Geochemistry Group
Research in Progress Meeting

GGRiP 2025

Tuesday 8th - Thursday 10th April 2025
University of Birmingham

Programme & Conference Abstract Booklet

Chair's Welcome

On behalf of the whole Geochemistry Group committee and the Local Organising Committee, I'd like to welcome you to the 2025 Research in Progress meeting, here at the University of Birmingham!

We have an excellent, varied and fascinating series of oral and poster presentations over the next three days, and I'm really excited to hear about the research our community has been involved in this past year. The Local Organising Committee has also arranged a brilliant series of social events, including a photo competition, an open mic night and a curry. As always, the community at GGRiP is what makes the meeting, and what I'm most looking forward to is meeting old friends and making new connections at the meeting.

I'd personally like to thank Emma Hanson, Gemma Baker, Kerys Meredew and James Bendle – the Birmingham Local Organising Committee - for all their hard work in pulling together the conference. Also the Lapworth Museum staff: Jon Clatworthy, Andy Jones and Jake Atterby, and PhD Matt Allison for their work helping to support the fringe event. Thanks as well to the Birmingham masters students who have volunteered their help with the conference.

It is not an easy task, and they have by all accounts made GGRiP 2025 a brilliant event, showcasing not only the excellent geochemistry research that we do as a community, but also introducing some local flavour into the social programme.

I'd also very much like to extend a huge thanks to our Industry Sponsors – all of whom are listed in this booklet – whose continuing generosity mean that GGRiP continues to be an affordable and inclusive conference, particularly for ECRs, MSc and PhD students. Please do visit their booths – I'm sure they're all excited to meet you!

The Geochemistry Group is a Special Interest Group of both the Mineralogical Society of Great Britain and Ireland, and The Geological Society of London, and I'd like to thank them for their support, both financial and logistical. In particular, the advice from Kevin Murphy and Russell Rajendra of the MinSoc has been extremely helpful during the organisation of this conference.

Finally, I'd like to thank the rest of the Geochemistry Group committee for their help in organising the conference. This is my first year as Chair of the Geochemistry Group, and without their support, particularly Marie-Laure Bagard (Secretary) I would have been totally lost! As usual, we will hold our AGM at the conference – and we do have some vacant committee roles so if you are interested in getting involved (all levels of experience are welcomed), please do speak to one of the committee members.

I genuinely hope you have a great time here in Birmingham!

Paul Savage

Many thanks to all of our sponsors for their generous support of this meeting.

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Local Organising Committee

Dr James Bendle

James is a geochemist specialising in palaeoclimatology, investigating modern and past climate environments using biomarker-based approaches. He has recently begun to cross disciplines into speleology and archeology.

Dr Emma Hanson

Emma is an Experimental Officer within the Earth Sciences department. Her PhD research involved high resolution coccolith geochemistry from the Miocene to the recent, including stable isotope and Sr/Ca analysis. She currently works on coccolithophore cell geometry in aiding past CO_2 reconstructions.

Kerys Meredew

Kerys is a final-year Volcanology PhD student. Her research combines GIS-based structural investigations with geochemical analysis of volcanic tephra to investigates how magmatic systems are perturbed by volcanic sector collapse, focusing on the 2018 collapse of Anak Krakatau (Indonesia).

Gemma Baker

Gemma is a final-year PhD student in Organic Geochemistry at the University of Birmingham. Her PhD focusses on using organic biomarkers and compound-specific isotope analysis to interpret the dietary profiles of lemurs.

If you have any questions or comments, please email ggrip2025@gmail.com

Code of Conduct

The Mineralogical Society is a learned society, which, through its members, has a duty in the public interest to provide a safe, productive and welcoming environment for all participants and attendees of our meetings, workshops, and events regardless of age, gender, sexual orientation, gender identity, race, ethnicity, religion, disability, physical appearance, or career level.

This Code of Conduct applies to all participants (including members and non-members) in Society-related activities, including, but not limited to, attendees, speakers, volunteers, exhibitors, staff, service providers, representatives to outside bodies, and applies in all MinSoc activities, including ancillary meetings, events and social gatherings.

Behaviour

The Society values participation by all attendees at its events and wants to ensure that your experience is as constructive and professionally stimulating as possible. Participants are expected to behave in a respectful and professional manner - harassment and, or, sexist, racist, or exclusionary comments or jokes are not appropriate and will not be tolerated.

Harassment includes:
- sustained disruption of talks or other events,
- inappropriate physical contact,
- sexual attention or innuendo,
- deliberate intimidation,
- stalking, and intrusive photography, or
- recording of an individual without consent.

It also includes discrimination or offensive comments related to age, gender identity, sexual orientation, disability, physical appearance, language, citizenship, ethnic origin, race or religion. The Mineralogical Society expects and requires all participants to abide by and uphold the principles of this Code of Conduct and transgressions or violations will not be tolerated.

Breach of the Code of Conduct

If an incident of proscribed conduct occurs either within or outside the event premises during an event, then the aggrieved person or witness to the proscribed conduct is encouraged to report it promptly to a member of staff or the event's principal organiser/appointed 'Safety Officer'.

Once the Society is notified, a member of staff or the senior organiser of the meeting or the Safety Officer will discuss the details with the individual making the complaint. Any witnesses who have been identified, and then the alleged offender will be consulted before determining an appropriate course of action.

Confidentiality will be maintained to the extent that it does not compromise the rights of others.

Conference Details

GGRiP 2025 is being hosted by the **School of Geography, Earth & Environmental Sciences** at the **University of Birmingham**. The conference will be held in the **Alan Walters Building (R29)** on the Edgbaston Campus, University of Birmingham (B15 2TT).

Lunch and coffee breaks will be provided daily. The conference catering is wholly vegetarian.

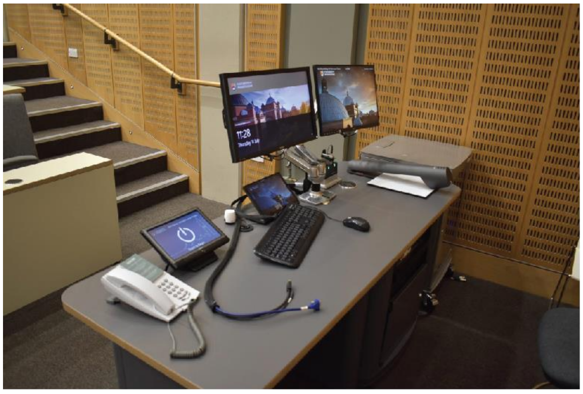
Presenter Guidelines

Oral Presentations

Presenters will be assigned a **15 minute slot**. Talks should last for a maximum of **12 minutes**, allowing **3 minutes for questions**. All oral presentations will take place in the ground floor **Main Lecture Theatre (G03)**. A PC running Microsoft Powerpoint and Adobe Acrobat software will be available.

All talks must be uploaded in either PowerPoint or PDF format to the conference PC, either in the morning or break before your allocated session. Volunteers will be available to assist.

Main lecture Theatre (G03)

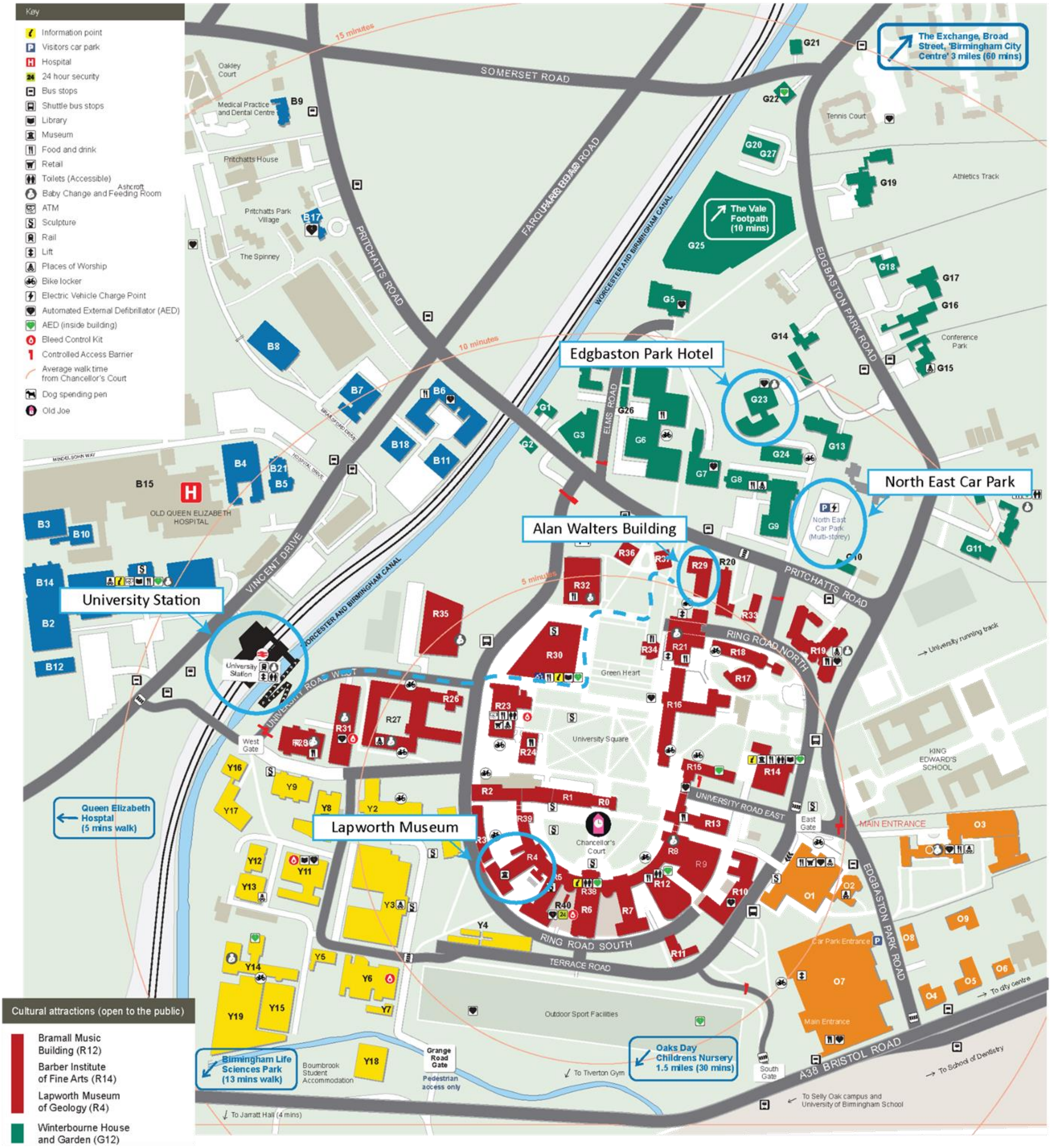


Available PC setup

Poster Presentations

Posters must be formatted to **A0** specification in **portrait orientation**. This is equivalent to 1189 mm (46.8 inches) high and 841 mm (33.1 inches) wide. All poster presentations will take place in the ground floor **Lecture Theatre 2 (G11)**. Each poster will be assigned a number, which will correlate to the board the poster should be displayed on. Velcro will be provided.

Campus Map


Key
Information point
Visitors car park
Hospital
24 hour security
Bus stops
Shuttle bus stops
Library
Museum
Food and drink
Retail
Toilets (Accessible)
Baby Change and Feeding Room
ATM
Sculpture
Rail
Lift
Places of Worship
Bike locker
Electric Vehicle Charge Point
Automated External Defibrillator (AED)
AED (inside building)
Bleed Control Kit
Controlled Access Barrier
Average walk time from Chancellor's Court
Dog spending pen
Old Joe
Edgbaston Park Hotel
North East Car Park
Alan Walters Building
University Station
Lapworth Museum
The Exchange, Broad Street, 'Birmingham City Centre' 3 miles (60 mins)
The Vale Footpath (10 mins)
Queen Elizabeth Hospital (5 mins walk)
Birmingham Life Sciences Park (13 mins walk)
Oaks Day Childrens Nursery 1.5 miles (30 mins)
SOMERSET ROAD
PRITCHATTS ROAD
FARQUHAR ROAD
VINCENT DRIVE
EDGBASTON PARK ROAD
RING ROAD NORTH
RING ROAD SOUTH
UNIVERSITY ROAD WEST
UNIVERSITY ROAD EAST
TERRACE ROAD
A38 BRISTOL ROAD
ELMS ROAD
WORCESTER AND BIRMINGHAM CANAL
OLD QUEEN ELIZABETH HOSPITAL
KING EDWARD'S SCHOOL
MAIN ENTRANCE
Green Heart
University Square
Chancellor's Court
Outdoor Sport Facilities
Athletics Track
Conference Park
Tennis Court
Oakley Court
Medical Practice and Dental Centre
Pritchatts House
Pritchatts Park Village
The Spinney
Ashcroft
West Gate
East Gate
South Gate
Grange Road Gate
Pedestrian access only
Boumbrook Student Accommodation
Car Park Entrance
Main Entrance
North East Car Park (Multi-storey)
To Tiverton Gym
To Jarratt Hall (4 mins)
To Selly Oak campus and University of Birmingham School
To School of Dentistry
To city centre
University running track
5 minutes
10 minutes
15 minutes
Cultural attractions (open to the public)
Bramall Music Building (R12)
Barber Institute of Fine Arts (R14)
Lapworth Museum of Geology (R4)
Winterbourne House and Garden (G12)

Travel

We recommend delegates use public transportation networks to travel to Birmingham and the University. For more information please check our website.

By Train

Most services to Birmingham will arrive at New Street Station, located in the city centre. You can travel directly from New Street Station to the University by the cross-city line. These trains run regularly, with journey times of approximately 10 minutes.

