Chapter 8

Raw Material and Regionalization in Stone Age Eastern Africa

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Abstract Stone tools are the dominant artifact type at Paleolithic sites, and the kinds of stone tools used and their methods of manufacture form some of the richest datasets to assess temporal and geographic patterning in hominin behavior. Using these datasets to compare different lithic assemblages requires comprehensive analytical frameworks that be applied across multiple sites, but this is complicated by the varied nature of the different rock types used in the past. The bedrock lithology of eastern Africa is particularly varied, and we show for a range of Early Pleistocene-to-Holocene-aged archaeological sites that the type and frequency of raw material used, particularly quartz, has significant impacts on a number of typological, technological, and metric variables used to measure variation across time and space, severely weakening our abilities to assess the extent to which past geographic variation in the archaeological record in particular can be attributed to hominin behavior or bedrock geology. Convergence (homoplasy) in particular may be difficult to discern, as even similar behaviors resulting from shared cultural traditions (homology) may result in very different looking artifact types because of the nature of the rock types used.

Keywords Lithic analysis • Inter-assemblage variability • Toolstone • Data comparability

Introduction

Recognizing regional 'identities' is a persistent feature of analyses of Paleolithic variability and the processes that produced it, whether these identities are defined as industries, industrial complexes, facies, populations, or some other taxonomic term (cf. Will et al. 2014; Shea 2014; see also discussion in Reynolds 2020; O'Brien and Bentley 2020). For decades, particular efforts have been made to define regional variants among Middle Stone Age (MSA) sites in Africa, where broadly defined industrial complexes such as the Aterian and Lupemban seem to spatially co-vary with major biomes such as the Sahara Desert and the Central African Rainforest, respectively (e.g. Clark 1988, 1993; McBrearty and Brooks 2000; Scerri et al. 2014; Jones and Stewart 2016; Scerri 2017). Inter-regional variation for MSA sites appears to be greater than seen in preceding Acheulian sites, although variation in some 'terminal' Acheulian assemblages may anticipate later MSA patterns (Tryon et al. 2005; Potts et al. 2018). Because MSA sites in Africa appear to be associated with *Homo sapiens*, there is a particular interest in linking the developing regionalization in the archaeological record (i.e. geographically distinct behavioral variability) to other lines of evidence that suggest extensive population structure (i.e. geographically distinct biological variability) among Middle and Late Pleistocene *H. sapiens* (Mackay et al. 2014; Scerri et al. 2018; see also discussion in Groucutt 2020; Spinapolice 2020).

Despite the widespread recognition of a number of large scale regional MSA variants, few are formally defined (see Scerri 2017), particularly in eastern Africa, where in some cases particular industries are well defined, but are reported from one or two sites at most, contributing to a general sense of regional heterogeneity rather than providing a useful comparative tool (reviewed in Tryon and Faith 2013; see also Ranhorn and Tryon 2018). We believe that carefully defining regional variation is an important research

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objective. As a prelude to this, our goal here is to outline the impacts of lithic raw material variability on attempts to do so. Certainly, there are a number of instances where the selection of specific kinds of raw material may be a defining feature of an artifact industry and presumably the populations that made them. Well-known examples include the preference for finer-grained rocks seen among Howiesons Poort MSA assemblages in southern Africa (Ambrose and Lorenz 1990; Brown 2011; Oestmo 2017), and the association of particular obsidian quarries with Savanna Pastoral Neolithic and Elmenteitan pastoralists in the late Holocene of eastern Africa (Ambrose 2012; Goldstein and Munyiri 2017). These patterns reflect clear choices made by past human groups, choices likely caused in part by various properties of the rocks chosen for use, such as predictable fracture qualities, edge durability, color, or other properties (e.g. Braun et al. 2009; Pargeter and Hampson 2019).

However, rather than focusing on the role of human choice in using particular kinds of rocks, we emphasize the extent to which the properties of the rocks themselves influence the types of variables archaeologists use to define regional variability. Specifically, we highlight some of the ways in which the properties of the available stone raw material used for tool production may create archaeologically detectable variability that masks behavioral similarity, in effect making cases of behavioral convergence difficult to identify. While some studies in northern Africa (Scerri et al. 2014) suggest that in some cases, geographic patterning in hominin lithic reduction strategies can transcend local differences in raw material, this issue remains under-explored in eastern Africa.

Lithic Raw Material Variability in Eastern Africa

Hominins in eastern Africa used a wide range of different types of rocks for the manufacture of stone tools, with the diversity of the available types of rocks a reflection of the region's complex geological history (Fig. 8.1). Sedimentary rocks include chert, often formed in past and present saline lakes, with well-known outcrops found at Lake Natron and Olduvai Gorge in Tanzania and Lake Magadi in Kenya (Stiles et al. 1974; Hay 1968, 1976), and shale at Mtongwe on the Kenyan coast (Omi 1984). Igneous rocks include lavas that vary in texture and composition, from coarse-grained basalts at Koobi Fora and Olorgesailie, Kenya (Noll 2000; Isaac et al. 1997), trachytes from West Turkana (Harmand 2007), phonolites from Rusinga Island (Tryon et al. 2014), and obsidians, particularly from the Central Rift Valley in Kenya (Brown et al. 2013). Quartz is available as part of the pre-Cambrian basement rocks found throughout the region, best exposed outside of the Rift Valley, found in abundance at places such as Lukenya Hill in Kenya (Gramly 1976), Nasera in Tanzania (Mehlman 1977), and throughout neighboring portions of central Africa, as at Matupi Cave, D.R.C. (Van Noten 1977; Muya wa Bitanko 1985–1986). Metamorphic rocks include various metasomatized volcanic rocks from Kanjera (Braun et al. 2008), mylonitized lavas from Isimila, Tanzania (Howell et al. 1962), and quartzites found at sites such as Nsongezi, Uganda (Cole 1967). Fossil wood was used at some sites on the eastern shores of Lake Turkana in Kenya (Kelly 1996).

