Quartär

Internationales Jahrbuch zur Eiszeitalter- und Steinzeitforschung

International Yearbook for Ice Age and Stone Age Research

Band – *Volume*
63

Edited by

Werner MÜLLER, Sandrine COSTAMAGNO, Berit V. ERIKSEN, Thomas HAUCK, Zsolt MESTER, Luc MOREAU, Philip R. NIGST, Andreas PASTOORS, Daniel RICHTER,Isabell SCHMIDT, Martin STREET, Elaine TURNER

Verlag Marie Leidorf GmbH · Rahden/Westf.
2016

200 Seiten mit 160 Abbildungen

Manuskript-Richtlinien und weitere Informationen unter http://www.quartaer.eu
Instructions for authors and supplementary information at http://www.quartaer.eu

Bibliographische Information der Deutschen Nationalbibliothek

Müller, Werner / Costamagno, Sandrine / Eriksen, Berit V. / Hauck, Thomas / Mester, Zsolt / Moreau, Luc / Nigst, Philip R. / Pastoors, Andreas / Richter, Daniel / Schmidt, Isabell / Street, Martin / Turner, Elaine (Eds.):
Quartär: Internationales Jahrbuch zur Eiszeitalter- und Steinzeitforschung; Band 63
International Yearbook for Ice Age and Stone Age Research; Volume 63
Rahden/Westf.: Leidorf, 2016
ISBN: 978-3-86757-929-5

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliographie.
Detaillierte bibliographische Daten sind im Internet über http://dnb.ddb.de abrufbar.

Gedruckt auf alterungsbeständigem Papier

Verlag Marie Leidorf GmbH
Geschäftsführer: Dr. Bert Wiegel
Stellerloh 65 - D-32369 Rahden/Westf.

Tel: +49/(0)5771/ 9510-74
Fax: +49/(0)5771/ 9510-75
E-Mail: info@vml.de
Internet: http://www.vml.de

ISBN 978-3-86757-929-5
ISSN 0375-7471

Umschlagentwurf: Werner Müller, CH-Neuchâtel, unter Mitwirkung der Herausgeber
Redaktion: Werner Müller, CH-Neuchâtel, Sandrine Costamagno, F-Toulouse, Berit Valentin Eriksen, D-Schleswig, Thomas Hauck, D-Köln, Zsolt Mester, H-Budapest, Luc Moreau, D-Neuwied, Philip R. Nigst, GB-Cambridge, Andreas Pastoors, D-Mettmann, Daniel Richter, D-Leipzig, Isabell Schmidt, D-Köln, Martin Street, D-Neuwied und Elaine Turner, D-Neuwied
Satz, Layout und Bildnachbearbeitung: Nicole Bößl, D-Erlangen und Werner Müller, CH-Neuchâtel

Druck und Produktion: druckhaus köthen GmbH & Co. KG, D-Köthen

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Technological analysis of bifacial leafpoints from Middle/Upper Palaeolithic transitional industries

Technologische Untersuchungen an bifaziellen Blattspitzen aus Technokomplexen am Übergang vom Mittel- zum Jungpaläolithikum

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Abstract - Leafpoint industries were widely spread in Central Europe. Bifacially shaped leafpoints became an "index fossil" for Middle/Upper Palaeolithic transitional industries. This paper presents a comparison of bifacial leafpoints from Szeleta Cave, Nietoperzowa Cave, Brno-Bohunice Kejbaly, Sajóbábony-Méhésztető, Jankovich Cave, Vedrovice V, Moravský Krumlov IV and Muselievo. The leafpoints were analysed by the scar pattern (working step) method in order to reconstruct their *chaîne opératoire* and the general knapping concept of the tools. The aim of the analyses was to check if the leafpoints ascribed to different transitional cultures share similar concepts of tool making or schemes of manufacture.

Zusammenfassung - *Technokomplexe mit Blattspitzen sind in Mitteleuropa weit verbreitet. In ihnen dienen die bifaziellen Formen von Blattspitzen als „Leitfossilien". In dem vorliegenden Beitrag werden bifazielle Blattspitzen aus der Szeleta-Höhle, Nietoperzowa-Höhle, Brno-Bohunice Kejbaly, Sajóbábony-Méhésztető, Jankovich-Höhle, Vedrovice V, Moravský Krumlov IV und Muselievo vorgestellt und miteinander verglichen. Es soll der Frage nachgegangen werden, inwieweit die verschiedenen Blattspitzen vergleichbare Werkzeugkonzepte und Herstellungsprozesse aufweisen. Hierzu wurden die Stücke mit Hilfe der Arbeitsschritt-analyse untersucht.*

Keywords - Middle/Upper Palaeolithic transition, leafpoint industries, Central Europe, bifacial tools, knapping technology
Übergang vom Mittel- zum Jungpaläolithikum, Blattspitzenindustrien, Mitteleuropa, bifazielle Werkzeuge, Abschlagtechnologie

Introduction

Leafpoints are one of the characteristic elements of the Middle/Upper Palaeolithic (MP/UP) transitional industries in Central Europe. The transition between the Middle and the Upper Palaeolithic in Central Europe has been a point of interest of researchers for over 100 years (Kadić 1916; Kozłowski L. 1922; Sawicki 1925; Bohmers 1939; Hülle 1939; Prošek 1953; Zotz 1959). So far, several separate industries such as the Szeletian, Bohunician, Bábonyian, Jankovichian, Jerzmanowician, Ranisian, Altmühlian have been attributed to this period (Hülle 1939; Prošek 1953; Vértes 1956; Chmielewski 1961; Koenigswald et al. 1974; Valoch 1976; Svoboda & Svobodová 1985; Gábori-Csánk 1990; Gladilin & Demidenko 1990; Hahn 1990; Kozłowski J. 1990; Allsworth-Jones 1990; Adams 1998; Bolus 2001; Ringer 2001; Djindjian et al. 2003; Tostevin & Škrdla 2006; Richter J. 2009; Mester 2010, 2014a; Flas 2011). A few of them were combined into larger technocomplexes, due to the similarities of the assemblages, e.g. the Lincombian-Ranisian-Jerzmanowician (Chmielewski 1961; Flas 2011, 2013). According to stratigraphic and chronometric analyses, other industries, e.g. the Bábonyian (Ringer 1983, 2000, 2001), the Jankovichian (Gábori-Csánk 1990, 1993; Mester 2009, 2014b; Markó 2013), could be ascribed to periods earlier than the traditionally classified and classic transitional industries, i.e. the Szeletian and the Lincombian-Ranisian-Jerzmanowician.

Despite the high intensity of research focused on this period, the problem of the MP/UP transition is still a vivid and debatable topic. Most of the key sites were excavated early in the 20th century (Jankovich Cave, Ranis, Nietoperzowa Cave, Szeleta Cave) and were either completely or more or less completely excavated, thus impeding or even precluding further investigations. Therefore, contemporary analyses are based either on old collections or newly-discovered sites. Both approaches have their drawbacks. Old collections cannot be treated as complete due to the exploration methods used in the early 20th century. In most cases, they are rich in tools and large artefacts, but bulk of the debitage is missing (Jankovich Cave, Mauern, Szeleta Cave). On the other hand, new sites are usually defined according to the presence of

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elements characteristic of complexes observed in assemblages recovered from old excavations. Therefore, it is necessary to use new methods of analyses which can produce the basis for a more critical overview of particular assemblages, and add fresh information into the on-going debate.

In general, MP/UP transitional industries in Central Europe are characterized by the presence of both Middle and Upper Palaeolithic features, but also features not present either in the former or in the latter. One of these are bifacially knapped leafpoints which are often treated as index fossils for the transitional industries and the whole period. Their presence is the only feature which links all transitional industries; therefore they are often called the leafpoint industries (Freund 1954; Chmielewski 1961; Valoch 1966; Hahn 1990; Bolus 1995, 2004; Demidenko & Usik 1995; Gladilin et al. 1995; Kozłowski J. 1995; Ringer 1995; Foltyn 2003; Ruebens 2007; Jöris & Street 2008).

Generally speaking, there are two types of leafpoints, one type was made on blades and shaped bifacially. Such leafpoints are the characteristic feature of the Lincombian-Ranisian-Jerzmanowician technocomplex (Hülle 1939; Chmielewski 1961; Pope 2008; Flas 2011). The second type was entirely bifacially knapped and these tools are characteristic of, for instance, the Szeletian, Bohunician, Bábonyian, Jankovichian complexes.

Although leafpoints have usually been regarded as a key feature in defining the cultural attribution of a given assemblage, they have rarely been the subject of a separate analysis or even a comparison of their technological coherence or conceptual and morphometric features (Hahn 1990; Kozłowski J. 1990; Nerudová & Krásná 2002; Mester 2009, 2010; Nerudová 2010; Nerudová et al. 2010; Kot 2014; Nerudová & Neruda 2015).

The aim of this paper is a detailed technological analysis of leafpoints enabling their complex comparison and testing their coherence from the point of view of a general knapping concept and regional variability.

Methods and Material

A unified method of analyses had to be chosen, however, in order to include leafpoints deriving from both old and new collections. It was impossible to use the refitting method since the old collections lack debitage. Therefore, the author decided to use a newly introduced method of scar pattern (working stage) analysis (Richter J. 1997, 2001; Pastoors & Schäfer 1999; Urbanowski et al. 2005; Migal & Urbanowski 2006; Perreault et al. 2013; Kot 2014; Pastoors et al. 2015), which enabled the *chaîne opératoire* and the general tool concept to be defined by analysing the tools without their debitage.

The method is based on a simple principle: on the basis of several defined features (Pastoors & Schäfer 1999; Kot 2014) the relative chronology of neighbouring negatives, visible on the surface of the analysed tool, can be established. If one defines the relative chronology of all neighbouring negatives visible on the surface of the tool, then a Harris matrix graphic can provide the basis for determining separate knapping stages. If the bifacial tool bears traces of approximately 100–200 negatives, a Harris matrix of individual negatives is hardly informative. By combining the negatives of removals with similar morphology into coherent knapping sequences, more information on the relative chronology of the knapping sequences is produced and provides the basis for further analyses of the goals of particular knapping stages. Nevertheless, the analysis has its limitations. The reconstructed *chaîne opératoire* is limited to the negatives visible on the surface of the tools. For example, exhausted tools only show the last steps of knapping and rejuvenation and there is no possibility to observe the very first stages of the manufacturing process. The results of the analysis may be extended by analyzing unfinished tools and refitted tools.

The scar pattern method of analysis was introduced by J. Richter (1997, 2001) and A. Pastoors (Pastoors & Schäfer 1999) over 20 years ago. Since then, it has been developed and adapted by several researchers (Boëda 2001; Jöris 2001; Urbanowski 2004; Urbanowski et al. 2005; Kot & Richter 2012; Kot 2014;) in response to individual requirements and the specification of the analysed tool types. So far, it has been used with success mainly for bifacial tools, handaxes (Boëda 1995a, 2001, 2013) and Keilmessers (Boëda 1995b; Jöris 2001; Urbanowski 2004; Kot 2014). Only a few analyses of leafpoints were made using this method (Graßkamp 2001; Kot & Richter 2012; Kot 2013, 2014).

The paper presents the results of analyses of 112 bifacially knapped tools from transitional leafpoint industries at eight key sites. In order to observe the full range of these artefacts, it was decided to analyse Szeletian, Jerzmanowician, Bohunician, Bábonyian and Jankovichian leafpoints. For these assemblages, collections from eponymous sites were chosen (Fig. 1), i.e. Szeleta Cave (15 artefacts), Nietoperzowa Cave (10 artefacts), Brno-Bohunice Kejbaly (10 artefacts), Sajóbábony-Méhésztető (14 artefacts), Jankovich Cave (20 artefacts). In order to create a global picture, it was decided to include the early Szeletian leafpoints from Vedrovice V (16 artefacts), Moravský Krumlov IV (8 artefacts) and leafpoints from the Balkans from Muselievo (19 artefacts) too.

Results

Nietoperzowa Cave

Nietoperzowa Cave is a multilayered site located in Jerzmanowice village in the Polish Jura. Waldemar Chmielewski excavated the site in the 1950s and found

Site	Number of analysed pieces	Number of bifacial pieces	Literature
Szeleta Cave	15	197	(Kadić 1916; Vértes 1956; Allsworth-Jones 1986; Simán 1995; Mester 2002, 2010; Ringer 2002; Lengyel & Mester 2008; Lengyel et al. 2009;)
Nietoperzowa Cave	10	≈100	(Kozłowski L. 1922; Sawicki 1925; Chmielewski 1961; Flas 2011)
Brno-Bohunice Kejbaly	10	≈30	(Valoch 1976, 1982, 2008; Nerudová 2000a; Nerudová & Krasna 2002; Škrdla & Tostevin 2005; Richter D. et al. 2009)
Sajóbábony-Méhésztető	14	50	(Ringer 1983; Ringer & Adams 2000)
Jankovich Cave	20	35	(Gábori-Csánk 1990, 1993; Mester 2008; Markó 2013)
Vedrovice V	16	≈40	(Valoch 1984, 1993; Nerudová 2000b)
Moravský Krumlov IV	8	36	(Nerudová 2008; Neruda & Nerudová 2009, 2010; Nerudová & Neruda 2015)
Muselievo	19	≈300	(Dzambazov 1967; Chmielewski 1977; Haesaerts & Sirakova 1979; Sirakova & Ivanova 1988; Sirakova 2009)

Fig. 1. List of analysed artefacts.

Abb. 1. *Liste der analysierten Artefakte.*

a collection of artefacts dominated by bifacial leafpoints and their fragments in layers 4, 5 and 6 (Chmielewski 1961). The assemblage formed the basis for the definition of the Jerzmanowice culture, which he attributed to the large Lincombian-Ranisian-Jerzmanowician technocomplex. It is characterized by the presence of both Upper Palaeolithic elements such as the use of blade technology, burins and endscrapers, as well as some transitional elements such as bifacial leafpoints. The artefacts are mostly made on flints.

In total 10 artefacts from Nietoperzowa Cave were analysed: 2 fully bifacially worked finds and 8 pieces made on blades with traces of bifacial shaping. All of them can be described as leafpoints.

Leafpoints

Two different kinds of preform production can be distinguished in Jerzmanowice. Most of the leafpoints are made on wide and relatively thick blades obtained from bidirectional cores. These leafpoints are strikingingly slender (width/length index: 0.36). Although no bidirectional cores were found in the assemblage, the blade morphology shows that large cores with a wide and slightly convex working surface were being utilised. The *chaîne opératoire* of the production of blade leafpoints can be divided into the following stages:

I. Blank production. The technology can be called predetermined since the definitive shape of the blade was leafpoint. The use of a bidirectional technology simplified the preparation of the blank shape. A detailed scheme of the planned shape of the blank cannot be defined due to the absence of blade cores in the assemblage.

II. Thinning. After the blade blank had been produced, its ventral surface was flattened and the blade was thinned with flat removals, deriving in particular from the proximal part of the ventral side (Fig. 2). The aim being to remove the bulb and convexities of the ventral surface.

III. Shaping. The following step was to shape the blank. The ideal shape for the blank was a leafpoint shape, so that further modification would not be necessary. Some artefacts (Fig. 3) are excellent examples of blanks which only needed removal of the bulb in order to be used as a leafpoint. But in the majority of cases, more or less invasive retouch was necessary in order to create the convexities of both edges, to maximize tool symmetry and tip exposure. The removals were adjusted according to the requirements but a clear scheme of shaping cannot be observed at this stage of knapping. Flat removals on the ventral surface were intended to thin the blank even further and adjust the angle of the edge, while semi-flat removals on the dorsal face served to change the shape of the tool.

