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DOI: 10.26485/AAL/2017/63/1

SPATIAL, FUNCTIONAL AND COMPARATIVE ANALYSIS OF A LATE PALAEOLITHIC SWIDERIAN CULTURE SETTLEMENT AT KRAKÓW-BIEŻANÓW SITE 15

ABSTRAKT Niniejszy artykuł jest studium poświęconym organizacji przestrzennej osadnictwa kultury świderskiej na stanowisku w Krakowie-Bieżanowie 15. W trakcie szerokopłaszczyznowych badań ratowniczych (2004-2008), pozyskano tam liczne materiały krzemienne wiązane z tą kulturą. Pochodzą one zarówno z obiektów, jak np. niewielkiej krzemienicy (KB-15/1 – obiekt 1), czy skupiska materiału (obiekt 2 i 3), jak również ze znacznej części przebadanej partii stanowiska, gdzie zostały podjęte jako znaleziska pojedyncze. Analiza planigraficzna podstawowych grup narzędziowych, tj. liściaków (ostrzy) świderskich, drapaczy i rylców, pokazała, że ich rozrzut wokół obiektów archeologicznych nie jest przypadkowy i wskazuje on na zróżnicowanie w zakresie funkcjonalnej organizacji przestrzeni przez ludność kultury świderskiej na stanowisku. Niniejsze badanie miało odpowiedzieć na pytanie dotyczące właściwości tego zróżnicowania. W tym celu przebadano mikroskopowo część dostępnego materiału. Chociaż stan zachowania zabytków mocno ograniczył możliwość przeprowadzenie analizy traseologicznej, to poczyniono szereg cennych obserwacji. Szczególnie interesujące wnioski dotyczyły liściaków i drapaczy. Dodatkowo, liściaki świderskie, jako miarodajna kategoria zabytków związanych z kulturą świderską, zostały przeanalizowane przez zastosowanie metod morfometrycznych (analiza przekroju poprzecznego ostrza, analiza kąta ostrza, morfometria geometryczna kształtu liściaków), a płynące z nich wnioski uzupełniły badania traseologiczne. Uzyskane wyniki pozwoliły na wskazanie wyróżniających się obszarów (strefy liściaków, drapaczy i rylców) oraz ich interpretację funkcjonalną.

Słowa kluczowe: Paleolit schyłkowy, kultura świderska, analiza geometryczno-morfometryczna kształtu, analiza traseologiczna, analiza przekroju poprzecznego

ABSTRACT This article is a study devoted to the spatial organization of a settlement of the Swiderian culture at Kraków-Bieżanów site 15. In the course of wide-scale rescue excavations (1999-2008), numerous lithic materials associated with this culture were discovered. They come from archaeological features such as the small kshemenitsa (KB-15/1 – feature 1) or spots of material clustering (features 2 and 3), they were collected as single finds. The spatialanalysis of the basic tool groups, i.e. Swiderian points, endscrapers and burins, showed that their distribution around archaeological objects wasnot accidental and points to diversity in functional space organization at the site. The aim of this investigation was to find the reason for the nature of this differentiation. For this purpose, a part of the available material has been studied by means of use-wear analysis. Although the state of preservation of lithics greatly reduced the possibility of carrying out functional analysis, a number of valuable observations were made. Particularly interesting were results concerning Swiderian points and endscrapers. In addition, Swiderian points, as the most intriguing category of typological tool related to the Swiderian culture, were analyzed by morphometric methods (tip cross-sectional area analysis, tip angle analysis, geometrics morphometrics) which were subjected to corroborated use-wear studies. The results obtained indicated the distictive areas (points, endscrapers and burins zones) and shed light on their functional interpretation.

Keywords: Late Palaeolithic, Swiderian culture, Swiderian point, use-wear analysis, tip cross-sectional area analysis, tip angle analysis, geometric-morphometric outline shape analysis

Introduction

Swiderian is a late palaeolithic cultural unit documented over a vast area covering the eastern part of Germany, Poland, Latvia, Lithuania, Belorussia, the eastern part of Russia and Ukraine. It represents the younger phase of the Tanged Point Technocomplex (TPT) – a north european tradition developed at the end of the Allerød period in the south part of the circum Baltic area (Old Tanged Points – Bromme) which spread southward during the second part of the Younger Dryas period and the early Preboreal period (Swiderian, Ahrensburgian, Belloisian)[1].

[1] Kozłowski 1999; Szymczak 1999; Burdukiewicz 2011.

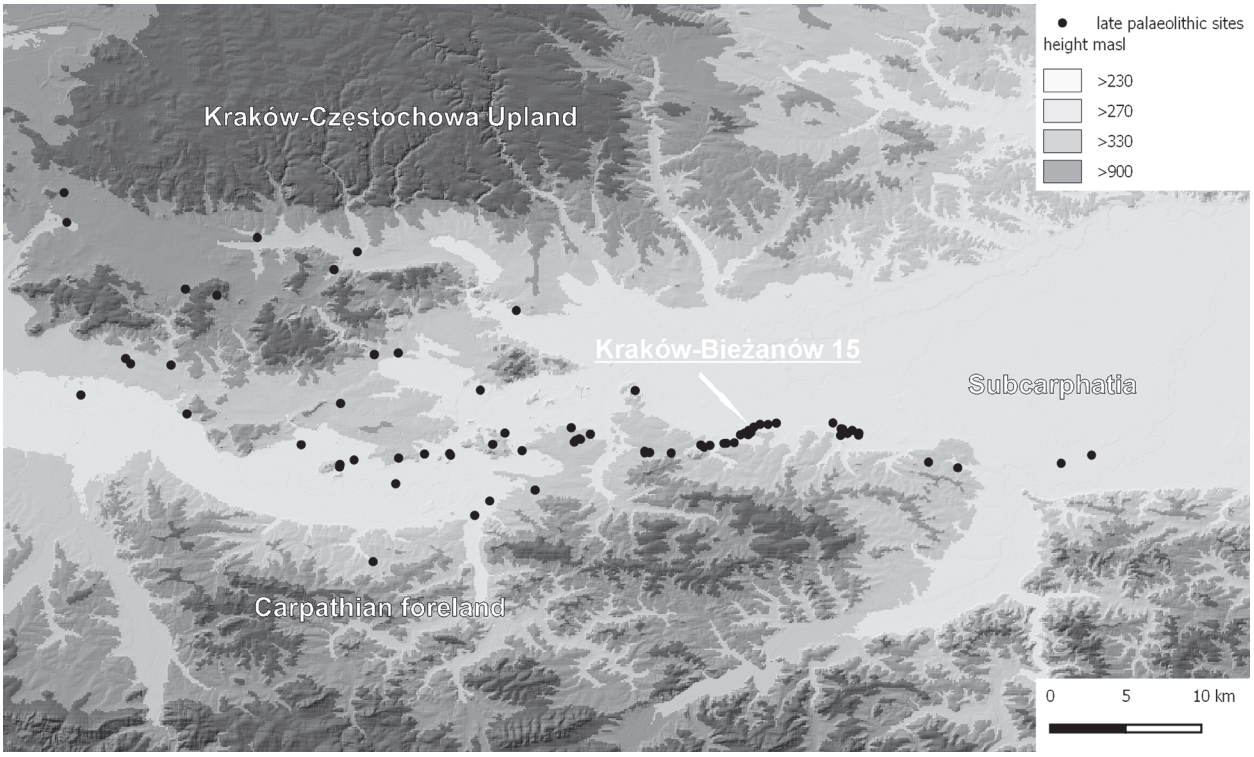

Fig. 1. Distribution of late palaeolithic sites
in the western part of the Northern Subcarphatia

Kraków-Bieżanów is located in Subcarpathia, a foreland of the Carpathians, on the southern slopes of the Vistula valley (Fig. 1). During the vast rescue excavation carried out there (1999-2008) a complex of several late palaeolithic sites were recognized. Together with dozens of other late paleolithic sites scattered along the Vistula valley (e.g. Tyniec, Przeginia Narodowa, Zagacie, Kraków-Kurdwanów, Kraków-Borek Fałęcki, Kraków-Kobierzyn and Zakrzów) it constitutes the biggest Swiderian settlement in the centre of southern Poland[2]. This paper is focused on the western and central part of the Kraków-Bieżanów site 15 where a relatively dense hierarchized pattern of the Swiderian settlement was uncovered (Fig. 2)[3]. This settlement consists of a small campsite (feature 1 – kshemenitsa Kraków Bieżanów 15/1 – Fig. 3, 4, 5) and two spots (feature 2 – Fig. 3, 6, 7 and 3 – Fig, 3, 8, 9).

All of these are surrounded by an area of scattered Late Palaeolithic artefacts (Fig. 3, 10, 11). This research assumes that at least some of the remains are synchronous and represent a single settlement episode, although no unambiguous proof like refitting can be shown. However, the primary observation of spatial arrangements of the scattered artefacts shows clear patterning of basic typological tools (points, scrapers, burins) which may support such a hypothesis. The analysis of those distinct areas and the spatial relation between them, as well as their function, is the main goal of this paper. The preliminary hypothesis of the paper is that numerous Late Palaeolithic finds document the complex activity and land-use pattern of the Swiderian community at the site. Additionally, morphometric methods applied to the tanged points generated additional information about the function of the tanged points, which is a fossil directeur of the Swiderian communities. The results of the analyses performed (tip cross-sectional area analysis, tip angle analysis) supports arguments for the reconstruction of hunting techniques in Swiderian communities. To assess the stylistic variance of the Swiderian points, quantitative and comparative analysis of points outline shapes based on geometric morphometrics were generated.

Methods

The use-wear analysis was conducted with a Nikon LV150 metallographic microscope (50x to 500x magnification) with an attached digital camera. Preliminary microscopic observations were made to recognize organic residues. Afterwards the flint surface was cleaned with warm water and

[2] Dagnan-Ginter and Drobniewicz 1974; Sachse-Kozłowska 1972; Kozłowski 1960; Czapkiewicz 1936.

[3] Byrska et al. 2006; Stefański 2012; Stefański and Wilczyński 2012.

Fig. 2. Distribution of Swiderian settlement features at Kraków-Bieżanów sites

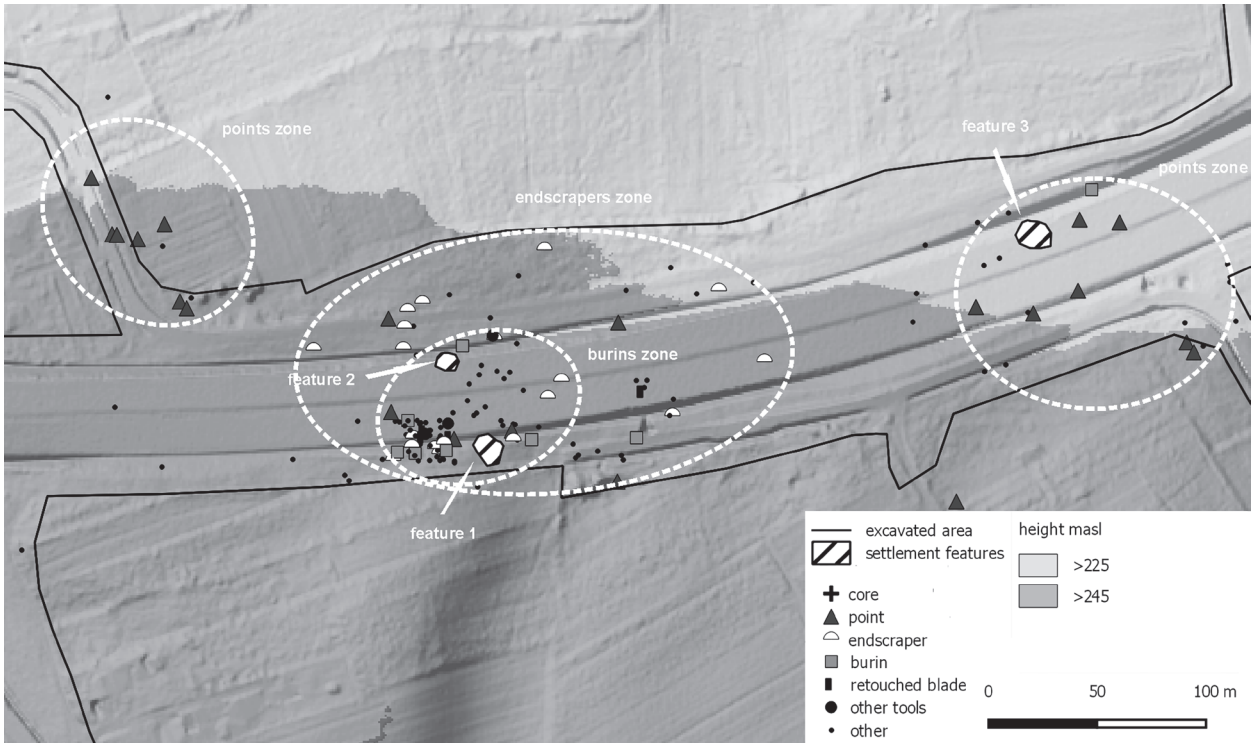

Fig. 3. Kraków-Bieżanów 15. Distribution of single finds attributed to Swiderian culture around a settlement features

