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# EIGHTH REPORT ON THE EXCAVATION OF KEMP'S CAVES

(Second and Final Report on NMC Permit No. 80/98/02/008 issued 26 February 1998)

Submitted to the South African Heritage Resources Agency in Fulfillment of the stipulations of excavation permit no.: **80/98/02/008** (Ref. no.: 9/2/233/13)

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This report covers the period 1 January 2000 to 31 December 2001 of the investigation of the Kemp's Caves palaeoanthropological site situated in the Ngodyama (formerly Krugersdorp) Nature Reserve in the Krugersdorp district, Gauteng Province.



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## Current state of research

Less excavation work at the site was undertaken than what was envisaged in the Seventh Report. This was due to more effort being channeled into preparation and collection based research. The preparation back-log has been reduced to manageable proportions and most of the specimens recovered to date have been identified and studied (100% of the collection excavated before 1998).

Although no hominid bones have as yet been discovered, upper Pleistocene age estimates for Kemp's Caves fall within the expected time period for the origin of anatomically modern humans, thus making further excavation at the site imperative. Estimate D008A of Curnoe's ESR date series, indicating a possible date of 112Ka for locality 7N8E, is exciting as this is a controversial period. Fuanal analysis has indicated that 11.4% of bones from the total assemblage (including more recent fossils) was burnt. This might indicate that the cave was used by humans. Analysis of the faunal remains will also provide more information on the climate and environment of that time.

The results of the ESR dates obtained place the research at Kemp's Caves in a new context. Very few fossil sites in South Africa have the potential to yield information on this time period. Closer collaboration with archaeologists interested in the fauna and palaeo-environment of the region will be considered. The dates need to be controlled and it is possible that comparative dating could give information not only on the age of the deposits but also on the suitability of the different methods for dating cave deposits of this type.

Research at this site is still a relatively recent development and further work on the exact mechanisms and dates of formation of the various taphonomical features is required.

*Fossil material excavated*

Currently, more than 7000 specimens have been either excavated from decalcified deposits or prepared from breccia. All faunal material is currently housed at the Dept. of Anatomy, University of Pretoria. To date a total of approximately 5000 specimens from Lower Kemp's Cave (LKC), representing 100% of the collection excavated from LKC before 1998, were studied by E Swanepoel of the Department of Anatomy, University of Pretoria. Some of the specimens included in the study were un-provenanced (specimens were stored in marked boxes which were destroyed by acidentital flooding while stored at Wits), others were manually and chemically prepared from breccia blocks from various localities in the cave while the rest originated from various decalcified deposits. Some of the specimens included in the study may also have been recent additions to the deposit.

The results of the analysis showed that the sample included mammalian species as well as a few avian and reptilian remains. Between 4 and 5% of the sample could be identified to species level and a total of 28 species were identified (see Appendix 1). Bovid remains account for a large percentage (76%) of the sample. The size representation in the sample might point to leopard or hyena as the accumulating agent.

Apart from *Equus capensis* (of which 5 specimens have been found), all species represented by the faunal sample either occurred in the area in the recent past or still occur there. This could indicate that no major climatic change occurred in the area in the last 100 000 a. One of the most interesting finds was the partial mandible of a large hyena. It was initially classified as *Pachycrocuta bellax* due to its large size, but was later reclassified as *Crocuta crocuta* on account of tooth morphology.

Taphonomic indicators, such as coprolites, tooth marks on bones, and large amounts of crunched bone fragments point to hyenas as the chief accumulating agent. Some evidence indicating the presence of leopards and porcupines is also present. In a recent conference presentation, De Ruiter (1998) suggested that leopards may have played a significant role in cave accumulations. Kemps Cave is currently inhabited by a leopard, occasionally bringing in some fresh prey.

**Dating (Undertaken by Dr D Curnoe)**

*Materials and Methods*

Six heavily fossilised teeth were selected from recently prepared breccia blocks from three localities in LKC, and a seventh was excavated from *in situ* deposits at a fourth locality during ESR field research at the site in 1996. Sample preparation and measurement followed conventional ESR laboratory procedures [1], fragments of enamel were mechanically removed from separate locations on these teeth using a diamond blade attached to a dentist's drill. The flat surface of the diamond wheel was used to remove around 50 to 100 mm from the outer surface of enamel. This removed the volume which was exposed to external a-rays, simplifying dose rate calculations. Enamel and dentine were also mechanically separated, and the enamel was ground by hand using a mortar and pestle and passed through a 150 mm sieve to ensure homogeneity of grain size. Multiple subsamples were prepared to test the uniformity of the samples, each being identical in weight. The enamel from one entire tooth and from seven sub-samples was contaminated with organic material, possibly dentine, and these could not, therefore, be analysed for dating.