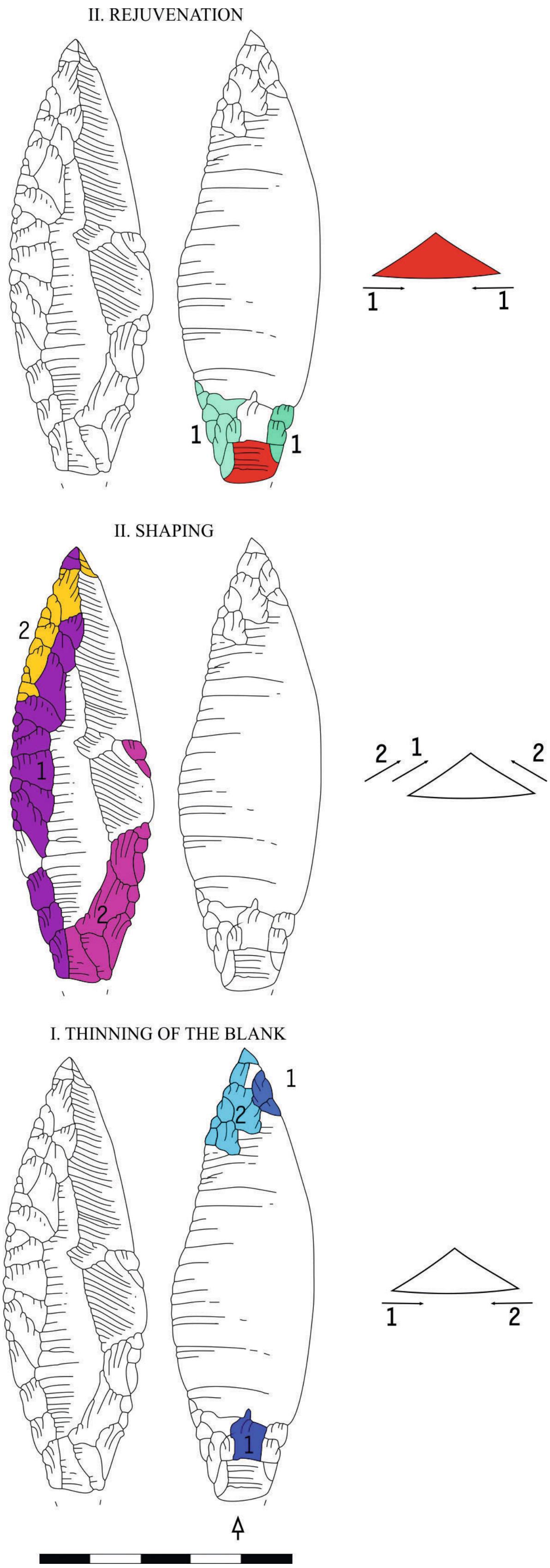
IV. Repairs. The key features of the Jerzmanowice leafpoints were their symmetry and shape. The thickness of the tool as well as its length were also important, but could be disregarded during repair of the tool, e.g. after breakage. If the tool was broken it could be reshaped close to the break, in order to recover the convexity of the edges and reproduce the symmetry of the tool, if necessary.

As well as blade leafpoints there are also artefacts knapped bifacially out of flint nodules. Their knapping technology can be described as follows:

I. Surface and shape formation, thinning. At this stage, the bifacially produced tool was knapped in a plano-steep alternate scheme (Fig. 4). Semi-steep removals were aimed at preparing an angle suitable for additional flat, thinning removals from the opposite face. Flat or semi-flat removals were derived from the same edge in order to thin and shape the lower as well as the upper surface of the object. This scheme was repeated, alternating from one edge to the other, creating a plano-steep biconvex cross-section. At this stage, the removals were placed at the angle to the vertical axis, so that the general shape of the artefact could be perceived.

II. Shape formation, further thinning. At this stage, flat extensive removals were struck at the angle to the vertical axis near the base and the tip. These removals were intended to create convex edges and to thin the tool.

III. Edge profile correction. The last step of the manufacturing process was aimed at the final



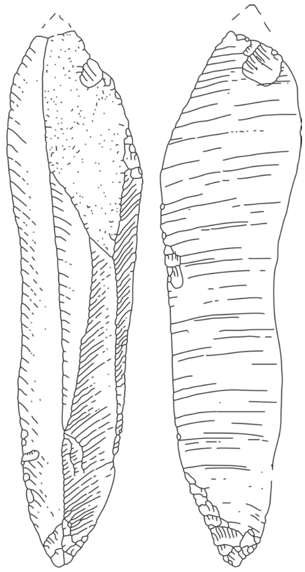


Fig. 3. Leafpoint from Nietoperzowa Cave. The tool is made on a leaf-shaped blade blank with traces of minor thinning on the ventral side in the proximal part. Illustration after Chmielewski (1961).

Abb. 3. *Blattspitze von Nietoperzowa-Höhle. Als Grundform des Werkzeugs dient eine blattförmige Klinge. Auf der Ventralseite finden sich am Proximalende geringe Spuren der Verdünnung. Zeichnung nach Chmielewski (1961).*

correction of edge line and symmetry. The morphology of the removals was adjusted to the necessary requirements: to thin, change the shape or sharpen the edge of the tool.

Even though two different ways of blank production can be observed at Jerzmanowice, further blank shaping is very similar in both *chaînes opératoires*. The most characteristic feature of the Jerzmanowice leafpoints is the great amount of attention given to the symmetry of the tools and their leaf shape. The whole manufacturing process was actually focused on obtaining a tool in the shape of a leaf with an isolated tip. Some of the tools bear traces of rejuvenation after breakage. Their subsequent repair was focused on recovering the shape and the symmetry of the tool.

Szeleta Cave

Szeleta Cave is a multilayered site located in the eastern part of Bükk Mountains (Hungary). The site was intensively excavated throughout the entire 20th century; first in 1906–1913 when O. Kadić (1916) undertook investigations to establish the stratigraphy of the site. In the course of this work, Kadić

Fig. 2. Shaping scheme of the leafpoints made on blades blanks. Nietoperzowa Cave. Blue: flat thinning, flattening removals; violet/pink/orange: shaping removals; green: reshaping/rejuvenation; (Drawings: M. Kot).

Abb. 2. *Schema der Formüberarbeitung der Blattspitzen auf Klingen. Nietoperzowa-Höhle. Blau: flache Verdünnung, abflachende Abschläge; Violett/Pink/Orange: formgebende Abschläge; Grün: Umformung/Verjüngung; (Zeichnungen: M. Kot).*

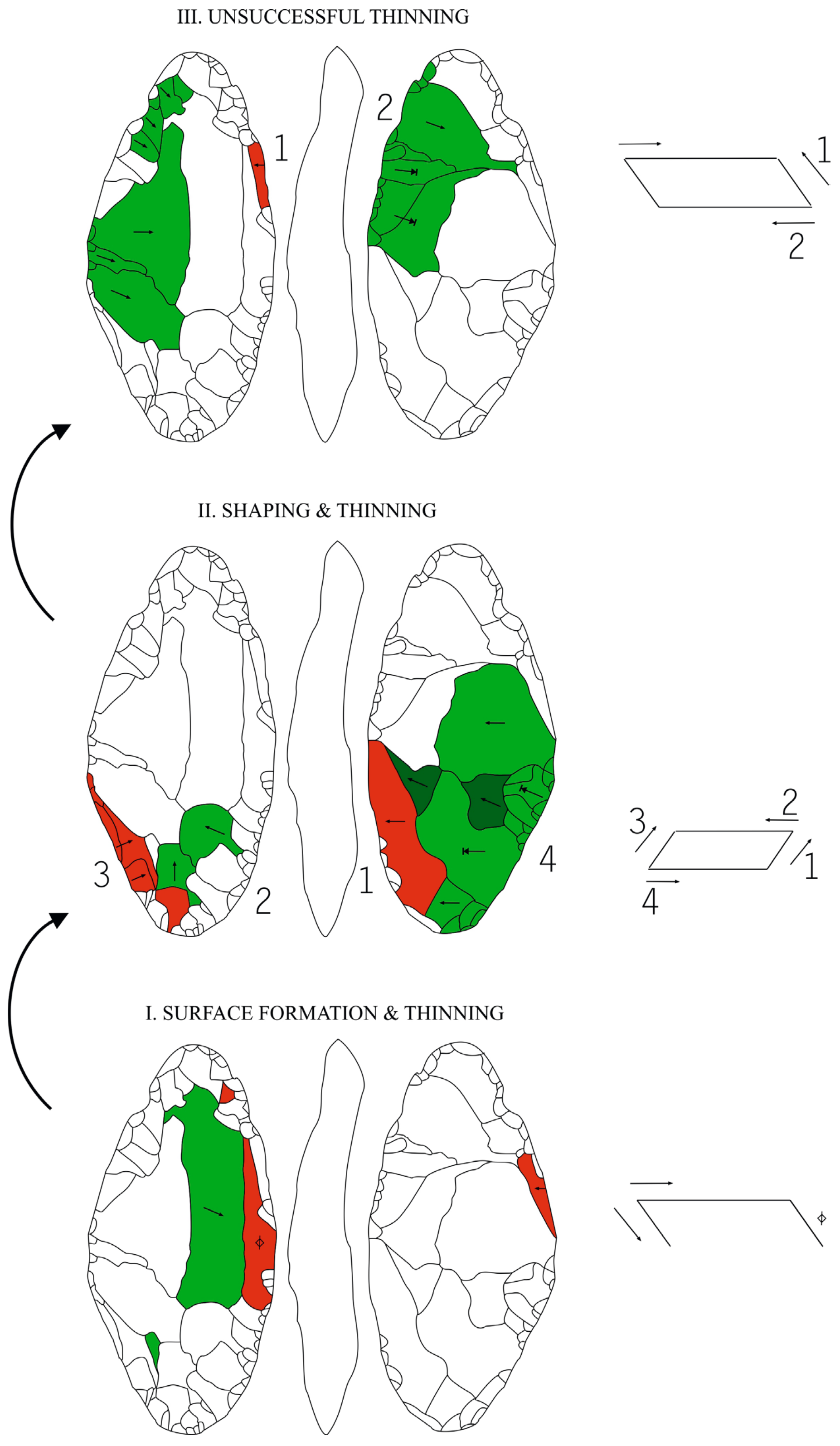


Fig. 4. Manufacturing scheme of the bifacial leafpoints from Nietoperzowa Cave. Green: flat thinning, flattening removals; red/orange: semi-steep removals; (Drawings: M. Kot)

Abb. 4. *Operationsschema der bifaziellen Blattspitzen von Nietoperzowa-Höhle. Grün: flache Verdünnung, abflachende Abschläge; Rot/Orange: halbsteile Abschläge; (Zeichnungen: M. Kot)*

differentiated as many as 11 layers, encompassing four Palaeolithic horizons. The upper three horizons produced symmetrical bifacial tools. In general, the stone inventory was rather diffuse and artefacts were scarce. The excavation produced some 2'000 flint artefacts of which a high number are leafpoints (n=168) (Lengyel & Mester 2008). The artefacts are mostly made on local felsitic porphyry. Some of the points were made of radiolarite and obsidian.

The analysed artefacts differ greatly in size but their common features are their modest thickness and, in the majority of cases, their regular shape. Based on analyses, the tools can be divided into three groups.

Leafpoints

Eight of the 15 analysed tools can be described as leafpoints. Each of these tools is similar in form, with a slender willow leaf shape (0.37 width/length index). They have two symmetrical edges converging at the tip and at the base. Only three of these artefacts have rounded bases, composing a separate surface. The described artefacts appear coherent from the perspective of technology. Generally one may name three basic tool production phases:

I. Decortication and surface forming. The initial stages of tool production can be observed due to the presence of unfinished artefacts. The Szeleta finds were mostly made on flat plaquettes of felsitic porphyry which greatly determined the shape of the tool and the steps necessary for its formation. First, even prior to decortication, the plaquette was generally shaped with steep blunting removals on both sides. Then a series of flat, extensive removals from both faces of the tool facilitated successful decortication. The tool was formed in a biconvex scheme of knapping (Fig. 5), where flat and semi-flat removals were struck on both faces analogically. At this stage removals were made perpendicular to the axis of the tool; it is difficult to note any evident traces of tool shaping.

II. Shaping. Here the biconvex scheme was continued. Removals were performed at right angles to the vertical axis and independently at the base and the tip. The removals on the surfaces of the tool often overlap to a great extent, thus thinning them simultaneously. The removal series at both the tip and the base were knapped with great accuracy. One can also observe a series of removals several times on both faces, each time aimed at correcting consecutive edge asymmetry.

III. Edge correcting. The final stage of manufacture was the correction of the edges and their profiles. At this stage, the entire length of the edge was knapped on both sides, both at the top and closer to the base, using a series of marginal semi-flat removals. The objective was to correct the tool shape and the edge profile, and, if possible, also to sharpen them. However, a few examples show that if the shape of the edge required further modification, a series of more invasive removals was undertaken on the tool, often slightly blunting the edge, but enhancing tool symmetry at the same time. A tendency for deriving sequences of alternate analogical removals on both faces can be observed.

IV. Corrections. A few artefacts bear traces of transversal breakage at the tip or at the base. In such cases, the tools display signs of post-fracture correction. The repair was aimed only at the correction of the post-fracture shape, and does not constitute a sequence of repeated edge retouch/resharpening.

On the basis of the conducted analyses it might be concluded that the Szeleta leafpoints are symmetrical and were originally aimed to be so. The shape of the tool was formed during a separate manufacturing stage, in a biconvex knapping scheme, and all consecutive steps followed the goal of maintaining the initial shape. Interestingly, the more advanced the manufacturing stage, the smaller the size of the derived removals. Wide, extensive removals were used during surface formation and decortication only, while edge shaping and correction are characterised by small, short removals. The most important elements of the tool were the two symmetrical edges converging at the tip. Although tip exposure was very important, the tip did not have to be sharp. Setting the tip in the alignment of the tool was more important. The base of the tool had two converging edges as well as a tip. In general, a rounded edge was created at the base, unless this was not possible due to tool thickness.

Knives

The second group consists of four tools similar in shape to those from Jankovich Cave (Gábori-Csánk 1990; Mester 2009; Markó 2013). They have a greater width/length ratio (index: 0.55) when compared to leafpoints (0.37), are asymmetrical in shape and have a separate base edge.

The artefacts from this group show an incoherent scheme of manufacture. Their common feature is a lack of visible stages of tool shaping, little attention in general for the shape of the edge and traces of rejuvenation retouches derived along one or two edges. In two of the cases analysed, a consequent scheme of knapping of the edge had been adopted. This scheme precluded the shaping of one edge first: from the moment of surface formation until its marginal retouching. Afterwards the second edge was formed analogically, but bears no traces of marginal sharpening retouch. After manufacturing, the tools underwent some rejuvenation along one or both edges. The rejuvenation consists of either resharpening or reorganization of the edge in order to create a borer, for instance (Fig. 6).

Based on the analyses, it can be stated that the Szeleta knives differ considerably from leafpoints in their morphology and knapping technology. These artefacts bear traces of numerous rejuvenation sequences. At the same time, they display either no or only slight attention to shape formation, whereas their symmetry appears to be a secondary phenomenon and no attempts to improve tool symmetry during knapping can be observed, even if this was achievable. One may assume that they were made on unfinished, unsuccessful leafpoints which were recycled in order to be used as cutting tools.

