DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2009/42

Spectral Core Gamma Log for Blokelv-1 Well, GGU 511101

Contribution to Petroleum Geological Studies, Services and Data in East and Northeast Greenland

Dan Olsen & Niels Schovsbo

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

G E U S

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2009/42

Spectral Core Gamma Log for Blokelv-1 Well, GGU 511101

Contribution to Petroleum Geological Studies, Services and Data in East and Northeast Greenland

Dan Olsen & Niels Schovsbo

Confidential report

Copy No.

Released 01-07-2025

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE END ENERGY

G E U S

Table of Contents

1. Introduction

This report presents the results of a spectral gamma and bulk density scanning of core sections from the well GGU 511101, Northeast Greenland. The well is informally referred to as the Blokelv well. The work was conducted by request of the GEUS project "Petroleum Geological Studies, Services and Data in East and Northeast Greenland". The core was drilled in the summer of 2008 and the experimental work presented here was conducted at GEUS Core Laboratory between 21st October 2008 and 25th November 2008. Mr. Morten Bjerager, GEUS, was contact person for the laboratory during the project.

Preliminary data of the core scanning were delivered to the project by e-mail on 27th October 2008, 6th November 2008, 11th November 2008, 2nd December 2008 and 11th May 2009. The data in the present report supersedes these preliminary data.

2. Analytical procedure

The Blokelv core was received as 1 meter sections wrapped in alumina foil. With intervals of approximately 2 meters in the depth direction, the core contained a metal can with a piece of core preserved inside. Each metal can had a length in the depth direction of 10 cm. With intervals of approximately 2 meters in the depth direction, the core contained a depth marking in the shape of a piece of wood with a written number that indicates the depth at that point in meters. The core diameter was measured at several places along the core to be 5.55 cm ± 0.1 cm. The 1 meter core sections were packed in flat plastic boxes, each holding 4 core sections. The core boxes were marked with top depth and bottom depth. Appendix A gives a listing of the core boxes and depth markings.

A total of 232 meters of core were scanned. The cores were in good condition, with recovery close to 100%. A large majority of the core length presented a full diameter, cylindrical core to the scanner. The fundamental requirement of the scanning procedure, that the scanned material is cylindrical, was therefore fulfilled for a large majority of the cores. Disintegrated sections were very rare. The bulk density log trace gives a good indication of the quality of the core: core sections where significant parts of the core are missing have bulk density traces with large amplitude variations and minimum bulk density readings below 2.2 g/ml.

The core sections were scanned with the spectral gamma and bulk density scanner of GEUS Core Laboratory. The core sections were scanned sequentially with the core sections being fitted together to present the scanner to a continuous core slowly passing the detectors of the scanner. The core sections were scanned without removing the alumina foil because the alumina foil prevented the cores from falling apart. However, the alumina foil wrapping was opened along the upper side of the core so that the gamma rays of the density scanner only penetrated the alumina foil layer along the lower part of the core. It is estimated that the thin foil had a negligible effect on both the gamma activity and the measured bulk densities, except at the ends of the core sections. At the ends of every core section several layers of alumina foil were present that caused a gap of 0.5 to 1.0 cm between the termination of one core section and the beginning of the next. This created a small attenuation of the spectral gamma activity, and also caused a biased bulk density signal at the core section ends.

Scanning was performed with a speed of 1 cm/min with read-out of the collected gamma and density data every 60 seconds. The spectral gamma data have intrinsically a low signal-to-noise ratio. To improve the readability of the gamma log the spectral gamma data were smoothed with a boxcar filter with a bandwidth of 10 cm. This procedure removes little spatial information from the data as the gamma scanner has a depth resolution of approximately 17 cm. The bulk density data were not smoothing, because these data intrinsically have a high signal-to-noise ratio and a depth resolution of approximately 1 cm. Therefore, smoothing is not necessary.

Filtering of the density data was done in order to remove the large amplitude variations caused by missing to crushed core or from gaps between the termination of one core section and the beginning of the next. The filtering was preformed in a way that the original high signal-to-noise ratio and depth resolution of approximately 1 cm is preserved.

The calculation of the K, U and Th concentrations assumes a bulk density of 2.4 g/ml. This value is determined as the mean value for the upper envelope of the bulk density log trace. More details of the analytical methods are presented in Chapter 3.

The Blokelv core was partially water saturated during the spectral gamma and bulk density scanning. A total of 7 core pieces were weighed before scanning, after scanning, and finally after drying in an oven at 60 ºC for at least 70 hours. The oven drying reduced the bulk density of the core pieces with 0.00–0.20 g/ml. Assuming a grain density of 2.65 g/ml for 3 core pieces of clean sandstone further indicated that these core pieces were nearly 100% saturated with water when they were scanned. These findings indicate that the spectral gamma and bulk density results of the present report pertain to a water saturated core.

The scanning was conducted in two runs, identified as Run A and Run B, each beginning with a calibration of the scanner. The cores of box numbers 1 to 31 were scanned in Run A and the cores of box number 31 to 63 were scanned in Run B. The cores of Box 31 were scanned in both Run A and Run B, and therefore, constitutes a repeat section with information about reproducibility. Information about the repeat section and other information about accuracy and reproducibility are presented in Chapter 4.

The spectral gamma log and the bulk density log are presented as follows:

1) on a single A4 sheet at scale 1:100 in Enclosure 1
2) on a single A3 sheet at scale 1:700 in Enclosure 2
3) on 20 A3 sheets at scale 1:50 in Enclosure 3.1 to 3.20

Electronic versions of the results of this report are present on the attached CD. See Chapter 5 for a list of electronic files.

3. Analytical methods

3.1. Spectral core gamma scanning

The natural gamma radiation of a core is recorded within an energy window of 0.5 - 3.0 MeV, using Tl activated NaI scintillation detectors, connected to a multichannel analyzer.

The core passes through a lead shielded tunnel at constant speed while the gamma activity is continuously recorded. For the Blokelv scanning a speed of 1 cm/min was used throughout the scanning, with data read-out every 1 minute, resulting in data points with 1 cm spacing. Nominally, each data point represents the mean gamma activity over a 1 cm depth interval, the assigned depth being the middle of the interval. Actually, the scintillation detectors record the gamma activity in a broader section of the core. The sensitivity profile in the depth direction of the core has approximately the shape of a gauss-function with a Full Width at Half Maximum (FWHM) of approximately 17 cm. The measured gamma activity is corrected for background gamma activity.

To improve the readability of the logs, the raw data were filtered with a box-car filter with a bandwidth of 10 cm. The smoothing causes a slight deterioration of the sensitivity profile in the depth direction to approximately 19 cm FWHM, still with an approximate gauss-shape.

Total gamma activity is reported in counts per second (cps). Bore-hole logs are usually reported with gamma activity in GAPI units traceable to the calibration facility known as the API pit at the University of Houston in Texas. The following empirical relationship has been established between GAPI units and the cps (counts per second) unit reported for total gamma activity on the GEUS core gamma scanner. The relationship is not certified and should be used only as a rough guideline:

$$GAPI = cps * (10/d)^2 * 3.3 \qquad \text{Eq. 3.1.1}$$

where d is the nominal core diameter in cm.

For the Blokelv core scanning Equation 3.1.1 becomes

$$GAPI = cps * 10.7 \qquad \text{Eq. 3.1.2}$$

Radiation from decay of potassium and the uranium and thorium decay series are recorded in separate energy windows. Concentrations are calculated using synthetic standards of concrete doped with known amounts of radioactive minerals in decay equilibrium. Concentrations of K, U and Th are reported as % K, ppm U and ppm Th, respectively. Relevant ratios are given. Concentrations are calculated on the assumption that decay equilibrium is established for both the thorium and uranium decay series. This is generally assumed to be true for geological samples (Schlumberger: Log interpretation principles/applications, Schlumberger Educational Services, 1991).

Because a concentration is the mass ratio between the mass of the element of concern and the total mass being analyzed, the calculation of a concentration requires knowledge of the mass being analyzed. For the spectral core gamma log this knowledge is provided by assuming a constant bulk density for the core. The value 2.4 g/ml was selected because the bulk density log indicates this value as the mean bulk density for the whole core. In principle, the bulk density measured for each data point along the log could be used for calculating concentrations. However, a significant part of the measured bulk density values are biased by missing core material, fractures, and the presence of alumina foil or metal cans. Therefore, a fixed bulk density value was chosen as basis for the concentration calculation, rather than a measured but potentially erroneous value.

The processing of the spectral core gamma data assumes that the core has a constant diameter. Core sections where this assumption does not hold have concentrations that are systematically biased. If core material is missing, the calculated concentration values are too low.

3.2. Bulk density scanning

The measurement of core bulk density is based on the attenuation of gamma rays passing through the core. The gamma rays come from a 30 mCi ^{137}Cs radioactive source emitting photons of energy 662 keV. A collimated beam of gamma rays with a diameter of 0.8 cm passes through the core and is recorded by a NaI scintillation detector.

At the scanning, the core passes the gamma ray source and detector assembly at a constant speed while the gamma ray attenuation is continuously recorded. The density scanning was conducted contemporaneously with the gamma scanning and therefore the scanning speed of 1 cm/min that applies for this operation also applies for the density scanning. Similarly, a read-out interval of 1 cm was used for the density scanning. However, the density data were not box-car filtered because the reproducibility of the density data was so good that smoothing was not necessary.

The processing of the bulk density data assumes that the core has a constant diameter. Core sections where this assumption does not hold have densities that are systematically biased. If core material is missing, the resulting density values are too low.

Filtering of the density data was done in order to remove the large amplitude variations caused by missing core, crushed core or from gaps between the termination of one core section and the beginning of the next. The filtering was performed in a way that the original high signal-to-noise ratio and the depth resolution of approximately 1 cm are preserved.

The density log includes data measurements with a spacing of approximately 1 cm. This totals of about 23 300 data points. Minimum bulk density readings below 1.5 g/ml was prior to the filtering removed from the data since these low values clearly reflects measurements of gaps.

The principle in the filtering process is a comparison of a running average measure of the data and the data itself. Step 1 in the filtering was to establish a running average measurement calculated in a 5 sample point window according to

$$Ravgi = \frac{\sum di + di \pm 1 + di \pm 2}{n} \qquad \text{Eq.3.2.1}$$

where *di* is the data value in depth *i* and *n* is the number of data measurement in the 5 point data window. The number of real data in the 5 sample point window may vary from 5 to 0, depending on the number of missing values.

Step 2 was the actual filtering part and was done according to

$$Ravgi - di \leq 0.1 g / ml \qquad \text{Eq.3.2.2}$$

The data, *di*, with a difference above 0.1 g/ml was removed from the data set by replacing it with the symbol '-999999', which is the missing value identifier in the present work. It should be noted that since the filtering according to Eq. 3.2.2 is only one sided then density measurements heavier than 0.1 g/ml compared to the average value is not filtered away.

Step 1 and 2 was repeated 5 times giving a total of 5 filtering runs. The efficiency of each filtering run was monitored by comparing the number of data measured removed in the run. Only a very small number of data measurements were removed in the last two filtering runs.

In three selected intervals comparison was made between core photos and density logs of the unfiltered, filtering run 3 and filtering run 5 in order to validate the filtering procedure. In all cases the filtering was found to have been focused on only the intentioned cases: crushed sections and low density spikes generated by gaps between core pieces. It has been noted in a few cases that high density spikes have been removed by the filtering. This has e.g. been observed for density spikes at 196.59 m (up to 3.8 g/ml) and at 177.18 m (up to 3.2 g/ml). The filtered and the unfiltered density data are shown in the accompanying logs.

3.3. Depth assignment

The depth list of Appendix A is the basic input to the depth assignment procedure.

The Blokelv core was scanned with a constant speed of 1 cm/min. The actual length of every core section in its scanning position was recorded, as well as the position of the section top and section bottom relative to the detectors of the scanner. Using this information every data point were assigned a laboratory depth relative to the top of the core. Because the lengths of core sections during scanning were not necessarily equal to the nominal lengths of the sections, the laboratory depth relative to the top of the core could not be converted to true core depth by simple translation. For every core section a rubber-band depth conversion were applied according to

$$CoreDepth(I, J) = Top(J) + (I - 0.5) * Increment * \frac{Bottom(J) - Top(J)}{Length(J)} \qquad \text{Eq.3.3.1}$$

where *CoreDepth(I,J)* is the depth assigned to data point no. *I* in core section no. *J*, *Top(J)* and *Bottom(J)* are the nominal depth of top and bottom from Appendix A, *Increment* is the depth interval between data points, and *Length(J)* is the length of section *J* during scanning. Additional minor corrections were applied to data point where the data collection had occurred across sections borders.

The depths assigned by the depth assignment procedure have an uncertainty relative to section borders of approximately 1 cm. The uncertainty may be estimated from the repeat section, cf. Fig. 4.1.

4. Reproducibility and accuracy

Reproducibility is defined as the ability to repeat a given determination. In this report reproducibility is reported at the 2σ level, indicating that a given determination with a probability of 95% will deviate less than the given reproducibility value from the mean value of many determinations.

Accuracy is defined as the closeness of a given determination to the true value.

4.1. Spectral gamma data

At the beginning of scanning Run A and scanning Run B the scanner was calibrated with the aid of 3 standards manufactured from concrete doped with known amounts of K, U and Th. The standards are identified as Ka1, Ua1, and Ta1. The U and Th of the standards stem from specimens of minerals known to be in decay equilibrium. The background radiation was determined by measuring on a scanner set-up without any core material. The latter set-up is technically treated as a fourth calibration standard identified as Tt1.

The calibration procedure yields information about reproducibility that is presented in Table 4.1. The reproducibility values have been scaled from the diameter of the standards, which is 10 cm, to the diameter of the cores, which is 5.55 cm. The reproducibility is given for the smoothing that was applied to the log data, i.e. a box-car filter with N=10. Reproducibility is dependent on the concentration of the elements, therefore Table 4.1 gives reproducibility values both for concentrations close to LLD (lower limit of detection) and for high concentrations. The actual concentrations where the reproducibilities were measured are given in Table 4.1. Because of mutual interference between the signals being measured, a high concentration for one of the elements will influence the reproducibility of the other two elements.

