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NOTES ON EXPERIMENT IN FLINT KNAPPING: 1

Heat Treatment of Silica Materials

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Abstract

Certain experimental evidence and field observations suggest that heat treatment of common silica minerals may have been an essential step in the manufacture of pressure flaked implements from these materials by prehistoric artisans.

Foreword

This is the first in a proposed series of notes treating prehistoric flint knapping technology from an experimental perspective. For example, in the process of replicating a Clovis, Folsom, or Yuma point, what steps are necessary in the production of a finished specimen? That is, precisely what techniques seem to have been used and in what order were they most likely to have been employed by prehistoric peoples.

Mr. Crabtree has been working on such problems for nearly thirty years, first at the Ohio State Museum and now at his home near Twin Falls, Idaho. During this time he has acquired an impressive store of working knowledge in the art of flint knapping, which he most recently demonstrated at the First Conference of Western Archaeologists on Problems of Point Typology (Swanson and Butler 1962). He first came to the attention of the Idaho State University Museum staff in 1957 as a result of his local reputation as a skilled flint knapper. Dr. Earl H. Swanson, Jr., director of the museum, became personally acquainted with him in 1958, was impressed with his skills, and ever since Mr. Crabtree has been a welcome and frequent consultant on problems involving flint technology. He has never before published the results of his experiments and observations, but has compiled them on a number of tape recordings. These have been transcribed by his wife, Evelyn, and are on file at the museum. In order to make this material available to a wider audience, Mr. Butler has begun editing the transcriptions and has initiated the present series of notes as a step towards a definitive volume based on Crabtree's experiments and observations.

I

Certain effects of heat and cold on stone materials, such as crazing, pot-lid fracturing, and frost-pitting (Watson 1950: 18 and Oakley 1957: 15-17), are well known to archaeologists. Also familiar is the belief that prehistoric peoples produced flaked stone implements by dripping water on heated stones (e.g., Lehmann 1927: 93-94, as quoted in Wallace and Hoebel 1952: 105) Probably because of the almost certainly mistaken nature of this belief, and its appeal to the lay public, archaeologists have shown a markedly negative interest in the possibility that prehistoric peoples may have treated certain stone materials at some stage in the manufacture of flaked stone implements.

II

From long experience as an amateur flint knapper, I have noted that volcanic rocks, such as ignimbrite (welded tuff) and obsidian, and opalites, and jaspers and agates on the borderline between agate and opal are readily workable in their native state. That is, these materials can be very easily pressure flaked. On the other hand, the more coarsely fibered and coaser microgranular silica minerals, which includes most chalcedonies, jaspers, cherts, and flints commonly used by prehistoric peoples, are extremely difficult to pressure flake in their native state. However if the same minerals are properly heat treated, they can be pressure flaked with ease. It is sometimes difficult to explain this to an inexperienced flint knapper, but the working qualities of the native and heat-treated silica minerals are quite different. The former is tough, relatively inelastic, and will not withstand the necessary pressure, while the latter has greater elasticity and will respond nicely to pressure. For example, if I attempt to pressure flake an untreated piece of flint collected at a quarry site, the largest flake that I can detach by pressure will usually measure no more than half an inch in length. But if the same material is heated, I can easily press off flakes of more than two inches in length with a hand held flaker. In addition to improving the working qualities of silica minerals, heat treatment also produces a distinct change in the texture and lustre of these minerals, and often a change in color as well.

I first observed this phenomenon while at the Ohio State Museum lithic laboratory in the thirties. There I had an opportunity to work with specimens of local flint, including Flintridge flint, a material used by the Hopewell of central Ohio in the manufacture of their finer flaked implements. In studying these implements, I noticed that they possessed a distinctly greasy lustre, while the native flint from which they were made had a dull lustre. Tests were made of the native flint using a sand bath and bunsen burner Specimens of the material were broken

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in two, with one piece kept as a control and the other heat treated in the sand bath. The heat-treated pieces developed a greasy lustre; the control pieces remained dull. The two groups were subsequently examined under an electron microscope to determine the nature of the change in the heat treated pieces. It was found that the crystals in the heat treated pieces had become much smaller.

