The use of intentional fracturing in bifacial tool production in the Middle Palaeolithic

Die Verwendung des absichtlichen Bruchs bei der Herstellung bifazialer Werkzeuge im Mittelpaläolithikum

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Abstract - The paper presents the results of the analyses of broken bifacial tools, described thus far as broken leafpoints and broken *Keilmesser*. They come from 20 Central and Eastern European Middle Palaeolithic and transitional Middle Palaeolithic/Upper Palaeolithic sites. Several different approaches were used to investigate the accidental/intentional character of the breakages. A number of distinct features indicate that, for at least ten of the analysed assemblages intentional fracturing was used to prepare a transversal surface, further used as the base (prehensile part) of the final tool.

Zusammenfassung - *Dieser Beitrag präsentiert die Ergebnisse einer Analysen bifazialer Werkzeuge, die bislang als zerbrochene Blattspitzen und zerbrochene Keilmesser beschrieben wurden. Sie stammen aus 20 mittel- und osteuropäischen Inventaren, die in das Mittelpaläolithikum sowie an den Übergang vom Mittel- zum Jungpaläolithikum datieren. Es wurden verschiedene Analysemethoden anegwendet um den unbeabsichtigten/intentionellen Charakter des Bruchs zu untersuchen. Eine Reihe verschiedener Merkmale deutet darauf hin, dass mindestens bei zehn der analysierten Inventare die bifaziellen Stücke intentionell zerbrochen wurden. Die Arbeitsschrittanalyse zeigt, dass die entstandene Bruchfläche im weiterführenden Herstellungsprozess als Basis (Griffbereich) für das endgültige Werkzeug genutzt wurde.*

Keywords - Central Europe, bifaces, knapping technology, scar pattern analysis
Mitteleuropa, Bifaces, Schlag-Technologie, Negativmusteranalyse

Introduction

Most Middle Palaeolithic (MP) assemblages with bifacial tools also contain broken bifacial tools. Transversal fractures result not only from postdepositional processes (Jennings 2011; Weitzel et al. 2014a, b) but also appear as a technical mistake during knapping (Weitzel 2010). The deliberate character of some MP bifacial tool breakages has so far not been discussed widely. However, such a feature was described in the case of Folsom bifaces in North America (Root et al. 1999; Deller & Ellis, 2001; Surovell et al. 2003). In the case of MP assemblages, intentional breakage as a knapping technique was also discussed by V. Lhomme (2014) for Levallois assemblages from the Chez Pourré-Chez Comte and Champlost sites in France. Intentional breakage was used there on tools made on flakes. In the case of bifacial tools, some first attempts at such a discussion were made by A. Pastoors (2001), who identified breakage as one of the stages of the *Keilmesser* knapping scheme. M. Urbanowski (2009) analysed the *Keilmesser* from Wylotne Rock Shelter and observed that in at least some cases the tool's backs were prepared by applying a transversal fracture after the preliminary shaping had been done. Therefore, he proposed the idea that the tools were deliberately broken during the manufacturing process. Beside these single remarks on the possible application of intentional breakage during the MP in Europe, no further studies have been undertaken on the topic so far. A recent project by the present author involved an extensive technological analysis of the MP symmetrical bifaces in Europe, covereing broken and unbroken artefacts. In the course of the project, it was found that at least part of the broken bifaces show features which might indicate intentional breakage. The present paper aims at addressing the issue of the use of intentional fracturing in the production of bifacial tools during the MP. The paper does not aim to find all intentionally broken bifacial tools in Europe, but rather it demonstrates the potential geographical and chronological extent of the described phenomenon. Attention shall be drawn towards broken bifaces, the possible application of intentional fracturing during production, and its general typological and technological consequences.

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Material and Methods

The paper presents results of the analysis of 129 broken bifacial artefacts from 20 European MP sites (for details see discussion below) and from various chronological contexts (MIS 8-MIS 3). The studied bifaces were made from different raw materials. The current paper presents a pilot study and the sample of artefacts can be treated as a random selection, demonstrating the wide geographical and chronological range of the described phenomenon.

In order to determine the deliberate character of the fractures, several elements have been taken into consideration. The first is the morphology of the broken surface. The features indicating intentionality follow the methodology proposed by Weitzel (2006, 2011, 2012) and Jennings (2011), i.e. experimental results which take into consideration the direction of the fracture, the presence of the impact point, and the curvature of the surface. The typology of fractures follows the one proposed by Jennings (2011) and Weitzel (2010, 2012).

The most characteristic feature indicating intentional breakage is the morphology of the broken surface. Three distinct types of fracture morphologies can be determined when the flint is deliberately fractured through direct percussion in the centre of its surface, i.e. the so-called "bend" or "snap" fracture, the "radial" fracture, and the "complete cone" fracture (Weitzel 2012: 46-49; Jennings 2011).

In the case of the so-called "bend" or "snap "fracture, the triangularly-shaped point of percussion (the Hertzian cone) can be visible near the struck surface (Anderson-Whymark 2011: 19; Tsirk 2014). In experimental studies, the point of impact was visible in 15 % (Jennings 2011) of the intentionally broken tools. If a stone slab is located under the tool during breakage, the fractured surface shows traces of two opposing impact points. Such breakage can be referred to as "anvil struck" (Anderson-Whymark 2011: 19). In this paper, it is termed "bend breakage on slab".

In the case of a "radial" fracture, the tool breaks radially into several pieces of triangular shape with two fracture surfaces (Jennings 2011; Weitzel 2012). One characteristic feature of a radial breakage is an entirely or partially preserved Hertzian cone appearing as a consequence of such a break (Fig. 1).

A "complete cone" appears when a fractured tool breaks radially into multiple pieces, while the Hertzian cone falls apart as a separate piece. In such a case, the Hertzian cone is a specific element. The breakage surface of other pieces is at least partially crushed (Weitzel 2010: 179-183).

All these morphological features can occur if the initiation point of the fracture is located in the middle of one of the surfaces of the biface. If the point of fracture initiation is located at the edge of the bifacial tool, a different morphology called a "peripheric breakage" occurs (Weitzel 2012: 44). In this case, the point of percussion is located near the edge and the breakage surface is curved. Such a fracture is often treated as a technological mistake, since it can appear during the knapping process (Weitzel 2011). The tool breaks as the result of a strike delivered above the so-called central line (Whittaker 1994).

One of the possibilities for determining an intentional breakage in the case of peripheric breakage is to find removals aimed at facilitating the break, such as notches (see below). Scar pattern analysis was used in order to address this issue and to determine the scheme of the knapping of the specific tool, based on the chronology of scars visible on the surface of the bifacial tool (Richter 2001; Soressi & Dibble 2003; Boëda 2013; Frick & Herkert 2014). The method is widely used as a substitute for refitting and allows identification of the general *chaîne opératoire* for a certain tool and its most important features. Scar pattern analysis is done separately for each tool, and the results can be compared in terms of the knapping scheme and morpho-technological differences of various tool parts (Boëda 1995, 2005; Kot & Richter 2012). In several cases, it was possible to refit two parts of the broken bifacial tool and analyse the whole artefact by investigating the scar pattern.

The last element of analysis involved the overall techno-morphological comparison of the broken and unbroken bifaces within an assemblage. This was done to consider the general division of the techno-functional parts of the tools and to compare them from the point of view of their morphology and method of manufacture and maintenance.

