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# Putslaagte 1 (PL1), the Doring River, and the later Middle Stone Age in southern Africa's Winter Rainfall Zone

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## ABSTRACT

Existing data suggest weak human occupation of southern Africa's Winter Rainfall Zone (WRZ) during later Marine Isotope Stage (MIS) 3, the causes of which are unknown. Here we report briefly on the results of recent surveys of alluvial terrace sites of the Doring River in the WRZ, which document occupation over a broad expanse of the later Middle Stone Age (MSA) and Pleistocene Later Stone Age. We then report on test excavations at one terrace site, denoted Putslaagte site 1 (PL1), describe in detail the assemblage of flaked stone artefacts produced from that excavation, and present two OSL ages obtained from 0.8 m to 1.5 m below surface. The results suggest that a) artefact accumulations at PL1 are dense, b) the technological systems documented are characteristically MSA but differ in form from the range of systems known from other excavated sites in the region, and c) that the assemblages accumulated in MIS 3. Taken together with the survey data the results introduce new variation into the later MSA in southern Africa, and imply reorganisation of land use in the WRZ in late MIS 3 rather than abandonment. We suggest that a research emphasis on rock shelter deposits may have produced misleading depictions of regional occupation.

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## 1. Introduction

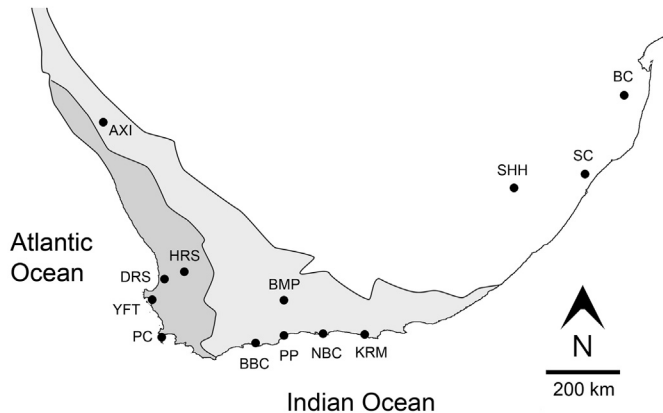
The archaeology of Marine Isotope Stage (MIS) 3 in southern Africa is important, witnessing the end of the Middle Stone Age (MSA) and the beginnings of the Later Stone Age (LSA) (D'Errico et al., 2012), but it is also somewhat perplexing (Mitchell, 2008). Whereas MIS 4 and MIS 2 are characterised by dense artefact assemblages in well-defined industries distributed across numerous sites (e.g., Volman, 1980; Deacon, 1984; Mitchell, 1988; Wadley, 1993, 2007; Soriano et al., 2007; Jacobs et al., 2008a,b; Villa et al., 2009, 2010; Brown et al., 2012; Porraz et al., 2013a), the archaeology of MIS 3, particularly after 50 ka appears comparatively quiet and less well resolved (Ambrose, 2002; Klein et al., 2004; Mitchell, 2008). This is most clearly the case in the south western part of South Africa, in the Winter and Year-Round Rainfall regions (WRZ/YRZ) which both receive significant winter rainfall input from the

seasonal north-ward migration of westerly winds (Chase and Meadows, 2007) (Fig. 1). Many of the most imposing archives in this area – including Klasies River, Nelson Bay Cave, Pinnacle Point, Blombos Cave, Diepkloof and Elands Bay Cave – appear to have been largely unused in the period 50–25 ka (Deacon and Thackeray, 1984; Deacon, 1995; Mitchell, 2008; Jacobs, 2010; Mackay, 2010; Brown et al., 2012; Faith, 2013), despite rich earlier periods of occupation and in some cases, reoccupation after 25 ka (Deacon, 1978; Parkington, 1980; Orton, 2006). This has led some researchers to suggest that southern Africa was largely depopulated in the period leading up to the MSA/LSA transition (Klein et al., 2004).

One of the issues with occupational models built on the late Pleistocene archaeological record of southern Africa is that the record as we discuss it is dominated by data recovered from rock shelters. This is partly a consequence of the fact that much of southern Africa is erosional. Although Pleistocene open sites are abundant, they invariably occur in deflated contexts, often as cumulative palimpsests (Bailey, 2007: 204), in which multiple phases of occupation are conflated on a single surface. Such sites

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**Fig. 1.** Modern rainfall zones of southern African showing major Middle Stone Age sites. Dark grey shading: Winter Rainfall Zone. Light grey shading: Year-round Rainfall Zone. No shading: Summer Rainfall Zone. Site abbreviations: Apollo 11 (AXI), Blombos Cave (BBC), Boomplaas (BMP), Border Cave (BC), Diepkloof (DRS), Hollow Rock Shelter (HRS), Klasies River (KRM), Nelson Bay Cave (NBC), Peers Cave (PC), Pinnacle Point (PP), Sehonghong (SHH), Sibudu Cave (SC), Ysterfontein (YFT).

are presently difficult if not impossible to date by other than relative means. This has in turn led to a strong research emphasis on rock shelters to the exclusion of open sites (although see Sampson, 1968; Henderson et al., 2006; Mackay et al., 2010; Fisher et al., 2013). The focus on rock shelters has important weaknesses, however. First, throughout the past most activities including the acquisition of food, water, tool-making and other manufacturing materials, and perhaps also social activities, were likely undertaken in open landscape settings. Thus, rock shelters represent only a limited and potentially biased portion of past behaviours. Second, the conditions governing rock shelter use may not have been consistent through time. In some periods rock shelters appear to have been used proportionally more often, leading to their overrepresentation in shelters and their near absence on the land surface (Hallinan, 2013).

As part of a broader archaeological research program in the Western Cape of South Africa we undertook surveys along the Doring River, situated in the rain shadow of the Cape Fold Belt mountains in the WRZ. During those surveys we identified numerous relict alluvial terraces with an abundance of MSA artefacts on their surface. We provide a brief report on the results of those surveys here and then describe in detail the results of test excavations undertaken on one terrace – denoted Putslaagte site 1 (PL1). The results suggest intensive occupation of the Doring River corridor during the later Pleistocene, including the production of large numbers of MSA artefacts during MIS 3, using a general but distinct set of core reduction systems. From this we infer that the absence of occupation noted in rock shelter sites in the WRZ during MIS 3 may reflect a reorganisation of landscape use rather than depopulation. This calls into question not only existing occupational models but also the utility of rock shelters, when viewed in isolation, for understanding past occupational dynamics.

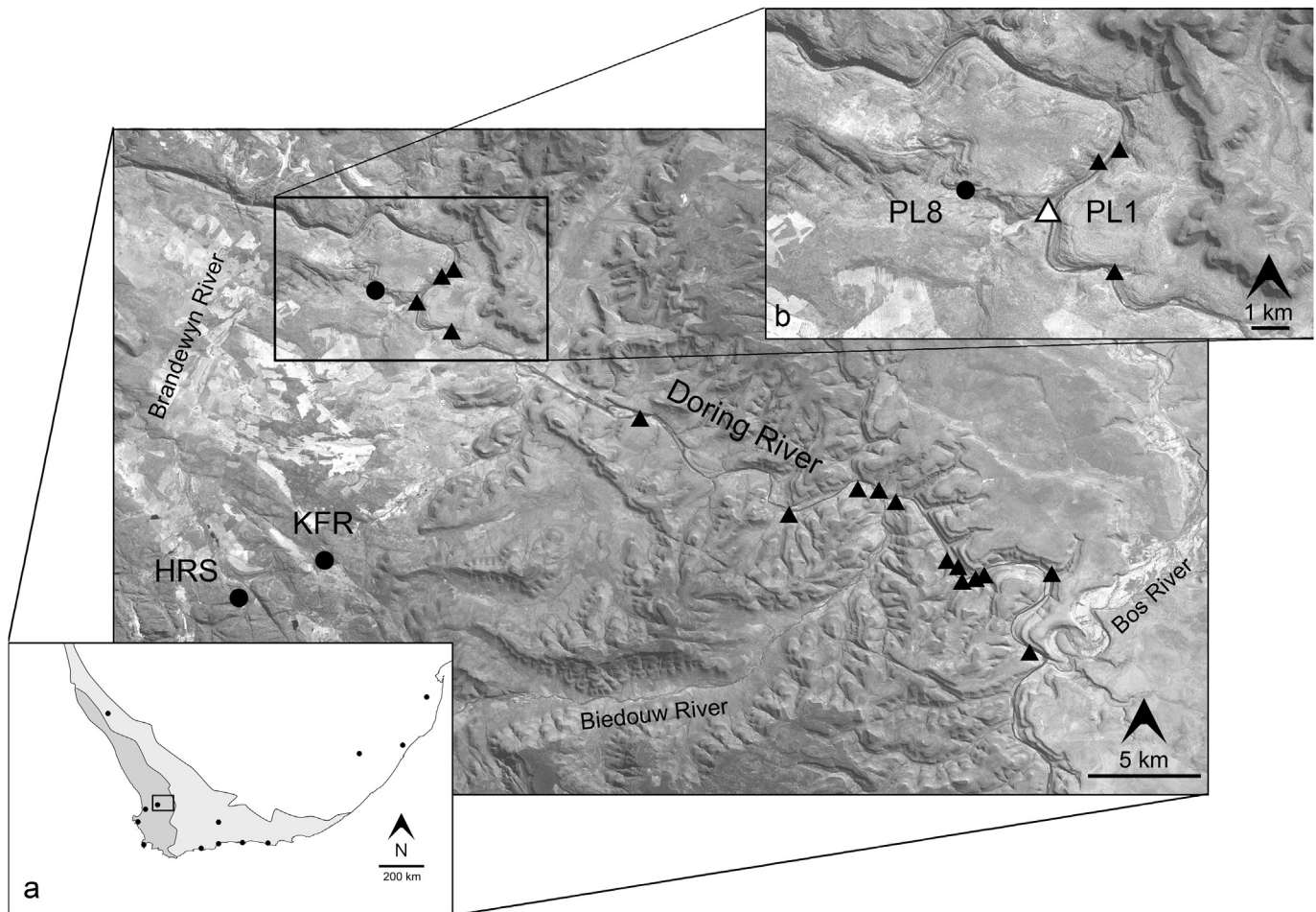
## 2. Late Pleistocene archaeological sequence in the modern Winter and Year-round rainfall zones

