Abstract: Several petroglyph sites situated on the south-eastern margin of the Kalahari have been under study for the past decade. We report here on research at three localities there, Nchwaneng, Potholes Hoek and Klipbak 1. Age estimates, based on palaeoclimatic constraints, contiguous artefacts, and microerosion analysis, were used to construct a provisional timescale. In terms of this, the rock art is mainly attributable to the Later and Middle Stone Ages, but panels at two sites are linked to the earlier Fauresmith tradition. Pleistocene petroglyphs begin with cupules only, are followed by cupules and outline circles, while the Holocene panels also include noniconic, human and animal depictions. The survival of the extremely early petroglyphs in this region is primarily attributable to the local lithology, a very weather-resistant quartzite.

The first intentional application of chronometric dating to subcontinental rock art took place during the 1951 excavations at Chifubwe Stream Shelter in Zambia (Clark 198), where wall petroglyphs extended down to a Later Stone Age level containing a Nachikufan 1 industry, that was later dated more securely elsewhere to between ~21 and 11 ka BP (Miller 1971; Sampson 1974). A major subsequent contribution was that of Walker (1987), who excavated three painted sites in Zimbabwe, from all of which he systematically recovered many painted wall spalls showing that paintings there ranged back to ~13 ka ago, but alas, he never extended this promising approach to any underlying fully Pleistocene levels. At the same time, in the 1980s, a study was undertaken in and around the Bushmanland region in South Africa (Beaumont & Vogel 1989), to see if a viable timescale for a particular petroglyph technique there could be constructed by dating many sites where it alone was associated with a single dateable lithic scatter. It was found that the scraped and hammered petroglyphs there were confined to the past 2 ka, whereas the fine-line technique could be traced to the Holocene onset, but not beyond, in part because, as archaeological visibility showed (Beaumont 1986), that semi-arid area was largely abandoned during glacial intervals from ~70–13 ka BP.

That fine-line timespan was confirmed during excavations at Wonderwerk Cave, also in South Africa (Fig. 1), where some 20 mobiliary plaques with mainly non-iconic motifs were recovered from Later Stone Age levels dating from 10–1 ka ago (Thackeray et al. 1981; Beaumont 1990). Further fieldwork there, in Excavations 3 and 5 (Beaumont & Vogel 2006), also produced engraved ochre fragments from Middle Stone Age contexts, one dating to ~70 ka and others from a stratum with pollen suggestive of a climate drier than now (E. M. van Zinderen Bakker, pers. comm.), lying above a date of 152 ka BP. While marking and sorting material from rearmost Excavation7, a further five or so engraved slabs were found in Late Fauresmith levels, associated with distinctive coarse terminal handaxes, that age
estimates show to predate 276 ka, thereby demonstrating that rock engravings in South Africa are of great antiquity (Beaumont & Vogel 2006; Chazan & Horwitz 2009).

Fig. 1. Main excavation in Wonderwerk Cave. Massive stalagmite on left, with the Fauresmith and Acheulian sediments visible behind it.

The project

Those finds raised the question of for how long back some petroglyphs in the subcontinental interior could have survived at open sites, where less restricted rock surfaces could have provided a fuller expression of the rock art repertoire being practiced at any given time. After due consideration, research commenced a decade ago (2000) in the south-eastern Kalahari, a region (Climate of South Africa 1986) of often high day temperatures and low rainfall (250–350mm per annum) for the following many reasons.

The first was the presence there of a range of north-south trending hills, the Korannaberge, comprised of one-billion-year-old quartzites of the Olifantshoek Supergroup (Visser 1998), a heavily metamorphosed and geochemically inert rock sort that shows low rates of surface damage, as shown by only lightly smoothed local Acheulian handaxes made of it. Also, a number of petroglyph sites were already known from that vicinity (Rogers 1908; Fock & Fock 1984) and more were later located, of which many have a marked complement of cupules, a sometime deeply (up to 5cm) hammered form (Kumar 2007) that would consequently have survived for very long on resistant quartzite surfaces. Furthermore, such rocks, being made up of indurated quartz grains, are ideally suited to dating by the microerosion method (Bednarik 2007), which can produce reliable estimates back to about 50 ka, if calibrated by data from a climatically comparable region elsewhere.

