STEENBOKFONTEIN 9KR: A MIDDLE STONE AGE SPRING SITE IN LIMPOPO, SOUTH AFRICA

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ABSTRACT

Steenbokfontein 9KR is a Middle Stone Age spring site in the Waterberg, Limpopo. It is situated in a geological remnant, the Vaalwater Formation, a former basin that filled with fine-grained siltstone and sandstone. The ready supplies of water and siliceous rock attracted Stone Age settlement. The petrographic and XRF analyses suggest that the rock used is silicified siltstone. The outcrop is exposed at the spring and the site appears to have been deliberately exploited for tool-making rock. Here, people tested rock slabs for their suitability and knapped some flakes and blades on site. The excavated area shows signs of post-depositional disturbance, and damage that resembles trampling is present on both lithics and geological pieces of siltstone. Phytolith preservation is excellent and a woodland savanna is implied by the identifications. Cyperaceae once grew around the spring, although they no longer do.

Keywords: Middle Stone Age, spring site, phytoliths, silicified siltstone, lithic technology

INTRODUCTION

The Middle Stone Age (MSA) spring mound site, Steenbokfontein 9KR (hereafter called Steenbokfontein), is on the farm of the same name on the Waterberg plateau, Limpopo Province (Steenbokfontein 9KR (Portion 1) S 24.04.661; E28.05.634) (Figs 1, 2). Steenbokfontein is unusual in Limpopo, archaeologically, geologically and environmentally, as we now explain.

From the 1950s onwards, archaeologists excavating MSA sites in the interior of South Africa recognized a lithic industry containing long blades, truncated blades with retouched edges, and long unifacial points. They named it after the town of Pietersburg (now Polokwane). Pietersburg industries are located principally in the north of South Africa, and they have not yet been documented north of the Limpopo River. Most Pietersburg sites in Limpopo Province are caves or rock shelters, the best known being Cave of Hearths (Mason 1962, 1988; Sampson 1974; Sinclair 2009), Olieboomspoort (Mason 1962; van der Ryst 2006), Bushman Rock Shelter (Plug 1981; Porraz *et al*. 2015) and Mwulu's Cave (Tobias 1949; Sampson 1974). The open site Blaaubank, a gravel donga near Rooiberg, has many felsite and quartzite Pietersburg tools overlying Earlier Stone Age ones (Mason 1962). Another open site, Kalkbank, also reported to have a Pietersburg industry, yielded only a few dozen lithics (Mason 1962) amongst the large faunal collection that is now known to have been accumulated predominantly by non-human agents (Hutson & Cain 2008). All these sites are below the Waterberg escarpment and, apart from Kalkbank, all have extensive sequences potentially beginning in an early phase of the MSA or even before that in the Earlier Stone Age. Their lithics are mostly made on rocks locally available in sizeable chunks that enable knapping of large, elongated products. The Pieterburg Industry, as presently defined, may well be a response to the availability of hefty blocks of fine-grained rock. Morphological characteristics are recorded in detail for Cave of Hearths, but this is not the case for most Pietersburg industries, and the term has often been used loosely, and clearly needs revision. It is also necessary to study more open sites in northern South Africa to see how their assemblages compare with the better researched ones from cave and rock shelter sites. A recently-excavated MSA spring and peat site, Wonderkrater (Barré *et al.* 2012; Backwell *et al*. 2014), which is near Mookgopong (formerly Naboomspruit), has contributed to this aim. Unfortunately the late MIS 6 and MIS 3 occupations have few lithics. Most are made on rhyolite; broken and whole flakes are in the majority, followed by broken blades and denticulates, many of which seem to be cutting tools (Backwell *et al*. 2014).

Cave of Hearths (Mason 1962, 1988; Sampson 1974) has a particularly long Pietersburg sequence. MSA lithics from Beds 5–8 include prepared cores, long blades, *Levallois* flakes, and unifacial and bifacial points occasionally on hornfels, but more often on quartzite and andesite (Mason 1962, 1988; Sampson 1974; Sinclair 2009). Long blades sometimes were manufactured from blocks of locally available andesite (Sinclair 2009). Olieboomspoort Rock Shelter is another MSA site of considerable significance (Mason 1962). Here a Pietersburg Industry made from felsite, quartzite, cryptocrystalline minerals and mudstone overlies an Earlier Stone Age assemblage and underlies a long Later Stone Age (LSA) sequence (Mason 1962; van der Ryst 2006). Bipolar flaking is part of this Pietersburg Industry (Mason 1962) as it is at the earlier Limpopo site, Kudu Koppie (Sumner 2013). Mwulu's Cave is thought to contain a late Pietersburg made on quartzite (Tobias 1949; Sampson 1974), as is also the case at Kalkbank (Sampson 1974) and Blaaubank (Mason 1962). Much farther east, the hornfels-dominated assemblages from Bushman Rock Shelter have long blades, retouched blades and elongated unifacial points (Plug 1981; Porraz *et al*. 2015).

Most excavated MSA sites in Limpopo are below the escarpment, but amongst the known ones on the Waterberg plateau, where Steenbokfontein is situated, is a small rock shelter, North Brabant (New Belgium 608 LR), which was excavated by Schoonraad and Beaumont (1968). Here the MSA component of the site was attributed to a 'Middle Pietersburg', and LSA artefacts were recovered from younger occupations with radiocarbon ages of AD 900 and AD 1100. Van der Ryst (1998) subsequently excavated the same shelter and retrieved MSA unifacial points from the oldest sediments. A few MSA blades, a bifacially worked tool and broken point were later found in a rock shelter at Schurfpoort 112 KR on the Waterberg plateau (van der Ryst 1998). At Goergap 113 KR rock shelter, also on the plateau, van der Ryst (1998) excavated a substantial MSA lithic collection. At the base, the lithics were generally larger than 50 mm and the length of some quartzite blades exceeded 150 mm. Points and knives (elsewhere sometimes called side scrapers) were common. In younger MSA layers of Goergap, the tools were smaller and there was a change in rock type from quartzite to felsite.

As this brief review demonstrates, few MSA sites have been studied in the Waterberg and Steenbokfontein is the first MSA open site excavated on the plateau. Since the Waterberg is a high-lying island in Limpopo, and is encircled by lower-altitude Pietersburg sites, we want to know whether the different locations and rock types influence the type of sites and lithic. Hornfels, for example, does not outcrop on the Waterberg plateau. The Waterberg is overwhelmingly characterized by coarse sandstone, yet the Steenbokfontein vicinity has abundant outcrops of fine-grained siliceous rock. This source of rock, suitable for knapping, attracted people in the MSA and the area is littered with the products of knapping. The spring is an added attraction, so LW selected the site for a trial excavation. It was clear from the start that there would be challenges, probably more so than is normal for open sites. We did not expect organic preservation, for example, because Waterberg sediments are usually acidic. Furthermore, the density of lithics lying on the ground surface points to low sedimentation rates and repeated visits by people. The water source would also have enticed animals regularly, so traffic would have been heavy around the spring. Our pre-excavation investigation of the surface lithics revealed secondary edge modification on all the pieces and we suspected that at least some of this was the result of repeatedly trampling the siliceous rock. We realized that a detailed taphonomic study would be required as part of the lithic analysis.

