Proceedings, Near Surface 2009 – 15th European Meeting of Environmental and Engineering Geophysics. Dublin, Ireland, 7 - 9 September 2009. European Association of Geoscientists and Engineers.

Near surface geophysical surveying of Northern Ireland from the air

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A recent low-level high resolution airborne geophysical survey of Northern Ireland has provided detailed imagery of ground radioactivity, electrical conductivity and magnetisation. Although airborne geophysics is usually thought of as a regional mapping method, these results are being used widely for near-surface applications - for shallow mineral exploration, geological mapping, environmental management and for research in these fields. Data have been licensed to industry and have prompted significant inward investment in mineral exploration. Together with complementary geochemical datasets, these near-surface geophysical results support environmental monitoring by regulators. They provide a basis for research in other fields, including structural geology, environmental radioactivity, soil science, groundwater management and geostatistics. Some of these applications are described. The project illustrates the value of airborne geophysical data in a range of economic sectors.

Introduction

In 2006 the Geological Survey of Northern Ireland (GSNI) completed the national low-level airborne geophysical survey of Northern Ireland, as part of the Tellus Project. Complementary soil and stream geochemistry data were also acquired. The strategic goals were to:

- provide an environmental baseline;
- contribute to sustainable land-use planning decisions by detecting and mapping geological conditions that may be associated with natural hazards;
- detect and map certain forms of industrial and agricultural contamination;
- help government to comply with the requirements of legislation regarding natural resources, soils and waters, including European Framework Directives;
- advance the development of Northern Ireland's natural resource industry.

Survey specifications

The survey was flown for GSNI by the Joint Airborne-geoscience Capability, a partnership of the BGS and the Geological Survey of Finland (GTK). The survey was flown with a De Havilland Twin Otter aircraft, used previously for geophysical surveys in Finland, equipped with two magnetometer sensors, 256-channel gamma-ray spectrometer, four-frequency electromagnetics (EM), radar altimeter and GPS navigation system. Survey parameters were:

Ground clearance: 56 m (244 m urban)	Sampling intervals:	7 m (magnetics)
Line spacing: 200 m	(approx)	17 m (EM)
Line direction: 345˚		70 m (radiometrics)

Improved geological mapping

Digital databases and imagery are publicly available. The geophysical results have provided new insights into Northern Ireland's geology, particularly where bedrock is obscured by glacial overburden or peat. Definition of faults, dykes and the major igneous complexes by the magnetics has been much improved (Figs 1 and 2). The complementary imagery of magnetics, radioactivity (Fig 3) and electrical conductivity (Fig 4) have facilitated mapping of soils, rock types and anthropogenic effects (Young, 2007).

In an innovative approach, McKinley and Leuangthong (2008) have used the closely spaced geophysical data to provide an apparently improved resolution of more widely sampled geochemistry. They examined the spatial variability of both geophysics and geochemistry and applied geostatistical variography and spatial analysis methods to integrate them. This approach maximizes the information generated from the geochemical survey, thus enabling more accurate interpretation of the geology, soils, natural resources and environment.

Environmental radioactivity

The data have been used to generate an improved map of radon risk. Areas of enhanced radon potential have been delineated by multivariate linear regression analysis of several datasets, including the radiometric channels. Radon risk in Northern Ireland is currently estimated only from sparse in-house radon measurements averaged over 5 x 5 km grid squares. Appleton et al. (2008) have developed a more predictive multivariate linear regression approach, using Tellus airborne radiometric data, soil geochemistry data and digital geology.

A detailed map of radioactive caesium fall-out has been produced (Scheib and Beamish 2009). The multi-channel gamma-ray spectrometer mapped the distribution of caesium in the soil, via the gamma-ray peak of ^{137}Cs at 662 keV. The variations in intensity across Northern Ireland correlate with the rainfall pattern across Northern Ireland in the days after the Chernobyl accident of 1986. Since deposition, ^{137}Cs has been retained or released according to the soil type and land-use and is most evident over upland areas.

