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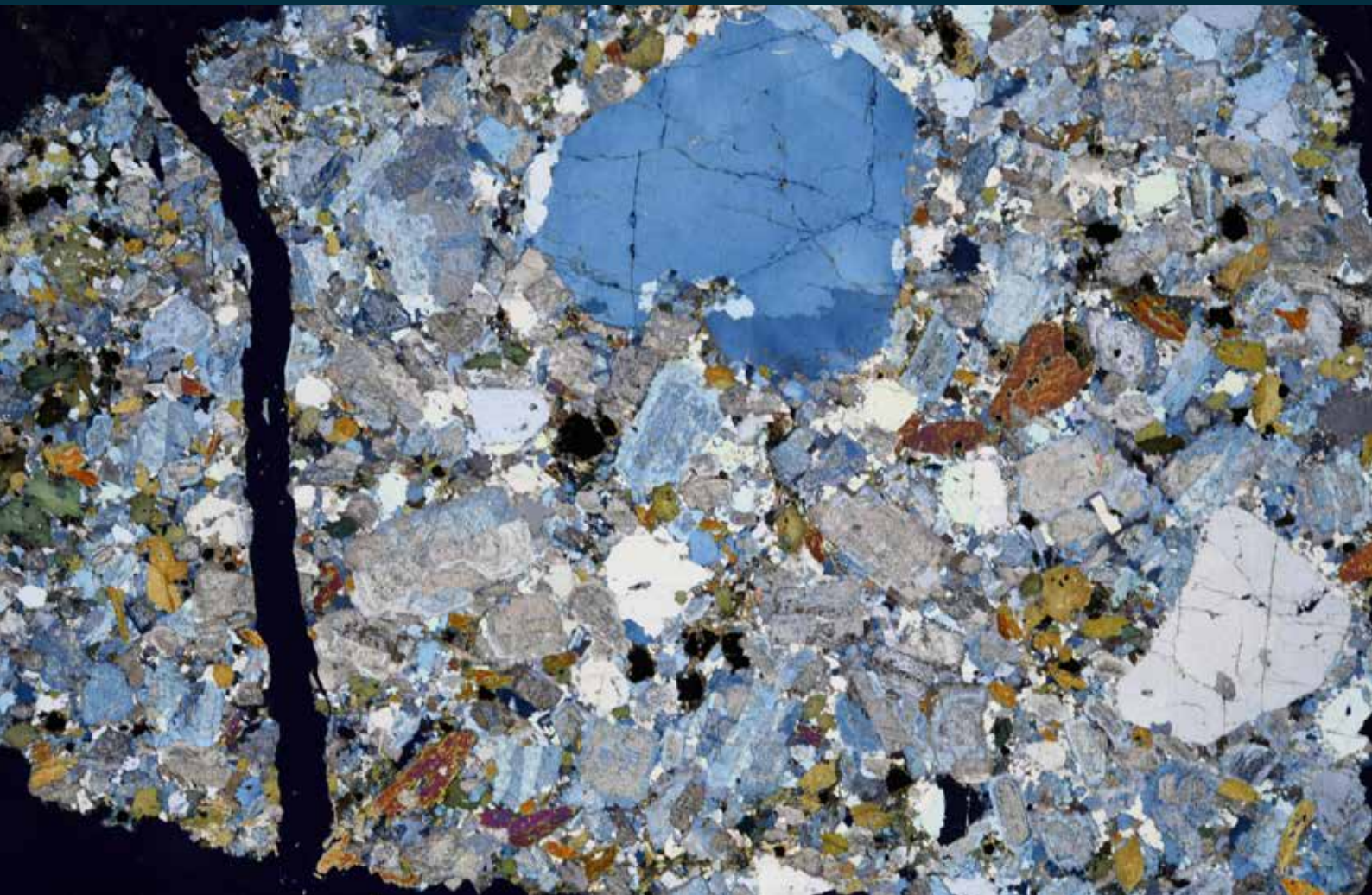
GSNI

Geological
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GEOLOGICAL SURVEY OF NORTHERN IRELAND

Annual Report 2023/24



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Director's statement:

Dr Marie Cowan

I am pleased to introduce the Geological Survey of Northern Ireland's (GSNI) 2023/24FY Annual Report. This report summarises how GSNI performed and the impact of our work for Northern Ireland's economy, environment and society.

As the Director of Geological Survey of Northern Ireland (GSNI), I am proud to present the 2023/24FY Annual Report, which has been another period of remarkable progress and significant achievements for our organisation. Our work, grounded in rigorous scientific research and innovation, continues to provide critical insights that support the economic growth and sustainable development of Northern Ireland (NI). This report highlights our key accomplishments and initiatives that underscore our commitment to excellence in geoscience.

One of the major highlights of this year has been GSNI's substantial contribution to a UK-wide study entitled "Potential for Critical Raw Material Prospectivity in the UK." This project aims to identify and evaluate the availability of essential raw materials necessary for the advancement of modern technologies and the green economy. Furthermore, our staff are supervisors on multiple PhD research projects, empowering the next generation of

geoscientists and ensuring a pipeline of talent and innovation in this field.

In another groundbreaking development, we helped the Department for Economy (DfE) launch the national geothermal demonstrator project, GeoEnergy NI. This initiative represents a significant step forward in our efforts to explore and harness geothermal energy, a sustainable and reliable source of heat. This project not only advances our understanding of geothermal resources but also aligns with one of our core values of sustainability.

Our commitment to preserving and utilising geological data has also seen a major milestone with the digital imaging and georeferencing of eight thousand thin sections. This massive undertaking enhances the accessibility and utility of our geological collections, enabling researchers and policymakers to leverage this valuable data in their work. By digitising these thin sections, we ensure their preservation for future generations and facilitate advanced research

through improved data integration and analysis capabilities.

The role of our national core store, often referred to as the “rock library,” was brought into the limelight this year through a collaboration with BBC NI. The filming highlighted the core store’s crucial role in supporting evidence-based policy research on groundwater and geothermal energy. This exposure has highlighted the importance of our geological archives and the research they support, reinforcing the value of our work to a broader audience.

Lastly, we undertook a significant operational change with the relocation of our office. This move, while logistically challenging, has positioned us in a more strategic location, enhancing our operational efficiency and facilitating better collaboration with our key stakeholders. At the time of writing a brand-new scanning electron microscope has just been installed and calibrated, together with staff training, which will support our team’s innovative work and allow us to continue leading in the field of geological research.

As we reflect on these achievements, it is evident that our success is driven by the dedication and expertise of our staff, the support of our parent government department DfE, and our collaborative efforts with academic institutions, public sector and industry research partners, and the public. Looking ahead, we remain committed to advancing geoscientific knowledge and providing critical insights that support

the economic, social, and environmental well-being of NI.

Thank you for your continued support and engagement with our work. Together, we will continue to explore, discover, and innovate for a sustainable future

Dr Marie Therese Cowan PGeo, MIOD MRIA
Director, Geological Survey of Northern Ireland





Introduction

GSNI is an office of the Department for Economy (DfE) in Northern Ireland staffed by scientists of the BGS. It was established under the Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959 and sits within the Energy Group of the DfE.

GSNI provides professional, technical and scientific research, data services and archive management to inform the development of NI's economy and to help protect its environment.

The work programme for DfE and associated terms and conditions are detailed in a service level agreement (SLA) between DfE and UK Research and Innovation (UKRI). The same applies to SLAs with Northern Ireland Environment Agency (NIEA) and other public sector bodies.

UKRI is a non-departmental public body sponsored by the Department for Science Innovation and Technology (DSIT) which governs the BGS and employs GSNI staff.

