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Corey O'Driscoll

Alex Mackay

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On the operation of retouch in southern Africa's Early Middle Stone Age

Corey A. O'Driscoll[1], Alex Mackay[1,2]

[1]Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW 2522, AUSTRALIA; [2]Department of Archaeology, University of Cape Town, Rondebosch, Western Cape 8801, SOUTH AFRICA.

Corresponding author: corey.odriscoll@outlook.com

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Abstract

The southern African Early Middle Stone Age (~315-80 ka) is often regarded as a period of behavioural stasis. Though regionalised technological and behavioural adaptions are identified throughout this period, there appears to be a lack of coherent and regular turnover of technological systems that becomes common in later periods. Here we test if the perception of Early Middle Stone Age technological stasis may be influenced by the typological approaches to the retouched implements that are frequently used as markers of technological change. We deploy an attribute analysis of 498 retouched implements from three Early Middle Stone Age assemblages from the Doring River Catchment, South Africa is used to test three hypothetical explanations of variation in implement form: strict typology, reduction-mediated typology, or maximum expediency. We find strongest support for a maximum expediency model in which retouch was flexibly applied across multiple retouch episodes, facilitated by preferential selection of larger blanks, producing a range of outcomes that rarely conform to classic types. These results encourage an interpretation of Early Middle Stone Age technology as representing a flexible and widely effective technological system, the subtleties of which have been masked by an historical over-emphasis on the limited retouched component.

Keywords: Early Middle Stone Age, lithic reduction, stone tools, retouched implements, Southern Africa

Introduction

Anatomical and genetic evidence places the origin of *Homo sapiens* in Africa around 315 ka (Richter et al. 2017). The approximately concordant emergence of the African Middle Stone Age (MSA[1]) suggests linked biological and cultural developments (McBrearty and Brooks 2000; Richter et al. 2017; Brooks et al. 2018), with regional variation in the MSA's onset potentially reflecting complex population sub-structure at the continental scale (Scerri et al. 2017; Scerri et al. 2016). The MSA is most effectively differentiated from the preceding Earlier Stone Age (ESA) by the concerted use of Levallois flaking methods, and the disappearance of large cutting tools such as handaxes and cleavers (Goodwin and van Riet Lowe 1929; Herries 2011). Unlike developments associated with the first appearance of modern humans in Europe, the appearance of other changes associated with modern humans in Africa are relatively subtle (Brooks et al. 2018), and many are apparently somewhat delayed. Long distance transfers of raw material implying extended social networks are discernible by 200 ka (Blegen 2017). Thermal transformation of silica rocks and the use of marine resources (Marean et al. 2007; Schmidt et al. 2020) were in place by the end of Marine Isotope Stage (MIS) 6, around 130 ka. Bone tool production appears in MIS 5 (Brooks et al. 1995; Bouzouggar et al. 2018), followed shortly thereafter by evidence for the use of ornaments and engravings (Vanhaeren et al. 2019; d'Errico et al. 2008; Bouzouggar et al. 2007; Vanhaeren et al. 2006; Henshilwood et al. 2004; Texier et al. 2010; Henshilwood et al. 2009; Henshilwood et al. 2014), likely reflecting explicit social signalling (Stiner 2014). Many of these developments persist and potentially expand during the later phases of the MSA (Stewart et al. 2020; Miller and Willoughby 2014; Tryon and Faith 2013), consistent with models of ratcheting or self-sustaining cultural complexity (McBrearty and Brooks 2000; Sterelny 2011; Tennie et al. 2009).

Owing to the fragmentary nature of archaeological data in the MSA it is difficult to be certain that the accumulation of innovations represent uninterrupted linear models of ratcheting complexity (Lombard 2012). As with the archaeological evidence, the fossil record for early *H. sapiens* does not demonstrate a linear progression to our contemporary morphology (Scerri et al. 2018). It has been argued that between disconnected populations, in time, space, and genetics, we would not expect to see a coherent structured technological response, with some innovations having long lasting influence and others being short lived variants (Scerri et al. 2018; Will et al. 2019). This leads to one of the most interesting changes through the MSA, the delayed appearance of what we might refer to as cultural 'taxa' (Reynolds and Riede 2019; Ranhorn and Tryon 2018). Though regionalised artefact-making traditions emerge in the Early MSA (Marean and Assefa 2005; Douze et al. 2015; Schmid et al. 2016; McBrearty and Brooks 2000), coherent and regular turnover of technological systems displaying common and distinctive elements seem to be a feature of the later MSA and Later Stone Age (LSA) in Africa, as they are of the Upper Palaeolithic in Europe. While early industries such as the Nasera, Nubian, and Aterian are named taxa in the culture historic tradition (Shea 2014), their defining technological characteristics are limited, inconsistently present through contiguous blocks of space and time, and can be extremely time-transgressive (Dibble et al. 2013; Scerri and Spinapolice 2019). In the case of the Nubian, they are also prone to convergence (Will et al. 2015).

In southern Africa, structured turnover of technological systems begins around 75 ka. Despite contested ages, the identifying characteristics of the sequential Still Bay (bifacial points), Howiesons Poort (backed pieces, complex notched/strangulated blades, 'Howiesons Poort' blade cores), and post-Howiesons Poort (unifacial points and convergent scrapers) technocomplexes are clear, and the

[1] For convenience we will refer to the both the African Middle Stone Age and African Middle Palaeolithic as Middle Stone Age or MSA, and restrict usage of Middle Palaeolithic to that period in Eurasia (Kleindienst 2006)

taxa are readily identifiable (Wurz 2013; Mackay et al. 2014a) even when they occur as surface assemblages (Dietl et al. 2005; Shaw et al. 2019; Minichillo 2005; Carrion et al. 2000; Mackay et al. 2010; Hallinan and Parkington 2017). Furthermore, when found in stratified contexts across much of central and western areas of southern Africa, their stratigraphic order is repeated and consistent across multiple sites (Steele et al. 2016). That the first two of these taxa are also associated with the production of engravings, ornaments, and organic tools, encourages their characterisation as reflecting behaviour that is in some way modern-like (Henshilwood 2012). However, such structure dissipates again through later MIS 3 (Bader et al. 2018; Bader et al. 2015; Will et al. 2014; Mackay et al. 2014b), with coherent sequences of regional change only re-emerging from roughly 25 ka (Bousman and Brink 2018; Mackay et al. 2019).

The period that precedes the first appearance of this coherent 'taxonomic turnover' pattern can be referred to generically as the southern African Early MSA (Mackay et al. 2014a), though it has been divided into three successive taxa, referred to variously as 'stages', 'sub-stages', and 'technocomplexes' (Lombard et al. 2012; Wurz 2002; Volman 1981; Douze et al. 2015): MSA 1, MSA 2a, and MSA 2b. This naming scheme devised by Volman (1984; 1981) is the most widely applied, but has seen several modifications and adjustments. For example, MSA 1 is also termed 'Early MSA' (both as 'early and 'Early'), MSA 2a is sometimes referred to as MSA I and Klasies River, and MSA 2b as MSA II and Mossel Bay (Singer and Wymer 1982; Wurz 2013; Lombard et al. 2012; Lombard 2012). This in itself raises issues with the concepts of technocomplexes based on typological distinctions, as there is a variety of reasons that it may not be immediately apparent whether a given assemblage is a part of a known technocomplex or is something new (Lombard et al. 2012). For consistency and simplicity we have used Volman's (1984; 1981) scheme to represent the current state of technocomplex divisions, and the Early MSA as the overarching term for the entirety of the period postdating the ESA and predating the Still Bay.

Unlike the Still Bay, Howiesons Poort, and post-Howiesons Poort, the differences between MSA 1, MSA 2a, and MSA 2b are subtle. They are linked by the common abundance of local raw materials, the flexible application of Levallois-like core reduction modalities, and a tool corpus in which notched flakes, denticulates, scrapers, and unifacial points are the most common elements (Douze et al. 2015; Volman 1981). They are differentiated largely by the sizes and proportions of blades and convergent flakes, and the relative abundance of retouched implements (Volman 1981; Lombard et al. 2012). As with North African cultural taxa such as the Aterian or East African taxa around the MSA / LSA transition (Ranhorn and Tryon 2018), the divisions of the southern African Early MSA do not appear to be time-bounded, with similar taxa identified in different intervals at different sites (Mackay et al. 2014a). Thus, while MSA 1, MSA 2a, and MSA 2b might be considered identifiable (Douze et al. 2015), they are not identifiable in similar ways to subsequent divisions of the southern African MSA. Indeed, they appear more similar to the sub-divisions of the Middle Palaeolithic in Western Europe, where comparable and contemporaneous technological changes may be identified at nearby sites (Jacobs et al. 2016), but refined, regionally-coherent sequences of technological turnover like those identifiable in the Upper Palaeolithic remain elusive (Gravina 2017; Faivre et al. 2017; Monnier and Missal 2014; Mellars 1996).

Our interest in this paper is why this should be so. Compared to the relatively rapid and well-structured changes that followed it, the ambiguous nature of technological change in the Early MSA has contributed significantly to the view that this was a period of relative cultural stasis (Douze et al. 2015; Wurz 2002, 2013; Lombard et al. 2012). Allied with the absence of engravings and ornaments, behaviour during the Early MSA may thus appear less 'modern' than that evidenced after ~75 ka (Henshilwood and Dubreuil 2011). Like the MP, the subtle proportional changes of common technological elements suggest a coherent but somewhat generic repertoire that was flexible in its deployment through time and space. Yet unlike the MP, the Early MSA was associated with modern humans, and there is no genetic evidence for a significant population change coincident with the start of the Still Bay (Schlebusch 2017; Hammer et al. 2011; Behar et al. 2008).

Though they typically account for low proportions of Early MSA assemblages, we focus in our paper on retouched implements (or tools), as these form such an effective discriminant of later MSA and LSA cultural taxa, and yet such a poor discriminant of proposed Early MSA cultural taxa. A variety of approaches can be taken to the study of such artefacts. In southern Africa, traditional typological approaches in which implements are categorised according to their final form have historically been dominant, as these are strongly associated with the construction of cultural taxa (Bar-Yosef and Van Peer 2009); such an approach, however, is demonstrably inadequate to the study of the Early MSA (Douze et al. 2015). More recently, dynamic *chaîne opératoire* approaches, which document production processes from raw material selection, to blank production, shaping, finishing, and discard, have become more prevalent. Such approaches have most often been applied to cores in southern Africa, with their application to retouched implements being limited to a few cases (Soriano et al. 2015; Villa et al. 2009b; Hogberg and Lombard 2016; Conard et al. 2012).

An alternative approach to the study of retouched implements comes from attribute-driven reduction analysis, in which indices are typically used to assess the effects on implement size and shape of the progressive removal of mass during reduction (Kuhn 1990; Clarkson 2002; Dibble 1987). The advantage of such approaches is that they avoid the teleological assumption inherent in many *chaîne opératoire* analysis that reduction is geared towards producing a final, intended form (Shott 2015; Holdaway and Douglass 2011; Dibble et al. 2016; Hiscock and Clarkson 2000). The approach thus allows that reduction may have been a continuous process that was responsive to the contingencies of successive knapping actions as well as the imminent needs of the knapper (Dibble 1995; Bleed 2001; Hiscock and Attenbrow 2003).

Past applications of reduction analysis of Middle Palaeolithic denticulates, notches, and scrapers has been used to argue that variation in implement form at discard results from a degree of reduction rather than a desired end-product (Dibble 1987; Hiscock and Clarkson 2007; Holdaway et al. 1996; Lin and Marreiros Submitted). A reduction hypothesis implies that reduction occurs as successive episodes of retouch and to enable the continual reduction of a piece, larger blanks with a greater amount useable edge would be manufactured and selected for retouch (Dibble 1987; Dibble 1995). Among notched and denticulated pieces, there is a relationship between blank size and number of notches which suggests that notches were added incrementally through an artefact's uselife (Holdaway et al. 1996; Hiscock and Clarkson 2007). Among scrapers, it has been argued that progressive retouch accounts for various subtypes that are typically considered discrete (Dibble 1995; also Clarkson 2005). Alternatively it has been suggested that the scraper reduction may follow multiple branching paths (Hiscock and Clarkson 2008), and the final form of scrapers may be strongly conditioned by a combination of initial blank form and reduction intensity (Kuhn 1992; Hiscock and Clarkson 2008).

