The Doring River Archaeology Project: Approaching the Evolution of Human Land Use Patterns in the Western Cape, South Africa

MATTHEW SHAW
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; ms152@uowmail.edu.au

CHRISTOPHER J.H. AMES
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; cames@uow.edu.au

NATASHA PHILLIPS
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; np989@uowmail.edu.au

SHERRIE CHAMBERS
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; sjrc913@uowmail.edu.au

ANTHONY DOSSETO
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; tonyd@uow.edu.au

MATTHEW DOUGLAS
College of Agricultural Science and Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583, USA; mdouglass3@unl.edu

RON GOBLE
Luminescence Geochronology Laboratory, 1400 R St., University of Nebraska-Lincoln, Lincoln, NE 68588, USA; rgoble2@unl.edu

ZENOBIA JACOBS
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences; and, Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; zenobia@uow.edu.au

BRIAN JONES
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; briangj@uow.edu.au

SAM C.-H. LIN
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences; and, Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; samlin@uow.edu.au

MARIKA A. LOW
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; marika.a.low@gmail.com

JESSICA-LOUISE MCNEIL
Department of Anthropology, Harvard University, Cambridge, MA 02138, USA; jlmcneil@g.harvard.edu

SHEZANI NASOORDEEN
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; shezani@gmail.com

COREY A. O'DRISCOLL
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; corey.odriscoll@outlook.com

***PaleoAnthropology* 2019: 400–422.** **ISSN 1545-0031**
doi:10.4207/PA.2019.ART138

ROSARIA B. SAKTURA
Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW 2522, AUSTRALIA; rk693@uowmail.edu.au

T. ALEXANDRA SUMNER
Department of Anthropology, DePaul University, Chicago, IL 60614, USA; asumner2@depaul.edu

SARA WATSON
Department of Anthropology, University of California-Davis, Davis, CA 95616, USA; sewatson@ucdavis.edu

MANUAL WILL
Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, 72070 Tübingen, GERMANY; manuel.will@uni-tuebingen.de

ALEX MACKAY
Department of Archaeology, University of Cape Town, Rondebosch 8801, SOUTH AFRICA; amackay@uow.edu.au

submitted: 27 August 2019; accepted 6 October 2019

ABSTRACT
The open-air archaeology of southern Africa is extremely rich, yet has been only modestly influential in constructions of Late Pleistocene human behavior. Here we report on two seasons of work conducted as part of the Doring River Archaeology Project, which aims to reveal patterns of human land use and technological decision-making from the Earlier Stone Age through to the appearance of herders in southern Africa's semi-arid interior. Across those two seasons we have mapped and analyzed more than 20,000 cores and tools across six open-air localities, with the small sample of available ages suggesting the accumulation of archaeologically-rich sediment bodies along the Doring River extends back to at least 200,000 years. Our results suggest clustering of artifacts at multiple temporal and spatial scales, from individual knapping events to aggregates of hundreds of bifacial tools. All known phases of the archaeological record appear to be represented in these assemblages, and previously documented contrasts between occupational patterns in the region's open-air and rock shelter localities is reinforced. These data confirm the critical importance of incorporating open-air data into depictions of the human past in studies of the African Paleolithic.

INTRODUCTION
The archaeological record of Africa extends across at least 3 million years (Harmand et al. 2015; McPherron et al. 2010). Within this context the southern African sequence is particularly well resolved due to a long history of research and the numerous rich and well-stratified sites in the region. Though open-air sites featured heavily in early southern African archaeology (Feilden 1884; Gooch 1882; Goodwin and van Riet Lowe 1929; Sampson 1968), the resolution of the record which the region now enjoys is built on the excavation of rock shelters, many of them providing sequences spanning much of the last 100,000 years (Beaumont 1978; Carter et al. 1988; Deacon 1979; Kaplan 1990; Parkington 1980; Porraz et al. 2013; Singer 1982; Wadley 1997; Wadley and Jacobs 2006; Wendt 1972).

The regional sequence as presently understood is divided into three ages, each subdivided into culture-historic units defined by distinctive aspects of lithic technology. The Earlier Stone Age (ESA) is divided into Acheulean and Fauresmith units and starts as early as 2 Ma (million years ago), though the termination age is somewhat poorly constrained to between 500 ka (thousand years ago) and 250 ka (Herries 2011; Wilkins and Chazan 2012). The Middle Stone Age (MSA) is divided into the Early MSA (itself subdivided into MSA1, MSA2a and MSA2b; [Volman 1981]), Still Bay, Howiesons Poort, post-Howiesons Poort, and Late MSA. The termination of the MSA is regionally staggered across southern Africa (Bousman and Brink 2017; Loftus et al. 2016) ranging from 44 ka to 26 ka (Opperman 1996; Villa et al. 2012). The Later Stone Age (LSA) is divided into Early LSA, Robberg, Oakhurst, and Wilton units. From around 2 ka, the arrival of herders in the region signals a final set of technological shifts which are generally identified by the presence of pottery and the remains of domesticates which might be classified as Neolithic (Sadr 2015).

While caves and rock shelters (hereafter rock shelters) usually provide good preservation of the record and are particularly useful for sequence-building, they necessarily represent limited points on the landscape and likely do not encompass the full range of prehistoric behavior. Furthermore, and with a few notable exceptions (Barham 1989; Carter 1978; Deacon 1976; Fisher et al. 2013; Hall 1990; Mazel 1989; Parkington 1988; Wadley 1984), excavation programs in southern Africa have typically focussed on single shelters or shelter complexes, with the effect that the data points these provide are spatially isolated from one another. This approach, although providing rich, local-scale data, makes it difficult to understand broader patterns of land use and settlement organization, and particularly how these adaptive structures evolved during the Pleistocene and Holocene. That objective is more fruitfully pursued through the integration of rock shelter sequences with open site data (Hallinan and Parkington 2017), as only by examining these archives together can we begin to understand the breadth of land use practices in the Pleistocene record.

The long-term objective of the Doring River Archaeology Project (DRAP) is to explore lithic technological organization as a window into the evolution of human planning and mobility through the Late Pleistocene and Holocene. The ability to adjust systems of movement—including the frequency, duration, purpose, and group-composition of moves—to changing resource configurations is a key element of the adaptive behavior of ethnographically-documented hunter-gatherers (Binford 2001; Kelly 1995). The distribution and form of stone artifacts across landscapes reflects decisions about stone acquisition and transport that are expected to be sensitive to the distribution of key resources mediated by systems of mobility (Andrefsky 1994; Bamforth 1991; Nelson 1991). Thus, assemblages of stone artifacts when studied at the landscape scale have the potential to inform us of changing patterns of ancient land use and, potentially, the evolution of this adaptive capability.

In this paper, we introduce the Doring River study area, including the distribution of resources likely to have influenced decisions about subsistence movements and technological systems, as well as the area's known archaeological archives. We then describe the project methodology and initial results of the first two field seasons in 2018 and 2019. These results confirm the abundance, antiquity, and patterning of archaeological material in both open and rock shelter sites in the Doring River, and highlight directions for future work.

STUDY AREA

Situated on the eastern, rain-shadow side of the Cederberg mountains, the Doring River drains approximately 28,000km^2 of semi-arid shrublands at the junction of the Fynbos and Succulent Karoo biomes (Figure 1). Rainfall in the area is strongly seasonal; the Doring River typically begins to flow following the onset of austral winter rains in May/June, and ceases to flow by the start of the hot, dry summer months (November/December) (Paxton 2008), being reduced thereafter to a chain of diminishing waterholes, some of which persist until the river begins to flow again in the subsequent winter. Surface water is otherwise limited in the Doring catchment. The eastern tributaries, such as the Bos and Tankwa Rivers that drain the Tankwa Karoo are wide, braided streams with deep, sandy channel fills. These eastern rivers only flow after heavy rains. The western tributaries drain the Cederberg and are more likely to retain some ponded water throughout the year. Prominent rivers to the west include the Groot, Driehoeks, Tra Tra, Biedouw, and Brandewyn Rivers, with the Groot and Biedouw in particular sustaining flows into early summer. The Doring River itself, particularly in the middle and lower reaches where it cuts through Bokkeveld and Nardouw Formation geology, is typically incised to a depth of more than 200m below the surrounding plateaux. The resulting steep valley through which it runs provides limited potential for significant migration during the Quaternary.

Soils in the Doring River catchment are typically sandy, acidic, and nutrient poor (Quick and Eckardt 2015), which combined with low annual rainfall has restricted the intensity of farming in the area. The many abandoned European-built stone structures along the river valley attest to the difficulties of sustaining subsistence-level food production in the area since the first colonial loan farms were established in the 1730s (Mitchell 2009). Nevertheless, grazing, particularly of sheep and goats, has been a persistent feature of European land use in the Doring River valley over the last 280 years (Neumark 1957). This is a continuation of preceding Khoisan herding in the area (Smith and Ripp 1978), albeit that indigenous pastoralists were more mobile which likely limited the impacts of grazing on specific locations, in contrast to the tenure-tethered grazing practices of the later colonists.

Human use of the Doring landscape extends from the colonial and indigenous pastoralist periods back into the Middle Pleistocene, based on the presence of characteristic ESA bifacial implements (i.e., handaxes) at the locality Uitspankraal 1 (Bleed et al. 2017). Stone artifacts are abundant on river-side sediment bodies in both upstream and downstream locations that have been surveyed (Mackay et al. 2014a; Smith and Ripp 1978). This abundance reflects the fact that the Doring River is not only a major regional water source, but also an important source of raw material for stone artifact manufacturing. The bedload of the river includes abundant cobbles of quartzite and hornfels, as well as rare cobbles of silcrete and small pebbles of chert and quartz (Low et al. 2017). Sources of hornfels are otherwise unknown west of the Doring River, though primary hornfels outcrops occur along dolerite dykes on the Karoo side of the river. The river-derived and outcrop-derived hornfels rocks can be differentiated by their cortex, the former being smooth, black, and rounded, and the latter typically having angular planes and rugose orange-brown surfaces.

Quartzite is available throughout the geology of the broader catchment, which comprises alternating beds of shale and sandstone/quartzite in the Nardouw, Bokkeveld, and Witteberg formations (Visser and Theron 1973). Small quartz pebbles are also commonly found eroding from the conglomerates, particularly in the Nardouw Formation units that prevail in the north-western (downstream) end of the catchment. Silcrete, a fine-grained pedogenic rock, occurs in two known primary locations in the Doring River catchment, Swartvlei and Agtersfontein, at elevations of 465masl (metres above sea level) and 580masl respectively, or approximately 250m and 325m, respectively, above the

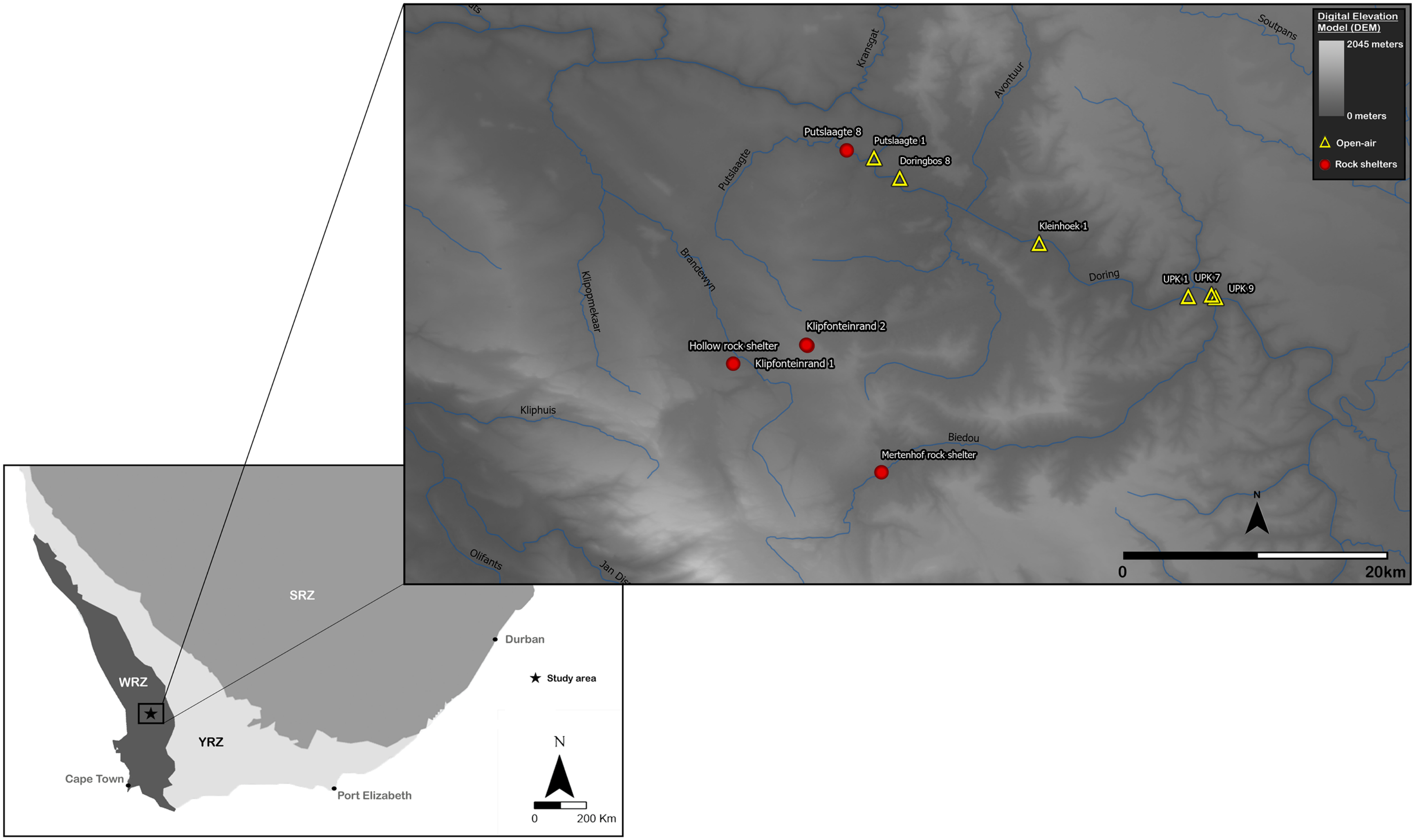

Figure 1. Location of the study area in southern Africa relative to modern rainfall zones. (A) Study sites and localities against regional digital elevation model (Jarvis et al. 2008). Red dots are rock shelter sites and yellow triangles are open-air localities on the Doring River discussed in this paper.

river. Swartvlei is characterized as a weathered rock mantled surface, consisting of fine to medium-grained textured silcrete with very well- to moderately-well sorted clasts. Agtersfontein is characterized by three outcrops and surrounding rock mantled surface. Material ranges in texture from fine-grained, well sorted clasts to very poorly sorted with pebble-sized quartz inclusions. Our surveys for silcrete in the catchment are currently incomplete, however, and more sources may be discovered. Based on visual classification, material from both known sources has been identified in the assemblages discussed below.

