DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/37

Restored digital airborne radiometric data from surveys flown in 1975 and 1976 by GGU between 63° and 69°N, West Greenland

Tapani Tukiainen, Thorkild M. Rasmussen,
Karsten Secher and Agnete Steenfelt

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

G E U S

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/37

Restored digital airborne radiometric data from surveys flown in 1975 and 1976 by GGU between 63° and 69°N, West Greenland

Tapani Tukiainen, Thorkild M. Rasmussen,
Karsten Secher and Agnete Steenfelt

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

GEUS

Contents

Abstract 3

Introduction 4

Data acquisition, instruments and methods 5

Remarks on the restored digital data 6

Data point location 6
Quality of the radiometric data 6
Missing data 6
Future use of the data 6

References 8

Maps and digital data 9

Map at scale 1: 2 500 000 of sensor altitude above terrain (in pocket)
Map at scale 1: 2 500 000 of total gamma radiation in units of uR (in pocket)
Map at scale 1: 2 500 000 of equivalent uranium, eU, in units of ppm (in pocket)
Map at scale 1: 2 500 000 of thorium, Th, in units of ppm (in pocket)
Map at scale 1: 2 500 000 of potassium, K, in percent (in pocket)

Abstract

Processed digital data from airborne radiometric surveys between 63° and 69° N, West Greenland, carried out in 1975 and 1976 by the Geological Survey of Greenland and the Danish Atomic Energy Commission's Research Establishment Risø have been restored and made available as one master ASCII-coded data set containing 610 000 records. Not all the data could be restored and the potential user of the data should acknowledge that the quality of the old data is low in comparison with data that can be obtained today. Five maps at scale 1:2 500 000 showing the distribution and magnitude of the measured geophysical parameters along flight paths are enclosed with the report.

Introduction

Airborne radiometric surveys were carried out between 63° and 69° N in West Greenland in 1975 and 1976. The surveys were conducted by the Geological Survey of Greenland (GGU) in collaboration with the Danish Atomic Energy Commission's Research Establishment, Risø. The general outline of the surveys is described by Secher (1976, 1977) and Christiansen & Sørensen (1979).

Processed digital data from these surveys were stored on three magnetic tapes that were transferred from Risø to GGU in 1986. Because of the waning political interest in uranium as fuel for energy production, the data on the tapes had not been used for some time. However, a new interest for the data arose in connection with mineral resource assessments of West Greenland undertaken by the Department of Economic Geology in 1999, and it was decided to re-examine the old data tapes to see what could be restored.

Transfer of data from the old magnetic tapes was attempted at GEUS during late 2002, but due to the very bad physical condition of the old magnetic tapes, the data could not be recovered using the facilities available at GEUS.

The original Risø tapes were therefore sent to the company DPTS Ltd, St Pauls Cray, Kent, England, a private company specialised in the recovery of data from old tapes. DPTS Ltd was able to recover most of the data as a very large number of small and unfortunately variably distorted ASCII files. Thus the recovered files were not in a format suitable for standard visualisation and processing programs.

The files were edited at GEUS in a complicated process involving several special Fortran programmes written for the purpose by one of the authors (TT). This resulted in a restored new master data set of 610 000 records (63.2 Megabytes). The data have been visualised in five maps produced by means of the Geosoft Oasis Montaj™ processing software The remaining part of the report briefly summarises relevant facts about the data and gives a few comments on the quality and further use of the data.

Data acquisition, instruments and methods

Table 1. *Specifications of the airborne radiometric system*

Aircraft:	Britten-Norman Islander
Gamma–ray spectrometer:	Four channel gamma-ray spectrometer designed and constructed at Risø. Crystal volume 11.1 litres consisting of six 6 x 4 inches NaI(Tl) detectors
Positioning:	Visual, supported by radar altimeter (5.000 ft) & automatic 35 mm camera (roll, timed interval of four seconds)
Digital data acquisition:	Punched paper tape

Table 2. *Survey specifications*

Airspeed:	120 km/h
Terrain clearance:	100 metres
Survey line layout:	Contour flying
Flight line location:	Digitised flight lines on stable base 1:100 000 enlargement of KMS 1:250 000 geodetic maps. Position based on visual and 35 mm camera

The two tables above summarise the main features for the acquisition of the data. The surveys were flown when digital equipment for field use was still in its early days.

