

# PROFESSOR THOMAS GERNON

## PERSONAL INFORMATION

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## APPOINTMENTS

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| 2023–PRESENT | <p>UNIVERSITY OF SOUTHAMPTON<br/><i>Professor of Earth Science &amp; Professorial Research Fellow</i></p> <p>I am a Professor of Earth Science at the University of Southampton and formerly a Fellow of the Alan Turing Institute, the UK's national institute for data science and artificial intelligence. My research explores the forces shaping Earth's surface over geologic time—including tectonic, volcanic, sedimentary, and metamorphic processes—and their influence on climate across diverse timescales. I founded the Earth Intelligence Laboratory (EILAB) to unlock the potential of interdisciplinary, data-driven approaches in Earth and environmental science. Supported by an ~\$8 million philanthropic grant, EILAB is pioneering machine learning applications to paleoclimate science and Earth surface processes, while also developing innovative tools to investigate the complex interconnections between the solid Earth, cryosphere, oceans, and climate system. Some of this work achieved 'Breakthrough' status in <i>Science</i> in 2024. Beyond research, I have demonstrated leadership in teaching, university administration, and PhD supervision, with a focus on bridging disciplines and ensuring that the skills and curriculum we teach address today's pressing scientific challenges.</p> |
| 2016–2023    | <p>UNIVERSITY OF SOUTHAMPTON<br/><i>Associate Professor in Earth Science</i></p> <p>I assumed significant administrative responsibilities, including serving as impact officer for the UK Research Excellence Framework. These efforts helped place SOES into the top 5 in the UK for Earth Systems &amp; Environmental Sciences.</p>  |
| 2010–2016    | <p>UNIVERSITY OF SOUTHAMPTON<br/><i>Lecturer in Earth Science</i></p> <p>Developing &amp; delivering modules and supervising research projects. I gained a Fellowship of the Higher Education Academy, recognising commitment to professionalism in learning and teaching in higher education.</p>   |
| 2008–2010    | <p>TRINITY COLLEGE DUBLIN<br/><i>Lecturer in Geology</i></p> <p>Research and undergraduate teaching including coordination of four modules. Obtained a certificate in 'Developing a reflective teaching portfolio for professional development'.</p>   |
| 2007–2008    | <p>UNIVERSITY OF BRISTOL &amp; DE BEERS CANADA<br/><i>Postdoctoral Research Associate</i></p> <p>Detailed geological mapping, data integration, and geochemical analysis of the Snap Lake Diamond Mine, Arctic Canada, to inform future development &amp; optimal mining practices.</p>  |

## EDUCATION

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- 2004–2007 PhD in Earth Science, **University of Bristol & De Beers** (with Sir Steve Sparks)  
Thesis: *Fluidisation and emplacement processes in kimberlite eruptions.*
- 2000–2004 BSc (Hons.) in Geology, **University College Dublin**, with First Class Honours.

## HONOURS & AWARDS

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- 2024 Finalist, Science/AAAS 'Breakthrough of the Year'.
- 2019 Fellowship of The Alan Turing Institute.
- 2012 Fermor Fund, Geological Society of London.
- 2011 Curry Fund, Geologists' Association.
- 2010 President's Award, Geological Society of London.
- 2010 Distinguished Geologists' Memorial Fund, Geological Society of London.
- 2009 Clough and Mykura Fund, Edinburgh Geological Society.
- 2009 Timothy Jefferson Field Research Fund, Geological Society of London.
- 2004 Cunningham Prize, Geological Survey of Ireland.
- 2000 Alumni Prize, European Commission's E.U. Contest for Young Scientists.
- 2000 Young Scientist of the Year award, Republic of Ireland.
- 1999 Geological Survey of Ireland award, Young Scientist Exhibition, Ireland.
- 1997 Institute of Physics of Ireland award, Young Scientist Exhibition, Ireland.