By Coach or Bus

National Express coach services run to Birmingham Coach Station, which is located in Digbeth. From here it is a 10 minute walk to New Street Station, or you can connect to local bus services. Numbers X61 and 63 travel from the Bus Mall, Moor Street Queensway, and from New Street Station, St. Martin’s Queensway, to the University (Bristol Road, at the corner of Edgbaston Park Road).

These services all run frequently from the city centre.

Driving

By car, the University is located two and a half miles from the city centre. For navigation, please follow sat nav instruction to B15 2SA, which will direct you to the North East Multi-storey Car Park (Pritchatts Road). Please note this car park does not have a lift. Parking charges apply between 8am and 6pm. Parking after 6pm is free. Charges start from £3.40 and are capped at £10. Payments can be made through RingGo (location 15677) or via the payment machines on floors one to five. Other on-street parking is also available in the areas surrounding campus, including Selly Oak.

Accommodation

There is a wide array of accommodation available in Birmingham at a range of price points.
Below is a short list of some suggestions:

- Edgbaston Park Hotel
- Bournbrook Inn
- Premier Inn City Centre(New St Station)
- Travel Lodge Birmingham Central Moor Street
- Britannia Hotel Birmingham - New Street Station
- EasyHotel - Birmingham City Centre
- Holiday Inn Express Birmingham - City Centre

Social Events

Icebreaker

Tuesday 8th April at 17:30 till late
Lapworth Museum of Geology (R4), University of Birmingham

Join us for our ice breaker event with a difference! We're hosting a **Fringe-style event**, which will include an **Open Mic night** and **Art & Photography competition**, in aid of raising money for the Midlands Arts Centre (MAC) **Green Futures** campaign.

Science is all about discovering universal truths – music and art are universal languages and are incredibly important to our society. At the centre of the MAC's Green Futures campaign is the belief that all young people deserve to feel educated and empowered in the face of the climate crisis. Green Futures raises money to programme free arts-based workshops and events that help children process climate change with clear eyes and hopeful hearts.

Light refreshments will be provided.

Please click here to **vote** for your winning entry!

Please also consider donating towards the **Green Futures fundraiser** by clicking here.

Conference Dinner

Wednesday 9th April at 19:00
Celebrity Indian Restaurant, 44 Broad St, Birmingham (B1 2HP)

The conference dinner takes place in the locally famous **Celebrity Indian Restaurant**, located in the heart of Birmingham. Food will be exclusively vegetarian and served family style. This is included as part of your in-person registration.

Please be sure to wear your conference name badge.

mac

Midlands Arts Centre

GREEN FUTURES

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Keynote Speakers

Dr Ross Whiteford (ECR Prominent Lecture Series)

Ross is a postdoc in computational geochemistry at Royal Holloway, University of London. He uses statistical and mechanistic models to reconstruct a variety of palaeoclimate signals, particularly those related to palaeo pH and palaeo CO_2.

Dr Aled Evans (Postdoctoral Research Medal)

Aled is a Postdoctoral Research Fellow at the University of Southampton, he uses geochemistry and geophysics to investigate fluid-rock interactions primarily in ocean crust and lithosphere.

Professor Clare Warren

Professor Clare Warren's research focuses on the evolution of mountain belts. She investigates rates, timescales and processes of element mobility, with a view to understanding how, where and when different elements concentrate or dilute in the crust.

Professor Kirsty Penkman

Kirsty is a Professor in Analytical Chemistry at the University of York, developing and applying analytical approaches to archaeological and geological questions. Her research focus is on the analysis of biomineral organics and how these molecules can inform us of an organism's life and death history.

Dr Tom Dunkley Jones

Tom is a micropalaeontologist, specializing in the study of fossil coccolithophore algae. His current research is focused on using coccolithophore organic biomarkers, and the isotopes and Sr/Ca ratios of calcium carbonate coccolith-plates to reconstruct past ocean and climate change.

Programme Day 1

Tuesday 8th April 2025

Location: Alan Walters Building

12:00 - 13:00 **Registration**
13:00 - 13:15 **Welcome/introductions**

Session 1: Old Rocks, New Tricks *(Chairs: Dr Jane Barling & Dr James Bendle)*

13:15 - 13:30 **Raimund Wahlen (Agilent)**
Novel tools for ICP method development in challenging matrices

13:30 - 14:00 **Clare Warren (Keynote)**
Making Mountains: The role of metamorphic processes in economic geology

14:00 - 14:15 **Matthew Allison**
Quantifying the uniformitarian assumption across 200 million years of GDGT-based temperature reconstructions

14:15 - 14:30 **Paul Savage**
The Si isotope compositions of TTGs indicates increased weathering of subaerial land ~3.7 billion years ago

14:30 - 15:00 **Tea/coffee break**
15:00 - 16:15 **Poster Session (G11)**

Session 2: Ice, Ice, Maybe? *(Chairs: Dr. David Wilson & Matthew Allison)*

16:15 - 16:30 **Craig Storey (Datech)**
Laser ablation ICP-MS and Laser Induced Breakdown Spectroscopy using Excimer and Femtosecond lasers from Applied Spectra – What can we ask and what can we learn?

16:30 - 16:45 **Emily Archibald**
Holocene dynamics of Thwaites Glacier (West Antarctica): New insights from offshore provenance records

16:45 - 17:00 **James Bendle**
Compound-specific δ^2H of algal biomarkers: a novel proxy for glacial meltwater inputs

17:30 - 20:00 **Icebreaker event (Lapworth Museum)**

Programme Day 2

Wednesday 9th April 2025

Location: Alan Walters Building

09:30 - 10:00	**Welcome tea/coffee**

Session 3: What's in the Ocean? *(Chairs: Dr Bridget Warren & Dr Pam Vervoort)*

10:00 - 10:15	**Mike Seed (Elementar)** *High precision stable isotope analysis of carbonate and water samples for paleoclimate applications using the Elementar iso DUAL INLET*
10:15 - 10:45	**Ross Whiteford (Keynote)** *Using Gaussian Processes to Reconstruct Phanerozoic Seawater Calcium, Magnesium, and Sulphate Concentrations*
10:45 - 11:00	**Molly Trudgill** *Glacial alkalinity in the Pacific Ocean constrained from paired oxygen and carbonate system reconstructions*
11:00 - 11:15	**Kirsty Edgar** *Stable isotope palaeoecology of middle Eocene to early Oligocene planktonic foraminifera from IODP Expedition 342, north-western Atlantic Ocean*
11:15 - 11:45	**Tea/coffee break**
11:45 - 13:00	**Poster Session (G11)**
13:00 - 14:00	**Lunch (Alan Walters Atrium)**

Session 4: Fossilised Fables & Ancient Labels *(Chairs: Dr Tom Dunkley Jones & Dr Marie-Laure Bagard)*

14:00 - 14:15	**Florian Kuhl (MK Versuchsanlagen)** *MK Mobile Labs: metal-free clean lab solutions in a container*
14:15 - 14:45	**Kirsty Penkman (Keynote)** *Through the Looking-Glass, and What Amino Acids Found There*
14:45 - 15:00	**Katie Brown** *Lithium isotopes in Holocene speleothems from the Yorkshire Dales: testing their application as weathering regime tracers*
15:00 - 15:15	**Thomas Marquand** *Using stable carbon isotopes to quantify the production and consumption of CO_2 and CH_4 in soils with changing water table depth*

Programme Day 2

Wednesday 9th April 2025

15:15 - 15:45	**Tea/coffee break**

Session 5: From Mantle to the Moon *(Chairs: Dr Aled Evans & Dr Kathryn Shaw)*

15:45 - 16:00	**Niel Williams (Thermo Fisher Scientific)** *Thermo Scientific™ Neoma™ MS/MS MC-ICP-MS: improved abundance sensitivity for uranium isotopic analysis*
16:00 - 16:15	**Matthew Varnam** *Crystal clear or a crystal ball? Major element profiles created by devitrification of picritic glass prior to melting in volatile-loss experiments*
16:15 - 16:30	**Hugo Moreira** *Tracing the redox-state of the upper mantle in the early Earth*
16:30 - 16:45	**Elsa Amsellem** *Primordial Signatures of Early Magma Ocean Crystallisation in Barberton Komatiites: Insights from Fe Isotopes*
16:45 - 17:00	**Catriona Menzies** *Using Geochemical Tools to Investigate Fluid Flow and Earthquake Processes*
19:00 - LATE	**Conference Banquet at Celebrity Indian Restaurant**

Programme Day 3

Thursday 10th April 2025

Location: Alan Walters Building

09:30 - 10:00 **Welcome tea/coffee**

Session 6: It's a Hard Rock Life *(Chairs: Dr Paul Savage & Dr Catriona Menzies)*

10:00 - 10:15 **Paul Watson (Elemental Scientific Instruments)**
Overview of Elemental Scientific's products for Geochemistry

10:15 - 10:45 **Aled Evans (Keynote)**
Ocean crustal veins record dynamic interplay between plate-cooling-induced cracking and ocean chemistry

10:45 - 11:00 **Sukalpa Chatterjee**
Formation of Paleoarchean greenstone belt by melting of evolving plume sourced from the deep mantle

11:00 - 11:15 **Kevin Wong**
Numerical modelling of H_2*-generating fluid-rock reactions in subduction setting*

11:15 - 11:45 **Tea/coffee break**

Session 7: Carbon Chronicles *(Chairs: Dr Ross Whiteford & Dr Savannah Worne)*

11:45 - 12:00 **Ariane Donard (Nu Instruments)**
Accessing new analytical approaches for high-precision and accuracy isotope ratio analysis with Sapphire XD Dual Path MC-ICP-MS/MS

12:00 12:30 **Tom Dunkley Jones (Keynote)**
Coccolithophore-based geochemical proxies

12:30 - 12:45 **Bridget Warren**
A tale of two $[CO_2]$ *proxies: an inter-proxy comparison of palaeo-*CO_2 *concentrations in the early Eocene*

12:45 - 13:00 **Rich Norby**
Forest biogeochemistry under elevated CO_2*: a survey of relevant results from BIFoR FACE*

13:00 - 13:30 **Lunch (Alan Walters Atrium)**
13:30 - 14:15 **AGM/Prize presentations**

Session 1

Old rocks, new tricks

Tuesday 8th April
13:00 - 14:30

Chaired by:
Dr Jane Barling and **Dr James Bendle**

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Designed and manufactured by Agilent, the Advanced Dilution System (ADS 2) integrates with Agilent ICP-OES and ICP-MS instruments. The autodilutor automates all common dilution tasks, including:

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DE46883496

Novel tools for ICP method development in challenging matrices

Wahlen, R., Brotherhood, A.

*raimund_wahlen@agilent.com

[1] Agilent UK Ltd, 5500 Lakeside, Cheadle, Stockport, SK8 3GR

Recent developments in both hardware and software options for our ICP-OES and ICP-MS instruments can help analysts generate high-quality data easier and more quickly with less user intervention than with older-generation systems.

We will describe novel tools such as the IntelliQuant feature on our ICP platforms which provide the analyst with a full picture of the entire sample composition quickly for method development and thereby guide the analyst in deciding which wavelengths - or isotopes - are the best options for target analytes or internal standard elements.

Options for addressing doubly-charged interferences in ICP-MS will be discussed as well as use of different collision/ reaction cell conditions with single- and triple-quad ICP-MS systems for previously challenging elements such as Si, S, P and F will be discussed.

Finally, automated hardware features to address high levels of dissolved solids in solutions will be compared.

Making Mountains: The role of metamorphic processes in economic geology

Warren, C.J[1]*, Oliveira da Costa, E.[1], Kunz, B. [1], Oldman, C.[1]

*clare.warren@open.ac.uk

[1] The Open University, Walton Hall, Milton Keynes, MK76AA, UK

Elements such as Li, Be, Sn, Cs, Ta and W are used in in wind turbines, solar panels, and batteries, and are therefore critical for the transition to green energies. They are mined from micas hosted in peraluminous granites and granitic pegmatites, lithologies usually formed via crustal melting of metasedimentary (and specifically metapelitic) protoliths. Most previous studies have suggested that magmatic or sedimentary processes such as extreme fractional crystallisation, melt extraction and/or protolith enrichment control the genesis of such deposits.

Metamorphic reactions in the deep and shallow crust may also play an important role in concentrating or diluting specific elements during crustal melting. Here we show that the pressure-temperature conditions, the melt reactions themselves and retrograde reactions all control the extent to which critical elements may be concentrated or diluted in the crust. For example biotite dehydration melting typically involves feldspars, quartz and aluminosilicates as reactants and the production of either garnet or cordierite as peritectic product, depending on pressure and bulk Fe/Mg. Biotite hosts all the elements of interest, whereas cordierite only hosts Li and Be, and garnet hosts none of the elements of interest. The production of these peritectic minerals therefore plays a role in the mobilisation of these elements.

At the other end of the metamorphic cycle, retrogression reactions break down minerals that may host critical elements and release them into circulating fluids or host in clays. Here we show examples from the breakdown of biotite and cordierite.

Quantifying the uniformitarian assumption across 200 million years of GDGT-based temperature reconstructions

Allison, M.[1]*, Dunkley Jones, T.[1], Greene, S.[1], Hall, J.[1], Duncan, B.[2], Jones, S.[1], Mandel, I.[3], Bendle, J.[1]

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[2] Antarctic Research Centre, Victoria University of Wellington, Wellington, 6140, New Zealand
[3] School of Physics and Astronomy, Monash University, Clayton, Vic. 3800, Australia

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isoGDGT's are a lipid-based, marine palaeoclimate archive[1]. They have been demonstrated to passively record temperature and can be found, archived in the marine sediment record as far back as the Jurassic. Here, we assess whether this system obeys the key geological tenant of Uniformitarianism, utilizing a Gaussian machine learning approach (OPTiMAL)[2].

