

## EEES Project Proposal Form – 2024 entry

<b>Project Title</b>	Developing trace element microanalytical tool for palaeoclimate reconstructions
<b>Key words</b>	
<b>Supervisory team (including email address)</b>	<b>PI: Pallavi Anand</b>  <b>Co-I: Barbara Kunz (OU), Yonas Weldeselassie (OU), Katrina Nilsson-Kerr (University of Bergen)</b>
<b>Is the PhD suitable for part time study?</b>	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>

### Project Highlights:

- Develop laser ablation technique for measuring trace elements in microfossils
- Training in analytical (with laser manufacturer) and statistical techniques
- Application of new technique in reconstructing past climate

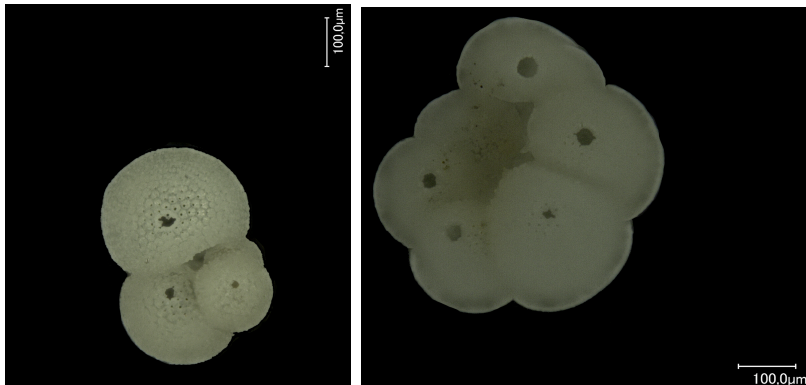
### Overview:

This project aims to advance microanalytical technique (laser ablation), by improving laser spot size, for measuring trace elements on microfossils of small size. The current laser technique is limited by the laser spot size (~30-40  $\mu\text{m}$ ) [1] and bulk of the atoms are lost at the plasma interface even after all the ablated materials reaches to the plasma. Therefore, there is huge potential for improvement of the laser technique that can help improve the sensitivity and the signal from the ablated material. This project will involve collaborative working with the laser manufacturer to improve signal acquisition for the analysis at smaller spot sizes as well as carry out large spot size measurements to calibrate signals. The improved technique will open possibilities for measuring small sample size that are currently not possible for application in Earth and Environmental Sciences for example biogeochemistry and palaeoclimatology.

Our climate is changing, and oceans are playing a key role in regulating the system as phytoplankton and zooplankton lock away carbon in their soft tissues and shells. The preserved calcareous and siliceous shells also lock away environmental signal in their chemistry capturing events at daily (e.g. molluscs) to weekly (e.g. coccolithophore) to monthly (e.g. foraminifera) resolution. Accumulation of these shells in sediments allow for extensive and detailed historical climate records to be reconstructed to understand mean state signal [2] which can be further explored using microanalytical techniques to improve understanding of seasonal/extreme events and processes responsible for these events [3] and/or in exploring new geochemical tools (e.g., distribution of U, Nd and Mn in shells for reconstructing river runoff [4]) of environmental significance. New technique will be applied to samples where the mean state signal or environmental information is known (using materials previously analysed for mean state signal or grown in culture or collected from plankton net/sediment trap) to test the fidelity of signal on a high temporal resolution. Furthermore, the technique will allow extraction of palaeoclimate signal from well dated marine core samples to reconstruct mean state, seasonal and extreme events in the past and understand the nature, frequency and magnitude of such extremes by utilising statistical techniques.

This project will also have potential to explore application of available laser ablation inductively coupled plasma mass spectrometer (LA-ICPMS) technique to other natural archives (e.g. diatoms) in Earth and Environmental Science.

Figure 1: Pictures of two planktic foraminifera species showing laser ablation pits using 40um laser spot size.



