NGU Report 2014.047

Mineral soil geochemistry in Nord-Trøndelag and Fosen

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

REPORT

Report no.: 2014.047 | ISSN 0800-3416 | Grading: Open

Title:
Mineral soil geochemistry in Nord-Trøndelag and Fosen

Authors: Finne, Tor Erik,
Reimann, Clemens and Eggen, Ola A.

Client:
Ministry of Trade, Industry and Fisheries/NGU

County:
Nord-Trøndelag and Sør-Trøndelag

Commune:

Map-sheet name (M=1:250.000)
Trondheim, Østersund, Namsos, Grong, Vega

Map-sheet no. and -name (M=1:50.000)

Deposit name and grid-reference:

Number of pages: 91 Price (NOK): 365
Map enclosures: -

Fieldwork carried out:	Date of report:	Project no.:	Person responsible:
May-December 2013	31.10.2014	351700	Belinda Flem

Summary:

During field work in the summer and fall of 2013, mineral soil samples were collected in a grid of 6x6km 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 57 elements.
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.
A selection of anomalies are briefly described, both areas of no known mineralizations, as well as anomalies of new elements in established ore-districts are covered.

Keywords: geochemistry	till	aqua regia

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

The international "Nordkalotten" project 1980-84 (Bølviken et.al, 1986) pioneered low sampling density multimedia geochemical mapping, covering the county of Finnmark in the Norwegian part of the Finnish-Swedish-Norwegian area north of the Arctic Circle. A similar approach was followed in 1986-87 in the adjacent counties Troms and Nordland. At that time, sampling and analysis were performed on stream sediments, stream water and till with a sampling density of 1 sample/40km^2. Stream sediments were analysed using several techniques: The fine fraction (<0.18mm) was analysed using XRF (Næss, 1988) as well as NAA (Ekremsæter, 1988) and HNO_3-extraction (Krog, 1987). The heavy minerals of the coarse fraction (> 0.18 mm) were analysed using XRF (Wolden, 1987). The till samples (<0.06mm fraction) were analysed for HNO_3-extractables (Kjeldsen, 1987) and for gold (Kjeldsen and Ottesen, 1988). The only available material of till samples from Finnmark, <0.06mm, was reanalyzed in 2011 using aqua regia extraction, resulting in data for some 60 elements (Reimann et.al, 2011). In much the same way, all till samples from Troms and Nordland were also reanalyzed, except now the < 2mm fraction was used (Reimann et al., 2011). In this report the survey covers the county of Nord-Trøndelag and adjacent parts of Sør-Trøndelag county on the Fosen peninsula and the municipalities of Trondheim and Malvik. This area was never mapped geochemically on a similar scale as the three northernmost counties, using mineral soil as sampling medium. 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). 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; Sæther, 1988).

The survey constitutes the first part of an intended completion of a mineral soil geochemistry map of Norway already started in North Norway, and is a part of NGU's program MINS – Mineral resources in South Norway.

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 to 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. As seen from the records in the NGU ore database in Figure 1, 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.

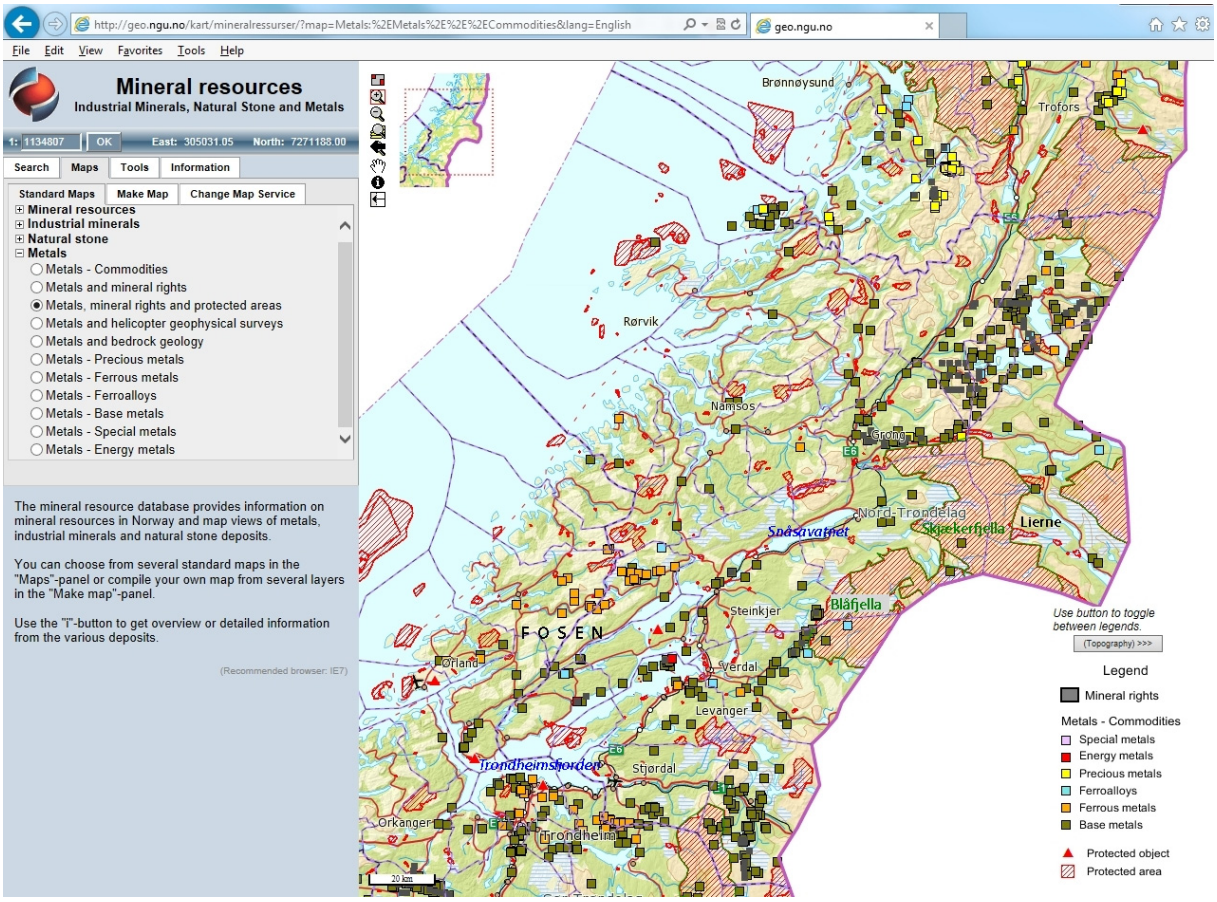


Figure 1 *Map of the surveyed area showing known ore mineralization occurrences, mineral claims and protected areas. GIS layers by NGU, the Directorate of Mining (Direktoratet for Mineralforvaltning), and the Norwegian Environment Agency (Miljødirektoratet)*

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 shows 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)

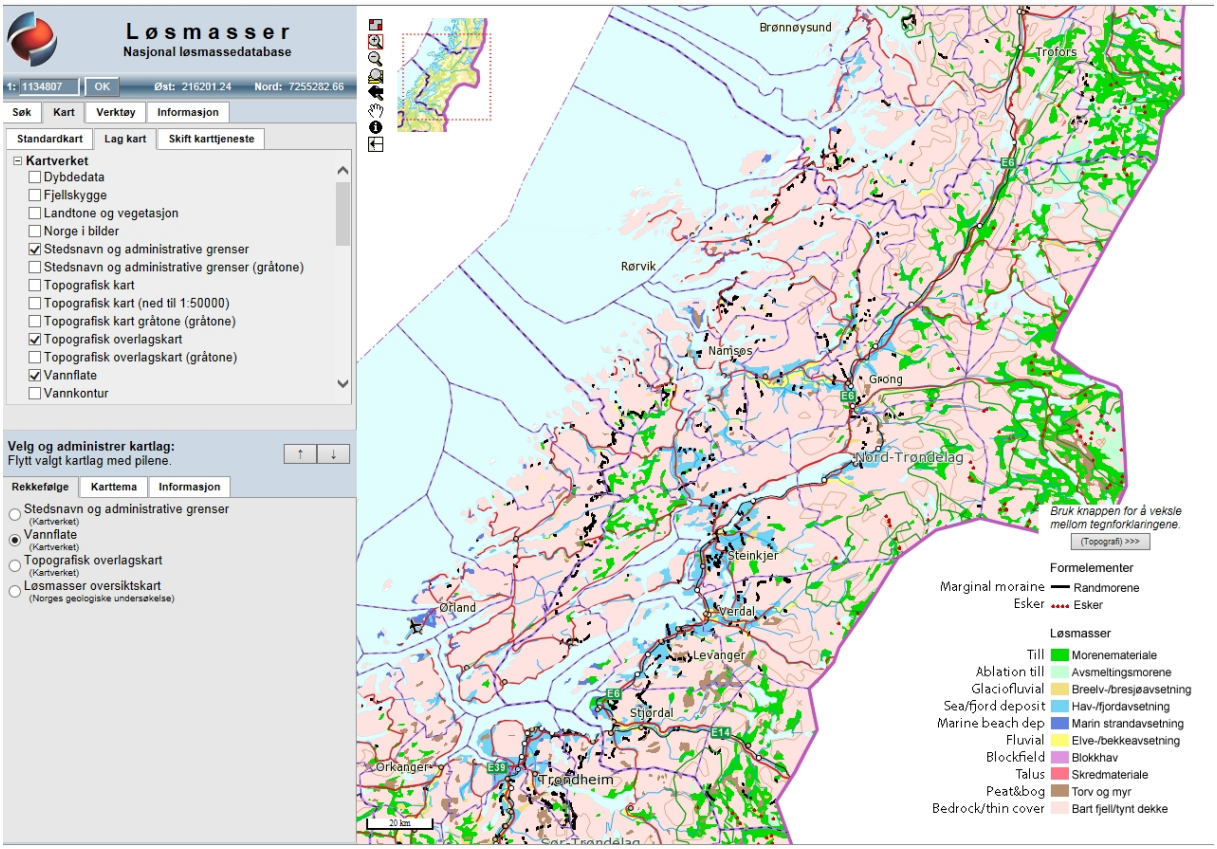


Figure 2 *Map of quaternary deposits in the surveyed area.*

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. The grid was overlain on topographical maps along with a line marking the highest marine level and of polygons delineating glaciofluvial deposits and areas with marine deposits to be excluded from sampling. 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. Sample pits were dug by paint-free steel spade down to well into the mineral soil layer, preferably to C-horizon in podzols. Samples were collected into Rilsan® plastic bags using a small steel trowel. Figure 3 shows a typical sample pit, the equipment used and a typical sample. Sample wet weight was on average 1.8 kg. Sample contamination was minimized by the field crew not wearing any jewellery 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 37 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.

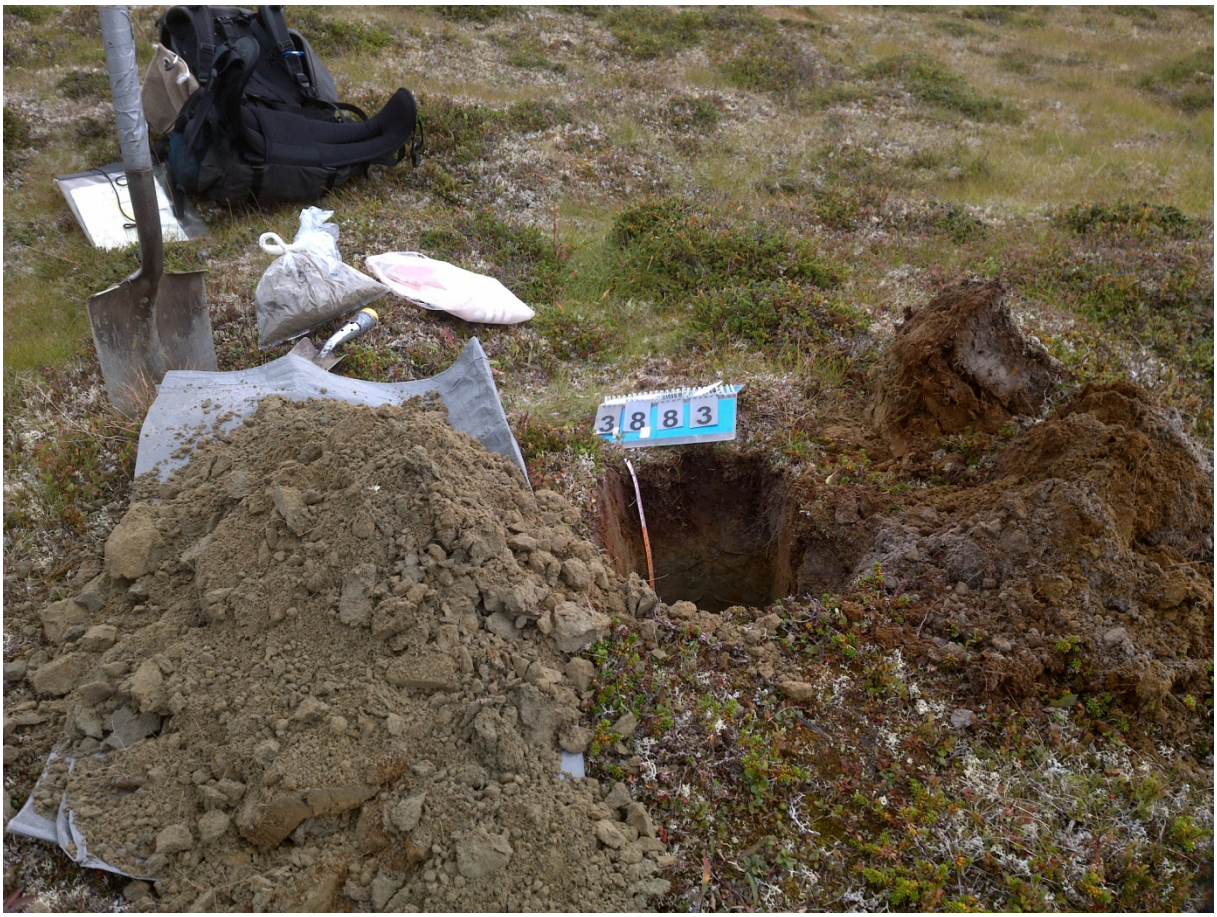


Figure 3 *Photo showing sample, sample pit and all essential tools. Photo O.A. Eggen*

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 1.4 kg. Subsequently all samples were dry sieved to <2mm (9 mesh), from which 2 aliquots of 90+ g were obtained. Surplus <2mm material as well as the >2mm fraction were 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. 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 MINN was inserted. In addition, 20 samples from the Nordland/Troms collection described by Reimann et al. (2011) and 5 samples of the GEMAS Ap standard (Reimann et al., 2012a) were evenly distributed into the sample series. The control samples were not always inserted in the exact same positions within the group.

3.3 Chemical analyses

The randomized series of 90+ g aliquots were shipped to ACME laboratories in Vancouver, Canada. The laboratory inserted further 33 splits of its own quality control (QC) sample DS10 for overall QC as well as 33 alliquots of 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 32 replicate pairs throughout the analytical sequence.

The MINN campaigns of 2011 and 2012 (Reimann et al., 2012b; Finne and Eggen, 2013) as well as the reanalysis on the Nordland/Troms samples (Reimann et al., 2011) followed the same procedure with successful quality assessment at the named laboratory. For all these campaigns, a 15 g sample weight was used for extraction.

The samples were digested in 90 ml aqua regia and leached for one hour in a hot (95 °C) water bath. After cooling, the solution was made up to a final volume of 300 ml with 5% HCl. The ratio of sample weight to solution volume is 1g per 20 ml. The solutions were analyzed using a Spectro Ciros Vision emission spectrometer (ICP-AES) and a Perkin Elmer Elan 6000/9000 inductively coupled plasma emission mass spectrometer (ICP-MS).

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 detection limit. 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 analysis.

X-charts are a simple yet 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", certified value is known. X-charts from this survey (for an example see Figure 4, plot to the right) indicate that no severe problems are present with regards to time trends or breaks in analytical results. All in all, most results for the standards were satisfactory. Table 1 and Table 2 identify the problematic elements.

3.4.1 Accuracy

The project standard MINN was used to estimate the accuracy of the analysis and to detect possible time trends or breaks in the analysis sequence. This standard material was also used in the Nordkinn (Reimann et al., 2012b) and Nord-Salten (Finne & Eggen, 2013) surveys and therefore gives the opportunity to compare the three surveys. The laboratory also used its own house standard, DS10, inserted throughout the analysis series. Table 1 and Table 2 display values for minimum, median and maximum, as well as precision for the analytical results for the standards MINN and DS10. For comparison with prior analytical results of the same standards, the median values from the Nordkinn study (Reimann et al., 2012b) are also given in Table 1. As an illustration of similarity in the MINN standard behavior, Figure 4shows X-charts of La for Nordkinn, Nord-Salten and this survey, respectively. In laboratory standard DS10 only Ta and Ge has so low concentrations that it remains problematic (Table 2).

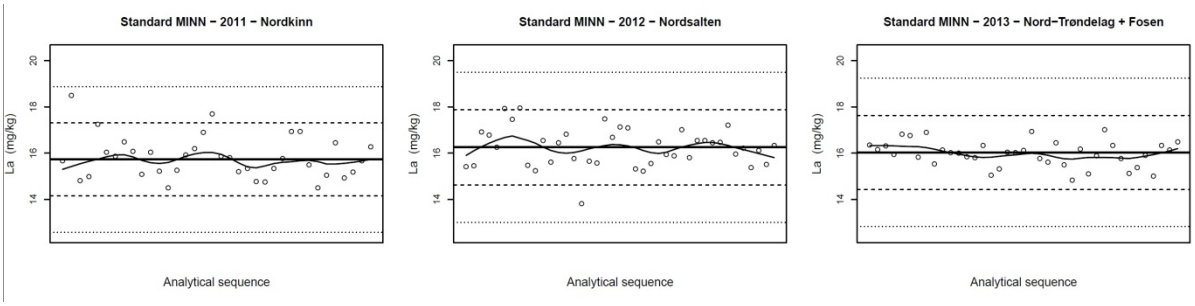


Figure 4 X-chart for La depicting stability for project standard "MINN" in year 2011 Nordkinn, year 2012 Nord-Salten and this study, showing similarity in median and precision in the three datasets. Dashed and dotted lines marks ±10% and ±20% deviation, respectively.

3.4.2 Precision

Table 3 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 this survey it was also decided that material from the B-horizon could be sampled, thus increasing the risk for sampling heterogeneous duplicate samples. In many cases the observed problems with precision were due to very low concentrations as in the case of our project standard MINN, i.e. analytical results at or below the limit of detection, like B, Pd, Pt, Re and Te. However, the field duplicate results reveal that some elements are plagued by poor reproducibility, and maps should be viewed with care. These include Ag, Au, Ge, Mn and Ta.

Practical detection limit (PDL) was established based on method described by Demetriades (2011), using the results for analytical (weighing) duplicates. The good results of the duplicates led us to use a lower PDL rather than the laboratory's method detection limit (MDL) for K, Mg and S. On the other hand, PDL had to be increased for Cu, Fe, Pd, Pt, Se and Te (see Table 6).

3.4.3 Quality of lead isotope analysis

Five samples of the GEMAS Ap standard were inserted to the analysis series. These samples had previously undergone Pb isotope analysis by extracting 0.5g in 7N HNO_3 in an ultraCLAVE Milestone, and finally analyzed by HR-ICP-MS (Reimann et al., 2012a). The results of the GEMAS samples from our study shows very good accuracy for the $^{207}Pb/^{208}Pb$ and $^{208}Pb/^{206}Pb$ ratios while good accuracy for the $^{206}Pb/^{207}Pb$ ratio compared to the prior analyses, and overall satisfactory precision, see Table 4.

33 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 to the analysis series by the lab. The results (see Table 5) shows again very good accuracy for the $^{207}Pb/^{208}Pb$ ratio while good accuracy for the $^{208}Pb/^{206}Pb$ and $^{206}Pb/^{207}Pb$ ratios.

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 6. 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 (Reimann et al, 2008). 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 7 displays the analytical results with a more common approach, showing median, 98th percentile value and maximum concentration for the Nord-Trøndelag and Fosen dataset and data for directly comparable Nordland/Troms dataset (Reimann et al., 2011). They are comparable in terms of grain size, laboratory procedures, and number of samples. For median, Q98 and maximum, the highest value between the three datasets is underlined.

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: Cumulative frequency diagrams. provides the CP-plots for all 57 variables.

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.

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 5.

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 S is 200 mg/kg, but the QC results indicate that values down to 20 mg/kg are still reliable. Thus a full order of magnitude real, natural variation would have been lost when setting all values below the MDL to for instance ½ of the detection limit.

Figure 5 *Legend of bedrock map used as backdrop of all geochemical maps in Appendix 2.*

5. DISCUSSION -- FIRST IMPRESSIONS

On the SE side of the lake Snåsavatnet are a number of sites with high values for As, Cd, Hf, Ni, Sb and a single Se, and to some extent also Cu and Pb. The area, Roktdalen, is on the border between metasediments to the SE and rhyolites to the NW. There are no known mineralizations in this area.

Due SW of Roktdalen, running southwesterly past the countyline and extent of this survey, are the Gula group and its eastern neighbor Funnsjø Group. Their fyllites and greenstone/amphibolites contain numerous base metal anomalies, perhaps not surprising, as these units host a large number of sulfide deposits.

South of the Blåfjella-Skjækerfjella National Park, five adjacent samples have high Pb-values, some are also high in Te and Bi, As and Co. This particular area has no known ore showings, and all the nearest entries in the ore database are pyrite and/or chalcopyrite bearing only.

In Lierne, South of the Grongfeltet ore-district, Tl, Y and partly Zn show high values. This area has a few records in the ore database, with Cu and Zn as ore elements, but apart from one location, they are showings only. The Zn anomalies coincide well, but there are no particularly interesting values when it comes to Cu. The samples for the ore database were not analyzed for Tl or Y.

The ophiolite of Leka is anomaly in itself; Of the three sample locations, two or three have values in the 95+ percentile class for Au, B, Cd, Co, Cr, Cu, Mg, Ni, Pt, Sb, Sc, and Se, and for Ag, As, Mn, Na, Pd, S, the area is also anomalous.

6. CONCLUSION

Table 7 shows that the analytical results for the Nord-Trøndelag & Fosen samples returned higher values for among others Au, Co, Cr, Cu, Ga, Hg, Nb, Ni, Pt, Re, Sc, Ti, W, and Zr, when compared to the data of Nordland and Troms. The comments given on some of the anomalies seen in the maps are indications that there may be additional elements of economic importance in well known mining areas. There are also areas outside of the national parks that have anomalous values for several elements of economic interest, but without any known mineralizations according to NGU's ore database

7. 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.

8. REFERENCES

Aitchinson, 1986. The statistical analysis of compositional data. Chapman and Hall, London.

Bargel, T., Huhta, P., Johansson, P., Lagerbäck, R.,Mäkinen, K., Nenonen, K., Olsen, L.,Rokoengen, K., Svedlund, J.-O., Väänänen, T.& Wahlroos, J.-E., 1999. Maps of Quaternarygeology in Central Fennoscandia, sheet 3: Iceflow Indicators, scale 1:1 000 000, and Quaternary stratigraphy, scale 1:2 000 000. Geological Surveys of Finland (Espoo), Norway (Trondheim) and Sweden (Uppsala).

Bølviken, B., Bergström, B., Björklund, A., Konti, M., Lehmuspelto, P., Lindholm, T., Magnusson, J., Ottesen, R.T., Steenfelt, A.,Volden, T. 1986. Geochemical Atlas of Northern Fennoscandia, Scale 1:4 000 000. Geological Survey of Norway.

Demetriades, A., 2011. *Understanding the Quality of Chemical Data from the urban environment - Part 2: Measurement Uncertainty in the Decision-making Process*. In *Mapping the Chemical Environment of Urban Areas*. Johnson, C.C., Demetriades, A., Locutura, J. and Ottesen, R.T. (Eds.). Wiley-Blackwell, Oxford, united Kingdom. ISBN 978-0-470-74724-7

Ekremsæter, J. 1988. *Geokjemisk kartlegging i Nordland og Troms. Dokumentasjon av total-innholdet av grunnstoffer i bekkesedimentenes finfraksjon (NAA analyse)*. (in Norwegian). NGU Report 87.178. 44 pp.

Filzmoser P., Hron, K., Reimann, C., 2009. *Univariate statistical analysis of environmental (compositional) data – Problems and possibilities*. Science of the Total Environment 407, 6100-6108.

Filzmoser, P., Hron, K., Reimann, C., 2010. *The bivariate statistical analysis of environmental (compositional) data*. Science of the Total Environment 408, 4230-4238.

Filzmoser, 2013. StatDA: Statistical Analysis for Environmental Data. R package version 1.6.7, http://CRAN.R-project.org/package/StatDA

Finne and Eggen, 2013. *Soil geochemical data from Nord-Salten, Nordland*. NGU Report 2013.015. 101 pp.

Finne, T.E. 1983. *Humusgeokjemi i Nord-Trøndelag. En videre bearbeiding av data fra Landsskogtakseringen 1960.* (in Norwegian). NGU report 1889/2. 9 pp and 15 maps.

Gabrielsen, R.H. & Ramberg, I.H. 1979: *Fracture pattern in Norway from Landsat imagery: Results and potential use*,Proceeding of the Norwegian Sea Symposium, Tromsø, Norwegian Petruleum Society. NSS 23, 1-28

Kjeldsen, S. 1987. *Geokjemisk kartlegging i Nordland og Troms. ICAP-analyse av løsmassenes fin fraksjon*. (in Norwegian). NGU rapport 87.142. 69 pp.

Kjeldsen, S. and Ottesen, R.T., 1988. *Geokjemisk kartlegging i Nordland og Troms. Data for innholdet av gull i løsmassenes finfraksjon*. (in Norwegian). NGU Report 88.084. 17 pp.

Krog, R. 1987. *Geokjemisk kartlegging i Nordland og Troms. Data for HNO3-løselig innhold av grunnstoffer i bekkesedimentenes finfraksjon*. (in Norwegian). NGU Report 87.180. 71pp.

Nasuti, A., Beiki, M & Ebbing, J. 2010: *Gravity and data acquisition over a segment of the Møre-Trøndelag Fault Complex,* NGU report 2010.049, 1-48

NIST SRM 981 Certificate of Analysis, https://www-s.nist.gov/srmors/certificates/981.pdf Retrieved Sep. 23 2014

NIST SRM 983 Certificate of Analysis, https://www-s.nist.gov/srmors/certificates/983.pdf Retrieved Sep. 23 2014

Næss, G. 1988. *Geokjemisk kartlegging i Nordland og Troms. XRF-analyse av bekkesedimentenes finfraksjon*. (in Norwegian). NGU Report 87.165. 69 pp.

R Core Team, 2014. R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org/

Reimann, C., Filzmoser, P., Garrett, R.G., Dutter, R., 2008. Statistical data analysis explained. Applied environmental statistics with R. Wiley, Chichester, U.K.

Reimann, C., Finne, T.E., Filzmoser, P., 2011. *New geochemical data from a collection of till samples from Nordland, Troms and Finnmark*. NGU report 2011.45. 152 pp.

Reimann, C., Demetriades, A., Birke, M., Eggen, O. A., Filzmoser, P., Kriete, C. & EuroGeoSurveys Geochemistry Expert Group, 2012a. The EuroGeoSurveys Geochemical Mapping of Agricultural and grazing land Soils project (GEMAS) - *Evaluation of quality control results of particle size estimation by MIR® prediction, Pb-isotope and MMI® extraction analyses and results of the GEMAS ring test for the standards Ap and Gr*. NGU Report 2012.051, 136 pp.

Reimann, C., Finne, T.E., Filzmoser, P., 2012b. *Soil geochemical data from the Nordkinn peninsula, Finnmark*. NGU Report 2012.016.

Reimann, C., Birke, M., Demetriades, A., Filzmoser, P. & O'Connor, P. (eds.) (2013): Chemistry of Europe's Agricultural Soils. Part A: Methodology and interpretation of the GEMAS Data Set.-Geol. Jb., **B 102**,: 528 pp: 358 figs., 86 Tables, 1 DVD; Hannover

Ryghaug, P. 1980. *Geokjemisk undersøkelse av skogjorda i Nord-Trøndelag i forbindelse med Landsskogtakseringens markarbeid sommeren 1960*. (in Norwegian). NGU report 402. 22 pp.

Sand, K. 1987. *Bekkesedimenter fra Nord-Trøndelag og Fosenhalvøya. En geokjemisk undersøkelse av en ikke-magnetisk tungmineralfraksjon*.(in Norwegian). NGU report 87.057. 77 pp.

Sæther, O.M. 1987. *Geokjemi i Nord-Trøndelag - en regional oversikt. Rapport med 1 vedlegg.* (in Norwegian). NGU report 87.082. 120 pp.

Sæther, O.M. 1988. *Geokjemiske undersøkelser i Nord-Trøndelag nøytronaktiveringsanalyse på bekkesedimenter.* (in Norwegian). NGU report 88.108. 86 pp.

Wolden, O. 1987. *Geokjemisk kartlegging i Nordland og Troms. Data for totalinnhold av grunnstoffer i bekkesedimentenes tungmineralfraksjon*. (in Norwegian). NGU Report 87.179. 69 pp.

Table 1: Minimum, median, maximum and precision values for the project standard MINN. Concentrations in mg/kg.

MINS 2013 LM (n=39) alphabetical												Sorteds by precision			
Element				Precision	Nordkinn	Element				Precision	Nordkinn	Element		Element	
	Min	Q50	Max		Q50		Min	Q50	Max		Q50		Precision		Precision
Ag	<0.002	0.008	0.026	66	0.005	Mo	1.1	1.8	2.1	7.4	1.8	Te	1057	Cr	6.5
Al	16480	17338	17955	2.8	17085	Na	18	54	61	6.6	35	Pt	754	Cu	6.5
As	1.56	2.02	2.73	9.7	2.2	Nb	1.4	1.9	2.2	12	1.8	Ta	272	Th	6.3
Au	<0.0002	0.0003	0.0043	210	<0.0002	Ni	18	20	22	5.4	19	B	213	Ba	6.0
B	<1	<1	2	213	0.5	P	343	367	408	5.1	368	Au	210	Li	6.0
Ba	46.1	49.9	56.5	6	49	Pb	11	13	15	3.8	13	Re	-202	Ca	5.8
Be	0.16	0.37	0.69	32	0.33	Pd	<0.03	<0.03	<0.03	117	<0.01	Pd	117	Mn	5.6
Bi	0.06	0.07	0.18	11	0.09	Pt	<0.004	<0.004	0.005	754	<0.002	Se	115	Ni	5.4
Ca	653	754	1401	5.8	744	Rb	64	69	78	4.4	67	Hg	87	Co	5.1
Cd	<0.01	0.01	0.08	86	0.01	Re	<0.001	<0.001	0.002	-202	<0.001	Cd	86	P	5.1
Ce	24	27	30	4.1	26	S	<20	86	93	3.4	100	Ag	66	Sr	5.1
Co	11	13	14	5.1	12	Sb	<0.02	0.03	0.06	35	0.03	Ge	55	Ti	4.9
Cr	20.9	22.9	25.2	6.5	23	Sc	2.2	2.6	2.8	6.6	2.1	In	54	Tl	4.7
Cs	4.12	4.36	4.77	3.5	4.2	Se	<0.5	0.2	0.7	115	0.3	W	39	Rb	4.4
Cu	10.2	11.3	12.9	6.5	11	Sn	0.4	0.6	0.8	10	0.6	Sb	35	Ce	4.1
Fe	29688	31111	32798	2.5	30902	Sr	2.8	3.3	3.7	5.1	3.6	Be	32	Pb	3.8
Ga	5.3	5.6	6.3	3.7	5.5	Ta	<0.05	<0.05	<0.05	272	<0.05	Hf	15	Ga	3.7
Ge	0.01	0.13	0.28	55	0.08	Te	<0.2	<0.2	<0.2	1057	0.01	Nb	12	Mg	3.7
Hf	0.07	0.14	0.19	15	0.09	Th	3.7	4.1	4.7	6.3	3.8	Bi	11	Y	3.5
Hg	<0.005	0.005	0.020	87	<0.005	Ti	1974	2205	2459	4.9	2163	Sn	10	Cs	3.5
In	<0.02	<0.02	0.06	54	<0.02	Tl	0.48	0.51	0.56	4.7	0.53	As	9.7	S	3.4
K	5213	5638	5956	3.2	5544	U	2.2	2.4	2.7	7.1	2.5	Zr	8.0	K	3.2
La	15	16	17	2.9	16	V	32	34	35	2.5	33	Mo	7.4	La	2.9
Li	14	16	18	6.0	16	W	<0.05	<0.05	0.32	39	<0.1	U	7.1	Al	2.8
Mg	5573	6005	6307	3.7	5946	Y	8.0	8.5	9.2	3.5	8.4	Na	6.6	V	2.5
Mn	192	232	273	5.6	235	Zn	56	61	68	6.6	59	Zn	6.6	Fe	2.5
						Zr	5.5	6.4	8.1	8.0	4.1	Sc	6.6		

Table 2: Minimum, median, maximum and precision values for laboratory standard DS10. Concentrations in mg/kg.

DS10 standard (n=33) alphabetical										Sorted by preciosion			
Element				Precision	Element				Precision	Element	Precision	Element	Precision
	Min	Q50	Max			Min	Q50	Max					
Ag	1.7	2.0	2.2	6.7	Na	533	627	718	8.0	Ta	89	Sc	5.5
Al	8854	10409	11333	4.9	Nb	1.3	1.6	2.2	14	Ge	79	Ba	5.4
As	41	45	48	3.8	Ni	70	76	82	3.2	Hf	28	La	5.3
Au	0.08	0.11	0.14	14	P	675	746	840	4.4	Be	22	Cr	5.3
B	4.4	6.4	9.6	19	Pb	129	150	166	5.6	B	19	Li	5.2
Ba	330	368	445	5.4	Pd	0.08	0.10	0.14	11	Se	19	Sr	4.9
Be	0.1	0.6	1.2	22	Pt	0.165	0.199	0.233	7.8	Re	16	Al	4.9
Bi	11	12	13	7.8	Rb	26	29	31	4.6	Au	14	Cd	4.6
Ca	9557	10627	11762	3.7	Re	0.029	0.056	0.070	16	Nb	14	Rb	4.6
Cd	2.3	2.6	2.8	4.6	S	2615	2829	2956	4.5	In	11	S	4.5
Ce	30	35	42	6.5	Sb	5.0	6.1	7.9	11	Pd	11	K	4.4
Co	11.8	13.1	14.8	3.2	Sc	2.5	2.8	3.1	5.5	Sb	11	P	4.4
Cr	51	56	60	5.3	Se	1.2	2.1	3.0	19	Ti	10	Y	4.3
Cs	2.5	2.8	3.1	2.9	Sn	1.4	1.6	1.8	7.3	Zr	9.5	Ga	4.2
Cu	146	157	177	3.7	Sr	54	62	71	4.9	Hg	8.8	Tl	4.2
Fe	24953	27516	29243	2.9	Ta	<0.05	<0.05	<0.05	89	Na	8.0	V	4.1
Ga	3.9	4.3	4.9	4.2	Te	4.4	4.8	5.6	7.6	Pt	7.8	Mo	4.0
Ge	<0.1	<0.1	0.2	79	Th	6.7	7.3	8	6.4	Bi	7.8	Mg	3.9
Hf	0.04	0.07	0.13	28	Ti	616	766	864	10	Te	7.6	As	3.8
Hg	0.25	0.30	0.39	8.8	Tl	4.5	5.1	5.4	4.2	Sn	7.3	Ca	3.7
In	0.2	0.2	0.3	11	U	2.3	2.5	2.7	6.8	W	6.9	Cu	3.7
K	2978	3412	3660	4.4	V	39	44	47	4.1	U	6.8	Mn	3.4
La	14	17	20	5.3	W	2.5	3.0	3.4	6.9	Ag	6.7	Co	3.2
Li	18	20	22	5.2	Y	6.6	7.8	9.3	4.3	Ce	6.5	Ni	3.2
Mg	6971	7787	8184	3.9	Zn	346	377	405	6.1	Th	6.4	Cs	2.9
Mn	785	890	969	3.4	Zr	2.8	3.3	3.8	9.5	Zn	6.1	Fe	2.9
Mo	15	16	18	4.0						Pb	5.6		

Table 3: Precision on analytical and field duplicates.

Analytical duplicates (37 pairs)				Field duplicates (37 pairs)				
Alphabetical		Sorted		Alphabetical		Nordkinn	Sorted		Nordkinn
Element	Precision	Element	Precision	Element	Precision	30 pairs	Element	Precision	30 pairs
Ag	28	Au	266	Ag	84	42	Re	-382	389
Al	2	Pt	150	Al	32	12	Pt	189	34
As	10	Te	146	As	48	40	Te	132	99
Au	266	B	115	Au	127	82	Au	127	82
B	115	Ge	71	B	79	54	Ge	107	55
Ba	5	Ta	68	Ba	43	19	Ta	107	69
Be	29	Pd	56	Be	55	32	Mn	89	22
Bi	11	Se	55	Bi	16	21	Ag	84	42
Ca	4	In	36	Ca	30	34	B	79	54
Cd	25	Be	29	Cd	41	58	Ni	64	13
Ce	3	S	28	Ce	44	29	S	64	46
Co	6	Ag	28	Co	29	16	Se	64	32
Cr	7	Hg	26	Cr	41	15	Be	55	32
Cs	3	Cd	25	Cs	20	9	Sb	53	18
Cu	3	Hf	24	Cu	41	22	La	53	34
Fe	2	W	24	Fe	38	10	Hf	52	27
Ga	4	Sb	21	Ga	35	11	W	50	29
Ge	71	Sn	11	Ge	107	55	Hg	50	48
Hf	24	Bi	11	Hf	52	27	As	48	40
Hg	26	As	10	Hg	50	48	Pd	46	251
In	36	Tl	8	In	45	36	Y	45	29
K	3	Mo	7	K	36	15	In	45	36
La	4	Cr	7	La	53	34	Ce	44	29
Li	5	Zr	7	Li	35	15	Ba	43	19
Mg	2	Co	6	Mg	26	16	Zr	43	20
Mn	3	Sr	5	Mn	89	22	Cd	41	58
Mo	7	Ba	5	Mo	32	35	Cu	41	22
Na	5	Na	5	Na	25	14	Cr	41	15
Nb	5	Zn	5	Nb	32	23	U	40	18
Ni	4	Nb	5	Ni	64	13	Sr	39	19
P	3	Li	5	P	36	24	Fe	38	10
Pb	2	Ca	4	Pb	30	11	Th	37	21
Pd	56	Th	4	Pd	46	251	K	36	15
Pt	150	La	4	Pt	189	34	P	36	24
Rb	4	Rb	4	Rb	28	14	V	36	10
Re	-4419	Sc	4	Re	-382	389	Ga	35	11
S	28	Ni	4	S	64	46	Li	35	15
Sb	21	Ga	4	Sb	53	18	Sc	33	11
Sc	4	P	3	Sc	33	11	Mo	32	35
Se	55	U	3	Se	64	32	Al	32	12
Sn	11	Cu	3	Sn	22	13	Nb	32	23
Sr	5	K	3	Sr	39	19	Tl	32	15
Ta	68	Ce	3	Ta	107	69	Pb	30	11
Te	146	Mn	3	Te	132	99	Ca	30	34
Th	4	Cs	3	Th	37	21	Ti	29	11
Ti	2	Y	3	Ti	29	11	Co	29	16
Tl	8	Ti	2	Tl	32	15	Rb	28	14
U	3	Mg	2	U	40	18	Zn	27	12
V	2	Pb	2	V	36	10	Mg	26	16
W	24	V	2	W	50	29	Na	25	14
Y	3	Fe	2	Y	45	29	Sn	22	13
Zn	5	Al	2	Zn	27	12	Cs	20	9
Zr	7	Re	-4419	Zr	43	20	Bi	16	21

Table 4: Pb isotope results of the GEMAS Ap standard compared with the analyses from the GEMAS project (Reimann et al., 2012a)

	MINS 2013 till analyses					GEMAS (Reimann et al.. 2012)				
Parameter	**Min**	**Mean**	**Max**	**StDev**	**CV%**	**Min**	**Mean**	**Max**	**StDev**	**CV%**
$^{207}Pb/^{208}Pb$	0.387	0.402	0.415	0.01043	2.60	0.401	0.403	0.406	0.00064	0.16
$^{208}Pb/^{206}Pb$	2.054	2.095	2.153	0.04187	2.00	2.042	2.064	2.074	0.00483	0.23
$^{206}Pb/^{207}Pb$	1.169	1.189	1.201	0.01327	1.12	1.195	1.201	1.221	0.00248	0.21

Table 5: Statistical results (minimum. mean. maximum and standard deviation) for the standard reference material.

