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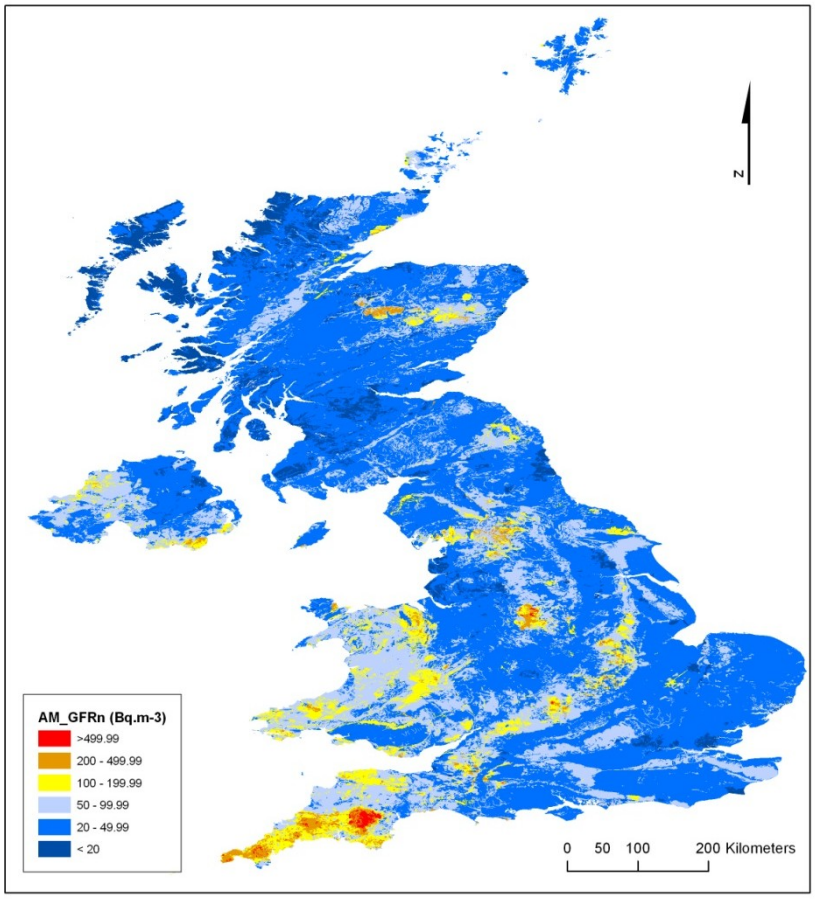
User Guide for the BGS-HPA OneGeology Radon Potential Dataset for the UK

Open Report OR/12/082



BRITISH GEOLOGICAL SURVEY

OPEN REPORT OR/12/082

User Guide for the BGS-HPA OneGeology Radon Potential Dataset for the UK

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Extract from 1:625 000 UK OneGeology Radon Potential Map.

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BRITISH GEOLOGICAL SURVEY

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

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Foreword

This report presents a description and review of the methodology developed by the British Geological Survey (BGS) and the Health Protection Agency (HPA) to produce a digital radon potential dataset for the United Kingdom based on the BGS OneGeology 1:625,000 scale geological data and HPA indoor radon measurements. The method has been critically assessed and its fitness for purpose determined by Don Appleton, and Cathy Scheib (BGS) and Zori Daraktchieva and Daryl Dixon (HPA).

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This report presents a description and review of the methodology developed by the British Geological Survey (BGS) and the Health Protection Agency (HPA) to produce an assessment of radon potential in the United Kingdom based on ground-floor radon measurements and the 1:625,000 scale digital geological data used for the OneGeology web site. The purpose of the guide is to enable users to have a better appreciation of how the dataset has been created and therefore better understand the potential applications and limitations that the dataset may have.

Acknowledgements

Kate Royse and Matt Harrison (BGS), Zori Daraktchieva and Daryl Dixon (HPA) are thanked for reviewing and suggesting improvements to this report.

1 Introduction

Founded in 1835, the British Geological Survey (BGS) is the world's oldest national geological survey and the United Kingdom's premier centre for earth science information and expertise. The BGS provides expert services and impartial advice in all areas of geoscience. Our client base is drawn from the public and private sectors both in the UK and internationally.