Steenbokfontein is situated within the Vaalwater Formation which developed in the central part of the main Waterberg Basin (Callaghan 1993:51). The Vaalwater Formation is the youngest part of the Waterberg succession (Jansen 1982). It is responsible for building the plateau in the area and the farm, near Visgat, is close to where the Formation reaches its maximum thickness of approximately 475 m (de Vries 1970:51). The Vaalwater beds were most likely deposited under shallow water in a slowly subsiding, small and isolated inland basin (Jansen 1982:53) that was as narrow as 6 km northwest of Vaalwater and no more than 40 km wide between Vaalwater and Dorset (de Vries 1970, 1973). Callaghan (1993:70) interprets the Vaalwater Formation as the end result of deposits in a littoral or shallow siliciclastic sea environment. The Formation has sediments that are finer-grained than those in the underlying Formations, such as the Cleremont Formation, and it consists of sandstone, siltstone and locally developed gritty sandstone (de Bruiyn 1971). The sandstone is rich in feldspar, plagioclase and orthoclase, whereas the siltstone comprises quartz, plagioclase, orthoclase, zircon and mica (de Bruiyn 1971). In places the siltstone is hardened where diabase intrusions caused contact metamorphism (de Bruiyn 1971:6) and some siltstones are locally silicified (de Vries 1970; Jansen 1982:50). Callaghan cut several thin sections for petrographic analysis. Thin section #1577 contained 89% quartz, 10% plagioclase feldspar, 1% chert and extensive quartz overgrowths, while thin section #1563 comprised 80% clay (K-rich), 20% silt, iron oxide cement and grains prolate to equate (Callaghan 1993:13). Today the fine-grained sediments are exposed mostly in streambeds where they are jointed (Jansen 1982:51) and have a blocky appearance. At Steenbokfontein fine-grained, jointed siltstones are exposed around the eyes of springs and these are the rocks that were exploited by people in the MSA. We thought it was important to conduct a petrographic study of the rock used for the lithics so that we could identify it securely and also characterize it because it is unique to this part of South Africa. Since it occurs in such a small locality it will later be possible to track rocks exported to other sites.

Several springs rise on the farm and one was selected for a small excavation. The presence of reliable water sources is unusual in the Waterberg, notwithstanding its name. The mean rainfall of the area is approximately 600 mm per annum (summer rainfall) and the vegetation is predominantly broad-leaved savanna with sour C_4 grass. Seasonal drought is not uncommon, but there are also years of rainfall well above the mean. *Combretum* spp., *Terminalia sericea*, *Burkea africana, Acacia karroo* and *Grewia* spp. are among the common trees and shrubs, while grasses include *Eragrostis* spp., *Panicum* spp., *Cenchrus ciliaris* and *Digitaria* spp. At present there is no noticeable difference between plants growing around the spring and elsewhere in the savanna surrounds and there are no Cyperaceae near the water.

THE EXCAVATION

EXCAVATION METHODOLOGY

A north-facing grid was mapped using an EDM (Fig. 2). Two permanent markers were painted yellow; one is a metal dropper cemented into the ground with a beacon of rocks, while the other is a bolt cemented into a concrete slab near the spring eye. The bolt in the concrete slab is the datum. Two metre squares (N4 and N5) were excavated to the base of the surface layer. Thereafter, a half metre (100 x 50 cm) was excavated to bedrock in square N4. All sediment was sieved through 2 mm mesh and the volumes of deposit removed were recorded (non-artefactual rock with any dimension larger than 5 cm was removed before the volumes were measured). Sediment colour was documented using a Munsell chart. Lithics 2 cm and larger were point plotted. Sediment cores were removed for Optically Stimulated Luminescence (OSL) dating from the base of the Surface layer (depth 13 cm), square N4, east wall, and the base of Layer 2 (depth 32 cm), square N4, north wall. Sediment samples were collected from all layers, some were specifically collected for phytolith analysis.

STRATIGRAPHY

Four layers were recognized between the surface and bedrock that was reached between 52 and 54 cm below surface (Fig. 3). The surface silt (Surface layer) comprises recent soil formation (Munsell colour 7.5YR 3/2 very dark greyish-brown; texture clayey; coherence strong) and the upper 5 cm was disturbed. Seventy litres of sediment were removed from N4 and 100 from N5. Two pieces of glass were recovered and lithics in both squares lay in disarray at various angles. The contact between Surface and rock-filled Layer 1 is abrupt (Fig. 3) and excavation became difficult because of the density of rocks.

Layer 1 sediment was a silty texture with medium coherence, and the Munsell colour was 7.5YR 6/2 pinkish-grey. Seventy-five litres were excavated from N4 and 40 from N5. Excavation in N5 was then discontinued. Near the base of Layer 1 the sediment is gritty and lithic concentrations are dense (Table 1). At the base of Layer 1, at a depth of between 28 and 29 cm, there is a stratum of small rock slabs and this was used as the marker between Layer 1 and Layer 2. Layer 2 sediment is gritty with rounded nodules of decomposed sandstone, weak coherence, and far fewer lithics than in Layer 1. The colour of Layer 2 is 7.5YR 6/2 pinkish-grey and 34 litres of sediment were excavated. The close-packed angular rocks in Layers 1 and 2 are not in primary context; they lie at various angles and have therefore been moved. The outcrop from which they originate lies below Layer 3 which comprises 54 litres of gritty sediment in pockets between the many close-packed rocks that form bedrock. The rubble at the base of Layer 3 formed from the desegregation of the siltstone regolith. Only a few lithics were recovered here.

200 g of sediment from Surface and 200 g of sediment from Layer 1 were processed by flotation by CS, using clear water and chiffon cloth screens with a maximum mesh size of 500 µm. The carbonized remains that were recovered through flotation consisted exclusively of grass root fragments, up to 20 mm long and less than 3 mm in diameter. They occurred from Surface into Layer 1 at a depth of 25 cm. Some roots were burned although the farm had not experienced a veld fire for more than 30 years (J. van der Walt personal communication, 2014). There was no organic preservation of bone or charcoal in the sediments.

Two sediment cores (one from Surface and one from Layer 2) were processed by Professor Zenobia Jacobs in the School of Earth Sciences, University of Wollongong, Australia. Reliable optically stimulated luminescence ages were not possible because grains of different ages are mixed in the sediments. This implies post-depositional disturbance of the area around the spring, a conclusion also supported by the stratigraphy and the lithic analysis at the site.

PETROGRAPHIC STUDY

A thin section was cut from a geological block collected near the Steenbokfontein spring. The thin section was prepared following standard techniques, and examined using a transmitted light microscope (Leica 2500 DM P) at the School of Geosciences, University of Witwatersrand. Petrographic examination included mineral identification, mineral shape, textures, and distinction between larger clasts and groundmass. Classification into rock type was based on petrographic observations.

This sample is a largely homogeneous, unfoliated and fine- to cryptocrystalline rock consisting of mineral constituents of variable grain-size (Fig. 4). The fine-grained material can be considered as matrix composed of cryptocrystalline quartz, minor carbonate and iron-oxide (hematite), the latter lending the rock its reddish colour. Microcrystalline (micritic) carbonate cannot be specified unambiguously, but is probably dolomitic (Ca-Mg rich) and/or sideritic (Fe-rich) in composition. Brownish to reddish hematite is abundant, occurring as granular, finely disseminated grains. Hematite is also identified as an infilling phase, replacing primary material in clasts that are elongate, angular and often needle-like in shape with a random orientation. These clasts range in length up to 2 mm, and are sometimes observed to be concentrated along specific horizons. Weathered, rounded brown clasts of carbonate (dolomite?) are also present. Opaque phases (~ 1% modal abundance) are difficult to identify, but may comprise sulfides and Fe-oxides (magnetite) that often appear in close association. Rare, detrital quartz grains show undulose extinction and are distinctly larger than matrix components. In places, the arrangement of quartz and Fe oxides resembles pressure-solution textures. Randomly, veinlets cross-cutting the rock are infilled with quartz and hematite. At high magnification, carbonaceous matter can be discerned as irregularly-shaped clots at micron scale. The nature of the groundmass quartz is not clear, and may represent detrital or precipitated material. In the former case, the rock would be classified as silicified siltstone, in the latter case as chert. XRF analysis has helped to resolve this issue.