		MINS 2013 till analyses					Reference values*
Parameter	**Material**	**Min.**	**Mean**	**Max.**	**Parameter**	**Material**	**Min.**
$^{204}Pb/^{206}Pb$	SRM 981	0.055390	0.059331	0.063329	0.003477		0.059042
$^{207}Pb/^{206}Pb$	SRM 981	0.879605	0.914901	0.944665	0.030798		0.914640
$^{208}Pb/^{206}Pb$	SRM 981	2.064976	2.170416	2.253285	0.107595		2.168100
$^{204}Pb/^{206}Pb$	SRM 983	0.000311	0.000371	0.000459	0.000058		0.000371
$^{207}Pb/^{206}Pb$	SRM 983	0.069480	0.071630	0.075510	0.003058		0.071201
$^{208}Pb/^{206}Pb$	SRM 983	0.012670	0.014110	0.016690	0.001726		0.013619

*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 (https://www-s.nist.gov/srmors/certificates/983.pdf).

Table 6: Statistical parameters for the mapped data. Till <2mm, aqua regia extraction on 15 g sample material. N=752. concentrations in mg/kg.

Ele.	MDL	PDL	Min	Q2	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q98	Max	Powers
Ag	0.002	0.002	<0.002	<0.002	<0.002	0.003	0.007	0.013	0.026	0.046	0.069	0.092	0.49	4.4
Al	100	100	321	818	1226	2409	7354	11787	16025	20695	23739	29833	51013	2.2
As	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.5	1.5	3.0	5.7	9.2	19	622	5.9
Au	0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0007	0.002	0.003	0.004	0.007	0.07	3.9
B	1	1	<1	<1	<1	<1	<1	<1	1.1	1.8	2.5	3.3	8.7	3.8
Ba	0.5	0.5	0.99	2.6	4.0	5.4	9.2	15	26	43	60	91	477	2.7
Be	0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.3	0.4	0.5	0.7	3.5	3.4
Bi	0.02	0.02	<0.02	<0.02	0.03	0.04	0.06	0.09	0.13	0.18	0.23	0.32	5.0	4.0
Ca	100	100	<100	<100	130	223	571	1201	2013	2593	3057	3539	13721	3.5
Cd	0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.03	0.05	0.08	0.09	0.13	0.57	3.2
Ce	0.1	0.1	0.8	2.1	3.7	5.6	11.8	23.4	38.1	53.7	65.9	79.1	150	2.3
Co	0.1	0.1	<0.1	<0.1	0.2	0.5	2.7	6.1	10	15	18	28	144	4.2
Cr	0.5	0.5	<0.5	0.9	1.8	4.9	15	26	39	60	81	124	1162	3.7
Cs	0.02	0.02	<0.02	<0.02	0.3	0.4	0.7	1.0	1.5	2.1	2.9	4.0	16	3.0
Cu	0.01	0.1	<0.01	0.3	0.6	1.0	4.5	13	23	36	46	68	346	3.8
Fe	100	300	<100	495	1085	2392	12367	19419	27238	36119	43688	53967	91834	3.1
Ga	0.1	0.1	0.2	1.0	1.5	2.2	3.0	4.3	5.9	8.1	10	13	20	2.0
Ge	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.3	3.1
Hf	0.02	0.02	<0.02	<0.02	<0.02	<0.02	0.04	0.06	0.09	0.13	0.16	0.19	0.37	2.4
Hg	0.005	0.005	<0.005	<0.005	<0.005	0.006	0.011	0.021	0.035	0.049	0.060	0.083	0.26	2.4
In	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.03	0.04	0.05	0.19	3.4
K	100	50	<50	107	146	198	345	696	1325	2368	3147	5442	13808	2.8
La	0.5	0.5	<0.5	0.9	1.7	2.6	5.1	9.5	16	21	26	32	150	2.6
Li	0.1	0.1	<0.1	<0.1	0.3	0.6	4.0	8.5	13	18	23	29	51	4.1
Mg	100	50	<50	60	146	383	2106	4370	6918	9915	12854	16614	37697	5.1
Mn	1	1	1.3	6.8	11	20	83	167	265	430	546	767	3241	3.4
Mo	0.01	0.01	<0.01	0.08	0.12	0.15	0.26	0.42	0.68	1.2	1.9	4.4	24	3.6
Na	10	10	<10	<10	15	23	41	66	100	151	208	254	534	3.0
Nb	0.02	0.02	<0.02	0.25	0.40	0.51	0.78	1.4	2.3	3.5	4.5	5.5	8.4	3.0
Ni	0.1	0.1	<0.1	0.17	0.34	1.1	5.1	14	24	36	52	86	752	4.3
P	10	10	20	36	48	63	140	276	506	675	741	921	2109	2.0
Pb	0.01	0.01	0.43	1.7	2.4	3.5	4.8	6.6	8.8	11.6	13.2	17.6	80	2.3
Pd	0.01	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.08	3.6
Pt	0.002	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.004	0.006	0.012	2.7
Rb	0.1	0.1	0.2	0.7	1.5	2.5	4.7	8.1	13.3	20.7	27.2	40.3	99.1	2.8
Re	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003	0.003	0.007	2.7
S	200	20	<20	<20	24	40	72	137	221	327	448	599	3888	2.9
Sb	0.02	0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.04	0.06	0.09	0.1	0.2	0.9	5.4
Sc	0.1	0.1	0.0247	0.21	0.32	0.56	1.37	2.17	3.05	3.99	4.98	6.28	25.5	3.0
Se	0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	0.31	0.62	1.06	1.31	1.74	3.54	3.8
Sn	0.1	0.1	<0.1	0.1	0.2	0.2	0.3	0.4	0.7	1.0	1.3	1.9	4.3	2.1
Sr	0.5	0.5	<0.5	1.0	1.6	2.3	4.2	6.9	9.8	14	17	21	52	2.1
Ta	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.061	4.4
Te	0.02	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.5	4.4
Th	0.1	0.1	<0.1	0.2	0.5	0.9	1.7	3.0	5.0	7.1	8.0	9.5	25	3.6
Ti	10	10	39	189	336	500	711	1032	1501	2109	2693	3621	9311	2.4
Tl	0.02	0.02	<0.02	<0.02	<0.02	<0.02	0.04	0.07	0.12	0.17	0.21	0.29	1.3	3.7
U	0.05	0.05	<0.05	0.11	0.19	0.27	0.45	0.68	1.0	1.5	2.0	3.2	52	3.2
V	2	2	<2	2.9	5.1	11	21	31	45	68	88	121	259	2.7
W	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	0.11	0.16	0.27	2.3	4.8
Y	0.01	0.01	0.21	0.61	0.88	1.3	2.6	4.8	6.9	9.1	11	14	65	2.5
Zn	0.1	0.1	0.2	0.9	1.8	3.4	14	27	39	53	65	76	249	3.2
Zr	0.1	0.1	<0.1	0.2	0.6	0.9	1.6	2.5	3.8	5.4	6.6	8.7	19	2.3

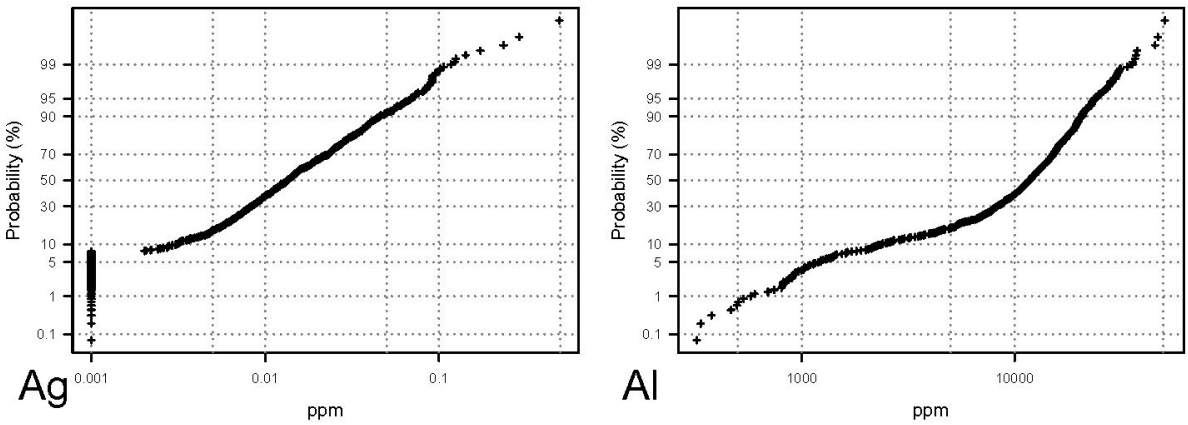
Isotope	MDL	PDL	Min	Q2	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q98	Max	Powers
$^{208}Pb/^{206}Pb$	-	-	1.22	1.73	1.8	1.86	1.93	1.99	2.05	2.1	2.13	2.17	2.64	0.3
$^{206}Pb/^{207}Pb$	-	-	1.07	1.18	1.19	1.2	1.23	1.27	1.32	1.38	1.43	1.52	1.96	0.3

Table 7: Comparison between Nord-Trøndelag & Fosen survey with Nordland & Troms survey (Reimann et al. 2011).

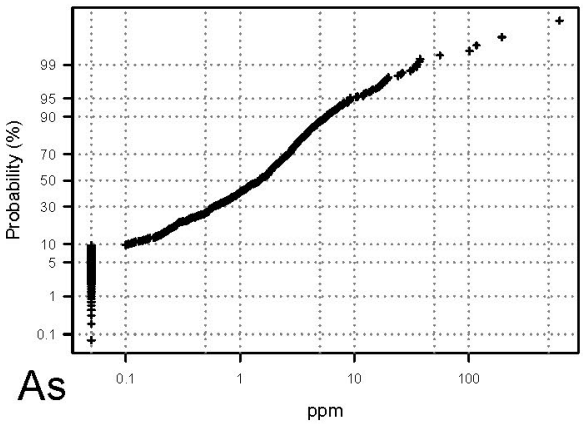
		Nord-Trøndelag & Fosen. N=752			Nordland + Troms N=982		
ELEMENT	**PDL**	**MEDIAN**	**Q98**	**MAX**	**MEDIAN**	**Q98**	**MAX**
Ag	0.002	0.013	0.092	0.49	0.015	0.12	0.45
Al	100	11787	29833	51013	9864	27054	44069
As	0.1	1.5	19	622	1.9	18	376
Au	0.0002	0.0007	0.007	0.07	0.001	0.004	0.026
B	1	<1	3.3	8.7	<1	2.8	9.4
Ba	0.5	15	91	477	31	165	405
Be	0.1	0.2	0.7	3.5	0.2	0.8	3.2
Bi	0.02	0.09	0.32	5.0	0.1	0.3	4.4
Ca	100	1201	3539	13721	1687	22245	207605
Cd	0.01	0.03	0.13	0.57	0.03	0.2	0.65
Ce	0.1	23	79	150	36	121	685
Co	0.1	6.1	28	144	8	24	55
Cr	0.5	26	124	1162	21	88	475
Cs	0.02	1.0	4.0	16	1.2	4.6	8.4
Cu	0.1	13	68	346	16	73	123
Fe	300	19419	53967	91834	18037	43188	89669
Ga	0.1	4.3	13	20	3	10	14
Ge	0.1	<0.1	0.2	0.3	<0.1	0.2	0.77
Hf	0.02	0.06	0.19	0.37	0.03	0.19	0.38
Hg	0.005	0.021	0.083	0.26	0.007	0.033	0.062
In	0.02	<0.02	0.05	0.19	<0.02	0.05	0.12
K	50	696	5442	13808	1659	8487	13630
La	0.5	9.5	32	150	16	59	413
Li	0.1	8.5	29	51	11	37	76
Mg	50	4370	16614	37697	5044	17559	49350
Mn	1	167	767	3241	195	751	1558
Mo	0.01	0.42	4.4	24	0	4	40
Na	10	66	254	534	74	347	2010
Nb	0.02	1.4	5.5	8.4	0.5	3	6.5
Ni	0.1	14	86	752	14	53	157
P	10	276	921	2109	518	1550	7430
Pb	0.01	6.6	17.6	80	4.9	24	180
Pd	0.03	<0.03	<0.03	0.08	<0.01	<0.01	0.03
Pt	0.004	<0.004	0.006	0.012	<0.002	0.002	0.007
Rb	0.1	8.1	40.3	99.1	17	73	295
Re	0.001	<0.001	0.003	0.007	<0.001	0.001	0.003
S	20	137	599	3888	<200	467	2655
Sb	0.02	0.04	0.2	0.9	0.04	0.33	0.96
Sc	0.1	2.17	6.28	25.5	1.7	5.8	11
Se	0.5	0.3	1.7	3.5	0.3	1.2	4.3
Sn	0.1	0.4	1.9	4.3	0.3	1.5	3.5
Sr	0.5	6.9	21	52	7.4	83	934
Ta	0.05	<0.05	<0.05	0.06	<0.05	<0.05	0.07
Te	0.2	<0.2	<0.2	1.5	<0.02	0.08	0.49
Th	0.1	3.0	9.5	25	5	17	72
Ti	10	1032	3621	9311	797	2583	3629
Tl	0.02	0.07	0.29	1.3	0.1	0.5	1.4
U	0.05	0.68	3.2	52	1	4	33
V	2	31	121	259	24	92	209
W	0.05	<0.05	0.27	2.3	<0.1	0.4	0.94
Y	0.01	4.8	14	65	5.8	23	106
Zn	0.1	27	76	249	32	107	230
Zr	0.1	2.5	8.7	19	1	10	16

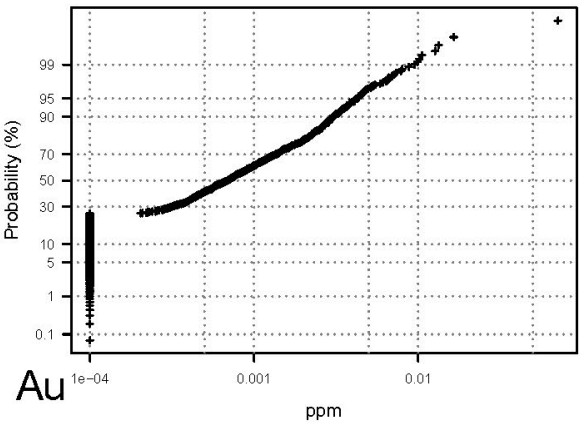
Appendix 1: Cumulative frequency diagrams.

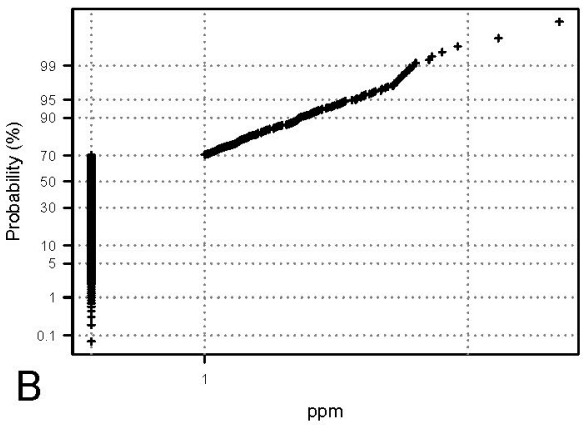
Please note that readings below the practical detection limit are set to half of the practical detection limit value.

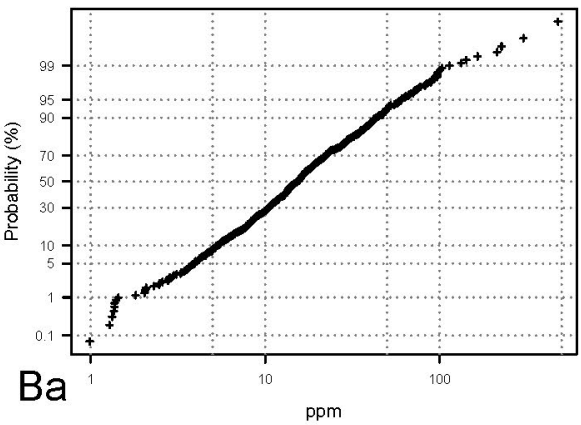

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.001
0.01
0.1
ppm
Ag

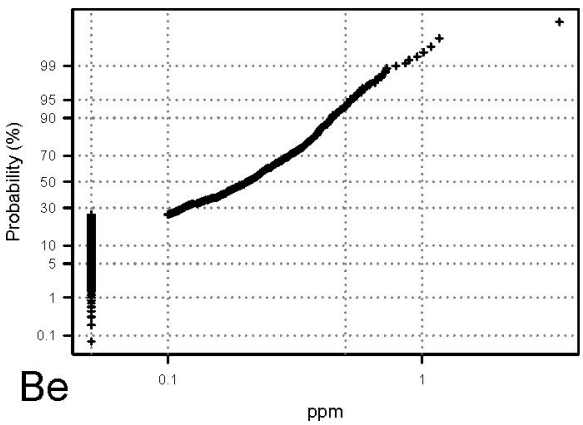
Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1000
10000
ppm
Al

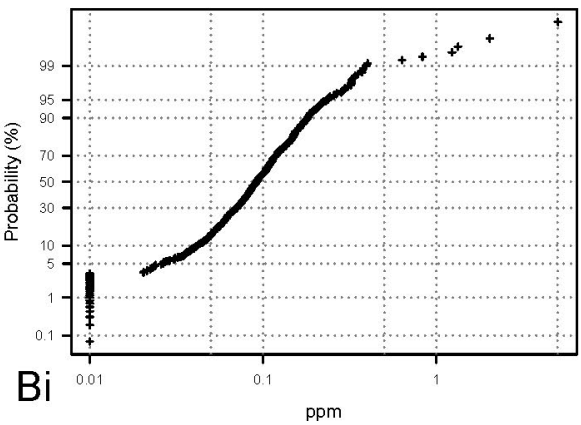

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.1
1
10
100
ppm
As

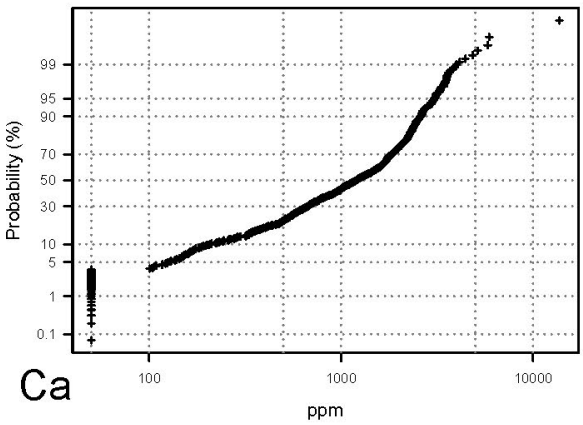

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1e-04
0.001
0.01
ppm
Au


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

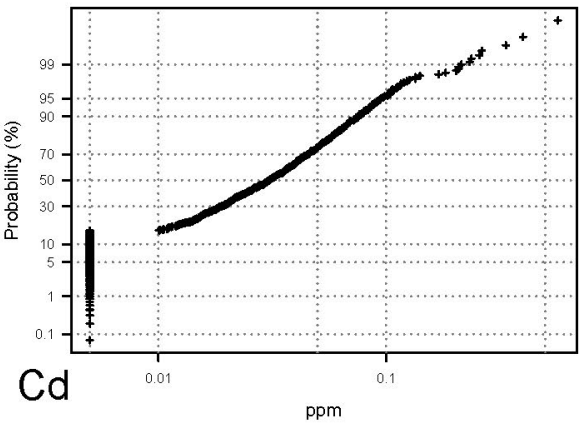

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1
10
100
ppm
Ba


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

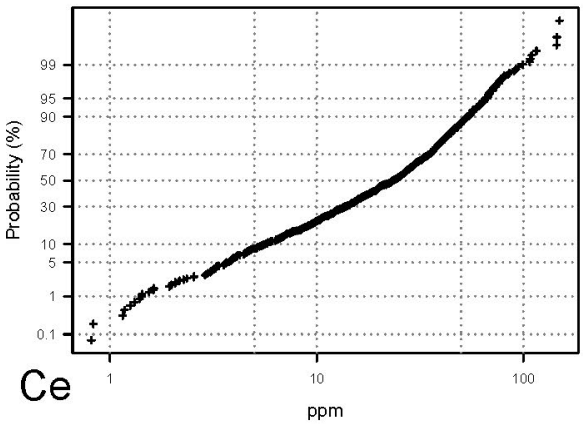

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.01
0.1
1
ppm
Bi



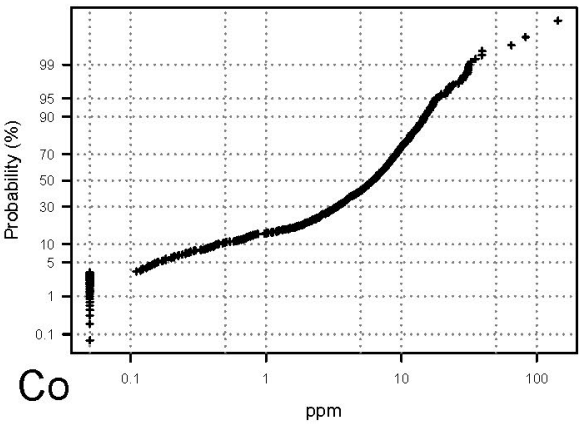
Ca



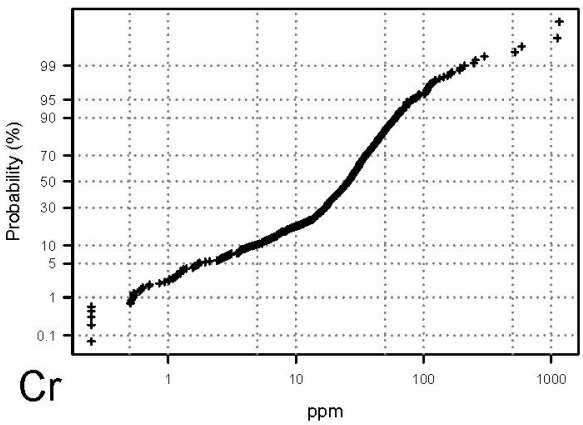
Cd



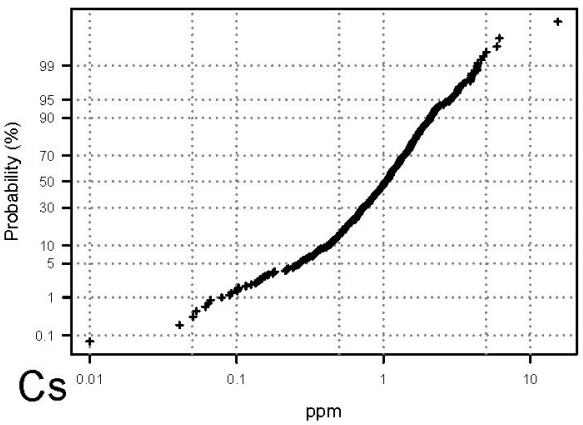
Ce



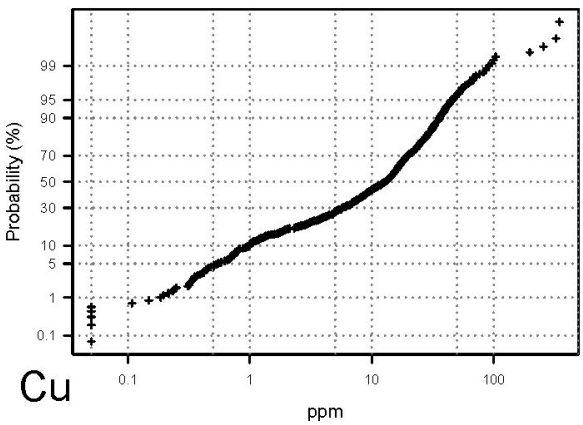
Co



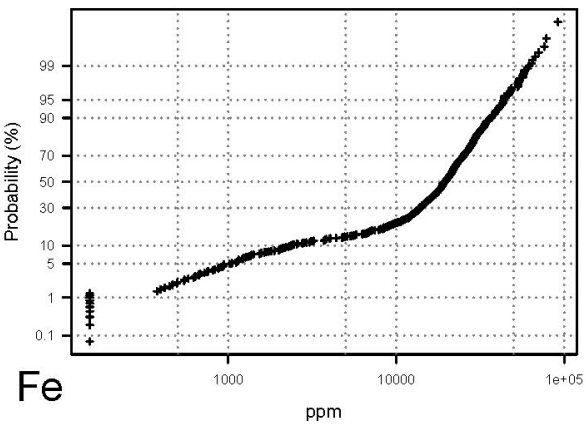
Cr



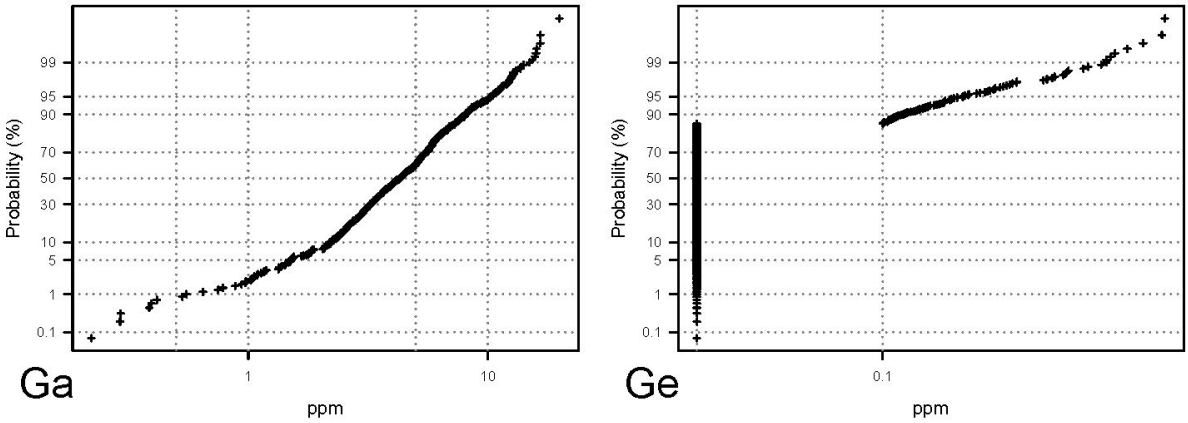
Cs



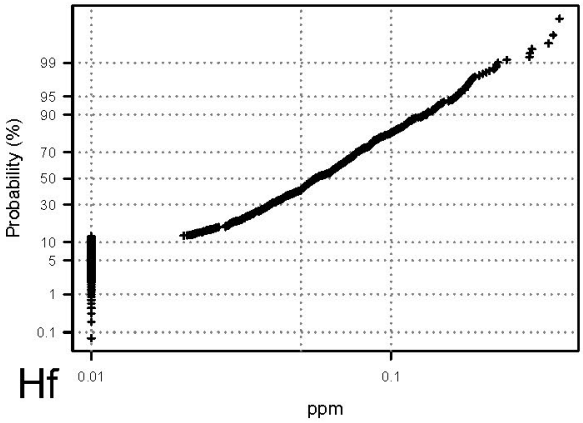
Cu

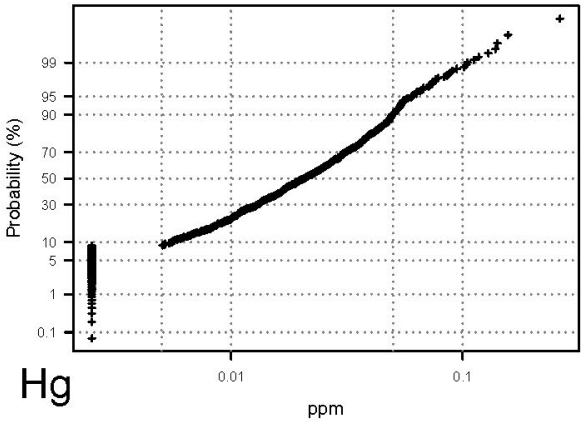


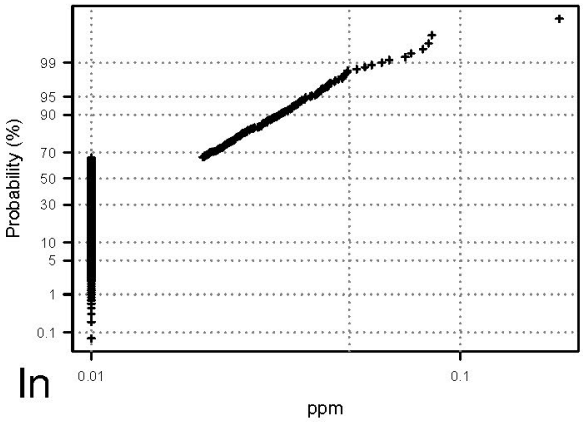
Fe

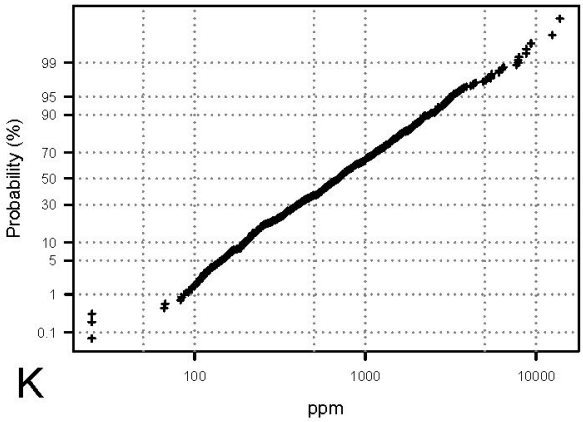

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1
10
ppm
Ga

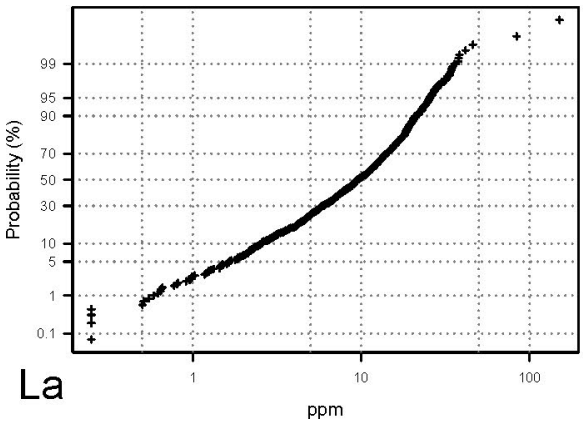
Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.1
ppm
Ge

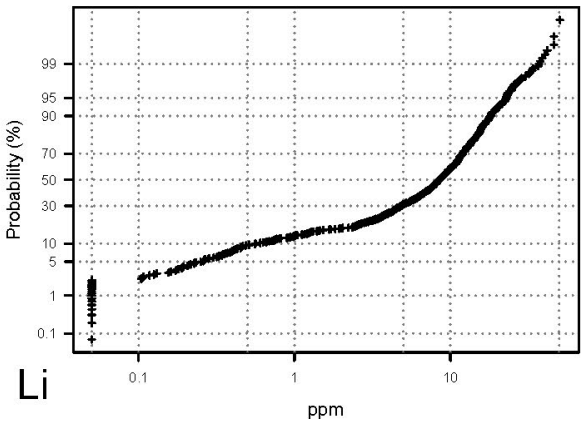

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.01
0.1
ppm
Hf

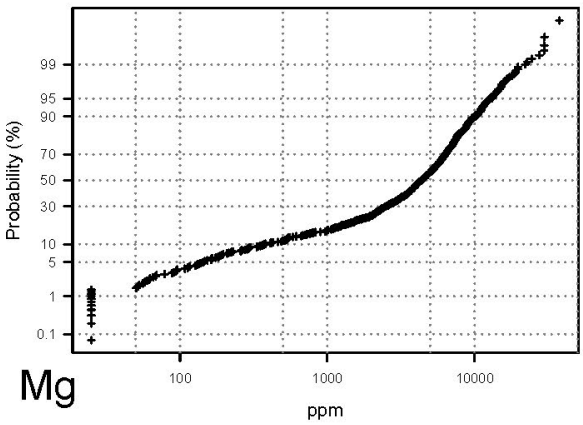

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.01
0.1
ppm
Hg


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

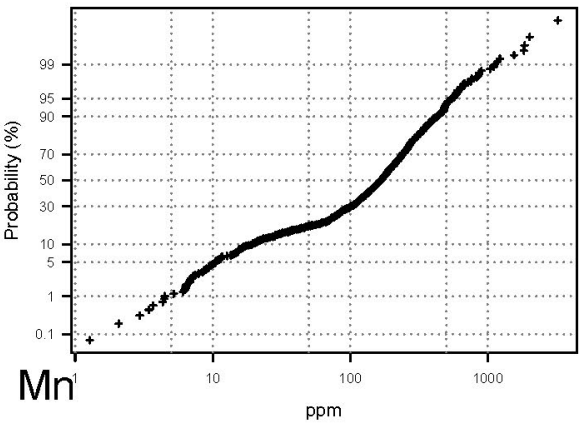

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
100
1000
10000
ppm
K


Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1
10
100
ppm
La

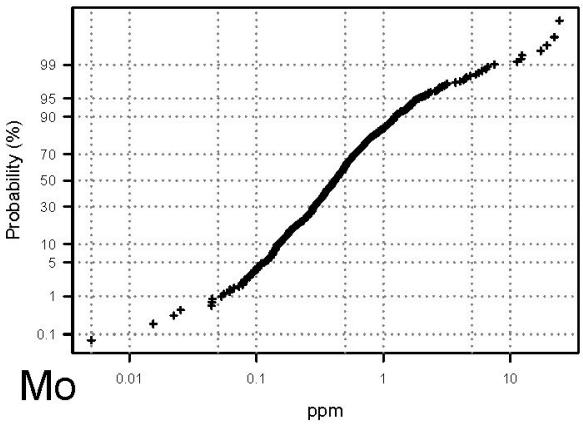

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.1
1
10
ppm
Li



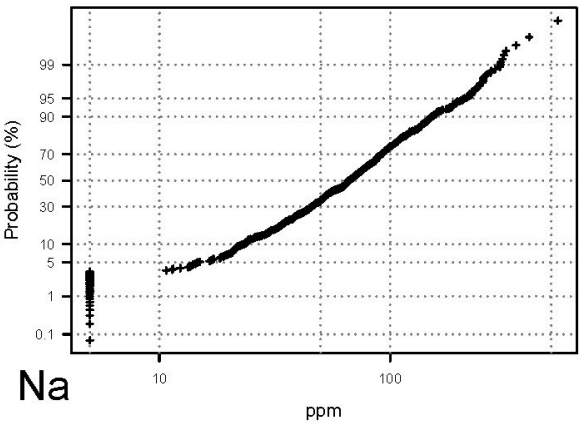
Mg



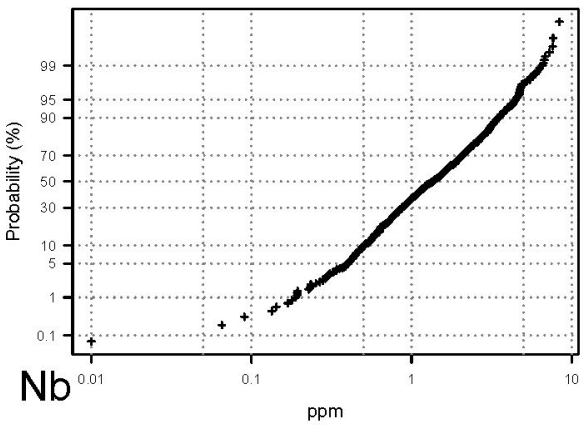
Mn



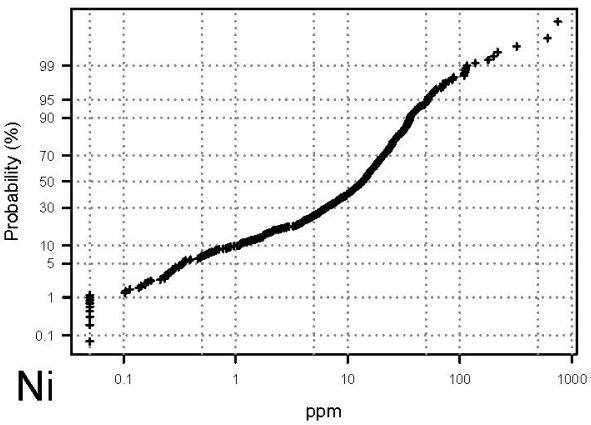
Mo



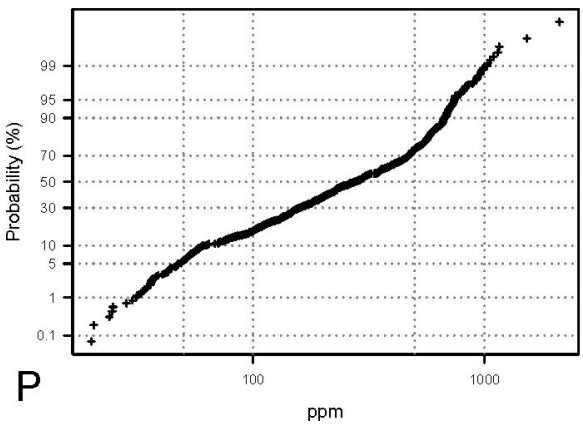
Na



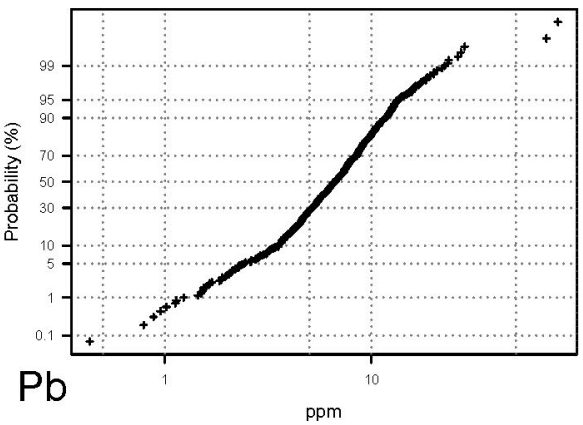
Nb



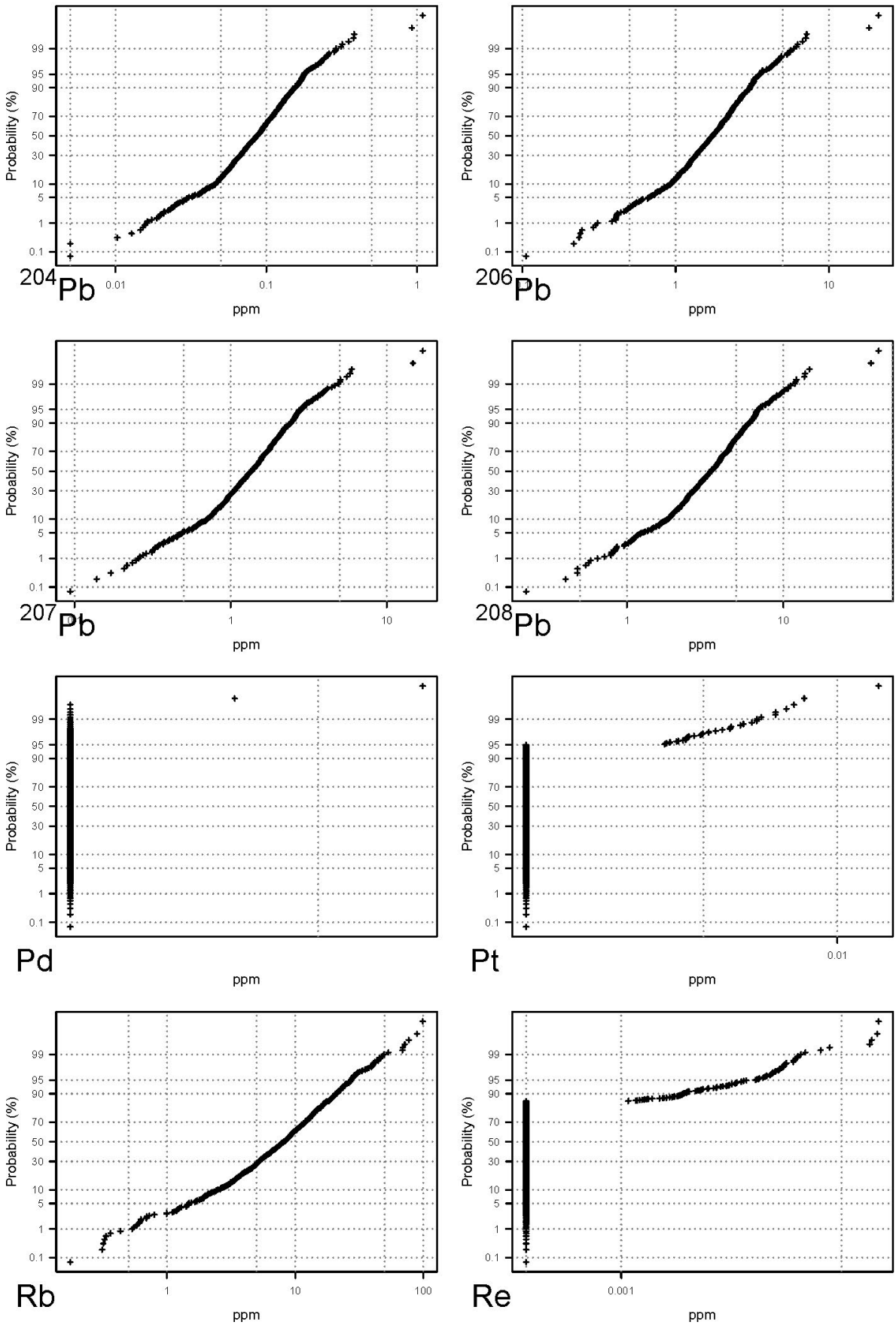
Ni

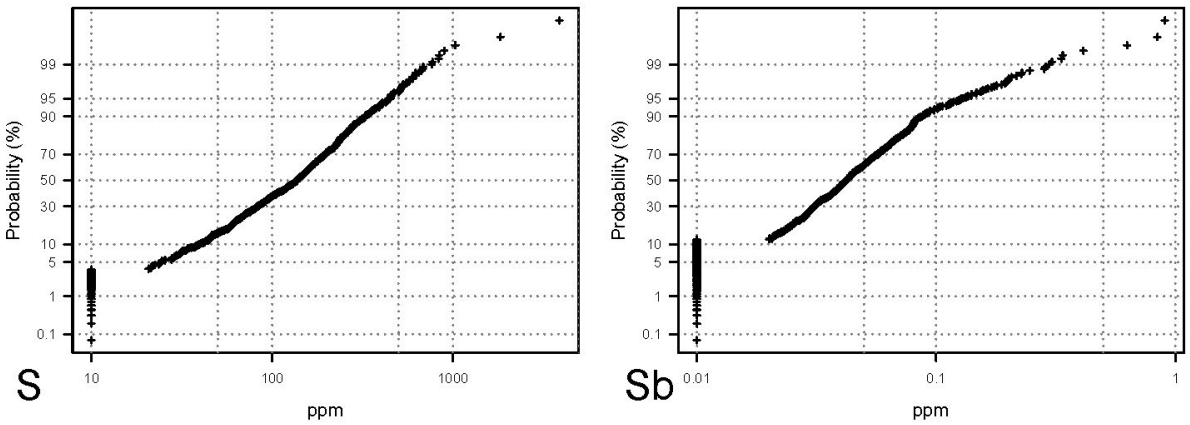


P

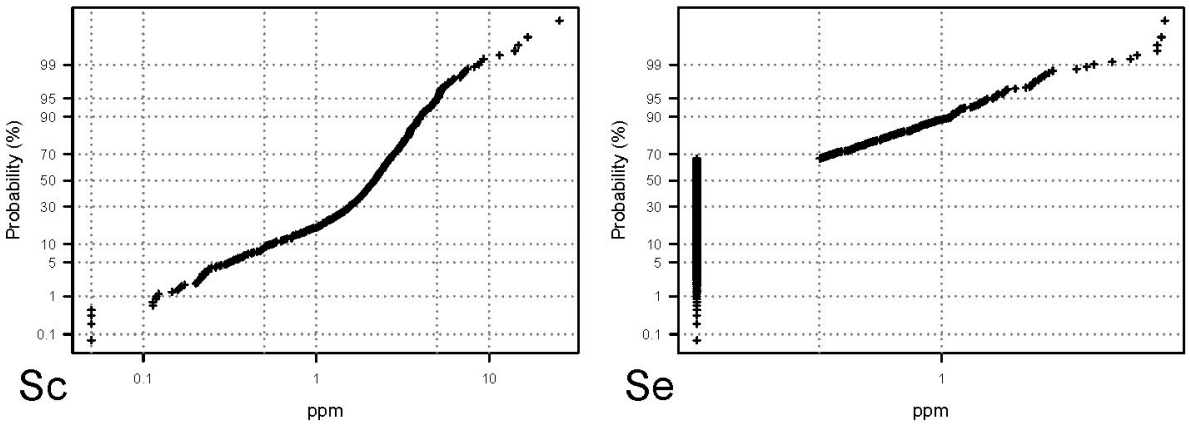


Pb

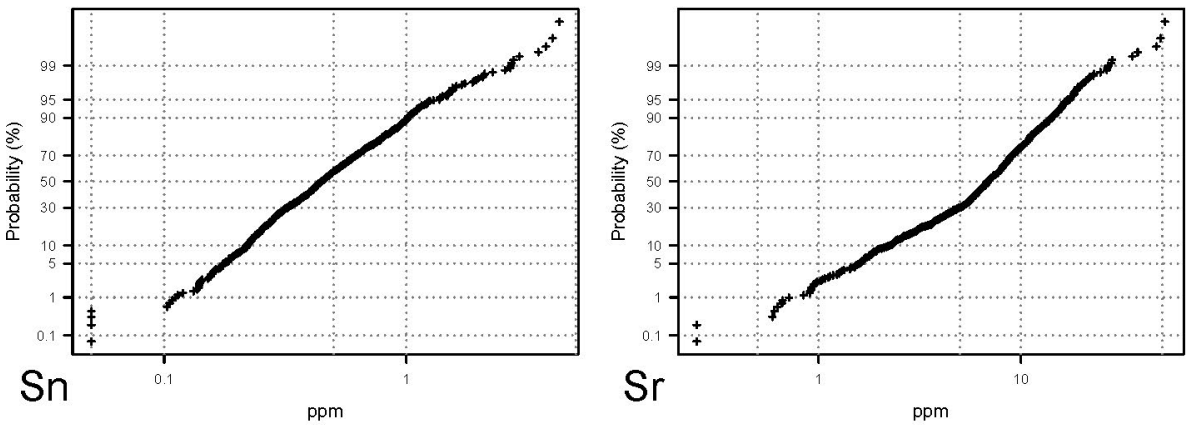

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
204Pb
0.01
0.1
1
ppm
206Pb
1
10
207Pb
208Pb
Pd
Pt
0.01
Rb
100
Re
0.001