Table 4.1 gives the reproducibility for both Run A and Run B. Within the statistical uncertainty the reproducibilities for the two runs are indistinguishable.

Table 4.1. Reproducibility (2σ level) @ concentration
Based on standards Ka1, Ua1, Ta1, Tt1, and Ba1

	K (%)		U (ppm)		Th (ppm)	
Run A:						
Reproducibility close to LLD	0.12	@ 0.5	1.5	@ 1.0	1.4	@ 1.0
Reproducibility at high concentration	0.4	@ 4.2	4	@ 50	5	@ 90
Run B:						
Reproducibility close to LLD	0.11	@ 0.5	1.6	@ 1.0	1.5	@ 1.0
Reproducibility at high concentration	0.3	@ 4.2	4	@ 50	4	@ 90

Table 4.2. Deviation from known concentration @ known concentration
Based on standard Ba1

	K (%)		U (ppm)		Th (ppm)	
Run A:						
Deviation @ concentration	0.09	@ 0.25	0.7	@ 0.5	0.8	@ 0.6
Run B:						
Deviation @ concentration	0.08	@ 0.25	0.9	@ 0.5	0.7	@ 0.6

Accuracy has been determined from measurements on a single standard manufactured from concrete doped with known amounts of K, U and Th. It is identified as standard Ba1. This standard is similar to the calibration standards but is not part of the calibration procedure. The results for standard Ba1 are given in Table 4.2. The table gives the actually determined deviations from the known concentrations. For all elements the deviations of Table 4.2 are 50 to 75% of the 2σ-reproducibilities at LLD given in Table 4.1. This indicates that close to LLD the accuracy of the work is similar to the reproducibility.

4.2. Total gamma activity data

The reproducibility of the total gamma activity data is dependent on the count-rate. Table 4.3 gives the reproducibility at 2σ level for the actual count-time of 60 seconds, and data smoothing with a box-car filter with N=10.

Table 4.3. Reproducibility of total gamma activity

Count rate (cps)	Reproducibility (cps)
1.0	0.082
2.0	0.116
4.0	0.165
10.0	0.260
20.0	0.368
40.0	0.521

4.3. Bulk density data

The bulk density scanner was calibrated with a procedure with two calibration end-points. The instrument was calibrated to yield a density of 0 g/ml when no core was present in the gamma ray path and the value 7.96 g/ml when a cylindrical standard of steel was present in the gamma ray path, 7.96 g/ml being the density of the steel. The diameter of the steel cylinder was 10 cm, and all measurements on core material with a different diameter are corrected for the resulting difference in absorption of the gamma rays.

The reproducibility of the bulk density determinations was calculated from sections of the log at the beginning and end of Run A and Run B where no core was present. At all occasions the reproducibility of replicate determinations was below 0.01 g/ml. A determination of the

Table 4.4 Comparison of bulk density determined by conventional methods and by density scanning.

	Conventional bulk density determination (g/ml)	Determination by density scanning (g/ml)	Deviation (g/ml)
Run A			
Section 59.82-59.94 m	2.352 ± 0.03	2.396 ± 0.010 (N=11)	+0.044
Section 83.30-83.50 m	2.794 ± 0.04	2.794 ± 0.027 (N=7)	+0.000
Section 95.20-95.64 m	2.381 ± 0.02	2.388 ± 0.041 (N=42)	+0.007
Section 116.32-116.58 m	2.288 ± 0.03	2.290 ± 0.031 (N=25)	+0.002
Mean deviation, Run A (density scanning – conv. determination)			+0.013
Run B			
Section 116.32-116.58 m	2.288 ± 0.03	2.291 ± 0.040 (N=25)	+0.003
Section 145.95-146.18 m	2.345 ± 0.02	2.380 ± 0.020 (N=21)	+0.035
Section 190.68-190.88 m	2.439 ± 0.03	2.435 ± 0.039 (N=19)	-0.004
Section 210.37-210.62 m	2.521 ± 0.02	2.518 ± 0.041 (N=24)	-0.003
Mean deviation, Run B (density scanning – conv. determination)			+0.008

Lithology:
Box 16-3 section 59.82-59.94 m: homogeneous sandstone
Box 22-4 section 83.30-83.50 m: sandstone-shale with high U contents
Box 26-1 section 95.20-95.64 m: cross-bedded sandstone
Box 31-3 section 116.32-116.58 m: homogeneous sandstone
Box 39-3 section 145.95-146.18 m: shale
Box 51-3 section 190.68-190.88 m: sandstone with minor shale, contents of salt
Box 56-4 section 210.37-210.62 m: shale, contents of salt

reproducibility on a steel cylinder with density 7.96 g/ml gave a reproducibility of 0.045 g/ml for Run A and 0.042 g/ml for Run B. The latter two figures include the contribution from any inhomogeneities in the steel as the determination was conducted while the steel cylinder was scanned at a speed of 1 cm/min.

For 7 core sections, the bulk density was determined by an independent method: By weighing and volume determination with a caliper. The resulting bulk densities together with the results from the bulk density scanning are presented in Table 4.4. The maximum deviation between the two types of bulk density determination is 0.04 g/ml with a typical deviation being 0.01 g/ml.

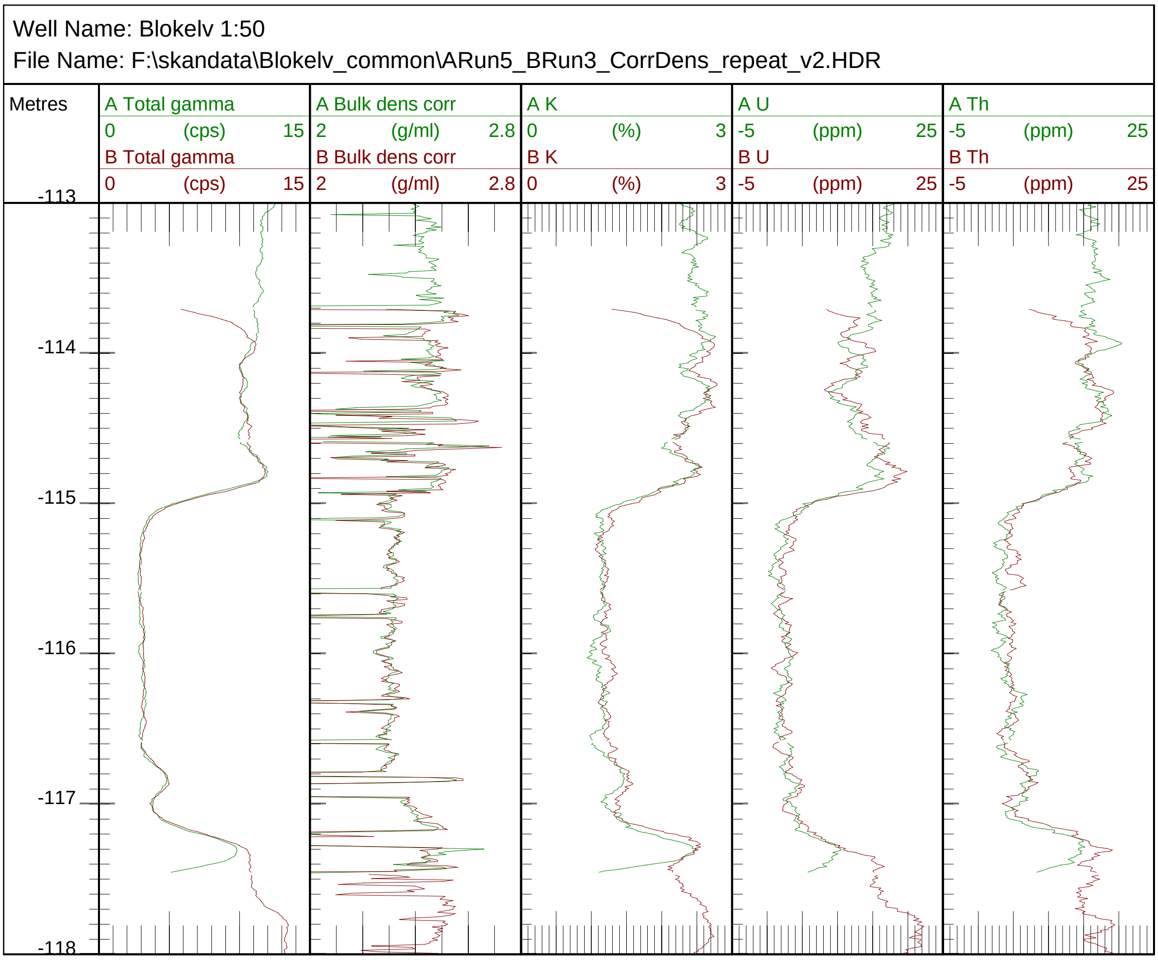


Fig. 4.1. Repeat section. Core box no. 31 scanned in Run A in green line, and the same section scanned in Run B in brown line.

4.4. Repeat section

Core box no. 31 was scanned both in Run A and in Run B, and provides a determination of the overall reproducibility of the scanning procedure, including the uncertainties pertaining to loading the scanner, and depth assignment. Fig. 4.1 presents a log of the repeat section.

Table 4.5. Reproducibility of repeat section, mean absolute deviation between Run A and Run B for core Box no. 31, depth interval 113.90 m to 117.25 m. The total number of repeat determinations is 346 with a depth spacing of 0.0097 m.

	Total gamma activity (cps)	Bulk density (g/ml)	K (%)	U (ppm)	Th (ppm)
Mean deviation	0.190	0.089	0.104	1.29	1.28
Deviation recalculated to 2σ reproducibility	0.279	0.126	0.147	1.82	1.81

Table 4.5 presents the mean absolute deviation between the determinations of Run A and Run B within the repeat section, the total number of paired determinations being 346.

For the spectral gamma data, the reproducibilities of Table 4.5 agree with the data of Table 4.1 and 4.3, being an independent check of the reproducibility.

For bulk density, the reproducibility of the repeat section is inferior to the results given in Table 4.4. This is undoubtedly caused by the core sections with missing material, where small inaccuracies in the alignment of the depth of the two parts of the repeat section results in large deviations of the measured bulk densities.

5. Documentation

Attached to this report is a CD that contains the following documentation:

1. File Blokelv_CoreScanning_GEUS_2009_42_v1.las with results of the bulk density and spectral gamma scanning in LAS 2.0 format. Data have been re-sampled by the program ViewLog 3.0.93 to a depth interval of 0.1 m.
2. File Blokelv_BulkDensity_GEUS_2009_42_v1.prn with results of the bulk density scanning in GEUS Core Laboratory's format with non-constant depth interval of approximately 0.01 m. ASCII text with space as data delimiter.
3. File Blokelv_SpectralGamma_GEUS_2009_42_v1.prn with results of the spectral gamma scanning in GEUS Core Laboratory's format with non-constant depth interval of approximately 0.01 m. ASCII text with space as data delimiter.
4. File Blokelv_CoreLog_s1000_GEUS_2009_42_v1.emf with a core-log in scale 1:1000 in Enhanced Meta-file format. Same file in pdf-format (*.pdf).
5. File Blokelv_CoreLog_s700_GEUS_2009_42_v1.emf with a core-log in scale 1:700 in Enhanced Meta-file format. Same file in pdf-format (*.pdf).
6. 20 files Blokelv_CoreLog_s50_<x>_GEUS_2009_42_v1.emf, where <x> takes the values 0, 1, 2, ... 20, with core-logs in scale 1:50 of 12-meter depth intervals. File format is Enhanced Meta-file. Same files in pdf-format (*.pdf).
7. File FinalReport_GEUS_2009_42_v1.pdf with the present report in pdf-format.

In the txt-files, missing data are indicated by the value "-999999".

Appendix A Box list

	Top Depth (m)	Bottom Depth (m)	Core length (m)
Box 1	1.72	5.51	3.79
Box 2	5.51	9.33	3.82
Box 3	9.33	13.12	3.79
Box 4	13.12	16.81	3.69
Box 5	16.81	20.56	3.75
Box 6	20.56	24.23	3.67
Box 7	24.23	27.80	3.57
Box 8	27.80	31.60	3.80
Box 9	31.60	35.25	3.65
Box 10	35.25	38.98	3.73
Box 11	38.98	42.80	3.82
Box 12	42.80	46.53	3.73
Box 13	46.53	50.23	3.70
Box 14	50.23	53.80	3.57
Box 15	53.80	57.61	3.81
Box 16	57.61	61.22	3.61
Box 17	61.22	65.00	3.78
Box 18	65.00	68.77	3.77
Box 19	68.77	72.32	3.55
Box 20	72.32	76.25	3.93
Box 21	76.25	80.00	3.75
Box 22	80.00	83.80	3.80
Box 23	83.80	87.60	3.80
Box 24	87.60	91.35	3.75
Box 25	91.35	95.20	3.85
Box 26	95.20	98.80	3.60
Box 27	98.80	102.45	3.65
Box 28	102.45	106.13	3.68
Box 29	106.13	109.85	3.72
Box 30	109.85	113.70	3.85
Box 31	113.70	117.46	3.76
Box 32	117.46	121.20	3.74
Box 33	121.20	124.90	3.70
Box 34	124.90	128.56	3.66

Continues ...

