NGU Rapport 92.314

Helicopter borne radiometric survey near Kautokeino, Finnmark

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RAPPORT

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Helicopter borne radiometric survey near Kautokeino, Finnmark

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Sammendrag:

A helicopterborne geophysical survey was flown by NGU on behalf of Outokumpu Finnmines Oy. over two areas near Kautokeino, Finnmark. The objective of the survey was to locate structures which are favourable for gold mineralization. These structures are associated with oxidation of graphite and magnetite, and so are associated with conductivity and magnetic lows. Radiometric data were initially processed to produce a total count map, but then subsequently reprocessed with the intention of producing radioelement and radioelement ratio maps. The intention of the reprocessing was to locate Davidite, a uranium mineral, which is associated with gold in the area. The quality of the data was unfortunately not good enough to produce ratio maps, but three radioelement maps were produced.

This report discusses the acquisition and processing requirements necessary to produce radioelement maps, and presents three radioelement maps for each of the two areas flown.

Emneord: Geofysikk	Radiometri	Fagrapport

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Appendices

Enclosed A3 sized maps at 1:40000 approximate scale

General

This report is a supplement to NGU report 91.256 (Walker, 1991), which describes a helicopter geophysical survey near Kautokeino, Finnmark undertaken for Outokumpu Finnmines Oy during September, 1991. When the survey was originally contracted, only maps of the total radiometric count were requested. Following the initial round of processing, NGU was commissioned to interpret the data (NGU Report 92.255, (Sandstad et al, 1992), and as part of this interpretation, uranium, thorium and potassium radiometric count maps were produced. Radioelement ratio maps were requested but the quality of the data was too poor to generate them.

This report describes those maps, their limitations and the operational requirements necessary for a multi-element radiometric survey.

Area: The survey covered two separate areas near Kautokaino in Finnmark Fylke, Norway, and consisted of a total of 2450 line kilometers. 1649 line kilometers were completed in the Cabardasjåkka area, which lies just north of Kautokeino, and 801 line kilometers were completed in the Reidnajavri area which lies approximately 25 kilometers to the south. Line spacing was nominally 50 meters, but additional lines were flown at a nominal 500 meter spacing to connect the Reidnjajavri area with a similar survey previously flown during 1989. The reader is referred to NGU report 91.256 for further details.

Equipment: Equipment operated in the survey included a four-frequency electromagnetic system, a helium optical pumped magnetometer, a VLF-EM system, a spectrometer, a video camera for flightline tracking, a radar altimeter and a radio navigation system. All data were recorded both in digital and in analogue form, with positioning data stored on video film as well as being recorded by the navigator in flight.

Purpose: The purpose of the survey was to locate structures favourable for gold mineralization. The gold mineralization is believed to be associated with breaks in graphitic conductors which can be identified through resistivity highs. These breaks are caused by oxidation of the graphite, and are therefore often associated with magnetic lows which result from the oxidation of magnetite into hematite.

Gold mineralization in the Kautokeino area has been associated with Davidite, a uranium mineral. Hence, one of the major goals of the geophysical interpretation in report 92.255

was to identify uranium anomalies which could be associated with breaks in the graphitic conductors described above.

Surface geology: In both areas, bedrock is poorly exposed and is covered by overburden with localized swampy areas, so the radiometrics will be of limited use in mapping bedrock lithology directly.

Aircraft and Equipment

Aircraft: The survey was flown using an Aerospatiale Ecureuil B-2 provided by Helikoptertjeneste A/S, based in Kinsarvik, Norway. Installation of the geophysical and ancilliary equipment was done by NGU in Trondheim. Base for operations in the Kautokaino area was on a small knoll outside Kautokaino near an installation operated by the Norwegian Department of Defence.

Spectrometer: The radiometric package consists of a 1024 cubic inch (16.8 liter) sodium iodide crystal detector coupled to a Geometrics gamma-ray spectrometer system. The detector consists of 4 crystals which are continuously stabilized by a micro-processor controlled spectrum stabilization package. Outputs from the detectors are first fed into a Exploranium GR-900 detector interface unit, and thence into a GR-800 multichannel spectrometer. The detector interface unit is responsible for stabilizing crystal temperature and for summing pulses output from the detector into a pulse stream which can be analyzed by the spectrometer. The spectrometer then sorts the resulting pulses into 1 of 256 channels, and counts the pulses in each channel. Each of channels 1 to 255 correspond to gamma rays in the 0 to 3 MeV range, assigning them to individual windows which are 11.81 keV wide, whilst channel 256 is reserved for the cosmic ray contribution lying in the 3 to 6 MeV range.

The crystal is mounted on a platform below the helicopter between the skids, and is operated with a recording cycle time of 1 second. Each recording cycle is divided into an acquisition period of 0.9 seconds and a period reserved for downloading data of 0.1 second. No upward looking crystal is present.

In addition to the counts in each of the 256 energy windows, the spectrometer outputs counts from the following windows:

Radioelement	Peak Energy	Energy Range	Window Range
Total Count 1	N/A	0.2 - 3.012	18-254
Total Count 2	N/A	0.4 - 3.012	34-254
^{40}K	1.46	1.37 - 1.57	116-132
^{214}Bi	1.76	1.67 - 1.87	141-157
^{214}Bi	0.609	.544 - .686	46-57
^{214}Bi	1.12 +	1.04 - 1.22	88-101
	1.76 +	1.66 - 2.42	140-204
	2.19		
^{208}Tl	2.62	2.42 - 2.83	204-237

where the peak energy and energy range are defined in MeV. ^{218}Bi is a member of the uranium decay series, and window centered on the 1.76 MeV decay is typically referred to as the uranium window. Similarly, thorium is not measured directly by its own decay, but rather by way its ^{208}Tl decay product with a peak centered at 2.62 MeV.

The GR-800 contains electronics which account for the dead-time of the instrument; that is, the length of time the acquisition period of the instrument is shortened because the instrument is occupied during the acquisition period by processing pulses. The dead-time is recorded by the data acquisition system and is used in processing.

