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ANALYSIS OF BIFACIAL ARTEFACTS FROM THE PALAEOLITHIC SITE OF TRBOUŠANY IIb (SOUTH MORAVIA, CZECH REPUBLIC)

ABSTRACT: A collection of pointed bifacial tools from the Palaeolithic site, Trboušany IIb, was studied using statistical analyses. Based on analysis of their morphology, technology, and other metrical aspects, they were compared to several other assemblages. The aim was to find out whether the analyses could be used to specify the chronostratigraphical position of lithic artefacts collected at the surface. In this particular case it turned out that bifacial tools were knapped in the same way at both the site of Moravský Krumlov IV and at Vedrovice V. Based on radiometric dates, both of the above-mentioned assemblages may be from a similar chronostratigraphical position, and in the context of lithic technology they are associated with the horizon referred to as the Upper Micoquian. This horizon, which overlaps in Moravian chronologically with the Lower Szeletian, is also associated with the collection from Trboušany IIb.

KEY WORDS: Palaeolithic – Bifacial tools – Knapping – Factor analysis – Czech Republic

INTRODUCTION

Despite the huge number of Palaeolithic localities recorded in Moravia (Nerudová 2008, Oliva 1989, 2005, Svoboda *et al.* 2002: 253) research is complicated because only a few of them have already been archaeologically examined. Detailed dating of Palaeolithic collections found at the surface is a quite difficult task, sometimes even impossible, mainly when "leading" types are missing or artefacts are chronologically "insensitive" (Dibble, McPherron 2006, Odell 1981, Valoch, Vencl 2010). Obtaining artefacts by surface prospecting is, nevertheless, the fundamental and most significant non-destructive archaeological method (cf. Gojda 2000, 2004, Kuna 2000, Nerudová 2008: 5). The impossibility of absolute dating isn't only a concern for open-air sites. We are often not able to determine the absolute age in stratified assemblages either. Whether it's due to their old age (beyond the scope of radiocarbon methods); unfavourable stratigraphic conditions (recently, for example, it has not been possible to date Magdalenian finds situated in the upper part of the Upper Vistulian loess immediately below the B-horizon); or the total absence of datable samples. As a result of this, various natural-scientific disciplines stand a chance. One of the instruments that we've started to lean on more and more recently is statistics. In contrast to the early simple methods which are still the most frequently used in Czech Palaeolithic archaeology (Klíma 1956), over the last few decades, mainly in prehistoric archaeology, more and more elaborate procedures have begun to be applied in the evaluation of assemblages (Kuchařík *et al.* 2010, Macháček 1997, 2008, Neustupný, John 2005). Statistics is a discipline that deals with exact data, so it should be accurate and strict. The results of statistical studies, however, are often affected by the nature or character of the input data and of course (sometimes) by the biased expectations of the person inputing the data (Bocquet-Appel, Demars 2000, Gould 1998).

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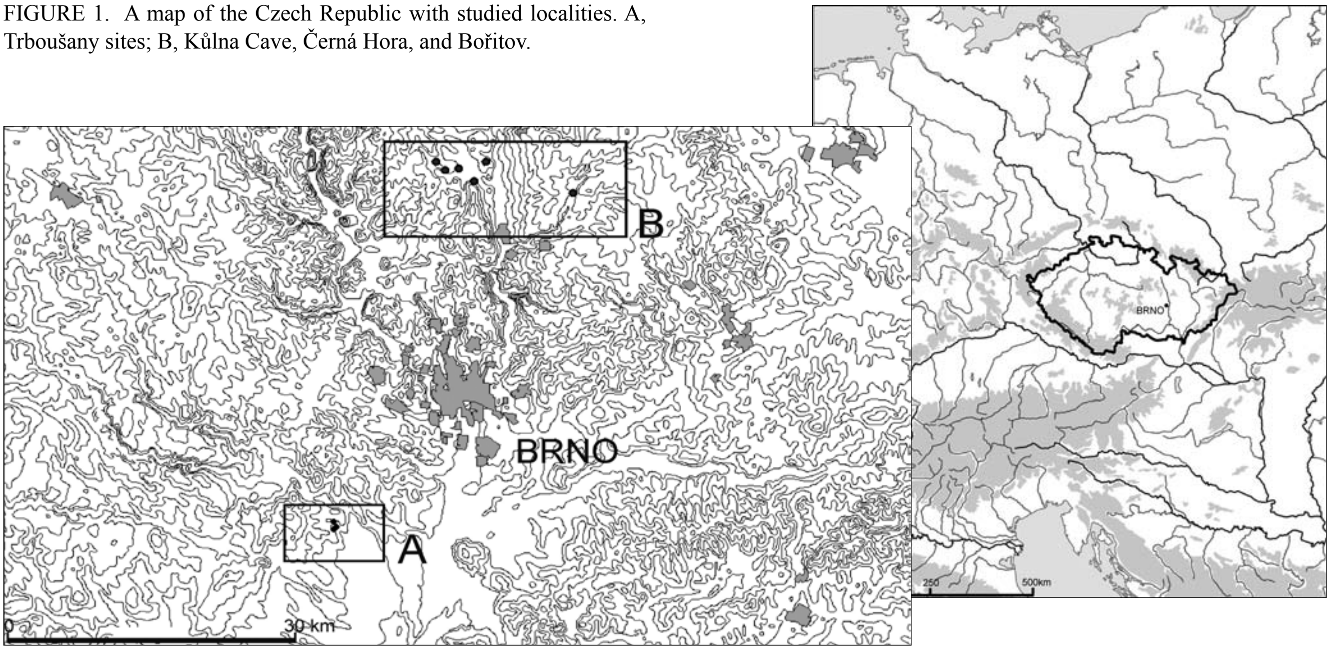
FIGURE 1. A map of the Czech Republic with studied localities. A, Trboušany sites; B, Kůlna Cave, Černá Hora, and Bořitov.



In this paper, using statistical methods, we aim to determine more exactly the chronological position of an assemblage of Palaeolithic chipped stone industry from the Trboušany IIb locality, collected by surface prospecting in recent years. The analyses focused on bifacial artefacts representing the *fossiles directeurs*, through which is might be ascertain whether their characteristics are more the Micoquian or Szeletian.

ARCHAEOLOGICAL BACKGROUND

Description of sites

Several Palaeolithic open-air sites have been discovered in the Trboušany area (about 15 km Southwest of Brno). This analysis focuses on the localities referred to as Trboušany I and Trboušany IIb. Even though these sites are close to each other, they differ in their geomorphological location. Trboušany I faces Southeast at a height of 242 m ASL, whiles Trboušany IIb faces North at a height of 220 m ASL. Both localities are almost equally far from present-day water sources (Nerudová 2008: Tab. 1) and have relatively the same access to raw material deposits because they lie less than 2 km from the border of the Krumlovský les area and raw materials were also accessible directly in the settlements (*Figure 1*). Due to the volume of artefacts recovered, the first locality may be considered as a very well supplied large base camp. The second site has yielded a certain amount of industry, but this is not very distinct and dating is problematic (Nerudová 2008).

MATERIAL AND METHODS

A total of 113 tools from nine sites were analysed. Artefacts from the localities of Trboušany I, II and IIb, Kůlna, Býkovice and Černá Hora (*Table 1*) were used for comparative purposes.

TABLE 1. Summary of analysed material. UA MZM, Anthropos Institute, Moravian Museum; Coll. A. Otta, private collection.

Site	Character of site	N	Source	References
Szeletian		31		
Trboušany I	Unstratified	30	UA MZM; coll. A. Otta	Oliva 1989; Hladíková 2002
Trboušany II	Unstratified	1	UA MZM	Oliva 1989
Micoquian		58		
Bořitov V	Unstratified	21	UA MZM	Oliva 2000
Býkovice II	Unstratified	1	UA MZM	Valoch 1977; Oliva, Štrof 1985
Černá Hora I	Unstratified	2	UA MZM	Valoch 1977; Oliva, Štrof 1985
Černá Hora II	Unstratified	1	UA MZM	Valoch 1977; Oliva, Štrof 1985
Černá Hora III	Unstratified	1	UA MZM	Valoch 1977; Oliva, Štrof 1985
Kůlna	Cave	32	UA MZM	Valoch et al. 1988
Trboušany		24		
Trboušany IIb	Unstratified	24	Coll. A. Otta	
Total		113		

The largest assemblages of tools came from Trboušany I, Trboušany IIb, Bořitov V and Kůlna Cave. The classification and analysis of a selected group of tools – bifacial artefacts – were carried out at two levels. The first of them was a traditional database system and the other a metric-morphological analysis of examined artefacts based on digital images. For these analyses only entire, non-fragmented artefacts were used.