We aim here to test whether, and to what, extent these propositions apply to comparable implements from the Early MSA. To be clear from the outset, we are not interested in testing the 'reality' or otherwise of Early MSA sub-divisions. Rather we are interested in understanding whether the operation of retouch as a continuous process in the Early MSA potentially confounds the utility of implement types as markers of technological change in this period. Such a finding may indicate that, rather than stasis, the seemingly generic nature of Early MSA technology in fact represents a flexible set of techniques that provided adaptive solutions across large tracts of space and time.

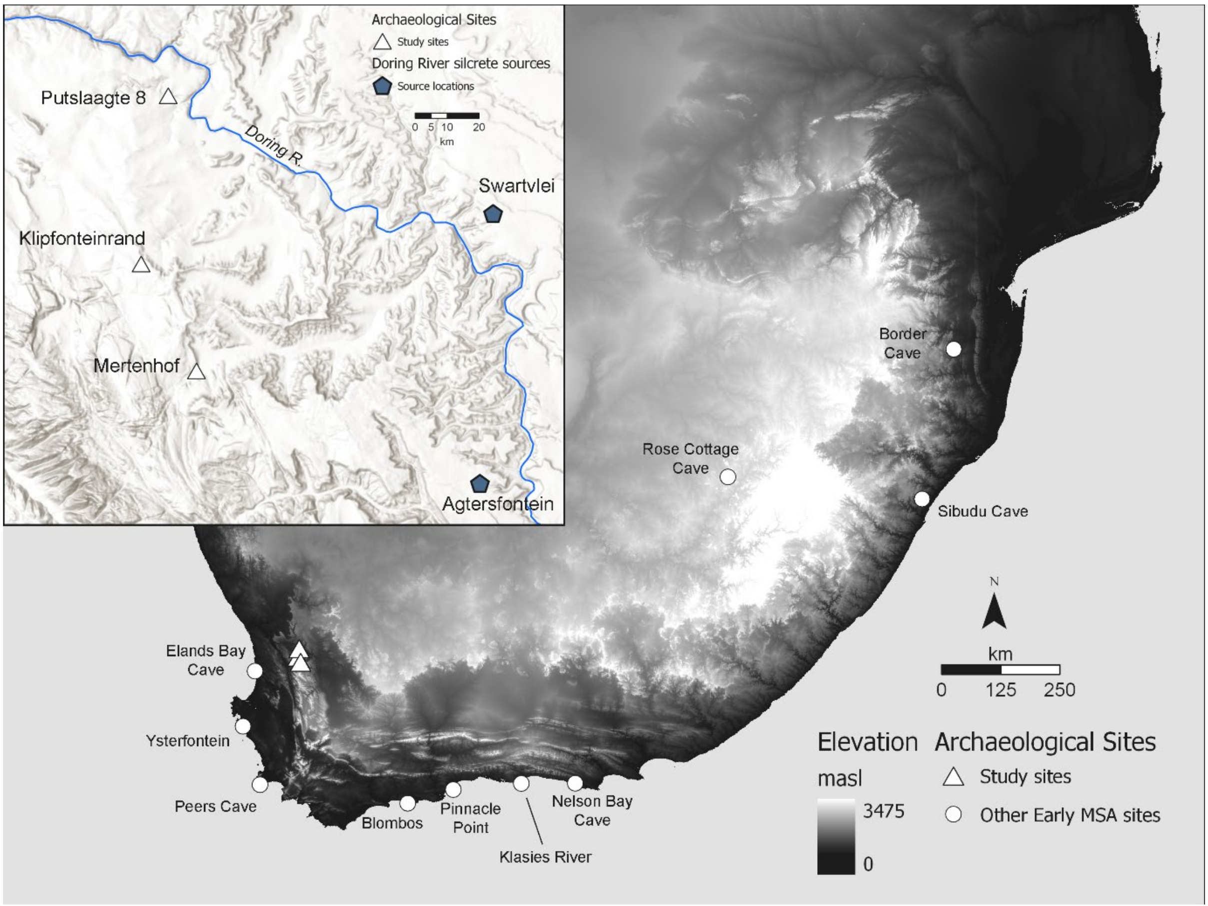

Fig 1 Location of study sites in the context of southern Africa and a selection of prominent Early MSA sites. SRTM data from: Jarvis et al. (2008). Inset, locations of Klipfonteinrand Rock Shelter (KFR), Mertenhof Rock Shelter (MRS), and Putslaagte 8 (PL8) relative to the Doring River and known silcrete sources within the catchment.

Materials and Methods

Sites, settings, and samples

For the purposes of our study, we analysed retouched and unretouched flakes from Early MSA layers at three excavated rock shelter sequences in the Doring River catchment, at the edge of South Africa's Cederberg Mountains (Figure 1). The sites are Klipfonteinrand (KFR), Mertenhof (MRS), and Putslaagte 8 (PL8). All three shelters occur in the same geological unit – the Nardouw Formation of the Table Mountain Group – providing local access to quartzite, sandstone, and small pebbles of quartz and more rarely chert from conglomerate units. These local lithologies also account for the majority of artefacts in each sample. Proximity to other lithologies, and most notably the fine-grained rocks hornfels, silcrete, and chert, varies between the sites (Low and Mackay 2018). The contact metamorphic rock hornfels was typically obtained from the cobble beds of the Doring River, at distances of 2 km, 13 km, and 19 km from PL8, KFR, and MRS respectively. Silcrete was generally obtained from primary sources on ridge tops that were non-local (>20 km) to all sites. In addition to rare pebbles in the Nardouw Formation conglomerates, chert is available as small clasts in the Doring River, and as primary sources in the far south east of the catchment (Smith and Ripp 1978).

KFR is a north-east-facing rock shelter located approximately 3.5 km from the Brandewyn River, a small, ephemeral tributary of the Doring River. The site was excavated by John Parkington in 1969 and again by Mackay and colleagues in 2011-2012. The MSA sequence includes post-Howiesons Poort, Howiesons Poort, and Early MSA material. Despite some mixing of the lower Howiesons Poort and uppermost Early MSA in Parkington's original sample, Volman assigned the assemblages from Parkington's spits 7, 8, and 9 to his MSA 2b grouping (Volman 1981). In the newly excavated sample, the Howiesons Poort is constrained to the strata LGSS and BS, and the Early MSA to the strata GGLBS and PBS. GGLBS is roughly equivalent to Parkington's spit 7, and PBS to spits 8 and 9. The assemblages from GGLBS and PBS in squares 1, 2 and 6, were analysed for this study, the resulting sample comprising 334 complete and broken retouched flakes (5.6% of the total assemblage) and 1935 complete unretouched flakes.

MRS is a north-facing shelter located 25 m upslope of the spring fed Biedouw (or Heuningvlei) River that feeds into the Doring River. Excavations at MRS began in 2013 and are on-going; bedrock has yet to be reached anywhere, with the deepest point currently 1.95 m below surface. The site has a well-defined sequence comprising Robberg, Late MSA, post-Howiesons Poort, Howiesons Poort, Still Bay, and Early MSA units (Schmidt and Mackay 2016; Will et al. 2015). Material analysed for this study derives from the Early MSA stratum DBS in squares 3 and 4 – the two deepest excavation units. The assemblage includes 122 complete and broken retouched flakes (3.9% of the total assemblage), and 747 complete unretouched flakes.

PL8 is a small north-facing rockshelter located in a low gorge on the Putslaagte River, a small, ephemeral tributary of the Doring River. The shelter was excavated in 2010 to bedrock at a maximum depth of 1.63 m (Mackay et al. 2015). Like MRS, PL8 retains a long sequence including examples of most known Late Pleistocene cultural taxa. The Early MSA material was first analysed by Mackay et al. (2015), and then reanalysed for this study by the lead author. The sample contained 40 retouched pieces (2.9% of the total assemblage), and 294 complete unretouched flakes.

The total sample of retouched flakes from the three sites is 498 retouched flakes, of which 213 (42.8%) are complete, with a further 2976 complete unretouched flakes (Table 1). Local rocks, notably quartzite and sandstone, dominate all samples, though PL8's proximity to the cobble beds of the Doring River is reflected by the abundance of hornfels in that assemblage.

Analytic methods

An attribute-based analytical approach was used to explore variation within and between the classic Early MSA implement types notched pieces, denticulates, scrapers, and unifacial points. Specifically, we set out to test three alternative hypotheses concerning the processes controlling implement form in our analytic sample:

H1. (Strict typology). Different implement types are discrete and intended end-products. Different kinds of retouch were applied to different kinds of implements with little to no overlap. Different blank forms were used to manufacture different implements, and there is no discernible relationship between measures of artefact size, retouch intensity, and artefact type. Lithology has no impact on implement type. There should be marked variation between implement types, but little variation within types.

H2. (Reduction-mediated typology). Different kinds of retouch were applied to different kinds of implements as per H1, but within types, intensity of retouch is responsive to blank size (larger blanks receive more retouch) and lithology (non-local rocks are more heavily retouched). There should thus be similarities in retouch form and location within implement types but considerable difference within and between implement types in reduction intensity for large, non-locally derived pieces.

H3. (Maximum expediency). Retouch was applied opportunistically to blanks of all forms and sizes. Larger flakes typically acquired more retouch, as did lithologies obtained from non-local sources, but different kinds of retouch were regularly applied to the same piece, and there is no identifiable relationship between blank shape, retouch form, or retouch intensity. In this instance, the types themselves are arbitrary partitions of continuous variability.

To test these hypotheses an extensive list of attributes was formulated based on a number of published sets (e.g. Wilkins et al. 2017; Högberg 2016; Villa et al. 2009a; Low 2019; Schmid et al. 2016; Mackay 2009; Soriano et al. 2007; Wurz 2013; Porraz et al. 2013), along with several adaptations and additions (definitions for each and how they were recorded can be found in Supplementary Information [SI]). Four kinds of data were recorded for this study: measured (continuous), categorical, ordinal, and calculated.

Measured attributes included maximum dimension (length), axial length, medial axial width, medial axial thickness, and maximum percussion length. There is some debate over the most representative way of measuring length of an artefact (maximum, axial, and percussion), and as such the three length measures were recorded to determine if the way length is measured influences the results (Andrefsky 2005; Lombard et al. 2013; Dibble 1995; Fagundes et al. 2007).

Categorical attributes include implement type, raw material, cortex source, platform type, reduction strategy (e.g. levallois, discoidal, laminar), retouch form, retouch location, notch type, notch location, and retouch direction. Further details on these variables are provided in SI, though we will discuss implement types in more detail here. Notched pieces are defined as retouched flakes with one or more non-adjacent notches and no other forms of retouch. For consistency of application, we follow Hiscock and Clarkson (2007) in defining a notch as a concavity at least 1.5 mm deep and 5 mm across, though this definition introduces some issues we discuss below. Notches can be both simple (a single retouch scar) or complex (multiple retouch scars within the concavity). Scrapers are defined as artefacts with one or more areas of scalar or parallel retouch at angles between 30° and 75°. We included three sub-types of scraper in our analysis – end, lateral, and other. End-scrapers can also be referred to as transverse scrapers, lateral-scrapers are often termed side scrapers and other-scrapers are those scrapers with steep scalar retouch on multiple margins and encompass Dibble's (1995) convergent and double scrapers.

Denticulates we define as flakes with two or more adjacent notches following Bordes (1961). However, there are two issues with this definition. The first is that the definition lacks precision on how to implement the term 'adjacent', as few denticulates have perfectly continuous notches (Picin et al. 2011). The second is how to interpret the term notch as used by Bordes (1961). The arbitrary size cut-off given by Hiscock and Clarkson (2007) suffices for notches but does not take into account smaller concavities that may form serrations or 'micro-dentitions' (Hiscock and Clarkson 2007). There have been arguments that such concavities may be the result of taphonomy and/or use-wear rather than anthropogenic retouch, to the point that they have been excluded from analysis owing to the uncertainty (Holdaway et al. 1996). The minimum size cut-off is used to limit the probability that a concavity is non-anthropogenic notching. An issue with this is that the term denticulates is often applied to any piece with two adjacent concavities, no matter the size, if an analyst believes they are retouch. As such, we have employed the term denticulate to classify pieces with at least two adjacent serrations (or micro-dentitions), notches, or a combination of the two. We treat this issue by using two sub-types of denticulates: those constituted by adjacent notches (termed notched denticulate) and those constituted by serrations (termed serrated denticulate). This latter sub-type may also contain notches, but the denticulation relates to smaller concavities.

