

THE MAGAZINE OF THE GEOLOGICAL SOCIETY OF LONDON

GEO

SCIENTIST
AUTUMN 2026

EARTH'S MISSING LEAD

A NEW EXPLANATION FOR
ONE OF GEOCHEMISTRY'S
OLDEST PARADOXES

SPACE FOR DISCOVERY
Refurbishing and restoring
the Lecture Theatre

SOCIAL OUTCOMES
Rethinking ground
investigation

CONTOURS & CURVES
Mapping a geoscience
career

HUTTON'S INFLUENCE
Deep time through
creativity

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19 November 2026 | Dr Lucia Perez-Diaz

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GEOSCIENTIST

The magazine of the Geological Society of London

CONTACT

geoscientist@geolsoc.org.uk

EXECUTIVE EDITOR

Dr Amy Whitchurch

ASSOCIATE EDITOR

Dr Hannah Bird

EDITOR-IN-CHIEF

Ruth Allington

DEPUTY EDITOR-IN-CHIEF

David Shilston

EDITORIAL

ADVISORY PANEL

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Dr Andrew Dobrzański

Leanne Hughes

Dr Ilias Karapanos

Louisa McAra

Dr Kevin Stephen

The Geological Society

Burlington House Piccadilly
London W1J 0BG
+44 (0)20 7434 9944
enquiries@geolsoc.org.uk

Publishing House

Unit 7 Brassmill Enterprise
Centre
Brassmill Lane
Bath BA1 3JN
+44 (0)1225 445046
sales@geolsoc.org.uk

Departmental Contacts

geolsoc.org.uk/contact-us

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Editor's welcome

Toward the end of last year, we invited our readers to tell us what they think of *Geoscientist*—what they enjoy, tend to skip, or would like to see more (or less) of.

It is heartening to see the strength of feeling readers have for the magazine. The survey results show that *Geoscientist* has a loyal and engaged readership, with 78% of respondents reading every or almost every issue.

More than half say they have always read the magazine, while over a quarter say they read it more now than they used to. For those reading less often, it seems the main obstacle isn't a lack of interest but a lack of time—with increasingly pressured lives, reading can feel like a luxury that competes with many other demands. There's appetite for shorter, accessible content that readers can dip into easily, so with this issue we have reintroduced our popular In Brief section (page 44) summarising recently published research and developments across the geosciences.

“**Geoscientist has a loyal and engaged readership**”

Survey feedback confirms an enduring connection to print. While readers appreciate having both print and digital options, nearly three quarters prefer print, with some saying they would read the magazine less—or not at all—if it were online-only. Just 8% expressed interest in reading the magazine through an app. In an increasingly digital



world, print offers something precious: a tactile, distraction-free experience. For geoscientists, that appeal is practical as well as emotional, with physical copies coming

in handy during long periods spent travelling or working in remote locations.

Respondents report using *Geoscientist* to keep up with developments across the geosciences, stay informed about Society activities, or simply because they find it enjoyable. Feedback on the magazine's content, tone, imagery and design shows strong satisfaction (>90%). Readers value the magazine's breadth and quality, as well as the sense of connection to the wider geoscience community that it provides. But there is clear appetite for expanded coverage of applied geoscience, engineering geology, hydrogeology and other industry-focused topics.

Digital engagement presents both a challenge and an opportunity. While views of *Geoscientist*.Online have grown strongly since launch in 2021, many survey respondents were unaware of the magazine's wider multimedia offer (such as our podcasts and Science Snapshot videos).

Above all, the survey shows that *Geoscientist* remains valued and well read. We will use the results to help sharpen content relevance, improve digital visibility, and shape the magazine's future—and we are hugely grateful to all who took the time to share their constructive feedback.

Read the full report at:
www.Geoscientist.Online

DR AMY WHITCHURCH
EXECUTIVE EDITOR



CSci
Chartered
Scientist

Chartership

A benchmark of professional excellence

Are you a Chartered Fellow? Have you thought about becoming a Chartership Assessor?

Extend your professional profile and career development; network with like-minded individuals; and support the future of the geoscience community.

Assessors are a key part of the Chartership process, as they review applications, hold interviews and recommend Fellows for Chartership.

There are many areas of geoscience that would benefit from more Assessors, such as the energy transition, renewables, minerals, mining and academia; although all areas of expertise are in demand.

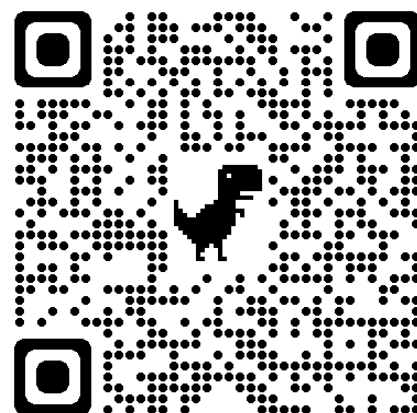
Benefits of becoming a Chartership Assessor

- Demonstrate your seniority
- Contribute to your CPD record - needed to maintain Chartered status - by reviewing applications
- Expand your knowledge of the innovative work emerging throughout the sector through exposure to new research within Chartership reviews
- Give back to the Earth sciences community
- Gain valuable interview experience
- Enjoy networking opportunities with other experienced professionals

To apply you must be a current Society Chartered Fellow and have either held CGeol or CSci status for ~5 years, or be in a senior career position.

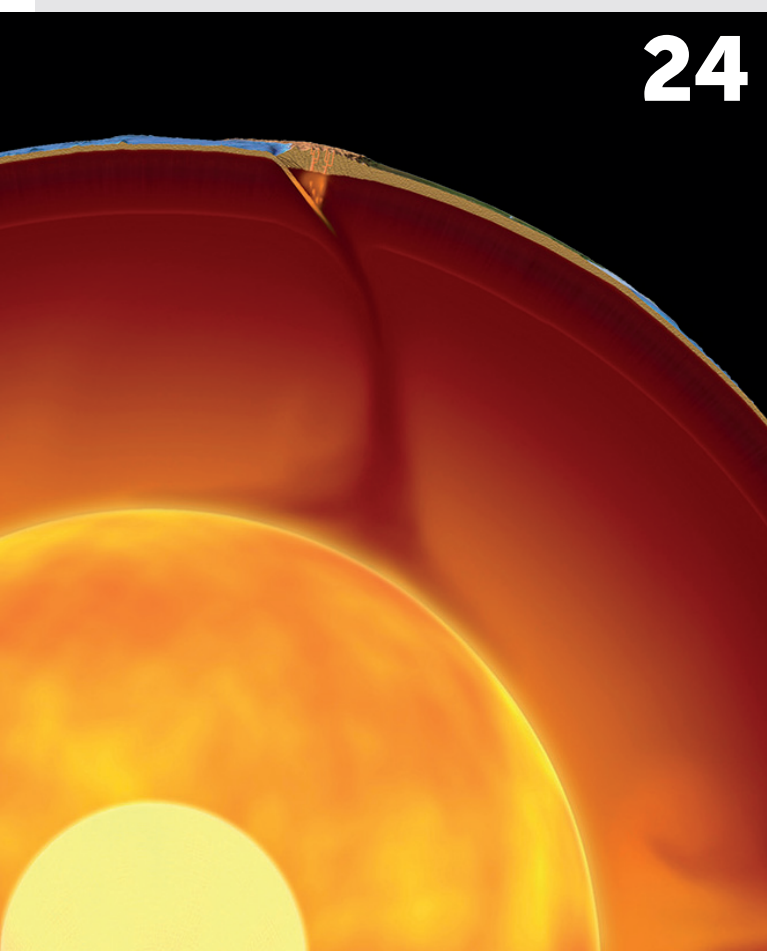
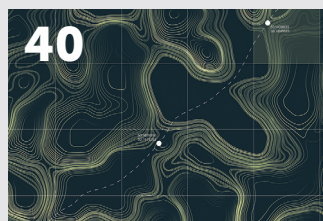
Training is provided, including in-person and online workshops with other Assessors.

Find out more by visiting www.geolsoc.org.uk/Membership/Chartership-and-Professional/Chartership-Assessors or by scanning the QR code below with your smartphone camera



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Dr Emma Watts, postdoctoral researcher at Swansea University, Wales and a 2026 recipient of the President's Award

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NEWS

SOCIETY AND COMMUNITY UPDATES



➔ SOCIETY NEWS

For the latest updates, visit our dedicated news desk at: geolsoc.org.uk/news

Championing geoscience

Society staff connected with the global geoscience community at the European Geosciences Union General Assembly



THE ANNUAL EUROPEAN Geosciences Union (EGU) General Assembly is the largest and most prominent geoscience conference in Europe. The event brings together tens of thousands of people from around the world to discuss research, share ideas and learn from the breadth of Earth and planetary sciences. Throughout the week, we were proud to represent the Society's work across education, scientific publishing, public engagement, and the intersection between science and policy.

The future of geoscience education

Variability in undergraduate enrolments on geoscience courses around the world has placed uncertainty at the centre of conversations about the subject's future. Common misconceptions, limited visibility and accessibility, and a lack of awareness of geoscience's relevance to global challenges all contribute.

Dr Natasha Stephen (Director of Science

and Engagement) joined a panel to share our experience of 'This is Geoscience', a campaign designed to reshape public perceptions and engage young people through relatable careers advice and high-quality resources.

Our findings aligned with those of international panellists: geoscience is often seen as 'dirty', poorly paid and limited to fieldwork. Global collaboration was highlighted as essential to tackle these misconceptions, while teachers and educators—often overworked and under-resourced—were recognised as vital to the future of the profession. Our 'Geoscience for the Future' resource also received a special mention as a highly transferable tool, now available in more than 20 languages.

The intersection between geoscience and policy

A cross-cutting theme at EGU26 explored how geoscience can support decision-

making on climate, energy and environmental issues, while strengthening communication between scientists and policymakers.

Society-led panels supported researchers in developing practical policy engagement skills, including drafting policy briefs, pitching research and understanding routes to policy impact. Dr Megan O'Donnell (Head of Policy and Communications) and Dr Tom Harvey (Science and Funding Officer) also contributed to discussions on how geoscientists can maximise the wider impact of their research beyond the scientific community.

Joy in science communication

Science communication was a major focus, with Society staff co-convening a session alongside members of the EGU Outreach Committee for the first time.

We highlighted the value of sparking joy and fostering emotional connections through activities such as family fun days, Earth Science Week and festival appearances, demonstrating how positive, memorable experiences can inspire curiosity and engagement with geoscience. The session also reinforced the importance of sharing ideas and good practice across the science communication community.

It was also wonderful to welcome visitors to our booth, where Bethan Littley (Senior Journal Development Editor) and Catherine Rawlinson (Commissioning Editor) showcased the Society's journals, Special Publications and book series, meeting authors, editors and researchers from across the geoscience community.



BRIDGING GEOSCIENCE, INDUSTRY AND FINANCE

Established in 2011 as the City of London Geoscience Forum, the Geological Society Business Forum was created to strengthen links between the geoscience, business and finance communities, demonstrate the value of geoscience expertise to the UK economy, and aid the efficient deployment of capital.

Changing priorities

At the time, the natural resources sector was buoyant, with companies regularly listing on the London Stock Exchange's Alternative Investment Market. The forum's founders saw an opportunity to bring business audiences to Burlington House for seminars sponsored by supportive companies, while also raising awareness of the Society and the contribution of its members.

Some 15 years later, the renamed and more inclusive Geological Society Business Forum continues to evolve under the strapline "bridging geoscience, industry and finance". While its early meetings focused mainly on the commercial aspects of the extractive industries, the programme has broadened to reflect changing priorities across industry, policy and society.

Recent and past events have explored subjects including decommissioning, future prospects for natural resources, ethical issues in resource production, carbon dioxide storage, critical minerals,

nuclear energy, geothermal energy, lithium and the wider energy transition. Forthcoming events include a discussion on subsurface storage of gas and energy in the form of compressed air and another on mine-water management.

We encourage readers to attend the forum's free meetings, which bring together geoscientists, investors, financiers, insurers, industry specialists and policy professionals to examine how geoscience can help address commercial and societal challenges.

Join the committee

The forum's committee and advisers are comprised of both geoscientists, many of them members of the Geological Society, and business representatives from oil and gas, mining, critical minerals and insurance.

The committee is keen to broaden its expertise and welcomes new members who can help deliver a geoscience-related programme relevant to business and finance audiences. Volunteers from across the sector are encouraged to get involved, particularly geoscientists working in city firms or in relevant areas of Government.

DR PETER DOLAN

Dolan & Associates Limited

GRAHAM GOFFEY

Forum Chair, Soliton Resources Limited

TO FIND OUT MORE

About upcoming events and take part, visit: geolsoc.org.uk/science-and-policy/specialist-groups/geological-society-business-forum or contact the forum Chair, Graham Goffey.

BUILDING RESOURCE RESILIENCE

A new report from the UK Critical Minerals Intelligence Centre reveals that shortages of end-of-life materials will limit the UK's ability to meet critical mineral demand through recycling over the next decade.

While the Government aims to meet 20% of annual demand through recycling by 2035, the report finds this is likely to be achievable for only a small number of minerals in the short term. However, the outlook improves significantly by 2050, when recovered materials could meet or exceed domestic demand for several critical minerals used in batteries, wind turbines and solar panels.

The report concludes that primary supply will remain essential in the near term, but investment in recycling infrastructure, reverse supply chains, skills and supportive policy will be crucial to building a more resilient, circular and secure critical minerals system that supports the UK's net zero ambitions.

Read the report at:

nora.nerc.ac.uk/id/eprint/541637





Shaping geoscience standards

From university degrees to employer training schemes, accreditation helps maintain quality and supports the development of future Chartered professionals

THE SOCIETY IS currently seeking volunteers to support its formal accreditation of university degree programmes and company training courses.

Academic accreditation

The Society's accreditation of undergraduate and taught postgraduate degree programmes in the Earth Sciences has taken place since 1997 and 2006, respectively. Most recently, we reaccredited undergraduate courses at the University of Southampton and University of West Indies,

St Augustine, Trinidad and Tobago.

Applications are approved by the Academic Accreditation Committee, which typically has 15 to 20 members. New members from academia, industry and public sector bodies are always welcome, and the Society is currently seeking enthusiastic volunteers. As a committee member, you will typically be asked to evaluate one or two programme submissions per year, working collaboratively with two other committee members and supported by the Accreditation Officer. Most work is

carried out via email, with occasional online meetings.

This is an excellent opportunity to contribute to maintaining high academic standards across geoscience education and to support the next generation of geoscientists. If you are interested in joining the committee, please contact Andy Saunders at ads@leicester.ac.uk.

Professional accreditation

The Society has offered accreditation of company training schemes since 2011, with the overall aim of increasing the number of professionally qualified individuals who work in the field of geoscience. Recent accreditations include Jacobs/Halcrow, Stantec and the Civil Engineering and Development Department, (CEDD), Hong Kong.

The accreditation formally recognises that a company provides opportunities for participants to gain the core skills, experience and competencies required to gain Chartered Geologist or Chartered Scientist status. Any company training scheme has first and foremost to serve the needs of the employer, and each will be unique in detail. Accreditation ensures that all schemes involve a process for continuing professional development that builds a culture of reflective planning and self-appraisal, with appropriate record keeping to provide supporting documentary evidence for a Chartership application.

Similar to academic accreditation, applications are reviewed and approved by the Professional Training Accreditation Committee, which depends on volunteer reviewers. If you are interested in providing support, by evaluating one or two submissions per year working collaboratively with two other reviewers, please contact Jason Canning, at jason.canning@nuclearwasteservices.uk.

ANDY SAUNDERS

Academic Accreditation Officer

JASON CANNING

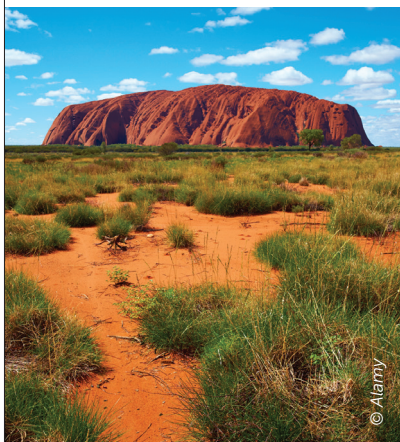
Chair of the Professional Training Accreditation Committee

GROWING OUR AUSTRALIAN NETWORK

We are pleased to announce the creation of a new Australian Regional Group, an idea brought forward by Society Fellows Craig Brock and Jonathan Durnell, who were interested in creating a local framework to connect and support other members in the country. They have been appointed Co-Chairs of a provisional committee.

The Society already has a strong, well-established presence in Australia, with over 300 members. This new Regional Group seeks to represent the growing number of members there, providing a collective voice in terms of professional standards. It also strengthens support for local members in Australia and provides a valuable platform for networking, professional development and community building activities.

This is an important and exciting development for the Society in terms of its international presence alongside our Hong Kong Regional Group.



FUNDING FUTURE COMMUNICATORS

The Society was awarded almost £10,000 through the Learned Society for Wales and the Williamson Trust's 'Trusted Voices' Grants Programme to nurture the next generation of science communicators in Wales and bring evidence-based conversations about climate change, resources and energy directly to festival-goers.

The funding supported a partnership between the Society, the British Geological Survey and Cardiff University to deliver the 'Green Energy Glade' at Green Man Festival,

an interactive space where visitors explored climate change, energy, Earth resources and sustainability through conversation, craft, play and creativity. It also enabled STEM undergraduates from across Wales to receive training in inclusive, evidence-based public engagement.

This funding builds on a successful, long-standing public engagement partnership between the three organisations, rooted in Welsh landscapes, local histories and environmental stewardship.

Safeguarding UK science research

THE SOCIETY CO-SIGNED a statement, prepared with the Science Council and its member bodies, expressing concern about proposed changes to UKRI funding for elements of UK research and development.

Research, development and innovation are proven drivers of productivity, economic growth and improved living standards. Long-term, stable investment is essential to creating high-skilled jobs, addressing challenges such as climate change, and delivering the ambitions of the UK's Modern Industrial Strategy.

The statement also highlights the vital role of curiosity-driven research in generating transformative ideas and

maintaining a resilient research base. However, it remains unclear how UK research will be managed following the proposed changes or how critical scientific capability will be safeguarded.

While recognising the fiscal pressures facing public investment decisions, the Science Council and its member bodies warn that abrupt or insufficiently consulted changes risk undermining confidence, disrupting research careers and weakening the long-term impact of public investment. Collectively, we stand ready to work constructively with UKRI and the government to support a strong, sustainable and globally competitive UK science system.

Serve on our Council and committees

COUNCIL MEMBERS SERVE as the Society's trustees and have collective responsibility for overseeing the Society's purpose, values, vision and strategy. They take the big strategic decisions and make sure we are conducting the Society's purposes for the public benefit, acting in the charity's best interests, managing our resources responsibly, being accountable, and acting in accordance with the rules.

