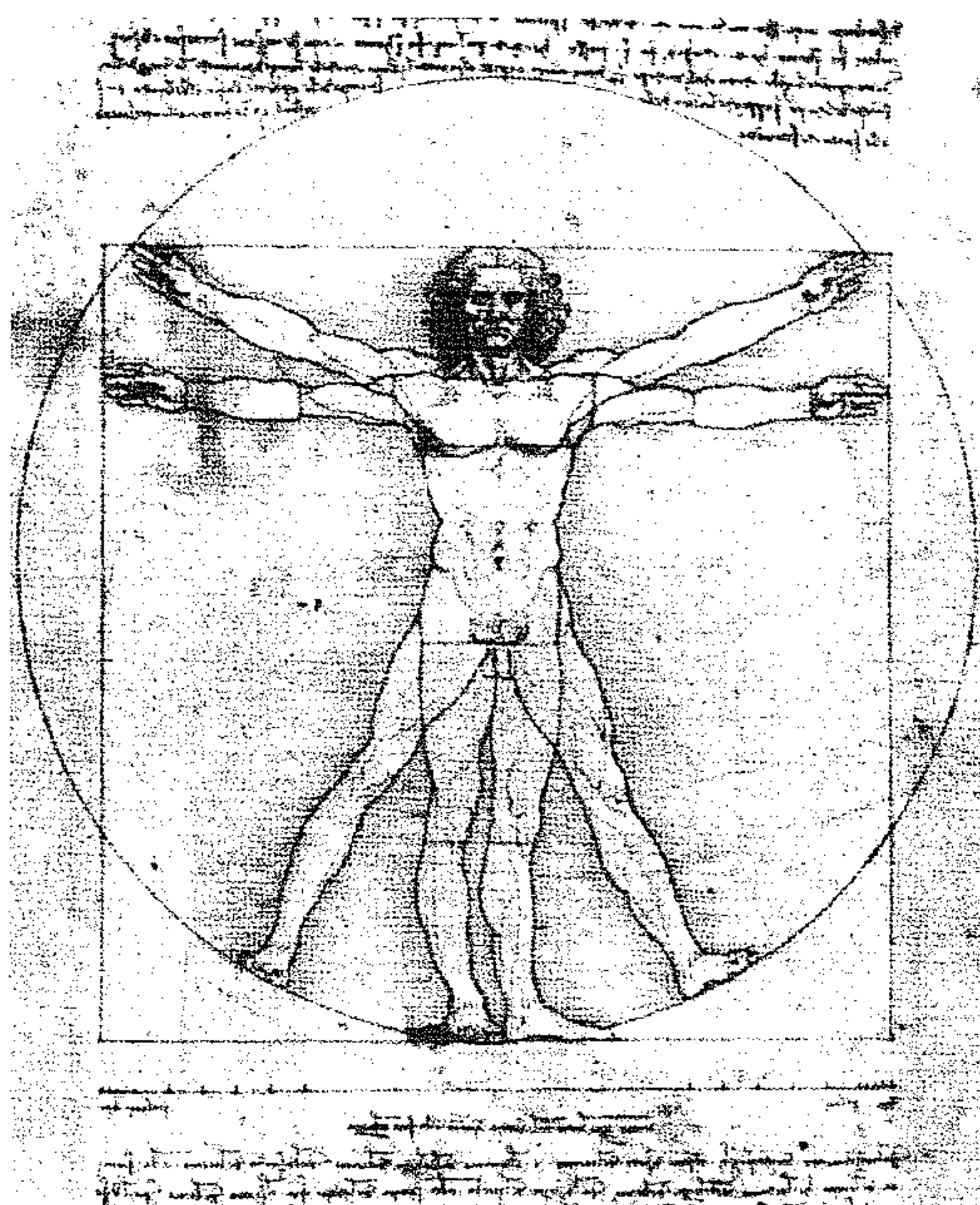


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*On cover: Drawing by Leonardo da Vinci (1452-1519) - Study of the human body*

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## **A Methodological Approach to Core Analysis.**

Lithic cores are like a photograph of only the last reduction gesture or method. But reduction sequences are very often non-linear and complex. Knapping accidents, unexpected qualities of raw material, production requirements, long time between removals or different knappers may force to a change in the reduction strategy. These changes may delete all the signs of previous configuration.

It is consequently not easy to apprehend this information and transform it into data in order to compare and summarize technical schemes. In this paper a methodological approach to core analysis is proposed illustrating temporal relationships between facets in a diagram.

The core diagram shows temporal relationships between removals. It also offers spatial information, as each knapping surface is separately presented in order to observe core complexity in a glimpse, the number of knapping surfaces and their relationships.

Finally, through the analyses and classification of removals attending to their purpose we can understand the different stages of work, the moment of abandonment of the reduction process, if there were reshaping stages or if the core was recycled as a tool.

Each type of removal has a different symbol and a group of removals with the same purpose forms a stage of the core reduction. Therefore it is possible to analyze and compare the same stage in different cores.

The core diagram is a flexible and powerful tool for the study of core reduction by sorting out the heterogeneous information provided by cores. Some examples from the 'Casa Montero' Neolithic flint mine (Madrid, Spain) will illustrate the diversity of technical strategies by means of this methodological approach.

**KEY WORDS:** *Methodology. Core analysis. Core classification. Casa Montero flint mine.*

The aim of this paper is to present a methodological proposal for the graphic representation of core analysis in order to explain the different phases of the work that have taken place. This work is being carried out in the framework of the Casa Montero research project (Consuegra, *et al.*, 2004, Díaz-del-Río, P., *et al.*, 2006).

