CORE KNOWLEDGE: VALUING THE UK'S GEOLOGICAL ARCHIVE

WITH THE UK'S NATIONAL GEOLOGICAL REPOSITORY REACHING CAPACITY, DANIEL CONDON AND EMMA BEE EXPLORE THE CRITICAL ROLE OF THIS VAST LIBRARY OF RAW GEOLOGICAL DATA AND HIGHLIGHT THE NEED TO FURTHER UNLOCK ITS POTENTIAL

THE UK'S NATIONAL GEOLOGICAL REPOSITORY (NGR) is a flagship science facility run by the British Geological Survey (BGS) in Keyworth, Nottinghamshire. Composed of three warehouses totalling approximately 3,000 m^2 of climate-controlled storage space, the NGR contains over 600 km of core, millions of rock and fossil specimens collected over centuries, and decades-worth of subsurface data. The NGR is the nation's largest curated collection of subsurface geological samples and related information, and represents the collective efforts of industry, academia, BGS and many affiliated organisations, past and present.

But the NGR is far more than a collection of rocks and records (Howe, 2023); it's a national asset that underpins science, innovation, industry and policy — past, present and future. Like a library, its contents are accessible to a broad community of users seeking authoritative information about the UK's subsurface environment.

However, the NGR currently faces some critical challenges. Nearing its physical limits for storage capacity, the

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INSIDE THE NATIONAL GEOLOGICAL REPOSITORY – A TREASURE TROVE OF UK GEOSCIENCE

CORE COLLECTIONS
- Onshore: 250+ km of drill core from over 15,000 boreholes
- Offshore: Over 350 km of drill core and other samples from approximately 800 wells

FOSSIL COLLECTIONS
- Type and stratigraphic fossils: Approximately 250,000 specimens
- Microfossils: Approximately 250,000 slides
- Locality-based fossils: Approximately 2.5 million specimens

ROCK & MINERAL COLLECTIONS
- Systematic British Rock Collection: Over 300,000 samples
- Thin sections: Over 200,000
- National soil and sediment survey samples

GEOSCIENCE RECORDS & ARCHIVES
- Over 20 km of records, including:
  - Field records, maps and borehole logs
  - Coal data and mine plans (approximately 20,000)
  - Seismic, geophysical, and geochemical data
  - Seismograms (approximately 100,000)
  - Magnetograms (22,000)
  - Marine and hydrogeological data

The NGR also houses important collections from other organisations, including the British Antarctic Survey, Natural History Museum, and Maritime and Coastguard Agency.

NGR has invoked a series of temporary closures for accepting new donations and is contending with decreased public funding. Yet, as the UK navigates the challenges of decarbonisation, resource security and climate resilience, the NGR's role in providing trusted subsurface data has never been more critical. How do we convey the economic, scientific and societal value of the NGR to decision makers and investors? And what role do foundational analogue collections play in our digitally enabled future?

Economic value

Anyone who works on UK geology will immediately understand the value of the collection, for both their research and for the nation's long-term benefit. Core and other samples, with their associated metadata, provide the rawest form of foundational data underpinning geological knowledge; they are quite literally the ground-truth. But how do we quantify the value of the NGR and ensure that others, who are less familiar with the significance of geology, understand its value *and* importance, and the need to invest in it? Together with colleagues at the BGS, we worked with a team of economic consultants at the firm Human Economics to not only tell the story of the value of the NGR to the nation but also to put some economic figures to it.

Whilst the question of economic value seems simple, answering it with compelling evidence is a challenge. We could think about the costs incurred in collecting the samples. For example, the NGR contains material from about 8,000 offshore wells collected over five decades. Using £25 million as the typical cost for an offshore well (NSTA, 2022; 2023) gives a total of £200 billion, underscoring the immense costs involved with acquiring the materials. But what are the materials worth after they have been used for their primary purpose, when they are curated and made available for wider use by the NGR? →

