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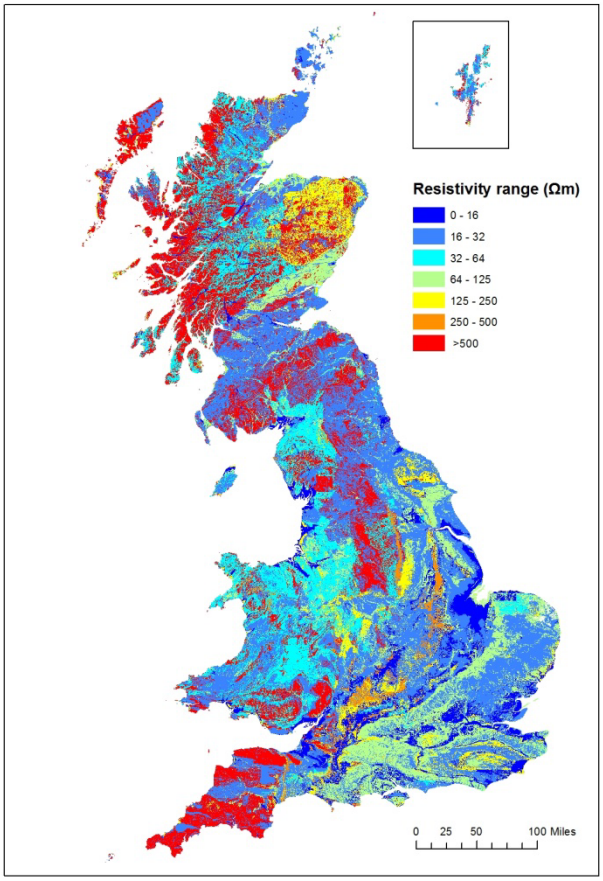
Electrical Resistivity Model of Great Britain: User Guide

Product development: Geo-properties

Open Report OR/14/030



BRITISH GEOLOGICAL SURVEY

PRODUCT DEVELOPMENT: Geo-properties

OPEN REPORT OR/14/030

Electrical Resistivity Model of Great Britain: User Guide

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1 Contents

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1 Introduction

This document provides information for users of the near surface electrical resistivity model of Great Britain. This model has been developed as part of the DiGMapPlus program at BGS.

The resistivity of geological units is an important factor in engineering activities where the electrical characteristics of the ground are required, e.g. in earthing of electrical systems. The resistivity of the ground is dependent on a number of factors which include the porewater resistivity, the saturation and the geology.

1.1 BACKGROUND

The near surface 'electrical resistivity model of Great Britain' has been developed from previous regional resistivity models carried out to inform the design of earthing systems for Western Power Distribution and United Kingdom Power Networks. This work is reported in Busby et al. (2012 and 2014).

The resistivity model is derived using an effective medium methodology to calculate bulk resistivity (Berg, 2007). The BGS National Geotechnical Properties Database (Self, 2012) and information from the BGS Streams database (British Geological Survey, 2009) were utilised to parameterise the input variables in the resistivity calculation. The derived resistivity values were coupled to the geology of Great Britain described in the soil-parent material map (PMM) (Lawley, 2008) using a spatial GIS join. The soil-parent material map (PMM) of Great Britain (Lawley, 2008) describes the characteristics of the near surface zone from which soils develop. Typically, this material is the first geological unit encountered beneath the base of pedological soil. The PMM is derived from the BGS 1:50k scale geological map of Great Britain, known as DiGMapGB-50 (British Geological Survey, 2011). The PMM compilation combines data from the bedrock and superficial (drift) geological maps to produce a model of the surface geology.

2 Who would benefit from the dataset?

It is envisaged that the near surface electrical resistivity model of Great Britain is of interest to a wide range of development organisations including infrastructure and utility companies, local authorities, green energy companies, developers and engineering consultants and contractors. The information is presented at 1:50k scale giving a cartographic accuracy of 50 m on the ground. This enables a detailed parameterisation of resistivity at a practical national scale applicable to stakeholders needs.

