

ARE THERE ANY NEW POSSIBILITIES TO UNDERSTAND FLINT REFITTING USING SPATIO-TEMPORAL ANALYSIS? A PROPOSITION OF A NEW METHOD

CZY ISTNIEJĄ NOWE MOŻLIWOŚCI ZROZUMIENIA SKŁADANEK KRZEMIENNYCH PRZY WYKORZYSTANIU ANALIZY CZASOWO-PRZESTRZENNEJ? PROPOZYCJA NOWEJ METODY

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*There is a place, a time and a space
No one can trace, that no one can trace
Somewhere a hill, where things are still
Just rain water spill, just rain water spill
Sleep in a dream of butter milk cream
You dance on a beam, dancing on a beam*

*Save me from this shallow land
Take me out of temper's hand
Drag me from the burning sand
Show me those that understand*

Emerson, Lake and Palmer
'A Time And A Place' from Tarkus, 1971

ABSTRACT: Refitting of flint materials is in recent times a standard method of dealing with flint materials. Among the archaeologists, however, there is a feeling of insufficiency and disproportion between the time needed for conjoining the blocks and the scientific effects coming out of them. Above all, there is at present no method for comparing different effects with other conjoined blocks. Regardless it comes from one archaeological site or whether are from different ages or territorially distant from each other. The paper presents a proposition of a new method for the analysis of flint refittings. The idea of research is to determine the relationships between the various detached pieces. The results are presented in a graph which we can further analyze and compare with others. The process itself is similar to the sim-

plification of functions invented by Newton and Gauss, which is why the name of the method: refitting calculus.

KEY WORDS: lithic studies, flint technology, refitting lithic artifacts, flint knapping, Swiderian technology, Paleolithic

When the refitting method was first introduced into archaeology in the nineteenth century, it was treated as a kind of interesting titbit (Cziesla, 1990). In the interwar period, it was used with more extensive research studies. It has been more than forty years since refitting has been permanently established in the study of flint technology (see Tomaszewski, 1986, for a summary of the state of knowledge until the 1980s). Refitting has been explored in a number of Polish studies focused on technological and spatial analyses (e.g., Fiedorczuk, 2006; Wąs, 2005; Dziewanowski, 2006). As R. Schild put it (Fiedorczuk, 2006, Preface to refittings from Rydno): ‘According to many researchers, most significant in this respect were refitting analyses conducted under the direction of André Leroi-Gourhan at Pincevent, France (Magdalenian camps; Leroi-Gourhan, Brezillon, 1966, 1972), and in Rheindahlen (Bosinski, 1966) and Etiolles (Pigeot, 1990)’. There is no doubt that these works have greatly influenced the understanding of flint technology and our knowledge about several of its aspects, while the mere refitting of elements has had the undoubted advantage of being an empirical and unambiguous activity, not disturbed by the perspective of personal interpretation. This has been a great step towards the technological understanding of flint assemblages and their cultural attribution without having to look at the typologies of tools (sometimes absent in the analysed assemblage) that were previously referred to in cultural identification. The 1970s and 1980s saw the rapid development of this research method and the development of several research projects that included the refitting of excavated technological elements (see Przeździecki, 2014, and the literature quoted therein). Michał Przeździecki noted that: ‘(s)everal papers (delivered during Big Puzzle Monrepos Conference, 1987, cf. Cziesla, Eickhoff, Arts, Winter, 1990) on, among others, the use of refittings in the context of broadly understood behavioural (technological, economic, spatial etc.) observations have entered the canon of literature, having still been an inspiration for a wide range of researchers, including the author of this work’. However, Przeździecki rightly observed that the first signs of dissatisfaction with the way flint materials were obtained were present already back then (Przeździecki, 2014, p. 8). In his paper entitled ‘Putting the Pieces Together: An Introduction to Refitting’, Jack L. Hofmann (Hofmann, 1992) wrote: ‘Today, it could be argued, site studies are simply not comprehensive or complete unless they include an investigation of refitted elements’. Some voices were also raised that not so much not intended to depreciate the idea of refittings, but rather indicated possible

methodological, interpretative restrictions and dangers related to the overenthusiastic use of the method in stone age research (e.g., Larson, Ingbar, 1992, p. 151–162). Currently, the sole beneficiary of the refittings are almost exclusively researchers studying the spatial organisation of stone age sites. It must be admitted that their works have a huge impact on the state of our knowledge related to the activity of people in prehistoric communities (see Fiedorczuk, 1995, on blades carried out outside the workshops found at a production site).

OBJECTIVE DIFFICULTIES IN UNDERSTANDING THE EFFECTS OF REFITTINGS

Starting our considerations from ancient Greece, we can see how important for the then perception of the world was the spatio-temporal thinking. Probably one of the ‘time-space confusions’ most appealing to present-day people was devised by Zeno of Elea as early as in the fifth century BC. In his paradox about Achilles and the tortoise, he suggested that anyone aiming to logically solve the problem of time and space will eventually be cornered. In the paradox, the tortoise escapes Achilles. At first, he is away from him and then they both move: the tortoise to escape from Achilles, and Achilles to catch up with the tortoise. After Achilles will have run half the distance to the tortoise, the tortoise will have advanced half the distance he ran since the beginning of the footrace. Having moved half the distance again, the tortoise will have escaped by half of his distance, and so on, Achilles is not able to get closer to the runaway. Yet at the same time, every Greek saw how a faster person catches up the person who escapes. Even today, many of us could not logically explain the error in reasoning. Focusing on the shorter and shorter sections of the distance covered by Achilles and the tortoise, our mind is focused not on the entirety of issue, but on less and less detail going to infinity.

On the other hand, it is very difficult to imagine spatio-temporal situations based on the reading of a description of a process happening simultaneously in different places, a fact well known by ancient historians who sought to construct consistent descriptions of the history of their homelands. While he described the history of the Peloponnesian, Thucydides (followed by Xenophon) adopted annual sections for clarity and recounted the war divided into sections with respect to the timeline, presenting significant events at various theatres of the war within a year. Other historians (e.g., Appian of Alexandria) employed a slightly different method. They divided the area of interest into smaller areas and described them in chronological order. In the latter case, therefore, the same person often appeared several times in the narrative as they turned up in various places described by the historian (the best example is probably the figure of Hannibal, who makes several appearances during the wars in Spain, Africa and Greece). The intention behind both methods was to facilitate the

understanding of the stories that were recounted. Historians could as well narrate what happened in different places at the same time week by week, and such attempts were also undertaken. But telling a story along with showing its cause and effect explanation would no longer be possible or understandable. Closer to our time, Isaac Newton saw the problem while discussing time and space in connection with his work on mechanics. Unable to solve the problem of time with simultaneous spatial changes, Newton concluded that ‘time and space are like a sensorium (as the sum of knowledge and experience, and thus as the specific attributes of the Creator). Thanks to it, God is not only present in the world and can get the direct knowledge of the world, but above all, He can exercise constant control over the world as a perfect Master’ (Ustyniak, 2015, p. 15) These are, according to Newton, beings independent of the order of things in them. This sparked a discussion leading to Leibniz’s view that time and space were nevertheless related to the order of things, surrounding them. Later, Kant came to the conclusion that time and space cannot be concepts, because we only capture individual relations between specific phenomena. Unfortunately, studying philosophical debates that end with Heidegger does not bring us any closer to an ability to practically imagine how shapes or spaces can change over time and how these changes can be compared with one another.

The problem of spatio-temporal perception springs out while excavated and documented reassembled flint material is described. A refitted block of conjoining lithic elements is formed as an inherent visual, material reversal of the process of reduction the flint raw material used to produce either a core or flake tool. In the first case, we deal with ‘sculpting’ the finished form and carving it. Larger pieces of raw material are typically detached at first, followed by the detachment of finer and smaller pieces. As a result, the specimen becomes to increasingly resemble the intended product. In the other technique, the purpose of production is ‘standard’ waste detached from the main core, showing characteristics (in fact, morphometric features) intended by the manufacturer. The following simplified schemes of the formation of assemblages associated with flint processing can therefore be distinguished:

Primary nodule – flint waste roughing out the core tool – flint waste refining the core tool – ready-made core tool (hand axe, Neolithic axe).

Primary nodule – flint waste shaping the core – ‘flint waste’ that is the purpose of production – used core (actual waste, or the base product for another technological line).

In the case of refitted blocks, what we do is a reverse operation, the resulting sequence being most often disturbed by the lack of either a small number or several elements. In the case of core tools, most frequently missing are finished (or very advanced in shape) specimens that had been taken outside of the workshop. In the second case, absent in the flint material are blades and flakes, which were the purpose of production or were carried away for a different purpose. In both cases, absent in refitted blocks is also flint waste that had been lost due to the post-depositional processes

or was used for other purposes, perhaps unrelated to tool production. We can therefore describe it on the timeline as facts corresponding to the processes:

1. Nodule (its existence/discovery by a flintknapper).
2. Picking up by a flintknapper.
3. Multi-stage processing, i.e., from 1 to... n operations consisting in the lithic reduction of the original mass of stone, which becomes increasingly reduced, with the use of knowledge, know-how, methods and techniques; flint waste found during archaeological research is the material remains of this process.
4. Selection of desirable products.
5. Transporting blanks outside the work area (or a site recognised using archaeological methods after some time).
6. Post-depositional processes decompleting the remaining part of a flint assemblage constituting the primary nodule.
7. Recovery of elements in the course of archaeological research.
8. Refitting pieces according to matching planes from 1 to n, consisting in obtaining an increasingly larger specimen constituting the primary nodule.
9. Complete block as an archaeological artefact consisting of conjoined fragments subject to formal and technological analysis.

Commentary:

1. The nodule may obviously reach the production site already partly worked, with scars on the surface. The method of its selection in terms of the raw material and its spatial properties is interesting from the point of the technological analysis as a ‘chaîne opératoire’;
2. Lithic reduction involves both conscious, intentional and accidental detachments (e.g., cracks resulting from the incompetence of a flintknapper or hidden cracks appearing during processing). The detachment of particular pieces (usually) produces the intended goal: either a ready-made tool or individual detached fragments (or one fragment) with intended parameters;
3. The selection of all desirable pieces from the assemblage, both end products and potential blanks (useful in the study of the spatial organisation within the camp), will not be discussed in this paper;
4. Apart from physical post-deposition processes, some pieces may not be found during excavations for a variety of reasons, for example, due to their size. In addition, although we are sometimes certain that some excavated lithics were part of an analysed nodule, we fail to determine their primary location within the nodule.

In order to illustrate the issue, I would like to use a graphic illustration that allows us to imagine the described processes. They may schematically represent two cones, converging at vertices; at their contact, we can see the plane of ‘the present’, i.e., the state (and time) of the assemblage of artefacts after excavations when their ordering and refitting according to the cracking planes is about to start (fig. 1).

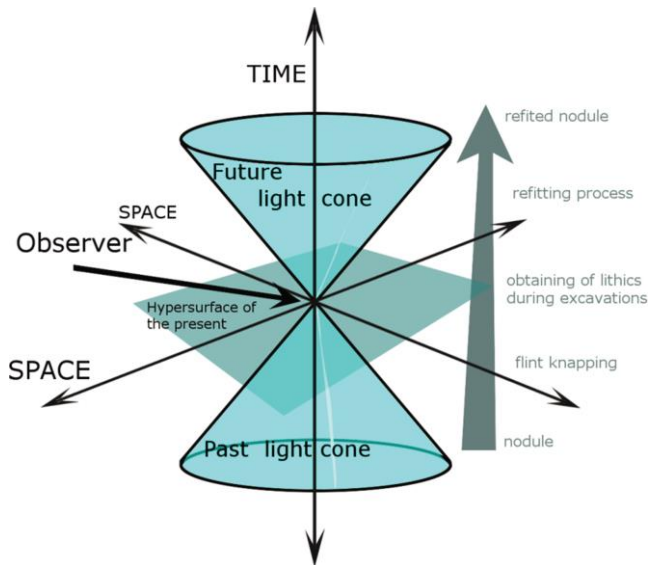


Fig. 1. Drawing showing the role of an archaeologist refitting an originally knapped flint nodule recovered in the present. The plane, at which the tops of the cones meet, is an imagined trench, which yielded a flint workshop. The bottom cone represents the original specimen, broken down from larger to the smallest fragments. The cone expanding upwards is a growing block to which successive flint pieces are added. The diagram flattens the third dimension (each recipient must imagine the plane and the shapes of the cones; it flattens the fourth dimension – time goes from the bottom to the top; and flattens the fifth dimension, or rather omits it. The diagram thus says nothing about what happened with individual fragments in time: how they were processed, destroyed, subjected to erosion and after having been excavated, further destroyed in the fourth dimension).

The refitting process produces different types of final nodules that are a rough equivalent of the original specimens (or the forms from which work started at the find spot). Although excavated artefacts are mapped on a two-dimensional plane, the effect of refitting is three-dimensional (the so-called block when a larger number of fragments are refitted or a refitting if there are only a few). The nodule grows up to a certain critical point, i.e., when it reaches the maximum amount of refittings, according to the person performing the refitting. The very process of adding particular fragments is neither continuous nor uniform in time and can be said to provide an additional, fourth dimension, similar to the change in the shape of the material during the primary formation. Therefore, the process is describable in four dimensions, and used for description are such categories as edges, planes and sides of the refitted block, the directions of lithic reduction, sides, the top and bottom of the form.

Once several such specimens are refitted, sooner or later a question arises:

1. What is the real effect of the refitting, can we somehow describe our activities in four dimensions, that is considering the changes in shape over time, and actually reconstruct in this way the changes in shape due to processing?

2. Does our multi-week work furnish our knowledge about flint production at all?
3. Is it possible to compare our results of refitting? How to compare the results of refitting between particular refitted blocks or, more broadly, between our refittings and techno-typological units, to which we tentatively attribute artefacts based on general knowledge?

Re. 1

Assuming that our goal is to show efficiency in finding matching pieces, there is no doubt that a great number of refitted elements testifies to the skilfulness and experience of the person who does the refitting. This is also kindly assessed by the promoters of doctoral theses in Poland and beyond and an essential element in obtaining funds for research.

Re. 2

It is unfortunate that recently published works have in no way broadened our general knowledge of technology. Focused mostly on spatial relations, they have merely brought a quantitative increase in information (Fiedorczuk, 2006). The conclusions repeatedly recapitulate what we have already known about technology often for several decades (Scerri, Gravina, Blinkhorn, Faivre, Delagnes, 2016; Delpiano, Peresani, 2017).

Re. 3

A method allowing the comparison between particular blocks has yet to be developed. My opinion that a descriptive or even a drawing layer are simply not enough is shared by many researchers. My first experience with refittings (Matraszek, Migal, Sałaciński, 2002) made me realise how little can be said about the similarities and differences in the way individual refitted blocks were processed. While I attempted to produce a formal description of particular refitted blocks, I understood that the only real effect is a visual image from the castings of tetrahedral axes made (in the middle of the refitting) and cores for blades, being the source of the raw material (in the form of a refitted block). Until today, I am unable to imagine, on the basis of my own description, what are the actual differences (if there are any) in terms of the method and implementation between reconstructed blocks of flint flakes. It seems that this is because the refitting process itself does not create a factual memory in our mind (Szewczuk, 1984), which allows us to remember it in its entirety (as we recall the phone number or the face of a friend, while we return to it in our mind).