A modern dataset of core-top isoGDGT assemblages (n=854) is used to train OPTiMAL and predict the Sea Surface Temperature (SST) on a compilation of ancient isoGDGT data (n=12,256). A new metric is presented here, designed to track any force acting the isoGDGT system, known or unknown, and is used to interrogate the temporal and spatial relationship between the modern and ancient data.

For the first time, this new metric allows for a qualitative comparison of forces impacting the production and archiving of isoGDGT's, highlighting that non-thermal events (e.g. oceanographic changes) are just as impactful on the record as thermal events (e.g. hot-house climates). Whilst long term changes in the isoGDGT system are observable in our analysis, we conclude that the system behaves in a Uniformitarian manner. That is to say, the modern ocean isoGDGT system is a reliable analogue of pasts ocean temperatures spanning the Holocene – Jurassic.

References:

[1] Schouten, S., Hopmans, E.C., Schefuß, E., Damste, J.S.S.: Distributional variations in marine crenarchaeotal membrane lipids: a new tool for reconstructing ancient sea water temperatures? Earth and Planetary Science Letters 204(1-2), 265–274 (2002)
[2] Dunkley Jones, Tom, et al. "OPTiMAL: a new machine learning approach for GDGT-based palaeothermometry." Climate of the Past 16.6 (2020): 2599-2617.

The Si isotope compositions of TTGs indicates increased weathering of subaerial land ~3.7 billion years ago

Greber, N.[1], Murphy, M.[2,3], Storck, J.-C.,[4] Reimink, J.[5], Dauphas, N.[6] & Savage, P.S.[3]*

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[1] University of Geneva, Switzerland
[2] Lamont-Doherty Earth Observatory, Columbia University, USA
[3] University of St Andrews, UK
[4] Institute of Geochemistry and Petrology, ETH Zurich, Switzerland
[5] Pennsylvania State University, USA
[6] The University of Chicago, USA

Multiple lines of evidence suggest that 25-75% of continental crust already existed by 3.0 Ga[1-2] but it is not clear how much of this crust sat above sea-level; nor is it clear how early in Earth's history the realm of subaerial continental crust became established. Constraining this is important, because weathering and erosion of emerged lands plays a significant role in the Earth system, exerting a control on the composition of the atmosphere and nutrients delivered to the oceans. Furthermore, emerged land hosts lakes and continental shelves that are thought to have provided ideal habitats for the emergence of life[3].

Studies have shown that the silicon isotope compositions of Archaean granitoids (TTGs) are resolvably heavier than their Phanerozoic equivalents, due to the presence of marine authigenic silica in the source region of TTG melts[4-5]. This silicified material provides a proxy for the Si isotope composition of Earth's early oceans and thus records the balance of its sources and sinks.[6] We show that the Si isotope compositions of TTGs changed geologically rapidly around 3.6 Ga – and suggest that the most likely explanation for this is an increase in isotopically heavy dissolved silicon derived from subaerial weathering of continental crust.

Modelling of this shift reveals that between 3.8 and 3.6 Ga, the relative magnitude of terrigenous input to the marine dissolved Si budget increased from near zero to 32 ± 15 %. This would suggest that, from 3.6 Ga onwards, continental weathering feedbacks were established and mass flux from land became an important source in the chemical budget of seawater - changes that likely exerted a positive effect on the evolution of life.

References:

[1] Reimink, J. R., *et al.*, (2023) *Geochemical Perspect. Lett.* **26**, 45–49;
[2] Korenaga, J. (2018) *Earth Planet. Sci. Lett.* **482**, 388–395;
[3] Pearce, B. K. D., *et al.*, (2017) *Proc. Natl. Acad. Sci. U. S. A.* **114**, 11327–11332;
[4] Deng, Z. *et al.* (2019) *Nat. Geosci.* **12**, 774–778;
[5] André, L. *et al.* (2019) *Nat. Geosci.* **12**, 769–773;
[6] Murphy, M. E. *et al.* (2024) *Geochim. Cosmochim. Acta* **368**, 34–49.

Session 2

Ice, ice, maybe?

Tuesday 8th April
16:15 - 17:00

Chaired by:
Dr David Wilson and **Matthew Allison**

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The Geological Society

UNIVERSITY OF BIRMINGHAM

Laser ablation ICP-MS and Laser Induced Breakdown Spectroscopy using Excimer and Femtosecond lasers from Applied Spectra – What can we ask and what can we learn?

Storey, C.[1]*, Darling, J.[1], Mottram, C.[1], Moreira, H.[1], Dunlop, J.[1], Chapman, G.[1], Bowie, S.[1] & Minkah-Kyei, S.[1]

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At the University of Portsmouth we have housed an Applied Spectra Resolution 193nm Excimer laser coupled with various different ICP-MS instruments since 2014. More recently, we installed an Applied Spectra J200 Tandem LA-LIBS instrument with a femtosecond laser source in late 2021 which can also be coupled to either of our current ICP-MS systems (Agilent 8900 and Nu Plasma 1). In this talk, I will share some perspectives on how these lasers have been used to deliver a variety of research projects, some of our recent developments including the coupling of LIBS and LA-ICPMS, the analysis of beam sensitive materials by femtosecond laser ablation, and our plans for future endeavours. Application under development include: Li quantification and mapping in a wide-range of materials; concurrent halogen, trace and U-Th-Pb isotope analysis of apatite; concurrent major and trace element analysis of geological glasses, sulphides and silicates; U-Pb of baddeleyite and beam sensitive phases; U-Pb in carbonates; Rb-Sr in micas. I will show the general layout of the laboratory and share some thoughts on what the capabilities are and what new questions we may able to ask including outstanding gaps in our knowledge.

Holocene dynamics of Thwaites Glacier (West Antarctica): New insights from offshore provenance records

Archibald, E.[1]*, van de Flierdt, T.[1], Marschalek, J.[1], Muxworthy, A.[1], Hillenbrand, C-D.[2], Stoner, J.S.[3], Dwyer, D.[3], Cargill, S.K[3], Wellner, J.S.[4] & the THOR Team[5]

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Thwaites Glacier in the Amundsen Sea sector of the marine-based West Antarctic Ice Sheet is losing mass at an accelerating rate, with its landward dipping bed making the glacier prone to rapid and irreversible ice loss in the near future. Analysis of the provenance of marine sediment records can provide insights how glaciers draining into the Amundsen Sea behaved in the past and how they will behave in a warming world.

Measurements of radiogenic isotopes on the fine-grained fraction of seafloor surface sediments from the Amundsen Sea continental shelf have previously revealed that detritus eroded under and supplied by Thwaites Glacier has distinct Nd and Sr signatures that differ from those of glaciogenic debris delivered by neighbouring Pine Island Glacier. This allows us to trace the relative supply of detritus to the offshore sites through time. Here we present new geochemical and paleomagnetic data from three Holocene sediment records collected on behalf of the Thwaites Glacier Offshore Research (THOR) project (2019/2020). We investigate (i) whether there have been provenance changes in the sediments over the past 10,000 years, and (ii) how we can utilize these changes for reconstructing past glacier dynamics.

New paleomagnetic secular variation measurements on U-channels provide independent stratigraphic constraints enabling more effective use of prior radiocarbon dates to improve both chronological accuracy and uncertainty. Applying these new age models, we have identified periods of major isotopic shifts in the sediment records during the Holocene, which are likely to indicate past phases of glacier retreat and readvance.

Compound-specific δ^{2}H of algal biomarkers: a novel proxy for glacial meltwater inputs

Bendle, J.[1]*, Ashley, K.[1], McKay, R.M.[2], Crosta, X.[3], Etourneau, J.[3], Anya, A.B.[2], Golledge, N.[2,4], Bertler, N.[2,4], Seki, O.[5], Willmott, V.[6], Schouten, S.[6], Riesselman, C.[7], Masse, G.[8], Dunbar, R.B[9]

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Over recent decades Antarctic sea-ice extent has generally increased, coincident with widespread thinning of West Antarctic ice shelves and rapid freshening of surface and bottom waters along the Antarctic margin. In contrast, the latest generation of Earth system models, which are used for future projections, generally simulate a decrease in sea ice. Here, we show that this mismatch may be due to an underrepresentation in climate models of evolving ice shelf cavities and the effects of meltwater fluxes on sea-ice dynamics. Our evidence comes from a 171m Holocene sediment core from the Adélie Land coastal region of East Antarctica that records environmental change through the Neoglacial transition – the last major baseline shift noted in geological archives of sea-ice behaviour in the Antarctic and is part of a mid- to late-Holocene global cooling trend. We present new records of compound specific fatty acid isotope analyses (δ^{2}H-FA), highly-branched isoprenoid alkenes (HBIs), grain-size, mass accumulations rates (MARs) and image analyses from a 171m Holocene sediment sequence from Site U1357 (IODP leg 318). In combination with published records we reconstruct Holocene changes in glacial meltwater, sedimentary inputs and sea-ice. The geological data, supported by high-resolution ocean modelling, provides a detailed record of changing glacial meltwater input, sediment transport and sea-ice variability, and reveals an episode of rapid Antarctic sea-ice increase against a backdrop of gradual climate warming during the mid-Holocene. We suggest that ice shelf cavity expansion in the Ross Sea associated with mid-Holocene grounding-line retreat led to accelerated freshening of surface waters, cooling, and sea-ice growth. Incorporation of this feedback mechanism into global climate models may therefore be important for accurate future projections of Antarctic environmental change. This work highlights that compound-specific δ^{2}H of algal biomarkers are a promising proxy for glacial meltwater.

Session 3

What’s in the oceans?

Wednesday 9th April
10:00 - 11:15

Chaired by:
Dr Pam Vervoort and **Dr Bridget Warren**

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EXCELLENCE IN ELEMENTS

Mineralogical Society

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High precision stable isotope analysis of carbonate and water samples for paleoclimate applications using the Elementar iso DUAL INLET

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Paleoclimate research is important for understanding past, current and future climate, providing the data needed to model and predict current and future climate change scenarios. Stable isotope analysis provides an essential tool for gathering past climate information from natural archives such as waters including ice-cores, ground waters, and biological waters; and carbonate materials such as foraminifera and other fossilized carbonates. Due to the often limited and small sample sizes available for stable isotope analysis it is vital that highly precise and accurate analysis can be carried out on the smallest of sample sizes.

Dual inlet technology remains the most precise, accurate and sensitive technique for pure gas, carbonate and water analysis. The Elementar iso DUAL INLET is a valuable tool for paleoclimate applications, enabling the analysis of pure gas samples within an incredibly compact footprint via our powerful lyticOS software suite. The 14-ultra low dead volume valves with bodies machined from a single block of high purity stainless steel and dedicated turbomolecular pump for the changeover valve guarantees zero residual memory effects between reference and sample gas.

The iso DUAL INLET can be optionally enhanced for the automated analysis of carbonate and water samples. With the iso AQUA PREP enhancement, up to 180 water samples can be analysed achieving δ18O precision better than 0.05‰ (1σ, n=10) and δ^2H precision better than 1‰ (1σ, n=10), for any environmental water sample. The iso CARB PREP enhancement enables automated analysis of up to 180 micro-fossil samples for ^{13}C and ^{18}O down to 20µg sample size. For the highest productivity, both carbonate and water analysis can be performed with the iso MULTI PREP enhancement with switching between modes needing simply a change of needle. The IRMS collector configuration can also be upgraded for “clumped isotope analysis” of carbonate materials.

We will highlight the performance of the iso DUAL INLET with carbonate and water functionality across a range of sample types for paleoclimate applications, supporting researchers building a detailed understanding of the past to better inform policy makers for the future.

Using Gaussian Processes to Reconstruct Phanerozoic Seawater Calcium, Magnesium, and Sulphate Concentrations

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In geochemistry, we often have datapoints which describe how some variable (such as an isotopic or elemental ratio) has changed through time. From those datapoints, we typically want to create a continuous line with attendant uncertainty. There are many methods to do this, all of which have upsides and downsides. One method that is particularly useful for geochemical times series is the Gaussian Process. A Gaussian Process is a flexible statistical tool that allows us to combine data constraints with an expected covariance structure. That means is that we're able to use both the datapoints themselves, and any understanding we have of how the variable in question has evolved, for instance information about the rate of change or periodicity. I will demonstrate the power of the Gaussian Process approach by using it to reconstruct seawater calcium, magnesium, and sulphate concentrations over the Phanerozoic.

Glacial alkalinity in the Pacific Ocean constrained from paired oxygen and carbonate system reconstructions

Trudgill, M.[1*], Gray, W.[1], Pavia, F.[2], Kobayashi, H.[3], Richard, P.[1], Fries, M.[1], Umling, N.[4], Rae, J.[5], Adloff, M.[6], Eggleston, S.[7], Paillard, D.[1], Berelson, W.[8], Adkins, J.[8], Isguder, G.[1], Manssouri, F.[1], Prinet, L.[1].

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[8]University of Southern California, USA

The response of the deep ocean carbonate system and $CaCO_3$ dissolution to changes in the carbon cycle (‘carbonate compensation’) is a first order control on atmospheric CO_2 on timescales of ~10^3 to 10^5 years. Although carbonate compensation could account for up to ~half of the glacial drawdown of CO_2, quantitative estimates of changes in ocean alkalinity are lacking. As such, the role of carbonate compensation in driving glacial-interglacial CO_2 variations remains poorly understood.