Council normally meets five times a year, usually on a Wednesday afternoon between 14:00 and 17:00. Most meetings are virtual with one meeting per year normally held in person. In addition, there is a one-day in-person strategy meeting.

Council members are invited to serve on a Standing Committee (External Relations, Finance & Planning, Professional, Publications & Information, and Science). Standing Committees generally meet three to four times a year, mostly virtually. Occasionally, a Council member may be invited to join other committees or working groups.

The typical time commitment is eight to ten days annually for Council members and around fifteen days for Officers.

Members vote for Council members through a ballot held each year, usually in March.

**Nominations close 23:59 on
Wednesday 15 January 2027**

MORE INFORMATION

To find out more and submit your nomination, visit geolsoc.org.uk/councilelections

For further questions or to express interest, please contact secretary@geolsoc.org.uk



Dear Members,

Have you considered serving as a Trustee (Council member) or on one of the Society's committees?

Our Society is committed to diverse and inclusive Council and Committees and invites nominations from all areas of our community.

A brief outline of the trustee role and time commitment involved is included here, with more information available on the Society website.

We look forward to receiving your nominations.

JESSICA T SMITH
President

SOCIETY AWARDS 2027

The Geological Society's Medals, Awards and Funds honour excellence across all areas of geoscience.

Nominating a colleague, or someone whose exceptional achievements or noteworthy contributions deserve recognition, is a meaningful way to celebrate impact across the geoscience community, particularly

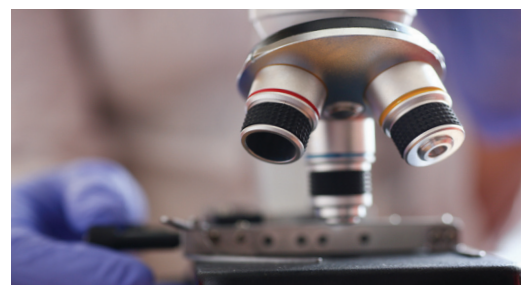
in industry and government, as well as those showing considerable promise early in their careers.

**Nominations close 23:59 on
15 October 2026**

For more information, visit geolsoc.org.uk/awards
Email: awards@geolsoc.org.uk

“To win any award as a scientist is an immense honour, let alone an early career award. It means so much not only because you have been selected by the awarding organisation, but also because you have been nominated by your colleagues. To think that my work has had an impact like that really is something special.”

Dr Alice Paine, a 2026 recipient of the President's Award



RESEARCH GRANTS 2027

Applications are now open for the Society Research Grants for 2027.

Please read the full guidance and requirements on the Society Awards and Research Grants page at geolsoc.org.uk/grants before applying. Only fully completed applications with supporting statements on the appropriate forms will be considered.

**Applications close at 23:59 on
15 February 2027**



The
Geological
Society

FERMOR SEED CORN GRANTS

- Grant scheme for those unable to apply for traditional research funding.
- Up to five grants, with an average award between £50,000 and £75,000

Applications open!



Submission deadline

2 October 2026



EGGC2

ENERGY GEOSCIENCE
CONFERENCE 2027

11-13 May 2027 | P&J Live, Aberdeen



Submit your abstract:
www.energygeoscienceconf.org

Following the success of its sell-out inaugural event, the Energy Geoscience Conference returns in 2027! The conference series aims to explore and develop the contribution of geology and geophysics to the low-carbon energy transition.

The event is a key forum for sharing geoscientific aspects of energy supply as geoscientists grapple with the subsurface challenges of remaking the world's energy system, balancing competing demands in achieving a low carbon future.

GESGB



The
Geological
Society



A SPACE FOR DISCOVERY: THE ROOM AT THE HEART OF GEOSCIENCE

For more than two centuries, across multiple homes and through the upheavals of scientific revolution, one room has sat at the heart of the Geological Society. Now, having secured its future at Burlington House for the next thousand years, the Society is ready to make that room worthy of the centuries ahead

WITH THE SOCIETY'S FUTURE at Burlington House ensured through a 999-year lease, we have a rare opportunity to invest in one of the most significant spaces in the history of geology—and to help shape its future.

Today, as the Society looks ahead to its third century, an ambitious project is underway to refurbish and restore the Lecture Theatre at Burlington House, the centre of many of the discoveries, debates and discussions that have shaped modern geoscience.

Our aim is not simply to modernise a well-used space, but to reveal its historic character, improve accessibility and sustainability, and ensure it remains a place of learning, debate and inspiration for generations to come.

A home for geology

Wherever you are in the world, if you work in, study or care about the geosciences, you are connected in some way to the Geological Society's home at Burlington House.

← At a meeting of the Geological Society of London on 18 December 1912, Charles Dawson claimed that four years earlier, a workman at the Piltdown gravel pit in East Sussex had given him a fragment of the skull that became known as the 'Piltdown Man'. The earliest photograph we have of the 'Meeting Room' (Lecture Theatre), is the one of the Ordinary General Meeting on 30 June 1954 where the Piltdown skull was confirmed to be a fraud.
© Geological Society of London

Founded in 1807 by thirteen pioneering geologists, the Geological Society is the oldest national geological society in the world. Since 1874, Burlington House has served as its home: a place where scientific knowledge is shared, professional standards are developed, collections are cared for, and the global geoscience community comes together to tackle some of society's greatest challenges.

At the centre of that activity sits the Lecture Theatre.

Known originally as the Meeting Room, this space has accompanied the Society throughout its history. Long before the move to Burlington House, the Meeting Room travelled with the Society through successive premises across London, always remaining central to its purpose. Since arriving in Piccadilly, it has continued to provide a place where geologists gather to exchange ideas, challenge assumptions and advance understanding of Earth.

In the early 1970s, the Meeting Room was transformed into the Lecture Theatre we know today. More than fifty years later, the time has come to reimagine the space once again.

Where ideas changed the world

Few scientific spaces can claim such a direct connection to the development of an entire discipline.

The Society's early meetings were →

“A place where geologists gather to exchange ideas, challenge assumptions and advance understanding of Earth”



The Lecture Theatre in 1974 showing the original colour scheme. The Lecture Theatre was given a false ceiling, covered windows and raked floor. The small window toward the top and centre of the image is the 'plant room' / tech control box, which was created as part of the re-development.

© Geological Society of London



renowned for lively debate. Unlike many learned societies of the nineteenth century, discussions were actively encouraged, with the room arranged in a parliamentary style to foster challenge and exchange. One meeting attendee, J. S. Lockhart, famously remarked, "Though I don't care for geology, I do like to see the fellows fight." Charles Babbage, a regular attendee at Society meetings, also praised the discussions for bringing together ideas and observations that ultimately led to important scientific conclusions.

Within this space, discoveries that transformed scientific understanding were presented and debated and refined.

Mary Anning's remarkable fossil discoveries, and some of the earliest known plesiosaurs and pterosaurs, were brought

“ Few scientific spaces can claim such a direct connection to the development of an entire discipline ”

before the Society, helping to revolutionise ideas about prehistoric life. In 1824, William Buckland presented the first scientific paper on *Megalosaurus*, the first terrestrial dinosaur. The first papers describing the Cambrian, Silurian, Devonian and Permian systems were also presented here, laying important foundations for the geological timescale used today.

On 4 January 1837, a young Charles Darwin presented his first scientific paper



For almost 200 years, the Society has recorded and celebrated the generosity of its supporters. This book documents donations towards the Society's move to Somerset House in 1828, with William Buckland, Roderick Murchison, Charles Lyell, William Wollaston and Adam Sedgwick among the signatories.

© Geological Society of London

to the Society, sharing observations made during the voyage of HMS *Beagle*. Seventy-five years later, the Meeting Room hosted the first presentation of the discovery of the Piltdown Man, when bone fragments were presented as the fossilised remains of a previously unknown early human. In 1954, it was also the venue where the official announcement was made exposing the Piltdown Man as one of the most famous frauds in science.

The room has also witnessed important moments in the Society's own history. In 1901, women attended an Ordinary General Meeting for the first time, helping pave the way for the election of the Society's first women Fellows in 1919. And when the newly refurbished Lecture Theatre opened in 1973, its inaugural lecture was delivered by Harrison Schmitt—geologist, Apollo 17 astronaut and the only geologist ever to have walked on the Moon.

Revealing the past, preparing for the future

The proposed refurbishment offers an exciting opportunity to reconnect the Lecture Theatre with its historic character while ensuring it meets the needs of a modern scientific society.

Historic photographs suggest that significant architectural features from the original Victorian Meeting Room may still survive beneath the 1970s redevelopment. Original windows, decorative detailing and elements of the room's earlier appearance may yet be revealed. The project will seek to uncover and celebrate these historic features wherever possible, restoring →

“Within this space, discoveries that transformed scientific understanding were presented and debated and refined”

AN INVITATION TO BE PART OF THE STORY

THE LECTURE THEATRE IS NOT SIMPLY A ROOM WITH AN INTERESTING HISTORY. IT IS A ROOM WHERE THE HISTORY OF GEOLOGY HAPPENED

The Society's history has been shaped by generations of Fellows, supporters and benefactors who invested in its future.

The refurbishment of the Lecture Theatre offers today's community a chance to do the same.

We are seeking to raise over £1 million to refurbish and secure the future of the Society's historic Lecture Theatre. The project will be supported through a range of philanthropic opportunities, enabling individuals and organisations to contribute in ways that are meaningful to them.

FOUNDING MEMBER PATRONS

Founding Member Patrons will play a particularly important role in bringing the project to life. Inspired by the spirit of the Society's original founders, this group of supporters will help shape the future of Burlington House, forming the bedrock from which we build a legacy, and will be recognised for their leadership gift and commitment to geoscience. We are seeking **13 Founding Member Patrons**—individuals or organisations to collectively unlock a vital programme of investment in the Society's future—each committing **£20,000** or more. A limited number of places remain.

THE FOUNDER'S CIRCLE

While inspired by our original founders, we welcome further interest. From a gift of **£3,000+**, the Founder's Circle brings together Fellows, members and friends of

the Society who wish to support the refurbishment at a significant level. Collectively, these early supporters will help ensure that the project can achieve its full ambition and impact.

SEAT DEDICATIONS

For those seeking a personal connection, seat dedications provide a lasting way to become part of the Lecture Theatre's story. Seats may be dedicated in honour of a mentor, colleague, loved one or personal passion for geoscience. Future generations of students, researchers and Fellows will gather in these seats to learn, debate and discover. Dedications range from **£500** to **£2,500**.

CORPORATE PARTNERSHIPS

The Society has a range of partnership opportunities for organisations that share its commitment to education, sustainability, innovation and the future of the geoscience profession. Bespoke opportunities are available for companies wishing to support the project and engage with the Society's international community.

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Every contribution, whatever its size, will help bring the project closer to reality.

Anonymous donations of any size are also welcome and will be respected in accordance with donors' wishes.



The Lecture Theatre as in use today, with the seats recovered in blue.
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“The refurbishment will create a more welcoming, accessible and sustainable environment for everyone”

a stronger connection between the space and its remarkable past.

At the same time, the refurbishment will create a more welcoming, accessible and sustainable environment for everyone who uses it.

Improved accessibility will help ensure that Fellows, visitors and speakers can participate more fully in Society activities. Enhanced environmental performance will support the Society's wider sustainability ambitions. Modern infrastructure and audiovisual technology will enable the Lecture Theatre to continue serving audiences both in person and online.

The Geological Society has always been

international in outlook. Today, members join lectures and scientific meetings from across the world. The refurbished Lecture Theatre will strengthen those connections, creating a space that reflects the global nature of contemporary geoscience whilst retaining the unique atmosphere that has characterised the room for more than two centuries.

The next chapter

A 999-year lease is a remarkable responsibility.

It represents confidence in the future of the Geological Society and a commitment to safeguarding Burlington House for generations yet to come. The refurbishment

of the Lecture Theatre is one of the first opportunities to honour that commitment.

For more than 200 years, this room has witnessed discoveries, debates and conversations that have shaped our understanding of Earth. The decisions made today will determine how it continues to serve the geoscientists of tomorrow.

The Society warmly invites Fellows, members, researchers, students, partners and friends around the world to be part of this next chapter.

Together, we can ensure that this extraordinary room remains a place where ideas are shared, discoveries are made and the future of geoscience continues to be shaped. 

SIMONE LENNOX-GORDON

Head of Development, The Geological Society of London, UK

MAKING A GIFT FOR THE FUTURE

To discuss the project or opportunities to support the campaign, please contact Simone Lennox-Gordon, Head of Development, or Jenny Boland, Director of Membership & Development, by emailing development@geolsoc.org.uk or calling +44 (0)20 7432 0947.

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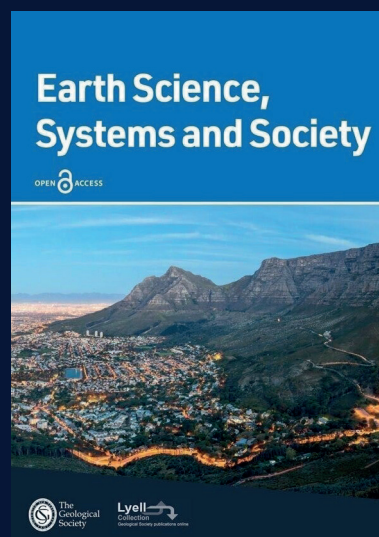
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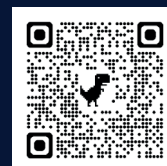


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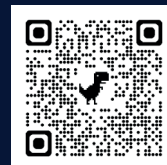
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VIEWPOINT

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COLUMN

Everything comes from Earth

Geodiversity and biodiversity underpin society and wildlife. A geosystem services approach is needed to recognise the value of geoscience, argue Murray Gray and Nathan Fox

"Nature and biosphere are used interchangeably," according to Professor Sir Partha Dasgupta's global report on *The Economics of Biodiversity* (2021, p.31), commissioned by the UK Treasury. The implication is that these are effectively synonyms. As geoscientists, we are used to nature writing, documentaries and media programmes being centred around wildlife, but when did the biosphere

become so dominant in our conception of nature and what are the implications?

Everything we have is derived from the planet itself. Yet, the critical role for geodiversity is often overlooked by a biodiversity focused view of nature. A geosystem services approach, which focuses on the benefits society gains from living on a geodiverse planet, should be used to argue for the foundational importance of geology as a subject.

Beyond biodiversity

Early writers on nature, including Charles Darwin, were polymaths interested in several sciences. Indeed, the word 'ecosystem' was introduced by British ecologist Arthur Tansley in 1935 to describe the biological and abiotic components of nature interacting as functioning systems. And over 50 years ago, concerns around the global loss of species led to the term 'ecosystem services' being used to describe the goods and services that society gains

from nature, including food, fuel (mainly wood), fibre and pharmaceuticals. However, nature writing involving 'ecosystems', 'ecosystem services' and 'nature' has become dominated by biodiversity and biological systems.

After the *Convention on Biological Diversity*—an international treaty dedicated to conserving biodiversity and ensuring the sustainable use and fair sharing of natural resources—was signed at



Stunning landscapes, such as Maletsunyane Falls, Lesotho, Africa, can offer tangible benefits to society if we capitalise on them more, say Murray and Nathan
© iStock

the Earth Summit in Rio de Janeiro in 1992, several geoscientists realised that they too study diverse physical Earth phenomena that are often threatened by human activities, coining the term 'geodiversity' as a result. Subsequently, 'geosystem services' were devised to describe the benefits society gains from living on a geodiverse planet, which we summarise in the box 'Geosystem services'.

Our classification of geosystem services falls into →

Geosystem services

The major benefits society gains from living on a geodiverse planet are:

REGULATING

1. Atmospheric and oceanic processes (e.g. dynamic circulations, atmospheric chemistry, air quality and climate regulation, hydrological cycle).
2. Terrestrial processes (e.g. rock cycle, carbon and other biogeochemical cycles, carbon sequestration, geomorphological processes, natural hazard regulation, erosion regulation).
3. Flood regulation (e.g. infiltration, barrier islands, river levees, sand dunes, floodplains).
4. Water-quality regulation (e.g. soil, sediments and rock as natural filters).

SUPPORTING

5. Soil processes (e.g. weathering, soil profile development) and soil as a growing medium.
6. Habitat provision (e.g. limestone pavements, caves, cliffs, salt marshes, dynamic habitats).
7. Land and water as platforms for human activity (e.g. building land, camping, canoeing).
8. Burial and storage (e.g. human and animal burial, municipal landfill, radioactive waste storage, oil and gas reservoirs, carbon capture and storage, water storage in aquifers, ice sheets).

PROVISIONING

9. Food and drink (e.g. freshwater and mineral water, beer and whisky, salt, geophagy).
10. Nutrients and minerals for healthy growth of plants, animals and humans.
11. Energy (e.g. nuclear, geothermal and hydroelectric energy, and tidal, wave and wind power).
12. Construction materials (e.g. stone, brick, aggregates, steel, cement, bitumen, glass).

13. Industrial minerals (e.g. fertilisers, pharmaceuticals, metals, alloys).

14. Ornamental products (e.g. gemstones, precious and semi-precious metals).

15. Fossils for sale.

CULTURAL

16. Environmental quality (e.g. local landscape character, therapeutic landscapes for physical and mental health).

17. Geotourism and leisure (e.g. mountain and coastal views, rock climbing, hiking, skiing, fossil collecting).

18. Cultural, spiritual and historic meanings (e.g. folklore, sacred sites, sense of place).

19. Artistic inspiration (e.g. geological materials in sculpture and inspiring art, literature, music, poetry).

20. Social developments (e.g. local geological societies, volunteering, field trips).

KNOWLEDGE

21. Earth history and geoheritage (e.g. evolution and extinction of life, origin of landforms, palaeoenvironments).

22. History of research (e.g. early identification of fossils, unconformities, igneous rocks).

23. Environmental monitoring and forecasting (e.g. baseline studies for climate change and pollution research, ice cores, sea level change).

24. Geoforensics.

25. Education and employment (e.g. sites for teaching and research, employment in industry, geoparks).

**Here we have classified geosystem services according to the Millennium Ecosystem Assessment—a major UN-sponsored international study conducted from 2001 to 2005 (millenniumassessment.org)—with the addition of a knowledge category (modified from Gray, 2018).*



two categories: those where biodiversity and geodiversity interact as functioning systems (here referred to as ecosystem services) and those that exist largely independently of biological systems (here referred to as geophysical services).

Ecosystem services include some terrestrial processes, such as the strong interactions between biota and erosional and depositional processes (particularly in rivers), including seed dispersal. Thus, geomorphological processes can play an important role in ecosystem dynamics.

Soils, too, are derived from the physical, chemical and biological weathering of rock and sediments and, as they are colonised by plants and animals, organic material and a soil ecology are added. Soil processes are therefore a crucial link between the abiotic and living world.

Habitat provision offers another example of this interaction. Cross-disciplinary research groups are investigating links between biodiversity and geodiversity through the *Conserving Nature's Stage* metaphor of biodiversity as the 'actors' on the landscape 'stage'. This approach proposes that conserving geodiversity has the potential to protect the habitats and niches into which wildlife can migrate at times of climate or environmental change.

