



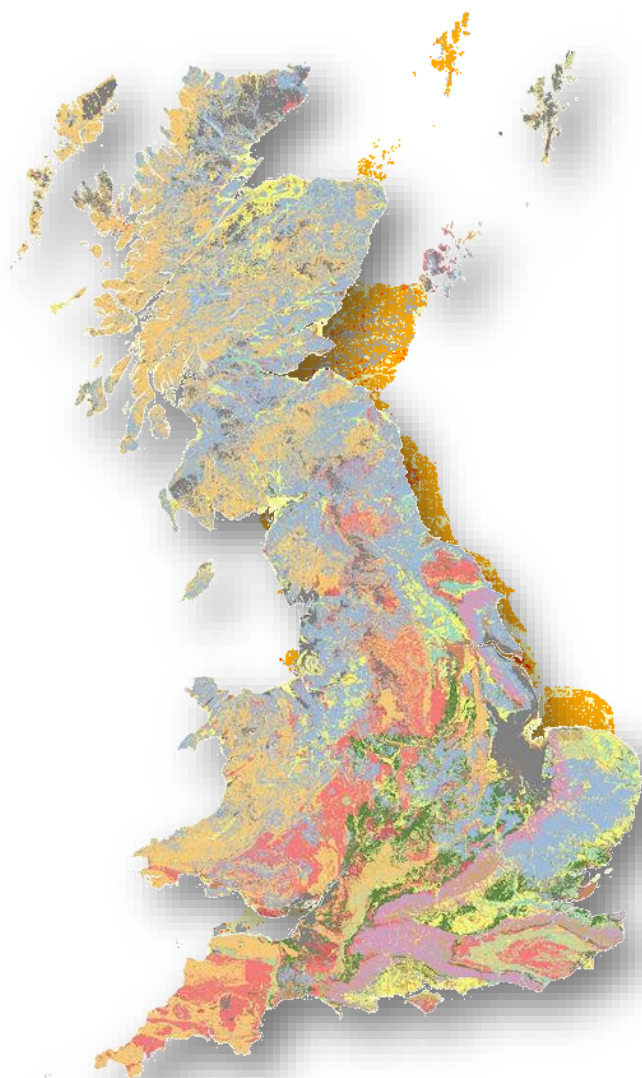
**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

User Guide DiGMapPlus Engineering Properties: Discontinuities dataset (version 1)

Environmental Modelling Directorate

Open Report OR/14/053



BRITISH GEOLOGICAL SURVEY
ENVIRONMENTAL MODELLING DIRECTORATE
OPEN REPORT OR/14/053

User Guide DiGMapPlus Engineering Properties: Discontinuities dataset (version 1)

The National Grid and other
Ordnance Survey data ©
Crown Copyright and
database rights 2015.
Ordnance Survey Licence
No. 100021290.

Keywords: Engineering
properties, discontinuities,
joints, bedding rock mass,
National dataset, User guide.

Front cover: BGS
Discontinuities dataset

Bibliographical reference: M
R DOBBS, R S Lawley.
2015. User Guide
DiGMapPlus Engineering
Properties: Discontinuities
dataset (version 1). *British
Geological Survey Open
Report*, OR/14/053. 20pp.

Copyright in materials
derived from the British
Geological Survey's work is
owned by the Natural
Environment Research
Council (NERC) and/or the
authority that commissioned
the work. You may not copy
or adapt this publication
without first obtaining
permission. Contact the BGS
Intellectual Property Rights
Section, British Geological
Survey, Keyworth,

e-mail ipr@bgs.ac.uk. You
may quote extracts of a
reasonable length without
prior permission, provided a
full acknowledgement is
given of the source of the
extract.

Maps and diagrams in this
book use topography based
on Ordnance Survey
mapping.

© NERC 2015. All rights
reserved

M R Dobbs, R S Lawley

Contributor/editor

K A Lee, P Hobbs

Keyworth, Nottingham British Geological Survey 2015

BRITISH GEOLOGICAL SURVEY

The full range of our publications is available from BGS shops at Nottingham, Edinburgh, London and Cardiff (Welsh publications only) see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications, including maps, for consultation.

