Gateway to the Earth

SCIENCE STRATEGY FOR THE BRITISH GEOLOGICAL SURVEY 2019 – 2023

British Geological Survey
Expert | Impartial | Innovative

UK Research and Innovation

Why geoscience matters

- UNDERSTANDING THE DYNAMIC EARTH
  Comprehending the internal motor of our planet, which has built the continental and oceanic crust and created a habitat for life.

- CREATING A SAFE AND HEALTHY PLANET
  Minimising the impact of unavoidable natural hazards and building a cleaner, sustainable environment.

- LIVING SUSTAINABLY ON THE EARTH
  Providing the foundation for the exploration and responsible use of global natural resources, now and in the future.

- DRIVING GROWTH
  Identifying the resources that build economic prosperity, support industry and promote innovative technologies.

- REDUCING GLOBAL INEQUALITIES
  Supporting science, education, industry and the public in developing nations.

Introduction to the strategy

Our vision

Our vision is for a safer, more sustainable and prosperous planet and a future based on sound geoscientific solutions.

Our mission

Our mission is to provide impartial and independent geoscience advice and data. We observe, monitor and characterise geological environments, both nationally and internationally, using our proven abilities in earth systems science. Collecting, analysing, interpreting and presenting data and knowledge are our core activities. We also build strategic partnerships with academic institutions, governments, industry and the public to develop our work and share our expertise. Our science is focused on sensing, understanding and predicting the Earth's behaviour, and delivering solutions for the national and global good.

'The world of research is constantly changing and the BGS must respond'

The world of research is constantly changing and the BGS must respond. New drivers for geoscience research enabled by the technological revolution — underground sensors, visualisation technology, big computing and data informatics — will allow the BGS to make major contributions to key earth science problems.

We will continue to provide the fundamental geological underpinning for the UK and will maintain and develop a world-class repository of geological information. Expanding our activities globally in response to the Sustainable Development Goals (SDGs) of the UN will also be a critical focus of our ongoing work.

Building on strategic progress

The UK Geoenergy Observatories are a decadal project supported by an initial £31 million capital investment by the UK Government and are based in two locations: Glasgow and Cheshire. The new scientific data on the underground environment and knowledge from these observatories will facilitate comparisons with geological conditions all over the world.

Further globalisation of our science is taking place through a multimillion-pound programme in developing countries to address challenges such as groundwater availability in East Africa, sustainable development in South-east Asian cities and volcano risk in the Caribbean.

Our role with the government, the public and industry will be to undertake three science and technology challenges, underpinned by state-of-the-art infrastructure. Our strategy will enable us to deliver expert, impartial and innovative science and solutions, and it will be supported by a new governance structure led by our independent BGS Board.

'Our strategy will enable us to deliver expert, impartial and innovative science and solutions'

Partnership and innovation

Maintaining and developing key partnerships will be essential to delivering our strategy. We will continue to engage nationally and internationally with diverse partners, including

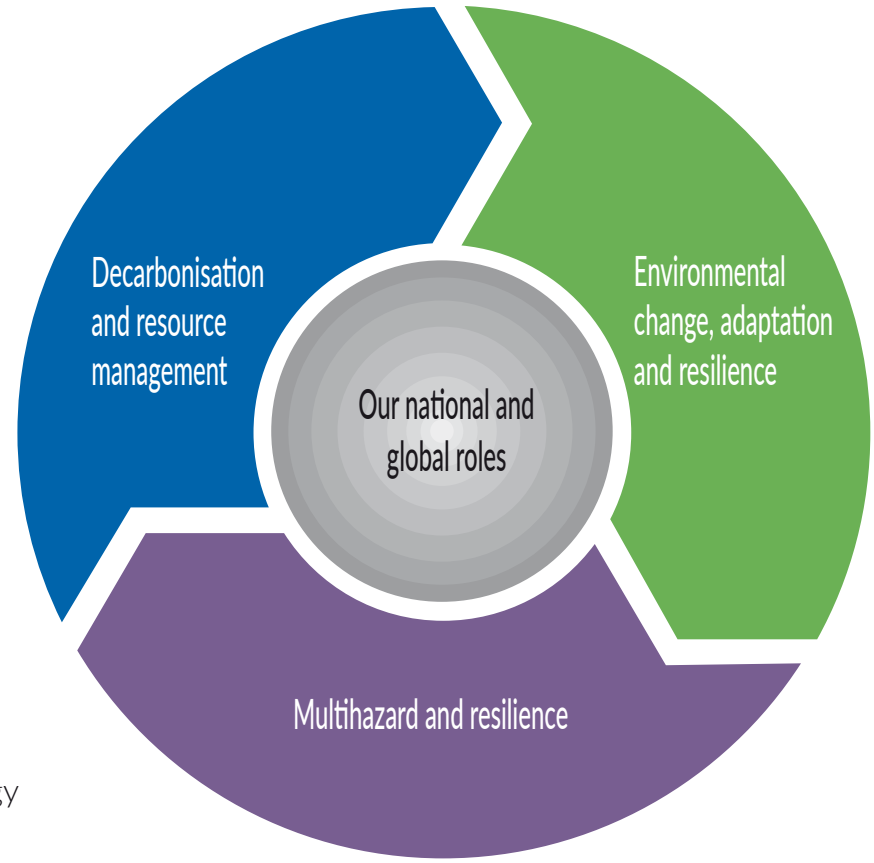
higher education and research institutions, governments and industry in the UK, Europe and globally, to develop strategic partnerships that align with and enhance our science strategy.

