Canteen Kopje: A new look at an old skull

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The Canteen Kopje (CK) skull was found by a diamond digger working the Vaal River gravels in 1929. It was hailed by Robert Broom as an exceptionally robust prehistoric individual that was ancestral to modern South African populations. Further exploration of the Vaal Gravels has confirmed the antiquity of the purported find locality, but the heavily restored CK cranium offers limited possibilities for morphometric re-examination or direct dating with which to test Broom's assertion. We used X-ray tomography to create a computerised 3D image that would provide optimal visualisation of the morphometry of the bony surfaces. The results showed that the CK cranium falls within the range of variation of Holocene Khoesan and lacks archaic features. We propose that it was probably a Late Stone Age intrusion into the Vaal Gravels or the overlying Hutton Sands.

Introduction

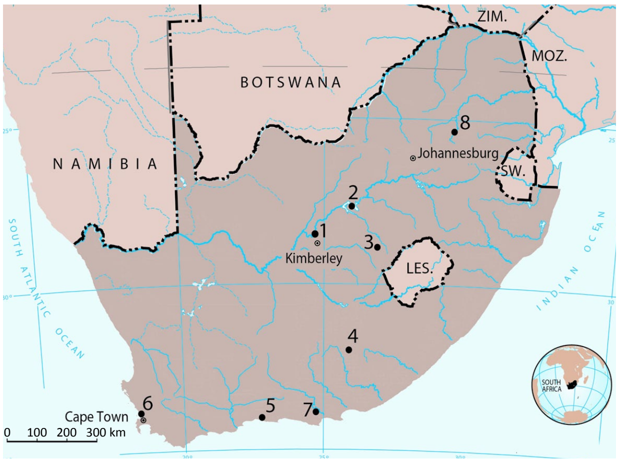
The Vaal River gravels first attracted attention in the late 19th century following the discovery of alluvial diamonds at Canteen Kopje (CK), then known as Klipdrift, situated about 36 km north-west of the city of Kimberley in the Northern Cape Province of South Africa (Figures 1 and 2). As diamond exploration continued, it became obvious that the Vaal Gravels were also an important archaeological locality yielding thousands of Acheulean artefacts.[1,2,3] In 1913, a heavily mineralised fragmentary skeleton was found at Boskop near Johannesburg; the skeleton was attributed to an archaic South African population.[4,5,6,7] The discovery a few years later of the Tuinplaas (or Springbok Flats) skeleton, associated with an extinct buffalo, was considered further proof of the presence of antecessors who differed from the extant populations of South Africa. Broom[8] noted:

> A few months ago, the discovery of the Springbok skull revealed to us the fact that many thousands of years ago there lived in South Africa a large-brained powerfully built race which was neither Bushman nor Bantu, and a race which in all essentials resembles the living Korannas [a Khoe group, remnants of whom lived along the Vaal and Riet Rivers[9,10]] so closely as to leave little doubt that the Korannas are the descendants.

Thus, the discovery in 1929 of human remains at the known Acheulean site of CK[11] filled a vacant niche in an already well-constructed paradigm – one that influenced the thinking of physical anthropologists for many years.

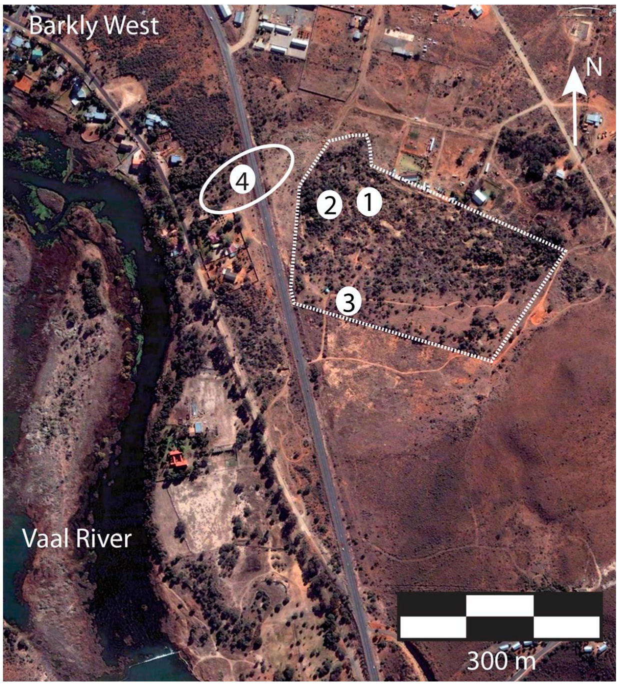
The CK remains, comprising fragments of a human cranium, were discovered by a diamond digger named Kenneth Kemp and passed to J.G. van Alphen, 'magistrate, writer and fossil collector'[12], who presented them to the McGregor Museum. The museum made the remains available to Robert Broom for examination. Broom[11] published the first description of the skull in *Nature*, describing it as a 'fossilised human braincase recovered from an alluvial deposit of the Vaal River at Canteen Kopje near Barkly West.' Curiously, he also refers to 'some fragments of limb bones' found with the skull, but did not describe them and they are not mentioned in the museum's 1929 accession record (MMK 215: 'Skull [incomplete]').