Though the dating remains somewhat contested, the later Pleistocene technological sequence of the WRZ/YRZ appears reasonably well understood (Lombard et al., 2012; Mackay et al., in press; Wurz, 2013). Earlier MSA assemblages are heterogeneous, dominated by a diverse range of rock types but often quartzite, with knapping systems featuring the production of flakes, blades and convergent flakes (including levallois points and pseudo-points) (Volman, 1980;

Thackeray, 2000; Henshilwood et al., 2001; Wurz, 2002, 2012; Mackay, 2009; Thompson et al., 2010; Steele et al., 2012; Will et al., 2013; Porraz et al., 2013a). Linking these lithic assemblages is a paucity of retouched flakes, with denticulates perhaps being the most common form (Volman, 1980; Thompson and Marean, 2008; Wurz, 2012; Will et al., 2013). Earlier MSA assemblages are currently known from many sites in the WRZ/YRZ, including Cape St Blaize, Nelson Bay Cave, Klasies River, Blombos Cave, Pinnacle Point, Die Kelders, Peers Cave, Ysterfontein, Hoedjiespunt, Elands Bay Cave, Diepkloof, Hollow Rock Shelter and Klipfonteinrand (Volman, 1980; Singer and Wymer, 1982; Avery et al., 1997; Henshilwood et al., 2001; Marean et al., 2007; Avery et al., 2008; Thompson and Marean, 2008; Mackay, 2009; Marean, 2010; Högborg and Larsson, 2011; Will et al., 2013; Porraz et al., 2013a).

From approximately 75 ka, lithic technologies in the WRZ/YRZ shift to the production of bifacial points and an increased prevalence of fine-grained rock types is noted at some sites (Evans, 1994; Henshilwood et al., 2001; Högborg and Larsson, 2011; Porraz et al., 2013a). Evidence for the use of pressure flaking has also been presented (Mourre et al., 2010). This period is known as the Still Bay industry. Still Bay assemblages have been identified at Blombos Cave, Peers Cave, Diepkloof, Hollow Rock Shelter (Volman, 1980; Henshilwood et al., 2001; Högborg and Larsson, 2011; Porraz et al., 2013a) and probably also open sites such as Soutfontein and Cape Hangklip (Minichillo, 2005; Mackay et al., 2010). The ages for the start for the Still Bay at Diepkloof are contested. Tribolo et al. (2013) argue that the Still Bay begins ~100 ka while Jacobs et al. (2008a,b) provide an earliest age of ~73 ka. At this stage, the Jacobs ages for the Still Bay have been reproduced at several sites across southern Africa; the Tribolo ages remain an outlier (see Mackay et al., in press; Porraz et al., 2013b for alternative interpretations based on these chronologies).

The Still Bay appears to end around 70 ka at many sites, and the nature of subsequent developments was for a long time unclear. The stratigraphically subsequent industry, known as the Howiesons Poort, was believed to begin ~65 ka, implying a ~5 ky hiatus after the Still Bay (Jacobs et al., 2008a). Recent work at Diepkloof and Pinnacle Point, however, and most notably Diepkloof, suggests that the Howiesons Poort is complex and may have initiated in the later stages of the Still Bay (Porraz et al., 2013a). The backed artefacts and small blades produced from unipolar prepared cores which best characterise the Howiesons Poort appear in the last few bifacial point-bearing layers at Diepkloof, with dates extending to around 70 ka at both Diepkloof (in the Jacobs chronology) and Pinnacle Point 5/6 (Jacobs et al., 2008a; Brown et al., 2012). In addition to backed artefacts, the earliest Howiesons Poort at Diepkloof contains numerous *pièces esquillées*, while a later phase contains both backed artefacts and large numbers of notched flakes. The final or classic Howiesons Poort contains more backed artefacts than notched flakes or *pièces esquillées*, a pattern replicated at nearby Klein Kliphuis (Mackay, 2011), and on the south coast at Klipdrift (Henshilwood et al., 2014). The fine-grained rock silcrete is more common during the Howiesons Poort than most other periods of the MSA but its prevalence fluctuates within the Howiesons Poort at many WRZ/YRZ sites (Volman, 1980; Singer and Wymer, 1982; Mackay, 2011; Porraz et al., 2013a,b). Heat treatment of silcrete has been noted at Diepkloof, Pinnacle Point and possibly also Klein Kliphuis (Mackay, 2009; Brown et al., 2012; Schmidt et al., 2013). The Howiesons Poort is a particularly common industry, having been noted at Klasies River, Nelson Bay Cave, Pinnacle Point 5/6, Boomplaas, Peers Cave, Diepkloof, Klein Kliphuis, Klipdrift and Klipfonteinrand (Deacon, 1979; Volman, 1980; Singer and Wymer, 1982; Mackay, 2006; Brown et al., 2012; Porraz et al., 2013a; Henshilwood et al., 2014). Open site expressions of the Howiesons Poort in the region are, however, scarce (Hallinan, 2013; though see; Carrion et al., 2000; Kandel and Conard, 2012).



**Fig. 2.** Study area, showing open sites along the Doring River (triangles) and nearby excavated rock shelters (circles). Inset panel (a): location of study area relative to modern rainfall zones, with important archaeological sites as per Fig. 1. Inset panel (b): location of Putslaagte valley near Doring River confluence. Site abbreviations: Hollow Rock Shelter (HRS), Klipfonteinrand (KFR), Putslaagte 1 (PL1), Putslaagte 8 (PL8).

After ~58 ka the Howiesons Poort gives way to the post-Howiesons Poort industry characterised by the replacement of backed artefacts by unifacial points and scraper forms (Volman, 1980; Mackay, 2011; Porraz et al., 2013a). At Diepkloof, Klasies River and Klein Kliphuis, core reduction remains oriented towards the production of blades in the early post-Howiesons Poort before later giving way to the production of flakes (Wurz, 2002; Mackay, 2009; Porraz et al., 2013a). At sites where it was common during the Howiesons Poort the prevalence of silcrete drops following the transition, though there is a lag between the cessation of backed artefact production and a decrease in silcrete in some cases (Mackay, 2011; Porraz et al., 2013a). The Howiesons Poort to post-Howiesons Poort transition is gradual at most sites where it has been examined (Soriano et al., 2007; Villa et al., 2010; Mackay, 2011; Porraz et al., 2013a). Consistent with this, the distribution of post-Howiesons Poort sites can be viewed as an attenuated subset of Howiesons Poort sites in the WRZ/YRZ. Occupation continues from one into the other at Klasies River, Pinnacle Point 5/6, Peers Cave, Diepkloof and Klein Kliphuis, but ceases at Nelson Bay Cave, Boomplaas and Klipfonteinrand.

After ~50 ka, occupation of almost all sites in the modern WRZ/YRZ appears to cease (Mackay, 2010; Mackay et al., in press). Klein Kliphuis and Boomplaas have limited occupation in this period, with low rates of discard at the former site (Mackay, 2010), but none of the other previously occupied MSA sites have clear signals of use from 50 to 25 ka. The technological characteristics of this

period have consequently been very hard to define. This contrasts with occupational and technological patterns outside the WRZ/YRZ, and particularly in the summer rainfall areas to the north and east (Mackay, 2010). At sites in those areas, a broad variety of MSA assemblages featuring blades, backed artefacts, unifacial points, bifacial points and scrapers are known to occur in pulses throughout later MIS 3 (Wendt, 1976; Carter, 1978; Kaplan, 1990; Clark, 1997; Wadley, 2005; Wadley and Jacobs, 2006; Vogelsang et al., 2010). An early occurrence of LSA technology has also been claimed for Border Cave in Swaziland (D'Errico et al., 2012).

Occupation (in many cases re-occupation) of sites is evident throughout the WRZ/YRZ from the start of MIS 2. Boomplaas, Byneskranskop, Elands Bay Cave, Kangkara, Nelson Bay Cave, Far-aoskop and Klein Kliphuis have stone artefact assemblages dating between 25 ka and 12 ka (Deacon, 1978, 1982; Schweitzer and Wilson, 1983; Manhire, 1993; Orton, 2006; Mackay, 2010). In all cases these sites lack characteristically MSA flakes and cores, with discoid and Levallois reduction effectively absent. These MIS 2 LSA assemblages often have an abundance of small blades and platform cores, and are ascribed to the Robberg industry (Deacon, 1984).

### 3. The Doring River corridor surveys

The Doring River is a large water-course situated in the middle of the modern WRZ, and draining approximately 24 000 km<sup>2</sup> of largely semi-arid and arid lands in the rain shadow east of the Cape



Fold Belt mountains (Fig. 2). Though seasonal, the annual outflow of the Doring is roughly equivalent to that of the Olifants River which lies to the west of the mountains and flows permanently. These two rivers run in parallel for approximately 70 km before converging and flowing to the sea together as the Olifants River. Although the Olifants River has large dams at multiple points and its terraces have been extensively cultivated, the annual flows and terrace characteristics of the Doring have seen considerably less manipulation by modern farming practices.

Due to its extensive catchment, the Doring contains a diverse range of flakeable rock types, with sandstone and quartzite dominant. Cobbles of the fine grained black metamorphic rock hornfels are also common, with cobbles of silcrete less frequent and pebbles of micro-/crypto-crystalline silicates and quartz occasionally observed. Additionally, sandstone, quartzite and quartz are common on the land surface through much of the catchment.

One of us (AM) spent an extended period camped on the Doring River during excavation of rock shelter sites in the Putslaagte valley, a small tributary of the Doring (Fig. 2). During that time a remnant area of alluvial terrace was noted at the Putslaagte/Doring confluence (Fig. 3). Our interest in the terrace was piqued by a) the abundance of MSA artefacts, b) the presence of small flakes suggesting minimal fluvial reworking, and c) the apparent absence of typical MIS 4 and early MIS 3 markers such as backed artefacts, bifacial points or unifacial points. The site had been designated Putslaagte site 1 (PL1) during previous surveys (Halkett, 1982).

