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Organic soil geochemistry in Nord-Trøndelag and Fosen

NGU
Norges geologiske undersøkelse
Geological Survey of Norway

Geological Survey of Norway
Postboks 6315 Sluppen
NO-7491 Trondheim, Norway
Tel.: 47 73 90 40 00
Telefax 47 73 92 16 20

REPORT

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Title:
Organic soil geochemistry in Nord-Trøndelag and Fosen

Authors: Tor Erik Finne and Ola A. Eggen	Client: NGU MINS
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Summary:

During field work in the summer and fall of 2013, organic soil samples were collected in a grid of 6 x 6 km in Nord-Trøndelag and Sør-Trøndelag’s municipalities of Trondheim and Malvik as well as on the Fosen peninsula. Together with samples for quality control, the <2mm fraction of samples from 752 locations were digested by aqua regia and analyzed for 53 elements and Pb isotopes. The elements Be, In, Pd, Pt, Re and Te are kept out of the map collection due to very poor analytical data quality.

Results are documented with respect to quality of data and in tables of descriptive statistics, as well as plots of the cumulative probability function and by single element maps on a backdrop of bedrock geology.

Keywords: geochemistry	organic soil	aqua regia
MINS		

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1. INTRODUCTION

This survey of the organic soil (humus) covers the county of Nord-Trøndelag as well as adjacent parts of Sør-Trøndelag county on the Fosen peninsula and the municipalities of Trondheim and Malvik. The area was never mapped geochemically on a similar scale as was the case in the three northernmost counties of Norway in the 1980-ies, where stream sediments and stream water as well as mineral soil (Reimann et.al 2011) were common sampling media for all the counties. However, large parts of the area (below the tree line in Nord-Trøndelag county only) were sampled for organic soil characterization in 1960, reported by Ryghaug (1980) and by Finne and Grønlie (1983). Sæther (1985) collected several sampling media on a 1 sample/ca 30km^2 scale, among them organic soil. A national survey of humus chemistry containing 460-500 sampling stations throughout Norway was carried out in 1977, and repeated 1985 (Njåstad et.al, 1994) provides data on an even lower sampling density. The national survey turned into a monitoring program by being repeated 1995 and 2005 (Meyer et.al, 2104). A higher sampling density mapping of stream sediments (1 sample/3km^2), covering Nord-Trøndelag and the Fosen peninsula, was carried out during the years 1983-1985 (Sæther, 1987, Sand, 1987, and Sæther, 1988). Figure 1 shows the extent of the different humus surveys.

This survey was planned and carried out in tandem with and in support of the mineral soil survey reported by Finne et.al (2014), and is a part of NGU’s program MINS – Mineral resources in South Norway. In this report the term humus is used synonymous with organic soil, mostly for space considerations.

2. DESCRIPTION OF SURVEY AREA

The prominent topographical features of the Trondheimsfjord's major part and its arm Beitstadfjorden, as well as its continuation through the lake Snåsavatnet are all strong indicators of the geologic history of the area. The ENE-NE direction of these features coincides with major strike and with fracture zones like the Møre-Trøndelag Fault Zone (Gabrielsen and Ramberg, 1979; Nasuti et al, 2010). Along the coast are gneisses of the "Western Gneiss Region", 1850-1500 Myr, present to a varying extent, until they join similar rocks of the Transscandinavian Intrusive Belt crossing from the coast SE-wards through Lierne into Sweden (the "Grong culmination"). Most of the area, however, is covered by the rocks of the Caledonian nappes. According to the NGU ore database, ferrous metals dominate the precambrian rocks, whereas in the greenstones and schist of the Caledonian nappes, the base metals are dominant. The mining intensity, measured as number of records per area classified as "Mining" or Test mining" in the NGU ore database is for Nord-Trøndelag county 3.8/1000km^2, whereas the values for Nordland, Troms and Finnmark counties are 3.5, 3.4, and 1.0 respectively.

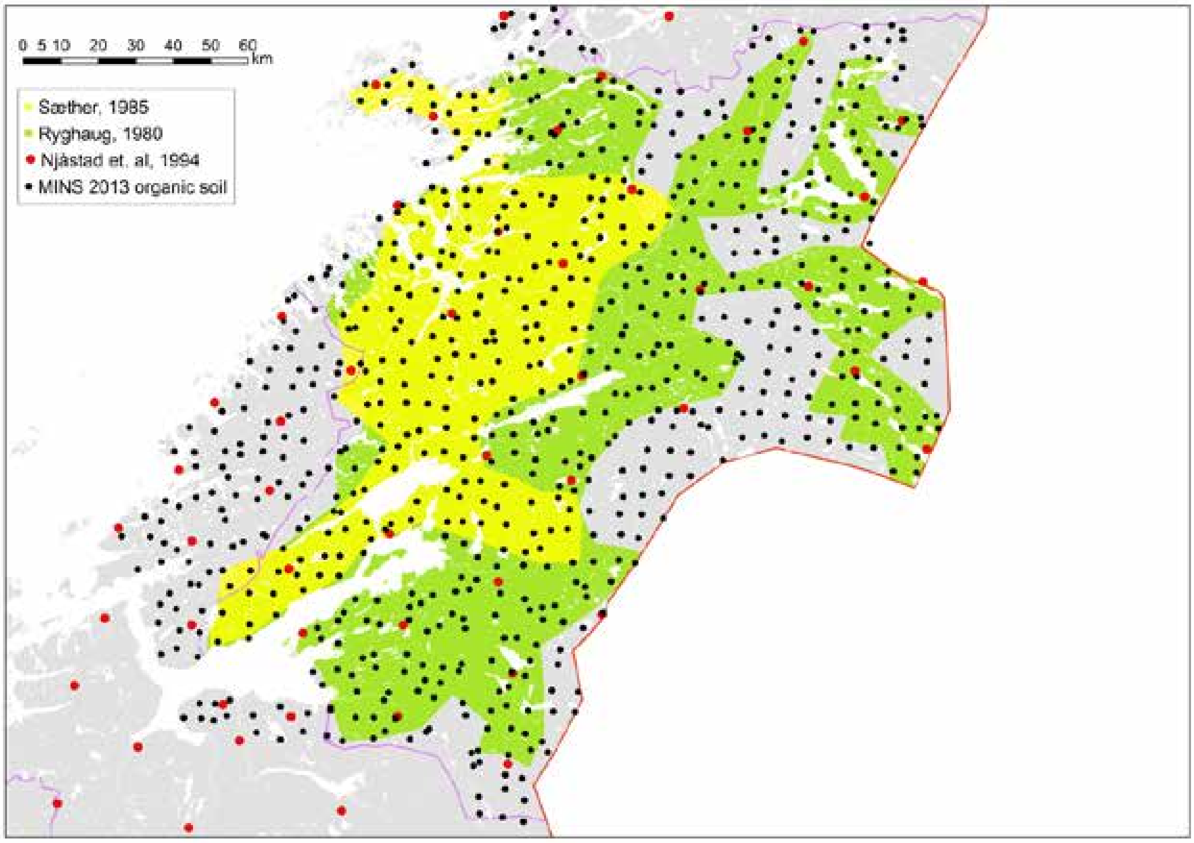

Figure 1: Area covered by previous and current studies.

The quaternary deposits of the area are dominated by areas of thin, discontinuous till material, interspersed with weathered rock of local origin. Figure 2 also show areas of till, mostly confined to lower altitudes in the mountain regions close to the Swedish border. Ice flow direction during the last glaciations is determined to be towards W-NW in general (Bargel et al, 1999), and is shown in the map as red points for each observation, with a line in the up-stream direction.

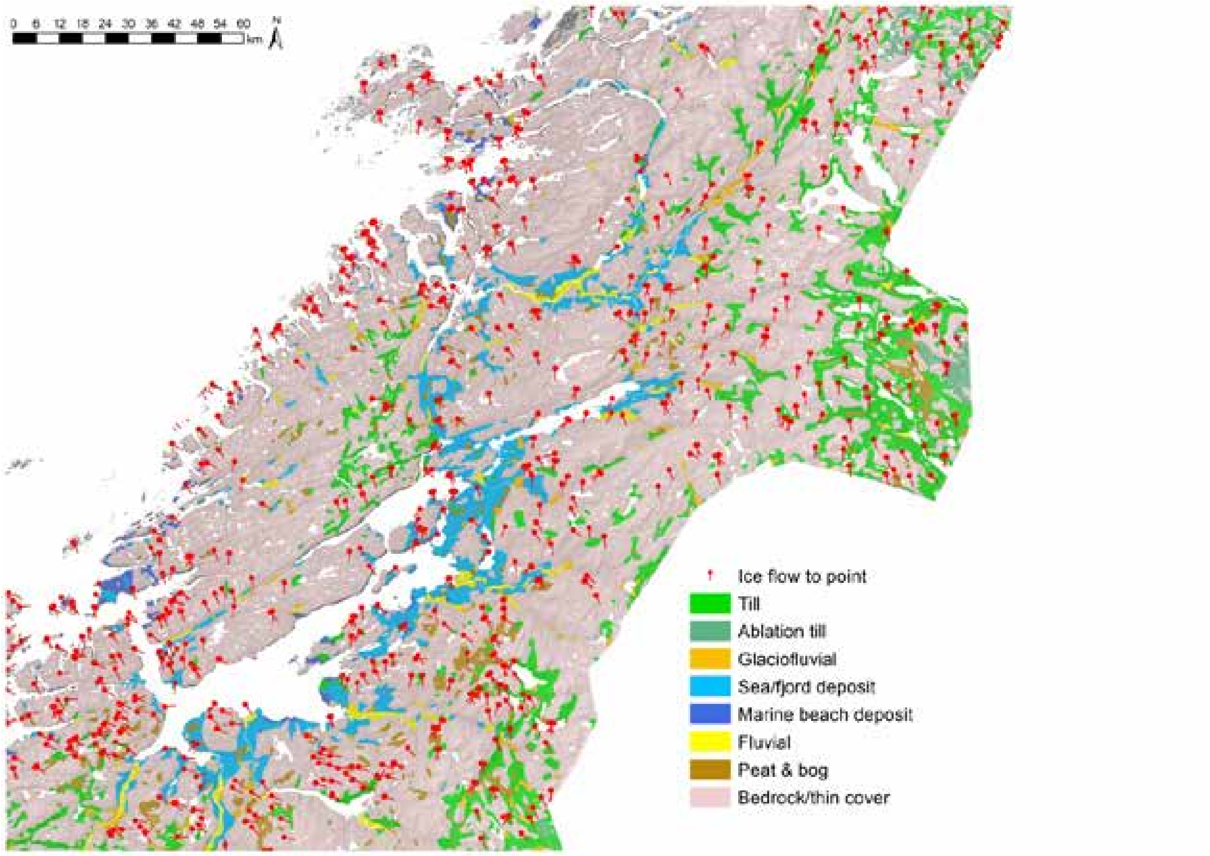

Figure 2:Map of quaternary deposits and ice movements in the surveyed area.

3. METHODS

3.1 Planning stage and field work

Aiming for a sampling density similar to the surveys of the three northernmost counties, a grid of 6x6 km was generated to assist in planning of field logistics. Within each of the grid squares, field workers were free to find a suitable location, with a minimum distance of 10-100 m from abandoned to high traffic roads. The chosen site should, if possible, accommodate both sampling of the C-horizon mineral soil sample as well as the organic soil sample. Each sample of the organic soil layer was composed of a minimum of five subsamples taken from an area of about 50x50m, and from positions with a minimum of canopy cover. Subsamples were collected by cutting through vegetation and humus layer either with a steel cylinder of diameter 10cm or by a steel spade, forming a wedge or rectangle with the same area. A steel knife was then used to separate the 0-3 cm layer from the above vegetation and the deeper soil layers, ensuring a minimum of mineral soil material entering the Rilsan® plastic sample bag. Figure 3 shows a typical sample site above tree line, where the subsamples positioned throughout the sample locality, as well as some of the equipment. All locations were photographed, their positions recorded by handheld (WAAS/Egnos) GPS, and observations on humus thickness and vegetation characteristics were noted. Sample wet weight was on average 1.3 kg. Sample contamination was minimized by the field crew not wearing any jewelry during sampling, and tools were wiped clean before collecting the next sample. For about every 20th sample a duplicate sample was collected 1-10m from original sample site, resulting in a total of 38 duplicate pairs. A total of 752 site/field samples were collected and accepted for further use, of these 95 were collected using helicopter for transport in remote areas.

Figure 3:Photo showing sample station, five subsamples and some of the tools. Photo T.E. Finne

3.2 Sample preparation

Upon arrival at the NGU laboratories, samples were dried in their original sampling bag for three weeks at temperatures below 40 °C. Sample dry weight was on average 0.55 kg. Subsequently all samples were dry sieved to <2mm (9 mesh), from which 2 aliquots of 1 dL were obtained and stored in Kautex polyethylene sample vial. Surplus <2mm material was stored in the original sample bag and saved for possible later usage. From all field duplicates, an additional split was generated.

Nylon sieves were used, and no jewelry was worn during preparation work. Cross contamination via sample dust during sieving was controlled by sieving samples one at a time in a vented box. All sieving equipment was cleaned using a vacuum cleaner in between every sample.

For the purpose of inserting a control sample in the analysis batch, two large volumes of organic soil were tested for homogeneity; a commercially available material from a garden center and natural peat material removed from the residential lot of one of the authors. After drying, sieving to less than 2 mm and splitting, 20 1g samples of each of the two candidates were extracted by HNO3 and analysed by ICP-AES. Following the same pattern, LOI was determined on 5g weighings heated to 480°C for 20 hours. The commercial soil was found to be the least homogenous, most likely due to its apparent added mineral soil mix of coarse (yet <2mm) material. The best choice material for control of stability of data was dubbed Nmv.

To facilitate use of this data set together with other data on acid extractable contents in humus, 15 samples from earlier investigations were included with this analytical batch. The preparation and analytical procedures differ somewhat between the data sets (see Table 1), but they nevertheless give an illustration of differences and similarities of these. The included samples were 10 of the 40 “LIT” samples of the 2005 GEOS transect (Reimann et.al, 2007), and 5 of the 42 samples collected in Finnmark 2005 (Jensen and Finne, 2006).

Following sample preparation, one series of all samples were randomized in a structured manner, so that for about every 17 samples sent to the laboratory, a field duplicate, its split and its ordinary sample as well as a split of the project standard Nmv were inserted. The control samples were not always inserted in the exact same positions within the group.

Table 1: Overview of previous studies and methods

39 control + 15 samples	Nmv (1 sample, 10 repetitions)	GEOS 2005	Finnmark 2005
N original, this survey	10 & 39 Repetitions	10 different samples, same 10	5 different, same 5
Original:			
Sample weight, extraction, instrument	1g HNO_3 ICP-AES	0,5 g **HNO_3 " Aqua Regia** **ICP-MS**	1g HNO_3 ICP-AES
Reference material	None	2x NIST1575a	3x H-3
This survey			
Method	5g, **HNO_3 " Aqua Regia, ICP-MS**		

3.3 Chemical analyses

The randomized series of 90+ g aliquots were shipped to ACME laboratories in Vancouver, Canada. The laboratory inserted further 28 splits of its own quality control (QC) sample CDV-1 for overall QC and 28 splits of the laboratory's own Pb isotope standard V16, as well as both of the certified reference materials NIST SRM 981 and NIST SRM 983 for Pb isotope QC. The laboratory also did replicate weighing, extraction and analyses of 28 replicate pairs throughout the analytical sequence.

A 5 g aliquot of the < 2mm humus sample material was first leached with concentrated $HNO_3$for 1 h and then digested in a hot (95 °C) water bath for an additional hour. After cooling, an aqua regia solution of equal parts concentrated ACS grade HCl, HNO_3 and de-mineralised H_2O was added to each sample (6 mL/g solid) to leach in a hot (95 °C) water bath for 2 h. After cooling, the solution was made up to a final volume with 5% HCl and then filtered. The sample weight to solution volume ratio is 1 g per 20 mL. The solutions were analysed using a Spectro Ciros Vision emission spectrometer (ICP-AES) and a Perkin–Elmer Elan 6000 inductively coupled plasma mass spectrometer (ICP-MS) for a suite of 53 elements plus the Pb-isotopes 204, 206, 207 and 208.

Analytical results were returned from the laboratory within one month after receiving the samples. The remainder of the sample material was stored in the event of mishaps with the first weighing, and for possible upcoming analyses following alternative procedures. Unused sample material was not returned, but destructed by the laboratory after the holding period, according to local regulations.

3.4 Quality control

To be able to estimate analytical precision based on analytical duplicates and to calculate the practical detection limits, it was agreed with the laboratory that all instrument readings were reported, independent of quantification and detection limits. For statistical calculations on the quality control part the instrument readings were used. Negative readings were replaced by a very low positive value prior certain statistical analyses.

Throughout the analysis there were inserted samples from certain previous studies for making it possible to do safe comparisons with these studies at a later stage. Results from these studies are not commented in this report.

3.4.1 Standard samples

X-charts are a simple but powerful way of studying the quality of the data. The data for a variable is plotted against its analytical sequence number, and by also plotting the median and deviation from the median it is possible to a) identify time trends or breaks in the analysis sequence, b) get an impression of precision by looking at the spread from the median, and c) get an impression of accuracy if the "true" or certified value is known.

X-charts from this survey indicate that no severe problems are present with regards to time trends or breaks in analytical results. Figure 4 serves an example where P and Pb in the MINS project organic soil standard Nmv are shown. The laboratory also used its own house standards, CDV-1 and V16, inserted throughout the analysis series. All in all, most results for the standards were satisfactory.

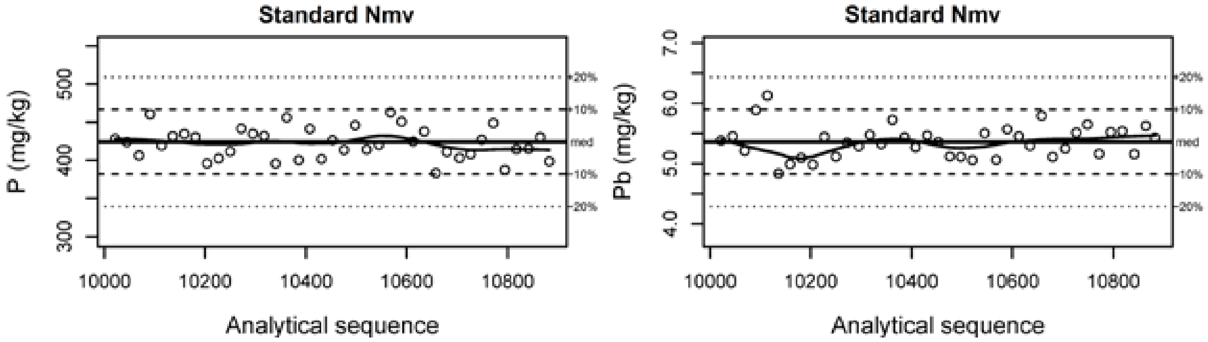

Figure 4: X-chart for P and Pb depicting stability for project standard Nmv. Dashed and dotted lines marks ±10% and ±20% deviation, respectively.

Values for minimum, median and maximum, as well as precision for the analytical results for the project standard Nmv and the laboratory standards CVD-1 and V16 are given in Table 2, Table 3 and Table 4, respectively.

3.4.2 Duplicate samples

Table 5 shows the estimate of precision based on the analytical duplicates and the field duplicates. The low precision is principally due to the natural variability shown in the difference between ordinary field sample and field duplicate samples. In most cases the observed problems with precision were due to very low concentrations as in the case of our project standard Nmv, i.e. analytical results at or below the limit of quantification, like Au, Be, Pd, Pt, Re and Te. In addition, the field duplicate results reveal that also elements In, V and W are plagued by poor reproducibility, and maps should be viewed with care.

Practical detection limit (PDL) was established based on method described by Demetriades (2011), using the results for analytical replicates. Good results of the replicates led us to use a lower PDL rather than the laboratory’s method detection (reporting) limit (MDL) for B, S, Sn, Th, Tl, V, W. On the other hand, PDL had to be increased for a range of elements; As, Au, Be, Cd, Ge, Hf, Li, Pd, Pt, Sc, Se, Te.

3.4.3 Quality of Pb isotope analysis

28 samples of both the NIST SRM 981 common lead isotopic standard (NIST.gov) and NIST SRM 983 radiogenic lead isotopic standard (NIST.gov) was inserted by the lab to the analysis series. The results (see Table 6) shows satisfactory accuracy for the SRM 981 and SRM analyses. The precision is not as satisfactory compared to the certified documentation, but we consider this to be less importance.

Among the inset of samples described in Table 1 Pb isotope data already existed for the Reimann et. al (2007) and Jensen & Finne (2006) studies. Despite differences in sample weight, extraction, and instrumentation the present study stands a comparison with these existing data. Table 7 and Table 8 shows a comparison of statistical parameters for the Reimann et. al (2007) and Jensen & Finne (2006) studies, respectively.

3.5 Data analysis

Geochemical data are compositional data, meaning that they do not contain truly independent values but only relative information; the reported concentrations of all elements analyzed depend on one another (Aitchison, 1986; Filzmoser et al., 2009). Such data have some special properties which can lead to wrong results when applying the methods developed for classical statistical data analysis (Reimann et al., 2013). Thus EDA (exploratory data analysis) techniques and simple order statistics as suggested by Reimann et al. (2008) are used here. All statistical calculations are determined by use of the freely available R software (R development core team, 2014) and the additional StatDA package (Filzmoser, 2013).

4. RESULTS AND COMMENTS

4.1 Data tables

A statistical overview for the dataset is provided in Table 9. The table is built around the minimum, maximum and median value, and also provides the values for a number of additional quantiles (percentiles) for the analyzed elements. As an additional measure of variation the “powers” are provided, which provide a direct impression of the orders of magnitude variation for each variable. When using classical statistical methods for calculation of the mean and standard deviation to derive at “thresholds” for anomalies, 2.6% of all data is often identified as anomalies at both ends of the distribution if the dataset has a normal distribution. The data at hand are far from normally distributed and therefore unsuited for classical statistics – thus the quantiles Q2 and Q98 (or Q5 and Q95) can be taken as lower and upper threshold for the data. However, quite often Cumulative Probability (CP) plots (see below) provide a better means of identifying anomalies in the data by inspection of shape of the curve.

Table 10 displays the analytical results with a more common approach, showing median, 98th percentile and maximum concentration for the organic soil dataset and data for the comparable 1985 national organic soil survey reported in Njåstad et.al (1994) dataset. For median, Q98 and maximum, the highest value between the four datasets is underlined. In the same table, Table 10 statistics for two other organic soil surveys by Sæther (1985) and by Ryghaug (1980) are also given. Sampling procedure for the latter called for 10 subsamples. These studies covers only parts of the MINS area, se Figure 1. All three datasets compared to the present are based on < 2mm humus ashed at 450-80 °C prior to HNO_3 extraction and ICP-AES analysis.

4.2 Cumulative probability (CP-) plot

Plots of the cumulative distribution function are one of the most informative displays of geochemical distributions (Reimann et al., 2008). In the plots the concentration is plotted along the X-axis and the cumulative probability is plotted along the Y-axis, and it allows the direct visual recognition of breaks in the curve which may be indicative of different geochemical processes. Breaks in the uppermost few percentiles of the distribution are often used as thresholds for anomaly identification. Readings below the PDL are here set to half the

PDL value for that element, respectively. Appendix 1 provides the CP-plots for all 53 variables and four Pb isotopes.

4.3 Maps

Many different methods for producing geochemical maps exist (see discussion in Reimann, 2005 or in Chapter 5 of Reimann et al., 2008). In mineral exploration so called “growing dot maps” as introduced by Bjørklund and Gustavsson (1987) are probably most often used. However, they focus the attention almost exclusively on the high values, the “anomalies” and are less well suited to study the data in more detail, e.g., in relation to geology. It may also be argued that the "growing dot map" has limitations in detecting local anomalies as they often do not display especially high values in relation to the whole dataset, but rather high values in relation to their local surroundings. Some of these shortcomings can be helped by giving special attention to the growth increment of the symbols, and the overall size of the symbols in the map image.

	EDA symbol set	EDA symbol set extremes are accentuated	EDA symbol set extremes are accentuated Used in this report	Precentiles used in this report
Highest values	+	■	■	95–100%
Higher values	+	+	●	75–95%
Inner values	·	·	·	25–75%
Lower values	○	○	○	5–25%
Lowest values	○	○	○	0–5%

Figure 5: The EDA symbol set.

The EDA symbol set aim to provide an optical weight for each symbol in the map (Reimann et. al, 2008). Lower values are shown by circles, the inner (most common and in many cases the "least interesting") values are shown as dots, while the higher values are shown by crosses in the original EDA symbol set. Figure 5 shows the original EDA symbols to the left, and modifications in the middle. The percentiles used for the classes are 5 – 25 – 75 – 95%. All the maps are prepared on a backdrop of a generalized bedrock map based on the available maps in scale 1:250 000 hosted by http://geo.ngu.no/kart/berggrunn/ . An excerpt of the legend for the 1:250 000 scale map series is shown in Figure 6. All geochemical maps are provided in Appendix 2. Please note that elements Be, In, Pd, Pt, Re and Te are kept out of the map collection due to very poor analytical data quality.

The dataset for this report is provided online (http://www.ngu.no/en-gb/tm/About-NGU/Projects/Mineralressurser-i-Sor-Norge-MINS Look for “Last ned data her”), and it is therefore possible and up to the reader to use different mapping techniques. Note, however, that in the provided data file all values below detection are marked as “<n”, n being the PDL, while NGU had the original instrument readings

available, i.e. values for every sample. NGU used the instrument reading values as these results often contain valuable information when using large datasets with hundreds of samples. For example, the laboratory's official detection limit for B is 1 mg/kg, but the QC results indicate that values down to 0.5 mg/kg are still reliable. Thus 10% real, natural variation would have been lost when setting all values below the MDL to for instance ½ of the detection limit.

Berggrunn tegnforklaring	Bedrock legend
2 - Sandstein	2 - Sandstone
3 - Konglomerat, sedimentær breksje	3 - Conglomerate, sedimentary breccia
7 - Sedimentære bergarter (uspesifisert)	7 - Sedimentary rock (unspecified)
8 - Skifer, sandstein, kalkstein	8 - Shale, sandstone, limestone
9 - Sandstein, skifer	9 - Sandstone, shale
10 - Kalkstein, skifer, mergelstein	10 - Limestone, shale, marlstone
11 - Kalkstein, dolomitt	11 - Limestone, dolomite
21 - Granitt, granodioritt	21 - Granite, granodiorite
22 - Dioritt, monzodioritt	22 - Diorite, monzodiorite
23 - Syenitt, kvartssyenitt	23 - Syenite, quartz syenite
24 - Monzonitt, kvartsmonzonitt	24 - Monzonite, quartz monzonite
25 - Mangerittsyenitt	25 - Mangerite syenite
26 - Ryolitt, ryodacitt, dacitt	26 - Rhyolite, rhyodacite, dacite, keratophyre
29 - Vulkanske bergarter (uspesifisert)	29 - Volcanic rocks (unspecified)
30 - Mangeritt til gabbro, gneis og amfibolitt	30 - Mangerite to gabbro, gneiss and amphibolite
35 - Gabbro, amfibolitt	35 - Gabbro, amphibolite
38 - Kvartsdioritt, tonalitt, trondhjemitt	38 - Quartz diorite, tonalite, trondhjemite
40 - Olivinstein	40 - Peridotite, pyroxenite
41 - Eklogitt	41 - Eclogite
45 - Anortositt	45 - Anorthosite
50 - Amfibolitt og glimmerskifer	50 - Amphibolite and mica schist
55 - Grønnstein, amfibolitt	55 - Greenstone, amphibolite
60 - Metasandstein, skifer	60 - Metasandstone, mica schist
61 - Kvartsitt	61 - Quartzite
62 - Glimmergneis, glimmerskifer, metasandstein, amfibolitt	62 - Mica gneiss, mica schist, metasandstone, amphibolite
65 - Fyllitt, glimmerskifer	65 - Phyllite, mica schist
66 - Kalkglimmerskifer, kalksilikatgneis	66 - Calcareous mica schist, calc silicate gneiss
70 - Marmor	70 - Calcite marble
71 - Dolomitt	71 - Dolomite marble
82 - Diorittisk til granittisk gneis, migmatitt	82 - Dioritic to granitic gneiss, migmatite
85 - Øyegneis, granitt, foliert granitt	85 - Augen gneiss, granite, foliated granite
87 - Båndgneis (amfibolitt, hornblendegneis, glimmergneis), stedvis migmatittisk	87 - Amphibolite, hornblende gneiss, mica gneiss locally migmatitic

Figure 6: Legend bedrock map

4.4 First impressions

As the main purpose of this report is to make the data publicly available together with a quality description, only some brief comments on the results will be given. When results of ongoing analysis of loss on ignition, pH, total carbon and total sulphur and nitrogen are reported, the data will be interpreted to a greater depth.

A few of the element maps outline distinct geographic features that to some degree is easily explained by other processes than those of interest for the ore prospector. Sodium, Na, is the most obvious, forming a continuous high value region along the coast. The marine influence through precipitation is seen for about 40 km distance from the coast. Mercury, Hg, on the other hand, does not show nearly the same continuous high level in the same area, and has numerous single point high values far from the coast, as well as some clusters of values above the 75%ile associated with a > 95%ile value. These are mostly located within the Caledonian schists or greenstones. Tin (Sn) is another element that demonstrates larger areas of high values. By first glance, one could think that also Sn was of marine origin, it should, however, rather be focused on the fact that most of the values are associated with granites or granitic gneisses.

Grongfeltet, known for its numerous base metal sulfide mineralizations, has several locations of high manganese concentrations, some of which are accompanied by high copper (and zinc) values. The samples in this area with high Cu-Zn concentrations may indicate real anomalies, and could easily be checked against data from the parallel mineral soil survey and similar data from the well explored area.

5. ACKNOWLEDGEMENTS

Fylkesmannen Nord-Trøndelag and the boards of all national parks in the area kindly accepted our application for “scientific investigation” in all the national parks – important when the whole picture is needed to understand its details. The municipalities that were asked, and the Blåfjella-Skjækerfjella national park board all granted legal provisions for use of helicopter, and a number of land owners kindly let us land on their properties. Guri Kjesbu at Værdalsbruket AS kindly gave car access to Juldalen, and we are also indebted to the landowner giving access to a military escorted road to Geitfjellet, Grong. We greatly appreciate the cooperative spirit of the local authorities and population; without it we could have risked the onset of snow before the field work was completed. The field crew did a formidable job: NGU's Malin Andersson, Belinda Flem, Guri Venvik Ganerød, Henning K. B. Jensen, Øystein Jæger, Agnes M. Raaness, Clemens Reimann, Anna Seither and Ola Vikhammer, as well as the authors. Jostein Jæger and Iselin Esp Pettersen worked relentlessly at the sample preparation lab by sieving, splitting and weighing the samples.

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Table 2: Minimum, median, maximum and precision values for the MINS project organic soil standard Nmv. Concentrations in mg/kg.

Nmv standard (n=38) alphabetical										Sorted by precision			
Element				Precision	Element				Precision	Element		Element	
	Min	Q50	Max			Min	Q50	Max			Precision		Precision
Ag	0,0	0,0	0,1	13,6	Ni	11,4	12,7	15,6	9,0	Pt	1286	Ni	9,0
Al	5767	6320	7348	7,1	P	383	424	463	4,8	In	309	Ga	8,7
As	2,23	2,91	3,66	11,70	Pb	4,84	5,36	6,13	4,92	Pd	219	Th	8,6
Au	-0,001	0,001	0,014	67,5	^{204}Pb	0,1	0,1	0,1	5,1	Te	94	Nb	8,2
B	1,8	2,4	3,8	18,0	^{206}Pb	1,2	1,3	1,5	5,9	Au	68	Cu	8,1
Ba	36	44	78	13,90	^{207}Pb	1,02	1,15	1,29	5,46	Re	63	Mg	8,1
Be	0,0	0,1	0,3	52,0	^{208}Pb	2,5	2,8	3,2	5,2	Be	52	Na	8,0
Bi	0,0	0,0	0,1	11,7	Pd	-0,0056	0,0014	0,0087	219,0	Ge	46	Mo	7,3
Ca	17607	19966	22241	3,48	Pt	-0,0023	0,0001	0,0025	1286,00	Ta	33	Al	7,1
Cd	0,1	0,1	0,2	15,5	Rb	4,4	5,0	5,7	5,7	Sn	25	Zn	6,9
Ce	6,5	7,0	7,8	3,1	Re	0,0000	0,0034	0,0092	63,1	W	24	La	6,3
Co	4,65	5,85	6,87	12,70	S	1655	3592	4369	9,99	Hg	18	Fe	5,9
Cr	19,1	22,2	28,6	10,0	Sb	0,1	0,1	0,2	10,9	B	18	^{206}Pb	5,9
Cs	0,5	0,5	0,6	4,1	Sc	1,4	1,7	2,0	12,5	Hf	18	Rb	5,7
Cu	19,7	23,3	31,6	8,14	Se	0,54	0,94	1,34	12,70	Tl	16	Sr	5,6
Fe	8316	9413	11161	5,9	Sn	1,2	2,0	17,3	25,3	Cd	16	^{207}Pb	5,5
Ga	1,3	1,6	1,8	8,7	Sr	34,3	37,2	45,2	5,6	Ba	14	U	5,4
Ge	-0,02	0,06	0,12	46,30	Ta	0,004	0,008	0,014	33,40	Ag	14	^{208}Pb	5,2
Hf	0,0	0,1	0,1	17,6	Te	-0,02	0,02	0,13	94,3	Co	13	K	5,2
Hg	0,0	0,0	0,1	18,4	Th	0,45	0,55	0,70	8,6	Se	13	^{204}Pb	5,1
In	-0,03	0,00	0,02	309,00	Ti	441	524	676	9,45	Sc	13	Pb	4,9
K	790	863	959	5,2	Tl	0,029	0,038	0,050	16,3	As	12	Zr	4,9
La	2,9	3,3	3,8	6,3	U	0,22	0,26	0,29	5,4	Bi	12	P	4,8
Li	2,89	3,61	4,77	9,90	V	5,63	12,30	17,70	11,70	V	12	Mn	4,7
Mg	3554	3921	5002	8,1	W	0,03	0,08	0,11	23,7	Sb	11	Y	4,1
Mn	174	192	221	4,7	Y	1,9	2,1	2,3	4,1	Cr	10	Cs	4,1
Mo	0,57	0,66	0,76	7,27	Zn	29,8	36,2	43,2	6,88	S	10	Ca	3,5
Na	129	146	183	8,0	Zr	2,6	2,9	3,5	4,9	Li	9,9	Ce	3,1
Nb	0,5	0,5	0,6	8,2						Ti	9,5		

Table 3: Minimum, median (Q50), maximum and precision values for the Acme standard CDV-1. Concentrations in mg/kg

Acme standard CDV-1 (N=28), alphabetical										Sorted by precision			
Element	Min	Q50	Max	Precision	Element	Min	Q50	Max	Precision	Element	Precision	Element	Precision
Ag	0,00783	0,0109	0,025	29	Ni	6,44	7,15	7,78	5,2	Pt	-668	Hg	8,2
Al	1536	1706	1914	5,1	P	387	415	457	5,4	Pd	-317	Pb206	8,2
As	0,861	1,52	1,83	17	Pb	1,05	1,15	1,33	8,2	Re	148	Zr	7,6
Au	0,00138	0,00266	0,005	25	Pb204	0,0119	0,0152	0,017	8,6	Ge	126	Na	7,2
B	9,84	12,6	14,3	9,0	Pb206	0,225	0,291	0,332	8,2	In	99	Ga	7,1
Ba	9,18	9,86	11,4	3,9	Pb207	0,206	0,239	0,268	8,3	Te	98	Pb208	7,0
Be	-0,0002622	0,0603	0,213	81	Pb208	0,551	0,612	0,716	7,0	Be	81	Ti	6,9
Bi	0,00984	0,0197	0,0277	23	Pd	-0,0048	-0,0007	0,0062	-317	Ta	78	Th	6,5
Ca	20140	21268	22813	3,4	Pt	-0,0024	-0,0001	0,0037	-668	Se	46	Rb	6,4
Cd	0,0204	0,0389	0,0538	23	Rb	2,39	2,73	3,03	6,4	S	32	Co	6,4
Ce	4,84	5,2	5,96	3	Re	-0,0015154	0,000319	0,00386	148	Ag	29	Zn	6,2
Co	1,91	2,08	2,4	6,4	S	-197,2	1018	1435	32	V	28	U	6,2
Cr	12,1	13,8	16,9	4,2	Sb	0,0122	0,0329	0,0482	21	Au	25	Cu	5,6
Cs	0,114	0,129	0,148	5,2	Sc	0,637	0,92	1,17	13	Li	24	P	5,4
Cu	8,24	9,36	10,2	5,6	Se	-0,0415573	0,323	0,571	46	Bi	23	Ni	5,2
Fe	2706	2886	3215	4,2	Sn	0,0513	0,092	0,145	17	Cd	23	Cs	5,2
Ga	0,557	0,678	0,804	7,1	Sr	115	124	129	3,6	Sb	21	Al	5,1
Ge	-0,0658984	0,0268	0,081	126	Ta	-0,0020997	0,00119	0,00348	78	W	18	K	4,3
Hf	0,0243	0,0494	0,0658	17	Te	-0,0127631	0,0187	0,073	98	Sn	17	Cr	4,2
Hg	0,0389	0,054	0,0718	8,2	Th	0,659	0,727	0,821	6,5	Hf	17	Fe	4,2
In	-0,0040796	0,00229	0,00962	99	Ti	27,3	30,9	34,5	6,9	As	17	Ba	3,9
K	1662	1779	1912	4,3	Tl	0,0111	0,0162	0,0222	11	Sc	13	Y	3,8
La	2,3	2,55	2,65	3,3	U	0,161	0,185	0,214	6,2	Nb	13	Sr	3,6
Li	0,423	0,576	0,753	24	V	0,405	3,41	4,58	28	Mo	12	Ca	3,4
Mg	1256	1306	1445	3,3	W	0,0423	0,0699	0,141	18	Tl	11	La	3,3
Mn	395	429	466	3,3	Y	1,48	1,56	1,68	3,8	B	9,0	Mg	3,3
Mo	0,174	0,215	0,259	12	Zn	22,8	26,2	29,1	6,2	Pb204	8,6	Mn	3,3
Na	52,3	60	68,3	7,2	Zr	1,1	1,26	1,45	7,6	Pb207	8,3	Ce	3,0
Nb	0,0314	0,0586	0,0702	13						Pb	8,2		

Table 4: Minimum, median (Q50), maximum and precision values for the Acme standard V16. Concentrations in mg/kg

Acme V16 standard (N=28) alphabetical										Sorted by precision			
Element	Min	Q50	Max	Precision	Element	Min	Q50	Max	Precision	Element	Precision	Element	Precision
Ag	0,034	0,0409	0,048	9,5	Ni	6,5	8,53	10,3	11	Be	-234648346,2	Co	13
Al	495	535	612	3,2	P	472	524	578	4,4	Re	1585317	B	12
As	1,14	1,65	2,27	13	Pb	3,22	3,44	4,16	2,6	Pd	914	Cr	11
Au	0,000392	0,00121	0,00788	47	^{204}Pb	0,0417	0,0461	0,0527	3,8	In	-464	Ni	11
B	3,78	4,99	6,38	12	^{206}Pb	0,81	0,868	1,05	3,3	Pt	257	Sb	11
Ba	1,51	2,18	2,59	7,0	^{207}Pb	0,684	0,727	0,909	2,5	S	173	Ce	11
Be	-0,0379628	0	0,0465	-234648346	^{208}Pb	1,64	1,8	2,16	3,4	Se	161	Fe	11
Bi	0,00152	0,0105	0,015	15	Pd	-0,0028	0,00023	0,00438	914	Te	144	La	10
Ca	3271	3468	3690	4,3	Pt	-0,0019	0,000148	0,00112	257	V	115	Cu	10
Cd	0,0644	0,0898	0,153	18	Rb	1,66	1,78	1,94	6,0	U	101	Ag	9,5
Ce	0,0847	0,113	0,162	11	Re	-0,0015	0	0,00691	2E+06	Sc	88	Cs	8,4
Co	0,939	1,2	1,93	13	S	-1223	222	604	173	Th	77	Na	8,2
Cr	284	364	455	11	Sb	0,0604	0,0765	0,105	11	Ta	72	Ba	7,0
Cs	0,0346	0,0394	0,0492	8,4	Sc	-0,0369002	0,207	0,555	88	Ge	72	Ti	6,6
Cu	6,45	7,5	20,8	9,8	Se	-0,1173872	0,124	0,458	161	Hf	66	Zn	6,0
Fe	3751	4702	5669	11	Sn	0,154	0,239	1,03	17	Au	47	Rb	6,0
Ga	0,136	0,256	0,354	41	Sr	10,9	11,5	12,2	4,6	Ga	41	Sr	4,6
Ge	-0,0474746	0,0493	0,131	72	Ta	-0,000995	0,00104	0,00257	72	Li	32	Mn	4,6
Hf	0	0,00806	0,0205	66	Te	-0,0593523	0,0108	0,113	144	W	29	P	4,4
Hg	0,0414	0,0551	0,0681	20	Th	-0,0506307	0,00524	0,0106	77	Hg	20	K	4,4
In	-0,0050964	-0,0005054	0,00499	-464	Ti	11,2	12,8	14,8	6,6	Tl	20	Ca	4,3
K	2105	2313	2488	4,4	Tl	0,00841	0,0126	0,0183	20	Zr	19	^{204}Pb	3,8
La	0,0359	0,0504	0,0847	10	U	-0,0008899	0,00288	0,00574	101	Nb	19	^{208}Pb	3,4
Li	0,0281	0,066	0,13	32	V	-1,5032125	0,462	1,46	115	Mo	18	^{206}Pb	3,3
Mg	544	584	663	3,3	W	0,0154	0,0372	0,0702	29	Cd	18	Mg	3,3
Mn	704	780	858	4,6	Y	0,0388	0,0486	0,0764	13	Sn	17	Al	3,2
Mo	1,31	1,79	2,58	18	Zn	37,8	44,9	48,6	6,0	Bi	15	Pb	2,6
Na	15,8	18,5	23,4	8,2	Zr	0,122	0,17	0,507	19	As	13	^{207}Pb	2,5
Nb	0,0768	0,108	0,149	19						Y	13		

Table 5: Precision on analytical and field duplicates and also replicate analyses..

