ENERGY GROUP



13TH UK GEOTHERMAL SYMPOSIUM

9-11 NOVEMBER 2026

The University of Leeds

The 13th UK Geothermal Symposium will be dedicated to showcasing the latest advances in geothermal energy research, innovations, and projects, bringing together geoscientists, engineers, and decision-makers from industry, academia, and the public sector. The symposium will feature research presentations, poster sessions, and interdisciplinary discussions aimed at advancing the understanding and application of geothermal energy in the UK, with case studies and learnings from international partners.

This year the conference will be held at the University of Leeds, close to their geothermal project and with a particular focus on campus-scale geothermal projects that are developing across the UK.

As the authoritative technical event for geothermal energy in the UK, this three-day conference welcomes professionals and students from across the sector to present on key themes including:

- Campus-scale geothermal projects
- Local and international case studies and lessons learned
- Subsurface geological and geophysical studies
- Ground source heat pumps
- Underground thermal energy storage
- Mine water heat recovery
- Deep geothermal heat and power production
- Subsurface research on integrated heating, cooling and storage, including for heat networks
- Geothermal energy for data centres
- Drilling practices and cost reduction
- Policy and regulation, including the subsurface evidence base and planning
- Risk management, seismic hazard assessment, community engagement
- Geothermal brines and critical minerals

This conference provides a platform for knowledge exchange and collaboration and is an essential event for anyone shaping the future of geothermal energy. We look forward to seeing you there!

For further information please contact
Email: energygroup@geolsoc.org.uk

Convenors:

Alexander Hudson

Alison Monaghan

Arka Sarkar

Sean Watson

Holly-Marie Owen

The Geological Society

At the forefront of energy geoscience
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#EGGS26

13th UK Geothermal Symposium

9-10 November 2026

Cloth Hall Court, Leeds and Virtual

Provisional Programme

Geothermal Core Workshop 13th UK Geothermal Symposium
10.00-13.00, 11 November 2026 (*Separate registration required)*
School of Earth and Environment, University of Leeds
Shallow aquifers present an opportunity to decarbonise through accessing their fluids and harnessing heat pump technology for geothermal heating and cooling. The Carboniferous Lower Coal Measures and Millstone Grit groups contain sandstone aquifers (the Elland Flags formation and Rough Rock Flags formation, respectively) that are present below the West Yorkshire region and have been targeted by the University of Leeds Geothermal Campus project. Sandstone aquifers such as these with mixed permeability systems represent analogues for other potential geothermal target aquifer systems nationally. With access to core samples recovered for these intervals, participants will gain firsthand experience in the characterisation and analysis of geothermal aquifer systems via a hands-on core workshop. Weather permitting participants will also get a tour of the sites belonging to the Leeds Living Lab. Hosts: Dr Arka Dyuti Sarkar and Dr Richard Collier

Day One Monday 9th November 2026	
08.30	**Registration**
09.00	**Welcome**
	Session One: Strategy, Policy & Regulation
09.15	**The Resource Is Ready: A Strategy to Build a Geothermal Nation** Charlotte Adams, *National Geothermal Centre*
9.30	**Next-generation geothermal: global market momentum and the UK opportunity** Kate Adie, *Wood Mackenzie*
9.45	**Navigating England's Geothermal Regulations: Current Requirements and Recent Changes** Diane Steele, *Environment Agency*
10.00 Virtual	**Governance and Regulation of High-Temperature Energy Storage within the European PUSH-IT project: Results from Interviews with Regulators and Operators** Margaret Stewart, *British Geological Survey*

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10.15	**Understanding Gender and Inclusion in the UK Geothermal Sector: Insights from a National Survey** Rebecca Nye, *WING UK*
10.30	**BREAK**
	Session Two: Campus Geothermal, Cities & Heat Networks
10.45	**Building a Geothermal Exemplar City: pathways for place-based urban heat decarbonisation** Emma Bramham, *University of Leeds*
11.00	**Assessing the potential for geothermal energy deployment in Greater Manchester: first steps towards a place-based solution for heating and cooling** Cathy Hollis, *University of Manchester*
11.15	**Geothermal Meets the Real World: Lessons from Delivering Open-Loop Geothermal on a Live University Campus** Richard Lane, *Drift Group*
11.30	**Deep Geothermal: Tales from a Project in Process** Paul Bushnell, *University of York*
11.45	**Oxford Brookes University Case Study** Rachel Feeney, *Erda Energy*
12.00	**Beyond the Borehole: Lessons from Szeged** Richard Toy, *Ventosus UK*
	Session Three: Community Engagement & Social Licence
12.15	**Community-led geothermal: developing a replicable model for rural heat decarbonisation in Pickering** James Van Alstine, *University of Leeds*
12.30	**The Heat Beneath Our Feet: Creatively inspiring public audiences with geothermal technologies** Rory Padfield, *University of Leeds*
12.45	**CeraPhi Case Studies** Karl Farrow, *CeraPhi Energy*
13.00	**LUNCH**
14.00 Virtual	**Cross-Atlantic Lessons in Community-Led Geothermal** Saxon Metzger, *Wilmington University*
	Session Four: Numerical Modelling & Digital Workflows
14.15	**Sketch-based Geological Modelling and Flow Diagnostic for Geothermal Exploration** Carl Jacquemyn, *Imperial College London*
14.30	**A novel approach to modelling Advanced Geothermal Systems using a 3D Geological Modelling Software** Rifky Wijanarko, WSP
14.45	**A probabilistic approach for rapid assessment of open-loop Ground Source Heating and Cooling (GSHC) and Aquifer Thermal Energy Storage (ATES) deployments** Matthew Jackson, *Imperial College London*
15.00	**BREAK**
15.15	**POSTER SESSION**
16.20	**High-density ATES design for a spatially constrained urban campus: Imperial College London's South Kensington campus** Meissam Bahlali, *Imperial College London*

16.35	**Exploring Challenging Subsurface Settings for ATES** Luka Tas, *Ghent University*
16.50	**Long-Term Performance and Sustainability of Asymmetric Open-Loop Geothermal Heating: Numerical Modelling of an 8-Month Extraction, 4-Month Recovery Strategy** Allegra Giblin Torlucci, *University of Leeds*
17.05	**End of day one**
17.05-18.05	**Drinks reception**

Day Two Tuesday 10th November 2026	
08.30	**Registration**
08:45	**Welcome**
	Session Five: Minewater Geothermal & Thermal Energy Storage
09.00	**Project IMPACT: Investigating Mine Potential for Cooling and Storage** Fiona Todd, *Mining Remediation Authority*
09.15	**Mine-Groundwater Interactions and the Effects on Mine Water Geothermal Resource Feasibility** Callum Thomas, *Durham University*
09.30	**Time-dependent GEMSToolbox: fast, accurate heat exchange for mine water heat storage** Difu Shi, *Durham University*
09.45	**Thermal Conductivity of the Lower Pennine Coal Measures & Upper Millstone Grit at the University of Leeds Geothermal Living Lab** Fleur Loveridge, *University of Leeds*
10.00	**Effective Thermal Conductivity of the Sherwood Sandstone, evaluated from time-lapse Electrical Resistivity Imaging** Adam Booth, *University of Leeds*
10.15	**BREAK**
	Session Six: Fractures, Reservoir Characterisation & UK Exploration
10.30	**De-risking UK Lower Carboniferous Limestone geothermal resources using legacy seismic and potential-field data** Mohamed Gouiza, *University of Leeds*
10.45	**From outcrop to reservoir: multi-scale fracture analysis for potential deep geothermal development in Cornwall** Priyanka Paul, *British Geological Survey*
11.00	**Seismic Anisotropy of Hengill geothermal area, southwest Iceland** Esme Glastonbury-Southern, *University of Leeds*
11.15	**Modeling fracture networks and fluid flow in the Þeistareykir geothermal area** Aastha, *University of Leeds*
11.30	**GEMINI Integrated Geophysical Surveys for Deep Geothermal Exploration in County Antrim** Michael MacKenzie, *Geological Survey of Northern Ireland*

11.45	**Imaging Aberdeen with seismic noise: passive seismic methods for geothermal exploration** David Cornwell, *University of Aberdeen*
12.00	**LUNCH**
	Session Seven: Innovative Techniques, Data & Monitoring
13.00	**Using Heat to Characterise Groundwater Flow in a Fractured Chalk Aquifer** Joseph Kelly, *University of Leeds*
13.15 Virtual	**Characterisation of ground source heat pump boreholes at the BGS Keyworth Campus 'Living Lab' in Nottingham, UK** David Boon, *British Geological Survey*
13.30	**Revisiting Borehole Heat Flow Estimates from the British Isles Using a Reproducible Computational Framework** Mark Ireland, *Newcastle University*
13.45	**Thermogeological tidbits from the Caledonian table: preliminary findings of THERMOCAL in the UK** Sean Watson, *University of Glasgow*
14.00	**Making Shallow Geothermal Work: Lessons from Deep Drilling** Ian Farmer, *Independent Drilling Consultant*
14.15	**The Geothermal Potential of the Humber Region** Eddie Dempsey, *University of Hull*
14.30	**Testing Geothermal Hypotheses beneath Corbetti, Ethiopia with 3D S-wave seismic tomography** Andy Nowacki, *University of Leeds*
14.45	**Trace Element Geochemistry of the Sorik Marapi Geothermal Field, Indonesia** Konstantin Nazarov, *University of Oxford*
15.00	**BREAK**
	Session Eight: Geothermal From Around the World
15.15 Virtual	**Structural Controls in the Hengill Geothermal System, Iceland** Brandon VanderBeek, *University of Oxford*
15.30 Virtual	**Geothermal Energy Applications in Poultry Farming: Opportunities for Climate Change Mitigation and Sustainable Development** Abdelmalek Atia, *University of El Oued, Algeria*
15.45 Virtual	**Expecting the Unexpected: The Geology of the Granite City** Clare Bond, *University of Aberdeen*
16.00	**Conference Summary & Discussion**
16.15	**Energy Group Update**
16.30	**Closing Remarks**
16.45	**End of day two**

Posters

The Missing Data Layer: Why Global Borefield Geometry Remains Undigitized and How Machine Learning Can Unlock Actionable Subsurface Insights
Tunca Alikaya, *borelogger.io*

MRMOLES: Mitigating Risks of Mineralisation and biofilms in Open Loop thermal Energy Systems Matt Bailey, *University of Plymouth*
Ultra-High-Temperature Underground Thermal Energy Storage (UHT-UTES) for Large-scale, Inter-seasonal Electricity Storage Ruixiao Liu, *Imperial College London*
Interpolation-free adaptive mesh Machine-Learning Surrogate for Rapid Simulation of Aquifer Thermal Energy Storage Hadrian Fung, *Imperial College London*
Experimental Study of PET-Derived Nitrogen-Doped Carbon Quantum Dots for Tailoring Soil Thermal Conductivity and Heat Storage in Shallow Geothermal Systems Amany Aboulrous, *Unviersity of Bradford*
A multi-method analogue study of fracture-controlled geothermal reservoirs in Cornubian granite, Cornwall Samuel Grainger, *University of Liverpool*
Neuro-Algebraic Digital Twinning Approach to Predict Critical States in Abandon Mineworkings Geothermal Flow. Oleksandr Letychevskyi, *Heriot-Watt University*
Updated national-scale geothermal data and maps from the British Geological Survey Alison Monaghan, *British Geological Survey*
Measuring thermal plumes and breakthrough in mines for geothermal exploitation and thermal storage Alison Monaghan, *British Geological Survey*
Subsurface characterisation of the UK Geoenergy Observatory using borehole distributed acoustic sensing (DAS) monitoring before and during geothermal testing David Fairweather, *University of Leeds*
Three-Dimensional Characterisation of Fracture Arrays in the Leeds Geothermal Campus Borehole Core: Implications for Fluid Flow in Mechanically Layered Reservoir Analogues Renato Diamanti, *University of Leeds*
Learnings from research to date at the UK Geoenergy Observatories and how these factor into future geothermal experiment design Mike Spence, *British Geological Survey*
Mixture Density Network-based Electrical Tomography Inversion: a Rapid Probabilistic Approach for Geophysical Geothermal Monitoring Theethach Phiranram, *University of Leeds*
The GEMINI project: Tackling communications and engagement challenges in a cross-border geothermal energy project Nicola Noller, *RML / GEMINI*
History Matching an Operating Aquifer Thermal Energy Storage (ATES) System Operating in the Heterogeneous Chalk Aquifer under London, U.K. Hayley Firth, *Imperial College London*
Monitoring shallow geothermal aquifers with active-source distributed acoustic sensing: feasibility studies on the University of Leeds Geothermal Campus Adam Booth, *University of Leeds*
Assessment of the feasibility for installation of high temperature mine thermal energy storage technologies in the Great Consolidated Mines, Cornwall: final results of the PUSH-IT Project. Poppy Edgecombe, *GEL*
An update on the operation of the United Downs Geothermal Plant, Cornwall. Poppy Edgecombe, *GEL*

The Potential for Geothermal Energy to Provide Low Carbon Heat to the Scottish Whisky Industry Callum Inglis, *Independent*
Heat When It Matters Most: Can High-Temperature Underground Thermal Energy Storage (HT-UTES) Improve UK Energy Resilience and What Role Can UKGEOS Play? Mark Griffiths, Arup

The Energy Group of the Geological Society would like to thank the following for their support for this conference:

Geosolutions
Leeds

Oral Presentations: Day One

Session One: Strategy, Policy & Regulation

The Resource Is Ready: A Strategy to Build a Geothermal Nation

Author(s): Charlotte Adams

Organisation(s): National Geothermal Centre

Abstract

The United Kingdom has geothermal resources of national significance, proven technologies and a world-class energy workforce, yet geothermal remains an overlooked component of energy policy. Approximately half of UK energy is used for heat, while geothermal currently supplies only around 0.3% of heat demand. Dependence on imported gas exposes households, businesses and public services to volatile prices, geopolitical shocks and the high carbon intensity of liquefied natural gas. A coordinated national strategy is therefore needed to turn technical potential into deployable projects.

This paper presents the National Geothermal Centre's strategic roadmap for making the UK a "Geothermal Nation", with ambitions to deliver 10 GW of geothermal heat and 1.5 GW of geothermal electricity by 2050. The roadmap has been developed around five interconnected challenge areas that currently constrain deployment: policy and regulation; market and finance; knowledge, education and skills; technology development and research innovation; and infrastructure integration.