In a conventional database, the artefacts were described by their morphology; (*Figure 2, Appendix 1*), dimensions

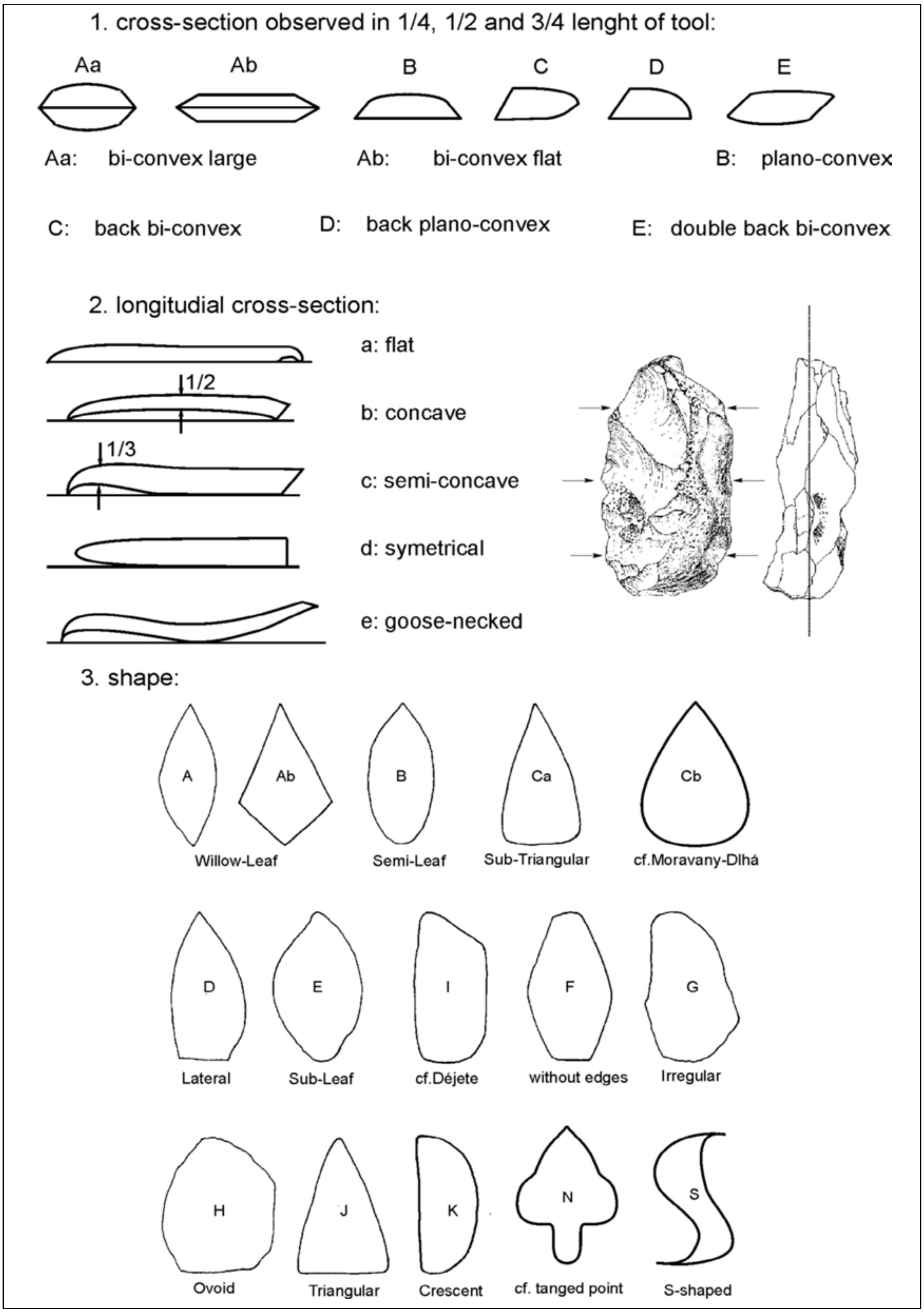


FIGURE 2. A descriptive schema of bifacial artefacts.

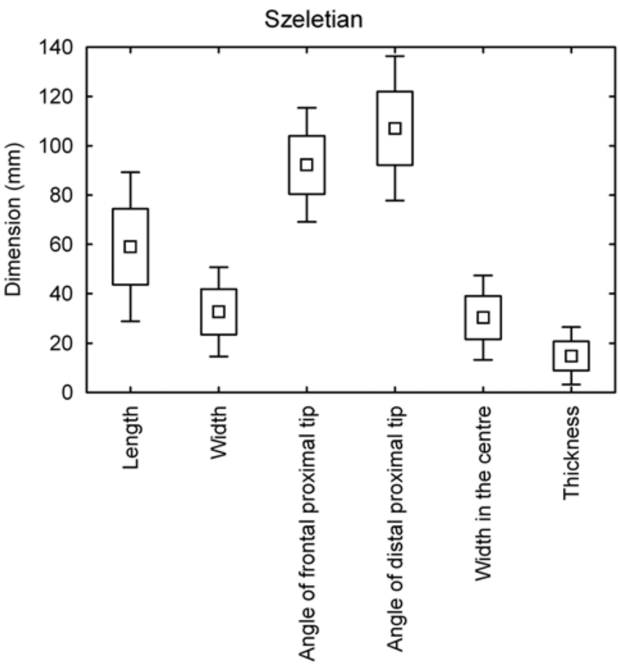


FIGURE 3. Box plot of measured variables for Szeletian tools. The square in each box indicates the sample mean, the boxes show mean ± standard deviation, and the whiskers represent mean ± 1.96×standard deviation.

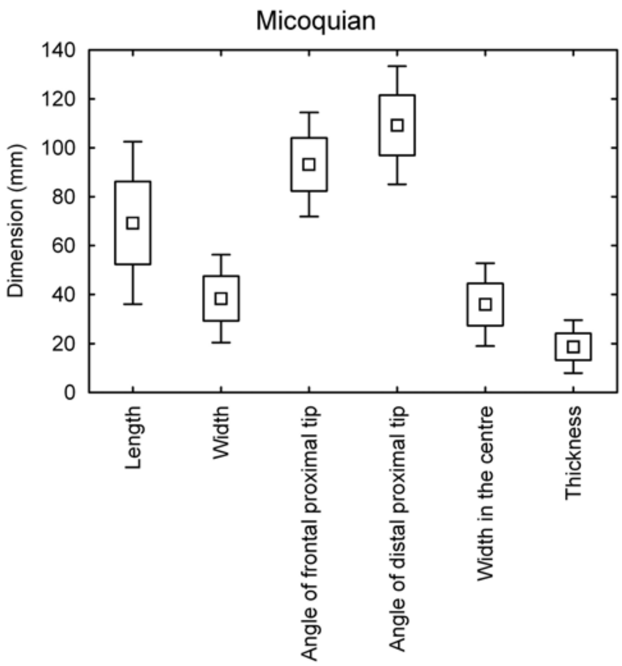


FIGURE 4. Box plot of measured variables for Micoquian tools. The square in each box indicates the sample mean, the boxes show mean ± standard deviation, and the whiskers represent mean ± 1.96×standard deviation.

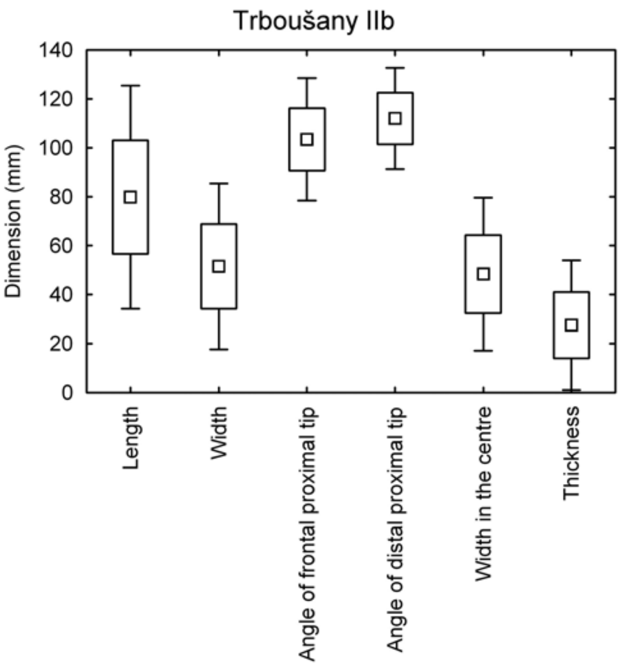


FIGURE 5. Box plot of measured variables for Trboušany IIb tools. The square in each box indicates the sample mean, the boxes show mean ± standard deviation, and the whiskers represent mean ± 1.96×standard deviation.

(length, width, thickness); and knapping technology. For this purpose a well-established descriptive system was used, whose principles, advantages and disadvantages have recently been clarified in detail (Nerudová *et al.* 2011: 27).

Entire artefacts were photographed for the "HROT" database. Contrast images were then converted into line drawings in a software application and with the help of a mathematic algorithm they were used to calculate the centre of gravity, perimeter, and area, and to determine precisely the angles of distal and proximal parts of points in individual artefacts. In order to obtain a set of data describing bifacial artefacts a computer programme was used to calculate selected parameters from a photograph or picture of an artefact. Box plots for length, width and thickness are shown in *Figures 3*–5. The programme uses two-dimensional digital photography of an artefact, which replaces the three-dimensional scanners (the principle as well as the practical application of the programme have already been published; Z. Nerudová *et al.* 2010b, 2011). This was then added with morphological data on each particular artefact, such as shape (*Table 2*), retouch type (*Table 3*), and retouch location (*Table 4*). The raw material from which the artefact was made was also determined (*Table 5*).

For further studies, a database of leaf points was used. This includes information on artefacts, which were mostly found in Moravia and are dated to between the Middle Palaeolithic and the beginning of the Upper Palaeolithic. The database currently comprises almost 550 entries.

The data was first sorted separately and then re-sorted after the both databases were interlinked. Entries with missing variables or duplicate entries were dropped. The data was analysed using the STATISTICA 9.0 and ArcGIS 9.3.

TABLE 2. Frequency of shapes (for explanation see *Figure 2*).

		Szeletian		Micoquian		Trboušany IIb	
		N	%	N	%	N	%
A	Willow-leaf	2	6.5	1	1.7		
B	Semi-leaf	6	19.4	2	3.4	6	25.0
Ca	Sub-triangular			5	8.6		
Cb	cf. Moravany-Dlhá	2	6.5				
D	Lateral	6	19.4	26	44.9	2	8.2
E	Sub-leaf	9	29.0	15	25.9	4	16.7
F	Edgeless	4	12.8			1	4.2
G	Irregular					4	16.7
H	Ovoid			4	6.9	6	25.0
I	cf. *Déjete*			4	6.9		
J	Triangular			1	1.7		
K	Semi-cirkular	1	3.2				
S	S-shape	1	3.2			1	4.2
Total		31	100.0	58	100.0	24	100.0

As far as the typological description is concerned, particular types of bifacial tools were distinguished using the well-established classification of Upper and Middle Palaeolithic retouched tool types. In classifying the tools from Kůlna Cave we have been led by the work of P. Neruda (2000, 2005, 2011), who has slightly modified an older work by G. Bosinski (1967) for the purpose of his dissertation. In our analysis, it proved useful to distinguish the following tool types: leaf points, bifacial backed knives, bifaces, small handaxes, plano-convex handaxes and small leaf-shaped handaxes (*Table 6*). At the same time, we are aware that the distinction boundary between a biface, a leaf point and a small leaf-shaped handaxe may be, above all in several Moravian assemblages, completely indeterminable, mainly if also coarse unfinished pieces are included into leaf points. From this point of view it would be maybe more suitable to designate these artefacts with a universal term "pointed bifacial tool".