Apparently, this is what happens: Heat treatment causes recrystallization of the more coarsely fibered and coarser micro-granular silica materials, which results in reduced crystal size, a change in lustre from dull to greasy, and an increase in the elasticity of the material. Excessive heat, of course, will cause more drastic changes and result in cracking or crazing of the material.

III

My own heat treatment experiments to date have been rather rudimentary. However, they may approximate similar efforts by ehistoric peoples. Before acquiring a ceramic kiln, I used an old-fashioned Majestic coal range. The oven lacked a thermostat and the heat varied considerably. In a typical early experiment, spalls of various types of silica minerals were embedded in a pan of clean sand, placed in the oven, and left there for days or weeks at a time. The results were often highly variable. Some of the specimens were obviously overheated; some remained unchanged; and some reached the desired state.

After considerable trial and error, I learned that silica minerals varied considerably in the length of time and amount of heat necessary to bring about the desired change. Some types required comparatively low temperatures; others required higher temperatures. For each type of silica mineral there appeared to be a critical temperature range below which, regardless of the length of time involved, no change would taken place and above which it would crack or craze. On the other hand, some of the minerals had to be held in the critical temperature longer than others in order to bring about the desired change. Any sudden raising or lowering of temperature, such as heating up the material too quickly or opening the oven door before slowly cooling off the oven, usually ended in extensive crazing or cracking of the mineral specimens.

The ceramic kiln that I use at present lacks a pyrometer. However, because I can maintain constant temperatures in the kiln, I have been able to estimate fairly closely the degree of heat and length of time necessary to effect the desired change in each type of silica mineral that I have worked with. More precise determinations could be made using a good pyrometer and time-temperature charts.

There is another important factor that needs to be taken into account when heat treating the minerals, namely, the relative thickness of the samples to be heat treated. Spalls, cores, and roughed out blanks that are comparatively thin can be heat treated more successfully than thick chunks or nodules. The thicker pieces do not heat or cool evenly and, as a result, crack or craze rather easily. The significance of this in the preparation of flaked tools, especially by prehistoric peoples, will be noted later.

In order to ascertain the effects of heat treatment on a given silica mineral, a specimen of the mineral should be split into a number of uniform spalls, one or two of which will be left untreated. Each of the other spalls should then be heat treated (using a sand bath) at a different temperature for varying periods of time (e.g., at 400, 900, and 1100 degrees Fahrenheit for 24, 36, and 72 hours respectively). Subsequently, an attempt should be made to pressure flake each of the spalls in a similar fashion using a hand held flaking tool. This serves two purposes: it is one way of judging the relative elasticity of the material in each case and, at the same time, it enables you to observe any change in the lustre of the heat treated spalls. When a piece of silica mineral has been heat treated, its surfaces may darken slightly, but there is no obvious indication that a change has taken place. Removal of a flake will immediately reveal any change in lustre or color. Heat treatment will sometimes result in striking color changes, and a properly heat treated specimen almost always possess a greasy lustre, provided that the surficial crust has been removed. If an unknown specimen possess this greasy lustre, I usually suspect heat treatment, for I have rarely encountered this lustre in a natural specimen.

In addition to the easily observable, and generally characteristic, greasy lustre of heat treated specimens, there may be another, more critical criterion for the determination of prior heat treatment in the case of unknowns. Professor Andrei Isotoff, Department of Geology, Idaho State Unisity, recently thin-sectioned a few silica mineral specimens that I had been working with. Optical examination of heat treated pieces revealed the presence of relic areas; i.e., microscopic islands of the original crystalline structure of the mineral. The universality and reliability of this criterion remains to be demonstrated; however, it does appear to hold promise as a means of identifying heat treatment in unknowns, and may well supplant my rule of the thumb with respect to lustre.

