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Testing a taphonomic predictive model of edge damage formation with Middle Stone Age points from Pinnacle Point Cave 13B and Die Kelders Cave 1, South Africa

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ABSTRACT

The interpretation of taphonomic and behavioral lithic edge wear formation is complicated by equifinality of edge damage morphologies. Rejecting hypotheses that edge damage originates from taphonomic processes is standard practice for many archaeological analyses and should be incorporated into lithic use-wear more explicitly. Quantitative hypothesis testing is advocated here, and facilitated by recording edge wear observations in an image referenced GIS spatial environment. A taphonomic predictive model was generated using trampling and flint-knapping experiments. Trampling experiments were conducted to determine how edge damage is distributed along tool edges due to non-use related, taphonomic processes. Experiments designed to test the assumption that undisturbed flakes do not preferentially orient either surface side-up (dorsal or ventral) were performed. Furthermore, it is argued that artifact orientation data, if available, can also be used to assess whether the frequency of edge damage is correlated with the degree of disturbance. This taphonomic predictive model is then statistically compared with frequency and distribution edge damage data from two South African Middle Stone Age sites. The research presented here illustrates the usefulness of edge damage distribution analysis for accounting for taphonomic processes as causal agents of edge damage formation, and strengthening behavioral interpretations regarding tool function. Bringing tool wear observations into a uniform spatial structure is one avenue for standardization of lithic use-wear analysis.

1. Introduction

Linking wear trace patterning on stone tools to behavioral processes is the cornerstone of lithic use-wear studies. In Stone Age and Paleolithic assemblages especially, behavioral linkages are made problematic by equifinality of edge wear morphologies and post-depositional processes (Pargeter, 2011; Shea and Klenck, 1993). Coarse-grained raw-materials, lack of ethnographic analogy, and a long duration of burial make interpreting stone tool function in Pleistocene assemblages difficult (Beyries, 1990; Grace, 1990; Thackeray, 2000). Macrofracture and residue trace analysis have led to some success, but are not independent of taphonomic considerations (Lombard, 2005; Rots et al., 2006; Wadley et al., 2004). Many lithic microwear applications require fine-grained, high-quality raw materials and comparison to archaeological sites that have undergone less post-depositional modification than many Paleolithic and Stone Age contexts. Making edge damage inferences with such assemblages requires developing a methodology that matches the minimal scale of meaningful observation, which is often simply noticeable damage along tool edges (Bird et al., 2007; Thackeray, 2000). Although the perspective of the approach advocated here is towards the Pleistocene, the experimental design and methodology should be applicable to a wide range of lithic use-wear studies.

An opportunity to advance Stone Age use-wear standardization lies in creating a framework that can statistically test the initial null hypothesis that use-wear observations are more parsimoniously linked to taphonomic rather than behavioral origin. Confronting the possibility that edge wear patterns formed from taphonomic processes at the outset tempers behavioral interpretations and provides statistical confidence in results presented by use-wear analysts. In this paper, a predictive model for post-depositional lithic edge damage formation is integrated from new and existing experimental data, and a framework for linking lithic edge damage with standard geoarchaeological analytical techniques is suggested. Three hypotheses of taphonomic edge damage formation that should be rejected to gain greater inferential footing are tested with archaeological data from the Middle Stone Age. Data were collected

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within a GIS environment that provides a standardized framework for quantitatively comparing frequency and distributions of microfractures between assemblages.

The predictive model of taphonomic edge damage formation stems from published experiments that suggest post-depositional lithic edge damage forms (a) indiscriminately along tool lateral edges, or 'randomly' (Pryor, 1988); and (b) with different intensity depending on which surface (dorsal or ventral) is in contact with disturbance processes (McBrearty et al., 1998, Tringham et al., 1974). This pattern is verified with a set of trampling experiments documenting that edge damage formation is distributed with equal probability across tool edges, and is biased against forming on whichever surface was facing upward (i.e., "side-up" *sensu* Burger et al., 2008) when exposed to trampling. With this information, the taphonomic model then requires some knowledge of how artifacts tend to be oriented surface side-up. Therefore, frequency of resting lithic surface side-up is estimated with a series of knapping and flake rolling experiments. Artifacts tend to initially land indiscriminately either dorsal or ventral surface side-up. However, post-depositional forces may alter the surface side-up frequency (Schick, 1984). The degree of post-depositional alteration may then be inferred from a fabric analysis of lithic orientations and inclinations (Lenoble and Bertran, 2004). Experimental edge damage frequency and strength of post-depositional processes are correlated (i.e., trampling intensity; Shea and Klenck, 1993), and if post-depositional processes are the main cause of edge damage formation, then this correlation is expected to be maintained archaeologically. With these taphonomic model predictions, two archaeological case studies from the Middle Stone Age (MSA) of South Africa are examined (Fig. 1), Pinnacle Point Cave 13B (PP13B) and Die Kelders Cave 1 (DK1).