Further surveys in the Doring River corridor led to the identification of numerous additional terrace sites with a broadly similar pattern (Fig. 4): relict terraces located either in back-flooding contexts at the confluence of the Doring and minor tributaries or on point bars at major river bends. In most cases, the terraces are covered in MSA and sometimes early LSA artefacts. The later LSA industries (Deacon, 1984) are generally poorly represented on the terraces so far surveyed; this stands in contrast to patterns identified towards the coast (Kandel and Conard, 2013). Some of these terraces have a significant colluvial drape, meaning that potentially ancient and young artefacts may have migrated across the sediment surface from adjacent slopes since the cessation of terrace formation. In many cases, however, there was little or no subsequent colluviation. Thus, though they may have been palimpsests, the assemblages on these non-colluviated terraces necessarily post-date the cessation of sediment accumulation. In such cases it would be theoretically possible to provide a maximum age for the

assemblages using OSL, and thus an age bracket using the presence of MSA artefacts as a *terminus ad quem* of >25 ka.

In addition, in both colluviated and non-colluviated terrace contexts it was often possible to isolate spatially-discrete assemblages of clear industrial affinity within otherwise temporally-mixed assemblages. These included a Robberg assemblage consisting of ~50 small blade cores on heated silcrete (Appelboskraal), a bifacial point manufacturing site with >140 points and associated thinning flakes eroding out from the base of a terrace (Klein Hoek 1) and an early post-Howiesons Poort site with laminar flakes, heated silcrete and at least nine unifacial points (Uitspankraal 7) (Fig. 4).

In total, we have so far identified bifacial point bearing assemblages at eight localities (including two instances of isolated points, two instances of two points together, and four instances of multiple points); unifacial points at seven localities of which five also have bifacial points; potentially early (pre-MIS 4) MSA assemblages at 11 localities; potentially late (post-MIS 4) MSA assemblages at four localities; Pleistocene/early Holocene assemblages at two localities; and ESA assemblages, as identified through handaxes, at two localities, both of which have a heavy colluvial drape. Interestingly, but concordant with the findings of Hallinan (2013) in the Olifants River corridor, no Howiesons Poort assemblages have as yet been located in the surveyed areas.

Our initial interest, however, was in PL1. The site appeared to include >10 000 flaked stone artefacts on the surface with a clear MSA signal and no obvious LSA input, yet lacked the characteristic markers of Still Bay, Howiesons Poort or post-Howiesons Poort. If the assemblage had been deposited since the cessation of sedimentation then several possibilities arose. First, the assemblage entirely ante-dated MIS 4, with no subsequent occupation. Second, the assemblage had components of MIS 5 and later MIS 3 but no significant MIS 4/early MIS 3 input. Third, the assemblage largely or entirely post-dated early MIS 3. In this final case the assemblage would conceivably belong in the documented sequence gap in the WRZ/YRZ sequence noted above. Our excavation and analysis aimed to test these possibilities.

#### 4. Excavations at Putslaagte site 1 (PL1)

The terrace site PL1 measures ~70 m east–west and ~50 m north–south, and covers ~2720 m<sup>2</sup>. Artefacts are unevenly distributed across its surface, with an average density of 20 artefacts >5 mm per m<sup>2</sup> (Shaw, 2013). At its highest point the sediment



Fig. 3. Images of PL1. Panel (a): PL1 terrace with Putslaagte valley to the left and Doring River on the right of panel. Panel (b): surface artefacts on PL1. Panel (c): Excavation pit.

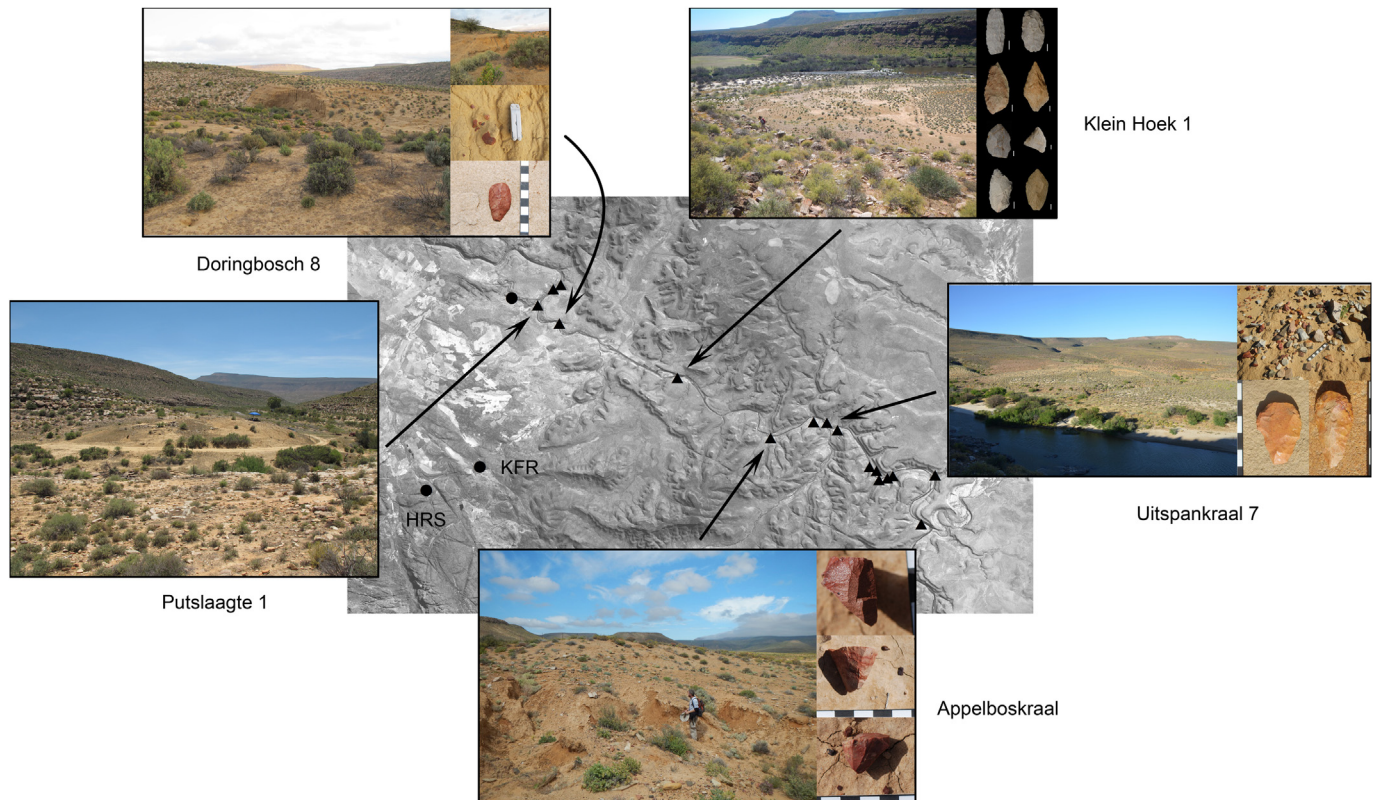


Fig. 4. Images from selected terrace sites along the Doring River.

body is ~6 m above the modern floodplain. There have been recent modifications to the terrace including arrangements of large stones probably forming the base of two small animal pens or 'kraals'. There are thus some large rocks on the sediment surface that were likely moved there in the relatively recent past. Otherwise, the surface lacks colluvium.

Excavations at PL1 were undertaken in January 2011. The objectives were to provide a small, controlled assemblage sufficient to characterise the site, to understand the distribution of artefacts through the sediment body, and to provide a profile to clarify site formation and for OSL dating. A single 2 m × 1 m test excavation – constituting <0.1% of the terrace surface – was opened at the highest point of the terrace. The two square meters were each subdivided into 0.5 m × 0.5 m quadrants, and excavation proceeded in horizontal 50 mm spits with no stratigraphic changes noted in the upper ~1 m. The only significant sedimentary change occurred ~1.0–1.2 m below surface when consolidated and pedal sediments and several large rocks were encountered, potentially indicating a palaeosol (Fig. 5). We noted no other distinct depositional units or laminations; the sediments were largely undifferentiated. This may imply that roots and other bioturbative agents have erased past depositional planes, or that the sediments reflect rapid, relatively large depositional events.

Excavation ceased at ~1.3 m below surface in one square and continued to ~1.8 m below surface in the other. In spite of the small excavation area, we recovered 6674 stone artefacts, as well as 15 pieces of ochre, one of which was ground. We also recovered ~8 g of bone, most of it poorly preserved but some fresh and likely modern. The modern fragments most likely derive from burrowing animals. We also identified two pieces of marine shell in contexts from immediately below surface. These fragments are not necessarily ancient, but do imply contact with the coastline a minimum distance of 80 km west over the mountains. Finally, we identified only