Symmetrical bifaces

Two artefacts cannot be incorporated into the groups

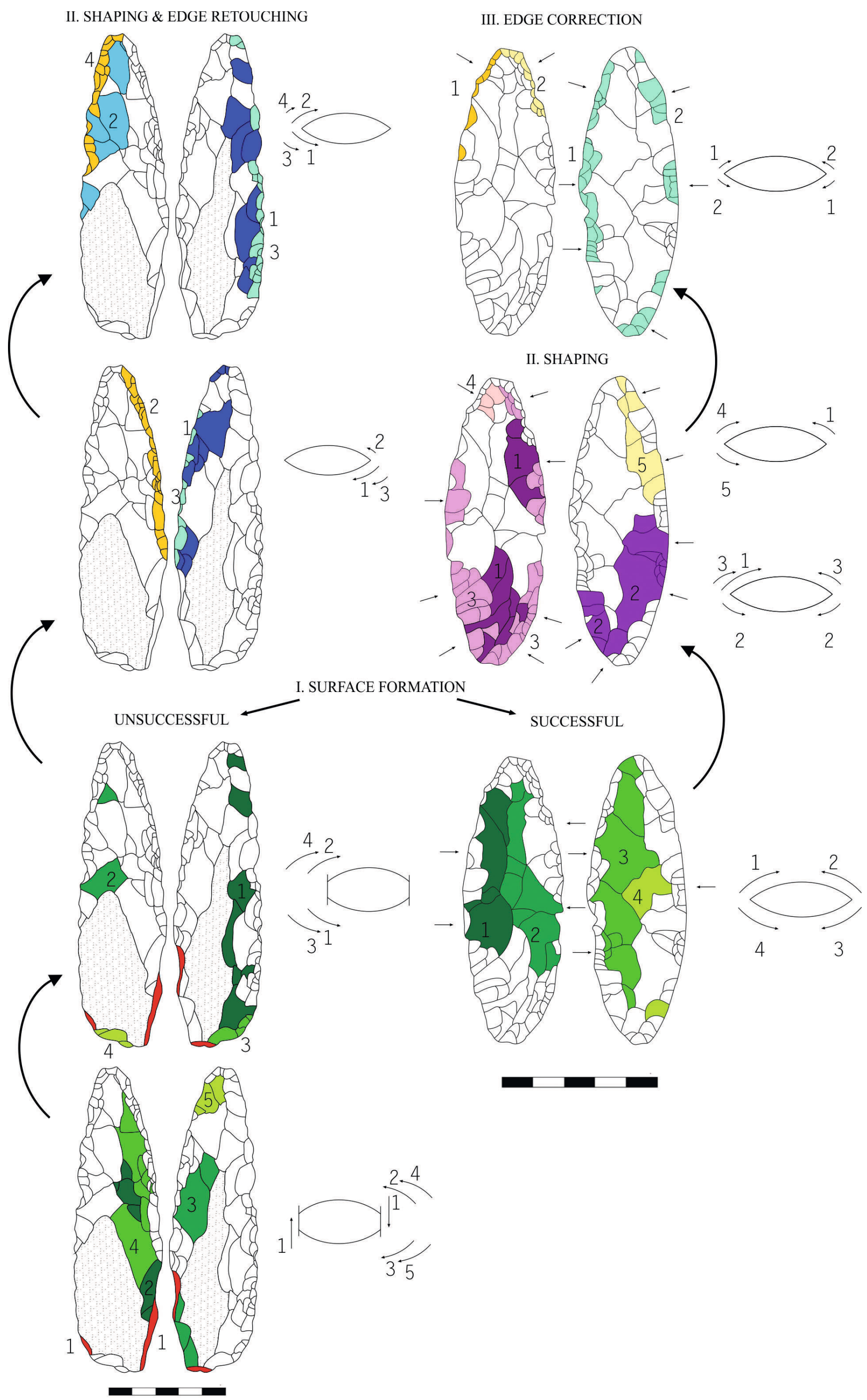


Fig. 5. Manufacturing scheme of the bifacial leafpoints from Szeleta Cave. Green: flat thinning, flattening removals; red/orange: semi-steep removals; violet/pink: shaping removals; yellow: marginal retouch; (Drawings: M. Kot).

Abb. 5. *Operationsschema der bifaziellen Blattspitzen von Szeleta-Höhle. Grün: flache Verdünnung, abflachende Abschläge; Rot/Orange: halbsteile Abschläge; Violett/Pink: formgebende Abschläge; Gelb: Kantenretusche; (Zeichnungen: M. Kot).*

described previously. These artefacts are quite broad in relation to their length and thickness (width/length index: 0.39, thickness/length index: 0.1). Their characteristic feature is a regular shape with a rounded base, but also the absence of an exposed tip (Fig. 7). The artefacts have an individually retouched edge at the tip placed transversely, or slightly at an angle, to the main axis of the tool. From a technological point of view, these artefacts were formed analogically to leafpoints.

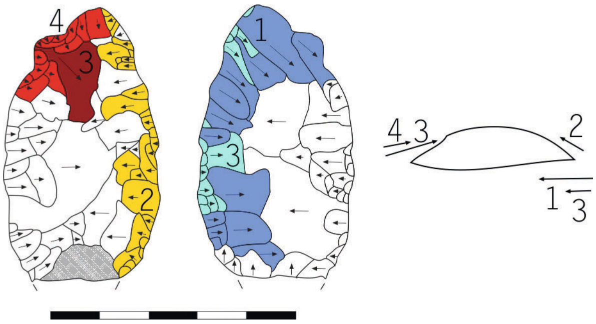


Fig. 6. Subsequent rejuvenation phases of the bifacially knapped knife from Szeleta Cave. In the last phase a kind of borer was exposed near the tip. Blue: flat thinning, flattening removals; red: semi-steep marginal retouch; yellow: sharpening retouch; (Drawings: M. Kot).

Abb. 6. *Nachfolgende Verjüngungphasen des bifaziellen Messers von Szeleta-Höhle. Aus der letzten Phase ist in der Nähe der Spitze eine Art von Bohrer erhalten. Blau: flache Verdünnung, abflachende Abschläge; Rot: halbsteile Kantenretusche; Gelb: schärfende Retusche; (Zeichnungen: M. Kot).*

I. Surface formation. This was undertaken by applying broad, semi-flat removals onto both tool surfaces. Even at this stage, a preliminary formation of the final tool shape is visible.
II. Shape formation. At this stage, removals were knapped at an angle to the vertical axis of the tool, in a similar fashion to removals on the leafpoints.
III. Edge profile correction. At this point, marginal removals following an edge scheme of knapping were taken off. The object of the removals was to correct the outline and profile of the edge. Both edges were treated uniformly. Similar treatment was also applied to the parts of the base close to the tip. During the knapping of the edge, removals were also taken from the tip, permitting the creation and preservation of a separate edge at the tip. On one tool, the tip removals are semi-steep and form a kind of acute working edge. On the other artefact, this edge is angular, forming a tip which is slightly asymmetrically exposed.

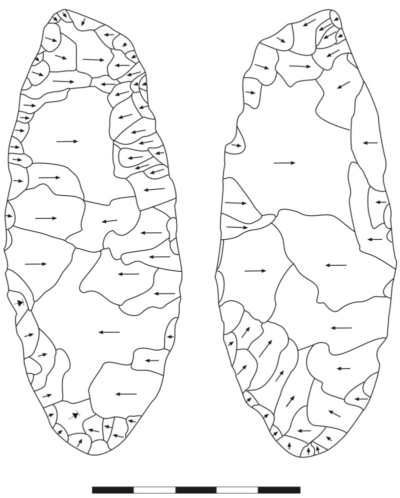


Fig. 7. Symmetrical biface from Szeleta Cave. The tool has no exposed tip but its manufacturing process shows due diligence to the tool symmetry and shape; (Drawings: M. Kot)

Abb. 7. *Symmetrisches bifazelles Werkzeug von Szeleta-Höhle. Das Werkzeug hat keine hervorstehende Spitze, aber das Operationsschema zeigt die Bestrebung nach Symmetrie und Form des Artefakts; (Zeichnungen: M. Kot)*

The artefacts from this group are a very interesting example of tools which are formed with due diligence to tool shape and edge profile. Also, the symmetry of these artefacts appears to have been a key issue in their formation process. However, as a result of the entire manufacturing process, artefacts with strongly parallel edges not convergent at the tip are created. The analysis of the whole manufacturing process, combined with the narrowness of the artefacts, seems to suggest that these forms were initially meant to be leafpoints. Nevertheless, intensive blank thinning made it impossible to introduce additional corrections to the shape and tip breadth-reducing sequences.

In summary, the artefacts are characterized by a well formed shape, neat edge profile, are symmetrical but lacking tip exposure. Both edges are sharply formed, though neither of them bears traces of intensive retouch, or even rejuvenations.

Vedrovice V

Vedrovice V is an open-air site located 40 km SW of Brno in the Krumlovský Les (Krumlovian Forest) region. Over 17'000 stone artefacts were found in a single archaeological horizon at this site , including over 700 tools – side scrapers, denticulated and notched tools, bifacial tools, a few endscrapers and mainly burins (Valoch 1993; Nerudová 2000b). Most artefacts were made of local cherts: very few were made of radiolarite and flint.

The analysed bifacial tools from Vedrovice V are made on cherts. Their dimensions range from 3.9 cm to 9.7 cm in length. Five of the artefacts are unfinished, failed or broken forms. Two artefacts were refitted from two fragments respectively, at least one of which shows signs of post-fracture repair. Although the morphology of the individual tools is very different, the artefacts show significant technological consistency. It was possible to trace the whole manufacturing process, due to the presence of artefacts abandoned at early knapping stages.

Leafpoints

Seven of the analysed artefacts can be described as leafpoints. Four of them are intact, the other two have broken tips. One artefact could be successfully refitted. Three artefacts are probably unfinished forms. All the Vedrovice V leafpoints are characterised by a high width/length index (0.54).

The artefacts are characterized by a specific scheme of nodule formation. First, one of the edges was formed by extensive, flat removals on both faces;

then the second edge was worked using semi-abrupt removals, also on both faces of the tool. Thus, an artefact was obtained, which is deltoid in cross section (Fig. 8). After the initial formation of the surface, the tool was shaped, its scheme at this stage being adapted to the needs of the tool.

On one of the artefacts, a consequent scheme of knapping of the edge can be observed throughout the manufacturing process, where one of the edges was completely formed, including the finest removals, and shape knapping on the opposite edge began only after the first edge was completed (Fig. 8).

Both edges, despite their specific knapping schemes, were worked and formed together during later stages of production. There was no preference for a particular edge, nor any evidence of the flaking of different removals on a particular face or edge. The artefacts do not bear marginal retouch, intended to sharpen the edge and straighten its profile. All of the removals observed on the artefact's surface are intended to thin the tool and form its final shape. Only a single artefact bears traces of rejuvenation. After breakage, the broken base was retouched along one of its edges, whereas the broken tip bears no traces of post-fracture repair.

Summing up, the leafpoints from Vedrovice V are characterized by considerable symmetry of the vertical axis and cross-section biconvexity. The symmetry of the artefacts obviously played a major role in their production. Even so, applying a consequent scheme of knapping of the edge did not appear to simplify the process of obtaining a perfectly symmetrical tool. However, the derived removals, especially those performed at the end of knapping on the second edge, are aimed at a maximum correction of the shape of the tool, even at the expense of blunting it slightly.

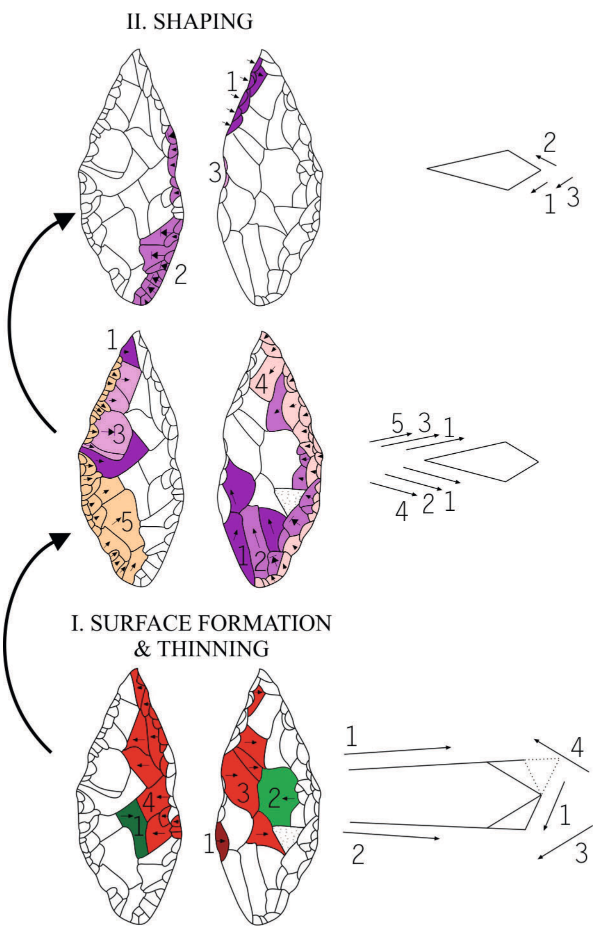


Fig. 8. Manufacturing scheme of the bifacial leafpoints from Vedrovice V. Green: flat thinning, flattening removals; red/orange: semi-steep removals; violet/pink: shaping removals; (Drawings: M. Kot)

Abb. 8. *Operationsschema der bifaziellen Blattspitzen von Vedrovice V. Grün: flache Verdünnung, abflachende Abschläge; Rot/Orange: halbsteile Abschläge; Violett/Pink: formgebende Abschläge; (Zeichnungen: M. Kot)*

Knives

Eight artefacts were analysed in the second group. Among these, there is a single tip, broken during an initial knapping phase, and seven completely preserved artefacts. All tools are marked by a coherent manufacturing scheme:

I. Surface and edges formation. This can be observed best of all on the broken artefact, abandoned as a preform. At this stage of manufacture the tools were knapped in the plano-steep alternate scheme, which consists of knapping abrupt removals on one face and flat removals on the other. The second edge is knapped analogous to and alternately to the first edge, producing the specific plano-steep, biconvex cross-section of the tool (Fig. 9). From the very beginning, flat removals are performed at an angle to the vertical axis of the tool and they extend far over the surface of the artefact. Flaking these types of removals alternately produces tip thinning and exposure. Some characteristic differences between the treatment of the apical and basal parts can be observed. After the formation of the plano-steep cross-section, flat, thinning removals were flaked from the tip replacing the old, semi-abrupt removals (Fig. 9), whereas one of the edges at the base was left semi-abrupt or shaped into a semi-abrupt form during the stage of tool shape formation, by a series of semi-steep removals. This edge is also more sinuous in profile than the opposing one. At further stages of manufacture, this edge has no retouch, or the retouch is limited to the apical parts (Fig. 9).

II. Retouch. In some cases, retouch is introduced in the form of semi-flat marginal removals onto the upper face of one of the edges. In others, one of the edges is retouched on the lower face and formed by small flat removals applied along the edge.

