

# Z METODYKI BADAŃ ARCHEOLOGICZNYCH

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## ON THE TYPOLOGICAL CLASSIFICATION OF STONE ARTIFACTS (CONTRIBUTION TO DISCUSSION)

During the IInd Palaeolithic Symposium held in Warsaw in 1965 S. Kowalski and myself presented a paper which was intended as material for discussion and dealt with the principles of the classification of stone implements<sup>1</sup>. Since then a number of papers on typological classification in archaeology have been published. They often expressed conflicting views and polemized with the opinions held by the two authors<sup>2</sup>. Consequently, I have felt it necessary to define my position towards new trends in archaeology, to make the opinions previously expressed more clear and to expand certain propositions.

To these remarks I would like to add considerations on the classification and typological definition of the middle palaeolithic knives of the Prądnik type which are the most controversial type in the typology of palaeolithic tools.

I hope these remarks will stimulate the extremely useful discussion as to the classification of archaeological sources which is one of the fundamental problems of archaeology. This is of special importance now when statistical and numerical methods are used not only to compare particular series of artifacts but also to distinguish the classification units themselves. Before these methods are applied, the theoretical principles of typological classification should be more clearly defined and more precise classification criteria should be worked out.

### TRADITIONAL METHODS OF TYPOLOGICAL CLASSIFICATION

Recently the Anglo-Saxon archaeologists are growing increasingly critical of the traditional classification of stone tools as worked out by the French school of the Palaeolithic. The principal objection made against the traditional palaeolithic typology which has resulted in the list of types presented by F. Bordes and D. de Sonneville Bordes<sup>3</sup> is the heterogeneity of the criteria used in the typological classification<sup>4</sup>. Accordingly, the research procedure leading to the classification of types,

<sup>1</sup> S. Kowalski, J. K. Kozłowski, *Uwagi o podstawach klasyfikacji typologicznej narzędzi kamiennych* [Remarks on the principles of the typological classification of stone implements], Kraków 1965, pp. 1—16.

<sup>2</sup> B. Balcer, *W sprawie klasyfikacji materiałów krzemianowych* [On the classification of stone materials], „Wiadomości Archeologiczne”, vol. 35: 1970, no. 2, pp. 147—163.

<sup>3</sup> F. Bordes, *Typologie du Paléolithique ancien et moyen*, Bordeaux 1961, vols. I—II; D. de Sonneville-Bordes, J. Perrot, *Essai d'adaptation des méthodes statistiques au Paléolithique supérieur*, „Bulletin de la Société Préhistorique Française”, vol. 51: 1963, pp. 323—333.

<sup>4</sup> L. R. Binford, S. R. Binford, *A Preliminary Analysis of Functional Variability in the Mousterian of Levallois Facies*, „American Anthropologist”, vol. 68: 1966, no. 2, pt. 2, pp. 238—295.

used without any changes since the beginning of this century, has been named "Intuitive sorting procedure".

We should, however, bear in mind that the lists of types which have been introduced into archaeological literature in the past 15 years are the result of a multistage classification (dendrogram) in which the classification of taxonomic units was based on various, mostly single, criteria. From this point of view, the classification of particular sets of stone artifacts was correct, notably in those cases where the definite taxonomic units corresponded to single criteria. In the case of a larger number of criteria the matter was more complex, since particular typological units were not unequivocal. The classification scheme used in the traditional typology can be represented as follows:

Classification unit <b>A</b>	— Criterium (attribute) <i>a</i>	— attribute state $a_1$
<b>A1</b> (attribute state $b_1$ )	<b>A2</b> (attribute state $b_2$ )	— Criterium <i>b</i>
<b>A1'</b> (attribute state $c_1$ )	<b>A1''</b> (attribute state $c_2$ )	

In this case we deal with three taxonomic units of different orders, within which set **A** was first divided into two subsets (**A1** and **A2**) and sub-set **A1** was in turn divided into two subsets of still lower order **A1'** and **A1''**. Set **A** was distinguished on the basis of criterium *a*, whereas all artifacts included in the set are characterized by a definite attribute marked as  $a_1$ . Attribute *b* can be distinguished for all artifacts of this set, but part of the artifacts will be characterized by attribute  $b_1$  and part by  $b_2$ . By using the same principle this procedure can be carried on.