Across these areas, sixteen recommendations create a practical pathway from ambition to delivery. Priorities include establishing a national delivery body; adopting targets; streamlining licensing and permitting; reducing first-well and geological risk; aligning public finance; developing a national project pipeline; supporting workforce transition; creating regional centres of excellence; improving open-access resource and demand mapping; and integrating geothermal with heat networks, electricity systems, industry, food production and data centres.

The strategy argues that geothermal is not a speculative future technology: many applications are already at technology readiness levels 8–9, and commercial projects operate across varied UK geologies. What is missing is a stable, investable and coordinated deployment environment. By working through these recommendations collaboratively, the UK can unlock secure, indigenous and price-stable energy, accelerate heat decarbonisation, retain transferable energy-sector skills, stimulate regional growth and build an exportable capability. The resource is proven, the technology is ready, and the case for action is urgent.

Next-generation geothermal: global market momentum and the UK opportunity

Author(s): Kate Adie

Organisation(s): Wood Mackenzie

Geothermal development has long been confined to geological sweet spots, where high thermal gradients coincide with natural permeability. This constraint has shaped market distribution globally and limited the sector's growth potential. Next-generation geothermal technologies are being developed to remove these barriers and expand the role geothermal can play in the global energy mix.

Enhanced and Advanced Geothermal Systems (EGS/AGS) are challenging geological limitations by creating engineered reservoirs, turning previously uneconomic resources into viable energy assets for deep geothermal heat and power. Superhot rock systems are being targeted in pursuit of greater power generation efficiencies, while geothermal paired with mineral extraction seeks to boost project revenues by co-producing critical minerals such as lithium from geothermal brines.

We present a comprehensive market analysis of the emerging next-generation geothermal sector, identifying which technologies are delivering results, where they are succeeding internationally, and the technical and policy enablers behind that success. Drawing on these international case studies and lessons learned, we examine the UK market context, benchmarking its progress against the global growth story. We assess the opportunities and challenges facing UK geothermal growth and set out the steps needed to create an environment in which next-generation geothermal can succeed.

Navigating England's Geothermal Regulations: Current Requirements and Recent Changes

Author(s): Diane Steele

Organisation(s): Environment Agency

Abstract

Most geothermal schemes in England require Environment Agency licences and permits to operate, unless an exemption applies. With the recent introduction of regulations for closed-loop systems and ongoing refinements to the permitting process, it is important to understand current requirements. This presentation will cover the regulatory framework for open-loop and closed-loop schemes, recent and emerging changes, and the evidence needed to support applications.

Governance and Regulation of High-Temperature Energy Storage within the European PUSH-IT project: Results from Interviews with Regulators and Operators

Author(s): Margaret Stewart, Andres Gonzalez Quiros, Corinna Abesser

Organisation(s): British Geological Survey

Abstract

The PUSH-IT (Piloting Underground Storage of Heat in GeoThermal Reservoirs) project is piloting the deployment of high-temperature underground thermal energy storage (HT-UTES) across six European sites in three technological settings: aquifers (HT-ATES); boreholes (HT-BTES); and mines (HT-MTES). As well as testing technologies, the PUSH-IT project also investigates societal engagement and governance across six pilot sites in Czechia, Germany, the Netherlands, and the United Kingdom.

Here, we present the initial results of a review and analysis of regulatory frameworks governing HT-UTES deployment in Europe, with particular focus on the PUSH-IT pilot locations. The analysis was carried out by interview with developers, regulators, and governing bodies, where we examined the permitting processes, stakeholder experiences, and key regulatory challenges affecting project development. Analysis of the interview data has enabled the identification of perceived regulatory barriers and informed the development of recommendations to support wider HT-UTES deployment across Europe.

Several common barriers were identified as contributing to prolonged permit evaluation and approval processes, including: limited regulatory familiarity with HT-UTES technologies and associated environmental impacts; insufficient guidance and accessibility of data; challenges in coordination between competent authorities; ineffective communication and/or frequent iteration between regulators and project developers; timing of the regulatory processes; lack of expertise in HT-UTES systems and technology; and the addition of further regulatory requirements when projects fall outside established frameworks. A common thread across all sites was the complexity of applying legislation and regulation created for other technologies (e.g. mining, water, oil and gas) to HT-UTES systems.
The interview process also identified positive recommendations to support HT-UTES deployment, including: online and up-to-date portals for relevant data; changes in legislation and regulation which is tailored to HT-UTES systems; good communication between regulators and developers; and higher levels of expertise to allow faster permitting.

Understanding Gender and Inclusion in the UK Geothermal Sector: Insights from a National Survey

Author(s): Rebecca Nye, Rebecca Bolton, Hester Claridge, Esme Glastonbury-Southern, Hannah Jukes, Oliver Ward, Suzie Doe, Simran Johal, Alexandra Sweeney, Sally Jack, Nadia Domanski, Lucy Cotton

Organisation(s): WING UK

Abstract

As the UK Geothermal industry grows, Women in Geothermal (WING) UK examine how gender diversity is represented and experienced within the industry, and what opportunities present themselves to increase accessibility and inclusion across the sector.

With a highly qualified workforce, our fledgling UK industry has the opportunity to learn from gender dynamics observed elsewhere in the geosciences, including the disproportionate loss of women as careers progress, often referred to as the ‘the leaky pipeline’ (Ranganathan, 2021). As the sector develops, there is an opportunity to ensure that the diversity present within today’s workforce is maintained across career levels and reflected in the senior leadership of the future. Results from a nationwide survey provide a snapshot of experiences across the UK geothermal sector. While respondents generally report high levels of leadership readiness, perceptions of whether senior leadership reflects the diversity of the wider workforce differ by gender. Additionally, we identify distinct gender differences in experiences of barriers to career advancement, including caring responsibilities, workload manageability, and a lack of role models and mentorship. These findings do not demonstrate that a ‘leaky pipeline’ currently exists within UK geothermal but highlight factors that may influence retention and progression as the sector matures.

WING UK presents the findings of this survey alongside outcomes from a panel of experts, exploring how these results should be interpreted and outlining practical actions that can be taken by organisations, individuals and allies, to prevent attrition of women from the industry at more senior levels. WING UK presents an ask to industry: how can we retain the diversity of today’s geothermal workforce as careers progress, creating a fair, sustainable and inclusive industry for the future?

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Session Two: Campus Geothermal, Cities & Heat Networks

Building a Geothermal Exemplar City: pathways for place-based urban heat decarbonisation

Author(s): Emma Bramham, James Van Alstine, Fleur Loveridge, Simon Rees, Nicholas Shaw, Catherine Bale

Organisation(s): University of Leeds

Abstract

The decarbonisation of urban heating and cooling will require more than the deployment of individual technologies. As heat-network zoning develops in England, cities need strategic approaches that integrate low-carbon heat sources, energy-system flexibility, planning, governance and community engagement. Geothermal energy offers significant potential but remains weakly embedded in mainstream urban heat planning.

Over the past four years, the University of Leeds has developed an interdisciplinary programme examining how geothermal energy could contribute to city-scale heat decarbonisation. This has combined subsurface resource assessment, modelling of heating, cooling and thermal storage, analysis of heat-network opportunities, planning and governance research, and sustained engagement with local government, industry, regulators and other stakeholders.

The Leeds case demonstrates substantial geothermal potential alongside important institutional and delivery challenges. Research suggests geothermal could contribute significantly to the city's heating needs while also supporting cooling, thermal storage and reduced pressure on the electricity system. However, technical potential alone is insufficient: deployment depends on whether geothermal becomes visible within planning, investment and heat-network decision-making.

Through successive research and co-creation activities, we identify five priorities for developing Leeds as a geothermal exemplar city:

1) a dynamic spatial and non-spatial evidence platform for resource planning and de-risking;
2) effective communication and community-engagement approaches;
3) integration of geothermal within city planning and heat-network policy;
4) anchor-load demonstrators, including major public-sector estates;
5) accessible evidence on resource availability, costs and system benefits.

We argue that an exemplar-city approach can provide a practical pathway from isolated geothermal projects towards coordinated, place-based deployment, with lessons transferable to other UK cities.

Assessing the potential for geothermal energy deployment in Greater Manchester: first steps towards a place-based solution for heating and cooling

Author(s): Cathy Hollis, Heather Bedford, Mads Huuse, David Johnstone

Organisation(s): University of Manchester

Abstract

Greater Manchester Combined Authority (GMCA) is one of the largest city-regions in the UK, comprising ten councils, an area of 1,276 km2 and home to over 3 million people. Through its Heat Network Zoning Policy, GMCA has set a target of increasing low carbon heat network capacity to >90GWh by 2030, with a goal of decarbonizing up to 36% of the regions heat demand by 2038.
The geology of Greater Manchester, with disused coal mines coupled with strong aquifers, offers the potential to develop a range of geothermal solutions. A cross-disciplinary network of geoscientists, engineers and social scientists at The University of Manchester have formed a Geothermal Network, which in March 2026 hosted a one day 'Heat Beneath our Feet' workshop on campus. The workshop brought together representatives from industry, universities, the GMCA, the BGS, and the Renewable Energy Association for short talks, discussions, and networking opportunities. Its aim was to discuss the potential, and challenges, of delivering geothermal solutions across the Greater Manchester region.

Key outcomes of the discussions were:

- Geothermal heat offers a primary delivery pathway for low-carbon heat, with bespoke solutions for different customers and heating needs,
- The neutral, trusted role of universities provides an opportunity to build public confidence in geothermal energy, through public engagement and demonstrator projects,
- Several critical barriers to deployment remain, including financial risk, disconnect of local, regional and national policy, supply chain and skills shortages, and a lack of system-level planning.

As a direct outcome of the workshop, a new project is now underway to map Greater Manchester's subsurface against regional infrastructure needs, to advise on optimal, site-specific geothermal systems. This work is tied to a wider project of geological mapping and geothermal simulation of key aquifers (Sherwood Sandstone Formation, Collyhurst Sandstone Formation, Lower Carboniferous Limestone Formation) across the northwest region.

CeraPhi Case Studies

Author(s): Karl Farrow

Organisation(s): CeraPhi Energy

Abstract

Pending

Deep Geothermal: Tales from a Project in Process

Author(s): Paul Bushnell, Matt Thompson

Organisation(s): University of York,

Abstract

In Spring 2025, the University of York launched a landmark geothermal energy project as a transformative step in its journey to Net Zero.

This multi-phased initiative will leverage the Earth's natural heat to provide sustainable energy solutions for our campus and potentially the wider community. The project positions the University of York, City and region as a leader in sustainable energy innovation, combining geothermal exploration with our renowned research and educational expertise.

We will share some of the challenges we have worked through to get to the halfway point of our project, reflecting on planning, community engagement, design, education, risk and more."

Oxford Brookes University Case Study

Author(s): Rachel Feeney

Organisation(s): Erda Energy

Abstract

Pending

Beyond the Borehole: Lessons from Szeged

Author(s): Richard Toy

Organisation(s): Ventosus UK

Abstract

Pending

Session Three: Community Engagement & Social Licence

Cross-Atlantic Lessons in Community-Led Geothermal

Author(s): Saxon Metzger, Dahlia Rose, Cale Cornelison

Organisation(s): Wilmington University, Polaris EcoSystems

Abstract

UK and EU deep-geothermal scale-up depends as much on community partnership and durable social license as on subsurface engineering. Projects more often fail in the consultation room than at the casing shoe, yet community engagement and benefit-sharing remain treated as adjacent rather than core deliverables. While the UK geothermal sector is now confronting these governance and capacity questions, U.S. Tribal energy programs have been answering them for three decades.

This talk distils lessons from Polaris EcoSystems, a Native-owned consulting firm advising Tribal Nations on energy planning, conservation, and federal funding strategy. Drawing on a portfolio of energy, conservation, and stewardship plans and dozens of solar, wind, microgrid, and infrastructure feasibility studies, we present a three-pillar framework for community-led subsurface energy development:

- Sovereignty and governance: embedding consent, co-management, and benefit-sharing before resource assessment, not after.
- Capacity building: workforce, technical, and administrative capacity as parallel deliverables, not deferred consequences.
- Finance integration: stacking grant, tax-credit, and concessional instruments around community-controlled vehicles.

The framework operationalises a model in which sovereign communities define energy goals, assess resources, and select technologies on their own timeline. We compare these structures against published UK community-geothermal engagement experience, including United Downs, Eden Geothermal, and mine-water schemes, and identify three transferable interventions for geothermal proponents working with rural, peri-urban, and culturally distinct host communities: pre-drill governance design, capacity-budget line-items at feasibility stage, and benefit-sharing structures aligned with community-defined outcomes.

The talk closes with practical recommendations for UK practitioners, funders, and policymakers seeking to accelerate deep-geothermal deployment without recreating the consultation failures the Tribal energy sector has spent a generation diagnosing.

Community-led geothermal: developing a replicable model for rural heat decarbonisation in Pickering

Author(s): James Van Alstine, Laura Smith, Rory Padfield, Emma Bramham, Fleur Loveridge, Russell Hoare

Organisation(s): School of Earth Environment & Sustainability, University of Leeds, DOAN Energy

Abstract

Deep geothermal heat networks remain an emerging approach in the UK, particularly in smaller towns where dispersed demand, limited project-development capacity and high upfront costs can constrain deployment. Yet rural communities may also offer distinctive opportunities to build networks around valued anchor loads, mobilise trusted local organisations and develop place-based governance models that retain local value.

Pickering, North Yorkshire, provides an emerging test-bed for this approach, where proposed closed-loop systems aim to harness higher than average temperature gradients in a 1.2 - 1.8 km deep, thermally conductive salt layer. A town-wide feasibility study identified a hub-and-spoke model in which geothermal energy centres anchored by schools, a leisure centre and businesses could progressively expand to serve additional commercial and residential users. Subsequent funded projects are advancing South and Central geothermal hubs using deep closed-loop borehole systems through engineering design, planning, off-taker engagement and investment preparation. The projects are also exploring governance, ownership and financing arrangements that could retain community influence and enable economic benefits to be shared locally.

A new University of Leeds partnership with Pickering Town CIC and its volunteer Geo Champions will document and examine this development journey. Combining stakeholder interviews with participatory filmmaking and sustainability storytelling, the project will capture community experiences, aspirations and concerns while identifying practical lessons for future geothermal schemes.

We use Pickering to ask what a replicable, community-led rural geothermal model requires across three interconnected dimensions: modular technical design; viable governance and financing arrangements that retain local value; and meaningful community participation throughout project development. The presentation will share early learning from this evolving programme and consider how Pickering might inform a practical blueprint for other rural towns seeking affordable, low-carbon and locally grounded heat.