Being aware, just like me, of the flaws in the description, researchers attempt to make up for the defects by provide the most detailed description possible of what they observed while they discovered new matching pieces, adding their own interpretations and impressions born in the course of the refitting process. This is not surprising, because a refitted block is, as it has already been mentioned, **a record of**

a certain four-dimensional or even a five-dimensional reality (assuming that everything that happened to the mass of stone once it had been knapped, i.e., the location of flint artefacts in the trench, is the fifth dimension). The understanding of the multidimensionality of the world does not come naturally to human beings. A look at different fields of science shows a constant tendency to reduce the number of dimensions, if a need arises. We can use the following analogy: using a physical map is not a problem for any educated person. Apart from two reduced dimensions rendering the reality (for simplicity, the problem of geode mappings on the plane solved by cartographers is dismissed here, despite being a beautiful example of a struggle with transforming a dimension for a better understanding of space), a third dimension is recorded in colour corresponding to the height. Looking at regions shown in an increasingly intense red colour on the map, we naturally guess that the place is a mountainous terrain, ‘protruding’ towards us. Acquired back at school, the habits allow us, for example, to imagine a cube drawn on a flat screen or a piece of paper (fig. 2). This is because some ‘mental maps’ were formed in the course of our education, a kind of mental shortcuts that allow us to properly understand various issues of multidimensionality.

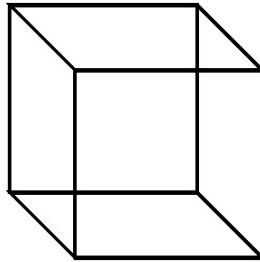


Fig. 2. It is obvious for everyone looking at this drawing that it represents a three-dimensional object.

We are not misled by the optical illusion that may suggest that the upper left corner is the corner of a back wall, and we are looking at the cube from the top, or that is a front wall’s corner and we are looking at the object from the bottom. The very possibility to imagine a cube comes from the fact that we are able to imagine such a solid, and the drawing in two dimensions only resembles it and refreshes its shape in our mind.

In such moments, we appreciate why geometry teachers forced us to carefully draw a geometrical task prior to solving it. Such concepts as a point, a line or a straight line are understood by everyone and allow us to find common ground for understanding and discussing the location of things in space. These mental maps may be different from reality in various aspects, as public transport plan at metro or tram stops clearly demonstrate. Such plans (fig. 3) in no way resemble reality (in many cities, apart from a schematic plan, there is a plan that takes into account the basics of geography, i.e., proportions, angles and distances between places on the plan

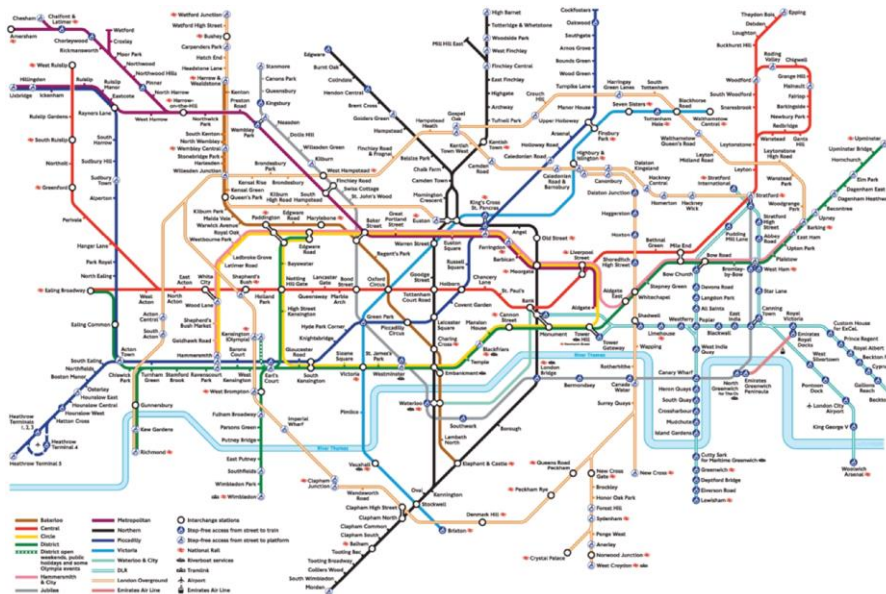


Fig. 3. Two exemplary London city plans. The upper underground plan does not show actual distances, angles and curvatures of the railway traction or the exact course of the river. It is, however, more useful for a person travelling by underground because it omits unnecessary information. Interestingly, the general course of the Thames is preserved to avoid a cognitive discomfort of the viewer. The course of the river might as well have been marked by a straight line (<https://tfl.gov.uk/maps/track/tube>).

in line with reality). At the same time, the ‘reality’ is the traditional terrain mapping recorded in our mind. Nevertheless, while we use the public transport plan, we want it to contain only the order of stops and the place where communication lines intersect, because that is where we can change the means of transport. The fact that the plan is simplified and the proportions of distances between stops are not consistent with reality poses no problem for us. Quite the contrary, it makes it much easier for first-time visitors to move around a city.

To pick the reference made earlier, in the case of a colorful physical geographical map, our knowledge of the location of mountains or depression is based on a contract recognised and respected by everyone. It’s about choosing the colours used on a two-dimensional representation. It is them that add that extra dimension that cannot

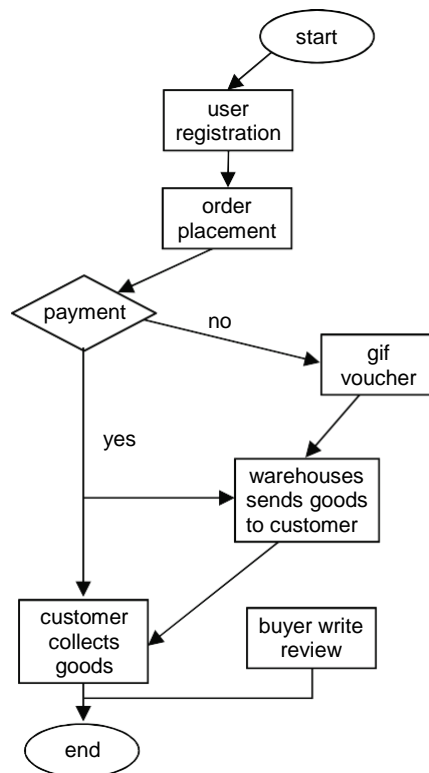


Fig. 4. Diagram of the online shopping process. The process diagram is one of the modern **quality management** tools. The purpose of its application is to graphically present each process, i.e. the sequence of operations, unit **processes** and elementary activities, along with the relation between them, which constitute the process from its start to completion. The presentation of a sequence of actions in the form of a flowchart allows us to better understand the essence of the process, with an important role the schema preparation stage, as many dependencies are discovered in the process of its creation (after: Encyklopedia Zarządzania, https://mfiles.pl/pl/index.php/Diagram_procesu online access: 25.10.2016).

be seen on the map. We can use this representation because we actually know three-dimensional objects from the surrounding reality and we can easily imagine similar objects even if we have never seen the Himalayas, but merely the Świętokrzyskie Mountains (to what extent our view is correct if we have never seen the Himalayas, even in the picture, is another matter).

Similar thought processes occur when we compare two completed refitted blocks. We are able to imagine only the shape of two stones, originally split and now conjoined together, as we learn from the visible cracks on the surface of the specimens. Other forms that are easily conceivable are a flake, a blade, or two such artefacts, matching easily. And yet, we would like to be able to compare processes (fig. 4), in order to get to the bottom of our interest – how different people differently fulfilled their need to produce similar flint tools. However, when more fragments can be variously refitted at various angles, what happens is a rapid ‘exhaustion’ of the mind, resulting from the lack of a mental visual representation of the phenomenon (Kirsch, 2010 also Wilson, Golonka, 2013). We give up the search for general understanding, or, to put in a different way, not give up but perhaps clearly see our limitations.

Unfortunately, we lack a natural ability to imagine a spatio-temporal process, let alone **compare** several such sequences, to identify the differences (or similarities) between two analysed working styles, to say how they were implemented in practice or to assess the consequences of the choices a flintknapper made in time (we are not any better in this respect than the above-mentioned Thucydides).

Researchers obviously make great efforts to achieve this goal. The possibly most comprehensive verbal description of a refitted block serves most often as such a prosthesis (which is sufficient). When we add to it two-dimensional drawings or pictures, which flatten the flint nodule, the reader is forced to laboriously compare details (fig. 7) and regrettably ultimately omits large excerpts of detailed descriptions (this is what happens in my case, but also other researchers kindly admitted to so doing). Nothing out of ordinary, such a conduct was described by psychologists of memory; we are able to associate and memorise what is logically arranged in our mind (Szewczuk, 1984). Thus, it turns out in practice that a focus on technological details, to which we are led by our research nature and insight, leads to an activity very much resembling ‘Find ten differences between pictures’ type of activity (fig. 5, 6).

See, for example, the results of a tedious reconstruction work performed by my friends (Bronowicki, Bobak, 1999), which resulted in the reconstruction of ten original flint blocks recovered from one Late Palaeolithic archaeological site, Ślęża 12. At attempt to refit 440 flint pieces (231 were ultimately refitted), produced a spatial image of the matching elements revealing the organisation of the camp space – the authors identified two artefact clusters, related to flint working locations. The researchers are inclined to conclude that the two distinguished clusters are related to two different people working flint while facing each other, as the ‘differences in style’

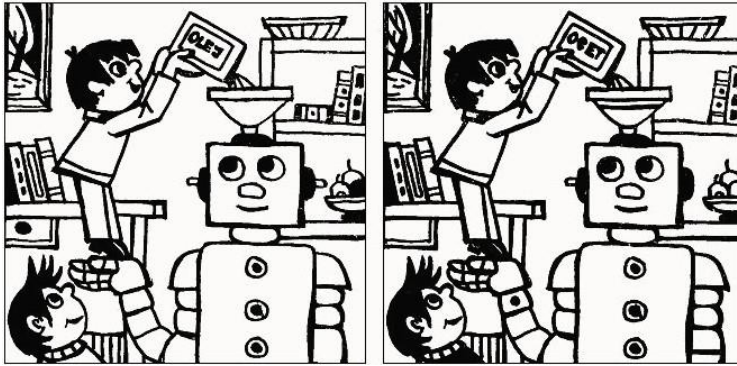


Fig. 5. Comparing the results of refittings resembles finding details between pictures. A useful activity for the mind, yet often not bringing us any closer to the goal – the understanding the process (<https://adonai.pl/relaks/testy/?id=72>).



Fig. 6. Although there are more than 20 differences between these two pictures, we are still able to recognise these people as the same, to say that not much time passed between the two shots, that the people in the background are unimportant for the understanding of the content, even though it is there where a substantial part of our narrative would be focused if were to painstakingly describe the differences between the pictures (for example, a man in the red jacket who is visible only in one photo). If we were to determine their chronology, this would probably be the key element to establish which photograph was taken first (<http://obywatelgc.com/fotograf-archiwum-spraw-mniej-aktualnych.html>).

observed between the blocks worked in individual clusters seem to suggest. Unfortunately, notwithstanding the truly admirable accuracy in refitting the specimens and careful, detailed descriptions, it is impossible to provide an objective answer to the question about differences, if there are any, between the ‘styles’ employed in both workshops. There is no any scale measuring similarity or differences in style, applied technical options or the succession of processes used, which tells us more about the differences described.

This helplessness is somehow expressed by the authors when they conclude that based on refitted blocks, they can estimate:

- the number of nodules originally brought to the site (there were ten);
- what technical measures were used for flint working (single and double platform cores);
- what was the final of core exploitation (blades detached from cores).

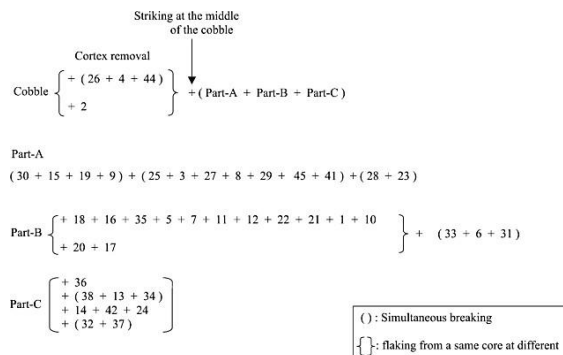


Fig. 7. Obsidian core refit used as an illustration of a technological process. Below, an attempted schematic technological description (Kobayashi, 2007).

The hypothesis about differentiated methods of flint working supposedly used by two different Flintknappers is presented as an additional conclusion. Unfortunately, the statement, or rather the hypothesis, is not substantiated in the analytical process, being rather a subjective belief of the researchers evoked by observations made during the refitting (see fig. 7, 8). From the point of view of logic, such a final conclusion, as a 'stipulative definition', does not have the logical value of truth or falsehood (Hołowko, 2005). It is therefore completely irrelevant to the readers of the study.

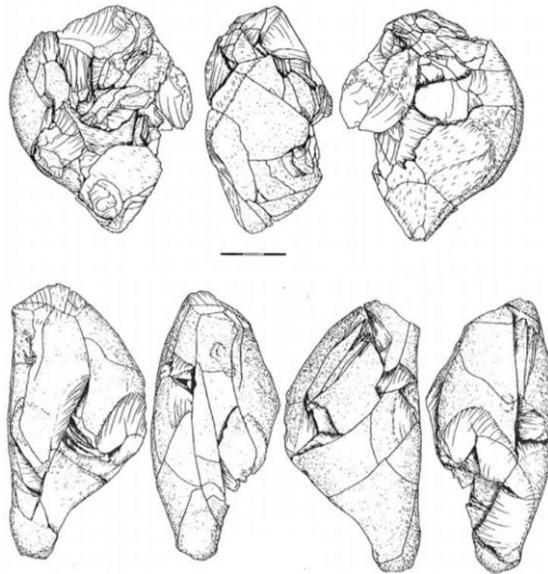


Fig. 8. Find 'ten differences' in lithic reduction methods between the two complete flint cores, glued and shown as original nodules (Bronowicki, Bobak, 1999).

Many experienced researchers and those reconstructing technology on the basis of refitted blocks honestly admit (in personal comments) that they are unable to understand their old refittings based on their descriptions themselves. What can be said today when we look at blocks refitted in the past? And what about their descriptions and the resulting conclusions? To what extent are they based on the results of refittings, and to what extent are they simply subjective beliefs? We should work out methods for more comprehensive descriptions of results so as to enable 'higher level' comparisons between them, and thus establish a common ground for those studying technology. Some interesting new propositions were put forward by researchers developing the 'scar pattern' trend (Clarkson et al., 2017; Wiśniewski, Serwatka, Badura, 2015), which seeks to understand the sequence of actions, similar to way presented below. According to the authors, it might be useful to use of different

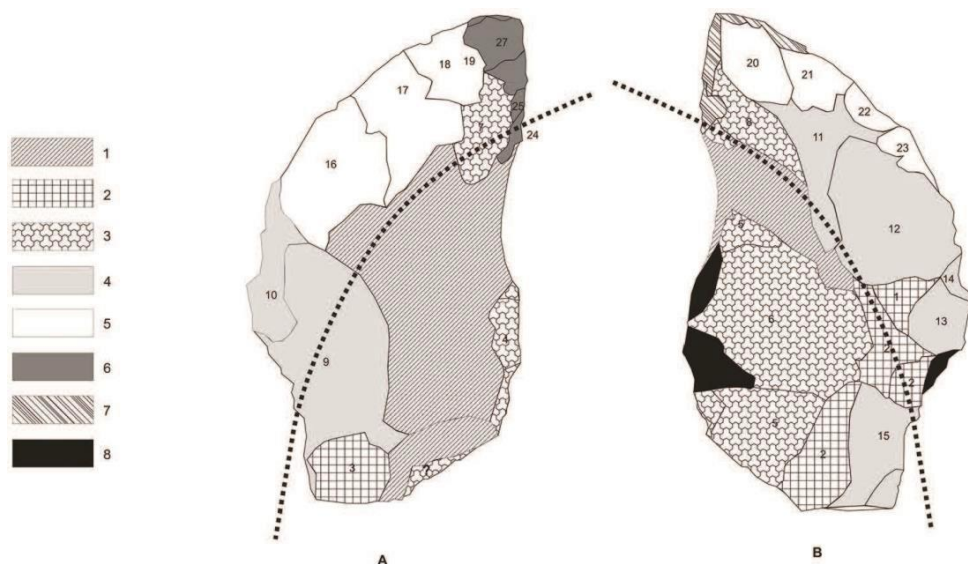


Fig. 9. Example showing the application of the ‘scar pattern analysis’ method to the description of a Middle Palaeolithic bifacial tool (according to Wiśniewski, 2015)

colours or symbols (fig. 9, 10). Unlike refitting, this is merely an attempt to describe the sequence of actions on the finished product.

