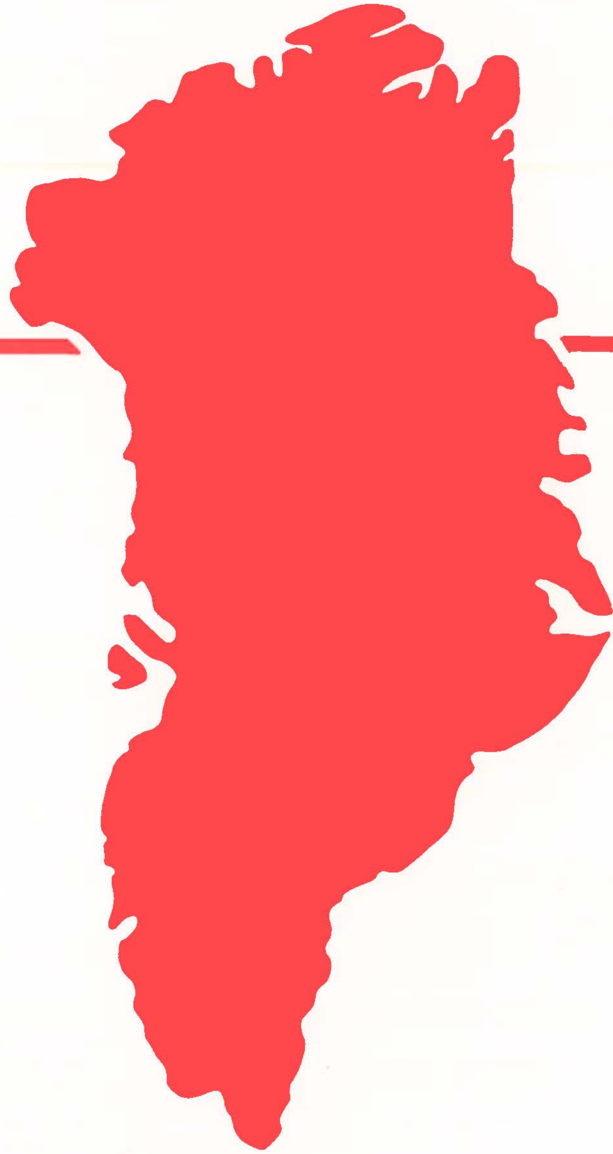
# Reconnaissance geochemical mapping of the Paamiut region (61°25′ to 62°45′N, 48°00′ to 50°00′W), South-West Greenland



Agnete Steenfelt, Else Dam
and Anette Petersen

## Open File Series 94/1

January 1994

GGU

GRØNLANDS GEOLOGISKE UNDERSØGELSE
Ujarassiortut Kalaallit Nunaanni Misissuisoqarfiat
GEOLOGICAL SURVEY OF GREENLAND

GRØNLANDS GEOLOGISKE UNDERSØGELSE
Ujarassiortut Kalaallit Nunaanni Misissuisoqarfiat
GEOLOGICAL SURVEY OF GREENLAND
Øster Voldgade 10, DK-1350 Copenhagen K, Denmark


The Geological Survey of Greenland (GGU) is a research institute affiliated to the Mineral Resources Administration for Greenland (MRA) within the Danish Ministry of Energy. As with all other activities involving mineral resources in Greenland, GGU's investigations are carried out within the framework of the policies decided jointly by the Greenland Home Rule Authority and the Danish State.

**Open File Series**

The Open File Series consists of unedited reports and maps that are made available quickly in limited numbers to the public. They are a non-permanent form of publication that may be cited as sources of information. Certain reports may be replaced later by edited versions.

**Citation form**

*Open File Series Grønlands Geologiske Undersøgelse*

conveniently abbreviated to:

*Open File Ser. Grønlands geol. Unders.*

GGU's Open File Series består af uredigerede rapporter og kort, som publiceres hurtigt og i et begrænset antal. Disse publikationer er midlertidige og kan anvendes som kildemateriale. Visse af rapporterne vil evt. senere blive erstattet af redigerede udgaver.


ISSN 0903-7322

GRØNLANDS GEOLOGISKE UNDERSØGELSE

Open File Series 94/1

# Reconnaissance geochemical mapping of the Paamiut region (61°25′ to 62°45′N, 48°00′ to 50°00′W), South-West Greenland

Agnete Steenfelt, Else Dam and Anette Petersen

January 1994

**Abstract**

Geochemical mapping by means of analysis of stream sediment and water collected at a density of 1 sample per 20-30 $km^2$ has been carried out over the southern part of the Archaean craton in West Greenland. The <0.1 mm fraction of the sediment samples was analysed by X-ray fluorescence and instrumental neutron activation techniques and results are reported for 41 major and trace elements. The conductivity and fluoride content of the water samples were determined.

The distribution of geochemical anomalies in the survey area indicates that base metal and gold mineralisation is associated with the Tartoq Group (basic metavolcanic and metasedimentary rocks) and also with large enclaves of metavolcanic supracrustal rocks in the gneisses on both sides of Kvanefjord, east of Paamiut. High values of Cr and Ni reflect the presence of ultramafic rocks in the amphibolitic enclaves.

A distinct geochemical province (high in lithophile elements and Y) is associated with a granitic complex in the south-eastern part of the region. Otherwise the gneiss terrain is low in LIL elements, high in $Na_2O$, CaO and Sr, and geochemically resembles that of the Fiskenæsset area to the north of Frederikshåb Isblink.

Anomalies of Au, Mo, Pb and Au appear to be associated with shear and fault zones and indicate hydrothermal mineralisation of possible Proterozoic age.

## Contents

## Introduction

The sampling carried out in the Paamiut region is part of the Geological Survey of Greenland (GGU) geochemical mapping programme based on drainage samples. The purpose of this programme is to provide reconnaissance geochemical data which may be used together with geophysical and geological information to outline provinces or zones with potential for mineral resources.

Samples were collected during the period July 8th to 21th by A. Steenfelt and A. Petersen. The sampling team was based at Paamiut (Frederikshåb) and used an AS 350 (Ecureuil) helicopter for transportation. The field and analytical work was financially supported by the Mineral Resource Administration for Greenland, part of the Danish Ministry of Energy.

The surveyed area lies administratively within the municipality of Paamiut.

## Geology

The Paamiut region lies within the Archaean gneiss complex of the Laurentian shield in West Greenland close to its southern boundary with the Proterozoic Ketilidian orogen (Fig. 1). Geological maps of the region have been published at scales of 1:500 000 (Allaart, 1975) and 1:100 000 (Higgins, 1974; Jensen, 1974, 1975; Escher & Jensen, 1976). The publications by Kalsbeek *et al.* (1990) and Bridgwater *et al.* (1976) contain summary descriptions of the area and comprehensive literature references. Two of the four 1:100 000 map sheets covering the Paamiut region have been described in detail by Higgins (1990).

The surveyed area consists mainly of felsic orthogneiss of tonalitic to granodioritic composition which contain layers and enclaves of supracrustal sequences. The latter are dominated by mafic metavolcanic rocks, except in the southeastern part of the area, where metasediments make up a significant proportion of the Isorsua Group supracrustal units (Masson, 1970). The gneisses and supracrustal rocks have been metamorphosed under amphibolite facies conditions. The supracrustal units are most extensive around Kvanefjord and Sermilik (Fig. 1) where they comprise amphibolites with intercalated ultramafic layers and lenses (Mísař, 1973). Further extensive sequences in the extreme south of the area are known as the Tartoq Group (see below).

An intrusive complex of granitic or granodioritic rocks occupies an area north-east of the head of Neria, and is here termed the Neria granite (Preston, 1969). The granite has many inclusions of metasediments and older gneisses, some very large and undisturbed. The Isorsua supracrustal sequences to the east and north-east of the outcropping granite are invaded by granitic to pegmatitic bodies and veins (Preston, 1969; Masson, 1970).

Most of the Archaean gneiss complex is believed to have formed between 2.8 and 3 Ga, while some granitoid rocks have yielded slightly younger ages (Kalsbeek *et al.*, 1990). The Neria granite, which was regarded by Preston (1969) as homogenised gneiss because it is foliated in places and has transitional (but also sharp) boundaries with the gneiss, has not been dated.

The mineral potential of the Paamiut region has almost exclusively been associated with the Tartoq Group supracrustals which occur on either side of Sermiligaarsuk fjord (Fig. 1 shows the occurrences on the north side). The Tartoq Group, described by Higgins & Bondesen (1966), Higgins (1968), and Berthelsen & Henriksen (1975), is dominated by greenschists and contains subordinate siliceous and calcareous schists and ultramafic pods. The occurrence of pillow structures, massive sulphides and banded iron formation (Appel, 1984) implies that the rocks were formed in a submarine environment. Several types of minor gold mineralisation have been described by Appel & Secher (1984) and Erfurt (1990). The supracrustals are intruded by granitic to pegmatitic bodies and veins. The Tartoq Group was assumed on field evidence to be of late Archaean age (Higgins, 1990), but an age estimate of 2944 +/- 7 Ma based on SHRIMP isotope analyses of zircons, has now been obtained for a granite body intruding the Tartoq metavolcanics (A. P. Nutman, pers. comm. 1994). The relationships of the Tartoq group with the surrounding gneisses has been obscured by later deformation and is not completely clear. It has been suggested that the sequence has experienced fewer deformation phases than the gneisses of the region in general, but on the other hand there are large inclusions of greenschist in the enclosing gneisses. Bridgwater *et al.* (1976) assumed that the enclosing gneisses represented a migmatite complex which was younger than the regional gneisses and which had intrusive relations to the Tartoq Group.

A prominent early Proterozoic dolerite dyke swarm (2130 +/- 65 Ma) transects the Paamiut region (Kalsbeek & Taylor, 1985). The main Proterozoic deformation and metamorphism associated with the Ketilidian orogeny is inconspicuous in most of the Paamiut region but in the southernmost part Ketilidian deformation and metamorphism is conspiceous and increases in intensity southwards. The area north of Sermiligaarsuk fjord has been subjected to faulting and northward thrusting (Higgins, 1990). A major NNE-SSW trending shear zone, the Vesterland shear zone, is also assumed to be of Proterozoic age (Bak *et al.*, 1975).

Recurrent alkaline magmatism in mid-Proterozoic time (Gardar Province; Upton & Emeleus, 1987) resulted in the formation of large intrusive centres south of the survey area as well as intrusion of major dyke swarms which extend into the Paamiut region. In addition to dolerites the Gardar dykes of southern Greenland include a range of trachytic, phonolitic and lamprophyric compositions, but in the Paamiut region they are almost exclusively dolerites (Higgins, 1990).

The latest magmatic events were the intrusion of probable Jurassic coast-parallel alkali dolerite dykes (Watt, 1969), carbonatitic lamprophyres dated at 170 Ma (Hansen, 1980), and a kimberlite dyke dated at 225 Ma (Andrews & Emeleus, 1971, 1976), all of which are assumed to be related to the opening of the Labrador Sea.

## Mineral exploration

Most of the mineral exploration activities by GGU and companies have been focused on the Tartoq Group and comprised geological reconnaissance and mapping, as well as geophysical surveys. A summary and evaluation of the activities are given in Erfurt (1990). Geochemical maps of South Greenland covering the outcrops south of Sermiligaarssuk show minor enrichment in Au and As (Steenfelt, 1990; Steenfelt & Tukiainen, 1991). The westernmost occurrence of the Tartoq Group on the south side of Sermiligaarsuk has recently been investigated by Nunaoil A/S. A small number (36) of reconnaissance stream silt and grab samples were collected by Greenex in the Kvanefjord supracrustals and a few anomalies in Au (max. 770 ppb) and Cu (max. 311 ppm) were obtained (Christensen, 1985).

## Physiography

The surveyed area is mountainous with peaks rising from around 600 m in the coastal parts to more than 1000 m at the margin of the Inland Ice. In most of the area the cliffs along the fjords are steep while the land between the fjords has a moderate relief with many lakes. An exception is the area north-east of the head of Neria where the topography is alpine and peaks are 1400 to 1500 m high. Local ice caps are common on the high ground. In general, the distribution of streams is sufficiently even to allow systematic sampling. However, in some of the high plateau areas proper streams are rare. The streams generally run from May to September, although those sustained by melting snow commonly dry up during July. Present day erosion of the crystalline rocks is weak and fine material is scarce in many streams. As a result a number of the samples did not contain enough fine fraction material for the entire analytical programme. The bedrock exposure is generally good, except in valleys and on low lying gentle slopes where the surface is covered by talus and vegetation (herbs, grass, low scrub).

## Sampling

Eleven working days and 32.5 helicopter flying-hours were spent during the sampling of 275 sites distributed over 7260 $km^2$. On average 26 samples were collected per day at an average density of 1 site per 26.4 $km^2$; 7 flying minutes were spent per sampling site, which corresponds to 16 flying seconds per $km^2$.

The sample sites were selected and marked on aerial photographs prior to the sampling, using criteria such as even distribution of the sites, a reasonable size of upstream drainage area, and a reasonable slope dip.

At each station *c.* 500 g of stream sediment was collected in a paper bag and 100 ml of stream water in a polyethylene bottle. In addition the radioactivity (total gamma-radiation) was measured on the surface of outcrops or stream boulders using a scintillometer (Table 1). To increase the representativity, each stream sediment sample was composed of subsamples from 3 to 7 different sites of sand and silt deposits in the stream bed or banks. Duplicate samples of both sediment and water were collected at 16 localities, which corresponds to 5.8 % of the total number of sample localities.

In addition to the sampling for the reconnaissance geochemical mapping a measurement of the gravity field was made at each locality by E. Hansen, who joined the geochemistry sampling team. The methodology and results of the gravity survey will be reported separately in the GGU Open File Series.