The instruments recorded the height above ground level (terrain clearance) and the counts in each of the four spectrometer channels every second, and stored the data on punch-tape. Because of the contour flying, the only possible type of navigation was visual, in-flight noting the passage of streams, lakes and other identifiable features in the landscape as fix-points, fiducials. The actual flight paths were manually traced on stable topographic base maps at scale 1:100 000 maps using fiducials and aerial photographs to locate the paths. The flight paths were later digitised in order to produce digital maps of the distribution of the measured parameters. The linking of data points to a digital location was done by assuming a constant flying speed between fiducials.

The gamma-spectrometer had been calibrated at a pad facility at Risø (Løvborg *et al.* 1981), which enabled the conversion of recorded counts per second in the four channels to simulated concentrations of radioactive components in the surface of the overflown terrain. The total gamma-radiation is given in units Ur, potassium as K%, equivalent uranium as eU ppm, and thorium as Th ppm. The quality assessment and the modelling (stripping) of the obtained measurements were done at Risø (Christiansen & Sørensen 1979; Løvborg *et al.* 1981). The magnetic tapes handed over to GGU contained records comprising flight route number, record number, data point location in geographical co-ordinates, terrain clearance, total radiation, K, eU, and Th.

Remarks on the restored digital data

The maps in paper size A3 (scale 1:2 500 000) attached with the report are produced from the restored data using Oasis Montaj™ software. The maps show the general spatial distribution of the data and the numeric range of the data parameters. Given the way the data were originally acquired and the resultant inaccuracies, the authors do not consider it reasonable to grid the data and present contour anomaly maps. As an alternative, the chosen data display at least give a good indication of the spatial distribution of the measurements.

Data point location

The flight paths were plotted on 1:100 000 scale equivalent enlargements of old 1:250 000 scale topographic maps (projection: Lambert, conform conic) that are now replaced by a new digital topographic base (KMS Vector G250). The maps in this report are based on the new topographic base *without correcting the data for differences between the old and new base maps.* In the opinion of the authors, the error is insignificant when plotted at scales >1:1 000 000, especially when the inaccuracies stemming from visual navigation and manual flight path tracing are taken into account.

Quality of the radiometric data

It must be remembered that the concentrations displayed in the maps of this report are simulated values resulting from a complicated mathematical modelling. Although the range of concentration values corresponds to those actually measured in rocks and stream sediments, and the regional variation agrees with that obtained in systematic stream sediment data (Steenfelt 2001), the accuracy is not good enough as documentation on a local scale. An important indication of the problems with the modelling is the large number of negative values for eU. Consequently, the data should be used with caution and absolute concentration values probably cannot be trusted.

Missing data

When restoring data from the old magnetic tapes, it could not be avoided that some of the data were irrevocably lost. Comparison of flight paths based on the restored data with the original flight path maps indicates that some of the daily flight routes are wholly or partially missing.

Future use of the data

The data were originally acquired as part of a national uranium resource assessment programme and they have been used well over the years for delineating areas of interest for uranium exploration, but also to map the geology in general. A number of monazite carrying pegmatites was located within the area between Nassutoq and Ikertoq fjords (Secher 1980). Another result of the survey was the discovery of a major carbonatite complex close to Sarfartoq SW of Kangerlussuaq airport (Secher & Larsen 1978; Secher 1986). Taken uncertainties into account the data can still be used semi-quantitatively to distinguish and outline certain rock types and trace geological boundaries in poorly known areas.

In many countries health issues related to the accumulation of radon in dwellings have been on the agenda in the public sector. The subject has also been brought up in Greenland, and it has been suggested that the data discussed in this report may be used to gain an initial impression of the scale of the problem in West Greenland.

Both gamma-radiation and radon production are a consequence of the radioactive decay of natural uranium and thorium isotope systems, so that there is a positive correlation between the concentrations of the radioactive elements in a given mass and its radon production. However in practice, a numerical relationship is difficult to establish because radon is a gas that easily escapes its source (e.g. a radioactive rock). Therefore, the radon concentration may either be rapidly diluted in free air above the source or may accumulate in underground cavities away from the source.