Field duplicates (38 pairs)				Analytical duplicates (38 pairs)				Replicate analyses (28 reps)			
Alphabetical		Sorted		Alphabetical		Sorted		Alphabetical		Sorted	
Element	Precision	Element	Precision	Element	Precision	Element	Precision	Element	Precision	Element	Precision
Ag	29	Pd	-1588	Ag	8,1	Pt	-39833	Ag	2,6	Pd	2187
Al	48	Pt	-1153	Al	5,5	Pd	-2229	Al	6,5	Re	324
As	34	Au	351	As	23	Au	305	As	10	Pt	243
Au	351	Re	232	Au	305	Re	180	Au	75	Te	148
B	24	Te	137	B	20	Te	91	B	22	Au	75
Ba	28	V	90	Ba	4,5	Be	71	Ba	2,8	Be	65
Be	71	Ti	83	Be	71	In	64	Be	65	In	53
Bi	21	Ga	81	Bi	7,9	Hf	31	Bi	7,5	W	32
Ca	20	Mn	75	Ca	7,3	Ta	31	Ca	2,8	Ta	22
Cd	21	U	71	Cd	9,1	La	29	Cd	6,4	B	22
Ce	66	Be	71	Ce	12	Ge	27	Ce	6,1	Ge	21
Co	48	In	67	Co	18	As	23	Co	12	Hf	19
Cr	60	Ce	66	Cr	5,2	W	22	Cr	6,9	Mn	17
Cs	57	Y	63	Cs	5,2	U	21	Cs	3,9	Se	17
Cu	44	Li	61	Cu	8,1	B	20	Cu	11	Mg	12
Fe	51	Cr	60	Fe	5,2	Y	19	Fe	8,4	Co	12
Ga	81	La	59	Ga	7,3	Co	18	Ga	7,0	Cu	11
Ge	36	Nb	59	Ge	27	Se	14	Ge	21	As	10
Hf	40	Cs	57	Hf	31	Th	14	Hf	19	Sb	10
Hg	21	Fe	51	Hg	8,0	Mn	14	Hg	5,4	Mo	9,2
In	67	Th	50	In	64	Ce	12	In	53	V	8,7
K	14	Zr	49	K	3,8	Mo	12	K	2,5	Fe	8,4
La	59	Co	48	La	29	Ni	11	La	6,4	S	8,2
Li	61	Al	48	Li	10	Tl	11	Li	7,9	Nb	8,1
Mg	31	Cu	44	Mg	3,9	Li	10	Mg	12	Zr	8,0
Mn	75	Ta	42	Mn	14	Sc	10	Mn	17	Li	7,9
Mo	27	Hf	40	Mo	12	Cd	9,1	Mo	9,2	Tl	7,6
Na	8,3	Ge	36	Na	5,6	Ag	8,1	Na	5,4	Bi	7,5
Nb	59	As	34	Nb	6,1	Cu	8,1	Nb	8,1	Sc	7,5
Ni	27	Se	31	Ni	11	Hg	8,0	Ni	5,5	Th	7,5
P	13	Mg	31	P	4,6	Bi	7,9	P	2,7	U	7,2
Pb	19	Ag	29	Pb	4,5	Ca	7,3	Pb	2,5	Ga	7,0
Pd	-1588	Tl	29	Pd	-2229	Ga	7,3	Pd	2187	Cr	6,9
Pt	-1153	Sc	28	Pt	-39833	Sn	7,1	Pt	243	Al	6,5
Rb	26	Ba	28	Rb	5,5	Zr	6,8	Rb	5,0	Cd	6,4
Re	232	Ni	27	Re	180	V	6,7	Re	324	La	6,4
S	22	Mo	27	S	6,2	Ti	6,4	S	8,2	Ce	6,1
Sb	21	W	27	Sb	5,7	S	6,2	Sb	10	Ni	5,5
Sc	28	Rb	26	Sc	10	Nb	6,1	Sc	7,5	Hg	5,4
Se	31	Zn	25	Se	14	Sb	5,7	Se	17	Na	5,4
Sn	23	B	24	Sn	7,1	Na	5,6	Sn	5,2	Sn	5,2
Sr	20	Sn	23	Sr	5,2	Al	5,5	Sr	2,0	Rb	5,0
Ta	42	S	22	Ta	31	Rb	5,5	Ta	22	Ti	5,0
Te	137	Cd	21	Te	91	Cr	5,2	Te	148	Zn	4,5
Th	50	Bi	21	Th	14	Cs	5,2	Th	7,5	Cs	3,9
Ti	83	Hg	21	Ti	6,4	Fe	5,2	Ti	5,0	Y	3,5
Tl	29	Sb	21	Tl	11	Sr	5,2	Tl	7,6	Ba	2,8
U	71	Ca	20	U	21	Zn	5,0	U	7,2	Ca	2,8
V	90	Sr	20	V	6,7	P	4,6	V	8,7	P	2,7
W	27	Pb	19	W	22	Ba	4,5	W	32	Ag	2,6
Y	63	K	14	Y	19	Pb	4,5	Y	3,5	K	2,5
Zn	25	P	13	Zn	5,0	Mg	3,9	Zn	4,5	Pb	2,5
Zr	49	Na	8,3	Zr	6,8	K	3,8	Zr	8,0	Sr	2,0

Table 6: Statistical results (minimum, mean, maximum and standard deviation) for the NIST standard

		MINS 2013 organic soil analyses				Reference values*	
Pb ratio		Min.	Mean	Max.	2*StDev	Mean value	±
^{204}Pb/^{206}Pb	SRM 981	0.055346	0.058771	0.060557	0.002797	0.059042	± 0,000037
^{207}Pb/^{206}Pb	SRM 981	0.891885	0.916921	0.964005	0.032714	0.914640	± 0,00033
^{208}Pb/^{206}Pb	SRM 981	1.971519	2.158194	2.282513	0.138801	2.168100	± 0,0008
^{204}Pb/^{206}Pb	SRM 983	0.000318	0.000375	0.000443	0.000058	0.000371	± 0,00002
^{207}Pb/^{206}Pb	SRM 983	0.066639	0.071622	0.073890	0.001662	0.071201	± 0,00004
^{208}Pb/^{206}Pb	SRM 983	0.011815	0.014490	0.015871	0.003116	0.013619	± 0,000024

*Overall limits of error are based on 95 % confidence limits for the mean of the ratio measurements and on allowances for the known sources of possible systematic error.

Table 7: Statistical results (minimum, 25 percentile, median, mean, 75-percentile, maximum, standard deviation and precision) for previous and present analyses of the Reimann et. al. (2007) study (N=10).

Pb ratio		Min	25 %	Median	Mean	75 %	Max	2xSD	Prec (%)
^{206}Pb/^{207}Pb	previous	1.1406	1.1519	1.1526	1.1642	1.1593	1.2300	0.0546	0.7
	present	1.1379	1.1503	1.1593	1.1659	1.1743	1.2150	0.0515	
^{206}Pb/^{208}Pb	previous	0.4734	0.4740	0.4743	0.4775	0.4754	0.4952	0.0145	1.8
	present	0.4595	0.4792	0.4850	0.4809	0.4859	0.4881	0.0175	
^{208}Pb/^{207}Pb	previous	2.4090	2.4290	2.4304	2.4373	2.4386	2.4836	0.0412	1.5
	present	2.3412	2.3803	2.4002	2.4249	2.4669	2.5431	0.1337	

Table 8: Statistical results (minimum, 25 percentile, median, mean, 75-percentile, maximum standard deviation and precision) for previous and present analyses of the Jensen & Finne (2006) study (N=5).

Pb ratio		Min	25 %	Median	Mean	75 %	Max	2xSD	Prec (%)
^{206}Pb/^{207}Pb	previous	1.1486	1.1510	1.1578	1.1603	1.1580	1.1861	0.0300	1.2
	present	1.1266	1.1347	1.1429	1.1452	1.1580	1.1638	0.0312	
^{206}Pb/^{208}Pb	previous	0.4747	0.4755	0.4765	0.4779	0.4771	0.4858	0.0090	1.5
	present	0.4596	0.4643	0.4706	0.4708	0.4790	0.4807	0.0182	
^{208}Pb/^{207}Pb	previous	2.4168	2.4211	2.4285	2.4288	2.4362	2.4415	0.0205	0.5
	present	2.4091	2.4288	2.4294	2.4324	2.4436	2.4511	0.0322	

Table 9: Statistical parameters for the mapped data. Humus <2mm, aqua regia extraction on 5g sample material. N=752, concentrations in mg/kg

Ele.	n<PDL	MDL	PDL	Min	Q2	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q98	Max	Power
Ag	0	0.002	0.002	0.029	0.047	0.057	0.068	0.11	0.20	0.44	0.86	1.14	1.76	5.87	2.3
Al	0	100	100	304	465	572	734	1087	2030	4221	7484	10435	14035	43010	2.2
As	110	0.1	0.3	<0.3	<0.3	<0.3	<0.3	0.5	0.8	1.3	1.9	2.7	5.7	112	2.9
Au	445	0.0002	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0008	0.0013	0.002	0.002	0.02	2
B	12	1	0.5	<0.50	0.6	0.7	1.0	1.3	1.8	2.4	3.0	3.7	4.3	6.5	1.4
Ba	0	0.1	0.1	6.54	11.0	13.1	16.5	23.9	35.5	50.1	70.4	89.6	114	286	1.6
Be	747	0.1	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.7	1
Bi	0	0.02	0.02	0.02	0.04	0.06	0.07	0.10	0.13	0.17	0.21	0.23	0.28	0.47	1.3
Ca	0	100	100	403	830	1148	1438	2086	2681	3446	4425	5344	8115	21802	1.7
Cd	0	0.01	0.05	0.06	0.12	0.19	0.25	0.36	0.51	0.71	0.92	1.1	1.3	1.9	1.5
Ce	0	0.01	0.01	0.48	0.72	0.93	1.3	2.2	5.1	12	25	38	68	404	2.9
Co	0	0.01	0.01	0.21	0.33	0.44	0.57	0.85	1.5	2.7	5.1	8.1	19	93	2.7
Cr	0	0.1	0.1	1.1	1.3	1.5	1.7	2.1	3.0	6.3	13	21	34	1112	3
Cs	0	0.005	0.005	0.026	0.053	0.068	0.090	0.139	0.266	0.508	0.974	1.30	1.81	4.31	2.2
Cu	0	0.01	0.01	2.7	4.2	4.8	5.5	6.4	7.9	10	14	19	34	305	2
Fe	0	10	10	376	601	704	930	1490	3003	6168	13293	18635	28188	183346	2.7
Ga	0	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.8	1.6	3.0	4.2	6.1	11	1.9
Ge	54	0.01	0.02	<0.02	<0.02	<0.02	0.03	0.07	0.14	0.22	0.31	0.38	0.44	0.64	1.8
Hf	40	0.001	0.006	<0.006	0.003	0.003	0.009	0.014	0.023	0.041	0.066	0.087	0.12	0.21	1.8
Hg	0	0.001	0.001	0.059	0.093	0.12	0.14	0.18	0.21	0.26	0.32	0.36	0.40	1.0	1.2
In	671	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.03	0.03	0.05	0.7
K	0	100	100	282	477	536	598	711	851	1009	1226	1428	1674	2527	1
La	0	0.01	0.01	0.21	0.31	0.42	0.57	1.00	2.4	5.3	12	20	39	174	2.9
Li	138	0.01	0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.6	2.6	5.0	9.4	47	3
Mg	0	10	10	302	591	794	912	1112	1401	1761	2449	3669	5257	35752	2.1
Mn	0	1	1	7.5	11	14	18	30	58	117	342	636	1270	5254	2.8
Mo	0	0.01	0.01	0.09	0.16	0.19	0.22	0.28	0.39	0.62	0.98	1.3	2.0	12	2.1
Na	0	10	10	28	52	64	75	103	153	257	359	417	484	789	1.5
Nb	0	0.01	0.01	0.03	0.05	0.07	0.10	0.18	0.42	1.0	2.0	2.8	3.5	6.8	2.3
Ni	0	0.1	0.1	0.9	1.2	1.4	1.6	2.2	3.2	5.3	9.4	14	22	361	2.6
P	0	10	10	200	386	462	534	644	775	951	1152	1276	1447	2141	1
Pb	0	0.01	0.01	3.1	9.7	12.7	15.8	20.2	27	34.7	43.8	50.9	64.4	3511	3.1
Pd	748	0.002	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.018	0.6
Pt	739	0.001	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.024	1.4
Rb	0	0.1	0.1	0.84	1.4	1.7	2.1	2.8	4.2	6.2	9.5	13	17	30	1.6
Re	605	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.003	0.011	1.3
S	13	100	50	<50	64	394	662	1048	1441	1854	2262	2464	2888	4008	2.2
Sb	0	0.02	0.02	0.05	0.13	0.16	0.19	0.25	0.33	0.43	0.53	0.60	0.68	123	3.4
Sc	9	0.1	0.15	<0.15	0.21	0.30	0.40	0.57	0.81	1.2	1.7	2.2	3.5	11	2.2
Se	16	0.1	0.15	<0.15	<0.15	0.23	0.32	0.55	0.90	1.3	1.8	2.3	2.9	5.3	1.8
Sn	1	0.02	0.15	<0.15	0.30	0.37	0.43	0.58	0.75	0.95	1.1	1.3	1.5	10	2.1
Sr	0	0.5	0.5	4.44	10.3	13.9	16.9	22.4	29.9	37.6	45.9	52.2	59.1	96.9	1.3
Ta	16	0.001	0.001	<0.001	<0.001	0.002	0.003	0.006	0.011	0.017	0.026	0.032	0.042	0.080	2.2
Te	753	0.02	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.3
Th	4	0.01	0.005	<0.005	0.030	0.048	0.066	0.11	0.20	0.38	0.78	1.2	1.9	7.6	3.5
Ti	0	1	1	21	30	40	53	87	161	316	622	914	1437	4437	2.3
Tl	0	0.02	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.11	0.14	0.16	0.20	0.55	1.5
U	0	0.01	0.01	0.02	0.03	0.04	0.05	0.09	0.20	0.49	1.3	2.2	4.7	24	3.2
V	28	2	0.2	<0.2	<0.2	0.3	0.7	1.5	2.9	6.6	14	20	32	80	2.9
W	0	0.1	0.01	0.01	0.03	0.04	0.04	0.06	0.08	0.11	0.16	0.20	0.30	3.0	2.3
Y	0	0.001	0.001	0.10	0.16	0.21	0.27	0.47	1.1	2.5	5.1	8.1	14	65	2.8
Zn	0	0.1	0.1	3.38	12.8	17.0	21.4	28.8	38.3	48.8	61.8	71.7	87.1	247	1.9
Zr	0	0.01	0.01	0.07	0.23	0.27	0.33	0.50	0.77	1.2	2.2	3.0	3.9	11	2.2

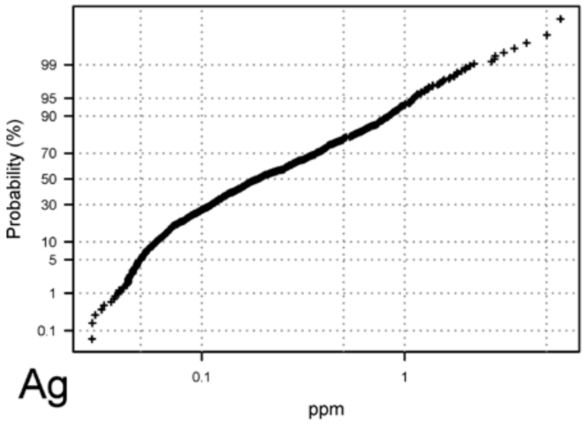
Pb ratio	Min	Q2	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q98	Max	Powers
^{208}Pb/^{206}Pb	1.8595	1.9974	2.0158	2.0333	2.0676	2.1020	2.1368	2.1677	2.1912	2.2115	2.2418	0.1
^{206}Pb/^{207}Pb	1.0399	1.1136	1.1190	1.1266	1.1379	1.1512	1.1650	1.1781	1.1894	1.2054	1.2584	0.1

Table 10: Comparison between Nord-Trøndelag & Fosen survey with Njåstad et. al. (1994), where the greatest value between the datasets is underlined. Statistics from other organic soil surveys covering parts of the MINS area from Ryghaug (1980) and Sæther (1985) (see Figure 1) are also given.

	MINS 2013 (N=754)			Njåstad et. al, 1994 (N=527)			Sæther, 1985 (N=217)			Ryghaug, 1980 (N=1244)		
Ele.	Q50	Q98	Max	Q50	Q98	Max	Q50	Q98	Max	Q50	Q98	Max
Ag	0.20	1.76	5.87	0.3	1	2.2	0.3	1.1	2.5	0.3	1.3	5.4
Al	2030	14035	43010	1700	15400	27700	1832	8854	18336			
As	0.8	5.7	112									
Au	<0.0005	0.002	0.02									
B	1.8	4.3	6.5	2.6	7	58.7	5	14.7	26.2			
Ba	35.5	114	286	45.8	238	483	31.4	109	162			
Be	<1.0	<1.0	4.7	0.2	2	3	0	0.2	0.4			
Bi	0.13	0.28	0.47									
Ca	2681	8115	21802	2200	8050	18600	3003	12595	21433			
Cd	0.51	1.3	1.9	0.8	3	12.4	0.4	1.27	1.6	0.5	1.7	14.6
Ce	5.1	68	404	4.5	51	130						
Co	1.5	19	93	1.9	13	29.8	1.1	9.61	21.1	4	40	131
Cr	3.0	34	1112				2.2	22.3	49.8	5	68.1	268
Cs	0.266	1.81	4.31									
Cu	7.9	34	305				5.7	18.7	24.8	9	55.4	2047
Fe	3003	28188	183346	2100	19600	49200	1738	13856	30369	0.27	3.49	16.6
Ga	0.8	6.1	11									
Ge	0.14	0.44	0.64									
Hf	0.023	0.12	0.21									
Hg	0.21	0.40	1.0	3	32	189						
In	<0.02	0.03	0.05	7	58	1300						
K	851	1674	2527	820	1950	3400	1119	2563	6017			
La	2.4	39	174	2	33	198						
Li	0.2	9.4	47	0.5	10	28.7	0.5	5.87	15			
Mg	1401	5257	35752	1100	4550	10900	1360	4982	11575			
Mn	58	1270	5254	60	1100	10000	139	1175	3602	145	2475	24411
Mo	0.39	2.0	12	0.6	3	9.5	0.4	1.44	2.6	0	2	9
Na	153	484	789	130	485	1700	304	821	1504			
Nb	0.42	3.5	6.8									
Ni	3.2	22	361	3.2	40	487	2.1	11.6	31.4	5	48.1	208
P	775	1447	2141	760	1400	2500	671	1413	2529			
Pb	27	64.4	3511	31.7	201	488	14.3	31.4	106	15	48	521
Pd	<0.01	<0.01	0.018									
Pt	<0.002	<0.002	0.024									
Rb	4.2	17	30									
Re	<0.001	0.003	0.011									
S	1441	2888	4008									
Sb	0.33	0.68	123									
Sc	0.81	3.5	11	0.5	3	10.8						
Se	0.90	2.9	5.3									
Sn	0.75	1.5	10									
Sr	29.9	59.1	96.9	23.7	70	103						
Ta	0.011	0.042	0.080									
Te	<0.2	<0.2	0.2									
Th	0.20	1.9	7.6									
Ti	161	1437	4437	110	845	1700						
Tl	0.08	0.20	0.55									
U	0.20	4.7	24									
V	2.9	32	80	6.2	40	99.3	4.5	33	80	11	100	245
W	0.08	0.30	3.0									
Y	1.1	14	65									
Zn	38.3	87.1	247	41.8	156	1600	32.7	95.4	312	35	127	1252
Zr	0.77	3.9	11	0.8	3	9.4	0.5	4.04	6.5			

Appendix 1: Cumulative frequency diagrams for all elements

Please note that readings below the practical detection limit are set to half of the practical detection limit value



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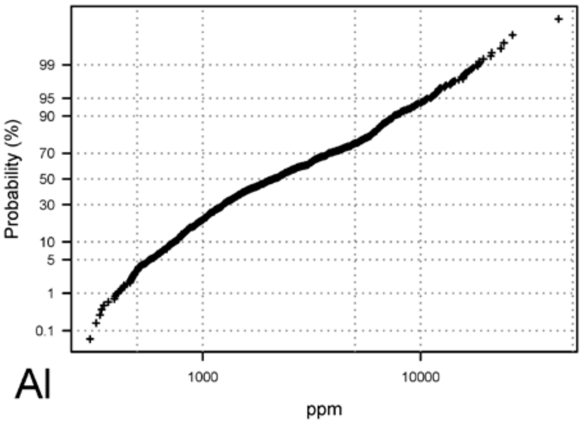

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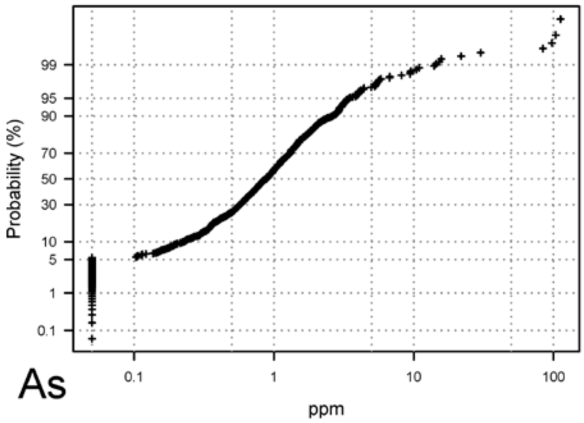

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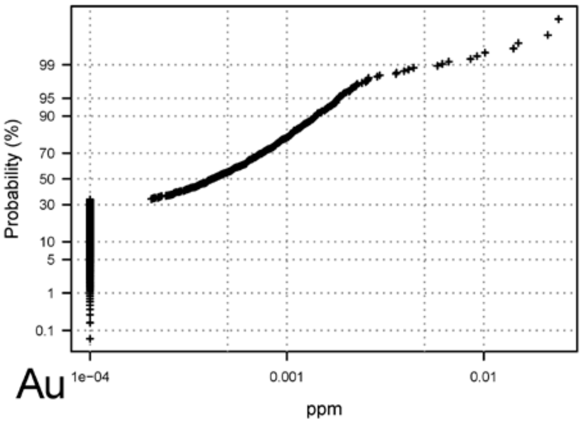

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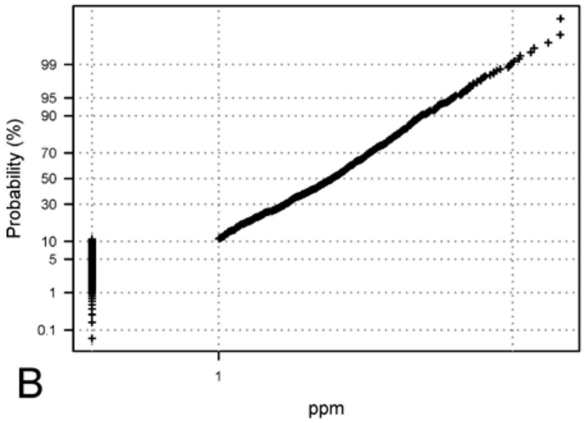

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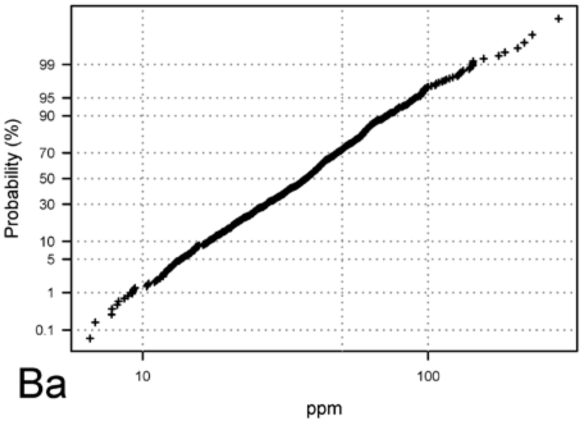

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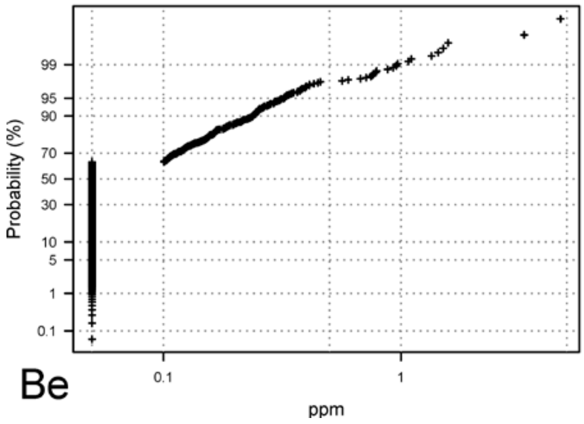

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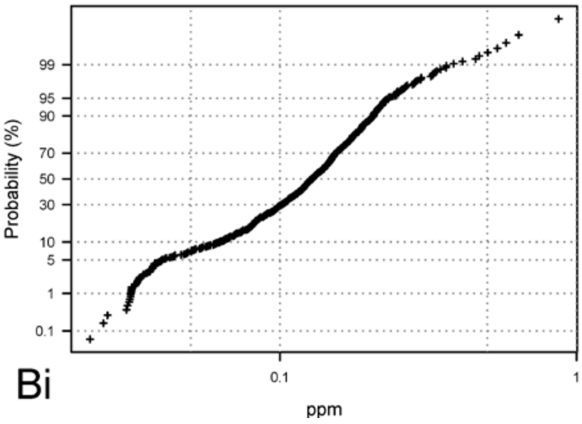

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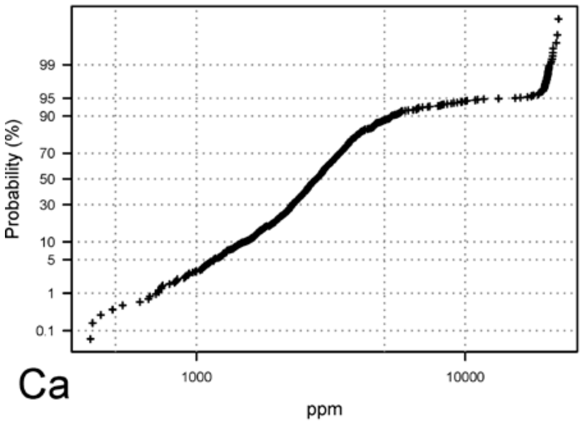

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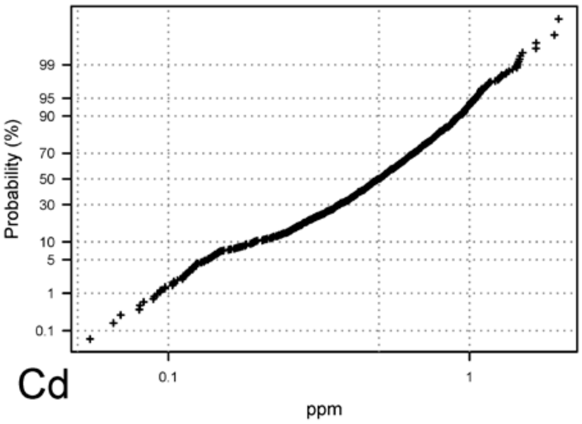

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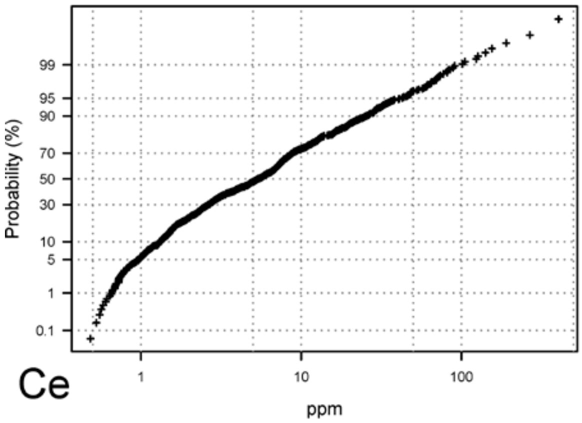

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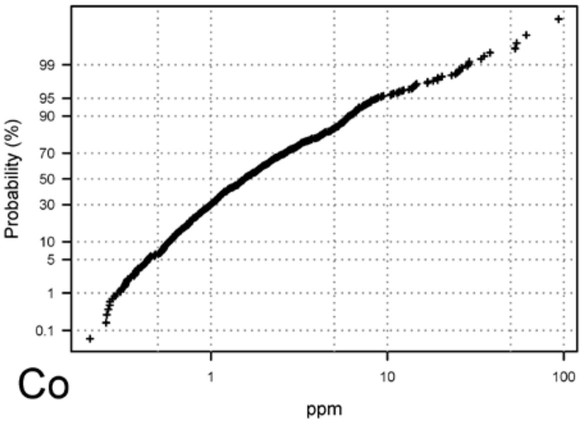

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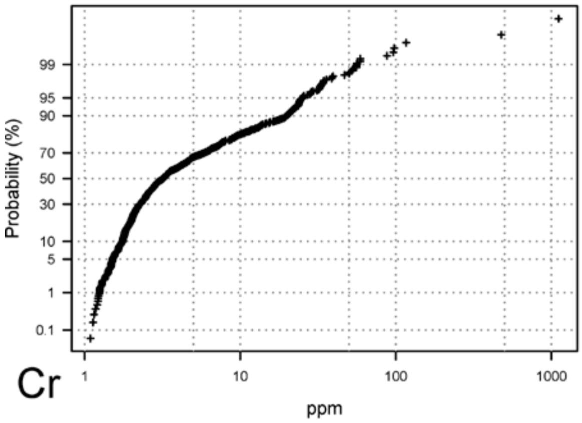

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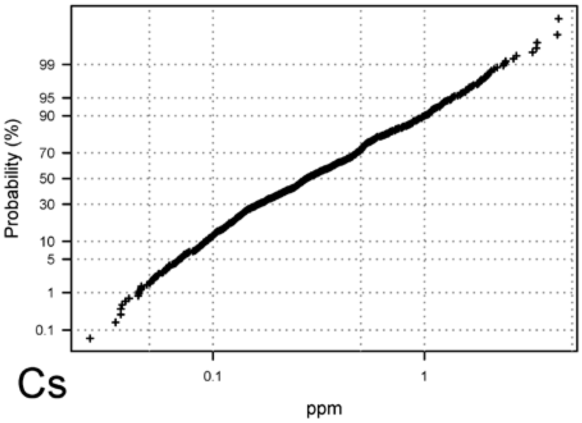

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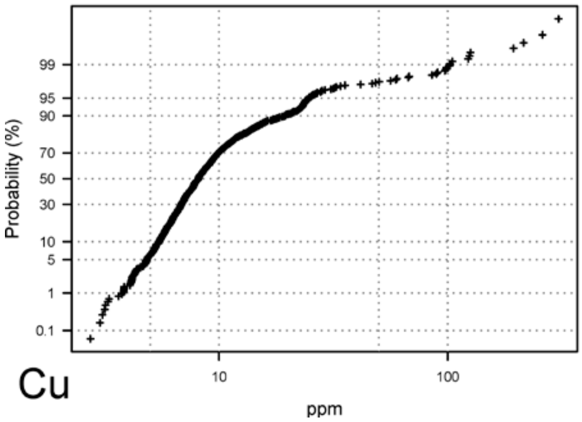

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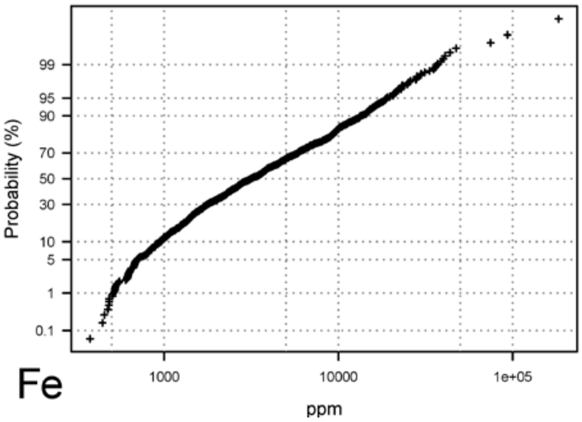

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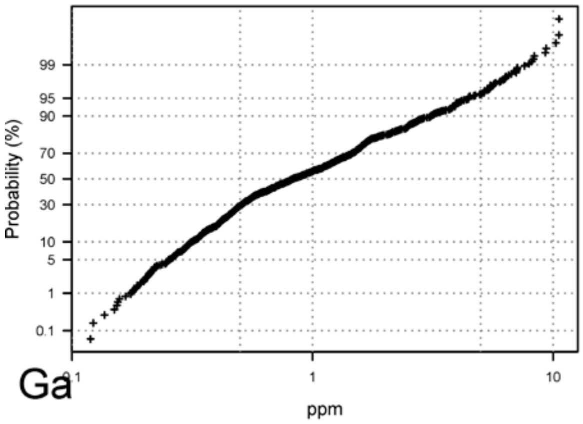

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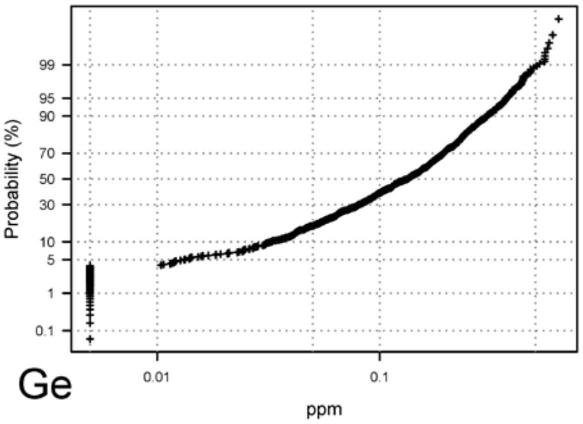