## Sample preparation and analysis

**Sediment**. The sample bags were dried at room temperature at the base-camp in Paamiut and then sent by ship to GGU, Copenhagen. Here the samples were further dried at 65°C and sieved into three grain size fractions using sieve apertures of 1 mm and 0.1 mm. The coarse fraction was discarded, the medium fraction archived, and the fine fraction submitted for analysis. The samples were analysed by the instrumental neutron activation (INA) method for Au and 34 other elements and by X-ray fluorescence using pressed powder tablets for 14 trace elements (XRF-trace) at Activation Laboratories Ltd, Canada. They were analysed for major elements at the Geological Survey of Greenland by X-ray fluorescence spectrometry on fused discs, using Na-tetraborate, except $Na_2O$ which was determined by atomic absorption spectrophotometry together with Cu. Some samples did not contain sufficient amounts of fine fraction to permit all three types of analysis, and this explains the different numbers of samples analysed: 276 INA, 211 XRF-trace, and 216 XRF-major.

**Water**. The water samples (totalling 275) were sent by ship to GGU, Copenhagen, where they were analysed *c.* 2 months after collection. The conductivity and fluoride concentrations were measured (Table 1).

## Data presentation

The analytical results from the Paamiut region are shown in this report as element distribution maps at the scale of 1:1 000 000 together with summary statistical parameters and histograms of the frequency distribution for each element (Figs 2 to 44).

Elements with insignificant concentrations, i.e. at or below the detection limit (Table 2), are not presented. In cases where an element has been determined by more than one method, only one of the data sets is presented: that regarded as the most reliable or determined at the lowest detection limit. The major elements are expressed as oxides and the plots represent analytical values recalculated as volatile free components. The amount of volatiles (as determined by loss on ignition) is on average 6.7 % (maximum value is 39.65 % and minimum 0.28 %). High amounts of volatiles were measured in samples with a high proportion of organic matter.

In the element distribution maps the size of a dot is proportional to the concentration in the sample. The scaling of the dot size is chosen so that regional variations in the geochemical background are displayed as clearly as possible. Maximum values are found in the statistical parameters in the figures, and values regarded as geochemical anomalies are shown on the anomaly map (Fig. 45).

## Comments on the element distribution patterns

In general the element distribution patterns reflect the lithogeochemical variation over the survey area and high values for some elements can often be interpreted to indicate mineralisation. In the Paamiut region the main contributors to the lithogeochemical variation are the gneisses, the supracrustal enclaves and the granite/pegmatite intrusions.

A difference in the lithochemical character of the gneisses between the northern and southern part of the region is indicated by the maps of $Na_2O$ and Sr where a change from higher to lower concentration level takes place from north to south across Kvanefjord. The same tendency is displayed by $Al_2O_3$ and CaO. In the field it was noted that plagioclase-hornblende gneisses predominated in the northern area and biotite gneisses in the southern.

The bands and enclaves of supracrustals dominated by amphibolite are reflected by elevated values of $Fe_2O_3$, MnO, CaO, Co, Cu, Sc, and V. The distribution of high values of MgO, Cr and Ni indicate that ultramafic rocks make up a significant proportion of the supracrustal sequences around Kvanefjord but are insignificant in the Isorsua and Tartoq Groups, which is in accordance with the field observations (Jensen, 1974, 1975; Escher & Jensen, 1976). High As is found in the Kvanefjord and the Tartoq Group metavolcanic rocks, whereas only slightly elevated values are spatially associated with the extent of the Isorsua Group supracrustal layers. High As is usually characteristic of submarine exhalative types of deposits which have been recognised in the Tartoq Group. Thus, the three main areas with layers of supracrustal rocks are geochemically and lithologically different suggesting that they represent different environments. Tentatively, the Kvanefjord amphibolites containing a significant proportion of ultramafic layers which may represent komatiitic lavas, could have formed in an ocean floor environment; the Isorsua Group with amphibolites and aluminium rich metasediments could represent a platform or rifted basin type of deposition; while the Tartoq Group greenstones with associated metavolcanic units of andesitic and rhyolitic composition could have formed in a volcanic arc environment.

Elevated concentrations of lithophile elements ($K_2O$, Rb, Th, LREE) and of Y characterise the area occupied by the Neria granite, north east of the head of Neria. The anomaly in lithophile elements extends north-eastwards from the outline of the granite, which is explained by the abundant coarse grained granitic and pegmatitic bodies and veins reported in that area (Masson, 1970). The distinct geochemical signature of the Neria area suggests that the granites and pegmatites were formed from a separate magma rather than through homogenisation of the gneisses as suggested by Preston (1969) and Higgins (1990). The signature of the samples derived from the granite with fairly high Rb, Th and Y suggests a crustal origin for the granitic magma.

## Element distribution indicating mineralisation

**Gold**. The distribution of samples containing gold cannot be directly related to a single rock unit or association, although some high values are located in or near outcropping units of the Kvanefjord or the Tartoq Group supracrustals. This is in contrast to samples with high concentrations of the gold pathfinder element As, which are all clustered within these same supracrustal groups. The other pathfinder element, Sb, shows slightly elevated background values for the Tartoq Group and the Kvanefjord supracrustals, but as in the case of Au, the highest values do not appear to be tied to any particular rock unit. Gold mineralisation is known to occur in outcrops of the Tartoq Group of the southern side of Sermiligaarsuk, and the present data suggests that the outcrops on the northern side of the fjord, particularly those in the east, also have a potential for gold mineralisation associated with arsenopyrite. The conductivity of stream water is high in the Tartoq Group possibly reflecting either increased concentrations of sulphate from weathering sulphides or hydrocarbonate from carbonatised lavas. The Kvanefjord supracrustals also appear to be favourable as hosts for gold mineralisation, as indicated by the As and scattered Au and Sb anomalies and by the stream silt anomaly of 770 ppb previously reported (Christensen, 1985). However, the overall distribution of elevated Au values in the Paamiut region suggests that gold mineralisation has also taken place in shear and fault zones of Proterozoic age (shown in Fig. 13).

**Base metals**. The distribution of the highest values for Cu, Ni, Zn are shown in Fig. 45. The Ni and Zn anomalies obtained by the INA analyses are included in this figure at sample points where only INA analyses have been carried out due to limited sample material. The INA data have not been used to produce maps because the detection limits are high (Table 1). The base metal anomalies cluster on the two groups of basic metavolcanic rocks, Tartoq Group (the western occurrence) and Kvanefjord. The Cu and Zn anomalies are not exceptionally strong, but the Kvanefjord supracrustals appear to have a potential for Ni mineralisation, presumably associated with the ultramafic rocks.

**Uranium and thorium**. The concentrations of U and Th in the southern part of the Paamiut region are very high compared with the Archaean terrain elsewhere in Greenland, except in the Godthåbsfjord region (Steenfelt *et al.*, 1990), whereas the Proterozoic Ketilidian orogenic belt to the south has been described as a geochemical uranium province (Armour-Brown *et al.*, 1983). It is noteworthy that the high U values are spatially separated from the high Th background associated with the Neria granitic magmatism. The highest U values are located on an east-west fault, probably of Proterozoic age (Higgins, 1990), running from the head of Neria fjord to the Inland Ice. This fault is also characterised by fluorine in stream water and stream sediment anomalies for Mo, Pb, Zn and some elevated Au values, all of which indicate that hydrothermal mineralisation has taken place in the fault.

## Conclusion

The geochemical survey of the Paamiut region in the southern part of the Archaean craton in West Greenland has provided new information on the nature of the gneisses and supracrustal layers which may be used in interpreting the plate tectonic setting of the rock formations. The Kvanefjord group of mafic metavolcanic rocks with a high proportion of ultramafic rocks has a potential for Ni, Au, and possibly minor Cu-Zn mineralisation. The gold and possible base metal potential of the Tartoq Group greenstones with subordinate felsic metavolcanic and metasedimentary rocks has been documented previously and led to exploration activities. The present results confirm the known potential. A new gold exploration target is indicated by anomalies of Au, Sb, U, Mo and Pb which appear to be associated with faults of Proterozoic or younger age. The Proterozoic orogeny just south of the survey area may have created favourable conditions for hydrothermal remobilisation and deposition of gold and other ore metals in structural traps in the Paamiut region.

**Acknowledgement**

The sampling benefitted greatly from the skill and enthusiastic cooperation of the UNIFLY helicopter pilots Staffan Forsstedt and Hans Hammer. Allen Nutman and Feiko Kalsbeek are thanked for permission to quote unpublished isotope data.

**References**

Allaart, J. H. 1975: Geological map of Greenland, 1:500 000, Sheet 1, Sydgrønland. Copenhagen: Grønlands Geologiske Undersøgelse.

Andrews, J. R. & Emeleus, C. H. 1971: Preliminary account of kimberlite intrusions from the Frederikshåb district, South-West Greenland. *Rapp. Grønlands geol. Unders.* **31**, 26 pp.

Andrews, J. R. & Emeleus, C. H. 1976: Kimberlites of West Greenland. *In* Escher, A. & Watt, W. S. (ed.) *Geology of Greenland*, 574-581. Copenhagen: Grønlands Geologiske Undersøgelse.

Appel, P. W. U. 1984: An iron-formation in the Precambrian Tartoq Group, South-West Greenland. *Rapp. Grønlands geol. Unders.* **120**, 74-78.

Appel, P. W. U. & Secher, K. 1984: On a gold mineralization in the Precambrian Tartoq Group, SW Greenland. *J. geol. Soc. Lond.* **141**, 273-278.

Armour-Brown, A., Steenfelt, A. & Kunzendorf, H. 1983: Uranium districts defined by reconnaissance geochemistry in South Greenland. *J. geochem. Explor.* **19**, 127-145.

Bak, J., Sørensen, K., Grocott, J., Korstgård, J. A., Nash, D. & Watterson, J. 1975: Tectonic implications of Precambrian shear belts in western Greenland. *Nature* **254**, 566-569.

Berthelsen, A. & Henriksen, N. 1975: Geological map of Greenland 1:100 000, Ivigtut 61 V.1 Syd, descriptive text. The orogenic and cratogenic geology of a Precambrian shield area, 169 pp. Copenhagen: Grønlands Geologiske Undersøgelse.

Bridgwater, D., Keto, L., McGregor, V. R. & Myers, J. S. 1976: Archaean gneiss complex of Greenland. *In* Escher, A. & Watt, W. S. (ed.) *Geology of Greenland*, 19-75. Copenhagen: Grønlands Geologiske Undersøgelse.

Christensen, K. 1985: Greenex prospektering 1985. (Ravn Storø and Thule prospecting licence). Report 4-85. Internal report, Greenex A/S, 3 pp.

Erfurt, P. 1990: Reconnaissance and exploration for gold and base metals in the area between Arsuk and Neria Fjords, South-West Greenland. Work performed 1971 to 1985: Results and discussion. *Open File Ser. Grønlands geol. Unders.* **90/10**, 30 pp.

Escher, J. C. & Jensen, S. B. 1976: Geologisk kort over Grønland, 1:100 000 Nigerdlikasik 62 V.2 Syd. Copenhagen: Grønlands Geologiske Undersøgelse.

Hansen, K. 1980: Lamprophyres and carbonatitic lamprophyres related to rifting of the Labrador Sea. *Lithos* **13**, 145-152.

Higgins, A. K. 1968: The Tartoq Group on Nuna qaqortoq and in the Iterdlak area, South-West Greenland. *Rapp. Grønlands geol. Unders.* **17**, 27-50.

Higgins, A. K. 1974: Geologisk kort over Grønland, 1:100 000 Midternæs, 61 V.2 Nord. Copenhagen: Grønlands Geologiske Undersøgelse.

Higgins, A. K. 1990: Descriptive text to 1:100 000 sheets Neria 61 V.1 N and Midternæs 61 V.2 N, 23 pp. Copenhagen: Grønlands Geologiske Undersøgelse.

Higgins, A. K. & Bondesen, E. 1966: Supracrustals of pre-Ketilidian age (the Tartoq Group) and their relationships with Ketilidian supracrustals in the Ivigtut region, South-West Greenland. *Rapp. Grønlands geol. Unders.* **8**, 21 pp.

Jensen, S. B. 1974: Geologisk kort over Grønland, 1:100 000 Nerutussoq 62 V.1 Syd. Copenhagen: Grønlands Geologiske Undersøgelse.

Jensen, S. B. 1975: Geologisk kort over Grønland, 1:100 000 Neria 61 V.1 Nord. Copenhagen: Grønlands Geologiske Undersøgelse.

Kalsbeek, F. & Taylor, P. N. 1985: Age and origin of early Proterozoic dolerite dykes in South-West Greenland. *Contr. Miner. Petrol.* **89**, 307-316.

Kalsbeek, F., Larsen, L. M. & Bondam, J. 1990: Descriptive text to 1:500 000, sheet1, Sydgrønland, 36 pp. Copenhagen: Grønlands Geologiske Undersøgelse.

Masson, H. 1970: Pétrographie et tectonique du complexe migmatique d'Isorssua (Frederikshåb, Groenland SW). Unpublished thesis, Univ. Lausanne, 190 pp.

Mísař, Z. 1973: Precambrian ultramafics south of Sermilik. *Bull. Grønlands geol. Unders.* **107**, 60 pp.

Preston, P. M. F. 1969: The petrology and structure of the north-eastern Neria area, South-West Greenland. Unpublished Ph.D. thesis, Univ. Durham, 248 pp.

Steenfelt, A. 1990: Gold content of regional stream sediment samples from South Greenland. *Open File Ser. Grønlands geol. Unders.* **90/5**, 12 pp.

Steenfelt, A., Thorning, L. & Tukiainen, T. 1990: Regional compilations of geoscience data from the Nuuk-Maniitsoq area, southern West Greenland. *Thematic Map Ser. Grønlands geol. Unders.* **90/1**, 9 pp.

Steenfelt, A. & Tukiainen, T. 1991: Geochemical mapping: distribution of gold, arsenic, antimony and tantalum in South Greenland. *Rapp. Grønlands geol. Unders.* **152**, 55-61.