It should be emphasized that the term criterium (attribute) is used to denote a concrete attribute found on all or part of artifacts of a given set. The attribute can be single (e.g. presence of absence of burin-scar) or may have a number of qualities (e.g. the shape of the working edge: convex, concave, wavy, straight, etc.). In each case we deal with at least two attribute states of a given attribute (in extreme cases with presence of absence). In this sense our concept of "attribute" corresponds to the "attribute state" of Anglo-Saxon scholars<sup>5</sup>

The taxonomic units of various orders thus classified are reduced to a common denominator within a concrete typological list. Though the classification of particular units can thus be correct and consistent, the grouping of units of different hierarchy in one order might raise doubts. In the example quoted above, the list of types contains under consecutive numbers artifacts assigned to subsets **A1'**, **A1''**, **A2**. In this case all the units claim to be recognized as types. Let us try to illustrate this procedure by the following example:

<sup>5</sup> D. L. Clarke, *Analytical archaeology*, London 1968, p. 145.

## Type A (end-scrapers)

Type A (end-scrapers)			Criterion <i>a</i> (position of the working edge) Attribute $a_1$ (parallel to the shorter axis of the flake)
A1 (blade end-scrapers)	A2 (flake end-scrapers)	Criterion <i>b</i> (kind of flake)	
( $b_1$ — on blade)	( $b_2$ — on flake)	(attributes $b_1$ and $b_2$ )	
A1' (simple)	A1'' (on re-touched blade)	A1''' (Aurignacian)	Criterion <i>c</i> (kind of side-working)
( $c_1$ — unworked)	( $c_2$ — worked by simple retouch)	( $c_3$ — worked by Aurignacian retouch)	(attributes $c_1, c_2, c_3$ )

In the typological list worked out by D. de Sonneville-Bordes the units mentioned here bear consecutive numbers (A1 — no. 1, A1' — no. 5, A1'' — no. 6, A2 — no. 8), and mix with other units classified on the basis of other criteria (including metrical ones, mainly concerning proportions).

Though particular "types" occurring in the classical lists do not represent taxonomic units of the same order, yet the essentially correct principle of their classification should be emphasized. This refers notably to cases where particular taxonomic units of the same order correspond to one sort of criterium, and particular "types" are defined by different attributes of a given criterium.

Replying to the criticism of Anglo-Saxon researchers, D. de Sonneville-Bordes rightly drew attention to the objective test of the classical list of types, namely to the consistently recurrent statistical relations between particular typological units in assemblages which represent definite and culturally differentiated units<sup>6</sup>.

Much more complex is the classification which takes into account several criteria and attributes. In this case we should try to define particular taxonomic units by using the same number of criteria, whereas the classical lists of types include units classified by applying varying numbers of criteria. This is illustrated by the above example, in which type A1 was classified by employing criteria *a*, *b* and *c*, and type A2 by employing only criteria *a* and *b*. In this case the traditional procedure as applied to typological classification does not lead to a satisfactory solution of the problem.

## THE STATISTICAL DEFINITION OF THE TYPE

In studying a definite set of stone artifacts (A) we can distinguish criteria (attributes) which serve to classify the set. As mentioned above, these are concrete

<sup>6</sup> D. de Sonneville-Bordes, *L'évolution du Paléolithique supérieur en Europe occidentale et sa signification*, „Bulletin de la Société Préhistorique Française”, vol. 63: 1966, no. 1, pp. 3—33.

attributes found on particular artifacts and occurring in different variants. Moreover, these attributes can be of quantitative nature, notably as metrical attributes of artifacts. The criteria (attributes) and their states (qualities), or quantities thus classified can be presented as follows:

$$\text{Criteria (attributes) } (a, b, c... y) \left\{ \begin{array}{l} a_1 a_2 a_3... a_x, \\ b_1 b_2 b_3... b_x, \\ c_1 c_2... c_x, \\ y_1 y_2... y_x \end{array} \right.$$

On this basis it is possible to distinguish  $N$  possibilities of mutual correlations of particular attribute states within  $y$  criteria (attributes). The number of combinations thus obtained can be very high:  $N = \frac{y!}{x! (y-x)!}$

Not all combinations, however, will really occur. Nor will the number of artifacts characterized by particular combinations of attribute states within  $y$  criteria be the same — some combinations will be represented by single artifacts, whereas other will be found on a larger number of artifacts.

This procedure used in typological classification was introduced by J. R. Sackett<sup>7</sup> and S. and L. Binford<sup>8</sup>. Their aim was to find a maximum number of criteria, defined as a "system of attributes". Naturally, in order to determine the frequency of artifacts with the some attribute states within a given attribute system it was necessary to use a computer (to detect correlations) and a calculus of probability to denote random (non-significant) and non-random (significant) correlations. Results thus obtained have greatly helped to make the definitions of particular concepts more precise and contributed to defining the type.