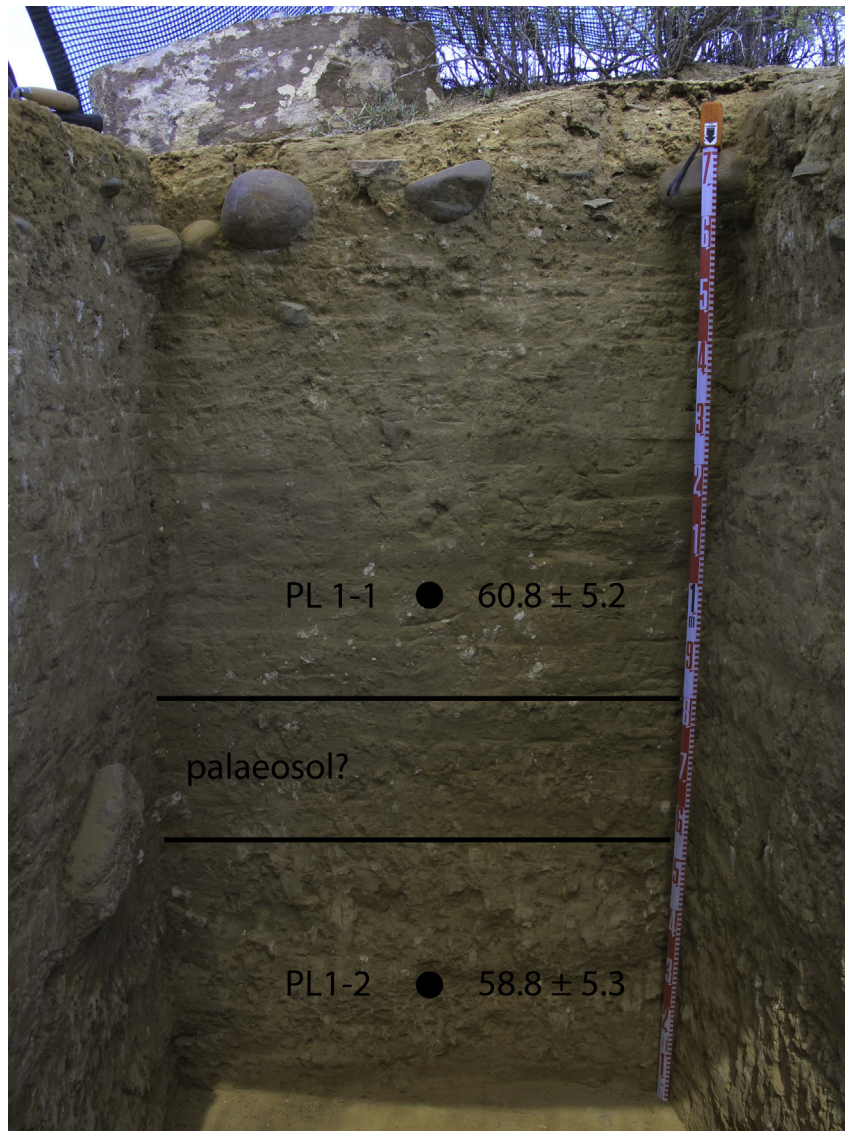
9 fragments of charcoal, two of which we dated by AMS. These derived from ~0.1 m to ~0.8 m below surface; both returned relatively recent ages of  $139 \pm 21$  (DAMS-003795) and  $227 \pm 36$  (DAMS-003796) radiocarbon years respectively. We interpret these results to reflect either downward migration of small particles in the sediment body though bioturbation or the remains of burned roots. The alternative – that the sediments accumulated recently – is incompatible with the geomorphic setting, archaeological remains and luminescence evidence (discussed below).

Artefacts were concentrated in the uppermost spits but rapidly decreased in number with depth (Fig. 6). The exception is a brief and muted spike in artefact numbers roughly concordant with the proposed palaeosol. These layers also have cores, which were absent in the immediately overlying spits. The depth/decay signal in the artefact numbers is inferred to reflect some downward migration probably through the root zone in the period since discard. The potential palaeosol may either be an independent accumulation, or a density barrier accumulating downward migrating artefacts.

## 5. Particle size and site formation at PL1

To investigate the environmental history of site formation at PL1, small amounts (<5 g) of loose bulk sediment from each spit in one square metre were separated with a 2 mm sieve and the <2 mm fraction was analysed with a Horiba LA-950 Laser Diffraction Particle Size Distribution Analyzer (15 replicates per spit). Data were analysed using R version 3.0.2 (R Core Team, 2014) with Folk and Ward (1957) summary statistics computed following Blott and Pye (2001) using the G2Sd package (Gallon and Fournier, 2013). Stratigraphically constrained clustering of spits was used for quantitative definition of depositional units. We used the constrained sum-of-squares clustering method (CONISS) implemented in the rioja package (Juggins, 2012) to ensure that only





**Fig. 5.** West section of excavation pit at completion of excavations. Locations of OSL samples are shown, as is the approximate location of the proposed palaeosol.

stratigraphically adjacent spits are considered for membership of the same cluster (Grimm, 1987).

Consistent with the field observations, particle size analysis indicates three major depositional units with diffuse boundaries around 0.8 m and 1.2 m below the surface (Fig. 7). The lower unit consists of fine sand that is moderately sorted, fine skewed, and mesokurtic. The middle unit is distinctive by a reduction in the sand fraction and decrease in sorting. Further work is currently underway to determine if this is a palaeosol. The upper unit is also dominated by fine skewed fine sand but is distinctive by being even less well sorted and platykurtic.

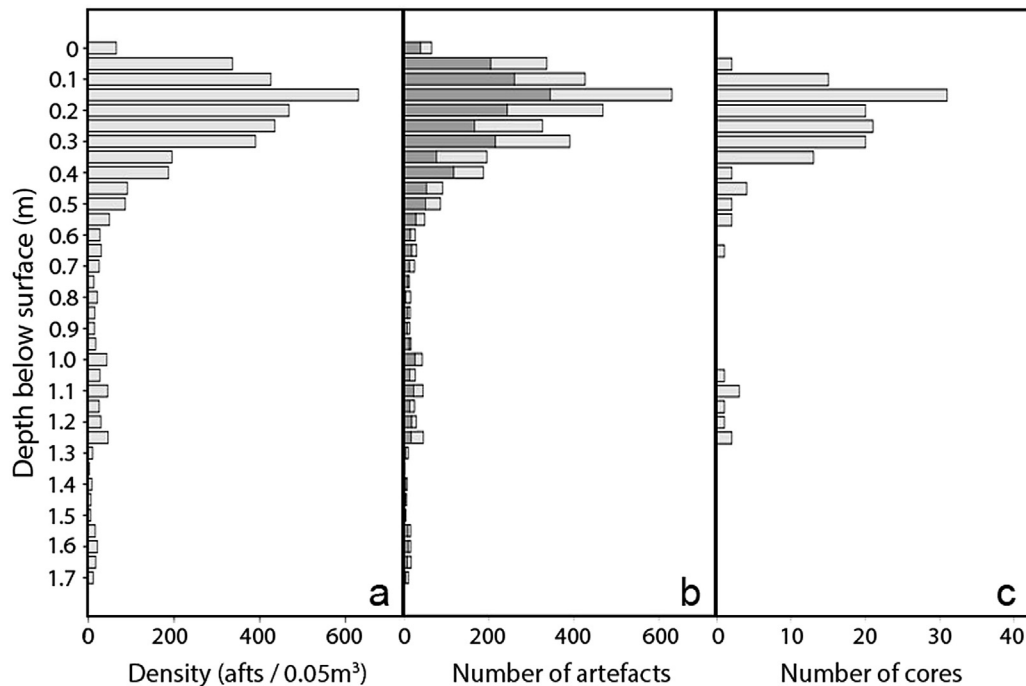
The dominance of fine sand suggests that the site is a slackwater deposit, which are usually fine-grained (fine sand and coarse silt) flood sediments deposited in areas of the floodplain that are sheltered from high-velocity flood flows (Heine and Heine, 2002). Slackwater deposits often represent floods of high magnitude, indicating extreme precipitation events in the upper reaches of the river catchments (Benito et al., 2003; Baker et al., 2009).

From about 1.0 m below the surface there is a uniform fining upwards sequence. In a floodplain landscape this is frequently interpreted as a point-bar deposit. Upward-fining is typical in

meandering channel point bar deposits because the energy of the flow at the top of the point bar is less than at the base where lag material is deposited in the thalweg (Smith, 1987). Alternative models for this architecture are ephemeral rivers that flow for limited periods of time, or flash floods of limited duration (Reading, 2001). Given the slackwater characteristics of this deposit, further work is required to be certain if the fining up sequence indicates an increasing frequency of flood events at the site over time or an unrelated gradual shift in the river architecture.

## 6. OSL dating

Two OSL samples were collected at 0.8 m and 1.5 m below surface, bracketing the possible palaeosol (Fig. 5). The upper parts of the deposit were not dated because of concerns over possible downward migration of material. To test whether this may also have been a problem in the deeper deposits, we used single grain OSL dating of individual grains of quartz to obtain an age for the two samples. Details about sampling, sample preparation and OSL and dose rate measurement procedures are provided in [Supporting Online Information](#).



**Fig. 6.** Distribution of artefacts through the excavated deposit. Panel (a): density of artefacts per spit. Panel (b): numbers of artefacts >15 mm (light shading) and small flaking debris (dark shading). Panel (c): numbers of cores.

Two thousand individual grains were measured of which only 178 grains (~9% of the total number measured) were used for final  $D_e$  determination. Reasons for rejecting individual grains are provided in Table S1. The  $D_e$  values for all the accepted grains are displayed as radial plots in Fig. 8 (Galbraith 1988, 1990) and show  $D_e$  distributions that are largely consistent with a central value. We consequently used the central age model (CAM) of Galbraith et al. (1999) to provide an estimate of  $D_e$  overdispersion (Table 1), and a weighted mean  $D_e$  estimate for both samples, and believe that this is meaningful with regards to the true burial dose received by all the grains. The final ages for the two samples are listed in Table 1, together with the supporting  $D_e$  and dose rate estimates. Uncertainty on the age is given at  $1\sigma$  (standard error of the mean) and was derived by combining, in quadrature, all known and estimated sources of random and systematic error. The two ages of  $61 \pm 5$  (PL1-1) and  $59 \pm 5$  (PL1-2) ka are statistically consistent with each other and suggest that the bracketed sediment was deposited fairly rapidly during late MIS 4/early MIS 3. At a minimum, these results confirm that the artefacts on the surface at PL1 were deposited during or after MIS 3, effectively precluding inputs from any periods earlier than the post-Howiesons Poort. We now describe in detail the flaked stone artefacts from the site.

and a further 3798 artefacts <15 mm which we class here as small flaking debris (SFD). These numbers are based on preliminary examination of 98.3% of quadrants; artefacts from four quadrants remain to be included. Of these ~6700 artefacts, a sample of 1566 (23% of the total) has so far been analysed in detail – analysis of the remaining material is on-going. The breakdown of artefacts by class and material type in the analysed is given in Table 2. In addition to the data from the analysed quadrants detailed in Table 2, we also analysed all remaining complete cores in the assemblage, giving a core total of 225. These cores form the focus of our discussion. We treat the entire sample as a single assemblage at this stage, as the number of analysed artefacts from the lower spits is currently too small to allow comparison. The decay signal in artefact numbers gives us reason to believe that most of the upper artefacts were initially deposited on or near the surface.