## SELECTED RESEARCH GRANTS

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Over the past 15 years, I have submitted on average 2 grant applications per year, requesting a total of £12 million as Principal Investigator (PI). My research activities to date have been supported by £8.1 million of UKRI, industry and philanthropic funds, with over 80% of this revenue awarded as PI. Funding highlights are as follows:

- 2024 Grant from a US-based Foundation, *Forecasting Future Worlds* (PI, £4.2m; to 2032).
- 2022 Grant from a US-based Foundation, *Decoding Earth's Ice Ages* (PI, £1.9m; to 2028).  
Higher Education Innovation Funding on *Geothermal energy* (PI, £17.9k).
- 2021 NERC grant (NE/W001233/1) on *Drivers of global suspended sediment* (Co-I, £796k).  
WSI Pilot Project with IBM Research UK on *Building data bridges* (PI, £8.4k).
- 2018 Turing Institute (EP/N510129/1) on *Machine learning of seismicity* (PI, £96.3k).
- 2017 NERC (NE/R004978/1) on *Solid Earth drivers of environmental change* (PI, £70k).
- 2013 NERC (NE/K00543X/1) on *Tephra diagenesis in the global carbon cycle* (Co-I, £582k).  
NERC IODP CASE (NE/K007386/1) on *Arc volcanism in the Caribbean* (Co-I, £73k).
- 2012 National Geographic Global Exploration Fund grant (GEFNE56-12, PI, €19k).  
EPSRC grant for *development of a Fluid Dynamics Laboratory* (PI, £39.6k).  
NERC Airborne Research and Survey Facility grant (ET12-14, Co-I, £100k).
- 2011-20 Four NERC Isotope Geosciences Facilities grants (PI; total: £161k), including:  
NEIF-2256.0320 (2020; £38.4k) on: 'Timescales of volcanism in the northern Afar'  
IP-1569-1115 (2016; £58k) on: 'Timescales of volcano-tectonic processes in the Ethiopian rift'  
IP-1240-0511 (2011; £19.7k) on: 'Early Cenozoic explosive volcanism in the North Atlantic'

## PROFESSIONAL SERVICE & MEMBERSHIPS

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- 2018-PRESENT Member, Academic Advisory Board, Web Science Institute, UoS, UK.
- 2019-PRESENT Member, Natural Environment Research Council's Peer Review College.
- 2017-PRESENT Proposal Reviewer, The Royal Society.  
2013-2016 External panelist for BSc revalidation, University of South Wales (2013, 2016).
- 2010-PRESENT PhD examiner, including at the University of Oxford (2019, 2021).
- 2010-PRESENT Fellow of the American Geophysical Union (lifetime since 2024).
- 2007-PRESENT Regular Peer Reviewer (e.g., Science Advances, Nature Geosci., Geology, EPSL, JGR).

## GRADUATE STUDENTS & POSTDOCTORAL FELLOWS

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Over the past decade, I've supervised 18 PhD students (fourteen to completion, four in progress), eight as lead supervisor<sup>†</sup>. The successfully completed PhDs are: Drs Holly Elliott<sup>†</sup>, Melis Cevatoglu, Michael Clare, Maya Coussens, John Emeana, Timothy Hughes, Stuart Hatter<sup>†</sup>, Finn Illsley-Kemp, Melanie Siegburg<sup>†</sup>, James Davey, Ben Callow, Emma Horn, Emma Watts<sup>†</sup>, & Rhiannon Rees<sup>†</sup>. The four current PhD candidates are: Jessica Rawlings<sup>†</sup>, Morgan Bugler, Sayon Jyoti Beura<sup>†</sup> and Aspen Sartin<sup>†</sup>. I've managed four PDRAs, from 2013-17 (Dr Hayley Manners), 2018-19 (Dr Jack Longman), 2018-present (Dr Thea Hincks), and 2024 to 2028 (Dr Chloe Griffin).

## TEACHING SUMMARY

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**Record of Service:** I am committed to delivering high-quality education and providing excellent pastoral support to our students. In my previous role, I dedicated about half of my time to supporting undergraduate and postgraduate students, teaching, fieldwork, and administration. I delivered approximately 55 modules and received an average teaching score of 88% across all student evaluations. I coordinated structural geology and GIS for the past 10 years, independent mapping projects for 7 years, and taught extensively on volcanic and mantle processes, successfully leading 15 large overseas field courses.

**Innovation:** During the Covid-19 pandemic, I developed an innovative online course for my third year [SOES3020 physical volcanology](#) module, incorporating highly interactive materials, cutting edge information, and live discussion sessions where the students could interact with leaders in the field. Because the students couldn't participate in as much field geology as usual, I instead brought the field to them—by assembling in the laboratory hundreds of metres of valuable volcanic drill-core from a diamond mine in South Africa. The exercise involved logging the core in detail, and reconstructing the volcanic geology of a valuable ore resource. They used their observations to make informed predictions about diamond grade and distribution in mines, and speculating on how these might be influenced by volcanic processes. I invited senior personnel from De Beers to join this session remotely so the students could ask questions and bring the material to life, conveying the value of their work for commercial operations.