The difficulty to define a type was repeatedly emphasized in traditional typology<sup>9</sup>. Hence the tendency that has recently appeared to discard the common terms used for taxonomic units and replace them by a letter-cipher system<sup>10</sup>. This tendency is doubtless right when the multistage classification (dendrogram) of traditional typology is concerned.

At the same time, in consistence with the principles of logic, a type should be regarded as a kind of model, established by empirical methods. Today the model cannot represent the "most typical" artifact (as often the case was in traditional typology), but it must be defined on the basis of the possibly largest set of artifacts with the use of several criteria which allow us to detect the most frequent combinations of their attributes. The type thus defined is of primary importance in the typological classification. Moreover, the increase in the number of criteria leads to the definition of typological units of the lower order, whereas the decrease in their number — to defining typological units of the higher order. In this way, the definition of the type as proposed by us in 1965 could be made more precise. On that occasion I have already drawn attention to the "specificity of recurrent relations between tools"<sup>11</sup>. In this sense our definition is close to that given by D. L. Clarke according to whom the type is "an homogenous population of artefacts

<sup>7</sup> J. R. Sackett, *Quantitative Analysis of Upper Paleolithic Stone Tools*, „American Anthropologist”, vol. 68: 1966, no. 2, pp. 356—393.

<sup>8</sup> L. R. Binford, *Systematics and cultural process*, „American Antiquity”, vol. 31: 1965, pp. 203—211.

<sup>9</sup> Kowalski, Kozłowski, *op. cit.*, pp. 11—12.

<sup>10</sup> Balcer, *op. cit.*, p. 155.

<sup>11</sup> Kowalski, Kozłowski, *op. cit.*, p. 10.

which share a consistently recurrent range of attribute states within a given polythetic set"<sup>12</sup>.

Owing to the statistical study of correlation frequency of particular attributes within a given number of criteria (attributes) it is possible to determine the homogenous or heterogenous character of a given set of artifacts. In this respect, three situations can be distinguished:

1) When within a given set only one attribute state within a given attribute complex attains a maximum frequency (e.g.  $a_1+b_1+c_5+d_1$ ) whereas other attribute correlations are represented by single specimens only.

2) When within a set there occur several attribute states within a given attribute complex which attain a maximum, roughly equal frequency e.g.

$a_1+b_4+c_5+d_1$  — represented by 20 % of specimens

$a_3+b_1+c_4+d_2$  — represented by 19 % of specimens, etc.

Beside, there occur correlations represented by single specimens, forming a "background".

3) When all combinations of attributes are represented by single artifacts.

By employing statistical methods it is possible to determine the significant or non-significant character of correlations between particular attributes.

Only when a given attribute state (within a given attribute complex) shows a high frequency and when the significant (non-random) character of the correlation of particular attributes is highly probable, a type can be regarded as a model of a definite taxonomic unit. The type thus defined is of empirical nature and at the same time close to the "ideal" type. The number of criteria used indicates the order of a given taxonomical unit.

The process of the typological analysis presented above consists in finding a possibly large number of criteria and corresponding attributes within a given set and allows us to establish the frequency of single correlations between particular attributes (i.e. within two attributes). When "pairs" of usually co-occurrent attributes are thus distinguished, the most vital connections between particular attributes can be established. This is of great importance for various aspects of the typological analysis, notably for determining the hierarchy of criteria, e.g. when traditional classifications are concerned. The usefulness of these determinations for the comparison of various sets and for establishing the seriation of their correlations demands a separate study and will not be discussed here. It should be stressed that in order to test the homogenous or heterogenous character of the sets, a detailed study of the correlations of two or three attributes was made by J. de Heinzelin de Braucourt who cited a number of interesting examples<sup>13</sup>. Methods described by the author concern both qualitative and quantitative attributes. The probability of the significant (non-random) and random character of correlations thus defined was estimated by L. R. Sackett<sup>14</sup> and L. Vértés<sup>15</sup>. We shall revert to this question when discussing the "knives of the Prądnik type".

<sup>12</sup> Clarke, *op. cit.*, p. 188.

<sup>13</sup> J. Heinzelin de Braucourt, *Principles de diagnose numérique en typologie*, „Memoires de l'Academie Royale de Belgique", vol. 14: 1960, no. 6, pp. 1—72.

<sup>14</sup> Sackett, *op. cit.*

<sup>15</sup> L. Vértés, *Analyse statistique des industries paléolithiques*, „Palaeohistoria", vol. 10: 1964, p. 15 ff.

