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Forsmark site investigation

Reprocessing of radiometric data – calculation of ground content of K, U, Th and Cs-137

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Sammanfattning

Detta dokument beskriver ombearbetning av radiometriska data insamlade vid en geofysisk helikoptermätning, vilken är en av de aktiviteter som utförts inom platsundersökningen i Forsmark.

Den geofysiska flygmätningen i Forsmarksområdet utfördes av Norges geologiska undersökning (NGU). Sveriges geologiska undersökning (SGU) har på uppdrag av SKB utfört en ombearbetning av de radiometriska data som samlades in av NGU. Det huvudsakliga skälet var att få information om cesium-137 beläggningen i området. Ett annat skäl var att göra en jämförelse mellan beräkningen (halt vid markytan) av K, U och Th utförda av NGU och nu av SGU. Den ursprungliga bearbetningen som NGU gjorde inkluderade inte beräkningen av cesium-137.

K, U, Th och cesium-137 data har levererats till SKB tillsammans med fullspektrumdata (256 kanals data).

Bilden av cesium-137 ser normal ut för området. Längs delar av Forsmarksån finns något förhöjda värden liknande de "våtmarksanomalier" som har konstaterats på ett antal ställen i Sverige. Den direkta orsaken till dessa våtmarksanomalier är inte helt klarlagd, men en enkel förklaring är att marken var snötäckt vid Tjernobylolyckan 1986 och att våtmarker nära bäckar etc var avrinningsområden för smältvattnet.

Jämförelsen mellan NGU:s och SGU:s beräkning av K, U och Th visar endast på smärre skillnader, möjligen är SGU:s radonkorrektion något bättre än NGU:s.

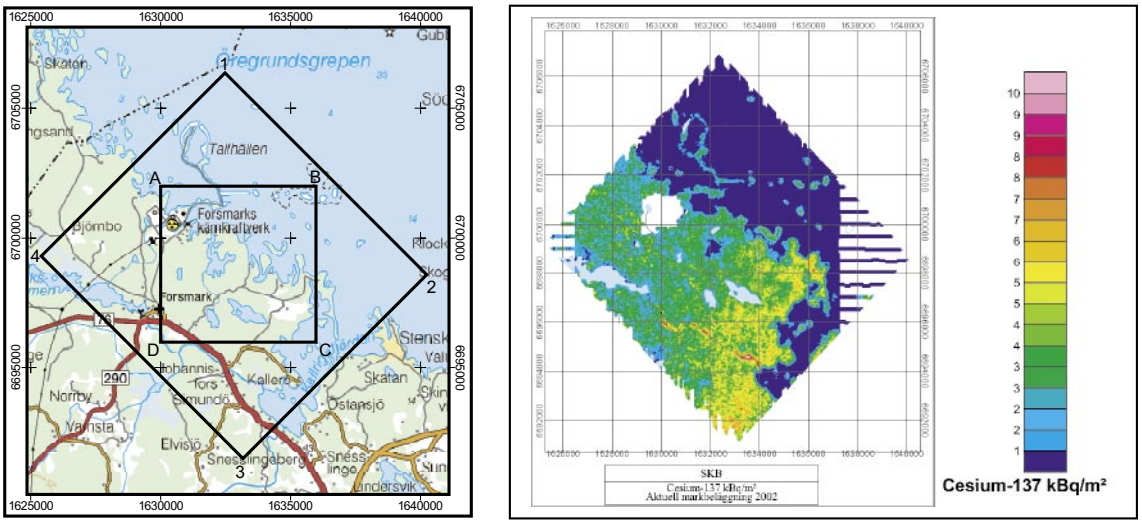

Figure 0-1. *Den vänstra bilden visar det aktuella området. Den högra visar beläggningen av cesium-137 för samma område.*

Contents

1 Background and objective

This document reports reprocessing of radiometric data gained from a helicopter borne geophysical survey /1/, which is one of the activities performed within the site investigation at Forsmark. The airborne survey, see Figure 1-1, was carried out by the Geological Survey of Norway (NGU). The equipment used by NGU for radiometric measurements is basically the same as the one used by the Geological Survey of Sweden (SGU). It is an Exploranium NaI detector with 16 litres downward and 4 litres upward looking detector together with a GR820 analogue to digital converter.