The Heat Beneath Our Feet: Creatively inspiring public audiences with geothermal technologies

Author(s): Rory Padfield, Lynn Wray, Adam Booth, Rebecca Smith, Nick Lewis, Jo Nockels

Organisation(s): University of Leeds

Abstract

Geothermal energy presents a distinctive challenge for research communication and public engagement: the processes, materials and infrastructures involved are largely invisible, operating across spatio-temporal scales that are difficult to experience. ‘The Heat Beneath Our Feet’, a creative projection and audio piece developed for Light Night Leeds 2026, explores how practice-based research and creative ‘thinking through making’ can support collective sense-making around the city’s geothermal potential.

Rather than incorporating creative methods during final dissemination, the project positions making as interdisciplinary inquiry. It asks how we might translate subsurface data across sensory, spatial and temporal registers without distorting scientific meaning. How can we communicate the subsurface as dynamic, active and attractive rather than as an invisible or unknowable void? And how can sensory, narrative and arts-based approaches help audiences and researchers engage with technical and societal issues in geothermal development?

The site-specific projection transports audiences across radically different scales: geographically through Britain, West Yorkshire and Leeds, to the university campus and the precise location beneath their feet; through deep geological strata to the microscopic scale of thin sections, fractures and fluid movement. Geological maps, fault models, borehole imagery and core scans are creatively translated into an experiential narrative, before the journey reverses to imagine connections between subsurface heat and urban heat networks. The journey is soundtracked with original works inspired by seismic characteristics from the university campus.

This process has united various science disciplines with creative practitioners and technologists across the University of Leeds. Through collaborative ‘thinking through making’, different forms of data, expertise and technologies of visualisation and sonification become shared objects for discussion and experimentation. We reflect on how creative practice-based action research enables researchers to explore geothermal possibilities from multiple perspectives and considers creative practice as a methodology for interdisciplinary sense-making rather than only for communicating established knowledge.

Harnessing History to Heat Homes

Author(s): Anna Hitchmough, Dave Banks

Organisation(s): Envireau

Abstract

A novel solution to district heating provision is the use of a flooded historic underground water transfer tunnel to support groundwater-sourced heat pumps providing thermal energy to a new prestige housing development in Lichfield.

This case study highlights the steps in the regulatory route to this unusual open loop groundwater-sourced heat pump solution carried out for Friels construction in collaboration with a Midlands-based water company.

The source of the groundwater is the Principal Sherwood Sandstone Aquifer. Fortuitously the site is located on top of a historic tunnel running through the Sandstone, previously used to transport groundwater between pumping stations against the natural flow direction. The presence of the tunnel and its inspection chambers meant that no boreholes had to be drilled to abstract and recharge the groundwater and no groundwater investigation consent was needed. However, a comprehensive hydrogeological risk assessment still had to be submitted to prove there would be no adverse impact on existing water features.

An update on will be made on the scheme's progress through the regulatory process along with commentary on the challenges of working within the current regulatory framework; which was not set up with the regulation GSHP schemes foremost in mind.

Geothermal Meets the Real World

Author(s): Richard Lane

Organisation(s): Drift Group

Abstract

Pending

Session Four: Numerical Modelling & Digital Workflows

Sketch-based Geological Modelling and Flow Diagnostics for geothermal exploration

Author(s): Carl Jacquemyn, Dmytro Petrovskyy, Mohammad Al Sa'd, Gary J. Hampson, Matthew D. Jackson, Valeria Nogales Herrera, Hester L. Claridge, Alexandros Daniilidis, Pierre-Olivier Bruna, Sebastian Geiger, Andrea Balza Morales, Alexander Grayver

Organisation(s): Imperial College London, TUDelft, U Cologne

Abstract

Faults are among the dominant containment uncertainties for geological CO_2 storage. Depending on their architecture, stress state, and the coupled thermo-hydro-mechanical-chemical processes acting on them, faults can behave as barriers that compartmentalise a storage complex, as conduits that leak CO_2 towards shallower formations, or as sources of induced seismicity. Crucially, none of these behaviours can be assessed at a single scale: the controls span single-fracture apertures of micrometres to fault systems of kilometres, and injection timescales of years to containment horizons of millennia.

This keynote draws together more than a decade of work to show how a genuinely multiscale workflow can constrain fault leakage likelihood and rates. At the single-fracture scale, laboratory stress–permeability measurements across a wide range of mudrocks yield an empirical model linking permeability decline under effective stress to bulk rock stiffness. Outcrop analogue studies of caprock damage zones supply the fracture network geometry and connectivity needed to upscale these single-fracture properties to fault-zone permeabilities. Validation against natural leakage systems, notably Green River (Utah), demonstrates that this experimental–modelling approach predicts leakage locations and rates without extensive history matching. Finally, integration with ML-assisted seismic interpretation, fault seal analysis, and constrained reservoir-scale simulations extends the workflow to basin screening, as applied in the Malay Basin.

This work argues that treating faults as barriers, conduits, and seismic sources within one cross-scale framework, rather than as a binary seal/leak question, is essential for de-risking fault-bound storage sites and building the stakeholder confidence needed for large-scale deployment.

A novel approach to modelling Advanced Geothermal Systems using a 3D Geological Modelling Software

Author(s): Rifky Wijanarko, Mark Cottrell

Organisation(s): WSP

Abstract

Due to the geological risks associated with open-loop geothermal systems (such as induced seismicity and/or chemical dissolution), there is a growing appetite for the development of closed-loop advanced geothermal systems (AGS). Unsuccessful open-loop geothermal systems (often due to insufficient thermal yield) can also be retrofitted to an AGS, provided the site has optimal geothermal temperatures. Using WSP's 3D geological modelling software FracMan®, powered by PFLOTRAN, an AGS can be simulated by modelling the wellbore loop(s) as a series of high permeability conduits to simulate open bores surrounded by the target host rock. The host rock is assigned the correct thermal conductivity value to accurately simulate heat transfer between the 'wellbore', and the host rock is otherwise assigned no porosity or permeability to ensure the model accurately captures the thermal conduction performance of the system. The model grid is refined around the wellbore and made coarse in the host rock to minimise simulation time while keeping the wellbore fully connected between injection and abstraction well locations.

Geothermal flow is simulated for a specified time period and flow rate. A temperature profile at the production well is outputted which can be used to estimate power output over time. The thermal flow simulations illustrate the evolving thermal-hydraulic conditions within the system, offering valuable insight into its long-term performance. These findings serve as essential input for developing a comprehensive strategy for sustainable geothermal resource management. This novel approach offers a quick and efficient way of developing a 3D model representation of the wellbore-host rock interaction to assess a site's geothermal resource (rather than an overly simplified analytical solution) that can be readily adapted to different wellbore designs and host rock parameters to determine the most optimal well spacing and configuration required to deliver a target power output for key clients and stakeholders.

A probabilistic approach for rapid assessment of open-loop Ground Source Heating and Cooling (GSHC) and Aquifer Thermal Energy Storage (ATES) deployments

Author(s): Matthew Jackson

Organisation(s): Imperial College London

Abstract

Ground Source Heating and Cooling (GSHC) and Aquifer Thermal Energy Storage (ATES) systems offer low carbon heating and cooling. Selecting the best technology or combination of technologies for a given installation requires estimates of system performance early in the design process when detailed, site-specific data are not available. It is common for early performance estimates to test only a few selected values of key input parameters. This approach fails to capture the range of potential performance, or the probability of a given performance, and does not allow identification of key uncertain parameters that impact predicted behaviour.

He we present a simple methodology for rapid, probabilistic assessments of GSHC and ATES system performance from uncertain data using a Monte-Carlo approach. The method does not require complex numerical simulations; rather, it allows the use of data from analogue systems to guide the range of input parameters that impact performance. It is assumed that the system under analysis is energy balanced and approximately volume balanced, and that system parameters and predictions can be represented using average values over a given heating or cooling cycle. The methodology is implemented in an open-source software tool. The method and software are demonstrated using a case study of Imperial's South Kensington campus in London.

Author(s): Meissam Bahlali, Carl Jacquemyn, Matthew Jackson

Organisation(s): Imperial College London

Abstract

Aquifer Thermal Energy Storage (ATES) offers a promising route to decarbonising heating and cooling in dense urban environments, but performance depends on reliable operation in heterogeneous aquifers under time-varying demand. Beneath central London, heterogeneity in the Chalk aquifer produces complex thermal plume behaviour and significant interference where multiple boreholes are deployed on confined sites. This study presents the design of an ATES system proposed for Imperial College London's South Kensington campus, a spatially constrained site with high heating demand.

The simulated configuration and operating limits are based on probabilistic scoping scenarios developed using Monte Carlo sampling of uncertain design and operational parameters. Selected scenarios are investigated using numerical simulations under realistic geological and operational constraints.

A bespoke dynamic flow-rate controller is implemented through time-dependent borehole boundary conditions. The controller adjusts individual doublet flow rates to meet a target heating and cooling demand while accounting for evolving production temperatures and heat-pump performance. Flow is allocated across doublets ranked by inter-borehole distance: the most widely spaced are activated first, with closer doublets activated as demand increases. Partial loading is allowed, and doublets are automatically shut down when warm-well temperatures fall below, or cool-well temperatures exceed, ambient groundwater temperature.

The base case represents a P50 scenario with five active doublets. Lateral plume spreading through high-permeability karst intervals causes thermal interference and, in some boreholes, thermal breakthrough, which is managed by the flow-rate controller. Despite complex plume development, the system delivers the target demand. Spacing boreholes using conventional multiples of the thermal radius would not achieve this. Although interference reduces thermal recovery, accepting and actively managing it enables higher energy delivery than designing the system to avoid interference. Our results suggest that high borehole density, combined with temperature monitoring and active control, may maximise energy supply from ATES systems in spatially constrained urban environments.

Exploring Challenging Subsurface Settings for ATES

Author(s): Luka Tas, Carl Jacquemyn, Meissam Bahlali, Matthew Jackson, Thomas Hermans

Organisation(s): Ghent University, Imperial College London

Abstract

By 2030, the European RED III directive targets supplying nearly half of the building sector's energy, consisting mostly of heating and cooling, with renewables. Achieving this ambitious goal requires aquifer thermal energy storage (ATES) systems to massively scale up and diversify beyond their traditional application in productive sandy aquifers. Two Belgian case studies illustrate approaches for assessing feasibility in more complex geological settings.

First, a very shallow and low-permeability aquifer on a university campus is explored. To meet energy demand, an unusually large number of wells would be required, each operating at its maximum, yet relatively low, hydraulic capacity. An extensive modelling study that incorporates subsurface and operational uncertainty was done, using only preliminary site data. Joint probability distribution estimation and kernel density estimation were applied to the outputs of Monte Carlo simulations. This resulted in an uncertainty-informed classification informing decision-makers about project feasibility before investing in costly field tests. To validate this approach, an extensive field campaign was conducted, including geophysical well logging, evaluation of well development strategies, clogging risk testing, and abstraction-injection tests.

The second case study focuses on a fractured quartzite reservoir. Although 14 ATES systems are operational in this reservoir, the efficiency of new installations remains highly uncertain due to uncertainty in preferential flow paths. We propose a well connectivity modelling strategy using the IC-FERST simulator and show its ability to actually reproduce field data. In addition, Monte Carlo simulations that include subsurface uncertainty were done for both a short-term tracer test and a long-term ATES operation. As such, we can identify key subsurface parameters influencing the predictions (with sensitivity analysis) and calculate probabilistic estimates of key indicators, such as thermal breakthrough risk and timing, and the expected energy recovery.

Together, these studies illustrate how uncertainty-aware modelling can support the development of ATES in non-traditional settings.

Long-Term Performance and Sustainability of Asymmetric Open-Loop Geothermal Heating: Numerical Modelling of an 8-Month Extraction, 4-Month Recovery Strategy

Author(s): Allegra Giblin Torlucci, Emma Bramham, Fleur Loveridge, Simon Rees, Tong Zhang, Mohammad Reza Zavvar Sabegh, Nick Shaw

Organisation(s): School of Earth and Environment, University of Leeds

Abstract

Transitioning urban buildings from older fossil-fuel reliant heating systems presents distinct hydrogeological and operational challenges. The University of Leeds (UoL) Geothermal Living Lab project commenced in 2022 as part of wider plans to decarbonise the campus estate by 2030. The project included drilling two open-loop geothermal wells that provided opportunities to explore potential decoupling of the engineering buildings and a residence hall from the campus-wide gas-driven steam network on to a decarbonised multi-faceted solution including ASHPs and geothermal. Expanding on initial ATES feasibility studies presented in 2025, this work uses well data to evaluate future operational dynamics and subsurface performance of a heating-only open-loop system at UoL.

Where traditional European heating models assume balanced, 6-month heating/cooling cycles, UK heating requires asymmetrical 8-month extraction/4-month re-equilibration cycles to satisfy heating demand. Using hydrogeological modelling and site-specific building load profiles, we investigate the subsurface response to this extended heat extraction regime.

Key parameters evaluated include: subsurface advective transport (local groundwater flow velocities/ hydraulic gradients control migration/stability of the cold thermal plume generated during 8-month extraction over 10-25 year periods); thermal breakthrough (well spacing sensitivity analysis, potential benefits of a 3rd well, and hydraulic vector alignment to determine time-to-breakthrough and long-term COP effects); and thermal recovery and operational risks (extent of localized aquifer cooling over multi-year cycles and effects of operations during peak winter demand).

Results highlight that proper subsurface characterisation of local groundwater flow regimes and rock properties is paramount. In high-demand asymmetrical heating systems, misjudging subsurface flow direction or velocities can accelerate cold-water breakthrough between the doublet, drastically reducing seasonal thermal efficiency. We present modelling outcomes based on the UoL system to guide choices for determining operational envelopes and engineering design for managing shallow open-loop heating doublets, offering a practical framework for retrofitting legacy university and municipal heating networks across the UK.

Oral Presentations: Day Two

Session Five: Minewater Geothermal & Thermal Energy Storage

Project IMPACT: Investigating Mine Potential for Cooling and Storage

Author(s): Fiona Todd, Rebecca Chambers

Organisation(s): Mining Remediation Authority

Abstract

At the beginning of 2026 the Mining Remediation Authority (MRA) undertook a world leading thermal energy storage test with the aim of unlocking future potential opportunities for mine workings to store excess energy from sources such as heat networks or data centres. We injected 98 MWh of energy over a 25-day period at the British Geological Survey's (BGS) UKGEOS Glasgow observatory, making it the longest and hottest heat storage test in Great British mine workings. Water was abstracted from a deeper mine seam and reinjected up to 32°C in a shallower seam. Data was collected from all available on-site sensors to understand environmental changes during heat injection, including water level and temperature, soil and atmospheric gas, water quality (including microbiology) and ground movement. This presentation will provide details of the experiment and outline some of the initial data analysis collected.