The maps presented in this report reflect the relative intensity of gamma-radiation from the various sources (mostly rock and soil) in the very upper part of the ground along the flight paths. The maps therefore provide some information on the distribution of radon source areas, but they do not reflect actual radon concentration levels.

The authors cannot recommend taking the use of the data much beyond this. Because flying was not possible in towns and villages, no direct measurements are available where a possible problem with radon would be felt the most.

If an investigation of possible radon accumulation in populated areas were to be taken to the next step the sensible approach would be to measure radon concentrations directly in the buildings. The data presented here can be used for prioritising areas, based on the general level of radiation as depicted in the data.

References

Christiansen, E. M. & Sørensen, P. 1979. Datahandling of Hugin air-borne gammaspectrometry. Unpublished report, Risø National Laboratory, Roskilde, Denmark. **N-29-79**, 90 pp.

Løvborg, L., Christiansen, E.M., Bøtter-Jensen, L. & Kirkegaard, P. 1981: Pad facility for the calibration of gamma-ray measurements on rocks. Risø National Laboratory, Roskilde, Denmark. **Risø-R-454**, 44 pp.

Secher, K. 1976: Airborne radiometric survey beween 66° and 69°N, southern and central West Greenland. Rapport Grønlands Geologiske Undersøgelse **80**, 65–67.

Secher, K. 1977: Airborne radiometric survey beween 63° and 66°N, southern West Greenland. Rapport Grønlands Geologiske Undersøgelse **85**, 49–50.

Secher, K. 1980: Distribution of radioactive mineralisation in central West Greenland. Rapport Grønlands Geologiske Undersøgelse **100**, 61–65.

Secher, K. 1986: Exploration of the Sarfartôq carbonatite complex, southern West Greenland. Rapport Grønlands Geologiske Undersøgelse **128**, 89–101. Secher, K. & Larsen, L. M. 1978: A new Phanerozoic carbonatite complex in southern West Greenland. Rapport Grønlands Geologiske Undersøgelse **90**, 44–50.

Secher, K. & Steenfelt, A. 1981: A preliminary radiometric map of Central West Greenland. Internal report. Unpublished report, Grønlands Geologiske Undersøgelse, Copenhagen, Denmark. 3pp + 1 map.

Steenfelt, A. 2001: Geochemical atlas of Greenland – West and South Greenland. Danmark og Grønlands Geologiske Undersøgelse Rapport **2001/41**, 39 pp. + CD-ROM.

Maps and digital data

The enclosed maps illustrate the distribution and magnitude of the parameters measured in the airborne radiometric survey:

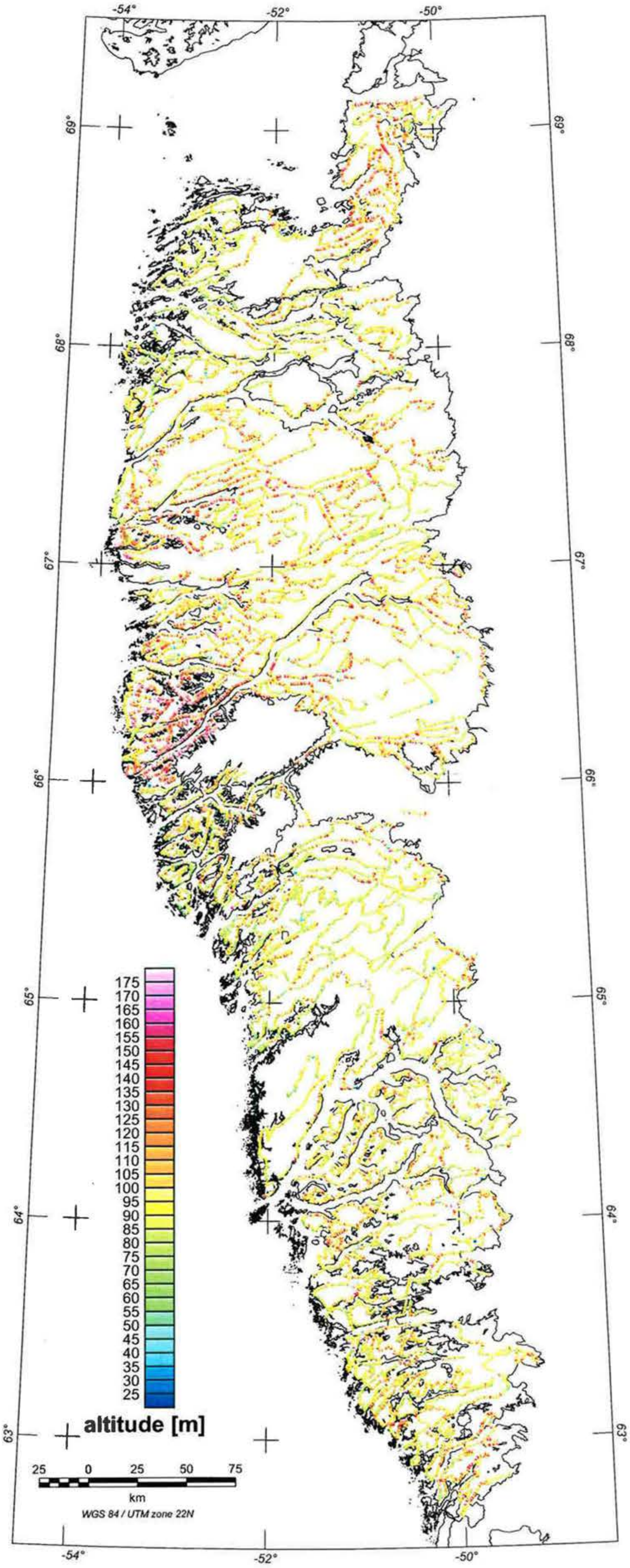
Plot of terrain clearance values (metres) along the survey flight paths
Plot of total gamma radiation Ur along the survey flight paths where terrain clearance was less than 100 m.
Plot of K% along the survey flight lines
Plot of eU ppm along the survey flight lines
Plot of Th ppm along the survey flight lines