SGU has upon request from SKB reprocessed the radiometric data. The primary objective was to obtain information about the Caesium-137 contamination within the survey area. Another objective was to compare the ground surface concentration of K, U and Th as calculated by NGU and now by SGU. The original processing carried out by NGU did not include calculation of ground concentration of Caesium-137.

The activity has been carried out according to the activity plan AP PF 400-04-46 (SKB internal controlling document).

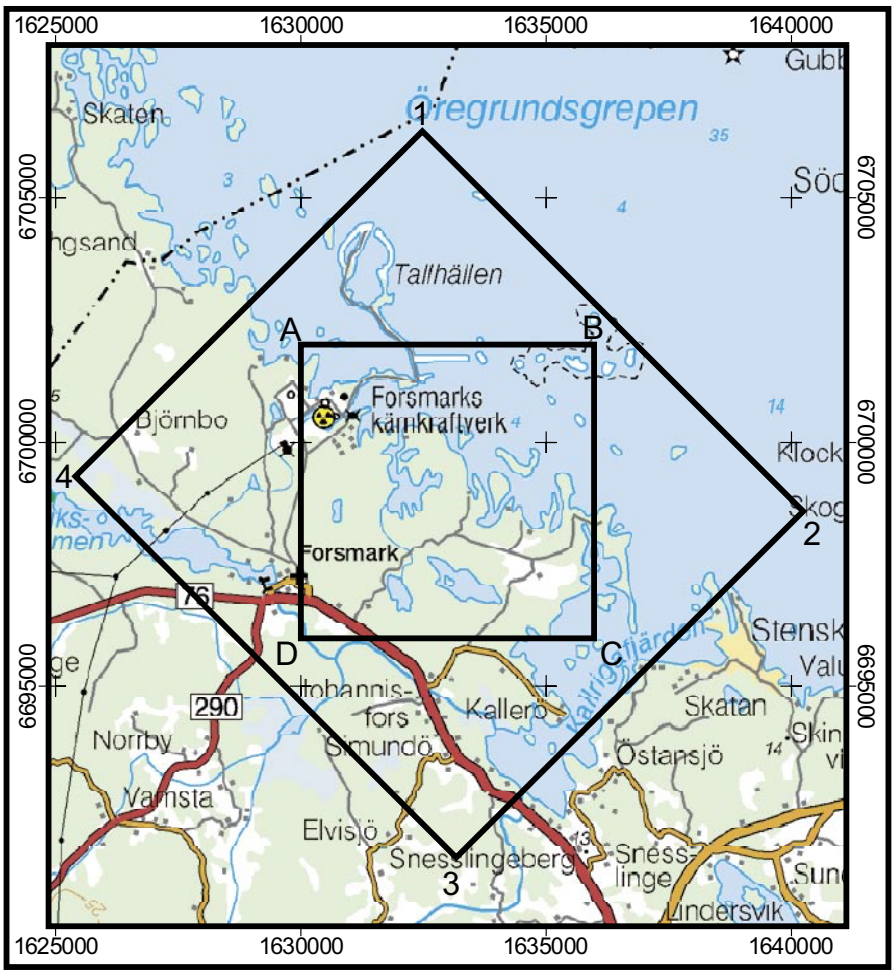

Figure 1-1. *The area covered by geophysical measurements from helicopter. Measurements are performed along north-south lines in the large diamond shaped area and along east-west lines in the smaller area.*

2 Data processing

The work was carried out in accordance with SGU quality system (SGUFf) /2/ for airborne data on a standard PC computer with OASIS MONTAJ/Geosoft software /3/.

Input data

Input data was XYZ files from NGU.

Preparing of 256 channel data set

From the raw data sets, 256 channel radiometric information was extracted. From NGUs delivery of radiometric data was the calculated K, U, Th, co-ordinates, altitude, time etc obtained.

The 256 channel data was linked to time, altitude, co-ordinates and the values for K, U and Th calculated by NGU.