These examples of rock types are but a small sample of the kinds of lithic raw material used for tool production at Stone Age sites in eastern Africa, and this diversity of rock types and their geological sources has been useful in petrographic and geochemical studies of artifact provenance (Merrick and Brown 1984; Feblot-Augustins 1990; Merrick et al. 1994; Noll 2000; Harmand 2007; Braun et al. 2008). However, these different kinds of rocks also vary substantially in terms of their hardness, durability, grain size, texture, and fracture mechanics. These properties affect how stone tools were made and how they were used, and as we argue below through a series of examples drawn from Early Pleistocene- to Holocene-aged sites, have important impacts on some of the qualitative and quantitative variables potentially useful in the construction of regionally specific ways of tool manufacture.

Handaxe Variability at Olduvai Gorge, Tanzania

In a remarkable series of papers, Jones (1979, 1980, 1994) outlined the results of the experimental replication and use of various artifact types to aid in the analysis of Acheulian and other Early Stone Age assemblages at Olduvai Gorge (Fig. 8.2). Several results are worth reiterating here, as they have broad implications for understanding more general patterning in the archaeological record. First, the form in which lithic raw material is initially available can impact the nature of the finished tool (see also Andrefsky 1994; White 1998). Specifically, bifaces made on cobbles will generally have thicker cross-sections rather than those made on slabs (or large flakes). At Olduvai Gorge, this contrast is seen most clearly between thicker basalt bifaces (made on cobbles derived from local streams; Fig. 8.2A) and thinner phonolite (Fig. 8.2B) and quartzite bifaces (Fig. 8.2C), the latter typically made on slabs or spalls found near outcrops.

Second, hardness, grain-size and texture influence the amount of retouch on an artifact. Jones experimented in making cleavers and handaxes made of various rock types available at Olduvai Gorge, and used them to butcher animal carcasses. This work showed that quartzite tools in particular could be used for long periods with little retouch or

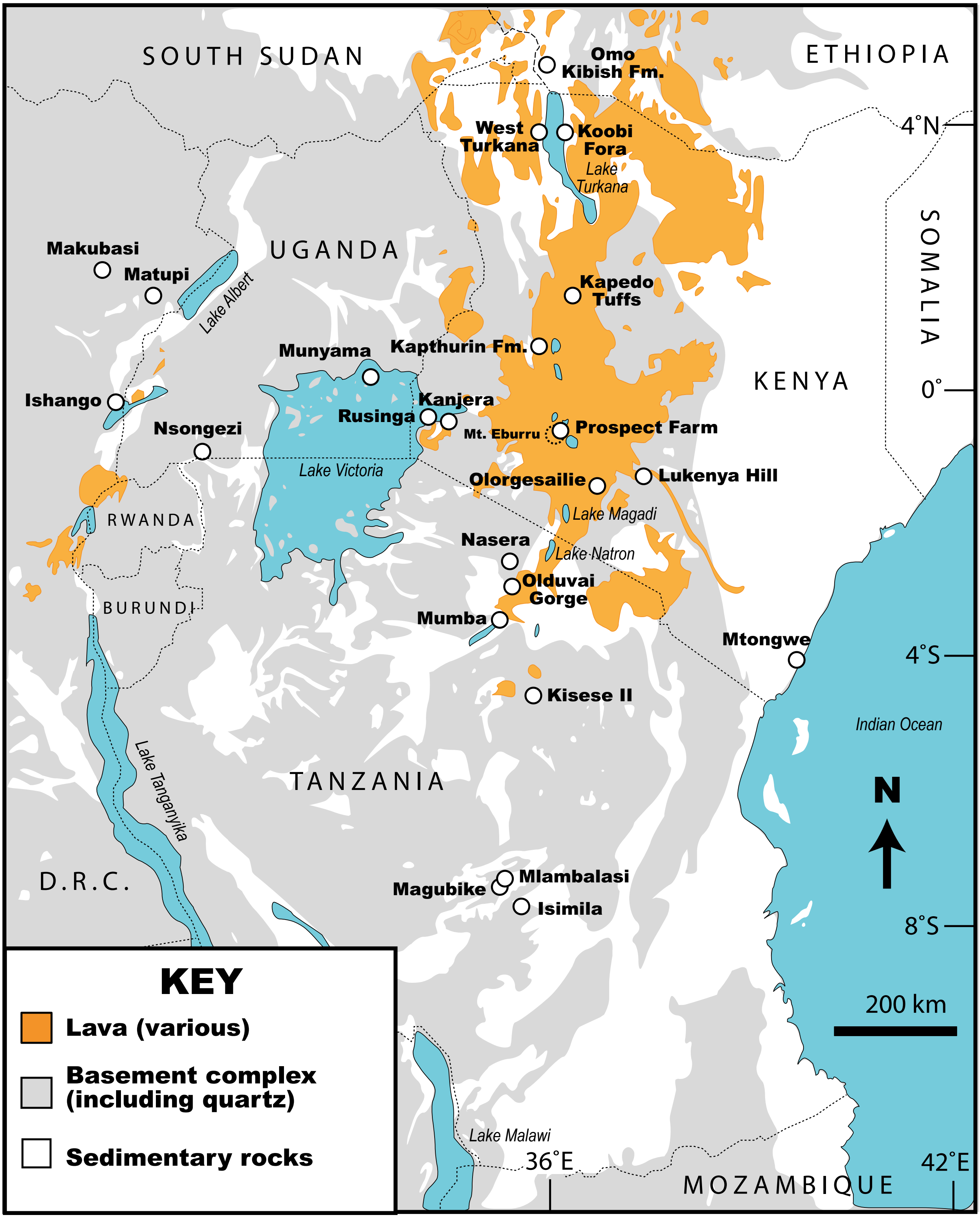

Fig. 8.1 Simplified geological map of eastern and central Africa, showing outcrops of lava, pre-Cambrian igneous and metamorphic basement rocks (including quartz), and sedimentary deposits, as well as key archaeological sites and geographic features mentioned in the text. Base map redrawn from Choubert and Faure-Muret (1985)