BGS's innovative digital data products aim to help describe the ground surface and what is beneath the whole of Great Britain. These digital products are based on the outputs of the BGS survey and research programmes and our substantial national data holdings. This data coupled with our in-house geoscientific knowledge are combined to provide products relevant to a wide range of users in central and local government, insurance and housing industry, engineering and environmental business, and the British public.

Further information on all the digital data provided by the BGS can be found on our website at http://www.bgs.ac.uk/products/home.html or by contacting: 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**

The Radiation Protection Division (RPD) was formed in 2005 when the National Radiological Protection Board merged with the Health Protection Agency (HPA) under the provisions of the Health Protection Agency Act 2004. As part of the Centre for Radiation, Chemical and Environmental Hazards, the RPD carries out the Agency's work on ionising and non-ionising radiations. It undertakes research to advance knowledge about protection of people from the risks of these radiations; provide laboratory and technical services; runs training courses; provides expert information and has a significant advisory role in the UK.

For further general information on radon contact: Radon Survey, Health Protection Agency

Centre for Radiation, Chemical and Environmental Hazards, Chilton, Didcot, Oxon OX11 0RQ

Direct tel. +44(0) 1235 822622; Fax. +44(0) 1235 833891; Email: radon@hpa.org.uk; Web: www.hpa.org.uk

The UK OneGeology Radon Potential Dataset was produced as the result of collaboration between the BGS and the HPA.

2 About the UK OneGeology Radon Potential Dataset

2.1 BACKGROUND

Radon is a natural radioactive gas, which enters buildings from the ground. Exposure to high concentrations increases the risk of lung cancer. Radon is the biggest source of human exposure to ionising radiation in the UK and is responsible for an estimated 1,100 lung cancer deaths a year (McColl et al., 2010). The Health Protection Agency recommends that radon levels should be reduced in homes where the annual average is at or above 200 becquerels per cubic metre (200 Bq m^{-3}). This is termed the Action Level. The Health Protection Agency defines radon Affected Areas as those with 1% chance or more of a house having a radon concentration at or above the Action Level of 200 Bq m^{-3}. The joint HPA-BGS digital RADON POTENTIAL DATASET FOR GREAT BRITAIN (http://www.bgs.ac.uk/radon/hpa-bgs.html) provides the current definitive map of radon Affected Areas in Great Britain.

OneGeology is an international collaborative project in the field of geology supported by 113 countries, UNESCO and major global geoscience bodies. It aims to enable online access to dynamic digital geological map of the world for everyone. The project uses the newly introduced

GeoSciML markup language and initially targets a scale of approximately 1:1 million. The OneGeology-Europe project (ECP-2007-GEO-317001; Baker and Jackson, 2010) identified that there was a need for an EU Radon dataset that was based on a common methodology rather than based on national datasets derived using widely different methodologies. Belgium and Norway produced radon potential/susceptibility maps as datasets for the OneGeology-Europe project.

Following a special session on the development of a Geogenic Radon Map of Europe held during the 10th International Workshop on the Geological Aspects of Radon Risk Mapping (Prague, September 2010), two interim actions were required of the participant countries:

1. Check usability of OneGeology project data for the proposed Geogenic Radon Map of Europe and
2. Produce a simplified (radon-relevant) geological map.

In view of this synergy between the aims of the EU Joint Research Centre led initiative to produce a Geogenic Radon Map of Europe and the OneGeology-Europe project, BGS and the HPA funded the production of a OneGeology Radon Potential map of the UK based on the 1:625 000 scale geological data available on the OneGeology-Europe portal (http://onegeology-europe.brgm.fr/geoportal/viewer.jsp). The primary objective was to make a UK OneGeology Radon Potential dataset available on the OneGeology portal (http://portal.onegeology.org/)..

2.2 WHO MIGHT REQUIRE THIS DATA?

Mapping of radon-prone areas at the OneGeology 1:625 000 scale can be used to inform European policy makers, politicians and the general public about the general variation of radon potential within the United Kingdom at the European scale. .

