DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2013/15

Predictive gold potential in entire southern West Greenland assessed by geological experience, artificial neural network and self-organizing maps analysis

Bo Møller Stensgaard (ed.)

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
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Contents

Introduction

By Bo Møller Stensgaard

This report presents the results of three different approaches to gold mineral potential mapping in the entire southern West Greenland. In a rather inaccessible and large area like Greenland, efficient use of data and the precise targeting of a geological phenomenon (in this case potential gold mineralised environments) are of great importance. Prior to this study, application of multivariate statistical modelling for mineral potential mapping in southern West Greenland was restricted to the Nuuk region as reported in Stensgaard (2008) and references therein. They used both a qualitative empirical approach and a model-driven approach for prediction of areas with gold mineralisations. The current study extends the analysis of the gold potential to the entire southern West Greenland (~61° to 67°N).

The first approach to the mapping of geological environments and thereby mineral potential mapping is a qualitative knowledge-driven approach, in which geochemical distribution functions from regional stream sediment samples are assessed and interpreted based on the geologists' experience and knowledge. Certain signatures in regional aeromagnetic data and the locations of known mineralisations are used to support the interpretation of the geochemical data. Single or combined parameters in the data sets used to recognise specific geological domains and the potential for gold mineralisations are presented.

The second approach is a quantitative unsupervised data-driven, artificial neural network analysis carried out on a variety of data sets. The selection of data sets are partly guided by an earlier multivariate statistical study in the Nuuk region, in which data signatures of gold occurrences were identified (Stensgaard 2008 and references therein). Forty-five training points covering the central Nuuk region, each representing a 200×200 m area in which one or several rock samples have yielded ≥1 g/t Au (our heuristic definition of a 'gold mineralised environment'), were used to train the neural network to recognise the characteristic data signatures of the training points in a variety of re-analysed data sets. The 'experience' gained by the artificial neural network in this way was then used to find similar signatures in data sets that covered the entire southern West Greenland. Several areas with favourability for gold are predicted by this approach. Follow-up in one of the areas together with investigations of the possible causes of the data signature of the specific geological environments predicted to be favourable for gold were conducted during fieldwork in 2009 and reported in Schlatter & Stensgaard 2012.

The third approach is a Self-Organising Map analysis (SOM) which identifies data distributions and correlations between different data types in a multidimensional data space. The selection of the geochemical elements included in this approach were guided by those traditionally seen as pathfinder elements for gold, and by elements that had been identified as characteristic for gold in previous studies of southern West Greenland.

The three different approaches are complementary to each other. The purpose of this report is therefore not to rank the different approaches, neither is it the intention to make a conclusion on the exact extent and position of favourable tracts (metallogenetic provinces/areas) for gold. The purpose is primarily to discuss and illustrate the different approaches of accessing the mineral potential for gold in southern West Greenland and provide exploration with input and inspiration for their own decisions and evaluations on where to go and do further investigations.

Summary of primary results

Several areas with favourability for gold (mineral potential mapping) are predicted. At the same time, the signatures of specific geological environments, known and new potential gold mineralised environments are also identified and investigated. Parts of the results presented here were used to guide the fieldwork conducted in 2009 (see Schlatter & Stensgaard 2012).

All three approaches used in the mineral potential mapping have provided valuable input to the identification and characterisation of areas already known to host gold mineralised environments and offered predictions of other areas favourable for hosting undiscovered gold mineralised environments. When viewing the results, it is important to keep in mind that we are dealing with regional data sets at a resolution that does not allow distinguishing spatially small gold targets. Instead, the data are utilised for pointing to areas that include favourable environments for gold mineralisations.

The supervised knowledge-driven approach was carried out for the region between Paamiut (62°N) and Sukkertoppen Iskappe (66°N). Geochemical and aeromagnetic signatures and anomaly patterns have clearly been related to lithological units and geological domains. According to this study, an under-explored arc-shaped belt termed Majorqaq in the northern part of the region, stretching eastwards from Maniitsoq to the Inland Ice contains many similarities to the well-known gold mineralised central Nuuk region. Also the northeastern part of the Bjørnesund belt, north of Frederikshåb Isblink is pointed out as being an area with settings indicative of a potential for gold mineralisations.

The neural network analysis were carried out for the region between Kobberminebugt in the south (~61°15'N) to north of Sukkertoppen Iskappe (66°35'N). Trained on known gold mineralised environments in the central Nuuk region, it very clearly outlines other known gold mineralised areas in southern West Greenland; e.g. the Sermiligaarsuk–Paamiut and Tartoq areas. This validates the likeliness, or capability, of the method to predict also hitherto unknown areas with a potential for gold mineralisations. The data sets analysed, either separately or in different combinations, are:

- regional stream sediment distributions of As, Cs, Rb, Th, U and the Ni/Mg ratio
- aeromagnetic data (total field and different derivatives)
- lineaments extracted by processing of gridded aeromagnetic data
- distribution of lithological units (supracrustal and mafic units) in the published 1:500 000 scale geological maps for southern West Greenland (Escher & Pulvertaft 1995; Keulen *et al.* 2010b)

New areas without an already established gold potential (areas without already known gold occurrences) are predicted by the neural network analysis in various parts of southern West Greenland. Of these, several contain indications (e.g. reports on samples with elevated gold, descriptions of mineralisations) that gold mineralisations might be present; e.g. in the Ivittuut – Arsuk Fjord area, the Bjørnesund area and Fiskenæsset area. Other areas, like the Isorssua area and the Sarqap Sermia – Sukkertoppen area, do not contain any reported indications of gold.

The self-organizing map (SOM) analysis appears to be a strong tool for delineating relationship between different geochemical elements. The SOM analysis was carried out for the region between Paamiut (62°N) and Sukkertoppen Iskappe (66°N). Instead of working on gridded data sets as for the two other approaches, this analysis was carried out on point-data representing individual stream sediment samples. Input data to the SOM were the geochemical elements As, Ce, Cs, La, Mo, Rb, Sr, Th, U, W, Zn, Zr and the Ni/Mg ratio. Only some of the stream sediment samples were analysed for Au and the SOM analysis was therefore carried out without including any Au-data as input. Instead, we compared by visual inspection the data clusters from the SOM analysis with the associated maps showing the Au concentration data for those samples analysed for gold. In this way it was possible to identify clusters based on As, Ce, Cs, La, Mo, Rb, Sr, Th, U, W, Zn, Zr and the Ni/Mg ratio that are associated with high gold concentrations. Samples belonging to these clusters, but not analysed for gold, are expected to originate from areas with a higher potential for gold compared to other clusters. A display of clusters in a geographic map shows that samples found to be associated with high gold concentrations (either measured or predicted) grouped into certain areas. The well-known gold endowed Nuuk region, including the area at Isukasia, and the gold mineralised area at Paamiut, were clearly picked up by the SOM analysis in this manner. The SOM analysis delineated areas that coincide with areas where samples with elevated gold concentrations have been reported, but where no or little information on identified gold mineralisations and/or occurrences are known from previous studies. This may indicate a generally good gold potential of the areas located around Ravn Storø, Bjørnesund and Fiskenæsset. Similarly, north of Nuuk at Sarqap Sermia and at Majorqaq, areas were outlined with an inferred good potential for gold.

When results of the three approaches are compared, there is a high degree of similarity in which areas are delineated as probably having a good gold potential. This is not surprising as they were carried out on the same data sets (for most of the analysed area), especially the stream sediment geochemistry data, but it still demonstrates a consistency of results obtained from the three approaches utilised. Differences in the resulting gold potential can often be attributed to differences in the input data. Careful evaluations of these differences can contribute to the interpretation of the overall results. It has not been the intention in this work to rank the different areas outlined a favourable for gold relative to each other.

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Analysis of regional data sets: Assessments of mineral potential based on geological experience

By Agnete Steenfelt & Bo Møller Stensgaard

Introduction

The present data analysis is biased by education, i.e. experience with interpretation of regional data sets. The objective is to give examples of single or combined parameters that may be used to recognise the geochemical and geophysical signature of specific geological units and mineralisation in regional data sets.

The study area covers a greater part of the Archaean craton in West Greenland, where post-Archaean events are limited to Palaeoproterozoic dolerite dykes and local Neoproterozoic and Jurassic carbonatites and lamprophyres. Known metal mineralisation comprise iron, gold, chrome; known mineral occurrences comprise olivine, diamond, and ruby.

The Nuuk region, in the centre of the study area, has been the subject of multi-parameter data analysis directed towards identifying parameters associated with gold mineralisation, but as a side effect, the geochemical and aeromagnetic properties of supracrustal environments was recognised (Appel *et al.* 2003; Hollis *et al.* 2004; Hollis (ed.) 2005; Nielsen *et al.* 2004, Nielsen *et al.* 2005).

The region to the north and south of the Nuuk region is less well known, and the available data have not previously been analysed together with the objective of identifying regional features indicating mineralisation or environments favourable to mineralisation.

The present contribution to the data analysis does not intend to be exhaustive. Rather it is an attempt to serve as base for comparison with an unbiased data analysis.

Data available

Stream sediment chemistry

Data represent chemical analysis (major and *c.* 30 trace elements) of the less than 0.1 mm grain size fraction of stream sediment samples collected in first, second or third order streams with upstream catchment basin of less than 20 km^2, and an average sampling density of 1 sample site per 30 km^2 (Steenfelt 1999, Steenfelt 2001ab). Stream sediment is a mixture of glacially eroded and weathered rock material largely from within the catchment basin. Relative to rock composition, fine fraction has enhanced concentration of ore minerals like gold, sulphides, small, hard and heavy accessory minerals (e.g. zircon, apatite, monazite, ilmenite, chromite, magnetite, garnet) and reduced concentrations of light, flaky minerals like micas and sericite (from weathered feldspar). This means that the chemistry of stream sediment fine fraction compared with the source rocks exhibit an increase in Fe, Ti, P, As, Au, V, Zr and decrease in K, Rb, Sr, Ba.

The geochemical maps presented here are contoured grid images, based on grids with a cell size of 5 by 5 km. Composite grids have been used to display where single element distribution patterns overlap.

Rock chemistry

Data represent the chemical composition of samples of rock collected with purposes of geological mapping and mineral exploration. With one exception, rock samples are not collected to reflect regional variation, and many are collected to document mineralisation rather than to be representative of the host rock. The rock data are used to display the distribution of high concentrations of certain ore forming elements.

Aeromagnetic data

Data represent airborne recordings of the total magnetic field along lines spaced 500m at a nominal altitude of 300 m above ground (Rasmussen, 2002). A large degree of the variation seen in the total magnetic field is caused by magnetic minerals, primarily magnetite and, less importantly, pyrrhotite, contained by the over-flown rocks. In younger formations, such as volcanic rocks, the polarity of the magnetised minerals is clearly reflected.

Aeroradiometric data

Data represent airborne recordings of gamma-radiation along contour flight lines approximately 100 m above ground. The gamma-radiation reflects the concentrations of Th, K and U in the over flown rock units. By its nature the data density is very irregular, very high along flight lines and very variable between flight lines. Variable data loss during storing of the original tapes (Tukiainen *et al.* 2003) has led to an even more irregular coverage. Despite this, the grids based on cell sizes of 5 by 5 km display the regional scale variation in radioelement concentration over the area rather well.

Distribution patterns related to lithology and mineralisation

On a large scale, the region is composed of orthogneiss and supracrustal rocks, orthogneiss being the major component. Variation within this overall division comprises conspicuous granitic to pegmatitic veins as well as anorthosite-gabbros and ultramafic bodies enclosed by either orthogneiss or supracrustal rocks. On a local scale, dolerite, alkaline ultramafic dykes and carbonatite intrusions occur, as well as banded iron formation. Most of these known lithological elements can be distinguished from each other in one single or in a combination of the available geochemical and geophysical parameters.

Orthogneiss domains

The regional geochemical data set outlines the granulite facies tonalitic orthogneiss areas in elevated Sr. Areas with granodioritic to granitic rocks are shown by elevated Rb. The two elements are almost complementary in their distribution patterns. Overlaps between the two patterns (black areas in Figure 1) can be interpreted to indicate younger granites intruding older granulite facies terrain. Granitic components are further marked by combined high values of lithophile elements Cs, Rb and U (Fig. 2). The pronounced zone of high concentrations of lithophile elements across the Nuuk region reflects several generations of known Neoproterozoic granitic and pegmatitic intrusions into supracrustal belts. High Th values are associated with Qôrqût granite in the Nuuk region, and are also recorded in a number of stream sediment samples in the poorly known north-western corner of the study region.

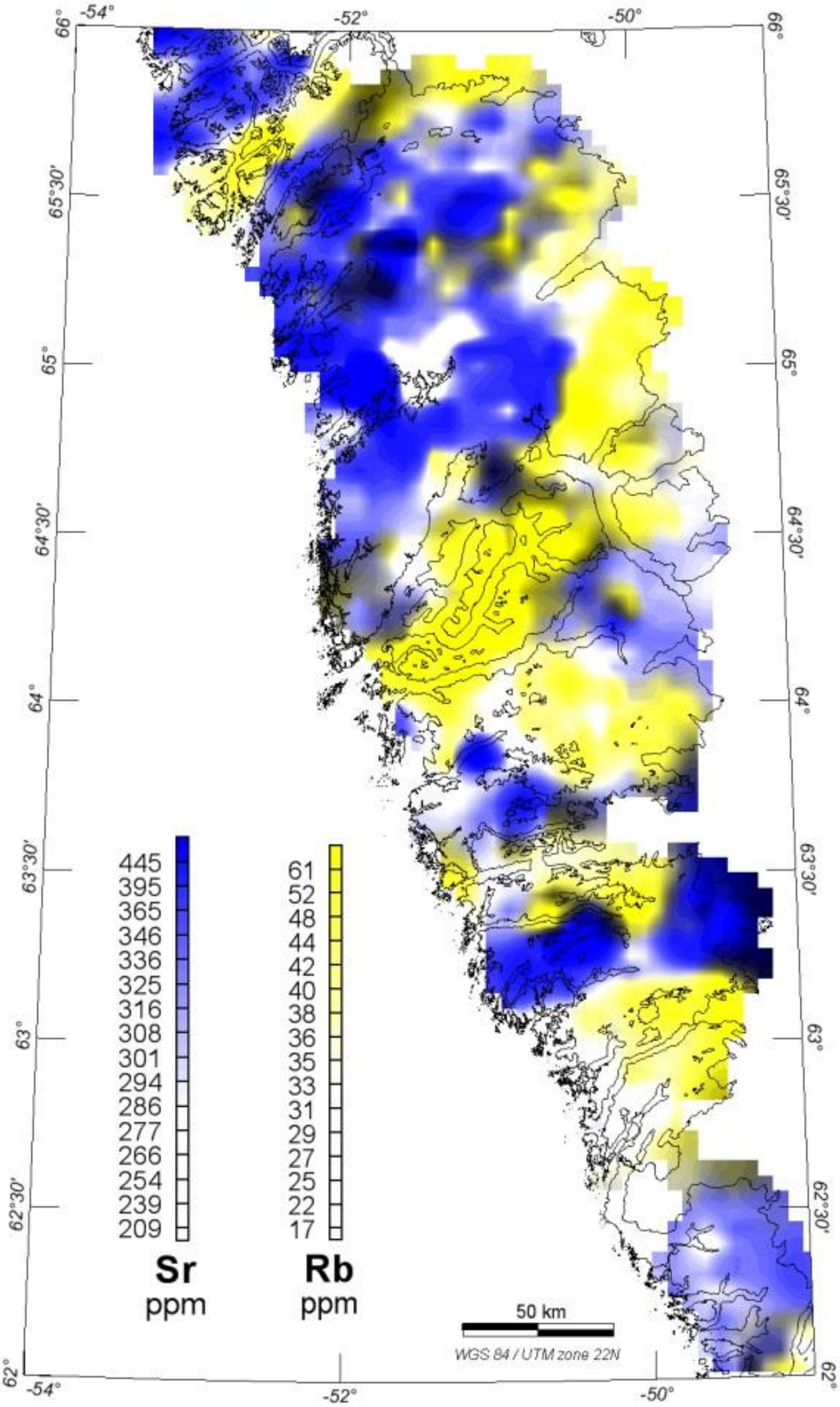

Figure 1. *Grids of Sr and Rb in stream sediment geochemistry.*

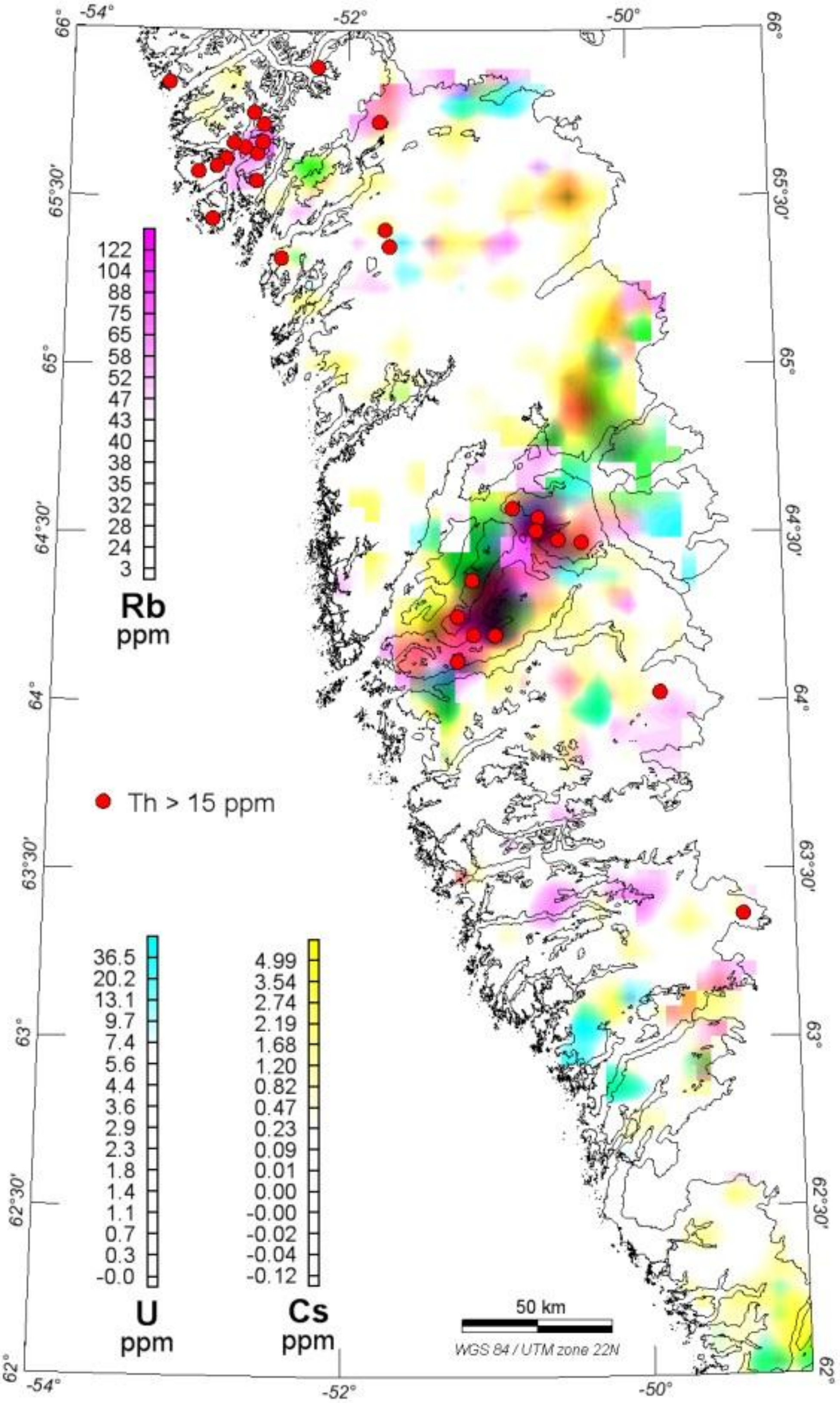

Figure 2. *Grids of Rb, U and Cs together with locations of samples with Th values above 15 ppm from stream sediment geochemistry.*

High magnetic field strength (dark areas in Figure 3) largely reflects granulite-facies orthogneiss, and there is an overall spatial correlation of high Sr with high magnetic field strength. Weakly positive to negative field strength (light grey to white) reflect supracrustal rocks and orthogneiss in amphibolite facies, both prograde and retrograde.

Tonalitic or granitic orthogneiss in the study region has no known directly associated economic mineralisation, but granitic veining in supracrustal belts may be indicative of hydrothermal mineralisation involving e.g. gold and uranium.

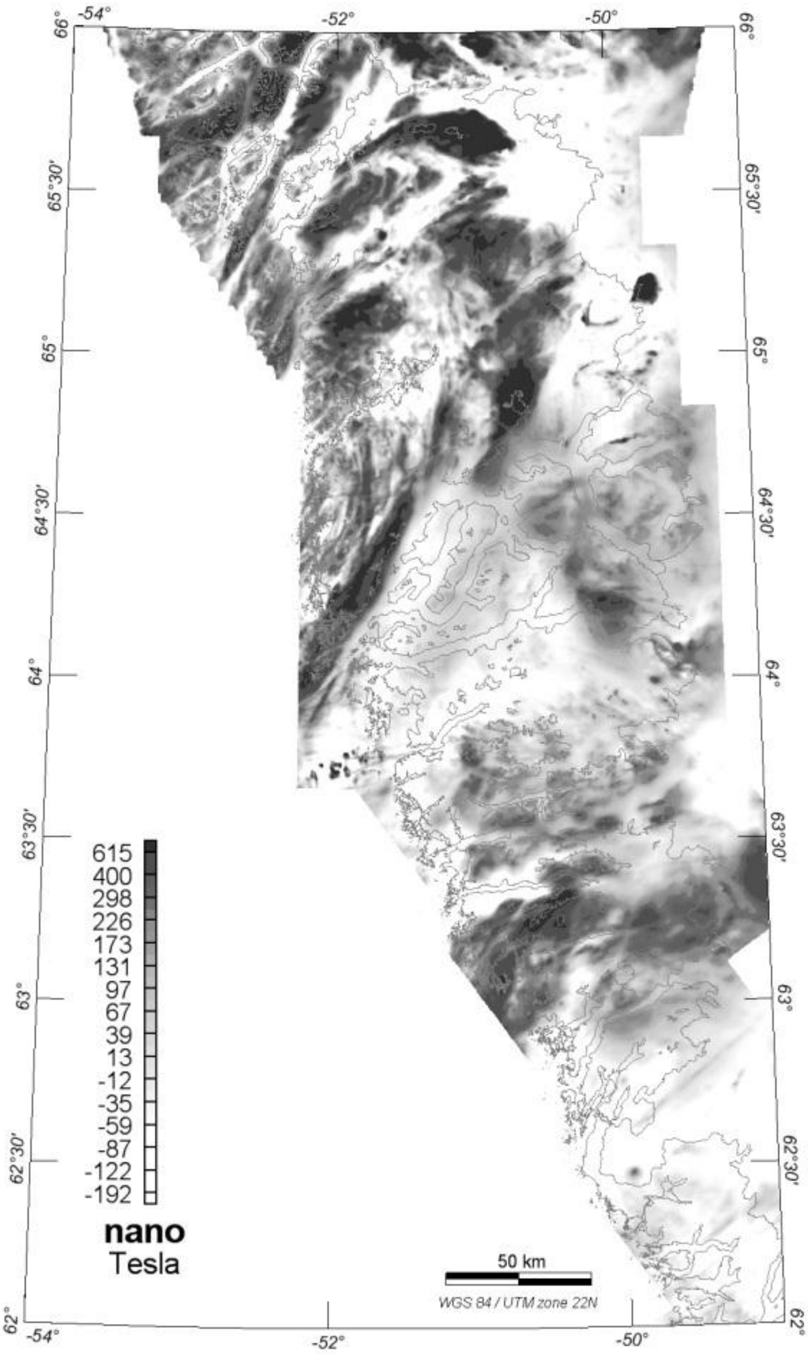

Figure 3. *Total magnetic intensity field from the high-resolution regional Aeromag data.*

Supracrustal belts

Elongated zones of elevated Ni concentrations in stream sediment samples reflect areas with belts of mafic infra- and supracrustal rocks or a high density of enclaves of such rocks. As a general feature, supracrustal belts with predominance of mafic rocks also have high values of Ni/Mg ratio (10000xNi/MgO), which has been attributed to sea-floor alteration (Nielsen *et al.* 2005, 2006; Fig. 4).

Additionally, the supracrustal belts have elevated Rb, presumably because of sedimentary rocks being present in the sea floor and basin environment. Figure 4 shows a significant overlap between the Ni and Rb distribution patterns, where the green overlap areas reflect corridors of mafic supracrustal rocks with granitic and pegmatitic veining. The belts with elevated Rb and Ni spatially correlate with zones of low magnetic field, and samples with highest Ni/Mg ratio are located in zones of low magnetic field (Fig. 5). The supracrustal belts are important hosts of gold mineralisation as shown by rock samples with elevated gold concentrations (Fig. 6).

Elevated Cu accompanies Ni in parts of the supracrustal belts and high concentrations of these two metals recorded in rock samples fall in high-level belts defined by stream sediment (Figs. 7 and 8).

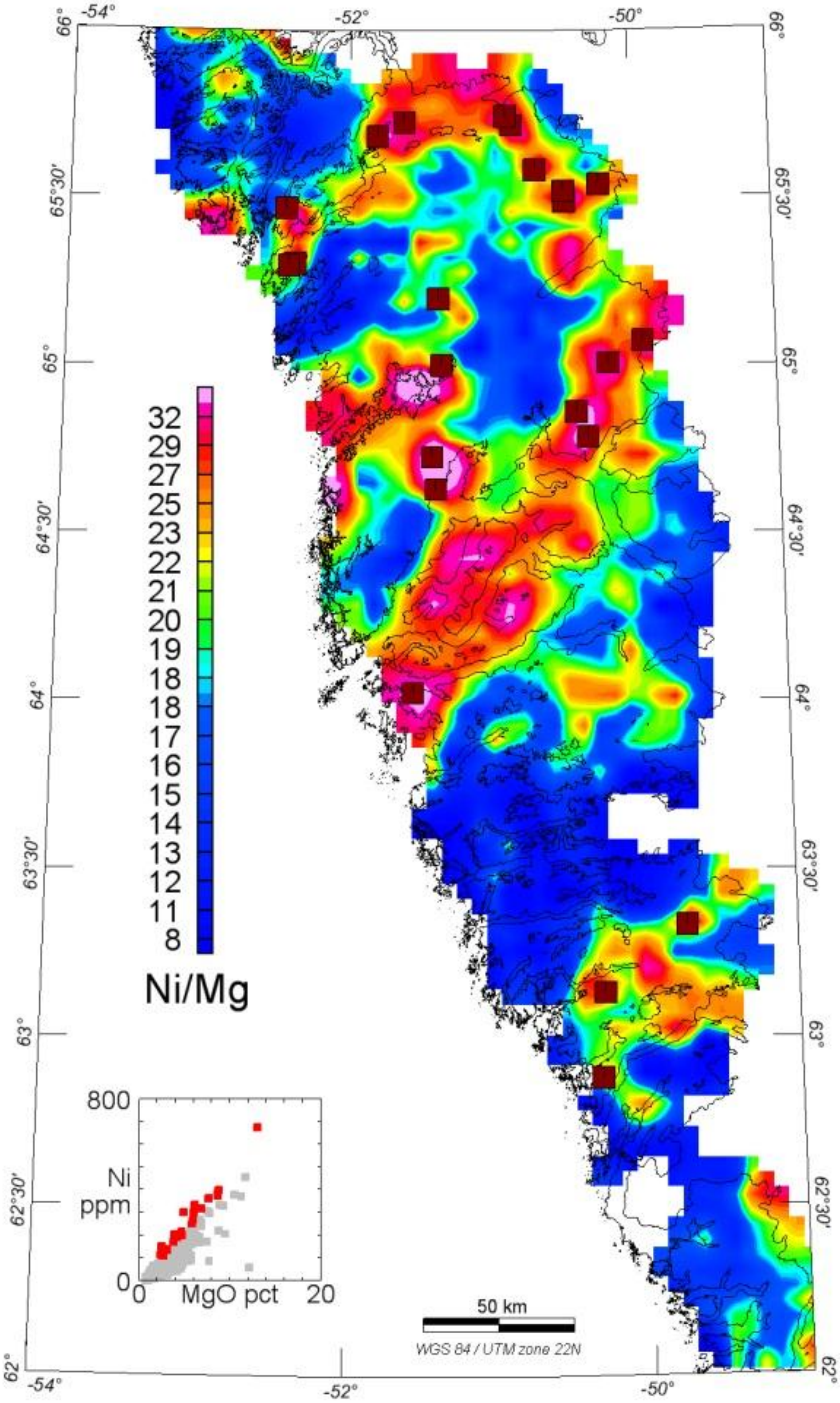

Figure 4. *Grid of the Ni/Mg ratio from stream sediment geochemistry together with locations of samples with highest ratios (corresponding to the red dots in the Ni versus MgO diagram).*

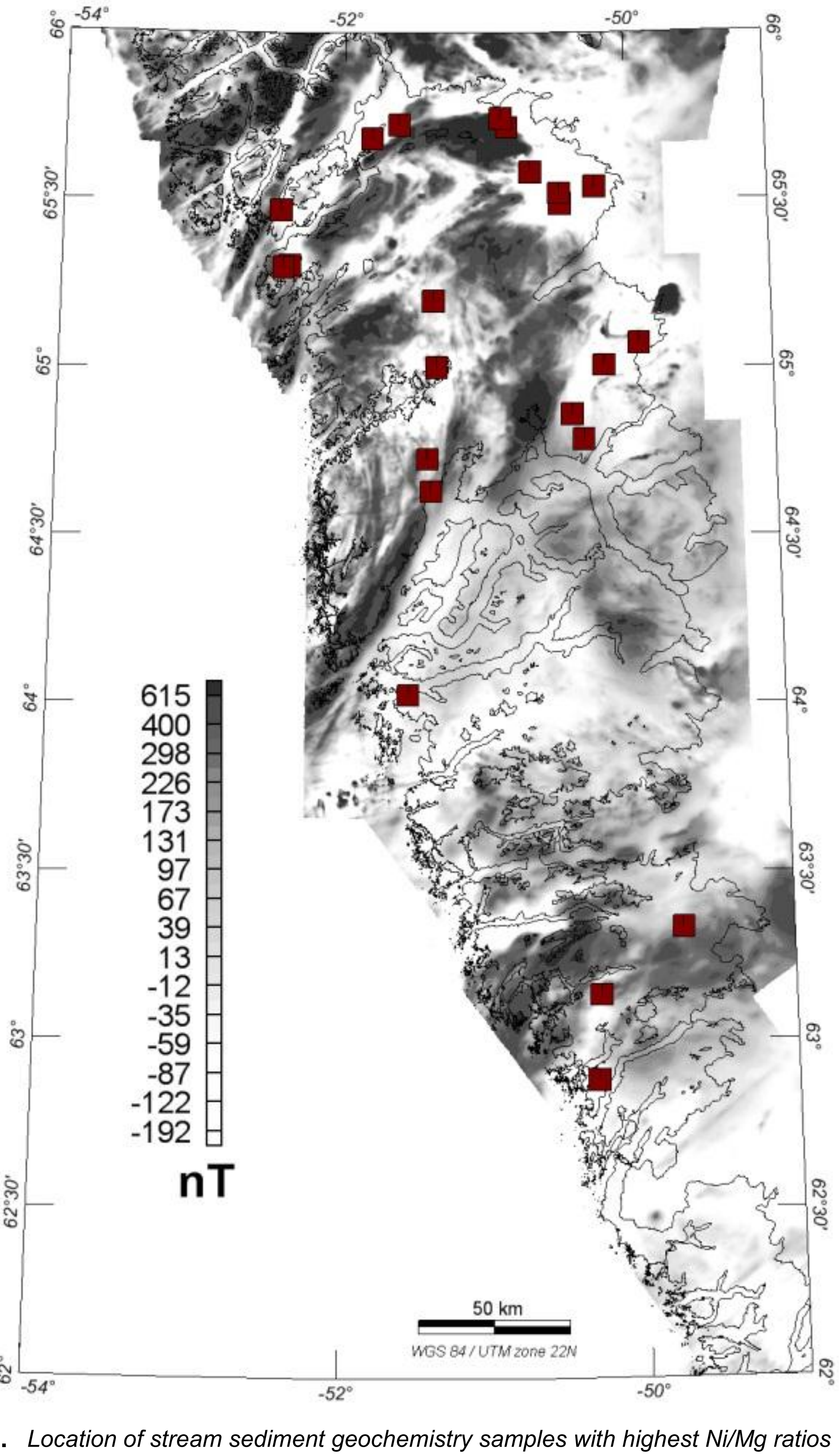

Figure 5. *Location of stream sediment geochemistry samples with highest Ni/Mg ratios (red squares, see Figure 5) plotted on top of the total magnetic intensity field. Highest Ni/Mg ratios are generally located in zones of low total magnetic intensity field.*