III. Repair. Six out of the eight analysed artefacts show signs of repair. In some cases, repair was limited to a resharpening of the cutting edge, in others to reforming the edge near the tip by knapping a series

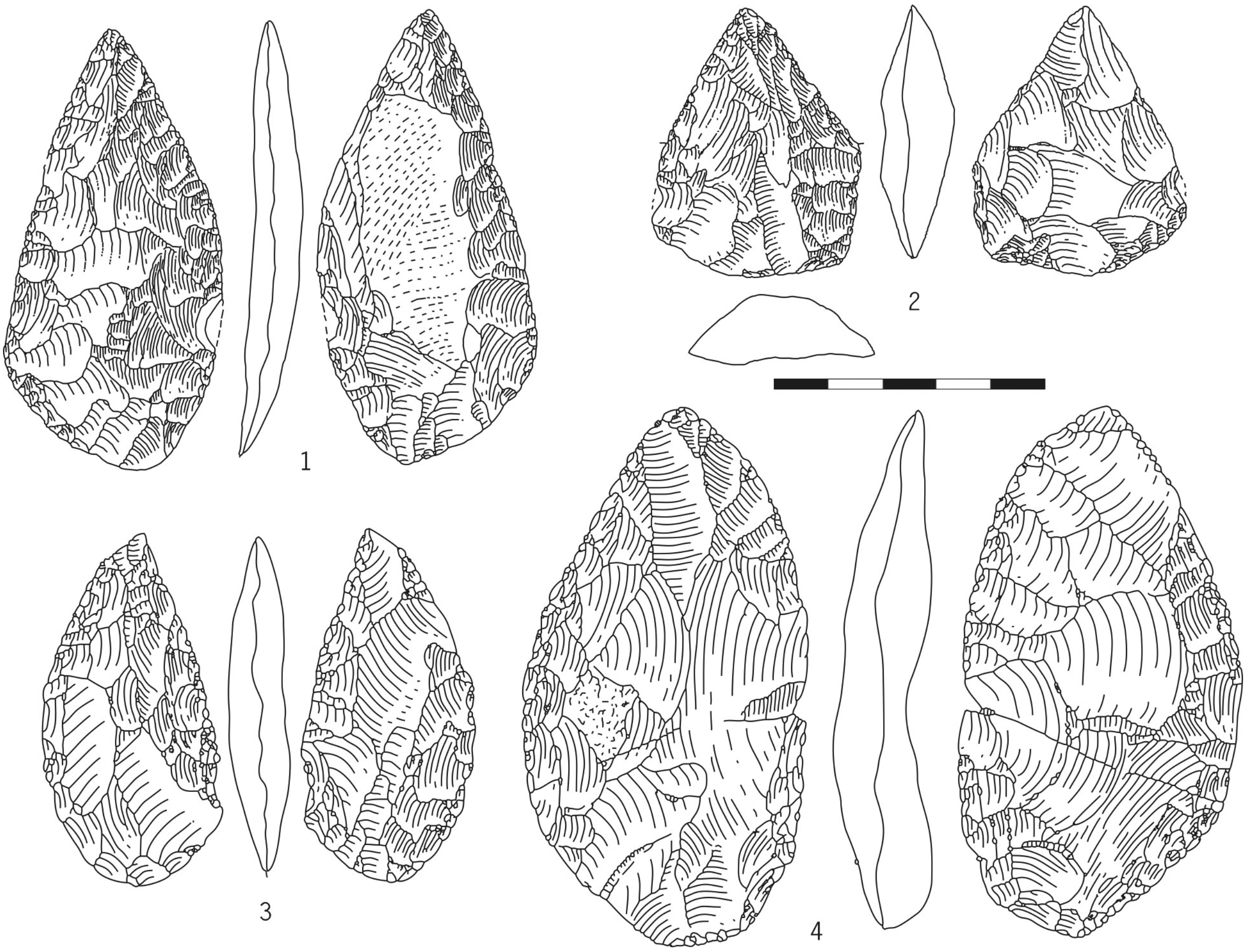


Fig. 9. Bifacial leaf-shaped knives from Vedrovice V. Illustrations after Valoch (1993).
Abb. 9. *Bifazielles blattförmiges Messer von Vedrovice V. Zeichnungen nach Valoch (1993).*

of alternating removals (re-sharpening of the cutting edge; thinning the opposing edge). Some of the tools were repaired by repeating the whole scheme of edge shaping.

The specific asymmetrical shape of the Vedrovice V knives is the result of the different character of the removals deriving from the cutting edge and the opposing edge. The cutting edge was repaired by retouching on one side only, while the opposing edge bears scars of removals derived, in most cases, on both sides. Therefore, the shape of the cutting edge changed at a slower rate than that of the opposing edge during the process of rejuvenation.

Although there are no visible signs of the intention to produce a symmetrical tool, the Vedrovice V knives do show that great care was taken in shaping the edge. There is also evidence of deliberate choice for tip exposure and preservation. The exposed tip is the result of performing alternate, angular, thinning removals and a retouch on both edges. In some cases, correction of the shape of the edge constitutes one of the repair stages. Even supposedly non-functional units such as the back of the tool or parts of the base are knapped and have a defined shape; moreover, the edges of the bases of the tools have a very straight and precise line.

Moravský Krumlov IV

The Moravský Krumlov IV site is an open-air multi-layered site situated in the area of the Krumlovian Forest (Krumlovský Les) region in the Czech Republic. In total, four archaeological horizons were distinguished, and the paper will concentrate on artefacts from one of them, namely the uppermost archaeological layer 0 (Neruda & Nerudová 2010: 160). The assemblage is interpreted as a workshop for the production of bifacial tools.

Among the eight artefacts analysed during this study, five are intact or have been refitted, and three are fragments of broken tools. One specimen has two, additional, refitted flakes completing the knapping scheme with a series of a few removals which are not visible on the surface of the tool. The artefacts are made of the local Krumlovský Les type chert. The results of the analysis revealed two stages of tool knapping:

I. Surface formation, thinning and decortication. A characteristic feature derives from almost abrupt removals on one of the edges. This might serve as the angle for further flat, thinning removals during an early stage of knapping. At this stage, the adopted scheme of action depended upon the selected nodule (Fig. 10).

- If the nodule was thick, then a vertical surface on one of the edges was created, and the tool was gradually thinned with flat, extensive removals derived from both edges onto the upper face. At a later stage, a flat lower face was formed and then the tool was further thinned with the use of semi-flat removals on the edge opposite to the

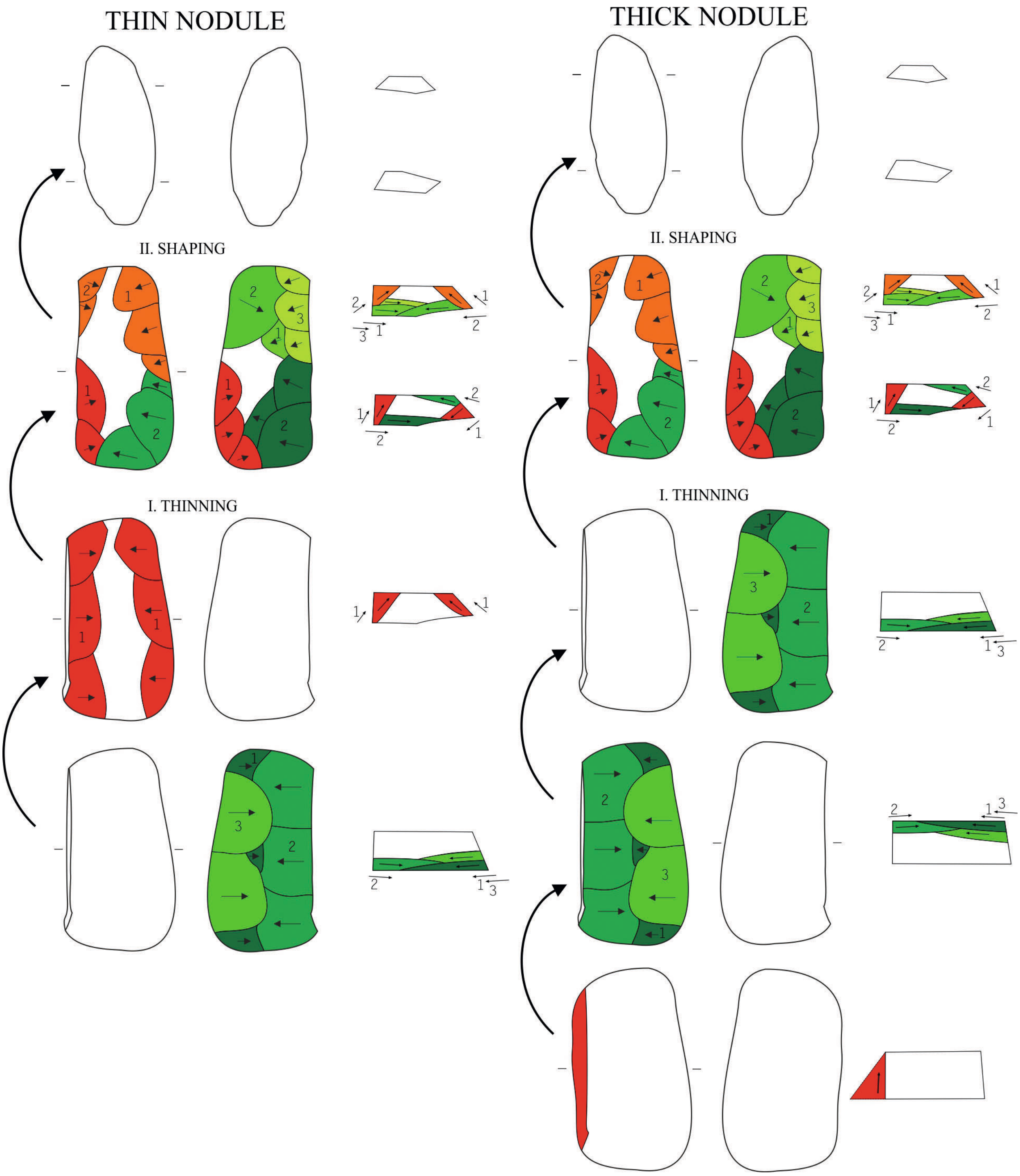


Fig. 10. Manufacturing scheme of the bifacial tools from Moravský Krumlov IV. Green: flat thinning, flattening removals; red/orange: semi-steep removals; (Drawings: M. Kot).

Abb. 10. *Operationsschema der bifaziellen Werkzeugen von Moravský Krumlov IV. Grün: flache Verdünnung, abflachende Abschläge; Rot/Orange: halbsteile Abschläge; (Zeichnungen: M. Kot).*

blunted one. The last stage of surface formation was the gradual removal of the vertical surface by extensive flaking of both faces from this edge.

- If the blank was a flat plate then a tendency can be seen for the formation of the flat surface of the lower face with flat, extensive removals. Next, semi-abrupt, decorticating and thinning removals were derived from both edges onto the upper face.

II. Shaping. This stage consisted of thinning and forming the edge at the base and the tip. The tip was formed separately from the base and the shaping of the base was undertaken before the tip was knapped.

- Base formation. At this stage, flakes were removed using a plano-steep alternate scheme of knapping. Subsequent knapping may be limited to semi-flat removals on the upper face.
- Tip formation. The part near the tip is usually plano-convex, triangular in cross-section, with a flat lower face (Fig. 10). One of the edges is formed by semi-abrupt removals on the upper face, whereas the opposite edge is formed by a series of flat removal derived on the upper face at an angle to the vertical axis of the tool. Due to the fact that the angular removals are derived from one edge only (and not alternating, as in the other assemblages), the tip is not on the vertical axis and the asymmetry of the tool is already apparent at this stage of knapping.

Since none of the analysed artefacts is a finished tool, it is not possible to say if the tools were destined to be leafpoints or knives. Although two artefacts had been retouched after breakage, it might be presumed that this was only an attempt at re-using a failed tool and not its intended shape. Several features indicate the reasons why tools were discarded and at which knapping stage. For example, where knapping was aimed at obtaining forms thin in cross-section (unsuccessful thinning disqualified the artefact); plano-convex in cross-section; with straight parallel edges, an exposed thin tip and an angular or rounded base. Such features might point to leafpoint production. Therefore, the diversification in the treatment of the edge during the manufacturing process might be due to technological reasons rather than the functional ones.

Brno-Bohunice Kejbaly

Brno-Bohunice Kejbaly is an open-air, single-layer site located within the boundaries of the city of Brno. The stone inventory is characterized by a fair amount of Levallois technology with a penchant for flaking prolonged, blade-like forms. At the same time, the toolkit includes bifacial forms such as leafpoints, as well as endscrapers (Valoch 1976: 37).

Bifacial tools are rather rare in the Brno-Bohunice Kejbaly collection (Valoch 1976; Škrdla & Tostevin 2005). The analysis comprised 10 artefacts, of which six came from excavations conducted in the 1970s by K. Valoch (1976). The other four artefacts came from excavations undertaken by P. Škrdla (Škrdla & Tostevin 2003, 2005). It was decided to describe both collections together due to similarities of production technology and the low numbers of artefacts in each assemblage. All the analysed tools are made of chert, and are characterised by their small size (average length: 6.29 cm) and thickness (average thickness: 1.42 cm). Based on the conducted analysis, the artefacts can be divided into two major groups.

Leafpoints

The group consists of three artefacts which are characterised by a biconvex cross-section, symmetrical shape, similar profile of both edges, exposed tip, precisely knapped and slightly exposed base and a high width/length index (0.44). One of these artefacts is an example of an unfinished tool, abandoned at the stage of its shaping/thinning. All manufacturing stages are visible on the other two artefacts, including marginal retouching. Artefacts belonging to this group are marked by the absence of traces of tool repair or edge re-sharpening. The artefacts are distinguished by their coherent knapping technology in which three main stages can be identified:

I. Surface formation, thinning. At this stage, the tool was knapped in a plano-steep alternate scheme. Semi-steep removals created a convenient angle for deriving further flat thinning removals on to the opposite face. Alternating flat or semi-flat removals were aimed at thinning and forming both surfaces of the tool (Fig. 11). The Brno-Bohunice Kejbaly leafpoints are characterized by very precise knapping. This may explain the application of an additional series of thinning and flattening removals aimed at removing semi-abrupt alternating surfaces in the second stage of tool thinning.

II. Shape formation, further thinning. At this stage, the tools were knapped in a circumfluent by deriving flat removals at an angle to the vertical axis and extending far over the surface of the tool (Fig. 11). Knapping at this stage was mainly focused in the areas near the base and near the tip, resulting in their exposure.

III. Edge profile correction. Further removals were adjusted in their placement and morphology according to the main objective; the formation of a straight, symmetrical edge. The removals were derived either from both surfaces, correcting the entire length of the edge, or they were applied only to the part near the tip.

