

On the variability of Middle Stone Age
lithic technology during MIS3 in KwaZulu-Natal,
South Africa

Dissertation

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Gregor Donatus Bader

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Dekan:

Prof. Dr. Wolfgang Rosenstiel

1. Berichterstatter

Prof. Nicholas J. Conard PhD

2. Berichterstatter

Prof. Dr. Michael Bolus

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II. Summary

The Middle Stone Age (MSA) of Southern Africa, a period roughly dating to between 300.000 and 30.000 years BP, has received intensive research within the last century and especially since the mid-1980s when scientists recognized that the origins of anatomically modern humans (AMH) reach back into the beginnings of the MSA. While in Asia, Australia, Europe and the new world AMH's presence is documented the first time between 100.000 and 15.000 years before present (BP) the oldest evidence from Africa dates back to 300.000 BP. Within this period several innovations emerged such as personal ornaments, symbolism, burials and advanced techniques of stone tool production, most of them later than 100.000 BP. Since stone artifacts are the most commonly preserved archaeological remains, the understanding of lithic technology and its variability throughout time and space represents the essential tool of stone age archaeology and allows the reconstruction of past human societies behavior in a broad spectrum of aspects including mobility patterns, adaption to different internal and external circumstances and cultural change. In the last decades a growing number of innovations associated with the term "cultural modernity" mentioned above was recovered from two distinct techno-complexes respectively the Still Bay (SB) and Howiesons Poort (HP). This and a high density of well-preserved archaeological sites on the west and south coast of South Africa led to a limited approach to the MSA both regionally and temporally. Consequently other time periods such as post Howiesons Poort (post HP), late MSA or final MSA associated with the Marine Isotope Stage 3 (MIS3) have received substantially less attention and the archaeological region of eastern South Africa, especially KwaZulu-Natal (KZN) remained understudied. In sum, five archaeological sites containing MSA occupations are present in KZN. However Sibudu remained a hallmark in the region for many years due to its extraordinarily good conditions of preservation and deep stratigraphic sequence. Umhlatuzana and Border Cave have received comparatively little attention and the remaining two sites Holley Shelter and Umbeli Belli have either been analyzed insufficiently or even completely forgotten. Thus this thesis aims to provide solid archaeological data for the MIS3 assemblages from Holley Shelter, Umbeli Belli and Sibudu. It shall further outline the degree of cultural variability and flexibility within this time period. The results rest on reinvestigations of previously excavated museum collections such as the material

from Holley Shelter but also on new data recovered from recent excavations using modern techniques of documentation and analytical procedures.

Zusammenfassung

Das Middle Stone Age (MSA) in Südafrika repräsentiert eine Zeitperiode, die vor ca. 300.000 Jahren begann und bis ca. 30.000 Jahre vor heute andauerte. Diese Zeitperiode war Grundlage intensiver Forschung innerhalb des letzten Jahrhunderts und ganz besonders seit der Mitte der 80er Jahre. Dies stand im Zusammenhang mit der damals gewonnenen Erkenntnis, dass der Ursprung Anatomisch Moderner Menschen (AMM) innerhalb dieser Zeit und in Afrika anzusiedeln ist. Während die ältesten Hinweise auf AMM außerhalb Afrikas frühestens um 100.000 vor heute dokumentiert sind, sprechen neueste Erkenntnisse dafür, dass die ältesten Vertreter unserer Art bereits zwischen 200.000 und 300.000 Jahren vor heute den Afrikanischen Kontinent besiedelten. Innerhalb dieses Zeitraums erfuhr die Menschheitsgeschichte zahlreiche Innovationen. Darunter befinden sich frühe Hinweise auf Schmuck in Form von durchlochenden Schnecken, Werkzeuge aus organischen Materialien wie etwa Knochen, Gravierungen auf Ocker und Straußeneierschalen sowie fortschrittliche Methoden der Steinbearbeitung. Oftmals wurden diese Artefakte in Verbindung mit dem Begriff der „Kulturellen Modernität“ gebracht. Die meisten dieser Innovationen traten innerhalb der letzten 100.000 Jahre auf. Da sich Steinartefakte über Jahrtausende oftmals perfekt erhalten, stellen sie die wohl wichtigste archäologische Quelle dar. Durch das intensive Studium von Herstellungstechniken und deren unterschiedlichen Variationen sowohl auf räumlicher als auch zeitlicher Ebene werden Erkenntnisse über das Verhalten früher Jäger und Sammler ermöglicht. Sie lassen unter anderem Rückschlüsse über Mobilität und Anpassungsverhalten an unterschiedlichste interne und externe Faktoren zu und ermöglichen uns auf diese Weise erstaunliche Einblicke in frühe Jäger und Sammler Kulturen. Ebenso repräsentieren sie ein nützliches Werkzeug für das Verständnis kulturellen Wandels. In den letzten Jahrzehnten führte eine außergewöhnliche Häufigkeit der oben beschriebenen Innovationen zu einem zunehmenden Forschungsschwerpunkt auf zwei spezifische Perioden innerhalb des MSA: das Still Bay (SB) und das Howiesons Poort (HP). Dies fand sowohl auf

zeitlicher wie auch regionaler Ebene statt. So führte eine relative Häufigkeit an Fundstellen mit außerordentlich guten Erhaltungsbedingungen zu einer regionalen Fixierung auf die Süd- und Westküste Südafrikas. Andere Regionen wie KwaZulu-Natal (KZN) an der Ostküste und andere Zeitperioden erfuhren demnach vergleichsweise wenig Aufmerksamkeit. Speziell Technokomplexe, die in die Marine Isotopenstufe 3 (MIS3) datieren, wurden eher stiefmütterlich behandelt. Obwohl insgesamt fünf Fundstellen mit MSA Schichten in KZN dokumentiert sind, erfuhr lediglich Sibudu außergewöhnlich viel Aufmerksamkeit. In geringerem Umfang rückten auch Border Cave und Umhlatuzana immer wieder in den Vordergrund. Die beiden verbleibenden Fundstellen Holley Shelter und Umbeli Belli hingegen wurden in der Vergangenheit teilweise ausgegraben und entweder unzureichend analysiert oder gar gänzlich vergessen. Die vorliegende Dissertation befasst sich mit eben dieser regionalen und zeitlichen Forschungslücke. Es ist das vorrangige Ziel, ein belastbares archäologisches Fundament für die Region KZN und die Zeit um MIS3 zu schaffen. Des Weiteren stehen die technologische Variabilität und damit der kulturelle Wandel innerhalb dieses Rahmens im Vordergrund. Als Forschungsgrundlage dienen Steinartefakt Inventare aus drei archäologischen Fundstellen: Umbeli Belli, Holley Shelter und Sibudu. Die Ergebnisse basieren sowohl auf Museumskollektionen im Falle von Holley Shelter als auch auf selbst durchgeführten Ausgrabungen in Umbeli Belli und Sibudu und damit einhergehenden Analysen unter Einbezug modernster wissenschaftlicher Methoden.

III. List of publications

i. Accepted publications

- (1) 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, e98359. (*APPENDIX i.a*)
- (2) **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. *The South African Archaeological Bulletin*, 70, 149-165. (*APPENDIX i.b*)
- (3) **BADER, G. D.**, CABLE, C., LENTFER, C. & CONARD, N. J. 2016. Umbeli Belli Rock Shelter, a forgotten piece from the puzzle of the Middle Stone Age in KwaZulu-Natal, South Africa. *Journal of Archaeological Science: Reports*, 9, 608-622. (*APPENDIX i.c*)
- (4) CONARD, N. J., **BADER, G. D.**, SCHMID, V. C. & WILL, M. 2014. Bringing the Middle Stone Age into Clearer Focus. *Mitteilungen der Gesellschaft für Urgeschichte*, 23, 121-127. (*APPENDIX i.d*)

ii. Manuscripts ready for submission

- (5) **BADER, G.D.** & CONARD, N.J. in prep. A Return to Umbeli Belli. First insights of recent excavations and implications for the final MSA in KwaZulu-Natal. (*APPENDIX ii.a*)

IV. Personal contribution

Description of the significance of the personal contribution according to § 6,2 PromO², of the University of Tübingen. Numbers follow the order from III. "List of publications".

1. I was supporting co-author responsible for parts of the data collection and illustration & artwork.
2. I was first and corresponding author responsible for data collection and interpretation, writing the manuscript and illustration & artwork. The co-authors helped with interpreting data (Will, M.) and co-writing the manuscript (Will, M. & Conard, N.J.).
3. I was first and corresponding author and responsible for data collection and interpretation, writing the manuscript and illustration & artwork. The co-authors helped with data collection (Lentfer, C.), writing the manuscript (Cable, C.) and overseeing the study as a supervisor (Conard, N.J.).
4. I was supporting co-author and assisted with editorial work as well as artwork & design and helped writing the manuscript.
5. I was first and corresponding author, responsible for data collection and interpretation, writing the manuscript and illustration & artwork. My co-author assisted by overseeing the study as a supervisor and assisted with writing.

Chapter 1: Introduction

Anatomically modern humans emerged about 200.00 to 300.000 years ago in Africa (Bräuer, 1984, McDougall et al., 2005, Richter et al., 2017, White et al., 2003). *Homo sapiens* is the most successful species ever lived on this planet equipped with a large package of abilities absent in any other living being. Our oversized brain, in all its complexity, has enabled us to effectively plan in advance, control environmental phenomena and even to leave this planet and to explore the universe. It is, however, not only our brain that makes us different but also physical properties such as our ability to walk upright, to carry things in our arms and especially to use our hands in order to produce tools. In modern times our tools are mostly computer which are controlling machines and hence more and more physical work conducted by humans becomes redundant. However, all these modern innovations once had an origin, and the first tools ever made were of physical nature. These tools were made by knapping rocks in order to achieve sharp cutting edges that fulfilled all kinds of physical work. To the best of our knowledge tool production began about 3.3 million years ago (Harmand et al., 2015). Raymond Dart suggested that early hominid ancestors, specifically australopithecines, used the bones and teeth of animals as tools long before they knapped rocks (Dart, 1957). This hypothesis was based on his investigations of bone accumulations with specific breakage patterns at Makapansgat. He called his model the “osteodontoceratic” culture, and it received strong criticism because of the possibility that other animals such as hyena, leopard or porcupine can be agents of comparable bone accumulations and breakage pattern (Brain, 1968, de Ruiter and Berger, 2000, Hendeby and Singer, 1965). Even if we accept the possibility that other materials than stone have been used by our earliest ancestors, a scenario that seems possible especially in the light of tool producing and hunting primates e.g. (McGrew et al., 1979, Pruett and Bertolani, 2007, Sanz et al., 2009), Dart’s theory has never received broad consideration. Archaeology depends on indisputable physically preserved artifacts and, although some very old evidence of organic tools exists (Böhner et al., 2015, Dennell, 1997, Movius, 1950, Schoch et al., 2015, Serangeli et al., 2015), in most cases stone tools are the only artifacts preserved. This doesn’t imply that australopithecines, *Homo erectus*, Neanderthals or *Homo sapiens* were using only stone tools, and certainly the lack of organic preservation produces a unilateral and biased picture about past human societies.

On the other hand this enforced dependency on a single raw material has resulted in an incredible amount of scientific methods and theories designed to extract even the most rudimentary information from stone tools (Andrefsky, 1994, Andrefsky Jr, 2005, Bisson, 2000, Boëda, 1993, 1994, 2001, Boëda et al., 1990, Bonilauri, 2010, Bordes, 1961, Brantingham et al., 2000, Bretzke et al., 2006, Conard and Adler, 1997, Conard et al., 2004, 2012, Delagnes et al., 2012, Dibble, 1987, Henshilwood et al., 2014, MacDonald and Andrefsky, 2008, Marks and Volkman, 1983, Odell, 1996, 2004, Pelcin, 1997, Rots et al., 2017, Scerri et al., 2015, Schmidt et al., 2013, 2015, Soriano, 2001, Soriano et al., 2007, 2009). The combination of many different approaches including production technology, typology, the investigation of morphological variation, experimental studies and ethno-archaeological studies allows us to state that stone tools are probably one of the most heavily examined archaeological remains. Stone artifacts enable us to draw conclusions about the behavior of past human societies in many aspects. The reconstruction of hunting behavior (Bretzke et al., 2006, Rots et al., 2017, Shea, 2006, Sisk and Shea, 2011, Villa and Lenoir, 2006) and raw material economy (Andrefsky, 1994, Brantingham et al., 2000, Braun et al., 2009, Driscoll, 2011) and the investigation of technological decision making and adaptations serve as ideal tools to reproduce temporal and regional traits and changes and can even be used as proxies for the understanding of mental capacities and flexibility (Haidle, 2010, Kandel et al., 2016 Lombard and Haidle, 2012, Lombard and Parsons, 2011). Thus, the investigation of stone artifacts remains one of the most powerful archaeological tools providing a large archive of information.

The oldest evidence for the systematic production of stone tools comes from Kenya and dates to about 3.3 Million years before present (Harmand et al., 2015). Although current evidence suggests that the human lineage could have split from the apes in Europe rather than Africa (Fuss et al., 2017), it remains accepted doctrine that the origins of human material culture developed in Africa. This is documented by the large number of sites throughout the continent comprising archaeological horizons from the oldest to the youngest periods in the world. If we accept the Lomekwian technology proposed by Harmand and colleagues (2015) as such, then this rather simple flaking technology marks the oldest evidence of human material culture. It consists mainly of simple cores, a few sharp edged flakes and some anvils and percussors. Although Harmand et al. (2015) suggest a substantial hand motor control

of the knappers was necessary to produce these 'tools', they also contribute the numerous knapping accidents and impact scars on core platforms to poor knapper percussion abilities. No member of the genus *Homo* is documented for these early times and hence the authors refer to *Kenyanthropus platyops* as a likely candidate for this knapping activity. Further evidence for such an early appearance of stone tool use comes from the Dikika site in Ethiopia where cut marks on bones have been recovered from layers older than 3 million BP associated with *australopithecus afarensis* (McPherron et al., 2010). Apart from these earliest finds, the Oldowan technology represents the first commonly accepted technocomplex. It is basically ascribed as a core tool and chopper industry (Leakey, 1951, Leakey et al., 1964) and roughly dated to between 2.3 and 2.5 Million years ago (Campisano, 2012, de la Torre, 2004, Roche et al., 1999, Semaw et al., 1997, 2003,). In the last few decades it has become increasingly evident that even early knappers were not simply crushing rocks in order to achieve coarse heavy duty tools but rather intentionally selecting and transporting raw materials, making use of sharp edged flakes and applying a simple tool maintenance strategy (Kimura, 2002, Braun and Harris, 2003, Braun et al., 2009, Toth, 1985). The succeeding Acheulean industry, which became famous even within the non-archaeological society due to the characteristic and symmetrically shaped handaxes, first appeared around 1.7 million years ago and has been interpreted as showing evidence for increasing complexity of human behavior (Diez-Martín et al., 2015, Beyene et al., 2013, Lepre et al., 2011, Chevrier, 2012). The standardized production of these specific tools, in order to achieve morphologically recurrent forms, has been associated with increasing planning depth and, hence, advanced mental complexity. Contrary to the preceding Oldowan and Lomekwian industries, the Acheulean is the first technocomplex commonly accepted to have been made entirely by the genus *Homo* and to spread widely over Africa (Diez-Martín et al., 2015, Texier et al., 2004), Asia (Corvinus, 2004, Shen et al., 2009) and Europe (Moncel et al., 2013, Vallverdú et al., 2014). However, as pointed out by Gabunia et al. (2000), the Acheulean is not the first lithic industry found outside the African continent as indicated e.g. by the pre-Acheulean industry from Dmanisi in Georgia. The Acheulean was a long living tradition, existing in Africa for almost one and a half million years. Somewhere between 200.000 and 300.000 years ago major changes in material culture appeared (McBrearty and Tryon, 2006). Core tools such as handaxes and choppers disappeared in favor of a knapped stone

technology basically ascribed as having frequent pointed forms with prepared platforms and prepared core technology. This period has been assigned the Middle Stone Age (MSA) and was defined in South Africa for the first time by Goodwin and van Riet Lowe (1929). Although investigations of archaeological material of more or less a scientific nature have been undertaken in the sub-continent from the late 19th century onwards (Maguire, 1997), Goodwin and van Riet Lowe were the first to bring scientific structure to the existing chaos. Although their chronological sub-division of the stone age into an early (ESA), middle, and late stone age (LSA) has received many adjustments and alterations throughout the last century, these terms are still valid in a broad sense.

Goodwin and van Riet Lowe also recognized that neither the MSA nor the LSA are homogenous entities, but rather they contain a variety of archaeological signals forcing a further subdivision of these periods. Hence, the MSA was subdivided into the Glen Grey falls industry, the Pietersburg variation, the Howiesons Poort variation (HP) and the Still Bay industry (SB). These names derive from the particular type sites even though some of them are surface scatters without clear stratigraphic attribution. However surprisingly many details published in 1929 are still valid. The SB complex serves as a good example. While Goodwin and van Riet Lowe already recognized the specific bifacial “laurel leaf” shaped points on a surface site near Still Bay, and hence announced them to be part of a coherent industry, in later times the existence of the SB was rejected due to a lack of stratified sites (Volman, 1981, 1984, Jacobs and Roberts, 2008). Yet since Evans (1994) excavations at Hollow Rock shelter and the more recent investigation of the well stratified SB assemblage at Blombos Cave (Henshilwood et al., 2001, Soriano et al., 2015, Villa et al., 2009) the SB industry has become commonly accepted, even well established, and has been subject to countless archaeological examinations concerning the evolution of modern human behavior (Henshilwood, 2012, Lombard et al., 2010, Mohapi, 2012, 2013, Soriano et al., 2015, Villa et al., 2009, Wadley, 2007, d’Errico et al., 2008, Soriano et al., 2009, Vanhaeren et al., 2013,).

Yet, many aspects of archaeological investigation have changed during the last century due to new advances in research techniques and the systematic examination of archaeological sites. Rock shelters and cave sites represent ideal sediment traps and often preserve deep stratigraphic sequences with archaeological remains dating

back hundreds of thousand years in a chronological order. Hence, they provided (and still do so) ideal preconditions for archaeological examinations and approaches to further structure our chronology of the MSA. In 1974 Garth Sampson presented his revised Stone Age chronology (Sampson, 1974) which followed recommendations from the 1965 Wenner-Green Symposium held at the Burg Wartenstein in Austria (Bishop and Clark, 1967). One of the major changes was the attempt to avoid the preexisting terms like ESA, MSA and LSA defined by Goodwin and van Riet Lowe (1929) and to use instead cultural terms such as Mossel Bay or Wilton only if they were related to a site carefully excavated (Sampson and Deacon, 1976). Hence Sampson grouped the entire stone age into several groups such as the Oldovan, Acheulian, the Pietersburg, the Bambata, Howiesons Poort or Oakhurst complex, each of them further subdivided into regionally distinct industries. The major problem with Sampson's model was, however, the almost exclusively typological approach which lumps together assemblages no matter if stratified or surface collected, under the consideration that similar types of retouched tools represent similar groups. In addition dating was still an issue in these days. As we know today early radiocarbon dates (e.g. Clark, 1959, Cramb, 1961, but see also Vogel, 1972) produced insufficiently young ages for the MSA and even our most modern methods of calibrating ^{14}C curves allow dating only back to 50,000 years ago (Bayliss, 2016, Reimer et al., 2016). Thus radiocarbon dating is not useful for most of the MSA sequence. Other researchers such as Beaumont (1978) and Butzer et al. (1978), Thomas Volman (1981, 1984), Singer and Whymer (1982) or Janette and Hilary Deacon (Deacon, 1995, Deacon, 1984, Deacon and Deacon, 1999) who contributed substantially to our modern understanding of the Stone Age returned to the classic subdivision in ESA, MSA and LSA and provided solid evidence based on controlled excavations and stratigraphic observations. Today the MSA is subdivided into many periods such as Early MSA, Still Bay, Howiesons Poort, post Howiesons Poort, Late MSA or final MSA. But during the last decades it has become more and more clear that a generalization of the MSA which is valid for the entire sub-continent of South Africa is impossible. This is not surprising in the light of the large size of South Africa and the high variability of environmental settings comprising tropical rain forest, low-veld grassland, semiarid deserts and high mountains. This environmental diversity clearly must have an influence, to some degree, on human subsistence and settlement strategies as is reflected by the cultural remains. This, however, does not

imply that human culture is entirely determined by nature, although that might seem logical. However, “logic is the beginning of all wisdom...not the end” (Mr. Spock, *Star Trek VI: The undiscovered country*, 1991) and humans are not an entirely logical species. It is a broad spectrum of diverse internal and external factors that govern human decision making. Certainly changes in climate, rainfall and sea level have a strong influence on vegetation and therefore, the migration of animals (Chase and Meadows, 2007, Mackay et al., 2014a, McCall and Thomas, 2012, Weninger et al., 2009, Ziegler et al., 2013). It would be insufficient though to limit human decisions down to a dependency on migratory prey species. These factor alone cannot explain human personal preference, social identity and individual needs. Archaeologists can only approximate these internal factors by taking ethno-archaeological observations into account (Binford, 1978, 1982, Lee, 1968, Wiessner, 1977, 1983, 1989, Woodburn, 1968). This is not meant to suggest here that analogies should be drawn to dead societies but it is rather that they can be useful as a way of understanding human nature.

Turning back to the MSA, in the last decades it became evident that some archaeological periods such as e.g. SB and HP provide similar archaeological signals throughout most parts of South Africa. But their timing and duration lack in coherence and have been shown to be highly diverse (Guérin et al., 2013, Jacobs and Roberts, 2008, Jacobs et al., 2008a, b, Steele et al., 2016, Tribolo et al., 2009, 2013, Wadley and Jacobs, 2006,). At the current stage we simply don't know if these diverse dates are the result of different measurement techniques, or mistakes or if they are indeed valid and imply large differences in the first appearance of these technocomplexes depending on the regional context. Having a closer look at the archaeological assemblages of these time periods and using a holistic approach that goes beyond standard typologies raises doubts as to the real similarity of these assemblages (Lombard et al., 2010, Porraz et al., 2008, 2013). Other periods, such as the early MSA or MSA 1, (Schmid et al. 2016, Singer and Whymer 1982, Wurz, 2000, 2002) haven't been considered often so far and the most coherent signal is limited to the cape region and the south coast. Other assemblages and especially those dating to Marine Isotope Stage 3 (MIS3) were considered to be more diverse than preceding periods and lacked consequently in substantial research until the end of the last decade (Will et al., 2014, 2015, Conard et al., 2012). The cultural diversity of these assemblages is certainly only one reason for this lack of research. Other complexes

such as SB and HP simply acquired exceptional attention because they included different kinds of innovations often associated with the term “cultural modernity” e.g. the production of personal ornaments (d’Errico et al., 2005, Henshilwood et al., 2004, Vanhaeren et al., 2013), engravings on ochre and ostrich eggshell (Henshilwood et al., 2009, 2011, 2014, Mackay, 2010, Texier et al., 2010), bone tools (Backwell et al., 2008, Becher, 2016), the intentional heat treatment of silcrete (Brown et al., 2009, Schmidt and Mackay, 2016, Schmidt et al., 2013, 2015, Wadley and Prinsloo, 2014) or the earliest evidence for burials including grave goods (d’Errico and Backwell, 2016). Some researchers have developed theories about the evolution of the human mind and language (Wurz, 1999, d’Errico and Vanhaeren, 2009). Hence the vast majority of literature over the last two to three decades dealing with the MSA of southern Africa has focused on the SB and HP complexes (Backwell et al., 2008, de la Peña and Wadley, 2014a, b, de la Peña et al., 2013, Guérin et al., 2013, Henshilwood et al., 2001, 2012, 2014, Jacobs et al., 2008b, Lombard, 2006, Lombard et al., 2010, Mackay, 2011, McCall and Thomas, 2012, Soriano et al., 2007, 2009, 2015, Texier et al., 2010, Tribolo et al., 2009, 2013, Villa et al., 2009, Wadley, 2007, Wadley and Mohapi, 2008, Wurz, 1999). The MSA archaeology of southern Africa though has been limited both regionally and temporally. Although the sub-continent has an incredible number of sites preserved in different kinds of environments, the south and west coast and the cape region have received the most attention. To a certain degree this was the result of the large amount of rock shelters and cave sites in these regions – especially those with astonishingly good preservation conditions and long stratigraphic sequences such as Klasies River (Singer and Whymer 1982, Wurz, 2000, 2002), Pinnacle Point (Brown et al., 2009, Marean et al., 2010), Blombos cave (Henshilwood, 2005, Henshilwood et al., 2001, 2009, 2011, Thompson and Henshilwood, 2014), Diepkloof (Porráz et al., 2008, 2013, Texier et al., 2010, Tribolo et al., 2009, 2013) Klipdrift (Henshilwood et al., 2014) or Elands bay Cave (Porráz et al., 2016, Schmid et al., 2016, Tribolo et al., 2016). A long research tradition anchored at the universities of Cape Town and Stellenbosch, immediately connected with pioneering researchers such as Janette and Hilary Deacon (Deacon, 1984, Deacon, 1995) or John Parkington (Parkington, 1972, Parkington and Bailey, 1988, Parkington et al., 2004), who explored a large number of the archaeological sites in this region, has also had an influence. Furthermore, the southern regions of South Africa exhibit a wide and open landscape

with relatively scarce vegetation providing ideal preconditions for archaeological survey.

Contrary to this situation, KwaZulu-Natal (KZN) in the eastern part of South Africa contains highly dense vegetation which is likely covering many potential archaeological sites, particularly along the coastline. Although archaeological investigations taking place before World War two are documented from this region, many of them have been of a destructive nature, are poorly documented, or are covered today by modern housing and road developments (Maguire, 1997). Pioneer work using adequate methods of excavation has been done by Aron Mazel who discovered a large number of LSA sites and also MSA sites such as Sibudu (Mazel, 1984, 1986, 1988a, b.). Further, Gordon Cramb (Cramb, 1952, 1961) and Jonathan Kaplan (Kaplan, 1989, 1990) conducted fieldwork at Holley Shelter and Umhlatuzana and uncovered fairly deep MSA deposits. In 1934 Raymond Dart conducted excavations at Border Cave on the northernmost edge of KZN (Cooke et al., 1945) and later Cooke, Malan and Beaumont (Beaumont, 1978, Butzer et al., 1978, Grün and Beaumont, 2001) continued research at the site. When Aron Mazel found Sibudu and conducted a first test excavation there in 1983 (Wadley and Jacobs, 2004) he uncovered Iron Age deposits directly overlying typical MSA layers without any evidence for an LSA occupation in between. His research scope at this time was the investigation of the ecology of Holocene LSA hunter gatherers in the Thukela Basin (Mazel, 1988a) and thus the absence of LSA deposits at Sibudu led him to abandon the site. It took another 15 years until Lyn Wadley who excavated Rose Cottage Cave in the Basotulian ecozone recognized the great potential of Sibudu and conducted new excavations there from 1998 onwards (Wadley, 2001, Wadley and Jacobs, 2004). Her work at this large rock shelter uncovered one of the most complete and stratigraphically intact archaeological sequences in the entire sub-continent. It covers the youngest deposits of the final MSA roughly dating to around 35ka (Wadley, 2005b), late MSA (~47ka) (Villa et al., 2005), as well as post-HP (~58ka) (Cochrane, 2006), HP (~65 – 59ka) (Wadley and Mohapi, 2008), Still Bay (~77 – 72ka) (Wadley, 2007) and pre Still Bay (> 80ka) (Wadley, 2012). From 2012 onward a German team from the University of Tübingen under the leadership of Nicholas Conard has continued excavations at Sibudu with a major focus on the post HP (Conard et al., 2012, Conard and Will, 2015) and pre Still Bay Layers. All together the work at Sibudu has resulted in an incredible amount of data covering all aspects

of human material culture and ecology including stone tools (Conard et al., 2012, Conard and Will, 2015, de la Peña and Wadley, 2014a, b, de la Peña et al., 2013, Langejans, 2012, Lombard, 2006, Lombard and Phillipson, 2015, Mohapi, 2012, Rots et al., 2017, Soriano et al., 2009, Villa et al., 2005, Villa and Lenoir, 2006, Wadley, 2005b, Will et al., 2014), organic artifacts (Backwell et al., 2008, Rots et al., 2017, Becher, 2016), personal ornaments (d'Errico et al., 2008) the use of ochre (Lombard, 2006, Soriano et al., 2009, Wadley, 2005a), botanical (Sievers, 2006) and faunal remains (Val, 2016, Val et al., 2016, Clark and Plug, 2008, Clark and Ligouis, 2010) as well as micromorphological investigations (Wadley et al., 2011, Goldberg et al., 2009). This makes Sibudu to one of the most important and best studied archaeological sites not only in southern Africa but even in the world.

Chapter 2: Objectives and expected output

Although the extraordinarily good preservation conditions for stone and organic artifacts and the well preserved stratigraphy at Sibudu contributed essentially to the understanding of the MSA, the strong research focus on the site resulted into a hallmark position of Sibudu within a large region. Apart from Umhlatuzana (Kaplan, 1989, 1990, Lombard et al., 2010, McCall and Thomas, 2009, Mohapi, 2013), which is situated approximately 45 km from Sibudu, only Border Cave, about 300 km to the north, has acquired consideration in the last decades (Beaumont, 1978, Butzer et al., 1978, Grün and Beaumont, 2001, Klein, 1977, Villa et al., 2012). Comparative analyses between those sites have been scarce and when done only isolated aspects were considered. In spite of its great significance Sibudu has remained in regional isolation, without any considerable archaeological framework. This is reflected in attempts to compare assemblages from Sibudu to other high potential sites such as Blombos Cave, which is located over a thousand kilometers distant (Soriano et al., 2015), or even to European Middle Palaeolithic sites (Villa and Lenoir, 2006). Such approaches deserve some credit, but in the light of increasing consciousness of MSA assemblage complexity and variability they rest on unstable ground. Keeping in mind the broad spectrum of external and internal drivers causing assemblage variability, as discussed above, it is my strong conviction that researchers first must understand archaeological signals on a site base and second on a regional scale. This forms the base for any further theory building and

understanding of human cultural complexity. Hence this thesis attempts to describe and understand the MSA lithic technology of MIS3 on a regional scale. I tried to achieve this by considering three archaeological sites in KZN within a maximum distance of 90 km from each other: Holley Shelter and Umbeli Belli, which serve as case studies here, and Sibudu as a reference site. The archaeological site Holley Shelter was excavated in the 1950s by Gordon Cramb (Cramb, 1952, 1961) but insufficiently studied. All work on Holley Shelter conducted for this thesis rests on a reexamination of the artifacts excavated by Gordon Cramb. Umbeli Belli represents the second archaeological case study and comprises both, data from the original excavation by Charles Cable in (1984) in 1979 as well as new results from archaeological excavations conducted by myself and Nicholas Conard in 2016 and 2017.

Chapter 3: Results and Discussion

In this chapter the results of the research undertaken in KZN are summarized and discussed. It follows a chronological order organized by archaeological site and year of publication. It announces the results of our investigations at Sibudu published in 2014 first (Will et al., 2014) followed by the results from Holley Shelter (Bader et al., 2015) and Umbeli Belli (Bader et al., 2016, Bader and Conard, in prep). The last publication (Conard et al., 2014) is out of chronological order but needs to stand at the end since it represents an overview over the topic rather than a case study.

Chapter 3.1: Characterizing the MIS3 post HP/Sibudan assemblage of Sibudu – *Will et al. 2014 (APPENDIX i.a)*

As pointed out in Chapter 1 research in the MSA of southern Africa has focused firstly on a regional and secondly on a temporal specific framework. This has led to an insufficient understanding of the regional archaeological signal of KZN and archaeological periods post-dating SB and HP have subsequently been neglected. The work of Will et al. (2014), discussed here, concerns this second issue and tries to work out a better understanding of the Sibudu post HP (~ 58 ka) based on the uppermost six archaeological layers BM - BSP. It further builds upon a preceding

analysis published by Conard et al. (2012) trying to provide a diagnostic profile for this time period and proposing the alternative name Sibudan instead of post HP. The main objection against the preexisting terminology is based on the argument that “informal terminology is untenable, because it implies that material cultural remains can be characterized by what they are not, rather than by their positive characteristics” (Conard et al., 2012: 181). They tried to achieve these aims by using a techno-functional approach that can be understood as the hypothetical subdivision of a tool into an active, prehensile and intermediate part. The active part is considered to be the main cutting edge or point and hence undergoes frequent transformation processes by breakage or re-sharpening. This approach is deduced from a French system (Boëda, 2001, Bonilauri, 2010, Lepot, 1993,) and considers only the retouched component of the assemblage BM - BSP. The work of Will et al. (2014) deals with the entire lithic assemblage including blanks, tools, cores and the raw material distribution and hence sets a technological framework for the preceding analysis as well. Will et al. (2014) applied a combined approach between attribute analysis and *chaîn opératoire*. The first method deals with counting, documentation and measurements of stone artifact attributes related to knapping technique, function and technology in general (Shott, 1994, Odell, 2004, Scerri et al., 2015). The big advantage of this method is the production of quantifiable and reproducible sets of data. The second method of *chaîn opératoire* analysis concerns the understanding of core reduction methods and the activities prehistoric hunter gathers conducted at the site (Boëda et al., 1990, Soressi and Geneste, 2011). It is important to note at this stage that Will et al. (2014) used a cutoff size for their analysis of 2.5 cm. This is a common procedure in the analysis of lithic assemblages simply in order to narrow down the overwhelming amount of lithic artifacts to a representative sample and hence quicken the overall analysis. This does however not mean that smaller pieces are discarded but they receive less attention and are being analyzed only with regards to specific research questions. It is important to note that not all MSA assemblage in Southern Africa have been analyzed under the same conditions and, hence, our methods need to be kept in mind when comparative studies are applied. Further, Will and colleagues examined the inner assemblage variability in order to test if the entire stratigraphic sequence (BM – BSP) can be considered to be a single cultural entity or if it exhibits variability throughout the sequence. The results of this study can be summarized as follows:

The entire sequence BM – BSP shows a coherent archaeological signal without major changes through time. The raw material procurement strategy points towards the frequent use of local raw materials, especially dolerite. Around 60 to 70% of all artifacts from individual layers are made of this material and the frequently observed rounded cortex points to the use of local river cobbles. Hornfels represents the second most common material in this assemblage and the finest grained material used at Sibudu. No secure outcrop for hornfels has been detected yet but previous investigations suggest that the nearest possible source is about 15 – 20 km distant (Wadley and Kempson, 2011). Other materials such as quartzite, quartz, jasper or crypto crystalline silicates (CCS) occur rarely. There is a conspicuous correlation between the fine grained hornfels and the percentage of retouched tools. The knappers at Sibudu manufactured about 48% of all retouched tools on hornfels and this stands in contrast to the low blank ratio of hornfels. The ratio between tools and blanks is double as high for hornfels than for dolerite and this implies that people intentionally selected this material for the preparation of tools. One of the main features characterizing the Sibudan technocomplex hinges on the reorganization of traditional tool types and the proposal of a taxonomy deduced from techno-functional criteria. The techno-functional tool “classes” recognized at Sibudu are dominated by a specific form that Conard et al. (2012) named Tongati tools after the u-Thongathi river close to Sibudu. These are pieces with a short triangular and symmetrically retouched point forming the active part. These pieces are understood as “box cutters” in their function. Their reduction cycle is understood as being oriented from distal to proximal, meaning that the active point of the piece becomes shorter and more flat-angled over the time. Contrary to that the second most common tool class, the Ndwedwe tools named after the municipal district around Sibudu, are elongated unifacial tools providing steeply retouched lateral edges. Following the concept of Conard and colleagues (2012) these pieces have become narrower during their reduction cycle while their length remained constant. In addition Will et al. (2014) designated a further tool class namely ACT (asymmetric convergent tools). This category was included into Tongati tools by Conard et al. (2012) previously. Later though their overall morphology, including one curved and relatively steep retouched edge opposed to a straight cutting edge that has been considered as the active part led Will et al. (2014) to the conclusion that they represent a distinct signal. Few other tool classes such as Biseaux, NBT and splintered pieces are evident and their

description can be taken from Conard et al. (2012) and Will et al. (2014). The Sibudan assemblage contains a relatively high percentage of tools in between 18 and 27% and even concerning the relatively large cut of size applied here the tool percentage is probably higher than in the most other MSA assemblages.

The investigation of core technology showed that most cores in the Sibudan assemblage can be considered as either parallel or platform cores (Conard et al., 2004) the latter often reduced along a narrow or flat surface. Inclined cores on the other hand are almost absent. In general, knappers at Sibudu produced flakes but blades have also been frequently knapped and represent between 11 and 20% of the assemblage. It is evident that blades are often retouched and have been subject to a different percussion technique than flakes. For most flakes strong developed bulbs, contact points, cones and thick platforms reflect the use of direct and internal hard hammer percussion. Blades on the other hand show poor developed bulbs, frequent proximal lips and often shattered bulbs. These characteristics are commonly associated with the use of soft stone percussion (Pelegriin, 2000). In conclusion, Will et al. (2014) presented one of the first detailed analyses of a post HP inventory from KwaZulu-Natal. They showed that, contrary to the preexisting picture of the post-HP, it is by no means less advanced or more informal than other technocomplexes. The Sibudan assemblage from layer BM – BSP exhibits a well-structured organization of lithic technology and a robust techno/typological signal including distinct tools and core technology. The characteristic techno-functional tool classes e.g. Tongati and Ndwedwe tools are not considered to be type fossils but organizational elements within the Sibudan that might occur in other preceding or succeeding assemblages as well. But in the Sibudan assemblage these tools occur in exceptionally high proportions and this is clearly a defining feature of this period at Sibudu.

Chapter 3.2: Holley Shelter and its place within the MSA chronology of eastern South Africa – *Bader et al. 2015 (APPENDIX i.b)*

This chapter concerns the outcome of our work (Bader et al., 2015) on the MSA site Holley Shelter situated roughly between Pietermaritzburg and Wartburg. Three major goals were the subject of this analysis. The first was simply to describe and characterize the lithic assemblages from Holley Shelter excavated by Gordon Cramb

in the 1950s. Although Cramb published two articles on his work (Cramb, 1952, 1961) his analysis was incomplete and of entirely typological nature and left many questions open. The second problem was the absence of reliable radiometric dates. Cramb published two radiocarbon dates for the MSA occupation of 4400 +/- 150 and 18.200 +/- 500 BP. With respect to modern MSA research however this is pretty unlikely and as suggested by Wadley (2001) they represent a minimum age at best. Due to legal issues in terms of the sites landownership at the time of our analysis we were not able to conduct re-excavations and take samples for absolute chronological ages. Thus, we tried to achieve an age estimation based on techno/typological comparisons with other regional MSA assemblages. The third question concerned the understanding of the regional MSA signal of KwaZulu-Natal and it's variability and is directly linked to the second problem described in Chapter 1 and 2.

When Cramb (1952, 1961) excavated Holley Shelter in the 1950s he excavated the site in artificial spits due to his observation that the sediment was of dust like consistency and homogenous in color and, thus he could not identify natural archaeological horizons. This method was commonly applied and is still applied today sometimes in the absence of clear stratigraphic differences. The major problem at Holley Shelter was that Cramb did not always excavate spits of the same thickness. Some of them were three inches thick, others six and others again 12 and hence we had to develop a sampling system as described in detail in *APPENDIX i.b.* All together our analysis covered a sequence of 1.05m in depth subdivided into six analytical units assigned Inch 0-6, 6-12, 12-18, 18-24, 24-30 and 30-42. Our analysis followed the same approach as applied by Will et al. (2014) using a combination of attribute analysis, *chaîne opératoire* and techno-functional aspects. At Holley Shelter we were using a cut-off size of 3 cm. Briefly summarized, the most distinct features identified at Holley Shelter are first a predominance of hornfels artifacts, second a high number of characteristic unifacial points, third probably the highest number of splintered pieces ever counted in an MSA assemblage and, lastly, a core technology closely linked to local raw material conditions. Due to conspicuous similarities with the Sibudan assemblage of the type site, the retouched tools and especially the unifacial points have been analyzed with regards to the same techno-functional system described by Conard et al. (2012) and Will et al. (2014). Further, we identified different morphological features within the splintered pieces from Holley Shelter and thus tried to structure this variability. We observed three different types of

splintered pieces designated as single edge, opposed edge and diagonal splintered pieces (see APPENDIX i.b, Fig. 3 & 4). In addition the core technology at Holley Shelter showed recurrent and clear reduction patterns and hence we provided a schematic model for core reduction including two major types designated as narrow sided and semi-circumferential platform cores (APPENDIX i.b, Fig. 2).

The entire sequence of 1.05 m thickness doesn't provide a uniform archaeological signal though but rather significant variability through time. Based on techno/typological criteria we were able to identify three occupational horizons within the sequence:

The lowermost (Inch 30–36 and 36-42) is characterized by a predominance of quartz artifacts having been often knapped in a bipolar way. Hornfels artifacts are second most common but retouched tools are almost absent in this horizon. Most of the cores are bipolar ones and the overall flake dominated assemblage exhibits frequent plain platforms. Only few examples provide evidence of platform preparation. The total number of artifacts >3cm is the lowest in the entire sequence and comprises only 87 pieces.

The second occupational horizon at Holley Shelter is consistent with Inches 12-18, 18-24 and 24-30. In this part of the sequence the number of artifacts is respectively high and the assemblage is characterized by a blade and point based technology exhibiting frequent unifacial points. The blades are considerably long and thick and show frequent evidence of platform preparation. Different to the Sibudan assemblage (Will et al., 2014) we identified soft stone hammer percussion most commonly applied to the production of blanks no matter if they show flake, blade or point dimensions. Hornfels is the most commonly used raw material in this part of the sequence reaching values up to 90% while quartz and other materials occur rarely. The percentage of tools is considerably high, up to 43%. Although our sample could be biased first by the relatively large cut-off size of 3 cm compared to other assemblages and by the possibility of selective sampling in the 1950s excavation we still argue that knappers at Holley Shelter produced more frequently retouched tools compared to other assemblages. We also argue that such a selective sampling would have produced a similar high percentage of eye-catching pieces throughout the sequence rather than the gradual changes seen (see also APPENDIX i.b). The two most distinct features of the middle occupational horizon are unifacial points and splintered

pieces. No bifacial tools have been observed. Differing from Sibudu, the most characteristic tool class in this occupation horizon are Ndwedwe tools. These pieces are considerably larger and more massive than the pieces from Sibudu. But in their general morphology and considering within the techno-functional aspect they are quite similar. In addition, a large number of splintered pieces of all three kinds mentioned above are characteristic of this assemblage. The most common examples are opposed edge splintered pieces followed by single edge pieces. Few examples of diagonal splintered pieces occur in the upper part of this horizon. In terms of core technology major changes also appear compared to the underlying sequence. We identified a recurrent signal of typical platform cores that have been adapted towards the natural slab-like morphology of hornfels in this region. Most common are semi-circumferential platform cores with frequently prepared platforms. These cores have been used for the detachment of thick, elongated blades with a unidirectional scar pattern. Some examples of narrow sided cores appear as well. In general, the entire part of the sequence is dominated by blades rather than flakes.

The uppermost occupational horizon at Holley Shelter is represented by Inch 0-6 and 6-12 and is characterized by the almost exclusive use of hornfels. Due to previous notes by Gordon Cramb (1952) suggesting the uppermost layer contains a mixture of MSA and LSA artifacts we set our focus on specific LSA markers. Contrary to Cramb's notion, we were not able to detect any clear LSA signal in this upper part of the sequence. Cramb mentioned that he uncovered the so-called Smithfield N assemblage only in the smaller excavation area at Holley Shelter while our analysis dealt with the larger one. This raises questions about the depositional nature of the shelter and if it is likely that LSA hunter gatherers used the shelter differently than those of the MSA. Certainly, these questions could only be answered by new excavations. As in the intermediate section semi-circumferential and narrow sided platform cores appear and blades with thick, faceted butts are the most common blanks. The major difference compared to the middle occupation is the almost complete absence of the typical unifacial Ndwedwe tools. The high percentage of splintered pieces in different forms remains not only constant but even increases. Between 40 and 60% of all tools are splintered pieces in this assemblage. Even if a selective sampling strategy affected the assemblage composition this is still probably the highest amount of splintered pieces ever documented for an MSA assemblage.

As pointed out earlier, Holley Shelter remained undated and thus it was part of our research scope to achieve an age estimation based on techno/typological comparisons with surrounding sites. Sibudu served as main reference site due to our own experience with the assemblages and its well dated deposits. We also included other known sites within a maximum radius of 300 km. These sites were Umhlatuzana, Border Cave and Rose Cottage Cave. We set our analytical focus on core reduction, blank types and specifically tools. But apart from those features we also tried to compare the inner assemblage variability observed at Holley Shelter to other sequences, especially the ones from Sibudu and Umhlatuzana, assuming that trends in raw material distribution, occupation density and tool manufacture would affect sites in a close regional framework in a similar way. It turned out that in many aspects the occupational horizons at Holley Shelter feature similarities to the MIS3 assemblages of KZN. We identified the same techno-functional groups typical for the Sibudan such as Ndwedwe and Tongati tools, although in different proportions, as well as ACT's which are characteristic for the middle sequence at Holley Shelter. Also the core technology features similarities to this assemblage although parallel cores are much more common in Sibudu than they are at Holley Shelter. We also found that the chrono-cultural succession comprising a quartz dominant assemblage, with few formal tools in the older assemblages and a gradual shift to hornfels and a high number of unifacial points in the overlying assemblages, is a common feature shared by Sibudu and Umhlatuzana in their post-HP sequence. These and other observations (*APPENDIX i.b*) served as our main arguments to include Holley Shelter roughly into the MIS3. Specifically, the middle part of the sequence provided strong evidence to be connected to the Sibudan of the type site. However, to a certain degree Holley Shelter remains exceptional due to the high percentage of splintered pieces observed in the upper and middle occupational horizons. Different site functions could be an answer for this diversity but final conclusions would require further investigations using different analytical methods.

Thus, if we accept our chrono-cultural attribution of Holley Shelter to the early MIS3 then two major conclusions arise. The first one improves previous results from Sibudu (Will et al., 2014) that MIS3 lithic technology is well structured and contains several diagnostic features not being less sophisticated than HP or SB technologies. Core technology and tool production both point to similar mental templates within the prehistoric hunter gatherers living during MIS3 in the area. The second, and more

serious perception, is that besides major overlaps in technology these assemblages show a high degree of regional variability. This reflects a large degree of flexibility and the ability to adapt both mentally and physically to different kinds of circumstances caused by environmental and or social conditions.

Chapter 3.3: Umbeli Belli, the forgotten MSA site of KwaZulu-Natal – *Bader et al. 2016 (APPENDIX i.c)*

In this chapter the results of our first investigation of archaeological material recovered from Umbeli Belli will be summarized and discussed. These results rest on a museum collection excavated in 1979 by Charles Cable and stored almost 40 years in the KZN-Museum Pietermaritzburg. Our research scope for this analysis was at a primarily descriptive stage. Since the material is previously unpublished, the Umbeli Belli lithic assemblage required a detailed analysis in order to form a foundation for further discussion. Secondly, following our research at Holley Shelter the absence of absolute chronological ages required a comparative analysis again in order to build a rough chronological framework for the assemblage. This publication discusses the further reaching interpretations of the comparative analysis concerning cultural material evolution and higher theories in a rudimentary state since the paper was specifically written to provide a solid base for continuous studies (including the re-excavation of the site).

Archaeological sites containing MSA occupations are scarce in KZN. For many years Sibudu, Umhlatuzana and Border cave have been the only sites under consideration and only recently the author and colleagues brought Holley Shelter back into perspective. All four sites have been known to contain MSA occupations for many years. In the case of Umbeli Belli, the site itself was well known but the research scope of the former excavator Charles Cable focused on the Holocene LSA of KZN led to a situation where Umbeli Belli was ignored in terms of its contribution to MSA research. Cable (1984) only mentioned the presence of typical MSA artifacts at Umbeli Belli in one sentence, without providing any further details. The rediscovery of Umbeli Belli as an MSA site is due to Gavin Whitelaw from the KZN museum in Pietermaritzburg who brought the site to our attention in early 2014. When Charles Cable excavated Umbeli Belli in 1979 he removed the first 20 to 30 cm of sediment in

a total of 9m² (*APPENDIX i.c Fig. 2*). In order to clarify the maximum depth of sedimentation he further excavated four squares down to bedrock and uncovered another ~1.20m of sediment which he described as a heavily leached orange soil that was only subdivided by a layer of naturally accumulated rocks. Underneath these rocks he found typical MSA stone artifacts and those have been subject to our re-investigation published in 2016 (Bader et al., 2016). Following our previous work at Sibudu and Holley Shelter we applied an approach consisting of attribute analysis and *chaîne opératoire* in order to combine qualitative observations with quantifiable data. Further, we were able to conduct small scale residue analysis on some of the points and thus to provide first evidence on a potential purpose of use.

An initial examination of the Umbeli Belli assemblage implied that it is entirely different than what we found at Sibudu and Holley Shelter. This became most evident as a large number of bifacial pieces and the intensive use of quartz in addition with hornfels and other materials was observed. The assemblage we are dealing with was excavated in artificial spits and their exact depth remains unknown but based on Cables field diary they were between 5 and 10 cm thick. All MSA artifacts have been recovered from spits 5, 5A, 5B, 5C and 6. Following our work at Holley Shelter and Sibudu we used a 3 cm cut-off size in order to receive comparable data. As opposed to the situation at Holley Shelter, Charles Cable applied relatively modern excavation methods and sieved all sediment through a 5 mm mesh. Thus, small debitage is preserved and we were able to investigate this size category with regards to raw material distribution patterns and specific techno-economic questions - such as the presence of shaping flakes (Soriano et al., 2009, Conard et al., 2012). Within these spits a relatively large variability of different raw material types was observed. The most common raw materials for the entire sequence are hornfels, dolerite and quartz but the distinct separation between hornfels and dolerite is problematic at Umbeli Belli. Both raw materials have been brought to the site by the nearby Mpambanyoni River as evident from numerous rounded cortical surfaces. All pieces, no matter if hornfels or dolerite, are very fine grained and a clear distinction between those two materials was often not possible. Very few pieces are made out of the coarse dolerite known from Sibudu, and we suggest the true proportion of hornfels to be probably much higher (Bader et al., 2016). Different other materials such as sandstone, mudstone or CCS occur as well, but all in low numbers (apart from quartzite). Chronologically we observe a trend from hornfels and dolerite being the most

common raw materials in the lower and middle part of the sequence towards an increasing importance of quartz in the upper two spits 5 and 5a. About 30% of all pieces exhibit cortex and most of it is round and smoothed. Thus, most raw materials knapped at Umbeli Belli have been collected from the nearby river. The blank production at the site is different to Holley Shelter and Sibudu. The most common blank types are flakes throughout the sequence and blades and bladelets rarely occur. But a comparative attribute analysis showed that platforms of blades are much more often prepared than the ones of flakes suggesting that knappers invested more time and effort into the detachment of elongated products. Bladelets would mostly fall outside our cut-off size, but we screened the small debitage and identified a total of 69 bladelets within the MSA sequence. This is surprisingly low in the light of a relatively large number of bipolar bladelet cores made out of quartz compared to other core types such as platform, parallel and inclined cores (*APPENDIX i.c, Table 4 and 5*). Different scenarios for this discrepancy are possible, including offsite discard of bladelets, fragmentation or that a limited number of bladelets was successfully removed from the brittle quartz cores. In general, we could not observe a clear structure in terms of core technology for any of the spits. It seems that knappers at Umbeli Belli applied different kinds of core reduction methods to all kinds of raw material. The association between quartz and bipolar technology remains the only clear signal and this occurs in the upper part of the sequence (Spit 5 and 5a) directly underlying a rockfall event separating MSA and LSA occupations. The retouched tool component is one of the most characteristic features of the MSA occupation at Umbeli Belli. Bifacial technology is commonly associated with the SB assemblages of southern Africa (Soriano et al., 2015, Villa et al., 2009, Porraz et al., 2013). But recently de la Peña et al. (de la Peña et al., 2013) and also Will and Conard (2017) pointed out that, at least in eastern South Africa, bifacial technology is not limited to the SB but comes and goes throughout the MSA. These are not entirely new results as Kaplan (Kaplan, 1989, Kaplan, 1990) and Wadley (Wadley, 2005b) provided evidence for bifacial technology at the end of the MSA formally known as final MSA. The lithic assemblages from the MSA occupations at Umbeli Belli show strong evidence for both unifacial and bifacial points and the associated shaping technology. The maximum percentage of tools reaches 19%, which is considerably less compared to the Sibudan assemblages from Sibudu and Holley Shelter. The most common tool categories within the spits 5B and 5C are unifacial and bifacial points. In

this part of the sequence also the artifact density as well as the percentage of tools reaches the highest values (*APPENDIX i.c, Table 7*). During our analysis of these assemblages in early 2015 we could not see clear trends in tool technology throughout the sequence and hence analyzed the spits 5B and 5C as one analytical unit. Unifacial points occurred in this unit about twice as often as bifacial ones and most have been made on elongated blanks via intensive surface shaping. Based on previous work by Clarkson (2002) we derived a descriptive scheme for the identification of regular, invasive and surface retouch (*APPENDIX i.c, Fig. 3*) simply in order to illustrate what we mean by these terms. Following this more than the half of all unifacial and almost all bifacial points exhibit intensive surface retouch and due to Cables careful excavation methods the corresponding shaping flakes have been identified at Umbeli Belli as well. These pieces are defined by Soriano and colleagues (2009) and are discussed in further detail in the upcoming chapter (see also *APPENDIX ii.a*). Their presence at Umbeli Belli, in association with many surface shaped tools proves that an essential part of the tool production chain took place at the site. We found a close correlation between hornfels and dolerite and the manufacture of tools. Following Orton (2008), we calculated the raw material retouch index and could confirm that hornfels and dolerite have significantly more often been chosen for the production of tools. Most of the unifacial and bifacial points are made of this raw material as well. With respect to the high frequency of these tools we examined those using metrical calculations in order to estimate their likely use. We measured width and thickness of all points and calculated the Tip Cross Sectional Area (TCSA) and Perimeter (TCSP) (Mohapi, 2012, 2013, Shea, 2006, Sisk and Shea, 2011, Wadley and Mohapi, 2008,) assuming that these values can give evidence for projectile use. In addition we measured the Tip Penetrating Angle (Larsen-Peterkin, 1993, Villa and Lenoir, 2006) in order to confirm our results. All values point towards a possible use, especially of the bifacial points as projectiles, some more within the range of spearheads but some even within the range of arrow heads. In addition, C. Lentfer conducted a small-scale residue analysis and confirmed that some pieces (especially one example made out of quartz; *APPENDIX i.c, Fig. 7 Nr. 4*) have evidence of proteinaceous residues, embedded hair and pinkish stains on the proximal part being associated with hafting and the use as projectiles. A general observation, especially on the bifacial points, was their recurrent and conspicuous symmetry leading to a short discussion concerning these

tools to be desired end products or curated forms. The general conclusion about this follows Odell (1996) who argues that curation is the result of a complex set of behavior first and that frequent “formal specificity” can be evidence for a concept of shape rather than curation. This does not imply that we exclude the influence of curation on the tool assemblage of Umbeli Belli.

In a further step we tried to estimate the age of the MSA occupation at Umbeli Belli using a comparative analysis with Sibudu, Umhlatuzana, and Holley Shelter. As discussed in *APPENDIX i.c*, no diagnostic features of either SB or HP could be identified at Umbeli Belli. Further, a direct comparison with Holley Shelter, which is supposed to belong to the Sibudan complex, showed strong differences between those assemblages. Neither the characteristic Ndwedwe tools nor the high number of splintered pieces are part of the archaeological signal. The high percentage of bifacial and unifacial points associated with frequent bipolar quartz reduction and slight evidence for a hollow-based point (*APPENDIX i.c, Fig. 6, Nr. 7*) finally pointed towards a possible attribution to the final MSA. Final conclusions couldn't have been made due to the absence of unambiguous examples of hollow-based points as well as the insufficient knowledge of the final MSA and its different regional expressions. The final statement of Bader et al. (2016) is cautious in the light of missing ages. We state that Umbeli Belli was a place which was attractive to prehistoric hunter gatherers for many reasons, including the close proximity to water and prey as well as raw material, the protective nature of the shelter itself and the exposed situation providing view over the valley. It has been shown that people spend considerable amounts of time at the place, produced hunting weapons, used them and brought them back to the site. The work on this old collection represents the starting point for new research using modern standards of excavation and analysis.

Chapter 3.4: A Return to Umbeli Belli. First insights of recent excavations and implications for the final MSA in KwaZulu-Natal – ***Bader & Conard in prep.*** (*APPENDIX ii.a*)

This chapter concerns the first results from new excavations at Umbeli Belli under the leadership of myself and Nicholas Conard. Excavations have been carried out in early 2016 and 2017 with the support of a mixed team of German and South African

archaeology students. Due to the previous work conducted by Charles Cable which provided relatively scarce information on the stratigraphic situation of Umbeli Belli one of our major ambitions was a revision of the stratigraphy including geological and archaeological observations. As a second step we wanted to characterize one specific geological horizon (GH7) with regards to the lithic technology and with special focus on the retouched tool component. The observation of distinct chrono-cultural markers, the so called hollow-based points in this horizon implied an attribution to the final MSA complex. Other “guide fossils” such as SB points (Villa et al., 2009, Wadley, 2007), segments (Wadley and Mohapi, 2008, Wurz, 1999) and unifacial points (Bader et al., 2015, Conard and Will, 2015, Will et al., 2014) are common in large quantities in specific technocomplexes but can appear in almost every assemblage within the last 100.000 years. Hollow-based points, though, have been only documented from final MSA contexts in eastern South Africa, dating roughly between 30 and 40 ka. Hence, an attribution of the GH7 assemblage to the final MSA was much likely. In addition, first rough age estimates using optically stimulated luminescence (OSL) by C. Tribolo (pers. com.) place the GH7 assemblage within MIS3. Similar to the post HP assemblages (see also Chapter 3.1 and 3.2) the final MSA of Southern Africa has been poorly understood and this is probably a result of the strong research focus on HP and SB contexts, but also of the relative scarcity of sites providing comparable archaeological signals. While the winter rainfall zone (WRZ) lacked in any considerable final MSA signal until recently (Mackay et al., 2014b), the summer rainfall zone (SRZ) including KZN shows a diverse situation. This region includes very young final MSA assemblages, e.g. at Sibudu (Wadley, 2005b) and Umhlatuzana (Kaplan, 1989) dating to between 35 and 40 ka and very old LSA assemblages from Border Cave probably predating 40 ka (Villa et al., 2012) that have nothing in common with the final MSA signal from Sibudu and Umhlatuzana. Although this period seems to be rather exceptional the final MSA of KZN has not been properly defined and thus this was the second major ambition of Bader and Conard (in prep). As shown in *APPENDIX ii.a* we subdivided the entire archaeological sequence into 8 distinct geological horizons. The differences have been observed in terms of sediment consistency and color change but also visible changes in artifact density have been considered. Two horizons, GH4 and GH6 are boarders rather than real layers and have been defined simply as accumulations of roof spall. GH6 matches Cables (1984) layer of “naturally accumulated rocks” that

separates the MSA and LSA occupations. Hence GH7 was supposed to represent the first horizon clearly associated with an MSA occupation and this could be confirmed by our own observations on the lithic assemblage. GH7 reaches a maximum thickness of 28 cm and is defined as reddish brown, fine homogenous sand with small amounts of quartzite spall. In several cases we applied different analytical methods compared to our previous work. At first we were using a cut-off size of 2 cm. Before we could excavate the MSA assemblages at Umbeli Belli we had to dig through 40 to 50 cm of LSA material requiring a smaller cut-off size than MSA assemblages because most relevant artifacts in these layers are smaller than 3 cm. Thus, in order to produce comparable data throughout the entire sequence we decided to adapt this approach for the MSA assemblages too. Secondly, similar to our previous work at the old collection from Umbeli Belli (*APPENDIX i.c*) we didn't apply the techno-functional approach. Instead we used a combination between chaîne opératoire and attribute analysis and added our own concept concerning the shape of retouched tools. This was the result of our observation that the retouched points from GH7 exhibit two distinct morphological groups that feature many aspects of modern arrowheads. These modern arrowheads can be subdivided into two types. Broad heads are characterized by a triangular shape with sharp lateral cutting edges causing lots of inner bleeding when they are used for hunting purposes. Broad heads are flat and wide. Over longer distances they tend to be deflected by wind, however, because of their large surface. The second group is called target points and designed for target shooting. These points are more bullet-like in shape, round and fly stable over long distances (*See APPENDIX ii.a for further discussion*). It was through the authors knowledge of this projectile system that this association with the points from Umbeli Belli arose. At first sight two different morphological pointed forms have been recognized featuring strong similarities with the modern points described above and hence we named these forms broad heads and target points. In order to verify our impression we took several metrical values. The two most relevant ones are first the relation between width and thickness measured always at 2 cm distance to the distal tip. We choose the 2 cm distance since it allowed us to include most of the points into our statistics no matter if they were broken or not. The second value was the Tip Penetrating Angle (TPA) having been calculated by measuring the maximum width of the point 1 cm distant from the tip and using a trigonometric formula provided by Dibble and Bernard (1980). We were using this indirect method for comparative

reasons since Villa and Lenoir (2006) applied the same method to point assemblages from Sibudu. Both metrics implied strongly different values for broad heads and target points (see also *APPENDIX ii.a, Table 4*). Broad Heads have a high width/thickness ratio and a wide TPA compared to target points having a low width/thickness ratio and an acute TPA. In addition almost all of these points exhibit intensive basal thinning which is commonly associated with hafting facilities. The general hypothesis using this approach was the assumption that different shapes provide different physical properties that are desirable for hunter-gatherers depending on the purpose of the tool. We did not make final conclusions about the different kinds of use these pieces might have served because further studies including residue and use wear analysis are relevant. However, based on the physical properties their use as projectiles is likely. Within the category of broad heads we included four distinct hollow-based points. This was due to our impression that the hollow base of these pieces does not necessarily represent a functional advantage but could rather be a variation within a broad context of tool technology. Hollow-based points have been considered at least since the late 1980s (Kaplan, 1989) to be the only distinct feature associated with the final MSA (See also *discussion section APPENDIX ii.a*). An objective count of all hollow-based points ever published showed that including the specimens from Umbeli Belli only 26 of them exist. Apart from two isolated pieces, one from a undated surface site called Kleinmonde (Clark, 1959) on the eastern cape and one from Border Cave associated with an age between 80.000 and 100.000 (Beaumont, 1978) all pieces from Umhlatuzana and Sibudu come from final MSA context. From our point of view it is unlikely that these isolated find category is the only recurrent archaeological signal that determines the final MSA. Thus, we reviewed the phenomenon hollow-based points and took our metrical and technological data into account as well as ethno-archaeological observations. We could show that hollow-based points are by no means different than straight based broad heads in terms of physical properties and discussed a possible hafting scenario that would be applicable to both hollow and straight based points. Ethno-archaeological comparisons with san material culture (Wiessner, 1983, 1989) further provided evidence that the base of a projectile can be subject to purely individual decisions while the shape often reflects social identity and is standardized. We could show that the final MSA at Umbeli Belli provides a clear archaeological signal including highly characteristic tools that appear in large

quantities and hollow-based points are embedded into this signal rather than being exceptional. Another important result from the GH7 assemblage involves the shaping technology. We were able to identify a large quantity of flakes standing in direct association with the terminal shaping process of tools. These shaping flakes have been identified in the work of Soriano and colleagues (2009). The authors of this study defined three stages of shaping flakes based on their work at the SB assemblages from Sibudu and their analysis implied that over 90% of all flakes in these layers are directly associated with a shaping process. However, it was our impression that the definition of these three stages was relatively subjective and apart from the final stage 3 we were not able to reproduce the system (*APPENDIX ii.a*). Therefore, we only counted diagnostic stage 3 shaping flakes at Umbeli Belli which totaled 17%. This percentage is not much smaller than the 28% published for the SB assemblage at Sibudu (Soriano et al., 2009) or the 30% published for the SB layers at Diepkloof (Porráz et al., 2013). In addition, we identified a large number of flakes from Umbeli Belli that are likely to be shaping flakes, as well, but are strongly fragmented and thus couldn't be included. The relevance of this insight increases in the light of suggestions that intensive shaping is a diagnostic feature of the SB (Porráz et al., 2013, Soriano et al., 2009) not having been identified in other MSA assemblages. However, at Umbeli Belli we could show that this technology is not limited to the SB but can appear in other assemblages in comparable high frequencies, such as during the final MSA.

In conclusion, we argue that the final MSA represents a well-structured archaeological signal that is clearly distinct from other assemblages but not less sophisticated. We could show that hollow-based points are an embedded feature within a diagnostic technocomplex. The final MSA is a key period for understanding cultural change at the end of the MSA. Especially in the light of overlapping chronological ages between final MSA and early LSA (ELSA) (Villa et al., 2012) Umbeli Belli is situated within a hot-spot archaeological region that will contribute essentially to our understanding of cultural and demographic change in the coming decades. We further argued that the scientific potential of Umbeli Belli was highly underestimated and we propose the site as a reference site for the final MSA in eastern South Africa.

Chapter 3.5: Bringing the Middle Stone Age into clearer focus – **Conard et al. 2014**
(APPENDIX i.d)

The fifth and last article included into this thesis was placed at the end of this summary, rather than in chronological order, as it includes results that have been achieved by numerous scientists over the last years including myself. It is the outcome of an international conference held at the castle Hohentübingen in 2014 and organized by N.J. Conard, C. Miller and G. Porraz. It was the major ambition of the conference to restructure our understanding of the MSA complexity and variability and question pre-existing models of chrono-cultural successions proposed by Jacobs et al. (2008a) and Henshilwood (2012). The basic critique concerns the research focus being limited to SB and HP periods and the proposal of those periods being well-structured, sophisticated and well-dated compared to previous and succeeding ones. Conard et al. (2014: 124) suggest a “longing for order and clarity” within a previously complicated and poorly understood archaeological sequence as a possible driver for this blurred situation manifested within the so called “synthetic model” (see also APPENDIX i.d, Fig. 2). In first instance fairly contradictory chronometric ages for the SB and HP at Diepkloof were discussed. Jacobs et al. (2008a) provided dates of 75-71 ka and 65-59 ka and thus implied both periods were relatively short lived. However, Tribolo and colleagues raised questions on the correctness of these dates in the light of significantly older dates of a longer cultural duration achieved by their team (Tribolo et al., 2009, 2013). In a second instance it became evident that not only the chronometric ages but also the cultural signals of these periods are not unidirectional but diverse both temporally and regionally. Porraz and colleagues (Porraz et al., 2013) e.g. showed that the HP at Diepkloof exhibits internal technological differences and de la Peña et al. (2013) provided similar evidence from Sibudu due to the presence of bifacial technology within the HP complex. On a larger scale the work of many researchers including the authors (Bader et al., 2015, 2016, Bader and Conard, in prep, Conard et al., 2012, Conard and Will, 2015, Lombard and Parsons, 2011, Will and Conard, 2017, Will et al., 2014,) has shown that this variability exists not only within the HP and SB but most likely in all MSA complexes. Thus, the work of Conard et al. (2014) and hence the outcome of the conference in 2014 represents a revised theoretical and empirical model of the MSA. It further represents the thread of the current thesis and thus stays correctly at the end of this discussion.

Chapter 4: Conclusion

This thesis represents the results of three and a half years of intensive research aiming to improve our understanding of cultural change and complexity within the MSA of South Africa. The focus was limited both temporally and spatially to the MIS3 assemblages of KwaZulu-Natal. This was not a decision by chance but arose from the observation that research on the MSA within the last decades was either too limited to rather sensational isolated aspects or to the attempt of understanding the broad picture in the absence of reliable archaeological data. It is my strong conviction that archaeologists first need to understand cultural variability on a site based scale, and later regional scale, before they open their minds to any higher theory. This thesis does not represent a final stage of research but the ongoing attempt to provide reliable data for the archaeological region of KwaZulu-Natal. Three out of five known MSA sites in this region, namely Holley Shelter, Sibudu and Umbeli Belli, have been subject to this thesis and thus it likely represents the most comprehensive work in the region on the MSA based on self-acquired data. In summary, the results can be outlined as given below.

First we generally confirm that the archaeological signal of MIS3 is diverse and exhibits the frequent observation of inner and inter-assemblage variability. However, this does not mean that it is entirely unstructured. If we accept the chronological placement of Holley Shelter shortly after the HP and within the broad range of the Sibudan than several statements can be proposed. Both the knappers at Sibudu and Holley Shelter had a similar mental template with regards to their material culture as evident from numerous overlapping tools and reduction chains. But within this mental template we found evidence for individuality on a site based scale. Although the general assemblage composition is similar in many aspects we see significant differences in size and distribution patterns. While the Sibudan knappers produced large amounts of Tongati tools firstly, and Ndwedwe tools secondly, at Holley Shelter we see a reversed picture with the Ndwedwe tools found at the site being the largest in the entire KZN region. Also, patterns of core reduction point to a similar technological orientation but at Holley Shelter the likely access to large hornfels slabs from primary outcrops favored the reduction of large blades from semi-circumferential and narrow sided platform cores. In addition, to the best of our knowledge Holley Shelter represents the only site with an overwhelmingly high percentage of splintered

pieces associated with clear MSA technology. On a larger scale we see similarities in cultural change through time, most evident from the similar pattern of raw material choice at Sibudu, Holley Shelter and also Umhlatuzana. Observations on the last site are exclusively based on literature (Kaplan, 1989, 1990) but we see in all three sites a gradual change from quartz dominated assemblages with few retouched tools towards a preference of hornfels and dolerite and large quantities of pointed tools shortly after the HP. All these observations certainly remain to be tested by new excavations using modern standards and would be strengthened by the inclusion of absolute chronological ages, especially at Holley Shelter.

Moving forward in time, Umbeli Belli has started to improve our knowledge of the end of the MSA in KZN. We have shown that the final MSA technology at the site is well structured and provides frequent evidence for specific tools that are most likely associated with projectile technology. For this study we developed a morphometric approach specifically designed for the archaeological signal observed at Umbeli Belli. We discussed the phenomenon of alien-type artifacts such as hollow-based points and showed that this does not necessarily indicate the influence of foreign groups (Clark, 1959) but can be the result of personal decision and preference. It remains true, however, that final MSA assemblages comparable to Umbeli Belli seem to be restricted to KZN, so far. Other assemblages associated with the end of the MSA, e.g. at Rose Cottage in the Basutolian eco-zone (Clark, 1997a, b), Border Cave at the northern edge of KZN (Beaumont, 1978, Villa et al., 2012) or Putslaagte 1 In the WRZ (Mackay et al., 2014b) seem to be significantly different and also exhibit diverse dating results. Others such as e.g. Sibebe in Swasiland (Price-Williams, 1981) are insufficiently published and require detailed reinvestigations in order to clarify their relation to the KZN sites. Yet it needs to be said that also a reinvestigation of the Umhlatuzana and Sibudu final MSA assemblages should be conducted to explain the cultural signal we received so far from the eastern part of South Africa. However it is possible that the cultural fragmentation during MIS3 mentioned by Mackay and colleagues (2014a) is a gradual process and reaches his maximum extend at around 30 to 40 ka. It was discussed in Chapter 1 that the reasons for cultural variability and change can be of diverse origin, including external and internal factors, and we probably won't be able to state any concrete conclusions on this aspect at any time. As outlined by Lombard and Parsons (2011) innovations have been subject to frequent invention, discard and re-invention for several reasons, even within relatively

short periods, and this is how culture has to be understood. I finally conclude with a similar statement to one made by Conard et al. (2014) regarding the MSA conference in Tübingen: At the end more questions appear than answers. But this should be seen in the most positive light as it stimulates our attempt to move on and develop innovational methods in order to understand our past. Science, and thus stone-age archaeology, is dynamic rather than static and attempts to improve itself continuously yet will likely never reach perfection.

References

- ANDREFSKY, W. J. 1994. Raw-Material Availability and the organization of technology. *American Antiquity*, 59, 21-34.
- ANDREFSKY JR, W. 2005. *Lithics: Macroscopic approaches to analysis*. Cambridge: Cambridge University Press.
- BACKWELL, L., D'ERRICO, F. & WADLEY, L. 2008. Middle Stone Age bone tools from the Howiesons Poort layers, Sibudu Cave, South Africa. *Journal of Archaeological Science*, 35, 1566-1580.
- BADER, G. D. & CONARD, N. J. in prep. A return to Umbeli Belli. First insights of recent excavations and implications for the final MSA in KwaZulu-Natal.
- 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. *The South African Archaeological Bulletin*, 70, 149-165.
- BADER, G. D., CABLE, C., LENTFER, C. & CONARD, N. J. 2016. Umbeli Belli Rock Shelter, a forgotten piece from the puzzle of the Middle Stone Age in KwaZulu-Natal, South Africa. *Journal of Archaeological Science: Reports*, 9, 608-622.
- BAYLISS, A. 2016. Rolling out revolution: Using radiocarbon dating in archaeology. *Radiocarbon*, 51, 123-147.
- BEAUMONT, P. B. 1978. *Border Cave*. Unpublished Ph.D. thesis. University of Cape Town.
- BECHER, J. 2016. *Die organischen artefakte von Sibudu, Südafrika*. Unpublished B.A. thesis, University of Tübingen.
- BEYENE, Y., KATOH, S., WOLDEGABRIEL, G., HART, W. K., UTO, K., SUDO, M., KONDO, M., HYODO, M., RENNE, P. R. & SUWA, G. 2013. The characteristics and chronology of the earliest Acheulean at Konso, Ethiopia. *Proceedings of the National Academy of Sciences*, 110, 1584-1591.
- BINFORD, L. R. 1978. *Nunamiut ethnoarchaeology*. New York/London: Academic Press.
- BINFORD, L. R. 1982. The archaeology of place. *Journal of Anthropological Archaeology*, 1, 5-31.
- BISHOP, W. W. & CLARK, J. D. Background to evolution in Africa; proceedings. Symposium on systematic investigation of the African Later Tertiary and Quaternary (1965: Burg Wartenstein, Austria), 1967. University of Chicago Press.
- BISSON, M. 2000. Nineteenth century tools for twenty-first century archaeology? Why the Middle Paleolithic typology of François Bordes must be replaced. *Journal of Archaeological Method and Theory*, 7, 1-48.
- BOËDA, E. 1993. Le débitage discoïde et le débitage Levallois récurrent centripède. *Bulletin de la Société préhistorique française*, 90, 392-404.
- BOËDA, E. 1994. *Le concept Levallois, variabilité des méthodes*, CNRS éditions.
- BOËDA, E. 2001. Détermination des unités techno-fonctionnelles de pièces bifaciales provenant de la couche acheuléenne C3 base du site de Barbas I. In: CLIQUET, D. (ed.) *Les industries à outils bifaciaux du Paléolithique moyen d'Europe occidentale*. Actes de la table-ronde internationale organisée à Caen, 14-15 Octobre 1999, ERAUL 98: 51-76. Liège: ERAUL.
- BOËDA, E., GENESTE, J.-M. & MEIGNEN, L. 1990. Identification de chaînes opératoires lithiques du Paléolithique ancien et moyen. *Paléo*, 2, 43-80.
- BÖHNER, U., SERANGELI, J. & RICHTER, P. 2015. The Spear Horizon: First spatial analysis of the Schöningen site 13 II-4. *Journal of Human Evolution*, 89, 202-213.
- BONILAURI, S. 2010. *Les outils du Paléolithique moyen, une mémoire technique oubliée ? Approche techno-fonctionnelle appliquée à un assemblage lithique de conception Levallois provenant du site d'Umm el Tiel (Syrie centrale)*. Unpublished Ph.D. thesis, Nanterre, University of Paris X.
- BORDES, F. 1961. *Typologie du Paléolithique ancien et moyen*. Bordeaux: Delmas.
- BRAIN, C. 1968. Who killed the Swartkrans ape-men. *South African Museums Association Bulletin*, 9, 7-39.