Working together with our stakeholders — government, industry and the public — we can improve our ability to co-develop practical solutions, starting with the impacts expected and working back to enhance technology and science requirements.

Our goal is to develop innovative ways of ensuring our science can be used by our stakeholders and to provide our expertise, data and information to stimulate growth and jobs. Ensuring that the economic, social and scientific value of our work is realised is key to our progress. We will achieve our goal by developing new methodologies, technologies and data products, and by utilising our UK Geoenergy Observatories as a focus for innovation.

Strategic approach

The BGS has a legacy of providing geological information nationally and globally. We will build on this legacy, aligning our strategy with the UN's SDGs and responding to initiatives such as the UK Government's Industrial Strategy and the Global Challenges Research Fund, as well as playing a key role in the Geospatial Commission.



Our science will contribute significantly to three global challenges:

- **Decarbonisation and resource management:** reducing emissions and rationalising energy production and use.
- **Environmental change, adaptation and resilience:** geoscience to help us adapt to environmental change, including the built environment.
- **Multi-hazard and resilience:** investigating how hazardous processes affect people and property, and providing solutions to build resilience and sustainability.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'Digital data will continue to be made available openly and freely'

Developing our research infrastructure

Our UK Geoenergy Observatories programme is a key part of our development of large research infrastructure and we intend to further develop infrastructure for the subsea industry, catchment observatories and a global informatics infrastructure for geological hazards. Our data science infrastructure will be enhanced by a new way of working for the BGS, and we will accelerate the transition from static (3D) to dynamic (4D) mapping and modelling. Digital data will continue to be made available openly and freely.

Delivering the BGS strategy

Delivery of the science strategy is outlined in Figure 1. Our digital strategy, delivered by the chief digital officer, is embedded across the three challenges and links to technical digital delivery across operations. Similarly, innovation is woven through the entire science and operational delivery and cuts across the spectrum of activity from research to commercialisation.

