

Field and Technical Report

GA-MOHANA HILL SOUTH ROCK SHELTER: A LATE HOLOCENE HUNTER-GATHERER ROCK SHELTER SITE IN THE SOUTHERN KALAHARI BASIN

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(Received October 2023. Revised February 2025)

ABSTRACT

The Holocene period in southern Africa holds a diverse and valuable archaeological record that sheds light on the hunter-gatherer culture and their adaptation strategies. Of particular interest is the southern Kalahari Basin, an ecotone region transitioning from subtropical savannah to the semi-arid savannah of the Kalahari Desert. Within this context, several Holocene archaeological sites in the southern Kalahari Basin offer detailed palaeoenvironmental information that directly relates to the archaeological record. However, despite the informative nature of these sites, inconsistencies remain regarding the timing of wet phases that have yet to be fully understood. In this study, we present the findings from the first excavations at Ga-Mohana Hill South Rock Shelter in the southern Kalahari Basin. The site reveals an intact Later Stone Age (LSA) deposit, radiocarbon dated using accelerator mass spectrometry (AMS) to 2730–2490 cal BP. This timeframe roughly corresponds to a period of tufa formation at Ga-Mohana Hill, estimated at 3.0±0.9 ka. These results indicate wetter conditions than the present, with seasonal water flow down the rock shelter's sides. The significance of Ga-Mohana Hill South Rock Shelter as a new Late Holocene hunter-gatherer site lies in its contribution to the broader investigation of hunter-gatherer landscape utilisation and adaptation in the region.

Keywords: Later Stone Age, Wilton, hunter-gatherer, rock shelter site, Kalahari, human-environment interaction

INTRODUCTION

Southern Africa preserves a rich and diverse archaeological record of hunter-gatherer culture and adaptation through the Holocene. The mid-Holocene Climatic Optimum brought wetter conditions in some regions, such as the Namib Desert (Kinahan 2018), while others, like the West Coast of South Africa, experienced drier conditions (Chase & Meadows 2007; Jerardino 2022). Many sites from this period are linked to the Wilton industry (Lombard *et al.* 2012; Lombard *et al.* 2022), with rock art also prevalent (Thackeray 1983). The Late Holocene saw a dynamic and fluctuating return to drier conditions across some parts of southern Africa (Chase &

Meadows 2007), with evidence for population expansion in some regions (Deacon 1974; Loftus *et al.* 2019), but the regional and temporal specifics of hunter-gatherer responses were not uniform across the variety of ecological settings in the subcontinent.

The interest of the southern Kalahari Basin lies in its role as an ecotone, a transitional area between subtropical and semi-arid savannahs (Fig. 1), where environmental changes are more pronounced (Risser 1995; Smith *et al.* 1997), potentially offering insights into how hunter-gatherers adapted to shifting climates. Several Holocene sites in the region, including deposits attributed to the Robberg, Oakhurst and Wilton industries, align with broader southern African timelines (Humphreys & Thackeray 1983; Beaumont & Vogel 1989; Beaumont & Morris 1990; Tooth *et al.* 2013). This rich archaeological record suggests a persistent, or at least frequently reoccurring, presence of hunter-gatherers in the southern Kalahari Basin.

A handful of Holocene archaeological sites in the southern Kalahari Basin provide detailed palaeoenvironmental records. At Wonderwerk Cave, wetter conditions and expanding grasslands (~6200–5400 ka) coincide with the highest artefact density, while aridity (~3000–2000 ka) corresponds with fewer artefacts (Ecker *et al.* 2018; Rhodes *et al.* 2022). Kathu Pan shows a shift from dry to humid (~4–2 ka), with human occupation linked to wetter conditions (Lukich *et al.* 2019; Lukich *et al.* 2020). At Ga-Mohana Hill, tufa formation episodes occur at 15–6 ka and ~3 ka, based on U-Th dating, indicating prolonged wetter phases (Von der Meden *et al.* 2022).

The combination of palaeoenvironmental and archaeological evidence from the southern Kalahari suggests a strong link between wetter local conditions and increased evidence for human occupation. This indicates that water availability has been a significant factor in shaping human populations in the region during the Holocene. However, despite the valuable insights provided by data from the sites discussed above, there are inconsistencies in the timing of wet phases that cannot be fully explained. Factors such as dating resolution, geographical variation, and differences between