- BRANTINGHAM, P. J., OLSEN, J. W., RECH, J. A. & KRIVOSHAPKIN, A. I. 2000. Raw material quality and prepared core technologies in Northeast Asia. *Journal of Archaeological Science*, 27, 255-271.
- BRÄUER, G. 1984. A craniological approach to the origin of anatomically modern Homo sapiens in Africa and implications for the appearance of modern Europeans. In: SMITH, F & SPENCER, F. (eds.) *The origins of modern humans: A world survey of the fossil evidence*, 327-410. New York: Liss.
- BRAUN, D. R. & HARRIS, J. W. 2003. Technological developments in the Oldowan of Koobi Fora. *Treballs d'Arqueologia*, 2003. 117-144.
- BRAUN, D. R., PLUMMER, T., FERRARO, J. V., DITCHFIELD, P. & BISHOP, L. C. 2009. Raw material quality and Oldowan hominin toolstone preferences: evidence from Kanjera South, Kenya. *Journal of Archaeological Science*, 36, 1605-1614.
- BRETZKE, K., MARKS, A. E. & CONARD, N. J. 2006. Projektiltechnologie und Kulturelle Evolution in Ostafrika. *Mitteilungen der Gesellschaft für Urgeschichte*, 15, 63-81.
- BROWN, K. S., MAREAN, C. W., HERRIES, A. I. R., JACOBS, Z., TRIBOLO, C., BRAUN, D., ROBERTS, D. L., MEYER, M. C. & BERNATCHEZ, J. 2009. Fire as an engineering tool of early modern humans. *Science*, 325, 859-862.
- BUTZER, K. W., BEAUMONT, P. B. & VOGEL, J. C. 1978. Lithostratigraphy of Border Cave, KwaZulu, South Africa: a Middle Stone Age sequence beginning c. 195,000 b.p. *Journal of Archaeological Science*, 5, 317-341.
- CABLE, C. 1984. Economy and technology in the Late Stone Age of southern Natal. *Cambridge Monographs in African Archaeology*. BAR.
- CAMPISANO, C. J. 2012. Geological summary of the busidima formation (Plio-Pleistocene) at the Hadar paleoanthropological site, afar depression, Ethiopia. *Journal of Human Evolution*, 62, 338-352.
- CHASE, B. M. & MEADOWS, M. E. 2007. Late Quaternary dynamics of southern Africa's winter rainfall zone. *Earth-Science Reviews*, 84, 103-138.
- CHEVRIER, B. 2012. *Les assemblages à pièces bifaciales au Pléistocène inférieur et moyen ancien en Afrique de l'Est et au Proche-Orient : nouvelle approche du phénomène bifacial appliquée aux problématiques de migrations, de diffusion et d'évolution locale*. Unpublished Ph.D. thesis. Nanterre: University of Paris X.
- CLARK, A. M. B. 1997a. The final Middle Stone Age at Rose Cottage Cave: a distinct industry in the Basutolian ecozone. *South African journal of science*, 93, 449-458.
- CLARK, A. M. B. 1997b. The MSA/LSA transition in Southern Africa: New technological evidence from Rose Cottage Cave. *The South African Archaeological Bulletin*, 52, 113-121.
- CLARK, J. D. 1959. *The prehistory of Southern Africa*. Harmondsworth: Penguin Books.
- CLARK, J. L. & LIGOUIS, B. 2010. Burned bone in the Howieson's Poort and post-Howieson's Poort Middle Stone Age deposits at Sibudu (South Africa): behavioral and taphonomic implications. *Journal of Archaeological Science*, 37, 2650-2661.
- CLARK, J. L. & PLUG, I. 2008. Animal exploitation strategies during the South African Middle Stone Age: Howiesons Poort and post-Howiesons Poort fauna from Sibudu Cave. *Journal of Human Evolution*, 54, 886-898.
- 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, 65-75.
- COCHRANE, G. W. G. 2006. An analysis of lithic artefacts from the ~60 ka layers of Sibudu Cave. *Southern African Humanities*, 18, 69-88.
- CONARD, N. J. & ADLER, D. S. 1997. Lithic reduction and hominid behavior in the Middle Paleolithic of the Rhineland. *Journal of Anthropological Research*, 53, 147-175.
- CONARD, N. J. & WILL, M. 2015. Examining the causes and consequences of short-term behavioral change during the Middle Stone Age at Sibudu, South Africa. *PLoS ONE*, 10, e0130001.
- CONARD, N. J., SORESSI, M., PARKINGTON, J. E., WURZ, S. & YATES, R. 2004. A unified lithic taxonomy based on patterns of core reduction. *South African Archaeological Bulletin*, 59, 12-16.

- CONARD, N. J., PORRAZ, G. & WADLEY, L. Y. N. 2012. What is in a name? characterizing the Post-Howiesons Poort at Sibudu. *The South African Archaeological Bulletin*, 67, 180-199.
- CONARD, N. J., BADER, G. D., SCHMID, V. C. & WILL, M. 2014. Bringing the Middle Stone Age into clearer focus. *Mitteilungen der Gesellschaft für Urgeschichte*, 23, 121-127.
- COOKE, H. B. S., MALAN, B. D. & WELLS, L. H. 1945. 3. Fossil man in the Lebombo Mountains, South Africa: The 'Border Cave,' Ingwavuma District, Zululand. *Man*, 45, 6-13.
- CORVINUS, G. 2004. Homo erectus in East and Southeast Asia, and the questions of the age of the species and its association with stone artifacts, with special attention to handaxe-like tools. *Quaternary International*, 117, 141-151.
- CRAMB, J. 1952. A Middle Stone Age industry from a Natal rock shelter. *South African Journal of Science*, 48, 181-186.
- CRAMB, J. 1961. A second report on work at the Holley Shelter. *South African Journal of Science*, 57, 45-48.
- D'ERRICO, F. & BACKWELL, L. 2016. Earliest evidence of personal ornaments associated with burial: The conus shells from Border Cave. *Journal of Human Evolution*, 93, 91-108.
- D'ERRICO, F., HENSHILWOOD, C., VANHAEREN, M. & VAN NIEKERK, K. 2005. Nassarius kraussianus shell beads from Blombos Cave: evidence for symbolic behaviour in the Middle Stone Age. *Journal of Human Evolution*, 48, 3-24.
- 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, 2675-2685.
- D'ERRICO, F. & VANHAEREN, M. 2009. Earliest personal ornaments and their significance for the origin of language debate. In: BOTHA, R. & KNIGHT, C. (eds.) *The cradle of language*. New York: Oxford University Press.
- DART, R. 1957. *The Osteodontoceratic culture of Australopithecus prometheus*. Transvaal Museum, Pretoria.
- DE LA PEÑA, P. & WADLEY, L. 2014a. New knapping methods in the Howiesons Poort at Sibudu (KwaZulu-Natal, South Africa). *Quaternary International*, 350, 26-42.
- DE LA PEÑA, P. & WADLEY, L. 2014b. Quartz knapping strategies in the Howiesons Poort at Sibudu (KwaZulu-Natal, South Africa). *PLoS ONE*, 9, e101534.
- DE LA PEÑA, P., WADLEY, L. & LOMBARD, M. 2013. Quartz bifacial points in the Howiesons Poort of Sibudu. *South African Archaeological Bulletin*, 68.
- DE LA TORRE, I. 2004. Omo Revisited: Evaluating the technological skills of pliocene hominids. *Current Anthropology*, 45, 439-465.
- DE RUITER, D. J. & BERGER, L. R. 2000. Leopards as taphonomic agents in dolomitic caves-Implications for bone accumulations in the hominid-bearing deposits of South Africa. *Journal of Archaeological Science*, 27, 665-684.
- DEACON, H. J. 1995. Two Late Pleistocene-Holocene archaeological depositories from the Southern Cape, South Africa. *The South African Archaeological Bulletin*, 50, 121-131.
- DEACON, H. J. & DEACON, J. 1999. *Human beginnings in South Africa: uncovering the secrets of the Stone Age*. Cape Town/Johannesburg: David Philip Publishers.
- DEACON, J. 1984. *The Later Stone Age of Southernmost Africa*. BAR Oxford.
- DELAGNES, A., TRIBOLO, C., BERTRAN, P., BRENET, M., CRASSARD, R., JAUBERT, J., KHALIDI, L., MERCIER, N., NOMADE, S., PEIGNÉ, S., SITZIA, L., TOURNEPICHE, J.-F., AL-HALIBI, M., AL-MOSABI, A. & MACCHIARELLI, R. 2012. Inland human settlement in southern Arabia 55,000 years ago. New evidence from the Wadi Surdud Middle Paleolithic site complex, western Yemen. *Journal of Human Evolution*, 63, 452-474.
- DENNELL, R. 1997. The world's oldest spears. *Nature*, 385, 767.
- DIBBLE, H. L. 1987. The Interpretation of Middle Paleolithic scraper morphology. *American Antiquity*, 52, 109-117.
- DIBBLE, H. L. & BERNARD, M. C. 1980. A Comparative study of basic edge angle measurement techniques. *American Antiquity*, 45, 857-865.

- DIEZ-MARTÍN, F., YUSTOS, P. S., URIBELARREA, D., BAQUEDANO, E., MARK, D., MABULLA, A., FRAILE, C., DUQUE, J., DÍAZ, I. & PÉREZ-GONZÁLEZ, A. 2015. The origin of the Acheulean: the 1.7 million-year-old site of FLK West, Olduvai Gorge (Tanzania). *Scientific reports*, 5, 17839.
- DRISCOLL, K. 2011. Vein quartz in lithic traditions: an analysis based on experimental archaeology. *Journal of Archaeological Science*, 38, 734-745.
- EVANS, U. 1994. Hollow Rock Shelter, A Middle Stone Age site in the Cederberg." *Southern African Field Archaeology*, 3, 63-73
- FUSS, J., SPASSOV, N., BEGUN, D. R. & BÖHME, M. 2017. Potential hominin affinities of *Graecopithecus* from the Late Miocene of Europe. *PLOS ONE*, 12, e0177127.
- GABUNIA, L., VEKUA, A., LORDKIPANIDZE, D., SWISHER, C. C., FERRING, R., JUSTUS, A., NIORADZE, M., TVALCHRELIDZE, M., ANTÓN, S. C., BOSINSKI, G., JÖRIS, O., LUMLEY, M.-A. D., MAJSURADZE, G. & MOUSKHELISHVILI, A. 2000. Earliest pleistocene hominid cranial remains from Dmanisi, Republic of Georgia: Taxonomy, Geological Setting, and Age. *Science*, 288, 1019-1025.
- GOLDBERG, P., MILLER, C. E., SCHIEGL, S., LIGOUIS, B., BERNA, F., CONARD, N. J. & WADLEY, L. 2009. Bedding, hearths, and site maintenance in the Middle Stone Age of Sibudu Cave, KwaZulu-Natal, South Africa. *Archaeological and Anthropological Sciences*, 1, 95-122.
- GOODWIN, A. J. H. & VAN RIET LOWE, C. 1929. The Stone Age cultures of South Africa. *Annals of the South African Museum*, 27, 1-289.
- GRÜN, R. & BEAUMONT, P. 2001. Border Cave revisited: a revised ESR chronology. *Journal of Human Evolution*, 40, 467-482.
- GUÉRIN, G., MURRAY, A. S., JAIN, M., THOMSEN, K. J. & MERCIER, N. 2013. How confident are we in the chronology of the transition between Howieson's Poort and Still Bay? *Journal of Human Evolution*, 64, 314-317.
- HAIDLE, MIRIAM N. 2010. Working-memory capacity and the evolution of modern cognitive potential: Implications from Animal and Early Human Tool Use. *Current Anthropology*, 51, 149-166.
- HARMAND, S., LEWIS, J. E., FEIBEL, C. S., LEPRE, C. J., PRAT, S., LENOBLE, A., BOES, X., QUINN, R. L., BRENET, M., ARROYO, A., TAYLOR, N., CLEMENT, S., DAVER, G., BRUGAL, J.-P., LEAKEY, L., MORTLOCK, R. A., WRIGHT, J. D., LOKORODI, S., KIRWA, C., KENT, D. V. & ROCHE, H. 2015. 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. *Nature*, 521, 310-315.
- HENDEY, Q. B. & SINGER, R. 1965. Part III: The faunal assemblages from the Gamtoos Valley Shelters. *The South African Archaeological Bulletin*, 20, 206-213.
- HENSHILWOOD, C. S. 2005. Stratigraphic integrity of the middle stone age levels at Blombos cave. In: D'ERRICO, F. & BACKWELL, L. (eds.) *From Tools to Symbols. From Early Hominids to Modern Humans*. Witwatersrand University Press, Johannesburg.
- 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, 205-237.
- HENSHILWOOD, C. S., SEALY, J. C., YATES, R., CRUZ-URIBE, K., GOLDBERG, P., GRINE, F. E., KLEIN, R. G., POGGENPOEL, C., VAN NIEKERK, K. & WATTS, I. 2001. Blombos Cave, Southern Cape, South Africa: Preliminary report on the 1992–1999 excavations of the Middle Stone Age levels. *Journal of Archaeological Science*, 28, 421-448.
- HENSHILWOOD, C. S., D'ERRICO, F., VANHAEREN, M., VAN NIEKERK, K. & JACOBS, Z. 2004. Middle Stone Age Shell Beads from South Africa. *Science*, 304, 404.
- HENSHILWOOD, C. S., D'ERRICO, F. & WATTS, I. 2009. Engraved ochres from the Middle Stone Age levels at Blombos Cave, South Africa. *Journal of Human Evolution*, 57, 27-47.
- HENSHILWOOD, C. S., D'ERRICO, F., VAN NIEKERK, K. L., COQUINOT, Y., JACOBS, Z., LAURITZEN, S.-E., MENU, M. & GARCÍA-MORENO, R. 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. *Science*, 334, 219-222.

- HENSHILWOOD, C. S., VAN NIEKERK, K. L., WURZ, S., DELAGNES, A., ARMITAGE, S. J., RIFKIN, R. F., DOUZE, K., KEENE, P., HAALAND, M. M., REYNARD, J., DISCAMPS, E. & MIENIES, S. S. 2014. Klipdrift Shelter, southern Cape, South Africa: preliminary report on the Howiesons Poort layers. *Journal of Archaeological Science*, 45, 284-303.
- JACOBS, Z. & ROBERTS, R. G. 2008. Testing times: old and new chronologies for the Howieson's Poort and Still Bay industries in environmental context. *Goodwin Series*, 10, 9-34.
- JACOBS, Z., ROBERTS, R. G., GALBRAITH, R. F., DEACON, H. J., GRÜN, R., MACKAY, A., MITCHELL, P., VOGELSANG, R. & WADLEY, L. 2008a. Ages for the Middle Stone Age of Southern Africa: Implications for human behavior and dispersal. *Science*, 322, 733-735.
- JACOBS, Z., WINTLE, A. G., DULLER, G. A. T., ROBERTS, R. G. & WADLEY, L. 2008b. New ages for the post-Howiesons Poort, late and final Middle Stone Age at Sibudu, South Africa. *Journal of Archaeological Science*, 35, 1790-1807.
- KANDEL, A. W., BOLUS, M., BRETZKE, K., BRUCH, A. A., HAIDLE, M. N., HERTLER, C. & MÄRKER, M. 2016. Increasing behavioral flexibility? An integrative macro-scale approach to understanding the Middle Stone Age of Southern Africa. *Journal of Archaeological Method and Theory*, 23, 623-668.
- KAPLAN, J. 1989. 45000 years of hunter-gatherer history in Natal as seen from Umhlatuzana Rock Shelter. *Goodwin Series*, 6, 7-16.
- KAPLAN, J. 1990. The Umhlatuzana rock shelter sequence: 100 000 years of Stone Age history. *Southern African Humanities*, 2, 1-94.
- KIMURA, Y. 2002. Examining time trends in the Oldowan technology at beds I and II, Olduvai Gorge. *Journal of Human Evolution*, 43, 291-321.
- KLEIN, R. G. 1977. The mammalian fauna from the Middle and Later Stone Age (Later Pleistocene) levels of Border Cave, Natal Province, South Africa. *The South African Archaeological Bulletin*, 32, 14-27.
- LANGEJANS, G. H. J. 2012. Middle Stone Age pièces esquillées from Sibudu Cave, South Africa: an initial micro-residue study. *Journal of Archaeological Science*, 39, 1694-1704.
- LARSEN-PETERKIN, G. 1993. Lithic and organic hunting technology. In: PETERKIN, G. L., BRICKER, H., MELLARS, P.A. (eds.) *Hunting and Animal Exploitation in the Later Paleolithic and Mesolithic of Eurasia*. American Archaeological Association: Washinkton DC.
- LEAKEY, L. S., TOBIAS, P. V. & NAPIER, J. R. 1964. A new species of the genus Homo from Olduvai Gorge. *Nature*, 202, 7-9.
- LEAKEY, L. S. B. 1951. *Olduvai Gorge: A Report on the evolution of the hand-axe culture in beds I-IV. With Chapters on the Geology and Fauna* Cambridge: Cambridge University Press.
- LEE, R. B. 1968. What hunters do for a living, or, how to make out on scarce resources. In: LEE, R.B. & DEVORE, I. (eds) *Man the hunter*. Chicago: Aldine Publishing Company.
- LEPOT, M. 1993. *Approche techno-fonctionnelle de l'outillage lithique moustérien: essai de classification des parties actives en termes d'efficacité technique*. Unpublished Master thesis. Nanterre: University of Paris X.
- LEPRE, C. J., ROCHE, H., KENT, D. V., HARMAND, S., QUINN, R. L., BRUGAL, J.-P., TEXIER, P.-J., LENOBLE, A. & FEIBEL, C. S. 2011. An earlier origin for the Acheulian. *Nature*, 477, 82-85.
- LOMBARD, M. 2006. First impressions of the functions and hafting technology of Still Bay pointed artefacts from Sibudu Cave. *Southern African Humanities*, 18, 27-41.
- LOMBARD, M. & PARSONS, I. 2011. What happened to the human mind after the Howiesons Poort? *Antiquity*, 85, 1433-1443.
- LOMBARD, M. & HAIDLE, M. N. 2012. Thinking a bow-and-arrow set: Cognitive implications of Middle Stone Age bow and stone-tipped arrow technology. *Cambridge Archaeological Journal*, 22, 237-264.

- LOMBARD, M. & PHILLIPSON, L. 2015. Indications of bow and stone-tipped arrow use 64 000 years ago in KwaZulu-Natal, South Africa. *Antiquity*, 84, 635-648.
- LOMBARD, M., WADLEY, L., JACOBS, Z., MOHAPI, M. & ROBERTS, R. G. 2010. Still Bay and serrated points from Umhlatuzana Rock Shelter, Kwazulu-Natal, South Africa. *Journal of Archaeological Science*, 37, 1773-1784.
- MACDONALD, D. H. & ANDREFSKY, W. 2008. The role of lithic raw material availability and quality in determining tool kit size, tool function, and degree of retouch: A case study from Skink Rockshelter (46NI445), West Virginia. In: ANDREFSKY, W. J. (ed.) *Lithic technology: Measures of production, use and curation*. Cambridge: Cambridge University Press.
- MACKAY, A. 2010. The late Pleistocene archaeology of Klein Kliphuis Rock Shelter, Western Cape, South Africa: 2006 Excavations. *The South African Archaeological Bulletin*, 65, 132-147.
- MACKAY, A. 2011. Nature and significance of the Howiesons Poort to post-Howiesons Poort transition at Klein Kliphuis rockshelter, South Africa. *Journal of Archaeological Science*, 38, 1430-1440.
- 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.
- MAGUIRE, R. 1997. A history of middle and late stone age research in the kwazulu-natal coastal area from 1871 to the beginning of the second world war. *Studies in honor of Professor J. Eloff*. National Cultural History Museum 6, 43-58.
- MAREAN, C. W., BAR-MATTHEWS, M., FISHER, E., GOLDBERG, P., HERRIES, A., KARKANAS, P., NILSSEN, P. J. & THOMPSON, E. 2010. The stratigraphy of the Middle Stone Age sediments at Pinnacle Point Cave 13B (Mossel Bay, Western Cape Province, South Africa). *Journal of Human Evolution*, 59, 234-255.
- MARKS, A. E. & VOLKMAN, P. 1983. Changing core reduction strategies: a technological shift from the Middle to the Upper Paleolithic in the Southern Levant. In: TRINKHAUS, E. (ed.) *The Mousterian legacy: human biocultural change in the Upper Pleistocene*, BAR.
- MAZEL, A. D. 1984. Diamond 1 and Clarke's Shelter: report on excavations in the northern Drakensberg, Natal, South Africa. *Annals of the Natal Museum*, 26, 25-70.
- MAZEL, A. D. 1986. Mgede Shelter: a mid- and late Holocene observation in the western Biggarsberg, Thukela Basin, Natal, South Africa. *Annals of the Natal Museum*, 27, 357-387.
- MAZEL, A. D. 1988a. Nkupe Shelter: report on excavations in the eastern Biggarsbeg, Thukela Basin, Natal, South Africa. *Annals of the Natal Museum*, 29, 321-377.
- MAZEL, A. D. 1988b. Sikhanyisweni Shelter: report on excavations in hte Thukela Basin, Natal, South Africa. *Annals of the Natal Museum*, 29, 379-406.
- MCBREARTY, S. & TRYON, C. 2006. From Acheulean to Middle Stone Age in the Kapthurin Formation, Kenya. In: HOVERS, E. & KUHN, S. L. (eds.) *Transitions before the transition: Evolution and stability in the Middle Paleolithic and Middle Stone Age*. Springer US, Boston.
- MCCALL, G. S. & THOMAS, J. T. 2009. Re-examining the South African Middle-to-Later Stone Age transition: Multivariate analysis of the Umhlatuzana and Rose Cottage Cave stone tool assemblages. *Azania: Archaeological Research in Africa*, 44, 311-330.
- MCCALL, G. S. & THOMAS, J. T. 2012. Still Bay and Howiesons Poort foraging strategies: Recent research and models of culture change. *African Archaeological Review*, 29, 7-50.
- MCDUGALL, I., BROWN, F. H. & FLEAGLE, J. G. 2005. Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature*, 433, 733-736.

- MCGREW, W. C., TUTIN, C. E. G. & BALDWIN, P. J. 1979. Chimpanzees, tools, and termites: Cross-cultural comparisons of Senegal, Tanzania, and Rio Muni. *Man*, 14, 185-214.
- MCPHERRON, S. P., ALEMSEGED, Z., MAREAN, C. W., WYNN, J. G., REED, D., GERAADS, D., BOBE, R. & BEARAT, H. A. 2010. Evidence for stone-tool-assisted consumption of animal tissues before 3.39 million years ago at Dikika, Ethiopia. *Nature*, 466, 857-860.
- MOHAPI, M. 2012. Point morphology and the middle stone age cultural sequence of Sibudu Cave, KwaZulu-Natal, South Africa. *The South African Archaeological Bulletin*, 67, 5-15.
- MOHAPI, M. 2013. The Middle Stone Age point assemblage from Umhlatuzana Rock Shelter : a morphometric study. *Southern African Humanities*, 25, 25-51.
- MONCEL, M.-H., DESPRIÉE, J., VOINCHET, P., TISSOUX, H., MORENO, D., BAHAIN, J.-J., COURCIMAULT, G. & FALGUÈRES, C. 2013. Early evidence of Acheulean settlement in Northwestern Europe - La Noira Site, a 700 000 year-old occupation in the center of France. *PLOS ONE*, 8, e75529.
- MOVIUS, H. L. 1950. A wooden spear of third interglacial age from lower Saxony. *Southwestern Journal of Anthropology*, 6, 139-142.
- ODELL, G. 1996. Economizing behavior and the concept of "Curation". In: ODELL, G. (ed.) *Stone Tools, theoretical insights into human prehistory*. New York: Plenum Press.
- ODELL, G. H. 2004. *Lithic Analysis. Manuals in archaeological method, theory, and technique*, Kluwer Academic, New York.
- ORTON, J. 2008. A useful measure of the desirability of different raw materials for retouch within and between assemblages: the raw material retouch index (RMRI). *Journal of Archaeological Science*, 35, 1090-1094.
- PARKINGTON, J. E. 1972. Seasonal mobility in the late stone age. *African Studies*, 31, 223-244.
- PARKINGTON, J. & BAILEY, G. N. 1988. *The archaeology of prehistoric coastlines*. Cambridge: Cambridge University Press.
- PARKINGTON, J., POGGENPOEL, C., HALKETT, D. & HART, T. 2004. Initial observations on the Middle Stone Age coastal settlement in the Western Cape, South Africa. In: CONARD, N.J. (ed.) *Settlement dynamics of the Middle Paleolithic and Middle Stone Age II*. Tübingen: Kerns.
- PELCIN, A. W. 1997. The formation of flakes: The role of platform thickness and exterior platform angle in the production of flake initiations and terminations. *Journal of Archaeological Science*, 24, 1107-1113.
- PELEGRIN, J. 2000. Les techniques de débitage laminaire au Tardiglaciaire: critères de diagnose et quelques réflexions. *L'Europe Centrale et Septentrionale au Tardiglaciaire. Confrontation des modèles régionaux*, 7, 73-86.
- PORRAZ, G., TEXIER, P. J., RIGAUD, J. P., PARKINGTON, J., POGGENPOEL, C. & ROBERTS, D. L. 2008. Preliminary characterization of a middle stone age lithic assemblage preceding the 'classic' Howiesons Poort complex at Diepkloof Rock Shelter, Western Cape Province, South Africa. *Goodwin Series*, 10, 105-121.
- PORRAZ, G., SCHMID, V. C., MILLER, C. E., TRIBOLO, C., CARTWRIGHT, C. C., CHARRIÉ-DUHAUT, A., IGREJA, M., MENTZER, S., MERCIER, N., SCHMIDT, P., CONARD, N. J., TEXIER, P.-J. & PARKINGTON, J. E. 2016. Update on the 2011 excavation at Elands Bay Cave (South Africa) and the Verlorenvlei Stone Age. *Southern African Humanities*, 29, 33-68.
- 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, 3376-3400.
- PRICE-WILLIAMS, D. 1981. A preliminary report on recent excavations of Middle and Late Stone Age levels at Sibebe Shelter, north-west Swaziland. *The South African Archaeological Bulletin*, 36, 22-28.

- PRUETZ, J. D. & BERTOLANI, P. 2007. Savanna Chimpanzees, *Pan troglodytes verus*, hunt with tools. *Current Biology*, 17, 412-417.
- REIMER, P. J., BAILLIE, M. G. L., BARD, E., BAYLISS, A., BECK, J. W., BLACKWELL, P. G., BRONK RAMSEY, C., BUCK, C. E., BURR, G. S., EDWARDS, R. L., FRIEDRICH, M., GROOTES, P. M., GUILDERTSON, T. P., HAJDAS, I., HEATON, T. J., HOGG, A. G., HUGHEN, K. A., KAISER, K. F., KROMER, B., MCCORMAC, F. G., MANNING, S. W., REIMER, R. W., RICHARDS, D. A., SOUTHON, J. R., TALAMO, S., TURNEY, C. S. M., VAN DER PLICHT, J. & WEYHENMEYER, C. E. 2016. IntCal09 and marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon*, 51, 1111-1150.
- RICHTER, D., GRÜN, R., JOANNES-BOYAU, R., STEELE, T. E., AMANI, F., RUÉ, M., FERNANDES, P., RAYNAL, J.-P., GERAADS, D., BEN-NCER, A., HUBLIN, J.-J. & MCPHERRON, S. P. 2017. The age of the hominin fossils from Jebel Irhoud, Morocco, and the origins of the Middle Stone Age. *Nature*, 546, 293-296.
- ROCHE, H., DELAGNES, A., BRUGAL, J. P., FEIBEL, C., KIBUNJIA, M., MOURRE, V. & TEXIER, P. J. 1999. Early hominid stone tool production and technical skill 2.34 Myr ago in West Turkana, Kenya. *Nature*, 399, 57-60.
- ROTS, V., LENTFER, C., SCHMID, V. C., PORRAZ, G. & CONARD, N. J. 2017. Pressure flaking to serrate bifacial points for the hunt during the MIS5 at Sibudu Cave (South Africa). *PLOS ONE*, 12, e0175151.
- SAMPSON, C. G. 1974. *The stone age archaeology of Southern Africa*. New York: Academic Press Inc.
- SAMPSON, C. G. & DEACON, J. 1976. The Stone Age Archaeology of Southern Africa. *The South African Archaeological Bulletin*, 31, 58-63.
- SANZ, C., CALL, J. & MORGAN, D. 2009. Design complexity in termite-fishing tools of chimpanzees (*Pan troglodytes*). *Biology Letters*, 5, 293-296.
- SCERRI, E. L., GRAVINA, B., BLINKHORN, J. & DELAGNES, A. 2015. Can lithic attribute analyses identify discrete reduction trajectories? A quantitative study using refitted lithic sets. *Journal of Archaeological Method and Theory*, 23, 669-691.
- SCHMID, V. C., CONARD, N. J., PARKINGTON, J. E., TEXIER, P.-J. & PORRAZ, G. 2016. The 'MSA 1' of Elands Bay Cave (South Africa) in the context of the southern African Early MSA technologies. *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, e0149243.
- SCHMIDT, P., PORRAZ, G., SLODCZYK, A., BELLOT-GURLET, L., ARCHER, W. & MILLER, C. E. 2013. Heat treatment in the South African Middle Stone Age: temperature induced transformations of silcrete and their technological implications. *Journal of Archaeological Science*, 40, 3519-3531.
- SCHMIDT, P., PORRAZ, G., BELLOT-GURLET, L., FEBRUARY, E., LIGOUIS, B., PARIS, C., TEXIER, P.-J., PARKINGTON, J. E., MILLER, C. E., NICKEL, K. G. & CONARD, N. J. 2015. A previously undescribed organic residue sheds light on heat treatment in the Middle Stone Age. *Journal of Human Evolution*, 85, 22-34.
- SCHOCH, W. H., BIGGA, G., BÖHNER, U., RICHTER, P. & TERBERGER, T. 2015. New insights on the wooden weapons from the Paleolithic site of Schöningen. *Journal of Human Evolution*, 89, 214-225.
- SEMAW, S., RENNE, P., HARRIS, J. W., FEIBEL, C. S., BERNOR, R. L., FESSEHA, N. & MOWBRAY, K. 1997. 2.5-million-year-old stone tools from Gona, Ethiopia. *Nature*, 385, 333.
- SEMAW, S., ROGERS, M. J., QUADE, J., RENNE, P. R., BUTLER, R. F., DOMINGUEZ-RODRIGO, M., STOUT, D., HART, W. S., PICKERING, T. & SIMPSON, S. W. 2003. 2.6-Million-year-old stone tools and associated bones from OGS-6 and OGS-7, Gona, Afar, Ethiopia. *Journal of Human Evolution*, 45, 169-177.
- SERANGELI, J., BÖHNER, U., VAN KOLFSCHOTEN, T. & CONARD, N. J. 2015. Overview and new results from large-scale excavations in Schöningen. *Journal of Human Evolution*, 89, 27-45.

- SHEA, J. J. 2006. The origins of lithic projectile point technology: evidence from Africa, the Levant, and Europe. *Journal of Archaeological Science*, 33, 823-846.
- SHEN, G., GAO, X., GAO, B. & GRANGER, D. E. 2009. Age of Zhoukoudian Homo erectus determined with ²⁶Al/¹⁰Be burial dating. *Nature*, 458, 198-200.
- SHOTT, M. 1994. Size and form in the analysis of flake debris: Review and recent approaches. *Journal of Archaeological Method and Theory*, 1, 69-110.
- SIEVERS, C. 2006. Seeds from the Middle Stone Age layers at Sibudu Cave. *Southern African Humanities*, 18, 203-222.
- SINGER, R. & WYMER, J. 1982. *The Middle Stone Age at Klasies River Mouth in South Africa*. Chicago: University of Chicago Press.
- SISK, M. L. & SHEA, J. J. 2011. The African origin of complex projectile technology: An analysis using tip cross-sectional area and perimeter. *International Journal of Evolutionary Biology*, 2011, 1-8.
- SORESSI, M. & GENESTE, J.-M. 2011. Special Issue: Reduction Sequence, Chaîne Opératoire, and Other Methods: The epistemologies of different approaches to lithic analysis. *PaleoAnthropology*, 334, 350.
- SORIANO, S. 2001. Status fonctionnel de l'outillage bifacial dans les industries du Paléolithique moyen: propositions méthodologiques. *Les industries à outils bifaciaux du Paléolithique moyen d'Europe occidentale*. Etudes et Recherches Archéologiques de l'Université de Liège, 98, 77-84.
- 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, 681-703.
- SORIANO, S., VILLA, P. & WADLEY, L. 2009. Ochre for the toolmaker: Shaping the Still Bay Points at Sibudu (KwaZulu-Natal, South Africa). *Journal of African Archaeology*, 7, 41-54.
- SORIANO, S., VILLA, P., DELAGNES, A., DEGANO, I., POLLAROLO, L., LUCEJKO, J. J., HENSHILWOOD, C. & WADLEY, L. 2015. The Still Bay and Howiesons Poort at Sibudu and Blombos: Understanding Middle Stone Age technologies. *PLoS ONE*, 10, e0131127.
- STEELE, T. E., MACKAY, A., FITZSIMMONS, K. E., IGREJA, M., MARWICK, B., ORTON, J., SCHWORTZ, S. & STAHLSCHEMIDT, M. C. 2016. Varsche Rivier 003: A Middle and Later Stone Age site with Still Bay and Howieson's Poort assemblages in southern Namaqualand, South Africa. *PaleoAnthropology*, 2016, 100-163.
- TEXIER, P.-J., ROCHE, H., BRUGAL, J.-P. & HARMAND, S. 2004. KS5, a transition site between the oldowan (KS1) and the early acheulean (KS4) from Kokiselei site complex (West Turkana, Kenya). *Paleoanthropology Society Annual Meeting*. Montréal, Canada.
- TEXIER, P.-J., PORRAZ, G., PARKINGTON, J., RIGAUD, J.-P., POGGENPOEL, C., MILLER, C., TRIBOLO, C., CARTWRIGHT, C., COUDENNEAU, A., KLEIN, R., STEELE, T. & VERNA, C. 2010. A Howiesons Poort tradition of engraving ostrich eggshell containers dated to 60,000 years ago at Diepkloof Rock Shelter, South Africa. *Proceedings of the National Academy of Sciences*, 107, 6180-6185.
- THOMPSON, J. C. & HENSHILWOOD, C. S. 2014. Tortoise taphonomy and tortoise butchery patterns at Blombos Cave, South Africa. *Journal of Archaeological Science*, 41, 214-229.
- TOTH, N. 1985. The oldowan reassessed: A close look at early stone artifacts. *Journal of Archaeological Science*, 12, 101-120.
- TRIBOLO, C., MERCIER, N., VALLADAS, H., JORON, J. L., GUIBERT, P., LEFRAIS, Y., SELO, M., TEXIER, P. J., RIGAUD, J. P., PORRAZ, G., POGGENPOEL, C., PARKINGTON, J., TEXIER, J. P. & LENOBLE, A. 2009. Thermoluminescence dating of a Stillbay–Howiesons Poort sequence at Diepkloof Rock Shelter (Western Cape, South Africa). *Journal of Archaeological Science*, 36, 730-739.
- TRIBOLO, C., MERCIER, N., DOUVILLE, E., JORON, J. L., REYSS, J. L., RUFER, D., CANTIN, N., LEFRAIS, Y., MILLER, C. E., PORRAZ, G., PARKINGTON, J., RIGAUD, J. P. & TEXIER, P. J. 2013. OSL and TL dating of the Middle Stone Age

- sequence at Diepkloof Rock Shelter (South Africa): a clarification. *Journal of Archaeological Science*, 40, 3401-3411.
- TRIBOLO, C., MERCIER, N., VALLADAS, H., LEFRAIS, Y., MILLER, C. E., PARKINGTON, J. & PORRAZ, G. 2016. Chronology of the Pleistocene deposits at Elands Bay Cave (South Africa) based on charcoals, burnt lithics, and sedimentary quartz and feldspar grains. *Southern African Humanities*, 29, 129-152.
- VAL, A. 2016. New data on the avifauna from the Middle Stone Age layers of Sibudu Cave, South Africa: Taphonomic and palaeoenvironmental implications. *Quaternary International*, 421, 173-189.
- VAL, A., DE LA PEÑA, P. & WADLEY, L. 2016. Direct evidence for human exploitation of birds in the Middle Stone Age of South Africa: The example of Sibudu Cave, KwaZulu-Natal. *Journal of Human Evolution*, 99, 107-123.
- VALLVERDÚ, J., SALADIÉ, P., ROSAS, A., HUGUET, R., CÁCERES, I., MOSQUERA, M., GARCIA-TABERNERO, A., ESTALRRICH, A., LOZANO-FERNÁNDEZ, I., PINEDA-ALCALÁ, A., CARRANCHO, Á., VILLALAIN, J. J., BOURLÈS, D., BRAUCHER, R., LEBATARD, A., VILALTA, J., ESTEBAN-NADAL, M., BENNÀSAR, M. L., BASTIR, M., LÓPEZ-POLÍN, L., OLLÉ, A., VERGÉS, J. M., ROS-MONTOYA, S., MARTÍNEZ-NAVARRO, B., GARCÍA, A., MARTINELL, J., EXPÓSITO, I., BURJACHS, F., AGUSTÍ, J. & CARBONELL, E. 2014. Age and date for early arrival of the Acheulian in Europe (Barranc de la Boella, la Canonja, Spain). *PLOS ONE*, 9, e103634.
- VANHAEREN, M., D'ERRICO, F., VAN NIEKERK, K. L., HENSHILWOOD, C. S. & ERASMUS, R. M. 2013. Thinking strings: Additional evidence for personal ornament use in the Middle Stone Age at Blombos Cave, South Africa. *Journal of Human Evolution*, 64, 500-517.
- VILLA, P. & LENOIR, M. 2006. Hunting weapons of the Middle Stone Age and the Middle Palaeolithic : spear points from Sibudu, Rose Cottage and Bouheben. *Southern African Humanities*, 18, 89-122.
- VILLA, P., DELAGNES, A. & WADLEY, L. 2005. A late Middle Stone Age artifact assemblage from Sibudu (KwaZulu-Natal): comparisons with the European Middle Paleolithic. *Journal of Archaeological Science*, 32, 399-422.
- VILLA, P., SORESSI, M., HENSHILWOOD, C. S. & MOURRE, V. 2009. The Still Bay points of Blombos Cave (South Africa). *Journal of Archaeological Science*, 36, 441-460.
- VILLA, P., SORIANO, S., TSANOVA, T., DEGANO, I., HIGHAM, T. F. G., D'ERRICO, F., BACKWELL, L., LUCEJKO, J. J., COLOMBINI, M. P. & BEAUMONT, P. B. 2012. Border Cave and the beginning of the Later Stone Age in South Africa. *Proceedings of the National Academy of Sciences*, 109, 13208-13213.
- VOGEL, J. C. & BEAUMONT, P. B. 1972. Revised radiocarbon chronology for the Stone Age in South Africa. *Nature*, 237, 50-51.
- VOLMAN, T. P. 1981. *The middle stone age in the southern cape*. Ph.D. thesis, University of Chicago.
- VOLMAN, T. P. 1984. Early prehistory of southern Africa. In: KLEIN, R. G. (ed.) *Southern African prehistory and palaeoenvironments*. Balkema.
- WADLEY, L. 2001. Excavations at Sibudu Cave, KwaZulu-Natal. *The Digging Stick*, 18, 1-4.
- WADLEY, L. 2005a. Putting ochre to the test: replication studies of adhesives that may have been used for hafting tools in the Middle Stone Age. *Journal of Human Evolution*, 49, 587-601.
- WADLEY, L. 2005b. A typological study of the final Middle Stone Age stone tools from Sibudu Cave, Kwazulu-Natal. *The South African Archaeological Bulletin*, 60, 51-63.
- WADLEY, L. 2007. Announcing a Still Bay industry at Sibudu Cave, South Africa. *Journal of Human Evolution*, 52, 681-689.
- WADLEY, L. 2012. Two moments in time during Middle Stone Age occupations of Sibudu, South Africa. *Southern African Humanities*, 24, 79-97.
- WADLEY, L. & JACOBS, Z. 2004. Sibudu Cave, KwaZulu-Natal : background to the excavations of Middle Stone Age and Iron Age occupations : Sibudu Cave. *South African Journal of Science*, 100, 145-151.

- WADLEY, L. & JACOBS, Z. 2006. Sibudu Cave : background to the excavations, stratigraphy and dating. *Southern African Humanities*, 18, 1-26.
- WADLEY, L. & KEMPSON, H. 2011. A review of rock studies for archaeologists, and an analysis of dolerite and hornfels from the Sibudu area, KwaZulu-Natal. *Southern African Humanities*, 23, 87-107.
- WADLEY, L. & MOHAPI, M. 2008. A Segment is not a monolith: evidence from the Howiesons Poort of Sibudu, South Africa. *Journal of Archaeological Science*, 35, 2594-2605.
- WADLEY, L. & PRINSLOO, L. C. 2014. Experimental heat treatment of silcrete implies analogical reasoning in the Middle Stone Age. *Journal of Human Evolution*, 70, 49-60.
- WADLEY, L., SIEVERS, C., BAMFORD, M., GOLDBERG, P., BERNA, F. & MILLER, C. 2011. Middle Stone Age bedding construction and settlement patterns at Sibudu, South Africa. *Science*, 334, 1388-1391.
- WENINGER, B., CLARE, L., ROHLING, E., BAR-YOSEF, O., BÖHNER, U., BUDJA, M., BUNDSCHUH, M., FEURDEAN, A., GEBE, H. G. & JÖRIS, O. 2009. The impact of rapid climate change on prehistoric societies during the Holocene in the Eastern Mediterranean. *Documenta praehistorica*, 36, 7-59.
- WHITE, T. D., ASFAW, B., DEGUSTA, D., GILBERT, H., RICHARDS, G. D., SUWA, G. & CLARK HOWELL, F. 2003. Pleistocene Homo sapiens from Middle Awash, Ethiopia. *Nature*, 423, 742-747.
- WIESSNER, P. 1977. *Hxaro: A regional system of reciprocity for reducing risk among the !Kung San*. Ph.D. dissertation, University of Michigan, University Microfilms, Ann Arbor.
- WIESSNER, P. 1983. Style and social information in Kalahari San projectile points. *American Antiquity*, 48, 253-276.
- WIESSNER, P. 1989. Style and changing relations between the individual and society. In: HODDER, I. (ed.) *The Meanings of Things: material culture and symbolic expression*. HarperCollins Academic, London: Unwin Hyman.
- WILL, M. & CONARD, N. J. 2017. Assemblage variability and bifacial points in the lowermost Sibudan layers at Sibudu, South Africa. *Archaeological and Anthropological Sciences*.
- 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, e98359.
- 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, e0131824.
- WOODBURN, J. 1968. An introduction to Hadza ecology. In: LEE, R.B. & DeVEVORE, I. (eds.) *Man the hunter*. Chicago: Aldine Publishing Company.
- WURZ, S. 1999. The Howiesons Poort backed artefacts from Klasies River: An argument for symbolic behaviour. *The South African Archaeological Bulletin*, 54, 38-50.
- WURZ, S. 2000. *The Middle Stone Age at Klasies River, South Africa*. Ph.D. thesis, Stellenbosch University.
- 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, 1001-1015.
- ZIEGLER, M., SIMON, M. H., HALL, I. R., BARKER, S., STRINGER, C. & ZAHN, R. 2013. Development of Middle Stone Age innovation linked to rapid climate change. *Nature Communications*, 4, 1905.

A: APPENDIX

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Characterizing the Late Pleistocene MSA Lithic Technology of Sibudu, KwaZulu-Natal, South Africa

Manuel Will^{1*}, Gregor D. Bader¹, Nicholas J. Conard^{1,2}

1 Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, Tübingen, Germany, **2** Senckenberg Center for Human Evolution and Paleoecology, University of Tübingen, Schloss Hohentübingen, Tübingen, Germany

Abstract

Studies of the African Middle Stone Age (MSA) have become central for defining the cultural adaptations that accompanied the evolution of modern humans. While much of recent research in South Africa has focused on the Still Bay and Howiesons Poort (HP), periods following these technocomplexes were often neglected. Here we examine lithic assemblages from Sibudu that post-date the HP to further the understanding of MSA cultural variability during the Late Pleistocene. Sibudu preserves an exceptionally thick, rich, and high-resolution archaeological sequence that dates to ~58 ka, which has recently been proposed as type assemblage for the “Sibudan”. This study presents a detailed analysis of the six uppermost lithic assemblages from these deposits (BM-BSP) that we excavated from 2011–2013. We define the key elements of the lithic technology and compare our findings to other assemblages post-dating the HP. The six lithic assemblages provide a distinct and robust cultural signal, closely resembling each other in various technological, techno-functional, techno-economic, and typological characteristics. These results refute assertions that modern humans living after the HP possessed an unstructured and unsophisticated MSA lithic technology. While we observed several parallels with other contemporaneous MSA sites, particularly in the eastern part of southern Africa, the lithic assemblages at Sibudu demonstrate a distinct and so far unique combination of techno-typological traits. Our findings support the use of the Sibudan to help structuring this part of the southern African MSA and emphasize the need for further research to identify the spatial and temporal extent of this proposed cultural unit.

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* E-mail: manuel.will@uni-tuebingen.de

Introduction

Recent archaeological, palaeoanthropological and genetic research demonstrates that modern humans evolved on the African continent. Fossils of modern humans date back as far as 200,000 years ago (= 200 ka), and starting from Africa *Homo sapiens* dispersed to the rest of the world [1–6]. Studies in the African Middle Stone Age (MSA), which dates between ca. 300 and 30 ka, have focused on the biological and behavioral evolution of our species, as well as the geographic expansion of modern humans. The MSA of southern Africa plays a central role in these questions due to its long research history and the wealth of excavated sites [7–9]. Most importantly, southern African MSA sites including Klasies River [10,11], Blombos [12,13], Pinnacle Point 13B [14,15], Sibudu [16,17], and Diepkloof [18–20] provide a long and well-dated chrono-cultural framework.

With documentation of the biological origin of *Homo sapiens* in Africa [1–4], researchers shifted their focus to the MSA, which had been previously neglected, to examine the nature and tempo of cultural change in early modern humans. Since the late 1990s, archaeological finds in the southern African MSA with unexpectedly early dates led researchers to rethink the evolution of modern human behavior. These finds include among others: abstract

depictions on ochre and ostrich eggshell [21–24], ochre processing kits [13], personal ornaments [25,26], bone artifacts [27,28], heat treated artifacts [29], and potentially bow and arrow technology [30]. Due to these discoveries, the African continent and particularly southern Africa has become the center of attention for studying the cultural evolution of *Homo sapiens* [1,5,31] (but see [32–34]).

Many of these early complex elements of the material culture were observed in two sub-stages of the southern African MSA, the Still Bay (SB) and Howiesons Poort (HP). Backed tools and laminar technology characterize the HP, whereas bifacial technology with foliate points mark the SB [35–39]. Scholars often consider these cultural units as indicating advanced cognition and sophisticated socio-economic behaviors of their makers. This view has resulted in a strong research emphasis on the SB and HP [5,40–45]. Some researchers even associate the innovative technological and socio-economic aspects of the SB and HP with subsequent dispersals of modern humans to Eurasia (e.g. [5,46]).

While research has focused on the supposedly unique aspects of the SB and HP, earlier and later periods of the MSA were often considered as unsophisticated, less innovative or conventional in their technology. In this view, the SB and HP represent two short-lived but culturally advanced episodes preceded and followed by

less behaviorally sophisticated phases. Based on this reasoning, some scholars invoke a model of discontinuous cultural evolution in modern humans in which complex material culture appears and disappears abruptly in the South African MSA [41,43,47–51]. Although ecological causes are sometimes cited (e.g. [47,51]), most of the proponents of these ideas call upon demographic collapses to explain their model. As a consequence of this purported depopulation, smaller isolated groups of people lost traditions that were previously shared with other groups over large areas (e.g. [41,50]).

These views have increasingly attracted criticism. Some scholars argue that the proposed model of cultural evolution is overly simplistic [52,53]. Moreover, the current archaeological evidence contradicts this theory: many SB and HP localities such as Diepkloof, Sibudu or Klasies River were not abandoned by the inhabitants afterwards. Instead, people occupied these sites continuously without evidence for stratigraphic hiatuses. Phases of occupation that follow the HP sometimes even exhibit higher intensities of settlement, such as at Sibudu. Additionally, recent synthetic research has found that more sites existed at ~58 ka than during the SB phase [54–57], although differences in settlement systems, taphonomy and discovery biases might influence this measure. Current studies on lithic assemblages from the SB and HP have also documented a higher degree of temporal and regional variability than acknowledged before [35,39,58–62]. At Diepkloof, researchers have argued that both SB and HP occupations date earlier and last longer than at other MSA localities in southern Africa [20]. Based on current evidence, regional and temporal variation occur in all periods of the MSA and the number and occupation intensities of sites post-dating the HP appear to refute hypotheses favoring demographic collapses following this technocomplex.

The focus on the SB and HP remains a problem facing current research on technological variability during the southern African MSA. This emphasis has resulted in a lack of detailed studies for other phases of the MSA in an otherwise well-studied region (see [19,35,39,52,54,60,63,64]). Hence, assemblages from these periods are frequently attributed to informal stages such as “post-HP” or “pre-SB”. Considering this research bias, it comes as no surprise that some scholars consider lithic assemblages after the SB and HP as technologically rudimentary, unsophisticated, or a return to a conventional “pre-SB” MSA [41,47,50,65–67]. Yet, in order to track technological change in the southern African MSA, all of its phases must be studied with the same intensity.

The “post-HP” of Southern Africa and at Sibudu

Regarding the later part of the southern African MSA, lithic assemblages that succeed the HP and fall within MIS 3 comprise the so-called “post-HP” [11,68], “MSA 3” [8] or “MSA III” [10]. At present, these labels act as catch-all categories with little scientific value [54,63,69,70]. For instance, Wadley ([69], p. 2404) summarizes the current view of the “post-HP” as being poorly understood while at the same time regarded as “dark ages” that followed the HP. Even so, many sites from this time period exist in southern Africa, such as Apollo 11, Border Cave, Diepkloof, Klasies River, Klein Kliphuis, Melikane, Sibudu, Sehonghong and Umhlatuzana (see [9,54,71]). They include localities with ephemeral settlements but also with thick occupation sequences (e.g. Sibudu, ca. 1.5 m from ~58–38 ka [68], Klasies River, ca. 1.2 m at ~58 ka [60]).

Finer subdivision of the MSA that follows the HP, covering a period of approximately 30 ka, have been made primarily at sites that feature long sequences from this time span. At Sibudu, for instance, Wadley and Jacobs [68] distinguish the informal phases

“post-HP” (~58 ka), “late MSA” (~48 ka), and “final MSA” (~38 ka). These informal terms, however, have not been applied by other researchers in a uniform manner. In most recent publications, the term “post-HP” is used to address the earlier phases of MIS 3 (ca. 58–40 ka; including “late MSA” assemblages) and “final MSA” – with hollow-based points as characteristic tool forms in KwaZulu-Natal – to denote the following period that ends with the onset of the LSA [9,39,57,64,71].

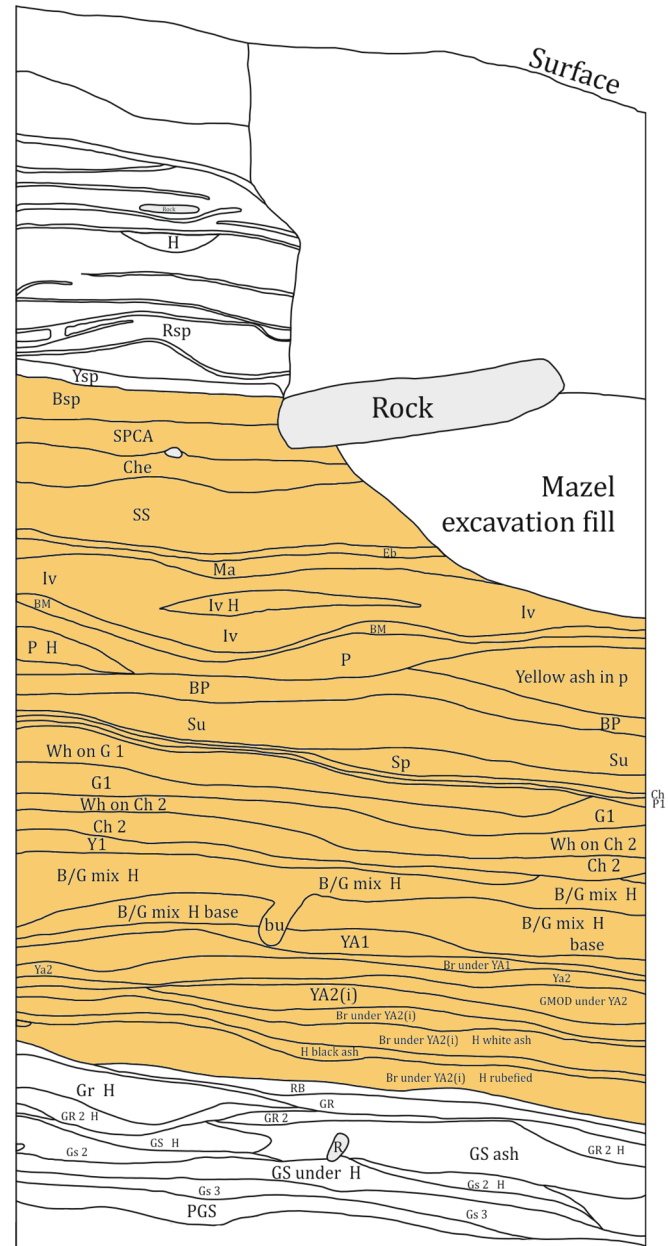
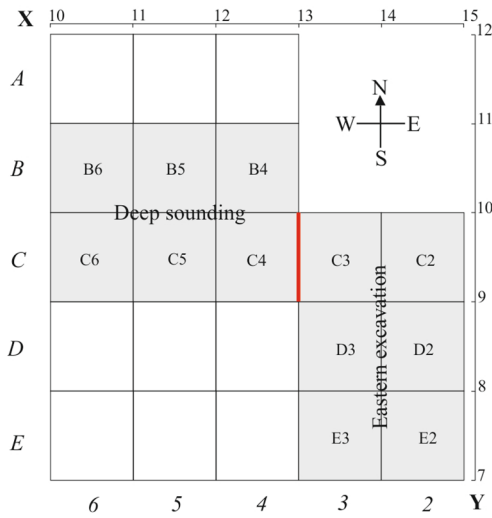
In terms of their geographical distribution, MSA sites postdating the HP occur throughout southern Africa and can be found in various climatic and environmental contexts (see [9,54,71]). A decline in the number and intensity of occupations after the HP in the Western Cape, especially between 50–25 ka (e.g. [19,59,71]), has sometimes been interpreted as indicating low population densities during MIS 3 in southern Africa (e.g. [41,46,48,72], but see [54]). These observations, however, do not correspond to the pattern in the eastern part of southern Africa. Here, the number of sites increases and several localities with thick and rich occupation sequences, such as Umhlatuzana [73,74] or Sibudu [57,63,68], occur during this period (see also [54,71] for discussion and references).

Scholars defined the MSA lithic assemblages that follow the HP for the most part on the basis of what they lack, such as bifacial points or backed pieces, instead of what they contain (see [57,63]). The only unifying characteristics frequently cited for the “post-HP” are a greater variety of flake tools and numerous unifacial points that replace backed artifacts as the principal tool category (e.g. [9,39,60,71]). In our view, the “informal” or “conventional” MSA character that is often attributed to assemblages following the HP derives from a combination of several factors. First, they reflect a wide range of assemblages from different chronological, environmental and techno-economic contexts. Second, the lithic assemblages are often poorly studied and poorly published. Additionally, scholars have frequently mentioned the (near-) absence of engravings, ornaments or worked bone for this period (e.g. [5,39,40,54]). While some of these elements of the material culture occur exclusively in the HP (e.g. engraved ostrich eggshell [23,75]) and their quantity is much higher, assemblages of the “post-HP” in southern Africa have also provided worked bone [28,76], potential engravings on ochre [77] and other elements of complex behaviour (see below).

It is the main objective of this paper to help correct the research bias toward the HP and SB by providing new, detailed data on lithic assemblages that follow these technocomplexes. Our work concentrates on the archaeological site of Sibudu as it constitutes a promising candidate to study the period following the HP. The “post-HP” sequence at Sibudu is approximately one meter thick with more than 30 individual archaeological layers [68]. These finely laminated horizons provide the best stratigraphic record of this period known anywhere on the sub-continent (Figure 1). Archaeological layers at the top and base of this thick sequence have been dated to ~58 ka, providing an exceptionally high temporal resolution. The whole “post-HP” sequence might have accumulated over only a few centuries or millennia [40,57,68].

Recent research on the “post-HP” sequence of Sibudu contradicts notions of large-scale population collapses after the HP. These studies also provide ample evidence for advanced technological behaviors of modern human populations living at Sibudu during this period. The sequence that follows the HP (< 60 ka) exhibits burning events that are frequently stacked, indicating that people made repeated use of hearths and settled more intensively at the site after the HP [70,78–82]. Results from dating and sediment micromorphology support this assertion in showing a higher rate of anthropogenic sedimentation and find

Sibudu, C4 east profile



Sibudu, C3 north profile

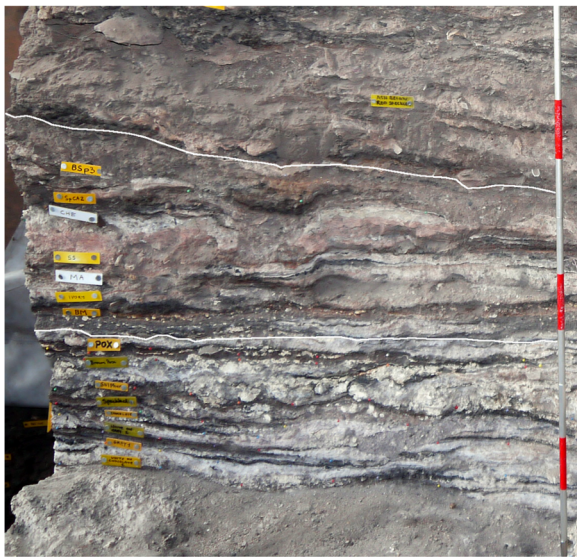


Figure 1. Excavation area and stratigraphic sections of the “post-HP” sequence from Sibudu. Upper left: Excavation grid. The lithic assemblages from the Sibudan come from the “Eastern Excavation”. Right: Sketch of the stratigraphic section of the eastern profile (C4, after Wadley). The complete “post-HP” sequence is highlighted in orange (layers BSP-BR Under YA2). Bottom left: Photograph depicting the stratigraphic section of the northern profile (C3) during excavations in 2013. The white lines mark the seven uppermost layers of the “post-HP”, or Sibudan, sequence from the top of BSP until the bottom of BM. Note the very fine lamination of archaeological layers in different colors caused by frequent combustion features (photograph by M. Will).
doi:10.1371/journal.pone.0098359.g001

densities in the these layers [63,68,83]. Geoarchaeological analyses document that the inhabitants constructed bedding made from sedges in the “pre-SB”, HP, “final MSA” and “post-HP” layers [80,83,84]. The more frequent occurrence of bedding constructions, burning and other forms of site use and maintenance during the “post-HP” suggests intensified occupations and a change in domestic organization [80,83]. Just as during the SB and HP, people produced ochre powder on-site during the “post-HP”

[69,77] and used it as part of a compound adhesive for hafting stone tools, indicating advanced mental capacities and technical skill [85–90]. A particular phenomenon of the “post-HP” layers are large patches of ground ochre on the cemented ashes of burnt hearths. Wadley [69] argues that these cemented ashes served as work surfaces for the production of ochre powder, suggesting an especially extensive use of this raw material. Bone tools, often cited as markers of cultural complexity [27,91,92], occur in the “Pre-

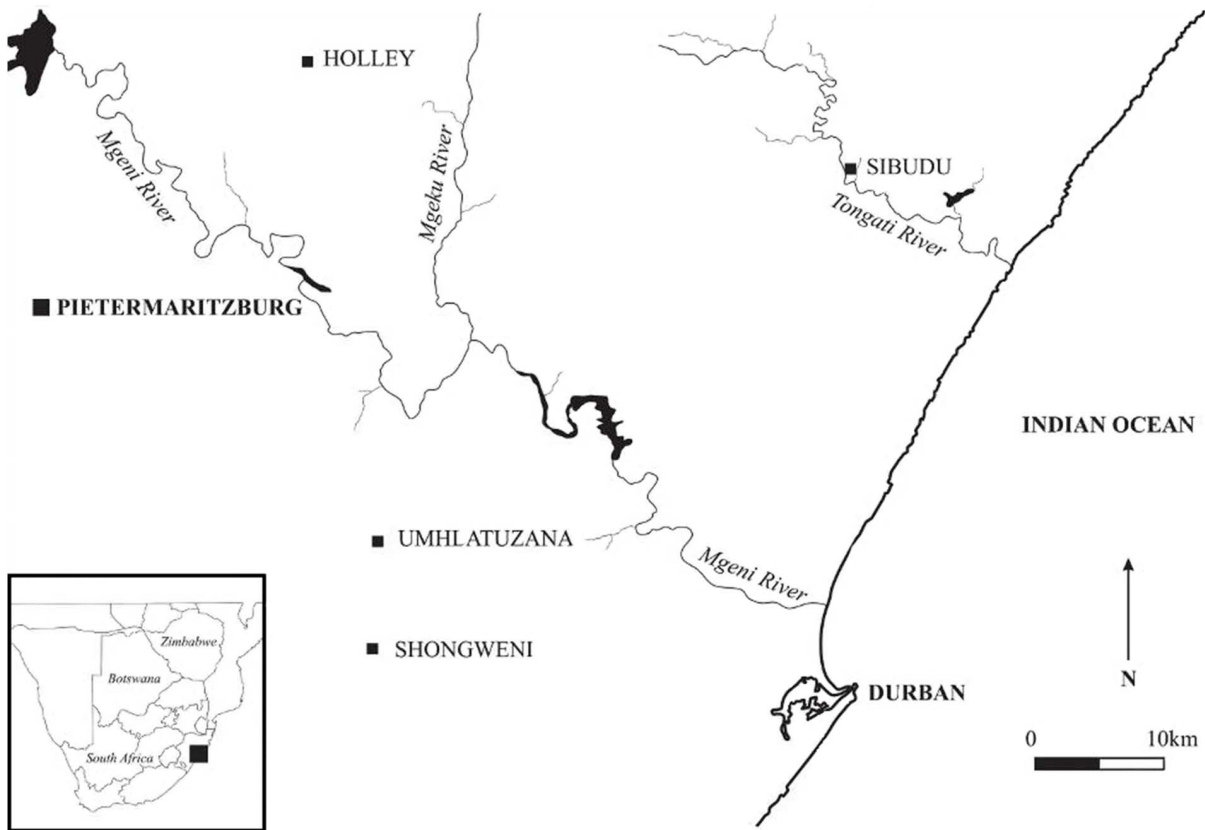


Figure 2. The archaeological site of Sibudu. Geographic location of Sibudu in KwaZulu-Natal (top, after [68]) and view on the excavation area within the rock shelter (bottom; photograph by M. Ecker).
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SB”, SB, HP and “post-HP” assemblages. The “post-HP” yielded two notched pieces, one smoother, one splintered piece, and one pressure flaker [28,76].

On the basis of these features and an analysis of the highly structured and characteristic tool assemblages, Conard, Porraz and Wadley [63] recently proposed Sibudu as the type locality of a new sub-unit of the MSA, the “Sibudan” [63] which is not identical with the “Sibudu technocomplex” proposed by Lombard *et al.* [9]. They ([63], p. 181) justified the naming of a new sub-unit of the MSA on the basis that “informal terminology is untenable, because it implies that material cultural remains can be characterized by what they are not, rather than by their positive characteristics”. Conard *et al.* [63] distanced themselves from the informal “post-HP” and proposed the term Sibudan for the assemblages they studied, based on positive features. They stress that the Sibudan is not intended as a one-to-one equivalent of the “post-HP” of southern Africa, which would simply be replacing one label with another. Instead, the term is used to organize the many excavated assemblages from Sibudu, with these high-quality lithic data providing a point of comparison for further research. Conard *et al.* ([63], p. 181) also emphasize “that defining a new cultural taxonomic unit is a process” and they recommend conducting additional research to evaluate the viability of this term. In conclusion, they proposed the Sibudan as an organizational unit that constitutes a first step towards the nomenclature for the cultural sequence after the HP. We thus regard the Sibudan as a cultural-taxonomic unit that needs better characterization and contextualization in order to test its utility.

While Conard *et al.* [63] studied the tool assemblages and proposed a working model to characterize them, complete data was not then available on other technological aspects of these lithic assemblages. Here, we present our findings from a detailed technological analysis which are crucial to define the key elements of the Sibudan lithic technology and evaluate its short-term diachronic variability. With this approach we intend to further the understanding of technological variation during the Late Pleistocene MSA of southern Africa and provide a high-resolution empirical basis for comparative work. We also investigate the utility of the Sibudan as a possible cultural-taxonomic unit to help organize the sequence after the HP, by comparing our findings with lithic assemblages from other localities of this time period.

Materials and Methods

The archaeological site of Sibudu is a large rock shelter situated above the Tongati River (also spelled “uThongathi”) in KwaZulu-Natal approximately 40 km north of Durban and 15 km from the Indian Ocean (Figure 2). The locality has yielded a rich archaeological sequence with deposits that span a time range of >75–37 ka [17,68,70,78]. Sibudu is one of the few sites in South Africa that has yielded evidence for both SB and HP occupations, as well as the periods before and after [40,63,78]. The long-term excavations by L. Wadley provide a sound stratigraphic framework [17,68]. The archaeological layers discussed here are almost completely anthropogenic, show little post-depositional disturbance and feature good organic preservation [70,79,80]. New field work at Sibudu has been carried out by a team of the University of Tübingen under the direction of N. Conard since 2011, building on the previous excavations by L. Wadley. The research permit to conduct archaeological excavations at Sibudu is issued under the KwaZulu-Natal heritage Act No. 4 of 2008 by Amafa AkwaZulu-Natali and is valid until December 2017. The permit holder is Nicholas Conard of the University of Tübingen (permit number: REF: 0011/14; 2031CA 070). All recovered archaeological

specimens are permanently stored at the KwaZulu-Natal Museum in Pietermaritzburg (South Africa, 237 Jabu Ndlovu Street).

During the excavations we adopted Wadleys stratigraphic system and layer designations (see [68] Tab. 2) and added systematic 3D piece plots of all classes of archaeological materials with a total station to the field methods. In each quarter meter, excavation proceeded in 2–3 cm thick *Abträge* that followed the slope of the sediments and never crosscut geological strata. The maximum volume of one *Abtrag* was a 10-liter bucket of sediment. These *Abträge* constitute the smallest time unit we discern at Sibudu and sometimes equal defined archaeological strata. We chose archaeological layers as the units to analyze the lithic assemblages as they constitute the best basis for inter-assemblage comparisons.

For this study, we analyzed the lithic assemblages from the 7 uppermost layers BM-BSP of the “post-HP” sequence from an area of 6 m² (ca. 1.5 m³ of sediment; Figure 1), that we excavated in three seasons between 2011–2013. The results for six of these assemblages are presented in the following, with one layer (SS) being excluded due to the low number of lithic artifacts (n<100). The assemblages contain a total of 59,390 stone artifacts, with 2,649 pieces >25 mm and 56,741 small debitage products < 25 mm (Table 1). For a detailed characterization of the technology of these assemblages, we examined the procurement and use of lithic raw materials, investigated reduction sequences, evaluated the methods and techniques of reduction and performed typological and techno-functional analyses of tools.

We examined all stone artifacts >25 mm individually, combining attribute analysis and reduction sequence approaches. Attribute analysis quantifies the various traces on lithic artifacts that result from the knapping process and records metric traits in order to reconstruct technological behavior [93–97]. In addition to observations by hand lenses we sometimes used light microscopy. Our qualitative investigation follows the concept of *chaîne opératoires* [99–100] or reduction sequences [101–103]. This approach studies the methods of core reduction and the stages of lithic manufacture that people performed at the site. We also conducted quantitative analyses on samples of the small debitage products to calculate raw material proportions and frequencies of retouching activities.

As the method of core reduction constitutes an essential point in characterizing the technology of MSA people, and description of core types should be comparable between sites, we employed the unified taxonomy by Conard *et al.* [104]. We analyzed the tool inventories of the lithic assemblages with regards to typological, technological and techno-functional aspects. Although researchers have legitimately criticized the traditional typological approach to retouched artifacts [105–108], a list of defined tool types still provides a broad means of comparison between different sites and technocomplexes. We recorded tool types with a special recognition of the typology of the southern African MSA (*cf.* [109–112]). Most importantly, scholars in South Africa have defined “unifacial points” in a very broad sense which include a wide range of convergent and pointed forms with both marginal and invasive retouch. A unifacial point in this definition may be the equivalent of a convergent scraper, a marginally retouched Levallois point, or a triangular flake that was modified at the distal tip only [63,111,112].

Conard *et al.* [63] recently published a novel classification scheme for tools in the Sibudan based on a techno-functional method that differs from traditional typological (“type fossil”) approaches. This new procedure was devised, among other reasons, to organize assemblages rich in unifacial points, as the very broad definitions of unifacial points in South Africa obscure subtle morphological and metric differences. The new classifica-

Table 1. Distribution of single finds (>25 mm) and small debitage (<25 mm).

Layer	Single finds	Small debitage	Total lithics
BSP	822	13644	14466
SPCA	578	10019	10597
CHE	133	2792	2925
MA	178	4421	4599
IV	676	20389	21065
BM	262	5476	5738
Total	2649	56741	59390

doi:10.1371/journal.pone.0098359.t001

tion scheme rests mainly on an emphasis of the reduction and transformation of tool types that are usually treated as static entities [105,107,113]. In addition, they [63] employed a techno-functional approach (*sensu* [114–117]), which divides tools into a transformative, prehensile and intermediate part and studies the treatment of these portions separately. Upon these methods, Conard *et al.* [63] classified tools based on the identification of specific patterns of repetitive retouch on different parts of the tool which indicate formal and distinct retouching cycles. On these grounds, several tool classes and tool cycles were defined, including two categories that would usually be subsumed under the label unifacial points: “Tongatis” (Figure 3) and “Ndwedwes” (Figure 4). Conard *et al.* ([63]) provide further descriptions and depictions of these tool classes and their retouch cycles, including naturally backed tools (NBTs; Figure 5: 1–6). This new tool taxonomy presents a working model that needs to undergo critical appraisal with additional techno-functional, use wear and residue analyses.

In 2013, we recognized asymmetric convergent tools (ACT) as an independent tool class and retouch cycle among our enlarged sample of unifacial points of which the majority was originally classified as Tongatis. The main characteristic of ACTs is the eponym asymmetric and convergent distal end. It is formed by one convex retouched edge and one opposing straight edge which is frequently not retouched (Figure 5: 7–10). Additionally, most ACTs exhibit steeper retouch on the convex lateral, creating a blunt edge. The opposite straight edge features a sharp feathered termination. The cross-sections of ACTs are mostly asymmetric and often exhibit a thick ridge near the convexly retouched lateral edge. From our preliminary observations of the different varieties of these specimens and their reduction stages ($n = 38$), ACTs appears to change only at their initially unretouched working edge, where use-wear and edge damage accumulate continuously, thus decreasing the width of the piece during their tool cycle.

We analyzed flaking efficiency and reduction intensities for assemblages and individual raw materials as additional technological and techno-economic measures. Flaking efficiency measures the efficiency by which a knapping strategy converts a mass of stone into flake edge [118–120]. It is calculated for complete blanks by dividing edge length by mass. Higher values indicate a more efficient use of raw materials within assemblages. We use this measurement as it provides “an effective means of tracking technological change” ([120] p. 620). The reduction intensity of assemblages can have a strong influence on their technological and typological parameters. We thus examined it in two separate ways. For one, the ratio of blanks to cores provides a rough approximation. The higher the ratio, the more intense has an assemblage been reduced (e.g. [121]). Secondly, the intensity of

core reduction can be measured by average core and flake length or thickness. Assemblages with shorter or thinner flakes and cores are more heavily reduced, assuming that knappers used nodules with consistent starting size [121,122].

Results

Raw Material Procurement

Knappers at Sibudu used a variety of lithic raw materials. Results of previous studies [58,123] suggest that they can be divided into two categories. The majority consists of local raw materials, including dolerite, quartzite, milky white quartz and sandstone. Non-local raw materials are mainly represented by hornfels, with rare pieces of jasper and crypto-crystalline silicates (CCS; Figure 6).

The local dolerite is an igneous granular-appearing rock that varies significantly in grain-size and mineral composition. In general, it is a hard, rough and homogeneous raw material. Dolerite occurs mainly as tabular slabs in sills and dykes. A dolerite intrusion into the sandstone cliff is located only a few hundred meters away from Sibudu. Further potential sources are a large number of dolerite dykes and sills in the near-by Dwyka tillite and the Pietermaritzburg Formation [123,124]. The sandstone presumably derives from local resources, as the shelter itself is part of the Natal Group sandstones. However, people during the MSA also used sandstones that appear to be finer-grained than the shelter wall. The inhabitants of Sibudu collected most of the milky white quartz and quartzite from the Tongaati River where these raw materials still occur today [123]. Our own observations of frequent smoothed and rounded pebble cortex on these materials support this assertion.

Hornfels (metamorphosed shale) constitutes the finest-grained material used at Sibudu. It is dark-grey to black, dense, massive and has a high silica content. The hornfels shows favourable knapping characteristics and produces sharp but potentially fragile edges. Hornfels of the quality found in the MSA assemblages is not present in the direct vicinity of Sibudu today. The closest known outcrop of hornfels occurs in the Verulum area ~15–20 km south of the site [123].

Knappers mainly used dolerite and hornfels for producing stone artifacts throughout BM-BSP, with a combined frequency of > 93% for each assemblage (Table 2). Out of these two, dolerite dominates in all layers. Other raw materials like quartzite, quartz or sandstone never reach more than 5% abundance. CCS and jasper occur only in a few assemblages (CCS: BSP, SPCA; jasper: MA, IV) and in very small amounts (<1%). The inhabitants used principally the same range of raw materials throughout the sequence, and there is little diachronic variability in their

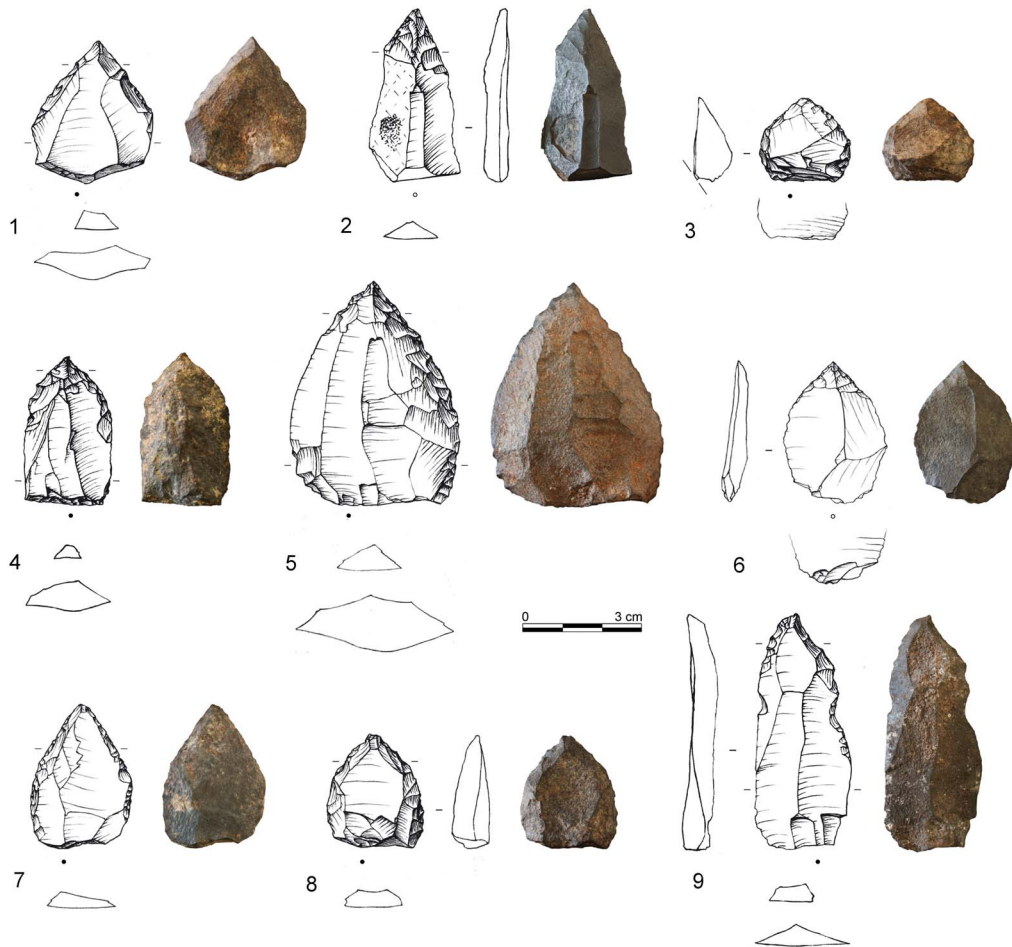


Figure 3. Examples of Tongatis from BM-BSP. 1: IV, dolerite, D3-532.1; 2: BSP, hornfels, E3-8.6; 3: IV, dolerite, C3-631.2; 4: BM, dolerite, E2-444; 5: IV, dolerite, E3-665; 6: BM, hornfels, E3-737; 7: IV, dolerite, D3-435; 8: IV, dolerite, E3-584; 9: BM, dolerite, D2-434. Drawings by F. Brodbeck and G. Porraz; photographs by G. Porraz. After [63] Fig. 7. doi:10.1371/journal.pone.0098359.g003

abundance (Figure 7). The amount of dolerite as dominating raw material ranges between 58% (SPCA) and 69% (BM). The percentage of non-local hornfels varies between 25–38% and correlates negatively with the proportions for dolerite. The successive layers BM and IV exemplify this pattern, in which an increase in hornfels leads to a drop in dolerite and *vice versa*. Local raw materials always outnumber non-local ones, with the later accounting for roughly a third of the assemblages. In sum, we observe consistency in the choice and range of raw materials, including abundant import of non-local tool stones, with some temporal differences in the frequency of their use.

