoidal and especially unidirectional bladelet core reduction strategies exhibit the highest degree of efficiency.

On the basis of the compiled data within the DFG project presented above the possibility arises to correlate the results of the efficiency analysis with

horizon	all core reduction strategies			discoidal (with and without flat base)			Levallois recurrent centripetal			Levallois recurrent unidirectional			unidirectional bladelet		
	μ (%)	σ	n	μ (%)	σ	n	μ (%)	σ	n	μ (%)	σ	n	μ (%)	σ	n
Balve IV	16.4	21.3	53	13.3	16.2	8	24.8	19.3	10	0	0	5	11.1	17.7	23
Balve III	27.7	18.9	26	16	9.5	5	38.5	13.8	10	37.7	33.3	3	14.9	14.5	7
Balve II/III	23.6	17.1	21	18.3	16.1	3	35.9	6.8	7			1	13.5	19.8	8
Balve II	35.5	30.1	60	27.9	17.7	14	48.3	16.9	11	45.6	27.4	10	1.3	4.7	13
Balve I	49	9.5	3							43.5	0.9	2			

Fig. 13. Balver Höhle: Amount of convexity preparation of the reduction surface of different core reduction strategies; (μ = mean, σ = standard deviation).

Abb. 13. Balver Höhle: Anteil der Präparation der Konvexität auf den Abbaufächern der Kerne von verschiedenen Strategien der Grundformproduktion; (μ = Mittelwert, σ = Standardabweichung).

paleo-ecological data in order to analyse the interaction between climatic conditions and the economisation of working processes. Therefore a data base comprising a sufficient set of statistically relevant data of the lithic as well as the faunal remains and corresponding climate data is needed. To the authors it seems possible that specific ecological circumstances may force people to process resources more efficiently. As for the Balver Höhle no updated climate data are available and the attribution of the faunal remains to the different horizons is in most cases uncertain (Kindler 2007) such an analysis can unfortunately not be conducted at the moment.

Discussion

The discussion about technological innovations at the transition from the Middle to the Upper Palaeolithic has a long tradition (Obermaier 1912), and is consequently seen as a key factor for our understanding of this period. Within this context, the bladelet has become more and more important over the past years, as revealed by numerous publications concerned with this topic (see Bon et al. 2002; Le Brun-Ricalens 2005; Maíllo Fernández et al. 2004). Different methods of bladelet production seem to be of great value for the differentiation of the early phases of the Aurignacian (Bon 2006; Teyssandier 2008). However, the bladelet production described for some late Middle Palaeolithic sites is interpreted in different ways. The observed continuity is, on the one hand, seen as evidence for the transfer of specific technological knowledge (Cabrera Valdés et al. 2006; Maíllo Fernández et al. 2004; Bernaldo de Quirós & Maíllo Fernández 2009); on the other hand, only as part of the overall spectrum of technological knowledge within the entire Middle Palaeolithic. The production of blades or bladelets appears neither as a reflection of cognitive evolution nor as a simple diagnostic marker (d'Errico 2003; Pastoors 2009).

The analysis of the lithic production systems of the different horizons of the Balver Höhle demonstrates that unidirectional bladelet cores appear within all artefact assemblages and display the same mode of configuration. The corresponding conceptual reservoir is diverse and contains the same reduction strategies, such as the volumetric concept and different methods of surface exploitation. What all horizons have in common is that the given shape of the local raw material is integrated in the configuration of the cores. The bladelet cores are no exception; rather they should be seen as excellent examples.

Similarities with the Cantabrian sites of Cueva Morín and El Castillo can be observed (Maíllo Fernández et al. 2004). The well-known sites of Cueva Morín and El Castillo have long research traditions, and are of great importance for Palaeolithic research in Southwestern Europe (Vega del Sella 1921; González Echegaray & Freeman 1971; 1973; 1978;

Cabrera Valdés 1984; Maíllo Fernández & Baquedano 2006a; 2006b). They are located in Northwestern Spain, not far from Santander in Cantabria. Since 2007, staff of the Neanderthal Museum has been studying the lithic industries of different sites from the late Middle Palaeolithic to the early Upper Palaeolithic on both sides of the Pyrenees, realised within the framework of a DFG research project. Among the studied sites are levels 13, 12 and 11 from Cueva Morín and levels 22 and 20 from El Castillo (collection of Obermaier's excavation at Madrid).