Statistical analysis

The use of multivariate statistical methods was somewhat limited with regard to the character of the data (qualitative and quantitative). Nominal variables were converted into series of dummy variables, which led to the proportion of variables to cases rising excessively. That is why correspondence analysis could not be used because either several marginal frequencies were equal to zero by all the examined parameters; or there was such limited input data we could not get any relevant results. Factor analysis was employed to explore correlations among variables. This analysis is used to explain the variance among variables in terms of a lower number of latent variables – so-called factors. It helps to uncover joint variations exerting influence on independently measured datasets. Factor analysis aims to describe each observed variable as a combination of effects of individual factors.

TABLE 3. Frequency of retouch types.

		N	%
a	Abrupt	46	40.8
b	Sharp	54	47.7
c	Scalar	13	11.5
Total		113	100.0

TABLE 4. Frequency of retouch location on the artefacts.

		N	%
a1	Unifacial marginal	2	1.7
a2	Unifacial	3	2.6
b1	Bifacial marginal	12	10.7
b2	Bifacial	83	73.5
c	Combination suface + marginal	13	11.5
Total		113	100.0

TABLE 5. Frequency of raw materials.

	N	%
Andesite	2	1.9
Býčí skála-type chert	1	0.9
Cretaceous chert (spongolite)	42	37.0
Erratic flint	4	3.5
Chert unspecified	6	5.3
Krumlovský les-type chert	43	38.1
Limnosilicite	6	5.3
Moravian Jurassic chert	1	0.9
Olomučany-type chert	1	0.9
Radiolarite Szümeg	1	0.9
Quartz	1	0.9
Undetermined	4	3.5
Troubky-Zdislavice-type chert	1	0.9
Total	113	100.0

TABLE 6. Frequency of tool types.

	Szeletian		Micoquian		Trboušany IIb	
	N	%	N	%	N	%
Leaf point	28	90.3	7	12.1	24	100.0
Handaxe	3	9.7				
Bifacial backed knife			18	31.1		
Small handaxe			22	37.9		
Small leaf-handaxe			6	10.3		
Planconvex handaxe			5	8.6		
Total	31	100.0	58	100.0	24	100.0

General characteristics of tools from Trboušany
From a typological point of view, tools from both sites at Trboušany can be mostly classified as leaf points whereby from Trboušany I there are also three handaxes (*Table 6*). Both of the localities exhibit the same variability in the range of point shapes, only the proportions of a few shapes may be a little different. At Trboušany I, we mainly find the D-, E-, A-, and B-shapes (with predominant E-shape – nine cases in total) supplemented with K-, Cb-, and F-shapes (*Table 2*). At Trboušany IIb the D-, E-, B-, and H-shapes occur accompanied by F-, S-, and G-shapes. The H-shape is most frequent (six cases in total).

Apart from the Cb-shape, which turns up in Moravian collections as the less frequent Moravany-Dlhá-type points, both of the Trboušany collections include ordinary point shapes (with regard to Szeletian). But whereas the D-, E-, A-, B-, or Cb-shapes can be connected to finished tools, the H-, F-, and G-shapes are blanks. The above two sites, however, differ from each other in the level of elaboration of leaf points. For this reason we can consider Trboušany IIb as a place where the artefacts were probably manufactured.

The locality of Trboušany I is dominated by 20 specimens of size less than or equal to 6.0 cm in length, followed by six specimens of sizes 6.1–8.0 cm in length. Smaller (less than or equal to 4.0 cm) and larger (equal to or greater than 8.1 cm) categories are represented by a single specimen each (*Table 7*). Trboušany IIb is dominated in 12 cases by points of size less than or equal to 8.0 cm, less frequent are those of size equal to or greater than 8.1 cm (five cases in total), equal to or greater than 10.0 cm and equal to or greater than 12.1 cm. The size category of 4.1–6.0 cm comprises only five specimens. The point-size classes at Trboušany IIb are in general 2 cm larger than those at Trboušany I.

These size differences in tools suggest a possible difference between the sites being investigated, and the way in which we should perceive the analysed artefacts. One set of artefacts are smaller, more elaborate and more uniform in shape; while the others are larger, their final forms are less clear and they are also less uniform.

General characteristics of Micoquian tools
In the tools from the Micoquian culture, we find the number of their types increases, including bifacial backed knives, small handaxes, small leaf-shaped and plano-convex handaxes and leaf points. The largest group comprises bifacial backed knives with 18 specimens and small handaxes (22) specimens (*Table 6*). There are only 18 specimens of the other types mentioned above (small leaf-shaped and plano-convex handaxes and leaf points).

There is also a clear difference between Micoquian tools and the tools analysed from the Szeletian site. Micoquian artefacts are larger, because the 6.1–8.0 cm size is slightly predominant. This size of tool with the 8.1–10.0 cm size are more prevalent than the smaller size class (4.1–6.0 cm; *Table 7*). The size of the Micoquian tools resembles the size of the tools from Trboušany IIb, including two isolated very long specimens (*Table 7*).

TABLE 7. Dimensions (cm) of retouched tool types.

	Szeletian		Micoquian		Trboušany IIb	
	N	%	N	%	N	%
2.1–4.0	2	6.5	1	1.7		
4.1–6.0	20	64.5	21	36.3	5	20.8
6.1–8.0	6	19.3	22	37.9	12	50.0
8.1–10.0	3	9.7	12	20.7	5	20.8
10.1–12.0			1	1.7	1	4.2
12.1–14.0			1	1.7	1	4.2
Total	31	100.0	58	100.0	24	100.0

The number of morphological or typological variants of bifacial artefacts at the Micoquian localities under review is virtually identical to the Szeletian. The Micoquian is dominated by D-shapes – that is lateral points – (26 specimens), and these are followed by E-shaped points (almost leaf-shaped). Other shapes are either unique or have only a few specimens (*Table 2*).

RESULTS

Dimensions and raw materials

From a comparison of box plots (*Figures 3–5*) and *Table 8,* it is evident that bifacial artefacts are generally smaller. Tools of size 4.1–6.0 cm are predominant, followed by tools of 6.1–8.0 cm in length. These two size groups together make up 76% of all the artefacts examined. The 8.1–10.0 cm size makes uponly 17% of the artefacts and the other groups (larger or smaller artefacts) have only one specimen each. Extreme size values, in the sense of the largest specimens, can only be found in Trboušany IIb and in the 7a layer from the Kůlna Cave. The smallest specimens were identified in Bořitov V and in Trboušany I. *Table 8* show how these size classes are affected by the raw material used. Most of the commonly used raw materials exhibit a median size value within the category 6.1–8.0 cm, sometimes with several outliers (for example in Cretaceous chert or the Krumlovský les-type chert). Other raw materials, seldom used or in a way unattractive, exhibit the median tool size value within a much larger size class (e.g. 8.1–10.0 cm). The talk is mainly of limnosilicite, andesite and the Troubky-Zdislavice-type chert (*Table 8*). Nevertheless, higher metrics are also evident in Krumlovský les-type chert and unspecified type of chert. In all of the above-mentioned raw materials the primary size was much larger and so were the tools, which were knapped using them. This applies above all to Micoquian artefacts from Kůlna.

Characteristics of tool types

Within the studied set of multiple data groups – different types of retouched bifacial tools have been distinguished. Besides the dominant leaf points (further unspecified) there are various types of small handaxes, bifacial backed knives and bifaces. Cretaceous chert as well as the Krumlovský les-type chert were used for manufacturing leaf points, bifacial backed knives, small handaxes and small leaf-shaped handaxes. Various raw material types at the localities under review, however, were exploited with different intensity. Besides a distinctive preference for the Krumlovský les-type chert associated with particular types of bifacial tools at Trboušany I or IIb we can also observe a lesser incidence of rare or exotic raw materials, above all in Micoquian artefacts from Kůlna (*Table 8*).

Following up the relationship between size and tool type we will come to the conclusion that the smaller the artefacts, the higher the variability of retouched tool types. Extremely large input size was only observed in two or three tool groups: leaf points, bifacial backed knives and small handaxes.

There is still something to say about the relationship between tool type and tool shape. The description of individual shapes inclusive of their characteristics is presented in *Figure 2*. As already stated above, A-, B-, and E-shaped points are typical in the Szeletian. The last mentioned, E-shape, however, is also characteristic of bifacial backed knives, small handaxes, small leaf-shaped handaxes, and bifaces. The shape referred to as D, usually associated with backed tools, was observed in leaf points, small handaxes and knives (exceptionally also in one of the side-scraper types). The category of Ca-shaped points occurs in small handaxes and small plano-convex handaxes. This shape is usually connected with triangular points of post-Aurignacian age, but it evidently can also be found among the Micoquian inventory. The Cb-shape is rather exceptional in Moravian assemblages because it should be

TABLE 8. The relation between raw material type and tool size (cm).

