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DATED HOLOCENE HUMAN REMAINS FROM SOUTH AFRICA: RECALIBRATION AND BROAD CONTEXTUALIZATION

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ABSTRACT. The study of human remains can provide valuable information about aspects of past populations. Here we present an updated database consisting of 590 radiocarbon (^{14}C) dates for human remains from Holocene South Africa before European contact. We calibrated or recalibrated all the previously published dates using the most recent calibration curve for the southern hemisphere. Each date is roughly georeferenced and plotted according to their Stone Age or Iron Age contexts, revealing the broad distribution pattern of dated Holocene human remains across South Africa—perhaps reflecting aspects of past population distribution and densities, but also underscoring historical collection practices, archaeological research focus, and preservation conditions. We use Kernel Density Estimation models to show peaks and troughs of dated remains through time, with Later Stone Age peaks at ~5.5 ka cal BP, ~2 ka cal BP and ~0.5 ka cal BP, and Iron Age peaks ~1.1 ka cal BP and ~0.5 ka cal BP, some of which show broad correspondence to climatic data. Our data, based on dated remains only, do not provide a full reflection of past populations, and our large-scale, coarse-grained analysis cannot yet assess the reasons for the peaks in dated human remains in detail. Yet, the study provides a new resource, and a data-driven overview that highlights aspects to be explored with further contextual analyses against the available archaeological records, population histories and climatic indicators through time and across space.

KEYWORDS: human remains, Iron Age, kernel density estimation models, Later Stone Age, radiocarbon aggregation methods, radiocarbon dating.

INTRODUCTION

Archaeological interpretations remain incomplete without an understanding of the people who inhabited the sites (Larsen 2000, 2015), and human remains can inform on aspects of human behavior, demography, and health. Southern Africa (Africa south of the Zambezi River), with its ancient human origins and rich population diversity (Schlebusch et al. 2017, 2020; Fortes-Lima et al. 2023), has much to offer in this regard (e.g., Sealy 2016a; Pfeiffer et al. 2020; Steyn et al. 2019; Loftus and Pfeiffer 2023; Rifkin et al. 2023). Human remains represent an integral part of the population record of a region, and South Africa (the current geopolitical republic) has a long history of reporting on human skeletal remains. Initially, this was done to describe the various population groups of the world according to their perceived physical typologies, and later in a more contextual way to help understand past lifeways or aspects of disease and dental health (see Morris 2022 for discussion).

Morris (1992) compiled the first inventory of Holocene human remains curated by the various South African museums and universities. He arranged the data according to the South African biomes and provided useful information about where and by whom they were found, some aspects of their archaeological context, their dates where available, any associated grave goods, skeletal parts retrieved and references. Since the publication of his catalogue, radiocarbon (^{14}C) dating methods have been refined to allow more accurate and precise measurements from small

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*Corresponding author. Email: emma.loftus@lmu.de samples, and advances have been made in the calibration protocols of radiocarbon dates (Bronk Ramsey 2008; Loftus 2023). Consequently, there are ever greater numbers of radiocarbon dates available for regional synthetic analyses and a more widespread awareness of the methods available for interpreting radiocarbon data (e.g., Loftus et al. 2019; Loftus and Pfeiffer 2023).

Revised syntheses of both the Stone Age (Lombard et al. 2012, 2022) and Iron Age (Huffman 2007, 2009) archaeological sequences have also been published based on dated assemblages (Table 1). We acknowledge that not everyone agrees fully with these syntheses (e.g., Orton 2014; Moffett 2020; Wilkins 2020), and that no concise overview can capture the richness and variability expressed over the more than two million years of human endeavor represented in the archaeological record of southern Africa. Yet, lacking any other comprehensive overviews, these summaries provide a pragmatic, heuristic shorthand for communicating and learning about complex data and broad spatiotemporal trends. Importantly, the synthesized sequences do not automatically imply culture historical assumptions, nor do they assume a teleological understanding of evolutionary processes (biological or socio-technical). Instead, they provide data-driven catalysts for future discussion and exploration by creating a template to situate large-scale techno-typological patterning within a chronological framework (Lombard et al. 2022).

With this contribution we revisit the Holocene human remains of South Africa. Pre-Holocene human remains from the region are less abundant and often highly fragmentary—direct radiocarbon dates from such remains are rare, given patterns of collagen preservation in southern Africa (but see Dusseldorp et al. 2013 for summary). We provide a revised georeferenced database of all the dated remains we were able to trace (SOM 1). We calibrated or recalibrated all the radiocarbon age estimates and aligned them broadly with the archaeological sequences presented in Table 1. This alignment does not automatically imply that the dated individuals were directly associated with a specific technocomplex or period, but merely that they lived during a chronological phase when most archaeological contexts show broadly similar and recognizable trends in material-culture. We use the resulting data to roughly map the distribution of Stone Age *vs* Iron Age human remains, record variation in the frequency of human remains and/or burials through time, and broadly associate these variations with the archaeological phases and some climatic indicators. The aim of the paper is not to interpret or explain the complete Holocene human remains record of South Africa, but to highlight possible spatiotemporal trends and other aspects or patterns that require further exploration.

MATERIALS AND METHODS

As a point of departure for our database, we extracted all the radiocarbon dated individuals from the Morris (1992) catalogue and conducted a systematic search for additional and subsequently published radiocarbon dates obtained for individuals in South African institutions. We also included data from unpublished reports and requested information about newly dated skeletons from various curators across the country. Here, we focus on South Africa, but future research could productively include neighbouring southern African countries, given broad similarities in the archaeological frameworks. However, we believe the numbers of dated remains from other countries are likely many fewer, given the generally lower numbers of radiocarbon dates from these countries (Loftus et al. 2019).

Table 1 Synthesized sequence for South African Holocene archaeological phases (after Huffman 2007, 2009; Lombard et al. 2012, 2022).

Stone Age sequence synthesized			Iron Age sequence synthesized		
Phase	Main expressions	Broad duration	Phase	Arbitrary divisions	Broad duration
ceramic final Later Stone Age	1493–97 CE	<2 ka	Late Iron Age	1840–1300 CE	~0.2–0.7
final Later Stone Age	632 CE–1948 BCE	~1–4 ka	Middle Iron Age	1300–900 CE	~0.7–1 ka
Wilton	2686–5834 BCE	~4–8 ka	Early Iron Age	900–100 CE	~1–1.8 ka
Oakhurst	6755–10839 BCE	~7–12 ka			

Only the remains of individuals with dates falling within the Holocene (≤11.7 ka) and before contact with European settlers since about CE 1650 were included. Each entry is accompanied by its repository accession number (identification code). Some sets of remains have been reburied in line with the wishes of descendent communities so that our inventory does not reflect all the human remains still under curation. Instead, it is a database of individuals for whom pre-contact Holocene radiocarbon dates are available. We incorporated site names into the unique ID's created for the purposes of this study to help facilitate future sorting according to site, town, or region, and for calibration purposes indicate whether the Stone Age sites are located in the inland or along the coast (to accommodate the expected marine reservoir). Each entry has one or more associated references that report on excavation, dating, bioanthropological and/or archaeological information (SOM 1).