XRF ANALYSIS

This study was carried out using a pXRF: a Thermo Scientific Niton XL3t 950 portable XRF analyser equipped with a GOLDD+ drift detector and a miniaturized x-ray tube with an excitation source of 50 kV. An area of 8 mm in diameter was analysed. Measurements were acquired using a lead receptacle stand into which the spectrometer is placed. Using this receptacle and testing the flat surfaces of rocks keeps the distance between the sample and the spectrometer constant. Acquisition time for all samples was 180 seconds. Site choice for reading spots is limited by surface topography, because a flat surface is preferable. pXRF results on whole samples are inferior to XRF readings on powdered samples. This pXRF testing method was, however, considered adequate for a preliminary study of the rocks. Two rocks from the Steenbokfontein spring were sampled and each rock was split so that four pieces were analysed.

The preliminary XRF readings demonstrate that the four rock samples are silicified; one sample had Si readings of 31%, while the other three were between 41 and 46%. They contain relatively high percentages of aluminium (4-8%), iron (4-5%) and potassium (1.6-2.6%). In combination with the petrographic analysis, the XRF results suggest that the rocks used for tool manufacture at Steenbokfontein are silicified siltstone. Although the rock is cherty in appearance, the relatively low percentages of silica imply that silicified siltstone is a closer match than chert.

PHYTOLITH ANALYSIS

COUNTING AND CLASSIFICATION

Of the sediment samples collected from square N4, four were chosen for phytolith analysis from Layers 1 to 3 from both the southwestern and southeastern quadrants. Phytolith morphotypes were extracted following standard procedures described in Pearsall (2000) and Piperno (2006). The procedure involved treating approximately 2-3 g of sediment with 10% hydrochloric acid in a hot water bath at 70º C to remove carbonates, then washing in distilled water by centrifuging and decanting. Organic matter was removed from the samples by adding 30% hydrogen peroxide and placing in a hot water bath at 70º C. Samples were sieved through a 250µm sieve and finally density separation of phytoliths was achieved by adding 5 ml of sodium polytungstate solution at 2.4 g/ml density. Phytoliths were mounted on microscope slides using glycerol and observed under x400 magnification using a Zeiss CP-achromat light microscope mounted with a camera to identify the taxonomically important phytolith morphotypes.

Phytolith morphotypes were classified following published micrographs and descriptions by various authors and wherever possible named according to the ICPN Working Group of Madella *et al.* (2005) and interpretations of their taxonomic origin are also based on published data. Poaceae phytolith morphotypes (grass silica short cells – GSSCs) were classified according to Twiss *et al*. (1969), Alexandre *et al*. (1997), Piperno (2006), Barboni and Bremond (2009) while phytoliths produced by non-Poaceae were classified according to Runge (1999), Albert *et al*. (1999), Piperno (2006), Mercader *et al*. (2009) among others. Phytolith abundances were gauged by scanning one vertical column of each slide, and the phytolith morphotype count ranged from 360 to 680 in the samples analysed. Because of issues of multiplicity (the production of several different phytolith forms within a single plant species) and redundancy (similar phytolith forms being produced by several plant species) (Rovner 1971), it is difficult to assign a definite taxonomic classification to a specific morphotype. However, some morphotypes may be attributed to particular taxa, for instance grass subfamilies can be identified by their quantities, size, their occurrence in combination with other morphotypes, and depending on their environmental settings (Twiss 1992; Piperno 2006; Barboni & Bremond 2009; Table 2).

Phytolith types were grouped into ten main categories (Table 2). Of these, the presence of four morphotypes, which are produced exclusively in epidermal short cells of grasses and are of known taxonomic significance (Twiss *et al*. 1969; Piperno 2006), allows for the identification of some of the main grass subfamilies: (1) cross, (2) bilobate (the few cross-types present are grouped with bilobates in this study), (3) saddle type (short and long) and (4) rondel-shaped. The cross and bilobate morphotypes predominate in the subfamily Panicoideae; the saddles are dominant in the subfamily Chloridoideae and rondels are typically associated with subfamily Pooideae (Table 2). Phytoliths that occur in all members of the grass family and other monocots are: (5) cuneiform bulliform as well as (6) elongate types (psilate and echinate long cells; tabular and cylindric elongates) that are also produced by some trees, or dicots in general (Piperno 1988; Thorn 2001; Mercader *et al*. 2009; Novello *et al.* 2012). Other non-Poaceae phytoliths were grouped as: (7) globular granulate that is often associated with trees/dicots (Alexandre *et al*. 1997; Runge 1999; Mercader *et al*. 2009), (8) the parallelepiped blocky types that are usually associated with wood/bark of woody species (Albert *et al*. 1999; Mercader *et al*. 2009), (9) the hat/cone-shaped and achene phytolith morphotypes that are characteristic of Cyperaceae (sedges) (Piperno 1988, 1989; Ollendorf 1992) and (10) the globular psilate that have several origins occurring in both monocots and dicots and are not useful in taxonomic discrimination (Piperno 1988, 2006). Table 2 shows the nomenclature of the main phytolith categories observed and their plant attribution according to the literature.

RESULTS

Phytoliths are well preserved and are abundant in all four samples analysed. The micrographs of some of the phytolith morphotypes are shown in Fig. 5. The relative abundance (%) of each morphotype is represented in Fig. 6. The counts presented here were reached by counting one vertical column only of the microscope slides. Poaceae morphotypes are particularly useful in separating some of the grass subfamilies and their habitats. Here they represent more than 40% in all samples apart from sample N4 SE Layer 2 (top) with 37%, with the highest contributor in all four samples being the rondel shaped morphotypes (27-35%, Fig. 5E, F). This type was, in the past, generally attributed to C_3 high altitude/cold climate grasses of the subfamily Pooideae (Twiss *et al*. 1969; Twiss 1992), however rondels are now considered to be the most redundant phytolith morphotype occurring in all the main grass subfamilies (Bamford *et al*. 2006; Barboni & Bremond 2009; Mercader *et al*. 2010; Novello *et al*. 2012; Cordova 2013). Rondels were found to occur in large numbers (up to 95%) in the genera *Sporobolus* and *Eragrostis* (subfamily Chloridoideae, hot dry climate grasses) by Novello *et al*. (2012) in agreement with the previous aforementioned studies in Africa. Because the trapeziform sinuate morphotype that is reported to confirm the presence of C_3 Pooideae cold climate grasses was not observed in the samples (Barboni & Bremond 2009), these morphotypes are most likely to have been produced by C_4 grasses.