PREVIOUS ARCHAEOLOGICAL WORK

Six rock shelters have been excavated in the catchment of the Doring River, though we concentrate here on the five located downstream of the Groot/Doring confluence: Hollow Rock Shelter, Klipfonteinrand 1, Klipfonteinrand 2, Mertenhof, and Putslaagte 8 (see Figure 1). These sites are located at 2km (Putslaagte 8), 13km (Klipfonteinrand 1 and 2), 17km (Hollow Rock Shelter), and 19km (Mertenhof) from the Doring River, allowing us to explore patterns of material transport away from the major regional water source. The sequences from these sites are reasonably coherent (Low and Mackay 2016; Mackay et al. 2015) and consistent with generally recognized patterns of regional technological change (Table 1). The only notable, recurrent weakness in these sequences across the last ~80 kyr is the limited amount of material found from the early to mid-Holocene, though artifact densities are typically also very low throughout the Late MSA (~50–25 ka).

In addition to these rock shelters, a single open site has been excavated on the Doring River at Putslaagte 1 (Mackay et al. 2014b). The locality is one of several discrete sediment stacks which occur along the Doring River corridor, and which invariably preserve stone artifact assemblages from the Earlier, Middle, and Later Stone Ages. The large assemblage recovered from Putslaagte 1 dates to <58 ka and has been assigned to the Late MSA. The technological system found at the site is distinctive, and features reduction of flat hornfels cobbles using simple prepared platforms to produce large and usually cortical flakes. Platforms on the Putslaagte 1 cores were rarely re-prepared and cortex ratio analysis suggests that the cortical flakes were transported away from site, presumably for use elsewhere in the catchment (Lin et al. 2016; see also Holdaway and Douglass 2015 for discussion of approach).

Similar transport patterns have been inferred based on comparison of the Early Later Stone Age sample from Putslaagte 8 with that from another sediment stack locality, Uitspankraal 7 (Low et al. 2017). Here again, dominant flaking systems make use of hornfels cobbles, in this case to produce blades exploiting natural ridges along the cobble edge. Both blades and blade cores are abundant at Uitspankraal 7, but only blades appear in significant numbers in the Putslaagte 8 Early LSA assemblage, which is located 2km from the Doring River and thus the source of hornfels. It is inferred that the hornfels blades were preferentially transported, whereas the cores were discarded at source-proximate locations such as Uitspankraal 7.

The Early LSA assemblage from Uitspankraal 7 was recovered from a surface cluster of technologically coherent archaeological material in one small area of the 40,000m^2 sediment stack. This was one of several clusters identified at the locality during work in 2014 (Low et al. 2017; Will et al. 2015). Material apparently associated with the Late Holocene with Neolithic, and mid Holocene Wilton, Oakhurst, Early LSA, post-Howiesons Poort, and Still Bay all showed distinct patterns of distribution and clustering across the surface. The patterning of this surface material prompts several questions: 1) Was the material exposed on the surface since the time of original deposition, or was it buried after discard and subsequently exposed by erosional processes? 2) If buried and then exposed, how long would surface-exposed material take to disaggregate—that is, to lose its pattern of clustering—under modern erosional conditions? 3) Furthermore, what distortions in assemblage composition would result from this process? That is, were certain elements more likely to be dispersed than others, and how might this affect interpretations of the archaeological data?

To investigate these questions, we conducted an actualistic experiment with a replicated assemblage that mimicked a typical LSA microlithic assemblage, comprising freehand and bipolar cores, as well as small flakes and blades (Phillips et al. 2018). We placed and mapped the assemblage in 2014, and regularly documented spatial disaggregation across 22 months. Many of the artifacts moved considerable distances within the observation period, to the extent that disaggregation of the assemblage would have occurred within a few centuries, and that within a millennium most of the assemblage would have been incorporated into the bedload of the Doring River. Given this, persistent or sustained subaerial exposure of the archaeology of the Doring River sediment stacks throughout the past is expected to have erased the kinds of the spatial patterning we had previously documented, and which we document further below. Alternatively, brief or intermittent periods of exposure and/or net sediment loss in the past may have redistributed artifacts from certain periods while preserving patterning in others. While these and other formational/erosional models remain to be tested, it is clear that the sediment stacks are heavily erosional under present conditions, a point reinforced by under-cutting of historical European structures on the sediment bodies (see below).

The most likely cause of recent erosion is grazing of stock under European land tenure (Smith and Ripp 1978). Due to the limited water and poor feed in the Doring catchment, stock would inevitably have been concentrated in and around the river for long periods, accelerating already high natural rates of erosion (Phillips in preparation). The effect of grazing on these sediment stacks is particularly evident at the locality of Klein Hoek 1 where a fence line provides a comparison of a pre and post grazing area (mentioned in the results sections) These sets of observations provided impetus for the Doring River Archaeology Project.

TABLE 1. LOCAL ROCK SHELTER SEQUENCE SUMMARY BASED ON SITES SHOWN IN FIGURE 1.

Locality	ESA	Early MSA	Still Bay	HP	Post-HP	Late MSA	Early LSA	Robberg	Oakhurst	Early/mid Holocene	Wilton	Pottery
PL8		>76	?	71-58	71-58	33-45	25-21	21-18	<18			<1
KFR1		pres.		pres.	pres.			22-16	16-13	10.1-6.3	6.3-3.8	
KFR2											4.7-3.6	1.7-1.3
HRS		?	87-72									
MRS		pres.	pres.	pres.	pres.	pres.		pres.			?	pres.

AIMS AND METHODS

The aims of this project are influenced by the sensitivity and fragility of the sediment stacks as well as the overall scale of the Doring River catchment. A method that allows for the expeditious documentation of high-resolution data was implemented as a Phase I approach, focusing on the recording of specific artifact types (implements, cores, and some non-flaked objects) that would serve as the foundation for further decisions on future analysis (Phases II and III). The aims of the Doring River Archaeology Project are thus as follows:

1. to record the distribution of archaeological material across sediment stacks along the Doring River;
2. to assign temporal ranges where possible to this material both by relating technological characteristics to those from the known regional sequence, and by radiometric dating where possible;
3. to examine similarities and differences between the composition and technological characteristics of assemblages at localities along the river with those recovered from rock shelter sites 2km, 13km, 15km and 19km away; and,
4. to use the information from 1, 2, and 3 above to understand past patterns of land use and technological planning in the catchment.

The project has three methodological phases that can run separately or concurrently. While we will outline the methods for all phases, here we concentrate on Phase I as this accounts for the bulk of work completed so far, and for the results that we will later present. Prior to describing the phases of data collection, however, we outline the processes by which sediment stack localities[1] were identified and defined, and protocols for mapping 'off-stack' material.

IDENTIFICATION OF ARCHAEOLOGICAL LOCALITIES

Our analyses so far have concentrated on the distribution of archaeological material as it occurs on sediment stacks along the Doring River. As noted earlier, these sediment stacks are large, discrete accumulations of sandy sediment that occur in low energy contexts along the river—typically at the confluence of the Doring and its minor tributaries, or on the inner portion of major river bends. Due to its deeply incised profile, accommodation space for long term accumulation of sediment is generally limited along the Doring River, such that there are no terrace successions. The sediment stacks are thus relatively easily differentiated from modern overbank deposits by their elevation (3–30m above the river), distance from the nearest active river channel (usually >100m), distinctive reddish orange color (the modern river sands are white), and indurated texture. Due to the low frequency of suitable accommodation space, and the intensely erosional nature of the region, the stacks tend to have well-defined boundaries at which the underlying colluvium is exposed.

Nominally, identification of sediment stacks localities would occur as part of Phase I, and specifically during reconnaissance surveys that take in the length of the Doring River from its confluence with the Bos River to the point where it merges with the Olifants River. That reconnaissance would involve both mapping and analysis of relevant artifacts (see below) on sediment stacks, and also any material encountered during walking between sediment stacks—thus characterizing the background scatter of material along the river. In practice, across the first two seasons we only focussed on stacks that had been identified during prior work in the area (Mackay et al. 2014b), with no 'off-stack' survey or analysis undertaken as yet. Such work will become more common as we move into the less well-surveyed upper and lower reaches of the river.

PHASE I

Once a sediment stack has been identified, its boundaries and major sediment units are mapped. Thereafter, the goal of Phase I analysis is rapid appraisal of the artifact distributions with sufficient information to make preliminary interpretations of any clustering that might inform Phase II and III research priorities (see below). As such, Phase I has two components. The first component involves the recording and analysis of all cores, implements (i.e., retouched stone tools), anthropogenically modified non-flaked stone implements, ochre, pottery, and historic metal and glass across all identified sedimentary stacks with no size cut-off (SOM Table 1). All anthropogenically modified ochre was recorded, as well as unmodified fragments greater than 30mm in maximum dimension; no other artifact classes were size-limited for analysis. The decision to focus on cores and implements for Phase I reflects their potential to act as time-sensitive markers relative to the known regional excavated sequence. The decision is also pragmatic—the sheer quantity of unretouched flakes and other fragments, estimated to be in the hundreds of thousands per locality—would make analysis of even a limited proportion of them hugely time-consuming, limiting our potential for coverage of the archaeology of the catchment. Thus, though flakes can, of course, be equally if not more informative about time-specific technological behavior, their analysis is restricted to Phase II.

No artifacts were collected during Phase I—all were analyzed in-field and replaced at their point of origin. The spatial location of each artifact was recorded using a handheld mobile GIS system. In Season 1 (2018), artifacts were recorded on Trimble Juno 3B units using ArcPad 10.2 and the device's internal receiver, with an accuracy of 3–5m. Analysis in 2018 was conducted concurrently by two lithic analysts. In 2019, artifacts were recorded using the ESRI ArcGIS Collector mobile application on Apple iPad Mini 4's linked wirelessly by Bluetooth to a Bad Elf Surveyor Pro GNSS receiver with an accuracy between 1–3m (see Ames et al. submitted for methodological details). The shift to this system allowed us to incorporate Bluetooth-enabled Sylvac Cal-evo digital calipers, providing the capability for rapid and low-error capture of a limited set of metric data. The internal cameras on these devices also allowed photographs to be taken of most artifacts (minimal cores and unworked ochre were typically not photographed). Full, non-overlapping coverage of each locality was achieved by dividing each locality into parallel ~2m-wide transects using black nylon string. The improved recording system (see Ames et al. submitted) made it possible to have more concurrent lithic analysts (faculty, postdoctoral fellows, and post-graduate students), who were shadowed by archaeological student volunteers from universities in South Africa and Australia.

A limited set of traits was recorded for all artifacts, summarized in SOM Table 1. Where possible, artifacts were assigned to culture historic units as established in the prevailing regional framework augmented with data from excavated sites in the catchment (for attributes and SOM Table 2 for time-sensitive artifacts). The functional assumption here is that certain kinds of artifacts are more common during certain time periods than others, and can thus act as pseudo-markers for those periods (though see below). To be clear, this approach is simply a preliminary means for estimating the age of archaeological material in what are surface scatters which we intend to test and ideally replace once we have excavated samples and radiometric ages. To facilitate consistency between researchers, a reference collection of artifacts from excavations at Putslaagte 1, Putslaagte 8, Klipfonteinrand, and Mertenhof was put on display in the field house.

