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THERMALLY ALTERED SILICEOUS STONE FROM PREHISTORIC CONTEXTS: INTENTIONAL VERSUS UNINTENTIONAL ALTERATION

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Recent studies have demonstrated that the flaking characteristics of certain siliceous stone materials are enhanced by carefully controlled annealing and that intentional annealing was indeed practiced by prehistoric Native Americans. A note of caution is extended here to investigators who might extend evidence for thermally altered siliceous stone from a site to interpretations that intentional annealing was practiced at the site. The use of fire in quarrying has a long history throughout the world, and much heat-treated material from sites may have been thermally altered unintentionally, the result of quarrying practices.

Since recent, germinating articles (Shippee 1963; Crabtree and Butler 1964) which suggest that prehistoric man found it advantageous to thermally alter his lithic raw materials prior to fabrication of artifacts, research has intensified in the study of the thermal alteration of siliceous stone materials. Currently, the terms "thermal alteration," "thermal pretreatment," "heat treatment," and "annealing" are used interchangeably for this procedure.

Experimenters have found that various types of annealing under various controls result in an array of changes in siliceous stone. Recent studies show that desirable changes, in terms of knappability, take place in chert and many other siliceous stones if they are heated slowly, at relatively low temperatures, and out of direct contact with intense heat. These desirable changes, in terms of knappability, occur during heat treatment through the removal of interstitial water, and the closer fit of a material's microcrystals where certain elements or impurities, other than SiO_2, serve as fluxes (Purdy 1974:51). The result of carefully controlled annealing is that "the heated rock responds more like glass than a rock aggregate" in the process of flintknapping (Purdy 1974:51). Since materials become more like glass after annealing, this annealing also facilitates the generation of sharper edges than would otherwise be possible (Don Crabtree, personal communication).

While most researchers have found that a relative precision in temperature control is required to produce knappably desirable changes in siliceous stone, field archaeologists have demonstrated that intentional, controlled annealing was indeed practiced prehistorically in several areas of North America. Certain of these practices were extracted by Hester from ethnographic literature from western North America, and include the practice of the Reese River Shoshoni of placing flint intended for knapping "under fire and ashes for a period of five nights"; the Shoshoni along the Snake River of eastern Idaho roasted flint in the ground; and, the Shivwits of northwestern Arizona "reportedly roasted flint in a barrel cactus before it was flaked" (Hester 1972:63). The presumed purpose of these aboriginal techniques was to keep the source material out of direct contact with intense heat, to keep the material from being subjected to rapid temperature changes, and to allow the heat to be evenly and slowly distributed throughout the batch of raw material.

Field archaeology is revealing that the most common technique for intentional heat treatment which can presently be documented was to dig a pit, lay in the raw material, cap it with a protective covering (limestone slabs in the case of Shippee's discovery), and build a fire over this preparation, maintaining the fire for some extended period of time. It is reported (Mandeville 1973:182) that David Cole of the Museum of Natural History at Eugene, Oregon has indicated that such caches are rather common in the Northwest. The sophistication of these prehistoric annealing practices is truly remarkable in light of the detailed research which has been required to determine the precise steps required to produce desirable changes through thermal alteration.

Other evidence for intentional heat treatment comes from a discussion of material from a quarry site and nearby campsite on Antelope Creek in southern Idaho (Crabtree and Butler 1964:3). There is a great deal of evidence of knapping debris at the quarry site, but none for heat treatment, while some material from the campsite, which is identical to quarry material, was definitely heat treated. While this evidence looks good (and probably is), it is possible that such " . . . thermal alteration may have taken place accidentally, for example, from forest fires or at hearths" (Purdy and Brooks 1971:324).

It is now generally accepted, however, that the thermal pretreatment of chert was practiced by prehistoric Native Americans and that, under properly controlled annealing conditions, it does improve the flaking quality of the material (Mandeville and Flenniken 1974:146).