Weathering of minerals also transfers elements into soils,

“This geosystems service approach demonstrates that abiotic nature is as—if not more—important than biodiversity”

from where they are taken up by plants and animals and eventually become part of human diets; medical geology has tended to focus on toxic elements rather than those vital to the health of plants, animals and humans.

Even therapeutic landscapes reveal the value of this broader view of nature: being out in nature brings many physical and mental health benefits. These are usually associated with forests, meadows, parks and gardens, yet landscapes encompass complex topographies that should be recognised as equally important, such as mountain views, waterfalls and coastal walks.

Geophysical services include use of the subsurface for burial and storage, abiotic sources of food and drink (e.g. rock salt, mineral water), energy (e.g. tidal, geothermal, nuclear), construction materials, industrial minerals, ornamental products, as well as cultural and leisure services (e.g. geotourism, artistic inspiration, outdoor activities such as rock climbing and hiking) and knowledge services (e.g. environmental monitoring, geoforensics).

This geosystems service approach demonstrates that abiotic nature is as—if not more—important than biodiversity. Abiotic nature not only supports biodiversity and human life but has important values of its own.

Life's foundations

Life on Earth is facilitated and sustained by its physical foundations. All of nature is

fundamentally related to the abiotic world; all healthy life depends on the platforms, habitats and nutrients derived from the physical planet (supported by energy from the Sun). Very little biodiversity would exist without geodiversity.

Abiotic nature should therefore be regarded as crucial to developing environmental management and nature conservation strategies and contributing to societal success and wellbeing. Without this, our land management and conservation policies and practices are deficient.

Given that we undervalue the physical foundations of nature, it is perhaps unsurprising that geology—the discipline devoted to studying our physical foundations—sometimes struggles to command attention. As we enter a geopolitical age involving the grab for Earth's (and even lunar and planetary) resources, the geosystem services approach is surely one that could and should establish geoscience as a fundamental subject that is crucial to our future on this planet and beyond. **G**

PROF MURRAY GRAY

Queen Mary University of London, UK

DR NATHAN FOX

Michigan Institute for Data and AI in Society, USA

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A full list of further reading is available at [geoscientist.online](https://www.geoscientist.online).

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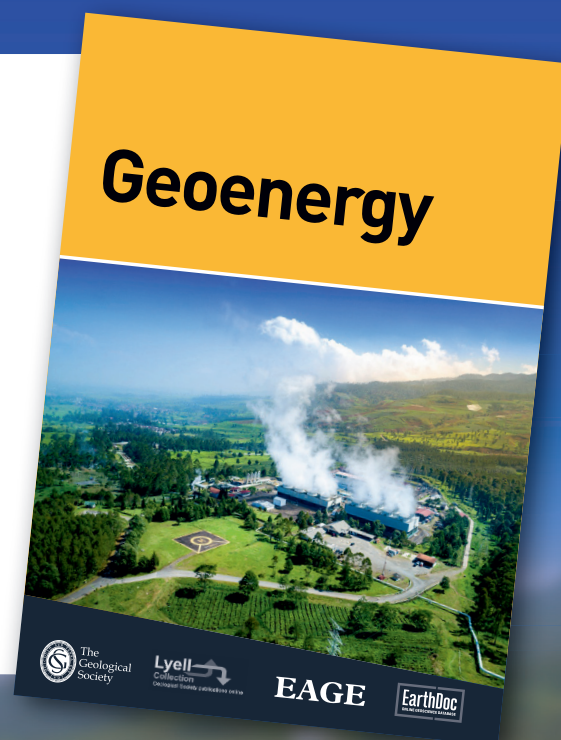
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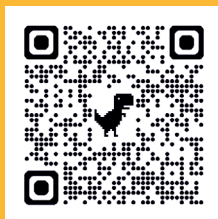
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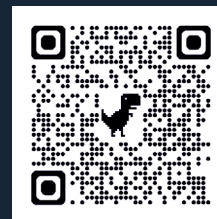
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LETTER

The lady of Kent's Cavern

DEAR EDITORS,

I read with interest the article *Obscurity and notability* by Caroline Lam (*Geoscientist* 36 (2), 10–12), and especially the reference to Mrs Cazalet. I wondered if I could identify her and came across Marianne Cazalet, which led me to question whether she could be the lady of Kent's Cavern, Torquay?

Nineteenth-century women collectors of natural history are often absent from the scientific record, or, if included, are generally mentioned only by

surname and marital status. Mrs Cazalet, who assisted John MacEnery (1797–1841) at Kent's Cavern during the 1820s, is no exception. A clue to her identity may perhaps be gleaned from the writings of the geologist William Pengelly (1812–1894) FRS, FGS, who from the mid-1830s was a resident of Torquay. In the *Transactions of the Devonshire Association* (Vol III, July 1869, p. 493), in a paper entitled *On the alleged occurrence of Hippopotamus Major and Machairodus Latidens in Kents*

Cavern, Torquay, Pengelly writes that MacEnery was "on the most friendly terms with Mrs Cazelet, who was his co-religionist"; and, as she had "a collection of the cavern fossils", it could safely be inferred that he knew all the specimens in it.

The key word here is "co-religionist". Father John MacEnery was Roman Catholic and in service at Tor Abbey as private chaplain to the Cary family. A possible candidate for his "co-religionist" is Marianne Cazalet (1787–1859), wife

of the Church of England clergyman James Cazalet. Though not of the same denomination, both belonged to the broad centre of Christian belief and so shared common ground.

The lady referred to as Mrs Cazalet is also thought to have helped MacEnery's excavations financially. To be his patron, she must have been of reasonable wealth, a member of the higher echelons of society.

Marianne was born Marianne Arnold and was baptised at Halstead, Kent, on 15 December 1787. She was the daughter of George Arnold Arnold, formerly George Arnold Sargent, and



Drawing of Kent's Cavern by John Marten (1825). Could Marianne Cazalet be the lady of Kent's Cavern? asks David.
© Geological Society of London, LDGSL/400/22

“It is possible that Marianne Cazalet was the lady of Kent’s Cavern, the patron of John MacEnergry’s excavation”

Mary Ann Arnold. On 13 December 1810, at St George, Bloomsbury, she married her cousin James Cazalet, son of Peter Cazalet, merchant and then banker, and Sarah Langston. Her family background places her among the financially secure and socially well-connected.

MacEnergry began his excavation of Kent’s Cavern in late 1825. On 17 February 1826, the Geological Society’s Museum received from Mrs Cazalet several bones from Kent’s Hole, or Kent’s Cavern; on 6 April 1827, it received a collection of recent and fossil corals collected at Torquay (*Transactions of the Geological Society* 2, 1829). At that time the museum was in Bedford Street, a little over half a mile from Bedford Square, where the Cazalet family had lived and had connections. Marianne is therefore likely to have known of its existence, especially as Mrs Cazalet senior, Sarah, was interested in Natural Philosophy and a subscriber to the Royal Institution lectures (she is listed as such in the *Charter and Bylaws of the Royal Institution* published in 1806).

Marianne’s movements during the 1820s are difficult

to determine, and I do not know of any document confirming that she was the lady at Torquay. Yet the known facts do not preclude it. Her children’s baptisms and later records show a geographically mobile family, and Mr Cazalet, and presumably Mrs Cazalet, had left Torquay before 19 June 1826, reportedly in a direction beyond Newton Abbot. This would accord with the period in which Mrs Cazalet’s cavern bones reached the Geological Society.

Nor did Torquay vanish from the Cazalets’ story. Marianne’s extended family had later associations with the town, and when she died on 1 November 1859 at Porteus House, Paddington, London, probate records noted her as late of Watcombe, Torquay.

Marianne Cazalet feasibly qualifies as the Mrs Cazalet who assisted John MacEnergry. Marianne’s marriage and beliefs make her a plausible “co-religionist”; she had the means to assist MacEnergry’s excavation; she lived within reach of the Geological Society’s Museum; and her known movements do not rule out a visit to Torquay in late 1825 and early 1826. It is therefore possible that she was the lady of Kent’s Cavern, the patron of John MacEnergry’s excavation, and the collector of all those bones and fossils two hundred years ago. **G**

DAVID C RAYMENT FRSA FLS

Local history author with training in natural and contemporary sciences, and mathematics and computing, UK

VIEWPOINT

SCIENCE

Is water lava?

Fabian Wadsworth and Edward Llewellyn explore a playful yet serious nomenclature debate about water, sparked by the podcast *The Rest Is Science*.

The Mineral Cup was launched by Eddie Dempsey in 2017 and is now an annual competition where people vote for the best of two minerals.

Controversially, ice won the award in 2019, initiating the debate of whether ice is really a mineral. The answer amongst geoscientists is a begrudging ‘yes’ because ‘mineral’ is simply another name for a naturally occurring inorganic crystalline solid (Clopton, 1994).

A block of ice is made from many crystals of ice. Does that therefore mean that ice is a monomineralic rock? If so, does that then imply water is molten rock? And if we go that far, is it fair to refer to water as lava? That’s the line of mind-bending reasoning that YouTube and co-host of *The Rest Is Science* podcast Michael Stevens has taken. The logic seems hard to fault, but it is also clear that this is stretching the definition of lava.

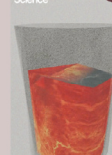
To be or not to be lava
Let’s first consider ice volcanoes—or cryovolcanism more generally—on Solar System bodies such as Enceladus and Europa (Spencer et al., 2009; Sparks et al., 2017), where great geyser-

type features erupt water and ice in ways not seen here on Earth. In that context, water is unequivocally a form of lava.

For anyone who finds this hard to accept, it can be tempting to adjust the definitions of mineral, rock, or lava to somehow exclude ice and water from those categories. Since ice did win the Mineral Cup 2019, it seems hard to argue that it is not a mineral. Instead, one might suggest that ice is not a rock, as rock should be formed or involved in geological processes. Yet this doesn’t really solve the issue as ice is a key player in our geological world—anyone who has learned about glacial U-shaped valleys knows the geological power of ice (Bennett and Glasser, 2011).

Similarly, we might be tempted to say that lava (and its subterranean counterpart magma) should not just be molten rock, but molten rock that is forged in Earth’s mantle or by melting and assimilation in the crust. However, water is a key part of these processes and, in fact, without water a lot of partial melting of mantle or crustal rocks simply wouldn’t occur (Ohtani, 2020; Grotzinger and Jordan, 2020). From that earliest formation of

Science



A three-quenching glass of lava illustrates the debate around water’s nomenclature. © Gallagher Podcasts Ltd

magma, water is a constituent of all molten rock on Earth—all lavas contain a fraction of water dissolved in the magmatic liquid and it is incorporated in some magmatic minerals. Therefore, water is erupted from volcanoes, just as lava frequently is.

Then if we think of gaseous water, large explosive eruptions are, volumetrically, dominantly water at Earth’s surface. From that point of view, volcanoes can reasonably be thought of as places on Earth where gaseous water erupts, and lava, pyroclasts, and other gases are just along for the ride.

From lava to life
Michael’s argument appears to hold water. But that doesn’t mean that all water is lava. In Earth’s 4.5-billion-year history, almost everything on our planet (including the constituents of humans) has erupted from volcanoes at some point. That doesn’t mean we call

LISTEN HERE

Explore the podcast episode at [youtube.com/@TheRestIsScience](https://www.youtube.com/@TheRestIsScience)

everything lava. Over time, solidified lava becomes other things, such as sediments or soils, nutrients, and solutes in oceans. The sediment may be lava-like in its chemistry, but it is no longer definable as lava. That is, lava loses its identity through the changes that come with time.

If we apply that same logic to Michael’s glass of three-quenching water lava, while it may be lava in the glass, it stops being lava as soon as it becomes part of our metabolism. So, while it might be true that all water has been lava for a period of time, not all water on Earth is lava today. What a wonderful reminder of the driving force for endless mutable change: geological time. **G**

PEDRO FABIAN WADSWORTH
Ludwig Maximilians-Universität München, Germany

PROF EDWARD LLEWELLYN
Duffin University, UK

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LETTER

Keep thinking!

DEAR EDITORS,
I read *Is water lava?* (*Geoscientist* 36 (2), 28) with amused interest. If water is lava, then are evaporites igneous rocks?

Ice may have won the Mineral Cup in 2019, but who nominates the minerals and who votes? Beware of pseudo-democratic constructs before water is renamed Watery McWaterface.

While Clopton (1994) may define a mineral

as a naturally occurring inorganic crystalline solid, not all naturally occurring inorganic crystalline solids are minerals.

Thank you for the thought-provoking Viewpoint. Where would geology be without doubt, reason and questioning? Seductive arguments do not necessarily lead to factual truth, and logic can be false! **G**

CHRIS DANILEWICZ FGS CGEOL
Engineering Geologist, UK

The mystery of **EARTH'S** missing lead

DEEP WITHIN EARTH'S MANTLE, PRESSURE-STABILISED SULFIDE MINERALS MAY HIDE A LONG-SOUGHT RESERVOIR OF ANCIENT LEAD, SUGGESTS SIMON REDFERN, OFFERING A NEW EXPLANATION FOR ONE OF GEOCHEMISTRY'S OLDEST PARADOXES

FOR MORE THAN half a century, geochemists have wrestled with an uncomfortable problem. Earth appears to be missing some of its lead. Not literally, of course, lead is abundant in ore deposits, occurs in volcanic rocks, and has been mined and used by humans for thousands of years. But when scientists compare the composition of lead's various forms (or isotopes) in Earth's crust and mantle with the composition expected from the meteorites that formed the Solar System, something does not add up.

The lead preserved in rocks from

Earth's surface appears too radiogenic. There seems to be too much lead produced by radioactive decay and not enough primordial, unradiogenic lead left over from the early Solar System. Somewhere, geochemists reasoned, there must be a hidden reservoir containing the 'missing' unradiogenic lead. This puzzle became known as the 'lead isotope paradox', and it has shaped thinking about Earth's chemical evolution for decades.

My recent research carried out with colleagues at Nanyang Technological University, Singapore, offers a possible solution (Liu et al., 2026). Using high-pressure crystal structure prediction and quantum mechanical calculations, we find that unusual lead–sulfur minerals may become stable deep within Earth's mantle under immense pressure. Could

these minerals lock away ancient lead for billions of years, effectively hiding it from the rest of the planet? The work brings together mineral physics, geochemistry and planetary science, and suggests that Earth's deep interior may host previously unknown minerals capable of influencing the isotopic evolution of the entire planet.

Reading Earth's history

Lead isotopes are among the most powerful tools available to geochemists. They preserve information about the timing of planetary differentiation, crust formation, mantle evolution and recycling processes operating over geological time. Three isotopes of lead, ^{206}Pb , ^{207}Pb and ^{208}Pb , are produced by the radioactive decay of uranium and thorium isotopes. A fourth isotope, ^{204}Pb , is non-radiogenic and remains unchanged through time. By comparing ratios such as $^{206}\text{Pb}/^{204}\text{Pb}$ and $^{207}\text{Pb}/^{204}\text{Pb}$, geochemists can reconstruct how different parts of Earth evolved chemically.

The problem is that Earth's mantle and crust appear more radiogenic than expected if the planet formed from material with a chondritic composition similar to primitive meteorites, representative of the building blocks of the Solar System. Somewhere, a complementary reservoir rich in unradiogenic lead seems to be missing. →

“The ‘lead isotope paradox’ has shaped thinking about Earth’s chemical evolution for decades”

New calculations show that unusual lead–sulfur minerals may become stable deep within Earth's mantle, potentially locking away ancient lead for billions of years. Small amounts may be episodically remobilised into the convecting mantle, as illustrated by this artist's impression of Earth's internal structure © Planetary Visions Ltd / Science Photo Library

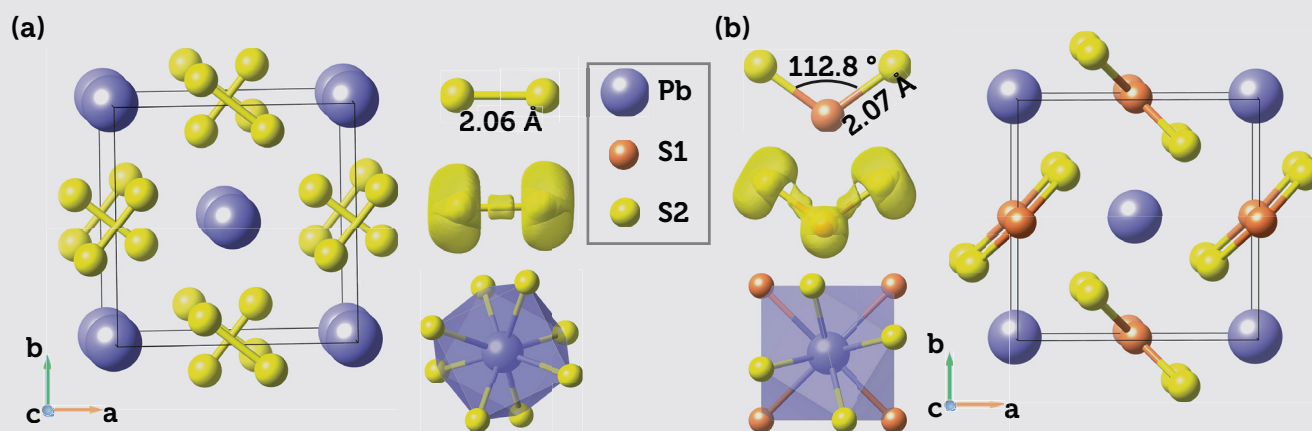


Figure 1 | Crystal structures of lead polysulfides. Crystal structures of PbS_2 at 10 GPa (a) and PbS_3 at 30 GPa (b), along with the calculated electron localization function of polysulfur units. Large purple, small orange, and small yellow spheres represent lead (Pb) and sulfur (S_1 and S_2) atoms, respectively. (Figure reproduced from Liu et al. (2026) Nat. Commun. 17, 2913; doi.org/10.1038/s41467-026-69772-8, published under a CC BY-NC-ND 4.0 licence)

For decades, many researchers suspected that the missing lead was hidden in Earth's metallic core. Lead has a moderate affinity for sulfur and metallic phases, so it was plausible that lead followed sulfur into the core during the violent differentiation of the early Earth. But there is a problem with that idea. Experimental measurements of how lead partitions between metal, sulfide and molten silicate suggest that the core cannot contain enough lead to balance the isotope budget on its own. That has led scientists to search for alternative hidden reservoirs elsewhere inside Earth.

Minerals at extreme conditions

One possibility is that the missing lead is stored in deep mantle sulfides. Lead is a chalcophile element, meaning it preferentially associates with sulfur. Near Earth's surface, lead commonly occurs as galena (PbS), the main ore mineral of lead. Sulfur-bearing minerals and melts are also known from mantle rocks, and sulfur is continuously cycled into Earth's interior through subduction. However, very little is known about how lead-bearing sulfides behave under the extreme pressures and temperatures of Earth's deep mantle. At

depths approaching the core–mantle boundary, pressures exceed 130 GPa (more than a million times atmospheric pressure), while temperatures may approach 4,000–5,000 K (3,700–4,700°C). Under such conditions, familiar minerals often transform into entirely new crystal structures.