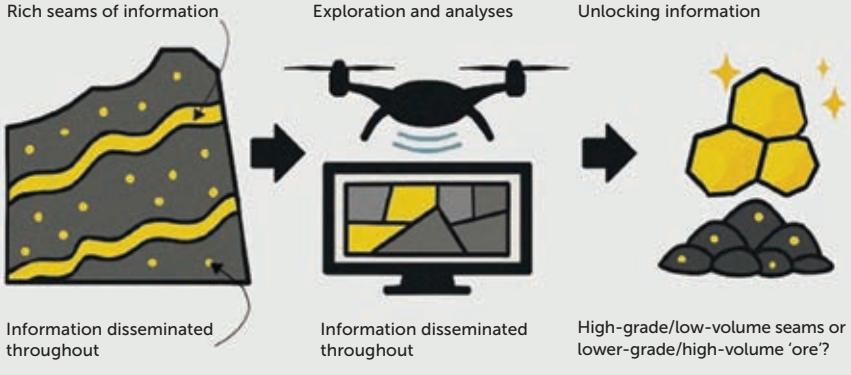
This study used a case-studies approach, choosing four recent and ongoing case studies that cover historical, current and future uses, and operate across a range of timescales: shale gas exploration, geological disposal of radioactive waste, carbon capture and storage (CCS) and geological energy storage. We could have used many other examples, including oil and gas exploration in the 1960s, groundwater security, mineral exploration, climate change adaptation or infrastructure engineering (such as tunnels), but time and resources were limited.

For each case study, the team worked with subject matter experts to understand the role the NGR collections played in each sector. How many cores were examined? Were they offshore or onshore? How useful was the derived information (nice to have vs. essential)? A critical question was the counter-factual, hypothetical scenario: if the NGR did not exist, what would need to be done to attain the same level of knowledge to underpin the development of that topic? Starting investigations from scratch, the experts estimated that about 30% of the number of wells would be required if their sample collection was planned/optimised, allowing us to assign a value to the information obtained.

The economists used this approach to determine a benefit-cost ratio (BCR) for the NGR that complied with the Government Green Book and Guidance. A BCR is a tool used in cost-benefit analyses to assess the value for money of a project or facility and is calculated by dividing a project's total benefits by the total costs. Based on just four case studies, the BCR for the NGR was estimated to be about 36, that is, a return of up to £36 for every £1 invested (BGS, 2025; Human Economics, 2025). Such a BCR is considered high for economic assessments. Yet, the quantified inputs were conservative, so as not to over-inflate the BCR, and independent testing by other economists confirms the estimate is robust. The value reflects the intrinsically high costs of acquiring core from under the North Sea, costs that are primarily borne by industry and are not incurred by the NGR.

Beyond economics

Beyond the headline financial figures, the report highlights several important narrative themes. Chief among them is that the collections are somewhat independent from their original purposes and can (and will) be continually repurposed as needs, opportunities and national priorities evolve. Examples of repurposing include materials gathered during hydrocarbon exploration that now play a vital role in advancing CCS, as well as coal mine samples that are now used for shallow geothermal energy.



Gold mine or prospect? | Is the NGR a gold mine with rich seams of information or a deposit with value disseminated throughout — or a combination of both? *(BGS © UKRI)*

Whilst the financial valuation of the NGR is important, its broader societal value is equally significant. The NGR serves as a vital resource for students and early-career geoscientists, offering hands-on access to real-world geological materials and key reference collections that span a wide range of UK geology, supporting teaching and research projects. Like a national library or other national archive (such as the UK BioBank or the Millenium Seed Bank), the NGR safeguards irreplaceable records of the UK's geological history that are a resource to support research, innovation and application.

The repository also underpins public policy, environmental protection and infrastructure planning. It supports the work of BGS as well as a wide network of partners engaged in UK geoscience, from academics and consultants to planners and regulators. Importantly, the collection is agnostic of end use and has proven invaluable when unexpected demands on the subsurface arise. Examples include the recent shale gas 'boom', the growth of CCS, the development of geological energy storage, research into critical minerals and the emerging interest in natural hydrogen – activities that are likely to continue to be NGR use cases for the coming decades. Archived materials can suddenly become critical to new sectors, allowing the NGR to support different stages of subsurface technology development, from early appraisal through to implementation. The NGR's value lies in its ability to support exploration of the known and unknown, over decades.