The published detailed radon mapping, at the 1:50 000 scale (Miles et al., 2007, 2011), is more appropriate at the national scale to: (i) help to ensure that the health of occupants of new and existing dwellings and workplaces is adequately protected; (ii) assess whether radon preventive measures may be required in new buildings; and (iii) for the cost-effective targeting of radon monitoring in existing dwellings and workplaces.

2.3 WHAT THE DATASET SHOWS?

The UK ONEGEOLOGY RADON POTENTIAL DATASET provides, within a 1:625,000 scale geological framework, a general indication of how the estimated arithmetic mean ground-floor radon concentration varies within the United Kingdom

3 Technical Information

3.1 DEFINITIONS

The UK ONEGEOLOGY RADON POTENTIAL DATASET provides a generalised map of the Estimated Arithmetic Mean Ground-floor Radon (AM-GFRn) concentration in dwellings in the UK.

3.2 SCALE

The UK ONEGEOLOGY RADON POTENTIAL DATASET is produced for use at scales of 1:250,000 to 1:1,000,000.

3.3 FIELD DESCRIPTIONS

Table 1 Attribute table field descriptions for UK ONEGEOLOGY RADON POTENTIAL DATASET

FIELD NAME	FIELD TYPE	DESCRIPTION	FIELD CONTENT
AM_GFRn	String	Estimated Arithmetic Mean Ground-floor radon concentration (Bq m^{-3})	*One of the following*: <20 20-49.99 50-99.99 100-199.99 200-499.99 >499.99
Geology	String	Geology code derived by concatenating UK OneGeology Bedrock and Superficial Geology LEX_RCS codes	e.g. TEVY-MDSS\ROCK-ROCK
Limitation	String	Statement indicating that information should not be used for regulatory (i.e. Building Control or Radon Affected Area) purposes in the UK	Not for regulatory use in the UK
Radon_Info	String	Advice on where further information for health protection and legal purposes can be obtained	Further information available at ukradon.org
RELEASEDAT	String	Dataset title and release year	UK_ONEGEOLOGY_AM-GFRn_RADON_POTENTIAL_2012

3.4 CREATION OF THE DATASET

3.4.1 Introduction

The methodology described in this guide is a modification of the method used for producing the 1: 50 000 scale radon maps of the UK (Miles and Appleton, 2005; Appleton and Miles, 2005; Scheib et al., 2009; Miles et al., 2007, Miles et al., 2011; Appleton et al., 2011). In the integrated radon potential mapping method (Miles and Appleton, 2005), indoor radon measurement data are grouped by geology prior to mapping the variation in radon potential between and within geological units.

The Health Protection Agency has a database of nearly 500 000 houses in which long-term measurements of radon concentration have been made, and whose locations are accurately known. Ground floor radon (GFRn) data were used for this OneGeology Radon Potential map because this is the unit of measurement for the JRC European radon mapping projects (Dubois et al., 2010). Some of the HPA indoor radon measurement locations in the UK used for 50k

mapping do not have a separate ground floor measurement so could not be used for the OneGeology radon potential mapping project (Table 2). This is because in some cases the data on storey of measurement is missing because the householder did not fill in the questionnaire, or the data comes from an earlier survey in which the floor level data was collected differently.

Table 2 Number of GFRn measurements used for OneGeology 625k radon potential mapping compared with total number of indoor radon measurement locations

Country	Total No. measurement locations	No. ground floor radon (GFRn) measurements	% of GFRn measurements
England	440700	365213	83
Northern Ireland	23039	20383	88
Scotland	17913	15070	84
Wales	14296	11476	80

Some practical problems are likely to occur when the accurately located indoor radon data and generalised 625k geology data are used to produce a geological radon potential map. In particular, generalisation of the 50k superficial geology by buffering to produce 625k scale superficial geology amplifies some very narrow alluvium polygons into wide strips of alluvium. As a consequence, some house measurement locations will be assigned to the incorrect geological combination using the 625k geological data.