A large proportion of the artefacts in the analysed sample were classed as SFD (50.5%,  $n = 791$ ). Flakes, both complete and broken, are the next most common class (28.0%,  $n = 439$ ), followed by cores (7.4%,  $n = 115$ ). Flaked pieces, defined here as broken flaked artefacts containing neither positive percussion features nor a single complete scar (Hiscock, 2007), account for a

**Table 1**  
Dose rate data, equivalent dose and OSL ages for the sediment samples from PL1.

Sample code	Moisture content (%)	Dose rates (Gy/ka)			Total dose rate (Gy/ka)	$D_e$ (Gy)	Age model	Number of grains	Over-dispersion (%)	Optical age (ka)
		Beta	Gamma	Cosmic						
PL1-1	5 (3.5)	$1.44 \pm 0.08$	$1.17 \pm 0.13$	0.21	$2.84 \pm 0.21$	$172.6 \pm 6.6$	CAM	96/1000	$23 \pm 4$	$60.8 \pm 5.2$
PL1-2	5 (0.3)	$1.18 \pm 0.07$	$1.01 \pm 0.10$	0.20	$2.40 \pm 0.17$	$141.1 \pm 7.7$	CAM	82/1000	$40 \pm 5$	$58.8 \pm 5.3$

## 7. Flaked stone artefacts from PL1

The total number of recovered artefacts is, as noted above, 6674, comprising 2876 artefacts >15 mm in maximum dimension

further 10.5% ( $n = 135$ ) of the assemblage. Retouched flakes, excluding flakes used as cores, were extremely uncommon (0.4%,  $n = 5$ ). Six hammerstones were also identified, with sandstone the most common rock type used – this implies at least some use

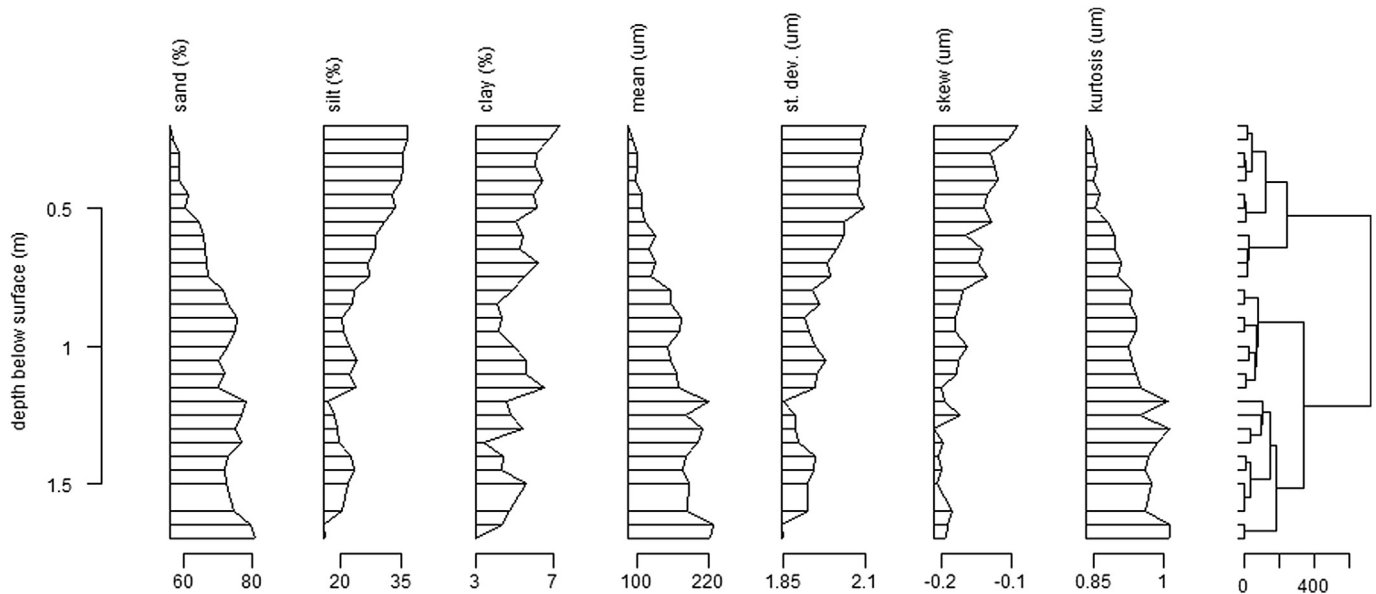


Fig. 7. Stratigraphic plot showing percentages by mass of sand, silt and clay along with Folk and Ward (1957) summary statistics and the results of the stratigraphically constrained cluster analysis. For data and code see <http://dx.doi.org/10.6084/m9.figshare.1035786>.

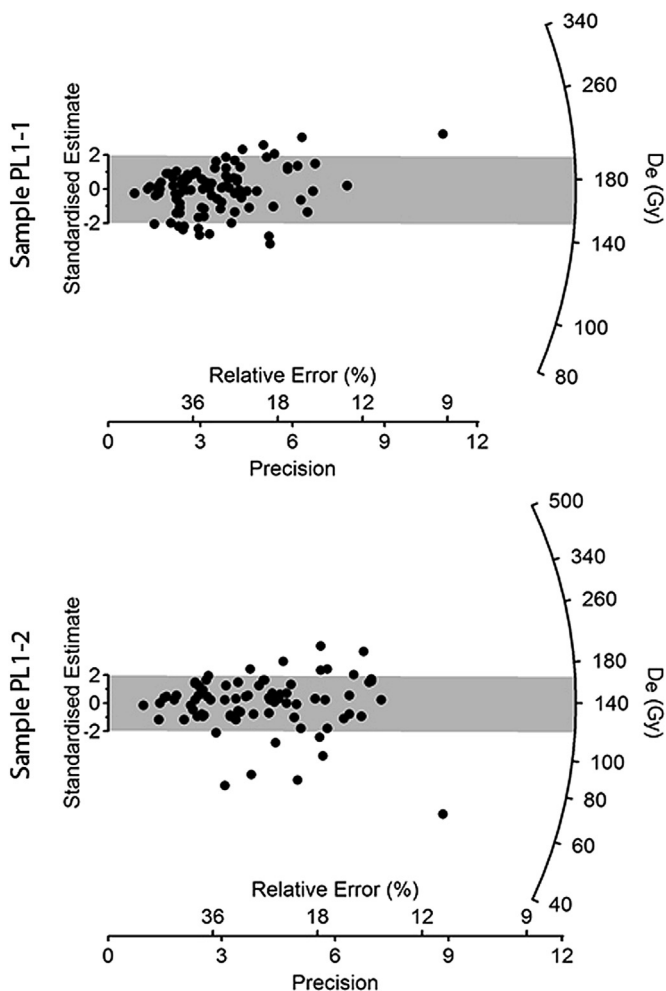


Fig. 8. Radial plots for OSL samples PL1-1 and PL1-2.

of soft stone hammers (Soriano et al., 2009) at the site. In addition to flaked and battered stones, the analysed assemblage included 45 unworked cobbles and pebbles. At least some of these are likely to have been unused rocks that were transported to the site for use as cores; others may have been unused hammerstones, or hammerstones retaining no diagnostic traces of use.

Hornfels dominates the artefacts in all classes, accounting for 74.1% ( $n = 1160$ ) of the assemblage total. Quartzite accounts for a further 15.6% ( $n = 244$ ), with small contributions from quartz, sandstone, micro-crystalline and crypto-crystalline rocks (both subsumed as CCS), and other rocks. The contribution of silcrete to the assemblage is very small (1.0%,  $n = 15$ ). All of these rocks appear to have been derived principally from the Doring River, situated ~100 m east of the site. The river is bedrock-controlled on the east bank and is unlikely ever to have been further from the site than it is at present. Of the 447 artefacts displaying cortex in the assemblage, 445 had cobble cortex indicating a riverine source. Instances of outcrop cortex were identified only on one quartzite artefact and one crystal quartz artefact.

Table 2  
Artefacts by class and material type.

Class	Hrnf	Qtzt	Qtz	Silc	CCS	Sand	Oth	Total	%
Flakes	280	120	2	10	13	14	0	439	28.1
Retouched flakes	4	0	0	0	1	0	0	5	0.4
Flaked pieces	116	25	3	1	2	4	14	165	10.5
Cores	92	17	0	0	0	6	0	115	7.4
Hammers	1	0	0	0	0	0	5	6	0.4
Manuports	7	4	19	0	0	7	8	45	2.9
SFD	659	79	23	4	12	9	5	791	50.5
Total	1160	244	47	15	28	40	32	1566	100.0
%	74.1	15.6	3.0	1.0	1.8	2.6	2.0	100.0	

Approximately 73% ( $n = 148$ ) of complete flakes retained some cortex, while almost 25% ( $n = 49$ ) have cortex coverage exceeding



50% of their dorsal and platform surfaces. Differences in the prevalence of cortex between the two main material types (hornfels and quartzite) are minor. Similarly, 50% ( $n = 85$ ) of complete hornfels cores and 46% ( $n = 23$ ) of complete quartzite cores had cortex exceeding 50% of their surface. Almost 90% ( $n = 152$ ) of hornfels cores and 72% ( $n = 52$ ) of quartzite cores had cortical coverage exceeding 25% of their surface. These data tend to confirm the predominantly local origin of the stone used in flaking at the site and suggest that PL1 may effectively have functioned as a quarry.

Flaking techniques as identified from the discarded flakes largely reflect early stage reduction and the subsequent use of centripetal, unidirectional and prepared core technology (PCT) flaking techniques (Fig. 9). Early reduction stages are demonstrated by the presence of cortex on 25% of intact flake platforms. Unidirectional scarring was present on 63.9% ( $n = 85$ ) of complete flakes with two or more dorsal flake scars; instances of one (30.8%,  $n = 41$ ) and two rotations (5.3%,  $n = 7$ ), generally orthogonal to the percussive axis, reflect centripetal reduction systems. Approximately 12% ( $n = 28$ ) of flakes with complete platforms show preparation in the form of fine faceting, with dihedral platforms accounting for a further 4% ( $n = 9$ ). Only four Levallois flakes were identified in the analysed sample, and a single laminar flaking product is the only direct evidence for blade production (though others were noted in the full assemblage, e.g., Fig. 9H).