We use further categories within the attribute 'type'. Artefacts classified as 'mixed retouched' (also termed 'composite tools' by Sinclair 2009) exhibit more than one identifiable typological characteristic, such as artefacts with both 'scraper' retouch and one or more notches, or patches of serrations. Artefacts classified as 'minimal' typically have only one or two non-notch scars, while the type 'other' subsumes all remaining pieces, including artefacts that would be classified as specific types given different research questions such as core-on-flakes, scaled pieces (e.g. *pieces esquilles*), backed pieces, and burins.

Our ordinal variables are number of retouch patches and number of notches. Number of retouched patches is a count of the total number of discrete locations around a flake's perimeter to which retouch was applied. Thus, where retouch is continuous around the entire perimeter, the patch count is one. Number of notches is a count of notches as defined above.

Calculated variables include elongation and measures of retouch intensity. Elongation was calculated as the ratio of axial length to medial axial width. Retouch intensity measures include Geometric Index of Unifacial Retouch (GIUR, Kuhn 1990), Invasiveness Index (II, Clarkson 2002), and proportional perimeter retouch (hereafter, 'retouch extent'). GIUR was designed for scrapers with unifacial dorsal retouch and II was designed to work with invasive unifacial and bifacial retouch, though both have proved effective for denticulates (Hiscock and Clarkson 2007). Proportional retouch extent (also referred to as retouch perimeter by Hiscock and Attenbrow 2003) is the length of the perimeter that has been retouched as a proportion of the total perimeter length.

Several potentially relevant measurements were not recorded, including notch dimensions, retouched lateral edge curvature, edge angle, surface area to platform area ratio. Notch dimensions – length and depth – were excluded as it is difficult to obtain consistent and precise measurements of individual notches as it can prove problematic to define the exact start and end of a notch, particularly where notches were adjacent one another. Thus, we deployed the defining size criteria noted above as a minimal requirement but did not attempt further precision. Hiscock and Clarkson (2007) noted in any case that notch size did not play a part in differentiating MP types. Lateral edge curvature was replaced by recording each third of the flake edge (proximal, medial, distal) as either expanding, parallel, or converging. Edge angle has been shown as a poor measurement in differentiating retouch types and is difficult to measure consistently (Roland and Dibble 1980; Valletta et al. 2020). Edge angle was measured to aid in defining a scraper, but further exact and repeated measurements were not recorded. Dibble (1987) designed the ventral surface area to platform area ratio to determine the amount a piece may have been reduced and, while platform thickness, exterior platform angle, and platform area have been shown as good indicators for flake length (e.g. Lin et al. 2013; Dibble and Rezek 2009; Muller and Clarkson 2016; Shott et al. 2000), the surface area to platform area ratio has been argued to have limited explication for reduction intensity (Hiscock and Tabrett 2010).

The results of our analysis will be framed around four questions that relate to the stated hypotheses:

Q1. What types are present and how were they retouched?

Q2. Were different kinds of blanks used for the production of different implements?

Q3. Is there any relationship between blank/implement size and reduction intensity?

Q4. Is there any relationship between lithology and reduction intensity?

A fifth question arising from the answers to these first four will also be addressed:

Q5. Was the production of notched pieces and denticulates discrete?

All analyses conducted in this study used R statistical software (R Development Core Team 2019) with packages *janitor* (Firke et al. 2020), *ggplot2 (Wickham et al. 2020a), dplyr (Wickham et al. 2020b)*, *tidyverse (Wickham 2019)*, *kable* (Hao et al. 2019), *reshape2* (Wickham 2020), and *gmodels* (Warnes et al. 2018). ANOVA tests with Tukey HSD for pair-wise tests and chi-squared were conducted to determine statistically significant differences in numerical variables. For ANOVA, and associated Tukey HSD pair-wise tests, all numeric variables were checked for symmetrical distribution and transformed if necessary (all tests can be found in SI). An alpha level of 0.05 is employed as the threshold for significant difference and adjusted residuals of greater than two have a greater than expected frequency. This paper has also used medians rather than mean, unless otherwise stated, as the mean has greater sensitivity to outlier values. For this analysis, simple and complex notches have been lumped together, unless otherwise stated.

Results

Q1. What types are present and how were they retouched?

Earlier in this paper, we defined types according to standard conventions, including their shapes and kinds of retouch used in their production. We also included a type 'mixed' for those artefacts that included characteristics of more than one type, and which could thus not confidently be assigned to any. Examples of each type can be found in Figure 2.

A relatively high proportion – 12.7% – of our types were classed as minimal (Table 1) and a further 10.3% (all from 'other') have only three to five retouch scars, probably reflecting the abundance of raw material around the shelters; the vast bulk of all implements were made on locally available rocks. Other than minimally retouched pieces, notched pieces are the most common type, followed in decreasing frequency by denticulates, mixed retouch, and scrapers (Table 1). Our sample of unifacial points is small (n=4) and these will consequently play only a minor role in subsequent analyses. At 12.2% there are similar amounts of mixed pieces as there are minimal, suggesting that many implements had characteristics of more than one type.

We can explore this issue further by looking at the application of different forms of retouch – notably scalar, parallel, notches, serrations, and nibbling – to different implement types (Table 2). As would be predicted by H1, scrapers and unifacial points are dominated by distinctive retouched types 'scalar' and 'parallel', with some having a mix of scalar/parallel and nibbling or 'other' (unclassifiable) retouch. A small proportion (~6.7%), however, show a mix of scalar/parallel and notched/serrated retouch. A similar pattern holds for notched pieces and denticulates, where notching, serration, and a mix of the two account for 50-60% of pieces. Around a quarter of all notched pieces and denticulates also show some scalar/parallel retouch, and one in seven denticulates exhibited all recorded forms of retouch (scalar, parallel, notched, serrated, nibbling, and other). The notched pieces exhibiting scalar retouch are all complex notches.

The variability in retouch form for types raises the possibility that this diversity of retouch may be linked to separate reduction episodes, rather than the creation – in a single event – of a multifaceted tool. The interaction between quantity and diversity of retouch form can be estimated by the number of discrete, discontinuous retouch patches and the number of retouch forms present on a piece. This relationship implies that a piece with a greater number of patches and forms has undergone a greater number of reduction episodes. The data confirm this relationship (Table 3): the more patches that were retouched on an implement, the greater the diversification of the retouch forms employed on an implement.

Fig 2 Examples of artefact typological groups. a-c: notched. d-i: denticulates. j, q, r: mixed retouch. k, m, p: scraper. l, n, o: unifacial point. a-o share central scale. p-r have individual scales. Both ventral and dorsal present, lateral margins present for k and o. Orientated with platforms to the top, arrows note notches, and dashed lines indicate scalar retouch

Note that a 'patch' in this usage is any continuous length of retouch – it is an ordinal measure of the number of discrete areas of retouch on an artefact and does not represent retouch extent. A well-made scraper will typically feature a single retouch patch, while a notched piece may comprise several.

That caveat aside, the data reinforce the impression that, while some implements were manufactured in a discrete fashion, retouch was often deployed opportunistically and variably.

A final issue to address here concerns the placement of retouch around pieces. This issue pertains both to the distinction between types and between sub-types. Each implement type exhibits variability in the location of retouch, though across all types retouch is consistently most common on the distal margin (Table 4). This is particularly true of scrapers, which were almost all flaked on the distal (93.7% of pieces). Unsurprisingly, this results in a high proportion of end scrapers (Table 5). However while some lateral scrapers – those retouched along one entire margin – do occur, the presence of equal numbers of scrapers retouched on both the distal and lateral margins ('scraper – other'), suggests that the distinction between sub-types is arbitrary.

> Q1. What types are present and how were they retouched?
>
> A1. Numerous types are present, and there is considerable evidence for continuity between types and between sub-types. Different kinds of retouch were frequently applied to the same implement, and the same kind of retouch was applied to different implements. Scrapers and unifacial points have higher proportions of scalar/parallel retouch, while notched pieces and denticulates have higher proportions of notch and serrated retouch. These relationships were not discrete; the more retouch a piece received, the more likely it is to display multiple forms of retouch.

Q2. Were different kinds of blanks used for the production of different implements?

H1 predicts a relationship between blank form and implement type; H3 predicts no such relationship, and that artefact shapes selected for retouch will mirror the proportions of the overall flake population. Three quarters of unretouched flakes in our sample are asymmetrical in shape, with almost a quarter being convergent, and the small remaining balance being parallel (Table 6). Proportions of blank shapes generally differ between implement types. While most types were made on asymmetric blanks, there was some active selection for convergent blanks, expressed most strongly for unifacial points, denticulates, and 'mixed retouch'. Though retouch will have exacerbated convergence for unifacial points, in all cases tapering of the unretouched margin suggests that retouch augmented rather than defined the convergent shape. Parallel shapes are over-represented in all types, though most conspicuously among mixed retouch, notched pieces, and scrapers. Where blades – flakes that are both parallel and elongate – were retouched, they were most often from the optimal phases of debitage (Table 6). Pearson's Chi-squared adjusted residuals (x^2 = 40.35, df = 12, p-value = <0.001), however, suggest that convergent blanks are significantly over-represented only for denticulates (adj. res. = 4.0826) and mixed retouch pieces (adj. res. = 2.9578), while parallel blanks were over-represented only among mixed retouch pieces (adj. res. = 2.1315).

A second element of blank form not captured by shape relates to the flaking processes used in blank production (Table 6). While the vast majority (96.5%) of flakes in our sample were either produced expediently or could not be related to a specific production strategy, laminar and Levallois blanks are over-represented among implement types. Consistent with the high proportions of parallel flakes, laminar blanks are disproportionately common among scrapers (Pearson's Chi-squared: x^2 = 96.578, df = 21, p-value = <0.001, adj. res. = 2.1844), minimal (adj. res. = 3.3695) and notched pieces (adj. res. = 5.7499). Levallois blanks were generally exceedingly rare in our sample, but were nonetheless over-represented, particularly among denticulates (Pearson's Chi-squared: x^2 = 96.578, df = 21, p-value = <0.001, adj. res. = 1.3858), minimal (adj. res. = 5.9745), and mixed retouched implements (adj. res. = 1.3858). Thus, as for blank shape, there is some evidence for selection of blank form in implement production, and that form varies to some extent between types. Interestingly, while minimal pieces have a similar proportion of asymmetrical blanks to unretouched flakes, they have a much greater proportion of Levallois and laminar production.

The final aspect of blank selection we consider relates to blank size. While we have no *a priori* reason to assume that different implements required blanks of different sizes, such a finding would be consistent with the expectations of H1 and not expected in H3. Between typological groups there is no difference between blank size metrics (Table 7). Overall, the blanks selected for retouch were longer, thicker, and wider than typical unretouched flakes, and this is true for all implement types (Table 3). Between types, however, differences are minimal; only the axial lengths of scrapers and unifacial points differ significantly (Tukey HSD, adjusted p-value = 0.0002), and the sample size for the latter is very small.

> Q2. Were different kinds of blanks used for the production of different implements?
>
> A2. There is some limited support for this proposition. Larger blanks were preferentially selected to produce all implement types. There is some preferential selection for convergent and parallel blanks, and blanks produced by laminar and Levallois methods. Most implements, however, were made on asymmetric blanks.

Q3. Is there any relationship between blank/implement size and reduction intensity?

Results so far suggest selection for larger blanks when choosing flakes for retouch. An extension of this is the prediction (H2) that larger implements will receive more retouch. In our sample (Table 8), the relationship between implement size and measures of retouch intensity (GIUR, II, retouch extent) is reasonably constant, though retouch extent tends to decrease gradually against implement size.

The measures of retouch intensity we have used here work well for types of retouch that are often applied continuously, such as scalar or parallel retouch. We expect them to work less well for notches, however, which are typically not invasive, which were probably not often maintained, and which do not necessarily cover large areas of an implement's edge. The preponderance of notched pieces and denticulates on the left side of graphs in Figure 3 support this contention.

Looking, then, at the relationship between flake size and number of notches, we note a general trend that as flake size increases so to do the number of notches (Table 9). This trend is most pronounced in measures of length (maximum dimension, maximum percussion length, axial length) and is not replicated in width and thickness, suggesting that length is the primary driver. Retouched pieces with a single notch do not differ greatly in size to implements without notches, but flakes with multiple notches are typically larger than those with one or no notches (Table 9). Thus, while retouch extent scales with artefact size for most implement types, it increases at a faster rate for pieces with notches, to the effect that larger pieces received proportionally more notches. An interesting side note here is that blank selection for large pieces with multiple notches is not neutral; preference for convergent blanks increases with number of notches. This may explain significant selection for convergent blanks among denticulates (which always have multiple notches) but not among notched pieces (which often have only one notch).