Upton, B. G. J. & Emeleus, C. H. 1987: Mid-Proterozoic magmatism in southern Greenland, the Gardar Province. *In* Fitton, J. G. & Upton, B. G. J. (ed.) *Alkaline Igneous Rocks. Geological Society London Special Publication* **30**, 449-471.

Watt, W. S. 1969: The coast-parallel dike swarm of Southwest Greenland in relation to the opening of the Labrador Sea. *Can. J. Earth Sci.* **6**, 1320-1321.

Table 1. Instrumentation at the Geological Survey of Greenland

Field measurement of gamma-radiation: Saphymo-Srat SPP-2 scintillometer

Water samples:

Conductivity: Chemotest JK 8800

Fluoride concentration: Orion EA 920 pH/ion analyzer

Table 2. Analytical detection limits

Instrumental Neutron Activation Analysis (Activation Laboratories Ltd.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Au | 5.0 ppm | Ag | 5.0 ppm | As | 2.0 ppm | Ba | 100.0 ppm |
| Br | 1.0 ppm | Ca | 1.0 % | Co | 5.0 ppm | Cr | 10.0 ppm |
| Cs | 2.0 ppm | Fe | 0.02 % | Hf | 1.0 ppm | Hg | 1.0 ppm |
| Ir | 5.0 ppm | Mo | 5.0 ppm | Na | 500.0 ppm | Ni | 50.0 ppm |
| Rb | 30.0 ppm | Sb | 0.2 ppm | Sc | 0.1 ppm | Se | 5.0 ppm |
| Sn | 0.01 % | Sr | 0.05 % | Ta | 1.0 ppm | Th | 0.5 ppm |
| U | 0.05 ppm | W | 4.0 ppm | Zn | 50.0 ppm | La | 1.0 ppm |
| Ce | 3.0 ppm | Nd | 5.0 ppm | Sm | 0.1 ppm | Eu | 0.2 ppm |
| Tb | 0.5 ppm | Yb | 0.05 ppm | Lu | 0.05 ppm | | |

X-ray Fluorescence Spectrometry (pressed powder tablets) (Activation Laboratories Ltd.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ba | 5.0 ppm | Co | 5.0 ppm | Cr | 5.0 ppm | Cu | 5.0 ppm |
| Ga | 5.0 ppm | Nb | 2.0 ppm | Ni | 5.0 ppm | Pb | 5.0 ppm |
| Rb | 2.0 ppm | Sr | 2.0 ppm | V | 5.0 ppm | Y | 2.0 ppm |
| Zn | 5.0 ppm | Zr | 5.0 ppm | | | | |

**List of figures**

Grønlands Geologiske Undersøgelse

# GEOLOGICAL MAP

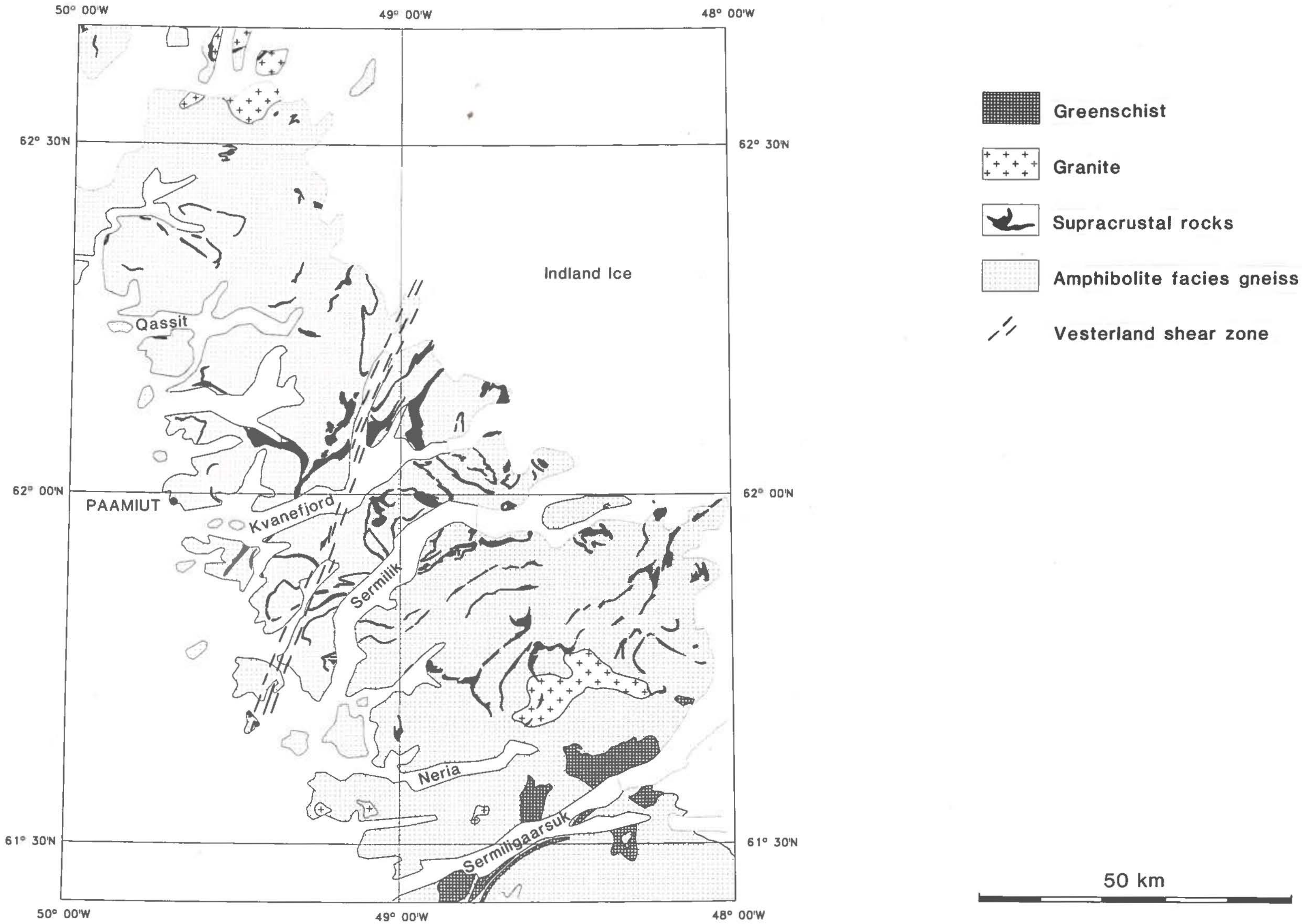



Fig. 1

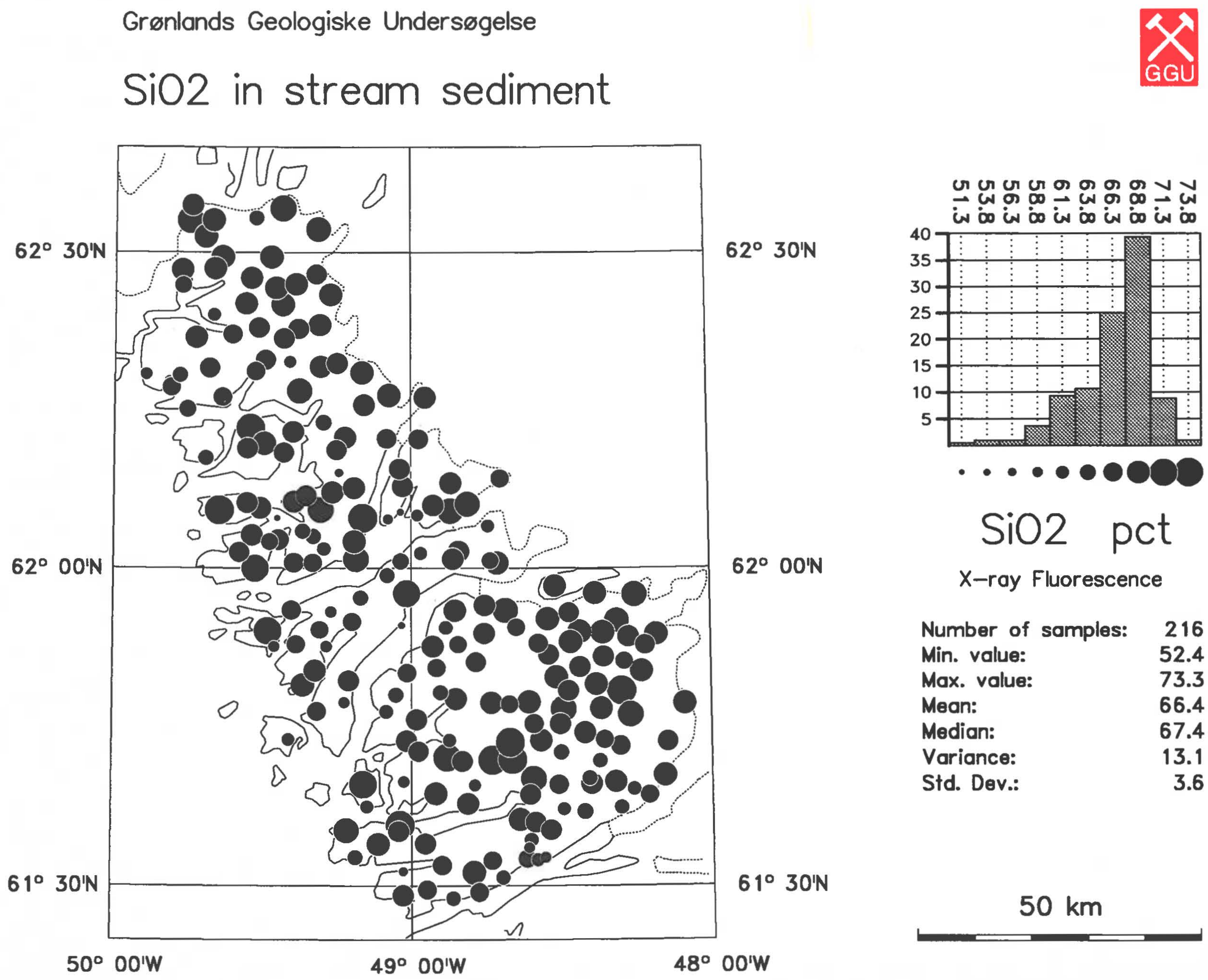
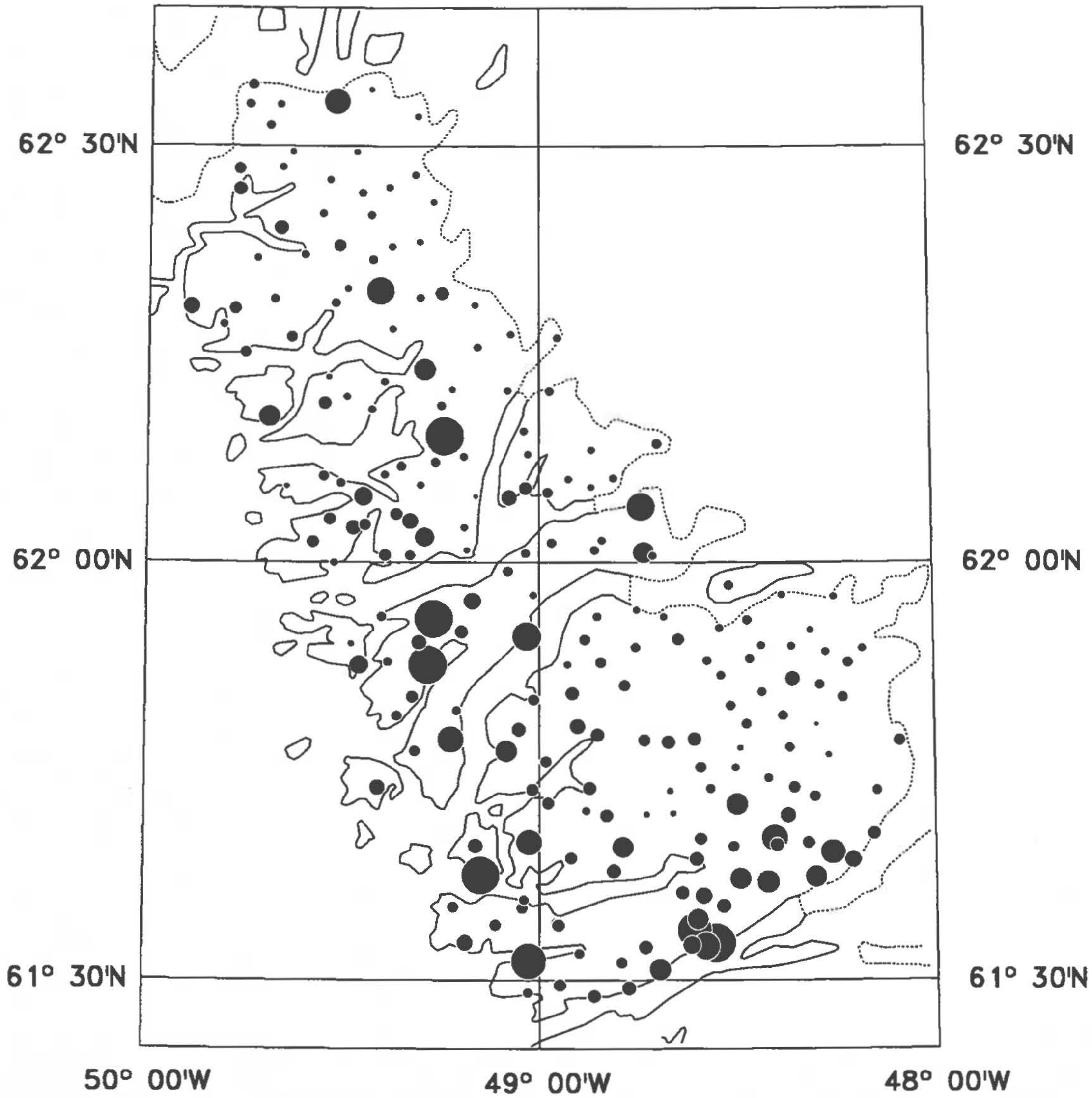
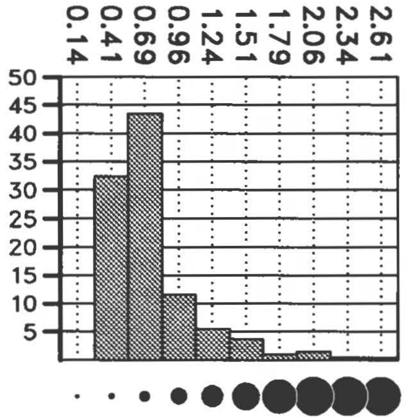