As noted, retouched flakes were rare in the assemblage. The only types present were single instances of an end-scrapers and a notched flake. Four of the five retouched flakes were made from hornfels, the remaining example from CCS. We further add that during examination of the remaining ~77% of the assemblage not discussed here, no implements (defined here as morphologically-regular retouched flakes), and specifically no unifacial or bifacial points and no backed artefacts were observed. Such artefacts were also absent among 413 analysed surface finds from 18 m<sup>2</sup> of the site (Shaw, 2013), which similarly documents a lack of retouch and a paucity of blades.

Consistent with the evidence from flakes, core reduction strategies at PL1 demonstrate a range of methods indicating rudimentary exploitation of local quartzite and hornfels nodules. Due to the somewhat expedient nature of the core reduction, standard typological assignments were not always suitable, and cores were thus initially classified in terms of scar patterns (Fig. 10). This classification was followed by assigning each to a technological type in instances where diagnostic reduction strategies could be identified. Types include PCT (including Levallois) cores and cores-on-flakes (CF); all others are classified simply as 'cores' (Fig. 11).

With respect to metrics, the length of a core was measured along the flaking axis of the final flake scar or, in cases where the final scar could not be determined, by orienting the core using its longest scars. The width was taken perpendicular to length at the

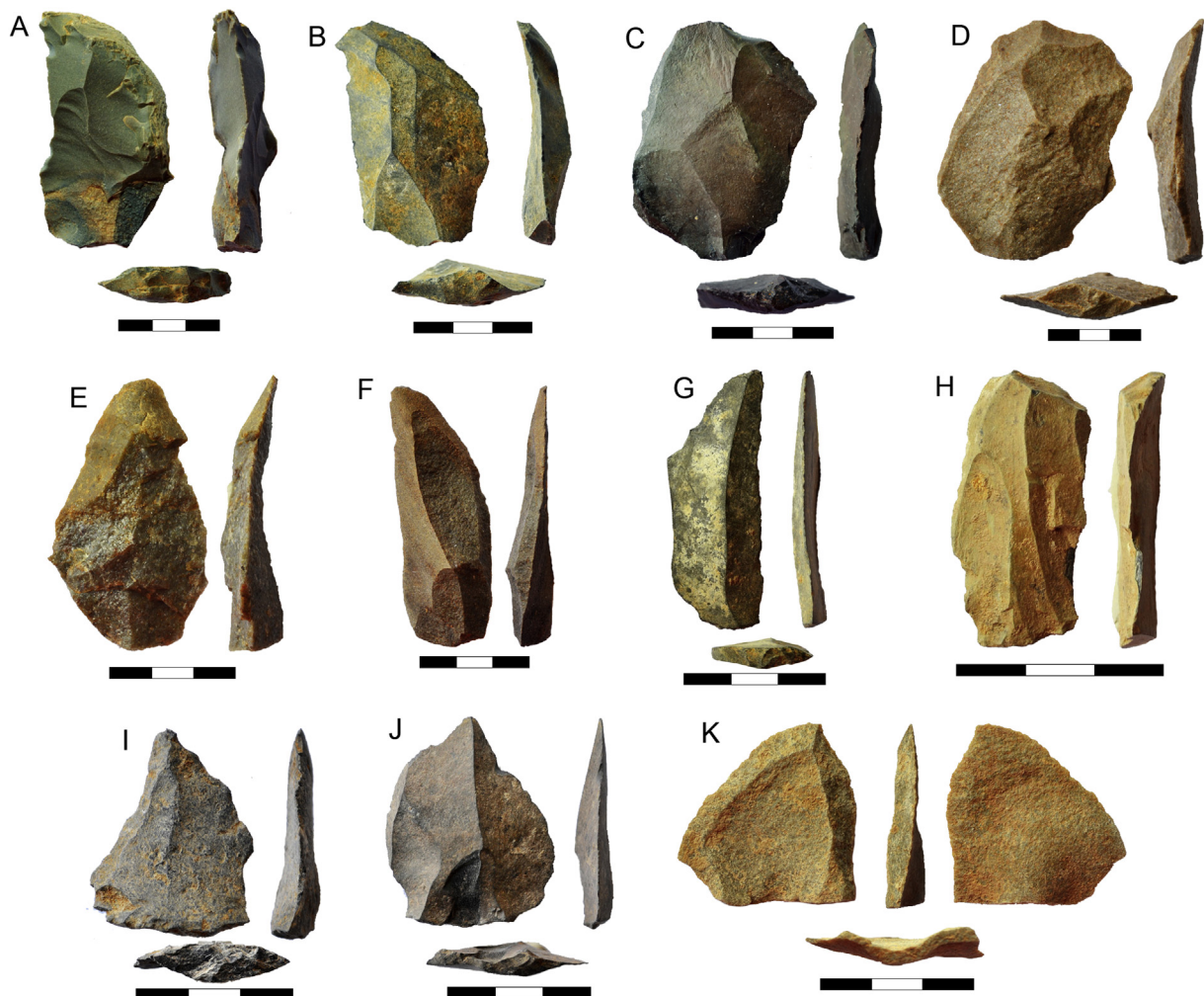


Fig. 9. Selected flakes from PL1. A, eclat debordant; B–D, levallois flakes; E, flake; F & G, elongate cortical flakes; H, recurrent blade; I–K, convergent flakes (pseudo-points).

widest margin and thickness, at a midpoint at right angles to width.

Table 3 provides an overview of the metrics for all cores grouped by raw material type. Quartzite cores demonstrate both the highest mean values for all measures but also the widest variance in values. Reasons for the higher range of values in this case include the larger size of quartzite cobbles relative to other materials, and the highly variable extent of reduction as measured by scar counts (cf., Potts, 1991; although note Braun et al., 2005; Clarkson, 2013) (Fig. 12). Where scar counts of hornfels cores are fairly modal, those for quartzite are widely dispersed and vaguely intimate bimodality. Conceivably this reflects differences in the quality of quartzites.

**Table 3**  
Metrics for all analysed complete cores.

Material	Statistic	Length (mm)	Width (mm)	Thick (mm)	Weight (g)
Hornfels ( <i>n</i> = 170)	Mean	39.4200	37.5250	18.0400	38.0000
	Minimum	38.75	25.04	11.60	31.00
	Maximum	40.09	50.01	24.48	45.00
	S.D.	0.94752	17.65646	9.10754	9.89949
	Variance	0.898	311.750	82.947	98.000
Quartzite ( <i>n</i> = 50)	Mean	51.0309	49.4968	23.1306	75.4925
	Minimum	19.55	24.52	9.10	8.00
	Maximum	100.78	89.46	67.39	291.00
	S.D.	12.74306	11.29021	10.15893	49.68281
	Variance	162.386	127.469	103.204	2468.382
CCS ( <i>n</i> = 2)	Mean	40.4700	55.6800	23.1700	59.5000
	Minimum	40.47	55.68	23.17	59.50
	Maximum	40.47	55.68	23.17	59.50
	S.D.	.	.	.	.
	Variance	.	.	.	.
Silcrete ( <i>n</i> = 2)	Mean	65.7226	72.6576	51.5340	320.5650
	Minimum	20.71	35.98	15.05	27.47
	Maximum	138.56	165.08	149.68	1908.09
	S.D.	23.07189	23.96483	27.43083	342.32694
	Variance	532.312	574.313	752.451	117187.732
Other ( <i>n</i> = 1)	Mean	42.2500	53.4650	16.4400	42.2500
	Minimum	27.94	38.11	14.30	13.00
	Maximum	56.56	68.82	18.58	71.50
	S.D.	20.23740	21.71525	3.02642	41.36575
	Variance	409.552	471.552	9.159	1711.125

The most prevalent scar pattern in the PL1 core assemblage is centripetal-bifacial (CB) with unidirectional-bifacial (UB), unidirectional-unifacial (UU) and centripetal-unifacial (CU) expressing similarly high percentages (Fig. 10). The CB and CU together represent over 35% of all reduction patterns. In part, the centripetal, or radial, detachment of flakes represents exploitation patterns characterizing not only prepared cores at PL1 but other core forms as well. In such cases, cores tend to exhibit heightened levels of reduction on their production surfaces when compared to other forms while at the same time retaining cortex either toward the centre of one or more surfaces or on one surface entirely. More prevalent than CB and CU patterns are the UU and UB methods for detaching flakes from nodules, together representing 36% of reduction patterns.

Prepared cores at PL1 (*n* = 27) comprise 12% of the core assemblage and are characterized by preferential (Fig. 11G) and to a lesser extent, centripetal recurrent (Fig. 10H) forms (Boëda, 1991, 1993, 1995). A comparison of length, width, thickness and weight measures between prepared cores and all other cores from PL1 demonstrate the similarity in length and width values while displaying marked differences in measurements for both thickness and weight (Table 4). In some sense, the difference in weight is likely a function of the presence of a number of large quartzite cobbles that display minimal reduction and retain most of the

available volume. The variability in form with respect to thickness in part relates to the observed thinness of many of the prepared cores from the site (Fig. 11).