> Q3. Is there any relationship between blank/implement size and reduction intensity?
>
> A3. Yes, retouch generally scales with artefact size. Among notches artefacts, larger pieces generally have more notches than smaller pieces.

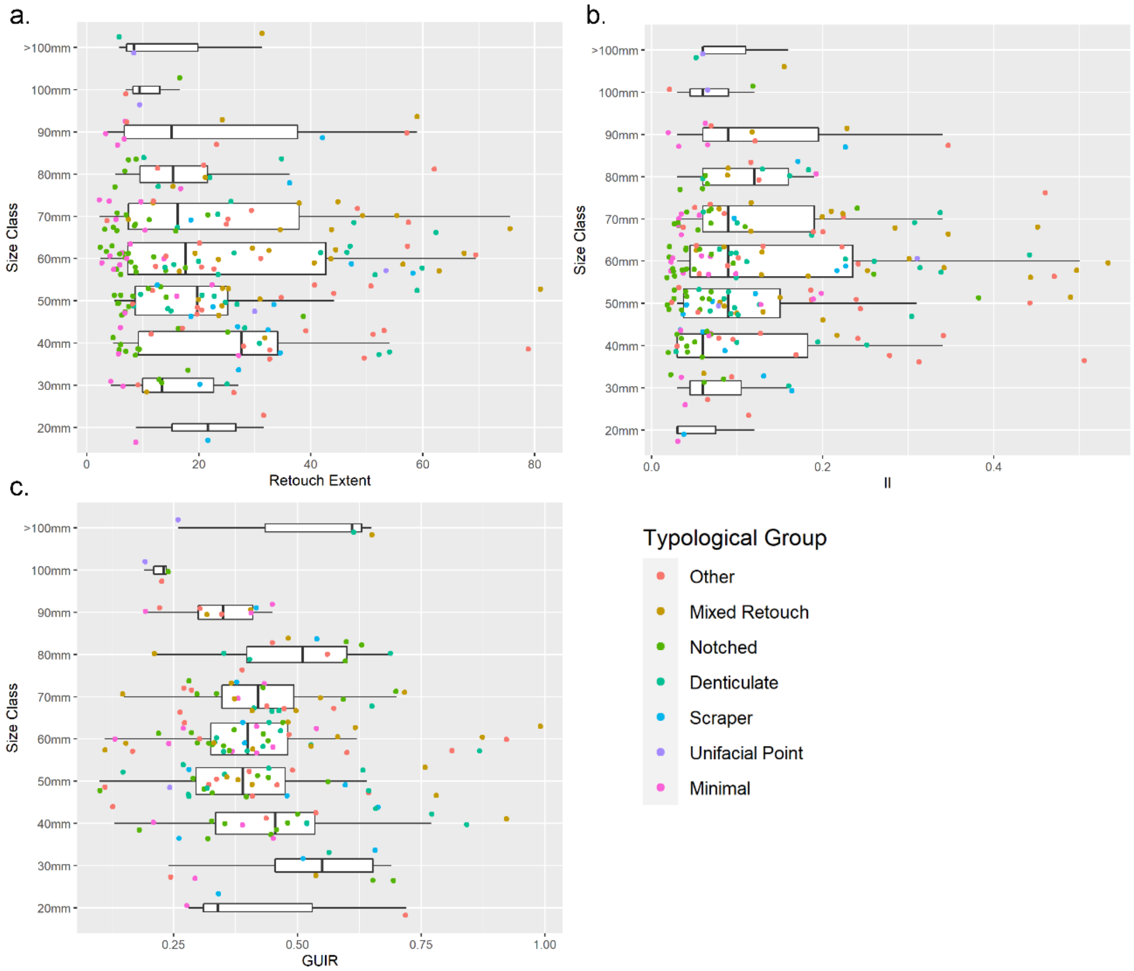

Fig 3 a. Boxplot of complete retouched flakes size class by retouch extent **b.** Boxplot of complete retouched flakes size class by Invasiveness Index (II) **c.** Boxplot of complete retouched flakes size class by GUIR. Boxplot width dictated by number of specimens and within size class boundaries are the number of specimens for each typological group. Points are within the boundaries of the specific boxplots are randomly distributed along the y-axis but not along the x-axis.

Q4. Is there any relationship between lithology and reduction intensity?

The third question concerns the relationship between lithology and retouch intensity. H2 and H3 both predict more extensive reduction of non-local lithologies. Non-local materials at MRS and KFR are all hornfels, silcrete, and fluvially derived pieces, while for PL8 only silcrete can be assumed to be non-local.

There is no clear preference for lithology among any implement types (Table 1), with quartzite the highest proportion of each group, though scrapers have the highest proportion of hornfels (20%), double the proportion in other typological groups. There is no clear difference in the metrics nor retouch intensity measures between local and non-local materials (Table 10). Only GUIR is significantly different (Tukey HSD, adjusted p-value = 0.028).

A second set of tests was conducted by adjusting the parsimonious assumption that sandstone, quartz, and quartzite without cortex is of local origin. The assumed origin of hornfels, silcrete, and cortical pieces remains the same but all quartzite, sandstone, and quartz pieces without cortex are coded as of unknown origin. There is no difference in the results by adjusting the assumption of lithology source. The only difference in the two assumptions is that GUIR is no longer statistically significantly different in the latter, though it is still higher in local and unknown source compared to non-local. There is no selection of lithology for typological groups and non-local lithologies do not receive more retouch than their local counterparts. This fits between the expectations of H1 and H2.

Q4. Is there any relationship between lithology and reduction intensity?

A4. No, we found no clear evidence for a relationship between lithology and reduction intensity. Local and non-local raw materials were subject to comparable degrees of retouch.

Q5. Was the production of notched pieces and denticulates discrete?

Both denticulates and notched pieces are types with some quantity of notch retouch (including micro-dentitions, or serrations). In the case of denticulates, notches are placed adjacent one another on the blank edge; in the case of notched pieces, notches, if more than one, are placed apart. Earlier in our results, we noted that different episodes of retouch on a given blank (defined by patches) often took different forms. With respect to pieces with at least one notch we also noted that the number of notches increased with the size of the blank, implying that the addition of multiple notches was a means of utilising available blank edge. A question that arises from these observations is, if notches were added sequentially, and if each retouch decision was potentially independent of the previous one, are notched pieces and denticulates necessarily discrete forms? With the addition of each new notch, the knapper had a choice of whether to place it adjacent to or away from the last one. If denticulates and notches pieces are discrete types, we would expect discrete pathways; that is, a denticulate pathway in which each additional notch was placed adjacent the previous one, and a notched piece pathway in which each notch was placed away from previous ones.

In Figures 4 and 5 we explore the process of accumulating notches as an event tree, where at each step (i.e. with each additional notch) the knapper confronts a binary choice to place the new notch adjacent or away from other notches. Figure 4 includes complete pieces only, while Figure 5 includes both complete and broken pieces to increase sample size. Note that serrations are not included in the notch count because, as noted in Methods, they were difficult to quantify consistently, and thus denticulates defined by the presence of serrations alone are excluded.

Each cell in the event tree describes the resulting retouch configuration, and the number and percentage of cases of that configuration occurring in our analysed sample. As there are multiple pathways to some cells, the null probability is not evenly spread between cells. For example, there are five separate configurations possible for four notches, but three pathways to the configuration '3 adjacent, 1 discrete' and only one pathway to '4 discrete'. If denticulates and notched pieces were discrete types, we would expect skew in the data to the peripheral pathways; if they are not, the distribution of outcomes should accord with the number of pathways to each different outcome.

The event tree provides no support for the suggestion of discrete denticulate and notched piece pathways. For any given number of notches, the distribution of outcomes does not differ from random (Goodness of fit chi-square test on values by row in Figures 4 and 5 never achieve a p value lower than 0.2275). At each step, a knapper placed a new notch adjacent to and discrete from previous notches with equal likelihood. While this process produced 'denticulates' with up to four adjacent notches, these seem more likely to be the outcome of chance than design. At this point it is worth recalling the earlier observation of increasing preferential selection for large convergent blanks with number of notches across notched pieces and denticulates; blank selection appears to have been more deliberate than notch placement for implements with multiple notches.

Q5. Was the production of notched pieces and denticulates discrete?

A5. No, the evidence does not support the proposition that these types are meaningfully distinct.

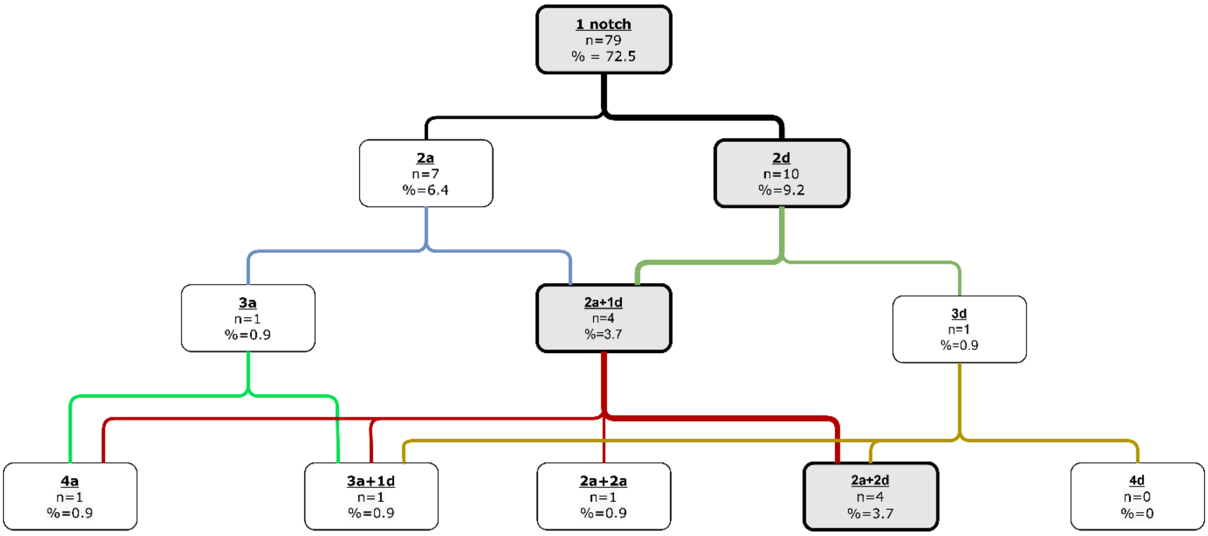

Fig 4 Notch event tree for complete notched retouched flakes. a = adjacent and d = discontinuous. Shaded boxes are for the greatest number of cases .. Results in boxes are for goodness of fit chi-squared tests for observed and expected notch counts (produced with diagram.net)

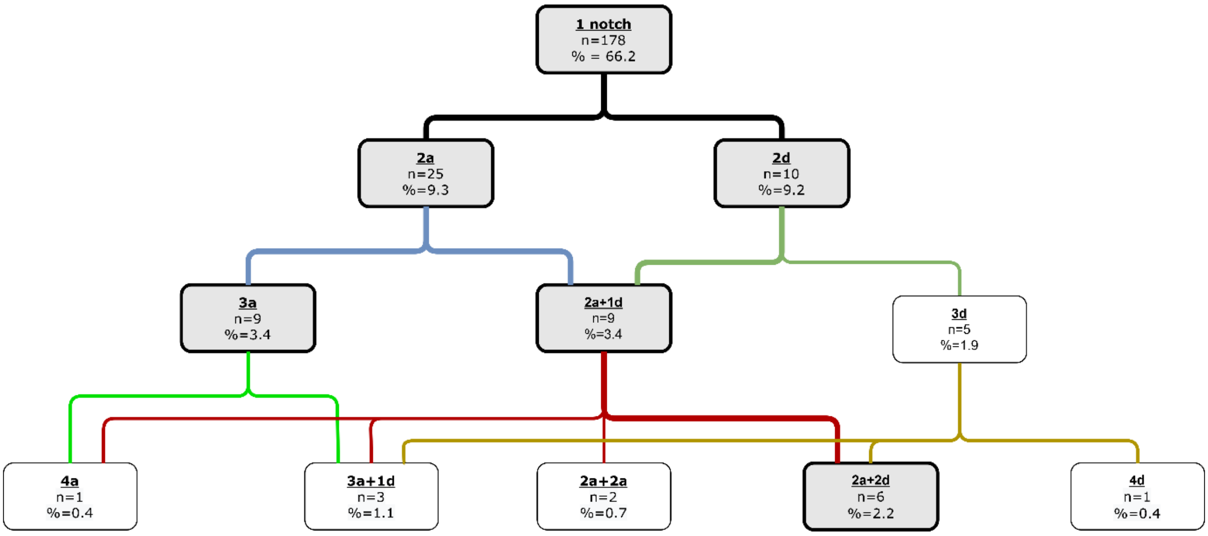

Fig 5 Notch event tree for both complete and broken notched retouched flakes. a = adjacent and d = discontinuous. Shaded boxes are for the greatest number of cases . Results in boxes are for goodness of fit chi-squared tests for observed and expected notch counts (produced with diagram.net)

Discussion

While none of our hypotheses is fully supported by the data, support is weakest for H1 (Strict typology). While selection for blank shape and retouch processes differs somewhat between types, similarities between types are greater than their differences. The data show that retouch form is not restricted to a single type but crosscuts types, and many retouched pieces exhibit multiple types of retouch. Increasing instances of retouch (patches) on a piece increases the variance in retouch form. While large flakes were typically selected for retouch, there is no difference in the size of blanks used for different types and the selection of blank shape is not exclusive to a given type.