Calculation of K, U, Th and Caesium-137

From 256 channel radiometric information, calculation of ground concentration of K (%), U and Th (ppm) and Caesium-137 (Bq/m²) was carried out in accordance with SGUs quality system for radiometric processing /2/.

The conversion from counts per second to K %, U and Th ppm is based on SGUs calibration pads in Borlänge with known contents of K, U and Th /4/.

The conversion from counts to Bq/m² for Caesium-137 is based on a calibration carried out at Sundbro airfield in conjunction with SSI, Radiation Protection Agency and FOA, Military Research Establishment.

3 Results and data delivery

The SICADA reference to the delivered data is field note no Forsmark 42.

3.1 Ground surface concentration of Ceasium-137

The Caesium concentration in the Forsmark area, Figure 3-1, is “normal” for an area that was affected by the fallout caused by the Chernobyl accident in late April 1986, see Figure 3-2. No exceptional enrichment has been detected by the airborne survey. The highest values in the area are in the order of 10–20 kBq/m², and the mean value is a few kBq/m². This is about 10% of the contamination in the Gävle area.

The distribution of the 1986 fallout was ruled by the weather. Figure 3-2 shows therefore, in principle, were rainfall transported Caesium to the ground. Minor variations within the Forsmark area can therefore be explained by local variations in extent and timing of the rainfall in this particular area.

Along a small river (Forsmarksån), in the southern part of the area, there is an increase of Caesium-137. This seems to be the same effect that is known from a number of other places in Sweden. When the Chernobyl accident occurred, the country was still partly covered with snow and a simple explanation is that wet areas near lakes and rivers were more contaminated with Caesium-137 when the snow melted after the accident.