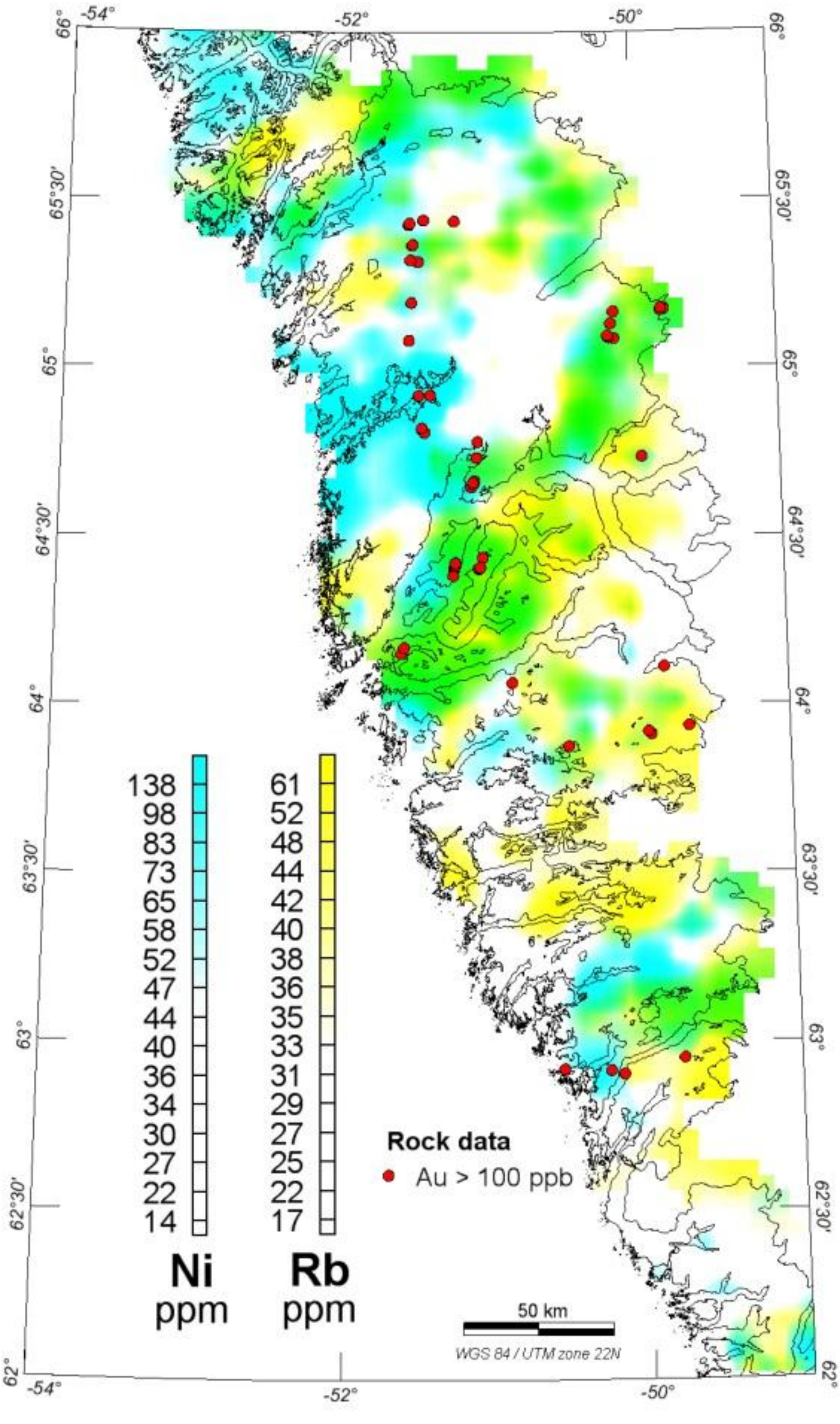

Figure 6. *Grids of Ni and Rb from stream sediment geochemistry together with locations of sample geochemistry yielding Au values above 100 ppb. Areas, coloured green by the overlapping grids, correspond generally to areas which hosts mafic supracrustal rocks with granitic and pegmatitic veining.*

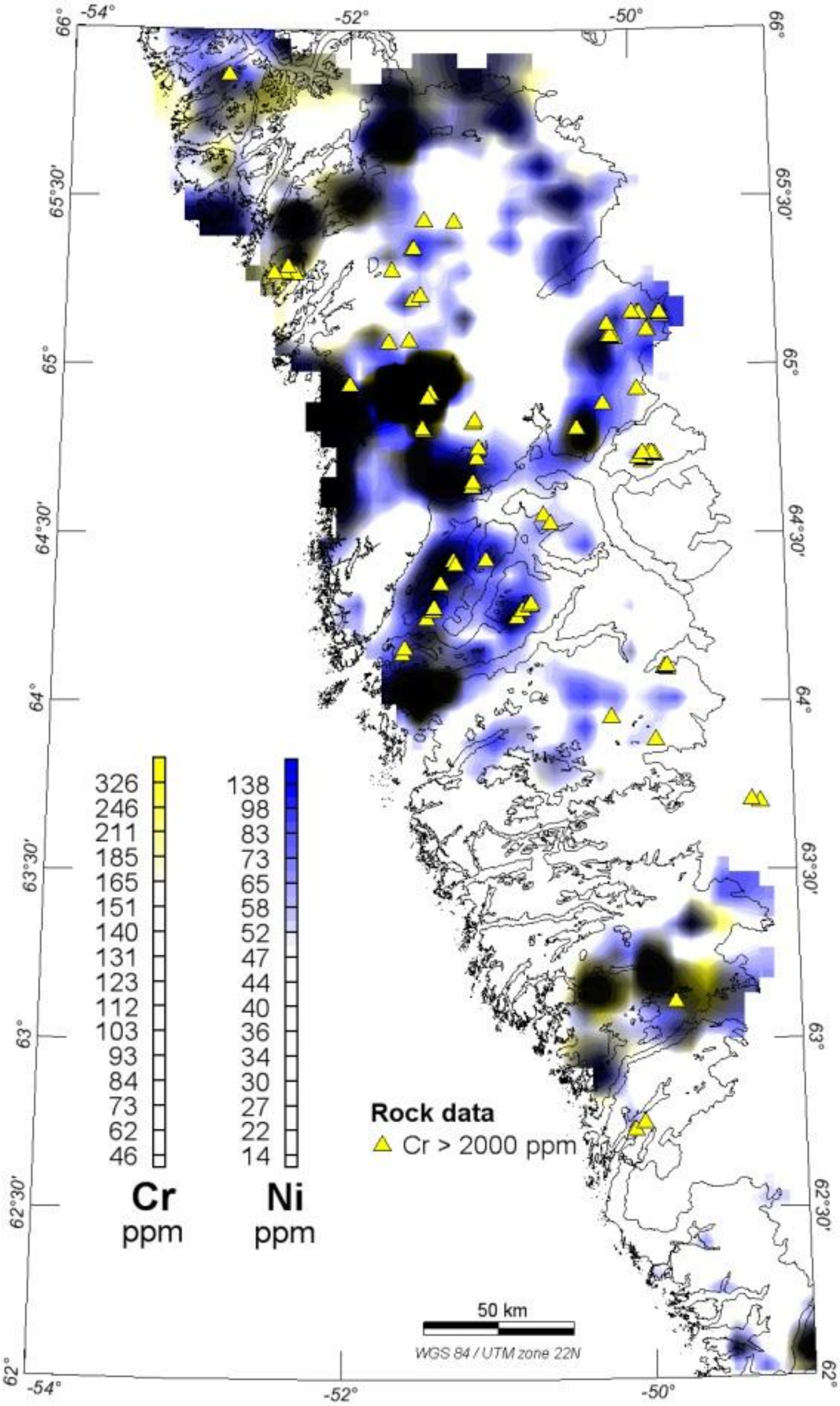

Figure 7. *Grids of Cr and Ni from stream sediment geochemistry plotted together with locations of rock sample geochemistry with Cr above 2000 ppm.*

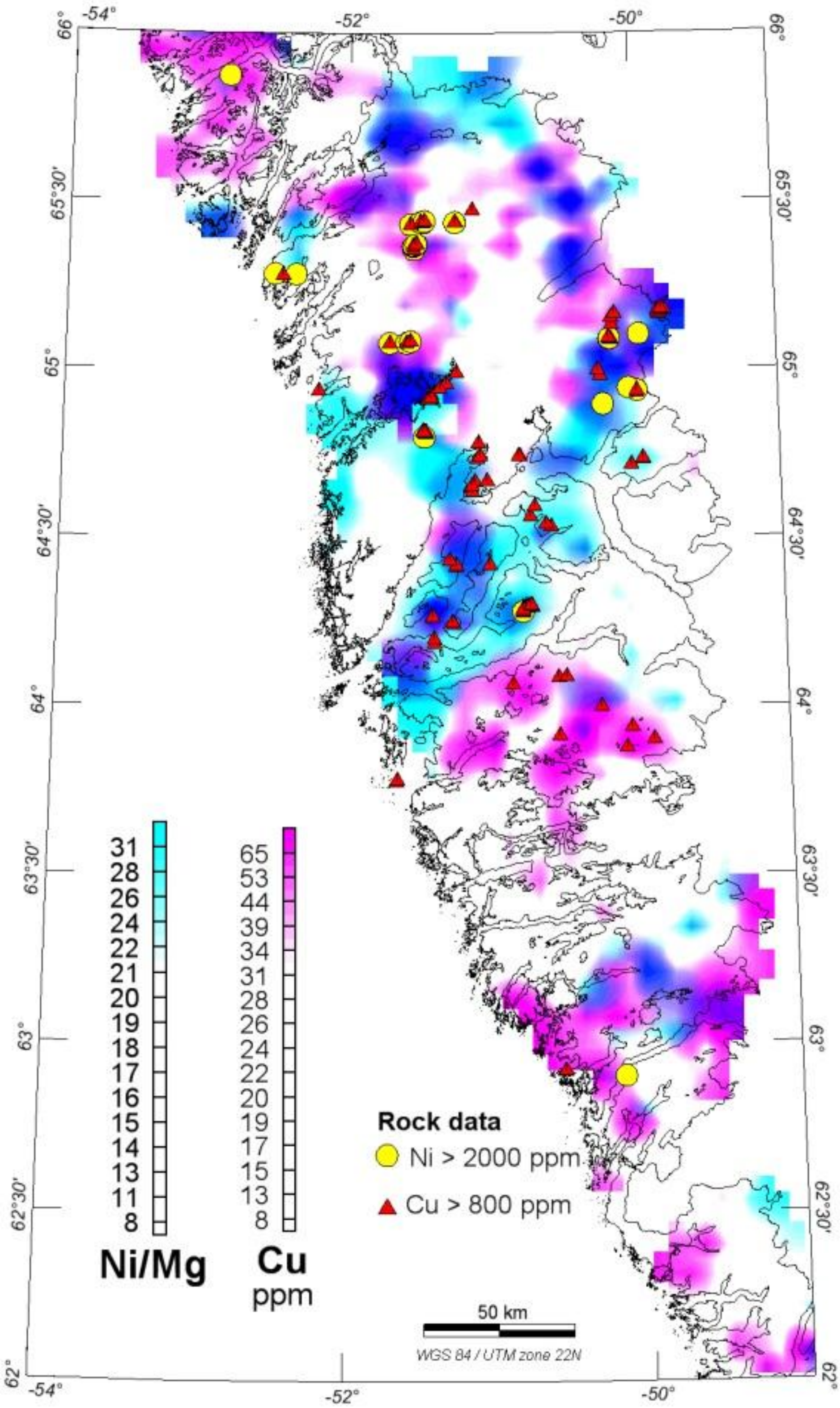

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Figure 8. *Grids of Ni/Mg ratio and Cu from stream sediment geochemistry plotted together with locations of rock sample geochemistry with Ni above 2000 ppm and Cu above 800 ppm.*

Mafic to ultramafic plutons

Mafic to ultramafic rock bodies are common in the supracrustal belts, but also form layered intrusive complexes outside the supracrustal belts. Ultramafic bodies are revealed by high Ni and Cr concentrations (black areas in Fig. 7).

Rock samples with high Cr concentrations are from the black areas confirming the validity of the stream sediment data. Some high-Cu areas are in the southern part of the study area associated with the Fiskenæsset anorthosite complex and associated mafic supracrustal rocks. The mafic plutons are hosts to known mineralisation with Cr, Ni, Au and potentially hosts platinum group elements. An ultramafic pluton in the Fiskefjord group of ultramafic bodies has been exploited for olivine.

The distributions of other elements associated with mafic rocks like V, Cu, Zn and Ti are shown in Figures 9 and 10.

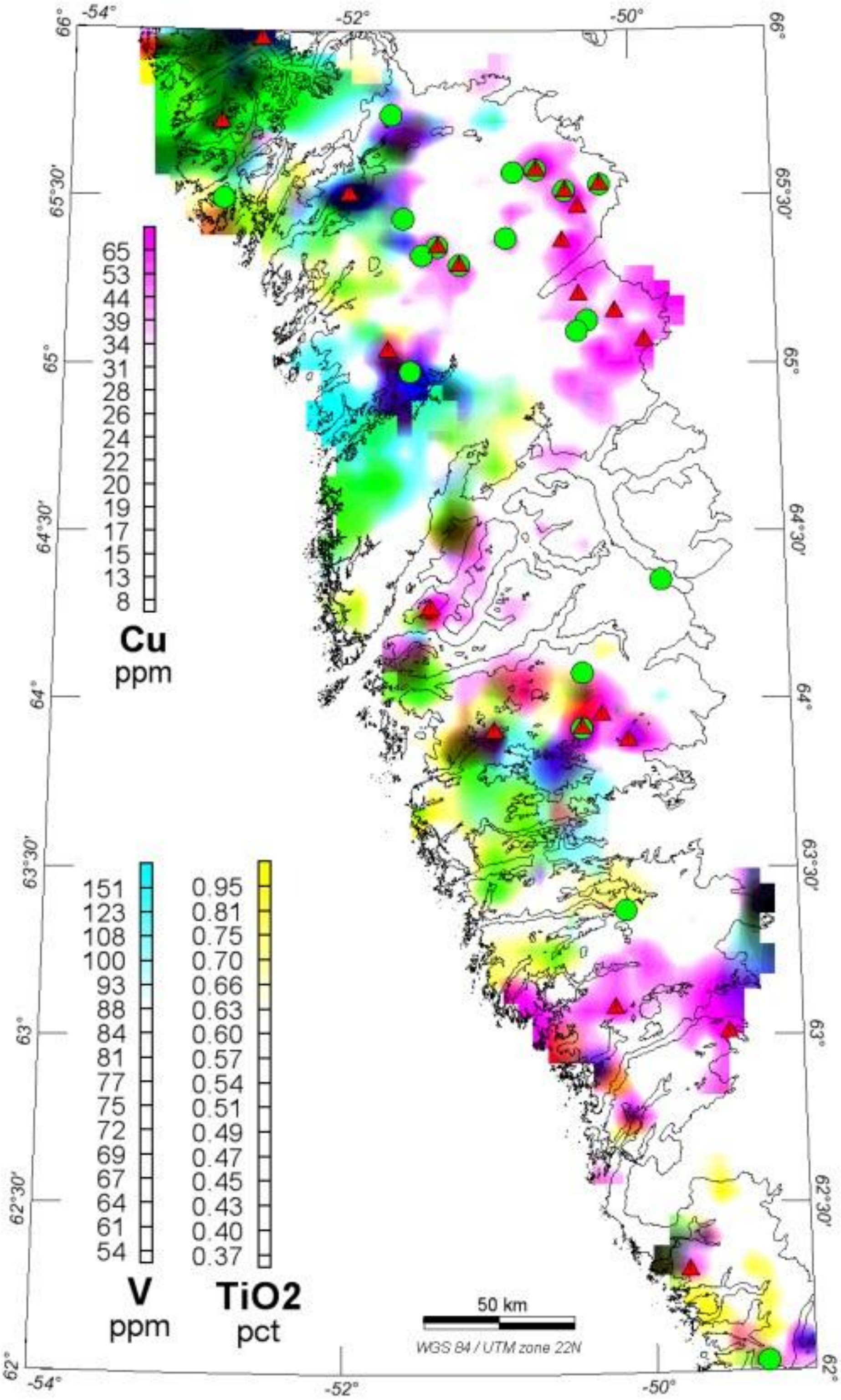

Figure 9. *Grids of V, TiO_2 and Cu from stream sediment geochemistry plotted together with locations of the most elevated Cu (red dots in plot of Cu versus MgO) as red triangles and elevated Zn (red dots in plot of Zn versus SiO_2) as green circles (see Figure 10).*

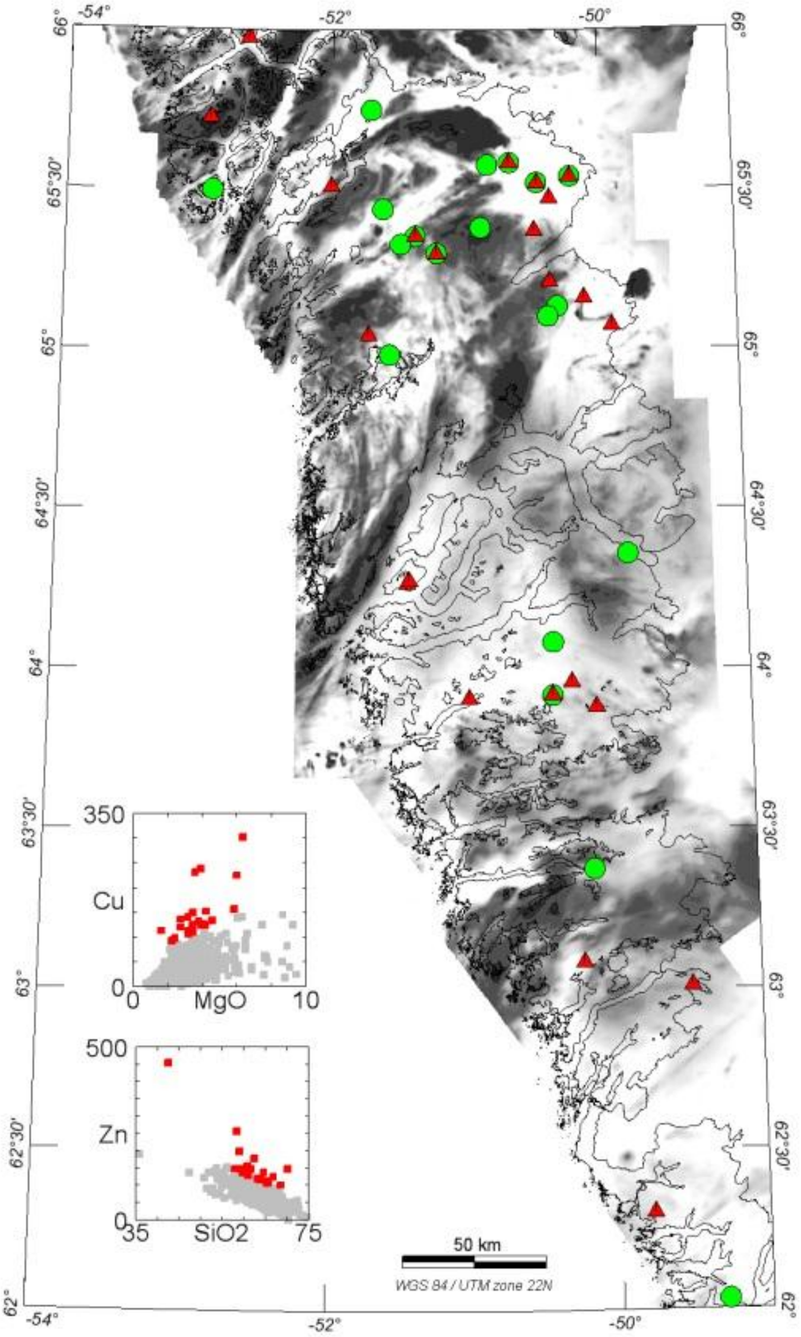

Figure 10. *Location of highest Cu/MgO ratios and Zn/SiO_2 ratios from stream sediment sample geochemistry plotted on top of the total magnetic intensity field. Elevated Cu (red dots in plot of Cu versus MgO) as red triangles and elevated Zn (red dots in plot of Zn versus SiO_2) as green circles.*

Summary of observed features related to mineral potential

The geochemical and aeromagnetic regional data have distribution patterns that are clearly related to lithological units. The main division into orthogneiss terrain and supracrustal belts plus an outlining of the larger mafic and anorthosite complexes can be made using the element distribution patterns in Figures 1 to 11. This is done in Figure 12 and 13.

Rock sample location in Figure 14 illustrates the intensity of the exploration/geological observation over the region. It is obvious that the arc-shaped belt termed Majorqaq in the northern part of the region is under-explored, and also that the north-eastern part of the Bjørnesund belt warrants more exploration. The Majorqaq belt has many geochemical and aeromagnetic similarities to the Nuuk belt and also embraces a number of stream sediment anomalies for Ni, Cr, Cu, Zn. Figure 7 suggests that the belt also hosts ultramafic bodies.

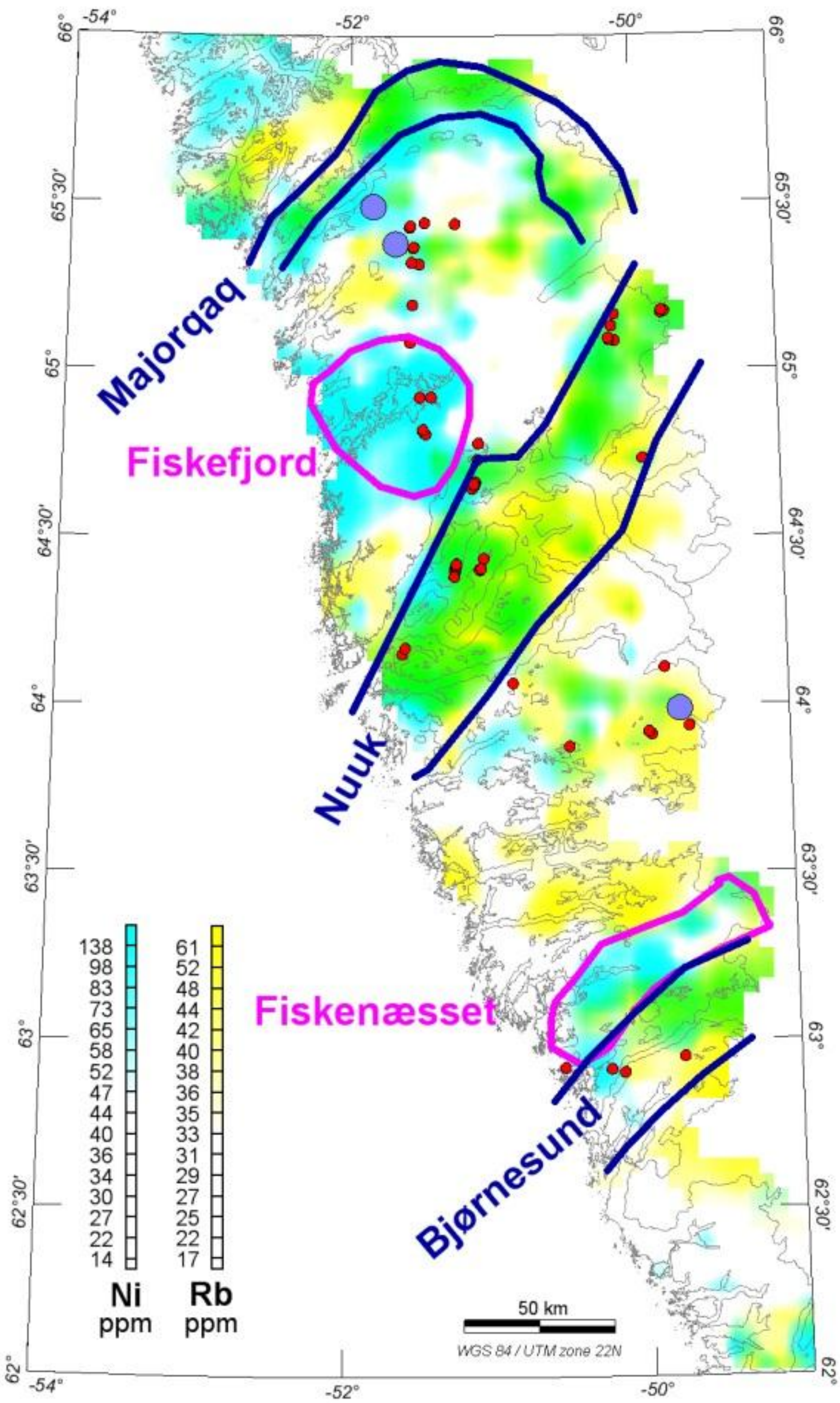

Figure 11. *Grids of Ni and Rb from stream sediment geochemistry plotted together with locations of sample geochemistry yielding Au values above 100 ppb (the red dots). Violet circles indicate the location of the three carbonatite complexes in the region. The major corridor (the Majorqaq, Nuuk and Bjørnesund corridors) with high content of supracrustal rocks are outlined by blue lines. Outline of areas with major mafic or anorthosite complexes are indicated by purple lines.*

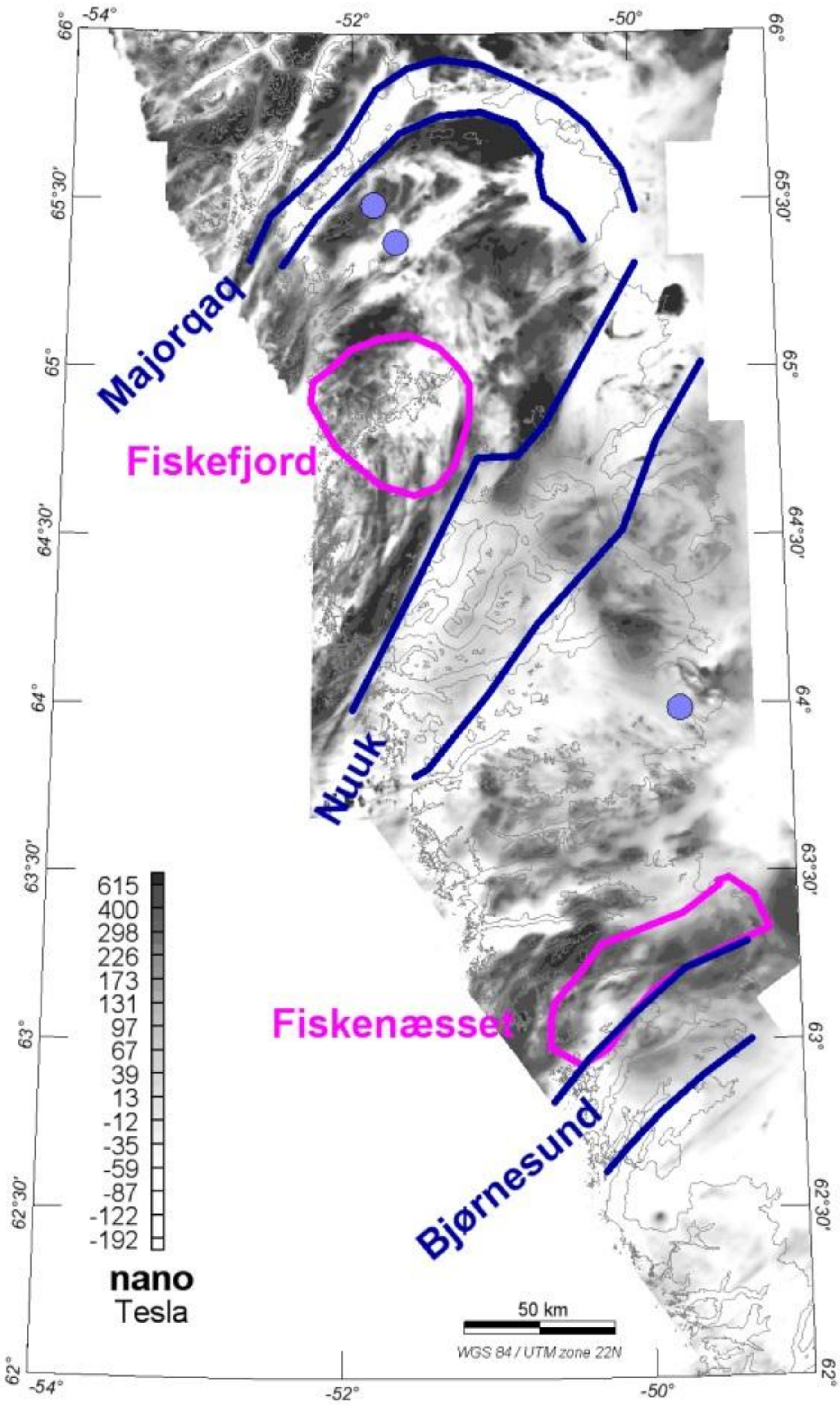

Figure 12. *Total magnetic intensity field in greyscale. The major corridor (the Majorqaq, Nuuk and Bjørnesund corridors) with high content of supracrustal rocks are outlined by blue lines. Outline of areas with major mafic or anorthosite complexes are indicated by purple lines. Violet circles indicate the location of the three carbonatite complexes in the region.*

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Analysis of regional data sets: Predictive gold potential using neural network analysis

By Bo Møller Stensgaard

Artificial neural network concept

An artificial neural network is a mathematical structure simulating or modelled on the human neural network, able to tackle statistical problems such as pattern recognition, multivariate analysis learning and memory. The essential feature of such a structure is a network of simple processing elements (artificial neurons) coupled so that they can cooperate. For further description of the artificial neural network technique and its application to mineral potential mapping, please refer to Carranza (2009) and references herein.

In this report, several data sets representing different properties (a geological map, geochemical distributions, geophysical data, etc) of a selected area are used as input to the neural network analysis. The selected area is referred to as the training area. If the data sets are in the form of grids, these grids are referred to as training grids.

A so-called target grid is created for the training area. The target grid is composed entirely of zeroes and ones (0 & 1) that identifies specific sub-areas (pixels in the grids) where e.g. a desirable feature exists (e.g. known mineral occurrences exist; with the ones, referred to as targets) and where it does not exist. This grid is used to tell the neural network where desirable features exist.

The neural network is then shown both the target grid and the training grids and from this the neural network learns/analyse the characteristics of the sub-areas in the training grids. This constitutes the training of the neural network. Joint signatures of the data sets (training grids and target grids) are then identified and stored in memory by the network.

The network is then shown similar data sets (data grids) from another area. These grids are called simulation grids for the area and the area itself is referred to as the simulation area. The simulation area can be a larger extent of the same geographical region, or it can be another geographical region separated from the training area. The neural network now applies what it has learned from the first set of training data grids to the simulation data grids, pointing to 'similar' areas. The resulting output from this is a database containing a classification of the area. The results show the tracts of the simulation region that are most similar to the data signatures defined for the targets in the training. The output values are in the range from 0 to 1 (or equivalently in percentage from 0 to 100%) with 1 meaning identical to signatures defined for the targets and 0 meaning not at all similar; values in-between are varying degrees of similarity. The output values can be gridded and thus shown on a map.

Target and simulation areas

Based on the distribution of gold mineralised samples the target area was defined (see section on Targets – gold occurrences below). The target area stretches from the central part of Storø, central Godthåbsfjord, in the southwest to north of Isukasia in the northeast (Fig. 1).