To gain insight into the broad distribution of the dated human remains, the site where they were found are geographically grouped according to the South African 1:50000 topographic map grid (https://shop.geospatial.com/publication/1TFM8QGY2F2M49Y8BZQ15X7Q75/South-Africa-1-to-50000-Scale-Topographic-Maps, visited September 2023). The first and second sets of two digits reflect latitude and longitude respectively, while the two-letter code ([A-D] [A-D]) reflects the particular map sheet, as divided into quadrants and sub-quadrants, labelled from top [AB] to bottom [CD]. Thus, each sheet spans an area of 15’×15’ (https://ngi.dalrrd.gov.za/index.php/what-we-do/maps-and-geospatial-information/41-sa-mapsheet-referencing, visited September 2023: see also SOM 1). Latitude and longitude are derived from this map ID, reflecting the top left corner of each map on the grid. This coarse-grained level of geographic information is suitable for broad spatial assessment on a regional or subcontinental scale as we aim to do here. More detailed spatial analyses of smaller areas will require more accurate mapping of the precise locations where the human remains were found.

Every entry in our database is associated with a unique radiocarbon ID number assigned by the laboratory that produced the date, along with the original uncalibrated radiocarbon age and measurement error. Most dates were obtained directly from an individual's sampled bone collagen, but in some instances (~40) dates were obtained from closely associated charcoals or other bone material—such dates mostly represent the more recent Iron Age human remains. We calibrated or recalibrated all the radiocarbon measurements, using the most recent calibration curve for southern Africa (SHCal20: Hogg et al. 2020), and provide the calendar date ranges at the 95.4% range (both cal BP and cal BCE/CE presented, SOM 1). Due to how the calibration procedure works, the true age of the sample can lie anywhere in this range, and the entire range must be considered (see Hare and Loftus 2018).

Working on a large regional scale, it is necessary to consider the marine radiocarbon reservoir for variable amounts of marine protein in the diet of coastal-dwelling individuals, because dietary protein is preferentially reflected in bone collagen. Radiocarbon from marine environments is generally several hundred years “too old,” meaning that organisms that ingest substantial amounts of marine protein have older radiocarbon ages than equivalently aged organisms that acquire carbon from purely terrestrial or atmospheric sources (e.g., herbivores, plants) (Alves et al. 2018). Individualized estimates of the proportions of dietary marine protein indicate substantial variation amongst Later Stone Age foragers (e.g., Loftus and Pfeiffer 2023). We therefore used a simplified procedure to partially compensate for this complication by calibrating each coastal radiocarbon date for foraging people with a mixed calibration curve that incorporates between 10–50% of a marine input to the diet (MarineCal20: Heaton et al. 2020). (Note that no corrections were made for three dates from coastal Iron Age contexts as farming groups are believed to have consumed little, if any, marine food.) This is a conservative and overly generalized method of accounting for marine protein in the diet of coastal dwellers that will result in increased age ranges for each date. A more targeted approach would require a localized delta offset for each subregion (see Alves et al. 2018), and more individualized estimates of marine dietary intake by using, for example, stable carbon isotope ratios (Lewis and Sealy 2018; Loftus and Pfeiffer 2023). These approaches are, however, unpragmatic and computationally unrealistic for a first attempt at a large-scale inventory of dated human remains as presented here. One of the purposes of this database and our broad-scale analyses thereof is to serve as an updated resource from which to launch more detailed investigations at centennial or sub-regional scales that employ more precise estimates of marine dietary intake and the local marine reservoir.

To evaluate the frequency of dates associated with the Holocene human remains, we used Summed Probability Density (SPD) and Kernel Density Estimation (KDE) methods. The SPD method is a widely used tool for the aggregation of radiocarbon dates, providing a curve with peaks and troughs that reflect the relative frequency of radiocarbon dates through time (see discussions and critiques of SPD approaches in Williams 2012, Carleton and Groucutt 2021, and Crema 2022). The approach simply sums the nonnormal distributions of calibrated radiocarbon dates. The resulting distribution curve can be greatly affected by the shape of the calibration curve (e.g. "plateaus" or "jumps" which reflect major shifts in the rate of radiocarbon production through time). It is generally only considered reliable for sample numbers of >500, and care must be taken not to overinterpret minor fluctuations in the shape of the SPD curve, especially given the lack of any measure of uncertainty associated with the SPD (Williams 2012; Crema 2022). In response to the limitations of SPD approaches, KDE methods are increasingly used, particularly in the context of open-access calibration and chronological modeling software (e.g. Bronk Ramsey 2017). The *KDE_Model* tool in OxCal (v.4.4) generates multiple KDEs by repeatedly sampling subsets of a set of dates, and aggregating these KDEs into an ensemble, which has the advantage over an SPD of providing a visual estimate of uncertainty, as an envelope around the combined curve (Bronk Ramsey 2017; Crema 2022). The KDE method used in OxCal derives an appropriate bandwidth from the dataset itself. This tool provides smoother distribution curves than an SPD function and generally offers a more conservative estimate of the frequency of dates through time (Bronk Ramsey 2017; Crema 2022).

Well-dated, continuous palaeoenvironmental datasets were selected to provide a generalized picture of environmental shifts throughout the Holocene for comparison with the burial record. Considerable variation in precipitation trends is believed to have occurred across the subcontinent over this period, due to the different forcings on subtropical and temperate weather systems that bring moisture to the summer and winter rainfall regions (e.g., Zhao et al. 2016). In these regions, more than two-thirds of precipitation occurs in the relevant season, with a year-round rainfall region lying geographically between the two, and receiving rainfall from both systems throughout the year. We thus selected records (e.g., Talma and Vogel 1992; Scott et al. 2003; Fischer et al. 2007; Chevalier and Chase 2015; Chase et al. 2019, 2020), that reflect broad trends in both regions but recognize that the complexity of climatic shifts throughout southern Africa make this synthetic approach highly reductive. Note that the published age models for each record are presented here, with no attempt made to correct or synchronize the various records.

RESULTS

The Morris (1992) catalogue listed 182 dated individuals; our inventory now includes 590 dates for the remains of people who lived during the Holocene in the area now known as South Africa. Of these, 491 dates are associated with the Stone Age, 77 with Iron Age contexts, and for 22 individuals their possible archaeological phase is unknown based on the available dating and distribution information. The earliest 22 dates represent Holocene individuals who lived roughly contemporaneous with the Oakhurst technocomplex, followed by 83 dates roughly contemporaneous with the Wilton (Table 1). Based on their associated contexts, 246 dates fall within the final Later Stone Age. All these individuals represent people who followed hunter-gatherer lifeways. The dated remains of 27 people may be associated with the ceramic final Later Stone Age, representing pastoralist or herding lifeways (Table 1). For 113 dates associated with the Stone Age falling within the last two millennia, we could not distinguish between the final Later Stone Age and the ceramic final Later Stone Age phases, because of the spatiotemporal overlap between these two technocomplexes and inadequate archaeological information—these are indicated as “uncertain final Later Stone Age” in the database.