Results

Morphology of the broken surface

Among the 137 analysed fractured surfaces, 96 show features enabling the determination of the point of fracture initiation (Hertzian cone, ring cracks, wedge-shaped fracture lines, conchoidal fracture marks or the lipping of the fracture edge), with 68 of these presenting traces of a bend fracture and 28 of a peripheric one. Bend fractures appear as the result of force applied to the upper (N = 44) or lower (N = 24) face of the tools (Fig. 2). The upper/lower surface division was established independently for each tool based on the convexity of the surfaces and edge treatment. A convex suface with a series of retouches was treated as the upper surface, whereas the flat surface lacking edge retouches was considered the lower one. In the case of non-deliberate tool breakage, one would expect a random, i.e. rather equal distribution of breakages initiated from both surfaces. Therefore, the substantial prevalence of fractures caused by force delivered to the upper (more convex) surface can be considered one

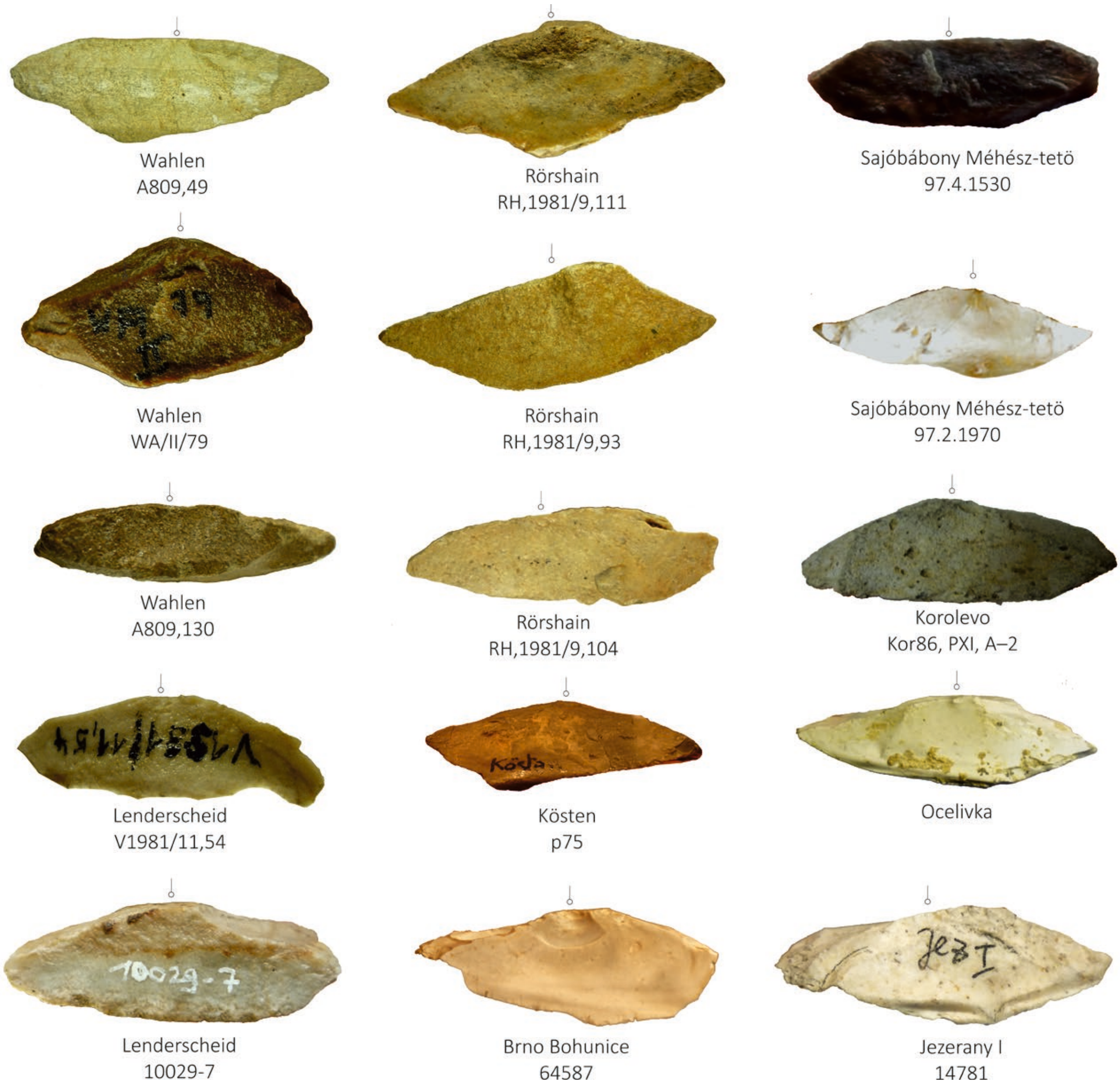

Fig. 1. Radial fracture surfaces with a visible point of impact.
Abb. 1. *Oberflächen radialer Frakturen mit erkennbarem Schlagpunkt.*

indication for an intentional character of the break. Placing the bifacial artefacts on its flat surface while striking the convex one might have improved its stability.

For bend fractures, the most important feature indicating the deliberate character of the fracture is the presence of the impact point. The impact point is visible in the case of 46 (67.6 %) analysed surfaces (Fig. 2). In eight cases, the morphology of the fracture surface indicates the use of the fracture on slab technique. It can be found in Mauern (N = 4, Koenigswald & Müller-Beck 1975), Sajóbábony Méhész-tetö (N = 2, Ringer & Adams 2000), Rörshain (N = 1, Luttropp & Bosinski 1967) and Jezerany I (N = 1, Valoch 1966) (Fig. 3).

Because the analysis focused on bifacial tools instead of entire assemblages, neither radial breakages nor conical cones were documented.

The timing of breakage during the chaîne opératoire

In 49 cases, a transversal fracture was not the last working step performed on the tool. They were either subsequently retouched along the edges, or the part near the base was reworked. In several cases, extensive reworking was conducted after the breakage.

Even if tools show no traces of knapping after their breakage, they may still have been worked but, due to the limitations of scar pattern analysis, this cannot always be determined. Only if scars extend onto the breakage surface can we be sure they were reworked after breakage. If the retouch was only applied to other parts, e.g. near the tip, it is impossible to determine whether it was done before or after the breakage happened.

For the following description, the analysed tools are divided into three groups – triangular symmetric bifaces, triangular asymmetric bifaces and rectangular bifaces.

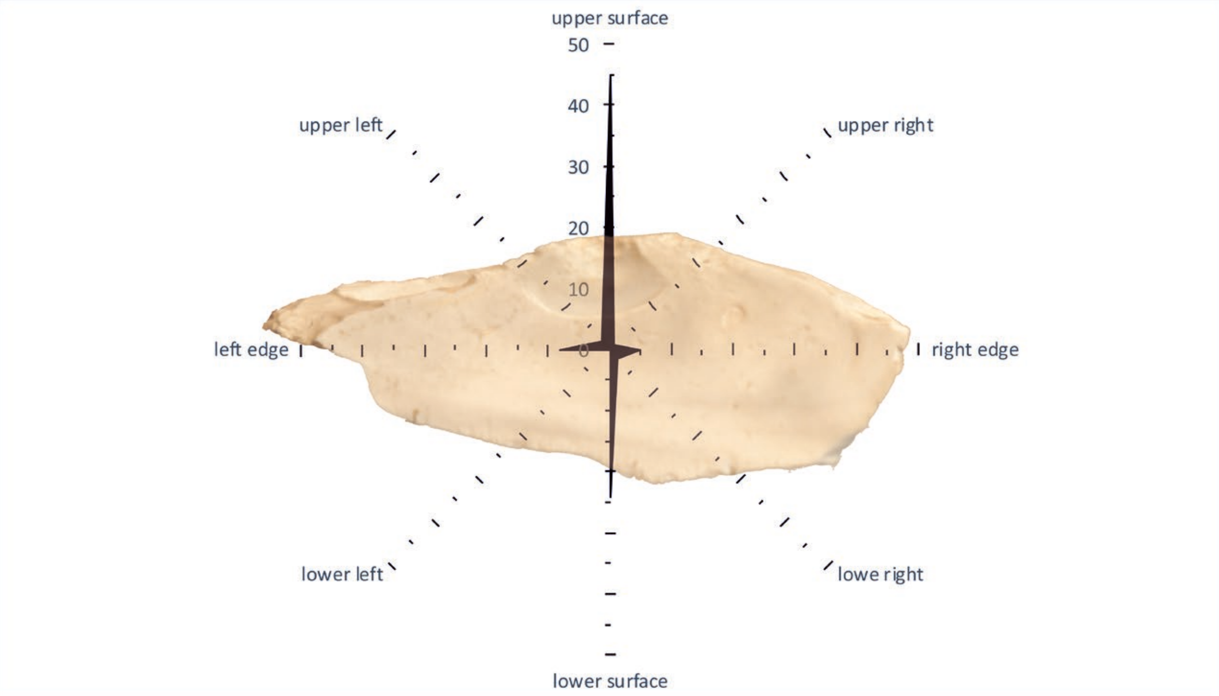

Fig. 2. Direction of forces causing the fracture.
Abb. 2. *Ausrichtung der Schlagachse beim Bruch.*

Triangular symmetric bifaces

This specific group includes tools of an isosceles triangular shape with two straight, symmetrical edges convergent at the tip and a base formed by transversal breakage, found in Rörshain (N = 6) and Wahlen (N = 4) (Fiedler et al. 1979). The tip, even though it is protruding, was not retouched more carefully than the rest of the edges. The triangular bifaces have two techno-functional units treated differently during the *chaîne opératoire*, i.e. the cutting edges and the base.