## Introduction: what does a core mean?

The process of knapping begins with the mental abstraction of the final product. Its materialization involves a series of more or less complex sequences and a variable waste of raw material. It is similar to sculpture in the sense that a shape of the knapping surface is required to obtain the desired product. In certain way in every *débitage* there is some degree of *façonnage* (Boëda, 1991). Knapping strategies are constrained by physical abilities of human or hominid species, technical skill, raw material economy and, of course, the final objective of the production. The higher the level of abstraction, the better the level of efficiency reached (Delagnes, 1995). The work of technologists implies the deconstruction of the process so as to apprehend the original idea of the knapper and the gestures that were carried out in order to materialize that idea.

Lithic cores are the result of knapping and they reflect the last moment before abandonment. Sometimes cores are the consequence of more than one reduction scheme, but successive removals erase previous work. The final product is a complex three-dimensional shape that provides data not only about gestures, but also about individual experience, tradition, economic strategies, and productivity.

There have been several methodological approaches to core analysis. Some of them consist in morphological descriptions, technological analysis (Boëda, 1994, Terradas, 1995), or graphical representation of technical attributes (Dauvois, 1976). Most of them have contributed to the general knowledge about some well defined reduction schemes such as the Levallois method. But usually there are a great number of cores that we cannot explain with these approaches. We also need to obtain objective and quantitative data from cores in order to explain some economic aspects and compare different types of cores and productions.

There are several factors that make it difficult to understand lithic cores. Final shape is an important disturbing agent, so it is necessary to summarize and explain the different processes that have contributed to that morphology. In contrast to what happens to flakes, a core has work evidences distributed in several facets. These facets can be grouped into several planes (knapping surfaces). Another factor is that the complex morphology of a core is the result of more than one sequence, and it can also be the result of more than one reduction strategy. A core can be abandoned before the reduction strategy is finished, or when the reduction goal has changed. When work has been intense, previous evidences of removals are erased.

Some incidences like fractures, veins, hinges, plunging, heat treatment, etc, can take place during the process, so the work may have to be interrupted or reoriented.

It is also possible that there was a great lapse of time between one removal and the next one or, on the contrary, the reduction sequence could have taken place in a short time.

And the last factor involved in core analysis is the circumstance that the person who made them may have been learning to knap (Högberg, 2008).

### Classifying cores

In order to simplify and make cores intelligible this paper proposes a methodology for the analysis and representation of cores. This is an extension of a previous core classification essay (Castañeda, 1999). This classification is organized in three hierarchical levels. The first level of discrimination is the number of knapping surfaces. It is important to consider each surface with any working evidence as a knapping surface. The reason to adopt this criterion is the fact that each striking platform may become a knapping surface if it is prepared, for example in alternant bifacial reduction sequences or if the work is reoriented. In the same way, each knapping surface may become a striking platform if it is needed. Anyway, the fact is that both of them are working surfaces. To distinguish one knapping surface from another and to decide which removal belongs to each one, it is important to consider that each knapping surface is a geometric plane with variable morphology. Its original shape is habitually transformed by its intersection with other knapping surfaces. They can be more or less flat or envolvent, but they are almost always convex. A knapping surface is composed of a group of removals with the same angles and a common aim. If the angle between one removal and the adjacent is very acute and discordant with the objective of the other close removals, it probably belongs to a different knapping surface.

If we classify cores according to the number of knapping surfaces they present, they may be unifacial (UF), bifacial (BF) or multifacial (MF) (Fig.1.a).

The second level of classification is the relationship between surfaces. Unifacial cores can be abrupt (A) or simple (S) if the angle between the striking platform and the knapping surface is close to the right angle or close to the acute angle respectively. Bifacial cores are orthogonal (O) if both knapping surfaces can be reduced to a cube form and removals in one surface do not affect the exploitation in the other surface. If both knapping surfaces are dependent from each other and there is an interaction edge, then the core is classified as secant (S), that is, the working surfaces are two curved surfaces that intersect from the point of view of geometry. In that case, it can be hierarchical (H) if there are different aims of work in each surface, or non-hierarchical (NH) if there are not. Multifacial cores can present just one knapping surface destined for production, more than one, or none. This means that one or several surfaces are enhanced because of the purpose of their removals. In this case, a knapping surface destined to blank production becomes more important than configuration or striking platform surfaces. Work then is focused on this main knapping surface in order to obtain the desired results.

Then they can be classified as hierarchical with one main knapping surface (1H), hierarchical with two main knapping surfaces (2H) or non hierarchical (NH), if there is no knapping surface in which work had more importance than in the others. This may occur in the case of multifacial cores that have been abandoned before a production sequence has begun or in those cores with expeditive reduction schemes.

The third level of classification is the direction of the removals. Unifacial and Orthogonal bifacial cores can present unidirectional, perpendicular or bipolar removals.



