Experimental Heating of Flint Objects

BY LARS LARSSON

Abstract

The author has been engaged for a number of years in the excavation and study of depositions from the Neolithic that include a considerable number of flint objects, mainly axe- and chisel-heads intentionally altered by heating. Only a small number of such depositions have been identified in Denmark and Sweden, dating from the Early Neolithic until the Late Neolithic. However, small numbers of heated flint objects have been found on many sites, mainly in relation to megalithic tombs, causewayed enclosures and palisade structures. They are also found in other circumstances, such as in postholes of houses.

In order to investigate the process of heating the flint artefacts, experiments were conducted with different types of fires. The results of these are presented. It was possible to determine that the alteration of the flint objects was not the kind of spectacular pyrotechnical event with sound and colour changes that a large group of people could readily have observed. Instead, it was a process that involved heat treatment as a much less public event

Introduction

In Neolithic Southern Scandinavia, as in other areas, flint had a special position as a raw material for making a variety of tools. Flint was not only an important element of daily activities, however; it also became a catalyst of exchange and ritual. Flint became a very important element for marking relationships between people as well as their conceptions of a different world, populated by deities and dead ancestors. In the latter relationship flint axes played a very special role. Deliberate deposition of axes in Southern Scandinavia chiefly occurs in wetlands, but also in mineral soil and at special structures such as megalithic graves (Karsten 1994).

The deposition of flint tools could also involve changing the material through heating. A small number of sites have large amounts of such material, while the majority of other sites, such as megalithic graves and palisade structures, have a smaller number of objects altered by fire, primarily axe-heads and the production debitage from these tools (Larsson 2019b).

A large number of axe-heads have been found deposited in wetlands. However, just

Fig. 1. Thin-butted flint axe-head from the Strandby site, Funen, Denmark. Photo by Rógvi N. Johansen, Foto/medie afd. Moesgaard.

Fig. 2. Small pit at the Kverrestad site with axe fragments affected by fire. Photo by Lars Larsson.

a small number of these show traces of heat-alteration.

So far, just a small number of Neolithic sites in Scandinavia have been shown to have an abundance of flint objects affected by heating.

A special and so far rare type of site with examples of fire-altered flints, including a large number of fragments of thin-butted and thin-bladed axe-heads, is located on a prominent hill at Svartkylle, south-eastern Scania. In a survey of the area, at least three concentrations of fragments were found on the surface (Larsson 1989). However, no features were revealed in a test excavation, which might be due to erosion caused by heavy ploughing. Two other sites with a large number of axes affected by fire have been identified: Strandby on Funen (Andersen 2009) (Fig. 1) and Stensborg in central Sweden, south of Stockholm (Larsson & Broström 2011, 2014), dated to the Early Neolithic/early Middle Neolithic.

A similar kind of site but different in date was discovered only some 17 km from Svartkylle. At Kverrestad, south-eastern Scania,