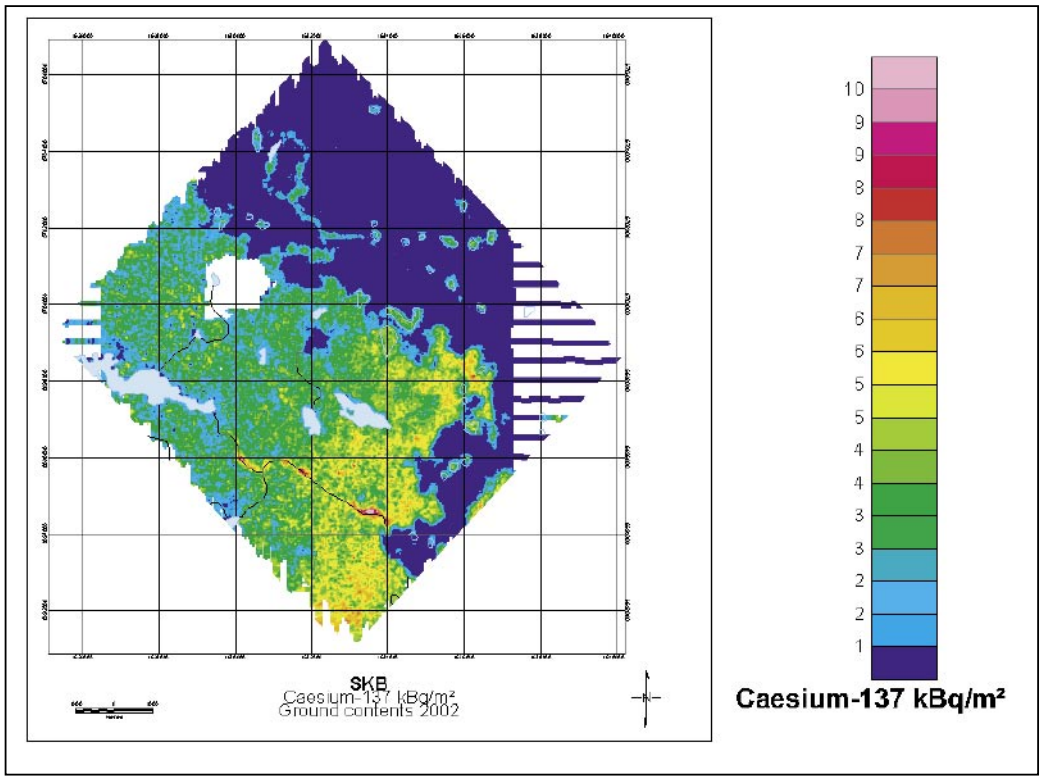

Figure 3-1. *The Caesium-137 concentration in the Forsmark area.*

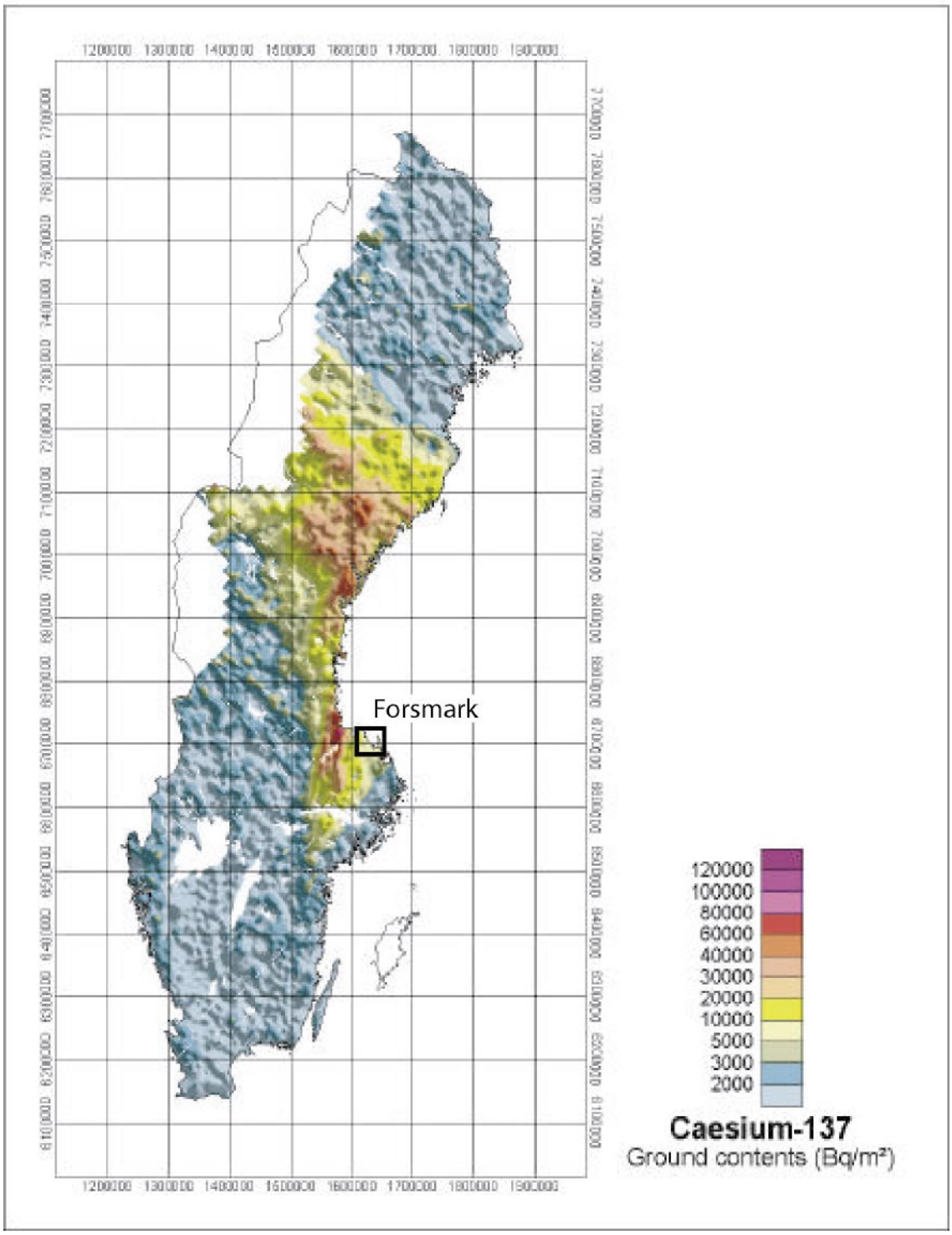

Figure 3-2. *Caesium-137 fallout (1986) over Sweden.*

3.2 Comparison between NGU and SGU processing

A comparison of the calculations of K, U and Th ground content performed by NGU and SGU shows only minor differences. However, the removal of radon effects on the Uranium data made by SGU seems to have been somewhat more successful.

