High Resolution Palaeoenvironmental Reconstruction from Lake Suigetsu, Japan (Ref IAP2-18-54)

University of Glasgow, SUERC

In partnership with BGS & University of Newcastle

Supervisory Team	• Dr Richard Staff, University of Glasgow • Prof Melanie Leng, BGS • Dr Emma Pearson, University of Newcastle
Key Words	**1. Palaeoenvironmental reconstruction;** **2. Biomarkers** **3. $\delta^{18}O$** **4. Radiocarbon dating** **5. Climate change**

Overview

In light of 21st century anthropogenically-influenced climatic change, one of the main scientific endeavours of our generation is to gain a fundamental understanding of the earth's climate system. This is essential for the identification of the underlying drivers of global climate, as well as our understanding of the patterns of differential geographical responses to those drivers. Contemporary climate data lack the range of extremes and length of records needed to achieve this fundamental understanding and, for this reason, the study of long, high-resolution palaeoclimate records has become an international scientific priority.

Arguably, the best and most-widely cited record of palaeoclimatic change – the key global reference 'type site' – is that provided by the Greenland ice-cores, due to their highly precise suite of multi-proxy palaeoenvironmental data (NGRIP members 2004), and their annual resolution, layer-counted chronology. However, similarly high quality palaeoenvironmental archives from elsewhere in the world remain scarce.

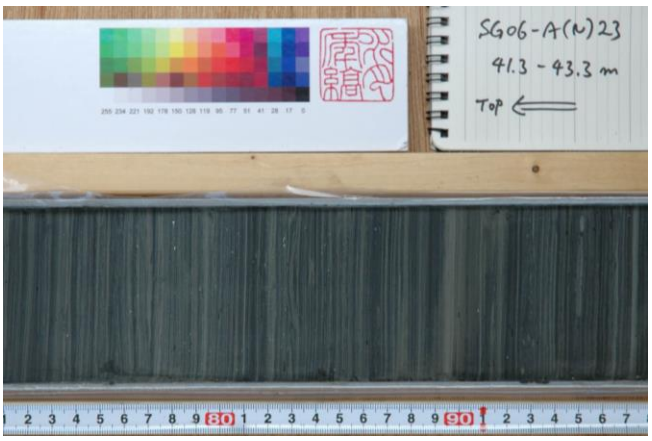
Here, we have the opportunity to obtain such high quality, multi-proxy palaeoenvironmental data from a sediment core extracted from Lake Suigetsu, central Japan, supported by an annual precision varve chronology (spanning ~10,000 to 50,000 years before present) akin to that of the annually-layered Greenland ice-cores (Nakagawa *et al.* 2012; Schlolaut *et al.* in press).

Lake Suigetsu, central Japan: 'SG14' drilling rig a speck in the distance. (Photo: R.A. Staff.)

The global importance of the site for palaeoclimatic research was demonstrated by its recognition by Walker *et al.* (2009) as an auxiliary stratotype for the onset of the current interglacial, the Holocene. Moreover, >800 radiocarbon dates of terrestrial plant macrofossils picked from the Lake Suigetsu sedimentary archive, combined with the independent varve chronology, have provided the central archive for the 'IntCal' international consensus radiocarbon calibration curve (Bronk Ramsey *et al.* 2012; Reimer *et al.* 2013), and thus, implicitly, radiocarbon data from

Suigetsu are applied by all users of radiocarbon dating, since calibration is an integral stage of the method.

The PhD research proposed here will take advantage of this exceptional chronological control to produce high resolution, cutting edge palaeoenvironmental proxy data of truly world leading quality.

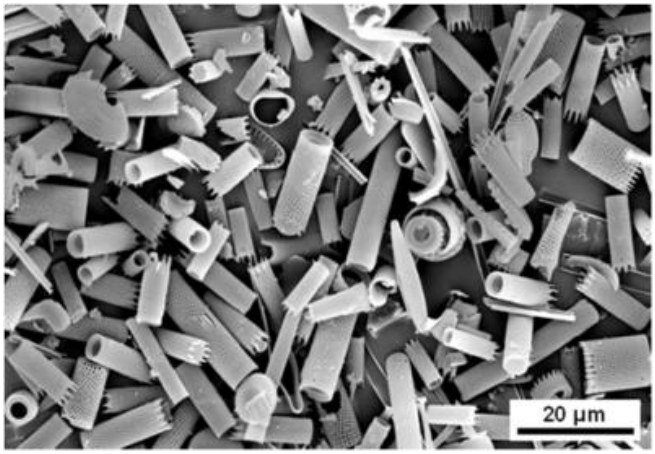


Section of Lake Suigetsu sediment core 'SG06' showing distinctive laminations (varves).
(Photo: T. Nakagawa.)