Grønlands Geologiske Undersøgelse
SiO2 in stream sediment
GGU
62° 30'N
62° 00'N
61° 30'N
50° 00'W
49° 00'W
48° 00'W
51.3
53.8
56.3
58.8
61.3
63.8
66.3
68.8
71.3
73.8
40
35
30
25
20
15
10
5
SiO2 pct
X-ray Fluorescence
Number of samples: 216
Min. value: 52.4
Max. value: 73.3
Mean: 66.4
Median: 67.4
Variance: 13.1
Std. Dev.: 3.6
50 km

Fig. 2

Grønlands Geologiske Undersøgelse

# TiO2 in stream sediment




TiO2 pct

X-ray Fluorescence

| | |
|---|---|
| Number of samples: | 216 |
| Min. value: | 0.31 |
| Max. value: | 2.70 |
| Mean: | 0.75 |
| Median: | 0.65 |
| Variance: | 0.13 |
| Std. Dev.: | 0.36 |


Fig. 3

Grønlands Geologiske Undersøgelse

# Al2O3 in stream sediment

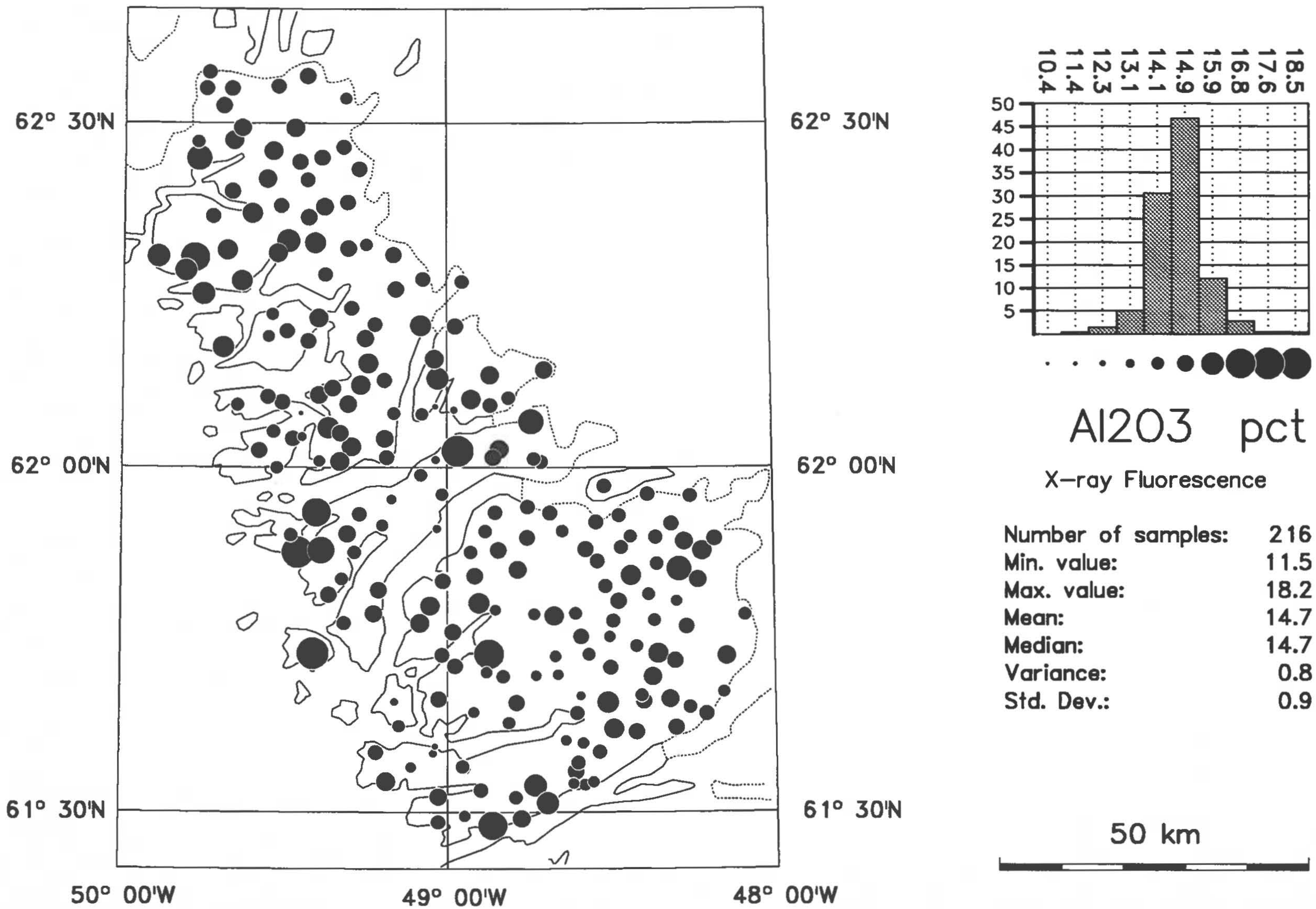
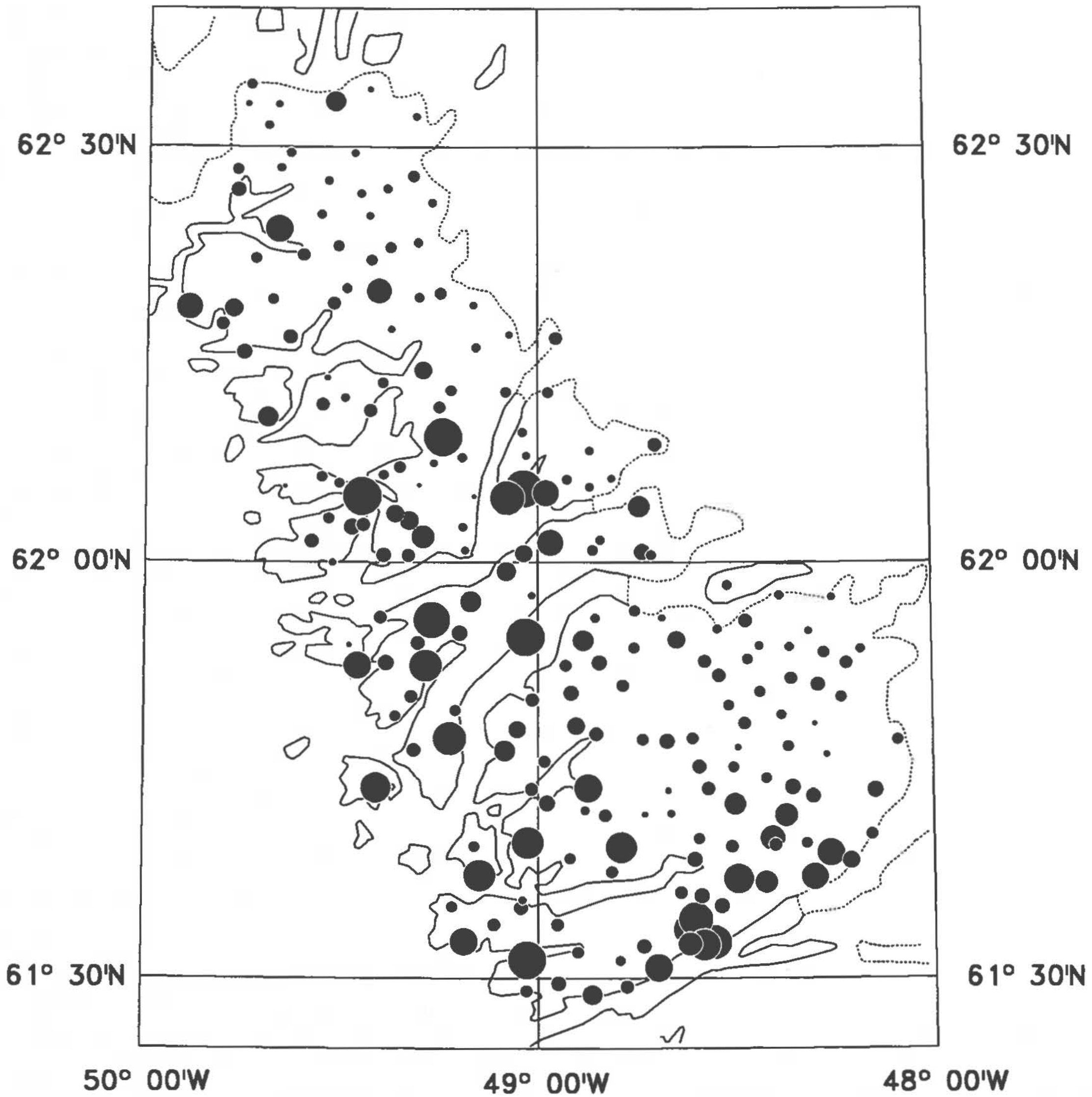


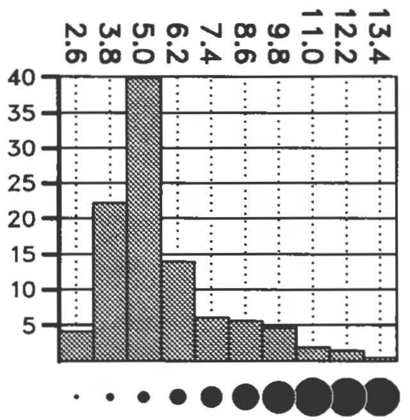

Fig. 4

Fig. 5

Grønlands Geologiske Undersøgelse

# Fe2O3 in stream sediment




Fe2O3 pct

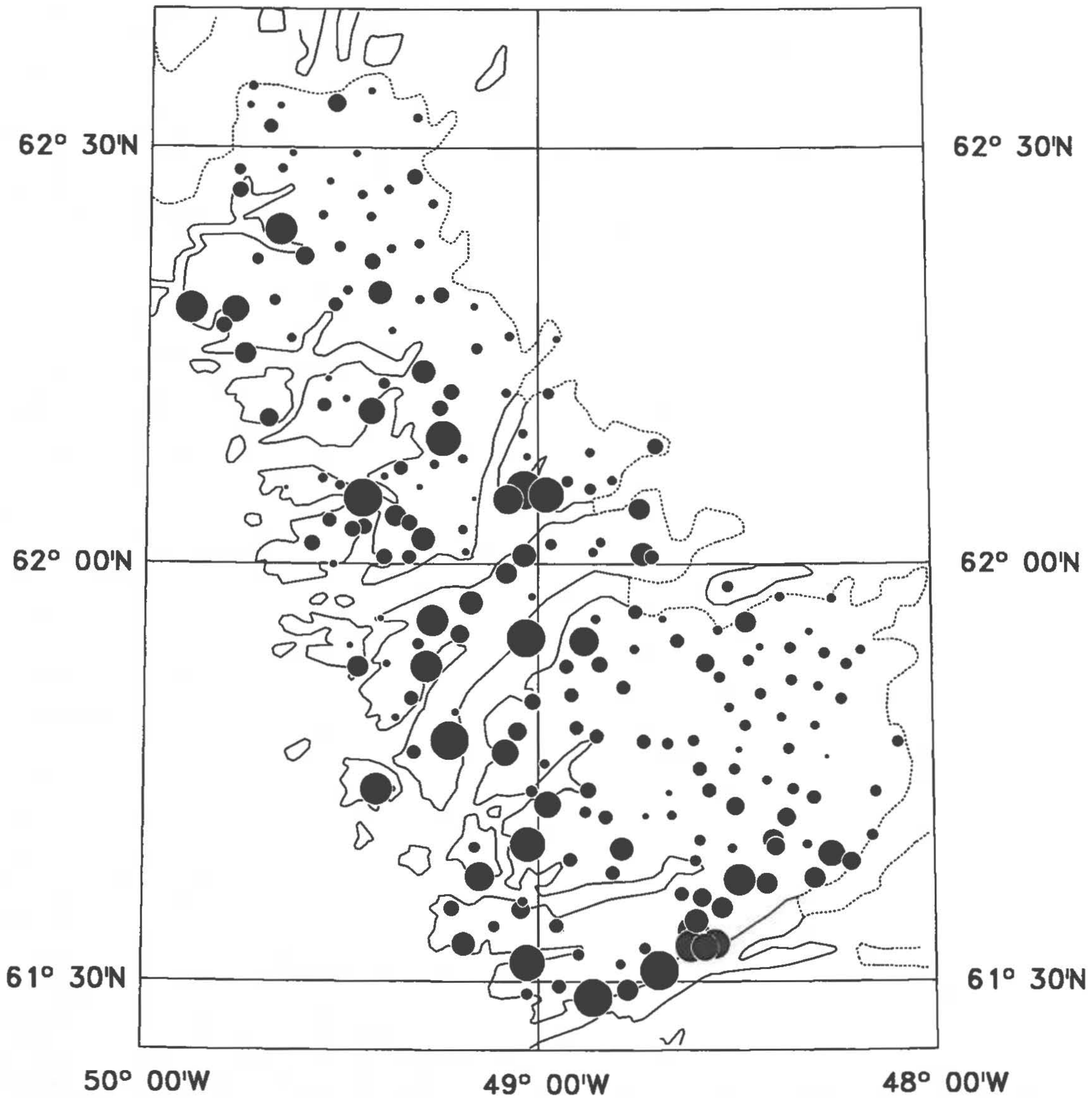
X-ray Fluorescence

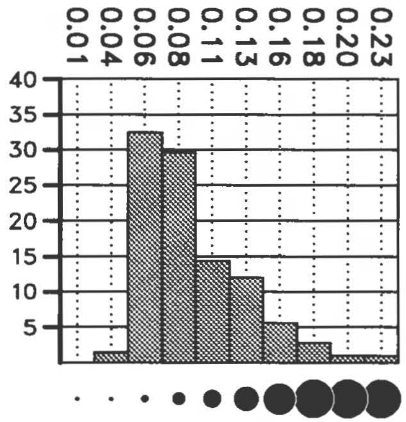
| | |
|---|---|
| Number of samples: | 216 |
| Min. value: | 2.4 |
| Max. value: | 13.3 |
| Mean: | 5.6 |
| Median: | 5.1 |
| Variance: | 4.0 |
| Std. Dev.: | 2.0 |