Near-surface anthropogenic pollution

Landfill sites and contaminant plumes from landfills and industrial sites have been mapped using the airborne EM data (Beamish, 2007). Landfills may release fluids and airborne EM has detected pollution plumes down-slope of several sites. The surface expressions of exposed sites have also been detected by magnetics and radiometrics. Airborne screening may provide a rapid means of screening remote rural areas for illegal dumps.

Carbon and peat studies

There is a requirement to map the extent of carbon in soil. In a geostatistical approach, Rawlins et al. (2009) used the airborne radiometrics to improve estimates of soil organic carbon (SOC). Radiometric data (K band) increase the precision of SOC predictions when included in linear mixed models of SOC variation. This offers the possibility of making provisional estimates of soil organic carbon at a greater density than is possible by soil sampling. The radiometric data have also been used in a trial study for estimating the thickness of peat, by relating the attenuation of radiation from bedrock due to thickness of overlying peat.

Conclusion

Although airborne geophysics is usually thought of as a regional mapping method, the new airborne geophysical data of Northern Ireland have been used widely in various near-surface applications. The data have already had a significant economic impact. When released to the mining industry, the data prompted a surge in prospecting activity for gold and base metals across Northern Ireland that has resulted in 70% of the province being licensed for mineral prospecting, with an associated investment commitment of £15 million. As well as encouraging the development of natural resources, at the same time the information provides baseline standards for environmental monitoring and for environmental research in diverse fields.

Acknowledgement

The Tellus Project was funded by the Department of Enterprise, Trade and Investment and by the EU Building Sustainable Prosperity programme, through the Department of Agriculture and Rural Development.

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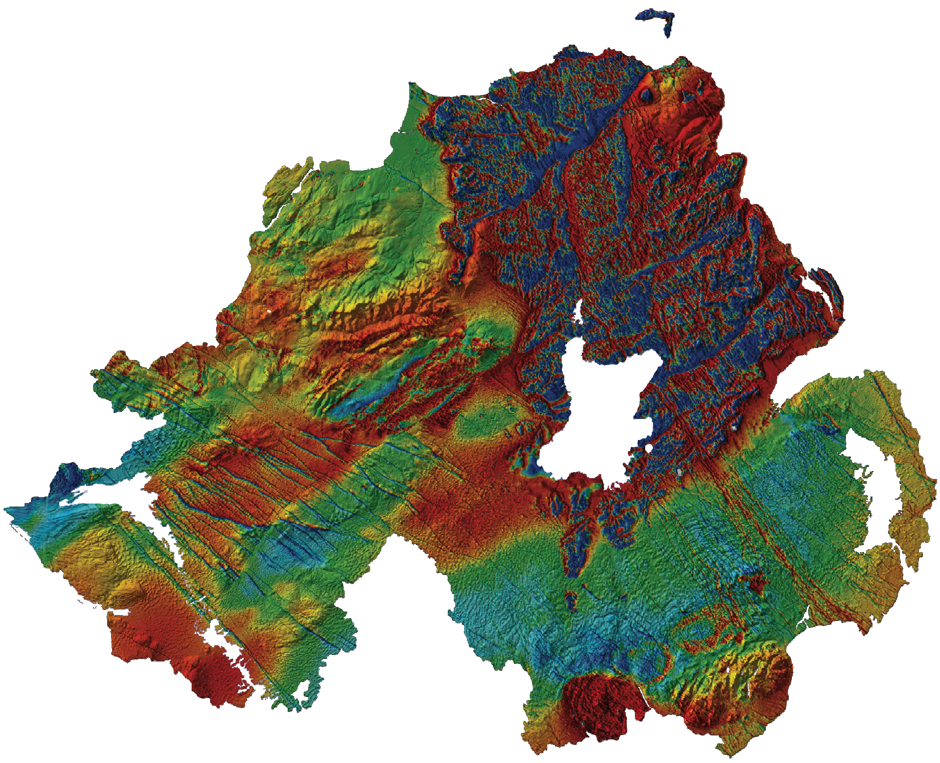