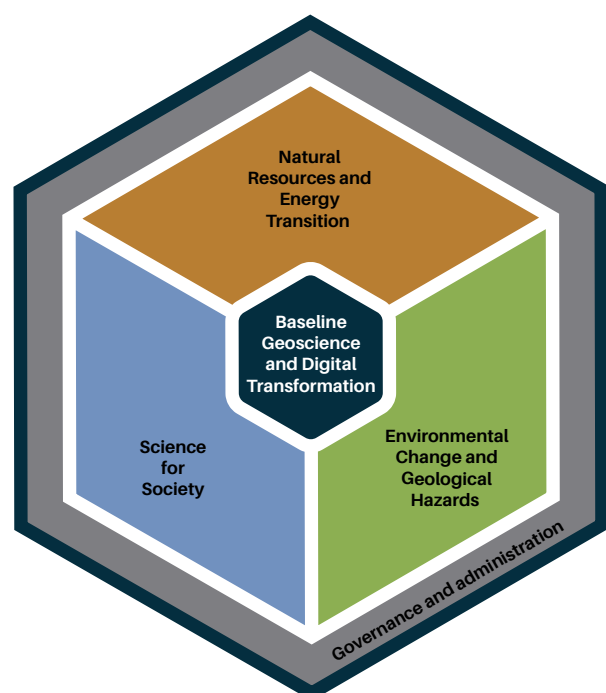
Governance and administration

The policies and processes framework for the operation and administration of GSNI are documented in the GSNI Procedures Manual, a key reference in any audit of GSNI. To provide an effective governance and assurance mechanism, DfE reviews progress on its SLA with GSNI at quarterly SLA review meetings.

The SLA review meetings are chaired by the DfE Director of Business, Gas, Minerals and Petroleum

Division. The purpose of the meeting is to review GSNI's SLA performance dashboards, monitor spend against budget, and manage risk.

The GSNI Director chairs monthly meetings of the GSNI Executive where monthly reports are reviewed,



issues and opportunities are considered, risks are escalated, and health and safety items are managed.

We deliver our public-good science through four science and innovation programmes using a coordinated approach to address local, national and global challenges. A summary of each of these has been provided below.

Natural resources and energy transition

An essential part of GSNI's work is ensuring our geoscience knowledge and expertise helps NI make best use of natural resources in a sustainable way and that policy decisions are informed by data and high-quality research. To this end, the Natural Resources and Energy Transition work programme supports the regulatory duties of DfE and wider government through the provision of technical expertise.

The green technology revolution relies on critical raw materials, sustainable use of groundwater resources and utilisation of low-carbon subsurface energy solutions. The Natural Resources and Energy Transition work programme increases the understanding of the distribution of these resources in Northern Ireland, and how subsurface properties and the modelling of geological processes can help in planning for the energy transition and sustainable uses of water resources.

Environmental change and geohazards

Climate change is the most pressing environmental issue we face, impacting our coastline, infrastructure, built environment and natural ecosystems. The Environmental Change and Geohazards work programme increases the understanding of changes to our natural and built environment, the vulnerability of our environment to geological hazards how it is responding to climate-driven challenges.

Key tasks within the Environmental Change and Geohazards work programme include enhancing geological hazard characterisation by implementing new monitoring techniques, increasing knowledge of groundwater to help reduce groundwater

vulnerability, assessing coastal change to reduce coastal vulnerability, and increasing the understanding of the urban and built environment to support climate resilient development.

Baseline geoscience and digital transformation

Good data underpins sound decision making and the expansion of our national baseline geoscience data is necessary to ensure we have the right data to address future challenges such as the supply of energy, raw materials and water. The demand for open access to data resources is increasing; data users want access to authoritative, modern, and increasingly, real time data. Our archives hold a wealth of information that must be accessible in order to be appraised against today's geoscience challenges.

The Baseline Geoscience and Digital Transformation work programme expands our geoscience data holdings and delivers GSNI's data to end users by supplying the underlying infrastructure, applications and processes that support all of the other work programmes.

Science for society

NI faces several societal challenges that present an opportunity to highlight the key role that geoscience must play in addressing these. By communicating with the public and our stakeholders and by strategically informing and supporting relevant government policy, we can raise awareness of and begin to address these challenges.

Increasing societal challenges will require an increased number of future geoscientists to enhance NI's sustainability and economic resilience which can be achieved by developing an inclusive approach to geoscience education. This is complemented by supporting sustainable geological tourism and using it as an effective and powerful means of bringing geoscience directly to society.

Public science role

GSNI'S mission is to deliver high quality scientific evidence and expert knowledge to inform the sustainable use of natural resources and sound

environmental governance whilst helping society transition to a low carbon economy and adapt to a changing world.

We achieve that through four overarching strategic objectives:

- Society, economy and environment: Delivering geoscience data and evidence to progress the economic and social ambitions of Northern Ireland while protecting and enhancing its natural environment.
- People and assets: Recruiting, developing and supporting our people and assets to provide high impact, innovative, efficient and effective public service.
- Partners and customers: Engaging with and listening to the public and stakeholders to inform our work and help build trust in, and understanding of, geoscience and the GSNI. Strategically informing and supporting key decisions and policies on national geological issues in Northern Ireland.

- Unlocking our data: Unlocking the value of our paper records and physical collections in our archive and through digital transformation of our data and delivery mechanisms.

Statutory responsibilities

GSNI was established under the Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959. As an office of DfE, GSNI has a number of statutory responsibilities as laid out in NI legislation as indicated in the table below:

NI legislation that determines GSNI’s statutory responsibilities

Theme	Legislation
Minerals	Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959
	Mineral Development Act (Northern Ireland) 1969
Planning	Planning Act (Northern Ireland) 2011
	The Planning (General Development Procedure) Order (Northern Ireland) 2015
	The Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 2015
Petroleum	Petroleum (Production) Act (Northern Ireland) 1964 and secondary legislation in 1987 & 2010
Abandoned Mines	Mineral Development Act (Northern Ireland) 1969
National Core Repository	Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959
Climate Change	Climate Change Act (Northern Ireland) 2022



Section 1

Our public-good science

Delivering the GSNI strategy

GSNI Science Advisory Committee

The role of the GSNI Science Advisory Committee (SAC) is to advise the GSNI Director and senior leadership team on the development and delivery of GSNI's science strategy. The SAC comprises just over 20 external members from all sectors, trade bodies and professional bodies in NI, and representatives from Ireland and elsewhere in the UK.

This SAC aims to meet twice per year and the position of Chair rotates amongst the university representatives; this year the SAC met online in January.

GSNI Science Task Force

The GSNI Science Task Force (STF) was established in September 2022 and has the following roles:

- Review current research science and ensure links into relevant NI government policies.
- Prioritise future research that aligns with and meets the requirements of the GSNI science strategy.
- Maximise the impact of our science; and ensure benefits for society.

The membership of the STF consists of GSNI scientists who aim to meet quarterly. This year, the STF met in-person in April, August, and December.

The STF reports to the GSNI Executive with the focus being to strategically prioritise research as part of the GSNI work programme and to respond to new research challenges as they arise.

Science into policy

GSNI's position as an office within DfE provides a valuable opportunity to inform and support public policy development right across NI government, and to inform debates and decisions on relevant issues. Using this approach, it is providing the scope to identify policy trends and opportunities not just within NI, but throughout the rest of the UK, Ireland, and the rest of Europe.

GSNI staff have a wide range of expertise demonstrated through the breadth of science work programmes making it possible to provide valuable contributions to relevant policy consultations, calls for evidence and requests for information. Topics covered this year were centred around climate change including mitigation and adaptation related policies, as well as there being a strong focus on energy infrastructure.


Summary of science into policy

A list of policies that GSNI has provided input to are provided in the table below. Specific examples of science into policy are provided in the next section.

Department / Organisation	Policy
DAERA	Consultation on Carbon Budgets and 2030 and 2040 targets for Northern Ireland
DAERA	Consultation on UK Climate Change Committee Advice for Northern Ireland
DfE	Consultation on Offshore Renewable Energy Installation (OREI) Policy Options for Northern Ireland
DfE	Internal DfE engagement on Approach to 10X Technologies and Clusters
DfE	Consultation on Draft Tourism Strategy for Northern Ireland
DfE	Consultation on Onshore Petroleum Licensing Policy for Northern Ireland
DfI	Call for Evidence in relation to a potential focused review of the Strategic Planning Policy Statement (SPPS) on the issue of climate change
DfI	Internal DfE engagement on Energy Infrastructure and Mineral Development Thresholds
DfI	Consultation on the Review of Regional Strategic Planning Policy on Renewable and Low Carbon Energy

Summary of outputs

10  Peer-review papers and books

9  Public webinars and invited talks

21  Conference abstracts

7  GSNI-led fieldtrips

10  Reports

9  Public in-person events

1  Magazine article

3  TV / radio appearances

Summary of SLA objectives

A summary of the work programme delivered as part of the DfE SLA is provided in the table below.