The samples were irradiated using a calibrated $^{60}Co$ gamma source with doses of: 0, 5, 10, 20, 40, 80, 160, 240, 320 and 400 Gy. The past irradiation dose, $D_E$, and the associated errors were determined using the procedures outlined by Grün & Brumby [2].

ESR measurements were carried out at room temperature on a Bruker ECS 106 with a 15 kG magnet and a rectangular 4102 ST cavity. The measurement conditions are routinely used for enamel samples: accumulation of 100 scans 20.48 ms Time constant, 2048 bit spectrum resolution (with a total sweep time of 20.972 s), 120 G sweep width, 2 mW microwave power, 1.015 Gpp modulation amplitude, 10.24 ms conversion factor. Signal noise was reduced by Fourier transformation and high frequency stripping [3]; baseline corrections were made where necessary using Bruker spectrometer software. The signal to noise ratio was poor for most samples due to the young age, and relatively high interference levels of organic signals. This added considerable uncertainty for the smallest $D_E$-values with errors ranging from <1% to 30%.

Isotopic concentrations in teeth and sediments were analyzed with inductively coupled plasma mass spectrometry (ICP-MS) for uranium (U) and thorium (Th), and flame photometry for potassium (K). Cosmic dose rates were estimated from present depth below ground of the deposits of around 6±2m.

Water content at the site was found to be negligible at around two percent. For the calculation of dose-rates, conversion factors of Adamiec and Aitkin [4], alpha efficiencies of Grün and Katzenberger-Apel [5] and beta dose attenuation factors of Yang *et al.* [6] were used.

*Dating results and discussion*

The $D_E$-values, results of chemical analysis of samples and sediments, external and internal dose rates, dentine and total dose rates, and age calculations are presented in Table 1. All samples except D8a are within error, with no significant difference between early U-uptake (EU) and linear U-uptake (LU) age estimates. D8a is believed to be from the collapsed roof of LKC and is the oldest sample dated. It is characterised by high dentine uranium concentration, leading to a large difference between EU and LU ages. The youngest sample is Holocene in age dated about 6.1±0.4 ka. All other teeth date to the Upper Pleistocene and range from about 11±0.6 ka to 140±8 ka.

The time range of deposits exposed at Kemp's Caves covers the critical period during the emergence of modern humans in the hominid fossil record. Other sites in southern Africa place this at over 90 ka at Klasies River Mouth [7] and from Border Cave less than 90 ka [8]. Kemp's Caves is the latest site to contain fossils from this time period, and is important also for its apparent lack of significant human and natural disturbance of fossil bearing deposits.

Future dating research at the site should attempt to replicate ESR dating results by applying a range of methods including luminescence, U-series and radiocarbon dating. It also provides great potential for addressing current problems experienced in applying of ESR dating to tooth enamel from Pliocene-Pleistocene hominid caves sites in southern Africa, which is at present the only viable dating method for these sites [9,10].

**Activities since November 1999** (date of previous report)

Apart from various day visits to collect breccia stored in the cave from previous excavations and to monitor the state of the cave and the deposits only one excavation excursion was undertaken in November 2001.

*Excavation excursion:* 2001\11\26-30

Several preliminary visits were made in the weeks before the excursion in order to organize the breaking of the breccia block at locality 6N 6E.

This block was broken with explosives after the necessary permissions were obtained. This was necessary due to the safety considerations. Only the edge of the breccia block at locality 6N 6E was still resting against the wall of the cave and any attempts to break it with feathers and wedges would most probably have resulted in the block dislodging and falling in the gully directly below. Above the rock a hanging member occurred. Several large cracks were evident in this formation and it was feared that should the breccia block dislodge and fall the vibration might bring down this part of the roof. The safest strategy was thought to be the use of explosives which enabled the breaking of the block while nobody was in the cave.

Commercial explosives could not be used since this would have generated high levels of vibration in the rock formations. It was feared that this might dislodge the unstable part of the roof. This type of explosive also causes fragments of rock to fly about since it produces large volumes of gas during detonation. This rendered it unsuitable for this application since the fragments of breccia needs to be recovered for preparation after breaking.