Other reasons relate to the finding during initial reconnaissance that local petroglyphs were largely confined to smoothed quartzite sheets, on which were seen potholes, lines of chatter-marks, and the plucking of large bedrock slabs to produce angular present-day pools, all of which suggest past glacial impacts. This inference was confirmed during a visit by geologists M. de Wit and J. Ward, who linked these
features to southward ice movement during Permo-Carboniferous times 320–270 million years ago, when Africa, as part of Gondwana, was situated near the south pole and associated tillites accumulated, after which it drifted to its present position (Mac Rae 1999). Of particular relevance here are the rock pools, which, with occasional hillside seeps, would have been the sole regional source of that essential requirement for early human survival, namely constantly available surface water, given that rainfall soon sinks away on the surrounding plains of Kalahari sand.

Final reasons relate to two studies further south (Deacon & Thackeray 1884; Beaumont 1986; Beaumont et al. 1995) which both showed that the arid western interior of the subcontinent was largely abandoned during cooler and drier glacial times, when local populations were displaced to wetter surrounding areas. Research at Equus Cave showed (Johnson et al. 1997) that regional rainfall fell to about a third of that now during the last Glacial Maximum, resulting in Kalahari sand remobilisation from ~60–12/6 ka ago (Bateman et al 2003) and an occupational hiatus at Wonderwerk Cave between ~70 and 12 ka BP (Beaumont & Vogel 2006). From that evidence it can be predicted, by way of the global SPECMAP stack (e.g. Shackelton 1995) that human occupation of the study area was probably largely restricted to three interglacials that were as warm or warmer than now, the Holocene, the Last Interglacial, and the Holsteinian, about 400 ka ago.

Results

Although many petroglyph sites in the study area were inspected, more detailed work has, as yet, been confined to only three localities, namely Nchwaneng, Potholes Hoek, and Klipbak 1, concerning which details are as follows:

Nchwaneng

At this previously recorded locality (Rogers 1908; Fock & Fock 1984), a Kalahari sand-encircled inselberg, the northern slopes run down to a flat smoothed quartzite surface c. 45 x 70m in extent, on the far side of which is a low outcrop, where glacial plucking has produced a number of rainwater-fed pools up to 3m across and 2m deep (Fig. 2). Systematic recording of the rock art over that entire area in October 2001 documented some 1500 discrete images, of which ~80% show surface abrasion, sometimes to an extent that renders them barely perceptible ‘on passing the finger over’ (Rogers 1908), perhaps, most recently, due to sand blasting during drier Holocene intervals (Beaumont at al. 1984). Forms are dominated by cupules, but also present are circles, lines, stars, crosses, triangles, U and V shapes, dots, blobs, and a few human figures, with the 4% balance being semi-naturalistic zoomorphs, usually in profile outline, including eland, giraffe, rhinoceros, gemsbok, zebra and lion, all of which are historically recorded from this region (Skead 1980).
A small excavation west of the large rock pool (Fig. 2) in 1986-87 revealed two successive and mainly quartz-based Later Stone Age industries (Swartkop and Wilton) dating from ~8–0.3 ka ago (Beaumont & Vogel 1989), underlying which was undiagnostic Middle Stone Age material on quartz and quartzite that is best placed in the ~130–70 ka range. Subsequently found directly north of the large pool was a spread of Middle Fauresmith lithics, typified by small refined handaxes, convergent points, and blades (Beaumont & Vogel 2006) based on jasper and quartzite, with a conservative age of ~400 ka, based on the ~540 date for a comparable assemblage at nearby Kathu Pan 1 (Beaumont 1990; Porat et al. 2010). And from the eastern edge of this site came a couple of much larger quartzite handaxes, pointing to a still earlier Acheulian presence, with the field data therefore confirming the predicted occupations over the past 400 ka, but with an additional earlier one.