A) Cutting edges. Both edges were treated identically, and both are equally straight in profile. They were shaped through precise removals from both artefact faces, but neither face bears traces of sharpening or marginal retouches, which is often the case with *Keilmesser* (Jöris 2006; Kot 2016). The edges converge at the exposed tip, however, in some cases it is not sharp (Fig. 4). Furthermore, some specimens exhibit a lack of interest in the tip's sharpness and older removal sequences or transversal fractures are evident near the tip (e.g. Rörshain Rh. 53). This shows that convergent edges with straight profiles were more important than sharp tips during the tool manufacturing process.

B) Base. This is a flat surface located transversally to the tool axis. It was formed through a fracture. One of the artefacts had its base formed by two fracture scars (Rörshain Rh.53). Additionally, most tools had their bases formed midway through the manufacturing process, before the final shaping of the edges. However, there are no traces of the preparation of the fracture via notch preparation.

The most interesting tool examined is a triangular bifacial tool from Wahlen (WH_49) (Fig. 4). The artefact contains a transversally broken base which refits to the broken tip. This base was removed from the tip early in the manufacturing process after shaping, but before the final retouch of its edges. The percussion point is visible at the base. It is located in the centre of the upper face. More interestingly, the fracture scar was rough due to the nature of the raw material used for tool manufacturing (it is a heavily calcinated sandstone). The base of the tool's tip, however, is perfectly flat, which indicates that its fracture scar was polished after the breakage to smoothen the roughness and irregularities of the base. The abrasions on the upper face of the removed fragment's base, which caused the elimination of removals, as well as the fragment's biplanar character, may prove that the upper face of the broken base was used as a slab in order to polish the fracture scar at the tip. After the tip removal, which – judging by the polishing traces – was intentional, further tool knapping was conducted. First, two series of thinning removals on the upper face were done. Next, a series of small removals was conducted on both faces, aimed at correcting both edge profiles. As a result of all these actions, a tool in the form of a highly elongated triangle was created, with convergent edges and a transversal, flat base surface. The tool in this shape is 12.4 cm long.

Generally, based on the scar pattern analysis, one can determine the following knapping procedure:

A) Surface preparation & tool thinning. In the first stages of the knapping process, two different

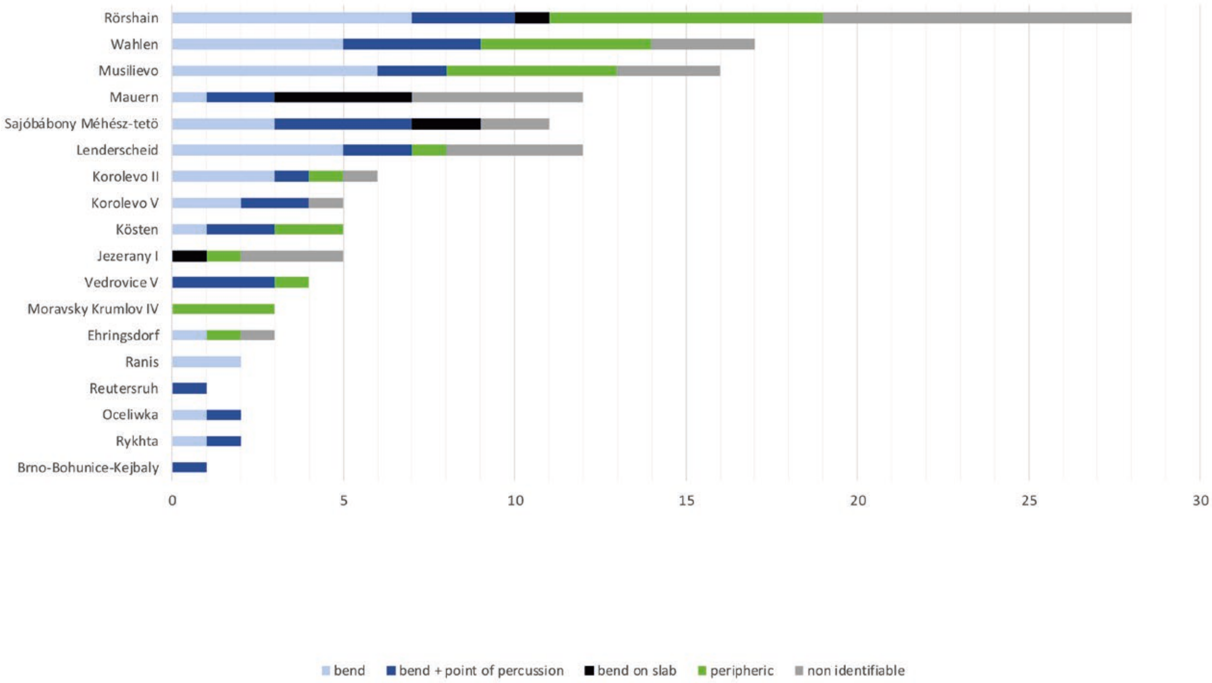

Fig. 3. Distribution of different types of fractures within the analysed assemblages.

Abb. 3. *Verteilung der verschiedenen Brucharten innerhalb der untersuchten Inventare.*

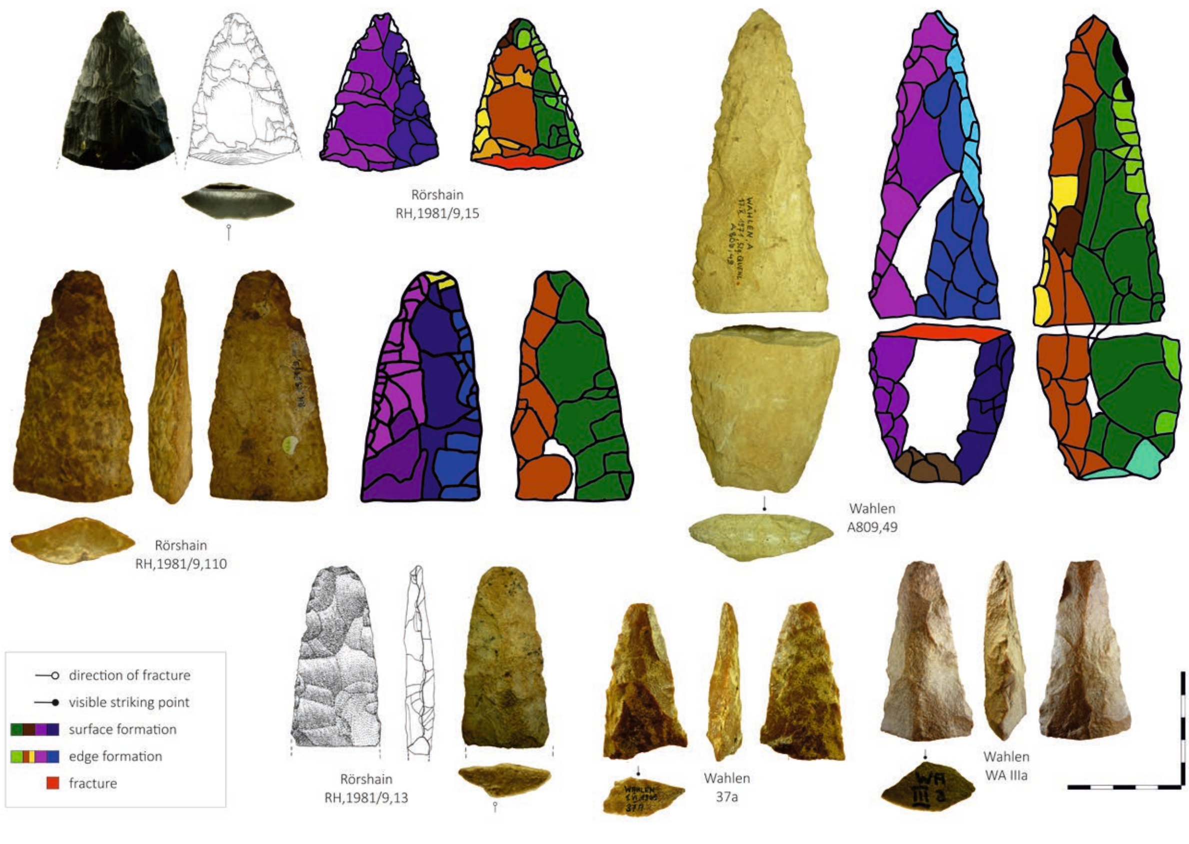

Fig. 4. Symmetric bifaces with a base prepared through the use of transversal fracture surfaces (drawings after Luttropp & Bosinski 1967; photo M. Kot).