The above mentioned problems were solved by drilling the rock and inserting explosives with a high velocity of detonation to crack the breccia without causing too much vibration and without flinging fragments of rock about. To displace the cracked rock water was poured into the drilled holes after the explosive was inserted. The explosive produced a small volume of gas at detonation that together with the water in the drill hole produced a very high pressure. As a result the water is forced into the cracks caused by the explosion effectively displacing the rock fragments without flinging them about. Heavy rubber mats were also placed over the block before the explosives were detonated to further prevent flying fragments.

The use of explosives was very successful. Very little damage was done to fossils compared to the conventional mechanical breaking. It was without doubt also the safest method of breaking the remainder of this block into manageable pieces. Several blocks of breccia are still in the cave awaiting breaking into smaller pieces and removal for preparation.

No excavation of decalcified deposits were undertaken. The profile of the excavation in the entrance to the Northern Extension was cleaned of material dislodged by animals (most probably porcupines). The recovered materials were screened, sorted, cleaned and accessioned in the usual manner.

## Future research envisaged

Since the current permit has lapsed a new permit application will reflect the envisaged future excavations in the Caves. Currently preparation of already excavated and collections based research breccia is continuing.

## Acknowledgements

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## References

1. Grün, R. (1989). Electron spin resonance (ESR) dating. *Quaternary International* **1**, 65-109.
2. Grün, R and Brumby, S. (1994). The assessment of errors in the past radiation doses extrapolated from ESR/TL dose response data. *Radiation Measurements* **23**, 307-315.
3. Grün, R. (1998). Reproducibility measurements for ESR signal intensity and dose determination: high precision but doubtful accuracy. *Radiation Measurements* **29**, 177-193.
4. Adamiec, G. and Aitken, M. (1998). Dose-rate conversion factors: update. *Ancient TL* **16**(2), 37-50.
5. Grün, R and Katsenberger-Apel, O. (1994). An alpha irradiator for ESR dating. *Ancient TL* **12**, 35-38.
6. Yang, Q., Rink, W.J. and Brennan, B.J. (1998). Experimental determinations of beta attenuation in planar dose geometry and application to ESR dating of tooth enamel. *Radiat. Meas.* **29**(6), 663-671.
7. Grün, R., Shackleton, N.J. and Deacon, H.J. (1990a). Electron-spin-resonance dating of tooth enamel from Klasies River Mouth Cave. *Curr. Anthopol.* **31**(4), 427-432.

8. Grün, R., Beaumont, P. and Stringer, C.B. (1990b). ESR dating evidence for early modern humans at Border Cave in South Africa. *Nature* **344**, 537-539.

9. Curnoe, D. (1999). *A contribution to the question of early Homo in southern Africa: researches into dating, taxonomy and phylogeny reconstruction*. Unpublished PhD Thesis, The Australian National University.

10. Curnoe, D., Grün, R. and Thackeray, F. (1999). Direct ESR dating of a Pliocene Hominid from Swartkrans. Submitted to *J. Hum. Evol.*

Appendix A: Species list – Kemp's Caves

**Hystricidae:**

1. *Hystrix africeaustrais* (Porcupine)

**Leporidae:**

2. *Lepus saxatilis* (Scrub hare)
3. *Pronolagus randensis* (Redrock rabbit)

**Procaviidae:**

4. *Procavia capensis* (Rock dassie)

**Equidae:**

5. *Equus burcelli* (Burchell's zebra)
6. *Equus capensis* (Cape zebra (Extinct +/- 10 000 years))

**Bovidae:**

7. *Raphicems campaestris* (Steenbok)
8. *Aepyceros melampus* (Impala)
9. *Antidorcas marsupialis* (Springbuck)
10. *Damaliscus dorcas phillipsii* (Blesbuck)
11. *Alcelaphus buselaphus* (Red Hartebeest)
12. *Connochaetes taurinus* (Blue Wildebeest)
13. *Connochaetes gnou* (Black Wildebeest)
14. *Tragelaphus Strepsiceros (*Kudu)
15. *Hippotragus niger* (Sable)
16. *Taurotragus oryx* (Eland)
17. *Bos taurus* (Domestic cattle)

**Suidae:**

18. *Phacochoerus aethiopicus* (Warthog)
19. *Potamochoerus porcus* (Bushpig)

**Hyaenidae:**

20. *Hyaena brunnea* (Brown hyaena)
21. *Crocuta crocuta* (Spotted hyaena)

**Canidae:**

22. *Canis mesomelas* (Black-backed jackal)
23. *Vulpes chama* (Cape fox)

**Felidae:**

24. *Panthera pardus* (Leopard)

**Primates:**

25. *Papio cynoceplaus ursinus* (Chacma baboon)
26. *Homo sapiens sapiens* (Human)

