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Rotten ivory as raw material source in European Upper Palaeolithic

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ABSTRACT

Human manipulation on mammoth ivory is widely known from the archaeological record of the Upper Palaeolithic. The ring notching technique to break a tusk can be documented from the Early Aurignacian with continuous traditions in the Gravettian/Pavlovian. Experiments with rotten and fresh elephant ivory highlight for many Palaeolithic objects the analogy to breakage patterns in a significant decomposition process. The use of rotten ivory is especially evident in several Upper Palaeolithic art objects. These ivory plates, showing a concave inner surface caused by rotting, were the raw material for several Aurignacian figurines from the Swabian Alb (Southern Germany) and Gravettian figurines from Southern Moravia. The use of rotten ivory in a "carve and splinter technique" will be discussed for the lion man from Hohlenstein-Stadel. Strategies of deliberate maceration can reduce working costs. Procurement of rotten ivory is conceivable as a chaîne opératoire, either starting by killing the animal and caching of the tusks, or harvesting of specific weathered material from the land surface. In particular, the latter behavior gives reason to consider that raw material acquisition as "recycling".

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1. Introduction

The earliest evidence of figurative art is typically associated with the arrival of *Homo sapiens* in Central and Western Europe. Tusks of *Mammuthus primigenius* served as raw material for the oldest figurines of those anatomically modern humans in Europe. While expression of Neanderthal art has been recently debated (Zilhão et al., 2010; Peresani et al., 2011, 2013; Roebroeks et al., 2012), non-utilitarian treatment of mammoth ivory or teeth is known only in rare cases (Dobosi, 2001).

Although the Aurignacian art objects of the Swabian Alb themselves and their cultural implications are widely known, only little investigations have been carried out on the taphonomy of mammoth ivory. Technical aspects of ivory working were first taken under focus by Joachim Hahn and some of his scholars. The detected "ring notching technique" for transversal breaking of tusks to pieces had been used in several cases of Aurignacian and Gravettian sites (Hahn et al., 1995, 30; Christensen, 1999, 60–66; Khlopachev, 2001, 215–216, Fig. 1; Thiault, 2001, Fig. 12–14; Scheer, 2001). Most of those experiments were undertaken with fossil mammoth ivory. The practical background is its accessibility because of its exclusion from the Washington Convention (CITES). Consequently, some studies could not focus on the differences between fresh and more or less rotten mammoth ivory. Malina and Ehmann (2009) reconstructed the Aurignacian flute from Geissenklösterle Cave (Swabian Alb, Southern Germany) by splintering a spall of fossil mammoth ivory. They confirmed the adequate properties of fossil ivory which are different from recent ("fresh") material. The advantage of using such a weathered spall was not part of their conclusions.

The use of weathered and recent elephant ivory confiscated by customs officials at two German airports allowed testing of an experimental range of different raw material conditions for a better understanding of its properties. Breaking patterns and other observations including soaking pretreatment allow discussion of Palaeolithic use of mammoth tusks in an advanced decomposition or macerated stage.

2. Taphonomy of Proboscidean tusks

Tusks of the Upper Pleistocene woolly mammoth and recent elephants display similar material properties. Cross sections show a rosette shaped inner fibre structure, a Schreger pattern (Trapani and Fisher, 2003). The different angle of the Schreger lines (the fibre texture) is reasoned mainly by the different bending of the tusks: the heavily bent mammoth tusks display acute Schreger line angles of less than 90°, while the slightly curved or elongated elephant tusks show obtuse Schreger line angles of 100° or more

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degrees (Penniman, 1952). They are best visible in the outer dentin cones next to the cement–dentin junction (CDJ).

The dentin cones consist of 50–65% calcium phosphate. Dentin rates approximately 3 on the Mohs scale of mineral hardness. The outer cement consists of 70% calcium-hydroxylapatite and, with a Mohs hardness of 5, is the hardest organic material animals produce. The dentinal tubules contain fluid and cellular structures. They are three-dimensionally cross-linked. As Trapani and Fisher (2003) describe, during dentin deposition sets of odontoblasts move in phase with each other and 180° out of phase with adjacent sets. The growing of the dentin cones is influenced by the diet and environmental conditions, and the growth rings can be used as individual signatures. Cross-sections of the right and left tusk are identical. X-ray scans of complete tusks can provide for the same diagnosis as do virtual cross sections. Summarizing, living dentin does not build up any cleavage faces along the conical growing rings. Longitudinal breaking patterns on fresh ivory display practically isotropic properties while transversal breaks show the outlined Schreger patterns (Fig. 1).

