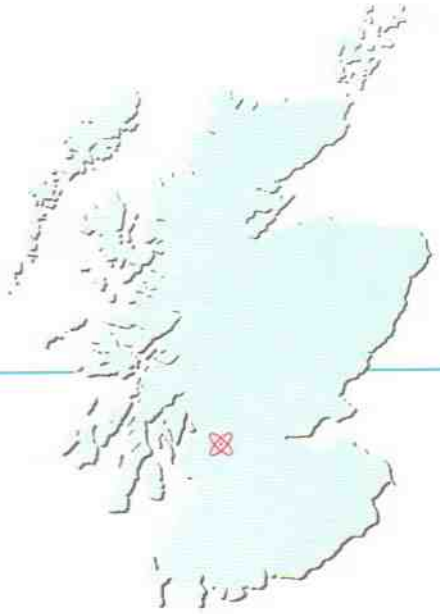
Scottish Universities Research & Reactor Centre



REPORT

A feasibility study of airborne radiometric survey for UK fallout.

March 1988

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CONTENTS

1. INTRODUCTION

Brief details are presented of a feasibility study of the use of aerial radiometric survey techniques to map local variations of fallout and natural radioactivity in Scotland.

Airborne gamma ray spectrometry is well established for Uranium prospection (see references), but has also been used for environmental monitoring outside the U.K. In 1978 a combined U.S./Canadian team used four aircraft to search for radioactive debris from the Soviet Cosmos 954 satellite (Bristow, 1978 and Grasty, 1980) in remote parts of Canada. More recently the Swedish Geological Company performed a successful National mapping exercise in the first few weeks after the Chernobyl accident (Linden and Mellander, 1986). The information from this work was used to direct available ground effects to those places where they were most urgently needed.

Whereas peak Chernobyl fallout in Sweden reached >60 Bq m^{-2} of ^{137}Cs, it was expected that U.K. levels were considerably smaller. The immediate aims of this study therefore were to establish whether U.K. levels could be readily distinguished from natural backgrounds, and to determine the spatial extent of selected contaminated areas with a view to defining possible sampling stratigies for future work.

2. THE PROTOTYPE DETECTOR

A prototype aerial gamma spectrometer was assembled comprising a single 11 x 4 inch NaI scintillation crystal viewed by 7 photomultipliers, and housed together with a battery powered EHT supply in a thermally insulated container. The counter was coupled to a Canberra Series 10 portable 4096 channel analyser, and interfaced to a Zenith portable computer, both kindly loaned to us by Mr S. Smythe, U.K. Managing Director of Canberra-Packard.

The detector produces an integrated γ counts (450-3000keV) of over 20,000 counts per minute at a height of 300m over contaminated pasture. In a 30s count the minimum detectable limit for ^{137}Cs is typically equivalent to 2kBq m^{-2} at 2σ.

3. FLIGHT DETAILS

Two separate flights were undertaken to evaluate the system, using the Department of Agriculture and Fisheries of Scotland Cessna Titan aircraft (GDAFS), operated from Edinburgh airport by North Air Aviation.

The first flight over the Wigtown pennisula and the Mull of Galloway took place on 19 February. Sweep-search grids were arranged at a bearing of 160^{0} with parallel tracks spaced one mile apart, and flown at a nominal height of 300 ft. Data from the spectrometer were logged every 30s together with

navigational coordinatates (from the onboard Decca Tans System) and radar altimetry.

A second survey was also undertaken over north and south Uist on 6 March 1988. In this case the search grids were aligned north-south and spaced apart by two minutes of longitude for ease of navigation.

The North Air pilots showed considerable verve and skill in keeping close to the projected flight paths at low altitude and over variable terrains.

Nonetheless some variations in flight altitude were inevitable (typically $\pm$50 ft) and a manoeuvre was undertaken to estimate the effect of altitude on detector sensitivity. This involved overflying the same terrain at 200, 400, 600, 800 and 1000 ft sequentially and recording integral data at each height.

Illustrations of the aircraft, detector and flights are appended.