According to Broom[11], the CK human remains were heavily mineralised and discovered 'in a deep alluvial bank' (the museum's accession record suggests a depth of '8 ft'), but the exact find spot at the site is unknown. Seven decades later a 90-year-old digger, Mr Eddie Fortune,[13] recalled that Mr Kemp's claim had been along the north-western edge of the diggings, east of the old Kimberley Road. This recollection would place the find spot of the CK skull downslope from the declared Provincial Heritage site zone of Canteen Kopje (Figure 2), possibly in a unit of the Younger Vaal Gravels closer to the river and chronologically more recent than the deposits within the declared heritage zone (Figure 3).[14] Previous claims that the skull fragments came from the Younger Gravels beneath the Hutton Sands within the main Canteen Kopje site seem unlikely, given that there is no fossil bone preservation at this locality.[15,16] The Younger Gravels at the main site are thought to be late Pliocene to Lower Pleistocene in age,[3] corroborated by recent cosmogenic nuclide burial ages ranging from 1.89±0.19 Ma to 1.26±0.10 Ma for the Younger Gravels at Windsorton.[17]



1, Canteen Kopje; 2, Boskop; 3, Florisbad; 4, Hofmeyr; 5, Matjes River Rock Shelter; 6, Peers Cave; 7, Tsitsikamma; 8, Tuinplaas (Springbok Flats).

FIGURE 1: Map of South Africa showing the locations of Canteen Kopje and other sites.



Location of excavations: 1, Beaumont and McNabb[54]; 2, Forssman et al.[57]; 3, Chazan et al.[58]; 4, the location of Kenneth Kemp's dig as proposed by Eddie Fortune is denoted by a circle. Note that the Canteen Kopje National Monument zone lies +16 m above the Vaal River.
Note: Please see the full reference list of the article, Smith P, Nshimirimana R, De Beer F, et al. Canteen Kopje: A new look at an old skull. S Afr J Sci. 2012;108(1/2), Art. #738, 9 pages. http://dx.doi.org/10.4102/sajs.v108i1/2.738, for more information.

FIGURE 2: Aerial photograph showing the Canteen Kopje Provincial Heritage Site zone (demarcated by broken line), Vaal River and surrounding area.

Broom[11] described the CK specimen as one of the largest and most robust he had ever examined. Broom identified the specimen as ancestral to modern South Africans, probably more recent than the Tuinplaas or Boskop skulls. The CK specimen was one of a number of crania discovered in South Africa in the first part of the 20th century that were grouped together because of their large cranial capacity and presumed antiquity into the so called 'Boskop' physical type. These crania were found throughout South Africa, some apparently associated with Middle Stone Age artefacts or in 'pre-Bushman' archaeological horizons.[18,19,20,21,22,23,24,25] Accordingly, the crania played an important role in early discussions of the origin of the southern African Khoesan.[26,27,28,29,30,31,32,33] New developments in the field have enabled researchers to date some of these specimens and re-examine their association with a specific archaeological horizon. At the same time, the application of advanced imaging and statistical techniques have provided better resolution and analysis of the size and shape of incomplete specimens, thus enabling their integration into the current human evolutionary record. This reclassification has been carried out for skeletal remains from Tuinplaas,[34] Matjes River Rock Shelter,[35] Hofmeyr,[36] Peers Cave[37] and other localities.[38] Ranging in age from the late Pleistocene to the post-contact period, these specimens provide a chronological framework with which to evaluate the CK skull and assess the probability that it derives from the Vaal Gravels.

Materials and methods

Description of the Canteen Kopje skull

The CK cranium is incomplete. It comprises most of the occipital bone except for the basi-occiput, incomplete right and left temporal bones, part of the right mastoid process, most of the left parietal, but only fragments of the right parietal and left side of the frontal bone; about two-thirds of the lateral part of the supra-orbital margin and the orbital root of the zygomatic process are also present (Figure 4). The supra-orbital margin is broken inferiorly, which limits assessment of its size and shape. The left lateral portion of the frontal bone shows a pronounced, forward-projecting supra-orbital ridge, associated with a well-defined post-orbital sulcus. The supra-orbital ridge continues laterally as a pronounced supra-orbital shelf that forms the orbital root of the zygomatic process. The ascending portion of the lateral fragment of the frontal squama is low, but full and rounded. The superior temporal line is pronounced with a well-developed crest. The mastoid process is broad and is bounded medially by a deep digastric groove. Medial to this groove are two parallel, well-developed crests, with the medial one the most distinct.

Broom modelled the missing parts of the cranium in plaster of Paris: the face, the orbits, the glabella, the vault and most of the right side of the frontal and parietal bones, and the sphenoid (Figure 4). The resulting reconstruction shows a very long and low calvarium with projecting supra-orbital ridges and a short, broad face. Based on this reconstruction, Broom[11] estimated cranial length (glabella to lambda) as 215 mm, maximum cranial breadth as 140 mm and basi-bregmatic height as 140 mm. It should be emphasised that three of the four landmarks used (glabella, bregma and basion) were missing and arbitrarily defined by Broom.

The occipital and parietal bones of CK are flattened superior-inferiorly, with lambda inferiorly located and there is a prominent occipital bun. How much of the flattening results from post-depositional compaction, and/or the

Source: McGregor Museum archive

FIGURE 3: Two views of diamond diggings at Klipdrift (Canteen Kopje): (a) on the Vaal River and (b) above the river.

reconstruction, is difficult to establish. Wells[25] questioned the accuracy of the restoration, specifically the curvature of the parietal fragments and angulation of the occipital bone. He pointed out that the vault contour was somewhat lower and flatter in the restoration than in the original illustration given by Broom[11], exaggerating the length of the skull. Even if the restoration exaggerated the length of the occipital chord, it would not have affected the length of the occipital arc, which is exceptionally long (measuring 120 mm from lambda to the most anterior portion of the incomplete basi-occiput).