There is greater support in our data for H2 (Reduction-mediated typology), though it is equivocal. As per H1, there is some differentiation in the way different types were retouched, but the distinction blurs as retouch events increase. Both retouch extent and notch count roughly scale with an increase in blank size (mainly length). Different sub-types of scrapers likely exist on a reduction continuum within that typological class, but the type-level distinction between denticulates and notched pieces appears to be false. There is no support for H2's expectation that non-local lithologies should exhibit a greater intensity of retouch.

The data provide the greatest support for H3 (Maximum expediency). Minimal, mixed, and 'other' types are prevalent and multiple forms of retouch were routinely applied to the same artefact. The positive relationship between number of retouch patches and number of retouch forms offers compelling evidence for implement production that defies ready typological classification. While the expectation that blanks were indiscriminately chosen for retouch is not supported by our data, the scaling of retouch intensity to larger blanks is consistent with both H2 and H3, which fit within the expectations of a reduction methodological approach (Dibble 1995; Holdaway et al. 1996; Hiscock and Clarkson 2007). The apparently arbitrary nature of notch placement that confounds meaningful separation of notched pieces and denticulates further suggests that these types were the inadvertent product of opportunistic knapping decisions.

Our data largely invalidates strict typological classifications, with many implements fitting into either a reduction mediated typology that is influenced by the form of initial reduction or a maximum expediency model that is influenced by the number of retouch episodes. Unifacial points may be typologically distinct, however our data relating to these artefacts is limited. The small sample of data we have for scrapers fits a reduction-mediated typology where morphology changes as reduction continues, a result shared with Dibble (1995), Hiscock and Clarkson (2008), and Lin and Marreiros (Submitted) for MP scrapers. Notched pieces and denticulates are not typologically distinct but share retouch form, with the event tree supporting a notch reduction continuum driven by retouch form rather than typology. The notch reduction process concurs with Holdaway et al. (1996) and Hiscock and Clarkson (2007) that notched pieces undergo a continual process of reuse as notches are progressively added to some specimens as they are needed. All other retouched pieces fit within maximum expediency expectations and allow for a level of flexibility in behavioural responses to changing needs.

While the results here are consistent with many previous studies conducted in Europe (e.g.Hiscock and Clarkson 2007; Lin and Marreiros Submitted; Dibble 1987; Holdaway et al. 1996; Dibble 1995; Brumm and McLaren 2011), they problematise the use of implement types as markers of technological change in the Early MSA. The lack of coherent 'taxonomic turnover' in this period has propagated a long-held belief that this was a period of behavioural stasis. Our results allow for a different interpretation of Early MSA technology, one in which large flakes were manufactured and then maintained through the flexible application of a variety of retouch techniques (Railey and Gonzalez 2015; Shea 2015; Lin and Marreiros Submitted). Individual implements were not reified types but became increasingly diversified as they were subject to more retouch, presumably over the course of their uselives. Rather than a marker of its inefficiency, the application of such an approach across large tracts of space and time suggests that it provided a functional, adaptive structure that could be modulated to meet an array of different environmental and functional contingencies. In many ways, it is the origins and meaning of the later taxonomic turnover pattern that requires explanation, rather the generalist technological strategies that account for so much of human history. While our data provide no remit to discuss the causes of later structured turnover, it is intriguing to posit that more formalised approaches to implement production may have traded-off regularity of tool form against a reduction in knappers' ability to respond to imminent needs, at least in the retouched component of the tool-kit.

A second point to make here, reiterating Douze et al. (2015), concerns the value of typology in reconstructing behavioural and technological change in the EMSA. Retouch contributes between 2.9-5.6% to each of our three assemblages. If these samples are then halved through breakage, and then halved again through unclassified types, then any typological determination is made on only a tiny fraction of an assemblage. If many of the partitions within that fraction are meaningless, then the remaining quantum that typology contributes to our understanding of the past at this time seems negligible (Mackay et al. 2014a; Wurz 2012; Steele et al. 2012).

Third, there is a broader need for further engagement with the 'atypical', or 'informal' retouch components across all phases of the past. Rather than being remaindered for their failure to fit archaeologists' typological templates, we need to better understand their position within the wider technological repertoire. An attribute-based breakdown of the operation of retouch enables integration of atypical pieces, revealing the structure of implement populations in more detail than can be obtained through typological or normative *chaîne opératoire* approaches alone (Bar-Yosef and Van Peer 2009). Our results have shown that it cannot be assumed that denticulates and notched pieces are distinct just because they are identifiable. Conversely, however, this does not preclude the possibility that in some instances these types constituted discrete end-products. Recording their relative frequency of these two types is insufficient to test the extent of their separation or to determine why they may be present in one instance but not another. Such further testing may clarify the generality of our proposed 'maximum expediency' approach to reduction. Notably, this holds as true for the Still Bay and Howiesons Poort as it does for the EMSA. By shifting our analytical focus to understanding the operation of retouch as a continuous process we may be able to better reveal variability in past technological responses.

Conclusion

The objective of this paper was to test whether the operation of retouch in southern Africa's Early MSA confounded the utility of implement types as markers of technological change. Our data, for the most part, did not fit the strict typological determinations that have been used to underpin the classic technocomplexes. Instead, we found support for a maximum expediency approach to implement production that provided flexibility across multiple retouch episodes, presumably in response to the knapper's imminent needs. The perceived lack of change through the EMSA is at least partly a result of the assumption that meaningful change is vested in the typological fraction of an assemblage, and that an approach emphasising flexibility is somehow less adaptively valuable than one in which tool production is reified.

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References

Andrefsky, W. (2005). *Lithics: Macroscopic Approaches to Analysis* (Vol. 2). Cambridge: Cambridge University Press.

Bader, G. D., Tribolo, C., & Conard, N. J. (2018). A return to Umbeli Belli: New insights of recent excavations and implications for the final MSA of eastern South Africa. *Journal of Archaeological Science: Reports, 21*, 733-757, doi:10.1016/j.jasrep.2018.08.043.

Bader, G. D., Will, M., & Conard, N. J. (2015). The lithic technology of Holley Shelter, KwaZulu Natal, and its place within the MSA of southern Africa. *South African Archaeological Bulletin, 70*(202), 149-165.

Bar-Yosef, O., & Van Peer, P. (2009). The Chaîne Opératoire Approach in Middle Paleolithic Archaeology. *Current Anthropology, 50*(1), 103-131, doi:10.1086/592234.

Behar, D. M., Villems, R., Soodyall, H., Blue-Smith, J., Pereira, L., Metspalu, E., et al. (2008). The dawn of human matrilineal diversity. *Am J Hum Genet, 82*(5), 1130-1140, doi:10.1016/j.ajhg.2008.04.002.

Bleed, P. (2001). Trees or Chains, Links or Branches: Conceptual Alternatives for Consideration of Stone Tool Production and Other Sequential Activities. *Journal of Archaeological Method and Theory, 8*(1), 101-127.

Blegen, N. (2017). The earliest long-distance obsidian transport: Evidence from the ∼200 ka Middle Stone Age Sibilo School Road Site, Baringo, Kenya. *Journal of Human Evolution, 103*, 1-19, doi:10.1016/j.jhevol.2016.11.002.

Bordes, F. (1961). Mousterian cultures in France. *Science, 134*(3482), 803-810.

Bousman, C. B., & Brink, J. S. (2018). The emergence, spread, and termination of the Early Later Stone Age event in South Africa and southern Namibia. *Quaternary International, 495*, 116-135, doi:10.1016/j.quaint.2017.11.033.

Bouzouggar, A., Barton, N., Vanhaeren, M., d'Errico, F., Collcutt, S., Higham, T., et al. (2007). 82,000-year-old shell beads from North Africa and implications for the origins of modern human behavior. *Proc Natl Acad Sci U S A, 104*(24), 9964-9969, doi:10.1073/pnas.0703877104.

Bouzouggar, A., Humphrey, L. T., Barton, N., Parfitt, S. A., Clark Balzan, L., Schwenninger, J. L., et al. (2018). 90,000 year-old specialised bone technology in the Aterian Middle Stone Age of North Africa. *PLoS One, 13*(10), e0202021, doi:10.1371/journal.pone.0202021.

Brooks, A. S., Helgren, D. M., Cramer, J. S., Franklin, A., Hornyak, W., Keating, J. M., et al. (1995). Dating and context of three Middle Stone Age sites with bone points in the Upper Semliki Valley, Zaire. *Science, 268*, 548-553.

Brooks, A. S., Yellen, J. E., Potts, R., Behrensmeyer, A. K., Deino, A. L., LEslie, D. E., et al. (2018). Long-distance stone transport and pigment use in the earliest Middle Stone Age. *Science, 360*, 90-94.

Brumm, A., & McLaren, A. (2011). Scraper reduction and "imposed form" at the Lower Palaeolithic site of High Lodge, England. *J Hum Evol, 60*(2), 185-204, doi:10.1016/j.jhevol.2010.09.005.

Carrion, J. S., Brink, J. S., Scott, L., & Binneman, J. N. F. (2000). Palynology and palaeoenvironment of Pleistocene hyaena coprolites from an open-air site at Oyster Bay. *South African Journal of Science, 96*, 449-453.

Clarkson, C. (2002). An Index of Invasiveness for the Measurement of Unifacial and Bifacial Retouch: A Theoretical, Experimental and Archaeological Verification. *Journal of Archaeological Science, 29*(1), 65-75, doi:10.1006/jasc.2001.0702.

Clarkson, C. (2005). Tenuous Types: 'Scraper' reduction continuums in the Eastern Victoria River Region, Northern Territory. In C. Clarkson, & L. Lamb (Eds.), *Lithics 'Down Under': Australian perspectives on Stoen Artefact Reduction* (pp. 21-34, BAR International Series S1408). Oxford: Archaeopress.