50 km

Grønlands Geologiske Undersøgelse

# MnO in stream sediment




## MnO pct

X–ray Fluorescence

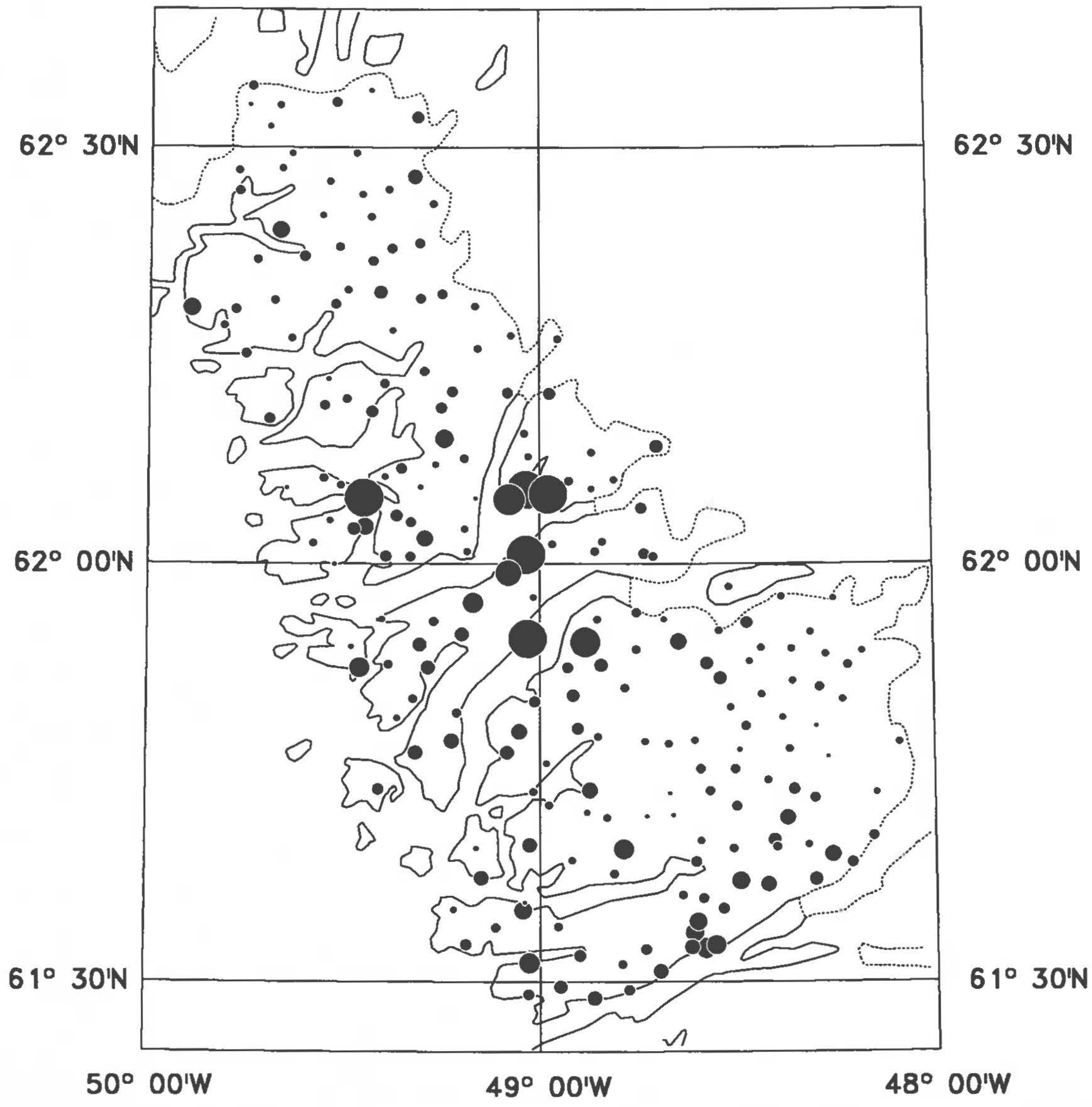
| | |
|---|---|
| Number of samples: | 216 |
| Min. value: | 0.04 |
| Max. value: | 0.23 |
| Mean: | 0.09 |
| Median: | 0.08 |
| Variance: | 0.00 |
| Std. Dev.: | 0.04 |

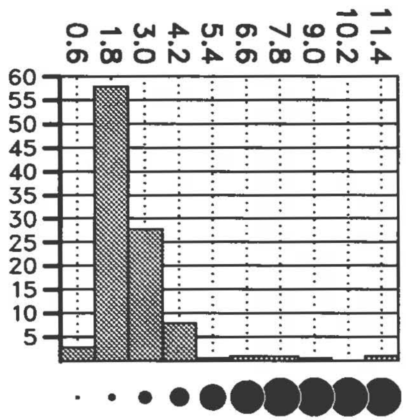
50 km

Fig. 6

Grønlands Geologiske Undersøgelse

# MgO in stream sediment




## MgO pct

X-ray Fluorescence

| | |
|---|---|
| Number of samples: | 216 |
| Min. value: | 0.9 |
| Max. value: | 11.7 |
| Mean: | 2.6 |
| Median: | 2.2 |
| Variance: | 1.9 |
| Std. Dev.: | 1.4 |

50 km

Fig. 7

Grønlands Geologiske Undersøgelse

# CaO in stream sediment

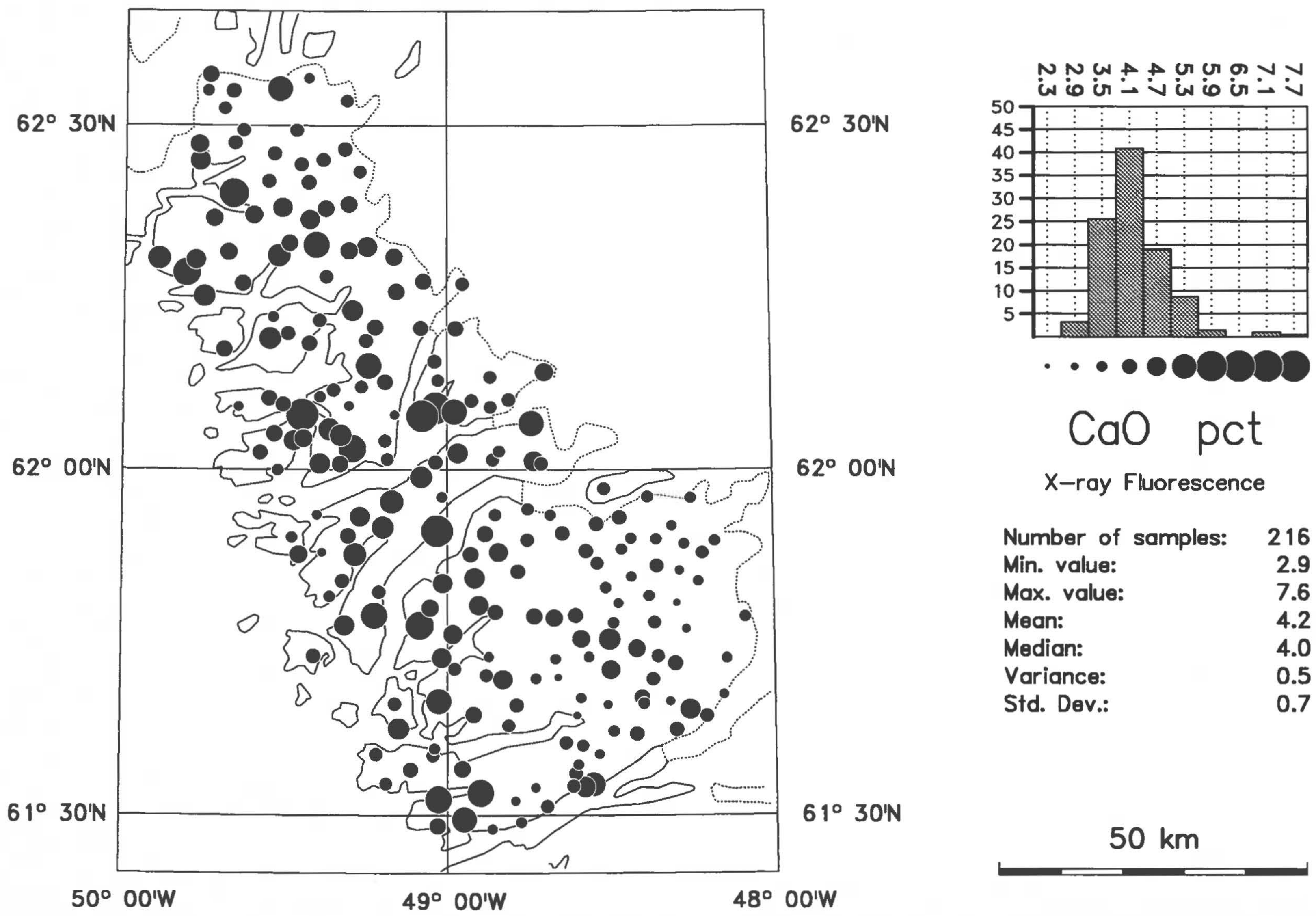
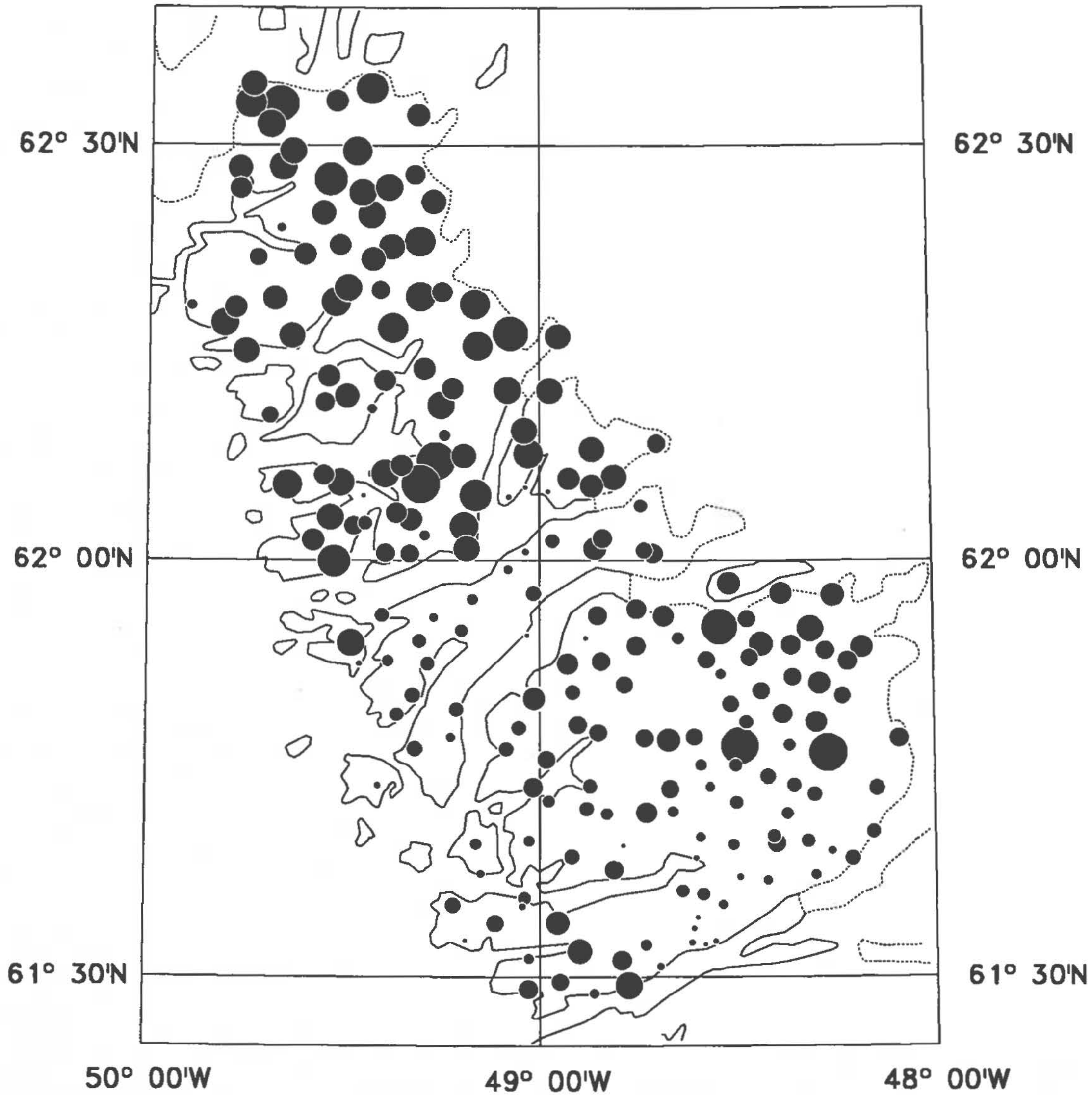
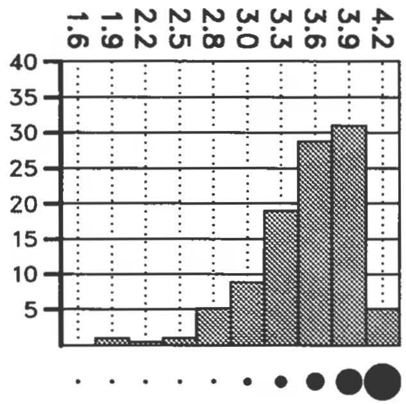



