The 3D skills of a BGS geologist are constantly adapting to meet the changing needs of the UK, say **Martin Smith, Diarmad Campbell, John Powell** and **David Schofield**.

Responding to a world of change

The BGS is proud of the central role our surveying has played in the development of geology as a science. We are equally proud of our contribution to the understanding of key issues such as the age and evolution of the Earth and life, the origin and classification of rocks, and the impact of humans on the earth system. With 175 years of dedicated surveying behind us, the UK is already better served with geological information than most other countries. However, in today's rapidly evolving, knowledge-based economy, we must continually adapt our surveying to meet the changing needs of society.

The changing face of the geological map of the UK gives us an ideal way to see how geological surveying has evolved within the BGS. With time, the map has become much more detailed reflecting an advancing model of stratigraphy and structure as greater understanding of geological processes develops. At the same time, the BGS has moved from nineteenth century map-makers to twenty-first century 3D digital map- and model-builders. This has been achieved in three main phases.

The first 'discovery' phase (1835–1950), was driven by the need to find coal and other resources to fuel the Industrial Revolution, maintain economic expansion and support war efforts. During this time, the Geological Survey was funded wholly by the government but largely set its own agenda for mapping the country. Surveying mainly involved observing and recording geological exposures and landforms. Initially, the understanding of earth processes was in its infancy, and attempts to present views of the subsurface were quite basic although the geologists often had a sound appreciation of the depth dimension.

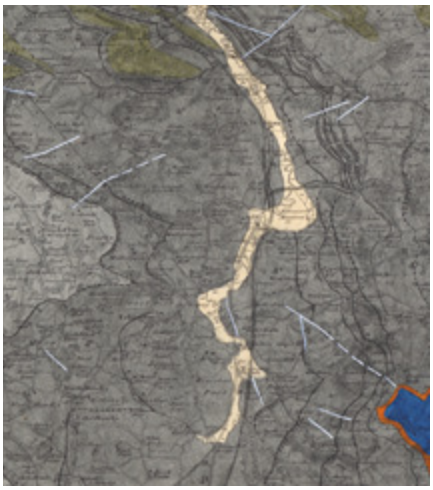
The first recognised 'Geological Survey' map (1834–5) produced before the formal founding of the Geological Survey in 1835, recognised relatively few subdivisions of the rocks.

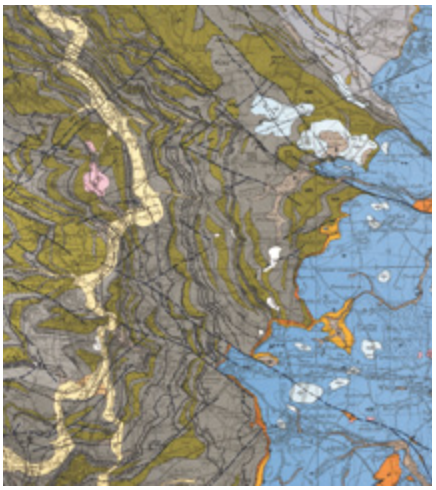
With time, more detailed maps were produced, especially of the coalfields; these were targeted for repeated investigation because of their economic importance. Helped by boreholes, underground access in coal mines, and mapping of well-exposed and mountainous areas such as the Scottish Highlands, 3D models were being created by geologists in their heads, and their understanding of the subsurface was often excellent. However, it was difficult to express and publish this knowledge through 2D geological maps with their occasional cross-sections. To address this problem other types of diagrams were being produced: contour diagrams, horizontal sections and perhaps most importantly, serial sections. But these hand-drawn diagrams were only available in limited numbers and for locations selected by the geologist.

The second, 'consolidation' phase (1950–80), after the Second World War, coincided with major expansion in the geosciences and huge advances in our understanding of the planet. An increase in the Survey's staff led to the compilation of larger databases of UK geology. Comprehensive coverage of the UK was largely achieved and maps contained greater levels of detail and understanding.

The Survey developed its programme to respond to changing needs, government demands and a broader community of users. New practices included large collaborative projects, rapid responses

Three famous Survey geologists, Ben Peach, Charles Clough and John Horne — key figures in advancing the understanding of Highland geology in the nineteenth century.





Comparison of maps from 1878 and 1956 of part of the Yorkshire Coalfield near Sheffield. Note the greater detail (coal seams, major sandstones, faulting and Superficial Deposits) in the later map — a response to the need by coal and construction industries for detailed information.

to national events and more detailed subsurface interpretations. However, these were specialised documents largely understood only by geologists; non-geologists such as planners, policy-makers and developers were unable to use them effectively. Simplified thematic environmental geology maps produced in the 1980s helped address this problem and the first steps in digital mapping were being taken.

Henry De la Beche's map (1834–5) of the Torquay area showing Devonian limestone (blue) and Permian breccias (wavy red lines) but no faults. This was the first geological map published by the Geological Survey.

The current 'responsive' phase (1980–2015) is dealing with today's environmental, climate and resource challenges, and an increasing demand for instant access to spatial information via the World Wide Web at all scales. This has accelerated the BGS's move into targeted surveys responding to specialised needs: waste management, groundwater resources and flooding, major infrastructure projects, applied urban geology, education, geoconservation. Digital maps now encompass the whole UK, are highly accessible over the web, and are readily combined with other data in geographical information systems. Our surveying agenda is often set by the user-community and the science priorities of government. The focus is now shifting to the construction and delivery of usable digital 3D geoscientific models. Not only are these able to express the geologist's full understanding of the subsurface, but they are easy to use; so much so that non-geologists can be trained in a matter of minutes to predict subsurface conditions anywhere they choose within the model.

So what will the next generation of the geological synthesis of the UK look like? We are already constructing a digital 3D model of the entire subsurface of the UK but matching the complexity of the existing 2D map will be a major challenge testing our geologists both in digital 3D modelling techniques and in using their intuition to model surfaces and populate the rock volumes beneath our feet. Traditionally, an understanding of geological relationships and training in observation, recording and interpretation was learnt through time spent examining rocks at the 'rockface'. Over 175 years, fieldwork, mentoring and debate in the field have equipped generations of BGS geologists to describe and analyse earth processes in 3D. Today, this is changing; many geologists are now highly computer- and modelling-literate but the teaching of geology and university field-based courses are in decline. Is a new type of geologist — one bound to a virtual digital world and distanced from reality — evolving? Maintaining an appropriate balance between traditional, but fundamental, geological expertise and the demands of the digital age is a key challenge for the BGS in the twenty-first century if it is to sustain the range of geological skills needed to serve the national interest.

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A BGS geologist using BGS•SIGMAmobile equipment to capture data digitally in the field.