Compton scattering coefficients were calculated using software and test pads purchased by NGU from Dr. R.L Grasty, of the Geological Survey of Canada. The experimental procedures used in these measurements are described in NGU report 92.315 (Walker, 1992).

The spectrometer has not as yet been calibrated for atmospheric attenuation, and standard attenuation coefficients are used which assume a fixed temperature and pressure. When the data were processed, test range data to convert counts in each window to apparent radioelement concentrations in the ground were not available, and data are presented in counts per channel.

No use was made of the cosmic energy channel between 3 and 6 MeV because a cosmic calibration flight had not been flown before the data were processed.

Field operations

This section is a discussion of the operational requirements for radiometric surveys. Sources include the Geometrics GR-800 manual, a report by the IAEA (1991) and commercial practice. More general project operations are discussed in NGU report 91.256.

Recommended equipment checks: The IAEA recommends daily detector gain and resolution checks which are more stringent than those recommended in the GR-800 manual. These checks ensure that the sensitivity of the system to the radioelements being measured will remain constant. Changes in gain or stability should be accompanied by new determinations of system sensitivities over a test range and by remeasuring the Compton scattering coeffients.

Gain: Detector gain determines the energy band assigned to each window in the spectrometer. In the GR-800, individual channels are fixed at 11.81 keV each. A 1% gain error will mean that every 100 windows, the energy window assignments will be shifted by one window: window 99 will lie where window 100 should be. Gain changes will therefore mean gamma ray photopeaks will drift in their, and is the worst case out, of their respective windows, and so to will the sensitivity to the various radio-elements being measured also change.

Checks for detector gain are recommended by the IAEA before and after each working day. The checks consist of recording the total counts in the uranium and thorium channels from uranium and thorium sources set out at a fixed position relative to the detectors. If the count rate is constant to within statistical error, the system gains are stable.

Stability: To check spectral stability, the IAEA recommends calculating the resolution of the system after each gain check. Resolution measures how much energy the system scatters into adjacent channels from a source that ideally should lie in just one channel.

Resolution is in practice calculated from the peak width of the ^{137}Cs photopeak. Changes in resolution generally widen photopeaks, and are accompanied by the reduced probability that a gamma-ray will produce a count within its assigned channel window. That is, the system sesitivity diminishes with poorer resolution.

Geometrics recommends checking detector gains twice daily when the detectors are first powered up, and daily once they have been on for three days. They also recommend checking the GR-800 daily for spectral stability. Other required checks are given in chapter 3 of the Geometrics manual for the GR-800. My experience is that it was in practice sufficient to check detector gains and spectral stability once daily or before every flight if the spectrometer was stable.

Recommended survey procedure: Since radiometric measurements are quite sensitive to ground moisture, under ideal conditions they should be delayed following rain fall. However, this would be virtually impossible to implement in Norway, where snow and rain can be problematic. To account for reduction in the radiometric signal from atmospheric scattering, the a barometric altimeter and thermometer to measure outside air temperature should be included in the airborne equipment package. Such equipment is more important for fixed wing surveys than in helicopter surveys. In helicopter surveys, altitude is lower and atmospheric effects are consequently smaller.

The IAEA recommends a test flight to determine the cosmic scattering coefficients is recommended once per installation, with periodic checks at 1500 m AGL recommended once per week. In a survey with a multiple instrument package, in particular an EM system, this requires disconnecting the EM system for the test flight. In this case, the benefits gained from the radiometric check flight do not outweigh the potential for degrading the EM data by powering the system off. It is sufficient to monitor the aircraft background with the regular flights over open water that monitor variations in radon background.

To monitor the variable component of atmospheric radon, excursions over a large lake are recommended at least twice during the course of a flight, and more often if background is found to change appreciably. The radon background is then assumed to vary linearly between background readings. Alternative approaches to account for radon gas fluctuations are to fly a repeated test line, so data can be normalized to atmospheric variation, or to fly a line at 2000 ft. altitude, where the signal from the ground is small. However, the latter choice is not preferred because the distribution of radon gas at 2000 feet can be appreciably different than at survey elevation.

For logistical, timing and cost reasons, it is impossible to delay a survey during periods of rainfall. The IAEA recommends keeping a log of rainfall in the survey area, but since rainshowers are often localized, such a log can only serve as a warning. A test line over an area common to every flight, can be used to assess the repeatability of the data. However, since soil moisture conditions can be quite variable, significant variations in gamma ray absorbtion can occur from point to point and it is not possible in practice to make corrections for the variability introduced by soil moisture.

Actual field procedure: The gains on the NGU spectrometer are usually adjusted once at the outset of the survey. No backgrounds were measured. This is suffucient to produce a total count radiometric map, as was specified at the outset of the survey, but leads to difficulties if more refined radiometric maps are required.

Processing

This section deals with the processing of the radiometric data from this survey. For further details, refer to NGU report 91.256.

Spectrometer: Data processing in profile format consists of three steps: 1. To eliminate count variability due to deadtime in the system, 2. To remove the effects of background radiation and 3. To strip Compton scattering effects from the data, including attenuation of the signal in the atmosphere. Once the data have been corrected in profile format, they can then be gridded and/or ratioed to produce radioelement and radioelement ratio maps.

In the deadtime correction, the raw counts in each channel are divided by the difference between the acquisition time and the deadtime. The result is the count rate that would have been measured if the spectrometer were continually active, assuming a constant radiative flux.

Once the signals have been corrected for deadtime, background radiation is then removed. Because no background lines were flown over water at survey elevation, background levels were determined from 20 second averages of the count rate from EM background lines. Background data from flights 1 and 2 are presented in Table 1.