Based on the analysis it can be stated that the Brno-Bohunice Kejbaly leafpoints are characterized by careful knapping aimed at tool shape, tip exposure and obtaining relatively thin tools. Despite their different shapes, these artefacts were produced according to the same concept, and the purpose of production was identical for each tool. Two convex and reciprocally symmetrical edges were treated in

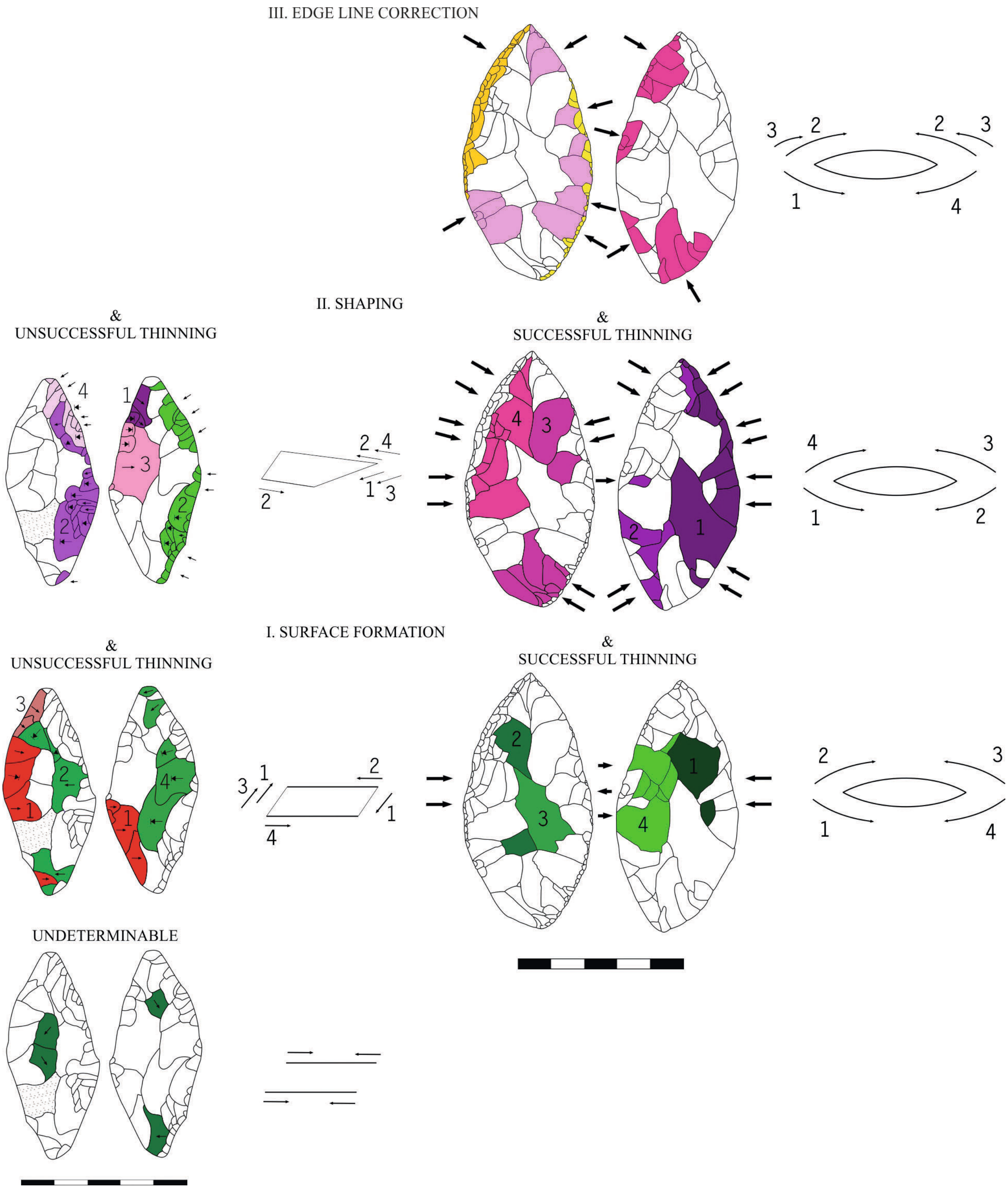


Fig. 11. Manufacturing scheme of the bifacial leafpoints from Brno-Bohunice Kejbaly. Green: flat thinning, flattening removals; red/orange: semi-steep removals; violet/pink: shaping removals; yellow: sharpening retouch; (Drawings: M. Kot)

Abb. 11. *Operationsschema der bifaziellen Blattspitzen von Brno-Bohunice Kejbaly. Grün: flache Verdünnung, abflachende Abschläge; Rot/Orange: halbsteile Abschläge; Violett/Pink: formgebende Abschläge; Gelb: schärfende Retusche; (Zeichnungen: M. Kot)*

the same way during the manufacturing process. The final retouch is derived onto both edges on the upper face, but is preceded by flat, tiny removals near the tip, derived onto the lower face. Both the apical part and the part located closer to the base are formed in the same manner, and final retouch is also present on the parts near to the base, which points to retouch being applied for purposes other than edge sharpening.

Knives

The second group included seven artefacts. They all are plano-convex in cross-section. Both edges were formed semi-abruptly onto the upper face.

Differences in the manufacturing of the base and in the edges near the base can be observed. Some of the tools included in this group display a considerable symmetry in the vertical axis; however, almost all of them have been repaired and have re-sharpening traces on at least one edge. Numerous repairs are visible on the surfaces of the tools and hinder the analysis of their *chaîne opératoire.* Certainly, one can say that production was not as coherent as the one utilized for the leafpoint tools. Based on the analysis, only two stages can be distinguished:

I. Surface and edges formation. Two distinct schemes were applied at this stage of manufacturing. In the first scheme, sequences of flat, extensive removals were derived from both edges in order to produce a completely flat lower face (Fig. 12). In contrast, the upper face was formed with semi-steep removals derived from both edges and the base. In the initial stage, this particular nodule shape was necessary in order to decorticate the tool and create favourable angles for flat, thinning flakes. However, at a later stage when the semi-steep removals on both edges should have been flattened, some of the tools were abandoned due to unsuccessful thinning. The second scheme comprised a plano-steep alternate knapping strategy. Both schemes are based on the same concept of preparing an abrupt angle for thinning removals; nevertheless, in the latter case, these removals are derived alternately while in the former case, they are derived analogically. The first scheme was applied, with one exception, to thick flakes only. Its use might also be connected with the Levallois core concept, abundant at Brno-Bohunice Kejbaly.

The edges were prepared after general formation of the surface. Flat removals on the lower face were aimed at correcting only the angle and the profile of the edge, while removals on the upper face were aimed at sharpening the edge and correcting the shape. During the final stage one of the edges was retouched from the upper face. The opposing edge is characterised by a greater inclination to the vertical axis than on the retouched edge. This makes the artefacts asymmetrical near the tip.

II. Repair. In its simplest version, repairs would have been limited only to deriving a series of percussions onto the lower face of one edge, alternating with a series of semi-flat sharpening retouch onto the upper face of the other edge. During more extensive repairs, however, removals were derived onto all faces of both edges respectively. First of all, flat removals onto the lower face of both edges were derived. On the edge opposite to the retouched one, flat angular and extensive removals were derived; their scars sometimes even running parallel to the retouched edge. The next stage was the sharpening retouch derived on at least one of the edges of the upper face. During rejuvenation, care was taken to keep the retouched edge almost vertical, converging with the opposite edge and more inclined at the tip.

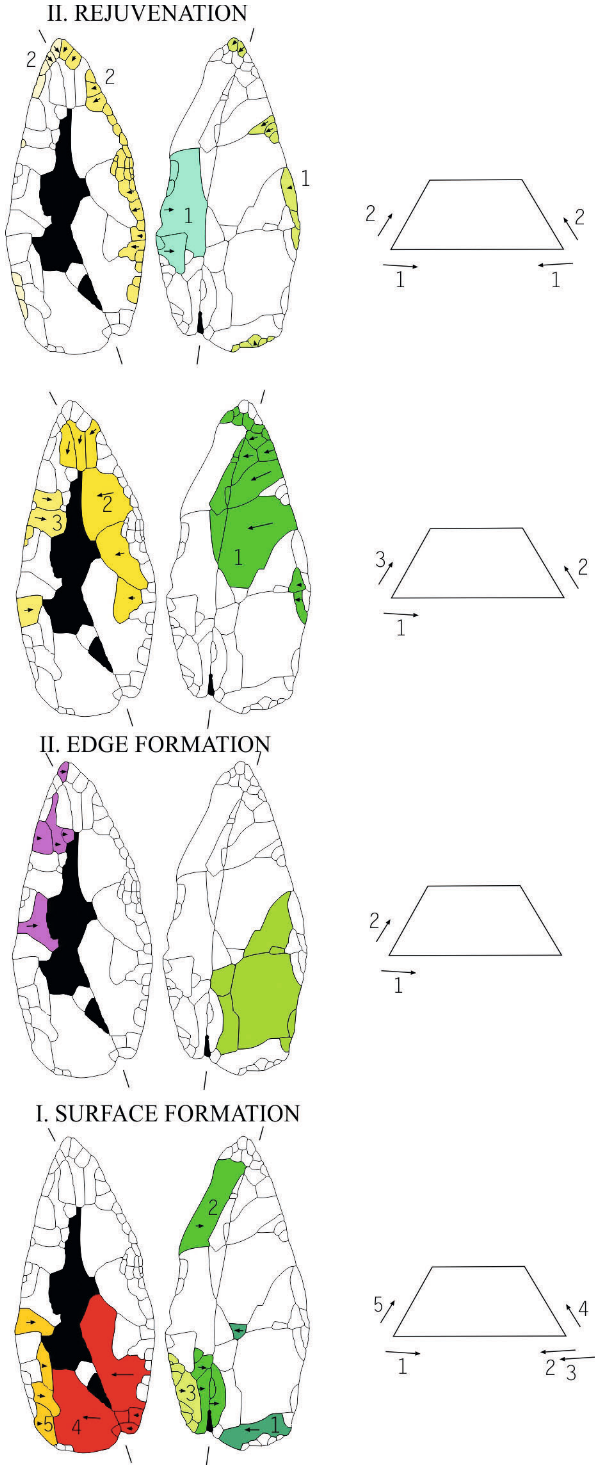


Fig. 12. Manufacturing scheme of the bifacial leaf-shaped knife from Brno-Bohunice Kejbaly. Black: termic surface damages; green: flat thinning, flattening removals; red/orange: semi-steep removals; violet/pink: shaping removals; yellow: sharpening retouch; (Drawings: M. Kot)

Abb. 12. *Operationsschema der bifaziellen blattförmigen Messer von Brno-Bohunice Kejbaly. Schwarz: thermischer Flächenschaden; Grün: flache Verdünnung, abflachende Abschläge; Rote/Orange: halbsteile Abschläge; Violett/Pink: formgebende Abschläge; Gelb: schärfende Retusche; (Zeichnungen: M. Kot)*

Summing up, the knives from Brno-Bohunice Kejbaly are characterised by the different treatment of both edges. Symmetry of shape is associated with the parallel repair of both edges, but the aim of deriving removals from both edges during repairs was not identical. As found, the tools seem to be single cutting edge tools, highly exhausted as a result of several stages of repair. The shape of the artefacts is diverse and represents the mean result of subsequent tool repairs. The consecutive repairs could even have led to tip obliteration and the creation of the tool in the form of an endscraper.

Jankovich Cave

Jankovich Cave is located on a steep slope of Öregkő hill, in the Gerecse Mountains in Hungary. The main excavations at the site were conducted by J. Hillebrand between 1913 and 1917 and in 1925. The researcher distinguished four geological layers in which he distinguished two archaeological horizons (the Magdalenian and the early Solutrean) (Hillebrand 1935). The results were verified in 1956 by L. Vértes (Vértes 1956, 1968). He discovered the uppermost sediment level in the trench at the entrance of the cave, referred to as Magdalenian by Hillebrand. In total, Hillebrand obtained fewer than 150 stone artefacts, 35 of them described as bifacial leafpoints (Jánossy et al. 1957). The majority of the tools are made on liver-coloured or olive-green radiolarite. Only a few artefacts are made of flint. 20 out of the 35 bifacially knapped artefacts found in Jankovich Cave were studied. As a result of the treatment of the edges, the analysed artefacts can be divided into two groups.

Leafpoints

A single artefact from Jankovich Cave can be described as a leafpoint (Fig. 13). It has a symmetrical leaf shape and bears multiple phases of shaping, which permit previous stages of the manufacturing process and the applied scheme of knapping to be determined. The final form has a biconvex cross section. Almost all scars visible on the surface of the tool come from a series of subsequent and repetitive shaping and thinning removals of either the base part or the part near the tip. The tool bears no traces of sharpening retouch. Even at the very late stage of preparation, a series of extensive removals were derived, aimed at thinning the tool near the tip. The very last marginal retouch applied near the tip was intended to correct the shape of the edge, which was slightly blunted due to multiple hinge removals. There are no traces of tool rejuvenation.

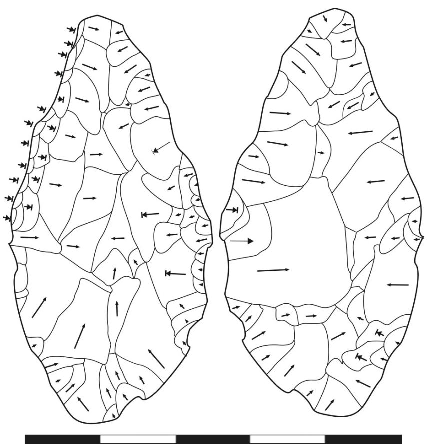


Fig. 13. Bifacial leafpoint from Jankovich Cave; (Drawings: M. Kot)

Abb. 13. *Bifazielle Blattspitze von Jankovich-Höhle; (Zeichnungen: M. Kot)*

Knives

The majority of the bifacially knapped tools from Jankovich can be described as knives. Their characteristic feature is the presence of a rounded, separately shaped base and two converging edges, both retouched either on the upper face or alternately. Intensive retouch occurs on the edges near the tip, which thus becomes more exposed, and sometimes even creates a kind of protrusion. The artefacts show signs of rejuvenation, most often on both edges.

Most artefacts have numerous traces of rejuvenation which have obliterated initial stages of tool formation. Only a few of the artefacts have minor rejuvenations, providing the possibility of observing previous stages of manufacture. In such cases, the formation of the surface of the artefact proceeded in a fully alternate, plano-steep scheme of knapping (Fig. 14). First of all, flat, extensive removals on both faces of the tool were derived alternately. Then, semi-flat/semi-abrupt alternate removals were derived on the second face of each edge. In contrast to bifacial tools from other sites, where an analogous technique of nodule formation had been applied, this technique led to the formation of extremely thin, almost biplan artefacts at Jankovich (Fig. 14). However, the production of thin artefacts had its drawbacks, manifested mainly in problems with rejuvenation and resharpening of the edge. Therefore, there was not enough space left for the appropriate correction of the angle. Thus, after several rejuvenation phases, the tools became almost rectangular in cross-section with two flat surfaces and edges blunted with an abrupt retouch.

The Jankovich knives show no standardization in the adopted rejuvenation schemes. Even so, there is an observable tendency to rejuvenate tools in an edge analogical scheme of knapping, where first preparatory and correcting removals were derived on the lower face and afterwards on the upper face of one edge. This procedure was repeated on the second edge, also in a bottom-top scheme.