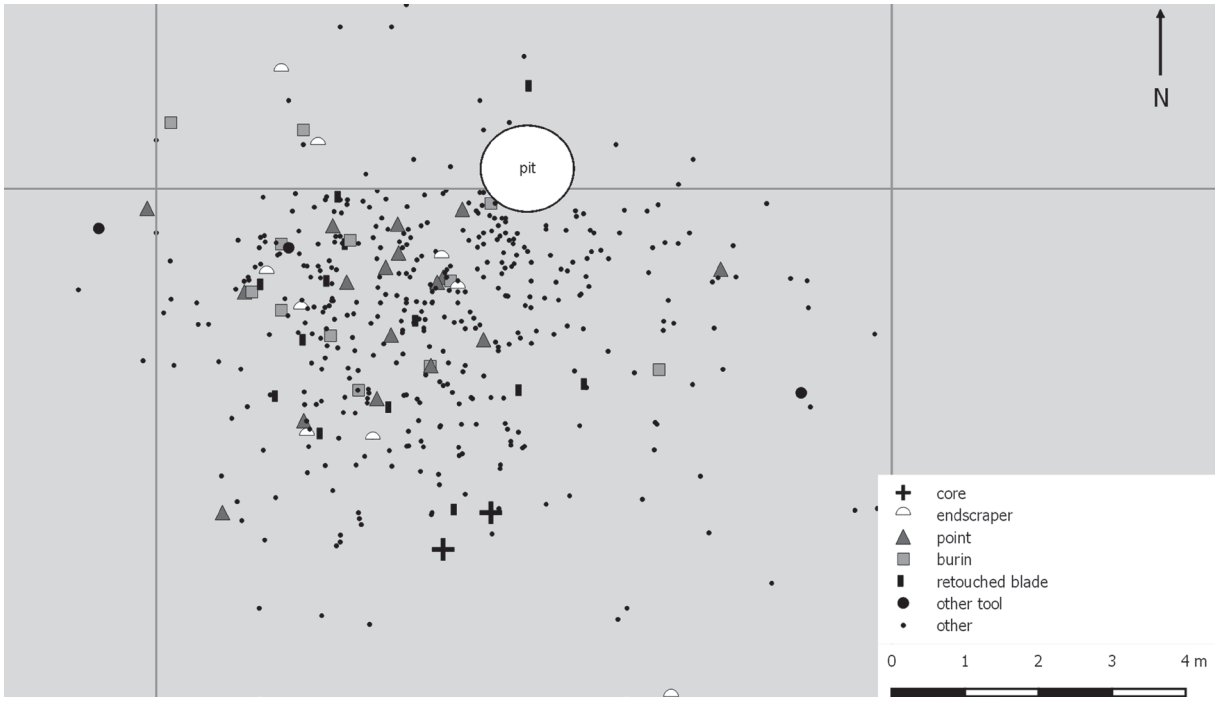

Fig. 4. Kraków-Bieżanów 15. Feature 1 – kshemenitsa (KB15/1); spatial arrangements

detergent to remove contamination and washed with pure acetone. The artefacts were viewed under magnification of 50x, 100x and 200x. This allowed for detailed identification of individual traces micro-flake scars and polishes. The microscopic analysis of use-wear traces was performed on all lithic tools and samples of unretouched products of debitage (flakes and blades). The result of use-wear analysis was compared with the experimental dataset to produce a reliable outcome.

The Swiderian points are considered highly variable in terms of their shapes and sizes. There are many quantitative traits which can be used for analysing the diversity of these artefacts (Fig. 12). In this study it has been decided to focus on traits which are valid in terms of projectile weapons' efficiency and performance. The analysis consists of three methods including: tip cross-sectional area analysis, tip angle analysis and geometric-morphometric outline shape analysis. Tip crossectional area (TCSA) is a ballistically significant dimension that can be used to differentiate between projectile weaponry types, such as arrowheads, dart-tips and spear-points[4]. Crossectional areas simply inform on how much force must be used for a point to achieve penetration. The method of calculating the crossectional area of an artefact is simple and it consists of multiplying the maximum width and thickness and then dividing the ratio by two. The measurements of TCSA are then compared with the TCSA values of ethnographic projectile points, whose function as projectile implements is known. Extensive data on TCSA values for ethnographic projectile points are included in the works of Thomas[5], Shott[6] and Shea[7]. These datasets serve as a comparative standard for this study. Angles of projectile point tips are considered to be of major functional importance. Of all other features of projectile point, tip angle is most tightly constrained by functional requirements[8]. On the basis of experimental studies with ancient projectile weapons, it has been proven that points with tip angles wider than 55° are no longer considered able to penetrate skin and create wounds[9]. The optimal threshold for arrowheads is considered to be between 30-40[10]. Considering the relatively small number of Kraków-Bieżanów leaf points, it has been decided to include specimens from other representative Swiderian sites: Rydno and Nobel. This has been done by measuring the angles of Swiderian points based on in publications of the sites. The measurement of angles for all specimens was performed in tpsDig by using the angle gauge tool. Next, observations were compared with the data obtained by Felix Riede for Federmesser,

[4] Bretzke, Marks, and Conard 2006; Shea 2006; Sisk and Shea 2009.

[5] Thomas 1978.
[6] Shott 1997.
[7] Shea 2006.
[8] Dev and Riede 2012.
[9] Beckhoff 1966.
[10] Friis-Hansen 1990.

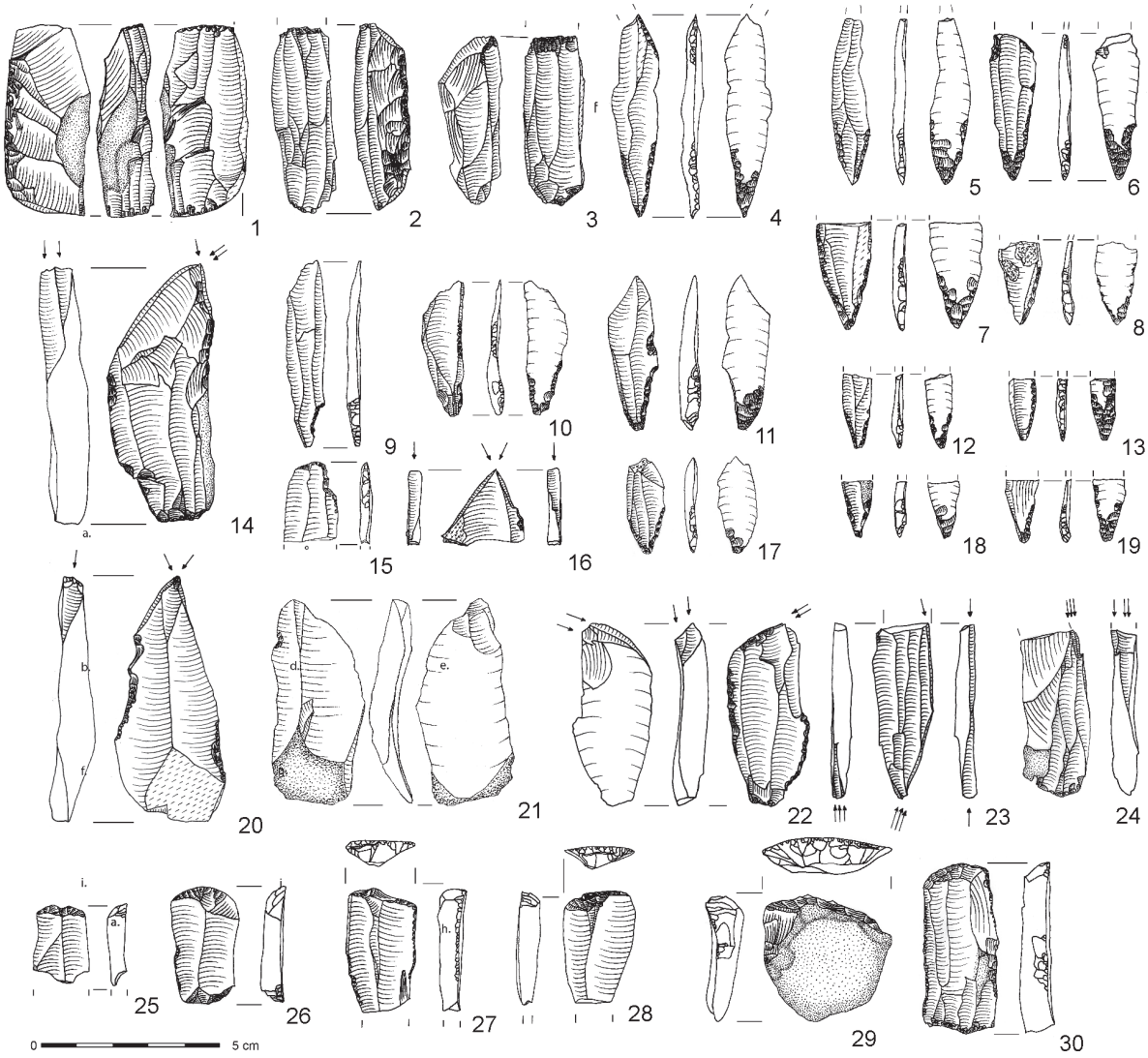

Fig. 5. Kraków-Bieżanów 15. Feature 1 – kshemenitsa (KB15/1); lithics

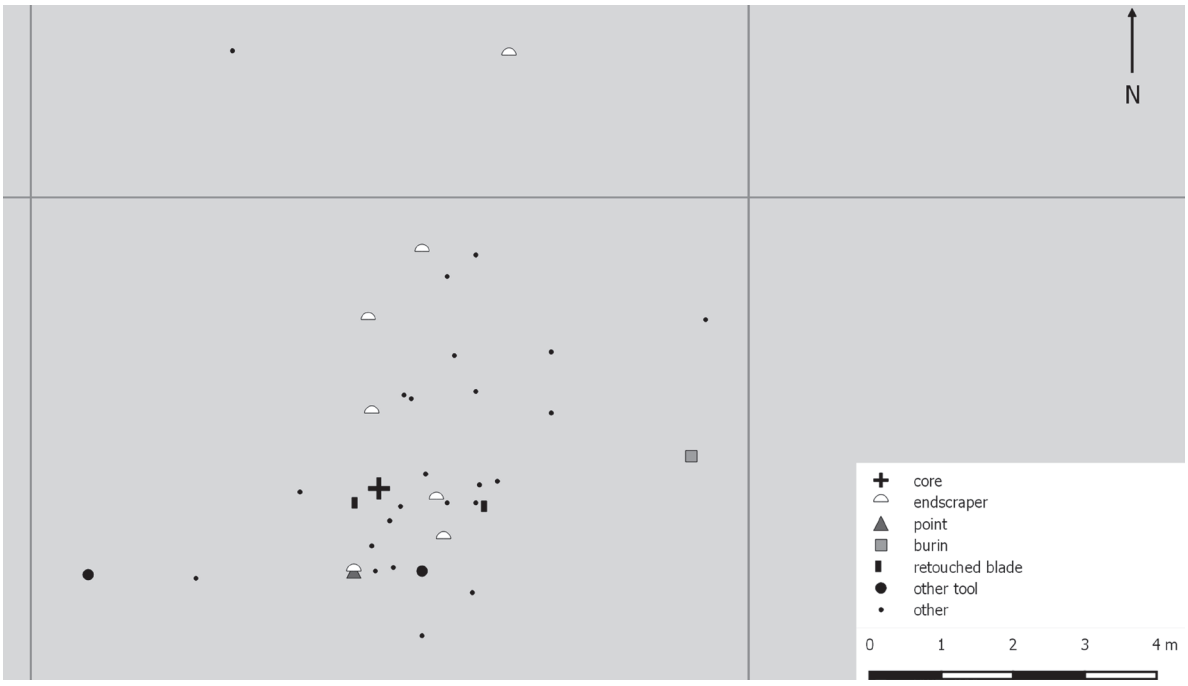

Fig. 6. Kraków-Bieżanów 15. Feature 2; spatial arrangements.