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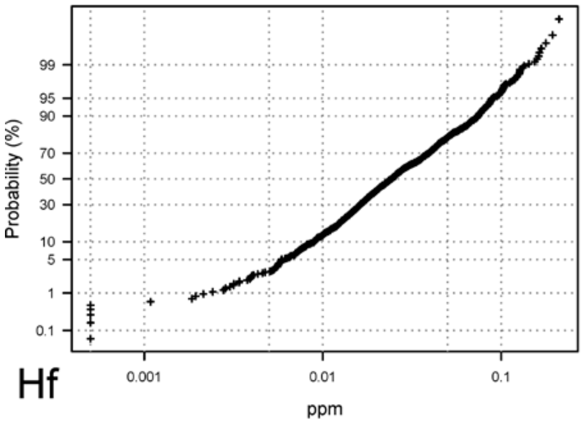

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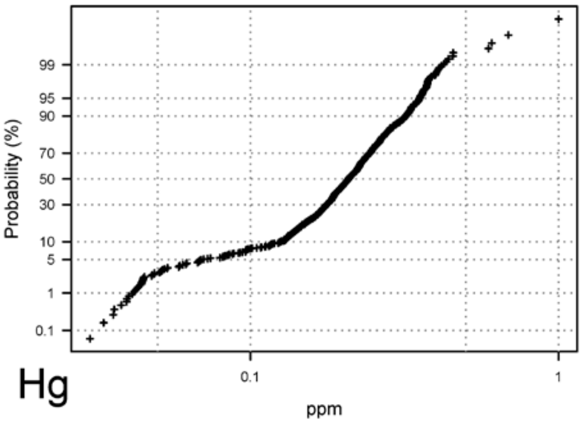

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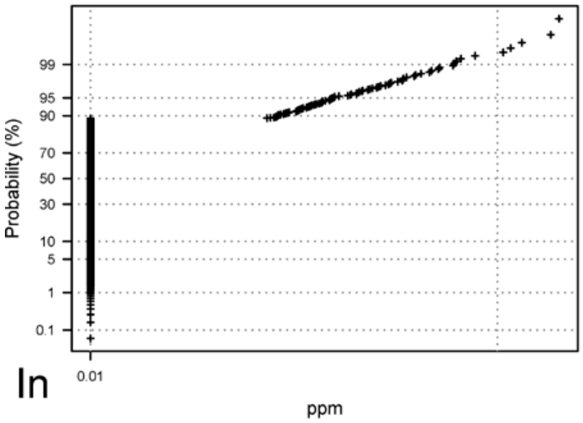

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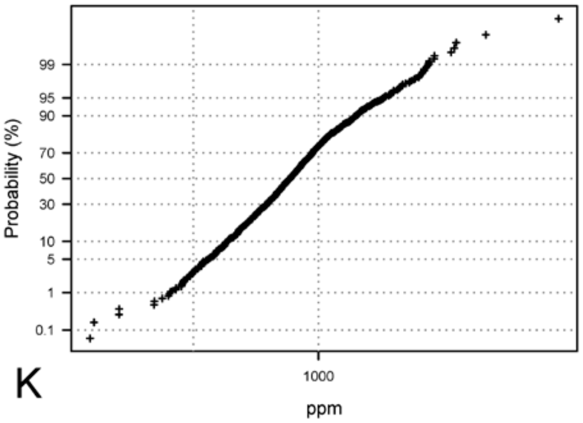

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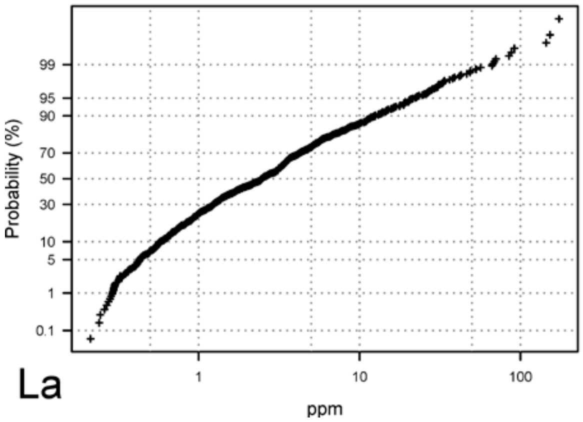

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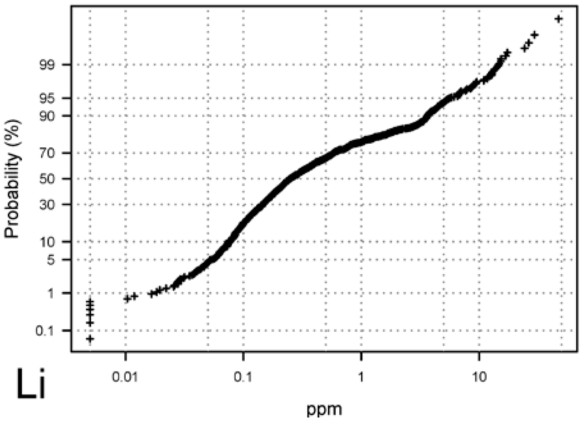

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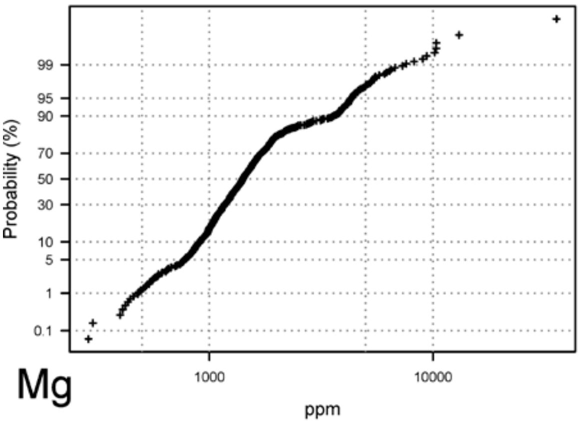
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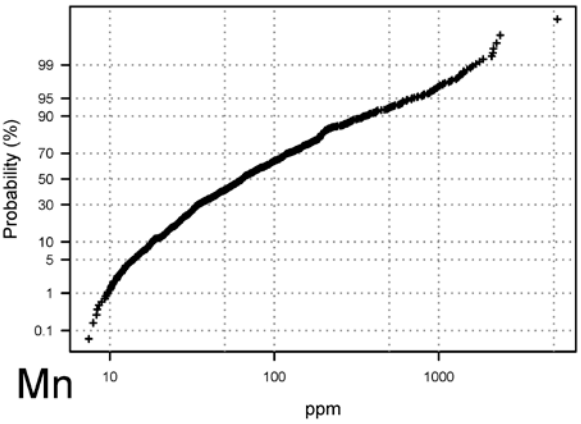
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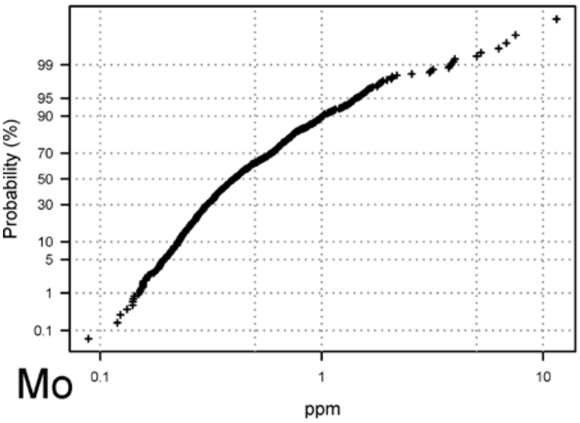
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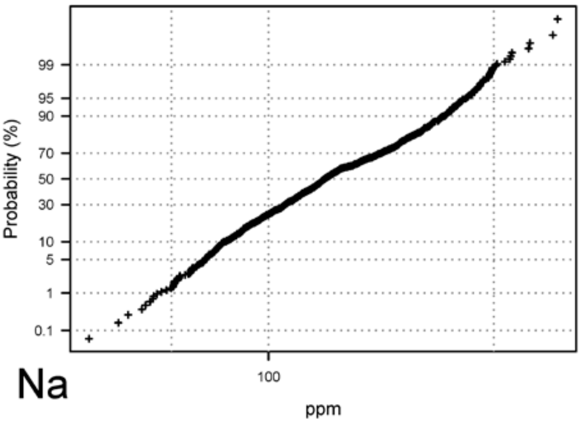
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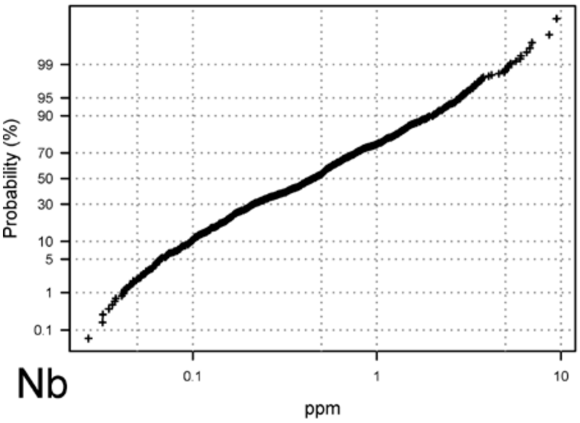
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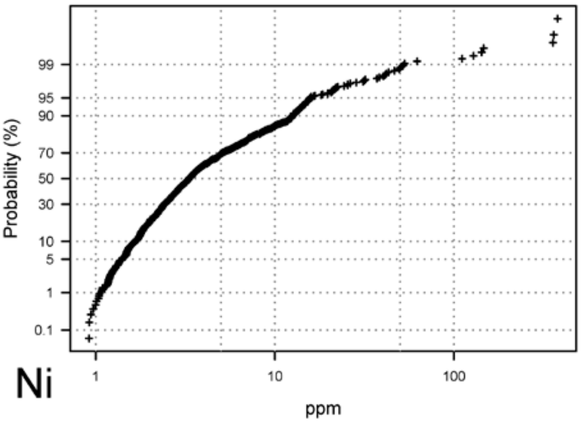
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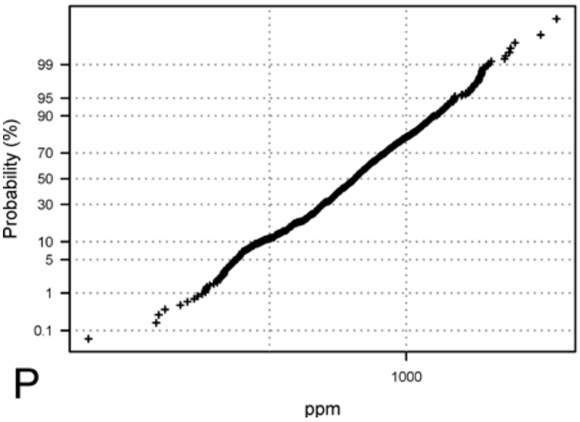
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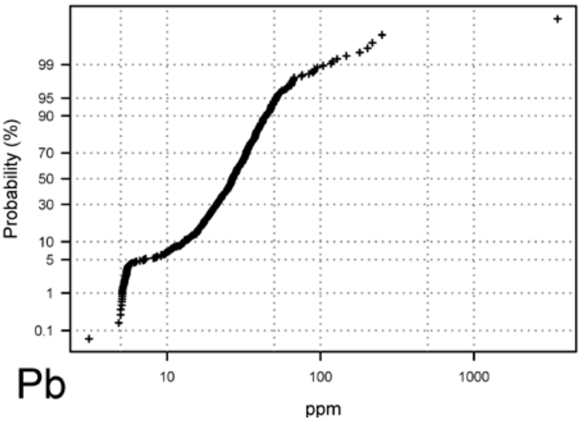
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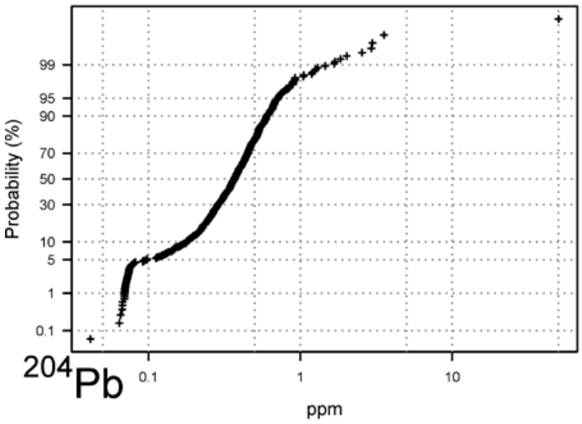
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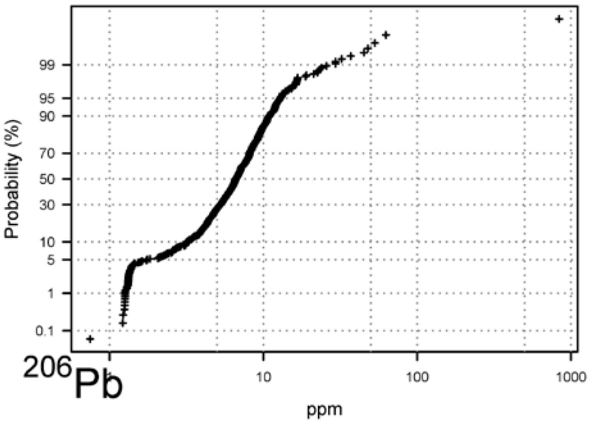
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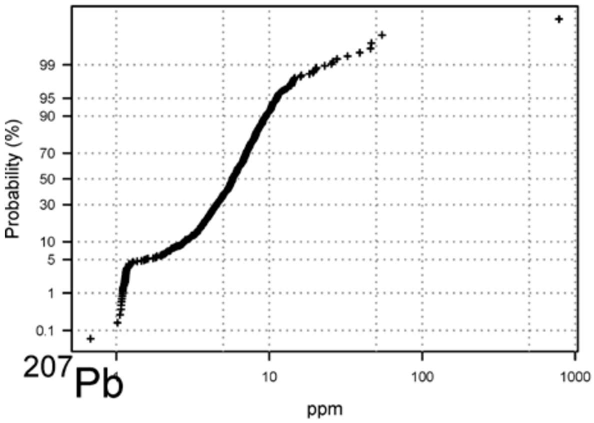
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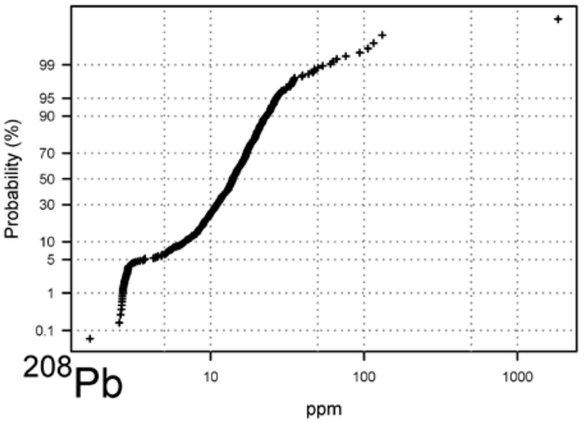
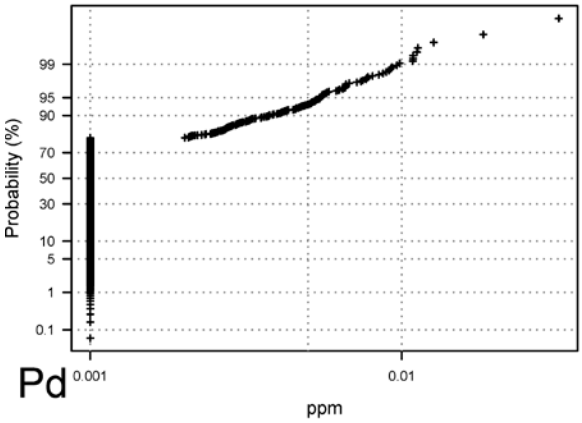
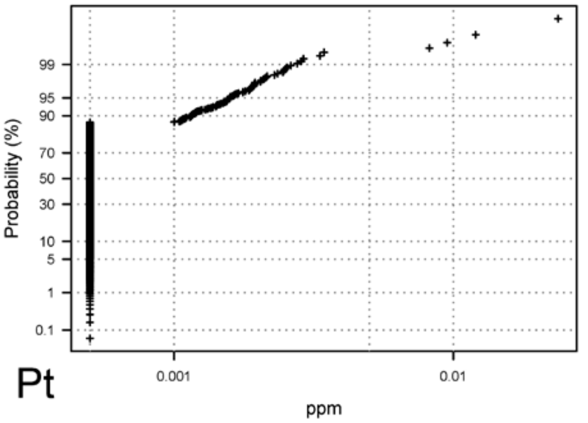
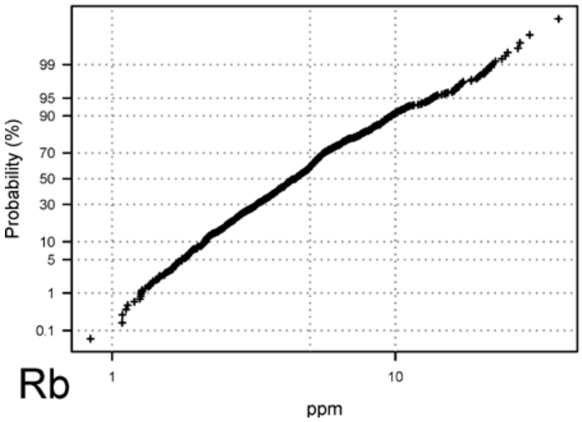
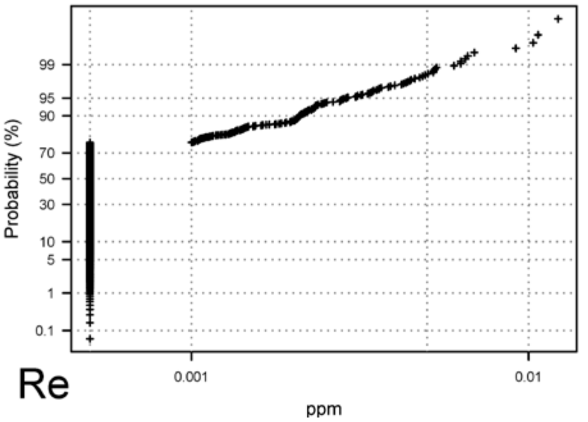
0.1
10
100
1000
ppm
^{207}Pb