The Iron Age sample represents African farmers/agriculturalists whose ancestors originated around Nigeria in western Africa and migrated eastwards and southwards over the course of several millennia (Fortes-Lima et al. 2023). The distinction between Early and Late Iron Age archaeological contexts is believed to represent the arrival of new communities in the region, antecedents to Nguni- and Tswana-speaking communities today (Huffman 2007). Dated human remains broadly contemporaneous with the Early Iron Age number 13, with the Middle Iron Age 12, and the Late Iron Age 52. Note that the number of dates grossly underestimates the number of individual sets of remains from some Iron Age sites—for example, more than 120 individuals were recovered from Mapungubwe and K2, two adjacent sites dating to around the turn of the 1st millennium CE. However, destructive sampling of human skeletal material from these sites faces considerable ethical scrutiny over the concerns of descendent communities, and the number of direct dates from these sites is unlikely to increase as the remains have been reburied.

In Figure 1 we show the broad distribution of dated Holocene human remains across South Africa, separated into individuals associated with either their Stone Age or Iron Age contexts. This analysis reveals the large portions of the country from which no recorded, radiocarbon dated human remains have been recovered. The result is probably an artefact of human remains collection practices, archaeological research focus, and preservation conditions on the one hand, and a broad reflection of population distribution and densities on the other (for the distribution of Stone Age *vs* Iron Age stone walling and occupation see Huffman 2007; Sadr 2012; Lombard et al. 2020). Stone Age remains cluster around the coastal regions in the Western Cape and Eastern Cape, with some sites also located in the Northern Cape, KwaZulu-Natal, and Free State (Figure 1). One of the northern-most dated Stone Age individual is Bronkhorstspruit TM92-136 (SOM 1), of whom the mummified remains were found in a cave, and her Khoe-San (Stone Age) population affinity was confirmed through mtDNA (Pereira 2007). Most of the dated Iron Age remains were retrieved from the Limpopo Province, with some also from the North West, Free State, KwaZulu-Natal and Mpumalanga. This spatial distribution may reflect the broad southward migration of incoming agriculturalists in the eastern regions of South Africa (Figure 1). Currently, there are no dated Iron Age human remains from any of the Cape provinces, which reflects limited settlement of these regions by agriculturalists due to climatic factors (Russell 2020). Table 2 shows the approximate number

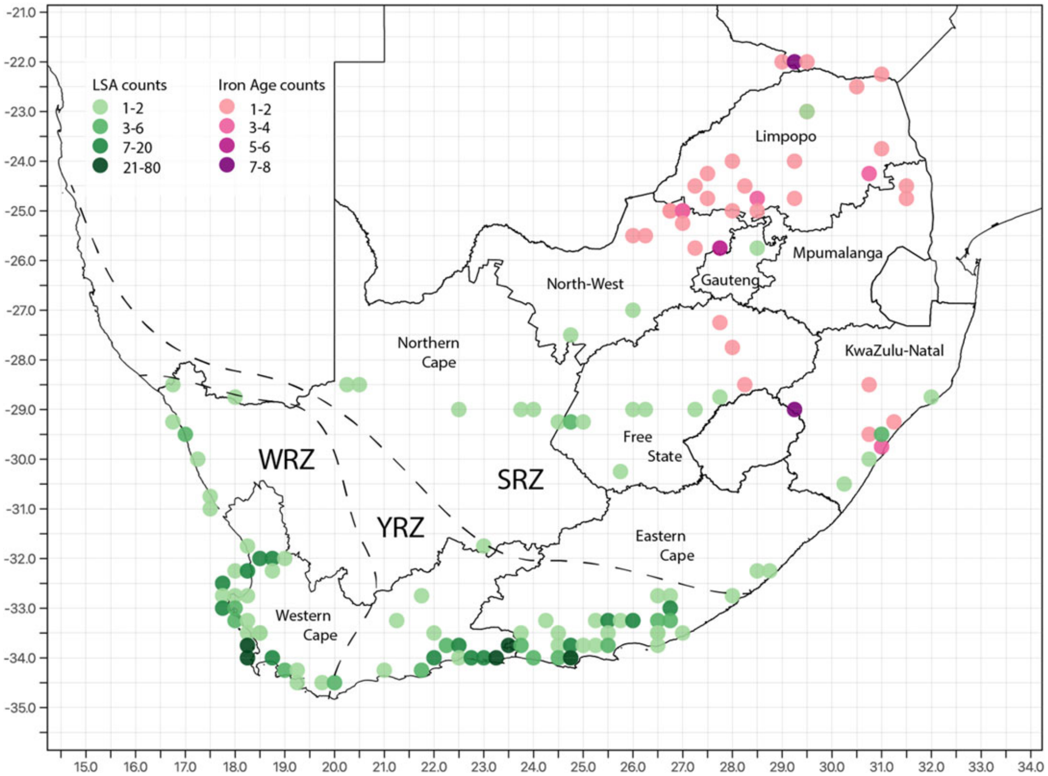

Figure 1 Map grid of South Africa with the approximate locations of sites from which radiocarbon dated human remains in this dataset (SOM 1) were retrieved, distinguished according to remains associated with either the Stone Age or the Iron Age. The darker the spot the more numerous the dated human remains (note the differing scales). SRZ: summer rainfall zone (where >66% of rainfall falls during the summer months), WRZ: winter rainfall zone, and YRZ: year-round rainfall zone, which receives rainfall throughout the year.

of dated human remains recovered from each rainfall region. The greater number of dated remains from the winter- and year-round rainfall zones (n = 466 combined) relative to the summer rainfall zone (n = 125) may reflect bone and collagen preservation conditions in these climatic zones and likely also partly reflects patterns of institutional research intensity across the country, and dating practices within hunter-gatherer and agriculturalist archaeology. However, the density of hunter-gatherer burials along the clement southern Cape coast surely speaks to the habitability of this region in the past.

The KDE plot (Figure 2) for the Later Stone Age remains (n = 491) shows at least three major peaks, at ~5.5 ka cal BP, ~2 ka cal BP and ~0.5 ka cal BP. Smaller peaks are apparent in the earlier part of the Holocene, but the small sample size associated with this phase compromises the interpretative power of the fluctuations. The mid-Holocene peak at ~5.5 ka cal BP seems to be broadly associated with the early phase of the Wilton technocomplex (Table 1). Some authors explained the high degree of standardisation evident in this technocomplex as a response to difficult environmental conditions, and archaeological evidence for markedly lower populations during the Wilton compared to the preceding Oakhurst or the subsequent post-Wilton Later Stone Age phases (Deacon 1984; Wadley 1989; Sealy 2016b). These interpretations require future testing against new fine-grained environmental data (e.g., Chase et al. 2019, 2020), foraging-fitness assessments

Table 2 Approximate number of dated human remains in each rainfall seasonality zone (see Figure 1).