Bromme and Ahrensburgian points[11]. The overall morphology of a projectile point is an informative feature which may shed light on the point's application within the vast spectrum of ancient hunting techniques. Swiderian points are considered highly variable in terms of morphology. This fact creates an inconsistency according to their alleged function, as arrowheads should be rather morphologically uniform to meet the ballistic requirements of projectile weapons[12]. To explore the morphological diversity of Kraków-Bieżanów Swiderian points, a geometric morphometric outline shape analysis was used. The outline shapes of the points from Kraków-Bieżanów were compared with each other but also with specimens from the other relevant archaeological sites of Nobel[13] and Rydno[14] in the course of principal component analysis (PCA). Photographs were used to obtain outline shapes of Kraków-Bieżanów points. As for the other samples, the illustrations included in the sites monographs were digitalized. Points were placed with the tang part turned to the left and according to their axis of symmetry, following the standard method of artefact orientation described by McPherron and Dibble[15] and also by Costa[16]. Next a set of 100 equidistant landmarks was placed around the perimeter of artefacts in the tpsDig program[17]. Landmark data was then exported to PAST (Palaeontological Statistics) software[18], where the Procrustes superimposition[19] was performed. To interpret utilization of the Swiderian points, data from experimental tests, as well as these are presented in the literature were used.

The lithic assemblages were also analysed by standard lithic analysis which allows for the interpretation of the Swiderian settlement at the site. The same procedure was applied to single finds linked with the Swiderian but documented outside of the homogenous settlement features. In the last case, because of a small number of lithics dated to the Neolithic or Bronze Age scattered around the site, only unquestionable elements were included (mostly blades struck from opposite platform cores, but also tanged points, cores, burins, endscrapers and retouched blades). A spatial procedure was performed to examine a concentration of particular types of typological tools which hypothetically represented zones of different activities. In this case, it was tested by planigraphic method using coordination data of the lithics acquired during excavations. Basing on these data, maps showing the clustering of tools were constructed to visualise the range of these functional zones.

Results

The aim of the examination of the use-wear was to test the function of the most frequent types of tools and some debitage. The results were further used as an argument in studying archaeological features. Unfortunately, a factor which greatly affected the research was weathering which wore down weak or little developed use-wear traces. The most reliable results come from analysis of the numerous tanged points and endscrapers, as the micro and macro traces observed were well-developed. The result of use-wear analysis is shown in charts (Fig. 13). The general indication is that most of the tools were used for hunting and post-hunting activities.

Altogether, 43 Swiderian points were examined. Of these, 19 are badly preserved which makes analysis impossible. In 14 cases, they were recognized as arrowheads, 10 were unused. One common feature which characterizes the Swiderian points is the distinctive macro fracturing including longitudinal and transverse breakage of tips; step- or hinge-terminated bending fractures; and burin-like or spin-off fractures (Fig. 14). In addition, micro traces resembling polishing were recognized. They appear as the long, shining, sometimes bright, serrated bands which run on one or both surfaces of the flint artefacts. Another type of micro traces are scratches. Both types of micro traces overlap each other (Fig. 15). The location and direction of linear traces suggest the way Swiderian points were hafted. This indicates a clear relationship between the axis of shaft symmetry and the axis of the Swiderian point. The surfaces were also covered also other traces which resulted from contact with animal tissue, mainly hide. These polishes are visible mainly on protruding parts and usually are accompanied by rounding of these parts (Fig. 16). They are often not very clear due to postdepositional factors. These traces can be interpreted in two ways. Firstly, these marks could be hafting traces. Alternately, they could have originated from transportation in a container of hide or some other organic material used to carry weapons during hunting. This hypothesis is confirmed by the results of experimental studies devoted to storage and transport of lithic tools

[11] Dev and Riede 2012.
[12] Hughes 1998.
[13] Sulgostowska 1989.
[14] Schild et al. 2011.
[15] McPherron and Dibble 1999.
[16] Costa 2010.
[17] Rohlf 2004.
[18] Hammer, Harper, and Ryan 2001.
[19] Comp: Rohlf and Slice 1990.

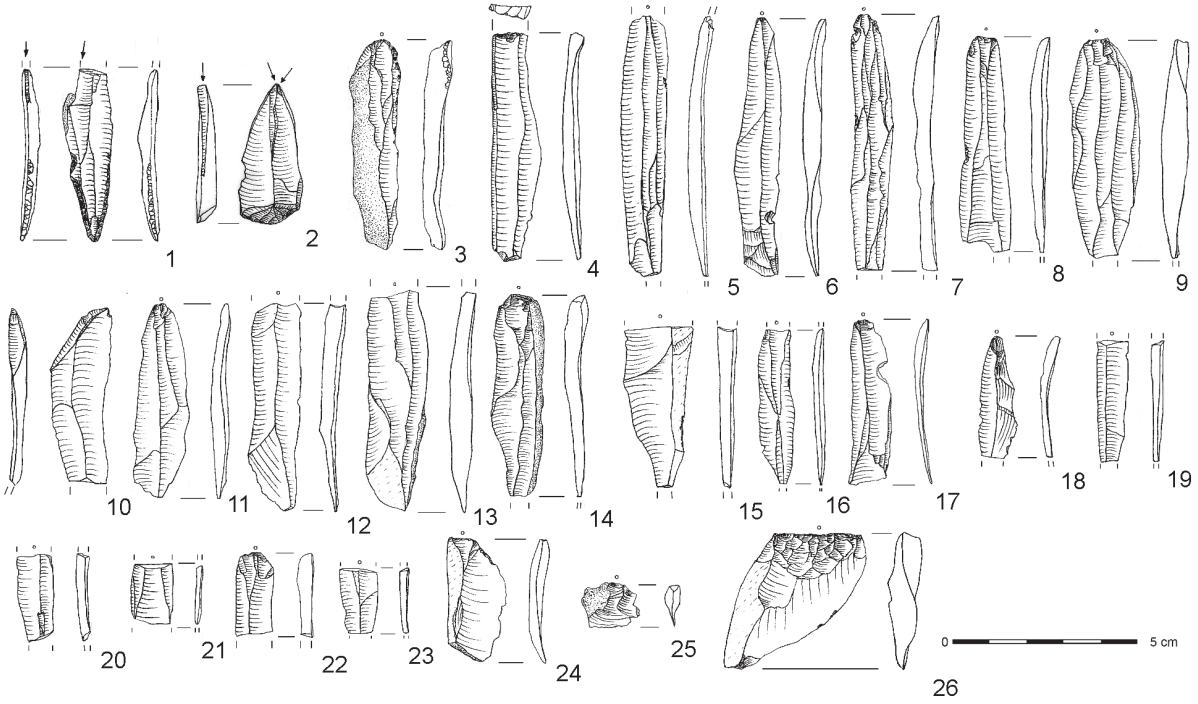

Fig. 7. Kraków-Bieżanów 15. Feature 2; lithics

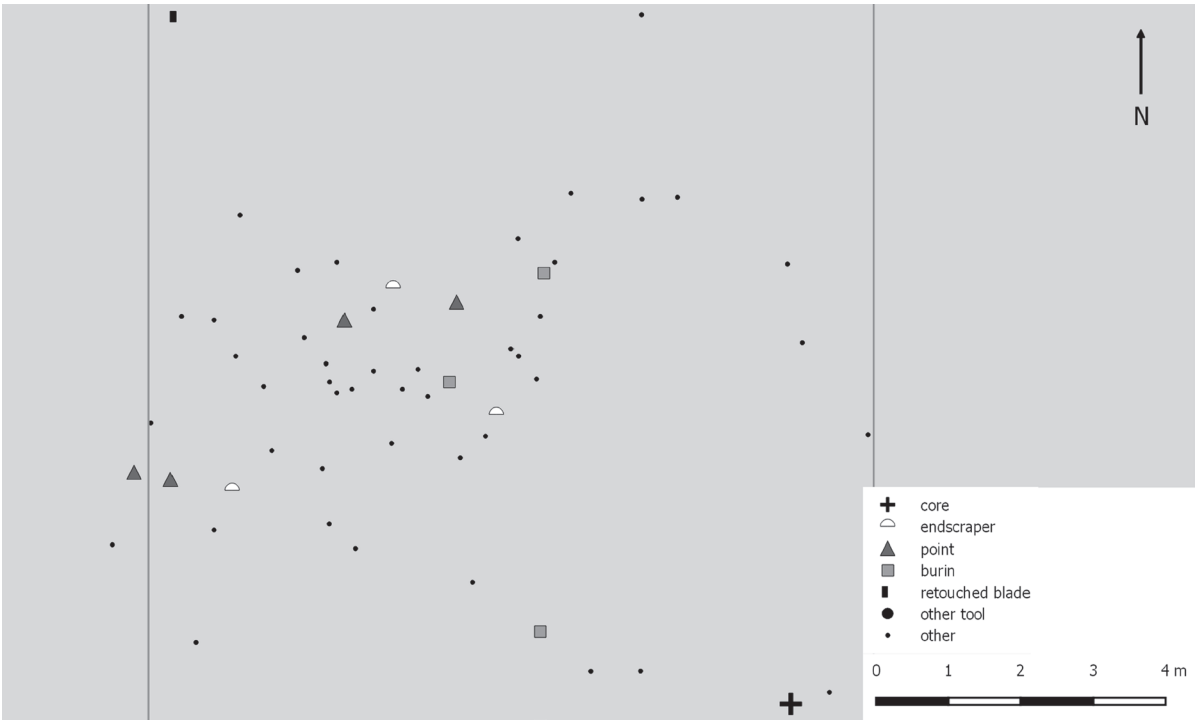

Fig. 8. Kraków-Bieżanów 15. Feature 3; spatial arrangements

in various types of containers (i.e. quivers, pouches) made from skin and bone.