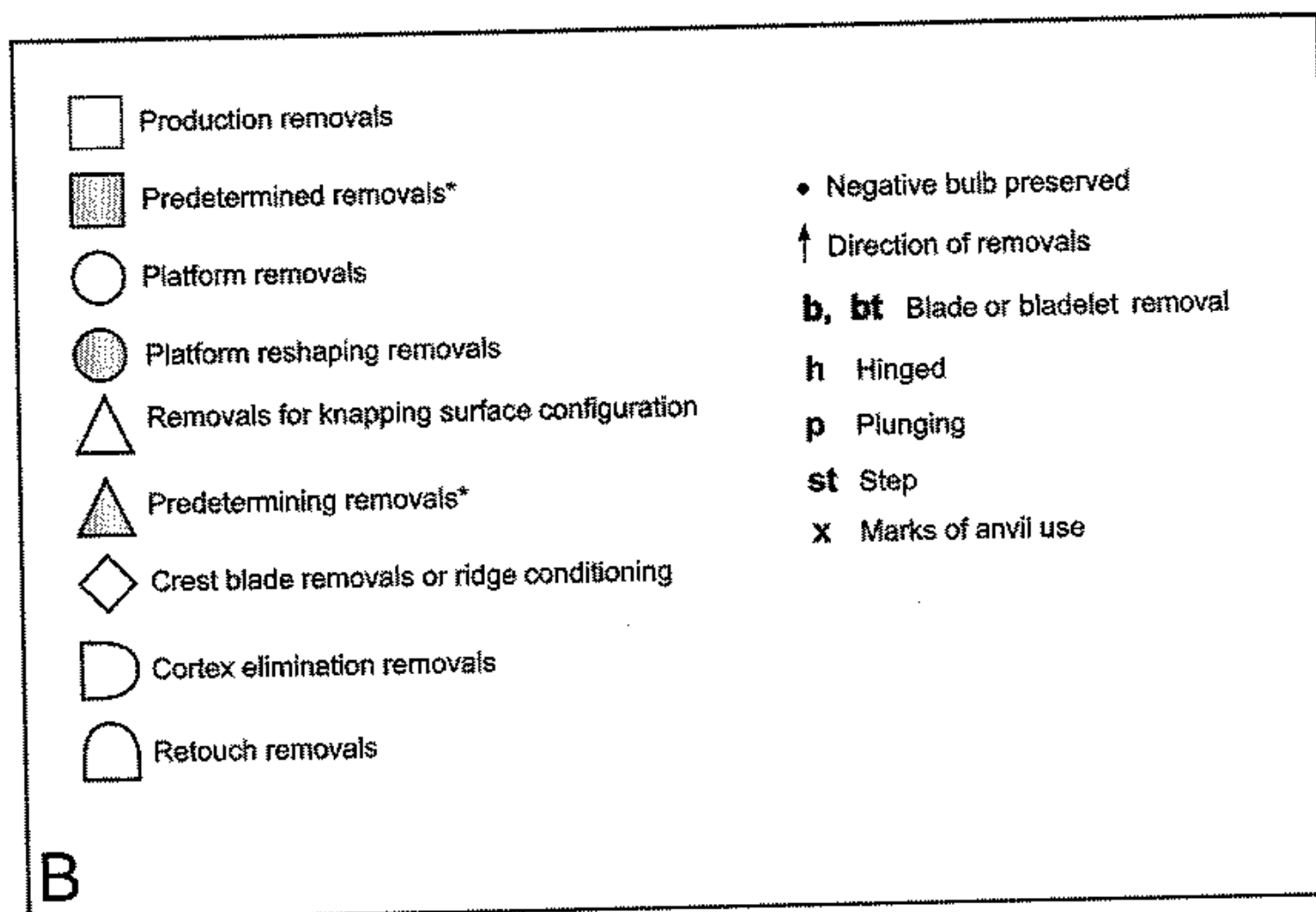
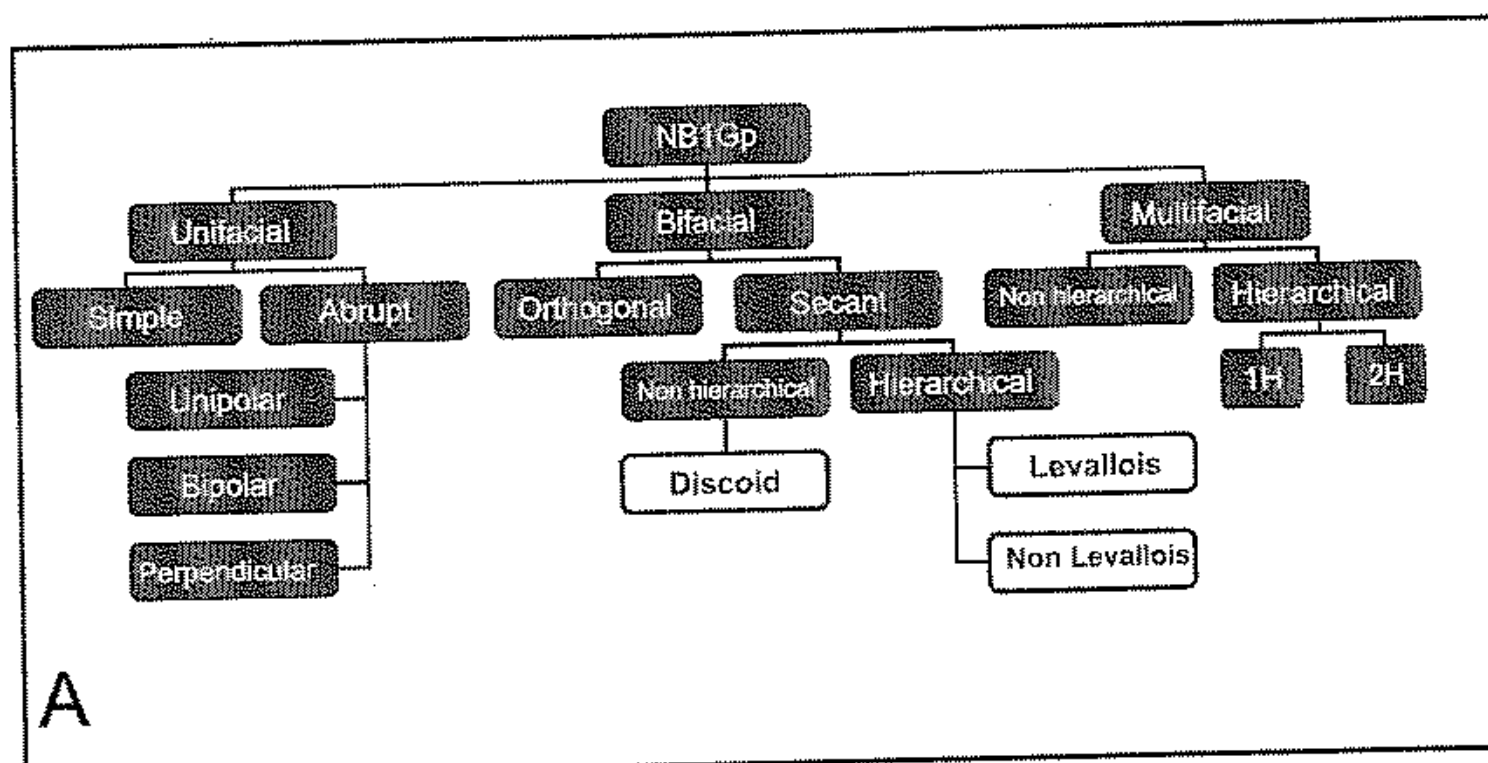