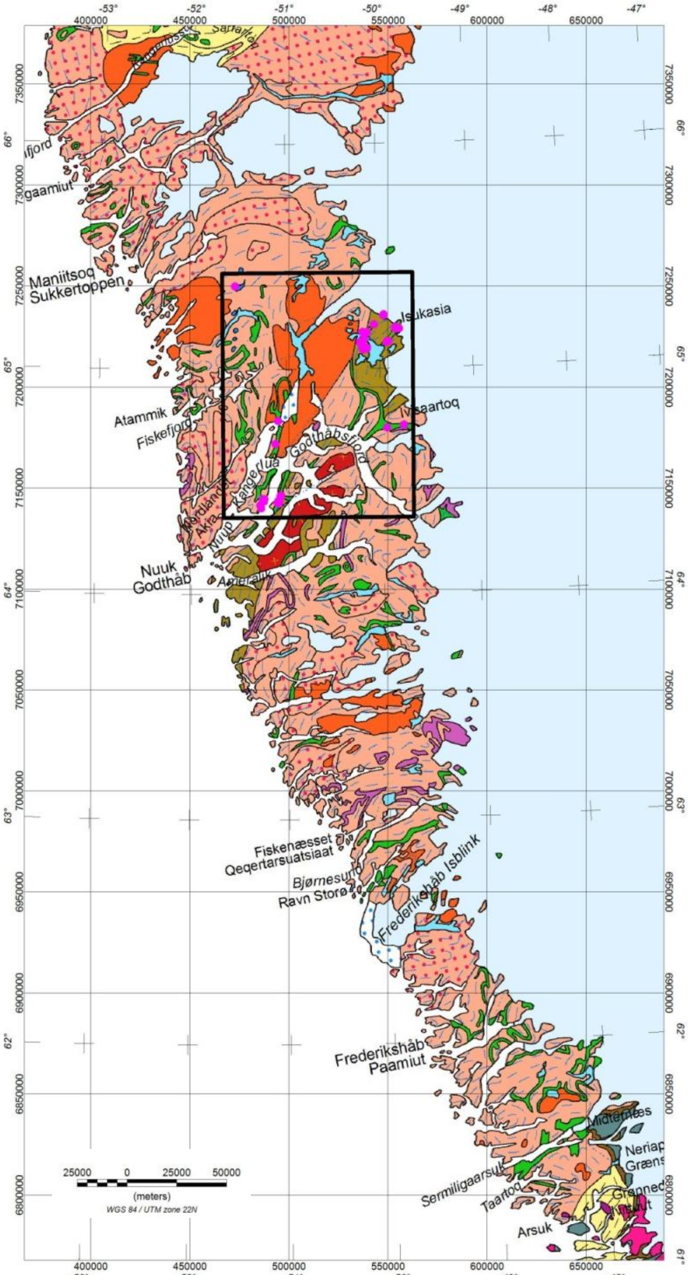


Figure 1. *Geological map of the entire southern West Greenland. The target area is outlined by the rectangle in black colour while the gold occurrences used as targets are indicated by purple circles. Please refer to Escher & Pulvertaft (1995) and Keulen et al. (2010b) for the geological legend.*

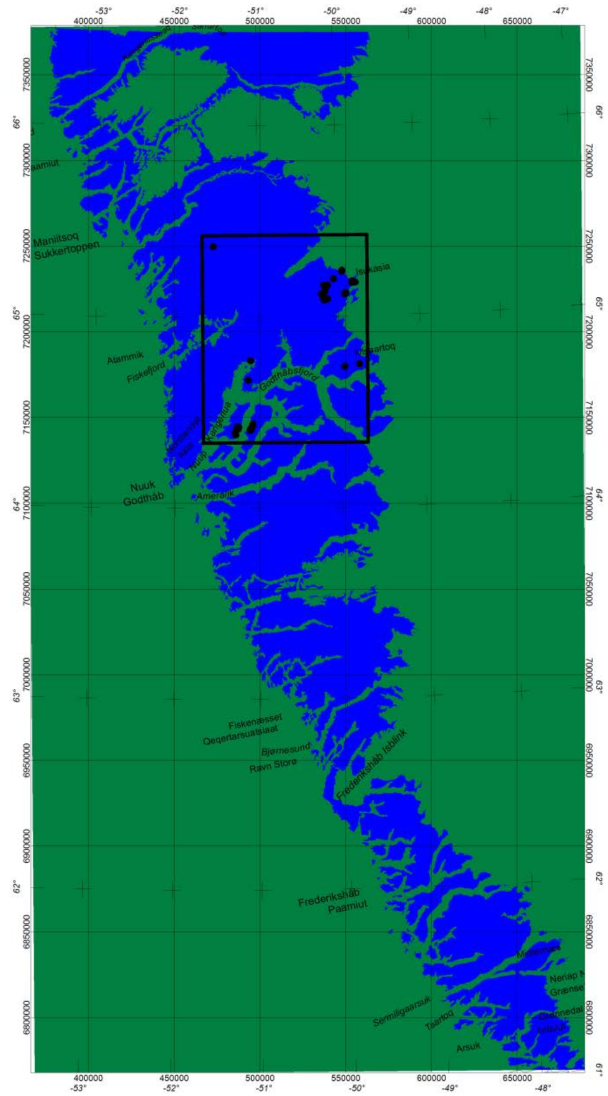


Figure 2. *Overview of the areas designated in the neural network analysis as training (enclosed by the black rectangle) and simulation areas (area in green and blue colours). The results or output from the neural network are masked so that sea, fjords, larger lakes, ice-caps (areas larger than 2.5 km^2) and the inland ice are filtered out. This remaining and included area is shown in blue. Black circles indicate the locations with gold occurrences used as targets (training points).*

The simulation area covers the entire southern West Greenland from just north of Kobberminebugt in the south (~61°15'N) to just north of Sukkertoppen Iskappe (66°35'N) in the north (Fig. 2). The neural network simulation is carried out for the entire simulation area (the entire area in Fig. 2). However, the predictive results for areas covered by sea, inland ice, fjords, larger ice-caps/sheets and larger lakes are removed; that only realistic results with valid data are shown (Fig. 2).

Analysed data sets

The data sets covering the entire southern West Greenland used and tested here as input for the predictive gold targeting using neural network are described below.

The selection of the data sets are based on the results from previous analyses of the gold potential in the Nuuk region and the subsequent follow-up fieldwork (Nielsen *et al.* 2004; Stensgaard 2008; Stensgaard *et al.* 2006a; Stensgaard *et al.* 2006b), together with the general experiences and results from investigations in two resource assessment projects carried out from 2004–2007 in the Nuuk region (64°–66°N, Stendal *et al.* 2008; Thorning *et al.* 2011 and references therein) and later in southern West Greenland 2008–2010 (61°30–64°N, Kalvig & Thorning 2011 and references therein).

All data sets are in grids with cell size of 200 m × 200 m.

Targets – gold occurrences

The targets used in the predictive analysis are defined as localities where one or more rock samples have yielded concentrations of 1 ppm Au or more. A target is defined as constituting one grid cell; i.e. a 200 m × 200 m area.

The targets are extracted from a compilation of information on gold mineralised sites and samples that were reported in Stensgaard *et al.* (2006b). This compilation contained information about sample localities and analytical data from the GEUS database GEUSGREEN (Tukiainen & Christensen 2001) and from a review of all available data reported in publicly released reports from exploration companies working in the Nuuk region and adjacent areas (from c. 63°30'N to 65°30'N). The latter include all reports mentioned in Appel *et al.* (2003) and two additional reports on data from Bjørneøen (Skyseth 1998a,b; Smith 1998a,b). Only data reported prior to 2005 are used.

A total of 45 targets (also referred to as gold occurrences) are defined in this way (Figs. 1 and 2). Some of these 200 m × 200 m assigned targets are adjacent, forming a larger coherent area (Fig. 3).

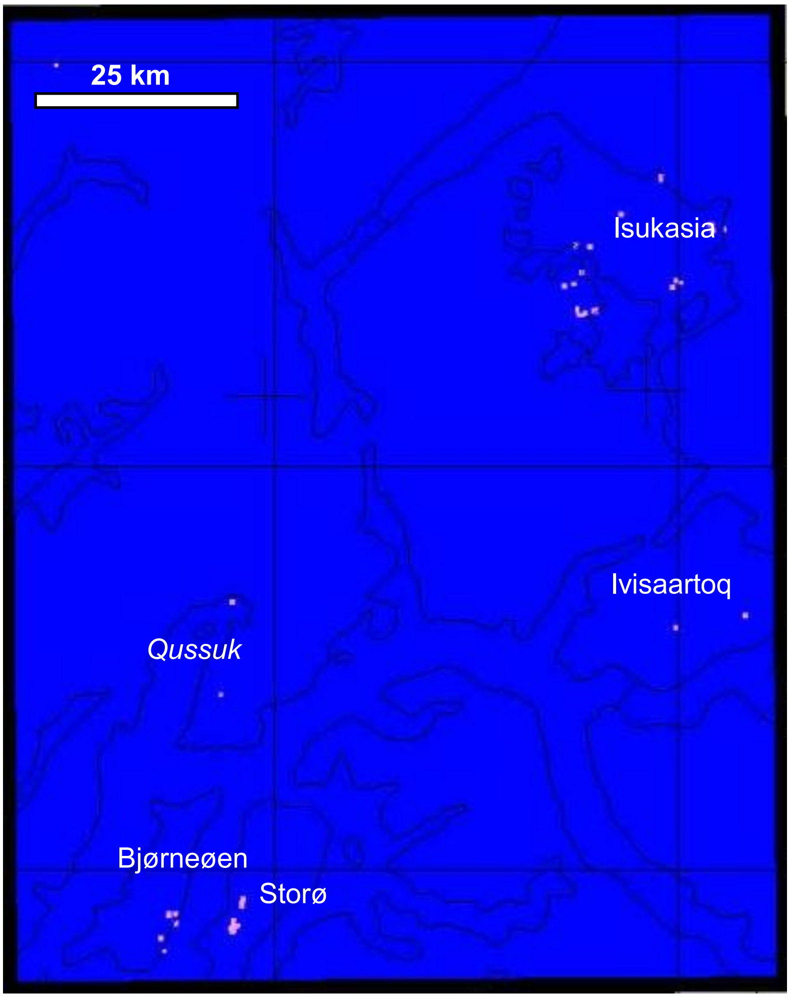


Figure 3. *Training area with gold occurrences (targets) as 200 m × 200 m grid cells in purple.*

It is important to remember that only the characteristics of the gold mineralised sites in the Nuuk region are used for a prediction throughout the entire southern West Greenland. Also, the gold targets are in the current work treated and used as one group of targets even though they statistically (Stensgaard *et al.* 2006b) and geologically (Appel *et al.* 2003; Kolb *et al.* Submitted 2012; Nielsen *et al.* 2004; Stendal *et al.* 2008) in some cases can be interpreted to represent different gold mineralising models.

The known gold-bearing samples above 1 ppm outside the Nuuk region (please refer to Stensgaard *et al.* (2006b) for the precise extent) that are not included as targets (both those known prior and after 2005), are used to cross-validate the results of predictions of areas favourable for gold.

Training and simulation data

Training and simulation grids for the following data types (covering the training and the simulation areas) are generated and used as input to the neural net analysis:

Aeromagnetic data
The magnetic data used are from the regional aeromagnetic surveys carried out in the joint GEUS and BMP Aeromag 1995, 1996, 1998 and 1999 projects (Rasmussen, 2002).

The above surveys were flown along N–S-oriented lines with a line spacing of 500 m and nominal altitude above ground of 300 m. Orthogonal tie-lines were flown with a separation of 5000 m. The sampling interval along the lines is approximately 7 m. The data were gridded with a 200 m sampling interval.

From the total magnetic intensity field, a number of derived parameters can be calculated, such as the first vertical derivative (gradient), horizontal derivatives in different directions, amplitude of the horizontal gradient vector and analytic signal of the total magnetic intensity field. Although the derivatives are calculated from the total magnetic field, and as such do not include any additional information, the anomalies expressed by the derivatives are sharper and enhances short wavelength responses from shallow or sub-outcropping structures. Thereby, they reflect or emphasize lithological boundaries and faults more clearly than the total magnetic field. This decomposition of the field may be advantageous when used in the analysis. The grid based neural network approach cannot itself extract these different field properties embedded in the total magnetic intensity field data.

Based on empirical distribution function analysis of data signatures for gold occurrence sites in the Nuuk region (Nielsen *et al.* 2004; Stensgaard *et al.* 2006b), it was observed that (i) the vertical gradient, (ii) the amplitude of the horizontal gradient vector and (iii) the horizontal gradients in N, NW, E and SE directions all contained significant data signatures of the environments hosting the gold occurrences.

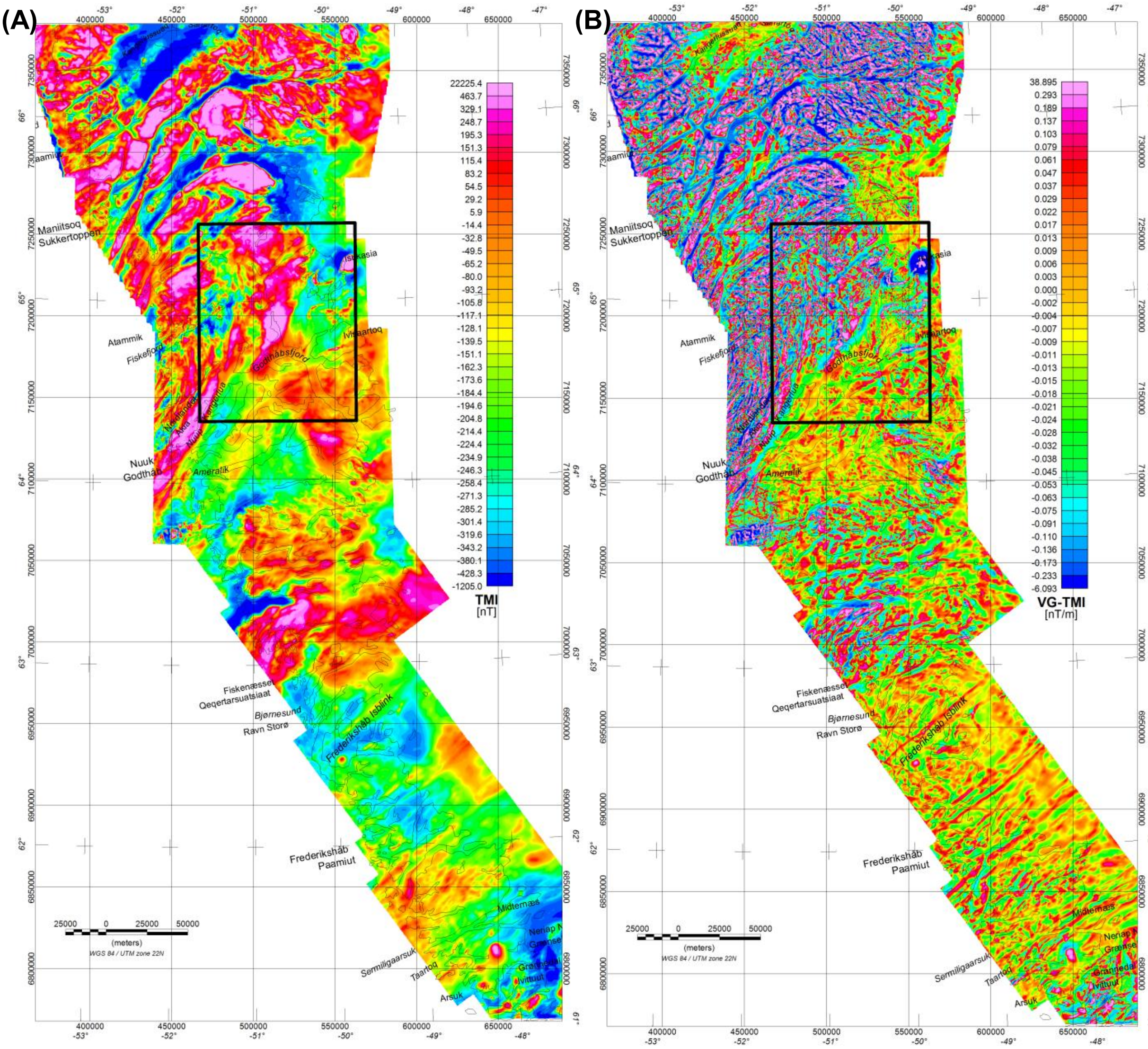


Figure 4. *(**A**) Total magnetic intensity field and (**B**) vertical gradient of the total magnetic intensity field for entire southern West Greenland. The data are extracted from a merged representation of the aeromagnetic data from the joint GEUS/ BMP Aeromag 1995, 1996, 1998 and 1999 projects.*

Stream sediment geochemistry data

Stream sediment samples have been collected from the study area during several campaigns through many years and analysed in several batches at various facilities (Steenfelt 1999, 2001a,b). The analytical data from these campaigns have previously been calibrated and presented as a geochemical atlas containing element distribution maps as contoured grid images for the entire West and South Greenland (Steenfelt 2001a).

The compilation of the analytical data involved quality control and calibration of different data sets to ensure that the resulting data from different laboratories and years were consistent. The sampling and compilation of the data in the geochemical atlas were designed to outline the large-scale chemical variation. The consistency of the data is obviously advantageous, but the low sampling density is not ideal for the present study. However, it is still the most comprehensive and uniform data set available. Furthermore, even with the relative low resolution, the data set have earlier proven useful for outlining and identifying areas with a potential for gold (Nielsen *et al.* 2004; Stensgaard 2008).

For the purpose of the present study, grids within the area limited by the study area were extracted from the geochemical atlas.

Based on empirical distribution function analysis of data signatures for gold occurrence sites (Nielsen *et al.* 2004; Stensgaard *et al.* 2006b) it was concluded that the geochemical elements As, Au, Cs, Rb, Th, U and the Ni/Mg ratio carried a significant data signature for the gold occurrences (see Figures 5–7).

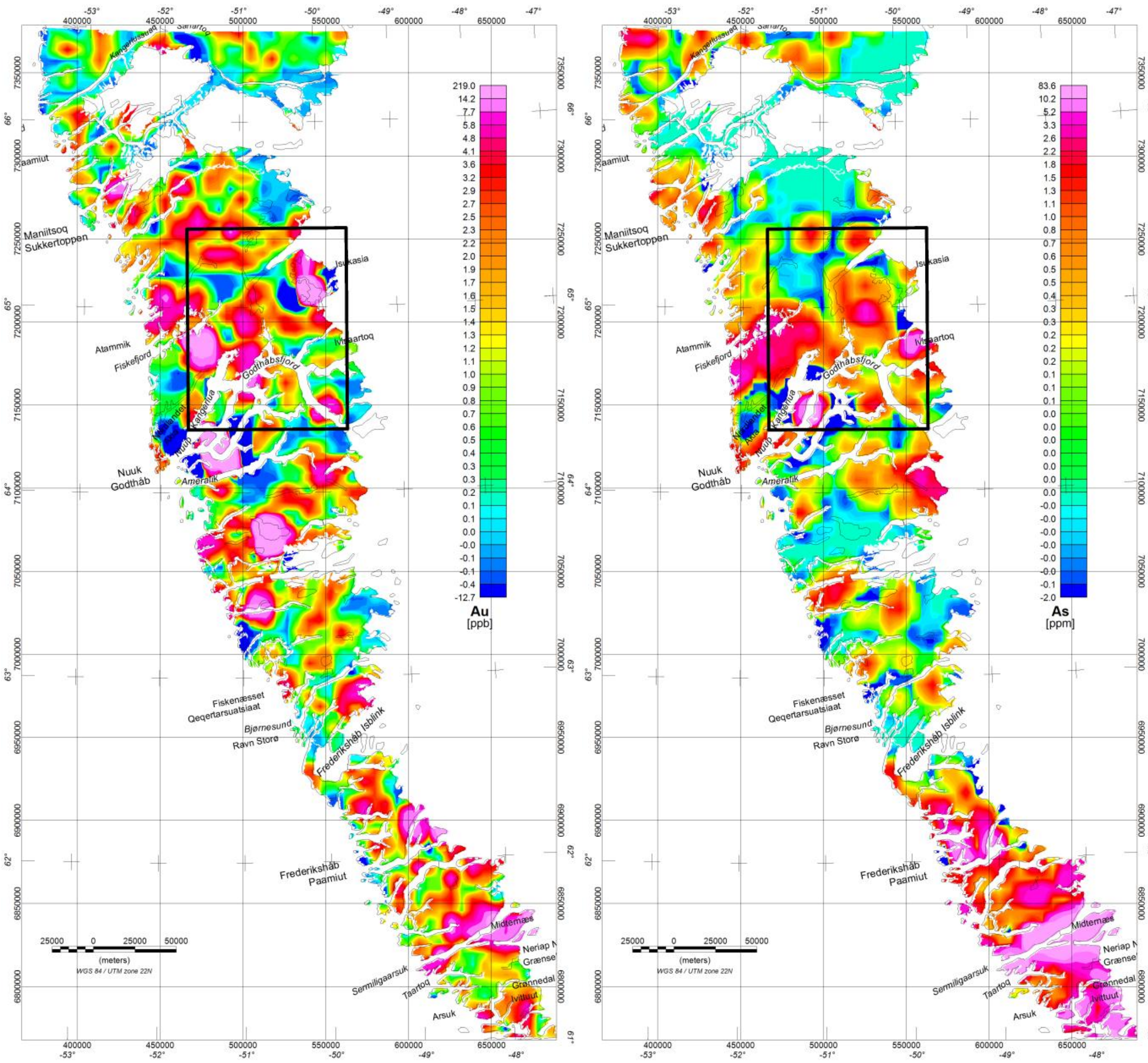


Figure 5. *Distribution of Au and As from fine-fraction stream sediment geochemistry.*

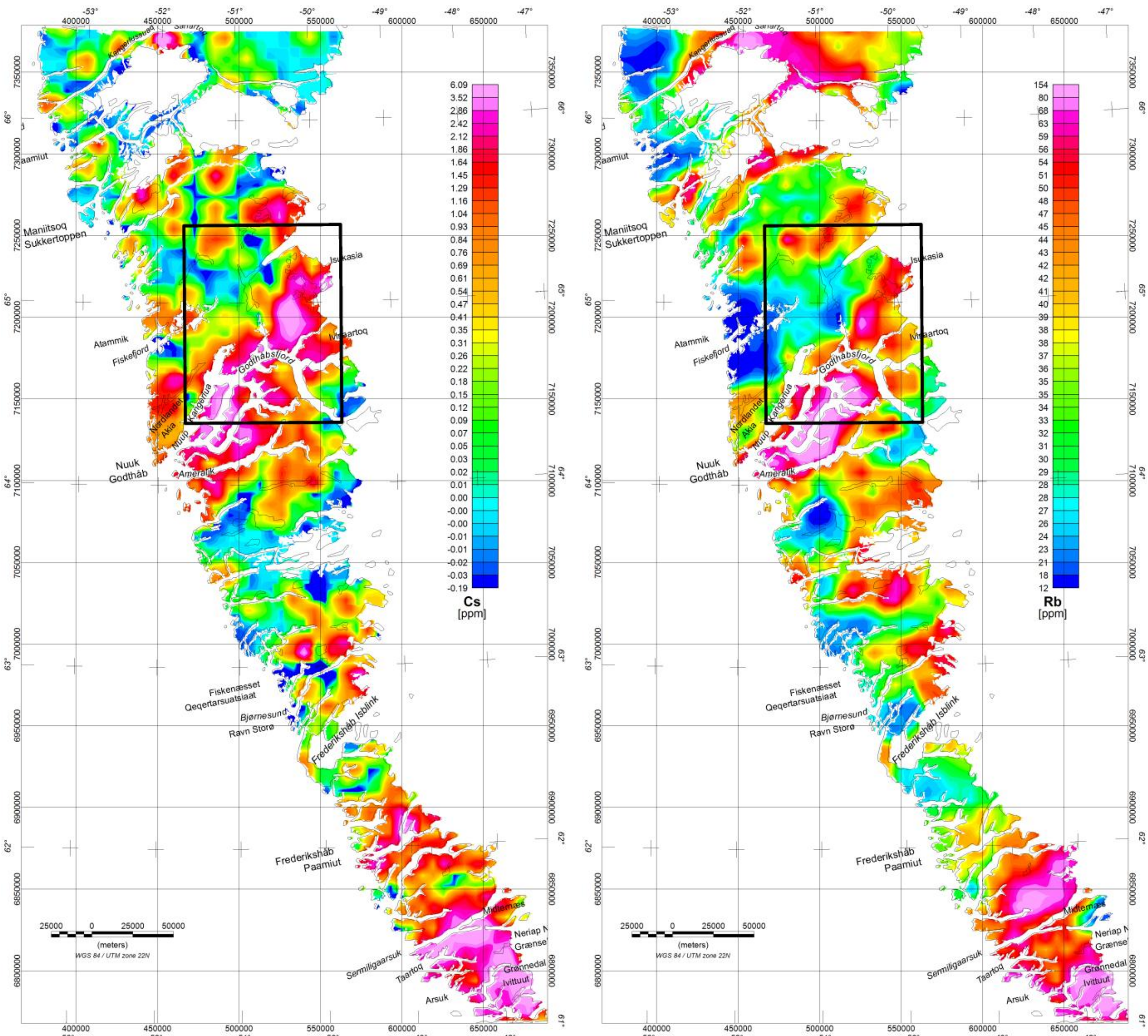


Figure 6. *Distribution of Cs and Rb from fine-fraction stream sediment geochemistry.*

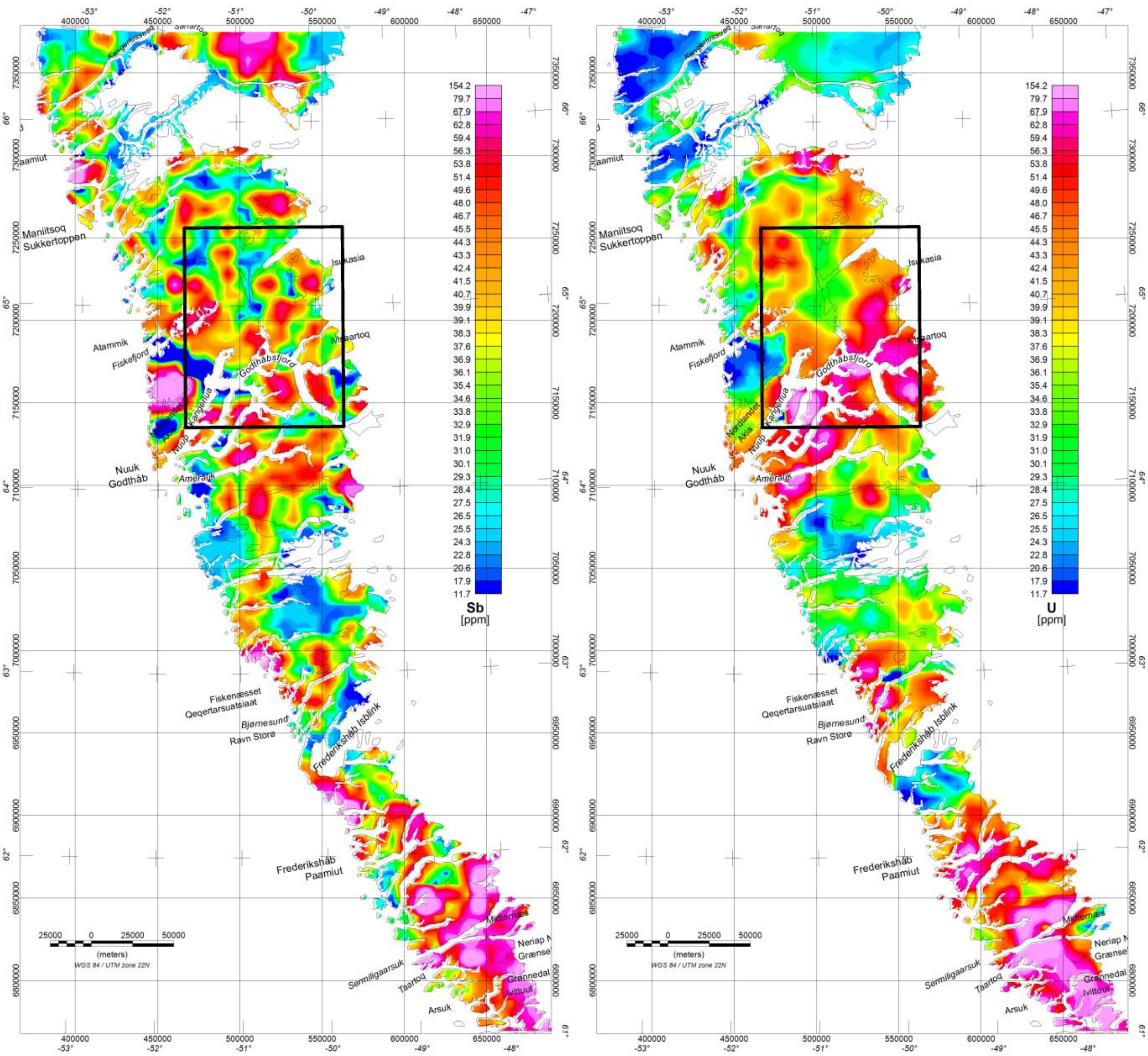


Figure 7. *Distribution of Sb and U from fine-fraction stream sediment geochemistry.*

Lineament data

Based on empirical distribution function analysis of sites with and without gold occurrences in the Nuuk region, Stensgaard *et al.* (2004; 2006b) concluded that gold occurrences in the training area are characterized by having a strong signature in the amplitude of the total magnetic intensity field and the horizontal gradients in different directions. This is interpreted to reflect that the gold occurrences in many cases seem to be related and/or located within or adjacent to geological "linear features" (lineaments), which can either be related to structural zones (faults, shears and thrust zones) or to rock unit boundaries/edges. These relationships are supported by geological field observations, investigations of the gold occurrence sites and the general geological mapping of the area.

An extraction of lineaments from the total magnetic intensity field data has been carried out. The extraction is in two steps. Firstly, a texture analysis is applied that highlights local intensity variations, which again enhances short wavelength features within the magnetic data set. The local intensity variations are often referred as edges and discontinuities despite that the magnetic field is always a smooth function. The edge and discontinuity concepts are only valid with reference to image terminology. The regions with magnetic short wavelength features correspond to lithological boundaries, faults and shear zones, and dykes. Secondly, another discontinuity detection method is applied to the output of the texture analysis. This detects the skeletal structure of the features with short wavelength. The output of this is a set of binary skeletal line segments that shows the spatial variation in orientation and structural offsets. For further details on the method refer to Kovesi (1991, 1997), Lam *et al.* (1992) and Holden *et al.* (2012). The initial lineaments derived from the aeromagnetic total intensity field were represented as spatially distributed line features. These lines were reanalysed and lines shorter than 600 m (3 times the length of a grid cell size) were removed. A buffer zones of 100 m around the remaining lineaments are applied so that each line occupies a total of 200 m in thickness in a grid representation of the lineaments; i.e. identical to the grid cell size. The resulting lineament map is shown in Figure 8.

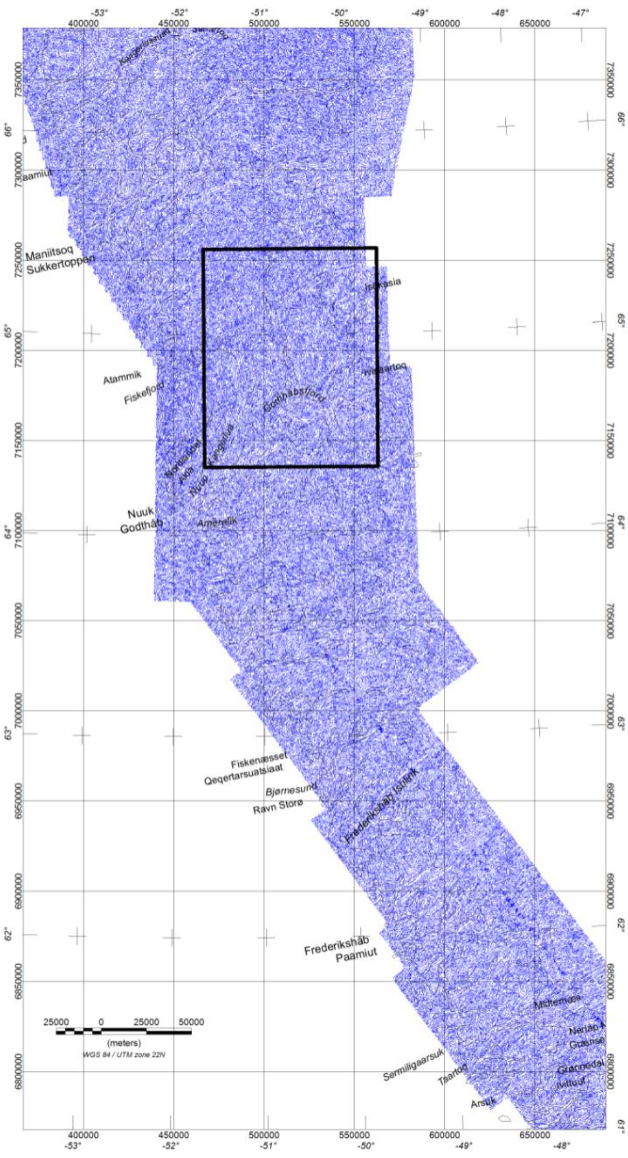


Figure 8. *Lineament map from aeromagnetic total intensity field data. A buffer-zone of 100 m on both sides of the extracted lineaments has been applied.*

Rock units

Gold mineralized sites in the Nuuk region are mostly found within or adjacent to supracrustal and/or mafic units/enclaves. Based on this observed relationship, an extraction of all supracrustal and mafic rock units were carried out from a new but yet unpublished digital version of the 1:500 000 scale geological map of the region. The digital geological map in scale 1:500 000 is a recompilation of various data and represents a modified, corrected and homogenized version of the published 1:500 000 scale geological map series, sheet 1 to 14. The maps that are relevant for the simulation area are published by Escher & Pulvertaft (1995) and Garde (2007).

