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Experimental Flintknapping Replication-A Valuable Method of Archaeological Analysis

Deborah Olausson

Experimental flintknapping in the science of archaeology has a long history. One of the first to use flintknapping in order to explain prehistoric processes was Sven Nilsson, who had knapped gunflints since his childhood (Johnson 1978: 337). One of the issues which was of great interest to the archaeologists was the origin of the so-called "thunderstones"; *i.e.*, handaxes. At the international congress in prehistoric archaeology in 1868 held in Norwich, England, Sir John Evans demonstrated that he could manufacture similar objects merely by using stone tools. Thereby he could support the growing understanding that the human hand manufactured these objects a long time ago (Johnson 1978: 337). In the following article, I will be looking at the various ways in which replicative flintknapping has been used in interpreting the archaeological record. Most of the examples come from Scandinavian archaeology.

Since this modest but important beginning, replicative (to replicate = to make an exact copy) studies of flint tools have come to play an increasingly larger part in the field of archaeology. Today there are hundreds of people who deal with flintknapping (Olausson 1998). However, the majority are not archaeologists by profession; rather they flintknap in their spare time. In this article, interest will be focused on flintknapping as it can be used to answer questions about what we find in the archaeological record. Since it

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takes many years of practice to become a skilled flintknapper, there are few individuals who have both the detailed archaeological knowledge and the skilled craftsmanship that characterize a dexterous flintknapper. Errett Callahan, with his knowledge of both fields, is quite exceptional in this respect. When this combination is lacking in a single person, cooperation between the flintknapper and the archaeologist can lead to results that neither of them would have been able to achieve on his or her own.

By way of introduction, it is necessary to clarify what we mean by the term "experimental". "Experiment", particularly within the natural sciences, means testing a hypothesis under controlled circumstances. However, in our everyday language, we use the word in a somewhat broader sense and mean practical activity in order to answer a question. In this chapter we will apply the latter sense of the word "experimental". In other words, we will discuss a number of different experiments where replicative flintknapping has been used to solve or cast light upon central archaeological issues. In most of his writing, Errett Callahan has been careful to explicate what he means by the term "experimental".

Replication

The goal of many flintknapping projects is making a copy of a prehistoric object. When the "modern" art of flintknapping was young, flintknappers spent a lot of time finding different ways to achieve the desired effect. At that time it was the product, rather than the process, that played the central role. Therefore, most of the earliest literature was filled with practical "tricks" that were designed to solve specific problems with which the flintknappers were faced (see, early issues of the magazine *Lithic Technology* or *Flintknappers' Exchange*). In earlier works, it is evident that certain flintknappers used knapping tools made of modern materials (see the Danish knapper, Anders Kragh 1964).

Once many of these practical difficulties had been solved, experimental flintknapping entered a new phase where not only the *product* but also the *process* was deemed important. Those interested in flintknapping now began to consider manufacturing stages in reduction. The American flintknappers Errett Callahan (Callahan 1979) and Don Crabtree (Crabtree 1966, 1967a) were early spokesmen for this way of thinking. It was understood that the reduction technique (*i.e.*, how the mechanical power is transferred from the flintknapper to the stone) and the reduction method (*i.e.*, the order in which technique, platform preparation and impact or pressure is applied) leave information which is valuable to our understanding of the processes (Madsen 1992: 95).

Therefore, experimental flintknapping that is aimed at acquiring this type of knowledge gives us new possibilities for understanding the thought processes underlying every separate reduction sequence, what is often called *chaîne opératoire*. Through our understanding of the different choices, the conscious as well as the unconscious ones,

which the separate reduction sequences express in an archaeological collection, it should be possible for us to also understand the cognitive processes of the prehistoric craftsperson (Karlin and Julien 1994, Madsen 1992, Pelegrin 1990).

Manufacturing stages

Flintknapping is a subtractive process; *i.e.*, material is removed in order to achieve the final product. What is removed, the flakes, is not destroyed and it can be studied. But the flakes become comprehensible only through replicative experiments. For the experienced flintknapper, the flakes are a source of information about the technological processes, platform preparation, angle of impact, soft or hard technique, etc. Through studying the flakes as well as the final product, the flintknapper also gains an insight into the stages that his or her ancient counterpart used in manufacture (Callahan 1979, Crabtree 1966, Newcomer 1971, Whittaker 1994). These stages are to some extent defined by the physical properties and also by certain technological properties of the flint raw material. But the flintknapping process also means that the craftsperson is constantly faced with different choices (Whittaker 1994: 206). Which decision the flintknapper makes is dependent on many different factors: his or her skill, possible limitations concerning time or raw material, the flintknapper's own preferences, and the technological tradition in which the flintknapper is schooled. These factors illuminate some of the possibilities offered by experimental flintknapping for an analysis of archaeological material.