Most of the analysed artefacts from this group have a characteristic shape with a rounded base, and two edges converging at the exposed tip. The artefacts

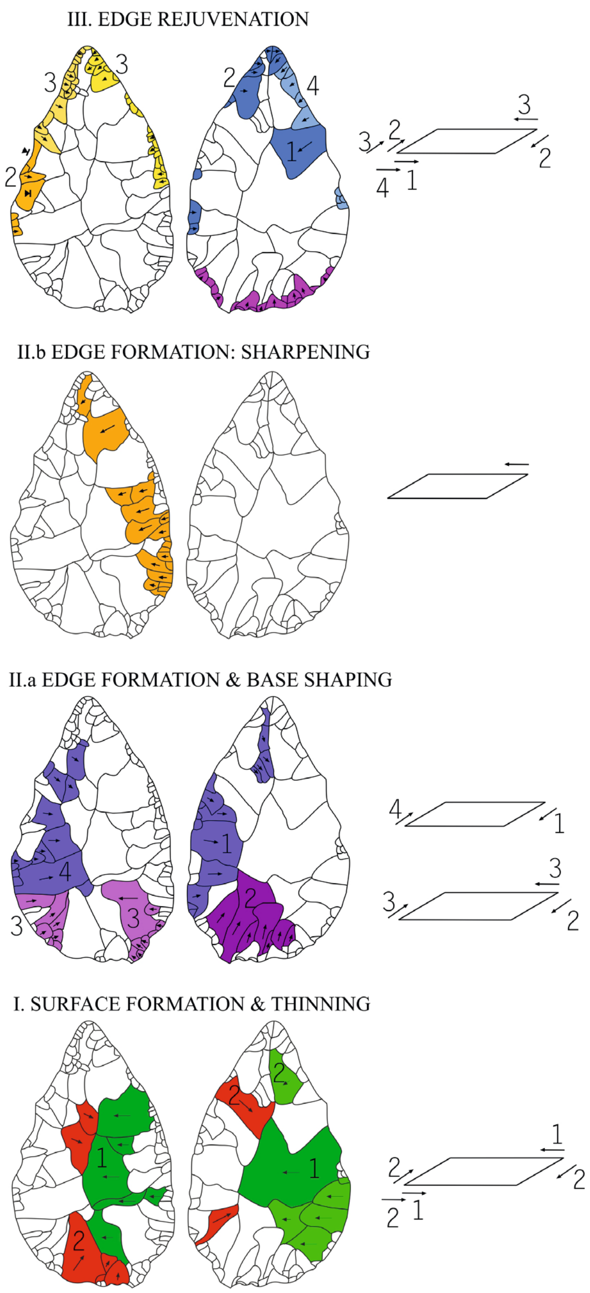


Fig. 14. Manufacturing scheme of the bifacial leaf-shaped knife from Jankovich Cave. Green: flat thinning, flattening removals; red: semi-steep removals; violet/blue: shaping removals; yellow/orange: sharpening/resharpening retouch; (Drawings: M. Kot)

Abb. 14. Operationsschema der bifaziellen blattförmigen Messer von Jankovich-Höhle. Grün: flache Verdünnung, abflachende Abschläge; Rot: halbsteile Abschläge; Violett/Blau: formgebende Abschläge; Gelb/Orange: schärfende/nachschärfende Retusche; (Zeichnungen: M. Kot)

are asymmetrical near the tip because one of the edges, the retouched one, is vertical while the opposite edge converges at an angle near the tip. The shape of the tool is the result of the applied tool formation and rejuvenation technique. This technique comprised formation of the base by deriving angular removals from both edges at the base, and from the edge opposite to the retouched one in particular. This edge was formed with the use of angular removals closer to the tip. At the same time removals forming the retouched edge were performed perpendicular to the vertical axis, which in consequence led to the creation of a specific shape which characterizes the majority of artefacts. During subsequent rejuvenations, tool shape could have been changed, as in the case of artefacts preserved in a heavily exhausted form, which bear traces of multiple rejuvenations.

It can be concluded that the knives from Jankovich Cave are tools with differently treated edges, where only one edge is retouched along its entire length. The artefacts also bear traces of multiple rejuvenations and edge resharpening, usually on the apical parts. The tools show that great care was taken with tip exposure and preservation during successive rejuvenation phases. However, in some cases, the tip was removed in order to thin the apical part of the cutting edge. Subsequent formation and rejuvenation phases are not oriented at obtaining a symmetrical tool, but only at effective thinning and resharpening of the edge.

Sajóbábony-Méhésztető

Sajóbábony-Méhésztető is an open-air, single-layer site located in NE Hungary in the Bükk Mountains region. It is located near Sajóbábony village, about 8 km to the N of Miskolc. The artefacts are made of felsitic porphyry or hydroquartzites from the Bükk Mountains (Ringer 1983; Ringer & Adams 2000). The inventory is characterized by an absence of Levallois technology. There is a variety of forms in the assemblage, including bifacial knives, leafpoints and Bábony-type knives (Ringer 2000; Ringer & Adams 2000).

Of the 14 pieces analysed, five are intact artefacts, and nine are only fragments. Among the artefacts studied, several tools were found to be similar in terms of morphology. However, these should not be regarded as functional forms, but as attempts to find analogies in the production of the artefacts, and possibly in rejuvenation schemes.

Leafpoint

A single artefact from the Sajóbábony-Méhésztető collection can be described as a leafpoint (Fig. 15: 1). This tool, biconvex in cross-section, has a transversal fracture surface at the base. The artefact has a well-exposed tip and is symmetrical in its vertical axis. Both edges have a straight profile. The tool was formed in the following way:

I. Surface formation and shaping. Surface formation and shaping proceeded in a plano-steep alternate scheme. Flat removals were applied on one face and semi-abrupt ones on the other in order to maintain an appropriate edge angle for further removals. The scheme was repeated twice, applying large extensive removals. The subsequent series of removals were less extensive than the previous ones which focused on

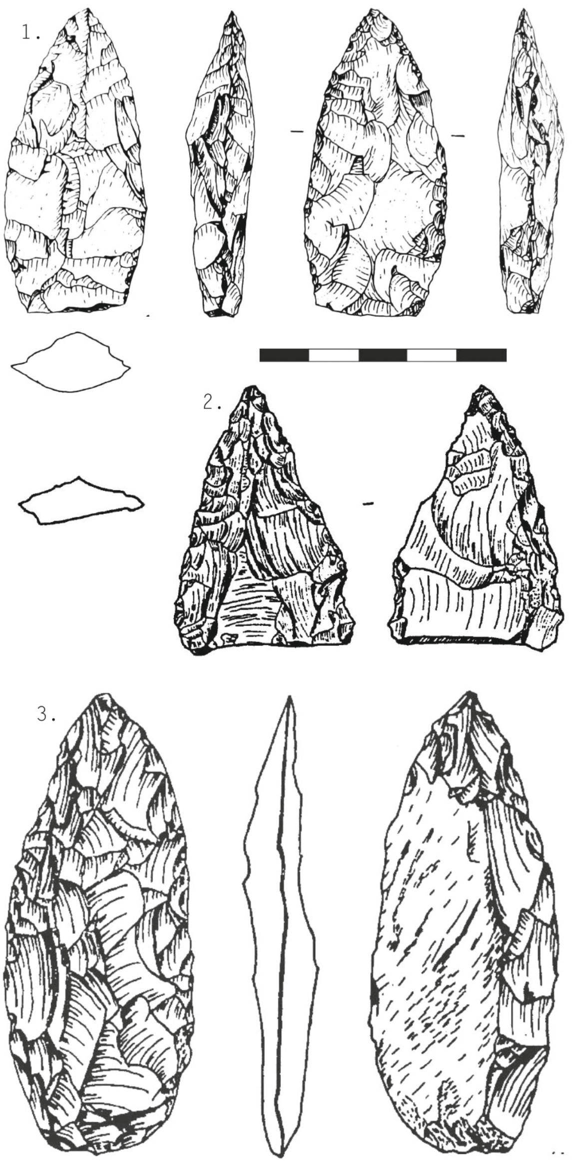


Fig. 15. Bifacially knapped tools from Sajóbábony-Méhésztető. (1) leafpoint, (2) knife with a base made on transversal breakage, (3) bifacially knapped knife. Illustrations after Ringer & Adams (2000), Ringer (1983).

Abb. 15. *Bifazielle Werkzeuge von Sajóbábony-Méhésztető. (1) Blattspitze, (2) Messer mit Basis, die auf Querbruch gebildet wird, (3) bifazielles Messer. Zeichnungen nach Ringer & Adams (2000), Ringer (1983).*

areas requiring thinning or shape correction. Hence, sequences on the first edge focused on the base and areas near the tip, whereas sequences on the second edge were performed in the centre of the edge.

II. Transversal breakage. This could have been the result of either intentional or accidental action.

III. Edge formation and shaping. A series of flat removals were applied onto the lower face near the fracture scar, as well as an alternate series of semi-flat and flat removals located near the tip, positioned at an angle to the vertical axis of the tool.

IV. Edge retouch. There is a fine, marginal retouch on both sides. The retouch of one of the edges was focused on the central portion of the edge. In the case of the second edge it was located closer to the tip. The artefact displays equal edge treatment. Marginal retouch was designed to correct the profile of the edge.

The character of breakage is difficult to speculate on. From the technological perspective, it is interesting to observe the activities which took place immediately after breakage when a series of flat removals were derived near the base in order to reconstruct the leaf shape and the convexity of the edges.

Knives

There are 13 items in this group. Eight of them are characterized by the presence of two edges converging at the tip and a transverse fracture at the base (Fig. 15: 2-3). They are characterized by significant tip exposure and a careful maintenance of the tip. They can be considered as broken forms, yet they all show a considerable consistency of morphology at the stage of abandonment. In addition, a single artefact which has a natural transversal surface used as a tool base proves that these artefacts can be regarded as a separate group in which almost all the tools were retouched at least once after breakage.

The remaining four artefacts lack traces of breakages but have two edges converging at the tip and the base. In contrast to the artefacts with broken bases, the process of knapping focused on achieving a long and sharp edge, without taking the tip into account. Both edges are retouched and rejuvenated equally. The symmetry of both tools is most likely connected with the identical treatment of both edges. These tools are characterized by a specific production scheme.

I. Surface formation. This was conducted in a plano-steep alternate knapping scheme with semi-abrupt removals on one face, and then flat and extensive removals on the other face of the same edge. This procedure was then alternately repeated on the other edge of the tool. A series of semi-abrupt removals created an appropriate angle for the knapping of additional flat, extensive removals on the opposite face. At subsequent knapping stages, the lower face was either flattened or left plano-steep.

II. Edge formation/breakage/rejuvenation. Subsequent knapping steps were aimed at formation and retouch of the edge by undertaking alternate removals on both faces. In most cases, only one of the edges was retouched along its entire length. During further knapping and rejuvenation, the plano-convex cross-section was preserved by applying flat removals onto the lower face, derived from the opposite edge. Retouch on the other edge of the tool was limited to its apical part.

Rejuvenation traces in the form of edge resharpening retouch, introduced after breakage of the tool, testify to the fact that these artefacts were utilized in the shape in which they were found. They are characterized by the great care taken to maintain the profile of one edge, most frequently the longest edge. Preserving the exposed tip, sharpening and rejuvenation were of considerable importance for these tools, at least in the case of the apical parts of the second edge.

Most of the artefacts show traces of retouch produced prior to breakage. However, there are no obvious traces of shaping or attempts to improve the symmetry of the tool. Nevertheless, this situation can be the result of analysing only fragments of tools instead of complete specimens prior to breakage.

Muselievo

Muselievo is an open-air single-layer loess site located on the right, steep bank of the Osam River about 8 km before its confluence with the Danube (Bulgaria). The site is a leafpoint workshop located in the vicinity of a flint outcrop. During excavations in the 1970s (Dzambazov 1967; Chmielewski 1977; Haesaerts & Sirakova 1979; Sirakova & Ivanova 1988), a large inventory of flint was recovered at the site, with over 500 leafpoints and huge amounts of debitage flakes from the production of bifacial tools. The artefacts were made on flint nodules collected on the slope where the site is located. The assemblage is rich in preforms and unfinished pieces. Some of them were also analysed in this paper in order to extend the *chaîne opératoire.*

All of the artefacts are characterized by a considerable variety of forms, from long (10 cm) and slender to short (5 cm long) but with significant thickness and width. Most artefacts are characterized by asymmetrical edge profiles, as well as a tendency to retain cortex surfaces on one edge near the base. The cortical fragment forms a transversal surface which is often set at an angle to the axis of the tool. Such cortical surface placement is associated with the application of specific tool knapping schemes. On the basis of scar pattern analysis and differences in the treatment of the edge, the tools can be classified into three groups.

Leafpoints

The leafpoints from Muselievo are characterized by their slenderness (width/length index is 0.32), biconvex cross-section, the highly regular line of the edge and its straight profile (Fig. 16). The bases of the described tools are either prepared or left without any additional knapping and retain some cortex.

A characteristic feature, and the most distinctive one, is not only the symmetry of both edges at the tip and at the base, but also the presence of tool shaping sequences. The location of these sequences depends on where the edge required correction. In some cases, the final retouch sequence corrected the shape of the tool near the base.

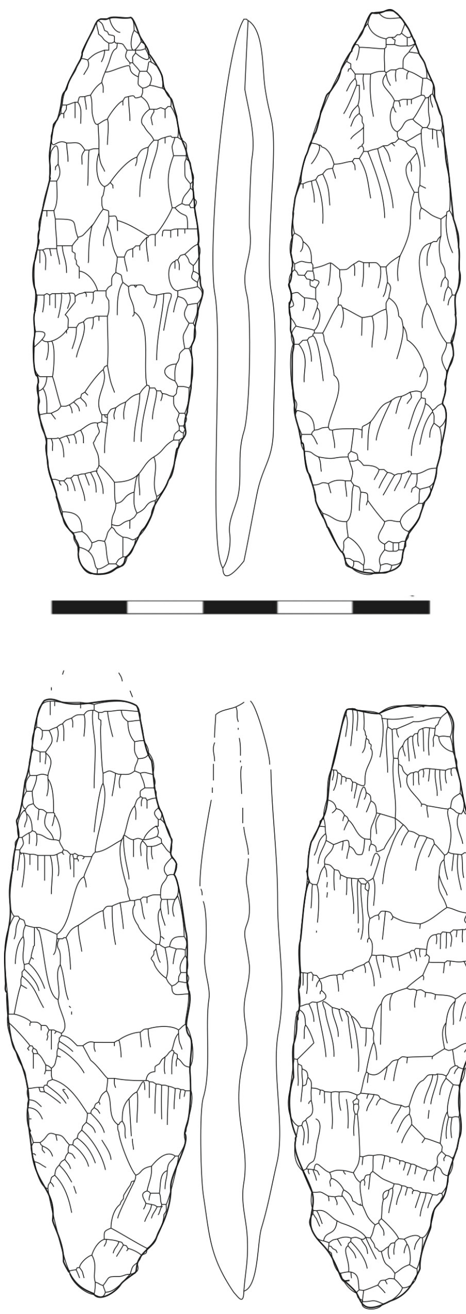


Fig. 16. Bifacial leafpoints from Muselievo. Illustrations after Sirakova (2009).