Ethnographic references are often used to support the contention that the purpose of heat treatment was to increase the workability of a raw material. A closer look at some of these references indicates that often the purpose of the heating was to facilitate the fracture or cleavage of small cobbles or pebbles of source material so that they could be worked, and not necessarily to improve the materials' workability. This seems to be the process used in fracturing flint cobbles in the Victoria River region of Australia (Elkin 1948:110), for fracturing the white quartz pebbles in the Andaman Islands (Man 1883:380), for breaking up pieces of jasper, chert, obsidian, or common flint by the Viard Indians of California (Powers 1877:104), and for breaking up boulders by the Nyasaland tribes of Southern Rhodesia (Robinson 1938).

The usual subjective indicators of the field archaeologist or laboratory analyst for identifying thermally altered siliceous stone is the presence of lustrous surfaces and color changes in the material (Collins and Fenwick 1974:140). In fact, while it is suggested that prehistoric man thermally altered raw material to improve its workability (Shippee 1963; Crabtree and Butler 1964), it has been suggested that Hixton Silicified Sandstone from Wisconsin was heat treated "to improve its appearance, if not to improve its flaking characteristics" (Behm and Faulkner 1974:275).

Precise determinations as to whether or not siliceous stone has been thermally altered can be made through neutron activation analysis. The most common identification of heat treated siliceous stone remains that of visual inspection of the artifact in conjunction with visual inspection of the quarry source material (if known or if available).

The note of caution extended here regards the application of the terms "heat treatment" or "heat pretreatment" to prehistoric artifacts which display evidence of thermal alteration. This caution is extended because the terms "heat treatment" and "heat pretreatment" imply the intentional alteration of the siliceous source material, extending to the implication of intentionally altering the material for the purpose of improving its knapping and/or fracture-edge sharpness characteristics. Certain researchers (e.g., Collins and Fenwick 1974:141) are explicit in stating that their evidence for intentional heat treatment is suggestive, and that "there is nothing to prove conclusively that the heating of chert at the site was intentional." However, other researchers reason that the presence of thermally altered material at a site indicates intentional pretreatment. For example:

> Prehistoric peoples probably were aware of the advantage conferred by thermally altering their lithic materials because the chipping debris recovered from archaeological sites has been intentionally flaked following subjection to heat [Purdy 1974:52].

However, while such flaking was surely intentional, the subjection to heat for the purpose of improving flaking characteristics may not have been.

Much of the available literature on prehistoric quarrying and mining techniques for chert and other minerals in both the New and Old Worlds indicate that fire was often used as an agent in combination with water to break up rock deposits in order to reveal chert or other minerals which were the sources of the quarry efforts. It is stated that "fire setting was a normal mining technique for some 3000 years" (Singer, Holmyard, and Hall 1956:565). Firesetting was used to split the hard rock at the Mitterberg Mines in the Tirol of southern Russia during the Bronze and Iron Ages (1600-800 B.C.) (Singer, Holmyard, and Hall 1956:565-66).

The quarrying technique for procuring limestone slabs for the megalithic structures on Spain's Balearic Islands during the Talayotic period (1300-123 B.C.) are suggested to have involved the use of fire:

> Reconstructing, we can say that wood fires were set in a perimeter trench and covered by mud, stone or other material to cut down infra-red radiation and convection losses, and thus, concentrate heat at the limestone-air interface. Such closed wood fires . . . would hasten the dissociation process [Kopper and Rossello-Bordoy 1974:168].

The aboriginal acquisition practices for copper mining in the Lake Superior basin have also been reconstructed:

> The method of mining was as follows. The Indian miners followed the veins of pure copper from its rock matrix with the aid of fire and water and large beach boulders used as hammers. The rock surrounding the pure copper was heated by fire, then cracked by sudden chilling with cold water, then pounded loose with boulder hammers and pried away with wooden levers [Quimby 1960:52].

These last three references regard prehistoric mining and quarrying techniques for nonsiliceous minerals, but the fire technique is also recorded for chert quarrying in the New World.