Skill

Experimental flintknapping can help us to judge the degree of skill in at least three ways. Firstly, the experienced flintknapper can shed light on his or her perceived difficulty in making a certain type of artefact. Through such studies, modern flintknappers have reached a number of postulates concerning the degree of difficulty for different manufacturing operations. For example, artifact size is an important factor. Most of today's flintknappers agree that the degree of difficulty increases exponentially with object dimension, it is much harder to make a 30 cm long blade than it is to make one which is 10 cm long (Pigeot 1990: 130).

Secondly, modern flintknapping experiments have tried to identify properties in both the flakes and the artefacts that enable us to discern and describe the degree of skill represented by a certain material. Jean Arnold has for example studied cores from two chronological phases in a settlement belonging to the Chumash Indians in California. Through quantifying the number of knapping mistakes per core from each phase, she saw that there were far fewer mistakes in the later industry. Her conclusion was that there were specialists in the latter context (Arnold 1987: 232-ff.). This direction has above all

been applied on American material (see, Costin 1986, Michaels 1984, Shafer and Hester 1983), but some studies have also been made based on European material (Olausson 1983a, 1992, Stafford 1995).

The growing interest in flintknapping has in later years encouraged the establishment of more courses in the subject. These have among other things led to a growing interest in how individuals learn flintknapping and if there are any innate properties that make some more skilled than others (Olausson 1998, in press). Based on his own experiments, N. H. Shelley has been able to demonstrate that it is possible to discern flint material made by a beginner (Shelley 1990: 187). This type of analysis opens up the possibility of identifying beginners in the archaeological material as well. Nicole Pigeot has established three degrees of skill in flint manufacture at the site of Etiolles from the Magdalénian Period (Pigeot 1990, *cf*. Karlin and Julien 1994) (Fig. 1).

By taking his own flintknapping experiments as a starting point and studying cores and flakes from the Late Palaeolithic Trollsgave settlement, Anders Fischer drew the conclusion that flintknappers of varying degrees of skill had been working there. Moreover, he suggested that the least skilled of these was a child (Fischer 1990: 44). Examples where children become visible in the archaeological material are few (but see, Derevenski 2000), which is why this example points to exciting possibilities for further research.

Raw material

The flintknapper is the person who is best suited to make statements regarding different raw materials' suitability for knapping (Crabtree 1967b). In the term "suitability" there are many qualities which are partly culturally, partly technologically determined. The category of raw material that we call "flint" includes in reality many different materials with different properties. One property, but not the only one, that may have had importance for prehistoric man, was the workability; *i.e.*, how easy the material was to work. This must be weighed against for example accessibility when it comes to answering questions surrounding the suitability of the raw material (Jeske 1989, Olausson 1983a, 1983c). Lis Nielsen, for example, has been able to establish that the Early Neolithic people in what is now Denmark preferred Danianflint, which contains coarser material, when making thin-butted axes. The reason for this choice, Nielsen claims, was that the coarser material made the axe tougher and therefore more durable when used. On the other hand, this coarseness meant that the Danianflint was *harder* to work than a more fine-grained flint. Neolithic knappers then had to take into consideration both of these conflicting properties when choosing their raw material (Steinberg and Pletka 1997). Practical experiments, involving production as well as use, can help us understand how the properties of the raw material influence these variables. The next step will be to contemplate how prehistoric people could have weighed the different costs and on which