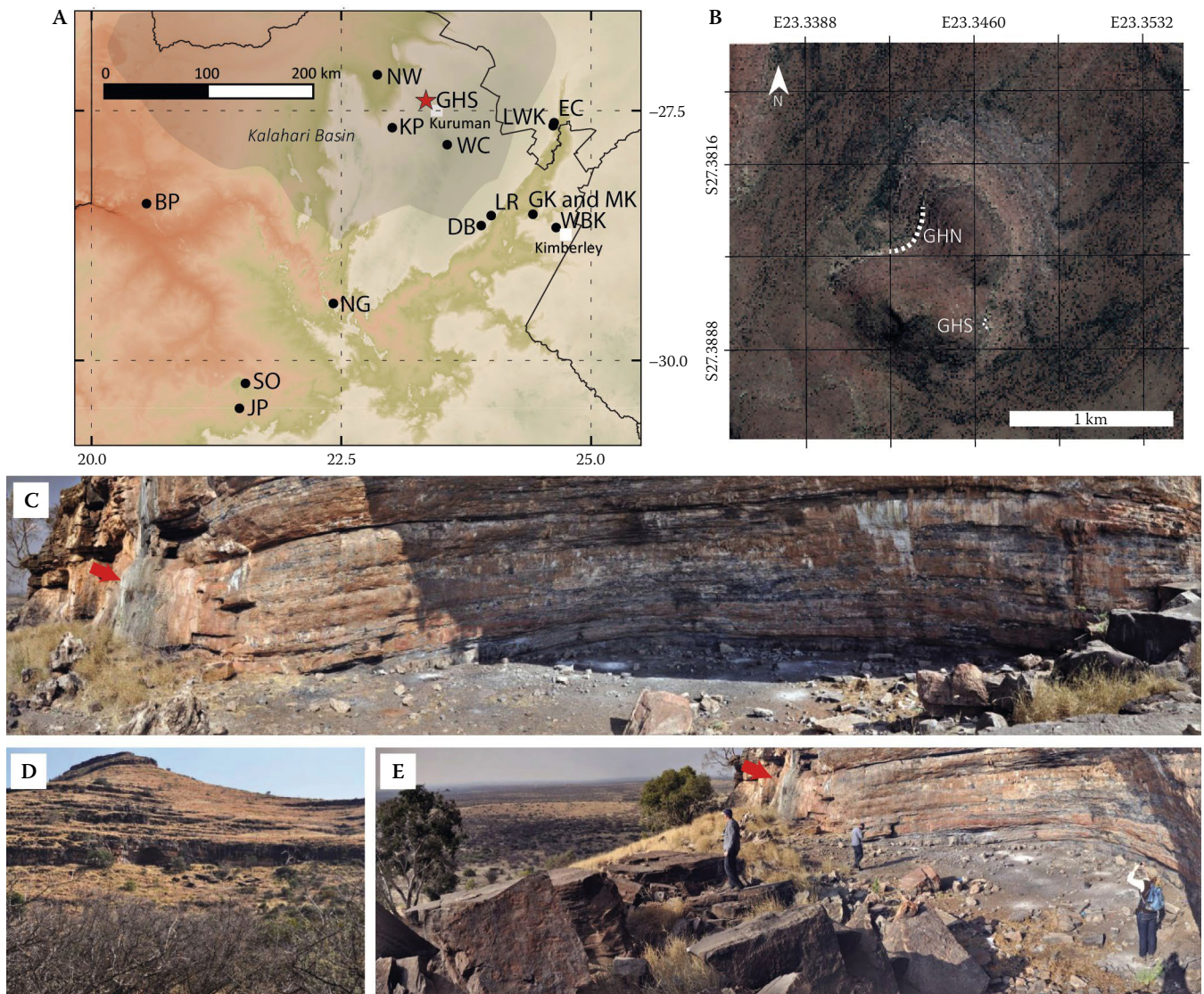


FIG. 1. A) Location of Ga-Mohana Hill South Shelter (GHS) relative to key sites. Light grey highlights boundary of Kalahari Basin. NW = Nchwaneng, KP = Kathu Pan, LWK = Little Witkrans, EC = Equus Cave, WC = Wonderwerk Cave, LR = Limerock Shelter, GK = Groot Kloof, MK = Malony's Kloof, WBK = Wildebeest Kuil, DB = Dikbosch, BP = Biesje Poort 2, NG = Nauga, SO = Springbok Oog, and JP = Jagt Pan. B) Bird's-eye view of Ga-Mohana Hill showing locations of Ga-Mohana Hill North Shelter (GHN) and GHS. C) Panoramic view from dripline towards back of GHS. Red arrow shows cascade tufa. D) View from east at base of talus slope. E) Panoramic view from north side of GHS. Red arrow shows cascade tufa.

paleoenvironmental proxies all contribute to this kind of variability (Lukich *et al.* 2020; Lukich & Ecker 2021). Additionally, the limited number of sites with available data makes it impossible to draw definitive conclusions about human-environment interaction in the southern Kalahari. To address these uncertainties, it is necessary to conduct further research in a wider range of locales that feature both palaeoenvironmental and archaeological data.

Here, we report results from the first excavations at Ga-Mohana Hill South Rock Shelter in the southern Kalahari Basin. We show that the site has preserved an *in situ* LSA deposit dated by accelerator mass spectrometry (AMS) carbon-14 to 2730–2490 cal BP. This roughly corresponds to a period of tufa formation at Ga-Mohana Hill dated to 3.0 ± 0.9 ka (2σ error range of 3.9–2.1 ka), and indicating wetter conditions than today, with water flowing down the sides of the rock shelter at least seasonally.

GA-MOHANA HILL

Ga-Mohana Hill (−27.387451 S, 23.343199 E) is a visually striking feature 12 km north-west of the town of Kuruman on the eastern edge of the Kuruman Hills (Fig. 1). It is an important living heritage

locale used by nearby communities who associate it with *Noga ya metsi*, a powerful spiritual force who is manifest in the form of a snake and is both revered and feared (Maape 2021; Wessels *et al.* 2022). Ga-Mohana Hill is actively used today for prayer, ritual, and other community activities, including the collection of water from dolomitic pools after significant rains, and the collection of firewood. The main areas for many of the spiritual activities are the two largest rock shelters on the hill, one situated on the north side of the hill which our archaeological team describes as Ga-Mohana Hill North Rock Shelter (GHN), and one on the south side of the hill, Ga-Mohana Hill South Rock Shelter (GHS). A detailed 3D model and virtual tour of Ga-Mohana Hill, informed by local values and traditions, is available at <https://rockartportal.org/Ga-Mohana.html>. The approach used to create the model, which we believe responds appropriately to its political, cultural and social context, is described by Wessels *et al.* (2022).

The long history of Ga-Mohana Hill as a special place is evidenced by the hill's rock art and archaeology. Both rock shelters at Ga-Mohana preserve rock paintings that are extensively weathered, although they are better preserved at GHS (Fig. 2). These are

