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Comparison of Northern Ireland radon maps based on indoor radon measurements and geology with maps derived by predictive modelling of airborne radiometric and ground permeability data

J.D. Appleton [a,*], J.C.H. Miles [b], M. Young [c]

[a] British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK
[b] Health Protection Agency (HPA) – Radiation Protection Division, Chilton, Didcot, Oxon OX11 0RQ, UK
[c] Geological Survey of Northern Ireland, Department of Enterprise, Trade and Investment, Colby House, Stranmillis Court, Stranmillis Road, Belfast BT9 5BJ, Northern Ireland

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ABSTRACT

Publicly available information about radon potential in Northern Ireland is currently based on indoor radon results averaged over 1-km grid squares, an approach that does not take into account the geological origin of the radon. This study describes a spatially more accurate estimate of the radon potential of Northern Ireland using an integrated radon potential mapping method based on indoor radon measurements and geology that was originally developed for mapping radon potential in England and Wales. A refinement of this method was also investigated using linear regression analysis of a selection of relevant airborne and soil geochemical parameters from the Tellus Project. The most significant independent variables were found to be eU, a parameter derived from airborne gamma spectrometry measurements of radon decay products in the top layer of soil and exposed bedrock, and the permeability of the ground. The radon potential map generated from the Tellus data agrees in many respects with the map based on indoor radon data and geology but there are several areas where radon potential predicted from the airborne radiometric and permeability data is substantially lower. This under-prediction could be caused by the radon concentration being lower in the top 30 cm of the soil than at greater depth, because of the loss of radon from the surface rocks and soils to air.

1. Introduction

In order to prevent the public receiving high exposures to radon, it is necessary to identify those areas most at risk. The potential for high indoor radon concentrations depends on multiple factors including the amount of radium-226 in the ground underneath buildings, and the permeability of the ground. As a result, indoor radon tends to be correlated with local geology (Appleton and Miles, 2005; Barnet et al., 2008; Kemski et al., 2009; Scheib et al., 2009). The probability of homes in Northern Ireland having radon concentrations above the UK Action Level (AL, 200 becquerels per cubic metre of air, Bq m^{-3}) is currently estimated on the basis of the results of radon measurements in homes, grouped by 1-km squares where there are sufficient results in the square, or interpolated from the nearest measurements for squares where there are too few results (Green et al., 2009). This approach does not take any account of the geological influence on indoor radon (Appleton and Miles, 2010). An integrated mapping method has been developed to use indoor radon results in conjunction with geological boundaries to map radon potential

Table 1
Methods used for calculating the estimated percentage of dwellings above 200 Bq m^{-3} in each 1 kmBS polygon for the integrated geology–grid square radon potential (RP_{irg}) map.

No. radon measurements in BS group	No. of polygons	Description of method used to estimate RP_{irg} (%>200 Bq m^{-3})
>79	38319	RP_{irg} based on GM and GSD of nearest 30 radon measurements or all measurements in a polygon if >30; Bayesian GSD corrected for measurement uncertainty
25–79	13679	RP_{irg} based on GM of nearest 10 measurements; GSD is average of national GSD and Bayesian GSD corrected for measurement uncertainty
10–24	9704	RP_{irg} based on GM of all data in the same BS group in N. Ireland; GSD is average of national GSD and Bayesian GSD corrected for measurement uncertainty
<10	6869	RP_{irg} based on GM of all data in the same BS group in N. Ireland and national GSD (2.27)
0	2816	Assessment of RP_{irg} based on analogy with similar geological combinations for which radon data are available

* Corresponding author. Tel.: +44 115 9363207; fax: +44 115 9363200.
E-mail address: jda@bgs.ac.uk (J.D. Appleton).

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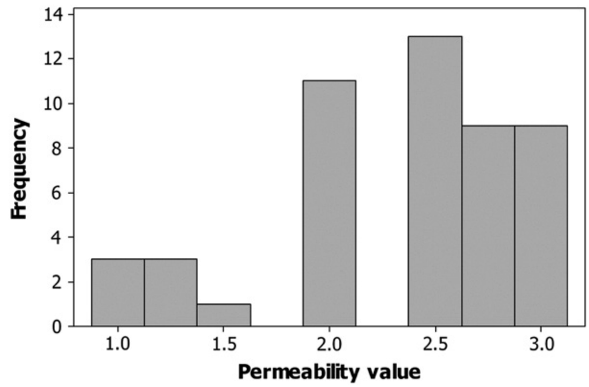

Fig. 1. Histogram of permeability values for data grouped by 5 km grid square and geology for Palaeozoic and Palaeogene intrusives in the SE sector of Northern Ireland (not including the Mourne Mountains Granite Complex).

(RP_{irg}) with greater accuracy and detail than currently available for Northern Ireland (Miles and Appleton, 2005). This method is applied to indoor radon and geological data available in Northern Ireland and the results are compared with the 1-km grid square radon potential (RP_{ir}) map based solely on indoor radon measurements.