Inevitably, only a proportion (7.2%) of the artifacts recorded could be assigned to culture historic units. This is partly because many of the artifacts were in the early stages of reduction—unsurprising given that the Doring River is a source of both hornfels and quartzite for artifact manufacture—and partly due to issues of identifiability discussed at greater length below. Essentially, we have to accept a high rate of Type II (false negative) errors in our culture historic assignment during Phase I analysis, due to the high proportion of lithic artifacts that transcend named stone tool technocomplexes (Shea 2014). Type I errors (false positive) are likely to be less common due to limited overlap in 'diagnostic' artifact types but will have occurred, especially because analysts were encouraged to make assignments to culture historic units where probable with reference to the excavated collections; some of these attributions will inevitably have been erroneous. At least one principal analyst with extensive experience in the local sequence was present throughout the surveys to help limit such false assignments.

In addition to in-field analysis, artifacts assigned to culture historic units were 3D scanned using a Rexscan DS2 Silver structured light scanner. Distinctive implement and core types were also scanned at the discretion of the analyst. During 2018, artifacts were scanned in-field, the scanner being powered by a dual-battery system installed in the project vehicle. Due to high temperatures at the start of Season 2, scanning was conducted at the field house. Artifacts to be scanned had their locations recorded with a metal tag attached to a nail, were scanned the next day at the field house, and then returned to their point of origin. The same protocol was used for detailed artifact photography of selected artifacts. The scans are intended to serve several purposes. The first is for visual communication of key artifact types. The second is to enable comparison of artifacts between open-air localities, and between open-air localities and excavated collections. The third is as an archive—as noted above, the open-air localities of the Doring River appear to be eroding quickly under modern conditions, and many of the artifacts that are currently on the surface will conceivably be lost within a generation. After two seasons, 1521 artifacts have been scanned as part of Phase I.

The artifact attributes collected as part of individual point data allow large clusters of similar artifacts to be identified, whether or not these can be assigned to culture historic units. However, small clusters can be difficult to identify, and many clusters are poorly represented by cores and implements, occurring instead as concentrations of flakes. In order to control for this, the second component of Phase I involved mapping clusters of artifacts as polygons. Diverse criteria were allowed when deciding whether to map a cluster with a polygon. Polygons were made wherever a spatially-coherent assemblage of technologically similar artifacts was observed. They were also made where clusters of artifacts of a similar, distinctive material were observed. Finally, they were used to map scatters of refit sets involving three or more artifacts. While no dedicated refitting work was undertaken, opportunistic refits were recorded when observed.

All sediment stacks analyzed during Phase I were photographed using a DJI Mavic Pro drone (1/2.3" 12 Megapixel censor), which was flown over the locality in a grid pattern at 40m altitude. The resulting images were stitched in AgiSoft Photoscan and used to generate high-resolution orthomosaics, and further processed to create vegetation-free digital surface models of each stack. These surface models can in turn be used to map flow paths and estimate erosional sensitivities (Ames et al. submitted; Howland et al. 2018). It is important to recognize that there are complex issues with creating UAV derived surface models that require explicit treatment before they can be used in a scientifically valid framework; an issue we consider in more detail elsewhere (see Ames et al. submitted). The boundaries of each sediment stack, as well as the major sedimentary units within them were mapped using the same mobile GIS platform used for recording artifact polygons.

PHASE II

Phase II involves in-field analysis of all artifacts (including unretouched flakes and fragments) over 20mm, in targeted clusters identified during Phase I, and their mapping *in situ* using a Trimble R7/R8 Real Time Kinematic (RTK) GNSS system. Base station coordinates are post-processed using the Canadian Geodetic Survey of Natural Resources online precise point positioning service, which were then used to recompute the RTK rover datasets in Trimble Geomatics Office Version 1.63. Whereas the objective for Phase I is to identify sediment bodies and characterize the broader spatial and technological patterns on these surfaces, the objective of Phase II is to provide the fine-grained technological data necessary to understand lithic transport and reduction through the catchment—by making comparisons both between Doring River assemblages and between the river assemblages and those from the excavated rock shelters.

Clusters for Phase II are thus selected based on the information they are likely to offer concerning particular technological systems or temporal intervals relative to previously analyzed samples. For example, the Phase II analysis of a Robberg cluster at the locality Uitspankraal 9 undertaken by Sara Watson in 2018 was intended to test propositions by Low and Mackay (2018) regarding the characteristics of Robberg technology near sources of raw material. So far, Phase II analysis has been completed on 4583 artifacts from two clusters, though the results are not presented here.

PHASE III

As suggested in the description of the Phase I methodology, there are problems with attempting to relate sets of artifacts from open site contexts to those from the local and regional culture-historic framework. First, the framework is incomplete. A strong example is the regional paucity of archaeological evidence from the Late MSA (Mitchell 2008). The assemblage from Putslaagte 1 suggests that this pattern may reflect limited use of rock shelters in this period rather than limited presence in the region. Similar patterns of alternation between occupation of rock shelters and open sites has been noted towards the west coast of South Africa through the mid to Late Holocene (Jerardino and Yates 1996), a period that is also poorly represented in rock shelters in the Doring River catchment. In spite of this, the regional framework is almost exclusively constructed using rock shelter data.

Second, it is not reasonable to assume that technological behaviors at different points on the landscape will always resemble each other, even if they occur in the same period. While the culture historic framework provides an averaged depiction of technology in a spatial block at a period of time, decisions about what kinds of artifacts to transport, in addition to potential functional differences between sites, may result in partitioning of a technological system at different locations (Barton and Riel-Salvatore 2014). Previous work in the Doring River catchment suggests the operation of such factors, such that, for example, Late MSA and the Early LSA assemblages identified in one part of the system are constituted very differently from the expression of the same system elsewhere in the catchment.

Third, even allowing for clustering of temporally-coherent artifacts, exposed open-air site assemblages are always prone to conflation of occupation from multiple periods—the palimpsest effect (Bailey 2007)—and these can be difficult if not impossible to disentangle. Thus, we cannot expect the signal in our Phase II analyses to be entirely 'clean' to the extent that that term is meaningful.

Recognizing these limitations, the project incorporates excavation and radiometric dating of sediment units adjacent to targeted clusters, including both those for which we presume already know the age, and those for which we have no analogues in the regional framework. Phase III work will commence once Phase I has been completed and we have a more comprehensive understanding of the available resources across the studied open-air localities. Excavation will ultimately facilitate our project aim of understanding technological behavior across space and time in the Doring River catchment, with culture history providing a functional, if limited, interim framework.

RESULTS

At the completion of two seasons of work, mapping of artifact distributions across six sediment stacks has been completed. The total analyzed sample so far is 24,221 artifacts, comprising 17,646 cores, 3657 retouched flakes, and 2918 other pieces (including pottery, ochre, anvils, grindstones and hammerstones). Here we focus our attention on five stacks that illustrate the range of depositional contexts, ages, and clustering patterns that occur. Artifact summaries for these localities are given in Table 2 (raw material), Table 3 (implement typologies), and Table 4 (industries). We describe the completed stacks in a downstream sequence starting at the Biedouw/Doring confluence.

UITSPANKRAAL 9 (UPK9)

Situated at the confluence of the Doring and Biedouw Rivers, Uitspankraal 9 (pronounced *ate-spun-krahl*) (UPK9) is a low vegetated rise at the distal end of a colluvial slope, cov-

TABLE 2. LITHIC RAW MATERIALS, PROPORTION BY LOCALITY FOR MAJOR LITHOLOGIES ONLY.

Locality	Quartzite	Hornfels	Quartz	Silcrete	Chert	Sandstone
UPK9	39.5%	28.4%	13.0%	5.1%	12.2%	1.7%
UPK7	39.4%	38.2%	8.9%	6.4%	4.6%	2.5%
UPK1	51.4%	38.5%	4.3%	2.5%	2.1%	1.2%
KH1	36.4%	53.7%	2.5%	2.8%	3.0%	1.5%
DB8	17.8%	67.3%	5.5%	4.3%	4.7%	0.2%
PL8	27.5%	64.9%	0.8%	3.9%	1.2%	1.7%

TABLE 3. COUNTS FOR MAJOR IMPLEMENT CLASSES BY LOCALITY.

Locality	Backed	Denticulate	Grindstone	Hammerstone	Naturally Backed Knives	Point-bifacial	Point-unifacial	Scaled piece	Scraper-other*
UPK9	24	13	51	259	102	1	2	121	823
UPK7	12	34	36	57	13	12	17	109	174
UPK1	3	1	5	6	0	8	3	6	40
KH1	3	12	3	30	3	133	12	10	82
DB8	8	4	9	20	6	2	11	18	61
PL1	0	0	1	3	0	0	0	8	2

*The class 'scraper-other' includes a wide range of scraper forms such as lateral scrapers, end scrapers, and continuous or thumbnail scrapers.

TABLE 4. COUNTS FOR ARTIFACTS ASSIGNED TO INDUSTRIES BY LOCALITY.*

Locality	ESA	Early MSA	Still Bay	HP	Post-HP	Late MSA	Early LSA	Robberg	Oakhurst	Early/mid Holocene	Wilton	Pottery
UPK9	1	?	1	5	2	12	1	**267**	**238**	**64**	**83**	509
UPK7	0	?	19	11	**51**	**95**	**55**	36	59	?	**49**	178
UPK1	29	?	9	5	2	28	1	0	0	?	4	105
KH1	3	?	**183**	10	32	230	10	**28**	0	?	10	0
DB8	0	?	6	6	10	28	1	20	6	?	9	2
PL1	0	?	0	0	2	**81**	4	0	0	?	0	0
Total	**33**	**?**	**218**	**37**	**99**	**474**	**72**	**351**	**303**	**?**	**155**	**794**

*Question marks used for the Early MSA and Early to Mid-Holocene reflect the lack of clear identifying characteristics for these periods. Red-bold is used to denote localities at which a given industry occurs in a cluster with apparently intact flaking debris, i.e., not only the diagnostic cores and implements. Questions marks and light grey shading indicate industries for which we currently lack appropriate diagnostic markers.

ering 27,013m^2. The sediment stack here is generally <1.5m high and sits at an elevation of 15–30m above the Doring River. At the west end, this sediment stack has several erosional embayments on both the north and south sides, the latter being the most significant. To the northeast, the sediments have been largely washed away, leaving a lag deposit of artifacts intermixed into the colluvium. The intact eastern part of the stack is cut at the south edge by an excavated feature probably constructed to constrain water runoff along the adjacent road. This cutting reveals a five-part sedimentary sequence comprising basal colluvium overlain by a well-developed nodular calcrete, another colluvium, indurated sands, and finally loose vegetated sands that are likely the result of recent aeolian processes. Immediately to the south of the cutting, sediment has been eroded down to the upper colluvium, and in the process has under-cut the foundations of an historical structure by 400mm (Figure 2B). Two samples of nodular calcrete were excavated from the immediate subsurface in this cutting and submitted to the Wollongong Isotope Geochronology Lab; they provided U/Th isochron ages of 226±25 ka (S91090) and 202±48 ka (S91091) (SOM Table 3). Excess detrital thorium in both samples limits more refined ages.

The survey at UPK9 concentrated on the areas of extant sandy sediment, with a five meter buffer into the surrounding colluvium. A total of 9486 artifacts was recorded in surveys at this locality. ESA and MSA artifacts are largely restricted to the exposed colluvium (see Figure 2), though there is little evidence for a lag of LSA artifacts on that unit, suggesting both that the current extent of the sand units is close to their original extent, and that the sand units were the focus of occupation. The exception is the aforementioned lag at the north-eastern edge of the locality. Otherwise, LSA and Neolithic (pottery) artifacts are restricted to exposures on the sediment stack.

The distribution of identifiably time-specific artifacts displays comparable signals of clustering to those noted during previous work at Uitspankraal 7 (UPK7). In the exposures on the western part of the stack, we observe a three-part horizontal 'sequence' running from west to east. At the western edge of the southern exposure, scaled pieces, large 'D-shaped' scrapers known locally as naturally backed knives (see further discussion below), and core-scraper-anvils typical of the local Oakhurst (14–8 ka) are common (see Figure 2). Moving east, we find 17 small 'thumbnail' scrapers made on silcrete and chert, and several backed artifacts, all typical of the mid-Holocene Wilton (8–2 ka) (Thackeray 1977). Towards the end of the exposure, pottery characteristic of the last 2000 years appears, and extends further into the upper exposures on the north side of the stack. The 'sequence' here is interesting insofar as the different components are not directly overprinted on one another. If the artifacts were eroding from a vertically stacked sediment sequence, then we would expect a more typical palimpsest effect. We hypothesize that the results instead reflect a shifting focus of occupation that tracks the eastward migration of the dune crest up the drainage depression through the Holocene. Excavation and dating at the locality are required to test this proposition.

The eastern part of UPK9 features more than 200 artifacts assigned to the Robberg (22–16 ka), which are comparatively rare in the western area. Robberg artifacts occur in three clusters—two dominated by silcrete and one by chert—which fringe the margins of the intact sediments but are largely absent from the erosional features on top of them. The general distribution of Robberg artifacts suggests that they either underlie the sediment stack in this area or occur close to the contact between the calcrete and the lowermost sands. A Phase II analysis has been conducted on one of the silcrete-rich Robberg clusters in this area with a publication in preparation.

