**Export permits**

Please note an export permit must be linked to an object or site that has to be created on SAHRIS! If the object/site you want to work on has not been created yet, you would need to do so. Thanks!

The proposal should include (you can fill these in below):

* a list of participants (name, affiliation, phone no, email addresses) and how they are involved;
* the name and address of the facility, including address, it is being scanned at;
* name and address of the museum/university department that currently hosts the object;
* names of the responsible person(s) during transport and while the fossil is at the facility;
* the period/time frame during which the fossil(s) will be outside the country;
* detailed information on the fossil(s), especially as it is a "unique" specimen;
* detailed information on the research project behind it & methodology including expected outcomes (i.e., the reason for export);
* the written confirmation of the institution that currently hosts the object that the object may be used as proposed and be returned in good condition;
* should there be any damage/destructive analysis (e.g., coating for higher resolution) undertaken, this needs to be stated in detail;
* Statement why this study cannot be done in South Africa.

**Applicant (name and affiliation): this is usually the museum curator!**

Dr. Bernhard Zipfel, Evolutionary Studies Institute, University of the Witwatersrand, Private Bag 3, Wits, 2050.

**Applied for (principal researcher):**

Dr. Shaw Badenhorst, Evolutionary Studies Institute, University of the Witwatersrand, Private Bag 3, Wits, 2050.

**Participants with affiliations, email addresses, phone numbers (& their role):**

Prof. Kirsty Penkman: University of York, UK, [kirsty.penkman@york.ac.uk](mailto:kirsty.penkman@york.ac.uk), 01904 322574, dating specialist

Dr. Marc Dickinson: University of York, UK, [marc.dickinson@york.ac.uk](mailto:marc.dickinson@york.ac.uk), 01904 322574, dating specialist

**Institution incl. address that currently hosts the object:**

Evolutionary Studies Institute, University of the Witwatersrand, Private Bag 3, Wits, 2050.

**Facility incl. address at which the experiment will be done:**

Department of Chemistry  
University of York, Heslington, York, YO10 5DD, UK   
Tel: work +44 (0)1904 322511

**Table of objects or upload file:**

The 38 specimens I am seeking to use for dating (based on the catalogue book entries):