WP	No.	Objective	Target Achieved in 2022/23
Governance	1	Governance and project evaluation	
	2	Strategic communications	
	3	Administration, finance and contract support to GSNI	
	4	Leadership	
Natural Resources	1	Mineral licensing and policy support	
	2	CRMs prospectivity	
	3	Geothermal prospectivity	
	4	Groundwater resources	
	5	Subsurface properties characterisation to support climate change adaptation and mitigation	
	6	Natural resources and energy research in the area of climate change adaptation and mitigation	
Geohazards	1	Abandoned mines and emergency response planning	
	2	Geological hazards	
	3	Groundwater catchments	
	4	Coastal change and marine environment	
	5	Urban and built environment	
Digital	1	Curate, maintain and promote the GSNI core store	
	2	Expand and develop our baseline geoscience data holdings	
	3	Provide data collection, storage and delivery mechanisms	
	4	Digitising and publishing our records and collections	
	5	Delivering new and innovative data products and services	
Science for Society	1	Planning and enquiries	
	2	Public policy	
	3	Stakeholder engagement	
	4	Sustainable tourism	
	5	Education and public engagement	
Geothermal	1	Reconnaissance and Survey	
	2	Test Boreholes	
	3	Thermal response tests	
	4	Feasibility and design	
	5	Visualisation and engagement	
	6	Project support	



Science highlights

Natural resources and energy transition

Minerals licensing support

Operational support for the DfE Minerals and Petroleum Branch licensing regime continued as business as usual through the year. No new mineral prospecting licences (MPLs) were awarded in the period, and none were removed from the portfolio. GSNI carried out assessments and reviews of submitted annual reports along with environmental assessments for the notified exploration activities to support DfE in the administration of licences.

The annual mineral return from quarry operators indicated a slight drop in production between 2021 and 2022 despite an increase in the number of returns received. GSNI compiles the returns submitted to DfE under legislation covered by the Quarries (Northern Ireland) Order 1983.

The Judicial Review of the mineral licensing process brought by Derry and Strabane District Council in 2019 was rescheduled twice during the year. GSNI provided written support for DfE as part of this process.

Research to support critical raw materials policy development

The 2022 UK Critical Minerals Strategy and the 2024 EU Critical Raw Materials Act set a clear strategic direction on the importance of minerals for future

green growth taking into consideration the energy transition and net zero goals.

In 2022, BGS launched the Critical Minerals Intelligence Centre (CMIC) to improve the resilience of the UK's critical mineral supply chain and to begin a national-scale assessment of the critical minerals within the UK and recently published a report "Potential for Critical Raw Material Prospectivity in the UK" providing a national-scale assessment of the geological potential for critical raw materials in the UK.

GSNI and DfE have contributed to this work by establishing a portfolio of research and data gathering to better understand the distribution of platinum group elements (PGEs), antimony (Sb), molybdenum (Mo), graphite (C) and vanadium (V) and other critical raw materials (CRMs) in NI. Work on PGEs is through the Trinity College Dublin 'Critical Ireland' project, whilst work on Sb, V and C has been started with assistance from BGS. A further PhD project looking at CRMs and base metals is underway at Edinburgh University. Two PhD proposals have been submitted for funding on Sb and Mo.

This work is intended to inform DfE of potential opportunities for CRMs in the region as it develops a policy position on mineral development.



The launch of GeoEnergyNI at Parliament Buildings, Stormont, October 2023.

Launch of GeoEnergy NI

GSNI is supporting the DfE in the delivery of two geothermal exploratory and feasibility studies that will be used to better understand the subsurface and to identify sites to drill and install one shallow geothermal system and one deep geothermal system in NI. The project is formally known as GeoEnergyNI and the data and learning from this will be used to demonstrate that a viable geothermal heat resource is accessible at depth, to encourage private investment and to inform the development of a policy and regulatory framework that supports and promotes opportunities to unlock NI's geothermal energy potential. GeoEnergy NI is being delivered alongside GSNI's four main science and innovation work programmes.

The key milestones from this year include:

- The project was officially launched at the Pavilion, Stormont Estate in June 2023, which was attended by key stakeholders from across the sector.
- Geophysical surveys in Antrim in and around the College of Agriculture Food & Rural Enterprise (CAFRE) Greenmount Campus were completed in July 2023.

- The planning application for drilling on the Stormont Estate was submitted in August 2023.
- The GeoEnergy Discovery Centre was launched in October 2023 and its first roadshow took place in February 2024.
- Belfast City Council approved the planning application to explore shallow geothermal potential through exploratory drilling and testing on the grounds of Stormont Estate in March 2024.

Contribution to the Belfast Local Area Energy Plan (LAEP)

GSNI was a primary stakeholder for the Belfast Local Area Energy Plan (LAEP), with GSNI being on the Steering Committee over the 11 months.

Recognising the need to plan the most effective pathway to reach net zero while assessing the planned development within the Innovation District, Belfast City Council appointed the Energy Systems Catapult to develop a LAEP for the City of Belfast and Innovation City Belfast (ICB).

The LAEP seeks to recognise the importance of assessing the unique characteristics of Belfast as part of the net zero transition and utilise place-based data



The abandoned Whitespots-Conlig lead mines, one of many sites monitored by GSNI.

and network system modelling as a foundation to simulate the most effective pathway to achieving net zero for the region. This foundational piece of work will help Belfast attract funding into the city and will feed into the wider business case for potential LAEP roll out across NI and link with the future Citywide Climate Action Plan.

Working towards a potential resource map for groundwater – Ballinderry Catchment

Following publication of the ‘Northern Ireland Groundwater Environment’ and the accompanying map in 2023, GSNI are undertaking more detailed groundwater studies on a catchment scale.

The Ballinderry catchment was selected for this pilot study following a consultation with relevant stakeholders. New 1:10,000 scale bedrock and superficial aquifer maps have been produced and a pilot groundwater sampling campaign has been conducted successfully collecting and analysing 10 new groundwater samples.

Groundwater has a key role to play in our sustainable development including as a potable water resource and in the energy transition as part of open-loop

geothermal and in hydrogen production. A detailed knowledge of the physical and chemical properties of groundwater is essential to optimise how we use and protect these valuable resources. The new maps will provide the basis for more localised aquifer properties, better understand the groundwater environment and derisk groundwater exploration and improve its protection.

Environmental change and geological hazards

Abandoned mine programme

GSNI continued its Abandoned Mine Monitoring Programme encompassing NI’s 2,400 recorded historic mine workings. A total of 52 inspections were conducted during the year with no mitigation measures and remedial works required. In addition, GSNI continued to deliver its abandoned mine 24/7 emergency response service.

Research was focused on assessing stability of abandoned salt mines within Carrickfergus and assessing any potential impact on nearby infrastructure networks. This included the re-appraisal of terrestrial surface motion data attained



Church Bay, Rathlin Island taken on a guided tour for a local walking group.

by GSNI since 1991 using precise levelling, Global Navigation Satellite System (GNSS) and sub-surface extensometer data acquisitions. This has been combined with evaluation of interferometric synthetic-aperture radar (InSAR) acquisitions acquired through Earth-observing satellites from 1991 to present day.

GSNI commenced the development of a new abandoned mine database that will bring together all historic mine reports, literature, photographs, inspection reports, remediation reports and site investigation results. The database will be a valuable resource for those carrying out planning development in areas of abandoned mines as well as those who have a general interest in NI's mining heritage. The database is due for public release in Autumn 2024.