Abb. 4. *Symmetrische bifazielle Geräte deren basales Ende durch eine transversale Bruchfläche präpariert wurde (Zeichnungen nach: Luttropp & Bosinski 1967; Foto: M. Kot).*

knapping schemes can be determined. The first one involves initial surface elaboration in a plano-abrupt manner. In such a scheme, the series of scars on one face is semi-steep, while on the other face it is flat, with the second edge formed alternately (Rörshain Rh_15, Rh_103). As a result of such knapping, the tools are biconvex in cross-section. The second scheme leads to the creation of tools with a plano-convex cross-section. This way of knapping involves a surface/edge analogical scheme of knapping (Kot 2013) with potential correcting of the edges through retouch onto the upper face. The tools which were formed in this way (Rörshain Rh_13, Rh_110) have an elongated shape, almost parallel edges and an inconspicuous tip.

B) Base formation. The base was prepared by a single or double bend fracture. Bend fracture was identified in five out of ten analysed (Fig. 5) artefacts. The impact point is visible on three of them (Fig. 4). A single fracture shows the morphology of a peripheric breakage. No features of fracture on slab were identified in this group of artefacts.

C) Edge formation. Performed as a series of initially fairly invasive and then gradually smaller flat removals. These sequences are designed not only to correct the edge profile but also to shape the edges and improve symmetry. In the case of tools knapped in a plano-abrupt manner at the previous stages of manufacturing, a series of retouch scars are initiated alternately at the tip, along with flattening removals forming the edges farther away from the tip. The tools knapped in this way are triangular and have an exposed tip. In the case of using the second method, the removals are made mostly on the convex/upper face of a tool with minor corrections on the lower face.

Asymmetric bifaces with a broken base

Another separate group of tools are asymmetric ones characterised by the presence of two converging edges and a base prepared by applying a transversal fracture. The base is usually at an angle to the tool's vertical axis. Such tools were found in 14 sites (Fig. 6).

Some of the artefacts of this kind from Lenderscheid (Grahmann 1951) and Wahlen are characterised by the presence of two notches placed alternately on both edges, near the fracture scar. The break runs either through or below the notches' central part (Fig. 7).

One can distinguish three major techno-functional units which were treated differently during the manufacturing process:

A) Cutting edge. Most frequently this is the longer and more convex one of the two edges, formed with flat removals initiated on the lower face, and semi-flat removals on the upper face, with a possible correction on the lower face or with flat or semi-flat precise retouches on both faces. A series of repairs are visible on the edge in the form of retouch scars. Several edge resharpening scars near the tip move the vertical axis of the tool closer to the opposite edge. Subsequent retouches also lead to edge angle widening as well as edge blunting. In consecutive removal sequences on the cutting edge, removals are initiated orthogonally to the edge and, therefore, if the edge was slightly convex at the beginning of exploitation, subsequent removal series lead to an increase in its convexity.

B) Distal posterior part. Located opposite the cutting edge; usually the shorter tool edge. The edge closer to the tip converges with the cutting edge at the tip. The retouch, however, includes only the part near the tip, as a result of which the edge is less precisely knapped and more sinuous in profile than the cutting edge. If the tool was knapped more elaborately, then the tip is well formed. In other cases, retouch on the distal posterior edge was limited to the edge; it does not overlap with the tip as a result of which the tip moves off the vertical axis. In several cases, one is dealing with removals initiated at the tip, along the vertical axis and the edge. This caused the formation of a transversal edge on the tip, which was subsequently retouched and repaired (see Rörshain 4/2

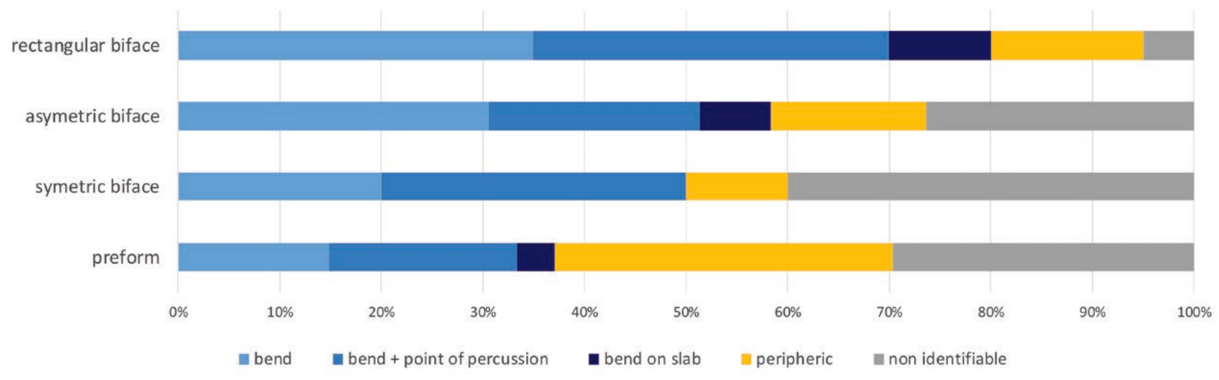

Fig. 5. Distribution of different types of fractures among identified tool types.

Abb. 5. *Verteilung der verschiedenen Brucharten nach bifaziellen Werkzeugtypen.*

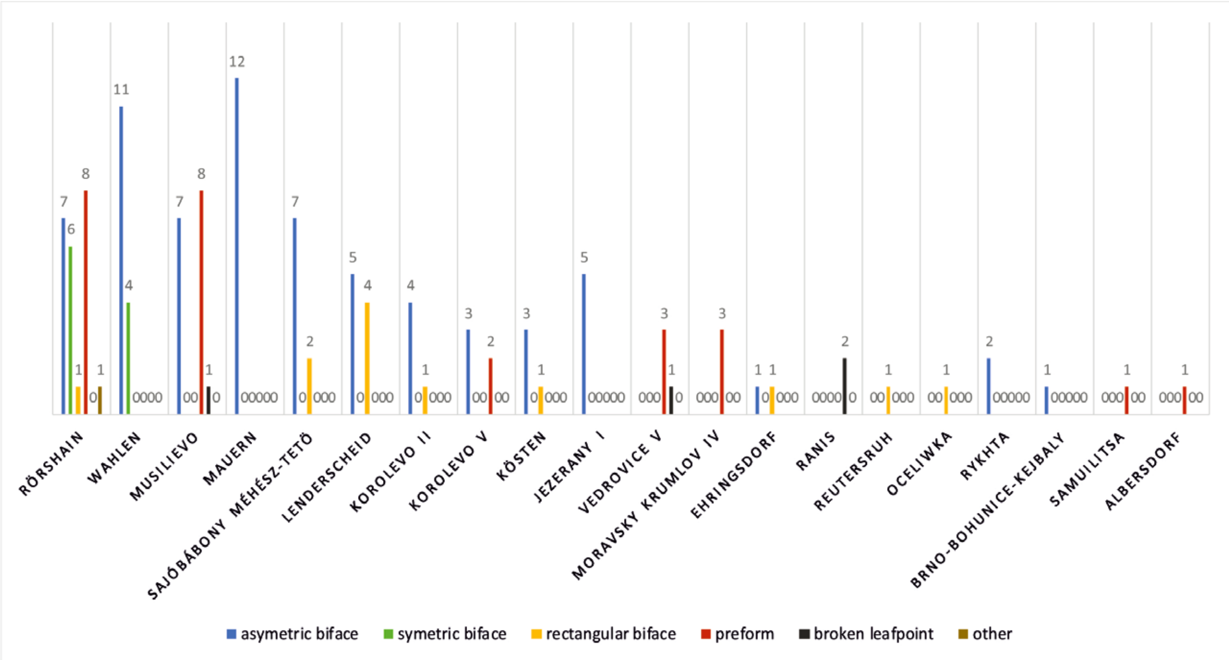

Fig. 6. Distribution of different types of tools with a broken base among the analysed assemblages.