Modern computational mineral physics allows researchers to explore these extreme conditions theoretically, even where experiments remain difficult. In our study, we used the computational method 'Crystal structure AnaLYsis by Particle Swarm Optimization' (CALYPSO) to predict crystal structures, combined with density functional theory calculations to search systematically for stable compounds in the lead–sulfur system at pressures up to 150 GPa.

Rather than assuming known structures, the calculations allow crystal structures to emerge naturally according to the laws

of quantum mechanics. The calculations recovered familiar lead sulfide phases but also predicted something unexpected: two previously unknown high-pressure lead polysulfides, PbS_2 and PbS_3 . These compounds become thermodynamically stable only under high pressure. Both contain unusual sulfur–sulfur bonding arrangements that do not occur in ordinary galena.

Exotic sulfur chemistry

One of the most striking aspects of the predicted minerals is the way sulfur behaves under compression. At ambient conditions, sulfur usually forms discrete molecules or simple sulfide ions. Under extreme pressure, however, sulfur atoms are forced much closer together and new bonding configurations become favourable.

In PbS_2 , sulfur forms paired S_2 units. In PbS_3 , sulfur forms bent trisulfur groups resembling tiny V-shaped molecular fragments embedded within the crystal structure (Fig. 1).

Calculations of the electron localization function, a way of visualising where electrons are concentrated within a crystal, show strong covalent bonding between sulfur atoms in these units. The effect is especially clear in PbS_3 , where the sulfur

“Deep planetary interiors host materials unlike anything familiar at the surface”

atoms behave very differently from sulfur in common sulfide minerals.

Pressure actually stabilises sulfur–sulfur covalent bonds. Compression increases the overlap of electron orbitals between neighbouring sulfur atoms. This stabilises the covalent bonds by widening the energy difference between bonding and antibonding states, and lowering the overall energy of the structure. This type of chemistry has become increasingly important in high-pressure materials science over the past decade. Similar pressure-stabilised polysulfides have been predicted or synthesised in several other systems, including calcium and barium sulfides. Our work suggests that lead may participate in comparable deep-Earth chemistry.

Surviving the deep mantle

Finding new crystal structures is interesting, but for geochemistry, the crucial question is whether these phases could actually survive inside Earth. To answer that, we calculated the pressure–temperature stability fields and melting behaviour of the different lead sulfides. The results were revealing (Fig. 2). Ordinary PbS remains stable over a huge pressure range and has an exceptionally high melting temperature. Even under conditions approaching those near the core–mantle boundary, our molecular dynamics simulations indicate that PbS would remain solid in a crystalline form rather than melt into a liquid.

That matters because a solid mineral trapped deep in the mantle can remain isolated for extremely long periods of time. If lead became concentrated in sulfide compounds early in Earth's history, these minerals could effectively shield lead from uranium and thorium, which remain preferentially associated with silicate rocks. Over billions of years, the surrounding mantle and crust would continue generating radiogenic lead through radioactive decay, while the isolated sulfide reservoir retained its original, unradiogenic isotopic composition. In other words, the deep mantle could preserve a hidden archive of primordial lead.

“Pressure-stabilised sulfides may influence chemical evolution on other planetary bodies”

PbS₂ and PbS₃ behave differently. PbS₂ has a melting temperature near or above the temperature profile of the deep mantle, suggesting that it could also remain crystalline and stable. PbS₃, however, has a lower melting temperature and may exist in molten form under some deep mantle conditions. This distinction turns out to be potentially important.

Releasing ancient lead

One of the longstanding challenges of the lead isotope paradox is explaining not only where unradiogenic lead could be stored, but also how traces of it occasionally reappear in volcanic rocks derived from the mantle. Some ocean island basalts and mantle xenoliths contain unusually unradiogenic lead isotope signatures that seem to require interaction with ancient, isolated reservoirs. Our calculations suggest a possible mechanism.

PbS could act as a stable long-term store of lead deep within the mantle. Under sulfur-rich conditions, however, some PbS might react with additional sulfur to form PbS₃. Because PbS₃ melts more readily, it could become mobile and migrate upward through the mantle. As pressure decreases during ascent, PbS₃ eventually becomes unstable and decomposes, potentially releasing small amounts of ancient unradiogenic lead back into the convecting mantle. This provides a plausible route for episodic remobilisation of lead from deep hidden reservoirs into shallower mantle regions, from which the primordial lead could find its way to Earth's surface through volcanic activity.

Importantly, our work does not prove that this process definitely occurs inside Earth. Many factors remain uncertain, including the density of sulfide melts in mantle rocks and how the melts move through or between mineral grains. Whether sulfides form interconnected

networks or isolated pockets strongly affects their mobility. But our calculations do demonstrate that pressure-stabilised lead sulfides are thermodynamically viable under realistic mantle conditions. That alone significantly expands the range of possible deep-Earth lead reservoirs.

Beyond lead

To non-specialists, the idea of missing lead isotopes may sound obscure. Yet the implications reach far beyond one element. Differences in the ratios of an element's isotopes underpin much of our understanding of how planets evolve. They allow scientists to estimate the timing of core formation, reconstruct mantle convection and crustal recycling, and infer the chemical evolution of Earth over billions of years. If part of Earth's lead inventory has been hidden away in deep mantle sulfides since the earliest history of the planet, that changes how geochemists interpret isotopic records preserved in volcanic rocks.

More broadly, such work highlights how mineral physics and geochemistry increasingly intersect. For many years, deep Earth geochemistry was constrained largely by the minerals that could be synthesised experimentally at moderate pressures. Advances in computational methods now allow researchers to predict entirely new classes of materials stable only under extreme conditions. These hidden minerals may play major roles in controlling the distribution of volatile elements, in influencing the patterns of isotopes of an element that act as geological fingerprints, and affecting redox-sensitive species inside planets.

The implications extend beyond Earth. Sulfur-rich planetary interiors occur elsewhere in the Solar System, including within Mercury and some differentiated asteroids. Pressure-stabilised sulfides →

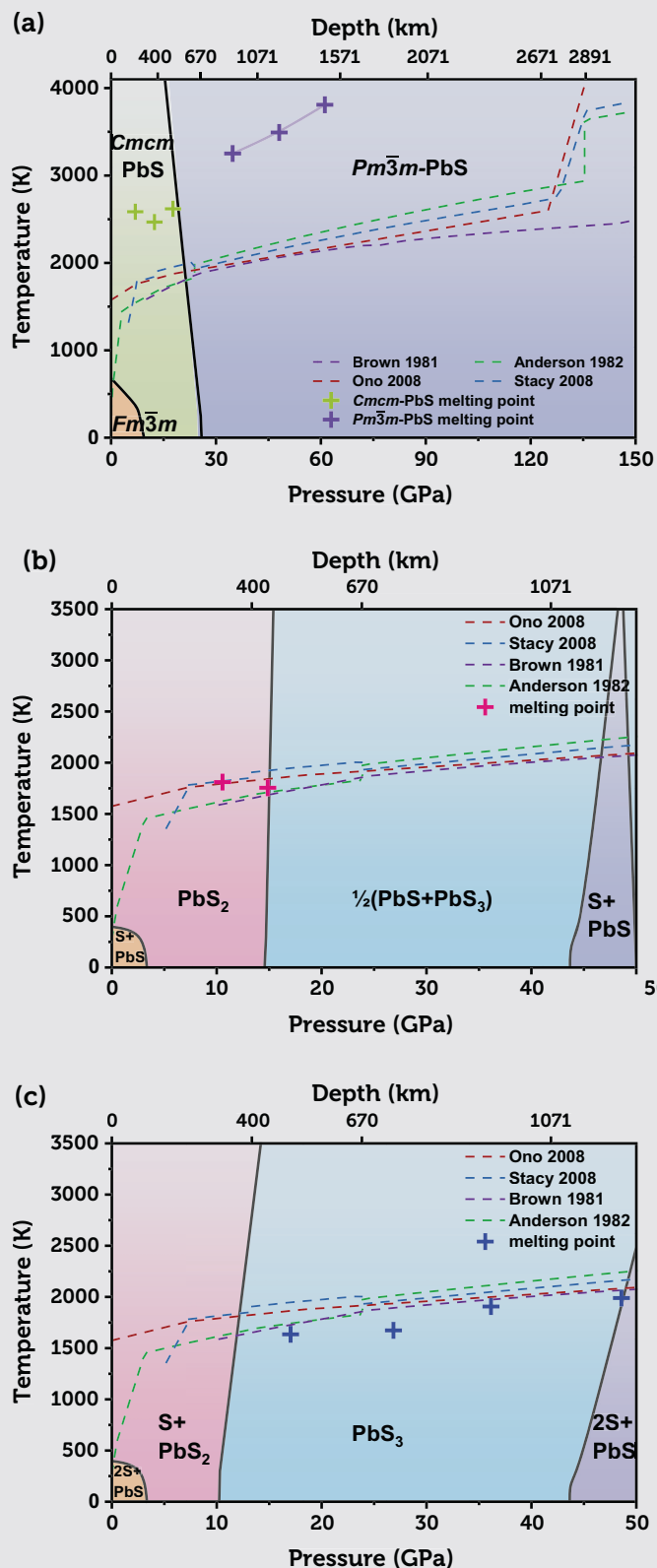


Figure 2 | Pressure-temperature phase diagram of Pb-S compounds. Phase diagrams of PbS (a), PbS₂ (b) and PbS₃ (c). Our simulations show that PbS has a melting point (+ symbols) well above the temperature profile of the deep mantle (dashed lines) and remains stable, in a solid crystalline form throughout the mantle (panel a, where purple and green indicate different crystalline configurations for PbS). PbS could therefore act as a long-term store of lead in the deep mantle. However, PbS₂ and PbS₃ behave differently. PbS₂ (pink, panel b) has a melting point near or above the temperature profile of the deep mantle, so could remain crystalline and stable. PbS₃ (blue, panel c) has a lower melting temperature and may exist in molten form under some deep mantle conditions. This provides a plausible route for the remobilisation of lead from deep, hidden reservoirs into the shallower mantle and surface via volcanism. Phase boundaries are indicated by grey solid lines. Dashed lines represent Earth's geotherm. Cmcm, Pm3m and Fm3m indicate different crystalline structures (space groups with different symmetry operations, lattice systems, atomic arrangement). (Figure modified from Liu et al. (2026) Nat. Commun. 17, 2913; doi.org/10.1038/s41467-026-69772-8, published under a CC BY-NC-ND 4.0 licence)

may therefore influence chemical evolution on other planetary bodies as well.

Deep Earth surprises

Earth's mantle occupies more than 80% of the planet's volume, yet much of its mineralogy remains uncertain. Over the past two decades, high-pressure mineral physics has repeatedly revealed that deep planetary interiors host materials unlike anything familiar at the surface. Minerals once thought exotic or impossible can become stable under compression. The discovery of pressure-stabilised lead polysulfides adds another example to that growing list.

Whether these exact phases exist abundantly in Earth's mantle remains to be tested experimentally. Future work combining high-pressure synthesis, synchrotron diffraction and isotope geochemistry will be needed to evaluate their abundance and behaviour more directly. Nevertheless, our calculations provide a physically plausible solution to one of geochemistry's oldest puzzles.

Far beneath our feet, hidden within Earth's deep mantle, ancient lead may have been quietly preserved for billions of years inside minerals that can exist only under enormous pressure. **G**

PROF SIMON REDFERN

Nanyang Technological University, Singapore

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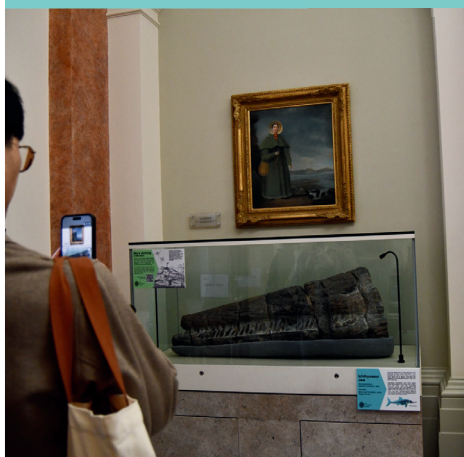
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FROM GROUND CONDITIONS TO SOCIAL OUTCOMES

TRACEY RADFORD DISCUSSES THE EXPANDING ROLE FOR ENGINEERING GEOLOGISTS AND THE NEED TO RETHINK THE PHILOSOPHY THAT UNDERPINS GROUND INVESTIGATIONS IN THE UK

ENGINEERING GEOLOGY HAS traditionally been framed around a simple and powerful premise: *if we understand the ground well enough, we can design safely*. That remains true, but it is no longer the complete picture.

Ground conditions affect more than structures; they shape how buildings perform for the people who rely on them. They affect how well buildings endure, how reliably they function, and how much confidence communities can place in them over time.

As engineering geologists, we know that the ground matters, and our profession has built a rich vocabulary for describing its behaviour and risks. What we have been less good at is explaining what those subsurface conditions mean in social terms. That matters because infrastructure policy is now concerned not just with what gets built, but with what it delivers: growth, homes, reliable services and resilience.

Our profession has an opportunity—and a responsibility—to show how understanding the ground can help society build better. It's time to rethink ground investigation.

Social infrastructure

Ground-related risks are usually described in technical or contractual language such as delay, redesign, claims, cost overrun—but their consequences extend much further. When infrastructure is delayed, so too are the benefits it is meant to bring: better connectivity, affordable energy, and access to schools, hospitals and care services.

Poorly understood ground conditions can stall projects and inflate costs, but they can also delay improvements in the services and places people depend on. Social infrastructure shapes so much of everyday life. When ground conditions are misunderstood or overlooked, the consequences are ultimately borne by →



When infrastructure is delayed, so too are the benefits it is meant to bring, such as access to schools, hospitals and care services. Construction work on the site of a new hospital in Whitechurch, a suburb of Cardiff, Wales, which is on track to open in spring 2027
© iStock

“Ground conditions affect more than structures; they shape how buildings perform for the people who rely on them”

the people who use those places: disrupted services, unsafe buildings, reduced trust in institutions and, in some cases, exclusion from opportunity altogether.

As professionals we do not always make that connection clearly enough. Part of that means giving social infrastructure—our housing, hospitals, schools, colleges, prisons and courts—which support our communities and public services the same attention as the infrastructure that supports our transport, energy, water, etc., and enables economic growth and productivity.

There has been a broader shift towards thinking about infrastructure in terms of lived experience: who can access it, how it functions in practice, and who benefits from it. For example, the National Infrastructure Commission's *Infrastructure Resilience Roundtable* (NIC, 2020) stressed the need to anticipate shocks and stresses and to plan for adaptation over time, making clear that resilience is a matter of public interest, not simply technical good practice. The report noted that *'in the last two years we have seen major floods, the worst loss of power and water for a decade, and many disruptions to rail and telecom service provision. Covid-19 has shown that significant high impact disruptions can and do happen.'* And geopolitical events since then have only strengthened the point, with renewed pressures on energy supply and defence resilience.

Public funding is under increasing pressure, and investment has to be directed where it will make the greatest long-term difference. Cost overruns and delays are not abstract failures. An overspent scheme can crowd out funding for others. A hospital delayed is care postponed. A prematurely deteriorating asset diverts resources away from frontline services. Seen in that light, ground investigation is not only a technical exercise; it is also a way of managing social risk.

Who bears the risk?

These issues are particularly acute when viewed through the lens of housing and social equity. The UK Government has pledged to build 1.5 million new homes



The UK Government has pledged to build 1.5 million new homes in England over the life of this parliament, which is likely to bring more geotechnically complex land into development. Decisions about where we build, what investigations are undertaken and how early uncertainty is addressed influence who is exposed to periodic hazards and who is protected from them © Getty

in England over the life of this parliament, at an average rate of around 300,000 a year, which includes seven new towns (GOV.UK, 2025a & 2025b). That scale of ambition is likely to bring more constrained and geotechnically complex land into development with subsurface conditions becoming a strategic issue rather than a technical detail. Decisions about where we build, what investigations are undertaken and how early uncertainty is addressed directly influence who is exposed to periodic hazards such as flooding, or to longer-term burdens such as subsidence, and who is protected from them.

“There has been a shift towards thinking about infrastructure in terms of lived experience”

Recent housing developments affected by slope instability or drainage failure illustrate the point starkly (e.g. Menteth, 2025a & 2025b). Residents can find themselves living in homes that are unsafe or unsellable, with responsibility fragmented between developers and local authorities. Pressure to build quickly can, if poorly managed, transfer ground risk to the communities least able to absorb it.

Flood risk tells a similar story. Around 6.3 million properties in England—roughly one in five properties today—are already in areas at risk of flooding from rivers, the sea and/or surface water. Many of those at-risk areas were designated long before modern climate projections, and the total could rise to around 8 million, or one in four properties, by 2050, once climate change is taken into account (GOV.UK, 2025c & 2025d). Consequently, UK investment in flood defences has risen to the order of £20–25 billion over the past 25 years, through successive national programmes since 2000, including more than £6 billion invested since 2010 and multi-year



capital programmes exceeding £5 billion in the 2020s (Burnett & Bolton, 2026).

Taken together, these examples point to the long-term social cost of underestimating ground and hydrological risk. The role of ground investigation in anticipating long-term change therefore becomes even more critical. When slopes fail and roads close, the consequence is not only disruption to transport networks; it can mean missed appointments, longer journeys to school or work, interrupted care and communities cut off from essential services. All of this strengthens the case for understanding groundwater behaviour, soil response and land stability over decades rather than only at the point of construction.

Learning from our own history

The history of engineering geology in the UK is one of continual adaptation (Fig. 1), with each phase of that evolution changing the questions we ask of ourselves and the ground.

Post-war reconstruction placed emphasis on data gathering and observational practice. Later decades brought repeated reminders of the consequences of insufficient or poorly scoped investigation, prompting the development of standards,

guidance and shared best practice.

Advances in digital data, GIS and improved ground modelling strengthened our ability to interpret and communicate subsurface conditions at scale. The continued evolution of UK ground investigation standards, including updates that align practice with international classification and Eurocode expectations, reflects that learning curve and the growing importance of consistency in reporting, interpretation and data capture.

More recently, the emphasis has shifted again, towards decision-led ground modelling, in which subsurface information becomes a risk-management tool.

Seen this way, the philosophy of ground investigation has evolved through a series of deeper questions. We have moved from asking how much data we have, to questioning its quality, then whether we are obtaining the right data for the decision in hand. The next step in that evolution may be the most important: is the information collected helping to shape better outcomes for society (see box 'Shaping better outcomes')?