A feature of the CK skull, which has not been previously described, is a well-defined circular depression located on the left side, some 44 mm posterior to the rim of the orbit and directly above the superior temporal line (Figures 4a–b and 5a). This lesion is approximately 2 cm in diameter with smooth, inwardly sloping margins and slightly raised edges (Figure 5a). The bone surrounding the lesion shows no cracks or breaks that would indicate that damage occurred around the time of death or post-mortem.

A depression of similar size and form is present on the frontal bone of at least one other cranium from the Northern Cape held in the McGregor collection – an adult female (catalogue number MMK 292) described in the McGregor museum's accessions catalogue as: 'Skull only, no lower jaw. Koffiefontein. 19/6/1946. [Presented by] W [illiam] Fowler'. It is one of about 57 burials excavated by Fowler in the environs of Koffiefontein that were attributed to the Late

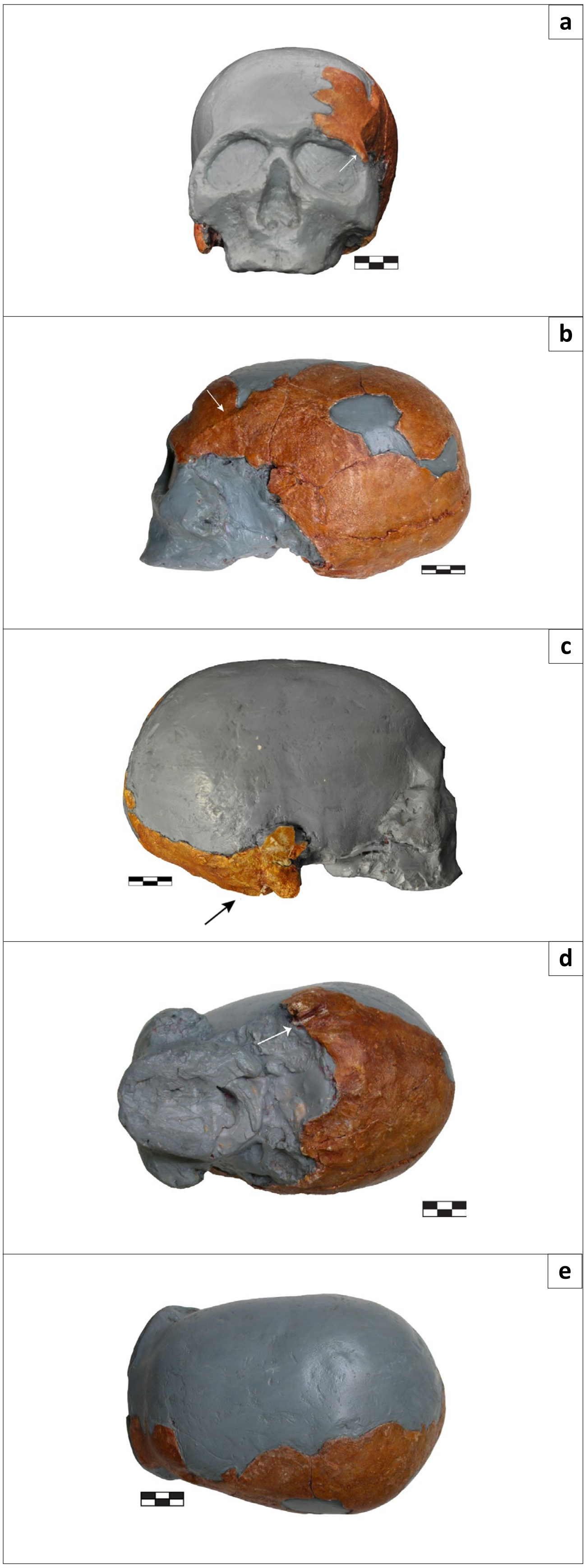


FIGURE 4: Broom's reconstruction of the Canteen Kopje cranium. Reconstructed areas in plaster of Paris are grey. Note (a) the broken inferior margin of the supraorbital region; (a–b) the pronounced lateral projection bounded superiorly by a broad shallow groove, the sloping forehead, marked superior temporal line and lesion on the frontal bone; and (c-d) the pronounced muscle markings around the mastoid process with a deep digastric groove.