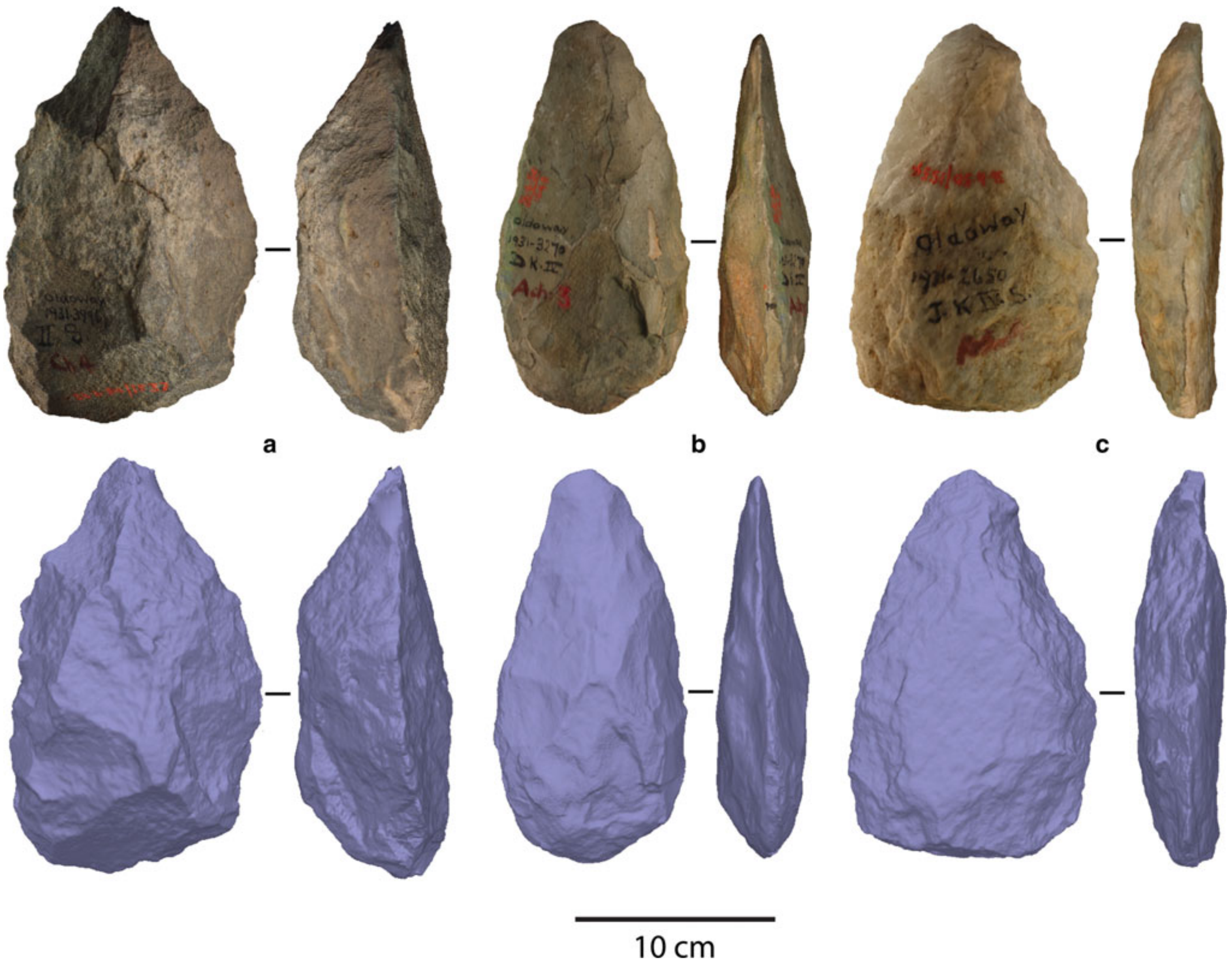

Fig. 8.2 Photographs and digital renderings of handaxes made from **a** quartzite, **b** basalt, and **c** phonolite from Olduvai Gorge, Tanzania, housed at Harvard University's Peabody Museum of Archaeology and Ethnology, Cambridge, Massachusetts, USA

resharpening, because the irregular grain boundaries in the rock provided a natural sort of saw-tooth edge. In contrast, phonolite artifacts had rather brittle edges that dulled rapidly and needed frequent re-sharpening. As a result of these material differences, the degree of re-sharpening varies by rock type (i.e. phonolite bifaces are more intensively retouched), impacting a number of variables used to assess inter-assemblage differences at Olduvai Gorge (Callow 1994; Roe 1994). In general, increased amounts of retouch affect final artifact size and shape at discard as well as scar count, and can reduce inter-analyst agreement (Proffitt and de la Torre 2014). At Olduvai Gorge in particular, the morphological differences between the basalt, phonolite, and quartzite bifaces caused by the nature of the available raw material are the sorts of variables that had previously been used to distinguish between different artifact industries, in this case, the Developed Oldowan and the Acheulian. The significance of these industrial classifications goes beyond issues of archaeological nomenclature, however, as researchers frequently equate particular industries with specific hominin taxa, as was the case with Mary Leakey (1971) for the Developed Oldowan and *H. habilis*, and the Acheulian and *H. erectus*.