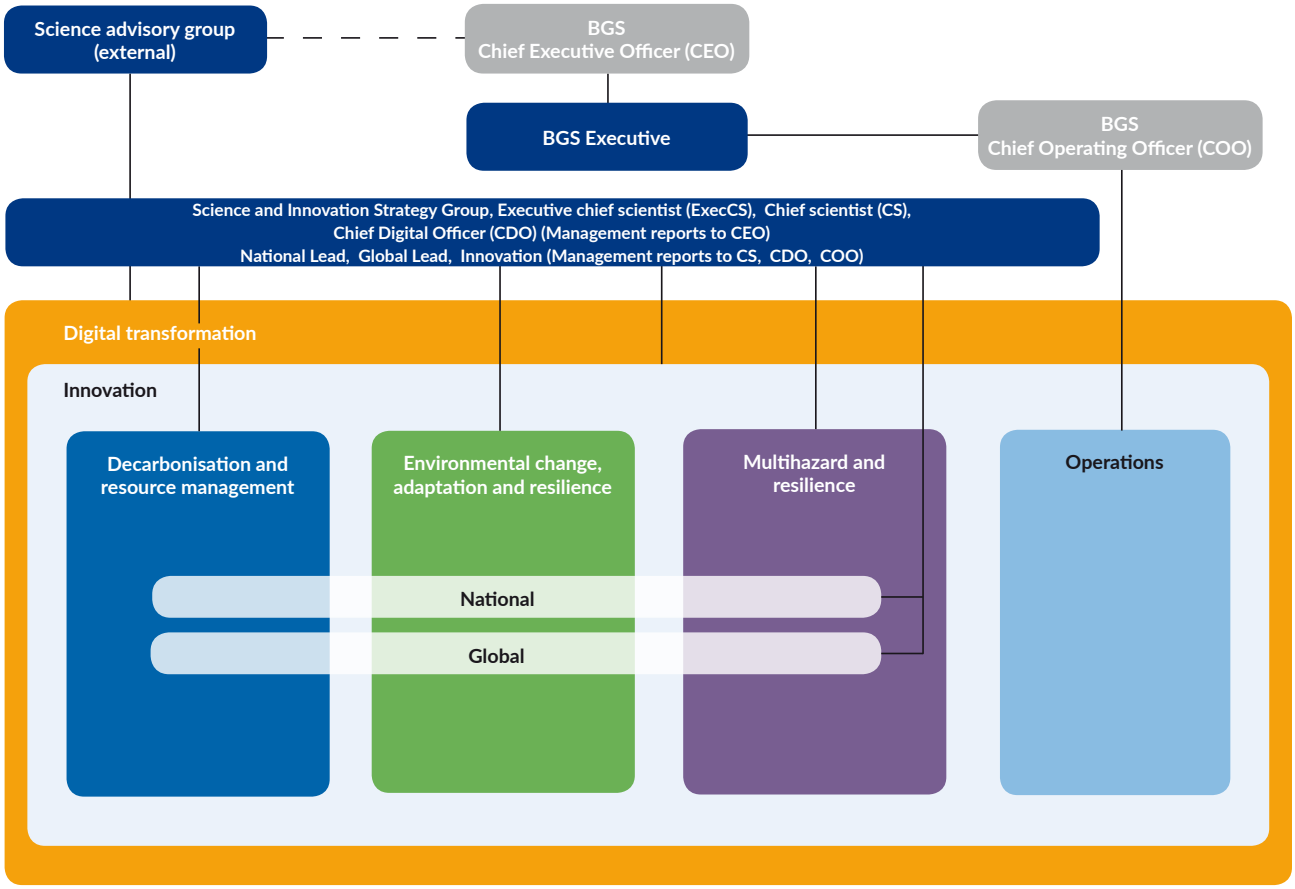

Figure 1 Delivery of the science strategy.

The science challenges

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Challenge 1: decarbonisation and resource management

This challenge will contribute to the following UN SDGs:

Goal 7: affordable and clean energy

Goal 8: decent work and economic growth

Goal 9: industry, innovation and infrastructure

Decarbonisation of power production, heat, transport and industry is a major challenge and one that intrinsically involves geoscience. The BGS will investigate the feasibility of different technologies for decarbonisation and resource management.

Decarbonisation and resource management

Geo-disposal: radioactive waste

Deep geological disposal is a key solution to long-term, safe management of radioactive waste but it requires understanding of complex subsurface processes for up to one million years in the future. Important science considerations include:

- Containment: understanding of subsurface fluid processes is vital to the containment of radioactive materials.
- Siting: understanding the geology of a geo-disposal site will inform safe site selection.

Geo-disposal: carbon capture and storage

- Planning a CO_2 storage site: developing a carbon dioxide (CO_2) storage pilot.
- Developing and maintaining technologies and methodologies: predicting the evolution of the CO_2 plume by observing site behaviour before, during and after injection of CO_2.
- Containment: selecting and characterising geological sites that are expected to enable permanent containment.
- CO_2 injection, pressure management and storage optimisation: understanding the limits on pressure increases, improving methods for injection and managing pressure increases.
- Planning and licensing regulation.