Digitisation: Unlocking potential

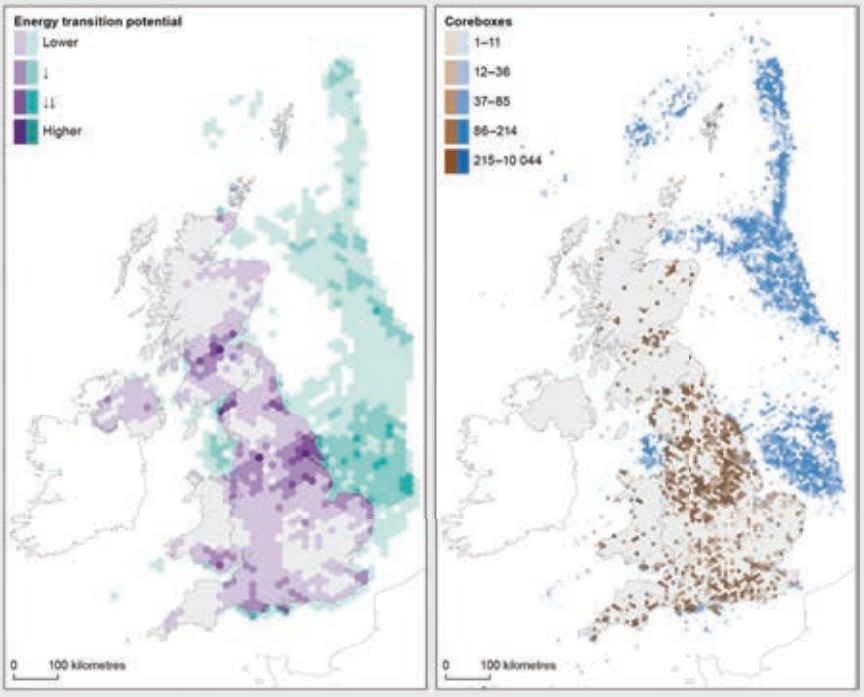
New opportunities lie in unlocking the value embedded in the NGR physical collections through digitisation. We are on the cusp of revolution driven by the increasing application of artificial intelligence (AI), so the question of digitisation is primary. At present, physical access is mostly required to extract information from the collection (although some key datasets are already digitally available, including an extensive range of high-resolution core photographs), but what outcomes might AI and high-performance

computing offer once the physical assets are scanned and made digitally available?

'Digitisation' means different things to different people and sectors. Photographing is a form of digital capture, but it has limited 'actionability'. Digitising a human can range from a simple photograph to advanced imaging, like X-rays or MRI scans, and even biological sampling, such as blood tests. The same applies to NGR collections, where digitisation could range from photography through to core scanning using X-rays for imaging, and geochemical analyses, to sample analyses to quantify porosity, age, composition, etc. Each method reveals different levels of detail, collectively forming a digital representation of the analogue sample.

The end use dictates the 'depth' of digitisation required and each sector is likely to have a common set of minimum requirements, which could vary with time. There is a trade-off between breadth/coverage and depth/detail, which need to be balanced to find a sweet spot. One size does not fit all, so an adaptive infrastructure is required. Digitisation that creates actionable, 'research-ready' data providing sufficient information for most needs should include high-resolution images, georeferencing and structured metadata. Digitising information such as core scans, key physical property measurements, and other standard geological analyses would provide actionable data that can support a wide range of applications, from CCS to groundwater management.

It is exciting to consider the suite of technologies now available for deployment. Digitisation of text records using optical character recognition and natural language processing allows for intelligent searches, pattern recognition and integration across datasets that can transform static archives into dynamic, queryable resources. Physical samples can be digitised through high-resolution scanning, hyperspectral imaging and X-ray fluorescence. Thin sections can be fully scanned and digitised to reveal mineralogical and structural details, enabling remote analysis and cross-comparison. The application of machine learning to data will enable data processing at rates and scales far beyond what is currently limiting, opening new areas of geodata processing and analyses.



Mapping the NGR to national needs | The correlation between energy transition potential (the capacity or opportunity of a region to shift from fossil fuels to low-carbon energy sources) and the geographical distribution of core held in the NGR is high. Such mapping highlights how NGR collections can be mapped to high-priority geology using an intelligence-led approach that maximises the benefits of digitisation. *(BGS © UKRI)*

> **“New opportunities lie in digitisation”**

Advances in machine learning and AI will drive a step change in how we interact with geoscience data and information, and digital readiness is key for the discipline (Bergen et al., 2019). Together, these technologies and this approach form the backbone of 'NGR+', a vision to be collectively developed for a digitally accessible, research-ready NGR that contributes to underpinning UK geoscience in the digital age. This transformation will not only preserve the UK's geological heritage but also unlock its potential for current and future generations.