Size and Retouch Intensity Among MSA Sites in Northern Kenya and Southern Ethiopia

Tryon et al. (2008) explored the extent to which raw material variation explained differences among MSA sites found in the Rift Valley of northern Kenya (the Kapthurin Formation, the Kapedo Tuffs, and the Lake Turkana basin) and southern Ethiopia (Omo Kibish). They focused on two variables similar to those originally examined by Jones at Olduvai Gorge: The size of naturally occurring raw material packages and the influence of rock type on retouch intensity.

They demonstrated that distance from the Rift margin is a good predictor of average artifact size, a fact driven by (1) hominin use of cobbles and (2) progressive declines in cobble size with increased transport distance by water along rivers and streams. In this model, the actual location of the raw material sources used is unknown, but the assumption is that transport of clasts begins at erosional nickpoints at the Rift margin (Fig. 8.3A) and continues towards the axis of the Rift. As shown in Fig. 8.3A, the pattern of size decline with distance is true both for lava and chert cores, with the further finding that for any given site, chert cores were on average smaller than lava ones. Eren et al. (2013) report the same pattern further south from MSA sites at Olduvai Gorge. This general size effect exists because the lava flows from which the cobbles ultimately derive are vertically thick and spatially extensive, whereas chert beds or nodules are thin and/or spatially constrained. The initial form of the raw material impacted the final size of the artifact, which varied by raw material type (lava vs. chert). Because of this, artifact size alone is a difficult variable to use in analyzing geographic patterns of behavioral variability.

The second finding reported by Tryon et al. (2008) was that retouch intensity was consistently higher on chert compared to lava artifacts (Fig. 8.3B) for these northern Kenyan and southern Ethiopian sites. The reasons for this are unclear. It may relate to the durability of the raw material, such that the edges of the more brittle chert artifacts required more frequent re-sharpening, as suggested above for the phonolite handaxes at Olduvai Gorge, or that hominins preferentially selected chert for artifacts needing retouch. It may also be that retouch is simply more visible to the archaeologist on chert rather than on lava artifacts, a problem more often explicitly recognized for quartz artifacts (David et al. 1981; Mehlman 1989; Bisson 1990). Whatever the reason, the fact that retouch intensity varies by raw material type causes a number of problems for comparing across assemblages made up of different rock types, particularly when employing classical typologies that rely on retouched tools such as that developed by Bordes (1961). Assemblages made by the same group of hominins in different geological zones could look very different simply because of the kinds of lithic raw material available, a phenomenon also long recognized in assessments of variability among similarly-aged western European Mousterian sites (Rolland and Dibble 1990).

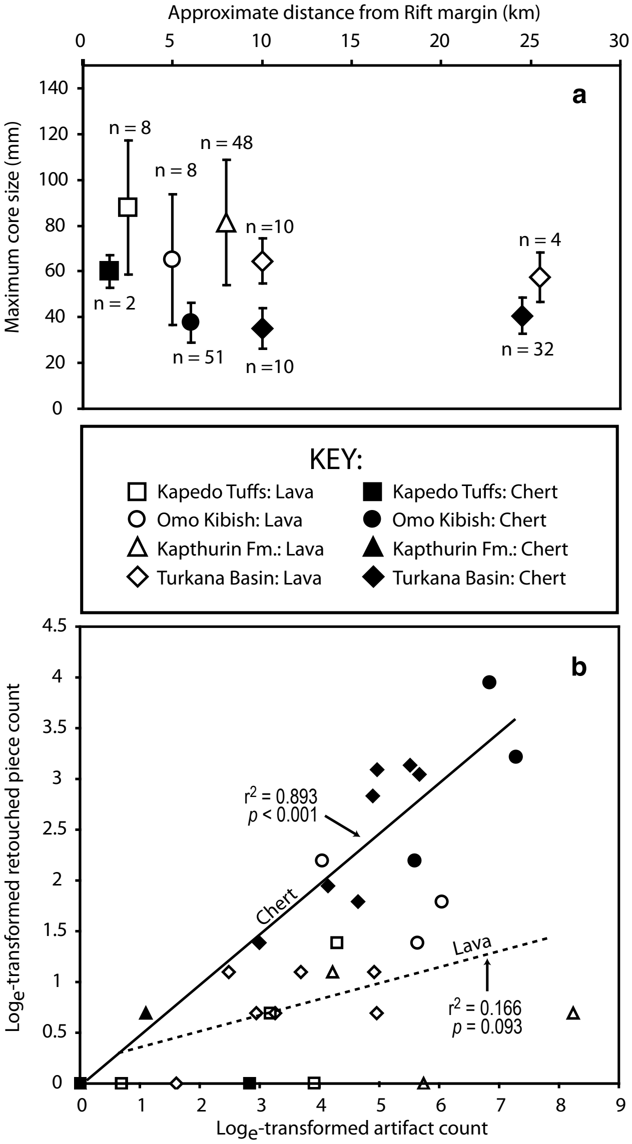

Fig. 8.3 Bivariate plots showing the impact of different raw material types (lava and chert) on core size and retouched piece frequency from Middle Stone Age sites in northern Kenya and southern Ethiopia, adapted from Tryon et al. (2008). **A** Shown are mean and standard deviation of core maximum size in mm; horizontal position of each raw material type slightly offset to accommodate size range. Core size diminishes with increased transport distance (from Rift Valley axis), but lava cores are always larger than chert ones, in part because of larger initial sizes at outcrop form. **B** Plot of retouched piece count by raw material type, showing that retouched pieces are always significantly more common among chert artifacts than those of lava. Values are log-transformed to accommodate variance in sample size