Bilobate shaped (mainly C_4 tall Poaceae of warm wet climates – subfamily Panicoideae, Fig. 5B) and saddle shaped (C_4 short Poaceae of dry climates – subfamily Chloridoideae, Fig. 5C,D) phytoliths occur in almost similar amounts with each only contributing 4-6% of the total count with the saddles reaching 10% in one sample. Globular granulate (Fig. 5H) morphotypes that are typically associated with trees/dicots seem to be the second most abundant phytolith type, varying from 23 to 39% and they are used to provide information on the relative density of woody plants within the vegetation type (Alexandre *et al*. 1997). Cyperaceae achene phytoliths (Fig. 5L,M,Q), which appear similar to the *Scirpus*-type and unknown possible *Cyperus*-type achenes described by Piperno (1989) and Iriarte *et al*. (2010) were observed in low frequencies. Phytolith achenes typical of the genus *Cyperus* and *Kyllinga* (Piperno 1989; Iriarte *et al*. 2010) were observed, but were very rare compared to the '*Scirpus*' type. Hat-shaped/cone phytoliths that are typical of Cyperaceae (sedges) together with these achene phytoliths are represented in low frequencies (1 to 2%). Another type of globular psilate morphotype was encountered (Fig. 5O); its surface appeared either rough or smooth with a central depression.

Parallelepiped blocky morphotypes (Fig. 5J) occur in percentages that range between about 8% and 17%. They are often associated with the bark/wood of woody species, but they have been reported to occur in some sedges and grasses (Novello *et al*. 2012). They were observed in some woody species of Fabaceae, Ebenaceae and Clusiaceae in Mozambique (Mercader *et al*. 2009). In addition, elongate tabular morphotypes with a 'laminate median swelling' (Fig. 5R) similar to those observed by Novello *et al*. (2012), which are associated with herbaceous plants, were observed in low frequencies, and it is not clear if Fig. 5P is a broken Fig. 5R morphotype or just a short variant of the same. One globular decorated morphotype (Fig. 5N) that is similar to globular echinates typical of Palms (Piperno 2006) was observed. Only side protrusions are clear in the morphotype encountered.

THE LITHIC ANALYSIS

TAPHONOMIC INSIGHTS

Most of the lithic pieces in the three layers studied are patinated so we developed gradations of patination (see next section), and we recorded the percentage of surface that is patinated (Table 3). Greater patination occurs in the oldest layer, thus, as can be observed in Table 3, about 80% of the Layer 3 lithics have heavy Degree 3 patina. The differences in patination through time suggest that the three layers have some stratigraphic integrity, notwithstanding the evidence for weathering and trampling. This interpretation is supported by the uneven densities of lithics through time. The base of Layer 1 and the base of Layer 2 have higher lithic densities than the middle or top of either of these layers, and Layer 3 has the lowest lithic density of any of the layers (Table 1). If the three layers were the result of a dumped deposit we should have expected patination to be mixed through all layers and for the densities of lithics to be similar.

A preliminary analysis of the Steenbokfontein assemblage highlighted four important characteristics which influenced the subsequent analysis and interpretation. First, it is made almost entirely from silicified siltstone which outcrops at the spring. Secondly, some flakes are geological, not anthropogenic. Raw blocks of siltstone at the site are rectangular slabs weathered from the highly jointed outcrop. Many blocks are missing corners that appear to have been removed by mechanical processes. These natural removals result in pseudo-flakes and pseudo-cores. Any piece without a clear platform and bulb of percussion was eliminated from the sample analysed. Thirdly, most of the silicified siltstone slabs and flakes display various degrees of white patina, probably produced by alternate submersion in water when the spring level was high, and exposure to sun and wind when water levels were low. Some of the pieces have white patina only on one face, suggesting partial burial and exposure. Finally, regardless of their morphology or the extent of weathering, most pieces appear damaged. Indeed, all the stone tools have secondary edge modification likely to have been produced by human and animal trampling. Trampling characteristics are: 1. frequent crushing (particularly in Layer 1) (Table 3); 2. dull or blunt edges on half the pieces (Table 3); 3. extensive secondary edge modification on pieces from Layers 1 and 2; 4. 60% of all lithics have more than three directions of secondary edge modification and, 5. a high percentage of irregular, dispersed scars on blank edges. In order to test this hypothesis we performed an experimental programme to compare truly retouched lithic assemblages to trampled assemblages and we later compared this to the archaeological material of this site. This experimental programme is a research in progress.

THE LITHIC TECHNOLOGICAL ATTRIBUTE ANALYSIS

We employ the *chaîne opératoire* approach (Karlin *et al.* 1991), which views an assemblage as the outcome of cultural choices. As several scholars have pointed out (for example Dibble 1995; Shott 2003; Tostevin 2013) the *chaîne opératoire* approach can be highly subjective if a purely qualitative, systemic approach is used. In order to make this study as objective as possible, we incorporate various quantitative parameters. Furthermore, after the attribute analysis, we use basic statistics to support the qualitative arguments.

The large lithic collection from the Surface layer was excluded because we assumed these lithics were disturbed, and we analysed lithics only from Layers 1 3. We established the cut-off between chips and blanks as 2 cm. The chips include pieces with a wide range of morphologies and they are not studied further here. For the 273 pieces > 2cm we analysed both complete and fragmented pieces.

The lithic assemblage was divided into three broad analytical categories: (1) cores, (2) blanks with or without secondary edge modification and (3) chips. Variables recorded for the technological analysis are described in de la Peña (2015: table 3).

In order to assess the taphonomic alteration of the lithics, we used the following macro trace parameters:

Presence/absence of crushing/fissuration: Crushing is defined as steep step and hinge fracture resulting from contact with the edge of the flake at an angle approaching 90 degrees.

Degree of bluntness of the edges (sharp, dull and blunted): The whole edge of the piece is assessed for relative bluntness. If it is fresh it is called sharp. If the piece has lost some of its sharpness, it is called dull. If it has rounded edges and/or steep sides from crushing/trampling, it is called blunt.

Position of secondary edge modification relative to a particular edge. The maximum number of positions is ten because we count secondary edge modification that appears on the central ridge of the dorsal face of flakes.

Regularity (coherence/incoherence pattern of scars): Regularity refers to the overall similarity (size, shape, depth) and general resemblance of different secondary edge modification scars to each other on one piece.

Continuity (isolated, dispersed, continuous): This refers to the location and grouping of secondary edge modification. 'Isolated' refers to a single secondary edge modification scar whereas 'continuous' secondary edge modification is sequential along an edge.

Presence/absence of edge fracture: This records broken flake edges. A simple example is the distal tip of a convergent flake.

The predominant morphology of scars (semicircular/half-moon, quadrangular, trapezoidal, triangular, irregular) (González-Urquijo & Ibáñez Estévez 1994).

The types of scar morphology: this parameter scores the number of scar morphology types.

Degrees of patina: 0 = no patina, 1 = slightly patinated, 2 = medium patination, 3 = entirely patinated.

QUALITATIVE INSIGHTS

The three layers share technological characteristics so they are described together. Later we use metrics to investigate potential distinctions. Three of the cores represented in layer 1 (Fig. 7 A, B, C) are prismatic blade cores. The siltstone naturally appears in rectangular blocks, and this type of natural morphology was ideal for blade prismatic reduction. The fourth core is a core on flake for bladelets (Fig. 7 D).

Blade prismatic production is well represented in the assemblage, not only by the prismatic cores already mentioned, but for many blade blanks with rectilinear profiles, trapezoidal cross sections and predominantly unidirectional scar patterns (Figs 8, 9). Most of these blanks were obtained without platform preparation because most of the platforms are plain or cortical (Fig. 9). Faceted platforms may be 'pseudo' ones, as they were probably produced through an *a posteriori* trampling process; originally, they might have been plain platforms.