In addition, there will be loss of spatial detail in the resultant radon potential map when a bedrock geological unit with high radon potential (e.g. Inferior Oolite Group Northampton Sand Formation) is grouped together with low radon potential units (such as the Grantham Formation and Inferior Oolite limestones) into the generalised 625k Inferior Oolite Group. Other similar examples include where: (1) the high radon potential Lower Jurassic Marlstone Rock Bed (ironstone) is grouped into the Lias which is predominantly low radon potential mudstones with subsidiary siltstone, sandstone, thin limestones; and, (2) high to moderate radon potential Namurian limestones are grouped together in the Millstone Grit which is predominantly low radon potential mudstones with subsidiary siltstones and sandstones. This loss of spatial detail is inevitable when a more general geological classification is used (there are 406 bedrock codes used for the 50k radon map of England and Wales compared with about 125 bedrock codes in the Onegeology 625k data).

3.4.2 Processing geological data

The geological data used to produce the UK OneGeology Radon Potential map was produced by unioning the 625k superficial layer (derived from the 50k superficial) and DiGMapGB-625 bedrock layer with a 1-km OS grid. Each polygon was given a unique KM1COMBO code produced by concatenating the 1 km grid square identifier, bedrock LEX-RCS and superficial LEX-RCS codes (e.g. 10205440\TEVY-MDSS\ALV-XCZS). Dykes were removed from the bedrock data before unioning with the superficial data because dykes are grossly amplified in size for portrayal at this scale and it would be inappropriate to include dykes in the data set because many more houses would be incorrectly attributed to dykes because of their grossly amplified size at this map scale.

There are about 125 625k OneGeology bedrock geology units in England and Wales, approximately the same number in Scotland and 50 in Northern Ireland. 232 bedrock (Figure 1) and 10 superficial geology units are required to cover the whole of the UK (Figure 2).

Attribution of geological codes for radon mapping requires that data for the same bedrock are sometimes given different codes in different areas. This is required to avoid high radon potential associated with specific bedrock\superficial geology combinations in restricted areas influencing radon potential estimates for the same bedrock\superficial combination in adjacent areas where there is good evidence that the radon potential is low.

To aid the differentiation between regions and facilitate comparison between 50k and 625k radon potential maps, an "S" was added to the front of the bedrock LEX-RCS\ superficial LEX-RCS code if the geological polygon is located in Scotland.

Differentiation of Devonian data for Devon, Cornwall, the Lake District–Cheviots and Wales was achieved by using the D, C, L and W as prefixes to the bedrock\superficial combination code.

Differentiation of the Ordovician/Silurian in the Lake District from Ordovician/Silurian in Wales was achieved by applying a "K" prefix to the bedrock\superficial codes for polygons in the Lake District and also to the Cheviot Volcanics in Scotland.

Differentiation of the Grampian and Helmsdale granites, which are characterised by high radon potential was carried out by adding GRAM or HELM to S-UISD-FELSR to produce GRAM\S-UISD-FELSR and HELM\S-UISD-FELSR codes for these two areas. Elsewhere in Scotland, UISD-FELSR is characterised by low radon concentrations.

The geological data from Northern Ireland was processed separately to facilitate comparison between the 1:250k radon potential data (Appleton et al., 2011) and the new 1:625k radon data.

Figure 1 OneGeology-Europe (DiGMapGB-625) simplified bedrock geological map of the UK