Unfortunately, due to the nature of the human mind being able to grasp only three dimensions, *while we keep adding fragments to one another, what we notice is merely change in shape, not the process*. The process we would like to ‘notice’ and describe is produced as a higher order product in the mind, being the result of generalisations and subjective (often very apt) impressions.

There is obviously nothing new in this statement, especially for historians who have been recurrently seeking to flatten the fourth dimension so as to present the results of their ideas, most often graphically, to make them comparable. This is done by reducing the number of dimensions. Some examples include figures presenting the dates of reign of particular dynasties or the development of states on the timeline: the greater number of provinces, boldening the graph, the greater significance of the state or kingdom (fig. 11).

One of the most interesting and inspiring attempts at rendering spatial and temporal processes in two-dimensional space was presented by a Polish mathematician Andrzej Góralski. In his book *Twórcze rozwiązywanie zadań (Creative problem solving, Warszawa, 1980, p. 116–122)*, Góralski describes an unusual solution to the problem how to show the territorial changes of the Polish state over time. For the author, the key was to identify the ‘centre of gravity’ of the state (in the 1970s this consisted in painstakingly cutting the outlines of maps from different historical

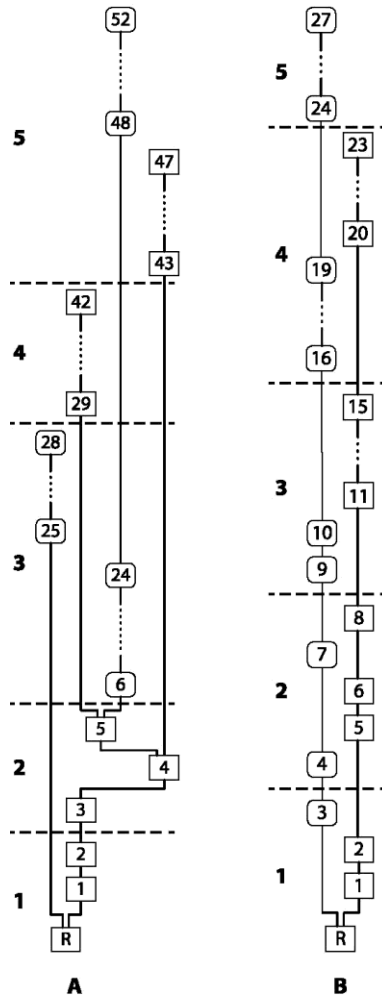


Fig. 10. Example showing the application of the Harris matrix method to describe a Middle Palaeolithic bifacial tool providing an opportunity to compare two different artefacts (according to Wiśniewski, 2015).

periods) and finding them in twenty-year intervals by means of a plump blob. These points, corresponding to the centres of gravity, were plotted on a two-dimensional map showing the then Polish state. Then the mathematician linked the points showing how this point changed in time, thus creating a graphical picture of the process of the territorial changes of the state (fig. 12). The ready-made diagram clearly shows periods when Poland did not expand territorially and when the territory expanded to the east and then returned to the west. If similar diagrams were made for Germany and Russia, we might compare the trends, apart from the borders of the countries and their actual areas, focusing only on the process of changing the centre of gravity.

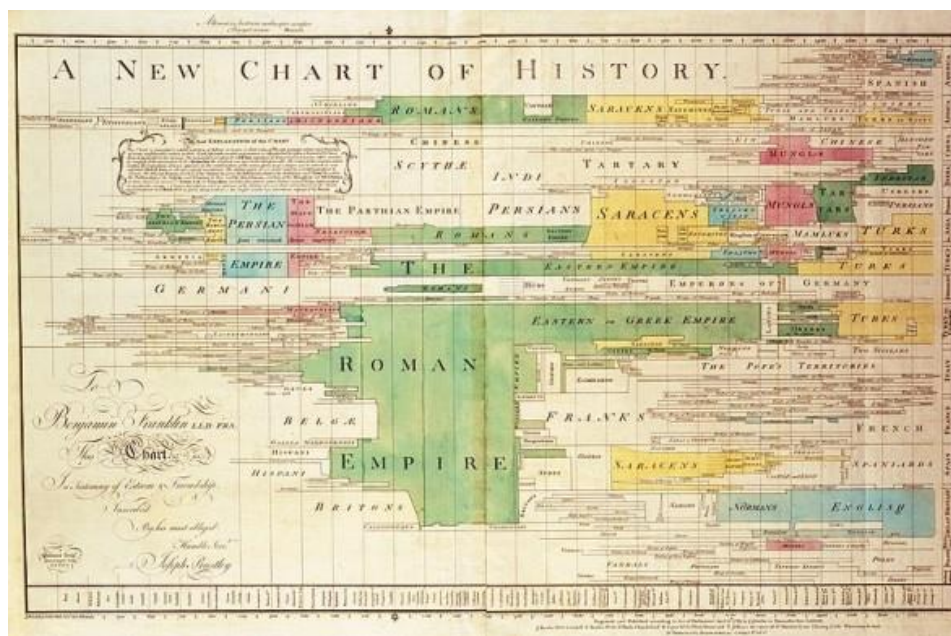


Fig. 11. Example showing an attempt to display substantive content on the axis in time in a two-dimensional space, including the process of territorial changes. Note the marked period of the power of the Roman Empire, but also of some exotic powers such as Mongolia or Persia (after: https://en.wikipedia.org/wiki/A_New_Chart_of_History).

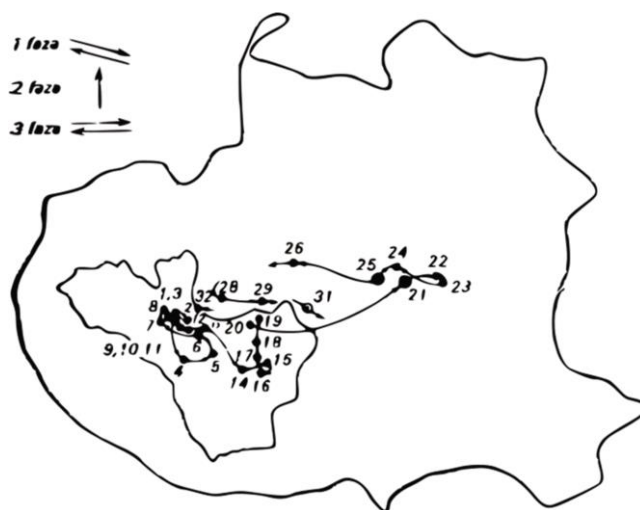


Fig. 12. Illustration showing how the centre of gravity of Poland, measured in 20-year intervals, changed from the beginning of the Polish statehood to the end of pre-partition Poland (late 18th century). You can see how the centre of the state moved in some years quickly to the east and how quickly it moved back to the west (Góralski, 1980).

Cutting the long story short, several attempts have been undertaken to visualise the temporal-spatial processes (see Qiang, 2012, p. 25), aiming to understand the events and, above all, compare various components of occurring and observed changes. It is obviously different now when planning plays a different role in the organisation of work (fig. 4). The question arises, however, whether it is possible at all to compare the reconstructions of technological processes related to flint working recorded in the form of detached and reassembled flint pieces.

REFITTED BLOCKS AS AN EMPIRICAL RECORD

Every flint flake is a tangible record of at least several factors:

- 1) general knowledge about the purpose of production (bifacial or tetrahedral form, production of Levallois blades or points, e.g. a flake can be a record of the process as a waste product, a blade can be a record of a process as an end product);
- 2) knowledge how to produce flint tools, i.e., the selection of raw material and appropriate implements, the knowledge of the '*chaîne opératoire*' (the use of the whole nodule for the production or only of a large flake, use of a hammer-stone or antler hammer, etc.). This is also manifested in cracked pieces, errors and wrongly chosen tools, but also macro and micromorphic features observable on worked pieces that allow us to 'read' the type of tools used for working flint;
- 3) craftsmanship, i.e., how skilfully a flintknapper uses tools, makes informed choices considering the sequence of undertaken actions. In practice, this means if s/he can undertake sensible decisions where work on the nodule should start; about the rhythm of lithic reduction, if s/he can avoid mistakes while knapping the stone: apply precise blows with the right force and with the use of appropriate micro actions, imperceptible to the viewer briefly observing a flintknapper at work. Although many of the above intentions cannot be evaluated in the course of the subsequent qualitative assessment of a product, this is nevertheless our cognitive goal to try to recognise them. It is clear that some of these factors testify to the knowledge acquired during 'schooling' (student – master), while others are just a record of the craftsman's talent and skill. It goes without saying that most difficult for us is to describe which elements in the observed empirical reality (i.e., pieces of conjoined refitted flints) are the manifestation of particular factors described above, the scope of knowledge of prehistoric manufacturers or their skills in implementing subsequent activities or even production skills. The fact that someone was not (or is currently not) able to make a beautiful flint point, can be related to the following limitations:

1. Flintknappers do not know the production process. Reason – lack of general knowledge about the process.

2. Flintknappers have inadequate knowledge of flint working, and their abilities do not allow them to design an appropriate technique and a sequence of operations leading to the successive reduction of stone to shape a point (in practice, for example, a producer sees an import and tries to imitate it without knowing the sequence of activities). Reason – they do not know the chain of operations.

3. Flintknappers have a general knowledge of the process of production but are unable to put it into practice. Nevertheless, in effect, they are able to produce a specimen of poor quality. Reason – lack of adequate experience or patience, ‘bad day’.

4. The producer knows the production process from the teacher and the sequence of operations, which they put into practice, but take bad decisions while working. They must repeatedly correct their mistakes and as a result, the obtained specimen is not a quality product. Reason – lack of skill or talent resulting from restrictions such as age.

I believe that in order to be able to follow the verifiable scientific procedure, so that the arguments were not lost in the maze of obscure figures, statistics and conjectures, **we urgently need to develop a new method enabling objective comparisons of reconstructed processes of lithic reduction.** I would like to use this tool to describe:

- the sequence of activities constituting the production sequence leading to the production of end product(s),
- the differences and similarities in the processes employed in working on similar or the same types of products, which are best visible in the sequence of activities.

A possible another result is a more objective assessment:

- whether individual artefacts have one production goal (specific type of product, a flake, blade or core form),
- whether individual artefacts were produced by one person (the ability to follow regularly repeated activities),
- whether technical efficiency and knowledge is similar in individual cases (whether we are dealing with the same product idea, only worse or better implemented).

In this paper, I would like to present a completely new way of analysing refitted blocks, considering only relations between particular elements constituting a refitted block (fig. 13). This is a proposition of a new language of description, which is helpful in the reconstruction of technologies, enabling a comparison of refitted blocks. This would be an additional analysis, overlapping the findings made by investigators while they perform reconstruction activities (fig. 14). I assume that past Flintknappers did not detach subsequent blades by accident but following some pre-intended order, which was a consequence of factors to some extent discussed above, that is:

1. Knowledge acquired from the teacher regarding the end product; the sequence of activities leads to the specified goal.
2. Possibilities of putting the acquired information into practice, to the extent enabled by the knowledge how to perform the task. It is therefore possible to make mistakes and correct them in a continuous production process.
3. Practical skills and talent. The bad choices of the manufacturer manifest themselves as clumsiness in the shape of intended products and the lack of control over the process.



Fig. 13. The order, direction and mutual relations of successive fragments of clothing can tell us a lot about the cultural tradition, the household habits, as well as the personal preferences of a person.

A similar assumption lies at the core of my proposal for research on lithic reduction strategies (<http://atelieranglais.over-blog.com/article-the-clothes-part-1-116296264.html>).

It seems that due to the above-described limitations in understanding time and space, a better understanding of the flint working process can be achieved similarly to that in other fields of science (Qing, 2012; Tversky, 2011; Kirsh, 2010), by ‘flattening’ several dimensions to a two-dimensional record. This may represent a spatio-temporal analysis, which is now performed by describing the sequence and relations between particular elements making up a larger block. I found inspiration for such a record in analyses carried out by representatives of other disciplines based on

Allen's algebra principles. Without going into further details (see Asmussen, Qiang, Maeyer, Weghe, 2009; Qiang et al., 2010), which are quite irrelevant to the further understanding of this paper and method, what differs this approach from the previous practice is that *the proposed description method takes into account only relations between particular* elements of a refitted block, an assumption present in Allen's algebra.



Fig. 14. Based on the location of individual items of clothing, and the relations between them, we are able to draw conclusions about, for example, the profession of a person wearing a costume (https://www.ingless.pl/system/article_photos/names/000/000/262/large/faf3dfa4ea-profesje.jpg?1473275491).

Although I was inspired by the considerations and literature on Allen's algebra (fig. 15), my further work is based on a slightly different approach (Allen, 1983), the most obvious difference being the fact that in the case of refitted blocks, the process observed in the form of subsequent fragments is discreet and easily quantised by particular successive elements added to the block. Put simply – time-space processes are seen only as quantised time segments 'recorded' with fragments of knapped flint from the worked nodule.

The results of analyses are presented in the form of graphical representations containing encoded relations between all fitting elements that constitute refitted blocks. They are represented by a two-dimensional, triangular graph. Graphs obtained for different blocks can then be compared and described as individual shapes, and technological details can be added to the description. Although merely the first

| | |
|---------------------------|--|
| I_1 equal I_2 | if $I_1^- = I_2^-$ ^ $I_1^+ = I_2^+$ |
| I_1 starts I_2 | if $I_1^- = I_2^-$ ^ $I_1^+ < I_2^+$ |
| I_1 started-by I_2 | if $I_1^- = I_2^-$ ^ $I_2^+ < I_1^+$ |
| I_1 finishes I_2 | if $I_1^+ = I_2^+$ ^ $I_1^- > I_2^-$ |
| I_1 finished-by I_2 | if $I_1^+ = I_2^+$ ^ $I_2^- > I_1^-$ |
| I_1 meets I_2 | if $I_1^+ = I_2^-$ |
| I_1 met-by I_2 | if $I_2^+ = I_1^-$ |
| I_1 overlaps I_2 | if $I_2^- > I_1^-$ ^ $I_1^+ < I_2^+$ ^ $I_1^- > I_2^-$ |
| I_1 overlapped-by I_2 | if $I_1^- > I_2^-$ ^ $I_1^+ < I_2^+$ ^ $I_2^- < I_1^-$ |
| I_1 during I_2 | if $I_1^- > I_2^-$ ^ $I_1^+ < I_2^+$ |
| I_1 contains I_2 | if $I_2^- > I_1^-$ ^ $I_2^+ < I_1^+$ |
| I_1 before I_2 | if $I_1^+ < I_2^-$ |
| I_1 after I_2 | if $I_2^+ < I_1^-$ |

Fig. 15. Eleven Allen's relationship as the basis for the so-called Allen algebra used in spatial-temporal analyses – mainly in data processing (Allen, 1983).

attempts at using the method have been undertaken thus far, it seems that we can identify *significant properties* of individual analysed specimens. This is why I decided to present the results in this paper, although I have been still working on developing the method.

The analytical process proposed here resembles the changing of a function to a much simpler one, as we see in the mathematical process invented by Newton and Gauss. Hence the proposed name: 'refittings calculus', as an activity aimed at *tracking changes* in the relations between added elements in time and space. In our case, the function we study is a spatio-temporal change taking place in the flint form (block), reduced to the form of a two-dimensional graph.