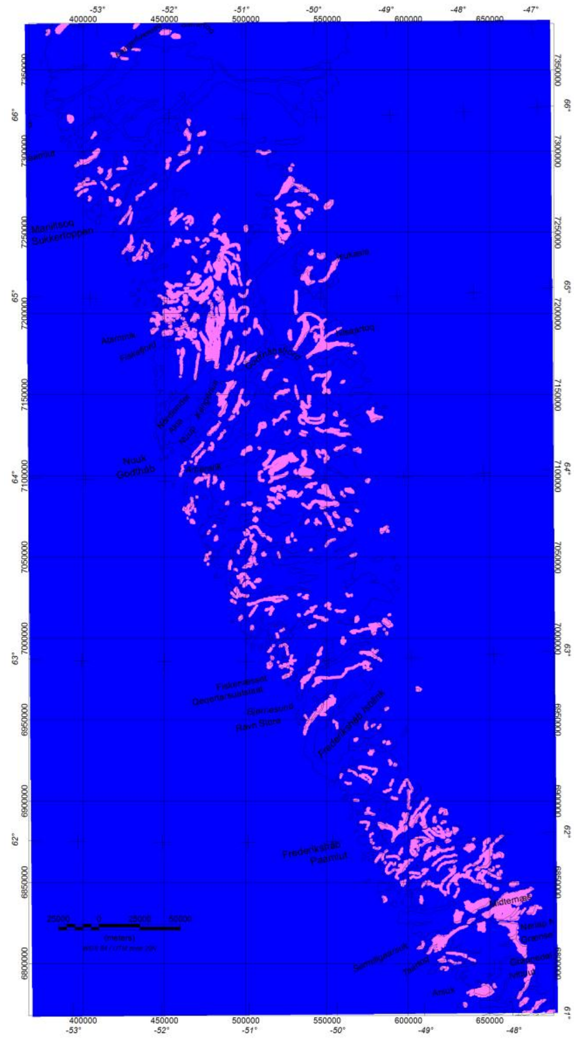


Figure 9. *Map showing the distribution of supracrustal and mafic rock units (in purple) extracted from the new 1:500 000 geological digital map of southern West Greenland, which is used as input to the neural network analysis. To take care of uncertainties related to the scale of the map and to include areas adjacent to of the extracted rock units, the polygons representing the rock units have been buffered or expanded by 600 m. Thus, the selected rock unit occupies a larger area than what appear on the geological map.*

Polygons corresponding to supracrustal and mafic rock units are extracted from the map. Due to uncertainties caused by the scale of the map, a buffer zone of 600 m were applied to the outline of all the extracted polygons. This expansion of the polygons is also done to include areas adjacent to the supracrustal and mafic units. The resulting polygon files were then converted into a grid file in which the value 0 were assigned to areas outside polygons and the value 1 were assigned to areas inside the polygons (Fig. 9). The location of the gold occurrences (targets) in relationship to this grid can be seen in Figure 10, which illustrates well the association between these rock units and the gold occurrences.

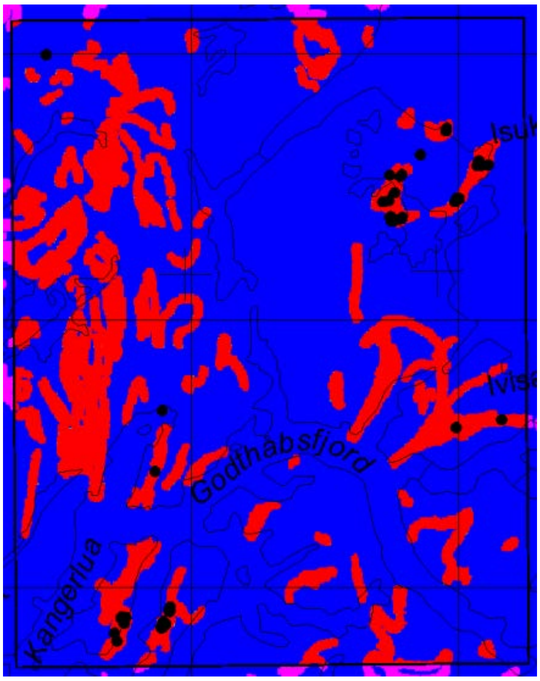


Figure 10. *The 45 gold occurrences used in the neural network analysis as training points (targets) plotted on top of the 600 m buffered supracrustal and mafic rock units extracted from the 1:500 000 geological map from southern West Greenland. A clear relationship between the location of the gold occurrences and the rock units is evident.*

Gold favourability results from neural network analysis

Based on the above data sets as input, a neural network analysis for prediction of gold favourability/prospectivity was carried out. The data sets used in the analysis are summarised in Table 1.

Table 1. *Data sets used in the neural network analysis for predictive gold prospectivity.*

Data type	Data set	Notes
Fine-fraction stream sediment geochemistry distribution	Cs	None
	Sb	None
	As	None
	U	None
	Rb	None
Aeromagnetic data	Vertical gradient of total magnetic intensity field	None
Lineament data	lineaments derived from aeromagnetic data	Texture image-based analysis and discontinuity mapping of aeromagnetic data.
Rock units	supracrustal and mafic rock units	Extracted from 1:500 000 geological map

First, analyses are carried out separately for each of the eight selected data sets in Table 1. Subsequently, different combinations of data sets are being analysed jointly.

A qualitative cross-validation of the predictions is performed that also takes into account that the targets used as input to the neural network analysis only consist of gold mineralised sites defined from data/information reported prior to 2005. The locations of gold occurrences reported after 2005 serves as an independent check of the validity of the predictions. Each prediction is compared and evaluated critically; taking into account the distribution and resolution of the data set they are based upon. In addition, the predicted most favourable areas are reviewed and discussed in relation to the presently known distribution of gold mineralisations and the general geological settings in the entire southern West Greenland.

In the following sections, a sub set of the predicted most favourable areas will be discussed in order to illustrate the approach and exemplify some of the results. It is not the intention to prioritize among the most favourable areas, and not all areas of interest are included here.

Predictions according to single data sets

Figures 11 to 14 show the predictive results for the neural network analysis carried out for single data sets. In summary, these results will outline data signatures most similar to those obtained from the gold occurrence sites (training points).

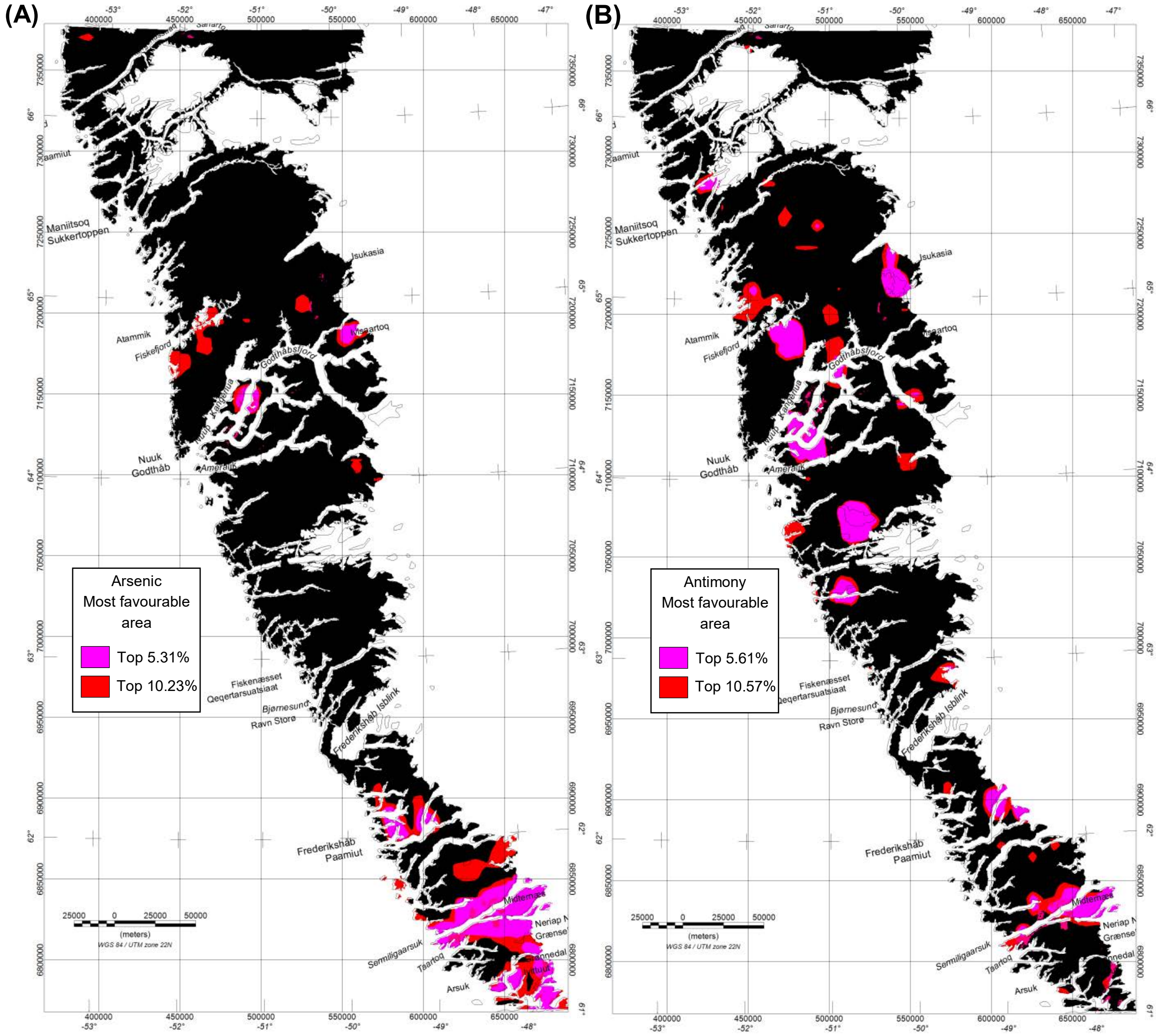


Figure 11. *The most favourable area for gold within the entire southern West Greenland according to the neural network analysis of (**A)** As and (**B)** Sb fine-fraction geochemistry distribution. The 45 gold occurrences from the Nuuk region are used as training points. The percentages are denoting cumulative areas, i.e. for arsenic, the top 10.23% refers to the 10.23% most favourable area for gold according to the As fine-fraction geochemistry distribution (both the purple and the red coloured areas). The black coloured areas are the remaining area that were analysed.*

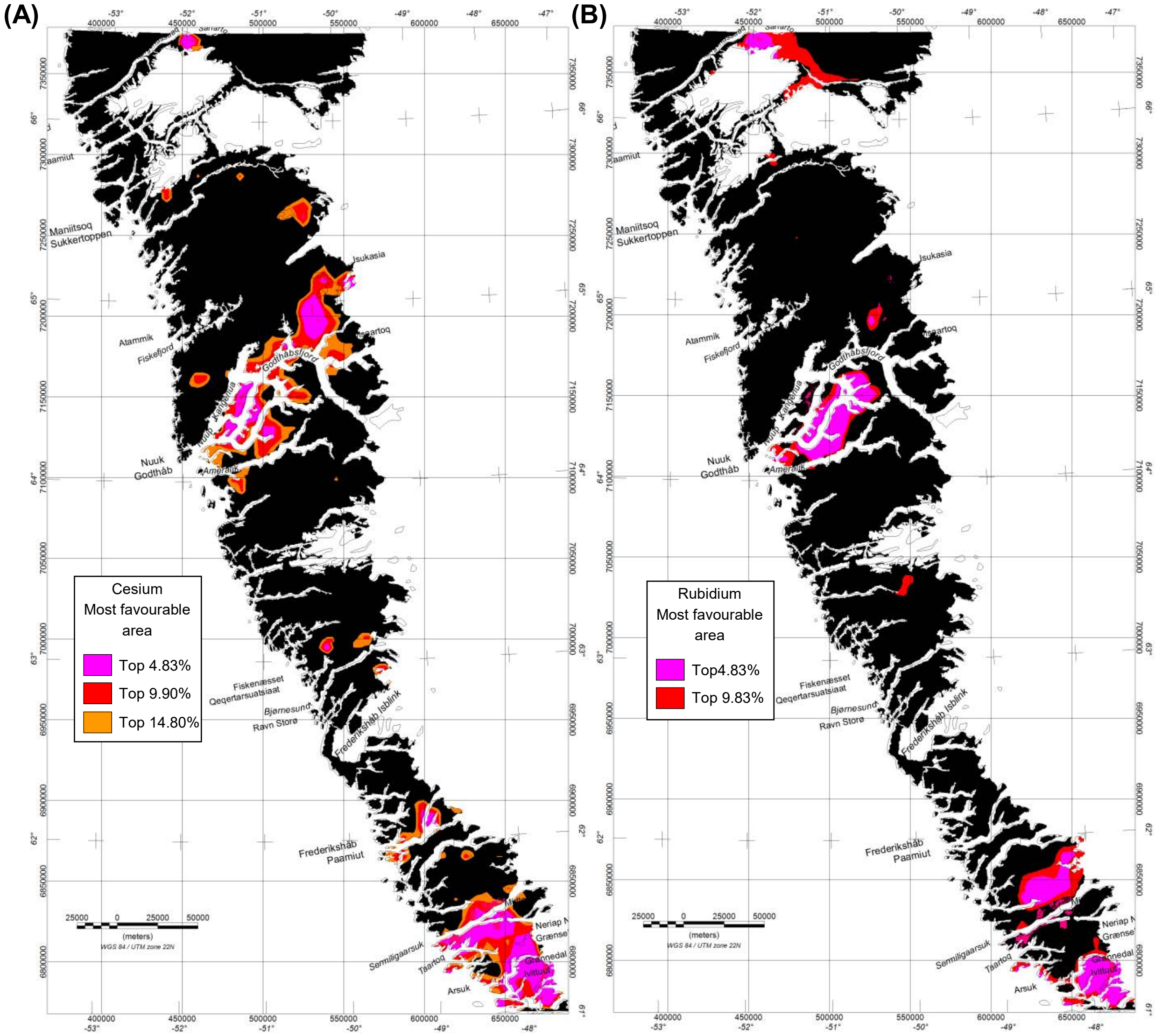


Figure 12. *The most favourable area for gold within the entire southern West Greenland according to the neural network analysis of **(A)** Cs and **(B)** Rb fine-fraction geochemistry distribution. The 45 gold occurrences from the Nuuk region are used as training points. See Figure 11 for further explanation.*

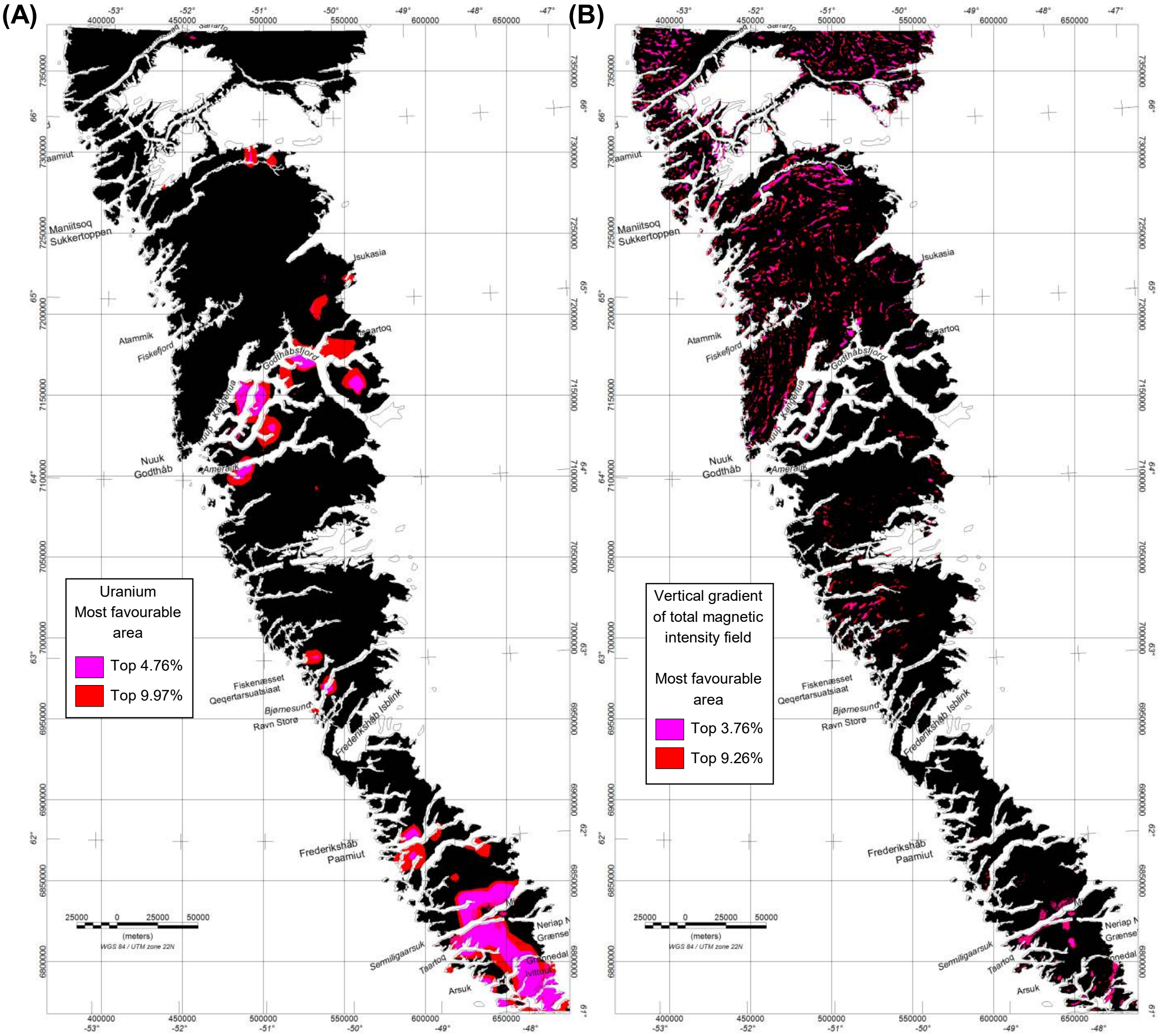


Figure 13. *The most favourable area for gold within the entire southern West Greenland according to the neural network analysis of* ***(A)*** *U fine-fraction geochemistry and* ***(B)*** *the vertical gradient of total magnetic intensity field. The 45 gold occurrences from the Nuuk region are used as training points. See Figure 11 for further explanation.*

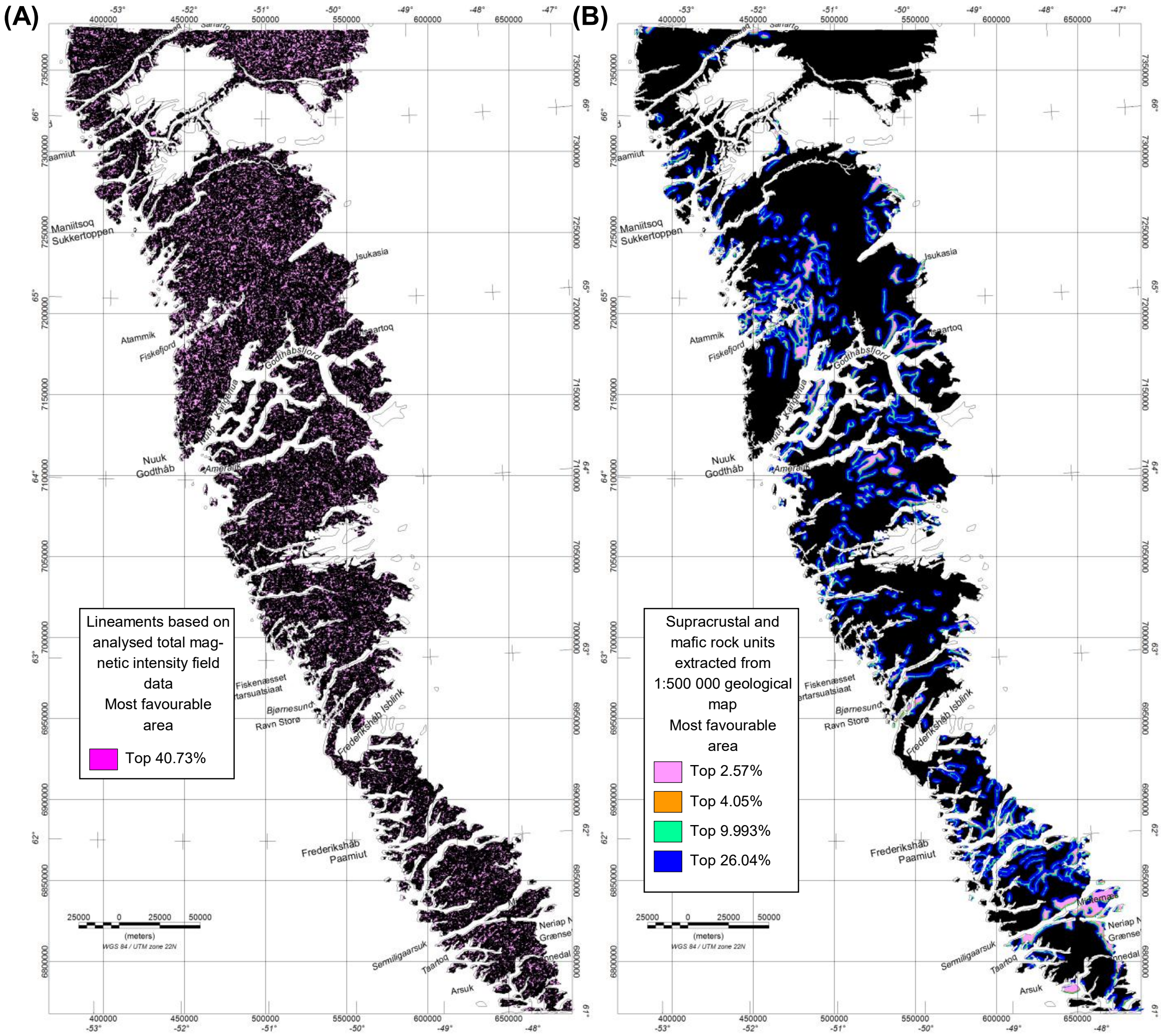


Figure 14. *The most favourable area for gold within the entire southern West Greenland according to the neural network analysis of **(A)** lineaments derived from analysis of derived representations of the total magnetic intensity field and **(B)** supracrustal and mafic rock units extracted from the 1:500 000 geological map. The 45 gold occurrences from the Nuuk region are used as training points. See Figure 11 for further explanation.*

Predictions based on combined data sets

Geochemistry distributions

Based on stream sediment geochemistry distributions for As, Cs, Rb, Sb, and U the predictions from the neural network analysis clearly outline the well-known gold favourable SW–NE oriented corridor in the central Nuuk area. For the inner easternmost part of this corridor, this result is not surprising since the 45 gold occurrences used as training points all are located in this part of the corridor. However, areas outside the target area, but still within the established Godthåbsfjord gold favourable corridor (and known to host gold occurrences, as e.g. areas at Sermitsiaq and east of Nuuk), are also predicted to have high favourability. Further away and to the south of the target area, the Sermiligaarsuk–Tartoq area is also predicted to be favourable for gold. The Sermiligaarsuk–Tartoq area is already established as well-known for its gold occurrences and gold endowment (Kolb 2011). In addition, areas more recently identified to host gold occurrences, e.g. the area in the inner part of the fjord east of Paamiut, and the area at Midternæs and Arsuk, are pick-up by the prospectivity analysis. The ability of the analyses to predict areas outside the target area, qualitatively validates the results of the prediction and gives confidence to the method.

The locations within the 9.7% most favourable area for gold according to the stream sediment geochemistry distribution for As, Cs, Rb, Sb, and U (Fig. 15) where no or very little prior information on gold occurrences exists, are provided below. These areas will be described and discussed further in the sections on the prospectivity analyses carried out for stream sediments geochemistry data sets combined with other data sets. The 9.7% most favourable area with no or little previous information on gold occurrences are:

- **Ivittuut–Arsuk Fjord area:** A larger area around greater Ivittuut, stretching towards Grænseland to the north and Kobberminebugt to the south (area 1 in Figure 16).

- **Isorssua:** A very small area north of Midternæs within the Archaean craton (area 2 in Figure 16; the small area is located within a larger E–W oriented corridor that is included in the 20% most favourable area for gold); an area with mapped mafic/supracrustal units. Gold mineralisations are not known from this area.

- **Bjørnesund–Fiskenæsset:** Two small areas north of Frederikshåb Isblink (area 3 in Figure 16). The northernmost area is located just north-east of the settlement Qeqertarsuatsiaat (Fiskenæsset). The southernmost area is located at the margin of the Inland Ice just north of the Frederikshåb Isblink glacier.

- A larger area east of the north-eastern part of Sukkertoppen Iskappe (area 4 in Figure 16), at the northern part of the Paradise Valley. This area is located just north of the Southern Nagssugtoqidian Front which represents the boundary structure (thrust zone) between the non-reworked North Atlantic Craton and the Palaeoproterozoic reworked Archaean gneisses belonging to the Foreland zone of the Palaeoproterozic Nagssugtoqidian orogen. According to the geological map, this area is dominated by gneisses and a few large amphibolite units. Gold mineralisations are not known from this area. A gold anomalous stream sediment sample within the 9.7% most favourable area has been collected from the area just west of the area.

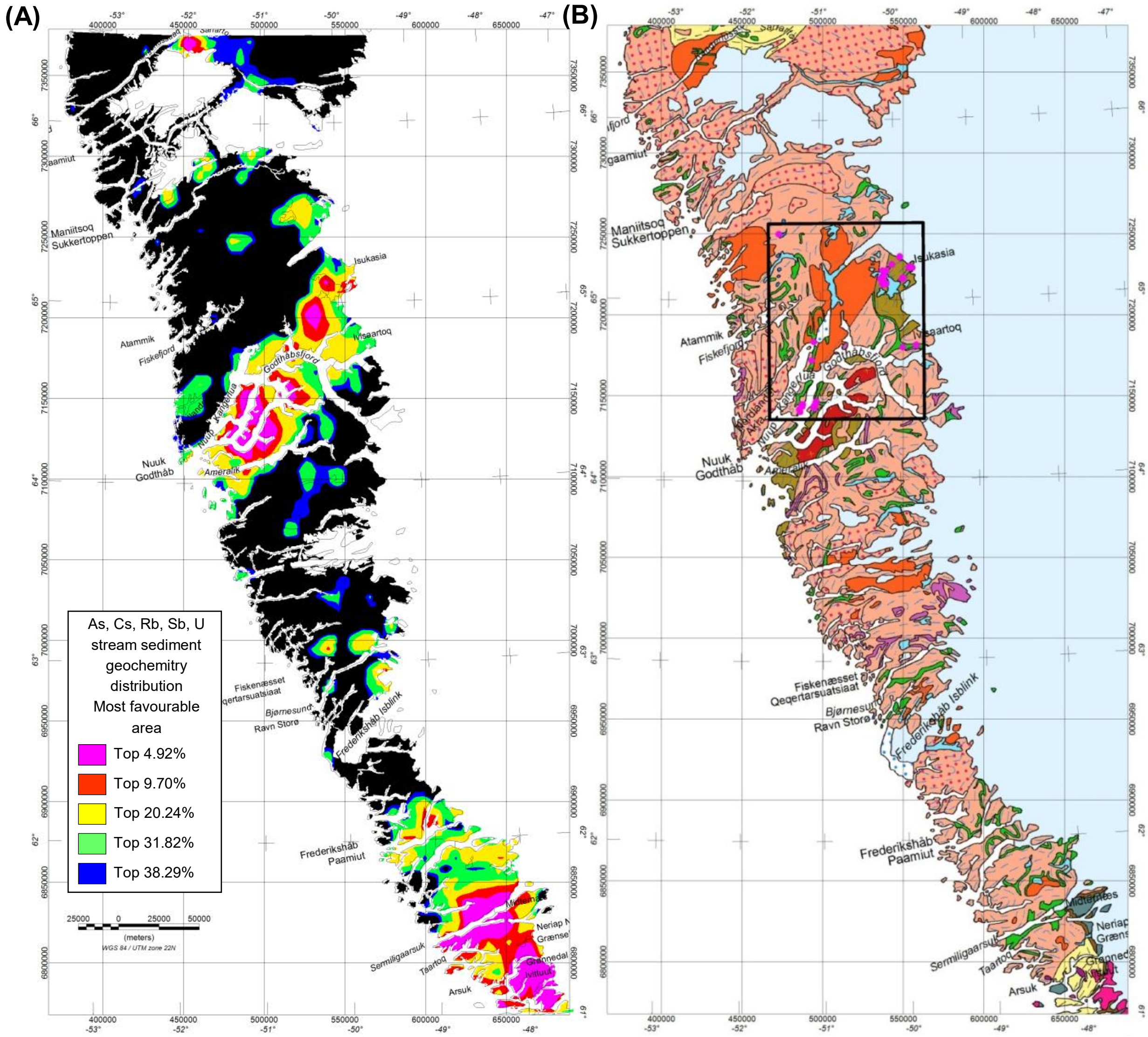


Figure 15. ***(A)*** *The most favourable area for gold according to the neural network analysis of stream sediment geochemistry distributions of As, Cs, Rb, Sb and U.* ***(B)*** *The simplified geological map (from digital version of scale 1:2 500 000 geological map; Escher & Pulvertaft (1995)). The percentages in (A) are denoting cumulative areas, i.e. the top 20.24% refers to the 20.24% most favourable area for gold (both the purple, red and yellow coloured areas).*

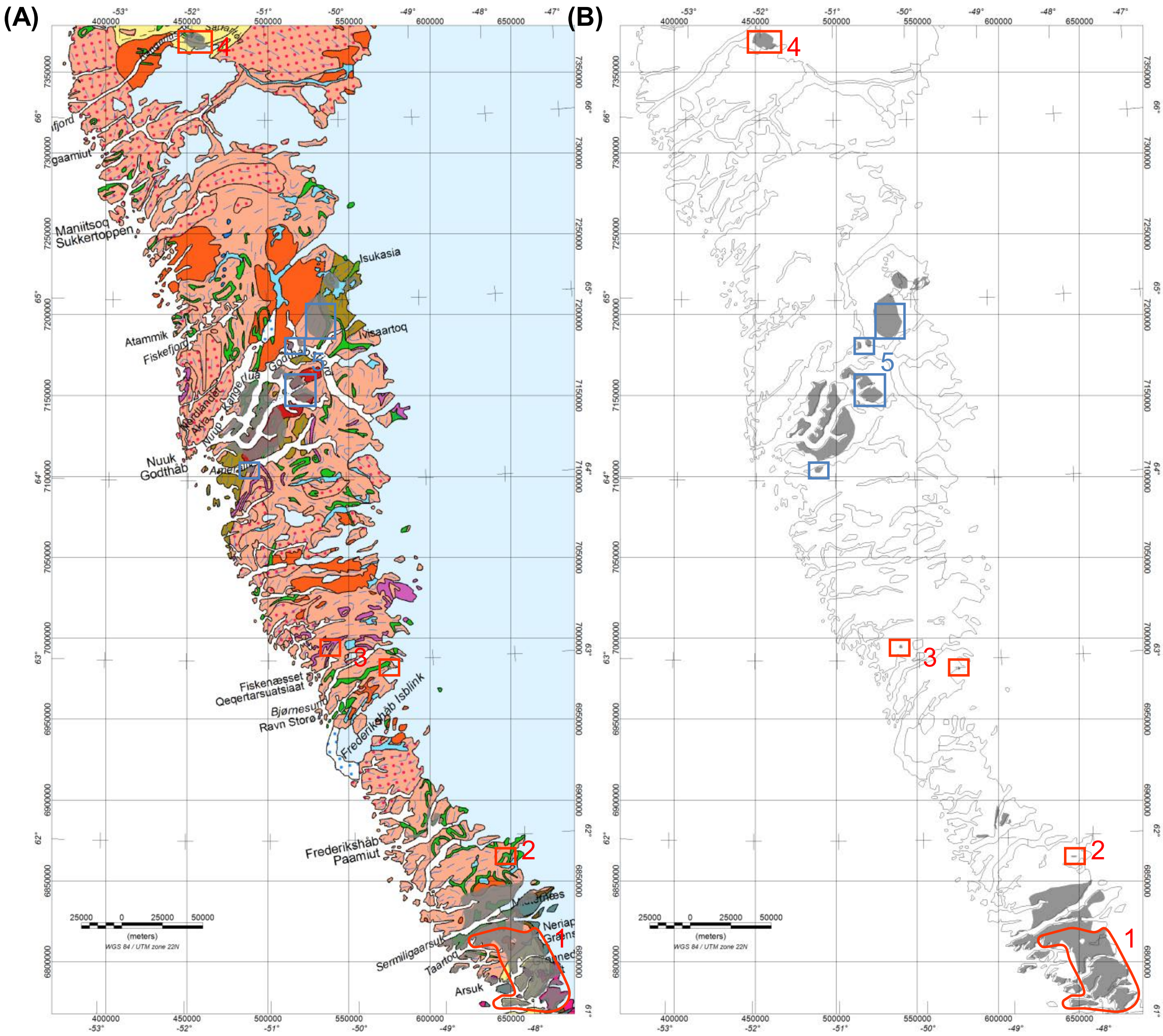


Figure 16. ***(A)*** *The 9.7% most favourable area (transparent grey) for gold according to the neural network analysis of stream sediment geochemistry distributions of As, Cs, Rb, Sb and U displayed superimposed on the simplified geological map (from digital version of 1:2 500 000 geological map; Escher & Pulvertaft (1995)).* ***(B)*** *The 9.7% most favourable area as grey polygons displayed on top of the outline of coast and ice. Areas marked by red polygons are within the 9.7% most favourable area for gold where no or very little prior information on gold occurrences exists. Areas marked by blue polygons are within the 9.7% most favourable area for gold and within the well-established Nuuk gold-endowment corridor where no known gold occurrences have been reported.*

Geochemistry and lineaments

The results of the combined neural network analysis of (i) lineaments derived the total magnetic intensity field and (ii) stream sediment geochemistry distribution for As, Cs, Rb, Sb, and U are shown in Figure 17. Again, it is important to consider, that only gold occurrences from the central Nuuk region within the training area have been used to predict other favourable areas in southern West Greenland.