Figure 1. A. Scheme of the classification of the cores. Modification from Castañeda, 1999. B. Symbol code used in the core diagram. \*It refers to the concept of predetermination used by Boëda in the sense that there is an initial idea of the final product and it needs a complex configuration of the knapping surfaces in order to be materialized. That is, there are some predetermining removals whose purpose is to prepare the surface for the removal of the desired predetermined blank.

Unifacial cores can also be centripetal. Multifacial cores can also be classified in the same way according to the direction of the removals if they present one or two knapping surfaces destined to production. This is the case of blade cores with one unipolar or bipolar knapping surface.

This classification is very useful when working with flake cores. Blade cores are usually more complex, so a specific classification of multifacial cores is needed. Nonetheless, it is a basic system of classification. It only provides a scheme to sort out cores; therefore, to obtain more technological information another tool is required.

### Core diagram

In order to capture the technical information and the chronological order of the work a core diagram is proposed. The first aim of this method is to provide a graphical representation of the sequences that have contributed to the "history" of the core. Secondly, it attempts to describe the reduction strategy. Finally, it tries to become a tool for the quantification of data and to represent this quantification for it to be intelligible in a glimpse. The diagram is inspired in some concepts of Harris' stratigraphic method (Harris, 1979). As a site is the result of an accumulation of different anthropic activities during a period of time, the cores present the evidences of different phases of the knapping reduction sequence. Removals in a core may cut and modify previous ones, in the same way as some strata cut other strata and give form to the final complex appearance of a site.

Some requirements are needed to use the core diagram. In the first place, it is necessary to take into account both a concept of knapping surface which includes the striking platforms, and their delimitation. In the second place, it is necessary to identify the purpose of the removals and knapping surfaces, which is sometimes very difficult. Once this has been explained, grouping removals in sequences is easier; that is, a sequence is composed of a group of removals with the same aim. Finally, it is important to order extractions in a chronological order. This task usually presents some difficulties and may sometimes be impossible for all the removals.

The core diagram consists in a representation of all the removals — with the possibility of summarizing some of the less important ones — in their respective knapping surfaces, which are represented in columns.

For core diagrams to be comparable, some rules have to be established, so that information is always represented in the same way. Unifacial and bifacial cores are easy to represent. The first knapping surface must be placed on the right and the second on the left.

But when there are more than three knapping surfaces it is important for the diagram to be easy to understand to place each knapping surface carefully. A third knapping surface usually affects the previous ones, so it is better to put the first one and the second one at the sides and the third between them. When this happens, a bifacial core becomes



trifacial. Sometimes a unique knapping surface may be modified by two new surfaces. This way, a unifacial core becomes trifacial. In that case, the first knapping surface must be placed in the middle.

A fourth knapping surface must be placed at the left of the third one, and a fifth must be positioned between the third and the fourth ones. This rule of placement of the knapping surfaces is not very strict. The aim is to arrange the final sequence in the middle, specially if it is composed of production removals, and show the diagram in a simply way. The knapping surfaces must be named in chronological order from the first to the last.

Each removal is numbered by their order in the reduction sequence. Oldest removals must be put at the base of the diagram and successive ones over them joined by a line. If it is impossible to sort certain removals in time they must be placed at the same level joined with a discontinuous line. The aim is to represent the temporal sequence, so redundant lines must be omitted.

A symbol code is proposed in order to explain the purpose of each removal, as Figure 1.b shows. The direction of removals can be placed next to the symbol of the extraction with an arrow. The orientation of these arrows must reflect the possible turns that have taken place during the knapping process. Therefore, orientation of the core is very important. As a general rule the main knapping surface determines the orientation of the core, with the last removal of that surface oriented with the negative bulb in the upper side. The main knapping surface is the one with a higher degree of production work. If one such surface does not exist or if there is more than one with a similar degree of production work, the main knapping surface will be the one with the biggest amount of work.

