Palaeo-landscapes and hydrology in the South African interior: Implications for human history

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HOW TO CITE:
Carr AS, Chase BM, Birkinshaw SJ, Holmes PJ, Rabumbulu M, Stewart BA. Palaeo-landscapes and hydrology in the South African interior: Implications for human history. S Afr J Sci. 2024;120(3/4), Art. #17569. https://doi.org/10.17159/sajs.2024/17569

ARTICLE INCLUDES:
☐ Peer review
☐ Supplementary material

KEYWORDS:
Pleistocene, archaeology, palaeo-lake, Middle Stone Age, palaeoecology

PUBLISHED:
27 March 2024

Significance:

Recent research reveals that the arid western interior of South Africa has experienced substantially more humid conditions on several occasions during the last 70 000 years. These findings, likely regional in scope, speak to changes to the resource base available to prehistoric hunter-gatherers. Together with recent archaeological findings from this region, there has emerged a growing recognition that previously archaeologically overlooked areas of South Africa's arid interior need to be included in models of human history. This presents new challenges for archaeologists and palaeoclimatologists, particularly given the prevalence of surficial, rather than stratified, archaeological evidence throughout much of this region.

Introduction and context

South Africa hosts a remarkable archaeological record that stretches deep into the past.[1] It is a region at the centre of discussions surrounding human prehistory, and findings relating to southern African archaeology attract international media and public interest. This archaeological record has motivated a substantial ancillary body of research that seeks to reconstruct the long-term evolution of regional climates and landscapes. Such changes will have shaped the resources available for past hunter-gatherer societies, and represent local manifestations of the global glacial and interglacial climatic cycles that prevailed throughout the Pleistocene.[2,3] In South Africa, data for the late Pleistocene (the last 125 000 years) suggest glacial-interglacial changes in mean annual temperature of 5–6 degrees[4] and time-varying fluctuations in the extent and intensities of (subtropical) summer rainfall and/or winter rainfall[5]. Such palaeoclimatic information feeds into questions concerning regional ecological responses and whether (and the extent to which) observed archaeological shifts are indicative of behavioural adaptations to environmental change.

The distribution of archaeological sites across South Africa, some of which have been subject to decades of investigation, is geographically uneven. Simply laying a map (Figure 1) of the major Middle to early Later Stone Age (MSA to early LSA; ~300 ka to ~20 ka) sites onto a map of modern aridity might tempt one to infer that the distribution is a logical outcome of humans mostly using the more humid, well-resourced landscapes of the coastal margins and the wetter (and upland) eastern half of the country. Indeed, one of the largest 'gaps on the map' covers the western interior of South Africa, which broadly maps to the Nama Karoo Biome, a region characterised by arid conditions (an aridity index of 0.16±0.07 and mean annual precipitation of 250±90 mm[6]) and shrubby vegetation with sparse grass cover. While less prominent in the literature, archaeological materials spanning the Acheulian to the Later Stone Age have been described throughout even the most arid parts of this region.[7,8] Indeed, in some cases, these descriptions formed some of the earliest palaeoenvironmental and archaeological investigations undertaken in the region.[9] A major difference in the arid interior is that researchers are often dealing with *surface archaeology*; that is, scattered artefacts either lying directly on the land surface, or only shallowly buried (Figure 1). This stands in contrast to the deeply stratified deposits preserved and available to study in rock shelters, which are much more common along the Cape south coast and in adjacent mountain systems. In the absence of such stratification, even the *relative* age of surface materials is difficult to establish, and direct numerical dating can be particularly challenging.

Notwithstanding, one might ask what the abundant presence of such archaeological materials, even across rather arid landscapes, represents. Could it indicate a 'background scatter', generated by an essentially sparse human presence over long periods? Could it suggest that people were regular visitors at certain times, perhaps using these environments when conditions were more favourable? Such questions speak to the adaptive flexibility of human populations in the past[10], and, indeed, over the decades, several workers have speculated whether particular biomes or environments were more or less favoured at certain times[11]. We might further speculate, as some workers have, as to whether the materials we do observe are focused on particular landscape settings that offer desirable resources, and what clues such evidence provides in terms of how people used the landscape.[12]

Our recent paper[13] sought to set a framework for addressing these questions, not through analysis of archaeological materials, but by first considering the more basic question of whether there were good reasons (or more specifically, optimum times) for humans to have occupied these (presently) arid regions. The paper joins a growing body of work[14-16] that challenges assumptions that the South African central interior was characterised by aridity during cooler global glacial phases[17,18].