4. INTERPRETATION OF SPECTRA AND CALIBRATION OF RESPONSE

The spectra themselves were acquired into 1024 channel segments. However, the computer link to the MCA in this prototype system was by serial interface and it was not practical to transfer the full spectrum each 30s. Instead six regions of interest integrals were defined to enclose principal gamma photopeaks of ^{137}Cs (662keV), ^{134}Cs (796keV), ^{40}K (1462keV), ^{214}Bi (1768keV), ^{208}Tl (2609keV) together with a total window (450-3000keV) for conversion to total dose rate. The six integrals were transferred to the computer each 30s with the MCA running in a cummulative mode. Every 15 minutes or so, the full spectrum was transferred to the computer and stored for archival purposes.

Back in the laboratory data disks were collated in a fast AT compatible computer, combined with flight coordinates, pre-processed and tranferred to the University of Glasgow mainframe computer for final scaling and production of contour maps.

Preprocessing comprised correction for spectral overlap from high to low energy regions (due to Compton scattering and photopeak overlap), using a standard spectral stripping procedure with coefficient determined from laboratory standard sources.

This yielded net window counts for each region of interest. The net ^{137}Cs counts over 10 ground locations, which had previously been measured both with hand held NAI detectors and by analysing soil samples with a Ge spectrometer (McDonald, 1987) were regressed with 'truth' data, to provide a working calibration. There was excellent correspondence

between airborn and other methods, providing some confidence in the conversion from counts in 30s to Bq m^{-2} of total ^{137}Cs deposition.

The contour maps were produced in Glasgow by a series of Fortram programmes calling Ghost 80 subroutines. Maps for ^{137}Cs, ^{134}Cs, ^{40}K, $^{214}Bi(U)$, $^{208}Tl(Th)$ and total activity were produced.

5. FALLOUT MAPS FOR THE WIGTOWN PENINSULA, MULL OF GALLOWAY, NORTH UIST AND SOUTH UIST

The ^{137}Cs distriubtions for the Wigtown Peninsula, Mull of Galloway, North and South Uist (appended) provide a clear indication of the extent and range of variation of fallout contamination in the survey areas. From $^{134}Cs/^{137}Cs$ ratios we believe that most of the contamination shown is due to fallout from Chernobyl, and it is notable that extreme variations occur over rather small distances (only a few miles).

With this in mind it is evident that aerial survey has a major role to play in identifying contaminated areas, and in targetting ground efforts to the places where they are most needed.

6. CONCLUSION AND RECOMMENDATION

The feasibility study was successful in showing that ^{137}Cs can be readily detected from the air, that the U.K. fallout levels from Chernobyl are extremely variable on local scales. Aerial prospection appears to offer major benefits compared with the enormous ground-based effort which would be needed to provide high resolution fallout maps.

The single detector assembled for this study had a 2σ mdl of ~2kBq m^{-2} with a 1 mile spatial resolution when used in a light aircraft flying at 120 miles per hour. While this is sufficient to verify the potential of the technique it is neither in keeping with the full capabilities of modern technology nor with the requirements of a rapid response system for environmental monitoring.

Development work is now urgently needed to establish a more sensitive detector, acquisition and analysis system incorporating advances in electronics and computer technologies, and to devise and evaluate survey stratigies over a wider range of terrains and natural backgrounds.