Launch of NI Coastal Observatory

October 2023 saw the launch of the NI Coastal Observatory, created by ESRI Ireland in partnership with the Department for Agriculture, Environment and Rural Affairs (DAERA). The NI Coastal Observatory was an objective of the Coastal Forum Working Group, of which GSNI is a member, with the aim of facilitating and making available coastal datasets

that are urgently required to inform sustainable management of the coast.

DAERA commissioned several surveys using multiple methodologies including LiDAR surveys of both the coast and nearshore areas, the collection of high resolution orthophotography, acquisition of satellite derived bathymetry data, historical aerial photographs and of course, bedrock and superficial geological datasets of the coastline. GSNI worked closely with DAERA to produce the geological datasets for the coastline extending 200m inland and to the 10m depth contour offshore.

Whilst the Observatory has been launched, work will continue on developing the platform, increasing functionality and expanding the datasets to allow for more informed change analysis and coastal vulnerability assessments to take place.

Completion of AGEO project

The Platform for Atlantic Geohazard Risk Management (AGEO) reached its conclusion in May 2023. This four-year project was for a total of €3.2 million and funded through the EU Interreg Atlantic Area. GSNI was one of 13 partners from five countries



GSNI stakeholders at the AGEO final conference in Lisbon, April 2023.

across the Atlantic Area; Portugal, Spain, France, Ireland and the UK.

GSNI's individual role in the project was to deliver one of the five Citizens' Observatories with the aim of improving risk management systems at key sites. For GSNI, this was done through the Causeway Coast Citizen's Observatory where we worked closely with the National Trust to monitor rockfalls at the Giant's Causeway and Carrick-a-rede, and engaged with staff, other stakeholders and the general public to raise awareness of geohazards not just on the Causeway Coast but across NI.

Activities in the last few months of the project included attending the final project conference in Lisbon, together with key stakeholders for GSNI including DfE and the NIEA. The conference highlighted the success of the project, key achievements and demonstrated the plans for continuing aspects of the work after the project end.

New engineering geology map for Belfast

A draft of the new Belfast Engineering Geology map has been completed, delivering an update to the original 1970s map to meet the needs of numerous

geotechnical, civil and environmental engineering stakeholders.

This revision gives an overview of the distribution of superficial deposits, the underlying bedrock formations, and depth to the base of estuarine deposits across the Belfast City area. Understanding the nature, distribution and thickness of superficial deposits is crucial to understanding the engineering challenges faced during construction. In addition, the distribution and nature of raised beach, marine and estuarine deposits can help provide insights into the impacts of future sea level rise, given their emplacement during a marine transgression. The reverse of the sheet provides maps of depth to the bedrock and till surfaces, as well as generalised descriptions of the geological formations encountered. A series of illustrations describe a conceptual model of the development of superficial deposits in Belfast during the Quaternary period.

More than 12,000 boreholes were used to model the depth of the bedrock surface across the model area, and 7755 stratigraphic layers interpreted from 3624 boreholes were used to construct the basal surface of estuarine deposits and the top of the till surface. As well as using borehole descriptions, the models used



GSNI developed a new engineering geology map for the greater Belfast area.

data from cross-sections constructed as part of a 3D geological model of Belfast.

Science into policy

Planning development management

GSNI, through DfE, is a statutory consultee for planning applications in the development management process as stipulated in The Planning (General Development Procedure) Order (Northern Ireland) 2015. This is for all mineral applications and for all applications for hydrocarbon exploration or extraction. In addition, GSNI is a non-statutory consultee for planning applications that may be impacted upon by geological issues including but not limited to abandoned mines, compressible ground, and geological hazards. This year, there were 182 planning consultations, with 48% being statutory.

As part of the development management process, GSNI supports Planning Officials through the provision of expert advice including recommending necessary site investigations needed for specific sites and reviewing a wide range of assessments including, but not limited to, Environmental Statements, slope

stability reports, landslide risk assessments and mine risk assessments.

Geothermal Advisory Committee

The Geothermal Advisory Committee (GAC) for NI was established in July 2021 bringing together experts from industry, academia, public sector, and professional organisations based in the UK and Ireland. This group provides independent advice to DfE aimed at informing, supporting, and developing public policy on geothermal energy for NI as part of the new NI Energy Strategy.

This year, the GAC had four meetings to advise and input to the following outputs:

- GSNI's submission and individual survey interviews for DfE Skills for the Energy Transition research (May).
- GeoEnergy NI Project and Communications survey overviews, DfE Heat Policy update and GSNI's new Geothermal Geoportal release.
- Input into the invite list and participated in DfE's Geothermal Regulatory Workshop (October).
- Provided feedback on mechanical, engineering



View of development in the Titanic Quarter, Belfast. © ChrisHillPhotographer

and plumbing Heat Pump Event proposal (December).

- Provided feedback on proposed GeoEnergy NI Virtual Reality module structure.

GO-Science – Future of the Subsurface Foresight Project

GSNI is working with the Government Office for Science (GO-Science) on their Future of the Subsurface Foresight Project and helped to facilitate the NI regional stakeholder workshop in December 2023.

The project is looking at the range of current and future uses of the subsurface, including infrastructure, sustainable water management, geothermal energy, use of finite space, and climate adaptation. Through extensive stakeholder engagement across the UK, it will identify any gaps in knowledge, policy and/or regulatory frameworks that can be further explored to ensure the subsurface is utilised to its full potential.

The NI regional workshop was attended by a range of public sector organisations with an interest in the subsurface. This included representatives from DfE, DfI, DAERA, NI Water, the Utility Regulator, the Agri-

Food and Biosciences Institute (AFBI), local councils and members of staff from GSNI.

The outputs from the workshop will feed into the final project report identifying outputs that will develop an evidence base, methodologies, and tools to explore the future uses and long-term trends regarding the subsurface.

Call for Evidence on Planning Policy and Climate Change

In January, DfI published a Call for Evidence in relation to a potential focused review of the Strategic Planning Policy Statement (SPPS) on the issue of Climate Change. The call for evidence will inform whether the current policy framework provided for by the SPPS in relation to climate change remains appropriate and fit for purpose.

GSNI provided a comprehensive response to the Call for Evidence that included a request to include consideration of the subsurface as part of the 'Purpose of Planning' section as a result of the increased pressures that climate change will place on this space. Comments were also provided on specific subject policies identified within the consultation document by DfI including flood risk, transportation,



Slope instability that caused the closure of parts of the walking trail at the Giant's Causeway.

and development in the countryside. Additional comments were provided on other subject policies included within the SPPS but not mentioned in the consultation including coastal development and minerals.

A request was made to include a specific subject policy on ground conditions and geological hazards given the increase in slope instability events in relation to extreme weather. This was also highlighted due to several ground instability incidents that had affected high profile developments. The impacts of climate change will require a much greater consideration of ground conditions, something that is currently not recognised within the SPPS.

NI's Geodiversity Charter

Together with NIEA, GSNI produced NI's Geodiversity Charter that runs from 2021 to 2024. The Charter encourages promotion and management of our geodiversity and the integration of geodiversity into policy and decision-making. By creating a greater awareness and understanding of our geodiversity it will lead to better protection of our geological heritage and the ability to sustainably manage our natural resources, so that we can enjoy the full range

of economic, social and environmental benefits it provides.

To encourage a greater awareness of geodiversity and the integration of geodiversity into policy and decision-making GSNI and NIEA embarked upon an engagement programme this year that continued with local government and included central government and academia for the first time. GSNI and NIEA delivered presentations to Department for Communities (DfC) (Historic Environment Division) as part of their monthly webinar series, and to DAERA as part of their weekly webinar series organised by the Office of the Chief Scientist. Presentations have also been delivered to the Place and Prosperity Committee of Ards and North Down Borough Council as well as to the School of Geography and Environmental Science at Ulster University.

NI Carbon Budget Consultation

In February, GSNI responded to the consultation on the NI carbon budgets as published by DAERA. This document included consultation on NI's 2030 and 2040 emissions reductions and targets and the first three carbon budgets. These targets were identified



Imaging of the GSNI thin section collection.

as part of the Climate Change Act (Northern Ireland) 2022.