Alt-text: Two images of laser ablated shells of planktonic foraminifera showing holes in chambers of foraminifera (post laser ablation analysis). Both foraminifera tests are off white in colour with a black background and are approximately 250 -400 µm in size. The laser holes are of approximately 40µm in size and appear on all visible chambers of both tests on the apertural side. There is a scale bar of 100µm shown on both images.

**Methodology:** The method development for this project will be achieved by working with the lead researcher of the laser manufacturer (Dr Kunz). The existing LAICPMS methodology operational at the OU will be enhanced through optimising signals for small ablation analyses (using quad lock) of elements that are routinely analysed. These methodological improvements have potential to improve signal acquisition. The technique will be applied to reconstruct both mean state and extreme climate (temperature, rainfall/runoff seasonality) in the past using well dated IODP and other core-top samples (in possession) using statistical approaches (Dr Weldeselassie).

#### **Training and skills:**

The student will receive specific training on LA-ICPMS from Dr Kunz and from a researcher working in laser manufacturing industry, foraminifera and microfossil specific knowledge from Drs Anand and Nilsson-Kerr and statistical analyses and modelling from Dr Weldeselassie (School of Mathematics and Statistics at the OU).

The student will also receive skills training. OU offers a diverse set of training courses throughout their PhD.

Specific skills that will be acquired during this project include:

- Developing cutting edge geochemical microanalytical techniques
- Data handling and interpretation following statistical analysis and modelling
- Scientific communication through writing, poster and oral presentations to academic and non-academic audiences
- Co-supervision on your own devised OU's master's project and teaching research methods to A level Nuffield funded summer students.

**Partners and collaboration:** This project will benefit from a wide range of collaboration from industry to international scientific community. In particular, there will be collaboration with



scientists working on individual foraminifera analysis Ed Hathorne (GEOMAR) and other researchers (UK/US/India) with modern culture and plankton tow samples.

**Possible timeline:**

Year 1: Obtain training in sample processing on laser ablation sample preparation and existing methodology. Develop technique for improving laser spot size on standards and microfossil samples. Learn statistical techniques for extracting signal. Present data at the Micropaleontological Society annual meeting.

Year 2: Apply newly developed technique on modern and previously characterised samples to test the fidelity of the technique and signal measured for palaeoclimate reconstructions. Write a manuscript on technical advancement and application.

Year 3: Finish remaining analytical work, data analyses, and present results at an international conference and write up thesis and manuscripts.

**Further reading:**

1. Richey, J. N., Fehrenbacher, J. S., Reynolds, C. E., Davis, C. V. and Spero, H. J. (2022) Barium enrichment in the non-spinose planktic foraminifera, *Globorotalia truncatulinoides*. *Geochimica et Cosmochimica Acta*, 333, 184-199, doi.org/10.1016/j.gca.2022.07.006.
2. Groeneveld, J., Ho, S. L., Mackensen, A., Mohtadi, M., & Laepple, T. (2019) Deciphering the Variability in Mg/Ca and Stable Oxygen Isotopes of Individual Foraminifera. *Paleoceanography and Paleoclimatology*, 34(5), 755–773. <https://doi.org/10.1029/2018PA003533>
3. Brinkmann, I., Barras, C., Jilbert, T., Mareike Paul, K., Schweizer, M., and Phillipsson, H. L., (2022) Drought recorded by Ba/Ca in coastal benthic foraminifera, *Biogeosciences*, 19, 2523-2535, doi.org/10.5194/bg-19-2523-2022.
4. Nilsson-Kerr, K., Anand, P., Sexton, P. F., Leng, M. J., Misra, S., Clemens, S.C. and Hammond, S.J. (2019) Inter-hemispheric climate controls on late Pleistocene Asian summer monsoon subsystems, *Nature Geoscience*, 12, pp. 290-295.

**Further details:**

Please contact Supervisor ([pallavi.anand@open.ac.uk](mailto:pallavi.anand@open.ac.uk)) for further information and informal discussion about this project.