

# DIGITAL GEOLOGICAL MAPPING OF UK QUATERNARY DEPOSITS USING THE BGS SIGMA SYSTEM

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## Abstract

*Technological advances in surveying, cartography and GIS have changed the face of geological mapping at the British Geological Survey. In the space of ten years the process has developed from a largely paper-based system to a system which is entirely digital. The SIGMA (System for Integrated Geospatial Mapping) workflow uses a suite of GIS based applications that can be used in the field on a specialised tablet PC and enables final cartographic compilation in the office. This article outlines some of the processes used to create a geological map of superficial deposits (non-bedrock geology such as glacial and floodplain deposits) from pre-fieldwork preparation to the final map or spatial data set.*

## Keywords

*Geology, Mapping, GIS, Quaternary, British Geological Survey, SIGMA*

## 1 Introduction

Geological mapping has been the core role of the British Geological Survey for almost 185 years, since early BGS geologists started colouring selected sections of their maps using water colour paints to represent the different rock types which lay beneath their feet. Today geologists at the BGS continue to collect observations to develop the next three dimensional generation of geological data output. The techniques of geological field observation remain largely the same - our predecessors would have recognised the hammer, compass, hand-lens and tape we carry as they have been crucial throughout the generations. Several things however are very different, as a result of the industrial, social and technological revolutions. The top hat and tweeds replaced by gore-tex and gilet and the horses hay allowance changed to car hire. Pacing distances was made obsolete by the advent of reliable GPS devices and finally there are a greater number of women geologists than there were several decades ago.

Top-hats aside, the greatest changes have been in information technology. The medium for recording observations has changed from paper to entirely digital. Traditionally the geologist was armed with a 'fieldslip', which even into the 2000's was a trimmed square of Ordnance Survey (OS) 1:10 000-scale map, initially large scale with no contours but as the base maps improved 5m interval contours were included. They would proceed to pencil in the geological lines and observations as they walked across the terrain. Today geologists use a ruggedized tablet PC, similar to an iPad, to record their data. This is the BGS SIGMA system, the computer has inbuilt hardware features such as GPS and the Arc-based custom GIS has a sketch tool, photograph annotation tool and the ability to handle layers of topographic maps and photographs.

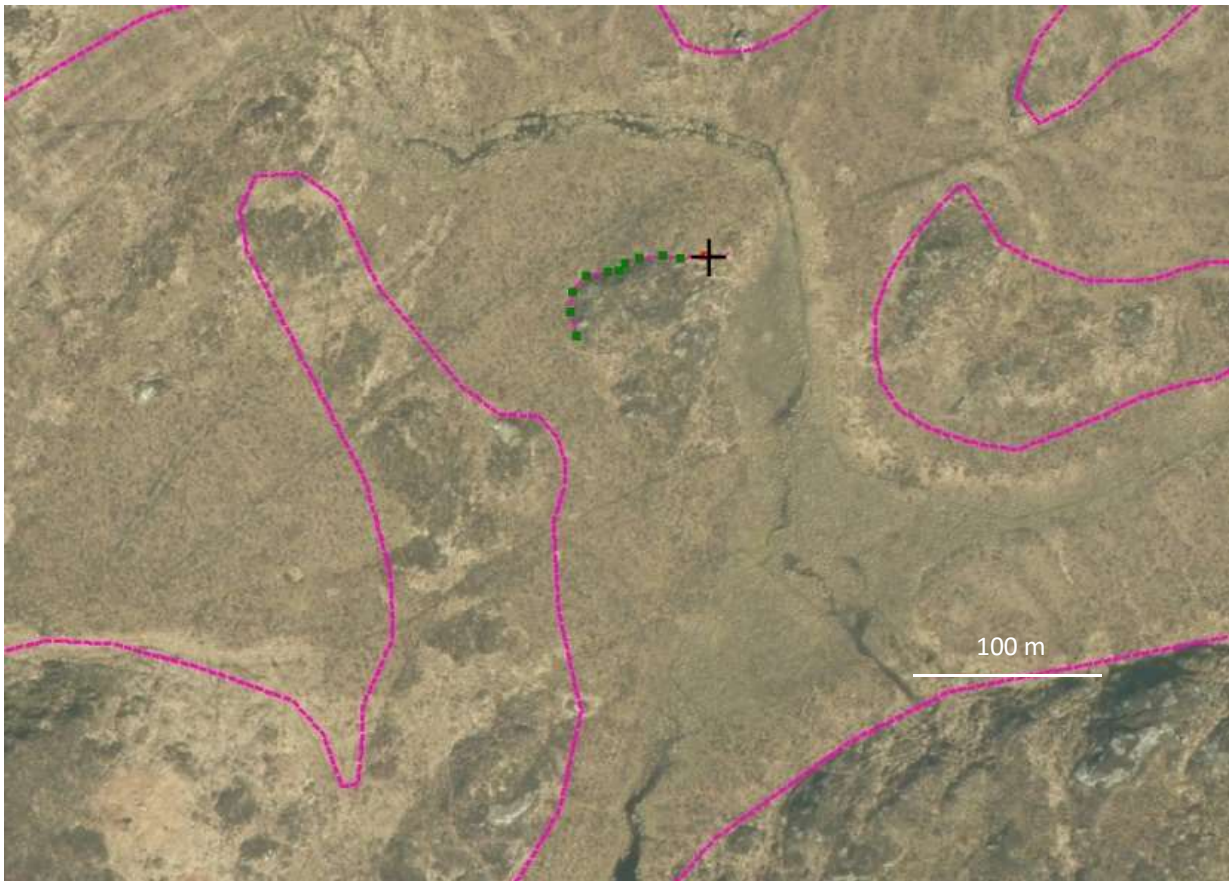
The digital data collected in the field can be easily converted into a variety of delivery formats depending on the intended purpose. Commonly this will now be for a digital, 3D geological model, as well as two-dimensional map data to be added to the national geological map (DigMapGB).