Abb. 6. *Verteilung der verschiedenen basal gebrochenen Werkzeugtypen innerhalb der analysierten Inventare.*

and Rh_101, Rh_39 in figure 7). Closer to the base, the distal posterior edge is knapped less diligently and is more sinuous in profile. This tool part is also usually not affected by repairs, or the repairs are aimed at this part directly to change its shape or blunt it with a steep retouch.

C) Base. A part formed by a transversal breakage (Fig. 1), made during the manufacturing process or after completion of the artefact. Five artefacts, mostly from Wahlen, have two breakage scars on the base (e.g. Wahlen WH_C16, WH_4c, WH_X608). The second fracture occurs in those tools in which the first fracture was not transversal but at an angle to the tool axis.

Even though each tool from this group represents different knapping schemes, the final goal was comparable for all cases. The tools' characteristic elements were created in a similar manner, yet at different manufacturing stages. For this reason, the crucial formation stages are outlined below. It should be noted, however, that their order was different on each tool, and sometimes one stage appeared during another stage (e.g. shaping the tip while forming the tool surface, e.g. Lenderscheid V11_57). The production of such a tool type consisted of the following steps:

A) Surface formation. At this stage, the tool is formed via a series of extensive, flat and semi-flat removals. The plano-convex cross-section is achieved by forming both edges with a series of semi-flat removals onto the upper face first, and next with a series of flat removal onto the lower face. Such a scheme can be observed, e.g. in Lenderscheid, Wahlen, Rörshain. In Sajóbábony Méhész-tetö, Wahlen and Korolevo II (Demidenko & Usik 2009), the tools at this stage were knapped with the use of an alternate plano-abrupt scheme. Semi-abrupt removals were initiated on one face, and then flat and invasive removals were conducted on the other face of the edge. This procedure was then repeated alternately on the other tool edge. Semi-abrupt removals allowed for the creation of an appropriate angle for the further initiation of extensive flat removals on the lower face. This surrounding scheme (Kot 2013) creates biconvex cross-section tools. At subsequent knapping stages, the lower face was either flattened (Sajóbábony Méhész-tetö 91.10.63) or left as plano-convex (Sajóbábony Méhész-tetö 91.257.1).

B) Shape formation at the tip. This stage of knapping is well visible on artefacts from Wahlen and Lenderscheid. At this stage, all artefacts show remarkable conceptual cohesion, and all have semi-steep removal series forming the tip shape. They also assist with preparation for a series of flat removals on the other face. The second edge is formed with a series of flat, fairly precise removals at the tip. Quite possibly, the retouch might have been done already after the breakage, in order to resharpen the edges.

C) Edge formation. A stage visible only on tools from Sajóbábony Méhész-tetö and Wahlen. Subsequent knapping steps were based on formation and retouching of the edges through alternate removals on both edge faces. During further knapping and rejuvenation, the plano-convex cross-section of

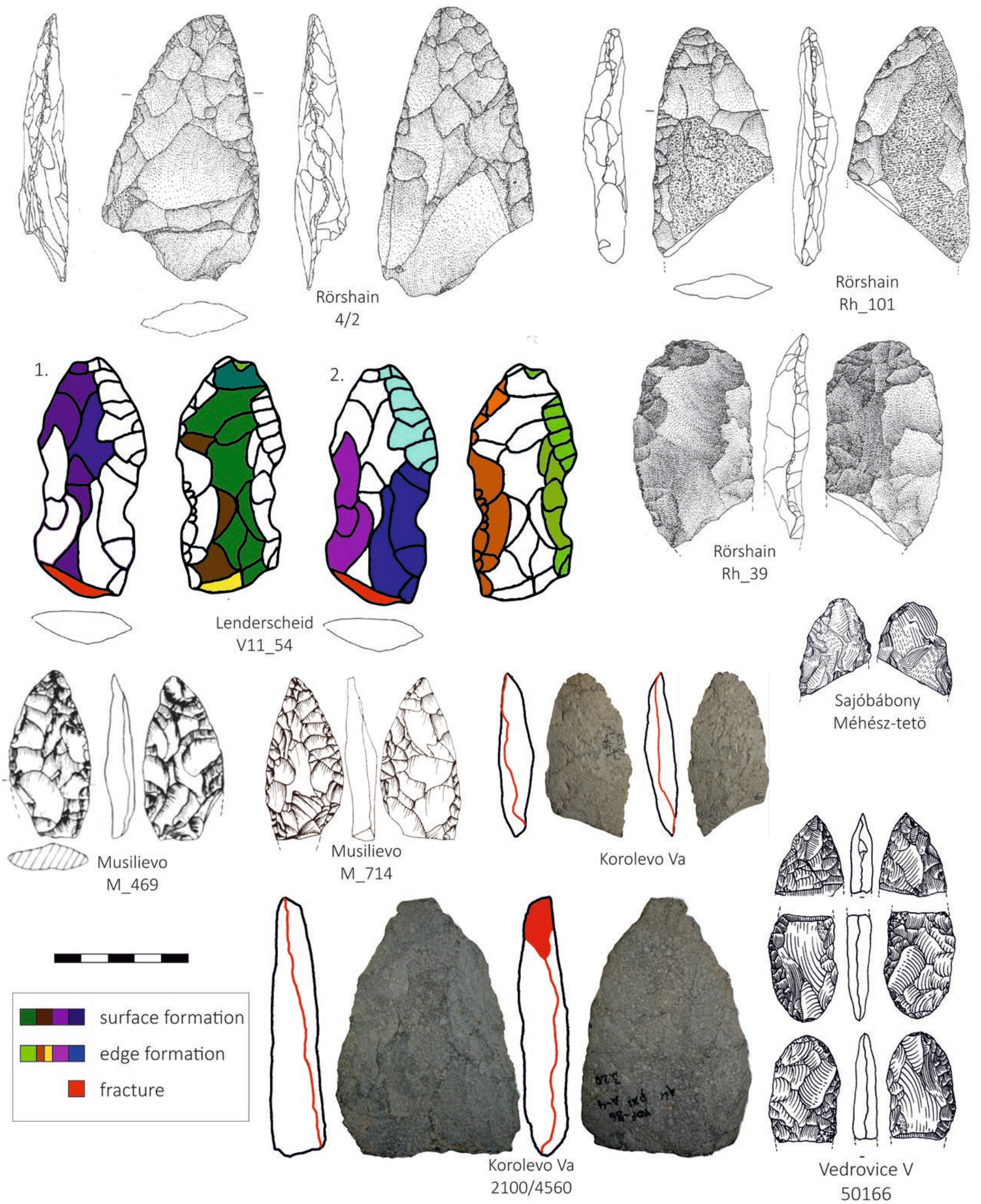

Fig. 7. Asymmetric bifaces with a base prepared through a transversal fracture surface (drawings after: Luttropp & Bosinski 1967; Sirakova 1990; Valoch 1993; Ringer 2001; photo: M. Kot)

Abb. 7. *Asymetrische bifazielle Geräte deren basales Ende durch eine transversale Bruchfläche präpariert wurde (Zeichnungen nach: Luttropp & Bosinski 1967; Sirakova 1990; Valoch 1993; Ringer 2001; Foto: M. Kot)*

the cutting edge was preserved by applying flat removals onto the lower face from the opposite edge. In most cases, only one of the edges was retouched along its entire length. The retouch on the other tool edge was limited to the apical part. In the case of tools with a greater convexity of both edges and insignificant tip exposure, the retouch also overlaps the tip. Removals are also initiated from the tip's edge forming their specific rounded shape. This suggests that the tip and its exposure were not an essential element of these tools.

D) Notch formation. This step can be observed on three artefacts from Lenderscheid, two from Wahlen, and a single tool from Musilievo (Sirakova 1990). It involves a series of flat removals introduced on one face, and then, in the same area, a series of semi-flat or semi-steep smaller and more intrusive removals on the other face. The second notch was formed in the same way but alternately to the first one. The notches were not always performed at the end of the production process. In one case (Lenderscheid V11_56), the sequences leading to notch formation were performed already at the stage of surface formation and were incorporated into subsequent tool production stages. This, and the above-described transversal character of the fracture, suggest that these tools were broken intentionally and the alternately knapped notches were made to facilitate the process of breaking and to increase its precision.