To realise this digital future requires a strategic and agile approach that aligns with evolving national priorities, uses emerging technologies and builds upon ongoing investments. It's easy to think of the NGR as a gold mine with 'value' in every part of the collection, but perhaps we are better off approaching it as a prospect, a resource that requires evaluation, careful consideration of worth to stakeholders and development of suitable extraction and delivery strategies. Are there rich seams of valuable information that can be mapped out and unlocked through targeted digitisation, or is the value distributed equally throughout? Must we consider some form of wholesale digitisation? Perhaps there will also be lots of secondary value in the 'tailings', the metadata and records. To link any effort to realise value from an asset, we need to balance public- →

good needs and economic prudence with operational resilience. The NGR must be resourced not only to maintain its collections but to adapt, digitise and serve the evolving needs of the UK's geoscience community.

Infrastructure delivers

The NGR is at capacity, prompting a strategic reappraisal and rationalisation of collections to optimise space. However, the growing demand for new insights from geological data, driven by emerging sectors like CCS, geothermal energy and hydrogen exploration, means that additional storage and digitisation infrastructure are essential. Investment in expanded facilities and digital platforms will ensure the NGR remains fit for purpose in the decades ahead.

TAKE A VIRTUAL TOUR

Tour the NGR at **bgs.ac.uk/geological-data/national-geological-repository/ngr-tour**

The rationale for ensuring the NGR's sustainability is clear. National needs, from clean growth and the energy transition through to environmental resilience, and new technologies and industries, require subsurface data. Such data are critical to addressing challenges including CCS, geothermal energy, safe disposal of radioactive waste, groundwater security, critical minerals and major infrastructure development. The NGR supports cutting-edge science across academia, government and industry. Further unlocking its contents will enable new discoveries and accelerate innovation. It does not provide all the answers but is a very efficient way to access data and information that can de-risk projects and reduce costs, in both discovery research and the applied sectors. The NGR is a foundational asset for national infrastructure and environmental stewardship, and a catalyst for geoscience research, innovation and impact.

Where should we start? We know where the major uses of the subsurface will likely occur because this is dictated by both the geology and existing infrastructure, such as offshore pipeline networks. As such, it is possible to develop an 'intelligence-led' approach to digitisation, where each sector could develop a bespoke approach to unlocking the value of the NGR for their sector, within the underpinning infrastructure of the NGR. Developing a strategic and co-designed approach, with input from government departments, regulatory bodies, industry and academia to investment in digitisation should ensure that efforts are focused where they are most needed, that value for money is maximised over time.

Just as libraries have evolved from physical books to digital platforms, enabling remote access, searchability and integration with other systems, the NGR must undergo a similar transformation. Digitisation will allow researchers, regulators and industry to 'order' geological information as easily as downloading an ebook, unlocking new efficiencies and insights. Imagine being able to download entire collections for a region or geology of interest and read or interact with that collection using machine-learning tools, at a scale not previously possible. Where this analogy with libraries breaks down is that the materials in the NGR are not 2D surfaces with text and images: they are varied and heterogenous 3D objects and digitisation will never create a true facsimile. Thus, the case for disposing of core once scanned is limited because the samples may one day be required for additional testing.

The NGR's estimated BCR of 36 provides compelling evidence that past investments have yielded substantial returns. This historical performance is a strong predictor of future value, especially as national priorities shift toward decarbonisation, resilience and sustainable development. Although the economics of decarbonisation industries using the subsurface will differ from other subsurface activities, it is almost certain that the future BCR of the NGR will be greater than one! Other ways of valuing the NGR will also emerge, including de-risking projects, helping smaller companies explore new areas, supporting regulation, and providing timely guidance to industry and government on new technologies.

The NGR is a prime example of national data sharing at its best, with numerous companies contributing and sharing information for the long-term collective benefit of the nation.

Geological legacy

The NGR is not just a repository; it is a dynamic, national asset that underpins science, innovation and policy. Its curated collections offer irreplaceable insights into the UK's subsurface, and its adaptability ensures relevance in a changing world. To unlock the NGR's full potential, we must invest in digitisation, infrastructure and sustainable stewardship. The time to act is now, so that future generations can continue to benefit from this geological legacy. Investing in the NGR is not just about preserving the past; it's about enabling the future.

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FURTHER READING

A full list of further reading is available at geoscientist.online.

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