The best documentation comes from the Flint Ridge quarries in Ohio and from the novaculite quarries in Arkansas. At the novaculite quarries in Arkansas:

> Seeming evidence of the use of fire in quarrying is found in some of the lateral diggings where there has been undermining. Here certain faces of the Novaculite, protected from the weather by overhanging ledges, display blackened patches which may be due to the ancient fires [Holmes 1919:198].

We have information regarding the use of fire at Flint Ridge from Gerard Fowke's archaeological explorations:

> Careful observation . . . enables us to follow the prehistoric quarryman in his labors. He selected a spot . . . then sunk a pit . . . to the surface of the flint. On this he made a fire; and when the stone was hot he threw water on it, causing it to shatter. Throwing aside the fragments, he repeated the process until he penetrated the underlying limestone to a depth which allowed him sufficient room to work conveniently. The top and freshly made face of the flint was thickly plastered with potter's clay, after which fire and water were again utilized for clearing away the limestone until a cavity was formed beneath the flint layer. Thus a projecting ledge would be left from which the burnt parts were knocked off with heavy stone hammers until the unaltered flint was exposed [Fowke 1902:622-23].

There are also indications of the use of fire in prehistoric chert quarrying at the Nehawka quarries in Cass County, Nebraska. Excavations were conducted at these quarries in 1969 and 1970 by the Nebraska State Historical Society. In these excavations, areas of burned limestone and chert were revealed, suggesting that "some nodules in the bedrock may have been removed in this fashion" (Ronald Kivett, personal communication).

Some investigators refute the general use of fire in chert quarrying, stating that there is a "uniform presence in all the sites of fissures and exposures" which could have allowed for the removal of chert material "by the simple wedge and pry means supplemented by the application of direct percussion" (Ellis 1940:58). Nevertheless, it is reasonable to suggest that at least some chert quarrying was accomplished with the aid of fire.

As a result of prehistoric chert quarrying techniques employing intense heat, some chert would have become thermally altered as the result of quarrying techniques. The appearance of "heat treated" materials in prehistoric living sites may not be the result of intentional thermal alteration, but merely the result of a quarrying technique.

Many of the color variations which are recorded for some siliceous stone materials may be the result of the use of fire in quarrying. Hixton Silicified Sandstone from Wisconsin appears in a variety of colors in prehistoric, worked artifacts, and these colors "occur naturally" in small seams in the source area (Behm and Faulkner 1974). It is also noted that these color ranges have been produced through heat treatment experiments (Behm and Faulkner 1974:275). It may be that the color variation which appears to be naturally occurring in small seams in this and other source areas may be the result of ancient quarrying activities, and may not be a natural occurrence.

One of the best checks on the question of thermal alteration versus intentional heat treatment is to match on-site siliceous materials with the source materials' variability in the source area. For a large number of sites in different areas, the great majority of siliceous stone on the site is from a nearby source. These sources should be checked for color variation and evidence of fire on strata exposures which could possibly indicate the use of fire during prehistoric quarrying activities in the area.

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NEW INFORMATION ON THE EUROPEAN DISCOVERY OF YUCATAN AND THE CORRELATION OF THE MAYA AND CHRISTIAN CALENDARS

MICHAEL P. CLOSS

It has been known since 1972 that Ponce de Leon discovered Yucatan in 1513. New information confirming this is found in the books of Chilam Balam where the Maya record that the Spanish first arrived in their land at that time. The sundry data indicate that 8 July 1513 (N.S.) falls in Tun 13 of Katun 2 Ahau. This relation provides a new test for correlations of the Maya and Christian calendars. The Goodman-Martinez-Thompson correlation passes the test and the Morley-Spinden correlation fails it.

Writers on the Maya and historians have long believed, as did Scholes and Roys (1968:88), writing in 1948, that: "In 1517 Francisco Hernandez de Cordoba, sailing from Havana on a westward voyage, discovered the peninsula of Yucatan and explored its northern and western coastlines from Cape Catoche to Champoton." This voyage of Cordoba was shortly followed