Uranium calculated by NGU and SGU shows the largest difference in the mean value.

In general, determinations of the Uranium content show the largest uncertainty and differences of 10–20% in mean values are quite normal. The difference between the NGU and SGU calculations is in that order. A simple explanation is that the Uranium calibration of NGU deviates from the one made by SGU.

The statistical software used to produce Figure 3-3 includes a scaling function of the data to fit in the window. (Inside each window. i.e. Uranium NGU NGU /SGU SGU the same scaling is used for both the X and Y axis).

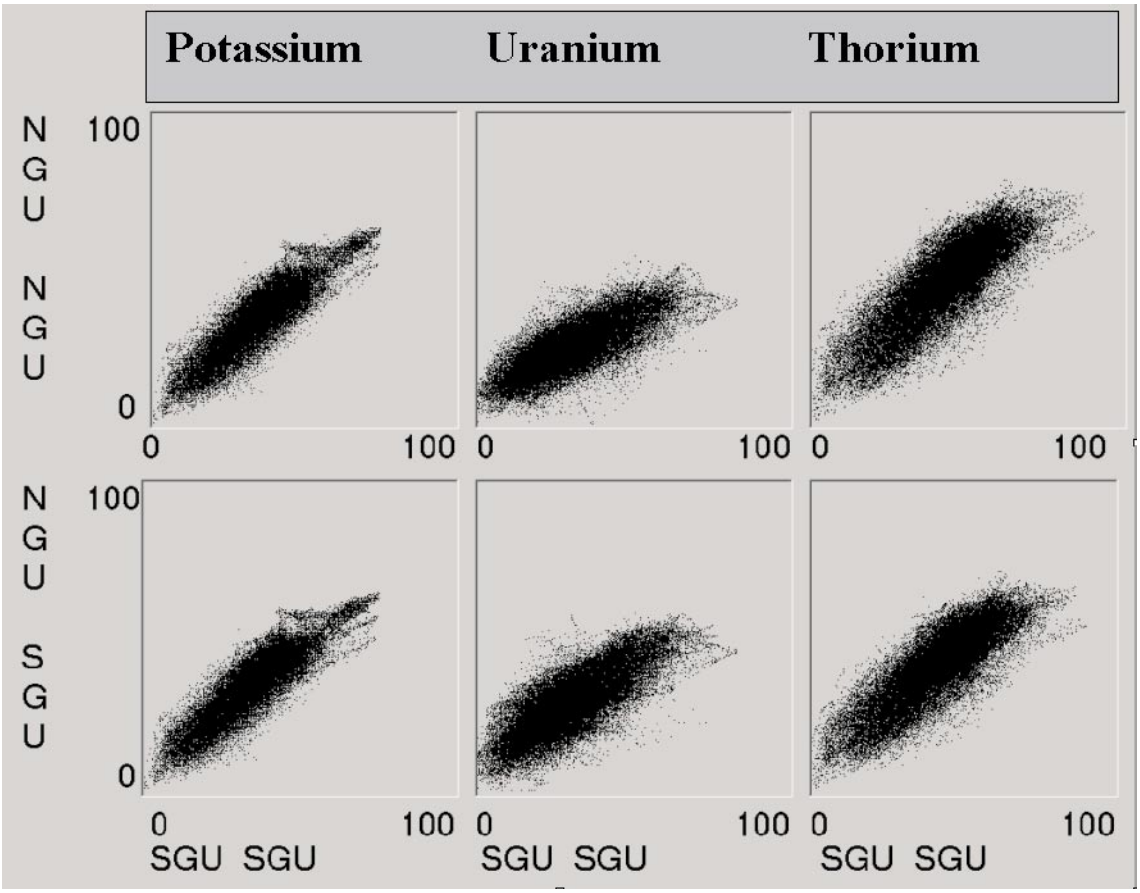

Figure 3-3. *Comparison between Earlier SGU data over the area (SGU SGU), NGU data processed by NGU (NGU NGU) and NGU data reprocessed by SGU (NGU SGU). There are only minor differences between the three data sets.*

3.3 Data delivery

Two files of data, calculated data and raw data, and a Caesium-137 grid file have been delivered to SKB.