1.1. Edge damage background

1.1.1. Stone tool morphology

Formation of wear patterns on tool edges is dependent on numerous behavioral factors including direction, strength, and duration of force applied to edges (Odell, 1981; Tringham et al., 1974). The distribution of behavioral edge damage along tool edges is related to edge shape and angle, the direction of motion, and hafted or prehensile configuration (Kamminga, 1982; Keeley, 1980; Odell, 2004; Rots, 2003; Tringham et al., 1974; Vaughan, 1985). In contrast, damage due to post-depositional processes such as trampling, compaction, weathering, fluvial transport, freeze-thaw cycling, and sediment slumping should produce edge wear without strong location preference (Eren et al., 2011; McBrearty et al., 1998; Pryor, 1988; Shea and Klenck, 1993; Tringham et al., 1974). Sediment substrate also influences the rate of edge damage formation since the penetrability of the substrate determines how quickly artifacts will be buried (Gifford-Gonzalez et al., 1985; Pryor, 1988). The frequency with which tool edges will form visible damage is strongly determined by lateral edge angle and the shape of the edge. During use, very acute edge angles will form extensive damage more readily than steeper angles (Grace, 1989). Retouch of the lateral edges increases the lateral edge angle. Therefore, two equally utilized edges, one with a steep edge angle and one with an acute angle, may display unequal damage due to the difference in edge angle. The study presented here demonstrates a method to standardize lithic edge damage recording using an image analysis GIS framework, which is easily amenable to including edge angle as a factor in future work. However, the influence of edge angle is not considered here since the archaeological application is on unretouched, convergent MSA points that have strong bilateral symmetry and acute edge angles around their perimeter. Taken as mean edge angle (i.e., arctangent of point thickness divided by ½*max width), the convergent points from PP13B (95% CI mean edge angle = $29.1° \pm 0.9°$) and DK1 ($34.3° \pm 1.6°$) would be classified as "thin" (i.e., <45°) by Akoshima (1987) as well as the trampled backed blades used in the trampling experiments ($34.3° \pm 3.5°$). It is anticipated that any influence of edge angle would be minor and there is no reason to suspect an assemblage level pattern of edge angle bias on convergent points from either site compared in this study.

Edge shape morphology may also influence the formation of edge damage (Tringham et al., 1974). Convex lateral edge protrusions may form damage more readily during longitudinal use compared to concave lateral edges, whereas concave lateral edges may have functional properties such as shaving that may encourage edge damage formation from use (Grace, 1989). Edge damage formation due to post-depositional processes may also be strongly influenced by differences in lateral edge shape. However, a geometric morphometric analysis of convergent point shape from several MSA sites indicated that no systematic bias in edge shape exists that would influence the distribution of edge damage (Schoville, 2010). In other words, the left sides of convergent points, on average, are as convex as the right sides. The influence of convergent point shape and taphonomic edge damage formation is not explicitly accounted for in this study, however, it should be noted that by limiting the analysis to typologically defined "convergent points", shape variability is greatly reduced compared to an analysis of an entire assemblage of detached pieces.

1.1.2. Surface side-up orientation

Post-depositional processes also preferentially influence edge damage formation depending on which artifact surface faces disturbance forces. Due to gravitational forces, weathering, trampling, and compaction tend to be directed downwards, which may cause damage formation to occur more heavily on one surface of artifacts over the other. Faunal analysts have utilized this side-up weathering pattern to infer exposure time and deposition rates on bones distributed on the landscape (Behrensmeyer, 1978). Bone surfaces that are side-up will be much more heavily weathered than the downward facing surface. Analyzing side-up patterns can be informative of the degree of rolling experienced by faunal remains (Behrensmeyer, 1978; Schoville and Hurtado, 2001) and inform skeletal element abundance interpretations (Todd and Rapson, 1999). How surface side-up influences post-depositional lithic damage formation is not as well utilized for understanding lithic taphonomy compared to fauna. Tringham et al. (1974) note

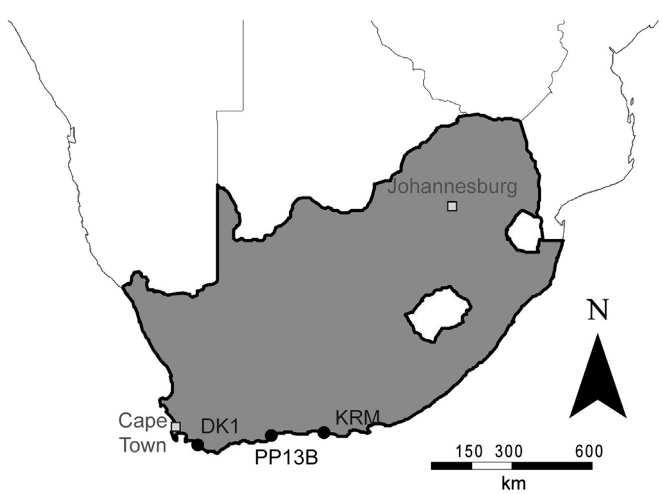

Fig. 1. Location of MSA caves PP13B and DK1 along the southern coast of South Africa.