Using EM background lines to determine radiometric backgrounds is a technique which has be used to process data from systems with no upward looking crystal in areas where no large lakes exist. The technique suffers from four problems 1: The atmospheric component of the radon background may be different at 1000 feet than at surface, 2: 1000 feet is only approximately 1/2 the elevation required to eliminate the ground signal 3: The cosmic count rate at 1000 feet will be slightly higher than the cosmic count rate at survey elevation 4: The thorium signal from the ground will be scattered into the uranium channel, yielding an artificially high uranium signal.

The backgounds in Table 1 exhibit consdierably more variation than would be expected statistically. For a 20 second average, a count rate of 200/sec should vary by 3 counts, and a count rate of 20/sec by about 1 count. The variations seen in the table exceed the statistically expected variations and are most likely due to sources on the ground. Nevertheless, these estimates on background are the best available.

Following background corrections, the data are stipped of the Compton scattering effects using the following stripping equations, viz.

$$n_{k,k} = (n_t(\alpha\gamma - \beta) \quad + n_u(a\beta - \gamma) \quad + n_k(1 - a\alpha))/K$$
$$n_{u,u} = (n_t(g\beta - \alpha) \quad + n_u(1 - b\beta) \quad + n_k(b\alpha - g))/K$$
$$n_{t,t} = (n_t(1 - g\gamma) \quad + n_u(b\gamma - a) \quad + n_k(ag - b))/K$$

where K is given by

$$K = 1 - g\gamma - a(\gamma - g\beta) - b(\beta - \alpha\gamma).$$

The single subscripts are counts corrected for background, and the double subscripts indicate the Compton corrected result.

The stripping coefficients, α,β,γ,a,b and g were calculated from test pad measurements made at NGU in May 1992 and are as follows:

$\alpha = 0.246$	A = 0.055
$\beta = 0.364$	B = 0.0
$\gamma = 0.741$	G = 0.0

and are characteristic of a system with very good signal processing. Data are then corrected for atmospheric attenuation to an effective height of 250 feet (76.2) meters using the following attenuation coefficients supplied with the system:

Channel	Attenuation
Total Count	0.0072
Potassium	0.0085
Uranium	0.0082
Thorium	0.0061

where the attenuation is the exponential rate of decay per meter. Atmospheric Compton scattering of energy from one channel into another is neglibable at survey altitude is negligable and not considered.

The NGU spectrometer has not been calibrated into effective ppm radioelement concentrations, so data are presented as a count rate in each window.

Grids of the profile data were made with an Akima spline interpolation technique using processing software acquired from Aerodat Ltd., a method which is not recommended by the IAEA due to inherent statistical variations in the data. The preferred technique is one where grid values are computed from a weighted average of all points lying within a circular area.

Once the data were gridded, they were then smoothed with a Hanning filter (to remove the statistical variation mentioned above), contoured and coloured as described in NGU report 91.256.

TABLE 1

Background variation at 1000 feet

Average count rates over 20 seconds on EM background lines

FLIGHT 2

TIME	TOTAL	U	K	Th
10:44:50.0	216.78	9.70	21.13	6.19
11:03:30.0	188.94	10.03	20.06	4.96
11:22:00.0	269.22	11.27	28.18	8.09
11:36:40.0	239.47	8.81	23.76	6.58
11:55:00.0	188.66	9.36	19.06	4.40
12:17:00.0	205.78	8.81	18.73	5.07
12:39:10.0	200.86	9.20	18.90	5.91
13:01:10.0	234.39	8.87	23.48	6.30

FLIGHT 3

TIME	TOTAL	U	K	Th
14:22:50.0	205.34	8.64	18.90	5.91
14:41:40.0	161.00	6.07	16.99	4.46
15:01:00.0	182.80	8.19	17.00	4.68
15:22:40.0	234.57	6.81	24.60	6.36
15:40:30.0	191.48	8.08	20.01	5.63
15:58:20.0	189.84	7.19	18.51	5.74
16:13:40.0	205.13	7.97	19.63	5.07
16:31:30.0	251.84	8.82	24.55	5.19
16:38:20.0	251.99	8.37	26.23	6.42

Map Products

Data from both areas were processed at 1:10000 and 1:20000 scales. Because of the size of the maps at 1:10000 scale, both areas were divided into two parts (a north part and a south part) and these parts were plotted as separate, but overlapping maps.

Copies of these maps at about 1:40000 scale are included in Appendix A, and originals are available from NGU on request.

Discussion

Three radiometric maps were produced for each of the Cabardsjåkka and Reidnjajavri areas, one for each radioelement window. Comparisons with results of the 1986 helicopterborne survey of the area (NGU report 86.054) shown that both contained the same major trends. Furthermore, the uranium map was used by Sandstad et al (1992) for follow-up ground work and led to the discovery of Davidite associated with a break in the conductors: a potential area for mineralization. However, the source of many airborne uranium anomalies could not be found on the ground.

Attempts to generate radioelement ratio maps proved to be disappointing, and lack of suitable background measurements is a likely culprit. The radiometric component of the survey was carried out only with the intention of producing a total count map, and field procedures were sufficient to produce one: background and system gain errors, unless extreme, only have a marginal effect on the final product. Gain errors will mostly affect the upper end of the energy spectrum where the accumulated offset in channel energies is largest; however the contribution of specific channels to the total count there is small. Background variations, due for example to variation in atmospheric radon, are usually small relative to the total count and so are also not important in a total count survey.

The radioelement maps included in Appendix B are certainly satisfactory in that major features mapped during a prior survey are duplicated. What is unclear is how much better the maps could have been had the data been acquired with the intention of producing radioelement maps.

Attempts to produce radioelement ratio map were not successful. Such products are sensitive to background corrections and drifts in system gain. An incorrect background where the count rate is low can lead to drastic changes in the ratio. Gain drift can also lead to appreciable radioelement ratio errors if significant part of the photopeak drift are displaced from their windows. In this case, the most likely cause is that background has not been sufficiently well determined.

In order to successfully map radioelement concentrations and ratios, as a minimum backgrounds should be measured before and after every flight and the system gain and resolution should be checked and recorded daily. Because the Kautokeino area is flat, cosmic corrections were not important, since the cosmic effect could be treated as a constant background effect. The aircraft background component of this correction can be determined from flights over open (fresh) water.