In addition, the consultation sought views on the UK Climate Change Committee's (CCC) 'Advice Report: The Path to Net Zero' that outlined various scenarios to allow NI to reach its net zero targets. GSNI responded to say that the recommendations of the CCC should be followed as they are consistent with the Intergovernmental Panel on Climate Change's (IPCC) required projected emissions levels if global warming is to be limited to 1.5°C.

GSNI also responded to say that the speculative option for achieving net zero proposed by the CCC should be delivered due to the emissions gap that results from the other suggested pathways. This option is of relevance as it includes the use of geoscientific solutions to deliver climate change mitigation measures. This includes the potential for carbon capture and storage, that could be delivered in NI through the sequestration of carbon by mineral precipitation in basaltic rocks. It also proposes the use of enhanced rock weathering to sequester carbon dioxide from the atmosphere through the dissolution of silicate rocks such as basalt.

Digital data access and products

Access to geotechnical data

GSNI holds borehole and site investigation records acquired through GSNI projects, other government schemes or by voluntary donations that span the width and breadth of the country. These can be both shallow trial pits of a metre's depth, or deep exploration boreholes. The deepest in NI being the Larne No. 2 borehole at over 2000m.

As part of the restructuring of the GSNI enquiry service, historic borehole and site investigation collections have been made available online. This ensures data that relates to the subsurface is readily available for a number of end-users including engineers, developers, planners and researchers.

Historical collections

GSNI has undertaken a review of our extensive historical archive to identify material for scanning. This includes historic geological mapping, mineral and petroleum exploration reports, abandoned mines material and petrology reports.



GSNI completed the Newry 1:10,000 scale superficial geology mapping.. ©Tourism Ireland/Gareth McCormack

This work was essential for a number of reasons. Firstly, to derive new compilations of material to underpin GSNI science and innovation work programmes. One example of which is the historic mineral exploration reports that will be vital in supporting CRM research. Secondly, GSNI has been tasked with reducing the amount of physical collections held at our key storage facility at Castle Buildings due to increasing pressures for space from other government departments. As a result of this work, the GSNI footprint in the stores has been reduced to 50% through organisation, digital capture and disposal of materials.

Imaging of GSNI's thin section collection

One of the initial tasks undertaken by our new Geomaterials Technician was to curate GSNI's collection of thin sections. This involved moving the collection of almost 8000 thin sections slides to the new GSNI office before sorting, cleaning, and curating the collection. The thin sections database was also reviewed to check the metadata.

Work began on producing digital images of the collection using a 3D-printed imaging station that enabled the capture of full slides in both plain and cross polarised light. The process was carried out

using a raspberry pi to control both the camera and the polarisers on the imaging station. The images were captured using a 50MP camera and were subsequently labelled in an automated process using the database.

Finally, the images were linked to a GIS that has already enabled researchers to explore the collection and to select slides for further analysis. When the collection is complete the images and the GIS layers will be made available online to enable access to this valuable resource.

Development of geothermal portal

Work continued to review the archives of exploration data held by GSNI and to identify, digitise and create metadata for these resources. These include: historic exploration wells, reports and seismic and gravity surveys. These metadata records and their resources are loaded to the dedicated geothermal portal on the GSNI data catalogue. When complete, the geothermal portal will increase the availability of information that researchers and industry are able to use to help build and strengthen the geothermal sector.



Core samples that have been digitally imaged as part of the core store digitisation project.

1:10,000 scale geological mapping review

GSNI began geological mapping in NI in 1947, with systematic mapping on a sheet-by-sheet basis continuing ever since with NI now being one of the best geologically mapped areas in the world. In 2010, GSNI produced the first seamless map of NI at a scale of 1:10,000. This map was a compilation of the earlier mapping that had been undertaken by different methods throughout the 60 years of compilation.

As methods of mapping have changed and priorities have refocused, the GSNI 1:10k mapping was assessed, as part of a wider BGS review into geological mapping, against a framework to determine the areas that need revision. This may be for different reasons such as the previously unseen subsurface insight being provided by later Tellus surveys or because the areas mapped had initially neglected the superficial deposits.

The review identified the areas of mapping that were in most need of revision. This will feed in to a roadmap to determine strategic priorities for revision in line with GSNI's science and innovation work programmes.

Enquiries

GSNI responded to 453 enquiries with an average time to completion of nine days. The sector represented and enquiry type have been collated from the enquiries database and are shown in infographic.





The GeoEnergy Discovery Centre has welcomed over 1000 visitors to date.

GSNI core store

Cataloguing and conservation of the core archive continued, with a number of collections being added. These included the teaching collection from the former geology department at Queen's University Belfast and the research collection of T. B. Anderson.

Camera equipment purchased as part of DfE capital funding allowed a new set up for imaging of both core material and thin sections to be carried out. As part of a trial, 200 core trays were imaged and a procedure for cataloguing the collection was piloted that will enable the collection and resulting images to be accessed online.

The core store received ?? visitors in the year, including geoscience students and researchers studying subjects that include low-carbon cement manufacture, carbon storage, geothermal and Triassic and Jurassic palaeoclimate.

Engaging stakeholders and the public with our science

All-Ireland Sustainability Summit

GSNI once again participated in and was one of the event partners in the All-Ireland Sustainability Summit, in March 2024. This seminal event for sustainability across the island of Ireland was hosted by Triterra with the intention of inspiring individuals and organisations to drive and accelerate positive change towards sustainability and net-zero.

GSNI chaired and participated in one of the final panel discussions on the Net-Zero Stage, 'Sustainability within the agri-food sector: the role of climate action for water and food security', with specific input from GSNI on the role that groundwater resources play in the agri-food industry and the importance of its sustainable use. Other organisations represented on the panel were from the Global Food Security Institute at Queen's University Belfast, the School of Earth Science at University College Dublin, and from AFBI.

Attended by well over 250 people, those present were from a diverse range of sectors including business, industry, government (central and local),



GSNI participated at the All-Ireland Sustainability Summit in March 2024.

community and voluntary. It was a great opportunity to network with audiences that would not typically be aware of GSNI’s outputs and activities and how they contribute to sustainability.

GeoEnergy Discovery Centre (GDC) roadshow

In October 2023, DfE officially launched the GDC at Parliament Buildings as part of Science at Stormont. The GDC includes detailed information on geothermal energy as well as interactive virtual reality headsets, augmented reality and demonstrator

Webinar Title	Company
Research into the Geothermal Energy Sector in Northern Ireland	BGS and Arup
Ground Source Heat Pumps Today and Tomorrow	Genius Energy Labs
Drilling Down Into Geothermal Energy	Dragon Drilling
Why Geothermal? Analysis of Community Acceptance to Promote Energy Justice	Texas Geothermal Energy Alliance and UT Bureau of Economic Geology
The Value of Geothermal for a Clean Energy Transition	International Renewable Energy Agency
Imaging Subsurface Geology Using Gravity Measurements From the Air	Metatek
Assessing the Goldilocks Zone for Open Loop Ground Source Heat Pump Systems	Agua Enodo
GeoMap™ Beta - A Deep Dive into the Research Behind the Subsurface Data	Project InnerSpace
Making Geothermal Heat Projects Happen	TownRock Energy



The BBC visited the GSNI core store in December 2023 as part of a climate change feature.

tables showcasing NI geology as well as heat pump technology and drilling processes. The centre was open to the public to visit on the Stormont Estate before embarking on a roadshow in February 2023, visiting several locations including the Giant's Causeway, Coleraine and the Foyle Arena. GSNI helped organise, contribute to and staff this inaugural roadshow.

The team welcomed over 1000 visitors from both schools and members of the public to the centre, where they were provided with an interactive, educational and fun experience from the Geo Ambassadors.

Geothermal webinar series

GSNI worked with Queen's University Belfast, Geothermal Association of Ireland and Geological Survey Ireland GSI this year to host nine webinars on geothermal energy all of which are available on the GSNI YouTube channel. In total, the webinars attracted 1381 registrants from 70 countries.