Quantifying Quartz Variability at Nasera

The use of systematic comparative analytical frameworks is central to our understanding of technological regional variability, but our work at Nasera rockshelter in northern Tanzania has emphasized in particular some of the problems involved when applying analytical strategies developed using rocks such as flint, chert, or silcrete such as those developed for Pinnacle Point 5-6 (Wilkins et al. 2017) to artifact assemblages made of quartz. Nasera rockshelter is on the margin of the Serengeti Plains, and is an important reference site for much of the Late Pleistocene in eastern Africa, containing quartz-dominated MSA, 'transitional,' and Later Stone Age (LSA) lithic assemblages including the Mumba industry, one of the regional variants considered in narratives of eastern Africa as a central region for the origin and dispersal of modern humans (Mehlman 1989; McBrearty and Brooks 2000; Mellars 2006; Mellars et al. 2013). Temporal changes at Nasera have been argued to represent in part the impact of demographic shifts leading to larger or denser human populations (Tryon and Faith 2016) based on evidence for changes in the local environment and increased occupation intensity. Ranhorn (2017) focused on understanding the nature of lithic technology that occurred with these shifts in environmental or demographic variables, specifically investigating aspects of lithic technology demonstrated to be related to aspects of flintknapper learning and copying, using analytical approaches initially developed by Tostevin (2012).

Tostevin (2012) divided comparative analyses of lithic artifacts into four technological domains related to choices made during the process of tool manufacture, including core modification, platform maintenance, direction of core exploitation, and dorsal surface convexity (Table 8.1). A fifth category was also used in his inter-assemblage comparisons, toolkit morphology, which includes how retouched pieces were further selected and modified for use. Tostevin's system was developed specifically for comparing sites in areas rich in flint in both the Mediterranean basin and eastern Europe, and in those contexts, we believe that the system works remarkably well. Scerri et al. (2014) also applied Tostevin's analytical approaches to assemblages in northern Africa, and with the addition of multivariate analyses such as principal component analysis (PCA), demonstrated regional patterns in lithic technology.

Ranhorn's (2017) application of the Tostevin analytical approach to Nasera, and to other quartz-dominated assemblages in eastern Africa, however, revealed a number of interesting complications, which can be distilled down to two important and distinct issues. The first of these involves the basic reading of the artifacts themselves, and the second involves the broader analytical framework, specifically the arrangement of attributes and their associated technological domains.

Firstly, and as noted above, the ways in which quartz fractures as well as the optical properties of the rock make it difficult to reliably recognize many of the lithic attributes seen on other rock types, a widely recognized problem with the material in eastern Africa and central Africa (David et al. 1981; Mehlman 1989; Bisson 1990; Cornelissen 2003; Diez-Martin et al. 2009) and elsewhere (e.g. Driscoll 2011). Ranhorn applied the Tostevin framework to Nasera, as well as other sites in Kenya with artifacts made up of other raw material types. At the Kenyan sites of Prospect Farm, Prolonged Drift, and multiple localities in Koobi Fora, where the majority of the artifacts were made on obsidian or various types of chert, Tostevin's comparative system worked well. At Nasera, many of the same measured attributes were not easily measured in a replicable way, and therefore removed from the comparative analyses. For example, patterns of flake scar directionality were obscure and difficult to confidently 'read,' and this lack of confidence in these data precluded analyses relating to early- and late-stage core reduction methods.

Table 8.1 Summary of the comparative approach developed by Tostevin (2012) and estimates of our confidence in its application to quartz-based artifact assemblages

Technological domain	Flintknapping step/Attribute	Estimated confidence of measurement in quartz
Core modification	Core orientation	Low
	Core management	Low
Platform maintenance	Platform treatment	Low
	External platform angle (degrees)	High
	Platform thickness	High
Direction of core exploitation	Direction of early exploitation	Low
	Direction of late exploitation	Low
	Percentage cortex	Medium
Dorsal surface convexity	Elongation of the longitudinal convexity: length/width ratio	High
	Shape of convexity: debitage lateral edges	Medium
	Curvature of convexity: profile	High
	Lateral convexity: cross-section	High
	Vertical convexity: width/thickness ratio	High
Toolkit morphology	Tool laminarity	High
	Tool vertical convexity	High
	Shape of tool cutting edges	Medium
	Shape of distal terminus	High
	Curvature of cutting edge	Medium
	Application of unique retouch	Medium
	Location of tool retouch	Medium

Secondly, the arrangement of attributes and their associated technological domains may differ in quartz-based technologies than in those for which Tostevin's (2012) approach was devised. In bipolar technologies specifically, the knapper transfers energy such that it travels from two opposing sides of the cobble or pebble, and one can vary this method by striking obliquely, vertically, or transversely towards the anvil, thus creating lateral, split, or transverse flake fragments (see Callahan 1987 and Jones 2006 for detailed descriptions). One resulting and recurring phenomenon involves the formation of forms such as "splinter pieces", wedges, and *pieces esquillees,* or scaled pieces, abundant in the Nasera assemblage, which are difficult to classify as either a core or flake (Villa et al. 2012), an issue encountered elsewhere, such as in the case of Karari scrapers (Harri Isaac et al. 1976) and other "core tools" (cf. McPherron 2009). In our Nasera analysis, this ambiguity had downstream effects for which attributes we measured on the piece and how, and importantly for our analysis, to which technological domain their associated measurements belonged. All of these issues further complicate the comparability of quartz datasets to those from elsewhere in Africa where quartz technologies are less common.

Table 8.1 summarizes our estimates of the utility of Tostevin's (2012) system as currently applied to quartz-based technologies. Fundamentally, attribute-based analyses require inter-analyst and intra-analyst reproducibility. Our ability to consistently measure these attributes varied along an ordinal scale which we divided into "low", "medium", and "high". Attributes with "low" utility indicate that a re-evaluation of the domain itself may be warranted; in effect this rating is nearly equivalent to a "not applicable" score. Attributes with a "medium" value indicate ambiguities that tend to be associated with the readability or measurability of the attribute in various quartz grades. Finally, a "high" value indicates an attribute that can be systematically measured utilizing commonly used measurement techniques such as caliper measurements. Refitting studies similar to those outlined by Scerri et al. (2016), and specifically attuned to the various forms of quartz grades, may help refine these estimates or better isolate useful variables in the future.