The most favourable area will still in general outline regions identified by the stream sediment geochemistry (see former section). However, by adding the lineament data it is possible to pay special attention to structural elements (e.g. structures (faults, thrust zones, shear zones), rock units outlines/contacts/contrasts etc.) and observe their contribution to the results. With the addition of the lineament data to the neural network analysis, many of the favourable areas can be linked to mapped geological features (see e.g. Figure 9).

When considering the input of the lineament data it is important to remember that the lineaments are extracted from aeromagnetic data surveyed with a line spacing of 500 m and nominal 300 m draped ground clearance. Some of the mapped geological features and trends are therefore not evident and resolved in the magnetic data. Consequently, when using the results on favourability, care should be taken not to over-interpret the mapped sites as well-defined direct targets. Instead, the areas pointed to as being more favourable represents geological environments favourable for gold forming processes. The favourability mapping should be seen as an attempt to provide an input to the selection of areas and features, where more detailed work and data should be considered.

The predictions for the training area and the adjacent area in the Nuuk region will shortly be described. For areas with known gold occurrences, outside the training area in the Nuuk region, the most favourable area at Sermiligaarsuk–Tartoq and Paamiut will be used to exemplify the prediction results of the joint analyses of lineaments and stream sediment geochemistry distribution for As, Cs, Rb, Sb, and U.

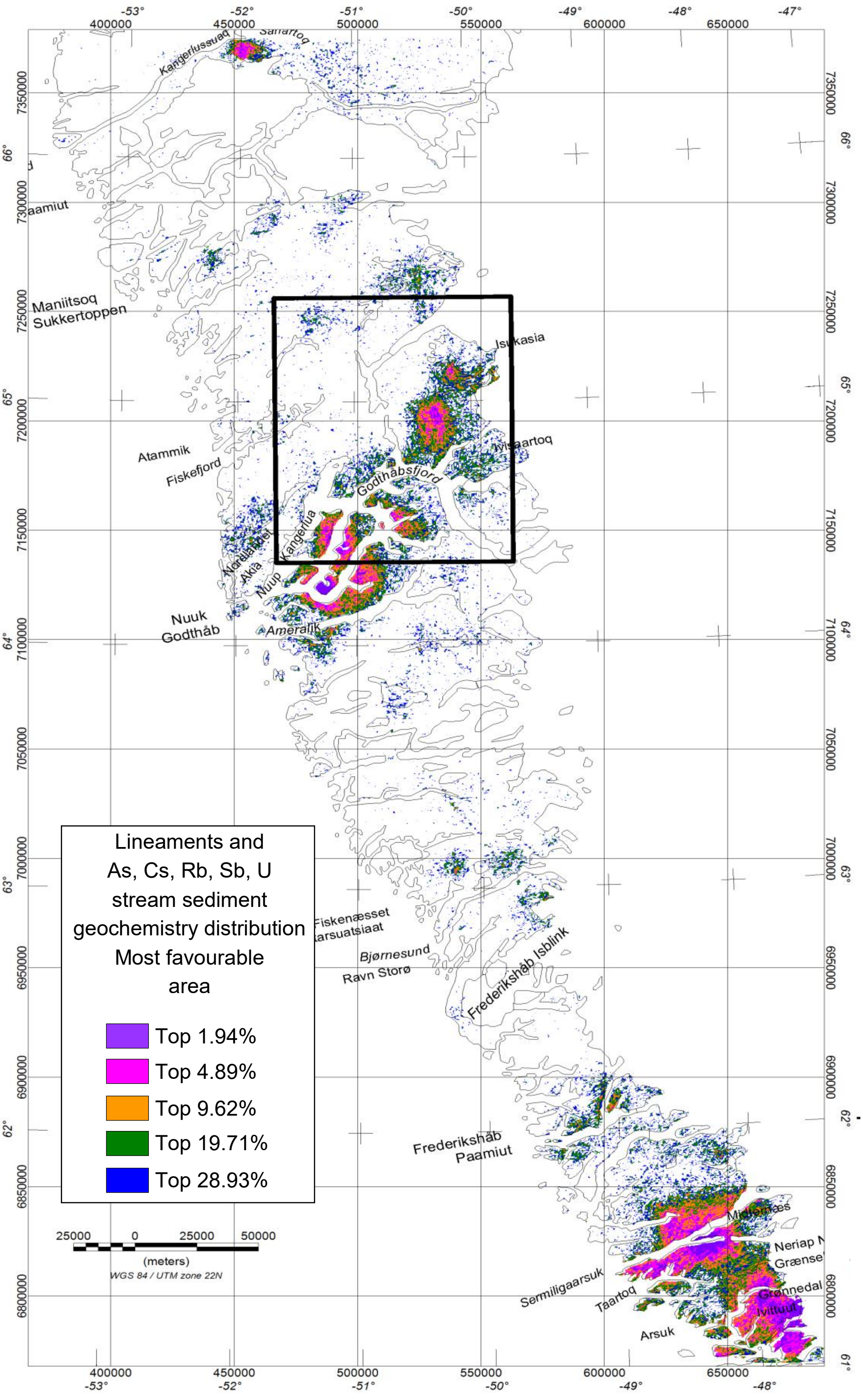


Figure 17. *The 28.93% most favourable area (displayed in 5 top intervals) for gold according to the joint neural network analysis of lineaments and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U.*

Areas with well-known gold endowment

The Nuuk region

Based on stream sediment geochemistry distribution for As, Cs, Rb, Sb, U and the lineaments derived from processed total magnetic intensity field data, the predictions (Fig. 18) from the neural network analysis clearly outline the well-known gold favourable SW–NE oriented corridor in the central Nuuk area. (Appel *et al.* 2003; and references therein; Kolb *et al.* Submitted 2012; Stendal *et al.* 2008; Thorning *et al.* 2011)

It is not surprising that the inner easternmost part of this corridor within the training area is being classified as most favourable, since the 45 gold occurrences of the target area used as input all are located here. However, a couple of favourable areas within the training area falling *outside* areas with known gold occurrences (training points), e.g. the Ujarssuit Nunaat area south of the Isua area and the Ivisaartoq area, are of interest. Reconnaissance follow-up during field work in the northernmost part of the Ujarssuit area (Stensgaard 2008) based on other mineral potential analysis (Nielsen *et al.* 2004; Stensgaard *et al.* 2006b), resulted in positive indications for the gold potential in this area; which may be taken as a validation of the results.

Gold anomalous rock samples and stream sediment samples are e.g. known from areas at Sermitsiaq and east of Nuuk and south of the outer part of Sermilik (Appel *et al.* 2003; Stensgaard *et al.* 2006b; Thorning *et al.* 2011). These areas outside the training area are all outlined as favourable for gold by the neural network analysis (Fig. 18).

The Qussuk area in the Nuuk region is well-known for its gold occurrences (Fig. 18, Kolb 2011; Schlatter & Christensen 2010) does only appear when the 10% to 30% most favourable area is considered. One likely explanation for the predicted low favourability could be that the pre-2005 training points only include two locations from the Qussuk area (as most of the gold occurrences in this area were found after 2005) and that these gold occurrences have a different manifestation in the data than the other gold occurrences. This is consistent with earlier investigations of the signatures and mutual prediction capability of individual gold occurrences and classification of gold occurrences in the Nuuk region (Nielsen *et al.* 2004; Stensgaard *et al.* 2006b).

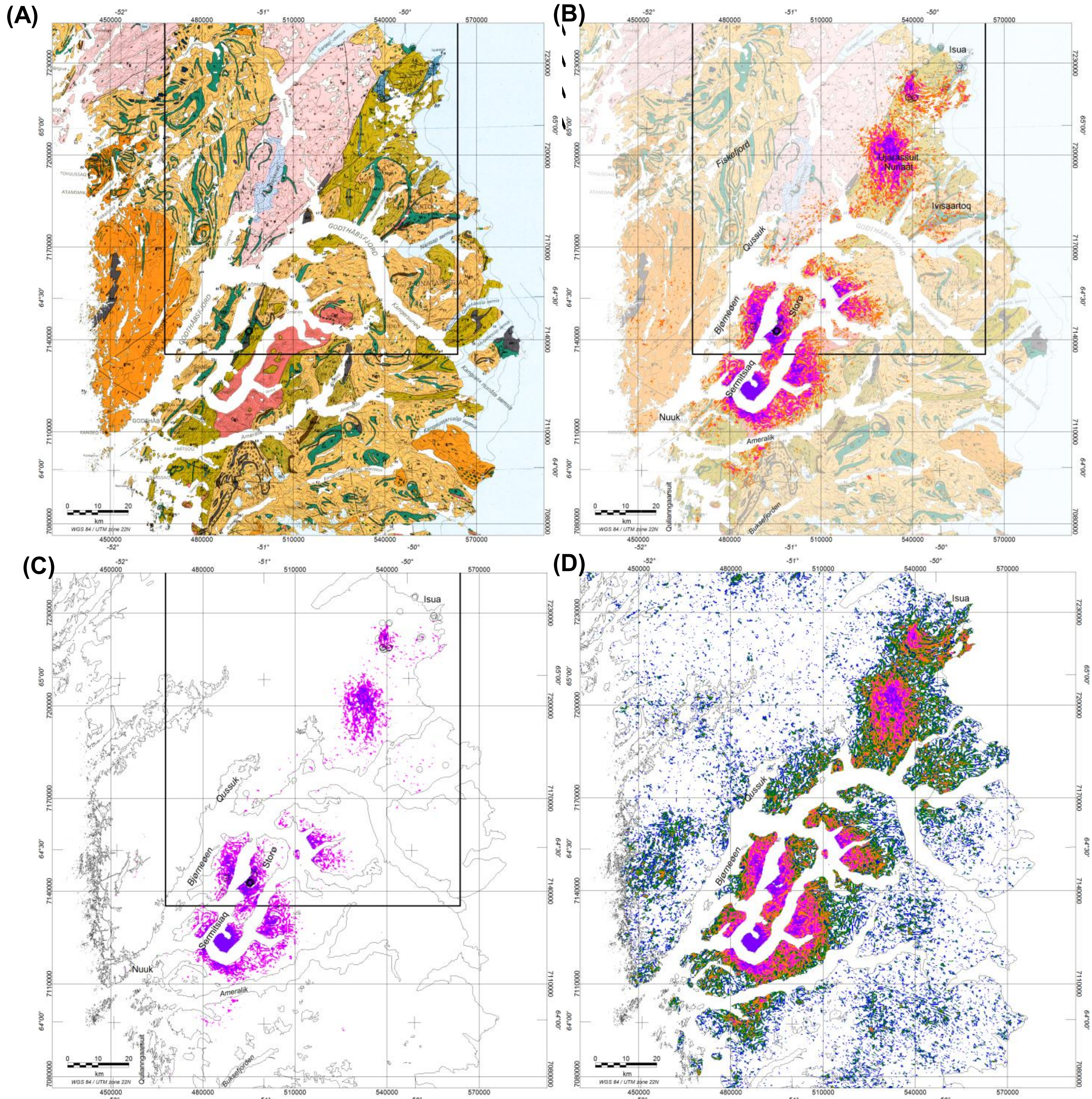


Figure 18. ***(A)*** *Geological map of the Nuuk region with known locations of gold occurrences in the area (Kolb et al. 2012) displayed on top (black open circles). Geology extracted from the existing 1:500 000 geological map from the area. For geological legend refer to Allaart (1983).* ***(B)*** *The 90.4% most favourable area for gold (in three colour intervals) displayed on top of the geological map.* ***(C)*** *The 95.1% most favourable area for gold (in two colour intervals).* ***(D)*** *The 71% most favourable area for gold (in five colour intervals). The favourable area is according to the neural network analysis of lineaments derived from processed total magnetic intensity field data and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U.*

Lineaments and As, Cs, Rb, Sb, U stream sediment geochemistry distribution Most favourable area

- Top 1.94%
- Top 4.89%
- Top 9.62%
- Top 19.71%
- Top 28.93%

The Sermiligaarsuk – Tartoq area

Several gold mineralised features are known within the volcano-sedimentary succession of the Tartoq Group and the Sermiligaarsuk–Tartoq area is well-known for its gold endowment (Fig. 19, Kolb, 2011). An example on the predictions is shown in Figure 20.

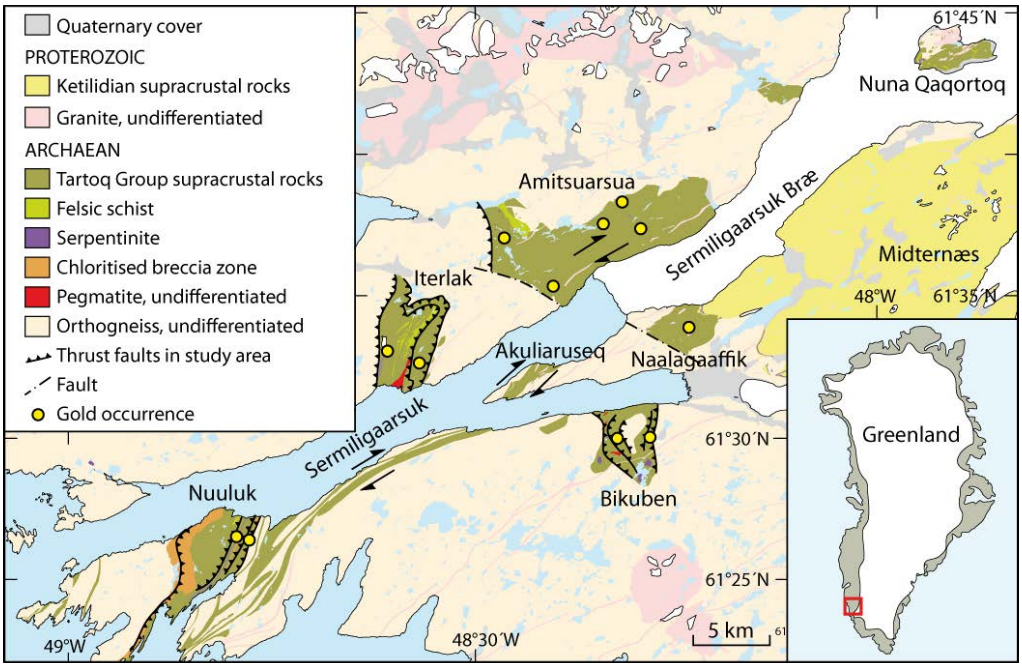


Figure 19. *Schematic geological map of the Tartoq gold province (from Kolb 2011).*

The analysis also outlines a large part of the Sermiligaarsuk–Tartoq area as being favourable for gold (Fig. 20). At Nuuluk, the known gold is hosted in two distinct NNE–SSW-trending 50–100 m wide and 5 km long hydrothermal altered quartz-vein bearing zones. At Iterlak, the gold is hosted in two NNE–SSW-trending areas, approximately 100 m wide and 200–400 m long zones in which high gold values are recorded from hydrothermal alteration zones. At Amitsuarsua, gold mineralisations are hosted within ENE–WSW-trending quartz-bearing hydrothermal alteration zones. At Naalagaarfik and Akuliarusaq, gold is found in ENE–WSW-trending hydrothermal zones. For the predicted most favourable areas that contain a structural grain, the trends of the above mentioned gold-mineralised zones are recognised (Fig. 20). South of Sermiligaarsuk–Tartoq, is outlined another large area as being favourable for gold.

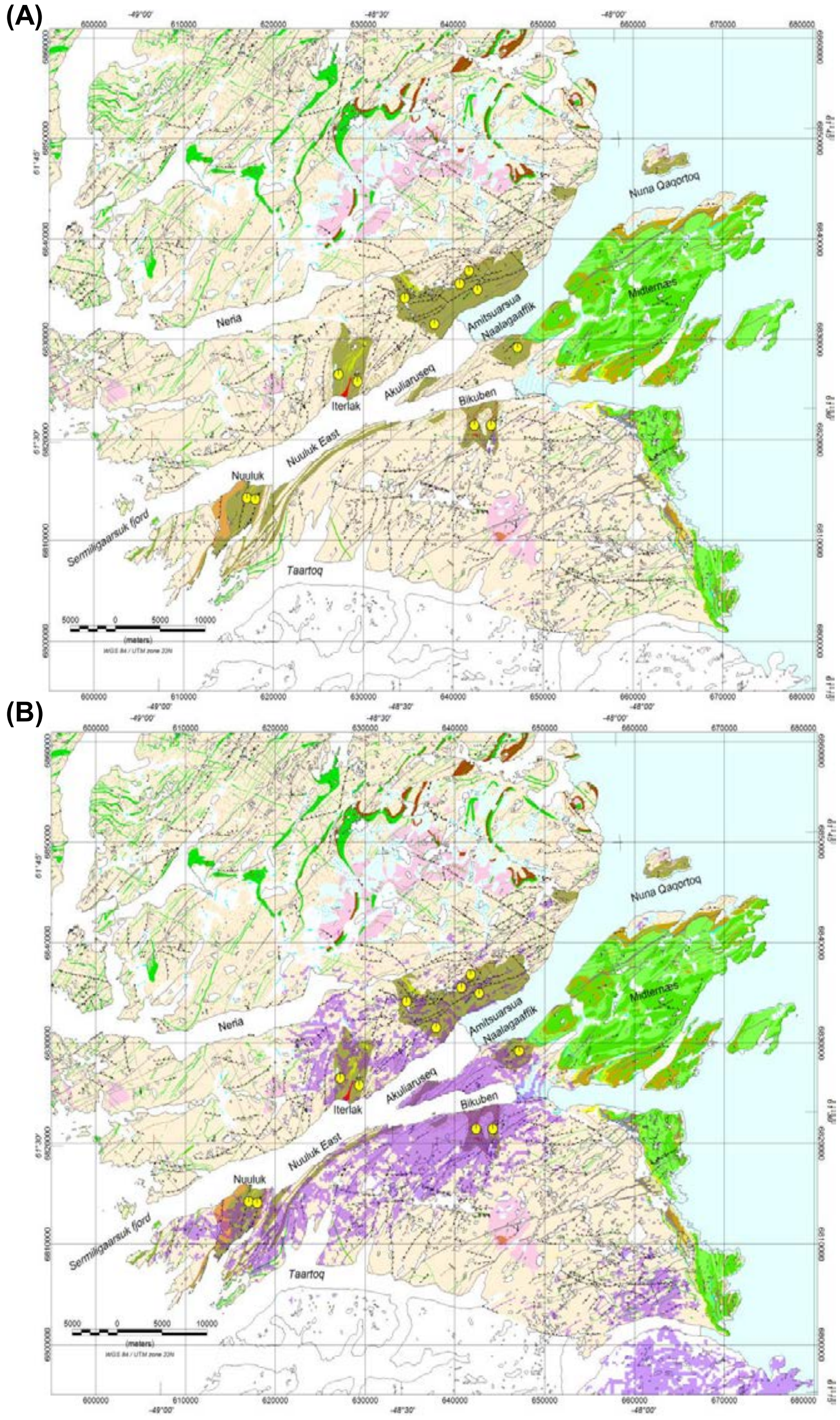


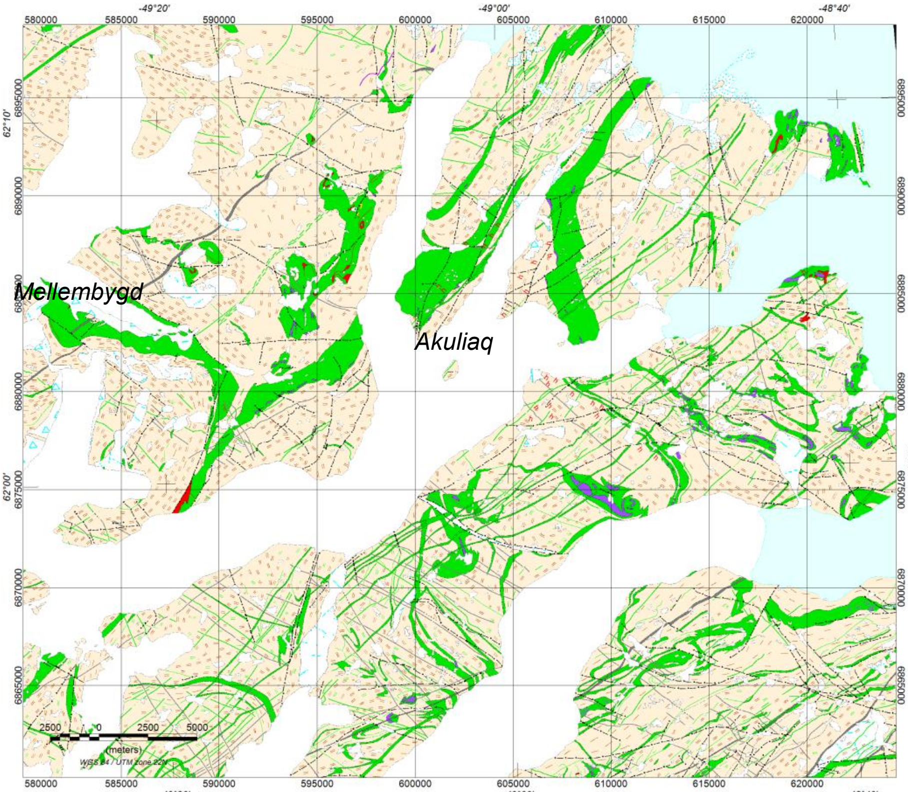
Figure 20. ***(A)*** *Geological map of the Sermiligaarsuk –Tartoq area with known reported locations of gold occurrences (Kolb 2011) displayed on top (yellow circles).Geology extracted from the existing 1:100 000 digital geological map (Keulen et al. 2010b). The geological map south of Tartoq is not digitalised, and this area has therefore been omitted.* ***(B)*** *The 1.94% most favourable area for gold (in transparent purple) displayed on top of the geological map. The favourable area is according to the neural network analysis of lineaments derived from total magnetic intensity field data and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U. For geological legend refer to Keulen et al. (2010b).*

The Paamiut area

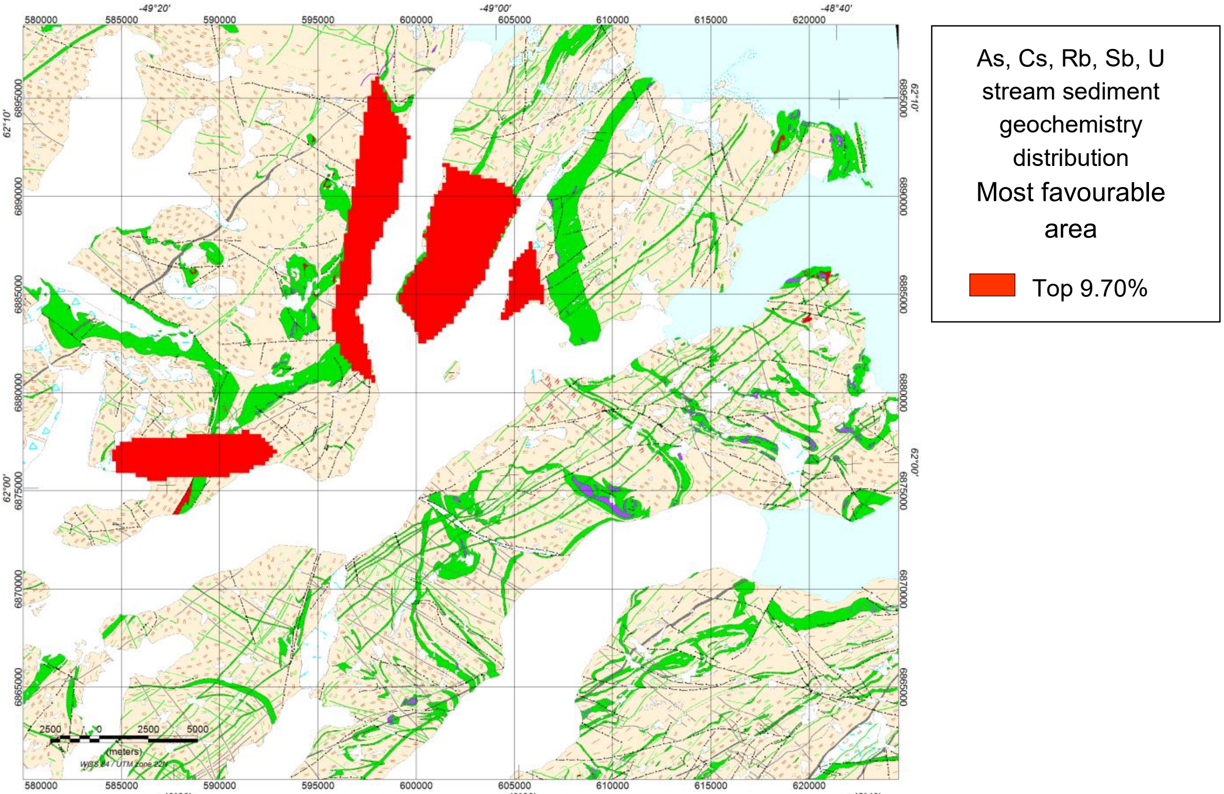
For the Paamiut region, the most favourable area (Fig. 21) mimics the presently known distribution of gold occurrences at the Akuliaq peninsula and the trend of some of the mineralized features known from this region.

At the Akuliaq peninsula, the exploration company NunaMinerals A/S has lately carried out work and identified gold mineralisations along shear zones and at intersections between shear zones. Rock samples have returned up to 11.8 ppm Au (Kolb 2011). The gold is hosted in hydrothermal quartz-veins. The peninsula is characterized by an approximately 1 km wide, northeast-southwest trending supracrustal belt with komatiitic and basaltic flows and volcaniclastic rocks. A 100 m wide southeast trending high strain zone can be traced along the peninsula. Quartz vein systems are widespread. The veins are generally 2–20 cm wide, only a few are wider, reaching up to 20 m in width (Kolb *et al.* Submitted 2012). East of the Akuliaq is the Mellembygd gold occurrence. This occurrence is within the predicted 10% most favourable area (Figs 21C and 21D). Structurally the Paamiut area is interpreted to be an analogy to the frontal and lateral ramp thrust systems found in fold-and-thrust belts and back thrusts which exists in modern collisional orogens (Kolb 2011). Just east and south-east of the Akuliaq peninsula are several favourable areas indicated; these are within the continuation of the structures that contain the gold-bearing quartz-systems at Akuliaq and may provide interesting areas for follow-up. This area comprises numerous thrust/shear zone splays/duplexes and flower structures, which are also noted by Kolb (2011) as a potential favourable locus for gold mineralizing fluids.

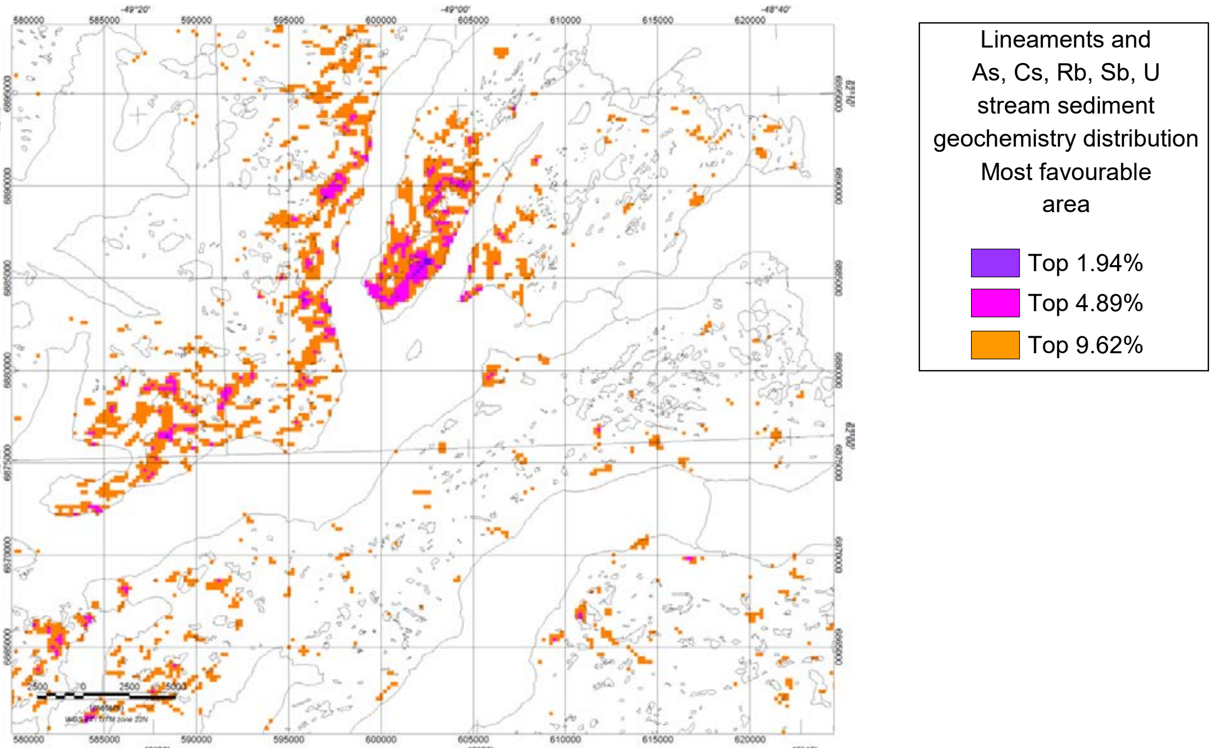
(A)


Mellembygd
Akuliaq
580000
585000
590000
595000
600000
605000
610000
615000
620000
-49°20'
-49°00'
-48°40'
62°10'
62°00'
(meters)
WGS 84 / UTM zone 22N

(B)


As, Cs, Rb, Sb, U
stream sediment
geochemistry
distribution
Most favourable
area
Top 9.70%
580000
585000
590000
595000
600000
605000
610000
615000
620000
-49°20'
-49°00'
-48°40'
62°10'
62°00'
(meters)
WGS 84 / UTM zone 22N

(C)



(D)

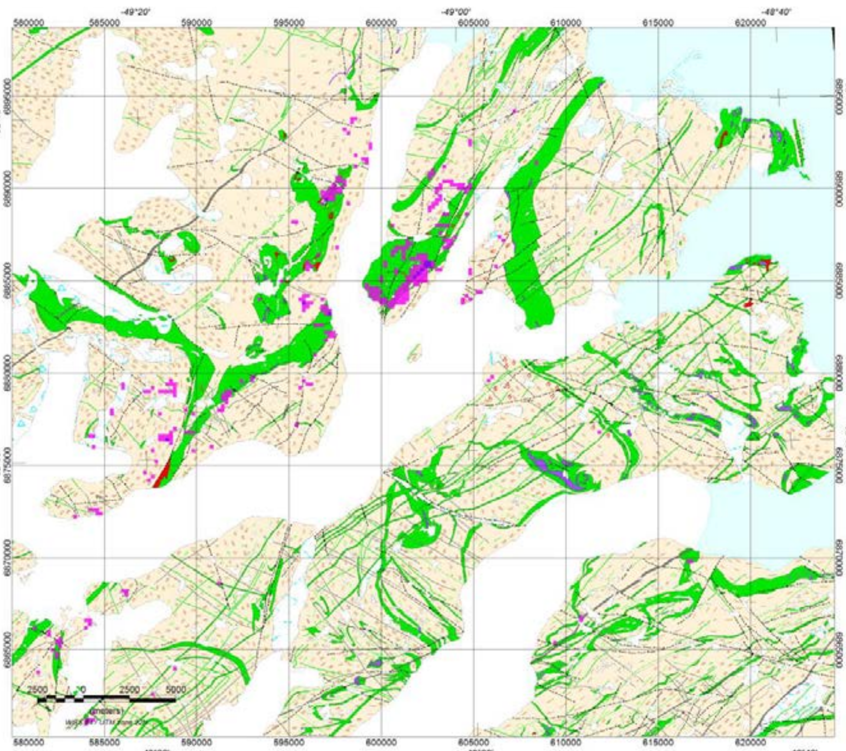


Figure 21. ***(A)*** *Geological map of the area east of Paamiut. For geological legend refer to Keulen et al. (2010b).* ***(B)*** *The 9.70% most favourable area for gold according to the neural network analysis of stream sediment geochemistry distributions of As, Cs, Rb, Sb and U only.* ***(C)*** *The 9.62% most favourable area (coloured in three intervals) for gold according to the joint neural network analysis of lineaments and stream sediment geochemistry distributions of As, Cs, Rb, Sb and U.* ***(D)*** *As in (B) but now only the 1.94% and 4.89% most favourable areas displayed on top of the geological map.*

Areas without well-known gold endowment

In the following, some favourable areas without presently known gold occurrences will be discussed.

