

“ colliery spoil heaps, iron mines and processing works, and power stations are marked by relatively high values of natural radioelements ”

Airborne gamma-ray spectrometry was developed initially for uranium exploration but is now used for a wide variety of applications. It measures gamma radiation from the ground surface to a depth of about 30 centimetres. This includes both natural and man-made radioactivity.

The Hi-RES-1 survey of central Britain was carried out to assess a range of environmental and resource applications of airborne survey data. The survey area covers a wide range of rock and soil

power station fly ash disposal. Although a multisensor approach was adopted for these projects, only the airborne gamma-ray data are covered here.

The results of Hi-RES and GTK-BGS airborne surveys illustrate a number of uses of the data at both the regional and local scale. A ternary potassium–uranium–thorium (K–U–Th) image of the eastern half of the Hi-RES survey area shows a close correlation with mapped geology and soil type (*see below*) and illustrates the potential of the data for

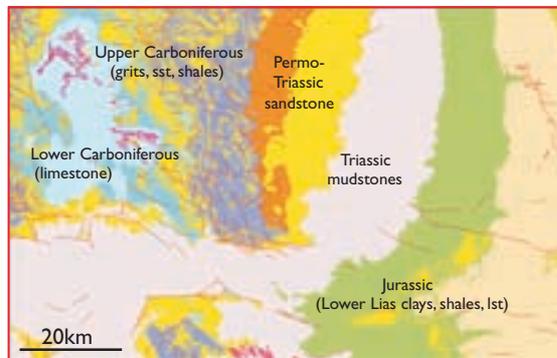
# Airborne measurement of radioactivity

## For geological survey and environmental monitoring

by David Jones

types. It includes many urban centres and has a long history of extractive and manufacturing industry. There are regions with relatively high indoor radon levels, and areas contaminated by fallout from nuclear weapons testing, the Chernobyl accident and discharges from the Sellafield nuclear fuel reprocessing plant. Small targets within the Hi-RES-1 area were flown in collaboration with the Geological Survey of Finland (GTK) to investigate specific sites in more detail. These included landfills, colliery spoil heaps and old gravel workings used for

mapping surface rocks, superficial deposits and soils. The limestones of the Derbyshire Peak District are relatively enriched in uranium. This ties in well with higher uranium values measured in soils from regional geochemical sampling for the G-BASE project (*see page 10*). The limestones are also associated with relatively high radon in soil gas and indoors; more than 10% of homes, locally more than 30%, being above the UK Action Level of 200 becquerels per cubic metre. Other, less extensive, radon-prone horizons are also highlighted in the



A ternary potassium–uranium–thorium (K–U–Th) plot of the eastern part of the Hi-RES survey area (left) correlates closely with the mapped geology (right). The limestones of the Peak District are relatively enriched in uranium (blue colours in ternary plot).

airborne data with relatively high uranium contents. These include the Marlstone Rock and the Lincolnshire Limestone formations.

Although generally relatively high in uranium, individual limestone formations in the Peak District show appreciable variation in uranium content (*right, top*). This suggests that it may be possible to use the airborne data to map radon prone areas in some detail; an evaluation is currently in progress.

Colliery spoil heaps, iron mines and processing works, and power stations are marked by relatively high values of all three natural radioelements, but most notably thorium. Such features are especially well delineated on the higher spatial resolution data from the GTK–BGS survey. A number of such sites have been investigated by ground gamma spectrometry and sampling. The ground data typically show a greater range of radionuclide concentrations because the airborne data are averaged over a larger ground area. The ground data match well with the airborne results and confirm that anomalies are associated with colliery waste, iron and steel processing wastes, and the storage of fly ash adjacent to coal-fired power stations.