DESCRIPTION OF THE ANALYTICAL PROCEDURE. RECORD OF RELATIONS

The analysis starts with the selection, identification and recording of relations between particular conjoining elements in a refitted block (fig. 16). This leads to the principles I was guided by when producing graphs. I selected the following relations that can characterise two matching flint pieces:

Older – younger. This relation describes the time sequence between two matching elements, dorsal and the ventral side (relation 'before' – 'after'). I will not delve into more details since this relation is unambiguous in our case: if one object is older, the other is naturally younger. Thus, two of Allen's relations ('overlaps' and 'overlapped by', see fig. 17), merge in one in this case. At the same time, broken pieces, i.e., two matching fragments of e.g., one flake, were not treated as conjoining elements, being a result of an obvious, from the point of view of technology, simul-

taneous event (equivalent to the ‘equal’ relation, see fig. 17), not bringing any added value to our understanding of technological operations.

Adherent. One fragment matches a larger piece – a core form. There can also be two fragments, ‘of equal importance according to the researcher’, adhering (‘meets’ relation, see fig. 17).

Consistent. Both conjoining elements have the same direction and orientation of detachment. No such relation is present in Allen’s.

Opposing. Conjoining elements have the same direction but an opposite orientation. No such relation is present in Allen’s.

Parallel. The two conjoining fragments are parallel to each other, so the direction of the blow was the same. No such relation is present in Allen’s.

Perpendicular. A working name for every other relation between two fragments – these are usually recorded as ‘perpendicular to each other’. It seems that if a need arises, during an analysis of refitted blocks of a different type than the ones studied in the case study on the Late Palaeolithic technology presented below, this relationship could be further divided into more precisely defined relations. No such relation is present in Allen’s.

| Relation | Symbol | Pictorial Example |
|---------------------------------|--------|-------------------|
| <i>before – after</i> | < > | |
| <i>equal</i> | = | |
| <i>meets – met by</i> | m mi | |
| <i>overlaps – overlapped by</i> | o oi | |
| <i>during – contains</i> | d di | |
| <i>starts – started by</i> | s si | |
| <i>finishes – finished by</i> | f fi | |

Fig. 16. Allen’s Spatial temporal relations, with pictorial examples (Allen, 1983).

In practice, the analytical procedure consists in reassembling the elements of a block and then disassembling them so as to be able to record all relations between particular fragments (except, as I mentioned, broken fragments) or keeping record already during the refitting phase, which is more difficult because it requires later sorting according to the older-younger sequence. This creates a tabular record showing all observed relations. Presented below (table 1) is a fragment (first 30 out of 158) of relations between matching refittings from a block of 56 refittings observed and conventionally recorded with simple symbols facilitating later work. It is worth

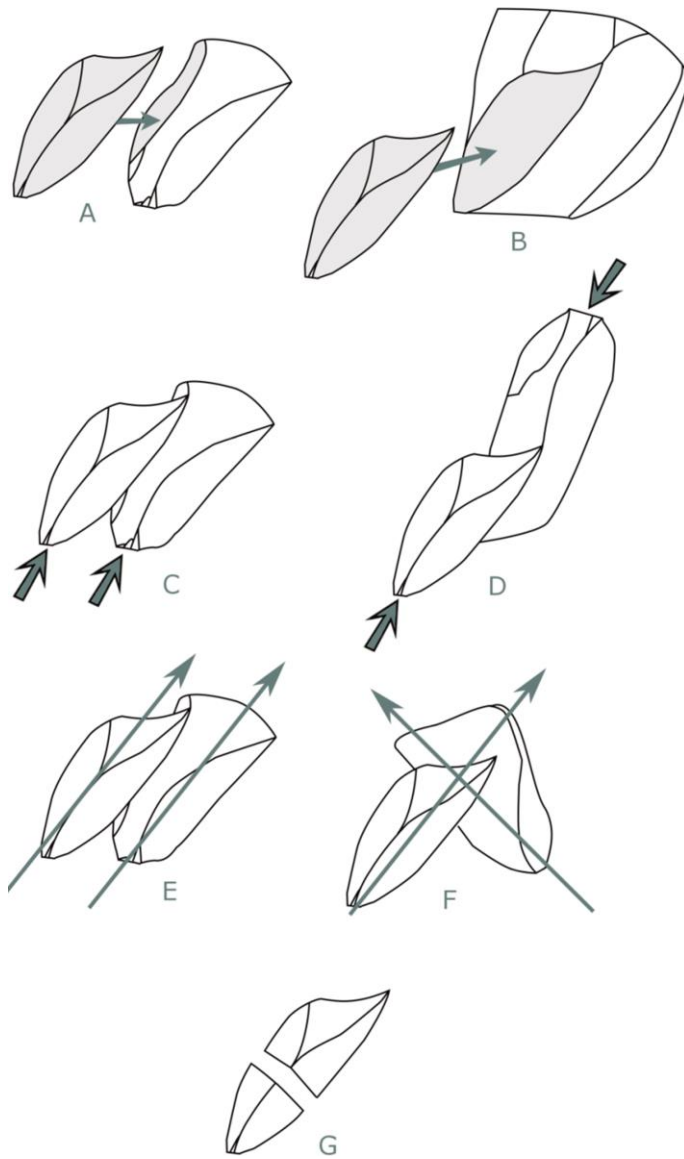


Fig. 17. Drawing illustrating relations between two elements taken into consideration while constructing graphs.

- A. 1 "Age" relations – older element is at the top, younger one at the bottom (the older one, i.e., removed earlier from the core).
- B. 2 Adherent relation – 'meets' – (flake adherent to the nodule).
- C. 3 Consistent relation – the same direction and orientation of removal.
- D. 4 Opposing relation – the same direction, opposing orientation.
- E. 5 Parallel relation – axes of removal of particular flakes parallel to each other.
- F. 6 Perpendicular relation – axes of flakes are not parallel to each other.
- G. 7 equal relation – fragment broken during removal – this relation was not included in analysis.

noting that many elements have more than one inter-element match and in this way the number of relations, which a fragment enters, significantly increases (for example, fragments 23, 24 or 11, which have relations in different temporal phases of the block). This is an important factor enabling a subsequent analysis of the lithic reduction process. The relations described in the Table are in practice absolutely clear and it seems that, depending on the questions asked and the purpose of the analysis, may change (for example, we can record from plane of a bifacial tool was reduced, or, in the case of double platform cores, from which striking platform a blade was detached). A tabular ordering of relations between individual fragments enables an easy conversion of our observations into a graph. First of all, it orders detached flint pieces. In my case, number 1 is a fragment to which subsequent pieces are added in a sequence (the youngest one in process). This is either a core in the case of blade production or flake technology or a preform, when, for example, an axe or a biface is produced. The highest number is thus ascribed to a fragment that is not overlapped by any other. From the perspective of a flintknapper, this is the first detached piece from the analysed block.

Table 1. Example showing how relations between the elements making up one of the refitted blocks analysed in the text can be recorded

| N | Recorded relations between two fragments of a refitted block | The meaning of the contractual record |
|----|--|--|
| 1 | 1X2, 2T1 | (Fragment) 1 is perpendicular to 2, 1 overlaps 2 |
| 2 | 3=4, 3L4, 3A4 | 3 is parallel to 4, 3 is overlapped by 4, 3 consistent with 4 |
| 3 | 5=3, 5L3, 5A3 | 5 is parallel to 3. 5 is overlapped by 3, consistent with 3 |
| 4 | 6x5, 6L5 | 6 is perpendicular to 5, 6 is overlapped by 5 |
| 5 | 6x3, 6L3 | 6 is perpendicular to 3, 6 is overlapped by 3 |
| 6 | 7=8, 7L8, 7A8, 7/F | 7 is parallel to 8, 7 is overlapped by 8, 7 is removed from the side of platform F |
| 7 | 8=9, 8T9, 8V9, 8/F | 8 is parallel to 9, 8 overlaps 9, 8 removed from platform F |
| 8 | 10=8, 10T8, 10A8, 10/F | 10 jest parallel to 8, 10 overlaps 8, 10 removed from platform F |
| 9 | 11=12, 11T12, 11v12 | 11 parallel to 12, 11 overlaps 12, 11 opposed to 12 |
| 10 | 12=45, 12T45, 12A45, 12/F | 12 parallel to 45, 12 overlaps 45, 12 consistent with 45, 12 removed from platform F |
| 11 | 13=12, 13T12, 13A12, 13/F | 13 parallel to 12, 13 overlaps 12, 13 consistent with 12, 13 removed from platform F |
| 12 | 14=15, 14L15, 14V15 | 14 parallel to 15, 14, is overlapped by 15, 14 opposed to 15 |
| 13 | 17=16, 17T16, 17A16 | 17 parallel to 16, 17 overlaps 16, 17 consistent with 16 |
| 14 | 20=19, 20T19, 20V19 | 20 parallel to 19, 20 overlaps 19, 20 opposed to 19 |
| 15 | 21=22, 21L22, 21A22 | 21 parallel to 22, 21 is overlapped by 22, 21 consistent with 22 |
| 16 | 23=8, 23T8, 23A8, 23/F | 23 parallel to 8, 23 overlaps 8, 23 consistent with 8, 23 removed from platform F |
| 17 | 23=10, 23T10, 23A10 | 23 parallel to 10, 23 overlaps 10, 23 consistent with 10 |

| N | Recorded relations between two fragments of a refitted block | The meaning of the contractual record |
|----|--|--|
| 18 | 23=11, 23T11, 23V11 | 23 parallel to 11, 23 overlaps 11, 23 opposed to 11, |
| 19 | 23=13, 23T13, 23A13 | 23 parallel to 13, 23 overlaps 13, 23 consistent with 13, |
| 20 | 24=8, 24T8, 24V8, 24/R | 24 parallel to 8, 24 overlaps 8, 24 opposed to 8, 24 removed from platform R |
| 21 | 24=11, 24T11, 24A11 | 24 parallel to 11, 24 overlaps 11, 24 consistent with 11, |
| 22 | 24=13, 24T14, 24V14 | 24 parallel to 13, 24 overlaps 14, 24 opposed to 14 |
| 23 | 24=23, 24T23, 24V23 | 24 parallel to 23, 24 overlaps 23, 24 opposed to 23 |
| 24 | 25=26, 25T26, 25A26 | 25 parallel to 26, 25 overlaps 26, 25 consistent with 26 |
| 25 | 27=19, 27T19, 27V19 | 27 parallel to 19, 27 overlaps 19, 27 opposed to 19 |
| 26 | 27=20, 27T20, 27A20 | 27 parallel to 20, 27 overlaps 20, 27 consistent with 20, |
| 27 | 28=19, 28T19, 28A19 | 28 parallel to 19, 28 overlaps 19, 28 consistent with 19 |
| 28 | 28=27, 28T27, 28V27 | 28 parallel to 27, 28 overlaps 28, 28 opposed to 27 |
| 29 | 29=30, 29T30, 29A30 | 29 parallel to 30, 29 overlaps 30, 29 consistent with 30 |
| 30 | 29=27, 29T27, 29A27 | 29 parallel to 27, 29 overlaps 27, 29 consistent with 27 |
| 31 | 29<>28 | 29 adheres to 28 |
| 32 | 30=20, 30T20, 30A20 | 30 parallel to 20, 30 overlaps 20, 30 consistent with 20, |
| 33 | 30=27, 30T27, 30A27 | 30 parallel to 27, 30 overlaps 27, 30 consistent with 27 |
| 34 | 30 <> 28 | 30 adheres to 28 |

Signs used in the table

- X** fragments perpendicular to each other
- =** fragments parallel to each other
- A** fragments of the same direction and orientation
- V** fragments of the same direction and opposed orientation
- T** fragment overlapping another fragment
- L** fragment is overlapped by another fragment
- <>** fragment adheres to another one, or touches the core, relation – adherent fragments
- R** marking one of the sides of a double platform core (or in other cases, one of the faces of a bifacial tool)
- F** marking the other side of a double platform core (or in other cases, one of the faces of a bifacial tool)

GRAPH

The idea of a triangular graph for the presentation of relations in flint refittings was taken from Yi Qiang's work related to the presentation of spatio-temporal issues (Qiang et al., 2010). Although conjoining artefacts making the refitted blocks are not periods of time that are of most interest to the author, I found great inspiration in the practicality of the employed solutions, in particular the possibility of presenting a multidimensional space on a two-dimensional graph. Even though my proposition does not directly reproduce Yi Qiang's solutions (e.g., such as those presented in Yi Qiang's doctoral dissertation in 2012), it nevertheless produces thought-provoking effects (I would like to recommend here the publications from various fields, which Yi Qiang co-authored. Mostly related to geography, his works have also lately dealt with the archaeology of the First World War). Presented below is a method of creating a graph so as to enable subsequent comparisons of particular blocks.

1. The horizontal axis of the graph is the time axis at the zero point, i.e. when the individual fragments start to be added (fig. 18). Subsequent numbers represent the conjoining fragments ordered in accordance with the ‘older’ – ‘younger’ relation. In this way, the horizontal axis of the graph has as many numbered elements as the refitted block (minus broken pieces (relation that do not provide any information on the technological process)).

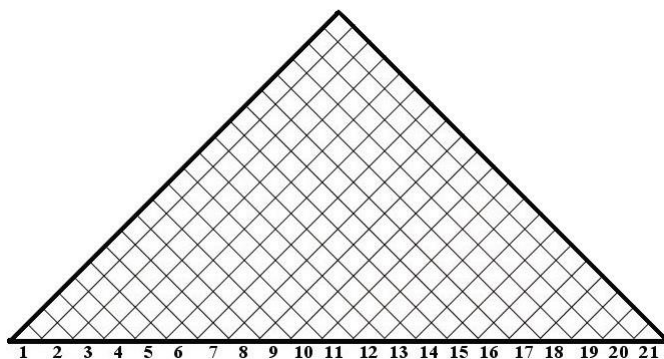


Fig. 18. Method of building the relation graph – marked on the horizontal axis is the number of fragments making up the block. The order of elements is determined by relations: ‘overlap’, is overlapped (‘older’ – ‘younger’). In terms of chronology, here fragment 1 is the last one removed from the core (successfully refitted) or is the form left after processing – usually a core. In the technological history such as we know it, fragment 22 is the first removed flint piece – usually a flake. We see that the graph allows us to record all relations occurring between all elements of the refitted block (in the field under the intersecting lines corresponding to the number of the element). For example, the relation between elements 2 and 1 is the triangular area directly above number 1. The relation between elements 3 and 1 is shown as a square between numbers 1 and 2.

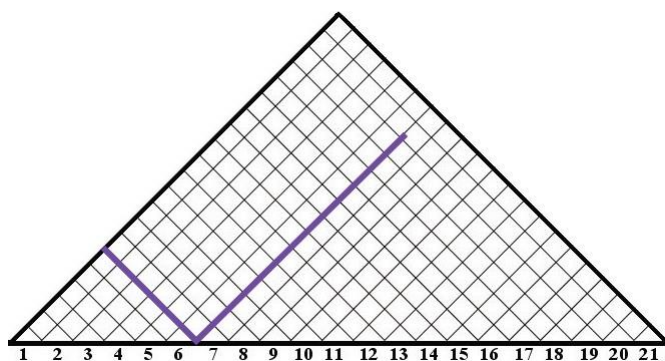


Fig. 19. Example showing two lines drawn from a place on the graph corresponding to fragment 7. All the points of contact and intersection with other lines corresponding to other fragments are potential relations (i.e., contact between these fragments in the refitted block). The field under this intersection of lines is the ‘field of relations’. At this point, the colour on the graph marks the specific type of relations between two fragments (except the relation – ‘overlaps’, ‘is overlapped’, because this is shown by the position of the fragment on the axis) and its character.