Once the core diagram is finished it is easy to represent all the quantitative data, such as the area employed in each sequence, weight reconstruction and volume of raw material spent, proportion of removals involved in each phase of the reduction sequence, or whatever aspect we wish to quantify. This is an important potential of this method, because quantification allows comparison.

The graphic representation of the classification of each removal by means of its purpose allows them to be grouped into different sequences of work. The diagram also allows for the inclusion of any kind of qualitative or quantitative data we may want to obtain from each removal: dimensions, angles, qualitative variations of the raw material, knapping method employed, etc. Therefore, we can compare different cores not only by means of a morphological description, based in the researcher's experience and subjective interpretation, but also using data we can observe in a glimpse without the disturbing effects of the complex morphology of a core. The core diagram can behave as a map that we can codify with different types of data and then we can make not only technological, but also social and economic interpretations. Several cores can be similar in morphology, and they can also display a similar succession of sequences, but they may be different in other characteristics that we would not be able to apprehend using only diacritic schemes

or long descriptions, like the quantity of raw material expended in each stage of the reduction sequence, for example.

### Some examples

To try out the core diagram two examples from Casa Montero flint mine (Madrid, Spain) are presented here (Figs. 2, 3, and 4). There is an important assemblage of more than 1800 classified cores, from 52 classified mine shafts with radiocarbon dates of 5400-5200 cal BC (Díaz-del-Río, *et al.*, 2006). Casa Montero has provided new insights on the Iberian Neolithic due to its chronology, scale, location and function. In addition to that, the lithic remains documented offers us with a picture of a big area of intense work, where there were probably several knappers, and showing a very interesting variability of reduction sequences. What Casa Montero presents in lithic technology is what we usually cannot find in domestic sites; that is, all the work previous to obtaining blades, including a complex system of decisions ranging from nodule selection, to assessment of the effort needed, productivity and volume of raw material squandered in the final moment of abandonment.

Two different cores from the Casa Montero assemblage have been selected. In Figure 3 we can observe a trifacial core made on a big flake blank (classified as MF 1H). The first sequence is to create a striking platform by removing the proximal end of the flake (KS1). Then, two knapping surfaces (KS2 and KS3) that intersect between them are made to configure the necessary convexities in order to extract a blade series developed in surface (KS3). There is a limited recurrence in this exploitation, so the core needs to be reconfigured. The work was interrupted at this point (Fig.2 and 4a).

As we have seen both in figures 2 and 4a, the main knapping surface (KS3) is not the first that was worked, but the surface that contains the production removals. We can see in the core diagram (Fig. 4a), that alternating series of configuration removals take place in KS2 and KS3. The small quantity of work in KS1 means that the reduction method carried out in this core did not require any rejuvenation of the striking platform, while KS2 and KS3 present the most intensive work (configuration and production).

We can also notice the systematic organization of the work with consecutive sequences of bifacial configuration of knapping surfaces 2 and 3 and production of blades in KS3. We can deduce from the absence of a new series of blade removals that the core is not exhausted, so we have to resort to other kind of explanations for its abandonment, such as inappropriate angles or excessive convexity as a result of a deficient reconfiguration work. A knapper with little skill might have been working on this core.