	2.1–4.0	4.1–6.0	6.1–8.0	8.1–10.0	10.1–12.0	12.1–14.0	Total
Krumlovský les-type chert	2	18	13	7	1	1	42
Cretaceous chert (spongolite)	1	14	21	6	1		43
Moravian Jurassic chert		1					1
Olomučany-type chert		1					1
Undetermined		3	1				4
Erratic flint		3	1				4
Býčí skála-type chert		1					1
Chert unspecified		4	1			1	6
Limnosilicite		1	1	4			6
Radiolarite Szümeg			1				1
Troubky-Zdislavice-tape chert				1			1
Quartz			1				1
Andezit				2			2
Total	3	46	40	20	2	2	113

typical of Moravany-Dlhá-type points. The K-, F-, S- and G-shapes are not considered final or finished. Here in the graph they are associated exclusively with leaf points. The only two (unfinished) shapes, H and I, can also be found among bifacial backed knives, small handaxes and small plano-convex handaxes. It seems as if some shape inter-stages would be typical only of leaf points while others rather only of handaxes. The overall variability of shapes (in total 13 described shapes) dominated by several principal shapes (D, E, A, B) is virtually in no way different from other assemblages examined and described in the past (Nerudová *et al.* 2010a, 2011).

Another important category affecting the tool morphology is the shape of cross-section, which is always defined at 1/4, 1/2 and 3/4 of the tool length. These shapes are mostly consistent or, in other words, the shape of cross-section does not vary in 76% of all samples. To be precise, in 13% we can observe the ab-shape – very flat, in 26% the aa-shape – lenticular (convex), in 10% the b-shape – plano-convex, and in 17% the c-shape – backed biconvex. But more interesting for us are the combinations of various shapes of cross-sections, which in my opinion illustrate an initiated and/or unfinished process of shaping or re-sharpening of an artefact. Within this category we also find the combinations, ab/c (broad lenticular convex and backed biconvex cross section), b/aa (plano-convex and very flat lenticular cross section), aa/c (very flat lenticular and backed biconvex cross section), aa/e/c (very flat – double-backed biconvex and backed biconvex cross section) or b/c (plano-convex and backed biconvex cross section). The c-shaped cross-sections – that is backed on one side – were identified in the 7a layer from Kůlna and in Trboušany IIb. Very flat artefacts, on the other hand, were identified among the Micoquian inventory from Černá Hora or from Kůlna.

The shape of the longitudinal section is in no way affected by the raw material, dimensions, tool type or the shape of cross-section and for this reason it was not included into further examinations. In a vast majority of the specimens (76%) the D-shape of longitudinal section was most commonly observed, whereas the A-shape was much less frequent (23%). The B-shape was recorded only in a single case (for explanation see *Figure 2*).

TABLE 9. Factor analysis, loadings on Factor 1 and 2. Loadings marked by asterisk are greater than 0.7. Chronological, metrical and morphological aspects of analysed tools. Distinguish phase of fassonage final tool, pre-form, reparation; for explanation other morphological aspects see *Figure 2.*

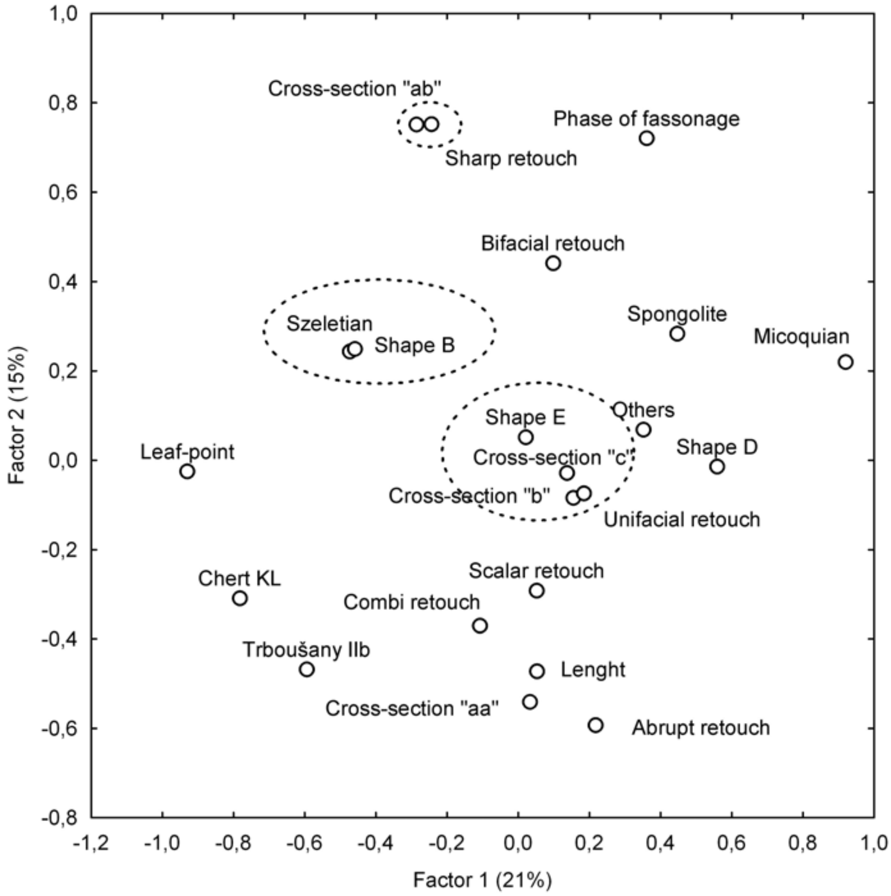
	Factor 1	Factor 2
Micoquian	0.93*	–0.17
Szeletian	–0.45	–0.27
Trboušany IIb	–0.61	0.44
Lenght	0.03	0.48
Leaf point	–0.93*	–0.02
Phase of *fassonage*	0.39	–0.71*
Cross-section "b"	0.12	0.13
Cross-section "c"	0.14	0.04
Cross-section "aa"	0.02	0.51
Cross-section "ab"	–0.24	–0.77
Shape_E	0.02	–0.07
Shape_D	0.59	0.01
Shape_B	–0.42	–0.31
Shape_others	–0.24	0.29
Abrupt retouch	0.20	0.60
Sharp retouch	–0.22	–0.76*
Scalariform retouch	0.04	0.29
Unifacial retouch	0.19	0.07
Bifacial retouch	0.12	–0.43
Combi retouch	–0.12	0.35
Chert_KL	–0.79*	0.26
Others	0.34	–0.04
Spongolite (cretaceous chert)	0.47	–0.26
Eigenvalue	5.12	3.55
Variability explained (%)	21.33	14.79

Factor analysis

Factor analysis of Szeletian and Micoquian attributes of bifacial tools enables us to carry out a more detailed evaluation of several typical phenomena (*Table 9*). Factor 1 shows the difference between Micoquian and the Krumlovský les-type chert. This chert type is associated most significantly with Szeletian culture, where it was dominantly used for making bifacial tools (see below). Even though in the assemblage we analysed, we identified only 33.8% of artefacts as leaf points made of this chert type and other leaf points were manufactured from different raw materials, we know that the Krumlovský les-type chert was also knapped into other types of bifacial tools. Looking in more detail at other raw materials including the Olomučany-type chert, erratic flint, radiolarian flint from Sümeg, limnosilicite, andesite and others, we find that all of them are minority raw materials (cf. *Tables 5, 8*). The only other really important raw material is Cretaceous chert, which is, in our case, connected predominantly with Micoquian bifacial backed knives from Kůlna. In fact, however, a total of six different types of retouched bifacial artefacts were manufactured from Cretaceous chert. In the analysis, the category of tools was simplified to the presence or absence of leaf points and it is evident that bifacial tools other than leaf points are typical of the Micoquian.

Factor 2 is characterised by negative values defining the degree of bifacial reduction, that is the phase of shaping, the ab-shape of the cross-section of an artefact, and the sharp marginal retouch on a tool (*Table 9*). We can conclude that the lower the degree of final shaping of an artefact, the lower the probability of a very flat cross-section and sharp

FIGURE 6. Visualisation of factor analysis results. Normalised varimax, principal component extraction.



marginal retouch. We can also display graphically the results of factor analysis, the relationship of Factor 1 to Factor 2 (*Figure 6*). It is evident that there is very close correlation between Szeletian dating and the B-shape. Another very close correlation can also be observed between the E-shape and the shapes of cross-sections of bifacial tools. The results of the factor analysis can be summed up in detail as follows. The length of bifacial artefacts in all the groups

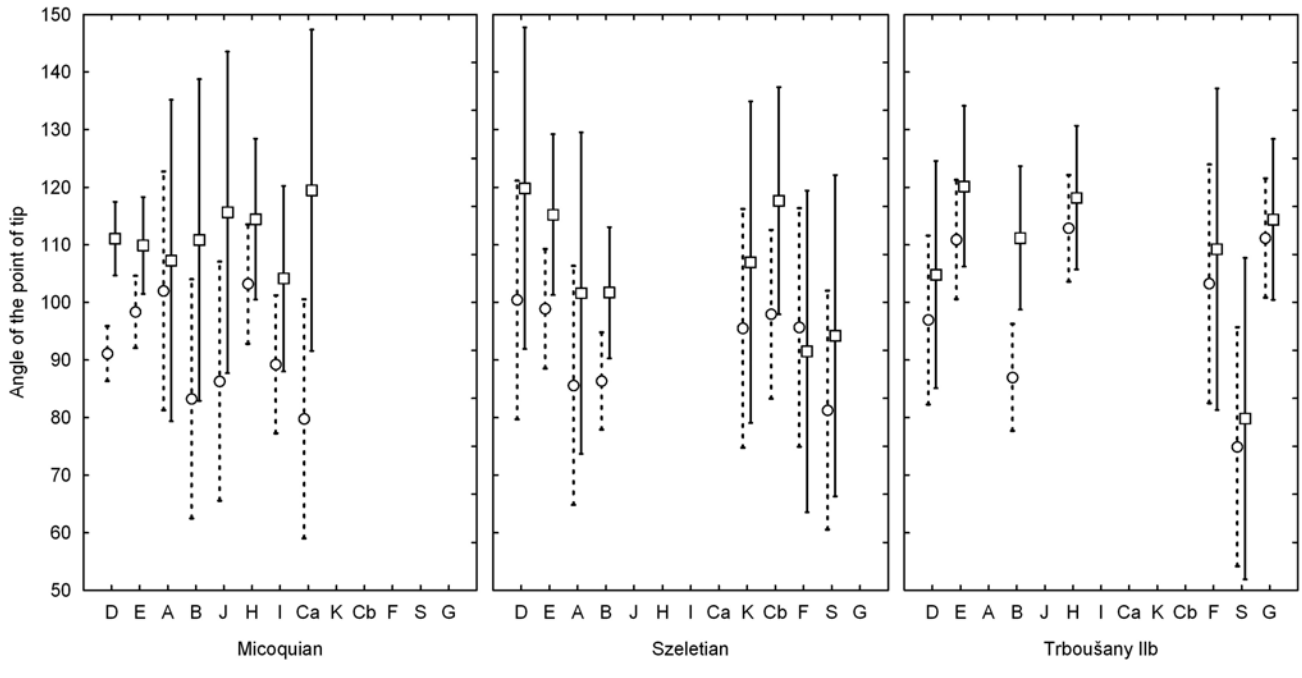


FIGURE 7. Comparison between individual shapes and angle values. Circle and square, median value; dashed line, angle of distal proximal tip; solid line, angle of frontal proximal tip.

studied is significant only in the aa-shaped cross-sections (*Figure 6).* E-shaped tools indicate correlation to unifacial scalar retouching. So, they probably define various bifacial backed knives and small handaxes.

