

EXPERIMENTAL HEAT-TREATMENT OF FLINT

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INTRODUCTION

The first question to be asked about the heat-treatment of flint and other similar siliceous materials is "Why bother if they can be shaped without heating?" The simple reason for heat-treatment of flint and other minerals of the same family is that the process in many cases drastically improves the quality of the material making it easier and more predictable to work. In some instances, treatment can produce an incredible difference between the original quality and that of the treated material; for example, a poor quality grey flint (producing a dull surface when broken) that would produce at best a thick, unattractive artefact covered in step and hinge fractures can be transformed into a higher quality material (producing a pink glossy surface when broken) that could then produce a thin, attractively flaked artefact.

The American Indians were perhaps the best known of the heat-treating cultures, they heat-treated their siliceous raw materials after shaping them into blanks for arrowheads, spearheads and knives, only removing the finishing flakes once treated (Waldorf 1998). It would appear that heat-treatment (to an undetermined degree) was carried out in and around Egypt, some of the fine sickle blades and daggers on display in the British Museum show the distinctive signs of heat-treatment.

Perhaps another reason for the desire to heat was that during the process most materials change colour, some only show slight changes, others change completely; for example, a creamy-yellow piece of flint

(depending on its location within the heating pit) can be removed from the pit having changed to a dark red colour. Other types of flint when heated produce swirls or stripes of different colour that make a piece of knapped material look like a piece of art, if indeed it was not considered as such un-treated.

METHODOLOGY

The initial stages of the experimental firing involved the digging of a "roasting pit". The model followed for the construction was that shown in the D.C. Waldorf video titled 'Roasting Rocks' though as the following information will show, a more comprehensive instructional source is much needed.

The location for the experimental work was relatively easy to decide upon as no special geological conditions are required, only that there is an adequate soil cover over any bedrock of around 30cm. The location was a field in the village of Hewelsfield, Gloucestershire (map ref SO 5567 0222). The field was overgrown and the only preparation prior to digging the pit was to remove the undergrowth. The location of the experimental work was reported to the NMR to avoid any confusion in future should the field be ploughed and examined for archaeological purposes.

The first pit was dug to a depth of 15cm to allow for three layers of insulating material:

Base layer – This layer of insulation provides a dry, soft bedding that cores and colour samples could be placed into rather than placing them on the damp

compacted soil at the base of the pit. The damp could of course have some affect on the final results of the experiment.

First Covering Layer – This layer of insulating material can serve a dual purpose depending on the varying amounts and quality of lithic material to be treated in the pit, it can be a final covering of insulating material if only one layer of blanks is to be treated, or it may be a middle “sandwich layer” into which the first layer of blanks are settled in a dual level (or more) pit, where different qualities of material are to be treated.

Second Covering Layer – This layer is the final insulation protecting the blanks buried in the pit from the heat of the fire above, it is also perhaps the most critical layer of the pit (as the results will show), if this layer is too shallow the flints below will become overheated and shatter, producing pot-lids and splinters.

FIRE STARTING AND MAINTAINANCE

The timber for all three experiments was collected from local deciduous woodland and no trees were damaged during this project. The wood collected was fallen deadwood from a mixture of hard and softwood trees including: Oak, Hazel, Ash, Yew and Birch. The driest material was selected; twigs and dry leaves were collected to start the fire, larger material (3cm to 6cm x around 1 metre) was collected as kindling and larger lengths (up to 15cm x 1 metre) were collected to feed the fire for the duration of the firing. A considerable amount of timber is needed to feed a fire for five to six hours, for each firing three trailer loads (1metre x 1.3metre trailer) of timber was required including kindling timber. Timber collection was the most time consuming exercise taking longer than the preparation of the core blanks.

Once the twigs and leaves were ignited the kindling timber was placed on top, the embers were then blown to increase the temperature and ignite the kindling. A constant supply of kindling was added to spread the fire over the whole of the pit surface. Once this was done, the larger timber was added as and when needed to keep the fire going and to provide flame cover over the whole pit.

FIRST FIRING 21ST JULY 2001

The base layer of the first firing was of sharp sand (obtained from a local builders merchant). A bed of around five centimetres in depth was laid down over the base of the whole pit. Into this sand ten cores were settled before being covered with the first covering. This was also a layer of sharp sand, laid down and compacted to a depth of approximately seven centimetres. A further ten cores were settled into the material before being covered with a mix of sharp sand and flint gravel. This layer was laid down around four centimetres in depth.