Technological Aspects

Debitage analysis. A quantitative analysis of debitage products demonstrates that unretouched blanks constitute the main category of stone artifacts in all layers (>69%; Table 3). Angular debris and especially cores (~2%) are rare. The most remarkable feature of the assemblages is their extraordinarily high proportion of retouched lithics compared to other MSA sites which are often characterized by less than 2% tools (e.g. [11,109]). Tools account for an average of 21% of the analyzed stone artifacts >25 mm. The percentage of retouched specimens ranges between 17% (BSP) and up to 27% (MA), showing a consistent signal of abundant retouching activities (Figure 8).

Blank production. Flakes constitute the most frequent type of blanks produced (~70%; Table 4). At the same time, blades and convergent flakes mark an important and persistent aspect of all assemblages (Figure 8). The proportion of blades varies between 11–20%, with convergent flakes being slightly less abundant (9–16%). There are clear sequences for the production of flakes, convergent flakes and blades, but not for bladelets. Most of the bladelets ($n=9$; 0.4%) appear to be by-products of the laminar system that focussed on the manufacture of blades. The unimodal distribution of blade widths in all assemblages (Figure 9) and the lack of bladelet cores, with the exception of BSP and SPCA, support this interpretation (see *core reduction*). Throughout the sequence, a consistent proportion of about a third of the blanks is complete. Among the blank fragments, we found a particularly high proportion of longitudinal breaks (20–30%).

Knappers manufactured blanks that are relatively large. On average, (convergent) flakes are ~40–42 mm long, occasionally exceeding 70 mm. The average length of blades is 48 mm with a width of 19 mm. Throughout the sequence, (convergent) flakes become increasingly larger. The oldest assemblage BM yields the smallest pieces, while the uppermost units SPCA and BSP demonstrate the largest ones. There is, however, no strong difference in their width or shape (length/width ratio). In contrast to these blank types, blades from all layers exhibit similar metric

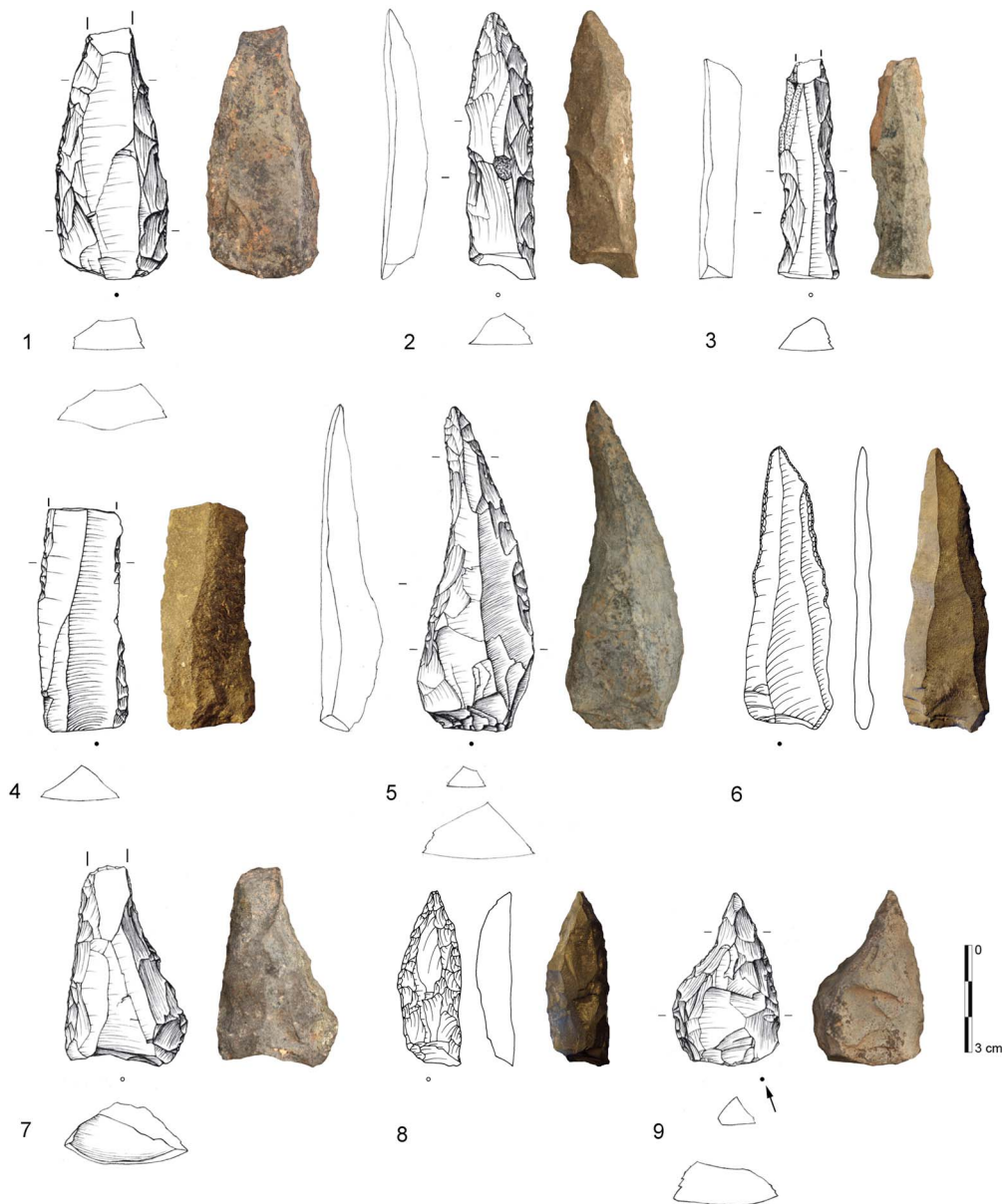


Figure 4. Examples of Ndwedwes from BM-BSP. 1: IV, dolerite, D3-460; 2: IV, dolerite, E2-322; 3: IV, dolerite, E3-521; 4: BSP, dolerite, D3-51; 5: IV, dolerite, D3-546; 6: BSP, hornfels, D2-77; 7: MA, dolerite, D2-293; 8: BSP, hornfels, D3-114; 9: SPCA, dolerite, E3-409. Drawings 1–5, 7, 9 by F. Brodbeck and G. Porraz; drawings 6 & 8 by M. Malina; photographs by G. Porraz. 1–3, 5, 7, 9 after [63] Fig. 11. doi:10.1371/journal.pone.0098359.g004

dimensions and length/width ratios of 2.5:1. These observations suggest that the inhabitants followed a uniform approach to produce blades with standardized dimensions and shapes. The unimodal distribution of blade widths, clustering around 18–20 mm, supports this assertion (Figure 9).

Core reduction. The most frequent core types are parallel ($n=23$) and platform ($n=19$) variants (Table 5). Among the remaining specimens there are three inclined, three bipolar, and four indeterminate broken cores. In total, the sample of cores is small for most assemblages. The uppermost layers BSP and SPCA show a strong dominance of parallel and platform cores, as does layer IV (Figure 10: 1–6; 8–11). All assemblages but MA feature parallel cores, many of which can be attributed to a Levallois system of reduction (*sensu* [98,125,126]). Inclined core variants, for the most part showing a discoid reduction method (*sensu*

[125,127]), occur exclusively in BSP and IV (Figure 10: 7). Only BSP features bipolar cores ($n=3$). Most of the cores show traces from the production of flakes ($n=31$), followed by blades ($n=14$), bladelets ($n=5$) and convergent flakes ($n=2$). All bladelet cores are derived from the two uppermost layers BSP and SPCA (Figure 11). However, the majority of cores is heavily reduced and thus provides only limited information from the final stages of core reduction. In order to overcome these shortcomings and gain a better understanding of the core reduction systems in layers BM-BSP, we studied the geometry and configuration of dorsal negatives on debitage products and cores in more detail. Three coexisting strategies of core reduction characterize the assemblages: Parallel (mostly Levallois), platform, and inclined (discoid).

Parallel cores occur frequently. They are characterized by two hierarchical, asymmetric and non-interchangeable surfaces, some-

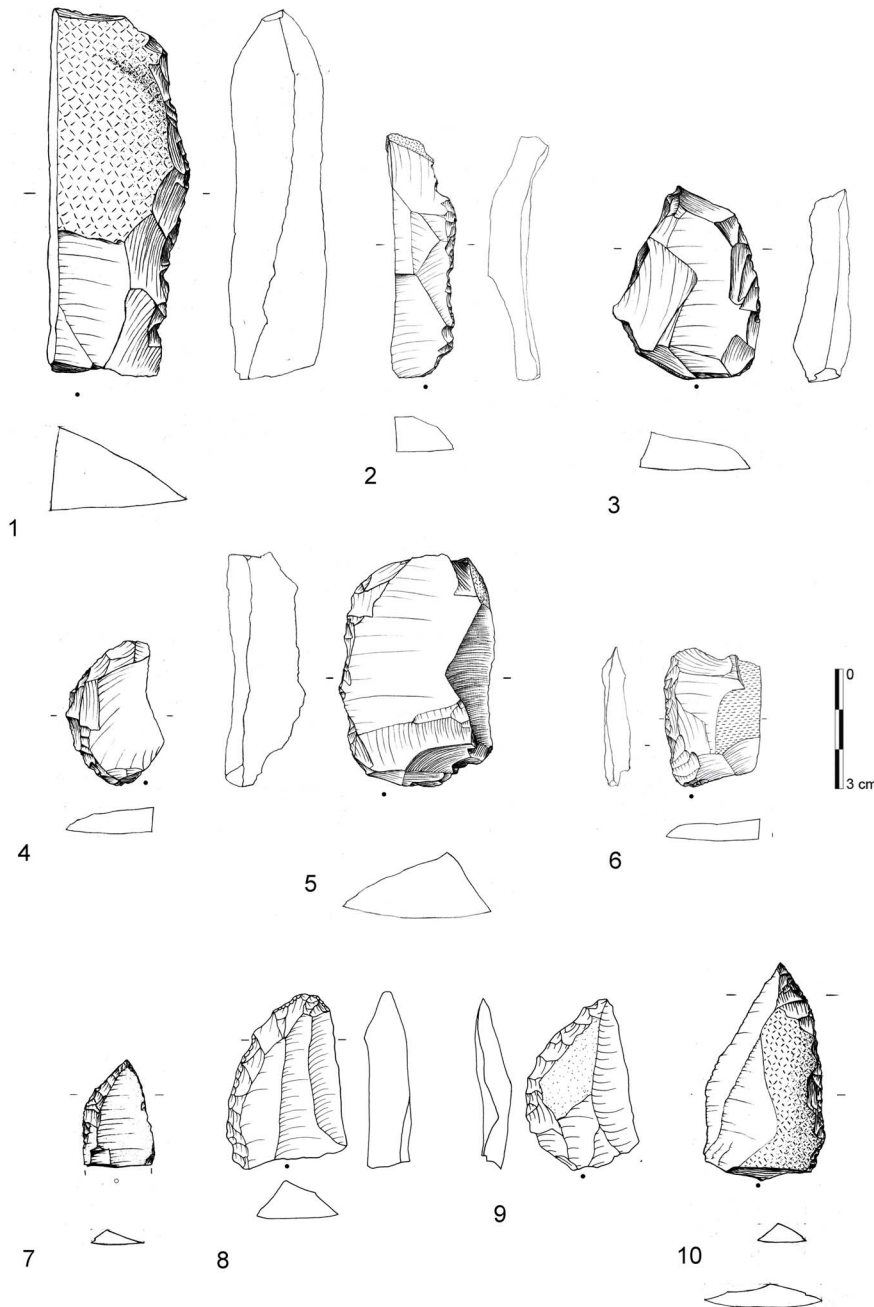


Figure 5. Naturally backed tools (1–6) and asymmetric convergent tools (7–10) from BM-BSP. 1: IV, dolerite, C3-392; 2: BSP, hornfels, C3-21; 3: IV, dolerite, E2-310; 4: IV, dolerite, E2-392; 5: BSP dolerite, D3-113; 6: SPCA, hornfels, E3-664; 7: BSP, hornfels, E3-38.2; 8: SPCA, dolerite, C2-237; 9: IV, dolerite, D3-371; 10: BSP, dolerite, E3-44. Drawings 1–7, 10 by F. Brodbeck and G. Porraz; drawings 8 & 9 by M. Malina. 1–5 after [63] Fig. 12. doi:10.1371/journal.pone.0098359.g005

times with intense preparation of the striking platform (Figure 10: 1–6). The side of the core opposite to the removal surface is either steeply prepared or covered with cortex. Knappers prepared the lateral and distal edges of the core with centripetal removals to create a convex removal surface. Both end products and core rejuvenation flakes occur for this reduction strategy. The products of this system include (convergent) flakes which are longer than wide but also blades. Platforms of these products are often faceted. The (convergent) flakes are mostly flat, have feathered terminations, and exhibit exterior platform angles (EPA) that are typically $>80^\circ$. The majority of the parallel cores, flakes and

maintenance products demonstrates unidirectional recurrent (Figure 10: 1, 2) or centripetal removals (Figure 10: 3, 5, 6). Knappers also removed blades in a unidirectional and recurrent manner from the parallel cores. These products are mostly flat and frequently exhibit faceted striking platforms.

The second strategy of core reduction that we observed is a platform method aimed at the production of blades (Figure 10: 8, 9), flakes (Figure 10: 10, 11) and bladelets (Figure 11). Knappers often set up multiple striking platforms with several removal surfaces and rotated the core during reduction. They reduced the platform cores from both broad and narrow surfaces. The blades

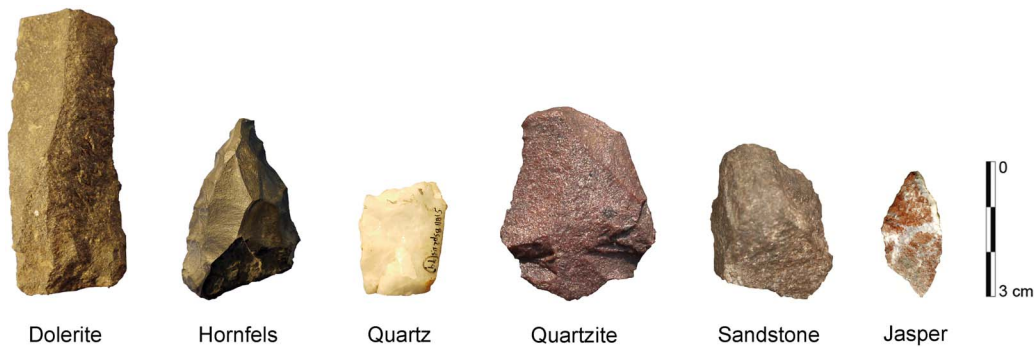


Figure 6. Selection of raw materials used by knappers in BM-BSP. Photographs by G.D. Bader.
doi:10.1371/journal.pone.0098359.g006

from these cores are characterized by plain striking platforms, an average width of ca. 19 mm and regular parallel edges. Most of the blades show recurrent unidirectional removals on the dorsal surface, but bidirectional patterns occur in lower numbers as well. From the six studied assemblages, only BSP ($n = 4$) and SPCA ($n = 1$) yielded cores for the production of bladelets (Figure 11). These cores demonstrate plain striking platform from which several bladelets are struck in a recurrent manner from one removal surface. The bladelet products are largely missing in BSP and SPCA.

A small number of cores and blanks also attests to the existence of an inclined reduction strategy with non-hierarchical and interchangeable surfaces without platform preparation, which appears to be confined to dolerite. Knappers reduced these cores by alternating removals from both surfaces around the entire circumference (Figure 10: 7). Products of this reduction sequence include the characteristic and frequent core edge flakes, in which the roughly triangular blank preserves part of the steep circumference of the discoid core on one lateral edge. The other main products of this method are short quadrangular flakes with inclined dorsal negatives and low EPAs ($< 80^\circ$).

In addition to these three main systems, we observed bipolar knapping on a few cores and flakes. This system of core reduction, however, occurs in very low frequencies and does not appear to be as structured and frequent as the other three methods. Furthermore, a total of 13 splintered pieces indicate a bipolar use of these specimens (*cf.* [128]).

Knapping technique. The inhabitants at Sibudu employed different knapping techniques depending on the blank type they produced. In all assemblages, flakes and convergent flakes were predominantly knapped using a hard stone hammer with direct and internal percussion. These products demonstrate an average platform thickness of around 6 mm in each assemblage ($n = 1241$) with very few butts thinner than 2 mm (4%). Bulbs are very frequent (72%) and often strongly developed with visible contact points or cones of percussion. Lips occur in low frequency (10%) and EPAs cluster around $85\text{--}90^\circ$. The high frequency of longitudinal breaks on flakes is also consistent with strong forces exerted by hard stone hammers that had direct contact with the core.

The knappers used a different approach to the production of laminar products. Based on approaches of previous studies [35,129], we recorded a list of attributes and measurements on blades for each assemblage (Table 6). The analyzed sample amounts to 393 blades. The results show that bulbs are abundant (60%) but poorly developed. Proximal lips occur frequently (24%) and shattered bulbs constitute an even more common feature (31%). The blades feature prepared platforms (faceted 17%,

dihedral 5%), but the majority of butts are plain (44%) or crushed (26%). Blade platforms are relatively thick with an average of 5.0 mm and a modal value of 3.0 mm. The EPAs cluster around 80° . We frequently observed contact points on the blades but almost no platform abrasion. Knappers often trimmed the proximal edges by small overhang removals prior to the production of a blade.

In summary, the discrete and metric attributes indicate that knappers predominantly used a soft stone hammer with direct internal percussion to produce blades. The abundance of shattered bulbs and contact points, the frequent occurrence of poorly developed bulbs and proximal lips, and the range of EPAs are consistent with results from experimental knapping with soft stone hammers [129,130], although these experiments were performed on flint. A marginal percussion movement can be ruled out by the low frequency of platforms < 2 mm (6%) and the lack of platform abrasion prior to blade removal. The fact that all four hammerstones found in BM-BSP are out of sandstone supports our findings.

Flaking efficiency and reduction intensity. We found a strong temporal trend in the diachronic comparison of flaking efficiencies (Figure 12). The oldest layers BM and IV yield the highest values for flaking efficiencies. In contrast, the minimum values come from the youngest levels BSP and SPCA, suggesting that knappers made less efficient use of stone materials in these assemblages.

Concerning the reduction intensity of the assemblages, there is a clear separation between two groups for the ratios of blanks to cores. Highly reduced assemblages include BM and MA with values of 123:1 and 66:1. In contrast, BSP, SPCA, CHE and IV yield consistent blank to core ratios that are far lower (33–38:1). Due to the low number of cores in some of the assemblages, these results need to be considered with caution. We thus also analyzed the sizes of flakes and cores, finding a consistent increase through time. The oldest assemblages BM and IV yield the smallest and thinnest blanks and cores, while the youngest assemblages (e.g. BSP, SPCA) demonstrate larger and thicker specimens. Blanks > 80 mm occur only in the uppermost assemblages. Hence, the inhabitants at Sibudu reduced their lithic raw material more intensively in the earlier assemblages compared to the younger ones.

Tool Assemblages

From a traditional typological point of view, unifacially retouched points characterize the six studied Sibudan assemblages (Figure 13). Unifacial points ($n = 277$) make up half of all modified pieces ($n = 555$) and constitute the most frequent tool type in each

Table 2. Distribution of raw materials.

Layer	Dolerite	Hornfels	Sandstone	Quartzite	Quartz	Jasper	CCS	TOTAL
BSP	535 (65%)	262 (32%)	11 (1%)	8 (1%)	5 (1%)	-	1 (0%)	822
SPCA	333 (58%)	222 (38%)	11 (2%)	9 (2%)	2 (0%)	-	1 (0%)	578
CHE	79 (59%)	50 (38%)	4 (3%)	-	-	-	-	133
MA	111 (62%)	58 (33%)	4 (2%)	3 (2%)	1 (1%)	1 (0%)	-	178
IV	406 (60%)	235 (35%)	21 (3%)	6 (1%)	-	8 (1%)	-	676
BM	181 (69%)	66 (25%)	12 (5%)	2 (1%)	1 (0%)	-	-	262
Total	1645 (62%)	893 (34%)	63 (3%)	28 (1%)	9 (0%)	9 (0%)	2 (0%)	2649

Rounded percentages are given in brackets.
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assemblage ranging between 38–54% (Figure 14; Table 7). They are followed by far fewer scrapers (17%) and lateral retouch on blades (8%). Other tool types that are usually frequent in MSA assemblages, like notches, denticulates, or splintered pieces, occur rarely (<3%). In some layers, these implements are absent (e.g. BM and CHE). Layers BM-BSP yield only 4 backed tools or segments (Figure 13: 1, 2) and 3 bifacial points. There is a marked increase of scrapers in the upper layers BSP-MA (17–24%) compared to the oldest assemblages IV (13%) and BM (12%). In general though, the range and frequency of tool types is homogenous.

From a techno-functional point of view, four formal tool classes and tool cycles characterize BM-BSP (see Figures 3–5): Tongatis, Ndwedwes, naturally backed tools (NBT), and asymmetric convergent tools (ACT). The four formal tool classes make up more than two thirds in each assemblage (67–77%; Table 8). Throughout the sequence, Tongatis are the most abundant tool class (27–42%), followed by Ndwedwes (16–25%). Tongatis and Ndwedwes thus constitute the hallmark of formal tools in BM-BSP, representing >50% of each assemblage with a combined total of 301 pieces (Figure 14). NBTs (Figure 5: 1–6) and ACTs (Figure 5: 7–10) occur in low but stable frequencies throughout the sequence (NBTs: 6–14%; ACTs: 3–9%). Other formal tools, comprising various forms of scrapers, denticulates and notches, play a minor role (3–13%).

We also examined technological aspects to assess the approach of knappers to execute retouch. The inhabitants preferentially selected elongated (18.5%) and convergent forms (33.5%) for secondary modification (Table 9). Still, most tools are made on regular flakes (48%). The knappers applied retouch predominantly to the dorsal side of the blanks (93%) and only in rare instances on the ventral side (3%) or bifacially (4%). Small stepped negatives are the most abundant type of modification on tool edges. Many times the retouch on tools is intense and invasive, with several layers of small overlapping negatives. The modification often covers long parts of the artifact edges, indicating abundant retouch and recycling activities taking place on-site. Concerning the preservation of tools, only a third is in complete state.

Reduction Sequences

We characterized reduction sequences for the different raw materials within each assemblage. In general, both the local dolerite and the non-local hornfels show complete reduction sequences, with products of all manufacturing phases present, indicating their on-site production. Having said this, hornfels exhibits a strong emphasis on the production, resharpening and curation of tools. In contrast to dolerite and hornfels, quartzite, jasper and CCS typically occur in the form of isolated blanks and tools. Sandstone and quartz are only represented by the early stages of knapping. For the latter, there are many cores (n = 3) compared to the few debitage products, suggesting that people exported quartz artifacts to other places in the landscape.

We analyzed the reduction sequences in more detail for the largest assemblage BSP including all artifacts >25 mm (n = 822). BSP mirrors the general observations previously discussed very closely. Dolerite exhibits all stages of the knapping process in relatively large numbers (84% blanks, 2% cores, 11% tools) with some highly cortical products from the earliest phases of reduction. Hornfels displays an emphasis on the distal reduction phases (66% blanks; 29% tools) and an underrepresentation of early manufacturing stages. Quartzite, sandstone and CCS appear in very low numbers and exclusively as finished blanks and tools. The early stages of production for these raw materials presumably occurred off-site during their procurement and previous use. The five quartz

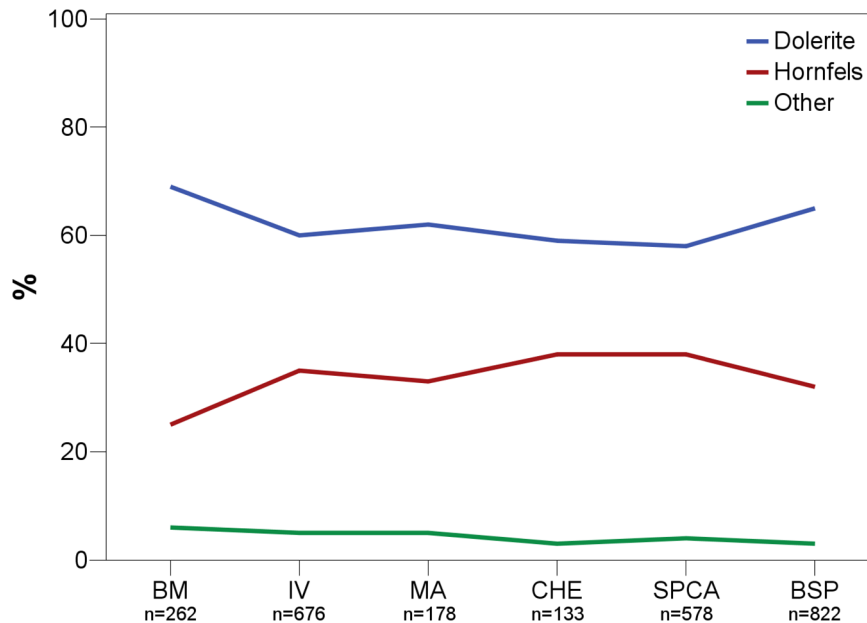


Figure 7. Percentual abundance of raw materials throughout BM-BSP. BM = oldest layer; BSP = youngest layer.
doi:10.1371/journal.pone.0098359.g007

artifacts from BSP include three cores but only two unmodified flakes, demonstrating an apparent lack of debitage products. The existence of a quartz bladelet core (Fig. 10: 1) and the absence of the corresponding bladelets in BSP support the observation that the inhabitants of Sibudu transported quartz artifacts outside the area of excavation.

Quantitative data support the qualitative observations of reduction stages taking place at Sibudu. The proportion of cortex on an artifact, whether from an outcrop or pebble source, can inform on its position in a reduction sequence as cortex cover decreases in a more or less continuous manner during the knapping process [93,131,132]. We assessed cortex on each artifact in increments of 20% from completely non-cortical (0%) to fully cortical (100%) and compared the results between layers and raw materials. In general, all Sibudan assemblages show a similar pattern in which all classes of cortex cover occur (Table 10). Non-cortical specimens amount to ~60–65%. The number of artifacts per increment class decreases gradually with higher cortex proportions. While there are many cortical specimens (>50%), fully cortical artifacts are rare (0–2%), suggesting that the initial

stages of decortification took place off-site. There are some assemblages with more cortical pieces (e.g. CHE, MA) than others (e.g. BSP, BM), but there is no consistent diachronic trend.

We also compared the cortex cover of artifacts made from dolerite and hornfels (Table 10). In general, both dolerite and hornfels show all proportions of cortex in each assemblage, indicating complete reduction sequences that took place on-site. For hornfels, however, there are more non-cortical specimens whereas dolerite exhibits more highly cortical artifacts (>50%). Only BSP and SPCA yielded enough quartzite specimens to roughly assess its cortex frequencies. In BSP and SPCA combined, only 1 out of 19 specimens show any amount of (pebble) cortex, indicating that knappers reduced quartzite mostly off-site.

In order to study the retouch and curation activities of the inhabitants, we quantified the retouch debitage among the small debitage for each raw material (<25 mm; see [63,133]). We analyzed a sample of small debitage from each assemblage (total $n=8193$). On average, retouch flakes amount to ~16% ([63], Tab. 3). The percentages fluctuate between 10–25%, suggesting extensive retouch and curation activities performed on-site

Table 3. Quantitative debitage analyses of the main lithic categories.

Layer	Blank	Tool	Core	Angular debris	TOTAL
BSP	640 (78%)	139 (17%)	19 (2%)	24 (3%)	822
SPCA	453 (78%)	104 (18%)	12 (2%)	9 (2%)	578
CHE	99 (74%)	29 (22%)	3 (2%)	2 (2%)	133
MA	123 (69%)	48 (27%)	1 (1%)	6 (3%)	178
IV	473 (70%)	179 (26%)	14 (2%)	10 (2%)	676
BM	196 (75%)	57 (22%)	3 (1%)	6 (2%)	262
Total	1984 (75%)	556 (21%)	52 (2%)	57 (2%)	2649

Rounded percentages are given in brackets.
doi:10.1371/journal.pone.0098359.t003

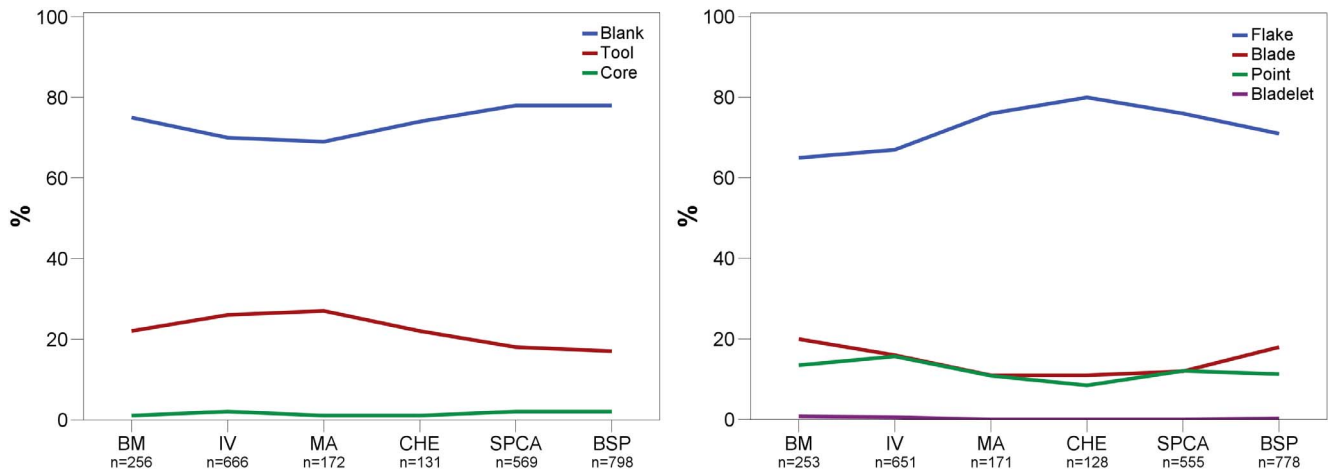


Figure 8. Frequencies of the main debitage categories (left) and blank types (right) produced throughout BM-BSP. BM = oldest layer; BSP = youngest layer. doi:10.1371/journal.pone.0098359.g008

throughout the sequence. This observation corresponds to the very high proportion of tools in these layers compared to many other MSA assemblages. The characteristics of the retouch flakes such as very low EPAs, the presence of a lip and diffuse bulbs of percussion attest to soft hammer percussion with a tangential knapping motion.

The density of lithic artifacts (>25 mm) and small debitage (< 25 mm) can help to assess the intensity of on-site reduction and site use. Figure 15 illustrates the densities of stone artifacts in layers BM-BSP, ranging between 30,000–50,000 n/m³ for lithic products <25 mm. Compared to values of South African MSA sites like Pinnacle Point 13BB (<5000 n/m³ for all occupation horizons; [134]) and our own excavations at Hoedjiespunt 1 ([135], ~600–3000 n/m³, unpublished data) the small debitage values are very high, suggesting repeated and intense occupations with widespread knapping activities taking place. There are, however, strong temporal fluctuations in the lithic densities, suggesting differing intensities of on-site stone knapping. The higher small debitage densities in BM and especially IV are roughly consistent with the observations that these assemblages are more intensively reduced.

Raw Material Economy

The knappers at Sibudu used their main raw materials in a different manner. Observations from the reduction sequences demonstrated that the non-local hornfels shows an emphasis on the production and curation of tools. The Raw Material Retouch Index (RMRI; [136]) supports this interpretation. Blanks made from hornfels (RMRI = 1.43) were more likely to be retouched than dolerite (RMRI = 0.81). The results from the debitage analyses by raw materials are also consistent with these observations. We found an overrepresentation of hornfels tools (48%) compared to the overall proportion of this raw material in the entire assemblage (34%). The ratio of tools to blanks is on average two times higher for hornfels compared to dolerite. In contrast, dolerite occurs most often in the form of unmodified blanks, with a marked underrepresentation of retouched pieces.

An independent t-test comparison of the weight, maximum dimensions and thickness of all complete tools (Table 11) shows that retouched artifacts from hornfels are significantly lighter, smaller and thinner than those from dolerite (p<0.002). Principally the same statistical results are obtained for the differences in maximum core dimension, weight and thickness between the two raw materials, with dolerite cores being significantly heavier, larger and thicker (p<0.031). Hornfels also exhibits by far the smallest,

Table 4. Distribution of blank types.

Layer	Flake	Convergent flake	Blade	Bladelet
BSP	552 (71%)	88 (11%)	136 (18%)	2 (0%)
SPCA	418 (76%)	69 (12%)	68 (12%)	-
CHE	102 (80%)	12 (9%)	14 (11%)	-
MA	130 (76%)	22 (13%)	19 (11%)	-
IV	435 (67%)	105 (16%)	106 (16%)	5 (1%)
BM	165 (65%)	36 (14%)	50 (20%)	2 (1%)
Total ¹	1802 (71%)	332 (13%)	393 (16%)	9 (0%)

¹Including blank types of retouched artifacts. Rounded percentages are given in brackets. doi:10.1371/journal.pone.0098359.t004

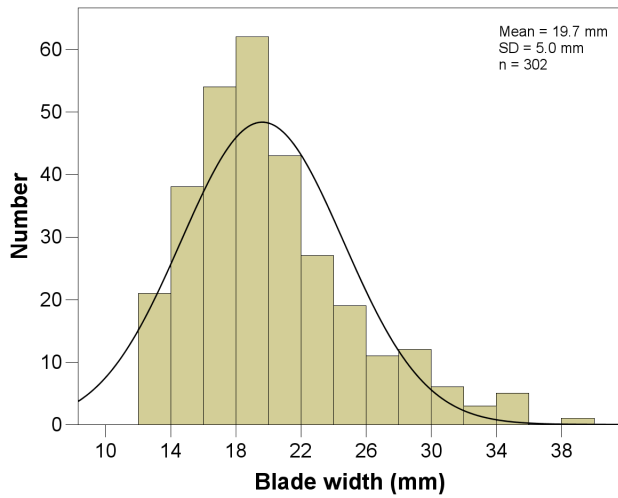


Figure 9. Distribution of blade widths (mm) from BM-BSP.
doi:10.1371/journal.pone.0098359.g009

lightest and thinnest blanks of all raw materials. The difference to unretouched dolerite blanks is highly significant ($p < 0.001$).

The knappers also varied their approach to core preparation with regards to raw materials as can be deduced from the types of platforms. Hornfels has the highest proportion of prepared platforms (29%), followed by dolerite (24%), and sandstone (19%). Very fine platform preparation with >5 small facets occurs most often on hornfels artifacts. In correspondence with this pattern, plain butts are far more frequent for dolerite than hornfels. In contrast, platform crushing and shattering is mostly associated with hornfels and quartzite, probably due to their more delicate nature. Regarding blank types, knappers produced flakes predominantly from dolerite, quartzite and sandstone. Quartz, jasper and CCS occur only in the form of flakes. The relative frequency of blades and convergent flakes is highest for hornfels, with dolerite being second. For hornfels, there are some very long blades and elongated convergent flakes with intense proximal overhang removals and abundant facettation of platforms. Some tool types also show a favored use of raw materials. Knappers made splintered pieces predominantly from hornfels while dolerite was preferentially used to manufacture notches and denticulates. In terms of techno-functional tool classes, knappers at Sibudu preferred hornfels for producing Ndwedwes and dolerite for the manufacture of NBTs.

The amount of small debitage products can provide information on the reduction of raw materials on-site [137–139]. We quantified a sample of small debitage products by raw materials in BSP ($n = 2324$). The resulting frequencies for hornfels and dolerite compare well with the abundances of artifacts >25 mm (Figure 16), demonstrating that knappers reduced both materials on-site. Consistent with their incomplete reduction sequences, small debitage products of quartzite, other raw materials and especially quartz are rare. Preliminary observations on the very large assemblage of small debitage products from the other layers ($n = 43097$) are consistent with these results. In each layer, there is abundant small debitage for dolerite and to a lesser degree for hornfels. In contrast, small knapping products for quartzite, quartz and other raw materials occur rarely. In terms of flaking efficiency, hornfels demonstrates the highest value among all raw materials, followed by dolerite with markedly lower values (Table 12). Sandstone and quartzite show the lowest edge length to mass ratios. These results suggest that among all raw materials, knappers used hornfels in the most efficient way, presumably to conserve this high-quality and non-local raw material.

The observed patterns of raw material economy occur alike throughout BM-BSP. Analyses of reduction sequences, frequencies of retouched forms, RMRI values, small debitage products, and flaking efficiencies suggest a stronger emphasis on retouch and curation for hornfels, with knappers investing more energy and time in the treatment of this non-local high-quality raw material compared to dolerite. An additional factor probably influenced these differences. While hornfels is fine-grained and easy to knap, its sharp edges are often fragile and have a tendency to break. Thus, they require more resharpening than the more durable tool edges of the coarser-grained dolerite (see [123]).

Discussion

Key Elements and Technological Variability of the Sibudan Lithic Assemblages BM-BSP

The period of the MSA following the HP in southern Africa (“post-HP”) has not been studied in great detail, particularly in comparison with the HP and SB technocomplexes (see [19,35,39,52,54,60,63,64]). We examined six lithic assemblages from Sibudu that post-date the HP, from the so-called Sibudan (*sensu* [63]), as part of the process of correcting this research bias.

The lithic assemblages of the Late Pleistocene sequence at Sibudu that we have analyzed here yield a robust technological signal. The key elements of BM-BSP include technological, techno-economic, techno-functional and typological aspects. These characteristics occur in a homogenous manner in each

Table 5. Distribution of core categories¹.

Layer	Parallel	Platform	Inclined	Bipolar	Indeterminate broken
BSP	6	5	2	3	3
SPCA	8	4	-	-	-
CHE	2	1	-	-	-
MA	-	1	-	-	-
IV	5	7	1	-	1
BM	2	1	-	-	-
Total	23	19	3	3	4

¹Core classification follows the taxonomy of Conard *et al.* [104].
doi:10.1371/journal.pone.0098359.t005

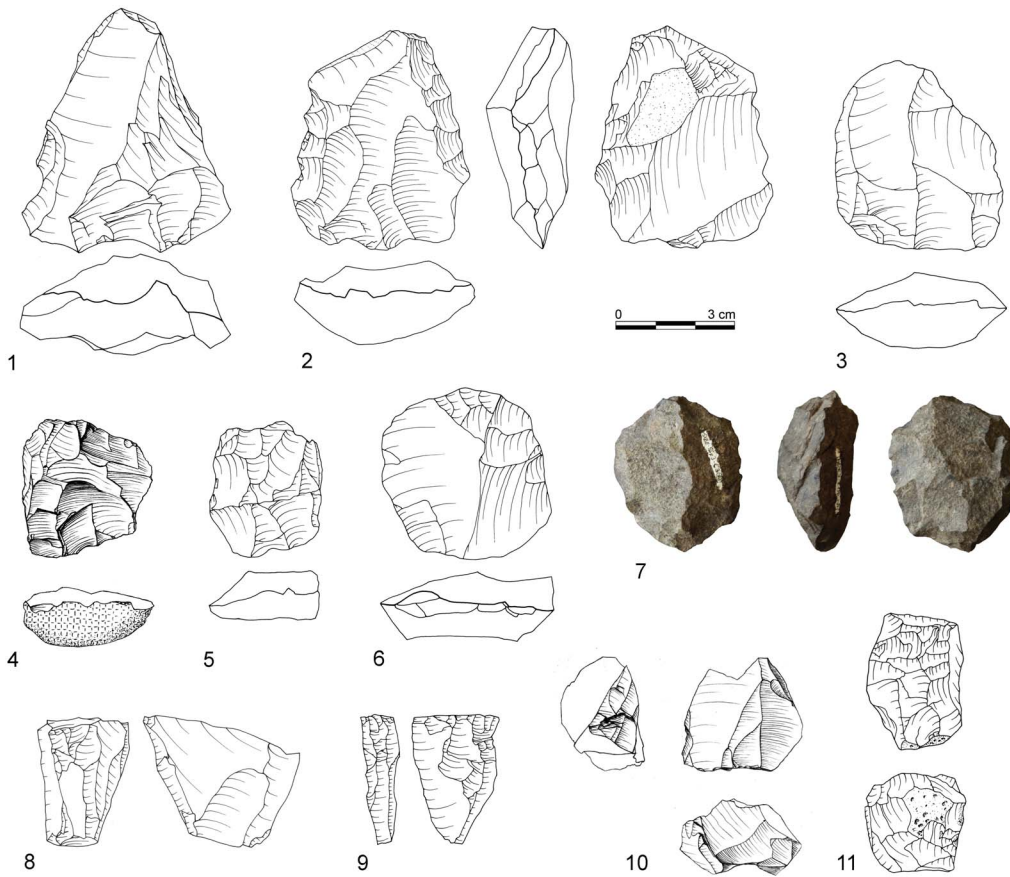


Figure 10. Core types from BM-BSP. 1: Parallel core (BSP, dolerite, E3-122); 2: Parallel core (BSP, hornfels, E3-206); 3: Parallel core (BSP, dolerite, C2-9); 4: Parallel core (BM, dolerite, D3-761); 5: Parallel core (SPCA, hornfels, E3, 550); 6: Parallel core (SPCA, dolerite, D2-243); 7: Inclined core (BSP, dolerite, C3-79); 8: Platform core, laminar products (SPCA, dolerite, E2-208); 9: Platform core, laminar products (SPCA, hornfels, C3-257); 10: Platform core (SPCA, dolerite, C3-149); 11: Platform core (BSP, hornfels, E2-16.1). Drawings 4 & 10 by F. Brodbeck; drawings 1–3, 5, 6, 8, 9, 11 by M. Malina; photograph 7 by M. Will. 4 & 10 after [63] Fig. 4. doi:10.1371/journal.pone.0098359.g010

assemblage and can thus help to define features of the Sibudan (*sensu* [63]). The lithic assemblages demonstrate that the inhabitants followed a consistent pattern of raw material procurement in the brief period we have studied so far, both in terms of their variety and abundance. Knappers used tool stones of local (dolerite, sandstone, quartzite) and non-local (e.g. hornfels) origin.

We also observed a uniform approach to the use of the two main raw materials dolerite and hornfels in terms of reduction sequences and the production of blanks. In accordance with its transport

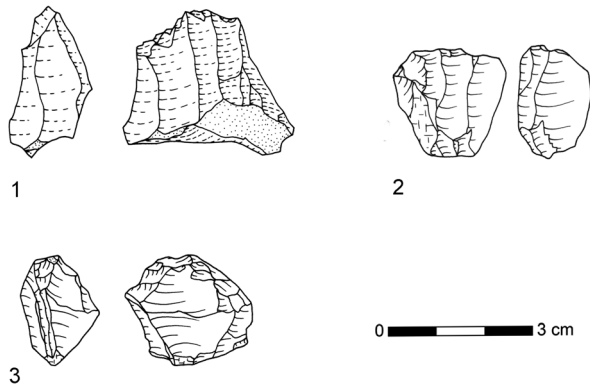


Figure 11. Selection of bladelet cores from BSP (1–2) and SPCA (3). 1: BSP, quartz, E3-273; 2: SPCA, hornfels, C3-149; 3: BSP, hornfels, D3-64.10. Drawings by M. Malina. doi:10.1371/journal.pone.0098359.g011

Table 6. List of attributes and measurements recorded on blades to diagnose the knapping technique.

Discrete attributes	
- Presence of bulb of percussion	(Y/N)
- Presence of proximal lip	(Y/N)
- Presence of shattered bulb	(Y/N)
- Presence of proximal trimming negatives	(Y/N)
- Presence of abrasion on platform	(Y/N)
- Presence of contact point of hammerstone	(Y/N)
- Presence of (partial) Hertzian cone	(Y/N)
- Type of platform	(plain, faceted, dihedral, cortical, crushed)
Measurements	
- Platform thickness	(in mm)
- Platform width	(in mm)
- Exterior platform angle	(in degrees)

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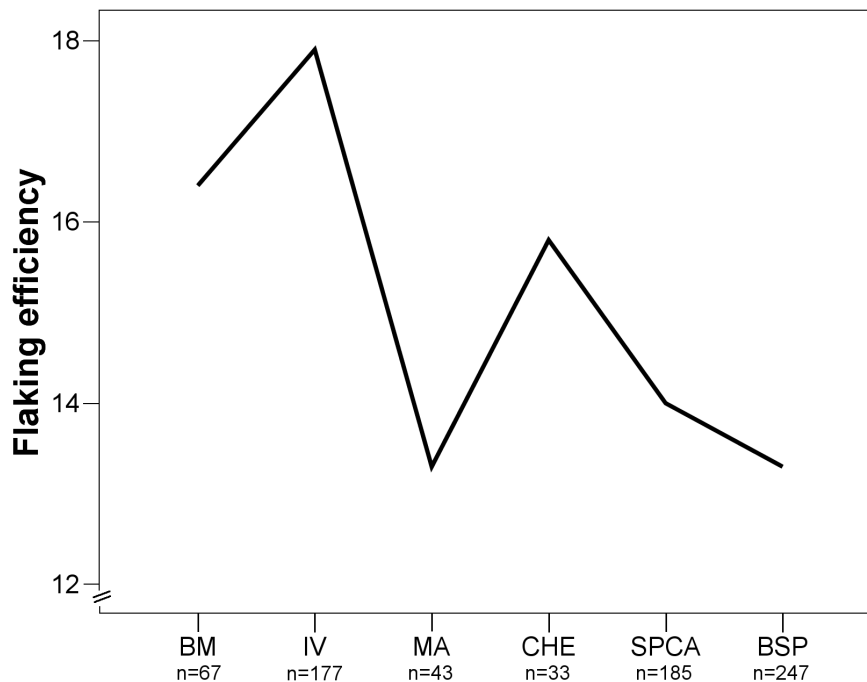


Figure 12. Mean values of flaking efficiency for BM-BSP. Flaking efficiency = edge length/mass. BM = oldest layer; BSP = youngest layer. doi:10.1371/journal.pone.0098359.g012

distance and high quality, people curated artifacts of hornfels more intensively than those of dolerite (*cf.* [121,122]). Our results are in agreement with observations from other research [58,123] suggesting that knappers had ready access to dolerite.

All the Sibudan assemblages we have studied so far are based on various blank types of large size (40–48 mm on average). Throughout BM-BSP, knappers produced blades with principally the same dimensions and shapes. Elongated and convergent products were preferentially selected for retouch and exhibit higher frequencies of prepared platforms. Furthermore, the co-existence of several reduction methods characterizes the layers of this study. Parallel and platform systems are frequent, with inclined cores playing a minor role. Only the parallel cores show extensive core preparation, with one quarter of all blanks exhibiting faceted platforms.

Knappers typically employed hard stone hammers to produce (convergent) flakes but soft stone hammers for blades in all assemblages. The proportion of retouched artifacts is exceptionally high among pieces >25 mm (17–27%), with a diverse and distinct inventory of formal tools. From a traditional point of view, unifacial points constitute the hallmark of implements in BM-BSP, while other typical MSA tools like denticulates and notches occur rarely. From a techno-functional perspective, four tool classes which amount to more than two thirds of all retouched specimens characterize the assemblages. The large number of Tongatis, Ndwedwes, NBTs and ACTs is a characteristic feature of the assemblages BM-BSP. The highly repetitive pattern of organizing the working edges for these implements also indicates a structured approach to tool manufacture, providing distinctive and well-defined tool cycles (see also [63]). We do not consider these tool classes as type fossils but as organizational elements within the Sibudan. They also occur in other periods at Sibudu, and their abundance will likely vary in other parts of the sequence pre- and post-dating the HP. We are currently working to refine this approach using a longer sequence of the Sibudan.

Finally, the six Sibudan assemblages document that similar knapping activities have been performed at the site. Throughout this part of the sequence, we found that the same stages of reduction taking place for each raw material. While dolerite and hornfels show mostly complete reduction sequences, quartzite, quartz, sandstone, jasper and CCS exhibit truncated manufacture sequences. The most prominent feature of the assemblages BM-BSP is their strong emphasis on the distal part of the reduction sequence. Compared to many other assemblages from the MSA, these layers exhibit a very high abundance of tools with intensively retouched and curated pieces as well as a large amount of retouching debitage. This observation is related to the intensive production and curation of tools in these layers. Of course, it is possible that other facies of the Sibudan show different features including lower proportions of tools and distal elements in the lithic technology.

While the Sibudan assemblages studied so far provide a strong and consistent technological signal, the high-resolution stratigraphy allowed for the recognition and evaluation of small-scale technological variation throughout the archaeological deposits. This behavioral variability is to be expected since the technological behavior of mobile hunter-gatherer groups is influenced by many ecological, social and functional parameters that change within short periods of time at the same locality (e.g. [140–142]).

We observed slight differences in the choice of raw materials. While the main types of tool stones remain the same, rare variants such as CCS and jasper occur only in a few assemblages. The abundance of non-local raw materials ranges between 25–38%. These variations might reflect differential access to the sources of raw materials or changes in the mobility system of the inhabitants such as smaller or larger home ranges and foraging trips. There is also some variation in the forms of tools produced, although there are no clear temporal trends in this part of the sequence. This variability could be an outcome of different activities performed at the site. Future studies will investigate site function and tool use in more detail. Finally, the difference in the reduction intensities of

Table 7. Distribution of traditional tool types.

Layer	Unifacial Point	Side Scraper	Lateral Retouch	Denticulate & Notch	End Scraper	Backed tool	Bifacial Point	Hammer-stone	Minimal retouch	Other
BSP	66 (48%)	24 (17%)	13 (9%)	4 (3%)	2 (1%)	2 (1%)	2 (1%)	1 (1%)	19 (14%)	6 (4%)
SPCA	48 (46%)	24 (23%)	6 (6%)	4 (4%)	3 (3%)	-	-	2 (1%)	9 (9%)	8 (8%)
CHE	11 (38%)	7 (24%)	3 (10%)	-	-	-	-	-	8 (28%)	-
MA	26 (54%)	10 (21%)	3 (6%)	-	1 (2%)	-	-	-	5 (11%)	3 (6%)
IV	97 (54%)	23 (13%)	15 (8%)	11 (6%)	1 (1%)	2 (1%)	1 (1%)	1 (1%)	20 (11%)	8 (4%)
BM	29 (52%)	7 (12%)	6 (11%)	-	1 (2%)	-	-	-	10 (18%)	3 (5%)
Total	277 (50%)	95 (17%)	46 (8%)	19 (3%)	8 (1%)	4 (1%)	3 (1%)	4 (1%)	71 (13%)	28 (5%)

Rounded percentages are given in brackets.
doi:10.1371/journal.pone.0098359.t007

the assemblages constitutes the most conspicuous technological variation in the studied sequence. The older assemblages (BM, IV) are more intensively reduced, with higher blank to core ratios and smaller debitage products. Consistent with this observation, these layers also feature the highest densities of small debitage. Interestingly, the density for ochre and faunal remains >25 mm that people left behind at the site does not follow the patterns of the lithics (Figure 17). These subtle distinctions between the upper and lower assemblages are most likely the result of differences in the use of the site, the access to raw materials and the system of mobility.

In contrast to studies which consider the “post-HP” as a phase of unstructured or unsophisticated lithic technologies during the MSA (e.g. [41,50,65,67]), we found clear cultural signals that unite the assemblages studied at Sibudu so far. These key elements occur homogeneously in many independent aspects of the lithic technology in six successively stratified assemblages of different sample sizes and reduction intensities, attesting to a structured lithic technology. Many of these characteristics, such as the well-recognizable tool assemblages with repetitive forms and distinctive reduction cycles, or the production of morphometrically standardized blades by soft stone hammers, demonstrate that the people at Sibudu did not possess a rudimentary or unsophisticated approach to stone knapping (*contra* [41,50], see also [63]).

Comparing the Sibudan to MSA Assemblages following the HP in Southern Africa

In order to move forward with the process of characterizing the Sibudan, it is essential to compare its lithic assemblages with those from other sites of this time period. Only then will it be possible to assess the spatial and temporal variation of the material culture following the HP and to consider where the Sibudan fits in the African taxonomy with its hierarchy of phases defined at the Burg Wartenstein meeting of 1965 ([143,144], see also [9]).

Recently, Lombard *et al.* [9] proposed the “Sibudu Industry” or “Sibudu technocomplex” to describe lithic assemblages at Sibudu that derive from both the “post-HP” (~58 ka) and “late MSA” (~48 ka) layers. They [9] view the Sibudu technocomplex as a pan-southern African phenomenon including assemblages from a list of ten sites that are characterized by the following typo/technological characteristics: most formal retouched is aimed at producing unifacial points which are predominantly produced by Levallois methods, with a tendency towards elongated forms with faceted platforms (*Sibudu point* as type fossil). Some plain butts occur as well. Side scrapers are present and there are rare bifacially retouched points and backed pieces [9,145]. While our results from the lithic assemblages BM-BSP are broadly consistent with these characteristics, many important technological elements that we have found do not feature in this list. Detailed information on the methods of core reduction, the types of blanks produced, the knapping techniques and the reduction sequences will need to be provided for a conclusive comparison.

The most straightforward approach to evaluate the place of the studied Sibudan assemblages within the cultural sequence of the Late Pleistocene MSA are site by site comparisons. We chose assemblages based on the availability of technological data, reliable stratigraphy and secure dating. We also selected localities that are broadly comparable in their age, geographical and environmental parameters, and patterns of site-use, although this was not always possible. Lithic assemblages from the eastern part of South Africa constitute the most promising comparisons due to the short geographical distances and similar environmental circumstances. The southern African summer rainfall zone has provided several MSA sites that follow the HP (see [9,54,71]).

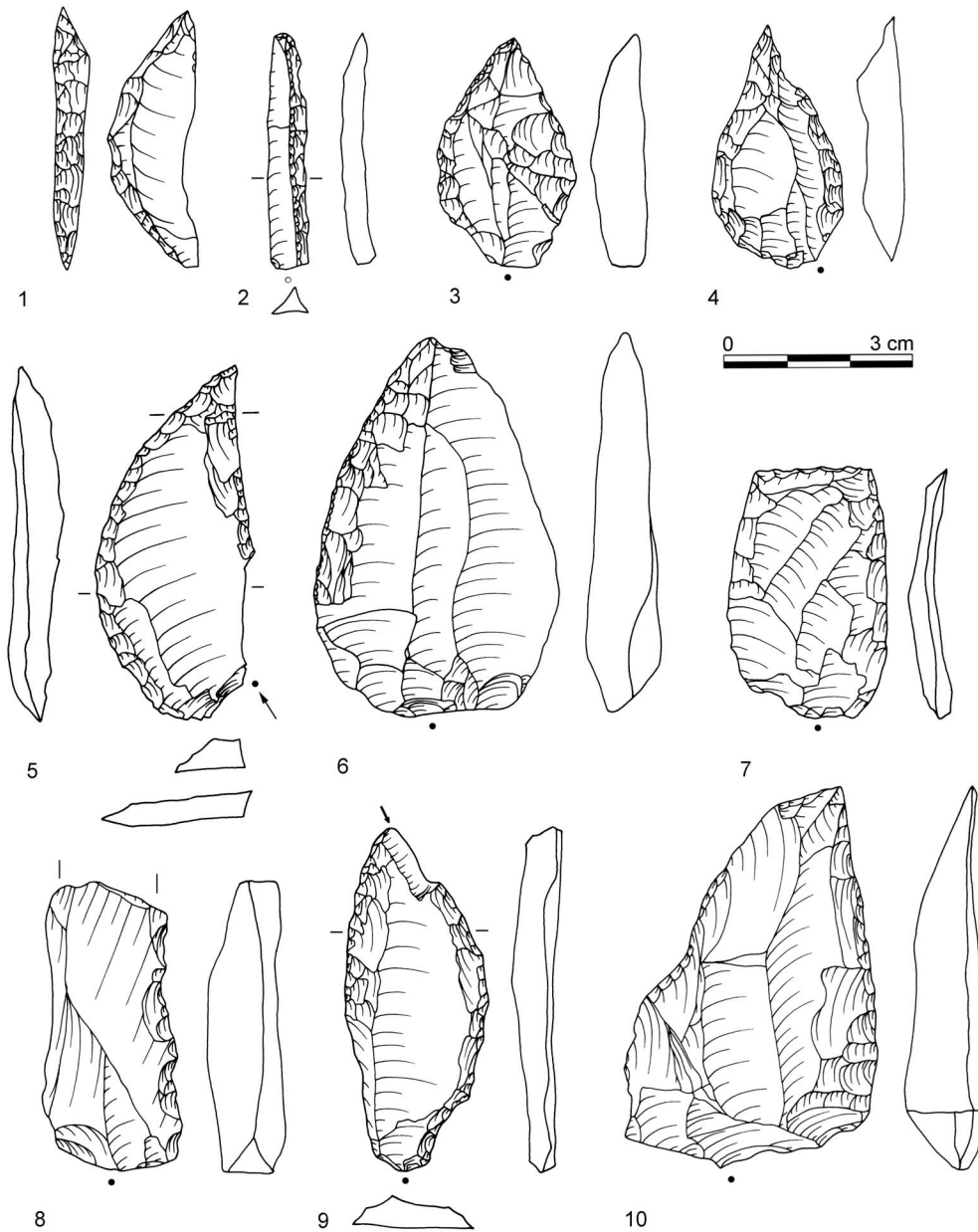


Figure 13. Selection of traditional tool types from BM-BSP. 1: Backed tool/segment (BSP, hornfels, D3-42.1); 2: Backed tool (BSP, hornfels, D3-17); 3: Unifacial point (BSP, hornfels, C3-42); 4: Unifacial point (BSP, hornfels, E3-40); 5: Unifacial point (BSP, hornfels, D3-18); 6: Unifacial point (BSP, hornfels, C2-8); 7: Biseau (IV, hornfels, E3-542); 8: Denticulate (IV, hornfels, D2-374); 9: burin (SPCA, hornfels, C3-273); 10: Side scraper (BSP, hornfels, C2-186). Drawings by M. Malina.
doi:10.1371/journal.pone.0098359.g013

Umhlatuzana Rock Shelter (URS) lies in KwaZulu-Natal only 90 km south-west from Sibudu and ~35 km from the Indian Ocean [73,145]. The earliest layers that follow the HP (“late MSA”, Levels 19–21) date to around 40–44 ka [74]. While there are some problems with the stratigraphy [73,145], recent OSL dating supports the integrity of the sediments [74]. In the following we describe the “late MSA” assemblages from URS (after [73,145]) and also include detailed descriptions of the unifacial points [64,74].

The lithic assemblages are large (17.000–70.000 pieces), suggesting intensive occupations and on-site knapping. Hornfels dominates the assemblages (60–90%), followed by quartzite (11–35%) and few other raw materials. Flakes with plain platforms

constitute the most frequent blank type, but faceted butts occur as well. Bladelets are more frequent than blades, with the latter being rare (n = 36). Knappers manufactured bladelets from both platform and bipolar cores, with an average width of 6 mm. The most frequent core forms are irregular and platform types, with bipolar cores being less abundant. Kaplan [73] mentions prepared core technology but provides no further descriptions. The majority of cores is very small with mean lengths of ~20 mm. Formal tools account for only 0.2%, but no size cut-off point was used for artifact counts [73,145]. Unifacial points (37–40%) dominate the tool assemblages, followed by bifacial points (4–11%) and scrapers (3–15%). Rare miscellaneous backed pieces, backed points and small segments complete the tool spectrum. Knappers

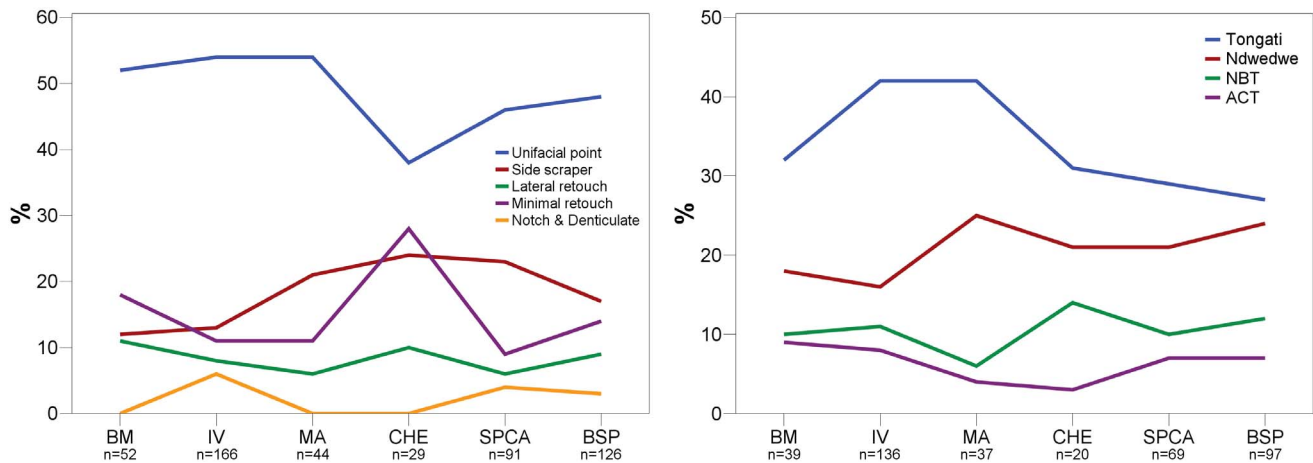


Figure 14. Percentual abundance of classic typological categories (left) and techno-functional tool classes (right). BM = oldest layer; BSP = youngest layer.
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preferentially selected hornfels and elongated flakes to manufacture unifacial points [64,74]. The points are generally of large size (~48 mm) and feature faceted platforms (22%). URS displays a variety of unifacial point forms, often with invasive retouch. The majority of the depicted unifacial points resembles Tongatis (see in [64], Fig. 5a: c, f, g, i, l), but there are also three potentials Ndwedwes (see in [64], Fig. 5a: e, h) and one ACT (see in [64]; Fig. 5a: k).

Overall, the “late MSA” at URS conforms to the Sibudan assemblages BM-BSP in several typo-technological aspects. The core reduction methods are broadly similar and the unifacial points at URS match the variety in forms, the size, the intensive retouch and the blank types of those manufactured at Sibudu (*cf.* [64,146]). Having said this, there are also differences. In contrast to the assemblages we have studied, URS features finely made bifacial points and very small backed segments. Additionally, the absolute number of retouched pieces ($n = 217$) in relation to the total assemblage ($n = 130,000$) is around five times lower for URS compared to Sibudu (tools $n = 555$; total assemblage $n = 60,000$). Discoid technology has not been reported at URS and it is unclear whether knappers produced convergent flakes. The abundance and small size of bladelets as well as the scarcity of blades also distinguishes URS. There are no information on rock type availability, raw material economy or knapping technique.

Rose Cottage Cave constitutes one of the few well-excavated, well-stratified and well-dated sites of eastern part of southern Africa [35,147,148]. The large cave lies in the Orange Free State ca. 350 km west of Sibudu. The early “post-HP” assemblages (THO, BYR) are dated to around ~50 ka by TL or ~57 ka by OSL [35]. We summarize the recent description of the lithic assemblages [35] with additional information from Harper [148].

The knappers at RCC used mostly local rocks, with more than 80% being opaline of high knapping quality, 10% tuff and few other raw materials. The inhabitants frequently produced blades (BYR 57%, THO 30%) but flakes are reported to be the primary objective of core reduction. The blades are mostly irregular, showing a low degree of standardization. Knappers produced blades by unidirectional reduction from the narrow face of the core. Cores make up 9–13% of the assemblages, with frequent bipolar cores in THO ($n = 25$) but not in BYR ($n = 1$). Flake cores dominate and Levallois flakes are common. The inhabitants used hard stone hammers with internal percussion to produce blades, often with faceted platforms (25%). Tool frequencies are high for

both BYR (14.6%) and THO (26.5%). Various scraper forms dominate the tool assemblages (55%), followed by unifacial and partly bifacial points (12%), some scaled pieces and rare backed pieces, notches and denticulates. The tool types show little standardization. Flakes form 55–72% of blanks used for retouched pieces, with blades amounting to 28–45%. Unifacial points were predominantly made on flakes. Knappers manufactured most of their tools on opaline, corresponding to its overall abundance. The large number of small debitage pieces indicates frequent on-site tool manufacture.

There are several parallels to the Sibudan assemblages BM-BSP, including the production of both blades and flakes, Levallois and platform reduction methods, the high number of retouched specimens, the variety of tool forms and the manufacture of tools on-site. The abundance of fine-grained raw materials around the site explains the lack of non-local raw materials. In contrast to RCC, however, knappers at Sibudu produced blades from both narrow and broad surfaces of cores with higher degrees of morphometric standardization. They also employed a soft stone hammer for the production of blades. There is no information on the existence and role of convergent flakes as desired blanks at RCC. In opposition to Sibudu, cores are frequent in the early “post-HP” at RCC but without discoid reduction. The relatively low frequency of unifacial points at RCC might be partially explained by the separation of convergent scrapers and unifacial points [35]. Of the three depicted unifacial points, two compare well to Tongatis (see in [35], Fig. 16: 7–8) but none to Ndwedwes or asymmetric points. This observation matches with Harpers [148] description that most unifacial points are thin and show symmetric triangular distal ends.

In a next step, we compared the six Sibudan lithic assemblages with geographically more distant areas of South Africa. Both the Southern (e.g. [10,11,149]) and Western Cape (e.g. [56,59,62,150]) have provided several localities with lithic assemblages post-dating the HP. Klasies River (KR) is a complex of caves and shelters located on the southern coast of South Africa about 200 km east of Mossel Bay. The locality is famous for its almost 20 m thick sequence which long served as the type site for the cultural stratigraphy of the South African MSA [10,11,151]. Most recently, Wurz [11] and Villa *et al.* [60] studied the “MSA III” lithic assemblages of Cave 1A that date to around ~58–60 ka [40,152].

Table 8. Distribution of techno-functional tool classes.

Layer	Tongati	Ndwedwe	NBT	ACT	Biseau	Splintered piece	Formal tool	Broken tool	Other
BSP	37 (27%)	34 (24%)	17 (12%)	9 (7%)	2 (1%)	4 (3%)	18 (13%)	15 (11%)	3 (2%)
SPCA	30 (29%)	22 (21%)	10 (10%)	7 (7%)	-	4 (4%)	13 (12%)	16 (15%)	2 (2%)
CHE	9 (31%)	6 (21%)	4 (14%)	1 (3%)	-	-	2 (7%)	7 (24%)	-
MA	20 (42%)	12 (25%)	3 (6%)	2 (4%)	-	1 (2%)	4 (8%)	6 (13%)	-
IV	74 (42%)	29 (16%)	19 (11%)	14 (8%)	2 (1%)	3 (2%)	13 (7%)	22 (12%)	2 (1%)
BM	18 (32%)	10 (18%)	6 (10%)	5 (9%)	-	1 (2%)	2 (3%)	13 (23%)	2 (3%)
Total	188 (34%)	113 (20%)	59 (11%)	38 (7%)	4 (1%)	13 (2%)	52 (9%)	79 (14%)	9 (2%)

Rounded percentages are given in brackets.
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The majority of raw materials is local, including quartzite, quartz, hornfels and chalcedony. Silcrete constitute the only potential non-local tool stone and occurs in low frequencies (but see [153]). Knappers primarily manufactured blades (>50%), with convergent flakes being rare. According to Wurz [11] there are also no cores for convergent flakes. The main core reduction method is unidirectional blade removals from semi-prismatic cores, beginning on the narrow face of the core and using symmetrical crested blades (see in [60]; Fig. 16). Blade widths range widely between 10–30 mm and do not show a normal distribution around one peak (in [60]; S. Fig. 21). Knappers employed direct internal percussion with a hard stone hammer to produce blades. About 10% of the artifacts are retouched. Side scrapers, denticulates and notches dominate the tool assemblages, but truncated faceted pieces occur as well. Unifacial points are rare (7%; [60]), but Singer and Wymer [10] report ~24%. Knappers preferentially selected blades (85%) over flakes (15%) for retouch. Almost all of the modified pieces are from the local quartzite, with few specimens from the potentially non-local silcrete.

Overall, the “MSA III” lithic assemblages at KR differ markedly from the Sibudan assemblages we have studied so far. While the existence of a blade production strategy with a comparable method of core reduction unites the assemblages, there are several major technological and typological differences. In BM-BSP flakes and not blades are the principal types of blanks produced, and disoid and Levallois core reduction method occur as well. The blades at Sibudu show higher standardization in size and shape, with a width distribution around a single peak. Furthermore, knappers usually manufactured blades with soft stone hammers and not hard stone hammers. While retouched specimens are relatively frequent at KR, the tool assemblages appear to be distinct. There is also a difference in the raw material economy at Sibudu, where knappers preferentially retouched and curated non-local tool stones.

Klein Kliphuis rockshelter (KKH) lies in the Western Cape of South Africa, approximately 200 km north of Cape Town and 70 km inland of the current coastline. The relevant assemblages of the “Early post-HP” derive from spits Dv and Dvi1-7 and date to ~58 ka [40,59]. We summarize the descriptions of these lithic assemblages by Mackay [56,59].

Silcrete, quartz and quartzite are local raw materials and account for almost all artifacts, with rare non-local hornfels (< 1%). Quartzite constitute the most common raw material overall, but there are marked changes in the procurement of tool stones. Blades amount to 10–20% of blanks with the rest being flakes of around 30–40 mm length (see in [56]; Fig. 8). Faceted platforms are frequent (16–41%) and the knappers employed Levallois, radial, platform and bipolar core reduction methods. KKH features many large cores (14–259 g), with few intensively reduced or exhausted specimens. The blades have a mean platform thickness of ~5 mm, EPAs of 82° and are often faceted (33%). Retouched specimens constitute 6% of all artifacts >25 mm (A. Mackay, pers. comment). Unifacial points are the most common formal implements, followed by scrapers. The actual number of unifacial points numbers, however, is low (*cf.* [56], Fig. 5): no units yielded more than five unifacial points and five spits exhibit only one or none. Backed tools occur in the earliest layers of the “post-HP” (Dvi6-7) as well as six bilaterally backed points. The high number of lithic products suggest intensive occupations and knapping activities. Mackay [120] also provides mean edge length to mass ratios of 28.65 for layers DV-Dvi7, fluctuating between 20–40.

Table 9. Number of blank types used for the manufacture of tools for the combined assemblages BM-BSP.

Blank	Tools (n)	Tools (%) ¹	Blanks (%) ²	%diff ³
Flake	262	47.5	71.0	-23.5
Convergent Flake	184	33.5	13.1	+20.4
Blade	102	18.5	15.5	+3.0
Bladelet	3	0.5	0.4	+0.1

¹Proportion of tools made on this blank type in all assemblages.

²Proportion of blanks in all assemblages.

³Tools (%) – Blanks (%).

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The “Early post-HP” at KKH resembles the Sibudan assemblages BM-BSP in terms of blank production, core reduction and core preparation. While there is no information on the production of convergent flakes, the size of the flakes and the proportions of blades to flakes are also similar. Unifacial points constitute the most frequent formal tool type at KKH, but their absolute number is very low with a diminished diversity in forms compared to the six Sibudan assemblages. The unifacial points depicted (see in [59], Fig. 8) resemble Tongatis. Comparable pieces to NBTs, Ndwedwes or ACTs are not presented. Average values of flaking efficiency at Sibudu fall below the range of KKH, indicating a less efficient use of raw materials. Interestingly, the majority of cores at Sibudu is heavily reduced, which is not the case for KKH. The lack of non-local artifacts at KKH can best be explained by the local availability of high-quality lithic raw material. Based on the values for platform thickness, blade production proceeded by internal percussion, but the kind of hammer used remains unclear. A conclusive evaluation will need to include a more detailed assessment of the knapping technique for blades and flakes, a technological analysis of the blanks produced, and the economy and reduction sequences of raw materials.

Diepkloof Rock Shelter (DRS) lies around 15 km inland from the Atlantic Ocean and yielded a thick stratigraphic sequence with frequent and intense occupations during the “post-HP” that compare well with Sibudu [18]. Porraz *et al.* [62] provide a short characterization of the lithic assemblages Danny to Claude (n = 1289, >20 mm), which are dated to 52+/-5 ka [20] and 55.4+/-2.0 ka [40].

The knappers used mainly silcrete, quartzite and quartz, with non-local raw materials amounting to ca. 50% of the assemblages. The majority of blanks are flakes (66%), followed by blades (19%), bladelets (8%) and few convergent flakes (3%). Core reduction is characterized by blade products, including HP-type debitage. Knappers produced blades with irregular forms by internal percussion using hard stone hammers. Flakes are morphologically variable and show unidirectional and centripetal dorsal negatives with little platform preparation. Retouched forms are frequent (14%). Scrapers in various reduction degrees constitute the most frequent tool form (27%), followed by unifacial points (14%). Some of the points show short triangular ends that are comparable to the Tongatis of the Sibudan (see in [62], Fig. 11: 7–9). Other tool forms include denticulates and notches (15%), burins (6%), truncated pieces (5%), backed pieces (4%) and splintered pieces (4%), and end scrapers (2%).

The provisioning with local and non-local raw materials, the production of flakes and blades, the coexistence of different core reduction methods and an emphasis on the distal reduction sequence reflect similarities between the “post-HP” at Sibudu and

DRS. However, Porraz *et al.* [62] note that there are important typological and technological differences between these assemblages, such as the lack of unifacial point categories other than the Tongatis and the absence of NBTs. They conclude that the “post-HP” at DRS should thus not be subsumed under the “Sibudu technocomplex” (*sensu* [9]). To these observations, we add that the production of convergent flakes only plays a negligible role at DRS and blades in the Sibudan assemblages BM-BSP are more regular and produced by soft stone hammers. Discoid technology and more frequent core preparation also distinguish these layers from Danny to Claude at DRS.

Our site by site comparisons demonstrate that the Sibudan assemblages that we have studied so far show several parallels in terms of technology, techno-economy and typology to other sites dating to early MIS 3. But there are also important differences in these domains. In particular, the abundance of unifacial points – and tools in general –, the clear patterning of production cycles and reduction histories for specific tool classes (e.g. Tongatis, *sensu* [63]), the use of a soft stone hammer to produce blades, the frequent manufacture of convergent flakes and the co-existence of several core reduction methods, including the discoid method, distinguish the Sibudan from most of these assemblages. We see two potential explanations for the observed patterns. First, the lithic assemblages BM-BSP could be interpreted as a special, site-specific case of the “post-HP” due to particular environmental circumstances, patterns of site use, mobility patterns or raw material availability. As an alternative explanation, our findings can be interpreted as supporting the working hypothesis by Conard *et al.* [63] that the lithic assemblages dated to ~58 ka at Sibudu yield a new signal of the early “post-HP” that can be attributed to a novel cultural-technological unit, the Sibudan.