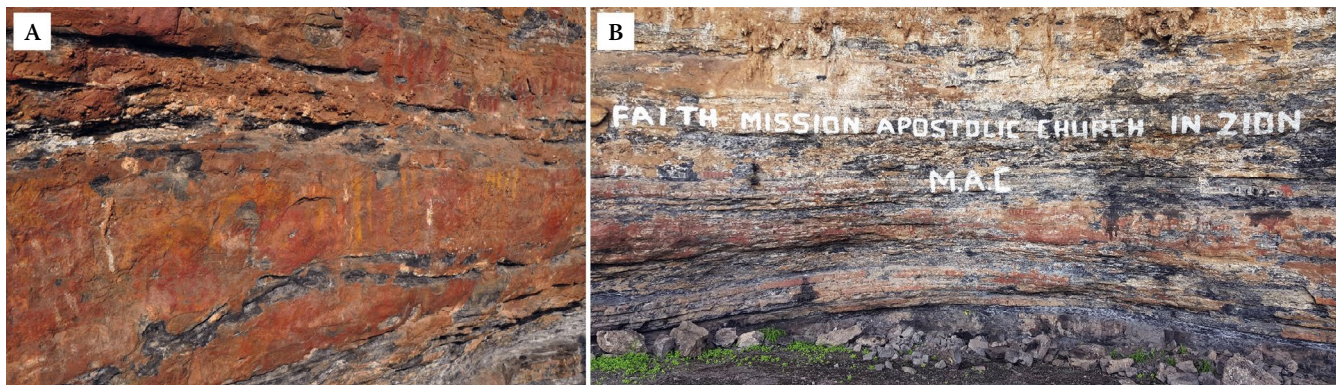


FIG. 2. A) Painted images on wall of GHS rock shelter. Photo taken in 2016. B) Overview of back shelter wall showing recent addition of “FAITH MISSION APOSTOLIC CHURCH IN ZION M. A. C” to shelter wall, first noticed by authors in 2018.

finger-painted geometric forms in red, orange, yellow, and more rarely, white pigments. The motifs commonly feature short parallel sets of vertical lines sometimes connected with a horizontal or curved lines. Some of these are similar to paintings on the cave wall at Wonderwerk Cave (Humphreys & Thackeray 1983; Beaumont & Morris 1990; Morris 2016). However, while there are painted ostriches, eland, elephants and other animals at Wonderwerk Cave, there are no clear animal forms present at Ga-Mohana Hill. Similar geometric motifs in the absence of figurative forms have been reported at Tierkop ~30 km to the south (Thackeray & Thackeray 1980), and at numerous other small shelter sites in the Kuruman Hills, Langeberg and along the Ghaap Escarpment (Fock & Fock 1984). In general, South African finger paintings are associated with more recent time periods, probably with the ceramic LSA and the last ~500 years (Van der Merwe *et al.* 1987; Beaumont & Vogel 1989).

On the lower slope of the north hill face there is exposed dolomite in a small usually dry stream bed with several pecked rock engravings. These engravings are mainly geometric, and complex curvilinear motifs with meandering lines that have been noted as snake-like (Beaumont & Morris 1990: 135–142). Snakes are linked to water and rain in the cosmology of many modern-day and historical Northern Cape populations, and the placement of the engravings at Ga-Mohana and other Kuruman River Valley sites at water sources (stream beds, pans) may be in part explained by this association (Beaumont & Morris 1990: 135–142). The artists and chronology of these engravings is debated. Engravings in the Kuruman River Valley at Batlharos appear to be associated with ceramic LSA and a radiocarbon date of 210 ± 30 BP (Beaumont & Vogel 1989). Other pecked engraving sites in the region depict Tswana-type shields and bilobial huts, ox-wagons, women in long dresses, men on horseback, confirming that at least some of the engravings are relatively recent (Morris 1988; Beaumont & Morris 1990; Maggs 1995). The diversity of forms at these sites could be a reflection of the demographic fluidity in the region as an important social frontier zone (Beaumont & Morris 1990). Some pecked engravings in the region, for example, as Nchwaneng, may be as old as c.2300 BP and associated with Wilton-type artefacts, suggesting a long chronology for this practice (Beaumont & Vogel 1989).

Located just uphill from the engravings is a rock gong formed by four large slabs of dolomite bearing 18 hollows resulting from repetitive beating with a stone over a prolonged period (Morris *et al.* 2018). A rock gong is a naturally resonant or ringing rock whose sound is activated by being struck at one or more places with another stone or stones. Rock gongs are known from other sites in the region where they are also associated with rock art, as at Kinderdam near Vryburg, east of Ga-Mohana (Morris *et al.* 2018).

Rock shelters and overhangs occur at several places around the north, east, and west faces of Ga-Mohana Hill at similar elevations of roughly 1410–1430 masl within a relatively weaker band of the dolomitic Gamohaan Formation close to the contact with the overlying Kuruman Member. Besides GHN and GHS, most of these shelters and overhangs lack accumulated sediments, but many have surface scatters of lithic artefacts. Lithic artefacts are also observed along the extensive talus slopes below the shelters and on the hilltop above them (Schoville *et al.* 2022). This includes finds typical of the Later, Middle, and Earlier Stone Age, indicating that human presence at Ga-Mohana Hill has a long chronology. A few factors may have drawn people to this location throughout prehistory, including protection offered by the rock shelters, vantage points for observing the surrounding landscape, and access to fresh water as there are several permanent and seasonal freshwater access points around Ga-Mohana Hill. Good quality raw materials for stone tool manufacture, including chert, banded ironstone formation (BIF), and quartz, are abundant in the Kuruman Hills (Wilkins 2017). Additionally, at Ga-Mohana Hill, a fine-grained, dark grey-green tuff outcrops above the rock shelters as a 30–40 cm thick layer within the dolomitic Gamohaan Formation (Sumner & Bowring 1996; Sumner 1997; Wilkins *et al.* 2020). This good quality raw material may have been an additional draw. Today, people are drawn to the site not only for physical reasons, but also for spiritual purposes (Maape 2021; Wessels *et al.* 2022), and this may have been true in the past. A collection of calcite crystals in the 105 ka deposits at GHN suggests a long chronology for non-utilitarian and ritual activities at Ga-Mohana Hill (Wilkins *et al.* 2021).

The two largest rock shelters on Ga-Mohana Hill have been the subject of detailed archaeological investigation. The largest, Ga-Mohana Hill North Rock Shelter has yielded stratified Middle Stone Age and LSA deposits, dated to ~15 ka, 31 ka, and 105 ka from top to bottom (Wilkins *et al.* 2020). The lowermost unit provides evidence for complex human behaviours, the collection of non-utilitarian objects and water container technology coeval with similar kinds of behaviours on the South Cape Coast, which has long been considered the ‘hub’ of complex early modern behaviours (Wilkins *et al.* 2021).