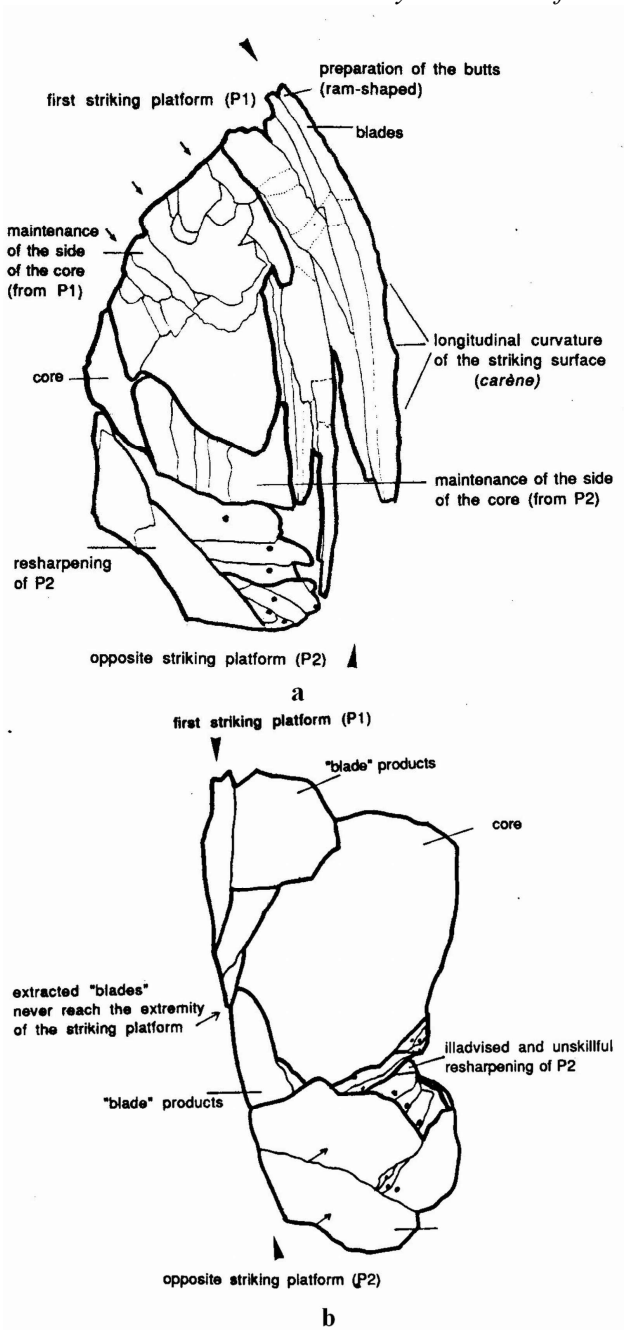

Figure 1. Two refitted nodules from Etiolles. a) shows a nodule whichhas been knapped by an experienced and skilled flintknapper while, b) shows a nodule which has been worked by a less experienced knapper, according to Pigeot's analysis (From Pigeot 1990, Figs. 2 and 5).

bases they made their choices (Högberg 1997).

Another beneficial effect from working with flintknapping is that archaeologists are better prepared to recognize knapping debitage from other materials besides flint, at least in the cases where the material has conchoidal fracture as flint does. An example of this is Lars Sundström's and Jan Apel's studies involving the manufacture of thin-butted axes of porphyry at the Funnel Necked Beaker site of Skumpaberget 2 in Närke, Sweden. Through their own experiences of flint axe manufacture and Apel's cooperation with Errett Callahan, these researchers have been able to analyse and describe a manufacturing sequence for porphyry axes much like the strategy for thin-butted axes made of flint (Sundström and Apel 1998). In this case, the understanding of the "language" of the flint has made other kinds of archaeological material comprehensible to the archaeologist (Callahan 1987).

Modern flintknapping has also meant that archaeologists are better prepared to recognize knapping tools used for the production of artifacts (Crabtree 1967a). The rounded and damaged spheres of flint that are often termed hammerstones have probably been used for pecking of non-flint material rather than for flintknapping (Harm Paulsen, personal communication, 1995). Through experiments with bipolar technique, Errett Callahan and Kjel Knutsson discovered a number of oddities on hammerstones and anvils that could be used as an indicator of work using bipolar technique (Callahan 1987).

Revealing the flintknapper

As we have mentioned before, the advantage of experimental flintknapping is that traces of many stages of the manufacturing process the flakes can be accessible in the archaeological record. In this way, the process is different from for example pottery manufacture and bronze casting, where many of the manufacturing stages become invisible to the archaeologist. Since many of our modern flintknappers are self-taught, they have developed a personal style which is often visible through close study of the knapping debitage. Furthermore, it is evident that there are different ways of achieving the same result (Coles 1979: 163). Through experiences from flintknapping experiments, we can examine a collection and -at best- discern "fingerprints" from individual flintknappers. As two examples of flintknapping experiments where the purpose was to identify criteria for discerning individual prehistoric flintknappers, John Whittaker's (1987) and Joel Gunn's (1975) are worth mentioning.