Here, we combine reconstructions of dissolved oxygen from the infaunal-epifaunal benthic foraminiferal $\delta^{13}C$ proxy ($\Delta\delta^{13}C$) and carbonate system reconstructions from boron proxies (B/Ca, $\delta^{11}B$) in benthic foraminifera to quantify changes in both respired CO_2 storage within the deep Pacific during the last glacial, and the response of the carbonate system to this addition/removal of respired CO_2. Our results provide the first quantitative estimates of the amount and timing of alkalinity changes in the deep Pacific over the last deglaciation. Our results indicate an increase in deep ocean alkalinity during the Last Glacial Maximum, and suggest the buffering of the deep ocean occurs substantially faster than the canonical timescale of ~5 kyr[1], with implications for our understanding of alkalinity cycling in both glacial times, and the long-term future.

Stable isotope palaeoecology of middle Eocene to early Oligocene planktonic foraminifera from IODP Expedition 342, north-western Atlantic Ocean

Edgar, K.M.[1]*, Breen, P.[2,3], Holmstrom, M.[4], D'Haenens, S.[2], Coxall, H.K. [4], Brombacher, A.[2] and Hull, P.M. [2]

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During the early Eocene through early Oligocene (~50-34 Ma), the Earth transitioned from the relative warmth of the early Eocene "hothouse" to a "coolhouse" climate state, associated with decreasing global temperatures, increasing latitudinal temperature gradients and ocean restructuring, culminating with a major increase in Antarctic continental ice volume across the Eocene-Oligocene transition ~34 Ma. Alongside these ocean climate transitions, marine plankton communities underwent pronounced restructuring, involving a loss of warm water favouring and oligotrophic species, ecological adjustments in some groups and diversification of cooler water species. Existing perspectives focus on low latitudes, and little is known about the planktonic foraminifera ecological responses at mid-high latitudes, where the strongest climatic and oceanic signals occurred. During Integrated Ocean Discovery Program (IODP) Expedition 342, offshore Newfoundland in the North Atlantic Ocean, multiple sites containing clay-rich sediments host well preserved ("glassy") foraminifera spanning the middle Eocene to Oligocene. The high quality, diverse assemblages of planktonic foraminifera are ideally suited for geochemical analyses allowing, arguably, accurate ecological reconstructions. Here we present ~550 new size-constrained, species-specific, planktonic foraminiferal stable oxygen and carbon isotope measurements for investigating palaeoecologies and ecological evolution in this environmentally sensitive region. The data comprise suites of ~5-20 species from 13-time windows spanning the middle Eocene to earliest Oligocene (~46-33 Ma) from IODP sites U1408 and U1411. These data provide insight into the palaeoecology of >50 extinct taxa, including the first size-specific isotopic data for multiple species during this critical transition interval.

Session 4

Fossilised fables & ancient labels

Wednesday 9th April
10:00 - 11:15

Chaired by:
Dr Tom Dunkley Jones and **Dr Marie-Laure Bagard**

MK Mobile Labs: metal-free clean lab solutions in a container

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[2] MK METALFREE CORP., Surprise, AZ, USA

Metal-free clean labs are of great interest for geochemical and cosmochemical research. Especially for chemical and isotopic analyses of trace elements, it is critical to protect samples against airborne contaminants and metal particles, while simultaneously ensuring the safety of the operator. MK Versuchsanlagen GmbH & Co. KG has more than 35 years of experience in metal-free cleanrooms and workstations with laminar airflow, and is a trusted partner in the scientific community.

The last years have shown that financial resources and space have become increasingly limiting factors in many places and areas of research. For this, MK Versuchsanlagen provides a solution by developing, designing, and installing complete metal-free cleanrooms and laboratories in mobile containers. A turnkey solution from a single provider with numerous advantages for the customer: rapid deployment, implementation of special safety precautions, adaptability to the users' needs, and mobility are the four main aspects of the MK Mobile Labs.

In our talk, we will discuss the basics of metal-free cleanrooms and present three examples of MK Mobile Labs that serve on a research vessel, as temporary solution on the roof a building (Fig. 1), or as long-term solution on the ground.

Fig. 1: View into an MK Mobile Lab with metal-free vertical laminar flow workstations

Through the Looking-Glass, and What Amino Acids Found There

Penkman, K.E.H.*, Dickinson, M., Nelson, N., Tomiak, P., Crisp, M., Demarchi, B., Wheeler, L., & Greeves, S.

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Chronology underpins our understanding of the past, but beyond the limit of radiocarbon dating (~60 ka), sites become difficult to date. Amino acid geochronology uses the time-dependent breakdown of proteins in biominerals, with the racemisation reactions (conversion between mirror-images) of amino acids having the potential to date the whole of the Quaternary. Recent studies have shown that a very small fraction of 'intra-crystalline' protein within mollusc shells, opercula, coral, eggshell and enamel forms a closed system, and if this is targeted, the difficulties due to leaching, contamination and environmental factors are removed. The analysis of a coherent calcite intra-crystalline system has enabled the development of a chronology back to at least 2.8 Ma, while enamel proteins allow time resolution well into the Pliocene.

Our research is now focusing on building chronological frameworks on a wide spatial and temporal scale, from Europe to Africa, Asia and Australia. Ever expanding the range of materials we are testing, we are also gaining an unprecedented understanding into biomineralisation, and the palaeoenvironmental signal that can be contained within the fossil protein. The information that chiral amino acid analysis provides on protein breakdown has led to its use in palaeoproteomics, and we are also making analytical advances into the realms of microfluidics, aiming to democratise the technique.

Lithium isotopes in Holocene speleothems from the Yorkshire Dales: testing their application as weathering regime tracers

Brown, K.[1]*, Wright, L.[1,2], Atkinson, T.[1], Hopley, P.[3], Wilson, D.[1]

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[3] School of Natural Sciences, Birkbeck, U.K.

The ^{7}Li value of cave drip-waters from which speleothems precipitate is hypothesised to be determined by local changes in weathering congruency: the ratio of primary mineral dissolution to secondary mineral formation[1]. To test this idea, we analysed ^{7}Li values in speleothems LH-70s-1, LH-70s-2, and LH-70s-3 spanning 12.3 ka – 1.0 ka from Lancaster Hole, Yorkshire Dales. These data were compared with previously measured ^{13}C, ^{18}O, Mg/Ca, and Sr/Ca records based on U-Th age models[2].

Over millennial timescales, our Li isotope records do not consistently replicate across speleothems, indicating that short-term fluctuations in ^{7}Li values arise from localised epikarst changes. Broadly correlated ^{7}Li, ^{13}C, Mg/Ca, and Sr/Ca values imply increased epikarst residence times when ^{7}Li values are elevated. This scenario reflects increased prior calcite precipitation, decreased drip rates, and extended water-rock interaction times. In this setting, the ^{7}Li values appear to be controlled by extended interaction times of water with glacial till washed into flow pathways through dolines. However, this correlation is not consistent for the entire length of the records. In LH-70s-1, an excursion to low ^{7}Li values coupled with elevated Mg/Ca, Sr/Ca, and ^{13}Cvalues is observed prior to 11 ka, immediately succeeding the Younger Dryas. This finding may indicate that significant regional changes in weathering congruency related to the increased supply and dissolution of primary silicates following the Younger Dryas, together with increased surface runoff due to heightened permeability and climatic water surplus, may override localised hydrological controls on speleothem ^{7}Li values to drive a regional signal over longer timescales.

References:

[1] von Strandmann, P.A.P. et al. (2017). EPSL, 469, pp.64-74.
[2] Atkinson, T.C. and Hopley, P.J. (2013). Speleothems and palaeoclimates.

Using stable carbon isotopes to quantify the production and consumption of CO_2 and CH_4 in soils with changing water table depth

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Carbon dioxide (CO_2) emitted due to soil carbon oxidation in drained peatlands is the source of 4% of anthropogenic greenhouse gas emissions globally[1] while waterlogged soils are the largest source of methane (CH_4) emissions. The amount of CH_4 and CO_2 emitted from soils results from the balance between production and consumption of CO_2 and CH_4 in the soil subsurface. Production of CO_2 and consumption of CH_4 occur primarily in oxic soil above or close to the water table while CH_4 production occurs in the anoxic soil below the water table. The depth of the water table is therefore a strong control on the overall soil emissions as confirmed by conventional gas flux measurements[2].

We present data from a series of five soil mesocosm experiments from the UK's largest drained peatland, the East Anglian Fens, in which we varied the water table depth. We couple gas flux measurements with stable carbon isotope ratios ($\delta^{13}C$) of CO_2 and CH_4 allowing us to constrain an inverse model of subsurface CO_2 and CH_4 production and consumption. This gives us a process-based understanding of the changes in emissions observed when we vary the water table. Our findings suggest that the drop in methane emissions observed when lowering the water table is the result of increased methane consumption and not decreased methane production. This result highlights the importance of considering the balance of production and consumption of methane when assessing potential emission reduction strategies.

References:

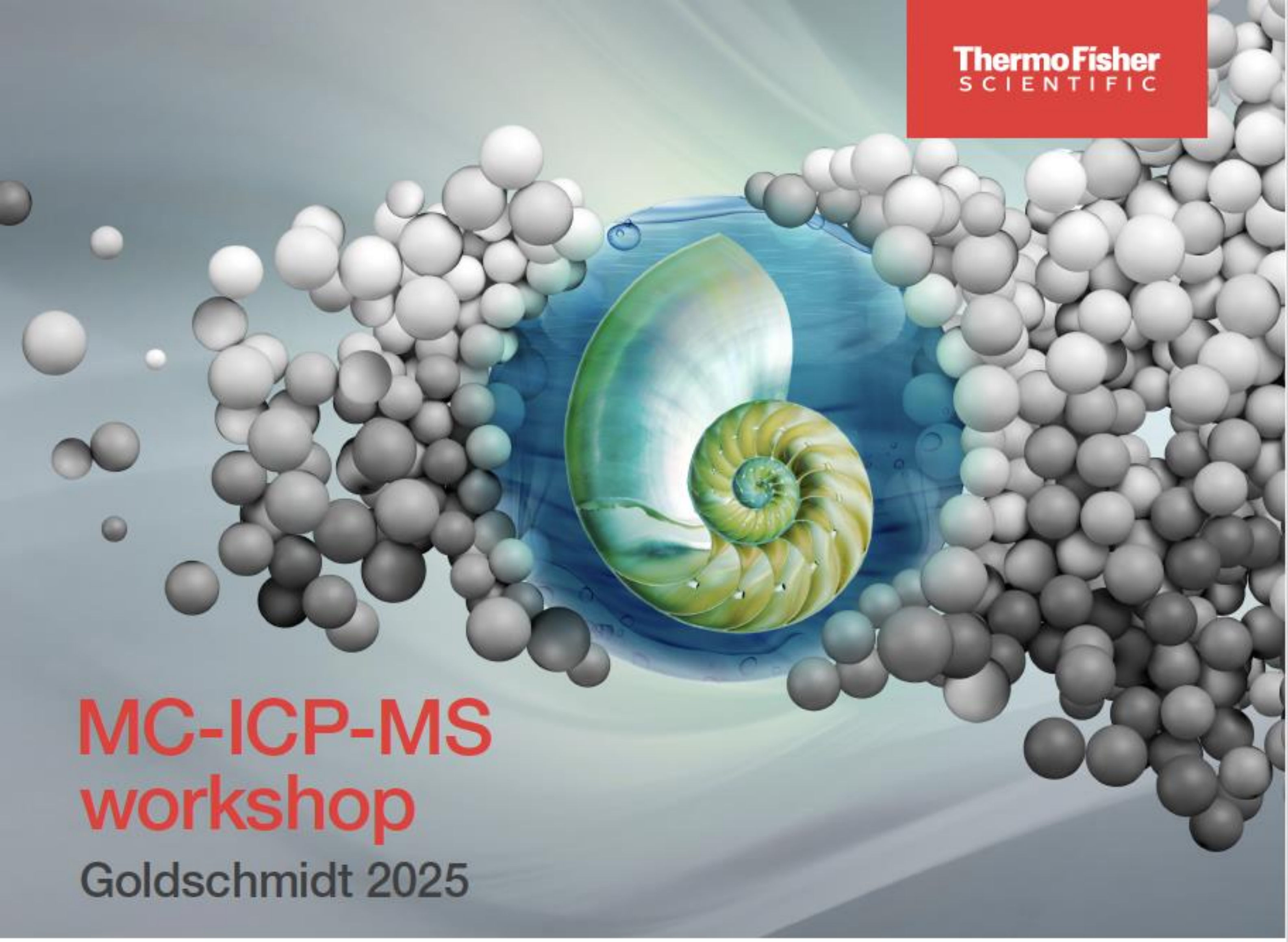
[1] Ramsar Convention on Wetlands (2021). *Restoring drained peatlands: A necessary step to achieve global climate goals.*
[2] Evans, C. D., Peacock, M., Baird, A. J., …, Morrison, R. (2021). Nature, 583, pp. 548-552.

Session 5

From mantle to the moon

Wednesday 9th April
15:45 - 16:45

Chaired by:
Dr Aled Evans and **Dr Kathryn Shaw**



MC-ICP-MS workshop

Goldschmidt 2025

Sunday July 6, 2025 | 09:00 - 17:00

Don't miss our Pre-Conference Workshop, at Goldschmidt 2025 (Prague, Czech Republic, 6-11 July), led by Dr. Claudia Bouman and Dr. Grant Craig, Thermo Fisher Scientific, and designed for users of Thermo Scientific™ Neoma™ (MS/MS) MC-ICP-MS.