Probability (%)
99
95
90
70
50
30
10
5
1
0.1
10
100
1000
ppm
S

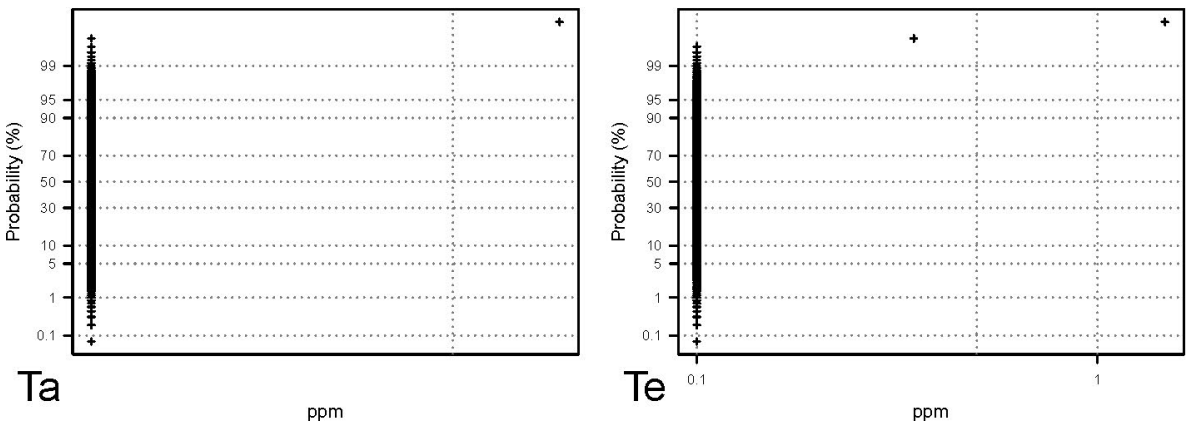
Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.01
0.1
1
ppm
Sb


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

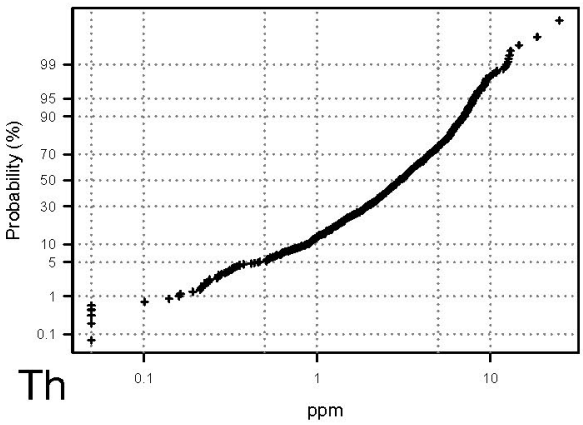
Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1
ppm
Se


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

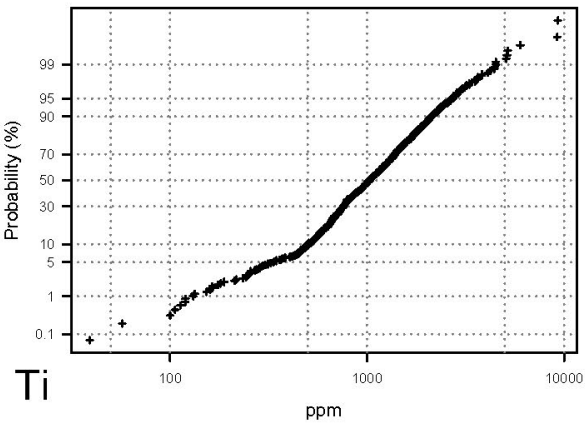
Probability (%)
99
95
90
70
50
30
10
5
1
0.1
1
10
ppm
Sr


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

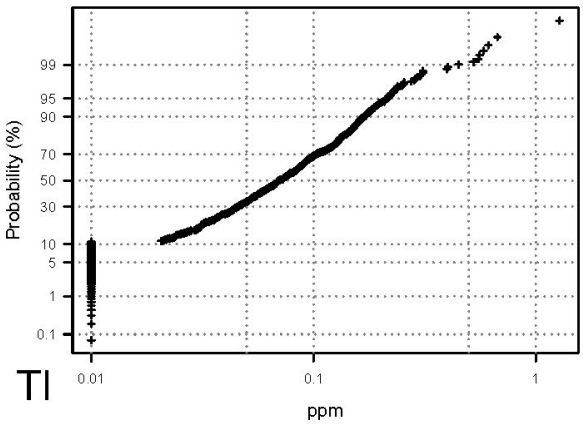
Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.1
1
ppm
Te



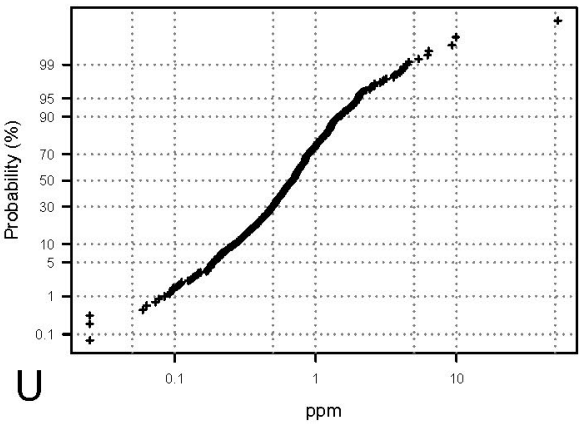
Th



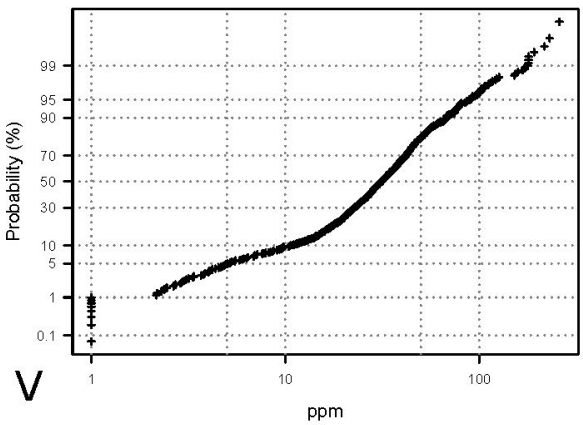
Ti



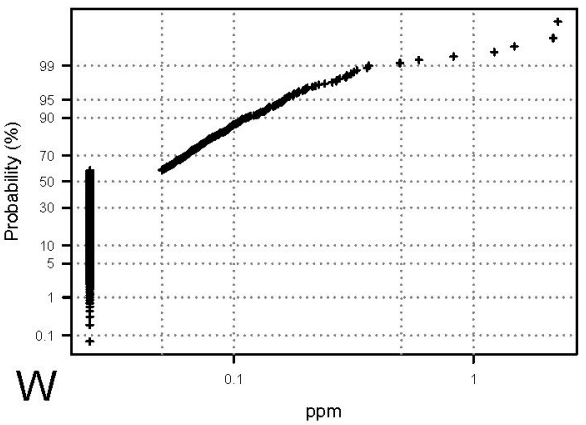
Tl



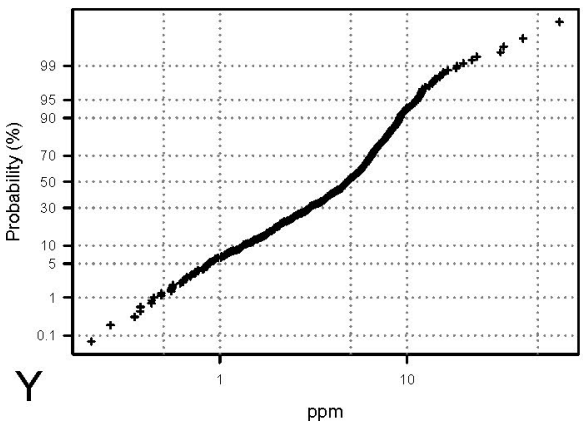
U



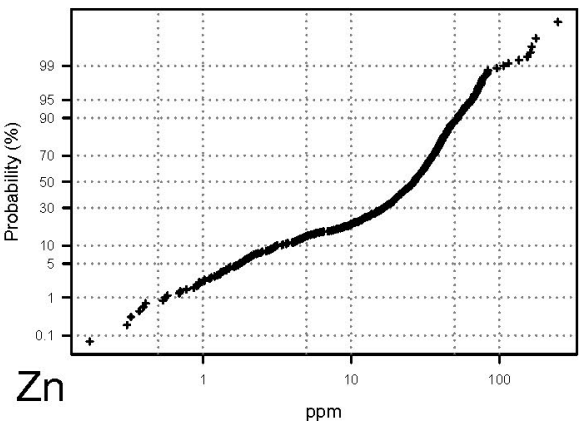
V



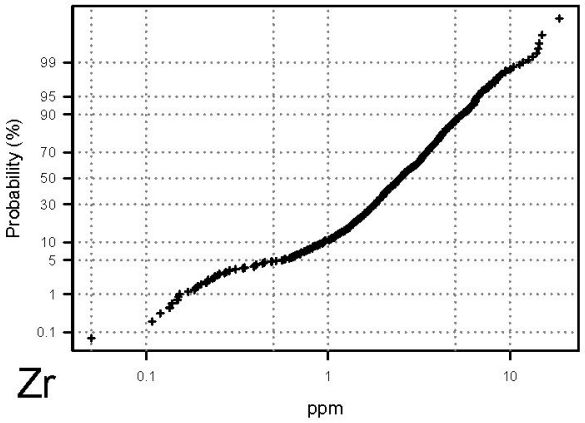
W



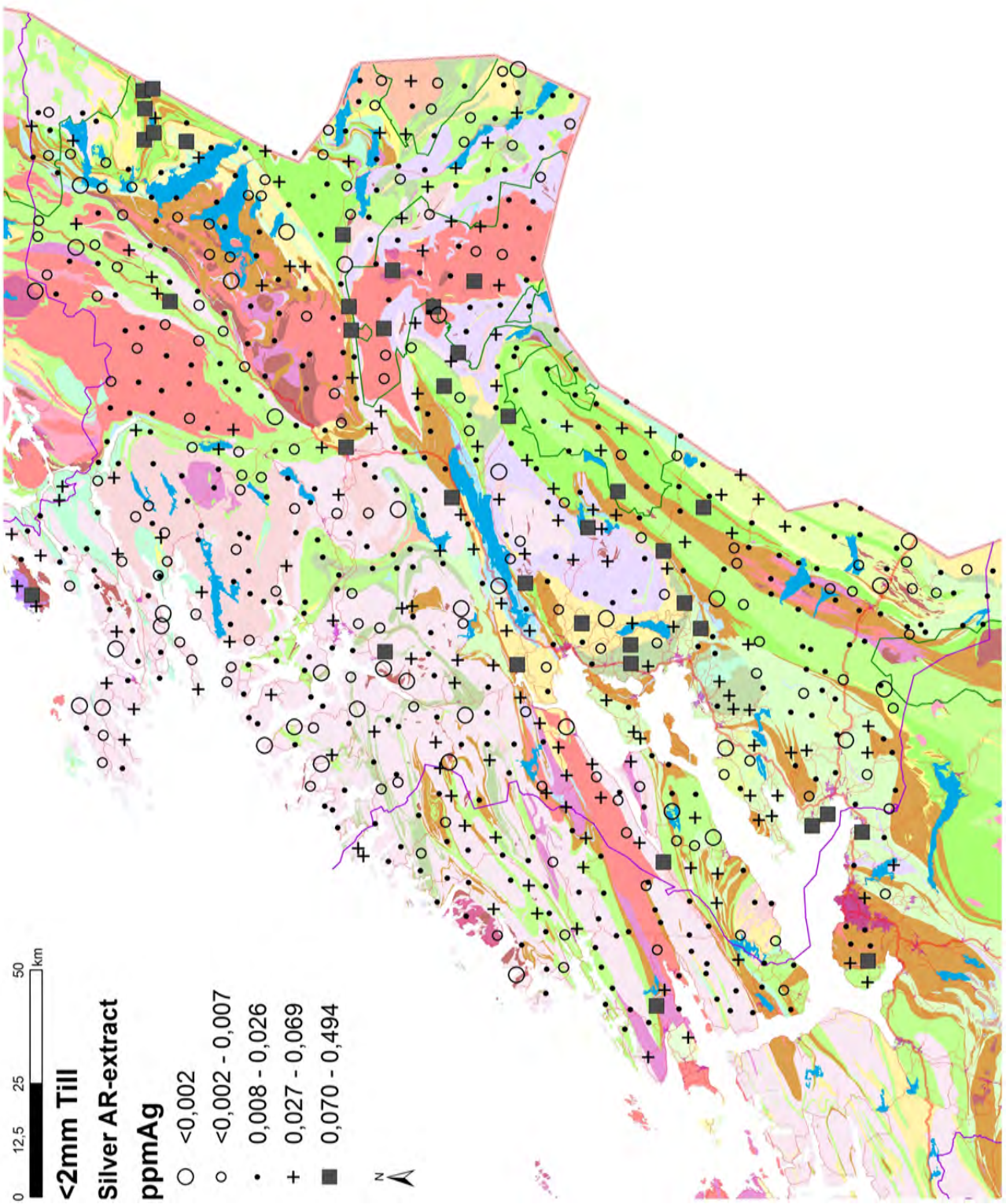
Y

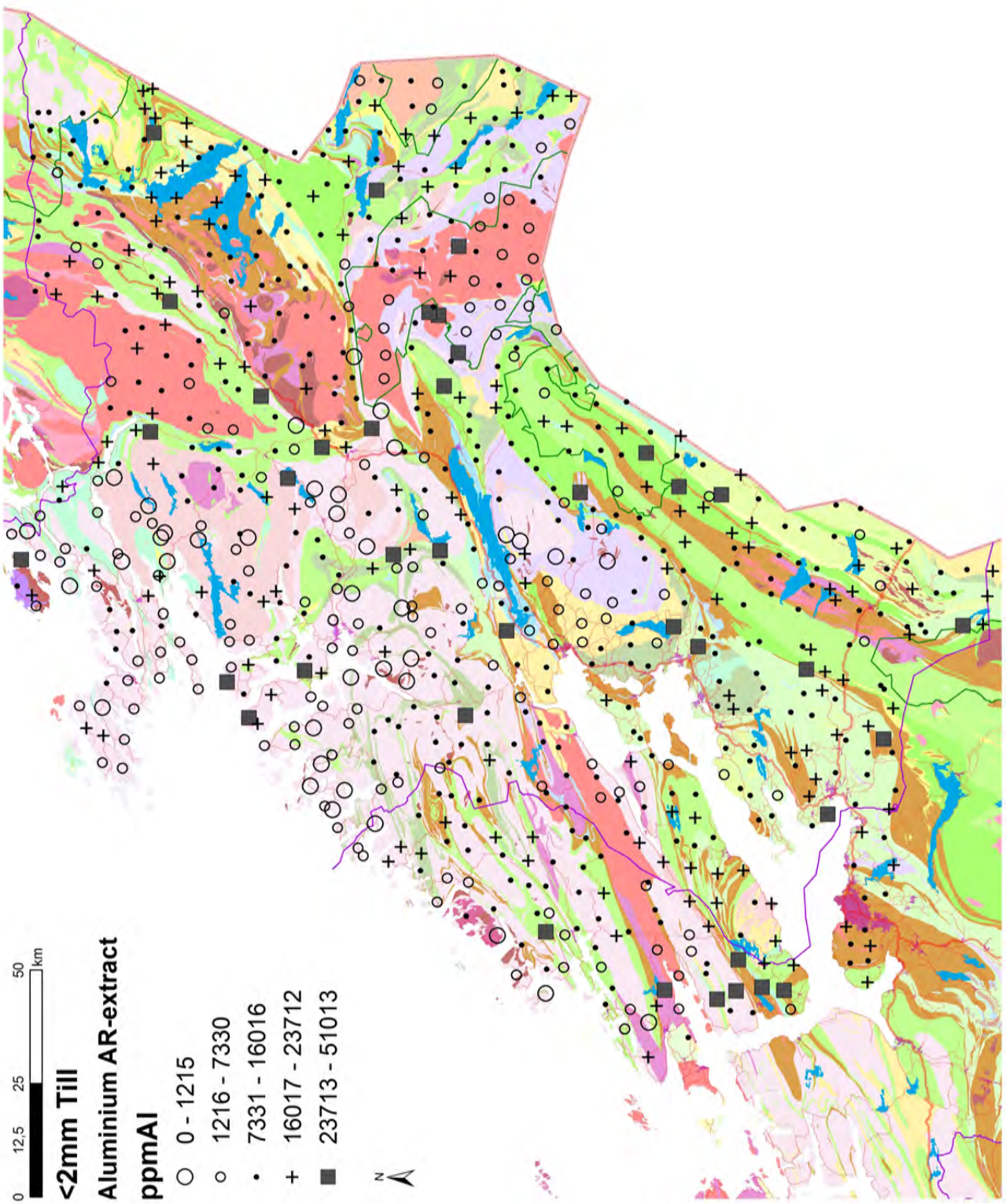


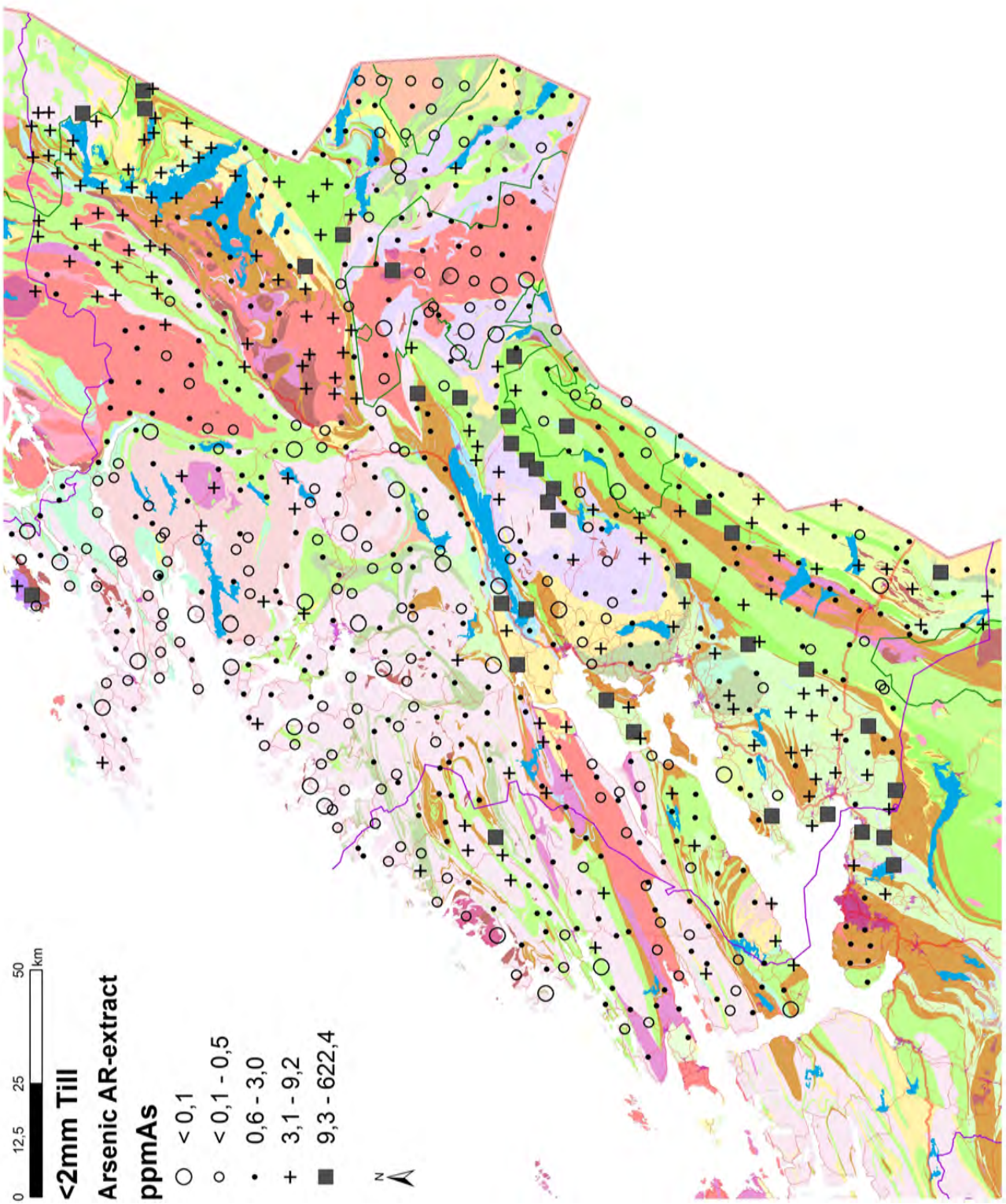
Zn

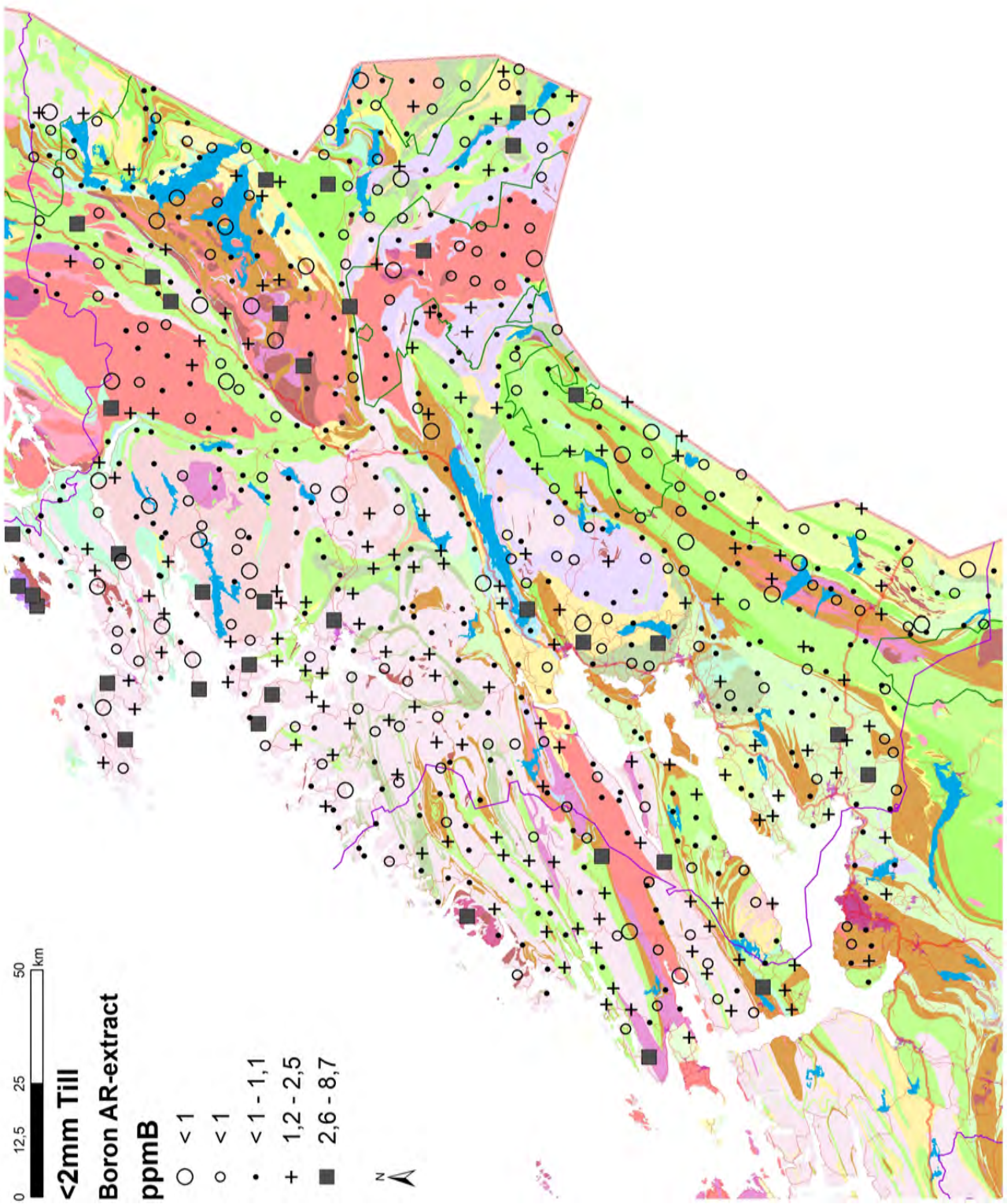

Probability (%)
99
95
90
70
50
30
10
5
1
0.1
0.1
1
10
ppm
Zr

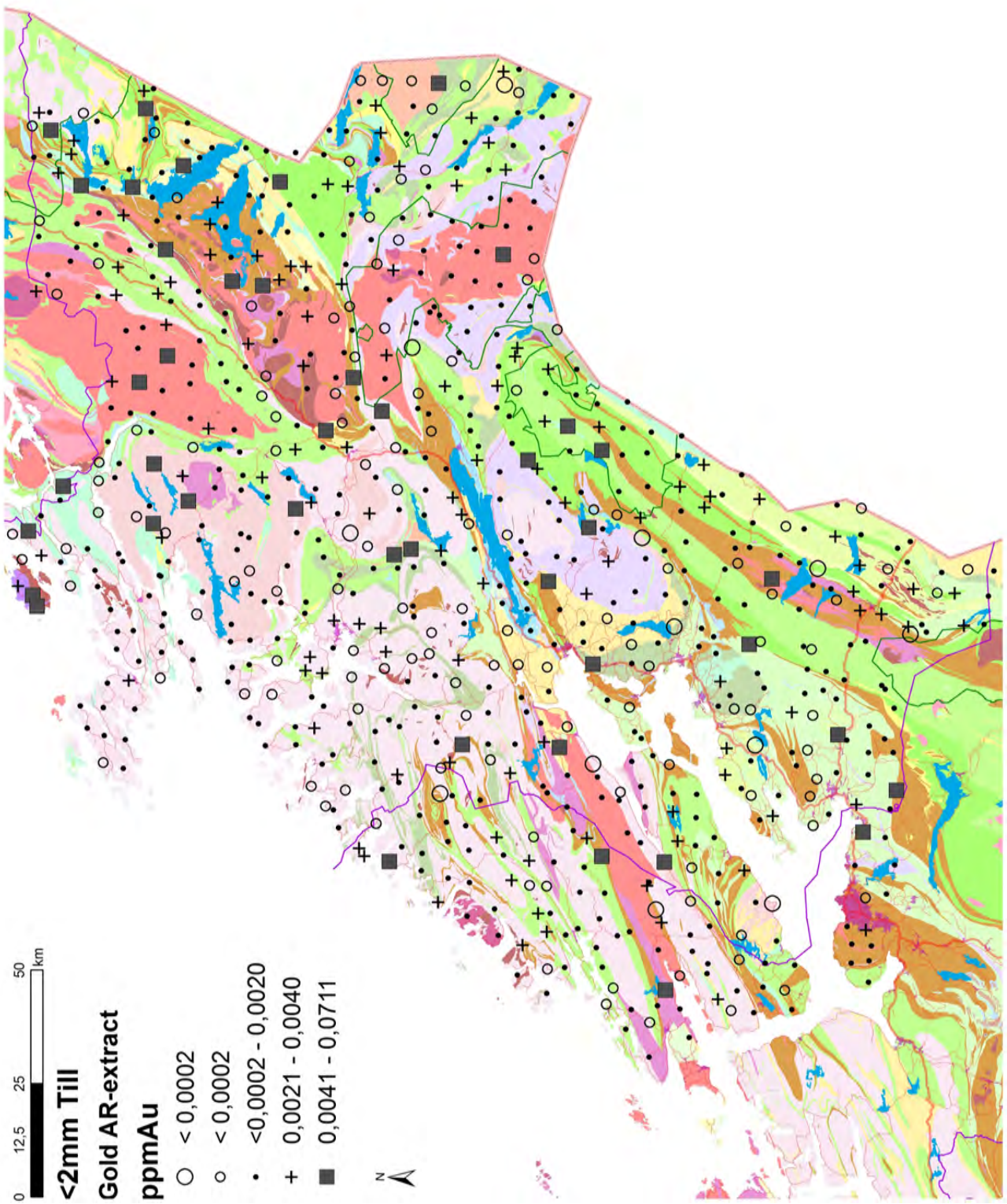
Appendix 2: Maps of geochemistry in mineral soil in Nord-Trøndelag and the Fosen peninsula.

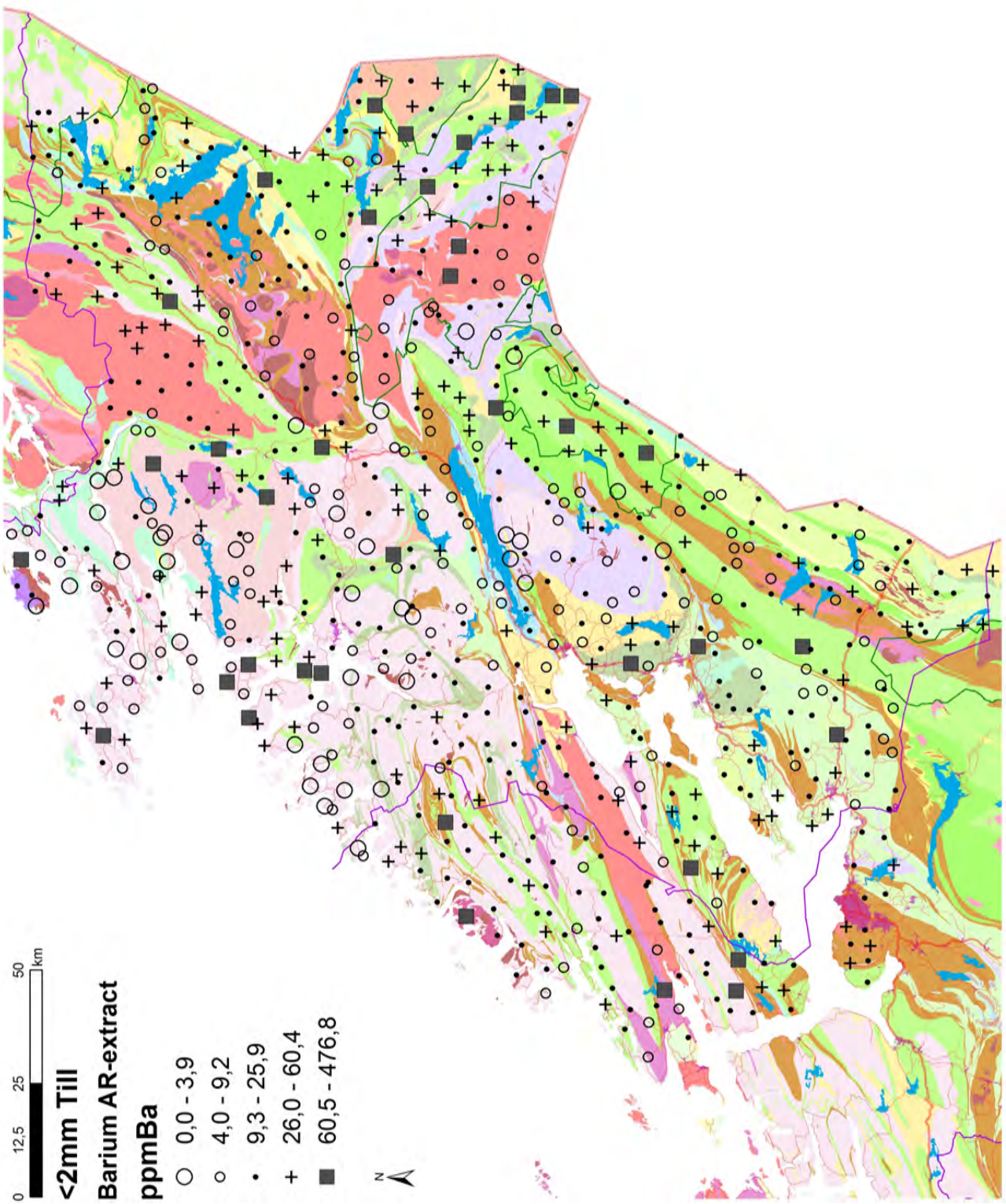

0
12,5
25
50
km
<2mm Till
Silver AR-extract
ppmAg
<0,002
<0,002 - 0,007
0,008 - 0,026
0,027 - 0,069
0,070 - 0,494
N

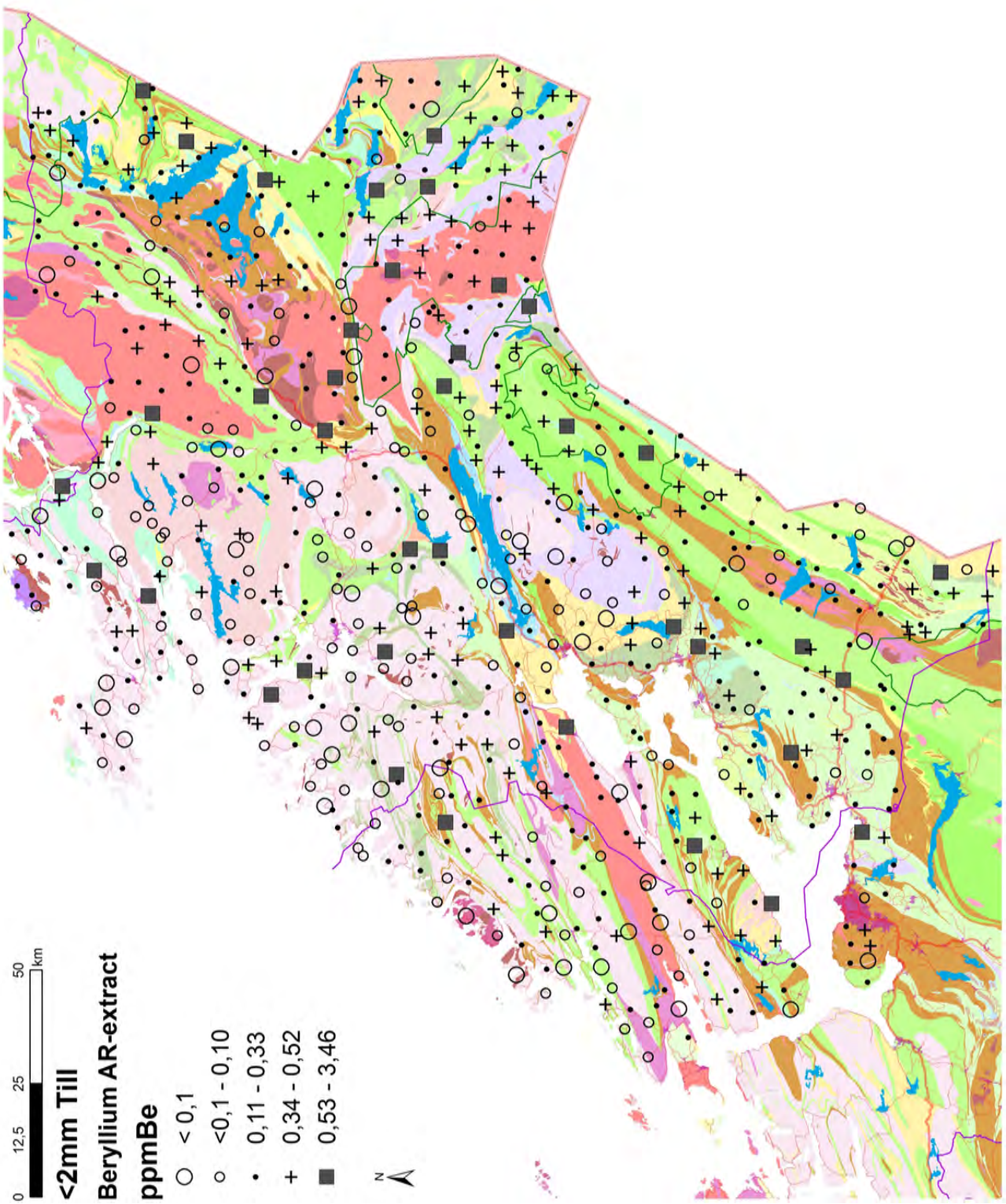

0
12,5
25
50
km
<2mm Till
Aluminium AR-extract
ppmAl
0 - 1215
1216 - 7330
7331 - 16016
16017 - 23712
23713 - 51013
N