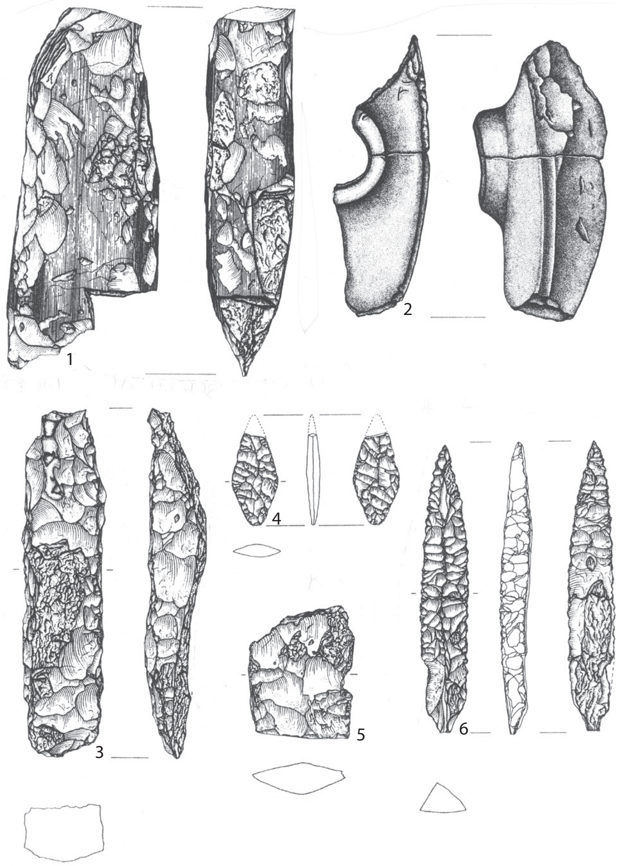

Fig. 3. Finds from the Kverrestad site, south-eastern Scania, southernmost Sweden. 1: flint axe-head, 2: fragment of battle axe, 3: flint chisel, 4: arrowhead made by pressure-flaking., 5: fragment of dagger and 6: tanged arrowhead. Scale 1:2. Drawings by Björn Wallebom.

a large number of flint objects affected by fire were found within an area of approximately 70×70 m (Larsson 2000a, 2000b, 2002). Excavation revealed a number of pits of varying size and depth, in which flint artefacts affected by fire had been deposited together with a considerable amount of fragmentary pottery. The largest pit was about 4 m long, the shortest less than 0.5 m (Fig. 2). Finds were made throughout the fill of the large pit, which shows that the artefacts were deposited during the entire process of infilling. Fragments from about a hundred thick-butted, concave-edged axe- and chisel-heads have been found, as well as arrowheads and other flint and stone tools (Fig. 3). A small number of burnt human bones, intentionally broken into small pieces just like the pottery, were also found, providing another example of the combination of humans and axes (Wilhelmsson & Macheridis 2016). The finds are dated to the late stage of the Battle Axe Culture.

As an interesting aspect of the "life cycle" of axes, it should be stressed that the axes at Kverrestad included rough, unpolished examples, where only the form had been shaped, as well as examples with very well executed polish of the entire body.

The choice of axes for destruction – or perhaps we should rather use the term *transformation* – is also obvious among the finds at Kverrestad (Larsson 2004, 2006). While more than 90% of the axe- and chisel-head finds display changes by fire, two-thirds of the scrapers, half of the tanged arrowheads and one-third of the arrowheads made by pressure-flaking – an exotic artefact form originating from central Germany (Larsson 2000b) without parallels in Scania – exhibit the same kind of alteration by fire. These marked differences point to intentional selection regarding which tool types were exposed to fire, and which were not.

Other sites have a significant proportion of objects affected by fire, but not on the same scale as those mentioned above.

At sites such as Hansted Ådal in eastern Jutland, Grønshøj on Zealand and Prinshaga in western Sweden a number of fire-damaged axe-heads were found in the course of surveys. As there is no indication of a megalithic tomb, they are regarded as ritual depositions. The finds from the former sites can be dated to the final part of the Funnel Beaker Culture (Larsson 2019a; Madsen 2019), and those from the latter to a late stage of the Middle Neolithic (Larsson & Arvidsson 2019). It is unclear whether the activities on these sites included heating of axe-heads in particular, in combination with other activities of settlement-like character, or if we are seeing here activities that were separated in time. No archaeological excavation has been undertaken.

Fire is the destroyer. Fire could also be regarded as the cleanser. The artefact undergoes remarkable changes during the act. A colour transformation takes place from natural black or grey to white. Some changes are similar to the cremation of a human body, when the colour of the bones changes to white. Ritual burning might have had a public, direct, evocative and even magical character. Fire as a medium for transformations connected with rites of passage has mainly been applied in mortuary practices, but has also been used in many other circumstances.