We support the latter interpretation, as we made great efforts to compare the assemblages at Sibudu to sites that are as similar as possible in terms of dating, type of site occupation, raw materials, geographical and environmental parameters. Sibudu and its occupation sequence after the HP are not exceptional with regards to these characteristics. All assemblages that we have compared derive from similar timeframes, feature raw materials of high and low flaking quality, show all stages of the lithic reduction sequence and derive from sites with repeated and intensive occupations similar to residential camps. Furthermore, the six studied Sibudan assemblages share several features with other “post-HP” assemblages, especially with the nearby sites URS and RCC, and are thus not an entirely isolated phenomenon. The perceived uniqueness of the techno-typological signal could also be attributed to the fact, that the Late Pleistocene MSA lithic technology of eastern South Africa is poorly documented, with few sites available for comparison. More detailed information on the lithic technology of URS and RCC, especially for aspects that we

Table 10. Cortex cover on artifacts for each assemblage and for the total sample of dolerite and hornfels.

% cortex	Layer	Raw material						
		BSP	SPCA	CHE	MA	IV	BM	Dolerite
0	525 (64%)	368 (64%)	74 (56%)	109 (61%)	410 (61%)	174 (66%)	963 (58%)	626 (70%)
1–20	124 (15%)	73 (13%)	20 (15%)	20 (11%)	94 (14%)	30 (11%)	232 (14%)	115 (13%)
21–40	88 (11%)	65 (11%)	18 (14%)	22 (12%)	75 (11%)	26 (10%)	200 (12%)	81 (9%)
41–60	31 (4%)	23 (4%)	8 (6%)	10 (6%)	45 (7%)	16 (6%)	92 (6%)	34 (4%)
61–80	34 (4%)	35 (6%)	6 (4%)	12 (7%)	36 (5%)	10 (4%)	99 (6%)	30 (3%)
81–99	15 (2%)	8 (1%)	5 (4%)	2 (1%)	14 (2%)	4 (2%)	42 (3%)	4 (1%)
100	5 (0%)	6 (1%)	2 (1%)	3 (2%)	2 (0%)	2 (1%)	17 (1%)	3 (0%)
Total	822	578	133	178	676	262	1645	893

Rounded percentages are given in brackets.
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could not yet compare, might reveal that they should be included within the Sibudan. In conclusion, we view the Sibudan as a working model that can help to organize part of the cultural sequence of the MSA during MIS 3. Based on the long excavation history, the thick and high-resolution stratigraphy and the outstanding preservation of materials, Sibudu is ideally suited to serve as a type site and reference point for further comparisons (see also [9,63]).

In view of the current data basis, the Sibudan appears to be a phenomenon during early MIS 3 which does not cover the entire period following the HP in terms of geography and chronology. Our comparisons have revealed several techno-typological parallels to sites from the eastern part of southern Africa but more pronounced differences to localities from the Southern and Western Cape. We want to emphasize, however, that the results and comparisons described here reflect work in progress. For now, we presented technological, techno-functional, techno-economic and typological data for six Sibudan lithic assemblages (BM-BSP) that date to ~58 ka and provided preliminary comparisons with other sites. Using these data, researchers can perform additional comparisons with assemblages post-dating the HP, test the utility of the Sibudan as a cultural-taxonomic unit and critically examine its spatio-temporal range. Regarding our own work at Sibudu, there are still many layers of the depositional sequence following the HP that need to be analyzed. The Tübingen fieldwork at Sibudu is ongoing with the aim to excavate the entire sequence that follows the HP in the coming years (see Figure 1). We expect to observe still greater variation in the strata dated to ~58 ka that have not yet been excavated by our team. The study of this variability can document patterns of short-term cultural behavior within the Sibudan. Characterizing the full range of variation will also represent an essential next step in testing and refining the ideas presented here.

Conclusion

The Late Pleistocene cultural sequence at Sibudu that we have studied here exhibits a distinct technological signal of modern humans living during the later MSA in the eastern part of South Africa. We were able to define key elements that characterize the lithic assemblages and document technological variability within a high-resolution stratigraphy. The markers that unite these assemblages occur in several independent technological and typological domains even though they differ in sample size and reduction intensity. Comparisons with other assemblages from southern Africa that post-date the HP demonstrate several techno-typological parallels, particularly with the geographically closest sites Rose Cottage Cave and Umhlatuzana. Having said that, the Sibudan assemblages BM-BSP yield a so-far unique combination of technological, typological and techno-economic characteristics. These results support the use of the Sibudan (*sensu* [63]) as a concept that can serve as a starting point for comparisons with other MSA assemblages of this timeframe. Further research on local, regional and sub-continental scales is necessary and will help to assess the spatio-temporal distribution of the Sibudan. This work should evaluate whether the Sibudan is confined to the eastern part of southern Africa during early MIS 3 or covers a broader geographical and chronological range. These studies will also help to define the place of the Sibudan in the taxonomic hierarchy (e.g. [9,143,144]).

The findings that we have presented here, alongside recent studies by other researchers [54,56,57,59,60,62], demonstrate the need to intensify research on periods that follow the SB and HP. From our analysis, we conclude that there is no reason to denote

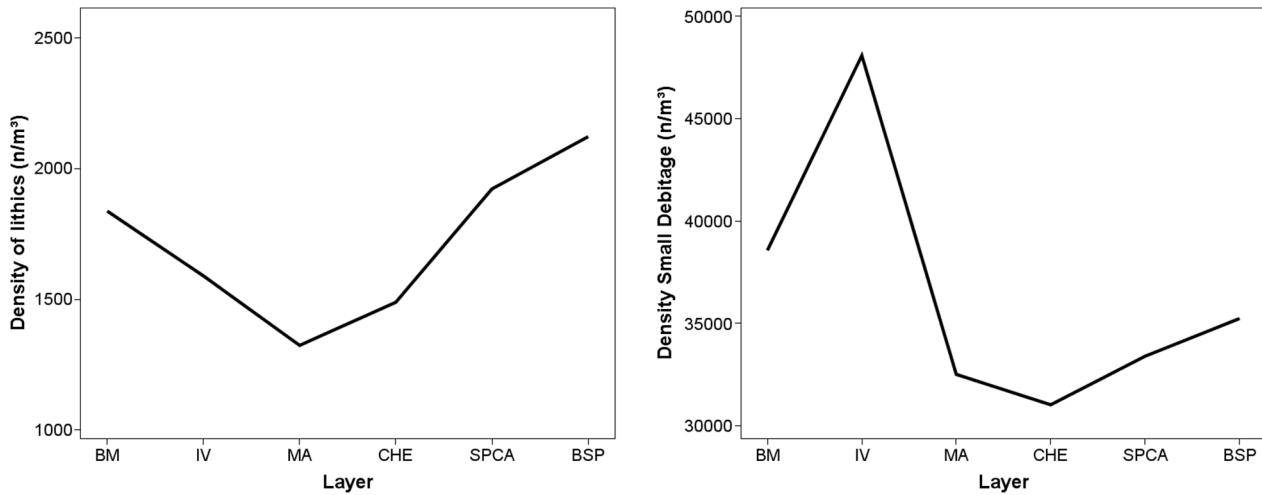


Figure 15. Density of lithic remains throughout BM-BSP. Lithics >25 mm (n/m³, left) and lithic remains <25 mm (n/m³, right). BM = oldest layer; BSP = youngest layer. doi:10.1371/journal.pone.0098359.g015

the technology of people living after the HP as “unsophisticated”, “conventional” or a “dark age”. Rather it seems to us that the lack of attention and detailed analyses devoted to this phase of the MSA resulted in a distorted picture. The results from the Sibudan assemblages BM-BSP refute these assertions by demonstrating that the knappers possessed a highly structured and sophisticated lithic technology. These findings are consistent with recent lithic studies at Diepkloof [62], Klasies River [60], Rose Cottage Cave [35] and Klein Kliphuis [56], suggesting that with an increased knowledge of this time frame, we gain a more realistic picture of spatial and temporal patterning of technological variability and cultural evolution of modern humans during the MSA of southern Africa.

Finally we stress that we do not see defining the Sibudan as a movement toward creating a rigid cultural taxon, but as part of a

process of inquiry and a step toward gaining a better understanding of the cultural dynamics of the MSA. Here we follow the arguments made by Brew [154] decades ago and view cultural taxonomy as a tool to help archaeologists answer questions about the past and as a means of organizing our ideas about the past. Like Brew, we are not striving to create a single, ideal taxonomy that is universally valid, for such a goal is illusory and ultimately futile. Instead we are working to identify the cultural variability at Sibudu as part of the process of characterizing the behavioral patterning within the MSA. The critical assessment of the Sibudan may or may not confirm the usefulness of this approach, but, by presenting these results, we intend to further our understanding of the cultural dynamics of the MSA and thereby provide new insights into the behavioral patterns of modern humans in

Table 11. Independent t-test comparison of metric attributes between complete artifacts made from dolerite and hornfels.

	Ø MD (mm) ¹	Ø Thickness (mm)	Ø Weight (g)
Tools			
Dolerite	46.4	9.6	14.4
Hornfels	42.5	8.1	7.4
<i>df</i> ²	430	430	430
<i>p</i> ³	0.002	<0.001	<0.001
Cores			
Dolerite	54.8	22.6	66.8
Hornfels	44.6	17.7	29.1
<i>df</i>	39	39	39
<i>p</i>	0.031	0.028	0.005
Blanks			
Dolerite	45.0	8.8	13.4
Hornfels	40.2	6.7	6.9
<i>df</i>	1459	1459	1459
<i>p</i>	<0.001	<0.001	<0.001

¹Maximum dimension of the artifact.

²Degrees of freedom.

³Significance value of the two-sided t-test ($\alpha=0.05$).

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Table 12. Flaking efficiency by raw material for the combined assemblages BM-BSP.

Raw material	n	Flaking efficiency ϕ^1	Max.	Min.	SD
Dolerite	734	14.3	60	2	9.2
Hornfels	283	19.6	89.9	3.9	11.1
Quartzite	10	11.9	30.9	3.3	9.5
Sandstone	11	12.7	30.2	1.9	8

¹Flaking efficiency is calculated after [120].
doi:10.1371/journal.pone.0098359.t012

southern Africa shortly before the main expansion of our species across the Old World. Since the study of this phase of the MSA has been neglected in the past, we hope to have shown that the period following the HP does warrant our close attention. The intense research in recent decades in southern Africa makes the subcontinent a suitable region for developing more precise models of cultural evolution during the MSA. Only through detailed studies of multiple regions within southern Africa and Africa as a whole will we have any chance of determining what role, if any, the cultural evolution in southern Africa played in the successful expansion of our species around the globe.

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Author Contributions

Conceived and designed the experiments: MW NJC. Performed the experiments: MW GDB. Analyzed the data: MW GDB NJC. Contributed reagents/materials/analysis tools: NJC. Wrote the paper: MW NJC.

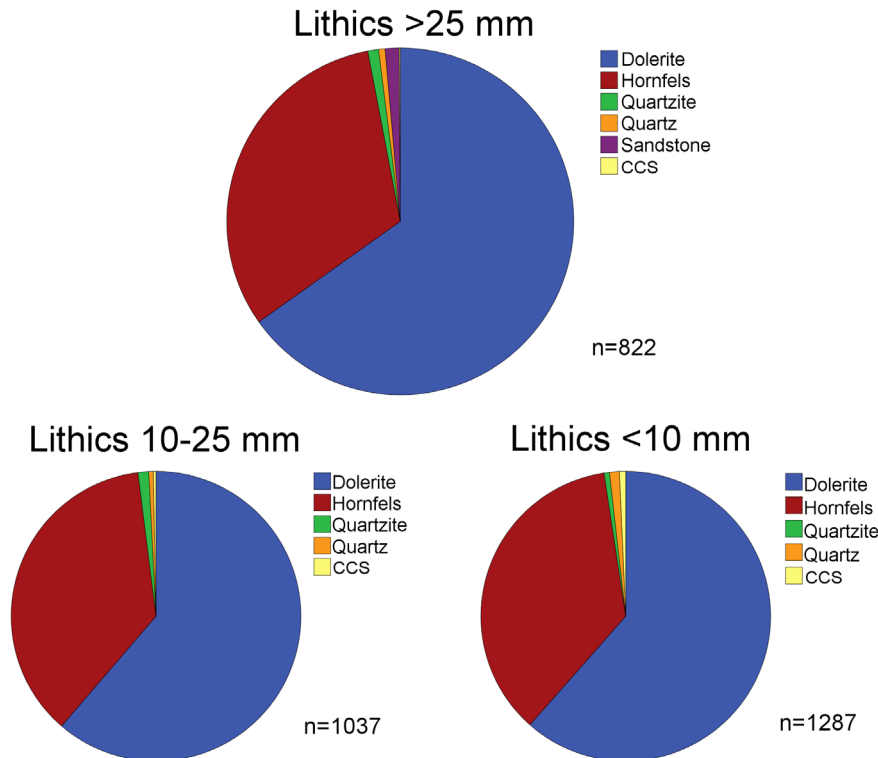


Figure 16. Proportions of raw materials in assemblage BSP. Lithics >25 mm (top), lithics 10–25 mm (bottom left) and lithics <10 mm (bottom right).
doi:10.1371/journal.pone.0098359.g016

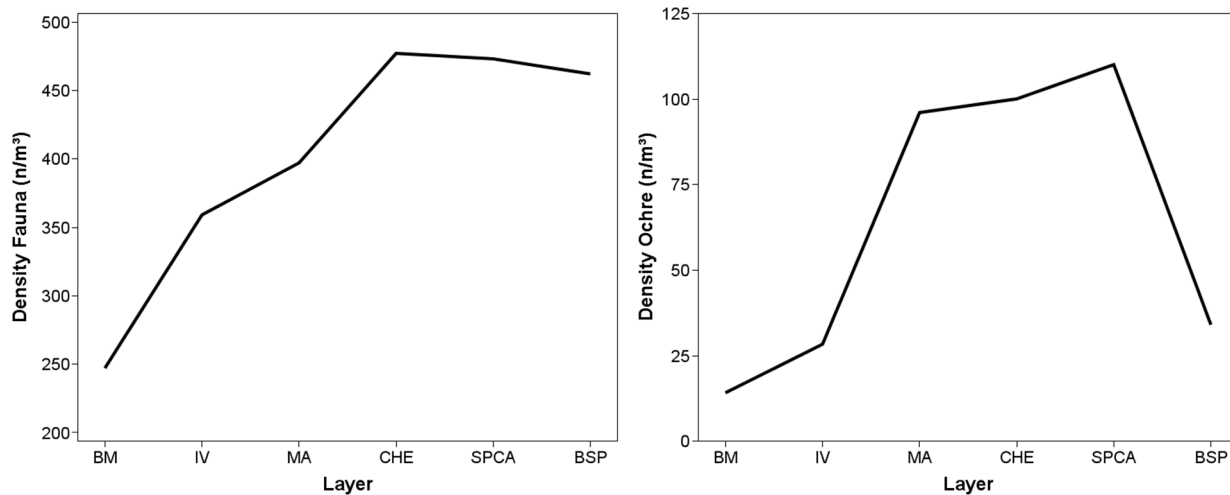


Figure 17. Density of faunal remains and ochre throughout BM-BSP. Faunal remains >25 mm (n/m³, left) and ochre >25 mm (n/m³, right). BM = oldest layer; BSP = youngest layer. doi:10.1371/journal.pone.0098359.g017

References

- McBrearty S, Brooks AS (2000) The revolution that wasn't: a new interpretation of the origin of modern human behavior. *J Hum Evol* 39: 453–563.
- White TD, Asfaw B, DeGusta D, Gilbert H, Richards GD, et al. (2003) Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature* 423: 742–747.
- Forster P (2004) Ice Ages and the mitochondrial DNA chronology of human dispersals: A review. *Philos Trans R Soc Lond B Biol Sci* 359: 255–264.
- McDougall I, Brown FH, Fleagle JG (2005) Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature* 433: 733–736.
- Mellars P (2006) Why did modern human populations disperse from Africa ca. 60,000 years ago? A new model. *Proc Natl Acad Sci USA* 103: 9381–9386.
- Rito T, Richards MB, Fernandes V, Alshamali F, Cerny V (2013) The first modern human dispersals across Africa. *PLoS One*: e80031.
- Goodwin AJH, van Riet Lowe C (1929) The Stone Age cultures of South Africa. *Annals of the South African Museum*. 289 p.
- Volman TP (1984) Early prehistory of southern Africa. In: Klein RG, editor. *Southern African prehistory and paleoenvironments*. Rotterdam: A. A. Balkema. 169–220.
- Lombard M, Wadley L, Deacon J, Wurz S, Parsons I, et al. (2012) South African and Lesotho Stone Age sequence updated (I). *South Afr Arch Bull* 67: 123–144.
- Singer R, Wymer J (1982) *The Middle Stone Age at Klasies River Mouth in South Africa*. Chicago: University of Chicago Press. 234 p.
- Wurz S (2002) Variability in the Middle Stone Age lithic sequence, 115000–60000 years ago at Klasies River. *South Afr J Archaeol Sci* 29: 1001–1015.
- Henshilwood CS, Sealy J, Yates R, Cruz-Urube K, Goldberg P, et al. (2001) Blombos Cave, southern Cape, South Africa: Preliminary report on the 1992–1999 excavations of the Middle Stone Age levels. *J Archaeol Sci* 28: 421–448.
- Henshilwood CS, d'Errico F, Van Niekerk KL, Coquinot Y, Jacobs Z, et al. (2011) A 100,000-year-old ochre processing workshop at Blombos Cave, South Africa. *Science* 334: 219–222.
- Marean CW, Bar-Matthews M, Bernatchez J, Fisher E, Goldberg P, et al. (2007) Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature* 449: 905–908.
- Marean CW (2010) Pinnacle Point Cave 13B (Western Cape Province, South Africa) in context: The Cape Floral kingdom, shellfish, and modern human origins. *J Hum Evol* 59: 425–443.
- Wadley L, Whitelaw G (2006) Middle Stone Age research at Sibudu Cave. *South Afr Humanit* 18: 341 p.
- Wadley L, Jacobs Z (2004) Sibudu Cave, KwaZulu-Natal: background to the excavations of Middle Stone Age and Iron Age occupations. *South Afr J Sci* 100: 145–151.
- Miller CE, Goldberg P, Berna F (2013) Geoarchaeological investigations at Diepkloof Rock Shelter, Western Cape, South Africa. *J Archaeol Sci* 40: 3432–3452.
- Porraz G, Parkington J, Rigaud J-P, Miller CE, Poggenpoel C, et al. (2013). The MSA sequence of Diepkloof and the history of southern African Late Pleistocene populations. *J Archaeol Sci* 40: 3542–3552.
- Tribolo C, Mercier N, Douville E, Joron J-L, Reyss J-L, et al. (2013) OSL and TL dating of the Middle Stone Age sequence of Diepkloof Rock Shelter (Western Cape, South Africa): a clarification. *J Archaeol Sci* 40: 3401–3411.
- Henshilwood CS, d'Errico F, Yates RJ, Jacobs Z, Tribolo C, et al. (2002) The emergence of modern human behaviour: Middle Stone Age engravings from South Africa. *Science* 295: 1278–1280.
- Mackay A, Welz A (2008) Engraved ochre from a Middle Stone Age context at Klein Kliphuis in the Western Cape of South Africa. *J Archaeol Sci* 35: 1521–1532.
- Texier P-J, Porraz G, Parkington J, Rigaud J-P, Poggenpoel 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 USA* 107: 6180–6185.
- d'Errico F, García Moreno R, Rifkin RF (2012) Technological, elemental and colorimetric analysis of an engraved ochre fragment from the Middle Stone Age levels of Klasies River Cave 1, South Africa. *J Archaeol Sci* 39: 942–952.
- Henshilwood CS, d'Errico F, Vanhaeren M, Van Niekerk K, Jacobs Z (2004) Middle Stone Age shell beads from South Africa. *Science* 304: 404.
- d'Errico F, Henshilwood CS, Vanhaeren M, Van Niekerk K (2005) *Nassarius kraussianus* shell beads from Blombos Cave: evidence for symbolic behaviour in the Middle Stone Age. *J Hum Evol* 48: 3–24.
- Henshilwood CS, d'Errico F, Marean CW, Milo RG, Yates R (2001) An early bone tool industry from the Middle Stone Age at Blombos Cave, South Africa: implications for the origins of modern human behaviour, symbolism and language. *J Hum Evol* 41: 631–678.
- d'Errico F, Backwell LR, Wadley L (2012) Identifying regional variability in Middle Stone Age bone technology: the case of Sibudu Cave. *J Archaeol Sci* 39: 2479–2495.
- Brown KS, Marean CW, Herries AIR, Jacobs Z, Tribolo C, et al. (2009) Fire as an engineering tool of early modern humans. *Science* 325: 859–862.
- Lombard M, Phillipson L (2010) Indications of bow and stone-tipped arrow use 64 000 years ago in KwaZulu-Natal, South Africa. *Antiquity* 84: 1–14.
- Henshilwood CS, Marean CW (2003) The origin of modern human behavior. Critique of the models and their test implications. *Curr Anthropol* 44: 627–651.
- Conard NJ (2005) An overview of the patterns of behavioural change in Africa and Eurasia. In: d'Errico F, Blackwell L, editors. *From tools to symbols: from early hominids to modern humans*. Johannesburg: Witwatersrand University Press. 294–332.
- Conard NJ (2008) A critical view of the evidence for a southern African origin of behavioural modernity. *South Afr Archaeol Soc (Goodwin Series)* 10: 175–179.
- Conard NJ (2010) Cultural modernity: Consensus or conundrum? *Proc Natl Acad Sci USA* 107: 7621–7622.
- 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. *J Archaeol Sci* 34: 681–703.
- Wadley L (2007) Announcing a Still Bay industry at Sibudu Cave, South Africa. *J Hum Evol* 52: 681–689.
- Villa P, Soriano S, Henshilwood C, Mourre V (2009) The Still Bay points of Blombos Cave (South Africa). *J Archaeol Sci* 36: 441–460.
- Henshilwood C (2012) Late Pleistocene techno-traditions in southern Africa: A review of the Still Bay and Howiesons Poort, c. 75–59 ka. *J World Prehist* 25: 205–237.

39. Wurz S (2013) Technological trends in the Middle Stone Age of South Africa between MIS 7 and MIS 3. *Curr Anthropol* 54 (suppl. 8): S305–S319.
40. Jacobs Z, Roberts RG, Galbraith RF, Deacon HJ, Grün R, et al. (2008) Ages for the Middle Stone Age of Southern Africa: implications for human behavior and dispersal. *Science* 322: 733–735.
41. Jacobs Z, Roberts RG (2009) Catalysts for Stone Age innovations. What might have triggered two short-lived bursts of technological and behavioral innovation in southern Africa during the Middle Stone Age? *Commun Integr Biol* 2: 191–193.
42. Lombard M (2009) The Howieson's Poort of South Africa amplified. *South Afr Archaeol Bull* 189: 4–12.
43. Henshilwood C, Dubreuil B (2012) The Still Bay and Howieson's Poort, 77–59 ka: Symbolic materials and the evolution of the mind during the African Middle Stone Age. *Curr Anthropol* 52: 361–400.
44. McCall GS, Thomas JT (2012) Still Bay and Howieson's Poort foraging strategies: recent research and models of culture change. *Afr Archaeol Rev* 29: 7–50.
45. Ziegler M, Simon MH, Hall IR, Barker S, Stringer C, et al. (2013) Development of Middle Stone Age innovation linked to rapid climate change. *Nat Commun* 4: 1905, doi:10.1038/ncomms2897.
46. Ambrose S (2002) Small things remembered: origins of early microlithic industries in sub-Saharan Africa. In: Elston RG, Kuhn SL, editors. *Thinking small: Global perspectives on microlithization*. Archeological Papers of the American Anthropological Association, Number 12. 9–30.
47. McCall GS (2007) Behavioral ecological models of lithic technological change during the later Middle Stone Age of South Africa. *J Archaeol Sci* 34: 1738–1751.
48. Cochrane GWG (2008) The transition from Howieson's Poort to post-Howieson's Poort industries in southern Africa. *South Afr Archaeol Soc (Goodwin Series)* 10: 157–167.
49. Powell A, Shennan S, Thomas MG (2009) Late Pleistocene demography and the appearance of modern human behavior. *Science* 324: 1298–1301.
50. Jacobs Z, Roberts RG (2008) Testing times: old and new chronologies for the Howieson's Poort and Still Bay Industries in environmental context. *South Afr Archaeol Soc (Goodwin Series)* 10: 9–34.
51. McCall GS (2011) Progression, regression or adaptation: further thoughts on the post-Howieson's Poort Middle Stone Age of South Africa. *South Afr Archaeol Bull* 66: 89–92.
52. Lombard M, Parsons I (2011) What happened to the human mind after the Howieson's Poort? *Antiquity* 85: 1433–1443.
53. Lombard M (2012) Thinking through the Middle Stone Age of sub-Saharan Africa. *Quat Int* 270: 140–155.
54. Mitchell P (2008) Developing the archaeology of Marine Isotope Stage 3. *South Afr Archaeol Soc (Goodwin Series)* 10: 52–65.
55. Lombard M, Parsons I (2010) Fact or fiction? Behavioural and technological reversal after 60 ka in southern Africa. *South Afr Archaeol Bull* 65: 224–228.
56. Mackay A (2011) Nature and significance of the Howieson's Poort to post-Howieson's Poort transition at Klein Kliphuis rock shelter. *South Afr J Archaeol Sci* 38: 1430–1440.
57. Wadley L (2013) MIS 4 and MIS 3 occupations in Sibudu, KwaZulu-Natal, South Africa. *South Afr Archaeol Bull* 68: 41–51.
58. Wadley L, Mohapi M (2008) A segment is not a monolith: evidence from the Howieson's Poort of Sibudu, South Africa. *J Archaeol Sci* 35: 2594–2605.
59. Mackay A (2010) The Late Pleistocene archaeology of Klein Kliphuis rock shelter, Western Cape: 2006 excavations. *South Afr Archaeol Bull* 65: 134–147.
60. Villa P, Soriano S, Teyssandier N, Wurz S (2010) Howieson's Poort and MSA III at Klasies River main site, Cave 1A. *J Archaeol Sci* 37: 630–655.
61. de la Peña P, Wadley L, Lombard M (2013) Quartz bifacial points in the Howieson's Poort of Sibudu. *South Afr Archaeol Bull* 68: 119–136.
62. Porraz G, Texier P-J, Archer W, Piboule M, Rigaud J-P, et al. (2013) Technological successions in the Middle Stone Age sequence of Diepkloof Rock Shelter, Western Cape, South Africa. *J Archaeol Sci* 40: 3376–3400.
63. Conard NJ, Porraz G, Wadley L (2012) What is in a name? Characterising the “Post-Howieson's Poort” at Sibudu. *South Afr Archaeol Bull* 67: 180–199.
64. Mohapi M (2013) The Middle Stone Age point assemblage from Umhlatuzana Rock Shelter: a morphometric study. *South Afr Humanit* 25: 25–51.
65. Henshilwood CS (2005) Stratigraphic integrity of the Middle Stone Age levels at Blombos Cave. In: d'Errico F, Backwell L, editors. *From tools to symbols: From early hominids to modern humans*. Johannesburg: Witwatersrand University Press. 451–458.
66. Deacon HJ (1989) Late Pleistocene palaeoecology and archaeology in the southern Cape, South Africa. In: Mellars P, Stringer C, editors. *The Human Revolution: behavioural and biological perspectives on the origins of modern humans*. Edinburgh: Edinburgh University Press. 547–564.
67. Mellars P (2007) Rethinking the revolution: Eurasian and African perspectives. In: Mellars P, Boyle K, Bar-Yosef O, Stringer C, editors. *Rethinking the Revolution: behavioural and biological perspectives on the origin and dispersal of modern humans*. Cambridge (UK): McDonald Institute Monographs. 1–14.
68. Wadley L, Jacobs Z (2006) Sibudu Cave: background to the excavations, stratigraphy and dating. *South Afr Humanit* 18: 1–26.
69. Wadley L (2010) Cemented ash as a receptacle or work surface for ochre powder production at Sibudu, South Africa, 58,000 years ago. *J Archaeol Sci* 37: 2397–2406.
70. Wadley L (2006) Partners in grime: results of multi-disciplinary archaeology at Sibudu Cave. *South Afr Humanit* 18: 315–341.
71. Mackay A, Stewart BA, Chase BM (2014) Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa. *J Hum Evol*. In press.
72. Klein RG, Avery G, Cruz-Urbe K, Halkett D, Parkington JE, et al. (2004) The Ysterfontein 1 Middle Stone Age site, South Africa, and early human exploitation of coastal resources. *Proc Natl Acad Sci* 101: 5708–5715.
73. Kaplan J (1990) The Umhlatuzana rock shelter sequence: 100 000 years of stone age history. *Natal Museum J Humanit* 2: 1–94.
74. Lombard M, Wadley L, Jacobs Z, Mohapi M, Roberts RG (2010) Still Bay and serrated points from Umhlatuzana Rock Shelter, KwaZulu-Natal, South Africa. *J Archaeol Sci* 37: 1773–1784.
75. Texier P-J, Porraz G, Parkington J, Rigaud J-P, Poggenpoel C, et al. (2013) The context, form and significance of the MSA engraved ostrich eggshell collection from Diepkloof Rock Shelter, Western Cape, South Africa. *J Archaeol Sci* 40: 3412–3431.
76. Cain CR (2004) Notched, flaked and ground bone artifacts from Middle Stone Age and Iron Age layers of Sibudu Cave, KwaZulu-Natal, South Africa. *South Afr J Sci* 100: 195–197.
77. Hodgskiss T (2013) Ochre use in the Middle Stone Age at Sibudu: grinding, rubbing, scoring and engraving. *J Afr Archaeol* 11: 75–95.
78. Wadley L (2008) The Howieson's Poort industry of Sibudu Cave. *South Afr Archaeol Bull (Goodwin Series)* 10: 122–133.
79. Schiegl S, Conard NJ (2006) The Middle Stone Age sediments at Sibudu: results from FTIR spectroscopy and microscopic analyses. *South Afr Humanit* 18: 149–172.
80. Goldberg P, Miller CE, Schiegl S, Ligouis B, Berna F, et al. (2009) Bedding, hearths, and site maintenance in the Middle Stone Age site of Sibudu Cave, KwaZulu-Natal, South Africa. *Archaeol Anthropol Sci* 1: 95–122.
81. Cain CR (2006) Human activity suggested by the taphonomy of ~60 ka and ~50 ka faunal remains from Sibudu Cave. *South Afr Humanit* 18: 241–260.
82. Wadley L (2012) Some combustion features at Sibudu, South Africa, between 65,000 and 58,000 years ago. *Quat Int* 247: 341–349.
83. Wadley L, Sievers C, Bamford M, Goldberg P, Berna F, et al. (2011) Middle Stone Age bedding construction and settlement patterns at Sibudu, South Africa. *Science* 334: 1388–1391.
84. Miller CE, Sievers C (2012) An experimental micromorphological investigation of bedding construction in the Middle Stone Age of Sibudu, South Africa. *J Archaeol Sci* 39: 3039–3051.
85. Lombard M (2004) Distribution patterns of organic residues on Middle Stone Age points from Sibudu Cave, KwaZulu-Natal, South Africa. *South Afr Archaeol Bull* 59: 37–44.
86. Lombard M (2005) Evidence for hunting and hafting during the Middle Stone Age at Sibudu Cave, KwaZulu-Natal, South Africa. *J Hum Evol* 48: 279–300.
87. Lombard M (2006) Direct evidence for the use of ochre in the hafting technology of Middle Stone Age tools from Sibudu Cave. *South Afr Humanit* 18: 57–67.
88. Lombard M (2008) Finding resolution for the Howieson's Poort through the microscope: micro-residue analysis of segments from Sibudu Cave, South Africa. *J Archaeol Sci* 35: 26–41.
89. Wadley L, Williamson BS, Lombard M (2004) Ochre in hafting in Middle Stone Age southern Africa: a practical role. *Antiquity* 78: 661–675.
90. Wadley L, Hodgskiss T, Grant M (2009) Implications for complex cognition from the hafting of tools with compound adhesives in the Middle Stone Age, South Africa. *Proc Natl Acad Sci USA* 106: 9590–9594.
91. d'Errico F, Henshilwood CS (2007) Additional evidence for bone technology in the southern African Middle Stone Age. *J Hum Evol* 52: 142–163.
92. Backwell L, d'Errico F, Wadley L (2008) Middle Stone Age bone tools from the Howieson's Poort layers, Sibudu Cave, South Africa. *J Archaeol Sci* 35: 1566–1580.
93. Shott MJ (1994) Size and form in the analysis of flake debris: review and recent approaches. *J Archaeol Method Theory* 1: 69–110.
94. Holdaway S, Stern N (2004) *A record in stone: The study of Australia's flaked stone artifacts*. Canberra: Aboriginal Studies Press. 400 p.
95. Odell HG (2004) *Lithic analysis*. New York: Springer US. 262 p.
96. Andrefsky W (1998) *Lithics: Macroscopic approaches to analysis*. Cambridge (MA): Cambridge University Press. 321 p.
97. Tostevin GB (2003) Attribute analysis of the lithic technologies of Stránská skála II–III in their regional and inter-regional context. In: Svoboda J, Bar-Yosef O, editors. *Stránská skála: Origins of the Upper Palaeolithic in the Brno Basin*. Cambridge (MA): Peabody Museum Publications. 77–118.
98. Boëda E, Geneste JM, Meignen L (1990) Identification de chaînes opératoires lithiques du Paléolithique ancien et moyen. *Paléo* 2: 43–80.
99. Inizan ML, Reduron M, Roche H, Tixier J (1995) *Technologie de la pierre taillée*. Préhistoire de la pierre taillée, Tome 4. Meudon: Cercle de recherches d'et dédes préhistoriques. 199 p.
100. Sorressi M, Geneste J-M (2011) The history and efficacy of the chaîne opératoire approach to lithic analysis: Studying techniques to reveal past societies in an evolutionary perspective. *PaleoAnthropology* 2011: 334–350.
101. Conard NJ, Adler D (1997) Lithic reduction and hominid behavior in the Middle Paleolithic of the Rhineland. *J Anthropol Res* 53: 147–175.
102. Shott MJ (2003) *Chaîne opératoire* and reduction sequence. *Lithic Technol* 28: 95–106.

103. Bleed P (2011) Loosening our *chaînes*: cognitive insights for the archaeological application of sequence models. *J Archaeol Anthropol* 2011: 297–304.
104. Conard NJ, Soressi M, Parkington JE, Wurz S, Yates R (2004) A unified lithic taxonomy based on patterns of core reduction. *South Afr Archaeol Bull* 59: 12–16.
105. Dibble HL (1987) The interpretation of Middle Paleolithic scraper morphology. *Antiquity* 52: 109–117.
106. Villa P (1991) Middle Pleistocene prehistory in southwestern Europe: The state of our knowledge and ignorance. *J Anthropol Res* 47: 193–217.
107. Dibble H, Rolland N (1992) On assemblage variability in the Middle Paleolithic of western Europe: History, perspectives and a new synthesis. In: Dibble H, Mellars P, editors. *The Middle Paleolithic: Adaptation, behavior and variability*. Philadelphia: University of Pennsylvania Museum Press. 1–28.
108. Bisson MS (2000) Nineteenth century tools for twenty-first century archaeology? Why the Middle Paleolithic typology of Francois Bordes must be replaced. *J Archaeol Method Theory* 7: 1–48.
109. Volman TP (1981) *The Middle Stone Age in the southern Cape*. Ph.D. dissertation, University of Chicago.
110. Wurz S (2000) *The Middle Stone Age sequence at Klasies River, South Africa*. Ph.D. dissertation, University of Stellenbosch.
111. Villa P, Delagnes A, Wadley L (2005) A late Middle Stone Age artifact assemblage from Sibudu (KwaZulu-Natal). Comparisons with the European Middle Paleolithic. *J Archaeol Sci* 32: 399–422.
112. Villa P, Lenoir M (2006) Hunting weapons of the Middle Stone Age and the Middle Palaeolithic: spear points from Sibudu, Rose Cottage and Bouheben. *South Afr Humanit* 18: 89–122.
113. Krukowski S (1939) *Paleolithic Prehistoria Ziemi Polskich*. In: Krukowski S, Kostorzewski J, Jakimowicz R, editors. *Prehistoria Ziemi Polskich*. Krakow: Polska Akademia Umiejetnosci. 1–117.
114. Lepot M (1993) *Approche techno-fonctionnelle de l'outillage lithique Moustérien: essai de classification des parties actives en terme d'efficacité technique*. Unpublished Masters thesis. Nanterre: University of Paris X.
115. Boëda E (2001) Détermination des unités techno-fonctionnelles de pièces bifaciales provenant de la couche acheuléenne C3 base du site de Barbas I. In: Clieue D, editor. *Les industries à outils bifaciaux du Paléolithique Moyen d'Europe occidentale*. Liège: ERAUL. 51–76.
116. Soriano S (2001) Statut fonctionnel de l'outillage bifacial dans les industries du Paléolithique moyen: propositions méthodologiques. In: Clieue D, editor. *Les industries à outils bifaciaux du Paléolithique Moyen d'Europe occidentale*. Liège: ERAUL. 77–84.
117. Bonilauri S (2010) *Les outils du Paléolithique moyen: une mémoire technique oubliée? Approche techno-fonctionnelle appliquée à un assemblage lithique de conception Levallois provenant du site d'Umm el Tiel (Syrie centrale)*. Ph.D. dissertation, Université de Paris-Ouest.
118. Braun DR, Harris JWK (2003) Technological developments in the Oldowan of Koobi Fora: innovative techniques of artifact analysis and new interpretations of Oldowan behavior. In: Moreno JM, Mora Torcal R, de la Torre I, editors. *Oldowan: Rather more than smashing stones*. Universitat Autònoma de Barcelona: Centre d'Estudis del Patrimoni Arqueològic de la Prehistòria. 132–144.
119. Braun DR (2005) Examining flake production strategies: examples from the Middle Paleolithic of Southwest Asia. *Lithic Technol* 30: 107–125.
120. Mackay A (2008) A method for estimating edge length from flake dimensions: use and implications for technological change in the southern African MSA. *J Archaeol Sci* 35: 614–622.
121. Roth BJ, Dibble HL (1998) The production and transport of blanks and tools at the French Middle Paleolithic site of Combe-Capelle Bas. *Antiquity* 63: 47–62.
122. Sullivan AP, Rozen KC (1985) Debitage analysis and archaeological interpretation. *Antiquity* 50: 755–779.
123. Wadley L, Kempson H (2011) A review of rock studies for archaeologists, and an analysis of dolerite and hornfels from the Sibudu area, KwaZulu-Natal. *South Afr Humanit* 23: 87–107.
124. Cochrane GWG (2006) An analysis of lithic artifacts from the c. 60 ka layers of Sibudu Cave. *South Afr Humanit* 18: 69–88.
125. Boëda E (1993) Le débitage Discoïde et le débitage Levallois récurrent centripète. *Bull Soc Préhist Fr* 90: 392–404.
126. Boëda E, Hou YM, Forestier H, Sarel J, Wang HM (2013) Levallois and non-Levallois blade production at Shuidonggou in Ningxia, North China. *Quat Int* 295: 191–203.
127. Peresani M (1998). La variabilità du débitage discoïde dans la grotte de Fumane (Italie du Nord)/The variability of discoid production at the grotte de Fumane. *Paléo* 10: 123–146.
128. Langejans GHJ (2012) Middle Stone Age *pièces esquillées* from Sibudu Cave, South Africa: an initial micro-residue study. *J Archaeol Sci* 39: 1694–1704.
129. Pelegrin J (2000) Les techniques de débitage laminaire au Tardiglaciaire: critères de diagnose et quelques réflexions. In: Valentin B, Bodu P, Christensen M, editors. *L'Europe centrale et septentrionale au tardiglaciaire*. Nemours: Mémoires du Musée de Préhistoire d'Ile de France 7. 73–86.
130. Roussel M, Bourguignon L, Soressi M (2009) Identification par l'expérimentation de la percussion au percuteur de calcaire au Paléolithique moyen: le cas du façonnage des racloirs bifaciaux Quina de Chez Pinaud (Jonzac, Charente-Maritime). *Bull Soc Préhistor Fr* 106: 219–238.
131. Dibble HL, Schurmans UA, Iovita RP, McLaughlin MV (2005) The measurement and interpretation of cortex in lithic assemblages. *Antiquity* 70: 545–560.
132. Douglass MJ, Holdaway SJ, Fanning PC, Shiner JI (2008) An assessment and archaeological application of cortex measurement in lithic assemblages. *Antiquity* 73: 513–526.
133. Porraz G (2005) *Dynamiques de formation des ensembles lithique set modes d'occupation des territoires au Paléolithique moyen*. Ph.D. dissertation, Université de Provence.
134. Marean CW (2010) Pinnacle Point Cave 13B (Western Cape Province, South Africa) in context: the Cape Floral kingdom, shellfish, and modern human origins. *J Hum Evol* 59: 425–443.
135. Will M, Parkington JE, Kandel AW, Conard NJ (2013) Coastal adaptations and the Middle Stone Age lithic assemblages from Hoedjiespunt 1 in the Western Cape, South Africa. *J Hum Evol* 64: 518–537.
136. Orton J (2008) A useful measure of the desirability of different raw materials for retouch within and between assemblages: the raw material retouch index (RMRI). *J Archaeol Sci* 35: 1090–1094.
137. Alpers-Afil N, Richter D, Goren-Inbar N (2007) Phantom hearths and the use of fire at Geshur Benot Ya'aqov, Israel. *PaleoAnthropology* 1: 1–15.
138. Hull KL (1987) Identification of cultural site formation processes through microdebitage analysis. *Antiquity* 52: 772–783.
139. Schiffer MB (1987) *Formation processes of the archaeological record*. Albuquerque: University of New Mexico Press. 448 p.
140. Binford LR (1980) Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. *Antiquity* 45: 4–20.
141. Bailey G (1983) *Hunter-gatherer economy in prehistory: A European perspective*. Cambridge (UK): Cambridge University Press.
142. Torrence R (1989) *Time, energy and stone tools*. Cambridge (MA): Cambridge University Press.
143. Bishop WW, Clark JD (1966) Systematic investigation of the African later Tertiary and Quaternary. *Curr Anthropol* 7: 253–256.
144. Clark JD, Cole GH, Isaac GL, Kleindienst MR (1966) Precision and definition in African archaeology. *South Afr Archaeol Bull* 21: 114–121.
145. Kaplan JM (1989) 45000 years of hunter-gatherer history in Natal as seen from Umhlatuzana Rock Shelter. *South Afr Archaeol Soc (Goodwin Series)* 6: 7–16.
146. Mohapi M (2012) Point morphology and the Middle Stone Age cultural sequence of Sibudu Cave, KwaZulu-Natal, South Africa. *South Afr Archaeol Bull* 67: 5–15.
147. Wadley L, Harper PTN (1989) Rose Cottage Cave revisited: Malan's Middle Stone Age collection. *South Afr Archaeol Bull* 44: 23–32.
148. Harper PTN (1997) The Middle Stone Age sequences at Rose Cottage Cave: a search for continuity and discontinuity. *South Afr J Sci* 93: 470–475.
149. Brown KS, Marean CW, Jacobs Z, Schoville BJ, Oestmo S, et al. (2012) An early and enduring advanced technology originating 71,000 years ago in South Africa. *Nature* 491: 590–593.
150. Mackay A (2009) *History and selection in the late Pleistocene archaeology of the Western Cape, South Africa*. Ph.D. dissertation, Australian National University.
151. Deacon HJ, Geleijnse VB (1988) The stratigraphy and sedimentology of the Main Site sequence, Klasies River, South Africa. *South Afr Archaeol Bull* 43: 5–14.
152. Tribolo C (2003) *Apport des méthodes de la luminescence à la chronologie des technofaciés du Middle Stone Age associés aux premiers Hommes Modernes du Sud de l'Afrique*. Ph.D. dissertation, University Bordeaux I.
153. Minichillo T (2006) Raw material use and behavioral modernity: Howiesons Poort lithic foraging strategies. *J Hum Evol* 50: 359–364.
154. Brew JO (1946) The use and abuse of taxonomy. In: *The archaeology of Alkali Ridge Utah*. Papers of the Peabody Museum of Archaeology and Ethnology 21: 44–66.

Research Article

THE LITHIC TECHNOLOGY OF HOLLEY SHELTER, KWAZULU-NATAL, AND ITS PLACE WITHIN THE MSA OF SOUTHERN AFRICA

GREGOR D. BADER^{1*}, MANUEL WILL¹ & NICHOLAS J. CONARD^{1,2}

¹Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, Tübingen, Germany

*Corresponding author. E-mail: gregor.bader@uni-tuebingen.de

²Senckenberg Center for Human Evolution and Paleoenvironment, University of Tübingen, Schloss Hohentübingen, Tübingen, Germany

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ABSTRACT

While the majority of research on the Middle Stone Age (MSA) in southern Africa has been conducted in the southern and western Cape, studies of the east coast of South Africa have become increasingly important due to the existence of well-stratified sites such as Sibudu. Because of the scarcity of comparable localities, however, we still know little about the spatial and temporal variability of MSA lithic technology in this region. We therefore chose to expand our research focus to other, lesser-known sites in the eastern part of South Africa. One such site is Holley Shelter which was excavated by Gordon Cramb between 1950 and 1960. Since its archaeological material was only studied in a cursory manner, we conducted a detailed technological study of the MSA lithic artefacts from Cramb's excavations, including attribute analysis and examination of reduction sequences. Our first aim was to assess the degree of potential mixing and recovery bias among the lithic material. We then characterised the different assemblages and investigated their diachronic variation throughout the occupation sequence. In order to obtain a rough age estimate of the so far undated sequence of Holley Shelter, we compared its lithic technology to other MSA sites in the eastern part of South Africa. Our results indicate three different phases of MSA occupation that vary in terms of raw material composition, core reduction, and tool manufacture. The assemblages are characterised by a blade and point technology that mostly derives from platform cores as well the highest proportions of splintered pieces reported from a southern African MSA site. The sequence does not feature Later Stone Age (LSA), Howieson's Poort, Still Bay or final MSA industries. Compared to other sites in the general region, the assemblages are most similar to lithic technology post-dating the Howieson's Poort, suggesting that the occupations fall broadly into the earlier part of MIS 3.

Keywords: lithic technology, Middle Stone Age, South Africa, KwaZulu-Natal, Holley Shelter.

INTRODUCTION

The discovery of an African origin of anatomically modern humans during the 1980s (Bräuer 1984; Smith *et al.* 1989; Stringer 1989; White *et al.* 2003; McDougall *et al.* 2005) led to an increased research interest in the archaeology of the Middle Stone Age (MSA, c. 300–35 ka) in the following decades. Scholars have paid special attention to indices of 'cultural modernity' that appear first during the MSA, including manifold applications of pigments as hafting element or base for symbolic engravings (Wadley 2005a; Henshilwood *et al.* 2009, 2011), heat-treatment of fine-grained raw material (Brown *et al.* 2009, Schmidt *et al.* 2013), the manufacturing of bone tools (Henshilwood *et al.* 2001, Backwell *et al.* 2008), personal ornaments like shell beads (Henshilwood *et al.* 2004; D'Errico *et al.* 2005), engravings on ostrich eggshell (Texier *et al.* 2010), and

the consumption of marine resources (Parkington *et al.* 2004; Conard 2005; Marean *et al.* 2007; Will *et al.* 2013). However, apart from these features, the analysis of stone artefacts, encompassing their production, reduction and use, represent an indispensable tool for prehistoric archaeologists to reconstruct past human behaviour and build comparative cultural-technological sequences.

During the last four decades, research on the MSA has focused on specific geographic regions rich in archaeological records. The western and southern coast as well as the Cape region of South Africa have been studied extensively owing to the existence of several sites with long and well-preserved stratigraphic sequences such as Klasies River Mouth (Singer & Whymer 1982; Wurz 2000, 2002), Blombos Cave (Henshilwood *et al.* 2001), Diepkloof (Texier *et al.* 2010; Porraz *et al.* 2013) or Pinnacle Point (Marean *et al.* 2010). Although there are some comparable sites in KwaZulu-Natal, namely Border Cave (Cooke *et al.* 1945; Beaumont 1978; Villa *et al.* 2012), Umhlatuzana (Kaplan 1989, 1990; Lombard *et al.* 2010; Mohapi 2013) and particularly Sibudu (Wadley & Jacobs 2004; Wadley 2005b, 2007; Conard *et al.* 2012; Will *et al.* 2014; Conard & Will 2015), the last is the only locality with detailed technological data from lithic assemblages, including information on core reduction methods, reduction sequences and knapping techniques.

In order to move forward in our understanding of the geographic and diachronic variation within MSA lithic technology of southern Africa, it is important to shift the focus of research to less investigated regions like KwaZulu-Natal. As a starting point for this project, we chose Holley Shelter and reanalysed its lithic material using state-of-the-art analytical methods.

THE MSA SEQUENCE OF KWAZULU-NATAL

In order to place the lithic technology of Holley Shelter within the MSA sequence of South Africa, it is necessary to provide a general outline of the characteristics of this period in KwaZulu-Natal. As this region is generally understudied, compared to the western and southern Cape, the best candidate to provide an overview for this region is the archaeological site of Sibudu. This locality provides the most complete and well-published MSA sequence of stone artefact assemblages in KwaZulu-Natal. We further include Umhlatuzana in this brief outline because of its proximity to both Sibudu and Holley Shelter. The MSA sequence of Border Cave at the very northern border of KwaZulu-Natal will also be analysed in the discussion section.

In contrast to the southern and western Cape, no stratified early MSA assemblages dating to >80 ka have been found in KwaZulu-Natal. Starting from bottom to top, the lowermost layers at Sibudu published so far date to 77.2 ka and are

informally designated as pre-Still Bay (Wadley 2012). Work on these layers is still in progress with little information available as of now. That being said, Wadley (2012) mentions large blades and flakes, as well as thin bifacial points.

The overlying layers date to 70.5 ka (Jacobs & Roberts 2008) and are described to be of Still Bay (SB) character, marked by the frequent occurrence of bifacial points (Lombard 2006; Wadley 2007). According to Wadley (2007), bifacial points and bifacial tools (including broken pieces) represent around 40% of the retouched tools in layers RGS and RGS2. Double pointed forms appear to be typical for the Still Bay. By comparison, unifacial points, backed tools and other formal tools like scrapers occur in very low proportions (10% and below). The distribution of blanks shows a flake- rather than blade-based industry (Wadley 2007: table 4). There is little information on core reduction methods. Wadley (2007) describes two radial, one cylindrical and one opposed platform core. At Umhlatuzana, Layers 25 to 27 have originally been attributed to the pre-Howieson's Poort. According to Lombard *et al.* (2010), however, they are most similar to a Still Bay industry. The assemblages are characterised by a flake-based technology with unifacial and bifacial points, but also segments (Kaplan 1989, 1990). What makes these layers unique so far is the existence of both unifacial and bifacial serrated points (Lombard *et al.* 2010). These pieces occur more frequently in the lower layers of the Still Bay at Umhlatuzana.

As in other parts of South Africa, Still Bay assemblages are followed by Howieson's Poort (HP) industries at both Sibudu and Umhlatuzana. The HP lithic assemblages of Sibudu have recently been described by de la Peña *et al.* (2013) and de la Peña and Wadley (2014a,b) and date to 63.8 ka (Jacobs & Roberts 2008). The HP at Sibudu shows many characteristics apart from backed tools, like small bifacial points from quartz (de la Peña *et al.* 2013), the production of very small quartz bladelets, and the frequent use of bipolar technology (de la Peña & Wadley 2014a). Different kinds of cores on flakes also play an important role during the HP occupations of Sibudu (de la Peña & Wadley 2014b). Apart from these features, the defining characteristics of the HP are the frequent occurrence of segments made on blades as well as a blade-based technology in general (Wadley & Mohapi 2008). The HP occupations at Umhlatuzana (Layers 22–26) are similar in this regard, showing a high amount of backed pieces and segments, a higher percentage of blades compared to the underlying layers, but unifacial and bifacial points are also present (Kaplan 1990).

The so-called post-Howieson's Poort (post-HP) period will only be summarised briefly here (see discussion for a more detailed description). Post-HP occupations at Sibudu follow the HP and date to *c.* 58 ka, thus falling into early MIS 3 (Wadley & Jacobs 2006; Jacobs *et al.* 2008). They reflect a much higher variability in lithic technology and are based on different methods of core reduction, proportions of raw materials, and blank production, that all change over time. The assemblages at Sibudu from this period are flake- rather than blade-based, without evidence of significant bladelet production (Conard *et al.* 2012; Will *et al.* 2014; Conard & Will 2015). Backed artefacts and segments are few in numbers and absent in most assemblages. They are replaced by unifacial points as the overall most frequent category of retouched pieces. The unifacial points encompass three different categories (Tongati, Ndwedwe, ACT), defined on techno-functional aspects and an emphasis on tool reduction and re-sharpening (Conard *et al.* 2012; Will *et al.* 2014). While unifacial points constitute the most important tool component in the upper layers of the post-HP (or Sibudan), there are marked differences throughout the

sequence, with some of the older assemblages showing more notched and denticulated implements, and only few or no unifacial points (Conard & Will 2015).

Layer RSP overlies the post-HP assemblages at Sibudu and is informally denoted as late MSA by Villa *et al.* (2005). The late MSA dates to approximately 48 ka (Wadley & Jacobs 2006; Jacobs *et al.* 2008). Uni- and bidirectional platform cores with simply prepared platforms dominate – including bladelet cores – whereas Levallois technology is not common (Villa *et al.* 2005: 405). While flakes are the most common end products, blades make up a considerable portion of up to 37%. Almost all of the pieces have been knapped using direct hard hammer percussion. The most common tool types are pointed forms (most of them unifacial) and side scrapers. In general, the tool component is high at 15%. According to Villa *et al.* (2005), few of the retouched pieces were made on blades. A late MSA industry also exists at Umhlatuzana and will be discussed in more detail later.

The youngest stage of the MSA in KwaZulu-Natal is informally named as the final MSA. At Sibudu it dates to *c.* 38 ka (Wadley & Jacobs 2006; Jacobs *et al.* 2008) and is characterised by a variety of scrapers, unifacial and bifacial points in comparable amounts. Most importantly, these assemblages feature hollow-based points. Although they are not very frequent, Wadley (2005b) emphasises that hollow-based points do not occur in any other layers at Sibudu and thus mark a distinct feature of this part of the occupation sequence. The cores are mostly minimal (“chunk with two or three randomly placed removals”) (Wadley 2005b: 54) or bipolar cores. However, a few examples of platform, radial and Levallois cores occur (Wadley 2005b). Knappers predominantly manufactured flakes (96%) rather than blades. Importantly, hollow-based and bifacial points are also an important feature of the uppermost three MSA/LSA-transitional layers at Umhlatuzana dated to ~36 ka, and single-platform cores are the most common core type (Kaplan 1989, 1990).

HOLLEY SHELTER

Holley Shelter is an elongated rock shelter on the eastern exposure of a large canyon, completely surrounded by dense vegetation. The site lies in a sandstone area that is drained by small streams that flow west to the Umgeni River (Cramb 1952) about 25 km northeast of Pietermaritzburg in KwaZulu-Natal. Holley Shelter is located around 60 km inland from the Indian Ocean (Fig. 1) and approximately 780 m above the current sea level. A waterfall runs from the top of the shelter into a small river about 20 m down the cliff, flowing in western direction through the canyon. During the time of excavation, the area was owned by Mr. J. Hunt Holley (Cramb 1952) and the site was subsequently named after him. As Holley Shelter constitutes an inland site, fluctuations of sea level had no direct influence in terms of resource availability over time, distinguishing the site from the majority of MSA localities in South Africa that are often scattered along the modern coastlines. Having said this, little Stone Age research has been conducted in the region around Holley Shelter in the last decades.

During the 1950s, Gordon Cramb excavated Holley Shelter in five short campaigns (Cramb 1952, 1961). He excavated in three different areas of the shelter, a smaller, a larger and a trial trench. The smaller area was excavated first and without using a grid system in order to “conserve the limited space” of the area (Cramb 1952: 181). Before he started excavating the larger area, Cramb dug a trial trench close-by in order to probe the stratigraphic situation. This line of action was based on his experience from the smaller section, that the sediments are “of

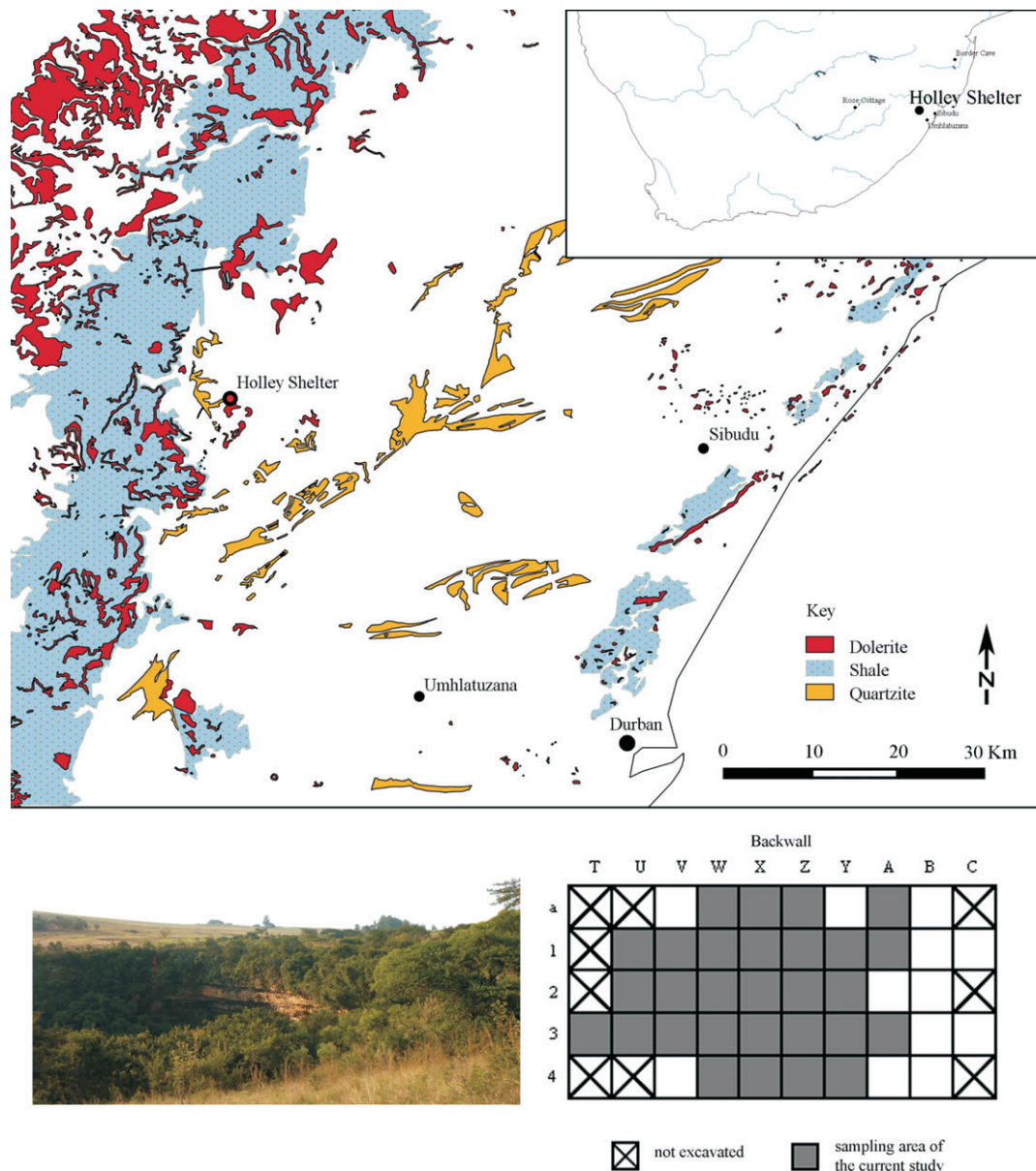


FIG. 1. Top: location of Holley Shelter, Umhlatuzana and Sibudu within the geological context of the region. Map is designed based on 1:250000 geological map by the Department of Mineral and Energy Affairs. **Bottom left:** view to the shelter. **Bottom right:** sampling area of the current study.

dustlike consistency” (Cramb 1961: 45) and too homogenous to identify separate layers. Due to these circumstances, Cramb excavated the bigger area in artificial inch spits and also used a grid system that he painted directly on the rock wall (Fig. 1). Unfortunately, there is no detailed information on the precise locality of the different trenches. Nevertheless, we were able to identify the larger excavation area in the northwestern corner of the shelter during a short visit to the site as the painted grid system was still preserved on the rock wall. In total, Cramb excavated this larger area within 38 square yards (~34.7 m²). He reached a maximum depth of 48 inches (1.22 metres), but not in all squares.

Cramb proposed that the uppermost 6 inches contain a mixture of LSA and MSA artefacts, marked by the appearance of thumbnail- and duckbill endscrapers as well as backed blades, whereas the lower levels comprise only MSA occupations. Cramb (1952) also mentioned the presence of beads of different colours in the first 3 to 9 inches. He also published two radiocarbon dates from the MSA part of the larger trench that date to 4400 ± 150 and 18.200 ± 500 bp. We, however, reject these dates because of the clear MSA character of the assem-

blages. Wadley (2001: 4) also argues that the previous dating “is not representative of any of the MSA occupations, which are probably too old for dating by the radiocarbon method”. As a result, the exact age of the MSA occupations at Holley Shelter remains unknown. Although Cramb’s original publications (1952, 1961) point towards an MIS 3 occupation of the shelter based on the frequent manufacture of unifacial points, this assessment lacks comparable technological and quantitative data for validation. We therefore decided to re-analyse the lithic assemblages from Holley Shelter with modern methods. We also plan to obtain new absolute age estimates from the site in the future, but the locality is currently not accessible owing to legal issues regarding land ownership.

MATERIALS AND METHODS

The archaeological material from Cramb’s excavation is stored in the KwaZulu-Natal Museum in Pietermaritzburg. The assemblages contain c. 4000 lithic artefacts in total. This study deals only with the artefacts deriving from the larger trench since it was excavated in coherent squares and therefore provides consistent horizontal and vertical distribution

patterns. During excavations, Cramb sometimes changed the depth of spits and, as a consequence, the connection between distinct spit-depths varies (e.g. Inch 0–6 and Inch 3–12). Therefore, we could not include all stone artefacts in a reasonable way into our analysis. We selected those lithic artefacts which could be clearly attributed to successive 6 inch thick spits (approximately 15 cm) throughout the entire sequence. These standardised spits serve as analytical units to group assemblages in the absence of defined archaeological layers (Inch 0–6, Inch 6–12). All these groups derive from a coherent area of grid squares as shown in Fig. 1. Based on this sampling procedure, we analysed 1980 pieces individually, including blanks >3 cm and all retouched artefacts and cores regardless of size (Table 1). In addition, we quantified the type of raw material for 493 artefacts <3 cm. Because of the small number of artefacts ($n = 5$) in the lowermost spit (42–48 inches), we excluded this unit from our analyses. Further, we counted artefacts from spits 30–36 and 36–42 together since they contain only 87 pieces and show comparable technological features. The uppermost unit (Inch 0–6) contains a total of about 600 pieces but due to time constraints, we could only include 388 pieces in our sample.

As a first step, we aimed to establish whether the assemblages provide reliable features that can help to answer the question of potential mixing. With mixing, we mean significant exchange of artefacts between lithic assemblages by means of vertical movement that occurred throughout the sequence (e.g. intrusive LSA elements in an MSA assemblage). In order to resolve this problem – in absence of any geomorphological or taphonomic data – we defined several criteria the assemblages should meet. First, the technological criteria of both cores and end products within a defined layer (in this case inch spits) should fit to one another. Specific types of core reduction also frequently produce characteristic technological elements and should thus be associated with them in unmixed assemblages. Second, one would not expect numerous distinct guide fossils of a specific techno-complex in an assemblage that otherwise do not belong to it. For example, bifacial Still Bay points do not usually occur within an LSA Robberg assemblage. Finally, refits or conjoins of artefacts indicate a certain degree of stratigraphic integrity if found in the same spit. In combination, the existence of these features in an assemblage render a large degree of mixing unlikely, but cannot ultimately exclude post-depositional vertical movement of artefacts between layers.

Another problem arising from the early excavation at Holley Shelter is the likely scenario that the original excavators operated in a selective way and preferentially collected eye-catching pieces – such as large retouched artefacts – rather than unmodified blanks, cortical or technological items. The nature of the lithic assemblages provides the best evidence against such an excavation and collection bias. If specimens of many different artefact categories – blanks, cores, tools, techno-

logical pieces – occur in different sizes and frequencies in each individual layer, it is likely that there was either no or only minimal selection. The existence of small or informal artefacts would thus testify against a strong collection bias. Furthermore, one would expect a continuously high proportion of eye-catching pieces in each layer if a systematic bias applies, rather than gradual changes in their frequencies compared to cores or unmodified blanks. These criteria, combined with information on the actual field methods, can mount evidence against a strong collection and excavation bias.

Our next aim was to characterise the different assemblages of the site and investigate their variation over time. In order to achieve these goals, we collected data on raw material composition and economy (Andrefsky 1994; Floss 1994; Brantingham *et al.* 2000; MacDonald & Andrefsky 2008), discrete and metric attributes resulting from the knapping process (Dibble 1997; Wurz 2000; Odell 2004; Dibble & Rezek 2009) and the variation of core reduction methods over time (Boëda 1994; Conard *et al.* 2004, Delagnes *et al.* 2012). For characterising blank production, we employed four categories: (i) Blades denote pieces that are at least twice as long as wide with parallel edges and a width of >10mm (Hahn 1991); (ii) Bladelets fall under the same definition, but are narrower than 10 mm; (iii) Flakes are blanks with variable edge morphologies and less than twice as long as wide; whereas (iv) Points refer only to flakes with a convergent distal end (Hahn 1991).

Although our approach is of technological nature, we point to the need of using uniform typological taxonomies in order to convey a coherent picture of tool assemblages that renders them comparable to other sites and regions. To this end, we followed South African tool taxonomies which are commonly used in this part of the world to classify retouched artefacts (Volman 1981; Wurz 2000; Villa *et al.* 2005). Owing to the very high percentage of retouched artefacts in Holley Shelter, we also employed a techno-functional approach (Lepot 1993; Boëda 2001; Soriano 2001; Bonilauri 2010) similar to a recent analysis by Conard *et al.* (2012) for the post-HP, or Sibudan, layers of Sibudu. This approach provides more detailed data on retouch patterns and morphologies of modified edges. It also increases the number of comparable technological attributes of retouched artefacts between different sites. In addition, we conducted morphometric studies similar to Mohapi (2013) for the unifacial points.

A CLASSIFICATORY SYSTEM FOR SPLINTERED PIECES

Owing to the high frequency of splintered pieces at Holley Shelter (see results), as well as their morphological and diachronic variability, we developed a new classificatory system for these artefacts. Most of the splintered pieces at Holley Shelter resemble specimens from the late MSA at Sibudu (Layer RSP), published by Villa *et al.* (2005) (Fig. 8, Nos. 7–9). While discussions on the function of these pieces as either bipolar cores or

TABLE 1. Distribution of artefact types throughout the sequence of Holley Shelter.

Unit	Depth below datum (cm)	Blank n (%)	Tool n (%)	Core n (%)	Pebble n (%)	Angular debris n (%)	Total
Inch 0–6	15.0	279 (71.9)	91 (23.5)	10 (2.6)	0 (0)	8 (2.1)	388
Inch 6–12	30.0	405 (69.7)	142 (24.4)	17 (2.9)	4 (0.7)	13 (2.2)	581
Inch 12–18	45.0	217 (57.4)	150 (39.7)	5 (1.3)	0 (0)	6 (1.6)	378
Inch 18–24	60.0	128 (50.0)	111 (43.4)	12 (4.7)	0 (0)	5 (2.0)	256
Inch 24–30	75.0	209 (72.1)	56 (19.3)	6 (2.1)	2 (0.7)	17 (5.9)	290
Inch 30–42	105.0	48 (55.2)	13 (14.9)	9 (10.3)	4 (4.6)	13 (14.9)	87
Total %		64.9	28.2	3.0	0.5	3.1	1980

wedges/chisels are still ongoing (Hayden 1980; Barham 1987; LeBlanc 1992; Shott 1999; Brun-Ricalens 2006; De la Peña & Wadley, 2014), recent residue analyses by Langejans (2012) provide additional support for the assumption that at least some of these pieces have been used as tools in a chisel-like manner in the HP layers at Sibudu. Here, we present a morphological model for a more detailed classification of splintered pieces. Our approach is comparable to the work of Hays and Lucas (2007) for Le Flagelot I in southern France. That being said, our approach is only macroscopic and based on the following criteria:

1. The overall morphology of the pieces.
2. The location of the splintered edges and their orientation to each other.
3. The direction of the splintered negatives on the dorsal and ventral sides, as well as their orientation to one another.

The results of this analysis are presented below (*Tool assemblages*).

RESULTS

RAW MATERIAL PROCUREMENT

The procurement of raw materials constitutes the first step in the operational sequence of producing stone tools and plays an important role in the technological organisation of mobile hunter and gatherer groups. The knappers at Holley Shelter used four different raw materials: hornfels, quartz, dolerite and quartzite (see Fig. 1). While there is a small number of artefacts made on unknown raw materials for which we do not know the source, there are no signs for long distance transportation (>20 km) of raw materials to Holley Shelter.

Among pieces >3 cm, the most common raw material is hornfels (Table 2), a relatively fine-grained black or grey stone of contact metamorphic origin (Cairncross, 2004). Hornfels commonly originate in areas where sedimentary rocks, like shale, and intrusive rocks, like dolerite or granite, come into contact. As shown in Fig. 1, such contact zones occur in numerous areas around Holley Shelter. Between inches 0 to 30, hornfels constitutes the dominant raw material with over 90% abundance in the uppermost spits 0–6 and 6–12 inches. Below these levels, the number of hornfels decline constantly until quartz becomes

the most frequent raw material used in lowermost inches 30 to 42. While its exact source remains unknown, quartz pebbles occur in the nearby river (Cramb 1952) and rounded, pebble-like cortex is frequently preserved on quartz artefacts from Holley Shelter. Besides hornfels and quartz, the inhabitants sometimes reduced quartzite and dolerite, but their frequency never exceeds 8%. Among pieces <3 cm, quartz has a disproportionately high abundance in all spits. This observation corresponds to the use of pebbles of small dimensions and the inherent fracturing tendencies of quartz, resulting in more (small) flakes per percussion event for quartz compared to other raw materials (Barham 1987; Conard 1992; Driscoll 2010). The proportion of close to 100% quartz for small debitage (<3 cm) in the two lowermost spits (inches 30–36 and 36–42), however, confirms a different provisioning of raw material in the earliest occupations at Holley Shelter.

CORE REDUCTION

At least three different strategies of core reduction characterise the MSA assemblages at Holley Shelter, following the unified core taxonomy proposed by Conard *et al.* (2004). First, platform cores occur in high frequencies in the upper five spits (inches 0–6, 6–12, 12–18, 18–24, 24–30) (Table 3). Second, most of the platform cores exhibit only one striking platform, mostly prepared but sometimes plain, associated with a unidirectional pattern of reduction. Rotated or multi-directional platform cores are rare. Third, cores often show flat cortical faces, suggesting the exploitation of slab-like raw materials, especially for hornfels. The majority of platform cores bear removal scars of blades, with a mean length of 35 mm.

We identified two different reduction strategies among the platform cores. The first and most common method can be described as ‘semi-circumferential platform core reduction’. In this system, knappers exploited one striking platform of the cores around several available edges by turning the core during the reduction process (Fig. 2, Nos. 3–4). The second and less common method is a narrow-sided core reduction. Here, platform cores are reduced exclusively along their narrow edge (Fig. 2, No. 5), explaining their identification as narrow-sided cores (Monigal 2001; Delagnes *et al.* 2012). In general, the semi-circumferential cores exhibit platform preparation more

TABLE 2. Distribution of raw materials used at Holley Shelter throughout the sequence.

Unit	Depth below datum (cm)	Hornfels n (%)	Dolerite n (%)	Quartz n (%)	Quartzite n (%)	Sandstone n (%)	Other n (%)
0–6	15.0	369 (95.1)	8 (2.1)	7 (1.8)	1 (0.3)	2 (0.5)	1 (0.3)
6–12	30.0	539 (92.8)	6 (1.0)	32 (5.5)	2 (0.3)	1 (0.2)	1 (0.2)
12–18	45.0	328 (86.8)	21 (5.6)	17 (4.5)	8 (1.9)	3 (0.8)	2 (0.5)
18–24	60.0	217 (84.8)	15 (5.9)	8 (3.1)	11 (4.3)	2 (0.8)	3 (1.2)
24–30	75.0	217 (74.8)	22 (7.6)	35 (12.1)	5 (1.7)	7 (2.4)	4 (1.4)
30–42	105.0	37 (42.5)	3 (3.4)	40 (46.0)	5 (5.7)	0 (0.0)	2 (2.3)

TABLE 3. Distribution of core types at Holley Shelter for each inch spit.

Unit	Depth below datum (cm)	Platform core circumferential	Platform core narrow-sided	Parallel core	Bipolar core	IBC
Inch 0–6	15.0	8	0	1	1	0
Inch 6–12	30.0	6	8	2	1	0
Inch 12–18	45.0	2	2	0	1	0
Inch 18–24	60.0	5	0	3	2	1
Inch 24–30	75.0	3	1	1	2	0
Inch 30–42	105.0	0	1	0	7	1

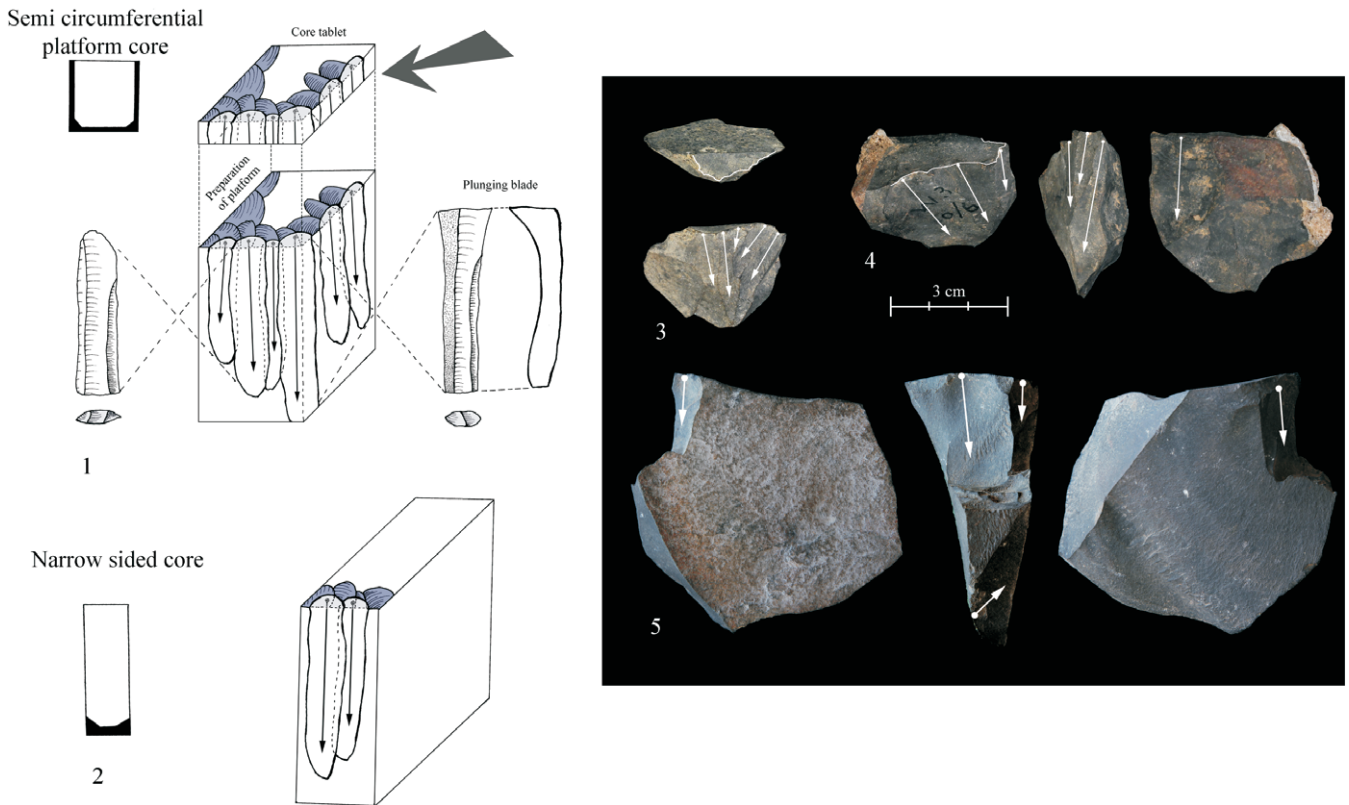


FIG. 2. (1–2) Schematic model of the two kinds of platform core reduction at Holley Shelter; (3–4) semi-circumferential platform core (hornfels); (5) narrow-sided core (hornfels).

often than the narrow-sided cores, but both core types frequently exhibit preparation of platforms. The primary products of both core types are thick elongated blades with unidirectional scar patterns and faceted platforms. We also found many products of core rejuvenation consistent with this strategy, such as core tablets with centripetal preparation and parallel negatives around the edge of the previous core, plunging blades and partially crested blades. Based on these observations, we can reconstruct the strategy of platform core reduction during the MSA at Holley Shelter as shown in Fig. 2, Nos. 1–2.