Not only has the mapping gone digital but the distribution of the final maps has taken the leap into the age of the smartphone too. Now anybody, anywhere in the country can download the latest geological information about the rocks which lie directly beneath their feet straight on to the screen of their phone or tablet. Last year, the very first geological lines and colours were downloaded into the national data set (DigMapGB) that had never seen a piece of paper.

## 2 Methods

Historically the BGS have conducted systematic geological surveys at 1:10 000, or previously at 1:10 560-scale, working towards full coverage across the UK, and completing a grid of printed maps at 1:50 000-scale. More recently the focus has been adjusted to suit current user requirements with data collected (possibly at larger scales) in areas with a potential for development or exploration. The methodologies employed by individual geologists vary but this section outlines one method of creating a geological map.

**2.1 Pre-fieldwork** Prior to any fieldwork it is common to conduct a preparatory survey identifying breaks of slope and changes in vegetation and soil using remote sensing software that may record aspects or changes in geology.



**Figure 1 Pre-field survey using aerial photographs**

SOCET SET® (BAE Systems) is a digital stereographic air photograph manipulation package that enables the display of topographic details at high resolution. By assessing the shape of the landscape and landforms alongside the changes in vegetation the geologist can build up a model of the subsurface and begin to map it out

SOCET SET® links to a GIS package so you can identify and digitise possible geological features before any fieldwork commences. These boundaries can then be ground-truthed in the field rather than laboriously traced out. The lines are stored as shape-files which are the main outputs of most of our initial geological data collection.

This linework is then imported into the SIGMA mobile system. SIGMA accepts scanned images such as aerial photographs, topographic maps, terrain hill-shades and pre-existing fieldslips that are georectified to British National Grid, and layers such as Digital Terrain Models (DTMs). Boreholes, reports and cross sections can be held on the computer accessible in the field. Field geologists used to be isolated from geological data whilst out in the field, now they can take all BGS digital

datasets with them and make new interpretations in the context of this selection of data. If the mapping area falls within a geological map sheet then there is automatic abstraction tool built into the software which will extract and collate data from BGS libraries.