**Table 4**  
Metric comparison of prepared cores and all other cores.

Statistic	Length (mm)	Width (mm)	Thick (mm)	Weight (gms)
<b>PCT cores</b>				
N	27	27	27	27
Mean	51.0300	50.0744	17.6537	58.5893
Minimum	38.75	25.04	10.25	20.00
Maximum	74.77	74.40	39.14	216.69
Std. deviation	10.13674	10.77615	6.88993	44.66380
Variance	102.754	116.125	47.471	1994.855
<b>All other cores</b>				
N	198	198	198	198
Mean	54.4818	55.2171	30.9312	138.8892
Minimum	19.55	24.52	9.10	8.00
Maximum	138.56	165.08	149.68	1908.09
Std. deviation	17.48605	18.59770	20.25100	205.43501
Variance	305.762	345.874	410.103	42203.542

On one hand, the reduced thickness of prepared cores may be explained via the selection of primary flakes for use as cores in some instances although, equally, evidence also exists for the exploitation of very flat nodules in other core forms so thin nodules were possibly also chosen for PCT reductions. There is evidence to indicate that some non-PCT cores (Fig. 11) from PL1 derived from primary flake blanks and the natural morphology of selected primary flakes would have provided opportunities for limited preparation of the selected blank; this would have been equally true for PCT reduction sequences. Specifically, the under (preparation) surface would have been suitably convex in the form of either the naturally rounded dorsal surface of a primary flake or a primarily flat-based flake with rounded margins, thus saving considerable morphological preparation of this surface of the core. The installation of one or more striking platforms would have been followed by lateral and distal shaping of the upper (production) surface via a centripetal pattern of preparation for preferential forms (Fig. 9B–D). Similarly, such reduction sequences would form the method of repeated flake detachment for recurrent forms. In effect, primary flakes would have provided the hierarchical delineation between the preparation and production surfaces of the core required for Levallois (prepared core) technology (Boëda, 1991, 1993, 1995; Van Peer, 1992; Chazan, 1997). In any event, the proposed use of such forms as cores intimately relates to an additional technological aspect of the PL1 core assemblage, the occurrence of cores-on-flakes.

Sixteen cores-on-flakes (CF) (7.1% of core assemblage), or 'flaked flakes' (cf., Ashton et al., 1991; Zaidner et al., 2010) were identified (Fig. 11) in the PL1 assemblage. In general, a CF can be identified by the bulb of percussion (remaining in part or as a whole) of the host flake and is defined as a flake from which additional smaller flakes are detached from its edges (Ashton et al., 1991). It has been debated whether CFs are cores, or whether they represent one variation in the post-detachment thinning of flakes (Goren-Inbar, 1988; Dibble and McPherron, 2007). Regardless, CFs are found in many lithic assemblages and include recognized types such as what Schroëder (1969) termed the truncated faceted type, also referred to as the 'Nahr Ibrahim technique' (Solecki and Solecki, 1970).

In general, the cores from PL1 represent a pattern of core reduction strategies employed by individuals using this specific location for the production of flakes via the exploitation of available raw materials in a technologically informal manner. Closer examination demonstrates the presence of some comparatively more

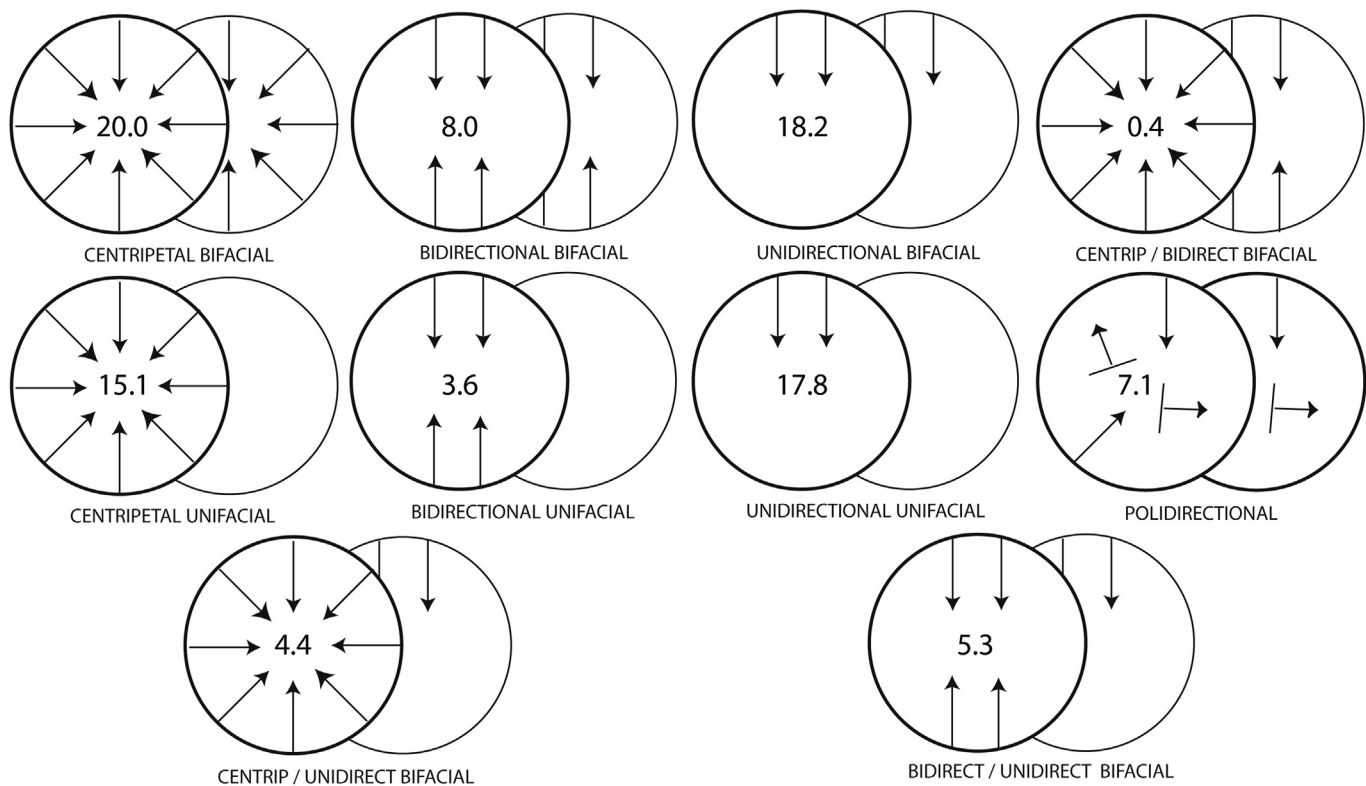


Fig. 10. Scar pattern classification system applied to PL1 cores and percentage of cores in each class.

elaborate tasks involving the likely production of (some) prepared cores on flakes and, otherwise, the use of flakes as cores to produce other flakes. Additional fine-grained observations include the identification – by characteristic pecking on one end – of at least one core that was derived from its original use as a hammerstone (Fig. 10D), thus indicating a measure of opportunistic recycling at PL1, and the presence of single instances of blades and bladelet cores (Fig. 11C). The latter are both made from hornfels and do not resemble equivalent cores from the Howiesons Poort or post-Howiesons Poort.

## 8. Discussion

Many aspects of the PL1 assemblage suggest that the site functioned as a primary flaking location in MIS 3, with a principal focus on reduction of hornfels and quartzite nodules/cobbles extracted from cobble beds of the adjacent Doring River. The quarry-like characteristics of the site explain the high proportions of cortex on flakes and cores and the fairly limited extent of core volume exploitation. This in turn may in part account for the relatively expedient nature of much of the documented core reduction.

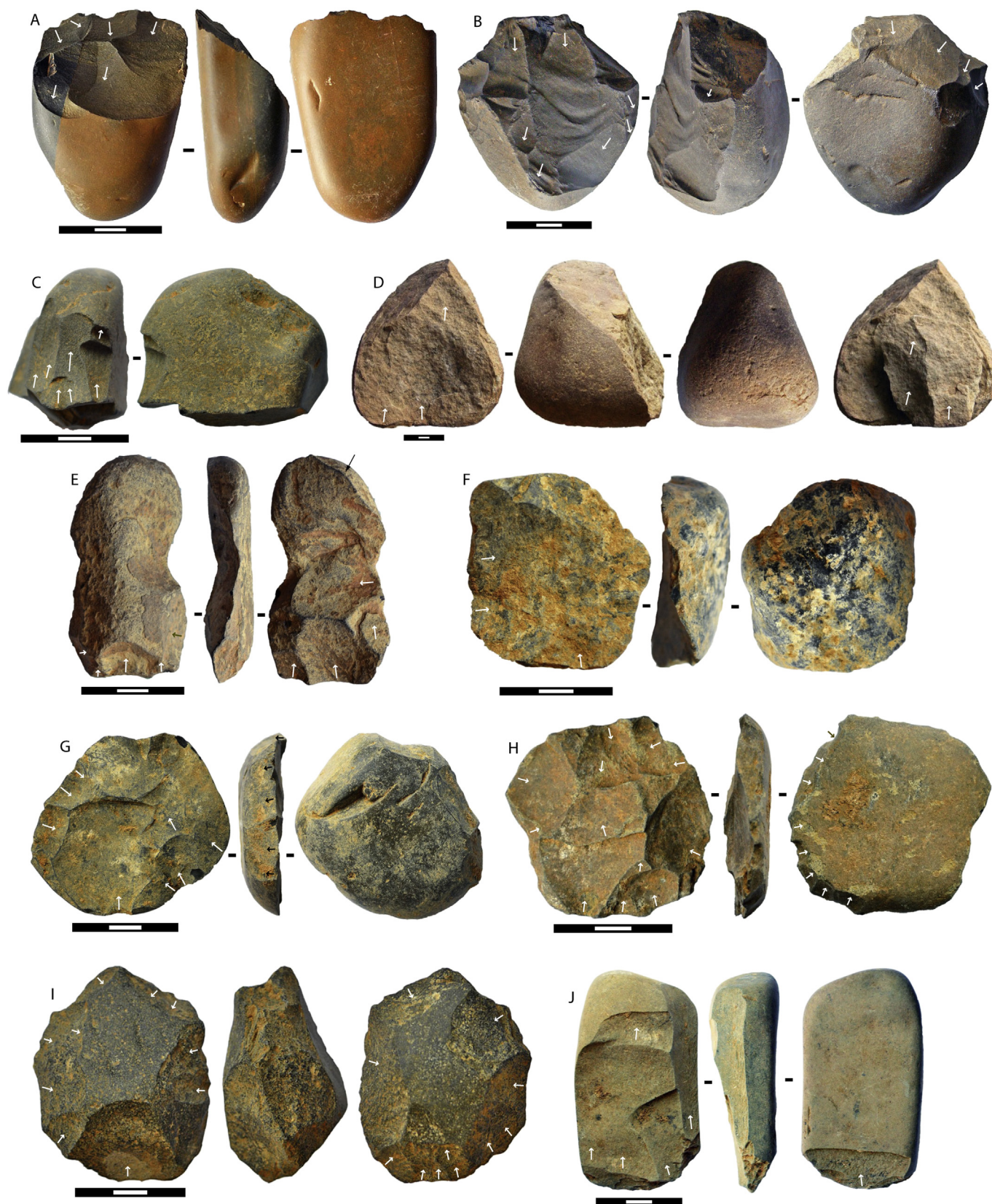
That primary core reduction occurred at PL1 may be taken as partial explanation of the density of finds at the site, but this requires some further discussion. We excavated a high point on an otherwise undifferentiated terrace surface at PL1, and our excavation encompassed <0.1% of the surface area available for excavation (and a much lower proportion of the available volume). However, we recovered ~6700 artefacts, or roughly 3350 artefacts/m<sup>2</sup>. Conservatively, we estimate that the presently-remaining terrace area contains >350 000 artefacts (allowing that densities in the excavated area are 10 times higher than average and that no significant assemblages exist below the tested sediment depths). Even