## CRITERIA OF TYPOLOGICAL CLASSIFICATION

The homogeneity of the criteria of the typological classification was pointed out both by D. de Sonneville-Bordes in her discussion with Anglo-Saxon scholars, and by B. Balcer in his polemics with the author and S. Kowalski<sup>16</sup>. These criteria are limited to morphological ones, whereas the other are only the result of the subjective interpretation of the form of artifacts<sup>17</sup>. This attitude seems principally sound. However, in my view, we should not completely discard what S. Kowalski and myself have named "technical criteria". Otherwise we should treat all morphological attributes of an artifact as equal and consequently get lost in a mass of details which would make a correct typological analysis impossible.

The "technical criteria" which are of a higher order since they group a series of morphological attributes of an artifact, allow us to make a "pre-selection" from the point of view of the manufacture process of a given tool. Naturally, the choice of this group of attributes is the result of the attitude of the investigator — in this case of this conviction consistent with the principles of historic materialism that the most vital sphere of human activity is the production process itself.

Consequently, we can distinguish purely morphological criteria (e.g. the shape of the working edge of an artifact) or technical ones which are the sum of selected morphological attributes (e.g. the kind of retouch, the way in which the tool apex was formed, the burin scar) subordinated to the reconstruction of the method by which a given tool was made. This procedure can be represented by the following scheme:

Simple morphological criteria	Technical criteria	Additional morphological criteria
Criterion A	Criterion A	Additional morphological criteria
Attribute $a_1$	Attribute $a_1$ is the sum of	$m, k, l, \dots, y$
$a_2$	$a_2$ „	$m_1+k_1+l_1\dots+y_1$
$a_3$	$a_3$ „	$m_2+k_2+l_2\dots+y_2$
$a_x$	$a_x$ „ etc.	$m_3+k_3+l_3\dots+y_3$

The scheme shown above can be illustrated by the following example:

Simple morphological criteria: **A**) shape of the working edge;

attributes:  $a_1$ ) straight;  $a_2$ ) convex;  $a_3$ ) concave etc;

Technical criteria: **A**) kind of retouch.

Technical attributes:	Additional morphological criteria		
	k) shape of retouch scars	m) interrelation between retouch scars	l) angle of retouch etc.
$a_1$ ) simple flaking	$k_1$ ) circular or irregular	$m_1$ ) adjoining but hardly overlapping	$l_1$ ) up to 45°
$a_2$ ) pressure flaking etc...	$k_2$ ) elongated with parallel sides	$m_2$ ) axis parallel diagonal to or adjoining the edge	$l_2$ ) up to 30°

<sup>16</sup> Balcer, *op. cit.*, p. 156.

<sup>17</sup> Sonneville-Bordes, *L'évolution...* p. 5.

Table I

	11	12	13	14	21	22	23	24	31	32	33	34	35	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	61	62	63	64	65	66					
11																																									
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21	18	1	—	7																																					
22	4	3	1	6																																					
23	6	2	—	1																																					
24	3	1	—	1																																					
31	13	2	1	7	12	6	2	1																																	
32	7	4	—	4	6	5	3	2																																	
33	9	—	—	3	7	2	2	2																																	
34	—	1	—	2	1	1	1	—																																	
35	1	—	—	—	—	—	1	—																																	
	↓	↓	↓	↓	↓	↓	↓	↓																																	
41	7	1	—	1	5	2	1	1	2	2	3	—	1																												
42	7	—	—	1	5	2	2	1	5	2	2	—	—																												
43	4	1	—	2	2	5	—	—	2	4	2	—	—																												
44	3	2	—	1	3	—	2	—	3	1	1	—	—																												
45	7	2	1	4	8	3	2	1	9	3	2	1	—																												
46	1	—	—	1	2	—	—	—	—	—	2	—	—																												
47	1	—	—	—	—	1	—	—	1	—	—	—	—																												
48	1	—	—	4	1	1	—	2	1	2	1	—	—																												
49	—	—	—	1	—	—	1	—	—	—	—	—	—																												
50	—	1	—	1	—	—	1	—	—	—	—	—	2																												
51	16	5	1	10	17	8	5	3	12	8	10	2	1	7	4	3	1	12	2	—	2	—	1																		
52	—	—	—	—	—	—	—	—	—	—	—	—	—																												
53	2	1	—	1	2	3	—	—	3	3	—	—	—	—	2	2	—	—	—	—	—	—	1	—	—																
54	3	1	—	1	2	—	2	—	4	—	—	—	—	1	1	—	2	—	—	—	—	—	—	—	—																
55	4	—	—	2	2	2	1	1	2	1	1	1	—	—	1	1	1	1	—	1	—	1	—	1	1																
56	4	—	—	1	3	1	—	1	2	1	1	—	—	2	1	1	—	1	—	—	—	—	—	—																	
57	2	—	—	—	1	—	—	1	—	2	—	—	—	—	—	—	—	—	1	—	—	1	—	—																	
61	12	4	—	5	10	5	2	3	7	8	5	1	—	4	4	2	1	6	—	—	2	—	1	13	1	1	1	1	1	3	2										
62	6	—	1	4	7	3	1	1	6	—	2	2	—	—	1	1	3	4	1	—	1	1	1	5	—	—	1	4	1	—											
63	4	1	—	1	3	1	2	—	3	1	1	—	1	3	—	—	1	2	—	—	—	—	—	4	—	1	2	—	—												
64	3	—	—	2	2	1	2	—	2	3	1	—	—	1	1	—	—	2	—	1	—	—	—	4	—	—	—	1	—												
65	5	1	—	1	2	2	2	1	3	2	2	—	—	—	3	2	—	2	—	—	—	—	—	4	—	2	1	—	—												
66	1	1	—	2	2	2	—	—	1	2	1	—	—	—	2	—	—	1	—	1	—	—	2	—	2	—	—	—	—												