Altogether, 41 endscrapers were examined. Of these, 17 were badly preserved. Another 16 were used as hide scrapers (Fig. 17), 3 for butchering (Fig. 18), 1 for bone or antler processing, 2 for unspecified activities, and 2 were unused. Use-wear analysis proved that typological endscrapers were usually used for scraping hide. The examination of endscraper fronts revealed that the retouched edges were heavily rounded and polished. Similar polish was noted also along the lateral edges of some specimens. Linear traces are arranged more or less perpendicularly to the frontal working edge, but parallel and aslant to the longer edges which indicates that these tools were simultaneously also used for cutting. Additionally, some endsrapers manifest single traces resulting from contact with

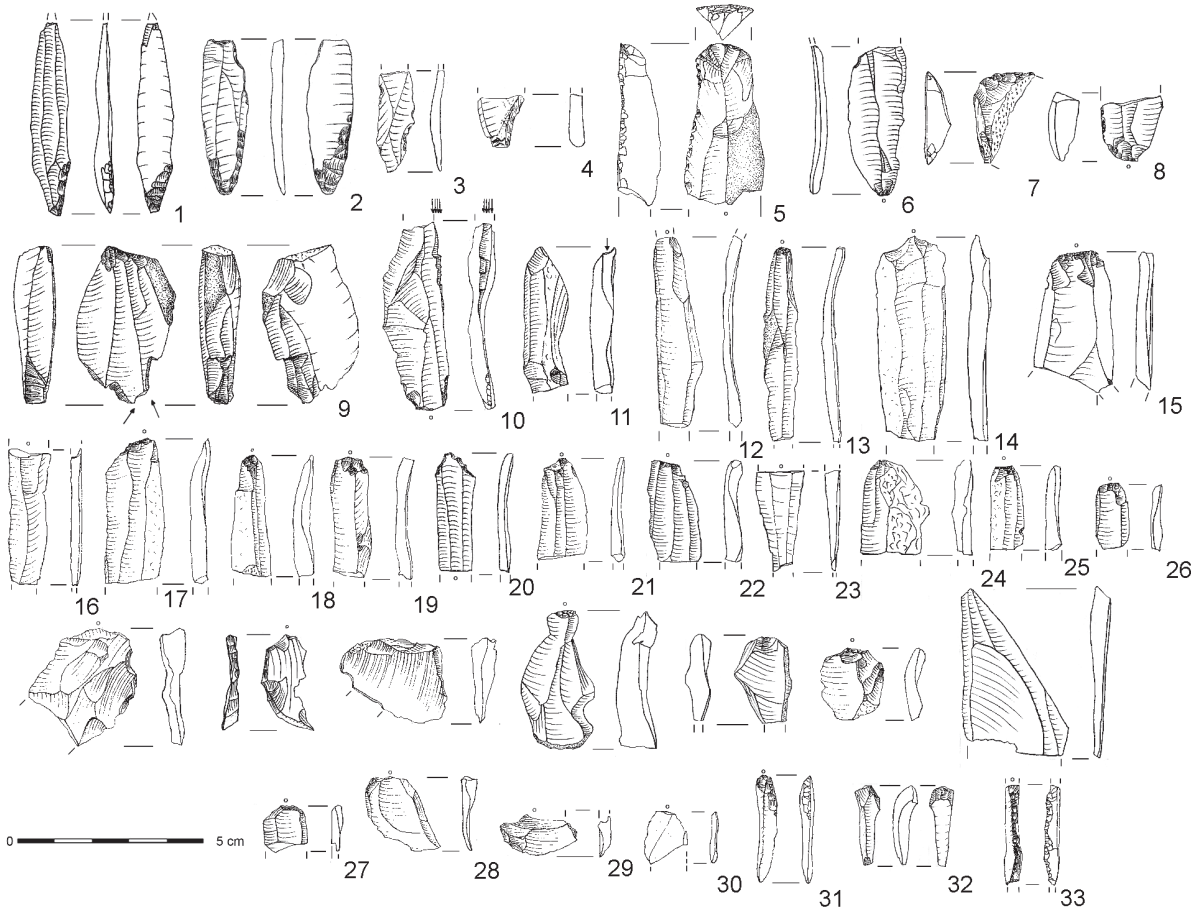

Fig. 9. Kraków-Bieżanów 15. Feature 3; lithics

antlers or bones which could indicate that they were sporadically used for butchering activities as well.

Altogether, 25 burins were examined (one combined with an endscraper). Of these, 14 were badly preserved. Another 3 were used for scraping and planing organic material, one for cutting bone/antler, one for soft tissue processing, two bear unspecified traces, and 4 were unused. The use-wear traces were noticed on negatives left by burin spalls detaching which suggests grooving activity (Fig. 19), as well as on unretouched longitudinal edges which suggests knifing.

The use-wear examination covered also the sample of debitage, which included 44 blades, 22 flakes or chunks, and 3 burin spalls coming from features 2 and 3. It can be concluded that almost none of them bear clear use-marks. Ambiguous traces of hide cutting were noticed only in the case of a single blade.

The results indicate that the TCSA values of Kraków-Bieżanów leaf points are clearly in the range appropriate for small arrowheads (Fig. 20). This seems to confirm the results of use-wear analysis. The only specimen which stands outside the range is a fairly large point with a thick base which resembles Bromme-Lyngby-type points. The angles of Swiderian points tips are relatively wide (Fig. 21). They are rather similar to those of Bromme points which, as F. Riede has emphasized, were used as dart tips rather than as arrowheads[20]. Only a small number of Swiderian points reach the 'optimal threshold' of the 30°-40° angle predicted for arrowheads. It can be assumed that specimens with wide angles are simply leaf point preforms, but the use wear analysis indicates that even the leaf points with wide and unretouched tips were also used as arrowheads (for example specimen 15/671). The results of the PCA indicate that the distribution of all three sample groups (Bieżanów, Rydno and North Eastern Poland) is normal as the specimens from subsequent sites do not form significantly different clusters. (Fig. 22). The first two principal components hold most of the variance (PC 1: 47,24% variance and PC 2: 16,98% variance), and only those components were considered during the analysis. A noticeable pattern exists in the distribution of the points studied, which is shown on the principal component 2 axis. The artefacts can generally be divided into two groups: on the left are leaf points which were made of fairly

[20] Dev and Riede 2012.

Table 1. Kraków-Bieżanów 15. A structure of assemblages related to Swiderian culture

Group	Category	feature 1		feature 2		feature 3		zone of scattered artfecats	
			%		%		%		%
Cores		7	0,98	1	2,56	1	1,82	3	2,27
	Nodule tested, Precores	2	0,28			1	1,82		
	Flake cores	1	0,14	1	2,56				
	Blade Cores	4	0,56					3	2,27
Blanks		354	49,23	25	64,11	33	60	80	60,61
	Blades	224	31,15	21	53,85	25	45,45	55	41,67
	Flakes	130	18,08	4	10,26	8	14,55	25	18,94
Tools		62	8,63	13	33,32	11	20	45	34,09
	Tanged Points	17	2,36	1	2,56	4	7,27	13	9,85
	Endsrapers	14	1,95	7	17,95	2	3,64	19	14,39
	Burins	12	1,67	1	2,56	3	5,45	7	5,3
	Retouched blades	14	1,95	2	5,13	1	1,82	4	3,03
	Truncations	3	0,42	1	2,56	1	1,82	1	0,76
	Retouched Flakes	1	0,14						
	Notched	1	0,14					1	0,76
	Combined tools			1	2,56				
Other	Chunks, chips	272	37,83			8	14,55	3	2,27
	Burin spalls	20	2,78			2	3,64		
	Microburins	2	0,28						
	Hammerstones	1	0,14					1	0,76
	Stone plate	1	0,14						
TOTAL		**447**	**100**	**77**	**100**	**100**	**100**	**257**	**100**

broad and thick blades, often with irregular edges and a wide-tip angle of up to 90°. Leaf points clustered at the right side of the plot are made up of very thin, slender blades with straight edges and narrow tip angles. In the latter group, the flat retouch of the basal part is also more carefully made and more invasive. It is hard to interpret the distribution of specimens according to principal component 1, since there are not so many points scattered according to this component. Observing the shift of morphology along this axis it can be concluded, that it represents a transition from rather small, lateralized specimens to those with a straight profile.

The collected data (Table 1) suggest that at least two types of settlement features may be indicated. The first type is represented by a small kshemenitsa (feature 1), the second type is represented by both spots (feature 2 and 3). The kshemenitsa consist of just several hundred lithics. The cores are extremely exhausted. The debitage is dominated by regular blades which were struck from cores prevoiusly prepared elsewhere. The tool ratio is relatively high, the most frequent type is Swiderian points. The points are followed by endscrapers, retouched blades and burins. Inside the feature was a small pit filled with knapping waste and a partly preserved stone plate. The use-wear analysis in this case was limited to typological tools (points, endscrapers and burins). Although functional identifications are limited, they seem to derive from post-hunting activity, as hide processing was mostly registered. This is confirmed additionally by broken arrowheads (Swiderian points) and other ones which seem to be preforms. Little effort was expended to maintain lithic resources. In this context, outstanding is a refit of several partly cortical flakes which indicate just a single nodule processing, as well as two small nodules which could be interpreted as reserves, although their dimensions indicate otherwise. Summarizing, this kshemenitsa represents a small hunting camp without any specific inner patterning of lithics. The second type of feature is spots with clusters of dozens of artefacts. In the case of feature 2, the inventory is limited almost exclusively to dozens of unretouched blades. These are accompanied by several tools including endscrapers, Swiderian point, burins and retouched blades. The whole set was investigated

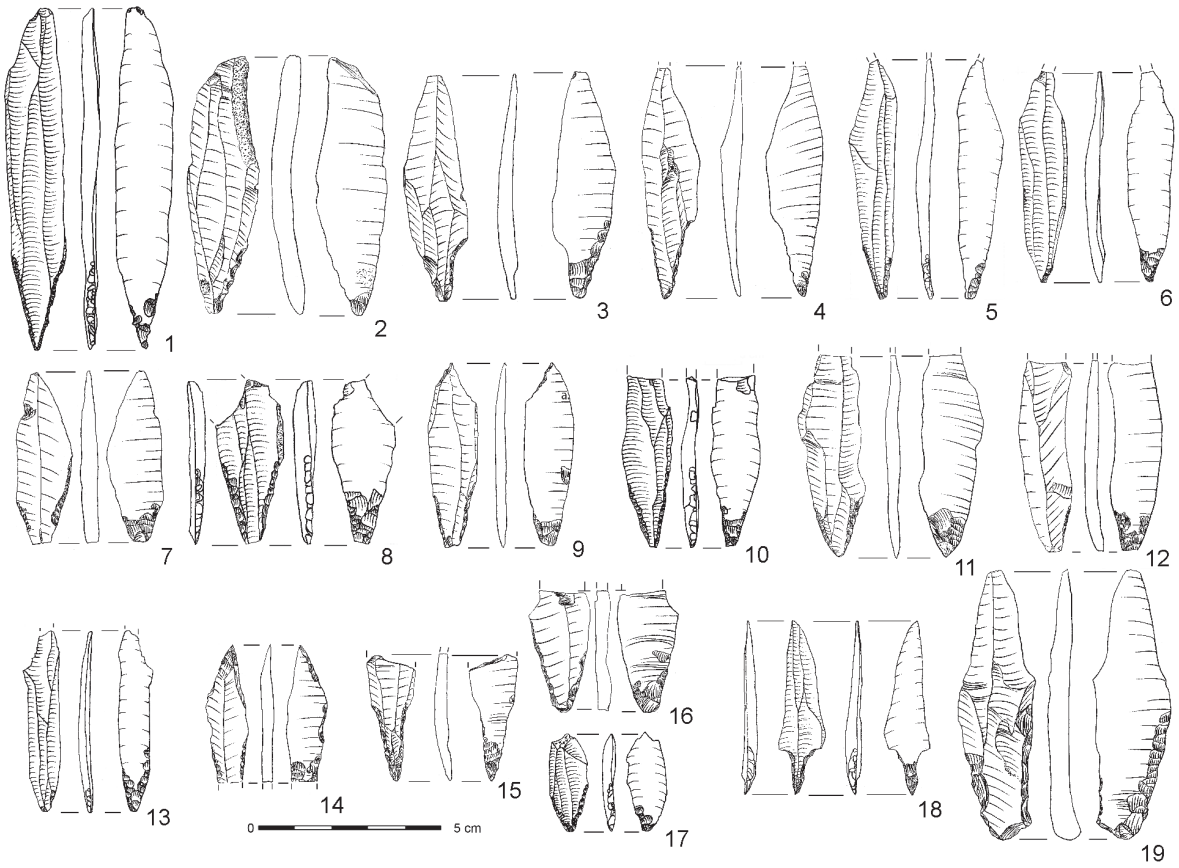

Fig. 10. Kraków-Bieżanów 15. Single finds attributed to Swiderian culture:
1-17 – Swiderian points; 18, 19 – other points

by means of use-wear analysis. It did not indicate any specialized activity as the number of succeeded use-wear matches were limited. The single identification on typological tools would also indicate a post-hunting activity. Surprisingly, the majority of the lithics seem to have been unused. This suggests a set of unretouched blades, because no knapping activity was registered, and the assembly has to be considered as hoarded. Feature 3 seems similar, although some traces of flint processing, as well as tool re-sharpening are visible. Unusually, in this last case most raw material are extra-local and were brought from the Carpathians (radiolarite from the Pieniny klipen belt) which makes it less likely to be linked with the rest of the structure. The spatial and functional analysis of scattered artefacts yielded interesting results. It allowed division of the space into distinct functional zones. The first is marked by the clustering of Swiderian points in the north-western part of a site where several points were found. As argued above, these tools served as arrowheads. It suggests the presence of a killing site. Unfortunately, only a narrow trench of this zone was excavated prior to the construction of motorway interchange. The similar structure is observed in the central part of the site where a several points were scattered. The most widely scattered tool type seems to be endscrapes. These created a vast zone surrounding a hunting camp on the north side. Conversely, burins are concentrated close by.