Relationship between point angle and point shape
Figure 7 illustrates the average size of distal and proximal angles of point tips in relation to the shapes studied. The final size of the angle was calculated as the mean of a series of multiple measurements. The values relate to all localities under review, both Szeletian and Micoquian. The presented graph reveals several facts: differences in measured angle values between so-called finished and unfinished artefacts, whereby the angle values in unfinished tools are much higher, and differences between "Szeletian" shapes and those which are rather "Micoquian", if we can refer to them with these auxiliary terms. The morphological shape reflects the measured angle values very well: B-, J- or Ca-shaped points have a relatively acute angle in their distal part and a relatively obtuse angle in their proximal part. But on the other hand, for example the E-shape, whose distal end is not so perfectly elaborate, has an angle value of more than 100° (*Figure 7*). Other shapes which are considered blanks, such as G, H or F, have very similar, if not almost identical, values of proximal and distal angle (for example in G-shape). Thus, the graph has singled out individual groups of points depending on their degree of elaboration.

If we displayed the Micoquian and Szeletian shapes separately, the most common shapes would again be D, E, A and B. Marked differences would be evident mainly in the A-shape. According to calculated values it is wider and thereby also shorter in Micoquian, whereas in Szeletian it is more slender and longer.

The relationship between the measured characteristics of a tool and the tool type confirms several earlier observations and shows us some new trends (cumulative *Figure 8*). The majority of leaf points will most probably fall within the range of 65–80 mm in length. Bifacial backed knives and handaxes will be represented less frequently within this range. Small leaf-shaped handaxes, small plano-convex handaxes and bifaces (*Figure 8*) should not be present here at all. An evident similarity in lengths and their metrical distribution can be observed in leaf points and bifacial backed knives. The trend is slightly descending whereby the tool length decreases generally by roughly 10 mm.

The mutual relationship between width and thickness with regard to the value of distal and proximal angle of point tips was confirmed by other observations where the value of both point angles has decreased with increasing tool length and, vice versa, increased with growing width and thickness of the artefact (without graph). This demonstrates that the majority of the artefacts are blanks whose point/s is/are not yet definitely shaped.

DISCUSSION

So, are we able to date the artefacts from Trboušany IIb gathered on ground surface?

Characteristics of the raw material used
The technology of lithic reduction was influenced to a considerable degree by the input raw material, which, at Trboušany IIb, was for the most part the Krumlovský les-type chert (83%) and much less often the Cretaceous chert (17%). The Krumlovský les-type chert is a very resistant raw material often including many inhomogeneities, crystal druses and frost cracks inside the pebbles. It occurs most often in the form of round pebbles, which are very hard to "initiate" in order to begin the reduction sequence. This has affected in many cases the quality, character, amount of products and the knapping technology used. To adapt

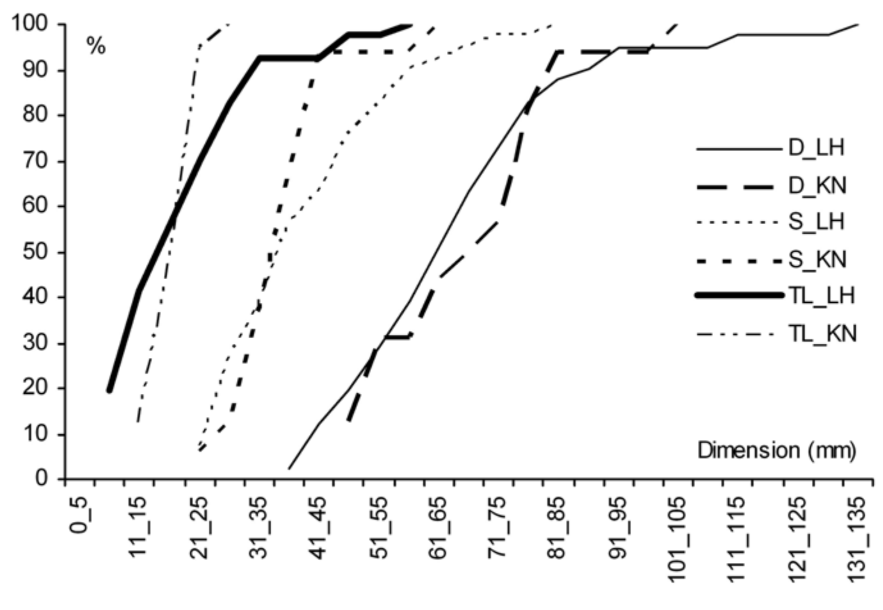


FIGURE 8. Cumulative analysis. D, length; S, width; T, thickness; LH, leaf point; KN, bifacial backed knife.

to these conditions, the Lower Szeletian knappers have elaborated a specific method of manufacturing leaf points (Neruda, Nerudová 2005, 2009, Nerudová, Neruda 2004). Knapping experiments with chert raw material from deposits on eastern slopes of Krumlovský les have shown that the common opinion on accessibility of high-quality and well-exploitable raw material is not so unequivocal (Neruda 2009a). Bad raw material properties represent a limiting factor not only to present-day experimenters but also to Palaeolithic hunters, who have solved the same technological problems, as is evident from available collections from this area. On the basis of experiments by P. Neruda and with regard to the raw material properties which he discovered, the most effective knapping method appears to be the flake or blade reduction strategy, which can even solve problems caused by material defects (Neruda 2009a). In spite of this, the Krumlovský les-type chert has been used for bifacial techniques much more often than for simpler knapping methods (Neruda 2009a: 94). Despite expectations, the leaf points here are made almost exclusively of local chert, whereby only a low percent of their relatively large overall number are indeed high-quality well-elaborated products, which do not exhibit any material defects. Most bifacially knapped artefacts bear evident marks of the trouble that the knappers had in coping with (breakage of an artefact as a result of a frost crack, uneven parts and unfinished places in the neighbourhood of inhomogeneities a. o.). Bifacial knapping was also paradoxically often applied to raw material form, which due to its shape completely rules out any lithic reduction (Nerudová 2009).

Knapping technology

At Trboušany IIb, we can see two different methods of knapping points. The first method, a "traditional" zigzag, makes use of chert pebbles. The primary simple cutting edge is formed by one or two blows applied to a suitable place on the pebble. The artefact in this phase approximates at most a unifacial or bifacial chopper, according to direction in which the primary flakes were detached (*Figure 9:1*). The next steps within a reduction sequence make the cutting edge gradually longer and at the same time also remove the cortex by applying blows to the surface (*Figure 9:2*). The pebble is then already trimmed on its perimeter by a series of detachments applied alternately to both faces (*Figure 9:3*) whereby the prospective shape may already be roughly indicated. The edges gradually become narrower in contrast to their former zigzag-like appearance. The almost finished artefact then looks a little like a small handaxe (*Figures 5, 9:4*).

The other method corresponds to the procedure described, which was reconstructed on the basis of refittings and is considered to reminiscent of the Micoquian technique of lithic reduction: using the technique of flaking, a back is formed on the artefact (or a natural back is used; *Figure 9:6*), from which thinning blows are delivered to both faces as if from a core platform. This procedure enables the reduction of the artefact's thickness without any significant loss in length *Figures 8, 9:7*). To this purpose massive first blanks, natural pebble fragments, or flat blocks were used. The incomplete pre-forms of such prepared bifacial artefacts are morphologically and technologically identical to Micoquian backed knives. The final artefact – a thin and elaborate leaf point (*Figure 9:9*) – does not emerge until the above-mentioned back is reduced. However, the predominance of pre-forms over final tools at most of the localities in the closest neighbourhood of Krumlovský les proves that this phenomenon did not occur very often. The problem of supposed archaic character of industries in the neighbourhood of raw material outcrops was discussed in the past (Oliva 1979: 54). Convincing arguments against this theory were made by J. Svoboda (1983), who wrote that the localities in the neighbourhood of raw material outcrops with numbers of coarse blanks would be workshops, which was, after all, recently also proved by excavations at one of such sites (Nerudová 2009).

Provided that any chronostratigraphically and/or geographically not very distant assemblages are compared, with the help of mathematic analyses it is possible to find and define among them certain rules concerning the variability of present bifacial artefacts. These, however, apply only to a specific range of studied assemblages and do not necessarily correspond to other detections (cf. Nerudová *et al.* 2011).

Statistical analysis, for example, is able to determine a precise difference between handaxes and cleavers and to distinguish them as two different tool types. Discriminant analysis of metrics has shown that both these groups differ from each other by the width of their tip; the tip is wider in cleavers, which is given by their different function. Another difference is in varied maximum thickness, where handaxes are thicker than cleavers (Shipton *et al.* 2009).