We publish an annual catalogue of our maps and other publications; this catalogue is available online or from any of the BGS shops.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as basic research projects. It also undertakes programmes of technical aid in geology in developing countries.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

BGS Central Enquiries Desk

Tel 0115 936 3143 Fax 0115 936 3276

email enquiries@bgs.ac.uk

Environmental Science Centre, Keyworth, Nottingham NG12 5GG

Tel 0115 936 3241 Fax 0115 936 3488

email sales@bgs.ac.uk

Murchison House, West Mains Road, Edinburgh EH9 3LA

Tel 0131 667 1000 Fax 0131 668 2683

email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road, London SW7 5BD

Tel 020 7589 4090 Fax 020 7584 8270

Tel 020 7942 5344/45 email bgs-london@bgs.ac.uk

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff CF15 7NE

Tel 029 2052 1962 Fax 029 2052 1963

Maclean Building, Crowmarsh Gifford, Wallingford OX10 8BB

Tel 01491 838800 Fax 01491 692345

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF

Tel 028 9038 8462 Fax 028 9038 8461

www.bgs.ac.uk/gsni/

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU

Tel 01793 411500 Fax 01793 411501

www.nerc.ac.uk

Website www.bgs.ac.uk

Shop online at www.geologyshop.com

Contents

1	Introduction.....	1
1.1	Background.....	1
2	Who would benefit from the dataset?	2
3	What the dataset shows	2
3.1	Classification	2
3.2	Types of discontinuity	3
3.3	Field descriptors	4
4	How the dataset was created	9
5	Technical information.....	10
5.1	Scale.....	10
5.2	Coverage.....	10
5.3	Data history.....	10
5.4	Limitations.....	10
6	Contact information.....	11
Appendix 1	Engineering Properties: Field Properties.....	12
Appendix 2.	Distribution of source data	13
Appendix 3	Mapping Scales	14
References		15

FIGURES

Figure 1: examples of stratification.....	3
Figure 2: examples of foliation	3
Figure 3: examples of rock mass character	4
Figure 4: Western shore of Orkney c. 3 m. north-west of Stromness. Qui Ayre. Unconformity of Lower Stromness Flagstones on Yesnaby Sandstone Formation [P000625].	4
Figure 5: (1) Foliated meta-greywacke, Bargaly Glen [P008449]; (2) Crenulation cleavage in schist. Photomicrograph PPL, X2.5 [P054611].....	5
Figure 6: (1) Blocky and platy bedded limestone Coupland Sike Limestone in Raisbeck Quarry near Wath [P223193]. (2) Tabular bedded psammite, Creag Ghrianch [P596858]	6
Figure 7: (1) Columnar jointing in basalt, Giant's Causeway [P006483]. (2) Exfoliation layers around Precambrian tuffs [P008089].....	7

TABLES

Table 1. Explanation of stratification plane descriptors.....	5
Table 2. Explanation of foliation descriptors	5

Table 3. Explanation of rock mass descriptors	6
Table 4. Explanation of additional discontinuity descriptors.....	7
Table 5. Explanation of the nominal scales of geological map data	8

1 Introduction

This document provides information for users of the ‘Engineering Properties: Discontinuities’ dataset.

Various terms have been used over the years to describe discontinuities and these often vary depending upon discontinuity type and the scale at which they are observed. Two of the more succinct and comparable ‘engineering geology’ definitions are provided below:

Discontinuities are breaks, fractures or planes of weakness in the rock mass. (BS5930:1999 amendment 2 – BSI, 1999).

The general term for any mechanical discontinuity in a rock mass having zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistosity planes, weakness zones and faults. (ISRM Suggested Methods for Rock Characterization, Testing and Monitoring - Ulusay & Hudson, 2007).

Within the context of this user guide and the ‘Engineering Properties: Discontinuities’ dataset, discontinuities are defined as a break in the continuity of a rock mass that has the potential to have zero or very low tensile strength. As such it includes all stratification planes (bedding, layering and lamination), all foliation planes (fissility, cleavage, banding) and all fractures (joints, faults, fissures) as defined in British Standard BS5930 and International Society for Rock Mechanics (ISRM) Suggested methods for rock characterization, testing and monitoring. It does not include interfaces (other than stratification planes/depositional interfaces) and chemical-solution breaks (such as solution cavities).

The discontinuities within rocks and soils play a major role in how the ground behaves in response to changes in stress. Discontinuities are therefore an important factor in civil engineering and extractive industry activities and may affect a number of different operations including excavation, extraction of resources, and the stability of voids, slopes and foundations.

The type, frequency and orientation of ‘discontinuities’ within rock and soil material depend on a number of factors including: emplacement; deposition environment; diagenesis; metamorphic history; strength; composition; mineralogy; and local and regional tectonics.

The ‘Engineering Properties: Discontinuities’ dataset is intended to provide information about the discontinuities present within rocks and soils at a formation scale in order to facilitate preliminary research for the planning and design of buildings, infrastructure, and resource extraction.