Reported here, Ga-Mohana Hill South Rock Shelter (GHS, Fig. 1) is located on the south side of the hill, just ~500 m south-east of GHN. Its mouth faces east and has a width of about 20 m, depth of 11 m, and height of 10 m. Within the shelter, the sediment lies flat. Very large rockfall in the front of the shelter may have helped to hold in the sediments and provides protection from the elements. The large talus slope in front of the shelter rises gradually from an elevation of ~1370 masl to ~1409 masl at the floor of the shelter. Surface finds in the shelter include glass, ceramics, bladelets and bladelet cores in chert and BIF, quartz crystals, and large LSA-type

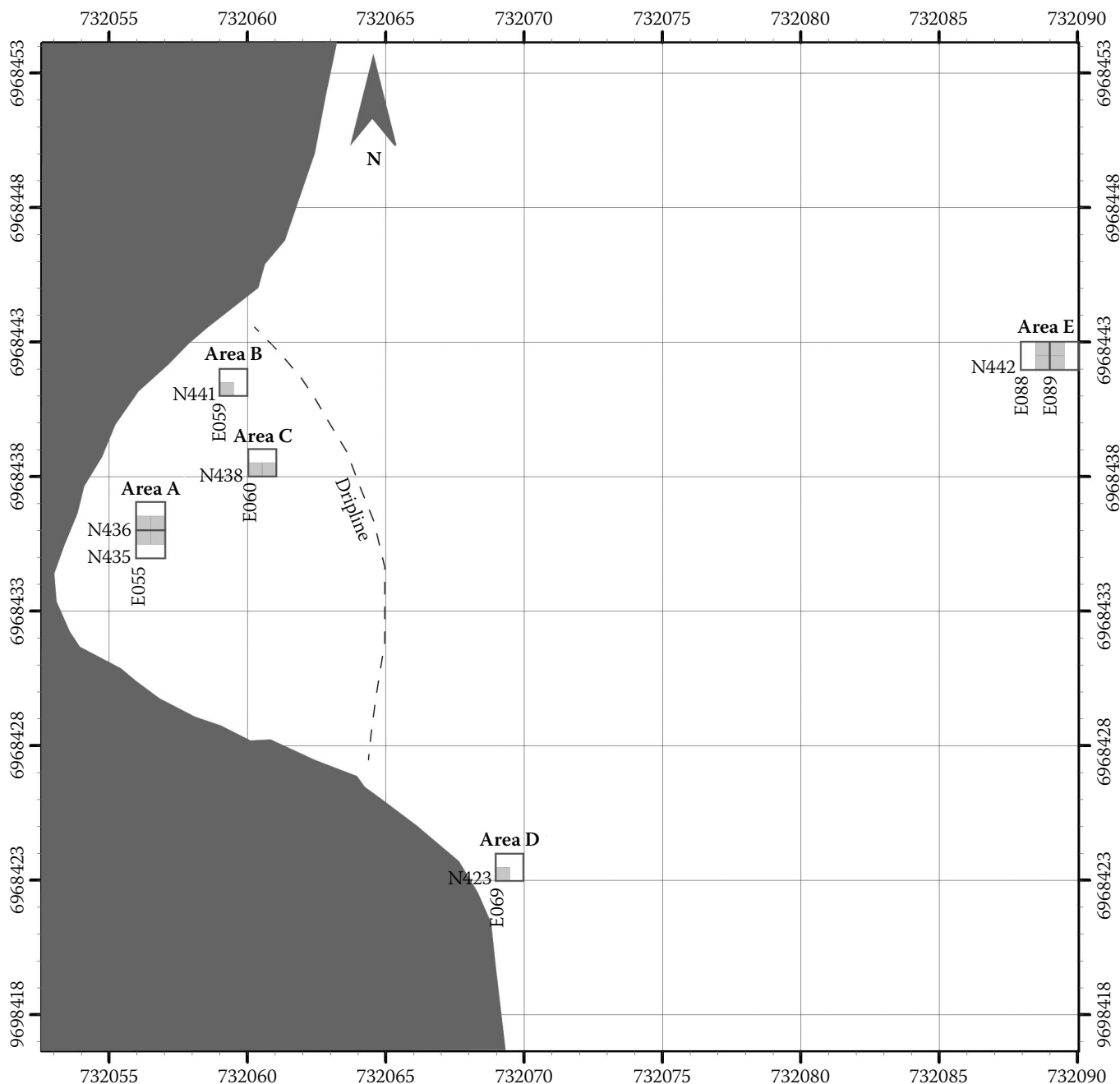


FIG. 3. Excavated areas at GHS. Excavated quadrats are shown in grey. Squares are named based on the south-west corner's Universal Transverse Mercator coordinates.

convex scrapers in chert and BIF. Artefacts are abundant on the surface of the talus slope. Today, this shelter is actively used by local communities, who have added text to the shelter wall (Fig. 2).

Tufa formations are abundant and widespread across Ga-Mohana Hill and have been the focus of an extensive sampling and U-Th dating programme. This study revealed five formation episodes 114–100 ka, 73–48 ka, 44–32 ka, 15–6 ka, and ~3 ka (Wilkins *et al.* 2021; Von der Meden *et al.* 2022). There are three Holocene-aged tufas of relevance here: sample 18-10.2 dated to 3.0 ± 0.9 ka, GHN-2 at 7.3 ± 0.3 ka, and GHS-5 at 10.7 ± 4.9 ka. Full analytical details on how these ages were measured, calculated, and calibrated are reported in Von der Meden *et al.* (2022). Samples GHS-5 and GHN-2 are cascade tufas from the south and north sides of Ga-Mohana Hill, respectively. Cascade tufas are sub-vertical accumulations of calcium carbonate that formed from ground waters resurging from various points in the bedrock. They are located on the cliff-faces adjacent to the rock shelters, and on the dolomite

steps above and below the shelters (Fig. 1C, E). Sample 18-10.2 is a sample cored from a dome tufa at the north shelter. The domes are calcium carbonate accumulations that formed in combination with bryophyte communities sustained by drip waters channelled via moss curtains draped over the lip of the rock shelter. Both tufa morphologies represent fresh surface water.