References

Geometrics, 1977: Model GR-800 multichannel gamma-ray spectrometer. Geometrics Ltd.

IAEA, 1991: Airborne gamma-ray spectrometer surveying. Tech. Reports Series No. 323, Vienna

Mogaard, J.O. and Skilbrei, J.R., 1986: Geofysiske målinger fra helikopter over kartbladene Kautokeino, Lappoloubbal, Seibe og Agiet, Finnmark fylke. Unpubl. NGU Report 86.054

Sandstad, J.S., Bjørlykke, A., Olesen, O. and Nilsen, K., 1992: Vurdering av malmpotensialet etter samtolkning av geodata i deler av Kautokeinogrønnsteinsbeltet, Finnmark. NGU report 91.255

Walker, P., 1992, Operation and calibration of the NGU airborne spectrometer. NGU report 92.315

Walker, P., 1991: Helicopter geophysical survey in Finnmark. NGU report 91.256

Appendix A

General Interpretive Considerations

Radiometrics: The dominant contribution to total count is from the uranium, thorium and potassium channels, although it is possible that trace amount of artificial isotopes can make acontribution, although their effects are generally small. Hence total count can generally be considered to be a linear combination of the three radioelement channels.

Count rate in a radiometric channel is proportional to the concentration of radiomentric sources, but is strongly attenuated by vegetation, snow cover, water and soil cover. Hence the total count channel to a large degree reflects the amount of exposed bedrock or rock fragments. It is possible to encounter radioactive soils, for example weathered uranium bearing schists or thorium bearing sands, but in general such sources are rare so total count is dominantly a measure of unshielded rock.

Uranium, thorium and potassium are often accessory minerals to certain kinds of mineralization, so radioelement maps are often of interest in mineral prospecting. Uranium is an accessory mineral in certain gold, phosphorous and fluorite deposits. Thorium is often associated with rare earths in pegmatites, and can be of importance in gold, tin and base metal exploration. Potassium anomalies can be the result of potassium alteration related. However, the amplitudes of such radioelement anomlies are as much affected by exposure as by the concentrations of the radioelement themselves: An exposed area with low radioelement concentration can produce a radiomentric anomaly as large or larger than a poorly exposed area with high concentration.

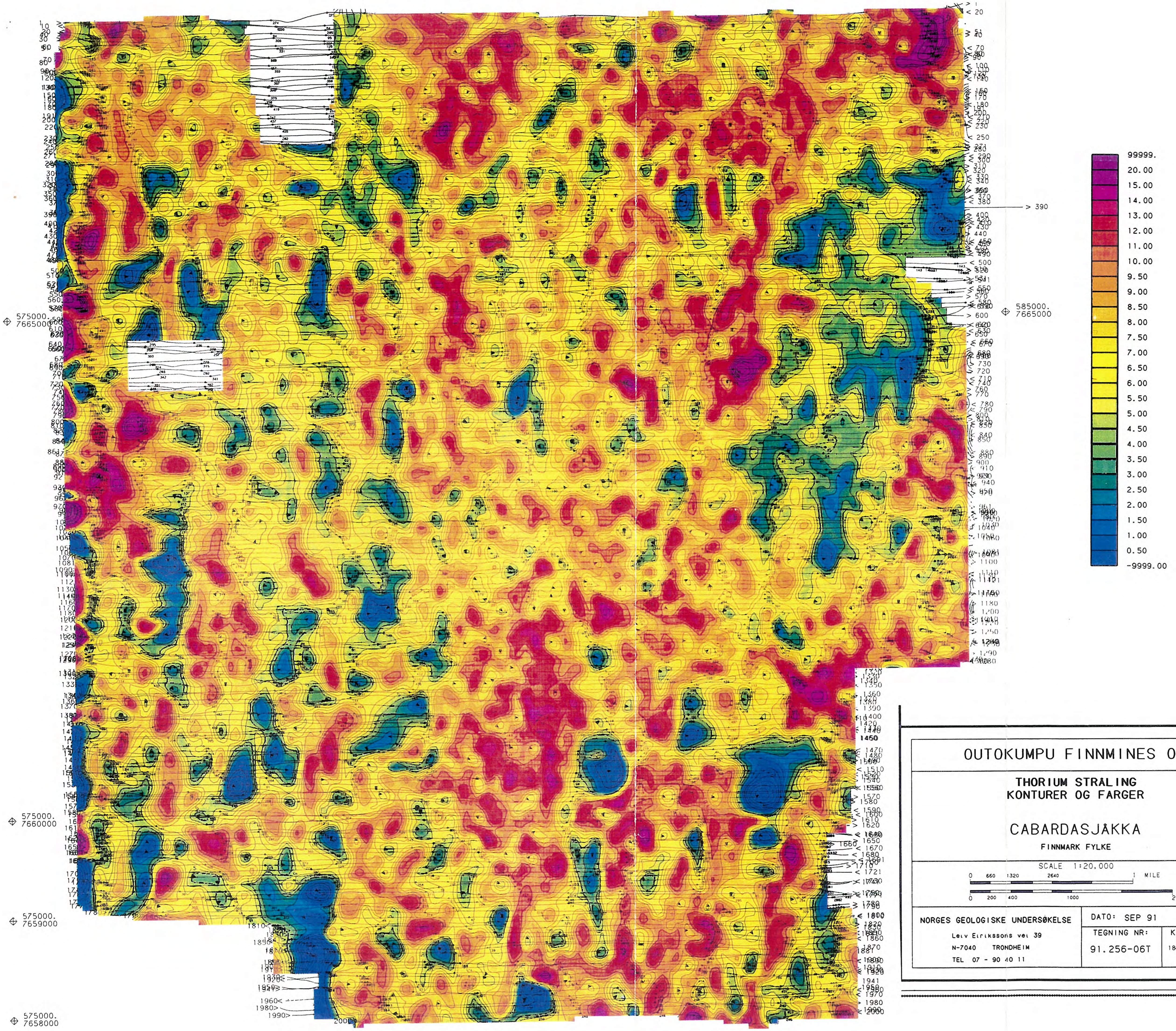
A common technique for reducing the sensitivity of a radioelement map to exposure is to produce a radioelement ratio map. If the sources are assumed to lie under the same amount of cover, each will be attenuated by roughly the same amount, so dividing one by the other will normalize both signals. Ratio maps have been successfully used to map differing lithologies, and to distinguish subtle geochemical variations within units identified as having a single lithology. Uranium-thorium ratio maps have been used to discriminate granophile mineralizations.

