Journal of Archaeological Science 39 (2012) 3741–3749

Contents lists available at SciVerse ScienceDirect

Journal of Archaeological Science

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

Evaluating morphological variability in lithic assemblages using 3D models of stone artifacts

Knut Bretzke [a,*], Nicholas J. Conard [a,b]

[a] Eberhard Karls Universität Tübingen, Institut für Ur- und Frühgeschichte, Abt. Ältere Urgeschichte und Quartärökologie, Burgsteige 11, 72070 Tübingen, Germany
[b] Senckenberg Center for Human Evolution and Paleoecology, Universität Tübingen, Schloss Hohentübingen, 72070 Tübingen, Germany

ARTICLE INFO

Article history:
Received 18 April 2012
Received in revised form
26 June 2012
Accepted 28 June 2012

Keywords:
Lithic technology
Quantitative methods
Upper Paleolithic
Levant
Yabroud

ABSTRACT

Technological and morphological variability in lithic artifacts is commonly used to identify taxonomic entities in Paleolithic research contexts. Assemblages are mainly studied using either linear distance measurements or qualitative assessments of morphologies. Here, we present a method to quantify morphological variability in lithic artifacts using 3D models of stone artifacts. Our study on the sequence of the Upper Paleolithic layers V–I from the site Yabroud II in western Syria, demonstrates that utilizing 3D models provides a new insight into the variability of lithic technologies. We use quantitative data on convexities, twist and scar patterns on cores and blades, attributes previously not readily quantifiable, to trace technological change through the archaeological sequence. We are able to identify differences and translate these findings into a grouping of the layers. While layers VI–II are characterized by technological continuity and were grouped together, layers V and I can be separated from this group and represent technologically different groups chronologically before and after. Our results demonstrate the potential of 3D models for studying morphological variability in lithic assemblages.

1. Introduction

The assumption that morphological variability in lithic artifacts can be used to build archaeological taxonomies is fundamental to Paleolithic research. From a methodological point of view, the morphology of lithic artifacts can be captured as a description or as a series of measurements. Descriptive attempts often have their shortcomings due to the degree of subjectivity inherent in the definition of types and their identification in lithic assemblages. In contrast, metric approaches are normally less prone to subjectivity. The location of measurement points can be defined and the calibrated measuring devices allow an objective estimation of morphological variability. The quality of the results, however, depends on the analytical relevance of the measurements applied and their links to specific research questions.

Controlled experiments have repeatedly demonstrated that a relationship exists between the shape of a flake and characteristics of the striking platform (Dibble and Whittaker, 1981; Dibble and Pelcin, 1995; Dibble and Rezek, 2009; Speth, 1972, 1974, 1975, 1981), hence the morphology of flakes is not driven by chance but in addition to experience by the technical systems available to the flint knapper. Systematic differences in the morphology of flakes are thus bearing analytical potential for Paleolithic research. Typically, standard measurements like length, width and weight are used to detect morphological differences. Although there are approaches to get estimates of more complex parameters such as convexities (Andrefsky, 1986), usually it is difficult to measure them with traditional measuring devices like calipers. Since the number of measurements normally used to study variability in lithic artifacts is relatively small and their distribution on the artifact is patchy, standard linear measurements can only roughly approximate the morphological characteristics of an artifact. New ways of quantifying morphologies are thus necessary to decrease the distance between the real object and its representation, as expressed in the measurements.

One chance for the development of archaeological methodologies toward the improvement of morphological characterizations arose from the rapid development of 3D scanning devices in recent years. Archaeologists have already begun to use the potential of 3D scanning devices for their work and to apply 3D scanners for documentation purposes on a variety of cultural remains like pottery (Koutsoudis et al., 2009) and fauna (Niven et al., 2009) or in-situ documentation of archaeological finds (McPherron et al., 2009). Considering the application of 3D scanners for the study of lithic artifacts, 3D models of lithic artifacts have been used to

* Corresponding author. Eberhard Karls Universität Tübingen, Department of Early Prehistory and Quaternary Ecology, Burgsteige 11, 72070 Tübingen, Germany. Tel.: +49 69 75421549; fax: +49 7071 295714.
E-mail address: knut.bretzke@uni-tuebingen.de (K. Bretzke).

0305-4403/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jas.2012.06.039

approach a variety of questions. The quantification of the amount of cortex on lithics (Lin et al., 2010), the estimation of original flake mass (Clarkson and Hiscock, 2011), typological (Grosman et al., 2008; Lycett et al., 2010) or morphometric (Eren and Lycett, 2012; Shott and Trail, 2011) studies are some examples. Despite differences in the specific research questions, all of these studies are characterized by a quantitative approach and the relative high degree of detail. Indeed, quantification and detail count among the main advantages for using 3D models for lithic analysis.

One of the main motivations for us to explore the potential of 3D models for lithic analysis comes from taxonomic problems we encountered when studying Upper Paleolithic (UP) laminar lithic assemblages from western Syria. To date UP assemblages of the Levant were usually classified within a two traditions framework (Belfer-Cohen and Goring-Morris, 2003; Bergman, 1987, 2003; Gilead, 1981, 1991; Marks, 1981; Williams and Bergman, 2010). In this framework, a blade/bladelet oriented tradition, the Ahmarian, is distinguished from a flake based entity, the Levantine Aurignacian (Gilead, 1981; Marks, 1981).