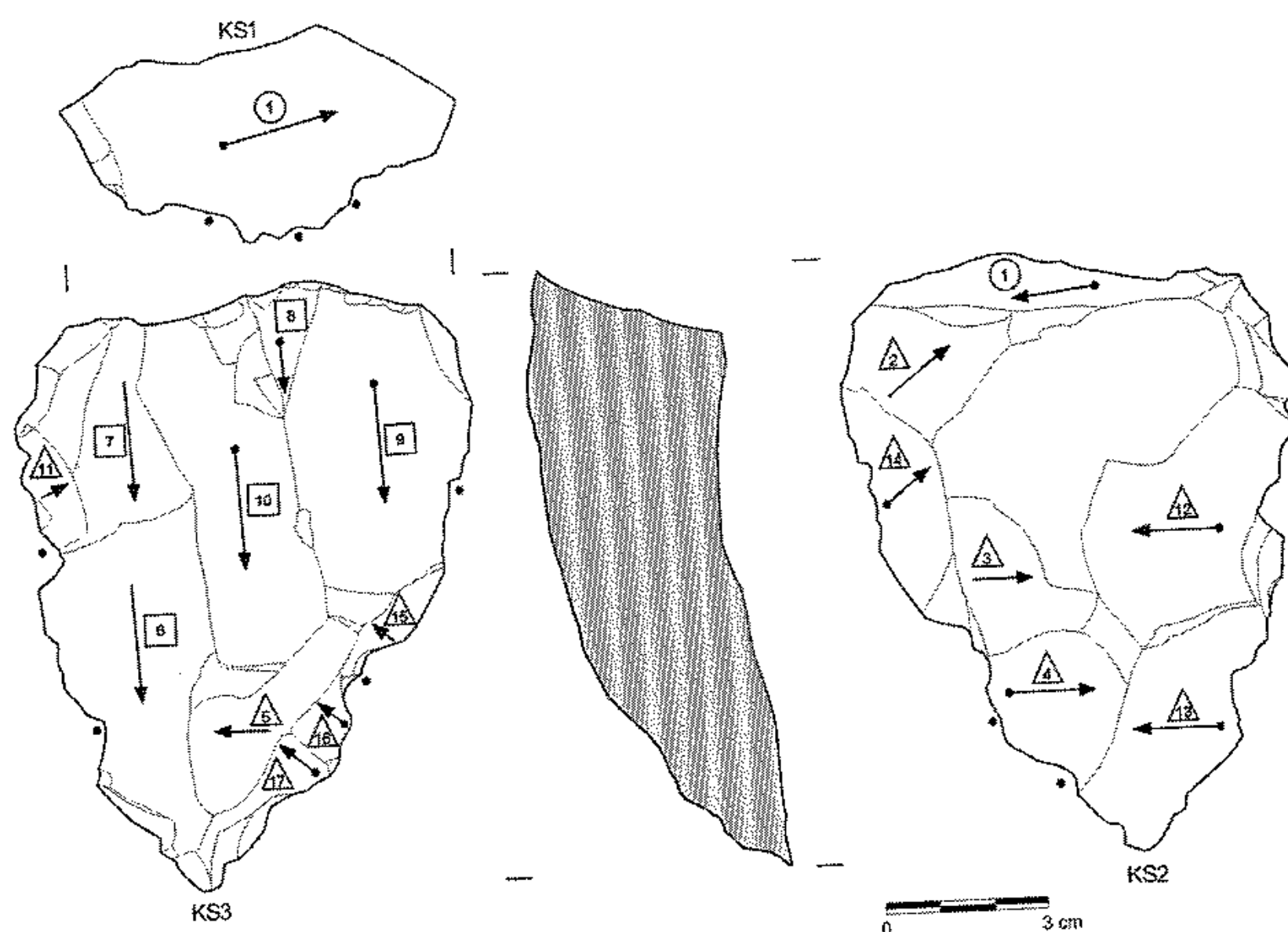


Figure 2. Drawing of a core from the Casa Montero flint mine classified as a multifacial with three knapping surfaces (MF 1H).

The other example shows a blade multifacial core (MF 1H) with four knapping surfaces (Fig. 3 and 4b). This core preserves a little of the initial configuration in KS1, KS2 and KS4. There has been an important work in the striking platform in order to rejuvenate it by means of the removal of small flakes and abrasion (KS3). The process ends because of the presence of veins while removing a series of recurrent blades in KS4.

The main knapping surface that rules the orientation of the core is KS4 (Fig. 3), because that is the only one that presents production removals. However, the knapping surface with a bigger quantity of removals is KS3 (Fig. 4b). The reduction method that has been used in this example gives a lot of importance to a very delicate work of configuration of the striking platform (KS3).

The work that has been carried out in this core is very systematic, with a precise succession of the different stages of the reduction method. As a consequence of this organization of the work, it becomes more efficient.