Ratioing the channels above the potassium peak at 1.36 MeV to the ones below it gives information on the burial depth of the source. A low ratio, indicating proportionally high Compton scattering, may indicate a source buried more deeply in the ground than a high ratio. Clearly this is useful for ground follow up work.

Since the radiometric method is directly related to lithogeochemistry, techniques such as factor and cluster analysis have been successfully applied to bedrock mapping.

Appendix B

This appendix contains photographically reduced copies of the uranium, thorium and potassium maps at 1:40,000 scale for the Cabardsjåkka and Reidnjajavri areas.



OUTOKUMPU FINNMINES OY

THORIUM STRALING
KONTURER OG FARGER

CABARDASJAKKA

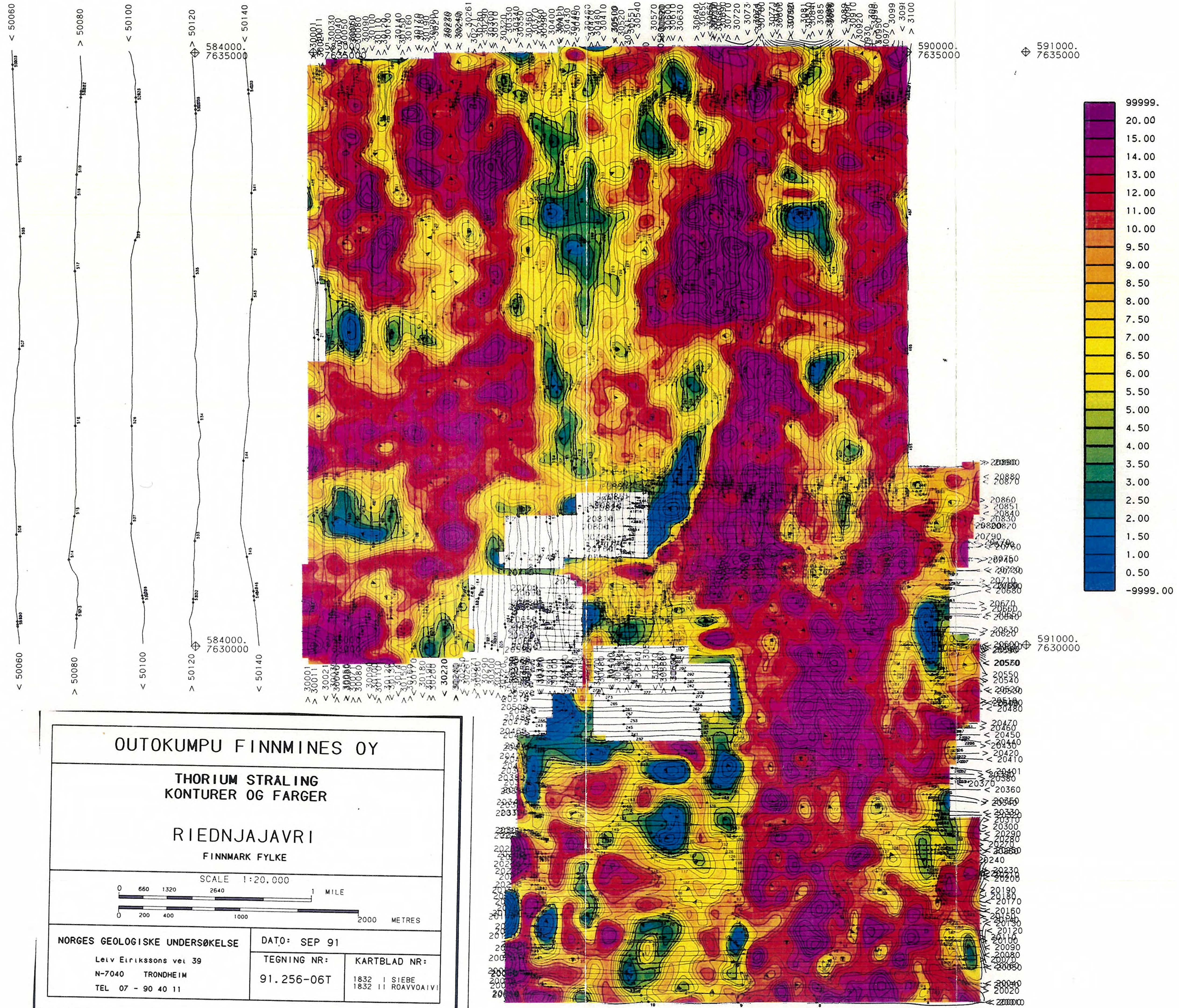
FINNMARK FYLKE

SCALE 1:20.000

0 660 1320 2640 1 MILE

0 200 400 1000 2000 METRES

NORGES GEOLOGISKE UNDERSØKELSE Leiv Eirikssons vei 39 N-7040 TRONDHEIM TEL 07 - 90 40 11	DATO: SEP 91 TEGNING NR: 91.256-06T	KARTBLAD NR: 1833 II KAUTOKEINO



