The University of Oxford Department of Earth Sciences

EARTHSCIENCES

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Sniffing out global volcanic fingerprints using mercury in Quaternary sedimentary records

Supervisory Team

- **Prof. Tamsin A. Mather** www.earth.ox.ac.uk/people/mather
- **Prof. Stuart A. Robinson** www.earth.ox.ac.uk/people/stuart-robinson
- **Prof. David M. Pyle** www.earth.ox.ac.uk/people/pyle

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Overview

Mercury (Hg) is one of the most important global pollutants circulating in the present-day Earth's ecosystem. Methylmercury is highly neurotoxic, damages the central nervous system, and is highly dangerous for its development. Anthropogenic Hg was recently regulated under the Minamata Convention. The amount of Hg from natural sources is probably close to anthropogenic levels and the amount of Hg released by the degassing of active volcanoes is one of the major components of this flux. Hg has also recently been proposed as a 'fingerprint' in the geological record for periods of heightened volcanism known as large igneous provinces (LIPs), associated with mass extinction events and other periods of rapid global change (Pyle and Mather, 2003; Percival et al., 2018).

The use of Hg as a marker for ancient LIP volcanism is gaining momentum and offers the exciting prospect of having a fingerprint that can link the timing of volcanism directly to the records of environmental changes in sedimentary cores. However, there remains much to understand about the atmospheric and sedimentary processes that lead to Hg enrichment in sediments. One way to further this understanding is to measure Hg in recent sediment cores where our chronology of volcanism is comparatively well constrained via historical accounts or other records.

Measurements of young sediments and ice cores can be used to track both global trends in post-industrial era atmospheric Hg (Drevnick et al., 2016), and to search for Hg 'spikes' in high resolution lake, peat and ice records records (e.g., Schuster et al., 2002; Roos-Barraclough et al., 2002; Ribeiro Guevara et al., 2010; Daga et al., 2016). None of these periods cover LIP-scale eruptions but even with the more precise age models of more recent sediments there are complications in correlating volcanic events to Hg spikes. For example, in peat cores studied by Roos-Barraclough et al. (2002) they find numerous Hg spikes, thought to be volcanic, from 7 – 9 kyr BP; but do not find similar peaks during other periods despite known historical large-scale volcanism (e.g., Tambora 1815, Laki 1783-84). They attribute this difference to changes in atmospheric humidity between the different periods.

There is much more to learn in terms of our understanding of the volcano-atmosphere-sediment Hg cycle from studying young sediments. This project will focus on recent lake cores. The terrestrial catchment of lakes implies relatively high sedimentation rates and input of higher plant material, offering the potential to understand how short-timescale Hg perturbations, may be captured in sedimentary archives.

The initial focus will be on already available core material from lakes such as Bosumtwi, West Africa and others from Central American, China, the Balkans and Iceland (e.g., Lake Logurinn) where volcanism occurs in close proximity to the environmental archives (Gudmundsdóttir et al., 2016).

Figure showing Lake Bosumwti, Ghana, one of the drill core locations Photo: ICDP (https://www.icdp-online.org/projects/world/africa/lake-bosumtwi/)

Methodology

Measurements of Hg and TOC in sediments will be first important steps within this project. These Hg measurements will be made using the Lumex RA-915 Portable Mercury Analyzer with PYRO-915 Pyrolyzer. TOC is measured using a Rock-Eval 6. This instrument also returns data on the sediment thermal maturity (T_{max})[1] and type of organic matter (hydrogen index, HI). Both these instruments are available in Oxford. For more details, see Percival et al. (2015). Other measurements might include trace element work using ICP-MS, tephra work and GC-MS analyses to look at the organic matter in the cores in more detail and determine whether its composition affects the sediment Hg concentrations.

Our first measurement target will be the ~540 ka Lake Bosumwti, West Africa record (Miller et al., 2016) in collaboration with William Gosling (University of Amsterdam). The Bosumtwi sequence (University of Minnesota core repository) is highly resolved in parts (laminated) and a new chronology (based on pollen chemistry) is in development. Hg spikes in the record will be correlated with known eruption dates and other environmental markers. Other targets include lakes in Central America (collaboration with Steffen Kutterolf, Geomar, Germany, e.g., Kutterolf et al., 2016), China (e.g., Hodell et al., 1999), the Balkans (collaboration with Melanie Leng, BGS, e.g., Just et al., 2016) and Iceland.

[1] Temperature at which there is a maximum yield of hydrocarbons during heating; a more thermally mature sample will have a higher T_{max}. It approximately scales with Vitronite Reflectance (VR) for a given sample set.

Timeline

Year 1: Training, core sampling and initial measurements.

Years 2 and 3: Measurements and further core sampling. Visits to collaborators.

Year 4: Data integration, thesis completion, papers for international journals/conference presentation.

Training & Skills

Oxford offers a full range of advanced courses and transferable skills training as part of its 4th year undergraduate course and DTP training programme.

Specialised training foreseen:

- Full training in sedimentary analyses and Hg analyses

- Sedimentary/tephrostratrigraphy field sampling training

- Conference presentations including conference field trips as appropriate

References & Further Reading

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Further Information

Contact: Tamsin Mather
(Tamsin.Mather@earth.ox.ac.uk)