Journal of Archaeological Science 38 (2011) 1727–1736

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Metallurgical analysis of copper artifacts from Cahokia

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ARTICLE INFO

Article history:
Received 7 December 2010
Received in revised form
2 March 2011
Accepted 4 March 2011

Keywords:
Cahokia
Metallurgy
Native copper
Cold-working
Annealing
Layering
Cutting

ABSTRACT

Copper artifacts from Cahokia Mounds, Illinois were analyzed from a materials science perspective to shed light on techniques used by Mississippian copper workers to deform nuggets of native copper into thin sheets. Eight small copper pieces from a copper-working site at Cahokia's Mound 34 were subjected to metallographic examination. Replication experiments thereafter recreated features of the artifacts under controlled conditions. It is concluded that copper sheets were thinned through repeated cycles of hammering and annealing performed at temperatures achievable in an open wood fire. The welding of sheets to create multilayered objects was not observed in any artifacts and could not be accomplished experimentally. Additionally, a possible cutting method used on some artifacts was identified.

1. Introduction

In the Mississippian culture, which encompassed much of present-day Southeastern and Midwestern United States from AD 1050 until European contact, copper was a key prestige good (Ehrhardt, 2009). The ceremonial and decorative copper items produced during this period, such as beads, repoussé plates, and copper-clad personal adornments, represent a zenith of prehistoric North American metalworking technique (Leader, 1988; Sampson and Esarey, 1993; Ehrhardt, 2009). Of all the major sites from this period, Cahokia, in southwestern Illinois, can be expected to have the dominant yield in copper artifacts because of its larger size, proximity to metal sources, and status as a ritual center. At present, however, it has yielded few copper objects, in contrast to the more numerous finds from Etowah, Georgia; Spiro, Oklahoma; and Moundville, Alabama; where, unlike at Cahokia, elite gravesite contexts have been examined (Ehrhardt, 2009).

Mississippian copper objects were crafted from nuggets of naturally-occurring and often highly pure native copper that were likely procured through long distance exchange from both Southeastern and Great Lakes sources (Hurst and Larson, 1958; Goad, 1980; Rapp et al., 1984), although "float" copper, found in the glacial drift across much of the Midwest, may also have been used (Halsey, 2008). The production process typically involved deforming nuggets into sheet or foil, from which objects were then fashioned via molding, embossing, perforation, riveting, and other sophisticated techniques (Cushing, 1894; Watson, 1950; Leader, 1988; Cobb and Evans, 2009; Ehrhardt, 2009). There has never been any credible evidence that Native Americans of the eastern United States employed melted metal technologies prior to European contact; instead, they relied on working (hammering) and annealing (heat treatment) to reshape copper nuggets (Schroeder and Ruhl, 1968; Clark and Purdy, 1982; Childs, 1994; Ehrhardt, 2009). Accordingly, of the two Mississippian copper sheet artifacts excavated from sites in Tennessee and examined metallographically by Schroeder and Ruhl (1968) and an additional two by Springer (2007), excavated from Moundville, Alabama, all were found to have been left in an annealed state after working. Replication experiments by Clark and Purdy (1982) suggested that thin native copper artifacts, such as these, were the product of repeated hammering and annealing cycles. Furthermore, Schroeder and Ruhl (1968) reported that the North American copper artifacts that they examined generally appeared to have been annealed at

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doi:10.1016/j.jas.2011.03.004

700–800 °C, and that one Mississippian copper object seemed to be "laminated", or composed of multiple sheets layered together. However, no technical analysis of copper materials from Cahokia has ever been conducted to verify that these broader statements about Mississippian and North American practices accurately describe the copper-working processes used at this site.

A "copper workshop house" dating to the early Moorehead phase (ca. AD 1200) was identified at Cahokia's Mound 34 by Gregory Perino in 1956 (Kelly et al., 2007; Kelly and Brown, 2010). Recent excavation by Brown and Kelly (Belknap et al., 2008; Kelly and Brown, 2010) at this site provides a uniquely valuable set of data for investigating copper production there. This study takes a materials science approach to characterizing certain aspects of the production process. Worked pieces of copper from Mound 34 were examined metallographically, and these findings were used as a baseline for several replication experiments. The specific questions addressed were: How were hammering and annealing used to thin nuggets into sheet, and what were the annealing conditions (time and temperature)? Did manipulations, such as bending, take place before or after the final anneal? Was the layering of multiple sheets used to make any of these objects? And, what method was used to produce the straight edges observed on several artifacts?