Rainfall zone	Number of dated human remains
Winter	193
Year-round	273
Summer	125

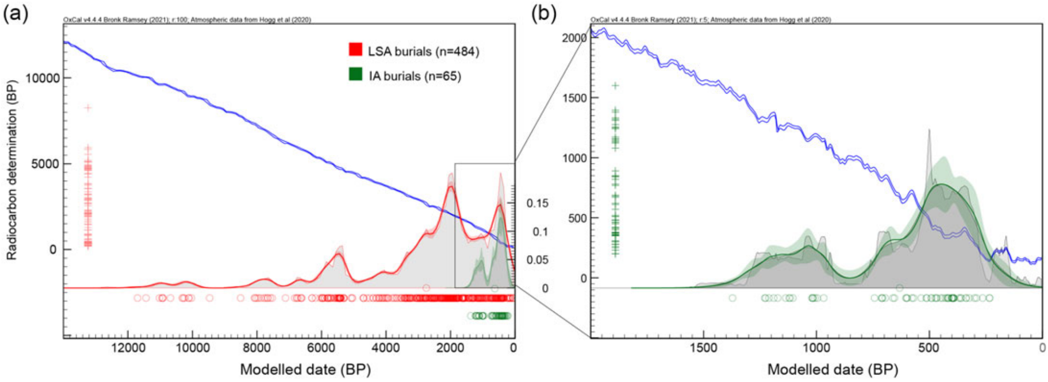

Figure 2 (a) Dataset of radiocarbon dated human remains, aggregated using KDE Models (OxCal v.4.4), distinguished according to remains associated with either the Stone Age or the Iron Age. (b) The Iron Age dated human remains only. NOTE: Dates of the remains of farming people and pastoralist or forager remains from inland locations are calibrated using SHCal20 (Hogg et al. 2020), while pastoralist and forager remains from near-coastal settings are calibrated using a mixed calibration curve that also incorporates 10–50% marine contribution (MarineCal20) to conservatively account for marine protein dietary intake.

(e.g., Lombard and van Aardt 2023), and genetic data for populations sizes (Schlebusch et al. 2017; 2020).

In their work on southwestern Cape burials, Loftus and Pfeiffer (2023) previously also identified the late Holocene peak at ~2 ka cal BP, and a subsequent decline in human remains. This may have been caused by societal upheavals within foraging groups as a result of the arrival of herders from eastern Africa (e.g., Sampson 2010; Sadr 2013; Breton et al. 2014). The DNA record also indicates a sharp rise in population density amongst the southern African groups at this time (Schlebusch et al. 2017, 2020). The subsequent decrease in human remains may then reflect the establishment of herding groups associated with the ceramic final Later Stone Age (Lombard et al. 2022). By ~500 years ago there is a late peak that may reflect intensified contact between Stone Age and Iron Age groups in the Northern Cape and Eastern Cape and it also coincides with the first European travellers to visit the Cape (Smith 1993; Hall and Smith 2000).

The KDE analysis of Iron Age farmer dates shows two marked peaks separated by a trough (Figure 2). Peaks fall roughly at 1.1 ka cal BP during the later phase of the Early Iron Age (Table 1) and at 0.5 ka cal BP during the Late Iron Age, at the same time as a peak in dated Stone Age human remains. An evaluation of the underlying dates (represented as circles underneath the KDE plot) shows that this structured distribution may reflect—at least in part—the small size of the dataset, although the apparent complete lack of dated remains between ~950–750 cal BP (1150–1250 cal CE) is certainly notable. The decline in dates in the latter half of the 2nd millennium may be due to a tendency amongst archaeologists not to date material attributed to the later part of the Late Iron Age, when dates may be too recent for reliable calibration, and the remains can be closely dated with relative dating methods, for example by ceramic association.

To assess variation between the number of dated human remains and the number of dates obtained from non-human archaeological material, we extracted the "non-human" dates for both the Holocene Stone Age and Iron Age contexts from the Southern African Radiocarbon Database (SARD: Loftus et al. 2019). For this analysis we used the SPD method, which is computationally more feasible for assessing large datasets than the KDE method (Crema 2022). The more complex shape of these curves (Figure 3), compared to the KDE curves (Figure 2), warrants some caution in the interpretation of the results.

Comparison of the human remains with other archaeological Later Stone Age dates confirms the previously observed peaks in excavated human remains at about 5.5 ka cal BP, 2 ka cal BP and 0.5 ka cal BP (Figure 3). For the ~5.5 ka cal BP and ~2 ka cal BP peaks in human remains the corresponding peaks in other dated material are, however, relatively lower, whereas the 0.5 ka cal BP peaks in both human remains and other dated material largely overlap with each other. The Iron Age dated human remains curve appears to broadly replicate several of the prominent peaks in the set of non-human archaeological dates (Figure 3), although there is no matching trough ~950–750 cal BP in the non-human dataset. This correspondence may indicate that the dated human remains reflect broader patterns in Iron Age research and dating endeavour, and/or it reflects the effect of the calibration curve on the SPDs. In general, the comparatively small size of the Iron Age burial dataset makes it difficult to gauge the validity of certain features, such as the near lack of dates between ~950–750 cal BP (1150–1250 cal CE).

Reconstructions of climatic and environmental conditions during the mid-Holocene indicate variability across the subcontinent (Figure 4; Zhao et al. 2016). In general, however, sea-surface temperatures increase during the Holocene compared to the preceding MIS 2 (Caley et al. 2018). Several climate indicators may be relevant to the Stone Age groups living in the Cape region. For example, broadly correlating with the ~5.5 ka cal BP peak observed in dated human remains is a downward trend in the extent of Atlantic sea-ice (Fischer et al. 2007), relatively high levels of humidity in the Eastern Cape (Baviaanskloof record: Chase et al. 2020), a distinct drop and sharp rise in both the eastern and western regions of the Western Cape (Cango Cave and Pakhuis Pass records: Talma and Vogel 1992; Chase et al. 2019), and an apparent increase in moisture availability in the Wonderkrater record from the northern Limpopo province (Scott 1982; Scott et al. 2003) (Figure 4). Broadly correlating with the ~2 ka cal BP peak is a sharp downward fluctuation in the Atlantic sea-ice record, a distinct rise in the humidity indicators of the Eastern Cape and eastern region of the Western Cape (Baviaanskloof and Cango Cave records), whilst the western region of the Western Cape experienced a drop in humidity (Pakhuis Pass record) (Figure 4). A compilation of multiple pollen records from the summer rainfall zone that covers most of the Northern Cape, and the other non-Cape provinces of South Africa indicates generally moist conditions at ~2 ka cal BP, declining thereafter (Figure 4; Chevalier and Chase 2015). The peak in dated Stone Age human remains at ~0.5 ka cal BP correlates with upward trends in humidity in several records (Figure 4).

