**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!**

Julien Benoit. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa.

**Applied for (principal researcher):**

Julien Benoit. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa.

Kudakwashe Jakata. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa.

Paul Tafforeau. European Synchrotron Radiation Facility, Grenoble, France.

Bernhard Zipfel. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa.

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

Julien Benoit. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa. Julien.benoit@wits.ac.za, 0117176687.

Kudakwashe Jakata. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa, kudakwashe.jakata@wits.ac.za, 0117176615.

Paul Tafforeau. European Synchrotron Radiation Facility, Grenoble, France. paul.tafforeau@esrf.fr

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

Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa.

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

European Synchrotron Radiation Facility, 71 Avenue des Martyrs, 38000 Grenoble, France

**Table of objects or upload file:**

- BP/1/8010: the partial skeleton of a small middle Permian parareptile

- BP/1/8033: The partial skull of a small late Permian cynodont

- 149-11-2019: an early Triassic coprolite

**Time frame:**

The specimens will be hand-carried to France on the 16th of August 2020 by Dr. Kuda Jakata in a secured case. The scan will be conducted by Dr. Kuda Jakata and Dr. Paul Tafforeau. The specimen will be taken back to South Africa by the 31st of July 2021 by Dr. Kuda Jakata.

**Aim/rationale:**

Rationale for BP/1/8010:

Parareptilia is the basal-most group of amniotes and is likely involved in the ancestry of several modern reptilian families (including turtles) (Tsuji and Muller, 2009). Because they might be ancestral to many different groups of reptiles (in particular, the possible origin of modern turtles and tortoises), the phylogeny and taxonomy of parareptiles is still hotly debated and not well understood yet (Tsuji and Muller, 2009; Bever et al., 2015). A new partial skeleton that includes the skull and anterior half of the body was discovered in 2017 in the South African Karoo. It might represent an early species of parareptile, maybe belonging to Broomia or a new taxon. However, the fossil is so delicate that any attempt to completely clean the matrix off the bones could damage the skeleton, which precludes further preparation. A digital preparation using regular CT-scanning is impossible since the material is full of iron nodules that preclude low energy X-ray to go through. The aim of this project is thus to scan this skeleton at a high energy beamline of the ESRF in order to prepare it digitally, in a non-destructive manner. This digital preparation will enable us to describe the skeleton and identify this specimen, which may prove crucial in resolving the phylogeny of parareptiles.

Rationale for BP/1/8033:

BP/1/8033 represents a new cynodont from the lowest part of the Late Permian, making it the oldest cynodont ever found. Cynodonts being the most direct ancestors of mammals among non-mammalian therapsids (Botha et al, 2007), a complete description of this specimen is dramatically important for understanding mammalian origins. Unfortunately, BP/1/8033 is too small to be safely prepared with an air-scribe, and digital preparation using a regular CT-scanning also failed to a large number of metallic nodules blocking low energy X-rays. Therefore, only a synchrotron scan can bring good quality data that this specimen deserves. As it represents a species new to science and possibly the oldest mammalian ancestor, this specimen has the potential to re-write mammalian evolutionary history.

Rationale for 149-11-2019:

This specimen is a coprolite from the early Triassic of the Oviston Nature Reserve (Eastern Cape). Preliminary CT scanning has revealed that it contains the complete articulated forelimb of a therocephalian (presumably Tetracynodon). As South African coprolites demonstrably preserve hair-like structures (Smith and Botha-Brink, 2011) and since the Oviston coprolite shows evidence of incomplete digestion (i.e. the presence of a completely articulated arm), it is very likely that hair is preserved in this coprolite, presumably belonging to the therocephalian that it contains. To find hair in this specimen would be the first time that direct evidence of hair is found in association with attributable fossil bone, and would demonstrate that hair originated in the last common ancestor of mammals and therocephalians at least 265 million years ago, some 65 million years before the very origin of mammals and 100 million years older than the currently oldest accepted evidence of hair (Ji et al., 2006). The hair-like structures identified by Smith and Botha-Brink (2011) are just a few microns wide. Such a resolution cannot be achieved using regular CT-scanning. Nano-CT-scanning may achieve such high resolution, but the X-rays would not be powerful enough to go through the encasing rock. Synchrotron scanning is the only option that enables a non-destructive study of this coprolite. The only alternative would be thin sectioning, which would be our last resort.

**Methodology (short):**

Our intention is to scan the specimens, using propagation phase contrast microtomography and high monochromatic energy. We will use the ID19 and ID17 beamlines associated to the maximum energy available (150 keV or higher) as well as the longest propagation distance (11 m) in order to maximize phase contrast. The ultimate aim is to produce a 3D models of the fossils using manual segmentation with Aviso 10.0 (VSG software).

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

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

No

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

The specimens have already been scan on a regular CT scanner, but this is not powerfull enough to achieve the contrast nor high resolution required for the observations we want to make.