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Taxa** | **Accession Number** | **Grid** | **Depth (inches)** | **Bed** | **Description** | **Photo** |
| **Early Stone Age** | | | | | | |
| *E. burchellii* | 601 | M-O/12-13 | 31-34 | 2 | Left lower deciduous 2nd molar | X |
| *E. capensis* | 82 | M-N/15 | 36 | 2 | Right molar | JA |
| *E. capensis* | 601 | M-O/12-13 | 31-34 | 2 | Left lower deciduous 2nd molar | KA |
| *E. burchellii* | 21 | O-Q/26-27 | 14-18 | 3 | Left upper 2nd molar | K |
| *E. burchellii* | 24 | Q/20 | 13-15 | 3 | Left deciduous molar | U |
| *E. burchellii* | 451 | P-Q/21 | 13 | 3 | Left lower M3 | W |
| **Loose Breccia (likely Beds 1-3)** | | | | | | |
| *E. burchellii* | 592 | - | - | 1-3 | Left lower 4th premolar | DD |
| *E. burchellii* | 105 | - | - | 1-3 | Left upper M3 | EE |
| *E. burchellii* | 50 | - | - | 1-3 | Right upper M3 | FF |
| **Middle Stone Age** | | | | | | |
| *E. burchellii* | 60 | M-P/15-17 | 24-26 | 4 | Left upper M1 | H |
| *E. burchellii* | 54 | M-O/10-12 | 26-28 | 4 | Left upper M2 | I |
| *E. burchellii* | 92 | M-O/12-13 | 23-25 | 4 | Left upper M2 | J |
| *E. burchellii* | 460 | CH | 120-132 | 5 | Deciduous molar | L |
| *E. burchellii* | 489 | CH | 120-132 | 5 | Right lower M3 | M |
| *E. burchellii* | 38 | CH | 120-132 | 5 | Left upper M2 | N |
| *E. burchellii* | 18 | CH | 144-156 | 6 | Upper right M2 | F |
| *E. burchellii* | 32 | CH | 108-120 | 6 | Molar fragment | T |
| *E. burchellii* | 407 | CH | 168-170 | 6 | Left lower M3 | CC |
| *E. burchellii* | 19 | CH | 96-108 | 7 | Right milk molar | O |
| *E. burchellii* | 77 | CH | 96-108 | 7 | Left upper M1 | P |
| *E. burchellii* | 434 | CH | 96-108 | 7 | Left lower 4th premolar | Q |
| *E. burchellii* | 222 | CH | 84-96 | 8 | Right upper M1 | S |
| *E. burchellii* | 58 | P/20 | 6-8 | 8 | Right upper M1 | V |
| *E. burchellii* | 33 | CH | 72-84 | 8 | Left milk molar | Y |
| *E. burchellii* | 8 | CH | 60-92 | 9 | Right upper M2 | BB |
| *E. burchellii* | 483 | CH | 60-72 | 9 | Right mandible with milk molars | LL |
| *E. burchellii* | 31 | CH | 60-72 | 9 | Right upper M2 | R |
| **Shallow Hole (ESA and MSA mixed)** | | | | | | |
| *E. burchellii* | 529 | V-W/15-19 | 31-34 | SH | Molar fragment | A |
| *E. burchellii* | 640 | V-W/15-19 | 31-34 | SH | Molar fragment | B |
| *E. burchellii* | 464 | P-T/16-19 | 20-22 | SH | Left, deciduous molar | C |
| *E. burchellii* | 466 | P-T/16-19 | 20-22 | SH | Left, lower M2 | D |
| *E. burchellii* | 490 | V-W/15-19 | 31-34 | SH | Molar fragment | E |
| **Later Stone Age** | | | | | | |
| *E. burchellii* | 152 | Q/20 | 45-48 | 10 | Right, upper premolar 4 | G |
| *E. burchellii* | 467 | Q/20 | 48-60 | 10 | Right milk molar | Z |
| *E. burchellii* | 409 | CH | 24-28 | 10 | Right, lower M2 | AA |
| **Iron Age** | | | | | | |
| *E. burchellii* | - | CH | Iron Age | 11 | Upper molar | GG |
| *E. burchellii* | - | CH | Iron Age | 11 | Upper molar | HH |
| *E. burchellii* | - | CH | Iron Age | 11 | Upper molar | II |

**Time frame:**

Once permission is granted, and the samples send, the dating will commence. The dates will be available in 2022.

**Aim/rationale:**

The Cave of Hearths (CoH), located in the Makapan Valley in the Limpopo Province close to the modern town of Mokopane, has long been an influential site to trace the evolution of hominins in southern Africa (Mason 1969; 1988, McNabb and Sinclair 2009). Apart from some earlier investigations, excavations were initiated in the 1940s and continued into the 1950s (Mason 1969). The CoH yielded *in situ* Acheulian (Early Stone Age; ESA) occupation in Beds 1 to 3. The ESA beds have been dated to between 780 000 and 500 000 years ago using palaeo-magnetism dating (Herries and Latham 2009). The CoH also has an extensive Middle Stone Age (MSA) occupation, found in Beds 4 to 9. Mason (1969, 1988) divided the MSA beds at the CoH, based on lithics, as follows: Bed 4 – Early Pietersburg Culture, Bed 5 – Middle Pietersburg Culture, and Beds 6-9 – Later Pietersburg Culture. The presence of lithics from the Pietersburg Industry places the MSA at the CoH in the MSA I and II, dating to between 128 000 and 75 000 (Wurz 2013). The site also has Later Stone Age (LSA) and recent Iron Age/historical occupations, in Beds 10 and 11 respectively (Mason 1969, 1988). Few archaeological sites in South Africa have such an extensive and successive occupations by hominins over millennia. The earlier radiocarbon dates (Mason 1988) vastly underestimated the time depth of the occupations, and these dates are no longer accepted (Wadley 2015).