Discussion

This study represents an attempt to carry out research the unique late paleolithic landscape management record revealed during vast rescue excavations. Part is a functional study (use-wear analysis) which gives additional arguments to understand unusual patterning of lithics. Although the use-wear analysis faced an obvious limitation (preservations of the artefacts, number of lithics) it produced valuable information about usage of lithic tools among Swideran societies in Kraków-Bieżanów. The distribution and usage of lithic tools seems to be well planned and focused on post-hunting activities. This study proves also that Swiderian points which are the most frequent tool amongst Late Paleolithic societies in the Odra, Vistula, Nemen and Dnepr basins were used as projectiles, as distinctive macroscopic and microscopic traces on the surfaces suggest that they were components of throwing weapons.

Fig. 11. Kraków-Bieżanów 15. Single finds attributed to Swiderian culture:
1-16 – endscrapers; 17-23 – burins; 24-30 – retouched blades

On the basis of the characteristics taken into account in this study, Swiderian points from Kraków-Bieżanów do not form a significantly different standard in comparison to points from Rydno and North Eastern centers of the Swiderian culture. Swiderian points represent the products of reduction of a double platform core of the Swiderian type. The minor modifications of blades which were transformed into leaf points, and hence their variability, indicate that Swiderian projectile technology was largely extensive and maintainable[21]. The question whether Swiderian points were used as arrowheads is not easy to answer. On the one hand, their TCSA values are clearly in the range of arrow points, on the other hand the relatively wide tip angles seem to to argue against this proposition. Their outline shapes are also various which is not the case for arrow-heads. The PCA analysis indicates that there are no significant differences between the outline shape of the points from subsequent sites. This partly excludes the idea, that regional manufacturing styles underlie the variability of Swiderian points, as it was observed among some ethnographic hunters and gatherers[22]. In our opinion, we may be dealing with two types of arrowheads in the sample being studied: one for unfletched arrows, which were fired at short distances at high power (broad points with wide angles) and more finely made arrowheads, probably for fletched

[21] Bleed 1986.

[22] Wiessner 1983.

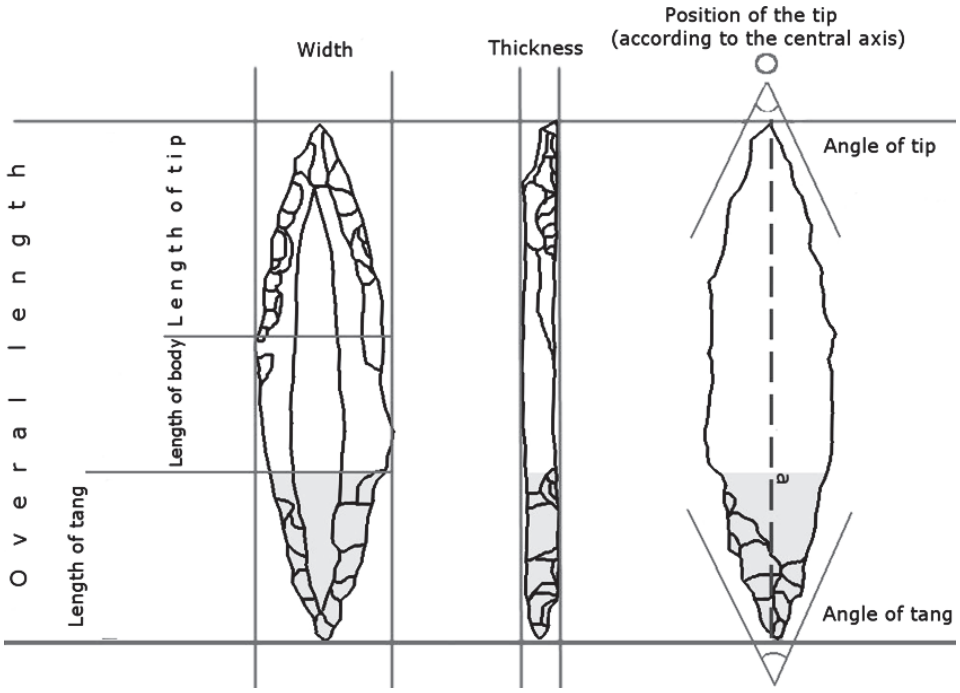

Fig. 12. Some quantitative characteristics of Swiderian points[25]

arrows, fired at greater distances. The purpose of using the points of the first type was not deep penetration, but the shock resulting from being hit at a short distance. These arrows may have been used at close quarters, for instance in an ambush hunting type situation. The second type of points probably served in hunting at greater distances, where the power of a projectile is not so important as accuracy and the ability to a tip to deeply penetrate hide, causing damage of internal organs and hastening the prey's death. Consequently a dichotomy between short distance, high powered projectiles and long distance, low power, highly penetrative projectiles emerges. Such dualities in ancient projectile technologies are proven to exist among ethnographic parallel hunter gatherer communities[23]. This phenomenon also occurs in modern archery, with heavy weapons used in hunting and light weapons used in target shooting[24].

Outcome of this study clearly points to patterning of Swiderian settlement structure at Kraków-Bieżanów 15. Although, this study has to make some assumptions about simultaneous settlement and the immediate discarding of tools, it gives an unusual glimpse into Swiderian landscape management. The study proves that this settlement is structured and most likely a reminiscent of hunting activity. These small, temporal features could be completed by a base camp found in the neighbourhood at Kraków-Bieżanów 20 site[26] (Fig. 2). The unusual set of finds from these two localities were only discovered because excavation was carried out over a vast area. Similar circumstances were found at other Kraków-Bieżanów sites[27]. Their function is not fully resolved as a use-wear analysis only brings incomplete data. Worth mentioning is a vast area of scattered artefacts surrounding settlement features. This is a question of zones where arrowheads cluster. The ballistic properties of Swiderian points, together with landscape modelling would suggest the use of small tributary valleys as part of a game-hunting strategy involving ambushing. The traces of tissue and hide processing are distant from the hunting camp which could be explained by possible impact of decomposing wastes on settlement area. Conversely, some traces of bone or antler processing were recognized close to the camp. This observation could be proved by the fact that 45% of the whole population of endscrapers were found outside of features, while in the case of burins it was only 28 %. There is no spatial differentiation inside a camp (Fig. 4). The main activity was focused on the maintenance of weapons (arrow-heads) or tools (endscrapers). In this case the two burins identified as processing organic material could be involved.

[23] Cundy 1989.

[24] Butler 1973; Higgins 1933.

[25] Comp: Szymczak 1987; Burdukiewicz and Schmider 2000.

[26] Klimek, Stefański, and Zając 2012.

[27] Stefański and Wilczyński 2012; Wilczyński 2015.

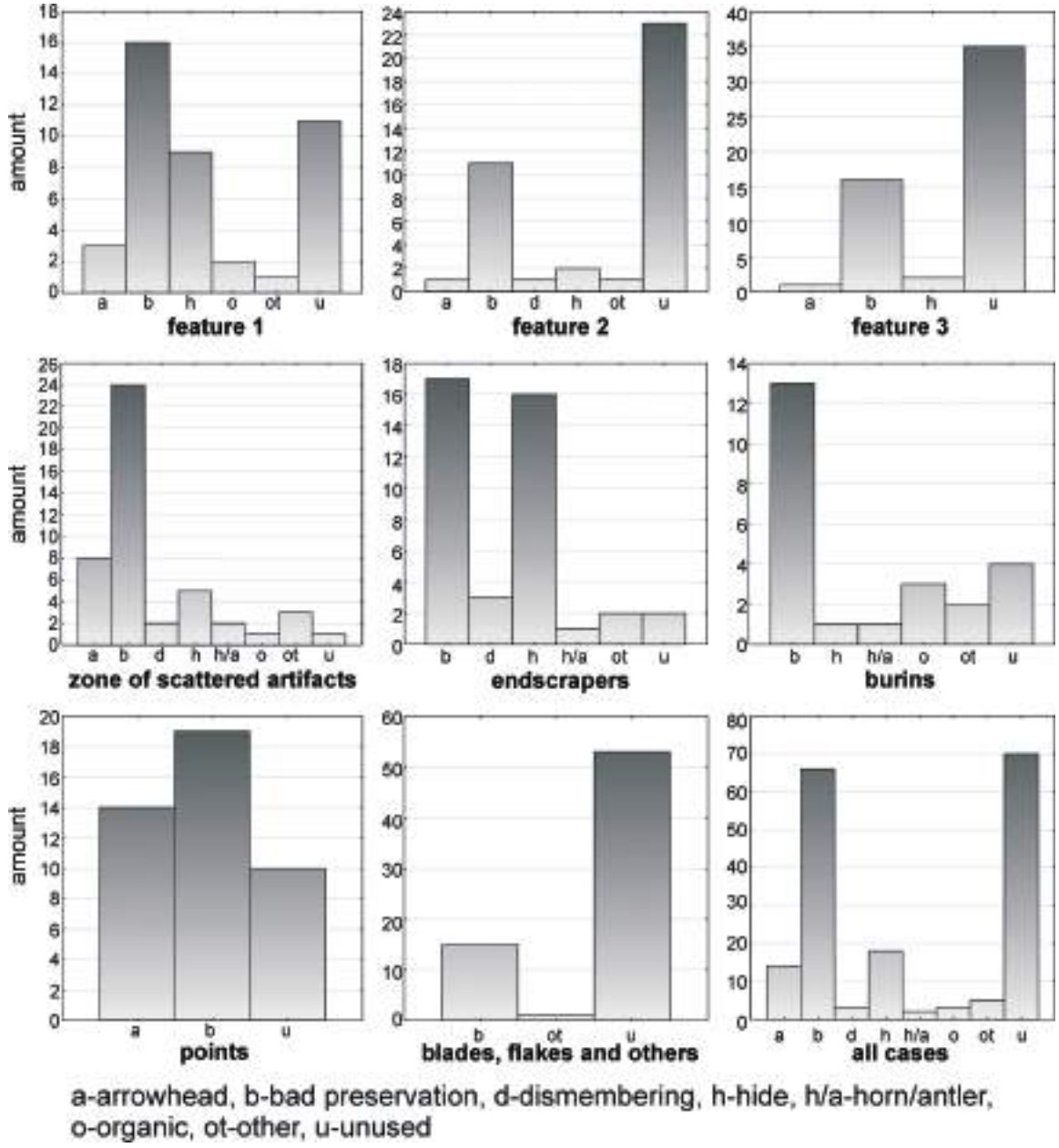

Fig. 13. Kraków-Bieżanów 15. The results of use-wear analysis

The date presented are, to some extent, comparable with the ethnographic record[28]. Unfortunately, the lack of organic material does not allow us to draw any far-reaching conclusions.

Acknowledgments

This study was supported by National Science Centre (grant: Late Paleolithic settlement dynamics in the western part of North Subcarpathia; UMO-2015/17/N/HS3/00158)

[28] Grøn and Kuznetsov 2004.

Literature

Beckhoff, K. 1966. *Zur Morphogenese Der Steinzeitlichen Pfeilspitze.* Die Kunde N.F. 17, 34-65.

Bleed, P. 1986. *The Optimal Design of Hunting Weapons: Maintainability or Reliability.* American Antiquity 51/4, 737-47.

Bretzke, K., A. E. Marks, and N. J. Conard. 2006. *Projektiltechnologie Und Kulturelle Evolution in Ostafrika.* Mitteilungen der Gesellschaft für Urgeschichte 15, 63-81.

Burdukiewicz, J. M. 2011. *Late Glacial Hunter--Gatherer Reactions to the Younger Dryas Cooling Event in the Southern and Eastern Baltic Regions of Europe.* Quaternary International 242/2, 302-12.

Burdukiewicz, J. M., and B. Schmider. 2000. *Analyse Comparative Des Pointes a Cran Hambourgiennes Du Bassin De L'oder Et Des Pointes a Cran Magdaléniennes Du Bassin Parisien.* Mémoires du Musée de Préhistoire d'Ile-de-France 7, 97-108.

Butler, D. F. 1973. *The New Archery. Cranbury,* NJ: A. S. Barnes.