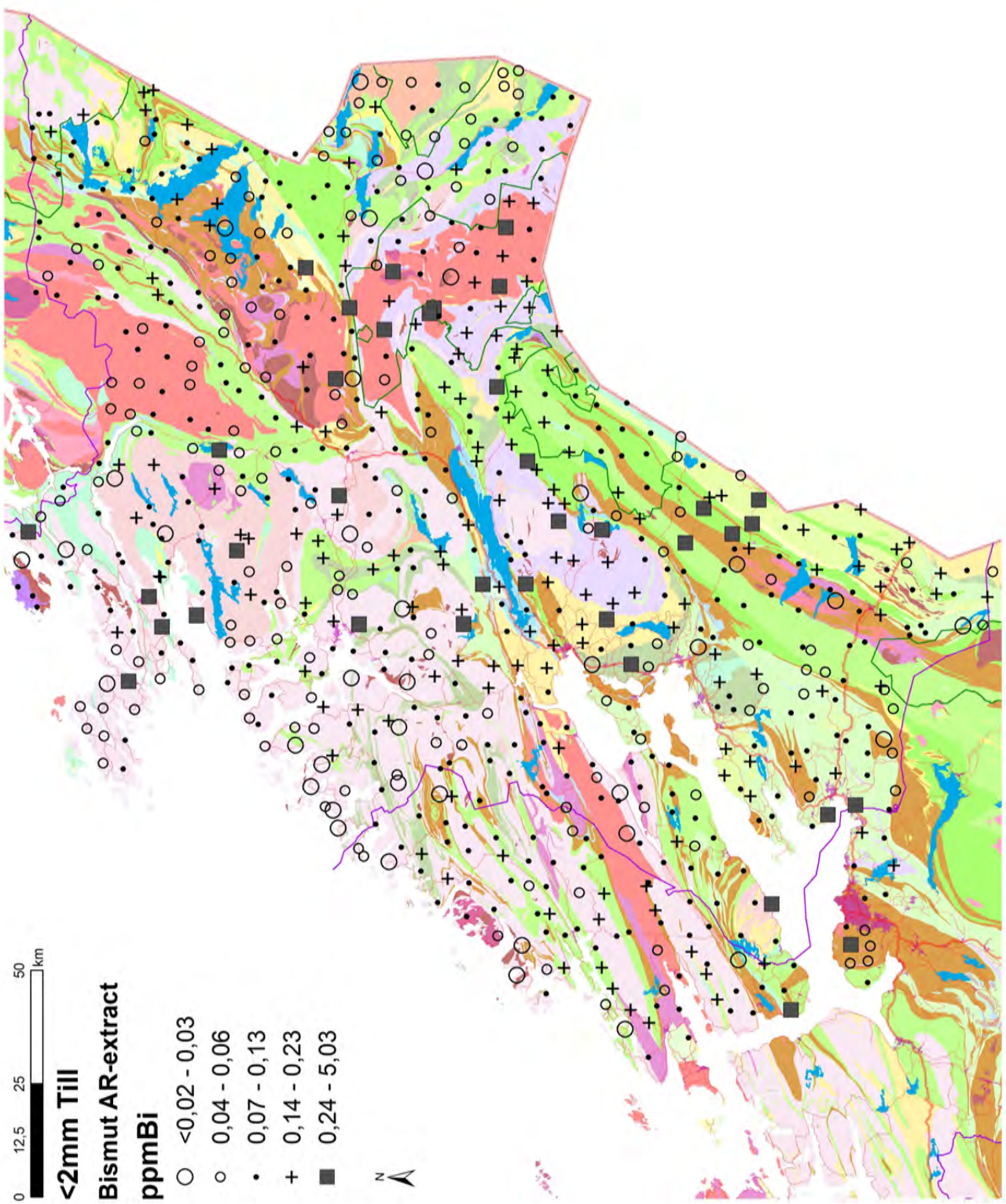

0
12,5
25
50
km
<2mm Till
Arsenic AR-extract
ppmAs
< 0,1
< 0,1 - 0,5
0,6 - 3,0
3,1 - 9,2
9,3 - 622,4
N

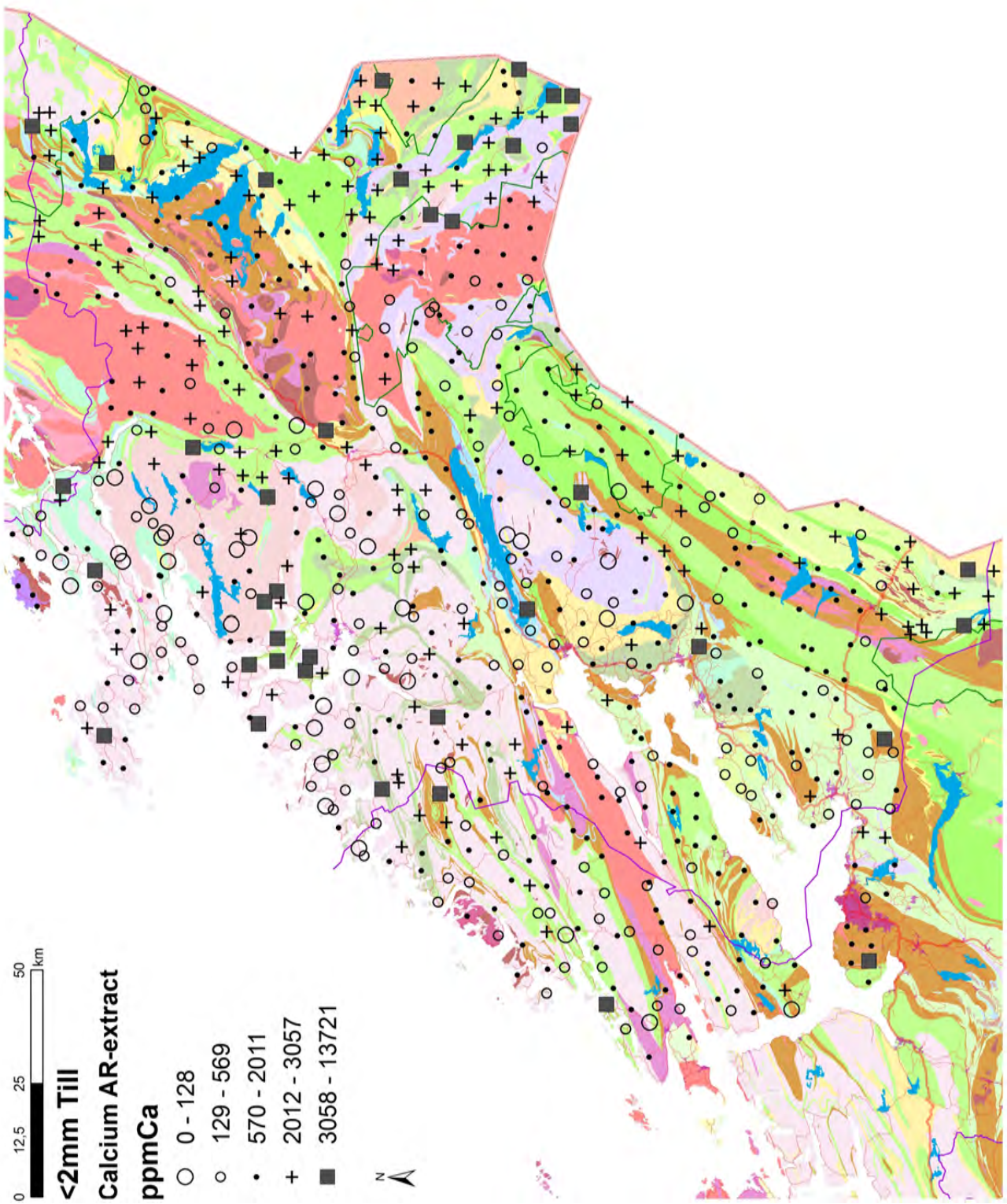

0
12,5
25
50
km
<2mm Till
Boron AR-extract
ppmB
< 1
< 1
< 1 - 1,1
1,2 - 2,5
2,6 - 8,7
N

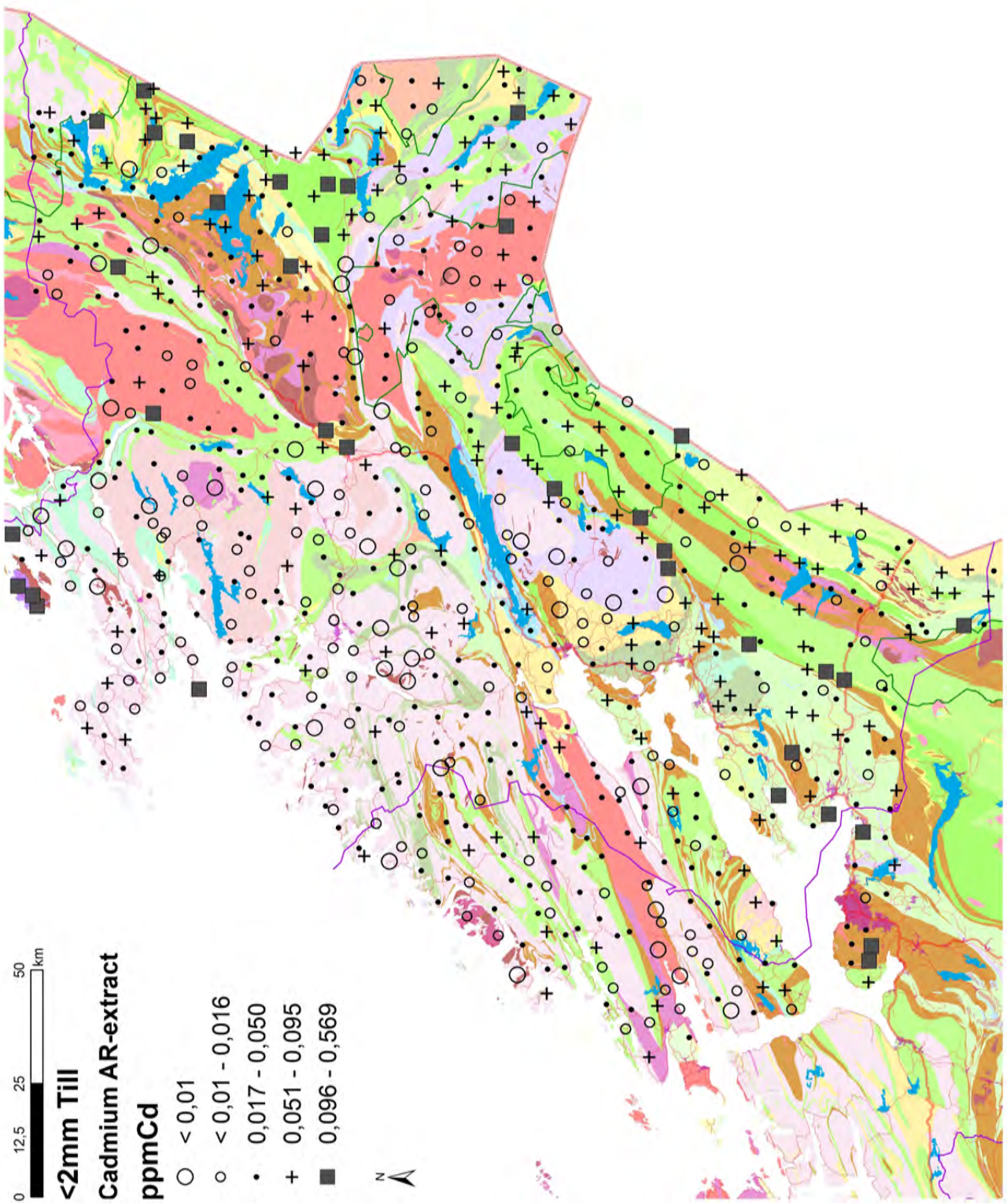

0
12,5
25
50
km
<2mm Till
Gold AR-extract
ppmAu
< 0,0002
< 0,0002
<0,0002 - 0,0020
0,0021 - 0,0040
0,0041 - 0,0711
N

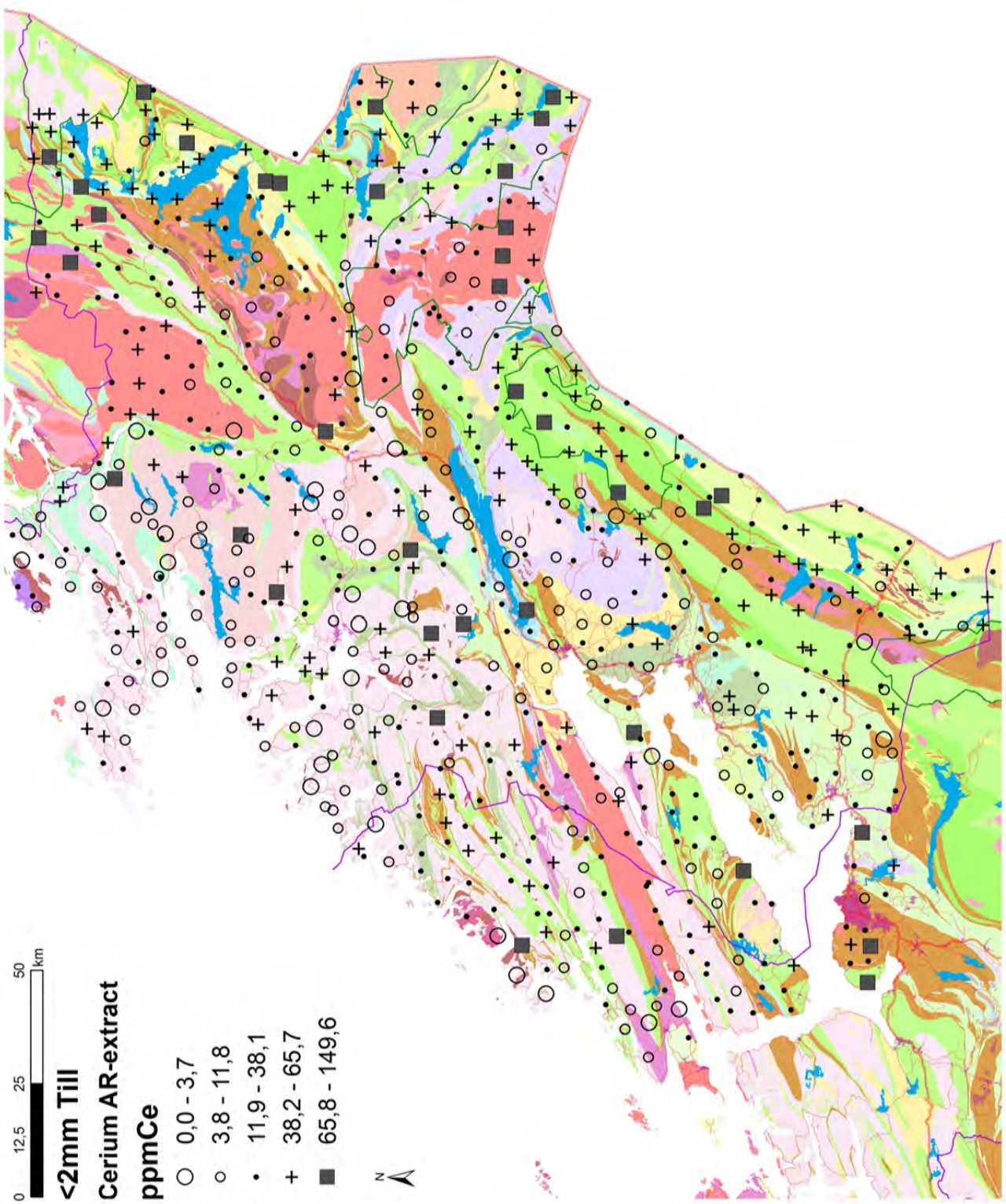

0
12,5
25
50
km
<2mm Till
Barium AR-extract
ppmBa
0,0 - 3,9
4,0 - 9,2
9,3 - 25,9
26,0 - 60,4
60,5 - 476,8
N

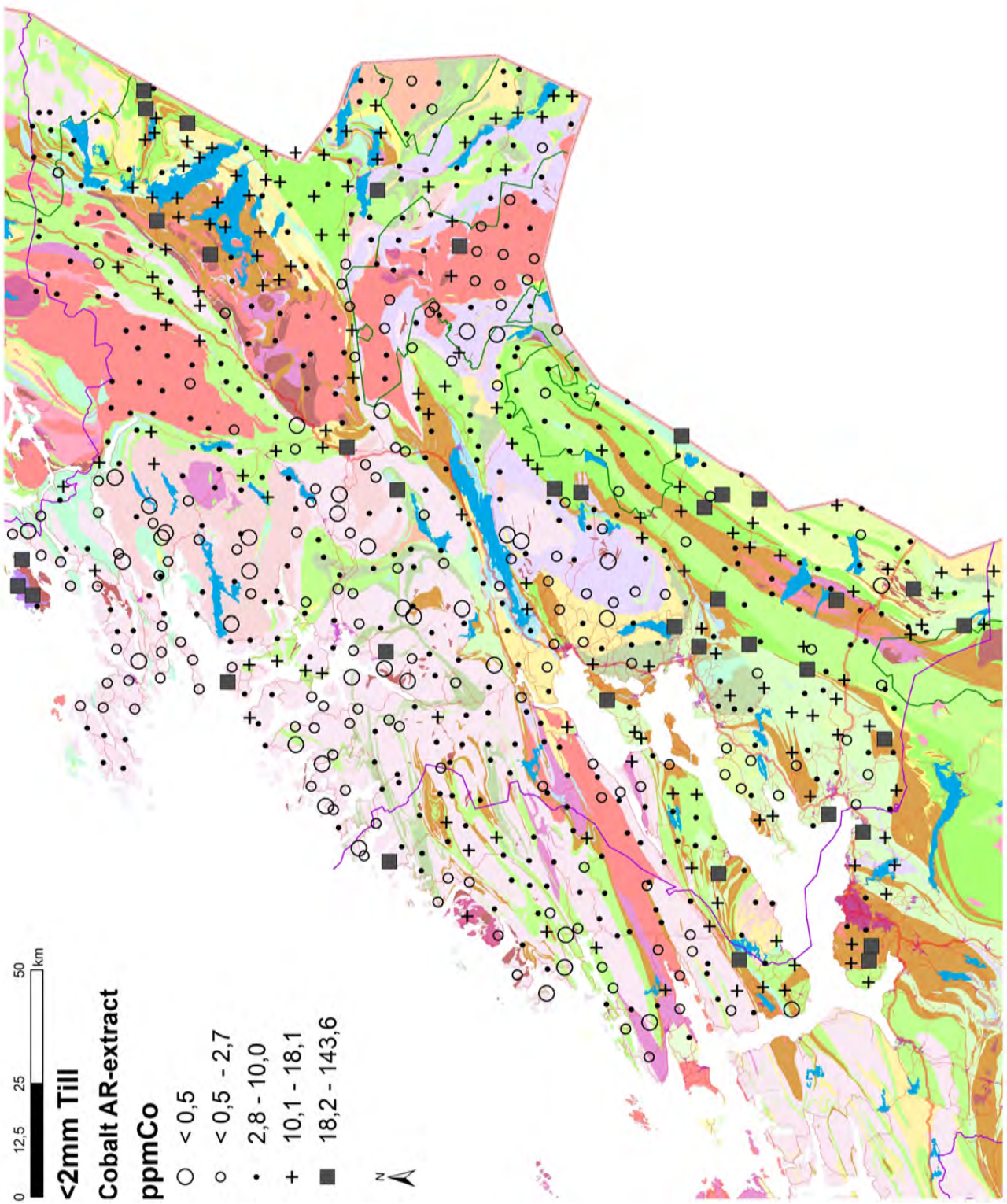

0
12,5
25
50
km
<2mm Till
Beryllium AR-extract
ppmBe
< 0,1
<0,1 - 0,10
0,11 - 0,33
0,34 - 0,52
0,53 - 3,46
N

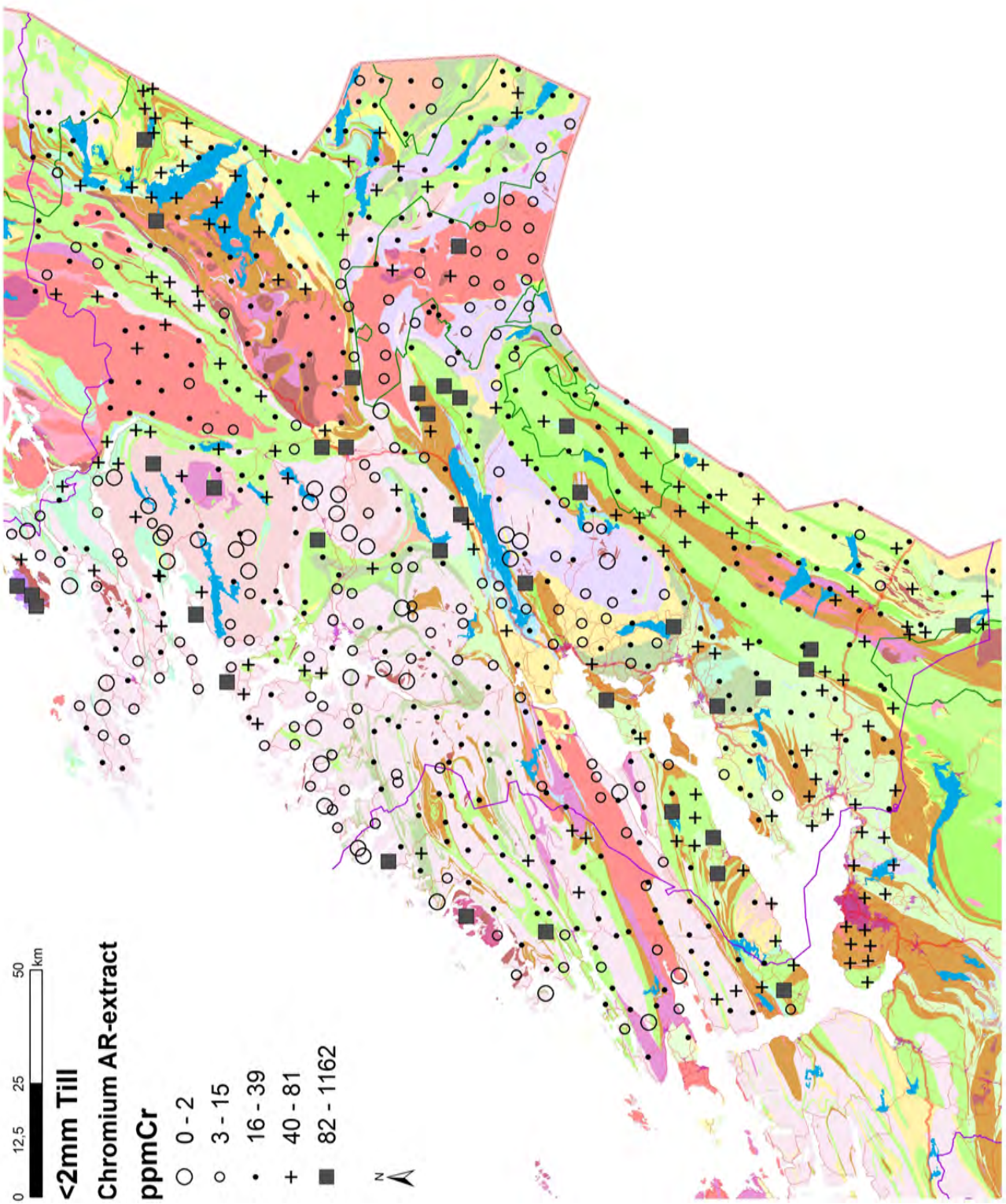

0
12,5
25
50
km
<2mm Till
Bismut AR-extract
ppmBi
<0,02 - 0,03
0,04 - 0,06
0,07 - 0,13
0,14 - 0,23
0,24 - 5,03
N

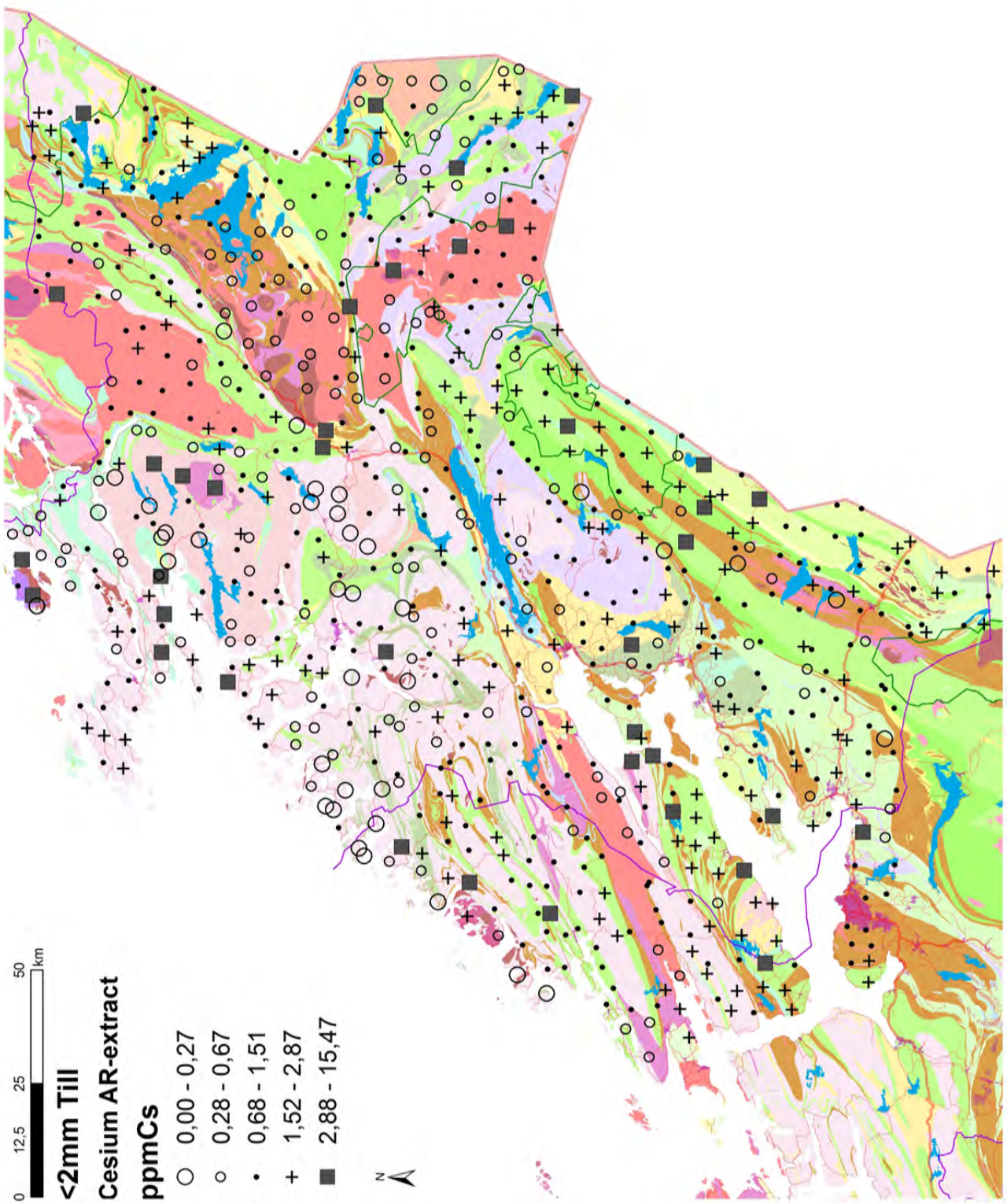

0
12,5
25
50
km
<2mm Till
Calcium AR-extract
ppmCa
0 - 128
129 - 569
570 - 2011
2012 - 3057
3058 - 13721
N

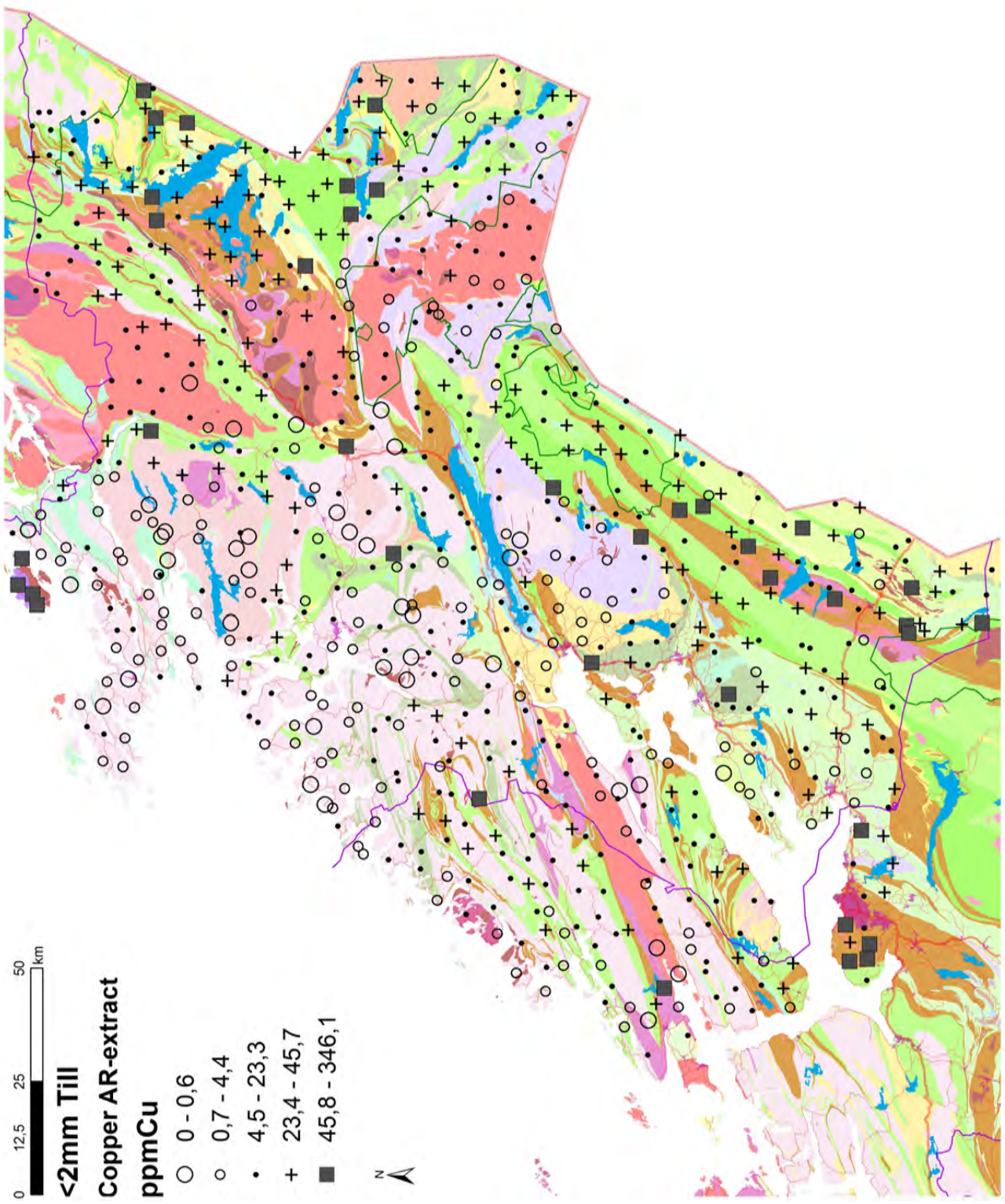

0
12,5
25
50
km
<2mm Till
Cadmium AR-extract
ppmCd
< 0,01
< 0,01 - 0,016
0,017 - 0,050
0,051 - 0,095
0,096 - 0,569
N

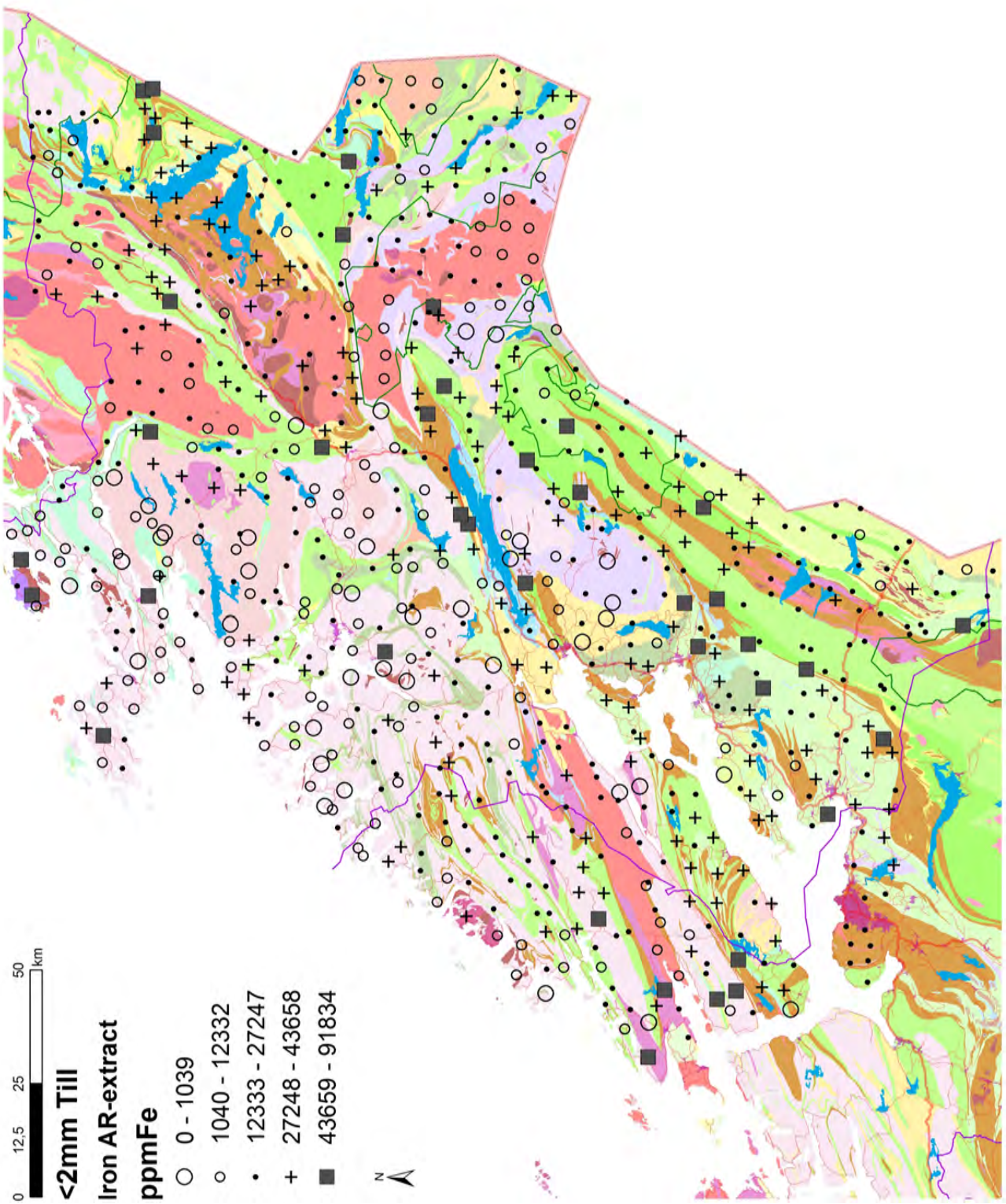

<2mm Till
Cerium AR-extract
ppmCe
0,0 - 3,7
3,8 - 11,8
11,9 - 38,1
38,2 - 65,7
65,8 - 149,6
0
12,5
25
50
km
N

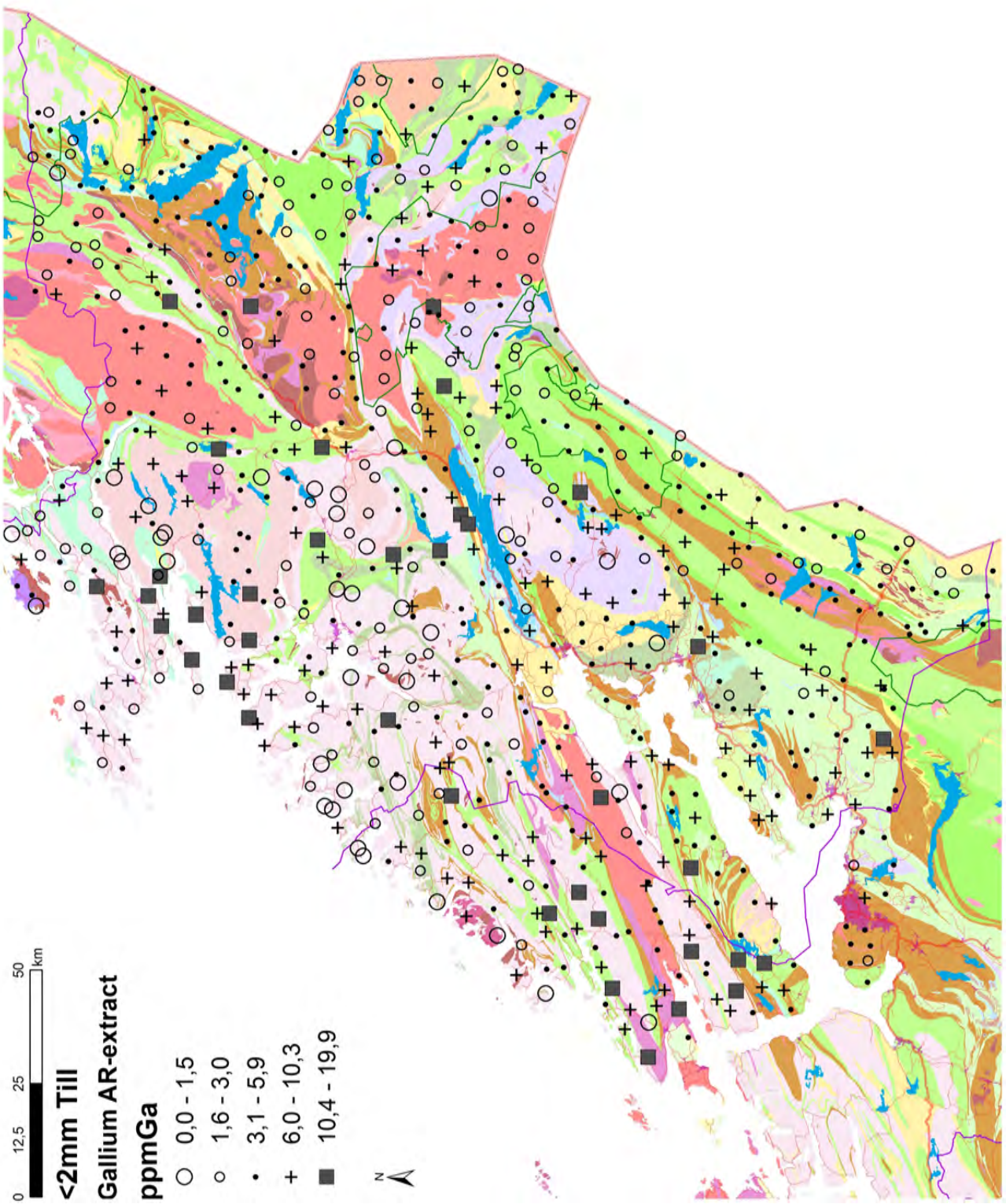

<2mm Till
Cobalt AR-extract
ppmCo
< 0,5
< 0,5 - 2,7
2,8 - 10,0
10,1 - 18,1
18,2 - 143,6
0
12,5
25
50
km
N