3 What the dataset shows

3.1 VALUES OF RESISTIVITY

The geology of Great Britain within the PMM is mapped with 1,464,139 polygons. Each polygon is attributed with a LEX-RCS code. This rigorous lithostratigraphic attribution scheme is derived from two attributes: a LEX (or Lexicon) description giving the name of the specific geological unit; and a RCS (Rock Classification Scheme) code giving its lithology. The compiled data contain 9514 unique LEX-RCS codes. Each LEX-RCS code is then parameterised with its expected range of saturation, porosity, clay content and pore fluid resistivity values.

5000 values of electrical resistivity are derived for each LEX_RCS code by randomly selecting the values of the input variables (from within their defined ranges) and running the resistivity calculation each time. This produces a modelled statistical distribution of resistivity for every geological classification. From these the 50th percentile (median) of the resistivity distribution is extracted along with the 20th and 80th percentile values and minimum and maximum values. These percentiles best summarise the expected range of resistivity values in the upper 3 to 5 m for each LEX-RCS code.

In most instances the RCS defines a single lithology but there are a substantial number of cases where multilithic units are described. In these instances, lithologies with different matrix resistivity are considered separately and two sets of resistivity data are derived for the unit. The two 'lithologies', with different resistivity characteristics, are hereafter referred to as lith1 and lith2, where lith1 is the primary lithology as identified from the BGS Lexicon description

The resistivity values are verified by comparison with electrical resistivity sounding data, held in the National Resistivity Soundings Database (Barker *et al.* 1996) and apparent resistivity estimates from airborne electromagnetic surveys (Beamish and White, 2012)

3.2 FIELD DESCRIPTORS

The data fields included in this dataset are described below:

Lithology (GEN_PMLITH)

This field describes the lithology(ies) identified in the parent material GIS.

Lexicon Rock Classification Scheme (LEX_RCS)

This field is the standard DiGMapGB-50 code that describes the lithostratigraphy of the geological units found in Great Britain. It provides the starting point for the parent material characterisation. It comprises a 'stratigraphic' code (LEX) and 'lithology' code (RCS).

Value of lith1 20th percentile resistivity (A20)

The 20th percentile value of resistivity calculated from the 5000 different realisations for lith1 of the LEX-RCS code.

Value of lith1 50th percentile resistivity (A50)

The 50th percentile (median) value of resistivity calculated from the 5000 different realisations for lith1 of the LEX-RCS code.

Value of lith1 80th percentile resistivity (A80)

The 80th percentile of resistivity value calculated from the 5000 different realisations for lith1 of the LEX-RCS code.

Range of lith1 resistivity (ARANGE)

The range of expected resistivity values for lith1 of the LEX-RCS code.

Value of lith2 20th percentile resistivity (B20)

The 20th percentile of resistivity value calculated from the 5000 different realisations for lith2 for the LEX-RCS code.

Value of lith2 50th percentile resistivity (B50)

The 50th percentile (median) of resistivity value calculated from the 5000 different realisations for lith2 of the LEX-RCS code.

Value of lith2 80th percentile resistivity (B80)

The 80th percentile of resistivity value calculated from the 5000 different realisations for lith2 for the LEX-RCS code.

Range of lith2 resistivity (BRANGE)

The range of expected resistivity values for lith2 for the LEX-RCS code.

Nominal Scale (NOM_SCALE)

This field describes the notional x-y spatial scale of the data. Most geological map data in the dataset is captured and presented at a scale of 1:50k. The field identifies a combination of scales used to create the map from the bedrock and superficial map sources. The available scales are show as follows:

Note: where the geology consists of a single lithology, lith1 and lith2 resistivity values are the same.