EXCAVATION AND DATING METHODS

In total, five areas across 12 quadrats (3 m²) were excavated at GHS (Fig. 3). Three of these areas (A–C) are in the rock shelter, and one (D) is just beyond the southern edge of the shelter adjacent to an extensive carbonate flow, and another (E) is 28 m down the talus slope in front of the shelter.

The excavation methods employed at Ga-Mohana Hill are detailed by Wilkins *et al.* (2020). Our initial excavation in 2016 was based on an arbitrary grid set to true north with a Brunton compass (declination -19°) and established over a single point (control

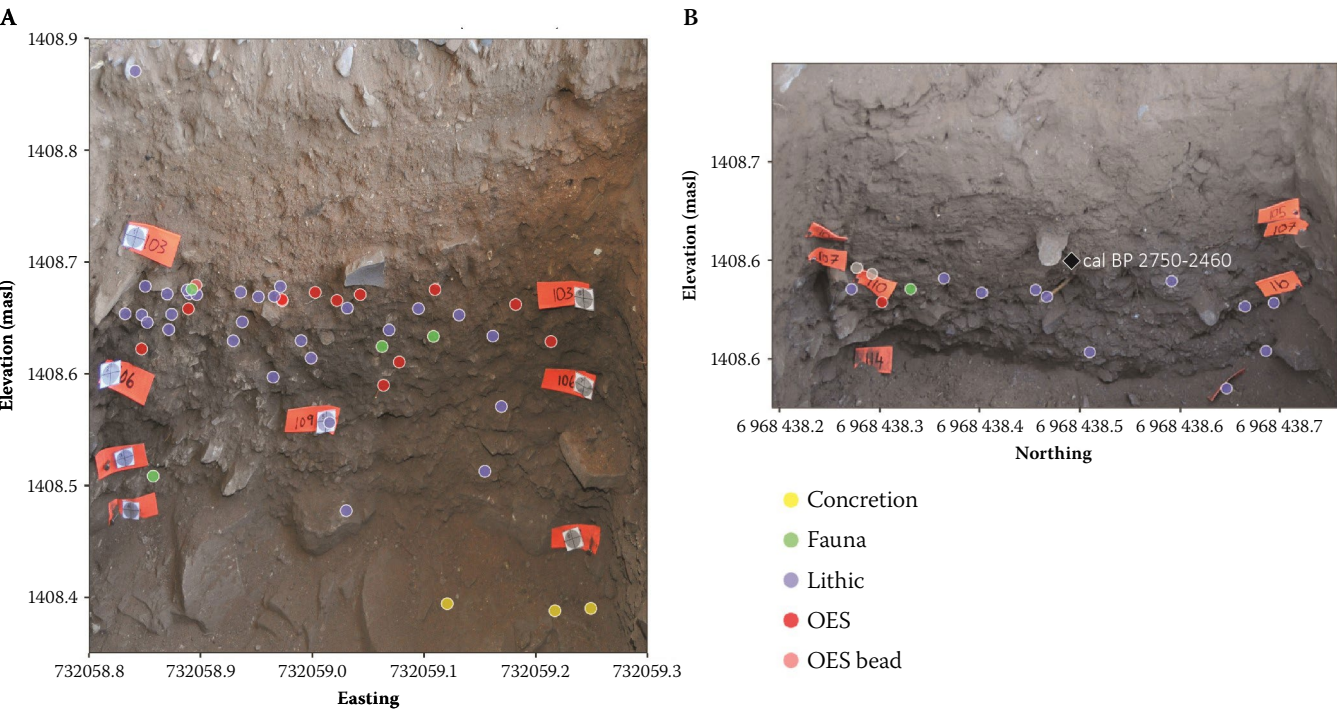


FIG. 4. Stratigraphic profiles in Areas B and C at GHS. A) Georectified photo of Area B north wall (N442 line) showing plotted find locations. B) Georectified photo of Area C west wall (E060 line) showing plotted find locations, including plotted charcoal (black diamond) dated using AMS radiocarbon analysis.

point 1) set at N5000 E5000 Z500. The following year, we fixed new control points to the WGS84 Universal Transverse Mercator (UTM) zone 34S grid using a Stonex S9III+ RTK base station and Stonex S8+ rover. A localisation procedure was performed using three permanent South African grid survey beacons that formed a geographic triangle containing Ga-Mohana Hill (see also Wessels *et al.* 2022). This procedure also converted the original ellipsoidal elevations to orthometric corrected elevations using the South Africa 2010 Geoid in Carlson SurvCE. The 2016 excavation data were then re-projected onto the UTM grid in GIS using an affine transformation of the original arbitrary control point coordinates onto the new RTK-collected WGS84 zone 34S coordinates. The result of this conversion is that the margins of our 2016 excavation areas do not plot directly onto 1 m UTM grid lines as would be preferable but are offset ~20 cm to the nearest half-metre line.

Excavation areas are hierarchically organised by site, square, quadrat, and lot. The 1 × 1 m² square is named for the south-west corner's last three digits before the decimal place of the UTM coordinates. All sediments were dry-sieved on site through a nested 10 mm/3 mm/1.5 mm sieve set. Except for the disturbed surface sediments, we piece-plotted all visible artefacts with no size cut-off.

One charcoal sample excavated from the DBAS at Area C (Fig. 4), pretreated according to the Acid-Base-Oxidation (ABOx)

(Bird *et al.* 1999) protocol, underwent AMS radiocarbon analysis at the Beta Analytic AMS Laboratory, Miami, USA. Calibration was performed using OxCal v. 4.4 (Bronk Ramsey 2001) and the SHCal20 calibration curve (Hogg *et al.* 2020).