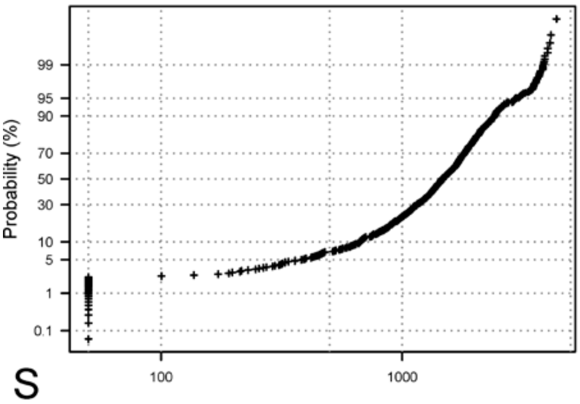

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
10
100
1000
ppm
^{208}Pb


Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.001
0.01
ppm
Pd

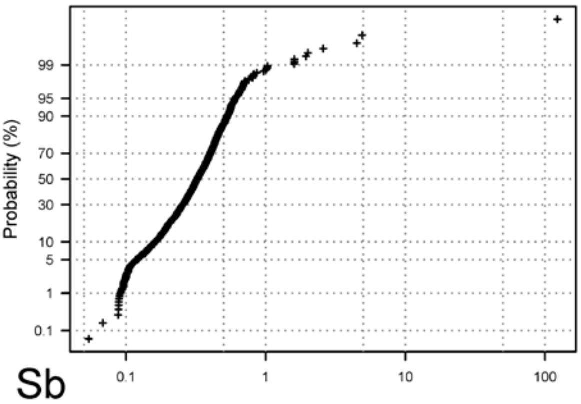

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.001
0.01
ppm
Pt


Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1
10
ppm
Rb

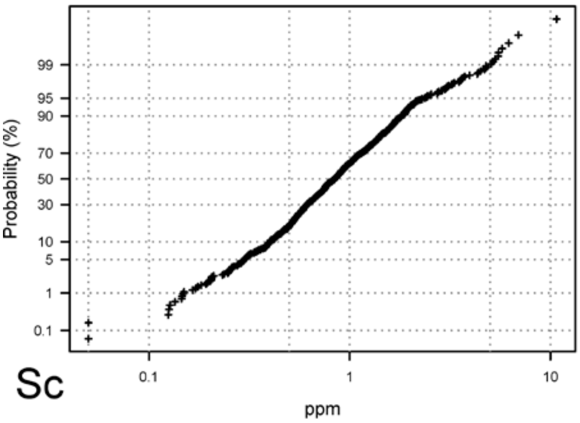

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.001
0.01
ppm
Re



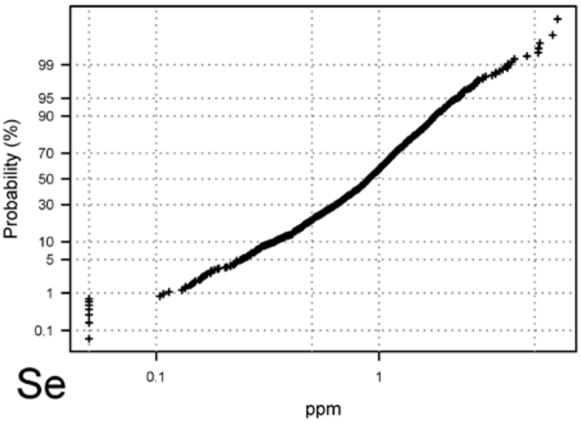
S



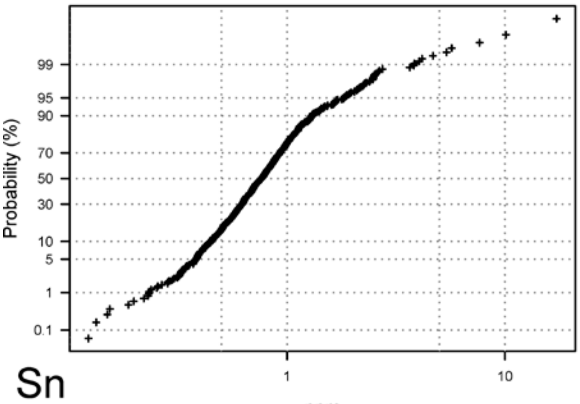
Sb



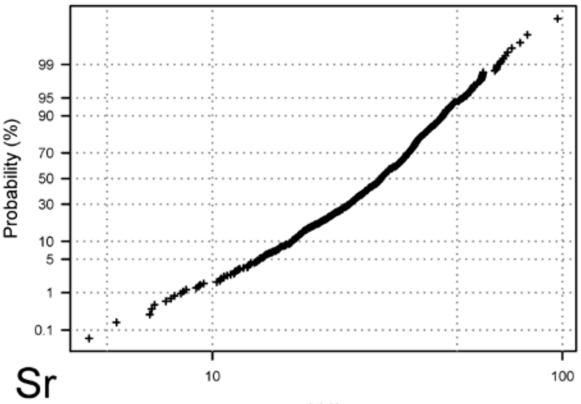
Sc



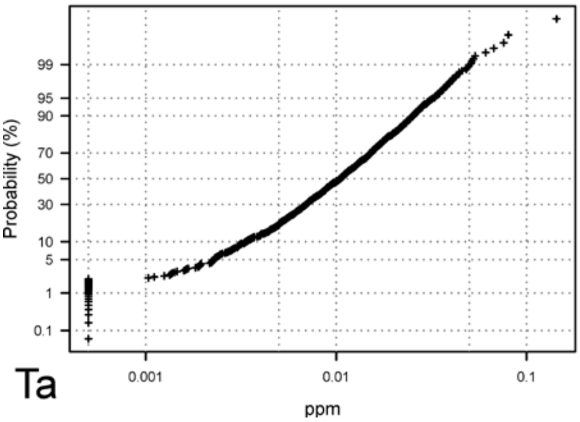
Se



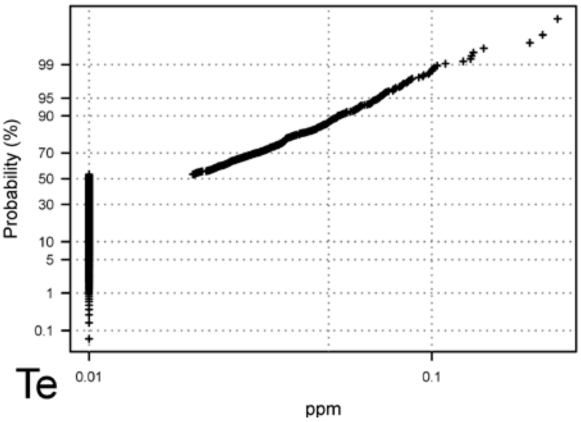
Sn



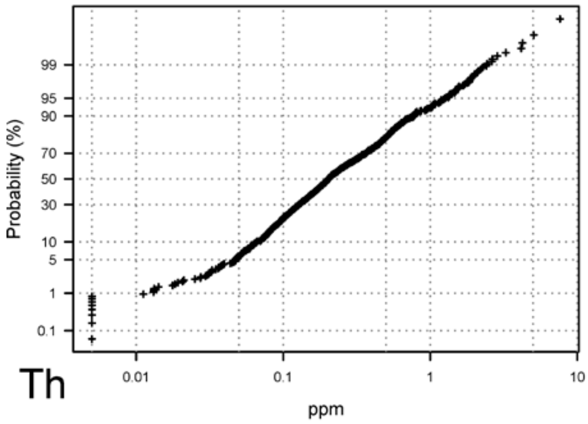
Sr



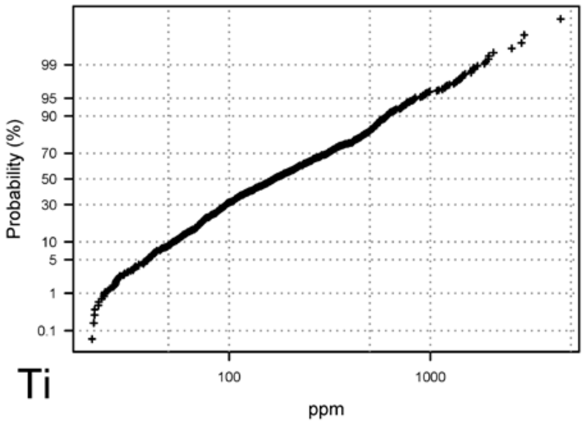
Ta



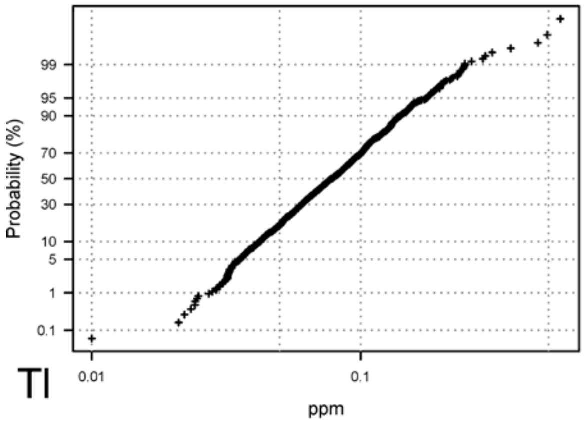
Te



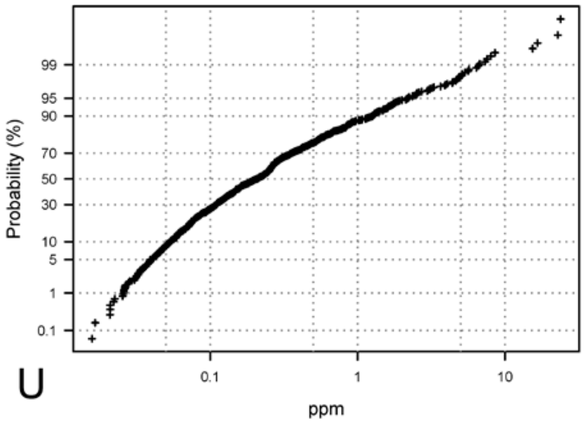
Th



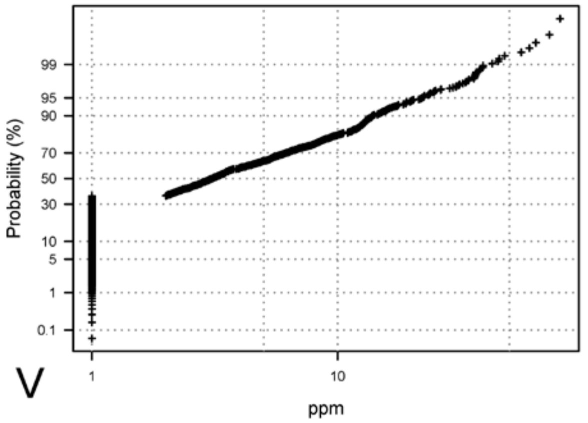
Ti



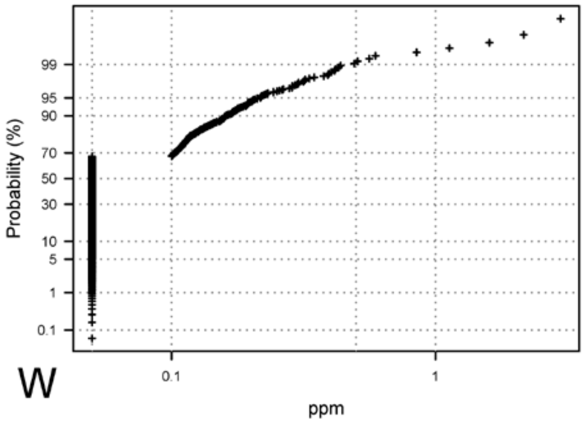
Tl



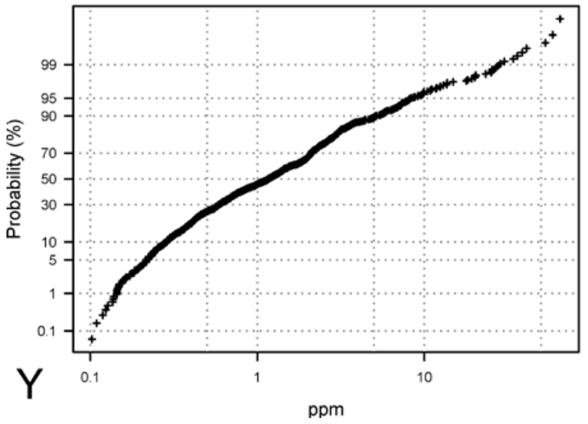
U



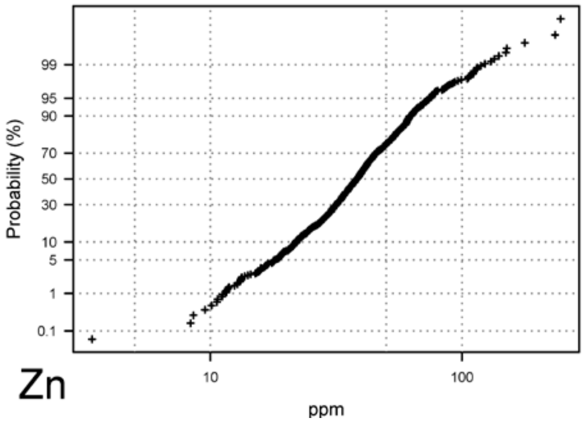
V



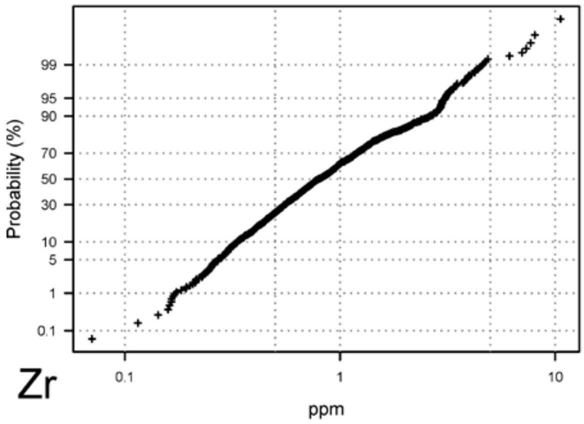
W

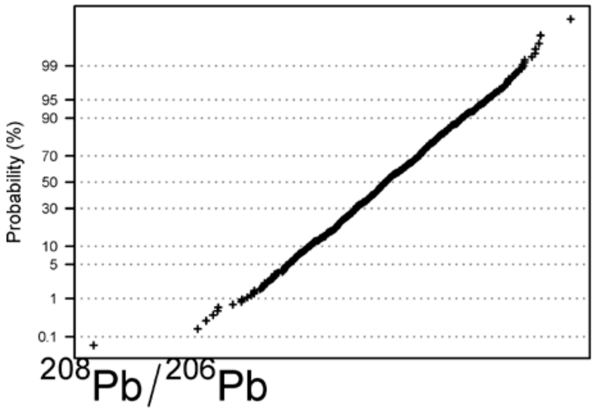


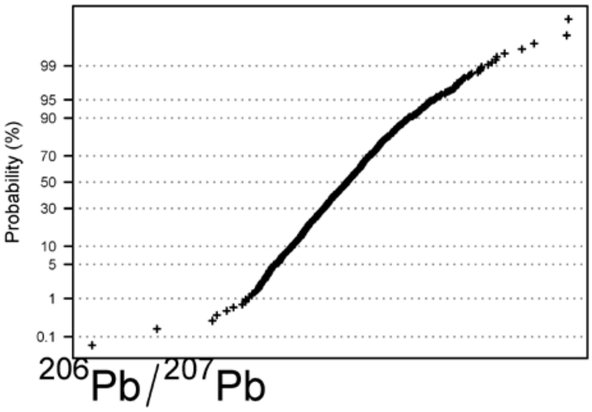
Y



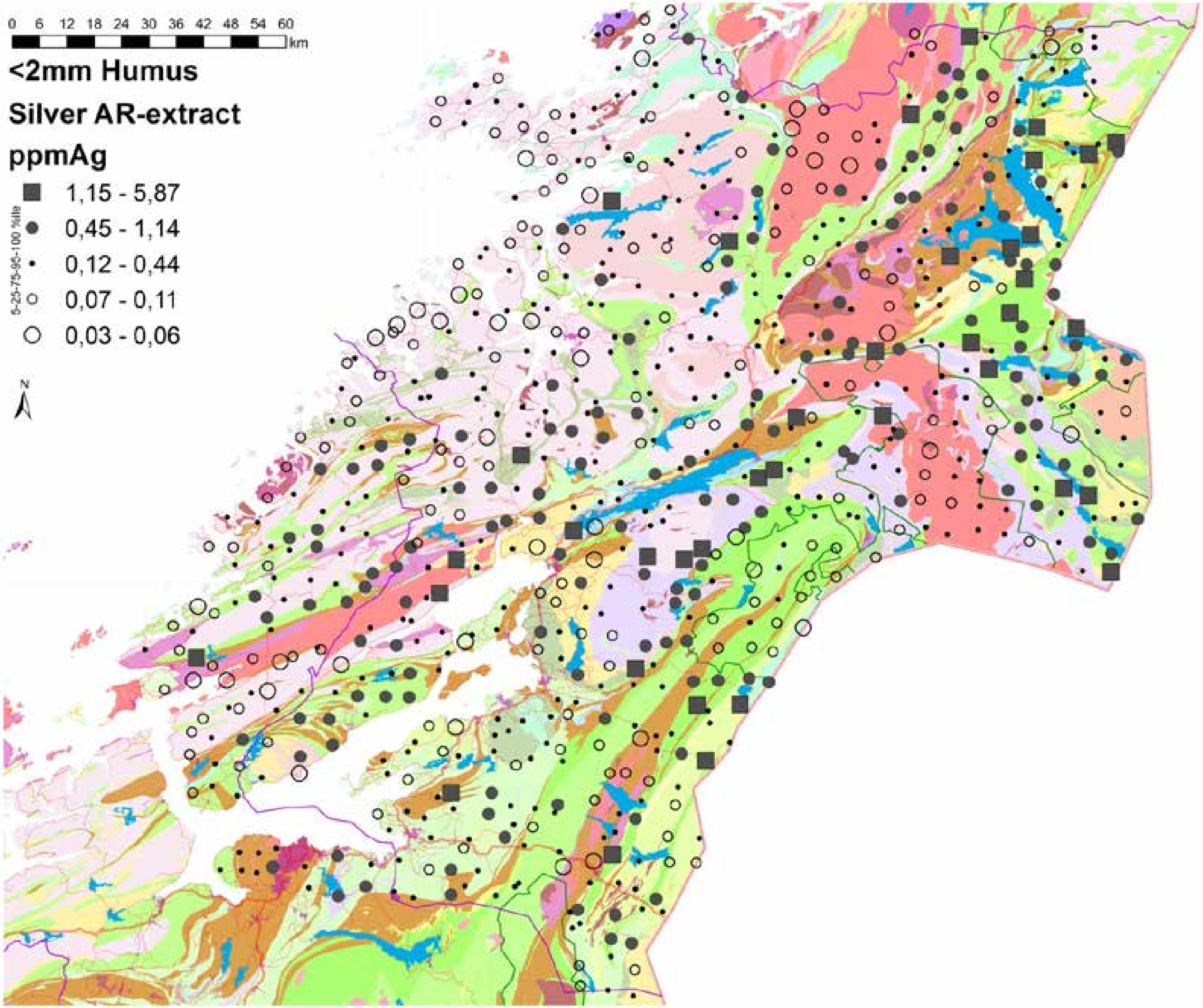
Zn

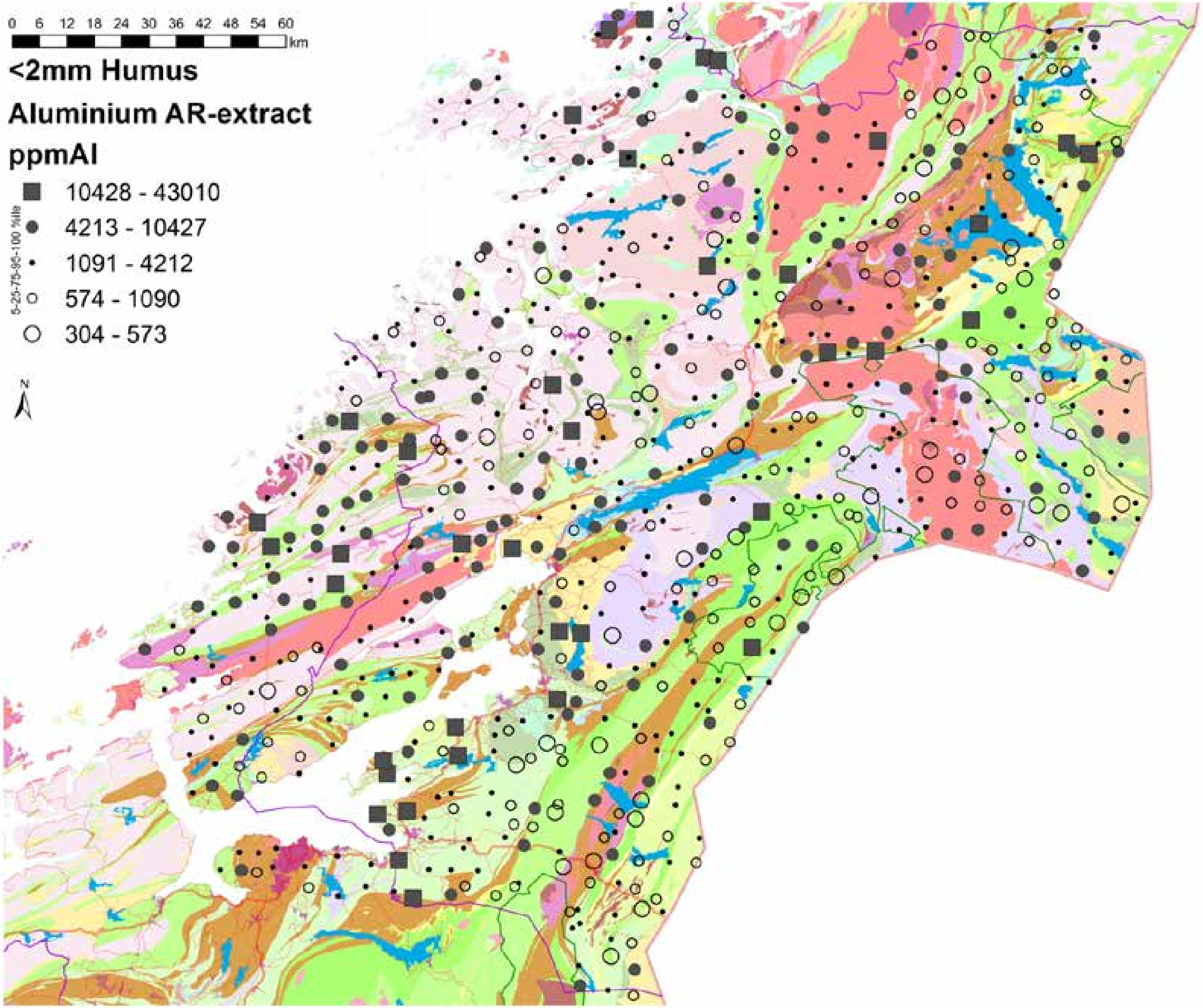

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.1
1
10
ppm
Zr

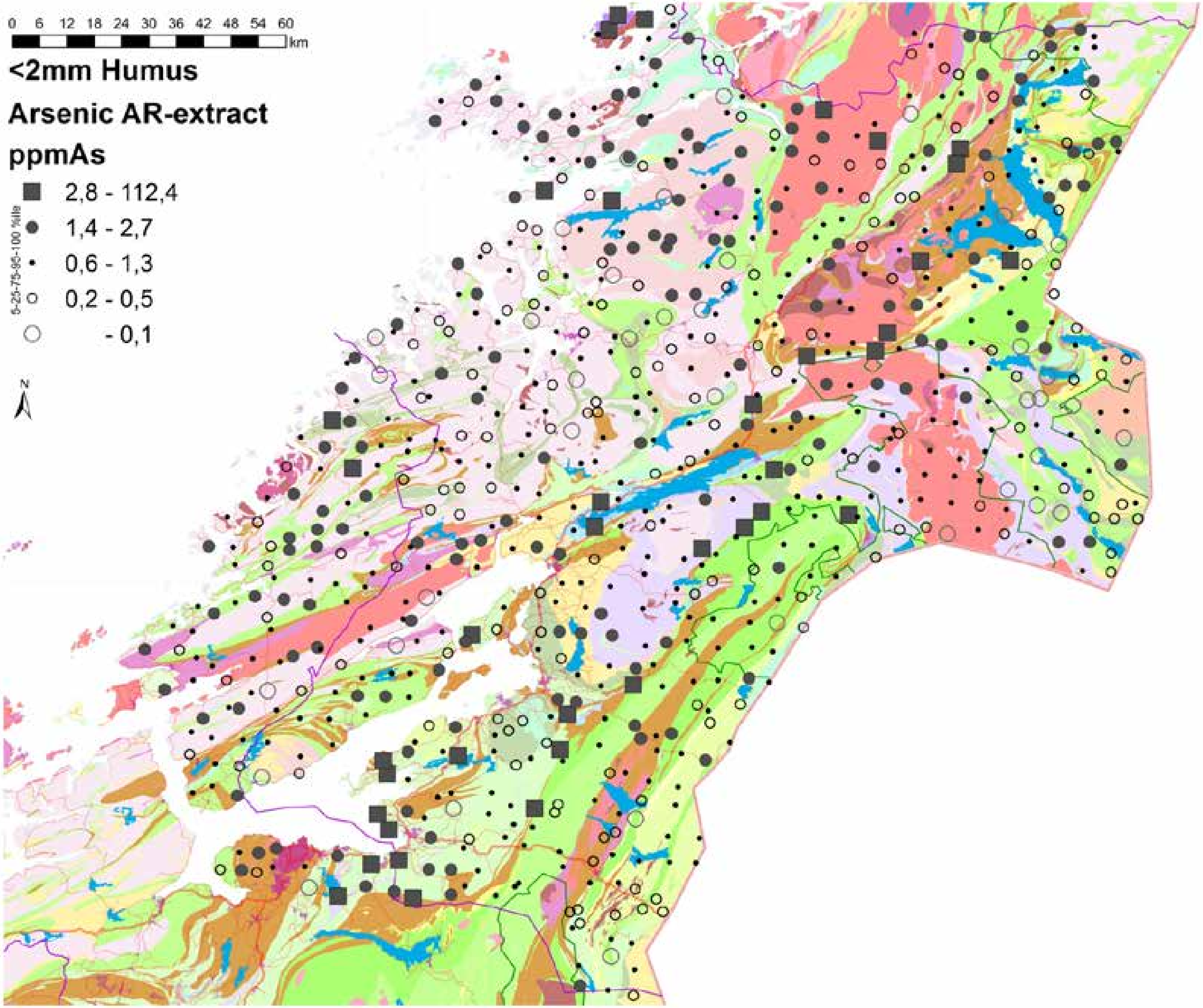

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
$^{208}Pb/^{206}Pb$

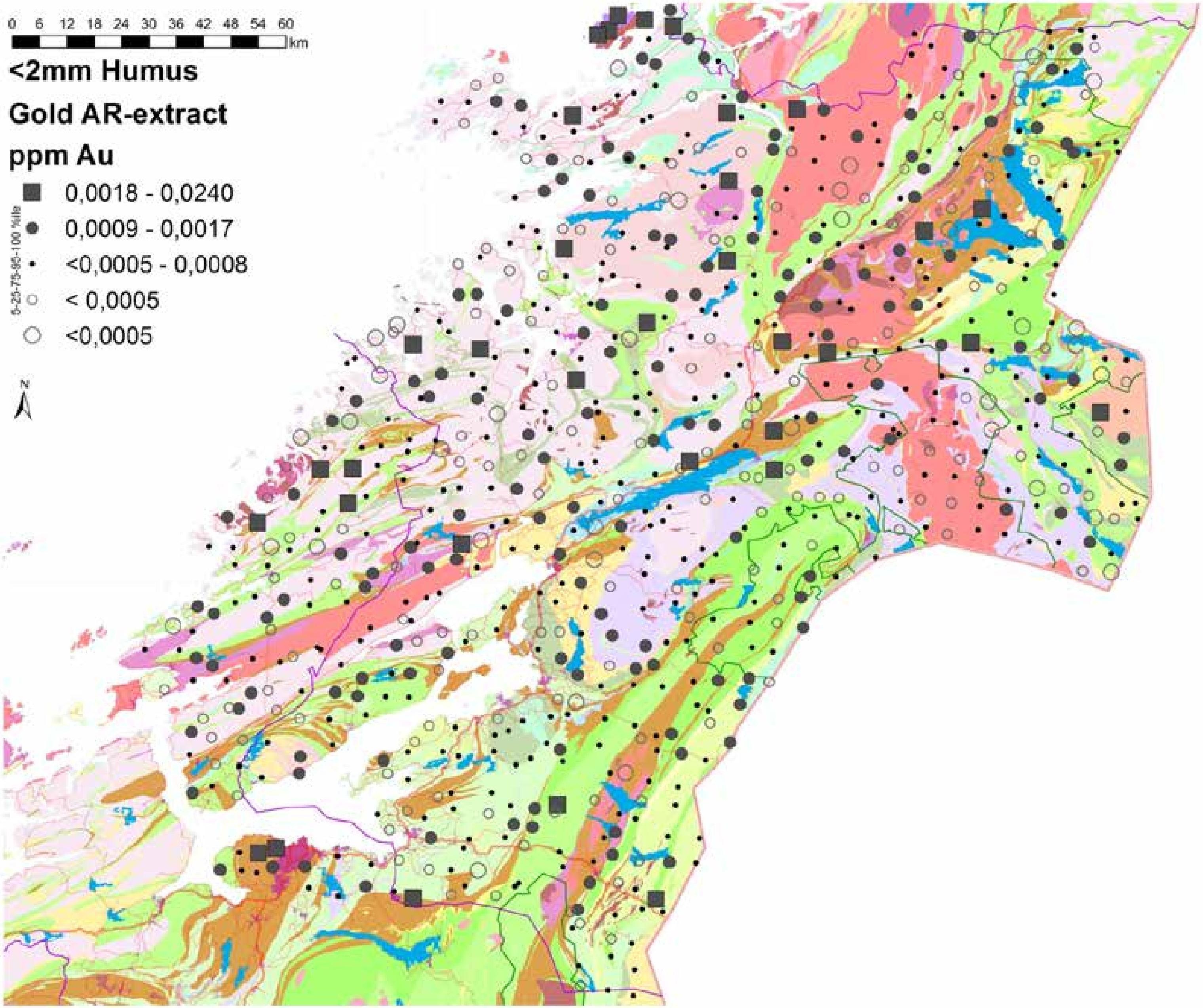

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
$^{206}Pb/^{207}Pb$

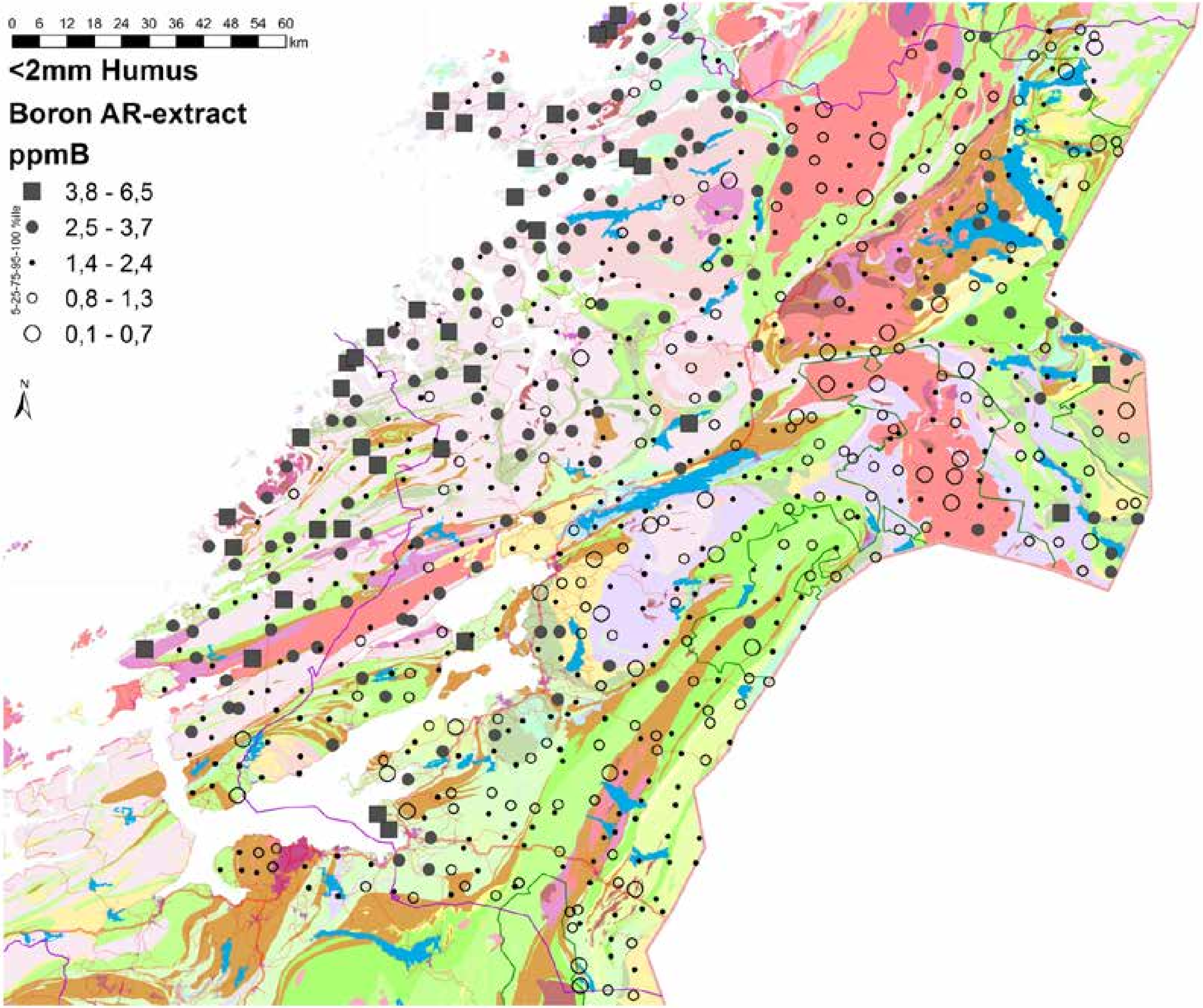
Appendix 2: Maps of geochemistry in organic soil in Nord-Trøndelag and the Fosen peninsula

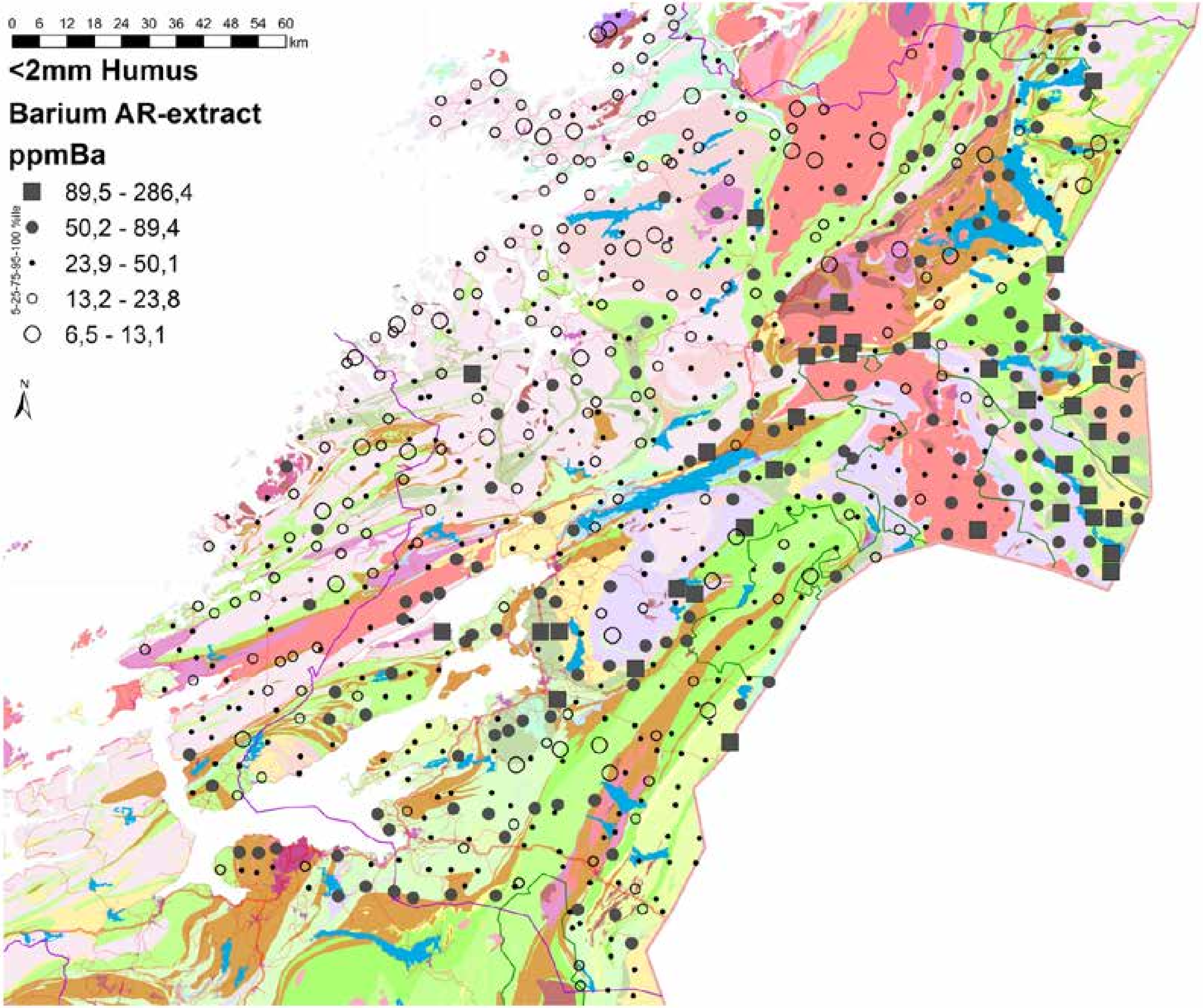

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Silver AR-extract
ppmAg
■ 1,15 - 5,87
● 0,45 - 1,14
• 0,12 - 0,44
○ 0,07 - 0,11
○ 0,03 - 0,06
5-25-75-95-100 %ile
N

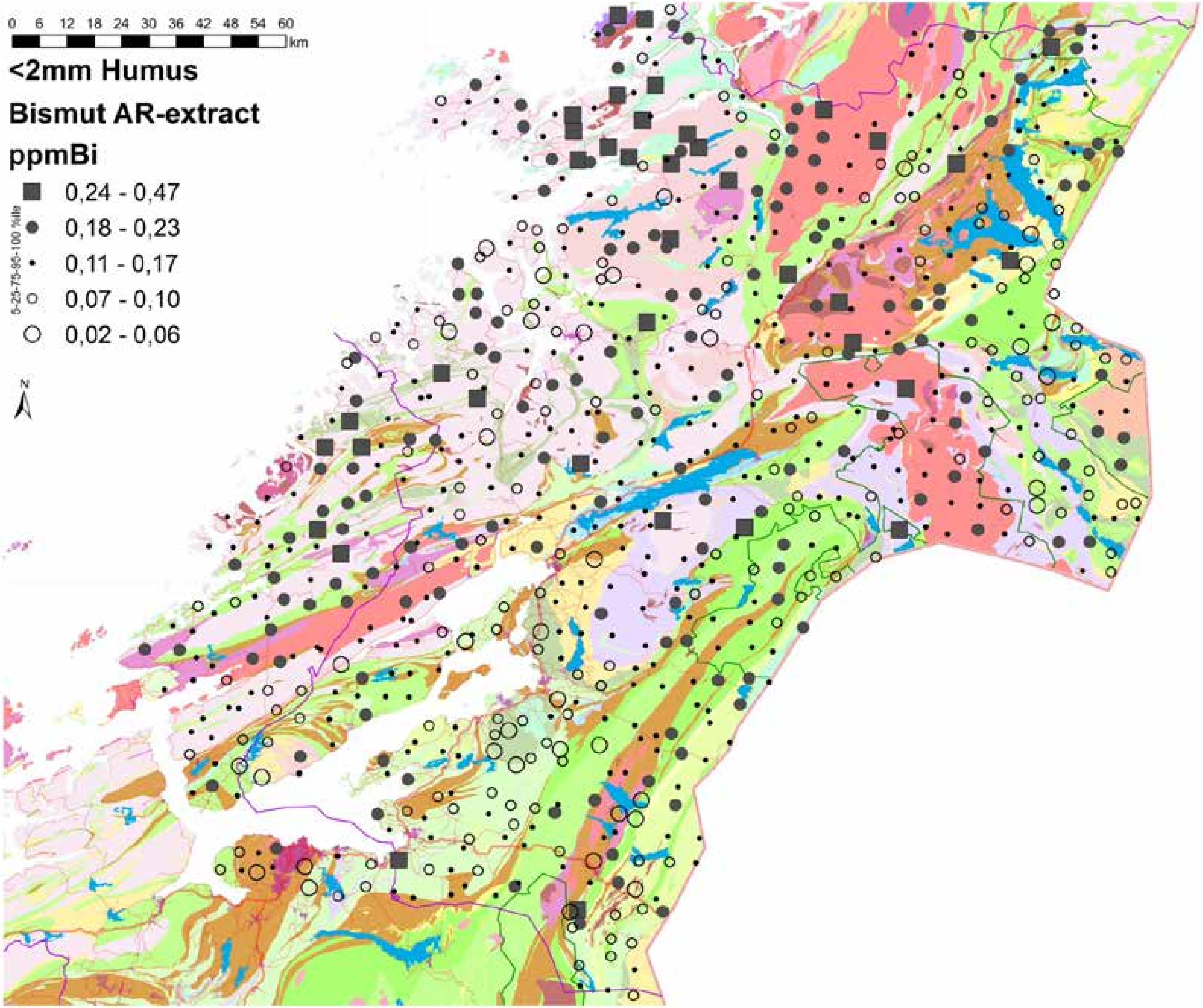

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Aluminium AR-extract
ppmAl
■ 10428 - 43010
● 4213 - 10427
• 1091 - 4212
○ 574 - 1090
◯ 304 - 573
5-25-75-95-100 %ile
N

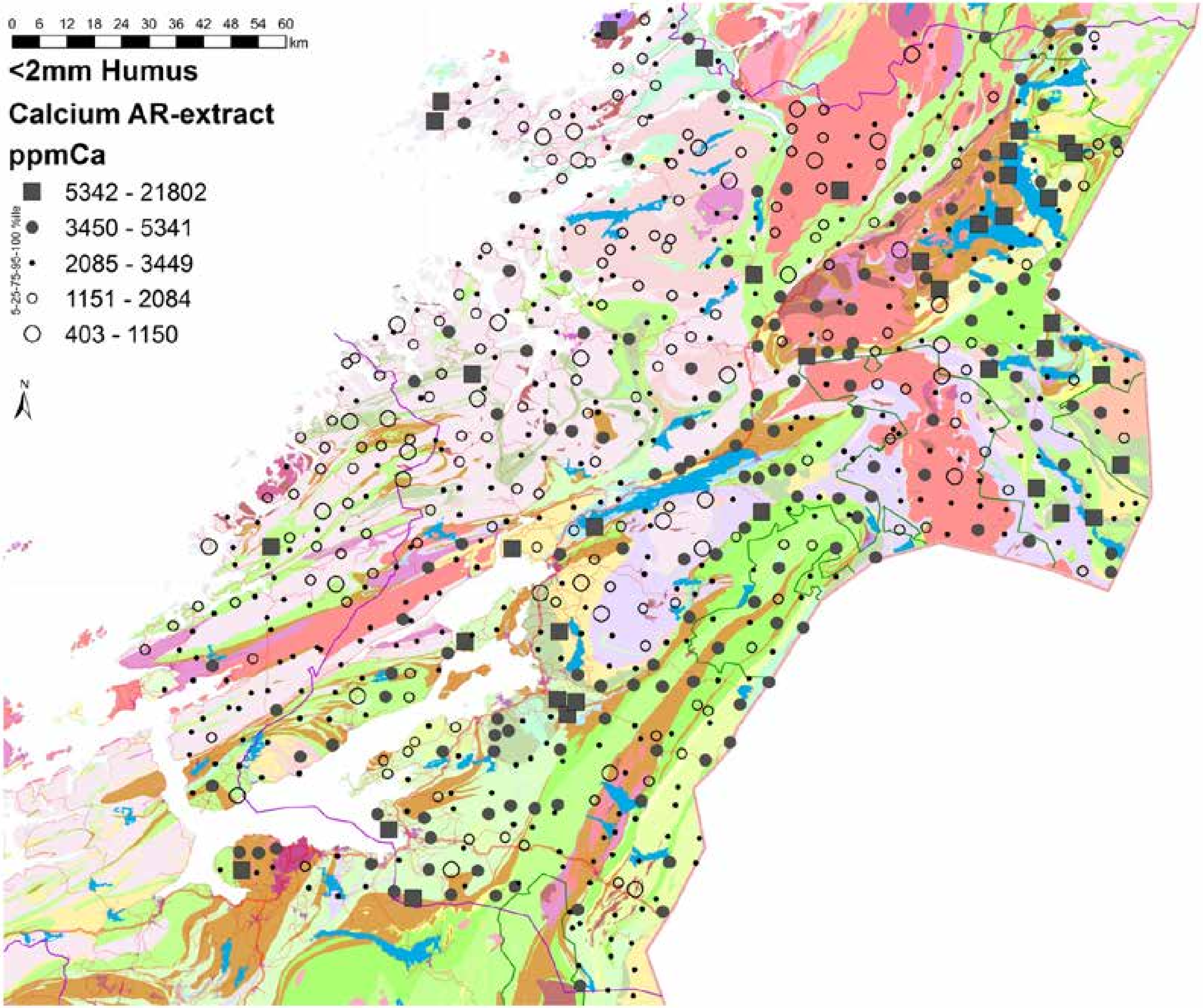

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Arsenic AR-extract
ppmAs
5-25-75-95-100 %ile
■ 2,8 - 112,4
● 1,4 - 2,7
• 0,6 - 1,3
○ 0,2 - 0,5
○ - 0,1
N

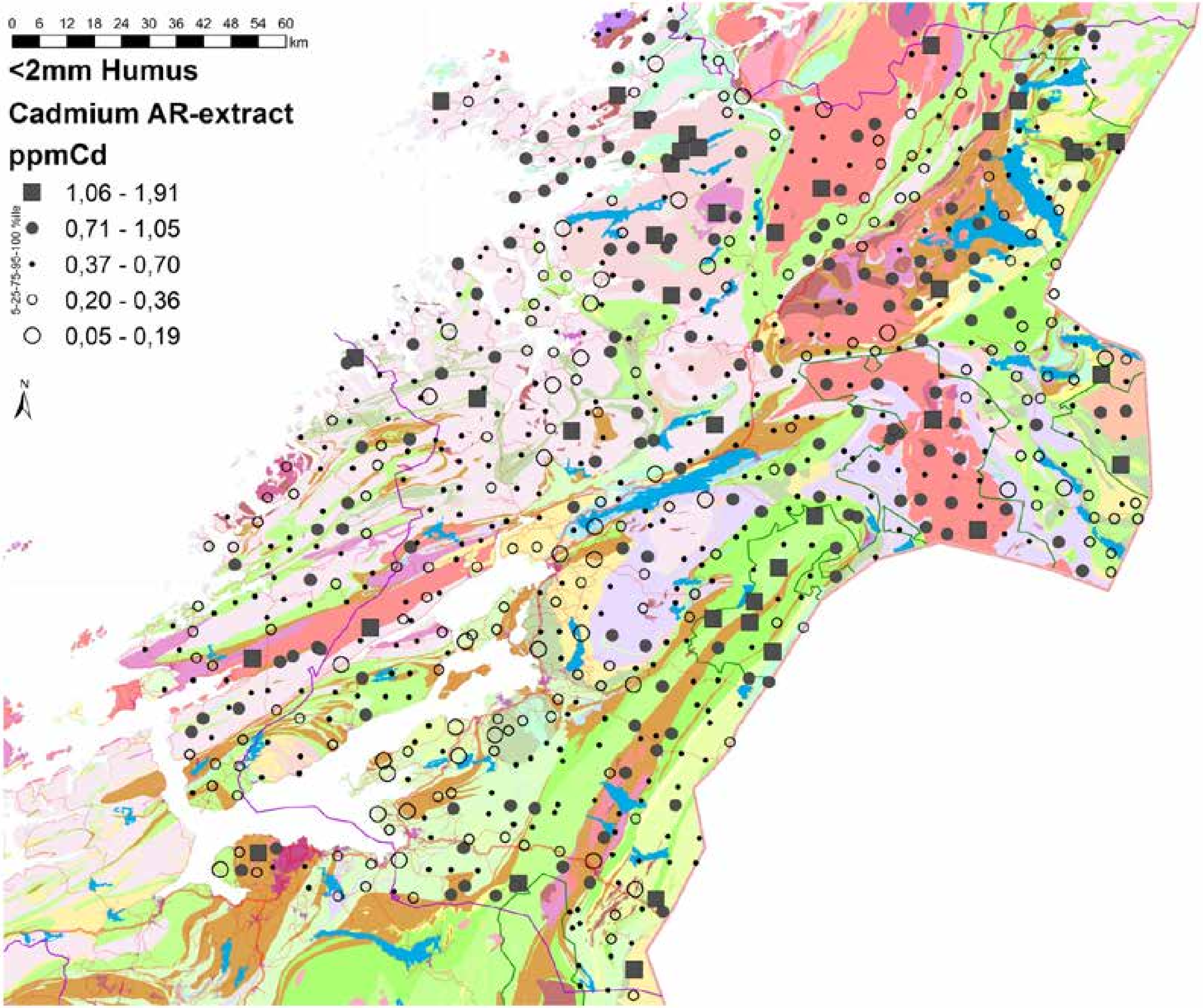

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Gold AR-extract
ppm Au
■ 0,0018 - 0,0240
● 0,0009 - 0,0017
• <0,0005 - 0,0008
○ < 0,0005
○ <0,0005
5-25-75-95-100 %ile
N

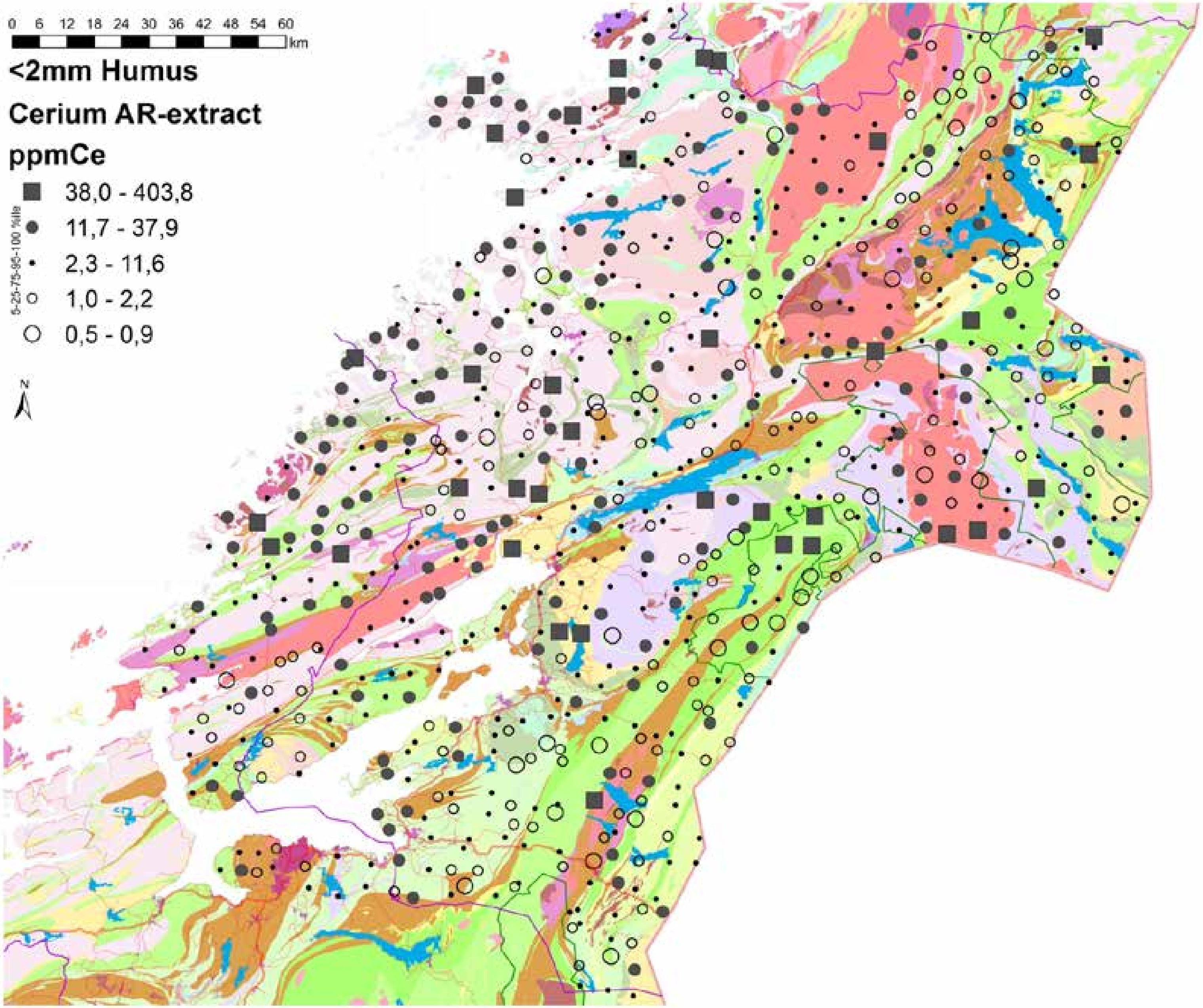

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Boron AR-extract
ppmB
■ 3,8 - 6,5
● 2,5 - 3,7
• 1,4 - 2,4
○ 0,8 - 1,3
◯ 0,1 - 0,7
5-25-75-95-100 %ile
N

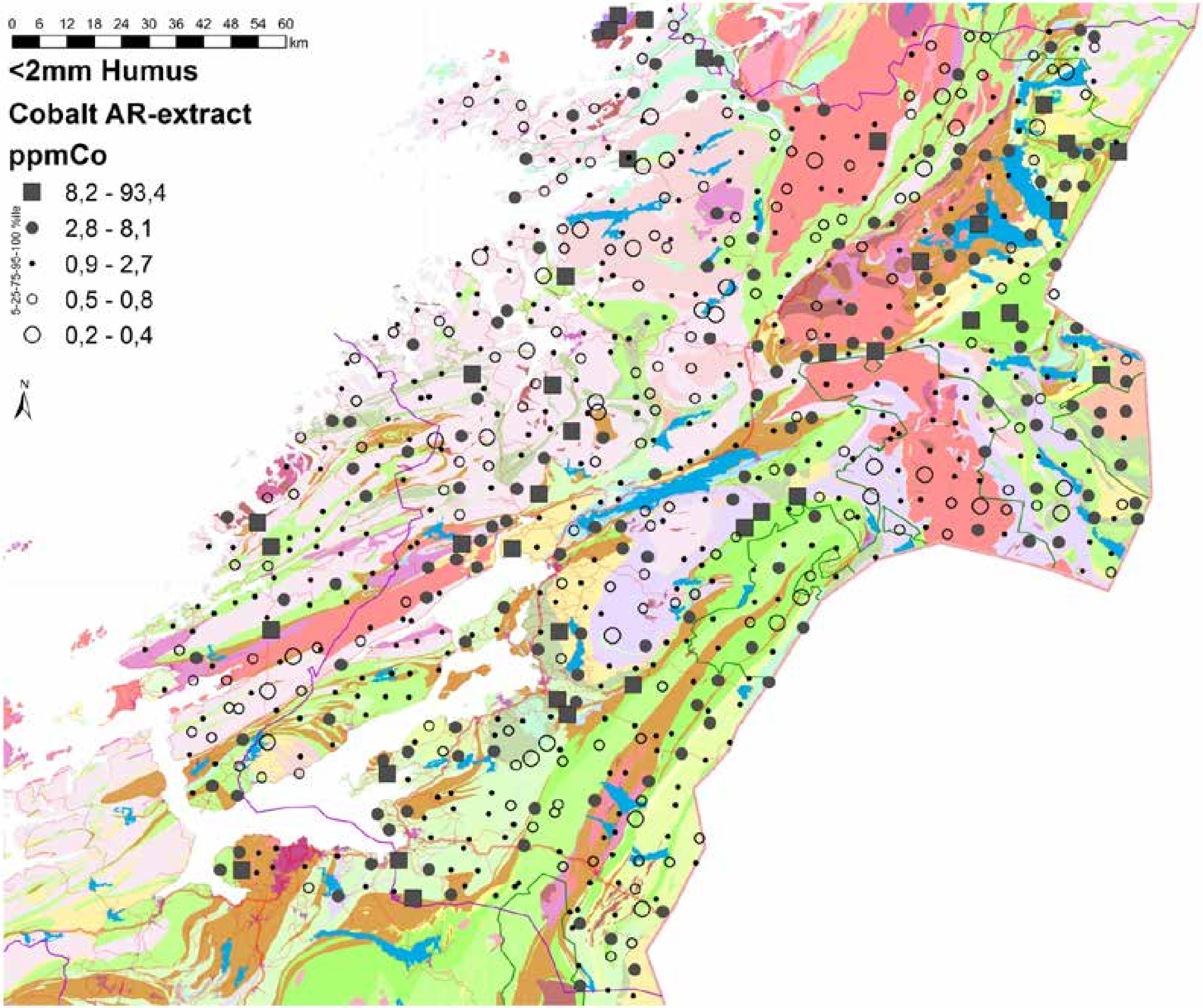

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Barium AR-extract
ppmBa
■ 89,5 - 286,4
● 50,2 - 89,4
• 23,9 - 50,1
○ 13,2 - 23,8
○ 6,5 - 13,1
5-25-75-95-100 %ile
N