Both the ESA and MSA occupations of the CoH fall outside the reach of radiocarbon dating, as they postdate 50 000 years ago. Obtaining dates especially for the CoH beds are challenging. Mason (1969, 1988) excavated a considerable portion of the *in situ* deposits, limiting the possibility of OSL dating. ESR dating remains a possibility, but this requires both fossils and breccia, and the latter are not available for the MSA at the CoH. Apart from the inferred dates for the ESA and MSA at the CoH, no dates are available for the LSA and Iron Age occupations. The imprecise dating of the CoH remains a serious constraint. Despite the site’s importance in earlier discussions on the evolution of hominins in South Africa, it has largely been excluded from archaeological debates on the ESA and MSA in particular due to the imprecise dating (Wadley 2015).

Recently, advances have been made in the use of amino acid geochronology for dating Quaternary samples (Penkman *et al.*, [2008](https://www.sciencedirect.com/science/article/pii/S1871101407000416), [2011](https://www.nature.com/articles/nature10305)). This dating technique measures changes in amino acid molecules by the time elapsed since they were formed. Briefly, all biological tissues such as teeth contain amino acids. All amino acids (except glycine) are optically active, having a stereo-center at their α-C atom. The amino acid can have two different configurations, ‘D’ or ‘L’ which are mirror images of each other. Living organisms keep all their amino acids in the ‘L’ configuration, but when an organism dies, control over the configuration of the amino acids ceases, and the ratio of D to L moves from a value near 0 towards an equilibrium value near 1, a process called racemisation. Measuring the ratio of D to L in a sample enables an estimation how long ago the specimen died. In the past, this method of dating could only be applied to molluscs and eggshells, but recent advances makes it now possible to use tooth enamel (Dickinson *et al.* 2019). The use of amino acid racemisation allows the possibility to obtain dates from archaeological samples like the CoH that was excavated several decades ago. The University of York in the UK, in particular Dr. Marc Dickinson and Prof. Kirsty Penkman (co-applicants) pioneered the use of enamel in amino acid racemisation dating. Very few molluscs and eggshells are present in the CoH faunal assemblage (<5 specimens, personal observation) and would therefore not be suitable. Moreover, this dating technique has been correlated with radiocarbon dates at various sites in the world to test the accuracy of the method. A current research programme is underway by Prof. Penkman to date samples from the Quaternary elsewhere in Africa, and the samples from the CoH will allow them to expand the application of this dating technique. For this dating technique, the following are required:

* 10 to 30 milligrams of enamel extracted from animal teeth.
* The animals selected for dating should have been identified to family level or lower, and the same taxon is ideal.
* A minimum of 3 to 5 samples are required per layer.

Following the excavations from several decades ago, the large mammal fauna was identified by Cooke (1969, 1988), the taphonomy of the ESA Beds 1-3 was studied by Ogola (2003, 2009), whilst Churcher (1970) investigated the Equidae (zebras), Ewer (1956) the Suids (pigs) and De Graaff (1960) the microfauna. The presence of carnivore chew marks, rodent gnaw marks (mostly by porcupines) and butchery evidence by hominins have been noted on the large mammal remains (Cooke 1969, 1988), suggesting a complex accumulation history for the fauna. At the time of the analyses of the large mammals remains, only teeth and crania were used for identification, a common approach several decades ago. More recently, some aspects of the MSA fauna have been restudied by postgraduate students if mine (Khoaele 2020, Masekwa 2020, Maloka 2021). From these recent studies, it is evident that the lack of more precise dates for the different beds at the CoH seriously undermines any meaningful future studies of the fauna from the CoH.