Oakhurst artifacts are prolific in the lag at the northern edge of this unit. The cluster here includes 80 naturally backed knives (see Figure 2) and 45 large scaled pieces. Both of these artifact types are made on hornfels, however, the latter are exclusively made on hornfels derived from the river cobbles (based on the cobble morphology of the cortex). The naturally backed knives, on the other hand, are made exclusively on hornfels derived from primary sources—contact metamorphism of clay-rick sediment adjacent to intrusions, such as dolerite dykes in the interior Karoo—identifiable by its characteristically rough orange exterior and near 90° joints. A small number of Wilton artifacts occur in pockets of exposure towards the top of the stack. Pottery is distributed in clusters across the entire area, as are historical artifacts including a saddle badge with an 1851 date, suggesting occupation through to the near-present.

Not all of the clusters that we identified can easily be assigned to culture-historic units. Quartz is generally uncommon in the assemblages of the Doring River (Low et al. 2017; Mackay et al. in press), however, the UPK9 assemblage reveals a striking concentration of bipolar cores made on this material towards the centre of the locality (see Figure 2). The area is adjacent to, but not overlapping, a cluster of Robberg-associated artifacts, and lacks other time markers that we can identify. Pottery is common around the concentration but no more so than elsewhere in the eastern stack. Quartz bipolar cores are the dominant signal in the Late Holocene assemblages at Klipfonteinrand 2 and Putslaagte 8, however, pottery also occurs in those layers (Nackerdien 1989; Plaskett 2012); currently this is the most plausible assignment for these artifacts, but further work is required to clarify this suggestion. Assemblages from earlier parts of the Holocene in this region typically show a predominance of scrapers (Thackeray 1977), which are not in evidence in this cluster.

Chert is similarly uncommon in regional assemblages, but again displays strong clustering at UPK9. As noted, one of these clusters is associated with the Robberg at the northern edge of the locality. More striking is the concentration of chert scrapers (n=64) at the south-western edge of the major Oakhurst cluster (see Figure 2A). These artifacts are materially and physically consistent, with heavy stepped retouch on the lateral margins and a straight to rounded distal edge. The most comparable artifacts we know from the broader region are those referred to as 'Woodlot' scrap-

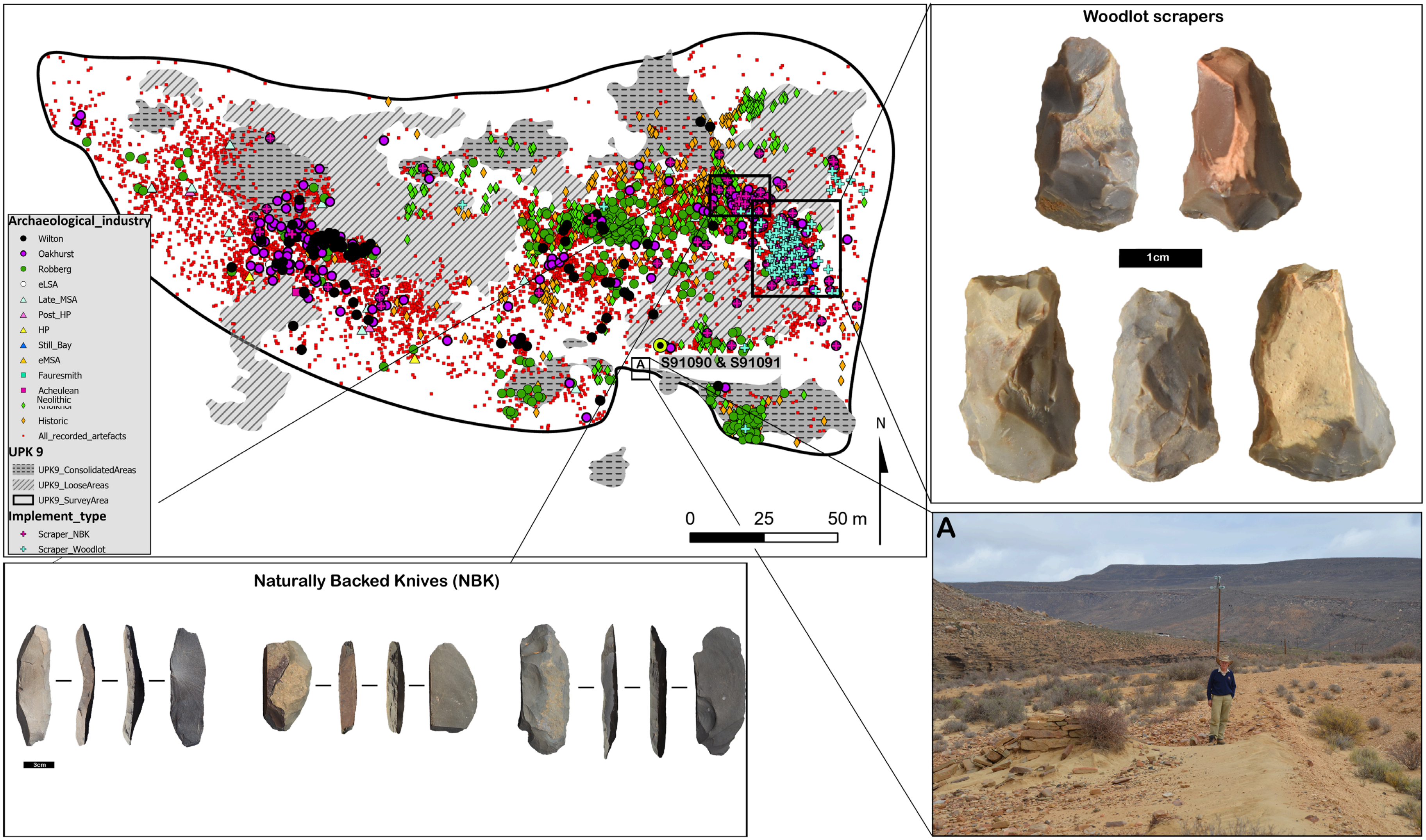

Figure 2. Distribution of artifacts and sediment bodies across Uitspankraal 9 (UPK9). (A) A sample of Woodlot scrapers from the eastern cluster. (B) Erosion beneath an historic structure.

ers dating 9–7 ka from sites in the southern Cape and Lesotho (Deacon 1984; Mitchell 2000); such artifacts are either not present in the mid-Holocene samples from Klipfonteinrand 1, or not differentiated in Thackeray's (1977) analysis of it.

UITSPANKRAAL 7 (UPK7)

UPK7 is an extensive sediment stack located on an ancient cobble terrace of the Doring, 12–26m above the current river valley and extending over the adjacent slope. The stack itself covers 42,326m^2. At the eastern edge of the stack is the modern dune crest, with deep erosional rills incising the sediment on the western and southern sides and exposing the indurated lower red sediments. Like UPK9, UPK7 has a basal colluvium but lacks an overlying calcrete. Indurated red sediments with nodular calcrete form the oldest identifiable unit, and this is overlain by a partly consolidated yellow sand unit, and capped by unconsolidated dune sands (Figure 3). We have so far obtained indicative multiple-aliquot optically stimulated luminescence (OSL) ages of quartz for the two upper sediment units only; results for the lower units remain in preparation.

Samples UNL-3808, UNL-3809, and UNL-3810 were collected from shovel-cut sections at depths of between 0.3–0.7m below present surface (see SOM Table 3). The samples traverse the site from east to west, though are, as noted, restricted to the less consolidated units. Samples were analyzed at the Luminescence Geochronology Lab at the University of Nebraska, Lincoln, using methods described in the SOM. Samples UNL-3809 and UNL-3810 were collected from the partly consolidated yellow sand unit and returned near identical ages of 30.3±1.3 ka and 30.5±1.4 ka respectively, reflecting accumulation of much of the sediment across this site around the MIS 3/2 boundary. Sample UNL-3808 was taken from the overlying unconsolidated dune sands and is dated to 0.069±0.005 ka. This suggests that the upper dune sand stabilized in the last century, which may reflect the elevated rates of recent erosion discussed previously.

We have previously published the results of detailed analysis of post-Howiesons Poort and Early LSA clusters at UPK7 conducted in 2014 and 2015 (Low et al. 2017; Will et al. 2015). Here we provide the broader context for those clusters from our recent Phase I survey. Phase I survey recorded 4285 artifacts at UPK7. Unlike UPK9, MSA artifacts are more common than those from the LSA at this locality. LSA artifacts occur principally at the top of the sediment stack and on the younger sedimentary units on the lower southern drape—those dating to around 30 ka. In the center of the locality, where younger sediments have been lost and where erosion is exposing and actively destroying the indurated red sediments, MSA artifacts are dominant and LSA artifacts essentially absent. Artifact density varies across the locality in ways not entirely controlled by surface exposure; artifacts are more commonly recorded on the exposed indurated surfaces of these sediment bodies, while large areas of loose sediment (younger sands) are devoid of artifacts. Density is highest in the exposure at the top of the stack, and on the indurated red sediments immediately to the south. On the younger sediment units in the southern and western part of the locality, artifact density is persistently low.

Leaving aside the Early MSA, UPK7 retains a signal from all identifiable culture-historic units. Still Bay artifacts are clustered on indurated red sediments in the south eastern erosional embayment, with a few more towards the center of the locality. A few Howiesons Poort artifacts also occur in this central area. Post-Howiesons Poort artifacts display strong clustering in the central area, with Late MSA artifacts well represented across the same sediment unit, extending to the west. The Early LSA cluster analyzed by Low in 2014–2015 is clearly identifiable in our Phase I work, occurring as a limited blow-out in the modern dune sands and resting on the partially consolidated yellow sandy unit dated elsewhere to around 30 ka. These Early LSA artifacts take up the entirety of the blowout and likely extend across a larger area below the modern sands. Robberg artifacts are much less common at UPK7 (n=36) than at UPK9 (n=267), but cluster strongly at the top of the stack. Oakhurst artifacts are well-represented in four different areas, but most notably at the top of the stack. Wilton artifacts are also concentrated in that area, as are potsherds, though the latter also occur in a series of clusters in loose sands around the fringe of the partly consolidated sands.

As with UPK9, there are clusters of material at UPK7 that we cannot easily reconcile with the known regional sequence. While at UPK9 these typically reflected behavioral aggregates, some of the occurrences at UPK7 more likely represent brief events. One of the more interesting is a splay of quartz artifacts on the southern slope, adjacent to the OSL sample UNL-3809, thus sitting above a sediment unit dating 30.3±1.3 ka (see Figure 3A). The cluster here comprises 29 cores—of which 23 are bipolar—an anvil and a hammerstone are within 46m^2. Twenty-two of the cores are made from quartz (all bipolar), five from hornfels and one each from chert and quartzite. While no refits were attempted on the bipolar quartz cores, one of the hornfels cores on the southern side of the splay refits an adjacent flake and a cortical hornfels blade located on the other side of the cluster about 6m away. While this cluster is likely LSA, and potentially quite recent, its position on the partly consolidated sands raises the possibility that it is coeval with the Early LSA cluster reported by Low et al. (2017). One of the observations made in that paper was that in rock shelter samples, hornfels blade production and small quartz bipolar flaking were intermixed, but in the open-air example, extensive hornfels blade production occurred without any significant bipolar flaking—quartz or otherwise—with the implication that those components of the technological system may have been undertaken separately. It is thus possible, though by no means certain, that the quartz bipolar splay on the lower south-west slope at UPK7 represents the other component of that system operationalized separately.