Another major contribution was the successful implementation of [a major overhaul of our undergraduate independent mapping projects](#), a crucial part of the degree. Pandemic related international travel restrictions required a re-think of teaching practice to ensure students received the necessary training and experience. Building on an earlier initiative I developed to enable students with physical disabilities to undertake alternative or desk-based projects that tested the same (geospatial) learning outcomes, I devised high-quality hybrid projects combining sophisticated geospatial analysis, including LiDAR remote sensing data, with local fieldwork along the Jurassic Coast. Notably, two students in our first two cohorts received the coveted Dave Johnston (national) Mapping Prize of the Geological Society of London.

**Recognition:** I was elected as Fellow of the Higher Education Academy (now AdvanceHE), demonstrating “commitment to professionalism in teaching and learning in higher education”. I earned a certificate in ‘Developing a reflective teaching portfolio for continuing professional development’ (issued by Trinity College Dublin, 2009) based on my work producing course material for mixed ability groups and students with learning disabilities in undergraduate programmes, in conjunction with the National Institute for Intellectual Disability. My efforts have shown that I’m committed to making geoscience content more accessible to a wider range of people, including those with disabilities and from less privileged or under-represented backgrounds. I was awarded the SUSU a ‘Most Engaging Lecturer’ award at the height of the COVID-19 lockdowns, reflecting my resolute commitment to the educational and pastoral needs of our students at a challenging time in their lives.

## MEDIA & OUTREACH HIGHLIGHTS

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**Media coverage:** My research outputs rank in the [top 10% for global reach](#), with many of my papers having [significant impact](#), featuring in *Nature*, *Science*, *National Geographic*, *TIME*, *Scientific American*, *New Scientist*, *New York Times*, *BBC*, *The Guardian*, *Smithsonian Magazine*, *Forbes* and over 1,000 other news articles, including [co-opted pieces in Newsweek](#) and *IFLScience*.

**Outreach projects:** I received the Curry Fund award from the Geologists’ Association, along with additional funding from the Geological Society of Edinburgh, to design and install interpretive panels on the natural history of the Fife coast in Scotland. Leading this initiative in collaboration with Fife Council and Scottish Natural Heritage, we successfully [delivered this project](#), bringing the science to life for local communities and tourists. Separately, I was part of a team that created an innovative sonification of [NASA impacts data](#) on the lunar surface and [diamond eruptions over time](#). Both projects featured in separate articles in *The Guardian* and led to a commissioned Commentary in *Nature Reviews Earth & Environment*.

**Education initiatives:** I was awarded the Royal Dublin Society Lecture Bursary to develop and deliver a program of interactive talks in schools and inspire the next generation. My research has featured in *Today's Science*, a U.S.-based science news service for high school and college students.

## INTERNATIONAL FIELDWORK

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I have carried out **extensive geological fieldwork in sixteen countries spanning six continents, and cumulatively spent over two years in the field gathering data.** Major field localities have included: Tenerife, Aragon & Almería (Spain); the Flinders Ranges & Arkaroola (South Australia); the Boset-Bericha Volcanic Complex (Ethiopia); the IODP Kochi Core Repository (Japan) and IODP Bremen Core Repository (Germany); South Soufrière Hills (Montserrat); Santorini (Greece); south-central Utah (USA); Snap Lake, Northwest Territories (Arctic Canada); Letseng Diamond Mine, Mokhotlong district (Kingdom of Lesotho); Fort à la Corne, Saskatchewan (Canada); Bakening Volcano, Kamchatka Peninsula, Far Eastern Siberia (Russia); Venetia kimberlite, Limpopo province (South Africa), and the Jwaneng & Orapa Diamond Mines (Republic of Botswana).