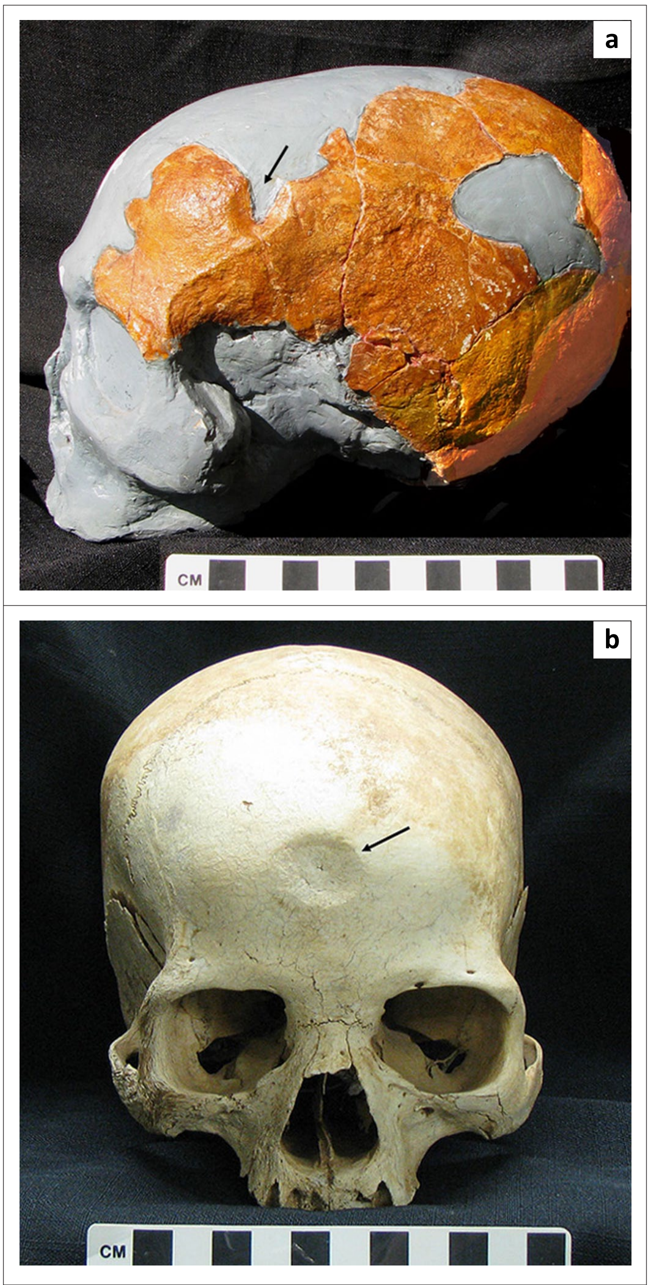


FIGURE 5: Photographs of cranial lesions on (a) the left side of the Canteen Kopje skull and (b) the frontal bone of Koffiefontein specimen MMK 292. Note the similar size and form of lesions in both specimens and the reparative bone on the floor of the lesion in MMK 292.

Stone Age Type-R stone-walled settlements along the Riet River.[39,40,41] In specimen MMK 292, there are clear signs of reparative bone formation in the central part of the affected area confirming that the lesion occurred during life (Figure 5b). It may have resulted from trauma, pressure from a cystic lesion of the scalp or an incomplete scrape trephination, as described by Drennan[42] on Khoesan crania. If we assume a similar aetiology for the lesion present on the CK skull, we may conclude that it too resulted from such a non-lethal event.

Broom's restoration of the CK cranium now shows many signs of wear and tear. The bones are coated with shellac that has discoloured with age and is chipped in places. The margins of the bones are deeply embedded in plaster, which obscures their edges, whilst the thick layer of shellac obscures the outer surface of the bones. A lateral skull X-ray radiograph was taken to evaluate the feasibility of freeing the bones from the plaster to facilitate a detailed study of its external and internal morphometry, as well as to check for matrix that could be used for dating or to establish provenance. The radiograph showed that the materials used by Broom in the skull reconstruction included a metal strut placed inside the cranial vault for support, whilst the bone fragments and joins were deeply embedded in the plaster, thus complicating any attempt to free them. As an alternative measure, a series of non-invasive investigations including X-ray computerised tomography (CT) scans was conducted to create a 3D computerised model of the skull that would differentiate between bone and plaster.

Computerised tomography scans of the skull

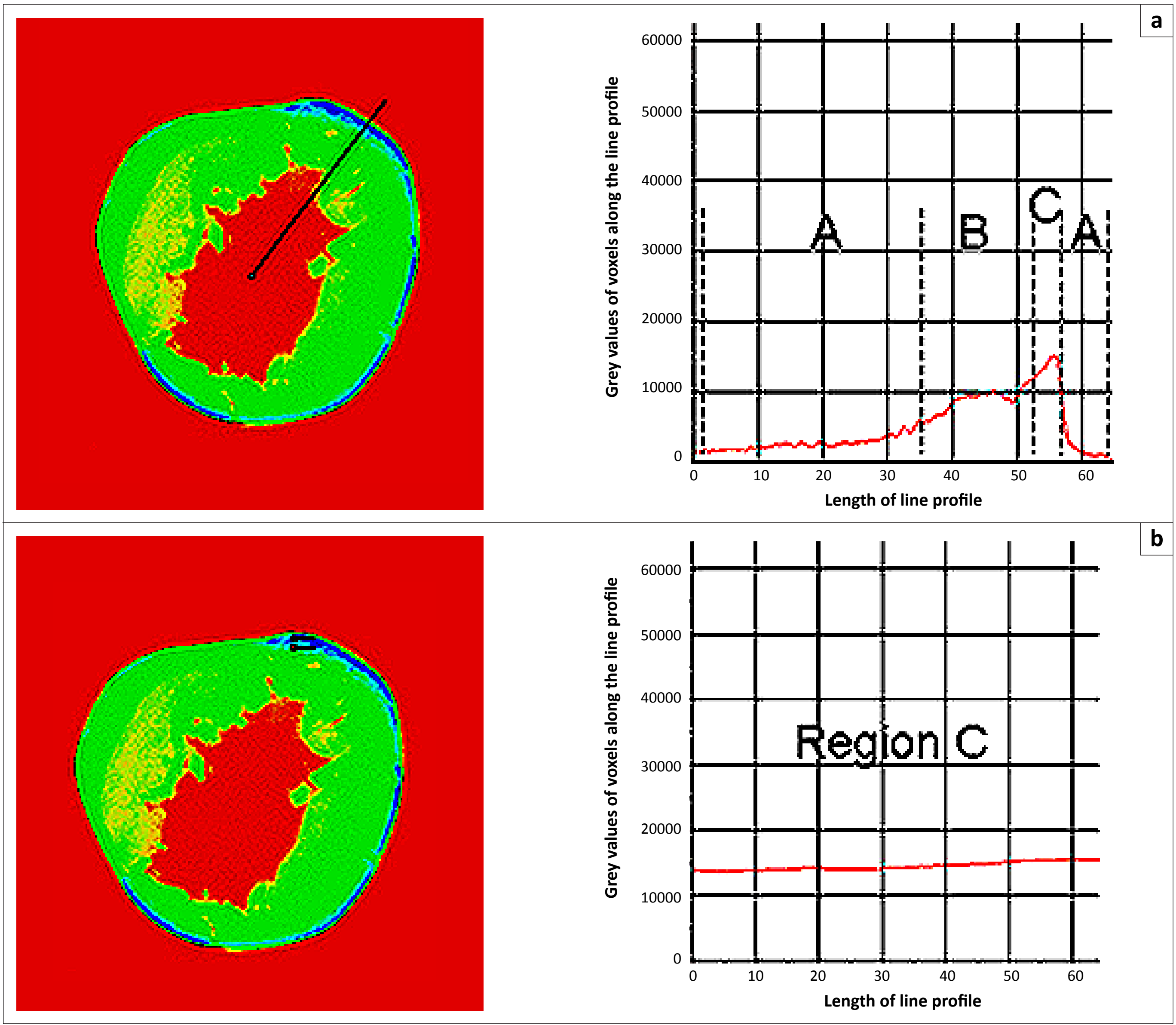
The X-ray CT scans of the reconstructed CK skull were carried out at the South African Nuclear Energy Corporation (Necsa) near Pretoria.[43] In view of its relatively large size, the anterior and posterior portions of the CK skull were scanned separately to improve spatial resolution by reducing the size of the scanned object. Scans were first taken with a focal point of 1 mm with corresponding 3D voxel size of 0.195 mm^3 and then with a focal point of 3 mm and a voxel size of 0.208 mm^3. A series of individual reconstructed 2D slices were stacked to provide a virtual 3D image (tomogram) of the sample. The radio-opacity of the bone versus plaster was computed using the grey value of voxels on a slice image through the reconstruction (Figure 6). Image-ProPlus (IPPLUS) digital software program[44] was used in the opacity analysis. The minimum thickness of the cranial bones at different locations on the skull was computed using VGstudioMax 3D visualisation software.[45]