Abb. 16. *Bifazielle Blattspitzen von Muselievo. Zeichnungen nach Sirakova (2009)*

Another characteristic feature is the alternating nature of analogous sequences of flaking on both edges. The last retouch at the tip was derived alternately, thus enabling the symmetrical outline of the tool to be maintained. These tools show no signs of rejuvenation even after breakage. Their knapping consisted of the following stages:

I. Surface formation. Surface formation was undertaken by applying a scheme of alternate plano-steep knapping. The steep removals were derived at an angle near the base and the tip, creating a blunt

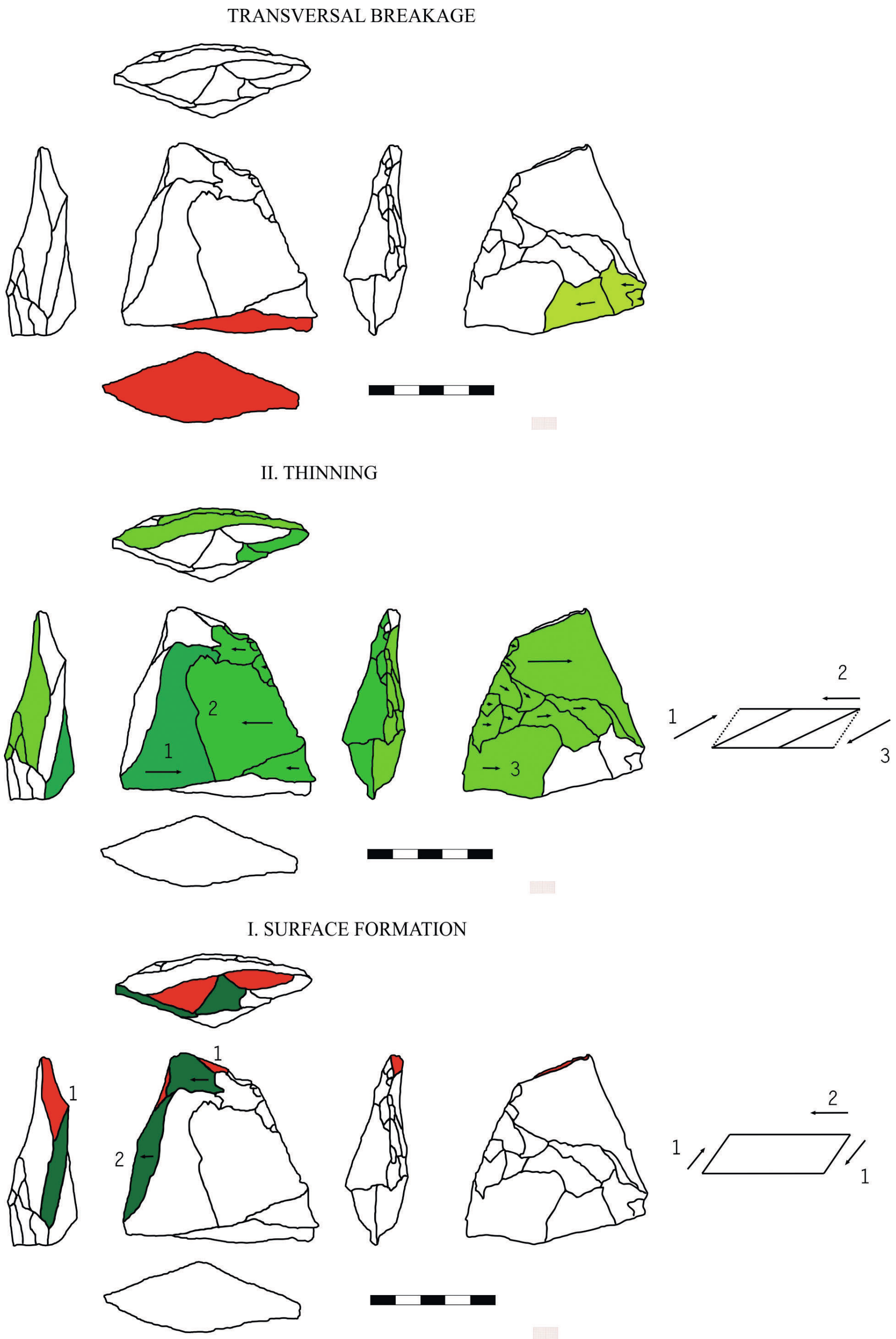


Fig. 17. Manufacturing scheme of the bifacial tools from Muselievo. Green: flat thinning, flattening removals; red: semi-steep removals; (Drawings: M. Kot)

Abb. 17. *Operationsschema der bifaziellen Werkzeuge von Muselievo. Grün: flache Verdünnung, abflachende Abschläge; Rot: halbsteile Abschläge; (Zeichnungen: M. Kot)*

surface which allowed for additional flat thinning and shaping removals (Fig. 17).

II. Thinning. At this stage, mainly flat and semi-flat removals were derived. They were not extensive and angular to the axis, especially close to the base.

III. Shaping, thinning, narrowing. At a further stage of shaping, flat, extensive removals were derived from the central part of the tool. Thus, the tool was narrowed and thinned.

IV. Edge formation, retouch. At this stage, a series of mainly marginal removals were derived, in order to shape the final edge. Knapping proceeded following an edge scheme, but the formation of the tool appeared to play a greater role than the application of these schemes. Thus, except for the general knapping scheme, additional sequences were adjusted to the needs and goals of the tool. At this stage, it was more important to retain the line of the edge rather than its profile, meaning the tool could have been even slightly blunted so as to obtain an appropriate edge line.

All the visible sequences were designed to achieve a particular goal, namely the production of a symmetrical, slender and thin tool with an exposed tip. An interesting feature is the presence of phase II sequences which were aimed not only at thinning but also to produce a narrower tool. As a result, the Muselievo leafpoints are characterized by considerable slenderness.

Leaf-shaped knives

The second group consists of slender forms in the shape of a willow leaf. They are characterized either by symmetrical edges converging at the well exposed tip or by a specific edge shape, one of which is almost straight and parallel to the vertical axis of the tool, while the other is convex at the tip, resulting in a tip which is asymmetrical to the axis of the tool (Fig. 18). Moreover, these tools are characterized by the parallel profiles of both edges at the centre, slenderness, and a substantial length in comparison to tool width and thickness (width/length index: 0.32). In several cases, there is a significant change in tool shape visible at the tip as a result of several rejuvenation sequences.

In all instances both edges are retouched but the rejuvenation is usually restricted to the apical parts. The part closer to the tip is narrower, and in some cases the retouch and rejuvenation have transformed the shape of the tool and exposed the apical part to such an extent that it resembles the tip of a borer.

The artefacts with edges which converge symmetrically at the tip also have a system of notches, mostly at the centre of one of the edges, suggesting the tools were hafted up to about half of their length. This is also indicated by the extent of retouch connected with rejuvenation. The asymmetric tools have part of their convex edge blunted by steep removals creating a type of "backing" at around ½ or ⅓ of their length. None of the tools bear traces of a separate preparation of the basal edge, nor is it visibly blunted. Hence, it seems that the base should not be treated as a distinct part of the tool. The following *chaîne opératoire* stages can be described:

I. Surface formation, initial thinning. It seems that a plano-steep alternate scheme of knapping was typical of the Muselievo knives at the early stages of the manufacturing process, during thinning and surface formation. Such a scheme led to the production of tools with a biconvex cross-section. Specimens of precisely this shape are predominant at Muselievo. Using this type of scheme would explain the morphology of the Muselievo bases, which both at the initial knapping stages and later in their highly exhausted forms retain remnants of cortical surfaces, set at an angle to the axis of the tool.

This pattern is consistent with observations on the preforms. At the initial stage of surface formation, the base was formed by a series of alternate abrupt percussions or natural transversal surfaces were also used for this purpose. Two alternately formed surfaces allowed for the introduction of flat angular alternate percussions on both faces of the tool. If steep alternate surfaces were created at both ends of the tool, placed at angles of about 90°, then knapping using angular percussions would lead to the creation of tools with a specific morphology.

II. Further thinning, shaping. During later thinning stages of the nodule, the tip was thinned by deriving flat angular removals from one edge onto both faces. Forms characterized by the presence of transversal surface residue at the tip and base (more often at the base), are typical of this type of knapping.

III. Edge preparation. At this stage the edge knapping scheme was used. Interestingly, the asymmetrical tool shape was achieved mainly at the very end, as a result

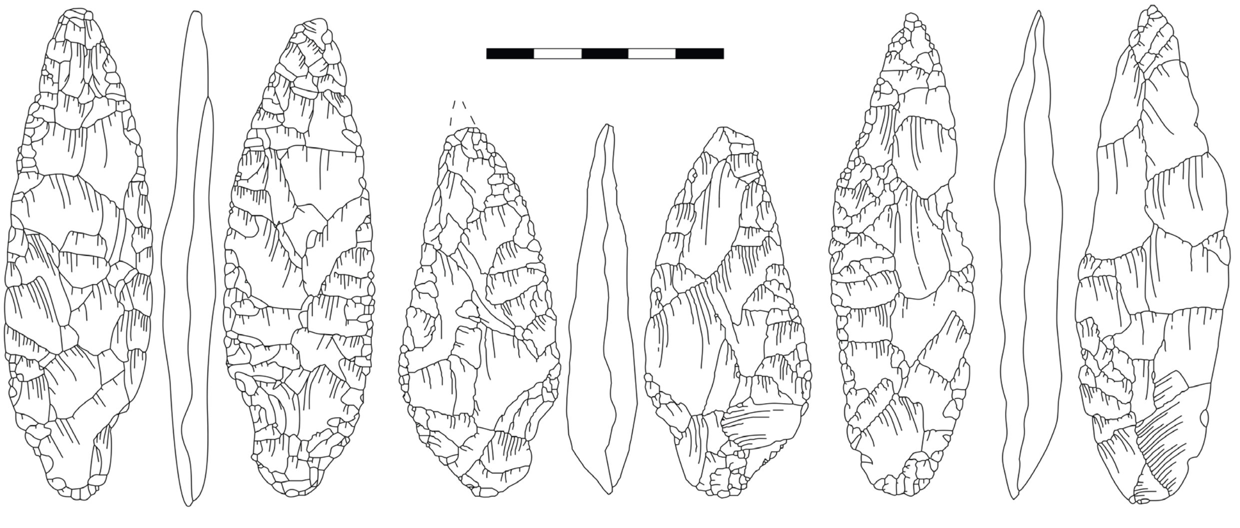


Fig. 18. Leaf-shaped knives from Muselievo. Illustrations after Sirakova (2009).

Abb. 18. *Blattförmige Messer von Muselievo. Zeichnungen nach Sirakova (2009).*

of angular removals derived from an edge near the tip. The asymmetry of the tool, however, must have existed at an early stage and must have been accentuated by the introduction of angular removals near the tip onto the convex edge, as well as transversal removals onto the straight edge. On strongly asymmetrical artefacts a differential treatment of the two edges can be clearly seen at this stage of manufacture. This can provoke the assumption that a straight cutting edge was deliberately formed, along with a convex distal posterior edge, from which thinning removals were derived at the tip, transforming the distal edge into a backed edge close to the base.

In some cases blunting removals were applied at this stage to form one of the edges near the base. Depending on the tool, back blunting sequences can extend from ⅓ to ⅔ of the length of the tool. At the base, blunting sequences were derived at an angle to the vertical axis, and converge with the cutting edge at the base outside the axis of the tool. The tools without blunted backs are characterised by the presence of a few notches located in similar positions along both edges.

IV. Edge retouching. The retouch of both edges was usually restricted to the apical parts. The retouch is fine and precise, derived each time on the upper face with the use of semi-flat and flat removals. It was aimed at sharpening rather than shaping the edges. It is clearly visible while the artefacts are characterised by a slight asymmetry of the profile of the edge, but there are no removals aimed at increasing tool symmetry and shaping the edge so as to give it a straight, convex line.

V. Repair. Rejuvenations consisted of flat removals on the lower face and retouch of the upper face. This is especially visible on tools which had been frequently repaired. However, during subsequent rejuvenations, considerable care had been taken to keep the tip in alignment with the vertical axis of the tool. Subsequent resharpening of the edge close to the tip made the tip narrower than the basal part. In some cases rejuvenation has changed the shape of the tool, transforming the apical part into a borer.

Although the Muselievo leaf shaped knives bear traces of shaping during their manufacturing process, tip preparation and rejuvenation appear to have been carried out independent of tool shape. Instead, there is a focus on edge retouching and resharpening.

Knives

This group consists of asymmetrical tools which are characterized by differential knapping of the edges . This group is not technologically consistent. The artefacts differ in many aspects, from morphology to technology and production schemes (Fig. 19). Nevertheless, a focus on working the edge rather than the tip or the symmetry of the tool is common to these tools. On the other hand, both edges show differential knapping, one has traces of retouch and rejuvenation, and the other is blunted and has no retouch. Most artefacts included in this group also bear traces of rejuvenation and resharpening near the tip.

The artefacts ascribed into the group reveal features characteristic of the leaf shaped knives, namely a tendency for alternate tool manufacturing schemes, as well as alternating retouch, and also the possibility of changing the retouched surface from the upper to the lower or to the opposite face of the tool during subsequent repairs. The retouch, as it can be seen, could be derived equally on the upper and the lower face of the tool. At the same time a preference for applying a series of flat tool thinning removals on both faces can be observed, even at very acute edge angles. Abrupt removals were undertaken only during the early stages of knapping, probably in order to increase the angle necessary for larger and more extensive and intrusive removals. During later stages of knapping, the steep surfaces were gradually removed.

It can be assumed that leaf shaped knives were hafted, as shown by their slender form the presence of analogically located notches and the absence of an edge at the back, whereas knives in the second group are tools most probably used without hafting.

Discussion

All bifacial tools from the leafpoint industries, except the Sajóbábony-Méhésztető assemblage (Ringer 1983; Ringer & Adams 2000) have been treated and described as leafpoints so far (Chmielewski 1961; Allsworth-Jones 1986, 1990; Kozłowski J. 1990, 1995, 2003; Gábori-Csánk 1993; Adams 1998, 2007, Tostevin & Škrdla 2006; Flas 2008; Mester 2009; Nerudová &

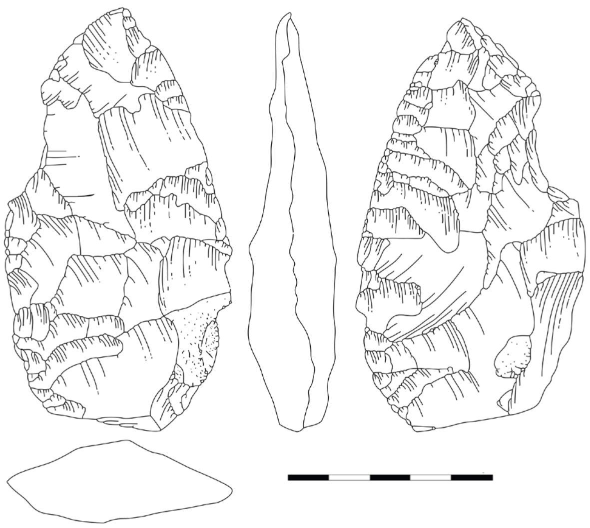


Fig. 19. Backed knife from Muselievo. Illustration after Sirakova (2009).

Abb. 19. *Keilmesser von Muselievo. Zeichnung nach Sirakova (2009)*

Neruda 2015) since they fit into the typological definition of these tools. They bear basic leafpoint features such as bifacial knapping, symmetry, tip exposure and are relatively thin and slender. Each of these features makes them distinguishable from other groups of artefacts such as unifacial points, convergent side scrapers, handaxes, leaf-shaped knives or *Keilmesser* (Debénath & Dibble 1994).

Although all the analysed artefacts fit into the typological definition of leafpoints, two different groups can be distinguished based on their general concept, morphology and knapping process. Some of the artefacts show that considerable care was taken in the shape, symmetry and tip exposure of the tool. These tools display no resharpening of the edge and were manufactured with the utmost precision. In the second group, there are tools that bear many traces of repair of the edge or resharpening. One edge was retouched along its entire length and the second edge is more angular, with less precise retouch concentrated around the apical part. The first group of tools can be called leafpoints, the second knives.

Leafpoints

Leafpoints may be recognized by the presence of two characteristic parts (techno-functional units) (Boëda 2013; Lemorini et al. 2016)

A) Cutting edges. The two edges converge at the tip. During tool thinning and edge formation, the knapper tried to achieve a bow-shaped edge, slightly rounded at the base and at the tip. A maximal thinning of the edges can be recognized as well as attempts to keep the profiles of the edges straight. At the same time, the knapper tried to preserve the final shape of the tool rather than the profile of the edge. Thus, if necessary, final sequences of marginal removals were introduced at an angle which allowed for maximal change in the shape of the edge. The angle might have been semi-steep, which would blunt the edge slightly, or very acute, which would yield a hinged edge.

A characteristic feature of leafpoints is the great care taken in producing a symmetrical tip and the even greater care regarding symmetry rather than clear tip exposure or sharpness. Therefore, if during the course of knapping, the ongoing exposure of the tip resulted in misalignment with the axis of the tool, the procedure was abandoned. This is why some artefacts have a tip which is not entirely retouched, or is broken and corrected only to a very slight degree.

Edges were knapped along their entire length in exactly the same way. In most cases a differential treatment of the parts near the tip could not be observed. The edges also have a slightly S-shaped profile because they were not retouched in a strict sense. Marginal removals were ultimately aimed at correcting the tool rather than keeping the profile of the edge straight. Removals were therefore introduced at the base or the tip, where they were necessary in order to maintain the symmetry of the tool. There are only a few instances where removals were introduced in such a regular way that they could be described as sharpening retouch.