How to set up and evaluate your Neoma (MS/MS) MC-ICP-MS analysis using Qtegra ISDS Software

Neoma (MS/MS) MC-ICP-MS offers unique, proprietary features combined with workflow-oriented software to achieve the ultimate precision and accuracy of your isotope ratio data. Join our free 1-day workshop that will demonstrate how Thermo Scientific™ Qtegra™ ISDS Software offers an intuitive, user-friendly interface for Neoma (MS/MS) MC-ICP-MS, from instrument control to data analysis.

Register here >

We will be covering:

- Tuning workflows and control of external peripherals
- Instrument calibration and detector alignment
- LabBooks setup and data processing
- Tips and tricks for tuning the MS/MS option

Registration is free of charge, food and beverages will be provided, but places are limited.

Presenters:

Dr. Claudia Bouman

Dr. Grant Craig

Learn more about MC-ICP-MS
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Thermo Scientific™ Neoma™ MS/MS MC-ICP-MS: improved abundance sensitivity for uranium isotopic analysis

Williams, N.[1]*, Craig, G.[2], Pfeifer, M.[2] , Bouman, C.[2] , Lloyd, N.[2]

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Accurately constraining lowest abundance Th and U isotopes has become an important tool in geochronology and for nuclear forensics, e.g., in dating geologically young samples or controlling nuclear proliferation. Multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS) has been used to accurately and precisely measure the isotopic composition of uranium for over two decades[1-3]. Due to uranium enrichment, samples often have a wide range of potential isotopic ratios, which is a challenge for analysis. In addition, the large abundance of the main isotopes ^{235}U and ^{238}U hamper measurements of smallest ^{234}U and ^{236}U intensities due to tailing effects superimposing on the lower signals.

The Thermo Scientific™ Neoma™ MC-ICP-MS offer several advantages to tackle these challenges. The $10^{13}\Omega$ amplifier technology extends the dynamic range of the Faraday Cup detectors, giving superior precision compared to $10^{11}\Omega$ amplifiers at signal intensities between several 10kcps to 10s of Mcps, related to their better signal-to-noise ratio[3].

The combination of the game-changing novel pre-cell mass filter and hexapole collision/reaction in a Neoma MS/MS MC-ICP-MS4 with the RPQ allows an abundance sensitivity of better than 50 ppb at 1 amu for ^{238}U. This is an order of magnitude improvement when compared to a conventional Neoma MC-ICP-MS with an RPQ.

We present Uranium isotope ratio measurements for the IRMM-183 to IRMM-187 series standard reference materials performed with improved abundance sensitivity on the Neoma MS/MS MC-ICP-MS. An amplifier with $10^{13}\Omega$ resistor was applied for the ^{234}U/^{238}U ratio determination and the ^{236}U/^{238}U measurements were recorded with a secondary electron multiplier (SEM) applying optimized RPQ settings to reduce the peak tail from ^{238}U to single cps.

References:

[1] Yamamoto, K. et al. (2024) Environmental Technology & Innovation. 36 pp 103761–103769.
[2] Boulyga, S.F. et al. (2016) J. Anal. At. Spectrom. 31 pp 2272-2284.
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[4] Craig, G. et al. (2021) Anal. Chem., 93 pp 10519-10527.

Crystal clear or a crystal ball? Major element profiles created by devitrification of picritic glass prior to melting in volatile-loss experiments

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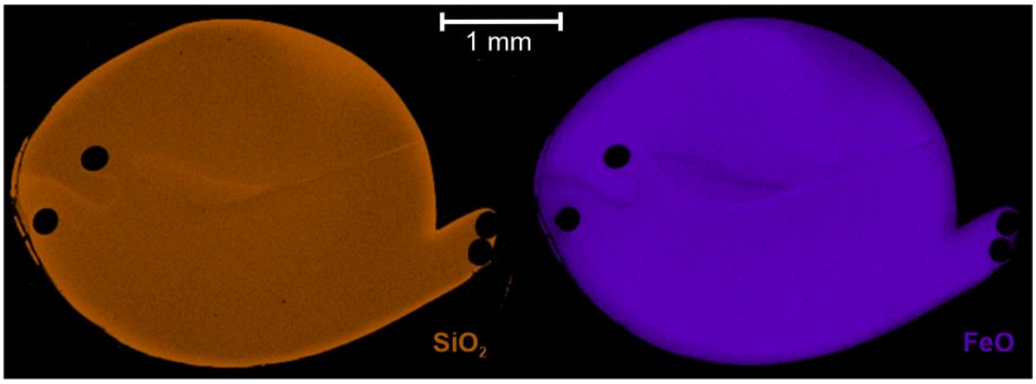
Experimental degassing studies heat synthetic silicate magma to characterize element volatilization in planetary and volcanological contexts. We created beads of synthetic lunar magma using six major-element components: SiO_2, FeO, Al_2O_3, MgO, CaO and TiO_2, dosed with minor Cl and Zn. The beads were lowered into a 1 bar, 1350 °C H_2-CO_2 gas-mixing furnace for 10–60 minutes, then drop-quenched into water.

All experiments run for ≤40 minutes displayed gradients in major elements in the 600 µm closest to the bead edge, as evident in BSE and EDS maps, and EPMA profiles. These gradients were most apparent for shorter durations, with a 6 wt% decrease in FeO and a 7 wt% enrichment in SiO_2. We propose that the starting synthetic glass rapidly devitrifies spinel and pyroxene (<1 min) concomitant with rapid heating. The remaining glass melts first, concentrating to the bead edge and creating the prominent gradients in FeO and SiO_2. Previously, crystallization was observed when heating lunar regolith at 40 °C/min[1], but rapid major-element redistribution is a previously unknown issue in volatile-loss experiments.

Devitrification and element redistribution are likely inherent processes in short-duration high-temperature experiments, so should always be considered for volatile degassing experiments. A similar process would also occur naturally in lunar glass beads if they remelted, providing an alternative explanation for ‘ingassing profiles’ of Na_2O and K_2O observed in 74220 volcanic beads and Chang’e impact beads. If correct, pyroclastic lunar beads with controversial 120 Ma model ages[2] should be examined for this evidence of post-formation heating and resetting.



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Tracing the redox-state of the upper mantle in the early Earth

Moreira, H.[1*], Storey, C.[1], Bruand, E.[2], Darling, J.[1], Parat, F.[3], Cotte, M.[4], Fowler, M.[1], Tual, L.[2] and Dhuime, B.[3]

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The redox state of the upper mantle in the early Earth is a key parameter as it would have buffered atmospheric composition and interacted with the ocean-atmosphere system. Recent work developing an oxybarometer based on S in apatite using µ-XANES has shown great promise as apatite can seamlessly incorporate reduced and oxidised S species and directly reflect the fugacity of host magmas. To overcome common secondary processes affecting matrix apatite such as alteration and recrystallisation, apatite inclusions trapped in zircon during magmatic crystallisation have been proven to be robust. This method has the advantage that the enclosing zircon can be dated and the mantle source traced via Lu-Hf and O isotopes analyses in zircon. To demonstrate that this approach works, we have studied 2.35 Ga TTGs and 2.13 Ga sanukitoids from the Mineiro Belt, Brazil. These rocks temporally straddle the Great Oxidation Event (GOE) and reveal a change from reduced to more oxidised conditions from pre- to post-GOE. This change is interpreted as the result of recycling of atmospherically-altered sediments into the mantle. As the Archaean is marked by subtle but important atmospheric events, such as the oxygenation 'whiffs', we analysed apatite inclusions in zircon grains from 3.4 Ga to 2.7 Ga sanukitoids to trace surface-mantle interactions in the early Earth. Remarkably, our dataset shows relatively oxidising conditions for all measurable inclusions (i.e., with S above limit of detection), suggesting a dynamic recycling mechanism in the early Earth potentially powered through oxygenation episodes.

Primordial Signatures of Early Magma Ocean Crystallisation in Barberton Komatiites: Insights from Fe Isotopes

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Isotopic anomalies in Archean rocks are increasingly recognized as potential signatures of early silicate differentiation events on Earth. However, identifying the precise mechanisms responsible for these isotopic fractionations remains challenging. The combined use of radiogenic and stable isotopes has shown promise in providing deeper insights into these processes. A Recent study has observed correlations between Fe isotopes and $\mu^{182}W$ in Isua metabasalts, suggesting FeO disproportionation in the lower mantle within the first 45 million years of Earth's history, during magma ocean crystallisation[1]. To further investigate fractionation processes during early silicate differentiation, we analysed komatiites from the Barberton Greenstone Belt (Weltevreden and Schapenburg), which exhibit decoupled initial εHf and εNd isotopic compositions, along with negative $\mu^{182}W$ signatures in the Schapenburg samples. Our findings reveal correlations between Fe isotopes and $\mu^{142}Nd$ in both Weltevreden and Schapenburg komatiites, as well as between Fe isotopes and $\mu^{182}W$ in the Schapenburg samples. These results imply that Fe isotope partitioning is linked to processes that induce Sm/Nd and Hf/W fractionation, likely associated with magma ocean crystallisation during early silicate differentiation. Additionally, we observe a correlation between $\mu^{182}W$, Fe isotopes, and $(Dy/Yb)_N$ in the Schapenburg samples, indicating that the deepest melts exhibit the most negative $\mu^{182}W$ values and are enriched in lighter Fe isotopes. This trend suggests a progressive dilution of a primordial signature, inherited from the early crystallisation of the magma ocean, in the mantle source of the Schapenburg komatiites.

References:

[1] Williams, H. et al. (2021). Sci. Adv.; 7.

Using Geochemical Tools to Investigate Fluid Flow and Earthquake Processes

Menzies, C. D.[1]*, Robertson, R. V.[1], Boulton, C. J.[2], Hepburn, L.[3], Nielsen, S.[1], Niemeijer, A. R.[4], and De Paola, N.[1]

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Interactions between fluids and rocks at plate boundaries result in major geochemical changes that help control variations of the composition of the oceans and atmosphere over geological time. Fluid distribution and redistribution exerts controls on the fundamental structure of plate boundaries and the earthquakes that result from movements of those structures. More specifically, fluids modify the chemical and physical properties of fault zones, which will influence future fault rupture style, or whether an earthquake propagates through that material at all. However, fluid flow paths, sources and fluxes, and the permeability evolution of fault zones throughout their seismic cycles remain poorly constrained, despite their importance to understanding fault zone behaviour.

We present an example from an active tectonic setting of how geochemical measurements can be integrated with geological, geophysical and material properties data to trace the role fluids play in the evolution of active tectonic processes. At the Alpine Fault plate boundary in New Zealand, stable and radiogenic isotopes (oxygen, hydrogen, carbon, strontium, helium) enable identification of fluid sources, fluxes, flow paths and fluid-rock interactions. This reveals that the geometry of the plate boundary focusses meteoric water onto the crustal-scale fault zone. In addition, we note that principal slip zone (PSZ) fault gouges display elevated oxygen isotope ratios compared with the wider damage zone. This signature may result from complex mechanochemical fluid-rock interactions during earthquake events, such as dehydration and dehydroxylation reactions, followed by local reincorporation of released ^{18}O enriched fluids into secondary mineral phases. To investigate the processes responsible for the observed natural isotope anomaly, we have constructed a suite of rock mechanics experiments where the inputs and outputs were analysed for oxygen isotopes. We identify that mechanical work under seismic slip conditions results in an oxygen isotope anomaly, whereas outputs from subseismic slip rate experiments display no such anomaly. In these experiments, we also note differing healing rates of fault rocks that have undergone seismic slip due to mechanical activation and the consequent generation of a more reactive fault gouge. This process involves co-seismic dehydration and breakdown of hydrated minerals, amorphisation, and grain comminution. Mechanical activation results in a fault gouge with significantly different mechanical properties that can be traced through measurable oxygen isotope anomalies.

Session 6

It’s a hard rock life

Thursday 10th April
10:00 - 11:15

Chaired by:
Dr Paul Savage and **Dr Catriona Menzies**

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Mineralogical Society

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Overview of Elemental Scientific's products for Geochemistry

Watson, P.[1]*

*p.watson@icpms.com

[1] Elemental Scientific Instruments Ltd., United Kingdom

I will present the wide range of products the ESI family of companies manufacture for use in the Geochemical area from sample preparation (acid purification, hotplates PFAware), complex elemental separation systems (prepFAST-MC), sample introduction (microFAST Isotope2) and a full range of laser ablation systems (ESL213, ESL193, imageGEO^{LIBS}).

Ocean crustal veins record dynamic interplay between plate-cooling-induced cracking and ocean chemistry

Evans, A.D.[1], Coggon, R.M.[1], Harris, M.[2], Carter, E.J.[3], Albers, E.[4], Guérin, G.M.[5], Belgrano, T.M.[6], Jonnalagadda, M.[7], Grant, L.J.C.[1], Kempton, P.D.[8], Sanderson, D.J.[1], Milton, J.A.[1], Henstock, T.J.[1], Alt, J.C.[9], Teagle, D.A.H.[1]

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[7] Savitribai Phule Pune University, IND
[8] Kansas State University, USA
[9] University of Michigan, USA

As ocean crust traverses away from spreading ridges, low-temperature hydrothermal minerals fill cracks to form veins, transforming the physical and chemical properties of ocean crust whilst also modifying seawater chemistry. This mechanism is proposed to explain why seismic velocities in ocean crust mature within 8 million years of crustal formation. However, heat flow studies indicate that advective heat loss and thus chemical exchange endures on average for 65 million years in oceanic crust.