Raw data

Raw data have been delivered in the file “Forsmark_1S_SPM256.XYZ” which contains the following channels:

X_RT90FIXINT:	x-values in meter (East–West),
Y_RT90FIXINT:	y-values in meter (North–South),
Flight:	Flight number from start of campaign.
RecNum:	Record number
Date:	YearMonthDay,
UtcTime:	Time in UTC.
Raltm:	Radar altimeter Distance above ground.
Baro:	Barometric pressure.
Temp:	Temperature outside helicopter (dummy).
LiveT:	Livetime in mS.
Cosmic:	Energy above 3 MeV
Res:	Resolution.
TC:	Total count.
CH256[0]:	First channel of raw data.
CH256[1]:	Second channel of raw data.
CH256[2]:	Third channel of raw data.
.	.
.	.
CH256[254]:	255th channel of raw data.
CH256[255]:	256th channel of raw data.

Calculated data

Calculated data have been delivered in the file “NGU_SGU_Bear_2004” which contains the following channels:

X_RT90FIXINT:	x-values in meter (East–West),
Y_RT90FIXINT:	y-values in meter (North–South),
Flight:	Flight number from start of campaign.
Date:	YearMonthDay,
UtcTime:	Time in UTC.
RecNum:	Record number
Raltm:	Radar altimeter Distance above ground.
UCORR_LAG:	Uranium in ppm. Results from NGU calculation.
ThCORR_LAG:	Thorium in ppm. Results from NGU calculation.
KCORR_LAG:	Potassium in %. Results from NGU calculation.
Baro:	Barometric pressure.
Temp:	Temperature outside helicopter (dummy).
LiveT:	Live time in mS.
Res:	Resolution.
TC:	Total count.
Cosmic_LAG:	Energy above 3 MeV.
Ka_2004:	Potassium in %. Results from SGU calculation.
Ur_2004:	Uranium in ppm. Results from SGU calculation.
Th_2004:	Thorium in ppm. Results from SGU calculation.
Cs_137_BQ_m2_Cor:	Cesium-137 in Bq/m². Results from SGU calculation.

4 Conclusions and discussion

The NGU and SGU processing of the radiometric data have yielded basically the same results. The Uranium data shows a minor difference in mean value. The NGU processing left some radon effects seen in the Uranium data. The SGU processing has reduced, although not completely removed, this effect from the Uranium data

The Caesium contamination within the area is moderate and very much in line with what could be expected as a result from the Chernobyl accident in 1986.

The uncertainties in the absolute value for radiometric processing are in the order of 10–20%. To this uncertainty, a number of factors contribute, e.g. the size and form of the detector, how it is mounted and how wet the ground is. Within the project “Nordisk Kärnsäkerhet (NKS)” efforts have been made to calibrate different systems for radiometric measurements. In spite of these efforts, differences up to 50% have been noted. Differences up to 10–20% have therefore to be regarded as acceptable.

5 References

/1/ **Rönning H J S, Kihle O, Mogaard J O, Walker P, Shomali H, Hagthorpe P, Byström S, Lindberg H, Thunehed H, 2003.** Forsmark site investigation. Helicopter borne geophysics at Forsmark, Östhammar Sweden. SKB P-03-41. Svensk Kärnbränslehantering AB.

/2/ **Geological Survey of Sweden.** SGU Quality system GUFf for airborne measurement and processing. *Http:\\www.sgu.se*

/3/ **Geosoft.** 256 channel Radiometric Processing system for Oasis Montaj. *Http:\\www.geosoft.com*

/4/ **Swedish Geological Company, 1988.** Kalibrering av SGABs flygburna spektrometer, SGAB TF8801.