Byrska, M., J. Fraś, A. Matoga, I. Pieróg, M. M. Przybyła, and D. Stefański. 2006. *Wstępne Wyniki Ratowniczych Badań Archeologicznych Na Wielokulturowych Stanowiskach 8, 11, 12, 14, 15 Oraz 20 W Krakowie-Bieżanowie, Woj. Małopolskie.* In *Raport 2003-2004. Wstępne Wyniki Konserwatorskich Badań Archeologicznych W Strefie Budowy Autostrad W Polsce Za Lata 2003-2004*, edited by Z. Bukowski and M. Gierlach, 523-27. Warszawa: Zeszyty Ośrodka Ochrony Dziedzictwa Archeologicznego (d. Zeszyty ORBA). Seria B: Materialy Archeologiczne.

Costa, A. G. 2010. *A Geometric Morphometric Assessment of Plan Shape in Bone and Stone Acheulean Bifaces from the Middle Pleistocene Site of Castel Di Guido, Latium, Italy.* In *New Perspectives on Old Stones: Analytical Approaches to Paleolithic Technologies*, edited by S. J. Lycett and P. R. Chauhan, 23-41. New York: Springer Science.

Cundy, B. J. 1989. *Formal Variation in Australian Spear and Spearthrower Technology.* Bar International Series Vol. 546.

Czapkiewicz, B. 1936. *Ślady Przemysłu Świderskiego Na Stanowiskach Wydmowych W Okolicy Krakowa.* Wiadomości Archeologiczne 14, 32-39.

Dagnan-Ginter, A., and B. Drobniewicz. 1974. *Przyczynki Do Znajomości Osadnictwa Schyłkowopaleolitycznego I Mezolitycznego W Okolicach Krakowa.* Materiały Archeologiczne 15, 5-39.

Dev, S., and F. Riede. 2012. *Quantitative Functional Analysis of Late Glacial Projectile Points from Northern Europe.* Lithics: the Journal of the Lithic Studies Society 33, 40-55.

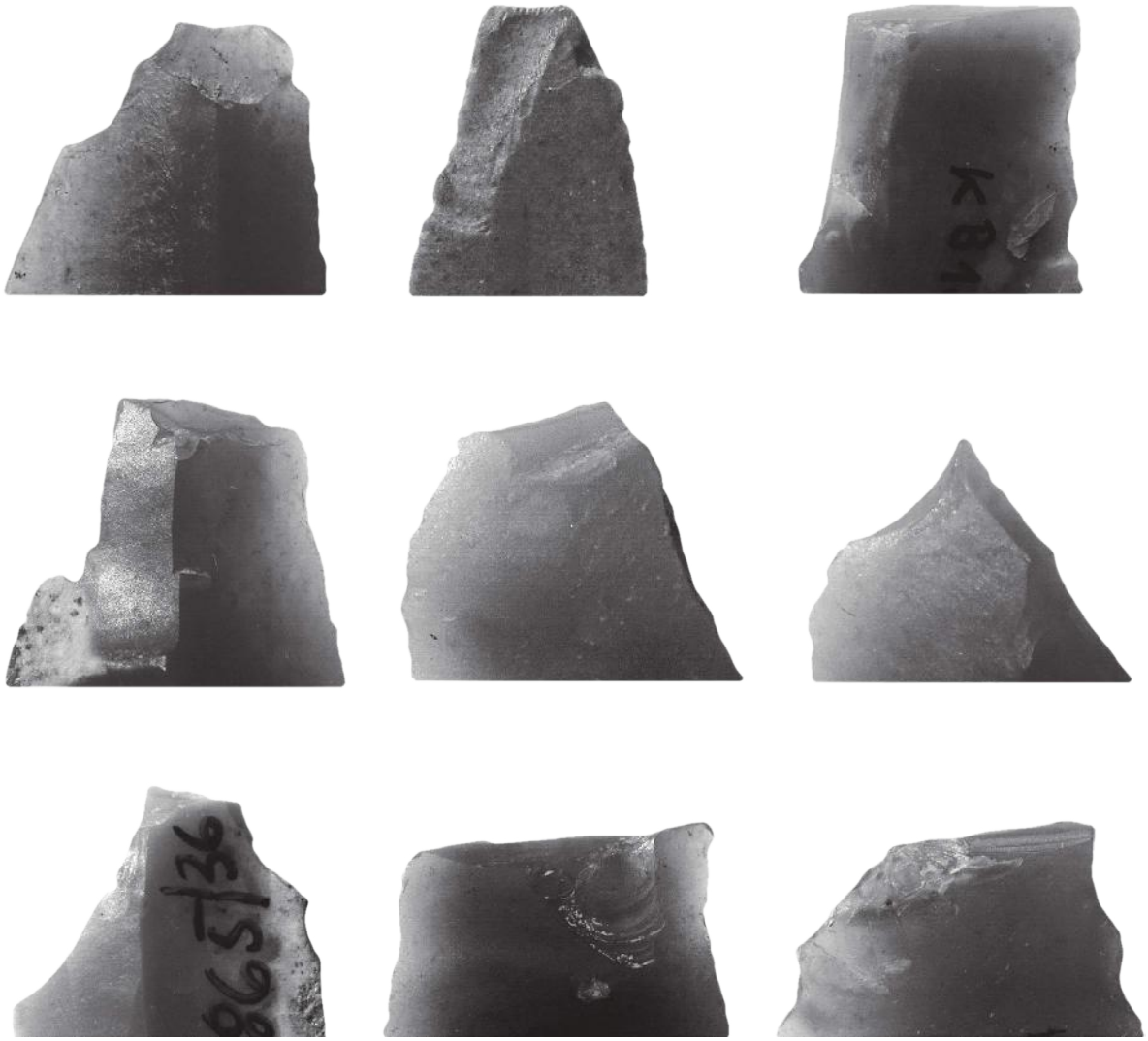

Fig. 14. Kraków-Bieżanów 15. The macro fracturing of Swiderian points

Friis-Hansen, J. 1990. *Mesolithic Cutting Arrows: Functional Analysis of Arrows Used in the Hunting of Large Game.* Antiquity 64, 494-504.

Grøn, O., and O. Kuznetsov. 2004. *What Is a Hunter-Gatherer Settlement? An Ethno-Archaeological and Interdisciplinary Approach.* In *Acts of the Xivth Uispp Congress.* Bar International Series 1302, 47-53. Oxford.

Hammer, Ø., D. A. T. Harper, and P. D. Ryan. 2001. *Past: Paleontological Statistics Software Package for Education and Data Analysis.* Palaeontologia Electronica 4/1, 9.

Higgins, G. J. 1933. *The Aerodynamics of an Arrow.* Journal of the Franklin Institute 216, 91-101.

Hughes, S. 1998. *Getting to the Point: Evolutionary Change in Prehistoric Weaponry.* Journal of Archaeological Method and Theory 5, 345-408.

Klimek, A., D. Stefański, and M. Zając. 2012. *Materiały Krzemienne I Kamienne Ze Stanowiska 20 W Krakowie-Bieżanowie (Tom V). Kraków--Bieżanów, stan. 20, edited ny M. Matoga.* Opracowanie wyników wyników badań: Report in the archive of The National Heritage Board of Poland.

Kozłowski, J. K. 1960. *Epipaleolit I Mezolit Stanowisk Otwartych.* In *Zeszyty Naukowe Uniwersytetu Jagiellońskiego: Prace Archeologiczne. Pradzieje Powiatu Krakowskiego, 67-98.* Kraków: Uniwersytet Jagielloński.

Kozłowski, S. K. 1999. *The Tanged Points Complex.* In *Tanged Points Cultures in Europe,* edited by S. K. Kozłowski, J. Gurba and L. Zaliznyak, 28-35. Lublin: Wydawnictwo UMCS.