Quartz and the Abundance of Typical Later Stone Age (LSA) Tools

As a further test of the impact of raw material on the typological composition of archaeological assemblages, particularly quartz, we consider here the role of retouch and raw material on the presence of artifact types considered diagnostic of the Later Stone Age, in particular backed microlithic crescents. The presence of backed microlithic crescents is frequently used as means to assess the onset of the Middle/Later Stone Age transition, the timing of which appears to vary regionally across eastern Africa (reviewed in Tryon et al. 2018). Here, we begin to explore the extent to which raw material may play a role in this apparent temporal heterogeneity in the adoption of new artifact forms. Specifically, we examine the relationship between the frequency of the use of quartz as a raw material and the abundance of backed microlithic crescents. Our sample includes only crescent-shaped microliths, which we define as generally small (≤ 30 mm) elongated flakes or flake fragments with deliberate, abrupt retouch (backing) on one of the long edges that provides a curved or crescent shape to the piece (see Leplongeon 2014). We do not include naturally backed or otherwise unmodified pieces that may well have served the same function as the deliberately backed ones.

In order to reduce conflating the impacts of temporal, spatial, and raw material variability, we draw on sites that generally date to the Last Glacial Maximum, ~18–26 ka (Clark et al. 2009) and include sites not only from across a range of longitudes and depositional contexts (from rainforest to savanna, open air sites and rockshelters) but also a number of different sites from the same geographic locale, summarized in Table 8.2, with site locations shown in Fig. 8.1. Our comparative sample includes 10 sites from four countries. From the DRC, we include Matupi Cave, 90–170 cm below surface (Van Noten 1977, 1982; Muya wa Bitanko 1985–1986), Ishango 11 NFP, SJ, and NT levels (Mercader and Brooks 2001), Makubasi SE Level 1 (Mercader and Brooks 2001), and Matangai Turu Level 1 (Mercader and Brooks 2001). The Ugandan sample is limited to Munyama Cave levels 80–120 cm (Van Noten 1971; Valcke 1974), with five sites from Kenya, all from the Lukenya Hill area, including GvJm22, Occurrence E (Gramly 1976), GvJm62 units B/C (Marean 1992; Barut 1997), GvJm46 LSA level (Barut 1997), GvJm16, 98.50–97.90 cm below datum (Merrick 1975) and GvJm19, 115–150 cm below surface (Barut 1997). The Lemuta industry at Nasera (levels 4–5) was formerly the primary Tanzanian lithic assemblage believed to date to the LGM that has abundant data on the abundance of backed microlithic crescents made on different raw material types (Mehlman 1989). However, more recent dating of the site suggests that the Lemuta industry substantially pre-dates the LGM (Ranhorn and Tryon 2018) and thus we excluded these data from our analyses.

Within our sample, there is a strong, significant negative relationship ($r^2 = 0.679$, $p = 0.003$) between the abundance of quartz in an assemblage and the frequency of backed microlithic crescents (Fig. 8.4). Because all sites generally date to the LGM, this relationship is unlikely due to temporal differences among sites in the sample. And the fact that this observed patterns holds for sites across ca. 900 km as well as among those less than a km apart indicates that geographic distance was not a factor. Therefore, we conclude that

Table 8.2 Tabulation of assemblage size, quartz abundance, retouched tool count, and backed microlithic crescent frequency from 10 Equatorial African sites dating to approximately the Last Glacial Maximum

Site	Artifact sample size (n)	% quartz (of total)	Retouched tool count	% backed microlithic crescents
Matupi Cave (90–170 cm)	1,376	96.0	69	1.4
Ishango 11 (NFP, SJ, NT)	1,678	98.2	26	7.7
Matangai Turu NW (Levels 1–2)	727	100.0	12	0.0
Makubasi SE (Level 1)	240	99.6	10	0.0
Munyama Cave (80–120 cm)	54,945	98.7	1522	30.6
Lukenya Hill, GvJm22 (Occurrence E)	40,757	65.2	936	73.2
Lukenya Hill, GvJm62, units B/C	19,893	76.6	400	13.5
Lukenya Hill, GvJm46 (LSA)	14,418	91.7	262	13.7
Lukenya Hill, GvJm16 (98.50–97.90 cm)	7,612	45.8	298	60.1
Lukenya Hill, GvJm19 (115–150 cm)	13,081	84.9	344	20.1

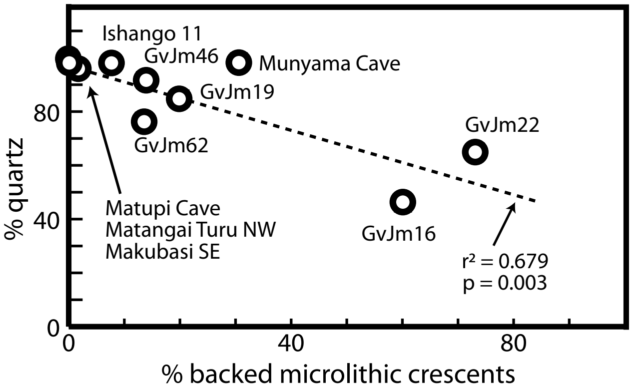

Fig. 8.4 Bivariate plot showing the negative relationship between the abundance of quartz in an archaeological assemblage and the frequency of backed microlithic crescents, a typical tool defining the African Later Stone Age. All 10 sites in this sample approximately date to the Last Glacial Maximum, and include assemblages from across Equatorial Africa. Data listed in Table 8.2

backed microlithic crescents are less frequent in quartz-based assemblages in eastern (and central) Africa. More broadly, this means that the frequency of at least some of those elements used to define regional variants are strongly dependent on the type of raw material used. In terms of defining the early LSA, at least part of the reason that backed microlithic crescents are so rare in some levels at sites such as Mumba (Mehlman 1989; Diez-Martin et al. 2009) and Kisese II (Tryon et al. 2018) might be the local abundance of quartz at those sites.