Bladelet production is only represented by the core on flake (Fig. 7D), although it is not so clearly represented among the blanks, as only five small fragmented pieces among the chip assemblage were identified as bladelets (from Layers 1 and 2).

The second knapping method is a centripetal reduction of the rectangular blocks in order to produce flakes. The blanks coming from this type of knapping method have crossed, centripetal or sub-centripetal scar patterns, and elongated triangular and right triangular cross sections. Again, it seems that this type of knapping method was accomplished without preparation of the platforms, because plain and cortical platforms are common in the assemblage whereas dihedral platforms have low representation (Fig. 9). The flake knapping method seems quite opportunistic and appears to have relied on the morphology of the blocks. Therefore, it does not seem that the knapping method can be viewed as a purely discoidal one. Moreover, there are no typical discoidal by-products like pseudo-*Levallois* points or side (core) flakes showing a 45 degree angle between dorsal face and platform (typical of discoidal reduction) (Boëda *et al*. 1990). The types of flake blanks represented seem to fit more into a multi-facial core definition without an established pattern. Most of the blanks with centripetal and sub-centripetal scar patterns and expanding shapes should belong to this unstandardized knapping method (Figs 8, 9). In contrast, most of the unidirectional blanks and unidirectional convergent blanks with parallel edges should belong to blade prismatic reduction and, as can be seen in Fig. 9, this includes more than half of the blanks. Moreover, part of the flake production should belong to the preparation and trimming of the blade prismatic cores. It should be highlighted that one point might be tentatively assigned to a *Levallois* reduction framework (Fig. 8), but no other blanks fit this knapping method.

Another general insight into the lithic assemblage is the small number of dorsal scars on the blanks (Fig. 9), which could mean that the knapping activity at the site might have been mainly for testing blocks, and for preliminary phases of knapping. This could mean that Steenbokfontein was a knapping workshop. The high representation of cortical platforms and cortical flakes also supports this hypothesis (Fig. 9).

Regarding formal tools, it is very difficult to give an idea of how many there may once have been because it is impossible to discriminate between purposeful retouch and secondary edge modification caused by post-depositional trampling. Some examples of equivocal formal tools are shown in Fig. 8 together with the *Levallois* point.

QUANTITATIVE INSIGHTS

Table 4 demonstrates that flakes are predominant in the lithic assemblage. One of the questions that can be answered quantitatively is whether the typometrical distribution of blades and flakes is normal or not. In the event that it is normal, this could mean that, for each of the knapping methods, there was continuous reduction. Whereas if not normal, this might imply several knapping methods, or that the types of blanks produced had very different typometric sizes.

In Fig. 10 the length, breadth and thickness distributions for Layer 1 and 2 flakes and blades are shown (Layer 3 is excluded because it has few items). For flakes, the size distribution is very similar in the two layers, whereas for blades Layer 1 seems to have larger blades than Layer 2, and possibly a bimodal distribution.

As can be seen in Table 5, from the Shapiro-Wilk normality tests, and the attributes of length and breadth, the distributions for Layer 1 flakes and blades are not normal. On the contrary, Layer 2 has normal distributions. This situation seems to reinforce the idea, already highlighted from the Layer 1 blade histograms (Fig. 10), that at least for the blades we might have two blank sizes. Thus, we proceed to a mixture analysis in order to assess this possibility. Mixture analysis is an agglomerative, hierarchical and univariate statistical test. It is a method of maximum likelihood estimation to recognize parameters of two or more univariate normal distributions grouped in a single sample (Barceló 2007). In this case we applied the mixture analysis to the breadth readings for flakes and blades of Layer 1. In both cases two groups were the most likely scenario, rather than one or three groups. In Table 6 we show the probabilities and the standard deviations of the groups.

DISCUSSION

Relatively few MSA sites have been studied on the Waterberg plateau and none is dated. Steenbokfontein is the first MSA open site excavated on the plateau. In contrast, several late LSA sites have been excavated here (van der Ryst 1998). Unfortunately Steenbokfontein could not be dated because sand grains of mixed age were present.

MSA stone tools were the only archaeological finds in the four layers excavated at Steenbokfontein. Petrographic analysis and XRF concur that the rock used was silicified siltstone. All the stone tools seem to have been made from the rock outcrop at the spring and they appear mixed with desegregated siltstone regolith as though they were knapped on top of the regolith and then exposed and trampled for years or even millennia. Mechanical secondary edge modification occurs on both archaeological and geological material and this presented major obstacles to the analysis of the stone tools because it was difficult to distinguish confidently between knapping, especially retouch, and accidental conchoidal fractures. In order to test our trampling hypothesis, we have designed a trampling experiment with geological siltstone from Steenbokfontein and this is the subject of a separate study.

At Steenbokfontein we have documented two main knapping methods: prismatic blade production and centripetal flake production. In Layer 1 it seems that there were different typometric size objectives for flakes and blades, whereas in Layer 2 we detected a normal distribution for flakes and blades, which probably means a continuous reduction process. The high proportion of cortex and the small number of scars on flake dorsal faces might be pointing towards a workshop, perhaps for testing rock slabs. We hypothesize, further, that this site was probably a knapping workshop where only initial knapping and testing of geological blocks took place. This makes Steenbokfontein unusual among the Limpopo sites discussed here. Not only is it an open site with lithics made on rocks that do not occur elsewhere in Limpopo, but it appears to be a special purpose destination. As explained at the beginning of the paper, the silicified siltstone used here has extremely limited geological occurrence. Notwithstanding this, LW has observed MSA tools made on silicified siltstone more than 20 km from the nearest outcrop, so rocks and/or lithic products were transported to other sites on the Waterberg plateau. It would be worth conducting a field survey to plot the distributions of these relatively rare rocks. Visits to sites like Steenbokfontein were probably part of the regular cycle of hunter-gatherers that lived in the area. Steenbokfontein thus adds to our understanding of variable site use in the MSA.

Our description of the Steenbokfontein lithic asssemblage makes it plain that the site cannot readily be placed within the Pietersburg Industry, not least because, apart from Cave of Hearths, descriptions of Pietersburg assemblages are too general to be useful. Pietersburg is epitomized by large elongated products, including long points that are usually unifacial and manufactured on blades (Mason 1962; Sampson 1974). Cores and end products are often made on hornfels (Mason 1962; Sampson 1974), a rock that sometimes occurs in large blocks that allow the knapping of long products. Other rocks that occur in large pieces, such as quartzite, were also used, suggesting that the variable appearance of Pietersburg assemblages may, to a degree, be influenced by available rocks. Although the Steenbokfontein assemblage does contain many blades, they are not as large as the ones appearing in the Pietersburg sites described by Mason and Sampson. The use of silicified siltstone is not recorded in any Pietersburg assemblage, so it is possible that the morphology of Steenbokfontein's assemblage has been constrained by this rock. Furthermore, if the site is a primary workshop, large products may have been transported to other sites. Our small excavation yielding only four cores cannot resolve the issue; further excavation and a larger lithic sample is required for this.