A microscopic study in April 2009 provided the following independent microerosion results that, in the absence of a calibration curve for the south-eastern Kalahari, are based on secure values for a climatically similar region, the Spear Hill petroglyph complex in the eastern Pilbara of Western Australia (Bednarik 2002a, 2002b). This examination indicated three intervals of petroglyph production, but only the youngest offered adequately preserved fractures to permit of quantitative microerosion assessment; the two earlier phases are clearly beyond the range of this method, and can be assumed to predate 50 ka in this long-term arid environment (Bednarik 1996). Of the several motifs of the youngest group checked to secure regularly angled fractures, three were found to provide conditions suitable for microerosion analysis. On the first, a semi-naturalistic rhinoceros image (Fig. 3), the area of the horn yielded five micro-wane measurements averaging 23 microns (range 21–26 microns), that, by way of the Spear Hill calibration curve, would result in an age estimate of about $E5144 +670/-450$ years BP, well within the Wilton (Beaumont 1990a). Then came a group of very shallow geometrically-arranged cupules near a giraffe image (Fig. 4), which yielded eight dimensions at 90° ranging from 7–10 microns (mean 8.5 microns), which, using the same calibration curve, would correspond to an age of $E1900 ± 340$ years BP, which is towards the end of Wilton times (Beaumont et al.)

**Fig. 2.** Nchwaneng, southern Kalahari, waterhole formed by plucking about 300 Ma ago. Probable Fauresmith and MSA cupules occur near its edge.
1995). And last was an eland figure that offered one split quartz crystal, the right hand edge of which was unsuitable, but the other provided seven wane-width determinations ranging from 25–29 microns (mean 27 microns), that using the same calibration curve, provides an early Wilton age estimate of E6060 +425/–470 years BP.

Petroglyphs of the second group comprise cupules and circles of similar width that are of significantly greater age, as indicated macroscopically by weathering condition and patination state (Fig. 5), while microscopically, these surfaces present low relief among crystals or grains, with negligible retreat of the cement. An exhaustive search yielded no evidence of surviving fracture edges, and, on that basis, these petroglyphs may be safely attributed to a timespan beyond the effective range of the microerosion method, thought to be in the order of 50 ka (Bednarik 1996).

Fig. 3. Nchwaneng site, petroglyph resembling a rhinoceros. of mid-Holocene age.

Fig. 4. Nchwaneng petroglyphs. The group of cupules the dental tool is pointing to is in the order of 2000 years old.
The oldest petroglyph phase is significantly earlier again, as shown by the almost flat microscopic relief where the motifs are well preserved, with surviving examples linked to just two occurrences: at the foot of some vertical panels adjacent to the large pool, and on its opposite margin, with a few second-phase cupules (Fig. 6). Some of the upright rock slabs have broken and become displaced in the distant past, so that the base of one of them partially conceals one of the horizontal cupules, while nearby, two of the severely weathered phase 1 cupules have begun to exfoliate by way of a pattern previously observed on cupules elsewhere (Bednarik et al. 2005; Bednarik 2008b).

In this process, a surface layer of up to 1mm thick within the cupule has been rendered more resistant to weathering than the underlying rock, and, as the latter is subject to slow dissolution, the cupule floor resists. However, in this particular case, the more resistant cutaneous layer has also begun to exfoliate (Fig. 7), with the emerging ‘cupule shadows’ seen to be retaining the shape of the cupule floor
faithfully. Although unproven, it is likely (Bednarik 2008b) that the resistant layer relates to the collective kinetic energy released by the thousands of hammerstone blows that are required to produce a cupule on hard quartzite (Kumar 2007).