Technologically, the lithic assemblages classified as Ahmarian are characterized by a single reduction strategy using single platform cores. Here a unidirectional reduction from the narrow face of the core produces mainly straight blades and bladelets (Davidzon and Goring-Morris, 2003; Marks, 2003). Tool assemblages are dominated by laterally retouched blades, often shaped into so called el-Wad points. In addition, assemblages assigned to the Ahmarian in northern Levantine contexts often document a reduction using opposed striking platforms (Azoury, 1986; Kuhn et al., 2003, 2009). In contrast, classic Levantine Aurignacian assemblages feature multiple reduction strategies to produce flakes, large blades and small bladelets (Marks, 2003). Tool assemblages from Levantine Aurignacian sites are composed among others of carinated scrapers, nosed and shouldered in particular, and retouched twisted bladelets (Belfer-Cohen and Goring-Morris, 2003; Bergman, 2003).

UP assemblages from our study area in western Syria, however, do not readily fall into either of these two taxonomic entities. One of the important UP sites in our study region in western Syria is Yabroud shelter II. The upper five archaeological layers in Yabroud II bear a strong blade component and have been assigned to different cultural entities of the Levantine UP. Belfer-Cohen and Goring-Morris (2003) attributed layer V to the Ahmarian and layers IV–I to the Levantine Aurignacian. There are, however, also other groupings found in the literature where either only layers V and IV belong to the Ahmarian tradition (Kuhn et al., 2003) or all layers from V to II (Schyle, 1992). Yabroud II layers V–I are true blade assemblages with an emphasis on unidirectional reduction, which probably would allow their designation to the Ahmarian. However, the production of twisted blades, the existence of multiple reduction strategies and carinated scrapers make these assemblages not fit easily into the Ahmarien (Azoury, 1986; Bakdach, 1982; Pastoors et al., 2009; Ziffer, 1981). On the other hand, the strong emphasis on blade production in all of the upper five layers at Yabroud II (Bakdach, 1982; Ziffer, 1981) may argue against an assignment to the classic Levantine Aurignacian. Classificatory difficulties exist not only at Yabroud II, but also at the important UP site Ksar Akil in Lebanon (Azoury, 1986; Bergman, 1987; Ohnuma, 1988; Williams and Bergman, 2010). About 100 km west from Yabroud, researchers have despite intensive studies over years, similar problems in the taxonomic designation of parts of the sequence, namely the layers XIII–IX at Ksar Akil (Bergman, 2003; Williams and Bergman, 2010). The taxonomic problems in the UP of the Levant might result in part from different approaches and perhaps a certain degree of subjectivity in the units of analysis. This can be illustrated by the importance of convexity and twist in blades. Ahmarian products are straight to slightly incurved, while Aurignacian blade/-lets are often twisted. These morphological characteristics reflect differences in the technology behind and were thus utilized as taxonomic markers. The decision, however, whether an artifact is straight or twisted is subjective, which makes inter-assemblage comparisons difficult.

Confronted with difficulties in the classification of major UP sites from our study region, we turned to methods that allow the quantification of critical morphologies on lithic artifacts to build a framework for our UP assemblages from new excavations at Baaz Rock shelter (Conard et al., 2006b, 2006c) and survey (Bretzke et al., 2012; Conard et al., 2006a) in western Syria. In this context we compiled data from the UP of Rust's excavations at Yabroud II as a starting point with which we could compare the assemblages recovered by the Tübingen Damascus Excavation and Survey Project (TDASP) team (Conard, 2006). This experiment with numerical methods was intended as a test of previous assessments of assemblages from western Syria, as well as an attempt to generate objective and reproducible data on UP assemblages. Although, we emphasize the utility of methods based on 3D scanning, we see such numerical methods as working in parallel to traditional qualitative and semi-quantitative methods, rather than replacing them. From this point of view, the kinds of numerical methods presented here can be used to test claims and classifications made on the basis of qualitative and semi-quantitative methods. If both kinds of methods are reliable, both approaches should lead to the same conclusions and reliable classifications. If on the other hand, the results diverge, researchers need to consider why the conclusions differ and what implications they have for our cultural taxonomies.

2. Material & methods

2.1. Lithic assemblages used in this study

We use here assemblages from the UP of western Syria as represented by the archaeological sequence excavated at the site Yabroud II (Bakdach, 1982; Rust, 1950). The site belongs to a series of rock-shelter containing an almost complete stratified record of the Paleolithic of the region ranging from the Lower Paleolithic and Middle Paleolithic in Rock Shelter I, the UP in Rock Shelter II to the Epipaleolithic in Rock Shelter III (Rust, 1933). The sites are located in Wadi Skifta, near the town of Yabroud, about 80 km north of Damascus (Fig. 1A). Between 1930 and 1933 Rust (1950) excavated in Rock Shelter II an area of about 15 m^2 and identified seven UP layers spanning a depth of about 1.5 m (Fig. 1B).

The aim of this paper is the identification of changes in lithic technology using attributes on cores and blades that are suitable to detect technological differences. We created a random sample consisting in total of 150 cores and 250 blades from Yabroud II, layers V–I. For each layer we selected 50 blades and 30 cores. We considered only complete blades without cortex. We included both flake and blade cores in the sample, but rejected specimens with only one or two negatives. All artifacts are housed at the Köln University and were kindly being made available by Jürgen Richter.

2.2. Attributes selected for the analysis

Not all morphological characteristics of lithic artifacts are equally suited to deduce significant differences in lithic technologies. Most appropriate are those reflecting the knappers decision between different options (Tostevin, 2003, 2011). Regarding lithic blade technologies, the convexities of a core's reduction surface are believed to be of particular importance. Replicative experiments have shown that both the longitudinal and transversal convexity