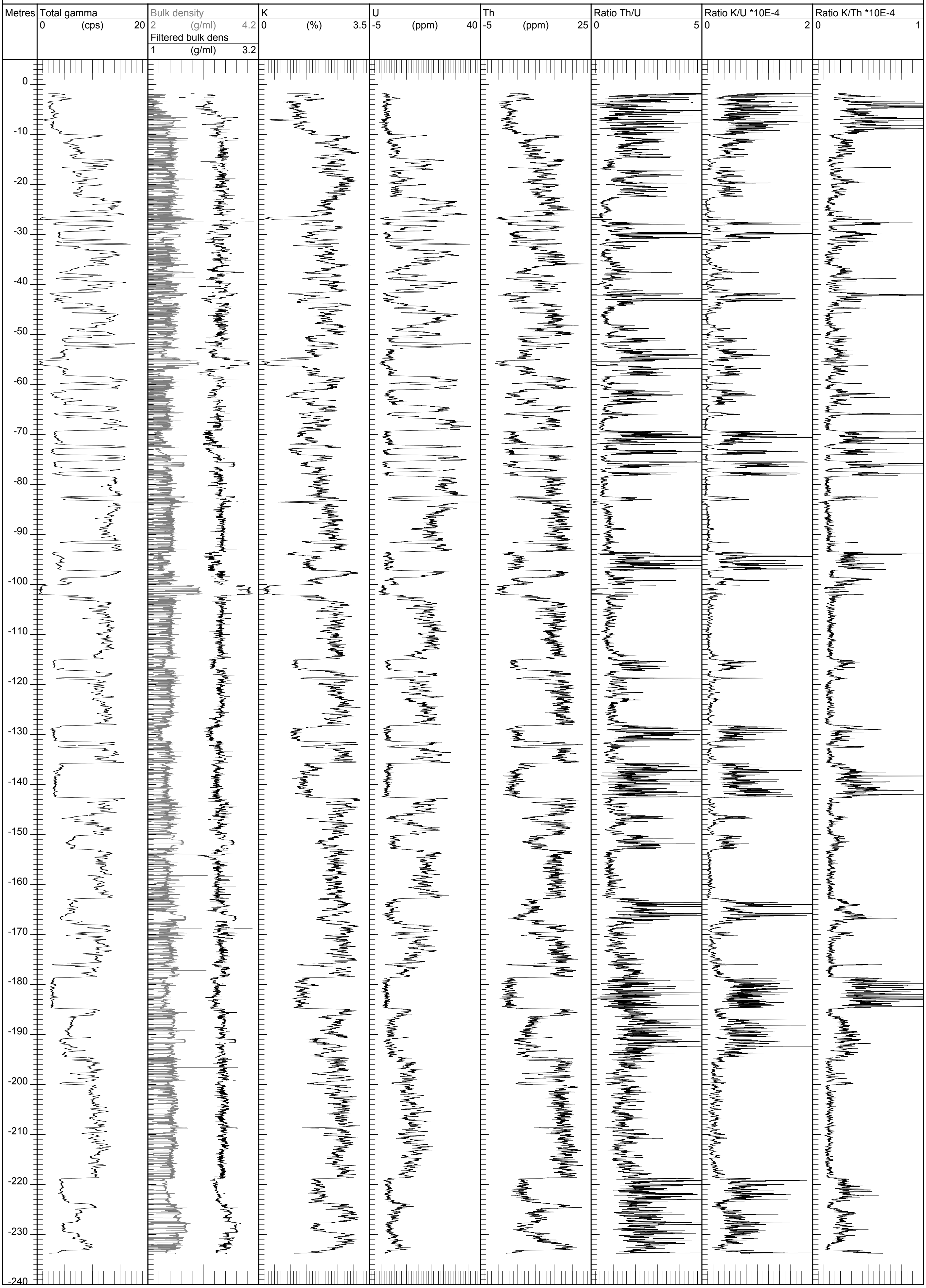
... Continued

	Top Depth (m)	Bottom Depth (m)	Core length (m)
Box 35	128.56	132.21	3.65
Box 36	132.21	135.90	3.69
Box 37	135.90	139.64	3.74
Box 38	139.64	143.35	3.71
Box 39	143.35	146.97	3.62
Box 40	146.97	150.79	3.82
Box 41	150.79	154.56	3.77
Box 42	154.56	158.26	3.70
Box 43	158.26	161.94	3.68
Box 44	161.94	165.66	3.72
Box 45	165.66	169.35	3.69
Box 46	169.35	173.04	3.69
Box 47	173.04	176.72	3.68
Box 48	176.72	180.33	3.61
Box 49	180.33	184.07	3.74
Box 50	184.07	187.95	3.88
Box 51	187.95	191.75	3.80
Box 52	191.75	195.40	3.65
Box 53	195.40	199.17	3.77
Box 54	199.17	202.90	3.73
Box 55	202.90	206.80	3.90
Box 56	206.80	210.62	3.82
Box 57	210.62	214.42	3.80
Box 58	214.42	218.25	3.83
Box 59	218.25	222.07	3.82
Box 60	222.07	225.84	3.77
Box 61	225.84	229.66	3.82
Box 62	229.66	233.40	3.74
Box 63	233.40	233.80	0.40

GEUS Report 2009/42 Enclosure 1

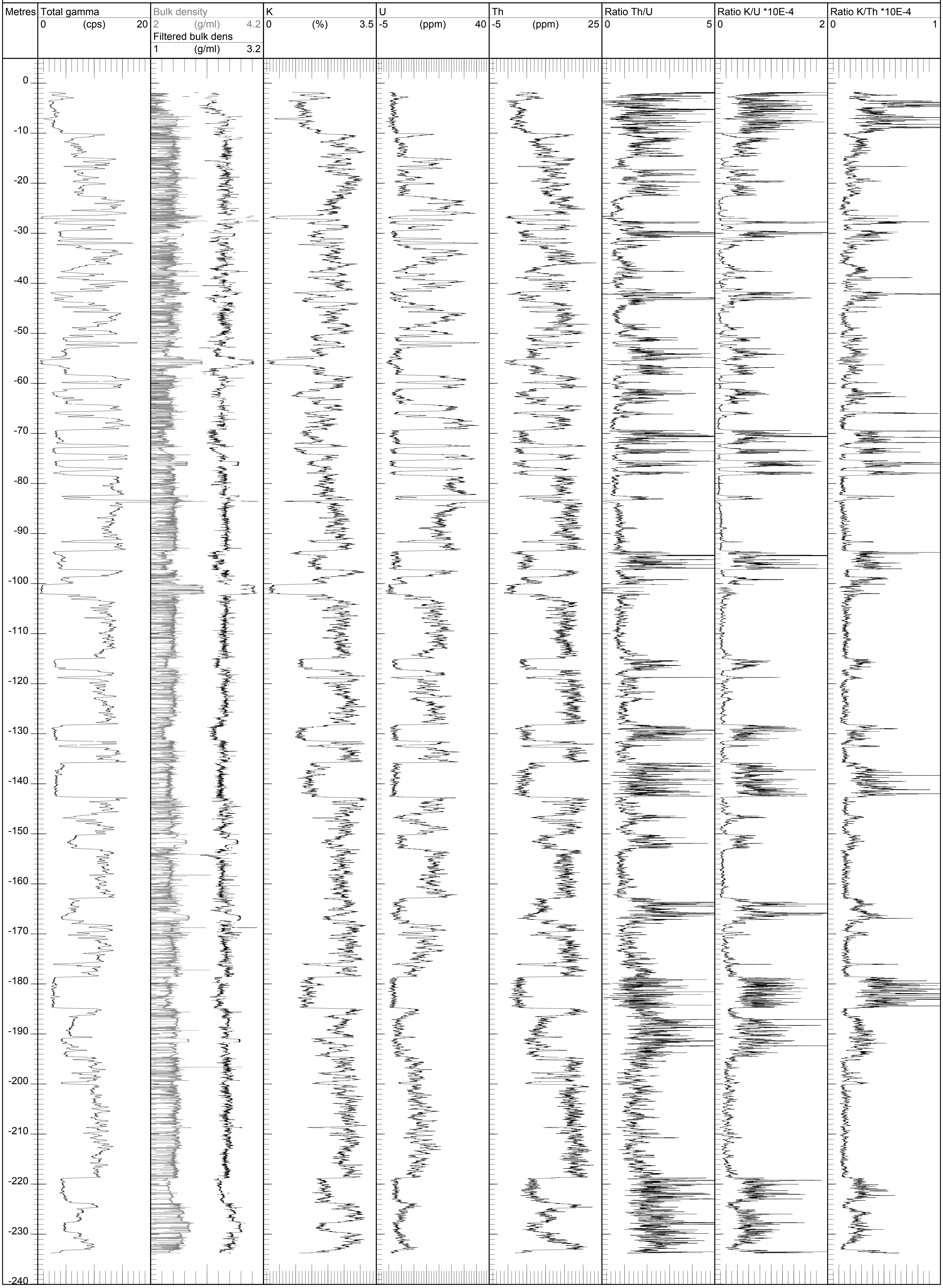
Well Name: Blokelv GGU 511101, scale 1:1000
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s1000.HDR

Off-scale peak at 83.52 m with Total gamma peak at 53.9 cps and U peak at 170.5 ppm.

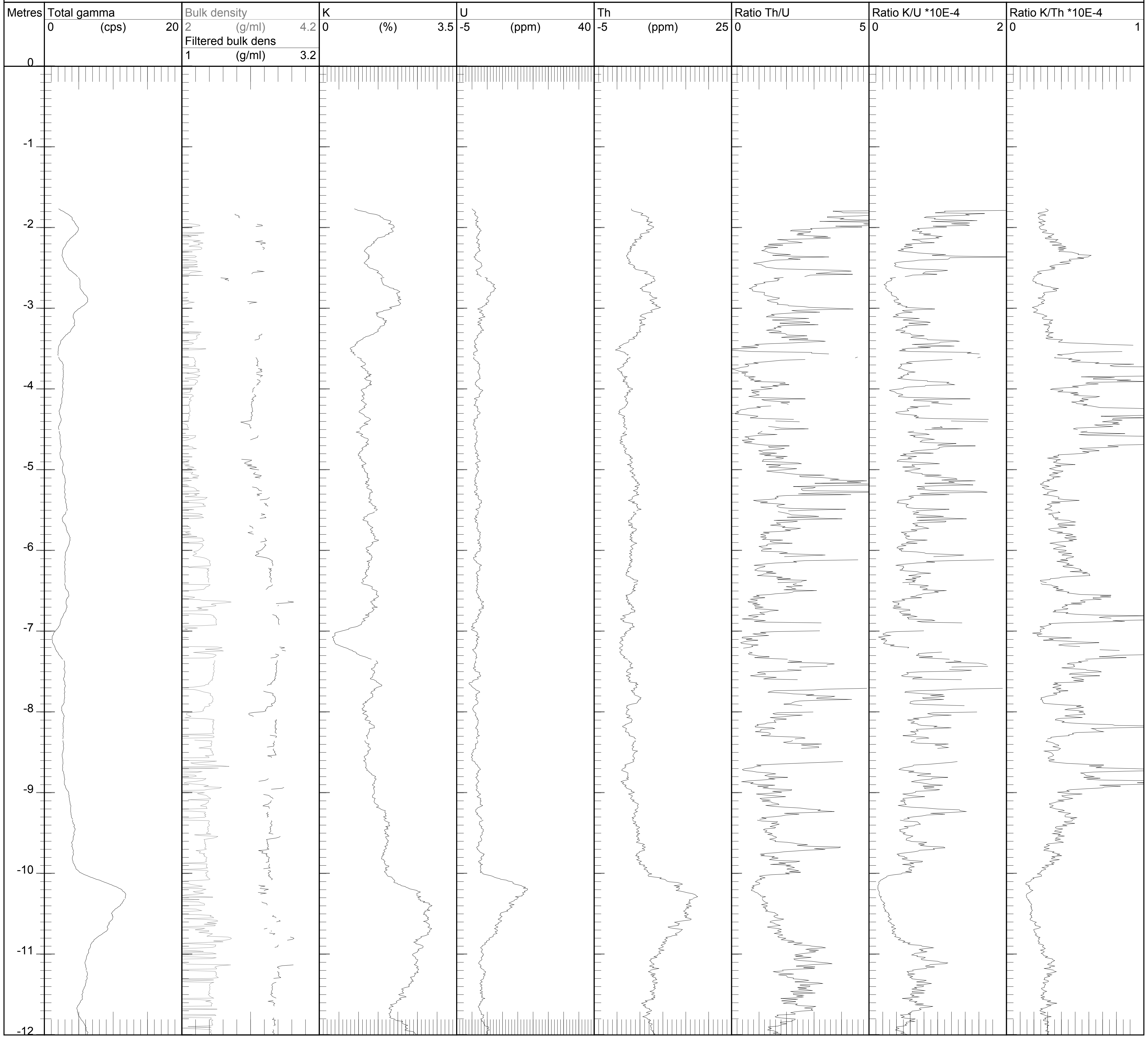


Well Name: Blokelv GGU 511101, scale 1:700
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s700.HDR

Off-scale peak at 83.52 m with Total gamma peak at 53.9 cps and U peak at 170.5 ppm.