By applying technical criteria which as a matter of fact are the sum of several morphological criteria subordinated to the reconstruction of the method by which a tool was made and thus are a sort of "attribute complex", we avoid an accidental selection of the criteria of typological classification.

The functional criteria consist exclusively of traces of use which are the subject of a separate non-typological sphere of study called traseology. Only when the traces of use are classified by traseological methods, they can be correlated with separate morphological criteria or with complexes of morphological criteria within given sets. This study is very promising as it allows us to get an insight into the way in which the sets of tools and other artifacts were used and into the structure of the production process itself, and of the way in which the demands of a primitive community were met<sup>18</sup>.

Finally, we have to agree both with D. de Sonneville-Bordes<sup>19</sup> and B. Balcer<sup>20</sup> that the "cultural and chronological" criteria refer only to the denomination of types and should not be linked with the classification of taxonomic units.

#### PROBLEM OF THE "KNIVES OF THE PRĄDNIK TYPE" (AN EXAMPLE OF APPLYING THE ATTRIBUTE SYSTEM)

The definition of the "knife of the Prądnik type" is one of the most debatable and difficult problems in the classification of palaeolithic tools. I have selected this example in order to illustrate the possibility offered by the statistical definition of a type based on the use of the attribute system.

Before defining particular criteria we should recall the definitions of this tool, which have been advanced so far and which will facilitate the selection of the criteria. In his definition of the knife of the Prądnik type, S. Krukowski called attention to the following elements associated with corresponding attributes<sup>21</sup>:

- working edge — lateral side,
- apex — on one end of the same side,
- obtuse end — from apex to base — parallel side truncated or arched,
- part near the apex — straight, composed of several particular scars (described as para-burin scars<sup>22</sup>).

The second definition of the tool was made by W. Chmielewski, who distinguished the following criteria associated with corresponding attributes<sup>23</sup>:

- Retouche — bifaciale plate, parfois partielle (si l'outil a été faite sur un éclat).
- Bord droit — rarement un peu concave — fait avec le bord opposé un trachant fin et perçant à l'extrémité distale,
- Le bord arqué — passe dans la partie proximale en un dos épais atteignant la moitié ou le  $\frac{2}{3}$  de la longueur de celui-ci.
- Les talons — gros souvent couverts de cortex.

Summing up this definition W. Chmielewski concludes that the knife of the Prądnik type is a kind of a "biface d'un type particulier".

<sup>18</sup> Cf. for example S. A. Semenov, *Pervobytnaya tehnika*, „Materialy i issledovaniya po archeologii SSSR", vol. 57: 1956.

<sup>19</sup> Sonneville-Bordes, *loc cit.*

<sup>20</sup> Balcer, *op. cit.*, p. 157.

<sup>21</sup> S. Krukowski, *Paleolit [The Palaeolithic]*, Kraków 1939, p. 55.

<sup>22</sup> W. Chmielewski, *Ensembles miccoquo-prondnikiens en Europe centrale*, „Geographia Polonica", vol. 17: 1969, p. 372.