Fig. 8

Grønlands Geologiske Undersøgelse

# Na2O in stream sediment




## Na2O pct

AAS

| | |
|---|---|
| Number of samples: | 216 |
| Min. value: | 1.9 |
| Max. value: | 4.2 |
| Mean: | 3.6 |
| Median: | 3.6 |
| Variance: | 0.2 |
| Std. Dev.: | 0.4 |

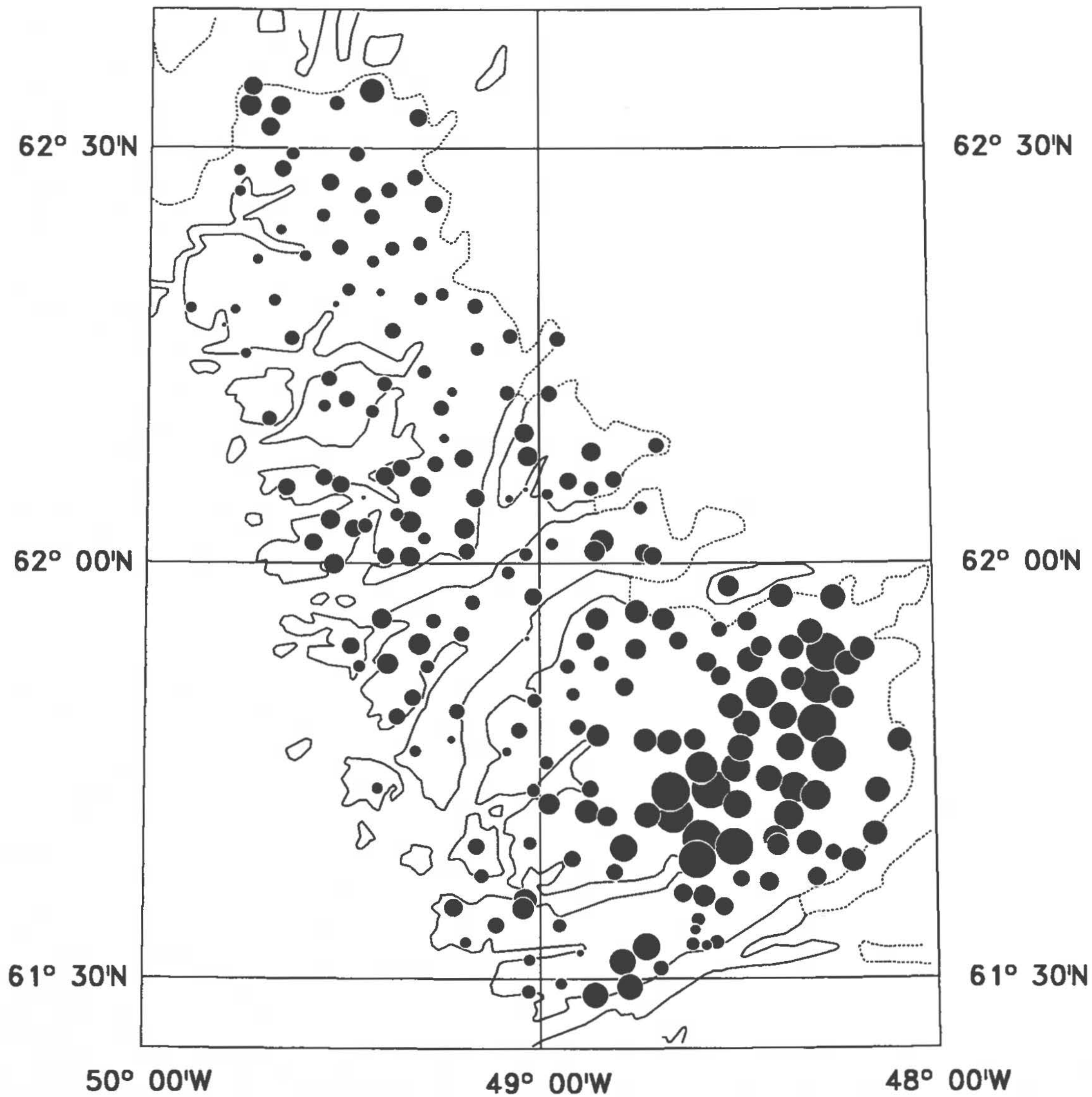
50 km

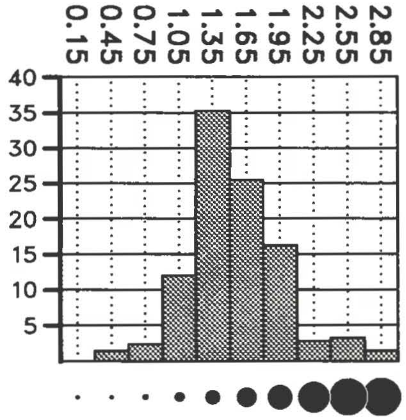
Fig. 9

Grønlands Geologiske Undersøgelse

# K2O in stream sediment

GGU




## K2O pct

X-ray Fluorescence

| | |
|---|---|
| Number of samples: | 216 |
| Min. value: | 0.43 |
| Max. value: | 2.91 |
| Mean: | 1.54 |
| Median: | 1.48 |
| Variance: | 0.17 |
| Std. Dev.: | 0.41 |

50 km

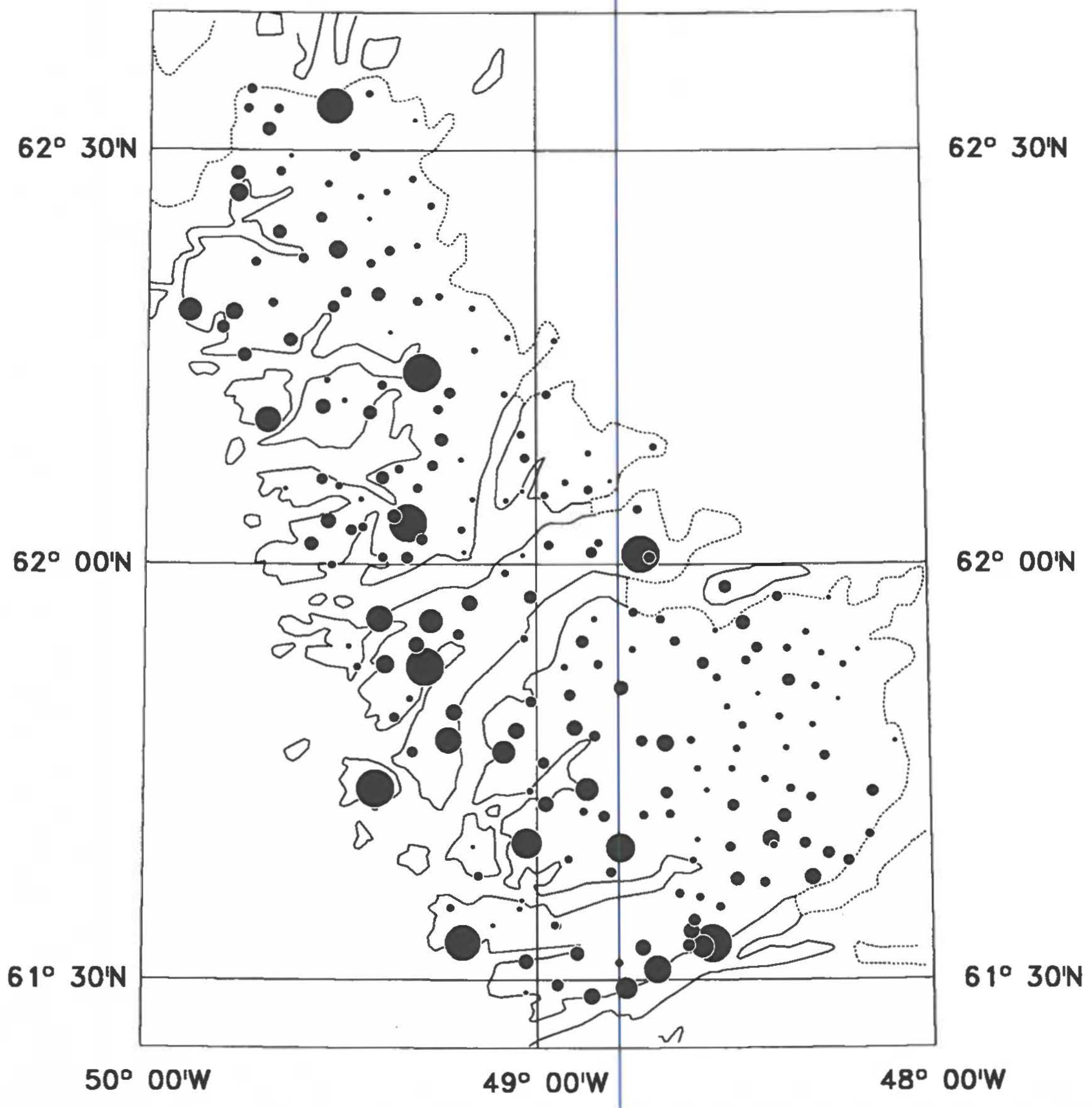
Fig. 10

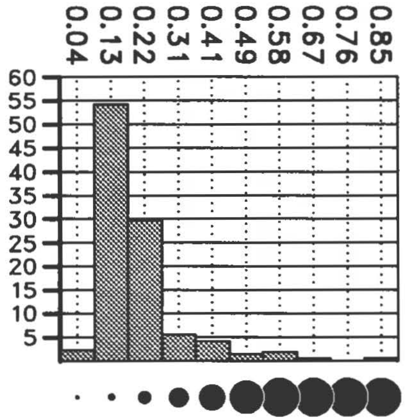
Fig. 11

Grønlands Geologiske Undersøgelse

GGU

# P205 in stream sediment




## P205 pct

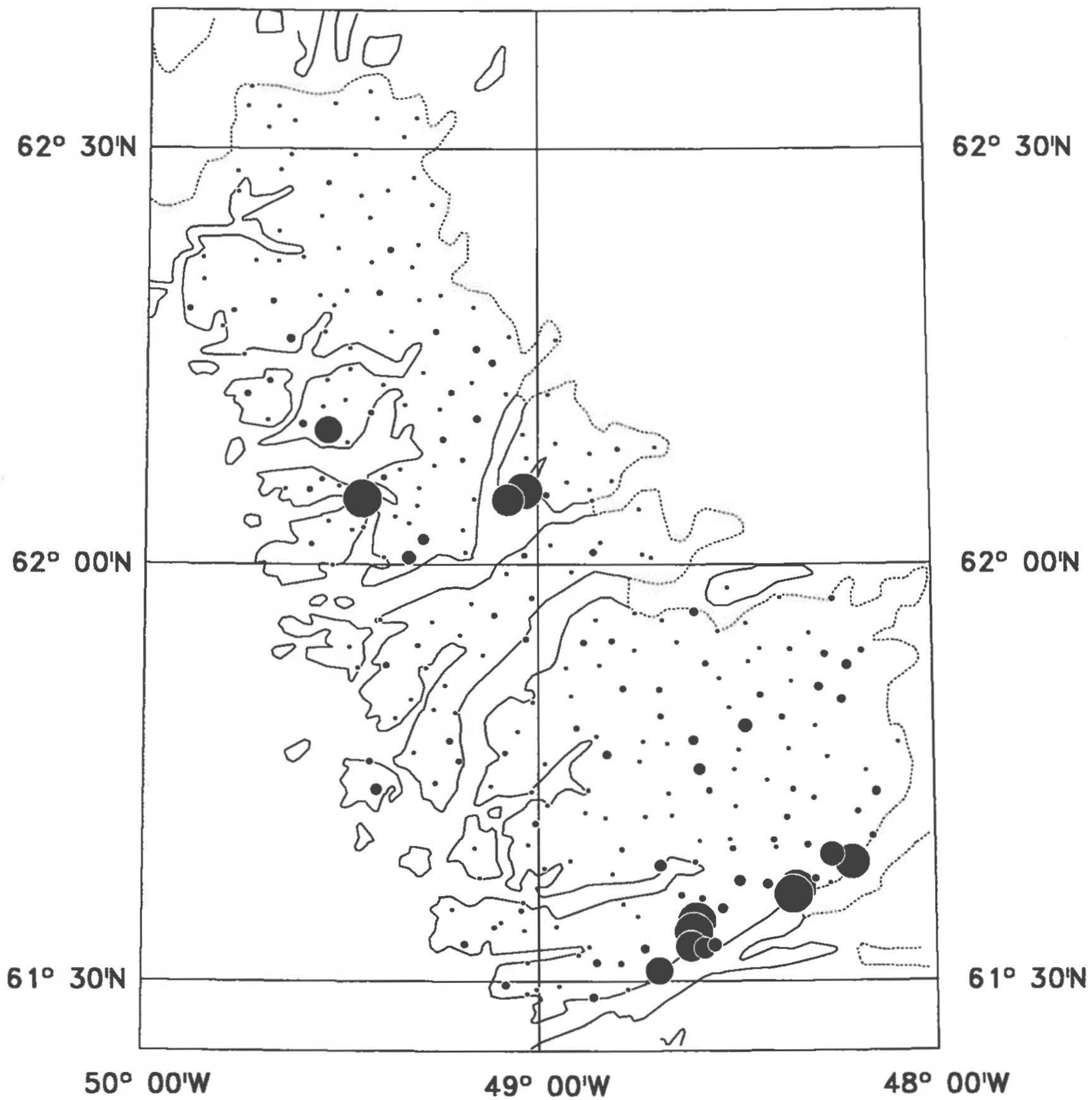
X–ray Fluorescence

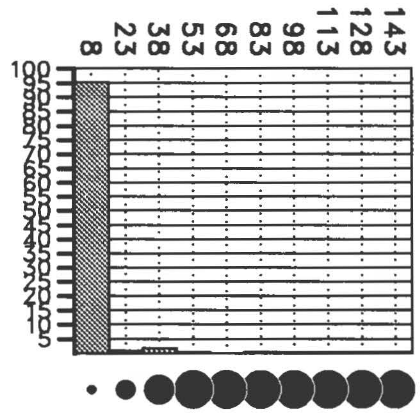
| | |
|---|---|
| Number of samples: | 216 |
| Min. value: | 0.08 |
| Max. value: | 0.89 |
| Mean: | 0.20 |
| Median: | 0.17 |
| Variance: | 0.01 |
| Std. Dev.: | 0.11 |