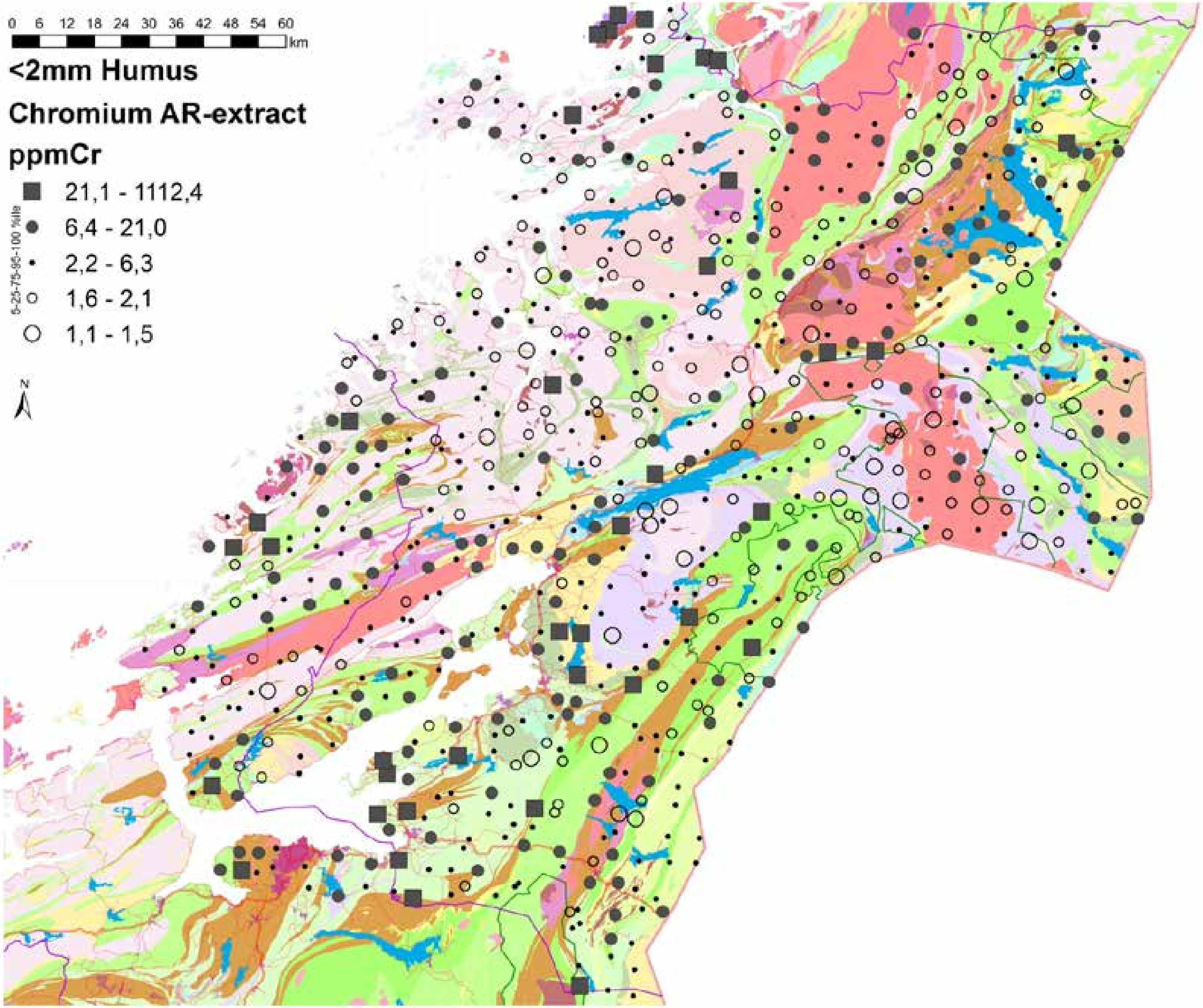

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Bismut AR-extract
ppmBi
0,24 - 0,47
0,18 - 0,23
0,11 - 0,17
0,07 - 0,10
0,02 - 0,06
5-25-75-95-100 %ile
N

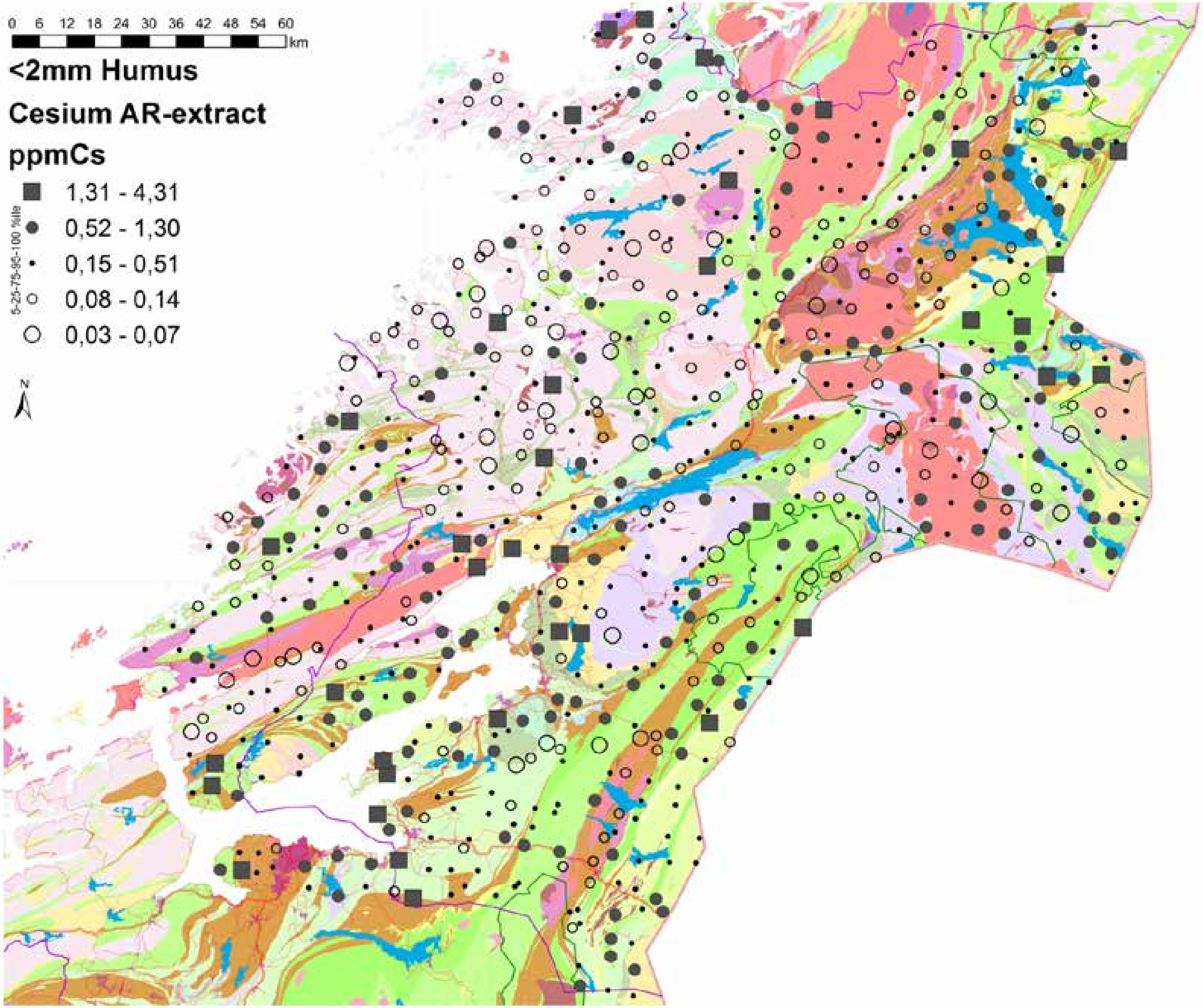

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Calcium AR-extract
ppmCa
5-25-75-95-100 %ile
■ 5342 - 21802
● 3450 - 5341
• 2085 - 3449
○ 1151 - 2084
○ 403 - 1150
N

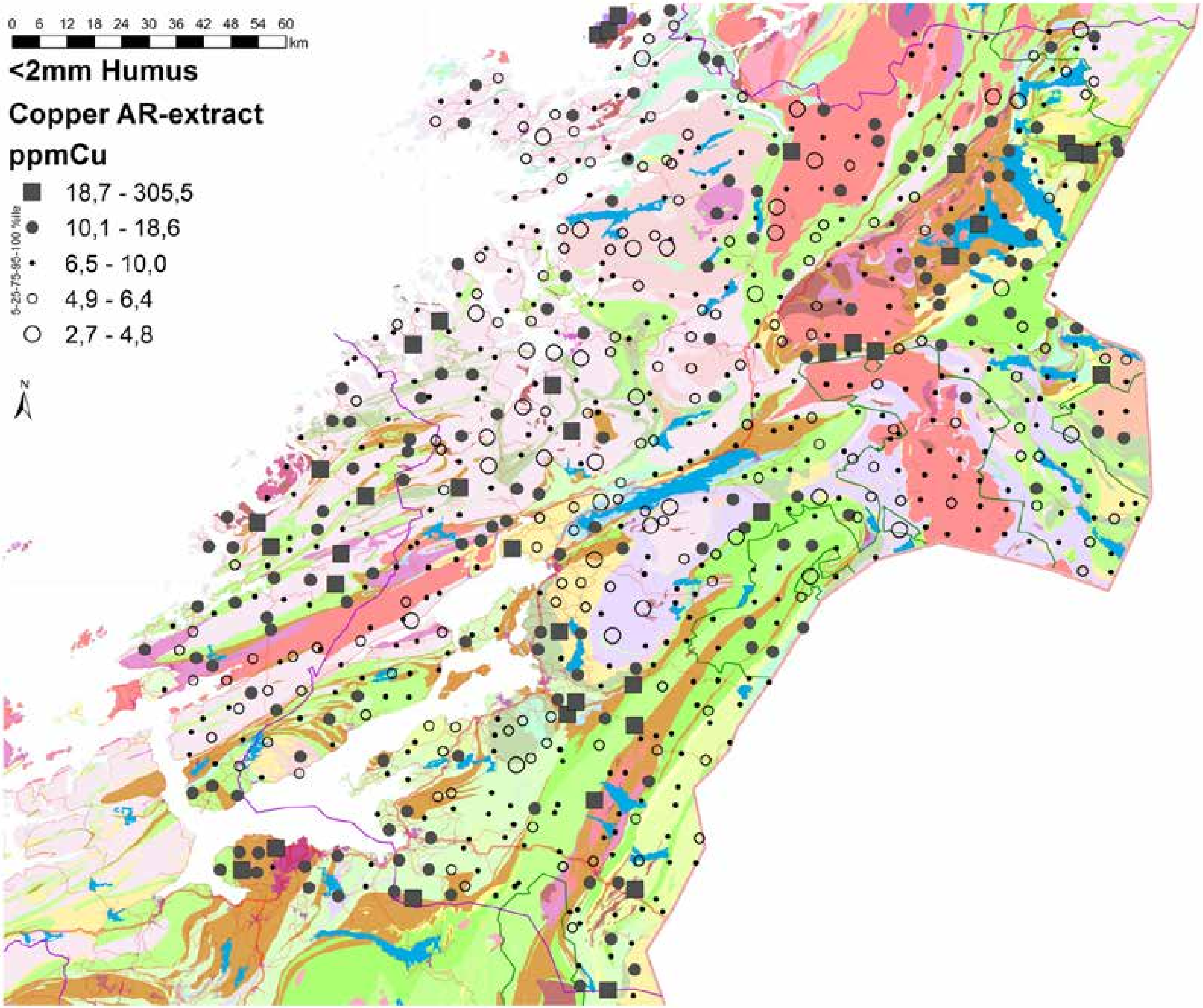

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Cadmium AR-extract
ppmCd
■ 1,06 - 1,91
● 0,71 - 1,05
• 0,37 - 0,70
○ 0,20 - 0,36
○ 0,05 - 0,19
5-25-75-95-100 %ile
N

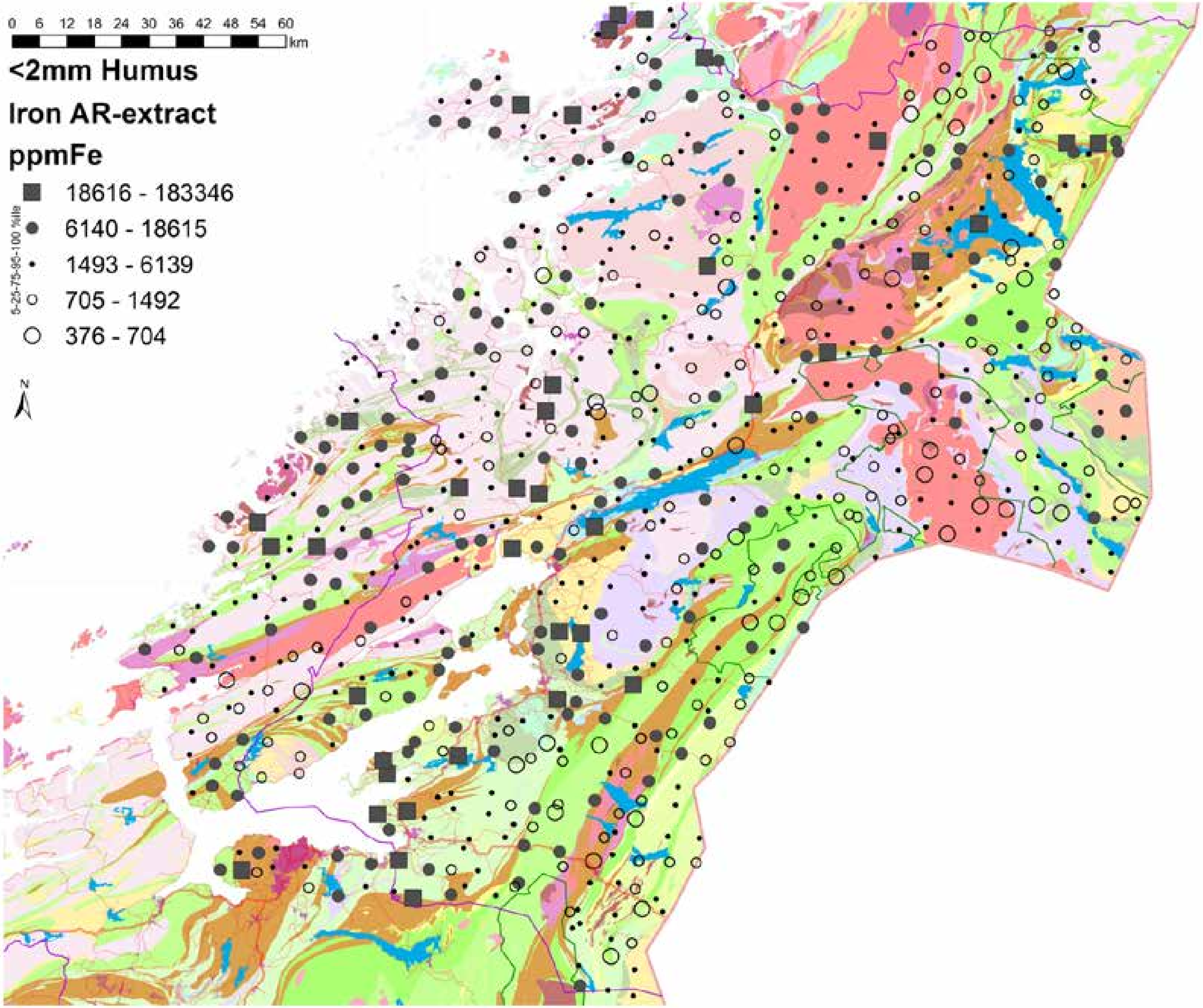

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Cerium AR-extract
ppmCe
38,0 - 403,8
11,7 - 37,9
2,3 - 11,6
1,0 - 2,2
0,5 - 0,9
5-25-75-95-100 %ile
N

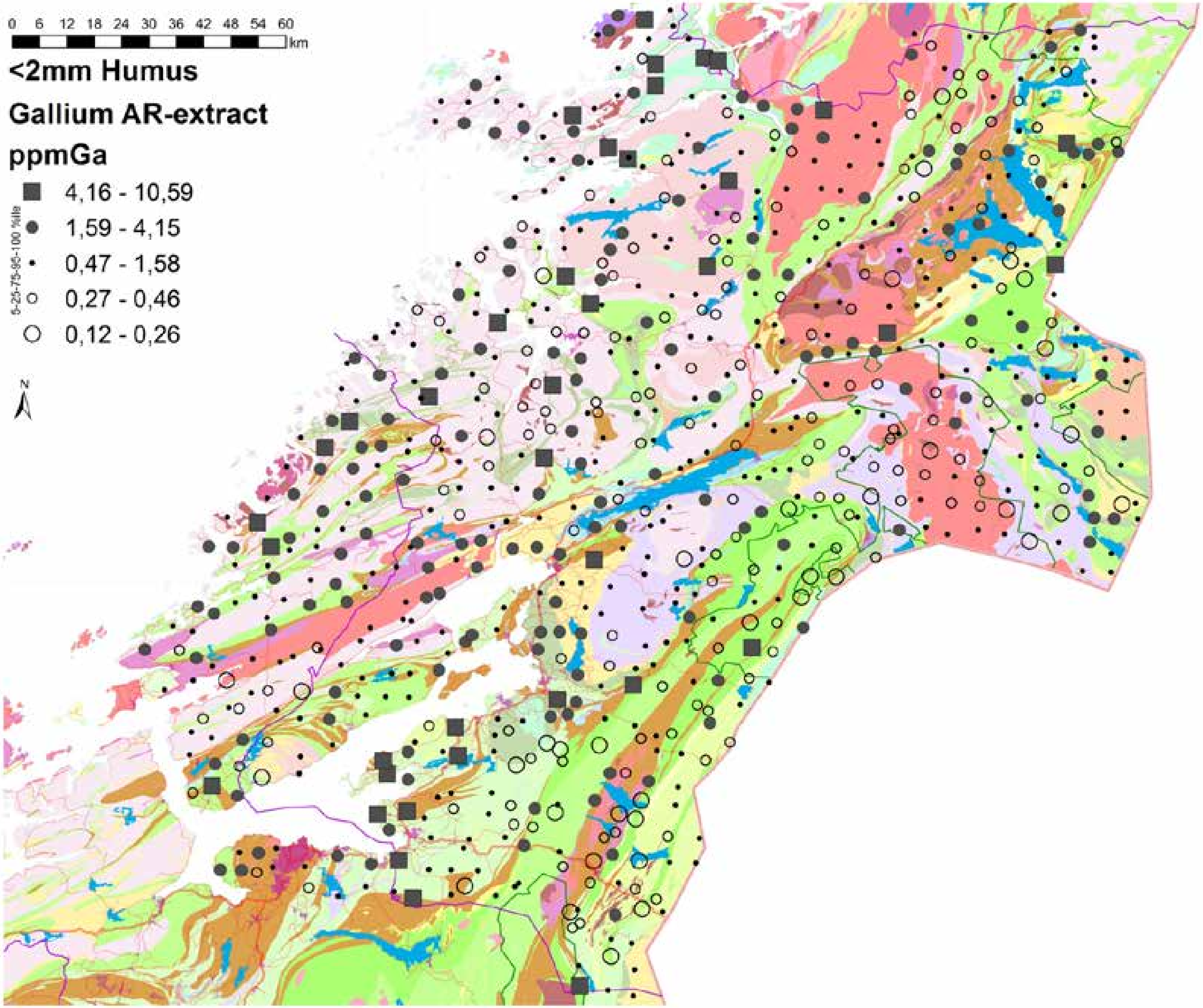

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Cobalt AR-extract
ppmCo
■ 8,2 - 93,4
● 2,8 - 8,1
• 0,9 - 2,7
○ 0,5 - 0,8
○ 0,2 - 0,4
5-25-75-95-100 %ile
N

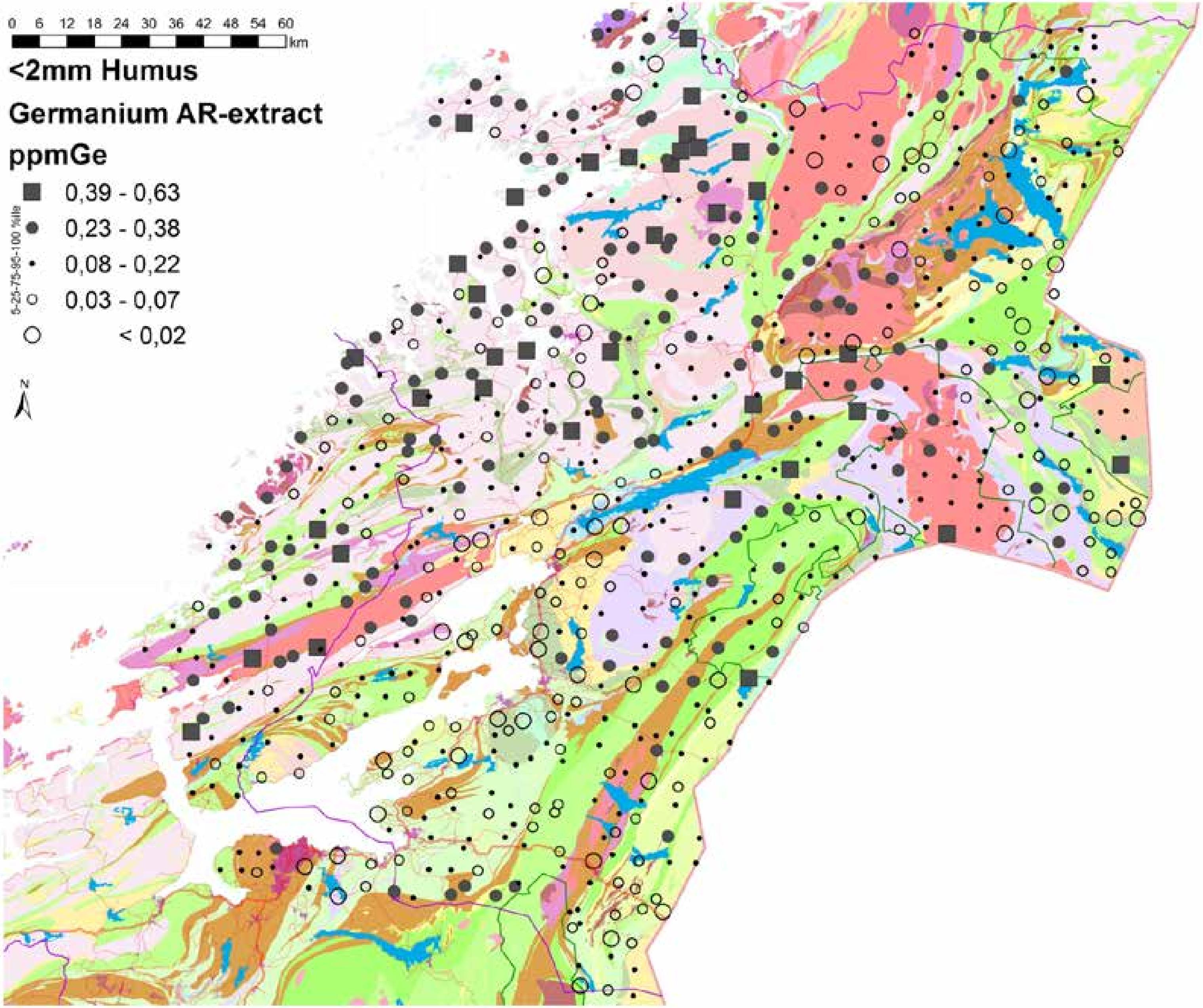

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Chromium AR-extract
ppmCr
5-25-75-95-100 %ile
■ 21,1 - 1112,4
● 6,4 - 21,0
• 2,2 - 6,3
○ 1,6 - 2,1
○ 1,1 - 1,5
N

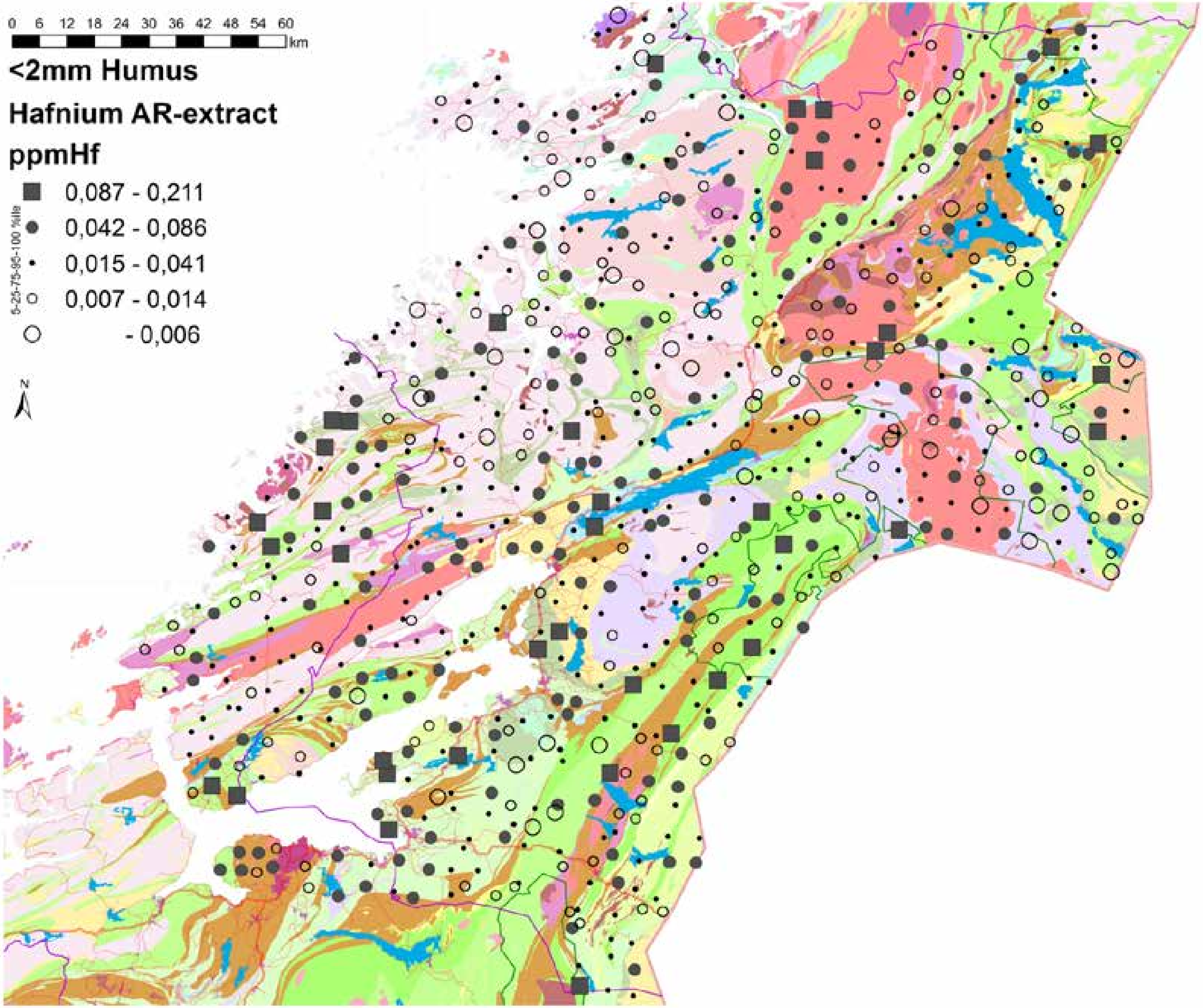

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Cesium AR-extract
ppmCs
1,31 - 4,31
0,52 - 1,30
0,15 - 0,51
0,08 - 0,14
0,03 - 0,07
5-25-75-95-100 %ile
N

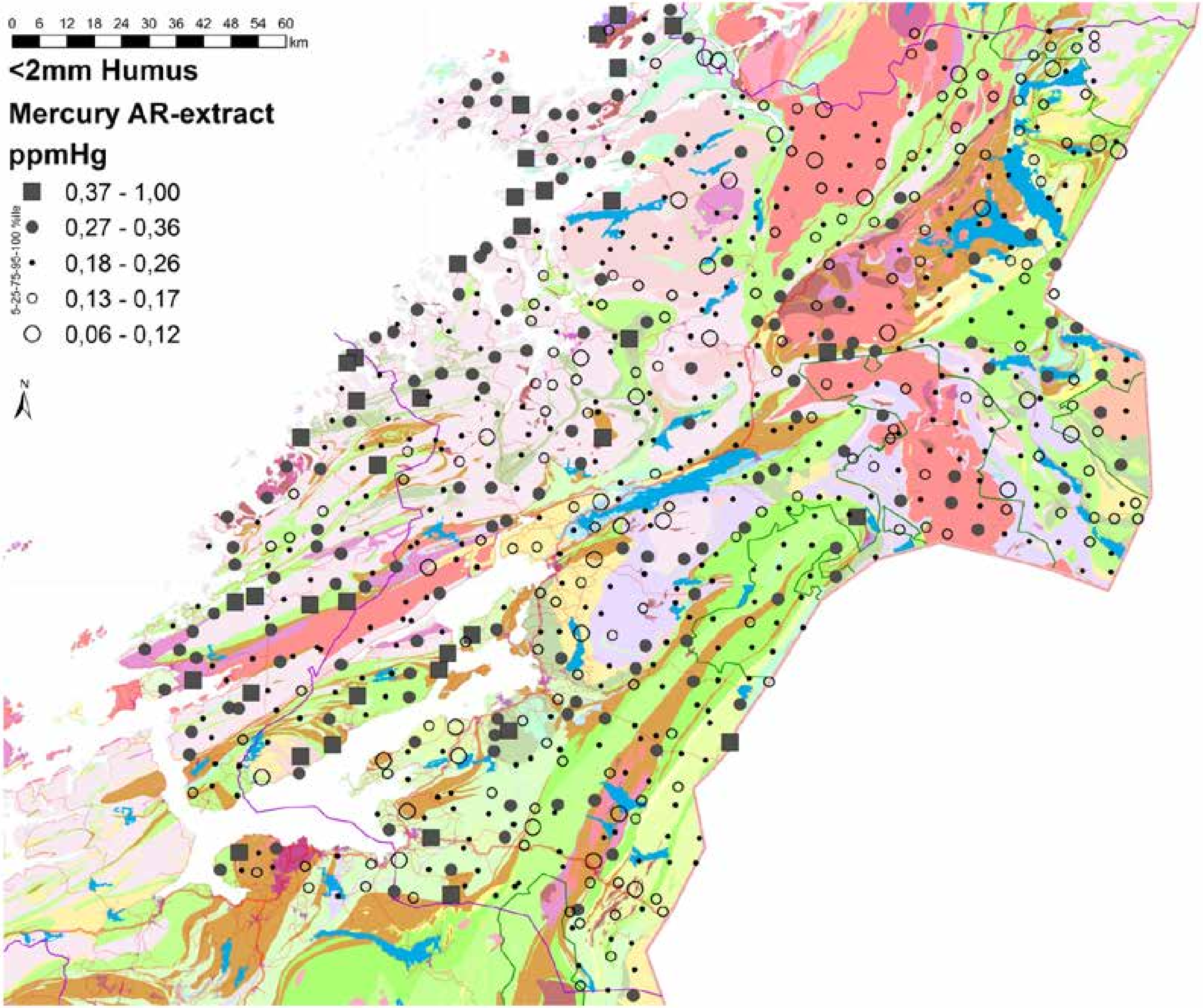

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Copper AR-extract
ppmCu
18,7 - 305,5
10,1 - 18,6
6,5 - 10,0
4,9 - 6,4
2,7 - 4,8
5-25-75-95-100 %ile
N

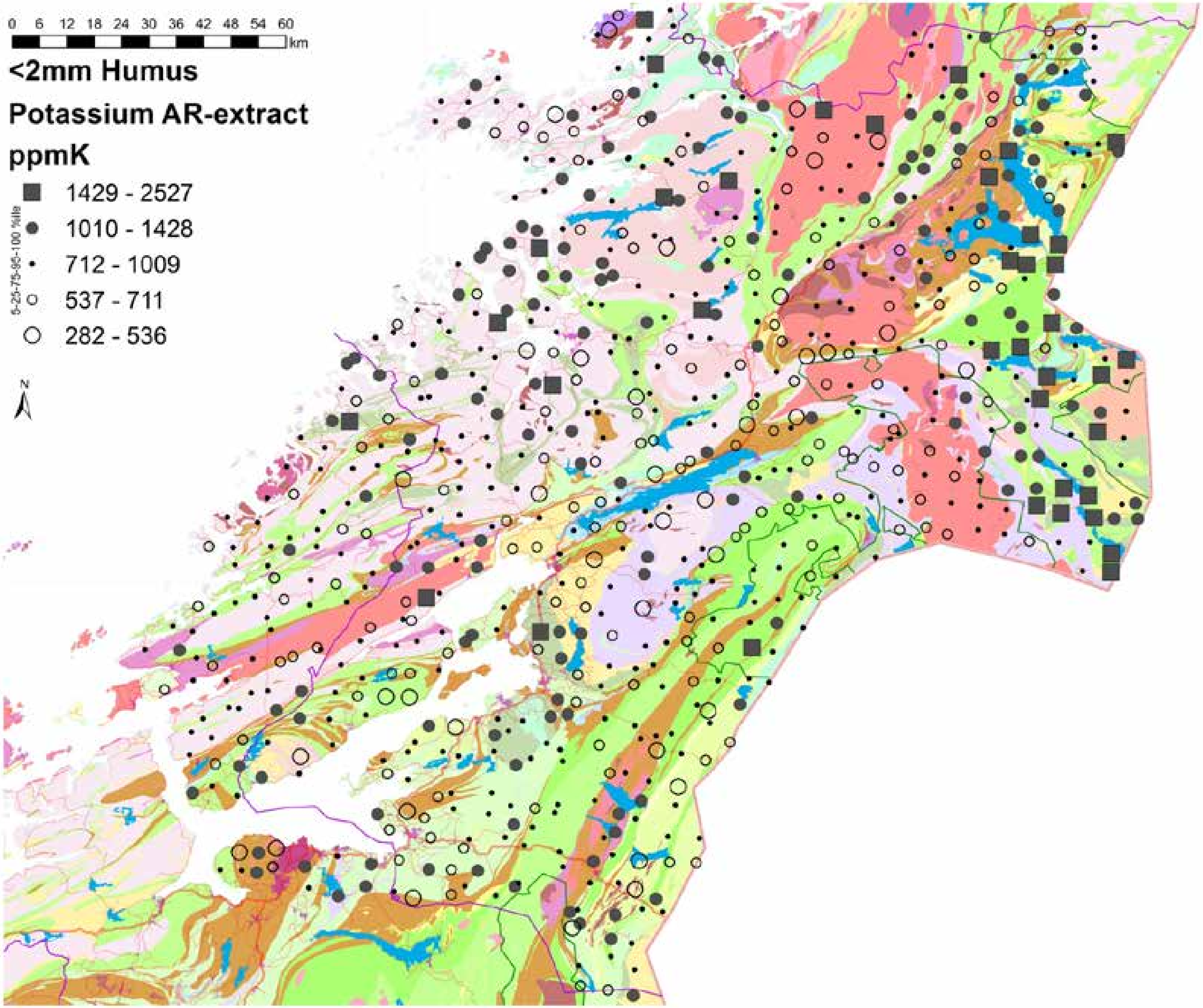

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Iron AR-extract
ppmFe
18616 - 183346
6140 - 18615
1493 - 6139
705 - 1492
376 - 704
5-25-75-95-100 %ile
N

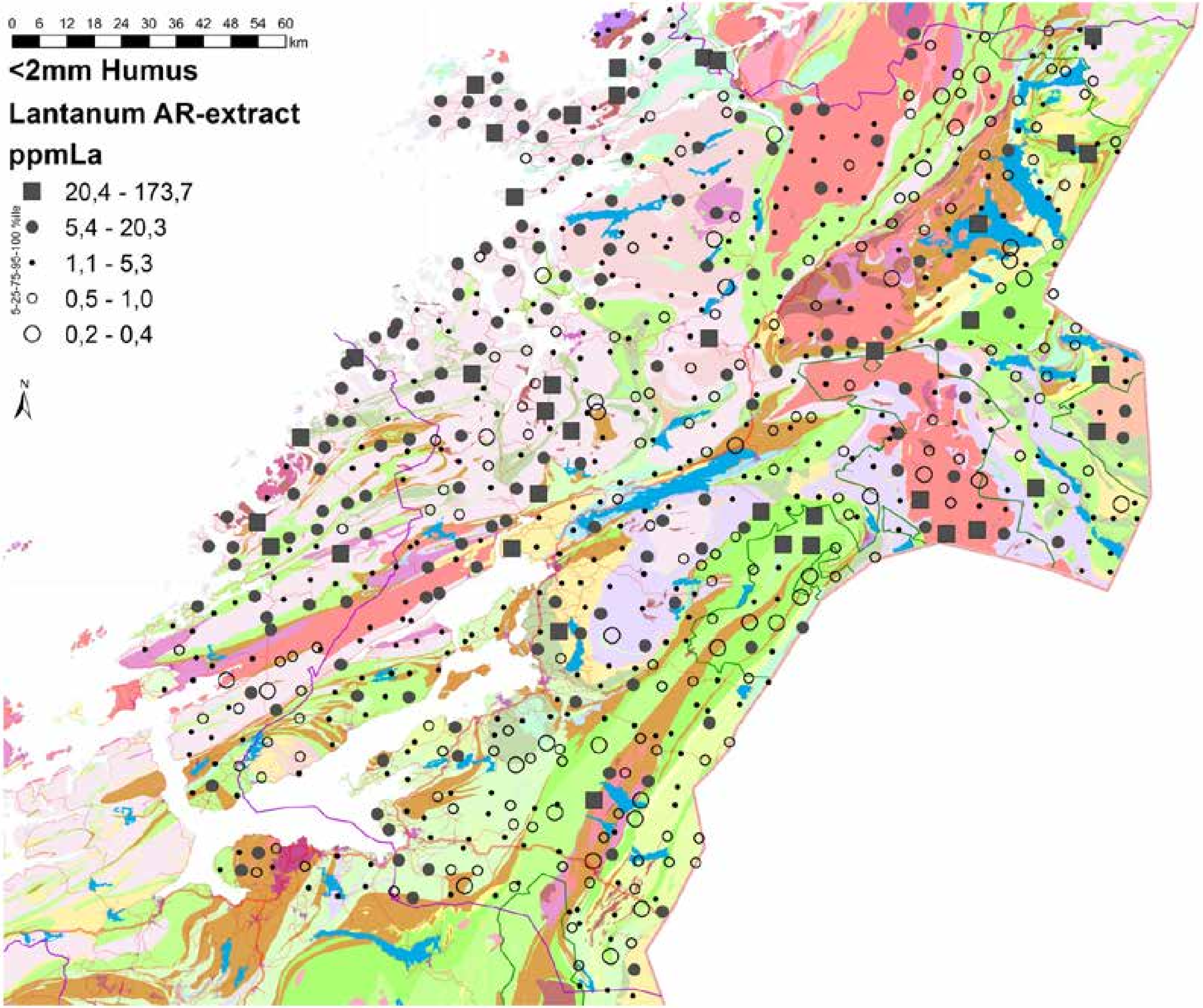

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Gallium AR-extract
ppmGa
■ 4,16 - 10,59
● 1,59 - 4,15
• 0,47 - 1,58
○ 0,27 - 0,46
○ 0,12 - 0,26
5-25-75-95-100 %ile
N

