Journal of Archaeological Science 74 (2016) 102–123

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Lithic raw material units based on magnetic properties: A blind test with Armenian obsidian and application to the Middle Palaeolithic site of Lusakert Cave 1

Ellery Frahm [a, b, *], Joshua M. Feinberg [a, c], Gilliane F. Monnier [a], Gilbert B. Tostevin [a], Boris Gasparyan [d], Daniel S. Adler [e]

[a] *Department of Anthropology, University of Minnesota, 301 19th Avenue South, Minneapolis, MN 55455, United States*
[b] *Department of Anthropology, Harvard University, Peabody Museum, 11 Divinity Ave, Cambridge, MA 02138, United States*
[c] *Institute for Rock Magnetism, Department of Earth Sciences, University of Minnesota, 310 Pillsbury Drive SE, Minneapolis, MN 55455, United States*
[d] *Institute of Archaeology and Ethnography, National Academy of Sciences, 15 Charents Street, Yerevan, Armenia*
[e] *Department of Anthropology, Old World Archaeology Program, University of Connecticut, 354 Mansfield Road, Unit 1176, Storrs, CT 06269, United States*

A R T I C L E I N F O

Article history:
Received 12 May 2016
Received in revised form
23 August 2016
Accepted 3 September 2016

Keywords:
Raw material units
Minimum analytical nodules
Rock magnetism
Obsidian characterization
Middle Palaeolithic
Southern Caucasus
Lithic analysis

A B S T R A C T

Classification of lithic artifacts' raw materials based on macroscopic attributes (e.g., color, luster, texture) has been used to pull apart knapping episodes in palimpsest assemblages by attempting to identify artifacts produced through the reduction of an individual nodule. These classes are termed "raw material units" (RMUs) in the Old World and "minimum analytical nodules" in the New World. RMUs are most readily defined for lithic artifacts in areas with distinctive cherts and other siliceous raw materials, allowing pieces from different nodules to be recognized visually. Opportunities to apply RMUs, however, are strongly limited at sites where lithic material visual diversity is low. The magnetic properties of obsidian, which result from the presence of microscopic iron oxide mineral grains, vary spatially throughout a flow. Consequently, obsidian from different portions of a source (i.e., different outcrops or quarries) can vary in magnetic properties. This raises the possibility that magnetic-based RMUs (mRMUs) for obsidian artifacts could be effective to distinguish individual scatters from multiple production episodes and offer insights into spatial patterning within a site or specific occupation periods. First, we assess the potential of mRMUs using obsidian pebbles from Gutansar volcano in Armenia. Second, we evaluate the validity of this approach based on a double-blind test involving an experimental assemblage of Gutansar obsidian flakes. Cluster analysis can successfully discern flakes from obsidian specimens containing high concentrations of iron oxides. Obsidian with more magnetic material has more opportunities for that material to vary in unique ways (e.g., grain size, morphology, physical arrangement). Finally, we apply the mRMU approach to obsidian artifacts from the Middle Palaeolithic site of Lusakert Cave 1 in Armenia and compare the results to traditional RMU studies at contemporaneous sites in Europe. In particular, we seek – but do not find – differences between retouch flakes (which reflect rejuvenation of tools) and the other small debris (which reflect other reduction activities). This result likely reflects the local landscape, specifically the abundance of obsidian and, thus, little pressure to curate and retouch tools. As this approach is applied to additional sites, such findings will play a central role in regional assessments about the nature and timing of the Middle to Upper Palaeolithic "transition" and the relationship, or lack thereof, between technological behaviors and presumed population dynamics.

1. Introduction

Classification of lithic artifacts' materials based on their macroscopic attributes (e.g., color, luster, texture, inclusions, fracturing properties) has been used as a means to identify individual

* Corresponding author. Department of Anthropology, University of Minnesota, 301 19th Avenue South, Minneapolis, MN 55455, United States.
E-mail addresses: frah0010@umn.edu, elleryfrahm@gmail.com (E. Frahm).

http://dx.doi.org/10.1016/j.jas.2016.09.001

knapping episodes in palimpsest assemblages. These classes tend to be called “raw material units” (RMUs) by Old World archaeologists (Roebroeks, 1988; Conard and Adler, 1997; Roebroeks et al., 1997) and “minimum analytical nodules” (MANs) by New World archaeologists (Kelly, 1985; Ingbar et al., 1989; Larson and Ingbar, 1992; Larson and Kornfeld, 1997). RMUs or MANs are generally considered to reflect individual nodules represented at a site. They are not equivalent to cores, but cores certainly belong to a MAN or RMU. Instead, they represent the entirety of cores, flakes, debris, retouched tools, and shatter that originated from one input of lithic material.