Both the 1-km grid and the integrated mapping methods can have significant uncertainties where indoor radon data are sparse. It is difficult to provide a consistent indication of the spatial variation of the likely reliability of the RP_{ir} and RP_{irg} maps although the density of indoor radon measurements is probably the best indicator (Green et al., 2009). Uranium concentrations in surface rocks and soils, estimated by airborne gamma spectrometry surveys of gamma-rays from ^{214}Bi, and referred to as eU (equivalent uranium), have been used to inform radon potential mapping in many countries (Appleton, 2007; Smethurst et al., 2008). The integrated geological–grid square radon mapping of England, Wales and Scotland did not use airborne geophysics or soil geochemical data, because neither is universally available in GB. In Northern Ireland, the Tellus Project has produced new geochemical and geophysical maps designed to support mineral exploration, inform land-use planning and provide environmental baseline data (Young and Earls, 2007; Beamish and Young, 2009). The study reported here develops and applies to the whole of Northern Ireland the predictive modelling methods of a pilot study (Appleton et al., 2008) which used linear regression analysis of a selection of relevant Tellus airborne and soil geochemical parameters in an attempt to refine the radon map based solely on indoor radon data and geology. In this study, a range of national and terrain specific linear regression models is statistically validated against the radon map based on indoor radon and geology in order to assess whether radon potential maps derived by predictive modelling of ground permeability, airborne gamma-ray spectrometry and soil geochemical data could usefully inform future indoor radon measurement programmes.

2. Materials and methods

Appleton et al. (2008) describe the airborne gamma-ray spectrometry and soil geochemistry data from the Tellus Project, together with

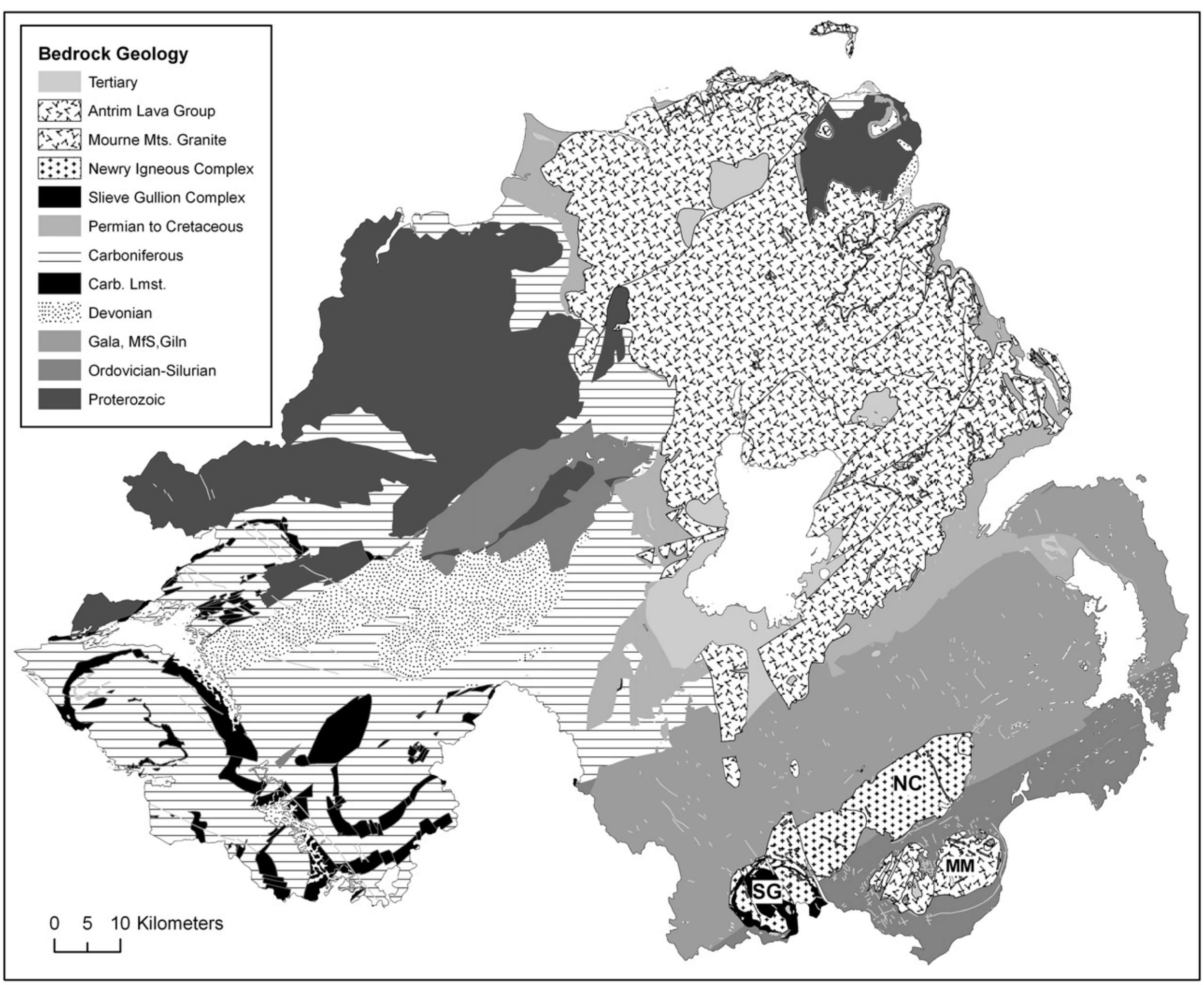

Fig. 2. Simplified bedrock geology of Northern Ireland. MM – Mourne Mountains Granite; SG – Slieve Gullion Complex; and NC – Newry Igneous Complex.