The attempt to make such a comparison between the group of leaf points and that of bifacial backed knives has revealed a metrical similarity between these two groups. The category of bifacial backed knives exhibits in almost all its dimensional aspects a relatively constant range, whereas leaf points are much more variable (*Figure 8*). For example handaxes do not reach this maximum thickness, or vary between 8 and 27 mm. The question thus is whether different groups of artefacts are sometimes perhaps not confused when particular tool types are classified.

The similarity between several Szeletian and Micoquian assemblages may be given not only by similar strategy of utilising raw materials or by a similar natural environment; identical technology in assemblages which can be considered parallel, basing on radiometric dates (Micoquian and Lower Szeletian; Neruda, Nerudová 2009), may suggest a common maker.

The question is whether the assemblages which are prevailingly made of (more than 80%) the Krumlovský les-type chert can be considered chronologically older (Vedrovice V, Moravský Krumlov IV, Trboušany IIb, Jezeřany II, Ořechov I), or whether it is just a pragmatic orientation on the nearest available raw material deposit

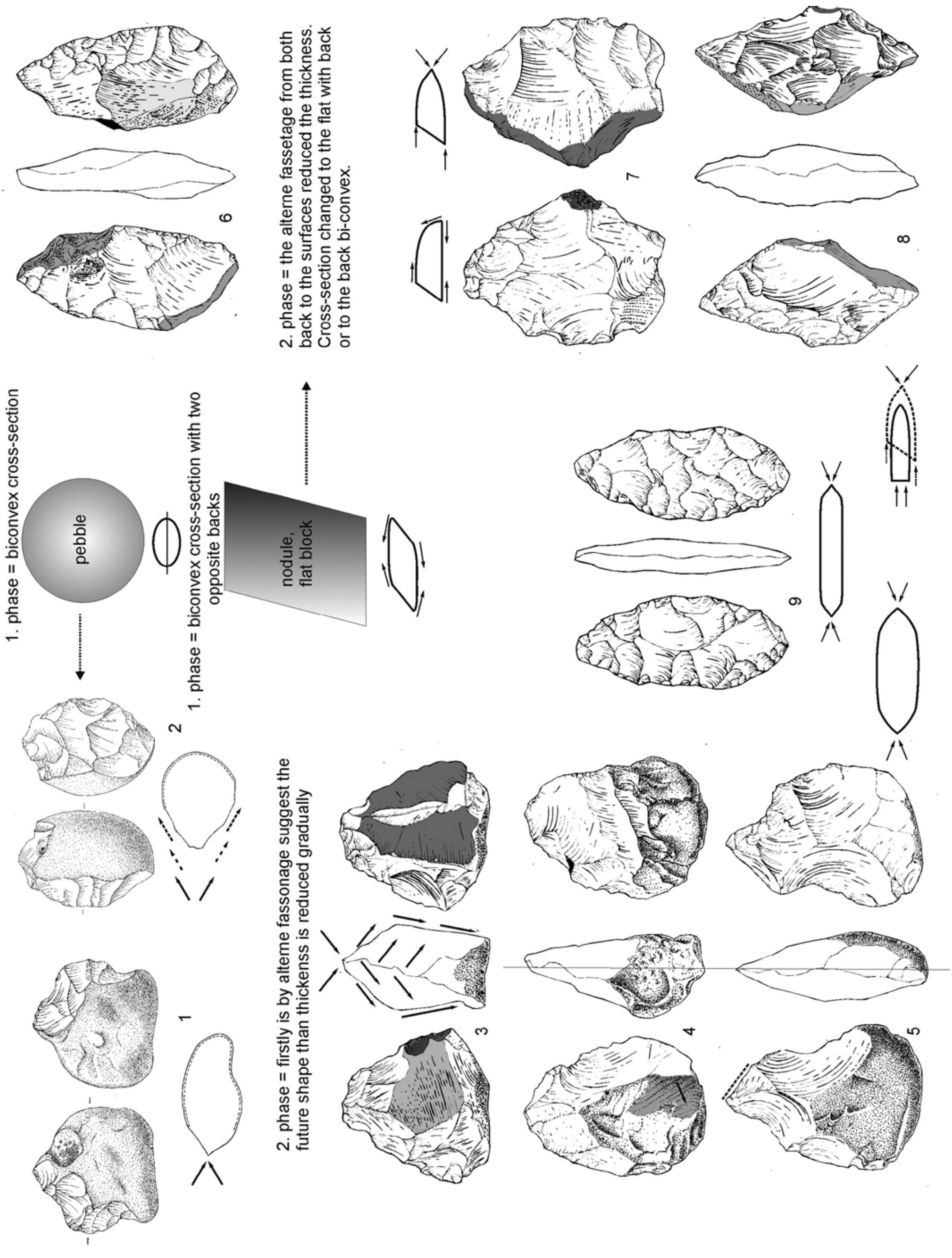


FIGURE 9. Schema of shaping of bifacial artefacts, based on analysed artefacts. Drawings T. Janků, visualisation Z. Nerudová.

(Svoboda 1983: 154). Similarly, K. Biró (2009: 51) writes about a range-of-action model which postulates that raw material deposits were directly visited by the settlement inhabitants.

Application of bifacial artefacts for cultural determination

Questions were discussed in the past about whether pointed bifacial tools can be dated culturally, how we should perceive these artefacts in chronological context or whether at all and how their external (evident) and internal (the way how they were perceived and used) nature has changed. The problem was treated with regard to chronological and geographical aspects (Nerudová *et al.* 2011), but unfortunately, with no unequivocal conclusions. Summing up the observations, the seemingly (?) high morphological variability of points is given by several factors:

– the raw material used;
– the tool's practical purpose;
– the settlement's purpose;
– distance from the raw material deposit.

In the Szeletian and Micoquian cultural complexes under review we do not have a sufficient amount of data to make a comment on all the above-mentioned aspects. We can try at least to summarise the available information.

The main types of Micoquian pointed bifacial tools are bifacial backed knives, whose variability is normally used to distinguish several facets of this technological complex. The differences, however, are determined on the basis of different technological procedures used in their manufacture. This detailed sub-division of Micoquian is so far not possible in Moravia (Neruda 2000, 2005, 2009b, 2011). Moravian Micoquian was therefore defined as a technological group with an incidence of pointed (backed knives) as well as non-pointed (various forms of side-scrapers) bifacial tools (Neruda 2009b, 2011, Nerudová *et al.* 2011).

Only four out of more than hundred known Moravian Szeletian sites have so far been examined *in situ*. The most important among them are Vedrovice V (Valoch *et al.* 1993) and Moravský Krumlov IV (Neruda, Nerudová 2010) which, on the basis of radiometric dates, are being connected with Lower Szeletian. In these assemblages we can observe an evident morphological and technological similarity between Szeletian and Micoquian (Neruda, Nerudová 2005, Nerudová 2009).

The possibility of cultural determination based on morphological analysis of bifacial tools in the Moravian Szeletian is considerably complicated by their high morphological variability, even though morphological analysis has shown that it is mainly the A-shapes (willow leaf-shaped), B-shapes (partly leaf-shaped) and E-shapes (almost leaf-shaped) which are dominant.

It has come to light that morphological variability increases at settlement localities where it is associated with the real purpose of tools used for various activities, such as cutting, scraping or drilling. Leaf points are typical not only for their multi-purpose nature but also for their being used very intensively and for a long time, as proved by the re-utilisation and re-sharpening of broken artefacts. These two facts explain the large variability of leaf points found in settlements. The GIS-analysis has also shown that morphological variability of points is lower at workshop localities or at those sites, which may be brought into connection with temporary activities. Another distinct element, which has considerably affected the size and maybe also morphology of points, is the raw material, from which particular tools were manufactured. GIS-analysis has proved that points, which were found at longer distances from the raw material deposit, diminish in size (Nerudová *et al.* 2011). Larger points, on the other hand, are recorded in those Szeletian assemblages, which are considered to be more recent (Neruda, Nerudová 2009, Nerudová *et al.* 2011).

It is to emphasise that the above-mentioned observations mainly apply to the early phase of Upper Palaeolithic, or to the preceding period. It was probably still within the early Upper Palaeolithic complex that several changes have occurred, which may have been related to changes in the purpose of the leaf points. In Moravian inventory, however, we can observe this phenomenon only indirectly (altered size of points, composition of raw materials used).

As already mentioned above, the high variability in shapes of Szeletian leaf points is a result of their intensive use, frequent re-sharpening or influence of other external factors, such as physical properties of the raw materials used, accessibility of raw material deposits, cultural affiliation a. o. Re-sharpening and repair of broken tools are usually so intensive that it is not only the size, centre of gravity or working (functional) part that changes; the overall tool morphology can become altered to such a high degree that even the tool type can be re-classified. Typological classification encounters a problem where repeated shaping of a tool associated with its use (re-utilisation) results in changes in its original size, shape and even typological classification (e.g. Dibble 1988, 1995). On the basis of experiments, refittings of particular materials and use-wear studies it was proved, and later also accepted in literature, that numerous types listed in the typology by Bordes do not reflect real tools but rather various results of their re-shaping (Bar-Yosef 2002, McPheron 2003, Migal, Urbanowski 2006, Richter 2004, Urbanowski 2009).

All of the above-mentioned factors mean that pointed bifacial tools from the Middle and Upper Palaeolithic can be used for cultural classification only in cases that their quantitative representation is sufficiently high. The possibilities of cultural determination, however, increase together with specialisation of leaf points.