<sup>23</sup> S. Kowalski, *Zagadnienie przejścia od paleolitu środkowego do górnego na obszarze Polski w aspekcie elementów postępu technicznego [The Problem of the Transition from the Middle to Upper Palaeolithic in Polish Territory in the light of Technical Progress]*, „III Sympozjum Paleolityczne", Kraków 1967, p. 5.



In order to establish the attribute system I have made use of the material recovered by S. Krukowski in the Ciemna cave and housed in the State Archaeological Museum in Warsaw<sup>24</sup>. I have distinguished 54 tools identified as knives of the Prądnik type and preserved well enough to allow us to reconstruct all elements. According to W. Morawski, the total number of these tools together with fragments is 81. Part of them<sup>25</sup>, however, consists of fragments unsuitable for this study.

On the basis of the definitions made by S. Krukowski and W. Chmielewski I have distinguished 6 principal criteria corresponding to particular elements of the tool. The criteria are exclusively qualitative. The quantitative criteria demand the use of another procedure and were therefore omitted from these considerations. For the same reason I did not use the criterium provided by the area of the tool covered with flat retouch, since it requires the employment of appropriate quantitative divisions. On the other hand, the surface and bifacial working is treated as a qualitative attribute concerning particular elements of a tool. In this case, only the absence or presence of this attribute has been established.

Thus the fundamental criteria of the classification are as follows:

1) Working edge — longer side sharpened by retouch — considered in regard to the kind of working. This is a complex criterium of a technical order, since it includes simple morphological criteria (position of retouch scars in relation to the edge and the flat side of the tool, cross-section through the tool, etc.) subordinated to the reconstruction of the manner in which the tool was prepared.

2) Working edge — considered in regard to shape.

3) Apex (defined by S. Krukowski as a "beak") considered in regard to the way in which it was worked (complex criterium).

4) Obtuse end (i.e. part of the back near the apex as far as the truncation which divides it from the truncated back, usually parallel to the working edge) — considered in regard to the way in which it was formed (also complex criterium).

5) Back — considered in regard to the way in which it was formed.

6) Base (as in S. Krukowski's definition — part of tool opposite to the apex, according to W. Chmielewski — "partie proximale") — considered in regard to the way in which it was worked.

The six criteria presented above (they are virtually the principal elements of the tool — cf. fig. 1) are associated with the following attributes:

1) The kind of working the edge:

11. Bifacial (i.e. worked on both sides along the whole length) and symmetrical (i.e. in which the ideal surface of the tool<sup>26</sup> is the secant of the interfacial angle formed between two surfaces of the tool near its working edge),

12. Bifacial and asymmetrical,

13. Unifacial and symmetrical,

14. Unifacial and asymmetrical (i.e. the ideal surface of the tool does not form the

<sup>24</sup> I wish to express my thanks to doc. dr hab. Jan Kowalczyk for his kind permission to study the collection from the Ciemna cave, housed in the State Archaeological Museum, Warsaw.

<sup>25</sup> W. M o r a w s k i, *Stanowisko paleolityczne w jaskini Ciemnej* [The palaeolithic site in the Ciemna cave] (B. A. dissertation in typescript). I am very grateful to Mr W. Morawski for his permission given to me to read his dissertation before it has been published.

<sup>26</sup> Cf. in this question S. K r u k o w s k i, *Stanowisko górno-solutrejskie z końca następowania ostatniego zlodowacenia w Polsce* [An Upper-Solutrean Site from the end of the last Glaciation in Poland], „Sprawozdania Polskiego Instytutu Geologicznego”, vol. 1: 1922, p. 424.

secant of the interfacial angle at the working edge but nears one surface of the tool or corresponds to it).

2) Shape of the working edge:

21. Straight,
22. Convex,
23. Wavy,
24. Slightly concave,

3) Apex:

31. Without para-burin scar,
32. With flat para-burin scars (single or multiple) forming an acute angle with the opposite surface of the tool,
33. With para-burin scar forming an obtuse angle with one side of the tool, and an acute angle with the other (i.e. situated as in proper burins)<sup>27</sup>,
34. Formed by splintered technique (bifacial),
35. Secondarily flaked.

4) Obtuse end:

41. Symmetrically thinned by bifacial retouch,
42. Asymmetrically thinned by bifacial retouch,
43. Thinned by bifacial retouch — with zigzag course of the edge,
44. Thinned on one side,
45. Thinned by splintered technique (as apexes of the truncated blades of the Kostenki type),
46. Thinned from the flaked notch by splintered technique (also reminiscent of certain truncated blades of the Kostenki type),
47. Blunted straight,
48. Blunted convex,
49. Blunted concave,
50. Absence of distinct blunted end (one common edge with the back).