Whittaker's study was based on material from a Pueblo settlement in southwest U.S.A. named Grasshopper Pueblo. Whittaker claimed to be able to discern groupings of points in the burial material. He proposed the hypothesis that these groups represented points made by different individuals. To test this, he carried out the following experiment: He chose one of the prehistoric points and he and four other modern flintknappers tried to

copy this point (Fig. 2). Although all of the flintknappers had attempted to replicate the *same* point, Whittaker's statistical analysis showed that the points made by each flintknapper could be discerned because of their different morphological characteristics (Whittaker 1987). An analysis like this could probably only be carried out on relatively complex forms where a certain degree of skill is required. The Scandinavian flint material contains shapes of varying degrees of complexity -ranging from unworked flakes to pressure-flaked daggers. Individuality in the simplest artifacts would not be easy to detect whereas it might be in the more complex ones. Controlled experiments that might give us an idea to where the limit is drawn have not yet been carried out.

Gunn's study population consisted of prehistoric artefacts from Idaho. With the help of a measuring method that uses laser beams, he tried to register flake traces on 30 bifacial objects, of which 25 had been made by modern flintknappers. A statistical analysis of the measurements showed that it was possible, in this study as well, to discern the work of different individuals (Gunn 1975). These and similar studies have shown that there is room for individual preferences, both conscious and unconscious ones, in the flintknapping craft. Through experiments with modern flintknappers, we can attempt to reach measurable properties on prehistoric artefacts that can make it possible to discern an individual knapper.

The operative scheme: *chaîne opératoire*

One of the cornerstones of archaeology is the idea that similarities between objects can be ascribed to temporal and cultural kinship. Flintknapping experiments have led to the insight that similarities in debitage, as well as between products, also can be used to discern groups in time and space. The idea is both simple and logical: the same normative system that regulates the appearance of tools also regulates the path that leads to the final product. The different choices of method, working position, technique, etc., that the flintknapper makes on the way to the goal are also partly culturally determined. We call this the operative scheme or *chaîne opératoire* (Short 2003). Therefore, thorough studies of flakes and flint objects can give us information on the cognitive system that underlies the dynamics of flintknapping.

A good example where this approach is applied can be found in Kjel Knutsson's dissertation *Making and Using Stone Tools* (Knutsson 1988). Central in this work is the postulate that similarities in the process of decision making in flint working, and in this case also quartz working, should be interpreted as the result of information transfer between individuals: the greater the similarities, the greater the degree of direct communication. Knutsson carried out manufacturing series that he compared with flint and quartz material from a number of Middle Neolithic settlements in Västerbotten, Sweden. With the help of among other things this method of analysis, Knutsson was able