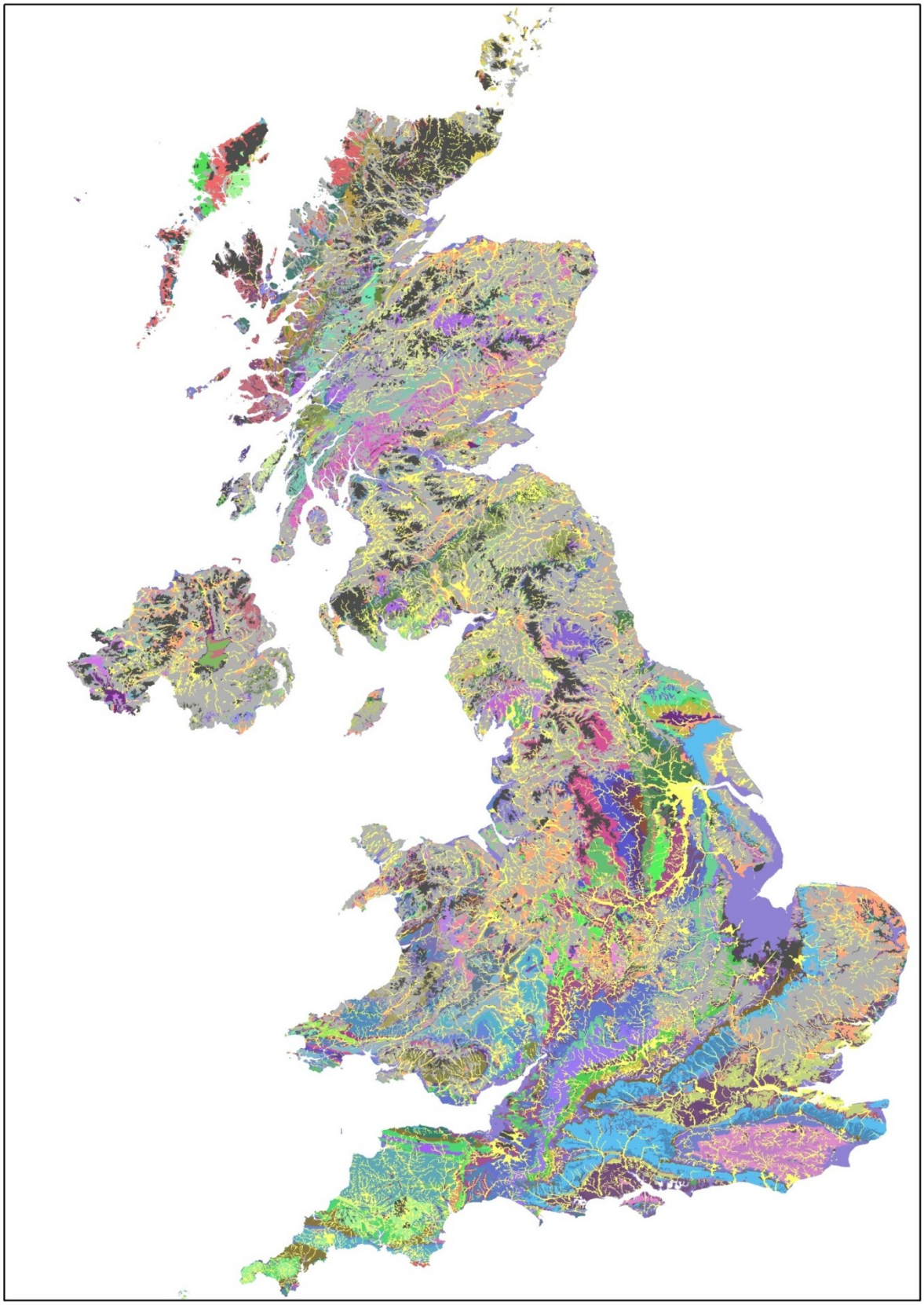

Figure 2 OneGeology-Europe (DiGMapGB-625) simplified surface geological map of the UK.

3.4.3 Methods used for estimating arithmetic mean ground floor radon concentration

The method and formulae used to estimate arithmetic mean ground floor radon (AM-GFRn) concentration for bedrock\superficial combinations (COMBOs) with different numbers of ground floor radon measurements are summarised in Table 3.

All AM-GFRn calculations are based on LnGFRn values.

The general formula used to calculate arithmetic mean is: AM = exp(GM + (GSD^2)/2), where GM and GSD are the arithmetic mean and standard deviation of the log-transformed data (not exponentiated back into Bq m^{-3}). Four Bq m^{-3} (outdoor radon) is subtracted from each ground floor radon measurement before converting to natural log (Ln) values, and then added back on to the AM at the end.

The lognormal distribution gives the mean of the distribution as

$$e^{\mu+\sigma^2/2}$$

where e^{μ} is the median of the distribution, and σ is the standard deviation of the variable's natural logarithm. In this study we used GM as an estimate of median. The formula avoids outliers unduly affecting the results and gives AMs that are very close to conventionally calculated AMs.

For bedrock\superficial combinations (COMBOs) with 25-99 ground floor radon measurements, KM1COMBO statistics were calculated using the BGS Point Average tool documented in Appleton and Adlam (2012). LnAM and LnGSD was calculated from nearest 10 measurements. Average KM1COMBO centroids were used to speed up computation.