Some of the results of my approach to the question of heat treatment are illustrated at the end of this note (see Figs. 1 and 2). All of the illustrated specimens were photographed under identical conditions; however, the black and white reproductions do not show changes in lustre and color as effectively as would color reproductions made under the same conditions.

IV

I should now like to briefly review and enlarge a little upon the evidence in support of the hypothesis that prehistoric peoples probably heat treated coarsely fibred and coaser micro-granular silica minerals in the process of shaping pressure flaked implements from these materials. One line of evidence has been mentioned earlier: the near impossibility of finely flaking these materials in their native state; the comparative simplicity of heat treating the materials; and the relative ease with which the same materials can be successfully pressure flaked after they have been heat treated. Presumably prehistoric artisans would have embedded such materials in sand or soil beneath their campfires, where, after a few days, the materials would have been adequately heat treated for their purposes. As indicated by my experiments, spalls, or spall cores, and thinned down blanks are more efficiently heat treated than thick chunks or nodules, which usually craze or crack in the course of heat treatment. Therefore, one would expect to find small pieces, but not whole nodules, of heat treated material at prehistoric sites.

Another line of evidence, closely related to the above, stems from a comparison of chunks of raw material, chipping detritus, blanks, and finished or partly finished implements found at prehistoric quarry and campsites. As a case in point, during the past year or so I have been working with material from a prehistoric quarry on Antelope Creek in southern Idaho. The quarry material is primarily a coarse textured jasper-agate. Some of this material was used in the experiments illustrated in Figs. 1 and 2. Although quarrying debris and chipping detritus are in abundance, there is no evidence of heat treatment at the site. However, at a nearby campsite, I have collected material identical with that at the quarry site, some of which definitely has been heat treated. Of particular interest in this case was the discovery of an untreated core and a series of flakes that conformed to the flake scars on the core. The flakes had been partially pressure flaked, revealing the characteristic greasy lustre resulting from heat treatment. Those areas of the flakes that had not been retouched retained the granular texture and dull lustre of the untreated core. The Antelope Creek sites are not singular occurrences, for I have observed similar situations elsewhere in the West.

The aforementioned evidence is by no means conclusive, but it would seem to point the way for further study of the problem. What were the geographic and temporal limits of heat treatment? Were all New World peoples familiar with the process? Did it also occur in the Old World? How long ago did prehistoric peoples discover the process and to what degree was it associated with pressure flaking? I believe that the answers to these questions may lead to important insights into the evolution of flint knapping technology among various groups of prehistoric peoples.

Acknowledgements

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KEY TO ILLUSTRATIONS

Examples of the Results of Heat Treating Silica Minerals

Fig. 1 **a,** untreated spall core of dull, brownish jasper.

b, flake struck from spall core **a,** subsequently heat treated, then partially pressure flaked to show change in lustre resulting from heat treatment. Unretouched area of flake retains surficial "crust" resembling the lustre and texture of the untreated core. This "crust" is common to most heat treated silica materials.

c, untreated spall of dull, red-brown jasper struck from same nodule as the heat treated blank shown in **d** and **e**.

d, heat treated blank of same material shown in **c.** This blank was first heat treated at a temperature of 900 degrees Farenheit, then pressure flaked at the tip end of the face shown in **d.** The rest of this face of the blank was left unretouched throughout the experiment and resemble the parent materal. At 900 degrees, the pressure flaked tip reveals only a slight change in color (a faint yellowing) and in lustre; some improvement in the flaking quality of the material also occurs.

e, opposite face of blank after it had been heat treated at 1100 degrees and then completely pressure flaked. The material is now a bright yellow mustard color and the lustre greasy, very different from the parent material.

Fig. 2 **a,** an untreated spall of dull, mustard yellow jasper.

b, same material as **a,** heat treated and subsequently pressure flaked. There has been no change in color; however, the lustre of the finely flaked specimen is greasy.

c, dull, milky white chalcedony core showing typical sub-conchoidal fracturing.

d, a flake struck from core **c** heat treated and subsequently made into a pressure flaked point. Note the greasy lustre and definitely conchoidal fracturing; there has also been a color change, from white to a pinkish hue.