Conard, N. J., Porraz, G., & Wadley, L. (2012). What's in a name? Characterising the 'post-Howiesons Poort' at Sibudu. *South African Archaeological Bulletin, 67*(196), 180-199.

d'Errico, F., Vanhaeren, M., & Wadley, L. (2008). Possible shell beads from the Middle Stone Age layers of Sibudu Cave, South Africa. *Journal of Archaeological Science, 35*(10), 2675-2685, doi:10.1016/j.jas.2008.04.023.
Dibble, H. (1987). The interpretation of Middle Paleolithic scraper morphology. *American Antiquity, 52*, 109-117.
Dibble, H. L. (1995). Middle Paleolithic Scraper Reduction: Background, Clarification, and Review of the Evidence to Date. *Journal of Archaeological Method and Theory, 2*(4), 299-368.
Dibble, H. L., Aldeias, V., Jacobs, Z., Olszewski, D. I., Rezek, Z., Lin, S. C., et al. (2013). On the industrial attributions of the Aterian and Mousterian of the Maghreb. *J Hum Evol, 64*(3), 194-210, doi:10.1016/j.jhevol.2012.10.010.
Dibble, H. L., Holdaway, S. J., Lin, S. C., Braun, D. R., Douglass, M. J., Iovita, R., et al. (2016). Major Fallacies Surrounding Stone Artifacts and Assemblages. *Journal of Archaeological Method and Theory, 24*(3), 813-851, doi:10.1007/s10816-016-9297-8.
Dibble, H. L., & Rezek, Z. (2009). Introducing a new experimental design for controlled studies of flake formation: results for exterior platform angle, platform depth, angle of blow, velocity, and force. *Journal of Archaeological Science, 36*(9), 1945-1954, doi:10.1016/j.jas.2009.05.004.
Dietl, H., Kandel, A. W., & Conard, N. J. (2005). Middle Stone Age settlement and land use at the open-air sites of Geelbek and Anyskop, South Africa. *Journal of African Archaeology, 3*(2), 231-242.
Douze, K., Wurz, S., & Henshilwood, C. S. (2015). Techno-Cultural Characterization of the MIS 5 (c. 105 - 90 Ka) Lithic Industries at Blombos Cave, Southern Cape, South Africa. *PLoS One, 10*(11), e0142151, doi:10.1371/journal.pone.0142151.
Fagundes, N. J., Ray, N., Beaumont, M., Neuenschwander, S., Salzano, F. M., Bonatto, S. L., et al. (2007). Statistical evaluation of alternative models of human evolution. *Proc Natl Acad Sci U S A, 104*(45), 17614-17619, doi:10.1073/pnas.0708280104.
Faivre, J. P., Gravina, B., Bourguignon, L., Discamps, E., & Turq, A. (2017). Late Middle Palaeolithic lithic technocomplexes (MIS 5–3) in the northeastern Aquitaine Basin: Advances and challenges. *Quaternary International, 433*, 116-131, doi:10.1016/j.quaint.2016.02.060.
Firke, S., Denney, B., Haid, C., Knight, R., Grosser, M., & Zadra, J. (2020). janitor: Simple Tools for Examining and Cleaning Dirty Data (Vol. r package edition 2.0.1).
Goodwin, A. J. H., & van Riet Lowe, C. P. (1929). *The Stone Age cultures of South Africa* (Paper presented at Annals of the South African Museum.).
Gravina, B. (2017). Intra-level technological change and its implications for Mousterian assemblage variability. The example of Le Moustier, layer G. *Quaternary International, 433*, 132-139, doi:10.1016/j.quaint.2016.02.061.
Hallinan, E., & Parkington, J. (2017). Stone Age landscape use in the Olifants River Valley, Clanwilliam, Western Cape, South Africa. *Azania: Archaeological Research in Africa, 52*(3), 324-372, doi:10.1080/0067270x.2017.1365438.
Hammer, M. F., Woerner, A. E., Mendez, F. L., Watkins, J. C., & Wall, J. D. (2011). Genetic evidence for archaic admixture in Africa. *Proceedings of the National Academy of Sciences, 108*(37), 15123-15128, doi:10.1073/pnas.1109300108.
Hao, Z., Travison, T., Tsai, T., Beasley, W., Xie, Y., Yu, G., et al. (2019). kableExtra: Construct Complex Table with 'kable' and Pipe Syntax. (Vol. R package version 1.1.0).
Henshilwood, C., d'Errico, F., Vanhaeren, M., van Niekerk, K., & Jacobs, Z. (2004). Middle Stone Age shell beads from South Africa. *Science, 304*(5669), 404, doi:10.1126/science.1095905.
Henshilwood, C. S. (2012). Late Pleistocene Techno-traditions in Southern Africa: A Review of the Still Bay and Howiesons Poort, c. 75–59 ka. *Journal of World Prehistory, 25*(3-4), 205-237, doi:10.1007/s10963-012-9060-3.
Henshilwood, C. S., d'Errico, F., & Watts, I. (2009). Engraved ochres from the Middle Stone Age levels at Blombos Cave, South Africa. *J Hum Evol, 57*(1), 27-47, doi:10.1016/j.jhevol.2009.01.005.

Henshilwood, C. S., & Dubreuil, B. (2011). The Still Bay and Howiesons Poort, 77–59 ka. *Current Anthropology, 52*(3), 361-400, doi:10.1086/660022.

Henshilwood, C. S., van Niekerk, K. L., Wurz, S., Delagnes, A., Armitage, S. J., Rifkin, R. F., et al. (2014). Klipdrift Shelter, southern Cape, South Africa: Preliminary Report on the Howiesons Poort layers. *Journal of Archaeological Science, 45*, 284-303, doi:10.1016/j.jas.2014.01.033.

Herries, A. I. (2011). A chronological perspective on the Acheulian and its transition to the Middle Stone Age in southern Africa: the question of the Fauresmith. *Int J Evol Biol, 2011*, 961401, doi:10.4061/2011/961401.

Hiscock, P., & Attenbrow, V. (2003). Early Australian implement variation: a reduction model. *Journal of Archaeological Science, 30*(2), 239-249, doi:10.1006/jasc.2002.0830.

Hiscock, P., & Clarkson, C. (2000). Analysing Australian stone artefacts: an agenda for the twenty-first century In.

Hiscock, P., & Clarkson, C. (2007). Retouched notches at Combe Grenal and the reduction hypothesis. *American Antiquity, 72*(1), 176.

Hiscock, P., & Clarkson, C. J. (2008). The construction of morphological diversity: A study of Mousterian implement retouching at Combe Grenal.

Hiscock, P., & Tabrett, A. (2010). Generalization, inference and the quantification of lithic reduction. *World Archaeology, 42*(4), 545-561, doi:10.1080/00438243.2010.517669.

Högberg, A. (2016). A Lithic Attribute Analysis on Blades from the Middle Stone Age Site, Hollow Rock Shelter, Western Cape Province, South Africa. *Lithic Technology, 41*(2), 93-113, doi:10.1080/01977261.2016.1144451.

Hogberg, A., & Lombard, M. (2016). Still Bay Point-Production Strategies at Hollow Rock Shelter and Umhlatuzana Rock Shelter and Knowledge-Transfer Systems in Southern Africa at about 80-70 Thousand Years Ago. *PLoS One, 11*(12), e0168012, doi:10.1371/journal.pone.0168012.

Holdaway, S., & Douglass, M. (2011). A Twenty-First Century Archaeology of Stone Artifacts. *Journal of Archaeological Method and Theory, 19*(1), 101-131, doi:10.1007/s10816-011-9103-6.

Holdaway, S. J., McPherron, S. P., & Roth, B. (1996). Notched Tool Reuse and Raw Material Availability in French Middle Paleolithic Sites. *American Antiquity, 61*(2), 377-387.

Jacobs, Z., Jankowski, N. R., Dibble, H. L., Goldberg, P., McPherron, S. J. P., Sandgathe, D., et al. (2016). The age of three Middle Palaeolithic sites: Single-grain optically stimulated luminescence chronologies for Pech de l'Azé I, II and IV in France. *Journal of Human Evolution, 95*, 80-103, doi:10.1016/j.jhevol.2016.03.010.

Kleindienst, M. R. (2006). On Naming Things. In E. a. S. T. K. Hovers, & S. L. Kuhn (Eds.), *Transitions Before the Transition. Interdisciplinary Contributions To Archaeology*. Boston, MA: Springer.

Kuhn, S. L. (1990). A geometric index of reduction for unifacial stone tools. *Journal of Archaeological Science, 17*, 583-593.

Kuhn, S. L. (1992). Blank form and reduction as determinants of scraper morphology. *American Antiquity, 57*(1), 115-128.

Lin, S. C., & Marreiros, J. (Submitted). Quina retouch does not maintain edge angle over reduction. *Lithic Technology*.

Lin, S. C., Rezek, Z., Braun, D., & Dibble, H. L. (2013). On the utility and economization of unretouched flakes: the effects of exterior platform. *American Antiquity, 78*(4), 724-745.

Lombard, M. (2012). Thinking through the Middle Stone Age of sub-Saharan Africa. *Quaternary International, 270*, 140-155, doi:10.1016/j.quaint.2012.02.033.

Lombard, M., Schlebusch, C., & Soodyall, H. (2013). Bridging disciplines to better elucidate the evolution of early Homo sapiens in southern Africa. *South African Journal of Science, 109*(11/12), doi:10.1590/.

Lombard, M., Wadley, L., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., et al. (2012). South African and Lesotho Stone Age Sequence Updated. *South African Archaeological Bulletin, 67*(195), 120-144.

Low, M. (2019). Continuity, Variability and the Nature of Technological Change During the Late Pleistocene at Klipfonteinrand Rockshelter in the Western Cape, South Africa. *African Archaeological Review*, doi:10.1007/s10437-018-9318-y.
Low, M., & Mackay, A. (2018). The organisation of Late Pleistocene Robberg blade technology in the Doring River Catchment, South Africa. *Journal of African Archaeology, 16*, 168-192, doi:https://doi.org/10.1163/21915784-20180014.
Mackay, A. (2009). *History and Selection in the Late Pleistoncene Archaeology of the Western Cape, South Africa*. Australian National University, Canberra.
Mackay, A., Cartwright, C., Heinrich, S., Low, M., Stahlschmidt, M., & Steele, T. E. (2019). Excavations at Klipfonteinrand reveal local and regional patterns of adaptation and interaction through MIS 2 in southern Africa. *Journal of Paleolithic Archaeology, 2019*, doi:https://doi.org/10.1007/s41982-019-00040-6.
Mackay, A., Jacobs, Z., & Steele, T. E. (2015). Pleistocene archaeology and chronology of putslaagte 8 (PL8) Rockshelter, Western Cape, South Africa *Journal of African Archaeology, 13*(1), 71-98.
Mackay, A., Orton, J., Schwortz, S., & Steele, T. E. (2010). Soutfontein (SFT)-001: Preliminary report on an open-air bifacial point-rich site in southern Namaqualand, South Africa. *South African Archaeological Bulletin, 65*, 84-95.
Mackay, A., Stewart, B. A., & Chase, B. M. (2014a). Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa. *Journal of Human Evolution, 72*, 26-51.
Mackay, A., Sumner, A., Jacobs, Z., Marwick, B., Bluff, K., & Shaw, M. (2014b). Putslaagte 1 (PL1), the Doring River, and the later Middle Stone Age in southern Africa's Winter Rainfall Zone. *Quaternary International, 350*, 43-58.
Marean, C. W., & Assefa, Z. W. (2005). The Middle and Upper Pleistocene African record for the biological and behavioral origins of modern humans. In A. Stahl (Ed.), *African Archaeology: A critical Introduction* (pp. 93-129): Blackwell.
Marean, C. W., Bar-Matthews, M., Bernatchez, J., Fisher, E., Goldberg, P., Herries, A. I. R., et al. (2007). Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature, 449*(7164), 905-908, doi:10.1038/nature06204.
McBrearty, S., & Brooks, A. S. (2000). The revolution that wasn't: a new interpretation of the origin of modern human behavior. *J Hum Evol, 39*(5), 453-563, doi:10.1006/jhev.2000.0435.
Mellars, P. (1996). *The Neanderthal Legacy: An Archaeological Perspective of Western Europe*: Princeton University Press.
Miller, J. M., & Willoughby, P. R. (2014). Radiometrically dated ostrich eggshell beads from the Middle and Later Stone Age of Magubike Rockshelter, southern Tanzania. *J Hum Evol*, doi:10.1016/j.jhevol.2013.12.011.
Minichillo, T. (2005). *Middle Stone Age Lithic Study, South Africa: An Examination of Modern Human Origins*. University of Washington,
Monnier, G. F., & Missal, K. (2014). Another Mousterian Debate? Bordian facies, chaîne opératoire technocomplexes, and patterns of lithic variability in the western European Middle and Upper Pleistocene. *Quaternary International, 350*, 59-83, doi:10.1016/j.quaint.2014.06.053.
Muller, A., & Clarkson, C. (2016). A new method for accurately and precisely measuring flake platform area. *Journal of Archaeological Science: Reports, 8*, doi:10.1016/j.jasrep.2016.06.015.
Picin, A., Peresani, M., & Vaquero, M. (2011). Application of a new typological approach to classifying denticulate and notched tools: the study of two Mousterian lithic assemblages. *Journal of Archaeological Science, 38*(3), 711-722, doi:10.1016/j.jas.2010.10.025.
Porraz, G., Texier, P.-J., Archer, W., Piboule, M., Rigaud, J.-P., & Tribolo, C. (2013). Technological successions in the Middle Stone Age sequence of Diepkloof Rock Shelter, Western Cape, South Africa. *Journal of Archaeological Science, 40*(9), 3376-3400, doi:10.1016/j.jas.2013.02.012.

Railey, J. A., & Gonzalez, E. J. (2015). The problems with flake types and the case for attribute analysis of debitage assemblages. *Works in Stone: Contemporary Perspectives on Lithic Analysis*, 11-32.

Ranhorn, K., & Tryon, C. A. (2018). New Radiocarbon Dates from Nasera Rockshelter (Tanzania): Implications for Studying Spatial Patterns in Late Pleistocene Technology. *Journal of African Archaeology, 16*(2), 211-222, doi:10.1163/21915784-20180011.