Table 1. Explanation of the nominal scales of geological map data

Field Value	Meaning
50	No superficial data is present for this sheet and bedrock data is available at 1:50 000 scale
250	No superficial data is present for this sheet and bedrock data is available at 1:250 000 scale
625_50	Superficial data is present for this sheet at a scale of 1:625 000 and Bedrock data is available at a scale of 1:50 000
50_50	Superficial data is present for this sheet at a scale of 1:50 000 and Bedrock data is available at a scale of 1:50000
35_50	Superficial data is present for this sheet at a scale of 1:35 000 and Bedrock data is available at a scale of 1:50 000
35_250	Superficial data is present for this sheet at a scale of 1:35 000 and Bedrock data is available at a scale of 1:250 000

Unique polygon identifier (UID)

This field gives a polygon identifier for DiGMapPlus products. This field uniquely identifies each object in the map. It is used for auditing and identification purposes.

Version of DiGMapPlus Resistivity Model

This is the code used by BGS to identify a type of version of DiGMapPlus product. In the case of this dataset the value of this field is set to “DiGMapPlus_Resistivity_V1”.

4 How the dataset was created

Data was collated and interpreted from a number of different sources currently held by BGS. The primary datasets used for the near surface electrical resistivity model of Great Britain are:

- Parent Material Map V6 dataset.
- BGS National Geotechnical Properties Database
- BGS Physical Laboratories Properties Database
- BRE Stone list (BRE)
- National Resistivity Soundings Database

Geological classification is undertaken on a lithostratigraphic basis since the age of the sedimentary deposits is a key factor in the parameter attribution. This approach means information from units for which there is a reasonable amount of data can be used to inform the parameterisation of units of similar age and type where there is little or no information available.

The DiGMapPlus dataset is compiled using the following workflow:

1. Identify characteristics, measurements and observations from archive records relating to the resistivity of surface materials (presence of clay minerals, porosity, saturation, measured resistivity etc).
2. Identify the Primary lithology (lith1) and secondary lithologies (lith2), where applicable, for each of the LEX-RCS codes found in the Parent Material Dataset.
3. Assess whether the range of available evidence statistically supports the range of possible classes (using typical tests such as ANOVA), or whether expert judgement is required to complete the parameter data (presence of clay minerals, porosity, saturation, measured resistivity) for the primary/secondary lithologies.
4. Calculate the 5000 realisations of resistivity using the Berg algorithm for each LEX-RCS code.
5. Carry out the statistical analysis of the modelling and extract the resistivity values for the desired percentiles.
6. Compile the spatial (map) by coupling the resitivity values to the soil-parent material map (PMM) of Great Britain (Lawley, 2008) through the shared LEX-RCS code.
7. Submit data for standard BGS digital-data checking procedures (to assess completeness and cleanliness of content).

5 Technical information

5.1 SCALE

The ***DiGMapPlus Near Surface 'Electrical resistivity Model of Great Britain'*** dataset is produced for use at 1:50k scale providing 50 m ground resolution.

The data are released in ESRI shapefile formats. Other formats such as MapInfo TAB are available on request. The standard data supplied to customers has polygons or areas in a single layer or theme.

5.2 COVERAGE

Data is provided to indicate the resistivity of rocks and soils across Great Britain (excluding the Isle of Man) as shown below. The scales of map data available to create this dataset are shown in Appendix 2.

5.3 DATA HISTORY

This is the first version of the dataset to be published (released 2014): It is derived from BGS Parent Material Map version 6. More details on this product can be found at this website http://www.bgs.ac.uk/products/onshore/soilPMM.html.