Geological evidence

Carr et al.[13] present a palaeohydrological reconstruction for a region largely encompassing the Nama Karoo (including some areas marginal to the Grassland and Savanna Biomes), spanning the last 70 000 years – a period encompassing the later MSA and the transition, at some point in the last 40 000 years, to the LSA. They followed up work that several decades ago reported evidence for lake shorelines *and* archaeological materials along the margins of now dry or ephemerally inundated pans, primarily at sites near to Brandvlei[8,19] in the Northern Cape Province and in the very western margins of the Nama Karoo Biome at Alexandersfontein, south of Kimberley[20]. Previous workers identified these palaeo-lakes and inferred the existence of perennial surface waters based on the presence of wave-deposited shorelines, lake mud deposits stranded above the modern pan floors, and even reports of workers

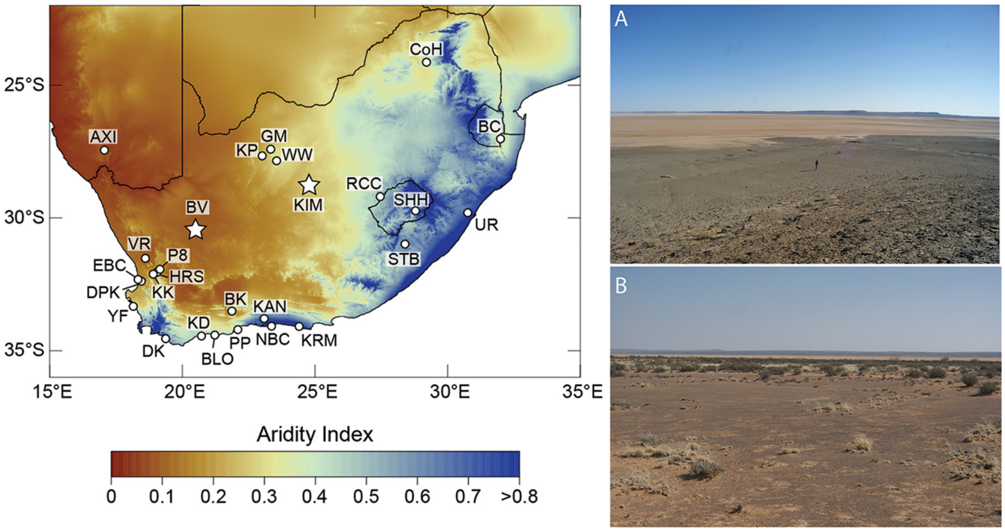

Figure 1: The distribution of major Middle Stone Age sites (some sites also include Early and Later Stone Age materials) in South Africa with a map of aridity (aridity index calculated with data from Trabucco and Zomer[6]). AXI=Apollo 11; BLO=Blombos Cave; BC=Border Cave; BK=Buffelskloof; CoH=Cave of Hearths; DK=Die Kelders; DPK=Diepkloof; EBC=Elands Bay Cave; GM= Ga-Mohana Hill North; HRS=Hollow Rock; KRM=Klasies River; KK=Klein Kliphuis; KD=Klipdrift; NBC=Nelson Bay Cave; PP=Pinnacle Point; P8= Putslaagte 8; RCC=Rose Cottage Cave; SHH=Sehonghong; STB= Strathalan B; UR=Umhlatuzana; VR=Varsche Rivier; WW=Wonderwerk; YF=Ysterfontein; KT=Kathu pan. The key locales investigated by Carr et al.[13] are shown (stars) (KIM= Kimberley and BV=Brandvlei). The photos of sites considered in this work show: (A) the margins of Hoek van Spruit se Vloer pan, south of Brandvlei, which exhibits varying densities of Middle and Later Stone Age lithic scatters around its margins (where the figure is standing); (B) the margins of Verkeerdevlei pan, southeast of Vanwyksvlei. Here the dark stoney surface in the foreground and middle ground is composed of abundant patinated artifacts, including diagnostic Middle Stone Age elements.

finding fish and crab remains during early 20th century quarrying.[19] In all cases, the likely ages of these deposits and landforms were weakly constrained. The new work first sought to address their ages through the application of radiocarbon and optically stimulated luminescence (OSL) dating methods. However, it was also able to identify additional sites with evidence pertinent to these questions; notably the presence of freshwater mussel deposits at pans that are today very rarely inundated. The application of OSL dating was particularly significant as this method could provide numerical ages for deposits that were devoid of organic matter or biogenic calcite (e.g. shell).