All four layers at Steenbokfontein contain similar phytolith morphotypes representing C4 grasses, some Cyperaceae, and woody plants. Since grasses produce huge numbers of phytoliths they tend to be over represented (Piperno 2006) so the vegetation characterized is probably more wooded than grassy, especially Level 2 (top) where there is a high proportion of globular granulates that are produced by dicots (Runge 1999; Mercader *et al*. 2009). No Cyperaceae grow around the spring now, so wetter conditions may have prevailed. Since there are no dates for Steenbokfontein, its environmental record cannot be compared meaningfully with other records. Nevertheless, its record is not unlike that from the spring site Wonderkrater. Here charcoal, phytolith and pollen data imply that MIS 6 occupations took place in warm, dry grassy savanna woodland and that the MIS3 conditions were cooler and wetter with extensive grassland with some woody shrubs (Backwell *et al*. 2014).

Other botanical remains at Steenbokfontein were restricted to burnt grass roots that intruded into the artefact-bearing layers. These illustrate the important taphonomic issue that seemingly *in situ* carbonized remains are not necessarily contemporary with the layer in which they occur. Experiments with fire have demonstrated heat transfer to substrates 10 cm below a fire; these carbonize buried organic material according to the temperature of the surface fire and its duration (Sievers & Wadley 2008; Aldeiasa *et al.* 2016). No hearth features were observed at Steenbokfontein so the grass roots recovered through flotation are likely to have been carbonized by surface grass fires, none of which has come through the area in the past 30 years.

CONCLUSIONS

The small excavation at Steenbokfontein 9KR was conducted close to a spring eye, one of several on the farm of the same name. The uppermost stratum of silt was immediately underlain by siltstone rubble embedded in silt. MSA lithics made on silicified siltstone were recovered throughout the sequence, from the surface to bedrock. Far fewer lithics were recovered from the top of bedrock (Layer 3) than from the other layers. They were often recovered lying vertically or at angles other than horizontal. This implies disturbance of the sediments, an interpretation supported by the mixture of sand grains that precluded OSL dating, and by the damage to lithics and unworked rock fragments. The secondary edge modification on archaeological lithics and siltstone pieces of geological origin is consistent with trampling by humans and animals when visiting the spring. Mechanical modification is likely to have taken place from the MSA to recent times and it has obviously influenced the distribution, not only of lithics, but also sand grains and phytoliths. Furthermore, the desegregated siltstone fragments and the stone tools have been affected by water, presumably as a result of fluctuating water levels in the spring. There is a water patina on most of the archaeological and geological fragments. Therefore, the major factors that altered archaeological material from Steenbokfontein are trampling, the change in the level of the water from the spring, and the long exposure of the material to the elements. Changing water levels may also have removed some original sediment from the rock-strewn layers.

Our preliminary excavation at the Steenbokfontein spring suggests that further work would be profitable in the vicinity. The high abundance and excellent preservation of phytoliths implies that further phytolith research could produce interesting vegetation studies at this site and its surrounds. Targeting an area away from the spring might also produce a less damaged lithic assemblage, and a sediment column with integrity that can be OSL dated.

Steenbokfontein cannot readily be compared to other MSA sites in Limpopo. This is not only because of the small sample of lithics analysed here, the post-depositional damage to the lithics, and the fact that silicified siltstone was not available at sites below the Waterberg plateau. Steenbokfontein is almost certainly a lithic workshop where blocks of rock were tested and knapped in a preliminary way. Recent work in southern Africa has revealed considerable variation in MSA sites across space as well as through time. Steenbokfontein adds to that variability and demonstrates the importance of studying open sites as well as the rich cultural traps created in caves and rock shelters.

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REFERENCES

Albert, R.M., Tsatskin, A., Ronen, A., Lavi, O., Estroff, L., Lev-Yadun, S. & Weiner, S. 1999. Mode of occupation of Tabun Cave, Mt Carmel, Israel, during the Mousterian Period: a study of the sediments and phytoliths. *Journal of Archaeological Science* 26: 1249–1260.

Aldeiasa, V., Dibble, H.L., Sandgathe, D. & Goldberg, P. 2016. How heat alters underlying deposits and implications for archaeological fire features: a controlled experiment. *Journal of Archaeological Science* 67: 64–79.

Alexandre, A., Meunier, J.D., Lezine, A.M., Vincens, A. & Schwartz, D. 1997. Phytoliths: indicators of grassland dynamics during the late Holocene in intertropical Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 136: 213–229.

Backwell, L., McCarthy, T.S., Wadley, L., Henderson, Z., Steininger, C.M., de Klerk, B., Barré, M., Lamothe, M., Chase, B.M., Woodborne, S., Susino, G.J., Bamford, M.K., Sievers, C., Brink, J.S., Rossouw, L., Pollarolo, L., Trower, G., Scott, L. & d'Errico, F. 2014. Multiproxy record of late Quaternary climate change and Middle Stone Age human occupation at Wonderkrater, South Africa. *Quaternary Science Reviews* 99: 42–59.

Bamford, M.K., Albert, R.M. & Cabanes, D. 2006. Plio-Pleistocene macroplant fossil remains and phytoliths from Lowermost Bed II in the eastern palaeolake margin of Olduvai Gorge, Tanzania. *Quaternary International* 148: 95–112.

Barboni, D. & Bremond, L. 2009. Phytoliths of East African grasses: An assessment of their environmental and taxonomic significance based on floristic data. *Review of Palaeobotany and Palynology* 158: 29–41.

Barceló, J. A. 2007. *Arqueología y estadística: Introducción al estudio de la variabilidad de las evidencias arqueológicas*. Barcelona: Universitat Autònoma de Barcelona. Servei de Publicacions.

Barré, M., Lamothe, M., Backwell, L. & McCarthy, T. 2012. Optical dating of quartz and feldspars: A comparative study from Wonderkrater, a Middle Stone Age site of South Africa. *Quaternary Geochronology* 10: 374–379.

Boëda, E., Geneste, J-M. & Meignen, L. 1990. Identification des Chaînes opératoires lithiques du Paléolithique Ancien et Moyen. *Paléo* 1990 2: 43–80.

Callaghan, C.C. 1993. The geology of the Waterberg group in the southern portion of the Waterberg Basin. *Geological Survey Bulletin* 104: 1–83.

Cordova, C.E. 2013. C_3 Poaceae and Restionaceae as potential proxies for reconstructing winter rainfall in South Africa. *Quaternary International* 287: 121–140.