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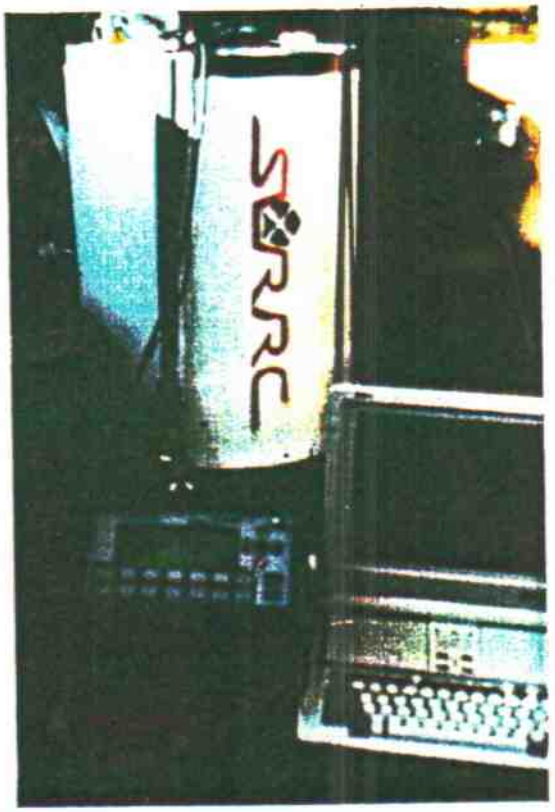
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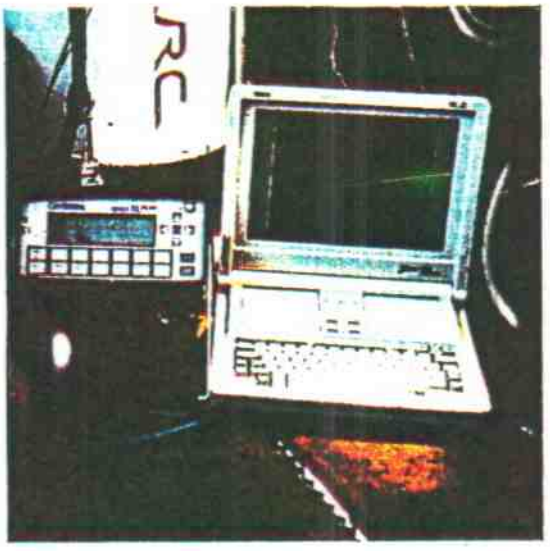