1.1 BACKGROUND

The properties and behaviour of rocks and soils fundamental to the planning and development of buildings and infrastructure were included in a series of BGS Technical Reports (‘A geological background for planning and development’) funded by the Department of the Environment during the 1980’s and 1990’s (reviewed in Smith and Ellison, 1999). Many of these characteristics were also included in a number of British Geological Survey 1:50 000 geological sheet brief explanations and the 1:1 000 000 scale engineering geology maps of the United Kingdom (Dearman et al., 2011, Dobbs et al., 2012).

In 2010 the British Geological Survey initiated a development programme to produce thematic datasets that identified and assessed a variety of engineering and soil properties in Great Britain. These include datasets for strength, excavatability, corrosivity (ferrous) and fill. Additional data for Bulking volume, foundation conditions, sulphate content and engineering rockhead are in development.

Along with the engineering properties datasets, the Baseline Products and Derived Products Programmes have also generated:

- Parent Material Model
- Superficial Thickness Model
- GeoSure ground stability data
- Methane and carbon dioxide from natural sources and mining
- Mining hazard (not including coal)
- Radon potential dataset
- Scans of onshore borehole logs for Great Britain
- Scans of geology and historic topography maps
- Aquifer Designation Data
- Permeability
- Infiltration SuDS map
- Susceptibility to Groundwater Flooding
- Geological Indicators of Flooding
- Soil Chemistry for Environmental Assessments

2 Who would benefit from the dataset?

It is envisaged that ‘discontinuities’ are of interest to a wide range of organisations concerned with planning and development of buildings and infrastructure, including utility companies, local authorities, developers and engineering consultants and contractors.

Engineering geologists and ground engineers (geotechnical engineers, rock engineers, tunnelling engineers etc) have long required information on nature, spacing and orientation of discontinuities within rocks and soils. Although the information presented in the ‘Engineering Properties: Discontinuities’ dataset (at a 1:50 000 scale) provides only a generic assessment, and isn’t suitable for specific site-design purposes, it does help to inform engineering geologists and ground engineers at the ‘desk study stage’ of investigation thereby allowing for more efficient planning and execution of proceeding ground investigations.

3 What the dataset shows

3.1 CLASSIFICATION

The ‘Engineering Properties: Discontinuities’ dataset forms part of a suite of GIS layers for different engineering parameters. The purpose of this dataset is to provide general guidance on the discontinuities present within geological units up to 2m below ground level, as defined on DiGMapGB-50. The GIS model displays the spatial variation of discontinuity properties in three fields including spacing of stratification planes, foliation and rock mass description. A fourth field documents additional discontinuity information not recorded in the other fields.

The classification systems used are based on BS5930:1999 (BSI, 1999), ISRM suggested methods for characterizing rock (Ulusay & Hudson, 2007) and the BGS rock classification scheme for metamorphic rocks (Robertson, 1999).

NOTE: The 'Discontinuities' model provides data
for the **uppermost 2 m** of all geological units distributed across Great Britain.

3.2 TYPES OF DISCONTINUITY

This dataset classifies discontinuities into 3 main categories, stratification, foliation and rock mass description, as described below. There is also an additional category to identify additional discontinuity features such as shears, columnar jointing, etc.

3.2.1 Stratification

Stratification planes are the dividing planes that separate each layer in a rock or soil from layers below and above it. It ordinarily delineates a change in colour, texture, structure or composition which is laterally persistent throughout the rock/soil body (Lapidus, 1990). Not all of these features necessarily represent a mechanical break, so while some stratification planes represent a plane of physical weakness with no appreciable tensile strength other planes may be no weaker than the layers which they divide.



Figure 1: Examples of stratification

3.2.2 Foliation

Foliation is the parallel orientation of platy minerals or mineral banding in rocks (Whitten & Brooks 1972). The term is often applied only to metamorphic rocks (Lapidus, 1990) but is also used here to describe layered structures formed by the separation and/or orientation of minerals in igneous rocks and to describe strongly developed, very closely spaced, bedding fissility which is found in some un-metamorphosed argillaceous rocks (shales). Not all foliation planes represent a mechanical break, so while some foliation planes represent a plane of physical weakness with no appreciable tensile strength other planes may be no weaker than the layers which they divide.



Figure 2: Examples of foliation

3.2.3 Rock mass description

Rock masses can be described, at a metre to decimetre scale, by the overall size and shape of the blocks that form it. These blocks are made by the intersection of discontinuities, usually joints, which have different orientations, spacing and persistence.