In contrast to platform cores, parallel reduction methods (Conard *et al.* 2004), which are similar to the concept of Levallois, play a minor role at the site. Nevertheless, the few ($n = 7$) but distinct examples demonstrate the application of this method by the inhabitants of Holley Shelter during the MSA. The scar patterns of these cores suggest end products with flake or point morphology. This observation is substantiated by a quartzite point, refitted to a parallel core. Both, core and point derive from the same spit (inches 18–24) and square.

Knappers predominantly applied bipolar reduction to small quartz pebbles, particularly in the two lowermost spits 30–36 and 36–42. Compared to the overlying occupation

levels, there is an overrepresentation of bipolar cores on quartz in the lowest two spits (inches 30–42). In contrast to the upper occupation sequence, only one platform core occurs in these spits.

In summary, knappers at Holley Shelter predominantly employed two different modalities of platform core reduction with intense preparation of platforms to produce blades in the upper and middle part of the sequence (inches 0–30). The majority of blades with faceted striking platforms derive from these highly prepared cores. Parallel core reduction plays only a secondary role in this technological system, whereas inclined (or formally discoid) cores (Boëda 1993; Peresani 2003; Conard *et al.* 2004) and their respective products are absent in the MSA sequence of Holley Shelter. In the lowermost spits, bipolar cores appear in higher frequencies, a technological change that is closely associated with a raw material procurement geared towards an intense use of quartz.

BLANK PRODUCTION

Blades constitute the main blank type produced during the MSA occupations of Holley Shelter. In the lowermost two spits (inches 30–36 and 36–42), the frequency of blades (24%) is

TABLE 4. Distribution of blank types throughout the sequence of Holley Shelter.

Unit	Depth below datum (cm)	Blade n (%)	Flake n (%)	Point n (%)	Bladelet n (%)	Total n
Inch 0–6	15.0	129 (35.0)	202 (54.7)	32 (8.7)	6 (1.6)	369
Inch 6–12	30.0	209 (38.1)	287 (52.3)	50 (9.1)	3 (0.5)	549
Inch 12–18	45.0	115 (31.3)	206 (56.0)	45 (12.2)	2 (0.5)	368
Inch 18–24	60.0	99 (41.4)	82 (34.3)	57 (23.8)	1 (0.4)	239
Inch 24–30	75.0	92 (35.1)	143 (54.6)	24 (9.2)	3 (1.1)	262
Inch 30–42	105.0	16 (26.2)	39 (63.9)	4 (6.6)	2 (3.3)	61

comparatively low for the site. The blade component increases particularly in the upper five spits (inches 0–6, 6–12, 12–18, 18–24, 24–30) with a minimum of 31% in spit 12–18 and a maximum of 41% in spit 18–24 (Table 4). Bladelets constitute only a minor part of the assemblages (including pieces <3 cm) ranging between 0.4 and 1.6%. Points occur in lower frequencies than blades. In the lowermost spits, between 24 and 42 inches, they represent only 7–9% of the blanks. In the middle part of the sequence (inches 18–24) points reach a maximum of 24% and the younger occupation levels (inches 0–6) feature 9%.

Apart from blades and points, flakes are the most numerous blank types within the individual spits with the exception of spit 18–24, where blades occur in higher frequencies than flakes. Most of these flakes, however, are probably the by-product of the unidirectional platform reduction system. The aim of the knappers to produce blades is supported by the fact that most pieces that have been transformed into tools by retouch in all levels exhibit blade dimensions (between 63.6 and 47.3%). In accordance with the decreasing number of points from inch 24 to 0, the proportion of tools made on points decreases from 34% to 15%. In parallel, the importance of flakes as blanks for tool production increases from inch spit 24 to 0.

The artefacts in the lowermost spits 24–30, 30–36 and 36–42 demonstrate primarily plain platforms (Table 5). By contrast, knappers prepared around 50% of the blank platforms in the four uppermost spits (inches 0–6, 6–12, 12–18, 18–24). The blanks exhibit a high frequency of shattered bulbs (44–71%) as well as (strongly) developed bulbs in all spits (Table 6). Proximal lips, on the other hand, are almost absent. A high frequency of

shattered bulbs is primarily associated with direct percussion by soft stone hammers (e.g. sandstone or limestone) (Pelegrin 2000; Soriano *et al.* 2007; Floss & Weber 2012). Contact points (or ring cracks) on the striking surfaces and ripple lines on the ventral faces are very common and associated with the application of a soft stone hammer. Although we are aware that most of these experiments have not been conducted with South African raw materials, our interpretation is supported by the fact that all hammer stones at Holley Shelter are of sandstone.

The striking platforms of the blanks are thick and wide for all spits (Table 6). The mean values for platform width varies between 15.2 and 19 mm with gradual changes. The platforms are also constant in their thickness that varies between a mean value for each assemblage of 5.3–6.5 mm. For all levels, the exterior platform angle (EPA), as described by Dibble and Rezek (2009), varies between a mean value of 82° and 84° (Table 6). Based on these observations, knappers predominantly employed soft stone hammers with a direct internal percussion movement, regardless of the type of blank they produced. The thick platforms in combination with the relatively high EPAs between 80° and 85° also explain the large dimensions of most blanks and tools at Holley Shelter (Dibble 1997; Pelcin 1997; Lin *et al.* 2013).

Regarding the dimension of blanks, blade length varies between 57 and 65 mm (mean value) with a maximum length of 134 mm. Flakes are markedly shorter, ranging between 38 and 44 mm mean length. They are also broader and thicker than blades in all spits. The number of completely preserved points and bladelets is too low to provide meaningful comparisons.

TABLE 5. Platform characteristics for all artefacts throughout the sequence of Holley Shelter.

Unit	Depth below datum (cm)	Faceted coarse n (%)	Faceted fine n (%)	Step flaking n (%)	Dihedral n (%)	Plain n (%)	Cortical n (%)	Crushed n (%)
Inch 0–6	15.0	39 (16.4)	49 (20.6)	11 (4.6)	12 (5.0)	98 (41.2)	4 (1.7)	25 (10.5)
Inch 6–12	30.0	68 (19.8)	53 (15.4)	20 (5.8)	22 (6.4)	127(36.9)	12 (3.5)	42 (12.2)
Inch 12–18	45.0	57 (23.0)	32 (12.9)	19 (7.7)	22 (6.4)	92 (37.1)	8 (3.2)	18 (7.3)
Inch 18–24	60.0	40 (23.7)	28 (16.6)	3 (1.8)	11 (6.5)	71 (42.0)	5 (3.0)	11(6.5)
Inch 24–30	75.0	30 (18.1)	6 (3.6)	9 (5.4)	12 (7.2)	80 (48.2)	4 (2.4)	25 (15.1)
Inch 30–42	105.0	2 (6.1)	2 (6.1)	0 (0)	3 (9.1)	20 (60.6)	0 (0)	6 (18.2)

TABLE 6. Knapping characteristics for all artefacts throughout the sequence of Holley Shelter.

Percussion marks	Unit	Unit					
		0–6	6–12	12–18	18–24	24–30	30–42
Bulb (%)	Shattered	69.7	71.3	64.2	55.2	43.5	61.8
	Well developed	10.3	9.2	13.2	16.4	14.3	11.8
	Developed	14.5	13.9	18.1	19.4	30.4	11.8
	Poorly developed	5.1	4.1	2.5	7.3	10.6	11.8
	na	0.4	1.5	2.1	1.8	1.2	2.9
Point of contact (%)		21.2	21.1	25.7	38.5	17.0	20.0
Ripple lines (%)		1.1	2.6	3.5	4.6	1.2	3.3
Hertzian cone (%)		2.5	0.4	1.4	4.1	2.8	8
Lip (%)		1.5	1.8	2.4	3.4	4.3	4.0
Platform thickness (mm)	Max	15	19	25	13	16	18
	Min	1	1	1	1	1	1
	Mean	5.3	5.7	6.5	5.9	5.3	5.8
Platform width (mm)	Max	35	37	58	42	46	44
	Min	1	4	4	1	1	5
	Mean	15.8	15.9	18.6	18	15.2	19
EPA (°)	Max	90	90	90	95	100	90
	Min	55	65	50	65	40	60
	Mean	83.5	84	81.8	83.3	81.7	82.9

TOOL ASSEMBLAGES

Holley Shelter features a comparatively low component of tools in the lowermost spits (30–36 and 36–42 inches), between 13.5 and 16%, which is still high for MSA assemblages. We observed an extremely high tool proportion in the upper and middle spits (inches 0 to 30). The frequency decreases from the middle part of the sequence (inches 18–24) where the assemblage contains a maximum of 43% retouched pieces (Table 1) to the uppermost spit (23.5% in inch 0–6). As a comparative value, the Sibudan at the nearby site of Sibudu has a maximum of 27% modified blanks >3 cm (Will *et al.* 2014). We are aware that the tool proportions from Holley Shelter have to be treated very carefully, keeping in mind the potential recovery bias associated with the old excavations as discussed above. Having said this, Cramb reports on the sieving of sediments (Cramb 1961), which is supported by the presence of small debitage products (<3 cm). While the frequencies of retouched specimens are probably overestimates, Cramb's application of relatively fine-grained field methods supports the observation that people frequently manufactured and curated tools at Holley Shelter.

The majority of retouched artefacts do not correspond to formally defined tool forms such as scrapers, but can be best described as minimally retouched blades, flakes or points (Table 7). There are only two tool categories that occur in significant numbers. Splintered pieces of different forms amount to between 26 and 61% of the tools (Table 7), making them the most frequent tool type in almost all spits. Most of these pieces (93.5%) are on hornfels. In the middle part of the sequence, unifacial points, that were also made on hornfels, occur frequently in proportions up to between 23 and 41% (Table 7).

By employing the morphological approach described above, we could identify three main categories of splintered pieces. **Single edge splintered pieces** (Fig. 3, Nos. 1–4) are characterised by splintering only on the distal edge, while the proximal part is well-preserved and thick, often with a developed bulb. There are either no or few splintered negatives on the proximal part. Although residue- and use-wear analyses are required to clarify the exact function and manner of use for these pieces, we suggest that this one-sided damage pattern might be an indication of hafting. **Opposed edge splintered**

pieces (Fig. 3, Nos. 5–10) show splintered negatives on a minimum of two straight and opposed edges. In some cases, all four edges are splintered. The orientation of the damage scars is parallel. As Hays and Lucas (2007) demonstrated, their experimental pieces showed splintering only on the actively knapped edge, while the opposed edge showed blunting only. They pointed out that splintered pieces with damage scars on two opposed edges might have been rotated during their use life. This could be an indication of rotating the opposed edge pieces from Holley Shelter during use as well. However, we recently conducted small-scale experiments using dolerite and quartzite flakes as chisels in order to split bone: during this experiment, both ends of the piece splintered without rotation. Finally, **diagonal splintered** pieces (Fig. 4) denote specimens with one straight and one opposed asymmetric edge, both with splintered negatives. Considering the orientation of the dorsal and ventral scars of these pieces, they have been most likely used obliquely to their main axis. The remaining pieces are mostly broken and do not fit in any of the three categories.

We are aware that we cannot exclude the possibility that splintered pieces from Holley Shelter have been bipolar cores, especially since no residue- or use-wear analyses have been conducted so far. We likewise admit that we cannot ultimately solve this problem here. However, based on the following criteria, we consider it unlikely that the splintered pieces from Holley Shelter functioned as cores. First, we observed many pieces that are made on blades and bear only marginal splintered negatives along the proximal and distal edges (Fig. 3, No. 7). These pieces produced tiny shatters, instead of useful flakes that could be seen as end products. We interpret this kind of splintered pieces as being in an early stage of their use cycle. Other specimens show complete coverage with negatives resulting from bipolar impact on both faces and exhibit intensely splintered edges (Fig. 3, Nos. 5–6). Interpreting those pieces as cores might be more comprehensible but in our view they reflect a final stage of their use life. This is mostly based on the observation that there is no evidence for bipolar knapping on any of the hornfels blanks at Holley Shelter, regardless of size. Furthermore, comparable pieces appeared during our

TABLE 7. Distribution of tool types throughout the sequence of Holley Shelter (including retouched tools and splintered pieces).

Tool type	Unit							Total
	0–6	6–12	12–18	18–24	24–30	30–36	36–42	
Backed piece	2	2	1	3	0	0	0	9
Burin	2	3	2	1	0	0	0	8
Denticulate	2	4	3	1	3	0	0	13
Stone hammer	1	1	1	0	3	0	0	6
Notch	8	6	3	0	2	0	0	19
Retouch on Blade	15	13	17	13	10	1	0	69
Retouch on Flake	9	6	10	5	4	0	0	34
Retouch on Point	6	6	4	2	2	0	0	20
Retouch on Bladelet	0	0	0	0	1	1	0	2
Scraper end	1	2	1	1	1	0	0	6
Scraper side	0	0	10	7	2	1	2	22
Splintered piece	42	86	61	29	20	4	1	243
Unifacial point	2	9	35	46	3	1	2	98
Unifacial tool	0	4	2	3	5	0	0	14
Strangled piece	1	0	0	0	0	0	0	1
Tools total N	91	142	150	111	56	8	5	563
Artefacts total N	388	581	378	256	290	50	37	1980
Tools total % per inch	23.5	24.4	39.7	43.4	19.3	16	13.5	

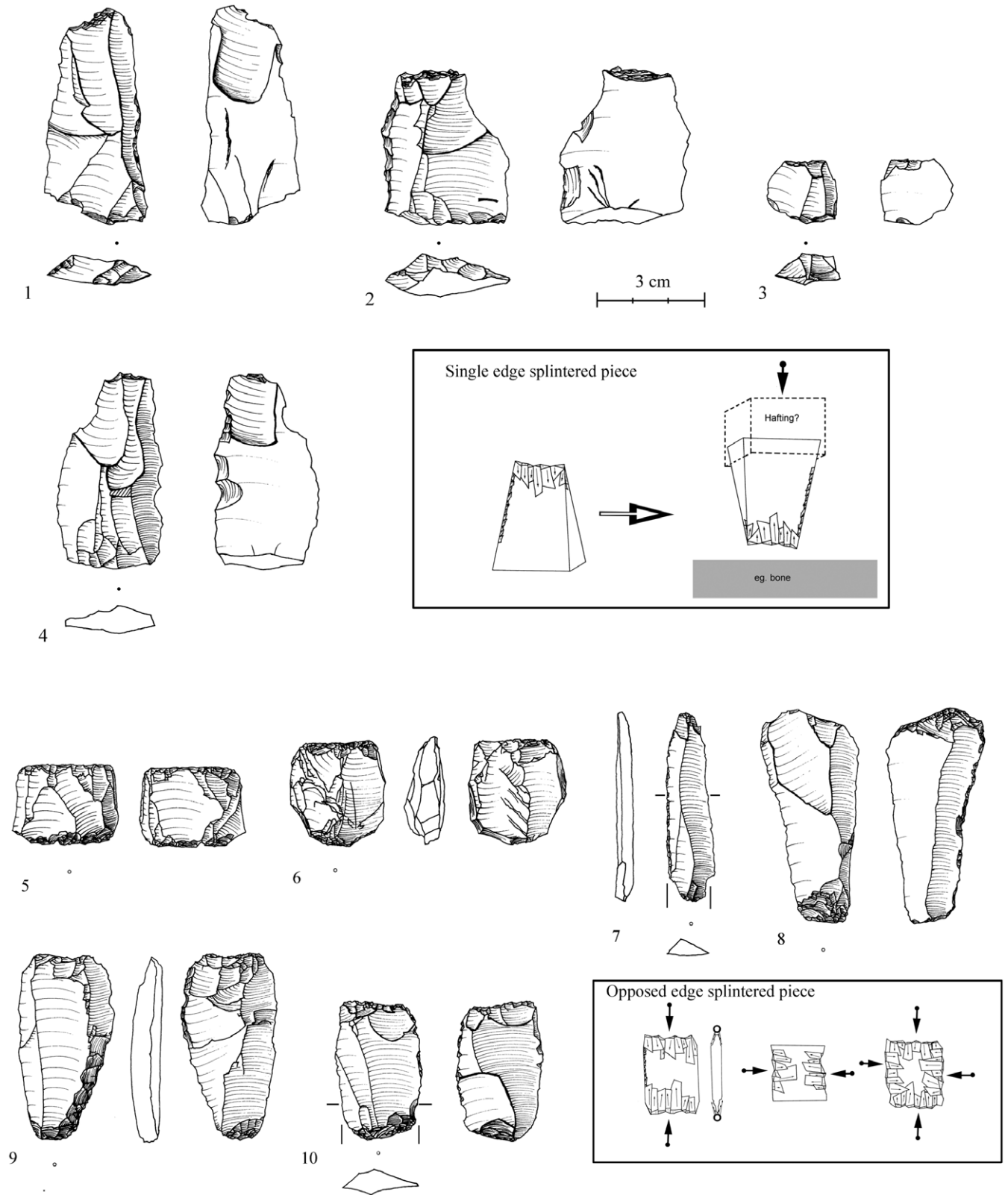


FIG. 3. (1–4) Single-edge splintered pieces; (5–10) opposed-edge splintered pieces (all hornfels) from Holley Shelter.

small-scale experiments mentioned above when we used unretouched dolerite flakes as chisels in order to split bone.

As Hiscock (2015) pointed out, bipolar reduction provides the possibility to reduce cores to very small sizes, which is an advantageous strategy especially when raw materials are scarce. This does not fit the circumstances at Holley Shelter, a site located in an environment very rich in raw material (Fig. 1). In addition, we recognised that many of the splintered pieces

have intentional retouch on their lateral edges (Fig. 3, No. 2, Nos. 7–9). This likely indicates a recycling process for exhausted tools. The majority of the splintered pieces are elongated and also quite thin (between 8 and 9 mm on average) with regards to their length (see Fig. 3, Nos. 7–9), making their use as cores difficult. Apart from the problems and discordances above, we tried to shed light on this special kind of artefact and its variability over time with the categories provided here. While we

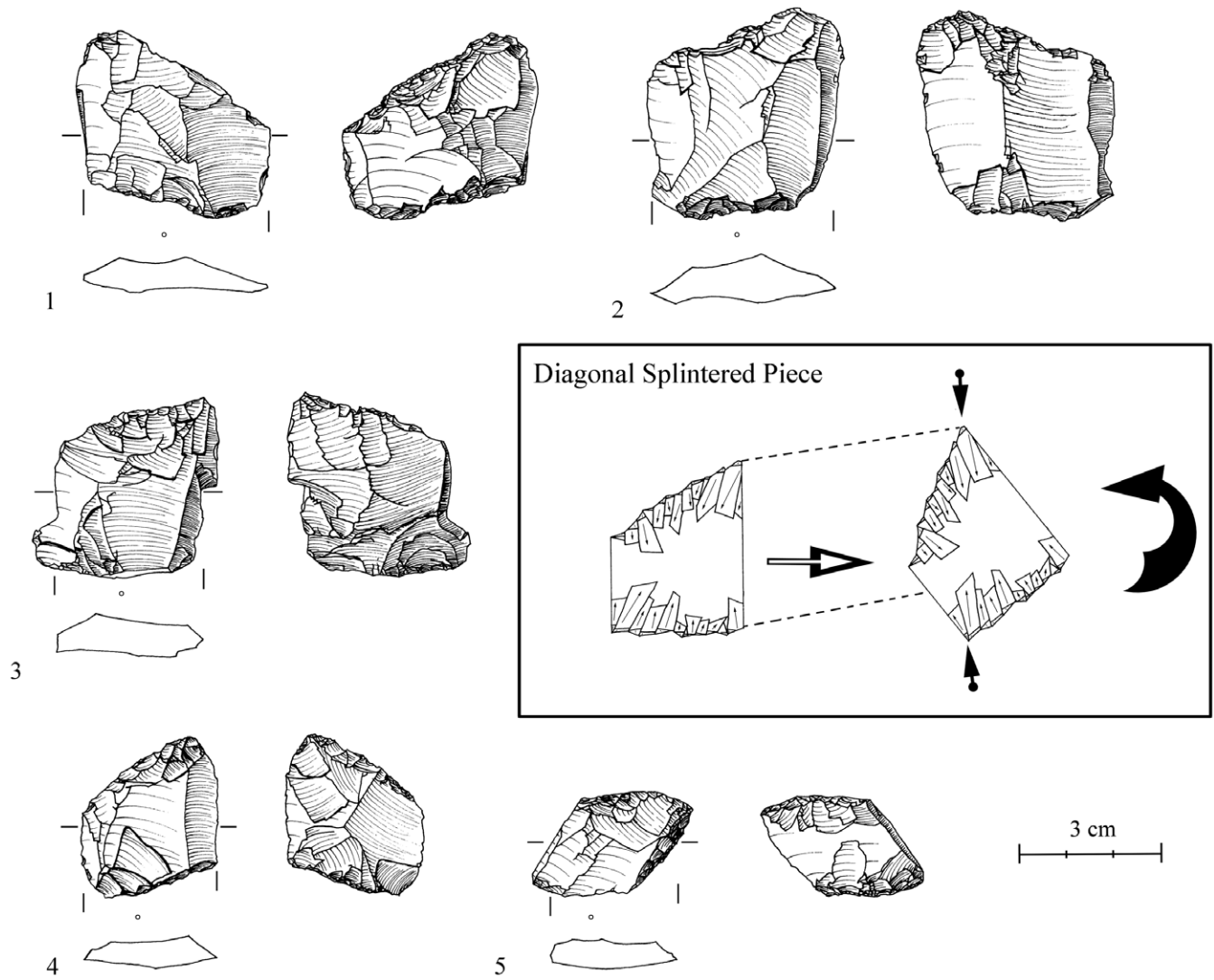


FIG. 4. (1–5) Diagonal splintered pieces (all hornfels) from Holley Shelter.

subsume splintered pieces as formal tools for the above reasons, Holley Shelter’s tool assemblage can easily be calculated without them (Tables 1, 3, 7).

Regarding their frequencies, **opposed-edge splintered pieces** (see Table 8) are the most common representatives in all spits, ranging between 40 and 76%. **Single-edge splintered**

pieces amount to between 14 and 18% in the uppermost three spits (inches 0–18). In the lower spits, they occur only in marginal frequencies. **Diagonal splintered pieces** only occur in the upper part of the sequence. In the 12–18 inch spit, they amount to 10%. In the overlying spits, the number declines to only 2%. Based on this new classification of splintered pieces,

TABLE 8. Classification of splintered pieces at Holley Shelter: *On tool* describes the number of pieces that bear retouch modifications in addition to their splintered edges.

Unit	Depth below datum (cm)	Single edge		Opposed edge		Diagonal		Broken		Total <i>n</i>	Total on tool (%)
		Total	On tool	Total	On tool	Total	On tool	Total	On tool		
Inch 0–6	15.0	7 (14.3%)	4	31 (63.3%)	8	1 (2%)	0	3 (6.1%)	2	49	28.6
Inch 6–12	30.0	15 (18.1%)	4	49 (59.0%)	7	6 (7.2%)	0	13 (15.7%)	4	83	18.1
Inch 12–18	45.0	10 (6.9%)	6	37 (62.7%)	7	6 (10.2%)	2	6 (10.2%)	2	59	28.8
Inch 18–24	60.0	2 (6.9%)	0	22 (75.9%)	10	0 (0%)	0	5 (17.2%)	4	29	48.3
Inch 24–30	75.0	1 (5%)	0	11 (55%)	2	0 (0%)	0	8 (40%)	3	20	25
Inch 30–42	105.0	0 (0%)	0	2 (40%)	0	0 (0%)	0	3 (60%)	2	5	40
Total <i>n</i>		20	14	152	34	13	2	38	17	245	

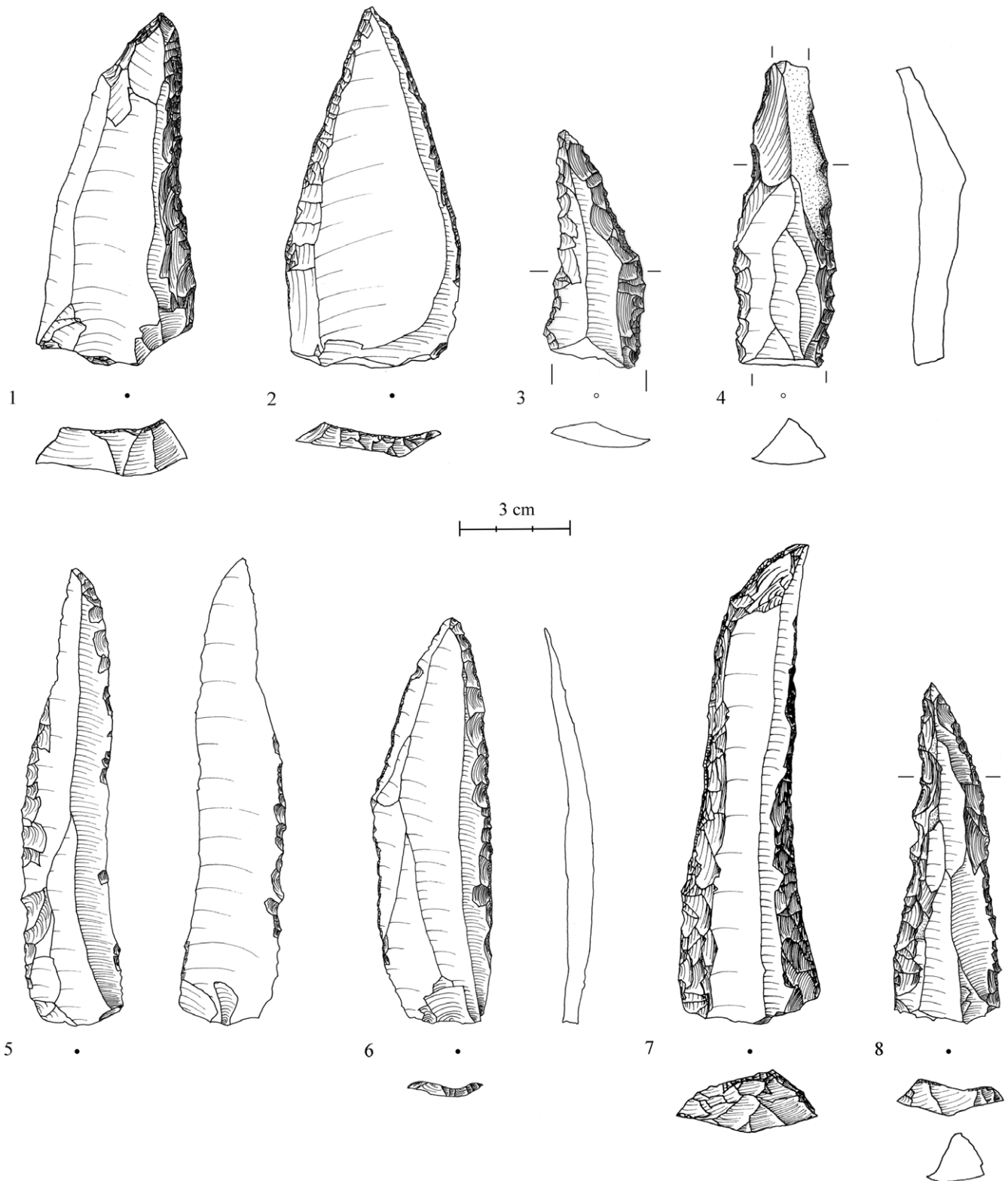


FIG. 5. (1–8) Unifacial points (all hornfels) from Holley Shelter.

we see clear temporal changes during the sequence of Holley Shelter.

Unifacial points constitute the second important tool type at Holley Shelter. They occur in significant numbers only in the middle of the sequence (inches 12–18 and 18–24). In these spits they are the most common tool type. Owing to the similarities between the unifacial points from Holley Shelter and Sibudu (especially layers BSP–BM) (Conard *et al.* 2012; Will *et al.* 2014) we decided to adopt the techno-functional system of analysis

for these tool classes proposed by Conard *et al.* (2012). Using this conceptual framework, most of the unifacial points from Holley Shelter can be classified as Ndwedwe tools (Fig. 5). Following the definition of Conard *et al.* (2012), Ndwedwe tools are “characterised by distinctive, strong, lateral retouch that usually runs the entire length of both sides of the tool. [...] With progressive retouch the pieces become narrower and narrower, while the length remains nearly constant over the course of reduction and modification” (Conard *et al.* 2012: 192).

TABLE 9. Morphometric comparison between Holley Shelter, Sibudu and Umhlatuzana (following Mohapi 2013). All metrics are in mm, mass is in grams. TCOSA is calculated following Hughes (1998) and Shea (2006).

Metrics (mm)	Statistics	Holley Shelter Inch 18–30	Sibudu Post-HP	Umhlatuzana Level 18–16	Umhlatuzana Level 23–19
Length	Mean	67	41.2	46	47.7
	Range	37–130	13–90	33–69	34–74
	<i>n</i>	45	169	13	18
Breadth	Mean	29.0	26.7	26.3	28
	Range	18–45	7–54	18–39	20–39
	<i>n</i>	46	226	16	20
Thickness	Mean	9.1	8.4	9	10.7
	Range	5–15	3–19	6–15	5–17
	<i>n</i>	46	275	17	20
Platform breadth	Mean	22.3	18.8	22.7	19.2
	Range	7–42	3–37	9–35	11–33
	<i>n</i>	45	145	23	19
Platform thickness	Mean	7.4	6.8	5.4	5.3
	Range	2–15	1–17	2–11	2–10
	<i>n</i>	45	153	23	19
Length/breadth ratio	Mean	2.3	1.6	1.8	1.8
	Range	1.3–4.8	0.5–5.0	1.2–2.6	1.3–2.7
	<i>n</i>	46	157	12	18
Mass	Mean	19.3	12.0	10.6	13.5
	Range	4.8–64.47	1.5–64.4	4.7–18.4	4.9–37.2
	<i>n</i>	46	148	10	18
TCOSA	Mean	135.3	119.0	122.8	153.9
	Range	60–280	13.5–465.5	54–234	60–297.5
	<i>n</i>	46	222	16	20

In inch spits 12–18 and 18–24, more than 60% of the unifacial points constitute Ndwedwe tools. Among the unifacial points, we also found some Tongati tools (Conard *et al.* 2012) and asymmetric convergent tools (ACTs) (Will *et al.* 2014). In contrast to Ndwedwe tools, Tongati tools are continuously reduced from the distal to the proximal end, but always retain their convergent distal configuration. ACTs are similar to Tongati tools, but the distal tip is always asymmetrical. Most specimens have steeper, retouched edges opposed to a sharp non- or only marginally retouched edge. These two tool classes appear in much lower frequencies than the Ndwedwe points at Holley Shelter. Additional techno-functional tool classes, such as naturally backed tools (NBTs), occur at Holley Shelter, but only in low frequencies. Table 9 compares several metrics of the unifacial points from Holley Shelter, Sibudu and Umhlatuzana. These comparisons show that the points from Holley Shelter are by far the longest and possess the highest length/breadth ratio. They are also characterised by very thick platforms and a high tip cross-sectional area (TCOSA; after Hughes 1998; Shea 2006; Sisk & Shea 2011).

DISCUSSION

STRATIGRAPHIC INTEGRITY OF THE LITHIC ASSEMBLAGES FROM HOLLEY SHELTER

As many stratigraphic and taphonomic studies have shown (e.g. Cahen & Moeyersons 1977; Hofman 1986; Eren *et al.* 2010; Staurset & Coulson 2014) archaeologists need to be particularly careful when interpreting assemblages without having detailed knowledge about the depositional and post-depositional situation of the site. Based on the results presented above, we can conclude that the stratigraphic situation at Holley Shelter is more reliable than appears from first sight. Within individual spit levels, we observed homogeneous technological signals from cores and blanks. There are also no diagnostic artefacts or tool types (e.g. LSA material such as small segments, microliths or microlithic cores) that do not fit

with the rest of the assemblages (Table 7). The high proportion of splintered pieces might be an exception, but this is discussed in detail below.

Although we found only one refit, both the core and its refitted product belong to the same spit and even to the same square. Further, the nature of the lithic assemblages suggests that we can exclude a strong selection of eye-catching pieces by Gordon Cramb, though there is a minor degree of recovery bias. This observation is based on the original excavator's report on sieving sediments and the concomitant existence of numerous pieces in the assemblage that are smaller than 1 cm without showing any outstanding feature. While the extraordinarily high amount of retouched artefacts may be exaggerated by recovery bias, unmodified blanks still constitute the most abundant category of lithic specimens throughout the sequence. In comparison with sites like Sibudu, which was excavated by state-of-the-art field methods, the high number of retouched artefacts is also not extraordinary. In conclusion, the MSA sequence of Holley Shelter features no obvious extent of mixing to a degree larger than at any modern site. The minor collection bias stemming from the old excavations does not ultimately compromise the nature and completeness of the lithic assemblages. We are thus confident in deriving further-reaching interpretations based upon the MSA material from Holley Shelter.

OCCUPATIONAL PHASES AT HOLLEY SHELTER BASED ON TECHNO-TYOLOGICAL ANALYSES

Based on the techno-typological analyses of the lithic assemblages, we distinguish three different occupational phases. The first comprises the lithic assemblages of the lowermost two spits (inches 30–36 and 36–42), primarily characterised by a different strategy of raw material procurement compared to the overlying inch spits. Here, knappers predominantly collected and used quartz, with hornfels being second in abundance. The number of tools is comparably low and bipolar percussion is the most prevalent core reduction strategy. The

abundance of quartz is associated with the organisation of the lithic technological system towards bipolar percussion. There are only few unifacial points ($n = 3$) and splintered pieces ($n = 5$). The latter occur exclusively as opposed-edge splintered pieces or broken specimens. The near absence of prepared platform cores results in a relatively low number (21.3%) of faceted butts, with most platforms being plain or crushed. The composition of blanks shows the highest abundance of flakes in the Holley Shelter sequence (63.9%). Finally, the number of artefacts >3 cm is the lowest for the entire sequence with only 50 pieces in the inch spit 30–36 and 37 specimens in inch spit 36–42.

The middle part of the sequence, inches 12–18, 18–24, and 24–30, comprise the second coherent technological system during the MSA occupations at Holley Shelter. The abundance of tools increases in these layers as well as the frequency of hornfels from bottom to top. From a metrical perspective, blanks and tools are larger compared to the underlying spits and artefact density is much higher. Knappers preferentially produced blades with faceted platforms but points are also frequent, especially in inches 18–24. In the same spit, 34% of the retouched tools are made on points confirming an increasing importance of this blank type. Different to the underlying spits, platform cores constitute the most important reduction strategy. People adopted soft stone hammer techniques for producing the majority of all blanks. Splintered pieces of all three categories occur and opposed-edge splintered pieces constitute the most common subtype. Single-edge splintered pieces increase towards the top of the sequence while diagonal splintered pieces occur the first time in the inch spit 12–18 of about 10%. Unifacial points appear in the highest frequencies in this part of the sequence. Based on direct comparison with unifacial points from the Sibudan (Conard *et al.* 2012; Will *et al.* 2014), most of these pieces are comparable to Ndwedwe tools.

The two uppermost spits (inch 0–6 and 6–12) correspond to a third coherent occupation phase. Although Cramb noted that the first six inches represent a mixture of LSA and MSA artefacts (Cramb 1961), we did not find any LSA signature in the lithic technology at Holley Shelter. Apart from a single strangled endscraper that could be of LSA character (see Goodwin 1930), the assemblage from the first spit conforms in all techno-typological aspects to a typical MSA technology without evidence for microlithic reduction systems (Deacon 1984; Opperman 1987; Carter *et al.* 1988). The assemblages from spits 0–6 and 6–12 are characterised by the almost exclusive use of hornfels, the preferential production of blades with faceted butts made on unidirectional platform cores, a low tool component compared to the underlying spits and the use of soft stone hammer percussion. Splintered pieces constitute the most abundant tool type, which are almost exclusively made on hornfels. All categories of splintered pieces, as defined above, occur with a dominance of opposed-edge splintered pieces. Single-edge and diagonal splintered pieces increase from top to bottom.

THE PLACE OF HOLLEY SHELTER WITHIN THE MSA OF SOUTHERN AFRICA

As stated above, the absolute age of the occupations at Holley Shelter remains unknown to date. Owing to the described problems of obtaining access to the site, we had no opportunity to extract datable material. We thus tried to narrow down the potential age of the MSA occupation at Holley Shelter by a techno-typological and morphometric comparison with other sites in South Africa, particularly its eastern part in the region of KwaZulu-Natal.

Owing to the absence of bifacial technology and small backed segments at Holley Shelter, we can exclude the existence of Howieson's Poort and Still Bay occupations at the site from our comparative analyses. The lack of bifacial cutting tools and hollow-based points also rules out a final MSA comparable to those at Sibudu or Umhlatuzana. These observations are important for chronological interpretations of the thick sequence at Holley Shelter, as the SB and HP are commonly found in various regions of southern Africa – including KwaZulu-Natal – and can serve as marker horizons for MIS 4 technology (Wadley 2007; Jacobs & Roberts 2008; Lombard *et al.* 2010; Mackay 2011; Henshilwood *et al.* 2014; but see Tribolo *et al.* 2013). Furthermore, the absence of final MSA markers at Holley Shelter helps to further narrow down the potential age of the site to before 35 ka.

There are two well-published sites in the vicinity of Holley Shelter: (i) Sibudu (Wadley & Jacobs 2004, 2006; Wadley 2005b, 2007; Wadley & Mohapi 2008; Conard *et al.* 2012, Will *et al.* 2014; Conard & Will 2015) located about 40 km away; and (ii) Umhlatuzana (Kaplan 1989, 1990; McCall & Thomas 2009; Mohapi 2008, 2013; Lombard *et al.* 2010) at about 60 km distant. In order to obtain more comparable data, we also included Border Cave (Cooke *et al.* 1945; Beaumont 1978; Villa *et al.* 2012) and Rose Cottage Cave (Wadley & Harper 1989; Clark 1997a; Harper 1997; Wadley 1997; Soriano *et al.* 2007) in our comparative analyses, which are both about 300 km away from Holley Shelter.

The only assemblages that compare well from the four sites mentioned above are those post-dating the HP. Most of these assemblages feature frequent unifacial points and all belong to MIS 3 (~58–24 ka). In the late MSA of Umhlatuzana, between 37 and 40% of the tools are unifacial points (Kaplan 1989, 1990). In the post-HP, or Sibudan, of Sibudu (layers BSP-BM) this tool form even comprises between 38 and 54% of all retouched artefacts (Will *et al.* 2014). Unifacial points with faceted butts are also characteristic for the post-HP or MSA3 at Border Cave (layer 2WA – 2BSUP) (Beaumont 1978; Volman 1981; Villa *et al.* 2012). At Rose Cottage Cave, unifacial points occur in both the pre-HP and the post-HP layers. Based on published drawings by Harper (1997), specimens from the pre-HP layers show a more leaf-shaped morphology with reduced butts that do not correspond to the morphology of unifacial points from Holley Shelter. Similarly to Holley Shelter, unifacial points occur predominantly in the middle part of the post-HP sequence at Rose Cottage Cave and their number decreases towards the underlying HP (Soriano *et al.* 2007). In contrast to Holley Shelter, however, the unifacial points from all four comparative sites exhibit flake or point proportions and not elongated blade shapes. While most unifacial points at Holley Shelter are best comparable to Ndwedwe tools from Sibudu (Conard *et al.* 2012), most other sites yield points that are more comparable with Tongati tools. As an additional point regarding tool kits, all comparative sites exhibit higher proportions of retouched artefacts during the post-HP/late MSA occupations compared to both under- and overlying layers.

In order to enlarge the possibilities of comparing assemblages we also conducted a morphometric analysis. Umhlatuzana and Sibudu constitute the best sites for such an analysis since they have detailed morphometric data. Table 5 directly compares various measurements between the unifacial points from the middle sequence of Holley Shelter with those from the late MSA at Umhlatuzana, based on work by Mohapi (2013) as well as the unifacial points from layers directly post-dating the HP at Sibudu based on our own data. The unifacial points from the different sites bear more similarities than differences. Most

measurements show only little variation of a few millimetres for mean values. Having said that, the Holley Shelter points are markedly longer and heavier and also have a higher length to width ratio than those from Umhlatuzana (both sections) and Sibudu. While there might be several reasons for this pattern, one simple explanation derives from the geographic position of Holley Shelter nearby many potential occurrences of hornfels (Fig. 1). The inhabitants of Holley Shelter thus had better access to larger amounts of hornfels compared to those at Sibudu or Umhlatuzana, an interpretation consistent with the existence of large blocks of this raw material in the MSA assemblages.

In terms of blank production, the post-HP at Border Cave is characterised by a higher percentage of blades which declines from the oldest post-HP layer 2WA with 80% to the youngest 2BSUP with 40% (Villa *et al.* 2012). Rose Cottage Cave also shows a strong signal of blade production in the occupations following the HP (Soriano *et al.* 2007). In the layers that follow the HP at Sibudu, blades never exceed 20% (Will *et al.* 2014; Conard & Will, 2015) and Umhlatuzana does not feature blades in significant frequencies during the late MSA (Kaplan 1990). Turning to core reduction strategies, the Sibudan at Sibudu also yielded many platform cores (Will *et al.* 2014: fig. 10, 8–9) which show technological similarities to Holley Shelter. At Holley Shelter, however, platform cores occur in much higher frequencies and play a more important role compared to Sibudu. While there is little published information on core reduction at Umhlatuzana, Kaplan (1989, 1990) mentioned single platform and bipolar cores. In the post-HP of Border Cave, narrow-sided cores occur as well as parallel cores (based on figures SI4, SI6 and SI8 in Villa *et al.* 2012). Finally, Rose Cottage Cave also yielded both laminar platform and parallel cores in the post-HP (Soriano *et al.* 2007: fig. 13).

Based on raw material proportions, Holley Shelter, Sibudu and Umhlatuzana share many similarities. The late MSA at Umhlatuzana features up to 80% of hornfels. In the older and younger strata, the number of hornfels artefacts declines and quartz becomes the most common raw material (Kaplan 1989, 1990). There is a similar trend in the Sibudan at Sibudu. Here dolerite followed by hornfels are the dominant raw materials (Will *et al.* 2014; Conard & Will 2015) while quartz is the more common raw material around the immediate transition between the HP and post-HP (Cochrane 2006; our own observations). These observations match well with the raw material shift at Holley Shelter from quartz, which dominates the bottom of the sequence, to hornfels in the middle and upper occupation horizons. Considering the short distances between Holley Shelter, Sibudu and Umhlatuzana, changes in environmental, demographic and socio-cultural variables probably affected the organisation of lithic technologies in similar ways at all three sites.

Apart from many similarities with stone artefact assemblages postdating the HP, there are differences in lithic technology of this period between the comparative sites and Holley Shelter. The extremely high proportions of retouched artefacts remain unique. This might be in part explained by the dominant use of hornfels in the upper and middle part of the sequence at Holley Shelter in combination with a minor recovery bias. Wadley and Kempson (2011) showed that hornfels is a relatively soft and fragile material, meaning that edges need to be resharpened more often compared to other raw materials. This could be one reason why knappers retouched hornfels more intensely than, for example, dolerite. It is conspicuous that the same over-representation of tools made on hornfels compared to other materials appears at Sibudu (Will *et al.* 2014; Conard & Will 2015). Having said that, we point to the fact that Umhlatuzana

shows low proportions of retouched artefacts although hornfels is the preferred raw material here (Kaplan 1989, 1990). The high proportion of retouched blanks at Holley Shelter in the middle and upper part of the sequence cannot be explained by the scarcity of raw material or long distance import. Under such conditions we would expect a higher variability in raw material composition and a higher proportion of retouched tools made on non-local raw materials compared to local raw material (*cf.* Bamforth 1986; Andrefsky 1994; Floss 1994; Auffermann 1998; MacDonald & Andrefsky 2008). However, this is not the case in the upper and middle part of the sequence at Holley Shelter where knappers almost exclusively used hornfels to produce both tools and unretouched blanks. Furthermore, many potential outcrops of hornfels occur within a 10 km radius around Holley Shelter and the inhabitants introduced large blocks of this raw material to the site. We have identified only a few pieces of potentially non-local raw materials and they exhibit less frequent modifications than hornfels. The situation might be different for the lowest phase of occupation, during which people preferentially collected and knapped quartz but continued to manufacture most tools on hornfels (10 out of 13).

Another feature that distinguishes Holley Shelter from most MSA sites in the eastern part of southern Africa is the high percentage of blades (on hornfels). Most of the comparative sites show much lower percentages of blades and tools are usually made on flakes and points (Kaplan 1989, 1990; Villa *et al.* 2012; Will *et al.* 2014). Only the blade-based post-HP assemblage from Rose Cottage Cave shows high percentages of retouched blades similar to Holley Shelter (Soriano *et al.* 2007). In part, this might again be associated with the natural proportions of hornfels and its abundant occurrence near Holley Shelter. Based on the frequent preservation of slab-like cortex on hornfels artefacts, we suggest that knappers intentionally chose large slabs from around Holley Shelter. Various authors have proposed that slabs often provide favourable conditions for producing blades (Moncel 2005; Carmignani 2010; Shimelmitz *et al.* 2011; Delagnes *et al.* 2012).

Turning to one of the main characteristics of Holley Shelter, the splintered pieces, in the uppermost part of the sequence with up to 61% of this tool category, show strong similarities to the Early LSA (ELSA) occupation at Border Cave (Villa *et al.* 2012) and Rose Cottage Cave (Wadley 1996; Clark 1997b). This observation, however, is the only similarity. In the ELSA at Border Cave, (i) the core technology becomes “unorganised” and “wasteful” (Villa *et al.* 2012: 13210) compared to the underlying post-HP, (ii) the percentage of blades strongly decreases, (iii) bipolar knapping becomes more important, and (iv) a systematic production of microliths is evident (Villa *et al.* 2012). The ELSA at Rose Cottage Cave is marked by irregular cores, bipolar knapping and bladelet production (Wadley 1996; Clark 1997b). We observed none of the above cited changes at Holley Shelter. By contrast, there is clear continuity in technology during the upper and middle part of the sequence. The frequent occurrence of splintered pieces at Holley Shelter is strongly associated with MSA technology, rendering this a unique feature of the site. In fact, we know of no other MSA assemblage in Africa with such a high proportion of splintered pieces.

In summary, the stone artefact assemblages from Holley Shelter share most similarities with lithic industries that post-date the HP in southern Africa. Furthermore, they are clearly distinguished from the Still Bay and Howieson’s Poort technologies which mostly date to MIS 4. The most parsimonious explanation is that the entire MSA occupation of Holley Shelter took place during MIS 3 and before ~35 ka. Based on

our data, we cannot completely reject Cramb's original observation of a short LSA occupation at the top of the sequence as most of his examples derive from excavation of the smaller area of the shelter which is not included in our analysis. This might be an indication of different activity areas during different times. Such an interpretation is also supported by Cramb's notion that "the paucity of split quartz pebble scrapers in the larger section – as compared with the smaller section – is puzzling." (Cramb 1961: 45).

CONCLUSION

We concur with Cramb's statement that "the entire assemblage can best be described as a point and blade industry in a perfect state of preservation" (Cramb 1952: 183). With our re-analysis of the original material, however, we could distinguish different technological phases and were able to show that the structure in lithic technology of Holley Shelter is much more complex. The three phases of occupation that we define most likely belong to settlements during MIS 3 following the Howieson's Poort. The uppermost part of the sequence comprises typical MSA technology together with an extremely high proportion of splintered pieces that is elsewhere only known from ELSA occupations (Clark 1997b; Villa *et al.* 2012). The middle part of the sequence resembles in many ways the Sibudan as defined by Conard *et al.* (2012) and Will *et al.* (2014). We base this assessment on similarities in core reduction, knapping strategies, morphometrics of unifacial points and provisioning of raw material, but also on the appearance of distinct techno-functional markers, namely the Ndwedwe and Tongati tools.

To the best of our knowledge, the frequency of splintered pieces at Holley Shelter is higher than for any other African MSA site. Based on this observation, we used a morphological classification system for this type of artefact. Apart from the still ongoing 'tool vs core'–debate, our results show that splintered pieces have a much higher morphological and temporal variability than recognised so far. These observations can serve as a starting point for more technological and functional studies of splintered pieces deriving from MSA contexts.

Our analyses of the techno-typological markers of Holley Shelter show that knappers possessed a highly structured lithic technology with many diagnostic features, outside of a Howieson's Poort or Still Bay context. If our temporal placement of the settlement within MIS 3 is correct, these results support recent arguments that the MSA after the HP in southern Africa is characterised by increased regionalisation and divergent cultural evolutionary trajectories, but does not show evidence for cultural regression (Mitchell 2008; Lombard & Parsons 2010, 2011; Mackay 2011; McCall 2011; Conard *et al.* 2012; Lombard *et al.* 2012; Villa *et al.* 2012; Porraz *et al.* 2013; Mackay *et al.* 2014; Will *et al.* 2014; Conard & Will 2015). At Holley Shelter, this hypothesis will need to be tested by absolute dates deriving from modern chronometric methods.

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REFERENCES

- Andrefsky, W.J. 1994. Raw-material availability and the organization of technology. *American Antiquity* 59: 21–34.
- Auffermann, B. 1998. *Rohmaterialnutzung im Magdalénien: Fundstellen am Nordrand der Schwäbischen Alb*. Folio-Verlag Wesselkamp.
- Backwell, L., D'Errico, F. & Wadley, L. 2008. Middle Stone Age bone tools from the Howieson's Poort layers, Sibudu Cave, South Africa. *Journal of Archaeological Science*, 35: 1566–1580.
- Bamforth, D.B. 1986. Technological efficiency and tool curation. *American Antiquity* 51: 38–50.
- Barham, L. 1987. The bipolar technique in southern Africa: a replication experiment. *South African Archaeological Bulletin* 42: 45–50.
- Beaumont, P.B. 1978. Border Cave. Unpublished PhD thesis. Cape Town: University of Cape Town.
- Boëda, E. 1993. Le débitage discoïde et le débitage Levallois récurrent centripède. *Bulletin de la Société préhistorique française*: 392–404.
- Boëda, E. 1994. *Le concept Levallois, variabilité des méthodes*. CNRS éditions.
- Boëda, E. 2001. Détermination des unités techno-fonctionnelles de pièces bifaciales provenant de la couche acheuléenne C'3 base du site de Barbas I. In: Cliquet, D. (ed.) *Les industries à outils bifaciaux du Paléolithique moyen d'Europe occidentale*. Actes de la table-ronde internationale organisée à Caen, 14–15 Octobre 1999, ERAUL 98: 51–76. Liège: ERAUL.
- Bonilauri, S. 2010. Les outils du Paléolithique moyen, une mémoire technique oubliée ? Approche techno-fonctionnelle appliquée à un assemblage lithique de conception Levallois provenant du site d'Umm el Tiel (Syrie centrale). Unpublished PhD thesis. Nanterre: Université de Paris-Ouest.
- Brantingham, P.J., Olsen, J.W., Rech, J.A. & Krivoschapkin, A.I. 2000. Raw Material Quality and Prepared Core Technologies in Northeast Asia. *Journal of Archaeological Science* 27: 255–271.
- Bräuer, G. 1984. A craniological approach to the origin of anatomically modern *Homo sapiens* in Africa and implications for the appearance of modern Europeans. In: Smith, F. & Spencer, F. (eds) *The Origins of Modern Humans: a World Survey of the Fossil Evidence*: 327–410. New York: Liss.
- Brown, K.S., Marean, C.W., Herries, A.I.R., Jacobs, Z., Tribolo, C., Braun, D., Roberts, D.L., Meyer, M.C. & Bernatchez, J. 2009. Fire As an Engineering Tool of Early Modern Humans. *Science* 325: 859–862.
- Brun-Ricalens, F.L. 2006. Les pièces esquillées: état des connaissances après un siècle de reconnaissance. *PALEO. Revue d'archéologie préhistorique*: 95–114.
- Cahen, D. & Moeyersons, J. 1977. Subsurface movements of stone artefacts and their implications for the prehistory of Central Africa. *Nature* 266: 812–815.
- Cairncross, B. 2004. *Field Guide to Rocks & Minerals of Southern Africa*, Cape Town: Struik.
- Carmignani, L. 2010. L'industria litica del livello fillie di Grotta del Cavallo (Nardò, Lecce). Osservazioni su una produzione laminolamellare in un contesto del Musteriano Finale. *Origini: Preistoria e protostoria delle civiltà antiche*: 7–26.
- Carter, P., Mitchell, P. & Vinnicombe, P. 1988. *Sehonghong: the Middle and Later Stone Age Industrial Sequence at a Lesotho Rock-shelter*. Oxford: BAR.
- Clark, A.M.B. 1997a. The final Middle Stone Age at Rose Cottage Cave: a distinct industry in the Basutolian ecozone. *South African journal of Science* 93: 449–458.
- Clark, A.M.B. 1997b. The MSA/LSA transition in southern Africa: new technological evidence from Rose Cottage Cave. *South African Archaeological Bulletin* 52: 113–121.
- Cochrane, G.W.G. 2006. An analysis of lithic artefacts from the ~60 ka layers of Sibudu Cave. *Southern African Humanities* 18: 69–88.
- Conard, N.J. 1992. *Tönchesberg and its Position in the Paleolithic Prehistory of Northern Europe*. Bonn: Habelt.
- Conard, N.J. 2005. An overview of the patterns of behavioural change in Africa and Eurasia during the Middle and Late Pleistocene. In: D'Errico, F. & Backwell, L. (eds) *From Tools to Symbols: from Early Hominids to Modern Humans*. Johannesburg: Witwatersrand University Press.
- Conard, N.J. & Will, M. 2015. Examining the causes and consequences of short-term behavioral change during the Middle Stone Age at Sibudu, South Africa. *PLOS ONE* 10: 1371.

- Conard, N.J., Porraz, G. & Wadley, L.Y.N. 2012. What is in a name? Characterising the post-Howieson's Poort at Sibudu. *South African Archaeological Bulletin* 67: 180–199.
- Conard, N.J., Soressi, M., Parkinson, J.E., Wurz, S. & Yates, R. 2004. A unified lithic taxonomy based on patterns of core reduction. *South African Archaeological Bulletin* 59: 12–16.
- Cooke, H.B.S., Malan, B.D. & Wells, L.H. 1945. Fossil Man in the Lebombo Mountains, South Africa: the 'Border Cave', Ingwavuma District, Zululand. *Man* 45: 6–13.
- Cramb, J.G. 1952. A Middle Stone Age industry from a Natal rock shelter. *South African Journal of Science* 48: 181–186.
- Cramb, J.G. 1961. A second report on work at the Holley Shelter. *South African Journal of Science* 57: 45–48.
- D'Errico, F., Henshilwood, C., Vanhaeren, M. & Van Niekerk, K. 2005. *Nassarius kraussianus* shell beads from Blombos Cave: evidence for symbolic behaviour in the Middle Stone Age. *Journal of Human Evolution* 48: 3–24.
- de la Peña, P. & Wadley, L. 2014a. Quartz knapping strategies in the Howieson's Poort at Sibudu (KwaZulu-Natal, South Africa). *PLOS ONE* 9: e101534.
- de la Peña, P. & Wadley, L. 2014b. New knapping methods in the Howieson's Poort at Sibudu (KwaZulu-Natal, South Africa). *Quaternary International* 350: 26–42.
- de la Peña, P., Wadley, L. & Lombard, M. 2013. Quartz bifacial points in the Howieson's Poort of Sibudu. *South African Archaeological Bulletin* 68.
- Deacon, J. 1984. *The Later Stone Age of Southernmost Africa*. Oxford: BAR.
- Delagnes, A., Tribolo, C., Bertran, P., Brenet, M., Crassard, R., Jaubert, J., Khalidi, L., Mercier, N., Nomade, S., Peigné, S., Sitzia, L., Tournepiche, J-F., Al-Halibi, M., Al-Mosabi, A. & Macchiarelli, R. 2012. Inland human settlement in southern Arabia 55,000 years ago. New evidence from the Wadi Surdud Middle Paleolithic site complex, western Yemen. *Journal of Human Evolution* 63: 452–474.
- Dibble, H.L. 1997. Platform variability and flake morphology: a comparison of experimental and archaeological data and implications for interpreting prehistoric lithic technological strategies. *Lithic Technology*: 150–170.
- 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: 1945–1954.
- Driscoll, K. 2010. Understanding quartz technology in early prehistoric Ireland. Unpublished PhD thesis. Dublin: University College Dublin.
- Eren, M.I., Durant, A., Neudorf, C., Haslam, M., Shipton, C., Bora, J., Korisettar, R. & Petraglia, M. 2010. Experimental examination of animal trampling effects on artifact movement in dry and water saturated substrates: a test case from South India. *Journal of Archaeological Science* 37: 3010–3021.
- Floss, H. 1994. *Rohmaterialversorgung im Paläolithikum des Mittelrheingebiets*, Bonn: Habelt.
- Floss, H. & Weber, M-J. 2012. Schlagtechniken. In: Floss, H. (ed.) *Steinartefakte: vom Altpaläolithikum bis in die Neuzeit*. Kerns.
- Goodwin, A.J.H. 1930. A new variation of the Smithfield Culture from Natal. *Transactions of the Royal Society of South Africa* 19: 7–14.
- Hahn, J. 1991. *Erkennen und Bestimmen von Stein- und Knochenartefakten: einföhrung in die Artefaktmorphologie*, Verlag Archaeologica Venatoria.
- Harper, P.T. 1997. The Middle Stone Age sequences at Rose Cottage Cave: a search for continuity and discontinuity. *South African Journal of Science* 93: 470–475.
- Hayden, B. 1980. Confusion in the bipolar world: bashed pebbles and splintered pieces. *Lithic Technology*: 2–7.
- Hays, M. & Lucas, G. 2007. Pièces esquillées from Le Flageolet I (Dordogne, France): tools or cores. In: McPherron, S.P. (ed.) *Tools Versus Cores: Alternative Approaches to Stone Tool Analysis*. Newcastle: Cambridge Scholars Publishing.
- Henshilwood, C.S., D'Errico, F., Vanhaeren, M., Van Niekerk, K. & Jacobs, Z. 2004. Middle stone age shell beads from South Africa. *Science* 304: 404–404.
- Henshilwood, C.S., D'Errico, F. & Watts, I. 2009. Engraved ochres from the Middle Stone Age levels at Blombos Cave, South Africa. *Journal of Human Evolution* 57: 27–47.
- Henshilwood, C.S., D'Errico, F., Van Niekerk, K.L., Coquinot, Y., Jacobs, Z., Lauritzen, S-E., Menu, M. & García-Moreno, R. 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. *Science* 334: 219–222.
- Henshilwood, C.S., Sealy, J.C., Yates, R., Cruz-Urube, K., Goldberg, P., Grine, F.E., Klein, R.G., Poggenpoel, C., Van Niekerk, K. & Watts, I. 2001. Blombos Cave, Southern Cape, South Africa: preliminary report on the 1992–1999 excavations of the Middle Stone Age levels. *Journal of Archaeological Science* 28: 421–448.
- Henshilwood, C.S., Van Niekerk, K.L., Wurz, S., Delagnes, A., Armitage, S.J., Rifkin, R.F., Douze, K., Keene, P., Haaland, M.M., Reynard, J., Discamps, E. & Mienies, S.S. 2014. Klipdrift Shelter, southern Cape, South Africa: preliminary report on the Howieson's Poort layers. *Journal of Archaeological Science* 45: 284–303.
- Hiscock, P. 2015. Making it small in the Palaeolithic: bipolar stone-working, miniature artefacts and models of core recycling. *World Archaeology*: 1–12.
- Hofman, J.L. 1986. Vertical movement of artifacts in alluvial and stratified deposits. *Current Anthropology* 27: 163–171.
- Hughes, S.S. 1998. Getting to the point: evolutionary change in prehistoric weaponry. *Journal of Archaeological Method and Theory* 5: 345–408.
- Jacobs, Z. & Roberts, R.G. 2008. Testing times: old and new chronologies for the Howieson's Poort and Still Bay industries in environmental context. *South African Archaeological Society Goodwin Series* 10: 9–34.
- Jacobs, Z., Wintle, A.G., Duller, G.A.T., Roberts, R.G. & Wadley, L. 2008. New ages for the post-Howieson's Poort, late and final Middle Stone Age at Sibudu, South Africa. *Journal of Archaeological Science* 35: 1790–1807.
- Kaplan, J. 1989. 45000 years of hunter-gatherer history in Natal as seen from Umhlatuzana Rock Shelter. *South African Archaeological Society Goodwin* 6: 7–16.
- Kaplan, J. 1990. The Umhlatuzana rock shelter sequence: 100 000 years of Stone Age history. *Southern African Humanities* 2: 1–94.
- Langejans, G.H.J. 2012. Middle Stone Age pièces esquillées from Sibudu Cave, South Africa: an initial micro-residue study. *Journal of Archaeological Science* 39: 1694–1704.
- Leblanc, R. 1992. Wedges, pièces esquillées, bipolar cores, and other things: an alternative to Shott's view of bipolar industries. *North American Archaeologist* 13: 1–14.
- Leport, M. 1993. Approche techno-fonctionnelle de l'outillage lithique moustérien: essai de classification des parties actives en termes d'efficacité technique. Unpublished Master's dissertation. Nanterre: University of Paris X.
- Lin, S., Rezek, Z., Braun, D. & Dibble, H. 2013. On the utility and economization of unretouched flakes: the effects of exterior platform angle and platform depth. *American Antiquity* 78: 724–745.
- Lombard, M. 2006. First impressions of the functions and hafting technology of Still Bay pointed artefacts from Sibudu Cave. *Southern African Humanities* 18: 27–41.
- Lombard, M. & Parsons, I. 2010. Fact or fiction? Behavioural and technological reversal after 60 ka in southern Africa. *South African Archaeological Bulletin* 65: 224–228.
- Lombard, M. & Parsons, I. 2011. What happened to the human mind after the Howieson's Poort? *Antiquity* 85: 1433–1443.
- Lombard, M., Wadley, L., Jacobs, Z., Mohapi, M. & Roberts, R.G. 2010. Still Bay and serrated points from Umhlatuzana Rock Shelter, Kwazulu-Natal, South Africa. *Journal of Archaeological Science*. 37: 1773–1784.
- Lombard, M., Wadley, L.Y.N., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., Swart, J. & Mitchell, P. 2012. South African and Lesotho Stone Age sequence updated. *South African Archaeological Bulletin* 67: 123–144.
- Macdonald, D.H. & Andrefsky, W. 2008. The role of lithic raw material availability and quality in determining tool kit size, tool function, and degree of retouch: a case study from Skink Rockshelter (46NI445), West Virginia. In: Andrefsky, W.J. (ed.) *Lithic Technology: Measures of Production, Use and Curation*. Cambridge: Cambridge University Press.
- Mackay, A. 2011. Nature and significance of the Howieson's Poort to post-Howieson's Poort transition at Klein Kliphuis rockshelter, South Africa. *Journal of Archaeological Science* 38: 1430–1440.
- Mackay, A., Stewart, B.A. & Chase, B.M. 2014. Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa. *Journal of Human Evolution* 72: 26–51.
- Marean, C.W., Bar-Matthews, M., Bernatchez, J., Fisher, E., Goldberg, P., Herries, A.I.R., Jacobs, Z., Jerardino, A., Karkanas, P., Minichillo, T., Nilssen, P.J., Thompson, E., Watts, I. & Williams, H.M. 2007. Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature* 449: 905–908.
- Marean, C.W., Bar-Matthews, M., Fisher, E., Goldberg, P., Herries, A., Karkanas, P., Nilssen, P.J. & Thompson, E. 2010. The stratigraphy of the Middle Stone Age sediments at Pinnacle Point Cave 13B (Mossel Bay, Western Cape Province, South Africa). *Journal of Human Evolution* 59: 234–255.

- McCall, G.S. 2011. Progression, regression, or adaptation: further thoughts on the post-Howieson's Poort Middle Stone Age of South Africa. *South African Archaeological Bulletin* 66: 89–92.
- McCall, G.S. & Thomas, J.T. 2009. Re-examining the South African Middle-to-Later Stone Age transition: multivariate analysis of the Umhlatuzana and Rose Cottage Cave stone tool assemblages. *Azania: Archaeological Research in Africa* 44: 311–330.
- McDougall, I., Brown, F.H. & Fleagle, J.G. 2005. Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature* 433: 733–736.
- Mitchell, P. 2008. Developing the archaeology of Marine Isotope Stage 3. *South African Archaeological Society Goodwin Series* 10: 52–65.
- Mohapi, M. 2008. A new angle on Middle Stone Age hunting technology in South Africa. Unpublished PhD thesis. Johannesburg: University of the Witwatersrand
- Mohapi, M. 2013. The Middle Stone Age point assemblage from Umhlatuzana rock shelter: a morphometric study. *Southern African Humanities* 25: 25–51.
- Moncel, M.-H. 2005. Baume Flandin et Abri du Maras: deux exemples de débitage laminaire du début du Pléistocène supérieur dans la Vallée du Rhône (sud-est, France). *L'Anthropologie* 109: 451–480.
- Monigal, K. 2001. Lower and Middle Paleolithic blade industries and the dawn of the Upper Paleolithic in the Levant. *Archaeology, Ethnology and Anthropology of Eurasia*, 1: 11–21.
- Odell, G.H. 2004. *Lithic Analysis. Manuals in Archaeological Method, Theory, and Technique*. New York: Kluwer Academic.
- Opperman, H. 1987. *The Later Stone Age of the Drakensberg Range and Its Foothills*. Oxford: BAR.
- Parkington, J., Poggenpoel, C., Halkett, D. & Hart, T. 2004. Initial observations on the Middle Stone Age coastal settlement in the Western Cape, South Africa. In: Conard, N. (ed.) *Settlement Dynamics of the Middle Paleolithic and Middle Stone Age* Vol. 2: 5–21. Tübingen: Kerns Verlag.
- Pelcin, A.W. 1997. The formation of flakes: the role of platform thickness and exterior platform angle in the production of flake initiations and terminations. *Journal of Archaeological Science* 24: 1107–1113.
- Pelegrin, J. 2000. Les techniques de débitage laminaire au Tardiglaciaire: critères de diagnose et quelques réflexions. *L'Europe Centrale et Septentrionale au Tardiglaciaire. Confrontation des modèles régionaux* 7: 73–86.
- Peresani, M. 2003. *Discoid Lithic Technology: Advances and Implications*. Oxford: British Archaeological Reports Ltd.
- Porráz, 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: 3376–3400.
- Schmidt, P., Porráz, G., Slodczyk, A., Bellot-Gurlet, L., Archer, W. & Miller, C.E. 2013. Heat treatment in the South African Middle Stone Age: temperature induced transformations of silcrete and their technological implications. *Journal of Archaeological Science* 40: 3519–3531.
- Shea, J.J. 2006. The origins of lithic projectile point technology: evidence from Africa, the Levant, and Europe. *Journal of Archaeological Science* 33: 823–846.
- Shimelmitz, R., Barkai, R. & Gopher, A. 2011. Systematic blade production at late Lower Paleolithic (400 200 kyr) Qesem Cave, Israel. *Journal of Human Evolution* 61: 458–479.
- Shott, M.J. 1999. On bipolar reduction and splintered pieces. *North American Archaeologist* 20: 217–238.
- Singer, R. & Wymer, J. 1982. *The Middle Stone Age at Klasies River Mouth in South Africa*. Chicago: University of Chicago Press.
- Sisk, M.L. & Shea, J.J. 2011. The African origin of complex projectile technology: an analysis using tip cross-sectional area and perimeter. *International Journal of Evolutionary Biology* 2011: 8.
- Smith, F.H., Falsetti, A.B. & Donnelly, S.M. 1989. Modern human origins. *American Journal of Physical Anthropology* 32: 35–68.
- Soriano, S. 2001. Statut fonctionnel de l'outillage bifacial dans les industries du Paléolithique moyen: propositions méthodologiques. *Les industries à outils bifaciaux du Paléolithique moyen d'Europe occidentale*: 77–84.
- Soriano, S., Villa, P. & Wadley, L. 2007. Blade technology and tool forms in the Middle Stone Age of South Africa: the Howieson's Poort and post-Howieson's Poort at Rose Cottage Cave. *Journal of Archaeological Science* 34: 681–703.
- Staurset, S. & Coulson, S. 2014. Sub-surface movement of stone artefacts at White Paintings Shelter, Tsodilo Hills, Botswana: implications for the Middle Stone Age chronology of central southern Africa. *Journal of Human Evolution* 75: 153–165.
- Stringer, C.B. 1989. Documenting the origin of modern humans. In: Trinkaus, E. (ed.) *Emergence of Modern Humans: Biocultural Adaptations in the Late Pleistocene*. Cambridge: Cambridge University Press.
- Texier, P.-J., Porráz, G., Parkington, J., Rigaud, J.-P., Poggenpoel, C., Miller, C., Tribolo, C., Cartwright, C., Coudenneau, A., Klein, R., Steele, T. & Verna, C. 2010. A Howieson's Poort tradition of engraving ostrich eggshell containers dated to 60,000 years ago at Diepkloof Rock Shelter, South Africa. *Proceedings of the National Academy of Sciences* 107: 6180–6185.
- Tribolo, C., Mercier, N., Douville, E., Joron, J.L., Reyss, J.L., Rufer, D., Cantin, N., Lefrais, Y., Miller, C.E., Porráz, G., Parkington, J., Rigaud, J.P. & Texier, P.J. 2013. OSL and TL dating of the Middle Stone Age sequence at Diepkloof Rock Shelter (South Africa): a clarification. *Journal of Archaeological Science* 40: 3401–3411.
- Villa, P., Delagnes, A. & Wadley, L. 2005. A late Middle Stone Age artifact assemblage from Sibudu (KwaZulu-Natal): comparisons with the European Middle Paleolithic. *Journal of Archaeological Science* 32: 399–422.
- Villa, P., Soriano, S., Tsanova, T., Degano, I., Higham, T.F.G., D'Errico, F., Backwell, L., Lucejko, J.J., Colombini, M.P. & Beaumont, P.B. 2012. Border Cave and the beginning of the Later Stone Age in South Africa. *Proceedings of the National Academy of Sciences* 109: 13208–13213.
- Vogel, J.C. & Beaumont, P.B. 1972. Revised radiocarbon chronology for the Stone Age in South Africa. *Nature* 237: 50–51.
- Volman, T.P. 1981. The Middle Stone Age in the southern Cape. Unpublished PhD thesis. Chicago: University of Chicago.
- Wadley, L. 1996. The Robberg Industry of Rose Cottage Cave, Eastern Free State: the technology, spatial patterns and environment. *South African Archaeological Bulletin* 51: 64–74.
- Wadley, L. 1997. Rose Cottage Cave: archaeological work 1987 to 1997. *South African Journal of Science* 93: 439–444.
- Wadley, L. 2001. Excavations at Sibudu Cave, KwaZulu-Natal. *The Digging Stick* 18: 1–4.
- Wadley, L. 2005a. Putting ochre to the test: replication studies of adhesives that may have been used for hafting tools in the Middle Stone Age. *Journal of Human Evolution* 49: 587–601.
- Wadley, L. 2005b. A typological study of the final Middle Stone Age stone tools from Sibudu Cave, KwaZulu-Natal. *South African Archaeological Bulletin* 60: 51–63.
- Wadley, L. 2007. Announcing a Still Bay industry at Sibudu Cave, South Africa. *Journal of Human Evolution* 52: 681–689.
- Wadley, L. 2012. Two 'moments in time' during Middle Stone Age occupations of Sibudu, South Africa. *Southern African Humanities* 24: 79–97.
- Wadley, L. & Harper, P. 1989. Rose Cottage Cave revisited: Malan's Middle Stone Age collection. *South African Archaeological Bulletin* 44: 23–32.
- Wadley, L. & Jacobs, Z. 2004. Sibudu Cave, KwaZulu-Natal: background to the excavations of Middle Stone Age and Iron Age occupations. *South African Journal of Science* 100: 145–151.
- Wadley, L. & Jacobs, Z. 2006. Sibudu Cave: background to the excavations, stratigraphy and dating. *Southern African Humanities* 18: 1–26.
- Wadley, L. & Kempson, H. 2011. A review of rock studies for archaeologists, and an analysis of dolerite and hornfels from the Sibudu area, KwaZulu-Natal. *Southern African Humanities* 23: 87–107.
- Wadley, L. & Mohapi, M. 2008. A segment is not a monolith: evidence from the Howieson's Poort of Sibudu, South Africa. *Journal of Archaeological Science* 35: 2594–2605.
- White, T.D., Asfaw, B., Degusta, D., Gilbert, H., Richards, G.D., Suwa, G. & Clark Howell, F. 2003. Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature* 423: 742–747.
- 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: e98359.
- Will, M., Parkington, J.E., Kandel, A.W. & Conard, N.J. 2013. Coastal adaptations and the Middle Stone Age lithic assemblages from Hoedjiespunt 1 in the Western Cape, South Africa. *Journal of Human Evolution* 64: 518–537.
- Wurz, S. 2000. The Middle Stone Age at Klasies River, South Africa. Unpublished PhD thesis. Stellenbosch: Stellenbosch University.
- 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: 1001–1015.



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Umbeli Belli Rock Shelter, a forgotten piece from the puzzle of the Middle Stone Age in KwaZulu-Natal, South Africa



Gregor Donatus Bader^{a,*}, Charles Cable, Carol Lentfer^{c,d}, Nicholas John Conard^{a,b}

^a Department of Early Prehistory and Quaternary Ecology, University of Tübingen Schloss Hohentübingen, Tübingen, Germany

^b Senckenberg Center for Human Evolution and Paleoenvironment, University of Tübingen Schloss Hohentübingen, Tübingen, Germany

^c Traceolab, Prehistory Department, Liège University, Liège, Belgium

^d Archaeology Program, School of Social Science, University Queensland, Australia

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ABSTRACT

Lithic technology in the Middle Stone Age (MSA) of southern Africa is key to reconstructing human daily life, people's interaction with their environment and technological and cultural change through time. Ongoing discussions about the evolution of technology in the MSA debate the causes of lithic variability within and between different assemblages across southern Africa. The well-known MSA sites such as Blombos Cave, Klasies River, Diepkloof and Sibudu serve as anchors for comparative studies by providing high resolution stratigraphies that cover long parts of the archaeological sequence. Researchers, however, should recognize that these and other key sites are often situated many hundreds kilometers away from each other and are located in diverse geographic settings, which raises questions about their comparability. It is therefore important to consider the archaeological signatures from less spectacular sites to help identify regional patterns and test models of cultural change at smaller spatial scales. KwaZulu-Natal serves as an excellent starting point to bring questions about continuity and change within the MSA into clearer focus, since the province contains several sites in close proximity to each other in comparable environments. Many of these sites, however, are still understudied or have even been forgotten completely. In this paper we describe the archaeological sequence of one such site, Umbeli Belli near Scottburgh. This site was excavated in 1979 by Charles Cable and contributes important information to the regional record of the MSA in KwaZulu-Natal.