For COMBOs with less than 3 ground floor radon measurements, expert judgement and comparison with published 50k radon potential data was used to select an appropriate AM, often by comparison with the data for similar COMBOs.

The UK OneGeology Radon Potential radon potential map resulting from this process is illustrated in Figure 3. In general, differences between the 50k and 625k radon potential maps are likely to be related principally to: (1) the more general geological classification used for the 625k map; and (2) the smaller number of house measurements used for the 625k mapping compared with 50k mapping. The uncertainties of AM-GFRn estimates are likely to be slightly higher than equivalent %>AL radon map data due to the smaller number of indoor radon measurements used to produce the AM-GFRN maps.

Table 3 Summary of methods used for calculating arithmetic mean ground floor radon depending on number of radon measurements in each COMBO

No. GFRn per COMBO	Description of method used to estimate AM- GFRn	Formula
>99	Gridded by HPA (arithmetic mean based on nearest 30 measurements)	Exp (GM + (GSD^2)/2)+4
25 – 99	Gridded by BGS using Point Average tool (arithmetic mean calculated from nearest 10 measurements and calculated using LnGFRn and AvLnGSD)	(Exp([LnGFRn10AV]+([AvLnGSD]^2)/2)+4
10 – 24	Arithmetic mean based on LnGM and COMBOAvLnGSD (average of calculated GSD and average GSD for the UK (2.5)) for COMBO	(Exp([LnGM]+([COMBOAvLnGSD]^2)/2)+4
3-9	Arithmetic mean based on LnGM and GSD 2.5 for COMBO	(Exp([LnGM]+(0.91629^2)/2))+4
0-2	Based on expert judgement, comparison with 50k radon data and AMs for similar COMBOs	