The fire was lit at and fed continuously for six hours. The temperature required (above ground) for successful heat-treatment is between 1200 and 1300 degrees. Un-tempered glass is known to melt at around 1200 degrees and therefore can be used to test whether the fire has reached the desired temperature. This was carried out at hourly intervals for six hours, the bottles melting after three and a half to four minutes; no more fuel was added and the fire was allowed to burn down overnight.

This firing was a partial success as all of the blanks at the base of the pit survived, were heat-treated and removed intact. However, the material in the upper level was only partially recovered intact as most blanks were damaged by excessive heat. This appears to have been the result of the second covering layer being too shallow, offering little protection from the intense heat of the fire above. The fire was left to cool. However, a cooling period of 30 hours

was required to allow the flint to cool to a temperature that would allow handling of the material. The flint was then excavated from the pit; the first noticeable changes observed were the impressive colour changes in the treated material.

CONCLUSION EXPERIMENT 1

Much was learned from this experiment in terms of pit construction and preparation, fire construction and maintenance. Without doubt the most crucial aspects of heat treating lithic material is making sure adequate insulation is used at each stage of preparation and that the quality of the lithic material itself is positioned within the pit according to its quality and size.

As an important word of warning: removal of lithic material from the pit should not be attempted until the insulating material has cooled to fingertip tolerance, not even with heat resistant gloves. If the blanks are removed prematurely there is a danger that the flint may crack or splinter as they come into contact with the cool air, thus wasting valuable material. There would also be a very real danger of violent cracking and splintering of the flint that could potentially cause severe injury.

SECOND FIRING 24 JULY 2001

The insulation material for this experiment was a fine kiln dried sand, the idea being that a finer material might protect the flint from the heat of the fire more successfully than the sharp sand and gravel mix used in the first firing.

The fire was lit and continuously fed for five and a half hours. Once again the temperature was tested at hourly intervals with un-tempered glass bottles that melted after three and a half to four minutes. The fire was then left to cool, once again, attended at all times for safety. The pit took thirty-nine hours to cool to a handleable temperature. This was nine

hours longer than the first experiment, which may have been due to the different insulating materials used, or perhaps the air temperature throughout the experiments. The weather throughout the first firing was cloudy and cool with a constant cool breeze, throughout the second firing the weather was clear and hot with no breeze.

Two problems were encountered, firstly, the fine sand settled as it was compacted prior to the firing, this appears to have pushed much of the sand out to the edges of the pit and away from the flint it was to protect. The result of this oversight was the total loss of the finer quality cores in the upper layer. Fortunately the poorer quality cores and blanks that were also in the upper layer survived as they treat at a higher temperature than the finer material. The second problem encountered was that the fine sand appears to have had the opposite to the desired effect as more heat seems to have been retained throughout the pit than in the first firing. This was evident by the number of breakages in the lower level of insulation, an area of the pit that had been successfully treated in the first experiment.

CONCLUSION (EXPERIMENT 2)

The results of the second firing would suggest that the kiln dried sand used for all of the insulation layers within the pit, is not suitable for this method of heat-treatment. Although the final covering layer of sand was again too shallow (due to the movement of the fine, dry sand) the temperature throughout the pit appears to have been too high, resulting in almost complete failure of the experiment. Therefore, in future experiments it was decided to carefully measure the depth of insulation at each stage of pit construction to make sure an even cover is laid down in each insulating layer. Estimating an even cover whilst pouring the insulation material over the blanks had proved an unsatisfactory method.

THIRD FIRING 28 JULY 2001

Once again the insulating material was changed, as the fine kiln dried sand used in the previous experiment, although suitable for re-use had not performed as expected. The insulation used for the third experiment was quarry “scalpings” (a mixture of limestone gravel, sand and dust). This material was chosen to assess the difference between the performance of fine sand against a much coarser material as insulation. It was hoped that the coarse material would prevent the overheating of the pit and reduce the heat retention that was evident in the first and second experiments.

A five centimetre deep lining of sand was applied to the bottom of the pit and the first layer of flint blanks (the finest quality) was firmly “settled in” before being covered with the new insulating material. A generous cover of scalpings was used to insulate the blanks; the thickness of the layers was increased to prevent overheating. This layer was applied to a depth of eight centimetres and was then compacted by careful trampling underfoot. One lesson learned from the first two experiments was that finer quality flint must be placed at a greater depth within the pit than coarse-grained “cherty” material. Coarse-grained material seems able to withstand exposure to higher temperatures and temperature fluctuations than fine quality flint. The final layer of blanks (the coarser material) was added, again being pushed firmly into place before the final covering layer of scalpings was added. This layer was applied to a depth of seven centimetres in an attempt to avoid the previous overheating problems.