Results

The line profile graph shown in Figure 6 shows the peaks representing the three media – the void, the plaster and the bone. For the bone area, the voxels varied between 1000 and 18 000 in grey values; for the plaster area, the values varied between 800 and 1000; and for the transitional area between the void and the plaster, the values varied between 500 and 900. These results show that the pixel density provided good definition between the bone, the plaster and the metal strut, with the opacity of the bone nearly double that of the plaster matrix (Figures 6 and 7).

The wall thickness analysis menu, used to map the thickness of the cranial bones at different locations on surface images, is shown in Figure 7. The thickness of the bone at different locations varied between 2 mm and 5 mm. Selected 3D reconstructions of sagittal sections through the parietal and occipital bones are shown in Figure 8.

Detailed examination of the supra-orbital region showed no evidence of frontal sinus extension into the preserved portion of this bone, as would be expected if the supra-orbital region



From 0 mm to 30 mm, voxels on the line profile represent the void inside the skull. From 30 mm to 40 mm, the line profile represents the transition between lower and higher opaque materials, in this case the void (lower attenuating material) and the plaster (higher attenuating material). This transition is represented in yellow in the image; in the transition area, the grey values rise from about 500 to about 900 voxels. From 40 mm to about 50 mm, the voxels on the line profile represent the plaster; their grey values vary between 800 and 1000. The transition between the plaster and the bone is represented in light blue between 50 mm and about 55 mm. The bone area is represented by the dark blue area on the slice; the voxels of the grey values representing the bone on the line profile vary between 1000 and 18 000. Most of the voxels representing the plaster on the line profiles have grey values less than 1000. The maximum grey value taken through the plaster was 8122 and the minimum was 6650. The maximum grey value for the bone was 15 595 and the minimum was 13 548, with a mean value of 14 481. Bone thickness measured from the line profile in different regions ranged from 2 mm to 5 mm.

FIGURE 6: (a–b) Line profiles on a 2D slice of the reconstructed Canteen Kopje skull illustrating the grey values of voxels representing the background (red and region A), the plaster (green and region B) and the bone (blue and region C) used to separate the bone from the plaster and to calculate the bone thickness.