STRATIGRAPHY, CHRONOLOGY, AND CULTURAL FINDS

Excavation in Area A yielded loose brownish-grey sandy silt with historical debris including coins and buttons, organic detritus, an ostrich eggshell bead, lithic artefacts including backed pieces, and a few fragmented faunal remains. Because the sediment was surficial, loose, and appeared recently disturbed, artefacts were not plotted. This loose sediment sat immediately above bedrock at 20 cm. In Area D, similar sediment, but sterile, was excavated to depth of 15 cm where the base of an extensive tufa flow visible on the adjacent shelter wall was encountered.

Areas B and C nearer to the front of the shelter had deeper *in situ* deposits (Fig. 4). Beginning ~30 cm below surface, we exposed a moderately compacted dark brown ashy silt (DBAS) in both areas. This deposit has a depth ranging from 15–40 cm immediately overlying bedrock. Excavation areas B and C are 2 m apart, but the surface of the DBAS is at nearly the same level in both excavation areas, with just minor dipping slightly to the south-east. Artefact

TABLE 1. Summary of the volume of excavated sediment (L), recovered artefact types (plotted finds only), and artefact density (n/L) by area and stratigraphic aggregate at GHS. Volume of excavated sediment in litres was calculated based on number of full buckets. OES = ostrich eggshell. The other category in this case is dung concretion, which was recovered from the base of the excavation just above bedrock.

Area	Strat. agg.	Volume excavated (L)	Fauna		Lithic		OES		Other		All	
			n	n/L	n	n/L	n	n/L	n	n/L	n	n/L
B	DBAS	49.0	6	0.12	29	0.59	13	0.27	1	0.02	49	1.00
C	DBAS	36.7	0	0	13	0.35	1	0.03	0	0	14	0.38
	Total		6		42		14		1		63	

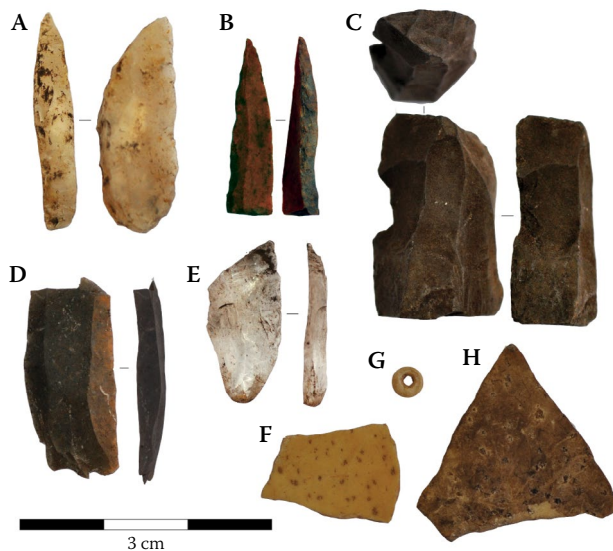


FIG. 5. Plotted artefacts from the DBAS at GHS. A) Backed piece, chalcidony. B) Triangular backed piece fragment, banded iron-stone formation. C) Retouched piece with steep distal retouch and lateral retouched notch on tuff. D) Bladelet fragment, tuff. E) Proximal bladelet fragment, quartz. F) Ostrich eggshell fragment. G) Ostrich eggshell bead. H) Ostrich eggshell fragment.

density is moderately high near the top of the deposit in both excavation areas and gradually decreases with depth (Fig. 4). At the base of Area B, a brecciated deposit (concretion) occurred on top of bedrock in the SE corner of the quadrat (Fig. 4).

The plotted charcoal sample from the DBAS yields an AMS age estimate of 2730–2490 cal BP (Beta-56292, 2550 $\pm$ 30 BP, $\delta^{13}C = -25.8$).

Plotted find frequencies and densities are summarised in Table 1. Our total sample of plotted finds from these limited excavation areas is small ($n = 63$) but reveals an LSA deposit with associated faunal remains. The lithic assemblage ($n = 42$) from the DBAS contains bladelets and backed pieces on chert, BIF, chalcidony, and quartz (Fig. 5). The plotted faunal assemblage ($n = 6$) includes ungulates from size classes 1 to 3. Fourteen ostrich eggshell fragments, including one bead, were also plotted. No ceramic fragments were recovered.

In general, artefacts lay flat within the sediment and there was no visible preferential orientation. While the sample size at this point is too small for detailed fabric analysis, our assessment is that the DBAS assemblage is in good context, that the archaeological deposit is laterally extensive across a good portion of the front of the shelter.

Area E was excavated to establish the depth of sediments on the talus slope and potential for encountering archaeological deposits there. A depth of 70 cm was reached before hitting bedrock. No artefacts were recovered beyond the surface.

DISCUSSION

This newly investigated deposit at GHS attests further to widespread hunter-gatherer occupation in the Kalahari Basin in the Late Holocene. The dates and microlithic artefact assemblage from the DBAS unit at GHS are consistent with comparable material excavated at Kathu Pan (Pta-3697: 3280 $\pm$ 60 BP), Wonderwerk Cave (Pta-2543: 2910 $\pm$ 60 BP, Pta-2542: 1890 $\pm$ 50 BP), Nchwaneng (Pta-4511: 2390 $\pm$ 50 BP), and Springbokoo (Pta-4205: 2630 $\pm$ 50 BP) that have been ascribed to the Wilton technocomplex (Deacon 1972, 1984; Sampson 1974; Beaumont & Vogel 1989; Beaumont & Morris 1990; Lombard *et al.* 2012). Other roughly coeval LSA assemblages also

designated as Wilton occur at Dikbosch 1 (Pta-1065: 3110 $\pm$ 60 BP) (Humphreys & Thackeray 1983), Equus Cave (Pta-2452: 2390 $\pm$ 60 BP), and Little Witkrans (Pta-4323: 2130 $\pm$ 60 BP; Pta-3418: 1830 $\pm$ 50 BP) (Vogel *et al.* 1986). Altogether, this points to hunter-gatherers occupying this southern edge of the Kalahari either side of and during the c.26 500-year-old period of the DBAS occupation unit at GHS, utilising a diversity of site types including caves, rock shelters, and pans, generating an essentially Wilton-type stone tool signature.