The Ivittuut – Arsuk Fjord area

An NW–SE orientated wide corridor inland along the margin of the Inland Ice from south-east of Ivittuut to just north of the inner part of Arsuk Fjord is predicted to have a high prospectivity for gold (Fig. 22).

The geology of this area is complex with mixed rock units and terrains with the Archaean craton to the north and the Palaeoproterozoic Ketilidian orogeny to the south. Also intrusions of the later, 1150 Ma Gardar igneous province are present in the area. In the southern and eastern part of the area outlined as favourable, along the Inland Ice, several smaller copper mineralizations are known; in some cases also with elevated gold content (Erfurt 1990; Erfurt & Lind 1990; King 1983; Mosher 1995; Secher & Kalvig 1987). These mineralisations are hosted within Ketilidian metavolcanic rock units in some cases interlayered with clastic metasediments. The Ketilidian supracrustals are located within the northwestern Border Zone of the Palaeoproterozoic Ketilidian orogen. The several kilometres thick, supracrustal succession comprises low to medium metamorphic grade metavolcanics and metasediments that rest unconformably upon the Archaean gneiss basement. The supracrustals have been divided into the Vallen Group, which largely consists of clastic sediments and the overlying Sortis Group, in which basic pillow lavas and related doleritic to gabbroic sills predominate (Bondesen 1970; Garde *et al.* 2002; Garde *et al.* 1998; Higgins 1970). However, the favourable area stretches into the basement gneisses of the Archaean craton that are intruded by early granites of the Ketilidian Julianehåb Batholith and the later Gardar intrusives. This could reflect that favourable settings also are present within the area dominated by the Archaean basement complex, between the Ketilidian supracrustals along the margin of the Inland Ice and Ivittuut. The favourable 'signature' picked-up could also be a reflection of the nearby Ketilidian supracrustals.

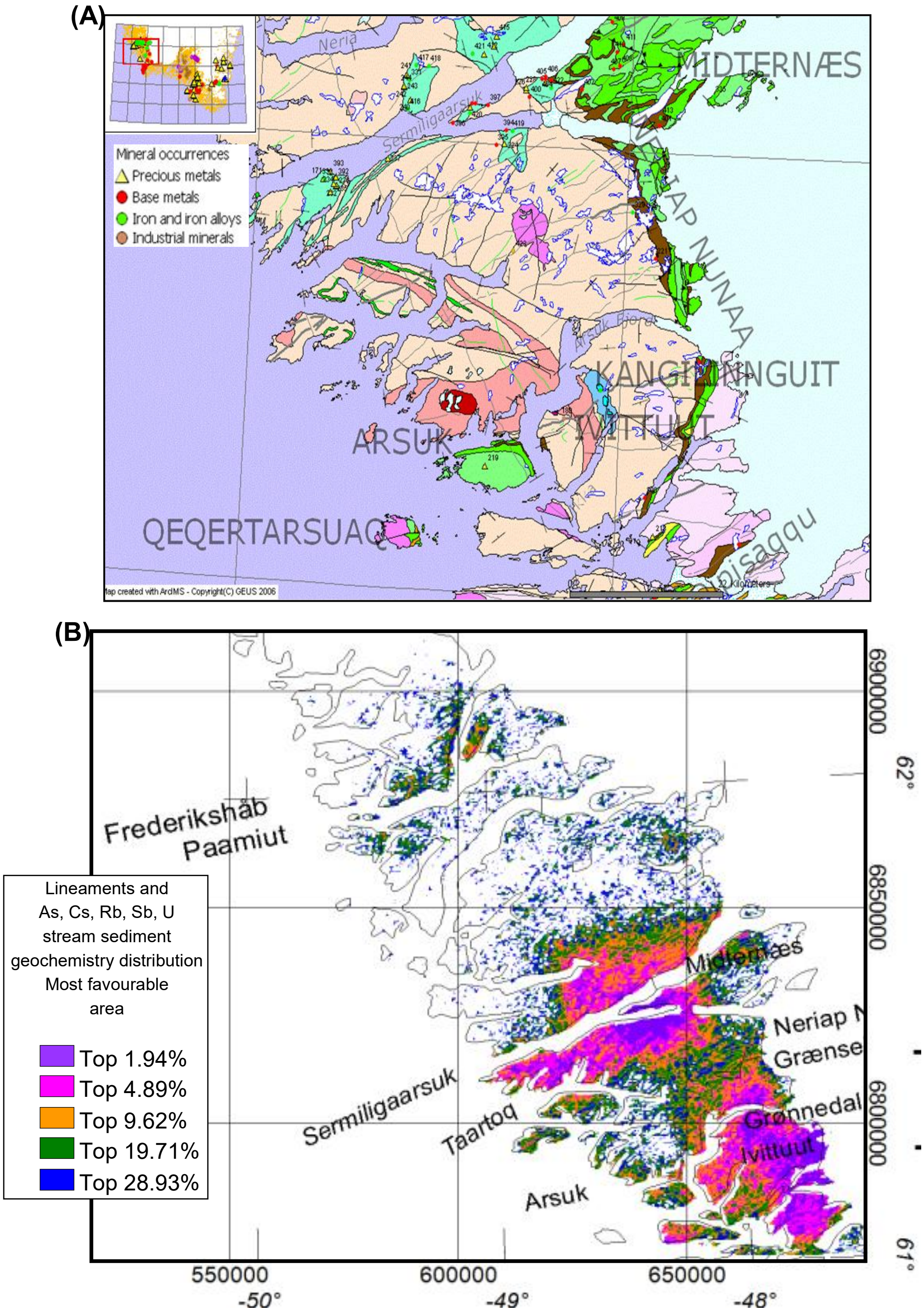


Figure 22. ***(A)*** *Simplified geology for the area between Ivittuut and Sermilgaarsuk with known mineralisations shown. Map from the Greenland Mineral Occurrence Map service at www.geus.dk/gmom. For geological legend refer to Garde (2007).* ***(B)*** *The 28.93% most favourable area (displayed in 5 top intervals) for gold according to the neural network analysis of lineaments and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U.*

The Isorssua area

A small area south east of Sermilik Bræ, north of Midternæs, is outlined as being favourable for gold (Fig. 23). Little is known from this area but it might represent a continuation of the frontal and lateral ramp thrust systems that are known to be gold mineralised from the Paamiut and Sermiligaarsuk–Tartoq areas (Kolb 2011). The area is characterised by small slivers/belts of amphibolites and mica schist. Keulen *et al.* (2010a) describe several mylonitic and cataclastic zones from the area just west of Isorssua. It is also noted that some of the metasediments in the Isorssua area resembles altered felsic volcanics found at Nigerlikasik (the fjord at Paamiut).

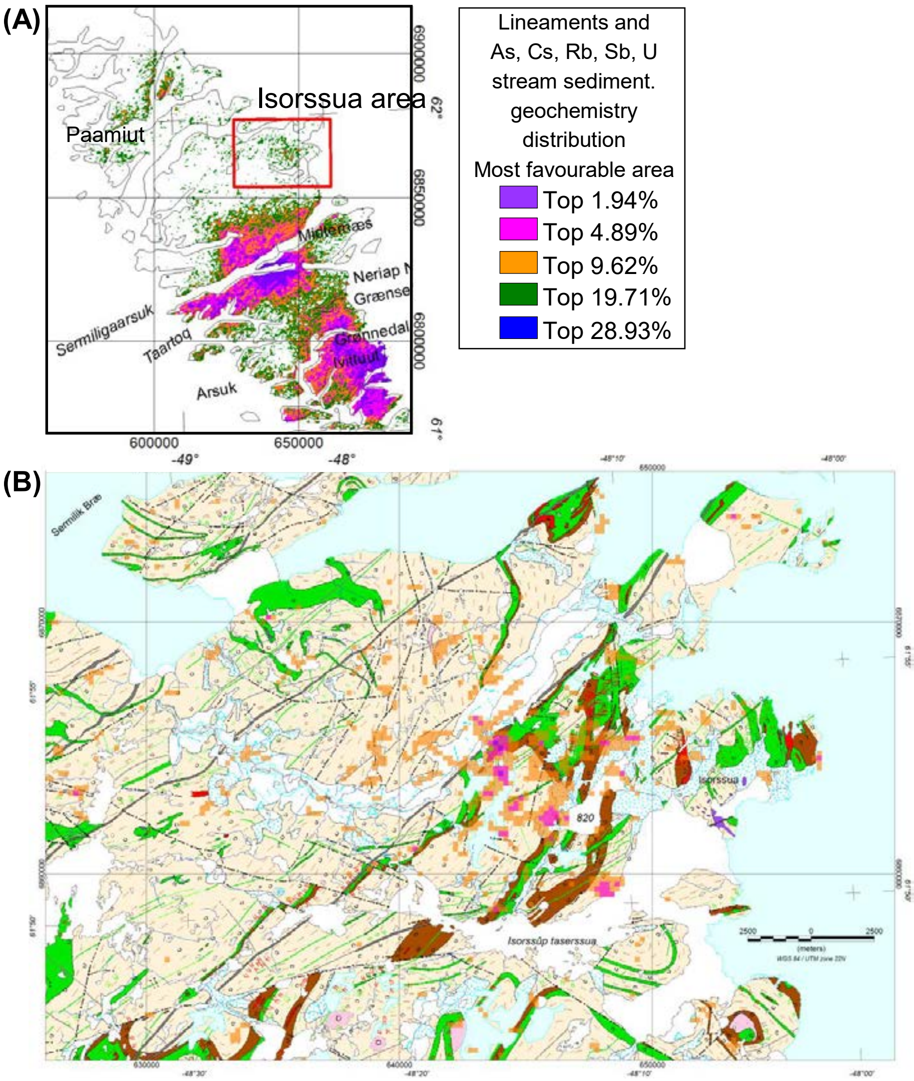


Figure 23. ***(A)*** *Location of the Isorssua area southeast of Sermilik Bræ with the 28.93% most favourable area (coloured in five intervals) for gold displayed on top according to the neural network analysis of lineaments and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U.* ***(B)*** *The geological map for the Isorssua area with the 9.62% most favourable area for gold (coloured in three intervals, see (A)).*

The Bjørnesund area
One area, located in the eastern extension of the Bjørnesund Supracrustal Belt, is being outlined as favourable for gold (within the ~10% most favourable area of the entire southern West Greenland; Fig. 24). This area is located at the margin of the Inland Ice north of the Frederikshåb Isblink glacier within mafic and supracrustal rock units of the Bjørnesund Supracrustal Belt. The basement of the Bjørnesund area comprises a 50 km long and a few hundred metres to three km wide E-W-oriented supracrustal belt dominated by amphibolites and quartz-dioritic gneiss. The greenstones are bordered towards the north and the south by tonalite-trondhjemite-granidiorite gneisses interpreted to have been intruded into the supracrustals. Sheets of leucogabbros, gabbros and anorthosite are interpreted to have been intruded into the amphibolites (Keulen *et al.* 2010a). Late granites intruded into the sequence of quartz-diorite amphibolite and anorthosite-gabbro. Based on work by the company Nunaoil A/S in 1996, anomalous elevated gold samples (ppb range, with the maximum up to 812 ppb Au) have been reported from the central parts of the Bjørnesund Supracrustal Belt (Erfurt 1991, Heilmann 1997, Heilmann 1998, NunaMinerals 2006). However, no gold mineralisation has been reported from the western and eastern part of the belt, in which also very little exploration work seems to have been carried out. See also Schlatter & Stensgaard (2012) for further description of results and the field work follow-up that were directed by the mineral potential mapping and carried out in the Bjørnesund area.

The Fiskenæsset area
Two areas east of the settlement Fiskenæsset, in areas with gneisses and interfolded amphibolites and anorthosite rock sequences, referred to as the Fiskenæsset Anorthosite Complex, is outlined as being favourable for gold (within the ~10% most favourable area of the entire southern West Greenland; Fig. 24).

Anomalous elevated gold samples have been reported from the northernmost area within hydrothermal alteration zones in contact/shear zones between the Fiskenæsset Anorthosite Complex and the gneisses and/or amphibolites in the area (Kolb *et al.* 2010). Besides these investigations, no field programs have focused on possibilities for gold in the area and within the predicted most favourable areas outlined by the neural network analysis.

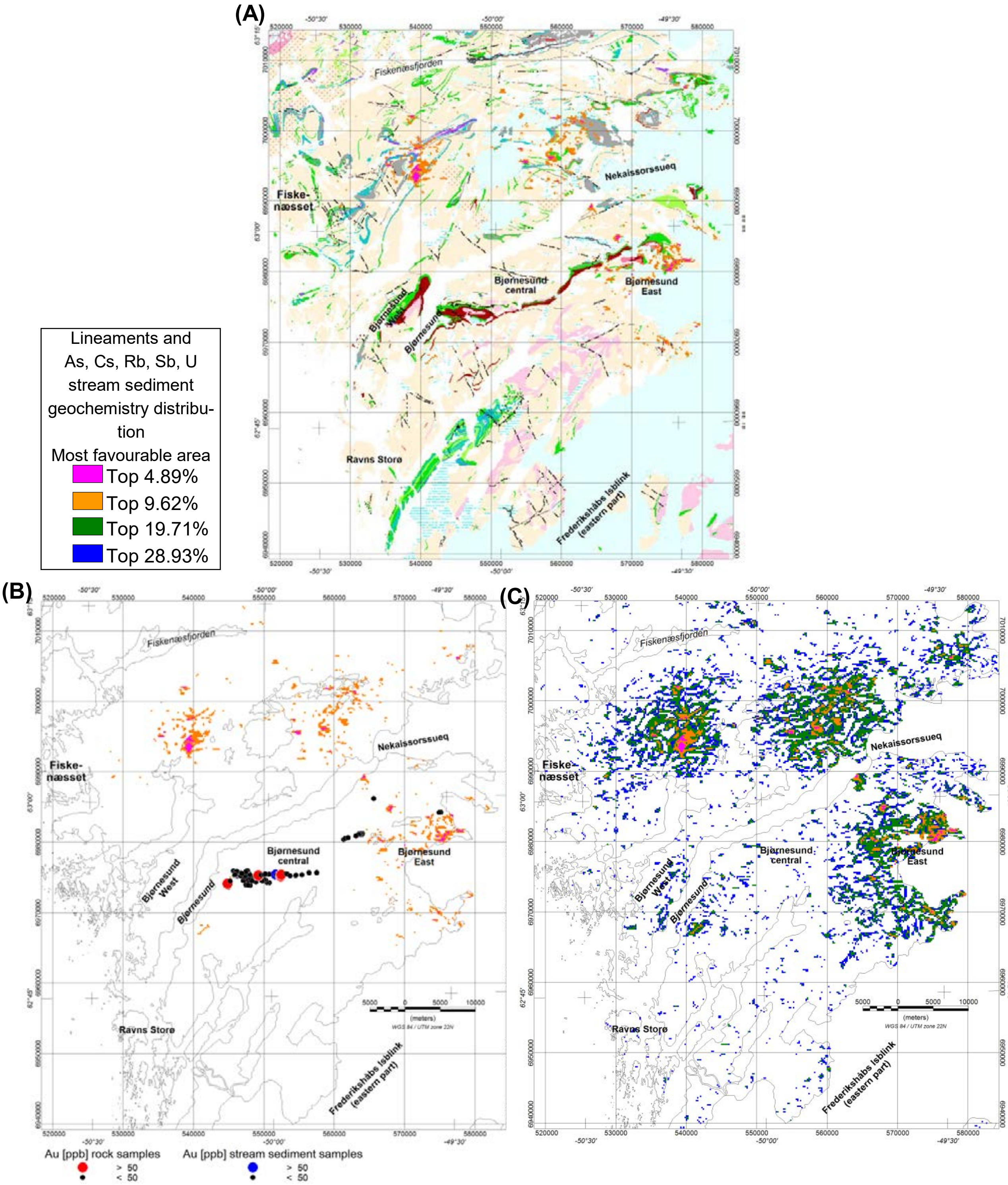


Figure 24. ***(A)*** *Geological map of the Buksefjord–Fiskenæsset area. For geological legend refer to Keulen et al. (2010b).* ***(B)*** *and* ***(C)*** *The 9.62% and 28.93% most favourable areas for gold, respectively, according to the neural network analysis of lineaments and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U. Figure 24.B displays rock and stream sediment samples collected by Nunaoil A/S in 1996 (Heilmann 1997) Plotted on top in larger red and blue circles are the samples with more than 50 ppb Au.*

Sarqap sermia – Sukkertoppen areas

According to the neural network analysis of lineaments derived from processed total magnetic intensity field data and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U only two areas north of the Nuuk–Isua region is outlined as being within the 4.9% most favourable area for gold in the entire southern West Greenland. The southernmost area is located north of Isua and the glacier-tongue Serqap Sermia (Fig. 25). The northernmost is found northeast of the Sukkertoppen Iskappe. The latter area is also strongly outlined and within the 1.9% most favourable area (Fig. 25B).

The favourable area north of Isua and the Serqap sermia consists of small scattered disconnected zones that are outlined as favourable (within the 9.6% most favourable area for gold, Fig. 25C). The area is dominated by complexes of gneisses and intercalated folded amphibolite and ultramafic units. The widths of the amphibolite units are seldom above one kilometre and the units are discontinuous. The outlined favourable zones correlate with the distribution of many of the smaller amphibolite and ultramafic units. Based on results from other mineral potential analyses (Nielsen 2004; Stensgaard *et al.* 2006b), the area was visited in 2006 during a short reconnaissance stop. Even though slightly elevated As, Cr and Ni values were obtained in stream sediment samples from the area, no clear validation were made of the gold favourability (Stensgaard 2008).

The outlined favourable area north of Sukkertoppen Iskappe is situated on the southwestern side of the outer part of the Sarfartoq valley (Fig. 25). The favourable area is characterised inclusion of the only larger mapped amphibolite units in the greater Søndre Strømfjord area (Allaart1982). This unit is referred to as the “Sarfartup nuna Klippe” by Talbot (1979) and is described as an allochthon of imbricate thrust slides comprising subaqueous volcanic, basic and ultrabasic sills and clastic carbonate sediments that are unconformable laid down upon quartzo-feldspathic gneisses. The sills were intruded after the other rocks had been folded and metamorphosed at low amphibolite facies. The allochton suffered penetrative strain in hydrous conditions as it translated southwards as two discordant sets of imbricate thrust nappes (Talbot 1979). It is suggested that the allochthon was transported 60 km from a zone of strong ductile overthrusting at Ikertoq (the Ikertoq thrust zone). The Sarfartup nuna Klippe is located within the zone subject to overthrust shearing as part of the southern expression of the Nagssugtoqidan deformation. South of the Sarfartup nuna Klippe is a bending, north-west trending structure mapped (marked as a thrust on 1:500 000 scale map of the area; see Allaart 1982). This structure forms a splay of the main structure 10 km further to the south and is described as the Southern Nagssuqtoqidian Front; the irregular ductile overthrust zone of deformation that marks the boundary of the Archaean Foreland. This Foreland was affected by deformation associated with the Palaoproterozoic Nagssugtoqidian orogen. South of this front, the Archaean basement is less affected by Palaeoproterozoic deformation. The outlined favourable area is located both within and outside Sarfartup nuna Klippe (Fig. 25). No detailed follow-up on the gold potential in this area is known.

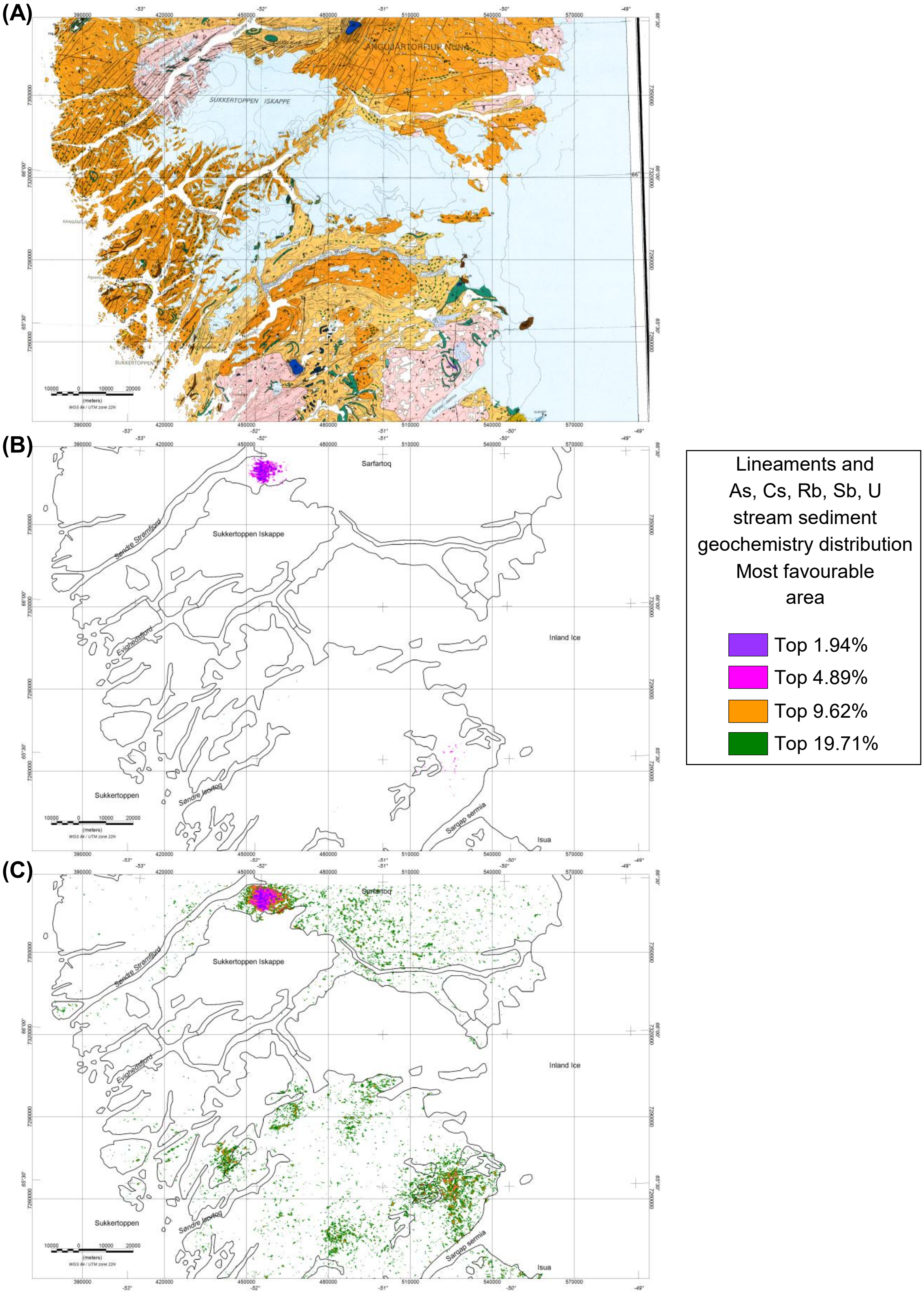


Figure 25. ***(A)*** *Geological map of the Nuuk–Sukkertoppen area. For geological legend refer to Allaart (1982).* ***(B)*** *and* ***(C)*** *The 4.59% (in two colour intervals) and 19.71% (in four colour intervals) most favourable areas for gold, respectively, according to the neural network analysis of lineaments and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U.*

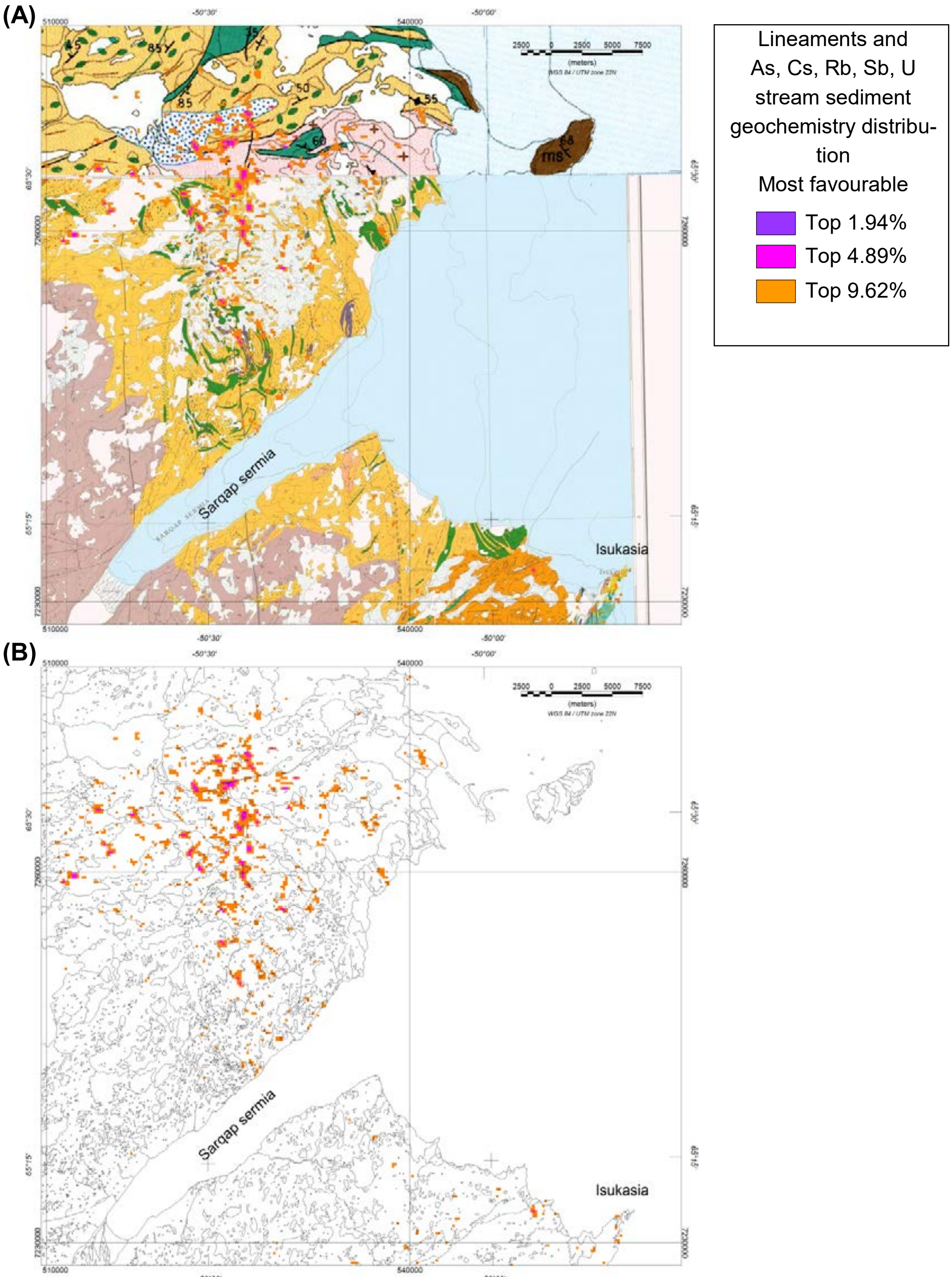
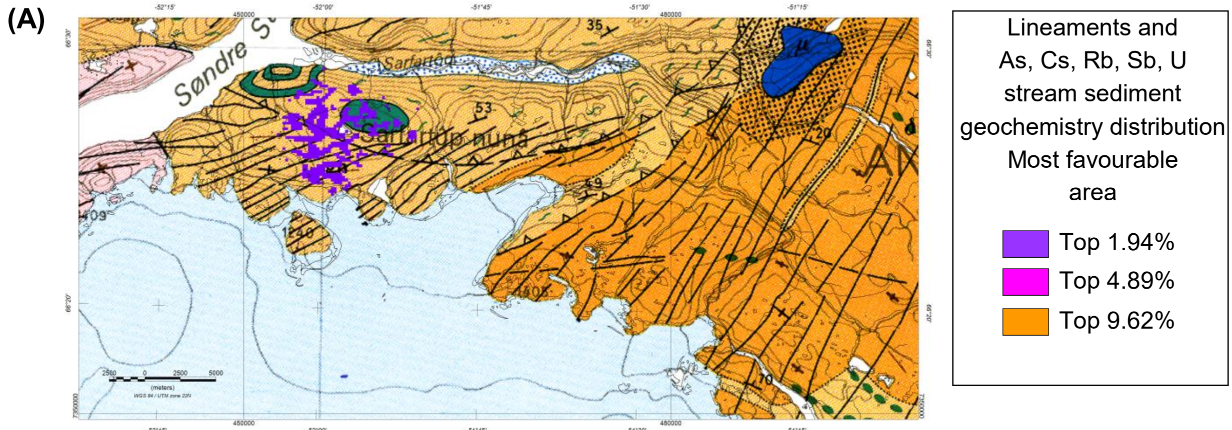
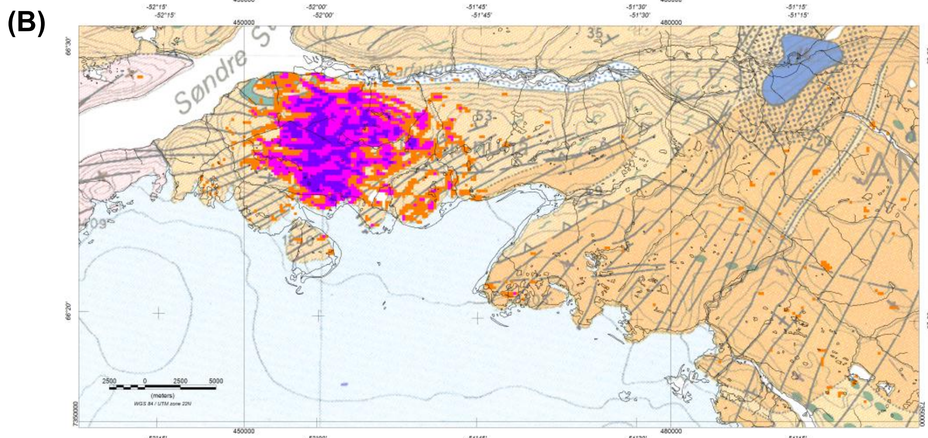
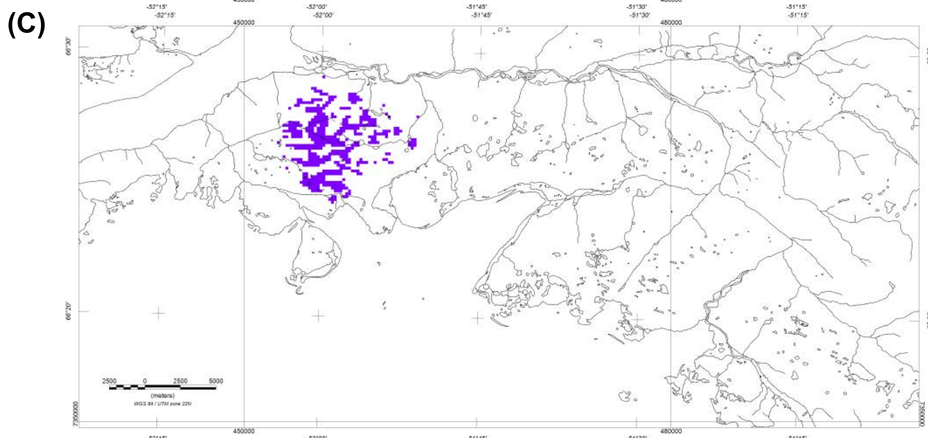


Figure 26. ***(A)*** *Geological map of the Nuuk–Sukkertoppen area. South of 63°30'N is the geological map in scale 1:100 000 used, north of this latitude is the map in scale 1:500 000 used (as this is the best published resolution for this area). For geological legend refer to Allaart (1982) and Garde (1987). Displayed on top of the geological map is the 9.62% (in three colour intervals) most favourable area for gold according to the neural network analysis of lineaments and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U.* ***(B)*** *Similar to Figure A but without the geological map.*







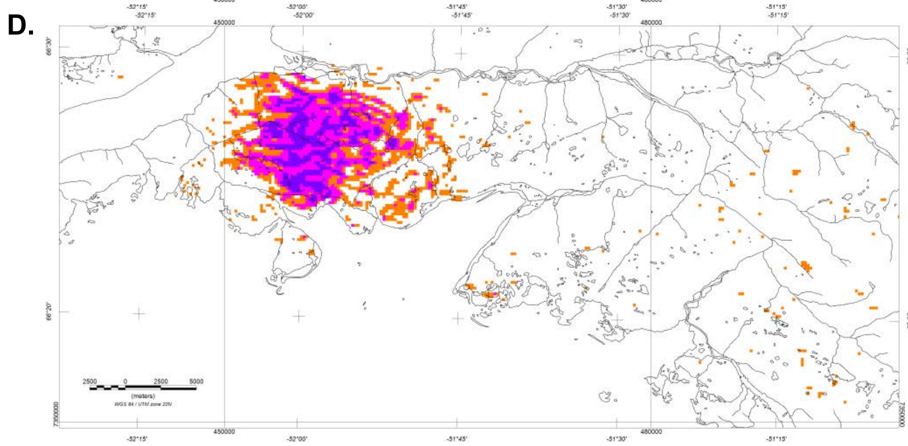


***Figure 27.** **(A)** and **(B)** Geological map of the area north of Sukkertoppen Iskappe with the 1.94% and 9.62 % most favourable areas, respectively, (in three colour intervals) most favourable areas for gold according to the neural network analysis of lineaments and stream sediment geochemistry distribution of As, Cs, Rb, Sb and U plotted on top. For geological legend refer to Allaart (1982) **(C)** and **(D)** Similar to (A) and (B), but without the geological map.*

Geochemistry, lineament and supracrustal/mafic rock unit distributions
The results of the combined neural network analysis for the entire southern West Greenland of lineaments extracted from the total magnetic intensity field, the stream sediment geochemistry distribution for As, Cs, Rb, Sb, U and the distribution of supracrustal/mafic rock units are shown in Figure 28. The areas identified as most favourable for gold are in general not much different from the results with joint analysis of geochemistry and lineaments.

