



A radiometric airborne geophysical survey of the Isle of Wight

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ARTICLE INFO

Article history:

Received 27 September 2010
Received in revised form 23 November 2010
Accepted 7 December 2010
Available online 26 January 2011

Keywords:

Airborne geophysics
Gamma-ray
Radiometric
Isle of Wight
Bedrock geology
GIS

ABSTRACT

A high resolution airborne geophysical survey across the Isle of Wight and Lymington area conducted in 2008 provided the first modern radiometric survey across the geological formations that characterise much of southern England. The basic radiometric data are presented and it is evident that bedrock geology exerts a controlling influence on the broad response characteristics of the naturally occurring radioelements. A GIS-based geological classification of the data provides a quantitative assessment and reveals that a relatively high percentage of the variability of the data is explained by the Cretaceous bedrock geology but this is much reduced in the Palaeogene. The three traditional Chalk units (Lower, Middle and Upper Chalk depicted on the currently available Geological Map) provide the lowest and most distinct behaviour within the Cretaceous sequence. Mineral content within the Chalk appears to increase with increasing age. A new method of representing the baseline radiometric information from the survey in terms of the mean values of the geological classification is presented. The variation of radioelement geochemistry within individual formations is examined in two case studies from the Cretaceous Lower Greensand Group and the Palaeogene Hamstead Member (Bouldnor Formation). The Cretaceous sequences provide the higher levels of discrimination of localised variations in radioelement distributions. A more detailed case study examines the potential influences from the degree of water saturation in the soil and superficial deposits.

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1. Introduction

A number of modern, high-resolution, multi-parameter geophysical surveys have been conducted over the past decade across onshore UK (Fig. 1). These High Resolution Airborne Resource and Environmental (HiRES) surveys have acquired radiometric (gamma-ray spectroscopy), magnetic and electromagnetic (conductivity) measurements at 200 m line spacings and at low altitude (<60 m). The earliest survey (HiRES-1) across the north Midlands (Fig. 1) used a lower survey resolution of 400 m and a typical flight altitude of ~90 m. The present study considers the small radiometric data set acquired over the Isle of Wight (IoW) and part of the Lymington area (Fig. 1) in 2008.

Airborne radiometric data are acquired over a wide gamma-ray energy spectrum and the spectral data are routinely processed to provide estimates of the naturally occurring abundances of the radiogenic materials potassium, thorium and uranium. The main component of gamma-ray flux is typically contained within the upper 30 cm of the Earth's surface. The airborne measurements thus provide a geochemical mapping capability obtained from concentrations of these materials in the upper 0.5 m.

The distribution of radioelements in rocks and soils is discussed by Dickson and Scott (1997) and is further reviewed by IAEA (2003). Potassium is a major component of the Earth's crust (2.35%). It is an alkali element and shows a simple chemistry. The major hosts of potassium in rocks are potassic feldspars (e.g. orthoclase microcline with ~13%) and micas (e.g. biotite and muscovite with 8%). Thorium is a minor component of the Earth's crust (~12 ppm). Major thorium bearing minerals (e.g. monazite and zircon) are stable during weathering and may accumulate in heavy mineral sand deposits. Thorium freed by the breakdown of minerals during weathering may be retained in Fe or Ti oxides/hydroxides and within clays. Uranium is a reactive metal with a low average abundance in the Earth's crust (~3 ppm). It may be present in rocks as the oxide and silicate minerals, uraninite and uranothorite; as trace amounts in other minerals or along grain boundaries possibly as uranium oxides or silicates.

Gamma-ray surveys are used in several fields of science. They are used for geological, geochemical, and environmental mapping, and allow the interpretation of regional features over large areas (IAEA, 1991, 2003). They may be used to estimate and assess the terrestrial radiation dose to the human population and to identify areas of potential natural radiation hazard. Regional surveys also provide a baseline data set against which man-made contamination can be estimated. The existing UK HiRES radiometric data sets have been applied to a range of such geoscience investigations many of which have focussed on environmental, health and soil