Energy storage

- Thermal: using a conversion-efficient approach to overcome fluctuations in the production of renewable energy.
- Cavern: initiating on- and offshore resource assessment for salt cavern storage of CO_2 or compressed-air energy.
- Formation: storing a range of injected fluids, such as heat, gas or water, within porous geological formations.
- Pumped: storing energy in the form of the gravitational potential energy of water.

Clean power: heat-cool

- Shallow geothermal: researching geological and hydrogeological systems and their thermal properties to exploit low-grade heat in the shallow subsurface.
- Deep geothermal: de-risking the exploitation of deep geothermal resources for power generation and researching the extraction of heat directly from magma.

- Offshore siting: undertaking 3D and 4D characterisation of offshore wind farms and tidal barrages, which have the potential to be a significant clean contribution to energy systems.

Earth resources for a low-carbon world

- Hydrocarbon systems: providing geological mapping of onshore and offshore hydrocarbon systems, both conventional and unconventional.
- Critical metals: understanding the origin, transport and concentration of the metals and materials that are critical for the transition to a low-carbon economy.
- Raw materials: monitoring global mineral production, trade flows and mineral statistics to ensure a sustainable supply of resources for a low-carbon economy.

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Challenge 2: environmental change, adaptation and resilience

This challenge will contribute to the following UN SDGs:

Goal 6: clean water and sanitation

Goal 11: sustainable cities and communities

Goal 13: climate action

Goal 14: life below water

Goal 15: life on land

We are exposed to substantial environmental changes, such as population growth and land-use change. We need to

- adapt to these changes in order to help reduce the vulnerability of social human and biological systems to them
- protect our resources, including water, soil and energy
- build resilience—that is, the capacity of the environment to respond to a disturbance by resisting damage and recovering quickly.

Environmental change, adaptation and resilience

Geo-environmental pressures

- Coupled interacting pressure: initiating studies of the interaction of different pressure regimes through environmental systems using traditional BGS science areas and newer forms of monitoring and modelling.
- Urbanisation: developing a 'whole systems' approach to the use, management and exploitation of the urban subsurface.
- Rural land use: understanding pollutant inputs, behaviour and trends at multiple scales in rural areas by maintaining our catchment observatories.
- Water resources: monitoring the changes in groundwater resource availability in response to environmental pressures and supporting development of a UK water resource management strategy.
- Industry: monitoring groundwater for legacy and emerging contaminants derived from industrial development to identify pollutants and their behaviour in the subsurface.
- Sea floor: developing the SubMarine project to advance UK capability in maximising the submarine geological environment.

Characterising resource resilience

- Coasts and deltas: assessing changes and mitigation in coasts and deltas and delivering solutions to specific problems.
- Soils and landscapes: mapping differing rates of erosion, loss of macronutrients and biodiversity.
- Urban resilience: assessing the subsurface for water quality/ quantity, waste management and the development of resilient railways, roads, pipelines and tunnel infrastructure.
- Groundwater and aquifer resilience: improving the assessment of groundwater vulnerability, risk and resilience using improved geological models.

Monitoring and forecasting

- Smart observing systems: developing systems to measure environmental change-related pressures that can accommodate a range of different types of environmental data and characteristics.
- Data pipeline: developing systems for managing environmental data and information flow, and transferring data and information between observing systems.
- Tool development: developing tools to characterise pressures, environmental systems, change and response factors to enable long-term modelling and decision making.

Environmental governance

- Policy advice: supporting effective decision making, with respect to environmental change mitigation, adaptation and resilience, by developing communications for policymakers and implementers.
- Critical evidence and information: defining the information needs of end users and improving partnerships with social scientists to support policy development and implementation.

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Challenge 3: multi-hazard and resilience

This challenge will contribute to the following UN SDGs:

Goal 3: good health and well-being

Goal 11: sustainable cities and communities

Goal 14: life below water

Goal 15: life on land

Natural hazardous processes have significant effects on economic growth, the built environment, lives and livelihoods. Risks and impacts of disasters are particularly severe in developing countries and climate change, which must be accounted for, will exacerbate this. Our work with partners worldwide to enhance understanding of hazards, vulnerability, exposure and risk will ensure our science is useful, usable and used.

Multi-hazard and resilience

Multi-hazard system

- Single hazard characterisation: improving our monitoring, characterisation, analysis and modelling of single hazard processes such as rockfalls or earthquakes.
- Multi-hazard characterisation and cascades: improving our monitoring, characterisation, analysis and modelling of the relationships between hazards, such as those between earthquakes and landslides.