E) Base formation. Out of 72 analysed fracture surfaces, bend breakage was identified in the case of 42 (58.3 %) artefacts. The impact point is visible at 15 (21 %) of them (Fig. 5). In 5 (7 %) cases, one can recognise a second impact point on the opposite side, indicating fracture on slab. Eleven artefacts show peripheric breakage and 19 fractures could not be identified.

F) Rejuvenation. The repairs most frequently involved that part of the tool nearest the tip and the entire cutting edge. The repair was carried out mostly in an edge scheme (Kot 2013) by initiating flat, thinning removals on the lower face, which formed an angle for a further retouch series on the upper face. Finally, if necessary, small correcting removals were performed on the lower face. The tool repair process, though it usually entailed the entire tool on both faces, was focused on retouching the cutting edge and the distal posterior part's edge. Nonetheless, the cutting edge retouch was more precise and often involved the entire edge. This step is visible mostly on Sajóbábony Méhész-tetö tools, which bear traces of repeated resharpening of the cutting edges. Subsequent sharpening retouches affected that part of the tool nearest the tip. All the rejuvenated tools are characterised by significant tip exposure and traces of the care provided to maintain it.

Rectangular bifaces

The third group consists of bifacially worked rectangular segments with two parallel retouched edges and two ends formed by transversal breakages (Fig. 8). Both edges are formed with semi-flat, thinning removals on both surfaces, and are characterised by an identical extent of processing, although one of them is usually straighter in profile. So far 11 such artefacts have been identified in: Lenderscheid (N = 4), Rörshain (N = 1), Kösten (N = 1), Reutersruh (Luttropp von & Bosinski 1971) (N = 1), Ehringsdorf (Behm-Blancke 1960) (N = 1), Sajóbábony Méhész-tetö (N = 2), Ocelivka (N = 1) and Korolevo II (N = 1).

A characteristic feature of the described tools is their specific manufacturing process (Kot 2014: 388–389). Both ends were broken not after but during the manufacturing process, as fracture surfaces and edges were later additionally retouched.

It is noteworthy that the segments were basically produced similarly, and their morphology is closely related.

A) Surface formation. During the first stage, a plano-abrupt, biconvex tool cross-section was formed. This was done with the use of a semi-steep alternate knapping scheme. A series of semi-steep removals was initiated from one face, and next, once the tool had been rotated, there was a series of flat, extensive removals on the same edge's opposing face. Later, the same process was repeated on the second edge alternately. This resulted in a biconvex tool cross-section.

B) Edge knapping. Subsequent removal series adapted their range and an invasiveness to the current state of edge. The aim was to obtain the straightest and most finely retouched edge possible. In the case of artefacts from Sajóbábony Méhész-tetö, a notch onto the lower face was created on one of the edges, probably in order to indicate the fracture line.

C) Transversal fractures on both ends. At this stage, both ends of the bifacial preform were removed. Out of 20 studied fractured surfaces 16 (80 %) are bend, and three (15 %) are peripheric ones (Fig. 5). Seven (35 %) bend fractures have a visible point of percussion. An additional two (10 %) show features indicating fracture on slab (Fig. 8).

D) Post-breakage corrections. The last stage involved post-breakage tool correction by applying small, flat removals on the fracture scar or by a steep retouching of the sharp parts between the edge and the breakage. In the case of artefacts from Sajóbábony Méhész-tetö, after both breakages marginal retouching was introduced to one of the edges.

The artefacts which are referred to as segments can be found mostly at sites where knives with a base formed by transversal breakage were also collected (Lenderscheid, Kösten, Sajóbábony Méhész-tetö, Korolevo II). Regarding the occurrence of rectangular segments and, as can be presumed, the manufacturing scheme using intentional half-product breakage, the analysed tools in the form of tip fragments with a transversely broken base appear to be very interesting. Perhaps these artefacts should be treated either as a side effect (waste) of the segment formation process, or as a waste product which was re-used to create tools with convergent edges and an exposed tip.

Assemblage comparison

In the case of several sites, such as Rörshain, Wahlen, Lenderscheid, Sajóbábony Méhész-tetö and Korolevo,

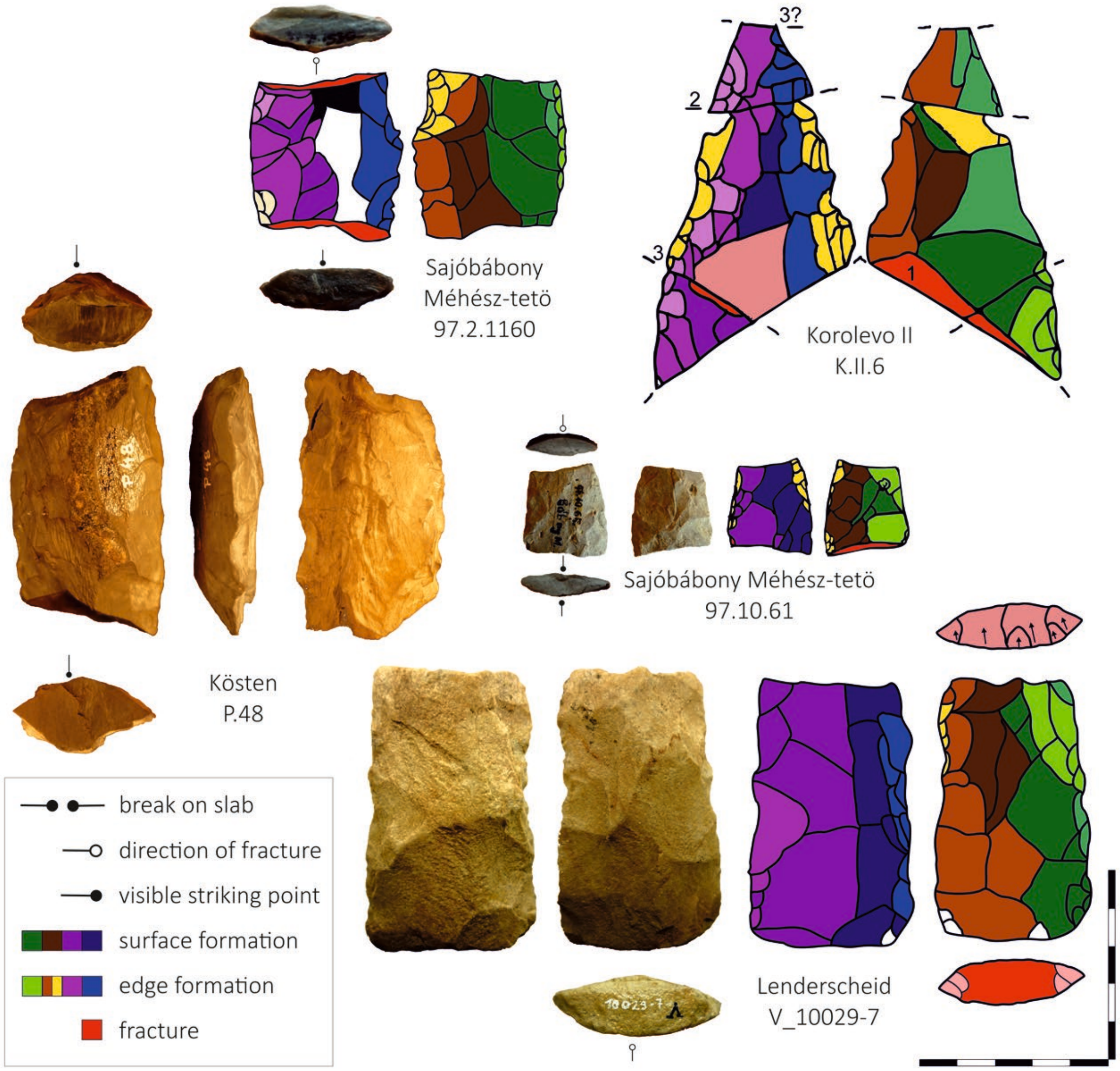

Fig. 8. Rectangular bifaces with a base prepared using a transversal fracture surface.

Abb. 8. *Rechteckige bifazielle Geräte deren basales Ende durch eine transversale Bruchfläche präpariert wurde.*

the analysed artefacts show multiple features indicating the use of intentional fracturing within the assemblage.