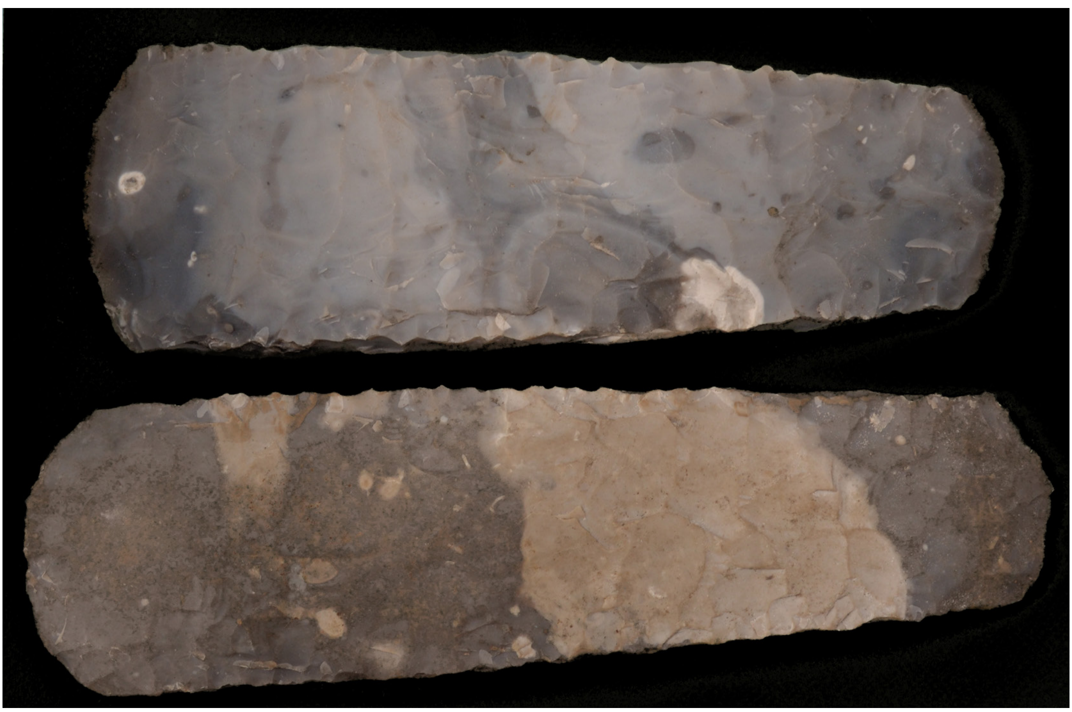

Fig. 4. Two of the axe-heads made for the experiments. Photo by Lars Larsson.

Flints in fire

The traces of heating of flints present a variety of shapes and colours. In some instances, there are just minor detachments in the form of small craters on the surface. The number of such detachments could have increased without affecting the rest of the flint object. However, in some cases the original colour might change to a reddish or blackish tone. The colour change is related to the type of flint used. The reddish colour depends on whether the flint has any iron content. Colour change might start before detachments are removed from the surface. With longer exposure to heat in a fire with free oxygen access, the flint starts to turn whitish and small fissures appear. Finally, the flint cracks into pieces.

In order to obtain a better understanding of how the intentional heating of flint objects was undertaken, experimental work was conducted at the former Historical-Archaeological Experiment Centre (*Historisk-Arkæologisk Forsøgs-center*) in Lejre, eastern Denmark. During a few days we were able to conduct experiments in order to get insight into how the heating was performed.

For the experiments, a flint knapping expert made some twenty copies of thin- and thick-butted axe-heads as well as some chisels similar to the types known from the sites mentioned above, dated to the late Early Neolithic and late Middle Neolithic (Fig. 4). The axe-heads were not ground, as this change was not expected to cause any major differences in heating effects. However, some of the flint axe-heads were placed in water for one to three weeks in order to find out whether this made any difference. It has been proven that flint absorbs water (Kragh 1964), and this might affect the object when heated. But the items intended for heating also included other flint objects, such as cores, blades and scrapers. A small number of stone axes shaped using modern stone-cutting saws were included in the test. It also included a small number of clay vessels of the kind made in the Battle Axe culture.