CONCLUSIONS

Comparing the bifacial tools from Trboušany IIb with those from Trboušany I, and with Micoquian artefacts from Kůlna and from the neighbourhood of Bořitov we can characterise the assemblage as follows:

– There are evident metrical and morphological differences between bifacial artefacts from Trboušany I and IIb.
– We can observe differences in the supposed purpose as well as geomorphological location of the two last mentioned sites.
– Even though all bifacial tools from Trboušany IIb were classified as leaf points (the differences between leaf points and bifacial backed knives are evident, but the group of leaf points is very varied, whereas bifacial backed knives are rather uniform), as far as their metrics and morphology are concerned, they are more reminiscent of Middle Palaeolithic artefacts from the Kůlna Cave or Bořitov V.

Although the factor analysis did not show unambiguous relation between Micoquian bifacial artefacts and tools form Trboušany IIb, based on the others analyses performed, the pointed bifacial tools or the whole assemblage of chipped stone industry from Trboušany IIb can be associated with Micoquian industry – not only due to the detected variability of leaf points but also on the basis of technological procedures used in their manufacture and of other morphometric parameters. In the area of Southern Moravia or Middle Danube Region, Micoquian has gradually developed into Szeletian representing its later phase, which arose independently in Central Europe. This assumption is based on technological and typological similarities between both of the above-mentioned cultures, on their absolute dating in Moravia and on specific economic displays in the early phase of Szeletian (Neruda, Nerudová 2009, 2010).

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APPENDIX 1. A descriptive schema of pointed bifacial artefacts.
The descriptive system of V. Chabai and J. Demidenko (1998: *Figure 2*) was taken into account because their approach has better reflected the requirements of attribute analysis and enabled to categorize data to groups with the same meaning. The description was adapted to the analysed material. *Figure 2:1,* shape of cross-section; *Figure 2:2*, shape of longitudinal section; *Figure 2*:3, morphological shape of bifacial tools.

APPENDIX 2. Description of analysed bifacial artefacts.
In this section characteristics are briefly described, which could not be taken into account in the database and which also may not be sufficiently obvious from the pictures. The same modified pictorial supplements were used to illustrate the observations described. Dimensions in the length–width–thickness sequence are given in mm. If possible, the form of raw material from which artefacts were made is also presented. The registration numbers (ID) are for guidance only because it is a private collection.

ID 2004, Krumlovský les-type chert (chert_KL)
68.42.29
Massive cortical flake (?). One part shows visible residues of the originated ventral surface. Standardised semi-product (*Figure 10*).

ID 2005, (chert_KL)
75.60.35
Nodule. Natural surface is visible in the proximal part and partly on both faces. The artefact partly exhibits sharp edges, the rest is eolised. The proposed shape is only simply prepared (without fine retouch), the edges are formed by rough "zigzag" (*Figure 10*).

ID 2006, (Cretaceous chert)
67.55.32
The form of the product is uncertain. The distal part was probably re-sharpened after its break-off, the faces are eolised but the edges are sharp and partly formed by rough "zigzag". One part shows a visible residue of the lateral side. The incidence of scalar retouch, perhaps an abandoned semi-product (*Figure 10*).

ID 2007, (chert_KL)
50.33.18
The form of the product is uncertain. The proximal part of the tip is absent, preserved is a residue of the natural surface with knapping marks (*Figure 10*). The artefact is partly damaged by frost and post-depositional fractures.

ID 2008, (chert_KL)
80.62.27
Pebble. Rough blank, one of the edges was used as the lateral side (see *Figure 10*). The mass of raw material and the proposed shape were devalued by knapping large blanks off both edges on both faces. Re-sharpening of the artefact would be possible only by an extensive reduction of its size.

ID 2009, (chert_KL)
92.46.23
Nodule? Morphologically cf. Micoquian backed knife. The tool has the lateral side partly retouched, the unprepared rest bears natural surface. Thinning blanks were knapped off the back on both faces. The opposite distal part is not sharp. The artefact is partly eolised (*Figure 10*).

ID 20010, (chert_KL)
53.53.30
Pebble. This specimen and two other items (ID 2008; the other is not analysed) are almost identical (*Figure 10*). The distal part is only indicated, the proximal part is not prepared.

ID 20011, (chert_KL)
81.58.32
Nodule? Both faces show visible residues of the natural surface. The shape is not indicated, only the sides are prepared by several simple removals (*Figure 10*).

ID 20012, (chert_KL)
72.45.27
The form of the product is uncertain. An artefact with prepared back. Thinning blanks were knapped off the back. One side is broken-off in its proximal part and the breakage is patinated. Possible result of some technological defect? (*Figure 11*).

ID 20013, (chert_KL)
75.53.20
Pebble? The distal part of the tip is pointed and sharp, the surfaces are eolised (*Figure 11*). Semi-product.

ID 20014, (raw material?)
43.22.8.
The form of the product is uncertain. Perhaps a re-sharpened tool – it is tiny and slightly S-shaped. The tool is partly damaged by post-depositional fractures (*Figure 11*).

ID 20015, (chert_KL)
61.18.9
The form of the product is uncertain. One of the few finished or almost finished leaf points! (*Figure 11*).

ID 20016, (chert_KL)
The form of the product is uncertain. Considering the thickness of cross-section it is a leaf point semi-product. One side was used as a back for knapping off thinning blanks (*Figure 11*).

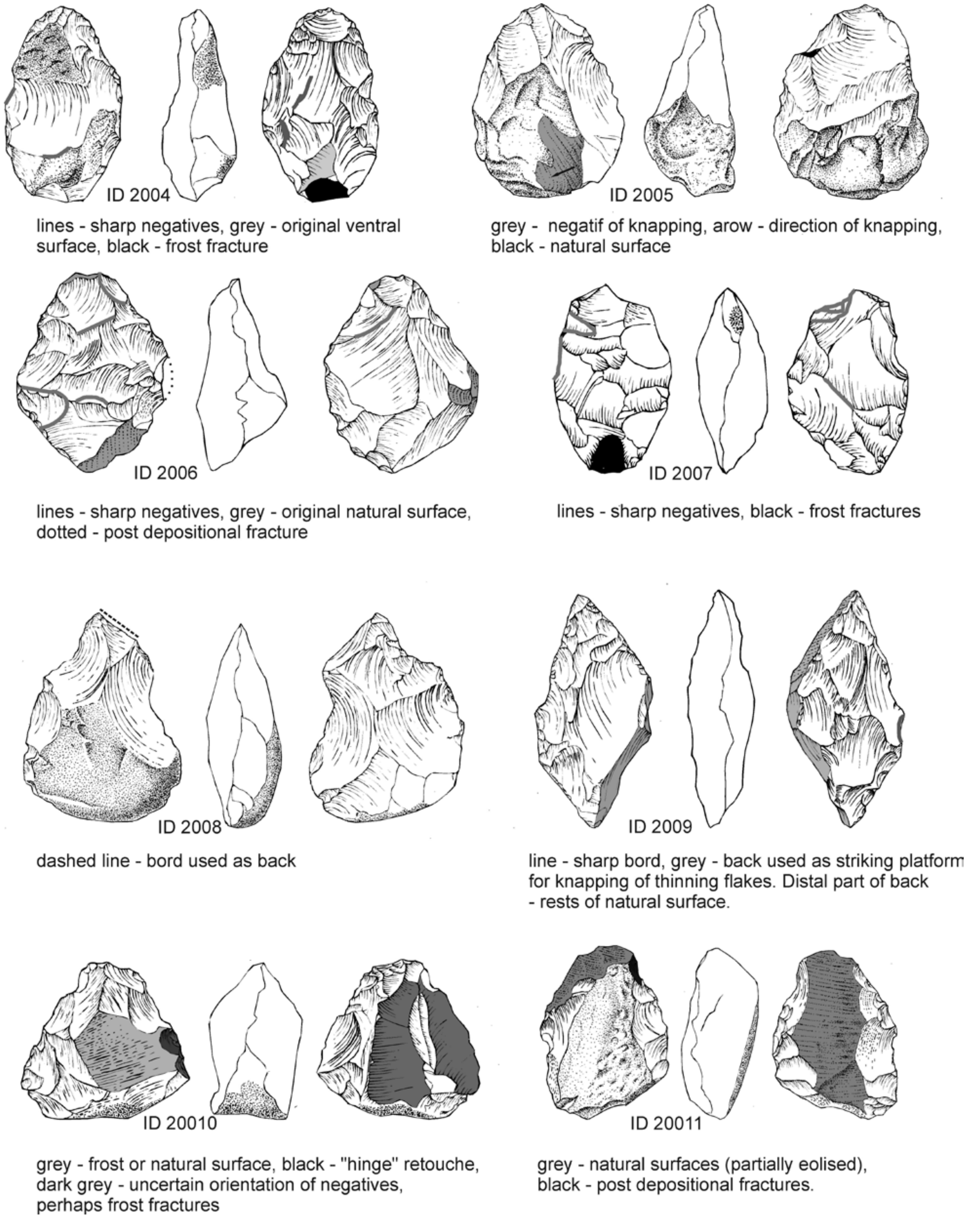

FIGURE 10. Technological features on studied bifacial artefacts. Different scales. Drawings T. Janků, visualisation Z. Nerudová.