## INTERNATIONAL COLLABORATIONS

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- Dr Guy Paxman, University of Durham: Landscape evolution controls on ice sheet nucleation.
- Prof Eelco Rohling, Utrecht University: Sea level and deep-sea temperature variations over 40 Myrs.
- Prof Roger Cooke, TU Delft & Resources for the Future: Understanding climate sensitivity.
- Prof Paul Hoffman, Harvard University, US: Geology of Cryogenian glaciations.
- Prof Jean Braun, GFZ Potsdam, Germany: Landscape evolution in the continental breakup aftermath.
- Prof Ben Mills, University of Leeds, and Dr Lewis Alcott, University of Bristol, UK: Global biogeochemical modelling of solid Earth processes.
- Prof Sue O'Reilly AM FAA FRSN & Prof Bill Griffin, Macquarie University, Australia: Variations in lithospheric structure and chemistry during continental breakup.
- Dr Brenhin Keller, Dartmouth College, US: Statistical geochemistry & origin of the Great Unconformity.
- Dr Sara Mazrouei, University of Toronto, Dr Rebecca Ghent, Planetary Science Institute, Arizona, US, and Dr Bill Bottke, SWRI, Colorado, US: Earth and Moon impact flux over geologic time.
- Dr Andrew Merdith, University of Adelaide: Tectonic forcings of environmental change in deep time.
- Prof Ross Mitchell, Chinese Academy of Sciences, Beijing: Orbital forcing on Snowball Earth.
- Prof Chris Spencer, Queens University, Canada: Effect of land plant evolution on crustal composition.
- Dr Finnigan Illsley-Kemp, Victoria University of Wellington, NZ, Dr Laura Wallace, University of Texas, and Dr Katie Jacobs, GNS, NZ: Origin of slow-slip earthquakes in the Taupo Volcanic Zone.
- Prof Sascha Brune & Dr Anne Glerum, GFZ Potsdam: Geodynamic modelling of rift evolution.

## INVITED PRESENTATIONS

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I have delivered over 70 presentations at international conferences (of a total of 120 papers at 70 conferences), workshops, seminars and public lectures. This has included over 30 invited presentations—three forthcoming at AGU 2024, EGU 2025 and Gordon 2025—some of which are as follows:

- 2025 Invited Speaker at 3rd Gordon Research Conference on Geochronology, Maine, US.
- 2025 Invited Speaker (2 invited talks) at European Geophysical Union, Vienna, Austria.
- 2025 Invited Seminars, GFZ Potsdam and Imperial College London.
- 2025 Invited Speaker, Centre for the History and Philosophy of Physics, Oxford.
- 2024 Invited Speaker at meeting of American Geophysical Union, Washington DC.
- 2024 Invited Speaker at Sonic Storytelling workshop, Faculty of Music, Oxford.
- 2024 Invited Seminars, Universities of Bristol, Oxford, Durham, UCL, Leeds & San Diego.
- 2023 Invited Seminars at UBC, Trinity College, and GFZ Potsdam: 'Supercontinent breakup'.
- 2021 Invited Keynote Speaker, Institute of Mathematics: 'Machine learning hydraulic fracturing'.
- 2021 Invited Seminar, VMSG, UK: 'The role of volcanism in shaping Neoproterozoic snowball Earth'.
- 2019 invited Seminar, Natural History Museum, London: 'Snowball Earth & the Moon's craters'.
- 2018 Invited Seminar, Earth Sciences, University of Oxford: 'Volcanism on Snowball Earth'.
- 2017 Invited Keynote Speaker at Goldschmidt geochemistry conference, Paris.
- 2016 Invited Keynote Speaker, Sprigg Symposium, Australian Earth Science Convention.
- 2014 Invited Keynote Speaker, Mineral Deposits Studies Group, Geol. Soc. London.
- 2011 Invited Lecturer, International Diamond School, UCL/Università Padua, Italian Alps.
- 2009 Guest Speaker to several school groups, Royal Dublin Society.
- 2008 Speaker, International Kimberlite Conference, Canada: 'Fluidization in volcanic conduits'.

## SELECTED PUBLICATIONS

As of 13 November 2024, I have 85 peer reviewed publications and a h index of 28. I have four papers under revision and a further three papers under review at leading disciplinary journals. A complete list is also available (provided).