BBC filming at the core store

With the help of the DfE Press Office, GSNI featured on BBC Newsline in December 2023, highlighting the

role of our core store in helping to address societal challenges in relation to climate change.

Lousie Cullen, BBC NI's Agriculture and Environment correspondent visited the core store and interviewed a number of GSNI staff who explained what the GSNI core store is, the information that it holds and the benefits it brings including in the support of the sustainable use of groundwater and geothermal energy. We were also joined by the Head of Business, Gas, Minerals and Petroleum within the Energy Group at DfE.

BBC NI produced an extended piece for social media highlighting the use of the 'rock library' that GSNI holds and the stories that it can tell about NI's geological history.

NI Science Festival events

GSNI were involved in various events as part of the NI Science Festival in February 2024.

- Together with Queen's University Belfast, GSNI hosted "The Mournes through time – Environmental change and cultural heritage" in Carcullion House, Hilltown. This event showcased the work of one of GSNI's PhD students focusing



Visitors to the GeoEnergy NI Discovery Centre using the virtual reality headsets.

on the environmental and cultural history of the Mourne using pollen preserved in peat sequences to reconstruct vegetation change and human activity.

- Together with the Marble Arch Caves, GSNI delivered the annual dye-tracing event, exploring the hydrogeology of the cave systems through an active demonstration. This showed how dye is used to find out where water goes to in karst systems with participants also entering the Marble Arch Caves to carry out a salt dilution gauging experiment to calculate the flow of water through the caves.

GeoEnergy NI visualisation and education resources

GSNI contributed to the development of a virtual and augmented reality package for the GeoEnergy NI project. This consists of nine modules that allow users to have a hands-on, immersive experience to learn more about NI geothermal potential. This resource can be used in the GDC and in classroom settings and will help people of all ages learn more.

GSNI also designed a suite of teaching resources aimed at Key Stage 2 pupils for the GeoEnergy NI project. The pack provides teachers with activities and supporting information to deliver classroom

activities exploring geothermal energy and its potential in NI.

Science and Stormont

GSNI attended the Royal Society of Chemistry's 'Science and Stormont' event in October 2023. The day allows fostering of close relations with policymakers and key stakeholders from the NI science and engineering community.

The GSNI Director chaired the panel sessions throughout the day on the theme of 'Building our future: research and innovation in Northern Ireland'. This included an MLA panel to discuss key questions arising from the day and to close the event.

GSNI was also one of the exhibitors at the event together with other key science education stakeholders for NI.

DfE's GeoEnergy Discovery Centre was officially launched in front of Parliament Building steps at Stormont on the same day. GeoEnergy NI project partners, led by GSNI, invited delegates attending the Science and Stormont event to combine a short visit to the centre.

Section 2

Our People

GSNI staff

At the end of year, GSNI had 12 members of staff.

Staff changes

There have been several staff changes in the past year:

- Sean Burke has left GSNI (and BGS) and has taken up a new position with the Coal Authority.
- Paul Wilson has been successful in his personal promotion application and has moved from Band 6 to Band 5.
- Kieran Parker has been appointed as the Applied Geohazards Geologist for GSNI, moving from Band 6 to Band 5 position.
- Kirstin Lemon has been appointed as the Science Programme Manager for GSNI, moving from Band 5 to Band 4 position.
- Anna Lawrenson joined GSNI as our new Geomaterials Technician, playing a key role in helping to digitise our collections within the Baseline Geoscience and Digital Transformation work programme.
- Sam Roberson, GSNI's Quaternary geologist transferred to BGS Scotland at the end of March 2024.

Office move

GSNI had to adapt the work programme to account for an unplanned office relocation as a result of the closure of Dundonald House. GSNI moved to the DfE Head Office in Adelaide House in September 2023.

Health, safety and well-being

Health, safety and well-being has continued to be a high priority as staff continue to operate in a hybrid working environment.

Two members of staff are involved in the BGS Mental Health and Wellbeing group which involves the development and implementation of a mental health strategy. This also includes the organisation of events to promote social and physical wellbeing in our office.

This winter our staff were offered the opportunity to receive high lumens desktop lights to mitigate against Seasonal Affective Disorder - seven staff availed of this pilot initiative.

Learning and development

Learning and Development (L&D) is primarily managed by the L&D team at BGS who provide and support training in leadership and management, behavioural / soft skills, IT, science, Health and Safety, bespoke coaching, mentoring and other training opportunities as they arise.

Mandatory training

Mandatory training has been completed in the following topic areas:

Topic	BGS	NICS
H&S	5	3
Cybersecurity and information management	11	1
Governance and management	8	1
EDI	2	2

Continuing Professional Development

Continuing Professional Development (CPD) is encouraged and supported at all levels.

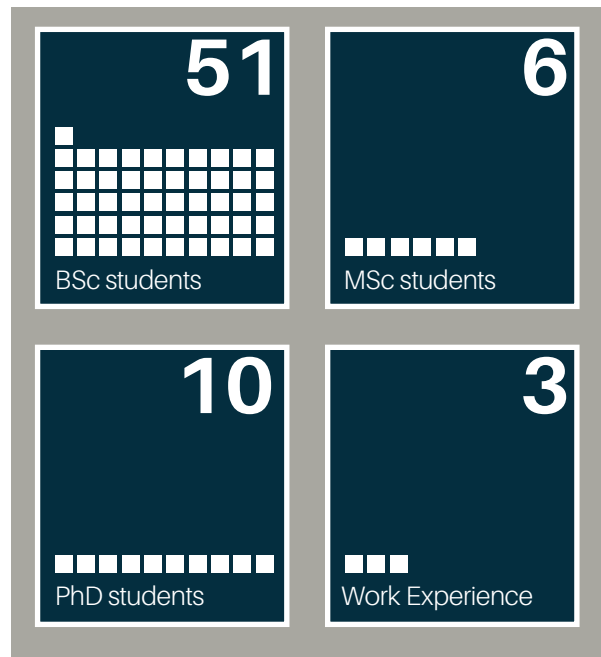
We are proud that our Director was elected from 43 nominated members of the Royal Irish Academy to be one of 12 members of the Academy’s Council at its annual Stated General Meeting in March 2024. This is the board of Ireland’s pre-eminent academic organisation and this role will involve participating in quarterly council meetings whilst continuing work on the North-South Standing Committee, and Council Recommended Members Committee.

Other CPD highlights for this year are as follows:

- One staff member completed the UKRI Emerging Leaders programme.
- One staff member completed the Insights Discovery Programme.
- All staff completed Carbon Literacy training delivered by Keep Northern Ireland Beautiful.
- All Line Managers have embarked upon a comprehensive suite of training courses designed to make better managers within BGS.

Equality, Diversity and Inclusion (EDI)

One member of GSNI staff is on the BGS EDI Steering Group, is a UKRI EDI Advocate and a member of several associated staff networks. This role allows for much needed insight into wider organisational initiatives providing valuable advice on how they can be applied at GSNI. Specific training activities this year



include: URGE (Unlearning Racism in GEosciences), Anti-Racism, Neurodiversity, LGBTQ+ Awareness.

GSNI is also a member of BGS’ Self-Assessment Team for the Athena Swan accreditation application for a Silver Award.

The GSNI Director delivered a “lunch and learn” session titled “GSNI and Neurodiversity, Making Accommodations for All”. This included raising awareness of different types of neurodiversity, and how we can support, enable and optimise working in a shared environment.

Supporting the next generation of geoscientists

GSNI are committed to supporting the next generation of geoscientists through engagement including work experience, provision of internships, school talks and MSc/PhD student supervision.

Procedures manual

All aspects of GSNI governance are detailed in the Procedures Manual, an internal organisational document, which is updated as required, reviewed and signed by all staff annually and is also audited cyclically by DfE.

Section 3

Financial summary

Income 2023/24.