5.4 LIMITATIONS

- The DiGMapPlus datasets have been developed at 1:50k scale and must not be used at larger scales. All spatial searches against the data should be done with a minimum 50 m buffer
- The distribution of the input data from the National Geotechnical Properties Database is shown in Appendix 1 and digital geological map data scales are in Appendix 1. Although the National Geotechnical Properties Database, BGS Physical Laboratories Properties Database and BRE Stone list (BRE) are the main sources for data their limited coverage means that data from BGS reports and other resources have been used.
- Local conditions may vary and this dataset should **not** replace site assessment. Further detail of the geology may be available on more detailed 1:10k scale geological maps.
- The spatial distribution of the data is limited by the spatial accuracy and resolution of the digital geological map data (DiGMapGB-50) (Appendix 2). Spatial mismatches of resistivity values relate to mismatches in lithology type (i.e. variation in LEX-RCS across map-sheet boundaries) do occur, and require resolution by reference to higher resolution map information where available. Further detail of the geology may be available on more detailed 1:10k scale geological maps.
- The various resistivity values presented are created as vector polygons and are available in a range of GIS formats, including ArcGIS (.shp), ArcInfo Coverages and MapInfo (.tab). More specialised formats may be available but may incur additional processing costs.
- Resistivity dataset is concerned with the properties and potential use of NATURAL geological deposits and conditions only. It does NOT cover any man-made constructions or materials.
- The resistivity values are based on, and limited to, an interpretation of the records in the possession of or available to The British Geological Survey at the time the dataset was created.
- The values of resistivity given are the statistical simulation derived from the parameter value of a rock or soil and do not necessarily represent the distribution that will be found on site which will depend on the local variability of the ground and climatic conditions. Such an assessment can only be made by inspection of the area by a qualified professional.
- An indication of the typical variability of resistivity of a rock or soil does not necessarily imply the resistivity of laminated or interbedded soil of rock are as the *in situ* values might ‘averaging’ of the resistivity of the different lithologies and will depend on the material type, the relative thicknesses of the different materials types and the resolution of the resistivity survey.

6 Contact information

For all data and licensing enquiries please contact:

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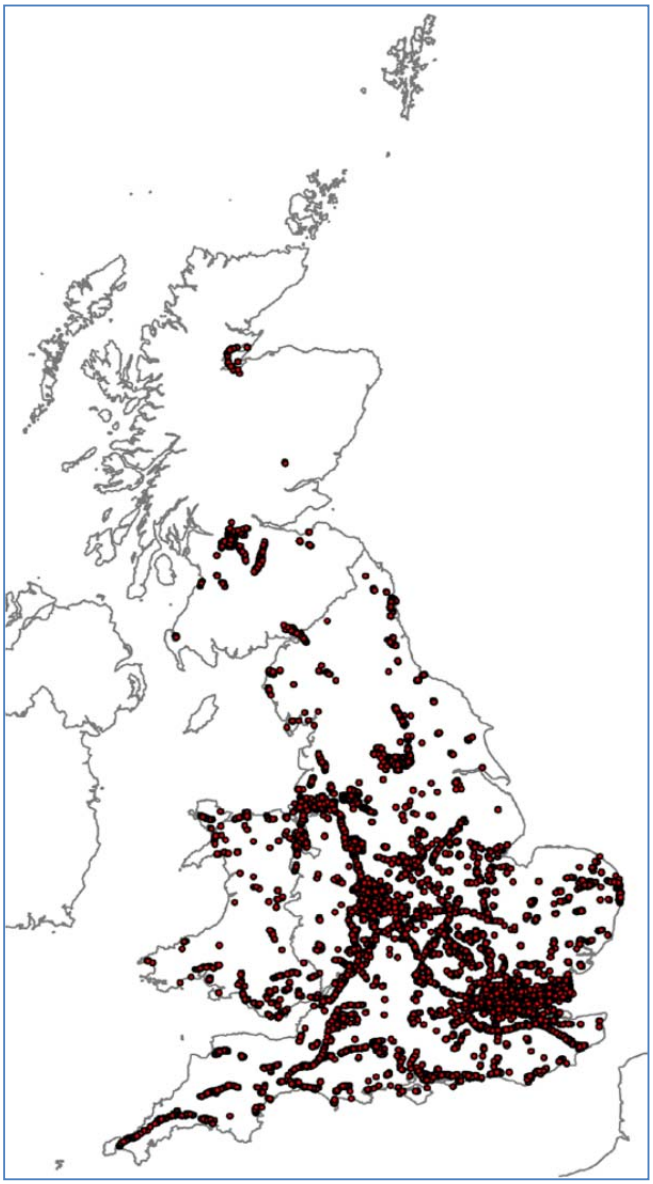
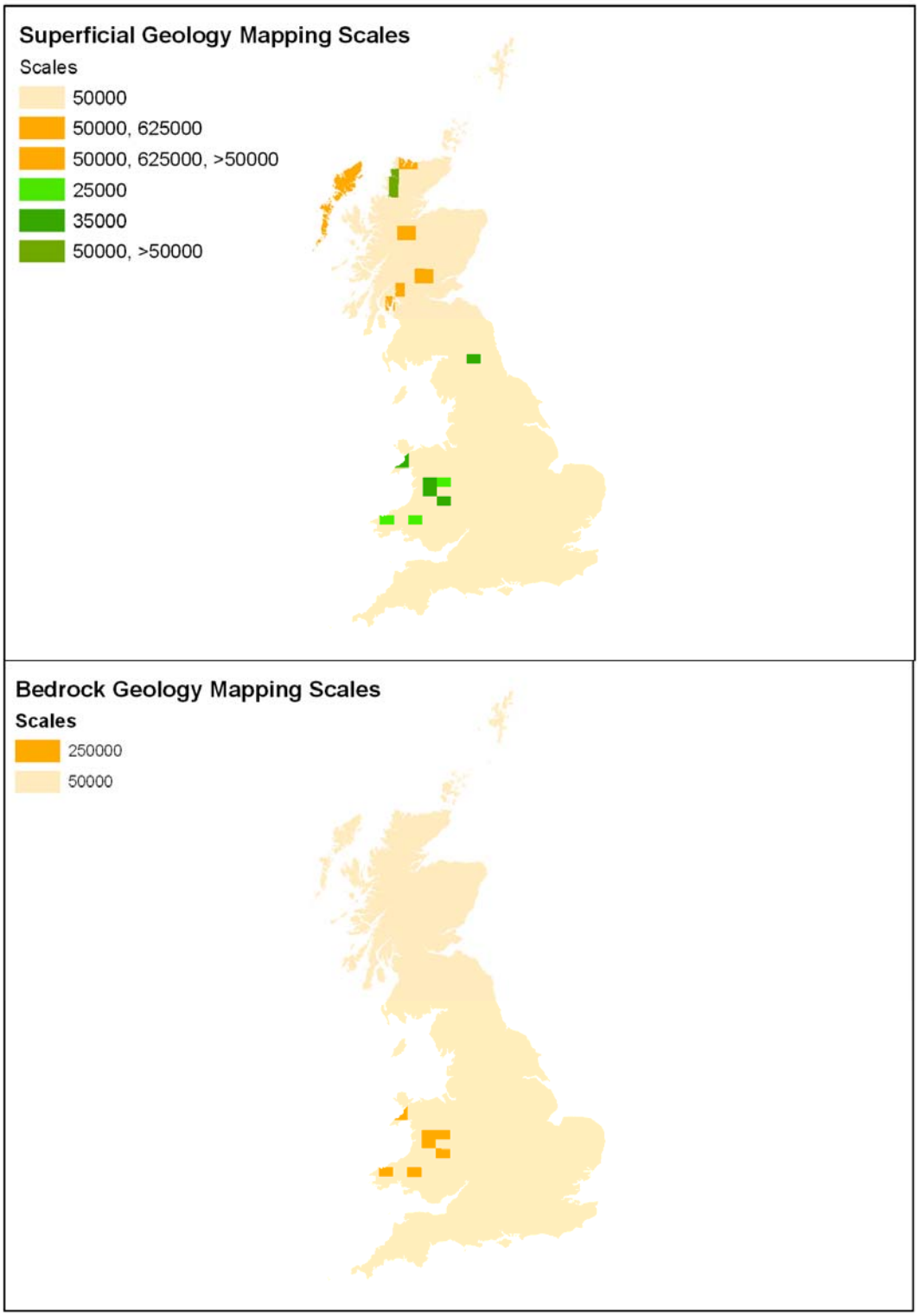
Appendix 1. Distribution of data held in the National Geotechnical Properties Database.



Appendix 2. Mapping Scales



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