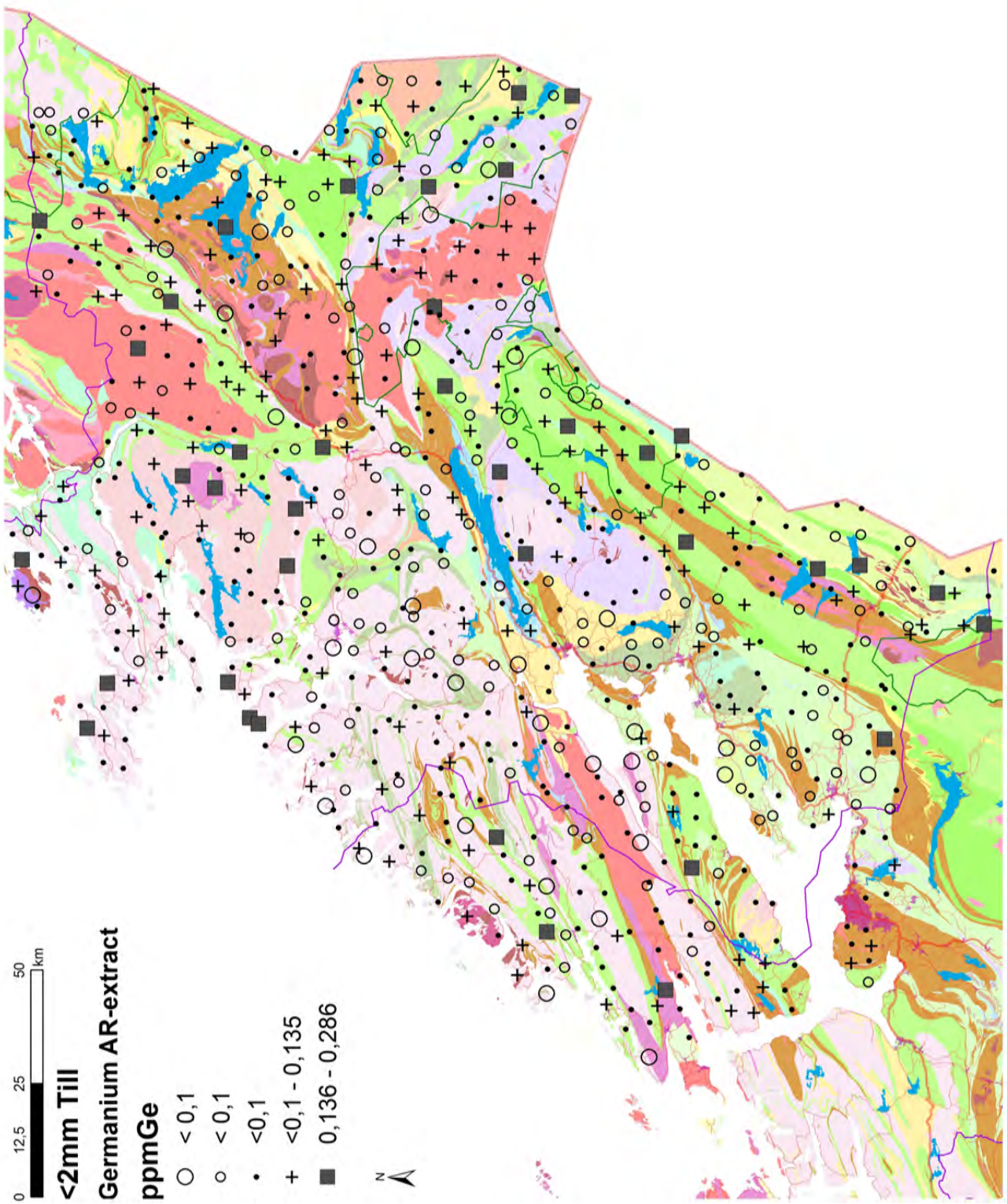

0
12,5
25
50
km
<2mm Till
Chromium AR-extract
ppmCr
0 - 2
3 - 15
16 - 39
40 - 81
82 - 1162
N

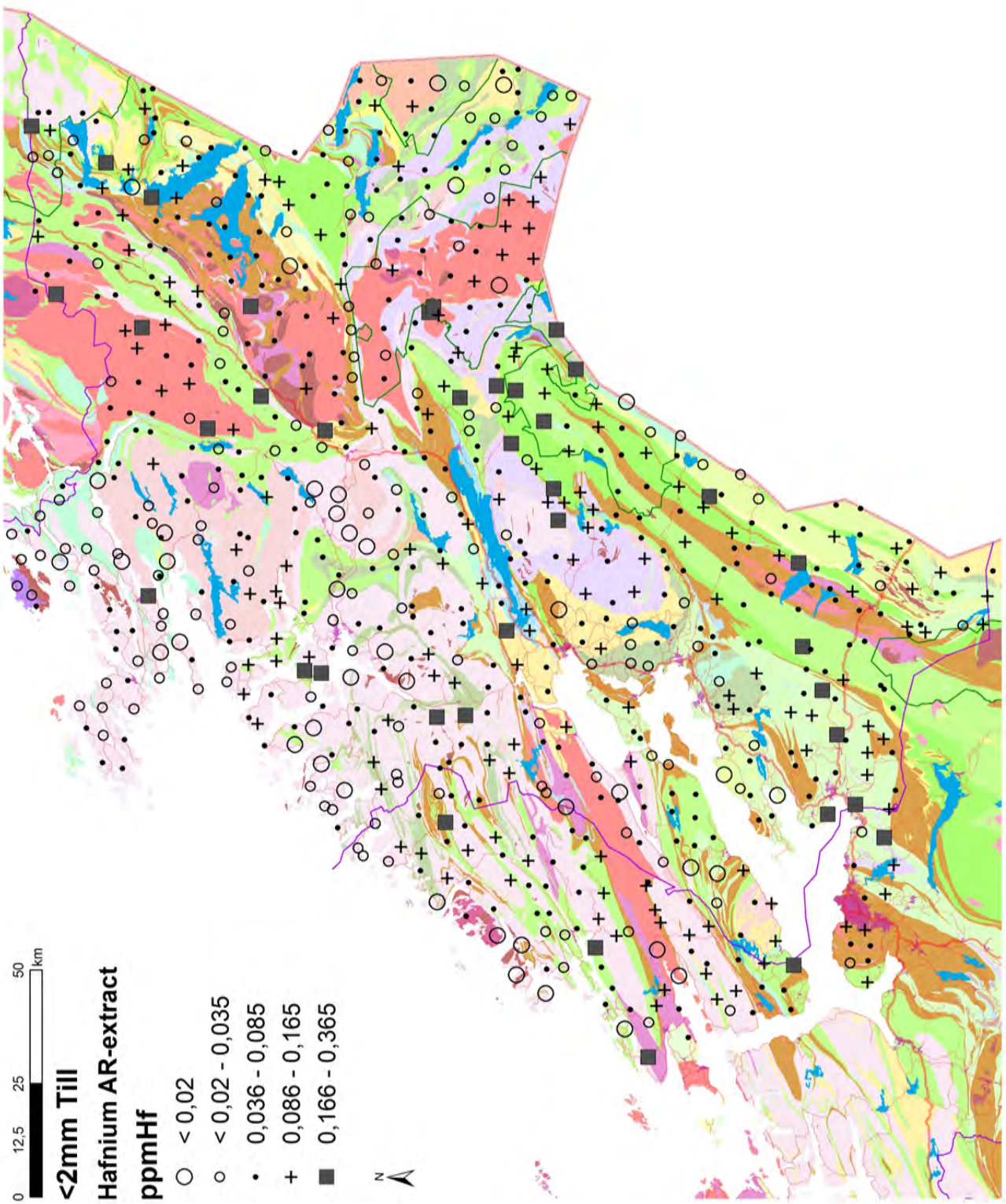

0
12,5
25
50
km
<2mm Till
Cesium AR-extract
ppmCs
0,00 - 0,27
0,28 - 0,67
0,68 - 1,51
1,52 - 2,87
2,88 - 15,47
N

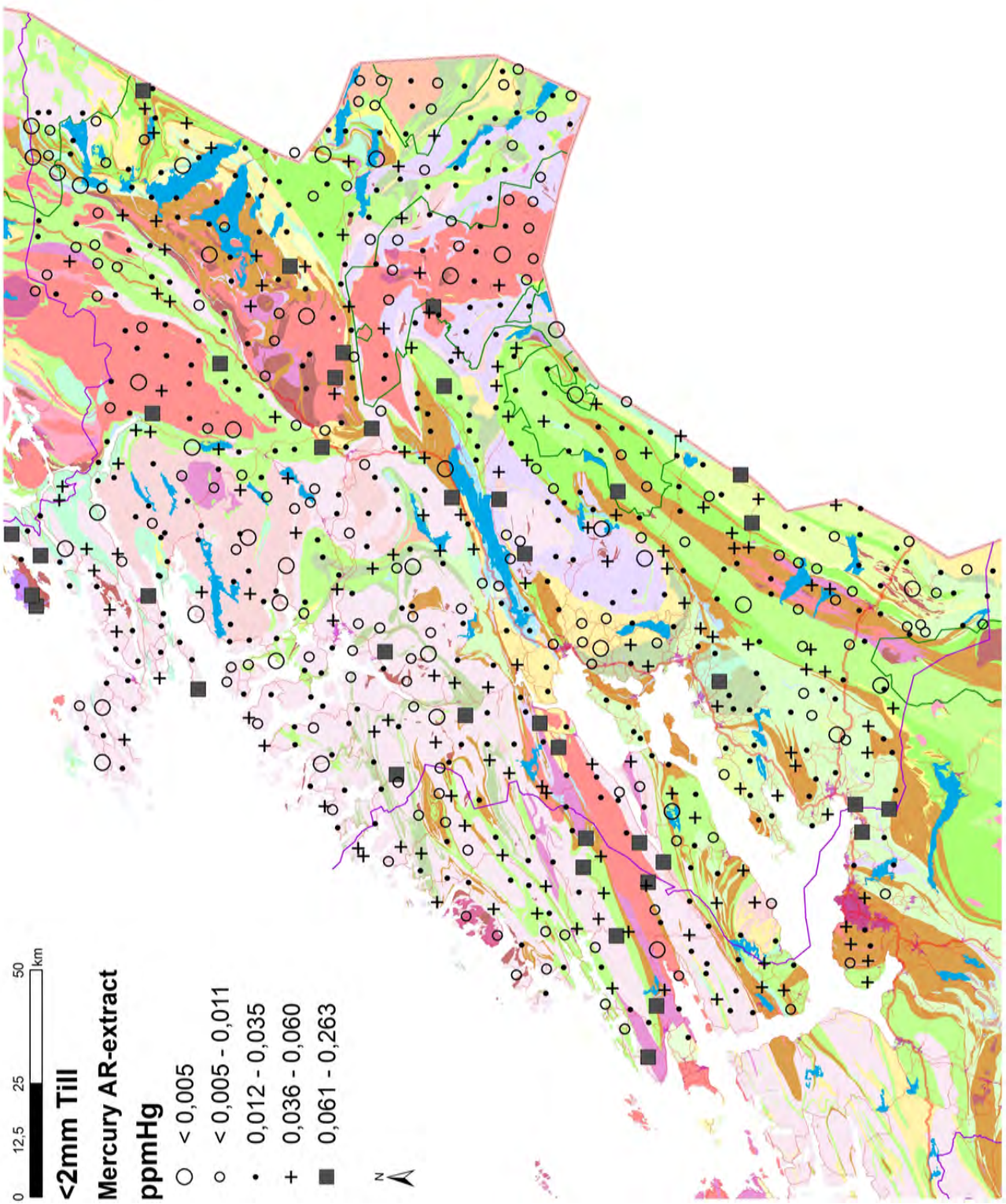

0
12,5
25
50
km
<2mm Till
Copper AR-extract
ppmCu
0 - 0,6
0,7 - 4,4
4,5 - 23,3
23,4 - 45,7
45,8 - 346,1
N

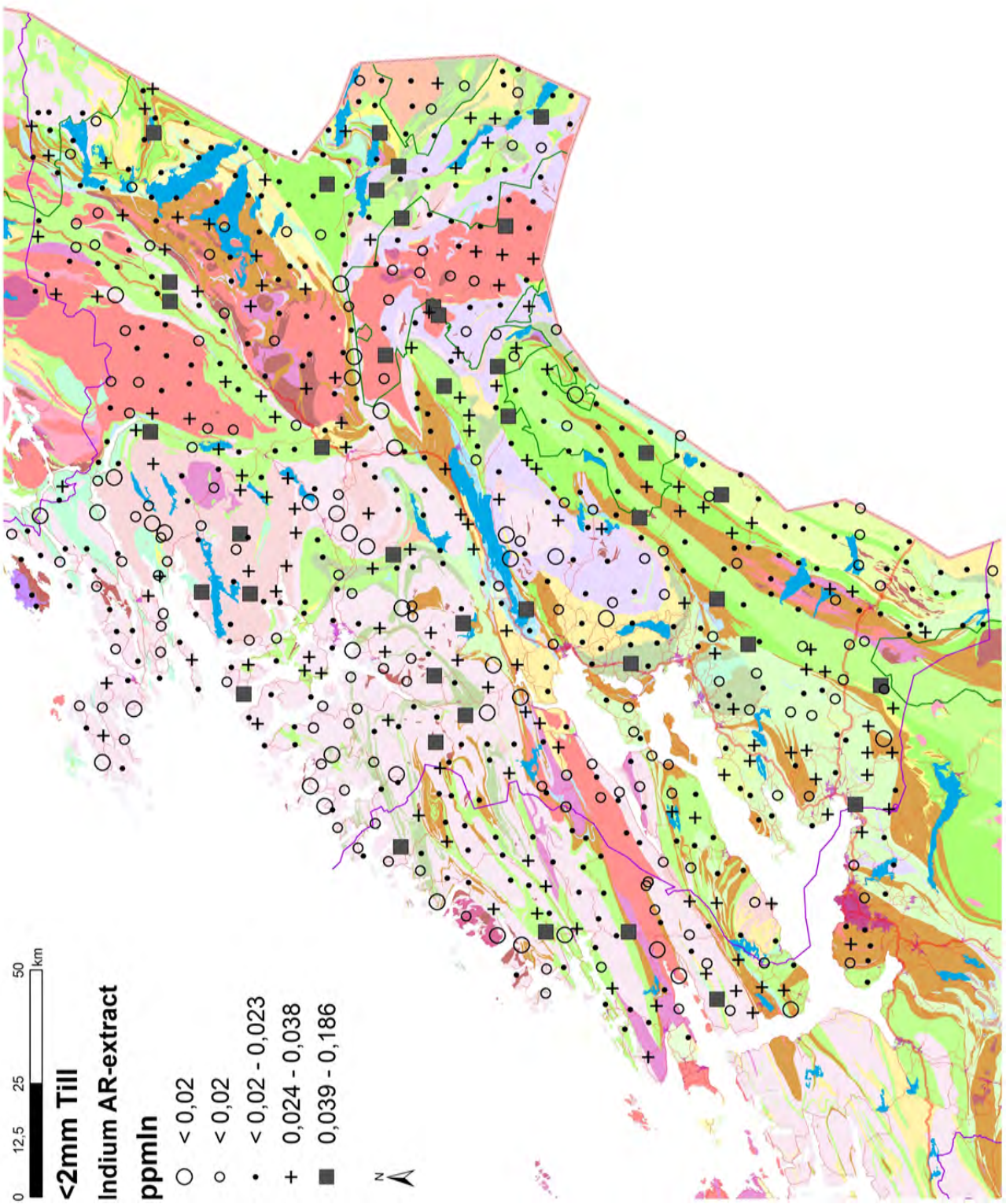

0
12,5
25
50
km
<2mm Till
Iron AR-extract
ppmFe
0 - 1039
1040 - 12332
12333 - 27247
27248 - 43658
43659 - 91834
N

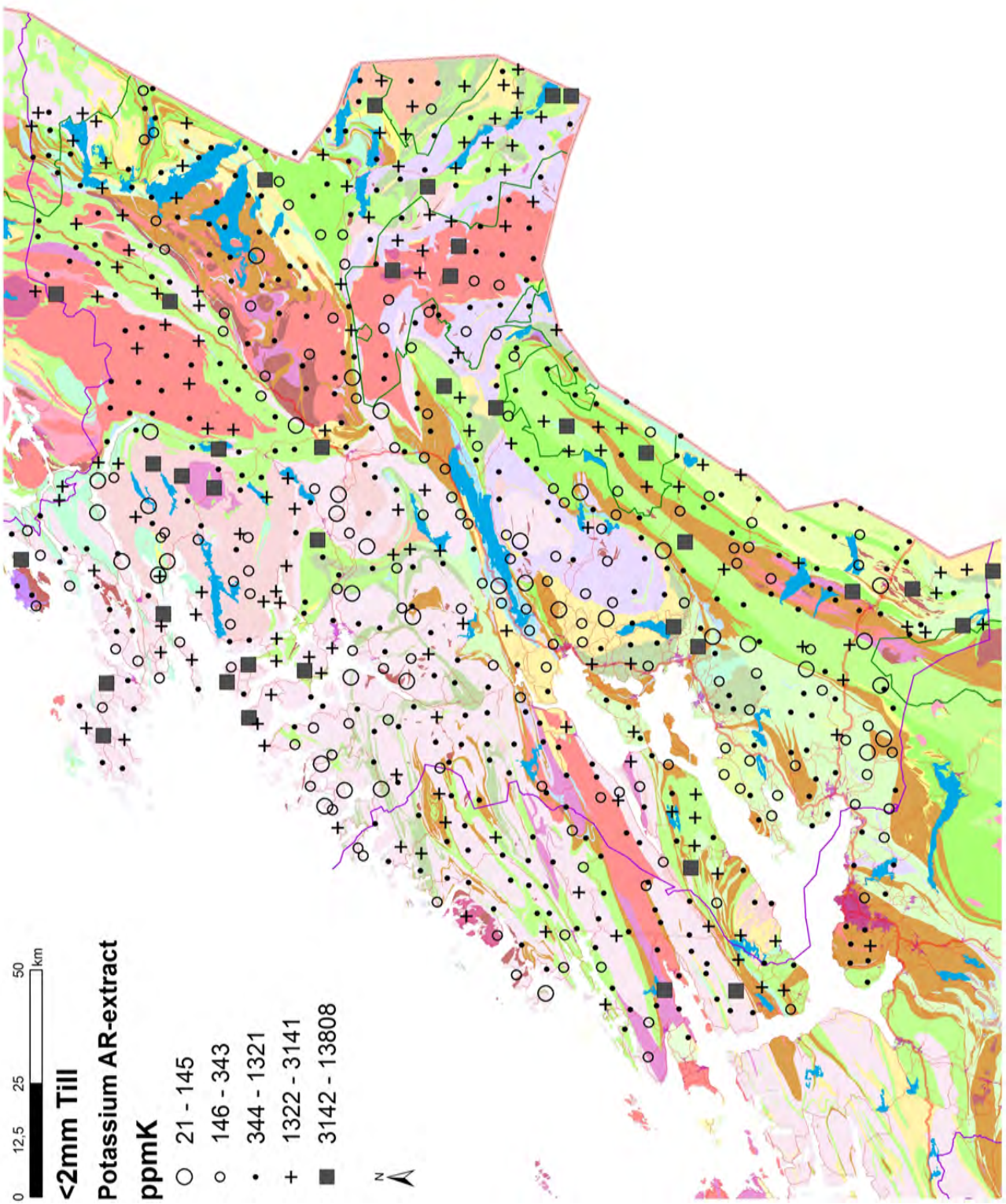

0
12,5
25
50
km
<2mm Till
Gallium AR-extract
ppmGa
0,0 - 1,5
1,6 - 3,0
3,1 - 5,9
6,0 - 10,3
10,4 - 19,9
N

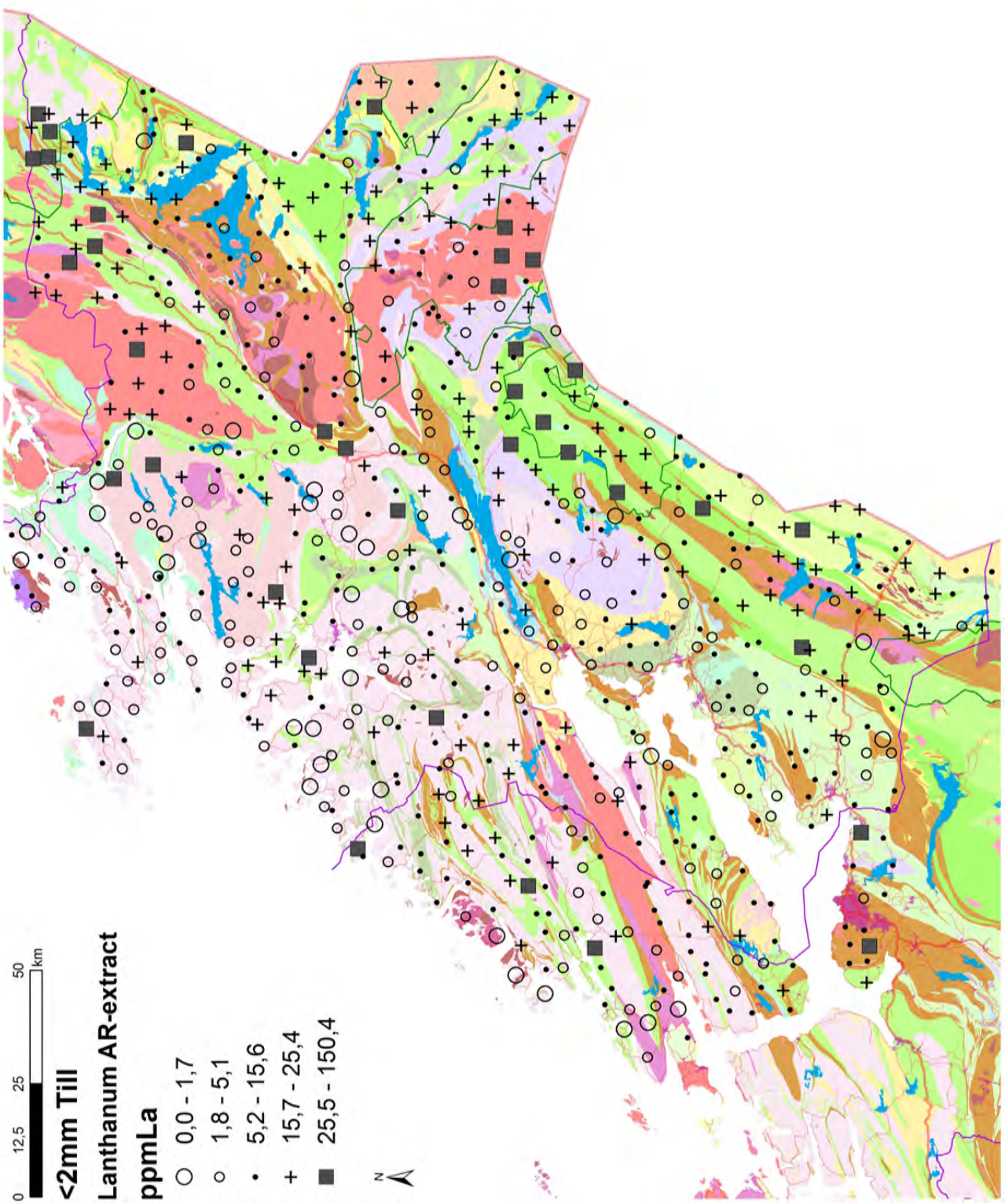

0
12,5
25
50
km
<2mm Till
Germanium AR-extract
ppmGe
< 0,1
< 0,1
<0,1
<0,1 - 0,135
0,136 - 0,286
N

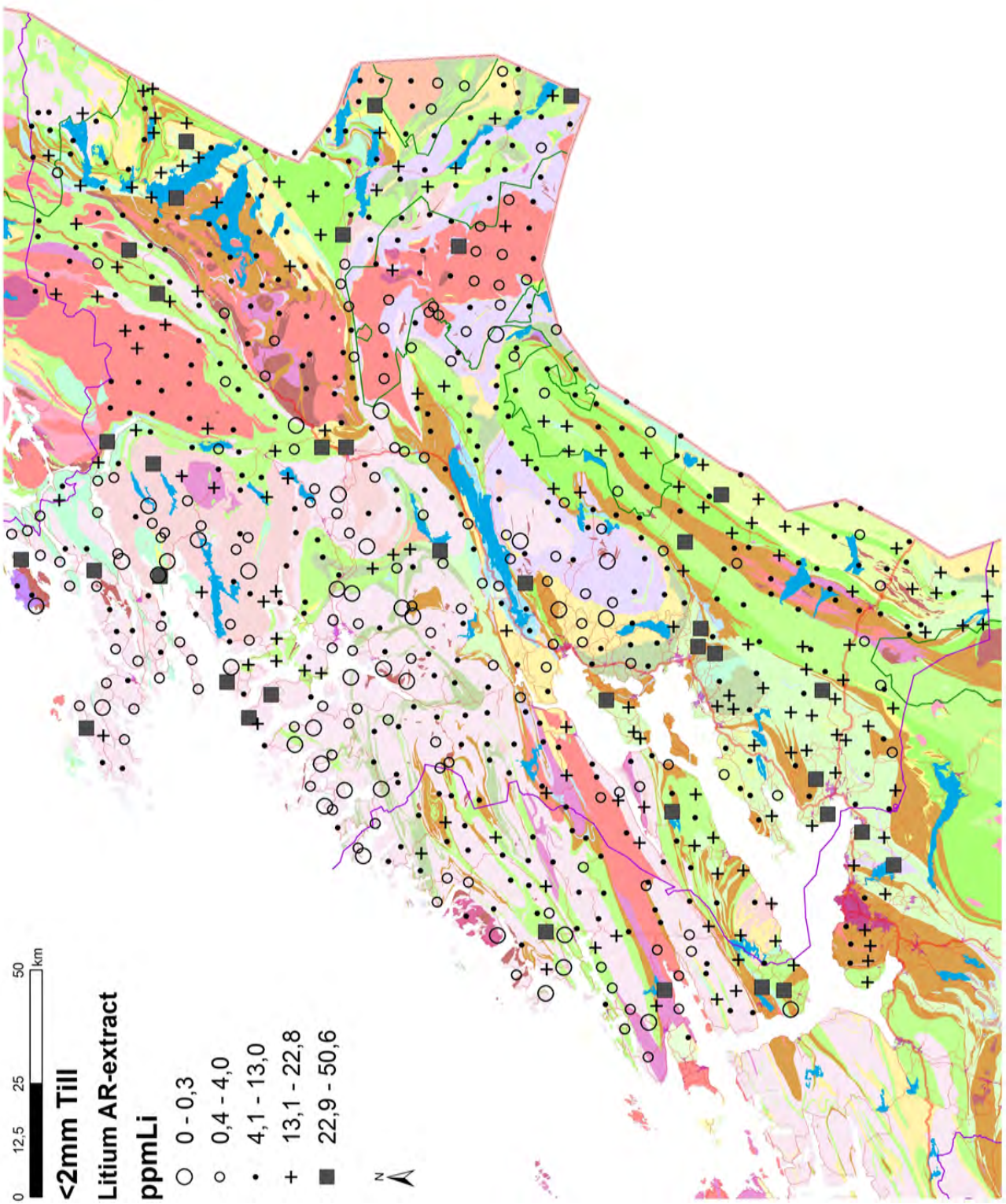

0
12,5
25
50
km
<2mm Till
Hafnium AR-extract
ppmHf
< 0,02
< 0,02 - 0,035
0,036 - 0,085
0,086 - 0,165
0,166 - 0,365
N

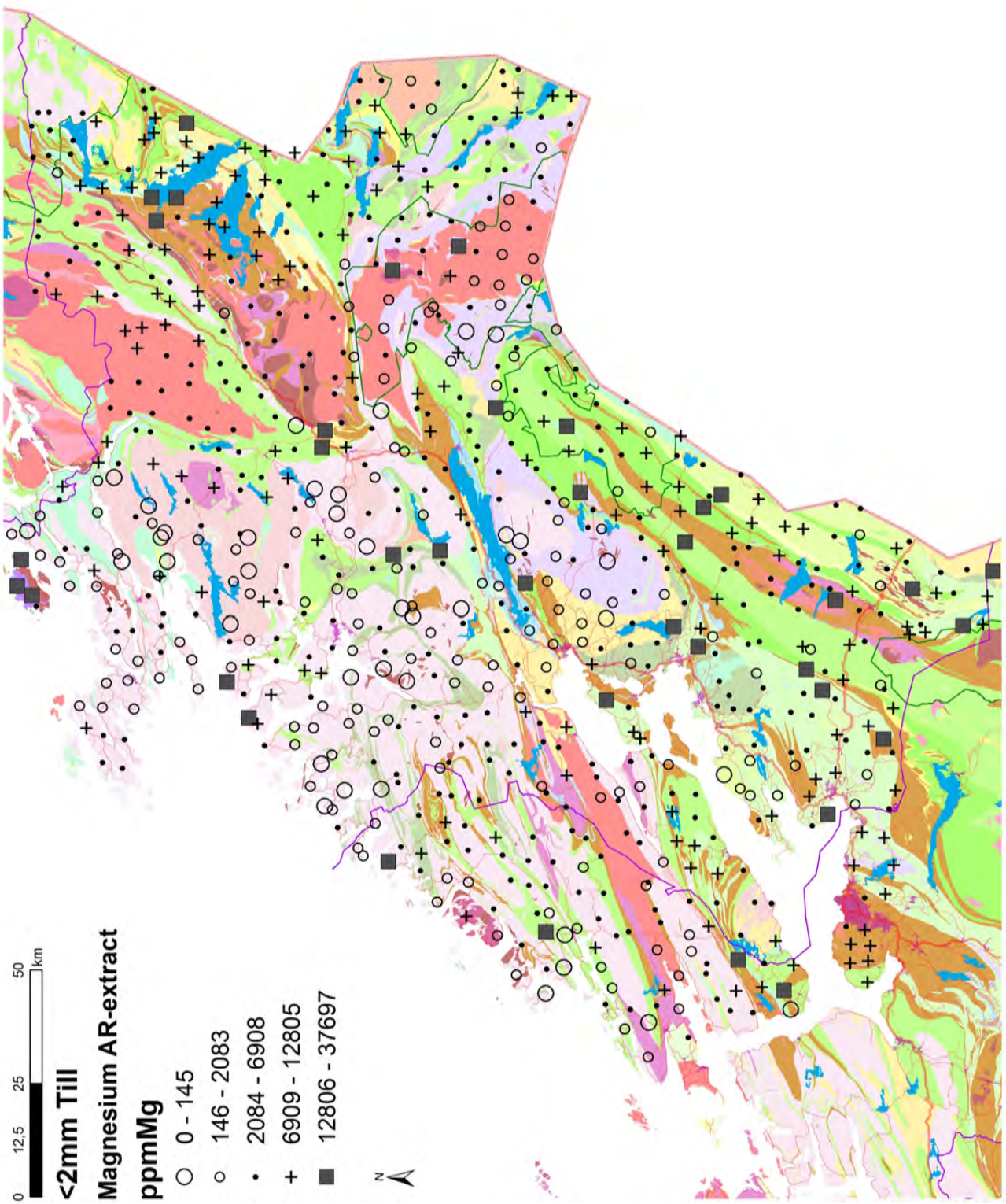

0
12,5
25
50
km
<2mm Till
Mercury AR-extract
ppmHg
< 0,005
< 0,005 - 0,011
0,012 - 0,035
0,036 - 0,060
0,061 - 0,263
N

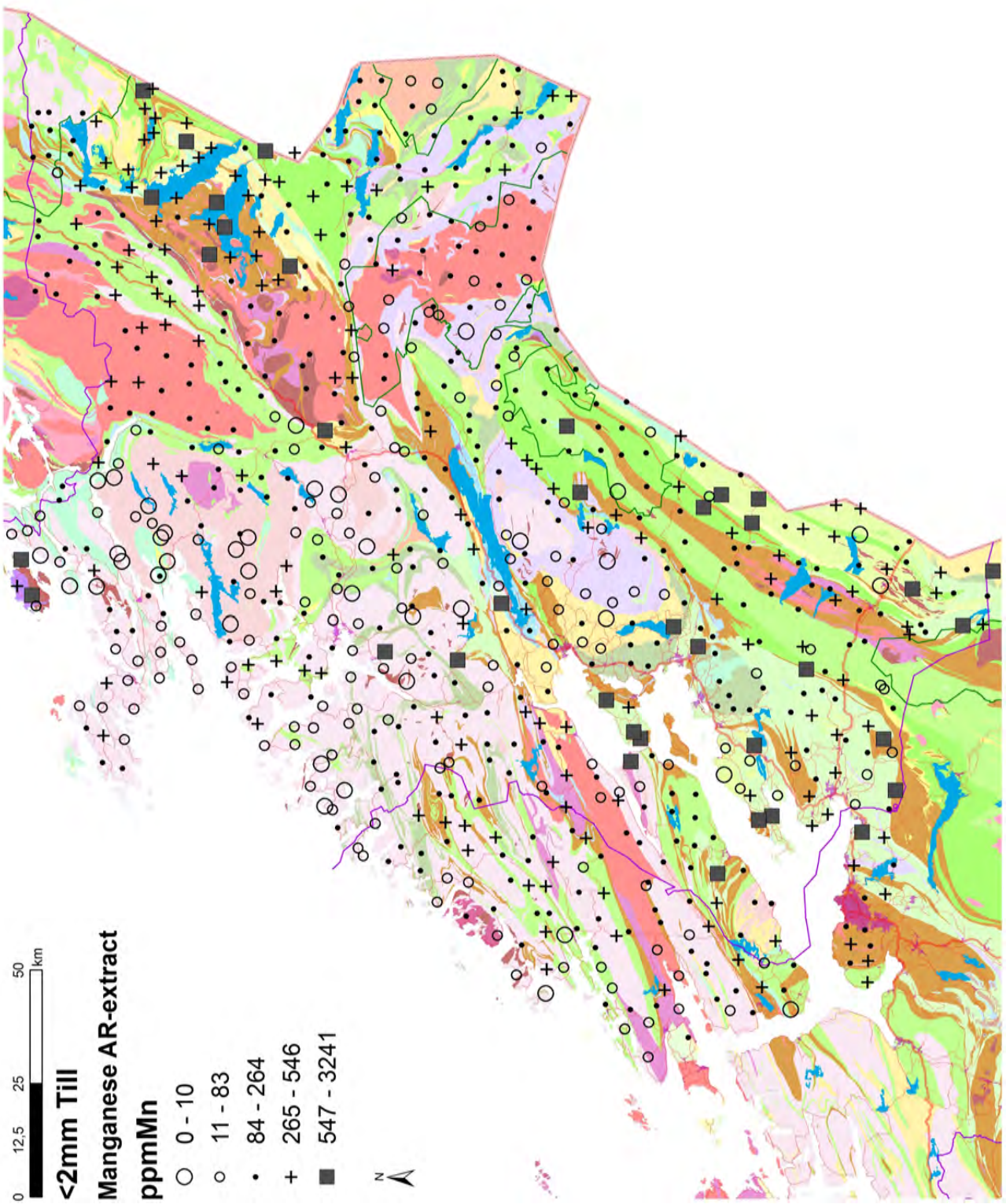

0
12,5
25
50
km
<2mm Till
Indium AR-extract
ppmln
< 0,02
< 0,02
< 0,02 - 0,023
0,024 - 0,038
0,039 - 0,186
N

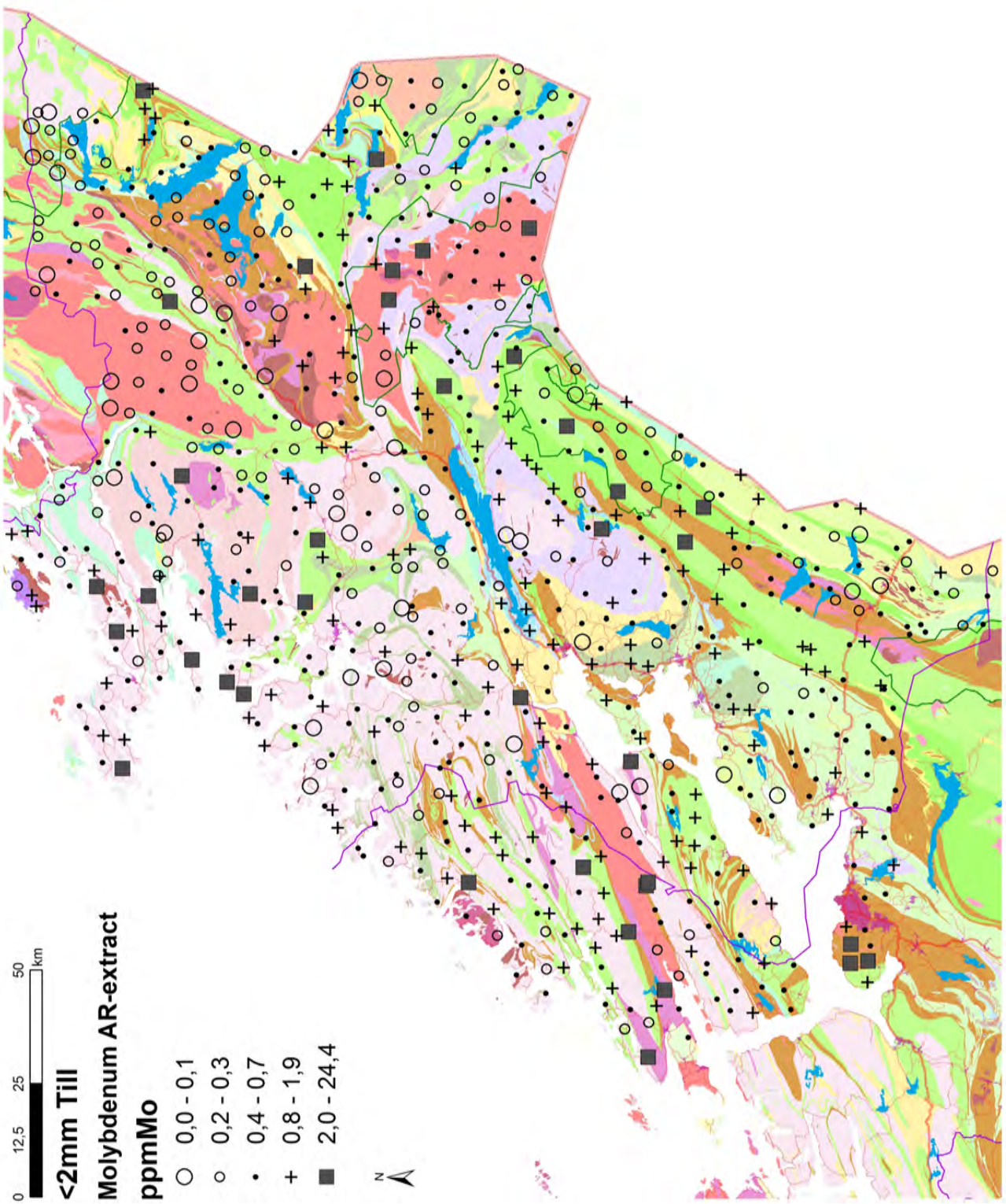

0
12,5
25
50
km
<2mm Till
Potassium AR-extract
ppmK
21 - 145
146 - 343
344 - 1321
1322 - 3141
3142 - 13808
N

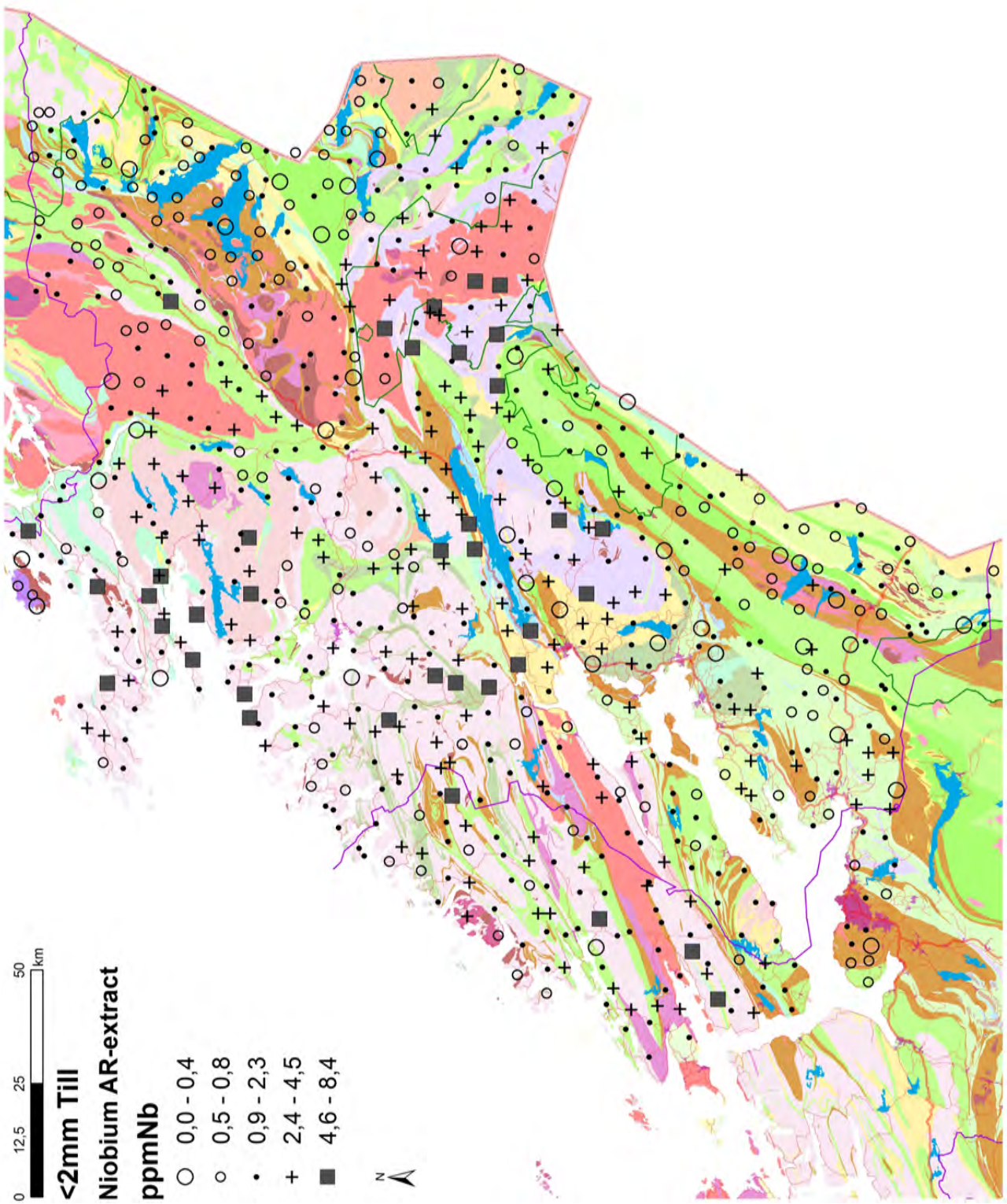

0
12,5
25
50
km
<2mm Till
Lanthanum AR-extract
ppmLa
0,0 - 1,7
1,8 - 5,1
5,2 - 15,6
15,7 - 25,4
25,5 - 150,4
N