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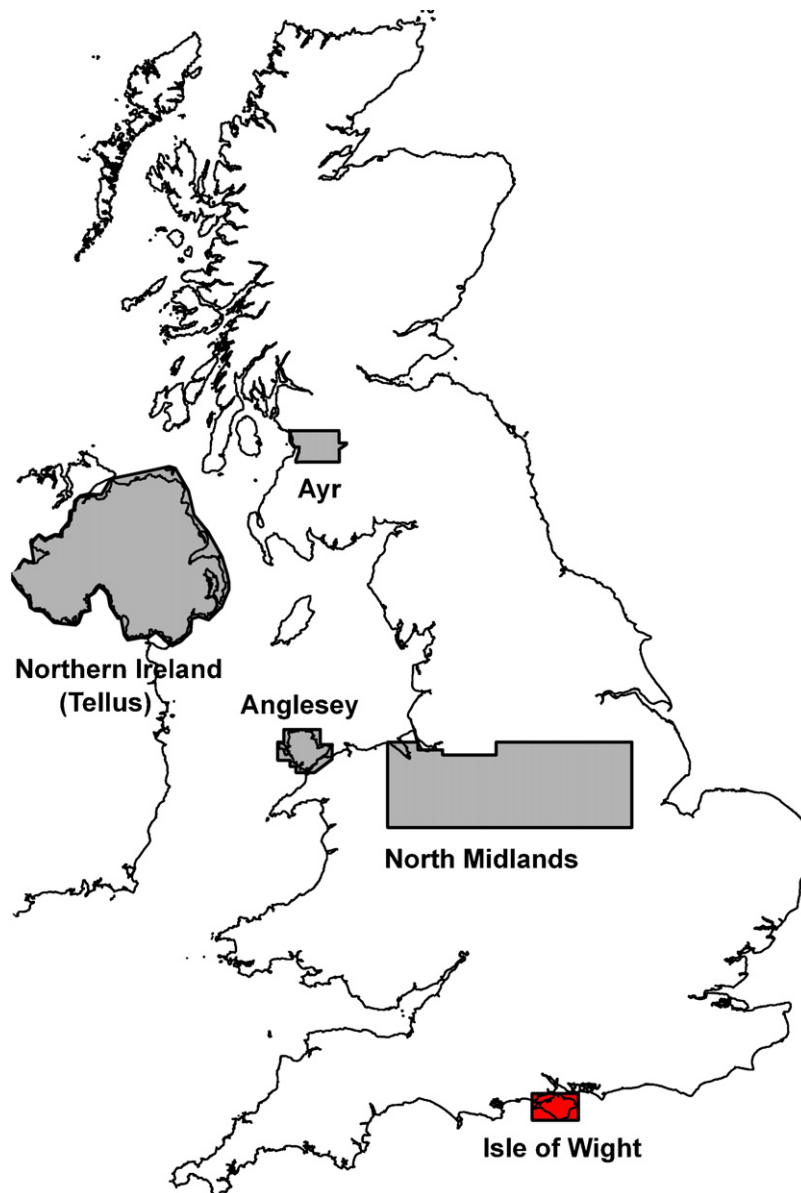


Fig. 1. Location map of main UK HiRES airborne geophysical surveys. The Isle of Wight survey is identified in the south.

science issues. An airborne and ground-based radiometric study considered the use of such data in relation to its potential to assess indoor radon levels (Scheib et al., 2006). The close correlation between airborne uranium measurements and indoor radon concentrations has been further developed using other HiRES data sets (Appleton et al., 2008).

A combination of HiRES-1 data and trial survey data were used to assess radioelement concentrations associated with coal-mine waste (Emery et al., 2005) that included ground follow-up studies. Lahti et al. (2001) and Lahti and Jones (2003) describe the distribution of man-made radioactive sources located by HiRES surveys, including colliery spoil heaps, iron ore mines and processing centres, fly ash adjacent to coal-fired power station sites, Chernobyl fallout (i.e. the man-made radionuclide Caesium, ^{137}Cs), nuclear reprocessing plant discharges and an isolated ^{60}Co source. Scheib and Beamish (2010) report the distribution of ^{137}Cs (largely Chernobyl-derived) across the northern UK based on the HiRES survey data.

The airborne datasets can also provide detailed information about the characteristics of the soil and its parent geological

material, including surface texture, weathering, leaching, soil depth, moisture and clay mineralogy (Bierwirth, 1997). The degree to which the HiRES radiometric data can be used to provide thematic maps of soils, particularly soil texture, in Eastern England was considered by Rawlins et al. (2007). The overall correlations of airborne radiometric estimates with soil survey data for potassium and thorium were large indicating that the two radioelements provide effective estimates of their concentrations in the soil and their distribution patterns. Parent material accounted for significant amounts of the observed variability. The study confirmed that the HiRES radiometric components potassium and thorium provide information on parent material and associated geochemistry in the 'young' landscapes of England and Wales.

In the UK context, the HiRES IoW survey, and the three geophysical data sets acquired in the south of England are highly distinct. Systematic airborne geophysical survey measurements in the south of England are confined to a vintage data set acquired as part the Mineral Reconnaissance Programme between 1957 and 1959 across south-west England (Cornwell et al., 1995). By modern standards, the radiometric information obtained was crude.

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