The peaks in dated human remains from Iron Age contexts also show some correlation with the summer rainfall zone precipitation and record and the Wonderkrater moisture index that are

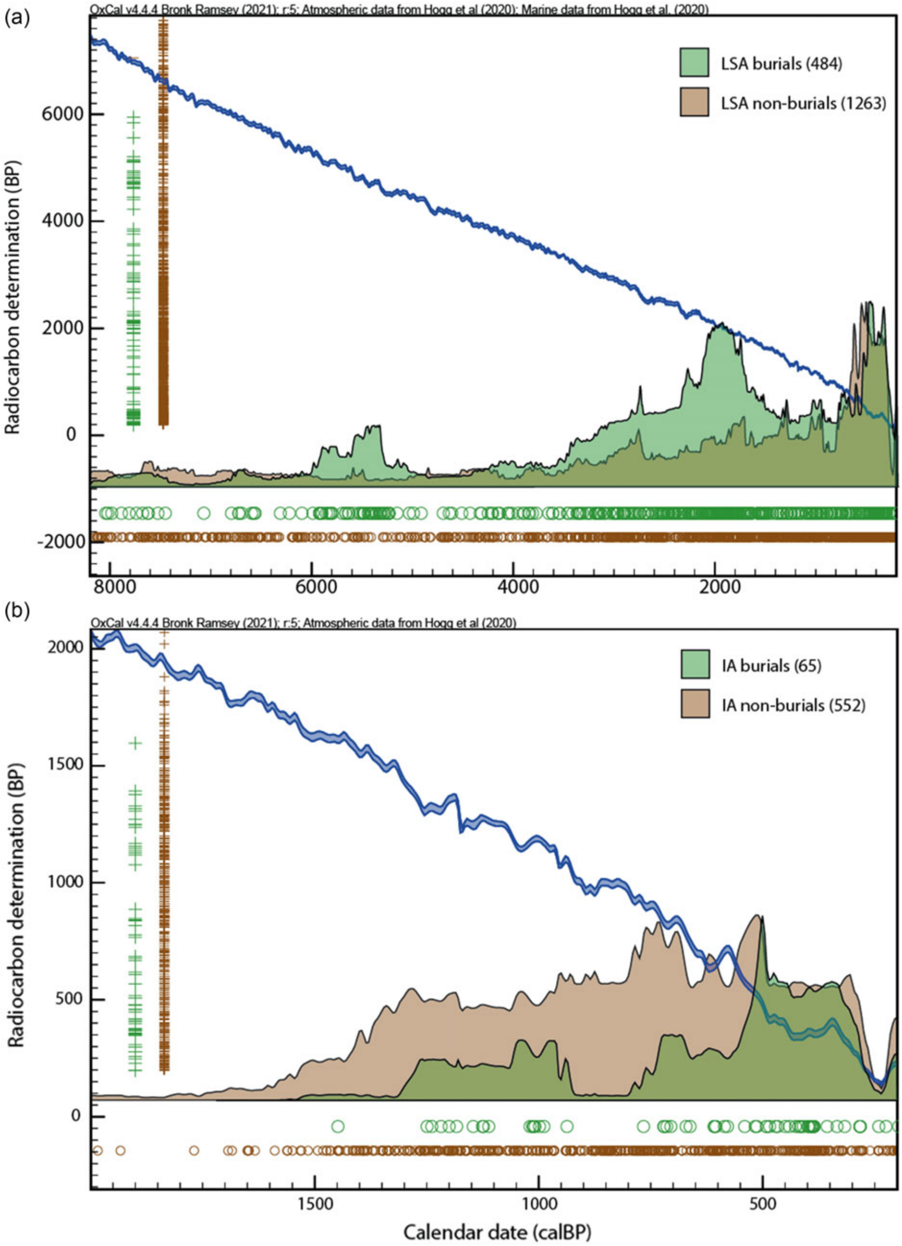

Figure 3 Summed probability density functions of burial dates (green curves) compared with non-burial dates (brown curves) extracted from the Southern African Radiocarbon Database (SARD: Loftus et al. 2019), for both the Later Stone Age (a) and Iron Age (b) contexts. Dates on marine materials (e.g., shell) are calibrated using the MarineCal20 curve (Heaton et al. 2020), whereas dates from coastal-dwelling LSA foragers are calibrated using a mixed curve (see Figure 2): otherwise SHCal20 was used (Hogg et al. 2020). Note these curves are shown to the same scale, although the human remains curves involve much smaller datasets.