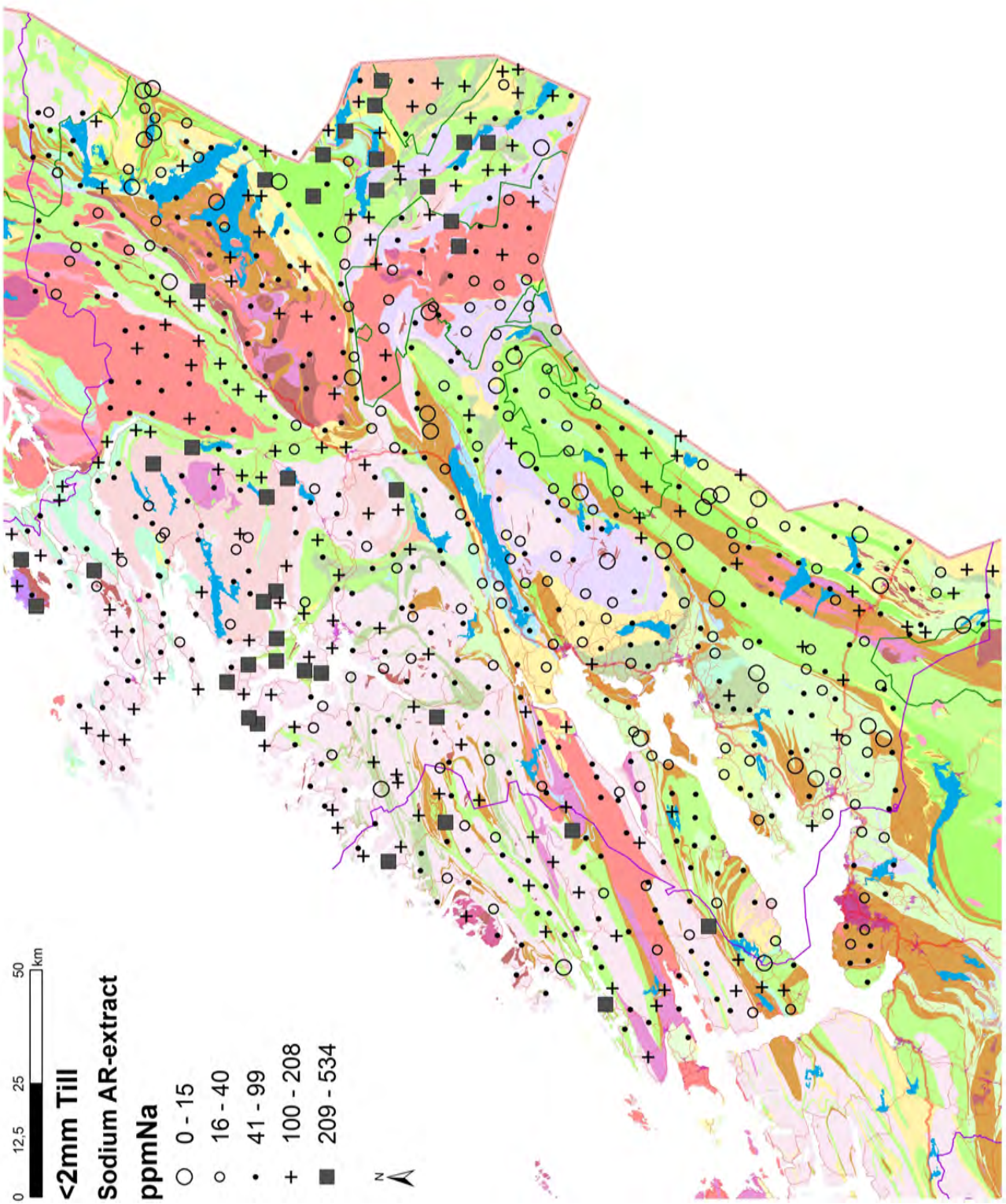

<2mm Till
Litium AR-extract
ppmLi
0 - 0,3
0,4 - 4,0
4,1 - 13,0
13,1 - 22,8
22,9 - 50,6
0
12,5
25
50
km
N

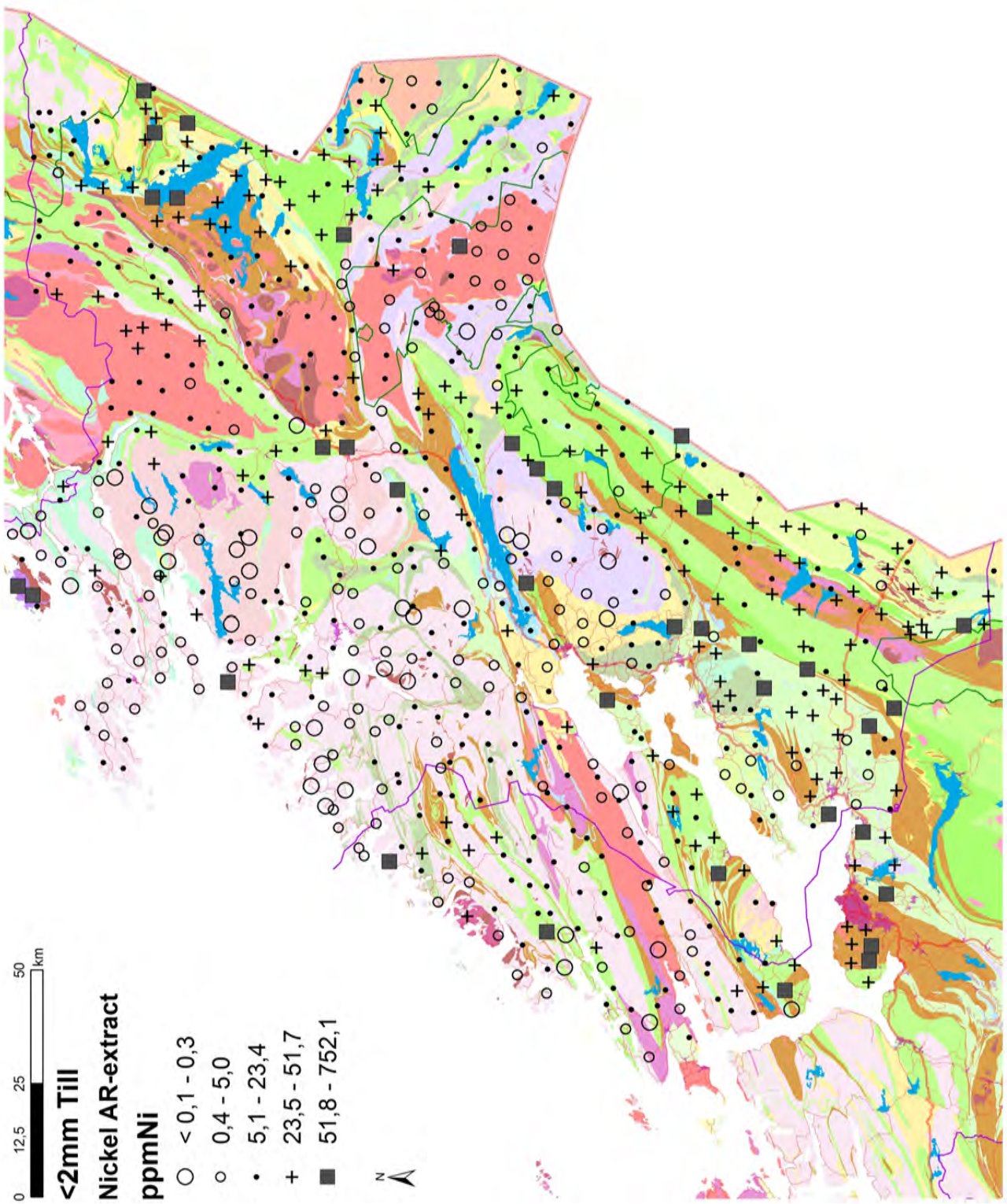

<2mm Till
Magnesium AR-extract
ppmMg
0 - 145
146 - 2083
2084 - 6908
6909 - 12805
12806 - 37697
0
12,5
25
50
km
N

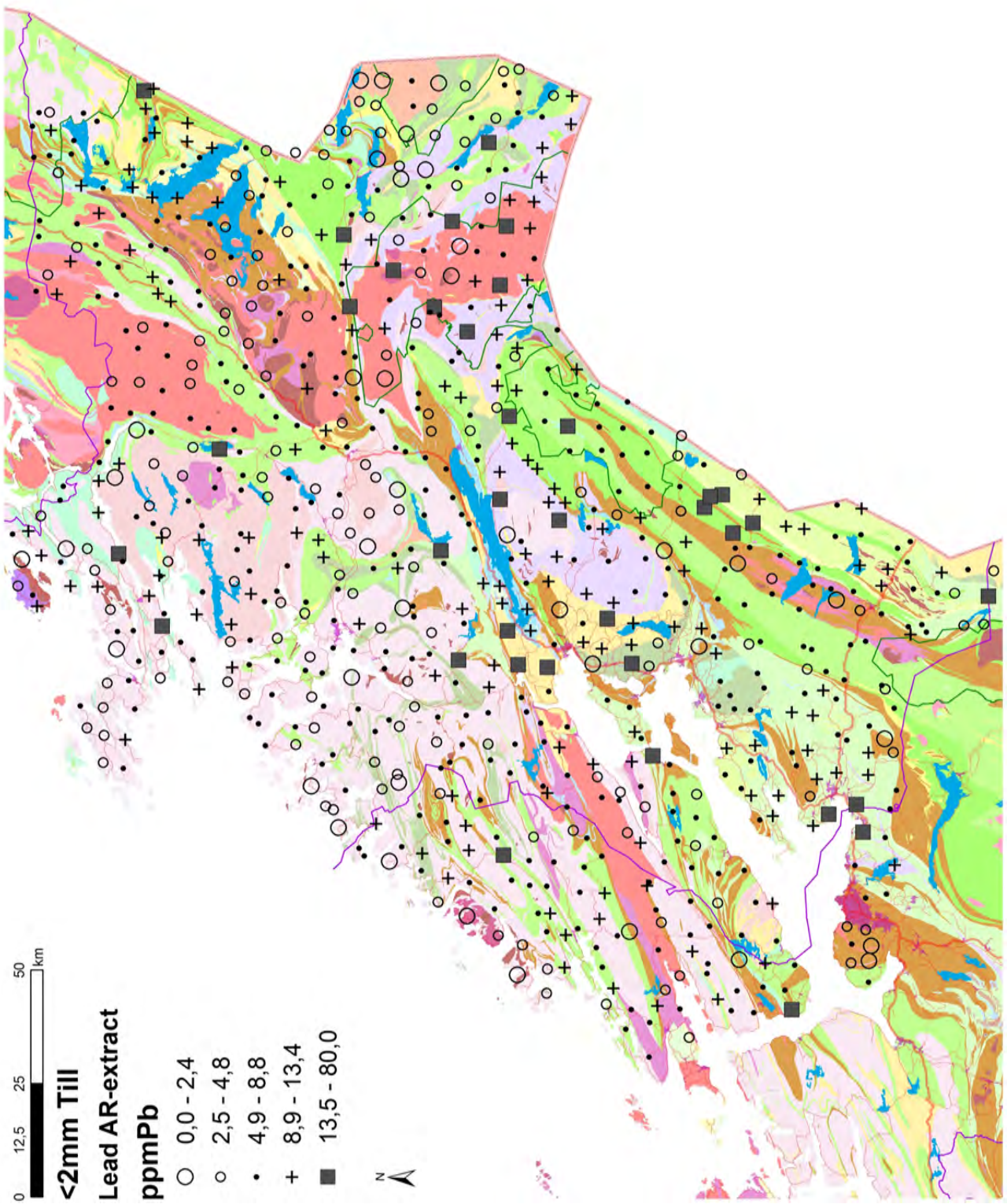

<2mm Till
Manganese AR-extract
ppmMn
0 - 10
11 - 83
84 - 264
265 - 546
547 - 3241
0
12,5
25
50
km
N

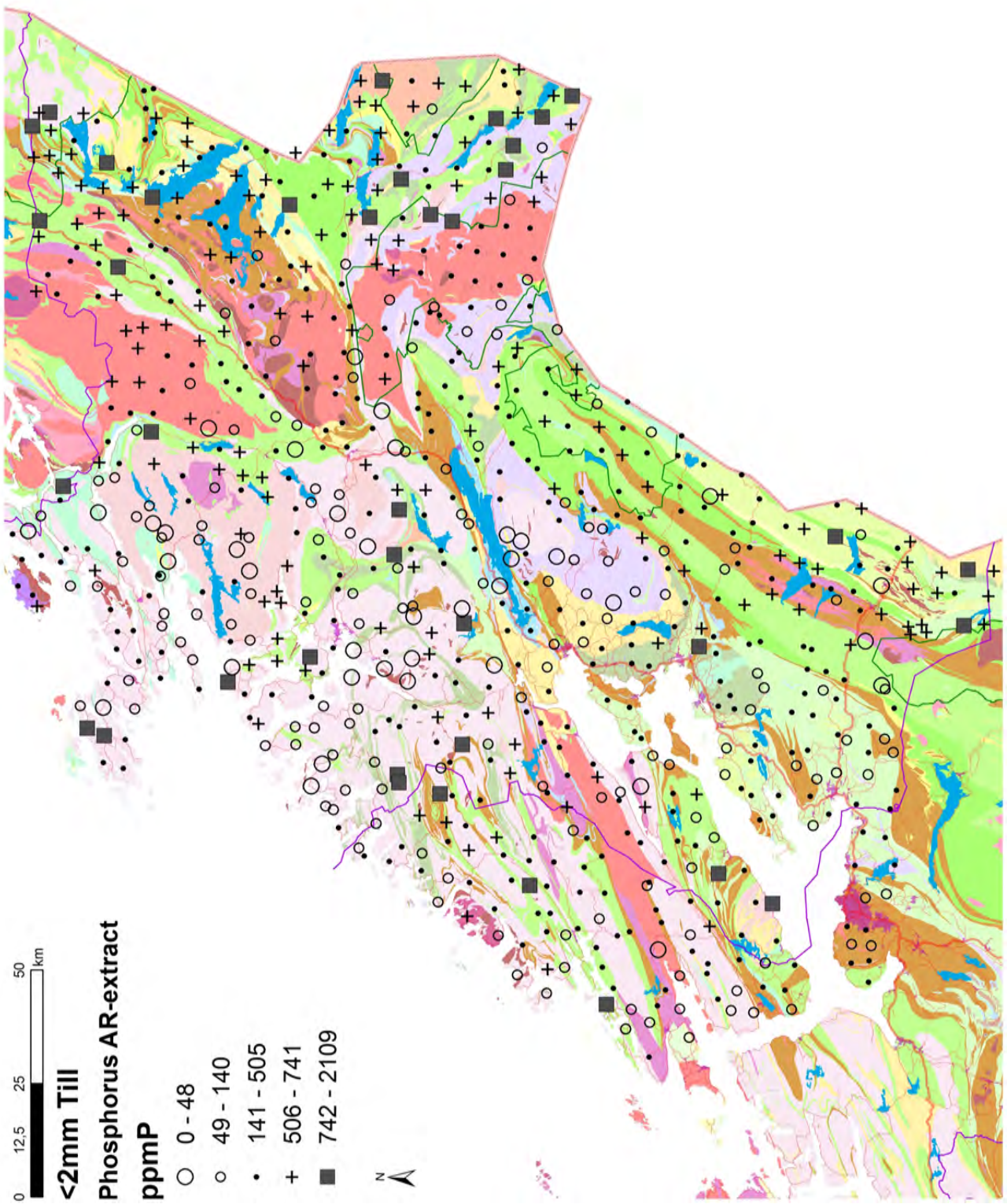

0
12,5
25
50
km
<2mm Till
Molybdenum AR-extract
ppmMo
0,0 - 0,1
0,2 - 0,3
0,4 - 0,7
0,8 - 1,9
2,0 - 24,4
N

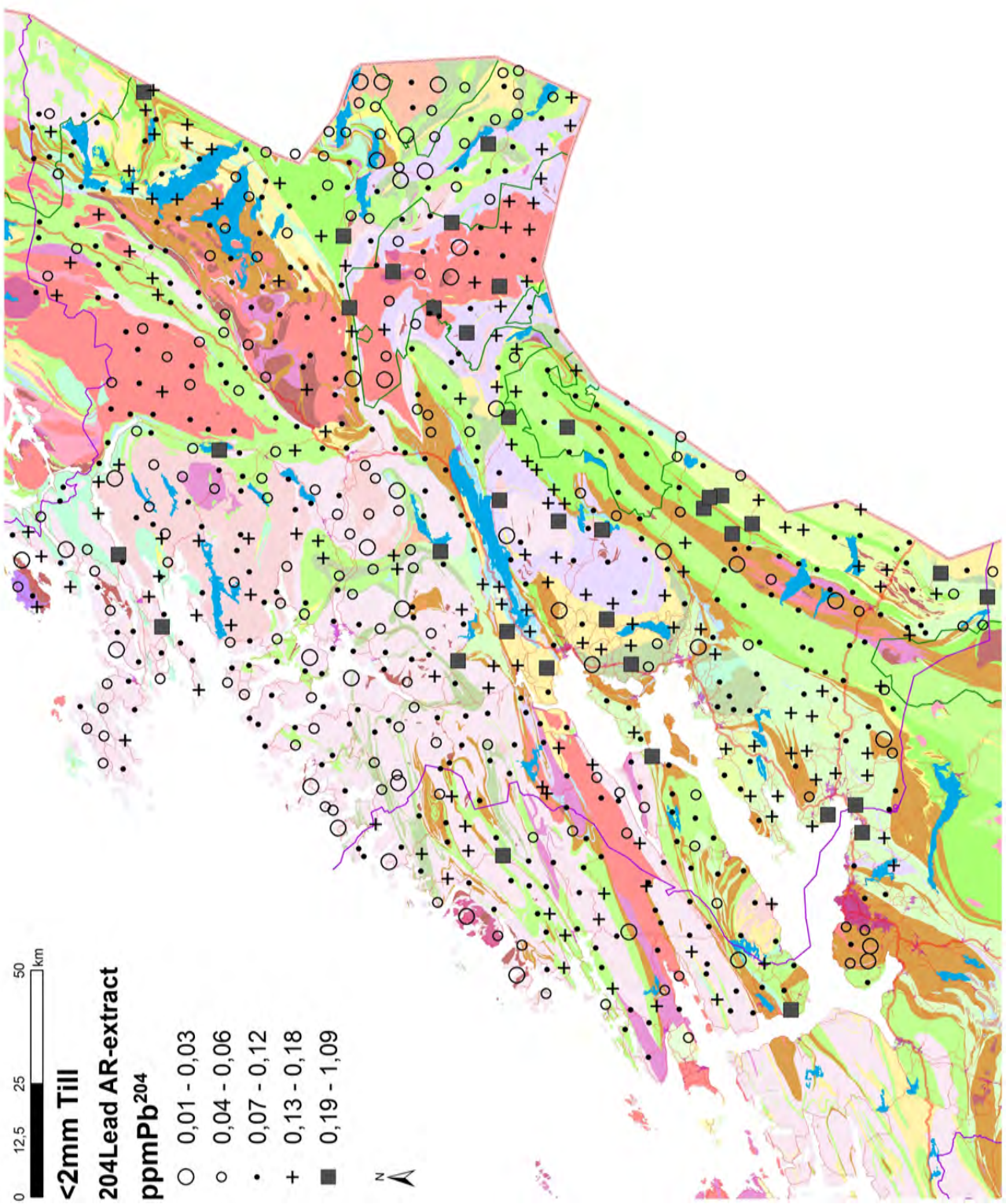

<2mm Till
Niobium AR-extract
ppmNb
0,0 - 0,4
0,5 - 0,8
0,9 - 2,3
2,4 - 4,5
4,6 - 8,4
0
12,5
25
50
km
N

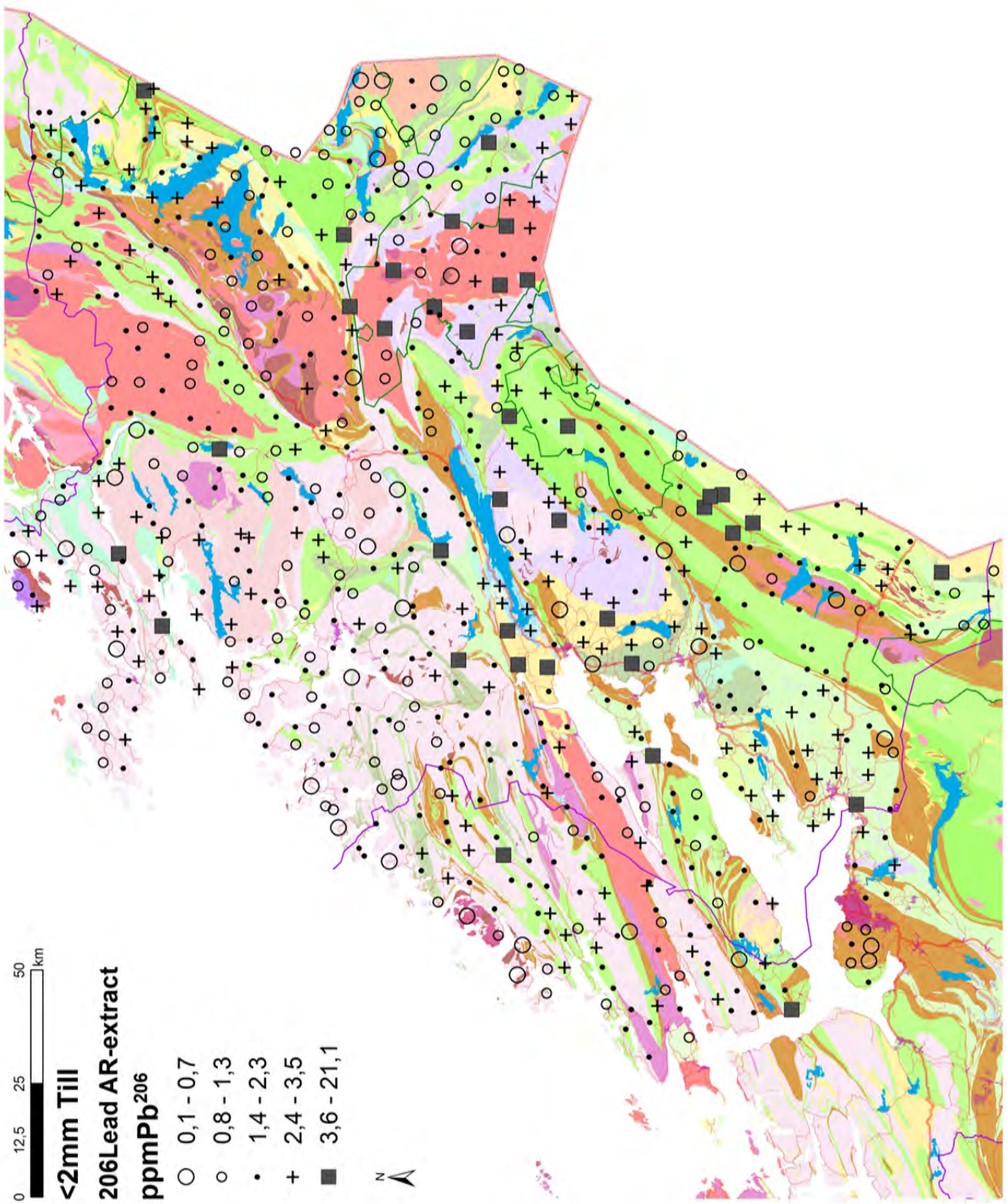

0
12,5
25
50
km
<2mm Till
Sodium AR-extract
ppmNa
0 - 15
16 - 40
41 - 99
100 - 208
209 - 534
N

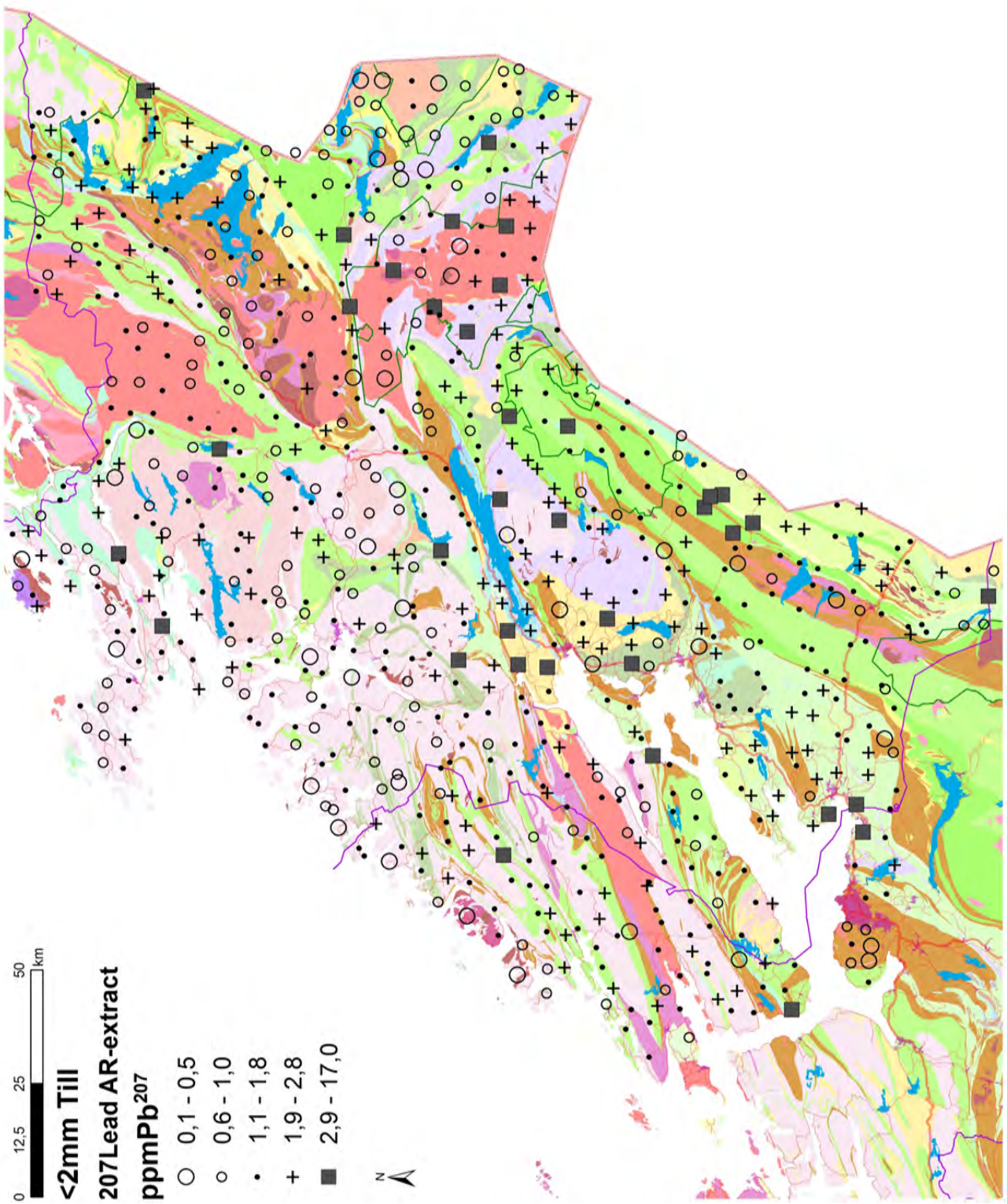

0
12,5
25
50
km
<2mm Till
Nickel AR-extract
ppmNi
< 0,1 - 0,3
0,4 - 5,0
5,1 - 23,4
23,5 - 51,7
51,8 - 752,1
N

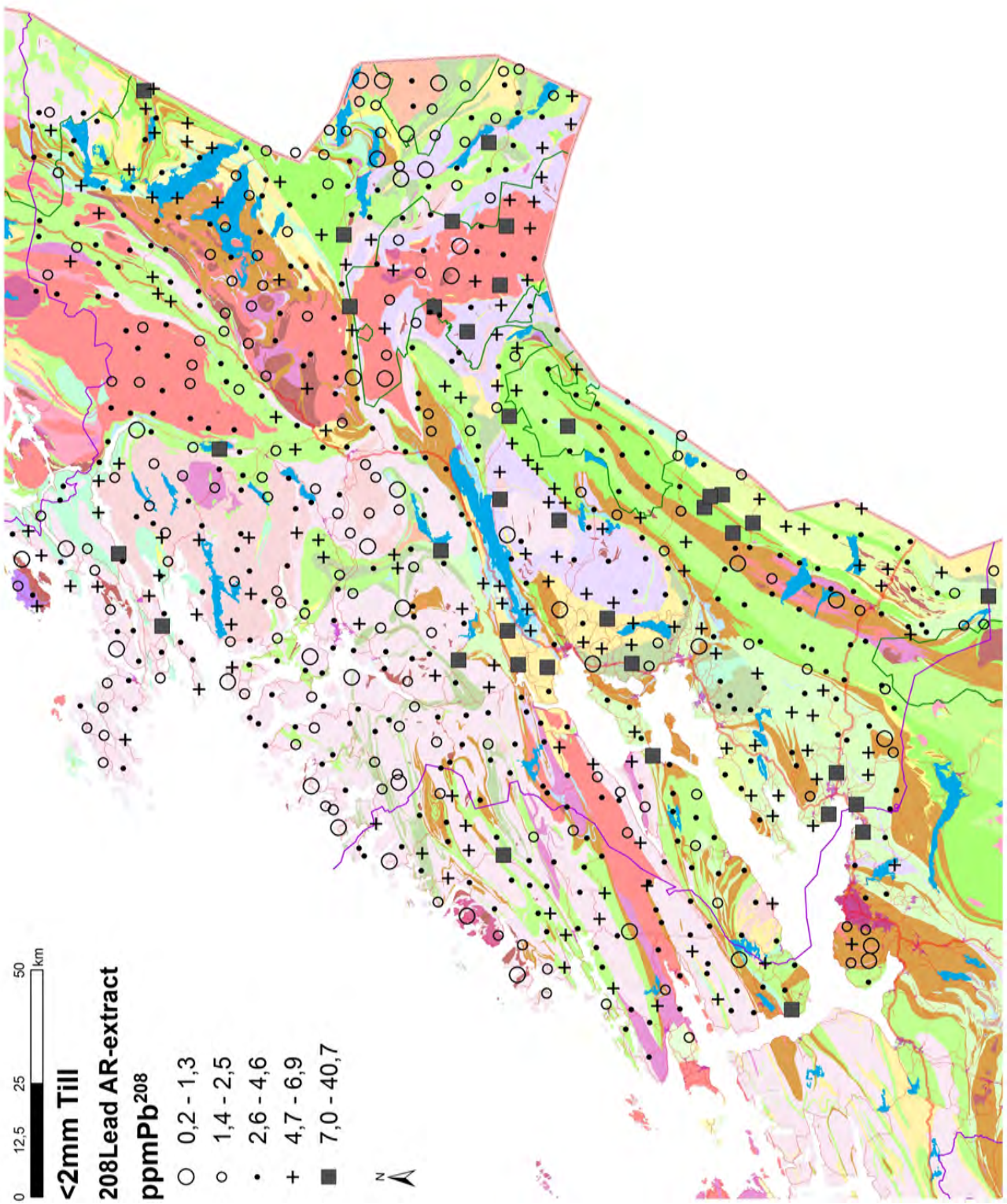

0
12,5
25
50
km
<2mm Till
Lead AR-extract
ppmPb
0,0 - 2,4
2,5 - 4,8
4,9 - 8,8
8,9 - 13,4
13,5 - 80,0
N

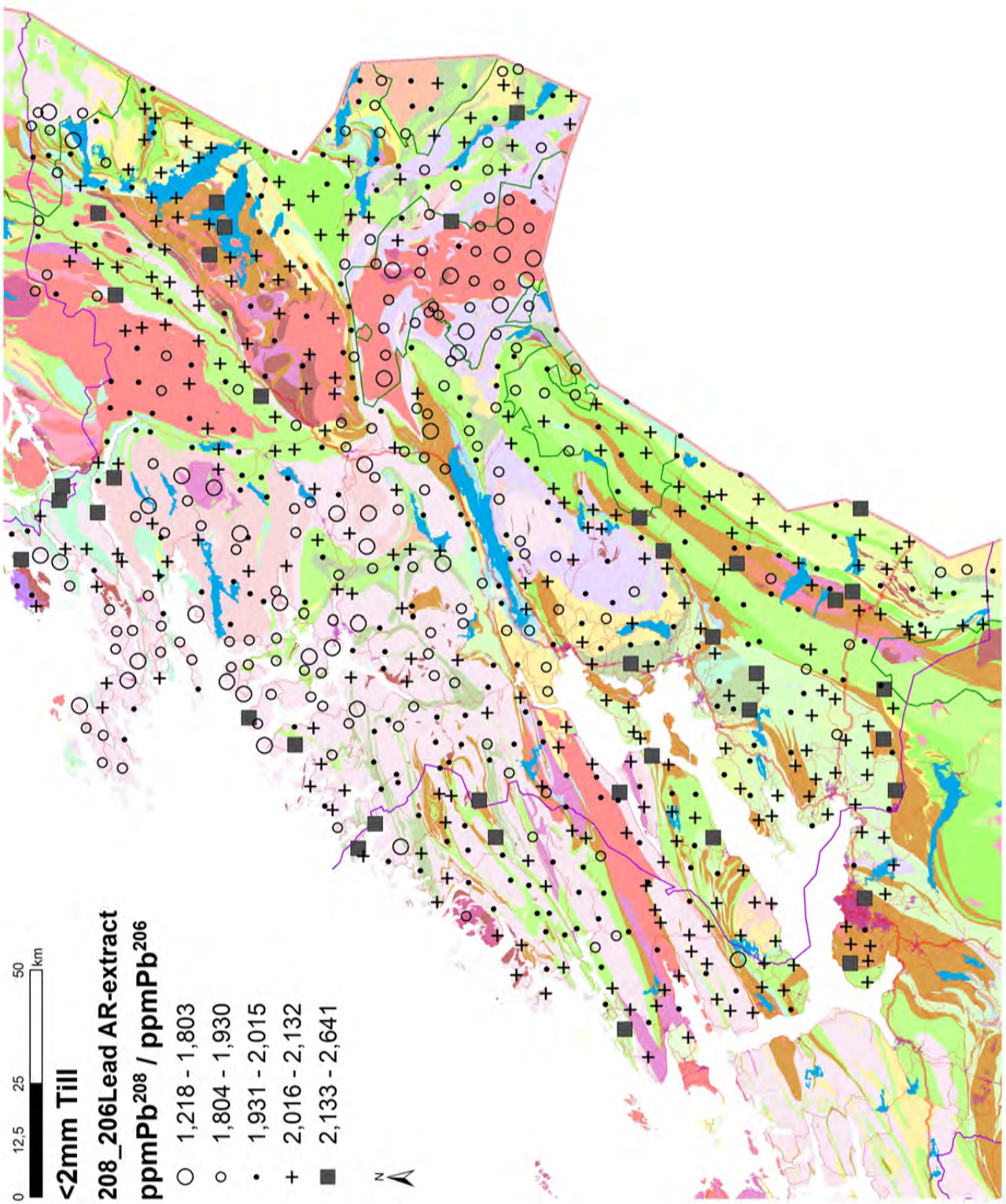

0
12,5
25
50
km
<2mm Till
Phosphorus AR-extract
ppmP
0 - 48
49 - 140
141 - 505
506 - 741
742 - 2109
N

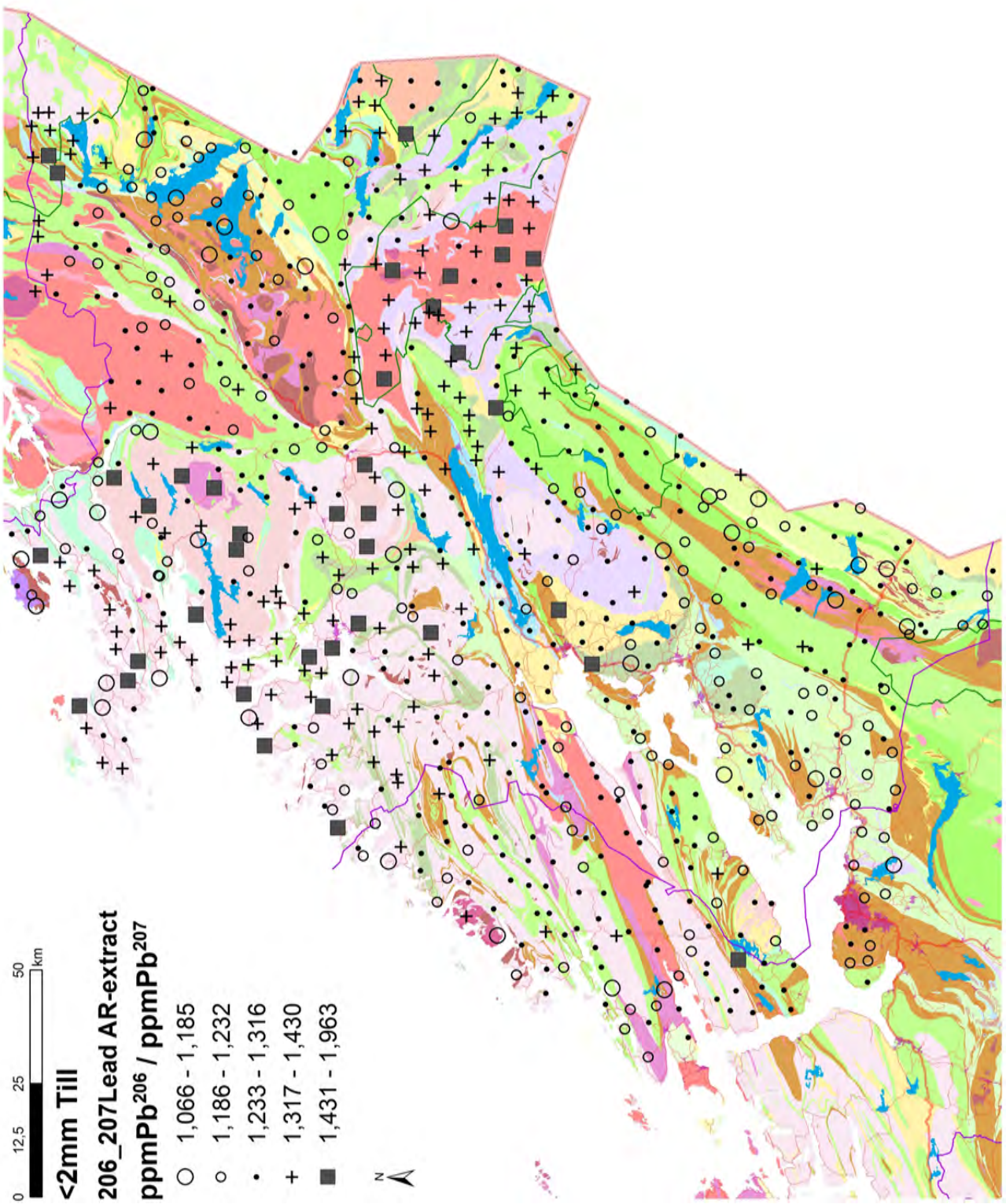

0
12,5
25
50
km
<2mm Till
204Lead AR-extract
ppmPb204
0,01 - 0,03
0,04 - 0,06
0,07 - 0,12
0,13 - 0,18
0,19 - 1,09
N