Income type	£*	%
NI Public Service Level Agreement	1,000,355	89.9%
BGS Teams (UKRI)	28,720	2.6%
Personal Development (UKRI)	39,842	3.6%
Research	44,003	4.0%
Total income	1,112,919	100%

*excludes overheads

Northern Ireland Public Science

GSNI predominantly provides public science research services to government departments and Northern Ireland councils, primarily for DfE as part of its three-year recurrent work programme managed under a service level agreement (SLA).

Additional research

GSNI also has funding from UKRI via BGS and EU programmes. GSNI-based staff work on BGS Teams (UKRI) either on external research or internal 'national-capability' or operational projects.

Professional development

As GSNI staff are UKRI employees, BGS (UKRI) pays for their continuing professional development (CPD), mandatory training including health and safety.



GSNI visiting an NI Water pumping test as part of work delivered through the NI Water SLA.

Summary of external SLAs

In addition to the main SLA with DfE, GSNI staff also work with a number of public sector organisations through other SLAs.

NIEA

GSNI has been operating under an SLA with the NIEA to deliver key actions under the Water Management Unit and Natural Heritage Directorates within NIEA. The current SLA is renewed annually with a work programme being established to deliver a number of key tasks.

Newry Mourne and Down District Council

GSNI has been operating under an SLA with Newry Mourne and Down District Council to deliver key actions to maintain UNESCO Global Geopark status for the region. The current SLA is for a one-year period, during which time there are a number of key deliverables.

NI Water

GSNI has been operating under an SLA with NI Water to provide hydrogeological oversight for the development of groundwater resources to supplement the Northern Irish drinking water supply. GSNI's main role is to scope relevant work required from external hydrogeological consultants, as well as the assessment and review of such work, and to present this internally to NI Water.

DAERA coastal datasets

GSNI has been operating under an SLA with DAERA for the provision of a superficial bedrock geology dataset for the NI supported by the methodology to produce a coastal superficial geology dataset produced in the previous year.

Section 4

Forward look

Coastal

Over the past few years, GSNI has been slowly increasing its capacity in coastal geology, aided greatly by our presence on the Coastal Forum Working Group, led by DAERA and DfI. However, we recognise that this needs to be augmented greatly especially in the frame of using geological data and information to aid climate change adaptation and to assist in the management of coastal change.

There are a number of key developments scheduled to take place in the next year. The first is the recruitment of a coastal geomorphologist and systems modeller, who will be based permanently at the GSNI office in Belfast. Sitting within the BGS Coasts and Estuaries team, this staff member will be employed to help deliver the CHAMFER (UK Coastal Hazards, Multi-Hazard Controls on Flooding and Erosion) and UK Gravel Barriers projects, both funded by the NERC National Capability Multi-Centre Science Programme. However, their remit will also provide for the development of the coastal geology programme within GSNI.

Additionally, GSNI is expected to participate in the forthcoming PeacePlus funding bid under Theme 5.2: Marine and Coastal Management. This will potentially include key strategic partners such as Ulster University, AFBI, Ulster Wildlife Trust, the National Trust and local councils and is expected to help develop and deliver decision-making tools to support coastal change management.

Minerals

Current mineral policy and legislation that dates back to 1969, is being reviewed by DfE, in light of climate change and the need to transition to a low carbon economy. The International Energy Agency has indicated that the role of policy makers is crucial in reducing the uncertainty and volatility that surrounds material demands.

GSNI will continue to provide scientific support and information to assist in this review process. Immediate focus will be on increasing the understanding of the mineral resources within NI by identifying targeted mineral research topics and working with Mineral Prospecting Licence holders to maximise existing knowledge and opportunities.

GSNI expertise will evaluate the resource potential in the wealth of geology that NI possesses and identify development opportunities. In doing so GSNI can establish whether there is the capacity to reduce the uncertainty that surrounds the supply of minerals considered most important for the economy, to support climate change adaptation and mitigation and for national security.

As we move away from a linear consumer base to a more circular mindset we will work to reduce the impact that we have on the environment and the climate as a whole.



Drilling of a stratigraphic borehole outside Dundonald House on the Stormont Estate as part of GeoEnergy NI.

Geothermal

GeoEnergyNI

Looking ahead to next year, activities will include the provision of scientific support and advice to DfE's contractors with exploratory drilling and testing of five boreholes on the Stormont Estate. This study is hoped to inform a future heat network to replace the current fossil fuel heating systems at some of the government buildings.

We will also play our part in the planned GDC road-shows including the Balmoral Show, a milestone event in NI's annual calendar with 120,000 visitors expected, and many schools who have booked to host the GDC on their grounds.

The third key component of this project is to feed in GSNI expertise to DfE's pre-planning application for a deep geothermal energy system at CAFRE's Greenmount campus near Antrim.

GEMINI

At the time of writing, the Special EU Programmes Body announced an investment from the PEACEPLUS Programme of €20m (£17.3m) for Geothermal Energy research and development.

The aim of this unique investment is to promote energy efficiency and the reduction of greenhouse gas emissions across NI and the border counties of Ireland through increased awareness and uptake of geothermal technologies for heat production.

The funding has been awarded to a multi-partner project entitled GEMINI: Geothermal Energy Momentum on the Island of Ireland. The project is made up of 14 organisations from across the island, led by Codema and includes both GSNI, and our long-standing delivery partner Geological Survey Ireland.

The GEMINI project will, for the first time on the island, develop a joint approach to a renewable technology on a cross-border basis; and is estimated to begin in Q3 of the next financial year.



The Garron Point landslide.

Geohazards

The work that GSNI carried out as part of the AGEO project has provided a serious impetus for further developing our geohazards work programme in the coming year. The increasing number and intensity of rockfalls at the site provided an insight into how geohazards are becoming a significant issue for our economy, especially through damage to tourism and transport infrastructure.

GSNI is working closely with the Shallow Geohazards (SGEO) Team at BGS to develop a road map on how to develop the geohazards work programme in NI. This began with a field visit from a number of the SGEO Team and will continue with further visits to explore the potential of developing projects to gain a better understanding on the controls and triggers of shallow geohazards in NI.

The aim for the coming year is to first develop a geohazards work road map, followed by the identification of data products that could be developed to underpin decision-making in areas at risk from geohazards. All of this will be developed using a co-design process with stakeholder engagement being key to ensuring the right products

are developed for the right people and that our science is delivering for the public good.

Education and skills

GSNI is ensuring a strong focus on developing and supporting geoscience education and skills in relation to our work programmes in the coming year. The transition to a greener economy will require a much greater emphasis on geoscience-related skills as identified in the DfE commissioned research project led by Energy and Utility Skills. GSNI is striving to assist with this by providing opportunities and support for a diverse range of educational activities.

GSNI is one of only a few geoscience work experience providers in NI and is developing a new process to allow for the participation of as many suitable work experience students as possible. This is being supported by the DfE Careers Service who can provide additional contacts for a wider range of potential students.

In addition, GSNI is promoting geoscience career opportunities for post-primary school pupils who may not be aware of the breadth of potential career opportunities in this area. This will include attendance at university careers fairs and communication with the



Boxes of core waiting to be accessioned in the core store.

DfE Careers Service, with the intention of developing this further if successful.

GSNI is passionate about ensuring that geoscience education and skills opportunities are available for all and are developing an EDI Action Plan, that will include an event planner to ensure maximum participation from under-represented communities. This will also include neurodiversity, a particular focus for the coming year with a number of staff planning to attend the UK Neurodiversity Conference to find out more.

Digitisation of GSNI's core store

GSNI have recruited a Geomaterials Technician who will be undertaking a programme of work to catalogue, curate, and digitise the GSNI geomaterial collections. The collections consist of rock specimens and fossils collected as part of GSNI mapping and research programmes, core and cuttings from boreholes, and soils, sediments and waters collected as part of the Tellus project. Together, these collections provide a valuable insight into the ground

beneath our feet and are an important resource for researchers and industry.

Creating digital assets of these resources will improve access to a national collection and enable further use of these materials in support of critical raw materials, geothermal exploration and improve our understanding of the ground on which we live.