Backed Pieces and the Later Stone Age Eburran in Kenya

The Eburran is one of the better studied LSA industries in eastern Africa, consisting of a developmental sequence of blade-based industries beginning in the early Holocene and persisting after the introduction of groups of dedicated 'Neolithic' pastoralists in the region ~5 ka. Five different Eburran phases are recognized on the basis of radiometric dates, stratigraphic superposition, and changes in the size and shape of blades and backed pieces seen among sites near the eponymous Mt. Eburru (Fig. 8.1) (Ambrose 1984; Wilshaw 2016), the geographic center for Eburran sites and the primary obsidian source for artifacts found at them (Frahm and Tryon 2018). Wilshaw (2012, 2016) has recently presented a detailed consideration of the definition of the Eburran, based on a number of qualitative and quantitative lithic analyses. Recognizing the impacts of raw material variation on studies of inter-assemblage variation, he restricted his study to assemblages dominated by obsidian (Wilshaw 2012: 65). While methodologically sound, this approach is ultimately restrictive in terms of defining regional entities, as it makes it difficult to directly compare contemporary, geographically adjacent archaeological entities found in areas where obsidian is absent, such as the quartz-dominated Kansyore and other late Holocene forager sites in the Lake Victoria basin (Seitsonen 2010). The presence of obsidian from Mt. Eburru at Lake Victoria sites (Merrick and Brown 1984; Frahm et al. 2017) implies some sort of connection between contemporary groups in the two regions, raising questions as to why the lithic artifacts they made are classified differently. For example, are these different cultural traditions or a by-product of archaeologist's analytical procedures?

Some of the difficulties in classifying Holocene LSA assemblages that are characterized by raw material variability can been seen at the site of GvJm22 at Lukenya Hill (Fig. 8.1), adjacent to but outside of the Rift Valley, where obsidian, chert, and quartz are locally available for tool manufacture (Gramly 1976; Merrick and Brown 1984; Merrick et al. 1994; Tryon et al. 2015). Because backed microlithic crescent size is one of the variables used to define different phases of the Eburran, we use the GvJm22 sample as a test of the impacts of different raw material type on

Table 8.3 Basic descriptive data for microlithic backed crescents from Holocene LSA Occurrence D and Late Pleistocene LSA Occurrence E from site GvJm22 at Lukenya Hill, Kenya, subdivided by lithic raw material type, including artifact count and maximum length in mm. Additional data from GvJm22 Occurrence C and from GvJm16 from Merrick (1975); dates from Merrick (1975), Gramly (1976), and Tryon et al. (2015). PN = Pastoral Neolithic

Site	Level	Archaeology	Age (ka)	Raw material	Count (n)	Average length (mm)	Range length (mm)
GvJm22	C	PN	2.2	Obsidian	40	18.4	12.0–32.0
GvJm22	C	PN	2.2	Chert	7	18.0	12.0–26.0
GvJm22	C	PN	2.2	Quartz	0	NA	NA
GvJm22	D	LSA	6.7	Obsidian	6	12.2±2.5	8.8–15.1
GvJm22	D	LSA	6.7	Chert	9	16.6±4.0	9.5–23.0
GvJm22	D	LSA	6.7	Quartz	2	12.2±4.1	9.4–15.2
GvJm22	E	LSA	37–15	Obsidian	21	23.0±7.2	13.0–43.6
GvJm22	E	LSA	37–15	Chert	98	21.2±4.0	12.6–34.8
GvJm22	E	LSA	37–15	Quartz	9	17.9±2.5	14.8–23.1
GvJm16	C	PN	2.2	Obsidian	13	16.7	12.0–23.0
GvJm16	C	PN	2.2	Chert	19	20.4	12.0–27.0
GvJm16	C	PN	2.2	Quartz	0	NA	NA
GvJm16	B	LSA	20–15	Obsidian	13	17.2	11.0–25.0
GvJm16	B	LSA	20–15	Chert	18	23.8	15.0–43.0
GvJm16	B	LSA	20–15	Quartz	0	NA	NA

backed microlithic crescent size from a single site. Summary data are reported in Table 8.3. Crescents, and backed microliths in general, are an appropriate artifact type for this comparison, as they tend to be replaced rather than re-sharpened with extensive use (Hiscock 2006), and what re-sharpening occurs affects lateral edge shape but has little impact on tool length. Therefore, a decline in size from repeated use as might be expected for artifacts from distant sources (e.g. Newman 1994) is unlikely to explain any observed differences within this artifact sample.

We first draw on our own measured sample of backed microlithic crescents drawn from the 1970s excavations at the site. For the Late Pleistocene LSA assemblages from GvJm22 Occurrence E (Gramly 1976; Tryon et al. 2015), a Kruskal-Wallis test of sample medians ($H = 8.868$, $p = 0.012$) indicates variation within our sample in terms of the length of quartz, chert, and obsidian crescents, with quartz crescents significantly smaller than those of either chert or obsidian (Mann-Whitney post-hoc test, Bonferroni corrected p values of 0.013 and 0.005, respectively). Occurrence D at GvJm22 overlaps in age with Eburran sites in the Central Rift, but the sample size of crescents ($n = 17$) and particularly those of quartz ($n = 2$) is lower than for Occurrence E because of a smaller excavated volume (Gramly 1975). Comparisons within Occurrence D suggest no significant differences between sample medians ($H = 5.359$, $p = 0.069$), although this is driven at least in part by the very small and highly variable quartz sample. Excluding quartz, an unequal variance t-test indicates that mean obsidian crescent length is significantly smaller than mean chert crescent length from Occurrence D at GvJm22 ($t = 2.400$, $p = 0.020$).