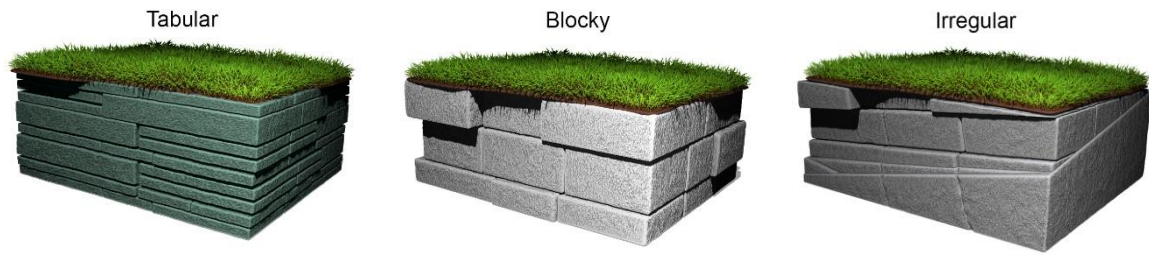


Figure 3: Examples of rock mass character

3.3 FIELD DESCRIPTORS

The data fields included in this dataset are described below. Field descriptions as they appear in the dataset are shown in Appendix 1.

General lithology (GEN_PMLITH)

This is a simplified geological description of the parent material geology and is derived from the DiGMapGB-50 BGS rock classification coding (see LEX-RCS below). In general the aim is to provide the user with a simplified, easy to use, lithological description.

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).

Stratification (DISCO_S)

The *Stratification (DISCO_S)* field describes the minimum and maximum spacing between stratification planes. Where there is more than one lithology present (heterolithic units) the smallest and largest spacing is given unless the formation is specifically described as interbedded (in RCS_D), in which case the maximum spacing is given as Bm (medium bedded/layered) unless otherwise indicated by additional data. A typical example of stratification is seen in figure 4, and described fully in table 1, below.



Figure 4: Western shore of Orkney c. 3 m. north-west of Stromness. Qui Ayre. Unconformity of Lower Stromness Flagstones on Yesnaby Sandstone Formation [P000625].

Table 1. Explanation of stratification plane descriptors

Description	Definition (DISCO_1)	Code (DISCO_S)
Laminated	Stratification spacing <0.02 m	La
Thinly bedded/layered	Stratification spacing 0.02 – 0.20 m	Bn
Medium bedded/layered	Stratification spacing 0.20 – 0.60 m	Bm
Thickly bedded/layered	Stratification spacing 0.6 – 2.0 m	Bk
Very thickly bedded/layered	Stratification spacing >2.0 m	Bv
Not bedded	The unit has no bedding/layering, bedding/layering is not persistent, or bedding/layering is inconspicuous.	NB
Null	Application of stratification description is not possible or is inappropriate for this unit.	

Foliation (DISCO_F)

The *Foliation (DISCO_F)* field describes the typical foliation or range of foliations that are likely to be present. Examples of foliation are seen in figure 5, and fully described in table 2, below.

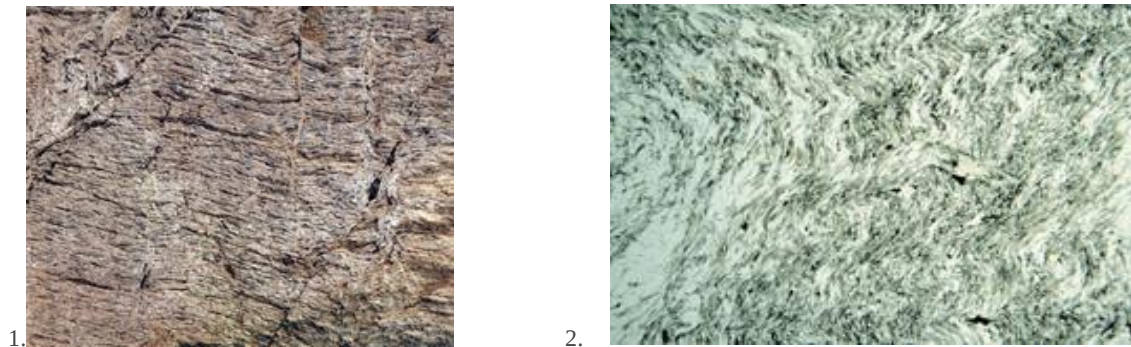


Figure 5: (1) Foliated meta-greywacke, Bargaly Glen [P008449]; (2) Crenulation cleavage in schist. Photomicrograph PPL, X2.5 [P054611]

Table 2. Explanation of foliation descriptors

Description	Definition (DISCO_F)	Code (DISCO_2)
Bedding fissility/ Slaty cleavage	Strongly developed, very closely spaced (mm), highly fissile parallel planes along which the rock can be parted into thin plates indistinguishable from each other in terms of lithological characteristics. May not be persistent throughout unit.	Fs