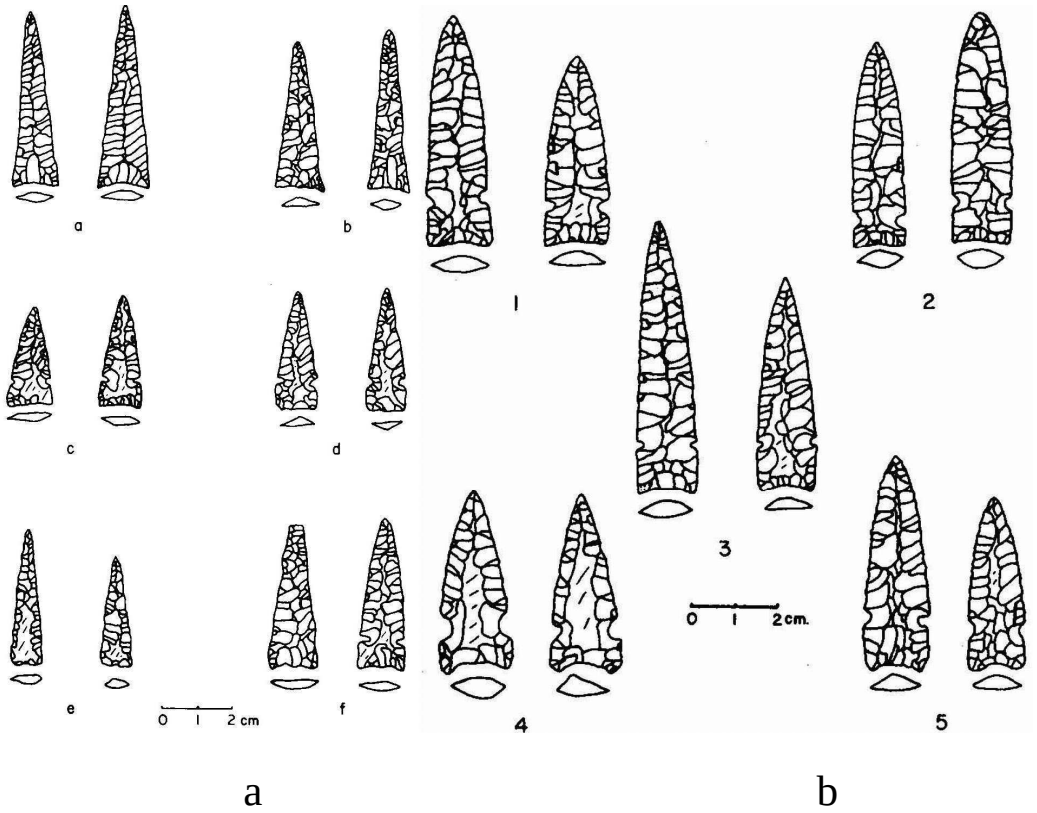

Figure 2. a) selected examples of points from 6 different burials at Grasshopper Pueblo in the southwestern US. Similarities between the points led Whittaker to believe they had been made by the same individual. The point to the right at "f" was chosen as a prototype to be copied by the modern knappers. b) points made by 5 modern knappers. All have tried to copy point "f" (Whittaker 1987, Figs. 2 and 5).

to distinguish between *in situ* development, diffusion, and immigration. The dissertation thus demonstrates how experimental flintknapping can help us to realize the research potential latent in an artefact category which is numerous but not sufficiently utilized; namely the flakes.

Bo Madsen's work with the Hamburg Culture's flint technology at Jels can serve as another example where experimental flintknapping has led to far-reaching conclusions about cultural affinity. Madsen's starting point was a large collection of late Paleolithic flint flakes and tools from Jels in Jutland. Madsen's goal was to study not only the retouched flints but also the flakes: "The unretouched flint is seen not only as a typological object, but as a product which is the result of a number of both functional and technical processes" (Madsen 1992: 93, my translation). Because of his studies of the Jels

material, Madsen was able to identify differences in technology between the Havelte phase and the Bromme phase. Madsen performed a series of goal-directed and controlled knapping attempts with blade manufacture in order to understand these two technological environments. All products were collected and all "cognitive", *i.e.*, intentionally manufactured, blades were numbered during the experimental reduction. The experiments and the observations from analysis of the prehistoric blade industries showed that the operative scheme used in the Bromme and Hamburg traditions respectively, were based on different lithic reduction methods (Madsen 1992: 113).

Manufacturing time and object value

Experiments with modern flintknapping can be used to estimate the time required for different manufacturing processes. Since we can never know if our work rhythms corresponds to that of prehistoric people, the goal of such experiments can never be to reach an exact answer about prehistoric time. But a series of time-controlled experiments can give us an estimate of relative time values. In these cases, we assume that the time we require for completing a task is a maximum time.

If one assumes that time had value for prehistoric people as well (Olausson 1986b), one of the criteria that should be useful in a discussion of object worth is how much time is invested in any particular task. For example, the author has used time-controlled manufacturing experiments in comparing thin-butted and thick-butted axes made of flint with similar axes made of "greenstone". The manufacturing experiments covered knapping and pecking as well as grinding. The results indicated that there was no significant difference in regard to manufacturing time between axes of flint and axes of greenstone (Olausson 1983a). Moreover, practical experiments with thin-butted axes of flint showed that a lot of the grinding on the axe body did not enhance the axe's performance, which led to the conclusion that the grinding may have had a social/prestige role rather than a practical one (Olausson 1983b).

One way of investigating the importance of this is through experiments. Based on a number of manufacturing experiments with flint axes (Hansen and Madsen 1983, Madsen 1984, Sehested 1884), we have a pretty good idea of the time required for the different manufacturing stages, from the choice of raw material to the finished ground axe. Errett Callahan has spent many years in concentrated work to replicate the type IV Late Neolithic Danish flint dagger. He estimates that about 20 hours of effective working time are required for the manufacture of a type IV dagger (Callahan 1984). This can be contrasted to the time required for the manufacture of other object types. At the other extreme, Lykke Johansen states that she can make a Mesolithic core axe in only 15 minutes (Johansen 1996: 21). Information about the time required for the manufacture of different tools, or in the example above, of different details on an object type, may give us information about the object's or property's *relative* worth for prehistoric people.