Mine-Groundwater Interactions and the Effects on Mine Water Geothermal Resource Feasibility

Author(s): Callum Thomas, Jeroen van Hunen, Julia Knapp

Organisation(s): Department of Earth Sciences - Durham University

Abstract

Understanding the hydraulic processes not just within flooded mines, but of the local groundwater regime is key for accurate characterisation and modelling of the heat extraction and storage potential of Mine Water Geothermal (MWG) systems. Here, we investigate the interaction between local groundwater regimes and MWG systems, using the software tool MODFLOW to develop a 3D groundwater model to assess the rate of groundwater flow through flooded mines.

We have completed conceptual modelling and sensitivity analysis, gaining a first-order view of how the distribution of hydraulic properties alters through-flow. Here, we present the results of i) conceptual modelling, ii) parametric sensitivity analysis, and iii) a statistically based empirical solution, aiming to assess how varying hydrogeology of mined strata influences the rates of groundwater flow through flooded mines, helping to de-risk MWG application.

Initial findings suggest that local groundwater flow has a significant role in the hydraulic conditions of MWG schemes and should be a key consideration when selecting sites for new schemes. Significant flow through the mines could have positive or negative impacts on the geothermal scheme, depending on the use case. For extraction schemes, a regular replenishment of upstream warm water would be beneficial for the longevity of the scheme, with mitigation of resource depletion. But for storage purposes, a strong flow through the mine would carry the warm water away from the site leaving it unsuitable. This is a particularly important consideration for seasonal storage and extraction schemes, such as the ICHS project at Durham University.

Time-dependent GEMSToolbox: fast, accurate heat exchange for mine water heat storage

Author(s): Difu Shi, Jeroen van Hunen, Julien Mouli-Castillo

Organisation(s): Durham University, University of Glasgow

Abstract

Mine Water Heat Storage (MWHS) in abandoned, flooded coal mines offer large-scale, low-carbon seasonal storage for former mining regions. Feasibility tools sit at two extremes: intensive 3D coupled-process simulators, or analytical solutions with limited site specificity. GEMSToolbox bridges this gap with fast semi-analytical heat exchange and efficient flow solvers for complex mine geometries. It currently targets heat extraction only.

Here we present the next stage of GEMSToolbox development: the transition from a one-step, quasi-steady framework to a time-stepping code representing charging, storage and discharging cycles, while retaining the speed needed for wide parameter exploration.

The natural route to time-dependence is superposition: the problem is linear in temperature, so an operating history can be built from the responses to a sequence of step changes. Applied to injection temperature at fixed flow it is exact, cheap, and remains the right tool. But heat storage is not usually that case: charging and discharging change the flow rate and reverse its direction, and the response depends on the flow, so no sum of temperature steps can represent it. Cycling therefore needs a formulation that carries the rock's thermal state through flow changes.

Following Rivas et al. (2026), we solve the rock conduction and represent its thermal memory by a kernel, compressed as a sum of exponentials. The rock is no longer an explicit unknown, leaving an inexpensive advection problem. For goaf (collapsed workings) the worked area is meshed from its digitised mine-plan outline, so its mapped shape sets the flow paths and residence times. Over repeated charge–discharge cycles it agrees closely with a converged numerical reference at a fraction of the cost. The same machinery covers open galleries, with the cylindrical rock response entering as its own memory kernel. We will report those results and progress toward a site-scale demonstration.

Using Heat to Characterise Groundwater Flow in a Fractured Chalk Aquifer

Author(s): Joseph Kelly, Fleur Loveridge, Adam Booth, Simon Rees

Organisation(s): University of Leeds

Abstract

Designing sustainable open-loop geothermal systems requires a good understanding of thermohydraulic ground properties. Several experimental and modelling techniques are deployed to derive a high-resolution characterisation of a shallow aquifer in the Chalk of West Berkshire; temperature data are obtained using distributed temperature sensing (DTS) of both u-loop and heated cable thermal response tests (TRT), then analysed using two distinct analytical approaches – the Moving Infinite Line Source (MILS) and Mass Heat Transport with Dispersion (MHTD) models.

Building on the work of Kyrkou et al. (2026), data from a distributed TRT has been analysed with greater complexity to derive estimates of groundwater flow rate changes with depth and build a hydrostratigraphy of the aquifer. This has been supplemented by further deployments of DTS-instrumented heated cable tests in two other boreholes at the same site, allowing comparison of temperature profiles to build a three-dimensional picture of fracture zone continuity between boreholes.

The MILS and MHTD models give broad agreement on flow rates in the high-flow upper zones, though a disparity emerges in the deeper low-flow region. Assessment of the temperature profiles in the three 100m-deep boreholes at Trumpletts Farm reveals a distinct signature of the Chalk Rock stratigraphic unit in all three, plus broadly continuous high flow zones, although flow is concentrated in distinct patterns of localized high-flowing fractures.

Analysis interpretation is complicated by the open borehole completions, and further testing in grouted boreholes on the University of Leeds campus is planned to provide a comparison dataset. A numerical model is being developed to allow validation of the analyses through synthetic TRTs, and forward modelling using derived parameters as an aid to system design.

Effective Thermal Conductivity of the Sherwood Sandstone, evaluated from time-lapse Electrical Resistivity Imaging

Author(s): Adam Booth, Mihai Cimpoiasu, Jimmy Boyd, Abir Al-Ajmi, Michael Spence, Paul Wilkinson, Jack Croft, Dave Hetherington

Organisation(s): University of Leeds, British Geological Survey, PDO

Abstract

Successful design of ground-source heat-pumps requires reliable determination of heat transport parameters, especially ground thermal conductivity. Thermal response tests (TRTs) are routinely undertaken to establish an effective thermal conductivity, □eff. Most TRTs express □eff as a bulk value for the depth range under test, although distributed approaches (e.g., using fibre optic temperature sensing) are becoming more widespread. Here, we present distributed evaluations of □eff using temperatures derived from cross-borehole electrical resistivity imaging (ERI) at the British Geological Survey's UKGEOS Cheshire facility, sampling a Sherwood Sandstone aquifer. ERI data are compatible with thermal monitoring since, when heated, the resistivity of water reduces due to improved ion mobility: typically, it is assumed that resistivity will reduce by 1-2% for every 1°C of heating. ERI can therefore detect and quantify evolving thermal plumes and, using an Infinite Line Source (ILS) method, we show that it can additionally provide estimates of □eff that are highly comparable with laboratory and in-situ equivalents.

During site commissioning in 2025, ERI data were recorded in a 3-day heat-tracing experiment, injecting 58.5 W/m into four 94 m-long closed-loop heating pipes. Cross-borehole ERI was conducted in two orthogonal transects using a BGS PRIME system, with a resistivity image obtained every 12 hours. 2D time-lapse inversions resolve resistivity decreases that track the heating schedule: heat concentrates around the boreholes, consistent with the conduction- rather than advection-dominated transport in the low-flow aquifer. Resistivity changes are expressed as temperature and, using an adapted ILS method, we evaluate □eff between [1.40-4.57] W/m.K. TRTs conducted with fibre optic distributed temperature sensing suggest □eff between [3.5-3.8] W/m.K, with laboratory tests on core samples somewhat lower at ~2.9 W/m.K. Sensitivity testing of the ERI-derived □eff suggests that uncertainties could be significantly reduced with further understanding of the fluid properties that govern the relationship between temperature and resistivity.

Session Six: Fractures, Reservoir Characterisation & UK Exploration

De-risking UK Lower Carboniferous Limestone geothermal resources using legacy seismic and potential-field data

Author(s): Mohamed Gouiza, Dave Healy, Nick Shaw

Organisation(s): Geosolutions Leeds - School of Earth, Environment and Sustainability, University of Leeds

Abstract

Lower Carboniferous limestones (LCL) are a potentially important deep geothermal resource across central and southern Britain, but their prospectivity remains difficult to assess because permeability is highly heterogeneous and subsurface geometry is uncertain. We use legacy hydrocarbon exploration and regional geophysical datasets from the Welton area, East Midlands, to develop an example of an integrated structural framework for geothermal assessment.

The study combines a reprocessed 3D seismic volume, 11 exploration wells, land-gravity data and aeromagnetic data. Seismic horizons and faults were interpreted and depth converted; Bouguer gravity and reduced-to-pole magnetic data were spectrally separated, enhanced and analysed for structural lineaments and source depths. 3D gravity forward modelling and density inversion, constrained by seismic geometry and borehole density logs, were used to test the subsurface interpretation.

Results reveal an asymmetric NW–SE-trending graben partitioned into a western rift-bounding fault corridor, an eastern relay system and a northern fault-intersection zone, with numerous fault-segment linkages. Potential-field lineaments reproduce the dominant NW–SE structural grain and locally extend or connect seismic-scale faults, indicating a deeper inherited structural template. Seismic-stratigraphic relationships also record late Carboniferous inversion, including localised doming, erosion of the top LCL and onlap of younger Carboniferous strata. In the south-west and east, uplift may have promoted exposure, meteoric circulation and palaeo-karstification within already fractured limestone. Gravity modelling shows that LCL and basement geometry alone cannot reproduce the observed field, indicating significant lateral density heterogeneity within the basement and/or Carboniferous succession.

The proposed integrated model suggests that the most prospective geothermal zones are likely to occur where several permeability-enhancing features coincide – i.e., major fault zones, relay and linkage structures, fault intersections, and inversion-related uplift with possible palaeo-karstification. This study demonstrates how integration of legacy seismic and potential-field datasets can reduce subsurface uncertainty and help prioritise future appraisal of structurally complex carbonate geothermal reservoirs.

From outcrop to reservoir: multi-scale fracture analysis for potential deep geothermal development in Cornwall

Author(s): Priyanka Paul, Dr. Richard Haslam, Dr. Christopher Rochelle

Organisation(s): British Geological Survey

Abstract

High radiogenic heat production in the Cornubian Batholith, together with well-connected fracture networks capable of sustaining deep fluid circulation, underpins its geothermal potential. With deep geothermal heat and electricity production commencing recently in Cornwall, an improved understanding of fracture architecture, connectivity and spatial variability is essential for reservoir characterisation for reducing uncertainty in subsurface models. We investigated these structural controls using the Land's End Granite, one of the best-exposed parts of the Cornubian batholith, as a surface analogue for fractured geothermal reservoirs in crystalline basement. Fracture architecture was characterised across multiple scales using aerial imagery, one-dimensional scanlines, manually digitised two-dimensional coastal exposures, outcrop photographs and three-dimensional drone-derived point-cloud models. The fracture network is dominated by NW-SE and NE-SW orientations, with subordinate E-W structures locally associated with granite-metasediment contacts and mineralised zones. Fracture spacing varies from comparatively regular to strongly clustered, indicating substantial heterogeneity in potential fluid pathways. Fractal and multifractal analyses identify scale-dependent behaviour, suggesting that fracture organisation reflects interacting tectonic, lithological and mechanical controls rather than a spatially uniform reservoir network. Two-dimensional topology reveals abundant connected branches and Y-nodes, consistent with mature and locally well-connected fracture systems. 3D models show hydrothermally mineralised fault cores (silica and Fe carbonates/oxides) bordered by alteration zones of reduced fracture density, with fracture intensity increasing sharply beyond them. The consistency between one-dimensional spacing patterns, two-dimensional connectivity and three-dimensional fracture intensity distributions provides a quantitative basis for understanding reservoir scale permeability in fractured granites. These results support construction of discrete fracture networks, estimation of permeability tensors and thermo-hydraulic modelling of fluid flow. They also demonstrate that a multi scale structural workflow can be applied effectively even in data poor regions, offering a robust approach for characterising fractured geothermal reservoirs.

Seismic Anisotropy of Hengill geothermal area, southwest Iceland

Author(s): Esme Glastonbury-Southern, Andy Nowacki, Brandon VanderBeek, Thorbjörg Ágústsdóttir, Dario Ingi Di Rienzo

Organisation(s): University of Leeds, University of Oxford, Iceland GeoSurvey (ÍSOR), Reykjavík Energy (Orkuveitan)

Abstract

Subsurface fracture networks play a key role in the circulation of geothermal fluids in the crust, and understanding these is crucial in characterising geothermal targets. Earthquakes occurring on faults in the shallow crust, recorded using a network of seismometers, provide a useful source of information about the subsurface.

‘Seismic anisotropy’ refers to the directional dependence of seismic wave speed, and can be measured using shear-wave splitting, when an S-wave from an earthquake splits into a polarised fast and slow component upon entering an anisotropic medium. The delay time between the components shows how strong the anisotropy is, and the orientation of the fast polarisation reflects the orientation of the anisotropic fabric, which can result from fractures within the crust which may be preferentially aligned and/or opened and closed in response to the crustal stress regime.

In this study, we investigate seismic anisotropy at Hengill in southwest Iceland. The region is host to Iceland’s two largest geothermal power plants, and experiences elevated natural seismicity as well as induced seismicity associated with the geothermal power plants. We use a seismicity dataset recorded between 2018 and 2021 to make shear-wave splitting measurements sensitive to the top few kilometres of the crust. Comparing our observations to datasets of mapped surface faults and borehole logs, we find good agreement between all three in certain places, however, in other areas where downhole data are not available, we find the fast polarisation orientation may disagree with surface mapping data by up to 73°, suggesting complex subsurface structures (e.g., faults and fractures at depth, or lithological features like dykes) may not always manifest at the surface. This study shows that imaging methods such as shear-wave splitting can provide subsurface insight for geothermal exploration prior to drilling, helping to reduce risk and improve decision-making within the geothermal industry.

Modeling fracture networks and fluid flow in the Þeistareykir geothermal area

Author(s): Aastha, David Healy, Emma Bramham, Andy Nowacki, Nick Shaw, Anette Mortensen

Organisation(s): Geosolutions Leeds, School of Earth, Environment & Sustainability, University of Leeds, Landsvirkjun, Iceland

Abstract

Structures such as fractures and faults play an important role as fluid flow pathways in geothermal reservoirs located in active tectonic regions. Fracture networks can act as either conduits or barriers to the movement of fluids and regulate the permeability, heat flow and associated geothermal activity in the subsurface. The Þeistareykir geothermal field, located within the Northern Volcanic Zone (NVZ) of Iceland, represents a structurally complex geothermal system governed by the interaction of both rift-related extension and transform-zone tectonics. Geothermal drilling results reveal substantial variations in temperature and permeability across the field, indicating strong structural controls on reservoir behaviour.