- Gernon, T.M.**, Mills, B.J.W., Hincks, T.K., Merdith, A.S., Alcott, L.J., Rohling, E.J.R. & Palmer, M.R. *Solid Earth forcing of Mesozoic oceanic anoxic events*. **Nature Geoscience**, 17, 926–935, doi: [10.1038/s41561-024-01496-0](https://doi.org/10.1038/s41561-024-01496-0) (2024).
- Gernon, T.M.**, Hincks, T.K., Brune, S., Braun, J., Jones, S.M., Keir, D., Cunningham, A. & Glerum, A., *Coevolution of craton margins and interiors during continental breakup*. **Nature**, 632, 327–335, doi: [10.1038/s41586-024-07717-1](https://doi.org/10.1038/s41586-024-07717-1) (2024). Article attracted an associated in-depth news feature in Science: Richter, H., In sweeping geological theory, mantle waves lift up plateaus. **Science**, 588 (6709), 588–589, doi: [10.1126/science.z1mp7qn](https://doi.org/10.1126/science.z1mp7qn).
- Russo, M., **Gernon, T.M.**<sup>‡</sup>, Santaguida, A. & Hincks, T.K., 2024. *Improving Earth science communication and accessibility with data sonification*. **Nature Reviews Earth & Environment** 5, 1–3; doi: [10.1038/s43017-023](https://doi.org/10.1038/s43017-023-023). <sup>‡</sup>Corresponding author.
- Gernon, T.M.**, Jones, S.M., Brune, S., Hincks, T.K., Palmer, M.R., Schumacher, J.C., Primiceri, R.M., Field, M., Griffin, W.L., O'Reilly, S.Y., Keir, D., Spencer, C.J., Merdith, A. & Glerum, A., 2023. *Rift-induced disruption of cratonic keels drives kimberlite volcanism*. **Nature** 620, 344–350, doi: [10.1038/s41586-023-06193-3](https://doi.org/10.1038/s41586-023-06193-3). Article attracted an associated in-depth news feature in Science: Voosen, P., 2023. *Origin of diamond-bearing eruptions revealed*. **Science**, 381 (6656), 362–363, doi: [10.1126/science.adj9527](https://doi.org/10.1126/science.adj9527).
- Gernon, T.M.**, Barr, R., Fitton, J.G., Hincks, T.K., Longman, J., Merdith, A., Mitchell, R.N. & Palmer, M.R., 2022. *Transient mobilization of subcrustal carbon coincident with Palaeocene-Eocene Thermal Maximum*. **Nature Geoscience** 15, 573–579, doi: [10.1038/s41561-022-00967-6](https://doi.org/10.1038/s41561-022-00967-6). Associated in-depth news feature in Science: Voosen, P., 2022. *Hidden carbon layer may have sparked ancient bout of global warming*. **Science**, 377 (6601), 12–13, doi: [10.1126/science.add6369](https://doi.org/10.1126/science.add6369).
- Rohling, E.J., Foster, G.L., **Gernon, T.M.**, Grant, K.M., Heslop, D., Hibbert, F.D., Roberts, A.P. & Yu, J., 2022. *Comparison and synthesis of sea level and deep-sea temperature variations over the past 40 million years*. **Reviews of Geophysics** 60, e2022RG000775, doi: [10.1029/2022RG000775](https://doi.org/10.1029/2022RG000775).
- Spencer, C.J., Davies, N.S., **Gernon, T.M.**, Wang, X., McMahon, W.J., Morrell, T.R., Hincks, T.K., Puhfal, P.K., Brasier, A., Seraine, M., & Lu, G.M., 2022. *Composition of continental crust altered by the emergence of land plants*. **Nature Geoscience** 15 (9), 735–740, doi: [10.1038/s41561-022-00995-2](https://doi.org/10.1038/s41561-022-00995-2). Associated Perspective: Greber, N., 2022. *Plant fingerprints in the deep Earth*. **Nature Geoscience** 15, p. 685–686; doi: [10.1038/s41561-022-01022-0](https://doi.org/10.1038/s41561-022-01022-0); Editorial, *Plants rooted in rocks*. **Nature Geoscience** 15, p. 683; doi: [10.1038/s41561-022-01030-0](https://doi.org/10.1038/s41561-022-01030-0), and Research Highlight: Grocholski, B., 2022. *Geochemistry: Deep-rooted change*, **Science**, 378 (6615), 37–38, doi: [10.1126/science.adf1655](https://doi.org/10.1126/science.adf1655).
- Longman, J., Mills, B.J.W., Manners, H.R., **Gernon, T.M.** & Palmer, M., 2021. *Late Ordovician climate change and extinctions driven by elevated volcanic nutrient supply*. **Nature Geoscience** 14, p. 924–929; doi: [10.1038/s41561-021-00855-5](https://doi.org/10.1038/s41561-021-00855-5).
- Gernon, T.M.**, Hincks, T.K., Merdith, A., Rohling, E.J., Palmer, M.R., Foster, G.L., Bataille, C.P. & Müller, R.D., 2021. *Global chemical weathering dominated by continental arcs since the mid-Palaeozoic*. **Nature Geoscience** 14, p. 690–696; doi: [10.1038/s41561-021-00806-0](https://doi.org/10.1038/s41561-021-00806-0).
- Mitchell, R.N.<sup>‡</sup>, **Gernon, T.M.**<sup>‡</sup>, Cox, G.M., Nordsvan, A.R., Kirscher, U., Xuan, C., Liu, Y., Liu, X. & He, X., 2021. *Orbital forcing of ice sheets during snowball Earth*. **Nature Communications** 12, 4187; doi: [10.1038/s41467-021-24439](https://doi.org/10.1038/s41467-021-24439). <sup>‡</sup>Contributed equally.
- Longman, J., **Gernon, T.M.**, Palmer, M.R., Jones, M.T., Stokke, E.W. & Svensen, H.H., 2021. *Marine diagenesis of tephra aided the Paleocene-Eocene Thermal Maximum termination*. **Earth and Planetary Science Letters** 571, 117101, doi: [10.1016/j.epsl.2021.117101](https://doi.org/10.1016/j.epsl.2021.117101).
- Gernon, T.M.**, 2020. *A sabbatical reboot*. **Science** 370 (6517), p. 738; doi: [10.1126/science.370.6517.738](https://doi.org/10.1126/science.370.6517.738).
- Mazrouei, S., Ghent, R.R., Bottke, W.F., Parker, A.H. & **Gernon, T.M.**, 2019. *Earth and Moon impact flux increased at the end of the Paleozoic*, **Science** 363, p. 253–257; doi: [10.1126/science.aar4058](https://doi.org/10.1126/science.aar4058). Associated Perspective: Koeberl, C., 2019. *When Earth got pummeled*. **Science** 363 (6424), p. 224–225; doi:

