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Movement of lithics by trampling: An experiment in the Madjedbebe sediments, northern Australia

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A B S T R A C T

Understanding post-depositional movement of artefacts is vital to making reliable claims about the formation of archaeological deposits. Human trampling has long been recognised as a contributor to post-depositional artefact displacement. We investigate the degree to which artefact form (shape-and-size) attributes can predict how an artefact is moved by trampling. We use the Zingg classification system to describe artefact form. Our trampling substrate is the recently excavated archaeological deposits from Madjedbebe, northern Australia. Madjedbebe is an important site because it contains early evidence of human activity in Australia. The age of artefacts at Madjedbebe is contentious because of the possibility of artefacts moving due to trampling. We trampled artefacts in Madjedbebe sediments and measured their displacement, as well as modelling the movement of artefacts by computer simulation. Artefact elongation is a significant predictor of horizontal distance moved by trampling, and length, width, thickness and volume are significant predictors of the vertical distance. The explanatory power of these artefact variables is small, indicating that many other factors are also important in determining how an artefact moves during trampling. Our experiment indicates that trampling has not contributed to extensive downward displacement of artefacts at Madjedbebe.

1. Introduction

Claims for the first evidence of human activity, or of new types of activity, at many archaeological sites depend on a close stratigraphic association between culturally modified materials and dated materials. To be confident of these associations we need a robust understanding of how artefacts are displaced from their original locations by post-depositional processes. Examples of problematic vertical separation of artefacts that complicate the interpretation of archaeological deposits have been known for some time. For example, Villa and Courtin (1983) describe conjoinable artefacts up to 1 m vertically apart and in different deposits. Similarly, Cahen and Moeyersons (1977) report refitting artefacts up with to 1 m of vertical separation at Gombe Point in Zaire. At FxJj50, Koobi Fora, Kenya, Bunn et al. (1980) report conjoinable pieces up to 50 cm apart vertically in brief occupation deposits of alluvial sandy silt. At Cave Spring, Tenessee, Hofman (1986) recorded refitting artefacts over 20–40 cm of vertical distance. Richardson (1992) observed a maximum vertical separation of 30 cm for conjoining artefacts from different excavation units at Kenniff Cave (Queensland, Australia). In this paper we use geological methods to explore clast form and size metrics to identify relationships that might help identify artefacts that have moved due to trampling, and given the form attributes of an assemblage, to understand the magnitude of movement that may have occurred in an assemblage.

Our motivation for this study arises from claims of vertical movement of artefacts in debates surrounding the timing of the first human occupation of Sahul, where the archaeological deposits are often sandy and lacking well-defined stratigraphy. Investigations at archaeological sites in northern Australia recovered small numbers of flaked stone artefacts from sandy rockshelter deposits associated with Optically Stimulated Luminescence ages (OSL) 50–60 k BP. The reliability of these associations has been

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questioned, with critics claiming that post-depositional processes have brought the stone artefacts in association with much older sediments. At Madjedbebe (formerly Malakunanja II), one of Australia's oldest sites, trampling of artefacts has been proposed as a possible cause of dislocation of artefacts down through the deposit into an association with sediments much older than the artefacts (Hiscock, 1990). In this paper we describe a trampling experiment directly relevant to Madjedbebe and other sites with sandy deposits.

Because of the importance of their effect on understanding artefact contexts and associations, trampling experiments are a mainstay of archaeological science (e.g. Driscoll et al., 2015; Eren et al., 2010). For example, Eren et al. (2010) summarised fourteen publications of trampling experiments, all aimed at understanding how human and animal trampling contribute to the spatial displacement of, and damage to, objects commonly found in archaeological sites. The aim of our experiment was to understand how artefacts move in a sandy deposit when trampled by walking. Specifically, we explored the relationship between artefact form parameters and the distance they were moved by trampling. We follow Eren et al. (2010) in focusing on short-term trampling events, and by recording the position, orientation and inclination of the artefacts between each trampling event.

The design of our experiment includes two novel elements not seen in previous trampling studies. First, the substrate for our trampling experiment was the same sediment as the archaeological site that motivated the experiment. A similar experimental setup was used by Benito-Calvo et al. (2011), who simulated an archaeological sediment fabric by adding clasts to a nearby non-archaeological deposit. In contrast, we conducted our trampling experiment directly on the spoil heaps of archaeological sediment removed during the 2012 excavations at Madjedbebe. The use of site specific archaeological sediment adds a degree of realism to our trampling model. Interactions between the experimental artefact movement and trampling more faithfully resemble what might have happened in the past because we used the archaeological sediments. This ensures a close match for texture and penetrability between the experimental setup and the archaeological site. Our experiment still has many differences from the archaeological contexts; for example, we were not able to exactly match the compaction and fabric, or directional properties, of particular archaeological layers. Furthermore, we cannot be sure of the nature of the archaeological sediment at the time the artefacts were deposited and trampled in prehistory, because post-depositional processes have likely altered the sediment matrix. However, our field observations were that the spoil heaps closely resembled the structure, cohesiveness, permeability and moisture content of the archaeological deposits at Madjedbebe.