Based on the finger-painted style of the rock art on the GHS rock shelter wall, the rock art is probably significantly younger than the archaeological deposits described here and not associated with them. It remains unknown whether the engravings and rock gong lower on the talus slope of Ga-Mohana Hill are linked in any way to the c.2600 BP occupation of GHS; they may also be younger, given the preponderance of geometric motifs that may be associated with pastoralists (Smith & Ouzman 2004).

Strong evidence for pastoralism in South Africa first emerges at ~2100 BP at Spoegrivier on the northern West Coast (OxA-3862: 2105 $\pm$ 65 BP) (Sealy & Yates 1994). The timing for the presence of early pastoralists in this region of the southern Kalahari is not yet confidently established. However, ceramic artefacts are often associated with pastoralism and are known at several sites dating by radiocarbon to ~1800–1600 BP such as Jagt Pan, Springbok Oog, Little Witkrans and Wildebeest Kuil (Beaumont & Vogel 1989; Beaumont & Morris 1990) (Fig. 6). Earlier deposits at Jagt Pan also contain ceramics and it has been suggested they date to ~2500 and 2700 BP based on radiocarbon analysis of OES (Pta-4309: 2450 $\pm$ 60 BP; Pta-4193: 2730 $\pm$ 60 BP) (Beaumont & Vogel 1989), but this early chronology is not widely accepted. Dates on OES display an uncertain reservoir effect that can make them appear too old due to ostrich consumption of geological carbonates (Vogel *et al.* 2001). Whether pastoralists or herding practices were in this general region by the time GHS was occupied or not remains an open question, but there is currently no evidence for pastoralist practices in the dated DBAS unit. It is possible that the finger paintings on the shelter wall are a pastoralist signature despite the absence of material traces on the shelter floor. Shelter walls and their floors are two separate worlds not easily linked (Inskeep 1971; Morris 2016); one could argue that a place visited for ritual purposes, for example, may not become littered with the material traces of subsistence activities.

That GHS was utilised during a wetter period at the site adds to a growing body of evidence linking Holocene landscape use in the southern Kalahari to patterns of water availability. Holocene hunter-gatherers likely adapted their strategies to maximise water availability in response to changing climates within the semi-arid environment. All dated Late Holocene occupations with paleoenvironmental evidence in the southern Kalahari roughly correlate with evidence for increased water availability, at Wonderwerk Cave (Ecker *et al.* 2018; Rhodes *et al.* 2022), Kathu Pan (Lukich *et al.* 2019; Lukich *et al.* 2020), and Maloney's Kloof (Herries *et al.* 2007; Doran *et al.* 2015). The general trend for correlation of wet periods and evidence for human occupation in the Holocene is in many respects expected because humans require water. However, when comparing this more recent record with earlier time periods an interesting contrast emerges. During the Pleistocene across Africa, there is a general trend for more sites during wetter periods, and fewer sites during drier periods (Lukich & Ecker 2021; Wilkins 2021), but humans appear to occupy sites in the Kalahari Basin even when the paleoenvironmental record or timing (i.e. during glacial phases) suggests drier conditions (Robbins *et al.* 2016; Chazan *et al.* 2020; Lukich & Ecker 2021; Wilkins 2021; Von der Meden *et al.* 2022). It is difficult to establish at this point whether this difference is due to

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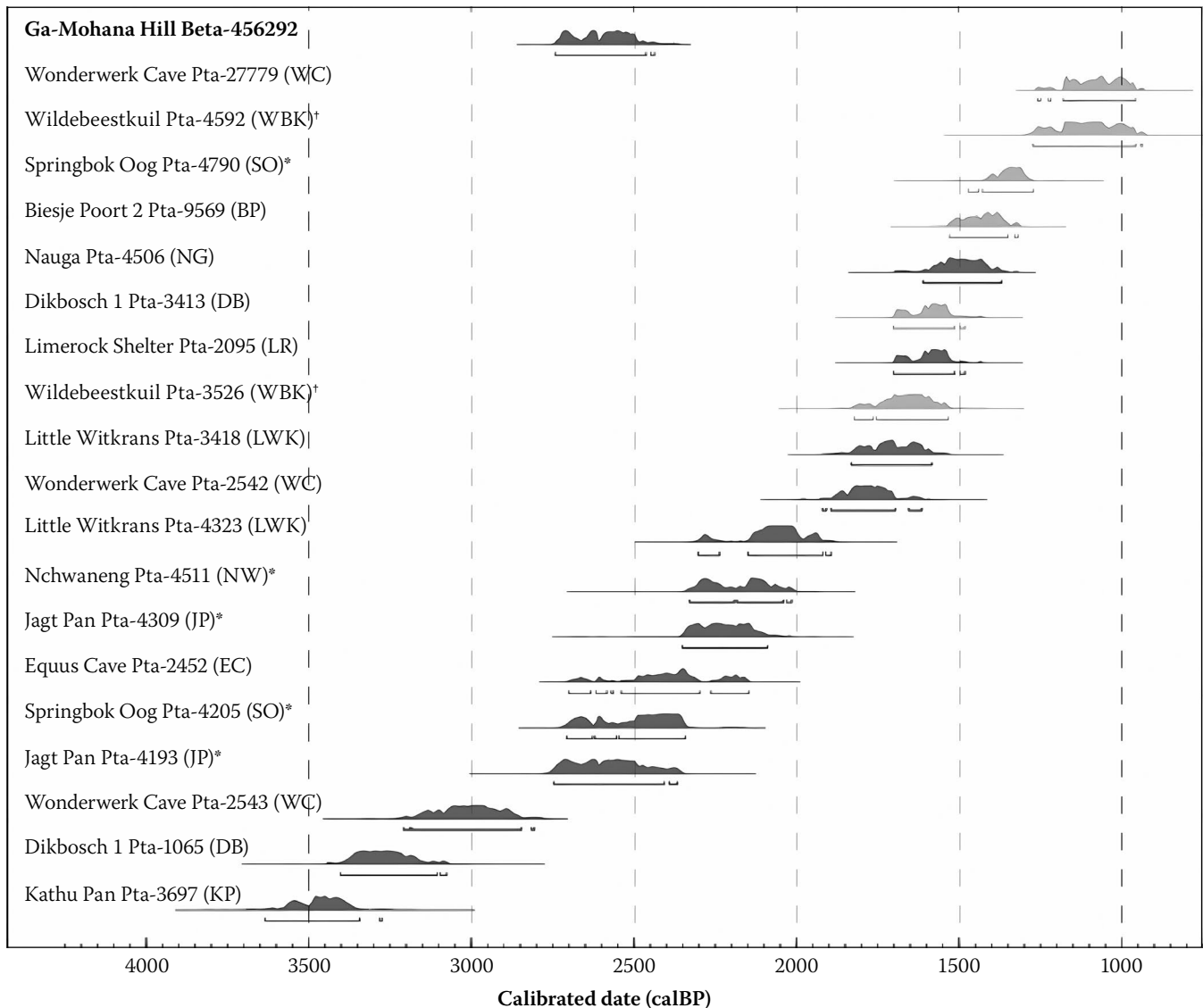