Comparisons *within* raw material types shows that at GvJm22, Holocene backed microlithic crescents are significantly smaller than Late Pleistocene ones for those made of obsidian ($p < 0.001$) and chert ($p = 0.008$), but not for quartz ($p = 0.313$).

Our measured sampled of backed microlithic crescents from GvJm22 is very small, limiting the strength of any inferences drawn from our statistical tests. However, published data from site GvJm16, ~500 m north of GvJm22 with a similar Late Pleistocene-Holocene archaeological sequence (Table 8.3), show patterns similar to those at GvJm22. At GvJm16, chert backed microlithic crescents are generally larger than those of obsidian, average backed microlithic crescent size declines over time, and quartz backed microlithic crescents are comparatively rare (Merrick 1975).

The presence of significant size differences of the same artifact class made on different raw materials from both Late Pleistocene and Holocene contexts strongly suggests a general pattern noted by Wilshaw (2016) specifically for the Eburran. That is, that raw material type can affect artifact size, one of several metric variables commonly used to characterize archaeological patterns.

Discussion and Conclusions

Taken in broader context, our results demonstrate that raw material must be considered when discerning Stone Age patterns of convergence (homoplasy) from shared cultural entities (homology), as similar behaviors may result in very different looking artifacts because of the nature of the rock types used. eastern Africa has a highly variable bedrock geology, with a number of different kinds of rocks available, many showing wide variance in a number of properties relevant to an archaeological analysis of stone tools. One outcome of this variability is the difficulty of devising straightforward criteria for the recognition of regional variation, particularly approaches that rely on metric criteria alone. As our examples drawn from throughout the Pleistocene and Holocene suggest, variation in the type of raw material used can drive variation in artifact size, retouch intensity, and recognition of a range of criteria used to construct geographically or temporally distinctive patterns of artifact manufacture.

We can have confidence in studies that rely on homology only when similarities that result from convergence, or homoplasy, can be reliably identified. In the context of this volume, we note that studying convergent evolution is useful for demonstrating that populations with distinctively different histories and developmental trajectories can produce remarkably similar things or evolve comparable forms. We have tried to show here using a number of examples from Early Pleistocene to Holocene archaeological sites in eastern Africa that the converse may also be true. That is, in the case of stone tools, sometimes even similar behaviors (i.e. ways of making tools), histories, or evolutionary trajectories can produce a very different seeming archaeological record, simply because of the types of rocks available and their mechanical properties. Of course, we can consider an alternative, that is, does use of similar rock types or raw material packages (e.g. cobbles, slabs, etc.) lead to similar technologies of raw material reduction and tool production? This may be the case in eastern Africa.

Clearly, understanding the underlying lithic raw material variability is a requisite step in explaining regional and inter-regional archaeological variation. One recent synthesis of eastern African lithic variability among MSA and early LSA sites (Faith et al. 2015) detected geographic differences in the presence and absence of particular artifact types between sites north and south of Equator, interpreted as possible evidence for the presence of spatially-defined boundaries in artifact production methods. As shown in Fig. 8.1, the Tanzanian record of sites such as Mumba, Nasera, Kisese II, Magubike, and Mlambalasi are all quartz dominated, while those in Kenya (with the exception of Lukenya Hill) are in areas rich in various types of lava. It is possible, therefore, that the apparently distinctive Middle and Late Stone Age technologies of Tanzania (e.g. the Mumba and Nasera industries) simply reflect properties related to the local availability of quartz. Whether or not the differences seen north and south of the Equator represent different behavioral traditions in the kinds of stone tools made or their methods of manufacture, or are simply a by-product of geology reflect hypotheses that remain to be tested.

We have sought to emphasize the importance of raw material for the analysis of eastern African Stone Age assemblages. This is of course nothing new, as lithic analysts have recognized for a long time that different rock types have very different properties that affect artifact form. Our point, however, is that approaches that seek to understand artifact variation at large temporal and geographic scales across Africa need to systematically take these differences into account (see Will and Mackay 2020 for a similar discussion). Otherwise excellent analytical approaches developed for isotropic rocks such as chert and flint are not easily adopted to rocks such as quartz, and developing different analytical protocols for different rock types leads to incomparable datasets, a problem similar to that caused by comparisons between Middle and Upper Paleolithic sites made using fundamentally different stone tool typologies (Grayson and Cole 1998). Ongoing work by the Comparative Analysis of Middle Stone Age Artefacts (CoMSAfrica) project (Will et al. 2019) may resolve some of these issues.

Statistical approaches such as the use of multiple regression and multivariate analyses (e.g. Scerri et al 2014) can deal with some of the impacts of raw material type (especially when comparing artifact frequencies), but the more pervasive problem is the role of raw material type on metric attributes, which are less easy to tease out with post hoc numerical tests. Digitization efforts might help reduce some of the ambiguity caused in the analysis of different raw materials, but as emphasized by Magnani (2014) and visible in Fig. 8.2, quartzite, quartz, and similar materials consistently cause a problem when using these approaches. Certainly, additional experimental approaches that elucidate the nuances of flaking mechanics in different raw materials are needed. Experimental replication of artifacts in quartz and other rock types suggests one way forward (e.g. Jones 2006; Gurtov et al. 2015; Pargeter and de la Peña 2017), as might efforts to better quantify rock texture and its impact on flaking mechanics (Brantingham et al. 2000; Noll 2000). Controlled experiments that use varied geological or synthetic materials in a series of standardized tests such as those devised by Pelcin (1997a, b, c) using glass represent another way forward. Substantial work remains to be done, but the promise of the development of a more accurate approach to geographic variation in lithic technology is one that makes these efforts worthwhile.

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