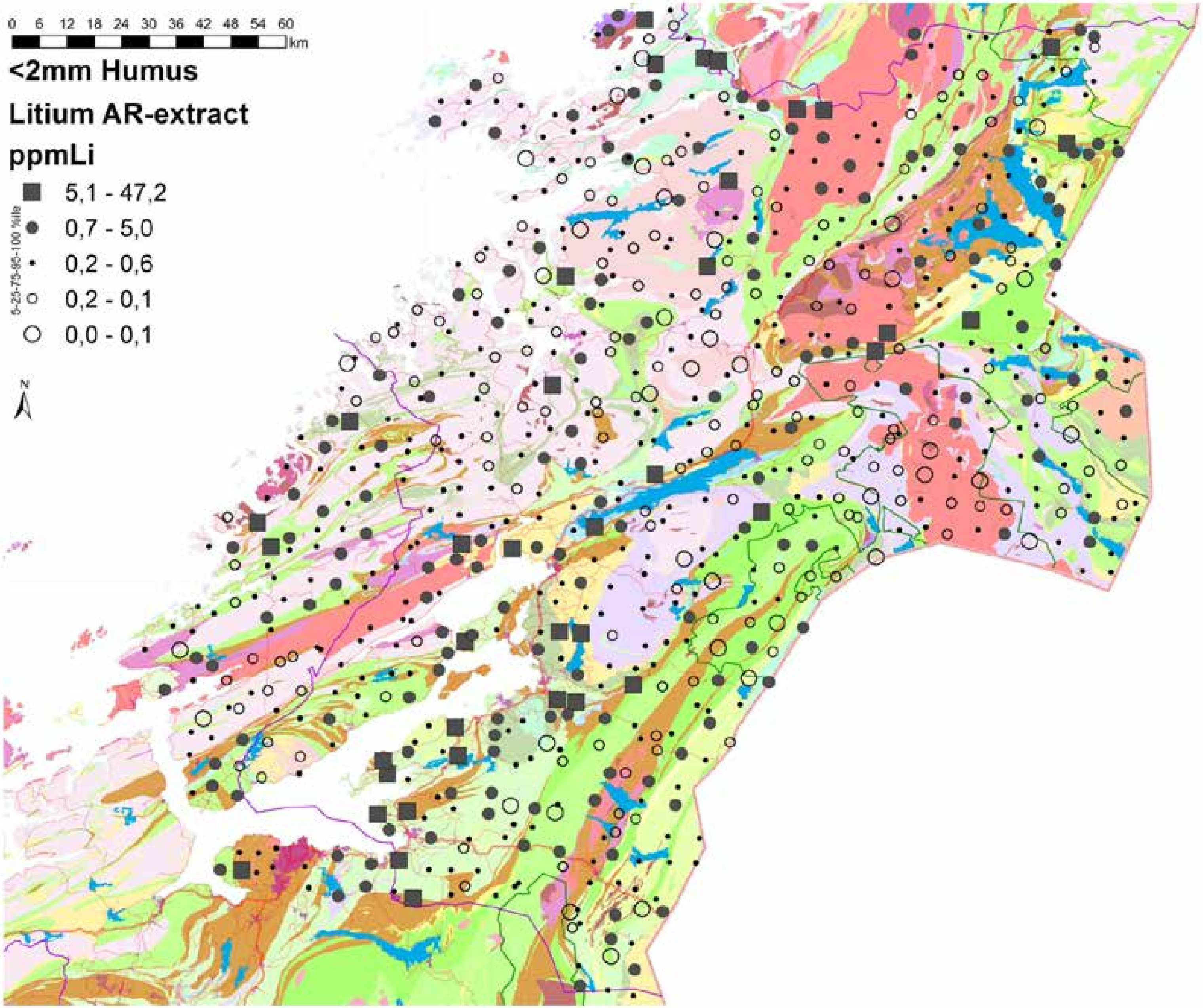

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Germanium AR-extract
ppmGe
■ 0,39 - 0,63
● 0,23 - 0,38
• 0,08 - 0,22
○ 0,03 - 0,07
○ < 0,02
5-25-75-95-100 %ile
N

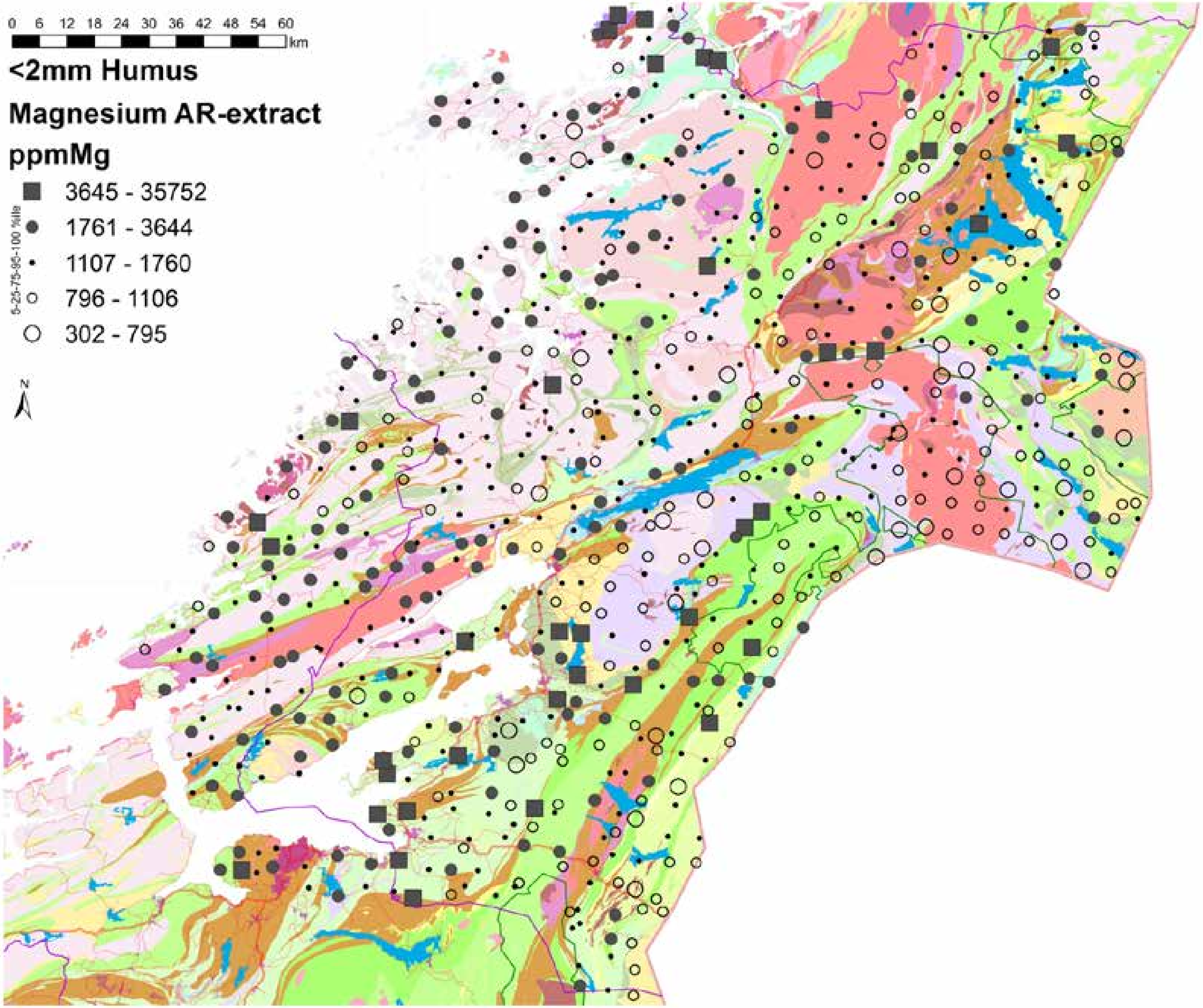

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Hafnium AR-extract
ppmHf
■ 0,087 - 0,211
● 0,042 - 0,086
• 0,015 - 0,041
○ 0,007 - 0,014
○ - 0,006
5-25-75-95-100 %ile
N

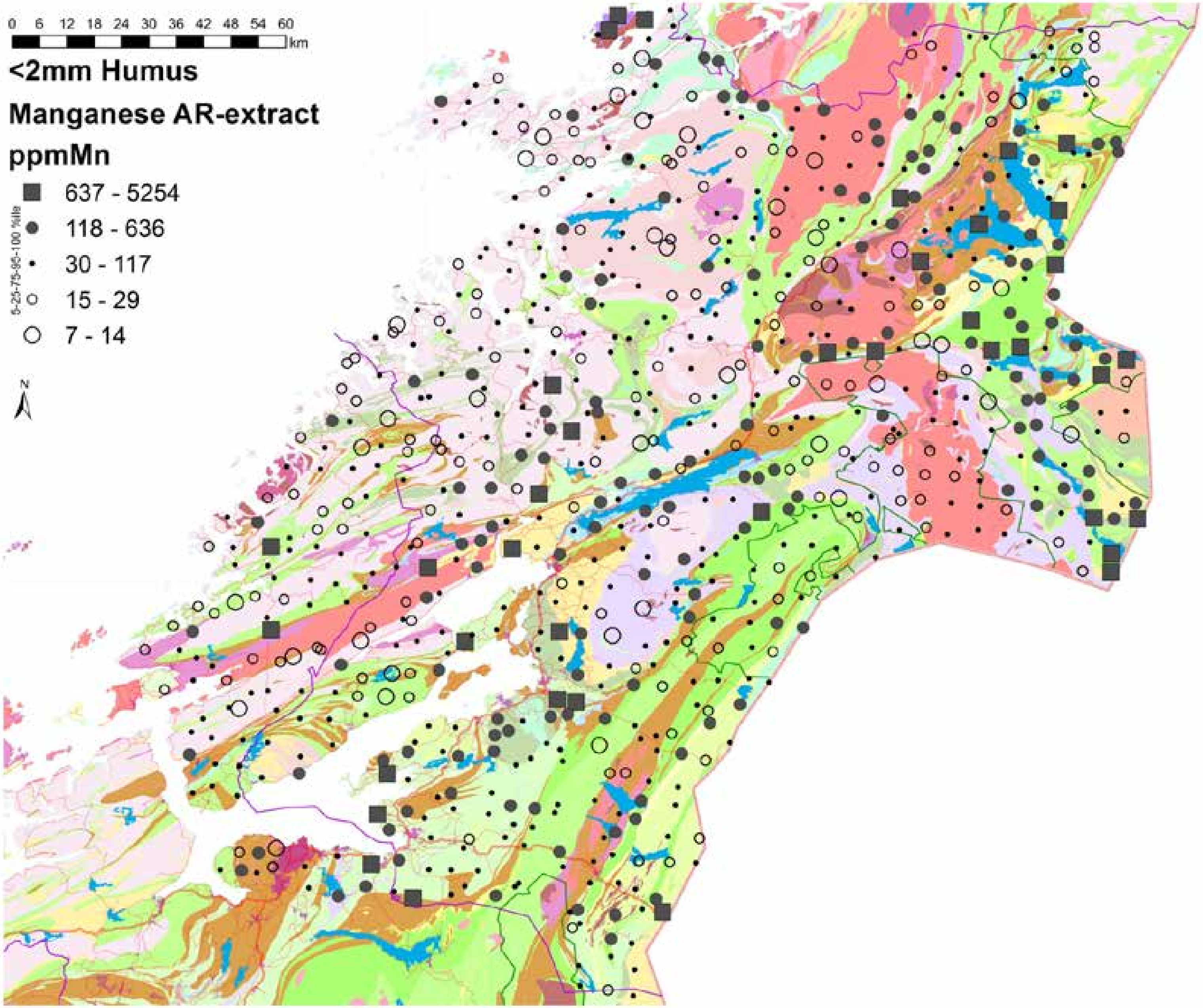

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Mercury AR-extract
ppmHg
■ 0,37 - 1,00
● 0,27 - 0,36
• 0,18 - 0,26
○ 0,13 - 0,17
○ 0,06 - 0,12
5-25-75-95-100 %ile
N

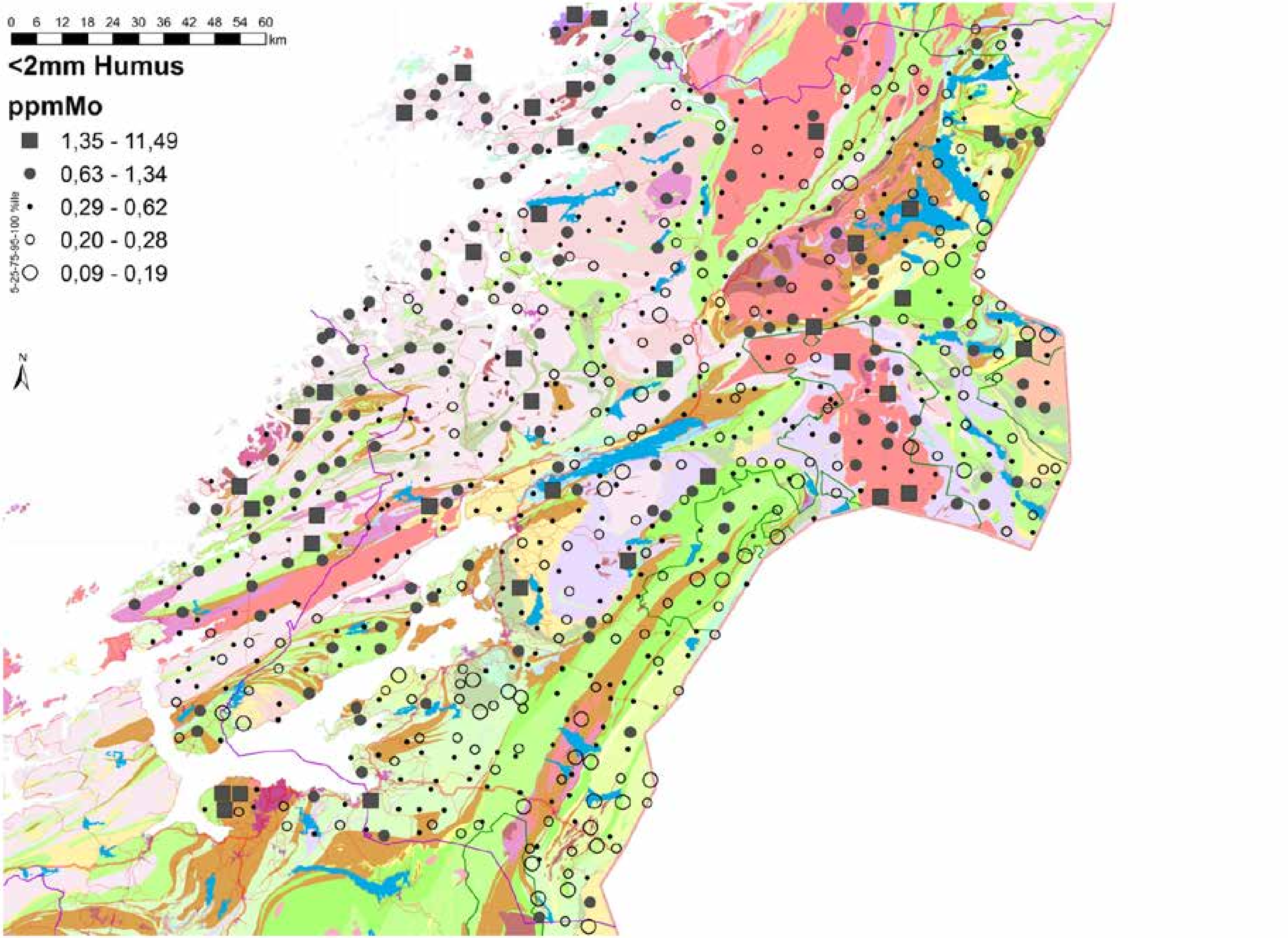

0 6 12 18 24 30 36 42 48 54 60 km
<2mm Humus
Potassium AR-extract
ppmK
■ 1429 - 2527
● 1010 - 1428
• 712 - 1009
○ 537 - 711
○ 282 - 536
5-25-75-95-100 %ile
N

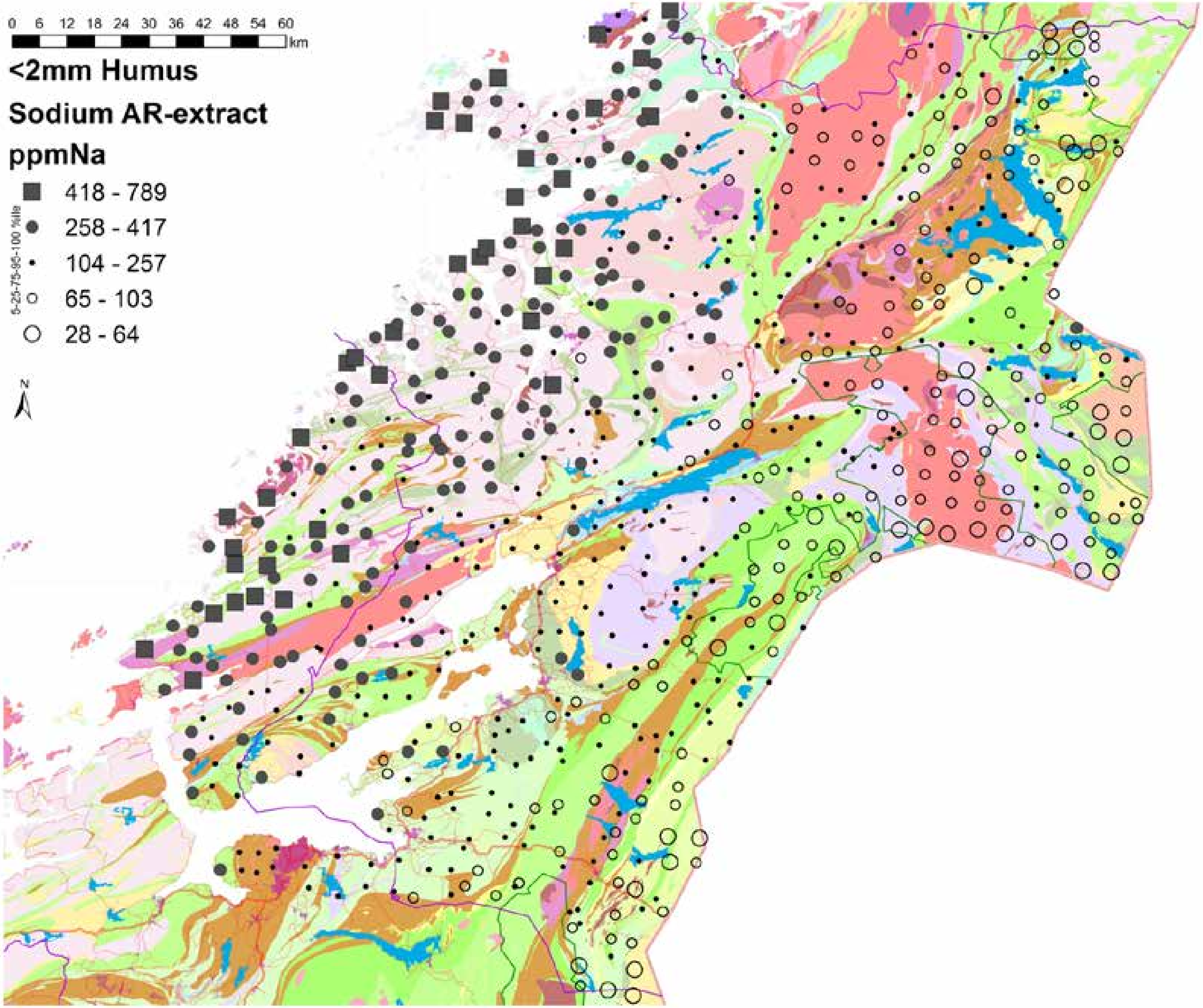

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Lantanum AR-extract
ppmLa
■ 20,4 - 173,7
● 5,4 - 20,3
• 1,1 - 5,3
○ 0,5 - 1,0
○ 0,2 - 0,4
5-25-75-95-100 %ile
N

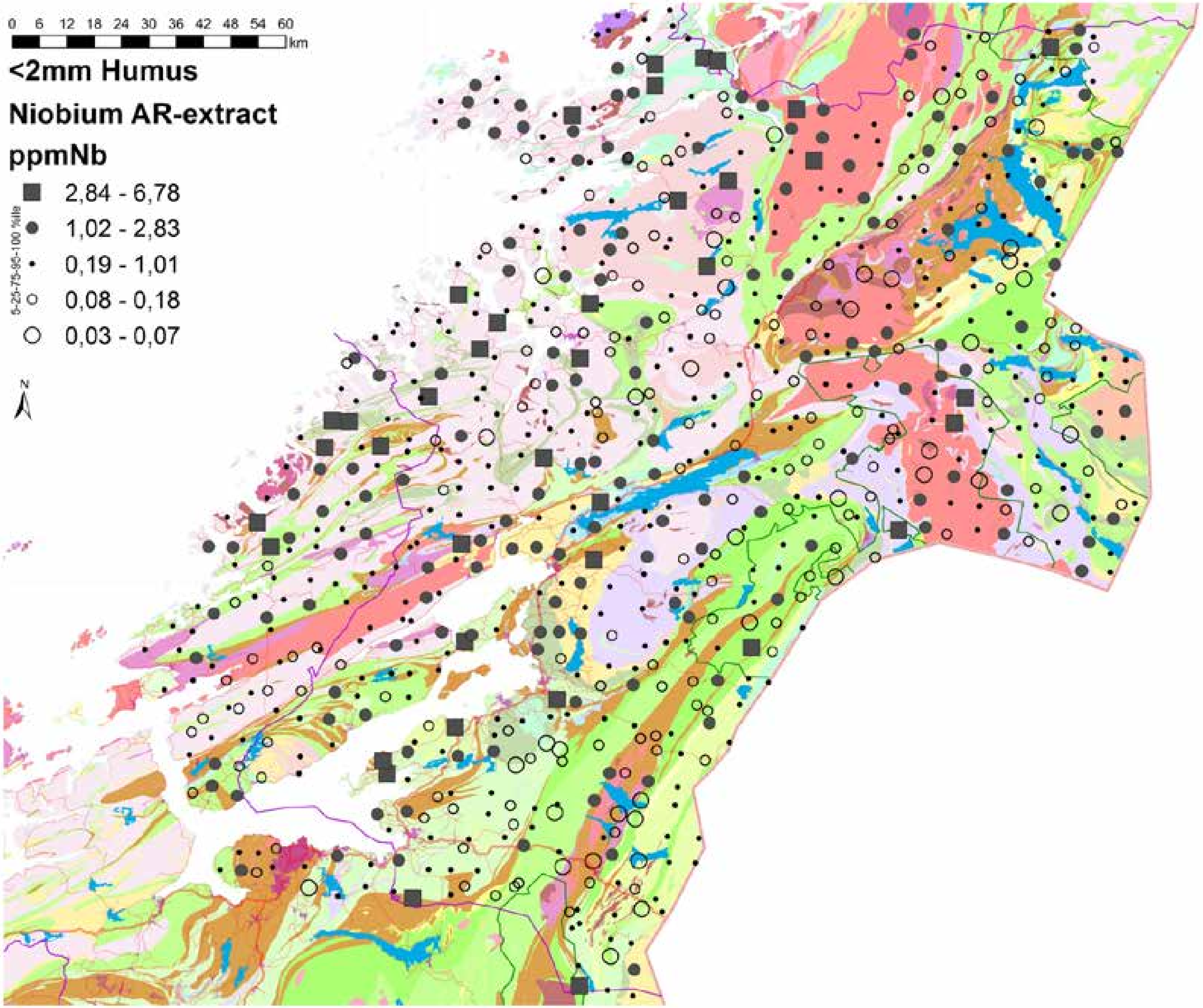

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Litium AR-extract
ppmLi
5-25-75-95-100 %ile
■ 5,1 - 47,2
● 0,7 - 5,0
• 0,2 - 0,6
○ 0,2 - 0,1
○ 0,0 - 0,1
N

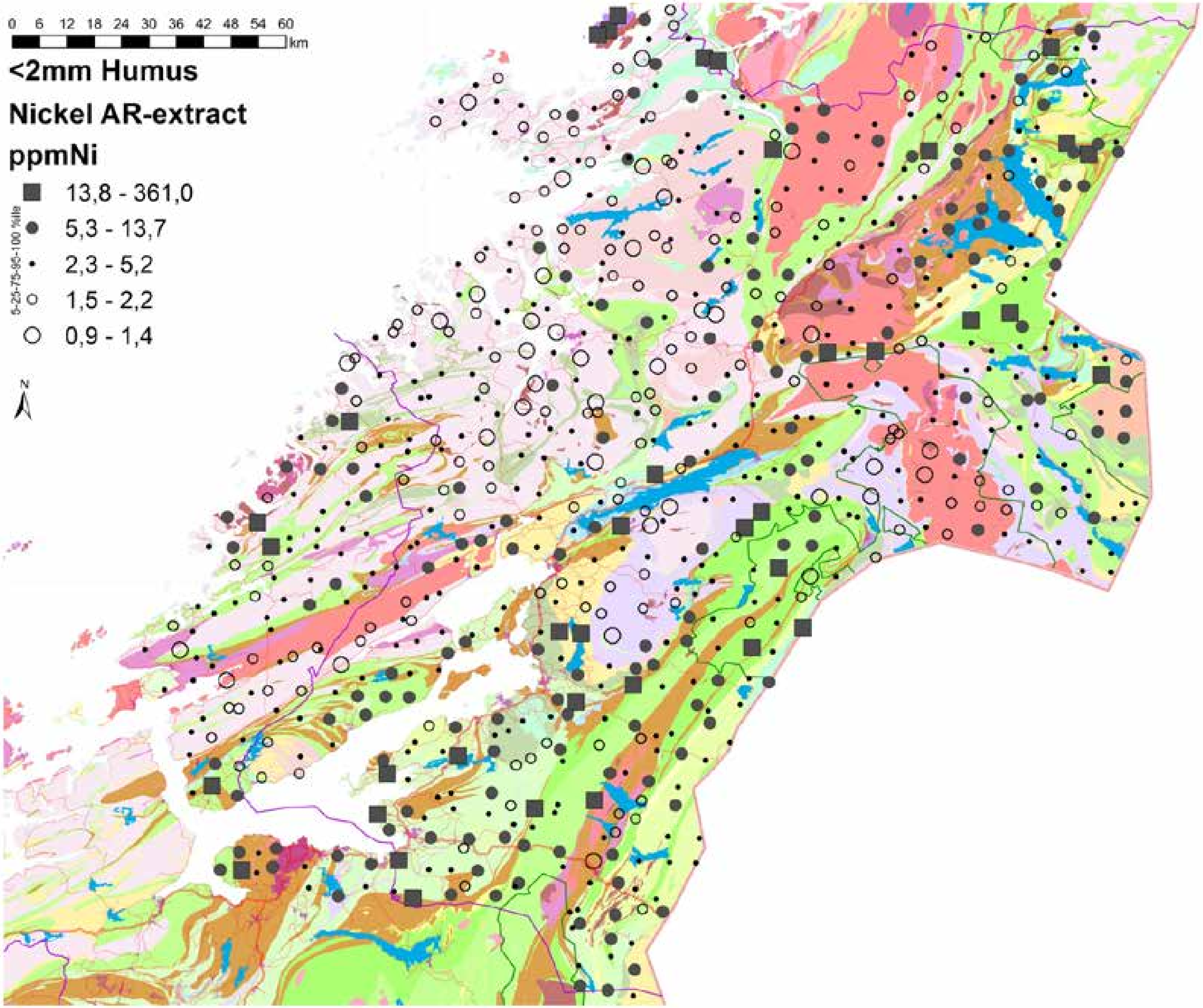

0 6 12 18 24 30 36 42 48 54 60 km
<2mm Humus
Magnesium AR-extract
ppmMg
■ 3645 - 35752
● 1761 - 3644
• 1107 - 1760
○ 796 - 1106
○ 302 - 795
5-25-75-95-100 %ile
N

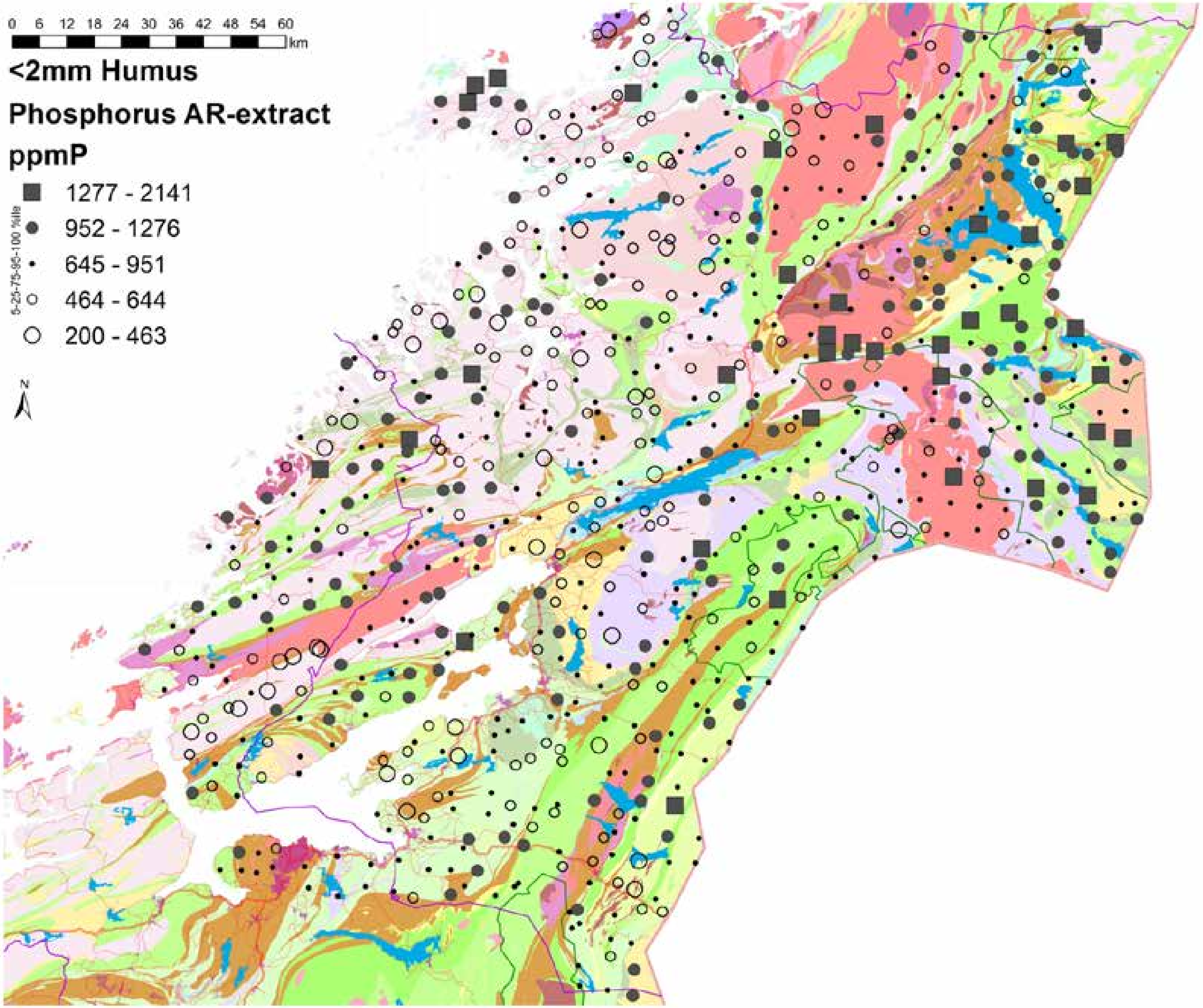

0 6 12 18 24 30 36 42 48 54 60 km
<2mm Humus
Manganese AR-extract
ppmMn
5-25-75-95-100 %ile
637 - 5254
118 - 636
30 - 117
15 - 29
7 - 14
N

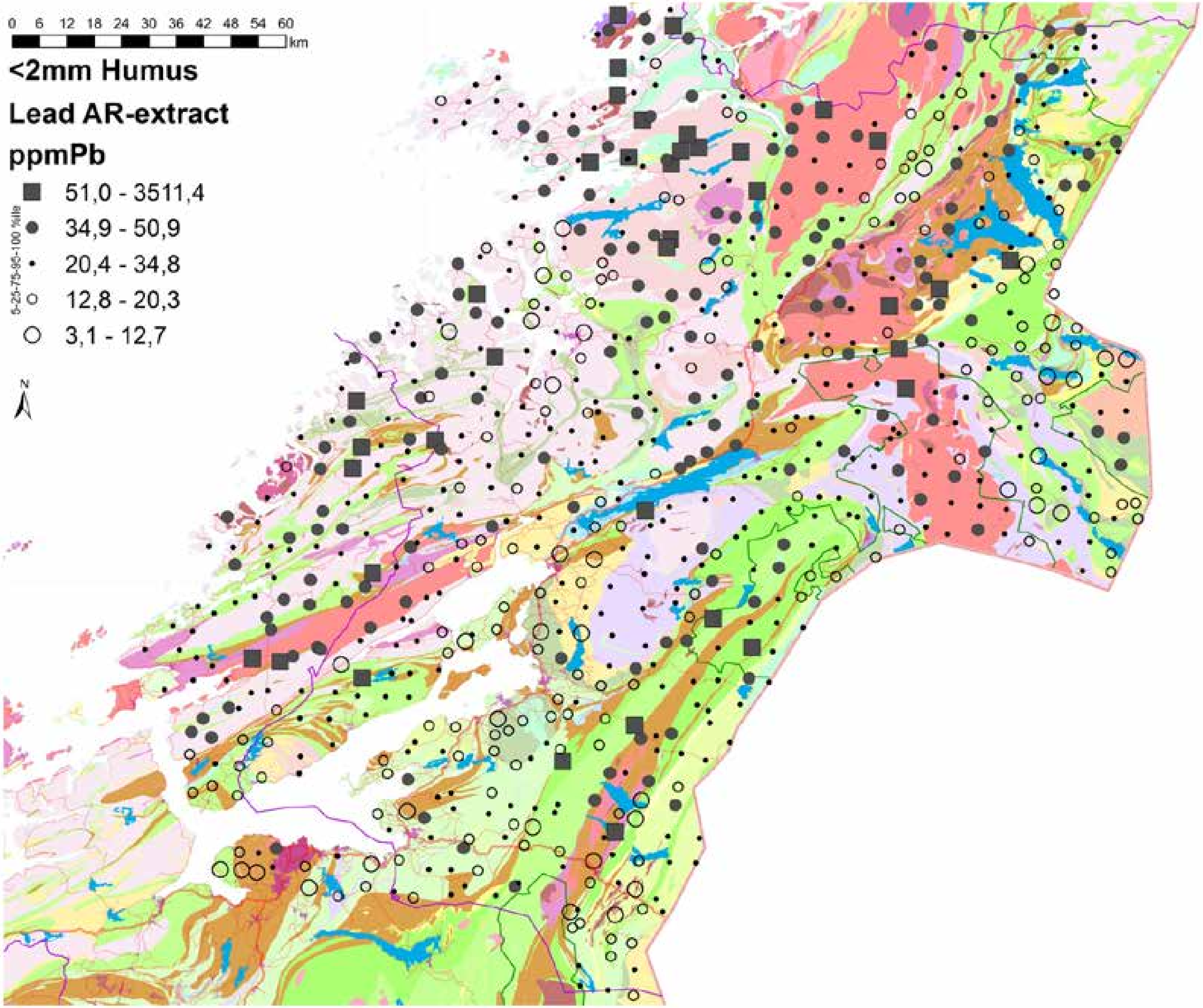

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
ppmMo
■ 1,35 - 11,49
● 0,63 - 1,34
• 0,29 - 0,62
○ 0,20 - 0,28
○ 0,09 - 0,19
5-25-75-95-100 %ile
N