OUTOKUMPU FINNMINES OY

THORIUM STRÅLING
KONTURER OG FARGER

RIEDNJAJAVRI

FINNMARK FYLKE

SCALE 1:20.000

0 660 1320 2640 1 MILE

0 200 400 1000 2000 METRES

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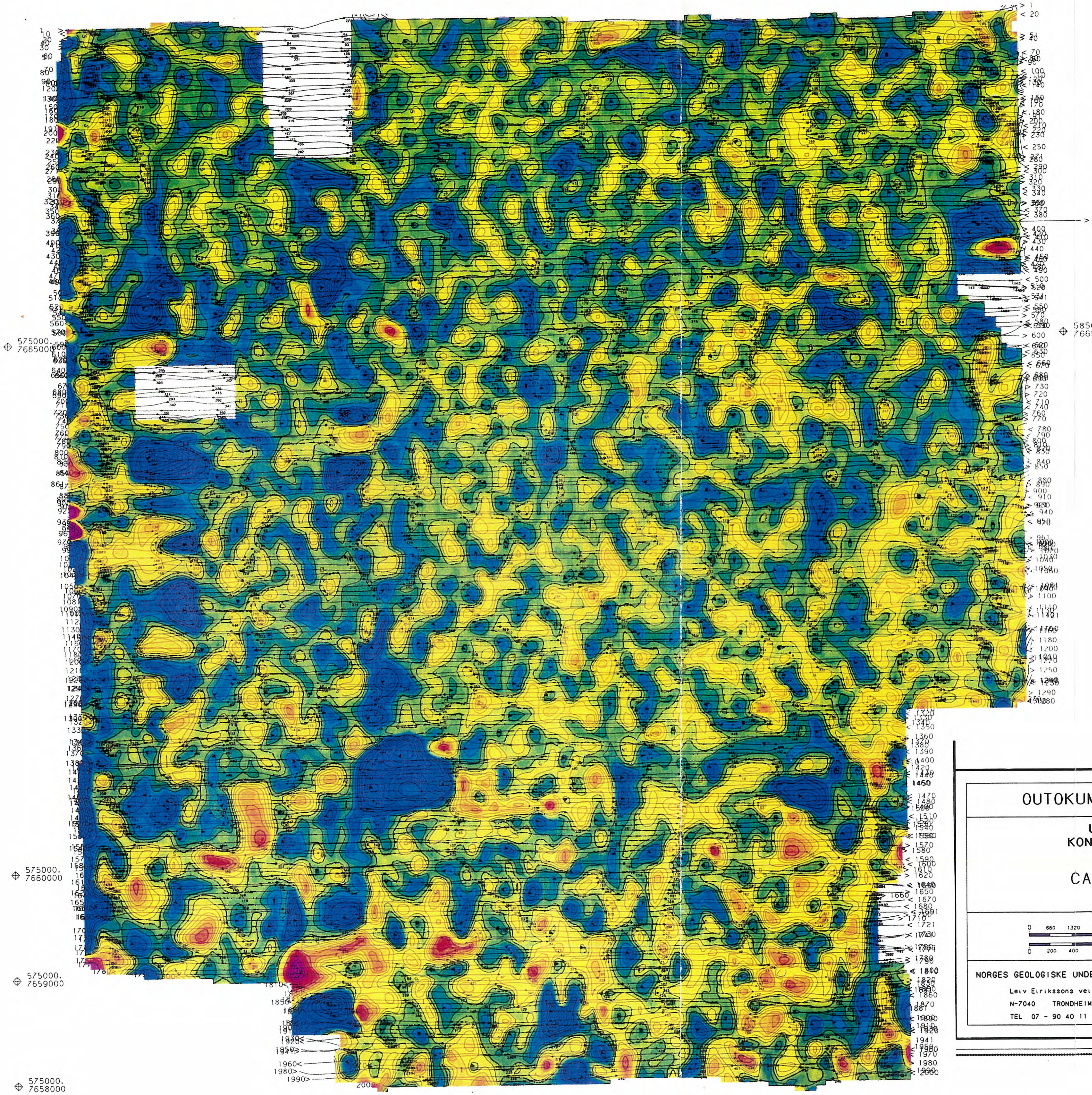
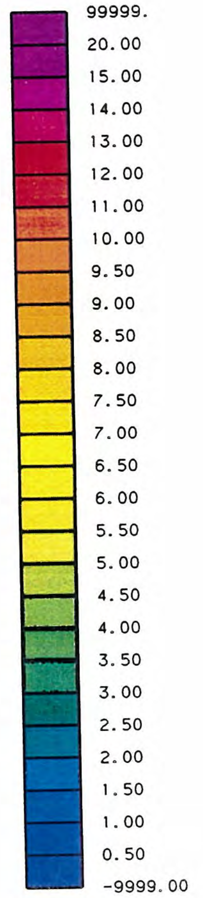
TEL 07 - 90 40 11