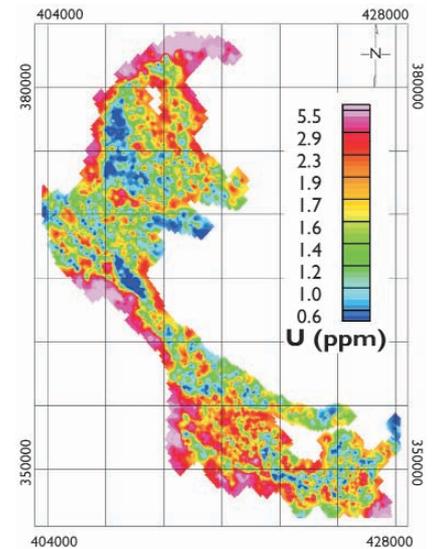
The good general agreement between the airborne and ground spectrometry is illustrated by the former iron foundry site near Staveley. The ground values show localised higher concentrations of thorium that produce lower level, more diffuse, anomalies in the airborne data. Lower levels of thorium are generally associated with areas where topsoil is present and there is established vegetation. The elevated thorium concentrations are probably associated with zircon sands used in the foundry. Uranium contents are also elevated in zircon sands and this is reflected in the data for the site. Former ironstone workings are also marked by higher thorium and uranium contents.

Colliery spoil heaps in the Shirebrook area of the GTK survey are relatively high in all three natural radioelements. Detailed ground work has confirmed the coincidence between the airborne anomalies and the presence of colliery spoil. Elevated radionuclide values (particularly for thorium) were observed near two coal-fired power station sites. These were found by ground

investigation to be related to areas of fly ash storage. Areas of lower radioactivity are caused by attenuation of gamma radiation by soil and vegetation cover.

Data for caesium-137 reflect three separate environmental inputs. These are well illustrated by data from the western half of the Hi-RES survey (*bottom right*). There are two main areas of higher caesium, one over the uplands of North Wales, the other related to the salt marshes and tidal flats of the Dee and Mersey estuaries. There is little doubt that the latter are largely a reflection of discharges from the Sellafield nuclear reprocessing plant. The upland effect is a combination of nuclear weapons test fallout and deposition following the Chernobyl accident. Both were greatest in uplands areas where rainfall is heaviest. An estimate of the input from weapons test fallout (provided by Simon Wright of the Centre for Ecology and Hydrology) was subtracted from the Hi-RES caesium data and appears to leave a residual caesium ‘high’ over the Welsh hills that is probably the result of Chernobyl. Ground measurements and sampling have been carried out to investigate caesium-137 variations in the Welsh hills and the Dee Estuary. These confirmed the airborne data and gave insights into sedimentation processes in the estuary.

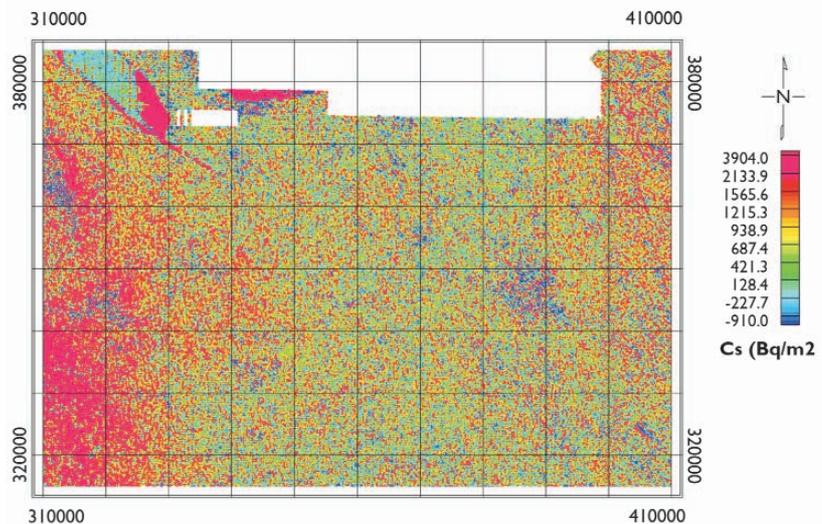
Airborne gamma surveys provide valuable baseline data against which to assess the future impact of industrial or accidental accumulations of radioactivity. ■



*In the Peak District, individual limestone formations vary appreciably in their uranium content. Grid squares are four kilometres across.*

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*Data for caesium-137 from the western half of the Hi-RES survey. The main areas of higher caesium levels are the uplands of North Wales and the Dee and Mersey estuaries.*