Experimental flintknapping and settlement analysis

Modern flintknapping experiments under controlled forms can contribute important information concerning time and quantification of amounts of flakes found on sites. Such information plays an important role in archaeology's central work with interpreting excavated surfaces. Examples of issues that arise here are: How much time does it take? How many flakes are produced in the execution of a certain work? What has been manufactured here? and Which activities were carried out here?.

Curation and duration of occupation

A question which archaeologists often ask is how long a site was occupied. The answer is based on what is left at the site, and here flintknapping experiments can often give us a better perspective so that we do not overestimate the significance of objects that are in fact quite *ad hoc*. How long it takes to make a certain object is also a factor that reasonably must have been taken into consideration in the decision to bring an object or leave it behind when a settlement is abandoned (Binford 1976). Knowledge about this can therefore help us to understand what is still there and what is missing from the settlement we are excavating (Nærøy 2000). Students participating in the short flintknapping lesson included in the archaeology studies in Lund are usually amazed because it takes no more than three minutes for most of them to make a simple flake scraper, even if they have never held a hammerstone in their hands before. Anders Fischer states, on the basis of manufacturing experiments, that it takes on average 2 minutes and 29 seconds for an experienced flintknapper to make a Bromme point (Fischer 1985: 10).

Time-controlled manufacturing experiments are also valuable when the archaeologist wants to estimate duration of occupation. A carefully planned experimental program led Peter Vemming Hansen and Bo Madsen to the conclusion that the material at the axe manufacturing site Hastrup Vænget corresponded to only 40-60 working hours (Hansen and Madsen 1983: 55). Based on a similar reasoning, Fischer claimed that the amount of flakes and artefacts in Trollesgave corresponded to only one or a few days' visit at the site (Fischer 1990: 46). How much time a certain amount of flakes represent is thus valuable information when interpretation of excavated material in temporal terms is desired (Olausson 1997). My view is that experiments will lead to the insight that we often overestimate how much time/effort the amounts of flakes or artefacts represent.

What has been manufactured here?

Through experimental replication studies it can be possible for the archaeologists to identify what has been made, even if the final product is absent. This work relies on attempts to identify types of flakes that are diagnostic for specific techniques or products. Such work has, for example, been done for quadrifacial axe production (Burton 1980,

Hansen and Madsen 1983, Högberg 1997) (Fig. 3), and Callahan and Apel's ongoing dagger project is another example of this kind of work. These studies have shown that the identification of different kinds of flakes that are diagnostic for a certain tool type is time-consuming work. The value of such work lies in two areas: First for locating manufacturing sites. Secondly, if we are able to define diagnostic flake types for type fossils, we can date sites where only manufacturing refuse is present even if formal tool types are absent.