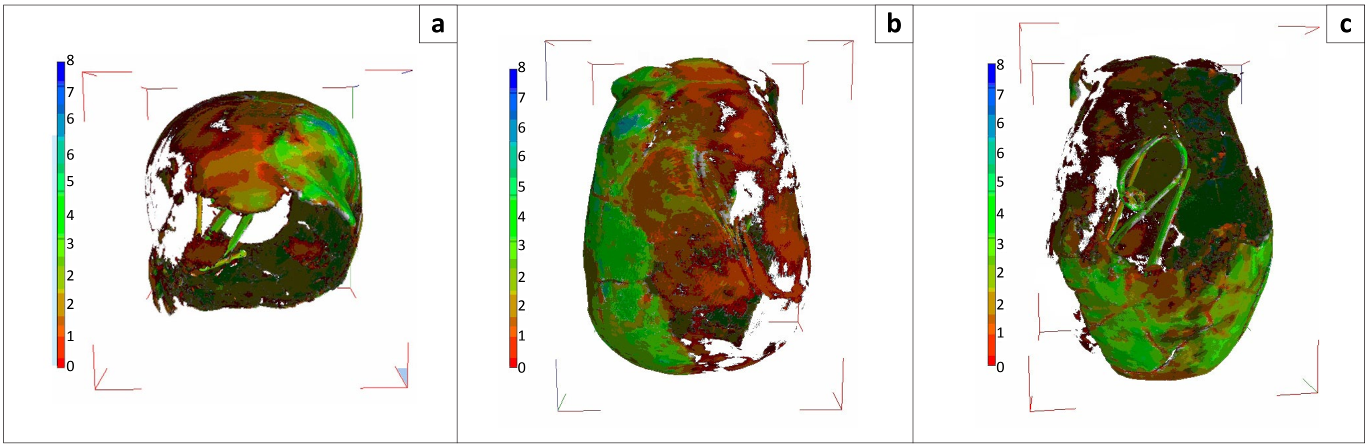
was especially thick. No evidence was found for sclerotic bone or bone resorption on the margins, on the surface of the parietal lesion or in the surrounding bone, nor was there any evidence of damage that might have been caused post-mortem.

The sliced tomogram showing the interior of the posterior half of the skull, primarily represented by the occipital bone, is shown in Figure 9. The endocranial surface is obscured in places, probably by materials used in reconstruction (perhaps hessian impregnated with plaster or glue), but there is no evidence of adherent sedimentary matrix that could be used for dating or to assess provenance.

Discussion

The X-ray CT scans confirmed that, during reconstruction of the CK skull by Broom, the bones were inserted directly into the plaster so that any attempt to separate them without causing further damage would be risky. The scans also showed that there does not seem to be any matrix adherent to the inner surface of the bones that could be used for dating or determining the stratum in which they were found.

Measurements taken on the reconstructed tomogram show the CK skull to have had a thin-walled cranium (Figures 6, 7 and 8). Where bones were in anatomical contact, there



Note: The colours represent different thicknesses (mm) as shown in the scale. On a scale of 0–10, values for bone are in the range 2–6, values for plaster are less than 2 and values for the metal strut are outlined in green (indicating similar radio-opacity to that of the bone).

FIGURE 7: Three 3D tomograms of the CK skull showing bone thickness across the skull: (a) frontal (b) superior and (c) inferior views. Bone and plaster were separated using the grey values of voxel representation. Some thin layers of plaster (red) are still present in the 3D image.

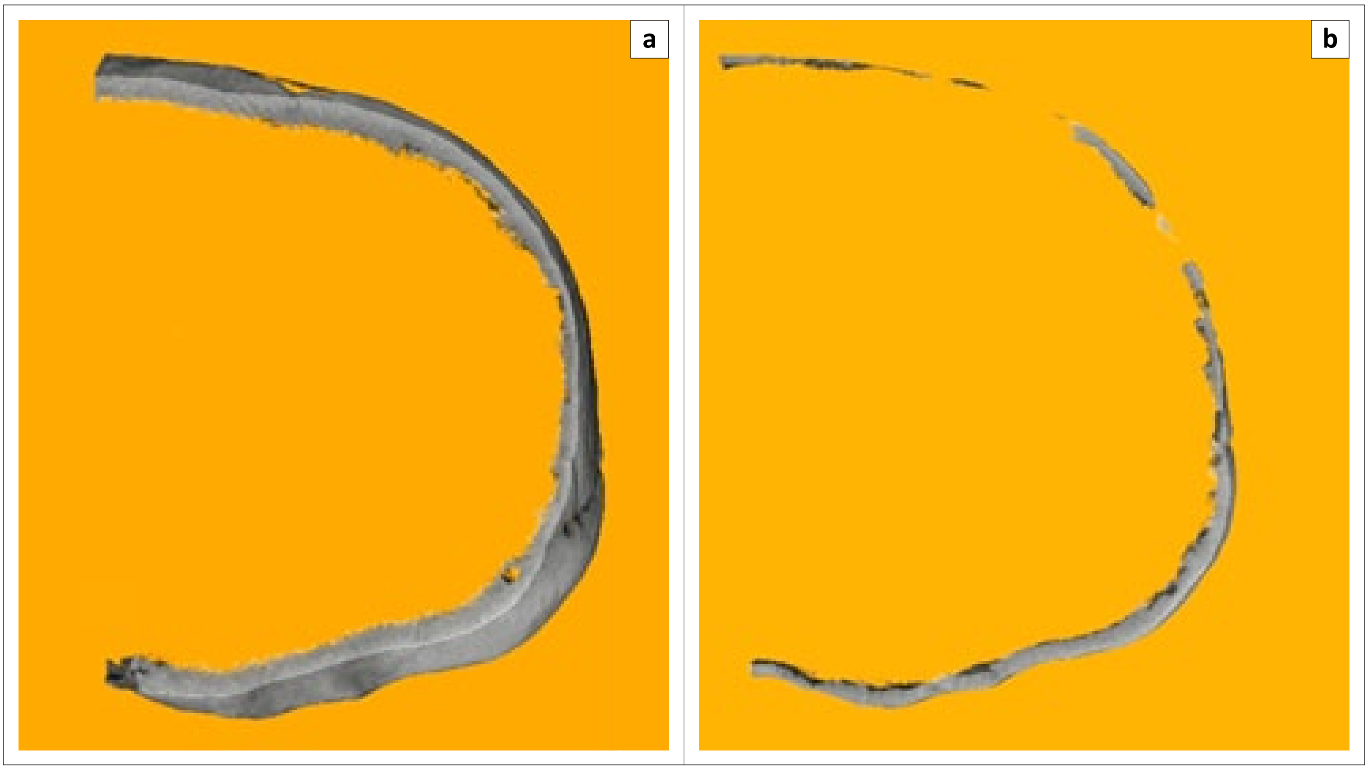


FIGURE 8: Two 3D reconstructions taken through the left parietal and occipital bones with filling materials removed: (a) oblique view and (b) sagittal view.