The restored digital data from the airborne radiometric survey are stored on CD-ROM using the following format:

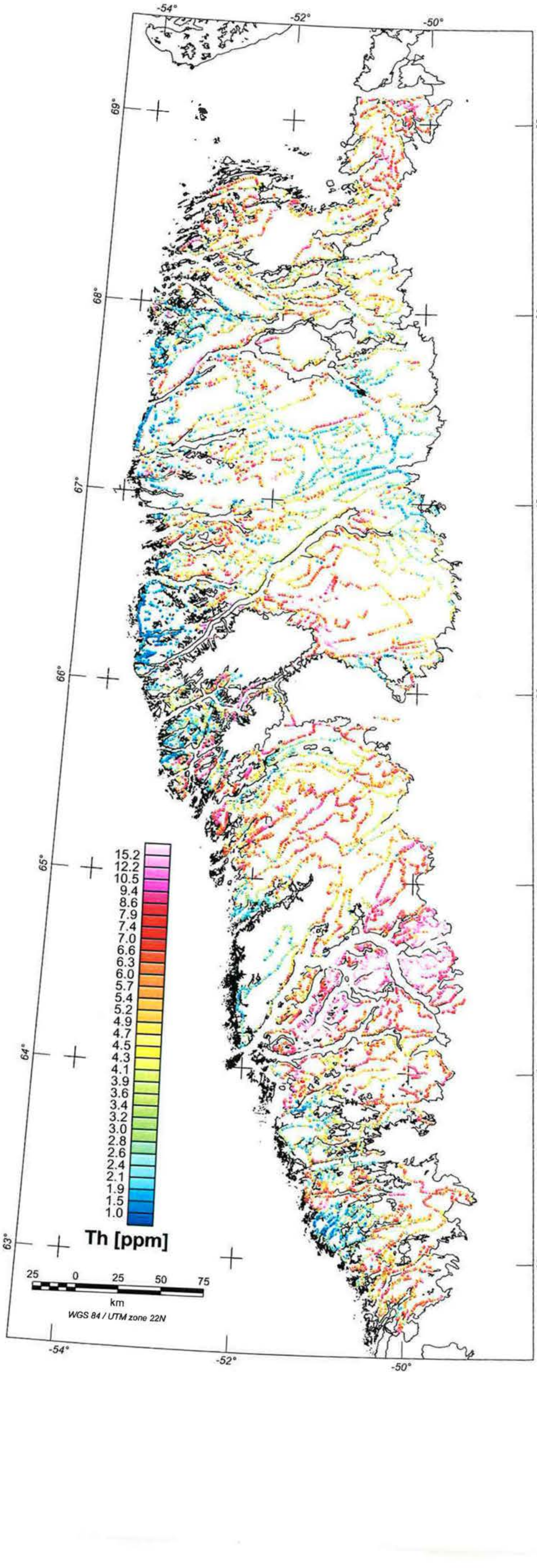
Coding: ASCII
File name: gam-master

Field 1	Flight line/record numbering & fix point information
Field 2	Flight line/record numbering & fix point information
Field 3	Flight line/record numbering & fix point information