Here I will present [1] new observations from recent and previous scientific ocean drilling sites that show vein widths broaden and strain accumulates with crustal age, whereas vein densities remain approximately constant. Together with in situ elemental and isotopic mapping, these data reveal multiple precipitation-fracturing episodes. This challenges the existing notion that ocean crustal veins are passively filled; rather, they are dynamic features of ocean crust aging. Combined with thermal strain modelling, these data indicate a positive feedback mechanism where cooling of the ocean plate induces cracking and the reactivation of pre-existing veins, ultimately resulting in further cooling. This proposed model reconciles the disagreement between contrasting geophysical datasets and demonstrates that ocean crust endures as an active geochemical reservoir for tens of millions of years after formation.

References:

[1] Evans et al., (2025) EPSL, *650*, p.119116.

Formation of Paleoarchean greenstone belt by melting of evolving plume sourced from the deep mantle

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Komatiites are fascinating high-temperature ultramafic volcanic rocks that are among the most ancient lavas on Earth. The unique petrogenetic processes associated with their formation can be understood by studying komatiites and associated mafic/ultramafic rocks which form a characteristic component in Archean greenstone belts. In this study, ultramafic komatiites and basaltic komatiites along with mafic and intermediate rocks from the Paleoarchean Gorumahisani and Daitari greenstone belts of the Singhbhum Craton in eastern India were analysed for their major and trace element composition along with ^{147}Sm ^{143}Nd isotope systematics.

The trace element abundances, combined with mantle melting models, reveal the progressive evolution and melting of a mantle plume at depths corresponding to 23 GPa to 6 GPa. The generation of komatiites can be modelled as a function of the depth and degree of melting, as well as the amount of garnet in the residue. The trace element signatures of mafic and intermediate rocks are consistent with their generation by fractional crystallization of olivine, chromite, pyroxene and plagioclase and indicate minimal effect of crustal assimilation during magma differentiation. Komatiites and basaltic komatiites have suprachondritic Sm/Hf (>1.4) and sub-chondritic Zr/Sm (<23), along with pronounced negative Hf anomaly. The mafic, ultramafic and intermediate rocks from the two-greenstone belt have sub-chondritic ^{147}Sm/^{144}Nd and positive ε^{143}Nd$_i$ between +0.84 and +4.08. These isotopic and elemental signatures in the studied komatiite samples are in line with komatiite magma generation from a source that has undergone Mg-perovskite fractionation at lower mantle conditions, possibly during magma ocean crystallization in the Hadean.

Numerical modelling of H_2-generating fluid-rock reactions in subduction settings

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At subduction zones, geophysical and petrological observations suggest that forearc mantle wedges can be serpentinised by fluids released from devolatilising subducting slabs[1]. This pervasive serpentinisation of the wedge may produce significant amounts of abiotic hydrogen (H_2) – a key source of natural energy both for industry and for primitive microorganisms in the overlying continental lithosphere. Characterising H_2 generation by mantle wedge serpentinisation is therefore paramount to constraining the magnitude and distribution of a deep biosphere, with possible additional benefits for the ongoing energy transition. However, the geochemical and geodynamical controls on wedge serpentinisation remain a subject of immense uncertainty, and hence the concentrations and fluxes of H_2 resulting from wedge serpentinisation are poorly constrained.

In this contribution, we utilise the Deep Earth Water model[2] to calculate relayed fluid-rock reactions at mantle wedge forearc pressure-temperature conditions referenced to subduction zone geodynamic models[3]. Our results demonstrate that a heavily serpentinised layer forms rapidly at the slab-wedge interface, which gradually progresses up the mantle with further serpentinisation over geological time (i.e., over more timesteps for reaction in our model). H_2 generation is strongly tied to the position of serpentinisation reactions in the mantle wedge, and is otherwise affected by equilibration to mantle wedge thermal conditions. Our approach therefore provides a means to test multiple different parameters on H_2 generation at subduction zones from a purely petrological viewpoint, with scope for investigating the impact of variable mass of input fluid, initial mantle wedge and slab fluid compositions, and mantle wedge thermal structures.

References:

[1] Vitale Brovarone et al., 2020. *Nat. Comms.* 11(1), 3880.
[2] Sverjensky et al., 2014. *Geochim. Cosmochim. Acta* 129, 125-145.
[3] van Keken and Wilson, 2023. *Prog. Earth Planet. Sci.* 10(1), 57.

Session 7

Carbon chronicles

Thursday 10th April
11:45 - 13:00

Chaired by:
Dr Ross Whiteford and **Dr Savannah Worne**

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Accessing new analytical approaches for high-precision and accuracy isotope ratio analysis with Sapphire XD Dual Path MC-ICP-MS/MS

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[1] Nu Instruments, UK –

The new generation of MC-ICP-MS and the (re)introduction of Collision/Reaction Cells (CRC) and MS/MS capabilities in recent years has enabled new analytical approaches towards common limitations and issues in high precision and accuracy isotope ratio analysis. Such methods include interference removal via collision/reactive gases such as H2 or N2, or mass shifting with reactive gases such as O2, N2O, or SF6 - often based previously established tandem ICP-MS approaches.

The new Sapphire XD MC-ICP-MS/MS combines the proven Dual Path design with a retractable double Wien mass filter and a new collector array with extended dispersion. The unique instrument design philosophy provides the greatest flexibility and versatility for users. Whether conventional isotope ratio analysis with or without mass filter such as for B, Si-Mg, Sr, or Hf, interference removal for K or Ca isotope systems, or mass shifting applications combining MS/MS and CRC such as for S (as SO) or Rb-Sr (as SrF) – Sapphire XD offers the ability to optimise the analytical setup for optimal performance – Every System, Every Mode.

In this contribution, we will present our most recent data and methodological approaches for various isotope systems that utilize combinations of the capabilities of Sapphire XD optimised for each isotope system/application. We will present data for Sr and Rb/Sr, Hf, Pb.

Coccolithophore-based geochemical proxies

Dunkley Jones, T.[1]*, Hanson, E.[1], Warren, B.[2], Gattupalli, S.[1,3], Jones, A.[1], Saavedra-Pellitero, M.[4], Slater, S.[3], Lear, C.[3], Badger, M. P. S.[2], Edgar, K. M.[1], Moossen, H.[5], Bendle, J.[1]

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Coccolithophores are single-celled phytoplanktonic algae that biomineralize calcified plate-like scales, known as coccoliths, within the cell and then extrude these to form an outer cell covering. Coccoliths can be super-abundant in marine sediments and have a fossil record extending back to the Late Triassic. As well as this 'hard-part' fossil record, alkenone lipid biomarkers, that are produced by a specific extant group of coccolithophores, are also commonly preserved in Cenozoic marine sediments and are the basis for a widely used sea surface temperature (SST) proxy, $U^{K'}_{37}$, and provide a means of estimating past atmospheric carbon dioxide concentrations based on the extent of photosynthetic carbon isotope fractionation.

Here, we present records of coccolith stable isotopic ($\delta^{18}O$ and $\delta^{13}C$) and trace metal (Sr/Ca) compositions, and alkenone saturation ($U^{K'}_{37}$) and $\delta^{13}C$ compositions across a series of time-slices that span Cenozoic climate evolution, from early Eocene warmth to the low CO_2, cold, glacial climates of the Pleistocene. Although separated in time, these case studies demonstrate the utility of coccolithophore-based geochemical proxies in paleoclimate reconstructions, as well as the complexity of geochemical signals of external environmental change that are mediated through intra-cellular processes. In particular, we will show the oldest (early Eocene) alkenone-based CO_2 reconstructions of SSTs and atmospheric CO_2, and the development of cell-size differentials in coccolith $\delta^{13}C$ in response to long-term declines in atmospheric CO_2 and increased cellular carbon limitation.

A tale of two [CO_2] proxies: an inter-proxy comparison of palaeo-CO_2 concentrations in the early Eocene

Warren, B.[1]*, Dunkley Jones, T.[2], Seki, O.[3], Badger, M. P. S.[1], Moossen, H.,[4] Edgar, K. M.[2], Bendle, J.[2]

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[4] Max Planck Institute for Biogeosciences, Germany

The link between atmospheric CO_2 concentration ([CO_2]) and temperature is key to understanding the future effects of anthropogenic CO_2 emissions. The Early Eocene Climatic Optimum (EECO, 53-49 Ma) was the warmest interval of the Cenozoic but also has the widest divergence in [CO_2] estimates from different proxy systems. Here, we present two contrasting palaeo-CO_2 reconstructions using molecular fossils from Site 16/28 sb-01 from the Rockall Trough, North Atlantic, 51-49 Ma. The alkenone CO_2 proxy, which uses microalgal biomarker $\delta^{13}C$, provides robust [CO_2] estimations for most of the Cenozoic, but becomes increasingly uncertain in high [CO_2]. Conversely, the C_3 plant proxy, which uses land plant $\delta^{13}C$, is seemingly suited to the wet environments of the EECO, but is less established, especially in high [CO_2].

We find that the two reconstructions produce radically different results. The alkenone proxy reconstructs [CO_2] of >1,000 ppmv, but with large uncertainty due to proxy limitations. Conversely, the C_3 plant proxy reconstructs [CO_2] at pre-industrial levels. Published EECO [CO_2] reconstructions fall into two groups: reconstructions using land plants (e.g. stomata), and reconstructions from other sources (e.g. palaeosols, boron). Alkenone [CO_2] reconstructions are higher than other non-plant proxies, but within their uncertainty range. The C_3 plant proxy agrees with other plant proxies, which all indicate radically lower [CO_2]. Given the extreme warmth of the interval, and the substantial disagreement with more well-established [CO_2] proxies, it seems unlikely that Eocene [CO_2] could be below modern levels, and conclude that [CO_2] reconstructions from higher plants are problematic in deep-time.

Forest biogeochemistry under elevated CO_2: a survey of relevant results from BIFoR FACE

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[1] Birmingham Institute of Forest Research (BIFoR), University of Birmingham

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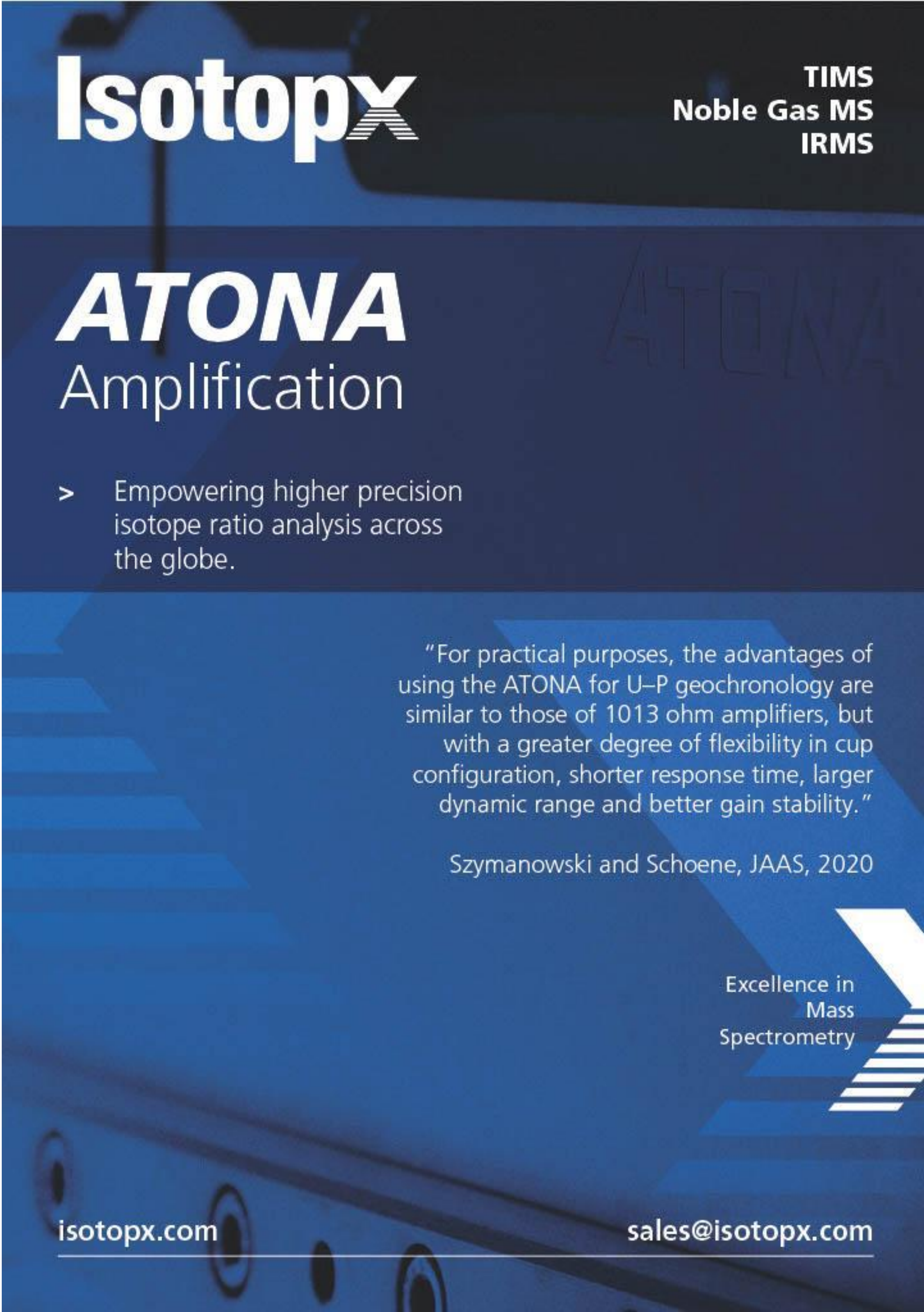
The Birmingham Institute of Forest Research (BIFoR) Free-Air CO_2 Enrichment (FACE) facility is one third of the largest global change experiment in the world (the other two thirds being EucFACE in Australia, and AmazonFACE near Manaus). BIFoR FACE is set in UK broadleaf forest dominated by 175-year-old and 25 m tall oak trees interspersed with sycamore, hazel, hawthorn, and holly. CO_2-enrichment, scheduled to run until 2031, commenced in spring 2017. The whole canopy volume of three 30m-diameter plots is immersed in air containing 150 ppm CO_2 above current atmospheric levels during daylight hours in the growing season. Three neighbouring plots act as controls. The whole forest system responds promptly and in a sustained way to elevated CO_2, with effects cascading through the ecosystem patch via closely coupled carbon, water, and nutrient cycles. Biogeochemical effects of elevated CO_2 found in FACE include: (i) an increase in Net Primary Production driven predominantly by a 10% increase in annual wood increment; (ii) a faster, more conservative nitrogen cycle with 74% reduction in N_2O emissions; (iii) a 40% increase in root exudate with an increased proportion of sugars compared to amino acids; (iv) increased microbial 'mining' of soil organic matter to supply inorganic N to microbes and plants; (v) changes leaf n-alkane ^{13}C; and (vi) changes in pollen, leaf, litter, and seed quality (i.e., elemental composition, particularly N, S, K and Fe) with implications for forest food webs and mineral cycling.