**Aves:**

27. *Struthio cameles* (Ostrich)

**Reptilia:**

28. *Geochelane pardalis* (Leopard tortoise)

Table 1: Results of chemical and sedimentological analysis and age estimates for samples from Kemp's Caves.

| | | | | SEDIMENT | | | | | EARLY U-UPTAKE | | | | LINEAR U-UPTAKE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | $D_E$ (Gy) | U(EN) (ppm) | U(DE) (ppm) | U (ppm) | Th (ppm) | K (%) | (µGy/a) | (µGy/a) | (µGy/a) | (µGy/a) | (µGy/a) | (ka) | (µGy/a) | (µGy/a) | (µGy/a) | (ka) |
| D3a | 10.6±3.0 | 0.52±0.05 | 0.55±0.06 | 0.40±0.04 | 2.67±0.27 | 0.36±0.04 | 370±16 | 49±8 | 100±15 | 4±1 | 523±25 | 19.2±1.1 | 47±6 | 2±0 | 468±21 | 21.4±1.2 |
| b | 12.0±0.3 | 0.17±0.02 | 0.31±0.03 | 0.40±0.04 | 2.67±0.27 | 0.36±0.04 | 370±16 | 49±8 | 31±5 | 2±1 | 452±19 | 26.3±1.3 | 14±4 | 1±0 | 438±19 | 27.5±1.3 |
| c | 8.9±0.3 | 0.15±0.02 | 0.36±0.04 | 0.40±0.04 | 2.67±0.27 | 0.36±0.04 | 370±16 | 49±8 | 29±5 | 3±0 | 451±19 | 19.7±1.4 | 13±3 | 1±0 | 433±18 | 20.6±1.4 |
| D4a | 5.4±0.7 | 0.13±0.01 | 0.07±0.01 | 0.96±0.05 | 4.84±0.48 | 0.23±0.01 | 423±19 | 53±8 | 22±4 | 1±1 | 499±21 | 10.8±1.5 | 11±1 | 0±0 | 487±21 | 11.1±1.5 |
| b | 5.4±0.5 | 0.08±0.01 | 0.09±0.01 | 0.96±0.05 | 4.84±0.48 | 0.23±0.01 | 423±19 | 53±8 | 14±1 | 1±0 | 491±21 | 11.0±1.1 | 7±0 | 0±0 | 483±21 | 11.2±1.1 |
| D6a | 2.6±0.1 | 0.03±0.01 | 0.15±0.01 | 0.40±0.04 | 2.67±0.27 | 0.36±0.04 | 370±16 | 49±8 | 13±1 | 1±0 | 433±18 | 6.1±0.4 | 6±1 | 1±1 | 426±18 | 6.2±0.4 |
| D7a | 5.2±0.2 | 0.03±0.01 | 0.04±0.01 | 0.96±0.05 | 4.84±0.48 | 0.23±0.01 | 423±19 | 53±8 | 5±1 | 0±0 | 481±21 | 10.8±0.6 | 2±1 | 0±0 | 478±21 | 10.9±0.6 |
| b | 5.6±0.4 | 0.03±0.01 | 0.04±0.01 | 0.96±0.05 | 4.84±0.48 | 0.23±0.01 | 423±19 | 53±8 | 5±1 | 0±0 | 481±21 | 11.6±1.0 | 2±1 | 0±0 | 478±21 | 11.7±1.0 |
| c | 6.5±0.3 | 0.03±0.01 | 0.04±0.01 | 0.96±0.05 | 4.84±0.48 | 0.23±0.01 | 423±19 | 53±8 | 5±1 | 0±0 | 481±21 | 13.5±0.9 | 3±0 | 0±0 | 479±21 | 13.6±0.9 |
| D8a | 89.7±0.7 | 0.01±0.01 | 31.8±1.5 | 0.67±0.07 | 3.80±0.40 | 1.09±0.11 | 342±15 | 122±21 | 4±2 | 376±49 | 844±55 | 107.0±7.0 | 2±0 | 178±24 | 666±35 | 140.0±8.0 |
| D9a | 17.0±1.7 | 0.05±0.10 | 0.18±0.02 | 0.46±0.05 | 2.19±0.22 | 0.36±0.04 | 367±16 | 47±8 | 12±1 | 2±1 | 428±18 | 40.0±4.0 | 5±1 | 1±0 | 420±18 | 40.0±4.0 |

EN=enamel; DE=dentine. Enamel thickness for all samples 1000 µm.