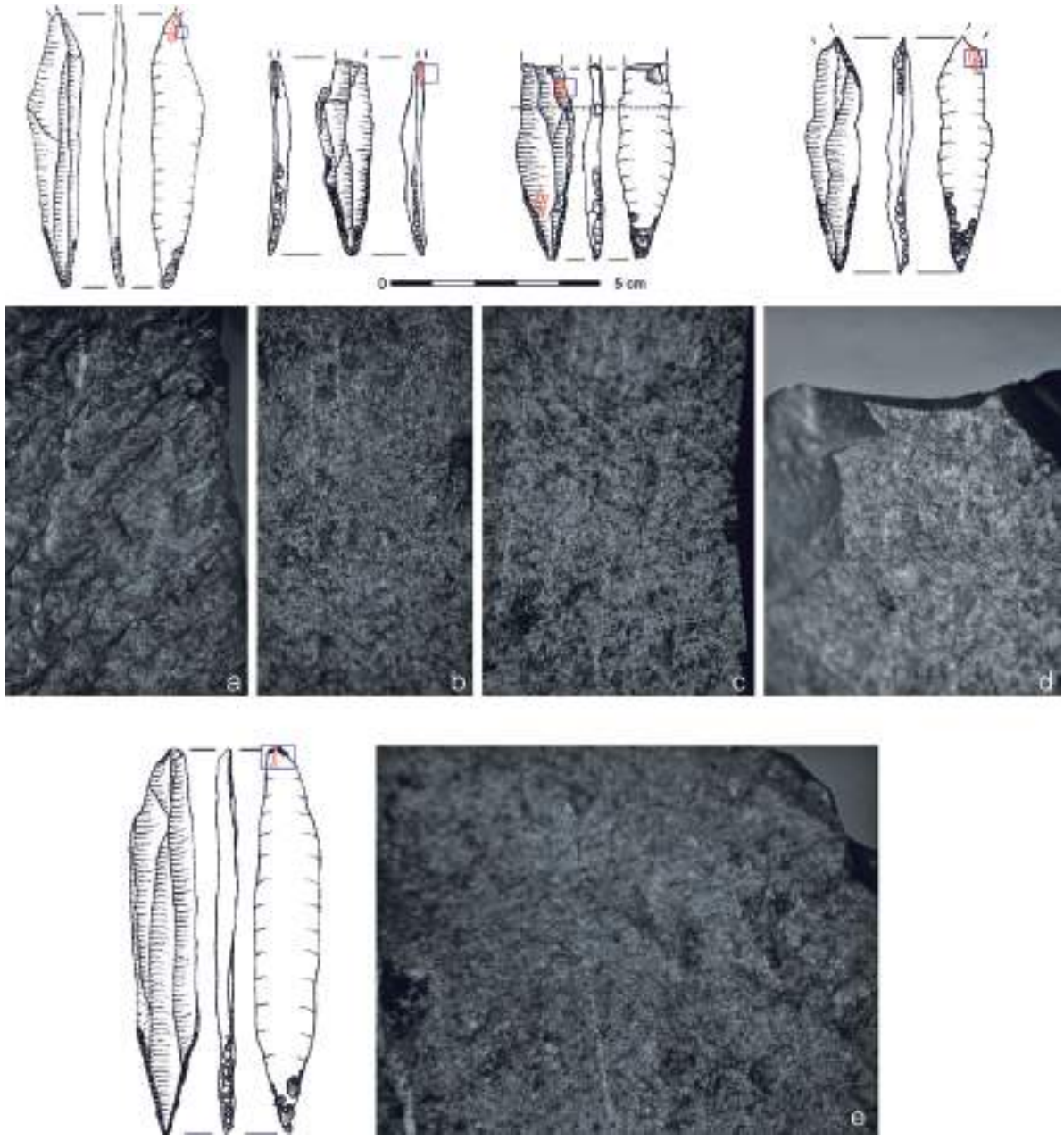

Fig. 15. Kraków-Bieżanów 15. The use-wear traces observed on Swiderian points

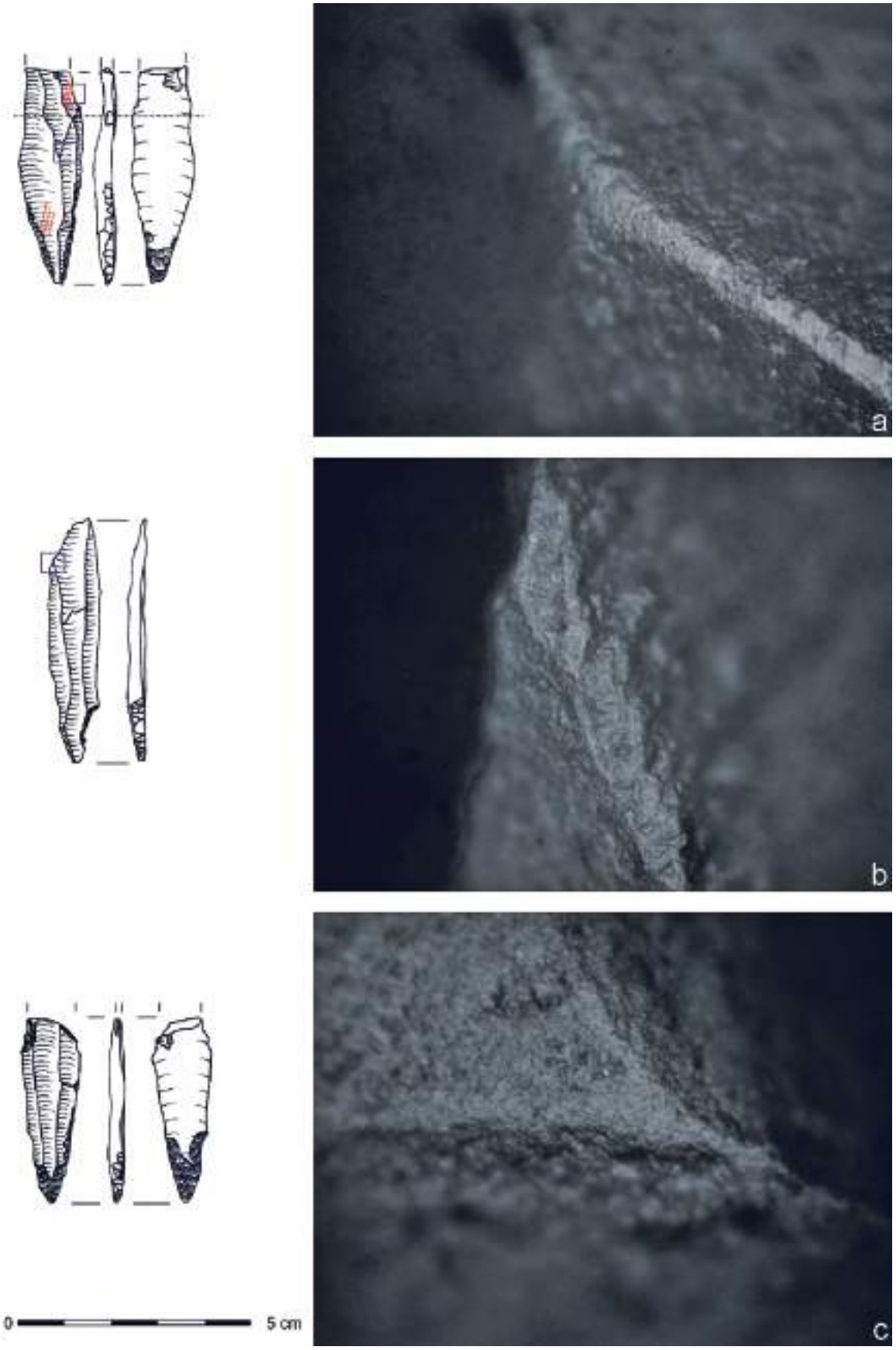

Fig. 16. Kraków-Bieżanów 15. The use-wear traces observed on Swiderian points

McPherron, S. P., and H. L. Dibble. 1999. *Stone Tool Analysis Using Digitized Images: Examples from the Lower and Middle Paleolithic.* Lithic Technology 24/1, 38-52.

Rohlf, F. J. *Tps Program Series Available at* Http://Life.Bio.Sunysb.Edu/Morph/.

Rohlf, F. J., and D. E. Slice. 1990. *Extensions of the Procrustes Method for the Optimal Superimposition of Landmarks.* Systematic Zoology 39, 40-59.

Sachse-Kozłowska, E. 1972. *Późnopaleolityczne Inwentarze Stanowisk Kobierzyna I Borka Fałęckiego Jako Przykład Krzyżówki Kulturowej Madleńsko-Świderskiej.* Światowit 33, 49-106.

Schild, R., H. Królik, A. J. Tomaszewski, and E. Ciepielewska. 2011. *Rydno. A Stone Age Red Ochre Quarry and Socioeconomic Center. A Century of Research.* Warszawa: Institute of Archeology and Ethnology of the Polish Academy of Sciences.

Shea, J. J. 2006. *The Origins of Lithic Projectile Point Technology: Evidence from Africa, the Levant, and Europe.* Journal of Archaeological Science 33, 823-46.

Shott, M. J. 1997. *Stones and Shaft Redux: The Metric Discrimination of Chipped-Stone Dart and Arrow Points.* American Antiquity 62, 86-101.

Sisk, M. L., and J. J. Shea. 2009. *Experimental Use and Quantitative Performance Analysis of Triangular Flakes (Levallois Points) Used as Arrowheads.* Journal of Archaeological Science 36/9, 2039-47.

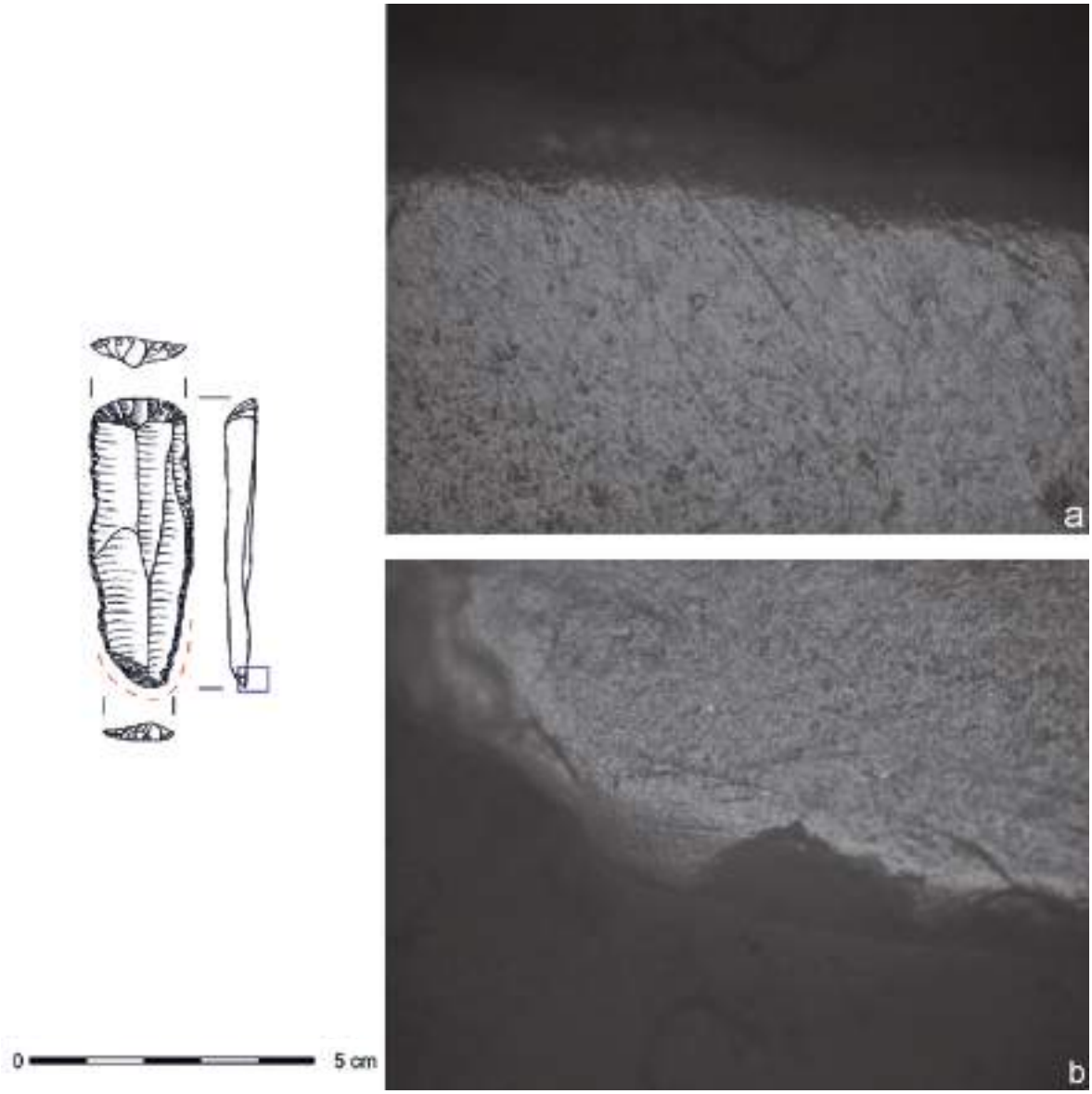

Fig. 17. Kraków-Bieżanów 15. The use-wear traces observed on an endscraper

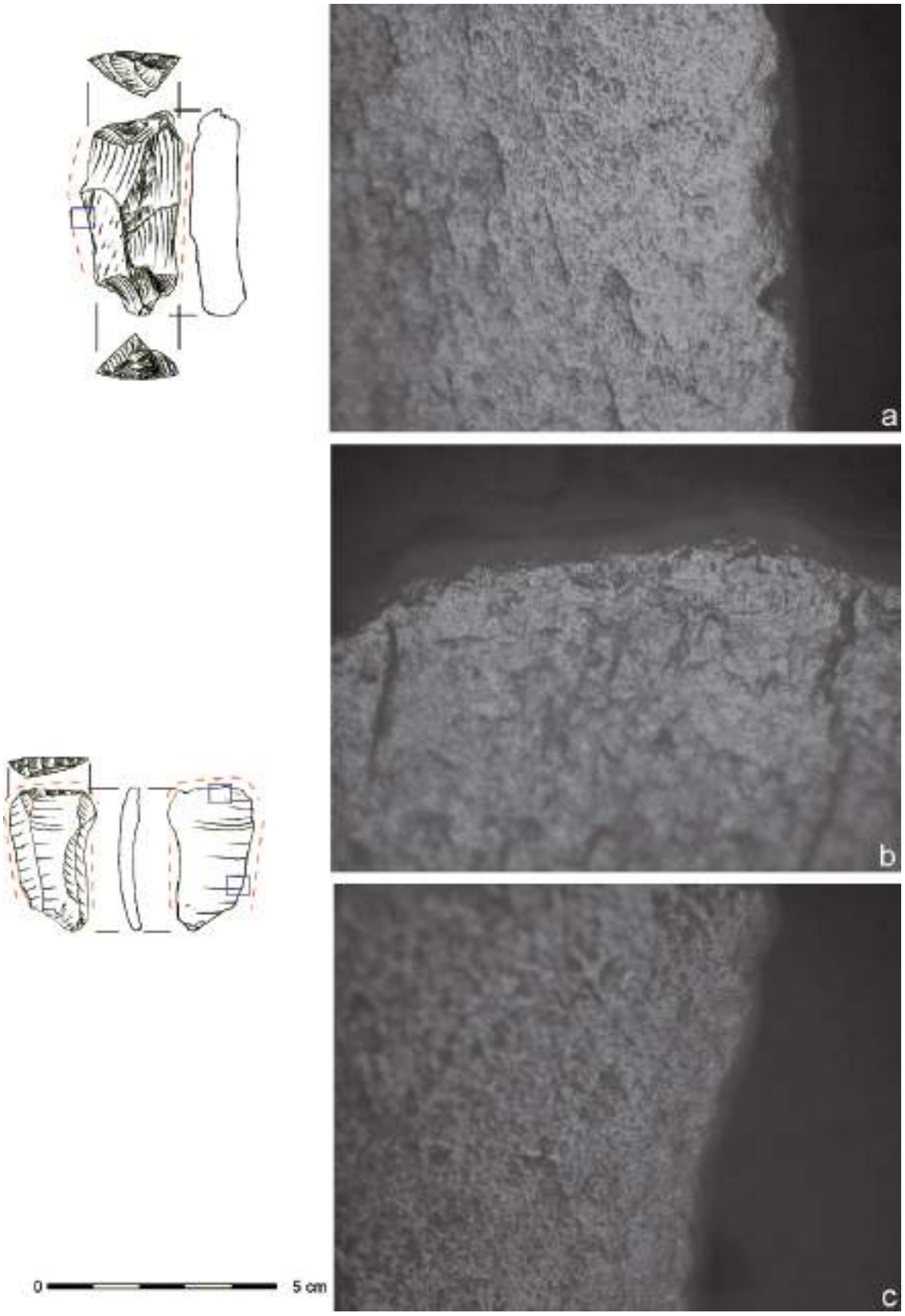

Fig. 18. Kraków-Bieżanów 15. The use-wear traces observed on endscrapers associated with hide and bone/antler processing. A-C -10x magnification.