This approach is supported by guidance from the International Association for Engineering Geology and the Environment (IAEG; Baynes & Parry, 2024) which invites us to see the ground model not simply as a technical artefact, but as a

foundation for better decisions from the outset of a project. At the planning stage, the conceptual model becomes a way of making uncertainty visible, shaping choices about where and how we build, and influencing the resilience, affordability and long-term outcomes that communities depend on.

Ground investigation as public value

The Government's *UK Infrastructure: A 10 Year Strategy* (GOV.UK, 2025) makes a clear link between infrastructure investment and wider public outcomes. That offers a helpful policy context for thinking about how decisions below ground influence what happens above it.

The strategy is clear about the outcomes it seeks, but less explicit about the practical conditions needed to secure them. At the same time, public spending and procurement guidance has placed greater emphasis on whole-life value and wider social, economic and environmental benefit, making it both easier and more necessary to describe ground investigation in those terms.

To do that, we need to talk about the value of ground investigation differently. Within the profession, phrases such as 'risk reduction' and 'programme certainty' are well understood, but they do not always resonate with those people who make →

Shaping better outcomes

What would we specify differently if ground investigation were judged not only by cost and project outcomes, but by the social risk it helps to prevent?

1. How would we define a good ground investigation if we judged it by the outcomes it helps secure, not simply the risks it helps avoid?
2. Who are we really trying to inform when we describe the ground—and who remains outside that conversation?
3. What case histories would we choose to publish and celebrate? And what does that say about what we value?
4. If the consequences of poor understanding are increasingly social as well as technical, what should we stop accepting as good enough?

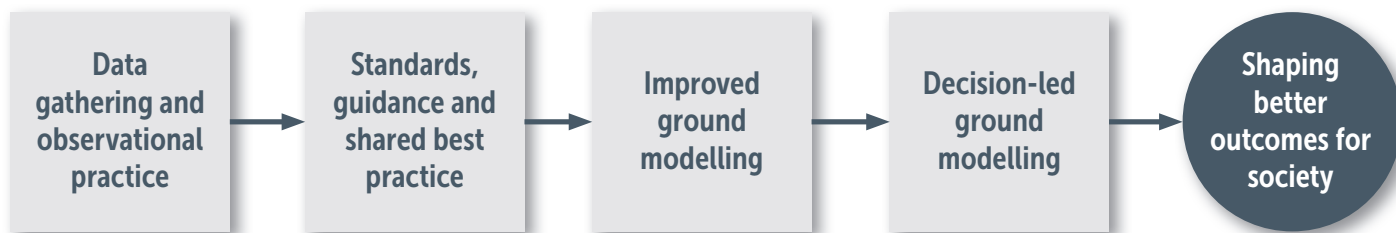


Figure 1 | The shifting emphasis of engineering geology. Since the mid-20th century, UK engineering geology has evolved from collecting and observing ground data towards decision-led modelling that supports risk management and consistency in practice. The next step is to ensure the information we collect also shapes better outcomes for society.

the decisions about funding. The case needs to be made in terms they recognise: fewer delays to housing delivery, lower whole-life costs for public assets, more reliable schools and hospitals, and greater confidence in regeneration programmes. A delayed scheme is not simply a matter for the project team; it can mean a school opening late, a ward remaining overcrowded, or a service continuing to operate from unsuitable accommodation. Framed in this way, ground investigation becomes part of how we secure productivity, social equity and better places, rather than simply a technical input.

Ground investigation is better understood as part of the public value of infrastructure rather than as a narrow preliminary cost. When it is proportionate, timely and well scoped, it reduces long-term risk and disruption and helps create safer, more adaptable and more trusted assets. Whereas a poor understanding of the ground can quietly undermine affordability, deliverability and service resilience over the life of an asset.

Data for growth

Although it has not yet progressed into legislation, the proposed Geotechnical Data Bill marks a shift in direction. By mandating the sharing of geotechnical data through the Government's National Underground Asset Register (NUAR), the Bill aims to address the long-standing problem of fragmented and inaccessible ground data. The intent to enable sharing of factual geotechnical data reflects a growing recognition that ground information is not just project data, but infrastructure in its own right.

Related policy direction already exists: *The Construction Playbook* (GOV.UK, 2020) sets expectations for how public works are assessed, procured and delivered. It also includes clauses and supporting material aimed at improving the sharing and reuse of subsurface/ground investigation data on public sector projects.

Greater openness in data sharing has the potential to reduce duplication, improve early-stage decision-making, and enable more equitable access to subsurface intelligence. More fundamentally, it challenges us to think differently about collaboration, moving from project-by-project ownership towards our industry taking collective stewardship of ground knowledge.

The NUAR provides an instructive analogue: a national approach to standardising and sharing underground asset information is intended to improve safety and efficiency and is associated with projected economic benefits from reduced disruption and better data access.

Case studies

For all the emphasis here on social infrastructure, the most readily available case studies and lessons learnt libraries—those essential repositories of real-world project outcomes, best practices, and operational insights—still come from more traditional forms of infrastructure. That imbalance is revealing. It suggests not that ground risk is less significant in healthcare, education, justice or housing, but that these projects are less often treated as sources of shared professional knowledge.

Part of the reason may be practical. Ground investigation for hospitals, schools, housing and justice facilities is often captured in project reports, planning portals and client archives rather than in peer-reviewed papers. By contrast, major civil schemes such as tunnels, dams and energy projects have generated a much more visible case-history literature. Yet social infrastructure has every bit as much to teach us: about consequence, performance, adaptation and the long-term relationship between the ground and the people who rely on what is built above it.

If we want ground risk in social infrastructure to be taken seriously, we also need to present the information



Engineering geologists are no longer only characterising strata or deriving parameters; we are increasingly informing planning decisions, shaping spatial development and contributing to resilience and equity © Getty

as knowledge worth sharing. Good case studies do more than document difficulty or failure. They explain context, uncertainty, decision-making and outcome in a way that allows others to learn. In that sense, publication is not simply a record of what happened on one scheme; it is part of how professional judgment is refined across the discipline.

The value of case studies applies equally to projects that went well and to those that did not. Well-chosen case histories of success can show what thoughtful investigation made possible, while honest accounts of difficulty or failure help the profession understand where judgment, scope or communication fell short. It's not about apportioning blame but understanding where we can do better, to take on the philosophy of "Standing on the shoulders of giants".

If the philosophy of ground investigation is continuing to evolve, then the case study has an important place within that evolution. It is one of the means by which experience becomes shared practice, and by which individual projects contribute to a wider understanding of public value.

“If we want ground risk in social infrastructure to be taken seriously, we also need to present the information as knowledge worth sharing”

An expanding role

All of this points to a wider professional role. Engineering geologists are no longer only characterising strata or deriving parameters; we are increasingly informing planning decisions, shaping spatial development and contributing to resilience and equity.

There is a risk, however, that if we do not engage at this level, social outcomes will be decided without ground insight. We may remain technically excellent yet confined to late-stage, low-influence roles, strategically irrelevant despite the importance of our knowledge.

Delivering better outcomes will require closer collaboration across disciplines than has traditionally been the case. Ground investigation must be integrated earlier with planning, environmental assessment, hydrology and asset operation, rather than treated as a discrete technical stage.

This is particularly important in social infrastructure, where the interaction between ground conditions, building performance and user experience is immediate and visible. Collaboration is not simply about efficiency; it is about ensuring that decisions made in isolation do not create unintended consequences for communities. Rethinking ground investigation is therefore not simply about how much data we collect, or even how good those data are. It is about asking a more fundamental question: *are we using our understanding of the ground to shape better outcomes for society?*

What if ground investigation were judged not primarily by its immediate cost, but by the social risk it helps to prevent?

If engineering geologists want to help shape the future of the built environment, we must explain the value of ground

data more clearly, collaborate earlier and place our expertise where decisions about funding, policy and place are made.

The question is no longer whether we understand the ground well enough to build safely, but whether we are using that understanding to help society build better. 

TRACEY RADFORD

Practice Director at AtkinsRéalis, UK

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UNEARTHED

Hutton's enduring influence on creativity

James Hutton's tercentenary has inspired exhibitions, concerts and artworks across Scotland. Steve Garrett reflects on how creative practice is sparking new ways of experiencing deep time

2026 MARKS 300 YEARS since the birth of James Hutton, often regarded as the founder of modern geology. Across Scotland, his tercentenary has inspired exhibitions, concerts, poetry, film and visual art that celebrate not only Hutton himself, but the enduring influence of his ideas.

These celebrations have formed part of the Scottish Geology Festival (scottishgeologytrust.org/festival), culminating in 'Hutton 300: The Concert' in June. Performed to a capacity audience in Greyfriars Kirk, Edinburgh—fittingly close to Hutton's grave—the concert brought together geology-inspired poetry, film and music to explore the intersection of deep time and geological processes on creative work, undoubtedly raising public awareness of Hutton's legacy.

Celebrating a pioneer

Why should we celebrate a pioneer of our discipline from hundreds of years ago? First and foremost, field observation was the foundation of Hutton's philosophical enquiry. His four-part *Theory of the Earth* (1795) evolved only after a lifetime of observing weather and soils on his farm and examining field relationships between rocks. Following Hutton's example,

observation remains the foundation of geology and is also a springboard for creative work.

Yet Hutton's legacy extends beyond careful observation. He used evidence to question powerful dogma, including prevailing ideas about the age of Earth and the formation of igneous rocks. This willingness to challenge assumptions remains an excellent example for geologists and artists alike, for whom curiosity and continual reappraisal are central to the creative process.

This openness to new ideas was also reflected in the company Hutton kept. As part of the close-knit community of scientists, engineers and philosophers of the Scottish Enlightenment, he routinely exchanged ideas. The cross-disciplinary nature of these personal connections provides a powerful model for the collaborations between geologists and artists that are flourishing today.

Perhaps this is why Hutton continues to resonate so strongly. A doctor, chemical engineer, farmer and natural philosopher, he was also an engaging companion who inspired great loyalty amongst his friends. This puts a relatable face to a radical thinker whose insights fundamentally altered humanity's perception of time,

'An end, a beginning.' Garron Point on the east coast of Scotland captured in pencil and yellow ochre, marking the point where the Highland Boundary Fault vanishes under the waves
© Calum Wallis

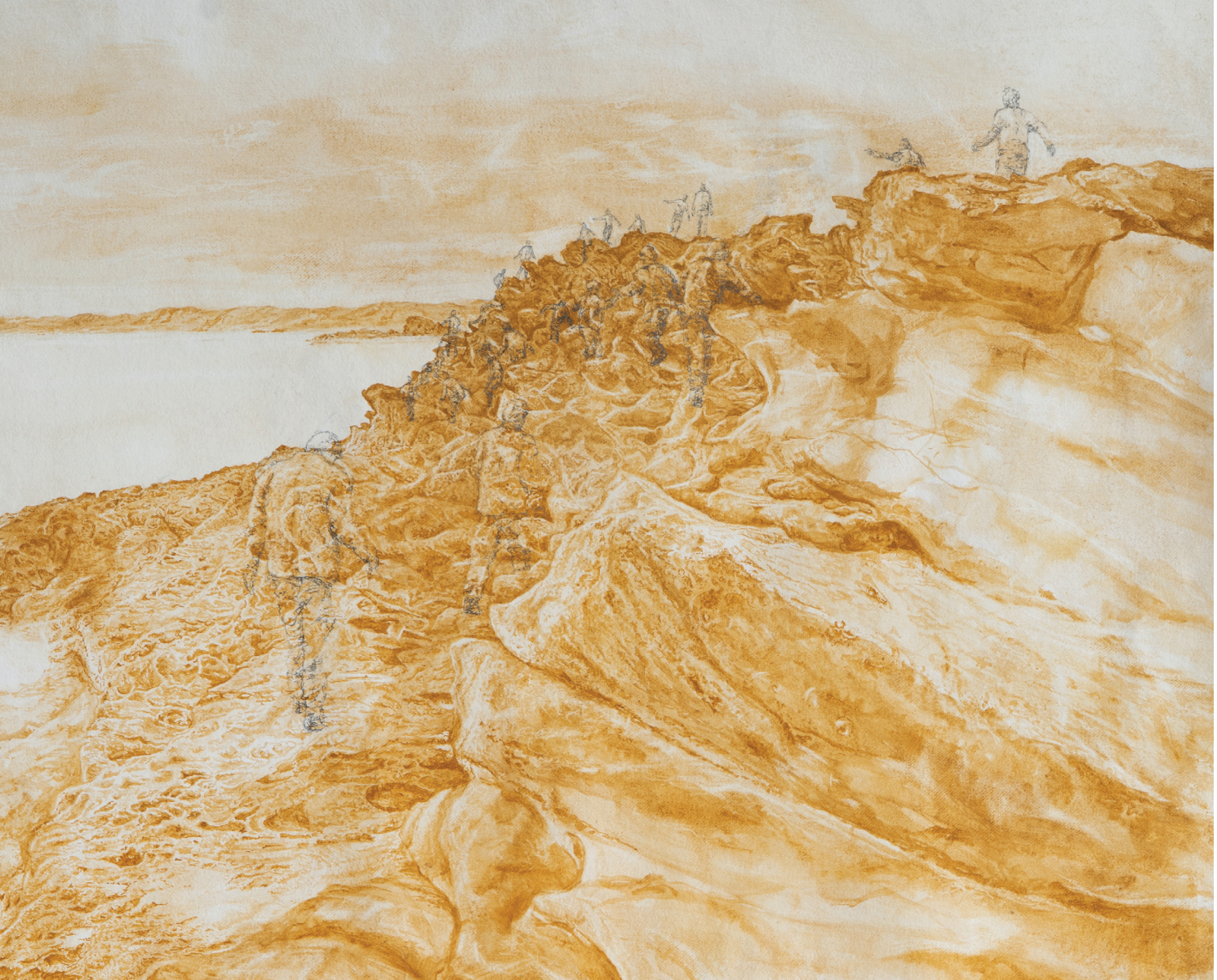


and whom many now see as deserving much wider global recognition.

Sharing perspectives

The vast extent of geological time that Hutton revealed can be difficult to grasp because it lies beyond ordinary human experience. Science provides evidence—strata, fossils, soil samples, data, climate records—but creative practice can translate that evidence into something felt emotionally, making the incomprehensible almost tangible.

Shared experience is often rooted in the field. The new Deep Time Trail at Siccar Point (james-hutton.org/deep-time-trail) invites visitors to stand before the famous unconformity that inspired Hutton's vision of "the abyss of time", with poetry, music and sound art linked to QR codes on way markers along the route.



Other artists have similarly retraced Hutton's footsteps, finding inspiration directly in the landscapes that shaped his thinking.

Geological ideas continue to resonate beyond science. Unconformities have inspired work in fabric, glass and writing, becoming metaphors for cultural loss and forgotten histories, while the slow movement of tectonic plates and the sudden rupture of earthquakes mirror the rhythms of personal life and the disruption of change. Even geological materials themselves—from ancient gneiss and sediments to synthetic Anthropocene debris—have become a shared creative language through which artists and geologists explore Earth's history.

Engaging generations

This year's Hutton-inspired exhibitions are reaching multiple generations,

particularly those events that are free or low-cost and located in city centres or other easily accessible venues. Younger audiences can be engaged very effectively, but often inconsistently if schools and parents do not take children to these events—a challenge exacerbated by geology's increasing absence from

“Geology reminds us of our insignificance within deep time and our power to alter the future trajectory of life on Earth”

Angela Palmer, artist

school and university curricula.

Creative events can bridge this gap because they allow science to be encountered physically rather than purely academically. Hands-on workshops create a direct connection with geological materials, while exhibitions encourage visitors to engage with rocks, landscapes and deep time in ways that are both intellectual and emotional.

Senior 'lifelong learners' are often among the most engaged audiences, with the time, capacity and resources to participate fully. Hutton himself was a role model for lifelong curiosity: he was 62 years old when he first visited Siccar Point and crystallised a lifetime of observing weather, soils, erosion and geology into one of the most influential insights in Earth science. →



'The Unconformities',
as identified by Hutton
at Jedburgh, Castle
Street and Salisbury
Crag in Edinburgh
depicted in Earth-
pigment dyed cotton
organza and silk
organza
© Louise Bennetts

“How extraordinary that Hutton stood in front of these familiar rocks, yet drew such extraordinary conclusions”

Louise Bennetts, artist

Reframing concerns

Hutton saw Earth as continually changing. Today, however, we are acutely aware of the unprecedented pace of human-induced environmental change. Against this backdrop, artists and creators can address pressing questions about climate change and biodiversity loss, responding to what has become known as solastalgia—the emotional distress caused by environmental change.

Creative work can help by building

a more emotional and reciprocal connection to Earth, revealing its beauty, complexity and deep time through materials. Local environmental action can also include artists reframing and reusing materials that might otherwise be under-appreciated or considered waste, encouraging audiences to see value in what is often overlooked.

In doing so, Hutton's concept of deep time can encourage greater humility and care for Earth, alongside a recognition that human wellbeing is inextricably linked to sustained biodiversity. From audience reactions at the many events this year, it is clear that creative work can restore a sense of curiosity and wonder. Viewers become aware that the rocks beneath our feet are not an inert backdrop, but an archive of planetary memory extending far beyond human history. Geological creativity can also slow people down, encouraging contemplation and holding people in an encounter with Earth long enough for perceptions to shift—something increasingly rare in a culture that values immediacy.

Three hundred years after Hutton reshaped our understanding of Earth, artists, musicians, poets and geologists continue to reinterpret his ideas for new audiences. The celebrations of this landmark year suggest that geology is not only a science of understanding the planet, but also a source of creative inspiration, curiosity and hope. If Hutton's legacy has been renewed in 2026, perhaps it will continue inspiring fresh ways of seeing Earth long into the future. 

Acknowledgements

I am very grateful for the thoughtful perspectives from geologists (Lucy Williams, Angus Miller), poets (Jack Cooper), musicians (Michael Begg, Karine Polwart), artists (Calum Wallis, Louise Bennetts, Angela Palmer, Becky Little), and those who, like myself, work in both geological and creative worlds (Patrick Corbett, Ruth Siddall, Phoebe Sleath). I encourage the reader to explore their work further for greater insight and inspiration.

STEVE GARRETT

Earth scientist and musician, UK



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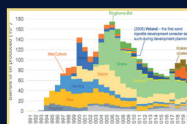
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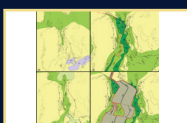
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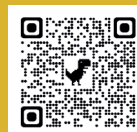
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Contours and curves

Maria Holloway-Strong maps a non-linear geoscience career

USED TO THINK careers were like well-drawn maps—clear contours, obvious routes, the occasional topographical ‘high’. I know quite a few people for whom their career has followed that linear path.

Mine did not.

Looking back, my career resembles a poorly drawn map: no north arrow, scale bar or legend. There were sudden elevation changes and a peat bog that I didn’t recognise until too late. Yet every aspect taught me something, and every detour brought me closer to the kind of geologist I am now.

Just remember: life is full of possibilities. Challenges are part of the journey. The most important thing is to keep going.