Another 'event' scale cluster occurs on the northern side of the locality, eroding out from the partly consolidated sands near OSL sample UNL-3810, dating 30.5±1.4

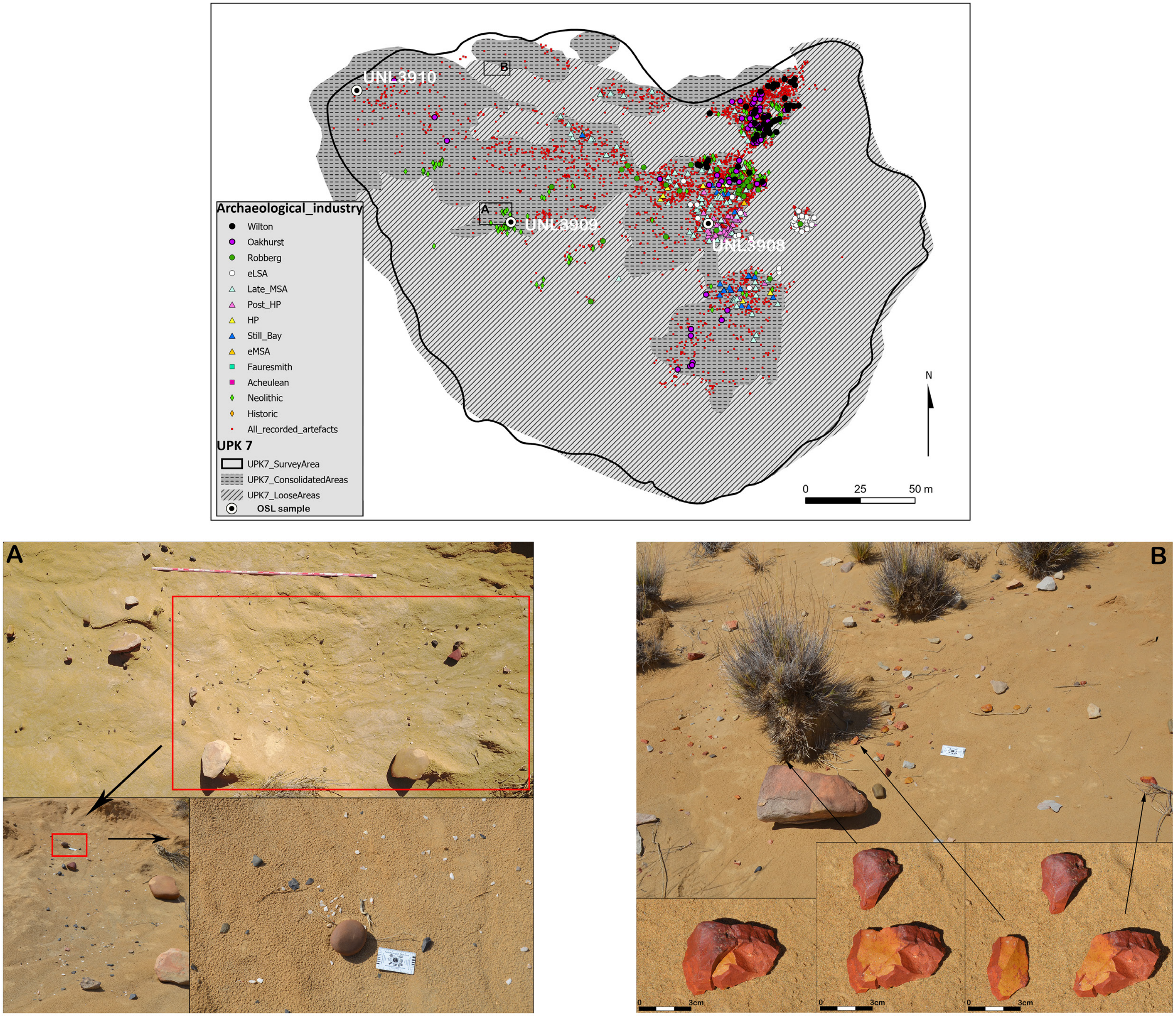

Figure 3. Distribution of artifacts and sediment bodies across Uitspankraal 7 (UPK7). (A) Cluster of quartz bipolar cores beneath an anvil. (B) Silcrete refit set.

ka. Here, in an area with a very low density of finds, we identified a cluster of silcrete flakes that is largely invisible with our Phase I point data. Three of the artifacts in this cluster are complete flakes that refit one another (see Figure 3B). The only silcrete core in the cluster was assigned to the MSA based on its pattern of reduction, suggesting persistence of MSA technology as late as 30 ka in the region. Interestingly, the flakes have a thin red 'skin' that is not cortical and a bright yellow interior. The color and exterior surface topography suggest that the rock was heated before flaking, while the bright yellow interior suggests that it was not heated, potentially highlighting some complexities in the identification of heat treatment in the area.

Nearby, at the far western edge of the locality, and apparently exposed on the cobble bench by erosion of the ~30 ka sediment unit, is a cluster of 12 preferential and recurrent Levallois cores. Eight of these are made from quartzite and two each from silcrete and hornfels. Abundant associated flaking debris suggests significant potential for refits but this was not attempted. Similar cores are also abundant in and around the exposures with major post-Howiesons Poort and Late MSA components, potentially suggesting that these relate either to another unknown phase within MIS 3 or to the Early MSA. The nearby OSL age provides a minimum age for this assemblage which, combined with the relative freshness of the artifacts, seems more supportive of a Late MSA association.

UITSPANKRAAL 1 (UPK1)

UPK1 is a very large sediment body, however, our work here was constrained to an area of 96,699m^2 due to the presence of tilled fields along the northern edge. The stack is 14–31m above the Doring River channel and divisible into four areas. At the western edge are slightly indurated yellow sands overlain by active modern dunes. In the central area are two erosional embayments exposing indurated red sediments potentially comparable to those in the main MSA area at UPK7. Along the northern edge is a well-developed nodular calcrete, probably analogous to that at UPK9, which forms the ridge on which the tilled field occurs. Attempts to obtain U/Th ages on these calcretes were unsuccessful due to excessive detrital content (S910414, see SOM). Due to the tilled field, only a small corridor along the southern edge of the ridge was suitable for survey. At the eastern edge of the locality is an extensive sheet of partially indurated brown sediment which may be colluvial rather than aeolian in origin and which is underlain by colluvial rocks and gravels.

Our Phase I surveys recorded 1252 artifacts at UPK1 (Figure 4). Unlike the other localities, ESA-assigned artifacts—represented entirely by handaxes—are reasonably well represented, though their distribution is largely constrained to the calcrete on the northern edge of the surveyed area. MSA artifacts are distributed across the locality, though concentrated on the exposed areas of indurated red sediment. LSA artifacts and pottery fragments are largely restricted to the western edge of the locality, occurring in blowouts where the slightly consolidated yellow sands are present, though there is a small cluster in the upper loose sands towards the center of UPK1.

The handaxes in the ESA samples are extremely diverse in size and shape, as we have noted previously, and the production systems relatively simple (Bleed et al. 2017; Magnani et al. 2016). The smallest complete example we recorded in Phase I had a maximum dimension of only 80.4mm; the largest measured 217.0mm. Artifacts from the Still Bay, Howiesons Poort, and post-Howiesons Poort—all indicative of MIS 4 and early MIS 3—are present in small numbers in the major erosional embayments associated with the MSA. Late MSA-assigned artifacts occur here too but these also occur in small numbers in blowouts on the indurated yellow sands to the west. In one blowout, a prepared hornfels core with a single platform was refit to two late flake removals. Given that the artifacts are almost certainly MSA, it suggests that the lightly indurated yellow sands began to accumulate around or before 30 ka, and may be consistent in age with the similar sedimentary unit at UPK7. Across the rest of that area, the only culture-historic unit represented is the Wilton, indicated by three thumbnail scrapers.

Not assigned to any culture-historic unit is a distinct concentration of flakes and cores in the southern part of the locality (see Figure 4A). All of the artifacts in this cluster are made from fine and homogeneous grey and blue-grey quartzite available in blocks on the adjacent scree slope. The cores are predominantly recurrent Levallois, some with large blade removals. Large blades are also reasonably common elsewhere in this erosional embayment. As with the UPK7 examples, these artifacts are inferred to be either Late or Early MSA.

KLEIN HOEK 1 (KH1)

The locality Klein Hoek 1 (KH1) occurs at the western (downstream) end of an extensive point bar. A fence line defines the eastern boundary of the locality. While artifacts are abundant in erosional features west of the fence line, less intensive grazing to the east means that there has been little erosion and thus limited surface exposure of artifacts. Artifacts no doubt exist in subsurface contexts in that area, but for the present we define the limits of the locality based on the visible extent of the archaeology, an area of 19,432 m^2 (Figure 5) that is 9–17m above the river.

Unlike UPK7 and UPK9, KH1 has a colluvial drape over most of its surface. While now separated from the adjacent scree slope by a minor drainage channel, we infer that this slope was connected to the scree in the past providing a continuous colluvial surface. Artifacts throughout the western part of the locality occur as a lag within this colluvium. Farther to the east, sandy sediments are preserved and a three-part sequence can be identified with the underlying colluvium exposed in patches throughout. The oldest unit, a compact brownish-red sandy deposit with a crumbly appearance and slightly friable consistence, sits immediately on top of the colluvium and is visible in only a few isolated areas. Covering this unit are indurated yellow-brown sands. Areas where this unit is intact have created

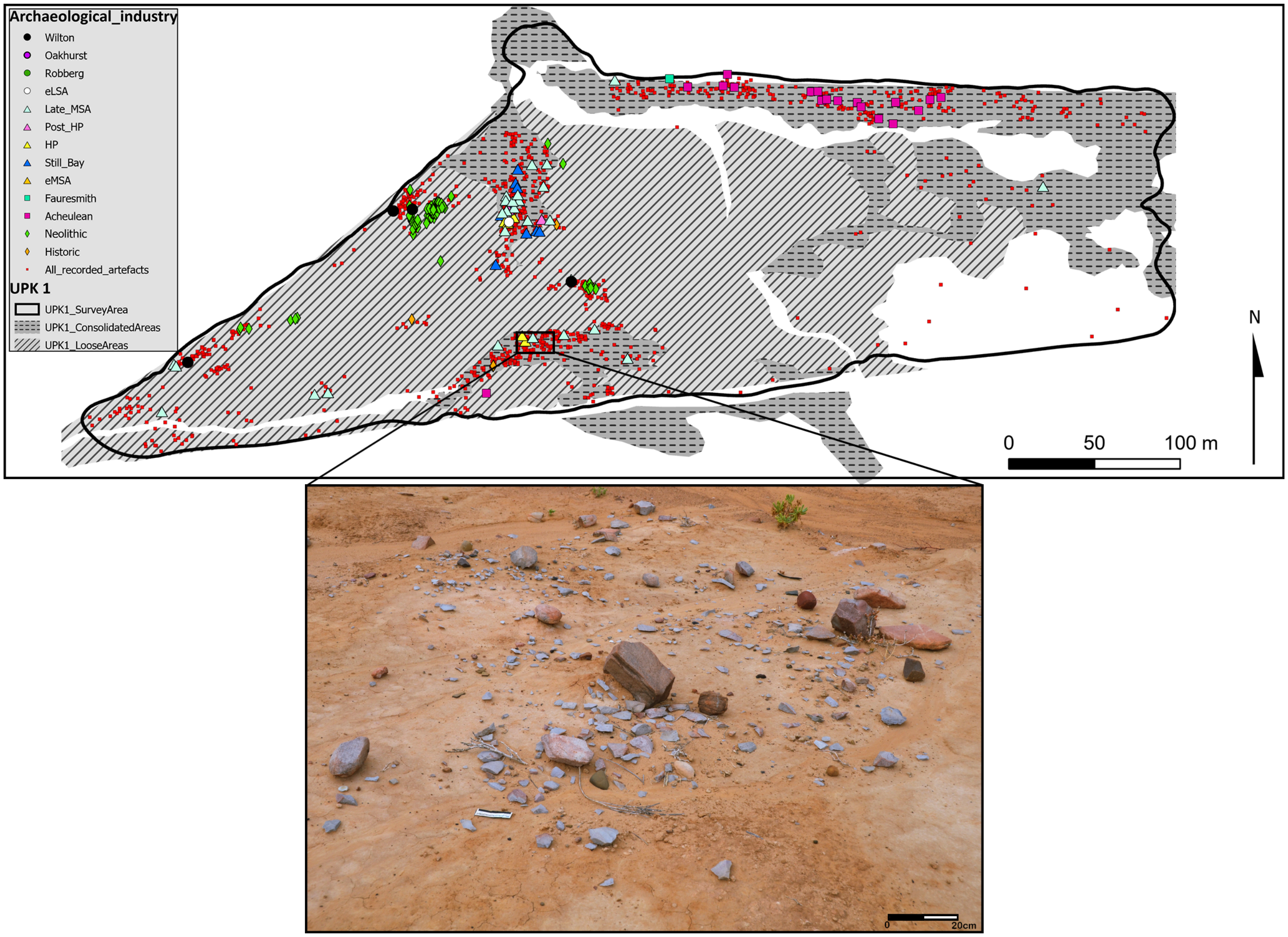

Figure 4. Distribution of artifacts and sediment bodies across Uitspankraal 1 (UPK1). (A) Dense cluster of recurrent Levallois cores, flakes and blades made from local blue-grey quartzite.

a series of small mounds across the study area. Capping this sequence are large swathes of modern vegetated sands, which are predominantly free of surface artifacts and likely preserve the sequence of indurated, possibly artifact-bearing, deposits below.

In total, 6747 artifacts were mapped at KH1 during Phase 1. As with the previously discussed localities, artifacts are absent from the modern vegetated upper sands but common in the erosional areas of the deposit. MSA and, to a lesser extent, ESA artifacts are common throughout the lag deposit on the western side of the locality, while some Pleistocene LSA (Early LSA and Robberg) artifacts occur on the eastern side. Late MSA cores are abundant and Post-Howiesons Poort artifacts reasonably common, but both are diffusely scattered among the colluvium; a few artifacts attributed to the Howiesons Poort and Early MSA were also recorded in this area. There is a reasonably well-defined—but small—cluster of Robberg cores located in a small depression at the top of a low rise on the eastern side of the locality. Immediately below this in an erosional feature near the base of the sedimentary sequence that contains a cluster of Still Bay artifacts. The cluster includes 183 bifacial pieces that we confidently assigned to the Still Bay (see Figure 5A), as well as four unifacial points and 13 end scrapers. A further 100 bifacially worked pieces are present in the scatter that are likely also associated with the Still Bay, though in most cases these were in early stages of manufacture and could not be confidently assigned. Thinning flakes associated with the production of points are abundant across the surface. All of this material appears to be eroding out from under the low mound on which the Robberg cluster sits. Phase II analysis was conducted on this Still Bay cluster and sediment samples for OSL dating were taken to constrain its age; these results will be presented elsewhere. In addition to the flaked stone artifacts, a single piece of engraved ochre was located toward the center of the scatter (see Figure 5B).