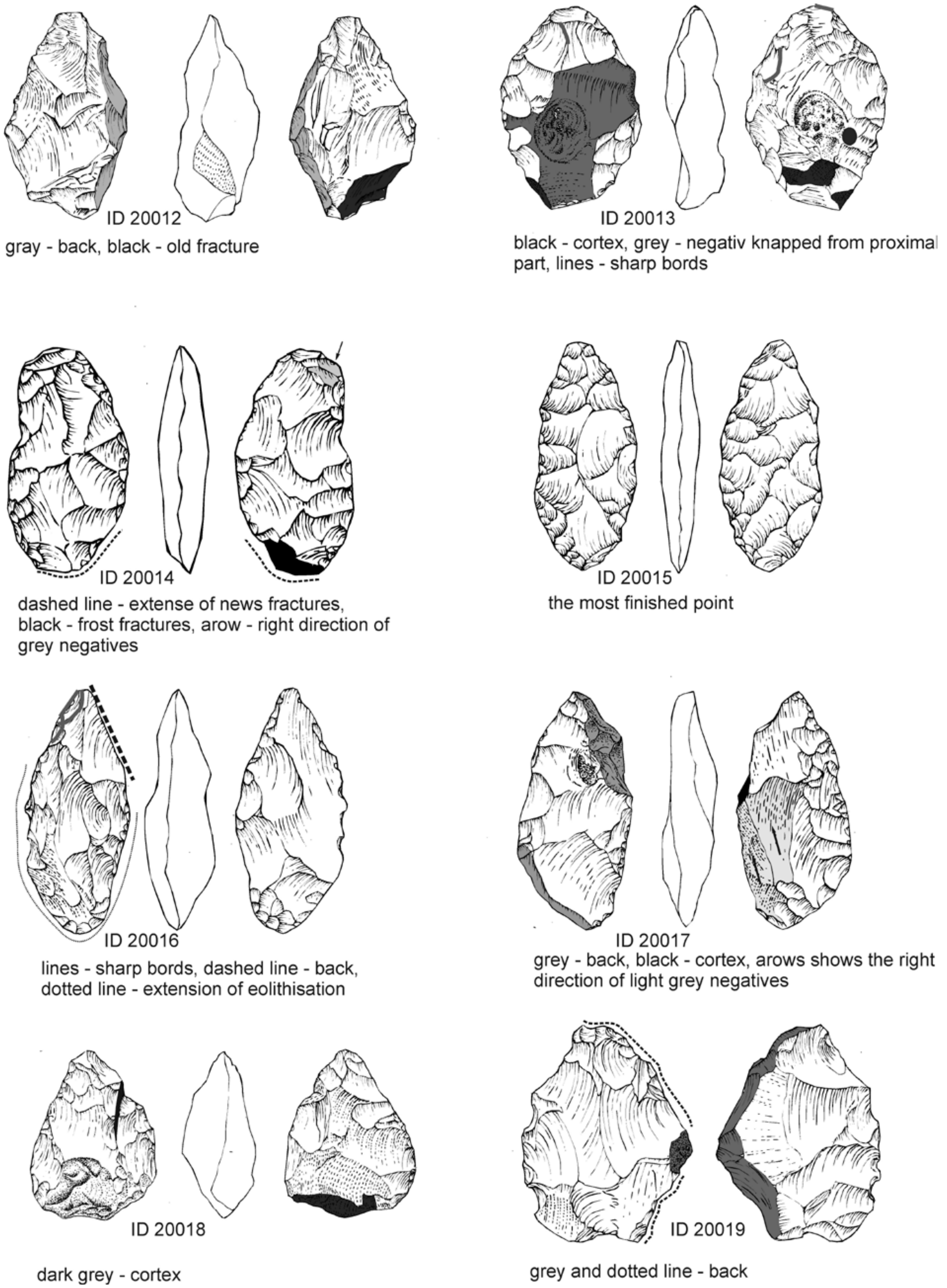

FIGURE 11. Technological features on studied bifacial artefacts. Different scales. Drawings T. Janků, visualisation Z. Nerudová.

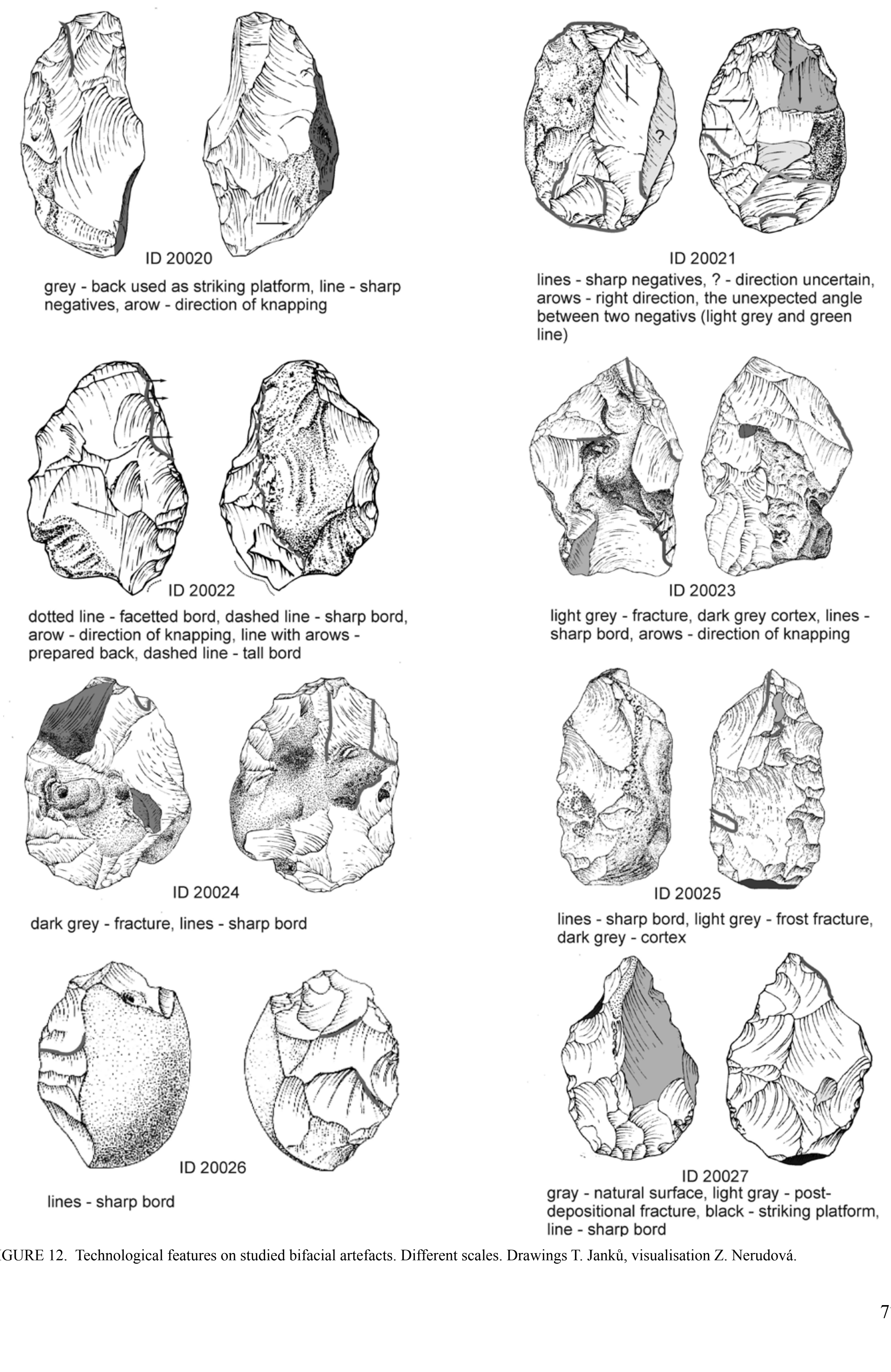

FIGURE 12. Technological features on studied bifacial artefacts. Different scales. Drawings T. Janků, visualisation Z. Nerudová.

ID 20017, (Cretaceous chert)
77.37.15
The form of the product is uncertain. Two opposite backs were used for knapping off thinning blanks (see *Figure 11*). Morphologically it is a pointed semi-product, partly eolised.

ID 20018, (Cretaceous chert)
62.50.25
Pebble? Visible is the same mode of preparation as with the previously described tools made on a chert_KL pebble (*Figure 11*).

ID 20019, (chert_KL)
76.60.19
Nodule? Morphologically cf. Micoquian backed knife. The greater part of the back was prepared, the rest of the natural plain surface is only partly visible. The back perimeter continues in the proximal part of the tool. Thinning blanks were knapped off the back on both surfaces. The opposite distal end is not sharp. The proximal tip of the point is not indicated (*Figure 11*).

ID 20020, (chert_KL)
88.48.32
Nodule? Morphologically cf. Micoquian backed knife. The sides are partly sharp, the surfaces are partly eolised (*Figure 12*).

ID 20021, (chert_KL)
66.46.27
Pebble. One lateral side shows continuous cortex on both faces. The distal and proximal tips are tapering off but the artefact is not pointed. The side opposite the cortical one is partly prepared and thinned, the rest is formed by a back with no scars of thinning blanks! Perhaps a semi-product (*Figure 12*).

ID 20022, (chert_KL)
55.39.23
Pebble. The tips are not prepared and the cortex prevails on one surface. The back was used as a striking platform for the detachment of thinning blanks. The distal tip of the point is "hinged" and the angle of detachment is incorrect. The faces are eolised. Perhaps a semi-product (*Figure 12*).

ID 20023, (chert_KL)
114.84.48
Pebble. Interchangeable with a unidirectional core, from which 1–2 blanks were knapped off. The sides leading to the distal pointed tip are partly thinned. Cortex and large inhomogeneities are visible on one side and surface, on the other surface with cortex residues. Abandoned semi-product? One part is slightly eolised (*Figure 12*).

ID 20024, (chert_KL)
92.73.59
Pebble. Both surfaces and one side are partly formed by the cortex, by inhomogeneities and druses. The shape is only slightly suggested, the sides were primarily partly prepared by the "zigzag" method. It was maybe a semi-product, partly slightly eolised (*Figure 12*).

ID 20025, (chert_KL)
135.6.46
Large pebble. One side and surface are prepared, the other surface is partly covered with cortex. The proximal tip is plunged and partly formed by cortex, which means that it is not finished. The tool is slightly eolised, some of the negative scars are sharp – see *Figure 12*.

ID 20026, (chert_KL)
74.58.42
Pebble. One side is "zigzag"-like worked. Half of the artefact is covered with cortex (see *Figure 12*), the sides are partly sharp, and the remaining parts of the artefact are eolised. Semi-product.

ID 20027, (chert_KL)
55.37.22
Flake? A part of the dorsal surface is covered with natural residues. The talon is visible. The majority of the surface is eolised. Perhaps a side-scraper semi-product? (*Figure 12*).

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