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Metalwork wear analysis: The loss of innocence

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ABSTRACT

Metalwork wear-analysis has now been practised for over two decades. In this paper the authors present the achievements of the discipline and critically assess the methodologies currently applied by practitioners. Whilst the achievements and contributions of the discipline to the wider study of archaeology, and to European prehistory in particular, are numerous, it is argued that an increase in scientific rigour and a focus on addressing limitations and open problems is required if metalwork wear-analysis is to flourish as a scientific field of research. Experimentation with higher magnifications and novel microscopic techniques is encouraged, alongside more standardised and explicit analytical protocols for analysis. More details and targeted descriptions of analytical protocols for experimental work are required: experiments must be designed to answer specific questions and address lacunas in knowledge. While at present the majority of practitioners focus their analyses on copper alloys from European prehistory, and most specifically from the Bronze Age, the authors suggest that a far wider range of materials are suitable for analysis including copper alloys from the Americas and iron alloys from historic and ethnographic collections. Expanding the range of materials studied would open the field up and give it far wider relevance to archaeology and material culture studies. Finally, it is argued that the discipline will advance more quickly if practitioners share their reference collections and databases of experimental marks digitally. The authors suggest that the creation of digital reference collections, open to all, would provide metalwork analysts with the opportunity to lead related fields of research such as lithic microwear and residue analysis, where individual reference collections are the norm and cross-comparability of analysis is therefore hindered.

1. Introduction

After nearly two decades of sustained research and experimentation, the wear analysis of archaeological metals is close to becoming a full-grown field of archaeological science. The subject initially emerged at the disciplinary nexus between lithic microwear studies and archaeometallurgy, and soon acquired its own distinctive goals, methods, and approaches. As new classes of bronze objects were examined microscopically and new traces were identified, however, new problems also emerged, which have exposed the limits of the discipline. In particular, a disconnection of sorts has emerged between metalwork and lithic wear studies owing to the oft-diverging research interests of their practitioners, the practical and material differences between the objects of study, and the lack of formal training in microwear analysis by many a metalwork specialist. As this position appears increasingly untenable, it is now urgent to reassess the developmental trajectory, methodology, and limitations of metalwork wear analysis in order to ensure its steadfast growth for years to come.

The aim of this article is to conduct this reassessment. The authors firmly believe that metalwork wear analysis is close to outgrowing the exciting, if rather disorderly, stage that characterises all pioneering fields of research, and is now coming of age. However, to mature as an independent branch of archaeological science, the discipline needs to lose its early innocence (*sensu* Clark, 1973). This minimally involves the development of a more reflexive approach to artefact experimentation and analysis, a broadly agreed strategy for filling its knowledge gaps, and a self-conscious decision as to where the subject is to stand in relation to lithic microwear analysis, archaeometallurgy, and experimental archaeology. In this article we explain how these goals may be achieved.

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After discussing issues of definition, we outline a brief history of the discipline, review its analytical methods, and present a number of key suggestions for its future development. We sincerely hope that our work will initiate a broader debate concerning the future of metalwork wear analysis, and how it can reach disciplinary maturity.

2. Issues of definition

Various terms have been employed to define the branch of wear studies dealing with metalwork. *Use-wear* (or use wear) *analysis* is the one used most widely in the literature (e.g. Dolfini, 2011; Gordon, 1985; Kamphaus, 2006; Kienlin and Ottaway, 1998). The term, borrowed from lithic microwear studies, refers to the wear visible on the edges and surfaces of an object, which is caused by use (1) (Hayden, 1979; Marreiros et al., 2015; Odell, 2004). The limits of this definition become apparent upon considering that many of the traces observed on metals are not linked to artefact utilisation, but to manufacturing and post-depositional processes (Gutiérrez-Sáez and Martín-Lerma, 2015; Li et al., 2011; Roberts and Ottaway, 2003). *Traceology*, a term similarly borrowed from lithic wear research, refers to the study of any traces visible on ancient tools (Fullagar and Matheson, 2014: 7063). Its use would avoid the implication that wear was only generated by use, or is solely found on the 'working parts' of the objects. The term, however, is normally used in lithic studies to encompass residue analysis, and is therefore too broad at present as residue analysis is wholly marginal within metalwork studies. *Functional analysis* has some currency in lithic wear research, but has rarely been employed outside it. Although used synonymously with use-wear analysis, it may in fact imply the application of methods and approaches lying outside the discipline (e.g. artefact classification and experimental archaeology). Furthermore, as with the term use-wear, it does not encompass the range of production and post-depositional marks observed on objects, and is also rather vague (Donahue, 1994: 156).