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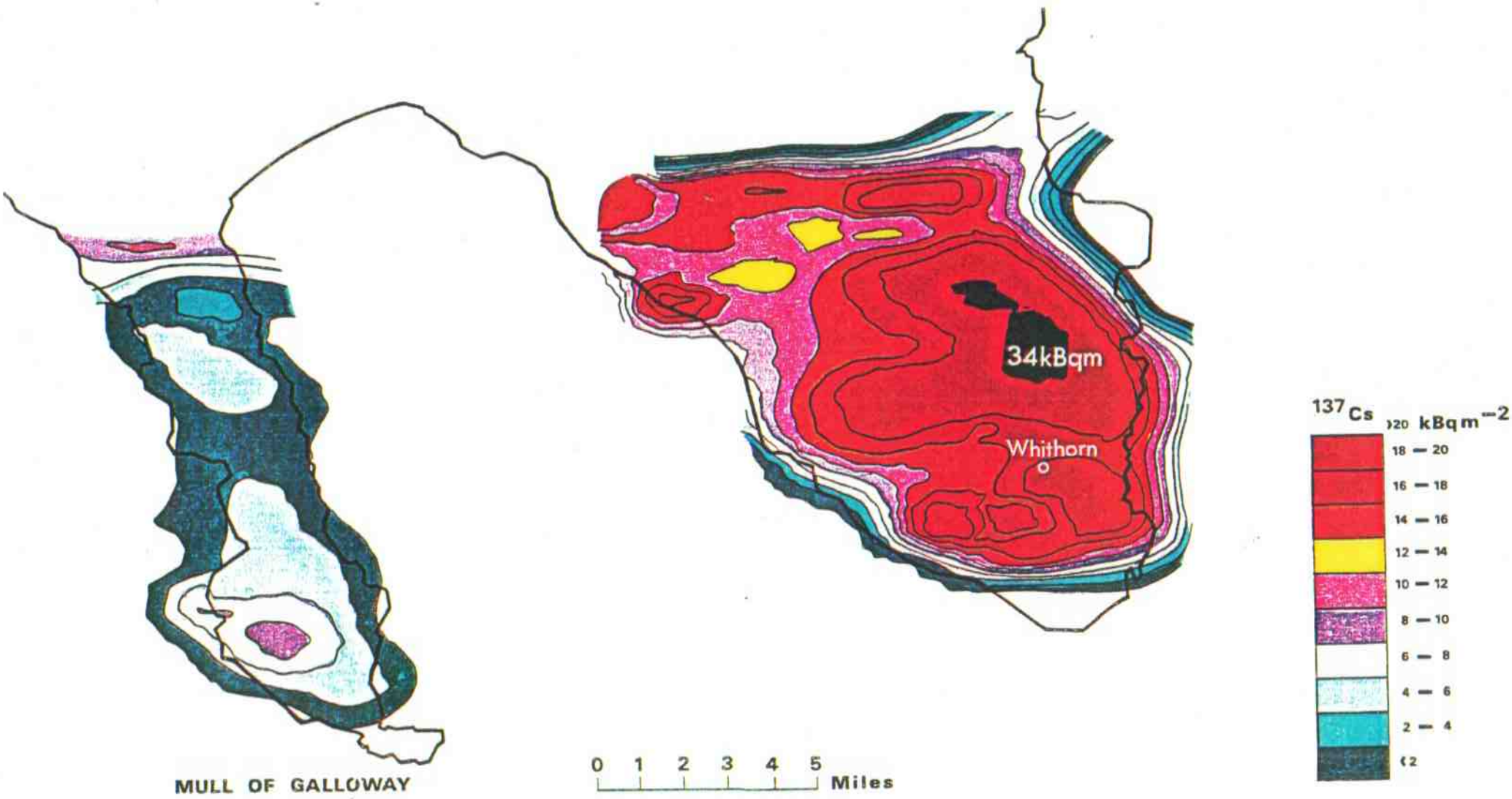
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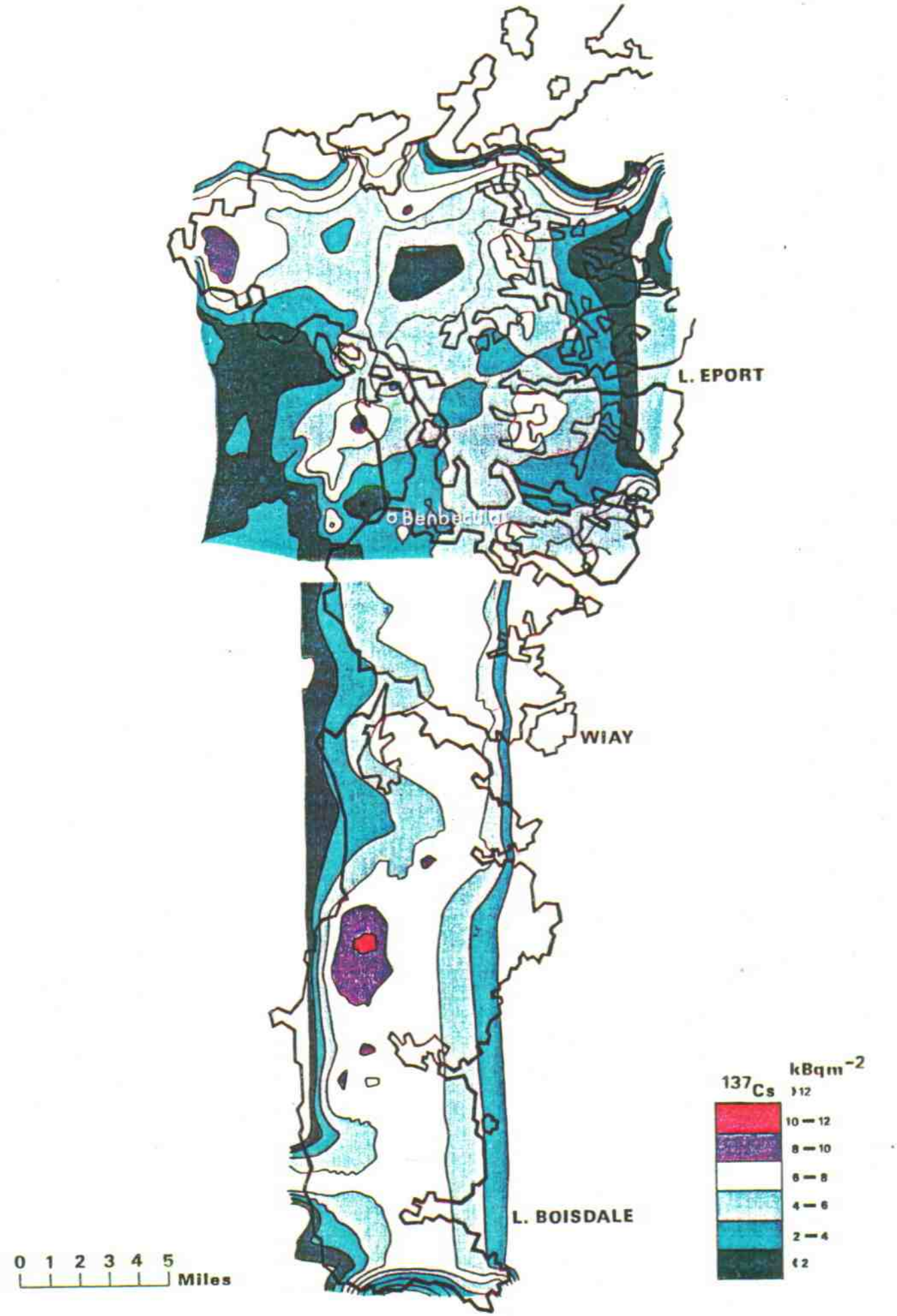
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