Overall, the fauna from the CoH have not been properly quantified, nor has the postcranial remains been identified. Based on some 2500 catalogue book entries (located in the Evolutionary Studies Institute, University of the Witwatersrand), the sample contains large numbers of Equidae and Bovidae. Equidae (zebras) are particularly common in the sample, occurring in all beds at the CoH (except Bed 1, which contain a total of 3 specimens of primate and Bovidae). There are some 650 Equidae specimens in the CoH faunal assemblage, consisting of the extinct Cape horse (*Equus capensis*) and the modern plains zebra (*Equus burchelli*, today regarded as *Equus quagga*) in particular.

The sample size I am seeking permission to sample is, admittedly, large. However, the following will be achieved through dating the samples:

* The Makapan Valley is a World Heritage Site, and advancing knowledge of this important region will be of major scientific importance. The dates will unlock the enormous potential of the CoH.
* A great number of potential projects can be conducted on the fauna from the CoH, which include 1) identifying the postcrania from the different beds, 2) obtaining and linking specific palaeo-climatic conditions during the ESA, MSA and LSA in the interior (of which little evidence currently exist), 3) studying the role of carnivores, rodents, birds of prey and hominins as agents of accumulation through taphonomic studies, and 4) landscape usage studies by hominins. These aspects are all complex, and will take several studies to form a complete understanding of them.
* I train postgraduate students in zooarchaeological analyses, and the CoH fauna will serve as a training ground for these students.
* Some recent studies have already showed the great potential of studying the fauna from the CoH. Masekwa (2020) was able to suggest that hyenas contributed some fauna to the MSA beds, and that more taxa can be identified from the postcranial remains. His study focused on the carnivore remains. Khoaele (2020), who studied the rock hyraxes, showed that despite hyena activity at the CoH, hominins undoubtedly contributed fauna to the different beds. Maloka (2021) found lechwe remains in Beds 7 and 8, indicating wetter conditions in the interior of South Africa during the Pleistocene.

This application is a separate, new application from a recent application that is dating a hyena bone accumulation immediately adjacent to the CoH (within a few meters of the CoH excavations), and which was collected by James Kitching in 1975.

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**Methodology (short):**

With this application, I am seeking permission to select Equidae teeth specimens from the different beds at the CoH, and submit them to the University of York for amino acid racemisation dating. The following protocols will be applied:

* Submit and sample a total of 38 Equidae teeth specimens.
* This represents 3 specimens per bed, with more specimens from the mixed components.
* Once permission has been granted by the ESI, a SAHRA export and destructive permit will be obtained.
* Each specimen will be photographed and re-identified (to species-level, sides, element, upper or lower, and state of fragmentation).
* The specimens will be send in batches per courier, sampled at the University of York by Dr. Dickinson, and returned to the ESI by courier.
* As there are potential constraints in using this dating technique, the youngest samples will be analysed first, then progressing to older samples.
* The focus of the sampling will be on fragmented teeth of the plains zebra, to minimally impact on the specimens of the extinct Cape horse.
* I am including specimens from two components, in addition to Beds 2-11, in the application. These are 1) from breccia that was removed prior to the excavations, and stored in the adjacent Hyena Cave in 1947. These breccias, called Loose Breccia, likely belong to Beds 2 or 3. Then 2) most fauna from the assemblage were excavated from what Mason (1969, 1988) called the Shallow Hole (based on observations from the catalogue book). The Shallow Hole is a mixture of both ESA and MSA fauna, and dates on this component will be important to interpret the fauna.
* Most tooth specimens are fragmented and the removal of 10 to 30 milligrams will have a minimal impact on the state of the specimens themselves (Appendix 1).
* The 38 specimens represent 6% of all the Equid teeth in the CoH faunal assemblage, thus leaving a considerable portion of the sample intact.

**Confirmation/permit by museum**: Curator letter

**Damage/destructive analysis? (if yes, explain in detail)**

Yes, 10 to 30 milligrams of teeth will be removed

**Statement why this study cannot be done in South Africa:**

This dating technique is not available in South Africa. The University of York pioneered and refined this method, and are considered world-leaders in this dating method.