The map I thought I had

At school, my map was simple: work hard, study medicine and become a forensic pathologist. Route mapped. Then geology happened. In Year 12, I took geology O-level and fell in love.

Route change #1

I wasn’t studying the correct A-levels required to enrol on a BSc in Exploration and Mining Geology—specifically, maths—

but I applied anyway and was accepted at university.

The transition was tough. The learning curve contours were very closely spaced—a lot of maths. I failed my mid-year maths exam, getting just 8%. I worked hard, passed my maths exam at the end of the year, and learned a valuable lesson about resilience.

Going from an all-girls’ school to being the only female on my course meant I quickly learned what it felt like to be female in a male environment. I was expected to take notes rather than take part in labs because my “handwriting was neat”. I couldn’t get safety boots that

“My career resembles a poorly drawn map: no north arrow, scale bar or legend. There were sudden elevation changes and a peat bog that I didn’t recognise until too late”

“My non-linear career has not been a weakness; it is a great asset,” says Maria
© iStock

fitted. I had to wear white abattoir boots underground because they were the only ones small enough. I was smuggled into mines because women were considered bad luck underground. On one field trip, I was expected to cook Christmas dinner for over 30 students and staff because I was the only woman and “must know how”. These experiences made me more determined to succeed.

Route change #2

At the start of my final year, illness forced an unexpected turn. I had to defer for a year. It was my first topographic low.

During my recovery, I applied for work experience and was offered a role with WS Atkins. I spent five months supervising ground investigations at the former East Greenwich Gasworks, now the site of the O2 Arena. I discovered that Tertiary and Quaternary deposits were interesting after all!

What initially felt like catastrophe turned into opportunity. I was offered a graduate role, returned to university with renewed energy, and graduated top of my class (it must have been all those notes I took!)—outperforming all my male peers. A topographic high.

After one year, I won a scholarship to study an MSc in Engineering Geology at Imperial College London, graduating with distinction, and returned to WS Atkins to work on major projects in the UK and overseas. My career was back on the map.

Route change #3

I loved my work, but it would be disingenuous not to acknowledge the sexism I experienced, particularly on site.

One project involved supervising a ground investigation. The site agent was clear he disliked working with women. He was obstructive, confrontational and undermining. I was young, alone and felt isolated.

I kept a detailed site diary. When those diaries were later reviewed by the client, the site agent’s behaviour was deemed unacceptable. He was barred from working on that client’s projects. It was a painful experience, but also formative. I learned

“What initially felt like catastrophe turned into opportunity”

the importance of maintaining a detailed site diary and I grew in personal resilience.

After several years at WS Atkins, I moved to a university to work as a research officer while studying part time for a PhD on chalk rock mass behaviour. It was another challenging period. There were moments when I felt like quitting. But I completed my doctorate and gained far more than technical expertise: discipline, analytical rigour, critical thinking, and—unexpectedly—excellent time-management skills.

The experiences on site and in academia made me determined to work for equity within the workplace. It was important to change the narrative from victim to activist, and to improve experiences for others.

During this time, I served on the committee for the Engineering Group of the Geological Society (EGGS). It helped me to keep going. I met kind, passionate colleagues who were supportive. It helped me stay connected to the good aspects of our industry and orientated on my career map.

Then life intervened again.

Route change #4

After having my first child in 2001, I wanted to return to work part time and have access to facilities to express breastmilk. My employer was not supportive. I felt I had to resign. Two more children followed, with health challenges that made returning to work unrealistic.

Motherhood is the most rewarding role I have ever had—and the hardest. I went from competence and confidence to navigating a world where I often felt lost, without a map. These years are described as a “career break”. I reject that term. This was a different career direction, one that developed skills in crisis management, stamina, multi-tasking, empathy, prioritisation and resilience.

During this time away from





"My role blends technical expertise, people management and supporting others in the industry," Maria explains
© Maria Holloway-Strong

engineering geology, I lived overseas as a "trailing spouse". My experience with attempting to combine breastfeeding with working led me to want to support breastfeeding women. I qualified as a breastfeeding counsellor and volunteered on a 24-hour helpline, ran education programmes, assessed workplaces for breastfeeding facilities and edited publications.

Route change #5

In 2016, my 24-year marriage ended. I returned to the UK with my three children, facing homelessness, unemployment, and profound uncertainty. Any map I thought I had was gone. This wasn't a career detour; it was a seismic rupture. This was my peat bog and definitely the biggest topographic low. But it brought clarity about what was really important—my children.

We started again from scratch. I found administrative work, a home, and schools for my children. Together, we drew a new map. Then, in 2018, I saw a job advertisement for Atkins. Despite a 17-year gap in engineering geology practice, I applied—and was offered the role.

Route change #6

Returning was hard. I rejoined at a junior grade among colleagues much younger than me. Technology had moved faster than geology, and I felt de-skilled. But my confidence grew, and my colleagues were patient and kind.

My career has gone from strength to strength. I've been promoted multiple times, built and led teams, and become a Chartered Geologist (CGeol) to add to my Chartered Engineer (CEng) status. I am a CEng assessor for the Institute of Materials, Minerals and Mining (IOM3), Chair of the Ground Engineering Advisory Panel for the Construction Industry Research and Information Association (CIRIA), sit on two committees of IOM3 and am a Steering Group Member for the CIRIA Guide *Engineering in Chalk*. I also have an MSc-level qualification as an expert witness. I am active within AtkinsRéalis in the equality, diversity and inclusion (ED&I) space.

In 2021, I won the Atkins Ground Engineering and Tunnelling ED&I award. In 2025, I won the WISE (Women into Science and Engineering) STEM Returner Award.

“Careers, like landscapes, are shaped over time”

In 2026, I was recognised as one of the Top 20 women in ground engineering by *Ground Engineering* magazine.

My role blends technical expertise, people management and supporting others in the industry. Varied experiences, including a PhD, motherhood, and working as a trained counsellor, have strengthened my analytical thinking, time management and interpersonal skills. Professional and personal experiences have motivated my work in ED&I. My non-linear career has shaped me to be a well-rounded, competent engineering geologist with good people skills.

Revisiting the map

My non-linear career has not been a weakness; it is a great asset. Detours expanded my skillset in ways a straight path never could.

Success isn't just about titles or timelines. It's about meaning, contribution, and staying connected to your values—even when the map looks messy.

Careers, like landscapes, are shaped over time. It is OK to not have your career perfectly mapped, to have a career map and not stick to the route, and to draw a new map as your life changes.

Sometimes, the most interesting destinations are the ones you never planned to visit. **G**



DR MARIA HOLLOWAY-STRONG
Principal Engineering Geologist at AtkinsRéalis, UK

This article is published in partnership with the *Quarterly Journal of Engineering Geology and Hydrogeology* and a thematic collection on the 'Fookes Meeting for Engineering Geology'. Access the full collection at lyellcollection.org/topic/collections/FMEG



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IN BRIEF

RECENT DISCOVERIES HIGHLIGHTED



Ocean-related climate damages are often absent from standard economic models
© Alamy

Ocean cost of carbon

THE ECONOMIC TOLL of climate change has been substantially underestimated, according to new research, because a critical component has been overlooked: the ocean. The social cost of carbon (SCC)—an estimate of the economic damage caused by emitting one additional tonne of carbon dioxide into the atmosphere in a given year—is widely used to inform climate policy and carbon pricing. Most estimates have focused on impacts on land and those that can be easily measured in economic terms; by contrast, ocean-related damages spanning ecosystems,

infrastructure and human health have remained largely absent from standard models.

Bernardo Bastien-Olvera, from the Scripps Institution of Oceanography, USA, and colleagues combined recent ocean science with economic analysis to estimate what they call an ocean-based or “blue” SCC. Their approach accounts for climate impacts on coral reefs, mangroves, fisheries and global ports, as well as wider losses to human wellbeing linked to declining marine ecosystems. By translating physical climate impacts into economic losses, the researchers capture both direct effects, such as reduced fisheries productivity or port disruptions, and wider societal impacts, including nutrition, health and biodiversity loss.

Under a high-emissions, business-as-

usual scenario, the ocean component alone adds an estimated US\$48 per tonne of CO₂ to the social cost of carbon, nearly doubling existing estimates. The authors calculate that including ocean damages raises the SCC from approximately US\$51 per tonne of CO₂ to roughly US\$97—a 91% increase.

A striking result is the prominence of fisheries-related health effects, which account for a large share of total ocean damages. In many low-income and island nations, fish provide essential protein and micronutrients; climate-driven declines in fish stocks can therefore translate into poorer health and increased mortality. Coral reefs also emerge as major contributors to projected losses, reflecting their vulnerability to warming and acidification and the high economic value of the services they provide, from tourism to coastal protection.

The researchers find that ocean-related damages are unevenly distributed, disproportionately affecting countries most reliant on marine resources. Lower-income countries and small island developing states, where marine ecosystems underpin food security, tourism and transport, face the greatest welfare losses of 20–30%.

Against the backdrop of 41.6 billion tonnes of global CO₂ emissions in 2024, the authors estimate that ocean-related damages amount to nearly US\$2 trillion in a single year, costs largely absent from current climate accounting. Looking ahead to 2100, the researchers project that market damages could reach US\$1.66 trillion annually, underscoring the growing economic risks of ocean change.

HANNAH BIRD

Details: *Nat. Clim. Chang.* **16**, 297–304 (2026); doi.org/10.1038/s41558-025-02533-5

Mapping mine water heat

A QUARTER OF ALL properties across Great Britain sit above an abandoned coalfield. The water in these flooded old coal mines could potentially be used to heat and cool local buildings. However, this low-carbon, geothermal heat source is currently underutilised, in part because it is difficult both to identify areas with the greatest potential for mine water heat and to clearly communicate that potential to policy makers and the local community.

Now Gareth Farr and colleagues at the Mining Remediation Authority, UK, report on a new approach for mapping and assessing opportunities for mine water heat recovery. Using existing data that record the depths to the mine workings and their water levels, as well as water temperature and flow, geological disturbances and the location of mine water treatment schemes, the team create a ranking system to identify promising areas. Those classified as 'Good', contain multiple overlapping flooded workings 30–300 metres below ground level (mBGL), with water shallower than 75 mBGL, and rising or recovered water levels. Other areas are ranked as 'Possible', 'Challenging', or 'No opportunity'; the latter includes locations with no recorded coal mines, only shallow workings (< 30 mBGL), dry or partially dry workings, or known mine gas.

Applying this geospatial mapping approach to Caerphilly County Borough in Wales—a region with an extensive coal mining history, with workings from the 1600s to 1991—the team show that ~25% of addresses are in areas with 'Good' opportunity for mine water heat, with a further ~32% in areas classified as 'Possible'. The researchers have created maps for several major cities across England, including Birmingham, Bristol, Leeds, Manchester and Newcastle, as well as all the coalfields in Wales.

The accuracy of the maps is limited by data availability, and the team is keen to stress that this approach does not remove the need for site-specific feasibility studies.

However, the maps serve as high-level screening tools, sufficient to aid local planning assessments and decisions on whether to trial a pilot scheme, for example. The approach will be developed to allow greater automation, thereby enabling the rapid and unified creation of insightful, easily digestible resources that help engage stakeholders and raise awareness of the great potential for mine water heat in plans for local heat networks.

AMY WHITCHURCH

Details: *Q. J. Eng. Geol. Hydrogeol.* **59**, qjggh2025-86 (2026); doi.org/10.1144/qjggh2025-086

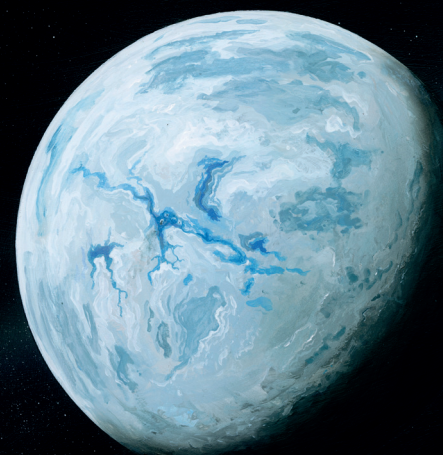
This article is part of the Q. J. Eng. Geol. Hydrogeol. Mine Water Energy collection available at: lyellcollection.org/topic/collections/mine-water-energy

Seafloor clues to Snowball Earth

THE CRYOGENIAN PERIOD (720–635 million years ago) witnessed two "Snowball Earth" glaciations—extreme global ice ages thought to represent the largest disruptions to Earth's carbon cycle in geological history. Yet, despite both events occurring under similarly frozen conditions, they differed dramatically in length: the Sturtian glaciation lasted approximately 56 million years, while the later Marinoan endured for just 4 million years. New research suggests the reason for this variation may lie beneath the oceans.

Trent Thomas, from the University of Washington, USA, and colleagues propose that differences in seafloor weathering (chemical reactions between seawater and oceanic crust that remove atmospheric carbon dioxide) can explain the contrasting durations. Previous hypotheses focused on differences in volcanic outgassing or dust and ice reflectivity, but the new model instead highlights the role of ocean chemistry and the structure of the seafloor itself.

Using carbon cycle modelling



Artistic depiction of Earth frozen over during the Huronian glaciation © Science Photo Library

constrained by geochronological and geochemical data, the researchers estimate that seafloor weathering during the Sturtian glaciation must have operated at rates 25–53 times higher than modern levels to keep atmospheric carbon dioxide low enough to sustain global ice cover for tens of millions of years. However, the shorter Marinoan glaciation required weathering rates less than 15 times modern levels.

The team argues that the concentration of marine sulfates may have influenced the different weathering rates. During the Sturtian, sulfate levels were likely extremely low, limiting formation of anhydrite minerals from hydrothermal vents to form cements in the pores of oceanic crust, thus making this crust more porous and susceptible to weathering. Increased weathering would have removed more carbon dioxide, prolonging glaciation through a positive feedback loop. Sulfate concentrations later rebounded during the Marinoan, suppressing weathering and allowing deglaciation to occur more rapidly.

As such, the findings suggest that seafloor weathering and changing ocean redox chemistry played a far more important role in regulating Earth's ancient climate stability than previously recognised.

HANNAH BIRD

Details: *Geology* **54** (2), 158–162 (2026); doi.org/10.1130/G53722.1



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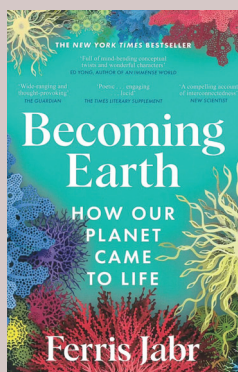
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BECOMING EARTH: HOW OUR PLANET CAME TO LIFE

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BY: Ferris Jabr (2024) Picador, 304 pp.
ISBN: 9780593133996
PRICE: £12.99

REVIEW BY MELANIE BREHAUT



If you are looking for a warm, joyful, thought-provoking and beautifully written book on how life on Earth came into being, you are in the right place.

The first indication that this is not your standard 'popular science' book is the dedication; rather than dedicating the book to a loved one or mentor, Ferris Jabr chooses the elements, dinosaurs and other fantastic life forms, and "the growers, builders, thinkers and teachers". His style of writing—eloquent, evocative, almost poetic—is immediately evident in the introduction, which highlights Jabr's childlike wonder about our planet and the deeply personal nature of the book.

Becoming Earth is split into three sections: rock, water, and air. For each, Jabr describes his global travels and the people he spoke to along the way, all with one overarching goal: saving Earth. From a deep mine pit in South Dakota, to hunting plankton off the coast of Rhode Island, to delving into geothermal

energy in the cold climes of Iceland, Jabr chats to a seemingly endless line of researchers who are chipping away at climate issues in today's world.

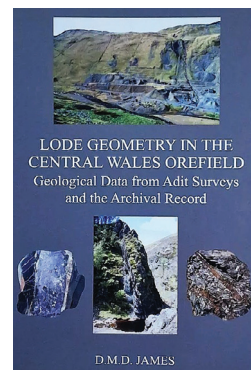
Palaeontology, human occupation and use, and the effect that has had on the planet, are covered in depth within each chapter, as well as a discussion of what we can do to mitigate these negative effects. The text is absolutely packed full of interesting (if often quite dispiriting) facts, as well as making the enthusiasm of both the writer and his interview subjects abundantly clear.

For full disclosure, this feels like the ideal time to mention the underlying theory that Jabr ascribes to. Developed by James Lovelock and Lynn Margulis in the 1970s, the Gaia hypothesis proposes that living organisms interact with Earth to create a self-regulating system. It has been controversial from the beginning, with many scientists disagreeing vociferously with the idea (even Jabr admits "Gaia is closer to a conceptual framework than a strict hypothesis"). Nevertheless, he has chosen to use this framework to build his book upon, and it can be a little jarring.

That aside, *Becoming Earth* is a fascinating book that will hold your interest right until the end. The ethereally beautiful way Jabr tells inspirational stories of new research being conducted just about outweighs the often quite heart-rending facts about the current state of our planet and what humans are doing to it.

LODE GEOMETRY IN THE CENTRAL WALES OREFIELD: GEOLOGICAL DATA FROM ADIT SURVEYS AND THE ARCHIVAL RECORD

BY: David James (2024) Self-published, 340 pp.
ISBN: 9781399975407
PRICE: £30



REVIEW BY ROB BOWELL

This is an extremely important archive of mining and geological history across the Central Wales Orefield (also referred to as the

Central Wales Mining District or the Mid Wales Mining District), covering the main extraction area of Aberystwyth towards Llanidloes.

The main lodes host zinc, silver, copper and baryte ores associated with ENE-WSW-oriented fault lines and connected to a phase of the Acadian Orogeny that affects Silurian and Ordovician rocks in the area.

Ore mining is believed to have started in Wales with the Romans, continuing through to the mid-1900s when the largest, Cwmystwyth, finally closed. As is so often the case, records of the geology and underground mine workings have potential to be lost as records held by mining companies and local councils are misplaced or destroyed with the passage of time. It is against this challenge that David James has meticulously assembled information from the surviving archives, coupled with his own underground fieldwork. As a retired Chartered geologist, he has used his time to examine the structural sedimentology and nature of mineralised lodes in the Central Wales Orefield to produce an →

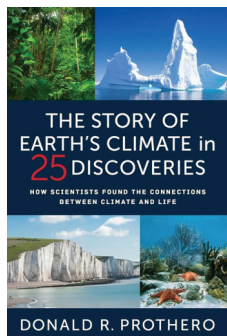
extraordinarily detailed record of the veins, geology and mines there.

This is not an easy book to read cover to cover and so it will likely attract readers looking for information on specific mines in the future. What they will find is a comprehensive description of underground workings, structural geology and stratigraphy, as well as notes on the nature of breccias found in the workings.

As mines become inaccessible and our only connection is via specimens within collections, this book bridges that gap and provides geological context to what would otherwise be museum artefacts. Anyone interested in the Central Wales Orefield or the metallogeny of the Caledonides or the United Kingdom should refer to this volume and hopefully some will be inspired to record similar information for other areas of British mining.