The results, when including the distribution of specific rock units, will be very much dependent on the presence of these. However, the geochemistry and lineament data also influence the results so that the resulting favourability internally in a mapped rock unit may vary. Variation in favourability among similar rock units may also occur.

The mapped rock units are influenced by interpretation and often also an unevenly distribution of observational data reflecting where and how mapping/fieldwork have been undertaken. This clearly also impacts the results from the analysis. The other data, the geochemistry and the lineaments derived from aeromagnetic data, are unprejudiced from interpretation and represent a more evenly distributed data sampling and subsequently even data resolution.

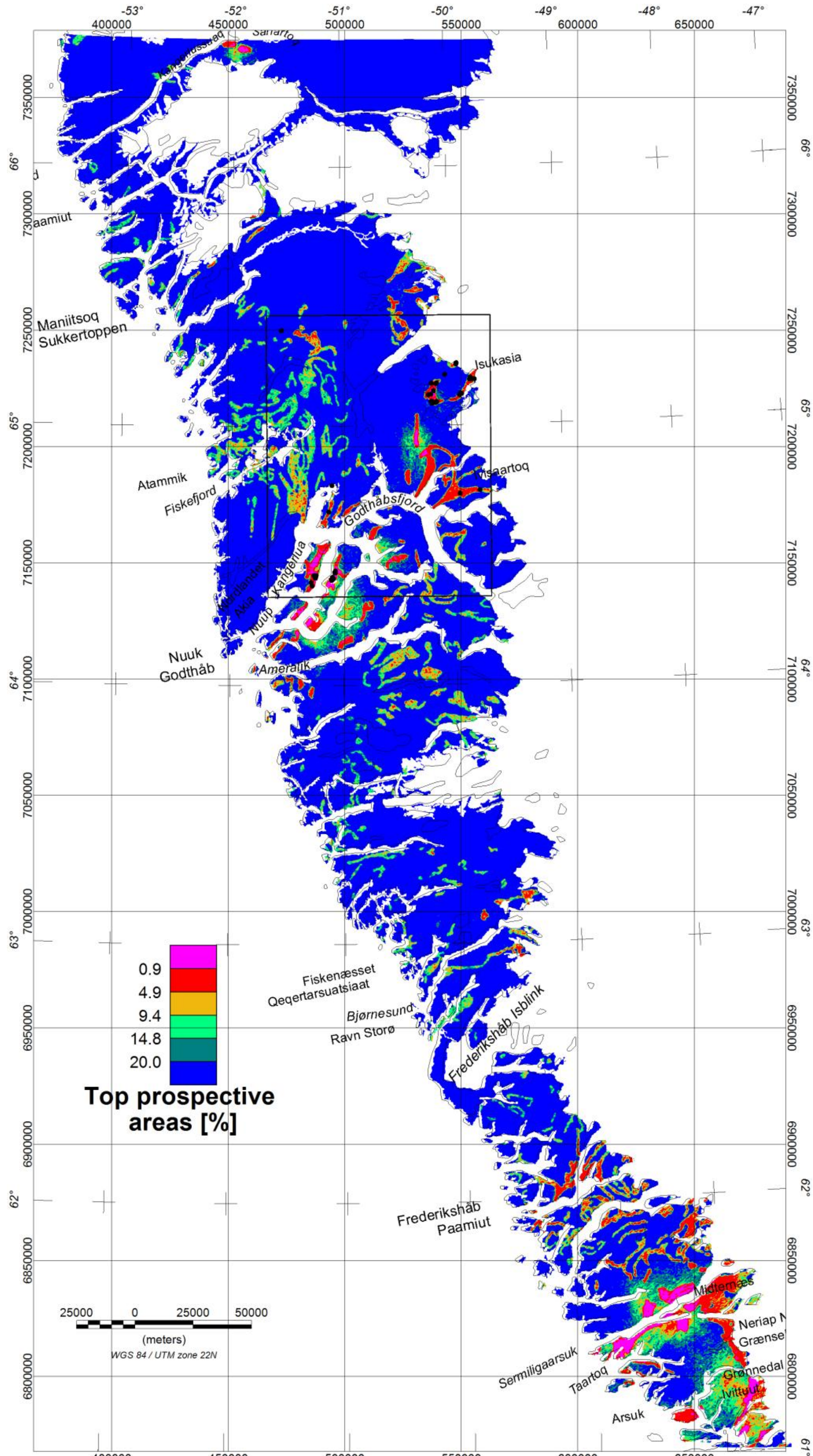


Figure 28. *The 20% most favourable area (displayed in 5 top intervals) for gold according to the neural network analysis of lineaments, stream sediment geochemistry distribution of As, Cs, Rb, Sb, U and distribution of supracrustal rock units. The training area (black box) in the central Nuuk region and the location of the training points used in the neural network net analysis are shown (black dots).*

Areas with well-known gold endowment

The Nuuk region

The supracrustal/mafic rock units at Bjørneøen, Storø, Sermitsiaq and Isua, that are well-known areas with gold occurrences, are all outlined as being within the 0.9% most favourable area for gold according to the joint analysis of stream sediment geochemistry, lineaments and supracrustal/mafic rock distribution (Fig. 29). However, also areas within supracrustal/mafic units east of Qoorqut, the northern side of central Ameralik, at Neriunaq, the Ujarssuit Nunaat area and the area north of Ujarssuit Nunaat towards the Ataneq fault fall within the 0.9% most favourable area. They should be considered in the future for their gold potential (Fig. 29B).

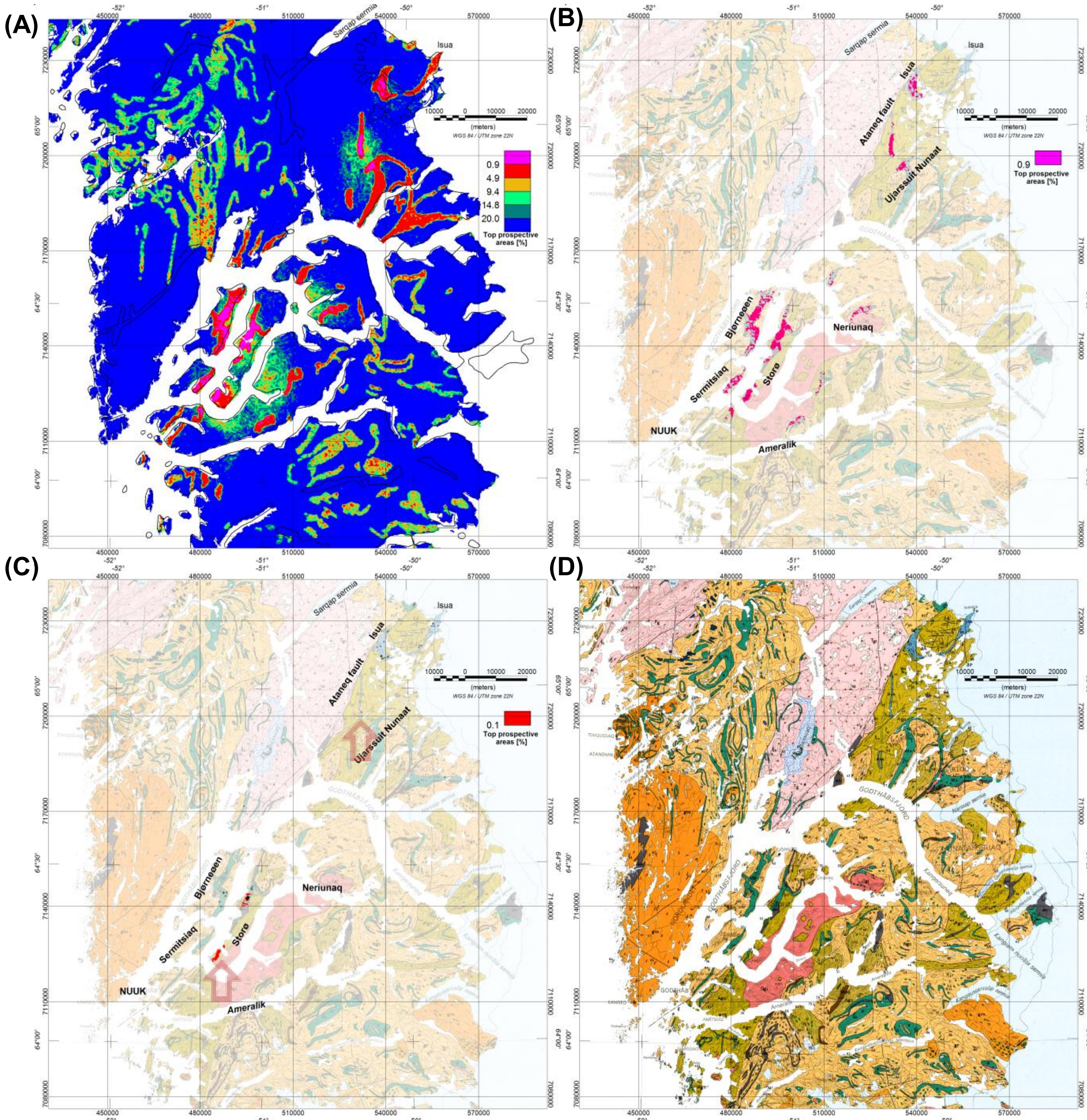


Figure 29. ***(A)*** *The 20% most prospective areas (displayed in 5 top intervals) for gold according to the neural network analysis of lineaments, stream sediment geochemistry distribution of As, Cs, Rb, Sb, U and the distribution of supracrustal rock units.* ***(B)*** *As in (A) but here only the 0.9% most favourable area. In this case plotted on top of dimmed-coloured 1:500 000 scale geological map.* ***(C)*** *As in (B) but here only the 0.1% most favourable area. The dimmed-coloured red arrows indicate areas outlined as favourable, but where no gold mineralisation is reported.* ***(D)*** *Geological map of the Nuuk region from the published 1:500 000 scale geological map. See Allaart (1982) for legend.*

The Sermiligaarsuk – Tartoq area

The well-known gold endowment in the Sermiligaarsuk – Tartoq area is clearly outlined by the 0.9% most favourable area for gold according to the joint analysis of stream sediment geochemistry, lineaments and supracrustal/mafic rock distribution (Fig. 30). Considering only the 0.1% favourable area (that is the 43 km^2 most favourable area for gold in the entire southern West Greenland) in the Sermiligaarsuk – Tartoq area, the Bikuben area, which is known to host gold occurrences, is clearly outlined (Fig. 30). Smaller areas (few pixels) at Nuuluk, Iterlak and Nalaagaaffik are also outlined as favourable, though these seems to be located a bit outside the known mineralised zones in this area. It is interesting to notice that areas at Nuuluk East and at Akuliaruseq, which are not well-known for gold endowment, are outlined as being within the 0.1% most favourable area.

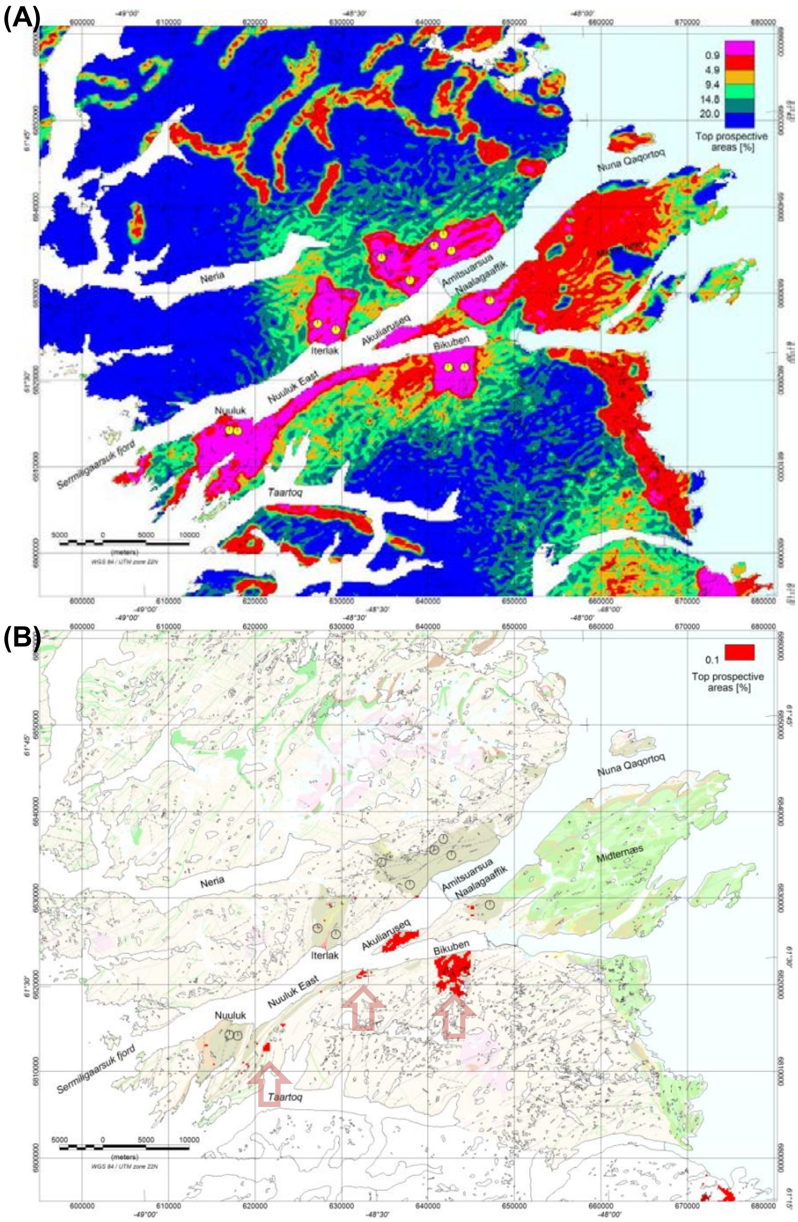
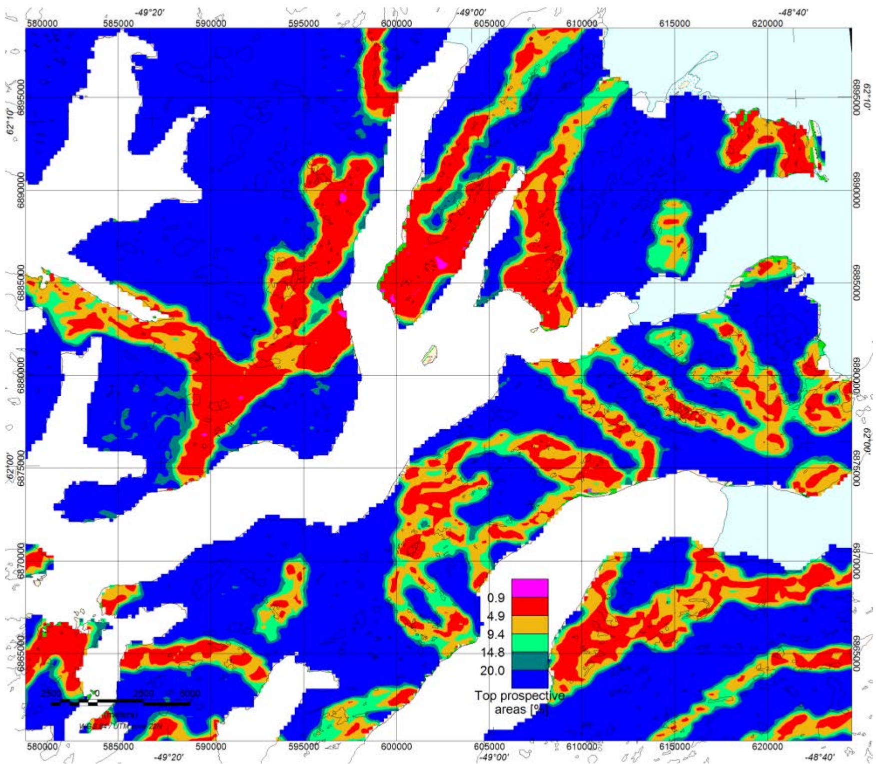


Figure 30. ***(A)*** *The 20% most prospective areas (displayed in 5 top intervals) for gold according to the joint neural network analysis of lineaments, stream sediment geochemistry distribution of As, Cs, Rb, Sb, U and distribution of supracrustal rock units.* ***(B)*** *As in (A) but here only the 0.1% most favourable area. In this case plotted on top of dimmed-coloured 1:500 000 scale geological map. The dimmed-coloured red arrows indicate areas outlined as favourable, but where no gold mineralisation is reported. Please refer to Keulen et al. (2010b) for geological legend.*

The Paamiut area

The well-known gold mineralized areas in the Paamiut area situated at the Akuliaq peninsula and west hereof are predicted as being favourable. However, smaller areas north of the peninsula and at the southwestern extension of the supracrustal rock units hosting the known gold mineralisation are also outlined (Fig. 31). No areas fall within the 0.1% most favourable area.

(A)



(B)

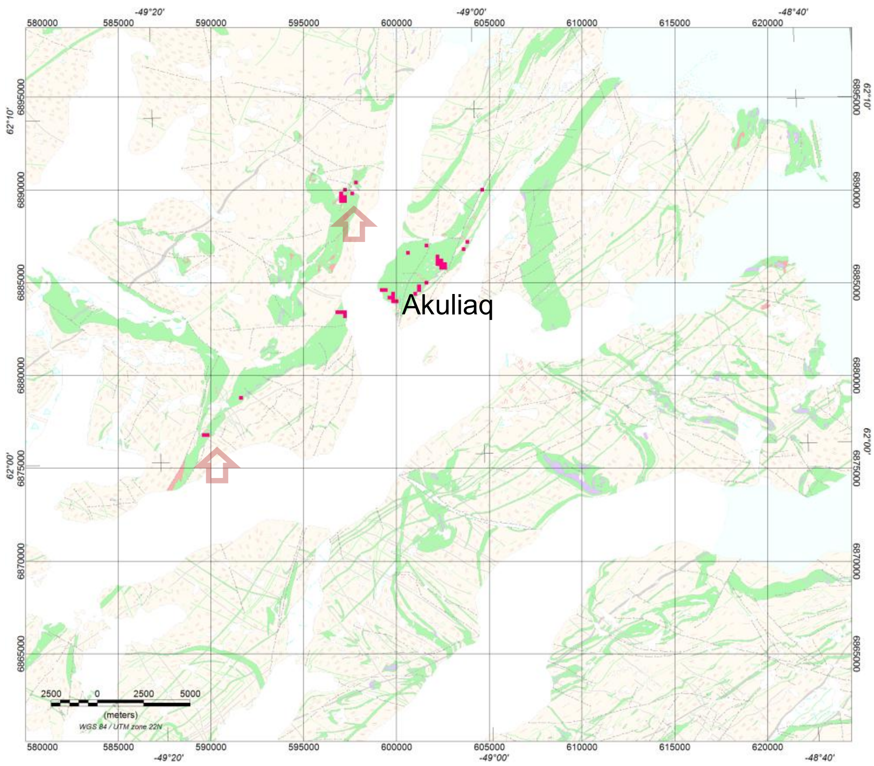


Figure 31. ***(A)*** *The 20% most prospective areas (displayed in 5 top intervals) for gold according to the joint neural network analysis of lineaments, stream sediment geochemistry distribution of As, Cs, Rb, Sb, U and distribution of supracrustal rock units.*
(B) *As in (A) but here only the 0.9% most favourable area. In this case plotted on top of dimmed-coloured 1:500 000 scale geological map. The dimmed-coloured red arrows indicate areas outlined as favourable, but where no gold mineralisations are reported. Please refer to Keulen et al. (2010b) for geological legend.*

Areas without well-known gold endowment

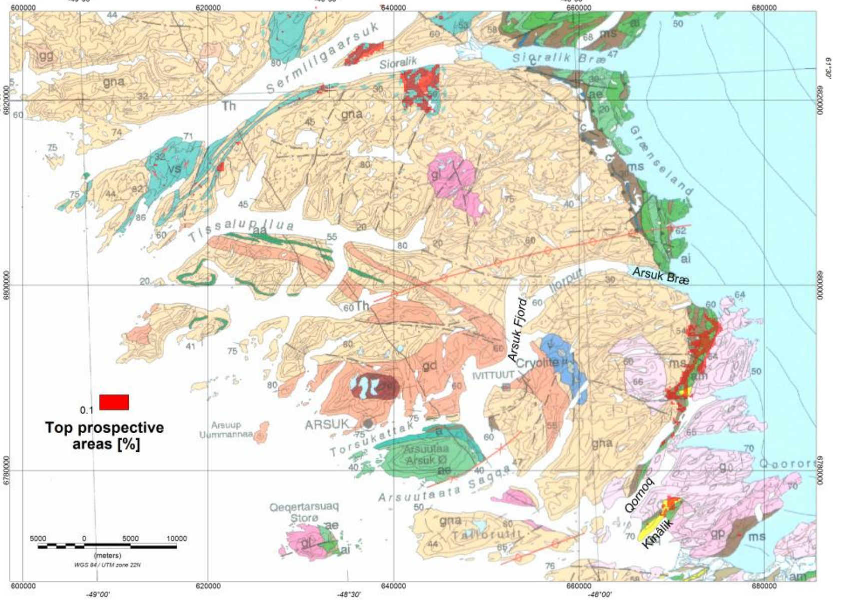
The Ivittuut – Arsuk Fjord area

A NNE–SSW orientated wide corridor along the margin of the Inland Ice from south of Arsuk Bræ and to Qornoq is outlined as being within the 0.1% most favourable area (Fig. 32) of the entire southern West Greenland (that is the 43 km^2 most favourable area) for gold by the joint analysis of lineaments, geochemistry and rock distribution. This area is within the southernmost extension of the Ketilidian Grænseland-Midternæs supracrustal succession that consists of a several kilometres thick package of metavolcanic rock units, in some cases interlayered with clastic metasediments. However, the southern extension is described as more deformed and metamorphosed than their northern counterparts are. Iron formations with minor occurrences of siderite, minor volcanogenic Pb-Zn-Ag mineralisations, chalcopyrite mineralised horizons between pillow lava flows and in pyroclastic rock units, and magnetite and minor pyrite mineralised quartzitic conglomeratic units are known in several areas within the Grænseland-Midternæs succession.

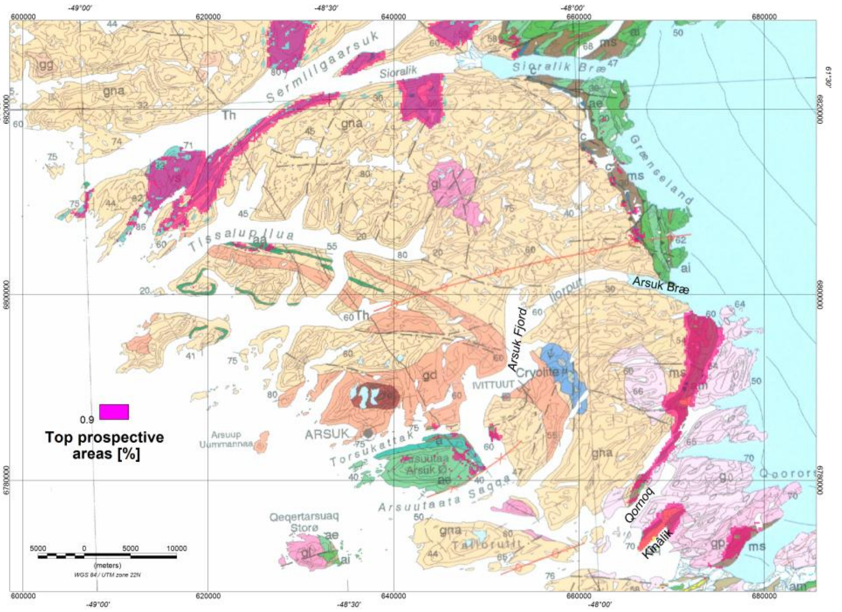
South of Qornoq, at Kînâlik (Fig. 32), another area, though smaller, is outlined as being within the 0.1% most favourable area. The metamorphosed rock units of the Grænseland-Midternæs supracrustal succession is here described as being overlain by strongly deformed siliceous metasediments and polymict conglomerate that grades upward into gritty quartzite, greywackes and semipelitic metasediments (Kalsbeek *et al.* 1990). Sulphide mineralisation of predominantly pyrite and pyrrhotite, together with minor chalcopyrite is widespread within the siliceous metasediment and conglomerate units. At Kînâlik chalcopyrite occurs in contact metasomatised calcareous rocks. Rock samples from this have given gold assays of 2–3 ppm (Kalsbeek *et al.* 1990).

When considering the 0.9% most favourable area, the entire supracrustal unit between Arsuk Bræ and Qornoq and the unit at Kînâlik are outlined (Fig. 32). However, also a larger area east of Kînâlik is included in the 0.9% favourable area together with areas of more limited extent at Arsuk Ø and in the Grænseland area (Fig. 32).

(A)



(B)



C.

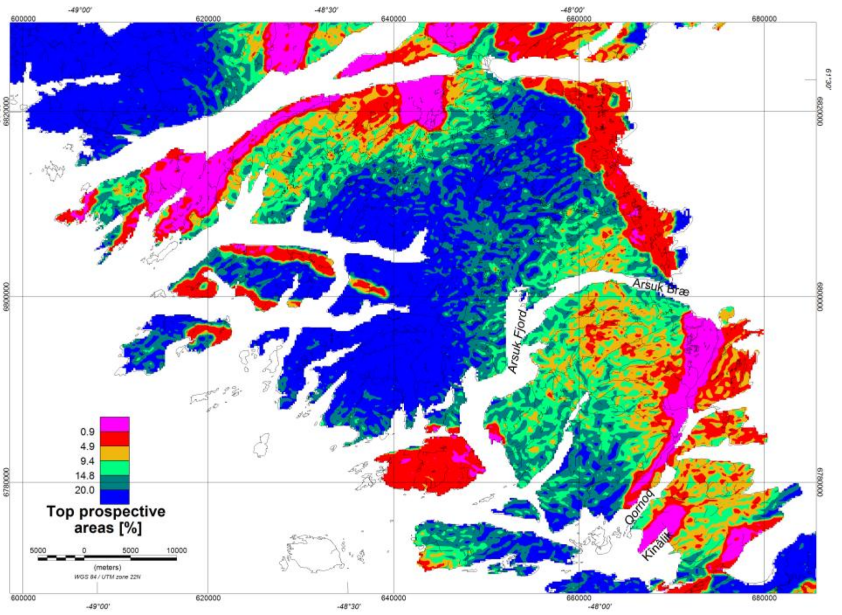


Figure 32. ***(A)*** *and* ***(B)*** *The 0.1% and 0.9%, respectively, most favourable areas for gold according to the joint neural network analysis of lineaments derived from processed total magnetic intensity field data, stream sediment geochemistry distribution of As, Cs, Rb, Sb, U and distribution of supracrustal rock units. The favourable areas are plotted on top of the 1:500 000 scale geological map. Please refer to Keulen et al. (2010b) for a legend.* ***(C)*** *The 20% most favourable area (displayed in 5 top intervals) for gold according to the joint neural network analysis of lineaments derived processed total magnetic intensity field data, stream sediment geochemistry distribution of As, Cs, Rb, Sb, U and distribution of supracrustal rock units.*

The Isorssua area

Two small areas in the Isorssua area are outlined as being within the 0.9% most favourable area for gold according to the joint neural network analysis of lineaments, geochemistry and rock distribution (Fig. 33). Both are located within the supracrustal rock units (see former section on the Isorssua area).

(A)

(B)

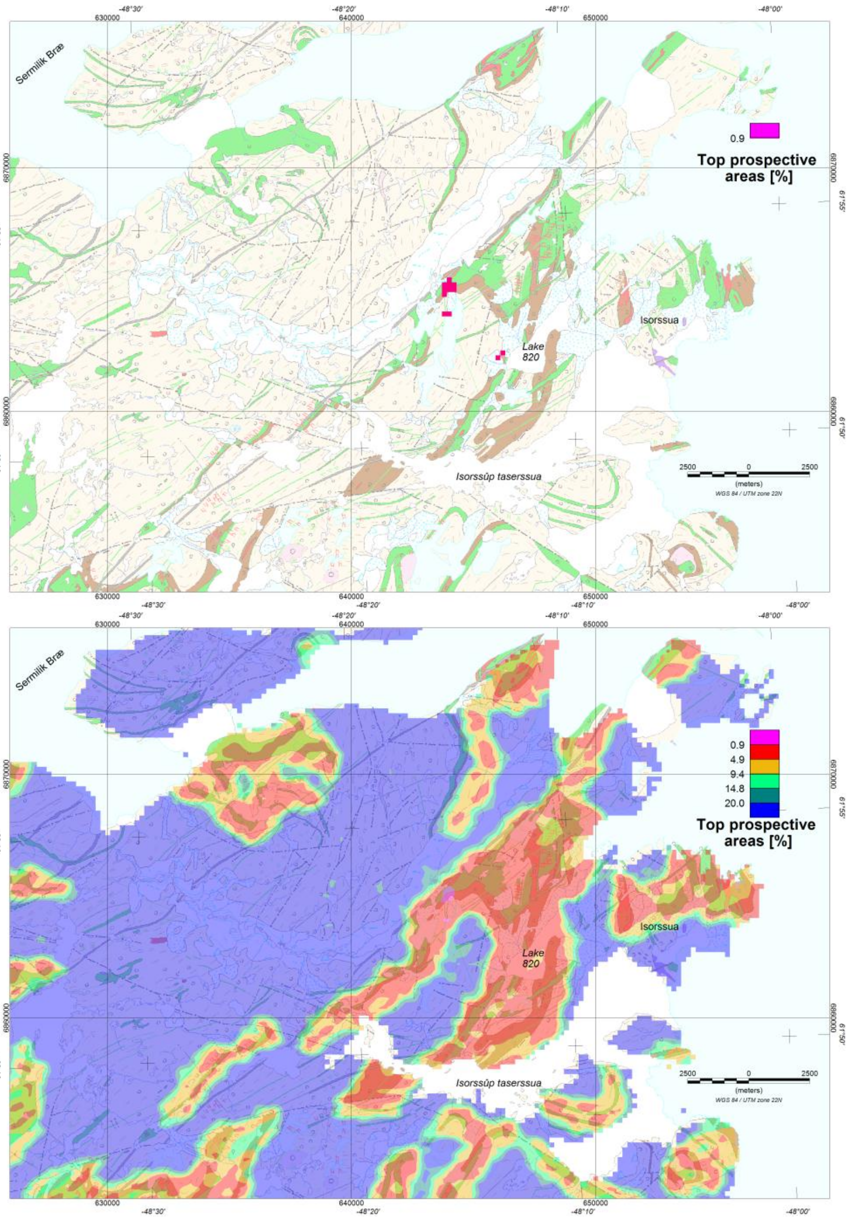


Figure 33. ***(A)*** *and* ***(B)*** *The 0.1% and 20% (in five colour intervals), respectively, most favourable areas for gold according to the joint neural network analysis of lineaments, stream sediment geochemistry distribution of As, Cs, Rb, Sb, U and distribution of supracrustal rock units. The favourable areas are plotted on top of the 1:500 000 scale geological map. Please refer to Keulen et al. (2010b) for a legend.*

The Bjørnesund area
An eastern extension of the Bjørnesund Supracrustal Belt outlined as being within the 10% most favourable area by the joint analysis of geochemistry and lineaments is also picked up by the analysis that further include the distribution of supracrustal and mafic rock units, and is here within the 2% most favourable area (Fig. 33).