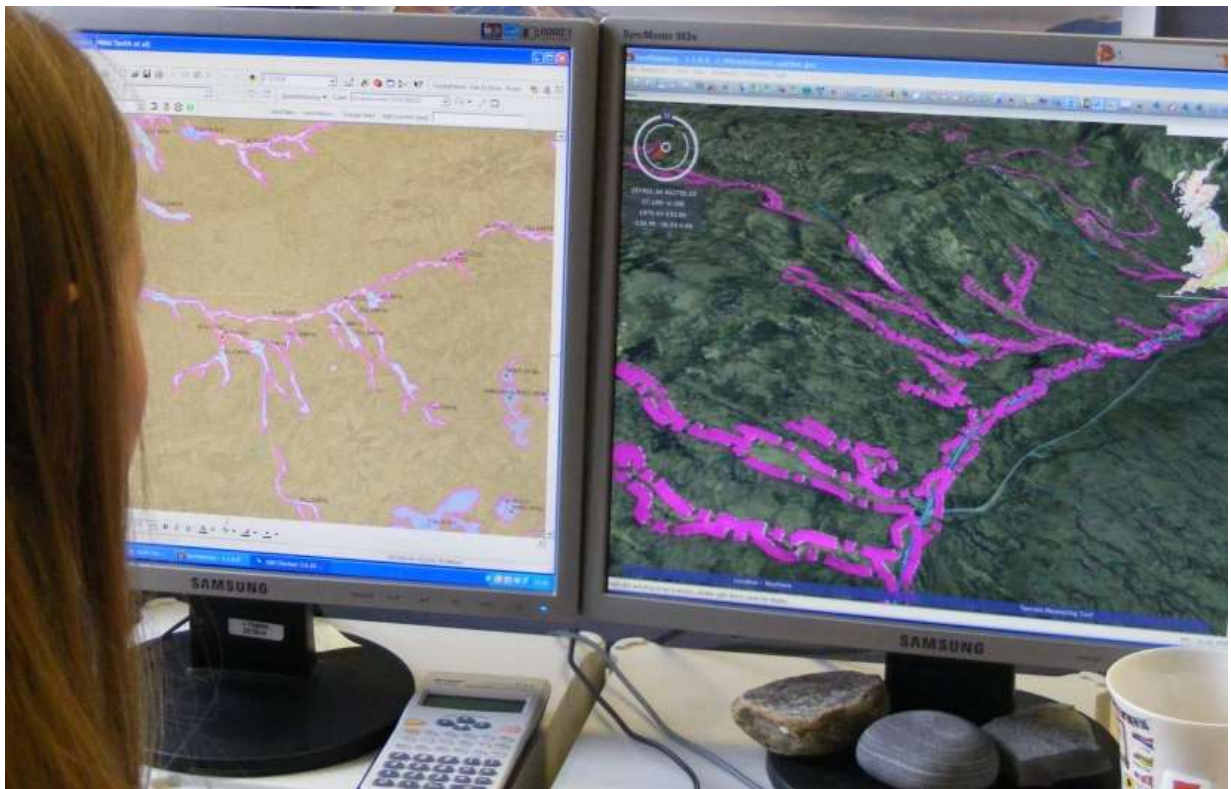
**2.2 Fieldwork** The data assembled in the office is transferred onto a tablet PC with an inbuilt GPS linked to the system which displays the users position. The GIS can display any of the loaded information and can apply transparencies to superimpose data, however it is often clearest to map with a simple background such as aerial photographs, contour lines and a hillshade. The SIGMA mobile system has a wide range of data input tools from a simple pen drawing facility for linear data to a point observation tool with a sophisticated interface to record logged sections. Two frequently-used tools are the notes facility and the geological line drawing tool. Photographs and sketches made in the field can also be stored and tagged with metadata such as directions and descriptions. All observations and information are saved in a geodatabase (Microsoft Access-based).



**Figure 2 SIGMA Mobile in use in the field**

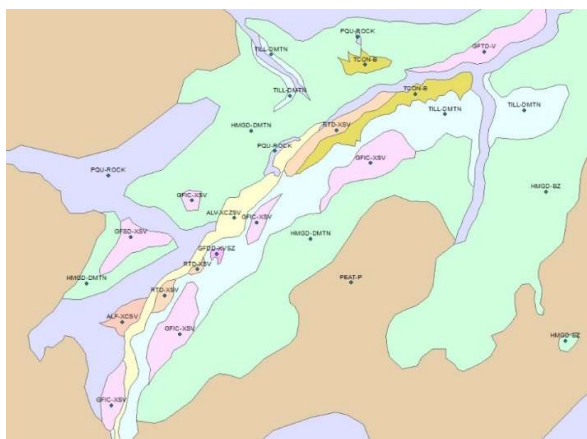
2.3 *Post-fieldwork* Once fieldwork has been completed the SIGMA mobile data can be transferred to the SIGMA desktop application on an office PC which has a very similar setup to the mobile version but with a wider variety of cartographic design elements. In this