Field 4	Flight line/record numbering & fix point information
Field 5	Latitude (decimal degrees) based on the old topographic maps
Field 6	Longitude (decimal degrees) based on the old topographic maps
Field 7	Terrain clearance (metres)
Field 8	Total gamma radiation Ur
Field 9	K %
Field 10	eU ppm
Field 11	Th ppm

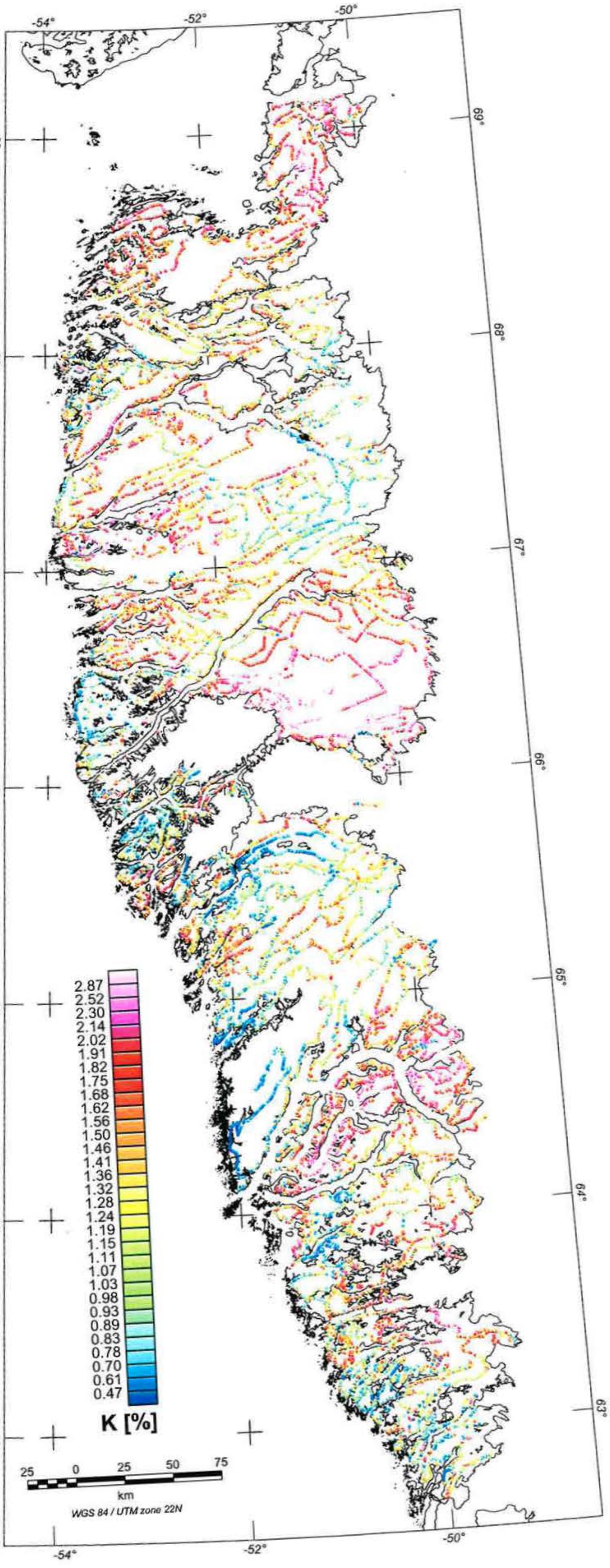
The data are available from GEUS on request and at cost.