- Forecasting: supporting the management of risks by governments by rapidly harvesting and analysing near real-time data to provide information about a hazardous or multi-hazardous event.

Risk analysis

- Impacts, vulnerability and exposure: characterising the potential impacts of a hazard or multi-hazards on populations, societies and their assets.
- Uncertainty: underpinning effective decision making by gaining a sound understanding of uncertainty in natural-hazard risk assessment.

Risk reduction

- Hazard and risk communication: working with risk-affected communities, particularly internationally, and tailoring science to meet their needs, improving the understanding of societies at risk and effecting action or behavioural change.
- Event response: providing responsive services, products or advice to decision makers such as governments before, during and after hazardous events.
- Resilience and recovery: working with partners to reduce risks, support redevelopment and identify ways to use the reconstruction process to improve a community's resilience following a hazardous event.

Multi-hazard data science

- Data acquisition: collecting and managing data from the monitoring of hazards or multi-hazard events, their processes and impacts.

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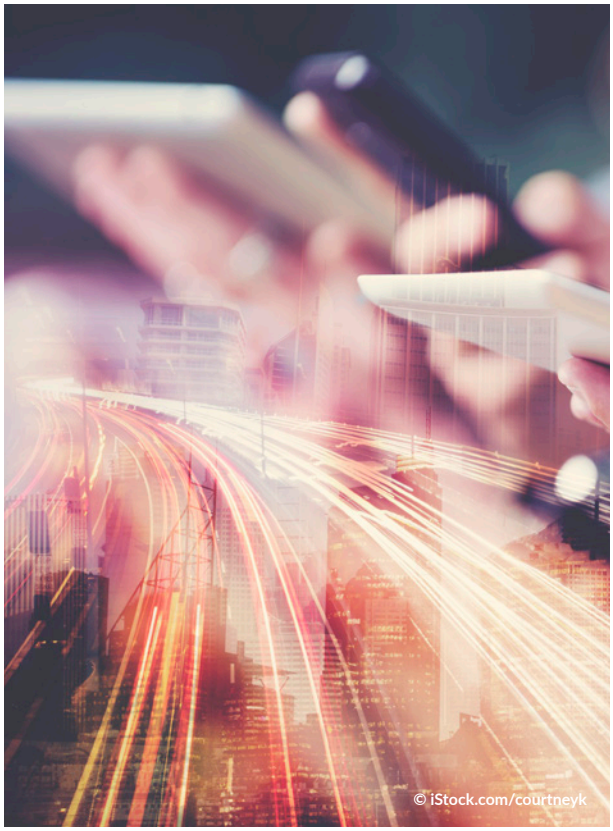
BGS digital transformation

The BGS is a data-rich organisation. Our data science and data infrastructure are fundamental to our future research and are critical assets that underpin all three of our strategic challenges.

Embracing new technology across the BGS will be crucial. We will invest in technologies to change our operating systems and to create a new cyber infrastructure for the BGS. This will include an integrated information system feeding into a global geoscience cloud, revolutionising data provision, forecasting and prediction, and supporting our three strategic challenges.

We will also develop new methods of delivering data to our customers and stakeholders to improve their user experience, including new insights into data and data tailored for impact and solutions.



Digital transformation

New data and acquisition techniques

- Acquiring primary data will enable us to conduct challenge-led science.
- Data acquisition will be essential to addressing significant knowledge gaps and to reduce uncertainty in critical areas.
- Improved capabilities to capture, process and store data will allow us to better characterise the environment and rock volumes in greater detail and with increased temporal resolution.
- We will look to develop our sensor technologies and improve monitoring capacity and the ability for it to be mobile.

Storage, network and access requirements

- We need to handle ever larger datasets and outputs from subsurface experiments, which calls for us to expand our storage, network and access requirements.
- We will work with partners to develop the capability to store and reference data.
- This includes the analogue data held by the BGS National Geological Repository and the BGS Library—samples, cores, maps and records.