Fracture analysis based on borehole televiewer interpretation highlights the structural character of the permeable feed zones, ranging from high-density fracture clusters, damage zones, very large aperture fractures, lithological boundaries and localized silicic intrusions. Moreover, fracture orientations also vary widely, implying that fluid flow is accommodated by multiple intersecting fracture sets rather than a single dominant structural trend. These results strongly indicate that geothermal fluid movement in Þeistareykir is constrained by the fault and fracture networks. To better understand these structural controls, we integrate a range of geological, geophysical, petrophysical, and drilling datasets from the Þeistareykir geothermal field into building 3D discrete fracture network (DFN) models across all major lithological units. Fluid flow simulations are performed through the DFNs to quantify permeability and its anisotropy. Such integrated structural characterization and modelling approach provides new insights into the fracture network geometry and connectivity at reservoir scale and how it governs bulk permeability and preferential fluid pathways in this tectonically complex environment. This study will lead to a better prediction of the reservoir behaviour and defining geothermal reservoir boundaries, ensuring the sustainable management and long-term utilization of geothermal resources in the region.

GEMINI Integrated Geophysical Surveys for Deep Geothermal Exploration in County Antrim

Author(s): Michael MacKenzie, James Shaw, Duygu Kiyan, Dieno Diba, Giuseppe Maggio, Vincent Roche, Emilio Carrillo

Organisation(s): Geological Survey of Northern Ireland, Dublin Institute for Advanced Studies, University College Dublin

Abstract

GEMINI (Geothermal Energy Momentum on the Island of Ireland) is a cross-border project that aims to de-risk geothermal development and support market growth through research and practical demonstration at multiple sites across the island of Ireland.

As part of GEMINI's deep sandstone reservoir exploration programme in County Antrim, multiple geophysical surveys have been completed across an area of approximately 530 km², significantly increasing both the spatial coverage and resolution of geophysical data compared with previous investigations in the region.

The surveys were undertaken within the Permo-Triassic Lough Neagh Basin, which has been identified as a prospective geothermal target owing to the presence of regionally extensive deep sandstone aquifers, including the Triassic Sherwood Sandstone Group (SSG). Characterisation of the basin is challenged by the extensive Paleogene basalt cover of the Antrim Lava Group and the limited availability of subsurface data. Borehole records indicate basalt thicknesses of up to approximately 800 m, while the depth to the top of the SSG ranges from around 500 m to 1,500 m across the study area. This spatial variability reflects the basin's complex structural evolution and highlights the uncertainty associated with geothermal resource assessment and development.

GEMINI partners acquired co-located gravity (606 sites; May to September 2025), magnetotelluric (119 stations; June to August 2025), and passive seismic (26 stations; deployed for 18 months) datasets across County Antrim. Ongoing processing and interpretation of these datasets will inform geological modelling, reduce subsurface uncertainty, and support geothermal resource assessment within the Lough Neagh Basin.

Imaging Aberdeen with seismic noise: passive seismic methods for geothermal exploration

Author(s): David Cornwell, Amy Gilligan, Clare Bond, Iona Copley, Joe Armstrong, Vahid Vaziri, John Underhill, Tristan Roberts, Bartosz Kurjanski, Jean-Christophe Comte, Jefferson Gomes, Francisca Robledo, Eoin McManus, Mauro Garcia Enriquez, Clarissa Gordon

Organisation(s): University of Aberdeen

Abstract

The Aberdeen Geothermal Feasibility Pilot is a £1 million NERC-funded project assessing the geothermal potential beneath Aberdeen. It combines a new research borehole, geological and thermal investigations, passive seismic surveys and long-term subsurface monitoring to improve understanding of the city's geology and support future low-carbon heat development. This talk will introduce the use of ambient seismic noise as a practical subsurface-imaging tool and present new results from two complementary deployments. A dense campus array is being used to investigate shallow geological variability around the research borehole, while a wider city-scale array is being used to develop velocity models across Aberdeen. The results show how ambient-noise methods can provide constraints on subsurface structure at relatively low cost, while also highlighting the challenges of working in a complex urban environment. The talk will consider how these methods can complement conventional geological and geophysical datasets, reduce uncertainty and support geothermal screening, site selection and appraisal.

Session Seven: Innovative Techniques, Data & Monitoring

Thermal Conductivity of the Lower Pennine Coal Measures & Upper Millstone Grit at the University of Leeds Geothermal Living Lab

Author(s): Fleur Loveridge, Aakash Gupta, Eve Hearnshaw, Emily Williams, Tochukwu Eze, Jared West, Richard Collier, Emma Bramham, Simon Rees

Organisation(s): University of Leeds, Cementation Skanska

Abstract

Thermal conductivity is one of the key parameters required for the design of closed loop shallow geothermal energy systems. In the UK, laboratory measurements of rock thermal conductivity were made as part of government supported campaigns exploring deep geothermal energy in the 1970s and 1980s, with data compiled for ground source heat pump applications more recently by the British Geological Survey. In situ thermal response tests are also routinely undertaken to support development of specific shallow geothermal projects, but these data are often held privately and are typically not publicly available. As a consequence, many UK strata remain to be well characterised in terms of their thermal properties.

As part of the University of Leeds geothermal campus living laboratory, there has been an opportunity to undertake detailed thermal properties profiling over several hundreds of metres of Lower Pennine Coal Measures and Upper Millstone Grit stratigraphy. Cuboid specimens were cut from sub-samples of the 500m of core available from two pilot holes drilled on the University campus. Laboratory testing using a C-Therm Modified Transient Plane Source (MTPS) has been conducted on up to six faces of 141 individual specimens of mudstone, siltstone and sandstone. The results show expected trends of increasing thermal conductivity with grain size due to higher quartz content in the coarser materials, with notable anisotropy, especially in the finer materials, all overlain by significant small-scale heterogeneity. Average material scale thermal conductivity values in excess of 3.5 W/mK indicate excellent shallow geothermal potential. Thermal response testing from closed loop boreholes at the same site show the differences between field and laboratory scale measurements and the importance of groundwater in understanding field behaviour, potentially greatly enhancing geothermal capacity.

Characterisation of ground source heat pump boreholes at the BGS Keyworth Campus 'Living Lab' in Nottingham, UK

Author(s): David Boon, Magret Damaschke, Dan Crow, Gershwyn Soanes, Jason Ngui, Elisabeth Steer, Joanna Thompson, Jack Heath, Holly Unwin, Romaine Graham, Jan Hennissen, Simon Kemp, Emily Gammon, Daniel Condon

Organisation(s): British Geological Survey, BGS Keyworth

Abstract

The Natural Environment Research Council (NERC) has a target to half its carbon emissions from heating by 2030 on the way to achieving Net Zero by 2050. The space heating of two mixed-use buildings on the British Geological Survey (BGS) Keyworth Campus in Nottinghamshire was decarbonised in 2025 using ground source heat pump systems (GSHP). The ground array comprises 28 vertical closed-loop boreholes installed to around 225m coupled to 5 x 60 kW capacity heat pumps.

The project includes a shallow geothermal 'Living Lab', featuring in-ground monitoring of 6 of the GSHP boreholes using hybrid fibre optical cables for distributed temperature sensing (DTS), distributed acoustic sensing (DAS), and electrical resistivity tomography (ERT). The DTS system continuously monitors borehole temperature every 0.25m down the well every 3 minutes to characterise heat extraction and recovery behaviour. The heat pump energy consumption, flow rates, and flow and return temperatures on the primary and secondary side and the heating circuit are logged every 30 mins enabling calculation of COP and Seasonal Performance Factors. One of the GSHP boreholes, named 'Keyworth D', was cored to 238.5m, providing continuous 102 mm diameter core from the Mercia Mudstone Group and Sherwood Sandstone Group. Geophysical logging, multi-property core scanning and other analyses have been performed by the BGS to characterise the ground and boreholes to support system modelling, wider geoscientific research and inform future drilling campaigns. Drilling and looping in the Mercia Mudstone Group was challenging (as expected) due to the weak mudstone with gypsum and complex alteration and weathering history contributing to poor rock quality which causing borehole instability and casing strings getting stuck.
Rock core analysis has generated a new comprehensive geoscientific dataset for the Mercia Mudstone Group including sedimentary and engineering geology logs, thermal conductivity measurements (lab and TRT), geophysical wireline data, Natural Gamma, Magnetic Susceptibility, Density, Radiographs, CT scans, XRF, XRD. The core analysis data is due to be released via NGDC in late 2026.

Revisiting Borehole Heat Flow Estimates from the British Isles Using a Reproducible Computational Framework

Author(s): Mark Ireland

Organisation(s): Newcastle University

Abstract

Terrestrial heat flow is a fundamental constraint on the thermal state of the Earth's crust and underpins studies of geothermal resources, lithospheric structure and basin evolution. Although extensive archives of borehole temperature and thermal conductivity measurements exist, their application is often limited by inconsistent methodologies, incomplete conductivity records and limited quantification of uncertainty. We use pyboreflow, an open-source Python framework under development, that enables standardised, reproducible and uncertainty-aware estimates of conductive heat flow from borehole observations.

Pyboreflow implements an interval-based Bullard method that considers temperature gradients across the vertical thermal-resistance structure, rather than relying on a single point conductivity measurement. Layered conductivity models retain the provenance of measured, interpolated and lithology-derived values, allowing uncertainty in conductivity to be propagated into heat-flow estimates. The workflow systematically evaluates depth intervals to identify quasi-linear conductive domains, allowing intervals affected by shallow climatic perturbations, groundwater flow or lithological heterogeneity to be distinguished from those representative of conductive heat transport. Raw and paleoclimate-corrected temperature profiles can be analysed, with uncertainty quantified through Monte Carlo simulation incorporating uncertainty in temperature observations, conductivity structure and climate forcing histories.

We apply the framework to boreholes from across the British Isles and compare revised estimates with published heat-flow values. Detailed analyses are undertaken for selected boreholes with comprehensive temperature, conductivity and stratigraphic data, while a wider set of boreholes lacking comprehensive data is re-evaluated using conductivities assigned using lithologies. Together, these analyses demonstrate how methodological choices and explicit treatment of uncertainty can materially affect inferred heat-flow patterns.

For several representative boreholes, revised heat-flow estimates differ from published values by more than 10 mW m^{-2}. Such revisions may propagate into regional geothermal models when extrapolated beyond direct borehole observations, potentially affecting interpretations of regional heat-flow patterns, geothermal gradients and the geological controls on heat-flow variability. These results suggest that existing regional heat-flow estimates warrant a systematic re-evaluation across the British Isles.

Thermogeological tidbits from the Caledonian table: preliminary findings of THERMOCAL in the UK

Author(s): Sean Watson, David Banks, Gioia Falcone, Ulrich Ofterdinger, Mahmoud Abdellatif, Tristan Bench, Alan J. Cresswell

Organisation(s): University of Glasgow, Queen's University Belfast, Scottish Universities Environmental Research Centre - SUERC

Abstract

The project THERMOCAL (EPSRC EP/U536878/1) aims to review existing data and to acquire new datasets on rock thermal conductivity, heat capacity and radiogenic heat production from the Caledonian orogenic belt (and adjacent terranes) of Northern Ireland, Scotland and Norway.

Collection and analysis of new samples is underway and a thorough review of existing data from Northern Ireland and Scotland has been carried out. Key findings from the reviews of existing data include:

- No clear, consistent correlation of thermal conductivity with depth has been found in the depth range 0 – 300 m.
- In metamorphic rocks, there is no clear correlation between conductivity and metamorphic grade, although lithology does appear to be important, with higher conductivities in quartzites and psammites than metapelites.
- While bulk (geometric mean) conductivities in the Dalradian and Moinian metamorphics tend to have an interquartile range of 3.0 to 3.8 W/m/K, anisotropy in the thermal conductivity tensor is significant in metamorphic rocks.
- Comparison of ranges of thermal conductivity from different studies has not revealed glaring inconsistencies. Scottish Caledonian granites tend to exhibit interquartile ranges in conductivity of around 2.8 to 3.7 W/m/K.
- "Old Red Sandstone" of the Midland Valley tends to have a higher interquartile range of thermal conductivity (3.1 to 3.8 W/m/K, N=72) than the Devonian Caithness Flagstones of the Orcadian Basin (2.3 to 3.2 W/m/K, N=118).
- Within a given stratigraphic unit, significantly differing thermal conductivity distributions are recorded at differing locations, suggesting that lateral differences in lithology and facies are important.
- Whole rock analysis of U, Th and K provide a powerful geochemical tool for estimating radiogenic heat production in a wide variety of lithologies and is currently being applied to historic data sets from the Caithness Flagstones and Moinian metamorphics.

Making Shallow Geothermal Work: Lessons from Deep Drilling

Author(s): Ian Farmer, Katrina Topping, Karen Spenley

Organisation(s): Independent Drilling Consultant, REA, Carbon 13

Abstract

Shallow geothermal energy offers a significant, reliable and low-carbon resource for decarbonising heating and cooling in the UK. However, deployment remains constrained by project cost, perceived drilling risk and limited industry confidence. Drilling can account for more than 40% of project cost and is often considered the highest-risk phase, particularly in complex or variable geology.

This paper examines how drilling techniques, technologies, engineering practices and safety systems developed through decades of complex oil and gas well construction can be transferred to UK shallow geothermal drilling. The UK is well positioned to exploit this knowledge, with extensive North Sea drilling expertise, technology and supply-chain capability. Historically, however, these approaches have been considered too costly or complex for shallow geothermal applications.

Drawing on four years of UK shallow geothermal project delivery and 30 years of international oil and gas drilling experience, the paper presents case studies from large-scale shallow geothermal developments across mixed and challenging geological settings. The projects demonstrate how oil and gas drilling methodologies—including enhanced planning, well engineering, risk management, drilling optimisation, equipment selection, real-time decision-making and rigorous safety practices—can improve productivity and reduce project risk.

The case studies demonstrate drilling-cost reductions of 30% and the delivery of projects previously considered technically challenging or commercially unviable. The results indicate that technology transfer, rather than technology development alone, can materially improve the economics and bankability of shallow geothermal projects.