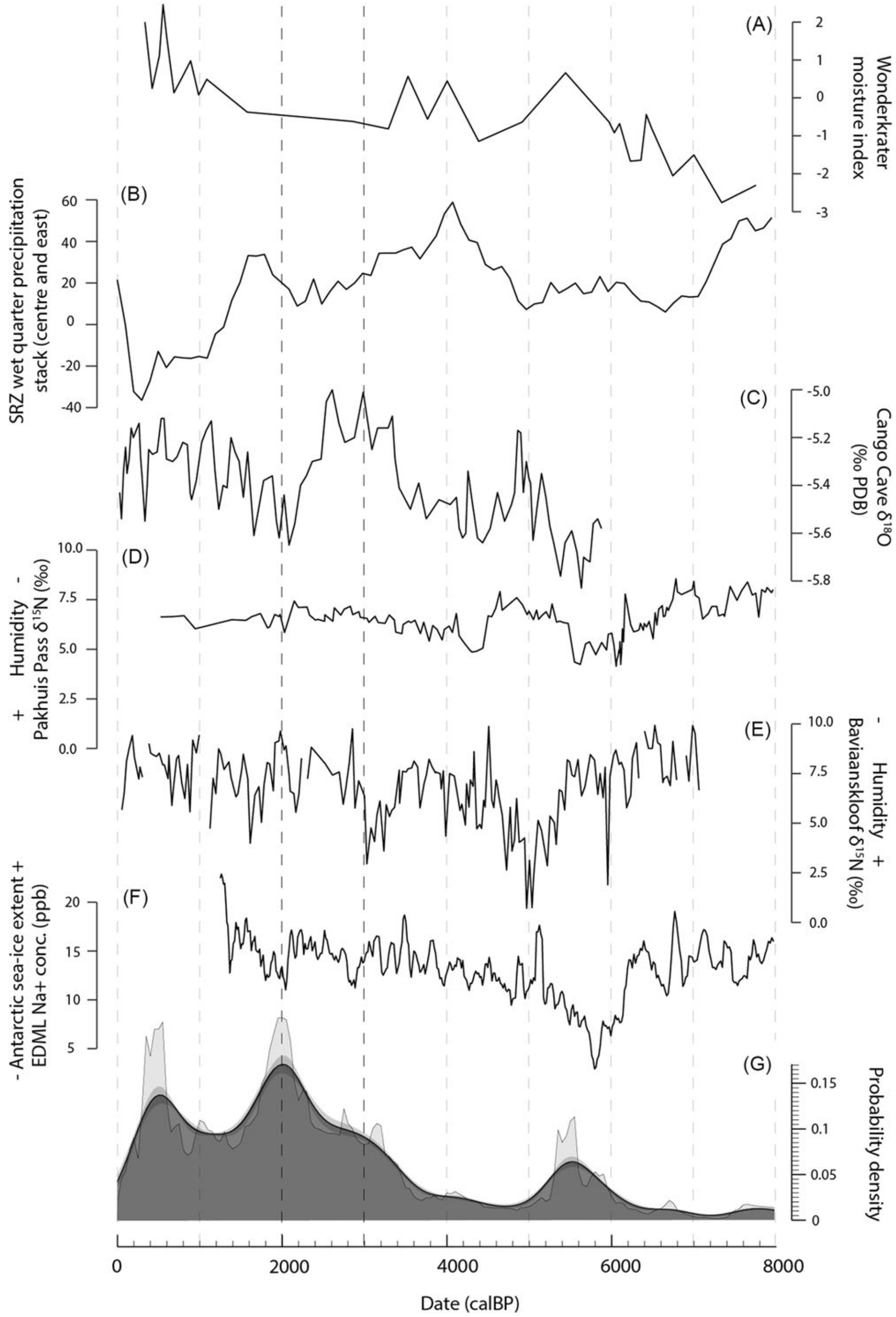

Figure 4 G: KDE distribution of LSA burials compared to regional climate records, reflecting conditions in the summer rainfall zone (A–B) and the winter rainfall zone (C–F). Precipitation dynamics in the year-round zone may be affected by both winter- and summer-rainfall systems. A: Moisture index (PC2) derived from Wonderkrater Spring, Limpopo Province, pollen record (Scott et al. 2003). B: Aggregated record of precipitation (wettest quarter) from multiple pollen records from central and eastern South Africa (Chevalier and Chase 2015). C: $\delta^{18}O$ record from Cango Cave speleothem, Western Cape, reflecting moisture conditions, including precipitation amount and moisture source (Talma and Vogel 1992). D & E: $\delta^{15}N$ records, reflecting moisture availability, from Pakhuis Pass (Chase et al. 2019) and Baviaanskloof (Chase et al. 2020) rock hyrax middens in the Western and Eastern Cape provinces, respectively. F. Sea salt sodium concentration from the EPICA DML ice core (Fischer et al. 2007), which indicates the areal extent of sea ice around Antarctica and thus reflect the relative north/south position of the westerly wind systems that bring winter rainfall to the winter and year-round rainfall regions.

relevant to their distribution in northeastern South Africa (Figures 2 and 4). For example, the ~1.1 ka cal BP peak correlates broadly with a marked downward trend in precipitation in the summer rainfall. The peak at 0.5 ka cal BP—also evident in the Stone Age dated human remains—seem to correspond with peaks in both records. Additionally, shorter, and higher resolution, paleoclimate records (not shown here) attest to regional effects of global climate events over this period, including the Medieval Warming Anomaly (~1000 to 1300 CE) and the Little Ice Age (~1500 to 1800 CE) (e.g., Tyson et al. 2000; Holmgren et al. 2001).

CONCLUDING DISCUSSION

The main purpose of this contribution is to present an updated database (SOM 1) of human remains excavated from South African Holocene contexts and to align their newly calibrated/recalibrated radiocarbon dates with the published syntheses of the relevant archaeological phases (Table 1). We applied a few analytical methods to detect possible patterns in the spatiotemporal distribution of the dated human remains and possible correlations with some climatic indicators (Figure 4). Subsequent to the Morris (1992) catalogue, this is the first attempt at a large-scale, multi-dimensional representation of dated human remains associated with the South African Holocene. The database, and the coarse-grained trends and correlations highlight aspects that require further detailed and contextual analyses to test their robusticity against the available archaeological records, population histories and climatic indicators through time and across space. Such studies have the potential to deepen our understanding about aspects of human behaviour, interaction, and demography that may not come to the fore through other lines of archaeological or anthropological inquiry.

For example, focusing on the skeletons of late Holocene foragers from the southwestern Cape coast with radiocarbon dates of 3500–900 BP, Loftus and Pfeiffer (2023) hypothesized that socio-economic change coincided with the arrival of pastoralists in the region, supported by a sheep bone age of 2310–1890 cal BP at Spoegrivier (Vogel et al. 1997; Coutu et al. 2021). Variation in forager behaviour included a shift from marine to more mixed diets, and perimortem trauma from interpersonal violence (Gibbon and Davies 2020; but also see Pfeiffer 2016). Some evidence for persistent burial places or “cemeteries” occurs at, or soon after, the introduction of pastoralism to the region (Pfeiffer et al. 2020). New burial clusters from this period may reflect attempts to control territory through direct ties with ancestors (Loftus and Pfeiffer 2023). This study shows how the arrival of groups with different lifeways and worldviews may disrupt and/or change the lifeways and worldviews of those they encounter on the landscape.

Burial behaviors associated with some of the remains may therefore reflect changes in social practices or societal stresses. However, they are unlikely to be a straightforward reflection of population size, given the complexity of some mortuary behaviors, where intentional internment is only one possible practice. The aggregation of radiocarbon dates to assess changes in archaeological density or past populations through time is a widely deployed approach, which assumes that variations in the frequency of dates through time reflect past human activity (Rick et al. 1987; Williams 2012). The approach is, however, subject to several limitations in its interpretative potential (Becerra-Valdivia et al. 2020; Carleton and Groucutt 2021; Crema 2022). For example, biases in anthropological and archaeological spatiotemporal research focus, shortcomings in sampling strategies, and varying preservation conditions may all be inherent in the data. What is more, not all human remains have been dated or linked with archaeological phases. For example, the 127 burials from Mapungubwe (n = 28) and K2 (n = 99) (Steyn 1994) are represented by only three directly dated skeletons, and two dates each (maximum and minimum date) for the sites in our inventory. At Matjes River Rock Shelter on the southern Cape coast, poor curation of the human remains has led to extensive commingling of the assemblage. Estimates of the number of individuals range between 86 and 103 (L'Abbé et al. 2008), many more than the 33 unique dates recorded in this dataset, which altogether span ten millennia. Without dates, the full collection of burials from these sites cannot be adequately represented in either behavioural, socio-economical or spaciotemporal models. That said, our inventory of human remains—with their newly calibrated/recalibrated radiocarbon dates and broadly associated archaeological phases—provides a revised, data-driven framework. The next phase of our project will be to use this framework to reintegrate the undated Holocene human remains and explore aspects of demography and behaviour based on the contexts from which they were excavated.