Figure 1 *Northern Ireland: total magnetic intensity, superimposed on a digital terrain model (DTM). (Red: high magnetization, blue: low magnetization)*

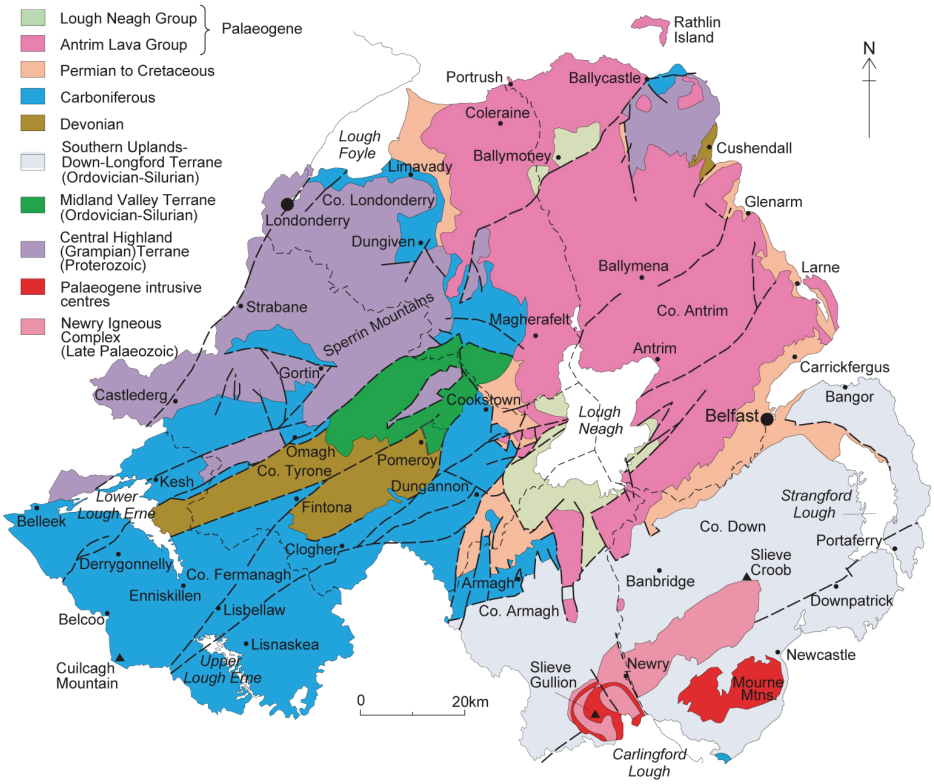

Figure 2 *Simplified geology of Northern Ireland prior to the survey (from Mitchell, 2004)*