were no overlapping or unnecessary gaps, indicating that the reconstruction did not exaggerate cranial length or modify angulation between bones. Broom's[11] claim that the CK skull was one of the most robust that he had examined was based on the well-developed areas of muscle attachments, especially the marked supra-orbital ridges. These and the large size and outline of the incomplete brow ridge and somewhat flattened frontal region, led him to describe the specimen as 'Australoid'. However, the partial suture closure at lambda indicates that the CK cranium represents a mature adult, so that the pronounced muscle markings on the temporal bones are not exceptional for a mature individual with powerful masticatory muscles. Moreover, Broom[46] had previously published a brief description of four crania of similar dimensions and robusticity to the CK skull, from what he described as a 'Hottentot grave probably 150–250 years old from near Upington'. The largest of these crania was 202 mm long, 139 mm wide and 139 mm high (basion–bregma height), that is, very similar to CK. In a subsequent summary of then known prehistoric crania, Broom[21] compared the specimens from Boskop, Florisbad, Fish Hoek, Tuinplaas and the Cape Flats, amongst others, and concluded that the CK cranium most closely resembled that from the Cape Flats. He referred to CK and the other skulls defined by him as 'Australoid', as specifically related to the robust 'Korana' population known from the Riet River and environs. However, although he identified the CK skull as ancient, at no point did he consider it to show specifically archaic features similar to those present in the Florisbad cranium.[47,48]

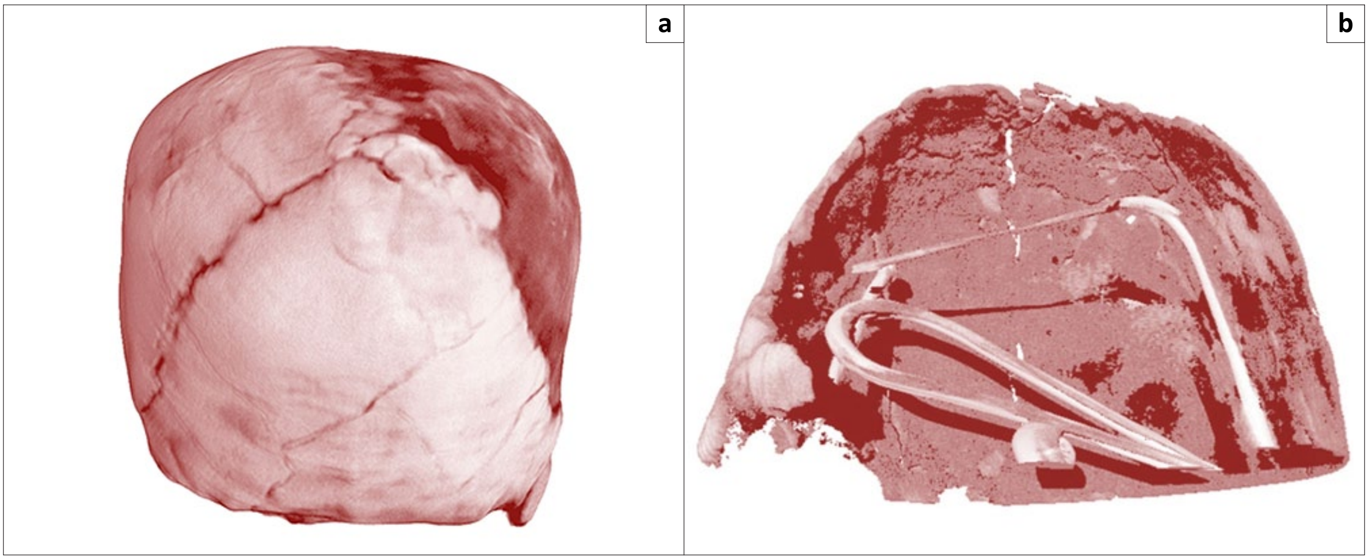


FIGURE 9: Occipital and parietal bones shown as (a) a 3D reconstruction from X-ray tomography, and (b) an internal view of the same area showing the endocranial surface and metal strut used in Broom's reconstruction of the Canteen Kopje skull.

Singer[30] reported that all the morphological features previously described as 'Boskopoid' or 'Australoid' were present in recent Khoesan populations and wrote a scathing denunciation of the use of type specimens for defining distinct racial types. Singer's contention has been supported by more recent studies, such as Morris[41] and Stynder et al.[38], which have demonstrated that the 'Boskopoid' specimens fall within the range of morphometric variation of recent Khoesan, when this definition is expanded to include specimens defined as 'Hottentot' or 'Korana' that were excluded from many analyses of indigenous South African populations defined as 'San' (see for example Howells[49]).

Renewed excavations, with more precise stratigraphic control, at sites such as Matjes River Rock Shelter[50] showed that the alleged association of 'Boskop type' specimens with Middle Stone Age artefacts[51] was erroneous and that the concept of an ancestral 'Boskop type' needed to be re-evaluated.[27,28,29] Indeed, many of the 'Boskop type' specimens are now known to be more recent than originally thought. For example, the Tuinplaas skull has now been dated to between 20 000–11 000 BP,[34] the Matjes River Rock Shelter skeleton No 1 to 2280±60 BP,[35] the Peers Cave specimen (SAM-AP4692) to the mid-Holocene[38] and the Cape Flats specimen has been dated by association to 150±50 BP.[52] Noteworthy is the fact that the latter specimen was considered by Broom to most closely resemble the CK skull.