In the case of Rörshain and Lenderscheid, at least some of the analysed artefacts show no correspondence to the unbroken bifacial tools, i.e. they do not resemble the broken parts of the existing unbroken artefacts. This is true for the triangular symmetric bifaces described above. Unbroken bifaces with long straight edges converging at the tip are absent from these assemblages. The edges of the unbroken bifacial tools are convex near the tip. Also in Lenderscheid, the asymmetric tools with an unexposed tip show no similarities to the unbroken artefacts from the site.

The situation differs in the case of asymmetric bifacial tools. Both the unbroken asymmetric bifaces and the broken ones show a similar morphology among the assemblages (Fig. 9). Both groups of artefacts show extensive similarities in their edge arrangement. Their base is located in most cases at an angle to the tool's vertical axis and has been blunted either by integrating a natural cortical surface or using transversal breakages or steep blunting removals.

In the case of rectangular bifaces, which are one of the most interesting tools made by applying intentional breakage, one can find similar rectangular tools in Korolevo II with both ends prepared by steep truncations (Fig. 8: K.II.6)

Such a comparison might indicate that intentional breakage was one of the techniques used for base preparation.

Discussion

All analysed tools, if published, were presented in the literature as broken bifacial tools (Grahmann 1951;

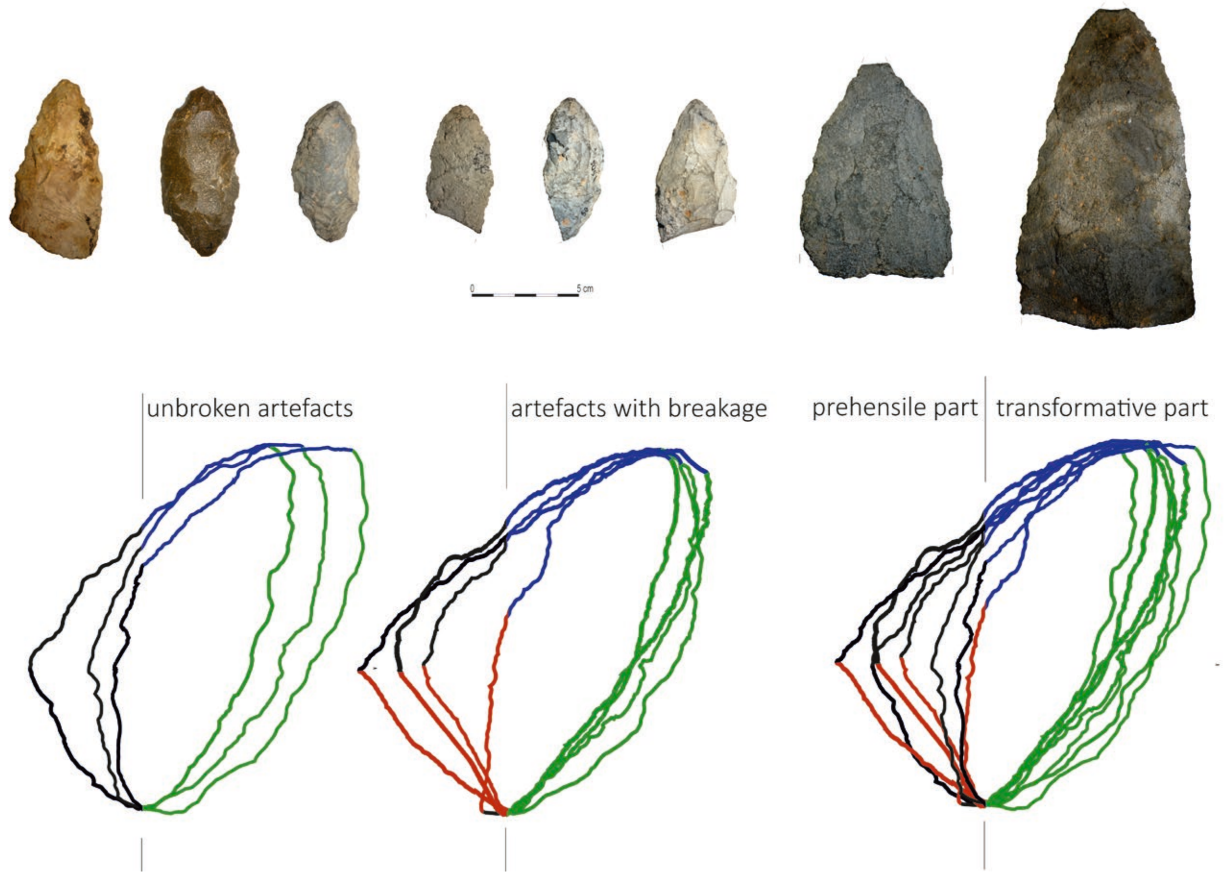

Fig. 9. A comparison of the shape of asymmetric tools with and without transversal breakages within the assemblages.
Abb. 9. *Vergleich der Umrisse assymetrischer Werkzeuge mit und ohne transversalen Bruchflächen innerhalb der Inventare.*

Luttropp & Bosinski 1967; Koenigswald & Müller-Beck 1975; Gladilin & Demidenko 1989; Hahn 1990; Ringer & Adams 2000; Fiedler 2001; Graßkamp 2001; Koulakovskaya 2001). Most of them show no traces of deliberate breakage. However, this study shows that in 16 out of 20 studied assemblages containing broken bifacial tools, one can find at least one piece which presents features that might indicate an intentional breakage.

Considering the strong argument based on the scar pattern analysis should be treated with some caution. A good example is the bifacial leafpoint from Vedrovice V, which was reworked after a transversal breakage (Kot 2013). The base was retouched and reused possibly as a cutting tool following sharpening edge retouch. However, the knapping sequences which appear after the breakage cannot be treated as proof of the deliberate breakage of the tool, all the more so as the tool changed its morphology after the breakage and was reshaped from a leafpoint into an asymmetric knife (Fig. 7).

Therefore, in order to determine intentional breakage, one should take into consideration a combination of multiple features. Table 1 presents the features which might be taken into consideration while identifying the use of intentional fracturing within the analysed assemblage:

Feature 1: A breakage in the middle of the operational chain;
Feature 2: A bend breakage with a visible point of percussion;
Feature 3: The presence of notches;
Feature 4: Recurrence within the group – the presence of more than one artefact with a broken base;
Feature 5: Recurrence between groups – the presence of different types of tools with breakages;
Feature 6: The similarity in morphology to unbroken pieces.

Features 1-3 are related to single tools, while features 4-6 refer to the whole assemblage or interrelation between different tool types. For this reason features 4-6 are not applicable to small samples. In case of ten sites with a small number of analysed pieces, five show up to two identified features (Tab. 1). Therefore, the hypothesis of a use of intentional fracturing should be treated with caution in case of Brno Bohunice, Vendrovice V, Ehringsdorf, Ocelivka or Rykhta. In the case of four sites (Samuilica, Ranis, Moravsky Krumlov IV, Albersdorf), one cannot see any of the determined features. Nonetheless, a group of seven sites show at least five out of the six above-mentioned features (Tab. 1), which can be a strong indication for the use of intentional fracturing within these assemblages.