THE STORY OF EARTH'S CLIMATE IN 25 DISCOVERIES: HOW SCIENTISTS FOUND THE CONNECTIONS BETWEEN CLIMATE AND LIFE

BY: Donald R. Prothero (2024) Columbia University Press, 480 pp.
ISBN: 9780231222617
PRICE: £25



**REVIEW BY
GEORGIA**

MELODIE HOLE

From an iceless greenhouse to a glacier-carved 'snowball', Earth has cycled through extremes that have repeatedly

reshaped the planet and its inhabitants. Donald Prothero takes readers on a sweeping 4.5-billion-year journey that reveals the intimate ties between climate and life, and illustrates how geology,

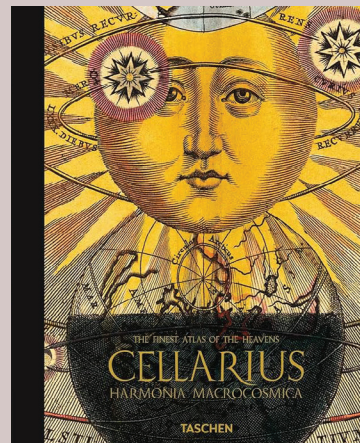
palaeontology, meteorology, and oceanography combine to illuminate the great 'Earth system'.

Prothero also shows us not only what we know but how we know it, through a clear overview of the diverse scientific methods used to reconstruct the past. Fossils reveal lost biomes, sediment records capture cyclical patterns of tectonics and life, dropstones and erratics testify to long-vanished glaciers, and ice cores and tree rings preserve annual, even seasonal, snapshots of past climates. This evidence spans temporal and spatial scales; from chemical processes by microscopic organisms to planetary shifts, such as atmospheric oxygenation and the slow burial of carbon dioxide at ocean floors.

The Story of Earth's Climate also highlights human tales, including palaeontologist Mary Dawson's work revealing that the High Arctic once hosted tropical animals and evidences migration routes to support the theory of plate tectonics. Often the only woman in her classes or navigating field parties that excluded women, Dawson was a pioneer who went on to become Chair of Earth Sciences at the Carnegie Museum of Natural History, USA, and received the highest honours in palaeontology. Through such vignettes, Prothero highlights the cultural contexts of scientific paradigm shifts, and how discoveries often face long journeys through doubt and resistance before becoming accepted fact.

The role of serendipity in discovery is also celebrated, such as the notable example of the Messinian salinity crisis where construction of the Aswan Dam revealed immense buried canyons along the Nile, mirrored by similar findings on the Rhône, and confirmed that the Mediterranean Sea had once stood three kilometres lower.

Finally, Prothero traces how the climate has shaped human history: the early Holocene climate optimum enabled agriculture and



HARMONIA MACROCOSMICA: THE FINEST ATLAS OF THE HEAVENS

BY: Robert van Gent (2025) Taschen, 248 pp.
ISBN: 9783754404935
PRICE: £125

REVIEW BY HANNAH BIRD

Cellarius Atlas, as it is more succinctly known, makes an immediate statement by its sheer size, as if it is a monument to celestial cartography. Housed in a decorative slipcase that echoes its gold-foiled cover, the book has all the ceremony of a collector's piece. Upon opening, a curated gallery of 17th-century engravings are reproduced with a level of clarity and scale that allows every flourish of linework to shine.

The opening chapter's text by astronomy historian Robert van Gent can be dense at times, packing a substantial amount of historical and scientific context into a small space. The narrative traces the long arc of humanity's attempts to understand the heavens: from ancient cultural reverence for constellations, through early scientific attempts at stellar cataloguing, to the development of celestial mechanics to calculate the positions of cosmic objects and the transformational impact of telescopes and, later, astrophotography. It also sets

the stage for Andreas Cellarius' *Harmonia Macrocosmica* of 1660, the work faithfully reproduced and expanded upon here.

The 29 illustrative plates are the heart of the volume, with most elaborately depicting the Ptolemaic geocentric worldview, placing Earth at the centre of the Universe. There are dedicated plates for Nicolaus Copernicus (whose revolutionary worldview placed the Sun at the centre of the Universe) and Tycho Brahe (combining the two worldviews, where the Sun orbits Earth and the other planets the Sun). Some of the plates also show how knowledge of Earth's landmasses, oceans and climate zones evolved over time, alongside depictions of the Sun's daily path, Earth's changing seasons and the Moon's phases as they were understood in the 17th century. The final eight plates highlight constellations, beginning with Christianised interpretations before returning to the mythic figures familiar today.

What makes these plates so captivating is the fusion of science with classical artistry. Roman and Greek mythological figures swirl across the skies; astrology, alchemy, theology and astronomy intertwine; and historical instruments for celestial observation, like cross-staffs and dividers, appear as reminders of the labour involved in mapping the night sky.

The volume concludes with a concise glossary of key terms, a useful catalogue of the constellations referenced throughout, and a short biography of Cellarius that situates his work within the wider history of astronomy.

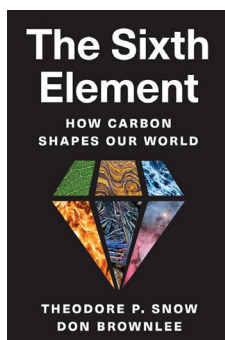
The production itself is exceptional, with thick pages, immaculate imagery and colours so vibrant they seem newly painted. While not a contemporary reference guide to the cosmos, the book offers something arguably more valuable: a vivid reminder that scientific ideas evolve not only through data but through culture, imagination and artistry. *Cellarius Atlas* invites the reader to reflect on how future generations might one day look back on our own models of the Universe with wonder.

early civilisation, the Medieval Warm Period aided Viking expansion, while the Little Ice Age may have inspired literary classics such as *Frankenstein*. The concluding chapter brings us to the present, warning of the scale and inevitability of the impacts of anthropogenic climate warming. By tracing how past climates have transformed, aided, and extinguished life, this book underscores the reality of today's unprecedented rate of change.

Prothero's writing treads a line between the autobiographical approach that much of modern popular science writing takes, and a purer focus on the concepts and chronicling of geological time. This results in a book with heft, but with the breadth and depth to resonate across the geoscience spectrum. The rich seam of scientific discovery throughout had me regaling friends with fascinating snippets long after I closed its pages.

THE SIXTH ELEMENT: HOW CARBON SHAPES OUR WORLD

BY: Theodore P. Snow and
Don Brownlee (2024) Princeton
University Press, 264 pp.
ISBN: 9780691125886
PRICE: £22



REVIEW BY R.
ARUN PRASATH
AND PRUTHUL
PATEL

Carbon may not belong to the ancient circle of five elements (earth, water, fire, air, and metal) created

from the ashes of the Big Bang, yet it plays a vital role in most things. We usually talk very little about carbon and its undeniable influence—from the smallest components of DNA to

the immensity of the Universe—but it stands as a cornerstone of existence. It is present in almost every part of our lives, visibly apparent in all living forms and in the materials that shape our world, from everyday items we use (such as cars, mobile phones, plastics and cement) to scientific advances like historical age-dating. As such, our first impression of the book is that it makes carbon seem like one of the most vital and fascinating elements in the field of chemistry. Coincidentally, its consideration here as the 'sixth element' matches its position in the periodic table because its atomic number is six (six protons in its heart and six electrons dancing around it).

The book is neatly structured, beginning with a brief introduction to carbon's origin, discovery and importance, explaining the complex chemistry in a clear and elegant way. The authors' playful take on scientific facts and explanations makes the reading experience both fun and enlightening, with sections on Sociable Carbon, Black Holes as Cosmic Vacuum Cleaners, Earth Residing in the Solar System's Prime Real-Estate District, and Mars' Location in our Astronomical Backyard. Snow and Brownlee conclude with an epilogue on the evolutionary history of research into carbon, which, for many readers, may also serve as a prologue or an extended abstract of the book. Here, they touch upon the struggles of scientists, particularly women, in academia during the early days of carbon research, which is crucial for understanding the human side of discovery.

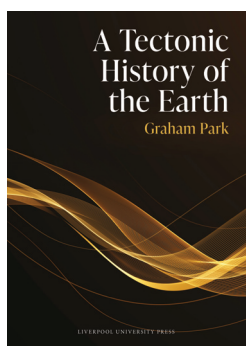
The contents are well complemented by photographs, graphs, tables and diagrams placed thoughtfully throughout. Meanwhile, notes at the end of each chapter provide definitions of key terms, supplementary information and references for further reading. Collectively, *The Sixth Element* will be enjoyable for both scientists and



anyone with the slightest interest in scientific history or curiosity to learn new things.

A TECTONIC HISTORY OF THE EARTH

BY: Graham Park (2025) Liverpool University Press, 332 pp.
ISBN: 9781780461144
PRICE: £31.99



**REVIEW BY
GAURAV KUMAR**

A Tectonic History of the Earth achieves something deceptively difficult: it presents 4.5 billion years of planetary

evolution as a coherent, process-driven narrative rather than a catalogue of events. The book's central strength lies in its consistent emphasis on causality (how early accretionary heat, mantle convection patterns, and lithospheric behaviour established boundary conditions that shaped all subsequent tectonic episodes). This thematic continuity, sustained across chapters spanning the Hadean to Cenozoic, allows readers to grasp Earth's history as an interconnected system rather than discrete eras.

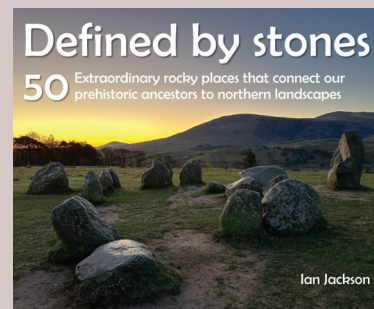
Graham Park's treatment of contested terrain is particularly noteworthy. Rather than presenting uniform certainty, he carefully delineates where evidence is robust, such as Phanerozoic plate reconstructions supported by palaeomagnetic data and ocean-floor stratigraphy, versus where models remain provisional, as with Archean tectonic styles or Proterozoic supercontinent geometries. This is subtly woven into the text without disrupting readability and teaches students how geologists construct

understanding from incomplete records. The book excels in showing how modern evidence (like seismic imaging, isotopic dating and structural analysis) constrain interpretations while acknowledging persistent ambiguities in deep-time reconstruction.

The author's handling of supercontinent cycles exemplifies the book's pedagogical sophistication. Park doesn't merely describe Nuna, Rodinia, and Pangea assemblages; he explains the geodynamic drivers (ridge-push versus slab-pull mechanisms, plume-induced rifting, collisional orogenesis) and traces their consequences through linked crustal growth, atmospheric oxygenation events, and biological radiations. This integrated approach, connecting tectonic, geochemical, and environmental change, reflects contemporary Earth system science perspectives.

Structurally, the progression from planetary formation through Precambrian craton stabilisation to Phanerozoic orogenic belts is logical, with each chapter building naturally on previous concepts. The Paleoproterozoic and Mesoproterozoic chapters effectively synthesise complex terrane histories (such as Australian, Indian, and Laurentian assemblages) using palaeomagnetic constraints and geochronology without overwhelming readers. Park's selective use of case studies (Barberton Greenstone Belt, Trans-Hudson Orogen, Caledonian-Appalachian correlation) illustrate principles without descending into exhaustive regional description.

However, the book's ambition creates occasional density variations. Some Paleozoic chapters, particularly on the Variscan and Central Asian belts, compress substantial tectonic complexity into limited space, which may challenge less-prepared readers despite clear prose. The balance between accessibility and rigour tilts appropriately towards undergraduate comprehension,



DEFINED BY STONES: 50 EXTRAORDINARY ROCKY PLACES THAT CONNECT OUR PREHISTORIC ANCESTORS TO NORTHERN LANDSCAPES

BY: Ian Jackson (2025) Northern Heritage Services Limited, 114 pp.
ISBN: 9781739486181
PRICE: £12

REVIEW BY COLIN WATERS

Defined by Stones is a companion to four previous books by Ian Jackson on "extraordinary rocky places" in Northumberland, Cumbria, Durham and the Roman northern frontier. This latest book extends across much of the same geographical area but also has forays into North Yorkshire. The 50 sites, selected for their significance in illustrating diverse connections between the landscape and its early occupants, are placed into four main categories: freeze and thaw; shelter and defence; implements; and ritual. The first eight sites are entirely non-anthropogenic in origin, which may seem strange given the topic, but aim to set the scene of natural climatic and vegetational change encountered by earlier settlers to this region.

A great selling point are the

excellent colour photographs, with the A4 landscape format using high-quality paper conducive to showing them at their best. The majority of images have been taken by the author, along with some from drones and museum collections. Each site covers a couple of pages, with a short explanation of its significance along with smaller illustrations and topographic maps.

The jargon-free descriptions for each site are typically well-crafted and very much aimed at non-specialists. Trained geologists and archaeologists may argue that the introduction to geochronological and archaeological time and descriptions of the geological evolution of the region are overly simplistic, but they are designed to provide just enough information to the intended audience.

Jackson is quite open about ongoing uncertainties in interpretations and at times raises the request for greater cross-disciplinary studies. Links to other resources are limited to a page of QR codes to high-level organisations that provide useful information, but there is no guidance for those interested in a particular site. This may not matter to many readers, but would be frustrating to those wanting more detail.

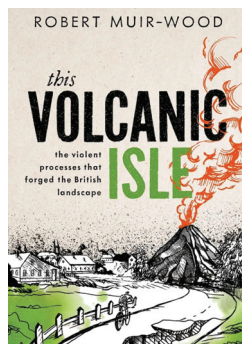
Many of the sites may be subtle, less famous than equivalents in southern Britain. However, the descriptions make clear that they are no less interesting. Despite aiming to encourage the general public to explore the landscape of northern England in greater depth, many geologists and archaeologists will still find value and inspiration through adding this book to their collections.

though postgraduate researchers will recognise depth in Park's treatment of subduction-accretion processes and orogenic mechanics.

Among recent tectonics texts, this volume occupies valuable pedagogical space: more historically comprehensive than Kent Condie's *Earth as an Evolving Planetary System* and more process-focused than regional syntheses. Its greatest virtue is demonstrating, through careful accumulation of evidence and argument, how geologists think about a planet that leaves only fragmentary records of its own transformation.

THIS VOLCANIC ISLE: THE VIOLENT PROCESSES THAT FORGED THE BRITISH LANDSCAPE

BY: Robert Muir-Wood (2024) Oxford University Press, 368 pp.
ISBN: 9780198871620
PRICE: £20



REVIEW BY
MIKE BOWMAN
This Volcanic Isle takes readers on a rich and detailed journey of Britain's Cenozoic history.

Throughout, Professor Robert Muir-Wood offers a deep and thorough analysis of the causes and outcomes of the diverse geological processes that have shaped Britain's landscape and scenery since the end of the Mesozoic.

The thoroughness of the discussion and level of detail is truly impressive. The book begins with the little-known

but important Sticklepath strike-slip fault in southern England, followed by discussion of the Hebridean Igneous Province as a failed constructive plate margin and the early history of the North Atlantic Ocean. Readers are then taken on a journey through the footprint of Alpine and Pyrenean tectonics after the collision of Africa with Europe, and finally the diversity of landscapes sculpted by ice sheets during the last Ice Age.

A bonus to the main story are the numerous off-track diversions into other aspects of global tectonic and geological processes that underpin the British Cenozoic transformation, including insights from the 'founding fathers' of geology, such as Charles Lyell. Figures are also simply presented and nicely complement the discussion; the absence of colour illustrations and photographs does not detract from the quality and context of the tale told.

It is difficult to simply pigeonhole where the book fits, but I do not think this is an issue. *This Volcanic Isle* is a geological journey written by an informed and knowledgeable enthusiast. As such, any geologist—whether a keen amateur or professional practitioner—will be fascinated by the story Muir-Wood weaves. Readers should take time to soak in and reflect on the book's rich content, especially the many non-intuitive links drawn and explanations proposed for how the landscapes and scenery of the British Isles may have developed and evolved since the end of the Cretaceous. It is a fascinating read and different from any geology-based book I have read before, helping us to understand the various dynamic processes that have shaped the British landscape we know so well today. **G**

MORE INFORMATION

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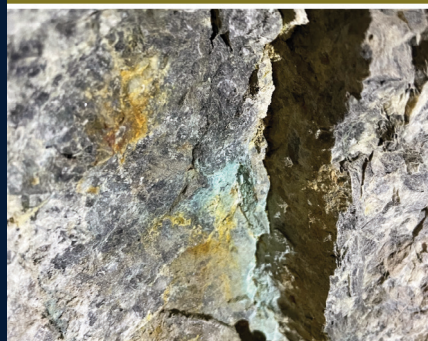
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Edited by
S.K. Mondal, L.C. Reisberg, J.M. González-Jiménez and H.S.R. Hughes



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Mineral Resources Related to Ultramafic–Mafic Magmas, from Archean to Present: Old Deposits and New Prospects of Chromite, Ti–V–Magnetite and Ni–Cu–(PGE) Sulfides

Edited by S.K. Mondal, L.C. Reisberg, J.M. González-Jiménez and H.S.R. Hughes

ISBN: 9781786206299

Publisher: The Geological Society

Hardback

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The energy transition required to address the climate crisis has substantially enhanced the need for new metal deposits. The Earth's evolutionary processes primarily control the formation and spatial distribution of metal resources. Orthomagmatic deposits of Ni, Cu, PGE (platinum-group elements), Cr, Ti and V are genetically linked to ultramafic–mafic magmatism. The growing demand for these resources has spurred prospecting and exploration of new regions. Much of the existing literature focuses on areas where mineralization has been investigated for economic reasons, which has facilitated access. These include the Bushveld Complex in South Africa and well-known deposits in Canada, Scandinavia, Australia, the USA and Russia. The mineralization–magmatism relationships of these well-studied occurrences are often assumed to provide a precise model for other areas. However, this may be an over-generalization, and each occurrence may instead have its own individual characteristics. This special volume, intended for both academic and exploration groups, comprises eleven chapters that explore the links between mineralization and magmatism in various settings.

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ANTHONY (TONY) HARRIS was born and schooled in Cardiff, and graduated in geology from Aberystwyth University in 1956, before conducting a PhD there on the southern Dalradian between Pitlochry and Blair Atholl. Throughout his studies, he excelled as a hockey goalkeeper up to international level.

In 1959, he married Noreen Jones and joined the British Geological Survey in Edinburgh, where he continued to map Dalradian rocks and parts of the Moine to the northwest. Eventually, he became Principal Geologist.

Influential geologist

Joining the University of Liverpool as a lecturer in 1971, Tony rose to Professor (1987), publishing many papers unravelling the structure and stratigraphy of Moine and Dalradian strata, contributing to them eventually being assigned supergroup status. He led an outstanding school of postgraduate field geologists and was the first to link the structures seen in these reworked metamorphic rocks of the orogenic hinterland to those in the Moine Thrust Zone. Through the International Geological Correlation Programme, he brought Caledonian-Appalachian geoscientists together, convening multiple groundbreaking conferences and associated publications. He edited and contributed to several seminal Caledonian books, including the *Revised Correlation of Precambrian Rocks in the British Isles* (Geological Society Special Report, 1994).