We propose here that the discipline be renamed *metalwork wear analysis*. Although this term has never been used in the context of metal traceology, it presents a number of distinctive advantages. Firstly, it does not solely focus on the analysis of use-related traces, and does not imply that certain portions of the object may carry a higher informative value than others. Yet it is close enough to the now-prevalent 'use-wear analysis' to be recognisable by both practitioners and the wider research community. Secondly, it explicitly refers to the methods and approaches of archaeological wear research while also capturing the specificities of the subject, e.g. the prevailing utilisation of low-power microscopy (see 3.1 and 4.2.3). Thirdly, it suggests that the general principles of the discipline are experimentally based and broadly derived from two areas of engineering research: tribology and fracture mechanics (Donahue, 1994). Presently, this is the term that best captures the distinctiveness of the subject whilst explicating its close relationship with lithic microwear studies.

3. Metalwork wear analysis: history and research advances

Metalwork wear studies developed much later than lithic microwear research despite Semenov's early foray into metal tools (Semenov, 1964). Such a late development has been ascribed to a number of reasons including the fear that recycling, manipulation, re-sharpening and corrosion would seriously limit the potential of metalwork wear analysis (Roberts and Ottaway, 2003: 120). It has also been attributed to long-standing preoccupations with typology as the chief avenue for assessing the functionality of ancient bronzes (Gutiérrez-Sáez and Martín-Lerma, 2015: 171). It may perhaps be added that researchers, and especially the students of the European Bronze Age, were for a long time reluctant to consider that our prehistoric past might have been a violent one (Keeley, 1996); hence their hesitation to search bronze weapons for combat marks or to test their use-value experimentally. The combined influence of these factors was ultimately responsible for the delayed emergence of metalwork wear analysis *vis-à-vis* lithic traceology.

The examination of use-related marks on prehistoric and historic copper alloys was pioneered from the late 1970s by a small number of European and American scholars, some of whom appear to have been unaware of each other's work. In Europe, Kristiansen (1978, 1984; 2002) assessed the functionality of Bronze Age swords using interdisciplinary approaches that encompassed, but were not limited to, the microscopy-enhanced observation of large assemblages of objects, while Schauer (1979) trialled the investigation of use marks on spear-heads. In America, Penman (1977) tested the potential of wear analysis on artefacts from the Old Copper culture, while Gordon (1985) studied indigenous bronze tools from Machu Picchu using a novel combination of microscopy and metallurgical analysis. These early studies may be commonly defined by (a) the non-specialist background of the scholars, none of whom had any formal training in lithic microwear analysis; (b) a certain lack of methodological sophistication, evident for example in the absence of experimentation with replica objects; and (c) their eclectic approaches, which employed optical microscopy within a broader spectrum of archaeological and analytical methods.

Pioneering studies of this kind were carried out until the late 1990s (e.g. Bridgford, 1997, 2000; Wall, 1987), when Kienlin and Ottaway (1998) first proposed a rigorous methodology for the wear analysis of copper-alloy objects, which deliberately drew on lithic microwear research. Their ground-breaking investigation of prehistoric axe-heads encompassed the following steps:

(1) field tests with replica axes in order to understand wear formation processes;
(2) taking dental casts of the cutting edges of experimental and prehistoric axe-heads;
(3) examining the dental casts using a low-power stereo-microscope in order to interpret ancient wear patterns by comparison with the experimental ones.

Kienlin and Ottaway's research marked the birth of modern metalwork wear analysis, and their 'classic' three-step approach has since been widely employed, albeit with some adaptations (see 4.1).

As most researchers were interested in prehistoric copper alloys from Europe, the new discipline made significant inroads into Copper Age and Bronze Age studies. In particular, four classes of artefact were afforded the greatest attention: swords, shields, spears, and halberds. Kristiansen and Bridgford's early work on swords was taken forward by Molloy (2007, 2008; 2010; 2011), who advocated a martial-arts approach to the study of these iconic prehistoric weapons. This was based on integrated wear analysis of archaeological objects and field experiments with replica swords, in which he tested the combat potential of the weapons in staged duels (Fig. 1). He was able to show that the alleged division between Middle Bronze Age 'rapiers' and Late Bronze Age 'cut-and-thrust' swords, which had long dominated Bronze Age studies, is incorrect as both types of weapon are suitable for thrusting and slashing attacks, and both display similar combat marks on their cutting edges. Other researchers concentrated on different problems. For example, Quilliec (2008) investigated both combat and destruction marks on a sample of swords from Atlantic Europe, paying special attention to any contextual differences which could shed light on codified practices of use and deposition. In a similar vein,