Archaeological context

Following recent excavations at Canteen Kopje within the Provincial Heritage Site zone (Figure 8), Beaumont and McNabb[15,16,53,54] identified three main archaeological horizons. Acheulean artefacts occur in the diamond-bearing colluvial sediments, the Younger Gravels (Rietputs A and B), which they termed Stratum 2 (a and b), and which include Victoria West cores and some of the largest handaxes ever discovered in South Africa.[15,54,55,56] At the top of Stratum 2a, a small lithic assemblage that includes blades, laminar Levallois products, convergent points, retouched points and manuports has been attributed to the Fauresmith (a transitional Early to Middle Stone Age industry).[16,53] The gravels are overlain by 0.2 m – 5.0 m of reddish sand known as the Hutton Sands (Stratum 1).[3] The presence of Later Stone Age artefacts on the surface and in the uppermost layer of the sands, with Middle Stone Age artefacts deeper within them, have now been reported from three different excavation areas at the site (Figure 2).[16,53,54,57,58] Although extremely rich in lithics, no faunal or human remains have been recovered from the Younger Gravels at the main CK locality, despite archaeological excavations at different localities within the site.

Kenneth Kemp was reportedly digging at a depth of some 2.4 m in an alluvial bank at Canteen Kopje when he found the skull. If Mr Fortune's recollection is correct, Mr Kemp was probably closer to the river bank than the main CK locality (Figure 2). Fossil fauna, including extinct forms, have been found some 4 km – 6 km to the south-east of CK on the river bank, for example at Pniel 6 and Powers site, where they are associated with Acheulean and Fauresmith artefacts.[14,16,53,59] However, it is unlikely that the CK skull originated in these deposits, because the skull is completely modern in appearance, thin walled, and lacks archaic features such as those found in the Florisbad specimen, dated to ca. 260 000 BP.[60]

The Hutton Sands cover the Vaal Gravels throughout the CK locality but vary greatly in thickness. They are thinnest in the distal part of the gravel units and increase in thickness in the lee of the gravel splay.[3] This variation is demonstrated by the fact that, in the northern part of the site, Forssman et al.[57] reported that the Hutton Sands were 1.0 m – 1.4 m thick, whilst in the southern part, Chazan et al.[58] excavated sands 3.5 m deep without reaching the Vaal Gravels. This variability means that, if working in the main CK locality, Mr Kemp may have still been digging in the Hutton Sands or may have only just reached the Vaal Gravels when he found the CK skull at 2.4 m. Minute bone fragments have been found in a Late Stone Age context in one area of the CK site (No 2 in Figure 2) dated to AD 1436–1870.[57] No human or animal remains have been found in other excavated Late Stone Age or Middle Stone Age localities.[16,54,58]

Conclusions

In terms of morphology and size, the CK skull falls within the range of variation of Holocene Khoesan as defined by Stynder et al.[38] Because the rate and extent of mineralisation of skeletal remains varies according to soil type and humidity,[61] Broom's comment[11] that the CK was heavily mineralised is not in itself evidence of antiquity. Moreover, the Tuinplaas specimen, which he also described as heavily mineralised,[8] has now been shown to date to the Later Stone Age.[34]

As we have shown, the known archaeological record of the site does not support an *in situ* provenance in the Vaal Gravels. The most likely interpretation is that the CK skull represents a recent intrusion either into the Hutton Sands, or alternatively into the Vaal Gravels at a locality where the sand cover was thin. Broom commented that the absence of jaws or teeth made it doubtful that the CK specimen derived from a burial. However, Broom did note in his initial report, that limb bones were found with the skull. Because these post-cranial elements are now missing (and were not described by Broom and presumably were not present when the CK skull fragments were first given to the museum in 1929), we cannot corroborate their existence nor whether they belonged to the same specimen. However, if the CK specimen originated in the Vaal Gravels, it is unlikely that skull fragments and limb bones from the same individual would be found together, given that, under fluvial conditions, bones of a skeleton tend to scatter and undergo hydraulic sorting based on shape, size and weight.[62]

The significance attached to the discovery and interpretation of the CK cranium provides a salutary lesson as to the role played by preconceptions in academic research. In this case the acceptance of 'Boskop man' as a fossil ancestor established a precedent that influenced the subsequent course of South African anthropology. Thus, the reported context, that is, the presence of Acheulean artefacts and the state of mineralisation of the CK specimen, encouraged Broom to set it apart from other recent South African crania and declare it an example of an ancestral race. As graphically described by Singer[52], this was based on:

> the 'divine method' of analysis … i.e. using very few facts, inadequate data, lots of gut reaction and an overflow of subjective opinions to make a pronouncement on the origin (ethnic, racial or species) of a skull (or even a tooth).

Although the 'Boskop' theory has been discredited and laid to rest in most scientific circles,[29,31,32,33,52] it is suggested that the CK restoration made by Robert Broom should be preserved as part of the historical record of Canteen Kopje.

Acknowledgements

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Competing interests

We declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this article.

Authors' contributions

P.S., L.J. and F.D. were responsible for the experimental design. R.N. performed the 3D analyses. L.K.H., D.M. and M.C. made conceptual contributions. P.S. wrote the manuscript with contributions from the other authors.

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