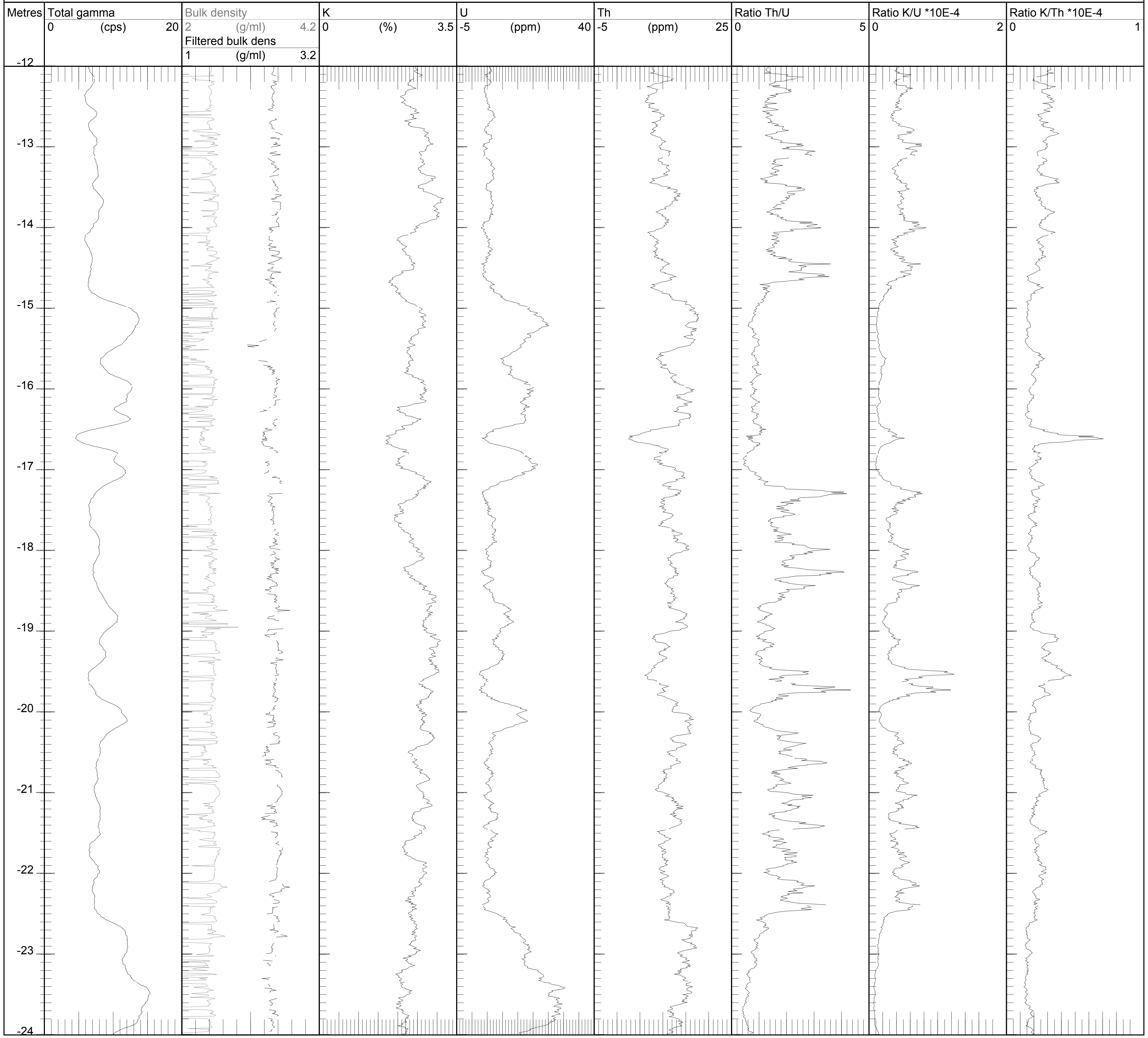


Well Name: Blokelv GGU 511101, scale 1:50, page 1/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_1.HDR

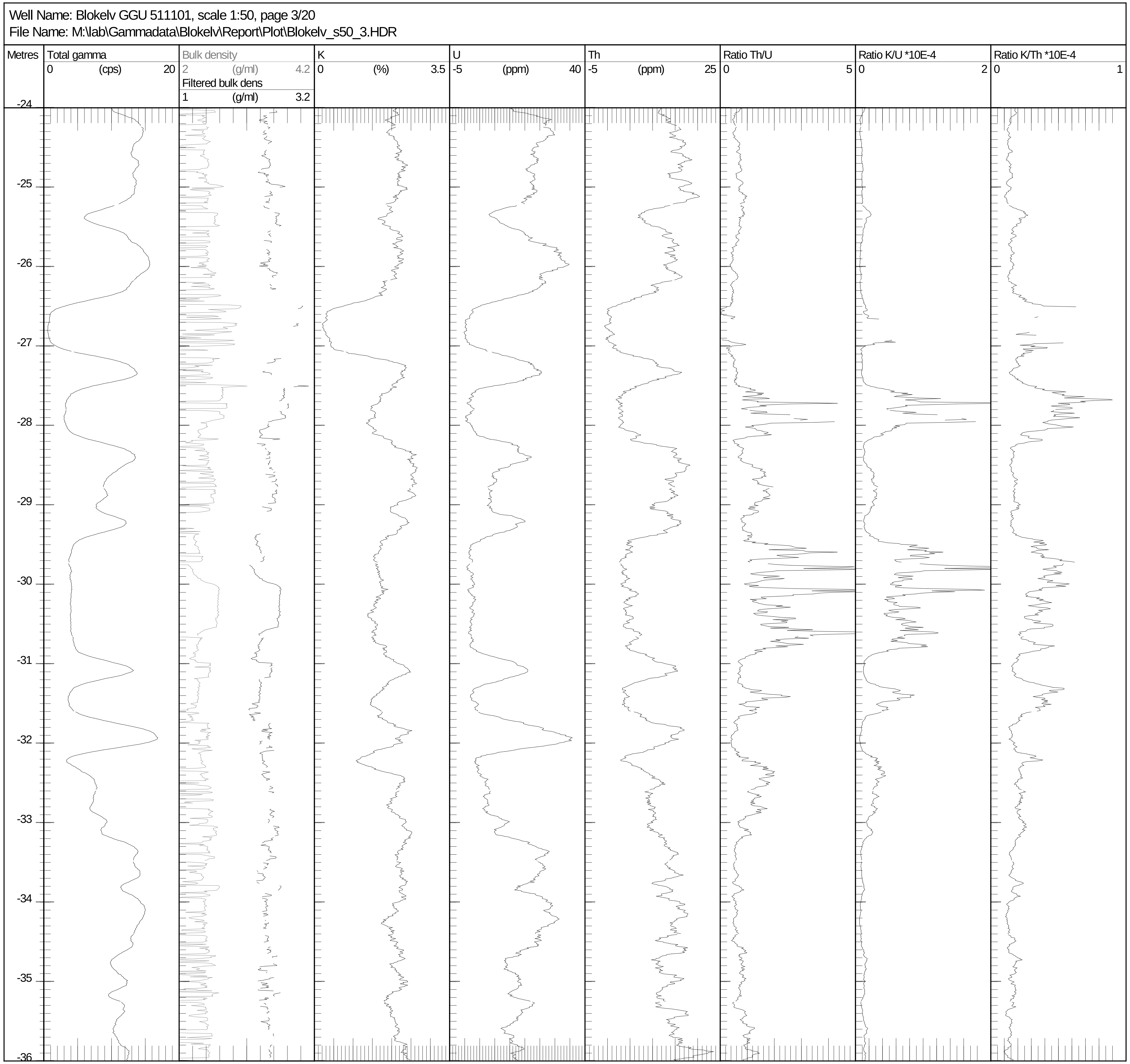


GEUS Report 2009/42
Enclosure 3.2

Well Name: Blokelv GGU 511101, scale 1:50, page 2/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_2.HDR