5) Back:

51. Cortical,
52. Thermical scar,
53. Backed with large flaking (usually two or three retouch scars),
54. Blunted straight (from the surface of the tool which was primarily surface flaked),
55. Slightly curved (reminiscent of the Audit knives),
56. Thin, i.e. formed where the non-worked often thermic scar intersects the surface covered by flat retouch,
57. Thinned, i.e. bifacially worked.

6) Base:

61. Unprepared (cortical, thermic or mixed)
62. Preserved striking platform (usually prepared),
63. Blunted by retouch — straight,
64. Blunted by retouch — convex "end-scraper-like",
65. Bifacially retouched (thinned),
66. Transversely broken.

The correlation of particular attributes within the criteria distinguished are shown on table I. The table has been made for 54 specimens, each having nearly

<sup>27</sup> Cf. also G. Bosiński, *Eine Variante der Micoque-Technik am Fundplatz Buhlen*, „Jahresschrift für Mitteldeutsche Vorgeschichte”, vol. 53: 1969, pp. 59—74.

all elements of the classification criteria. Altogether, within the six criteria 36 attributes were grouped.

In the first stage the table serves to detect the frequency of correlation between particular pairs of criteria. The most frequent correlations are:

21+11 represented by 18 cases				
21+51	"	"	17	"
11+51	"	"	16	"
11+31	"	"	13	"
51+61	"	"	13	"
21+31	"	"	12	"
51+31	"	"	12	"
45+51	"	"	12	"

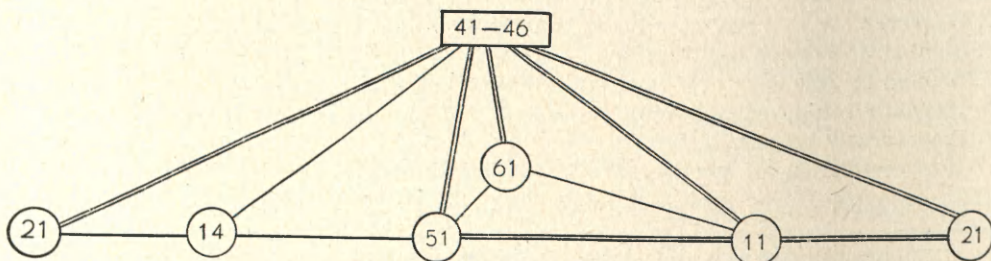
Other correlations are less frequent. In the set under discussion the attributes which correlate most often include a straight end with bifacial and summetrical working and a straight edge with a natural cortex back. Of the other characteristic correlations attention should be drawn to a natural cortex back (51) with a natural cortex base (61) and to an obtuse end worked by flaking technique (45) with a natural cortex back.

The most frequent correlations are those between the obtuse end (4) — the back (5) — the working edge (1, 2), whereas the way in which the apex was worked does not show any constant association with other elements; in other words, the presence of absence of a para-burin scar correlates equally with other elements of the tool. Thus the para-burin scar is not a distinct element correlating with a definite group of other attributes of the tool.

The correlations between criteria 1, 2, 4 and 5 will become more obvious when attributes referring to all kinds of end thinning (41-46) are grouped within criterion 4. The thinned end, which is a distinct part between the apex and the back proper, usually divided from it by a distinct truncation, is a characteristic element of the artifacts included in the set under discussion. The frequency of correlations between attributes 41-46 and other criteria is as follows:

(41—46)	with 51	in 28 cases	(51.8%	of artifacts)
(41—46)	" 21	" 25	" (46.2%	" " " )
(41—46)	" 11	" 16	" (29.6%	" " " )
(41—46)	" 61	" 17	" (31.4%	" " " )
(41—46)	" 14	" 10	" (18.5%	" " " )

The most frequent correlation is that between a thinned end and a blunt back, a straight edge and a natural base. On the other hand, the correlation of a thinned end with a bifacial symmetrical edge is somewhat more frequent (29.6%) than with an asymmetrical unifacial edge. The correlations mentioned above can be illustrated as follows:



The correlations which occur in over 29% of specimens have been marked by a double line. The remaining correlations occur in 24 to 18% of artifacts in the set

described. Only frequent correlations have been taken into account, though the probability of a single co-occurrence of a definite attribute, i.e. attributes 1 and 2, is about 6% (0.0625), and thus the lower frequencies of correlations between particular attributes can also be significant<sup>28</sup>.