De Bruiyn, H. 1971. The geology of the central portion of the Waterberg basin around Vaalwater, Northern Transvaal. Unpublished report of the Geological Survey of South Africa, 1971-0044: 1–11.
De la Peña, P. 2015. Refining our understanding of Howiesons Poort lithic technology: the evidence from Grey Rocky layer in Sibudu Cave (KwaZulu-Natal, South Africa). *PLoS ONE* 10(12):e0143451. doi:10.1371/journal.pone.0143451.
De Vries, W.C.P. 1970. Stratigraphy of the Waterberg System in the southern Waterberg area, Northwestern Transvaal. *Annals of the Geological Survey of South Africa* 7: 43–67.
De Vries, W.C.P. 1973. Sedimentary structures in the southern and central portions of the Waterberg area, Northwestern Transvaal. *Geologie en Mijnbouw* 52: 133–140.
Dibble, H.L. 1995. Biache Saint-Vaast, Level IIA: A comparison of analytical approaches. In: Dibble, H. & Bar Yosef, O. (eds) *The Interpretation and Definition of Levallois Variability*: 93–116. Madison: Prehistory Press.
Fredlund, G. & Tieszen, L.T. 1994. Modern phytolith assemblages from the North American Great Plains. *Journal of Biogeography* 21: 321–335.
González-Urquijo, J.E. & Ibáñez Estévez, J. 1994. *Metodología de análisis funcional de instrumentos tallados en sílex*. Bilbao: Universidad de Deusto.
Hutson, J.M. & Cain, C.R. 2008. Reanalysis and reinterpetation of the Kalkbank faunal accumulation, Limpopo Province, South Africa. *Journal of Taphonomy* 6: 399–428.
Jansen, H. 1982. The Geology of the Waterberg Basins in the Transvaal, Republic of South Africa. *Geological Survey Memoir* 71: 1–98.
Karlin, C., Bodu, P. & Pelegrin, J. 1991. Processus techniques et chaînes opératoires. Comment les préhistoriens s'appropient un concept élaboré par les ethnologues. In: Balfet, H. (ed.) *Observer l'action technique, les chaînes operatoires, pour quoi faire?*:101–117. Paris: CNRS.
Iriarte, J., Glaser, B., Watling, J., Wainwright, A., Birk, J.J., Renard, D., Rostain, S. & McKey, D. 2010. Late Holocene Late Holocene neotropical agricultural landscapes: phytolith and stable carbon isotope analysis of raised fields from French Guianan coastal savannahs. *Journal of Archaeological Science* 37: 2984–2994.
Madella, M., Alexandre, A. & Ball, T. 2005. ICPN Working Group. International Code for Phytolith Nomenclature 1.0. *Annals of Botany* 96: 253–260.
Mason, R.J. 1962. *Prehistory of the Transvaal*. Johannesburg: Witwatersrand University Press.
Mason, R.J. 1988. *Cave of Hearths, Makapansgat, Transvaal*. Archaeological Research Unit Occasional Paper 21. Johannesburg: University of the Witwatersrand.
Mercader, J., Astudillo, F., Barkworth, M., Bennett, T., Esselmont, C., Kinyanjui, R., Laskin Grossman, D., Simpson, S. & Walde, D. 2010. Poaceae phytoliths from the Niassa Rift, Mozambique. *Journal Archaeological Science* 37: 1953–1967.
Mercader, J., Bennett, T., Esselmont, C., Simpson, S. & Walde, D. 2009. Phytoliths in woody plants from the Miombo woodlands of Mozambique. *Annals of Botany* 104: 91–113.

Novello, A., Barboni, D., Berti-Equille, L., Mazur, J., Poilecot, P. & Vignaud, P. 2012. Phytolith signal of aquatic plants and soils in Chad, Central Africa. *Review of Palaeobotany and Palynology* 178: 43–58.
Ollendorf, A.L. 1992. Toward a classification scheme of sedge (Cyperaceae) phytoliths. In: Rapp, G., Jr. & Mulholland, S.C. (eds) *Phytolith Systematics: Emerging Issues*: 91–111. New York: Plenum Press.
Pearsall, D.M. 2000. *Paleoethnobotany: A Handbook of Procedures*. 2nd Edition. New York: Academic Press.
Piperno, D.R. 1988. *Phytolith Analysis: An Archaeological and Geological Perspective*. California: Academic Press Inc.
Piperno, D.R. 1989.The occurrence of phytoliths in the reproductive structures of selected tropical Angiosperms and their significance in tropical paleoecology, paleoethnobotany and systematics. *Review of Palaeobotany and Palynology* 61: 147–173.
Piperno, D.R. 2006. *Phytoliths. A Comprehensive Guide for Archaeologists and Paleoecologists*. Lanham, New York, Toronto, Oxford: Altamira Press.
Plug, I. 1981. Some research results on the late Pleistocene and early Holocene deposits of Bushman Rock Shelter, eastern Transvaal. *South African Archaeological Bulletin* 36: 14–21.
Porraz, G., Val, A., Dayet, L., de la Peña, P., Douze, K., Miller, C.E., Murungi, M.L., Tribolo, C., Schmid, V.C. & Sievers, C. 2015. Bushman Rock Shelter (Limpopo, South Africa): A perspective from the edge of the Highveld. *South African Archaeological Bulletin* 70: 166–179.
Rovner, I. 1971. Potential of opal phytoliths for use in paleoecological reconstruction. *Quaternary Research* 1: 343–359.
Runge, F. 1999. The opal phytolith inventory of soils in central Africa-quantities, shapes, classification, and spectra. *Review of Palaeobotany and Palynology* 107: 23–53.
Sampson, G.S. 1974. *The Stone Age Archaeology of Southern Africa*. New York and London: Academic Press.
Schoonraad, M. & Beaumont, P.B. 1968. The North Brabant Shelter, North Western Transvaal. *South African Journal of Science* 64: 319–331.
Shott, M.J. 2003. *Chaîne opératoire* and reduction sequence. *Lithic Technology* 28: 95–105.
Sievers, C. & Wadley, L. 2008. Going underground: experimental carbonization of fruiting structures under hearths. *Journal of Archaeological Science* 35: 2909–2917.
Sinclair, A. 2009. The MSA stone tool assemblage from the Cave of Hearths, Beds 4-9. In: McNabb, J. & Sinclair, A. (eds) *The Cave of Hearths: Makapan Middle Pleistocene Research Project: Field Research by Anthony Sinclair and Patrick Quinney, 1996-2001*: 105 137. Oxford: Archaeopress.
Sumner, T.A. 2013. A refitting study of late Early to Middle Stone Age lithic assemblages from the site of Kudu Koppie, Limpopo Province, South Africa. *Journal of African Archaeology* 11: 133 153.

Thorn, V.C. 2001. Oligocene and Early Miocene phytoliths from CRP-2/2A and CRP-3, Victoria Land Basin, Antarctica. *Terra Antarctica* 8: 407–422.
Tobias, P.V. 1949. The excavation of Mwulu's Cave, Potgietersrust district. *South African Archaeological Bulletin* 4: 2–13.
Tostevin, G.B. 2013. *Seeing Lithics: A Middle-Range Theory for Testing for Cultural Transmission in the Pleistocene*. Oxford: Oxbow Books.
Twiss, P.C. 1992. Predicted world distribution of C3 and C4 grass phytoliths. In: Rapp, G., Jr. & Mulholland, S.C. (eds) *Phytolith Systematics: Emerging Issues*: 113–128. New York: Plenum Press.
Twiss, P.C., Suess, E. & Smith, R. 1969. Morphological classification of grass phytoliths. *Proceedings: Soil Science Society of America* 33: 109–115.
Van der Ryst, M.M. 1998. The Waterberg Plateau in the Northern Province, Republic of South Africa, in the Later Stone Age. *BAR International Series* 715: 1–158.
Van der Ryst, M.M. 2006. *Seeking Shelter: Later Stone Age Hunters, Gatherers and Fishers of Olieboomspoort in the Western Waterberg, South of the Limpopo*. Unpublished PhD thesis: University of the Witwatersrand.

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Fig. 1. Limpopo Middle Stone Age sites mentioned in the text. Steenbokfontein is marked with an asterisk. BRS = Bushman Rock Shelter, COH = Cave of Hearths, GG = Goergap, KB = Kalkbank, KK = Kudu Koppie, MC = Mwulu's Cave, NB = North Brabant, OBP = Olieboomspoort, RB = Rooiberg (Blaubank), SP = Schurfpoort, WK = Wonderkrater.

Fig. 2. Steenbokfontein spring site with the excavation grid and datum. A. The spring, B. The excavation grid and datum.

Fig. 3. Steenbokfontein south wall stratigraphy of square N4, showing the silty Surface layer, rubble-filled Layers 1-3 and the jointed siltstone bedrock.