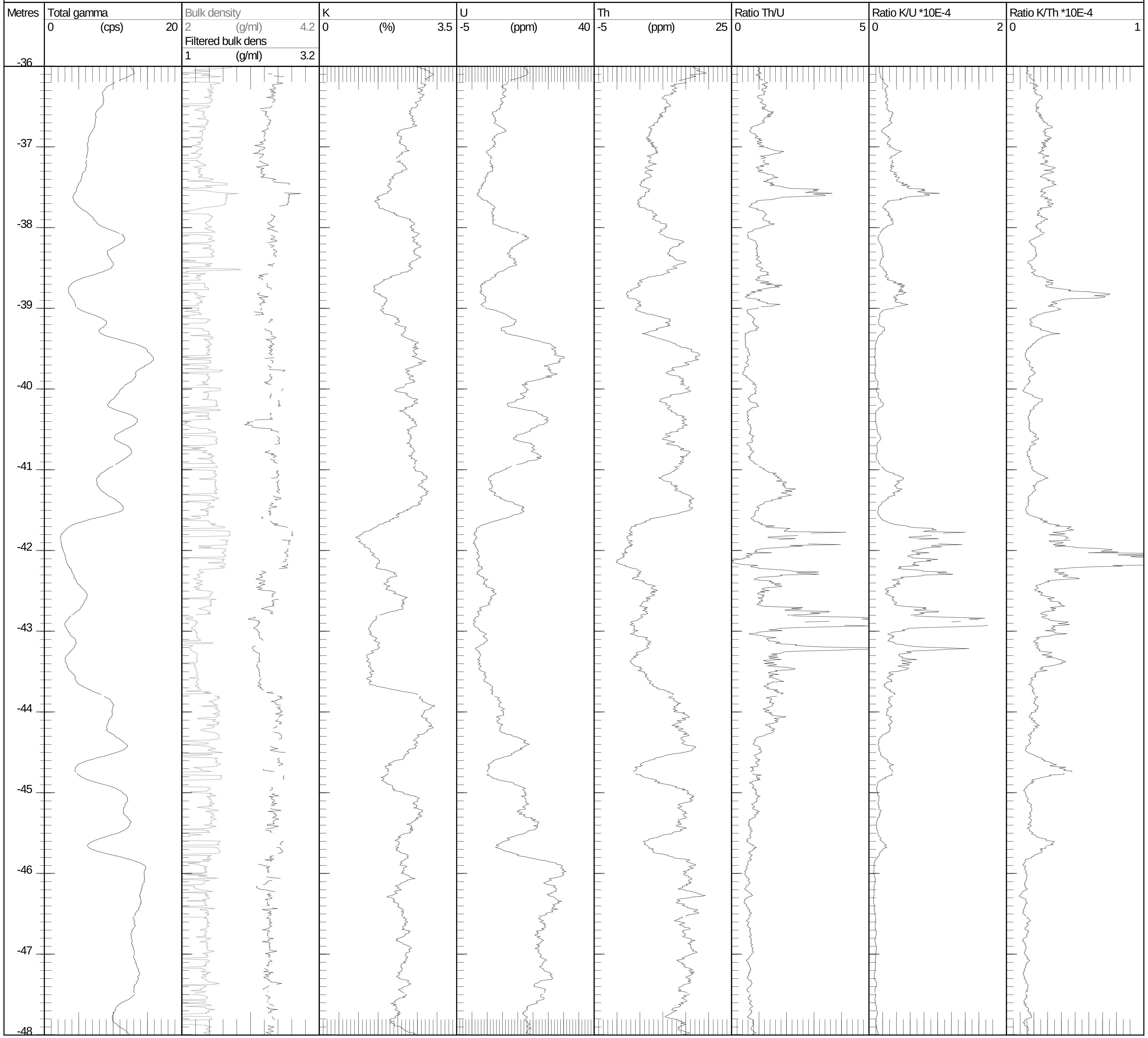


GEUS Report 2009/42
Enclosure 3.3

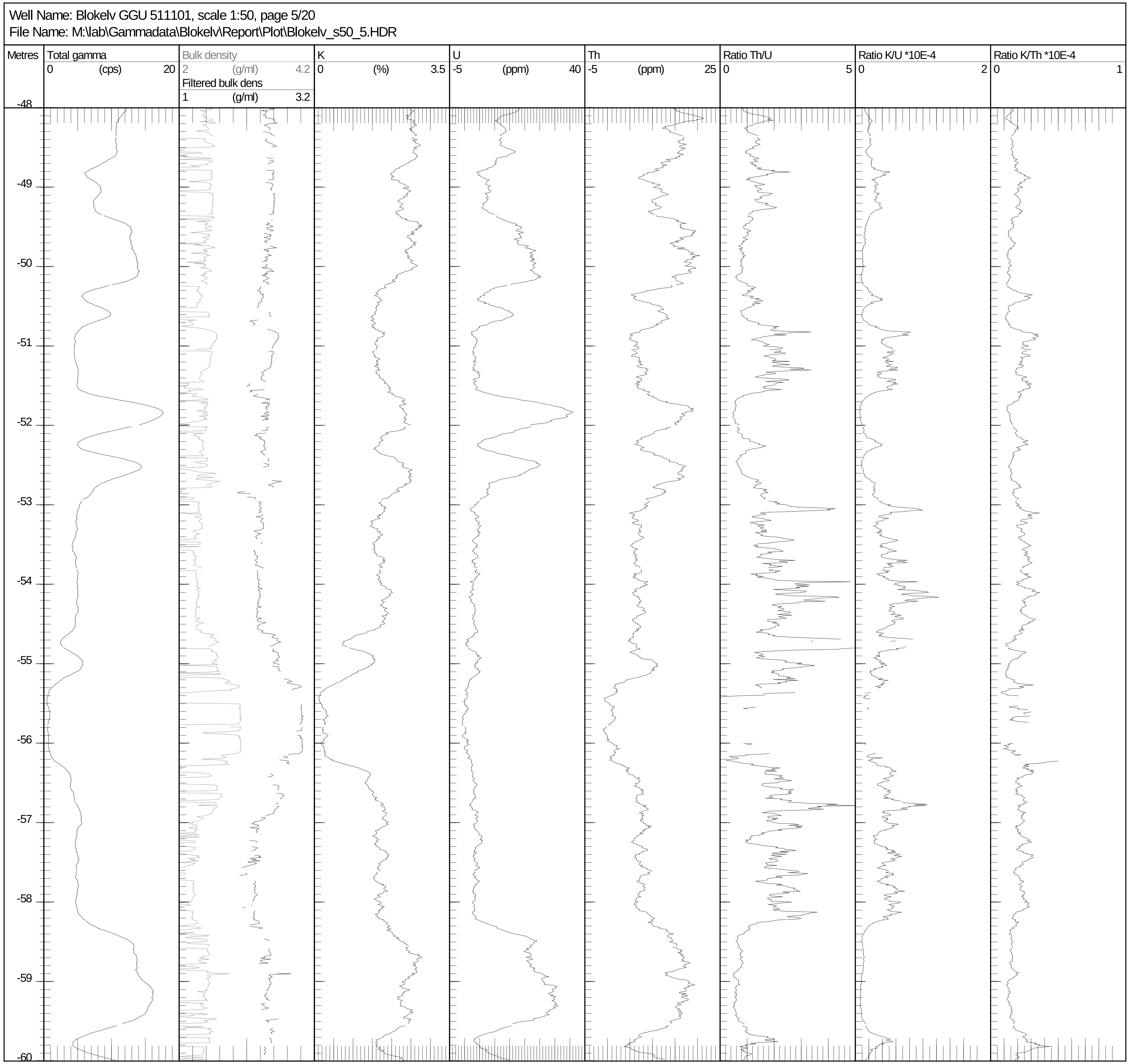


GEUS Report 2009/42
Enclosure 3.4

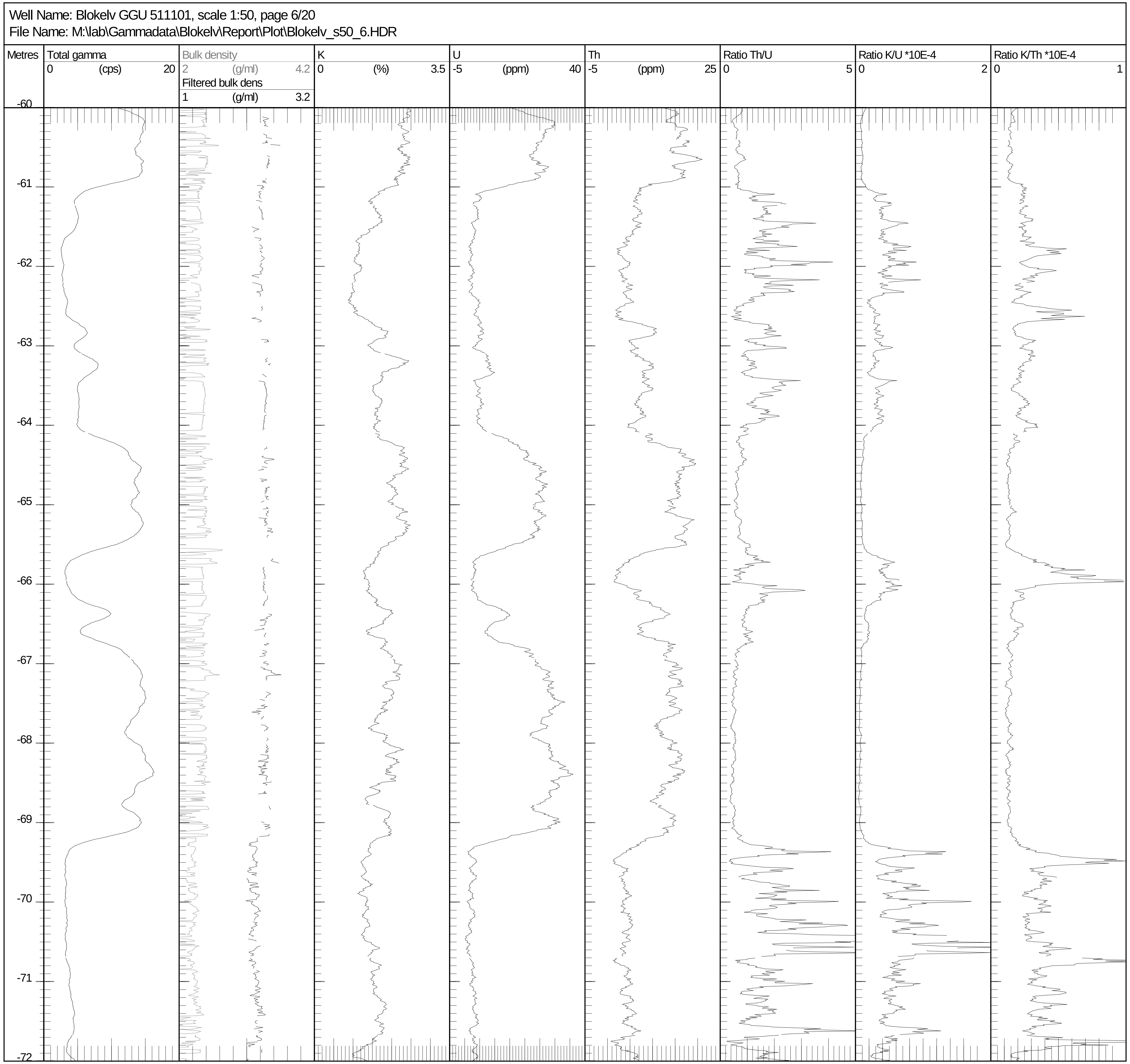
Well Name: Blokelv GGU 511101, scale 1:50, page 4/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_4.HDR



GEUS Report 2009/42
Enclosure 3.5



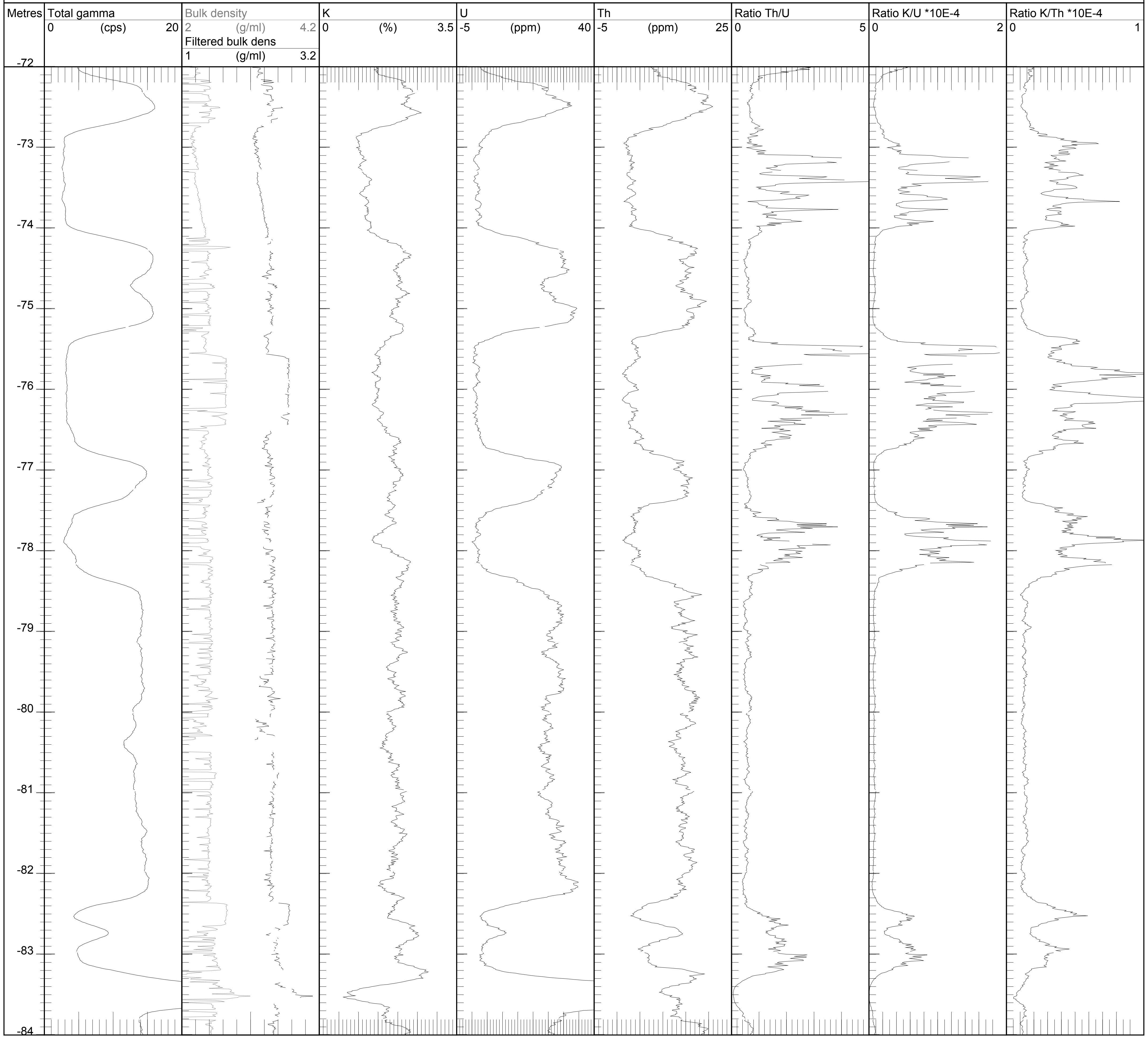
GEUS Report 2009/42
Enclosure 3.6



GEUS Report 2009/42
Enclosure 3.7

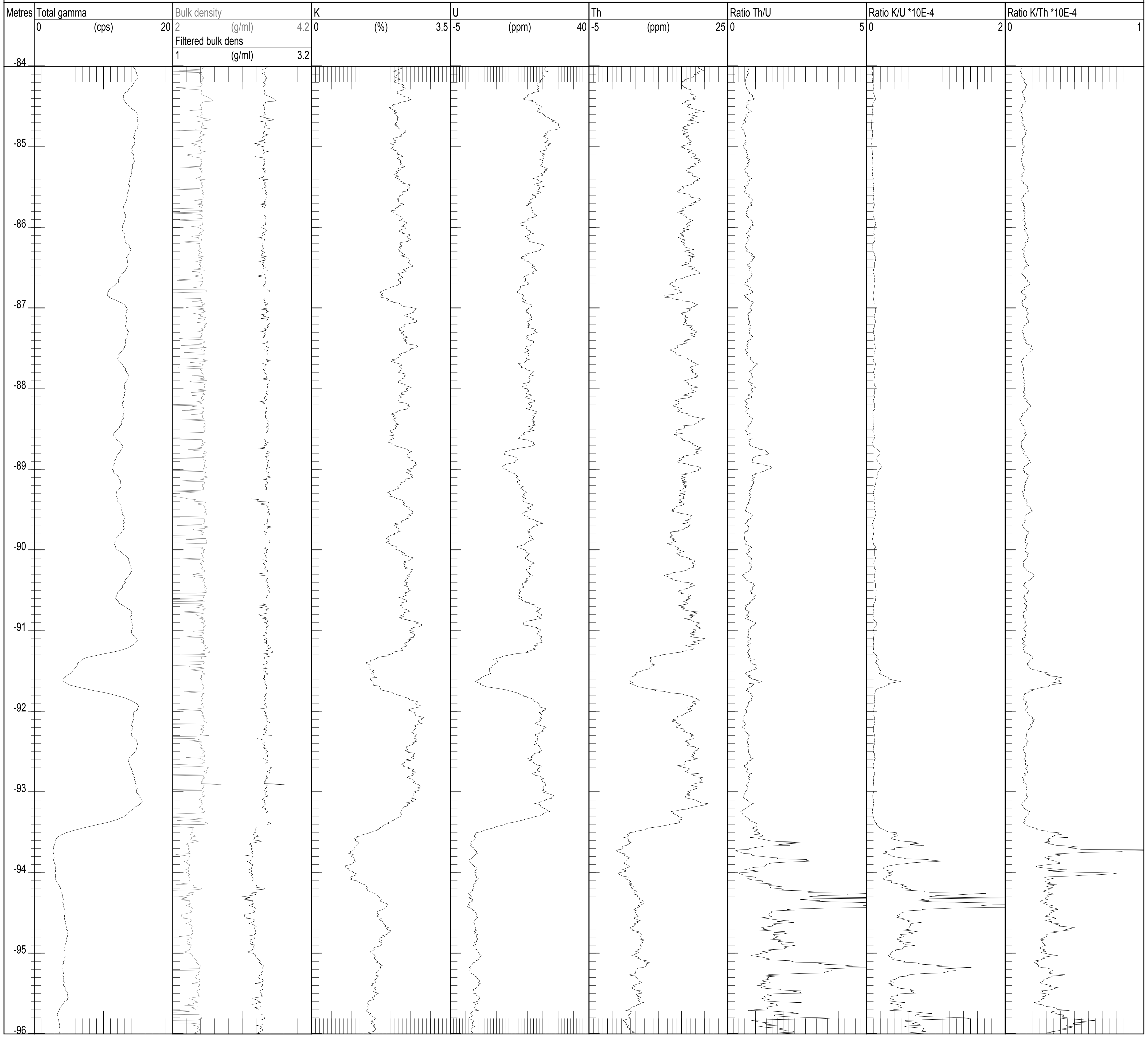
Well Name: Blokelv GGU 511101, scale 1:50, page 7/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_7.HDR

Off-scale peak at 83.52 m with Total gamma peak at 53.9 cps and U peak at 170.5 ppm.