Schistose Foliation	Strongly developed, closely spaced (mm-cm), highly fissile to poorly fissile, parallel and sub-parallel planes. All traces of bedding destroyed. May not be persistent throughout unit.	Sc
Gneissose Foliation	Well developed regular alternating bands (cm) of schistose material (highly to poorly fissile) and granofelsic material (unfoliated and unfissile). Foliation is more irregular and discontinuous than schistose foliation. All traces of bedding destroyed. May not be persistent throughout unit.	Gn
Not Foliated	The unit has no foliation, foliation is very rare or the foliation is non fissile and imparts no strength anisotropy to the unit.	NF
Null	Application of foliation description is not possible or is inappropriate for this unit.	

Rock Mass Description (DISCO_RM)

The *Rock Mass Description (DISCO_RM)* field describes the typical shape of the blocks that compose the rock mass. This may be highly variable depending upon the *RCS_D* description. Examples of rock mass (blocky and bedded) are seen in figure 6, and fully described in table 3, below.



Figure 6: (1) Blocky and platy bedded limestone Coupland Sike Limestone in Raisbeck Quarry near Wath [P223193]. (2) Tabular bedded psammite, Creag Ghrianach [P596858]

Table 3. Explanation of rock mass descriptors

Description	Definition (DISCO_RM)	Code (DISCO_3)
Massive	There are less than three pervasive discontinuity sets and/or the discontinuity sets are widely spaced (>5m between discontinuities).	Ma
Blocky	The rock mass is made up of approximately equidimensional blocks.	Bl
Tabular	The rock mass is made up of blocks where one dimension is considerably shorter than other	Ta

	dimensions.	
Irregular	The rock mass is made up of fragments which have a wide variation in size and shape. Includes shear and crush zones.	Ir
Not a Rock Mass	Rock mass description not applicable to artificial deposits, superficial deposits and very weak bedrock.	NR
Null	Application of rock mass description is not possible or is inappropriate for this unit.	

Additional Discontinuities (DISCO_ADD)

The *Additional Discontinuities (DISCO_ADD)* field describes other types of discontinuities that may be present and that are not accounted for by the other three fields.

Table 4. Explanation of additional discontinuity descriptors

Description	Definition (DISCO_ADD)	Code (DISCO_4)
Sheet jointing/ Exfoliation jointing	A pervasive, surface parallel, joint set may be present and extend up to 15 m below the surface.	Sj
Columnar jointing	Layers within the formation may have pervasive columnar jointing producing blocks where one dimension is considerably larger than other dimensions.	Cl
Sheared	Low angle fault planes with low residual shear strength may be present.	Sh
Fissured	Near surface joints associated with weathering extending from the surface downward may be present.	Fi
No additional discontinuities	No additional discontinuity types are known for this unit.	NS
Null	Application of additional discontinuity description is not possible or is inappropriate for this unit.	



Figure 7: (1) Columnar jointing in basalt, Giant's Causeway [P006483]. (2) Exfoliation layers around Precambrian tuffs [P008089].

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 1:50 000. 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:

Table 5. 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

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 'Engineering Properties: Discontinuities' dataset GIS are:

- Parent Material Map V6 dataset
- BGS National Geotechnical Properties Database
- BGS Lexicon of Named Rock Units
- BGS Map Sheet Explanations
- BGS Sheet Memoirs
- BGS Geoscience Imagebase
- BGS and Geological Society Regional Guides
- BGS Urban Planning Reports
- BGS Engineering Geology Formation Study Reports
- Site Investigation Records and Borehole Scans held in BGS archives

The DiGMapPlus datasets follow a standard workflow to create each dataset:

- Step 1: Identify characteristic, measurements and observations from archive records.
- Step 2: Categorise the observations into classes/groups of similar behaviours. Where possible using published standards of classification such as BS 5930, Eurocode 7 or other similar international or national standard.
- Step 3: Assess the range of lithostratigraphic variation of geological materials across Great Britain, in terms of the categories and classes identified in step 2 to create a 'lookup' dataset of expected attributes (material characteristics and behaviours) per lithostratigraphic unit.
- Step 4: Compile the spatial (map) components of the DiGMapPlus datasets with the 'lookup' dataset using standard GIS and data techniques to create a new 'map' of discontinuity characteristics.

Categorisation of the data, and assessment of the nature of discontinuities present within UK rocks and soils, has been made by expert judgement in order to create 'look up tables' of lithostratigraphic rock type and associated engineering properties. Assignments of characteristics and descriptors has been made at the 'formation' level of lithostratigraphic classification.