[10.1126/science.aav8480](https://doi.org/10.1126/science.aav8480); and News Feature: Voosen, P., 2019. *Moon's craters reveal recent spike in outer space impacts on Earth*, *Science*, doi: [10.1126/science.aaw7085](https://doi.org/10.1126/science.aaw7085).

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Hincks, T.K., Aspinall, W., Cooke, R. & **Gernon, T.M.**<sup>‡</sup>, 2018. *Oklahoma's induced seismicity strongly linked to wastewater injection depth*. *Science* 359, p. 1251–1255; doi: [10.1126/science.aap7911](https://doi.org/10.1126/science.aap7911). <sup>‡</sup>Corresponding author.

**Gernon, T.M.**, Hincks, T.K., Tyrrell, T., Rohling, E.J. & Palmer, M.R., 2016. *Snowball Earth ocean chemistry driven by extensive ridge volcanism during Rodinia breakup*. *Nature Geoscience* 9, p. 242–248; doi: [10.1038/ngeo2632](https://doi.org/10.1038/ngeo2632). Associated News & Views feature: Fairchild, I. J., 2016. *Ocean chemistry: Neoproterozoic glass-bleeding*. *Nature Geoscience* 9, p. 192–193; doi: [10.1038/ngeo2643](https://doi.org/10.1038/ngeo2643).

Blackford, J., Stahl, H., Bull, J., Berges, B., Cevatoglu, M., Lichtschlag, A., Connelly, D., James, R., Kita, J., Long, D., Naylor, M., Shitashima, K., Smith, D., Taylor, P., Wright, I., Akhurst, M., Chen, B., **Gernon, T.M.**, Hauton, C., Hayashi, M., Kaieda, H., Leighton, T., Sato, T., Sayer, M., Suzumura, M., Tait, K., Vardy, M., White, P. & Widdicombe, S., 2014. *Detection and impacts of leakage from sub-seafloor carbon dioxide storage*. *Nature Climate Change*, 4, p. 1011–1016, doi: [10.1038/nclimate2381](https://doi.org/10.1038/nclimate2381).

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