How can we realise the full potential of 175 years of meticulous observation and measurement? **Andrew Hughes** and **colleagues**[1] introduce the Open Environmental Modelling Platform.

Looking forward to making predictions

As described in the preceding pages, since the BGS was established in 1835, the British population has coped with many challenges. These have ranged from finding resources to fuel the Industrial Revolution, understanding and combating water-borne diseases such as typhoid, the threat of invasion and aerial bombardment, through to modern-day environmental problems and climate change. To help deal with these problems, decision-makers from governments and other organisations have required our help and advice.

Modern-day problems are many and various and potentially have a significant impact on our daily lives. Landslides can damage gas pipelines or block roads and railways. Groundwater levels are rising under major cities and affect foundations and buried infrastructure, such as railway tunnels and telecommunications cables. Heat flow causes problems in tube tunnels, but could be used to provide a source of energy for heating homes and offices in winter. To make informed decisions on these issues, we need an increasingly sophisticated understanding of the natural processes operating underground.

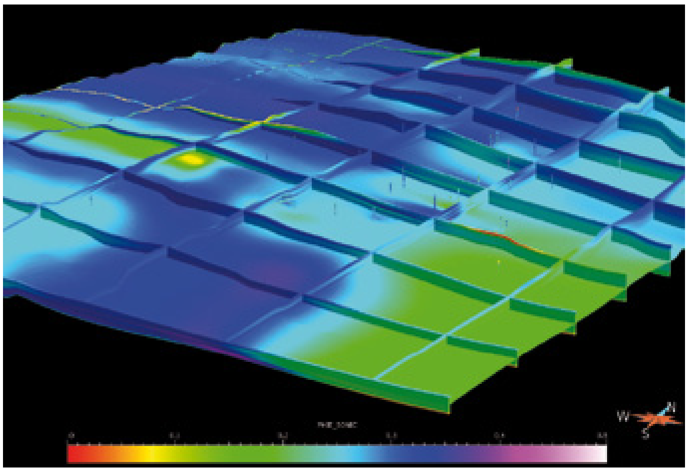
To solve these and other problems we require a system that takes the immediacy and power of weather forecasting and applies them to processes operating underground. We need tools and systems to manage the use of underground space and to understand properly the processes operating in it — for instance, water flow through rock — and the benefits and problems such processes cause. These problems may be short-term (for example, landslides) or long-term (such as sea water being drawn into aquifers). An understanding of how climate change acerbates all these problems also needs to be developed.

The principal method of developing, capturing and propagating geological understanding has changed fundamentally from the paper-based, 2D geological map to the digital, 3D framework model. In conjunction with our colleagues at INSIGHT, we have developed a unique geological modelling system known as GSI3D. The system is designed to capture field geologists' traditional 3D workflow and thought processes in a digital form. Models are being extended from the shallow to the deeper subsurface, into ever-more complex geological settings and are increasingly being integrated with models developed in the other environmental sciences.

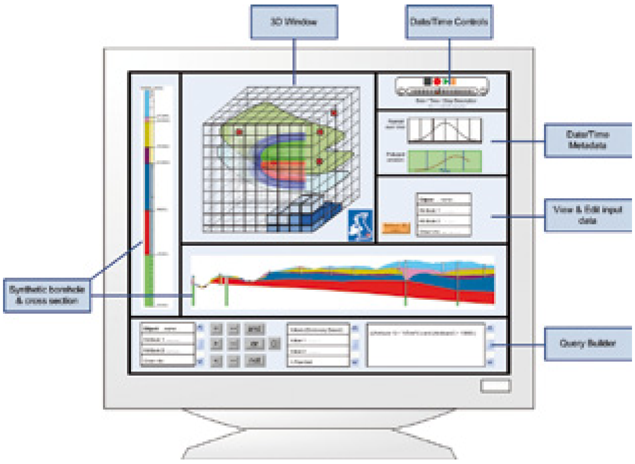
Within this 3D framework, earth observation from satellites, aircraft and ground-based systems is enabling us to measure surface and subsurface

A 3D geological model of the Isle of Wight, built with GSI3D.

[1] Jonathan Chambers, Jeremy Giles, Colm Jordan, Holger Kessler, Andrew Kingdon, Stuart Marsh, Richard Ogilvy and Denis Peach



Distribution of hydraulic properties from Propbase — taken from the Sherwood sandstone, Nottinghamshire.



Example of Open Environmental Modelling Platform screen.

properties at unprecedented levels of detail; for example, allowing us to monitor millimetre-scale movements in the landscape from satellites orbiting 700 kilometres above the Earth. On the ground, sites anywhere on the planet can be instrumented so that, minute-by-minute, we can detect how they respond to changes in their environment. We are world-leaders in developing technologies to achieve real-time monitoring of geological phenomena using electrical images of the Earth. In future, networks of smart sensors will be deployed that talk to each other so that, for example, higher levels of rainfall automatically trigger more frequent measurements of landslide movements.

We are organising our data to deliver a better understanding of how the physical and chemical properties of similar geological features vary, both internally and between features. This will help identify more efficiently the best places to deposit waste products, such as carbon dioxide and radioactive waste materials, and extract the resources necessary for life. New approaches to mathematical modelling are being developed, to improve our understanding of how water flows through rocks. Immersive visualisation systems, which use the same technology as computer games, allow interactions between geology, processes and landscapes to be understood in 3D space.

To bring all these techniques together, a system based on a combination of national datasets from the BGS and other organisations, linked mathematical models, advanced visualisation techniques, high-speed Internet and very powerful computers, is currently under development by the BGS. This system, known as the Open Environmental Modelling Platform, will be able to deal with complex problems and deliver the answers in a way that enables people from all walks of life to digest the information easily. Our aim is to answer simple questions on what happens underground by building and running a bespoke mathematical model and provide model output in a way already done by weather forecasters.

We have evolved from an organisation that provides its geological understanding, data and interpretations in the form of maps, to routinely using 3D geological models. The next stage of development is to provide decision-makers with a tool that helps them to manage the subsurface, its development and exploitation, and that uses models to predict the effects of change. The end result of this process will be better-informed decisions, from government ministers forming national policies, to families deciding whether to buy a house or what to do on a day out. This system will move the BGS from an organisation providing maps, through 3D models, to one that provides predictions based on those models.

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Geovisionary being used for geological mapping.