Also, some small areas in the Bjørnesund East region within the supracrustal belt towards the west are being outlined within the 3% and 4% most favourable area. The central part of the Bjørnesund Supracrustal Belt is not within the 8.5% most favourable area though gold mineralised sites have been reported from this part of the belt. See also Schlatter & Stensgaard (2012) for further description of results and the field work follow-up that were directed by the mineral potential mapping and carried out in the Bjørnesund area.

In the western part of the Bjørnesund Supracrustal Belt, on both sides of the Bjørnesund fjord, are smaller areas found to be within the 3–4% most favourable area. These areas were not picked up by the analysis based only on geochemistry and lineaments.

The Fiskenæsset area
Only small areas near the Inland Ice, north or the glacier Nekaissorssueq, are outlined as being within the 2–3% most favourable area in the Fiskenæsset area by the analysis based on stream sediment geochemistry, lineaments and distribution of supracrustal and mafic rock units (Fig. 34).

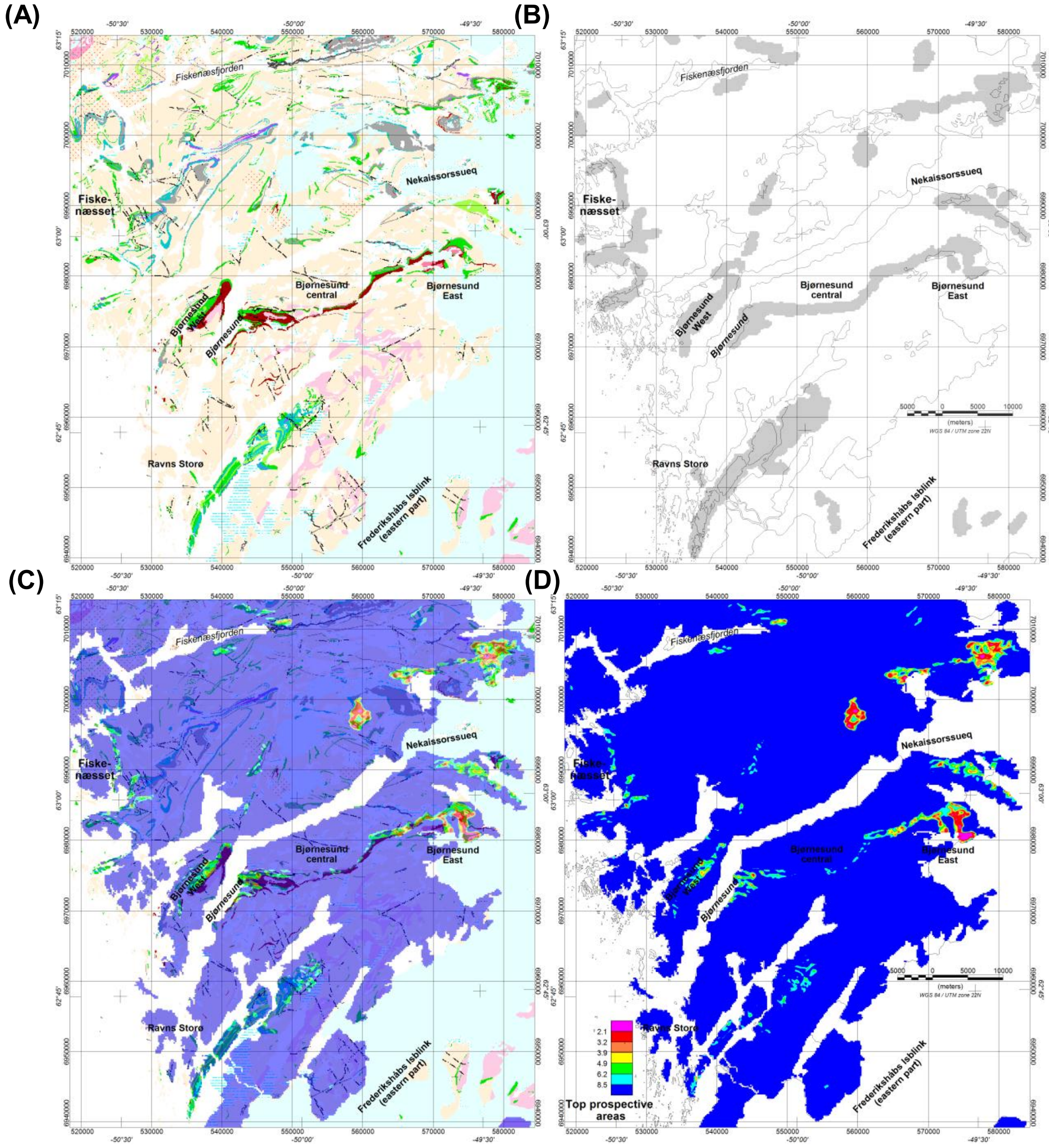


Figure 34. ***(A)*** *Geological map of the Bjørnesund – Fiskenæsset area. Please refer to Keulen et al. (2010b) for a legend.* ***(B)*** *The supracrustal and mafic units (plus a buffer zone of 600 m that were applied to the outline of all the extracted rock units) that were used as input to the joint neural network analysis of stream sediment geochemistry, lineaments and rock unit distribution.* ***(C)*** *The 8.5% most favourable area (in seven coloured intervals) for gold according to the neural network analysis of stream sediment geochemistry, lineaments and rock unit distribution plotted semi-transparent on top of the geological map.* ***(D)*** *as C but without the geological map.*

Sarqap sermia – Sukkertoppen areas

No areas north of Nuuk falls within the 0.1% most favourable area for gold according to the neural network analysis of stream sediment geochemistry, lineaments and rock distribution. However, considering the 0.9% most favourable area, an area north-east of Sukkertoppen Iskappe (Fig. 34) is clearly outlined. This area was also outlined by the analysis based only on stream sediment geochemistry and lineaments (see Fig. 27).

When the 2% most favourable area is considered, a few favourable pixels are emerging in the area north of the glacier Sarqap sermia (Fig. 34). When the 3% most favourable area is considered, also pixels within the Majorqaq valley are included (Fig. 35).

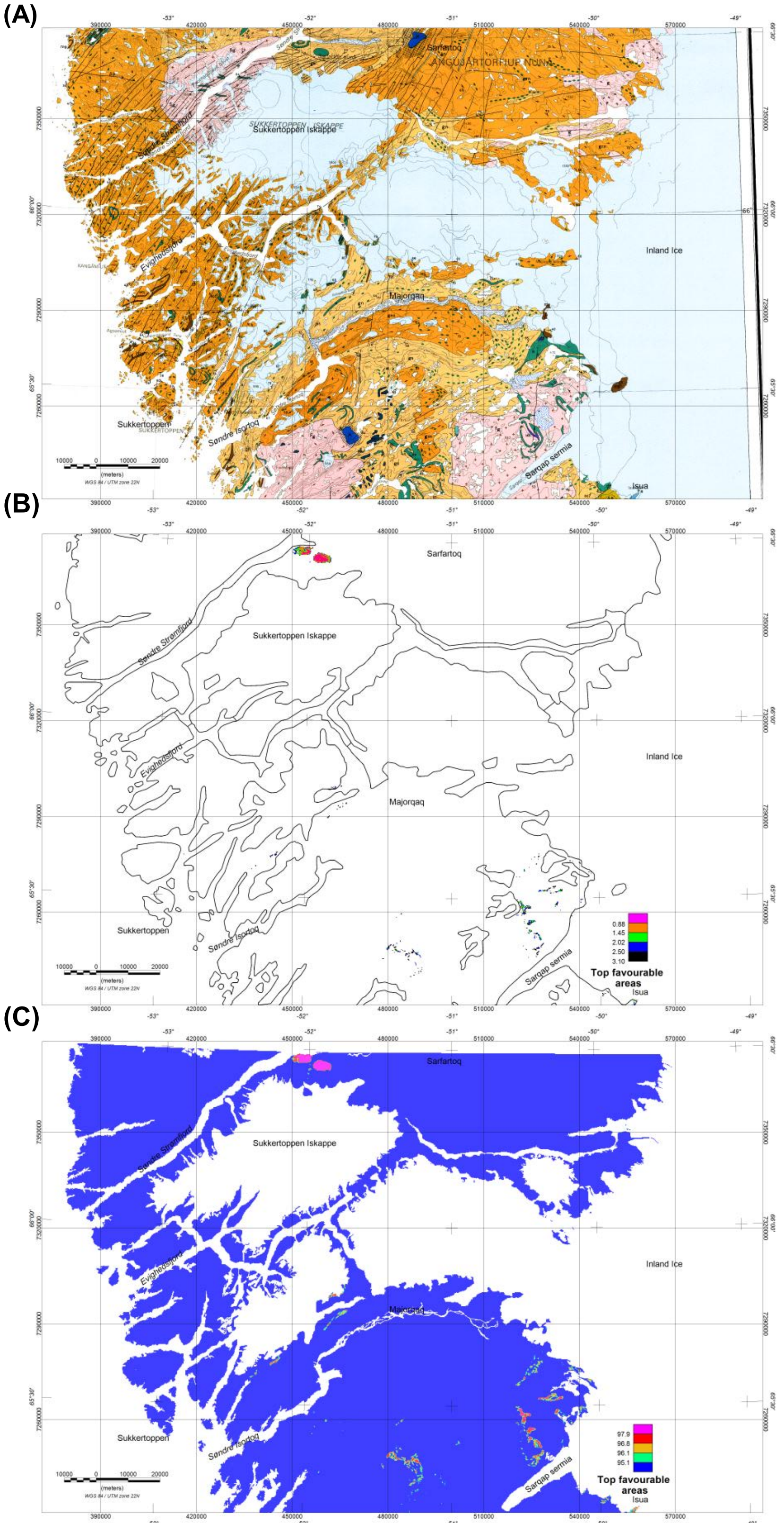


Figure 35. ***(A)*** *Geological map of the area north of Nuuk between Sarqap sermia and Sukkertoppen Iskappe. Please refer to Allaart (1982) for a legend.* ***(B)*** *The 0.8, 1.45, 2.02, 2.50 and 3.10% most favourable areas according to the neural network analysis of stream sediment geochemistry, lineaments and rock unit distribution plotted on top of each and displayed semi-transparent on the geological map.* ***(C)*** *As in (B), but here the 4.85% most favourable area coloured in four intervals (different intervals than in (B)).*

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Analysis of regional data sets: Predictive gold potential using multidimensional vector-based self-organizing map analysis

By Thorkild M. Rasmussen & Bo Møller Stensgaard

Introduction

Experiences from multi-parameter data analysis of regional geochemical and geophysical data in conjunction with field observations of mineral occurrences from the Nuuk region (Stensgaard *et al.*, 2007) show that a quantitative assessment of the regional data sets contributes valuable information as input to a general interpretation of the geology.

Self-organising map (SOM) technique

The multi-parameter analysis presented by Stensgaard *et al.* 2007 was based on application of Bayesian statistics. Another approach, which also is quantitative in nature, is the use of self-organising maps (Kohonen, 2001) to study the data distribution and correlation between different data types. The self-organising map is here used as a classification tool and the primary outcome is the identification of SOM cells and clusters of cells (and thereby areas) associated with a potential for gold mineralisation. No prior assumptions of the statistical nature of the data are required, but the results from the analysis can easily be subjected to statistical analyses.

The self-organising map (SOM) is visualised as a two-dimensional grid composed of hexagonal cells (SOM-space). The SOM presents the multi-dimensional data in a two-dimensional map, where a group of identical or similar input data are associated with a best matching unit (BMU) associated with a cell in the SOM (data reduction). Adjacent cells are furthermore associated with some similarity among the BMU's and thereby also the input data represented by the BMU's. The U-matrix is used to display distance relations in the data space. Similarity is here defined by using a standard metric measure of distance between normalised data. The normalisation is often, but not necessarily, based on transformation to unity standard deviation, by dividing the initial data values by the actual standard deviation. The SOM can furthermore be subjected to standard clustering methods, e.g. k-mean clustering (see Jain *et al.* 1999), whereby further simplification or data reduction may be obtained. The results presented in this report have been generated by applying the SiroSOM computer package of Fraser & Dickson (2007) to selected stream sediment geochemical data (Steenfelt 2001a,b) from southern West Greenland between latitude 62° and 66°N.

Identification of samples favourable for gold

The purpose of the analysis is to identify or predict areas, which may be favourable for gold mineralisation. Only a part of the stream sediment samples were analysed for Au, and geochemical elements that are expected to correlate to Au are therefore selected as input to the SOM analysis. These include the geochemical elements As, Ce, Cs, La, Mo, Rb, Sr, Th, U, W, Zn, Zr and the Ni/Mg ratio. Note that the Au concentration data are not included as input to the SOM analysis presented here. Instead, the results of the quantitative analysis are compared and evaluated by visual inspection of maps showing the results of the SOM analysis and the associated map of the available Au concentration data.

Figure 1 shows the geochemical data in a SOM presentation, where each of the geochemical elements is displayed by component values together with the U-matrix. The associated component map with Au concentrations is also displayed.

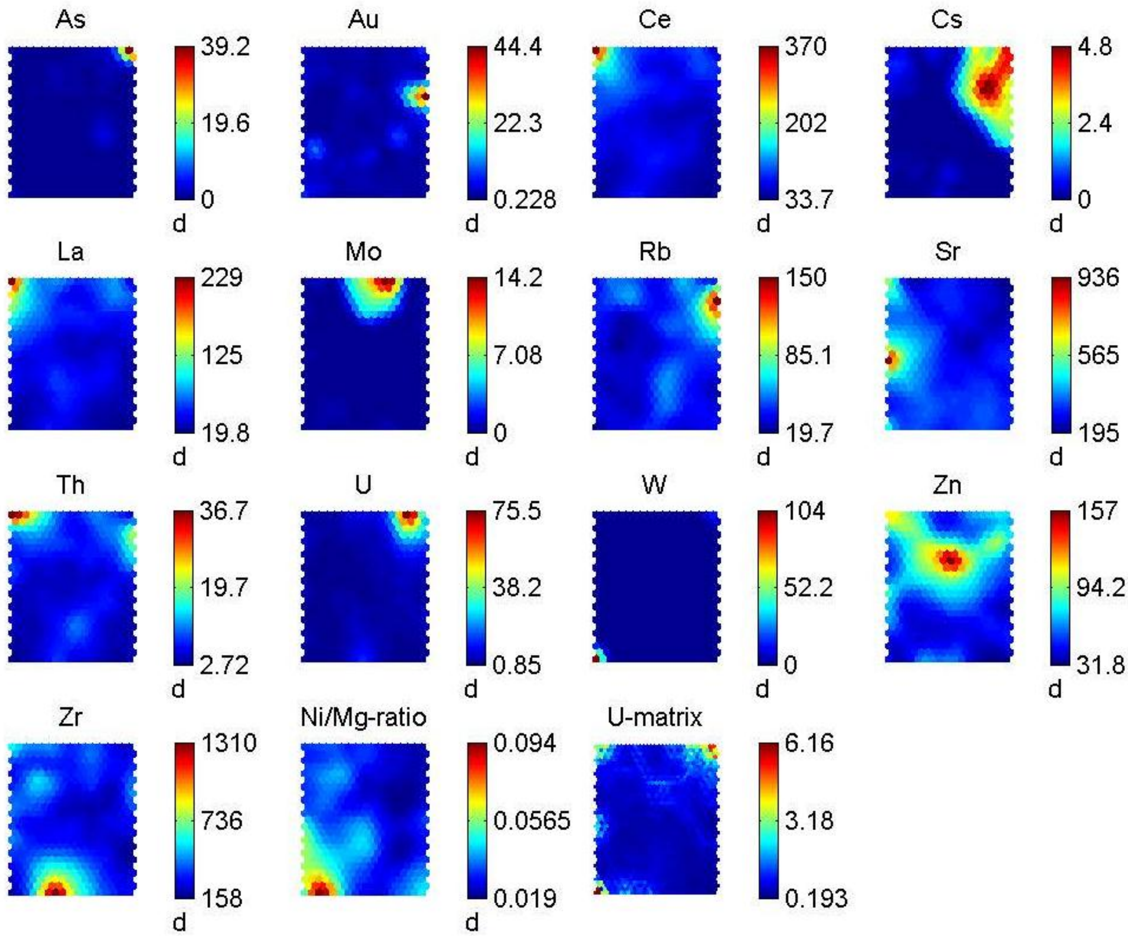

Figure 1. *Component plots in SOM-space and the SOM U-matrix. Au concentration data are not included in the SOM processing, but the Au concentrations are shown here based on those samples, where Au concentration data <u>are</u> available from the geochemical analysis. High Au concentrations are seen to have positive correlation with concentrations of Cs, Rb and Th and with intermediate value of Zr. The colour code for the U-matrix show the mean distance from one cell to the adjacent cells.*

The U-matrix and Au concentration data are repeated in Figure 2 together with the result of a k-mean clustering classification of the best matching units in the SOM. It is noteworthy that samples with the highest Au concentrations are associated with samples in clusters 1 and 6. However, some of the samples in cells within clusters 1 and 6 are associated with low Au concentrations. Thus, the k-mean clustering analysis is not optimum for the identification of areas (not analysed for Au) likely for gold mineralisation. Instead, an identification of favourable areas based on individual cells associated with high Au concentrations in the SOM is chosen (gray-shadded cells in Figure 2B). The areas that belong to these cells contain both samples already analysed for gold as well as samples that have not been analysed for gold previously. The areas that correspond to the individual selected cells are displayed geographically in Figure 3.

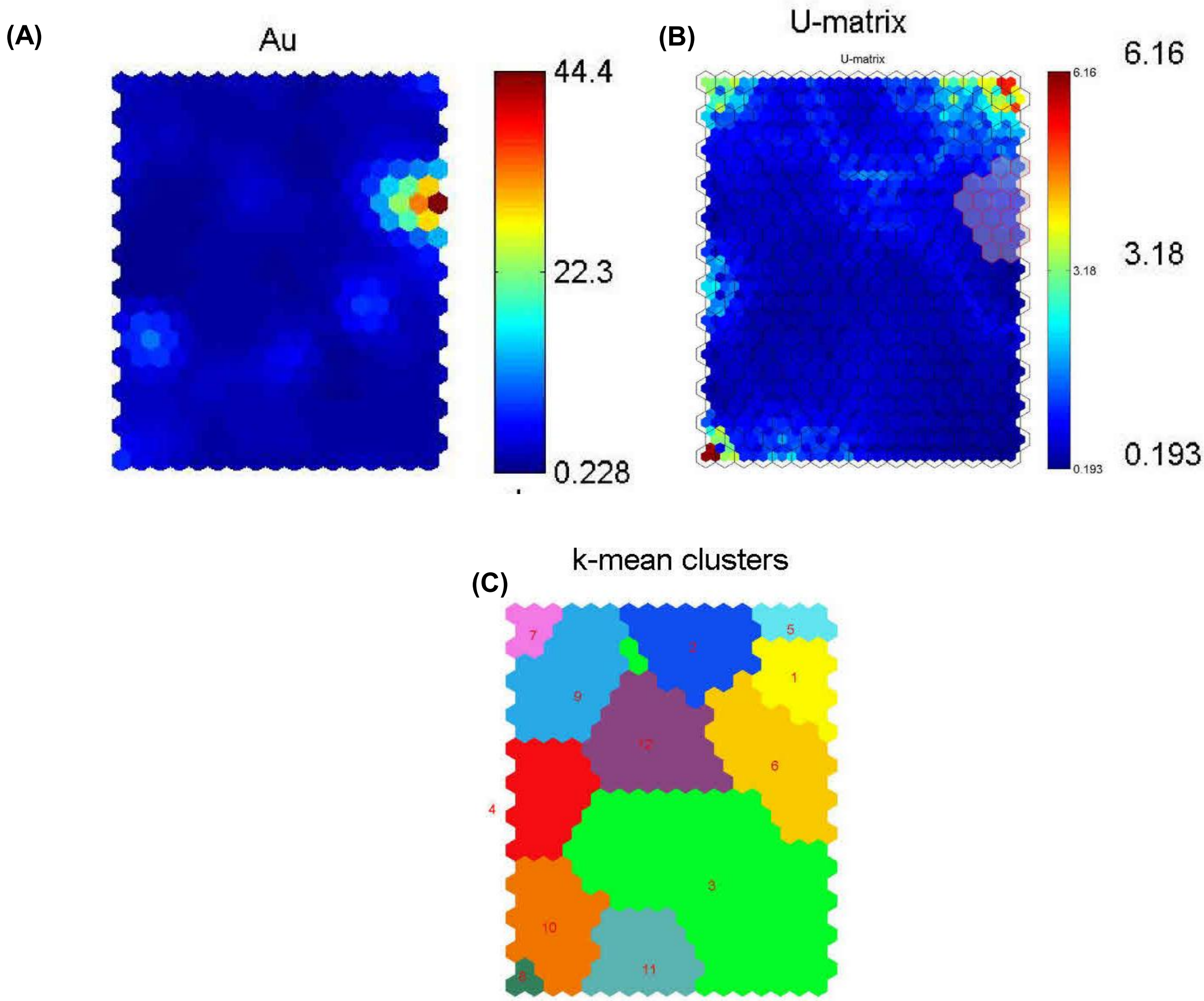

Figure 2. ***(A)*** *Au concentration data in SOM-space shown together with* ***(B)*** *U-matrix and* ***(C)*** *k-mean clustering results of the best matching units (BMU). Cells expected as indicative of areas having a higher potential for gold mineralisation are marked on the U-matrix by grey-shading (Fig. 2B).*

When reviewing the results of the clustering it is important to keep in mind, that the stream sediment distribution of gold in the samples has not been used as an input in the SOM analysis. The two selected clusters and corresponding samples have other geochemical signatures that relate them to each other and at the same time corresponds some samples that actually have yielded high gold concentrations.

Areas identified as favourable for gold by SOM

When the samples predicted to have a high concentration of gold according to the SOM analysis are visualised geographically two situations can occur:

1) The sample is located at an area having a potential for high gold concentration and the sample is also analysed for gold. The analytical value that has been determined can either support the prediction in case of a high obtained value, or it can reject the potential in case of a low value.
2) The sample is within a location predicted as having a gold potential, but the sample has not previously been analysed for gold.

When situation 1) occurs, it should be remembered that gold content in stream sediment geochemistry by nature can be highly uneven distributed. This implies that the obtained analytical value could be an outlier. A sample with low gold value does therefore not necessarily exclude the corresponding area as having a potential for gold.

Areas with samples that falls within the two categories defined above are outlined in Figure 4. The well-known gold endowed SE-NE oriented corridor in the Nuuk region is clearly delineated to have a potential for high gold concentrations. However, what is interesting for the Nuuk region is that a couple of areas within the corridor, where no gold occurrences have been identified previously, also are delineated as having a potential for gold mineralisation. Several closely grouped areas without samples analysed for gold are predicted (areas marked A to E in Figure 4). These areas are of interest for follow-up.

The known gold mineralised area around Isukasia, at the northeastern part of the known gold endowed corridor, is clearly predicted to have a potential for gold mineralisation (area marked F in Figure 4).

The known gold mineralised area east of Paamiut (area marked F in Figure 4) is predicted to have a potential for high concentration of gold; in this case several of the stream sediment samples from the area have been analysed for gold and with high gold content. North of the area known to host gold mineralisations, another area is delineated as having a potential for gold mineralisation. Here. no known gold occurrences have been identified previously. Areas with very limited information or no information on previously identified gold mineralisations are being pointed out in several areas. Four areas around Ravn Storø, Bjørnesund and Fiskenæsset are indicted to have a potential for gold mineralisation (areas mark I to K in Figure 4). North of the Nuuk region, four other areas are indicated.

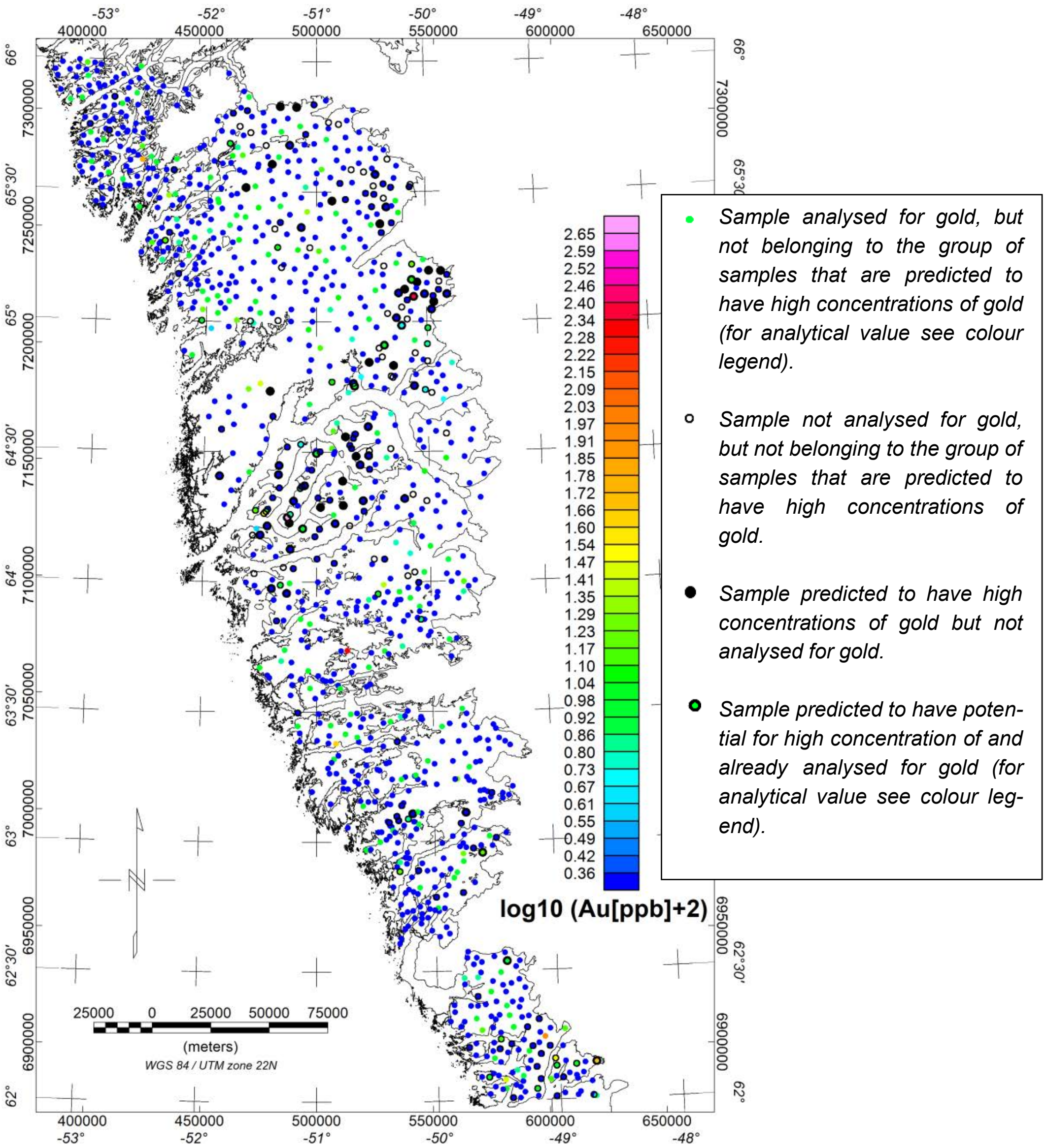

Figure 3. *Location of all stream sediment samples in southern West Greenland. Samples analysed for Au are shown by colour-filled small circles, where the colour code refers to log_{10} values of Au concentrations (plus 2) in units of ppm. Circles in dark blue colour correspond to 0 ppb Au. Open black-outlined small circles show samples not analysed for Au. Large black-filled circle are samples that are predicted to be associated with high Au concentrations; i.e. samples that belong to the selected cells in Figure 2B. Some of these samples have already been analysed for gold in which case the colour-filled circles will be plotted on top of the larger black-filled circles. If they have not been analysed for gold they will show up as large black-filled circles only. See also Figure 4.*

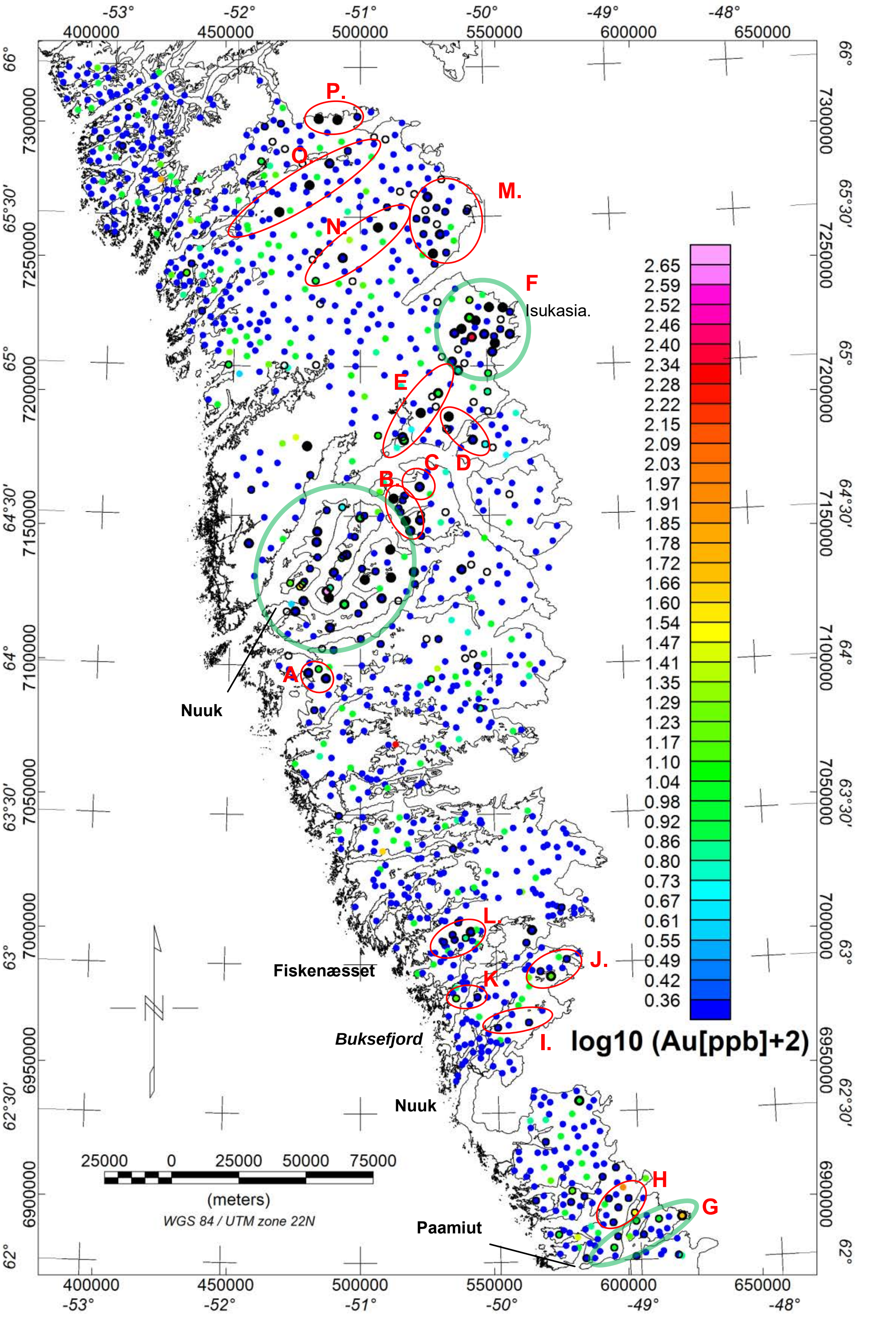

Figure 4. *SOM map of samples predicted to have potential for gold. See Figure 3 for figure caption.*

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