DATO: SEP 91

TEGNING NR: 91.256-06T

KARTBLAD NR: 1832 I SIEBE, 1832 II ROAVVOAIVI





OUTOKUMPU FINNMINES OY

URAN STRALING
KONTURER OG FARGER

CABARDASJÅKKA

FINNMARK FYLKE

SCALE 1:20.000

0 660 1320 2640 1 MILE

0 200 400 1000 2000 METRES

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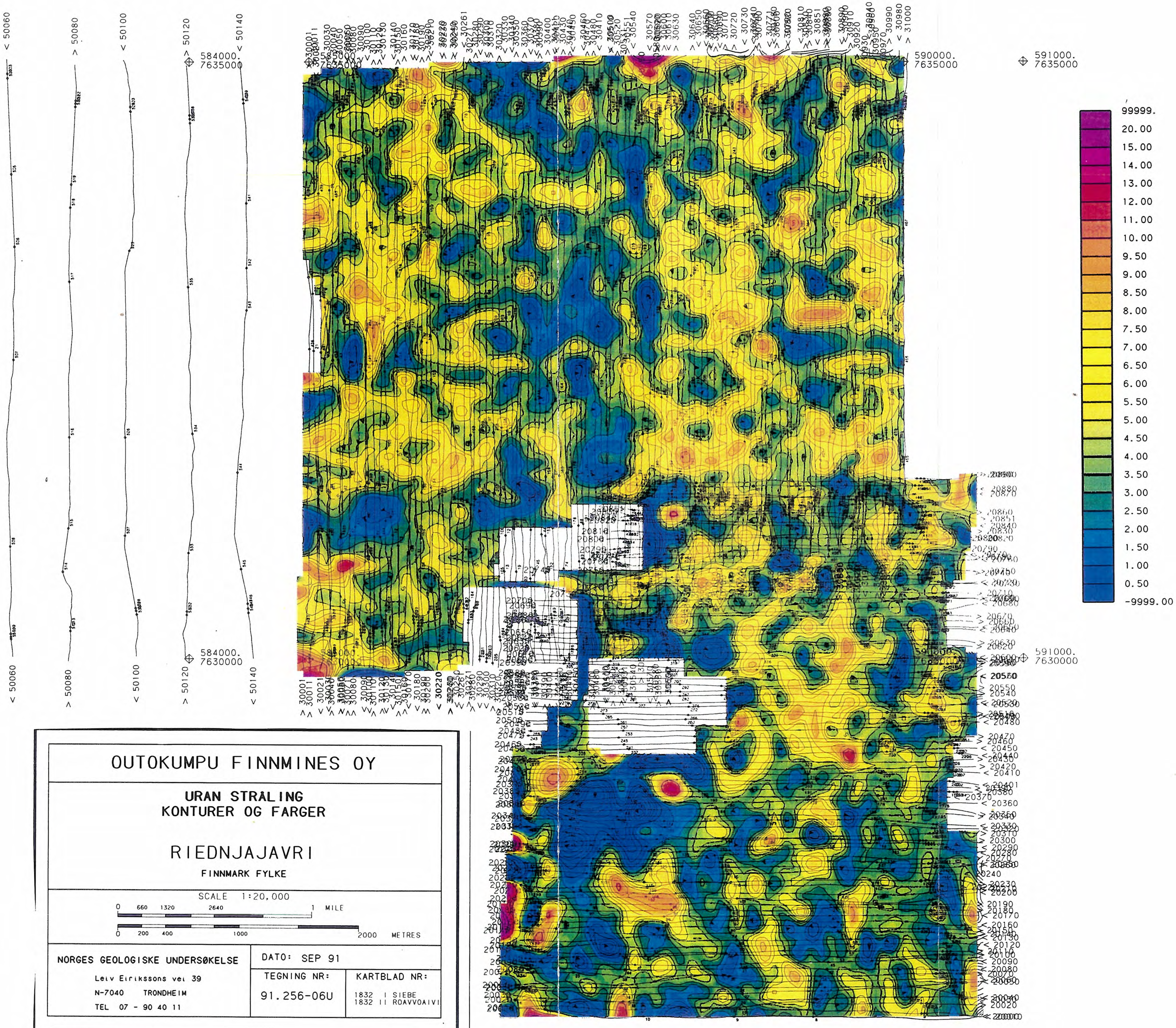

OUTOKUMPU FINNMINES OY

URAN STRALING
KONTURER OG FARGER

RIEDNJAJAVRI

FINNMARK FYLKE

SCALE 1:20,000

0 660 1320 2640 1 MILE

0 200 400 1000 2000 METRES

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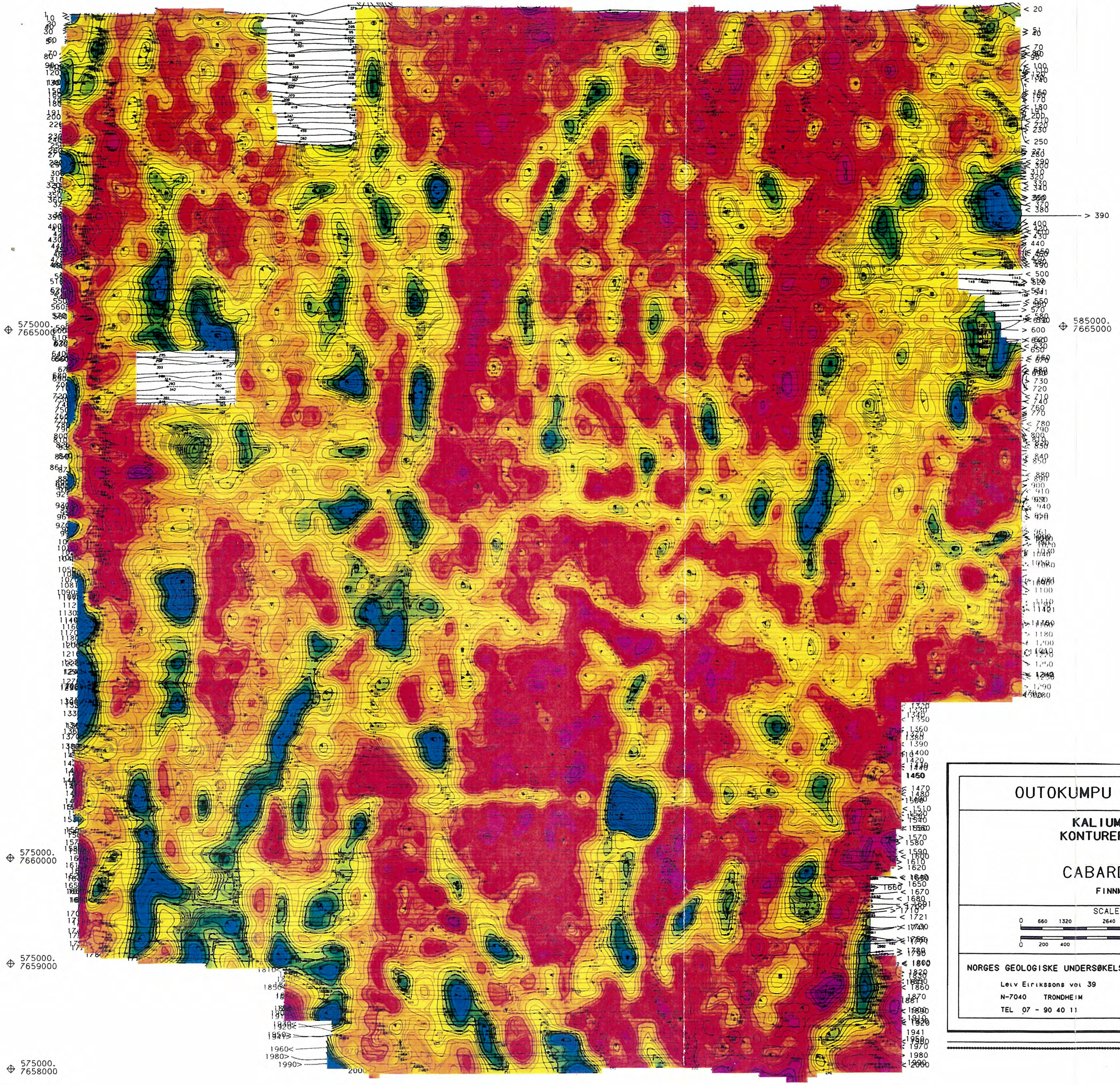