Poster Presentations

Please place your poster on the corresponding numbered poster board. Please also take a sticker if you are a student, to help facilitate judging.

1	Matthew Allison	*Quantifying the uniformitarian assumption across 200 million years of GDGT-based temperature reconstructions*
3	Neeraja Baburaj	*Early diagenetic control on cadmium isotope variation in modern marine sediments*
4	Gemma Baker	*Using stable isotopes for tracking gastrointestinal transit time in lemurs*
6	Lewis Banks	*Femtosecond LA-ICP-MS: A versatile workhorse, not just for high-precision isotopic measurements*
7	Manfredo Capriolo	*Methane Emissions from Volcanic Complexes: A Case Study from the Oslo Rift (Norway)*
9	Patthapong Chaiseanwang	*A 3-OH-FA-based Temperature Calibration for Southeast Asia*
10	Friso de Graaf	*Deep Atlantic Circulation Changes over the Plio-Pleistocene Boundary*
12	Daisy Fallows	*Does temperature drive enhanced carbon cycling in Holocene lake sediments?*
13	Luke Franks	*A Zn-Pb Isotopic Approach to Quantify Riverine Metal Source Variation During Changing Hydrological Conditions*
15	Emma Hanson	*Size-fraction Coccolith Stable Isotopes and Sr/Ca Ratios from the Miocene to Recent*
16	Changhai Hou	*Biomarker-Based Paleoclimate Study in U.S. East Coast Lakes: Insights from 3-OH-FAs and brGDGTs*
18	Julia Neukampf	*Halogen concentrations in chondrule mesostasis glass in ordinary and carbonaceous chondrites*
19	Kristijan Rajič	*Tracing mantle wedge metasomatism: Insights from stable strontium isotopes*
21	Pam Vervoort	*Quantifying net carbon cycle feedbacks across the Paleocene-Eocene Thermal Maximum*
23	Savannah Worne	*Multi-Stable Isotope Tracing to Assess Nutrient Cycling Dynamics During Algal Blooms*



Quantifying the uniformitarian assumption across 200 million years of GDGT-based temperature reconstructions

Allison, M.[1]*, Dunkley Jones, T.[1], Greene, S.[1], Hall, J.[1], Duncan, B.[2], Jones, S.[1], Mandel, I.[3], Bendle, J.[1]

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isoGDGT's are a lipid-based, marine palaeoclimate archive[1]. They have been demonstrated to passively record temperature and can be found, archived in the marine sediment record as far back as the Jurassic. Here, we assess whether this system obeys the key geological tenant of Uniformitarianism, utilizing a Gaussian machine learning approach (OPTiMAL)[2].

A modern dataset of core-top isoGDGT assemblages (n=854) is used to train OPTiMAL and predict the Sea Surface Temperature (SST) on a compilation of ancient isoGDGT data (n=12,256). A new metric is presented here, designed to track any force acting the isoGDGT system, known or unknown, and is used to interrogate the temporal and spatial relationship between the modern and ancient data.

For the first time, this new metric allows for a qualitative comparison of forces impacting the production and archiving of isoGDGT's, highlighting that non-thermal events (e.g. oceanographic changes) are just as impactful on the record as thermal events (e.g. hot-house climates). Whilst long term changes in the isoGDGT system are observable in our analysis, we conclude that the system behaves in a Uniformitarian manner. That is to say, the modern ocean isoGDGT system is a reliable analogue of pasts ocean temperatures spanning the Holocene – Jurassic.

References:

[1] Schouten, S., Hopmans, E.C., Schefuß, E., Damste, J.S.S.: Distributional variations in marine crenarchaeotal membrane lipids: a new tool for reconstructing ancient sea water temperatures? Earth and Planetary Science Letters 204(1-2), 265–274 (2002)
[2] Dunkley Jones, Tom, et al. "OPTiMAL: a new machine learning approach for GDGT-based palaeothermometry." Climate of the Past 16.6 (2020): 2599-2617.

Early diagenetic control on cadmium isotope variation in modern marine sediments

Baburaj, N.[1]*, Dickson, A.J.[1], van Helmond, N.A.G.M.[2,3], van Erk, M.R.[3], Zygadlowska, O.M.[2,3], Elms, H.C.[1], Slomp, C.P.[2,3]

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Marine sediments serve as a natural archive that record Earth's past climate conditions, and the development of isotope proxies in marine sedimentary records helps us to unfold paleoclimate and paleoenvironmental conditions. Among these isotopic proxies, stable cadmium isotopes ($\delta^{114/110}$Cd) have emerged as a promising indicator of large-scale changes in ocean chemistry over geological time, such as redox conditions and marine primary productivity.

The accumulation of cadmium in marine sediments is fundamentally linked to early diagenetic processes that govern its burial, precipitation and redistribution within the sediment. These processes also shape the cadmium isotope signatures preserved in these sediments. Therefore, understanding cadmium isotopic fractionation during burial in modern sediments is pivotal to utilise this proxy for reconstructing paleo-oceanographic conditions.

Here we present stable cadmium isotope data for modern sediments collected from marine Lake Grevelingen in the Netherlands, across two seasons with contrasting bottom water redox conditions. We present analyses of cadmium concentrations for the pore waters and both concentrations and isotopes for the sediments. Our results show how $\delta^{114/110}$Cd values vary downcore and how they respond to seasonal changes in bottom water redox conditions. These findings provide crucial insights into the mechanisms controlling the cadmium distribution in marine sediments, thereby contributing to our understanding of diagenetic effects on cadmium isotopic signatures, addressing a critical gap in the development of this emerging proxy.

Using stable isotopes for tracking gastrointestinal transit time in lemurs

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The gastrointestinal transit time of food in animals is an important factor within animal health and welfare, reflecting feeding ecology, energetic expenditure and digestive physiology. However, current methods for estimating transit time do not directly monitor the transit of the food itself and therefore leave unanswered questions. Here, we demonstrate the potential of a new method involving directly labelling food material with a heavy stable isotope (deuterium/^{2}H), allowing for direct tracking of that food material through the gut by isotopic analysis of faecal samples. Data for three lemur species – *Varecia variegata rubra, Lemur catta* and *Propithecus coquereli* – are presented here, showing δD ratios accurately track food transit time in organisms with simple-to-complex gastrointestinal morphologies and a range of expected transit times. These data demonstrate the potential of organic geochemistry techniques within modern ecology and could be applied widely across the animal kingdom to any animal that reliably consumes plant material.

Femtosecond LA-ICP-MS: A versatile workhorse, not just for high-precision isotopic measurements

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[2] Max Planck Institute for Solar System Research, Germany

Femtosecond laser ablation inductively coupled plasma mass spectrometry (fs-LA-ICP-MS) has become the 'go to' instrumentation for high-precision isotopic analysis of fractionation-prone matrices. In comparison to nanosecond (ns) laser sources, fs-lasers typically have a pulse length of one to two orders of magnitude shorter[1]. This ultra-short laser pulse facilitates ablation with minimal heating of the sample lattice, resulting in reduced isotopic (and elemental) fractionation induced at the ablation site[1]. Hence, fs-LA-ICP-MS is a popular tool to facilitate achievement of the ultimate precision and accuracy.

As the conventional application of fs-laser ablation instrumentation is high-precision and accuracy isotope ratio determination, these instruments are typically coupled to multi-collector (MC) ICP-MS instruments (e.g. [2]). Although there are fs-LA-ICP-MS publications beginning to be published on Time of Flight (TOF) instruments (e.g. [3]) with the specific application of imaging, there is a noticeable paucity of publications employing quadrupole (Q)-based ICP-MS instrumentation. Here, we show the versatility of the Teledyne Photon Machines Pharos fs-laser ablation instrument for mapping of trace elements using Q-ICP-MS instrumentation.

A consideration for trace element imaging with fs-LA-ICP-MS is that of crater geometry, especially when compared to ns-excimer lasers. Due to the inherent properties of the fs-laser beam, laser sources generating fs-pulses produce a Gaussian profile when considering the energy profile across the beam. While ns-laser ablation instruments can implement a device to homogenise the laser energy and deliver an ablation crater with a flat bottom and vertical walls, this is not possible with fs-ablation. Interrogation of the crater geometry on sulphides, a matrix traditionally challenging to ablate, shows that with optimisation of the ablation characteristics, including optimisation of beam delivery optics, a flat-bottomed crater can be achieved.

In the knowledge that fs-lasers can achieve flat-bottomed profiles in geological materials, we apply the technique to multi-elemental imaging of geological materials using Q-ICP-MS. We therefore highlight the versatility and suitability of fs-laser ablation to methodologies outside the realms of MC-ICP-MS techniques.

References:

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Methane Emissions from Volcanic Complexes: A Case Study from the Oslo Rift (Norway)

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Magma–sediment interaction is a key process in transferring carbon species from the lithosphere to the atmosphere–hydrosphere system [1], in promoting the formation of ore deposits [2], and in driving maturation or remobilization of hydrocarbons in petroleum systems [3]. Bile Island is a tiny island in the Oslo Fjord (Norway), where many dykes and a pyrobitumen-bearing sill crosscut Upper Silurian sandstones. These magmatic intrusions are related to the Oslo Rift activity, the northernmost branch of the 300 Myr-old Skagerrak-centred Large Igneous Province [4; 5]. Bile Island is located 600 m from one of the earliest volcanic plugs in the Oslo Rift, and the sedimentary succession in this area contains oil and pyrobitumen mainly sourced from Cambrian–Ordovician organic-rich shales. Via a multi-analytical approach (involving XRF, EMP, SEM-EDS, SEM-CL, Raman microspectroscopy, mass spectrometry and chromatography), we reconstructed the processes of magma–sediment interaction that remobilized the sandstone-hosted oil into the basaltic sill on Bile Island. Sandstones resulted enriched in Mg, Fe, Ca, Al, Ti, Cu and S from the intruding magma, whereas basalts resulted enriched in Si, H_2O and pyrobitumen from the host rock, especially during the hydrothermal stage as supported by TitaniQ data. Melt and fluid inclusions unveiled the abundance of different carbon species, such as magmatic CO_2 and thermogenic CH_4 and C_2H_6. Thermogenic carbon species are in close association with pyrobitumen, which mostly occurs within hydrothermal veins, vesicles and fractures, but also finely dispersed within basaltic rocks and within sandstone xenoliths. Furthermore, the light carbon isotope composition of pyrobitumen revealed its derivation from oil, inferring cracking and gas generation from the oil in the basaltic sill. Bile Island bears the evidence of CH_4 seepage from a volcanic centre, and represents a unique case study to constrain carbon emissions via magma–sediment interaction in the shallow portion of a basaltic plumbing system intersecting a petroleum system.

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A 3-OH-FA-based Temperature Calibration for Southeast Asia

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Reconstructing past climate variability is crucial for understanding long-term environmental change, especially in monsoon-dominated Southeast Asia. Organic geochemical proxies, including 3-hydroxy fatty acids (3-OH-FAs) and glycerol dialkyl glycerol tetraethers (GDGTs), offer insights into past temperature and pH conditions. However, there are no regionally specific SE Asian calibrations both these established (GDGTs) and novel (3-OH-FAs) proxies. We compare distributions of these two biomarker groups with environmental parameters in 48 lakes and 30 soils across a continental scale transect. In lake sediments, RAN_{13} moderately correlates with mean annual air temperature (MAAT; $R^2 = 0.52$), supporting its use as a novel palaeotemperature proxy[3,4]. RIN_{17} shows a weaker correlation ($R^2 = 0.32$), limiting its reliability, while RIN_{15} emerges as an additional temperature indicator ($R^2 = 0.60$). In soils, RAN_{17} strongly correlates with MAAT ($R^2 = 0.64$), while RAN_{15} exhibits a weaker correlation ($R^2 = 0.20$), challenging its broader applicability. GDGT proxies confirm the Cyclisation of Branched Tetraethers (CBT) as a feasible pH indicator ($R^2 = 0.41$), while MBT'_{5ME} correlates significantly with MAAT in lake sediments ($R^2 = 0.73$), but weaker in soils ($R^2 = 0.34$). Unlike previous studies in China, Europe, and Africa, we find insignificant correlations between 3-OH-FA-derived pH proxies and soil pH in Southeast Asia, suggesting microbial and hydrological influences override pH control[1,2]. These findings highlight the need for region-specific calibrations, as hydroclimatic factors and microbial ecology complicate proxy applications in monsoonal environments. Our key result is the strong potential of the novel RAN_{13} proxy as a palaeotemperature proxy for lake sediments.