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1. Introduction

The Middle Stone Age (MSA) of southern Africa falls within a temporal framework that reflects major changes and cultural developments during human evolution. The MSA, the period when modern humans evolved from both a biological and cultural perspective to become like all living people today, set the stage for the spread of modern humans across the globe and has become a major focus of international research in recent decades. Work in South Africa features prominently in the international discussions of the evolution of modern humans. In recent years extensive research has been undertaken mostly along the western and southern coast of South Africa but also increasingly in KwaZulu-Natal and the Limpopo-province. In KwaZulu-Natal the most famous sites are Sibudu (Conard et al., 2012; Conard and Will, 2015; d'Errico et al., 2008; De La Peña and Wadley, 2014a, 2014b, Jacobs et al., 2008b; Soriano et al., 2009; Wadley, 2001, 2007, 2013; Wadley and Jacobs, 2006; Wadley et al., 2011; Will et al., 2014), Umhlatuzana

(Kaplan, 1989, 1990; Lombard et al., 2010; McCall and Thomas, 2009; Mohapi, 2013) and Border Cave (Beaumont, 1978; Butzer et al., 1978; Cooke et al., 1945; Grün and Beaumont, 2001; Klein, 1977; Villa et al., 2012). Recently we have started to expand our research focus to another less known site in this region, Holley Shelter, in order to contribute to our understanding of the MSA, with a major focus on lithic technology (Bader et al., 2015). Nevertheless compared to other regions, known MSA sites in KwaZulu-Natal are relatively few, one reason being that many MSA sites, mostly open air/dune sites, which once existed were destroyed either by poor excavation methods or by roads and housing developments, and many already before World War II (Maguire, 1997). However, the main reason is due a lack of interest paid to MSA assemblages in the past. It has only been since the mid 1980s that the MSA has attained increased importance, when it became clear, that this period is linked to anatomically modern humans (Bräuer, 1984; McDougall et al., 2005; Stringer, 1989; White et al., 2003) and features abundant evidence for cultural modernity (d'Errico et al., 2005, 2008; Henshilwood et al., 2009, 2011; Mearan et al., 2007; Parkington et al., 2004; Texier et al., 2010; Will et al., 2013) dating far back before the European Upper Palaeolithic (Guérin et al., 2013; Jacobs and Roberts, 2008; Jacobs et al., 2008a; Tribolo et al., 2013). In some cases researchers

* Corresponding author.

E-mail addresses: gregor.bader@uni-tuebingen.de (G.D. Bader), clentfer@ulg.ac.be (C. Lentfer), nicholas.conard@uni-tuebingen.de (N.J. Conard).

intentionally searching for Later Stone Age (LSA) occupations found older MSA occupations, more or less by accident. One of these sites is Umbeli Belli near Scottburgh in KwaZulu-Natal. Although excavated in 1979, no analysis of the MSA assemblage from the site has been undertaken until now. It is part of ongoing research by the University of Tübingen to study and contextualize the MSA (Conard et al., 2014). Here we present our results on the lithic analyzes of the MSA assemblage of Umbeli Belli. This paper marks the beginning of intensive new research in this region, including excavations using modern archaeological procedure and radiometric dating. The broader aim of this project is to help our understanding of human adaptive behavior towards natural, environmental conditions and the driving factors of regional assemblage variability.

2. Umbeli Belli

Umbeli Belli is a small rockshelter about 24 m wide and 6 m deep (Cable, 1984). It is situated about 7 km inland from Scottburgh within the Mpambanyoni river valley (Fig. 1). The site lies about 20 m up the hill above a well-used road within a dense forest that hides the shelter completely. The rock shelter belongs to the Table Mountain series quartzite and lies within the South African Summer rainfall zone (SRZ). The hilly landscape surrounding the site is most densely populated but has numerous valleys with thick vegetation. Charles Cable excavated the site in 1979, and his main interest focused on the LSA occupation at the top of the sequence. He used a square grid system, sieved the sediments with a 5 mm mesh, and separated the sequence into geological layers (Cable, 1984). He opened up a trench of 9 m² and defined the x values for the meters with letters (B, C, D) and the y values with numbers (1, 2, 3, 4) (Fig. 2). Four squares (B2, B3, C2, C3) were excavated to bedrock. In the remaining five squares, only the first 20 to 30 cm of LSA deposits were excavated. During the excavation Cable identified four distinct geological layers. Layer 1 was up to 7 cm thick and consisted of a light brown, powdery deposit containing

archaeological material as well as modern material such as pieces of newspaper and animal droppings (Cable, 1984). The underlying Layer 2BE was a grey brown earth with scattered charcoal and ash reaching a thickness between 5 and 10 cm (Cable, 1984). This layer was dated using the radiocarbon method to 200 ± 50 BP and contained Late Stone Age material. The underlying Layer 2AL was limited to the front portion of the rock shelter where it attained a maximum thickness of 15 cm (Cable, 1984). This layer dated to 1140 ± 50 BP, but according to Cable the range of artifact variability was comparable to the overlying layer. The underlying Layer 3 represented a “heavily leached orange soil, sub-divisible only by the presence of a layer of naturally accumulated rocks” (Cable, 1984: 86). Cable noted that this rock fall overlay stone artifacts clearly attributed to an MSA occupation. He did not describe them, or the assemblages lying between Layer 2AL and the rock fall, any further, as they were outside the scope of his research at the time. Layer 3, which overlay a compact sterile sand, reached a thickness of up to 1 m but lacked features necessary to stratigraphically subdivide it further. Cable therefore excavated this deposit in artificial spits of about 10 cm (Cable 1979 – field diary). Spits 1 to 4 lay on top of the rock fall, while Spit 5, 6 and 7 underlay this geological feature. The MSA occupation was limited to Spits 5–6 and varied in thickness from 10 to 40 cm. Similar to the LSA layers at the top of the sequence, the MSA deposits became thicker towards the drip line of the shelter. Cable excavated first in Squares B2 and B3 down to the bedrock. Based on his observations that Spit 5 yielded increased artifact density toward the bottom, he decided to subdivide this spit further into stratigraphic units 5, 5A, 5B, 5C when he excavated the adjacent Squares C2 and C3 (Cable 1979 – field diary).

3. Materials and methods

During 2015 we analyzed the Squares C2 and C3 from Layer 3 since they provided the best stratigraphic resolution, especially in Spit 5 that was subdivided into 5, 5 A, 5B, 5C. Furthermore, the assemblages from

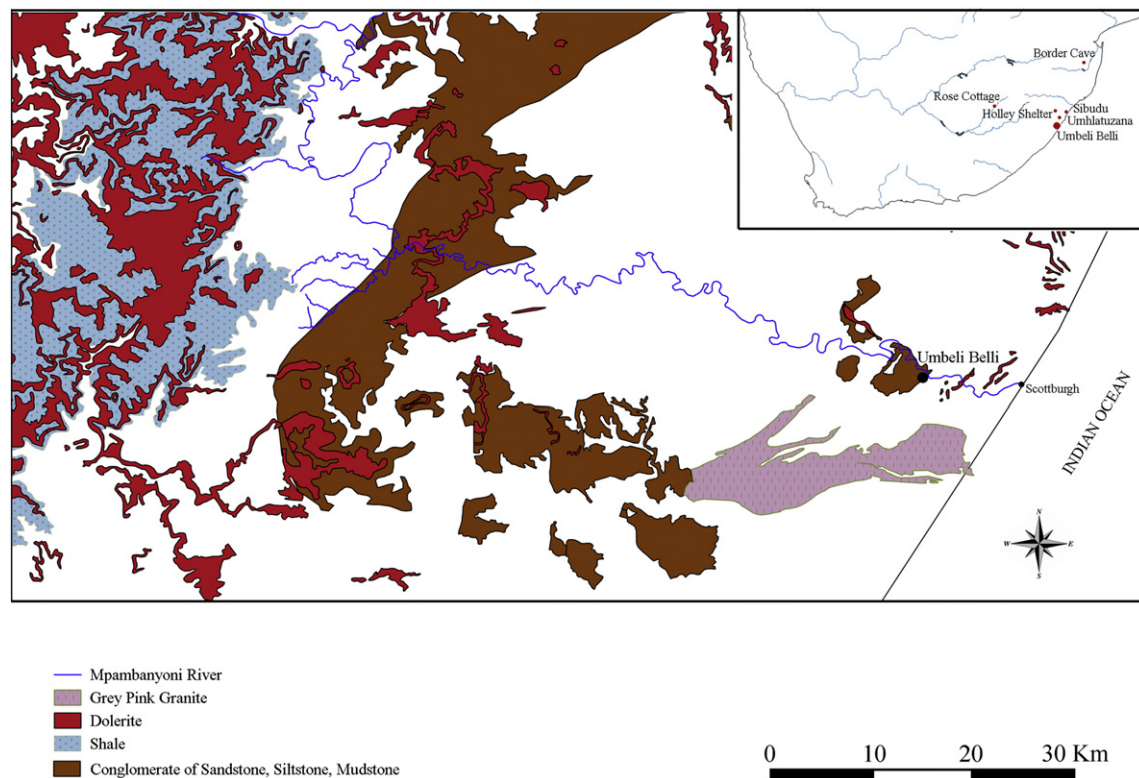


Fig. 1. Location of Umbeli Belli within the geological context and the archaeological landscape of the region. Map is designed based on 1:250,000 geological map by the Department of Mineral and Energy Affairs.

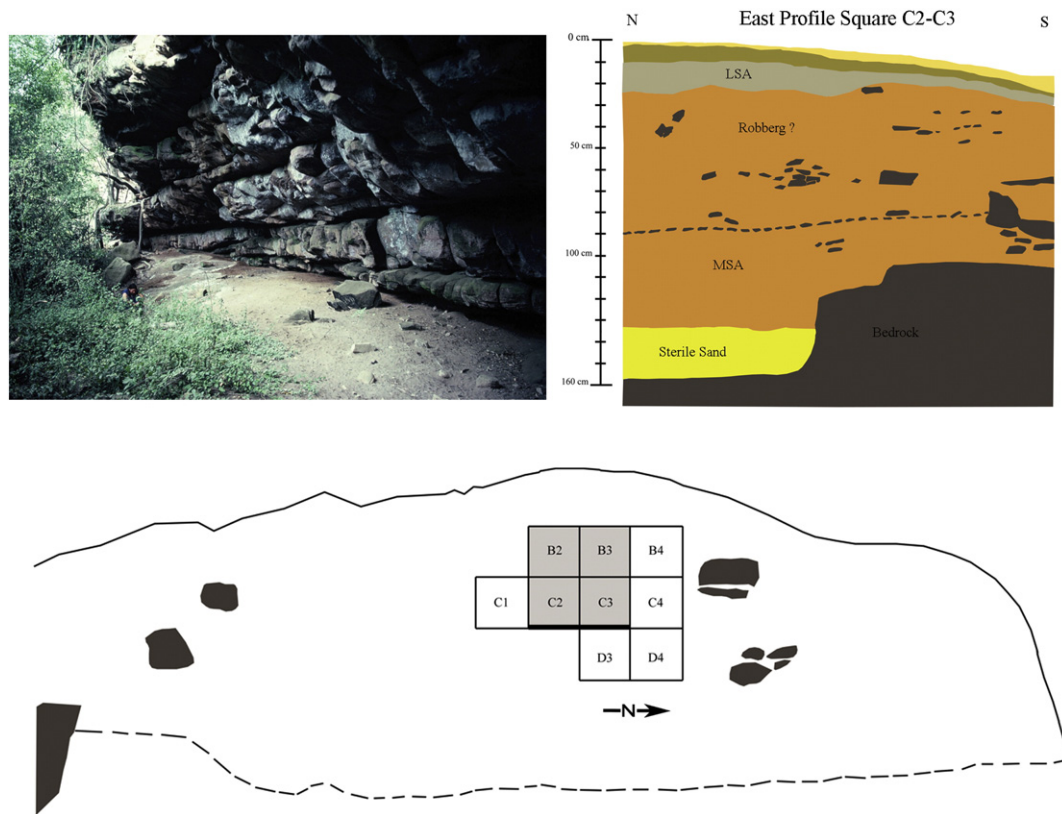


Fig. 2. Left: view to the rock shelter towards the south prior to the excavation in 1979; Right: Stratigraphy of the east profile (modified after Cable, 1984); Below: plan of the excavated squares so far (modified after Cable, 1984). MSA layers are only excavated in the grey squares.

Squares B2 and B3 which were highly compressed, provided a much smaller number of artifacts than C2 and C3. Similar to the LSA layers the MSA occupation becomes much thicker towards the front of the shelter. Altogether we were able to analyze 14,813 artifacts for the complete sequence from top to bottom. Out of this we selected all the pieces >3 cm, as well as all cores and tools regardless of size ($n = 1972$) for a detailed technological study. We chose 3 cm as the minimum size limit to obtain a sample of data comparable to our results from Sibudu and Holley Shelter where we followed the same procedure. For the remaining 12,841 pieces (<3 cm) we analyzed the raw material type and recorded technological information that helped to characterize the assemblages. The present paper deals only with the MSA assemblage underlying the rock fall (Spits 5, 5A, 5B, 5C, 6,) and contains 8653 pieces. 1100 artifacts meeting the criteria described above, were subject to detailed technological analysis. The overlying assemblage (Spits 1, 2, 3, 4) does not include artifacts characteristic of the MSA. These spits are characterized by microlithic bladelet production from bipolar quartz cores and the almost complete absence of typical MSA-like retouched forms, prepared cores and platforms. Although we will not describe this material that shows strong affinities to a LSA occupation here, we plan to publish information on the assemblage in the near future.

Due to the lack of radiometric dates, we refrain from making firm estimates of the age of the MSA occupation at Umbeli Belli. However, we are able to compare the assemblage with other sites in KwaZulu-Natal such as our own research sites, Sibudu and Holley Shelter, which provide the most promising comparative data, and also Umhlatuzana. The main goal of this paper is to provide a first description of the MSA assemblages, to characterize possible changes throughout the sequence and to hypothesize what people did at Umbeli Belli and why. In a further step we will try to put Umbeli Belli into a regional framework and to outline its potential contribution to our understanding of human behavior during the MSA. To achieve these goals we have used the method of attribute analysis (Andrefsky, 2005; Scerri et al., 2015) since it ideally

provides objective and reproducible results. We also examined the different steps of reduction that took place at the site (Conard and Adler, 1997; Dibble et al., 2005; Geneste, 1988; Shott, 2003). In terms of small debitage (pieces <3 cm), we paid special interest to flakes that can be directly linked to tool manufacture including retouch- and shaping flakes (Soriano et al., 2009). We also scanned the small debitage for bladelets since this blank falls outside our minimum size limit. To provide an impression of the relative importance of different types of retouch and shaping used during the occupation of Umbeli Belli and because of the relatively high number of retouched tools we analyzed retouch intensities by grouping them into three categories: regular, invasive and surface. Similar to Clarkson (2002) we divided the tools into a conceptual inner and an outer zone (Fig. 3). In our system a regular retouch affects only the margin of the artifact's edge in the conceptual outer zone and does not take much volume from the original blank. An invasive retouch affects large parts of the surface until the border of the inner zone, removing much more from the original volume of the piece than the regular retouch. The surface retouch affects the surface of the piece including the inner zone and sometimes even overlaps the conceptual middle line. This kind of retouch takes the biggest volume from the original piece and is associated with clear intentional shaping of the piece. While this concept is clearly subjective, it is fast and easily applicable during the lithic analysis and should only give a descriptive impression. For a first hypothesis about the potential use of the retouched tools, tip cross sectional area- (TCSA) and perimeter (TCSP) as well as the tip penetrating angle (TPA) values were calculated (Hughes, 1998; Larsen-Peterkin, 1993; Shea, 2006; Sisk and Shea, 2011).

We also conducted residue analysis on a very small sample of 6 bifacial points using low power and high power reflected light microscopy. The analysis followed standard micro-residue analytical procedure (e.g., Lombard, 2007: 409; Robertson and Attenbrow, 2008: 38–39). The tools were initially examined with a low power stereo binocular Zeiss

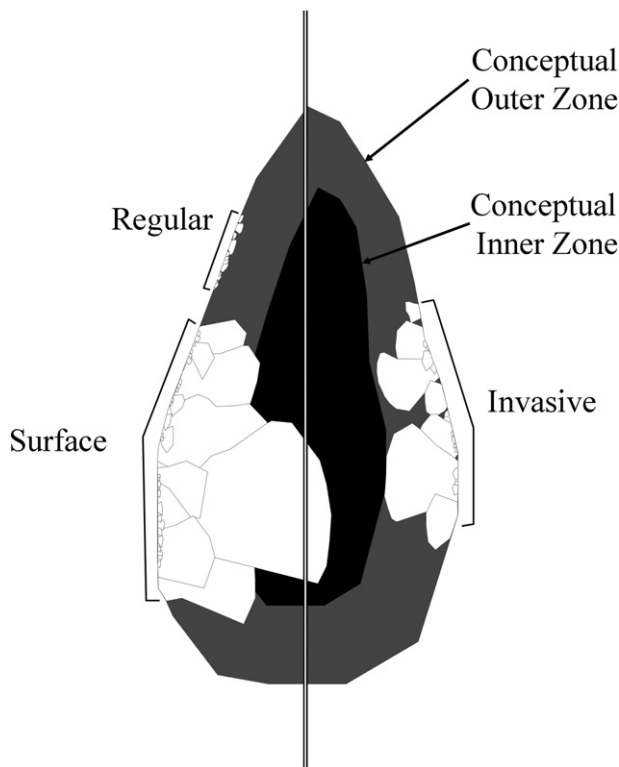


Fig. 3. Model of retouch type for unifacial- and bifacial points. (Derived from Clarkson, 2002).

microscope with a maximum magnification of $\times 50$ to record presence and distribution of discernible residues and sediment. For better resolution, tools were systematically re-examined at higher magnifications ranging from $\times 50$ to $\times 500$ using a metallurgical Olympus BX51M microscope fitted with dark field and bright field incident light sources, and polarising filters. Additional micro-residues were recorded and where possible, identified. Representative residues were photographed with a microscope dedicated Olympus SC100 camera.

In terms of core reduction methods we follow the unified lithic taxonomy of Conard et al. (2004) but consider also conventional definitions like Levallois (Boëda, 1994) or discoid (Boëda, 1993; Peresani, 2003). Typological characteristics follow South African standard designations as commonly used e.g. (Bader et al., 2015; Villa et al., 2005; Volman, 1981; Will et al., 2014; Wurz, 2000). Our description of blank types derives from Hahn's (1991) definitions of "blades" (double as long as wide with parallel edges), "bladelets" (like blades but narrower than 10 mm), "flakes" and "points" (flake with convergent edges).

4. Results

Our analyzes of the MSA assemblages within the different spits showed that the middle part of the sequence, specifically Spits 5C and 5B, show many similarities in terms of technology, percentage and types of tools and blanks and can therefore, in many aspects, be treated as a single unit. These two spits also appear to represent the main

occupational phase during the MSA due to the high artifact density and the cohesive lithic technology. For this reason we analyzed most of the features of these deposits together, but those characteristics which show marked differences throughout the sequence are discussed individually. We emphasize that there is outstanding good preservation of the stone artifacts which exhibit very sharp edges mostly without damage. Hence we suggest little post depositional movement of the artifacts from the MSA occupations.

4.1. Raw material

One of the most evident characteristics of the MSA assemblage at Umbeli Belli is the high variability of raw materials. This is a feature that Cable (1984) recognized also for the LSA occupation. As shown in Tables 1 and 2 the most common raw materials are hornfels and dolerite but quartz, quartzite sandstone, "ccs" (cryptocrystalline silicates like agates or chalcedonies), shale, mudstone and a few pieces of other volcanic rocks are also present. Within the different spits hornfels comprises between 27% and 58% of the assemblages >3 cm and dolerite between 20% and 36%. Notably the differentiation between these two types is not always clear since the dolerite used at Umbeli Belli is very fine-grained and quite similar to hornfels. Even using a microscope it was not always possible to differentiate between the raw material types. This is due to the formation process of hornfels via contact metamorphism with the intrusive dolerite (Cairncross, 2004). The distinction between those two materials in the case of Umbeli Belli however is probably not relevant since knappers exclusively selected fine grained stone for their tools regardless of the raw material. Hornfels and dolerite show the same type of cobble cortex (Table 3), and therefore both most likely originate from a similar source. Geological preconditions for primary outcrops of dolerite and hornfels occur about 3 to 4 km from the site (Fig. 1). However, the frequent occurrences of very smooth and round cobble cortex makes it more likely that these raw materials originate from the Drakensberg formations and were washed downstream to the site along the Mpambanyoni river. Apart from those two categories knappers frequently used quartz. Spit 5B marks an exception, where quartz appears in lower frequencies ($<10\%$). About 53% of the cortical quartz pieces shows cobble like cortex pointing to the Mpambanyoni as the raw material source. Knappers also used quartzite, but mostly at the base of the sequence in Spit 6. Apart from shale which features a slab-like cortex, all of these materials frequently preserve cobble cortex. The presence of slab like cortex for all kinds of raw material also indicates the occasional use of primary sources. Sandstone and mudstone in particular are likely to originate from primary sources, since Umbeli Belli lies in a corresponding geological formation (Fig. 1). Nonetheless most of the time the people at Umbeli Belli used river cobbles, and this does not change throughout the MSA sequence. We observed a general trend from base to the top of the MSA sequence showing increasing use of quartz and dolerite in parallel to a decrease in hornfels. Table 2 provides the raw material distribution of the pieces <3 cm. These data show that quartz played an insignificant role in Spit 5B. On the other hand quartz occurs in higher proportions relative to hornfels and dolerite in the other spits compared to the pieces >3 cm. This is due to our observation that the quartz cobbles were very small and were mostly reduced with bipolar technique, resulting in a high number of small pieces falling below our cut off size. Finally, we

Table 1
Distribution of raw materials throughout the sequence for all pieces >3 cm (in %).

Spit	Hornfels	Dolerite	Quartz	Quartzite	Sandstone	CCS	Shale	Mudstone	Volcanic	Other
5	27.7	36.2	23.4	8.5	2.1	0.0	0.0	0.0	2.1	0.0
5A	29.4	23.5	27.9	10.3	4.4	2.9	0.0	0.0	0.0	1.5
5B	58.1	22.0	7.9	5.1	2.1	1.5	1.8	1.5	0.0	0.0
5C	48.5	20.0	15.8	6.2	2.3	1.7	2.8	2.0	0.0	0.8
6	45.5	18.2	13.6	22.7	0.0	0.0	0.0	0.0	0.0	0.0

Table 2
Distribution of raw materials throughout the sequence for all pieces <3 cm (in %).

Spit	Hornfels	Dolerite	Quartz	Quartzite	Sandstone	CCS	Shale	Mudstone	Volcanic	Other
5	34.8	23.9	37.2	3.8	0.0	0.3	0.0	0.0	0.0	0.0
5A	24.4	21.5	50.4	0.6	1.1	1.4	0.0	0.0	0.6	0.0
5B	51.1	33.0	11.8	1.8	0.4	0.1	0.0	0.5	0.0	1.3
5C	36.5	6.7	52.0	3.2	0.0	0.9	0.4	0.1	0.0	0.1
6	52.4	33.8	8.4	2.7	1.8	0.3	0.0	0.3	0.0	0.3

observed a higher variability of different raw materials in the middle of the sequence, specifically in Spits 5A–5C compared with the overlying spit five and underlying Spit 6.

4.2. Core reduction

The MSA assemblages of Umbeli Belli contain a total of 24 cores including platform, parallel, inclined, bipolar cores and cores on flakes (Table 4). As shown in Tables 4, 5 and 6, there are no obvious patterns relating to raw material, desired end product and position within the stratigraphy. What becomes clear is firstly, that bipolar cores are always associated with quartz. As demonstrated by the two examples presented in Fig. 4 (Nr. 5 and 6) these cores have platform core-like morphologies but show splintered edges on both ends and bidirectional scars. The application of bipolar knapping on quartz is consistent with numerous studies of knapping characteristics of this raw material and the observation that the bipolar technique enables the knapper to reduce cores to a very small size (Barham, 1987; de la Peña and Wadley, 2014b; Driscoll, 2010, 2011; Hiscock, 2015; Will et al., 2013). Secondly, we observed that all the bipolar quartz cores are associated with bladelet production based on the scar patterns on the cores (Table 6). The maximum removal surface length of these cores lies between 8 and 25 mm. Nevertheless, quartz has not been reduced exclusively using the bipolar technique. This is exemplified by a very typical parallel (or Levallois) core made on quartz from Spit 5B (Fig. 4.1).

Thirdly, with respect to the remaining cores, platform cores represent the most common category. They are made from quartz, quartzite, dolerite and sandstone and almost all of them show parallel unidirectional removal scars relating to flake production. Many of them have been reduced in a semi circumferential manner, but about half can be designated as narrow sided cores (see Bader et al., 2015, Fig. 2). Apart from the bipolar bladelet cores, most cores show flake scars and only very few blade scars. However, although there are points in the assemblage (Table 8), none of the cores have point scars. Importantly therefore, the absence of specific cores e.g., point cores, cannot necessarily be extrapolated to indicate an absence of points. In other words, as shown for example by Marks and Volkman (1983), based on refitting studies at Boker Tachtit, terminal blank scars on cores cannot always explain the complete reduction sequence.

Only two cores (one inclined and one core on flake) from hornfels are present in the assemblage (Table 5). The inclined core (Fig. 4.2) is made on a small river cobble and produced flakes. One surface was

Table 3
Type of cortex per raw material for all cortical pieces.

Raw material	Cobble like cortex N (%)	Slab like cortex N (%)	Indet N (%)	Total N
Hornfels	119 (77.3)	11 (7.1)	24 (15.6)	154
Dolerite	55 (72.4)	10 (13.2)	11 (14.5)	76
Quartz	19 (52.8)	0 (0.0)	17 (47.2)	36
Quartzite	8 (36.4)	8 (36.6)	6 (27.3)	22
CCS	2 (25.0)	3 (37.5)	3 (37.5)	8
Sandstone	10 (76.9)	2 (15.4)	1 (7.7)	13
Mudstone	5 (50.0)	2 (20.0)	3 (30.0)	10
Shale	0 (0.0)	5 (100)	0 (0.0)	5
Other	1 (33.3)	0 (0.0)	2 (66.7)	3

centripetally reduced, while the opposite one has only a few small negatives and is largely covered with cortex.

In conclusion, it seems that no clear trends exist in terms of core technology related to specific spits or raw materials aside from the increase in bladelet production from bipolar quartz cores in the upper two spits of the MSA sequence. Due to the high numbers of blanks in comparison to the relatively small number of cores, we suggest that not all blanks have been knapped from the first stage of reduction on site. This would also explain the anomaly of the almost absence of hornfels cores despite this being the most commonly used raw material at the site. People probably went to the river or another raw material source, detached big flakes there and conducted the further steps such as shaping of tools on-site. We have slight evidence for this hypothesis from a big quartzite core lying next to the riverbed of the Mpambanyoni. However, we also have to take into account that our sample from only two square meters is not likely to reflect all spatial patterns of the site.

4.3. Blank production

The assemblage of Umbeli Belli is clearly flake dominated (Table 8). This does not substantially change from the base to the top of the sequence. All spits contain between 66% and 78% flakes. Table 9 provides metrical values for flakes, blades and points. Knappers produced about 50% of the flakes from hornfels and 23% from dolerite. Other raw materials have been knapped less intensely. Blades appear significantly less frequently than flakes do and compared to the latter, they are much more often knapped from hornfels. While Table 10 shows that most of the platforms throughout the sequence are plane, Table 11 clearly shows that the platforms of blades are much more often prepared than those of flakes. Blades also show slightly smaller and thinner knapping platforms. The exterior platform angle (EPA) of flakes, blades and points lies within the same range of variation, between 80 and 84°. Points however play a minor role in the assemblage. Due to the relatively high number of bipolar bladelet cores the question arises about the whereabouts of all the bladelets. Since most of them fall outside our size limit, we carefully looked through the small debitage, sorted all bladelets out and counted them. All together there are 69 bladelets within Spits 5 to 6 and almost all of them are made on quartz and hornfels. Given the many bipolar bladelet cores in the upper Spits 5A and 5, this number seems too small. We can exclude a selective sampling strategy based on Charles Cable's report. Due to the mesh size of 5 mm used at his excavation we would expect that only the very small bladelets passed through the sieve. Offsite discard is a likely scenario for this blank category. On the other hand we do not know how many bladelets could have been removed from a single core. Due to the brittle nature of quartz a lot of uncontrolled shatters would be expectable during the

Table 4
Distribution of core types throughout the sequence.

Spit	Platform	Core on flake	Parallel	Inclined	Bipolar
5	0	0	0	0	3
5A	2	0	1	0	4
5B	3	0	1	1	1
5C	3	2	0	1	1
6	0	0	0	0	1

Table 5
Distribution of core types per raw material.

Raw material	Platform	Parallel	Inclined	Bipolar	Core on flake
Hornfels	0	0	1	0	1
Dolerite	1	0	0	0	0
Quartz	3	1	0	10	0
Quartzite	2	0	1	0	0
CCS	1	0	0	0	1
Sandstone	1	0	0	0	0
other	0	1	0	0	0

knapping process and probably not every core delivered usable bladelets because of breakage during knapping. Apart from those 69 tiny bipolar bladelets from quartz we identified nine bladelets falling within our cut-off size. All of them come from Spits 5B and 5C and are made from hornfels. Six out of them are burin spalls. Most of these have intensive surface retouch on one or two surfaces, suggesting that they were detached from former unifacial or bifacial tools.

A significant number, about 30%, of the blanks from Umbeli Belli retain cortical surfaces and include the main raw material categories (hornfels, dolerite, quartz and quartzite). About half of those pieces retain >50% cortex on their surface. From this we can conclude that knapping activities from an early stage of reduction and onwards took place on site. However, this seems to be contradictory given the low number of cores described above. Apart from possible problems with the spatial distribution i.e. the small excavation area, we hypothesize that knapping activities at Umbeli Belli underlie dynamic fluctuations due to the close proximity to the raw material source. In other words, the scenario of offsite knapping does not predict that people behaved the same way exclusively at all times.

In order to detect differences in the raw material economy throughout the sequence, we calculated the flaking efficiency following Mackay (2008) but see also (Braun, 2005; Braun and Harris, 2003). Similar to other values, flaking efficiency does not change significantly over time. The values for all spits lie in between 19 and 23 mm/g (Fig. 5) and these values are higher than for example in the Sibudan of the type locality (Will et al., 2014). Compared to the data provided by Mackay (2008) for Diepkloof and Kleinkliphuis, Umbeli Belli correlates with the lower limit associated with unifacial point technologies postdating the Howiesons Poort (HP). Due to further technological questions in terms of core maintenance we have a small amount of data only. We found several plunging blades/flakes that corrected core convexities ($N = 11$) and also core tablets ($n = 7$) that prove that these steps took place on the site.

4.4. Tool production

Composition of different tool types in the Umbeli Belli assemblages ranges between 9% and 19% (Table 7). We included all retouched implements as well as hammer stones, burins, and splintered pieces in the counts. Almost all the splintered pieces from the MSA levels are similar to those described by Bader et al. (2015) as category 2 (opposed edge splintered pieces). Although there are debates about the attribution of these pieces either to the core or tool category (Barham, 1987; Brun-Ricalens, 2006; De la Peña, 2015; de la Peña and Wadley, 2014b; Hayden, 1980; Langejans, 2012; LeBlanc, 1992) absolute solutions

Table 6
Distribution of blank types in relation to core types, based on scar patterns on the cores.

Type of core	Flake	Point	Blade	Bladelet
Platform	5	0	2	1
Core on Flake	1	0	0	1
Parallel	2	0	0	0
Inclined	2	0	0	0
Bipolar	1	0	0	9

have not been forthcoming. Hence, we included the few pieces from Umbeli Belli into the tool category since most of them do not show clear removal scars on the surface but mostly only splintered edges on the periphery. As mentioned previously (Bader et al., 2015) we point to the importance of residue analysis in order to shed light on this debate. There is a clear distribution pattern in tool frequency and tool types from bottom to the top. The lowermost Spit 6 provides the lowest value of only 9% and includes one unifacial point and one bifacial preform. In the overlying two Spits 5C and 5B there is a peak for tools at 18.3%. In Spits 5A and 5 the tool proportion decreases again to <12%. In Spits 5, 5B and 5C we observed a clear trend of hornfels being the preferred raw material for the production of tools (Table 12). The numbers for Spits 5, 5A and 6 are difficult to discuss since they provide very low numbers of artifacts in general and tools in particular. Therefore the percentage numbers for Spits 5B and 5C are the most reliable ones. In addition to the percentage of different raw materials given in Table 12 we calculated the raw material retouch index (RMRI) following Orton (2008). The retouch index of all spits combined shows that hornfels has by far the highest value (RMRI = 0.23), followed by dolerite (RMRI = 0.18). Values for quartz, quartzite and others are 0.09 and below.

Within Spits 5B and 5C there is a much higher variability of tool types compared to the over- and underlying ones (Table 13). From a typological perspective all kinds of tools are present, including burins, scrapers, denticulates and also very few backed pieces. The most common tool types however are unifacial and bifacial points (Figs. 6 & 7) as well as pieces that can best be described as retouched flakes. The latter pieces mostly show retouched edges in different parts of the piece but do not fit into any formal tool category. In addition to unifacial and bifacial points we included other categories called unifacial and bifacial tools that we consider to be proximal or medial fragments of unifacial or bifacial points. However, since we cannot prove that these pieces were points, we listed them separately. Since the unifacial and bifacial points represent the characteristic tool type in Spits 5B and 5C at Umbeli Belli we provide a more detailed description of these pieces here.

Unifacial points are approximately double the number of bifacial points. Most of them are made on elongated blanks with intense retouch along both edges. More than half of the unifacial points have surface retouch (Table 14) as described in Fig. 3. The remaining pieces are invasively retouched and only a very few show a regular retouch along the edges. As noted above we were able to identify the corresponding shaping flakes following Soriano et al. (2009). The percentage of shaping flakes increases from Spit 5C with 3.4% to Spit 5B with 6.2%. These flakes all seem to have removed a fairly large volume of the tools surface and obviously did not affect only the edges (Fig. 8). Hence, we decided to describe these pieces as “unifacial shaping flakes” rather than “retouch flakes”.

Since most of the unifacial points from both layers (5B and 5C) are fragments we cannot give reliable results about the metrics of these pieces. In Spit 5B 15 out of 31 pieces are complete, in Spit 5C there are 10 out of 18. Based on the data we have, it seems that there is no significant difference between the two spits. The unifacial points have a mean length of about 47 mm, are between 28 and 30 mm wide and 6 to 7 mm thick. The values of breadth and thickness are more reliable measurements, since they were measurable in almost every case. Most of the unifacial points from both spits are made on hornfels, but there is a clear trend showing increased use of dolerite in Spit 5B (32.3%) compared to Spit 5C (5.6%).

The bifacial points show several differences in comparison with unifacial ones. Firstly, almost all the bifacial pieces have much more intense retouch that affects most of the surface on both faces (Table 14). In Spit 5C 9 out of 10 bifacial points show a complete surface retouch. In Spit 5B 17 out of 18 have completely shaped surfaces. This implies that intentional shaping of these pieces played a major role at Umbeli Belli. The number of bifacial shaping flakes increases from 0.6% in Spit

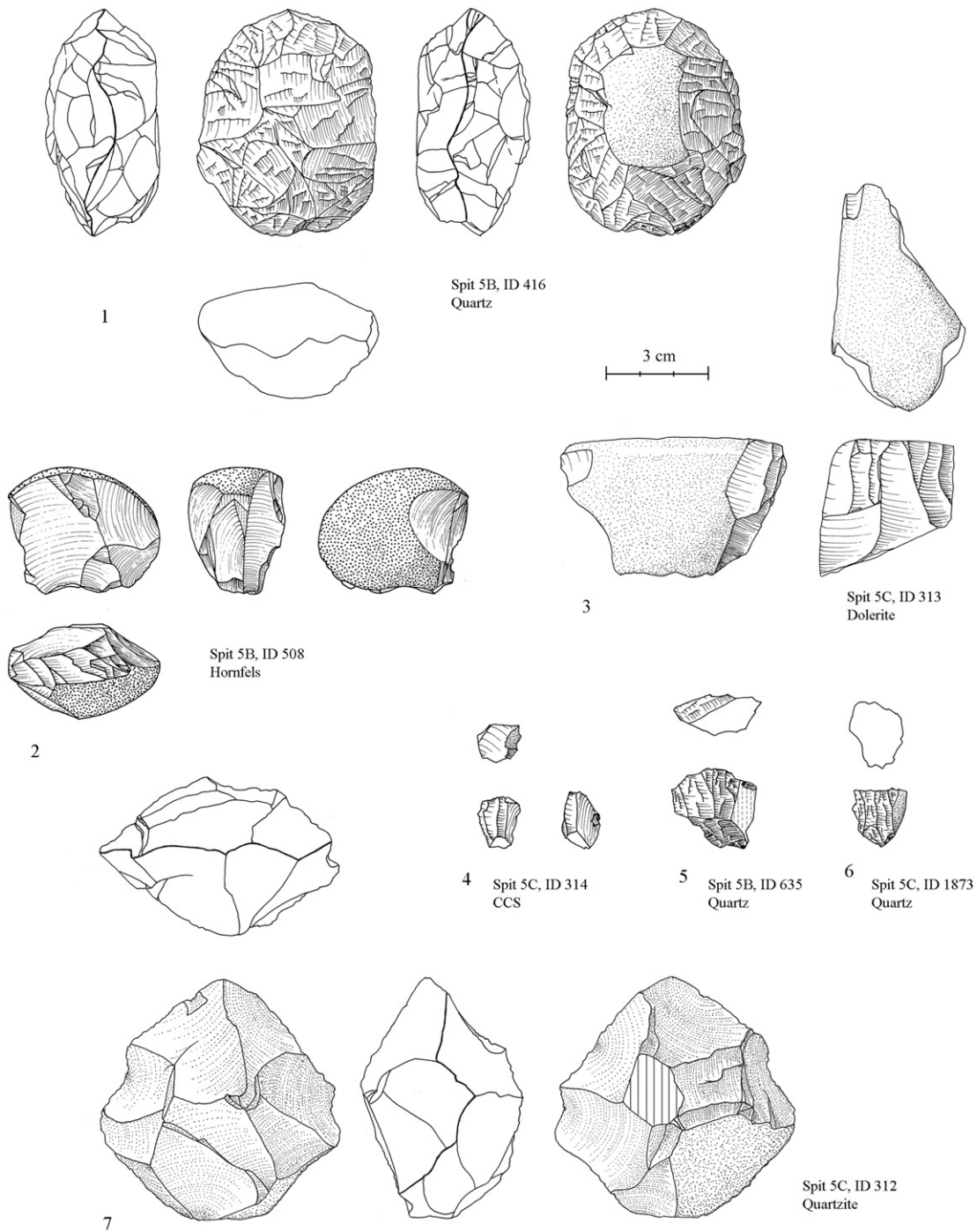


Fig. 4. Cores from Umbeli Belli. 1: parallel core 2 & 7: discoid core 3 & 4: platform core 5 & 6: bipolar core. (Drawings by Achim Frey and Gregor Bader).

5C to 1.4% (out of the total number of pieces <3 cm) in 5B. Almost all the bifacial points from both spits are made from hornfels. Only very few examples were made on dolerite and one single piece from quartz is present. We found a similar trend with increasing use of dolerite in Spit 5B, although this is not as strong as the one observed for the unifacial points. The maximum thickness and width of the points were measurable in most cases. The bifacial points from Spit 5B do not show large differences to the ones from 5C. They are on average only marginally thinner (7.6 mm) than the ones from spit 5C (8 mm). Most of the bifacial points are thinner than 1 cm, and they are between 2 and 3 cm in their maximum width. Some of them are very small and thin with a sharp tip (e.g. Fig. 6.1–3). Most pieces are not complete in length but

on average the complete pieces from Spit 5B and 5C counted together are 4 to 5 cm long.

4.4.1. The potential function of unifacial and bifacial points

To determine site function we tried to evaluate the potential use of unifacial and bifacial points. As demonstrated by several researchers, TCSA, TCSP as well as TPA are useful values for the identification of projectiles (Hughes, 1998; Larsen-Peterkin, 1993; Mohapi, 2012, 2013; Shea, 2006; Sisk and Shea, 2011; Wadley and Mohapi, 2008). Since only the breadth and thickness of a point are required to calculate the TCSA and TCSP these values are objective and easy to obtain with consistent reproducibility. There was no major difference between the

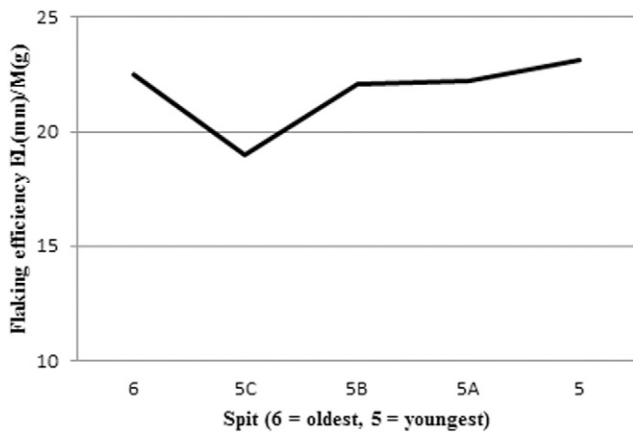


Fig. 5. Flaking efficiency throughout the sequence (calculated after Mackay, 2008).

TCSA and TCSP values between the two Spits 5B and 5C. Therefore we separated only bifacial and unifacial points, but treated the points from both spits as a unity. This was also to increase the sample size. According to Shea (2006) only complete pieces should be used for calculating cross sectional values since the maximum widths and thicknesses of the points are required. However, in most cases the majority of the tools are not 100% complete, and as a result sample sizes are markedly reduced. This is also the case at Umbeli Belli. In order to augment our data we provide TCSA and TCSP values for both, complete and incomplete pieces in Table 15. Based on our observations most of the broken pieces are nearly complete and did not lose significant amounts of their mass. Table 15 also shows that the values for all pieces and only complete pieces do not differ strikingly. Thus in the following section we refer to the values calculated for all pieces.

Based on the TCSA mean values given in Table 15, both unifacial and bifacial points fall within the general spread of Still Bay points, Porc Epic bifacial points and Aterian tanged points as given by Shea (2006). Our values for Umbeli Belli also lie entirely within the range of a large sample of MSA bifacial points from Mumba Cave studied by Bretzke et al. (2006). As is the case at Mumba, the data from Umbeli Belli also document a wide range of values and a lack of standardization. Bretzke and colleagues argue that these data indicate the use of multiple weapon systems within the same phase of occupation at Mumba. While most of the specimens from Umbeli Belli fall within the range of spear tips, some specimens have values comparable to ethnographic dart tips and even Neolithic arrowheads.

The TCSP values from Umbeli Belli (Table 15) fall within the variation of Still Bay points and Aterian tanged points compared to data given by Sisk and Shea (2011). TPA measurement is not often used, however it serves as an additional value in order to test results from TCSA and TCSP. In contrast to Villa and Lenoir (2006), we measured the angle directly using a goniometer. The result shows on the one hand, that the TPA of bifacial points is smaller in both spits (5B & 5C) than those of the unifacial points. The means of bifacial points are about $55^\circ \pm 13^\circ$ standard deviation and lie within the range of e.g., Solutrean foliate points (Larsen-Peterkin, 1993). The values for unifacial points are slightly higher with $64^\circ \pm 17^\circ$ standard deviation. Based on ethnographic studies Marie Soressi (2004) argues that TPAs between

Table 7
Distribution of artifact types throughout the sequence.

Spit	Blank N (%)	Tool N (%)	Core N (%)	Debris N (%)	Manuport N (%)	Total N
5	37 (78.7)	6 (12.8)	3 (6.4)	1 (2.1)	0 (0.0)	47
5A	52 (76.5)	8 (11.8)	7 (10.3)	1 (1.5)	0 (0.0)	68
5B	479 (78.8)	114 (18.8)	6 (1.0)	9 (1.5)	0 (0.0)	608
5C	268 (75.5)	67 (18.9)	7 (2.0)	12 (3.4)	1 (0.3)	355
6	18 (81.8)	2 (9.1)	1 (4.5)	1 (4.5)	0 (0.0)	22

Table 8
Distribution of blank types throughout the sequence.

Spit	Flake N (%)	Blade N (%)	Bladelet N (%)	Point N (%)	Total N
5	32 (74.4)	8 (18.6)	0 (0.0)	3 (7.0)	43
5A	40 (66.7)	17 (28.3)	1 (1.7)	2 (3.3)	60
5B	452 (76.2)	100 (16.9)	7 (1.2)	34 (5.7)	593
5C	263 (78.5)	49 (14.6)	2 (0.6)	21 (6.3)	335
6	15 (75.0)	2 (10.0)	0 (0.0)	3 (15.0)	20

35 and 65° are adequate for both incision and cutting activities, while angles over 65° are only useful for cutting activities. Following this line of reasoning, the bifacial points with their smaller TPA are in general more likely to have been used in an incisional way than the unifacial tools.

Based on the data presented here, we hypothesize that many of the bifacial and possibly some of the unifacial points from Umbeli Belli were used as projectiles. While we cannot confirm this from the current state of research, a preliminary analysis of six bifacial pieces from Spits 5B and 5C using low power and high power reflected light microscopy provides a degree of supportive evidence for this hypothesis. These artifacts had been washed prior to being stored in the KwaZulu-Natal Museum for several decades, but small traces of residues consisting of resins, proteinaceous residues and hematite, possibly derived from ochre, were found to be preserved on them. A more thorough examination of one quartz piece from Spit 5B (Fig. 7, Nr. 4) found numerous residues that appear to be related to use. These consist of 1) a proteinaceous residue film on the dorsal left distal-medial lateral margin, 2) a hair embedded in a film of residue on the inner edge of the ventral distal tip, 3) a red/brown stain across the ventral, distal surface, 4) an orange/brown residue on the ventral left distal lateral edge with charcoal inclusions, 5) an orange/brown residue on the ventral left distal lateral edge with charcoal inclusions, 6) a light orange/pinkish stain on the ventral and dorsal proximal to medial surfaces that is possibly associated with hafting, 7) spots of orange/pink resin with charcoal inclusions and some fragments of tissue on the proximal to medial parts of the ventral and dorsal surfaces, and 8) orange/brown resin with fibers and possibly starch granules on the dorsal left proximal surface.

The distribution of residues on the tool indicates that it had probably been hafted using a resinous medium. The presence of animal-derived residues, including the proteinaceous residue and hair as well as the stain on the distal end of the tool suggests that it may have been used for penetrating animal tissue, probably as a projectile. Following from this preliminary analysis, more definitive information about the residues and usage of this particular piece may be obtained from more detailed analysis using, for example, transmitted light microscopy, SEM and other diagnostic identification and testing procedures, and analysis of use traces. Nevertheless, this preliminary study and the observation that five of the six artifacts examined show preservation of use-related residues, demonstrate the great potential for residue studies at Umbeli

Table 9
Metrics sorted by blank types for all spits.

Type of blank	n	Length	Width	Thickness	Platform width	Platform thickness	EPA
Flake	n	451	712	793	473	488	480
	Min	12	7	2	1	0	40
	Max	87	102	85	52	34	110
	Mean	31.9	30.8	7.5	14.0	5.1	82.0
Blade	n	102	171	174	90	92	93
	Min	9	10	2	2	1	60
	Max	71	40	20	30	13	95
	Mean	44.7	18.9	6.4	11.6	4.5	84.1
Point	n	40	61	62	27	27	27
	Min	24	11	4	4	1	60
	Max	42	61	21	39	14	100
	Mean	35.2	31.4	9.5	21.1	6.3	81.9

Table 10
Type of platform preparation throughout the sequence.

Spit	Faceted fine		Crushed dorsal edge N (%)	Dihedral N (%)	Plain N (%)	Punctiform N (%)	Cortical N (%)	Crushed N (%)	Fracture plane N (%)
	Faceted coarse N (%)	N (%)							
5	7 (25)	0 (0)	1 (3.6)	3 (10.7)	14 (50.0)	1 (3.6)	0 (0.0)	2 (7.1)	0 (0.0)
5A	6 (15)	1 (2.5)	1 (2.5)	2 (5.0)	25 (62.5)	0 (0.0)	1 (2.5)	4 (10.0)	0 (0.0)
5B	61 (15.9)	11 (2.9)	7 (1.8)	26 (6.8)	232 (60.6)	3 (0.8)	15 (3.9)	22 (5.7)	6 (1.6)
5C	30 (15.5)	9 (2.3)	0 (0.0)	3 (1.6)	112 (58.0)	1 (0.5)	16 (8.3)	19 (9.8)	3 (1.6)
6	2 (15.4)	1 (7.7)	0 (0.0)	0 (0.0)	8 (61.5)	0 (0.0)	0 (0.0)	1 (7.7)	1 (7.7)

Belli. The analysis of further samples is necessary to confirm or refute our observations and will be the aim of future studies of the lithic assemblages from Umbeli Belli. A direct comparison of the artifacts from the old collection with those from recent excavations will be particularly necessary in order to exclude a possible contamination of the artifacts during the long storage time in the Natal Museum.

5. Discussion

Although Umbeli Belli was excavated 37 years ago, in a time when the MSA was not of major interest and not within the research scope of the excavator, Charles Cable conducted a methodical excavation. This becomes apparent in the presence of each kind of artifact in all size categories, including small- and microdebitage. Due to a homogeneous sediment type, Cable excavated in artificial spits, but defined them with sufficient consistency and detail to enable reconstruction of the archaeological stratigraphy. Therefore Umbeli Belli represents an archive of highly relevant information about the MSA that has been forgotten for many years. Our results presented here are the basis for a bigger project that aims to better understand the MSA in KwaZulu-Natal, its variability and the potential causes for it.

We have been able to identify a well preserved archaeological sequence that changes slightly from its base to the top. These changes become most evident in the composition of raw material, artifact densities, core technology and the tool types. The lowermost three spits (6, 5C, 5B) are characterized by a clear dominance of hornfels artifacts over those from dolerite, quartz and others. In the uppermost two Spits 5 A and 5 a marked shift in raw material is visible, with quartz and dolerite becoming more and more important. The upper two spits are associated with bipolar bladelet production from very small bipolar quartz cores. Apart from these bipolar cores there is no clear change in core technology throughout the sequence. Different kinds of cores, including platform, parallel and inclined cores (Conard et al., 2004) occur in each spit with no particular pattern of change. Furthermore, the almost exclusive presence of cobble like cortex on the artifacts, regardless of raw material, allows us to conclude that the nearby Mpambanyoni River was a main source of raw material for the site.

The site is close to all kinds of resources that would have been necessary for daily life. The shelter itself has a protective function against rain, sun and wind and serves simultaneously as a lookout over the nearby river that would certainly have been attractive to prey as well

Table 11
Type of platform sorted by blank type.

Type of platform	Flakes N (%)	Blades N (%)	Points N (%)	Bladelets N (%)
Faceted coarse	68 (12.9)	31 (31.3)	7 (25.9)	0 (0.0)
Faceted fine	13 (2.5)	3 (3.0)	6 (22.2)	0 (0.0)
Crushed dorsal edge	5 (1.0)	3 (3.0)	1 (3.7)	0 (0.0)
Dihedral	26 (4.9)	4 (4.0)	3 (11.1)	1 (20.0)
Plain	331 (62.9)	49 (49.5)	9 (33.3)	2 (40.0)
Punktiform	5 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)
Cortical	29 (5.5)	3 (3.0)	0 (0.0)	0 (0.0)
Crushed	44 (8.4)	3 (3.0)	0 (0.0)	1 (20.0)
Fracture plain	5 (1.0)	3 (3.0)	1 (3.7)	1 (20.0)

as people. Also, Umbeli Belli, situated only 7 km from the present day sea shore is the closest of all the MSA sites in KwaZulu-Natal. This distance is only marginally beyond the daily foraging radius of ethnographic hunter gatherers (Binford, 1978, 1982) and although sea level was far below the present one during most episodes of the MSA (Allott, 2005; Shackleton and Opdyke, 1973; Waelbroeck et al., 2002), the east coast of southern Africa has not been much affected, due to the steeply sloping undersea terrain in this region. Hence it is likely that people frequently visited the nearby sea and made use of its resources (Will et al., in press). In the LSA occupation of the site Cable (1984) recovered numerous brown mussels (*Perna perna*) that prove the use of marine resources during that time. Further research will help to clarify the question if that was the case during the MSA too.

Importantly, from our flaking efficiency and retouch index calculations for different raw materials it transpired that hornfels has the highest values for the retouch index meaning that people preferentially used this raw material for their retouched tools. This overlaps with results from Sibudu (Conard and Will, 2015; Will et al., 2014), Holley Shelter (Bader et al., 2015) and Umhlatuzana (Kaplan, 1989, 1990). This is relevant to determining site function which is reliant on understanding tool function and reasons for tool form, influenced perhaps by key drivers such as tool maintenance (Shott, 1986, 1989), recycling of broken tools (Bamforth, 1986), or the nature of the raw material itself (e.g., Wadley and Kempson, 2011).

Most of the tools manufactured at Umbeli Belli are unifacial and bifacial points and are made from hornfels. Wadley and Kempson (2011) point out that hornfels is relatively easy to knap but requires frequent retouch due to its soft and brittle edges and therefore the retouch on the Umbeli Belli points could be attributed solely to raw material requirements for production and maintenance of effective tools and edges. However, while this may be one component influencing the amount of retouch observed in the assemblage, we propose that curation of tools cannot be reduced to a single factor but is more the result of “a complex set of behaviors” (Bamforth, 1986), p.48, but see also Odell (1996). The overall presence of intensive and elaborate shaping rather than only retouch of the unifacial and bifacial points directly on the site, and the close proximity to the raw material rich river strongly suggests that the shape of these pieces was more likely intentional rather than the result of other factors such as raw material scarcity (Bamforth, 1986; MacDonald and Andrefsky, 2008). Furthermore the assemblage at Umbeli Belli exhibits the frequent observation of “formal specificity” as described by Odell (1996) and therefore the retouched component also cannot only result from re-sharpening or recycling, although this might play a certain role as well (e.g. Dibble, 1984, 1987, 1995; Frison, 1968; Goodyear, 1974; Hoffman, 1985). As Dibble (1995:

Table 12
Percentage of tools in relation to raw materials used for their production.

Spit	Hornfels N (%)	Dolerite N (%)	Quartz N (%)	Quartzite N (%)	Other N (%)
5	5 (83.3)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)
5A	2 (25.0)	2 (25.0)	2 (25.0)	1 (12.5)	1 (12.5)
5B	79 (69.3)	31 (27.2)	2 (1.8)	0 (0.0)	2 (1.8)
5C	46 (68.7)	9 (13.4)	8 (11.9)	0 (0.0)	4 (6.0)
6	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)

Table 13

Distribution of tool types throughout the sequence.

Type of tool	5	5A	5B	5C	6	Total
Backed Piece	0	0	1	1	0	2
Segment	0	0	1	1	0	2
Burin	0	0	2	2	0	4
Denticulate	0	0	1	1	0	2
Notch	0	0	2	2	0	4
Lateral Retouch	0	0	1	2	0	3
Retouch on Blade	1	0	7	1	0	9
Retouch on Flake	0	3	15	8	0	26
Retouch on Point	0	0	1	2	0	3
Scraper Side	0	1	6	1	0	8
Scraper End	0	0	6	4	0	10
Scraper Circular	0	0	1	0	0	1
Point Unifacial	3	0	31	18	1	53
Tool Unifacial	0	0	5	2	0	7
Point Bifacial	0	1	18	10	0	29
Tool Bifacial	1	0	7	3	0	11
Preform Bifacial	0	0	2	0	1	3
Splintered Piece	1	2	4	7	0	14
Hammer stone	0	1	0	0	0	1
Tools total N	6	8	111	65	2	
Tools total %	12.8	11.8	18.3	18.3	9.1	

314) mentions “these studies should not be taken to mean that *all* variability in tool morphology is due to tool maintenance involving resharpening or rejuvenation of the edges.”

The bifacial points for instance show mostly very symmetric edges forming an accurate tip throughout all size categories. This suggests that even if the pieces as found on the site represent the ultimate stage of reduction, the symmetric morphology played a significant role during every step within the reduction cycle. Hence we conclude firstly, that bifacial points and likely also unifacial points at Umbeli Belli are the result of intentional shaping in order to obtain sharp, pointed forms. While the functional purpose of these pieces is not yet clarified the preliminary study of residues in combination with TCSA, TCSP and TPA analysis suggest use as projectiles. We further propose that the good knapping qualities of hornfels and its abundance in the river were the primary drivers for the preferred use of this material. The consistency of flaking efficiency throughout the sequence shows that the knappers at Umbeli Belli produced cutting edges efficiently. The values are most comparable to industries containing unifacial points and postdating the Howiesons Poort (Mackay, 2008).

Based on artifact density, tool diversity and also core technology, we hypothesize that the middle part of the sequence (Spits 5C and 5B) represents the main occupational phase during the MSA at Umbeli Belli. The underlying spit 6 represents a gradual starting point of the settlement reaching its main occupational phase in Spit 5c and 5b. In the overlying two Spits 5A and 5 things change. In the raw material composition hornfels becomes less important and the numbers of quartz and dolerite pieces increase. The core technology changes from mixed to a dominance of bipolar cores and the typical tools, unifacial and bifacial points, disappear almost completely. In conjunction with this, the number of typical shaping flakes declines abruptly and the artifact density decreases dramatically. Based on these observations and also in accordance with Cables field diary, we cannot exclude a certain degree of mixing between the uppermost part of the MSA and the lowermost part of the LSA industry above due to the rock fall overlying Spit 5. Since the assemblage analyzed here is the material of only two square meters we have to consider sample size problems for our interpretations. Artifact density and tool diversity for instance could be affected by different spatial patterns through time. However without anticipating too much we observe these trends in the layers overlying the assemblage analyzed here both, in the old collection and the new one we've excavated in early 2016. In addition Cables trench lies right at the center

of the shelter, which is the spot providing the biggest surface protected against the weather. It is therefore likely that people always spent considerable amounts of time in this area.

5.1. Umbeli Belli within the regional sequence of KwaZulu-Natal

In this section we try to place the MSA occupation at Umbeli Belli into a regional framework and examine the implications the lithic assemblages have for our understanding of regional variability. This is hampered by the absence of absolute dates, but we can still proceed on the basis of comparative technological and typological observations.

One approach is to look for similarities between the assemblages from Umbeli Belli and other sites in KwaZulu-Natal. We start by excluding several assemblages. First, the material from Umbeli Belli is very different from that of Holley Shelter, which appears to fall within the variation of the Sibudan complex (Conard et al., 2012; Conard and Will, 2015; Will et al., 2014). While Holley Shelter is characterized by a blade technology associated with unidirectional, laminar reduction from hornfels slabs, numerous prepared platforms, a high number of unifacial Ndwedwe tools and splintered pieces, and by the complete absence of bifacial technology (Bader et al., 2015), none of these features are characteristic of the assemblages from Umbeli Belli. The temporal framework of Holley Shelter within the Sibudan is based on similarities with Sibudu and Umhlatuzana. The absence of shared features such as strong technological and typological similarities between these three sites and Umbeli Belli suggests that Umbeli Belli likely pre- or postdates the Sibudan complex. Certainly we can't exclude the influence of sample size and also site function but as pointed out in the section above our observations from recent excavations seem to confirm our impressions.

Furthermore, the presence of only two segments in the MSA assemblage of Umbeli Belli argues against an attribution to the Howiesons Poort (Cochrane, 2006; de la Peña and Wadley, 2014b; Henshilwood et al., 2014; Soriano et al., 2007; Wadley and Mohapi, 2008; Wurz, 1999).

The numerous bifacial points from Umbeli Belli point to the possibility of it being within the Still Bay complex (Lombard, 2006; Lombard et al., 2010; Mohapi, 2012, 2013; Villa et al., 2009; Wadley, 2007), but as several studies in recent years have shown, bifacial technology can be present in multiple phases of the MSA, including the pre-Still Bay, Howiesons Poort, Sibudan/post Howiesons Poort, late- and final MSA (Conard and Will, 2015; de la Peña et al., 2013; Lombard et al., 2010; Lombard et al., 2012; Porraz et al., 2013; Villa et al., 2005; Wadley, 2005, 2012, 2013; Will et al., 2014). Furthermore, as shown by Soriano et al. (2009, 2015), the SB technology at Sibudu is almost exclusively focused on bifacial production. Additionally, the number of unifacial points at Umbeli Belli is about twice as high as the number of bifacial points. This stands in contrast to the Still Bay assemblage from Sibudu (Mohapi, 2012; Wadley, 2007) but not to the one from Umhlatuzana, where unifacial points are more common than bifacial ones (Kaplan, 1990; Lombard et al., 2010). Umbeli Belli features neither the typical double pointed foliates from the Still Bay (SB) layers of Sibudu nor the serrated pieces from Umhlatuzana as described by Kaplan (1990) and Lombard et al. (2010). All the points are single pointed and most of them have an intentionally rounded base. Given the composition of tools the Umbeli Belli assemblage may also be attributed to the Pietersburg industry, since the Pietersburg is “characterized by elongated points on blades, more often unifacial than bifacial and with trimming confined to the periphery” (McBrearty and Brooks, 2000 p. 500). However, the Pietersburg industry is not well dated and not well characterized (McBrearty and Brooks themselves, 2000). Also the retouch on the points at Umbeli Belli is not confined to the periphery of the artifacts, but instead is often highly invasive.

Several parallels exist with the final MSA assemblages at Sibudu (Wadley, 2005) and Umhlatuzana (Kaplan, 1989, 1990). Both of them are characterized by the frequent occurrence of unifacial and bifacial

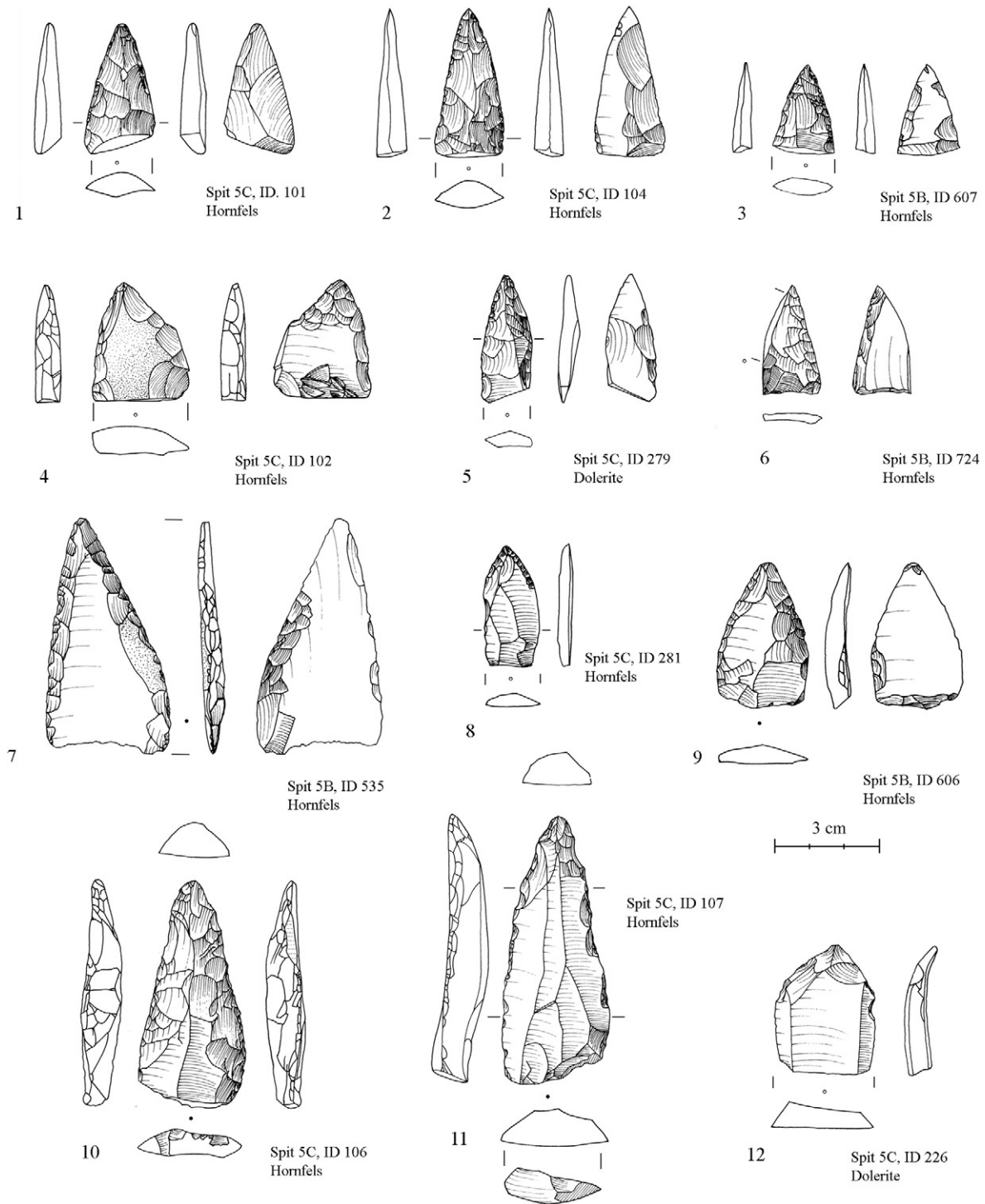


Fig. 6. Tools from Umbeli Belli. 1–7: bifacial points 8–12: unifacial points. (Drawings by Achim Frey and Gregor Bader).

points as well as the very distinct hollow based points. At Sibudu the assemblage is dominated by flakes. Cores are rare in general but within these, cores from quartz are the most common. Hornfels is the preferred raw material used for tools. The final MSA at Sibudu dates to 38.6 ± 1.9 ka using OSL. Similarly, at Umhlatuzana, hollow based points occur only in the Layers 16 to 18, which have been dated to 30,000–35,000 BP using radiocarbon. Our observations at Umbeli Belli are most consistent with an attribution to the final MSA, but within the assemblage excavated by Cable in 1979 we found only a single piece that can be

designated as hollow based point, similar to Sibudu and Umhlatuzana (Fig. 6 Nr. 7). These hollow based points seem to occur only in KwaZulu-Natal, are scarce within the assemblages and are restricted to the final MSA occupations (Wadley, 2005). Therefore, we hypothesize that Umbeli Belli includes a phase of occupation within the temporal range of the final MSA. This is consistent with the observation of Mackay et al. (2014) that several sites in the SRZ, including Holley Shelter, Driekoppen and Sehonghong were first settled after the Howiesons Poort.

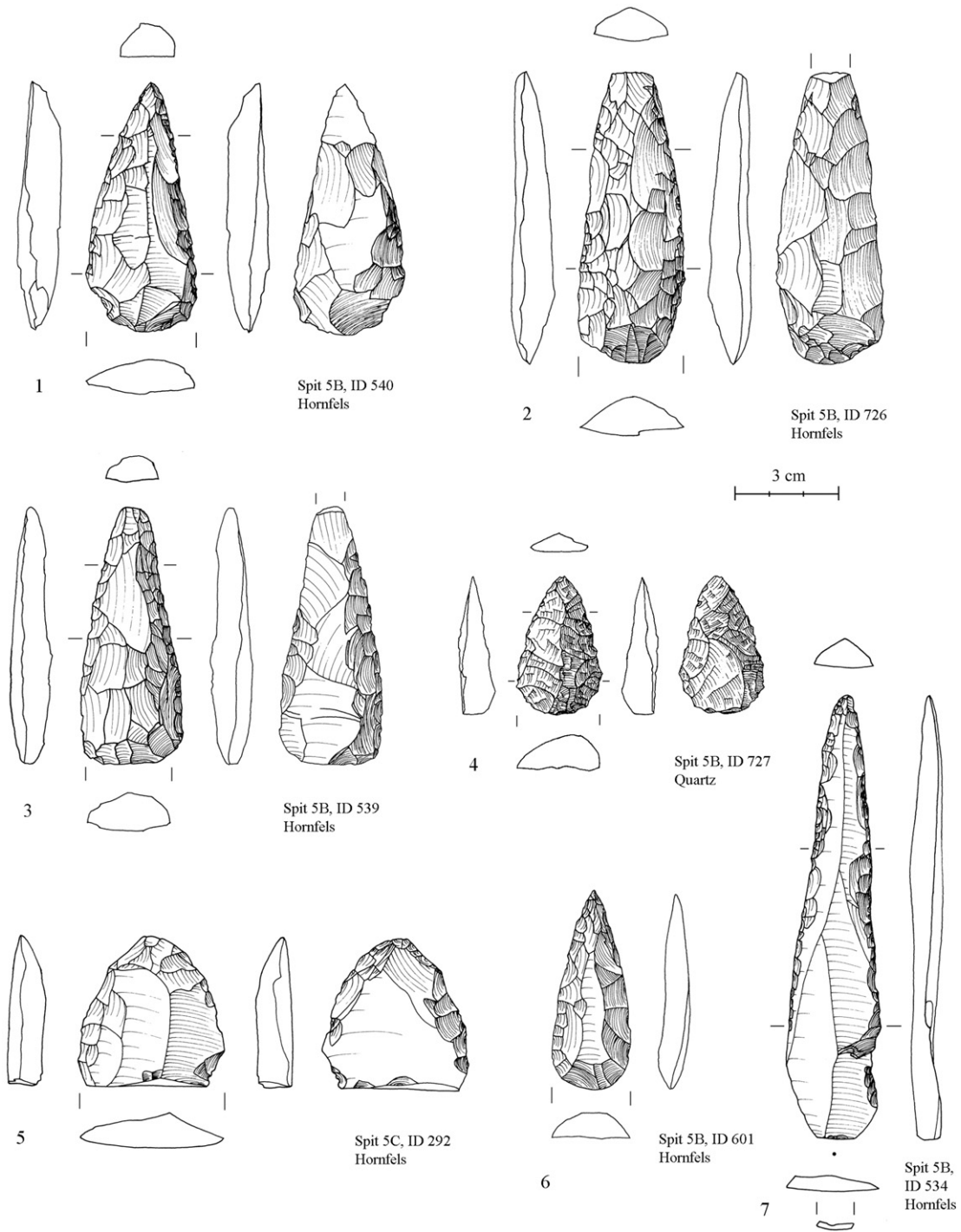


Fig. 7. Tools from Umbeli Belli. 1–5: bifacial points 6 & 7: unifacial points. (Drawings by Achim Frey and Gregor Bader).

Table 14
Type of retouch for unifacial and bifacial points.

Type of tool	Type of retouch	5B	5C
Unifacial point	Surface	15	11
	Invasive	11	6
	Regular	5	1
Bifacial point	Surface	17	9
	Invasive	1	1
	Regular	0	0

6. Conclusion

In this paper we have presented assemblages that were excavated more than three decades ago. Since this study marks the beginning of a new phase of research at Umbeli Belli, we focused on the site itself, its cultural sequence and proposed a chronological interpretation.

The site is located within an environment that supplied the prehistoric hunter gatherers with many key resources including water, food, lithic raw material, and protection against rain, sun and wind. Also the close proximity to the ocean as well as the resources of the Mpambanyoni River Valley likely attracted people to the shelter. The

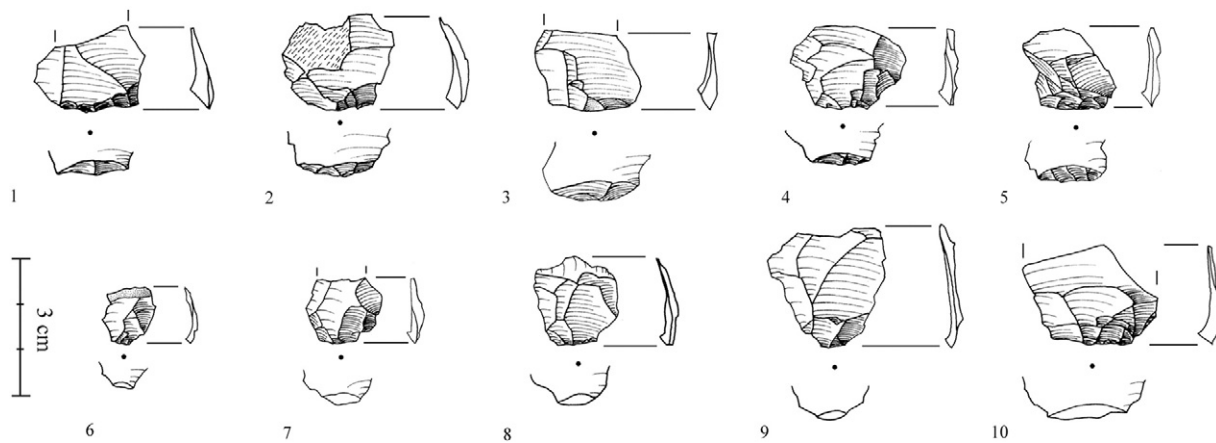


Fig. 8. 1–5: bifacial shaping flakes 6–10: unifacial shaping flakes. (Drawings by Gregor Bader).

well-preserved lithic assemblages from Umbeli Belli document complete reduction sequences from raw material acquisition, core reduction and maintenance, tool production to use and discard. The repeated production of highly specific forms of sharp pointed tools using intense surface shaping reflects an important cultural adaptation of the prehistoric knappers at the site. However, we are not yet able to demonstrate whether the technological signatures in the lithic assemblages are primarily a result of cultural preference, strong functional selection, or, perhaps most likely, a combination of both. We conclude that Umbeli Belli was a site where people spent considerable amounts of time, carefully manufactured their tools and used them. Residue analysis documents that hafted tools were used off the site before bringing them back to this attractive shelter that likely served as a center of social interaction.

Although we have not yet analyzed the faunal remains of Umbeli Belli, Charles Cables' field notes and our initial observations on the faunal collections housed at the KwaZulu-Natal Museum show that bone is poorly preserved. Nonetheless, we hope in the future to gain useful insights into prey selection, seasonality and subsistence patterns via the available faunal collections.

Within the last decade KwaZulu-Natal became increasingly important for the MSA research of southern Africa. While Sibudu has represented a hallmark for MSA archaeology in this region for many years, researchers are now beginning to focus more attention on the surrounding archaeological landscape of this verdant hilly region transected by numerous small streams and rivers. Recent research at Umhlatuzana (Lombard et al., 2010; McCall and Thomas, 2009; Mohapi, 2013) and Holley Shelter (Bader et al., 2015) exemplify this trend. Since, based on the standards of the southern African subcontinent, Umbeli Belli lies within close proximity to the other three MSA

sites, the assemblages provide considerable potential for further refinement of our understanding of the MSA in KwaZulu-Natal. Although not yet properly dated, cultural chronological arguments suggest that the site was occupied near the end of the MSA. Based on the encouraging observations from Cable's previously unpublished assemblages and the arguments discussed above, we are currently undertaking a new phase of controlled excavations at Umbeli Belli in the hopes gaining new data to test the interpretations and hypotheses discussed in this paper.

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References

- Allott, L.F., 2005. Palaeoenvironments of the Middle Stone Age at Sibudu Cave, KwaZulu-Natal, South Africa: An analysis of archaeological charcoal. Faculty of Science, University of the Witwatersrand, Johannesburg.
- Andrefsky Jr., W., 2005. *Lithics: Macroscopic approaches to analysis*. Cambridge University Press.
- 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. *S. Afr. Archaeol. Bull.* 70, 149–165.
- Bamforth, D.B., 1986. Technological efficiency and tool curation. *Am. Antiq.* 51, 38–50.
- Barham, L., 1987. The bipolar technique in Southern Africa: A replication experiment. *S. Afr. Archaeol. Bull.* 42, 45–50.
- Beaumont, P. B. 1978. Border cave. *Unpublished Ph.D. thesis*. University of Cape Town.
- Binford, L.R., 1978. *Nunamiut ethnoarchaeology*. Academic Press, New York/London.
- Binford, L.R., 1982. The archaeology of place. *J. Anthropol. Archaeol.* 1, 5–31.
- Boëda, E., 1993. Le débitage discoïde et le débitage Levallois récurrent centripède. *Bull. Soc. Préhist. Fr.* 392–404.
- Boëda, E., 1994. Le concept Levallois, variabilité des méthodes. CNRS éditions. .

Table 15

TCSA and TCSP values given for the points from spit 5B and 5C together.