While flint is the most common raw material at Cueva Morín, at El Castillo quartzite with fine grains of good quality is dominant, whereas flint is mostly used for bladelet production (Sarabia Rogina 1995; 1999). The most part of the raw material is of local origin, coming from locations with maximum distances of around 10 km. In Cueva Morín, mostly debris can be found in the immediate surroundings. Quartzite cobbles are common in fluvial sediments around El Castillo. At both sites the initialisation and preparation of the striking platform was realised in a simple way: One strike for each striking platform; no preparation for the lateral and distal convexity – either natural cortex or the lateral edge of different blanks are used as guiding ridges. Maíllo summarises the bladelet production at Cueva Morín and El Castillo as follows: The bladelet method trends to producing prismatic cores in either uni- or bidirectional manners. The core configuration is very simple, except a few examples. A great number of prismatic cores resemble some Aurignacian carinated end scrapers (Maíllo Fernández et al. 2004). Bladelet production in El Castillo and Cueva Morín is embedded in each horizon into different methods of lithic production. While surface conception, including Levallois recurrent uni-, and bidirectional and centripetal, is only present in levels 22 and 20 from El Castillo and level 11 from Cueva Morín, discoidal and discoidal bifacial cores are found in level 20 from El Castillo and levels 12 and 11 from Cueva Morín.

According to Slimak, the industry of the lower level of Champ Grand represents the best documented example for Middle Palaeolithic bladelet production (Slimak & Lucas 2005). The site is located near the Loire between Clermont-Ferrand in the west and Lyon in the east. Excavated between 1968 and 1983 by Popier, the quality of documentation is excellent. This – as far as we know – undated site is attributed to the Mousterian of Quina type. Two bladelet methods appear in diverse concept reservoirs, characterised by flake production.

The first method is realised on dorsal faces of flakes following Kostienki thinning or Nahr Ibrahim, with strong evidence of Keilmesser with distal thinning. The determination of this method poses some methodological problems: Notably the differentiation between tool manufacture and blade or bladelet production.

The other method uses the lateral edges of different blanks as guiding ridges. Unprepared natural surfaces or one single negative are used as striking platforms. The latter is comparable with the bladelet production identified at the Balver Höhle. Existing angles on the lydite plaques serve as guiding ridges and provide the required convexities. The striking platform was used ad hoc without preparation, or only slightly modified; one single negative was usually sufficient. No further preparation of the lateral and distal convexity was observed.

In this context, it seems necessary to have a look at the Bavarian sites of Zeitlarn 1-25 (district Regensburg) and Obernederhöhle, middle layers (district Kelheim). According to Uthmeier, the few cores of both sites indicate experimentation with controlled breakage by using guiding ridges without additional preparation of the distal convexities, resulting in blanks that often display hinge fractures (Uthmeier 2004).

The small assemblage of the Volkringhauser Höhle, close to the Balver Höhle, demonstrates a side-by-side usage of conventional Middle Palaeolithic reduction methods and strategies for the production of blades and bladelets (Tafelmaier 2009).

In all mentioned industries, local raw material plays a major role in lithic raw material acquisition. The observed and presented unidirectional bladelet method is based on the use of the natural shape of the lithic raw material. The cores were already prepared and only little preparation of the striking platform was necessary. Blades and bladelets were then struck. This approach is embedded in a concept reservoir dominated by opportunistically-reduced cores. Beside this simplistic behaviour, we observed constructed cores following either the surface or volumetric conceptions. In our opinion, the cores exploited according to the unidirectional bladelet method should be grouped together with the opportunistically-reduced cores such as the Kombewa ones.

The efficiency analysis of core configuration yielded a clear signal. From the lowest horizon (Balve I) to the top horizon (Balve IV), the degree of efficiency changes continuously. Further analysis in progress has to be awaited to provide a broader data base and to interpret and correlate these data with ecological data. Thereby a new method may allow assumptions concerning the interaction of environment and the economisation of working processes in stone technology.

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