Fig. 1

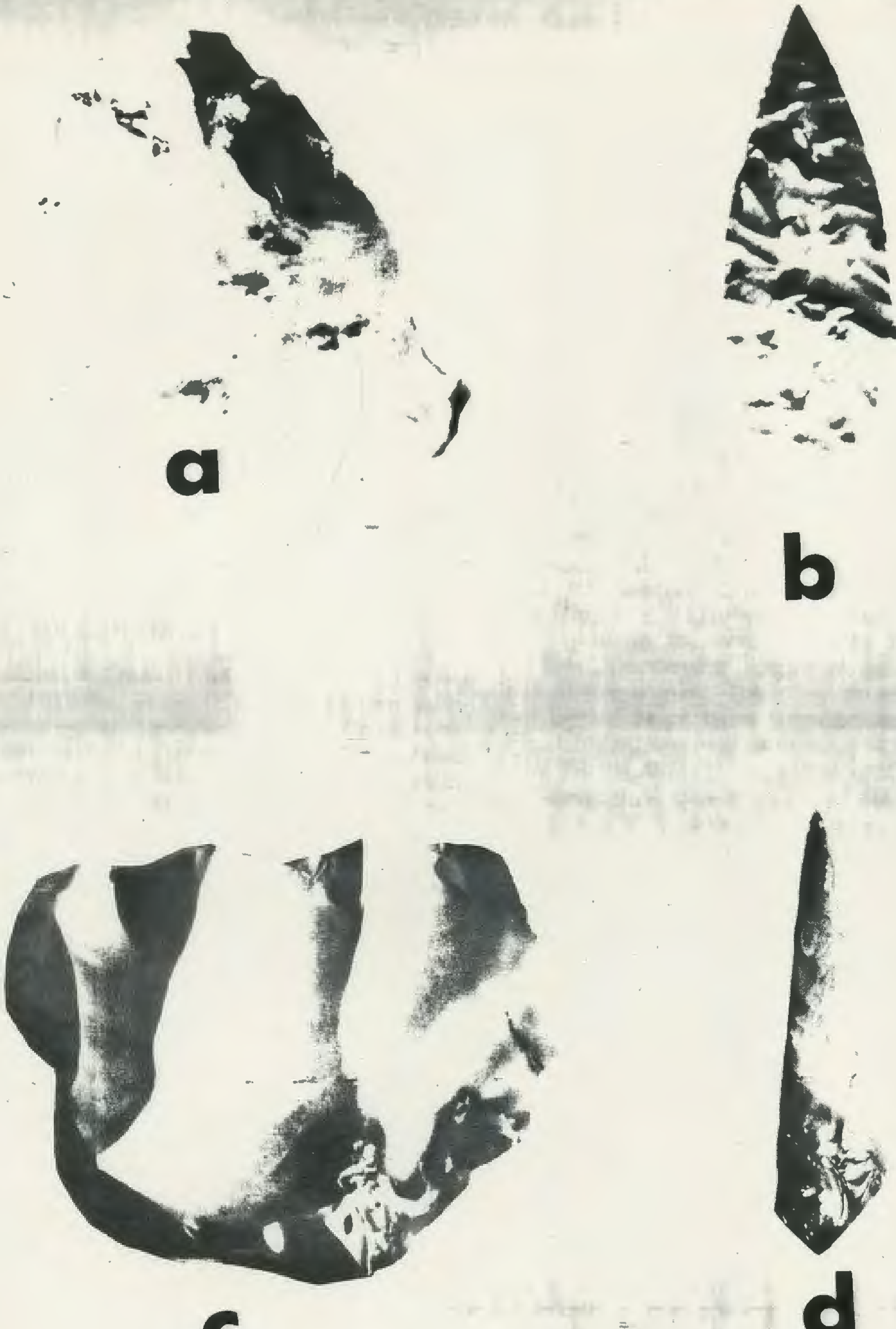

Fig. 2