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Deep Atlantic Circulation Changes over the Plio-Pleistocene Boundary

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Over the Pliocene-Pleistocene boundary (2.7 Ma), major ice sheets developed across North America and Eurasia in an event known as the intensification of Northern Hemisphere Glaciation (iNHG). The iNHG is the largest secular shift in the Earth's climate of the last 5 Ma and yet the nature of deep ocean circulation over this transition is poorly understood. Deep ocean circulation is a major driver of Earth's climate and moves heat and nutrients around the globe. A major component of deep ocean circulation is North Atlantic Deep Water (NADW) which forms in the surface ocean of the high latitude North Atlantic, sinks to depth, and is carried southwards. Modelling studies suggest that there was little change in the water mass structure of the deep Atlantic over the iNHG[1], while proxy evidence suggests that NADW export was either stronger[2,3], weaker[4,5], or unchanging[6] over the iNHG. This ambiguity is, in part, a result of the inability of carbon isotopes to distinguish between water mass mixing and biological productivity[7]. Here, we present new neodymium isotope records from a depth transect in the Central Atlantic Ocean over the iNHG. Neodymium (Nd) isotopes are a conservative water mass tracer, which can reveal past changes in water mass provenance independent of biological productivity. Our records show an increase in glacial-interglacial variability and a less radiogenic Nd signal in the Pleistocene, indicating a change in the ocean structure from a stable, stratified Pliocene deep Atlantic to a variable, NADW-dominated, deep water mass in the Pleistocene.

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Does temperature drive enhanced carbon cycling in Holocene lake sediments?

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Lakes are important sources of atmospheric methane and play a significant component in the global carbon cycle. Despite this, the relationship between methane cycling and temperature throughout the Holocene is poorly understood. Constraining this relationship can provide a valuable insight into how future systems may respond to the current climate crisis and identify natural variabilities in lake carbon cycling. Annually laminated (varved) lake sediments can provide high resolution palaeoenvironmental information linked to annually-resolved chronologies, making them ideal archives to assess environmental responses to the climate on seasonal to millennial timescales. Here we utilise a range of proxies, including chironomids (non-biting midges), lipid biomarkers (branched GDGTs, 3-hydroxy fatty acids) and compound-specific stable carbon isotopes (hopanoids) to produce a robust reconstruction of temperature and biogeochemical variability in Lake Nautijärvi, in southern Finland, a continuously varved sedimentary record covering the past 9900 years. Using brGDGTs, a high resolution (200 years) temperature reconstruction throughout the Holocene has been produced. MBT_{5ME} values show a cool early Holocene, with the coldest values seen around 8.2ka, before warming until 7ka and remaining a relatively stable climate, before a warming trend is seen from around 3ka to present day. Future work will focus on producing a methane cycling record to assess the relationship between temperature change and methane cycling in Nautijärvi. The varved sediment record may inform future carbon cycling predictions in boreal lakes in response to a warming climate.

A Zn-Pb Isotopic Approach to Quantify Riverine Metal Source Variation During Changing Hydrological Conditions

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Dissolved trace metal concentrations in rivers are influenced by natural processes and anthropogenic sources (e.g. wastewater effluents, mine tailing leachates, urban runoff) and catchment studies have shown that source contributions vary temporally and spatially. Standards set by the UK Water Framework Directive suggest safe limits on the freshwater concentrations of pollutants such as zinc (Zn) and lead (Pb), which many river systems exceed.

The Zn and Pb isotopic composition of rivers has a potential use in investigating the source and extent of anthropogenic pollution in river catchments[1,2]. The Zn isotope composition of water can be influenced by in-stream processes such as biological uptake and adsorption onto particulates - in contrast to Pb isotopes which are immune to in-stream processes. Pairing Zn-Pb isotope measurements with trace element, cation, DOC and hydrological parameters will enhance our ability to quantify and distinguish metal sources and catchment processes.

We present an initial study of the River Wear in northeast England. Legacy mine wastes dominate dissolved metal concentrations in the headwaters, with an increase in urban (wastewater treatment plant effluents, road runoff) and agricultural inputs going downstream. We sample a 70km transect of the river, and our initial results show large variations in Zn (29.5-291.6ppb) and Pb (0.3–11.45ppb) concentrations. An additional time series measured at an urban downstream location indicates strong variations in concentration with river flow rate. We will present initial Zn-Pb isotopic measurements targeting conditions of variable metal flux in the Wear to assess changing source(s) in this metal-contaminated catchment.

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Size-fraction coccolith stable isotopes and Sr/Ca ratios from the Miocene to Recent

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Coccoliths, the calcified remains of single celled organisms called coccolithophores, are well preserved in marine sediments, making them an excellent recorder of surface ocean environmental change through geological time. The geochemical analysis of these coccoliths has been recently used for determining biotic responses to palaeoenvironmental change, most notable through $\delta^{13}C$ stable isotopic analysis of coccolith size-separated microfractions.

During the late Miocene (7-5 million years ago), a marked isotopic divergence originated in coccolith $\delta^{13}C$ between small, lightly calcifying forms and large, heavily calcifying forms, which has been linked to a decline in atmospheric CO_2.

To investigate how these isotopic divergences may have been influenced by climatic events and nannofossil evolutionary changes, we generated a long-term record of coccolith geochemistry from the Miocene to recent (7.7 to 0.1 million years ago), with a further high resolution record spanning the Pliocene-Pleistocene Transition (3.01 to 1.38 million years ago). All samples come from IODP Site U1482 (Exp. 363), on the northwest Australian continental margin. The novel size separation technique allows for the rapid sample preparation of coccolith-rich sediments into very fine and very coarse fractions, allowing for the generation of the highest resolution size-specific coccolith geochemistry records over the two time periods to date.

Biomarker-Based Paleoclimate Study in U.S. East Coast Lakes: Insights from 3-OH-FAs and brGDGTs

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Lipid biomarkers preserved in lacustrine archives provide valuable insights into past climatic change[1]. Over recent decades, branched glycerol dialkyl glycerol tetraethers (brGDGTs) have been developed as paleoclimate proxies for lake settings[2]. More recently, proxies based on 3-hydroxy fatty acids (3-OH-FAs) have been proposed as a novel approach for palaeolimnology[3]. Yet regionally specific calibrations and applications are underdeveloped - for both these proxies - within the densely populated and economically important East Coast (EC) region of the USA. In this study, we analyzed 3-OH-FAs and brGDGTs from a latitudinal transect of lake surface sediments along the U.S. EC. Our results indicate that the 3-OH-FA-based soil temperature proxies RAN_{15} (previously applied to stalagmites) and RAN_{17} are unsuitable for calibrating mean annual air temperatures (MAAT) in EC lakes. In contrast, RAN_{13}, previously proposed as a lake temperature proxy in Chinese lakes, shows a strong linear correlation with MAAT without seasonal bias, while the brGDGT-based $\mathrm{MBT'}_{5\mathrm{ME}}$ exhibits a warm bias. Moreover, pH proxies derived from 3-OH-FAs, including the Branching Ratio, Branched Index, RIN, and RIAN, demonstrate linear relationships with lake water pH; however, the $\mathrm{CBT}_{5\mathrm{ME}}$ index outperforms these indicators in pH reconstruction. When applied to a sediment core from Lake Blauvelt, MAAT changes from the RAN_{13} proxy are closer to local temperature records and provide more reasonable absolute temperatures than $\mathrm{MBT'}_{5\mathrm{ME}}$-based temperatures, which are somewhat skewed towards the warm season. These findings highlight the value of combining proxies for climate reconstruction in EC lakes and the importance of leveraging their strengths in future studies.

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Halogen concentrations in chondrule mesostasis glass in ordinary and carbonaceous chondrites

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Halogens (fluorine [F], chlorine [Cl], bromine [Br], iodine [I]) act as tracers of processes in the solar nebula and the formation of the Solar System's inner planets. Studying their distribution in chondrites helps us understand the volatile evolution of Earth and other terrestrial planets.

To investigate halogen concentrations in chondrules and their role in protoplanetary disk processes, we analysed their behaviour in chondrule mesostasis glass. During crystallisation, halogens concentrate in the melt due to their incompatibility with most silicates and may either diffuse into the vapour phase or condense back into the melt as the chondrule cools.

We measured F, Cl, Br, I, sulphur (S), and major element abundances in 46 chondrules from Antarctic carbonaceous (DOM 08006, EET 92105) and primitive ordinary chondrites (EET 90628, GRO 06054, MET 00452, MET 96503) using secondary ion mass spectrometry (SIMS) and an electron probe microanalyser (EPMA). Halogen concentrations in carbonaceous chondrites range from F: 0.37-12.2 ppm, Cl: 0.22-290 ppm, Br: 0.002-0.83 ppm, and I: 30-432 ppb, while in ordinary chondrites, they range from F: 0.2-118 ppm, Cl: 0.3-2255 ppm, Br: 0.001-2.5 ppm, and I: 2.0-273 ppb.

In L-group ordinary chondrites, Br concentrations increase, and I concentrations decrease with increasing metamorphic grade (subtype 3.05 to 3.6), suggesting fluid mobility influences the halogen distributions. Halogen abundances in ordinary and carbonaceous chondrites are significantly lower than in enstatite chondrites[1], possibly due to differences in cooling, crystallisation, or the nature of halogen carriers in chondrule precursors across different regions of the solar nebula.

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Tracing mantle wedge metasomatism: Insights from stable strontium isotopes

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Fluid-rock interaction in the mantle wedge plays a crucial role in material cycling between Earth's crust and mantle, yet the origins of the fluids responsible for metasomatism remain debated. Here we present $^{87}Sr/^{86}Sr$ and $\delta^{88/86}Sr$ data for samples from metasediment, metamafic, and ultramafic clasts, as well as pore fluids, from IODP Expedition 366 in the Mariana Forearc. These samples, sourced from three mud volcanoes spanning an estimated depth-to-slab of ~12-18 km, provide insights into the evolution of fluid sources as a function of pressure-temperature variations.

The $^{87}Sr/^{86}Sr$ composition of the clasts and pore fluids ranges from 0.70495 to 0.70611, showing no systematic trends. In contrast, systematic variations in $\delta^{88/86}Sr$ are observed among samples from different MVs. The heaviest $\delta^{88/86}Sr$ is measured in limestone (0.630 ± 0.013 ‰), whereas metabasalts exhibit lighter values (0.145 ± 0.004 ‰). In serpentinized harzburgites, $\delta^{88/86}Sr$ decreases with increasing distance from the trench, from 0.493 ± 0.118 ‰ near the trench to 0.143 ± 0.091 ‰ in the furthest MV. A similar trend is observed in pore fluids, from 0.575 ± 0.020 ‰ near the trench to 0.194 ± 0.021 ‰ at the furthest site.

The combined use of $^{87}Sr/^{86}Sr$ and $\delta^{88/86}Sr$ suggests serpentinization in the shallow mantle wedge is influenced by sediment-derived fluids, while mafic-derived fluids become more dominant at greater depths. This study highlights $\delta^{88/86}Sr$ as a valuable tracer for fluid-rock interactions under elevated metamorphic conditions, offering new perspectives on fluid dynamics in subduction zones.

Quantifying net carbon cycle feedbacks across the Paleocene-Eocene Thermal Maximum

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The Paleocene-Eocene Thermal Maximum (PETM, 56 Ma) is an extensively studied paleoclimate event of massive carbon release because the intense global warming and widespread ocean acidification bear resemblance to the predicted worst-case near-future Earth conditions. While emission rate and carbon source were different from today's perturbation, valuable lessons can be learned from studying the PETM. For instance, whether climate or carbon cycle feedbacks amplify or mitigate the environmental disruption, and what feedback processes contributed to the global climate response. In this study, we quantify the magnitude and sign of 'net' carbon cycle feedbacks by integrating: (1) estimates of volcanic carbon emissions from the North Atlantic Igneous Province (active ~56 Ma and considered a major source of carbon release), and (2) the net global environmental response recorded in paleoclimate records such as $\delta^{18}O$ (temperature), $\delta^{11}B$ (ocean pH), and $\delta^{13}C$ (carbon cycle). The difference between the environmental response to volcanic emissions alone and the recorded global response is attributed to feedback processes. Our Earth system model results suggest that carbon release from positive carbon cycle feedbacks (e.g. non-volcanic) likely approached or exceeded volcanic emission rates at the onset of the PETM, raising pCO_2 by 1330 ppm and the global temperature by 4.4°C. The 'net' feedback emissions are negative during the PETM recovery. Carbon isotopes indicate that a sustained low emission flux of isotopically light carbon is required to slow down the $\delta^{13}C$ recovery driven by organic carbon burial, potentially pointing to additional thermogenic or biogenic methane release during the recovery phase.

Multi-Stable Isotope Tracing to Assess Nutrient Cycling Dynamics During Algal Blooms

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Stable isotope analysis of waters, including nitrates, ammonium and phosphates, are increasing used for tracing pollution sources and cycling in aquatic systems [1,2]. However, the spatial and temporal variability in stable isotopes has not been well quantified, particularly in relation to how isotopes are impacted by biological cycling through the growing season. Here, we present the initial findings from a multi-stable isotope approach to evaluate the changes in nutrient sources and cycling over annual cycle, in response to seasonal algal bloom formation and nutrient loading dynamics. Through case study of three different aquatic systems at Rutland Water, each with different nutrient loading pressures and algal bloom intensities, results from this research will inform further fellowship research, and ultimately the development of a water-stable isotope toolkit for evaluating nutrient cycling dynamics in lakes.

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