Similar to the syntheses of the archaeological sequences (Table 1), our inventory of dated human remains for the South African Holocene (SOM 1) is not designed to provide detailed interpretations on the observations highlighted here. Instead, it is intended as a heuristic tool for communicating and learning about complex data and broad spatiotemporal trends, highlighting areas that may be of future research interest. Increasingly, the necessity of research that requires the destructive sampling or institutional storage of human remains is being reassessed in the light of widespread and coalescing ethical concerns (see Schroeder 2020). Yet, many decades of research and curatorial efforts and resources are represented in a dataset such as that presented here and thorough data collations are imperative to maximise the cultural and scientific value of preserved human remains.

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SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit https://doi.org/10.1017/RDC.2024.22

REFERENCES

Alves EQ, Macario K, Ascough P, Bronk Ramsey C. 2018. The worldwide marine radiocarbon reservoir effect: definitions, mechanisms, and prospects. Reviews of Geophysics 56(1):278–305.

Becerra-Valdivia L, Leal-Cervantes R, Wood R, Higham T. 2020. Challenges in sample processing within radiocarbon dating and their impact in ^{14}C-dates-as-data studies. Journal of Archaeological Science 113. p. 105043.

Breton G, Schlebusch CM, Lombard M, Sjödin P, Soodyall H, Jakobsson M. 2014. Lactase persistence alleles reveal partial East African ancestry of southern African Khoe pastoralists. Current Biology 24(8):852–858.

Bronk Ramsey C. 2008. Radiocarbon dating: revolutions in understanding. Archaeometry 50(2):249–275.

Bronk Ramsey C. 2017. Methods for summarizing radiocarbon datasets. Radiocarbon 59(6):1809–1833.

Caley T, Extier T, Collins JA, Schefuß E, Dupont L, Malaizé B, Rossignol L, Souron A, McClymont

EL, Jimenez-Espejo FJ, García-Comas C. 2018. A two-million-year-long hydroclimatic context for hominin evolution in southeastern Africa. Nature 560(7716):76–79.

Carleton WC, Groucutt HS. 2021. Sum things are not what they seem: problems with point-wise interpretations and quantitative analyses of proxies based on aggregated radiocarbon dates. Holocene 31(4):630–643.

Chase BM, Boom A, Carr AS, Chevalier M, Quick LJ, Verboom G, Reimer PJ. 2019. Extreme hydroclimate response gradients within the western Cape Floristic region of South Africa since the Last Glacial Maximum. Quaternary Science Reviews 219:297–307.

Chase BM, Boom A, Carr AS, Quick LJ, Reimer PJ. 2020. High-resolution record of Holocene climate change dynamics from southern Africa's temperate-tropical boundary, Baviaanskloof, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 539:109518.

Chevalier M, Chase BM. 2015. Southeast African records reveal a coherent shift from high- to low-latitude forcing mechanisms along the east African margin across last glacial–interglacial transition. Quaternary Science Reviews 125:117–130.

Coutu A, Taurozzi A, Mackie M, Jensen T, Collins M, Sealy J. 2021. Palaeoproteomics confirm earliest domesticated sheep in southern Africa ca. 2000 BP. Scientific Reports 11(1): 6631.

Crema ER. 2022. Statistical inference of prehistoric demography from frequency distributions of radiocarbon dates: a review and a guide for the perplexed. Journal of Archaeological Method and Theory 29(4):1387–1418.

Deacon J. 1984. The Later Stone Age of southernmost Africa. British Archaeological Reports.

Dusseldorp G, Lombard M, Wurz S. 2013. Pleistocene Homo and the updated Stone Age sequence of South Africa. South African Journal of Science 109(5):1–7.

Fischer H, Fundel F, Ruth U, Twarloh B, Wegner A, Udisti R, Becagli S, Castellano E, Morganti A, Severi M, et al. 2007. Reconstruction of millennial changes in dust emission, transport and regional sea ice coverage using the deep EPICA ice cores from the Atlantic and Indian Ocean sector of Antarctica. Earth and Planetary Science Letters 260(1–2): 340–354.

Fortes-Lima CA, Burgarella C, Hammarén R, Eriksson A, Vicente M, Jolly C, Semo A, Gunnink H, Pacchiarotti S, Mundeke L, et al. 2023.The genetic legacy of the expansion of Bantu-speaking peoples in Africa. Nature. https://doi.org/10.1038/s41586-023-06770-6

Gibbon VE, Davies B. 2020. Holocene Khoesan health: a biocultural analysis of cranial pathology and trauma. International Journal of Osteoarchaeology 30(3):287–296.

Hall S, Smith B. 2000. Empowering places: rock shelters and ritual control in farmer-forager interactions in the Northern Province. Goodwin Series 8:30–46.

Hare VJ, Loftus E. 2018. Scientific dating methods in African archaeology. In: Oxford research encyclopaedia of African history.

Heaton T, Köhler P, Butzin M, Bard E, Reimer R, Austin W, Ramsey CB, Grootes P, Hughen K, Kromer B, Reimer P, Adkins J, Burke A, Cook M, Olsen J, Skinner L. 2020. Marine20—the marine radiocarbon age calibration curve (0–55,000 cal BP). Radiocarbon 62(4):779–820.

Hogg A, Heaton T, Hua Q, Palmer J, Turney C, Southon J, Bayliss A, Blackwell P, Boswijk G, Ramsey CB, Pearson C, Petchey F, Reimer P, Reimer R, Wacker L. 2020. SHCal20 Southern Hemisphere calibration, 0–55,000 years cal BP. Radiocarbon 62(4): 759–778.

Holmgren K, Tyson PD, Moberg A, Svanered O. 2001. A preliminary 3000-year regional temperature reconstruction for South Africa. South African Journal of Science 97(1):49–51.

Huffman TN. 2007. Handbook to the Iron Age: the archaeology of pre-colonial farming societies in Southern Africa. University of KwaZulu-Natal Press, Pietermaritzburg.

Huffman TN. 2009. Mapungubwe and Great Zimbabwe: the origin and spread of social complexity in southern Africa. Journal of Anthropological Archaeology 28:37–54.

L'abbé EN, Loots M, Keough N. 2008. The Matjes River rock shelter: a description of the skeletal assemblage. South African Archaeological Bulletin 63(187):61–68.

Larsen CS. 2000. Skeletons in our closet: revealing our past through bioarchaeology. Princeton and Oxford: Princeton University Press.

Larsen CS. 2015. Bioarchaeology: interpreting behavior from the human skeleton. Vol. 69. Cambridge: Cambridge University Press.

Lewis MC, Sealy J. 2018. Coastal complexity: ancient human diets inferred from Bayesian stable isotope mixing models and a primate analogue. PloS One 13(12), e0209411.

Loftus E. 2023. Radiocarbon dating in African Archaeology. In: Beyin A, Wright DK, Wilkins J, Olszewski DI, editors. Handbook of Pleistocene archaeology of Africa: hominin behavior, geography, and chronology. Springer International Publishing. p. 1931–1941.

Loftus E, Mitchell PJ, Bronk Ramsey C. 2019. An archaeological radiocarbon database for southern Africa. Antiquity 93(370): 870–885.