50 km

Grønlands Geologiske Undersøgelse

# As in stream sediment




As ppm

INAA

| | |
|---|---|
| Number of samples: | 276 |
| Min. value: | 0 |
| Max. value: | 140 |
| Mean: | 5 |
| Median: | 0 |
| Variance: | 256 |
| Std. Dev.: | 16 |

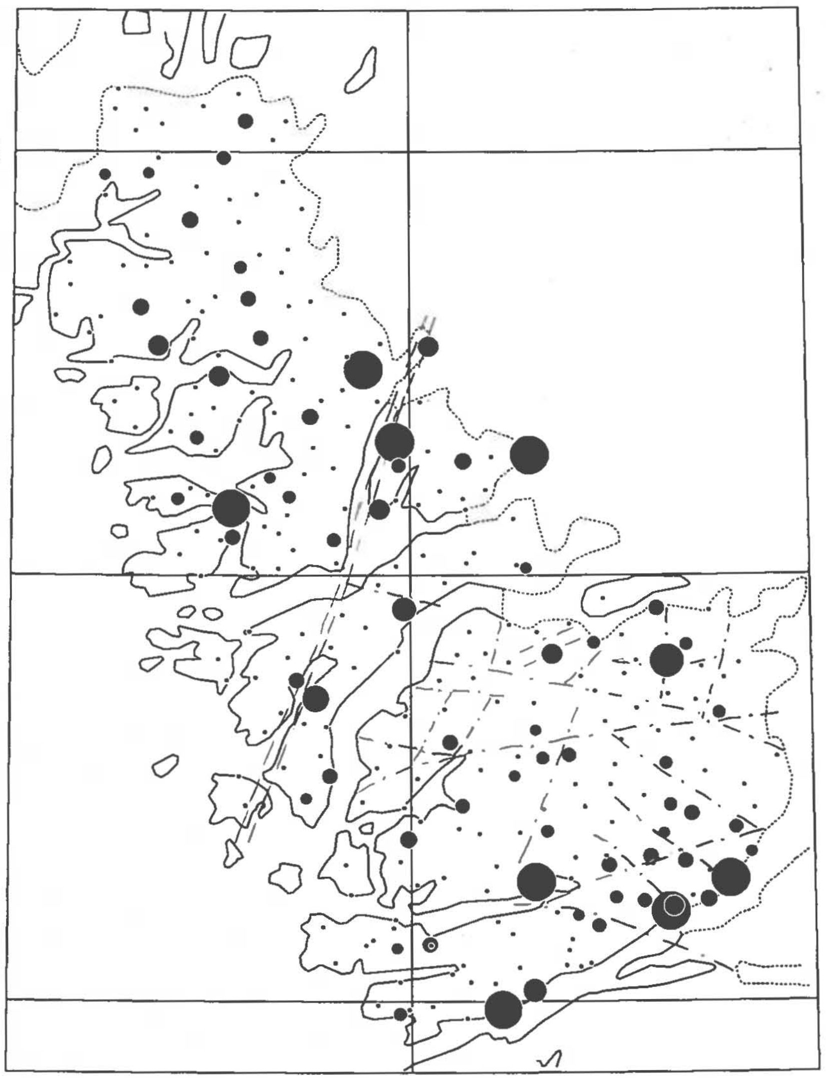
50 km

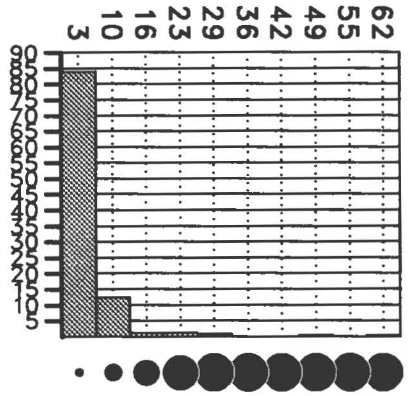
Fig. 12

Grønlands Geologiske Undersøgelse

GGU

# Au in stream sediment




## Au ppb

INAA

| | |
|---|---|
| Number of samples: | 276 |
| Min. value: | 0 |
| Max. value: | 82 |
| Mean: | 3 |
| Median: | 0 |
| Variance: | 88 |
| Std. Dev.: | 9 |

50 km

Fig. 13

Grønlands Geologiske Undersøgelse

# Ba in stream sediment

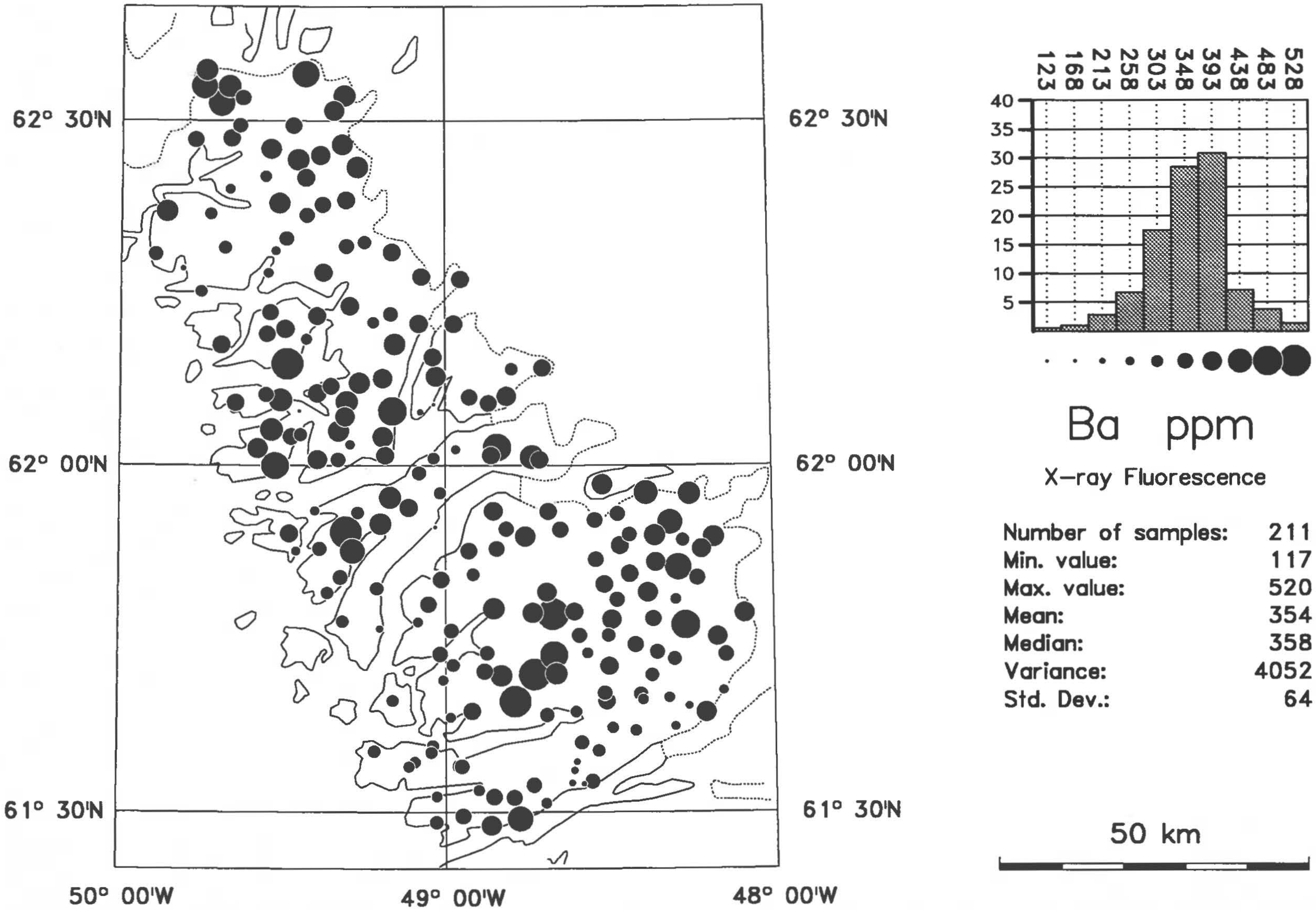
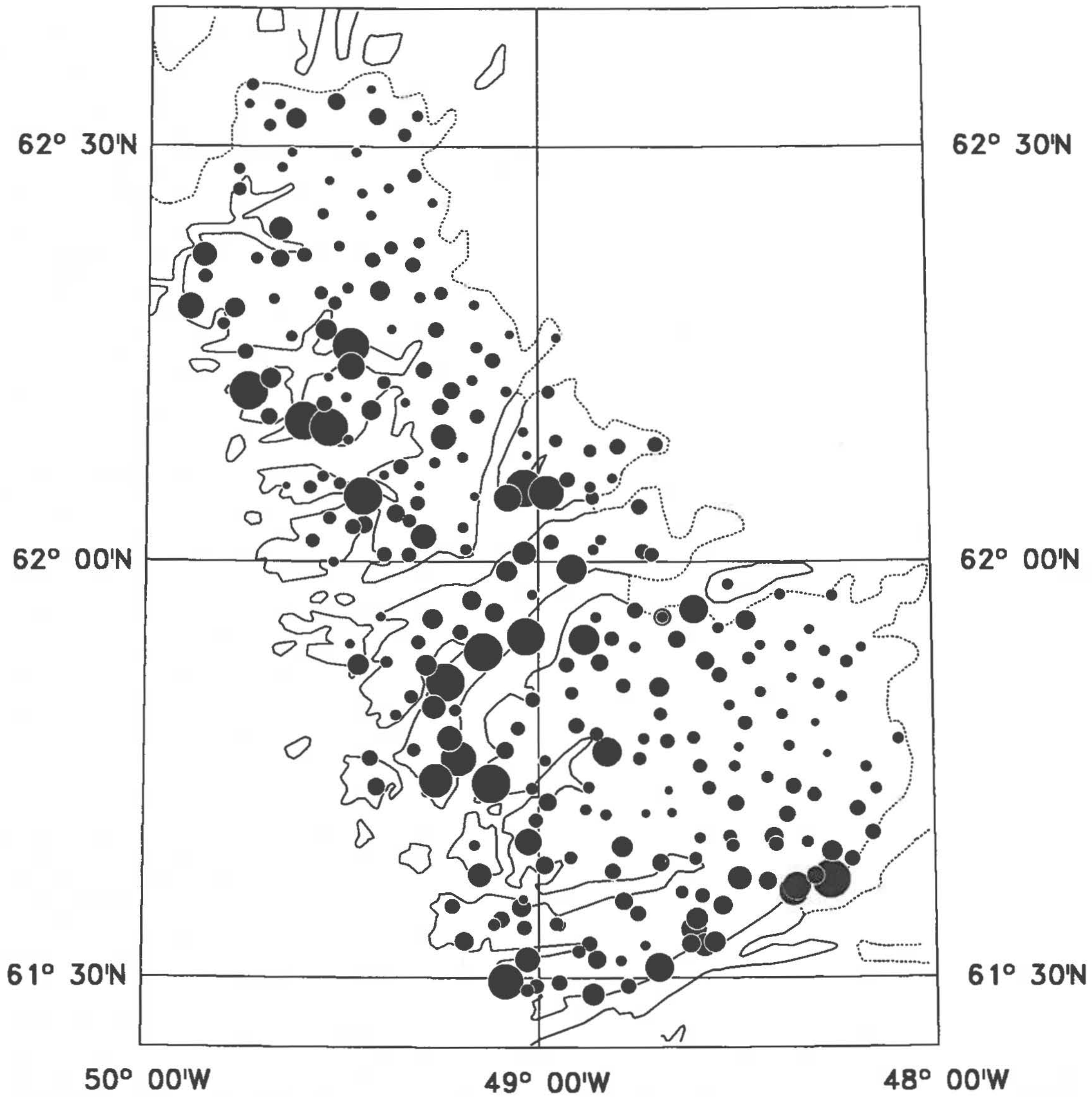
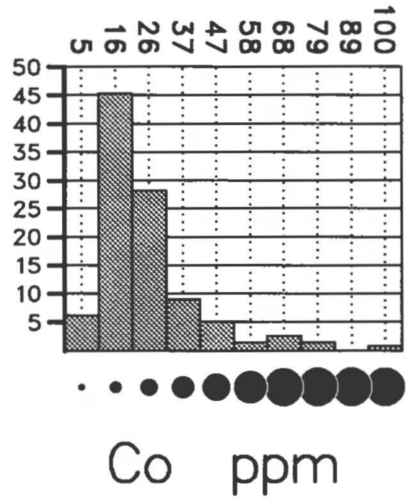



Fig. 14

Grønlands Geologiske Undersøgelse

# Co in stream sediment




| | |
|---|---|
| Number of samples: | 276 |
| Min. value: | 7 |
| Max. value: | 100 |
| Mean: | 24 |
| Median: | 20 |
| Variance: | 242 |
| Std. Dev.: | 16 |