	TCSA unifacial	TCSA bifacial	TCSP unifacial	TCSP bifacial
All pieces				
n	36	22	36	22
Min	16.0	28.0	24.1	29.1
Max	228.0	200.0	112.31	138.36
Mean	98.73	118.38	57.01	60.33
S.D	64.29	65.25	18.63	23.29
Complete pieces				
n	26	13	26	13
Min	30.0	45.0	32.0	37.36
Max	228.0	200.0	112.31	138.36
Mean	107.83	107.12	62.09	60.42
S,D	66.36	48.26	18.47	26.08

- Bräuer, G., 1984. A craniological approach to the origin of anatomically modern *Homo sapiens* in Africa and implications for the appearance of modern Europeans. The origins of modern humans: A world survey of the fossil evidence, pp. 327–410.
- Braun, D.R., 2005. Examining flake production strategies: Examples from the Middle Paleolithic of Southwest Asia. *Lithic Technol.* 30, 107–125.
- Braun, D.R., Harris, J.W., 2003. Technological developments in the Oldowan of Koobi Fora. *Treballs Arqueol.* 117–144.
- Bretzke, K., Marks, A.E., Conard, N.J., 2006. Projekttechnologie und kulturelle Evolution in Ostafrika. *Mitt. Ges. Urgesch.* 15, 63.
- Brun-Ricalens, F.L., 2006. Les pièces esquillées: état des connaissances après un siècle de reconnaissance. *PALEO. Rev. Archéol. Préhist.* 95–114.
- Butzer, K.W., Beaumont, P.B., Vogel, J.C., 1978. Lithostratigraphy of Border Cave, KwaZulu, South Africa: A Middle Stone Age sequence beginning c. 195,000 b.p. *J. Archaeol. Sci.* 5, 317–341.
- Cable, C., 1984. Economy and technology in the Late Stone Age of southern Natal. Cambridge monographs in African Archaeology. BAR.
- Caimcross, B., 2004. Field guide to rocks & minerals of Southern Africa. Struik.
- Clarkson, C., 2002. An index of invasiveness for the measurement of unifacial and bifacial retouch: A theoretical, experimental and archaeological verification. *J. Archaeol. Sci.* 29, 65–75.
- Cochrane, G.W.G., 2006. An analysis of lithic artefacts from the ~60 ka layers of Sibudu Cave. *South. Afr. Humanit.* 18, 69–88.
- Conard, N.J., Adler, D.S., 1997. Lithic reduction and hominid behavior in the Middle Paleolithic of the Rhineland. *J. Anthropol. Res.* 53, 147–175.
- Conard, N.J., Will, M., 2015. Examining the causes and consequences of short-term behavioral change during the Middle Stone Age at Sibudu, South Africa. *PLoS One* 10, e0130001.
- Conard, N.J., Soressi, M., Parkington, J.E., Wurz, S., Yates, R., 2004. A unified lithic taxonomy based on patterns of core reduction. *S. Afr. Archaeol. Bull.* 59, 12–16.
- Conard, N.J., Porraz, G., Wadley, L.Y.N., 2012. What is in a name? Characterizing the Post-Howiesons Poort at Sibudu. *S. Afr. Archaeol. Bull.* 67, 180–199.
- Conard, N.J., Bader, G.D., Schmid, V.C., Will, M., 2014. Bringing the Middle Stone Age into Clearer Focus. *Mitt. Ges. Urgesch.* 23, 121.
- Cooke, H.B.S., Malan, B.D., Wells, L.H., 1945. 3. Fossil man in the Lebombo Mountains, South Africa: The 'border cave', Ingwavuma District, Zululand. *Man* 45, 6–13.
- De La Peña, P., 2015. A qualitative guide to recognize bipolar knapping for Flint and Quartz. *Lithic Technol.* 1–16.
- De La Peña, P., Wadley, L., 2014a. New knapping methods in the Howiesons Poort at Sibudu (KwaZulu-Natal, South Africa). *Quat. Int.* 350, 26–42.
- De La Peña, P., Wadley, L., 2014b. Quartz knapping strategies in the Howiesons Poort at Sibudu (KwaZulu-Natal, South Africa). *PLoS One* 9, e101534.
- De La Peña, P., Wadley, L., Lombard, M., 2013. Quartz bifacial points in the Howiesons Poort of Sibudu. *S. Afr. Archaeol. Bull.* 68.
- D'errico, F., Henshilwood, C., Vanhaeren, M., Van Niekerk, K., 2005. Nassarius kraussianus shell beads from Blombos Cave: Evidence for symbolic behaviour in the Middle Stone Age. *J. Hum. Evol.* 48, 3–24.
- D'errico, F., Vanhaeren, M., Wadley, L., 2008. Possible shell beads from the Middle Stone Age layers of Sibudu Cave, South Africa. *J. Archaeol. Sci.* 35, 2675–2685.
- Dibble, H.L., 1984. Interpreting typological variation of Middle Paleolithic scrapers: Function, style, or sequence of reduction. *J. Field Archaeol.* 11, 431–436.
- Dibble, H.L., 1987. The interpretation of middle paleolithic scraper morphology. *Am. Antiq.* 52, 109–117.
- Dibble, H.L., 1995. Middle paleolithic scraper reduction: Background, clarification, and review of the evidence to date. *J. Archaeol. Method Theory* 2, 299–368.
- Dibble, H.L., Schurmans, U.A., Iovita, R.P., McLaughlin, M.V., 2005. The measurement and interpretation of cortex in lithic assemblages. *Am. Antiq.* 70, 545–560.
- Driscoll, K., 2010. Understanding quartz technology in early prehistoric Ireland (pH.D. thesis) University College Dublin.
- Driscoll, K., 2011. Vein quartz in lithic traditions: An analysis based on experimental archaeology. *J. Archaeol. Sci.* 38, 734–745.
- Frison, G.C., 1968. A functional analysis of certain chipped stone tools. *Am. Antiq.* 33, 149–155.
- Geneste, J.-M., 1988. Systèmes d'approvisionnement en matières premières au Paléolithique moyen et au Paléolithique supérieur en Aquitaine. *L'homme Néandertal* 8, 61–70.
- Goodyear, A.C., 1974. The Brand site: A techno-functional study of a Dalton site in north-east Arkansas. *Arkansas Archeological survey no 7*, Fayetteville.
- Grün, R., Beaumont, P., 2001. Border Cave revisited: a revised ESR chronology. *J. Hum. Evol.* 40, 467–482.
- Guérin, G., Murray, A.S., Jain, M., Thomsen, K.J., Mercier, N., 2013. How confident are we in the chronology of the transition between Howieson's Poort and Still Bay? *J. Hum. Evol.* 64, 314–317.
- Hahn, J., 1991. Erkennen und Bestimmen von Stein- und Knochenartefakten: einföhrung in die Artefaktmorphologie. Verlag Archaeologica Venatoria.
- Hayden, B., 1980. Confusion in the bipolar world: bashed pebbles and splintered pieces. *Lithic Technol.* 2–7.
- 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, 27–47.
- Henshilwood, C.S., D'errico, F., Van Niekerk, K.L., Coquinot, Y., Jacobs, Z., Lauritzen, S.-E., Menu, M., García-Moreno, R., 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. *Science* 334, 219–222.
- Henshilwood, C.S., Van Niekerk, K.L., Wurz, S., Delagnes, A., Armitage, S.J., Rifkin, R.F., Douze, K., Keene, P., Haaland, M.M., Reynard, J., Discamps, E., Mienies, S.S., 2014. Klipdrift Shelter, southern Cape, South Africa: preliminary report on the Howiesons Poort layers. *J. Archaeol. Sci.* 45, 284–303.
- Hiscock, P., 2015. Making it small in the Palaeolithic: Bipolar stone-working, miniature artefacts and models of core recycling. *World Archaeol.* 1–12.
- Hoffman, C.M., 1985. Projectile point maintenance and typology: Assessment with factor analysis and canonical correlation. In: Carr, C. (Ed.), For concordance in archaeological analysis: Bridging data structure, quantitative technique, and theory. University of Arkansas, Fayetteville, Westport.
- Hughes, S.S., 1998. Getting to the point: Evolutionary change in prehistoric weaponry. *J. Archaeol. Method Theory* 5, 345–408.
- Jacobs, Z., Roberts, R.G., 2008. Testing times: old and new chronologies for the Howieson's Poort and Still Bay industries in environmental context. *Goodwin Ser.* 10, 9–34.
- Jacobs, Z., Roberts, R.G., Galbraith, R.F., Deacon, H.J., Grün, R., Mackay, A., Mitchell, P., Vogelsang, R., Wadley, L., 2008a. Ages for the Middle Stone Age of Southern Africa: Implications for human behavior and dispersal. *Science* 322, 733–735.
- Jacobs, Z., Wintle, A.G., Duller, G.A.T., Roberts, R.G., Wadley, L., 2008b. New ages for the post-Howiesons Poort, late and final Middle Stone Age at Sibudu, South Africa. *J. Archaeol. Sci.* 35, 1790–1807.
- Kaplan, J., 1989. 45,000 years of hunter-gatherer history in Natal as seen from Umhlatuzana Rock Shelter. *Goodwin Ser.* 7–16.
- Kaplan, J., 1990. The Umhlatuzana rock shelter sequence: 100 000 years of Stone Age history. *South. Afr. Humanit.* 2, 1–94.
- Klein, R.G., 1977. The mammalian fauna from the Middle and Later Stone Age (Later Pleistocene) levels of Border Cave, Natal Province, South Africa. *S. Afr. Archaeol. Bull.* 32, 14–27.
- Langejans, G.H.J., 2012. Middle Stone Age pièces esquillées from Sibudu Cave, South Africa: An initial micro-residue study. *J. Archaeol. Sci.* 39, 1694–1704.
- Larsen-Peterkin, G., 1993. Lithic and organic hunting technology. In: Peterkin, G.L., Bricker, H., Mellars, P.A. (Eds.), Hunting and animal exploitation in the Late Paleolithic and Mesolithic of Eurasia. American Archaeological Association, Washington, DC.
- Leblanc, R., 1992. Wedges, pièces esquillées, bipolar cores, and other things: An alternative to Shott's view of bipolar industries. *North Am. Archaeol.* 13, 1–14.
- Lombard, M., 2006. First impressions of the functions and hafting technology of Still Bay pointed artefacts from Sibudu Cave. 18. Available http://reference.sabinet.co.za/webx/access/electronic_journals/nmsa_sah/nmsa_sah_v18_n1_a2.pdf.
- Lombard, M., 2007. The gripping nature of ochre: The association of ochre with Howiesons Poort adhesives and Later Stone Age mastics from South Africa. *J. Hum. Evol.* 53, 406–419.
- Lombard, M., Wadley, L., Jacobs, Z., Mohapi, M., Roberts, R.G., 2010. Still Bay and serrated points from Umhlatuzana Rock Shelter, Kwazulu-Natal, South Africa. *J. Archaeol. Sci.* 37, 1773–1784.
- Lombard, M., Wadley, L.Y.N., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., Swart, J., Mitchell, P., 2012. South African and Lesotho Stone Age sequence updated. *S. Afr. Archaeol. Bull.* 67, 123–144.
- Macdonald, D.H., Andrefsky, W., 2008. The role of lithic raw material availability and quality in determining tool kit size, tool function, and degree of retouch: A case study from Skink Rockshelter (46N1445), West Virginia. In: Andrefsky, W.J. (Ed.), *Lithic Technology: Measures of Production, Use and Curation*. Cambridge University Press, Cambridge.
- Mackay, A., 2008. A method for estimating edge length from flake dimensions: Use and implications for technological change in the southern African MSA. *J. Archaeol. Sci.* 35, 614–622.
- Mackay, A., Stewart, B.A., Chase, B.M., 2014. Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa. *J. Hum. Evol.* 72, 26–51.
- Maguire, R., 1997. A history of middle and late stone age research in the kwazulu-natal coastal area from 1871 to the beginning of the second world war. *Studies in honor of Professor J. Eloff*. National Cultural History Museum.
- Marean, C.W., Bar-Matthews, M., Bernatchez, J., Fisher, E., Goldberg, P., Herries, A.I.R., Jacobs, Z., Jerardino, A., Karkanas, P., Minichillo, T., Nilsson, P.J., Thompson, E., Watts, I., Williams, H.M., 2007. Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature* 449, 905–908.
- Marks, A.E., Volkman, P., 1983. Changing core reduction strategies: A technological shift from the Middle to the Upper Paleolithic in the Southern Levant. The Mousterian legacy: Human biocultural change in the Upper Pleistocene, pp. 13–34.
- 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, 453–563.
- Mccall, G.S., Thomas, J.T., 2009. Re-examining the South African Middle-to-Late Stone Age transition: Multivariate analysis of the Umhlatuzana and Rose Cottage Cave stone tool assemblages. *Azania: Archaeol. Res. Afr.* 44, 311–330.
- Mcdougall, I., Brown, F.H., Fleagle, J.G., 2005. Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature* 433, 733–736.
- Mohapi, M., 2012. Point morphology and the middle stone age cultural sequence of Sibudu Cave, KwaZulu-Natal, South Africa. *S. Afr. Archaeol. Bull.* 67, 5–15.
- Mohapi, M., 2013. The Middle Stone Age point assemblage from Umhlatuzana Rock Shelter: A morphometric study. *South. Afr. Humanit.* 25, 25–51.
- Odell, G., 1996. Economizing behavior and the concept of "curation". In: Odell, G. (Ed.), *Stone Tools*. Springer US.
- Orton, J., 2008. A useful measure of the desirability of different raw materials for retouch within and between assemblages: The raw material retouch index (RMRI). *J. Archaeol. Sci.* 35, 1090–1094.
- Parkington, J., Poggenpoel, C., Halkett, D., Hart, T., 2004. Initial observations on the Middle Stone Age coastal settlement in the Western Cape, South Africa. Settlement dynamics of the middle paleolithic and Middle Stone Age.
- Peresani, M., 2003. Discoid lithic technology: advances and implications. *British Archaeological Reports Ltd.*
- 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. *J. Archaeol. Sci.* 40, 3376–3400.
- Robertson, G., Attenbrow, V., 2008. Skin-working at Emu Tracks, New South Wales, Australia. *Lithic Technology. Lithic Perspectives from the Antipodes (Spring)* 33 (1), pp. 31–49.

- Scerri, E.L., Gravina, B., Blinkhorn, J., Delagnes, A., 2015. Can lithic attribute analyses identify discrete reduction trajectories? A quantitative study using refitted lithic sets. *J. Archaeol. Method Theory* 1–23.
- Shackleton, N.J., Opdyke, N.D., 1973. Oxygen isotope and palaeomagnetic stratigraphy of Equatorial Pacific core V28-238: Oxygen isotope temperatures and ice volumes on a 105 year and 106 year scale. *Quat. Res.* 3, 39–55.
- Shea, J.J., 2006. The origins of lithic projectile point technology: Evidence from Africa, the Levant, and Europe. *J. Archaeol. Sci.* 33, 823–846.
- Shott, M.J., 1986. Technological organization and settlement mobility: An ethnographic examination. *J. Anthropol. Res.* 42, 15–51.
- Shott, M.J., 1989. On tool-class use lives and the formation of archaeological assemblages. *Am. Antiq.* 54, 9–30.
- Shott, M.J., 2003. Chaîne opératoire and reduction sequence. *Lithic Technol.* 28, 95–105.
- Sisk, M.L., Shea, J.J., 2011. The African origin of complex projectile technology: An analysis using tip cross-sectional area and perimeter. *Int. J. Evol. Biol.* 2011, 8.
- Soressi, M., 2004. Die Steintechnologie des Spätmoustérien: Ihre Bedeutung für die Entstehungsgeschwindigkeit modernen Verhaltens und die Beziehung zwischen modernem Verhalten und biologischer Modernität. *Mitt. Ges. Urgesch.* 13, 9–28.
- 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. *J. Archaeol. Sci.* 34, 681–703.
- Soriano, S., Villa, P., Wadley, L., 2009. Ochre for the toolmaker: Shaping the Still Bay points at Sibudu (KwaZulu-Natal, South Africa). *J. Afr. Archaeol.* 7, 41–54.
- Soriano, S., Villa, P., Delagnes, A., Degano, I., Pollarolo, L., Lucejko, J.J., Henshilwood, C., Wadley, L., 2015. The Still Bay and Howiesons Poort at Sibudu and Blombos: Understanding middle stone age technologies. *PLoS One* 10, e0131127.
- Stringer, C.B., 1989. Documenting the origin of modern humans. In: Trinkaus, E. (Ed.), *Emergence of modern humans: Biocultural adaptations in the late pleistocene*. Cambridge Univ. Press, Cambridge.
- Texier, P.-J., Porraz, G., Parkington, J., Rigaud, J.-P., Poggenpoel, C., Miller, C., Tribolo, C., Cartwright, C., Coudenneau, A., Klein, R., Steele, T., Verna, C., 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.* 107, 6180–6185.
- Tribolo, C., Mercier, N., Douville, E., Joron, J.L., Reyss, J.L., Rufer, D., Cantin, N., Lefrais, Y., Miller, C.E., Porraz, G., Parkington, J., Rigaud, J.P., Texier, P.J., 2013. OSL and TL dating of the Middle Stone Age sequence at Diepkloof Rock Shelter (South Africa): A clarification. *J. Archaeol. Sci.* 40, 3401–3411.
- Villa, P., Lenoir, M., 2006. Hunting weapons of the Middle Stone Age and the Middle Palaeolithic: Spear points from Sibudu, Rose Cottage and Bouheben. 18. Available http://reference.sabinet.co.za/webx/access/electronic_journals/nmsa_sah/nmsa_sah_v18_n1_a6.pdf.
- Villa, P., Delagnes, A., Wadley, L., 2005. A late Middle Stone Age artifact assemblage from Sibudu (KwaZulu-Natal): Comparisons with the European Middle Paleolithic. *J. Archaeol. Sci.* 32, 399–422.
- Villa, P., Soressi, M., Henshilwood, C.S., Mourre, V., 2009. The Still Bay points of Blombos Cave (South Africa). *J. Archaeol. Sci.* 36, 441–460.
- Villa, P., Soriano, S., Tsanova, T., Degano, I., Higham, T.F.G., D'errico, F., Backwell, L., Lucejko, J.J., Colombini, M.P., Beaumont, P.B., 2012. Border Cave and the beginning of the Later Stone Age in South Africa. *Proc. Natl. Acad. Sci.* 109, 13208–13213.
- Volman, T.P., 1981. The middle stone age in the southern cape (Ph.D. thesis) University of Chicago (pH.D. thesis).
- Wadley, L., 2001. Excavations at Sibudu Cave, KwaZulu-Natal. *Digging Stick* 18, 1–4.
- Wadley, L., 2005. A typological study of the Final Middle Stone Age stone tools from Sibudu Cave, Kwazulu-Natal. *S. Afr. Archaeol. Bull.* 60, 51–63.
- Wadley, L., 2007. Announcing a Still Bay industry at Sibudu Cave, South Africa. *J. Hum. Evol.* 52, 681–689.
- Wadley, L., 2012. Two 'moments in time' during Middle Stone Age occupations of Sibudu, South Africa. *South. Afr. Humanit.* 24, 79–97.
- Wadley, L., 2013. MIS 4 and MIS 3 occupations in Sibudu, Kwazulu-Natal, South Africa. *S. Afr. Archaeol. Bull.* 68.
- Wadley, L., Jacobs, Z., 2006. Sibudu Cave: Background to the excavations, stratigraphy and dating. *South. Afr. Humanit.* 18, 1–26.
- Wadley, L., Mohapi, M., 2008. A Segment is not a Monolith: Evidence from the Howiesons Poort of Sibudu, South Africa. *J. Archaeol. Sci.* 35, 2594–2605.
- Wadley, L., Kempson, H., 2011. A review of rock studies for archaeologists, and an analysis of dolerite and hornfels from the Sibudu area. *KwaZulu-Natal. South. Afr. Humanit.* 23, 87–107.
- Wadley, L., Sievers, C., Bamford, M., Goldberg, P., Berna, F., Miller, C., 2011. Middle Stone Age bedding construction and settlement patterns at Sibudu, South Africa. *Science* 334, 1388–1391.
- Waelbroeck, C., Labeyrie, L., Michel, E., Duplessy, J.C., Mcmanus, J.F., Lambeck, K., Balbon, E., Labracherie, M., 2002. Sea-level and deep water temperature changes derived from benthic foraminifera isotopic records. *Quat. Sci. Rev.* 21, 295–305.
- White, T.D., Asfaw, B., Degusta, D., Gilbert, H., Richards, G.D., Suwa, G., Clark Howell, F., 2003. Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature* 423, 742–747.
- Will, M., Parkington, J.E., Kandel, A.W., Conard, N.J., 2013. Coastal adaptations and the Middle Stone Age lithic assemblages from Hoedjiespunt 1 in the Western Cape, South Africa. *J. Hum. Evol.* 64, 518–537.
- 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, e98359.
- Will, M., Kandel, A.W., Kyriacou, K., Conard, N.J., 2016. An evolutionary perspective on coastal adaptations by modern humans during the Middle Stone Age of Africa. *Quat. Int.* (in press).
- Wurz, S., 1999. The Howiesons Poort backed artefacts from Klasies River: An argument for symbolic behaviour. *S. Afr. Archaeol. Bull.* 54, 38–50.
- Wurz, S., 2000. The Middle Stone Age at Klasies River, South Africa (Ph.D. thesis) Stellenbosch University.

Bringing the Middle Stone Age into Clearer Focus

Nicholas J. Conard^{1,2}, Gregor D. Bader¹,
Viola C. Schmid¹ and Manuel Will¹

¹Universität Tübingen
Institut für Ur- und Frühgeschichte und Archäologie des Mittelalters
Abteilung Ältere Urgeschichte und Quartärökologie
Schloss Hohentübingen
D-72070 Tübingen, Germany
nicholas.conard@uni-tuebingen.de
gregor.bader@uni-tuebingen.de
viola.schmid@uni-tuebingen.de
manuel.will@uni-tuebingen.de

²Senckenberg Center for Human Evolution and Paleoenvironment at Tübingen,
Germany

Abstract: *Prior to the 1990s, archaeologists often viewed the Middle Stone Age (MSA) as a period less important for research than the Earlier Stone Age in which early Homo evolved and the Later Stone Age in which scholars envisioned a high degree of archaeological continuity with recent hunters and gatherers. With the realization that modern humans evolved in Africa during the MSA around 200 ka BP, this period became a central topic of international research. Subsequently, new excavations and research projects made southern Africa the leading region for research on the MSA. Based on the results of an international workshop held in Tübingen in September 2014, we summarize the state of this research and demonstrate that current models advocating a clear cultural sequence across the entire subcontinent with well-defined and largely homogeneous cultural-chronological units are too simplistic. Here we stress that the archaeological record of the MSA is more complex and regionally variable than has been recognized in current publications, including what we refer to as the Synthetic Model proposed by Jacobs, Henshilwood and other colleagues. Based on high-resolution observations presented at the workshop in Tübingen, we argue that research is entering a phase in which a more complex record of the MSA will come into clearer focus and improved models of behavioral change and spatial-temporal variation will emerge to examine the dynamics of cultural evolution during the MSA.*

Keywords: *Middle Stone Age, southern Africa, lithic technology, cultural sequence, behavioral variability*

Das Middle Stone Age besser in den Brennpunkt bringen

Zusammenfassung: Bis in die 1990er Jahre beschäftigte sich die Steinzeitforschung in Afrika hauptsächlich mit dem Earlier Stone Age, welches die Entwicklung der ersten Vertreter der Gattung *Homo* umfasst, sowie dem Later Stone Age, welches durch seine zeitliche Stellung mögliche Anknüpfungspunkte an rezente Jäger- und Sammlergruppen aufweist. Erst mit der Erkenntnis, dass moderne Menschen um ca. 200.000 vor heute in Afrika entstanden, begann die Archäologie sich auf das zwischen diesen Perioden liegende Middle Stone Age (MSA) zu konzentrieren. Seit den späten 1990er Jahren bezog sich die Forschung vor allem auf das östliche und südliche Afrika, um die frühe kulturelle Entwicklung von *Homo sapiens* nachzuvollziehen. Infolgedessen wurde das heutige Südafrika aufgrund der Vielzahl an neuen Grabungen und internationalen Forschungsprojekten zur archäologisch am besten erfassten Region für das MSA in Afrika. Im September 2014 veranstalteten wir einen Workshop in Tübingen, zu welchem internationale Teams geladen wurden, um die neuesten Forschungsergebnisse aus Südafrika und anderen afrikanischen Regionen zusammenzufassen, zu diskutieren und in den weiteren Kontext der frühen kulturellen Evolution des modernen Menschen zu stellen. Hierbei sollten vor allem Fragen nach deren Art und Verlauf gestellt und kritisch beleuchtet werden. Die kritische Evaluation dieser Ergebnisse zeigte, dass derzeitige vorherrschende Modelle zu stark vereinfachend strukturiert sind, um

die komplexe archäologische Realität des MSA zu erklären. Das gegenwärtig in der Diskussion dominierende „Synthetische Modell“ von Jacobs, Henshilwood und Kollegen besagt, dass die kulturelle Abfolge des MSA im südlichen Afrika durch zwei klar definierte, einheitliche und zeitlich eng begrenzte Technokomplexe, das Still Bay und das Howiesons Poort, charakterisiert ist. Diese beiden Einheiten sollen demzufolge zwei kulturell hochentwickelte Phasen widerspiegeln, die sich klar in ihrer materiellen Kultur von den Perioden davor und danach unterscheiden. Wir zeigen hier, dass die chrono-kulturelle Sequenz des MSA in Wirklichkeit um einiges komplizierter und regional variabler ist als ihr in dem vorherrschenden Modell zugestanden wird. Vor allem der intensive Fokus der Forschung auf das Still Bay und Howiesons Poort in den letzten Jahrzehnten hat zu einem verzerrten Bild der archäologischen Realität geführt. Neue Forschungsergebnisse zur materiellen Kultur vor und nach diesen Technokomplexen belegen einen vielschichtigeren Verlauf der kulturellen Evolution von modernen Menschen, zumindest in Südafrika. Unserer Meinung nach tritt die MSA-Forschung zurzeit in eine Phase ein, in welcher die räumliche und zeitliche Variabilität im Verhaltensrepertoire von *Homo sapiens* in den Mittelpunkt rückt und Forscher dadurch sowohl empirisch wie auch theoretisch besser fundierte Modelle zur kulturellen Evolution von modernen Menschen entwickeln werden.

Schlagwörter: Middle Stone Age, südliches Afrika, lithische Technologie, Kulturabfolge, Verhaltensvariabilität

Over the last two decades, studies of the Middle Stone Age (MSA) have moved from relative obscurity to a central focus of international research in early prehistory and paleoanthropology. This development was largely driven by the realization that *Homo sapiens* originated in Africa around 200 ka BP. The MSA spans the vast period between roughly 300 and 30 ka BP, encompassing the archaeological record for the evolution of anatomically and culturally modern humans in Africa.



Fig. 1: Participants of the international workshop “Contextualizing technological change and cultural evolution in the MSA of southern Africa” at Hohentübingen Castle. Front row from left to right: Nicholas Conard, Mareike Brenner, Susan Mentzer, Regine Stolarczyk, Daniela Rosso, Chantal Tribolo, Panagiotis Karkanis, Christopher Miller, Viola Schmid, Darya Presnyakova, Iris Guillemard; second row: Alex Mackay, Jorden Peery, Magnus Haaland, Michael Bolus, Patrick Schmidt, Manuel Will, Gregor Bader, Laura Basell, John Parkington, Sarah Wurz; third row: Pierre-Jean Texier, Stanley Ambrose, Benoît Chevrier, Norbert Mercier, Ralf Vogelsang, Andrew Kandel, Götz Ossendorf, Isabell Schmidt, Katja Douze, Will Archer, Guillaume Porraz. Photo: I. Gold.

From September 8 – 10, 2014, Nicholas Conard and Christopher Miller of the Department of Early Prehistory and Quaternary Ecology and the Institute of Archaeological Sciences at the University of Tübingen, together with Guillaume Porraz from the CNRS and the University of Paris X in Nanterre, hosted an international workshop at Hohentübingen Castle. The meeting aimed to address new trends in the study of the MSA, with a focus on lithic technology in southern Africa. In keeping with its main goal, the workshop bore the name: “Contextualizing technological change and cultural evolution in the MSA of southern Africa”. Gregor Bader, Viola Schmid, and Manuel Will, all Ph.D. candidates at the University of Tübingen, assisted in all stages of the planning and execution. Thirty-five researchers from Africa, Europe and North America participated in the meeting, including most of the active research teams studying the MSA. The workshop was funded by the German Science Foundation (DFG) and the French Ministry of Foreign Affairs (Fig.1).

Although stone artifact technology from southern Africa formed the central focus of the meeting, sessions also addressed topics concerning geoarchaeology and chronostratigraphy, as well as new research in eastern and western Africa. The program of the workshop and all abstracts can be found on the website of the Department of Early Prehistory and Quaternary Ecology of the University of Tübingen.

The long-term cooperation between the organizers at sites in southern Africa including Diepkloof, Sibudu, Elands Bay Cave, Hoedjiespunt, and Bushman Rock Shelter has produced a wealth of new information about the cultural and technological evolution of modern humans during the MSA. The presentation of new data from these projects to an international audience represented one central aspect of the workshop. Immediately prior to the main meeting, the members of the Elands Bay Cave project, which was funded by the German Science Foundation, met to report on results from recent excavations at this important site on the Western Cape of South Africa. Scholars from other active research teams working in southern Africa presented their work on Klasies River Mouth (Sarah Wurz), Blombos (Katja Douze), Pinnacle Point (Panagiotis Karkanas), Mertenhof and Varsche Rivier (Alex Mackay) as well as Holley Shelter (Gregor Bader).

Similarly, researchers from the collaborative research center in Cologne (SFB 806) reported new research on sites in Namibia including Apollo 11 and Pockenbank (Götz Ossendorf, Isabell Schmidt and Ralf Vogelsang).

To help contextualize the new research from southern Africa, Stanley Ambrose reported on excavations in the Central Rift region and southwestern Kenya and Benoît Chevrier presented his work in eastern Senegal. Additional papers addressed the various uses of ochre at Porc Epic in Ethiopia (Daniela Rosso), and cultural stratigraphic trends from the long sequence of Mumba Cave in Tanzania (Knut Bretzke), which have implications for large-scale cultural exchange and human migrations. Similarly, Laura Basell examined the relationships between cultural and environmental changes in eastern Africa.

In his keynote address, Christopher Miller presented an overview of the innovative geoarchaeological research in southern Africa and illustrated the many new insights about human behavior that studies using micromorphological methods and Fourier Transform Infrared Spectrometry have facilitated. Chantal Tribolo discussed the current

state of chrono-stratigraphic research on the MSA of southern Africa and pointed to uncertainties in what we refer to as the Synthetic Model advocated by Jacobs, Henshilwood and colleagues (Jacobs et al. 2008; Henshilwood 2012). Patrick Schmidt reported on his research that focuses on the tempering of silcrete. In contrast to colleagues such as Brown (Brown et al. 2009) and Wadley and Prinsloo (2014), he found that heat treating of silcrete does not require special cognitive skills or complex technology, but is rather a fairly straightforward process that can be done parallel to other activities at hearths (Schmidt et al. 2013). These are clearly areas of ongoing dynamic research and debate, where we can expect further breakthroughs in the coming years. In other methodological developments, Will Archer presented results from the Max Planck Institute in Leipzig that focus on developing new numerical methods for capturing patterns of variation in bifacial points of the Still Bay (SB). Archer and colleagues used three-dimensional CT scans to document lithic variability and to test competing explanations for technological change.

Turning to broader issues in human evolution, Regine Stolarczyk used the methods derived from problem-solution-distance analysis (Haidle 2010, 2012) to examine the cognitive complexity involved in the manufacture of organic artifacts from the MSA of southern Africa. Finally, Andrew Kandel presented a model, developed by the ROCEEH team of the Heidelberg Academy of Sciences and Humanities, for the evolution of behavioral hyperplasticity among *Homo sapiens* to help explain the appearance of cultural innovations, such as new lithic technologies and abstract engravings on ochre and ostrich eggshell.

What have we learned from the workshop? First, it is becoming increasingly clear that the Synthetic Model for the cultural chronology of the MSA of southern Africa, proposed by many scholars including Jacobs, Henshilwood, and others (Jacobs et al. 2008; Henshilwood 2012), reflects an oversimplification of the archaeological reality (Fig. 2). This model came into focus in recent years, and it represented a major breakthrough at that time. Its main thrust was the proposition that the Still Bay and Howiesons Poort (HP), which had previously been defined solely on their characteristic stone artifacts, represented well-defined cultural entities and periods of exceptional innovation. Proponents explained these observations by increases in population sizes as well as exchange of information between groups over long distances. The Synthetic Model was significantly based on results from excavations at sites including Blombos, Diepkloof, Sibudu, Hollow Rock Shelter, Klein Kliphuis, and Apollo 11, as well as from Jacobs' optically stimulated luminescence (OSL) dates from MSA sites across southern Africa. Building on these observations, many researchers argued that the SB and HP represented well-dated and short episodes of cultural florescence that correspond to ca. 75–71 ka BP and 65–59 ka BP, respectively. This synthesis of what had previously been rather unstructured information met considerable support in the archaeological community, since it fits expectations and perhaps also the longing for order and clarity in what had previously been a complicated and uncertain cultural sequence. The Synthetic Model had implications for many ideas under discussion related to the nature and tempo of cultural change and innovation during the MSA. The model, if valid, would also have major implications for our understanding of the relationships between environmental change, cultural change and population dynamics, as well as topics including claims for a causal relationship between the Toba volcanic super-eruption, population bottlenecks, and the spread of modern humans out of Africa (Mellars 2006; Mellars et al. 2013).

In recent years, this model has come under criticism. First, problems in reproducing the dates at Diepkloof raised questions about previous chronometric results (Tribolo et al. 2009, 2013). The sequence at Diepkloof also demonstrated that the HP is less narrowly restricted in time than was previously thought, and instead that the HP represents a long, multi-phased period of cultural and technological development rather than a homogeneous episode (Porráz et al. 2008, 2013). Additionally, Porráz and colleagues published data indicating that the HP was not a uniform spatial and temporal phenomenon.

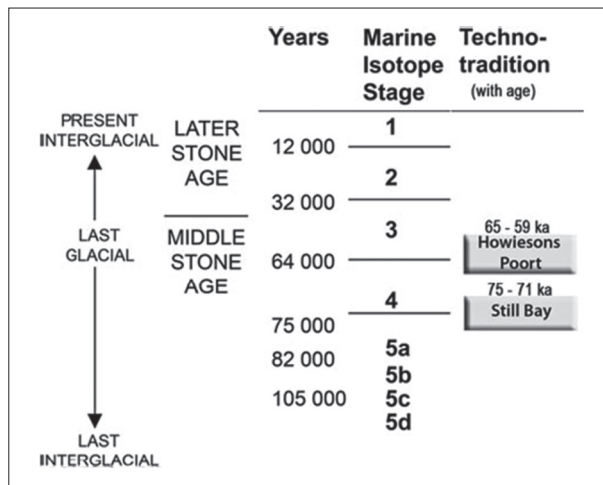


Fig. 2: Schematic representation of the cultural chronostratigraphy of the MSA in southern Africa after Henshilwood (2012). The authors point to the need to revise what we refer to as the Synthetic Model proposed by Henshilwood, Jacobs and colleagues (Jacobs et al. 2008). New data from Sibudu, Diepkloof and other sites indicate that the Still Bay and Howiesons Poort are not uniform cultural entities narrowly focused in time but rather dynamic, heterogeneous cultural phases. Additionally, as the cultural units before and after the SB and HP come into better focus, it has become increasingly clear that the material culture of these periods also shows greater spatial and temporal variability than had previously been assumed. Many of the participants of the Tübingen workshop are currently working to refine our view of the MSA in the light of new data on the cultural sequence from across southern Africa.

At the same time questions emerged about the SB. A critical look at Apollo 11 raised issues about the definition of the SB and to what extent any small assemblage with bifacial artifacts could be considered to belong to this cultural entity. The recent finding of small bifacial points made on quartz in an otherwise typical HP context characterized by an abundance of backed artifacts at Sibudu underlines this observation (de la Peña et al. 2013). Meanwhile excavations at Sibudu continued beneath the horizons Wadley had defined as “pre-Still Bay” and which Jacobs had dated to before the Still Bay (Wadley 2007). To the surprise of the team from Tübingen, the deepest stratigraphic units at Sibudu, called Adam, Annie, Bart, and Bea, all yielded abundant evidence for bifacial technology (Fig. 3) and assemblages that based on available arguments and our present knowledge, must be placed within the Still Bay complex rather than belonging to the “pre-Still Bay” (Conard 2013, 2014). Obviously, these observations are in no way a criticism of Wadley’s outstanding work at Sibudu, since her excavation stopped in the stratigraphic unit BS (Brown Sand) above these layers. Together with new technological and chronometric data from Diepkloof (Porráz et al. 2013; Tribolo et al. 2013) these

observations suggest a longer duration and a more complicated cultural trajectory of the SB than was previously acknowledged.

On a more general level, other colleagues, including Lombard, Conard, Porraz, and Will (Conard et al. 2012; Lombard et al. 2012; Will et al. 2014) have questioned the hypothesis that the SB and HP represented periods of exceptional cultural innovation and perhaps even the epicenter for the evolution of cultural modernity from both theoretical and empirical perspectives. These researchers demonstrated that modern humans after the HP continued to possess highly structured and sophisticated lithic technologies and maintained high population densities. These studies highlight the fact that a selective research focus on the HP and SB in recent years has led to a distorted picture of the periods that preceded and followed these technocomplexes. This bias is best exemplified by the usage of terms such as “pre-SB” or “post-HP”, the latter denoting a ca. 20,000 year-long period of cultural evolution following the HP.

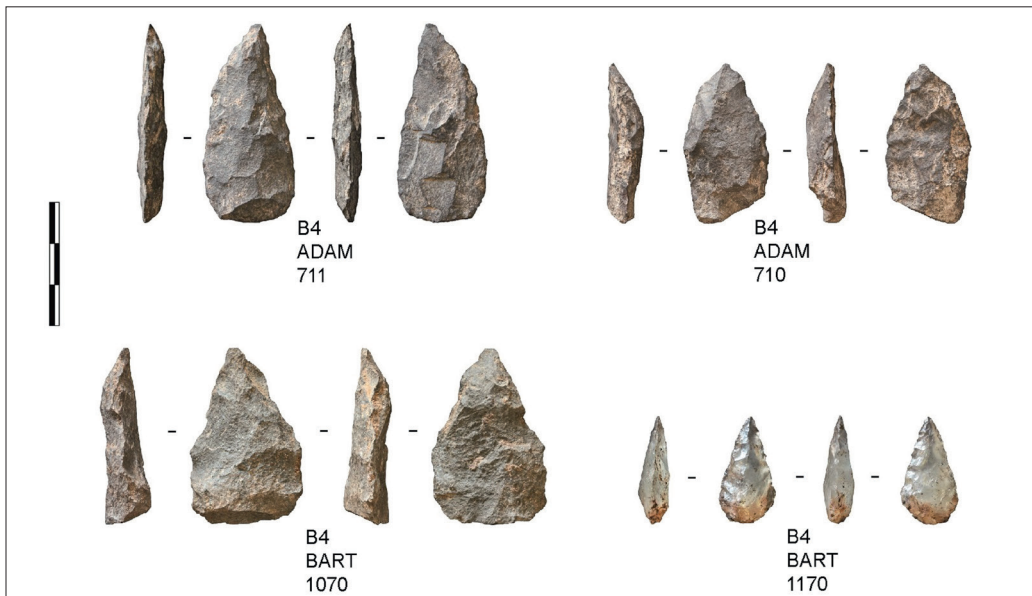


Fig. 3: Sibudu, KwaZulu-Natal, South Africa. Bifacial points from the so-called “pre-Still Bay”-layers at the base of the current excavation.

All of these observations raise serious questions about the validity of the Synthetic Model. While debate continues about the specific answers to the ambiguities raised above, new interpretations are gradually coming into focus. First we need to view technologies such as the manufacture and use of bifacial points and segments as dynamic functional adaptations that are mediated through learned behavior and cultural transmission, rather than as strict chrono-cultural markers or *fossils directeurs*. The new results from Sibudu and Diepkloof indicate that previous models for the SB and HP were too simplistic, suggesting a lack of more sophisticated approaches to interpret our data. At the moment, we are working to develop new ways of explaining the chrono-stratigraphic and cultural variability in the MSA. Work of international scholars including

those who presented papers at the workshop in Tübingen will help to correct errors in current views and will help to define a path that provides a more refined understanding of the cultural evolution during the MSA.

Finally, the presentations and discussions at the workshop have shown that the study of the MSA is an international, ever-growing and vibrant field of research. The fact that the Tübingen workshop yielded more questions than answers underlines the vitality of the field and illustrates the important challenges that the scientific community studying the MSA still faces. Having said that, the workshop showed that we have moved a long way forward in understanding the archaeological record of the MSA during the last two decades, both from theoretical and empirical points of view. More than just filling gaps, new results emerging from across Africa are elucidating the complex pathways of the cultural evolution and population dynamics of modern humans.

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References

- Brown, K. S., Marean, C. W., Herries, A. I. R., Jacobs, Z., Tribolo, C., Braun, D., Roberts, D. L., Meyer, M. C., and Bernatchez, J. 2009: Fire As an Engineering Tool of Early Modern Humans. *Science* 325, 859–862.
- Conard, N. J. 2013: The 2013 Excavation of the University of Tübingen in MSA deposits at Sibudu Rockshelter, KwaZulu-Natal. Excavation report on file at the KwaZulu-Natal Museum.
- Conard, N. J. 2014: The 2014 Excavation of the University of Tübingen in MSA deposits at Sibudu Rockshelter, KwaZulu-Natal. Excavation report on file at the KwaZulu-Natal Museum.
- Conard, N. J., Porraz, G., and Wadley, L. 2012: What is in a name? Characterising the ‘Post-Howieson’s Poort’ at Sibudu. *South African Archaeological Bulletin* 67, 180–199.
- de la Peña, P., Wadley, L., and Lombard, M. 2013: Quartz Bifacial Points in the Howiesons Poort of Sibudu. *South African Archaeological Bulletin* 68 119–136.
- Haidle, M. N. 2010: Working-Memory Capacity and the Evolution of Modern Cognitive Potential. Implications from Animal and Early Human Tool Use. *Current Anthropology* 51, S149–S166.
- Haidle, M. N. 2012: How to think tools? A comparison of cognitive aspects in tool behavior of animals and during human evolution. *Cognitive perspectives in tool behaviour*, Vol. 1. Available at: http://tobias-lib.uni-tuebingen.de/frontdoor.php?source_opus=6014
- 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, 205–237.
- Jacobs, Z., Roberts, R. G., Galbraith, R. F., Deacon, H. J., Grün, R., Mackay, A., Mitchell, P., Vogelsang, R., and Wadley, L. 2008: Ages for the Middle Stone Age of Southern Africa: Implications for Human Behavior and Dispersal. *Science* 322, 733–735.
- Lombard, M., Wadley, L., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., Swart, J., and Mitchell, P. 2012: South African and Lesotho Stone Age sequence updated (I). *South African Archaeological Bulletin* 67, 123–144.
- Mellars, P. 2006: Why did modern human populations disperse from Africa ca. 60,000 years ago? A new model. *Proceedings of the National Academy of Sciences of the U.S.A.* 103, 9381–9386.

- Mellars, P., Gori, K. C., Carr, M., Soares, P. A., and Richards, M. B. 2013: Genetic and archaeological perspectives on the initial modern human colonization of southern Asia. *Proceedings of the National Academy of Sciences of the U.S.A.* 110, 10699–10704.
- Porraz, G., Texier, P.-J., Archer, W., Piboule, M., Rigaud, J.-P., and Tribolo, C. 2013: Technological successions in the Middle Stone Age sequence of Diepkloof Rock Shelter, Western Cape, South Africa. *Journal of Archaeological Science* 40, 3376–3400.
- Porraz, G., Texier, P.-J., Rigaud, J.-P., Parkington, J., Poggenpoel, C., and Roberts, D. L. 2008: Preliminary characterization of a Middle Stone Age lithic assemblage preceding the 'classic' Howieson's Poort complex at Diepkloof Rock Shelter, Western Cape Province, South Africa. *South African Archaeological Society Goodwin Series* 10, 105–121.
- Schmidt, P., Porraz, G., Slodczyk, A., Bellot-Gurlet, L., Archer, W., and Miller, C. E. 2013: Heat treatment in the South African Middle Stone Age: temperature induced transformations of silcrete and their technological implications. *Journal of Archaeological Science* 40, 3519–3531.
- Tribolo, C., Mercier, N., Douville, E., Joron, J.-L., Reyss, J.-L., Rufer, D., Cantin, N., Lefrais, Y., Miller, C. E., Porraz, G., Parkington, J., Rigaud, J.-P., and Texier, P.-J. 2013: OSL and TL dating of the Middle Stone Age sequence at Diepkloof Rock Shelter (South Africa): a clarification. *Journal of Archaeological Science* 40, 3401–3411.
- Tribolo, C., Mercier, N., Valladas, H., Joron, J. L., Guibert, P., Lefrais, Y., Selo, M., Texier, P.-J., Rigaud, J.-P., Porraz, G., Poggenpoel, C., Parkington, J., Texier, J.-P., and Lenoble, A. 2009: Thermoluminescence dating of a Stillbay–Howieson's Poort sequence at Diepkloof Rock Shelter (Western Cape, South Africa). *Journal of Archaeological Science* 36, 730–739.
- Wadley, L. 2007: Announcing a Still Bay industry at Sibudu Cave, South Africa. *Journal of Human Evolution* 52, 681–689.
- Wadley, L. and Prinsloo, L. C. 2014: Experimental heat treatment of silcrete implies analogical reasoning in the Middle Stone Age. *Journal of Human Evolution* 70, 49–60.
- Will, M., Bader, G. D., and Conard, N. J. 2014: Characterizing the Late Pleistocene MSA Lithic Technology of Sibudu, KwaZulu-Natal, South Africa. *PLoS ONE* 9(5): e98359.

A Return to Umbeli Belli: First insights of recent excavations and implications for the final MSA in KwaZulu-Natal

Gregor D. Bader & Nicholas J. Conard

Abstract

Umbeli Belli rock shelter is a site in KwaZulu-Natal, South Africa that has been rediscovered recently by the author and colleagues, providing important archaeological data on the end of the Middle Stone Age (MSA). While preliminary age estimations using OSL place the MSA sequence into MIS3, the archaeological signal provides strong evidence that parts of the occupation at Umbeli Belli belong to the final MSA. In KwaZulu-Natal this period dates roughly to between 40 and 30 ka. New excavations at the site conducted in early 2016 and 2017 have brought additional evidence, particularly through the discovery of a highly distinct tool form, the so-called hollow-based points. Apart from two isolated pieces, one at Kleinmonde and one at Border Cave, this tool type has been found only within the final MSA occupations of Sibudu and Umhlatuzana. Notwithstanding the fact that hollow-based points are likely to represent one of the most solid *fossil directeurs* of the MSA, neither the tools themselves nor the corresponding assemblages in which they are found have so far been adequately described. Based on current results from Umbeli Belli we provide new technological evidence about the final MSA in the eastern part of South Africa. We observe that hollow-based points are an exceptional but not the defining feature of the final MSA. We further test pre-existing typological differentiations of traditional tool types, such as unifacial and bifacial points, and provide alternative assessments based on their morphological and physical properties.

Key words: Umbeli Belli, final MSA, broad heads, target points, shaping flakes

Introduction

The Middle Stone Age of South Africa is a period of abundant change in terms of human behavior and settlement dynamics (Conard et al., 2014, Kandel et al., 2016, Mackay et al., 2014a, McBrearty and Brooks, 2000, Will et al., 2013, 2015, Wurz, 2000, 2002). Apart from different kinds of innovations often summarized under the term “cultural modernity”, encompassing the production of personal ornaments (d'Errico et al., 2005, Henshilwood et al., 2004, Vanhaeren et al., 2013), evidence for burials including grave goods (d'Errico and Backwell, 2016), engravings on ochre and ostrich eggshell (Henshilwood et al., 2009, 2011, 2014, Mackay, 2010, Texier et al., 2010), and the intentional heat treatment of silcrete (Brown et al., 2009, Schmidt and Mackay, 2016, Schmidt et al., 2013, 2015, Wadley and Prinsloo, 2014), there are also significant changes through time and space in lithic technology. Some periods of the MSA, especially the Still Bay and Howiesons Poort, have received exceptional scholarly attention. This focus can be explained primarily by the association of these technocomplexes with many of the innovations mentioned above, but also due to specialized

lithic tool kits of these periods which have been associated with early evidence of composite tool technology and hence mental complexity among other things (Lombard and Haidle, 2012, Lombard and Phillipson, 2015). These observations, however, do not imply that earlier or later parts of the MSA are less advanced. Even if this would be the case, it would seem astonishing simply because of the fact that they have all been manufactured by the same kind of species, *Homo sapiens* (Grine et al., 2000, McDougall et al., 2005, Richter et al., 2017, Rightmire and Deacon, 1991, White et al., 2003). Researchers have also argued that these periods exhibit in general more technological diversity and provide evidence for regionalization (Mackay et al., 2014a, Wadley, 2005b, Will et al., 2015).

Recently, e.g. Mackay and colleagues (2014a) discussed possible scenarios of human dispersal and cultural variability across South Africa and throughout the MSA of this region. One of the suggestions they made was the fragmentation of cultural entities during Marine Isotope Stage 3 (MIS3) in association with unstable environmental conditions. Although such a scenario is possible and finds support by various researchers including ourselves (Bader et al., 2015, 2016, Chase and Meadows, 2007, Conard and Will, 2015, Will et al., 2015, Will and Conard, 2017) it rests in some parts on unstable empirical ground. This is due to our insufficient knowledge of some of the key periods within MIS3 – which lasts over more than 25,000 years – and as noted by Mackay and colleagues (2014a) more detailed and consistent technological analysis as well as re-dating of key sites is urgently needed. Recent studies started to illuminate especially the post-Howiesons Poort (post-HP) period postdating 60.000 BP (Bader et al., 2015, Conard et al., 2012, 2014, Conard and Will, 2015, Will and Conard, 2017, Will et al., 2014) and confirmed that some kind of technological regionalization appears. However, even within regional archaeological frameworks significant intra- and inter-assemblage variability exists on a techno/typological level (Bader et al., 2015). These circumstances are driven primarily by a combination of internal and external factors having an influence on individuals and communities and the inherent decisions being made.

Both external and internal factors represent difficult problems that challenge scientists of different discipline across the archaeological sciences. External factors such as climatic and environmental conditions and alterations (Chase and Meadows, 2007, Mackay et al., 2014a, McCall and Thomas, 2012, Weninger et al., 2009, Ziegler et al., 2013) represent important implications for a general understanding of cultural change because they provide measurable and quantifiable datasets facing archaeological contexts as well as the background conditions to which societies had to adapt. By contrast internal factors such as personal preference, social identity and individual needs represent a huge complex of agents potentially having an even larger influence on cultural change and hence should receive greater attention. The catch, however, is the lack of direct archaeological datasets and our dependency on ethnographic observations (e.g. Binford, 1978, Kelly, 1983, Lee, 1968, Wiessner,

1977, 1983, Woodburn, 1968). Although these observations contribute essentially to our understanding of hunter-gatherer lifestyles (e.g. Spencer, 1992), to a certain degree they can always be challenged by the risk of creating misleading analogies to past societies and thus should be evaluated carefully (Hodder, 1983, Shanks and Tilley, 1987).

Consequently the attempt of giving broad overviews over archaeological periods in order to explain cultural change are relevant and improve our understanding but will always be biased and limited to a certain degree. This being said, we can reach a deeper understanding of cultural change and variability if we narrow our focus to a regional scale and undertake detailed and comparative studies that rest on solid empirical ground. KwaZulu-Natal in the eastern part of South Africa represents an excellent research area in order to undertake such a regional approach, since the province contains several rock shelters in close proximity to each other preserving archaeological horizons from comparable time periods. While Sibudu and Border Cave (Backwell et al., 2008, Beaumont, 1978, Butzer et al., 1978, Conard et al., 2012, Conard and Will, 2015, de la Peña and Wadley, 2014a, b, de la Peña et al., 2013, d'Errico and Backwell, 2016. Grün and Beaumont, 2001, Klein, 1977, Villa et al., 2012, Wadley, 2001, 2007, 2012, Will et al., 2014) represent the best known sites due to their long and well-preserved stratigraphic sequences with exceptional preservation of organic artifacts (Backwell et al., 2008, d'Errico et al., 2008, Rots et al., 2017), smaller sites such as Umhlatuzana (Kaplan, 1989, 1990, Lombard et al., 2010, McCall and Thomas, 2009, Mohapi, 2013), Holley Shelter (Bader et al., 2015, Cramb, 1952, 1961) and recently Umbeli Belli (Bader et al., 2016, Cable, 1984) contribute to a refinement of our understanding of the MSA in KwaZulu-Natal.

Preliminary age estimations using OSL for the MSA sequence at Umbeli Belli suggest an occupation during MIS3 (Tribolo, pers. com). Our new excavations have also show that the shelter contains an archaeological horizon that can be associated with the final Middle Stone Age (final MSA) due to a sample of four highly distinct artifacts commonly referred to as hollow-based points. Until now, a total of only 22 of these points has been published and apart from single specimens from Kleinmonde (Clark, 1959) and Border Cave (Beaumont, 1978) all of them have been recovered from the final MSA layers at Sibudu and Umhlatuzana dating roughly to between 40-35 ka (Kaplan, 1989, 1990, Wadley, 2005b). Taking into account the close proximity of Umbeli Belli to Sibudu and Umhlatuzana (Fig.1), as well as the generally low sample size of hollow-based points and their restricted temporal and spatial distribution, an association of parts of the sequence at Umbeli Belli with the final MSA is a logic working hypothesis. Further evidence to support this interpretation comes from a technological comparison between Umbeli Belli and surrounding sites that we have recently undertaken (Bader et al., 2016). While the former study was based on an assemblage excavated in 1979, here we analyze artifacts excavated by the authors in 2016 and early 2017. We

provide a refined stratigraphic subdivision of Umbeli Belli and give a detailed description of nearly 3000 lithic artifacts (>2cm) recovered from the final MSA layer GH7 (see below). Here we focus on the retouched tool component and the products immediately associated with their production. We show that hollow-based points are an eye-catching but minor feature of the final MSA at Umbeli Belli. Furthermore, we discuss the phenomenon of hollow-based points from a taxonomic and methodical perspective.

Umbeli Belli then and now

Umbeli Belli is a rock shelter close to Scottburgh in KwaZulu-Natal, situated about 7km inland and overlooking the Mpambanyoni River. When Charles Cable excavated the site for the first time in 1979 his research scope was focused on the uppermost LSA layers 1, 2AL (Ashy lens) and 2BE (Brown earth) comprising the first 20 to 30 cm of the sequence (Bader et al., 2016, Cable, 1984). Layer 2BE and 2AL have been dated to 200 +/- 50 and 1140 +/- 50 BP using 14C measurements on charcoal. In order to test the thickness of the archaeological sequence Cable excavated four square meters down to what he presumed to be bedrock in the back of the shelter and to a “sterile sand” in the front. Charles Cable excavated in a square meter system and assigned the individual squares using letters A,B,C, etc. for the x- and numbers 1,2,3 etc. for the y-axis (Bader et al., 2016 Fig.2). B2, B3, C2 and C3 are the squares excavated down to “bedrock/sterile sand”. The entire stratigraphy underneath layer 2BE and 2AL reached about one meter and twenty thickness and remained undated. Cable (1984: 86) described the sediment as a homogeneous package of “*heavily leached orange soil, sub-divisible only by the presence of a layer of naturally accumulated rocks overlying Middle Stone Age artefacts*”. These MSA artifacts and a more detailed description of Cables excavation and the site were recently published (Bader et al., 2016). Here we provide a revised stratigraphic sequence due to our own renewed excavations at Umbeli Belli in 2016 and 2017. The updated stratigraphy rests on observations of color, sediment composition and artifact density. As illustrated in Fig. 2 Nr. 1 we undertook a subdivision of the archaeological sequence into eight geological horizons (GH). Since layer 1 was not preserved in each square and is supposed to be a mixture of modern and archaeological material (Cable, 1984) – plus the distinction between layer 2BE and 2AL was not evident in each square – our stratigraphy starts from GH2a, former layer 2AL. The geological horizons at Umbeli Belli are designated from top to bottom as follows:

GH2a (former layer 2AL): Munsell 5YR 5/1, 5/3. Grey reddish, silty sand with a lot of ash containing numerous brown mussels (*Perna perna*) and many small bio-galleries. Archaeological signal: Late LSA.

GH3: Munsell 5YR, 4/4. Reddish brown fine sand with silt. Numerous small pieces of quartzite spall. Artifacts without clear orientation. Increasing amount of quartzite spall in the lower parts of layer 3. Archaeological signal: Undefined LSA.

GH4: Rockfall 1. Only evident due to an increased number of quartzite spall. Some of the quartzite pieces are sharp-edged, some of them rounded and up to 20 cm in size. Layer 4 is relatively thin and marks the border between layer 3 and 5. Archaeological signal: Undefined LSA.

GH5: Munsell 5YR, 4/6. Reddish brown fine sand with significantly less quartzite spall than Layer 4. Relatively homogeneous. Archaeological signal: Undefined LSA.

GH6: Rockfall 2. Accumulation of horizontally oriented sharp-edged quartzite pieces, some of them up to 30 cm in dimensions. Consistent with Cable's layer of "naturally accumulated rocks" separating the LSA from the MSA occupation.

GH7: Munsell 5YR, 4/4. Reddish brown, fine and homogeneous sand with small amounts of quartzite spall. Archaeological signal: Final MSA.

GH8: Munsell 5YR, 4/4. Reddish brown, fine sand with larger amounts of quartzite spall compared to layer 7. Quartzite spall 2-5 cm in size and oriented in regular layers. Artifact density very high. Many artifacts observed in profile. Archaeological signal: Undefined MSA.

GH9: Munsell 5YR 5/4. Compact sand with few crusts. Relatively few artifacts but not entirely sterile. Consistent with Cable's sterile sand. Archaeological signal: Undefined MSA.

During the excavation each GH was further subdivided into very fine spits with a maximum thickness of 2 cm. These spits follow the natural slope of the sediments and do not crosscut geological horizons. This procedure allows us to detect changes in the archaeological sequence accurately and gives our data considerably high resolution. We also initialized a new 3D measurement system, using a Leica total station, which includes Cable's original squares. In order to avoid negative north-south values during the extension of the old squares we re-named Cables squares using the absolute coordinate of the squares (Fig. 1). Cables squares B4, C4 and D3 hence are 1/14, 2/14 and 3/13 in our system and are the ones relevant for this publication. We choose these square meters for the re-excavation because Charles Cable had already removed the uppermost LSA Units (1, 2BE and 2AL) and hence we were able to start the excavation immediately in GH3.

Materials and Methods

This publication concerns the morphological and physical aspects of all retouched artifacts recovered from GH7. In addition we included all unretouched blanks >2 cm and analyzed them with regard to their place within the reduction chain. We further developed a concept of core technology for the assemblage. In total, the paper deals with a sample size of 2975 artifacts. We basically apply a combined approach between the concept of *chaîne opératoire* (Boëda et al., 1990, Soressi and Geneste, 2011, Soriano et al., 2009) and attribute analysis (Andrefsky Jr, 2005, Scerri et al., 2015, Will et al., 2014). Following this procedure we are able to develop a detailed understanding of the technological system and to support our qualitative impressions with quantifiable sets of data. Since most of the retouched artifacts consist of what would be commonly described as unifacial or bifacial point (Lombard, 2006, Mohapi, 2012, Villa and Lenoir, 2006, Villa et al., 2009, Wurz, 2000, 2002), and due to our observation that the assemblage contains morphologically diverse forms, we developed a simple metrical system in order to provide comparable and quantifiable data. Because many of the tools are broken and thus insufficient for the measuring of most dimensions such as length, width and thickness we measured the width and thickness of all points no matter if unifacial or bifacial 2 cm from the distal tip. This procedure allows the inclusion of relatively small point fragments and thus produces higher sample sizes of comparable data. Further we measured the Tip Penetrating Angle (TPA) of all points using the indirect caliper method applied by Villa and Lenoir (2006) and Mohapi (2013). This was conducted by measuring the width of each point 1 cm from the tip and hence calculating the angle using a trigonometric formula provided by Dibble and Bernard (1980).

Apart from the retouched tools themselves we undertook a detailed analysis of the blanks immediately associated with the tool production, which are formally known as shaping flakes. Our definition of these flakes follows the work of Soriano and colleagues (2009) applied to a Still Bay assemblage from Sibudu (Wadley, 2007). Having said this, our analysis includes only such pieces corresponding to Soriano's definition of *Type 3 Shaping flakes*. This is due to our impression that the definition of *type 1* and *2* is relatively vague and allows abundant personal interpretation and hence subjectivity. Without criticizing the authors of the reference study above, we do not feel able to reproduce this subdivision on our own. This difference in analytical procedure needs to be considered when our data are compared to other assemblages.

Results

Stratigraphy

Our stratigraphic subdivision into eight geological horizons is founded on macroscopic observations and hence clearly needs to be tested considering archaeological signals. The sediment package of GH7 reaches a maximum thickness of 28 cm and one of the major questions concerns the correlation between geological and archaeological horizons (AH). In order to clarify whether the archaeological signal of GH7 is uniform or comprises different cultural entities we subdivided the GH into three parts ascribed as GH7.1, 7.2 and 7.3. This was conducted by clustering proportionally similar numbers of excavation spits for the three square meters considered here (Fig. 2 Nr. 2). We tested these analytical units in terms of raw material composition, absolute numbers of artifacts, type of blanks, the percentage of different kinds of tools and cores and the amount of shaping flakes. We observed slight changes, mainly in terms of raw material composition, the absolute number of shaping flakes and artifact density. In general, however, we propose the whole assemblage of GH7 to be part of the same techno-complex as illustrated below. Wherever relevant we present data for the individual sub-layers though.

Raw material

The assemblage from GH7 is highly dominated by hornfels with up to 75%, followed by quartzite (Table 1). We subdivided hornfels into three groups. Hornfels is defined as the clearly identifiably black to greenish and fine-grained material formed under contact metamorphic conditions (Cairncross, 2004). Some pieces at Umbeli Belli are heavily weathered and fragile already. Many of them looked like coarse sandstone at first glance. However since some of them broke accidentally during the excavation, we observed a black hornfels-like inner part of the pieces and hence concluded that this material must be some kind of heavily weathered hornfels. Further we found a specific variation of hornfels with a greenish color and macroscopic crystal inclusions. We were able to detect nodules of this material in the banks of the Mpambanyoni River as well and made a thin-section out of it. It turned out that this material is indeed hornfels too but was formed more distant to the immediate contact zone between the sediment rock and the intrusive rock. No evidence for a different primary outcrop can be suggested however (P. Schmidt pers. com.). This material is more coarse-grained and less homogeneous than common hornfels and hence we call it coarse-grained hornfels. Both variations rarely occur (Table 1). After hornfels in its different kinds of variation and quartzite including a green variation, quartz is the third most frequent raw material of GH7 and especially in the upper part of the sequence GH7.1. About 16% of all blanks from GH7 exhibit cortical surfaces and depending on raw material between 71-100% of them exhibit fluvial cortex (Table 2).

This confirms the author's previous observation (Bader et al., 2016) that people during the MSA of Umbeli Belli commonly used river cobbles from the nearby Mpambanyoni River. Taking into account the variation of raw material throughout the sequence, the most significant change is the increasing percentage of quartzite and even more quartz in favor of decreasing hornfels percentages from GH7.3 to GH7.1. Quartz increases from 3.6% in GH7.3 to 13.2% in GH7.1 and hornfels decreases from 74.9% to 62.9%.

The tool assemblage of GH7

In this chapter we distinguish between two general groups of tools namely chipped tools and non-chipped tools. The first group consists of all retouched artifacts, including splintered pieces, and represents 7.7% of the entire assemblage. The second group (0.4%) describes indirect tools or ones that have been used in order to produce other tools, designated as non-chipped tools (NCT) (Table 1). These are 10 hammer stones made out of quartz, quartzite and rarely hornfels on the one hand and a single grinding stone out of sandstone on the other hand. The chipped tool assemblage is dominated by pointed forms with 48%. These pieces exhibit in 37% a unifacial retouch and in 63% a bifacial or at least partly bifacial one. However in this paper we want to take one step back from traditional tool designations such as unifacial or bifacial point and offer an alternative approach with respect to other morphological and physical features that might have been more desirable to prehistoric hunter-gatherers. Basically this concerns the shape of those pieces, the angle of the distal tip formally known as TPA, the relation between width and thickness, the overall symmetry and the facility of hafting. Based on these criteria we were able to distinguish between two different groups of points that we call broad heads and target points (Fig. 3 & 4). These descriptions derive from modern arrowheads where broad heads are flat triangular tips with sharp lateral barbs. These tips are used for hunting purpose since the lateral barbs cause increased amounts of internal bleeding. Contrary to that target points have a bullet-like shape, are elongated and thicker and have no lateral barbs. They are basically used for practicing purposes since they are more robust and due to the absence of the lateral cutting edges deflection caused by wind etc. is less. These names are clearly biased since they imply that the points at Umbeli Belli have been used as projectiles. However it is first unquestionable that people intensively produced and used projectiles throughout the MSA (Backwell et al., 2008, Pargeter, 2007, Rots et al., 2017, Shea, 2006, Villa and Lenoir, 2006, Wadley, 2005a) and recently our own work on a small sample of points from Cable's Umbeli Belli assemblage using residue and use wear analysis brought additional evidence for this usage (Bader et al., 2016). It is secondly often useful to choose a biased name that evokes certain kinds of association in order to keep things in mind. Rice grain cores (Davis, 1980), laurel leaf points (Goodwin and van Riet Lowe, 1929) or bullet cores (Wilke, 1996) are biased names as well but everyone has relatively clear

morphological associations with these names. This is our aim using descriptions such as broad heads and Target Points.

Broad Heads & Target Points at Umbeli Belli

A broad head (Fig. 3) is a relatively thin and short triangular point with straight convergent edges. The base of these pieces is either straight (orthogonal to the tip) or hollow and exhibits frequent basal thinning. A broad head can be shaped either unifacially or bifacially and has a relatively wide TPA, sometimes over 100°. The mean value at Umbeli Belli is 71°. The lateral edges are sharp and the cross section is plano-convex. One of the most striking features is the ratio of width to thickness of ~4/1 measured 2 cm from the tip.

By contrast a target point (Fig. 4) is a relatively thick and elongated oval shaped point with slightly convex convergent edges. The base is always straight but exhibits frequent basal thinning as well. It can be either unifacially or bifacially shaped and has always a very acute TPA never exceeding 84°. The mean value at Umbeli Belli is 53°. Compared to broad heads the lateral edges are steeper. The cross section of target points is plano-convex and the width to thickness ratio is ~2/1, measured 2 cm from the tip.

Both broad heads and target points have been shaped intensively and most of them show either invasive or surface retouch (Bader et al., 2016). If these points are bifacial or at least partly bifacial than the ventral removals are always very flat producing a very sharp lateral edge comparable to a hollow ground knife. In both tool categories more than 60% exhibit a bifacial or partly bifacial retouch. Almost 18% of all chipped tools in GH7 are broad heads (Table 3) and their number decreases from bottom to the top (~20% in GH7.3 and 7.2 and 11% in GH7.1). This tool category includes four highly diagnostic hollow-based points (Fig.3 Nr. 1-4) and although e.g. Fig. 3 Nr. 2 and 4 have penetrating angles that lie within the scope of target points, the overall criteria in terms of shape and metrical ratios clearly fit with the broad heads. Table 4 shows relevant metrical values distinguishing broad heads from target points. Most evident are the differences in width/thickness ratio and TPA. Target points are with 21.4% the most common tool type in GH7 and similar to the broad heads their number slightly decreases from 24.3% in GH7.3 to 17.4% in GH7.1. Since a high percentage of both tool categories exhibits intensive bifacial shaping we do not feel confident in making absolute statements about the blank types that have been used. However we see a trend that broad heads have commonly been shaped out of relatively wide and thin flakes as indicated by Fig. 3 Nr. 1 and 8-11. Target points on the other hand seem to be made on thick and elongated blanks. Fig.4 Nr. 9 shows an example made on a thick, cortical blade and Fig. 4 Nr. 10 and 11 illustrate two preforms having been shaped beginning from the distal tip. Finally broad heads and target points

at Umbeli Belli are made to 100% from hornfels. We do not assume that this is a general feature for the definition of these pieces but at least at Umbeli Belli people were using this material exclusively. Together broad heads and target points represent 39.3 % of all chipped tools and thus the most distinct coherent signal of the studied assemblage.

Other tools

As every lithic assemblage GH7 at Umbeli Belli also encompasses a certain degree of variability. We identified three other consistent groups of chipped tools next to broad heads and target points. Those are first “bifacial tools”, second “ACT’s” and third “backed tools” (see description below and Fig. 5). 17.9% of all tools further are simply grouped together under the description “formal tools” including pieces like retouched flakes or blades (Fig. 5 Nr. 8 & 9) and some isolated scrapers (Fig.5 Nr. 10 and 12) and splintered pieces (Fig. 5 Nr. 13 & 14). Fig. 5 Nr. 11 can best be described as tanged or stemmed piece. This may raise questions at the first hand but both, JD Clark (1959) and Amelia Clark (1997) have documented few stemmed or tanged points associated with final MSA assemblages and thus finding a similar signal at Umbeli Belli is not surprising. Another 25% designated as broken tools consists of pieces that exhibit retouched edges but are too fragmented in order to bring them into any kind of comprehensible grouping. Finally 4.4% are broken points. Those are tiny tip fragments of unifacial or bifacial points not suitable for any further classification.

Bifacial tools

This category describes a few bifacial points that neither fit with the description of broad heads nor with the one of target points and represent 4.4% of the tool assemblage. The category includes true bifacial points and some preforms. Generally speaking, the end product described as true bifacial point here has a teardrop shape with a round convex base and slightly convex convergent lateral edges. Those pieces always exhibit basal thinning and are entirely bifacial. The TPA lies between 50-60° and contrary to broad heads and target points the cross section is bi-convex (Fig. 5 Nr. 6 and 7). Those pieces are made basically on quartzite, but also on quartz and hornfels.

ACT’s

Asymmetric convergent tools (ACTs) have been described already for the Sibudan assemblage of Sibudu (Will et al., 2014) and always have one curved and steeply retouched edge opposed to a sharp, frequently unretouched and straight edge. We will not address the techno-functional aspect of these pieces here since it is out of our research scope. However we adopted the name proposed by Will et al. (2014) in order to avoid confusion and because this descriptive taxonomy fits well with the pieces from Umbeli Belli. 5.2% have thus been assigned ACT (Fig. 5 Nr. 1 and 2) and are made

mostly on hornfels but in two cases on quartzite as well. The overall morphology of ACTs implies that the blunt retouched edge was designed for hafting facilities while the opposed unretouched edge was probably used for cutting activities. We have slight evidence for this hypothesis from a reddish stain on the ventral face of Fig. 5 Nr. 2 close to the blunt retouched edge. Ochre has been widely accepted as component of hafting adhesives (Wadley, 2005a) and thus this and other pieces will undergo residue and use wear analysis in the future in order to test our hypothesis.

Backed tools

The category backed tool at Umbeli Belli represents 3.5% of the entire chipped tool assemblage and includes blades and bladelets with one edge backed to a 90° angle which is opposed to a straight sharp cutting edge. Generally researchers have subdivided these tools into segments and trapezoids (Deacon, 1984, Wadley and Mohapi, 2008), the former one having a round shaped, backed edge and the last a trapezoidal one. Both types exist at Umbeli Belli (Fig. 5 Nr. 3-5) but due to the small number (N=8) we grouped them together. Segments and trapezoids represent the type fossils of the Howiesons Poort and have been subject to far reaching debates about modern human behavior basically due to strong similarities to Later Stone Age segments and their possible association with bow and arrow technology (Stapleton et al., 1927, Lombard & Phillipson, 2015). Nevertheless, as indicated here and by several other researchers, these tools are not limited to the Howiesons Poort and it is more their frequency that should be considered to be characteristic (Kaplan, 1989, 1990 Wadley, 2005b, Will et al., 2014).

Technological aspects

Shaping flakes

Shaping flakes are well represented at GH7 in Umbeli Belli (Fig. 6). Out of a total of 2934 blanks 500 pieces have been designated as shaping flakes making up to 17% (Table 5). With reference to the stratigraphic subdivision these flakes decrease in percentage from GH7.3 with 23.5% and 14.6% in GH7.2 to 9.2% in GH7.1. These specific flakes firstly described by Soriano et al. (2009) are directly linked to the production of surface shaped tools. Defining features are a lip, a low EPA, numerous negatives of previous removals on the dorsal surface (most of them oriented orthogonal to each other), a curved profile and mostly divergent or parallel lateral edges (Soriano et al., 2009). Further these pieces are supposed to be very thin. As pointed out above, we included only pieces associated with the final shaping stage (Type 3 flakes). We considered a flake to be a shaping flake if it bears a minimum of three of the features described above. We further subdivided them into bifacial and

unifacial shaping flakes by assuming a prepared platform to be the result of previous removals on the opposite surface of the tool. Soriano and colleagues did not undertake this separation probably because the Still Bay assemblage they were dealing with was almost entirely bifacial. However at Umbeli Belli large proportions of tools exhibit surface retouch only on one face and this clearly must result in shaping flakes as well. Unifacial shaping flakes are basically equivalent with retouch flakes described by Porraz (2005) and Conard et al. (2012). But since most of the pieces from Umbeli Belli are bigger than 2 cm and hence affected large proportions of the tool's surface we suggest the term unifacial shaping flake to be better suited here (see also Bader et al., 2016). In addition we included pieces without proximal preservation if they showed at least three other criteria and summarized them under the definition indeterminate shaping flakes. Unifacial pieces are with 7% the most common ones followed by indeterminate and bifacial ones (Table 5). Over 90% of all three kinds of shaping flakes are made out of hornfels. This corresponds well with the observation that surface shaped tools, especially broad heads and target points, are almost entirely made out of hornfels (Table1). Table 6 provides detailed metrical information about bifacial and unifacial shaping flakes. A few major differences have been observed though. Both are very thin exhibiting maximum thickness mean values between 2-3 mm. The shaping flakes at Umbeli Belli reach large dimensions over 50 mm in length and width (Fig. 6 Nr. 1-3) and some of them may be knapping accidents as indicated by Fig. 3 Nr.7. The length and width mean values for both types however lie in between 20 and 25 mm. The platform morphology of the shaping flakes is linear as described by Soriano and colleagues (2009) and the mean values of the EPA range around 60°, whereas 45° represents the lower limit for both types. The values for the platform width are the only ones differing to a major extent. While the mean value for unifacial pieces is 5.7 mm, bifacial pieces reach a value of 9.8 mm which is almost twice as much. Also the maximum dimension of platform width is much bigger for bifacial than for unifacial pieces. We interpret this as being related to our observation that frequent bifacial tools, especially target points (e.g. Fig. 4 Nr. 1, 4-8) show relatively few but wide removals on the ventral face compared to numerous but small removals on the dorsal face. This further explains the confusing observation that bifacial tools are more common than unifacial ones but unifacial shaping flakes on the other hand are more common than bifacial ones. Hence we can draw the conclusion that for the most surface-shaped tools (and taking aside the "true bifacial" category) shaping was conducted basically in a unifacial way but frequent bifacial reduction added sharpness, thinning and suited knapping angles.

Finally we point out that the 17% calculated for the shaping flakes in GH7 are likely to be an underestimation. Numerous pieces could not be included due to a high degree of fragmentation. However once we measured the maximum thickness for all blanks, no matter if fragmented or not, it turned out that hornfels blanks are in general much thinner than those ones made out of quartz or

quartzite. The mean values for the hornfels blanks range well within the borders of shaping flakes (Fig. 7). Taking this into account the true proportion of shaping flakes in the final MSA assemblage of Umbeli Belli is probably much bigger and even comparable to the figure Soriano describes with 28% (Type 3 shaping flakes) for the Still Bay Layers at Sibudu.