Summing up the above remarks it is possible to state that the whole set is dominated by tools with a thinned end, a natural blunt back and a straight working edge. The edge can be symmetrical and bifacial (characteristic of tools defined as knives) or asymmetrical and unifacial (characteristic of side-scrapers). Both groups of specimens can have a para-burin scar, as illustrated by the following list:

- 11 — 31 (absence of para-burin scar) in 13 cases
- 11 — 32-33 (presence of para-burin scar) in 16 cases
- 14 — 31 (absence of para-burin scar) in 7 cases
- 14 — 32-33 (presence of para-burin scar) in 7 cases.

The proportions of artifacts with and without para-burin scars are equal in both groups (11 and 14).

If instead of single correlations, the occurrence of definite attributes within all criteria is examined, a relatively pronounced dispersion becomes apparent. Only the combination

11 21 32 41 51 63

occurs four times. The following combinations occur three times:

11 23 32 41 51 63

14 21 32 41 51 61

The combinations which occur twice are:

11 21 32 41 52 62

11 21 31 41 51 61

11 21 31 41 53 61

11 21 31 41 51 62

11 22 32 41 51 61

11 22 31 41 51 61

14 22 32 43 52 62

14 21 31 41 51 63

The other combinations occur singly and therefore they are not quoted here. The total number of single combinations is 28.

It should be emphasized that when the shape of the working edge (criterion 2) is left out and attributes 41-46 are grouped together an identical coded, recurring 7 times (12.9%), is obtained:

11 (32-33) (41-46) 51 (63-64)

When we decipher this code we obtain: a tool with a bifacial and symmetrical

<sup>28</sup> To calculate the probability of the co-occurrence of single attributes the following formula can be used:

$$p^k = \frac{n}{k} p^k (1-p)^{n-k}$$

where  $n$  — whole number of test elements,

$p$  — probability of single co-occurrence of  $x$  attribute states with

$y$  attribute states within a given attribute system  $a$ ,

$k$  — number of test elements with a given co-occurrence of attribute states. Naturally, if  $p^k$  is very low, the correlations are significant, i.e. non-random. For the discussion of certain problems concerning the statistical definition of a type my thanks are due to doc. dr J. Piaskowski.

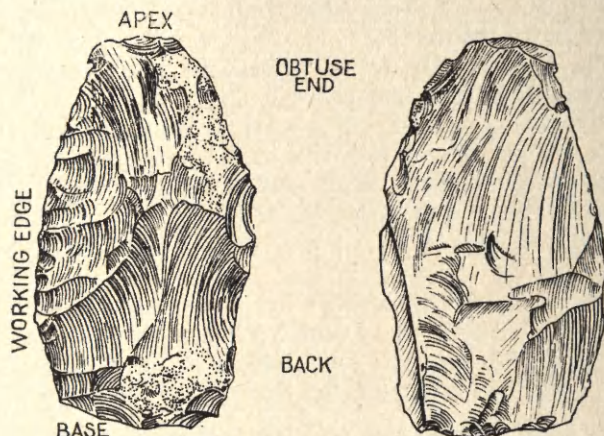


Fig. 1. Particular elements of Prądnik-knife

working edge, a para-burin scar, a thinned end, a natural blunt back, and a base blunted by retouch. This combination is the model of the knife of the Prądnik type, worked out on the basis of the set from the upper layer of the Ciemna cave.

#### FINAL REMARKS

Several important problems referring to the definition of a type have been left out from this study and will be discussed in a separate paper. One of these is the correlation of metrical attributes which demands special methods. The method to examine the variability of one attribute and the correlations between two and three metrical attributes has been already worked out by J. Heinzelin de Braucourt<sup>29</sup>. For the statistical definition of the type, however, it is necessary to take a large number of variables into account, and to work out a method of a correct selection of quantitative limits (divisions), when correlations between several attributes are examined. Neither have I discussed the problem of comparing sets which are analysed with regard to a series of qualitative attributes with the use of the criterium of chi-square. This question has been widely discussed by L. Vértés<sup>30</sup>. These methods are also of importance for the statistical definition of a type, based on the comparative analysis of several sets, as shown by J. R. Sackett<sup>31</sup>. Owing to them, it is possible to establish the variability of the correlation of attributes within a series of criteria in a number of sets (inventories). In this way a basis is created which allows us to study out only the variability of the frequency of taxonomic units as in traditional typology but also the evolution of types classified on the basis of the attribute states.

<sup>29</sup> Heinzelin de Braucourt, *op. cit.*, pp. 5—27.

<sup>30</sup> Vértés, *op. cit.*, pp. 20—31.

<sup>31</sup> Sackett, *op. cit.*, pp. 382—389.