Spatial data-creation and discontinuity attribution has been completed using ESRI ARCGIS software.

5 Technical information

5.1 SCALE

The ‘Engineering Properties: Discontinuities’ dataset is produced for use at 1:50000 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 likely discontinuities present within rocks and soils across Great Britain. The scales of map data available to create this dataset are shown in Appendix 3.

5.3 DATA HISTORY

Version 1 (released 2014): Derived from DiGMapGB-50 version 6.

5.4 LIMITATIONS

- The ‘Engineering Properties: Discontinuities’ dataset has been developed to provide general guidance on the discontinuities present in soils and rocks within geological units up to 2m below ground level, as defined on DiGMapGB-50.
- The ‘Engineering Properties: Discontinuities’ dataset has been developed at 1:50 000 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 ‘Engineering Properties: Discontinuities’ dataset has been developed at a formational scale, as such it does not detail intra-formational variation. This may be particularly pronounced with respect to foliation and stratification.
- The ‘Engineering Properties: Discontinuities’ dataset has been developed without consideration of faults and fault zones as the effect of these features occurs at a very local (i.e. large) scale. The Rock mass characteristics in particular will be especially affected by proximity to faults and fault zones. As such appropriate ground investigation and assessment is critical at a site specific scale.
- The spatial distribution of the data is limited by the distribution of the site investigation exploratory holes from which the geotechnical data have been extracted and the distribution of available information from sheet memoirs, reports, images and digital geological map data (DiGMapGB-50) (Appendix 2 & 3). Although the National Geotechnical Properties Database is the ‘first port of call’ for data it has limited coverage so other descriptive data from exploratory hole logs or from Site Investigation Reports has been used.
- Local conditions may vary and this dataset should not replace detailed site investigations. Further detail of the geology may be available on more detailed 1:10,000 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 3). Spatial mismatches of discontinuity characteristics related to mismatches in lithology type (i.e. variation in LEX_RCS across map-sheet boundaries) are unavoidable and require resolution by reference to higher resolution map information. Further detail of the geology may be available on more detailed 1:10,000 scale geological maps.

- ‘Engineering Properties: Discontinuities’ data 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.
- The ‘Engineering Properties: Discontinuities’ dataset is concerned with the properties of NATURAL geological deposits and conditions only. It does NOT cover any man-made constructions or materials.
- The ‘Engineering Properties: Discontinuities’ dataset is based on, and limited to, an interpretation of the records in the possession of The British Geological Survey at the time the dataset was created.
- An indication of the typical discontinuities present within rock or soil does not necessarily mean that the rock properties are consistent throughout the outcrop. Such an assessment can only be made by inspection of the area by a qualified professional.

6 Contact information

For all data and licensing enquiries please contact:

Central Enquiries

British Geological Survey

Kingsley Dunham Centre

Keyworth

Nottingham

NG12 5GG

Direct tel: +44(0)115 936 3143

Fax: +44(0)115 9363150

Email: enquiries@bgs.ac.uk

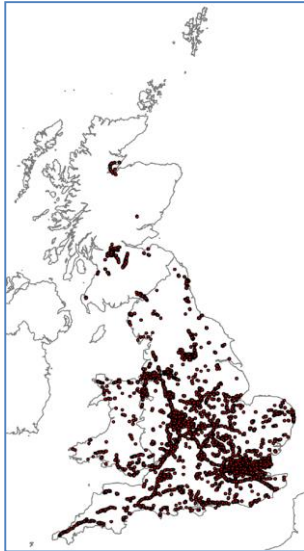
Appendix 1 Engineering Properties: Field Properties

Field name	Field description	Description
GEN_PMLITH TEXT	Generalised lithology description	This is a simplified geological description of the parent material and is derived from the original DiGMapGB-50 LEX-RCS coding compared with the hierarchical classification of UK rocks from the BGS RCS system. In general the aim is to provide the user with as simplified a lithological description as possible.
LEX_RCS TEXT	BGS Lexicon-rock classification scheme	This field is the standard DiGMapGB-50 code that describes 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).
DISCO_S TEXT	Stratification plane spacing	This field describes the minimum and maximum spacing between stratification planes, the dividing planes that separate each layer in a rock or soil from layers below and above it.
DISCO_1 TEXT	Stratification code	This field provides a code version of DISCO_S
DISCO_F TEXT	Foliation	This field describes the typical foliation or range of foliations likely to be present within the formation. Includes the parallel orientation of platy minerals or mineral banding present in metamorphic rocks, layered structures formed by the separation and/or orientation of minerals in igneous rocks and strongly developed, very closely spaced, bedding fissility which is found in some un-metamorphosed argillaceous rocks (shales).
DISCO_2 TEXT	Foliation code	This field provides a code version of DISCO_F
DISCO_RM TEXT	Rock mass characteristics	This field describes the overall shape of the blocks that form a rock mass at a metre to decimetre scale.
DISCO_3 TEXT	Rock mass code	This field provides a code version of DISCO_RM
DISCO_ADD TEXT	Additional discontinuities	This field describes other types of discontinuities that may be present and that are not accounted for by the other three fields.
DISCO_4 TEXT	Additional discontinuities code	This field provides a code version of DISCO_ADD
NOM_SCALE TEXT	Nominal 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 1:50,000. The field identifies a combination of scales used to create the map from the bedrock and superficial map sources.
UID	Unique identifier	Map metadata (identifies each spatial object uniquely)
VERSION	Version of the dataset	Map metadata (identifies dataset uniquely)