given that the assemblage may have formed over 30–35 ky, the fact that a) there is no obvious focal agent for occupation at PL1 and b) other terraces we visited had similar densities of artefacts, suggests to us that MSA archaeology is particularly dense through the Doring River corridor. The marked discrepancy between the density of surface finds (~20/m<sup>2</sup>) and excavated finds (~3350/m<sup>2</sup>) further suggests that the observable surface density will in some cases under-represent actual density by more than two orders of magnitude. The MSA archaeology of the Doring River corridor appears dense, but is likely far denser than it appears.

With respect to the 30–35 ky over which the assemblage may have formed, our PL1 assemblage must necessarily be characterised as a potential cumulative palimpsest. Other than the small pulse associated with the possible palaeosol we found no evidence for discrete horizons of artefact accumulations within the excavation area, and this is consistent with our observations at other terrace sites with large exposed sections. This, coupled with the site setting in a back-flooding tributary mouth, the composition of the sediments through the excavated sequence, and the statistically similar OSL ages taken 700 mm apart in the west section imply that PL1 is a slackwater deposit, most likely reflecting three or more large flood events in the Doring River around the start of MIS 3. Dated slackwater deposits are known from the Holocene and the Last Glacial Maximum in the Orange River and further north in Namibia (Heine and Heine, 2002; Herbert and Compton, 2007; Heine and Volkel, 2011), but have previously not been documented from MIS 3. Further OSL work along the river may allow the temporal range, magnitude, and periodicity of these events to be identified.

That PL1 is effectively a quarry and potentially a palimpsest does not explain the absence of typical late MIS 4/early MIS 3 retouched flakes, material selection or reduction systems. It is possible that retouched artefacts were not produced in large numbers at sources of primary stone extraction, but this does not explain the lack of





**Fig. 11.** A, unidirectional-unifacial core; B, unidirectional-bifacial core; C, unidirectional-unifacial core (bladelet); D, large quartzite core with refitted flake; E, core-on-flake (arrow indicates origin of strike and bulb); F, core-on-flake (arrows indicate flake scars); G–H, prepared cores (preferential and centripetal recurrent, respectively); I, discoid; J, example of core on flat hornfels nodule, a common type of raw material form at PL1.

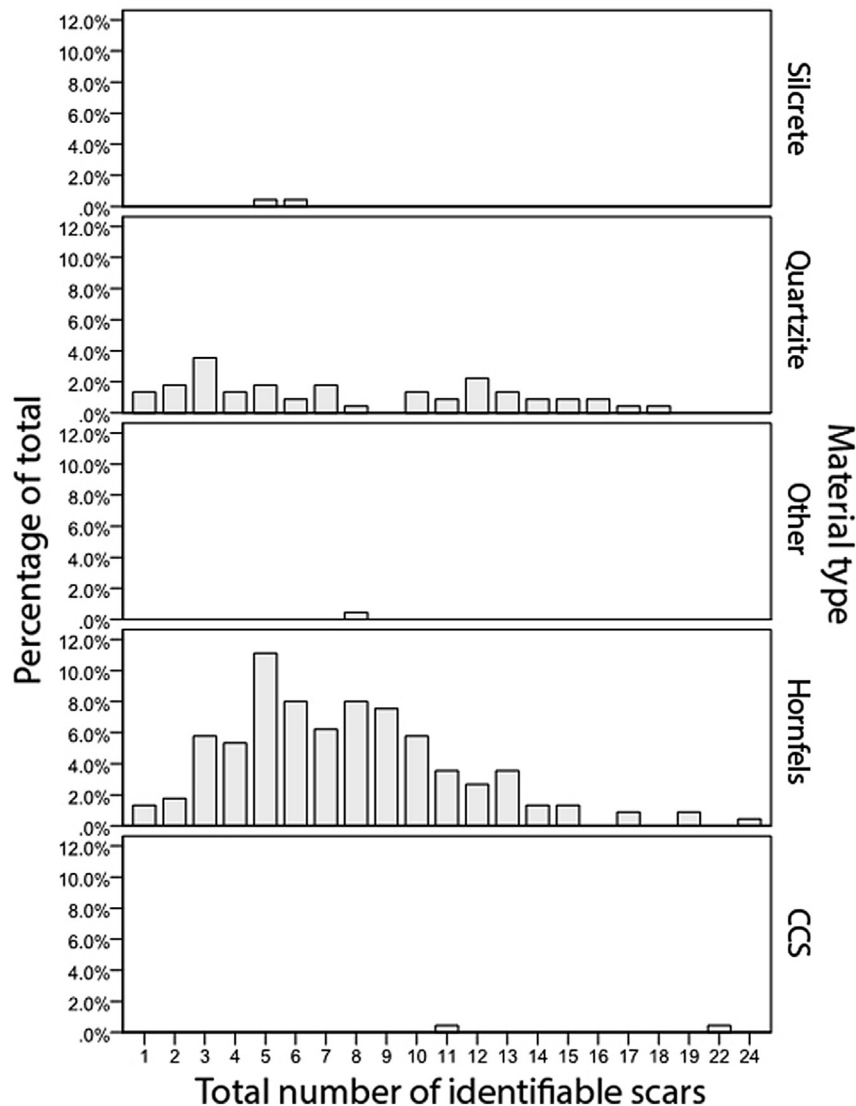


Fig. 12. Histograms of scar counts by raw material types.

silcrete rocks or laminar reduction. More importantly, it does not explain the pattern at other locations on the river, such as Uitspankraal 7 and Klein Hoek 1. Uitspankraal 7 has large numbers of silcrete flakes and blades, evidence of laminar reduction and the presence of multiple unifacial points, consistent with the typical early post-Howiesons Poort signal in the region (Mackay, 2011; Porraz et al., 2013a). As the physical situation of Uitspankraal 7 is similar to that of PL1, this cannot explain the absence of post-Howiesons Poort features at the site. The more likely explanation is that the assemblage at PL1, from the upper layers at least, is a primarily post-50 ka (eg., post-post-Howiesons Poort) accumulation.

Accepting that the assemblage described here is largely an expression of technological systems in later MIS 3, several implications arise. First, the argument for absence of occupation in the WRZ during later MIS 3 is not supported. The sample of rock shelters occupied >50 ka and subsequently abandoned in the region is sufficiently large as to render the pattern relatively robust. Yet we have large, dense accumulations of artefacts on the Doring River at this time. Alternatively, then, the observed pattern reflects

a reorganisation of settlement where occupation was more intensively focussed on the better-watered areas around major rivers and away from the tributaries. If so, it suggests that the rock shelter record may preserve only a specific subset of the occupational history of the region, and one that is insufficient to allow its full characterisation. Recent excavations of rock shelter sites such as Putslaagte 8, Klipfonteinrand and Mertenhof, along with re-excavation of Hollow Rock Shelter (Högberg and Larsson, 2011), all of which are located on Doring River tributaries will help test this hypothesis and further explore the land-use history of the areas.

Second, the MSA technologies of later MIS 3 in the WRZ, if PL1 can be taken to characterise them, seem to be focussed on fairly expedient centripetal and unidirectional reduction often of thin cobbles/nodules and primary flakes with little subsequent retouch. We found very limited evidence of laminar reduction and no implements that we would describe as typical of the assemblage. In contrast to periods such as the Still Bay, Howiesons Poort, post-Howiesons Poort and Robberg, decontextualized assemblages (eg., those lacking dates or other sequence components) from later



MIS 3 will be difficult to identify as such. This may explain past problems in identifying a characteristic late MSA industry in the region.

Third, there is no obvious consistency between the assemblage from PL1 and MIS 3 MSA industries known from southern Africa's Summer Rainfall Zone to the north and east. Those industries commonly have blades, backed artefacts, large side-scrapers, unifacial points and bifacial points, the last sometimes with distinct hollow-based morphologies (Carter, 1978; Kaplan, 1990; Opperman, 1996; Clark, 1999; Wadley, 2005; Jacobs et al., 2008a; Stewart et al., 2012; Mohapi, 2013). None of these artefacts are present in our excavated sample and none were noted on the surface of the site. This difference supports suggestions of technological fragmentation between regions in later MIS 3 (Jacobs and Roberts, 2009; Mackay et al., in press).

## 9. Conclusions

The Doring River has a rich late Pleistocene archaeological landscape, with open sites relating to the earlier MSA, Still Bay, post-Howiesons Poort, and Robberg industries. At PL1, however, we have identified occupation during later MIS 3 and with it a technological variant of the MSA not previously described in the region. This variant seems to comprise few morphologically-regular retouched flakes and fairly expedient flaking systems centred on centripetal and unidirectional reduction techniques. Though we cannot presently refine the dating, the existence of such variation in this time period challenges existing depictions of the occupational history of the region. We suggest that future research might profitably focus on the articulation of rock shelter and open site deposits, not only to better resolve regional occupational histories, but also to better understand patterns of land use through the late Pleistocene.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.quaint.2014.05.007>.

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