DORINGBOS 8 (DB8)

Doringbos 8 sits at the mouth of a short tributary of the Doring River and comprises a sediment stack approximately ten meters high, traces of which extend from 3–21m above the main channel of the Doring. Unlike other stacks, DB8 has been cut by periodic water flows from the trib-

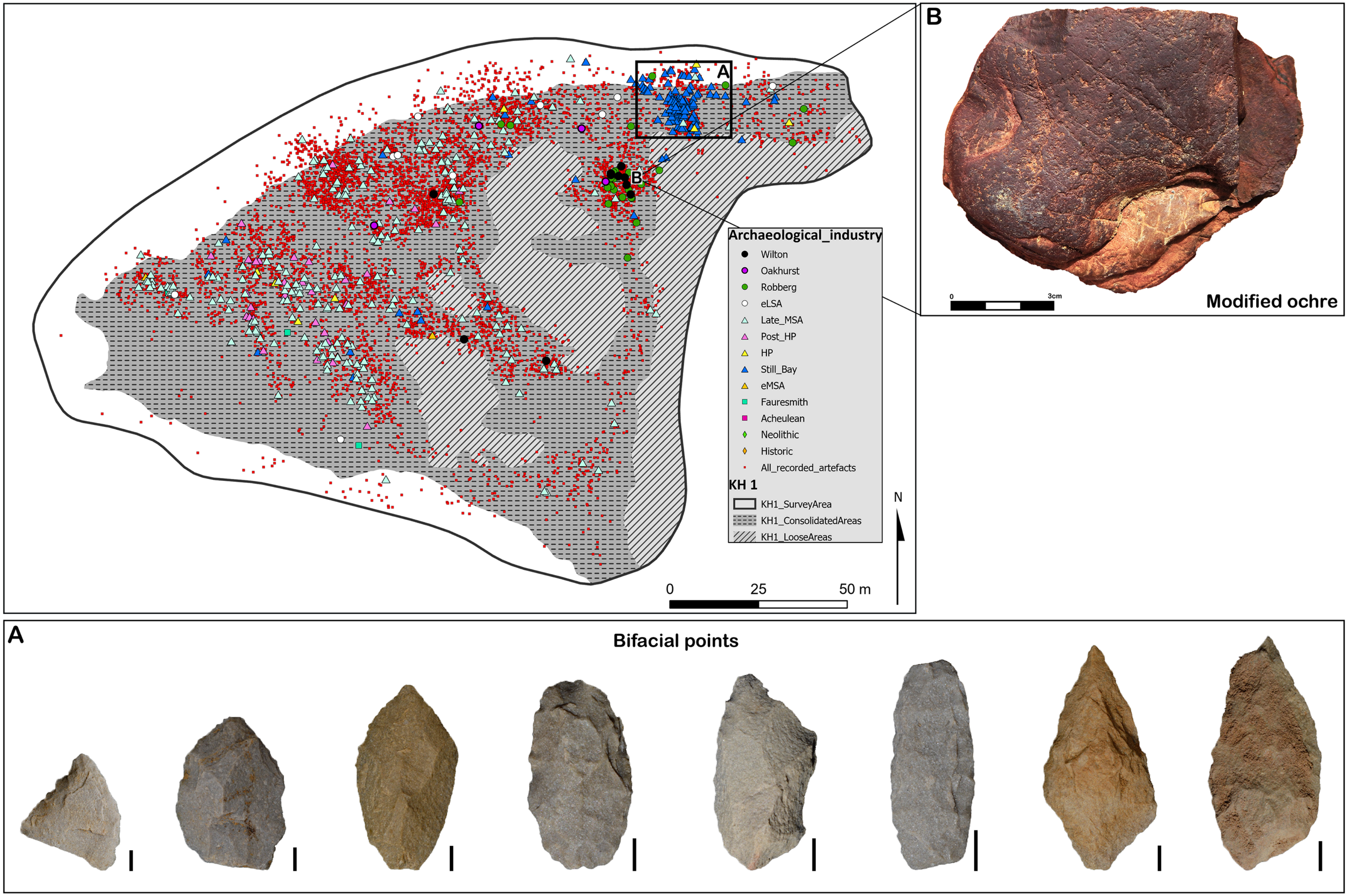

Figure 5. Distribution of artifacts and sediment bodies across Klein Hoek 1 (KH1). (A) A selection of bifacial pieces from the Still Bay cluster. (B) Engraved ochre in proximity to Robberg and Wilton artifacts.

utary, dividing it into separate northern (15,320m^2) and southern lobes (14,218m^2). The north face of the southern lobe provides a six-and-a-half-meter section with visible laminations (though no visible lenses of artifacts). We currently interpret this stack as a slackwater deposit, resulting from backflooding of the tributary by the Doring River. Erosion is common across the surfaces of both the southern and northern lobes, with large blowouts occurring in both. A minor drainage channel has formed at the junction of the northern lobe and the underlying bedrock on the north side, further accelerating sediment loss.

Steep scree slopes characterize the margins of the small tributary. Surface sediments across the two lobes are relatively uniform, consisting of compact, light brown fine sands. Although these exposed sediments are likely to vary in age, their uniformity aligns with available subsurface data. The 6.5m sedimentary sequence exposed between the two lobes by stream down-cutting is characterized by the cyclical deposition of fine sands that fine upward. In the north-west portion of the northern study lobe, more intensive erosion has exposed a colluvial surface. Slightly to the east, outside the study area and near the upper reaches of the short tributary, small patches of a brownish-red paleosol have been preserved, as have similarly small and isolated traces of more slackwater deposit. The paleosol is likely older than the slackwater deposit, although it may represent a soil associated with a particular time period during slackwater deposition in the tributary that was more conducive to soil formation processes at the upper reaches—the location where flood water would have been shallower with a slower rate of deposition.

Phase I survey documented 1814 artifacts at DB8 across both the northern and southern sections (Figure 6). LSA artifacts occur at the top of both stacks, with MSA artifacts below. Quartz-dominated LSA artifacts are common in the uppermost scatters on both lobes, as is chert. On the northern lobe, the MSA scatter exhibits a central cluster of silcrete, while being dominated by hornfels and quartzite elsewhere. We expect that the quartz-dominated upper scatters on both lobes are related to Late Holocene occupation. On the northern lobe there is a clear Wilton cluster sitting just above limited Oakhurst and Robberg signals.

The MSA scatters on both lobes include post-Howiesons Poort, Howiesons Poort, and Still Bay components, though these do not occur in the expected sequence relative to elevation in the either lobe. This may reflect either redistribution during erosion of the blowout, a complex depositional/sedimentation sequence (unlikely given the visible laminations), or mis-assignment of artifacts to industries. Only excavation could resolve these possibilities.

PUTSLAAGTE 1 (PL1)

Putslaagte 1 is the only previously excavated and published locality that we have so far surveyed. The locality comprises a single low mound covering 2941m^2 (Figure 7) situated on a distal spur at the confluence of the Putslaagte and the Doring Rivers. We did not distinguish multiple sediment bodies at PL1, though the mound includes two flat surfaces—one to the east and one to the west—the former of which is about 1.5m higher than the latter. The entire sediment stack is 6–14m above the current channel of the Doring River. Like DB8, PL1 was originally interpreted as a slackwater accumulation, and like DB8 it has been cut by activation of the tributary though it does not preserve an intact section as at DB8. OSL determinations in the 2010 excavation of the eastern (higher) mound surface at PL1 returned ages of 60.8±5.2 and 58.8±5.3 ka from 0.8m and 1.5m below surface respectively (Mackay et al. 2014b).

The entire surface assemblage at PL1 was originally assigned to the Late MSA based on both its distinctive characteristics and the OSL ages, combined with the absence of indicators from MIS 4. The results of our more comprehensive surface survey are broadly in line with that initial observation, though produce some valuable new observations. A total of 636 artifacts was recorded at PL1, with 193 assigned to the MSA; only four artifacts were assigned to the LSA. Of the other artifacts that could be assigned to industries, the vast majority belonged to the Late MSA. The four LSA-assigned artifacts were all allocated to the Early LSA. Surprisingly, the locality produced no clear evidence for occupation after ~22 ka, which is the local start of the Robberg. A small number of post-Howiesons Poort artifacts was observed, however, consistent with a formation age for the upper surface of around 58–61 ka. Both of these post-Howiesons Poort artifacts occurred on the northern edge of the lower mound surface. This area was also notably richer in silcrete (20 out of 480, 4.2%) than the upper mound surface (3 out of 157 pieces, 1.9%). Given that the lower mound surface is ~1.5m below the upper mound surface, and that the OSL ages were recovered from 0.8–1.5m below the surface of that mound, it may be that the lower surface effectively dates to ~58–61 ka, and thus formed within the post-Howiesons Poort interval.

DISCUSSION

The Doring River corridor was occupied from at least the Middle Pleistocene, and heavily occupied from the MSA into the historic period. Though we only recorded cores and implements—which typically account for quite small proportions of assemblages in the region—sample sizes were robust on all of the sediment stacks that we have so far studied. Visible artifact density was likely influenced by surface erosion; badly denuded localities like KH1 (0.35 cores and implements/m^2), UPK9 (0.32/m^2) and PL1 (0.22/m^2) have higher densities of artifacts than those such as DB8 (0.06/m^2) and UPK1 (0.01/m^2) on which both vegetation and the recent dunes have been preserved. Only in the western and northern parts of UPK7 do we see clear evidence for denuded surfaces that have low densities of artifacts. Interestingly much of this surface appears to date to around 30 ka, hypothetically allowing for accumulations of LSA material; these instead are concentrated towards the crest of the stack.

That the Doring River is a major source of stone for artifact manufacture likely increased the abundance of artifacts, particularly cores, along much of its course. How-

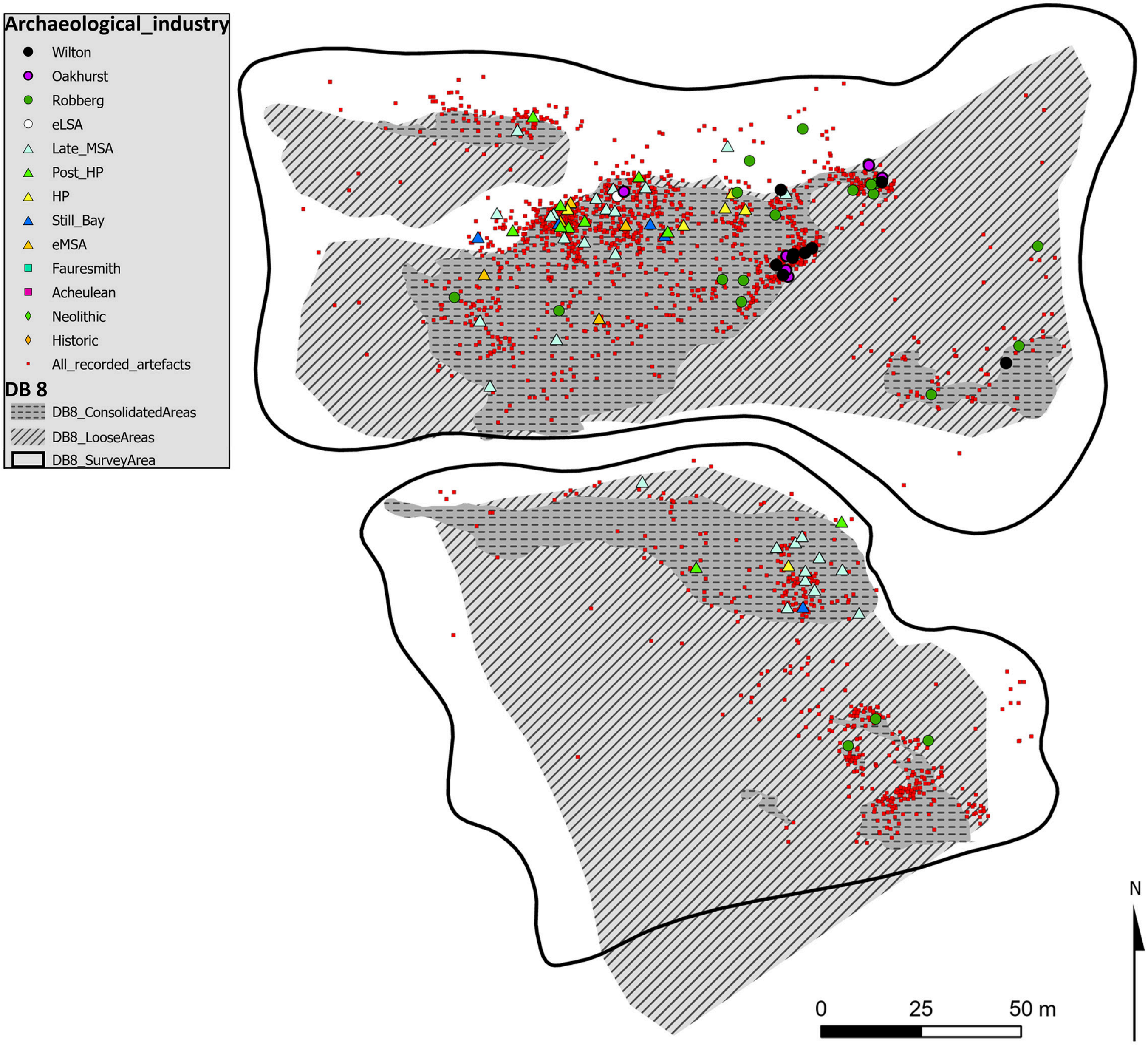

Figure 6. Distribution of artifacts and sediment bodies across Doringbos 8 (DB8).

ever, it is possible that the abundance of material on the sediment stacks reflects similar occupational decisions to those inferred by Sampson (1984) in his extensive Karoo surveys where locations selected for occupation were typically sandy, free of rock, and located close to—but not immediately on—reliable waterholes. All of the localities we examined were located at least ~100–150m from the current channel of the Doring River. Our ability to infer patterns of occupation at the landform scale, though, is limited by our survey strategy. While we surveyed a buffer of 5m around each stack, we have yet to conduct any systematic off-site surveys in the area, and thus whether these sediment stacks were more heavily occupied than other landforms in the Doring catchment is something of which we cannot yet be sure.