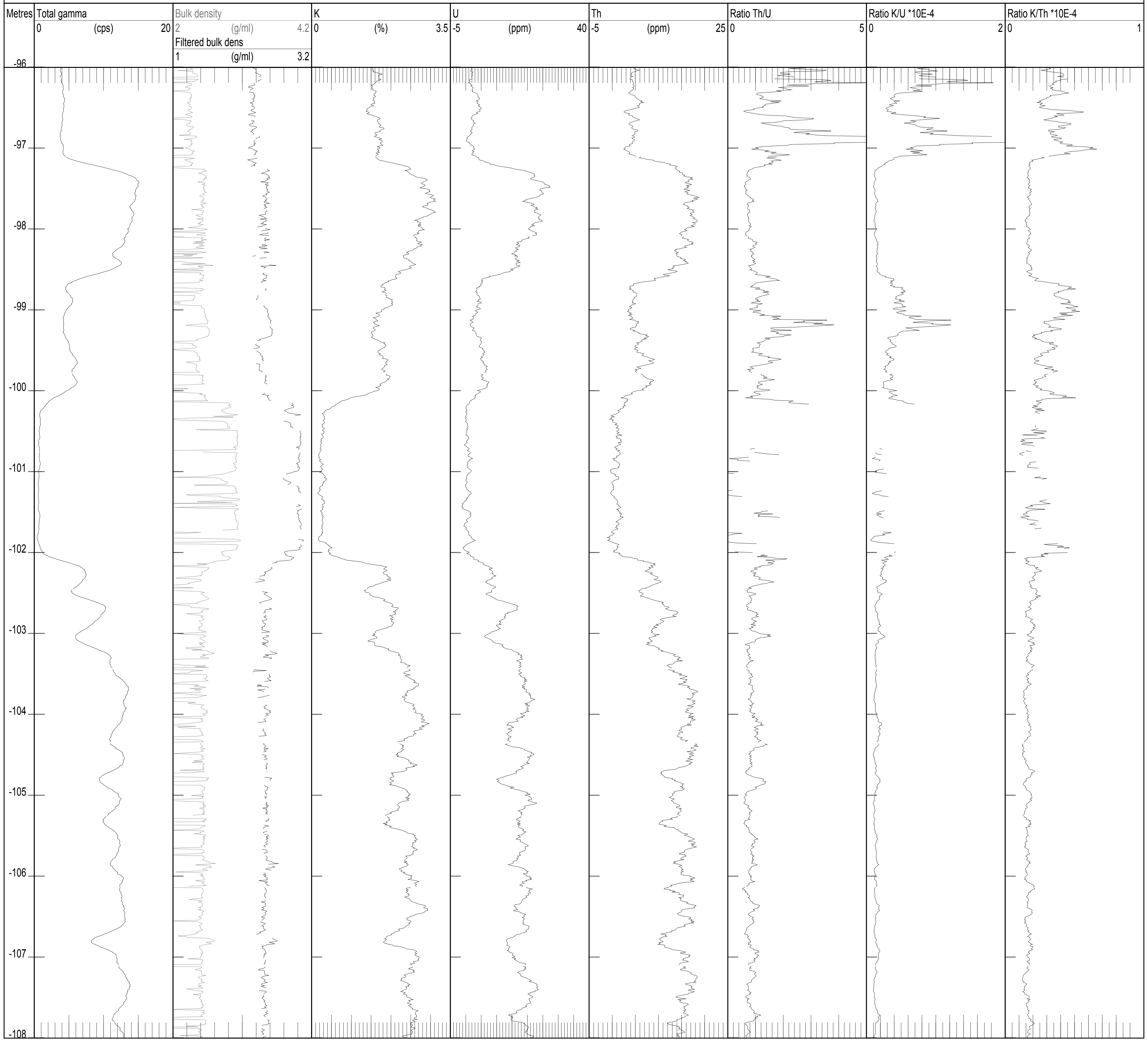
GEUS Report 2009/42
Enclosure 3.8

Well Name: Blokelv GGU 511101, scale 1:50, page 8/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_8.HDR

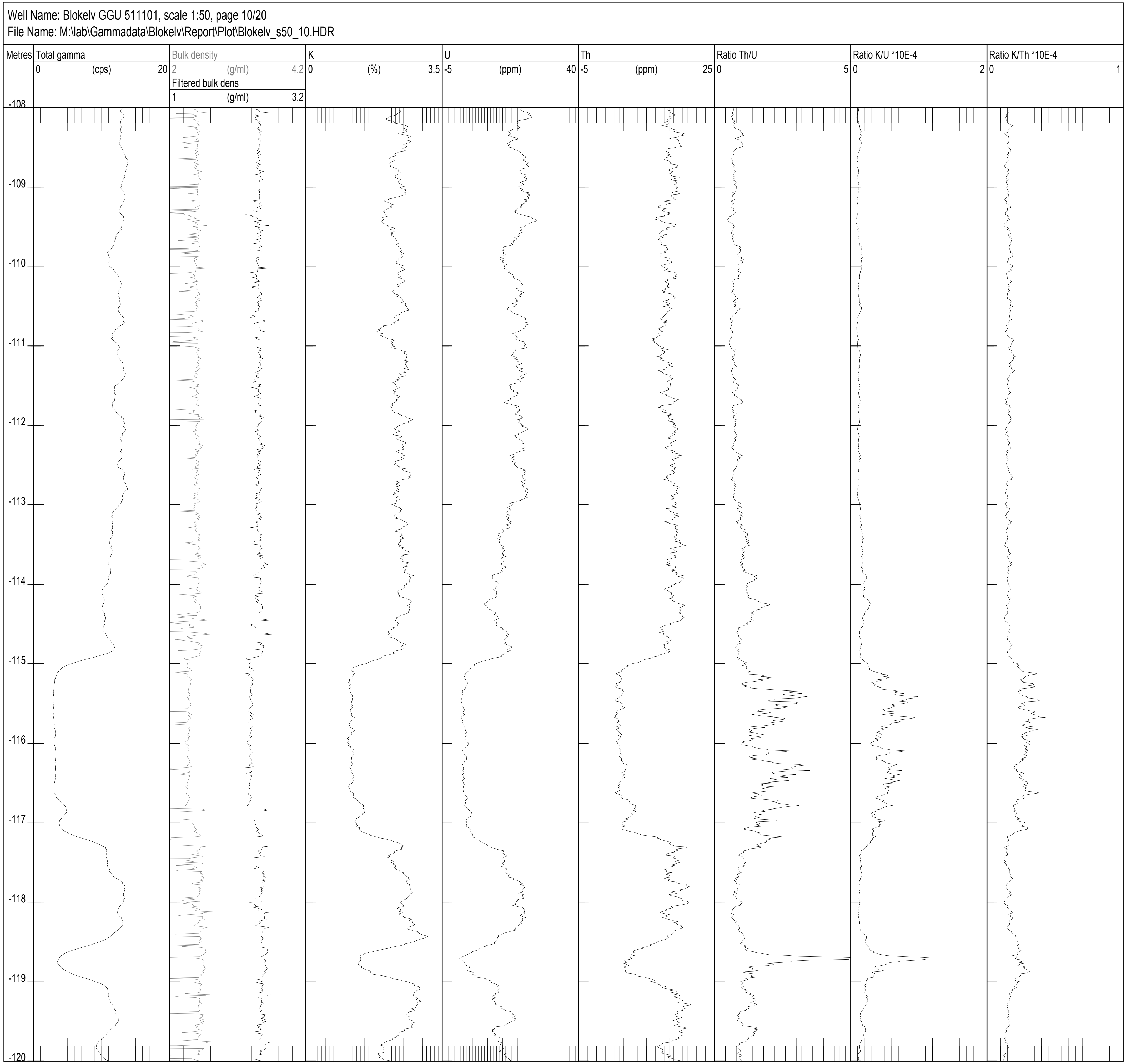


GEUS Report 2009/42
Enclosure 3.9

Well Name: Blokelv GGU 511101, scale 1:50, page 9/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_9.HDR

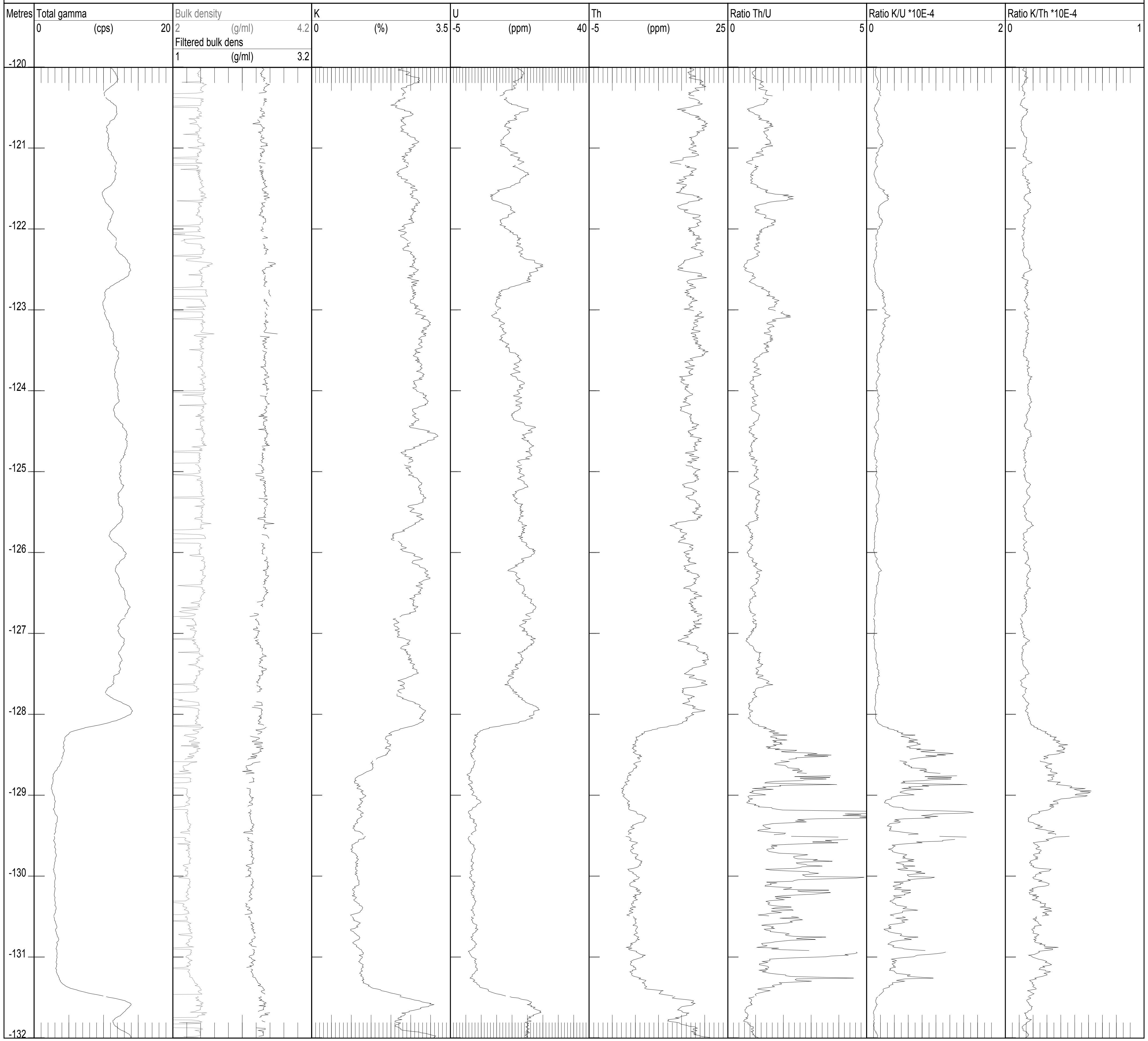


GEUS Report 2009/42
Enclosure 3.10



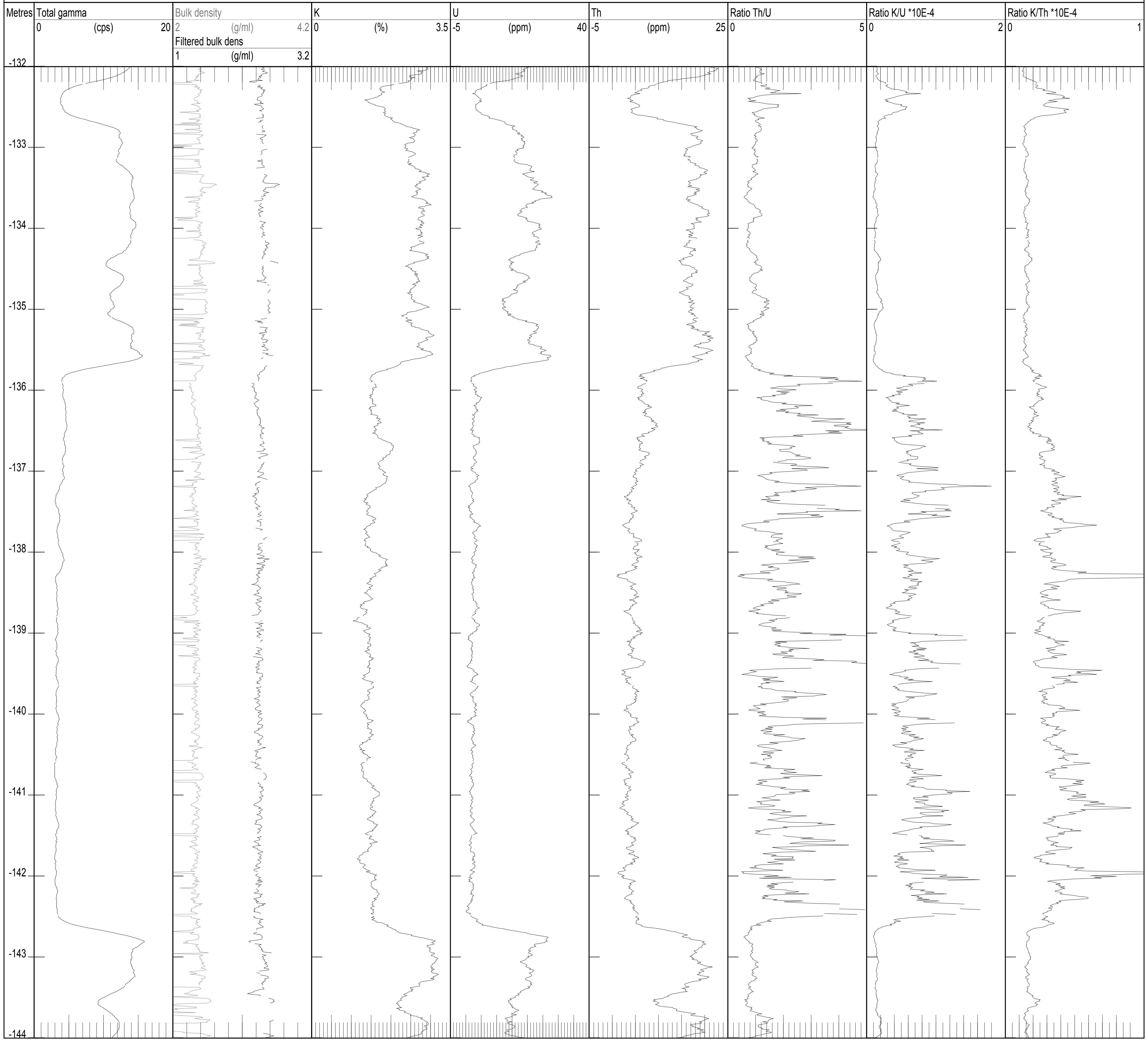
GEUS Report 2009/42
Enclosure 3.11

Well Name: Blokelv GGU 511101, scale 1:50, page 11/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_11.HDR