Loftus E, Pfeiffer S. 2023. Cultural disruption suggested by dates of Late Holocene Burials, Southwestern Cape, South Africa. Current Anthropology 64(4):454–463.

Lombard M, Bradfield J, Caruana MV, Makhubela TV, Dusseldorp GL, Kramers JD, Wurz S. 2022.

The Southern African stone age sequence updated (II). South African Archaeological Bulletin 77(217):172–212.

Lombard M, Caruana MV, van der Walt J, Högberg A. 2020. The Keimoes 3 desert kite site, South Africa: an aerial lidar and micro-topographic exploration. Antiquity 94(373):197–211.

Lombard M, van Aardt A. 2023. Method for generating foodplant fitness landscapes: with a foodplant checklist for southern Africa and its application to Klasies River Main Site. Journal of Archaeological Science 149:105707.

Lombard M, Wadley L, Deacon J, Wurz S, Parsons I, Mohapi M, Swart J, Mitchell, P. 2012. South African and Lesotho stone Age sequence updated (I). South African Archaeological Bulletin 67(195):123–144.

Mitchell P, Whitelaw G. 2005. The archaeology of southernmost Africa from c. 2000 BP to the early 1800s: a review of recent research. The Journal of African History 46(2):209–241.

Moffett A. 2020. The archaeology of metal production in Southern Africa. In: Oxford research encyclopedia of African history. doi: 10.1093/acrefore/9780190277734.013.602

Morris AG. 1992. A master catalogue: Holocene human skeletons from South Africa. Johannesburg: Witwatersrand University Press.

Morris AG. 2022. Bones and bodies: how South African scientists studied race. Witwatersrand University Press.

Orton J. 2014. SALSA: the Holocene technocomplexes, a reply to Lombard and colleagues. South African Archaeological Bulletin 69(199):110–112.

Pereira LM. 2007. Restoring context and identity to mummified remains from South Africa : uncovering hidden information [MSc., University of the Witwatersrand]. https://wiredspace.wits.ac.za/bitstream/handle/10539/6975/Dissertation.pdf?sequence=1

Pfeiffer S. 2016. An exploration of interpersonal violence among Holocene foragers of Southern Africa. International Journal of Paleopathology 13:27–38.

Pfeiffer S, Sealy J, Harrington L, Loftus E, Maggs T. 2020. A Late Holocene community burial area: Evidence of diverse mortuary practices in the Western Cape, South Africa. PloS One 15(4): e0230391.

Rick J. 1987. Dates as data: an examination of the Peruvian preceramic radiocarbon record. American Antiquity, 52(1): 55–73.

Rifkin RF, Vikram S, Alcorta J, Ramond JB, Cowan DA, Jakobsson M, Schlebusch CM, Lombard M. 2023. Rickettsia felis DNA recovered from a child who lived in southern Africa 2000 years ago. Communications Biology 6(1):240.

Russell T. 2020. The role of the Cape's unique climatic boundaries in sustaining specialised pastoralists in southern Africa during the last 2000 years. Azania: Archaeological Research in Africa 55(2): 242–257.

Sadr K. 2012. The origins and spread of dry laid, stone-walled architecture in pre-colonial southern Africa. Journal of Southern African Studies 38(2):257–263.

Sadr K. 2013. A short history of early herding in southern Africa. Pastoralism in Africa: Past, Present and Future 171.

Sampson CG. 2010. Chronology and dynamics of Later Stone Age herders in the upper Seacow River valley, South Africa. Journal of Arid Environments, 74(7):842–848.

Schlebusch CM, Malmström H, Günther T, Sjödin P, Coutinho A, Edlund H, Munters AR, Vicente M, Steyn M, Soodyall H, Lombard M. 2017. Southern African ancient genomes estimate modern human divergence to 350,000 to 260,000 years ago. Science 358(6363):652–655.

Schlebusch CM, Sjödin P, Breton G, Günther T, Naidoo T, Hollfelder N, Sjöstrand AE, Xu J, Gattepaille LM, Vicente M, Scofield DG. 2020. Khoe-San genomes reveal unique variation and confirm the deepest population divergence in Homo sapiens. Molecular Biology and Evolution 37(10):2944–2954.

Schroeder L. 2020. Revolutionary fossils, ancient biomolecules, and reflections in ethics and decolonization: paleoanthropology in 2019. American Anthropologist 122(2):306–320.

Scott L. 1982. Late quaternary fossil pollen grains from the Transvaal, South Africa. Review of Palaeobotany and Palynology 36(3):241–278.

Scott L, Holmgren K, Talma SA, Woodborne S, Vogel JC. 2003. Age interpretation of the Wonderkrater spring sediments and vegetation change in the Savanna Biome, Limpopo province, South Africa. South African Journal of Science 99:484–488.

Sealy J. 2016a. Intensification, diet, and group boundaries among Later Stone Age coastal hunter-gatherers along the western and southern coasts of South Africa. In: Lee-Thorp J, Katzenberg A, editors. The Oxford Handbook of the Archaeology of Diet. Oxford University Press.

Sealy J. 2016b. Cultural change, demography, and the archaeology of the last 100 kyr in Southern Africa. In: Jones S, Stewart B, editors. Africa from MIS 6-2: population dynamics and paleoenvironments. Springer.

Smith AB. 1993. Different facets of the crystal: early European images of the Khoikhoi at the Cape, South Africa. Goodwin Series. p. 8–20.

Steyn M. 1994. An assessment of the health status and physical characteristics of the prehistoric population of Mapungubwe [unpublished PhD thesis]. University of the Witwatersrand.

Steyn M, Whitelaw G, Botha D, Vicente M, Schlebusch CM, Lombard M. 2019. Four Iron

Age women from KwaZulu-Natal: biological anthropology, genetics and archaeological context. Southern African Humanities 32:23–56.

Talma S, Vogel JC. 1992. Late Quaternary paleotemperatures derived from a speleothem from Cango Caves, Cape Province, South Africa. Quaternary Research 37(2):203–213.

Tyson PD, Karlen W, Holmgren K, Heiss G. 2000. The Little Ice Age and medieval warming in South Africa. South African Journal of Science 96(3):121–126.

Vogel JC, Plug I, Webley L. 1997. New dates for the introduction of sheep into South Africa: the evidence from Spoegrivier Cave in Namaqualand. South African Journal of Science 93:246–248.

Wadley L. 1989. Legacies from the Later Stone Age. Goodwin Series 6:42–53.

Wilkins J. 2020. Is it time to retire NASTIES in southern Africa? Moving beyond the culture-historical framework for Middle Stone Age lithic assemblage variability. Lithic Technology 45(4):295–307.

Williams AN. 2012. The use of summed radiocarbon probability distributions in archaeology: a review of methods. Journal of Archaeological Science 39(3):578–589.

Zhao X, Dupont L, Schefuß E, Meadows ME, Hahn A, Wefer G. 2016. Holocene vegetation and climate variability in the winter and summer rainfall zones of South Africa. Holocene 26(6):843–857.