2. Materials and methods

2.1. Artifact examination

The artifacts in this study consist of eight objects recovered by Brown and Kelly at Cahokia's Mound 34, deriving from Gregory Perino's 1956 backdirt. All the items, shown in Fig. 1, are composed of copper sheet covered in black and green corrosion product. None of the objects appear to be finished pieces, but rather seem to be abandoned blanks or scraps. Some of the observed superficial features of the artifacts, listed in Table. 1, appear to be the result of specific production or manipulation techniques. Artifact 3 had been bent at a 90° angle. Artifacts 4, 6, and 8 all appear to be separating into two distinct layers in one or more places. Also, artifacts 6, 7, and 8 each display one or two distinctly straight edges, all characterized by a blunt profile with small burrs. This was interpreted as evidence that a common technique may have been used to cut all three. Because of the questions posed by these features, the following analyses focus predominantly on the artifacts described above.

Artifacts were cut across their width at areas of interest using a low-speed diamond saw (IsoMet 1000, Buehler, Lake Bluff, IL) in

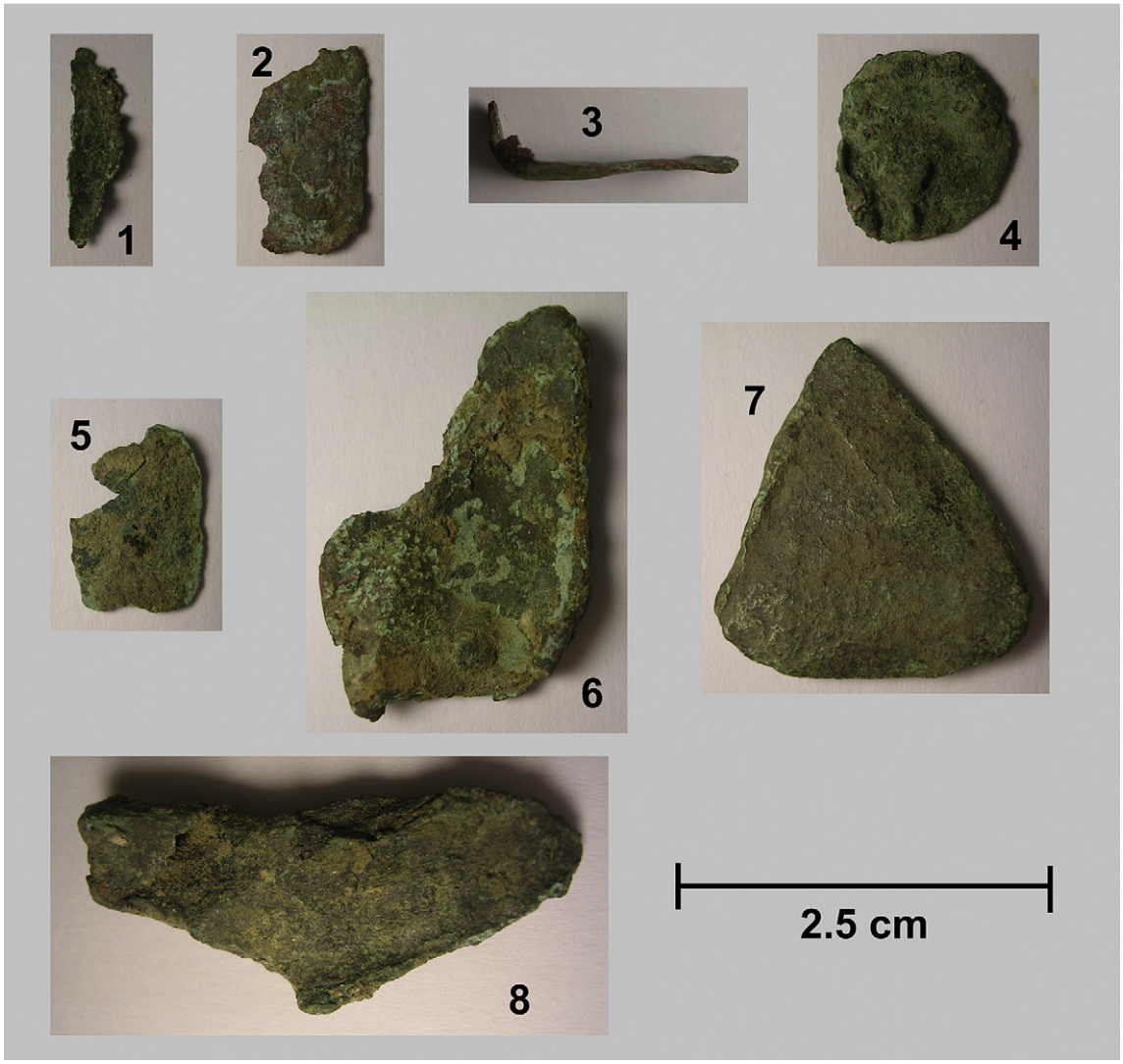

Fig. 1. Photographs of the eight copper artifacts from Cahokia's Mound 34 examined in this study.