Our second novel element is the use of a system for classifying artefact form that is derived from geological studies of the effect of particle form on their movement in sediments. Previous studies have used artefact length or mass as a proxy for artefact size to investigate the relationship between size and movement (e.g. Gifford-Gonzalez et al., 1985; Nielsen, 1991). As Eren et al. (2010) note, previous studies are not unanimous in demonstrating a relationship between artefact size and movement. This may be because length and mass by themselves are not especially sensitive variables when considering artefact movement. In studying the natural movement of clasts on the landscape, sedimentary geologists have developed a number of form quantification systems to investigate the transport history of sediments and characterize depositional environments (Benn et al., 1992; Blott and Pye, 2008; Oakey et al., 2005; Woronow and Illenberger, 1992). We adopted the simplest of these, the Zingg system (Zingg, 1935), to quantify artefact form and investigate its relationship with movement resulting from trampling. Although geological studies often refer to clast 'shape' when using the Zingg system (Barrett, 1980), this is a misnomer because shape strictly refers to the 'geometric properties of an object that are independent of the object's overall size, position, and orientation' (Mitteroecker, 2009; c.f. Dryden and Mardia, 1998). The Zingg system does not account for scaling, so in this paper we follow Blott and Pye (2008) and use 'form' to refer to an object's shape and size when using the Zingg system.

2. Madjedbebe

Previously known as Malakunanja II, Madjedbebe is a sandstone rockshelter at the edge of the Magela floodplain in the Northern Territory, Australia. Archaeological excavations were conducted at Madjedbebe in 1973 (Kamminga et al., 1973), 1989 (Clarkson et al., 2015; Roberts et al., 1990), 2012 and 2015. The 1989 excavation produced Thermoluminescence (TL) and OSL ages of 52 ± 11 and 61 ± 13 ka associated with the lowest artefacts in the deposit (Roberts et al., 1990). The nearby site of Nauwalabila returned similar OSL ages, bracketing the ages of the lowest artefacts at between 53 ± 5 and 60.3 ± 6 ka (Bird et al., 2002; Roberts et al., 1994). These dates were questioned by Hiscock (1990) and Bowdler (1991), and later by Allen and O'Connell (2003) and Allen and O'Connell (2014). We have previously discussed these concerns in detail in Clarkson et al. (2015). Here we focus only on Hiscock's suggestion of the possibility of downward displacement of artefacts into sterile layers through human treadage.

Hiscock cited previous work (e.g. Stockton, 1973) that documented vertical movement of artefacts up to 16 cm. If movements of this magnitude are common in sandy deposits such as Madjedbebe, then the artefacts associated with the 52 and 61 ka BP ages may have originally been deposited on a much younger occupational surface, and then been displaced downward into older deposits that are unrelated to human occupation. Hiscock's suggestion is that, for example, an artefact at the level of the 52 ka age, 242 cm below the surface, may have originally been deposited during occupation at c. 200 cm below the surface. Using a loess regression on the ages published in Clarkson et al. (2015), we can interpolate a calibrated age of 23.3 ka BP for 200 cm below the surface. The difference in age of 29,000 years between 242 and 200 cm below the surface is substantial, and the ages at each depth have very different implications for how we interpret the stone artefact assemblage.

Previously, we reported on two factors that suggest this kind of downward displacement has not been extensive at Madjedbebe (Clarkson et al., 2015). First, we noted that there are several artefacts found within the same excavation unit that conjoin. We take these conjoins as evidence that downward displacement has had only a small effect on this assemblage. Second, we showed that there are clear changes in the abundance of raw materials over time. These changes would be heavily obscured if there was substantial downward displacement of artefacts at Madjedbebe. We believe it is unlikely that all the artefacts associated with the 52 ka age are actually 23.3 ka old. However, we recognise the potential for artefact movement at the scale described by Hiscock, and with this experiment we intended to get a better understanding of what components of the lithic assemblage are most susceptible to this kind of downward displacement, and how much of the assemblage might have been displaced to this extent.

3. Materials and methods

3.1. Lithic assemblage

We collected nodules of white quartz from the landscape and