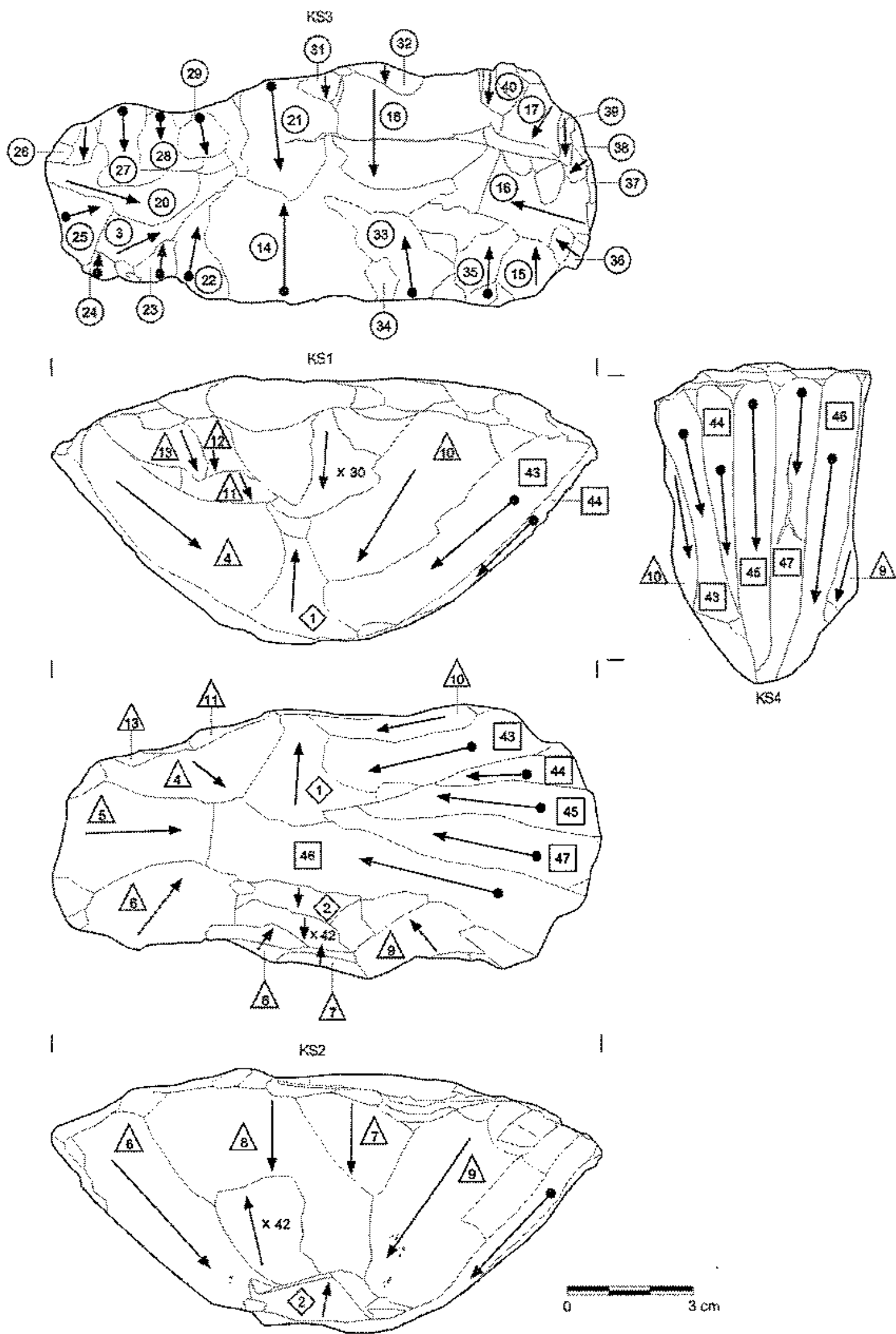


Figure 3. Drawing of a core from the Casa Montero flint mine classified as a multifacial with four knapping surfaces (MF 1H).

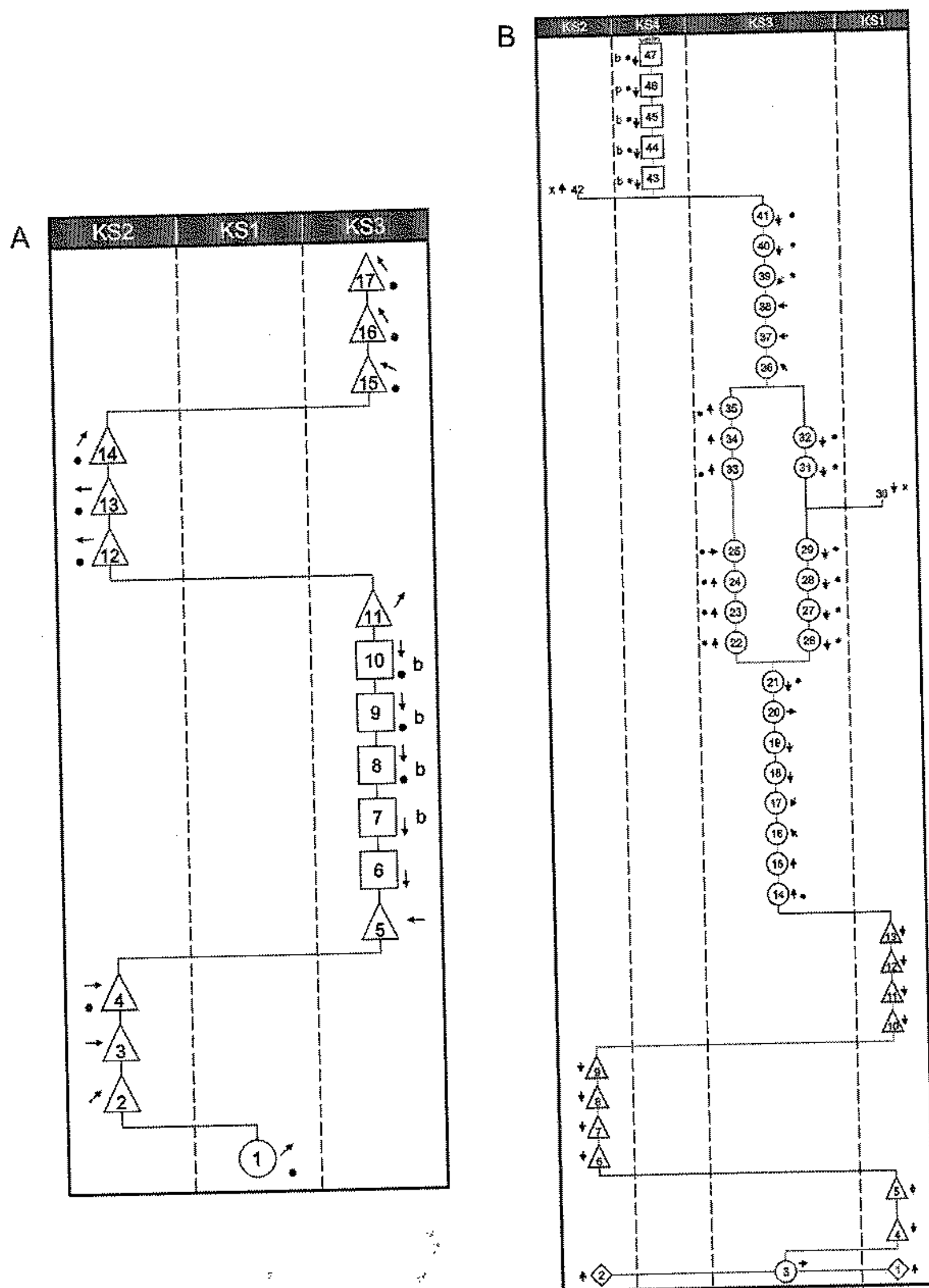


Figure 4. Diagrams from both previous cores. A. Core classified as a multifacial with three knapping surfaces. B. Core classified as a multifacial with four knapping surfaces.