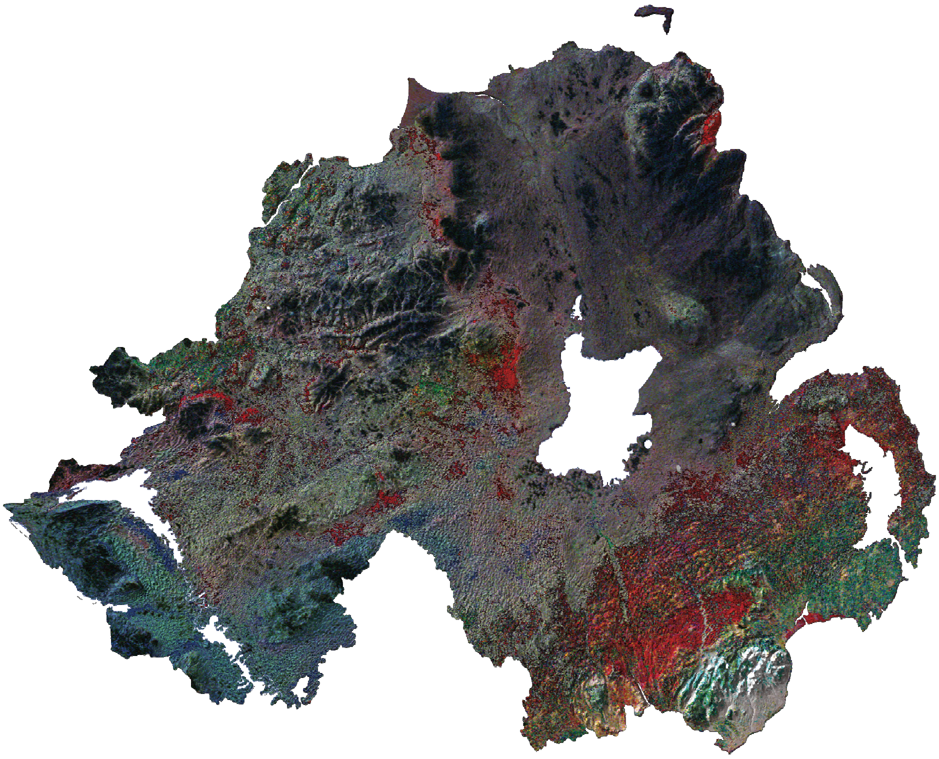

Figure 3 *Northern Ireland: radiometric image (ternary) superimposed on a DTM. (Red: K; , blue: eU; green: eTh)*

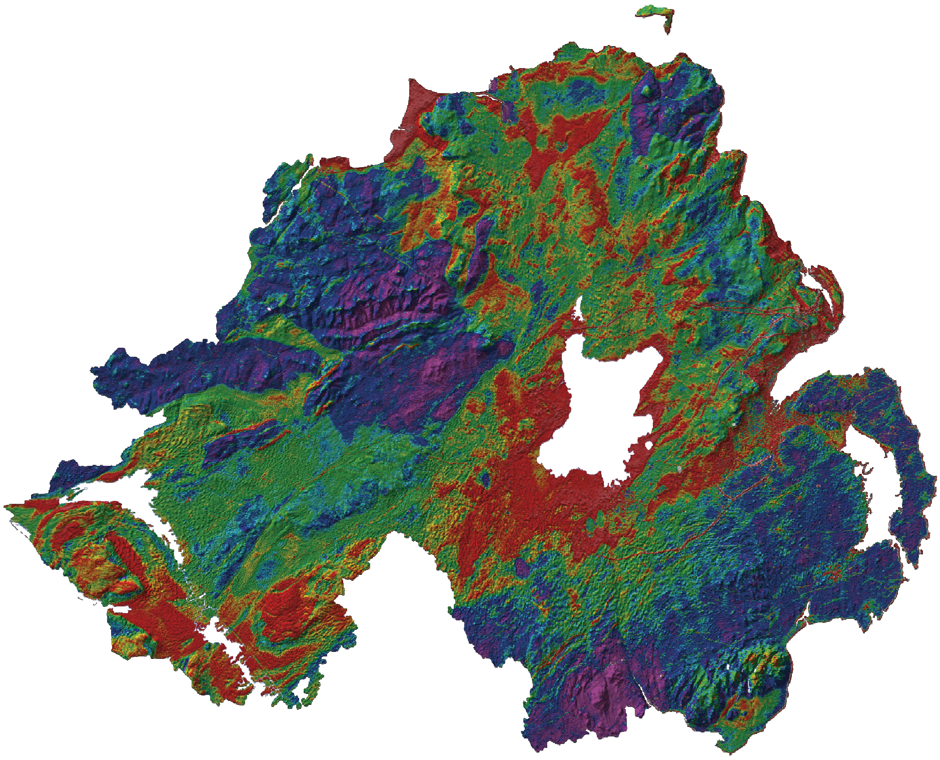

Figure 4 *Northern Ireland: electrical conductivity image superimposed on a DTM. (Red: high apparent conductivity; blue: low apparent conductivity)*