2. In the graph, each element has two corresponding 'relation lines' to the right and left (fig. 19). They show earlier and later relations between an element and all other elements it fits, i.e., if a fragment is overlapped by others: the fields to the right down from the line going to the right and elements overlapped by a given fragment: fields to the left down from the line going to the left.

3. The description of relations occurring between two fragments is marked with a colourful field under the intersection of lines corresponding to individual fragments. I chose blue for consistent relations, red for opposites and green for two relations (not to disturb the reception): adjacent and perpendicular. More colours can obviously be added, depending on our specific goals, i.e., what relations should be displayed in the graph to display lithic reduction process observed in refitted blocks that are to be compared.

The method of drawing and reading a graph (fig. 20), in the order of the numbering of the elements:

Above number '1' marked are relations of the last of the analysed fragments (the last one worked by the flintknapper and at the same time the one that is not added to another fragment, other fragments are added to it. In our case, it is a double platform core. It comes into two relations in the graph: with a flake (blade) marked as '2', which adheres to the core (green in the field under the crossing lines of relations of fragments 2 and 1) and a flake (blade) number '7', which also adheres to it. The line going to the right is thus the one showing previous relations and the line going to the left from number 7 corresponds to relations later in time from detached fragment 7. Apart from the already mentioned relation with element '2', it refits with element 7, to which it is perpendicular (also green in the field under the intersecting lines of relations of the two elements.) It does not enter into any relations with elements 1 to 9. Its place is based on the relations with other elements not included here (although visible on a larger graph). At this level of the graph, they do not enter into relations

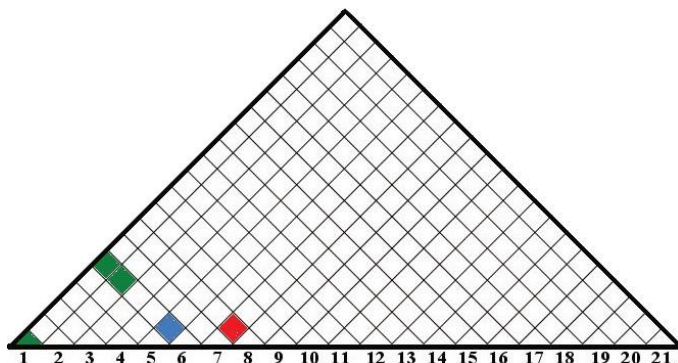


Fig. 20. Figure demonstrating how to build a graph showing relations between elements of a refitted block. The above graph includes elements that occupy the fragment delaminated by a bold black line.

with other elements (they are conjoining at higher levels, not included in this part of the graph for clarity). Element '5' (blade) is covered by element '7'; they have the same direction of blow and the same consistent sense (blue). In addition, blade 7 is covered by blade 9, which was knapped from the opposite side; is the relation of opposition (red in the relation field). This method makes it possible to build graphs showing all the relations between elements constituting a block and to compare the resulting interrelations, where time necessary for knapping and refitting is 'flattened' and the shape of a refitted block completely 'eliminated'.

Case Study. An example showing the practical use of the refitting calculus method to understand the differences and similarities in the technique employed to detach high-quality blades from double platform cores.

The refitting calculus method was first applied in practice to study the technique of knapping double platform cores typical in Poland for the Swiderian culture. My goal was to find out whether, by studying relation graphs:

- 1) it is possible to examine to what extent such visualizations **complement** the verbal narrative usually accompanying the description of refitted blocks;
- 2) **it is possible to track changes** in the graphs, and therefore whether it is possible to 'flatten' the dimensions so that we can follow the changes themselves in time (Newton's calculus), to be able to compare different refitted blocks in the graphs;
- 3) any significant **new technological data** can be observed;
- 4) there are any perceptible differences in the way a flint nodule was worked by **different flintknappers**.

The study was two-part: first, four flintknappers experimentally produced 16 series of double platform cores for blades. These were then refitted, and the relations within each block carefully recorded. Before discussing the results, let me present the assumptions behind the method of blade production, reconstructed on the basis of archaeological material. In the Polish archaeological literature, studies on the organisation of processing of double platform cores for blades serving as blanks for Swiderian tanged and willow-leaf points (fig. 21) was carried out by the author of this paper (Migal, 2006, 2007) and by a Szczecin- researcher, M. Dziewanowski (Dziewanowski, 2006). Based on the analysis of the historical material, experiments and refittings, the research concluded that the preparation sequences leading to the production of blanks, blades of precisely defined technological form, were very complex. Before a blade was detached, the flaking surface was prepared by two to five blows (fig. 22). Whether the producer had a 'preferential blade' in mind during the continuous production process and planned each blow accordingly (as W. Migal believes), or if high-quality blades were formed in a continuous process of greater or lesser preparation and detachment (Dziewanowski) is still debated. Unfortunately, it is not possible to reanalyse many of the blocks refitted by Polish Late Palaeolithic researchers (Fiedorczuk, 2006). Heavily glued, the elements are hard to reassemble.

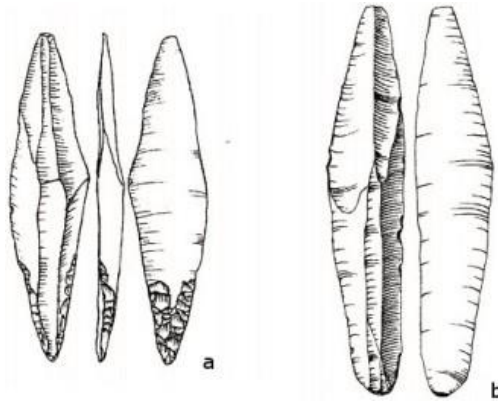


Fig. 21. Examples of:
 a. a typical Swiderian willow-leaf point,
 b. a preferential blade produced in a Late Palaeolithic society (Migal, 2007).

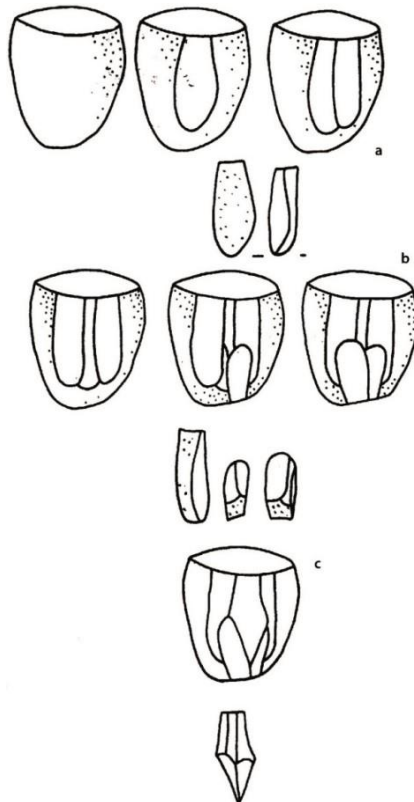


Fig. 22. Illustration showing the procurement of a blade to be worked out into a point. Note that in the most developed sequences (this is also visible in fig. 21), up to five effective previous removals were necessary to shape the blade dorsal face (Migal, 2007).

It is a fact, however, that even the author himself (Fiedorczyk, 2006) expressed the opinion that for reasons unknown, almost all elements can be refitted and that a small number of blades were carried away from the flint workshop. This seems to suggest that the production process was aimed at the detachment of single/few preferential blades or that the best blades were selected to be worked into pedunculated or willow-leaf points.

THE COURSE OF THE EXPERIMENT

Four people involved in the experiment, i.e., Marcin Dziewanowski, Marcin Wąs, Witold Grużdź and Witold Migal are Stone Age researchers, familiar with the issues of Late Palaeolithic lithic technology. They were asked to produce a few series of double platform cores each. A total of 16 series of cores with flakes and blades were thus obtained. The number of Late Palaeolithic series produced by individual researchers is as follows:

- M. Dziewanowski – five series,
- M. Wąs – three series,
- W. Grużdź – one series,
- W. Migal – seven series.

The next stage consisted in refitting particular series; selected for further research were seven series produced by MD, MW and WM (two series each) and one of the blocks refitted from materials excavated at a Late Palaeolithic (Swiderian) site (Grużdź, Pyżewicz, Migal, Przeździecki, 2012). The series were refitted (in the case of Suchodółka the refitted block was disassembled) and all relations between particular elements were recorded in accordance with the above-described rules. The resultant tables were then transformed into graphs presented and discussed below.

Block 4 (M. Dziewanowski)

Made of Senon flint, the block consists of 64 elements forming a double platform core with refitting blades forming the flaking surface, preparation flakes and high-quality blades detached after preceding preparation. If we want to read this graph in the order of the actions performed, from the right side of the graph we can see:

- numerous green fields along a line departing from fragment 64 (top left). It is the ‘line of relation’ determined by a flake preparing one of the platforms, and each green field marks a place, where blades or flakes were detached from such prepared surface. The relation between them can be described as perpendicular (recorded as green in fields under intersecting lines designated by the analysed fragment), In fig. 23, this is an auxiliary green line marked with the letter ‘A’ used as an illustration;
- a series of flakes preparing the detachment of a preparation flake from side B can be seen between flakes 63 to 51. The relations between the detached flakes

can be described as consistency or perpendicularity. Please note that the graph shows that all flakes were detached from the ridge to one side. There are no red fields corresponding to the opposite detachment of flakes. In the drawing, this fragment is marked with an ellipse and the letter 'C';

- flake 50 is a flake forming the opposite platform; in the figure, its relations with other fragments are marked with a line marked with the letter 'B';
- ellipse D shows a series of flakes and blades preparing the detachment of the preferential blade (when we look closely, it turns out that most were detached from platform A);
- the relations of the first preferential blade (number 29) were emphasised by the right-slanting line E. Note that it was detached from platform 'B';
- correction blades for the detachment of another preferential blade are marked with the letter 'F',
- 'G' line is a small flake rejuvenating platform 'B',
- red 'H' lines mark four consecutive preferential blades or blades of similar characteristics. Note that most of them were detached from platform 'B'.

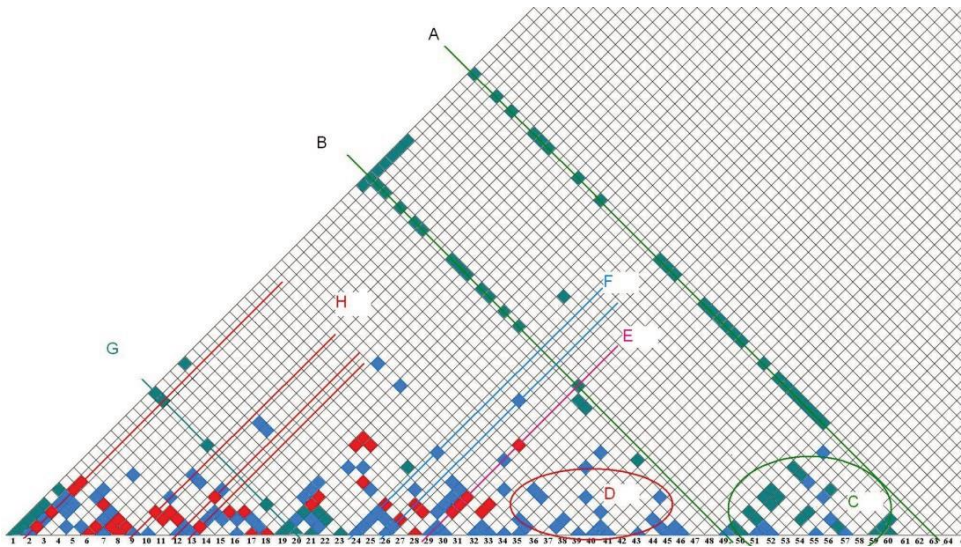


Fig. 23. Block 4. Graph showing the relations, including three described in the paper.

Based in the graph, the description of the entire block could be as follows: After removing a platform A detachment flake, a series of blows were applied to form the opposite side before removing the preparation flake B. After that, the opposite platform was formed with one blow. Once the flaking surface was initially formed by removing a few blades, the preferential blade was detached. A few flakes and blades

were then removed to rejuvenate the flaking face (e.g., F), and when this turned out to be ineffective, the striking platform B was rejuvenated by the detachment of another flake. This enabled the detachment of other preferential blades. After the last preferential blade had been detached, the core was abandoned (see fig. 24).



Fig. 24. Block 4 with marked elements visible as it is shown on the graph above: marked in the photo are platform removal flake A, flakes preparing platform removal flake B (ellipse C), platform removal flake B. Core '1'. Correction blades 14–16.

Block 5 (W. Migal)

This block consists of 57 elements. The core was made on a natural fragment of unprepared Świeciechów flint. In contrast to the previous core, the side thinning was used here, the back of the core remained unprepared and in the final phase, the platform was rejuvenated by removing platform rejuvenation flakes. It is interesting that one of the platforms was only rejuvenated in the last phase – a natural plane was previously exploited. Reading the graph from the right (fig. 25) we can see that:

- a massive flake (platform detachment flake) was detached from platform 'A' (no. 57),
- the side of the core was thinned – flake 55, line 'D' (see fig. 26),
- the side of the core was formed (blue ellipse 'E', flakes 47–53),
- the flaking surface was formed with flakes 30–43 (ellipse 'E' and green line 'B'),
- platform A (line F) was rejuvenated with one blow,
- the flaking surface was prepared to remove the first preferential blade (ellipse G) (see fig. 27),
- blades 28 and 18 are the first attempts at making preferential blades: 28 was too massive and hence unsuccessful and blade 18 had the desirable qualities,

- flake 20 was detached as a platform rejuvenation flake from platform ‘B’ (green line ‘B1’),
- the flake 19 was detached as a platform rejuvenation flake from platform ‘A’ (green line ‘A1’),
- after the platform was rejuvenated by removing flake 19, a preferential blade 19 was detached,
- another flake rejuvenating platform ‘A’ was detached,
- the last preferential blade (4) was detached.

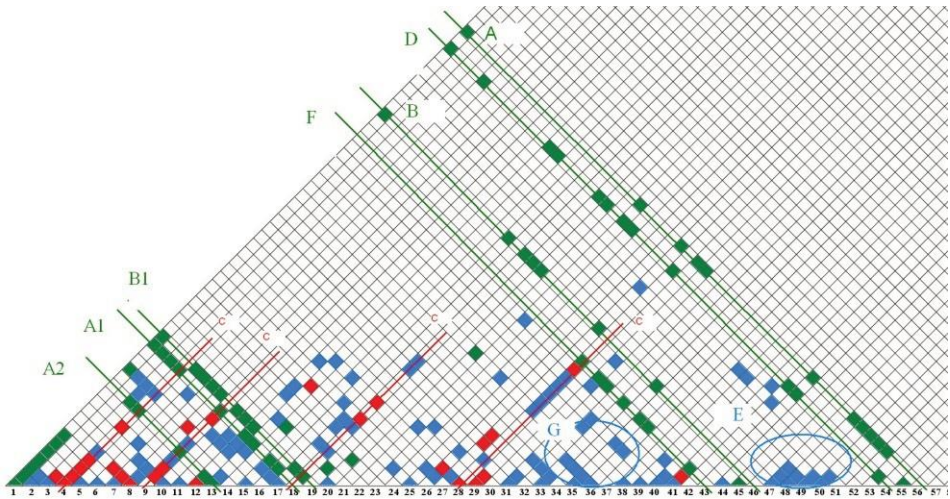


Fig. 25. Block 5. Graph showing the relations, including three described in the paper.



Fig. 26. Block 5 as a nodule used to produce a core. The platform removal flake is marked with the letter A; in the foreground, flakes 56 and 58, thinning the side of the core.



Fig. 27. Block 5 after detachment of flakes thinning the sides; visible from the top: flake 41 – one from the group of flakes forming the flaking surface (the digit in the picture is reversed). Also visible is the core (No. 1 – the digit in the picture is reversed).