Reynolds, N., & Riede, F. (2019). House of cards: cultural taxonomy and the study of the European Upper Palaeolithic. *Antiquity, 93*(371), 1350-1358, doi:10.15184/aqy.2019.49.

Richter, D., Grun, R., Joannes-Boyau, R., Steele, T. E., Amani, F., Rue, M., et al. (2017). The age of the hominin fossils from Jebel Irhoud, Morocco, and the origins of the Middle Stone Age. *Nature, 546*(7657), 293-296, doi:10.1038/nature22335.

Roland, N., & Dibble, H. L. (1980). A New Synthesis of Middle Paleolithic Variability. *American Antiquity, 55*(3), 480-499.

Scerri, E. M., Blinkhorn, J., Groucutt, H. S., & Niang, K. (2016). The Middle Stone Age archaeology of the Senegal River Valley. *Quaternary International, 408*, 16-32, doi:10.1016/j.quaint.2015.09.025.

Scerri, E. M. L., Blinkhorn, J., Niang, K., Bateman, M. D., & Groucutt, H. S. (2017). Persistence of Middle Stone Age technology to the Pleistocene/Holocene transition supports a complex hominin evolutionary scenario in West Africa. *Journal of Archaeological Science: Reports, 11*, 639-646, doi:10.1016/j.jasrep.2017.01.003.

Scerri, E. M. L., & Spinapolice, E. E. (2019). Lithics of the North African Middle Stone Age: assumptions, evidence and future directions. *Journal of Anthropological Sciences, 97*, 1-36, doi:10.4436/jass.97002.

Scerri, E. M. L., Thomas, M. G., Manica, A., Gunz, P., Stock, J. T., Stringer, C., et al. (2018). Did Our Species Evolve in Subdivided Populations across Africa, and Why Does It Matter? *Trends Ecol Evol, 33*(8), 582-594, doi:10.1016/j.tree.2018.05.005.

Schlebusch, C. (2017). Ancient genomes from southern Africa pushes modern human divergence beyond 260,000 years ago. doi:10.1101/145409.

Schmid, V. C., Conard, N. J., Texier, J. P., Parkington, J., & Porraz, G. (2016). The ‘MSA 1’ of Elands Bay Cave (South Africa) in the context of the southern African Early MSA technologies. *South African Humanities, Southern African Humanities*(29), 153-201.

Schmidt, P., & Mackay, A. (2016). Why Was Silcrete Heat-Treated in the Middle Stone Age? An Early Transformative Technology in the Context of Raw Material Use at Mertenhof Rock Shelter, South Africa. *PLoS One, 11*(2), e0149243, doi:10.1371/journal.pone.0149243.

Schmidt, P., Stynder, D., Conard, N. J., & Parkington, J. E. (2020). When was silcrete heat treatment invented in South Africa? *Palgrave Communications, 6*(1), doi:10.1057/s41599-020-0454-z.

Shaw, M., Ames, C., Phillips, N., Dosseto, A., Douglass, M., Goble, R., et al. (2019). The Doring River Archaeological Project: Approaching the evolution of human landuse patterns in the Western Cape, South Africa. *PalaeoAnthropology, 2019*, 400-422.

Shea, J. J. (2014). Sink the Mousterian? Named stone tool industries (NASTIES) as obstacles to investigating hominin evolutionary relationships in the Later Middle Paleolithic Levant. *Quaternary International, 350*, 169-179, doi:10.1016/j.quaint.2014.01.024.

Shea, J. J. (2015). Timescales and Variability in Hominin Technological Strategies in the Jordan Rift Valley: What Difference Does 1.3 Million Years Make? . In M. J. Shott (Ed.), *Works in Stone: Contemporary Perspectives on Lithic Analysis* (Vol. 1). Utah: University of Utah Press.

Shott, M. J. (2015). Works in stone: Contemporary perspectives on lithic analysis. In M. J. Shott (Ed.), *Works in Stone: Contemporary Perspectives on Lithic Analysis*. Utah: University of Utah Press.

Shott, M. J., Bradbury, A. P., Carr, P. J., & Odell, G. H. (2000). Flake Size from Platform Attributes: Predictive and Empirical Approaches. *Journal of Archaeological Science, 27*(10), 877-894, doi:10.1006/jasc.1999.0499.

Sinclair, A. (2009). The MSA stone tool assemblage from the Cave of Hearths, Beds 4–9. In J. McNabb, & A. Sinclair (Eds.), *The Cave of Hearths: Makapan Middle Pleistocene Research Project: Field Research by Anthony Sinclair and Patrick Quinney, 1996-2001* (Vol. 2009, pp. 105-137, BAR International Series 1940). Oxford: Archaeopress.
Singer, R., & Wymer, J. (1982). *The Middle Stone Age at Klasies River Mouth in South Africa*. Chicago: The University of Chicago Press.
Smith, A. B., & Ripp, M. R. (1978). An Archaeological Reconnaissance of the Doorn/Tanqua Karoo. *South African Archaeological Bulletin, 33*, 118-133.
Soriano, S., Villa, P., Delagnes, A., Degano, I., Pollarolo, L., Lucejko, J. J., et al. (2015). The Still Bay and Howiesons Poort at Sibudu and Blombos: Understanding Middle Stone Age Technologies. *PLoS One*, doi:10.1371/journal.pone.0131127

10.1371/journal.pone.0131127.g001.
Soriano, S., Villa, P., & Wadley, L. (2007). Blade technology and tool forms in the Middle Stone Age of South Africa: The Howiesons Poort and post-Howiesons Poort at Rose Cottage Cave. *Journal of Archaeological Science, 34*(5), 681-703, doi:10.1016/j.jas.2006.06.017.
Steele, T. E., Mackay, A., Fitzsimmons, K., Igreja, M., Marwick, B., Orton, J., et al. (2016). Varsche Rivier 003: A Middle and Later Stone Age site with Still Bay and Howiesons Poort assemblages in southern Namaqualand, South Africa. *PaleoAnthropology, 2016*, 100-163.
Steele, T. E., Mackay, A., Orton, J., & Schwortz, S. (2012). Varsche Rivier 003, a new Middle Stone Age site in southern Namaqualand, South Africa. *The South African Archaeological Bulletin, 67*(195), 108-119.
Sterelny, K. (2011). From hominins to humans: how sapiens became behaviourally modern. *Philos Trans R Soc Lond B Biol Sci, 366*(1566), 809-822, doi:10.1098/rstb.2010.0301.
Stewart, B. A., Zhao, Y., Mitchell, P. J., Dewar, G., Gleason, J. D., & Blum, J. D. (2020). Ostrich eggshell bead strontium isotopes reveal persistent macroscale social networking across late Quaternary southern Africa. *Proc Natl Acad Sci U S A*, doi:10.1073/pnas.1921037117.
Stiner, M. C. (2014). Finding a Common Bandwidth: Causes of Convergence and Diversity in Paleolithic Beads. *Biological Theory, 9*(1), 51-64, doi:10.1007/s13752-013-0157-4.
Tennie, C., Call, J., & Tomasello, M. (2009). Ratcheting up the ratchet: on the evolution of cumulative culture. *Philos Trans R Soc Lond B Biol Sci, 364*(1528), 2405-2415, doi:10.1098/rstb.2009.0052.
Texier, P. J., Porraz, G., Parkington, J., Rigaud, J. P., Poggenpoel, C., Miller, C., et al. (2010). A Howiesons Poort tradition of engraving ostrich eggshell containers dated to 60,000 years ago at Diepkloof Rock Shelter, South Africa. *Proc Natl Acad Sci U S A, 107*(14), 6180-6185, doi:10.1073/pnas.0913047107.
Tryon, C. A., & Faith, J. T. (2013). Variability in the Middle Stone Age of Eastern Africa. *Current Anthropology, 54*(S8), S234-S254, doi:10.1086/673752.
Valletta, F., Smilansky, U., Goring-Morris, A. N., & Grosman, L. (2020). On measuring the mean edge angle of lithic tools based on 3-D models – a case study from the southern Levantine Epipalaeolithic. *Archaeological and Anthropological Sciences, 12*(2), doi:10.1007/s12520-019-00954-w.
Vanhaeren, M., D'Errico, F., Stringer, C., James, S. L., Todd, J. A., & Mienis, H. K. (2006). Middle Paleolithic shell beads in Israel and Algeria. *Science, 312*, 1785-1788.
Vanhaeren, M., Wadley, L., & d'Errico, F. (2019). Variability in Middle Stone Age symbolic traditions: The marine shell beads from Sibudu Cave, South Africa. *Journal of Archaeological Science: Reports, 27*, 101893, doi:10.1016/j.jasrep.2019.101893.
Villa, P., Boscato, P., Ranaldo, F., & Ronchitelli, A. (2009a). Stone tools for the hunt: points with impact scars from a Middle Paleolithic site in southern Italy. *Journal of Archaeological Science, 36*(3), 850-859, doi:10.1016/j.jas.2008.11.012.

Villa, P., Soressi, M., Henshilwood, C. S., & Mourre, V. (2009b). The Still Bay points of Blombos Cave (South Africa). *Journal of Archaeological Science, 36*(2), 441-460, doi:10.1016/j.jas.2008.09.028.

Volman, T. (1984). The early prehistory of southern Africa. In R. G. Klein (Ed.), *southern African prehistory and palaeoenvironments.* (pp. 361-395). Boston: AA Balkema.

Volman, T. P. (1981). *The Middle Stone Age in the southern Cape*. University of Chicago, Chicago.

Warnes, G. R., Bolker, B., Lumley, T., & Johnson, R. C. (2018). gmodels: Various R Programming Tools for Model Fitting. (Vol. R package edition 2.18.1).

Wickham, H. (2019). tidyverse: Easily Install and Load the 'Tidyverse'. (Vol. r package edition 1.3.0).

Wickham, H. (2020). reshape2. (Vol. r package edition 1.4.4).

Wickham, H., Chang, W., Henry, L., Pederson, T. L., Takahashi, K., Wilke, C., et al. (2020a). ggplot2: Elegant Graphics for Data Analysis. (Vol. r package edition 3.3.2). New York: Springer-Verlag.

Wickham, H., François, R., Henry, L., & Müller, K. (2020b). dplyr: A Grammar of Data Manipulation. (Vol. R package version 1.0.0).

Wilkins, J., Brown, K. S., Oestmo, S., Pereira, T., Ranhorn, K. L., Schoville, B. J., et al. (2017). Lithic technological responses to Late Pleistocene glacial cycling at Pinnacle Point Site 5-6, South Africa. *PLoS One, 12*(3), e0174051, doi:10.1371/journal.pone.0174051.

Will, M., Bader, G. D., & Conard, N. J. (2014). Characterizing the Late Pleistocene MSA Lithic Technology of Sibudu, KwaZulu-Natal, South Africa. *PLoS One, 9*(5), e98359, doi:10.1371/journal.pone.0098359.

Will, M., Kandel, A. W., & Conard, N. J. (2019). Midden or Molehill: The Role of Coastal Adaptations in Human Evolution and Dispersal. *Journal of World Prehistory, 32*(1), 33-72, doi:10.1007/s10963-018-09127-4.

Will, M., Mackay, A., & Phillips, N. (2015). Implications of Nubian-Like Core Reduction Systems in Southern Africa for the Identification of Early Modern Human Dispersals. *PLoS One, 10*(6), e0131824, doi:10.1371/journal.pone.0131824.

Wurz, S. (2002). Variability in the Middle Stone Age lithic sequence, 115,000–60,000 years ago at Klasies River, South Africa. *Journal of Archaeological Science, 29*(9), 1001-1015, doi:10.1006/jasc.2001.0799.

Wurz, S. (2012). The significance of MIS 5 shell middens on the Cape coast: A lithic perspective from Klasies River and Ysterfontein 1. *Quaternary International, 270*, 61-69, doi:10.1016/j.quaint.2011.06.032.

Wurz, S. (2013). Technological Trends in the Middle Stone Age of South Africa between MIS 7 and MIS 3. *Current Anthropology, 54*(S8), S305-S319, doi:10.1086/673283.

Supplementary Information.

Note on Lithologies: There is one raw material worth noting as it is present at all three sites - DWS or decaying white stone. It appears to breakdown over time becoming soft, white, and crumbling. It is believed that this may be a poorly metamorphised hornfels, however this has not been confirmed. This has been grouped with hornfels for this analysis.

Note: For retouched and unretouched flakes there was no minimum maximum dimension employed.