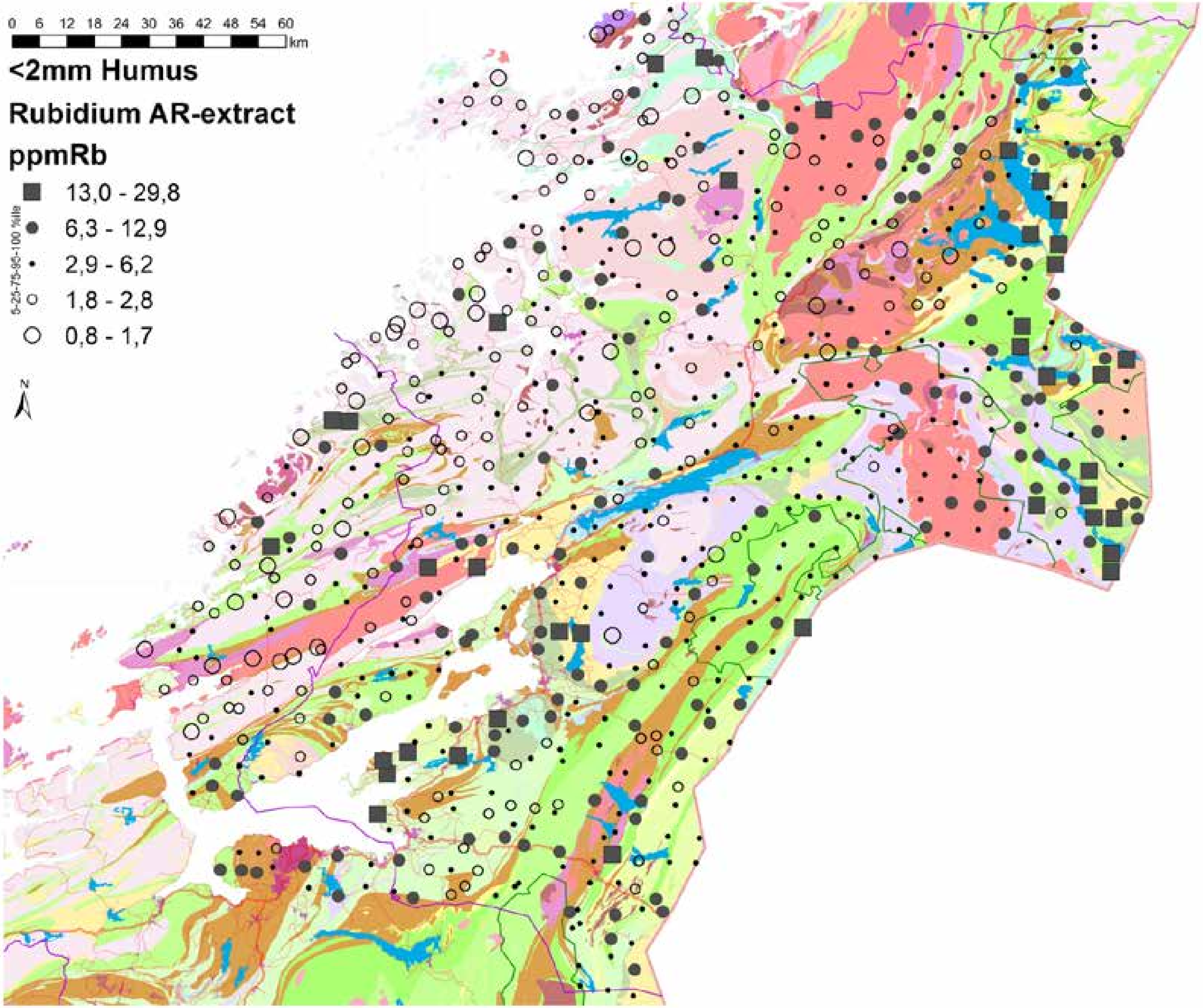

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Sodium AR-extract
ppmNa
418 - 789
258 - 417
104 - 257
65 - 103
28 - 64
5-25-75-95-100 %ile
N

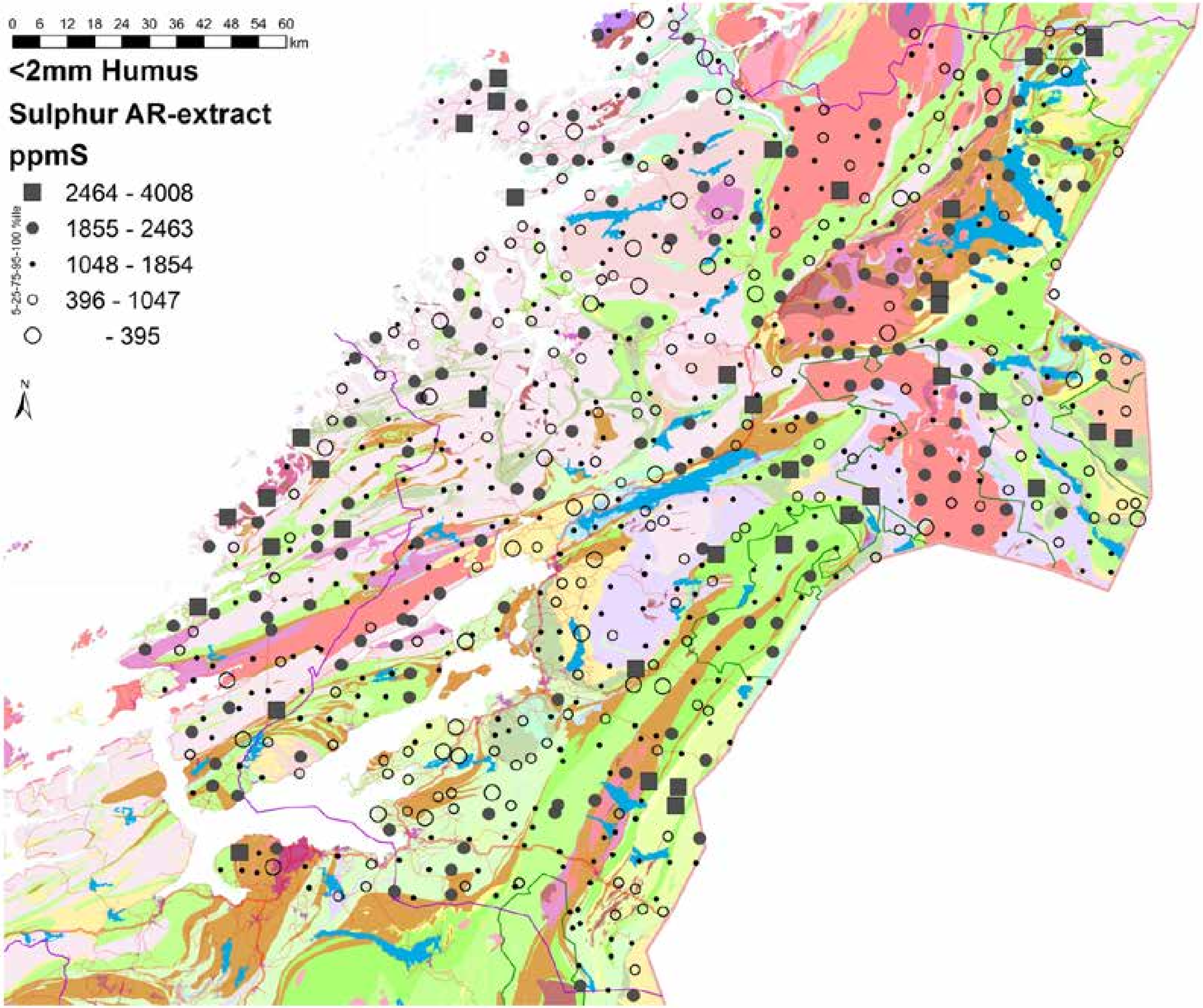

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Niobium AR-extract
ppmNb
5-25-75-95-100 %ile
■ 2,84 - 6,78
● 1,02 - 2,83
• 0,19 - 1,01
○ 0,08 - 0,18
○ 0,03 - 0,07
N

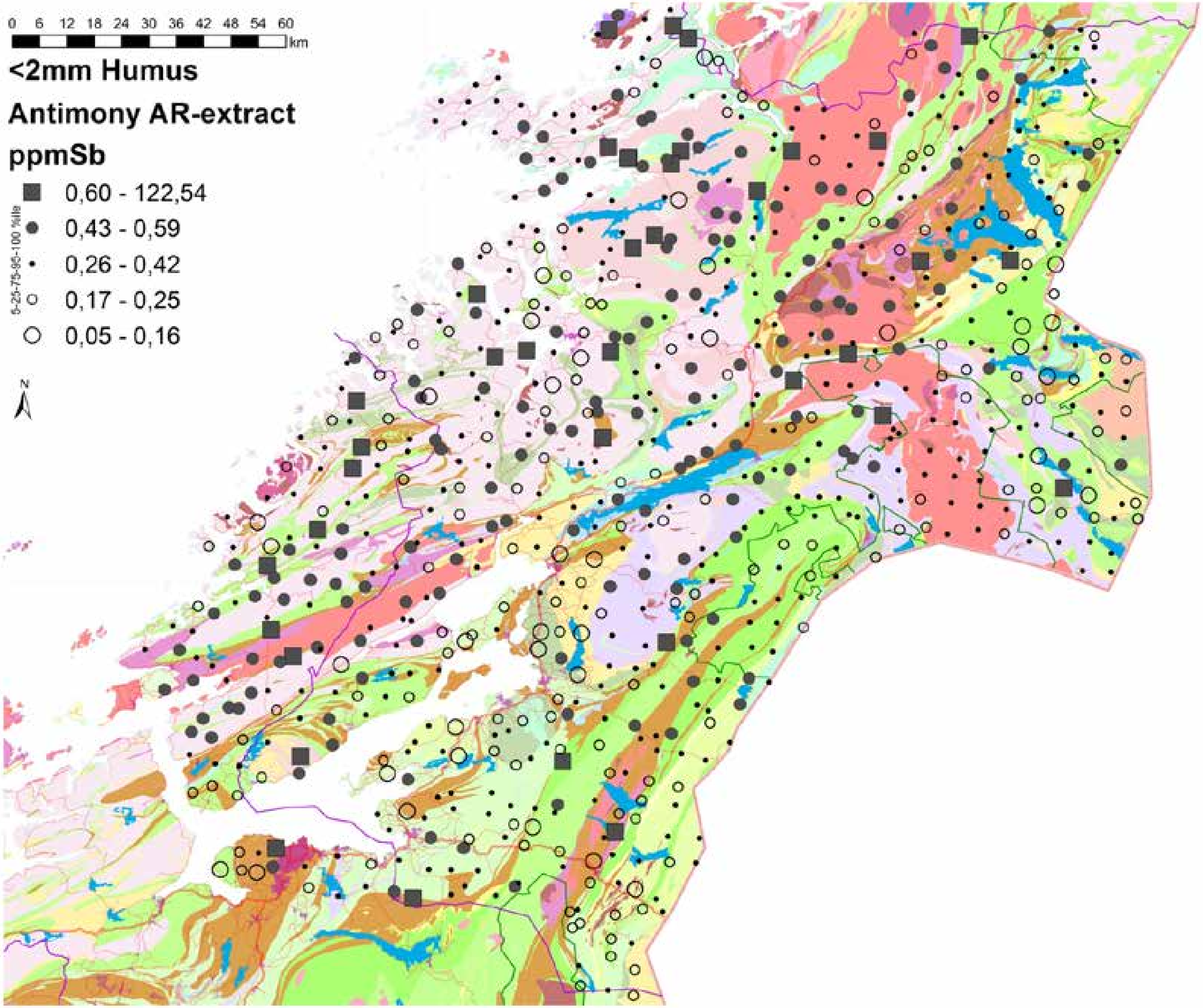

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Nickel AR-extract
ppmNi
■ 13,8 - 361,0
● 5,3 - 13,7
• 2,3 - 5,2
○ 1,5 - 2,2
○ 0,9 - 1,4
5-25-75-95-100 %ile
N

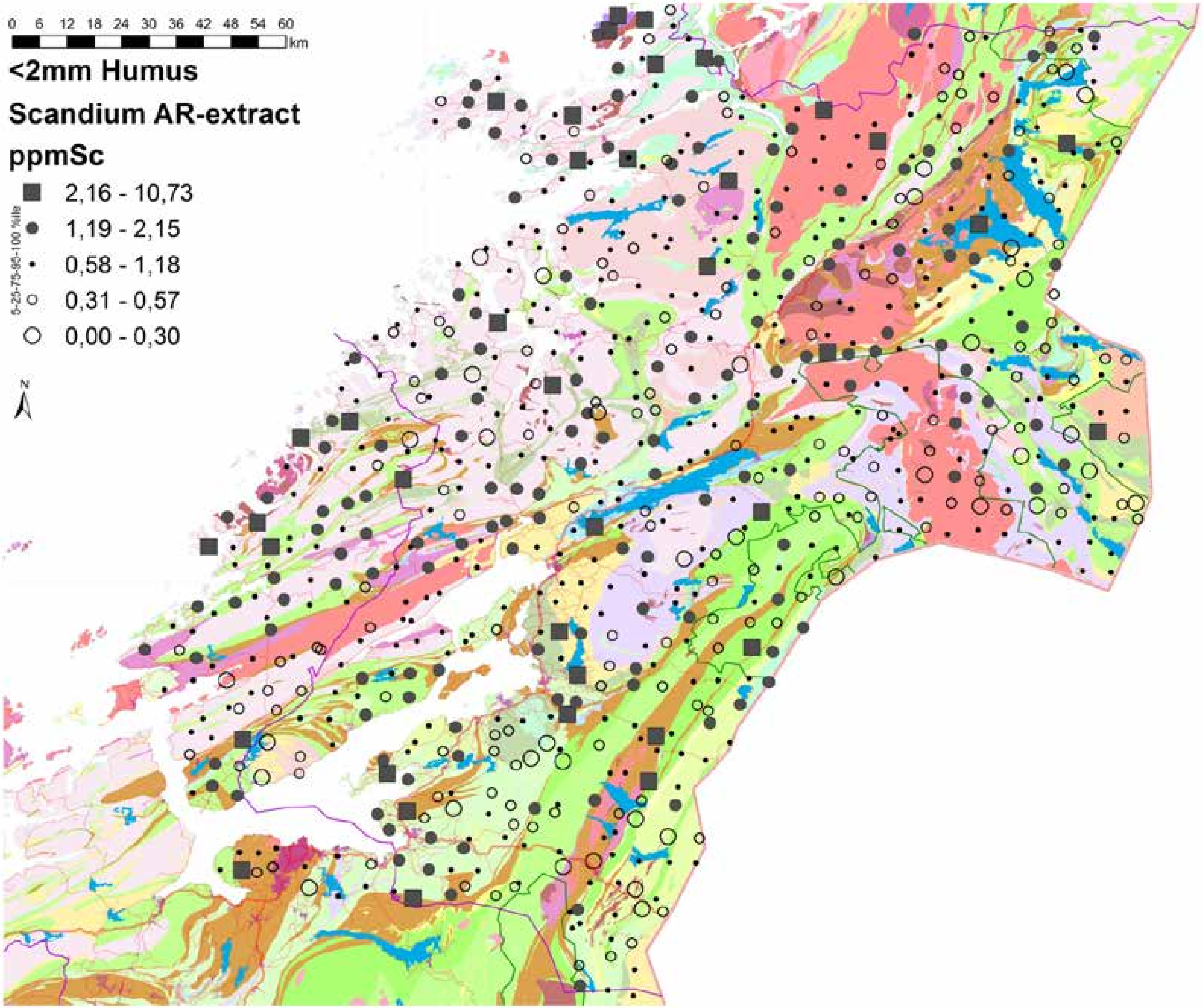

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Phosphorus AR-extract
ppmP
1277 - 2141
952 - 1276
645 - 951
464 - 644
200 - 463
5-25-75-95-100 %ile
N

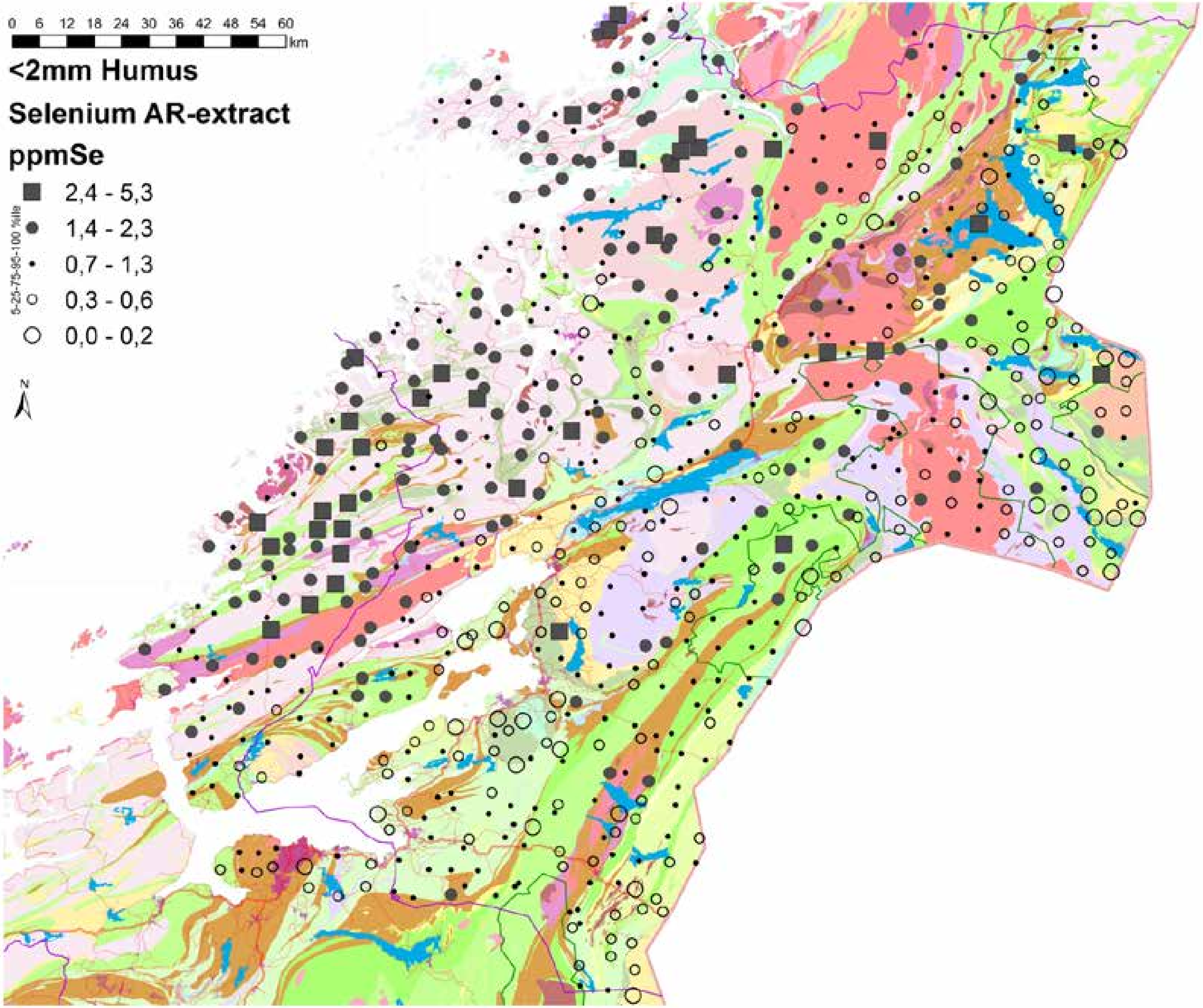

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Lead AR-extract
ppmPb
51,0 - 3511,4
34,9 - 50,9
20,4 - 34,8
12,8 - 20,3
3,1 - 12,7
5-25-75-95-100 %ile
N

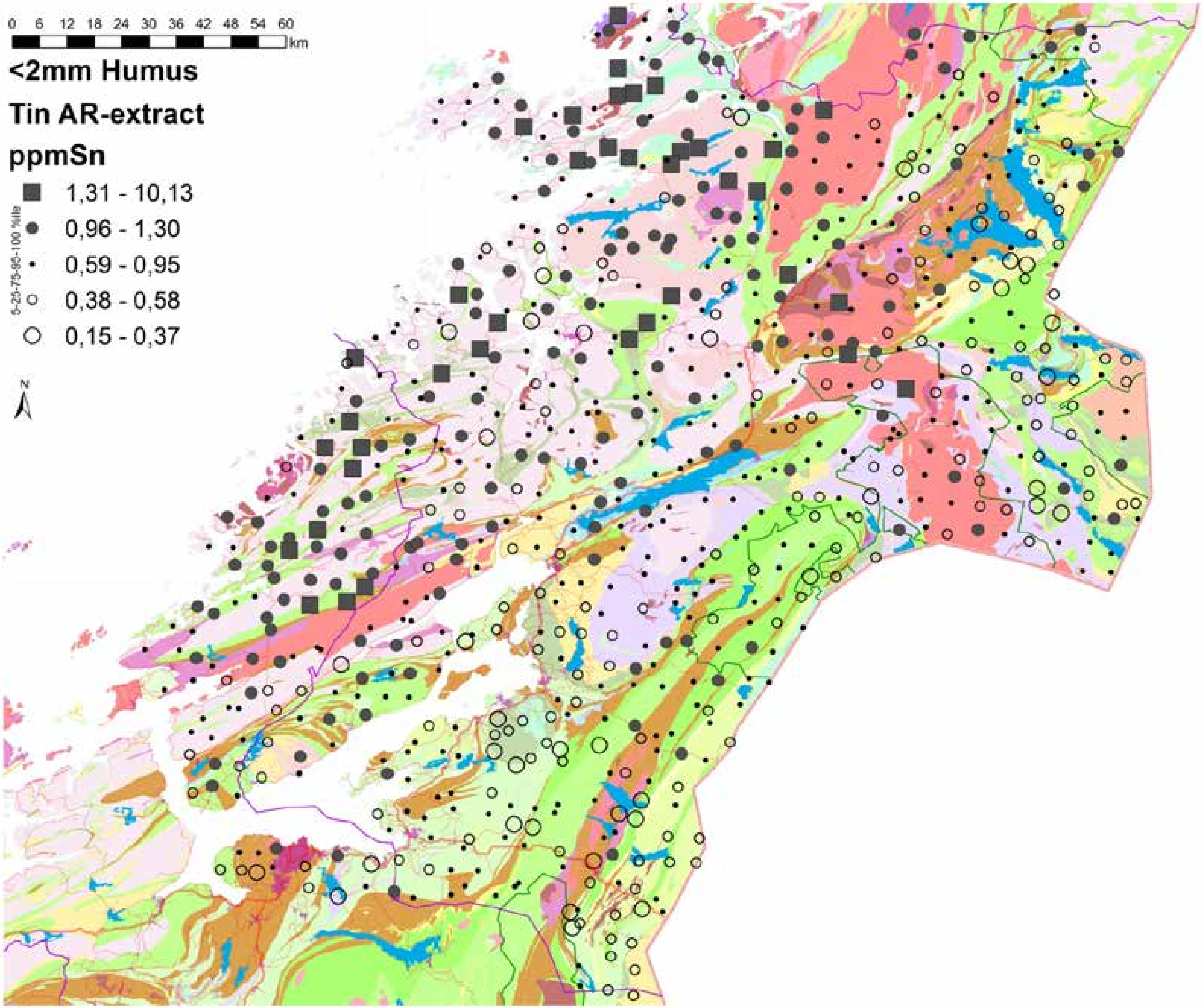

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Rubidium AR-extract
ppmRb
■ 13,0 - 29,8
● 6,3 - 12,9
• 2,9 - 6,2
○ 1,8 - 2,8
○ 0,8 - 1,7
5-25-75-95-100 %ile
N

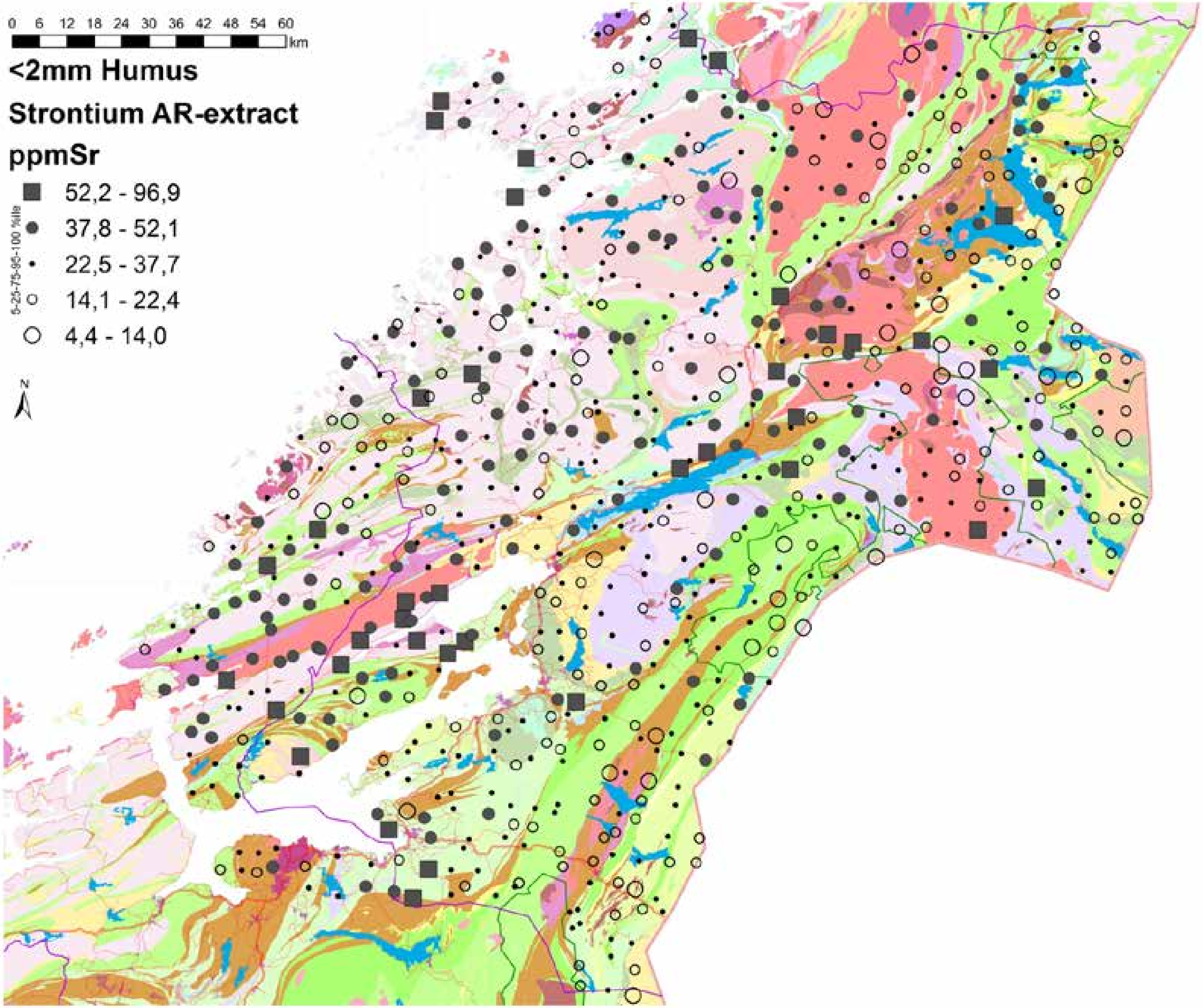

0 6 12 18 24 30 36 42 48 54 60 km
<2mm Humus
Sulphur AR-extract
ppmS
■ 2464 - 4008
● 1855 - 2463
• 1048 - 1854
○ 396 - 1047
○ - 395
5-25-75-95-100 %ile
N

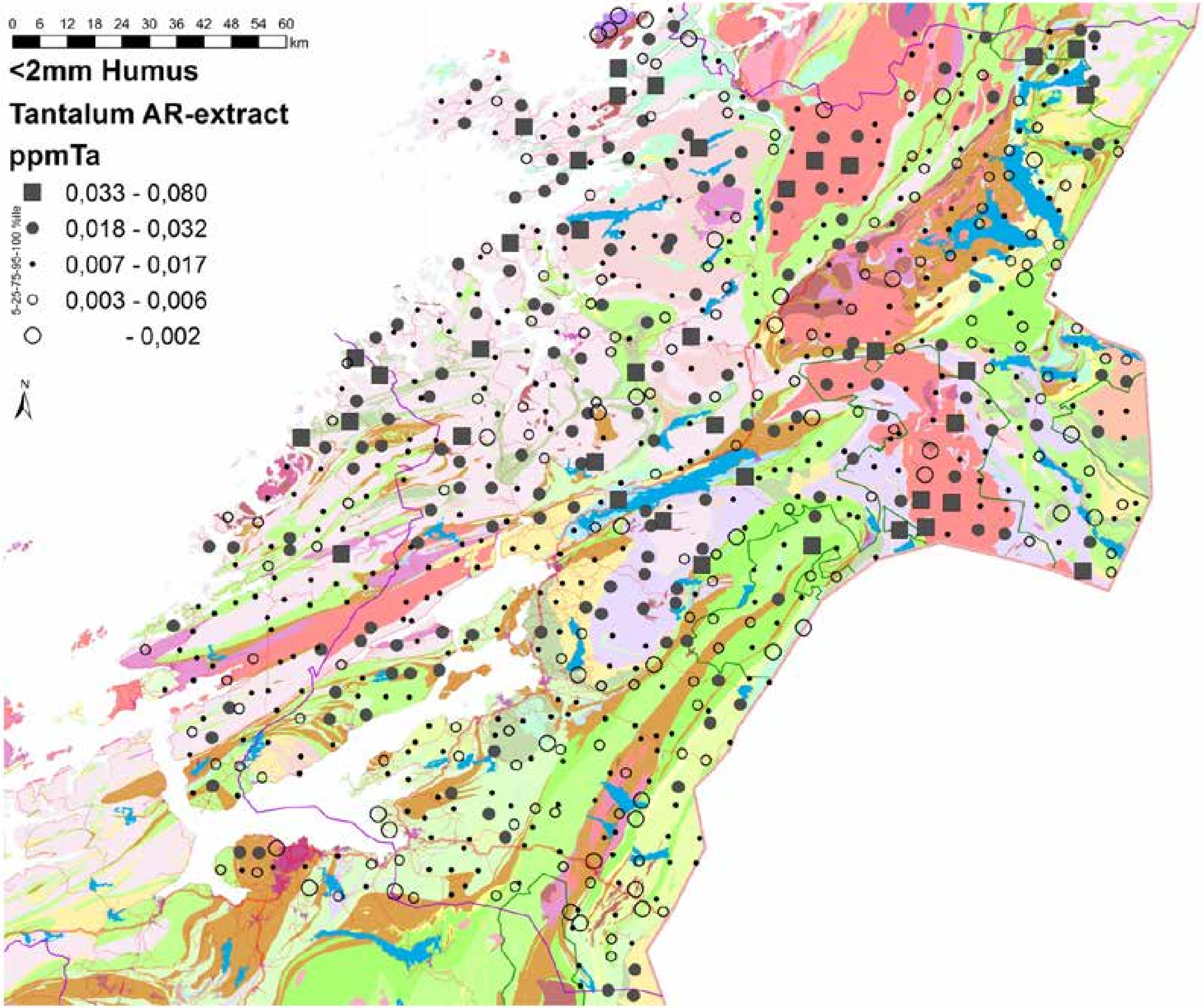

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Antimony AR-extract
ppmSb
0,60 - 122,54
0,43 - 0,59
0,26 - 0,42
0,17 - 0,25
0,05 - 0,16
5-25-75-95-100 %ile
N

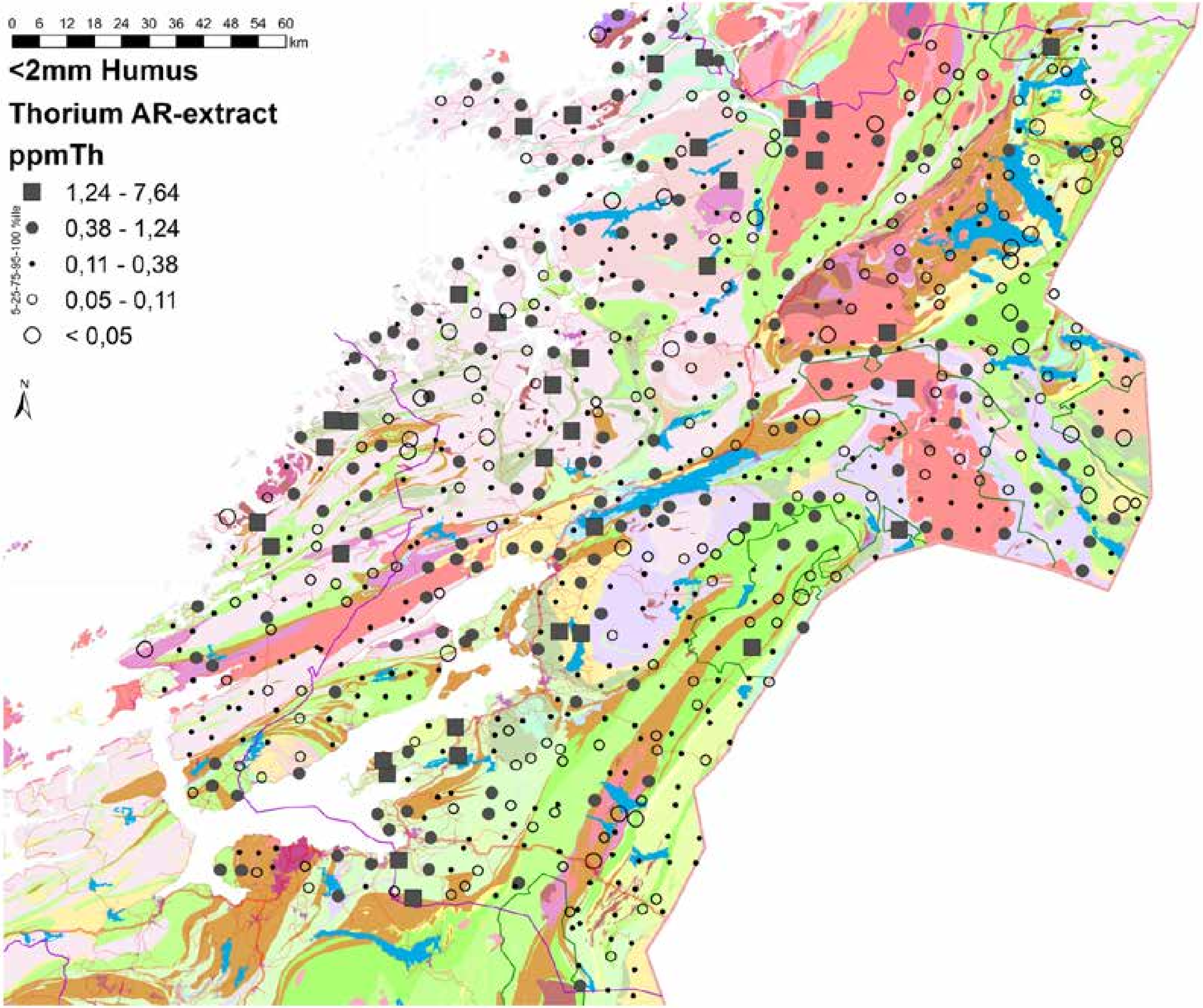

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Scandium AR-extract
ppmSc
5-25-75-95-100 %ile
■ 2,16 - 10,73
● 1,19 - 2,15
• 0,58 - 1,18
○ 0,31 - 0,57
○ 0,00 - 0,30
N

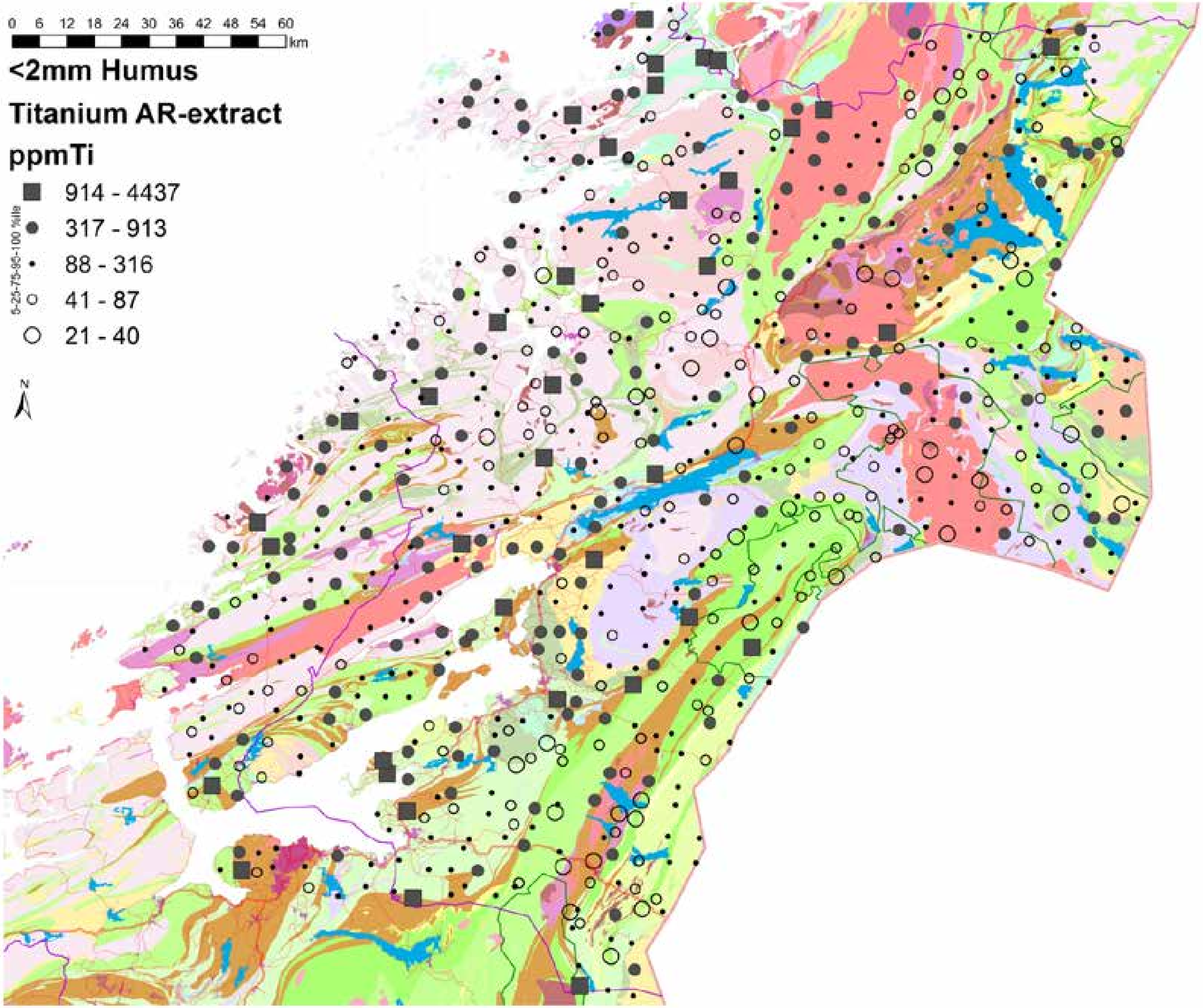

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Selenium AR-extract
ppmSe
■ 2,4 - 5,3
● 1,4 - 2,3
• 0,7 - 1,3
○ 0,3 - 0,6
○ 0,0 - 0,2
5-25-75-95-100 %ile
N