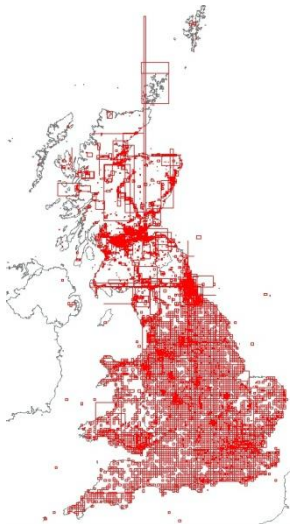
Appendix 2. Distribution of source data

Data held in the (a) National Geotechnical Properties Database, (b) Site Investigation Records, (c) Geoscience Imagebase, (d) sheet memoirs, (e) borehole scans

(a)



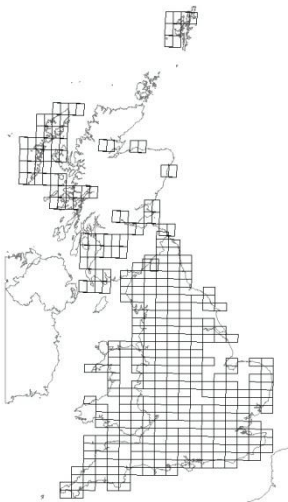
(b)



(c)



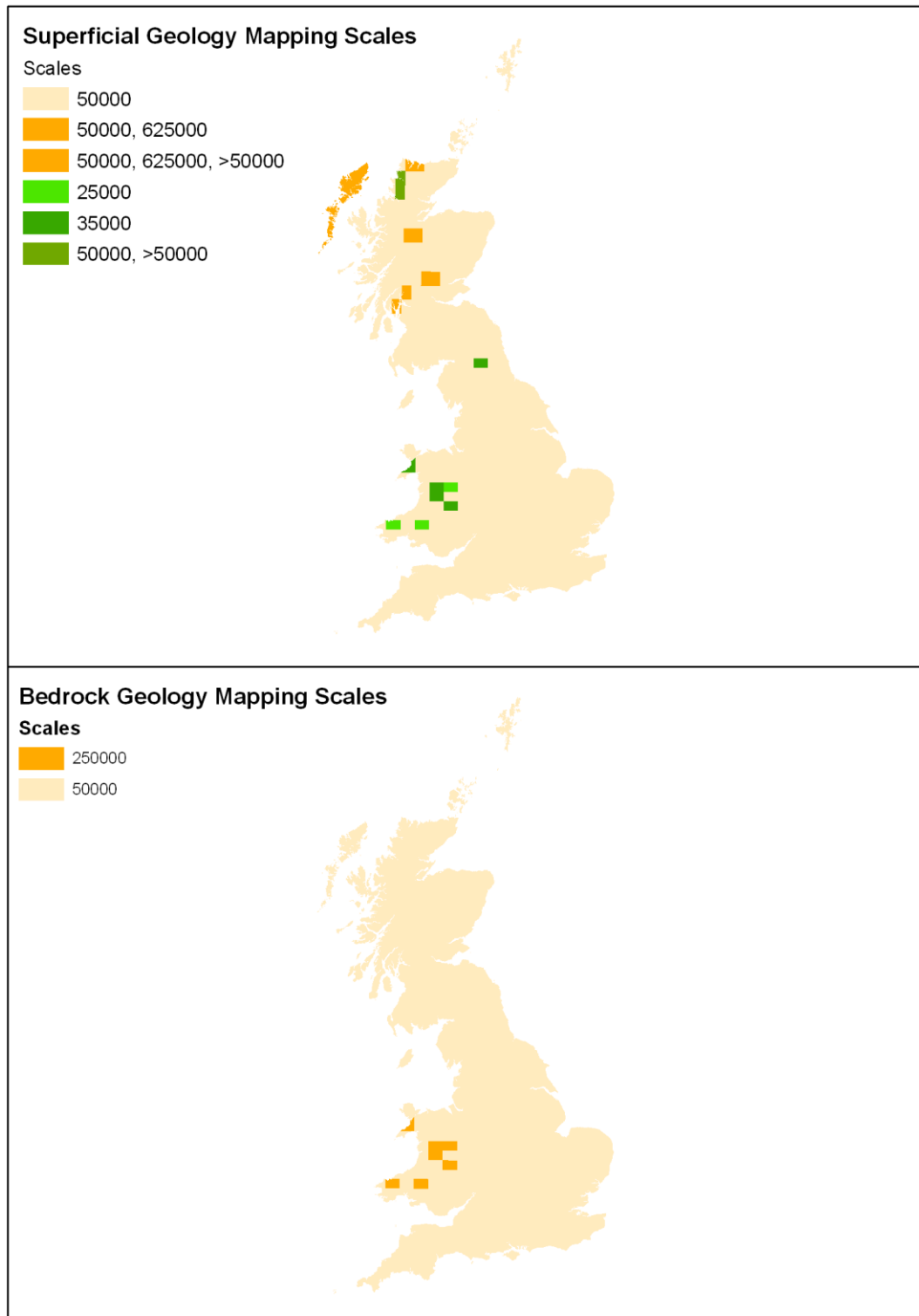
(d)