Classification of stone artifacts using the RMU/MAN approach (hereafter referred to only as RMU) has been most fruitful in regions that contain cherts and other siliceous materials, where subassemblages can be visually recognized (e.g., Conard and Adler, 1997; Adler et al., 2003; Vaquero et al., 2004, 2012, 2015; Dietl et al., 2005; Uthmeier, 2006; Vaquero, 2008; López-Ortega et al., 2011; Rensink, 2012; Machado et al., 2013; Moncel et al., 2014; Thomas and Ziehaus, 2014). The goal of RMU classification is not to identify the geological origins of the lithic materials (i.e., visual lithic sourcing). Instead, the aim is to recognize spatial, temporal, or techno-typological patterns – and, in turn, behavioral processes – within a site. For example, experiments have linked the scatter of debitage to the timing of its deposition (Stevenson, 1985, 1991), whereby debris from a particular knapping episode are increasingly dispersed across a site over time. Vaquero et al. (2012) used this phenomenon to document different knapping episodes and, thus, identify three occupation phases at Abric Romaní (Spain). Others have proposed links between a site's occupation duration and the proportion of “exotic” lithic materials, as classified visually (e.g., MacDonald, 1991; Richter, 2006). Furthermore, Conard and Adler (1997) and Turq et al. (2013) hold that the use of RMUs is critical for understanding the nature of lithic transport and reduction at Middle Palaeolithic (MP) sites. Specifically, they contend that, while MP assemblages throughout western Europe *appear* to reflect complete reduction sequences, they are, in actuality, palimpsests of diverse, independent instances of import, use, discard, and export. Another potential use of RMU analysis is evaluating the degree of post-depositional disturbance, much like lithic refits are used to assess artifact movement. Finally, the variety of RMUs at a site, when coupled with knowledge of their geological distribution on a landscape (i.e., primary sources or fluvial deposits), provides crucial information on transport distances and, in turn, mobility and territory size. In short, the clear identification of RMUs within a lithic assemblage, together with an understanding of their sources, can permit us to separate the multiple events and behaviors merged into a single archaeological site and to link them with larger patterns of mobility and land use (e.g., Larson and Kornfeld, 1997).

RMUs are most readily defined for lithic artifacts that are variable in appearance. Although the aim is identifying the artifacts produced through the reduction of an individual nodule, efforts are hampered if multiple nodules brought to the site had the same appearance. Consequently, RMUs tend to offer an estimate for the minimum number of cobbles (MNC) that contributed to an assemblage, not necessarily the actual number of cobbles (see Adler et al., 2003). Even when the artifacts in one RMU *do* correspond to a single cobble, that cobble could have been reduced at different times and places. Therefore, RMUs are roughly analogous to the Minimum Number of Individuals (MNI) in a faunal assemblage. That is, the number of RMUs helps to approximate the minimum number of cobbles transported to a site, especially when the visual classes are validated by refits. For example, at Abric Romaní, Vaquero (2008) conceptualizes 72 RMUs as 72 different inputs of lithic raw materials to this cave site, sometimes as cobbles, sometimes as single artifacts. A similar approach was previously used at Wallertheim in Germany (Conard and Adler, 1997; Adler et al., 2003). However, opportunities to apply RMUs are limited at sites where lithic visual diversity is low. For example, Machado et al. (2013) observe that this approach is hampered where people exploited expansive chert sources with macroscopic homogeneity. Given the similar appearance of many obsidians (e.g., “smooth, black, shiny,” Findlow and De Atley, 1978), an entirely (or primarily) obsidian-based lithic assemblage is rarely a suitable candidate for conventional RMU analysis. Here we demonstrate that the magnetic properties of obsidian artifacts, when combined with chemical characterization, can provide an alternative basis on which to define RMUs.

The magnetic properties of obsidian, which result from the presence of microscopic iron oxide minerals scattered through the glass, vary spatially throughout a flow (Frahm and Feinberg, 2013; Frahm et al., 2014, 2016). That is, obsidian from different portions of a source (i.e., various outcrops and/or quarries) can vary in magnetic properties. It is possible, at least in some cases, to magnetically discern the subsamples from a particular obsidian nodule among a larger population (Frahm and Feinberg, 2013; Frahm et al., 2014). Our initial tests also indicated that, if a scatter is comprised of multiple nodules from the same obsidian source, clusters in the magnetic data might be recognizable and reflect individual nodules (Frahm and Feinberg, 2013; Frahm et al., 2014). This outcome raised the possibility that magnetic-based RMUs (hereafter mRMUs) could be defined for obsidian artifacts and be used to untangle multiple production episodes. In turn, this approach could offer insights into a site's spatial patterns, occupation sequences, and other phenomena. Thus, we sought to evaluate the potential of mRMUs in a setting where lithic assemblages are composed entirely of obsidian.

Here we endeavor to define mRMUs, based on the magnetic properties of obsidian that vary throughout a flow, in Armenia, a region that was a crucial dispersal corridor for archaic humans out of Africa and into Eurasia (Fig. 1a) and that has abundant obsidian resources utilized by Middle and Late Pleistocene populations (Fig. 1b). First, we explore the potential to define mRMUs using a deposit of obsidian pebbles from the Gutansar volcanic complex (GVC; Fig. 1c). This is an especially large obsidian source with numerous outcrops and exposures scattered across ~70 km^2. Obsidian specimens collected from different locations at the complex vary in magnetic properties. We are, in essence, interested in identifying subsources within this source. Obsidian from the GVC composes more than 90% of lithic assemblages at nearby Palaeolithic sites, including the Lower Palaeolithic open-air site of Nor Geghi 1 (Adler et al., 2012, 2014; Gasparyan et al., 2014a) and the MP site of Lusakert Cave 1 (LKT1; Adler et al., 2012; Gasparyan et al., 2014b; Frahm et al., 2016).

Second, we test the validity of mRMU classification using a double-blind test involving an experimental assemblage of GVC obsidian flakes. The authors who produced this assemblage from a collection GVC obsidian specimens had no knowledge of their origins at the volcano, while the authors who conducted the magnetic measurements and statistical analyses did not know which specimens (or how many) were used to create the assemblage. The results show that hierarchical cluster analysis using magnetic measurements is successful at distinguishing obsidian specimens with relatively high concentrations of magnetic material (i.e., iron oxide grains). Specimens with the most magnetic material had the most robustly distinguished flakes. However, this approach does not effectively differentiate specimens containing relatively low concentrations of magnetic minerals. Obsidian that contains more magnetic material has more opportunities for that material to vary in unique, measurable ways (e.g., grain size distribution, morphology).