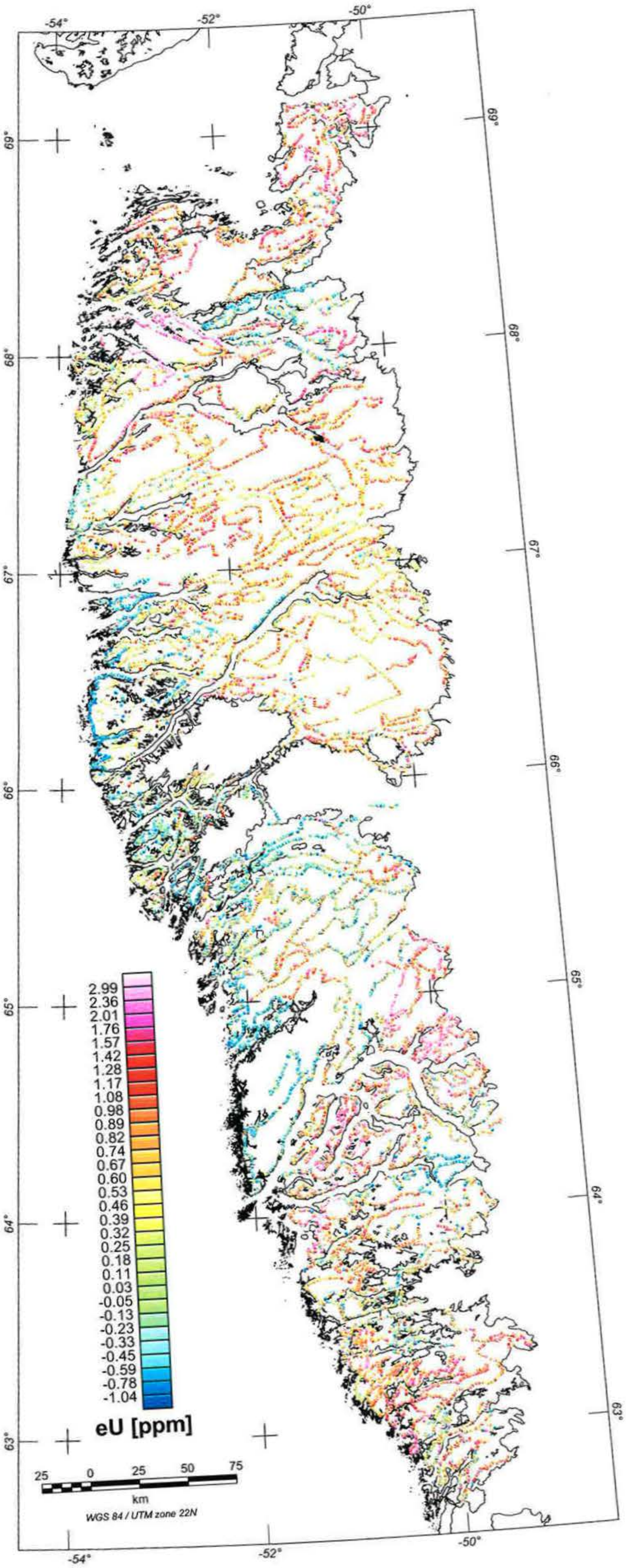


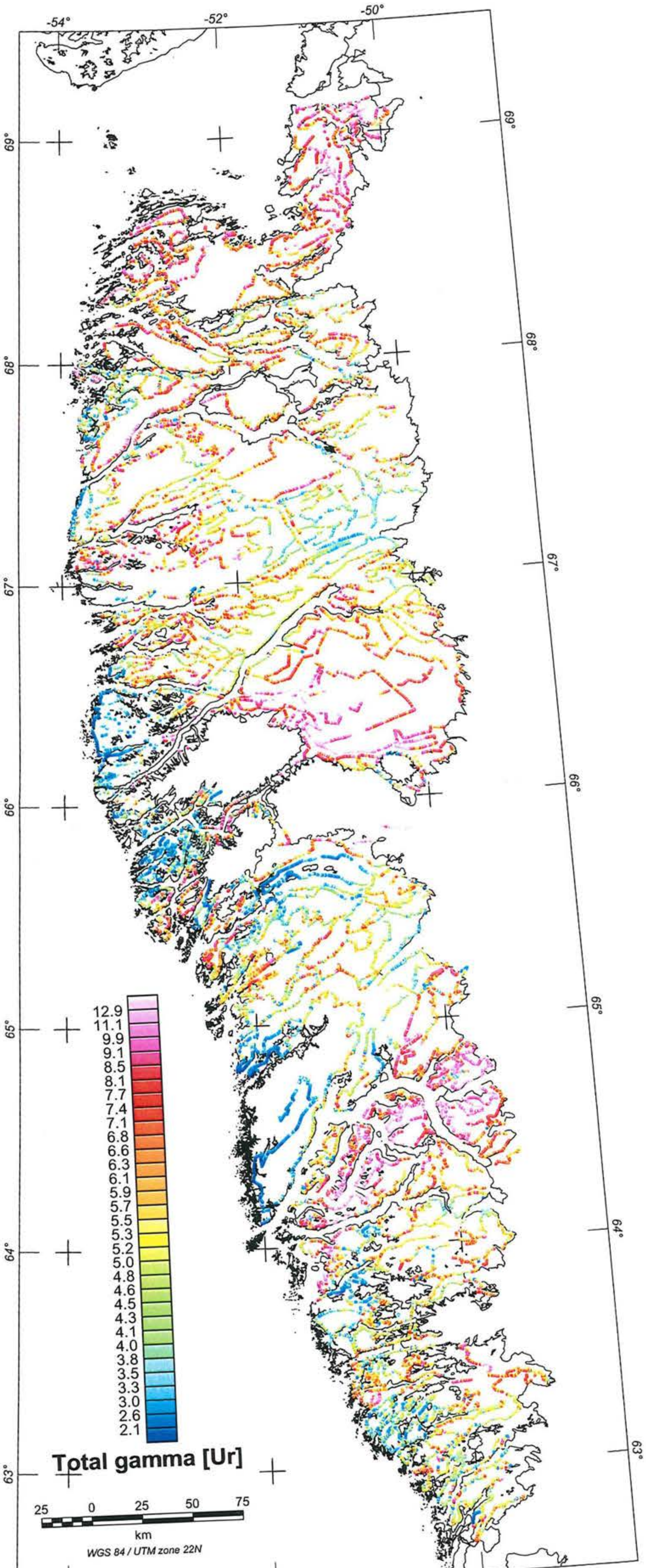
-54°
-52°
-50°
69°
68°
67°
66°
65°
64°
63°
175
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
altitude [m]
25 0 25 50 75
km
WGS 84 / UTM zone 22N



-54°
-52°
-50°
69°
68°
67°
66°
65°
64°
63°
15.2
12.2
10.5
9.4
8.6
7.9
7.4
7.0
6.6
6.3
6.0
5.7
5.4
5.2
4.9
4.7
4.5
4.3
4.1
3.9
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.1
1.9
1.5
1.0
Th [ppm]
25 0 25 50 75
km
WGS 84 / UTM zone 22N


-54°
-52°
-50°
69°
68°
67°
66°
65°
64°
63°
2.87
2.52
2.30
2.14
2.02
1.91
1.82
1.75
1.68
1.62
1.56
1.50
1.46
1.41
1.36
1.32
1.28
1.24
1.19
1.15
1.11
1.07
1.03
0.98
0.93
0.89
0.83
0.78
0.70
0.61
0.47
K [%]
25 0 25 50 75
km
WGS 84 / UTM zone 22N


-54°
-52°
-50°
69°
68°
67°
66°
65°
64°
63°
2.99
2.36
2.01
1.76
1.57
1.42
1.28
1.17
1.08
0.98
0.89
0.82
0.74
0.67
0.60
0.53
0.46
0.39
0.32
0.25
0.18
0.11
0.03
-0.05
-0.13
-0.23
-0.33
-0.45
-0.59
-0.78
-1.04
eU [ppm]
25 0 25 50 75
km
WGS 84 / UTM zone 22N


-54°
-52°
-50°
69°
68°
67°
66°
65°
64°
63°
12.9
11.1
9.9
9.1
8.5
8.1
7.7
7.4
7.1
6.8
6.6
6.3
6.1
5.9
5.7
5.5
5.3
5.2
5.0
4.8
4.6
4.5
4.3
4.1
4.0
3.8
3.5
3.3
3.0
2.6
2.1
Total gamma [Ur]
25 0 25 50 75
km
WGS 84 / UTM zone 22N