(e)



Appendix 3 Mapping Scales



References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: <http://geolib.bgs.ac.uk>.

BRITISH STANDARDS INSTITUTION. 1999. BS5930. Code of practice for site investigation, amendment 2. British Standards Institution, London.

DEARMAN, W R, DOBBS, M, CULSHAW, M G, NORTHMORE, K J, ENTWISLE, D C AND REEVES H J. 2011a. *Engineering geology (superficial) map of the United Kingdom, 1: 1 000 000*. British Geological Survey, Keyworth, Nottingham, UK. <http://nora.nerc.ac.uk/19267/>

DEARMAN, W R, DOBBS, M, CULSHAW, M G, NORTHMORE, K J, ENTWISLE, D C AND REEVES H J. 2011b. *Engineering geology (bedrock) map of the United Kingdom, 1: 1 000 000*. British Geological Survey, Keyworth, Nottingham, UK. <http://nora.nerc.ac.uk/19266/>

DEARMAN, W R, DOBBS, M, CULSHAW, M G, NORTHMORE, K J, ENTWISLE, D C AND REEVES H J. 2011c. *Extended key for the Engineering geology (superficial and bedrock editions) map of the United Kingdom, 1: 1 000 000*. British Geological Survey, Keyworth, Nottingham, UK. <http://nora.nerc.ac.uk/19268/>

DOBBS, M, CULSHAW, M G, NORTHMORE, K J, REEVES H J AND ENTWISLE, D C. 2012. Methodology for creating national engineering geological maps of the UK. *Quarterly Journal of Engineering Geology and Hydrogeology*, **45**, 335-347. <http://nora.nerc.ac.uk/19265/>

LAPIDUS, D. F. 1990. COLLINS DICTIONARY OF GEOLOGY. HARPERCOLLINS.

LEE, K A, LAWLEY, R S AND ENTWISLE, D C. 2012a. User guide DIGMapPlus engineering properties: strength dataset (version 1). British Geological Survey technical report OR/12/043, British Geological Survey, Keyworth, Nottingham, UK. 16pp. <http://nora.nerc.ac.uk/18097/>

LEE K A, A, LAWLEY, R S AND ENTWISLE, D C. 2012b. DiGMapPlus Engineering properties:strength. Methodology report. *British Geological Survey Open Report*, IR/12/016. British Geological Survey, Keyworth, Nottingham, UK. 22pp.

ROBERTSON, S. 1999. BGS rock classification scheme. Volume 2, Classification of metamorphic rocks. Research Report RR/99/002. Keyworth, Nottingham: British Geological Survey.

SMITH, A AND ELLISON, R A. 1999. Applied geological maps for planning and development: a review of examples from England and Wales. *Quarterly Journal of Engineering Geology*, **32**, S1 – 44.

ULUSAY, R. & HUDSON, J. A. (2007) The complete ISRM suggested methods for rock characterization, testing and monitoring : 1974-2006, Ankara, Turkey, Commission on Testing Methods, International Society of Rock Mechanics.

WHITTEN, D. G. A. & BROOKS, J. R. V. 1972. The Penguin Dictionary of Geology. Penguin Books Ltd.