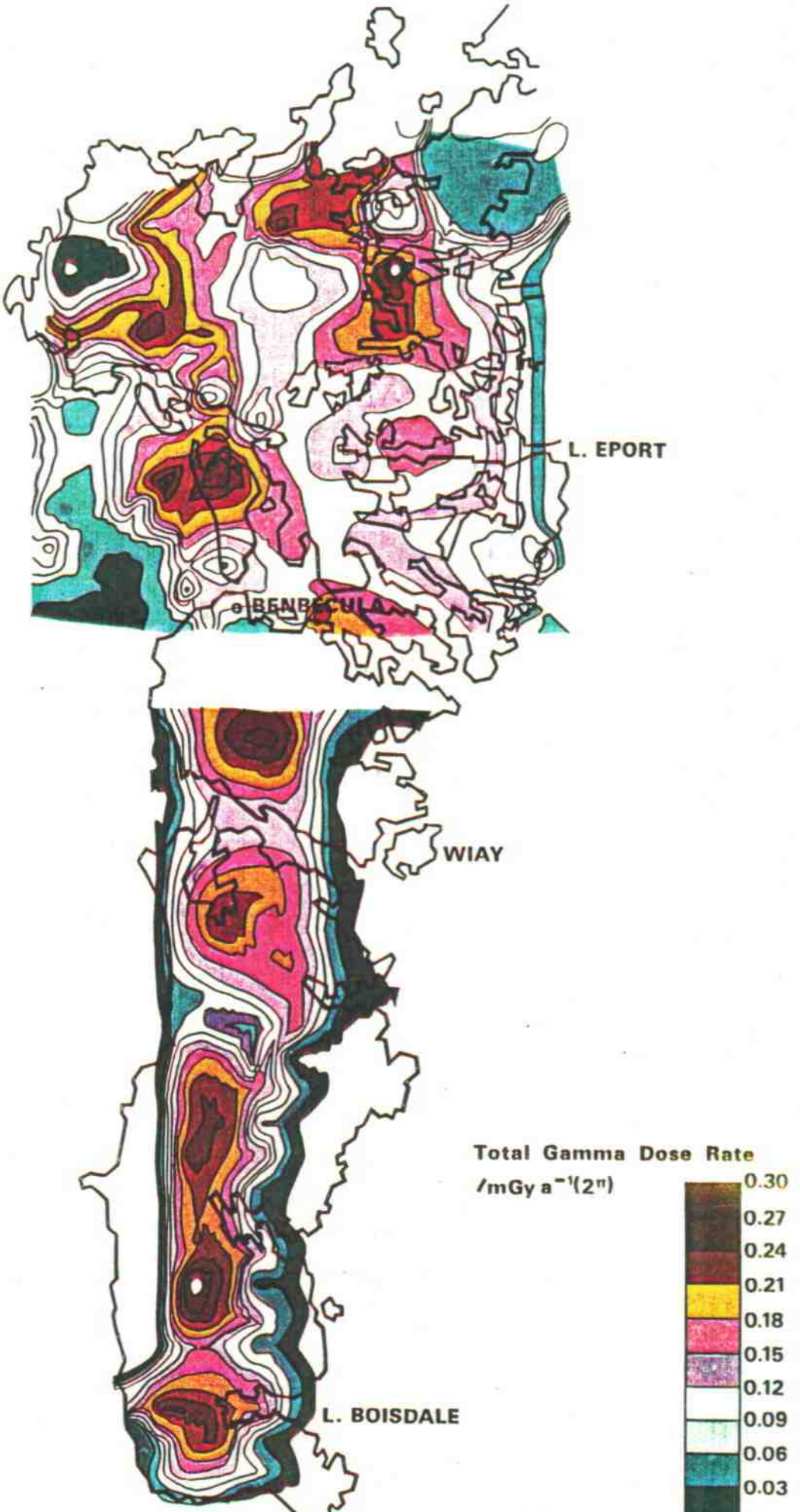
L. EPORT
BENBECULA
WIAY
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Total Gamma Dose Rate
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0.03
0 1 2 3 4 5
Miles