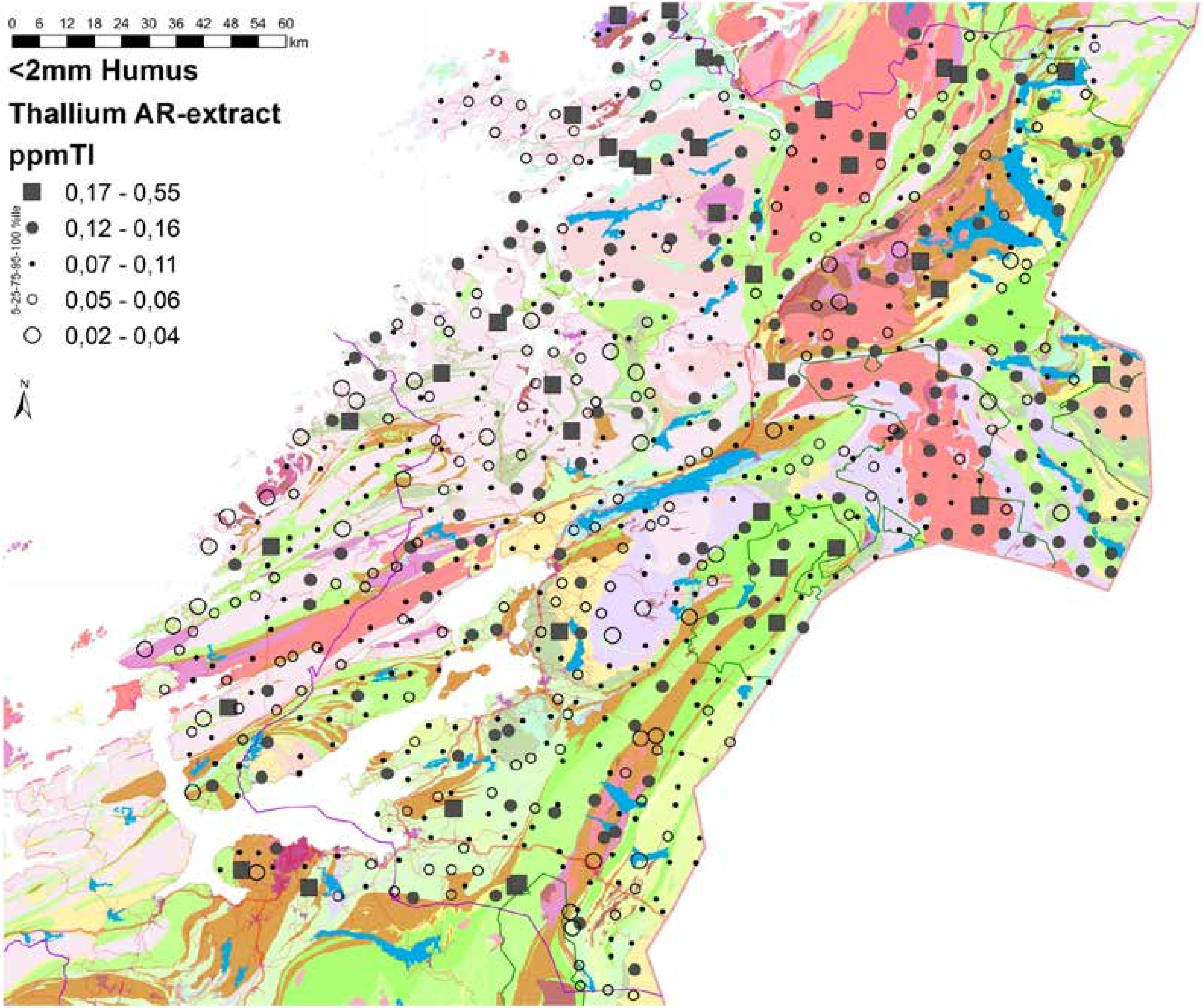

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Tin AR-extract
ppmSn
■ 1,31 - 10,13
● 0,96 - 1,30
• 0,59 - 0,95
○ 0,38 - 0,58
○ 0,15 - 0,37
5-25-75-95-100 %ile
N

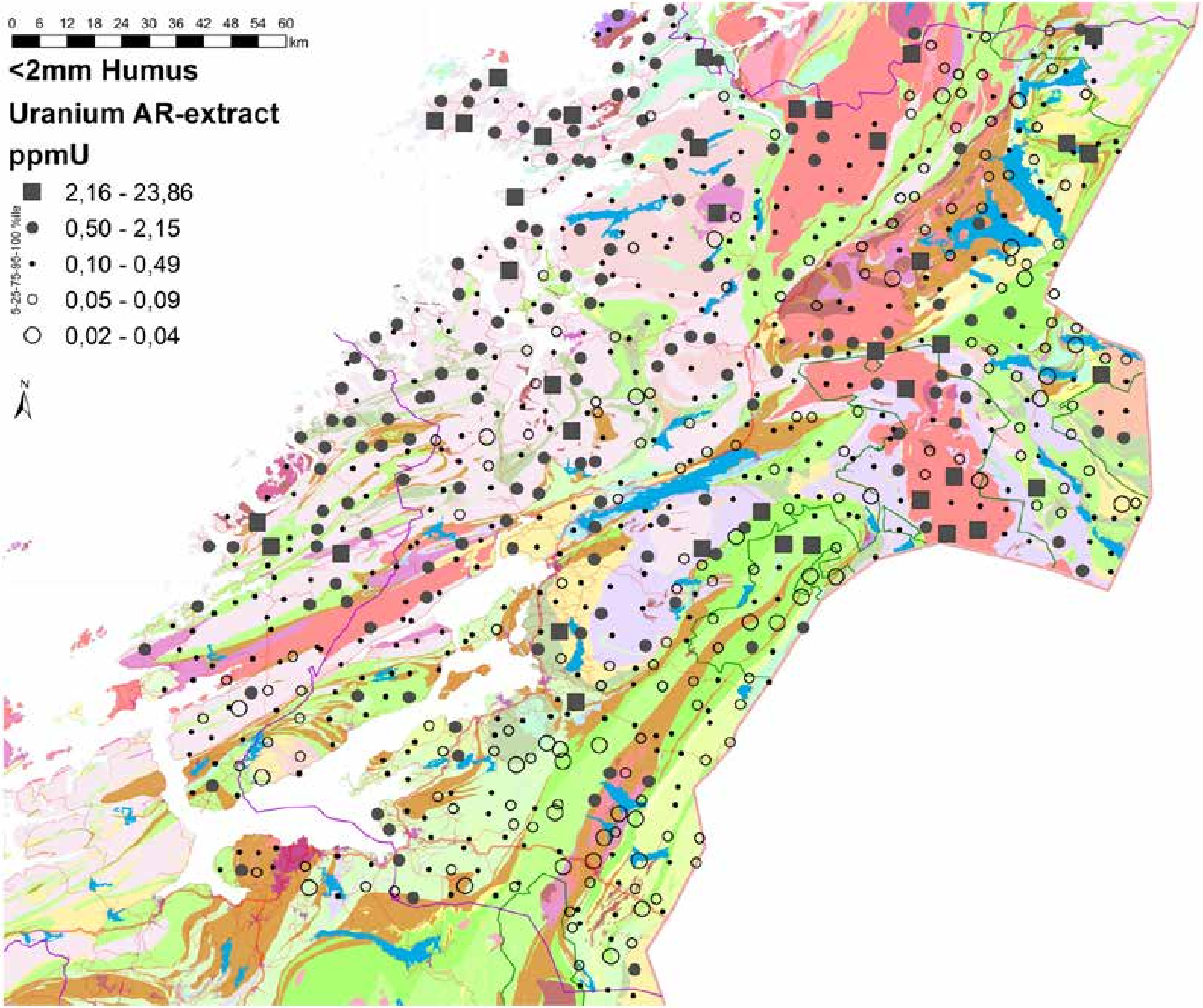

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Strontium AR-extract
ppmSr
■ 52,2 - 96,9
● 37,8 - 52,1
• 22,5 - 37,7
○ 14,1 - 22,4
○ 4,4 - 14,0
5-25-75-95-100 %ile
N

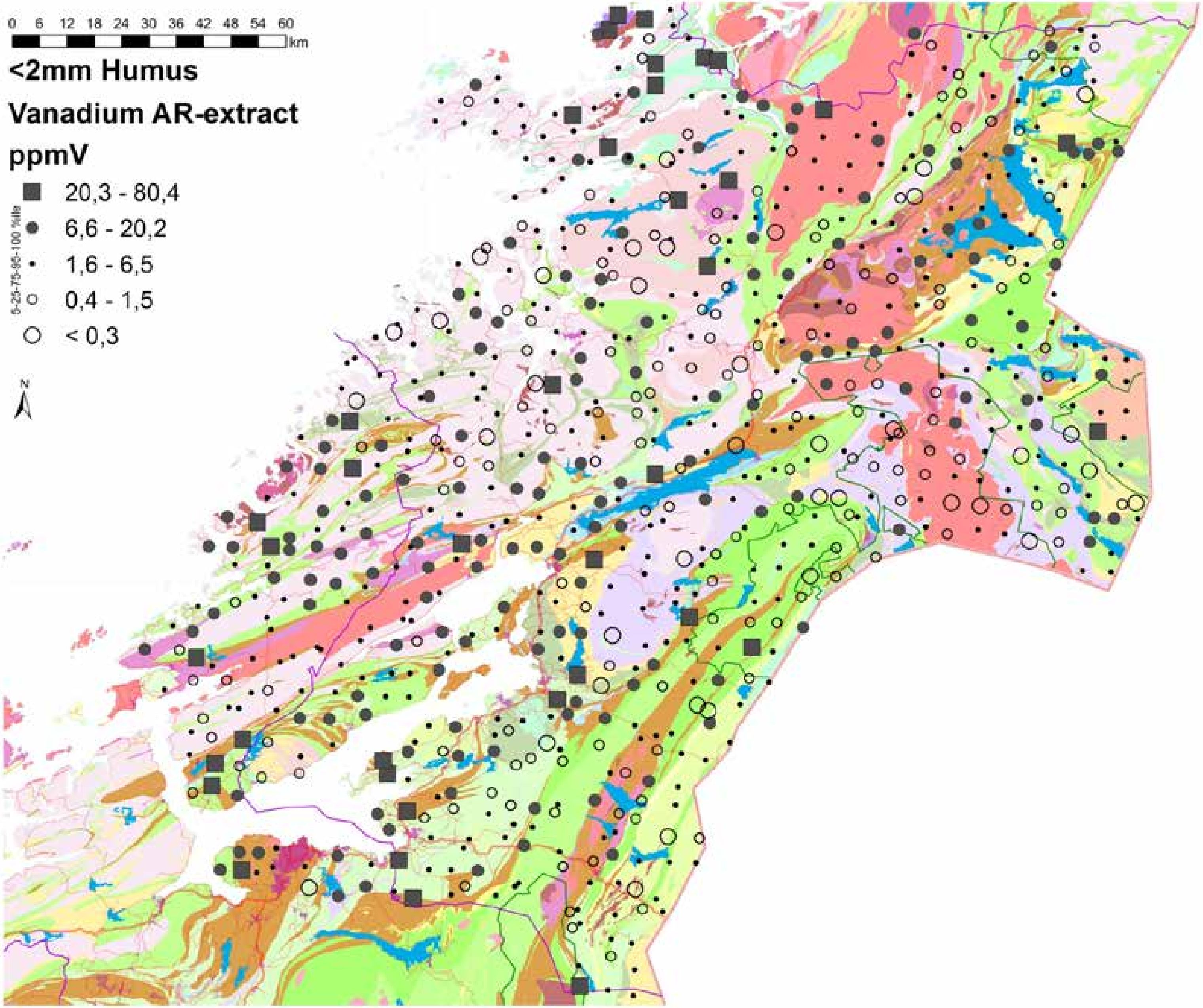

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Tantalum AR-extract
ppmTa
■ 0,033 - 0,080
● 0,018 - 0,032
• 0,007 - 0,017
○ 0,003 - 0,006
○ - 0,002
5-25-75-95-100 %ile
N

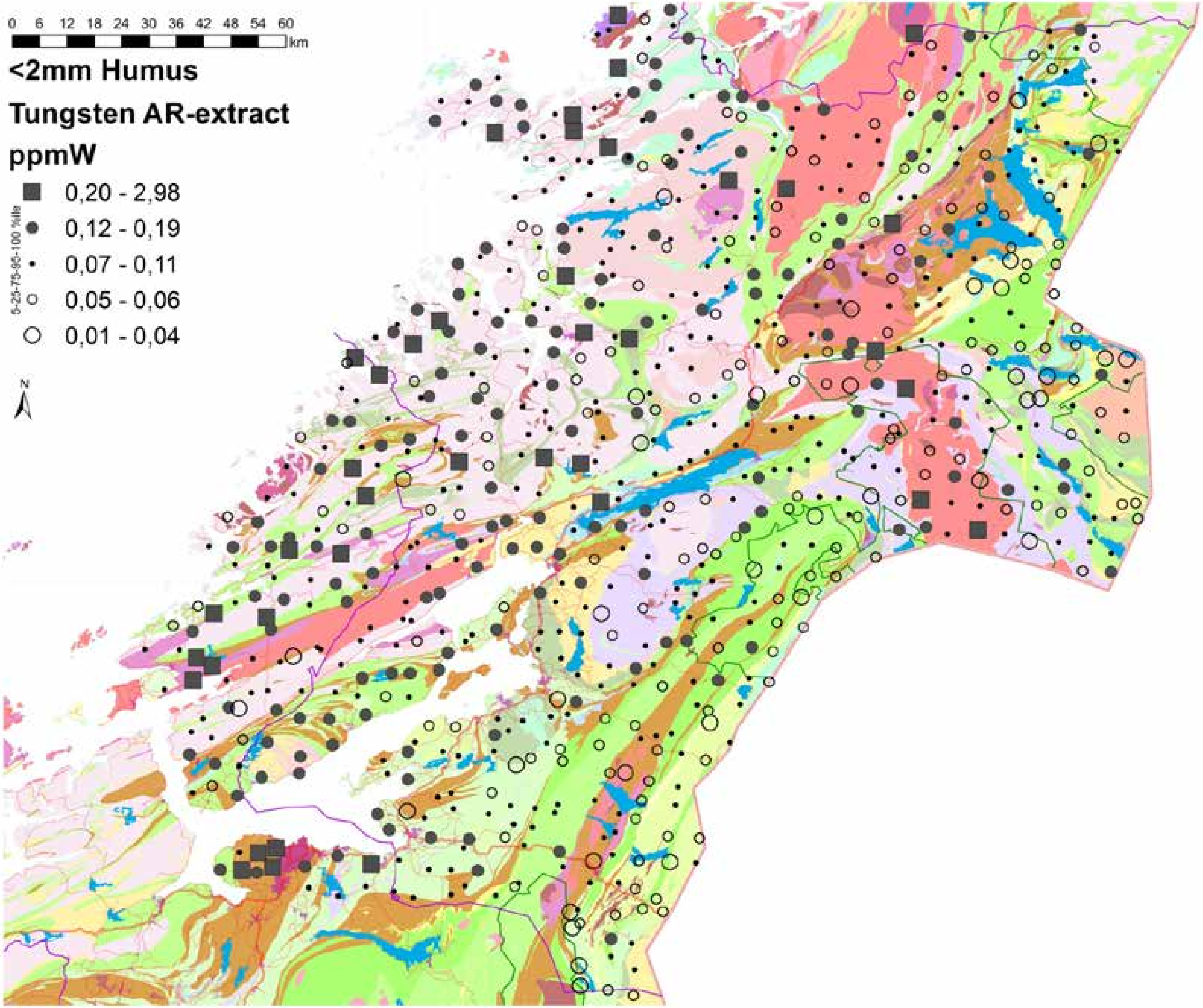

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Thorium AR-extract
ppmTh
5-25-75-95-100 %ile
■ 1,24 - 7,64
● 0,38 - 1,24
• 0,11 - 0,38
○ 0,05 - 0,11
○ < 0,05
N

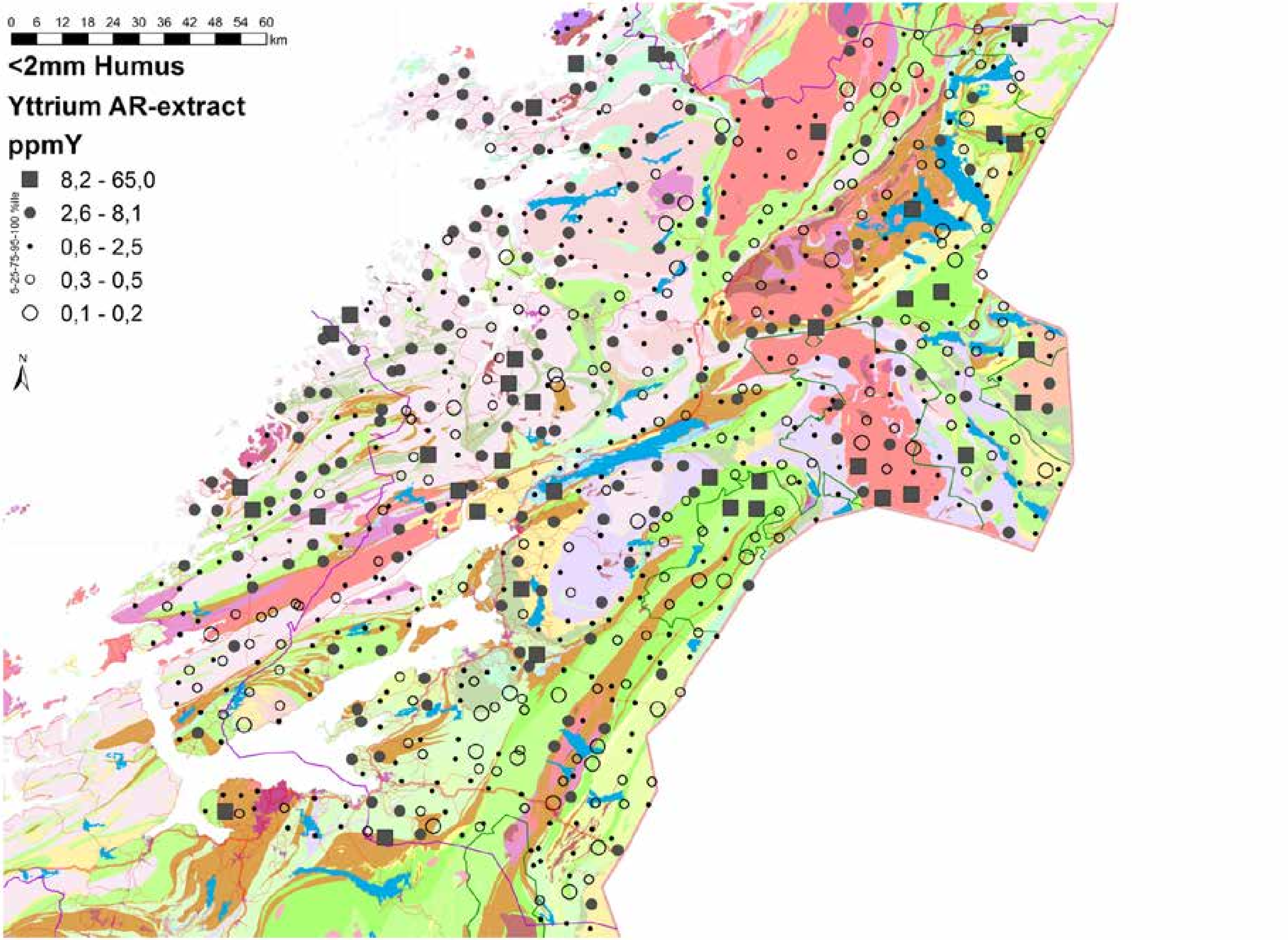

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Titanium AR-extract
ppmTi
■ 914 - 4437
● 317 - 913
• 88 - 316
○ 41 - 87
◯ 21 - 40
5-25-75-95-100 %ile
N

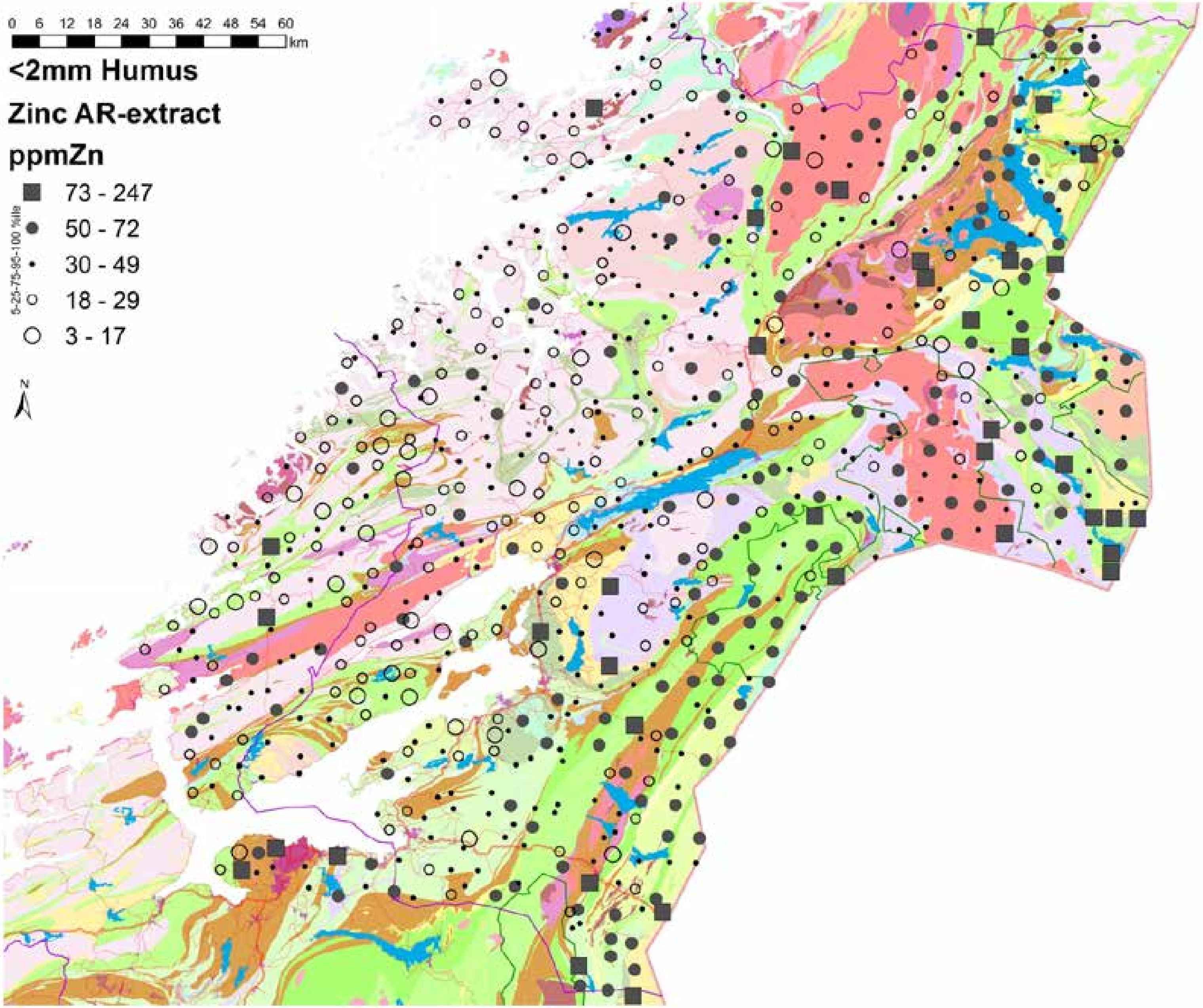

0 6 12 18 24 30 36 42 48 54 60 km
<2mm Humus
Thallium AR-extract
ppmTl
5-25-75-95-100 %ile
■ 0,17 - 0,55
● 0,12 - 0,16
• 0,07 - 0,11
○ 0,05 - 0,06
○ 0,02 - 0,04
N

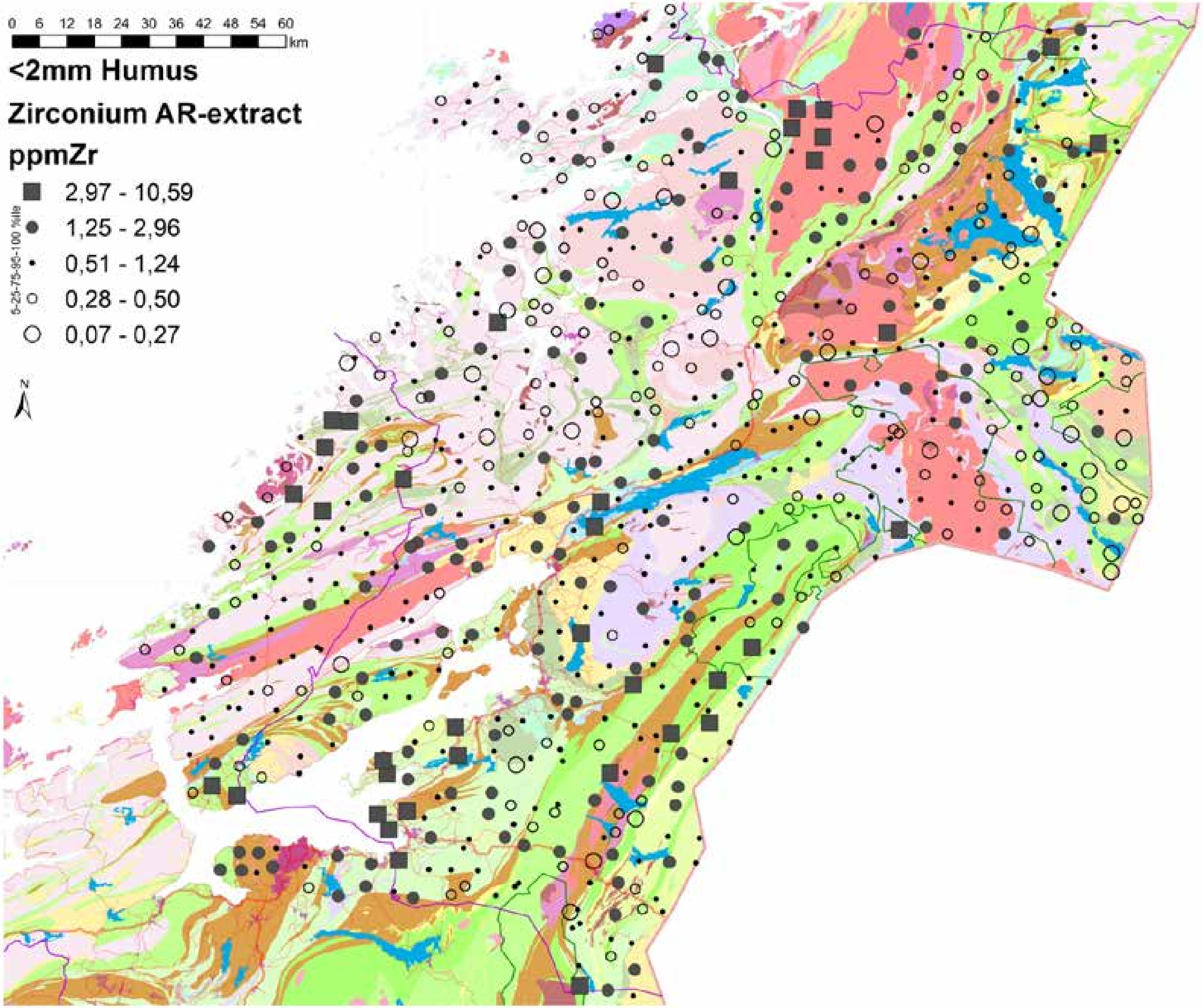

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Uranium AR-extract
ppmU
■ 2,16 - 23,86
● 0,50 - 2,15
• 0,10 - 0,49
○ 0,05 - 0,09
◯ 0,02 - 0,04
5-25-75-95-100 %ile
N

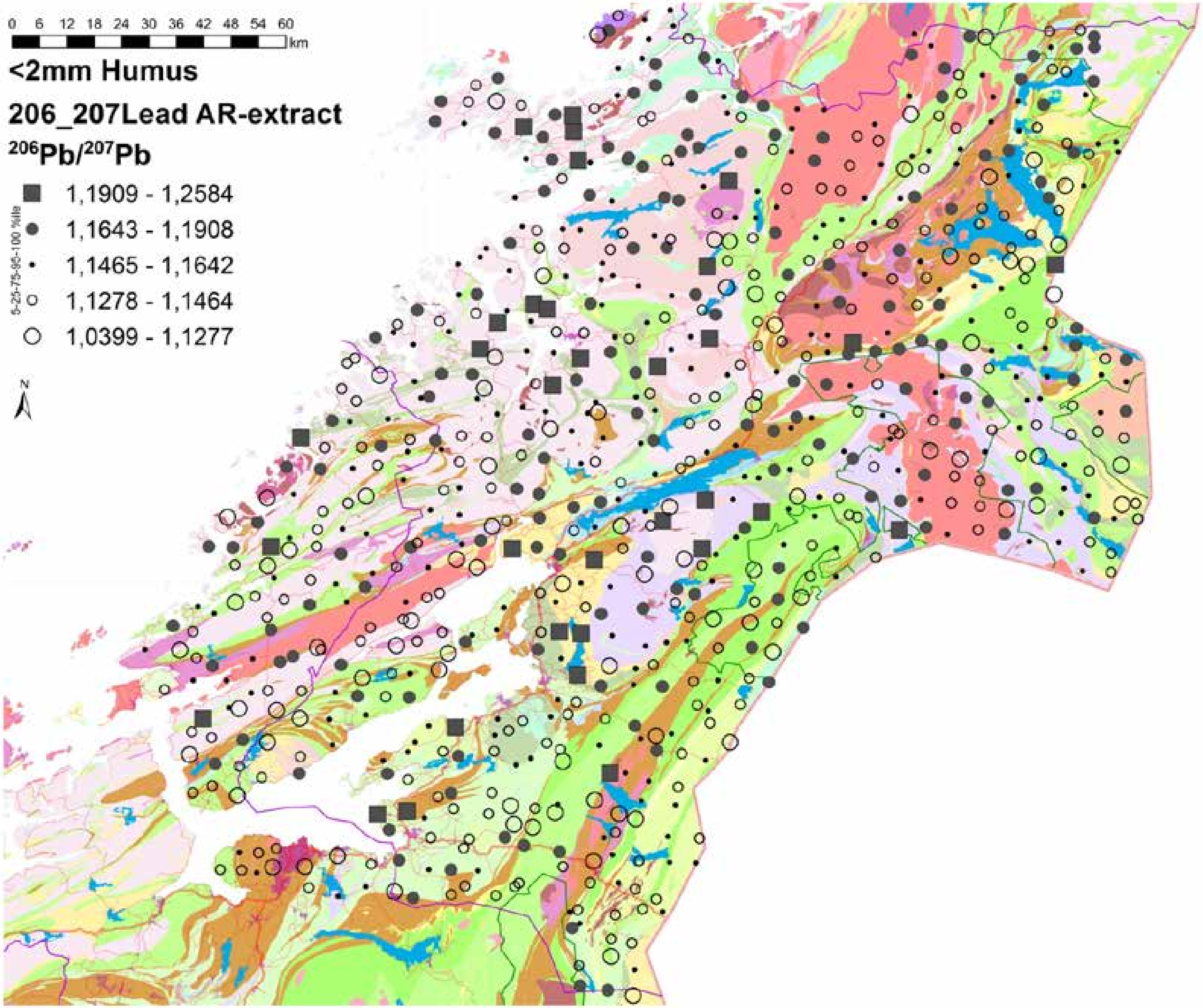

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Vanadium AR-extract
ppmV
■ 20,3 - 80,4
● 6,6 - 20,2
• 1,6 - 6,5
○ 0,4 - 1,5
○ < 0,3
5-25-75-95-100 %ile
N

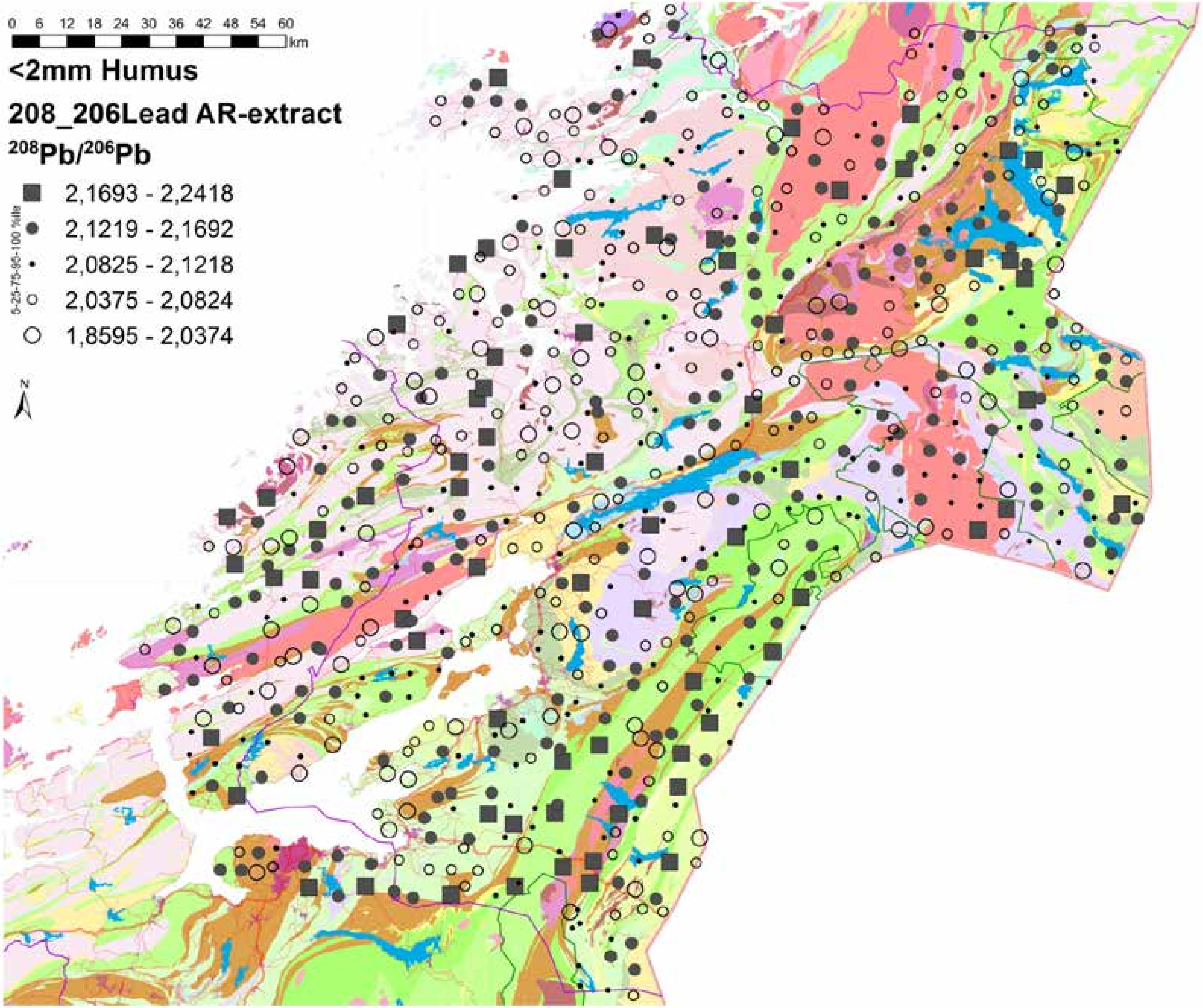

0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Tungsten AR-extract
ppmW
5-25-75-95-100 %ile
■ 0,20 - 2,98
● 0,12 - 0,19
• 0,07 - 0,11
○ 0,05 - 0,06
○ 0,01 - 0,04
N


0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Yttrium AR-extract
ppmY
■ 8,2 - 65,0
● 2,6 - 8,1
• 0,6 - 2,5
○ 0,3 - 0,5
○ 0,1 - 0,2
5-25-75-95-100 %ile
N


0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Zinc AR-extract
ppmZn
73 - 247
50 - 72
30 - 49
18 - 29
3 - 17
5-25-75-95-100 %ile
N


0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
Zirconium AR-extract
ppmZr
■ 2,97 - 10,59
● 1,25 - 2,96
• 0,51 - 1,24
○ 0,28 - 0,50
○ 0,07 - 0,27
5-25-75-95-100 %ile
N


0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
206_207Lead AR-extract
^{206}Pb/^{207}Pb
■ 1,1909 - 1,2584
● 1,1643 - 1,1908
• 1,1465 - 1,1642
○ 1,1278 - 1,1464
○ 1,0399 - 1,1277
5-25-75-95-100 %ile
N


0 6 12 18 24 30 36 42 48 54 60
km
<2mm Humus
208_206Lead AR-extract
$^{208}Pb/^{206}Pb$
5-25-75-95-100 %ile
■ 2,1693 - 2,2418
● 2,1219 - 2,1692
• 2,0825 - 2,1218
○ 2,0375 - 2,0824
○ 1,8595 - 2,0374
N