Fig. 28. Block 5 after detachment of flakes thinning the sides. Visible in the photo are blade butts and flakes removed from platform 'B' and flake 20, the only flake rejuvenating platform B.

While we compare blocks 4 and 5 in the graphs, we can see that the flintknappers adopted a different approach to achieve the same goal, manifested in less or more intensive platform processing and the preparation of a spot for the detachment of a preferential blade on the core. Another noticeable difference is the thinning of the sides of the core in Block 5, while in Block 4, which was made on a flat, plate-shaped nodule, only the base of the core was worked to form a wedge-shaped striking platform. In Block 4, high-quality blades were evenly detached from both platforms. Sometimes, blades with a rich counter-relief were formed as a result of two successive opposite detachments (Cf. Block 4, elements 12 and 13), while this is not observed in Block 5, where high-quality blades were formed on the dorsal side only by removing bladelets and preparation chips (see Block 5, elements 4, 9, 18, 28). At the same time, note that the detachment of one preferential blade was each time accompanied by the detachment of a platform rejuvenation flake. Compared to the previous one, this way of working was more focused on precise operations aimed at producing blades with strictly defined features, thus being less effective.

Block 6 (W. Migal)

Block 6 consists of 46 fragments. It was made of a natural, fairly flat crumb of Świeciechów flint. The graph (fig. 29) shows that at the beginning (fragments 39–46, ellipse B, see fig. 29 on the right), an attempt was made to regulate the shape of the future core from the side of platform side B.

Subsequent activities included:

- the detachment of two flakes 38 and 37 forming platforms A and A1 (see fig. 30),
- the detachment of two flakes 32 and 31 forming platform B (see fig. 30),
- the detachment of the first point from the platform formed by B1 detachment (flake 21),
- before and after the detachment of the first point (No. 21, C1), several blades and flakes forming the surface of the future preferential blade were detached (ellipse C),
- line C2 marks the preferential blade (part 12) detached from platform B,
- lines B2 and A2 mark another rejuvenation of platforms A and B (flakes 17 and 15, respectively, see fig. 29),
- once platform B was rejuvenated, two successive high-quality blades (marked with lines C3 and C4) were detached (fragments 8 and 4, respectively).

A great similarity is observed in the implementation of the idea presented in the diagrams of Blocks 5 and 6. A small number of blades and flakes detached from pre-prepared platforms is perhaps their most characteristic common feature. Core preparation by removing a fragment was preceded by some preliminary work. However, each preferential blade was detached from the preferred platform. In the case of block 6, all four blades were detached from platform B, in the case of block 5 – three

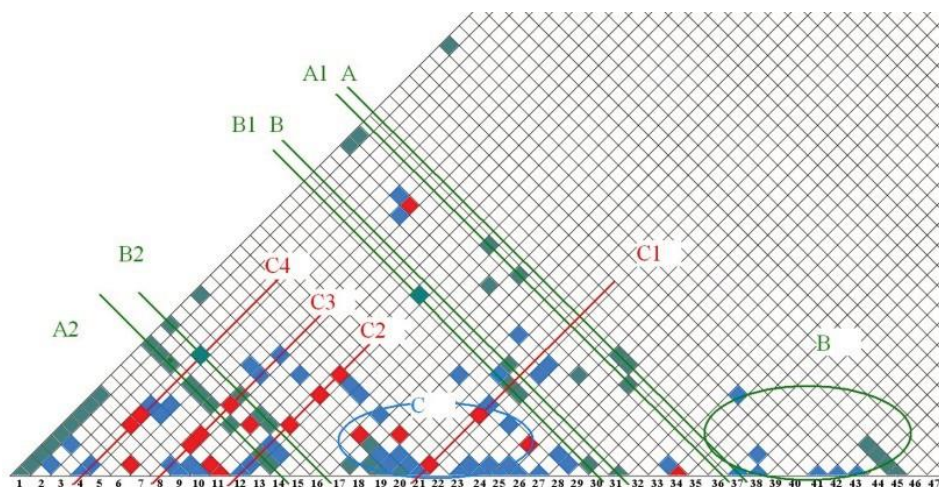


Fig. 29. Block 6. Graph showing the relations, including three described in the text.



Fig. 30. Block 6. General view.

out of four. This picture is very different from block 4, where the high-quality blades were detached parallelly from both platforms and alternately, sometimes one after another. This is confirmed by successive refittings made by the same manufacturer.

Block 8 (M. Dziewanowski)

This refitted block consists of 81 elements. The core was made of a flat concretion of Senon flint (fig. 32). The graph clearly shows the following elements:

- preparation of striking platforms A and B by removing flakes 81 and 80 (see fig. 33). Such core preparation was sufficient to obtain sixteen blades, which,



Fig. 31. Block 6, striking platform. Visible flakes rejuvenating platform A1.

in the opinion of the flintknapper and the author, show appropriate parameters to be worked into Swiderian points with only light retouch. The parameters include the appropriate size of the blanks, parallel sides or lenticularity in the longitudinal profile (see fig. 34). No preferences in the selection of the platform from which the selection blades were detached are observed in the graph. However, only one blade (element 26 m) shows all the features shown in figure 21, i.e., the scars of blades detached from opposite sides, connecting close to the centre of the specimen (see fig. 35). The blue ellipse marks an attempt to repair the core by platform rejuvenation and side blows, and yet this was not followed by the detachment of any preferential blades.

Block 10 (M. Waś)

The refitting was a result of core exploitation undertaken by a flintknapper who had hitherto showed no particular interest in making replicas using the Swiderian technology. During his work, the flintknapper regularly discussed with me the choice of the procedure, related to core preparation and the detachment of particular blades. This must be remembered while the results of the presented works are further

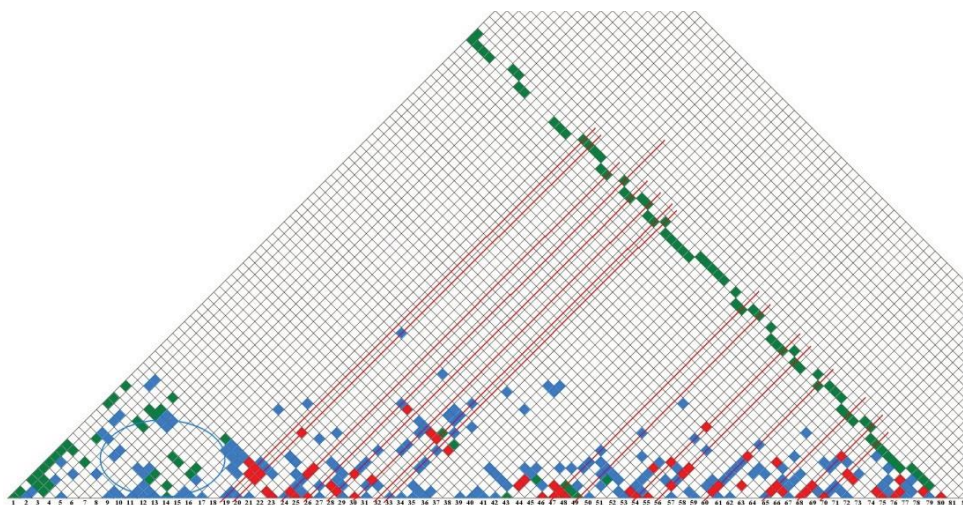


Fig. 32. Block 8. The graph shows the processes responsible for the consistent implementation of the idea of blade production in the Swiderian culture. After two crested blades were removed from two opposite sides of the core (note that there is a ‘opposing’ relation between crested blades 81 and 80 – marked in the graph with the red triangle above number 81), blades were detached consistently from both platforms. They could be easily worked into Swiderian points (either willow-leaf or pedunculated). The only preferential blade (see fig. 21) corresponding to the definition was detached as element 26 although other blades also had traces of opposing scars allowing their classification as ‘preferential blades’.



Fig. 33. Refitted block 8. Preparation of platform with two large flakes convergent at the top. Note that both platforms are formed at the same angle to the flaking surface.



Fig. 34. Block 8 during refitting – below the ruler, exemplary blades produced in the course of lithic reduction – some were classified as blades that can be used as blanks for Swiderian points.



Fig. 35. Two blades from block 8. On the left, blade 26 with a relief that allows it to be classified as a preferential blade; on the right, high-quality blade with only one opposing scar, although its parameters allow it to be included among high-quality blades.

monitored. The refitted block consists of 57 elements (fig. 36). A flat nodule of chocolate flint fragment from the Wierzbica quarry (fig. 37) was used as a raw material. Fragments with a ‘perpendicular’ relation related to core preparation (light green) were differentiated from blows shaping the platform (platform detachment flake – dark green) by the use of different shades of green.

The graph (fig. 36) shows the following processes marked additionally with ellipses or lines connecting the fields of relations:

- core preparation – preparing platform A, flake 57, green line A,
- ellipse D1 marks flakes forming the crest in the middle of the future flaking surface,
- preparation of platform B was marked with line B, flake 49,
- ellipse D2 is a series of flakes flattening the flaking surface from striking platform A,
- note flake 34 detached from platform A – a large flake flattening the flaking surface; when we trace its relations with later struck flakes and blades, we notice that most of them were removed from the opposite striking platform (hence the relations marked with a blue line from 34 to the left are opposite to later detached items),
- elements 18, 12 and 8 are more or less successful attempts to obtain points.

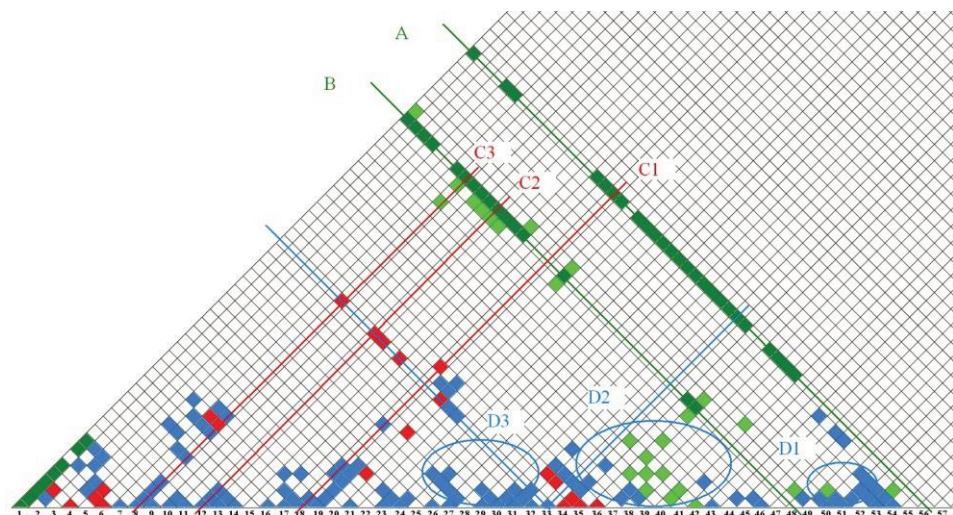


Fig. 36. Block 10. Graph modified by separating the colour of the ‘perpendicular’ reaction into light green – elements related to the preparation of the sides and the flaking surface, and dark green – elements related to the preparation of the platform, in this case, two platform removal flakes and the core.

The refitted block is described in the text.

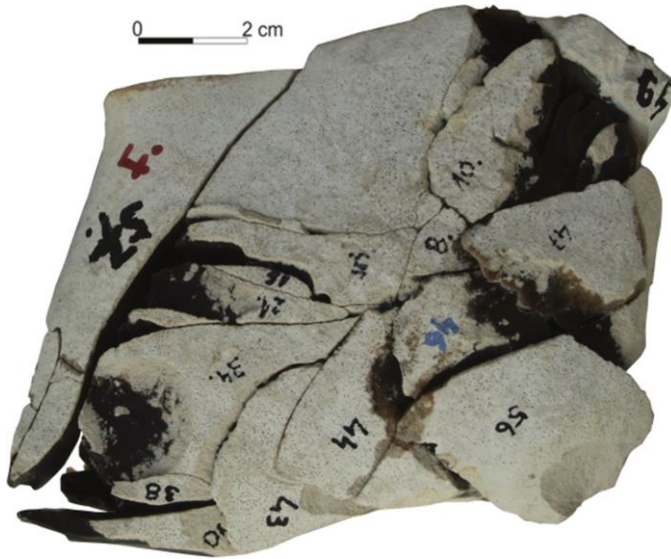


Fig. 37. Block 10. Preparation of the platform (elements 57 on the right and 49 on the left), flake 56 beginning the formation of the crest and core (bottom, not marked with a number).



Fig. 38. Block 10. View of the refitted block from striking platform A.

It is worth noting that the production style of this core differs from those discussed above – no additional platform rejuvenation is visible, similar to that in refitted blocks 4, 5 and 6. Appropriate angle of removal was achieved by removing subsequent elements from the flaking surface. Attempts to flatten the platform (fig. 34) are also visible in other refittings, e.g., in block 4 (fig. 23), they are represented by elements: 10, 18 and 29 (these lines are not marked not to complicate the graph but try to draw a ray from these elements to the 'left top' to see how many later blades have an opposing relation). It is similar in the case of blocks 5 (fig. 25; e.g., elements: 9, 12, 18 and 29, where 17 and 28 are the preferential blades detached after preceding detachments or attempts made to remove them) or Block 6 (fig. 29), where blade 12, with many relations on the ventral face side, is at the same time a preferential blade (see also fig. 23). This observation helps us to see that the detachment of a preferential blade significantly affected the later exploitation of the core – several subsequent elements are shaped on the dorsal face by preferential removals. Such a regularity would be impossible to register if it was not marked in the graph. From the technological viewpoint, this seems to be a novelty and as such will be discussed below.

Block 12

Last but not least, I shall discuss a block refitted from flint artefacts recovered during excavations. Attributable to the Swiderian culture, the materials were recovered at Suchodółka (Grużdź et al., 2012). This block, one from several, consists of 30 elements.

From right to left, the graph (fig. 39) shows the following processes:

- ellipse D1 marks the preparation of the flaking surface for point detachment by removing flakes and blades,
- line C1 is an empty space where probably a more or less successful preferential blade was detached. Absent from the refitted block, its presence is nevertheless suggested by the arrangement of neighbouring detachments,
- line C2 is a second attempt to remove a blade (see fig. 40),
- another line – C3 is the last attempt to remove a blade, not preserved in the archaeological record,
- line A is the last 'desperate' and ineffective attempt to rejuvenate the platform and prepare another place for another preferential detachment. It is interesting that this procedure was performed despite the really small size of the core. Except for small chips, it seems that missing both in the refitted block and in the graph are only two effectively detached blades. Unfortunately, due to the absence of elements related to the primary preparation of the striking platform, it is difficult to deduce to what extent preferential detachments were made from one platform. In the case of the block from Suchodółka, however, we can clearly see that despite the small size of the core (especially compared to

experimental specimens, such as block 8), the core reduction was well planned and rhythmic. Each preparation of the flaking surface resulted in an attempt (more or less successful, of course) to remove a preferential blade.