Outputs

Peer-reviewed papers and books

Beresford-Browne, A., Jolley, D., Millet, J., Stevenson, C., Watt, S., **Raine, R.** and Carter, E. (2024). Depositional system and plant ecosystem responses to long-term low tempo volcanism, the Interbasaltic Formation, Antrim Lava Group. Geological Society, London, Special Publications 547. <https://doi.org/10.1144/SP547-2023-75>

Hrysiewicz, A., Wang, X., Holohan, E., **Parker, K.**, Rodrigues, D., Falcao, A.P., Mangina, E., Gomes, R.C. (2024). Ground Surface Motions at AGEO Pilot Sites: Multi-temporal InSAR Observations and Geohazard Implications. In: Gomes, R.C. (Ed.) Citizens' Observatories on Geohazards. Springer, Cham. <https://link.springer.com/book/9783031533709>

Jaud, M., Le Dantec, N., Lummert, C., Cocquempot, L., Montoya-Montes, I., Pinto, C., Amaral Ferreira, M., **Parker, K.**, **Lemon, K.**, Rodrigues, D., Gouveia, F.P., Holohan, E., Correia, V., Gomes, R.C. (2024). Presentation of the Citizens' Observatory pilots. In: Gomes, R.C. (Ed.) Citizens' Observatories on Geohazards. Springer, Cham. <https://link.springer.com/book/9783031533709>

Mangina, E., Görgü, L., Holohan, E., Parker, K., Lemon, K. (2024). AGEO: Advanced Citizens' Observatory for Atlantic Geohazard Risk Management. In: Gomes, R.C. (Ed.) Citizens' Observatories on Geohazards. Springer, Cham. <https://link.springer.com/book/9783031533709>

Meju, M.A., Kulesa, B., Gallardo, L., Thompson, S., Ruffell, A., **Parker, K.** (2023). Improved imaging of ground deformation and brine seepage around abandoned flooded salt mines by joint inversion of multiphysics data. Journal of Applied Geophysics, 219. <https://doi.org/10.1016/j.jappgeo.2023.105217>

Molyneux, S.G., Harper, D.A.T., **Cooper, M.R.**, Hollis, S.P., **Raine, R.J.**, Rushton, A.W.A., Smith, P., Stone, P., Williams, M., Woodcock, N.H., Zalasiewicz, J.A.

(2023). A synopsis of the Ordovician System in its birthplace – Britain and Ireland. Geological Society of London, Special Publication 532. <https://doi.org/10.1144/SP532-2022-235>

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Parker, K., **Lemon, K.**, Gomes, R. (2024). Causeway Coast, Northern Ireland: Developing a geohazard citizen observatory to assist risk management. In: Gomes, R.C. (Ed.) Citizens' Observatories on Geohazards. Springer, Cham. <https://link.springer.com/book/9783031533709>

Smillie, Z., Demyanov, V., McKinley, J., **Cooper, M.** (2023). Unsupervised classification applications in enhancing lithological mapping and geological understanding: a case study from Northern Ireland. Journal of the Geological Society, 180 (4). <https://doi.org/10.1144/jgs2022-136>

Wilson, P., O Dochartaigh, B., **Cooper, M. R.**, **Ni Chonchubhair, R.** (2023). Northern Ireland's Groundwater Environment. NORA. <https://nora.nerc.ac.uk/id/eprint/535562>

Conference abstracts (talks and posters)

Abesser, C., Gonzalez Quiros, A., Boddy, J., **Raine, R.** (2023). The case for deep geothermal energy — unlocking investment at scale in the UK. Proceedings

of the 10th UK Geothermal Symposium, London, 20-22 November.

Abesser, C., González Quirós, A., Curtis, R., **Raine, R.**, Claridge, H. (2023). Geothermal Energy Use, Country Update for United Kingdom. Proceedings of the World Geothermal Congress, Beijing, 7-8 October.

Beckwith J., Stock M.J., **Cooper M.R.**, Holness M.B., Andersen J.C.Ø., Huber, C., Chew D.M., Carter E.J. (2023). The dynamics of carbonate assimilation in layered mafic intrusions. International Platinum Symposium, Cardiff, 4-7 July.

Carter, E.J., Stock, M.J., Beresford-Browne, A., Fereyrolles, A., **Cooper, M.R., Raine, R.** (2024). Rapid temperature fluctuations in the early Iceland plume revealed by olivine-spinel and melt thermometry. Volcanic and Magmatic Studies Group, Bristol, 3-5 January.

Cooper, M. (2023). Quantifying the Impacts of Faults and Dykes on Fluid Flow in Northern Ireland Permo-Triassic Reservoirs and Aquifers. Proceedings of the 10th UK Geothermal Symposium, London, 20-22 November.

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storage in the UK - a National screening approach. Proceedings of the 10th UK Geothermal Symposium, London, 20-22 November.

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Mackenzie, M., Clements, S., **Cowan, M.T.**, Lydon, C. (2023). Unearthing the heat beneath our feet in Northern Ireland: The GeoEnergy NI project. Proceedings of the 10th UK Geothermal Symposium, London, 20-22 November.

Mangina, E., Görgü, L., **Parker, K., Lemon, K.**, Holohan, E. (2023). AGEO: Advanced Citizens' Observatory for Atlantic Geohazard Risk Management. In: Gervasi, O., et al. Computational Science and Its Applications - ICCSA 2023 Workshops. ICCSA 2023. Lecture Notes in Computer Science, vol 14111. https://doi.org/10.1007/978-3-031-37126-4_43

Moscardini, R., **Raine, R.**, English, K.L., **Cooper, M.**, Haughton, P.D.W., English, J. (2023). Temporal and spatial variation in depositional environment and the effect on reservoir quality in the Sherwood Sandstone Group, Northern Ireland. Proceedings of the 10th UK Geothermal Symposium, London, 20-22 November.

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Cowan, M. (2023). Using Science to Produce Clean Heat, Create Jobs, and Warm Buildings. In-person talk for the GeoEnergy NI project launch, June 2023.

Lemon, K. (2023). Foundations of Mourne: The story of fire and ice – how the landscape was born. In person talk for Mourne Heritage Trust public lecture series, Newcastle Library, August 2023.

Lemon, K. (2023). Geodiversity and you: How geology made Northern Ireland. Webinar delivered for International Geodiversity Day, October 2023.

Lemon, K. (2023). The geology of Belfast. In-person talk for the Queen’s University Women’s Common Room Club, April 2023.

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Glossary

AFBI	Agri-Food and Biosciences Institute
AGEO	Platform for Atlantic Geohazards Risk Management
BGS	British Geological Survey
CAFRE	College of Agriculture, Food and Rural Enterprise
CCC	Climate Change Committee
CMIC	Critical Minerals Intelligence Centre
CPD	Continuing Professional Development
CRM	Critical Raw Materials
DAERA	Department for Agriculture, Environment and Rural Affairs (NI)
DfC	Department for Communities (NI)
DfI	Department for Infrastructure (NI)
DfE	Department for the Economy (NI)
DSIT	Department for Science, Innovation and Technology (UK)
EDI	Equality, Diversity and Inclusion
EU	European Union
GAC	Geothermal Advisory Committee
GDC	GeoEnergy Discovery Centre
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GO-Science	Government Office for Science
GSNI	Geological Survey of Northern Ireland
H&S	Health and Safety
ICB	Innovation City Belfast
InSAR	Interferometric Synthetic Aperture Radar
IPCC	Intergovernmental Panel on Climate Change
LAEP	Local Area Energy Plan
MLA	Member of the Legislative Assembly
MPL	Mineral Prospecting Licences
NERC	Natural Environment Research Council
NI	Northern Ireland
OREI	Offshore Renewable Energy Installation
PGE	Platinum Group Elements
SAC	Science Advisory Committee
SGEO	Shallow Geohazards

SLA	Service Level Agreement
SPPS	Strategic Planning Policy Statement
STF	Science Task Force
UK	United Kingdom
UKRI	UK Research and Innovation
UNESCO	United Nations Education, Scientific and Cultural Organisation
URGE	Unlearning Racism in GEosciences



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