In our ignorance we thought that heating was performed by putting the flint objects in a big bonfire. Previous uncontrolled experiences have shown that when flints are exposed to intensive heat they more or less explode, spreading fragments some distance from the bonfire. In this case one can easily imagine that bonfires were built at certain places well visible to a large number of people, where such pyrotechnical effects could readily be witnessed.

Three separate firings were conducted: two small and one large. The fuel was firewood from various deciduous trees, supplemented with splinters and straw. For temperature recording, special thermometers employed for pottery firing were used. To record even higher temperatures, clay cones were used that start to soften at various temperatures from 1048 up to 1085 degrees Celsius. In order to examine the effect of including animal products in a hot fire, a bovine femur was added.

In the first test the artefacts were placed within a bed of about thirty wooden logs (Fig. 5). The material included grey/black rather glossy Senonian flint, some pieces having a dull brown colour. At a temperature of 260 degrees Celsius the axe-heads started to change colour to white, and shortly after reaching 270 degrees a thin-butted axe-head that had been kept in water cracked in two with a faint ringing sound. Soon after this a thick-butted axe-head cracked. The heat increased to 630 degrees Celsius. The axe-heads were totally destroyed, leaving small, white chips. Some faint sounds could be heard during the process.

The large fire, two metres in length, one metre in width and about one metre high, included a number of axe- and chisel-heads, stone axe-heads, some pottery and a bovine femur. The fire continued to burn for an entire night. All the flints fragmented, leaving

Fig. 5. The large bonfire with a number of flint and stone objects as well as pottery.
Photo by Birgitta Piltz Williams.

hundreds of white chips. The stone axe-heads showed longitudinal cracks, and the bone had fissures caused by fire. The pottery vessels were all intact.

This experiment provided some interesting results. The flint object exploded but not with much sound, and the distribution of fragments was on a minor scale. The flint fragments flew out between 0.5 and 2.5 m from the bonfire. An audience might not have seen or heard much that could have attracted interest or surprise.

The fragments of the axe-heads were mainly tiny and thin, the ordinary shape of flints one might find in the archaeological excavation of hearths, where flints could have been unintentionally affected by the flames (Fig. 6).

In the third test a smaller bonfire was created, in order to try to keep the heat level somewhat lower, but the result was the same (Fig. 7). Thus, a quite different process must have taken place when the flint objects were affected by heat.

Fig. 6. Remains of an axe-head placed in the large fire. Photo by Lars Larsson.

The effects of heat treatment

It is known that in order to facilitate knapping, certain siliceous raw materials have been exposed to heat treatment. Such treatment, in order to improve the flaking behaviour of the material, is as old as the Middle Stone Age in South Africa (Brown *et al.* 2009; Schmidt *et al.* 2013; Stolarczyk & Schmidt 2018). Heat treatment has attracted a great

Fig. 7. A small bonfire was constructed in order to ensure better regulation of the heat. Photo by Karin Rogius.

Fig. 8. An axe-head and a chisel after heat treatment and heated in a fire.
Photo by Lars Larsson.

number of archaeologists. Several studies and experiments have been conducted in order to understand the process as well as the outcome of heat treatment (e.g., Olausson & Larsson 1982; Flenniken & White 1983; Eriksen 1997, 2006; Domanski *et al.* 2009; Domanski & Webb 2016).

Although the heat treatment of objects is well known in other parts of Europe, flint objects from southern Sweden deliberately affected by heat are relatively rare. The type of flint most extensively used for making larger objects is Senonian flint easy to flake (Olausson & Högberg 2008). Heat treatment does not facilitate knapping of this type of flint. It is from the later part of the Early Neolithic that heated flint objects have been identified. The practice continues throughout the Middle Neolithic and is also known from the Late Neolithic. This means that the process of heating flint objects was employed in the southernmost part of Sweden from about 3500 BCE until 1700 BCE.

In order to find out how the axe- and chisel-heads were affected by heat treatment, a number were placed in sand covered by a burning hearth. The temperature in the fire slowly rose to 630 degrees Celsius and to 350 degrees Celsius in the sand during the night when the heat treatment was conducted.