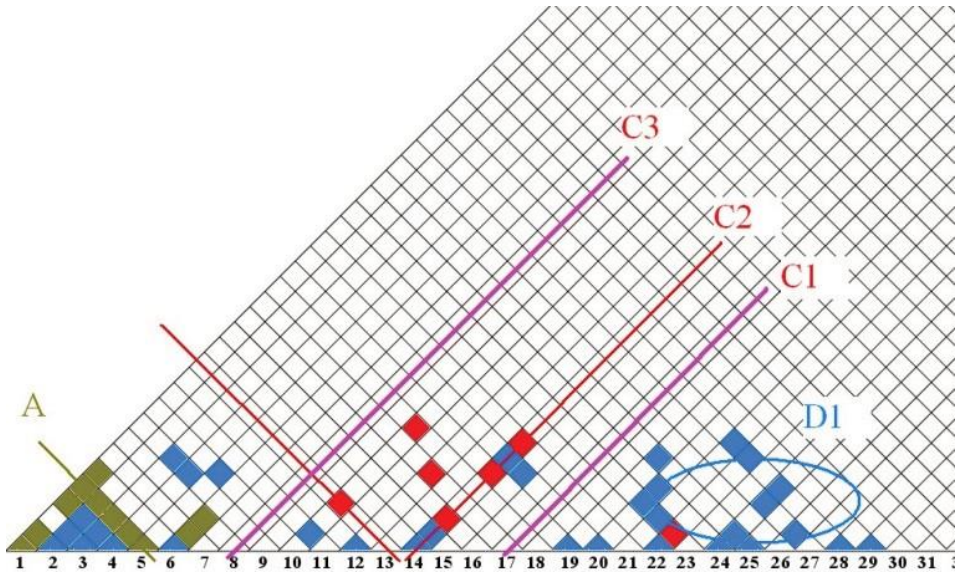


Fig. 39. Block 12. Archaeological material from Suchodółka described in the text.

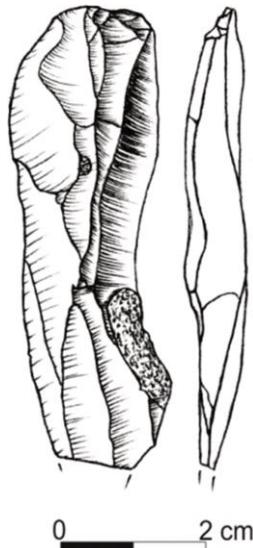


Fig. 40. Unsuccessful preferential blade nr 14 (line C2) from the Late Palaeolithic refitted block from Suchodółka described as block 12 (Grużdź et al., 2011).

COMPARISON OF SELECTED TECHNOLOGICAL ELEMENTS

Based on the above findings, we can transform the graphs to compare them with respect to chosen technological aspects. It is enough to eliminate some relations so that the graph shows only those that are of particular interest to us (conceptual elimination is the simplest, graphic effects are more evident). The following examples are probably not the only ones that we could use in different cases to highlight and understand the significant differences between the analysed refittings. Through the comparison of the graphs, we can conclude that:

1. Flintknappers employed various methods to prepare, use and rejuvenate the striking platforms (some differences were noted in style, know-how or habits).
2. The graphs show a different approach to the flaking surface preparation in order to obtain a good quality preferential blade – visible in the graphs are serial (successively from both platforms), or cyclical attempts to detach blades.
3. A visible cyclicity in rejuvenating the core platforms can be observed in some cases, as opposed to other realizations, where the work was suddenly abandoned.

CAN WE UNDERSTAND ANYTHING NEW OWING TO THE REFITTING CALCULUS METHOD?

It is already clear that the presented graphs let us notice hitherto overlooked technological phenomena. We used to analyse merely the flakes' dorsal face, or rather the layout of various visible scars. As far as the core is concerned, we studied its shape and scars arrangement. The refitting calculus method provides an opportunity to take a look at the ventral face, i.e., to trace how seriously particular detached fragments influenced later work. Of course, this is nothing new when, for example, the preparation of the striking platforms is considered. The proper detachment of a preparation flake affects minor core exploitation and the way several smaller blades are removed. It turns out, however, that in our case, and it seems that if we applied this research method to other cases the result would be similar, there are good reasons to take a look at some equally important blades, decisive for the later exploitation of the flake.

In this case, the fact that the recorded relations between individual fragments show a different distance from each other, understood as the number of detachments between two fragments may be an important observation. Close relations are not surprising – these are usually subsequent detachments, a testimony to the preparation and detachment of subsequent flakes. However, medium-distance relations, and even more distant ones, shows that particular removals were planned ahead. Here, some blades and flakes to a large extent determine how particular producers plan the

processing. It seems that we felt this intuitively before. We knew how important correct detachments forming the curvature of the preparation and the facet were. The graphs show their impact on the regularity and uniformity of processing, which is related to the style and perhaps the tradition in which the producer operated. It is interesting that in the case of our experiment, of great importance were properly detached preferential blades. It turns out that not only do they exhibit a rich relief of previous removals on their dorsal face (see fig. 44), but also touch several fragments from the dorsal face, enabling the proper continuation of work.

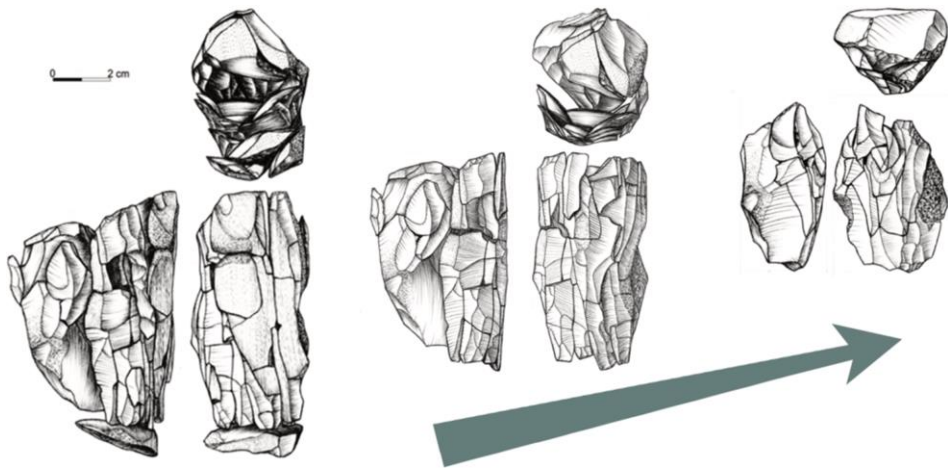


Fig. 41. Three stages of block 12 refitting. In the middle, unsuccessful preferential blade, marked as 14 in the graph (Gruzdź et al., 2011).

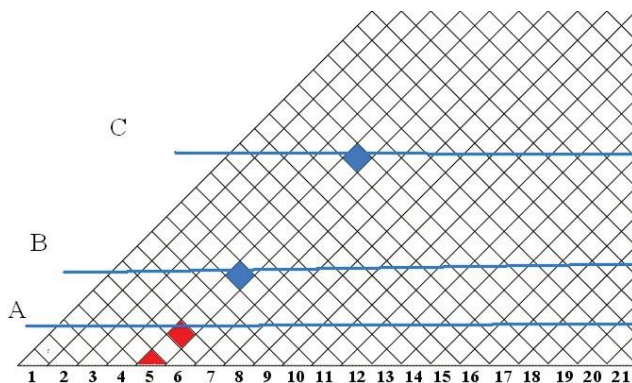


Fig. 42. Different distances between relations visible in block graphs. A. Close relations – direct relation between fragments 5 and 6 – one fragment comes after the other; the distance between fragment 8 and 5 equals three detachments. B. medium relations – seven fragments were detached between the detachment of fragment 12 and 5. C. distant relations – detachments 20 and 5 are 15 fragments apart.

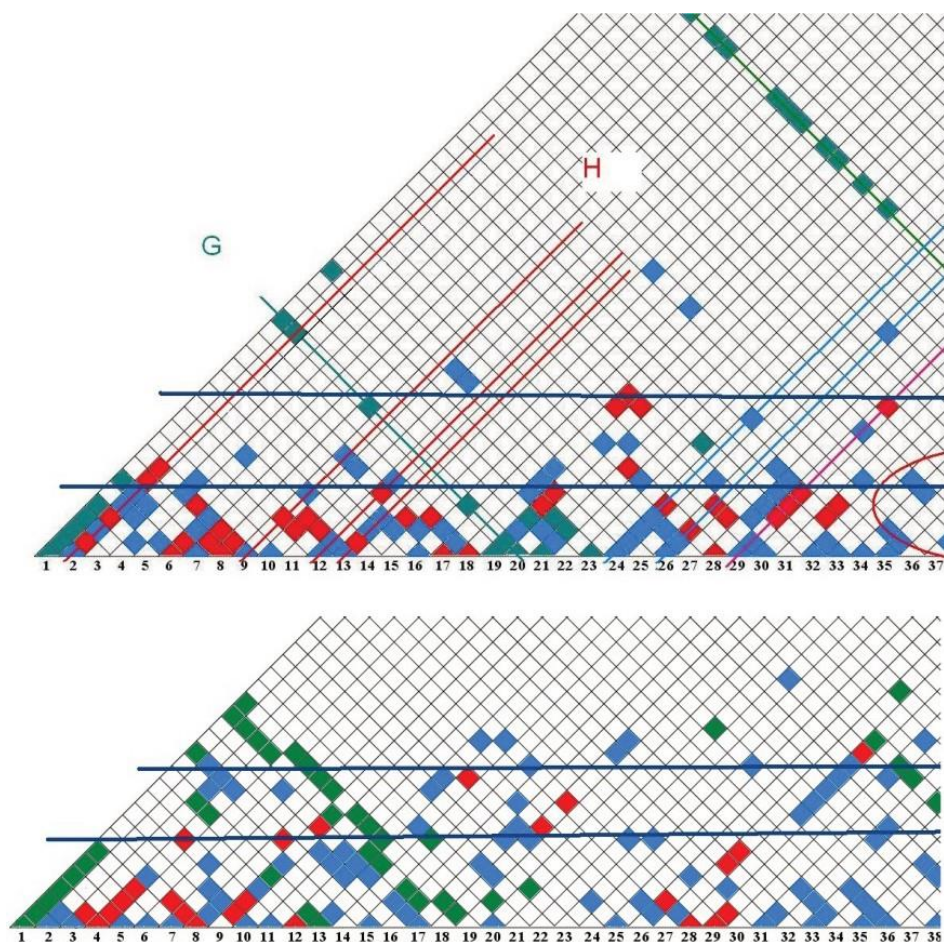


Fig. 43. Different distances between relations occurring during the exploitation of a double platform core – the example of opposite blades and flakes. The bottom-line marks medium relations (6–8 elements between removals) and the upper one, distant relations (11–13 elements between removal). For example, thirteen pieces were detached between flakes 32 and 18 in block 4 (the top drawing; higher line marking the distance between them); at the same time, a six-piece distance divides fragments 25 and 19 (also block 4) (bottom line).

CONCLUSIONS

The comparisons of graphs representing particular refittings have proved that when they used for the description and analysis of blocks, lithic reduction activities become much easier to understand. The graphs show both differences and similarities between individual refitted blocks. If we agree with that, we should develop a path of selecting relations, the number and type of which can be much greater than

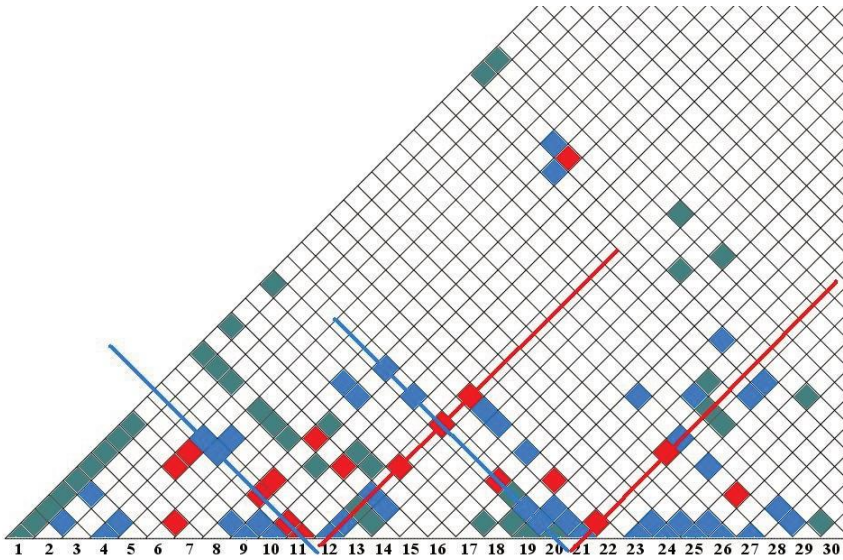


Fig. 44. Example showing selected preferential blades from block 6, which also happened to greatly affect further processing. In the case of blade 21, we see the consistent and opposing relations going to the right (under the red line), forming the dorsal side. The blue line, going to the left, shows the relations formed by later removed fragments touching blade 21 from the bottom. It can be seen that subsequent relations show a significant distance between detached fragments (e.g. between 21 and 8, the distance of 13 removals). Blade 12 exhibits similar features (we must remember that the core was already smaller, which impinges on the number of minor removals).

those presented above (for example, when we analyse bifacial or tetrahedral forms). It would be also interesting to undertake other attempts to describe the processes visible in the graphs, where I used coloured lines and ellipses. At the moment I am deeply convinced that the method presented herein constitutes a desirable new quality in the understanding of the effects of working with refitted prehistoric blocks. Obviously, the use of some ideal examples, or modern experiments, simply allowed for a clear presentation of the problem. It is also possible that such an operation associated first with the understanding of the technology and its experimental demonstration in practice will become an inseparable part of the analytical procedure related to the analysis of the original blocks. It is difficult to say in which direction my further research in this area will develop. At the moment I can say that I am deeply convinced that the presented method of analysis:

- makes it easier to mentally enter into the processes implemented practically by flintknappers, both contemporary and prehistoric, which gives hope for a better understanding of prehistoric technologies,
- has a chance to become a full-fledged new tool used for flint analysis,
- is an objective method allowing the presentation of results of refitting in such a way that other researchers can draw their own conclusions from the graphs,

- provides an opportunity to compare different refitted blocks, created in different scientific environments and sometimes territorially distant, in terms of their similarity regarding the technological style.

The fact that it is very time consuming is perhaps the major drawback of this analytical procedure. After a block is refitted, it must be disassembled and even several hundred relations between individual elements must be recorded. In addition, blocks that were permanently glued using cyanoacrylate substances in the past will be much more difficult to re-analyse. Either way, to what extent the proposed research method may be useful for achieving the research goal needs to be evaluated at an individual level. The use of computer methods to facilitate refitting of individual fragments and simplify the procedure for selecting fragments (Cooper, Qiu, 2006) offers hopes that we will be able to focus on other research issues, making better use of each newly refitted block.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY

- Allen, J. F.
1983 Maintaining Knowledge About Temporal Intervals. *Communications of the Acm*, 26(11), 832–843.
- Asmussen, K., Qiang, Y., Maeyer, P. de, Weghe, N. van de
2009 Triangular models for studying and memorizing temporal knowledge. In C. L. Gómez, B. D. Martí, T. I. Candel (eds.), *Proceedings of ICERI 2009 Conference. 16th–18th Nov 2009* (p. 1849–1859). Madrid: International Association of Technology, Education and Development.
- Boroń, T.
2006 Organizacja przestrzeni w krzemienicach mazowszańskich na przykładzie zespołów krzemienych ze stanowiska Nieborowa I, gm. Sawin, woj. lubelskie. *Archeologia Polski*, 51, 13–41.
- Bosinski, G.
1966 *Der paläolithischen Fundplatz Rheindahlen, Zeigelei Dressen-Westwand. Bonner Jahrbücher*, 166, 318–346.