B) Base. In most cases, the tool has an angular-shaped base formed by a series of angular removals introduced in two directions from both edges. The removals, however, are in some cases so precise (e.g. Szeleta Cave, Brno-Bohunice Kejbaly, Muselievo) that it is difficult to decide which end of the tool is meant to be the tip, and which end is the base. In such cases it was presumed that the tip part should be thinner than the part close to the potential base. Nevertheless, in some artefacts a separate basal edge can be distinguished. In such instances the edge is rounded and was formed by a series of separate angular removals (Szeleta Cave). In tools with a rounded base, their thickest part is at the base. These artefacts are thicker than the others. If the artefact was broken at the base it might have been corrected by reshaping the edges close to the base.

Knives

The other group of artefacts is knives, characterised by a differential treatment of the edges, where only one edge is retouched along its entire length. They bear traces of multiple rejuvenations and edge resharpening, usually entailing the apical parts. Due to the preparation received during the whole manufacturing process, each tool can be divided into the following techno-functional units:

A) Cutting edge. The edge is prepared by sharpening marginal retouch derived on one side only, usually on the upper face. The retouch of the cutting edge was applied in most cases to the entire cutting edge and extends down to the base. On the lower face, only flat and semi-flat edge angle correcting removals are derived (Iovita 2014). In most cases, this edge has traces of at least several rejuvenation stages focused around the tip, based on a repetitive marginal sharpening retouch along the edge. The edge converges with the opposite edge at the tip. The tip is generally well-exposed and thinned.

B) Distal posterior edge. This encompasses part or the entire edge opposite to the cutting edge. It converges with the cutting edge at the tip. It is characterised, just like the cutting edge, by semi-abrupt knapping of the upper face and flat knapping of the lower face. Its characteristic feature, however, is usually a greater inclination in alignment to the vertical axis of the tool than observed on the cutting edge (e.g. Jankovich Cave, Brno-Bohunice Kejbaly, Vedrovice V, Muselievo). Its main function was technological, aimed at keeping the tip exposed and/or adjusting the angle of the cutting edge near the tip, during subsequent resharpening phases. In most cases during the process of repair, flat angular and extensive removals were derived from this edge. Such removals were sometimes even parallel to the cutting edge. Their position resulted in a thinning of the tip and the cutting edge near the tip, but without the necessity of knapping from the cutting edge on to the lower face. Due to this procedure, the profile of the cutting edge remained straight and could be resharpened on the upper face. Any sequences of retouch present on this edge are placed closer to the tip. A marginal retouch is then performed on the upper face in most cases. The retouch is aimed at exposing the tip and sharpening the edge in order to make them functional. Retouch and removals on the distal posterior edge are less regular than the ones on the cutting edge and relate only to selected parts of the edge (usually the apical part). In some cases, repairs of the distal posterior edge were carried out along its entirety; in other cases, they were confined to the apical parts, resulting in a biangular profile.

C) Base. The base comprises an edge placed transversal or at an angle to the axis of the tool, and bearing a separate series of removals. On some tools, the base has been formed almost as a sharp edge by intensive thinning sequences. In other cases, the base is formed by semi-abrupt removals, by transversal breakage, or even left as a natural, cortical surface.

D) Back. Only a few of the analysed finds from the Vedrovice V and Muselievo assemblages were backed. On the bulk of the analysed artefacts, the distal posterior edge merges directly into the base of the tool. However, on some artefacts the distal posterior portion closest to the base is an edge formed by semi-abrupt removals. This represents either the remnant of a steep edge from the surface formation stage which was not removed, or was formed later, at the stage of edge shaping. It displays traces of corrections undertaken during subsequent phases of tool repair.

For most of the analysed knives a back, one of the characteristic features for *Keilmesser* (Jöris 2006), is not present. Generally speaking, a *Keilmesser* has an opposing edge to the cutting edge, is divided into two parts and knapped in different ways, resulting in a blunted back and a fairly sharp, angular distal posterior edge converging with the cutting edge (Jöris 2006; Iovita 2014). In the case of knives from the site analysed here, the entire opposing edge is the distal posterior edge. That is probably the reason why these tools have been described as leafpoints. Due to subsequent rejuvenations, the knives also have an exposed tip and two edges which converge more or less symmetrically at the tip. Without a detailed *chaîne opératoire* analysis, both of the concepts of artefacts presented here show similar morphology and morphometry.

Functions

So far, use-wear analyses of bifacial tools from the transitional industries have been undertaken on finds from Vedrovice V, Moravský Krumlov IV (Nerudová et al. 2010) and Sajóbábony-Méhésztető (Ringer & Adams 2000). Some 29 artefacts were analysed from Vedrovice V, 16 of them showed microscopic traces of usage (Nerudová et al. 2010: 145). The results of the scar pattern analysis on nine of these artefacts, presented above, showed that five of them are knives and four are leafpoints.

Four artefacts, interpreted as knives, bear traces near the tip similar to those observed on projectiles. However, as stressed by the authors of the use-wear analyses, these traces may also be of postdepositional origin (Nerudová et al. 2010: Fig. 9), since they display no evidence of impact scars. One of the knives, which is highly representative of this type of tool from the point of view of its structure (Fig. 9: 1), has longitudinal traces of contact with material of soft or medium hardness (Nerudová et al. 2010). The traces are located along the entire cutting edge and at the distal posterior edge near the tip (Nerudová et al. 2010: Fig. 9).

Two artefacts described as leafpoints have traces of dynamic activities localised near the tip (Nerudová et al. 2010: 146). Both pieces are actually broken tips. Unfortunately, the nature of the breakage is not definable. The third leafpoint has longitudinal traces of contact with material of soft or medium hardness (Nerudová et al. 2010: Fig. 9). These traces are located near the base along the only part of the edge which was not retouched or shaped during the manufacturing process and which derives from the original flake blank. The final leafpoint analysed here is the best example of this type of tool from Vedrovice V, due to the subsequent knapping scheme of the edge and its very intensive traces of use in boring or piercing material of medium hardness (Nerudová et al. 2010: 146).

If the ambiguous projectile traces are excluded, the only use-wear visible on the knives is the longitudinal traces on the cutting edge. In the case of the leafpoints, traces of use as a projectile are more reliable since they were observed only on the broken tips. The use of the other two leafpoints for boring/ piercing and probably cutting is also an interesting piece of information. Unfortunately, there is no possibility to verify if this was the intention, or simply a side effect of tool rejuvenation.

Only a single artefact from Moravský Krumlov IV bears use-wear traces. Transverse traces were interpreted as hide processing (Nerudová et al. 2010: 145). The artefact is actually an unfinished piece abandoned during preliminary shaping and probably reutilized.

Three of the bifaces from Sajóbábony-Méhésztető were analysed (Ringer & Adams 2000: 121), one of these finds is a leafpoint, a second find is a knife, according to the scar pattern analysis. Unfortunately, the tools bear only postdepositional traces and no use-wear. As stressed by the authors, the finds have no impact scars related to their use as projectiles (Ringer & Adams 2000: 123).

It is clear that the differentiation between leafpoints and knives presented here is not a functional but a technological one. The described groups of artefacts represent different tool concepts which are visible not only in their knapping schemes, but also in the techno-morphological features of particular tools. The proposed distinction does not define the function of particular tools or the whole group, but rather the key features which were crucial for the knapper in order to produce a useful tool.

Technological analyses of leafpoints have been very scarce so far (Hahn 1990; Graßkamp 2001; Mester 2009, 2010; Kot 2014; Nerudová & Neruda 2015). The only comparable analysis was undertaken for Moravský Krumlov IV by Z. Nerudová and P. Neruda (2015). On the basis of refittings they distinguished two basic strategies of nodule thinning and surface preparation. The first consisted of blunting one or two edges, enabling flat thinning removals to be knapped on both faces at a later stage. This scheme was mainly applied to thick nodules of raw material. The second scheme was used for thin flakes and was based on subsequent series of thinning removals on both faces.

The results presented above confirm those of Nerudová and Neruda (2015). Both of the schemes described here can be observed in the results of the scar patter analyses and are ascribed to the surface formation stage. Based on the scar pattern one can additionally see that surface formation was followed by a stage of shaping based on removals derived at an angle in order to change the form of the nodule near the tip and the base.

The scheme of knapping described on the basis of the finds from the Moravský Krumlov IV assemblage cannot be observed on finds from other sites. Even though the concept of blunting the edge in order to derive flat, thinning removals is also present in the other assemblages, it is always (except for two knives from Brno-Bohunice Kejbaly) used in an alternate manner on both edges. By applying this technique a biconvex cross section could be created and, more importantly, an intensive thinning of the knapped nodule. On the other hand, its limitations were reflected in the slenderness of the tool.

Conclusions

The results presented in this paper show that the analysed pieces can be distinguished into leafpoints and leaf shaped knives from a technological point of view, even though all of the finds are typologically leafpoints.

Both groups differ not only in their general concept and structure, but also in their scheme of knapping. The knives were produced using a plano-steep alternate scheme of knapping. This scheme is based on deriving steep blunting removals on one face in order to prepare a convenient angle for applying flat thinning removals on the other face. The opposite edge was knapped analogically but in an alternate manner, so that on the surface which was flattened from the opposite edge, blunting removals were derived in order to flatten the other face. Due to this method of surface preparation and thinning, the tool has a specific plano-steep, biconvex cross-section.

In most cases, steep surfaces, especially near the tip, were removed during later stages of manufacture. The remains of these surfaces can still be seen on some of the pieces in the central areas, near the base or the distal posterior edge, areas which were knapped with less accuracy. In the case of the isolated backed pieces, this can be a remnant of steep blunting removals from early stages of the manufacturing process.

In contrast to knives which are all knapped in a plano-steep alternate scheme (except the two knives from Brno-Bohunice Kejbaly which were knapped in a plano-steep analogical scheme), the leafpoints differ according to the scheme applied in their knapping. Chronologically older leafpoints, such as those from Sajóbábony-Méhésztető, Jankovich Cave, Muselievo, Brno-Bohunice Kejbaly, are knapped using the same scheme as knives, i.e. in a plano-steep alternate scheme of knapping. Yet, the Szeletian and most of the Jerzmanowician leafpoints were knapped differently. The early leafpoints, due to the use of an alternating scheme, have a lower width/length index averaging around 0.4-0.5. The only exceptions are the slender leafpoints from Muselievo (width/length index: 0.32).

On the other hand, leafpoints such as those from the Szeletian and Jerzmanowician have a higher width/length index, with an average of around 0.35. All leafpoints from Szeleta were manufactured using the biconvex knapping scheme, based on deriving semi-flat removals analogically on both faces of the tool. In the case of the Jerzmanowice leafpoints, fully bifacially prepared finds were produced using a plano-steep knapping scheme. However, the majority of the leafpoints are shaped on blades, originating from bidirectional debitage, so that the leaf shape was predetermined. Thus, bifacial knapping was limited to surface flattening and edge shaping.

It seems that the plano-steep alternate scheme of knapping is limited when it comes to the slenderness of the tool. The scheme enables intensive tool thinning, but the process of shaping demands angular removals which do not leave enough space for additional narrowing of the tool. The only assemblage which is characterised by both high tool slenderness and the use of a plano-steep alternate scheme is the one from Muselievo. Interestingly, in the knapping sequence of the Muselievo leafpoints one can clearly see a separate stage of tool thinning, not present in the other assemblages. As a consequence, in other assemblages where the alternate scheme of knapping is used, the leafpoints are typically thin, but relatively wide.

In the case of the early leafpoints (Muselievo, Jankovich Cave, Sajóbábony-Méhésztető, Brno-Bohunice Kejbaly) one can see that both knives and leafpoints are knapped with by the same alternate scheme of knapping. The difference in the treatment of both groups of artefacts appears during later stages of manufacture. For the knives, further steps of knapping are based on edge preparation, whereas the leafpoints are intensively thinned and then shaped, almost simultaneously.

In instances such as the early Szeletian from Vedrovice V, one can observe a diversification in knapping schemes used for leafpoints and knives. Whilst the knives are still knapped with the use of a plano-steep alternate scheme, the plano-steep analogical scheme was used to prepare the leafpoints. At Moravský Krumlov IV a specific scheme of knapping was also used for leafpoint production. Since none of the analysed pieces can be treated as a finished tool, and were abandoned at early stages of surface formation and shaping, it is impossible to distinguish either between knives and leafpoints or to determine if all the pieces from Moravský Krumlov IV were intended as leafpoints or whether some of them were intended to become knives.

The leafpoints from Szeleta Cave are made in a biconvex manner, but even at the earliest stages of knapping one can see the tendency for blunting the edge in order to prepare the correct angle for deriving decortication removals on both faces. By applying this scheme, slender leafpoints could be obtained. Even so, in contrast to a biconvex scheme, an alternate scheme of knapping was still very effective in thinning. Even though the Szeletian leafpoints are slender, they are relatively thicker than e.g. the ones from Brno-Bohunice Kejbaly.

At Jerzmanowice, a complete shift in leafpoint production can be observed. The tools are made on blades, very rarely on plaquettes. The use of a blade blank allows the production of more slender leafpoints, such as the finds from Szeleta.

At the same time, one can see a tendency to diminish the role of knives. Knives do not form a group of artefacts of distinguishable and specific knapping concept at either Szeleta or Jerzmanowice. However, in both assemblages there are multiple reutilised leafpoints, which resemble knives known from other assemblages in their shape and general morphology. To conclude, a shift in leafpoint production can be observed, which can be explained in two different ways.

The first hypothesis is that at the time when the concept of leafpoints appears, these tools were knapped using the same scheme as other bifacial tools in the industry e.g. knives. But in time, perhaps due to greater specialization or a change in desirable leafpoint proportions, the scheme of knapping changes. One can also observe variability between groups in the knapping schemes. The Lincombian-Ranisian-Jerzmanowician tradition changes more into blade technology; as a result, the bifacially knapped tools disappear, and the leafpoints begin to be made on blades.

In the Szeletian tradition, which is based on different raw materials not suitable for blade technology, the changes and specialization take a different direction. Knives are still made with the use of a plano-steep alternate scheme but the group begins to diminish. On the other hand, one can see that the knappers do search for a convenient production scheme of more slender leafpoints. The biconvex scheme is finally accepted as most suitable for obtaining slender leafpoints on flat plaquettes of felsitic porphyry. In light of such a hypothesis one can regard the finds from Vedrovice V and Moravský Krumlov IV as examples produced while a suitable scheme of leafpoint preparation was still being searched for.

Another possible explanation lies in the differences in raw material procurement. All the leafpoints from Muselievo, Brno-Bohunice Kejbaly and Jerzmanowice are made on flint. The tools from Jankovich were made on both flint and radiolarite. These good quality raw materials provide the opportunity of establishing a knapping scheme based on deriving flat, long removals and intensive thinning even at late knapping stages. On the other hand, cherts, felsitic porphyry used in the Szeletian (Szeleta Cave, Moravský Krumlov IV and Vedrovice V) are not suitable for blade technology or for deriving precise, extensive thinning removals. That is why, in leafpoints made on cherts and felsitic porphyry the removals become smaller as manufacture progresses. A tool which was not thinned successfully during decortication cannot be thinned later on. On the other hand, the raw material can be found in flat plaquettes (except Krumlovský Les chert which is found in nodules) which simplifies the process of leafpoint shaping.

The only exception in the analysed group would be the assemblage from Sajóbábony-Méhésztető in which one can see both the use of a plano-steep alternate scheme of knapping and felsitic porphyry or hydroquartzites as raw material. This example, as well as the diversification of knapping schemes between knives and leafpoints in Vedrovice V, speak more for the first hypothesis.

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