No visible changes could be documented when the objects were removed. However, when placed on a bed of hot charcoal, the flints slowly changed to a whitish colour; but they did not crack into pieces as during the experiments mentioned above (Fig. 8). During the colour change several fissures were observed, but the objects kept their original shape. Only small parts of the surface became loose. However, they were useless for any form of working.

The longer the objects were kept in the fire, the larger the parts of the surface became detached. The axe- and chisel-heads could stay intact for a long time, but if the objects were handled without care they broke into pieces, exhibiting shapes well known from the Neolithic sites mentioned above (Fig. 9).

This kind of treatment produced colour change in flint objects, just as with ordinary flints affected by fire, but they did not crack. Thus, no obvious destruction that would be visible to a large number of people took place. But to observers well aware of what happens to ordinary flints in fire, the effect on the flints should have been confusing or amazing if they did not know that the objects had previously been heat-treated.

So, the three days of experiments indicated that the previously held opinion, namely that the heating of flint objects was a public event with pyrotechnical attributes, was erroneous. Instead, it involves less spectacular actions. Even so, if those present were not in possession of the full knowledge, then the change in colour and the minor effect on the object might still have been regarded as magic.

Fig. 9. Fragments of an axe-head that was intentionally smashed to pieces after heat treatment and heated in a fire. Photo by Lars Larsson.

Evidence of heat treatment at sites

Even if the treatment could be made on the surface, with glowing charcoal and sand layers, it must have been easier to manage the process in a pit. If most of the axe- and chisel-heads were handled with heat treatment at the same time, then either a large pit or several smaller ones would have been used.

Experimentation has shown that it takes a considerable length of time before the soil at a depth of 20 cm below the fire will be affected even by intensive heating (Liedgren *et al.* 2017). As all of the sites mentioned above have been used for cultivation with ploughing to a depth of 20 cm or deeper, all evidence of firing at the original surface has been destroyed.

Even at Kverrestad, south-eastern Scania, where the topsoil in some parts of the excavation areas was thinner than 20 cm and situated directly on a bedrock of slate, no colour changes were identified that could be related to fire.

The features that have been found at sites with a considerable number of flint objects affected by heat would not have been suitable for heat treatment. The pits found are too small or hold a small proportion of charcoal and no sand. The most plausible explanation is, then, that heat treatment was performed at another location and the flint objects were brought to the site just for the final handling in a fire on the surface, when they changed colour and were intentionally cracked before the eyes of a surprised assembly. That this alteration of flint objects was carried out far from the source of the material, as at Stensborg in central Sweden, indicates that the knowledge of this kind of handling of objects could have been obtained together with other more practical information about reshaping and grinding. A member of the community might have been practising flint knapping as well as acting as an expert in magic. In late prehistory blacksmiths were regarded as capable of mastering not only iron but also forces of the immaterial world (Østigård 2007). A similar status was accorded to the knowledge and activity of the bronze smelter (Goldhahn 2007).

Animals and fire

When conducting experiments, it is not unusual to get spin-off incidents providing new insights into prehistoric life and circumstances.

Close by the place where the experiments were performed, a couple of oxen were grazing, which were to be trained for dragging stones as building material for a megalithic tomb. They remained unconcerned about our burning experiments until the fires were almost extinguished. At this point they both started becoming very obtrusive. Despite the heat, they reached for the grass as close as two decimetres from the pyre (Fig. 10). The reason might be that this grass was mixed with ash containing minerals that made it extremely tasty. We tried to chase them away without much success. It all ended with us sleeping around the fire so that we might test our expectations without interference from the oxen.

Forest clearings made in the Early Neolithic might have attracted wild animals. The aurochs was already extinct, but others might have shown the same interest. So, forest clearance might have been combined with hunting. We were later told that forest fires attract moose populations. Domesticated animals such as sheep are also fond of grass that has been burned.

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Fig. 10. Oxen were eager to graze near the fire. Photo by Karin Rogius.

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