- Brézillon, M. N.
1971 *La dénomination des objets de pierre taillée. Matériaux pour un vocabulaire des préhistoriens de langue française. IVe Supplément à Gallia Préhistoire*. Paris: CNRS Éditions.
- Bronowicki, J., Bobak, D.
1999 Schyłkowopaleolityczna pracownia krzemieniarska z miejscowości Ślęza (stanowisko 12) pod Wrocławiem. *Przegląd Archeologiczny*, 47, 7–25.
- Cahen, D.
1989 Refitting Stone Artifacts: Why Bother? In de G. Sieveking, M. H. Newcomer (eds.), *The Human Uses of Flint and Chert* (p. 1–10). Cambridge: University Press.
- Clarkson, C., Vinicius, L., Mirazon, M.
2006 Quantifying flake scar patterning on cores using 3D recording techniques. *Journal of Archaeological Science*, 33, 132–142.
- Cooper, J., Qiu, F.
2006 Expediting and standardizing stone artifact refitting using a computerized suitability model. *Journal of Archaeological Science*, 33, 987–998.
- Cziesla, E., Eickhoff, S., Arts, N., Winter, D. (eds.)
1990 *The Big Puzzle: International Symposium on Refitting Stone Artefacts, Monrepos, 1987. Studies in Modern Archaeology 1. British Archaeological Reports International* (Series 578). Bonn: Holos.
- Cziesla, E.
1990 *On Refitting of Stone Artefacts*. In E. Cziesla, S. Eickhoff, N. Arts, D. Winter (eds.), *The Big Puzzle: International Symposium on Refitting Stone Artefacts, Monrepos, 1987. Studies in Modern Archaeology 1. British Archaeological Reports International* (Series 578, p. 9–45). Bonn: Holos.
- Delpiano, D., Peresani, M.
2017 Exploring Neanderthal skills and lithic economy. The implication of a refitted Discoid reduction sequence constructed using 3D virtual analysis. *Comptes Rendus Palevol*, 16(8), 865–877.
- Dziewanowski, M.
2006 Flint Assemblage Dręstwo 37. A Preliminary Analysis of Predetermined Swiderian Debitage. In A. Wiśniewski, T. Płonka, J. M. Burdukiewicz (eds.), *The stone: technique and technology* (p. 149–166). Wrocław.
2012 *On the Classification of By-Products of the Reduction for Blades – Some Aspects of Technology in Swiderian Assemblages*. *Światowit*, 9/B, 223–233.
- Fiedorczuk, J.
2006 *Final Paleolithic camp Organization as Seen from the perspective of Lithic Artifacts Refitting*. Warszawa: Instytut Archeologii i Etnologii PAN.
- Góralski, A.
1980 *Twórcze rozwiązywanie zadań*. Warszawa: PWN.
- Gruzdź, W., Pyżewicz, K., Migal, W., Przeździecki, M.
2011 Multi aspect analysis of flint materials from Suchodółka 3 site, the Świętokrzyskie voivodship. *Światowit*, 9(50), 245–278.
- Hołówko, T.
2005 *Kultura logiczna w przykładach*. Warszawa: PWN.
- Hofman, J. L.
1992 *Putting the Pieces Together: An Introduction to Refitting*. In J. L. Hofman, J. G. Enloe (eds.), *Piecing Together Past: Applications of Refitting Studies in Archaeology, British Archaeological Reports International* (Series 578, p. 1–20). Oxford: Archaeopress.

- Kirsh, D.
2010 Thinking with external representations. *Artificial Intelligence and the Simulation of Behaviour*, 25, 441–454.
- Kobayashi, K.
2007 An obsidian refitting from Sos Höyük, eastern Turkey. *Ancient Near Eastern*, 4, 141–154.
- Larson, M. L., Ingbar, E. E.
1992 *Perspectives on refitting: Critique and a complementary approach*. In J. L. Hofman, J. G. Enloe (eds.), *Piecing Together Past: Applications of Refitting Studies in Archaeology*, *British Archaeological Reports International* (Series 578, p. 151–162). Oxford: Archaeopress.
- Leroi-Gourhan, A., Brézillon, M.
1966 L'Habitation Magdalénienne No. 1 Pincevent près Montereau (Seine-et-Marne). *Gallia Préhistoire*, 9, 263–38.
1972 *Fouilles de Pincevent: Essai d'analyse ethnographique d'un habitat magdalénien. VIIe supplément à Gallia Préhistoire*.
- Matraszek, B., Migal, W., Sałaciński, S.
2002 Składanki form rdzeniowych z jamy 424 z osady kultury pucharów lejkowatych ze stanowiska „Nad Wawrem” w Złotej, woj. świętokrzyskie. In B. Matraszek, S. Sałaciński (eds.), *Krzemień świetochowski w pradziejach, Materiały z konferencji w Ryni, 22–24.05.2000. Studia nad gospodarką surowcami krzemiennymi w pradziejach* (p. 237–254). Warszawa: Państwowe Muzeum Archeologiczne.
- Migal, W.
2006 *On Various Methods of Lyngby Point Production*. In A. Wiśniewski, T. Płonka, J. M. Burdukiewicz (eds.), *The stone: technique and technology* (p. 137–147). Wrocław.
2007 On preferential points of the Final Paleolithic in Central European Lowland. In M. Kobusiewicz, J. Kabacinski (eds.), *Studies in the Final Palaeolithic Settlement of the Great European Plain* (p. 185–200). Poznań: Instytut Archeologii i Etnologii Polskiej Akademii Nauk, Poznańskie Towarzystwo Prehistoryczne.
- Ustyński, I.
2015 *Człowiek a czas: Kant Husserl* (PhD Thesis). Łódź: University.
- Pigeot, N.
1990 *Technical and Social Actors: Flintknapping Specialists at Magdalenian Etiolles*. *Archaeological Review from Cambridge*, 9(1), 126–141.
- Przeździecki, M.
2014 *Krzemieniarstwo schyłkowopaleolitycznej kultury wolkuszańskiej w świetle analizy materiałów ze stanowiska 3 w Wolkuszu, gm. Lipsk n/Biebrzą, pow. augustowski, woj. Podlaskie* (PhD Thesis). Warszawa: University.
- Qiang, Y.
2012 *Modeling temporal information in a two-dimensional space*. Ghent, Belgium: Ghent University.
- Qiang, Y., Delafontaine, M., Asmussen, K., Stichelbaut, B., Tre, G. de, Maeyer, P. de, Weghe, N. van de
2010 Modelling imperfect time intervals in a two-dimensional space. *Control and Cybernetics*, 39(4), 983–1010.
- Szewczuk, W.
1984 *Psychologia Zapamiętywania*. Warszawa: PWN.
- Scerri, E. M. L., Gravina, B., Blinkhorn, J., Faivre, J.-P., Delagnes, A.
2016 Can lithic attribute analyses identify discrete reduction trajectories? A quantitative study using refitted lithic sets. *Journal of Archaeological Method and Theory*, 23, 669–691.

- Tomaszewski, A. J.
1986 Metoda składanek wytworów krzemienych i jej walory poznawcze. *Archeologia Polski*, 31(2), 239–277.
- Tversky, B.
2011 Visualizing Thought. *Topics in Cognitive Science*, 3, 499–535.
- Wąs, M.
2005 *Technologia krzemieniarstwa kultury janisławickiej*. Łódź: Wydawnictwo Inicjał.
- Wilson, A. D., Golonka, S.
2013 Embodied cognition is not what you think it is. *Frontiers in Psychology*, 4(58), 1–13.
- Wiśniewski, A., Serwatka, K., Badura, J.
2015 Nowe znaleziska kultury prądnickiej z terenu Płaskowyżu Głubczyckiego. *Śląskie Sprawozdania Archeologiczne*, 57, 7–30

CZY ISTNIEJĄ NOWE MOŻLIWOŚĆ ZROZUMIENIA SKŁADANEK KRZEMIENNYCH
PRZY WYKORZYSTANIU ANALIZY CZASOWO-PRZESTRZENNEJ?
PROPOZYCJA NOWEJ METODY

Streszczenie

Od ponad czterdziestu lat zadomowiła się na trwałe w studiach nad technologią krzemieniarską metoda składanek krzemienych. W latach 70. i 80. był to duży krok do zrozumienia technologii wyrobów krzemienych. W chwili obecnej pojawiają się głosy zwracające uwagę na ograniczenia w interpretowaniu składanek. Wiąże się to raczej ze wskazaniem ograniczeń metodycznych, interpretacyjnych oraz niebezpieczeństw związanych z nader entuzjastycznym wykorzystaniem tej metody. Główną przeszkodą jest tu problem analizy czasowo-przestrzennej poskładanych ponownie fragmentów krzemienych uzyskanych w trakcie wykopalisk. Składanka powstaje jako wizualne, materialne odwrócenie procesu obróbki surowca krzemienego pierwotnie zastosowanego do wytworzenia formy rdzeniowej bądź odłupkowej. W wyniku odwrócenia procesu powstają różnego rodzaju końcowe bryły stanowiące mniej więcej odpowiednik pierwotnego okazu. Po złożeniu kilku, kilkunastu takich bloków powstają prędzej czy później pytania:

1. Jaki jest realny efekt składania, czy możemy jakoś opisać nasze czynności w czterech wymiarach, czyli uwzględniając zmiany kształtu w czasie i rzeczywiście rekonstruować proces obróbki?

2. Czy nasza wielotygodniowa praca wnosi coś nowego do istniejącej już wiedzy o krzemieniarstwie?

3. Czy i jak można porównać nasze efekty składania ze składankami wykonywanymi przez innych badaczy?

Dotychczas brak było prostego pomysłu, jak porównywać ze sobą poszczególne gotowe bloki. Różnego rodzaju propozycje schematów (np. macierze Harrisa) nie wydają się zaspokajać naszych potrzeb. Wydaje się, że jest tak dlatego, że sam proces składania nie tworzy w naszym umyśle pamięci faktualnej (Szewczuk, 1984), która pozwala nam na przypomnienie sobie go

w całości (tak jak przypominamy sobie numer telefonu lub twarz znajomego). Wielowymiarowość świata nie jest pojmowana w sposób naturalny. Dlatego w różnych dziedzinach nauki, tam gdzie zachodziła potrzeba, zawsze dążono do zmniejszania ilości wymiarów. Podobnie powinno być w przypadku analizy składanek. Nasze procesy myślowe zachodzą, gdy porównujemy dwie gotowe składanki w postaci bloków. W naszej wyobraźni siłą rzeczy odnajdujemy jedynie kształt dwóch kamieni pierwotnie rozbitych i teraz sklejonych, o czym dowiadujemy się z widocznych pęknięć na powierzchni okazów. Chcielibyśmy jednak mieć możliwość porównywania ze sobą procesów, tak aby dotrzeć do sedna naszego zainteresowania, odpowiedzieć sobie, jak różni ludzie zaspokajali potrzebę wytwarzania narzędzi z krzemienia.

Bez wątpienia chcielibyśmy poszukiwać rozwiązań, aby w doskonalszy sposób opisać rezultaty prac tak, aby móc porównywać wyniki na „wyższym poziomie”, tworząc tym samym wspólną płaszczyznę dla wielu badaczy. W swojej propozycji chciałbym przedstawić całkowicie nowy sposób analizowania złożonych bloków, biorąc pod uwagę jedynie relacje zachodzące między poszczególnymi elementami składającymi się na blok. Jest to propozycja niejako nowego języka opisu, który pomaga przy rekonstruowaniu technologii, umożliwiając porównywanie ze sobą uzyskanych wyników. Niekako dodatkowa analiza nakładająca się na ustalenia i pozwalająca na nieco inne spojrzenie na materiał. Wychodzę przy tym z założenia, że pierwotny wytwórca, odbijając kolejne odłupki od formy, najczęściej nie robi tego przypadkowo, lecz według obranej przez siebie kolejności. Wydaje się, że opisane wcześniej ograniczenia w pojmowaniu czasowo-przestrzennym powodują, że lepsze zrozumienie procesu obróbki możemy uzyskać przez „spłaszczenie” kilku wymiarów do zapisu dwuwymiarowego. Efektem proponowanych analiz są graficzne przedstawienia zawierające zakodowane relacje między wszystkimi dotykającymi się do siebie elementami wchodzącymi w skład bloków składanek. Są one przedstawiane za pomocą dwuwymiarowego trójkątnego wykresu. Uzyskane dla różnych bloków wykresy, jako samodzielne kształty, można następnie ze sobą porównywać i opisywać, dodając szczegóły technologiczne. W chwili obecnej, jakkolwiek są to dopiero pierwsze próby stosowania takiej metody, wydaje się, że możemy dochodzić do *istotnych właściwości* poszczególnych analizowanych okazów. Proponowany przeze mnie proces analityczny przypomina czynność zamiany funkcji na o wiele prostszą, tak jak mamy do czynienia z procesem matematycznym wymyślonym przez Newtona i Gaussa. Stąd proponowana nazwa: „całkowanie składanek” (*refittings calculus*) jako czynność mająca na celu *śledzenie zmian* relacji pomiędzy dokładanymi elementami w czasie i przestrzeni. W naszym przypadku badaną przez nas funkcją jest czasowo-przestrzenna zmiana zachodząca w kształcie formy krzemiennej (bloku) doprowadzona do postaci dwuwymiarowego wykresu.

W artykule pokazano przykład zastosowanie metody *refitting calculus* dla zrozumienia różnic i podobieństw w technice wykonywania doborowych wiórow metodą rdzenia dwupiętowego. Prace składały się z dwóch etapów. W pierwszym eksperymentalnie zostało wykonanych przez 4 eksperymentatorów 16 serii rdzeni wiórowych dwupiętowych. Następnie wykonano ich składanki, notując relacje zachodzące w obrębie każdego bloku. W następnym etapie wykonane zostały składanki poszczególnych serii, przy czym do dalszych badań wyselekcjonowano 7 serii eksperymentalnych oraz jeden z bloków złożony z materiałów ze stanowiska schyłkowopaleolitycznego (Świderskiego) w Suchodółce (Gruzdź et al., 2012). Powstałe tabele zostały następnie przekształcone w wykresy omówione w artykule. Porównując wykresy, łatwo możemy stwierdzić, że:

1. Widoczny jest różny sposób przygotowywania, eksploatacji i odnawiania pięty pomiędzy wykonawcami (różnice stylu, *know how*, przyzwyczajień).

2. Wykresy pokazują różne podejście do formowania odłupni w celu uzyskania doborowego wióra preferencyjnego – widoczne na schematach są seryjne (od obu pięt sukcesywnie) lub cykliczne próby uzyskiwania ostrzy.

Już teraz można powiedzieć że prezentowane wykresy dają możliwość zwrócenia uwagi na zjawiska technologiczne, których dotychczas całkowicie nie braliśmy pod uwagę. Porównując schematy poszczególnych składanek, możemy powiedzieć, że korzystając z nich przy opisie i analizie bloków, wykonywane zabiegi krzemieniarskie są bardziej czytelne i pokazują zarówno różnice, jak i podobieństwa między poszczególnymi blokami. Oczywiście posłużenie się pewnymi idealnymi przykładami, czyli współczesnymi eksperymentami pozwalało jedynie na łatwe i zrozumiałe przedstawienie zagadnienia (przede wszystkim łatwość w wykonywaniu składanek). Wydaje się jednak, że taki zabieg związany najpierw z eksperymentalnym odtworzeniem technologii stanie się nieodłączną częścią zabiegu analitycznego związanego z analizą oryginalnych bloków. Trudno oczywiście przewidywać, w jaką stronę rozwiną się dalsze badania w tym zakresie. W chwili obecnej mogę powiedzieć, że jestem głęboko przekonany, że prezentowana metoda analizy daje lepszą niż dotychczas:

- możliwość mentalnego wejścia w procesy realizowane praktycznie przez wytwórców zarówno współczesnych, jak i pradziejowych, a to daje nadzieje na lepsze zrozumienie technologii prehistorycznych,
- ma szansę, aby stać się pełnoprawnym nowym narzędziem stosowanym do analiz krzemieniarskich,
- jest metodą obiektywną pozwalającą na przedstawienie wyników składanek w taki sposób, aby inni badacze mogli wyciągać z wyników własne wnioski,
- daje możliwość porównywania różnych składanek powstających w odmiennych środowiskach naukowych i nieraz odległych terytorialnie pod względem ich podobieństwa stylu technologicznego.