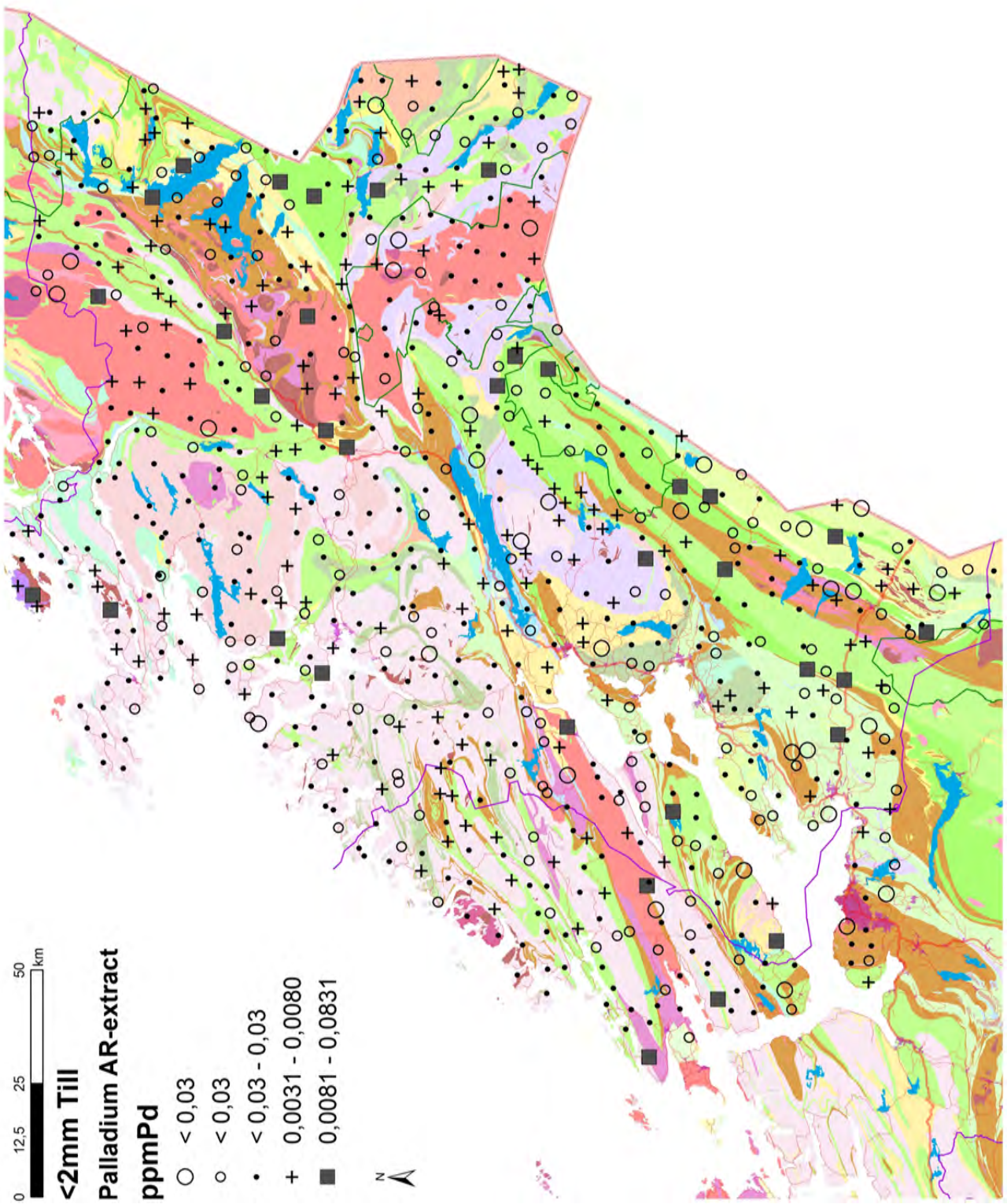

0
12,5
25
50
km
<2mm Till
206Lead AR-extract
ppmPb206
0,1 - 0,7
0,8 - 1,3
1,4 - 2,3
2,4 - 3,5
3,6 - 21,1
N

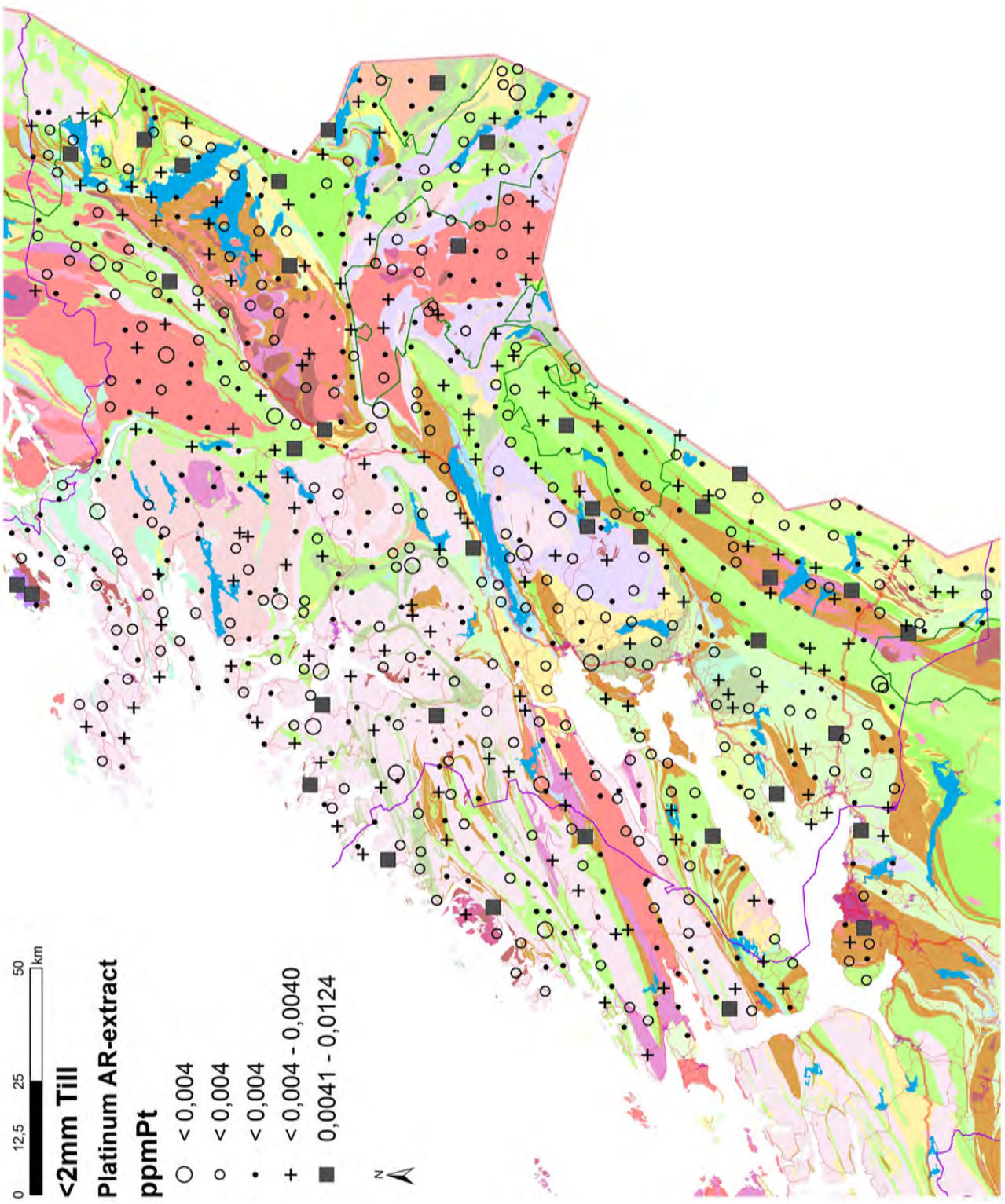

0
12,5
25
50
km
<2mm Till
207Lead AR-extract
ppmPb207
0,1 - 0,5
0,6 - 1,0
1,1 - 1,8
1,9 - 2,8
2,9 - 17,0
N

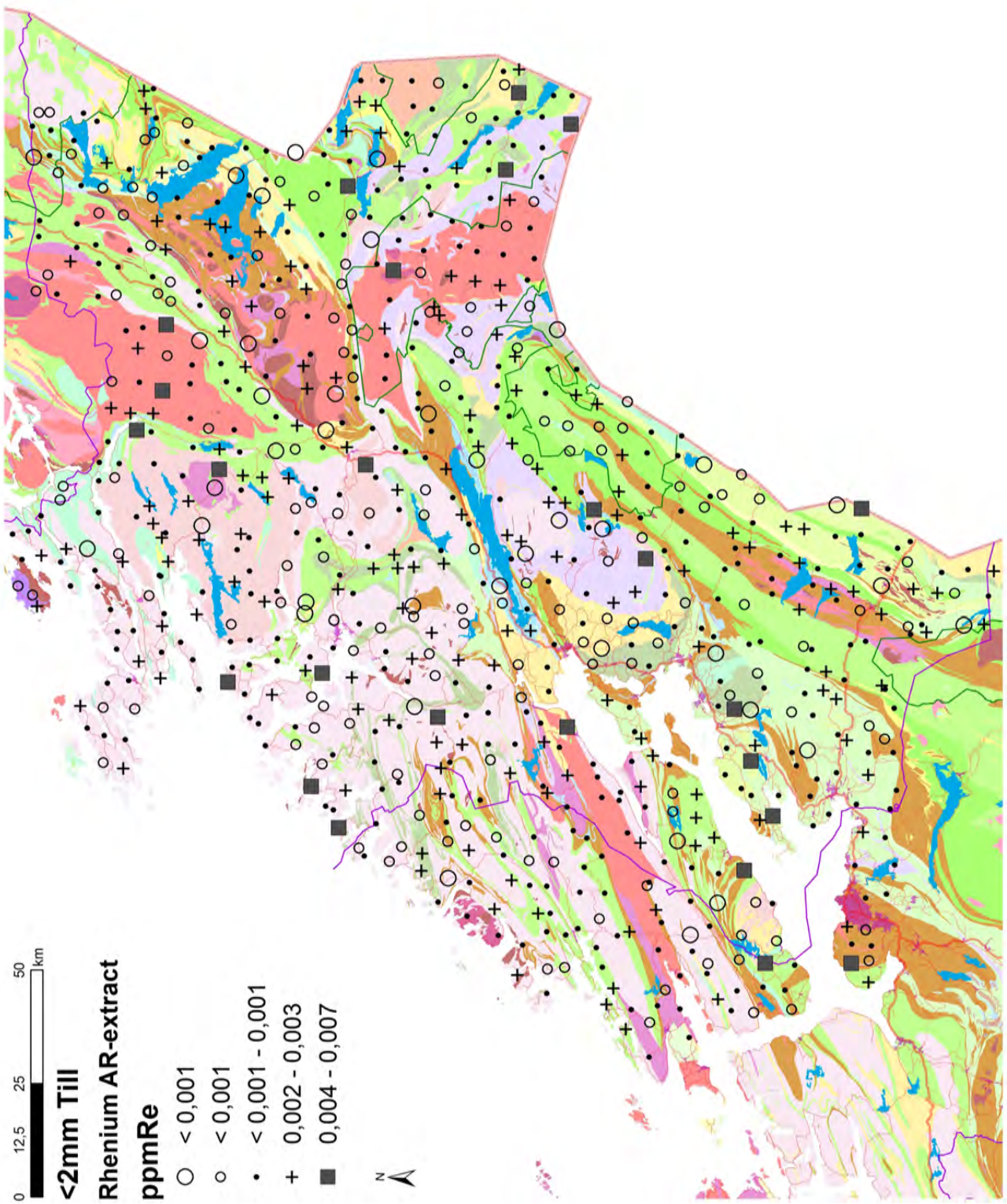

<2mm Till
208Lead AR-extract
ppmPb208
0,2 - 1,3
1,4 - 2,5
2,6 - 4,6
4,7 - 6,9
7,0 - 40,7
0
12,5
25
50
km
N

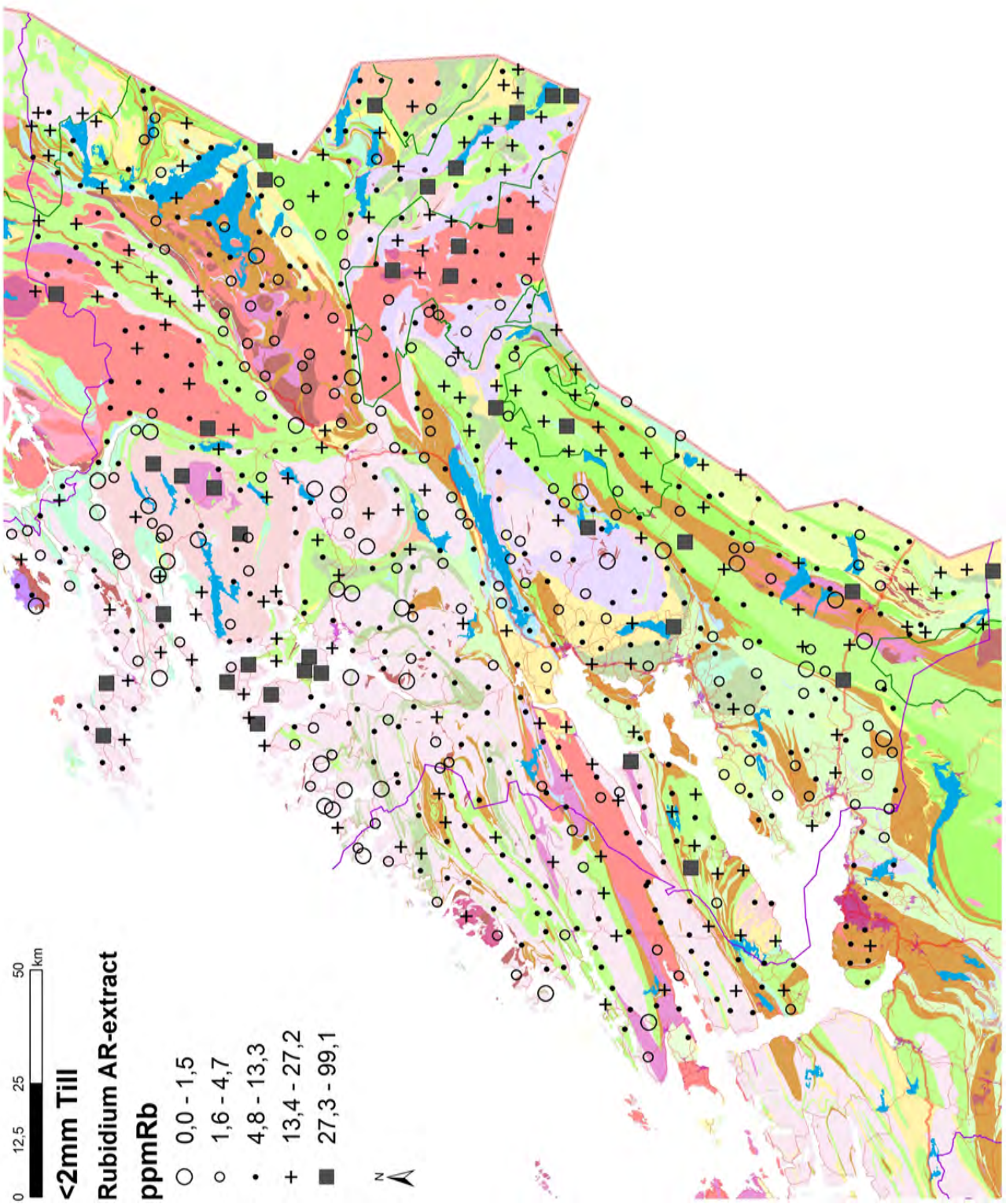

208_206Lead AR-extract
ppmPb208 / ppmPb206
1,218 - 1,803
1,804 - 1,930
1,931 - 2,015
2,016 - 2,132
2,133 - 2,641
<2mm Till
0
12,5
25
50
km
N

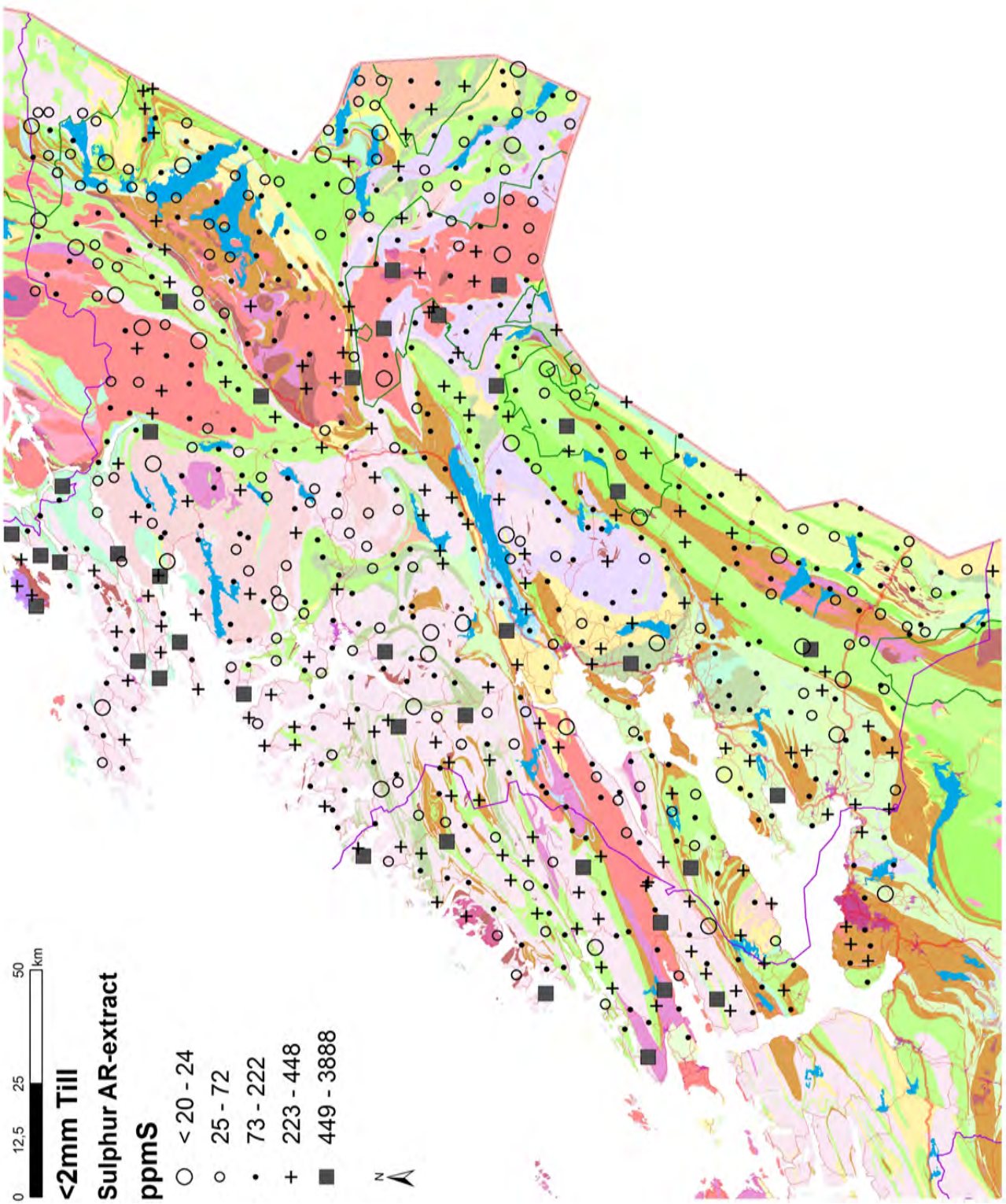

206_207Lead AR-extract
ppmPb206 / ppmPb207
1,066 - 1,185
1,186 - 1,232
1,233 - 1,316
1,317 - 1,430
1,431 - 1,963
<2mm Till
0
12,5
25
50
km
N

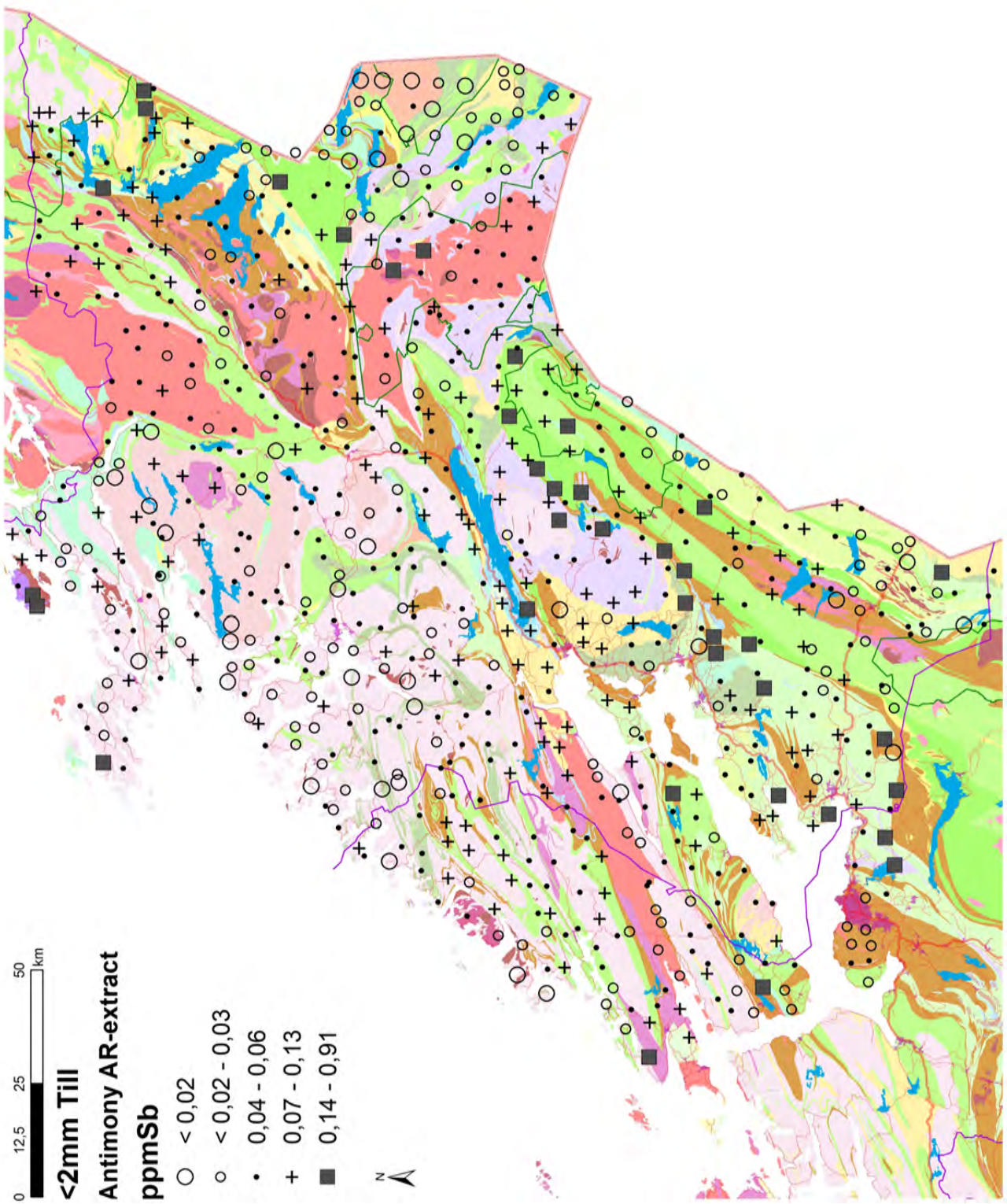

0
12,5
25
50
km
<2mm Till
Palladium AR-extract
ppmPd
< 0,03
< 0,03
< 0,03 - 0,03
0,0031 - 0,0080
0,0081 - 0,0831
N

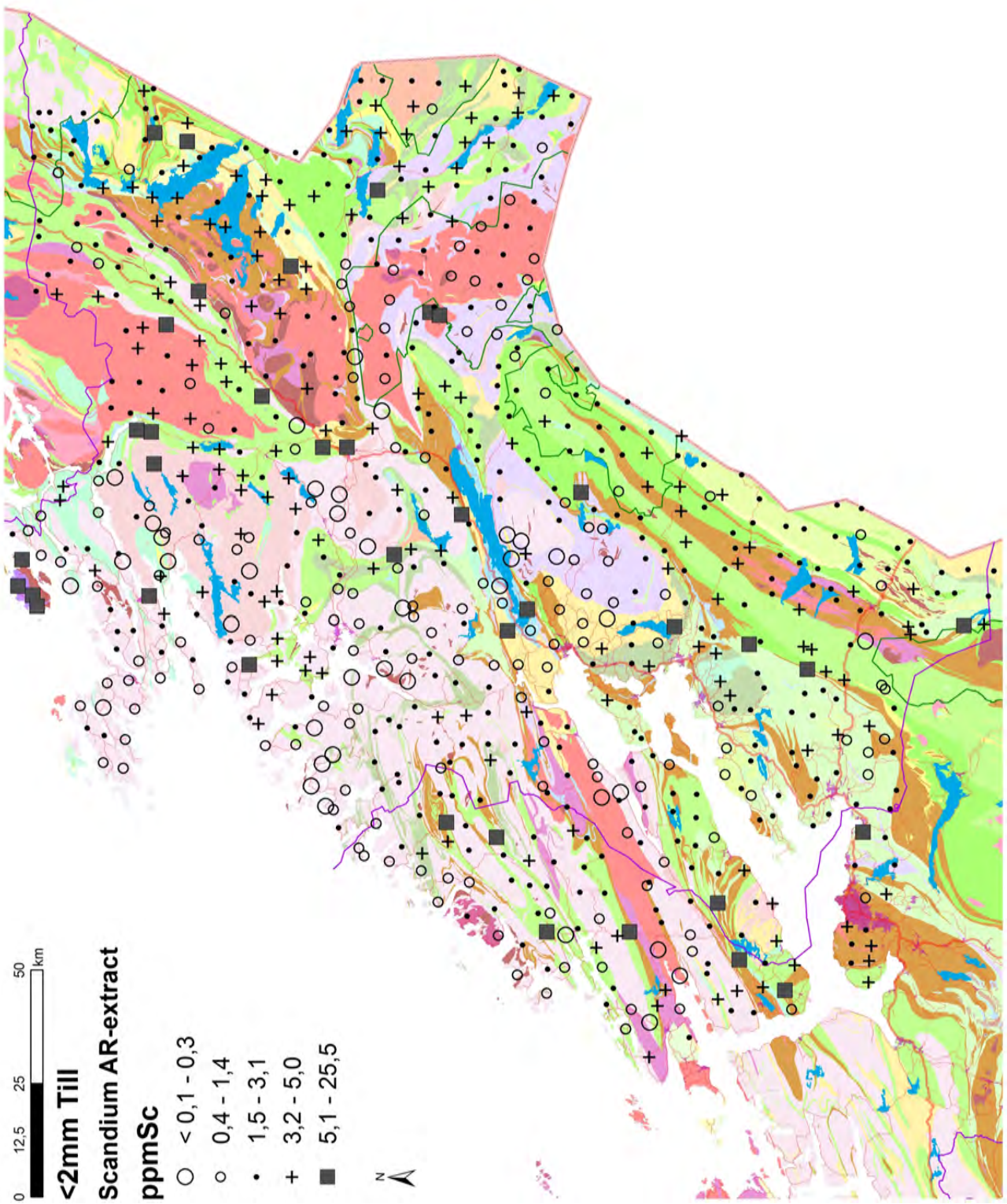

0
12,5
25
50
km
<2mm Till
Platinum AR-extract
ppmPt
< 0,004
< 0,004
< 0,004
< 0,004 - 0,0040
0,0041 - 0,0124
N

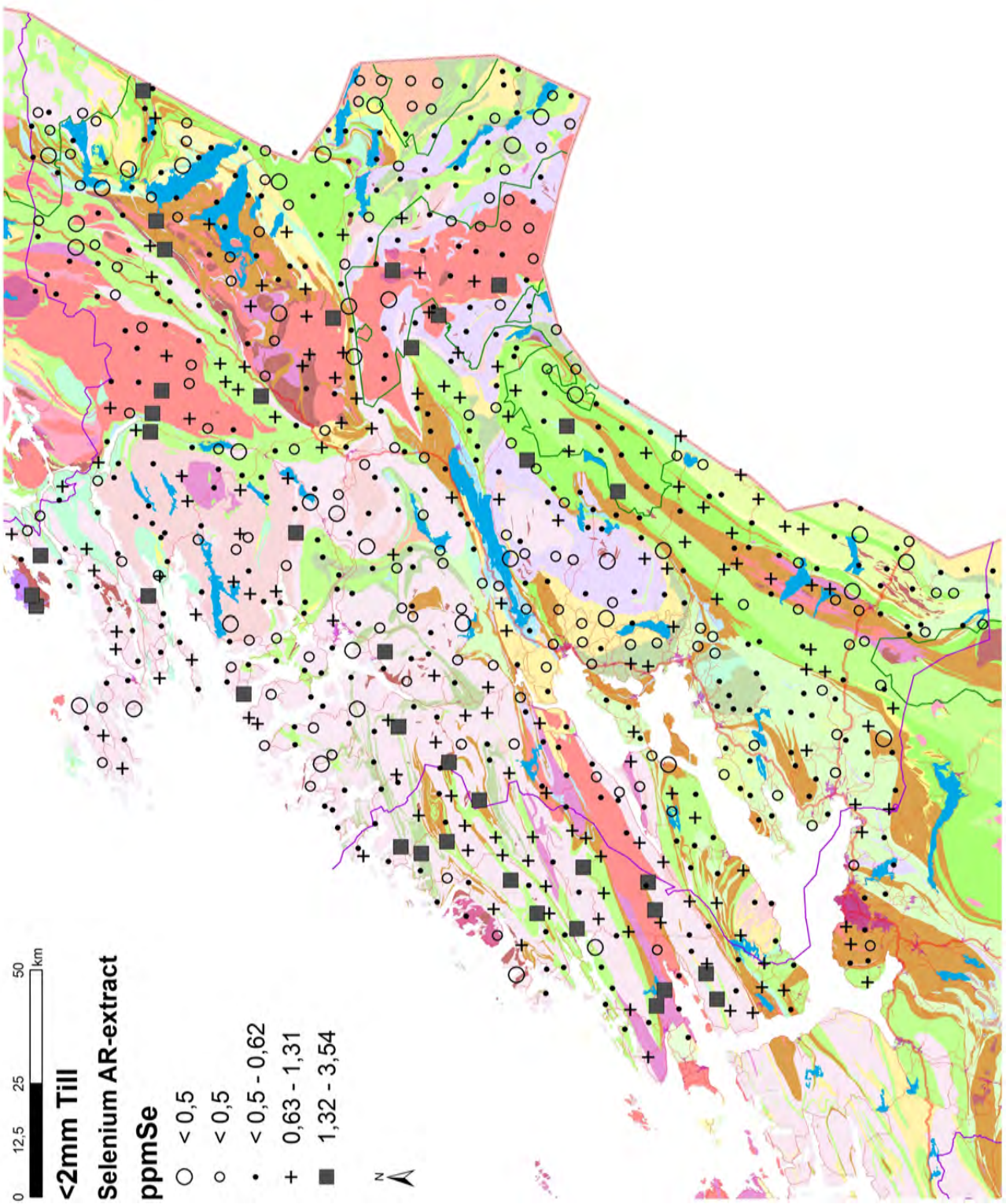

0
12,5
25
50
km
<2mm Till
Rhenium AR-extract
ppmRe
< 0,001
< 0,001
< 0,001 - 0,001
0,002 - 0,003
0,004 - 0,007
N

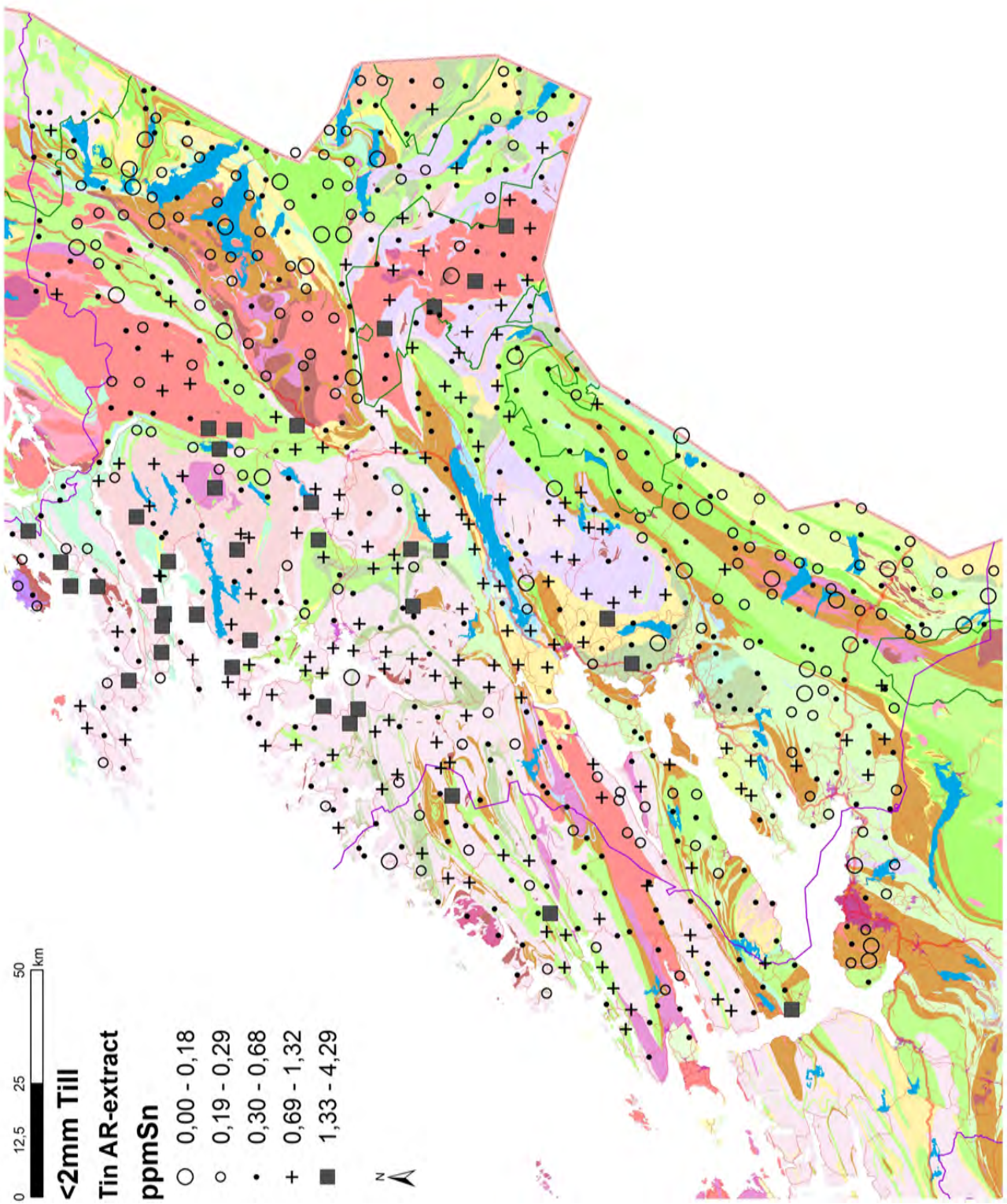

0
12,5
25
50
km
<2mm Till
Rubidium AR-extract
ppmRb
0,0 - 1,5
1,6 - 4,7
4,8 - 13,3
13,4 - 27,2
27,3 - 99,1
N

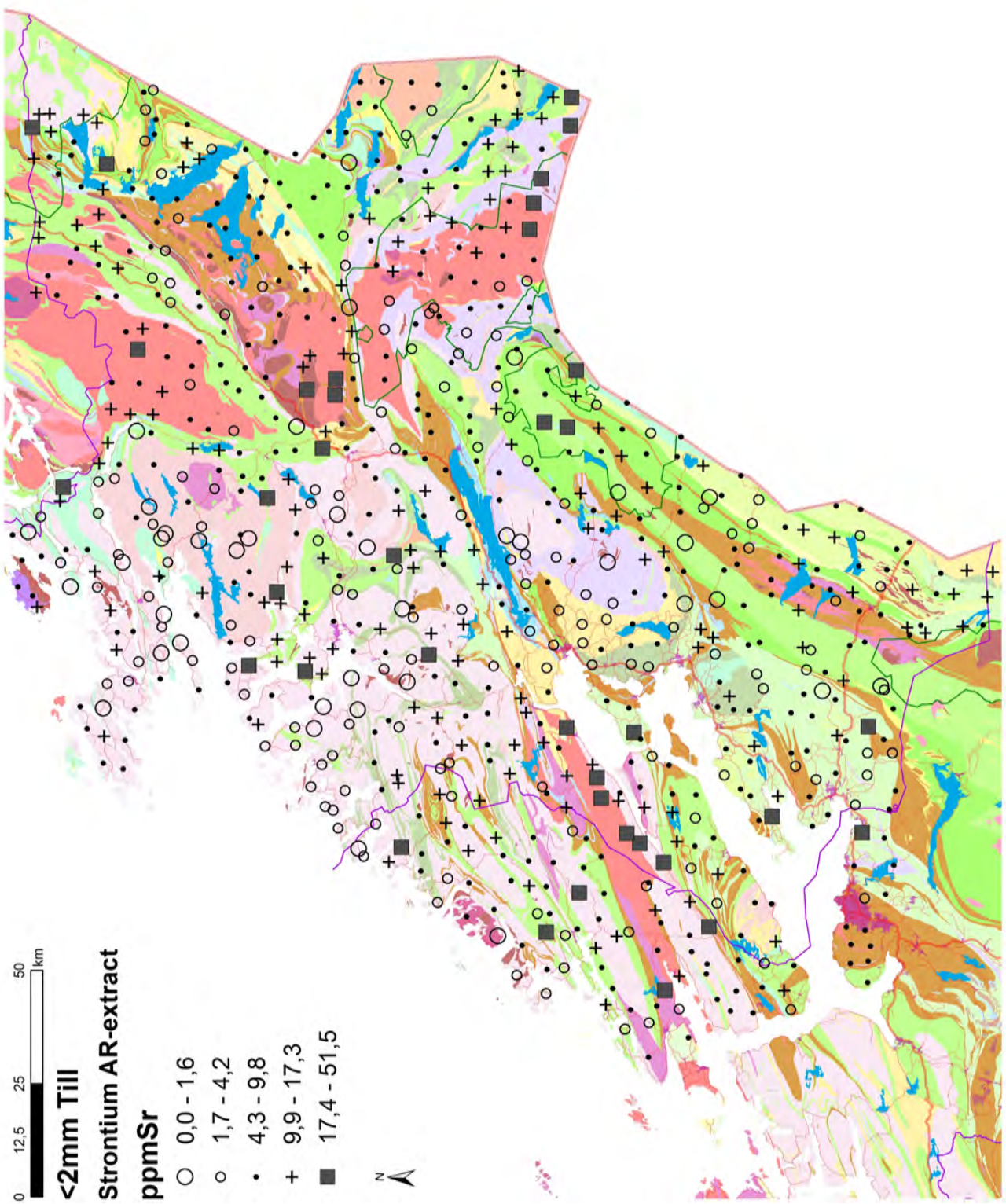

0
12,5
25
50
km
<2mm Till
Sulphur AR-extract
ppmS
< 20 - 24
25 - 72
73 - 222
223 - 448
449 - 3888
N

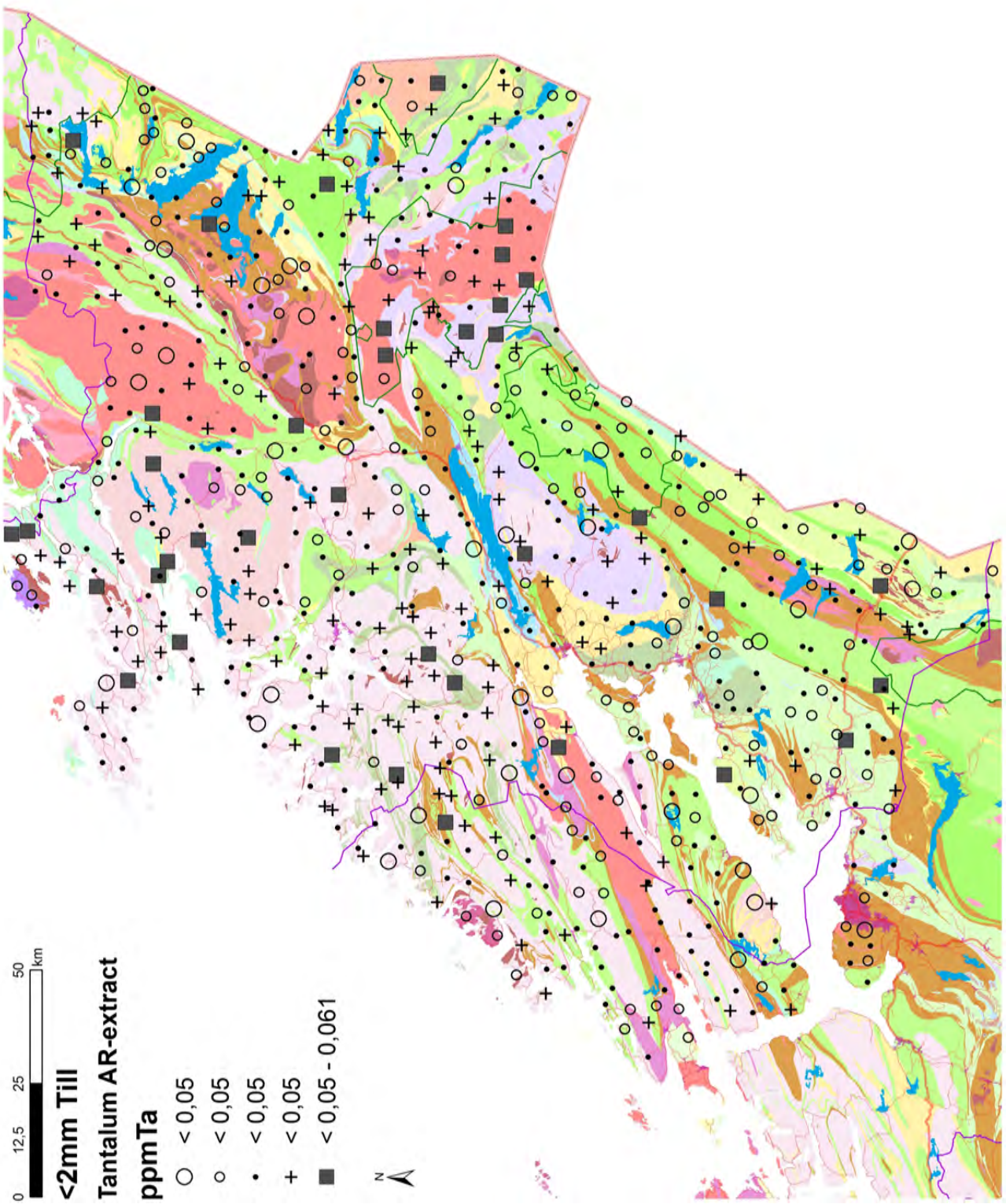

0
12,5
25
50
km
<2mm Till
Antimony AR-extract
ppmSb
< 0,02
< 0,02 - 0,03
0,04 - 0,06
0,07 - 0,13
0,14 - 0,91
N