Quantifying hydrological and ecological change

The results suggested the presence of perennial waters in the western arid interior at 55–39 ka, 34–31 ka and around 21 ka.[13] In the east of the study region, at Kimberley, the age of a previously hypothesised[20] 44 km^2 palaeo-lake was constrained to 25–32 ka; burial of these lake deposits by unambiguously Holocene age (10–11 ka) terrestrial colluvium further supported the notion that the cooler phases of the last glacial cycle were associated with a substantially different hydrological balance (i.e. ratio of evaporation to precipitation) from the present. A key development of this work was to move beyond dating phases of 'higher' moisture availability to develop a model that could account more specifically (i.e. climatically) for the hydrological changes implied by the geological evidence. By anchoring the model to the new geological data, we also sought to extend the findings to consider the implications for *regional hydrology*. For this we used the Shetran hydrological model[21] to simulate surface water as well as soil water and groundwater flow (Figure 2). The modelling implied that significant hydrological invigoration across much of the Orange River catchment would have been required to sustain these lakes, with the most dramatic changes in water balance in the west. Temperature change (lower temperatures leading to lower evaporation rates) was likely to be an important control, but increased rainfall was also needed to fully replicate the geological evidence. In the Brandvlei region, this amounted to potential evapotranspiration being reduced to 21% of present and rainfall increasing to 215% of present (to approximately 550 mm per year). A landscape of presently dry pans and ephemeral river channels was thus at times associated with perennial rivers and lakes and the regional water table would have intersected the modern landscape across stretches of this interior region (Figure 2). Modelling also facilitates the development of testable hypotheses; if water resources were an important control on human occupation of the interior, the outputs offer suggestions in terms of where to look for new archaeological evidence.

In water-limited ecosystems, once the regional hydrology changes, ecological changes will follow, and using the modelling results, it was possible to develop hypotheses as to the associated vegetation responses. Crucially, the likely response of herbivores to these new conditions could also be considered. Here the modelling predicts a wetter, grassier and more herbivore-rich environment; a much more resource-rich landscape that would have presented many opportunities for hunter-gatherer communities.[13] Indeed, there is independent faunal evidence to support these proposed changes[22], and the results also explain some intriguing (but rarely discussed) elements of the Pleistocene faunal record; notably the presence of aquatic mammals like hippos (*Hippopotamus amphibius*), and lechwe (*Kobus leche*) which feed on aquatic plants, in several late Pleistocene faunal records in the arid interior.[22]

Implications and future perspectives

Considering this evidence, a parsimonious explanation for the archaeological 'gap on the map' (Figure 1) in the arid interior is not one of unfavourable (palaeo)climates, but more likely a reflection of geology and geomorphology. That is, the landscape is (was) unsuited to the preservation of the sorts of stratified archaeological records that have attracted intensive research efforts elsewhere. It is worth noting that where such sites are located in the interior, such as Wonderwerk Cave, Ga-Mohana Hill and Kathu Pan to the north of the aforementioned lake study sites, Early Stone Age, MSA and LSA archaeology, including some early MSA materials dating to the penultimate glacial period (MIS 6), are indeed preserved.[14,15,23]

While unstratified, there is abundant surface archaeological evidence for hunter-gatherers in the interior region. The question of whether, at a regional scale, this is consistently concentrated around (palaeo) hydrological systems[24] requires more work, but Carr et al.[13] describe both MSA and LSA materials at all of their sampled/observed sites (Figure 1).