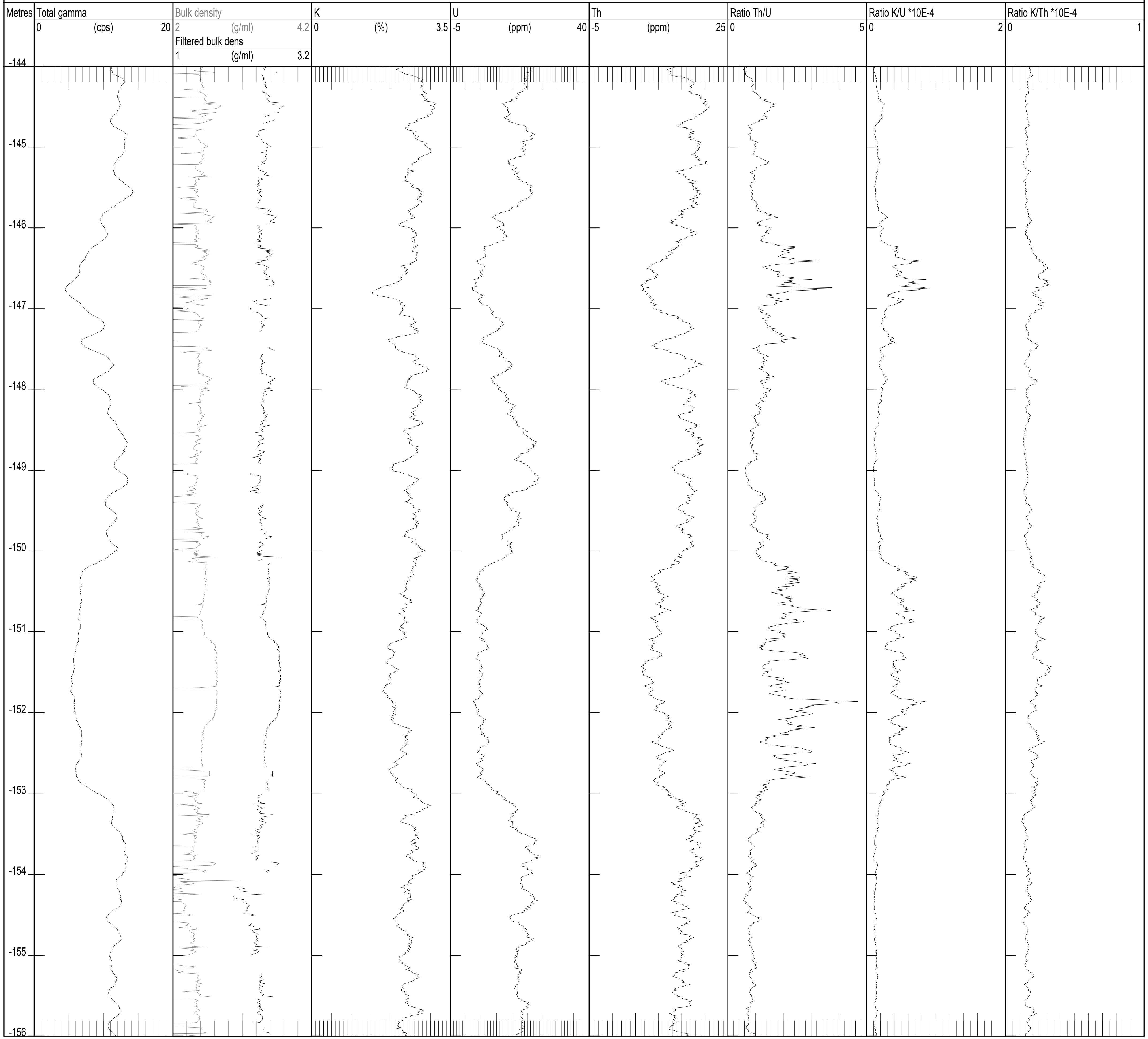
GEUS Report 2009/42
Enclosure 3.12

Well Name: Blokelv GGU 511101, scale 1:50, page 12/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_12.HDR



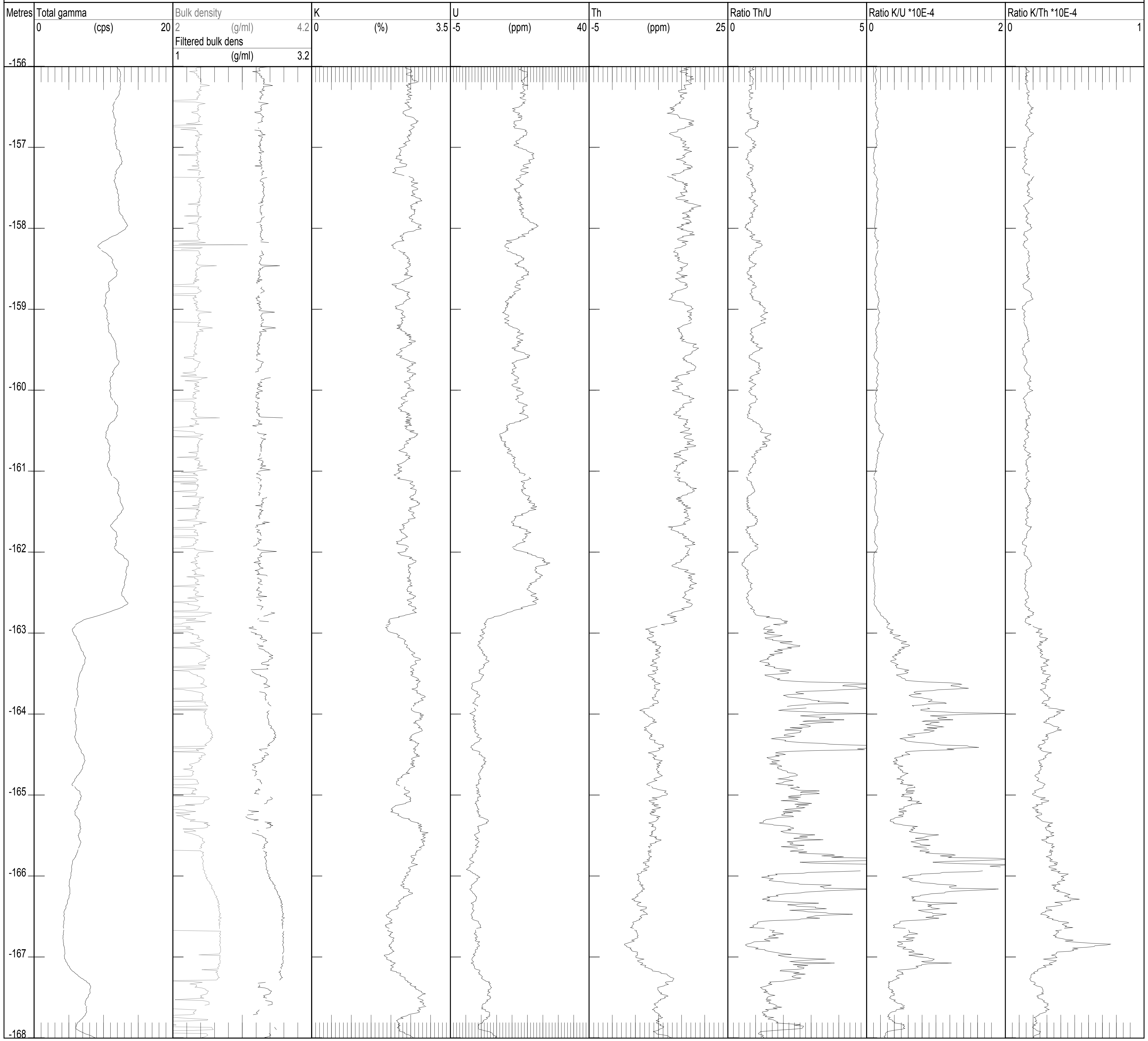
GEUS Report 2009/42
Enclosure 3.13

Well Name: Blokelv GGU 511101, scale 1:50, page 13/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_13.HDR



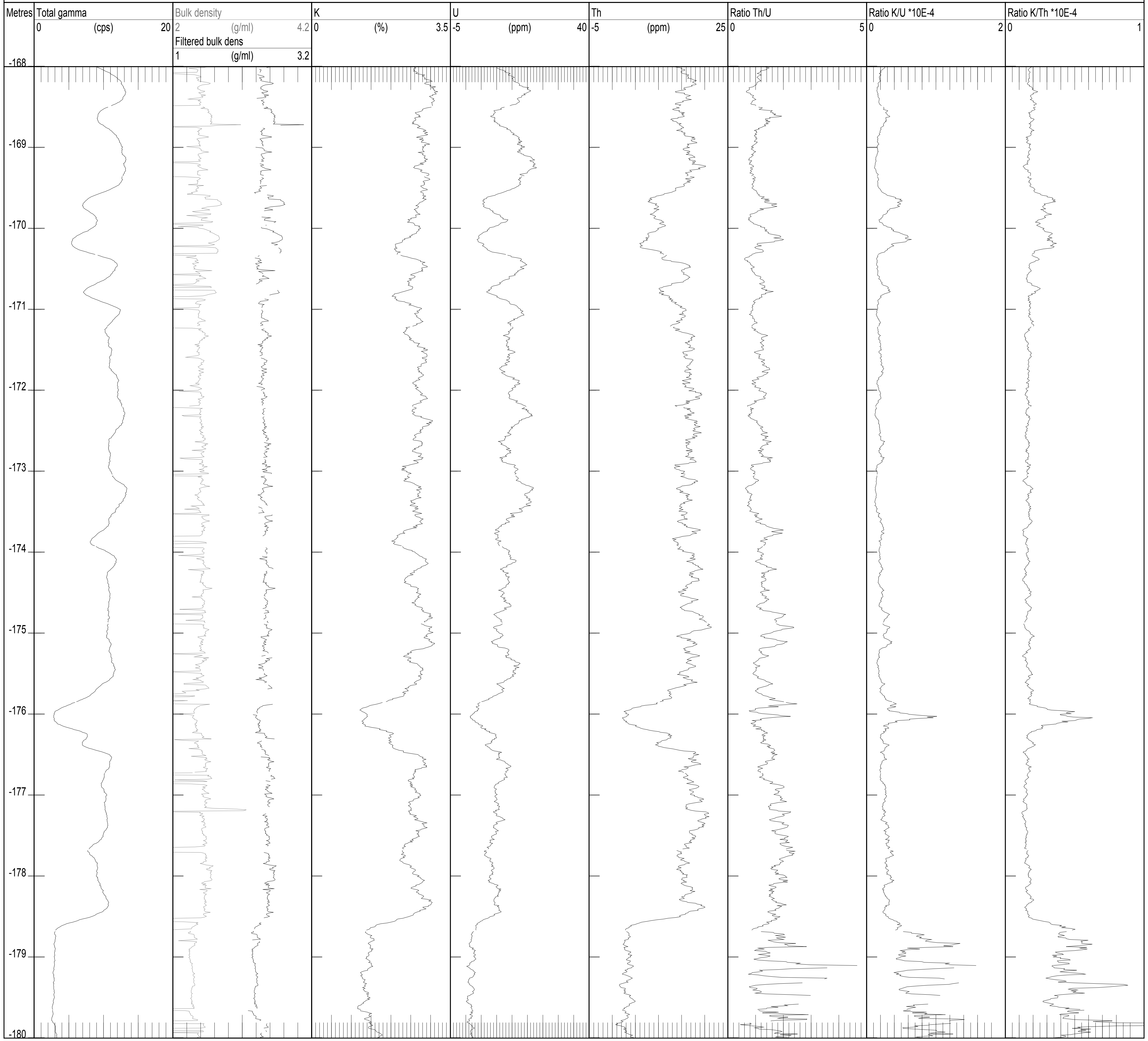
GEUS Report 2009/42
Enclosure 3.14

Well Name: Blokelv GGU 511101, scale 1:50, page 14/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_14.HDR



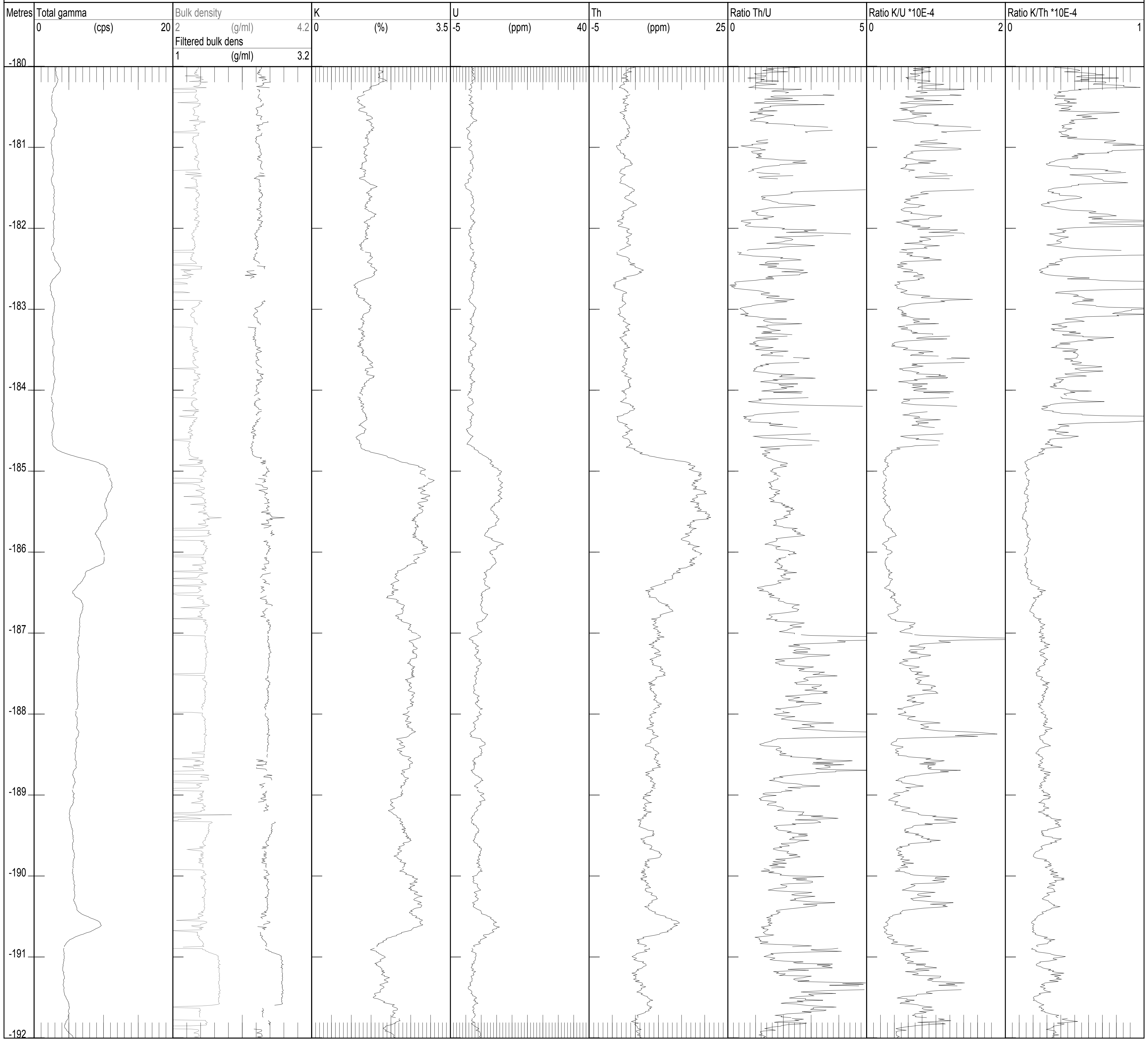
GEUS Report 2009/42
Enclosure 3.15

Well Name: Blokelv GGU 511101, scale 1:50, page 15/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_15.HDR