Increasing confidence and reducing costs in shallow geothermal may also provide a pathway towards wider deployment of medium- and deep-geothermal resources. Establishing a technically credible and commercially scalable shallow geothermal sector is therefore important not only for near-term heat decarbonisation, but potentially foundational to the UK’s wider geothermal industry.

The Geothermal Potential of the Humber Region

Author(s): David Peacock, Mark Anderson

Organisation(s): University of Hull

Abstract

A three-part assessment of geothermal energy potential is presented for the Humber region, comprising reservoir screening, geothermal favourability mapping and heat-extraction modelling. Reservoir screening identifies the Sherwood Sandstone as the most favourable target because of its relatively high temperatures, good reservoir properties and extensive data coverage. Geothermal favourability mapping indicates that the most favourable locations for development occur along the Humber Estuary corridor, including Hull and Grimsby, where reservoir temperatures and heat demand are highest. Heat-extraction modelling suggests that the Sherwood Sandstone could provide substantial quantities of low-carbon heat, although heat pumps would generally be required. While current energy prices limit economic competitiveness, integration with renewable electricity generation and seasonal heat storage could improve viability. Geothermal development could also reduce carbon emissions and enhance energy security. While site-specific models are presented, the next step is to develop technically and economically viable projects that integrate geothermal energy into regional low-carbon energy systems, supporting decarbonisation, energy security and industrial competitiveness.

Session Eight: Geothermal From Around the World

Testing Geothermal Hypotheses beneath Corbetti, Ethiopia with 3D S-wave seismic tomography

Author(s): Andy Nowacki, Ruiyi Yang, Brandon VanderBeek, Sebastian Rost

Organisation(s): University of Leeds, University of Bristol, University of Oxford

Abstract

Corbetti in Ethiopia is a silicic rift volcanic system where a 150 MWe geothermal power plant is planned. It is suspected from mapping, seismicity, remote geodesy (interferometric synthetic aperture radar; InSAR) and geoelectrical (magnetotelluric; MT) surveys that cross-rift faulting has led to a north–south compartmentalisation of the geothermal resource. However, how this is represented in the elastic structure is uncertain. Likewise, there is uncertainty in the nature of the deeper heat source at Corbetti. MT and InSAR also suggest that a region of high melt content is present, but estimates of its depth and likely responsibility for surface uplift do not closely agree. In this study, therefore, we seek to test these hypotheses of the presence of melt and compartmentalisation in the geothermal reservoir by comparison with seismic data. We use an existing catalogue of earthquakes and a Bayesian probabilistic approach to build an ensemble of millions of tomographic models of S-wave speeds in the subsurface below Corbetti down to ~15 km below sea level. This ensemble represents the probability of any given seismic velocity being present at each point in space. This probabilistic approach is necessary: firstly, data coverage is limited, and in this way we can obtain the uncertainty in the model everywhere; and secondly, we are able to use the probabilities we obtain to statistically test whether any existing hypothesis are supported by the seismic data. We find that the seismic evidence does not support the idea that there is a deep-seated (>2 km depth) separation between the north and south of the caldera, as suggested by InSAR, but it does weakly support the presence of a magma region at ~5 km depth. These results can be used in a risk-based framework to make future decisions on exploration at Corbetti and the work repeated at other sites worldwide.

Trace Element Geochemistry of the Sorik Marapi Geothermal Field, Indonesia

Author(s): Konstantin Nazarov, Jon Blundy

Organisation(s): University of Oxford

Abstract

The upflow zone represents the hottest and most permeable part of a geothermal system and feeds the productive outflow. It is conventionally identified using magnetotelluric surveys, downhole temperature logging and cation geothermometry, approaches that are costly and generally available only after substantial field characterisation or drilling. In volcanic-arc geothermal systems, dissolved elements are acquired through coupled high-temperature water–rock interaction and input of magmatic vapour, producing characteristic trace-element signatures that remain comparatively underused for spatially resolving reservoir structure and critical-element distributions.

Here, we report the first trace-element characterisation of the Sorik Marapi geothermal field in North Sumatra, based on 57-channel ICP-MS analysis of fluids from 19 production wells, integrated with operator flow-test data and the published conceptual model of the field. A tenor index comprising As, Sb, Tl, W, Ge and Mo increases monotonically from the north-eastern to south-western wells and correlates strongly with quartz temperature. This relationship persists after exclusion of the end-member well, indicating that the observed gradient reflects a field-scale pattern. The end-member well is located within the focused upflow previously identified from geophysical surveys, borehole geology and well-temperature data, and is the only production pad associated with surface thermal expression.

Importantly, the elemental ranking was established before the well locations were considered, providing an independent test of the existing conceptual model. The results demonstrate that a six-element trace-metal signature derived from a single analytical dataset can resolve the principal upflow zone using fluids already produced by the operating field, providing a complementary approach to conventional geophysical and downhole methods.

Deep heat sources and structural controls on pore space architecture in the Hengill geothermal system (Iceland) inferred from probabilistic anisotropic seismic imaging

Author(s): Brandon VanderBeek, Andy Nowacki, Thorbjörg Ágústsdóttir

Organisation(s): University of Oxford, Iceland GeoSurvey

Abstract

Constraining both the distribution of subsurface heat sources and the architecture of permeable pore space is critical to the exploration and exploitation of geothermal resources. The location and geometry of heat sources governs the thermal potential of a geothermal system, while fractures and other permeable structures control fluid circulation and the efficiency with which that heat can be extracted. Knowledge of both is therefore necessary for optimal well placement, reservoir modelling, and assessment of resource longevity. Passive seismic imaging provides a cost-effective means of characterising both the thermal anomalies and pore space structure of the subsurface. We demonstrate this approach using arrival times from natural and induced seismicity in the Hengill geothermal field (Iceland) to image the anisotropic P-wave velocity structure of the reservoir. A Bayesian Monte Carlo sampling method is used to construct likely velocity models and posterior parameter distributions from which we evaluate reservoir properties consistent with the seismic data. We find reductions in P-wave velocity at mid-crustal depths (~6 km) beneath the Hellisheiði production field that can be attributed to a previously unidentified magmatic system. From 3D variations in the orientation of seismic anisotropy, we assess the relative roles of fracturing and vertical porosity stratification in controlling the distribution of hydrothermal fluids. Production activities appear to impact the pore architecture such that fracturing is enhanced where fluids are re-injected into the subsurface while fluid extraction can result in fracture closure. From the strength of anisotropy, we place bounds on fracture densities and reservoir porosities. Our results highlight the potential of passive anisotropic seismic imaging to characterise geothermal systems.

Geothermal Energy Applications in Poultry Farming: Opportunities for Climate Change Mitigation and Sustainable Development

Author(s): Abdelmalek Atia

Organisation(s): University of El Oued, Algeria

Abstract

Poultry farming requires continuous control of indoor temperature, ventilation, and air quality to maintain bird health, welfare, and productivity. In regions characterized by hot summers, cold winters, or large daily temperature variations, conventional heating and cooling systems can result in high energy consumption, operating costs, and greenhouse gas emissions. Shallow geothermal energy offers a promising and sustainable alternative for improving the thermal management of poultry houses.

This research examines the potential application of geothermal energy in poultry farming, with particular emphasis on earth-to-air heat exchangers and other shallow geothermal technologies. By exploiting the relatively stable ground temperature, these systems can pre-cool ventilation air during hot periods and pre-heat it during cold periods, thereby reducing the energy demand of conventional heating and cooling systems. Improved thermal regulation can also help maintain stable indoor conditions, reduce heat stress, and support better poultry performance.

Geothermal-based climate control can reduce fossil-fuel consumption, greenhouse gas emissions, and overall energy demand. These benefits are particularly relevant in arid and semi-arid regions, where extreme outdoor temperatures increase the energy requirements of poultry production. Integration with efficient ventilation, renewable electricity, and smart environmental control can further improve system performance and reduce the carbon footprint of poultry farms.

The study highlights shallow geothermal energy as a promising solution for climate change mitigation and sustainable poultry production. Wider deployment, however, requires careful consideration of soil thermal properties, airflow requirements, system configuration, investment costs, maintenance, and local climatic conditions.

Expecting the Unexpected: The Geology of the Granite City

Author(s): Clare Bond

Organisation(s): University of Aberdeen

Abstract

Pending

Posters

The Missing Data Layer: Why Global Borefield Geometry Remains Undigitized and How Machine Learning Can Unlock Actionable Subsurface Insights

Author(s): Tunca Alikaya

Organisation(s): borelogger.io

Abstract

Globally, hundreds of thousands of geothermal boreholes are drilled each year for closed-loop ground source heat pump systems, thermal energy networks, and direct-use applications. Yet the vast majority of these bores are completed with no downhole measurement whatsoever — no deviation survey, no trajectory record, no as-built subsurface geometry. Industry estimates suggest fewer than five percent of geothermal bores are ever instrumentally surveyed. The result is a systemic data void: borefield design assumes ideal vertical geometry, but the subsurface reality — shaped by formation anisotropy, drill string behaviour, and local geology — is rarely verified.

This instrumentation gap is not a regional phenomenon. From North American residential GSHP installations to European district heating networks to campus-scale thermal energy systems in the UK, the same pattern holds: the tools available for borehole deviation measurement remain prohibitively expensive, operationally complex, and designed for the oil, gas, and mining sectors. The geothermal drilling market — dominated by small-to-mid-size contractors — has been structurally underserved.

This paper argues that closing this gap requires more than affordable hardware. As borefield trajectory data becomes available at scale, a second-order opportunity emerges: applying machine learning to correlate measured deviation patterns with geological formation data, drilling parameters, and regional trends. Randomized and Natural well trajectory behaviour — the characteristic way boreholes drift through specific lithologies — is a latent signal that, once captured across enough fields, enables predictive modelling of expected deviation, early detection of anomalous bore behaviour, and data-driven refinement of thermal performance assumptions. The transition from single-bore measurement to population-level trajectory intelligence transforms raw survey data into an actionable geotechnical asset.

This presentation introduces the concept of digitizing borefield geometry at scale, examines the global instrumentation gap, and outlines an emerging framework for extracting geological and operational insights from mass trajectory datasets using sensor platforms and machine learning.

MRMOLES: Mitigating Risks of Mineralisation and biofilms in Open Loop thermal Energy Systems

Author(s): Matt Bailey, Simon Gregory, Hosein Rezvani

Organisation(s): University of Plymouth

Abstract

Ground Water Heat Pump systems (GWHP) are a valuable tool in decarbonising the building sector. However, mineral or biofilm formation within these systems is known to cause blockages of pipework, heat exchangers and wells, which result in reduced efficiency and/or failure. This is a known barrier to uptake of open loop systems, despite advantages of high yield and efficiency over closed loop variants. Such fouling phenomena are poorly understood but are known to be controlled by a range of variables such as groundwater composition, temperature, oxygenation and surface effects.

In this talk/poster, we introduce our 26-month EPSRC project which will characterise the nature of problematic solid-phases and resolve how they are formed in GWHP systems. The project will determine how precipitates and biofilms relate to groundwater chemistry and, whether these phenomena are linked to particular sets of conditions or water 'types'. The ambition is to produce a user-orientated tool, to enable practitioners to assess the water quality risks for any proposed groundwater sourced heat pump installation within the UK and recommend solutions to avoid mineral or biofilm fouling.

Preliminary data are presented from our research, our proposed plan of work and an invitation to the community to share perspectives on this challenge.

Ultra-High-Temperature Underground Thermal Energy Storage (UHT-UTES) for Large-scale, Inter-seasonal Electricity Storage

Author(s): Ruixiao Liu, Matthew D. Jackson, Carl Jaquemyn, Meissam Bahlali

Organisation(s): Imperial College London

Abstract

Low-temperature (LT-) and high-temperature underground thermal energy storage (HT-UTES) are used to provide low carbon heating and cooling. Here, we investigate the potential for ultra-high temperature underground thermal energy storage (UHT-UTES) to balance renewable electricity intermittency over inter-seasonal timescales. During periods of excess renewable supply, groundwater is pumped from naturally porous, permeable underground reservoirs at depths > 500 m, heated to high temperature (>150°C) and pumped back underground for storage. When demand exceeds renewable supply, the high temperature water is produced from subsurface to generate electricity.

UHT-UTES offers several potential advantages over comparable technologies such as hydrogen storage: the surface facilities comprise conventional boilers and turbines, and expertise can be shared from hydrothermal electricity production. The technology can utilise deep saline aquifers and end-of-life hydrocarbon reservoirs which are geographically widespread and offer large storage and flow capacity.

However, key uncertainties remain concerning storage efficiency when the stored water temperature is significantly higher than the ambient reservoir temperature. Potential risks to sustainable operation are also present, including scaling and associated loss of storage and flow capacity, and/or the potential for rock weakening and seismicity.

This study reports numerical modelling to determine key controls on the storage efficiency of UHT-UTES considering a range of storage temperatures, reservoir heterogeneities, and real-life electricity intermittency. Results show that the underground storage efficiency of UHT-UTES is high; the relatively small losses are due to both thermal conduction and the convection of hot, buoyant groundwater, and vary depending on how heterogeneity impacts on thermal plume migration.

Despite the high underground storage efficiency, the round-trip efficiency for electricity generation is constrained by the turbine efficiency. Optimising the round-trip efficiency involves choosing storage temperatures that yield maximum turbine efficiency and minimal thermal storage losses in the reservoir. Current work focuses on addressing potential chemical reactions that impact sustainable operation.

Interpolation-free adaptive mesh Machine-Learning Surrogate for Rapid Simulation of Aquifer Thermal Energy Storage

Author(s): Hadrian Fung, Issac Ju, Carl Jacquemyn, Meissam Bahlali, Matthew Jackson, Gege Wen

Organisation(s): Imperial College London, Earthflow AI

Abstract

Aquifer Thermal Energy Storage (ATES) provides low carbon heating and cooling by storing thermal energy in shallow aquifers. System design requires numerical simulation of groundwater flow and heat transport under site-specific geological and operational conditions. The sharp thermal fronts surrounding ATES wells require high spatial resolution, particularly where geological heterogeneity creates preferential flow pathways and increases the risks of conductive loss and thermal interference. Dynamic mesh optimisation addresses this problem by concentrating resolution near wells and moving thermal fronts, but the resulting simulations remain too expensive for the design, uncertainty analysis and operational optimisation.