Fig. 4. Thin section photomicrographs (plane polarized light) of rock sample from Steenbokfontein. A. Elongate, angular, randomly orientated clasts in a matrix of cryptocrystalline quartz, minor carbonate and iron-oxide, B. Angular, elongate clast and veinlets infilled with quartz and hematite. Carbonaceous matter visible as irregularly-shaped clots; angular opaques are probably Fe-oxides, C. Magnified view showing quartz, carbonate matrix and carbonaceous matter and opaques.

Fig. 5. Microphotographs of phytoliths from the Steenbokfontein sediment samples analysed. Scale bars are 10µm except for C, F, K, R = 5µm and Q = 20µm. A. Cross, B. Bilobate, C. Short saddle, D. Long saddle, E. Rondel, F. Rondel, G. Cuneiform bulliform, H. Globular granulate, I. Elongate - cylindric, J. Parallelepiped - blocky, K. Elongate - tabular, L. Cyperaceae achene, M. Cyperaceae achene, N. Globular decorated - echinate type? O. Globular psilate with central depression, P. Tabular knobbed, Q. Articulated Cyperaceae achene, R. Elongate tabular knobbed.

Fig. 6. Histograms showing Steenbokfontein phytolith abundance in sediment samples from Square N4.

Fig. 7. Cores from Layer 1, Steenbokfontein. A, B, C. Prismatic blade cores, D. Core on flake to produce bladelets. Scale 1 cm.

Fig 8. Steenbokfontein blades, flakes, and lithics with secondary edge modification. Top left: Blade blanks from Layer 1, Top right: Flake blanks from Layers 1 and 2, Bottom: Examples of Steenbokfontein lithics with secondary edge modification. A and C are blade proximal fragments with secondary edge modification in their distal fractures. D. *Levallois* point.

Fig. 9. Attributes of blanks from Steenbokfontein. A. Percentage of scar pattern, shape of the blank, cross section and type of platforms in Layers 1-3, B. Shape of the blank and scar pattern in Layers 1 and 2, C. Percentage of cortex and number of scars on the dorsal face of lithics in Layers 1 and 2.

Fig. 10. Histograms of length, breadth and thickness of Steenbokfontein flakes and blades from Layers 1 and 2.

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TABLE 1. Changing density of Steenbokfontein lithics in square N4 through time

Layer	**n litres**	**n plotted lithics >2 cm**	**Lithics per litre**
Surface	**70**	128	**1.8**
Layer 1, top	**20**	37	**1.9**
Layer 1 to 22 cm	**40**	49	**1.2**
Layer 1, base, 28 cm	**15**	58	**3.9**
Layer 2, top to 30 cm	**10**	20	**2.0**
Layer 2, to 35 cm	**20**	21	**1.1**
Layer 2, base, to 40 cm	**4**	14	**3.5**
Layer 3 to bedrock	**54**	15	**0.3**

TABLE 2. Main phytolith morphotypes identified in the Steenbokfontein sequence with their taxonomic attributions according to the literature.

Morphotypes	Main taxonomic attribution	Reference
Cross and bilobate	Poaceae - Panicoideae, Arundinoideae/Danthonioideae	Twiss *et al.*1969; Fredlund & Tieszen, 1994; Piperno, 2006; Mercader *et al*. 2010
Saddle	Poaceae - Chloridoidae, Arundinoideae/Danthonioideae	Twiss *et al*. 1969; Mercader *et al*. 2010
Rondel	Poaceae - Pooideae, Chloridoideae	Twiss 1992; Bamford *et al*. 2006; Barboni & Bremond 2009; Novello *et al.* 2012; Cordova 2013
Cuneiform bulliform	Poaceae	Twiss 1992
Elongate (psilate, echinate, tabular, cylindric)	Monocots, Dicots	Piperno 1988; Thorn 2001; Piperno 2006; Mercader *et al*. 2009; Novello *et al*. 2012
Globular granulate	Dicots	Alexandre *et al*. 1997; Runge 1999; Mercader *et al*. 1997
Parallelepiped blocky	Dicots, some Monocots	Albert *et al*. 1999; Mercader *et al*. 2009; Novello *et al*. 2012
Hat/cone-shaped and achene phytoliths	Cyperaceae	Piperno 1989; Ollendorf 1992
Globular psilate	Monocots, Dicots	Piperno 2006

TABLE 3. Attributes of Steenbokfontein lithics from Layers 1 to 3. Percentages of degree of patina, percentage of patina, crushing, degree of bluntness, position of secondary edge modification, regularity, continuity, scars in fracture and edge fracture.

	Layer 1	Layer 2	Layer 3
Degree of patina (%)			
0	12.15	8.51	0.00
1	45.79	0.00	5.56
2	32.71	44.68	16.67
3	9.35	46.81	77.78
Percentage of patina			
0	11.32	8.51	0.00
1 to 10	0.94	0.00	0.00
11 to 40	7.55	4.26	11.11
41 to 60	37.74	21.28	0.00
61 to 90	16.98	27.66	0.00
91 to 99	17.92	0.00	0.00
100	7.55	38.30	88.89
Crushing (%)			
yes	50.26	17.31	34.62
no	49.74	82.69	65.38
Degree of bluntness (%)			
blunt	3.59	9.62	3.85
dull	54.87	38.46	46.15
sharp	41.54	51.92	50.00
Position of secondary edge modification (%)			
1	3.23	6	10
2	12.37	14	10
3	13.98	16	20
>3	70.43	64	60
Regularity (%)			
irregular	83.98	90	100
regular	16.02	10	0
Continuity (%)			
continuous	38.80	10	5
dispersed	56.28	84	70
isolated	4.92	6	25
Scars in fracture (%)			
yes	9.74	**32.69**	0
no	90.26	67.31	100
Edge Fracture (%)			
yes	19.57	34.62	47.83
no	80.43	65.38	52.17

TABLE 4. Technological categories at Steenbokfontein by layer. Chips are excluded from the percentages.

	Cores	**Flakes n (%)**	**Blades n (%)**	**Chips n**
Layer 1	4	125 (65.4)	66 (34.6)	482
Layer 2	0	29 (55.7)	23 (44.3)	85
Layer 3	0	10 (38.5)	16 (61.5)	115
Total n	**4**	**164**	**105**	**682**

TABLE 5. Shapiro-Wilk Normality tests conducted on lengths and breadths of flakes in Layers 1 and 2, Steenbokfontein. * = cases that are not normal

	Length flakes Layer 1	Breadth flakes Layer 1	Length flakes Layer 2	Breadth flakes Layer 2	Length blades Layer 1	Breadth blades Layer 1	Length blades Layer 2	Breadth blades Layer 2
n	82	119	17	28	24	64	9	23
Shapiro-Wilk (W)	0.9361	0.9469	0.9774	0.9378	0.8891	0.9279	0.9439	0.9466
p(normal)	**0.0005047***	**0.0001382***	0.9293	0.09725	**0.01275***	**0.001084***	0.6234	0.2479

TABLE 6. Mixture analyses of breadths of flakes and blades in Layer 1, Steenbokfontein.

Breadth flakes (two groups). Log l.hood: -297.4; Akaike IC: 603.1		
Probability	Mean	Stdev
0.62704	23.086	4.4579
0.37296	33.905	8.0467
Breadth blades (two groups) Log l.hood: -156.4; Akaike IC: 321.4		
Probability	Mean	Stdev
0.43051	28.022	7.3363
0.56949	16.934	3.6422