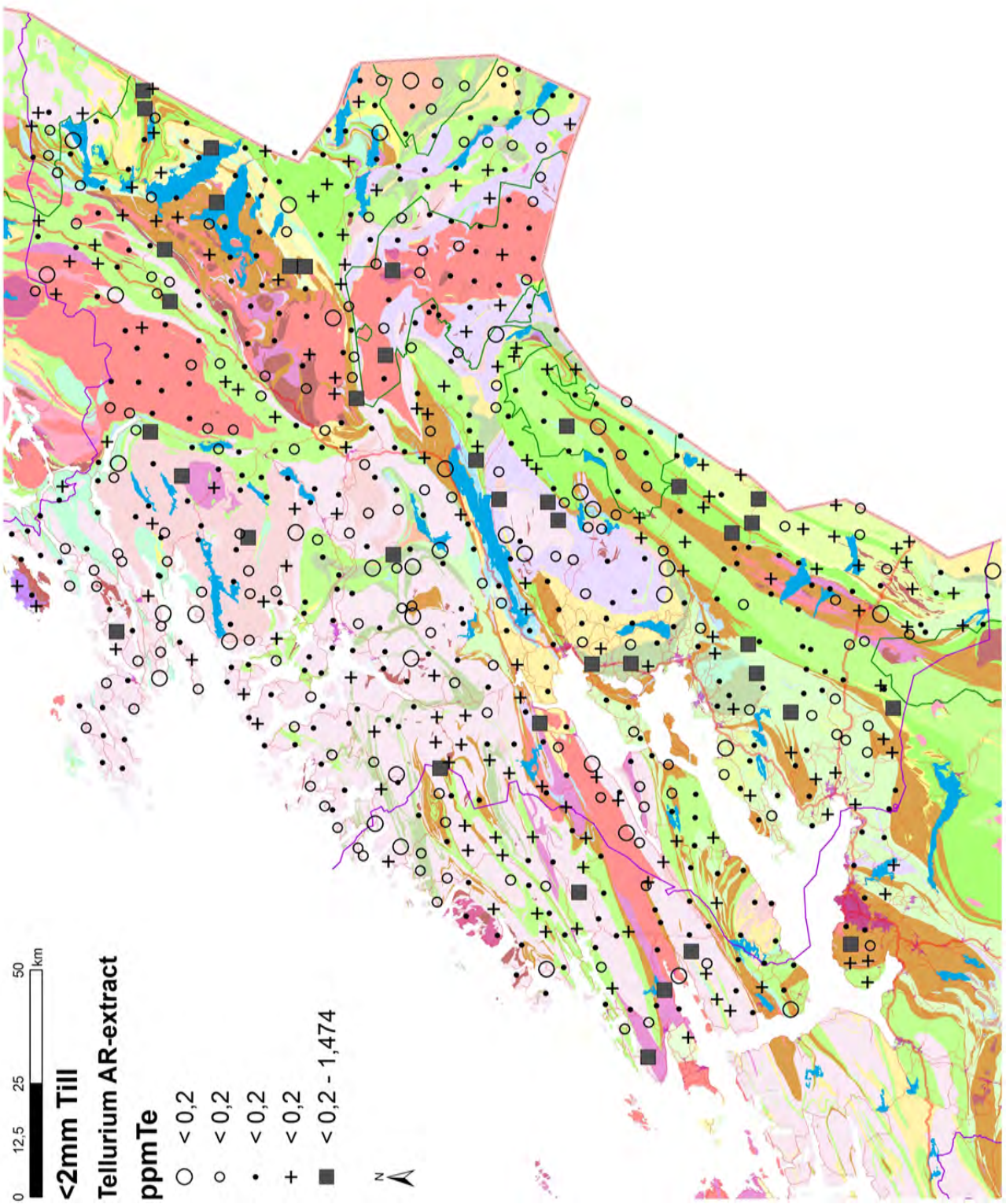

0
12,5
25
50
km
<2mm Till
Scandium AR-extract
ppmSc
< 0,1 - 0,3
0,4 - 1,4
1,5 - 3,1
3,2 - 5,0
5,1 - 25,5
N

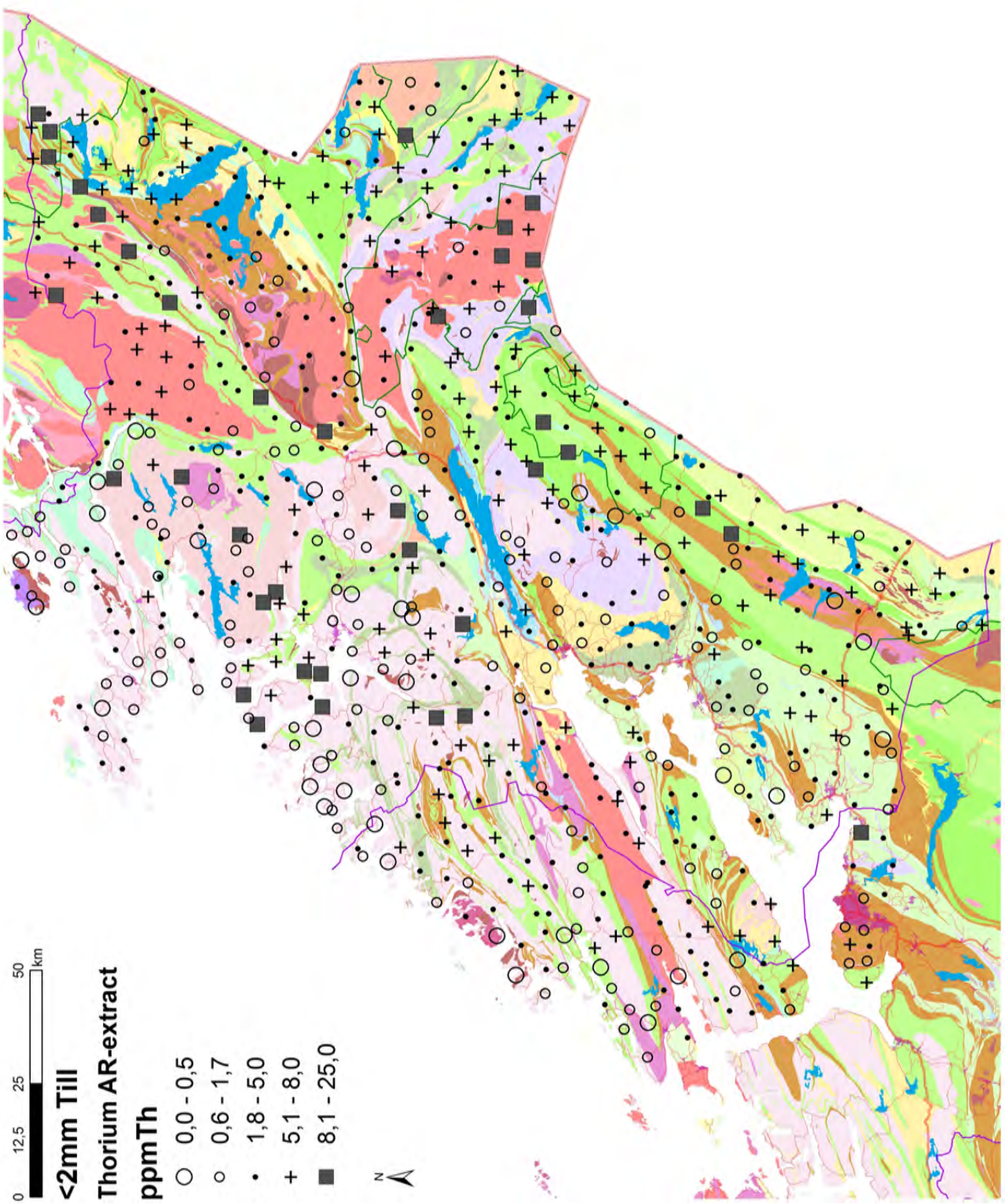

0
12,5
25
50
km
<2mm Till
Selenium AR-extract
ppmSe
< 0,5
< 0,5
< 0,5 - 0,62
0,63 - 1,31
1,32 - 3,54
N

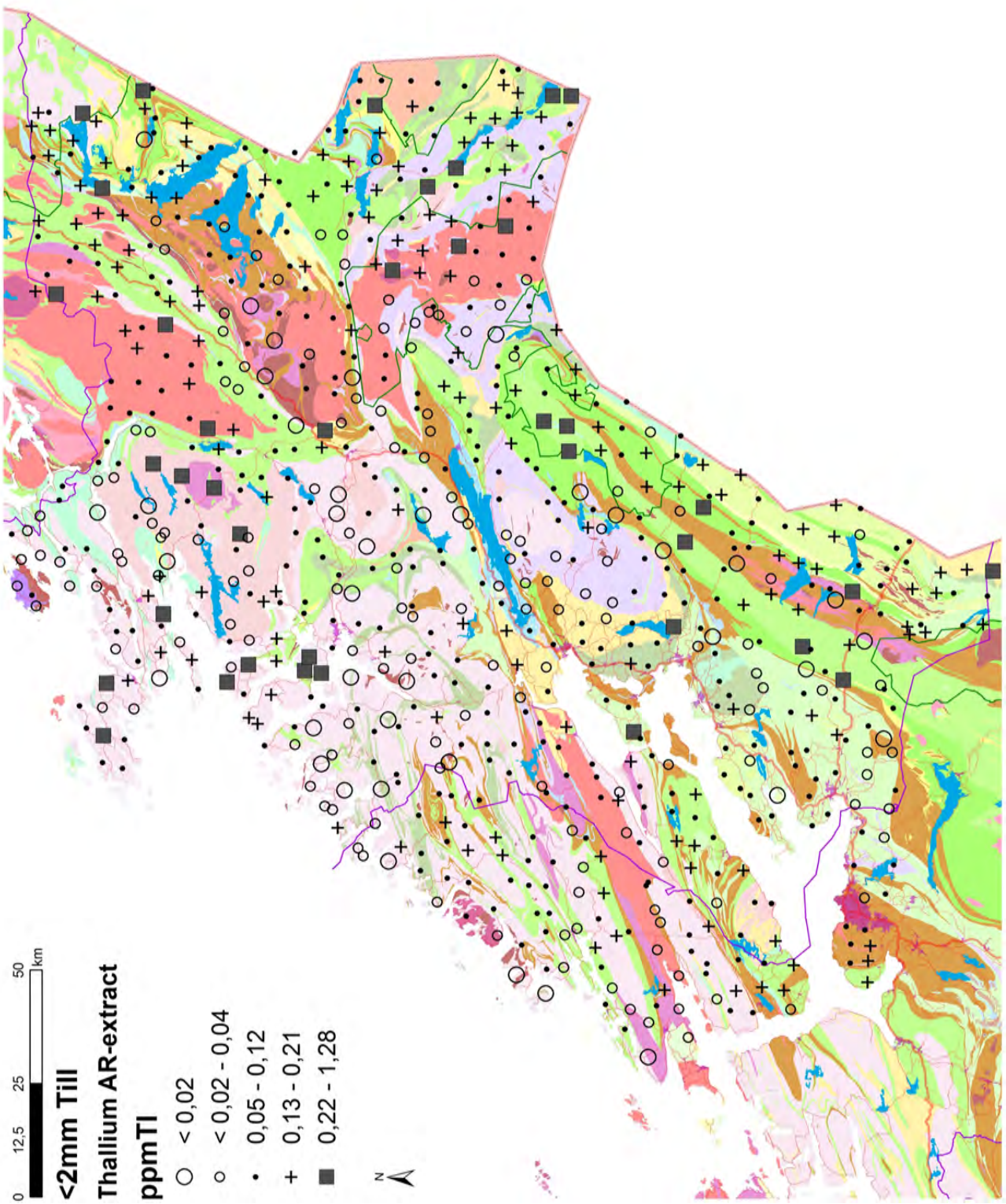

0
12,5
25
50
km
<2mm Till
Tin AR-extract
ppmSn
0,00 - 0,18
0,19 - 0,29
0,30 - 0,68
0,69 - 1,32
1,33 - 4,29
N

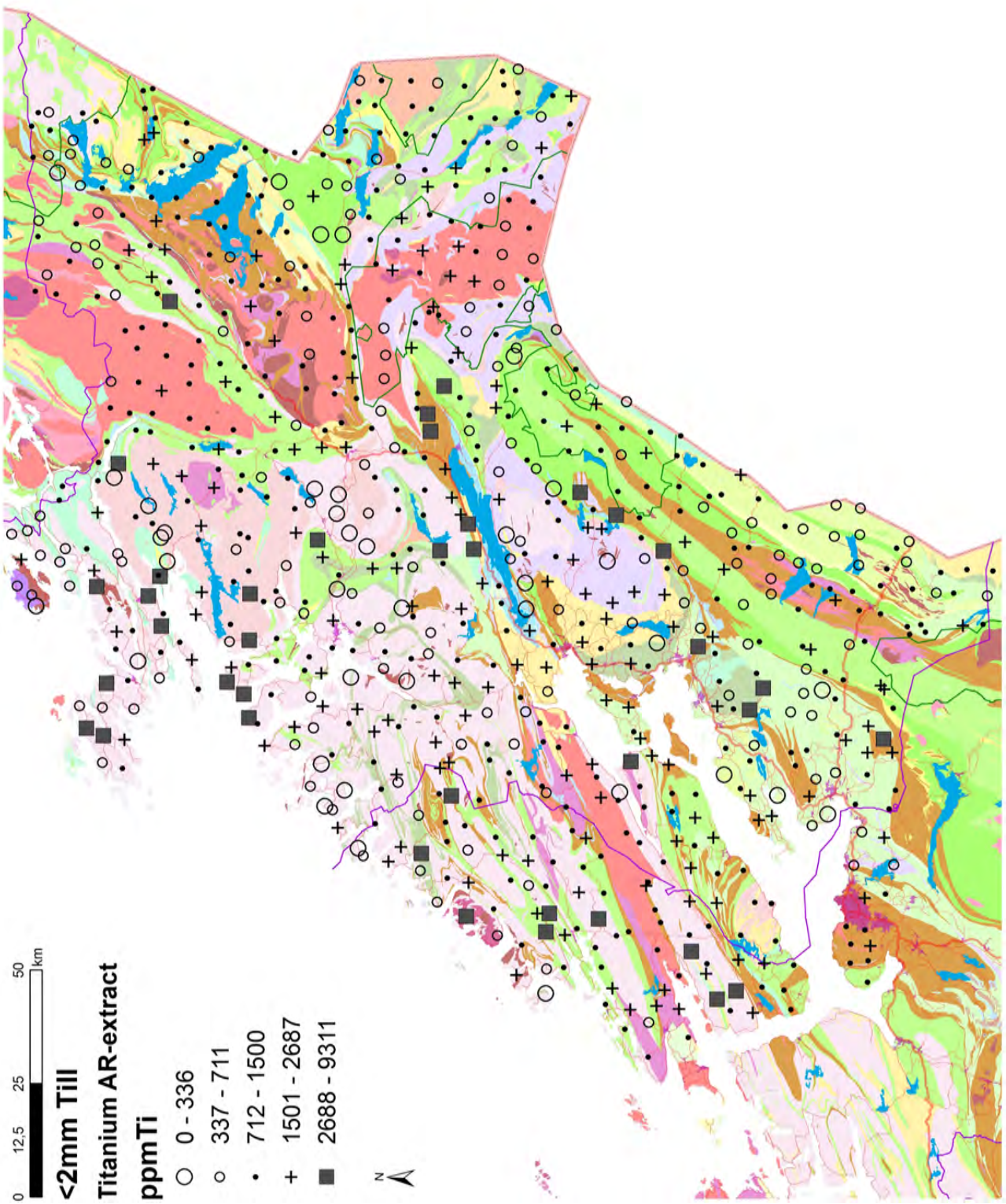

0
12,5
25
50
km
<2mm Till
Strontium AR-extract
ppmSr
0,0 - 1,6
1,7 - 4,2
4,3 - 9,8
9,9 - 17,3
17,4 - 51,5
N

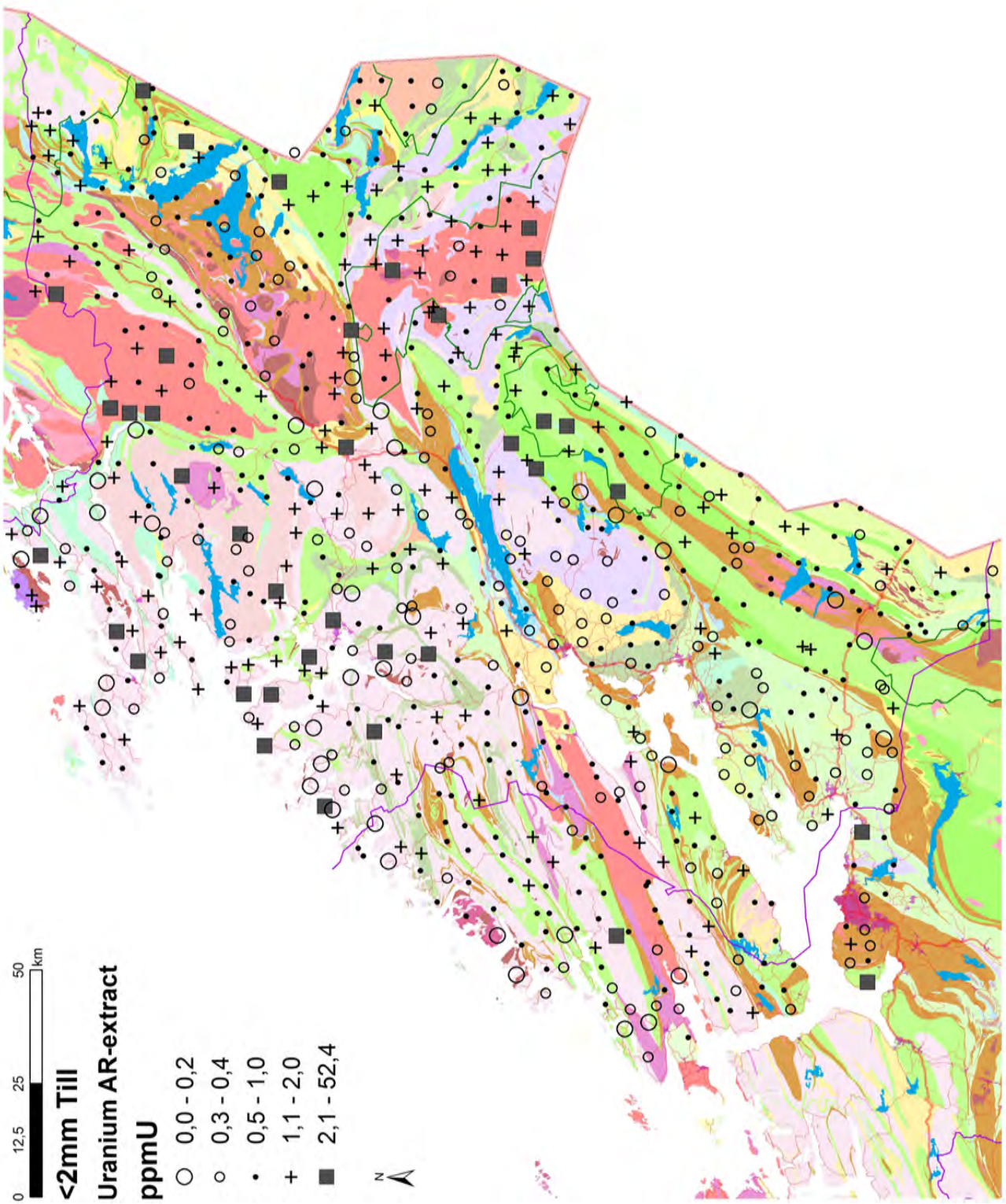

0
12,5
25
50
km
<2mm Till
Tantalum AR-extract
ppmTa
< 0,05
< 0,05
< 0,05
< 0,05
< 0,05 - 0,061
N

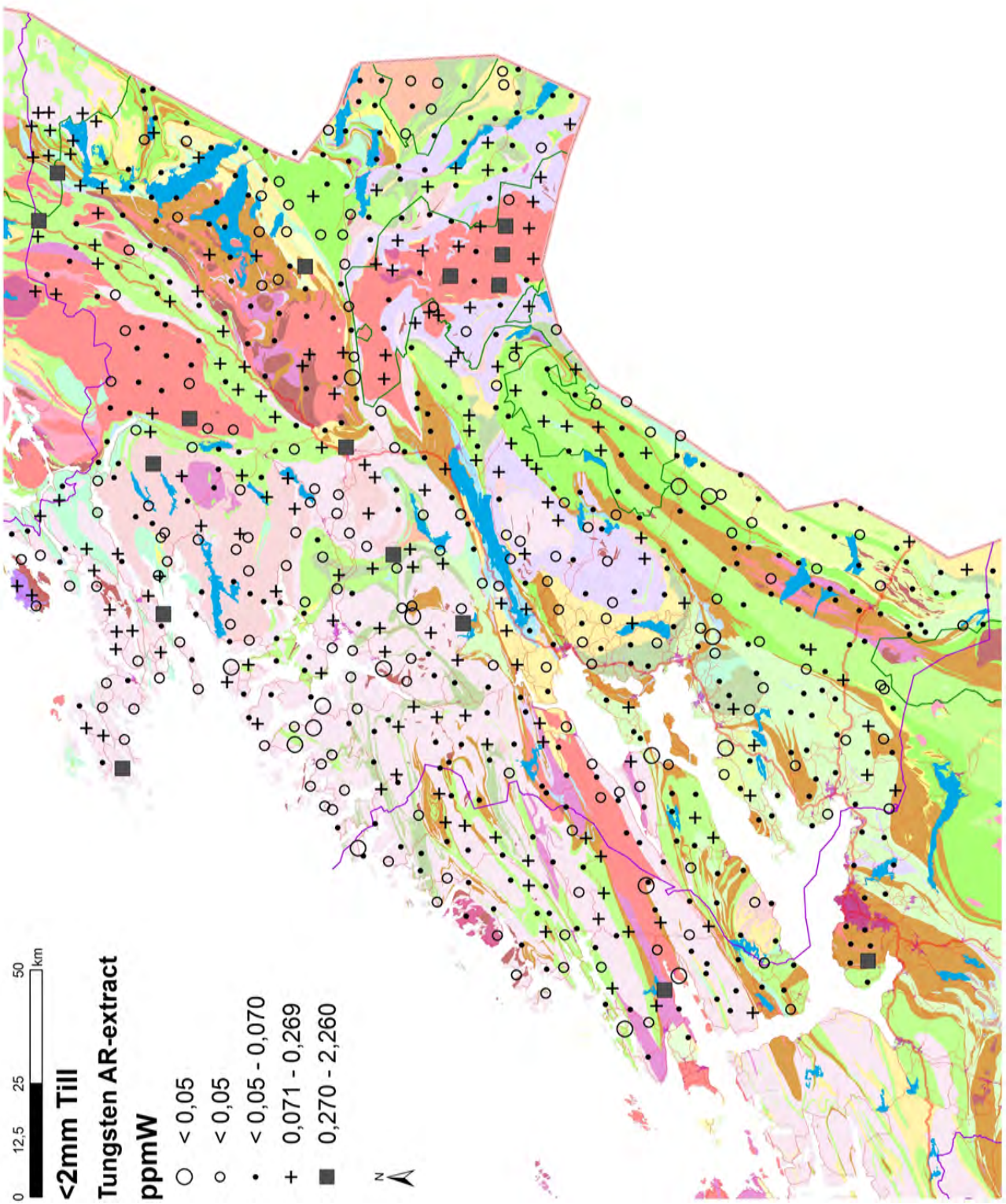

0
12,5
25
50
km
<2mm Till
Tellurium AR-extract
ppmTe
< 0,2
< 0,2
< 0,2
< 0,2
< 0,2 - 1,474
N

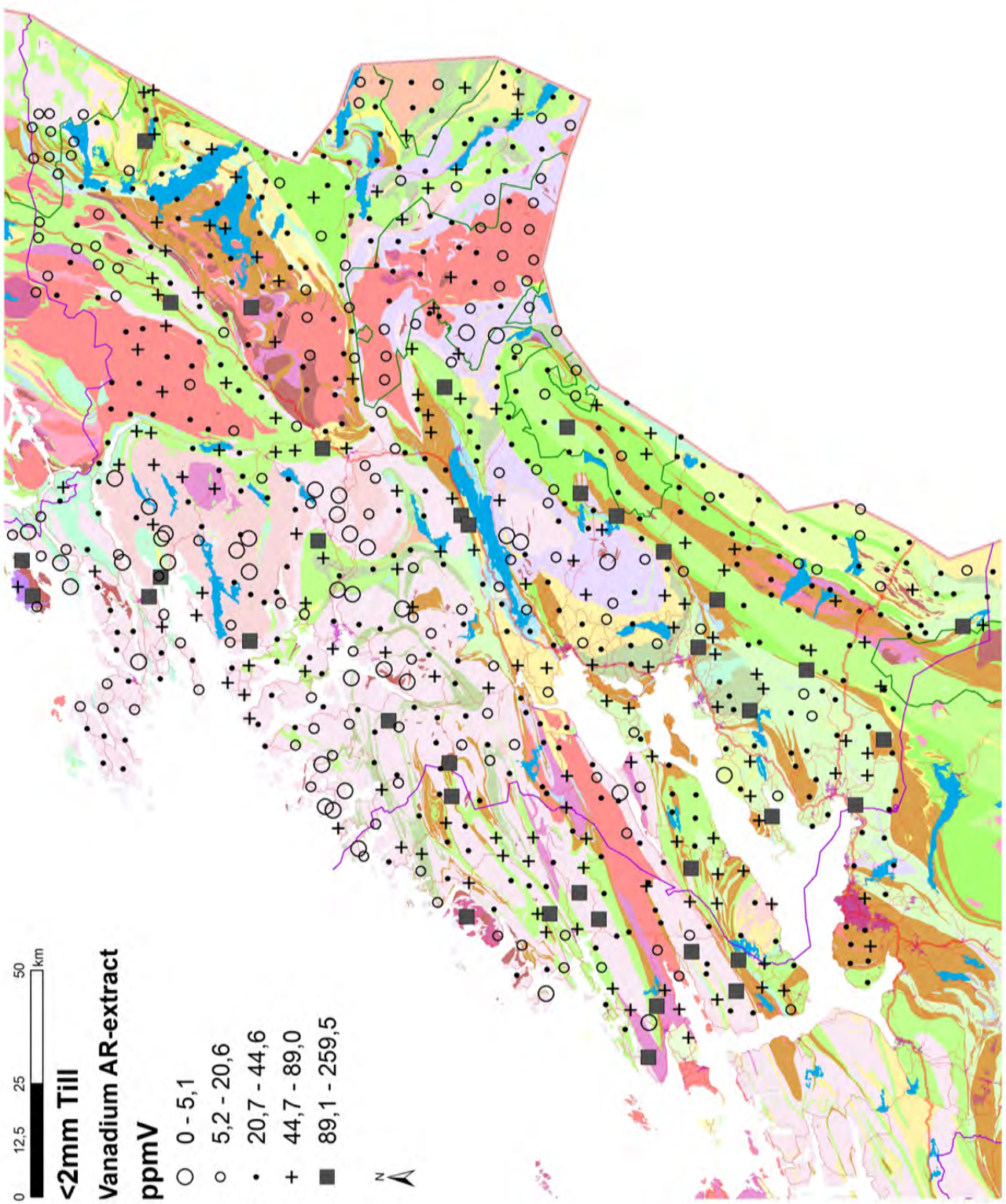

0
12,5
25
50
km
<2mm Till
Thorium AR-extract
ppmTh
0,0 - 0,5
0,6 - 1,7
1,8 - 5,0
5,1 - 8,0
8,1 - 25,0
N

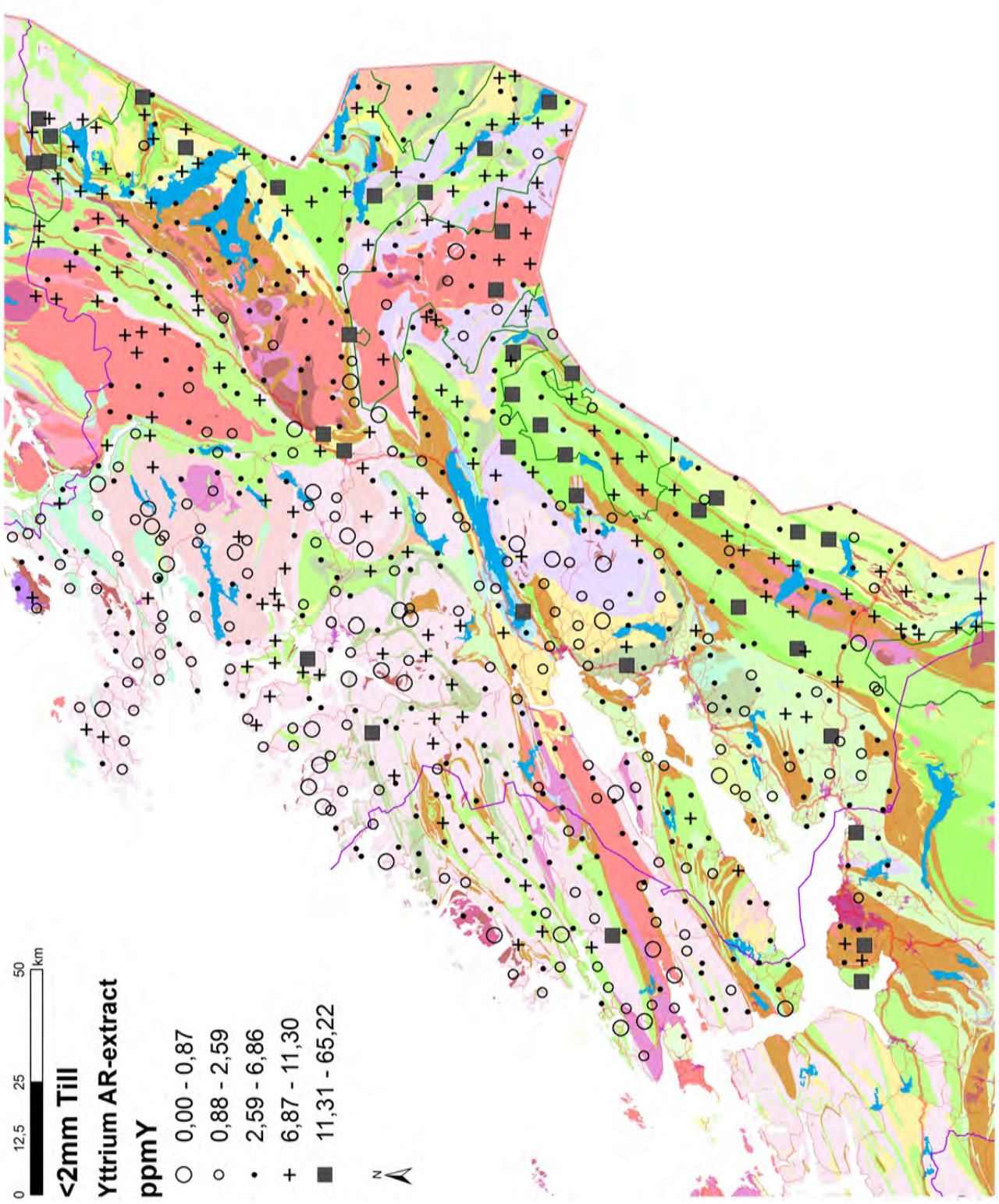

0
12,5
25
50
km
<2mm Till
Thallium AR-extract
ppmTl
< 0,02
< 0,02 - 0,04
0,05 - 0,12
0,13 - 0,21
0,22 - 1,28
N

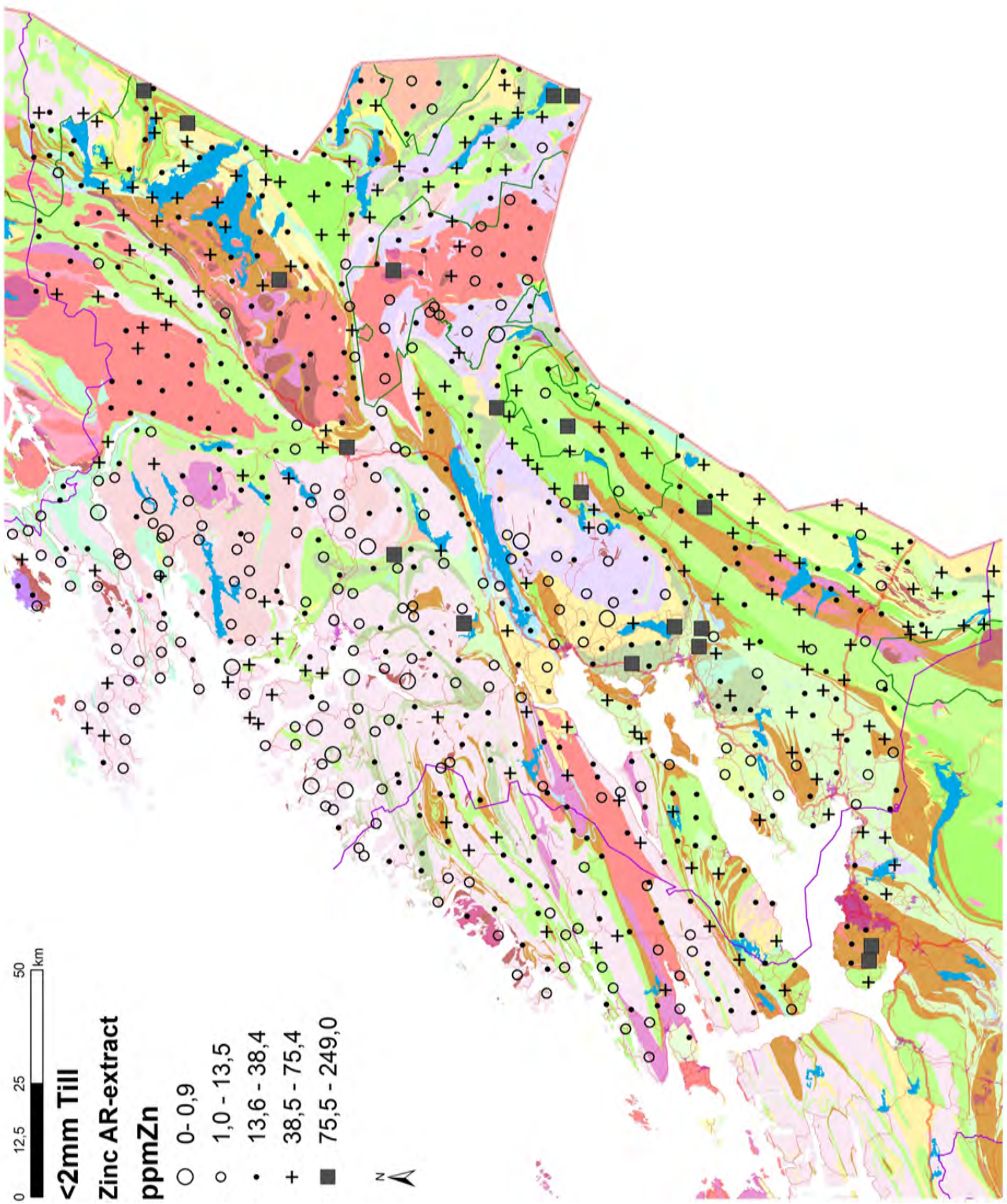

<2mm Till
Titanium AR-extract
ppmTi
0 - 336
337 - 711
712 - 1500
1501 - 2687
2688 - 9311
0
12,5
25
50
km
N

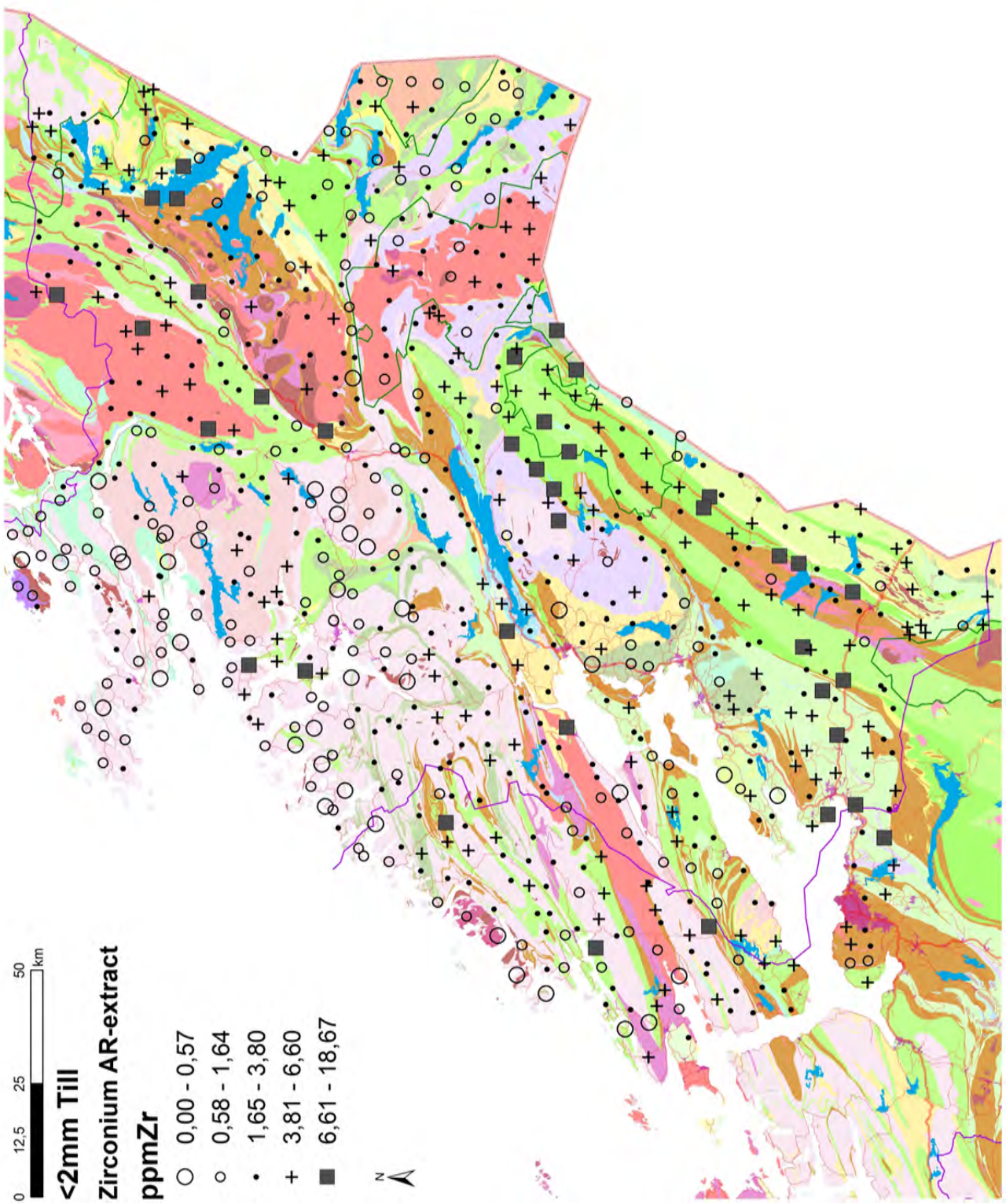

<2mm Till
Uranium AR-extract
ppmU
0,0 - 0,2
0,3 - 0,4
0,5 - 1,0
1,1 - 2,0
2,1 - 52,4
0
12,5
25
50
km
N


0
12,5
25
50
km
<2mm Till
Tungsten AR-extract
ppmW
< 0,05
< 0,05
< 0,05 - 0,070
0,071 - 0,269
0,270 - 2,260
N


<2mm Till
Vanadium AR-extract
ppmV
0 - 5,1
5,2 - 20,6
20,7 - 44,6
44,7 - 89,0
89,1 - 259,5
0
12,5
25
50
km
N


<2mm Till
Yttrium AR-extract
ppmY
0,00 - 0,87
0,88 - 2,59
2,59 - 6,86
6,87 - 11,30
11,31 - 65,22
0
12,5
25
50
km
N


0
12,5
25
50
km
<2mm Till
Zinc AR-extract
ppmZn
0- 0,9
1,0 - 13,5
13,6 - 38,4
38,5 - 75,4
75,5 - 249,0
N


<2mm Till
Zirconium AR-extract
ppmZr
0,00 - 0,57
0,58 - 1,64
1,65 - 3,80
3,81 - 6,60
6,61 - 18,67
0
12,5
25
50
km
N