Only after decomposition do the tusks start to develop cleavage patterns along the growing rings and break apart along the cones (Fig. 2). The duration of the weathering process is due to the climatic conditions: for a decomposition of a South African tusk, conical lamellar pieces were observed after ten years. In consideration of the fact that Pleistocene mammoth ivory is still in trade as raw material for modern ivory carvers, decomposition is obviously a question of local sedimentation without time limit.

3. Breakage patterns in the archaeological record *vs.* experiments

The use of bone retouchers has been known since the Middle Palaeolithic. It is related to well-documented Neanderthal sites (Verna and d'Errico, 2011; Daujeard et al., 2014). While hitting marks on long bone shaft fragments seems to be less practical in terms of a longer preservation of the hammers (Verna and d'Errico, 2011), the epiphysis of the long bones from big game are hard enough and feasible for longer use as hammers for flint-knapping (Daujeard et al., 2014).

Fig. 1. African elephant tusk: transversal section with sawn vs. broken surface (foto: Leif Steguweit = LS, scale 5 cm).

Fig. 2. Fossil ivory, conical breakage patterns (foto: R. Bücking, scale 5 cm).

Interesting details of anthropogenic manipulations were found on four worked pieces of mammoth tusks from Alberndorf, Lower Austria (Steguweit, 2005; Steguweit and Trnka, 2008). The site has been AMS dated, and four charcoal samples delivered the most reliable date of approximately 29–27 ka BP and fit within the late Aurignacian (Steguweit and Trnka, 2008). The removal of the tusk sections was done with the typical method of cutting a concave ring through the outer part of the tusk, the ring notching technique (Hahn et al., 1995). After the preliminary consideration, it is clear that conical inner breakage is possible only after decomposition.

As pretreatment for the breakage, two smaller opposite-standing notches were carved on object AL 774. The predetermined breaking point leads to controlled breaks, as well at AL 774, AL 840 and AL 1246 on the proximal side and at object AL 775 on both ends. In contrast, the distal ends of AL 774 and AL 840 are irregularly broken and splintery. Special attention is directed to the only surface which had been intensively worked after the separation: the distal surface from object AL 775. Because of the significant traces of use at the distal edge, object AL 775 was recently identified as a soft hammer for flint-knapping (Fig. 3).

Comparing the ivory hammer from Alberndorf with objects from other collections, I could identify similar traces of use on other ivory artefacts from the Gravettian sites of Předmostí Ia (13 objects, Fig. 4), Pavlov (5 objects) and Dolní Věstonice (1 object), recently published with elaborated descriptions and figures (Steguweit, 2005). More probable ivory hammers for flint-knapping can be identified from Eastern European sites, such as Avdeevo, Kostenki IV, Mezin, Suponevo, Sungir, Timonovka, and Eliseevichi (for details see Steguweit, 2005). There seem to be continuous traditions from Late Aurignacian to Gravettian and the cultures after the Last Glacial Maximum, showing patterns of exchange, trade or at least interactions. Experiments with a replica made of elephant ivory indicate the excellent properties of the ivory for flint-knapping, due to its hardness and weight. Hitting marks on the recent elephant ivory hammer accord with the archaeological record (Fig. 5).

4. Aurignacian figurines made of mammoth splinters

Deposits of tusks (ivory splinters) were described from Vogelherd cave, Hohlenstein-Stadel, Geissenklösterle and Hohlefels (Hahn, 1986; Hiller, 2003; Heckel and Wolf, 2014). Hahn (1986) interpreted the object accumulations as caches to allow maceration by water and sediment chemistry. Knapped ivory flakes are known from the Swabian Aurignacian. Some workers discussed the improvement of the fracture behavior by freezing the ivory (Khlopachev and Girya, 2010).

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