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Investigating experimental knapping damage on an antler hammer: a pilot-study using high-resolution imaging and analytical techniques

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ABSTRACT

Organic (bone, antler, wood) knapping tools were undoubtedly a component of early human tool kits since the Lower Palaeolithic. Previous studies have identified pitting and the occasional presence of embedded flint flakes as important features for recognizing archaeological bone and antler percussors. However, no systematic protocol of analysis has been suggested for the study of this rare archaeological material. Here we present qualitative and quantitative results of a preliminary analysis of an experimental knapping hammer, using a novel combination of microscopy (focus variation optical microscope and scanning electron microscope), micro-CT scanning and energy dispersive X-ray spectroscopy. These imaging and analytical techniques are used to characterize use-damage from the manufacture of handaxes. This paper highlights the strengths and weakness of each technique. Use-wear on the working area included attritional bone loss, micro-striations and compaction of the outer layer of the antler matrix from repeated hitting of the beam against the sharp edge of the handaxe during knapping. Embedded flint flakes were also identified in the pits and grooves. This combination of high-resolution imaging techniques is applicable to fragile archaeological specimens, including those encrusted by sediment or encased in matrix.

1. Introduction

In recent years, new and increasingly sophisticated imaging and analytical techniques have been applied to the study of past human behaviour: optical and laser microscope, X-ray, CT and Micro-CT scans, just to mention a few (e.g. Abel et al., 2012; Bello et al., 2013; Boschin and Crezzini, 2012; Evans and Donahue, 2008; Le Bourdonnec et al., 2010). The use of soft (bone, antler, wood) hammers and retouchers was a key innovation in early stone tool technology, first recorded in the archaeological record during Lower Palaeolithic (Acheulian of Boxgrove, UK ~500 kya; Wenban-Smith, 1985, 1999). The use of antlers as soft hammers can be identified from characteristic damage on the working area in form of micro-fractures. These have been described and recognized since the beginning of the 20th century (e.g. Bourlon, 1907; Girod and Massenat, 1900; Henri-Martin, 1907–1910). However it is the presence of small flint chips embedded in the surface of an antler that can ultimately confirm the use of an antler as a tool-maker. These small flint residues can be observed using a hand lens and binocular microscope at low magnification, but more informative results can be obtained using higher magnification photography and scanning electron microscopy (Bordes, 1974; Mallye et al., 2012; Olsen, 1989).

Several experimental studies have explored the use of bones as soft-hammers and retouchers, either as percussors or pressure flakers (e.g. Karavanić and Šokec, 2003; Mallye et al., 2012; Newcomer, 1971; Rosell et al., 2011; Semenov, 1964; Wenban-Smith, 1985, 1999), however, antler knapping-hammers have received little systematic attention (Lyman, 1994; but see Bordes, 1974; Olsen, 1989; Shipman and Rose, 1983). This is surprising as antler is the preferred soft-hammer for thinning and finishing of experimental handaxes, Mousterian scrapers and Upper Palaeolithic blades (Bordes, 1974; Crabtree, 1970; Flenniken, 1984; Johnson, 1978; Knowles, 1953; Newcomer, 1971; Ohnuma and Bergman, 1982; Whittaker, 1994; Wymer, 1968). The lack of detailed documentation and description of traces of use on antler

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knapping-percussors presents a major stumbling block to identifying fragmentary (Jéquier et al., 2012), poorly preserved, sediment-encrusted (Kuhn et al., 2008) or contentious archaeological examples (Goren-Inbar, 2011).

This paper presents the results of a preliminary analysis to document use-damage on an experimental knapping hammer using a range of analytical and imaging techniques (i.e. micro-computed tomography, focus variation microscopy, variable pressure scanning electron microscopy and energy dispersive X-ray spectroscopy). The strength and weakness of each technique have been highlighted. We illustrate microscopic use-wear features that are diagnostic of antler knapping hammers and propose a protocol for their analysing.

2. Material

The soft hammer used in the experimental study (Fig. 1A) was cut from the beam of an antler of a whitetail deer (*Odocoileus virginianus*) using a metal saw. Although cuts are still visible at the base ('handle') of the hammer, extensive use-damage has removed all but a vestige of the saw-marks at the 'apical' end (Fig. 1B). The hammer was part of the tool-kit used during flint-knapping experiments conducted at Boxgrove between 1995 and 1996. These experiments replicated sharp ovate handaxes similar to those found in the early Middle Pleistocene archaeological horizons at the site (Roberts and Parfitt, 1999). The tool-kit used by the flint knappers consisted of a hard (flint beach pebble) hammer, a soft hammer made from the base of a red deer antler and a lighter (172 g) antler bar-hammer, which is the focus of this study. Weathered flint nodules (from soliflucted gravels) and fresh flint from chalk exposures in the quarry at Boxgrove were used to manufacture handaxes. The antler hammer was held at the proximal end and struck against the tool-edge to detach flakes. Mostly, the knapper struck the hammer at right angles to the handaxe edge, but it was sometimes held at an oblique angle, or even parallel to the edge. Flaking alternated between a succession of light blows to first prepare and strengthen the striking platform (Fig. 2A), resulting in the removal of small chips, followed by a sharper blow to detach a larger thinning and trimming flake (Fig. 2B).