Computational tools and skills, and data management

- Data management is a key requirement to ensure good data governance and repurposing of collected data.
- We will look to employ machine-learning techniques and new technologies, building on internationally recognised standards that we will co-develop.
- Collaboration in data laboratories and data commons will require skills development to ensure we can continue to analyse, process and visualise data as effectively as possible.
- Developing capacity, capability and data management systems in developing countries will continue to be a priority.

Combined research infrastructure

- Research infrastructures and new capabilities will ensure we remain at the forefront of scientific computing technologies. These include:
  - hosting the European Plate Observing System's (EPOS) integrated core services
  - the OneGeology project
  - the International Union of Geological Science's Deep-time Digital Earth project
- We will research more effective use and integration of geospatial geological data with emphasis on the built environment, as part of the UK Geospatial Commission.
- We will use new techniques to improve access and links between datasets and work to comply with 'FAIR' data principles, making data findable, accessible, interoperable and re-usable.

Visualisation and modelling

- Visualisation will support technological innovations, including smartphone applications and crowdsourcing technology in developing countries facing complex multi-hazards and environmental degradation.
- We will develop conceptual models through the collection of geological data to support projects involving multiphase flow systems and in geophysical and geochemical science.
- Predictive models will be developed to forecast or predict the future evolution of a process on the basis of current understanding.
- Simulation models will be developed to assist model users to understand how decisions taken may influence (or may be influenced by) a complex system, for example hazard assessment around volcanoes.
- Simulations that mimic how individuals respond to risks will be developed with social scientists.
- Modelling of the Earth's geophysical characteristics will also be undertaken.

National and global geoscience

Maintaining a national geoscience programme requires the BGS to adopt a strategic regional approach while continuing to provide complete coverage of the UK where possible. New data-mining systems, real-time monitoring and citizen science will ensure coverage, for example in a national borehole database and in coastal vulnerability models.

We will continue to work with European partners in digital delivery and specifically in areas where the impact is directly related to the UK, such as common approaches to energy sources in north-western Europe or geohazards in Iceland. Globally, our focus will be to address challenges such as groundwater availability in East Africa, sustainable development in South-east Asian cities and volcano risk in the Caribbean.

Regional geological surveys

We will continue to initiate regional geological survey projects that will develop our wider geological understanding of the subsurface at regional and national scales. Survey techniques and data development will focus on increasing geological certainty in the 'zone of human interaction' to support regional clean growth, environmental management, planning policy and infrastructure resilience, and to reduce risks and incentivise investment.

'We will continue to initiate regional geological survey projects, in the UK and internationally, which will develop our wider geological understanding of the subsurface at regional and national scales'

The Northern Corridor Project will develop geoscience understanding to underpin demands on the subsurface arising from the sustainable management of natural resources, transport infrastructure and possible hydrogen, carbon capture and storage (CCS) and shale gas industrial networks. Similar regionally focused initiatives are being developed within central Scotland, to help support delivery of clean growth, and in Wales, to support the use of heat in the subsurface aimed at reducing greenhouse gas emissions.

UK National Geological Model

The National Geological Model (NGM) is an accurate, multiscaled, geospatial model of the subsurface arrangement of the rocks and sediments of the UK. We will develop the next generation NGM to present both shallow subsurface and volumetric bedrock information, enabling us to move the NGM from 3D to 4D. This improved NGM will provide a 3D framework that can be used by stakeholders for better decision making.

Marine geoscience expertise

Our aim is to be the main provider of seabed and subsurface geological information and interpretation to support the

development of offshore renewable energy and other global, marine resource and environmental sectors.

BGS marine geoscience will provide technical and scientific expertise to assess the scale of geological resources that exist on the sea floor. We will also lead research into hadal trenches by characterising the geology of these virtually unexplored deep areas of the seabed, providing data to support research investigating deep-seabed marine biology and habitats. We will continue to deliver scientific drilling operations for the International Ocean Discovery Program (IODP) until at least 2023, coordinating and delivering major scientific drilling projects.

Marine operations

We have over 40 years of expertise in surveying and sampling the seabed and subsurface. Our modern, purpose-built facility supports the development, operation and maintenance of marine research equipment, delivering a marine survey and sampling service with a range of novel equipment, including the RD2 robotic drill, which can retrieve cores of up to 55 m length in 4000 m of water, and a mobile, seabed mapping capability to provide sea-floor images and video.