Cores and blanks

Although the current paper is primarily concerned with the retouched component of GH7 a certain understanding of the reduction steps taking part on site is essential for all further interpretations. Several anomalies in core technology have been observed. First, the number of cores is very low. A total of 21 cores represent 0.7% of the entire assemblage (Table 1). Second, we observed a strong disparity between the number of hornfels cores and blanks. Although hornfels is the most common raw material throughout the sequence (Table 1), reaching values between 63-75%, cores made out of this material are scarce. Only five out of 21 cores are made from hornfels (Table 7). Having said this, more than the half of all cores is made out of quartz standing in contrast to the low number of quartz blanks. Beside this however we see a clear overall technological signal. 15 out of 21 cores can be summarized under the broad category of platform cores as defined by Conard and colleagues (2004). Further 14 out of them share distinct features. The most distinct common feature of these cores is an acute angle between knapping and removal surface between 55-80° (measured directly using a goniometer). About half of the knapping surfaces show secondary trimming. Most of these cores have a relatively flat back and a sometimes more, sometimes less convex ventral removal surface exhibiting lateral preparation in order to keep the ventral convexity upright. This can appear either on one or both laterals. Some of these cores have been turned around after the main removal surface was exhausted and reduced along the opposing (dorsal) face, using the former distal end as a platform. This special kind of platform core (Fig. 8 Nr. 1, 3 & 4) is neither limited to a certain type of end-product, nor to a specific raw material type. They have been made out of hornfels, dolerite, quartz and quartzite and used for the detachment of blades, flakes and bladelets. The most common blank types in general are flakes but blades represent 7.5% of the entire assemblage as well (Table 8). The acute angle of these cores points towards marginal rather than internal percussion in order to detach blanks. A high number of blanks not having been identified as shaping flakes exhibits lips on the proximal part (n=171) and the overall character of the blanks is relatively flat. Some of the cores are very flat as well and show flat blade or flake removals, e.g. Fig. 8 Nr. 3, supporting the idea that marginal percussion was common in GH7 at Umbeli Belli. Few other cores such as bipolar ones (Fig. 8 Nr. 5) or a single flat bladelet core (Deacon, 1984) are represented too. Contrary to our previous observations on the old assemblage from 1979 (Bader et al., 2016) we identified a well-structured

archaeological signal in GH7 having a distinct and recurrent core technology. We explain these differences to be basically influenced by our different and higher-resolved sampling strategy.

Discussion

More than one decade has passed since the final MSA of eastern South Africa has been announced explicitly (Wadley, 2005b). Apart from a couple of studies dealing either with specific types of tools (Mohapi, 2012, 2013) or the attempt to figure out a general understanding of cultural change throughout the MSA on a sub-continental level (Lombard et al., 2012, Mackay et al., 2014a) we still know little about the nature and variability of the final MSA. Besides one reason being the scarcity of known archaeological sites comprising relevant occupational horizons, the disproportionately high research emphasis put on Still Bay and Howiesons Poort assemblages may have accounted for this situation as well (d'Errico et al., 2008, de la Peña and Wadley, 2014a, b, de la Peña et al., 2013, Henshilwood, 2012, Henshilwood et al., 2009, Lombard et al., 2010, McCall and Thomas, 2012, Soriano et al., 2015, Villa et al., 2009, Wadley, 2007). The preservation of organic artifacts, evidence for symbolic behavior and personal ornaments have been driving agents of this focus just like a relatively homogeneous and advanced lithic technology. Succeeding assemblages during MIS3 indeed are more diverse and seem to exhibit a higher degree of regionalization (Bader et al., 2015, 2016, Conard et al., 2012, 2014, Conard and Will, 2015, Mackay et al., 2014a, b, Will et al., 2015; Will and Conard 2017). Most researchers will agree, however, that people living during MIS3 had the same mental capacities as those living in MIS4 or MIS2 and we strongly agree with Kandel and colleagues (2016) who suggest behavioral flexibility being probably the most important aspect during the MSA. Thus regionalization detected in lithic assemblages represents highly flexible behavior and needs to be considered with the same attention as organic tools, ornaments and art.

In the final MSA occupation at Umbeli Belli we were able to detect a specialized toolkit comprising clear diagnostic features which we designated as broad heads and target points. These tools have been identified using few but clearly defined and easily traceable properties. We suggest that the recurrent observation of the distinct shape of these tools cannot be entirely the result of a re-sharpening cycle (Dibble, 1995, Krukowski, 1939), since we observed similarly shaped points exhibiting different degrees of retouch (e.g. Fig. 3 Nr. 2 vs. Nr. 4). We rather believe them to be designed in a particular way respectively beginning already with the selection of the blank. Although the methodological approach we applied here does not include techno-functional investigations of our previous studies (Bader et al., 2015, Conard et al., 2012, Will et al., 2014) it would be applicable as well. We suggest that the specific shape of broad heads and target points was desired by the knappers but it is likely that the pieces have been subject to curation activities (Bamforth, 1986, Odell, 1996) that preserved this shape and also the physical properties described above. This reflects

the idea of e.g. Tongati tools (Conard et al., 2012) becoming shorter during their use life but preserving the distal triangular morphology. Far-reaching analyses of use trace and residues are required in order to test the function of broad heads and target points but due to the symmetry, morphology and TPA of both types we suggest a use as projectiles to be possible and probably as likely as for the Still Bay points of Blombos Cave (Villa et al., 2009). In any case we would expect these pieces to be perfectly suited for piercing and cutting purposes (Soressi, 2004).

The broad head assemblage from Umbeli Belli includes four hollow-based points. These tools have been so far the only recurrent archaeological signal associated with the end of the MSA in eastern South Africa. Thus at this stage this tool type needs to undergo a critical review. Hollow-based points may represent the most rarely described tools in the entire sub-continent South Africa. Taking together all known specimens from Umhlatuzana, Sibudu, Umbeli Belli, Border Cave and Kleinmonde only 26 pieces have been published, raising multiple questions. Several hypotheses about the scarcity of these pieces come to mind including them having symbolic value (Henshilwood and Dubreuil, 2011, Henshilwood et al., 2001, Wurz, 1999), representing emblematic or assertive style (Wiessner, 1983, 1989) or providing evidence for a link to similar cultural entities in different parts of Africa as suggested by Clark (1959). Having said this, an isolated artifact without a technological framework should never be used to test highly debated theories. We need to elaborate archaeological signals and provide reproducible information in order to test any kind of higher theory. At Umbeli Belli and other sites, hollow-based points are part of an archaeological signal, but not the defining feature alone. A defining feature is for example the overall presence of basal thinning on almost every point with proximal preservation. Out of 23 broad heads with proximal preservation at Umbeli Belli 19 show basal thinning and out of 18 target points 16 provide similar evidence. From a technological point of view a hollow base is a certain kind of basal thinning as well and Mohapi (2012, 2013) suggested this to stand in association with hafting facilities. This hollow base can be created either by intense and exact shaping (Fig. 3 Nr. 2) or by simply one or two blows to the proximal end (Fig. 3 Nr. 4). The hollow bases of the four pieces from Umbeli Belli and also the ones from Sibudu, Umhlatuzana and Kleinmonde are not identical (Fig. 9). There is clear variation in terms of symmetry, depth and accuracy. Some of them show almost straight and only slightly hollow-shaped bases, while others are deeply incised.

If we accept hollow bases to be a hafting facility we must first think about the way these pieces could have been hafted. No bending fractures or notches have been observed on the four pieces from Umbeli Belli. Further it would seem to be irrational to cover the wide and sharp lateral edges of these symmetrically shaped tools with robe or glue and hence diminish the extend of cutting edges (Mackay, 2008) especially if they were used as projectiles indeed (Knecht, 1997, Villa et al., 2009).

Therefore one likely scenario could be the insertion into a split wooden shaft which is significantly smaller in width than the point. Fixing could be done using glue on the medial part of the point and bending of the wooden shaft in order to keep the point in place simply via tension. Certainly replica experiments and analysis of use wear and residues are necessary to test this hypothesis. But staying on a theoretical ground for the moment such kind of hafting would likely affect damage on the proximal hollow edge if some kind of force hits the tip. Hence maintaining such a tool could likely result in deeper hollow bases without influencing the morphology of the lateral cutting edges. We included hollow-based points into the category of Broad Heads because apart from the hollow base they share all other features with them. A broad head with a straight base further could easily be hafted the same way as those with a hollow base and a straight base can easily be transformed into a hollow one. We clearly cannot exclude the possibility that most broad heads without a hollow base are actually preforms having been discarded before the final stage of production. Among others, Villa and colleagues (2009) identified most Still Bay points of Blombos cave being discarded in an early stage of production and only 40% of all points having received final shaping. At Umbeli Belli, however, the percentage of hollow-based points in relation to all broad heads is only 10%. Further as indicated by Fig. 9 Nr.1, 9 & 10 the hollow base is not necessarily bound to intensive overall shaping. It is rather an isolated property that can be applied to any kind of point no matter if retouched, shaped or not. Hence we state that it is likely that the hollow base is either the result of tool maintenance (Bamforth, 1986, Shott, 1986, 1989) or indeed a stylistic variation within the category of broad heads. This would fit with Wiessner's (1983) observation on !Kung projectiles being made by the same hunter over a certain period of time but showing strong variation among others on the base. Accepting the possibility that straight-based broad heads can be hafted the same way as hollow-based ones, we could argue that the hollow base has actually no functional aspect and hence must be stylistic as suggested by Stiles (1979). Further investigations, especially of the comparative assemblages from Sibudu and Umhlatuzana are required to test our hypothesis. But the close distance of between 60 to 90 km of all three sites and the previously suggested narrow temporal framework around 35 ka (Kaplan, 1989, Wadley, 2005b) may provide an ideal ground for further-reaching discussions dealing with questions of style, group identity and exchange networks (Wiessner, 1977, 1982). Certainly in addition we need to increase our understanding of human landscape use and settlement patterns during the entire MSA of KwaZulu-Natal. Dense vegetation, the destruction of especially open air sites during the past centuries (Maguire, 1997) and the research emphasis on caves and rock shelters may have led to misleading depictions similar to other regions of South Africa (Mackay et al., 2014b).

Turning back to a site-based scale, processes and activities at Umbeli Belli in prehistoric times remain to be evaluated. This, however, requires more data going beyond the analysis of lithic assemblages.

As indicated in our previous article on Umbeli Belli (Bader et al., 2016) we could confirm that organic remains are poorly preserved. Only three bones are preserved from GH7 but they are heavily weathered and fragmented. Even within an exclusive knapping site we would expect a higher percentage of organic artifacts though and thus preservation clearly is an issue at Umbeli Belli. Micromorphological investigations are under way but for now we state that the sediment must be highly acidic. This was observed on some of our dosimeter tubes being heavily corroded after one year in the sediment. We observed several dripping spots within the shelter during the rainy season as well as nesting birds. Bat guano or guano in general in association with water influence might have had a destructive influence on preservation of organic artifacts (Miller et al., 2013, Shahack-Gross et al., 2004). Apart from this poor organic preservation we recovered a large assemblage of 153 ochre pieces from GH7. Although ochre is not the topic of the current paper we can report for now that some of those pieces show evidence of grinding and even knapping. Taking aside every kind of symbolic context (Henshilwood et al., 2009, 2011, Mackay, 2010) and taking into account the high percentage of shaping debitage and tools we suggest that ochre might be related to the production and hafting of tools at Umbeli Belli (Bader et al., 2016, Soriano et al., 2009, Wadley, 2005a). Although further evidence is required in our recent publication on Cables assemblage (Bader et al., 2016) C. Lentfer confirmed that ochre was associated with hafting points at Umbeli Belli.

Finally we need to evaluate the meaning of the relative scarcity of cores, especially on hornfels. A total of 21 cores represent 0.7% of the entire assemblage. This is surprisingly low and comparable percentages for the Sibudan/post-HP assemblages of Sibudu forced Conard and Will (2015) to suggest that knappers frequently exported non exhausted cores. This theory could be applied to Umbeli Belli as well but we rather suggest alternative interpretations based on observations on the overall lithic assemblage. A large proportion of over 17% of the blanks is associated with a final stage of knapping (shaping) rather than an initial one. Yet 6% of all blanks exhibit more than 50% cortex, mostly fluvial cortex and show that initial reduction sometimes took place on the site as well. We do not know exactly about the dimensions of the primary raw material cobbles but based on the tool dimensions, especially those of target points, they must have been relatively large. Most of the cores we find at Umbeli Belli are exhausted. Knapping experiments, including our own, have shown that the preparation of a cobble and shaping of a tool results into several hundreds of flakes (>2cm) and thousands of small debitage pieces. Hence it is not surprising to find so few cores at Umbeli Belli. Further Umbeli Belli could represent a special case due to its close proximity to the Mpambanyoni River which is rich in raw materials. As suggested previously (Bader et al., 2016) it is likely that knappers at the site imported large flakes and blades in order to finalize their shaping there rather than the export of cores. The overall archaeological signal of GH7 at Umbeli Belli is well-structured, comprises morphologically distinct tool forms and a recurrent concept of flaking technology.

Conclusion

This study represents the first detailed analysis of a final MSA assemblage in eastern South Africa in more than a decade. This period has been poorly understood so far and apart from the isolated phenomenon of “hollow-based points” its treatment remained relatively informal. The final MSA marks the border to the LSA, the first period that was commonly accepted to feature a material culture similar to that of recent hunter-gatherer groups. Even though few widely accepted transitional industries between the MSA and LSA exist, the final MSA bears great potential to improve our understanding of cultural dynamics and their variation at the end of the MSA. It is further the key period in order to test in how far a strict distinction between MSA and LSA holds in light of an increasing awareness of complexity during the MSA. Thus the lack of research on this period is astonishing. The current study demonstrates that the lithic technology of the final MSA is by no means less sophisticated than other MSA technologies. The assemblage from GH7 at Umbeli Belli features a clear archaeological signal comprising an elaborate method of tool production and a well-structured core technology. Prehistoric hunter-gatherers at Umbeli Belli repeatedly produced pointed forms and many of them are well-suited for hunting activities. We could show that the exceptional hollow-based points of the final MSA are no isolated phenomenon and should be seen as an embedded feature of a diagnostic techno-complex. Although no organic artifacts are preserved, the scientific potential of Umbeli Belli has been underestimated so far and we propose that this forgotten rock shelter can serve as a reference site for the final MSA in KwaZulu-Natal.

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References

- Andrefsky Jr, W. 2005. *Lithics: Macroscopic approaches to analysis*. Cambridge: Cambridge University Press.
- Backwell, L., D'errico, F. & Wadley, L. 2008. Middle Stone Age bone tools from the Howiesons Poort layers, Sibudu Cave, South Africa. *Journal of Archaeological Science*, 35: 1566-1580.
- 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. *The South African Archaeological Bulletin*, 70: 149-165.
- Bader, G. D., Cable, C., Lentfer, C. & Conard, N. J. 2016. Umbeli Belli Rock Shelter, a forgotten piece from the puzzle of the Middle Stone Age in KwaZulu-Natal, South Africa. *Journal of Archaeological Science: Reports*, 9: 608-622.
- Bamforth, D. B. 1986. Technological Efficiency and Tool Curation. *American Antiquity*, 51: 38-50.
- Beaumont, P. B. 1978. *Border Cave*. Unpublished Ph.D. thesis. University of Cape Town.
- Binford, L. R. 1978. *Nunamiut ethnoarchaeology*, New York/London: Academic Press.
- Boëda, E., Geneste, J.-M. & Meignen, L. 1990. Identification de chaînes opératoires lithiques du Paléolithique ancien et moyen. *Paléo*, 2: 43-80.
- Brown, K. S., Marean, C. W., Herries, A. I. R., Jacobs, Z., Tribolo, C., Braun, D., Roberts, D. L., Meyer, M. C. & Bernatchez, J. 2009. Fire as an engineering tool of early modern humans. *Science*, 325: 859-862.
- Butzer, K. W., Beaumont, P. B. & Vogel, J. C. 1978. Lithostratigraphy of Border Cave, KwaZulu, South Africa: a Middle Stone Age sequence beginning c. 195,000 b.p. *Journal of Archaeological Science*, 5: 317-341.
- Cable, C. 1984. *Economy and technology in the Late Stone Age of southern Natal*. Cambridge Monographs in African Archaeology. BAR.
- Cairncross, B. 2004. *Field guide to rocks & minerals of Southern Africa*. Capetown: Struik.
- Chase, B. M. & Meadows, M. E. 2007. Late Quaternary dynamics of southern Africa's winter rainfall zone. *Earth-Science Reviews*, 84: 103-138.
- Clark, A. M. B. 1997. The final Middle Stone Age at Rose Cottage Cave: a distinct industry in the Basutolian ecozone. *South African journal of science*, 93: 449-458.
- Clark, J. D. 1959. *The prehistory of Southern Africa*. Harmondsworth: Penguin Books.
- Conard, N. J. & Will, M. 2015. Examining the causes and consequences of short-term behavioral change during the Middle Stone Age at Sibudu, South Africa. *PLoS ONE*, 10: e0130001.
- Conard, N. J., Soressi, M., Parkington, J. E., Wurz, S. & Yates, R. 2004. A unified lithic taxonomy based on patterns of core reduction. *South African Archaeological Bulletin*, 59: 12-16.
- Conard, N. J., Porraz, G. & Wadley, L. Y. N. 2012. What is in a name? characterizing the Post-Howiesons Poort at Sibudu. *The South African Archaeological Bulletin*, 67: 180-199.
- Conard, N. J., Bader, G. D., Schmid, V. C. & Will, M. 2014. Bringing the Middle Stone Age into clearer focus. *Mitteilungen der Gesellschaft für Urgeschichte*, 23: 121-127.
- Cramb, J. 1952. A Middle Stone Age industry from a Natal rock shelter. *South African Journal of Science*, 48: 181-186.
- Cramb, J. 1961. A second report on work at the Holley Shelter. *South African Journal of Science*, 57: 45-48.
- Davis, M. F. 1980. *Some aspects of Elands Bay Cave stone artefacts*. Unpublished B.A. (Hons.) Thesis, University of Cape Town.
- D'Errico, F. & Backwell, L. 2016. Earliest evidence of personal ornaments associated with burial: The conus shells from Border Cave. *Journal of Human Evolution*, 93: 91-108.
- D'Errico, F., Henshilwood, C., Vanhaeren, M. & Van Niekerk, K. 2005. Nassarius kraussianus shell beads from Blombos Cave: evidence for symbolic behaviour in the Middle Stone Age. *Journal of Human Evolution*, 48: 3-24.
- 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: 2675-2685.

- De La Peña, P. & Wadley, L. 2014a. New knapping methods in the Howiesons Poort at Sibudu (KwaZulu-Natal, South Africa). *Quaternary International*, 350: 26-42.
- De La Peña, P. & Wadley, L. 2014b. Quartz Knapping Strategies in the Howiesons Poort at Sibudu (KwaZulu-Natal, South Africa). *PLoS ONE*, 9: e101534.
- De La Peña, P., Wadley, L. & Lombard, M. 2013. Quartz bifacial points in the Howiesons Poort of Sibudu. *South African Archaeological Bulletin*, 68: 119-136.
- Deacon, J. 1984. *The Later Stone Age of southernmost Africa*, Oxford, BAR.
- Dibble, H. L. 1995. Middle paleolithic scraper reduction: Background, clarification, and review of the evidence to date. *Journal of Archaeological Method and Theory*, 2: 299-368.
- Dibble, H. L. & Bernard, M. C. 1980. A comparative study of basic edge angle measurement techniques. *American Antiquity*, 45: 857-865.
- Goodwin, A. J. H. & Van Riet Lowe, C. 1929. The Stone Age cultures of South Africa. *Annals of the South African Museum*, 27: 1-289.
- Grine, F. E., Henshilwood, C. S. & Sealy, J. C. 2000. Human remains from Blombos Cave, South Africa: (1997–1998 excavations). *Journal of Human Evolution*, 38: 755-765.
- Grün, R. & Beaumont, P. 2001. Border Cave revisited: a revised ESR chronology. *Journal of Human Evolution*, 40: 467-482.
- 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: 205-237.
- Henshilwood, C. S., D'errico, F., Vanhaeren, M., Van Niekerk, K. & Jacobs, Z. 2004. Middle Stone Age shell beads from South Africa. *Science*, 304: 404-404.
- Henshilwood, C. S. & Dubreuil, B. 2011. The Still Bay and Howiesons Poort, 77–59 ka: Symbolic material culture and the evolution of the mind during the African Middle Stone Age. *Current Anthropology*, 52: 361-400.
- Henshilwood, C. S., Sealy, J. C., Yates, R., Cruz-Uribe, K., Goldberg, P., Grine, F. E., Klein, R. G., Poggenpoel, C., Van Niekerk, K. & Watts, I. 2001. Blombos Cave, southern cape, South Africa: Preliminary report on the 1992–1999 excavations of the Middle Stone Age levels. *Journal of Archaeological Science*, 28: 421-448.
- Henshilwood, C. S., D'errico, F. & Watts, I. 2009. Engraved ochres from the Middle Stone Age levels at Blombos Cave, South Africa. *Journal of Human Evolution*, 57: 27-47.
- Henshilwood, C. S., D'errico, F., Van Niekerk, K. L., Coquinot, Y., Jacobs, Z., Lauritzen, S.-E., Menu, M. & García-Moreno, R. 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. *Science*, 334: 219-222.
- Henshilwood, C. S., Van Niekerk, K. L., Wurz, S., Delagnes, A., Armitage, S. J., Rifkin, R. F., Douze, K., Keene, P., Haaland, M. M., Reynard, J., Discamps, E. & Mienies, S. S. 2014. Klipdrift Shelter, southern Cape, South Africa: preliminary report on the Howiesons Poort layers. *Journal of Archaeological Science*, 45: 284-303.
- Hodder, I. 1983. *The present past: an introduction to anthropology for archaeologists*. London: Pica Press.
- Kandel, A. W., Bolus, M., Bretzke, K., Bruch, A. A., Haidle, M. N., Hertler, C. & Märker, M. 2016. Increasing behavioral flexibility? An integrative macro-scale approach to understanding the Middle Stone Age of Southern Africa. *Journal of Archaeological Method and Theory*, 23: 623-668.
- Kaplan, J. 1989. 45000 years of hunter-gatherer history in Natal as seen from Umhlatuzana Rock Shelter. *Goodwin Series*, 6: 7-16.
- Kaplan, J. 1990. The Umhlatuzana rock shelter sequence: 100 000 years of stone age history. *Southern African Humanities*, 2: 1-94.
- Kelly, R. L. 1983. Hunter-Gatherer mobility strategies. *Journal of Anthropological Research*, 39: 277-306.
- Klein, R. G. 1977. The Mammalian Fauna from the Middle and Later Stone Age (Later Pleistocene) Levels of Border Cave, Natal Province, South Africa. *The South African Archaeological Bulletin*, 32: 14-27.

- Knecht, H. 1997. Projectile points of bone, antler and stone: experimental exploration of manufacture and use. In: Knecht, H. (ed.) *Projectile Technology*. New York: Plenum Press.
- Krukowski, S. 1939. Paleolit. Prehistoria Ziemi Polskich. In: Krukowski, S., Kostrzewski, J. & Jakimowicz, R (eds.) *Prehistoria Ziemi Polskich. Encyklopedia Polska*. Krakow: Polska: Polska Akademia Umiejetnosci.
- Lee, R. B. 1968. What hunters do for a living, or, how to make out on scarce resources. In: Lee, R.B., DeVore, I. (eds.) *Man the hunter*. Chicago: Aldine Publishing Company.
- Lombard, M. 2006. First impressions of the functions and hafting technology of Still Bay pointed artefacts from Sibudu Cave. *Southern African Humanities*, 18: 27-41.
- Lombard, M. & Haidle, M. N. 2012. Thinking a bow-and-arrow set: Cognitive implications of Middle Stone Age bow and stone-tipped arrow technology. *Cambridge Archaeological Journal*, 22: 237-264.
- Lombard, M. & Phillipson, L. 2015. Indications of bow and stone-tipped arrow use 64 000 years ago in KwaZulu-Natal, South Africa. *Antiquity*, 84: 635-648.
- Lombard, M., Wadley, L., Jacobs, Z., Mohapi, M. & Roberts, R. G. 2010. Still Bay and serrated points from Umhlatuzana Rock Shelter, Kwazulu-Natal, South Africa. *Journal of Archaeological Science*, 37: 1773-1784.
- Lombard, M., Wadley, L. Y. N., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., Swart, J. & Mitchell, P. 2012. South African and Lesotho Stone Age sequence updated. *The South African Archaeological Bulletin*, 67: 123-144.
- Mackay, A. 2008. A method for estimating edge length from flake dimensions: use and implications for technological change in the southern African MSA. *Journal of Archaeological Science*, 35: 614-622.
- Mackay, A. 2010. The Late Pleistocene archaeology of Klein Kliphuis Rock Shelter, Western Cape, South Africa: 2006 Excavations. *The South African Archaeological Bulletin*, 65: 132-147.
- 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.
- Maguire, R. 1997. A history of middle and late stone age research in the KwaZulu-Natal coastal area from 1871 to the beginning of the second world war. Studies in honor of Professor J. Eloff. National Cultural History Museum, 6: 43-58.
- Mcbrearty, S. & Brooks, A. S. 2000. The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution*, 39: 453-563.
- Mccall, G. S. & Thomas, J. T. 2009. Re-examining the South African Middle-to-Later Stone Age transition: Multivariate analysis of the Umhlatuzana and Rose Cottage Cave stone tool assemblages. *Azania: Archaeological Research in Africa*, 44: 311-330.
- Mccall, G. S. & Thomas, J. T. 2012. Still Bay and Howiesons Poort foraging strategies: Recent research and models of culture change. *African Archaeological Review*, 29: 7-50.
- Mcdougall, I., Brown, F. H. & Fleagle, J. G. 2005. Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature*, 433: 733-736.
- Miller, C. E., Goldberg, P. & Berna, F. 2013. Geoarchaeological investigations at Diepkloof Rock Shelter, Western Cape, South Africa. *Journal of Archaeological Science*, 40: 3432-3452.
- Mohapi, M. 2012. Point morphology and the middle stone age cultural sequence of Sibudu Cave, KwaZulu-Natal, South Africa. *The South African Archaeological Bulletin*, 67: 5-15.
- Mohapi, M. 2013. The Middle Stone Age point assemblage from Umhlatuzana Rock Shelter : a morphometric study. *Southern African Humanities*, 25: 25-51.
- Odell, G. 1996. Economizing behavior and the concept of "Curation". In: Odell, G. (ed.) *Stone Tools, theoretical insights into human prehistory*. New York: Plenum Press.
- Pargeter, J. 2007. Howiesons Poort segments as hunting weapons: Experiments with replicated projectiles. *The South African Archaeological Bulletin*, 62: 147-153.

- Porraz, G. 2005. *Dynamiques de formation des ensembles lithique set modes d'occupation des territoires au Paléolithique moyen*. Unpublished PhD thesis, Université de Provence.
- Richter, D., Grün, R., Joannes-Boyau, R., Steele, T. E., Amani, F., Rué, M., Fernandes, P., Raynal, J.-P., Geraads, D., Ben-Ncer, A., Hublin, J.-J. & Mcpherron, S. P. 2017. The age of the hominin fossils from Jebel Irhoud, Morocco, and the origins of the Middle Stone Age. *Nature*, 546: 293-296.
- Rightmire, G. P. & Deacon, H. J. 1991. Comparative studies of Late Pleistocene human remains from Klasies River Mouth, South Africa. *Journal of Human Evolution*, 20: 131-156.
- Rots, V., Lentfer, C., Schmid, V. C., Porraz, G. & Conard, N. J. 2017. Pressure flaking to serrate bifacial points for the hunt during the MIS5 at Sibudu Cave (South Africa). *PLOS ONE*, 12: e0175151.
- Scerri, E. L., Gravina, B., Blinkhorn, J. & Delagnes, A. 2015. Can lithic attribute analyses identify discrete reduction trajectories? A quantitative study using refitted lithic sets. *Journal of Archaeological Method and Theory*, 23, 2: 669-691.
- 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: e0149243.
- Schmidt, P., Porraz, G., Slodczyk, A., Bellot-Gurlet, L., Archer, W. & Miller, C. E. 2013. Heat treatment in the South African Middle Stone Age: temperature induced transformations of silcrete and their technological implications. *Journal of Archaeological Science*, 40: 3519-3531.
- Schmidt, P., Porraz, G., Bellot-Gurlet, L., February, E., Ligouis, B., Paris, C., Texier, P.-J., Parkington, J. E., Miller, C. E., Nickel, K. G. & Conard, N. J. 2015. A previously undescribed organic residue sheds light on heat treatment in the Middle Stone Age. *Journal of Human Evolution*, 85: 22-34.
- Shahack-Gross, R., Berna, F., Karkanas, P. & Weiner, S. 2004. Bat guano and preservation of archaeological remains in cave sites. *Journal of Archaeological Science*, 31: 1259-1272.
- Shanks, M. & Tilley, C. Y. 1987. *Social theory and archaeology*. Cambridge: Polity Press.
- Shea, J. J. 2006. The origins of lithic projectile point technology: evidence from Africa, the Levant, and Europe. *Journal of Archaeological Science*, 33: 823-846.
- Shott, M. J. 1986. Technological organization and settlement mobility: An ethnographic examination. *Journal of Anthropological Research*, 42: 15-51.
- Shott, M. J. 1989. On tool-class use lives and the formation of archaeological assemblages. *American Antiquity*, 54: 9-30.
- Soressi, M. 2004. Die Steintechnologie des Spätmostérien: Ihre Bedeutung für die Entstehungsgeschwindigkeit modernen Verhaltens und die Beziehung zwischen modernem Verhalten und biologischer Modernität. *Mitteilungen der Gesellschaft für Urgeschichte*, 13: 9-28.
- Soressi, M. & Geneste, J.-M. 2011. Special Issue: Reduction sequence, Chaîne Opératoire, and other methods: The Epistemologies of different approaches to lithic analysis. *PaleoAnthropology*, 2011: 334-350.
- Soriano, S., Villa, P. & Wadley, L. 2009. Ochre for the toolmaker: Shaping the Still Bay points at Sibudu (KwaZulu-Natal, South Africa). *Journal of African Archaeology*, 7: 41-54.
- Soriano, S., Villa, P., Delagnes, A., Degano, I., Pollarolo, L., Lucejko, J. J., Henshilwood, C. & Wadley, L. 2015. The Still Bay and Howiesons Poort at Sibudu and Blombos: Understanding Middle Stone Age technologies. *PLoS ONE*, 10: e0131127.
- Spencer, C. S. 1992. Homology, analogy, and comparative research in archaeology. *Behavior Science Research*, 26: 163-168
- Stapleton, P., Hewitt, S. & Hewitt, J. 1927. Stone implements from a rock-shelter at Howieson's Poort near Grahamstown. *South African Journal of Science*, 24: 574 - 587.
- Stiles, D. 1979. Paleolithic Culture and Culture Change: Experiment in Theory and Method. *Current Anthropology*, 20: 1-8.
- Texier, P.-J., Porraz, G., Parkington, J., Rigaud, J.-P., Poggenpoel, C., Miller, C., Tribolo, C., Cartwright, C., Coudenneau, A., Klein, R., Steele, T. & Verna, C. 2010. A Howiesons Poort tradition of

- engraving ostrich eggshell containers dated to 60,000 years ago at Diepkloof Rock Shelter, South Africa. *Proceedings of the National Academy of Sciences*, 107: 6180-6185.
- Vanhaeren, M., D'errico, F., Van Niekerk, K. L., Henshilwood, C. S. & Erasmus, R. M. 2013. Thinking strings: Additional evidence for personal ornament use in the Middle Stone Age at Blombos Cave, South Africa. *Journal of Human Evolution*, 64: 500-517.
- Villa, P. & Lenoir, M. 2006. Hunting weapons of the Middle Stone Age and the Middle Palaeolithic : spear points from Sibudu, Rose Cottage and Bouheben. *Southern African Humanities*, 18, 1: 89-122.
- Villa, P., Soressi, M., Henshilwood, C. S. & Mourre, V. 2009. The Still Bay points of Blombos Cave (South Africa). *Journal of Archaeological Science*, 36: 441-460.
- Villa, P., Soriano, S., Tsanova, T., Degano, I., Higham, T. F. G., D'errico, F., Backwell, L., Lucejko, J. J., Colombini, M. P. & Beaumont, P. B. 2012. Border Cave and the beginning of the Later Stone Age in South Africa. *Proceedings of the National Academy of Sciences*, 109: 13208-13213.
- Wadley, L. 2001. Excavations at Sibudu Cave, KwaZulu-Natal. *The Digging Stick*, 18: 1-4.
- Wadley, L. 2005a. Putting ochre to the test: replication studies of adhesives that may have been used for hafting tools in the Middle Stone Age. *Journal of Human Evolution*, 49: 587-601.
- Wadley, L. 2005b. A typological study of the final Middle Stone Age stone tools from Sibudu Cave, Kwazulu-Natal. *The South African Archaeological Bulletin*, 60: 51-63.
- Wadley, L. 2007. Announcing a Still Bay industry at Sibudu Cave, South Africa. *Journal of Human Evolution*, 52: 681-689.
- Wadley, L. 2012. Two 'moments in time' during Middle Stone Age occupations of Sibudu, South Africa. *Southern African Humanities*, 24: 79-97.
- Wadley, L. & Mohapi, M. 2008. A Segment is not a monolith: evidence from the Howiesons Poort of Sibudu, South Africa. *Journal of Archaeological Science*, 35: 2594-2605.
- Wadley, L. & Prinsloo, L. C. 2014. Experimental heat treatment of silcrete implies analogical reasoning in the Middle Stone Age. *Journal of Human Evolution*, 70: 49-60.
- Weninger, B., Clare, L., Rohling, E., Bar-Yosef, O., Böhner, U., Budja, M., Bundschuh, M., Feurdean, A., Gebe, H. G. & Jöris, O. 2009. The impact of rapid climate change on prehistoric societies during the Holocene in the eastern Mediterranean. *Documenta praehistorica*, 36: 7-59.
- White, T. D., Asfaw, B., Degusta, D., Gilbert, H., Richards, G. D., Suwa, G. & Clark Howell, F. 2003. Pleistocene *Homo sapiens* from Middle Awash, Ethiopia. *Nature*, 423: 742-747.
- Wiessner, P. 1977. *Hxaro: A regional system of reciprocity for reducing risk among the !Kung San*. Ph.D. dissertation, University of Michigan, University Microfilms, Ann Arbor.
- Wiessner, P. 1982. Risk, reciprocity and social influences on !Kung San economies. In: Leacock, E., Lee, R. (ed.) *Politics and history in band societies*. Cambridge: Cambridge University Press.
- Wiessner, P. 1983. Style and social information in kalahari San projectile points. *American Antiquity*, 48: 253-276.
- Wiessner, P. 1989. Style and changing relations between the individual and society. In: Hodder, I. (ed.) *The meaning of things: material culture and symbolic expression*. London: Unwin Hyman, HarperCollins Academic.
- Wilke, P. J. 1996. Bullet-shaped microblade cores of the Near Eastern Neolithic: experimental replicative studies. In: Kozłowski, S.K., Gebel, H.G. (eds.) *Neolithic chipped stone industries of the fertile crescent and their contemporaries in adjacent regions*. Proceedings of the second workshop on PPN chipped lithic industries, institute of archaeology, Warsaw University, 3rd-7th April 1995.
- Will, M. & Conard, N. J. 2017. Assemblage variability and bifacial points in the lowermost Sibudan layers at Sibudu, South Africa. *Archaeological and Anthropological Sciences*.
- Will, M., Parkington, J. E., Kandel, A. W. & Conard, N. J. 2013. Coastal adaptations and the Middle Stone Age lithic assemblages from Hoedjiespunt 1 in the Western Cape, South Africa. *Journal of Human Evolution*, 64: 518-537.
- 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: e98359.

- 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: e0131824.
- Woodburn, J. 1968. An introduction to Hadza ecology. In: Lee, R.B., DeVore, I. (eds.) *Man the hunter*. Chicago: Aldine Publishing Company.
- Wurz, S. 1999. The Howiesons Poort backed artefacts from Klasies River: An argument for symbolic behaviour. *The South African Archaeological Bulletin*, 54: 38-50.
- Wurz, S. 2000. *The Middle Stone Age at Klasies River, South Africa*. Ph.D. thesis, Stellenbosch University.
- 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: 1001-1015.
- Ziegler, M., Simon, M. H., Hall, I. R., Barker, S., Stringer, C. & Zahn, R. 2013. Development of Middle Stone Age innovation linked to rapid climate change. *Nature Communications*, 4: 1905.

Figure Captions

Figure 1. *Top:* Geographic setting of Umbeli Belli and other MSA sites mentioned in the text. *Bottom:* Original trench by C. Cable reopened in 2016. *Right:* Site plan. White squares excavated by Cable down to top of GH3. Grey squares excavated by Cable down to bedrock/sterile sand. Green squares excavated by the Tübingen research team in 2016 and 2017.

Figure 2. *Top:* East profile stratigraphy of Umbeli Belli documented in advance of the excavation in 2016. *Bottom:* Subdivision of GH7 into GH7.1, 7.2, and 7.3 using proportionally similar numbers of spits as analytical units.

Figure 3. Unifacial and bifacial tools from Umbeli Belli summarized as broad heads due to common features illustrated in the text. 1 – 4, hollow-based specimens; 12, schematic depiction of a broad head derived from modern arrow heads and the characteristic width/thickness ratio. (Drawings by G. Bader & A. Oechsner).

Figure 4. Unifacial and bifacial tools from Umbeli Belli summarized as target points due to common features as illustrated in the text. 9 – 11, preforms; 12, schematic depiction of a target point derived from modern arrow heads and the characteristic width/thickness ratio. (Drawings by G. Bader & A. Oechsner).

Figure 5. Chipped tools from Umbeli Belli. 1 & 2, ACT's; 3 – 5 backed tools; 6 & 7, true bifacial points; 8, retouched blade; 9, retouched flake; 10, scraper side; 11, stemmed piece; 12, scraper end; 13 & 14, splintered pieces. (Drawings by G. Bader & A. Oechsner).

Figure 6. Shaping flakes from Umbeli Belli. 1,2,6,7,9,10, unifacial shaping flakes; 4,5,8,11,12,13,14, bifacial shaping flakes; 3 & 15 indeterminate shaping flakes. (Drawings by G. Bader).

Figure 7. Maximum thickness of all blanks regardless of preservation made out of hornfels, quartz and quartzite. Hornfels blanks are conspicuously thinner than those of other raw materials.

Figure 8. Selection of cores from Umbeli Belli. 1 – 4, platform cores; 5, bipolar core. (Drawings by G. Bader & A. Oechsner, Photos by J. Becher)

Figure 9. Variability of hollow-based points from KwaZulu-Natal sorted by invasiveness of the base.

Figure 1

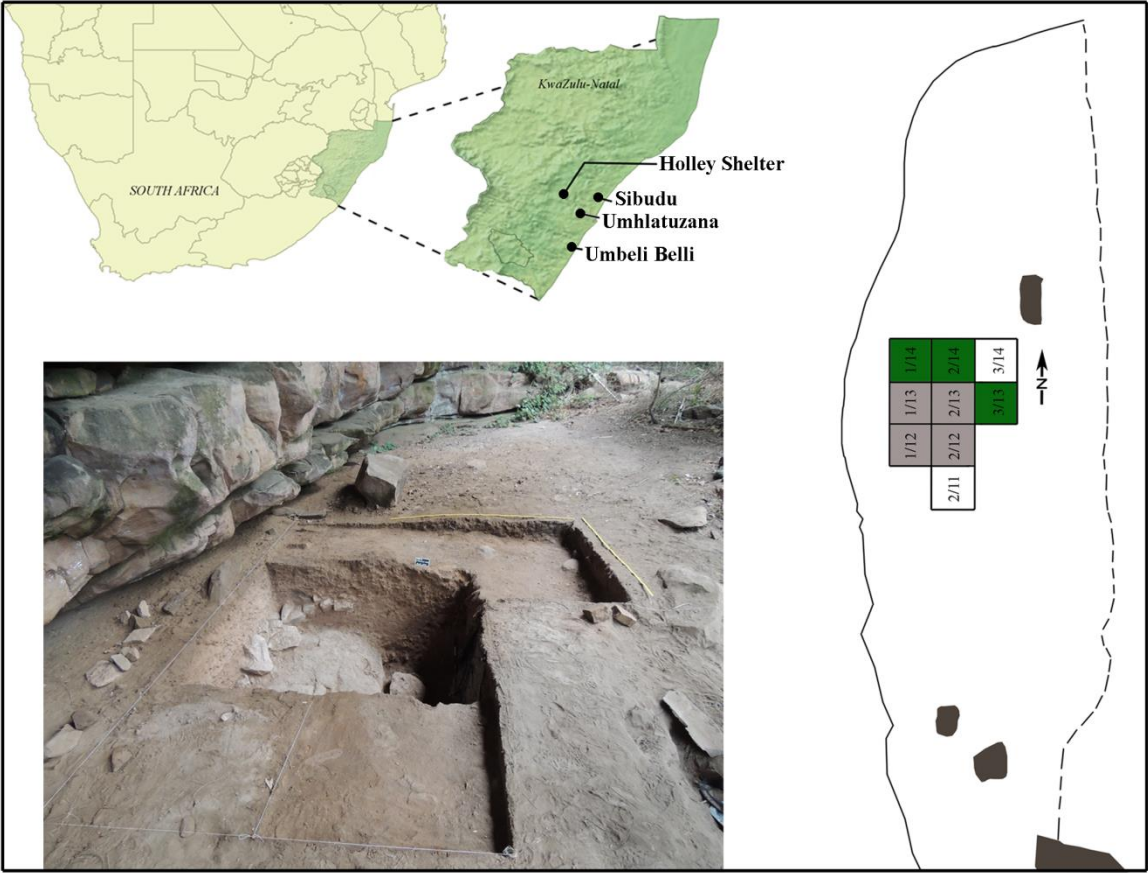
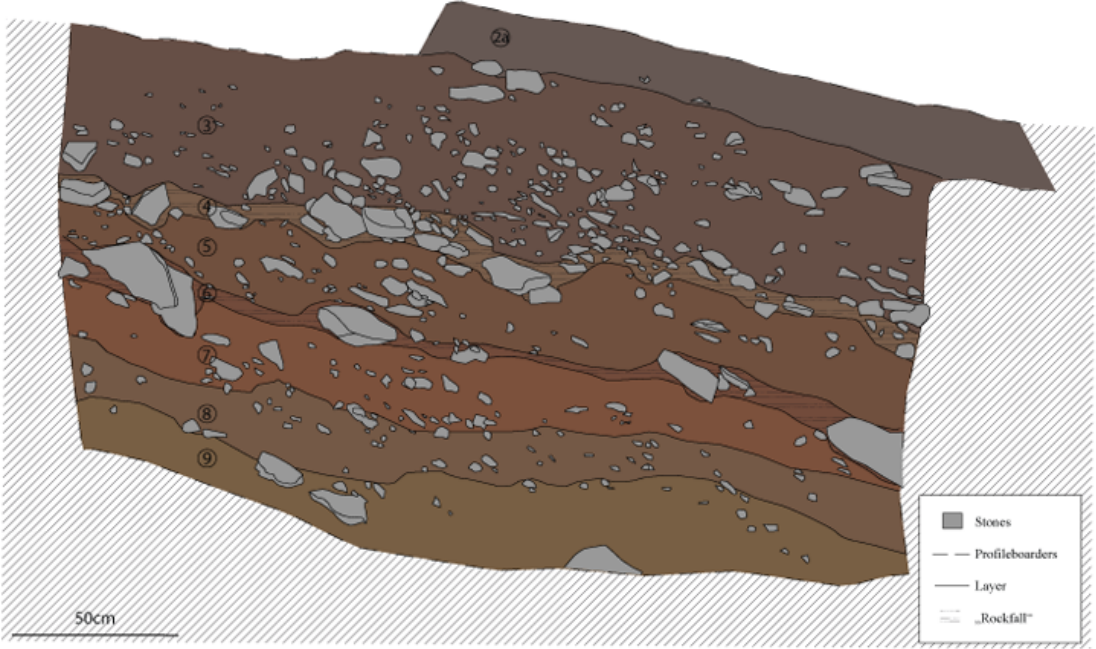


Figure 2



Umbeli Belli GH7

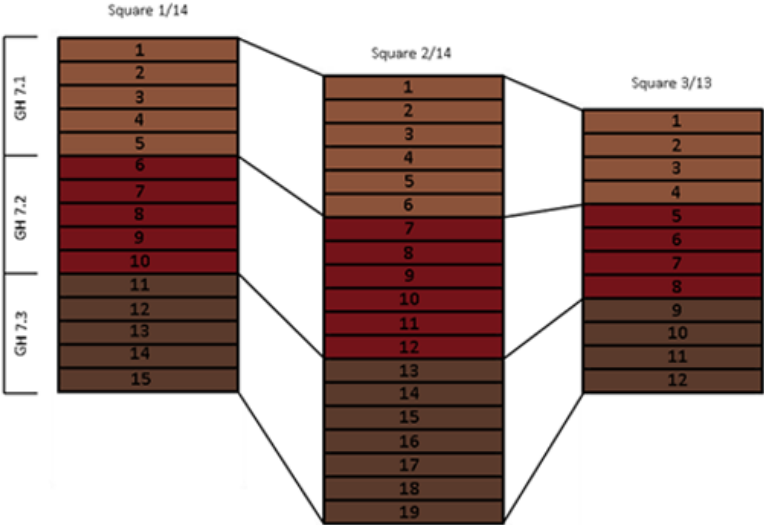


Figure 3

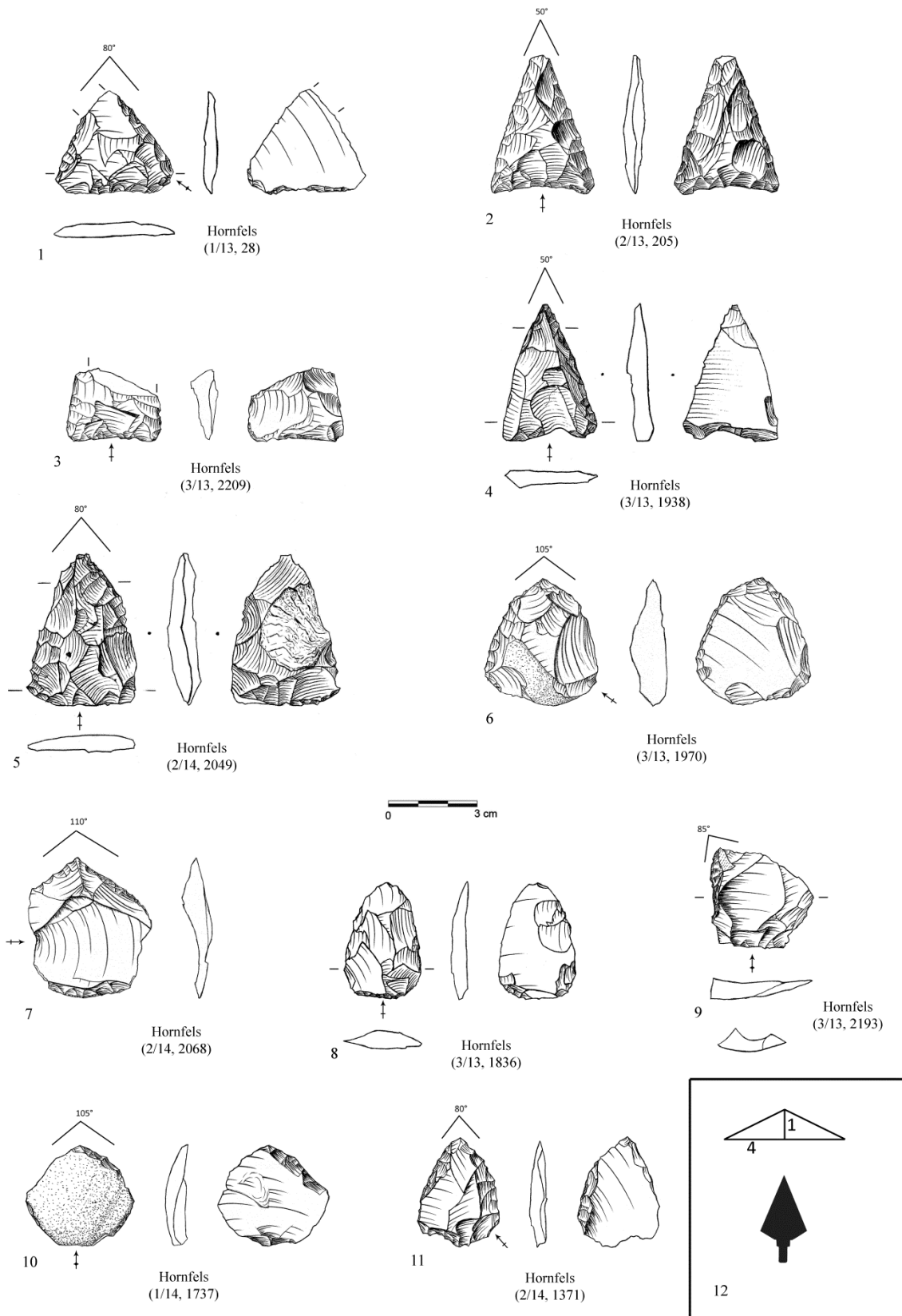


Figure 4

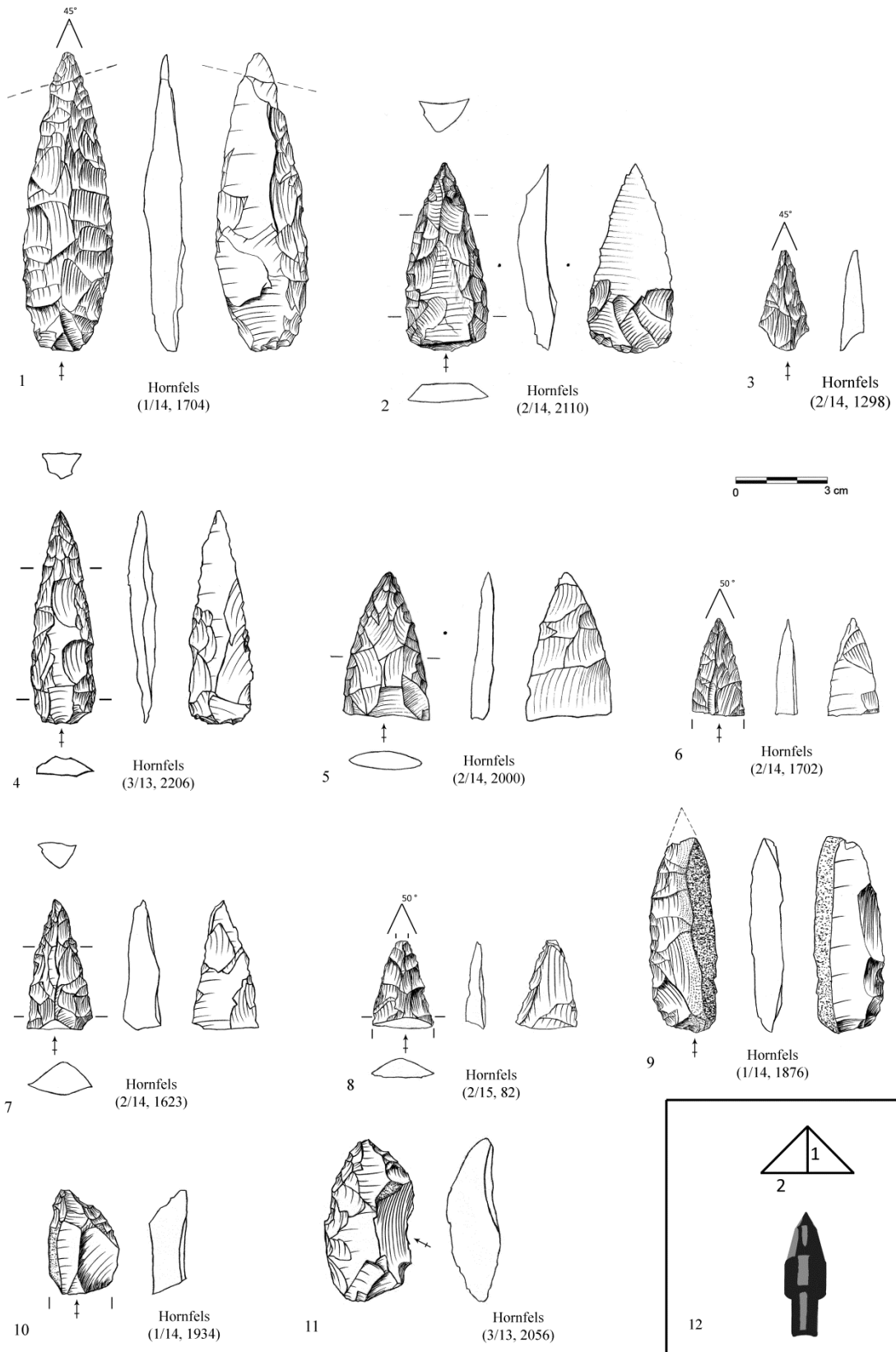


Figure 5

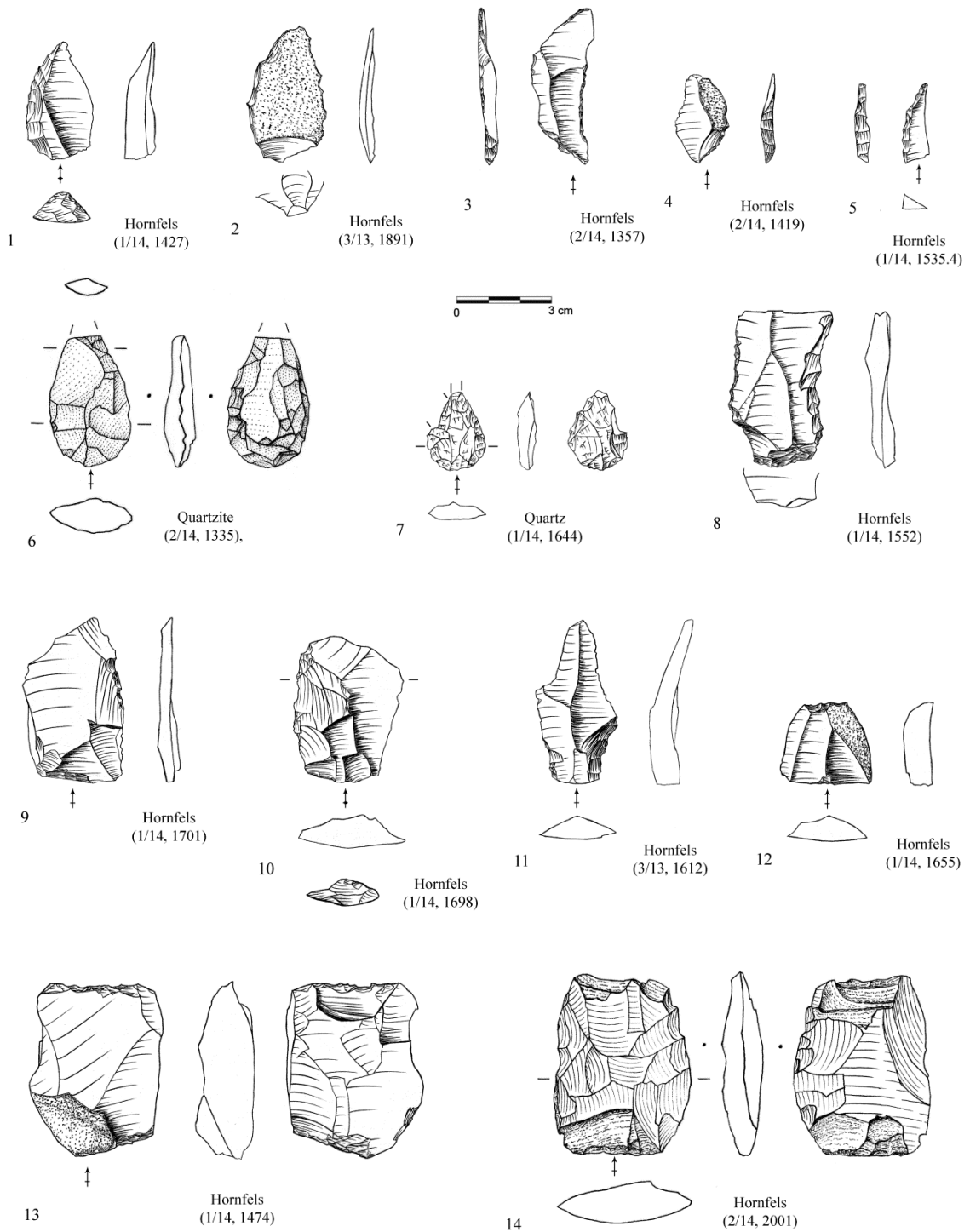


Figure 6

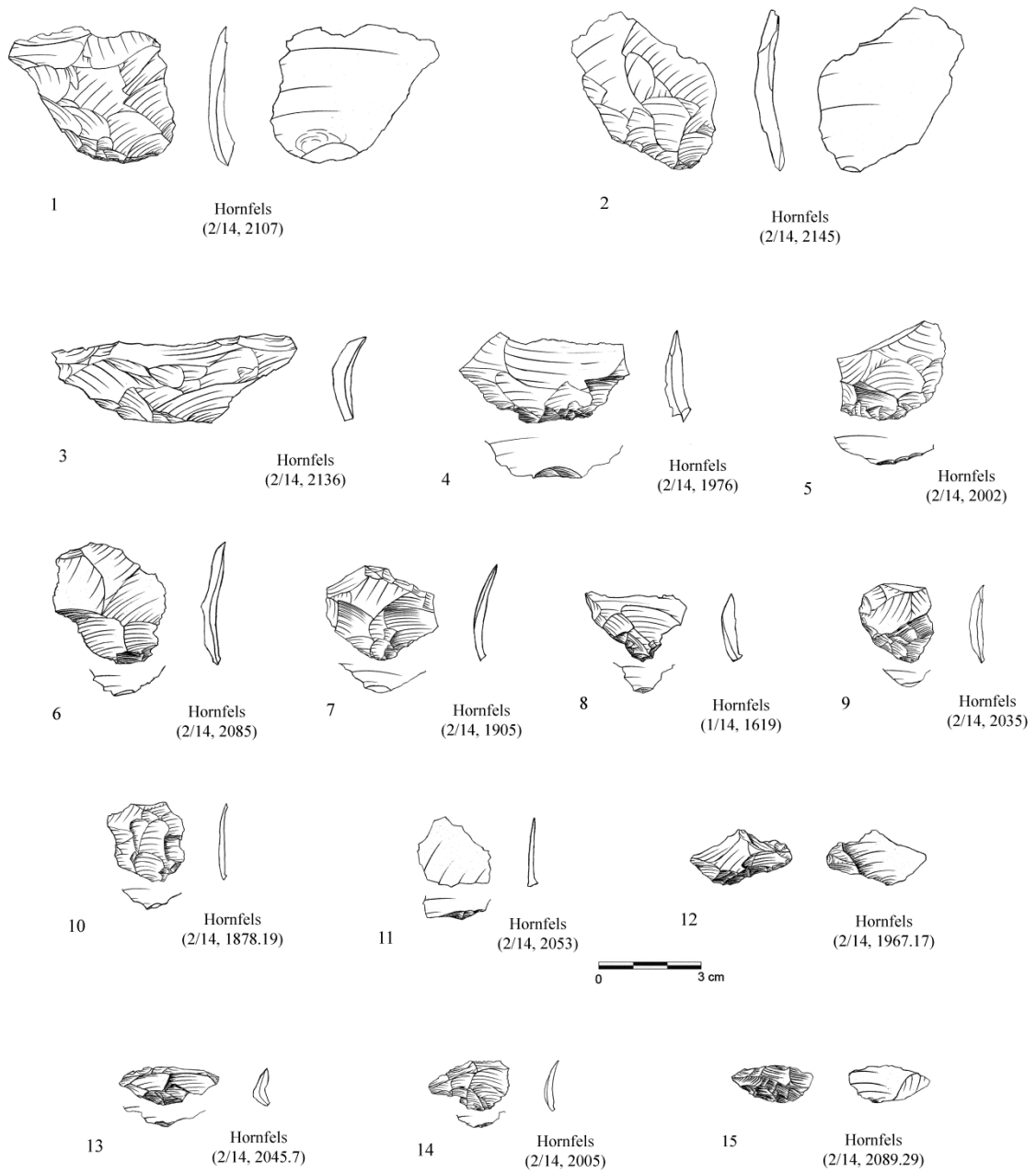


Figure 7

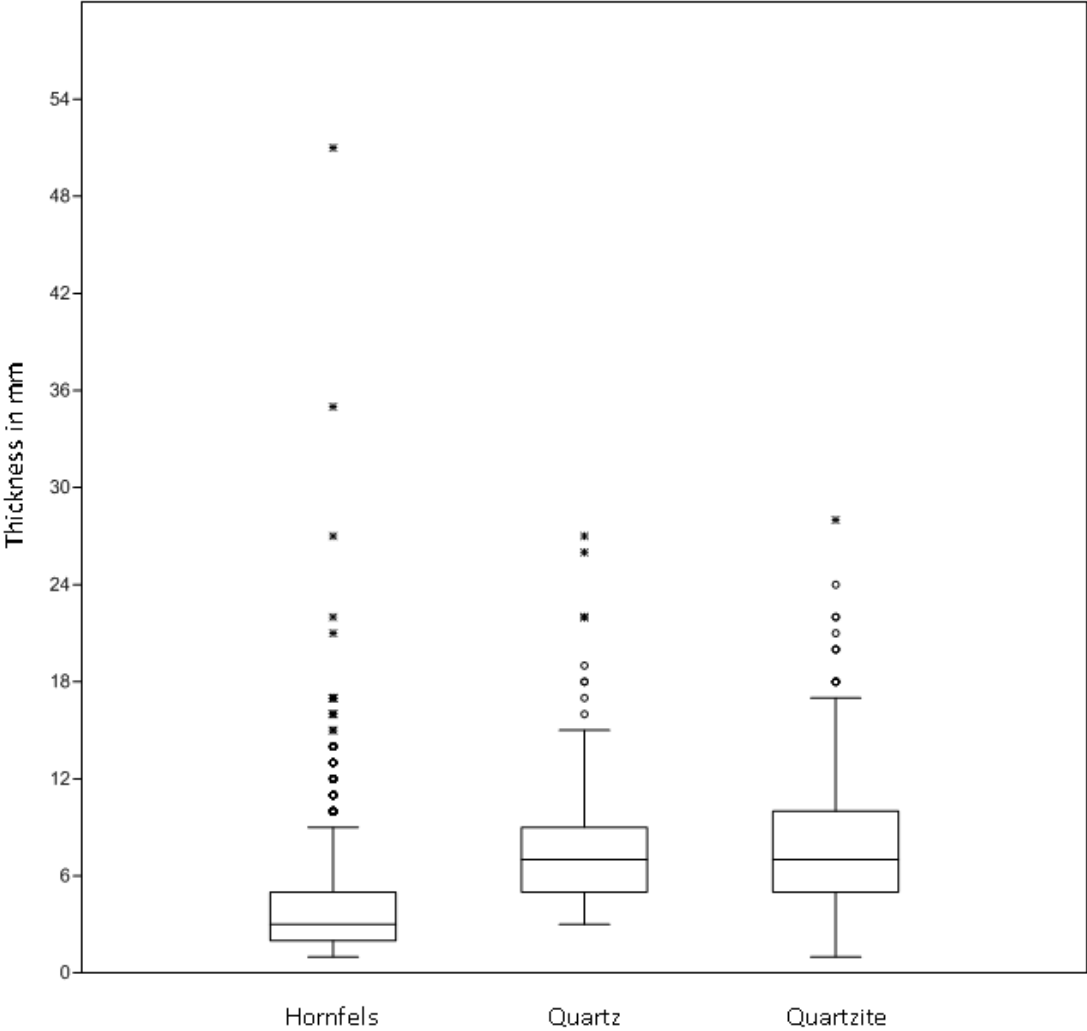


Figure 8

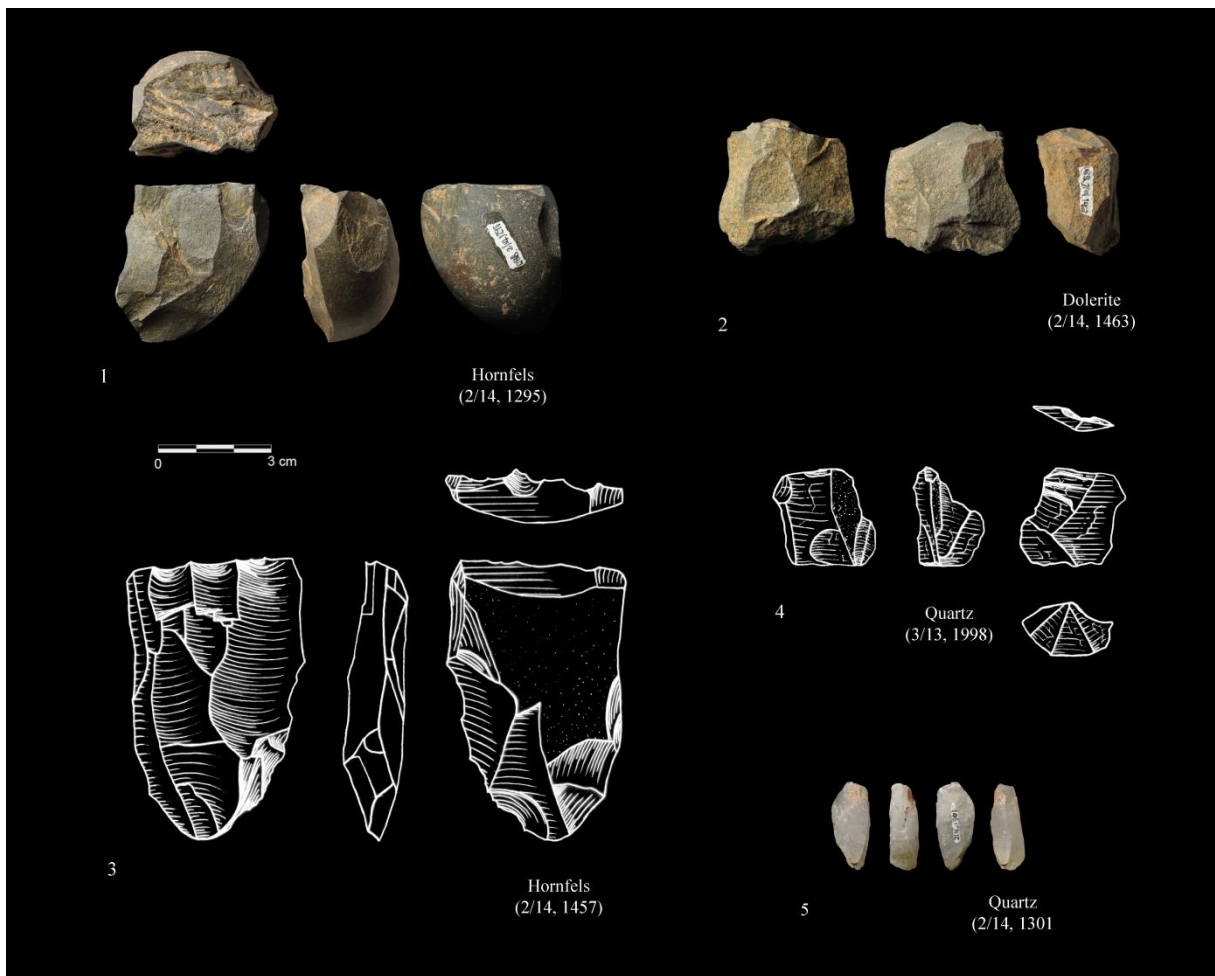


Figure 9

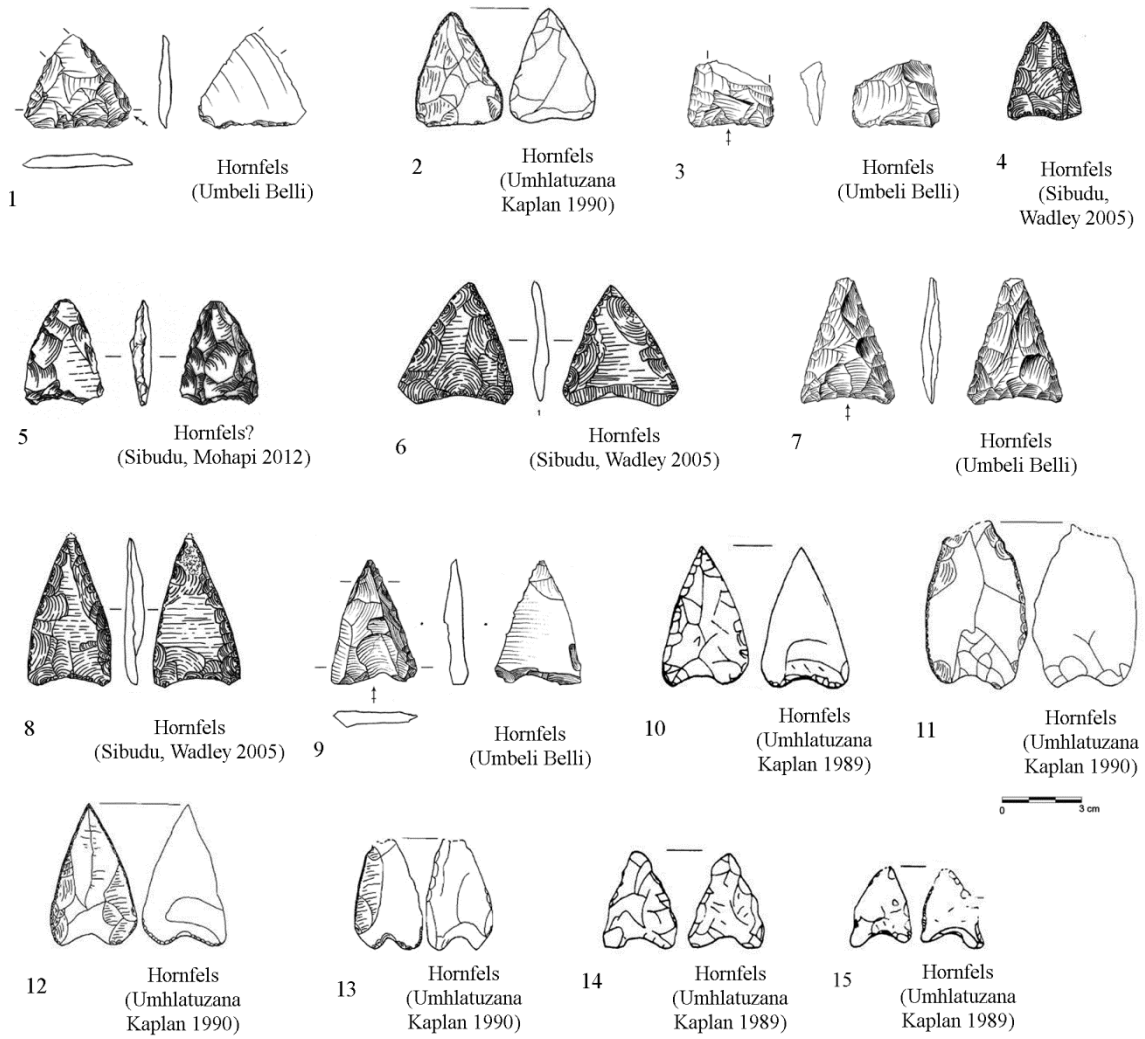


Table 1: Artifact types at GH7 (Umbeli Belli) sorted by raw material.

	Blanks %	Chipped tools %	NCT %	Cores %	Debris %	Total <i>n</i>	Total %
Hornfels	89.8	9.8	0.1	0.2	0.0	2102	70.7
Hornfels coarse	99.3	0.7	0.0	0.0	0.0	136	4.6
Hornfels weathered	95.8	0.0	0.0	2.1	2.1	48	1.6
Quartzite	94.2	3.6	0.7	0.7	0.7	411	13.8
Quartzite green	100.0	0.0	0.0	0.0	0.0	19	0.6
Quartz	88.1	4.0	2.0	5.4	0.5	202	6.8
Dolerite	97.4	0.0	0.0	2.6	0.0	39	1.3
CCS	100.0	0.0	0.0	0.0	0.0	8	0.3
Other	90.0	0.0	10.0	0.0	0.0	10	0.3
Total <i>n</i>	2708	229	11	21	6	2975	
Total %	91.0	7.7	0.4	0.7	0.2	100	

Table 2: Percentage of cortical blanks at GH7 (Umbeli Belli) sorted by raw material.

	Blanks total <i>n</i>	Cortical %	Pebble Cortex %
Hornfels	2086	16.2	82.2
Hornfels coarse	136	27.2	89.2
Hornfels weathered	46	39.1	88.9
Quartzite	401	10.2	73.2
Quartzite green	19	31.6	83.3
Quartz	186	15.6	93.1
Dolerite	38	18.4	71.4
CCS	8	12.5	100
Other	9	0.0	0
Total <i>n</i>	2929	477	395

Table 3: Tools from GH7 (Umbeli Belli) following the taxonomy developed in this paper.

	Broad heads	Target points	ACT's	Bifacial tools	Backed tools	Formal tools	Broken tools	Broken points	Total
<i>n</i>	41	49	12	10	8	41	58	10	229
%	17.9	21.4	5.2	4.4	3.5	17.9	25.3	4.4	100.0

Table 4: Metrical data and ratios for broad heads and target points at GH7 (Umbeli Belli).

	Statistics	Broad Heads	Target Points
Width	<i>n</i>	27	24
	Min	15	12
	Max	38	26
	Mean	23.4	16
	S.D.	6.1	3.4
Thickness	<i>n</i>	27	24
	Min	2	4
	Max	11	18
	Mean	5.7	7.6
	S.D.	2.1	3.2
Width/Thickness Ratio	<i>n</i>	27	24
	Min	2.5	0.8
	Max	7.8	3.8
	Mean	4.5	2.3
	S.D.	1.6	0.6
TPA (Caliper Method)	<i>n</i>	29	31
	Min	48.5	38.6
	Max	106.9	84.0
	Mean	71.0	53.0
	S.D.	13.9	11.6

Table 5: Numbers and percentages for unifacial, bifacial and indeterminate shaping flakes at GH7 (Umbeli Belli) sorted by raw material.

	Shaping UF %	Shaping BF %	Shaping Indet. %	Total <i>n</i>
Hornfels	95.2	92.5	96.8	475
Hornfels AL	0.5	2.3	0.6	5
Quartzite	3.3	3.0	0.6	12
Quartzite green	0.5	0.0	0.0	1
Quartz	0.0	0.0	0.6	1
Dolerite	0.5	2.3	1.3	6
Total <i>n</i>	209	133	158	500

Table 6: Metrical data for unifacial and bifacial shaping flakes at GH7 (Umbeli Belli).

	Length	Width	Thickness	Platform width	Platform Thickness	EPA
Shaping Flakes Unifacial						
<i>n</i>	119	177	207	194	206	204
Min.	9	13	1	1	0.5	45
Max.	53	54	8	18	6	88
Mean	22.1	22.9	2.7	5.7	1.4	60.9
S.D.	7.8	6.5	1.2	2.9	0.9	7.2
Shaping Flakes Bifacial						
<i>n</i>	67	112	133	120	129	128
Min.	12	14	1	2	1	45
Max.	38	42	7	26	70	79
Mean	21.6	24.7	3.0	9.8	2.9	61.0
S.D.	5.9	5.5	1.1	4.9	6.2	7.2

Table 7: Core types at GH7 (Umbeli Belli) (IBC = indeterminate broken core).

Type of core						
Raw Material	Platform core	IBC	Bipolar	Flat bladelet core	Core on flake	Total <i>n</i>
Hornfels	4	1	0	0	0	5
Hornfels weathered	1	0	0	0	0	1
Quartz	8	0	2	1	0	11
Quartzite	1	0	1	0	1	3
Dolerite	1	0	0	0	0	1
Total	15	1	3	1	1	21

Table 8: Percentages and numbers for different types of blanks at GH7 (Umbeli Belli).

Raw Material	Flake %	Blade %	Bladelet %	Point %	Total <i>n</i>
Hornfels	88.2	8.3	2.8	0.7	2086
Hornfels coarse	95.6	2.2	0.7	1.5	136
Hornfels weathered	95.7	4.3	0.0	0.0	46
Quartzite	91.8	6.3	1.3	0.8	401
Quartzite green	84.2	15.8	0.0	0.0	19
Quartz	88.7	5.4	4.3	1.6	186
Dolerite	84.2	13.2	2.6	0.0	38
CCS	87.5	0.0	12.5	0.0	8
Other (Shale, Mudstone, indet)	100.0	0.0	0.0	0.0	9
Total <i>n</i>	2611	221	75	22	2929