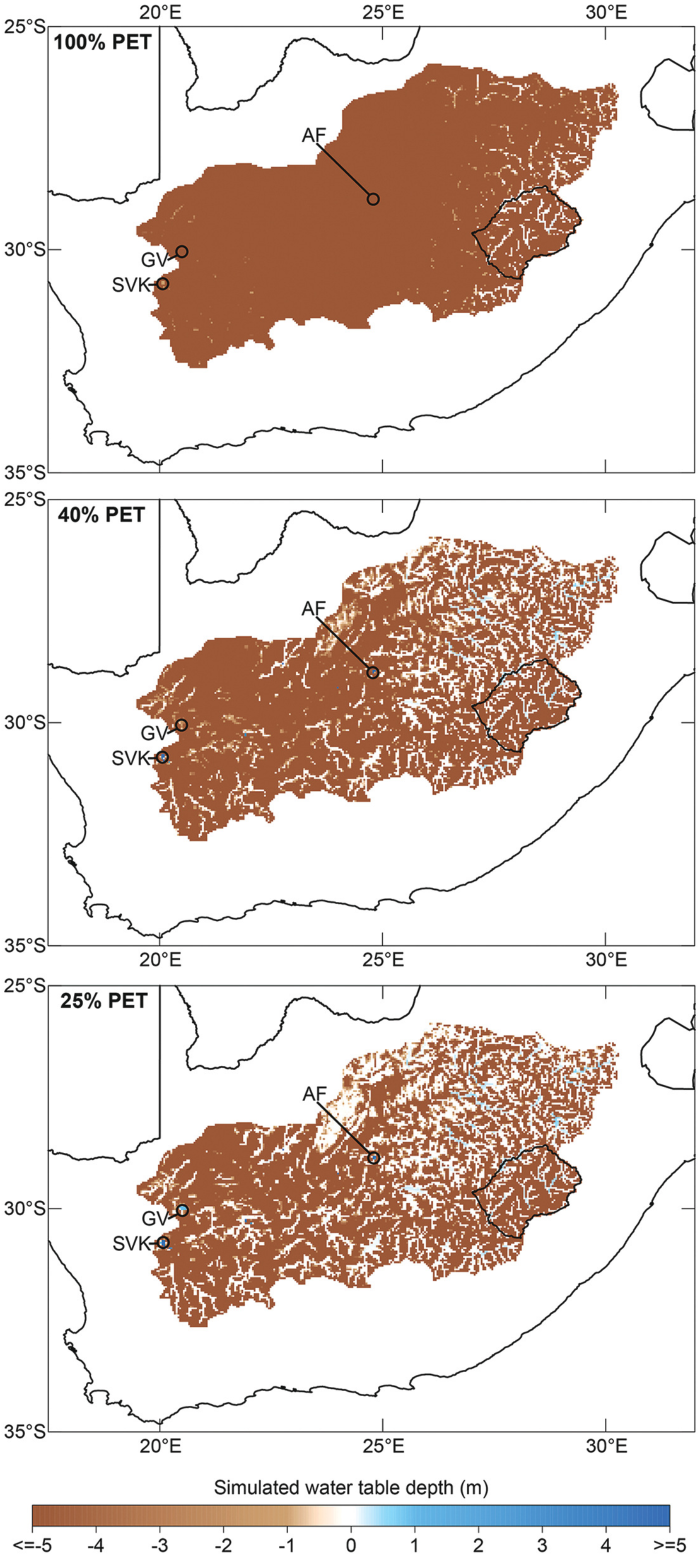

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Figure 2: The results of the Shetran modelling, showing the modelled depth of the water table across the Orange River catchment for several potential evapotranspiration (PET) scenarios; white and blue shading indicates the water table intersection with the modern ground surface.[13] It is important to consider that the size and climatic heterogeneity of the region depicted means that it is unlikely that all of it ever experienced precisely the same water balance or level of potential evapotranspiration. The situation is thus idealised rather than actual, but sites for which direct field evidence for palaeolakes and perennial surface water flow has been identified are also shown (GV = Grootvloer; SKV = Swartvolkvloer; AF = Alexandersfontein).

At Alexandersfontein the density reaches greater than 50 artefacts/m^2 at one locale on the edge of the proposed palaeo-lake.[13,20] Here MSA artefacts were also found in stratified deposits, although age constraints for these materials are required. Looking further afield, it is clear that several pan sites, while lacking obvious shoreline deposits, were also associated with abundant MSA lithic scatters, and this includes some sites for which the hydrological modelling predicts palaeo-inundation (Figure 2). The role of springs in shaping landscape usage should also be considered.[12]

Thus, one might wonder to what extent our collective views on South African deep history are skewed by the stark nature of the modern conditions in the arid zone, and by a research focus on deeply stratified archaeological sites on the coastal margins. A growing body of work is developing around this issue, including the description and dating of new sites such as Ga-Mohana[15] and work further afield in the Makgadikgadi Basin of Botswana[25]. More broadly, these works prompt us to consider the significance and potential of the interior surface archaeological record. The importance (and acknowledged challenges) of integrating surface archaeology into our wider understanding of human history is recognised globally, but the results discussed here suggest there is value in considering how the interior's open-air record of human existence can be integrated into a broader understanding of South Africa's past.[26] Given its very *emplacement* within the landscape, if its chronological hurdles can be overcome, this surface archaeological record has the potential to deliver new behavioural information. That it spans a wider temporal and spatial range than rock shelter sites, moreover, and captures a broader range of activities and behaviours[27], makes it all the more enticing. Crucially, though, to interpret the interior's archaeology properly, and to fully grasp its strengths and limitations, we must also start to understand the geomorphic processes that shape surface archaeology.[28] Doing so may be nothing short of the key to understanding when, why and how humans inhabited these perennial – but not permanent – thirstlands.

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