stage, all of the linework previously compiled is tidied up and joined together and attributed to comply with the BGS corporate data architecture. The field data can also be loaded into GeoVisionary™ (Virtualis/BGS) software which operates like a high-resolution Google Earth™



**Figure 3 Desktop compilation using GeoVisionary™**





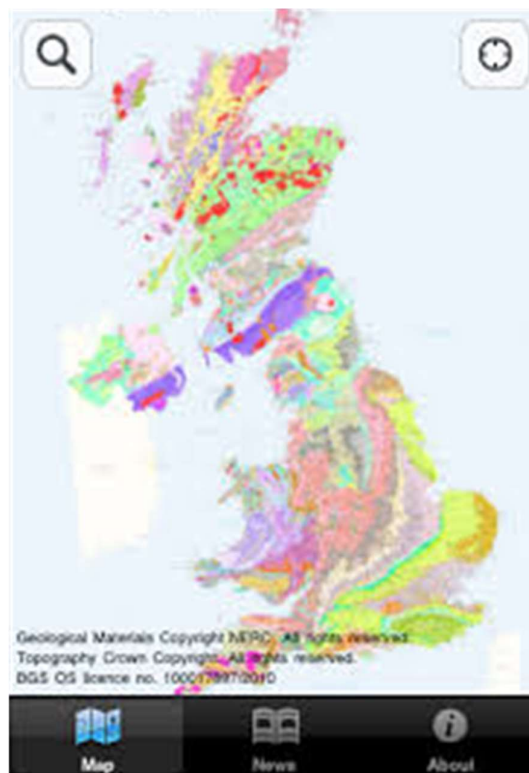
**Figure 4 Map of seeds and polygons at the SIGMA desktop stage**

style visualisation tool allowing the 3D accuracy to be checked. There are specific tools in SIGMA desktop to check that all the lines ‘snap’ and there are no gaps. This ensures that when it comes to creating map polygons they are closed and do not colour a proportion of the map incorrectly. The polygon building process includes placing seeds which code their geological attribution. These take the form of a two part code string. The first half gives the unit name for example “ALV” for alluvium (McMillan *et al.*, 2011) and the second half gives the rock composition such as “SZ” for sand and silt. The geological codes and lines are linked to corporate databases of colours and line styles so much of the final ‘look’ of the map is pre-determined. This ensures a consistent end product that complies with the national DiGMapGB database.

The GPS data enables post-fieldwork assessment of the data. For example if a desktop evaluation provides a slightly different interpretation of the geology and the GPS track shows that location has not been physically mapped (time constraints can mean that the mapper can’t physically enter every field) then the geologist is able to evaluate the different types of data gathered and decide which is more accurate. Once the data have been fully compiled fitting to neighbouring datasets and the geologist and reviewer is happy with it the final version will be sent off for approval (Jordan *et al.*, 2005) and progress into final stages of distribution in a variety of formats and outputs.

### 3 Outputs

Access to geological data has been made much easier since online web mapping systems have been widely available. The BGS ‘Geology Viewer’ uses a web-GIS to display bedrock and superficial polygons overlaid on a map of the UK. More recently the iGeology app has been developed by the BGS for use on mobile devices and tablets and has been downloaded by over 170,000 individual users. It presents DiGMapGB overlaid on open source topographic maps and uses the device’s GPS to locate the user. The data can be queried and is hyperlinked to detailed descriptions on the BGS website.



**Figure 5 The iGeology home page.**

The more advanced iGeology3D app employs ‘augmented reality’ to overlay geological polygons on the terrain as viewed by the devices camera in real time giving the user a geologist’s eye-view. The data is also available as a digital product for government regulators and industry to licence, and includes countrywide data which can be queried and hyperlinked to rock descriptions on the web.

### References

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