We demonstrate the Adaptive Physics Transformer (APT), a neural operator that learns directly from three-dimensional hr-adaptive numerical simulations without interpolating them onto a fixed grid. APT can perform one-step prediction of any subsequent timesteps from initial condition without intermediate timesteps, avoiding error accumulation from auto-regressive rollout. The method is trained and demonstrated used a dataset comprising 840 ATES single-doublet scenarios simulated over ten-years of seasonal injection and extraction cycles. At each timestep, dynamic mesh optimisation changes the node positions, node count and mesh topology to follow the evolving thermal fronts. This prevents direct application of conventional grid-based surrogates and graph models that require a fixed discretisation.

APT combines local graph-based feature extraction with global attention and predicts temperature at arbitrary spatial query locations. Anchor super-nodes ensure that the geometrically small but physically dominant well regions are retained during encoding. On the adaptive-mesh ATES benchmark, APT achieves a relative L_2 error of 0.011 and R^2 of 99.0%, outperforming interpolated grid-based models while reducing a complete 240-step forecast from approximately seven hours of very high resolution numerical simulation to approximately five seconds.

The present benchmark establishes the feasibility of rapid simulation for ATES compatible with any form of adaptive irregular meshes. Ongoing work is extending the training data beyond the current parameterised aquifer and well configurations to include realistic three-dimensional heterogeneity, faulted and layered aquifers, variable injection schedules and volumes, groundwater-heating-and-cooling cases, and thermally unbalanced operation. These extensions are intended to support practical evaluation of thermal breakthrough, recovery efficiency and heating and cooling supply under geological and operational uncertainty.

Experimental Study of PET-Derived Nitrogen-Doped Carbon Quantum Dots for Tailoring Soil Thermal Conductivity and Heat Storage in Shallow Geothermal Systems

Author(s): Amany Aboulrous, Mostafa Mohamed, Ashraf Ashour, Maria Katsikogianni

Organisation(s): Unviersity of Bradford

Abstract

Efficient ground-source heat pump and underground thermal energy storage systems depend strongly on the thermal conductivity and heat-storage capacity of the surrounding soil. This study investigates nitrogen-doped carbon quantum dots (NCQDs) derived from polyethylene terephthalate (PET) waste as a sustainable low-dose additive for tailoring these properties in shallow geothermal applications.

PET-derived NCQDs were produced by alkaline depolymerisation followed by hydrothermal carbonisation with urea as the nitrogen source. TEM showed quasi-spherical, well-dispersed particles with an average diameter of approximately 4.2 nm and a population below 10 nm. XRD and SAED indicated an amorphous to poorly crystalline carbon structure, while UV-Vis absorption bands at 228, 268 and 371 nm were consistent with aromatic carbon, surface functional groups and nitrogen-related states.

Thermal properties were measured using a KD2 Pro transient line heat-source method at 21–24 °C. Soil was compacted to a dry density of 1.50 g cm^{-3} at 6% gravimetric water content. Addition of 0.3 wt.% NCQDs reduced thermal conductivity from 1.548 ± 0.064 to 1.353 ± 0.063 W m^{-1} K^{-1}, corresponding to a 12.6% decrease. Thermal resistivity increased by 14.3%, from 64.6 ± 2.7 to 73.9 ± 3.3 °C cm W^{-1}. Volumetric heat capacity increased by 20.4%, from 1.679 ± 0.145 to 2.021 ± 0.354 MJ m^{-3} K^{-1}, while thermal diffusivity decreased by 19.9%, from 0.861 ± 0.142 to 0.689 ± 0.162 mm^2 s^{-1}.

In contrast, NCQD additions to distilled water up to 0.3 wt.% produced no measurable thermal-conductivity enhancement. These preliminary results indicate that PET-derived NCQDs can modify heat retention and transport through soil-specific interfacial effects, offering a promising route for sustainable thermal-property engineering in underground heat-storage systems.

A multi-method analogue study of fracture-controlled geothermal reservoirs in Cornubian granite, Cornwall

Author(s): Samuel Grainger, David McNamara, Elisabetta Mariani, Robin Shail, Chris Yeomans, Will McKenzie

Organisation(s): University of Liverpool, University of Exeter, Neo Geo Consulting Ltd, Cornish Lithium Plc

Abstract

Resource exploration in the Cornubian granite batholith, Cornwall, UK, targets hot, lithium-rich geothermal brines, the circulation of which is contained within a complex geological fault and fracture network. Understanding the structural controls on such fluid flow at reservoir depths is critical to de-risk exploration and development. As direct observations of reservoir structures at depth are limited, surface exposures of these granites, and the structural networks they host, can provide valuable 3D analogues of these resources.

We present an integrated field, drillcore, and remote sensing workflow to characterise analogue fault zones in Cornubian granite and assess their relevance to granite resources at depths. Surface analogues allow us to capture a 3D picture of fault zone geometry, which, when compared with 1D borehole data from targeted granite fault zones at depth, reveals important differences. Although broadly similar, dominant fracture set orientation varies in boreholes across Southwest England, with discrete structures strongly influencing datasets. Furthermore, while low-dip-angle fractures (<30°) dominate surface granite outcrop datasets, such structural populations become rare below depths of 250–500 m. We attribute this discrepancy between the two datasets to the fact that granite at shallow depths has experienced stress release driven by exhumation resulting in the increased population of Mode I horizontal fracturing. Consequently, horizontal or low-dip-angle fractures do not represent a significant fracture architecture control on hydrothermal, Li-rich fluid flow at reservoir depths.

We use these observations to build a data integration and validation workflow, applied here to stochastic fracture set generation for Discrete Fracture Network (DFN) modelling and 2D connectivity assessment. We also discuss the implications for fluid flow and fault zone process interpretation at depth. Our findings indicate that analogue fracture and fault zone datasets must be critically analysed before being incorporated into conceptual and numerical models.

Neuro-Algebraic Digital Twinning Approach to Predict Critical States in Abandon Mineworkings Geothermal Flow.

Author(s): Oleksandr Letychevskyi, Vasily Demyanov, Elma Charalampidou, Tomiwa Aderemy

Organisation(s): Heriot-Watt University

Abstract

Geological models are inherently uncertain because subsurface observations cover only a small fraction of the modelled geological space. Conventional simulations utilise various combinations of geological parameter values and ensemble geological realisations to evaluate the associated uncertainty. This is not necessarily equivalent to the full range of plausible subsurface conditions that the geothermal dynamic system can reach. This work demonstrates an application of neuro-algebraic approach to predict critical subsurface states of a geothermal flow system for an abandoned mine workings in the Glasgow area based on UKGEOS data and an ensemble of models [Aderemy et al 2026].

In the algebraic model, uncertain properties such as porosity and permeability are expressed as constraints and admissible intervals, while the behaviour of the subsurface is represented as sequences of symbolic state transitions based on the geothermal flow governing equations. Critical-state prediction is formulated as a reachability problem: an SMT solver determines whether any admissible scenario can reach a hazardous region, such as excessive pressure or a critical pressure drop near a production well. Backward modelling identifies the parameter ranges and the transition sequences leading to the hazard.

The algebraic component is integrated with an AI model that processes measurements and detects whether the system is approaching a critical condition. Training data may also combine historical observations with synthetic scenarios generated algebraically, including indirect indicators that are difficult to formalise in physical equations. When the AI flags a risk, the algebraic model verifies its reachability and explains the conditions under which it may occur.

The model can also synthesise preventive scenarios involving injection, production, drainage, pump control, or alternative wells. Initial experiments modelling pressure and enthalpy demonstrate the feasibility of the approach and its potential to reduce false-positive and false-negative predictions while supporting explainable, uncertainty-aware decisions for subsurface operation.

Updated national-scale geothermal data and maps from the British Geological Survey

Author(s): Alison Monaghan, Russell Lawley, David Boon, Mylene Receveur, Andres Gonzalez Quiros, Joanna Thompson, Ashley Patton

Organisation(s): British Geological Survey

Abstract

How many times during the 13th Geothermal Symposium do you think you will see the heat flow map of the UK, from the BGS (Busby et al. 2011, https://doi.org/10.1144/1470-9236/10-049)? In many conferences, it is more than once.

BGS is working to update a range of national-scale data and maps that form widely used, underpinning datasets across the geothermal sector. These are:

- heat flow
- temperature
- thermal properties
- geothermal asset register (projects, status, operational capacity etc.)

This poster will summarise the technical work and provide example outputs due to be delivered as digital datasets and products in the first half of 2027.
In more detail, some of the updates include:

- qualifying the uncertainty in the complex, legacy heat flow and measured temperature dataset and applying consistent paleoclimate and surface topography corrections
- incorporation of newly measured thermal conductivity data with higher resolution map data that will lead to greater regional variability in thermal properties data, supplied with statistics on the number of, and distance to, data points
- an initial version of an asset register to better track geothermal project pipeline across shallow to deep geothermal and underground thermal energy storage projects, improve reporting of UK installed and operating geothermal capacity to IEA geothermal, EGEC etc. Also to improve visibility of growth within sectors, such as 100’s kWth- MWth scale ground source heat/shallow geothermal projects.

Measuring thermal plumes and breakthrough in mines for geothermal exploitation and thermal storage

Author(s): Alison Monaghan, Andres Gonzalez Quiros, Eileen Callaghan, Mylene Receveur, Vanessa Starcher, Kyle Walker Verkuil, Jeroen Van Hunen, Julien Mouli Castillo

Organisation(s): British Geological Survey, University of Durham, University of Glasgow

Abstract

Real-world, at-scale thermal plumes and breakthrough have been measured in flooded, disused mine workings, demonstrating how the mine working type, which influences flow and heat transport, can affect system performance for geothermal exploitation and mine thermal energy storage.

Thermal plumes developed during two heat injection experiments in different flooded mine working levels at the UK Geoenergy Observatory in Glasgow recorded thermal breakthrough times (for 0.1°C change) of 4.8 and 2.3 days under similar test conditions. Synthesis of the mine abandonment plan, borehole, and outcrop data was used to characterise differences in the mine geometry and working type. New insights on how backfilled, collapsed, and open voids affected groundwater flow and heat transport were obtained from the hydrogeological, wellhead, and downhole direct temperature sensor data measured during and after pumping of the open loop borehole doublets.

Over 17 days, heat injection into the Glasgow Upper mine workings resulted in the gradual development of a thermal plume, within an area interpreted to have a greater percentage of backfill and more tortuous flow paths. After 3.9 days, temperatures at the abstraction borehole started to increase at ≈ 0.03°C/day, with a ≈ 2.3°C differential maintained 10 days after heat injection and pumping stopped. In the five-day Glasgow Main heat injection experiment, temperature increases after 1.4 days were ≈ 0.14°C/d, which was interpreted to result from preferential flow and heat transport pathways with less surface area for heat transport through conduction to the rock mass, and quicker transit time to the abstraction borehole.

This poster will provide an overview of the results and their implication, based on the 2026 publication ‘Influence of Mine Geometry and Working Type on Geothermal Exploitation and Thermal Storage. In: Mine Water and the Environment. https://doi.org/10.1007/s10230-026-01138-4 ‘

Subsurface characterisation of the UK Geoenergy Observatory using borehole distributed acoustic sensing (DAS) monitoring before and during geothermal testing

Author(s): David Fairweather, Adam Booth, Andy Nowacki, Fleur Loveridge, Jason Ngui, Jimmy Boyd, Ed Hough, Mike Spence, Jack Croft, David Hetherington, Matt Jackson

Organisation(s): University of Leeds, British Geological Survey, Imperial College London

Abstract

Geothermal resources are a key part of the energy transition and underutilised in the UK. The geographical suitability of geothermal as an energy source is determined by the underlying geology, and the ability to understand the heterogeneities of a geothermal site is crucial to successful and sustainable implementation. Subsurface insights are important in understanding the response of the site rock to thermal cycles. Faults and fractures can influence the subsurface fluid flow, which is critical for open-loop systems, whereas the efficiency of closed loop systems is determined by groundwater flow rate and the thermal conductivity of the host rock.

Distributed acoustic sensing (DAS) interrogators were deployed at the UK Geoenergy Observatory (UKGEOS) in Cheshire to monitor the subsurface response before and during thermal testing, with additional recording in the time following the test. The interrogation was applied to four clusters of fibre-optic cable each installed within five boreholes reaching depths of either 15 or 100 m. During baseline monitoring in June 2025, the sites Silixa iDAS instrument was used; thermal testing in February 2026 was additionally monitored by two Febus Optics A1 systems. The cable was monitored passively, but active-source shots were also taken to record offset and zero-offset (ZO) vertical seismic profiles (VSPs).

Here we present an analysis of DAS records acquired during the June 2025 baseline survey. We show 1D velocity models derived from the ZO active shots, and 2D transect velocity models produced from Bayesian inference using all offset shots. These results establish a seismic baseline ahead of an open-loop thermal tracer test (TTT) performed in February 2026. We also show a preliminary analysis of data acquired during the TTT, exploring the sensitivity of DAS to the induced thermal change of ~8°C at the site.

Three-Dimensional Characterisation of Fracture Arrays in the Leeds Geothermal Campus Borehole Core: Implications for Fluid Flow in Mechanically Layered Reservoir Analogues

Author(s): Renato Diamanti, Martina Rocca, Sandra Piazolo, Cathy Hollis, Arka Dyuti Sarkar, Richard Collier, David Healy

Organisation(s): University of Leeds, The University of Manchester, Queen's University Belfast

Abstract

Predicting the connectivity of fluid-flow pathways remains one of the principals aims in geothermal reservoir characterisation. Although fracture arrays are commonly assumed to act as interconnected networks, field and core observations frequently reveal contrasting degrees of cementation, suggesting substantial spatial variability in fluid circulation. To better describe the structural control on fluid migration in a mechanically layered geothermal aquifer, we characterized the geometry and displacement distribution of small fault zones preserved within the Leeds Geothermal Campus cores.

The analysed interval (approx. 3m) comprises a mechanically heterogeneous succession of Carboniferous interbedded sandstones and organic-rich mudstones and siltstones. Deformation is accommodated by a network of shear fractures, pull-apart and en échelon veins.

High-resolution X-ray computed tomography (CT) was used to quantify the three-dimensional core density. Image analysis was obtained through digital segmentation with DragonFlyTM, and strain was quantified through displacement analyses of selected layers using Python-based workflows.

Fault throw analysis reveals a decreasing trend in the displacement along fault strike, suggesting this is a lateral tip region of a fracture system. Three-dimensional displacement reconstructions show corresponding variations in vein geometry. Low-displacement sectors of the fault are characterised by enhanced shear-fracture segmentation and continuous vein networks. Conversely, higher-displacement sectors display narrow continuous shear fractures and increasingly segmented veins, consistent with enhanced shear deformation.