At Liverpool, he served as Head of Department (1983-94), overseeing the university's rapid growth and achievement of top ratings (leading him to become an advisor to other university Earth Science departments) and was twice Dean of the Faculty of Science (1994-2000).

Society contributions

In 1974, Tony appointed the first multi-editorial team for the *Journal of the Geological Society*, a major change that ensured consistent timely publication. As Chief Editor (1976-7) he helped the Society's journals achieve annual surplus for the first time, which persuaded Council to

“He unravelled the structure and stratigraphy of Moine and Dalradian strata, contributing to them eventually being assigned supergroup status”

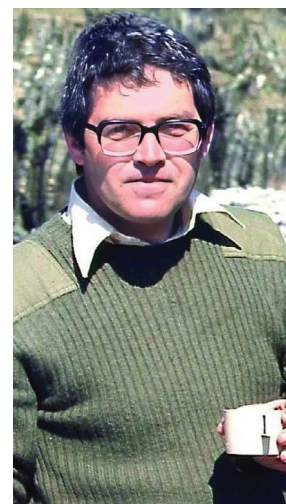
set up the Publishing House in 1987. He also served on Council, was elected Secretary (1979-81), received the Coke Medal (1984) and was elected President (1990-92). He was later one of the founding lights of *Geoscientist* magazine, serving as Editor (2001-2006) and Editor-in-Chief (2007-2012).

Awards and later years

Tony's Fellowship of the Royal Society of Edinburgh (1988) recognised his many contributions to Scottish geology, as did receipt of the Edinburgh Geological Society's Clough Medal (1989) and Liverpool Geological Society's Silver Medal (2003). Fiercely proud of his Welsh heritage, he was made an Honorary Professor at Aberystwyth University, and retired in 2001 to live near Cardiff, working as an Honorary Research Professor at Cardiff University.

Tony was an exceptionally sociable—and at times gently mischievous—person, with a great love of good food, drink and conversation. These he loved to share with his students and colleagues, many of whom became lifelong friends. He was scrupulously loyal to all and supportive of his staff at Liverpool and the Geological Society where he is still fondly remembered as a great leader.

He died on 5 August 2025, aged 90, after a long illness. He leaves Noreen, his children Elisabeth Siân and David Huw, and four grandchildren. **G**



© Alan Roberts

ANTHONY LEONARD HARRIS

1935 – 2025

A renowned hard-rock structural geologist focused on the Precambrian of the Scottish Highlands and past President of the Geological Society

BY BERNARD ELGEY LEAKE, WITH CONTRIBUTIONS FROM ROBERT (BOB) HOLDSWORTH AND OTHER FRIENDS AND FAMILY



**DAVID
NAYLOR**
1935 – 2025

An eminent geologist who made lasting contributions to Irish geology and global petroleum exploration

BY PAT SHANNON

DAVID (DAVE) NAYLOR was born in Cleckheaton, Yorkshire, and graduated from the University of Leeds with a degree in geology, leading to a lifelong career dedicated to understanding Ireland's geology and contributing to professional and learned geoscience bodies.

A lifetime of exploration

Dave's career began in 1957 as a field geologist with mining company De Beers in South Africa and Namibia. In 1964, he joined Chevron in Canada, working on regional subsurface, well site and helicopter-based mapping projects in the Northwest Territories, Yukon and other remote Canadian areas at a time when maps of the region were virtually non-existent.

In the late 1960s he co-founded Exploration Consultants Limited, a London-based consultancy that became heavily involved in the early days of North Sea oil and gas exploration. He later became its Managing Director.

Dave then spent almost a decade with the Northgate Group of companies, being responsible for their petroleum exploration acreage offshore Ireland, in Morecambe Bay, the southern North Sea and further afield.

He later worked as Project Manager for ERA-Maptec, a consultancy specialising in the interpretation of satellite imagery. For the past 25 years, he was consultant to the 162 Group in Dublin, including Petrel Resources which held licences in the Porcupine Basin, offshore Ireland.

Academia and civil service

Dave always remained close to academia. His PhD was from Trinity College Dublin where he researched the Devonian-Carboniferous succession in southwest Ireland. He was a lecturer in sedimentology and stratigraphy there for two years and spent a year as a Research Fellow at the University of Birmingham. He was Adjunct Professor at University College Dublin for many years too.

“Dave loved being in the field and believed that a geologist should never become too far removed from rocks”

He had a lifelong interest in the Devonian and Lower Carboniferous geology of southwest Ireland, as well as the country's offshore basins, publishing extensively on both for over 50 years. Co-author of five books and more than 70 other publications, his final piece in 2024 was in the *Irish Journal of Earth Sciences*, of which he was a founding editor.

Dave spent a period as Assistant Director of the Geological Survey of Ireland, where he oversaw their field-mapping programme, and was the technical representative for Ireland at European Commission Committees and the United Nations Conference on the Law of the Sea.

A full life

Dave loved being in the field and believed that a geologist should never become too far removed from rocks. He treated everyone with courtesy and respect. Always approachable and patient, he was a mentor to generations of geologists and possessed a treasure trove of fascinating stories from his worldwide adventures. He will be greatly missed in the geoscience sector as a kind, generous and wise colleague and friend, with encyclopedic geological knowledge. He was a true explorer.

Dave passed away in Kensington, Maryland, USA, on 15 June 2025, following a short illness. He is survived by Verney, his wife of more than 62 years, their sons Sean and Mark, and their two grandchildren. **G**

ANNETTE CUTLER died suddenly in her sleep on 14 February 2026, aged 74. It came as a great shock to her family, friends and colleagues.

Growing up in the coastal town of Saltburn-by-the-Sea, with the surrounding Huntcliff area a living record of the geological processes that shaped the North Sea coast over millions of years, fuelled Annette's lifelong interest in geography and geology. After graduating with an honours degree in geology from the University of Sheffield, Annette went into the oil industry, initially working at Shell and then Conoco, where latterly she became the R&D Programme Co-ordinator. Annette was also an Earth sciences tutor for the Open University.

A force for change

It 1974 Annette became a Fellow of the Geological Society and quickly demonstrated her abilities as a mover and shaker. Almost immediately, Annette became an active member of the Association for the Promotion of an Institution of Professional Geologists, though it took another three years before the Institution of Geologists (IG) was finally established and she became a member of the original Council.

The next step was to acquire a Royal Charter for IG members to bestow the more prestigious title of Chartered Geologist. Once again, Annette took an active role, but it was complex as the Society had its own Royal Charter and wasn't keen to consider the possibility of a future unification with IG. However, in 1991 the IG was finally formally unified with the Society and Chartered status for IG members was achieved. Annette was the first female Chartered Geologist to be appointed.

Over many years, Annette strengthened her involvement with the Society, serving on Council (1996-1999), as Vice-President (1996-1997), as Chair of the Fellowship and Validation Committee and Chair/Joint Chair of the Accreditation Committee (1996-1999), as a Member of the Corporation Affiliates Committee (2001-2006) and External Affairs Committee (1996-1997), as well as being part of the Working Group on Women (1996-1997) and a Chartership Scrutineer until at least 2003.

Driving energy innovation

Following voluntary redundancy from Conoco, Annette took a course in starting a business and, in 1994, Technology Initiatives was born. The company focused on managing technology innovation in traditional, low-carbon and emerging energies, bringing mainstream energy experience to monitoring and managing research in new and emerging technology programmes.

Realising that technology development to implementation and commercialisation would be much quicker with co-operation across the whole supply chain, under Annette's leadership, the company launched, developed and facilitated knowledge sharing networks in the UK, Europe and internationally. Following EU Commission grant awards, its major knowledge sharing network on carbon capture and storage (CCS), CO₂ NET, was active in Community Capacity Building across the whole CCS supply chain, remaining at the forefront of CCS technologies for over 12 years.

An educational legacy

Annette had a lifelong interest in education and was passionate about giving young people access to career opportunities. She believed that only by learning in the field can real understanding and passion for the subject truly be gained.

Through her support of the Society's education work, Annette helped encourage future generations into the profession. She has also left a significant legacy in her will, which will go towards realising her passion. 



© Francesca Sivers and Gillian Cutler

ANNETTE BARBARA CUTLER

1951 – 2026

A gifted
professional who
liked to get
things done and
achieve results

BY DR FRANCESCA
SIVERS AND DR
GILLIAN CUTLER
(ANNETTE'S SISTERS)

“Annette believed that only by learning in the field can real understanding and passion for geology truly be gained”



**WILLIAM
DAVID IAN
ROLFE**
1936 – 2025

Ian was a dedicated palaeontologist, best known for his work on Carboniferous arthropods

BY MICHAEL F RIDD

Born in Hornchurch, Essex, in 1936,

IAN ROLFE attended the Royal Liberty School where he was taught by John Reekie, an inspirational geology teacher. He gained a BSc and PhD from the University of Birmingham, with a thesis on the Silurian inliers of Scotland's Midland Valley, including work on the pod-shrimp *Ceratiocaris*, which shaped his future career.

Curiosity and collections

A spell (1961–2) curating the non-trilobite arthropods of Harvard University's Museum of Comparative Zoology allowed Ian to demonstrate that the two-metre long Carboniferous *Arthropleura* was a terrestrial forest dweller, not an aquatic trilobite relative as previously thought.

He was then appointed as a curator at the University of Glasgow's Hunterian Museum, a post he held for 24 years, during which his energy and imagination raised his and the museum's scientific profile. In 1967, he joined an expedition to the Upper Devonian reefs of Gogo, Western Australia, where superbly-preserved fish and over two thousand fossil phyllocarid crustaceans were collected, on which he later published.

An increase in Hunterian Museum staffing in 1978 included amateur fossil collector Stan Wood, who had a gift for spotting and extracting fossils and became well-known for discovering the earliest fully terrestrial amphibians at Bathgate in West Lothian. This included a reptile-like early vertebrate nicknamed Lizzie. As Stan's supervisor, international competition to buy this important fossil brought Ian into contact with politicians and broadcasters, including David

Attenborough, as he successfully made the case to keep Lizzie in Scotland.

In 1986, Ian moved to Edinburgh to become Keeper of Geology at the National Museum of Scotland. His exhibition work concentrated on developing briefs for the new Museum of Scotland, which opened in 1998. Meanwhile, he continued to support Stan's work, many of whose important finds Ian was able to acquire for the museum.

Ian retired in 1996, when he turned his research to the seventeenth-century Italian naturalist Cassiano dal Pozzo and the many geological artefacts in his 'Paper Museum'.

Dedication and distinction

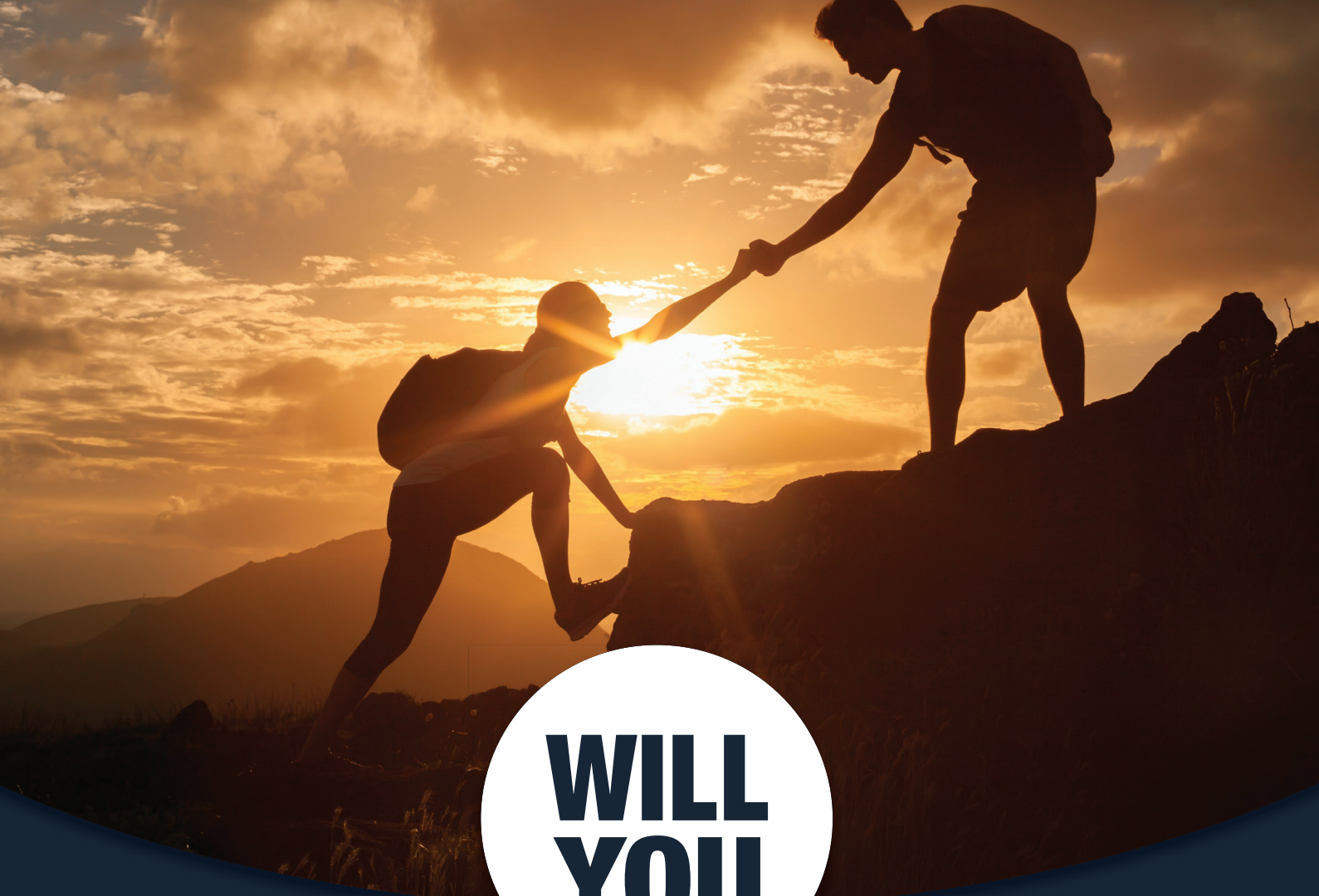
A Fellow of the Geological Society since 1960, in 1973 Ian became Editorial Chair of the Society's journal, and in 1980, Chair of its Conservation Committee. He was awarded the Society's Murchison Fund in 1978, and one of the first two Coke Medals in 1984. He was also President of the Palaeontological Association and the Geological Societies of Glasgow and Edinburgh at different times, as well as a Fellow of the Royal Society of Edinburgh.

Ian passed away on 26 September 2025. He was a brilliant researcher and a polymath with a bookish character. He loved books and yet he had no time for novels. He had no time for sport either, yet liked walking the Scottish hills with friends or spending time at his shared cottage beside Loch Linnhe. Since childhood he was a devoted choral singer. Ian's wife Julia predeceased him, but he is survived by daughters, Sara and Victoria, and two grandchildren. 

THE SOCIETY NOTES WITH SADNESS THE PASSING OF:

- Bate, Raymond
- Bennett, Donovan
- Booth, Basil
- Brown, Helen
- Diver, William
- Evans, Robert
- Firth, John
- Hawkins, Terence
- James, Stephen
- Jones, David
- Jones, Robert
- Jones, William
- Kelly, Simon
- Knott, Richard
- Lawrence, Eric
- MacDonald, Hugh
- Merten, Rudolf
- Montague, Keith
- Osterloff, Peter
- Petrides, George
- Petrie, William
- Reading, Peter
- Sims, Ian
- Smith, Andrew
- Sorapure, Richard
- Stainforth, John
- Sudlow, Derek
- Tabor, Bryan
- Wadge, Geoff
- Ward, Graham
- White, Tony

To submit an obituary, please contact
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"Be curious, enthusiastic and get involved"

→ DR EMMA WATTS is a postdoctoral researcher in tephrochronology at Swansea University, Wales, and a 2026 recipient of the President's Award

What are you currently working on?

As part of Dr Paul Albert's UKRI Future Leaders Fellowship, I am using sedimentary records (marine, lacustrine and ice cores) to investigate the frequency and magnitude of large explosive eruptions across Japan, with the aim of facilitating long-term ash fall hazard assessments. We search for cryptotephra (tephra layers not visible to the naked eye) within the cores and geochemically fingerprint the volcanic glass to a volcano and, if possible, a specific eruptive event. Also, I have been on fieldwork with a team of great scientists to build a database of volcanic glass chemical compositions from known Japanese eruptions to help in the identification process. Alongside this, I continue to work on characterising volcanism and magma generation across the Main Ethiopian Rift and Afar region (East Africa), specifically trying to understand how the frequency and style of volcanism changes over a volcano's lifetime.

What's a typical day for you?

Some days I am in the lab processing sedimentary samples, looking for tephra layers or counting tephra shards under the microscope. On others, I delve into geochemical datasets, read the latest publications, or write my own.

What advice would you give to someone hoping to work in your field?

Be curious, enthusiastic and get involved where possible. Learn a range of techniques, including coding and geographic information systems (GIS), and if you don't understand something, ask. If you're at university, attend seminars on a range of geology and geography topics, as that broader knowledge can really help. I also recommend joining the UK's Volcanic and Magmatic Studies Group and attending their annual meeting. I went as a third-year undergraduate and it was the best decision because I learned so much about volcanology and met new people who I still keep in touch with now. The community is very friendly; you just have to be brave enough to take the plunge!

What's your favourite thing about your work?

Volcanoes are incredibly fascinating and each one is somewhat unique. I love the puzzle they present, with each bit of new information or method unlocking a little more of the picture. I enjoy trying to apply this knowledge to how volcanoes shape Earth and its processes. Additionally, I have been lucky to collaborate with creative, intelligent and genuinely lovely people across the world, who have made the work ever more enjoyable.

Have you encountered any challenges?

Challenges are a part of science and life, so I feel the journey wouldn't be as interesting without them. As with many people, COVID presented a significant challenge during my PhD because my research was laboratory-based, so I had to come up with innovative approaches to carry out my work. However, that time led me to some fantastic new collaborations and to learn methods I otherwise might not have known, helping me to develop multidisciplinary skills. 🧠



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GeoFutures 2026: Critical Minerals

17-18 November 2026 | Hybrid conference

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- 📦 Innovation in understanding critical minerals and deposit geology
- 📦 New approaches to critical mineral exploration and targeting
- 📦 Geometallurgy, downstream processing and implications for mineral processing
- 📦 Circular economy along the mining value chain
- 📦 ESG and minimising environmental impact
- 📦 Supply chain mapping and minerals intelligence



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“

Far beneath our feet, hidden within Earth's deep mantle, ancient lead may have been quietly preserved for billions of years inside minerals that can exist only under enormous pressure

”

Prof Simon Redfern, p. 24



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