Our data do reveal interesting patterns of clustering—which we loosely define here as spatially coherent distributions of similar artifacts—at different spatial extents. At the finest scale, the Doring River sediment stacks appear to preserve occasional evidence of clustering that we might consider representative of 'events.' We see this most notably in the opportunistic refit sets at UPK7 and UPK1. In total, during the 2019 season we identified nine refit sets, to go with the three refit sets identified during our previous work (Low et al. 2017). All of the 2019 examples occurred in low density areas suggesting that refits are probably quite prevalent but often difficult to discern due to both the abundance of archaeology and the fact that our current surveys are focussed only on cores and implements. That these refit sets extend into the MSA supports the inferred

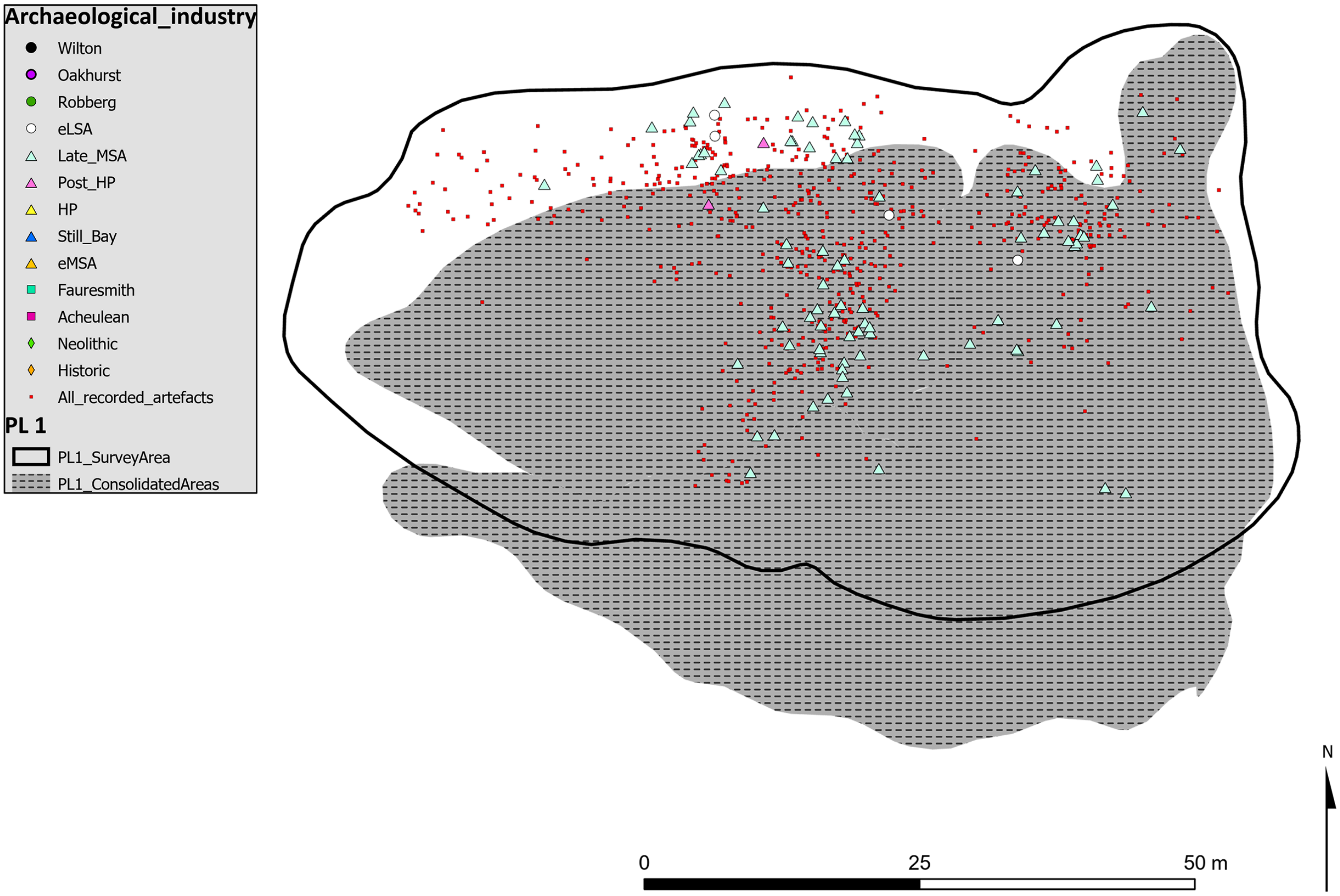

Figure 7. Distribution of artifacts and sediment bodies across Putslaagte 1 (PL1).

spatial integrity of the deposits across at least the last 30 kyr, though putative Still Bay at KH1 suggests that spatial integrity extends much deeper into the MSA.

At a somewhat larger scale—which we might term 'aggregates'—we found clusters with numbers of artifacts suggestive of either repeated occupation of specific locations on stacks or occupation by large numbers of people within limited areas. This occurs whether the aggregate is represented by retouched implements (e.g., Still Bay at KH1, Oakhurst and 'Woodlot/duckbill scrapers' at UPK9) or cores (e.g., post-Howiesons Poort and Early LSA at UPK7, Robberg at UPK9 and KH1). Some of these aggregates are unquestionably constrained by exposure visibility of appropriately-aged sediment surfaces. This is most notably true of the Still Bay at KH1, which likely extends under the adjacent mound, and the Early LSA at UPK7, which is entirely co-extensive with the blowout in which it is observed. It may also be true of the Robberg at UPK9 that likely continues across much of the indurated yellow sediment unit which is currently covered by recent dunes and vegetation. There is clearly significant excavation potential in these areas. In other cases, such as the eastern Oakhurst cluster at UPK9, the extent of the aggregate is not constrained by visibility and likely reflects the full spatial distribution of the phenomenon.

In addition to spatial clustering, there is evidence for vertical stacking of sediment units that is likely to warrant excavation. This is most clearly the case at DB8 where probable Late Holocene material overlies a succession of Wilton, Oakhurst, and Robberg, and then further below where MSA artifacts from the post-Howiesons Poort, Howiesons Poort, and Still Bay were mapped. Dating of the exposed section at DB8 is currently underway, though on the basis of the available evidence it seems plausible that a long cultural sequence is present at this locality. Vertical stacking of Late Holocene, Wilton, Oakhurst, and Late MSA also seems to occur in the northern erosional face of UPK7.

At the scale of industries or technocomplexes, clustering does seem to take different forms. For example, the Still Bay occurs as major (e.g., KH1) and minor (e.g., UPK7) clusters which are in both cases tightly spatially constrained. This is also true for the post-Howiesons Poort, Early LSA, Oakhurst, Wilton, and possibly the Robberg. So far, however, Late MSA clusters are always distributed as smears over relatively large areas. This may reflect the extended time interval that the Late MSA represents, which at ~25 kyr is around 3–5 times longer than the duration of the other industries. This is not to say that the defining features we have provided for the Late MSA hold for that entire duration. Indeed, this degree of technological stability would be unusual against the broader pattern of the last 75 kyr. Alternatively, then, if the simple prepared core systems on flat pebbles that we associate with the Late MSA are characteristic of only a portion of the period 50–25 ka, then the diffuse clustering we appear to see in the Late MSA may have a behavioral explanation. While we cannot evaluate this prospect with our available data, as noted below, the broader pattern of Late MSA artifact distribution is quite different to that of the other industries we have considered.

Consistent with previous work (Hallinan and Parkington 2017; Mackay et al. 2018), the Howiesons Poort is extremely poorly represented in our data so far. This is in spite of the fact that the Howiesons Poort—in contrast to most other industries—has clear identifying characteristics for implements, cores, and flakes. It is usually even possible to identify it through the abundance of silcrete in combination with the above markers. The paucity of Howiesons Poort artifacts in our surveys also stands in stark contrast to their abundance in excavated samples in the Doring catchment and across the Winter Rainfall Zone more broadly (Mackay et al. 2014a). The outcome here is essentially the inverse of that noted for the Late MSA, which was well-represented in our surveys but rare in shelters. Though fascinating, our sediment stack surveys remain incomplete, and as we have noted above do not take in open-air locations away from the river. The landscape-scale distribution of the Howiesons Poort in the Doring River valley remains only partially sketched thus far.

One other industry, or set of industries depending on the classification system (e.g., Lombard et al. 2012; Mackay et al. 2014a), that is poorly represented for different reasons is the Early MSA. We consider it likely that many Early MSA artifacts occur within our recorded sample, yet we currently lack confident identifying characteristics for this period. The only retouched flake types that we know to occur regularly in regional expressions of the Early MSA—notched and denticulate flakes—are also known to occur in the Late MSA and Early LSA (Porraz et al. 2016; Will et al. 2015). Of the denticulates that we recorded, most occurred as isolated instances, some of which were associated with Late MSA cores. So far, no clusters of denticulate pieces have been observed. We have also yet to find any cores capable of producing the kinds of very large blades and flakes often associated with the Early MSA, though blades >80mm were observed with recurrent Levallois cores at UPK1. Otherwise, this industry remains beyond the reach of our current approach.

CONCLUSIONS

The long-term objective of the Doring River Archaeology Project is to understand the organization of technology at the landscape scale through at least the Late Pleistocene. The localities that we have worked on so far provide an encouraging wealth of material from this interval, and display a spatial structure indicative of significant horizontal and occasionally vertical integrity in spite of extensive and likely recent erosion. Preliminary patterns suggest striking differences in the abundance and distribution of artifacts between different industries. The Late Holocene and Wilton are common in open sites despite having been rare in rock shelter excavations in the catchment. This is even more acutely true for the Late MSA. The Howiesons Poort, on the other hand, shows an inverted pattern of distribution—common in shelters, rare in the open. Only the Robberg and to a lesser extent the Oakhurst are common in all contexts. Conversely, the Early LSA is rare throughout.

These patterns, though, presume that we can identify artifacts from given periods using similar identifying characteristics in all contexts. We know from our past work in the catchment that this approach is fraught with issues. Technological systems are responsive to the availability of raw materials at a minimum, and probably also of water, as well as other variables with spatial and temporal distributions that are less easy to identify. We are also confronted with coherent clusters of material that we currently cannot place within the local sequence at all, though they may be expressions of entities known from the broader region. Both of these observations converge on the same solution, however—excavations are required to move beyond the process of dating-by-inference on which we currently rely. Survey work away from the sediment bodies is a further necessity before our broader project aims can be met, alongside completion of analysis of artifact assemblages and dating of sediments from the rock shelters we have excavated. The integration of these data sets should allow our broader goals to be met.

ACKNOWLEDGEMENTS

The Doring River Archaeology Project has been supported by grants from the Australian Research Council (DE130100068 & FT160100139) to AM. CA is supported by a post-doctoral fellowship from the Faculty of Science, Medicine and Health at the University of Wollongong.

ENDNOTES

[1]We use the term 'sediment stacks' to refer to large accumulations of sediment along the Doring River as described in the Identification of Archaeological Localities section. The term 'locality' is used to refer to any concentration of archaeological material, whether on a sediment stack or not. So far, all of the sediment stacks we have identified have also been localities in this sense.

REFERENCES

Andrefsky, W.A.J. 1994. Raw material availability and the organization of technology. *American Antiquity* 59(1): 21–34.

Bailey, G. 2007. Time perspectives, palimpsests and the archaeology of time. *Journal of Anthropological Archaeology* 26(2): 198–223.

Bamforth, D.B. 1991. Technological organisation and hunter-gatherer land use: a California example. *American Antiquity* 56(2): 216–234.

Barham, L.S. 1989. *The Later Stone Age of Swaziland*. Ph.D. thesis, Philadelphia, University of Pensylvania.

Barton, C.M. and J. Riel-Salvatore. 2014. The formation of lithic assemblages. *Journal of Archaeological Science* 46: 334–352.

Beaumont, P.B. 1978. *Border Cave*. M.A. thesis, Cape Town, University of Cape Town.

Binford, L.R. 2001. *Constructing Frames of Reference: An Analytical Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets*. Berkeley and Los Angeles, University of California Press.

Bleed, P., M.J. Douglass, A. Sumner, M. Behrendt, and A. Mackay. 2017. Photogrammetrical assessment of procedural patterns and sequential structure in "handaxe" manufacture: a case study along the Doring River of South Africa. *Lithic Technology* 2017: 1–11.