**Fig. 7.** Close-up view of two cupules subjected to cutaneous exfoliation.

**Potholes Hoek**

This locality, on the lower western flank of a saddle midway along one of the northernmost Korannaberge hills, was only recently found, but included for study because the c. 12 x 26m smoothed quartzite surface there is so little weathered, maybe because a fairly recent (Quaternary) removal of the overlying Permo-Carboniferous tillites. Present on it are a few dozen potholes, of the conical floor variety (Gilbert 2000; Bednarik 2008b), from 15–50cm in diameter and up to 35cm deep, that are entirely confined to smoothed surfaces regionally (M. de Wit, pers. comm.), and likely relate to subglacial rock debris and water movement during ice sheet wastage (Fig. 8). The potholes and a shallow pool in a rock hollow could have provided enough water for occasional human visits, as is suggested by a small area where erosion of the Kalahari sands flanking the west side of the smoothed surface has exposed an underlying rubble-rich sand layer containing a lightly weathered prepared core and a few flakes, all on quartzite. These lithics may indicate the presence of a sealed Acheulian(?) site in that vicinity, while an extensive upslope search produced a very sparse scatter of fresh and lightly smoothed artefacts that are taken to reflect between-site discard events of Middle Stone Age(?) and Acheulian age, respectively, with the latter similar in typology to those from Potholes Hoek.

Rock surfaces among the potholes and extending down to a certain elevation, perhaps marking a past maximum level of stagnant water, are evenly covered by a very thin (about 5 microns) brown patina, which also covers two (or more) discrete episodes of petroglyph production that are readily distinguishable by their microscopic weathering characteristics. Younger-phase petroglyphs on the lower end of the smoothed surface include some small cupules, circle motifs from 6–10cm across (Fig. 8), and some uncompleted circles, outlined by widely-spaced blows, which are whitish in colour, due to the ‘blistering effect’ caused by light reflection in very thin weathered cutaneous micro-fractures.
Fig. 8. Some of the potholes at Potholes Hoek, on a ~300-Ma-old surface. Note the circle petroglyph below the scale.

Fig. 9. Cupules at Potholes Hoek, Fauresmith or MSA.

Further north are 50–60 cupules of two types, small shallow specimens 2–3cm in diameter, and others 4–5cm across and up to 7mm deep that are significantly more worn than the former (Fig. 9). Near the western margin of the sheet are other small cupules and a circle motif, while further north are four more cupules on a surface that is more heavily weathered. Of note are two partially preserved cupules of the larger and older type that have been truncated by a later fracture of the support panel. Both show virtually no microscopic relief, with the cupule floors and that of the truncated surface being weathered far beyond the range of the microerosion method.
Klipbak 1

At this site near the crest of another Korannaberg hill, about 7km WSW of Potholes Hoek and ~120m above the Kalahari plains, a gully slope leads up to a rock pool 2m deep and 1 x 3m across that was formed by glacial plucking in Permo-Carboniferous times. Flanking that water source to the south and east is a flattish 9 x 20m smoothed quartzite surface that is heavily weathered, perhaps because its elevation may have led to a thinner initial tillite cover that was more rapidly eroded because of the steep surrounding relief.

Archaeological reconnaissance led to the location near the rock pool of a glass bead and a few coarse potsherds pointing to visits during the past millennium or so, while from an upslope area came a sparse lithic scatter referred to earlier in the Later Stone Age. Not far from that is a flat surface on the steep eastern hillside, on which were a fair number of typical Middle Stone Age specimens, and lastly, at the lower end of the slope to Klipbak 1, erosion was seen to have exposed fresh flaking debris that probably belongs to the Acheulian.

Mapping in 2001 showed that the smoothed support was covered by ~570 cupules up to 8cm across (mean 3cm) and 3.5cm deep (mean 0.8cm), ~40 outline circles up to 28cm in diameter (mean 8.0cm), ~30 rubbing areas, and 5 meandering lines, all much weathered, except for one or two reworked forms. Cupules showed no patterning, but over 80% fell into three discrete clusters on the horizontal panel, of which two are largely confined to cupules, whereas the third differs in having a far more even mix of cupules, circles, and rubbing areas; the balance are largely on close-by rocks and on a vertical face next to the pool. On downslope slabs are fresh hammered outlines of a giraffe and three eland, while on a low rock further south, on the lower end of the sandy slope up to the pool are two outline human males, one holding a ‘staff’, plus an indeterminate antelope that lacks its head (Rifkin 2009).