'We have over 40 years of expertise in surveying and sampling the seabed and subsurface'

'Working to mix earth and social scientists will ensure we develop novel, interdisciplinary research opportunities for ourselves and our partners'

Geoscience and society

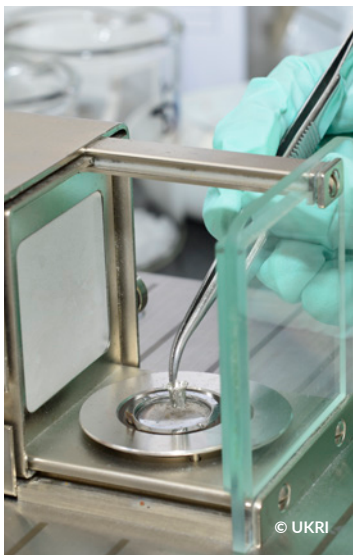
We will explore the way society understands, values and engages with our science. This will include issues associated with new, competing demands on the subsurface and the role of geoscience in decarbonisation. Collaboration on ownership and governance of the underground will be pursued with legal professionals and academics, as well as planners, utilities and policymakers, particularly in the urban setting. Working to mix earth and social scientists will ensure we develop novel, interdisciplinary research opportunities for ourselves and our partners.

BGS resources

Laboratory capability

Our laboratories provide analytical services and technical training, and undertake collaborative research with UK and international partners. Our laboratories include:

- **Geochemistry**: supporting research into pathways of beneficial and harmful elements through the environment to plant, animal and human receptors; refining uranium–daughter geochronology; isotope tracer technology.
- **Geotechnical and geophysical properties**: comprehensive, integrated rock and soil testing.
- **Mineral and petrography**: providing information on important minerals and materials.
- **Fluid processes**: researching the flow and containment of biological, chemical and physical fluids in the geo- and biospheres.
- **National Environmental Isotope Facility (NEIF)**: the BGS also manages NEIF on behalf of UKRI.



- **Centre for Environmental Geochemistry (CEG)**: the joint University of Nottingham/BGS Centre for Environmental Geochemistry focuses on research, training and teaching, reconstructing past environmental and climate change, and bio-geochemical cycling.

People and new skills

To enhance our data science infrastructure and to support our ambitions for improved ways of operating, we will require computer science experts in statistics, forecasting and prediction, artificial intelligence, and innovative data storage. Our future work requires more sophisticated interdisciplinary understanding and interaction with other disciplines, including the social sciences.

We will invest in geologists and geophysicists with appropriate skills for the appropriate, regional and site-specific geological study and processes associated with particular types of geology, for example underground radioactive waste disposal and CCS.

Our international and developing-country work will focus on specific UN SDGs. We will continue to engage with development professionals, exploring recruitment and partnership possibilities, to support this work.

Operations support

'Our science is supported by a highly experienced team across finance, human resources, estates and IT management'

Our science is supported by a highly experienced team across finance, human resources, estates and IT management. We will embed professional project management in our science challenges and digital delivery and we will ensure that a culture of health and safety is pervasive across the BGS.

Communications and public engagement

The communications and engagement team will work in partnership with staff and key external stakeholders, regularly reviewing its impact and embracing best-practice techniques.

Concluding statement

We can contribute to a safer, more sustainable and prosperous planet through the development and implementation of sound geoscientific solutions. This strategy defines how we will work to identify and apply those solutions over the next five years.

As a world-leading geological survey and global geoscience organisation, we must be fit for the future, embracing change and working to maximise our science, so we can make a greater impact in the UK and across the globe. To help us achieve that ambition, we have aligned our strategy with the UN Sustainable Development Goals to create a clear approach for ensuring our work contributes to global strategic priorities.

Partnership working will be essential. We will look to co-design solutions and create opportunities that support the

'Working together with stakeholders will ensure our work supports their needs and those of society'

development of our science and help to realise the potential of multidisciplinary approaches. Working together with stakeholders will ensure our work supports their needs and those of society: collaboration will maximise our impact.

This strategy will drive the BGS into the future and ensure we continue to deliver expert, impartial and innovative science of benefit to all.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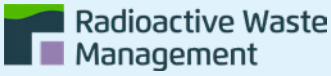
Our partners

Centres and major collaborations

Joint appointments

Key partner agencies



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