Note: Definitions for implement types are discussed in more detail below. Lithology and cortex (generally waterworn and outcrop) are used to infer artefact transport patterns in the Early MSA. Waterworn cortex is assumed to reflect acquisition of nodules from the Doring River, as its tributaries typically do not carry a cobble bedload (quartz is the exception, as quartz pebbles usually derive from Nardouw Formation conglomerates). Outcrop cortex occurs on quartzite and sandstone rocks around the sites under analysis but could equally represent transport from the cliffs and scree slopes that are ubiquitous throughout the catchment. Platform types have been identified as a characteristic the help delineate the Early MSA technocomplexes and may in some cases be informative of reduction systems. Blade types were recorded following Soriano et al. (2007) for all complete flakes with an elongation ratio ≥2, though these are not reported in the results due to the small number of blades and the variability in the types. Retouch location and notch location follow the artefact segmentation scheme in Clarkson (2002) and Hiscock and Clarkson (2007), though modified such that where one notch spanned two segments each segment receives a count of 0.5). This was done in order to remove some potential subjectivity in the location. Retouch form was recorded as scalar, notched, and parallel for each retouch location; notch type was recorded as simple or complex in the same way. This study did not to use the notch tool morphotypes presented by Picin et al. (2011) as they are somewhat restrictive on the types of variation that may be present.

Note: GIUR values were calculated for each segment individual and then divided by the total number of retouched segments. For all of the measures of retouch intensity, index value increases with the amount of reduction (Hiscock and Tabrett 2010). Both GIUR and II use a scale from 0 to 1 with 0 being no retouch. There is no number that indicates a piece is heavily retouched per se, rather a piece with index scores of 0.3 has received less retouch than one with index scores of 0.7. Hiscock and Clarkson (2007) used the GIUR value of >0.65 to delineate intensive retouch. Further details are available in "ODriscoll_Mackay_AttributeList".

Note: This study did not to use the notch tool morphotypes presented by Picin et al. (2011) as we believe they are too restrictive. Rather, this study uses notch count within the eight retouch segments of Clarkson (2002) along with direction and type of notch. This captures the same information but also allows for any further variation on a piece to be analysed without having to create additional morphotypes. To understand the path that notch reduction may follow as notches are added an event tree was created. The event tree is focused on notches and not serrations or other forms of retouch. This differs from the morphotypes of (Picin et al. 2011) that are based on the type of concavity (notch or serration), type of notch (simple, complex, or mixed), and is limited to three concavities. The tree diverges as notches are added and whether these notches are placed adjacent or discontinuously to each other.

Note on using R markdown file: R codes are written in R MarkDown and packaged in a RStudio project. Including in the file is all code for the tables and statistical tests. To run the code:

1. Install RStudio (https://www.rstudio.com/) and R Markdown (http://rmarkdown.rstudio.com/).

2. Extract all files in the zip folder into a new folder in the local directory.

3. Open "ODriscoll_Mackay_Rcode" in RStudio.

4. Make sure the working directory has been set to the new folder to which the zip files have been extracted.

5. Make sure the R packages in the setup tab have been installed.

6. Run "Knit HTML" function at the top of the source pane.

Tables:

Table 1: Count of complete retouched flakes within typological group and lithologies

Typological Group	Hornfels	Quartz	Quartzite	Sandstone	Silcrete	Total
Unretouched	356	211	1623	637	113	**2940**
Other	5	6	31	2	0	**44**
Mixed Retouch	4	1	26	2	1	**34**
Notched	5	2	41	7	0	**55**
Denticulate	1	2	29	2	0	**34**
Scraper	3	1	9	1	1	**15**
Unifacial Point	0	0	4	0	0	**4**
Minimal	0	3	21	2	1	**27**
Total	**374**	**226**	**1784**	**653**	**116**	**3153**

Table 2: Retouch form exhibited within each typological group

Form	Other (%)	Mixed (%)	Notched (%)	Denticulate (%)	Scraper (%)	Unifacial Points (%)	Minimal (%)
Nibbling	4.5	0.0	1.8	0.0	0.0	0	3.7
Notched	6.8	0.0	58.2	11.8	0.0	0	29.6
Other	11.4	0.0	0.0	0.0	0.0	0	48.1
Parallel	13.6	0.0	0.0	0.0	0.0	0	7.4
Scalar	22.7	11.8	10.9	0.0	53.3	50	7.4
Serrated	0.0	0.0	0.0	8.8	0.0	0	0.0
Notched & Serrated	0.0	8.8	0.0	32.4	0.0	0	0.0
Scalar & Parallel	4.5	2.9	0.0	0.0	13.3	0	0.0
Scalar/Parallel and Notched/Serrated	6.8	29.4	25.5	23.5	6.7	0	0.0
Notched/Serrated and Nibbling/Other	0.0	14.7	0.0	8.8	0.0	0	0.0
Scalar/Parallel and Nibbling/Other	22.7	17.6	3.6	0.0	26.7	50	3.7
All	6.8	14.7	0.0	14.7	0.0	0	0.0

Table 3: Patch count and number of retouch forms present

Retouch Form	1 Patch (%)	2 Patches (%)	3 Patches (%)	>3 Patches (%)
1 form	72.7	35.6	15	6.2
2 form	22.7	42.2	50	25.0
3 form	3.8	15.6	30	31.2
>3 form	0.8	6.7	5	37.5

Table 4: Typological group retouch location

	Other		Mixed Retouch		Denticulate		Notched		Scraper		Unifacial Point		Minimal	
Segment	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**
Proximal	34.9	65.1	29.4	70.6	23.5	76.5	3.6	96.4	26.7	73.3	25	75	14.8	85.2
Proximal Right	38.6	61.4	38.2	61.8	32.4	67.6	16.4	83.6	6.7	93.3	25	75	18.5	81.5
Proximal Left	48.8	51.2	47.1	52.9	44.1	55.9	10.9	89.1	26.7	73.3	25	75	14.8	85.2
Medial Right	47.7	52.3	55.9	44.1	55.9	44.1	25.5	74.5	26.7	73.3	50	50	11.1	88.9
Medial Left	56.8	43.2	52.9	47.1	70.6	29.4	23.6	76.4	26.7	73.3	25	75	14.8	85.2
Distal Right	40.9	59.1	70.6	29.4	55.9	44.1	21.8	78.2	33.3	66.7	75	25	11.1	88.9
Distal Left	52.3	47.7	67.6	32.4	58.8	41.2	29.1	70.9	46.7	53.3	25	75	22.2	77.8
Distal	68.2	31.8	79.4	20.6	67.6	32.4	36.4	63.6	93.3	6.7	75	25	29.6	70.4

Table 5: Scraper sub-class retouch location

	Scraper-End (n=8)		Scraper-Lateral (n=3)		Scraper-Other (n=4)	
Segment	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**	**Retouch (%)**	**No Retouch (%)**
Proximal	0.0	100.0	33.3	66.7	75	25
Proximal Right	0.0	100.0	0.0	100.0	25	75
Proximal Left	0.0	100.0	66.7	33.3	50	50
Medial Right	0.0	100.0	33.3	66.7	75	25
Medial Left	0.0	100.0	66.7	33.3	50	50
Distal Right	12.5	87.5	33.3	66.7	75	25
Distal Left	37.5	62.5	66.7	33.3	50	50
Distal	100.0	0.0	66.7	33.3	100	0

Table 6: Typological group non-metric attributes

	Flake Shape (%)			Reduction Strategy (%)		Blade Group (%)			
Typological Group	**Convergent**	**Asymmetrical**	**Parallel**	**Laminar**	**Levallois**	**A**	**B**	**C**	**D**
Unretouched	22.3	74.8	2.9	2.8	0.7	1.1	4.6	0.6	1.1
Other	22.7	63.6	6.8	6.8	0.0	0.0	9.1	0.0	2.3
Mixed Retouch	41.2	41.2	8.8	8.8	2.9	2.9	11.8	0.0	2.9
Notched	27.3	65.5	7.3	16.4	1.8	0.0	5.5	1.8	7.3
Denticulate	50.0	41.2	2.9	5.9	2.9	0.0	17.6	0.0	0.0
Scraper	26.7	66.7	6.7	13.3	0.0	0.0	0.0	0.0	0.0
Unifacial Point	100.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0
Minimal	18.5	77.8	3.7	14.8	11.1	3.7	11.1	0.0	0.0

Table 7: Typological group metric attribute table

	Metrics								Retouch Intensity			
Typological Group	**Count**	**Max Dimension (mm)**	**Max Percussion length (mm)**	**Axial Length (mm)**	**Axial Width (mm)**	**Axial Thickness (mm)**	**Elongation Ratio**	**Weight (g)**	**GUIR**	**II**	**Retouch Extent**	**Patch Range**
Unretouched	2976	30.64	25.34	22.59	20.08	5.46	1.13	4.00	0.00	0.00	0.00	0
Other	44	50.25	43.24	39.96	29.64	10.54	1.26	19.25	0.40	0.12	25.73	4
Mixed Retouch	34	56.26	51.35	45.92	34.20	10.39	1.26	22.60	0.48	0.18	31.55	5
Notched	55	51.90	46.81	39.13	29.36	8.76	1.41	14.00	0.37	0.03	7.46	1
Denticulate	34	52.33	49.77	41.62	28.50	9.22	1.39	21.05	0.44	0.10	24.93	11
Scraper	15	40.70	33.51	30.91	34.63	9.14	1.16	10.70	0.45	0.09	27.09	2
Unifacial Point	4	75.05	67.71	62.59	29.48	12.34	2.22	32.40	0.24	0.08	19.73	1
Minimal	27	55.18	52.00	44.49	29.78	11.51	1.33	19.80	0.38	0.03	6.49	1

Table 8: Size class retouch indices (size class is maximum dimension of complete artefact. i.e. 20mm size class means the piece measured between 10.01-20mm)

Size Class	Count	GUIR	II	Retouch Extent	Notch Range	Patch Range
20mm	3	0.34	0.03	21.65	0	0
30mm	11	0.55	0.06	13.37	2	1
40mm	30	0.46	0.06	27.55	2	3
50mm	46	0.39	0.09	19.72	4	3
60mm	55	0.40	0.09	17.60	4	11
70mm	37	0.42	0.09	16.18	4	7
80mm	15	0.51	0.12	15.39	3	3
90mm	10	0.35	0.09	15.15	6	5
100mm	3	0.23	0.06	9.46	1	0
>100mm	3	0.61	0.06	8.40	2	2

Table 9: Notch count attribute table.

	0	1	2	3	4	6
Metrics						
Count	103.00	79.00	17.00	6.00	7.00	1.00
Max Dimension (mm)	51.79	52.32	53.57	52.86	59.22	85.51
Max Percussion Length (mm)	44.68	47.60	49.73	49.02	51.66	77.65
Axial Length (mm)	42.81	42.52	39.24	39.95	48.09	63.16
Axial Width (mm)	29.72	28.81	32.62	35.33	29.80	35.84
Axial Thickness (mm)	9.94	8.91	11.29	11.52	9.23	11.45
Elongation Ratio	1.30	1.41	1.30	1.28	1.50	1.76
Weight (g)	19.20	15.50	27.60	28.85	19.80	35.90
Retouch Intensity						
GUIR	0.40	0.43	0.48	0.41	0.41	0.32
II	0.09	0.06	0.16	0.12	0.22	0.22
Retouch Extent	20.53	9.36	21.96	24.20	43.73	58.99
Blank Form						
Convergent	28.20	31.60	35.30	50.00	71.40	100.00
Asymmetrical	62.10	58.20	47.10	50.00	28.60	0.00
Parallel	4.90	7.60	11.80	0.00	0.00	0.00

Table 10: Non-local and local lithology metric attributes.

Source	Metrics							Retouch Intensity				
	Count	Max Dimension (mm)	Max Percussion Length (mm)	Axial Length (mm)	Axial Width (mm)	Axial Thickness (mm)	Elongation Ratio	GUIR	II	Retouch Extent	Patch Range	Notch Range
Assumption Set 1												
local	189	52.32	47.46	42.45	29.74	9.94	1.31	0.42	0.09	18.07	11	6
non-local	24	52.91	50.53	42.32	25.48	7.81	1.43	0.29	0.09	18.62	4	3
Assumption Set 2												
local	73	54.00	49.73	43.34	29.61	10.47	1.30	0.40	0.09	15.59	11	4
non-local	24	52.91	50.53	42.32	25.48	7.81	1.43	0.29	0.09	18.62	4	3
unknown	116	49.99	44.27	41.76	29.74	9.35	1.36	0.43	0.09	19.72	7	6