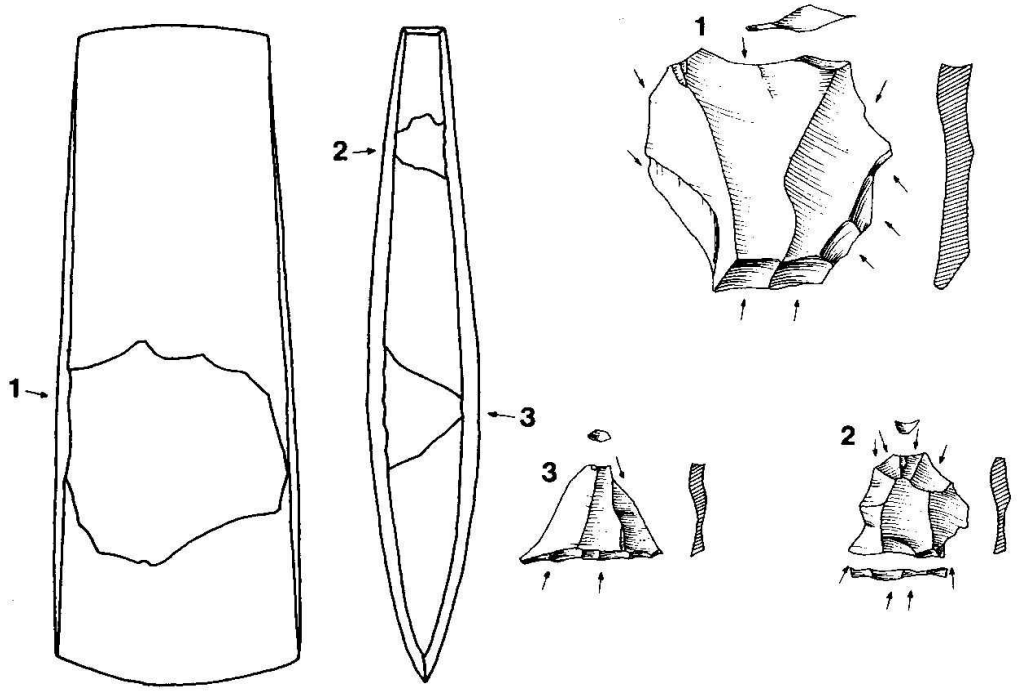

Figure 3. Diagnostic flakes for quadrifacial axe-production (Vemming Hansen and Madsen 1983, Fig. 11).

Through experiments we can get data for estimating production volumes through analysing amounts of flakes. The Danish site of Drengeås, which has been interpreted as a workshop site, is an example of this (Kempfner-Jørgensen and Liversage 1985). Lars Kempfner-Jørgensen and David Liversage estimated that there was at least 600 kg of flakes from manufacture of sickles on this site. Through experiments, one can estimate that between 900 and 1300 g flakes is produced during the manufacture of a sickle, which would mean that 450 to 670 sickles have been manufactured here. Archaeologically, the authors could see that the site had been used 6 to 10 times. This means that between 50 and 100 sickles were made each time, which the authors interpret as an overproduction

intended for trade (Kempfner-Jørgensen and Liversage 1985: 26).

Identifying knapping floors

Another common archaeological problem where experimental replication work can help us is in the interpretation of spatial patterning on excavated sites. When concentrations of knapping debitage are found, the issue arises whether this is a flintknapping site (primary deposition) or alternatively a dump where the collected flakes were thrown (secondary deposition). As an example of a test of the first possibility, we can again turn to Fischer's work with the Trollesgave settlement. In the excavation of the surface, 14,500 flint flakes were found. These were lying in concentrations with the largest in front of a small boulder. It was easy to imagine that this reflected a flintknapping site, where the knapper had used the boulder as a seat. Meticulous flintknapping experiments at Lejre Research Center resulted in a spatial deposition that was amazingly similar to the one from Trollesgave (Fig. 4). On the basis of these experiments, the interpretation as a flintknapping site was considered confirmed (Fischer *et al.* 1979, *cf.* Nærøy 2000).

However it is usually much more difficult to distinguish between primary and secondary flake scatters (Olausson 1986a: 12-ff.). Lykke Johansen initiated an experi-

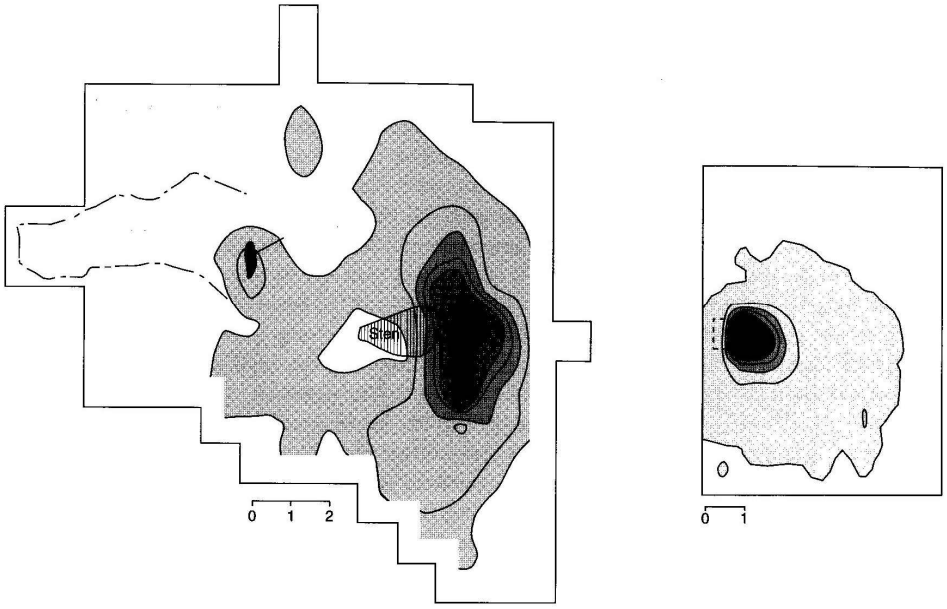

Figure 4. Left: The distribution of the 14,483 flakes recovered at Trollesgave-darker colors indicate larger concentrations. Right: The distribution of the 18,046 flakes in the Lejre experiment, registered in 0.5 x 0.5 m squares. The knapper's position is marked (Fischet *et al.* 1979, Figs. 1 and 6).