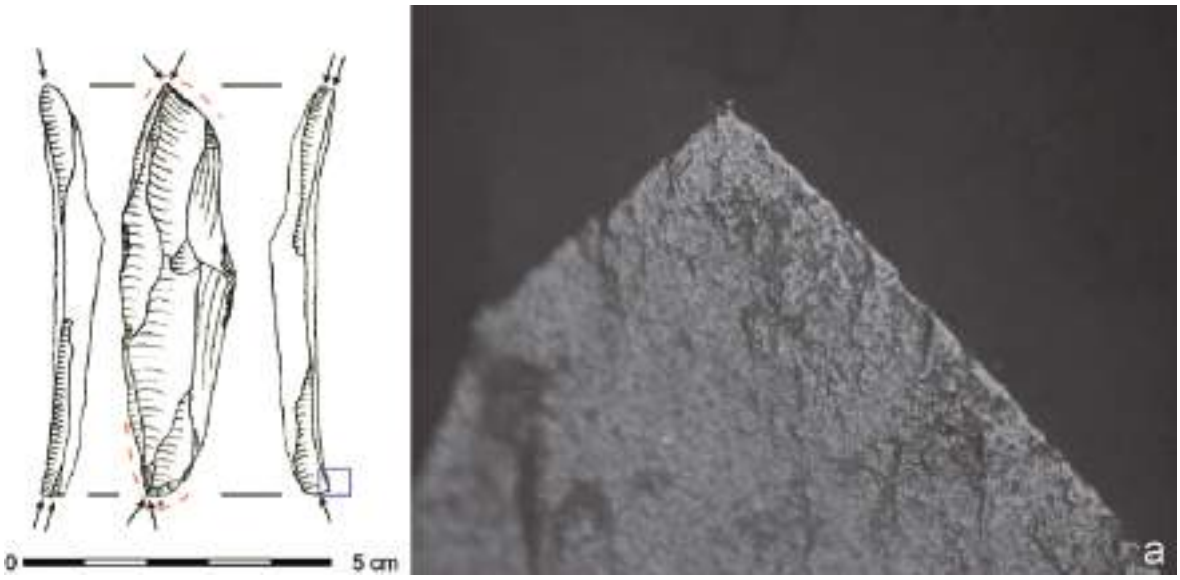

Fig. 19. Kraków-Bieżanów 15. The use-wear traces observed on a burin

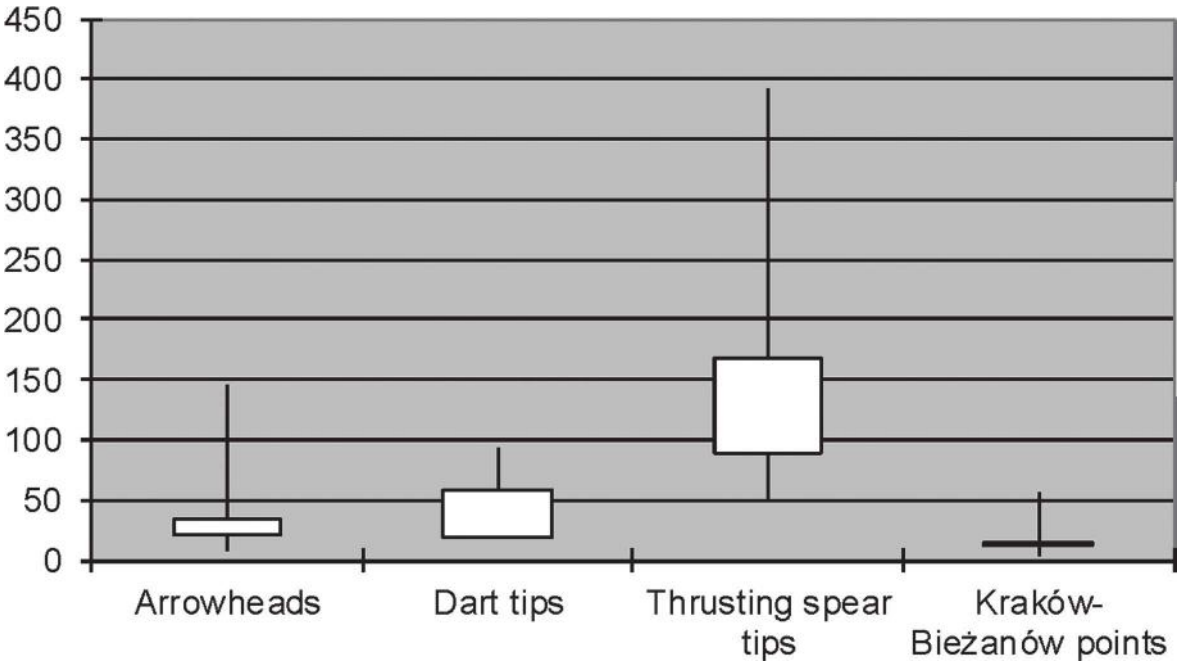

Fig. 20. Box and whisker plot showing the TCSA values of Kraków-Bieżanów willow leaf points in comparison to ethnographic projectile tips[29]

[29] Thomas 1978; Shott 1997; Shea 2006.

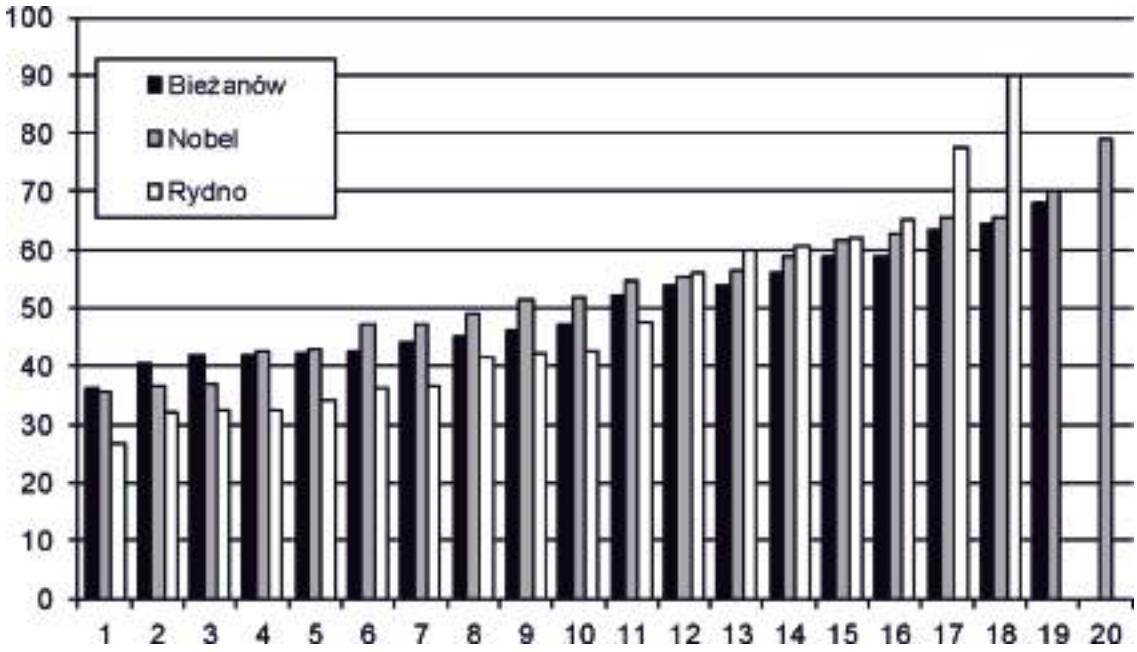

Fig. 21. Bar graph showing the values of tip angles of Swiderian points from Kraków-Bieżanów, Nobel and Rydno sites

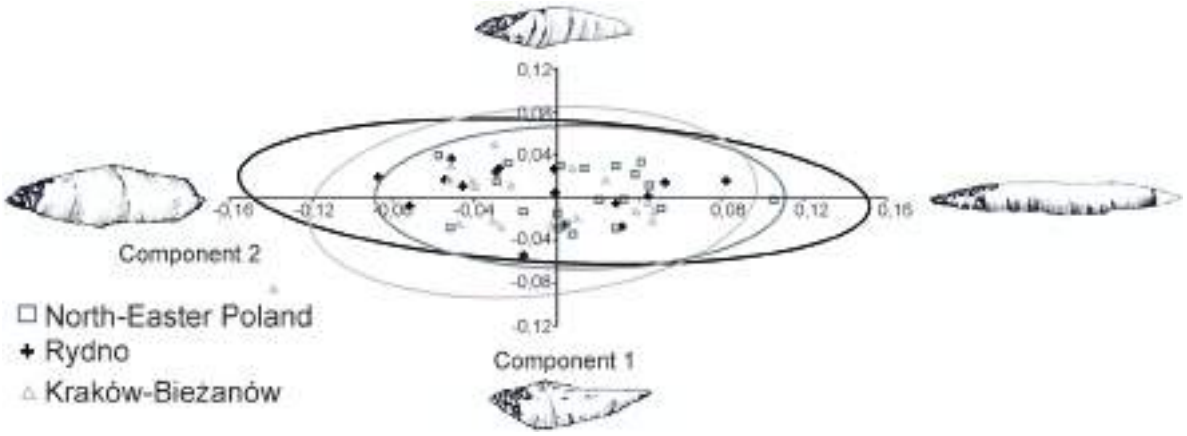

Fig. 22. Results of the principal component analysis with 95% ellipses for Swiderian points from Kraków-Bieżanów, Nobel and Rydno

Stefański, D. 2012. *Materiały Krzemienne Ze Stanowiska 15 W Krakowie-Bieżanowie (Tom Vii).* In M. M. Przybyła (eds.) *Kraków-Bieżanów, stanowisko 15 (nr autostradowy 99, 101 i 209):* Report in the archive of The National Heritage Board of Poland.

Stefański, D., and J. Wilczyński. 2012. *Extralocal Raw Materials in the Swiderian Culture: Case Study of Kraków-Bieżanów Sites.* Anthropologie (Brno) 50/4, 427-42.

Sulgostowska, Z. 1989. *Prahistoria Międzyrzecza Wisły, Niemna I Dniestru U Schyłku Pjejstocenu.* Warszawa: Państwowe Wydawnictwo Naukowe, .

Szymczak, K. 1999. *Late Palaeolithic Cultural Units with Tanged Points in North Eastern Poland.* In *Tanged Points Cultures in Europe,* edited by S. K. Kozłowski, J. Gurba and L. Zaliznyak, 93–101. Lublin: Wydawnictwo UMCS.

Szymczak K., 1987. *Perstunian Culture – the Eastern Equivalent of the Lyngby Culture in the Neman Basin.* In *Late Glacial in Central Europe. Culture and Environment,* edited by J. M. Burdukiewicz and M. Kobusiewicz. Prace Komisji Archeologicznej, 267-76. Wrocław: PAN.

Thomas, D. H. 1978. *Arrowheads and Atlatl Darts: How the Stones Got the Shaft.* American Antiquity 43, 461-72.

Wiessner, P. 1983, *Style and Social Information in Kalahari San Projectile Points.* American Antiquity 48/2, 253-76.

Wilczyński, J. 2015. *Materiały Schyłkowopaleolityczne Ze Stanowiska Kraków-Bieżanów 11 Oraz 30.* Materiały Archeologiczne 40, 101-24.

Wożny, J. 1996. *Schyłkowopaleolityczne Materiały Ze Stan. 329 W Toruniu Jako Przyczynek Do Zróżnicowania Liściaków Dwukątowych Kultury Świderskiej.* Sprawozdania Archeologiczne 48, 49-59.

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