The hammered grooves of the ungulate in Figure 10 are 10–15mm wide, and generally quite shallow, with the figure’s rear end formed by its deepest (up to 2mm) portion, which offered the best prospects for microerosion analysis, with one grain found to have been fractured very recently, in the past <100 years. Numerous suitable edges in a small area yielding 35 micro-wane measurements varying from 4 to 12 microns (mean 7.14 microns), that, using the Spear Hill calibration values, would provide an age of E1600 +1090/–700 years BP, which is at or near the end of Wilton times (Beaumont et al. 1995). Several circles that were checked provided no suitable surfaces, with the questionable exception of one in the main cupule concentration (Fig. 11), which offered a very diffuse micro-wane of 280 microns length, from which 7 micro-wane width values with a mean of 67.43 microns (range 60 to 72 microns) was obtained. This would, on calibration, correspond to an age of E15,080 +1660/–s1020 years BP, but, in view of the lack of any other suitable surfaces on the cupules and circles that were examined microscopically, it seems likely that this age could refer to subsequent re-working. In general, as with a nearby 18mm-deep cupule, the exposed quartz grains, although of inherently angular shape, have rounded ‘domed’ surfaces, and entirely lack detectable impact traces (conchoidal fractures, battering, internal fractures), on the basis of which an antiquity of less than 50 ka for either the circles or the cupules is most unlikely.
Discussion and conclusions

A consideration of data bearing on intervals when rainfall sufficed to sustain humans in the study area, the timespan of the lithics found in close proximity to the petroglyphs at Nchwaneng, and the temporal inputs provided by the microerosion measurements are here taken to all support the following provisional groupings:

First phase: Relatively well-made large deeply hammered cupules that occur in unstructured clusters on largely horizontal panels close to semi-permanent water sources, which are, given their considerably greater age than the following group, tentatively linked to a ~400 ka-old phase of the Fauresmith technocomplex. Observed at Nchwaneng and Potholes Hoek.

Second phase: Usually smaller and often shallower cupules that occur in smaller groups together with well-shaped and typically circular ~8cm wide motifs, that also fall beyond 50 ka and that are best referred to the Middle Stone Age. Observed at all three sites.
Third phase: Much more recent petroglyphs with variable complements of non-figurative and iconographic motifs that contiguous lithics and microerosion readings place entirely within the Holocene. Observed at Nchwaneng and Klipbak 1.

Further research will involve establishing if this threefold pattern can be replicated at other regional rock art sites and if the quartz grain-rich sediments in which the associated artefacts occur could produce optical ages that define pertinent timespans more closely. Other matters to be investigated are whether the very worn non-iconographic images at Nchwaneng also fall into phase 3, why phase 2 cupule bases are so much more weathered than the surfaces of linked quartzite artefacts, and whether the phase 1 cupules could extend into the Acheulian. Also requiring further attention are reports of many small phase 2 occurrences near transient water sources, and said to be usually comprised of circles, as also more wide-ranging fieldwork to determine if such circles are region-specific, or more widespread, but not recorded.

Our phase 3 age estimates are probably in accord with expectations, but attribution of the two earlier phases may be deemed excessively early, although we note that Middle Stone Age engraved plaques have already been recorded from a number of sites in South Africa. Furthermore, as previously mentioned, engraved slabs also occur only ~150 km away in a >270 ka-old Late Fauresmith context at Wonderwerk Cave, while specularite and haematite fragments, presumably for body decoration, are present throughout the Fauresmith, of which that level at Kathu Pan 1, 80 km to the south-east, is dated to 540 ka BP (Beaumont 1990b; Porat et al. 2010).

We conclude that very resistant quartzites in a portion of the Kalahari that was subjected to arid or very arid conditions for much of the Pleistocene has led to the preservation there of rock art back to ~400 ka ago, thereby providing a new perspective on the antiquity of this very human behaviour in and beyond Africa.

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