mental program to collect data regarding this. The goal of the program was to retrieve patterns that make it possible to distinguish between primary and secondary flakes on a prehistoric surface. As the image is complex and the variables are many, Johansen notes that the experiments must be repeated many times before any patterns become visible (Johansen 1996). A successful way of identifying primary flakes from flintknapping is to search for accumulations of microdebitage; *i.e.*, flakes that are 0.5 mm or smaller (Fladmark 1982).

Taphonomic processes

Experimental flintknapping can also help us to achieve better knowledge about taphonomic processes. An example of this research direction comes from Early Paleolithic sites in Koobi Fora, Kenya, where the violent natural forces and the long time-span make interpretations difficult (Schick and Toth 1993: 190-ff.). Kathy Schick and Nicholas Toth's experimental programs have involved constructing a number of living floors in different natural settings. After careful documentation, Schick and Toth left these artificial sites to their destiny: somebecame flooded, some were disturbed by animals, and others were washed away by heavy rains. Schick and Toth checked the sites periodically in order to document how these processes changed the original depositional patterns. Through these controlled experiments, archaeologists gained better knowledge that helped them interpret the patterns even on the earliest sites were accumulations of flakes, worked objects and bone remains have been found. We can hope that this work will allow researchers to be able to identify the degree of disturbance at each setting, in order to be able to interpret the link between the remains and the behaviour that created them.

Artifacts, eoliths and apes

We can conclude this chapter with an issue that was especially pressing when archaeology was a young science, namely how to distinguish between naturally and humanly worked flint. In 1910, S. H. Warren made one of the earliest attempts to attack this problem through experiments. The goal of Warren's experimental program was to imitate natural processes that might work flint and produce results similar to human actions. In this way, he hoped to reach a conclusion about what characterized naturally knapped flint and what could be identified as humanly knapped flint. Warren's conclusions, namely that the processes were the same and that it therefore was impossible to tell the difference on a single object, were also supported by the contemporary flintknapper Louis Capitan (Johnson 1978: 343-ff.). Seventy years later, Barbara Luedtke analysed a number of obsidian nodules that had been transported in a bag from Idaho to Michigan. Like Warren and Capitan, she concluded that it was impossible to separate natural and human knapping on single objects. On the other hand, if one analyses whole

collections and searches for combinations of properties instead of looking for diagnostic criteria, the differences can be detected (Luedtke 1986: 59).

A slightly different experimental direction that is worth mentioning is studies of flintknapping in apes for the purpose of identifying the physical and cognitive properties necessary for the knapping. R. V. S. Wright at the Bristol Zoo performed directed experiments with an orangutan named Abang in the 1970's. The goal of the experiments was to get Abang to learn how to remove a flake from a core and to use it as a cutting tool. Wright's conclusion was that the Australopithecines, whose cognitive and motor abilities corresponded to those of Abang, also would have been able to learn the same skills (Wright 1972).

Schick and Toth have elaborated on Wright's work and they are working with a chimpanzee named Kanzi. Kanzi can make several flakes from a core, but Schick and Toth point out that Kanzi's accomplishments are still below the level of that which has been accomplished by the hominids at Olduvai. Kanzi simply has not developed the same understanding for flint knapping as these hominids had, which means that even 2.5 million years ago, the Oldowan hominids had a greater cognitive capacity than what modern apes seem to be able to develop (Schick and Toth 1993: 137-ff.).

Conclusion

In this chapter I have tried to illustrate the fields where directed flintknapping experiments have been used to gather information with relevance to the archaeological interpretation process. The list is far from exhaustive. Well-controlled flintknapping experiments hold a great potential through the concrete information they can give us. The archaeologist need only start asking the questions.

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I would like to thank Errett Callahan for more than 25 years of collaboration and friendship. Because he is one of the few individuals who combine highly skilled knapping expertise with a knowledge of archaeology and archaeological questions, his contribution to archaeological research has been enormous. I would also like to thank Sara Olausson for translating this article from swedish to english.

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