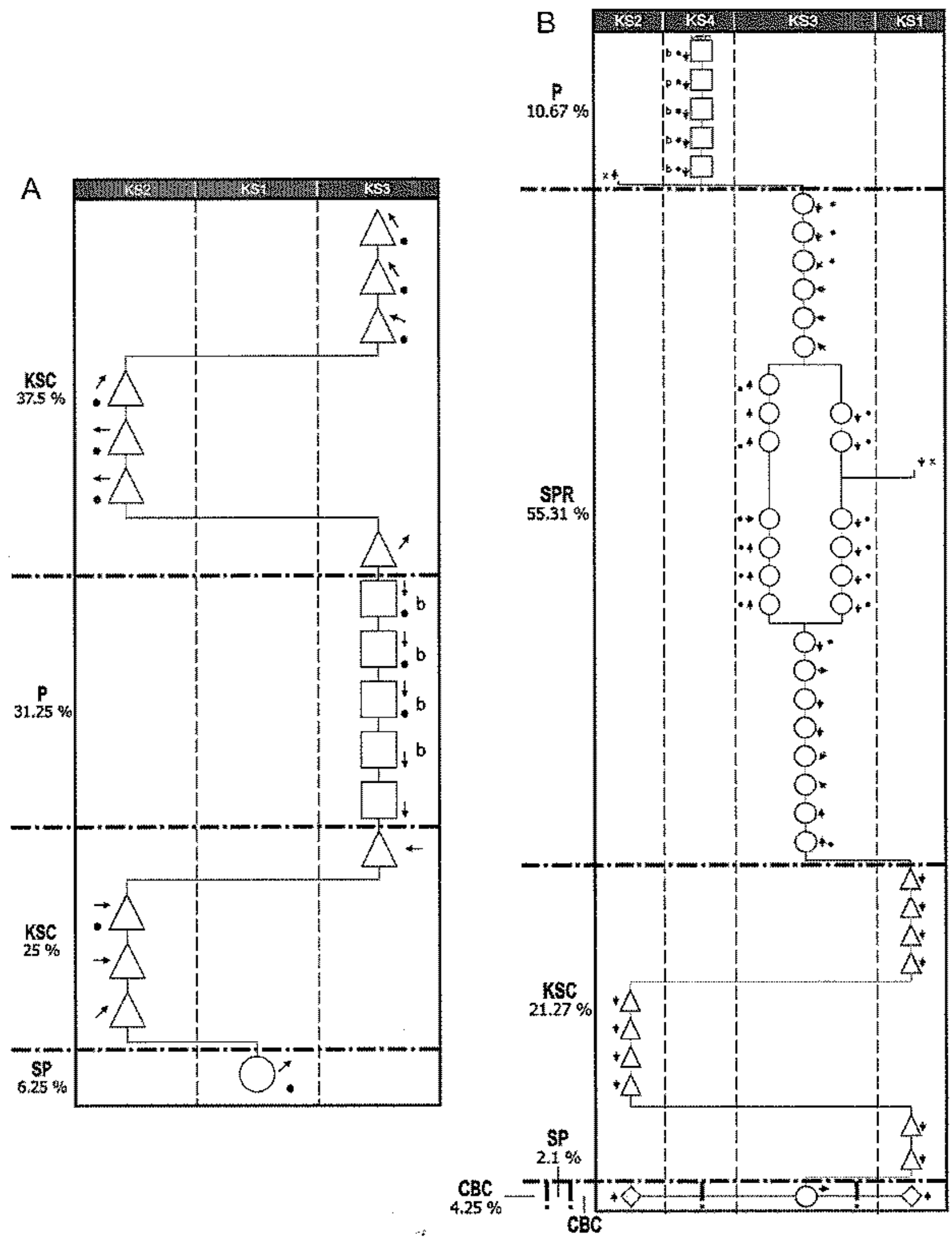


Figure 5. Comparison of the two core diagrams presented in this paper, with an example of the representation of the amount of work in each one. P: Production; KSC: Knapping Surface Configuration; SP: Striking Platform; SPR: Striking Platform Reconfiguration; CBC: Crest Blade Configuration.



We can compare these cores by means of the representation of the amount of removals of each phase of the *chaîne opératoire*, for example (Fig. 5). Therefore we can assess the differences in productivity and the variable moment and reasons of abandonment of each core.

Through this criteria, we can notice how different the amount of gestures employed in the striking platforms of both cores is. If we look at the representation of the number of removals, it seems that the first one, with 31,25% of the removals dedicated to production, had better results from the point of view of productivity than the second, with only 10,67% of production removals. But we cannot ignore an important kind of information expressed in the diagrams, which is the systematization of the work. The production sequence in the first core is followed by a reconfiguration sequence, so we do know that there were only five blade removals. On the contrary to that core, the final sequence of removals in the second core is the production sequence, so we can suggest that there were more than five blade removals. We should compare other kinds of information, like size of removals in each stage of the reduction work, in order to assess the efficiency of each reduction sequence. In a core diagram that represented this kind of information we would be able to see that the reduction sequence used in the second core (Fig. 5b) is more efficient than the first one (Fig. 5a).

### Concluding remarks

As concluding remarks, in this paper a system of representation of the information that a core provides is presented. The complexity of a number of factors involved in the final shape of a lithic core must be sorted and summarized in order to make it intelligible.

A simple system of classification is needed to classify any kind of cores, from the simplest ones to the most complex, even the non-standardized ones.

With the assistance of the classification and the diacritic schemes (Dauvois, 1976) it is interesting to carry out a core diagram where all the removals are placed in their respective knapping surfaces arranged in temporal order from the first to the last ones.

The interest of this method is that it allows comparisons among different cores and also the quantification of any kind of attributes or information provided by cores (Fig. 5). The diagram expects to leave the subjective information and the disturbing effects of the final shape of a core out. This method allows us to make a fast reading when a great amount of information is involved, as is the example of Casa Montero and other production contexts. It is possible to sort the information disregarding unnecessary details and focusing on what is important. Working with this core diagram it is possible to establish new classifications of, for example, blade and other standardized cores concerning issues such as productivity.

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