Project Proposal Form – 2022 entry

Project Title	**OU9 - Microbial survival in the Makgadikgadi Basin, Botswana**
University (where student will register)	The Open University
Which institution will the student be based at?	As above
If other	The student will spend time at the NHM in London
Theme (Max. 2 selections)	Climate & Environmental Sustainability ☐ Organisms & Ecosystems ☒ Dynamic Earth ☐
Key words	Extremophiles, geobiology, field work
Supervisory team (including institution & email address	**PI:** Karen Olsson-Francis. The Open University. Email: k.olsson-francis@open.ac.uk **Co-I:** Marcus Badger**.** The Open University. Email: marcus.badger@open.ac.uk Fulvio Franchi. Botswana International University of Science and Technology (BIUST). Email: franchiF@biust.ac.bw Keyron Hickman-Lewis. The Natural History Museum, London. Email: keyron.hickman-lewis@nhm.ac.uk
Is the project co-designed by a student?	Yes ☐ No ☒
Is the PhD suitable for part time study?	Yes ☒ This is a requirement of NERC

Project Highlights:

- Fieldwork in the Makgadikgadi Pan, Botswana
- Developing skills in geomicrobiology and molecular biology
- Isolating and characterising novel extremophiles

Overview:

Naturally formed salt pans are found in many arid and semiarid environments on Earth, including the USA, Australia, China and Africa. Studies have shown that certain microorganism (halophiles, i.e. salt loving) can life within salt pan environments and survive exposure to high salinity, desiccation, daily fluctuations in temperature and intense solar radiation.

The Makgadikgadi Basin in Botswana is the relict of a mega-paleolake system that originated during the Pleistocene. Nowadays, the basin consists of a system of ephemeral lakes consisting of several pans. The largest pans are the Ntwetwe Pan in the west and the Sua Pan in the East (Figure 1), each containing distinct morphological features that are remnants of an ancient lake system. These features

have been influenced by local environmental factors such as precipitation, water inflow and aeolian activity, and can act as a paleoclimatic archives for climate information. Preliminary work has demonstrated that diverse microbial communities exist with the pan; however, little is known about the ecological strategies utilized by these microbial communities in response to the environmental challenges presented by the pan.

Figure 1: An image of a salt pan in the Makgadikgadi Basin in Botswana.

Alt-text: Photograph showing blue sky over a pale-cream salt pan in Botswana.

The aim of this project is to develop an understanding of the processes underpinning the survival of microbial life within this hostile, polyextremophilic environment. It will primarily investigate 1) how microorganisms physiologically adapt to changes in environmental conditions; 2) the interactions that occur between the microbial communities and the host sediments (e.g., biominerals). The student will use a combination of field work and laboratory microcosm experiments for this study.

Methodology:

Microbiology (both dependant and independent culturing methods) and geological techniques will be applied to understand survival strategies that underpin viability in both the Ntwetwe Pan and the Sua Pan. Working with local partners at the University of BIUST, core samples will be collected from different morphological features observed in the pans. Physio-chemical, morphological and compositional analyses (e.g., with FEG-SEM, micro-CT scanning, Confocal Raman spectrosocpy) will be carried out to characterise the micro-environments and the spatial distribution of the microbiota trough the sediments. In parallel, DNA and RNA will be extracted, and the taxonomic and metabolic diversity will be characterised. This will be supported by cultivation and microcosm experiments to fully understand the physical and metabolic adaption mechanisms employed.

Training and skills:

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and 'free choice' external training. One CTC equates to 1⁄2 day session and students must accrue 100 CTCs across the three years of their PhD.

The student will be trained in specific, laboratory-based techniques in molecular biology (DNA extraction, PCR, gel electrophoresis, library preparation and DNA sequencing), geochemistry and culture-based microbiology by members of the research team. Short placements with the project partners will enable access to laboratory facilities and training in specific laboratory techniques. The student will also be trained in computer-based techniques, including bioinformatic analysis of sequencing data.

Partners and collaboration:

Keyron Hickman-Lewis (NHM, London) is experienced in palaeontology and using novel techniques to determine biogenicity and metabolic affinities to fossils. Barbara Cavalazzi (University of Bologna, Italy) has extensive in studying microbial geomorphology and the interaction between microorganisms and sediment.

COVID-19 Resilience of the Project:

Possible impacts of COVID would include the suspension of international travel, impacting fieldwork, and the possibility of local lockdowns restricting lab access. To mitigate the risks in the instance that fieldwork is prevented, we have local partners with the University of BIUST that are located close to the field site that would be able to collect the samples and ship them to the UK (this is how we have addressed the issue this year). In the instance of local lockdowns restricting lab access, the project would focus on bioinformatics, which would allow the project and research questions to progress.

Possible timeline:

Year 1: Perform a literature review and undertake field work in Botswana. Complete initial training in microbiology and geochemical techniques. Set up cultures for isolation and perform initial growth experiments. Start initial geochemical and morphological analyses.

Year 2: Continue with the geochemical and morphological analyses. Set up microcosm experiments under variable conditions. Perform metagenomic analysis of this field site and microcosm experiments to assess mechanisms underpinning survival. Present results at a national conference (e.g., Microbiology Society annual conference).

Year 3: Prepare and submit manuscript regarding the metagenomic work and related growth experiments identifying mechanisms underpinning survival within this site. Present data at an international conference (e.g., Gordon Applied and Environmental Microbiology). Write and submit thesis.

Further reading:

Knapik, J. J., Cosio-Lima, L. M., and Reynolds, K. L. (2015). Efficacy of functional movement screening for predicting injuries in coast guard cadets. *The Journal of Strength and Conditioning Research*, 29 (5), pp. 1157-1162.

Franchi, F., MacKay, R., Selepeng, A. T., Barbieri, R. (2020). Layered mound, inverted channels and polygonal fractures from the Makgadikgadi pan (Botswana): Possible analogues for Martian aqueous morphologies. *Planetary and Space Science*, 192, 1050482.

Barbieri, R., Cavalazzi., B. (2018). Microterracettes in Sabkha Oum Dba (Western Sahara, Morocco): Physical and biological Interactions in the formation of a surface micromorphology. *Astrobiology*, 18:10, 1351-1367.

Genderjahn, S., Alawi. M., Wagner, D., Schuller, I. (2018). Microbial community responses to modern environmental and past climate conditions in Omongwa Pan, western Kalahari: A paired 16S rRNA gene profiling and lipid biomarker approach. Journal of Geophysical Research: Biogeosciences, 13330-1351.

Further details:

Students should have a strong background in environmental microbiology and/or molecular biology. The student will join a research team that has extensive experience working with extremophilic microorganisms at the Open University, as well as working with an active team of geochemists.

Please contact Karen Olsson-Francis (karen.olsson-francis@open.ac.uk) for further information.

Applications should include:

- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from: CENTA application
- and an Open University application form, downloadable from: Home OU application form (if you are resident in the UK) or an Overseas OU application form (if you are an international applicant).

Applications must be sent to **STEM-EEES-PHD@open.ac.uk** **by Friday 7th January 2022 (12 pm, noon)**