FIG. 6. AMS date from GHS, calibrated alongside comparable radiocarbon dates for LSA assemblages at nearby sites. Dates associated with ceramic-containing assemblages are in light grey. Dates marked * indicate ages on ostrich eggshell that have been corrected for a 180-year reservoir effect prior to calibration (see Vogel et al. 2001), and the two dates from Wildebeest Kuil (†) are on charred bone. Site locations are shown in Fig. 1A. Calibration was performed using OxCal v. 4.4 (Bronk Ramsey 2001) and the SHCal20 calibration curve (Hogg et al. 2020).

dating resolution, or more limited palaeoenvironmental records as one moves back in time. Perhaps human occupations occur during short-lived wet phases that are not currently picked up in the record. In any case, the current patterns raise interesting questions about the nature of changing human adaptations and landscape use over time.

The timing of the ~3000 years ago wet period at GHS is out of sync with the highly resolved palaeoenvironmental record at Wonderwerk Cave. There, the period between ~3–2 ka shows in general higher aridity, although there are fluctuations (Ecker et al. 2018). This drier period at Wonderwerk Cave is associated with less dense artefact accumulations (Rhodes et al. 2022). At the same time, it is relatively wetter at GHS and there is a record of concurrent human occupation. This may reflect the reality that very local patterns of water availability most likely varied geographically across the southern Kalahari, and hunter-gatherers adapted by utilising different locales in different ways in response to changing water availabilities. For example, when water availability waned near Wonderwerk Cave, perhaps hunter-gatherers spent more time

at places like GHS. The two sites are ~60 km from each other, which is likely within the yearly foraging area of hunter-gatherers in the Kalahari. GHS is also located nearer to the Kuruman Eye, a significant freshwater spring located in the town of Kuruman, which likely offered a more permanent outflowing. Even if GHS is quite a walk away (12 km), that water could be contained and carried.

The utilisation of GHS would have been motivated by factors extending beyond resource availability alone. Social, cultural, and ritual considerations are also probable contributors. It is highly plausible that individuals employed these sites for purposes that transcend mere water access, emphasising the necessity for a comprehensive examination of landscape utilisation in the vicinity of Kuruman and, more broadly, in the southern Kalahari region.

Further research and a more comprehensive understanding of past climate conditions and human behaviour are needed to fully explore the dynamic relationship between humans and their environment in the southern Kalahari, but every new site adds a new datapoint. Continued investigations at GHS could work to extend excavations there and increase the sample size of cultural

material. There are many potential avenues for more palaeoenvironmental work at the site, especially as the sample of fauna and OES is expanded, which would be suitable for detailed isotopic analyses. Detailed study of the dated tufa deposits could also shed light on seasonality of water availability, as well as finding and dating more tufas to expand the existing record. Ongoing reconnaissance in the region is likely to continue to reveal the existence of new archaeological sites that can expand our knowledge about Holocene landscape use. Owing to the mobile nature of hunter-gatherers, multiple records from various locales are required to gain a thorough comprehension of their behaviour and movements. Continued consideration of the ritual significance of places on this landscape, coupled with the nuanced narratives of local ethnographies and rich intangible cultural heritage, will also provide new perspectives on how we engage with and understand the utilisation of Kalahari landscapes.

As a new Late Holocene hunter-gatherer site, GHS contributes to regional investigations of hunter-gatherer landscape use and adaptation. Hunter-gatherer populations in this region of the southern Kalahari were resilient to climate and environmental change, as evidenced by previous work showing their persistence through drier periods (Von der Meden *et al.* 2022). However, they were still partially shaped by the availability of water resources, potentially influencing their settlement patterns and subsistence strategies. This research highlights the importance of considering multiple factors, including past climate conditions, when studying the past and the development of cultural landscapes. Growing research in the area will have significant implications for understanding the long-term dynamics of human occupation and land use in arid and semi-arid regions and can, ultimately, inform efforts to manage and conserve these fragile ecosystems in the present day.

ACKNOWLEDGEMENTS

We would like to thank Simon Hall, Michael Chazan, the late Peter Beaumont, the South African Heritage Resources Agency, and McGregor Museum. Thank you, too, to UCT staff Louisa Hutton, Dolores Jacobs, Deborah Walbrugh, and all student lab and field contributors who assisted with excavations and lab work for GHS (Navashni Naidoo, Jani Louw, Leesha Richardson, Nathan Bickerton, Alyssa Eltzholtz, Josh Giesken, Tamara Jeggels, Patricia Groenewald and Amy Hatton). Jayne Wilkins is recipient of an Australian Research Council Discovery Early Career Research Award (DE 190100160). Additional funding was provided by the University of Cape Town, and the National (South Africa) Research Foundation Centre of Excellence (COE) in Palaeosciences (GENUS). We thank the Baga Motlhwane Traditional Council for permission to work at Ga-Mohana Hill and pay respect to the traditional owners of the land on which GHS is located.

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