The fracture arrays are partially sealed by quartz and pyrite crystals. Vein pyrite appears to occur exclusively in contact with organic-rich layers in the wall, likely indicating a highly localised control of vein fill mineralogy based on layer specific composition.

Our preliminary observations suggest that at the lateral tips of the shear zone, fluid circulation is enabled by higher fracture density. These findings have potentially important consequences for the prediction of fault zone permeability structure, and the distribution of vein-filling minerals in relation to fault zone displacement and local stratigraphy.

Learnings from research to date at the UK Geoenergy Observatories and how these factor into future geothermal experiment design

Author(s): Mike Spence, Vanessa Starcher

Organisation(s): British Geological Survey

Abstract

The UK Geoenergy Observatories are exceptionally well- characterised facilities for research and innovation in shallow geothermal energy and aquifer/ mine water thermal energy storage. This presentation highlights important features of the geology and hydrogeology for future users. It also signposts the extensive open access data and resources that are available and recent publications.

By way of example, thermal testing at the Cheshire Observatory has demonstrated the potential for induced groundwater flow and thermal transport in fracture systems within the shallow Sherwood Sandstone aquifer. The influence of different fracture systems can be investigated using the Observatory abstraction- injection wells, which are equipped with packers so that thermal recovery can be evaluated within specific test sections. In this way the pros (higher flow, higher power) vs potential cons (loss of stored thermal energy) of fracture flow can be investigated.

At the Glasgow Observatory mine water thermal experiments have established the time taken for heat to migrate through the workings and how this can be tracked using the in-situ sensor systems. This understanding provides a platform for future research on how thermal recovery varies between different types of mine workings, and the relative merits of e.g. packed mine waste vs open galleries for energy storage. There is also a six-year baseline monitoring dataset to support the analysis of seasonal variation in water level, subsurface temperature gradients and groundwater chemistry.

A complete set of 21 borehole data packs has recently been published for the Cheshire Observatory, together with a BGS drilling report that describes the during- drilling geological characterisation and the as- built borehole design. Similar datasets for the Glasgow Observatory have been used by researchers to constrain ground models and provide valuable information on fault/ fracture characteristics and potential flow paths; features that are difficult to assess using data from drilling, standard wireline logging and core.

Mixture Density Network-based Electrical Tomography Inversion: a Rapid Probabilistic Approach for Geophysical Geothermal Monitoring

Author(s): Theethach Phiranram, Sjoerd A.L. de Ridder, Andy Nowacki, Adam D. Booth

Organisation(s): University of Leeds

Abstract

The transition towards low-carbon energy resources has increased, with geothermal energy presenting a promising potential for sustainable alternative energy. In the UK, low-enthalpy geothermal resources have been increasingly investigated for ground source heat pumps. Electrical resistivity tomography (ERT) is valuable for geothermal applications because of the sensitivity to changes in formation fluid temperature, making it suitable for characterising and monitoring subsurface thermal processes. However, conventional deterministic inversion provides a single model and may inadequately represent the inherent non-uniqueness of the inverse problem. Probabilistic approaches based on Bayesian inference can quantify this uncertainty through the posterior probability distribution, but conventional methods such as Markov chain Monte Carlo (MCMC) are computationally demanding for high-dimensional and time-lapse ERT problems.

This computational burden is problematic for geothermal monitoring, where timelapse ERT surveys are needed, and each survey would require a new inversion. This study introduces a mixture density network (MDN)-based framework for rapid probabilistic ERT inversion, using convolutional neural network layers combined with a mixture density model to evaluate the posterior distribution of subsurface resistivity. Once trained, the network provides a posterior probability distribution of model parameters for any subsequent set of survey data within a few seconds. The framework is evaluated using one-dimensional vertical electrical sounding (VES) simulations and extended to two-dimensional ERT inversion. For the VES case, the MDN outperforms both a normalising-flow variational inference approach and conventional least-squares inversion under a uniform prior assumption. The framework is further demonstrated for two-dimensional ERT inversion, where it successfully reconstructs resistivity structures under informative priors, including Gaussian and predefined structural priors.

These results demonstrate the potential of MDN-based ERT inversion as a computationally efficient probabilistic alternative to conventional inversion approaches. The framework provides a foundation for rapid uncertainty-aware ERT inversion in geothermal applications, particularly for monitoring surveys, where successive datasets share similar prior information.

The GEMINI project: Tackling communications and engagement challenges in a cross-border geothermal energy project

Author(s): Nicola Noller, Aoife Braiden

Organisation(s): RML / GEMINI

Abstract

The GEMINI project, Geothermal Energy Momentum on the Island of Ireland, brings together 15 partners, from Ireland and Northern Ireland, to deliver new geothermal energy demonstration projects, including the first deep (2km) geothermal energy exploration borehole on the island of Ireland.

The project will also deliver a range of supporting data, products, toolkits, guidelines, and education and training programmes that are essential for the continuing development of the geothermal sector beyond the end of the project.

Success in these aspects depends upon direct engagement with a wide range of stakeholders, and the project has developed a comprehensive communications strategy to support the mixed-disciplinary partner base, deal with multiple funders, tailor materials for varied stakeholders, and prepare crisis management protocols. In addition, project engagement must navigate hurdles relating uniquely to the project area, including: the presence of a national border separating different legal, travel and policy jurisdictions; local geographical, political and language sensitivities; general lack of awareness of geothermal energy, and demonstrating technology in the absence of easily accessed operational examples.

Solutions to many of these issues rest with the partners themselves, whose knowledge of local sensitivities and past experiences, as well as their own mixed disciplines, provide support and know-how to other partners. This is further supported by external resources for comprehensive messaging guidance and communication training.

Crucially, GEMINI is hosting multiple public engagement activities, focused on the demonstration sites in Sligo, Belfast and Dublin.. A deliberative democracy programme in the cross-border area of Lough MacNean will facilitate respectful citizen engagement on geothermal energy, enabling the communities to shape what happens in their area as part of the energy transition.

History Matching an Operating Aquifer Thermal Energy Storage (ATES) System Operating in the Heterogeneous Chalk Aquifer under London, U.K.

Author(s): Hayley Firth, Matthew Jackson, Meissam Bahlali, Carl Jacquemyn, Gary Hampson

Organisation(s): Imperial College London

Abstract

The ATES system considered here comprises four borehole doublets that penetrate the heterogeneous Chalk aquifer in south-west London. Here we report a history matching exercise, undertaken with the aims of

(I) improving understanding of flow and heat transport during storage in the aquifer;
(II) identifying the cause(s) of low thermal recovery and
(III) informing the design of future ATES installations.

A four-step history-matching process was followed. Step 1 comprised quality control of geological and operational data. Step 2 developing multiple geological scenarios based on borehole data and field observations. Step 3 applied Nelder-Mead optimisation to iteratively refine model inputs to match pumping test data obtained during borehole commissioning. Step 4 employed Nelder-Mead optimisation to refine model inputs to match the operational temperature data.

Results show that flow during system operation occurs almost entirely within a high permeability karst layer of order 1-3 m in thickness, located at the top of the Chalk and encountered in many other boreholes across London. The warm and cool thermal plumes created during system operation are largely confined within this layer, so spread laterally and have a ‘pancake-like’ geometry. The plumes thermally interfere and have a large surface area to volume ratio, so suffer larger conductive losses than the cylindrical plumes more typical of ATES systems operating in less heterogeneous aquifers. These effects reduce the thermal recovery efficiency.

Predicted thermal recovery is also strongly impacted by ambient groundwater flow. The operational data are best matched by flow that is from east to west, contrasting with regional head mapping that suggests flow is towards central London to the north-east. Eastwards flow transports stored warm groundwater to the cool boreholes, causing thermal breakthrough and reducing the recovery of coolth. Our results suggest that local groundwater flow directions may be highly variable and must be determined at site.

Monitoring shallow geothermal aquifers with active-source distributed acoustic sensing: feasibility studies on the University of Leeds Geothermal Campus

Author(s): Adam Booth, Sjoerd de Ridder, Roger Clark, Shohruh Bokijonov, Andy Nowacki, Ravi Myanger, Joseph Kelly, Arka Dyuti Sarkar, Fleur Loveridge, Richard Collier, Emma Bramham and David Healy

Organisation(s): University of Leeds, DUG Technology, Queen's University Belfast

Abstract

The University of Leeds geothermal campus is a component of the university's ambitions to achieve net-zero emissions by 2030, and provides a living-lab research facility for exploring geothermal heating-and-cooling systems more widely. Several boreholes are located around the university campus, equipped with systems to undertake closed- and open-loop thermal experiments. They also feature fibre-optic cable, enabling distributed monitoring of temperature and seismic responses to thermal tests.

Here, we explore the performance of fibre optic distributed acoustic sensing, obtaining seismic velocity and attenuation models of the Elland Flags aquifer, between 38-92 m below ground level (mbgl) at our test site. These models provide baseline observations ahead of later stages of thermal testing, to explore the sensitivity of seismic properties to various heating scenarios: if seismic properties prove sufficiently sensitive, then seismic analysis can provide a remote means of tracking a subsurface thermal plume away from borehole monitoring. Our first set of tests featured sledgehammered seismic shots made at the top of the 250 m-deep borehole. Compressional seismic wave velocities were obtained to 160 m depth, and are typically 3100 ± 50 m/s through the Elland Flags. However, a Hashin-Shtrikman petrophysical framework suggested that this velocity uncertainty is compatible only with detecting temperature in excess of 26°C, 14°C above ambient temperature. This would be unlikely to occur in a shallow aquifer under current UK legislative scenarios.

We therefore extended our observation base by recording seismic shots at greater offset from the borehole top, at varied azimuth, and with a more impactful source. Currently being analysed, the resulting data may provide additional constraint from shear-wave velocities, and also inform fracture orientation through anisotropy characterisation.

Assessment of the feasibility for installation of high temperature mine thermal energy storage technologies in the Great Consolidated Mines, Cornwall: final results of the PUSH-IT Project.

Author(s): Poppy Edgecombe, Thomas Olver, Amy Peach-Gibson, Andres Gonzalez Quiros, Christopher Rochelle, Andy Marriott, Mylene Receveur

Organisation(s): GEL, British Geological Survey

Abstract

The Horizon 2020 funded project, PUSH-IT (Piloting Underground Seasonal Heat Storage in Geothermal Reservoirs), comes to a close in December 2026. The four-year project developed and tested high temperature underground thermal energy storage technologies. Mine water (MTES), aquifer (ATES) and borehole (BTES) thermal energy storage were developed across six European sites. A lead and follower site were selected for each.

The follower site for the development of high temperature MTES technologies is located in Cornwall, UK. Geothermal Engineering Ltd (GEL) and the British Geological Survey (BGS) evaluated the feasibility for the installation of MTES alongside the United Downs Geothermal Power Plant. The project concept was to store excess thermal energy in abandoned, now flooded mine workings (Great Consolidated and United Mines) beneath the site to aid the seasonal variation in demand for heating.

The mines proximal to the geothermal plant are large, complex networks of interconnected workings up to 500 m depth. The working consist of vertical/sub-vertical shafts, horizontal workways and stopped sub-vertical mineral lodes. Conceptual and numerical models were developed to evaluate the potential for MTES using potential operational scenarios. A database of historic mine plans and maps was compiled and georeferenced to key open shafts. This database was supplemented through a series of field campaigns and the installation of sensors to capture hydrological information.

This presentation details the results of this study and integration into the wider PUSH-IT project.

An update on the operation of the United Downs Geothermal Plant, Cornwall.

Author(s): Poppy Edgecombe, Thomas Olver, Amy Peach-Gibson

Organisation(s): GEL

Abstract

The UK's first geothermal power plant, located in United Downs, Cornwall, became operational in February 2026. The facility, developed by Geothermal Engineering Ltd (GEL), underwent a through testing and commissioning throughout 2025, before finalisation of connection to the UK's National Grid, marking operation.

Commissiong and optimisation of the now operational plant has followed a bespoke process, planned in conjunction with plant designers, Exergy ORC. Early operation and optimisation has allowed for further testing and in-turn, data collection at the ESP, and within surface infrastructure, providing further information on the reservoir. Furthermore, the optimisation process has provided learnings that will be taken forward to future operations at site, and to additional plants in earlier stages of development across the county.

The United Downs Geothermal Project acts as proof of concept for geothermal power projects across Cornwall and the wider UK, providing insight into all stages of development, from site selection and financing, through the planning and regulatory processes, drilling and well testing, and finally construction, commissioning and operation.

The Potential for Geothermal Energy to Provide Low Carbon Heat to the Scottish Whisky Industry

Author(s): Callum Inglis

Organisation(s): Independent

Abstract

Geothermal energy is a low carbon, low land-use and indigenous source of baseload energy, which could help address the UK's energy trilemma of sustainability, security and affordability. Geothermal has both residential and commercial applications, with many energy-intensive industries such as the whisky industry looking to decarbonise their businesses (SWA, 2025). Whilst lucrative to the economy, the whisky sector is responsible for up to 10% of Scotland's total energy demand (Andrews et al., 2025) and as a result, scope 1 and 2 emissions measuring over 600,000 tonnes of CO_2 in 2022 (Storegga, 2025). Whilst many of the 150 operating whisky distilleries in Scotland use renewable sources of electricity, many still use natural gas to power boilers that produce heat for the mashing and distillation processes which accounts for 83% of the sector's energy consumption (Brodies, 2026). Geothermal energy has the potential to replace, or at least reduce, the reliance on fossil fuels and provide the necessary heat for the distillation process during which a temperature of 78°C is required to boil the alcohol (Malts, 2025). This study aims to use the Ben Rinnes granite and a collection of distilleries near Dufftown, Moray to assess the feasibility of a Hot Dry Rock (HDR) geothermal project to provide low carbon heat for distillation. The regional geothermal temperature gradient (Scottish Government, 2013) suggests that hydraulically stimulated wells of ~3km depth will be required. The associated costs and productivity of these wells, as well as public acceptance and regulatory approval, are key challenges to overcome (Arup, 2025). However, with proactive public engagement, adopting key learnings from other operational projects, and further integrated geotechnical & engineering study, many of these risks could be mitigated.

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Heat When It Matters Most: Can High-Temperature Underground Thermal Energy Storage (HT-UTES) Improve UK Energy Resilience and What Role Can UKGEOS Play?

Author(s): Mark Griffiths, James Todd, Jordan Weddepohl, Mike Spence, Vanessa Starcher

Organisation(s): Arup, British Geological Survey

Abstract