Bousman, C.B. and J.S. Brink 2017. The emergence, spread, and termination of the Early Later Stone Age event in South Africa and southern Namibia. *Quaternary International* 495: 116–135.

Carter, P.L. 1978. *The Prehistory of Eastern Lesotho*. Ph.D. thesis, Cambridge, UK, University of Cambridge.

Carter, P.L., P.J. Mitchell, and P. Vinnicombe. 1988. *Sehonghong: The Middle and Later Stone Age Industrial Sequence at a Lesotho Rockshelter*. Oxford, British Archaeological Reports International Series 406. Archaeopress.

Deacon, H.J. 1976. *Where Hunters Gathered: A Study of Holocene Stone Age People in the Eastern Cape*. Claremont, South African Archaeological Society.

Deacon, H.J. 1979. Excavations at Boomplaas Cave - A sequence through the Upper Pleistocene and Holocene in South Africa. *World Archaeology* 10(3): 241–257.

Deacon, J. 1984. *The Later Stone Age in Southernmost Africa*. Oxford, Archaeopress.

Feilden, H.W. 1884. Notes on Stone Implements from South Africa. *Journal of the Anthropological Institute of Great Britain and Ireland* 13: 162–174.

Fisher, E., R.-M. Albert, G.A. Botha, H. Cawthra, I. Esteban, J.W. Harris, Z. Jacobs, A. Jerardino, C.W. Marean, F.H. Neumann, J. Pargeter, M. Poupart, and J. Venter. 2013. Archaeological reconnaissance for Middle Stone Age sites along the Pondoland Coast, South Africa. *PaleoAnthropology* 2013: 104–137.

Gooch, W.D. 1882. The Stone Age of South Africa. *Journal of the Royal Anthropological Institute* 11: 124–183.

Goodwin, A.J.H. and C. van Riet Lowe. 1929. *The Stone Age Cultures of South Africa*. Edinburgh, Neill and Co.

Hall, S. 1990. *Hunter-Gatherer-Fishers of the Fish River Basin: A Contribution to the Holocene Prehistory of the Eastern Cape*. D.Phil. thesis, Stellenbosch, University of Stellenbosch.

Hallinan, E. and J. Parkington. 2017. Stone Age landscape use in the Olifants River Valley, Clanwilliam, Western Cape, South Africa. *Azania: Archaeological Research in Africa* 52(3): 324–372.

Harmand, S., J.E. Lewis, C.S. Feibel, C.J. Lepre, S. Prat, A. Lenoble, X. Boes, R.L. Quinn, M. Brenet, A. Arroyo, N. Taylor, S. Clement, G. Daver, J.P. Brugal, L. Leakey, R.A. Mortlock, J.D. Wright, S. Lokorodi, C. Kirwa, D.V. Kent, and H. Roche. 2015. 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. *Nature* 521(7552): 310–315.

Herries, A.I. 2011. A chronological perspective on the Acheulian and its transition to the Middle Stone Age in southern Africa: the question of the Fauresmith. *International Journal of Evolutionary Biology* 2011: 961401.

Holdaway, S. and M. Douglass. 2015. Use beyond manufacture: non-flint stone artifacts from Fowlers Gap, Australia. *Lithic Technology* 40(2): 94–111,

Howland, M.D., I.W.N. Jones, M. Najjar, and T.E. Levy 2018. Quantifying the effects of erosion on archaeological sites with low-altitude aerial photography, structure from motion, and GIS: a case study from southern Jordan." *Journal of Archaeological Science* 90: 62–70.

Jarvis, A., H.I. Reuter, A. Nelson, and E. Guevara. 2008. Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database (http://srtm.csi.cgiar.org).

Jerardino, A. and R. Yates. 1996. Preliminary results from excavations at Steenbokfontein Cave: implications for past and future research. *South African Archaeological Bulletin* 51: 7–16.

Kaplan, J. 1990. The Umhlatuzana Rock Shelter seqeunce: 100 000 years of Stone Age history. *Natal Museum Journal of Humanities* 2: 1–94.

Kelly, R.L. 1995. *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways*. Washington, D.C., Smithsonian Institution Press.

Lin, S.C., M.J. Douglass, and A. Mackay. 2016. Interpreting MIS 3 artefact transport patterns in southern Africa using cortex ratios: an example from the Putslaagte valley, Western Cape. *South African Archaeological Bulletin* 71(204): 173–180.

Loftus, E., J. Sealy, and J. Lee-Thorp. 2016. New radiocarbon dates and Bayesian models for Nelson Bay Cave and Byneskranskop 1: implications for the South African Later Stone Age sequence. *Radiocarbon* 58(02): 365–381.

Lombard, M., L. Wadley, J. Deacon, S. Wurz, I. Parsons, M. Mohapi, J. Swart, and P. Mitchell. 2012. South African and Lesotho Stone Age sequence updated. *South African Archaeological Bulletin* 67(195): 120–144.

Low, M., A. Mackay, and N. Phillips. 2017. Understanding Early Later Stone Age technology at a landscape-scale: evidence from the open-air locality Uitspankraal 7 (UPK7) in the Western Cape, South Africa. *Azania: Archaeological Research in Africa* 52(3): 373–406.

Low, M.A. and A. Mackay. 2016. The late Pleistocene microlithic at Putslaagte 8 rockshelter in the Western Cape, South Africa. *South African Archaeological Bulletin* 71(204): 146–159.

Low, M.A. and A. Mackay. 2018. The organisation of Late Pleistocene Robberg blade technology in the Doring River Catchment, South Africa. *Journal of African Archaeology* 16: 168–192.

Mackay, A., C. Cartwright, S. Heinrich, M. Low, M. Stahlschmidt, and T.E. Steele. in press. Excavations at Klipfonteinrand reveal local and regional patterns of adaptation and interaction through MIS 2 in southern Africa. *Journal of Palaeolithic Archaeology*.

Mackay, A., E. Hallinan, and T.E. Steele. 2018. Provisioning responses to environmental variation in the late Pleistocene of southern Africa, MIS 5–2. In *Lithic Technological Organization and Paleoenvironmental Change*. E. Robinson and F. Sellet (eds.), Dordrecht, Springer, pp. 13–36.

Mackay, A., Z. Jacobs, and T.E. Steele. 2015. Pleistocene archaeology and chronology of Putslaagte 8 (PL8) rockshelter, Western Cape, South Africa. *Journal of African Archaeology* 13(1): 71–98.

Mackay, A., B.A. Stewart, and B.M. Chase. 2014a. Coalescence and fragmentation in the late Pleistocene archaeology of southernmost Africa. *Journal of Human Evolution* 72: 26–51.

Mackay, A., A. Sumner, Z. Jacobs, B. Marwick, K. Bluff, and M. Shaw. 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.

Magnani, M., M. Douglass, and S.T. Porter. 2016. Closing the seams: resolving frequently encountered issues in photogrammetric modelling. *Antiquity* 90(354): 1654–1669.

Mazel, A.D. 1989. People making history: the last ten thousand years of hunter-gatherer communities in the Thukela Basin. *Natal Museum Journal of Humanities* 1: 1–168.

McPherron, S.P., Z. Alemseged, C.W. Marean, J.G. Wynn, D. Reed, D. Geraads, R. Bobe, and H.A. Bearat. 2010. Evidence for stone-tool-assisted consumption of animal tissues before 3.39 million years ago at Dikika, Ethiopia. *Nature* 466(7308): 857–860.

Mitchell, L.J. 2009. *Belongings: Property, Family, and Identity in Colonial South Africa (an exploration of frontiers, 1725-c. 1830)*. New York, Columbia University Press.

Mitchell, P.J. 2000. The organization of Later Stone Age lithic technology in the Caledon Valley, Southern Africa. *African Archaeological Review* 17(3): 141–176.

Mitchell, P.J. 2008. Developing the archaeology of Marine Isotope Stage 3. *South African Archaeological Society Goodwin Series* 10: 52–65.

Nackerdien, R. 1989. *Klipfonteinrand 2: A Sign of the Times*. B.A. Honours, Cape Town, University of Cape Town.

Nelson, M. 1991. The study of technological organization. *Archaeological Method and Theory* 3: 57–100.

Neumark, S.D. 1957. *Economic Influences on the South African Frontier 1652-1836*. Stanford, USA, Stanford University Press.

Opperman, H. 1996. Strathalan Cave B, north-eastern Cape Province, South Africa: evidence for human behaviour 29,000-26,000 years ago. *Quaternary International* 33: 45–53.

Parkington, J.E. 1980. The Elands Bay cave sequence: cultural stratigraphy and subsistence strategies. *Proceedings of the Eighth Pan-African Congress of Prehistory and Quaternary Studies, Nairobi*, pp. 315–320.

Parkington, J.E., Poggenpoel, C.A., Buchanan, W., Robery, T., Manhire, A.H., and Sealy, J. 1988. Holocene coastal settlement patterns in the Western Cape. In *The Archaeology of Prehistoric Coastlines*, G.N. Bailey and, J.E. Parkington (eds.). Cambridge, Cambridge University Press, pp. 22–41.

Paxton, B. 2008. *The Influence of Hydraulics, Hydrology and Temperature on the Distribution and Habitat Use and Recruitment of Threatened Cyprinids in a Western Cape River, South Africa*. Ph.D. thesis, Cape Town, University of Cape Town.

Phillips, N. in prep. *Out in the Open: A Geoarchaeological Approach to Open-air Surface Archaeology in the Semi-arid Interior of South Africa's Western Cape*. Ph.D. thesis, Wollongong, University of Wollongong.

Phillips, N., J. Pargeter, M. Low and A. Mackay. 2018. Open-air preservation of miniaturised lithics: experimental research in the Cederberg Mountains, southern Africa. *Archaeological and Anthropological Sciences* 11(11): 5851–5877.

Plaskett, J. 2012. *The Stone Artefacts of Putslaagte 8: Exploring Variation in Stone Artefact Assemblages of the Western Cape*. Unpublished B.A. Honours, Cape Town, University of Cape Town.

Porraz, G., V. Schmid, C. Miller, C. Tribolo, C. Cartwright, A. Charrié-Duhaut, M. Igreja, S.M. Mentzer, N. Mercier, P. Schmid, N.J. Conard, J.P. Texier, and J. Parkington. 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., P.-J. Texier, W. Archer, M. Piboule, J.-P. Rigaud, and C. Tribolo. 2013. Technological successions in the Middle Stone Age sequence of Diepkloof Rock Shelter, Western Cape, South Africa. *Journal of Archaeological Science* 40(9): 3376–3400.

Quick, L.J. and F.D. Eckardt. 2015. The Cederberg: a rugged sandstone topography. In *Landscapes and Landforms of South Africa*, S. Grab and J. Knight (eds.), Dordrecht, Springer, pp. 85-93.

Sadr, K. 2015. Livestock first reached southern Africa in two separate events. *PLoS One* 10(8): e0134215

Sampson, C.G. 1968. *The Middle Stone Age Industries of the Orange River Scheme Area*. Bloemfontein, National Museum.

Sampson, C.G. 1984. Site clusters in the Smithfield settlement pattern. *South African Archaeological Bulletin* 39(139): 5–53.

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

Singer, R. and J. Wymer. 1982. *The Middle Stone Age at Klasies River Mouth in South Africa*. Chicago, University of Chicago Press.

Smith, A.B. and M.R. Ripp. 1978. An archaeological reconnaissance of the Doorn/Tanqua Karoo. *South African Archaeological Bulletin* 33: 118–133.

Thackeray, A.I. 1977. *Stone Artefacts from Klipfonteinrand*. B.A. Honours, Cape Town, University of Cape Town.

Villa, P., S. Soriano, T. Tsanova, I. Degano, T. Higham, F. d'Errico, L. Backwell, J. Lucejko, M.P. Colombini, and

P. Beaumont. 2012. Border Cave and the beginning of the Later Stone Age in South Africa. *Proceedings of the National Academy of Sciences USA* 109(33): 13208–13213.

Visser, H.N. and J.N. Theron. 1973. 3218 Clanwilliam. *Geological Series*. Pretoria, Government Printer, South Africa.

Volman, T.P. 1981. *The Middle Stone Age in the Southern Cape*. Ph.D. thesis, Chicago, University of Chicago.

Wadley, L. 1984. *Later Stone Age Hunter-Gatherers of the Southern Transvaal: Social and Ecological Interpretation*. Oxford, British Archaeological Reports International Series 380.

Wadley, L. 1997. Rose Cottage Cave: archaeological work 1987 to 1997. *South African Journal of Science* 93: 439–444.

Wadley, L. and Z. Jacobs. 2006. Sibudu Cave: background to the excavations, stratigraphy and dating. *Southern African Humanities* 18: 1–26.

Wendt, W.E. 1972. Premilinary report on an archaeological research programme in South West Africa. *Cimbebasia B* 2: 1–61.

Wilkins, J. and M. Chazan. 2012. Blade production ~500 thousand years ago at Kathu Pan 1, South Africa: support for a multiple origins hypothesis for early Middle Pleistocene blade technologies. *Journal of Archaeological Science* 39(6): 1883–1900.

Will, M., A. Mackay, and N. Phillips. 2015. Implications of Nubian-like core reduction systems in Southern Africa for the identification of early modern human dispersals. *PLoS One* 10(6): e0131824.