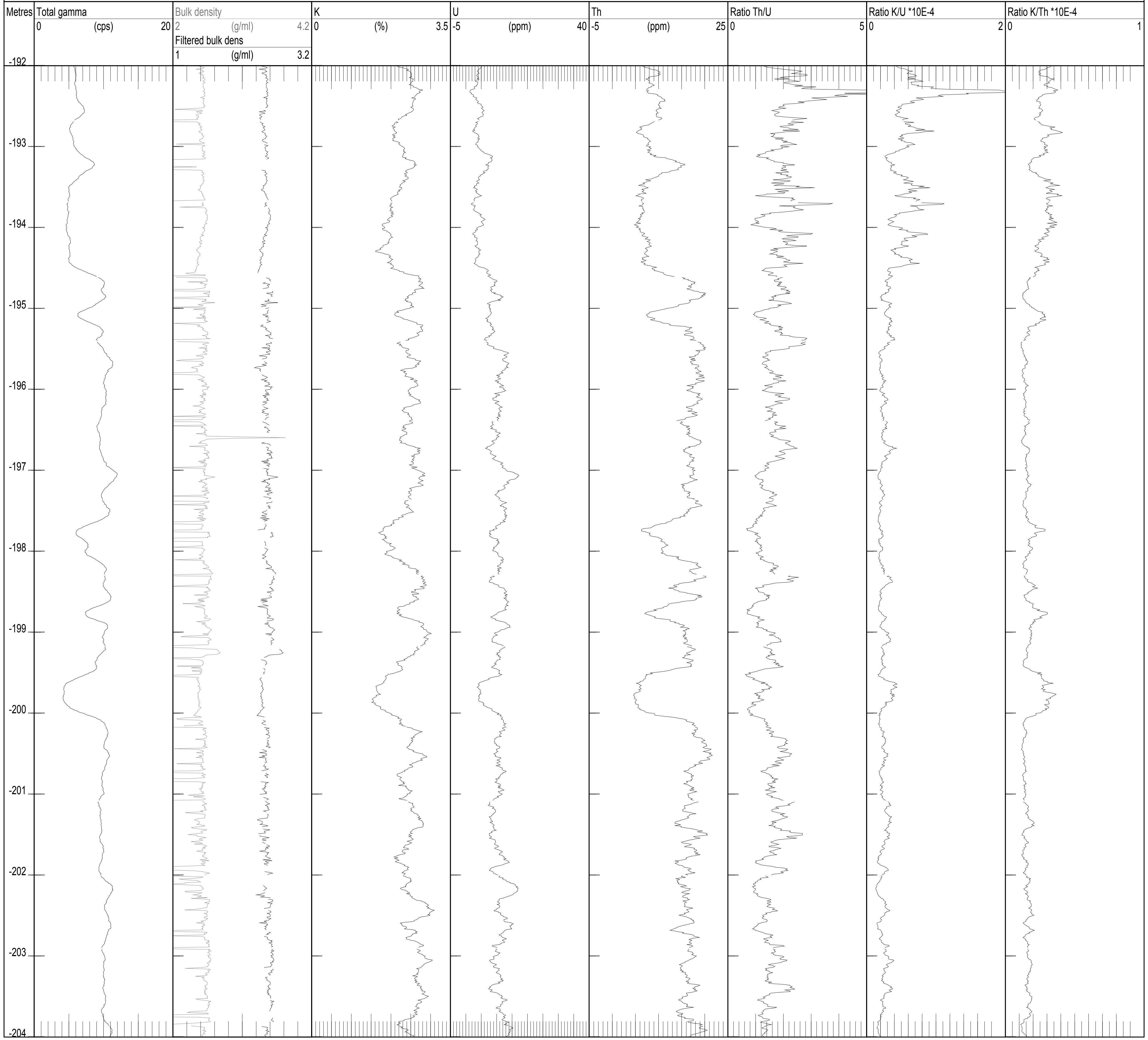
GEUS Report 2009/42
Enclosure 3.16

Well Name: Blokelv GGU 511101, scale 1:50, page 16/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_16.HDR



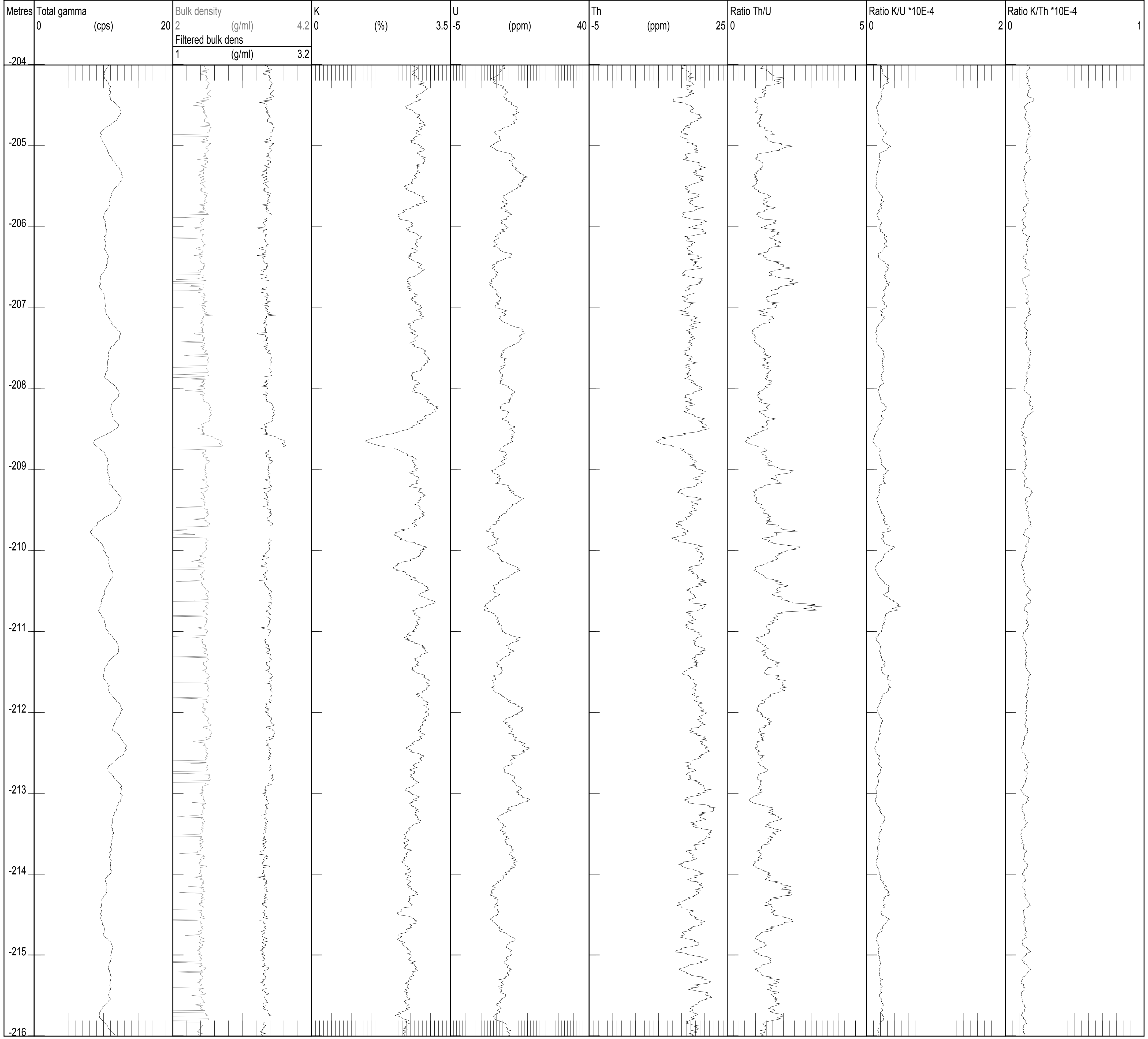
GEUS Report 2009/42
Enclosure 3.17

Well Name: Blokelv GGU 511101, scale 1:50, page 17/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_17.HDR

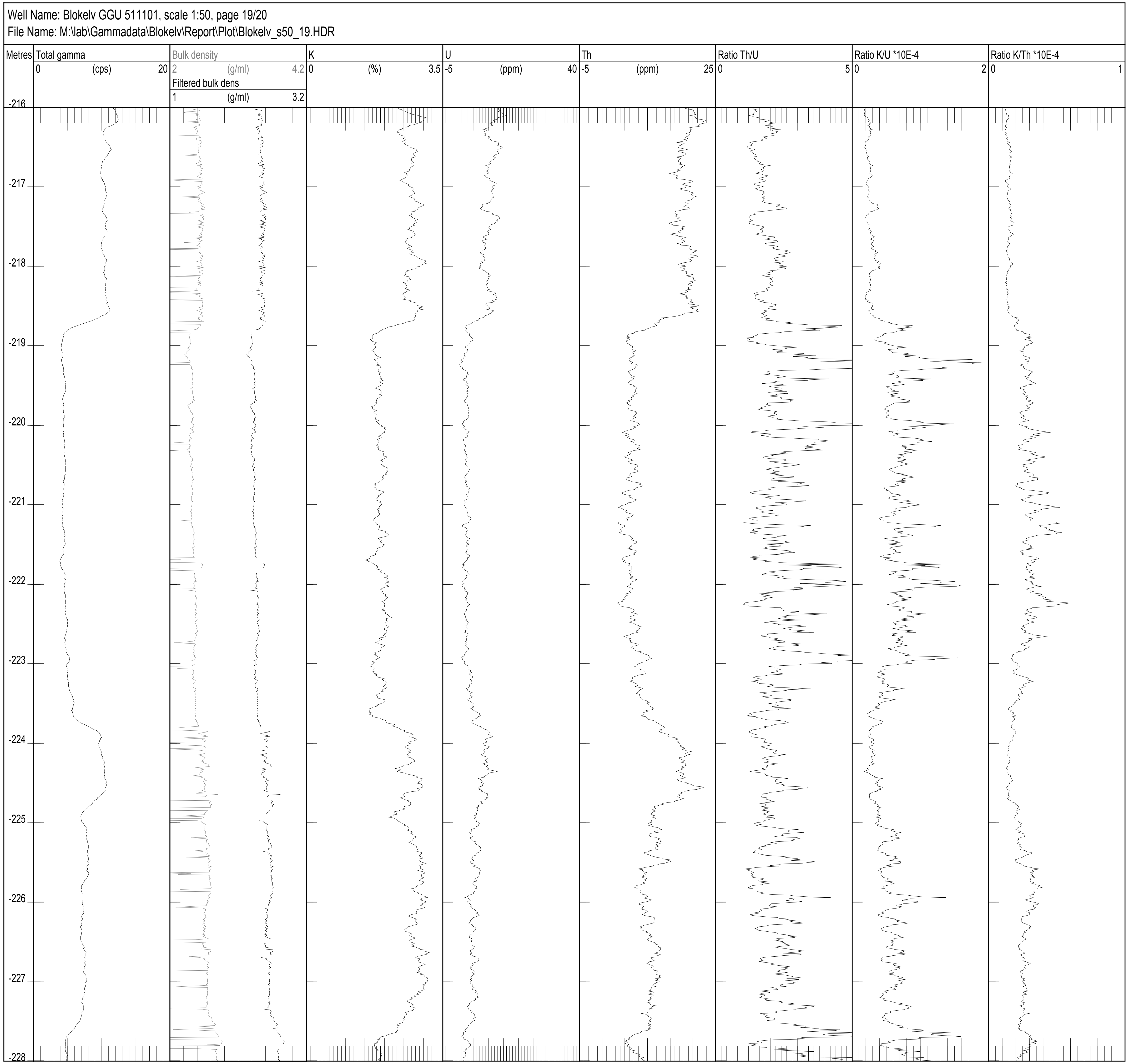


GEUS Report 2009/42
Enclosure 3.18

Well Name: Blokelv GGU 511101, scale 1:50, page 18/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_18.HDR



GEUS Report 2009/42
Enclosure 3.19



GEUS Report 2009/42
Enclosure 3.20

Well Name: Blokelv GGU 511101, scale 1:50, page 20/20
File Name: M:\lab\Gammadata\Blokelv\Report\Plot\Blokelv_s50_20.HDR