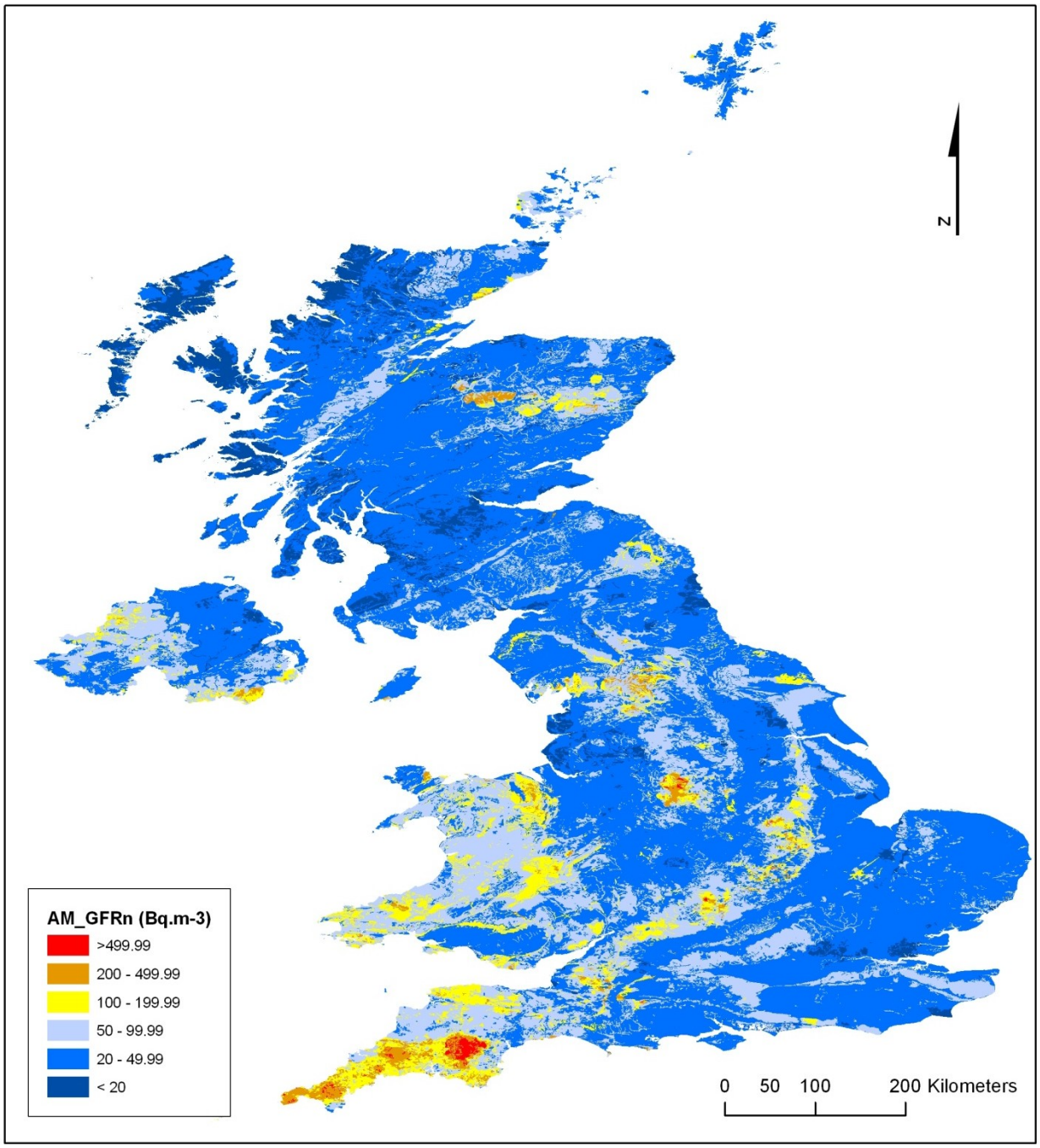

Figure 3. UK OneGeology AM-GFRn radon potential map (GCS_WGS_1984 projection)

3.5 DATASET HISTORY

The UK ONEGEOLOGY RADON POTENTIAL DATASET is based on Health Protection Agency (HPA) indoor radon measurements and BGS digital geology information. This product was derived from DiGMapGB-625 bedrock and OneGeology-625 superficial data sets. Each data layer is rectified to align with British National Grid origin. The indoor radon data is used by the BGS with the agreement of the HPA. Confidentiality of measurement locations is maintained through data management practices.

A 1:625 000 scale radon potential map was produced for England, Wales and Scotland in 1995 (Appleton and Ball, 1995) although only approximately 20,000 indoor radon measurements were

used for the 1995 map compared with the 400,666 used for the OneGeology radon potential mapping exercise.

3.6 COVERAGE

Data is coverage is for the United Kingdom (the dataset does not include the Isle of Man).

3.7 DATA FORMAT

The UK ONEGEOLOGY RADON POTENTIAL DATASET consists of vector polygons and is available in a range of GIS formats, including ArcGIS (.shp) and MapInfo (.tab). More specialised formats may be available but may incur additional processing costs. Due to the differences in precision of different formats and to small changes in precision during translation between formats, the absolute position of features in different GIS systems may vary by a few millimetres on the ground.

Important note regarding GIS format conversion: It is strongly recommended that the data is used in the format supplied and not converted to other GIS formats as errors can be cumulative. These issues of precision may appear to be minor but can lead to different answers being reported by different GIS software solutions.

3.8 LIMITATIONS

- The UK ONEGEOLOGY RADON POTENTIAL DATASET has been developed at the 1:625 000 scale and must not be used at scales larger than 1:250,000.

- The UK ONEGEOLOGY RADON POTENTIAL DATASET is concerned with radon potential related to NATURAL geological sources only. The data does NOT cover the impacts of man-made features.

- The UK ONEGEOLOGY RADON POTENTIAL DATASET is based on, and limited to, an interpretation of the records in the possession of The British Geological Survey and The Health Protection Agency at the time the data set was created.

- An indication of high radon potential does not necessarily mean that an individual property will have a high radon concentration and an indication of low radon potential does not mean that an individual property will have a low radon concentration. The only way to find out whether a property is in fact above, at or below the UK Action Level is to carry out a radon measurement. Guidance on measuring radon can be obtained from the HPA (www.hpa.org.uk/radiation/radon).

- The UK ONEGEOLOGY RADON POTENTIAL DATASET should NOT be used for regulatory (i.e. Building Control or Radon Affected Area) purposes in the UK. Radon information for legal and health protection uses in the UK is available at www/ukradon.org.UK

4 Contacts

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Web: http://www.bgs.ac.uk

Building Research Establishment, advice on radon: www.bre.co.uk/radon/

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