Methodology

The existing palaeoenvironmental data from Lake Suigetsu are primarily based upon palynological investigation (Schlolaut *et al.* 2017; Nakagawa *et al.*, in prep.). However, the response of plant species (and hence the pollen records that they produce) often lags behind the causative climatic changes (at a ~decadal to centennial scale). This proposed PhD studentship will therefore focus on two complementary palaeo-environmental proxies that might be expected to demonstrate greater sensitivity (i.e. more rapid response) to climatic perturbation – biomarker compound specific isotope analysis (including δD analysis; see, e.g., Rach *et al.* 2014) and stable isotopic analysis on extracted diatoms ($\delta^{18}O$; see, e.g., Leng and Sloane 2008).

Sampling from the Lake Suigetsu 'SG06' and 'SG14' sediment cores will be undertaken under the guidance of the broader "Lake Suigetsu Varved Sediment Project" PI, Prof Takeshi Nakagawa at Ritsumeikan University, Kyoto, Japan. The majority of the laboratory analysis will subsequently be undertaken primarily at the University of Glasgow (between SUERC and the Biomarkers for Environmental and Climate Science (BECS) research group, School of Geographical and Earth Sciences) under the primary supervision of Dr Richard Staff, with the further support of project partner Prof Jaime Toney. It is also intended that the student will spend time at both BGS for diatom $\delta^{18}O$ analysis (under the supervision of Prof Melanie Leng) and the School of Geography, Politics and Sociology for biomarker analysis (under the supervision of Dr Emma Pearson). There is scope for extended laboratory access at both BGS and the University of Newcastle as the student prefers.



Purified diatoms (predominantly Aulacoseira ambigua) extracted from the Lake Suigetsu 'SG06' sediment core. (Photo: M.J. Leng.)

The PhD student will be responsible, in consultation with the supervisory team, for refining the key research questions to be investigated, but it is imagined that the focus of the project will be upon high chronological resolution proxy analysis across specific major climatic transitions (as indicated by the existing pollen dataset), with lower resolution data to be generated for the remainder of the ~50,000 year time period for which Suigetsu provides robust chronological control.

Timeline

Year 1: Reviewing of existing literature in order to refine key research questions and establish hypotheses; training in core skills; sampling visit to Japan; initial processing of samples for biomarker and diatom stable isotopic analysis; attendance of short course in 'Radiocarbon Dating and Bayesian Chronological Analysis' (Mar 2020); PhD progression presentation.

Year 2: Majority of sample processing for biomarker and diatom stable isotopic analysis to be undertaken; on-going data analysis and statistical modelling; presentation at national conference (e.g. QRA ADM, Jan 2021).

Year 3: Completion of sample processing; completion of data analysis and statistical modelling; presentation at international conference (e.g. EGU, Apr 2022); thesis write-up and drafting of manuscripts for publication in high impact international peer-reviewed journals.

Final 6 months: Completion of write-up of PhD thesis; finalise manuscripts for publication.

Training & Skills

The supervisory team reflects the multidisciplinary nature of the project and includes experts in palaeoenvironmental reconstruction and Quaternary geochronology. Under the guidance of this team, the student will develop laboratory analytical skills in these complementary palaeoenvironmental reconstruction methodsdere. A fundamental stage towards the end of the project will be the comparison of the data generated with those from other key global archives, and further training will be provided in the robust intercomparison of geochronological data across geographical space involving Bayesian statistical modelling.

References & Further Reading

Bronk Ramsey, C. *et al.* (2012) "A complete terrestrial radiocarbon record for 11.2-52.8 kyr BP". Science 338, 370-374

Leng, M.J. and Sloane, H.J. (2008) "Combined oxygen and silicon isotope analysis of biogenic silica". Journal of Quaternary Science 23, 313-319

Nakagawa, T. *et al.* (2012) "SG06, a perfectly continuous and varved sediment core from Lake Suigetsu, Japan: stratigraphy and potential for improving the radiocarbon calibration model and understanding of late Quaternary climate changes". Quaternary Science Reviews 36, 164-176

Nakagawa, T. *et al.* (in prep.) "Deglacial abrupt warming events were driven by different mechanisms".

NGRIP Members (2004) "High-resolution record of Northern Hemisphere climate extending into the last interglacial period". Nature 431, 147-151

Rach, O. *et al.* (2014) "Delayed hydrological response to Greenland cooling at the onset of the Younger Dryas in western Europe". Nature Geoscience 7, 109-112

Reimer, P.J. *et al.* (2013) "IntCal13 and Marine13 radiocarbon age calibration curves 0-50,000 years cal BP". Radiocarbon 55, 1869-1887

Schlolaut, G. *et al.* (2017) "Pan-Hemispheric Bi-Partition of the Younger Dryas Stadial". Scientific Reports 7, 44983

Schlolaut, G. *et al.* (in press) "An extended and revised Lake Suigetsu varve chronology from ~50 to ~10 ka BP based on detailed sediment micro-facies analysis". Quaternary Science Reviews

Walker, M.J.C. *et al.* (2009) "Formal definition and dating of the GSSP (Global Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records". Journal of Quaternary Science 24, 3-17

For further reading on the "Lake Suigetsu Varved Sediment Project", see: www.suigetsu.org

Further Information

For further information or questions relating to this project proposal contact Dr Richard Staff at: richard.staff@glasgow.ac.uk.