The fire was lit and continuously fed for five and a half hours. The fire was again tested to confirm that the required temperature had been attained. As in the previous experiments this test was carried out at hourly intervals and each bottle melted within three and a half to four minutes. The fire was then left to cool and took an astonishing sixty-two hours

to cool to a temperature that allowed safe removal of the blanks. The results of this firing were excellent, only seven percent of the blanks placed in the pit were damaged by overheating, however, this was not unexpected as tester blanks of high quality had been placed in the upper level of the pit with the coarse material to test for cool spots in the pit. It was these “testers” that had failed and as all of the material in the upper and lower layers had heat treated successfully it would appear that no cool spots were present throughout the whole roasting pit.

The first cores to be disturbed by raking off the coals were again very close to the surface (but had survived as they were coarse material), though this would appear to be the result of fire maintenance; moving of the larger timbers on the fire to help contain the fire and aid efficient burning. This obviously disturbs the sand/gravel and causes the settling of the insulation material, which in turn exposes the upper blanks.

CONCLUSION (EXPERIMENT 3)

The considerable increase in cooling time may once again have been due to the extremely hot and dry weather conditions, or perhaps the new insulating material was responsible. However, on observation of the increasing cooling time throughout the three experiments, another possibility is that the moisture content of the soil beneath the pit became reduced with each firing and as a result the heat retention properties of the soil may have been altered. The problem of the upper insulating layer being disturbed by fire maintenance suggests that great care should be taken when moving any timbers on the fire to aid containment and efficient fuel consumption or that an additional three or four centimetres of insulation should be added to the upper layer to compensate for movement. Also, it may be a good idea to make the top layer of insulation a layer of heavy, coarse mate-

rial that will not settle or disturb as easily as soft sand.

It was this pit construction and insulation material that most resembled that shown by D.C. Waldorf in his instructional video “Roasting Rocks”.

OVERALL CONCLUSIONS

The most appropriate type of fire for the purpose of heat treating lithic material would seem to be a low, wide, well fed fire that concentrates heat, rather than a tall narrow ‘bonfire’ which allows a great deal of heat to escape; a “bonfire” is not only un-economical in terms of fuel, but also fuel collection time. Another important factor would appear to be that a thick bed of embers is required to retain the heat of the fire and as a result aid in achieving higher temperatures.

Fortunately dry, warm weather helped with the experimental work and no rainfall or even heavy dew affected the results. However it should be noted that adverse weather conditions could cause serious problems when heat treating, such as:

- Moisture within the surrounding soil could prevent fire reaching target temperature.
- Wet insulation layers and pit walls may affect the temperature attained.
- Water seeping into and around the heating or cooling flint could cause the material to crack or even shatter.
- Heavy rainfall could extinguish the fire, ruining the chances of successful heat-treatment.

The flint heat-treated in the three experiments changed colour, in some cases the colour change was considerable in others only a slight change occurred. There would appear to be a colour change trend relating to certain colours of flint. The following list is probably a huge oversimplification but appears to be

correct according to the three firings relating to this project.

colour before treatment	colour after treatment
white	off white / pink
grey	light pink / dark pink
yellow	orange / red
orange	red / burgundy
red	burgundy / purple / off brown
dark Red	purple / brown / dark brown
brown	dark Brown
dark Brown	smokey / black
black	no colour change

(NB. All samples of flint used in the three firings varied in quality, colour and place of origin within English flint regions.)

Although the colour change was impressive the real purpose of heat-treatment of lithic material is to improve the quality and workability of the stone. This was accomplished in all three experiments; even the material that was ruined was treated, just a little over treated! On removal from the pit the first confirmation of heat-treatment is the colour change, which is usually quite obvious, however, this is no guarantee that the quality of the flint is better than before treatment. If the flint became too hot in the firing, the whole piece of flint would shatter when struck with a hammer (hard or soft). When compared to the untreated material the surface of a heat treated piece of flint is identical in appearance and texture (colour change aside), the real confirmation of successful heat-treatment becomes apparent with the first flake or blade removal from the blank or core. The newly exposed material in the flake or blade scar should be shiny and have a glossy appearance (often referred to as a soapy lustre) and be smoother to the touch than

the previous surface. If this has been accomplished then heat-treatment has been successful.

By carrying out such experimental research we can learn a great deal about the methods used in the past for the improvement of flint quality. However, we can also learn a great deal from the remaining information and failures. Following the completion of all three experiments the entire heating pit was carefully excavated as if it was an actual excavation. With such information recorded it is possible that heat-treatment pits in the archaeological record can more easily be recognised, enabling a characteristic distinction between heat-treatment pits and the site of a hearth or bonfire.

BIBLIOGRAPHY

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