No.	Site	Country	Analysed pieces	Symetric bifaces	Asymetric bifaces	Rectangular bifaces	1	2	3	4	5	6	No of identified features
1	Lenderscheid	Germany	9	-	5	4	2	3	2	+	+	+	6
2	Rörshain	Germany	28	6	7	1	3	-	4	+	+	+	5
3	Sajóbábony Méhész-tetö	Hungary	9	-	7	2	6	1	5	+	+	+	6
4	Korolevo II	Ukraine	6	-	4	1	2	-	1	+	+	+	5
5	Kösten	Germany	6	-	3	1	2	-	2	+	+	+	5
6	Mauern	Germany	12	-	12	-	9	-	6	+	+	+	5
7	Wahlen	Germany	15	4	11	-	8	2	4	+	-	+	5
8	Korolevo V	Ukraine	5	-	3	-	3	-	2	+	+	-	4
9	Musilievo	Bulgaria	16	-	7	-	3	1	1	+	+	-	4
10	Jezerany I	Czech Republic	5	-	5	-	5	-	1	+	-	-	3
11	Rykhta	Ukraine	2	-	2	-	2	-	-	+	-	-	2
12	Oceliwka	Ukraine	1	-	-	1	1	-	1	-	-	-	2
13	Reutersruh	Germany	1	-	-	1	-	-	2	-	-	-	1
14	Brno Bohunice	Czech Republic	1	-	1	-	1	-	1	-	-	-	2
15	Vedrovice V	Czech Republic	4	-	1	-	1	-	3	-	-	-	2
16	Ehringsdorf	Germany	2	-	1	1	1	-	-	-	-	+	2
17	Samuilica	Bulgaria	1	-	-	-	-	-	-	-	-	-	-
18	Ranis	Germany	2	-	-	-	-	-	-	-	-	-	-
19	Moravsky Krumlov IV	Czech Republic	3	-	-	-	-	-	-	-	-	-	-
20	Albersdorf	Germany	1	-	-	-	-	-	-	-	-	-	-
		Total	129	10	69	12	49	6	35				

Tab. 1. List of analysed broken bifaces with identified features: (1) a breakage in the middle of the operational chain; (2) the presence of notches; (3) a bend breakage with a visible point of percussion; (4) recurrence within group – the presence of more than one artefact with a broken base; (5) similarity in morphology to unbroken pieces; (6) the recurrence between groups – the presence of different types of tools with breakages.

Tab. 1. *Liste der analysierten gebrochenen bifaziellen Geräte und den identifizierten Merkmalen: (1) Ein Bruch in der Mitte der Operationskette; (2) das Vorhandensein von Kerben; (3) eine Bruchfläche mit einem sichtbaren Schlagpunkt; (4) Wiederholung innerhalb des Inventars – das Vorhandensein von mehr als einem Artefakt mit einer basalen Fraktur; (5) Ähnlichkeit in der Morphologie zu ungebrochenen Stücken; (6) die Wiederholung zwischen Inventaren – das Vorhandensein verschiedener Arten von Werkzeugen mit Brüchen.*

Based on identified features, intentional breakages can be determined with reasonable certainty in Lenderscheid, Rörshain, Walhen, Mauern, Kösten, Sajóbábony Méhész-tetö and Korolevo II and with high probability (3-4 out of 6 features) in Musilievo, Jezerany I and Korolevo Va.

The obtained results indicate that in order to indetify the use of intentional fracturing within the analysed assemblage one should take several features into consideration and their reccurence within the assemblage. The list of features proposed here is only of use when a number of artefacts from an assemblage are analysed.

If one considers the chronological framework of this group of sites, it should be stressed that not all of the assemblages are well dated. Lenderscheid (Luttropp 1955; Fiedler 2010; Junga 2009) and Wahlen (Fiedler et al. 1979) are surface collections, ascribed to the *Keilmesser Gruppe* (Bosinski 1967) due to typological and technological features only. In Wahlen, the assemblage can be divided into three main chronological horizons – the Palaeolithic, Bronze Age and medieval period, with Palaeolithic artefacts prevalent (Junga 2009). The consistency of the mechanically separated MP inventory can be questioned, as can its chronological position. Based on the dating of Korolevo Va (Koulakovska et al. 2010), one should state that the analysed phenomenon began at least as early as during MIS 7a and was continued in MIS 5 and 6 (Sajóbábony Méhész-tetö, Ringer & Adams 2000) up to MIS 3 (Fig. 10). Therefore, the chronological range of the described phenomenon seems to be very wide. It should be stressed that this paper does not aim to describe the full picture of the application of intentional fracturing during the MP. The main scope is to present the phenomenon and to provide tools for further analyses.

Conclusions

The results indicate that complete tools also appear among broken bifaces, which were actually broken intentionally during their manufacturing process. Among the analysed broken bifaces one can determine

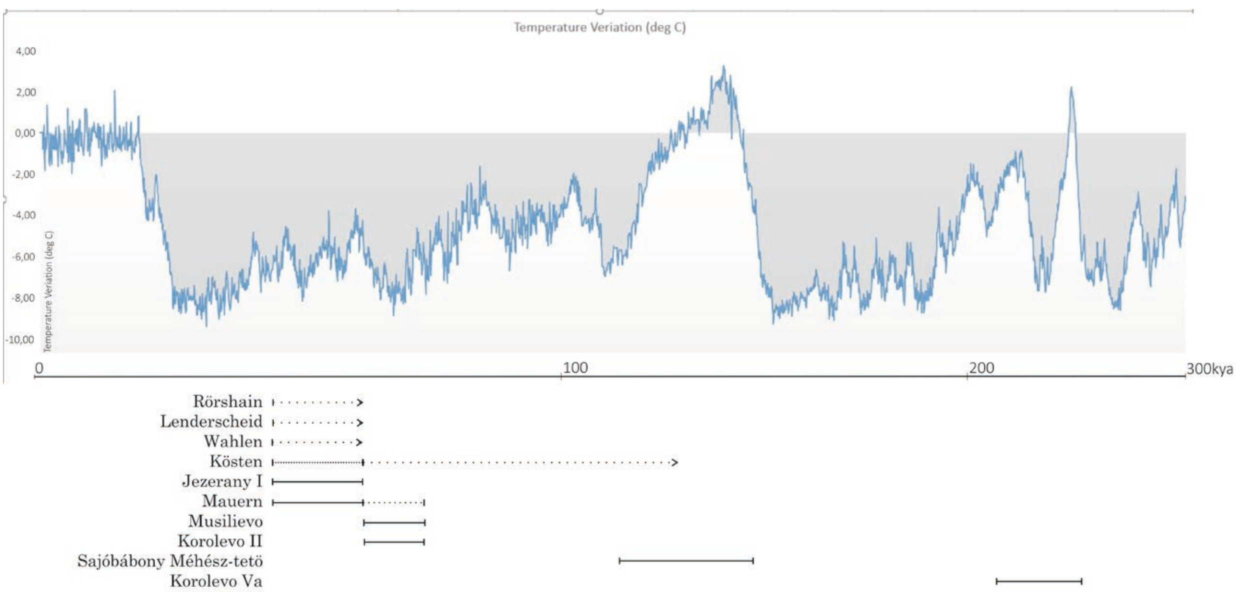

Fig. 10. Chronological distribution of the sites with the intentional breakage technique. Isotopic Temperature Record from the Vostok Ice Core (Petit et al. 1999).

Abb. 10. *Chronologische Stellung der Fundorte mit intentionel gebrochenen Stücken. Isotopentemperaturaufzeichnung aus dem Vostok-Eiskern (Petit et al. 1999).*

ten assemblages with intentional tool fracturing, i.e. Lenderscheid, Rörshain, Sajóbábony Méhész-tetö, Korolevo II, Kösten, Mauern, Wahlen, Korolevo Va, Musilievo, and Jezerany I. Intentional breakages were used as part of the knapping method in the production of at least three different types of tools. These tools are asymmetric bifaces of the *Keilmesser* type with their base formed by transversal breakage; rectangular segments with transversal breakages at both ends; and triangular, symmetrical bifaces with a transverse base surface formed by breakage. Significantly, several types of such artefacts are usually encountered in a given assemblage. This suggests the wide usage of intentional fracturing in a particular assemblage.

Both technological and typological studies of bifacial tools focus on their working parts and pay less attention to the prehensile parts of the tools (Rots 2009; Boëda 2013; Kot 2014; Brenet et al. 2017), whereas the prehensile part is crucial for understanding the tool's utility. It is the prehensile part which needed to be appropriately prepared by the knapper, for both, hand-held and hafted tools. The prehensile part also changes less than the other parts during the subsequent steps of the *chaîne opératoire* (Soressi & Dibble, 2003; Jöris 2006). Therefore, the present study shows that intentional fracturing was used in the MP as one of the techniques for preparing the transversal blunt surface of the prehensile parts of tools. What is more, the presence of such features in 16 studied sites indicate that the use of the intentional fracturing was not a local invention but was rather widespread both geographically and chronologically. For this reason, it is vital to reconsider the presence of broken bifacial tools in MP assemblages from the point of view of the described phenomenon. This paper can be a starting point for further analytical and experimental studies focussed on several aspects related to intentional breakage. The first one could focus on possible ways of controlling the fracture line, and testing possible knapping stages which could enhance such control. The second aspect could cover specific analyses of transversal surfaces used as prehensile parts in different types of bifacial tools in Central Europe during the Middle Palaeolithic.

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