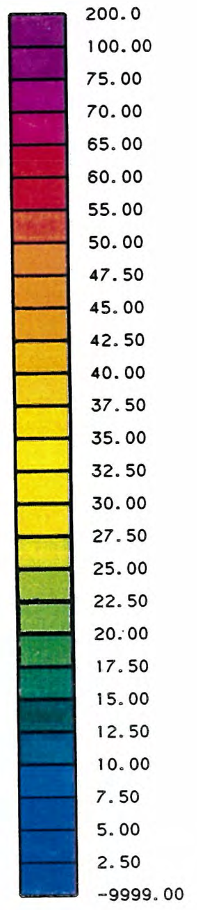

OUTOKUMPU FINNMINES OY

KALIUM STRÅLING
KONTURER OG FARGER

CABARDASJÅKKA

FINNMARK FYLKE

SCALE 1:20,000

0 660 1320 2640 1 MILE

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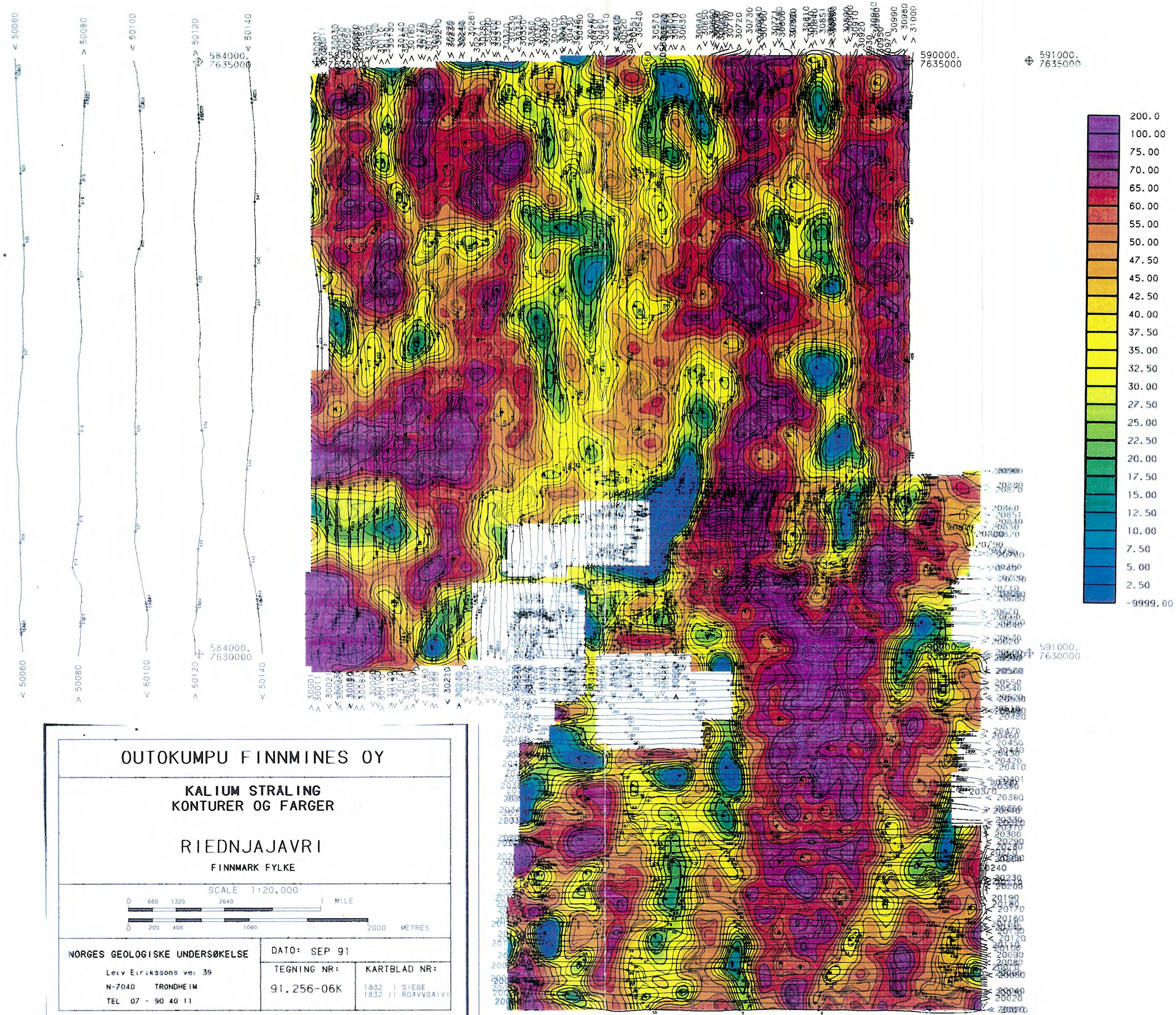

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