The antler bar-hammer was selected for this pilot study because of its shape, lack of tines and overall small dimensions which facilitate micro-computed tomography and SEM analyses. Similar bar-hammers are used widely by experimental flint-knappers, particularly in North America (Crabtree, 1967).

3. Methods

The antler was examined initially with a variable magnification binocular and observations were aided by illumination from a fibre-optic light source. Drawings were used to record the location and intensity of damage, and to indicate the position of the flint chips. An un-modified area of the antler used as a control for surface texture was also analysed. This corresponds to its central basal portion, where the hammer was held (Fig. 1F). Comparisons were also made with natural surface modifications on antlers described by Olsen (1989), d'Errico and Villa (1997) and Jin and Shipman (2010).

Micro-computed tomography (micro-CT) was undertaken to record the surface topography and to gauge the extent of surface damage in relation to antler density. The specimens were scanned using a HMX-ST CT 225 System (Metris X-Tek, Tring, UK). The instrument uses a cone beam projection system (Johnson et al., 2007) with a four megapixel Perkin Elmer XRD 1621 AN3 HS detector panel. Different settings were used to optimize contrast and minimize beam hardening. The final X-ray and scan parameters were as follows: tungsten target; 175 kV; 145 mA; 6284 projections with 0.354 s exposure and a voxel size of 42.9 μm. In order to reduce the effects of beam hardening the X-rays were filtered with a 0.5 mm thick copper plate. The long axis of the antler was oriented vertically with respect to the beam, thus ensuring maximum resolution whilst minimizing streak artefacts (Yu et al., 2004). The micro-CT data were reconstructed using CT-PRO software version 2.0 (Metris X-Tek) and rendered using VG Studio MAX 2.1 (Volume Graphics, Heidelberg, Germany).

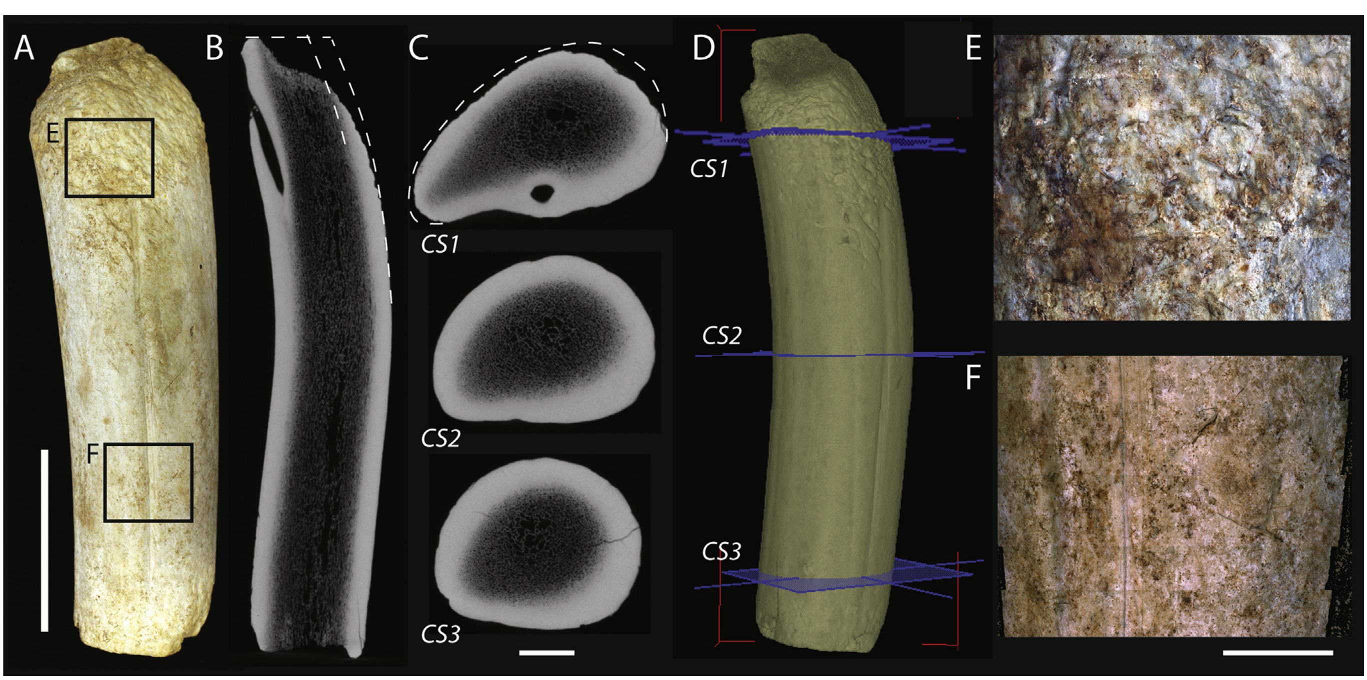

Fig. 1. (A) Photograph and longitudinal and transverse CT sections (B–C) of the experimental antler hammer. (D) CT surface rendering showing position of the cross-sections CS1–3. The original profile of the working area is indicated by the dashed lines. Scales A, B and D = 50 mm; C, E and F = 10 mm.