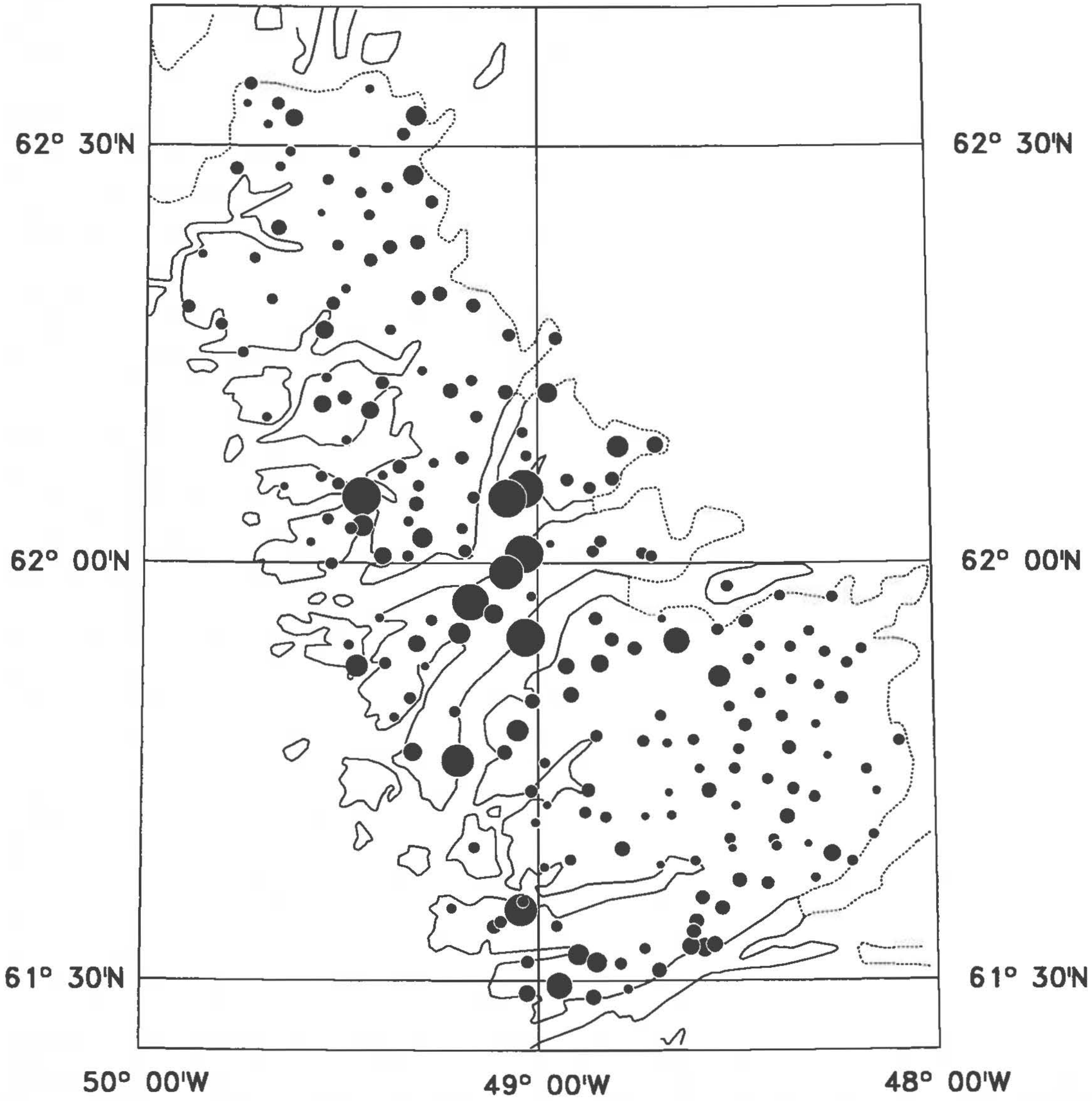
50 km

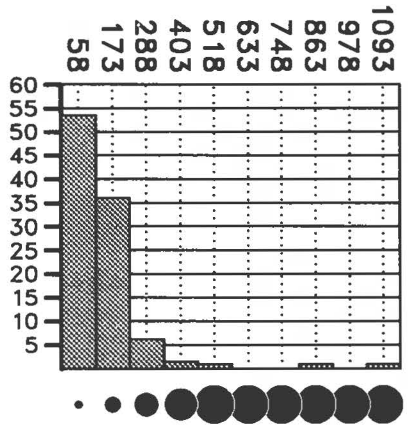
Fig. 15

Grønlands Geologiske Undersøgelse

GGU

# Cr in stream sediment




Cr ppm

X-ray Fluorescence

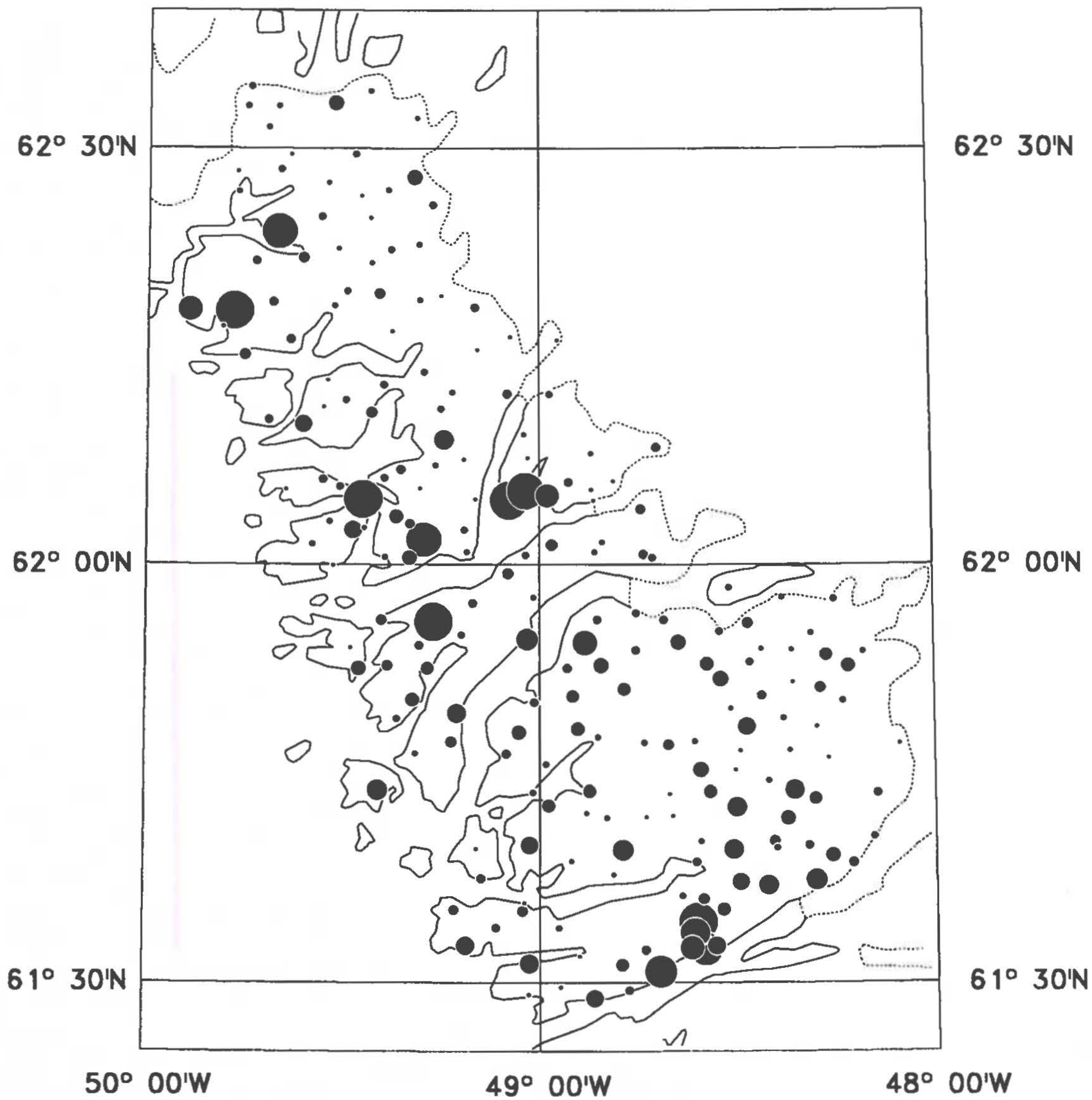
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 45 |
| Max. value: | 1140 |
| Mean: | 147 |
| Median: | 112 |
| Variance: | 18810 |
| Std. Dev.: | 137 |

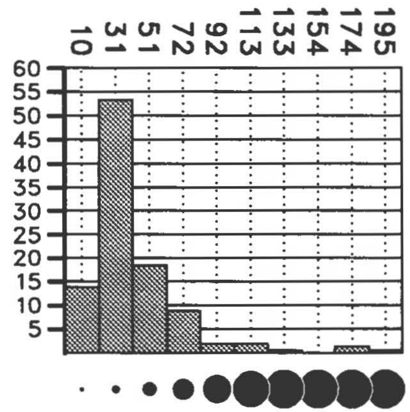
50 km

Fig. 16

Grønlands Geologiske Undersøgelse

# Cu in stream sediment




## Cu ppm

AAS

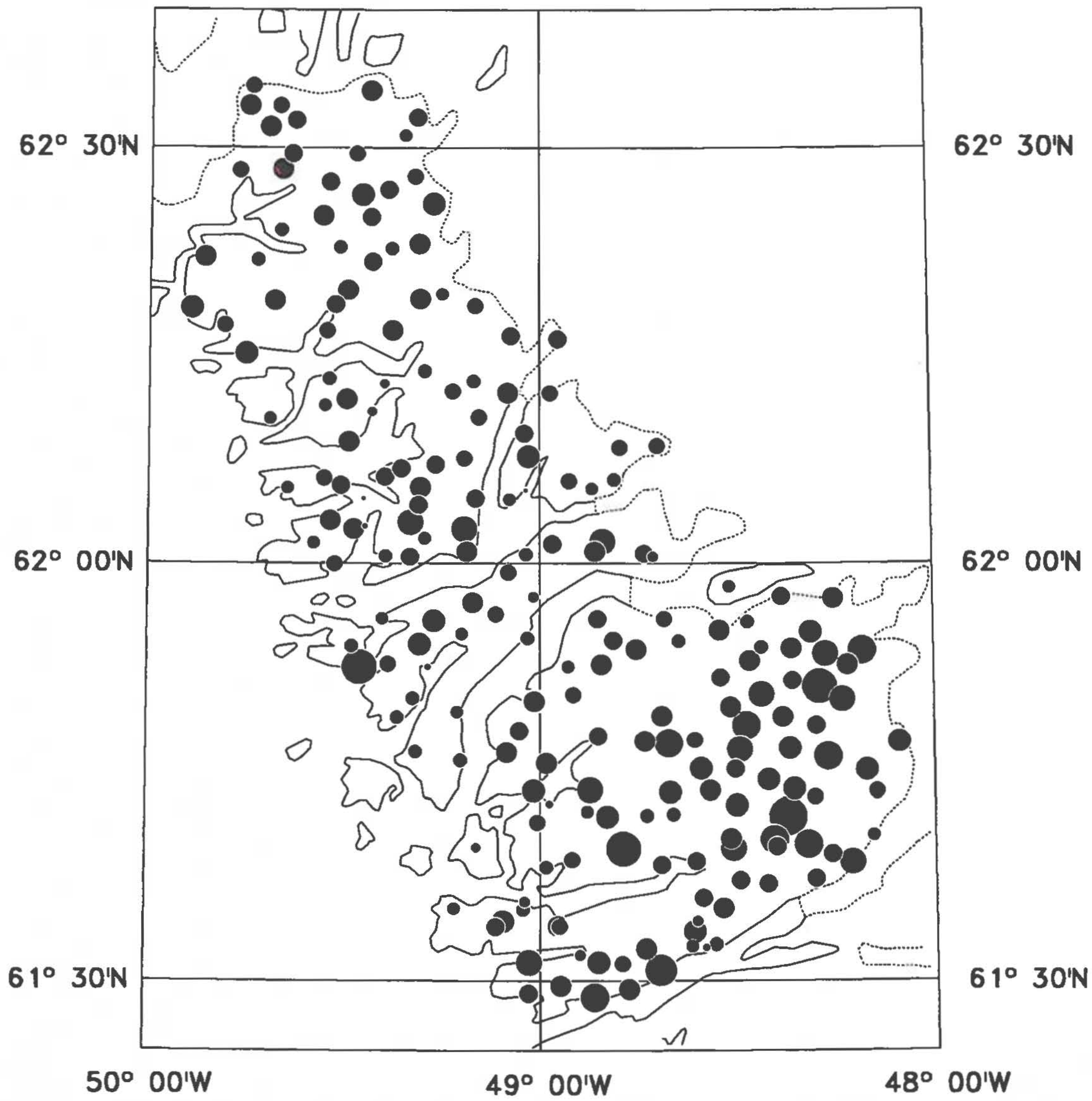
| | |
|---|---|
| Number of samples: | 218 |
| Min. value: | 9 |
| Max. value: | 203 |
| Mean: | 40 |
| Median: | 32 |
| Variance: | 787 |
| Std. Dev.: | 28 |

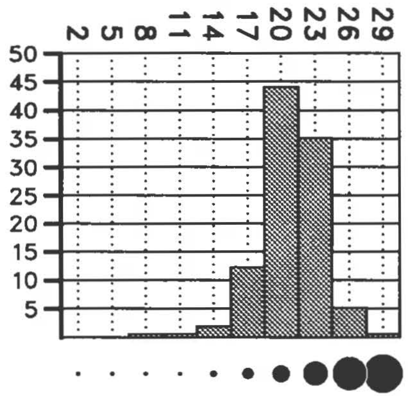
50 km

Fig. 17

Grønlands Geologiske Undersøgelse

# Ga in stream sediment




## Ga ppm

X–ray Fluorescence

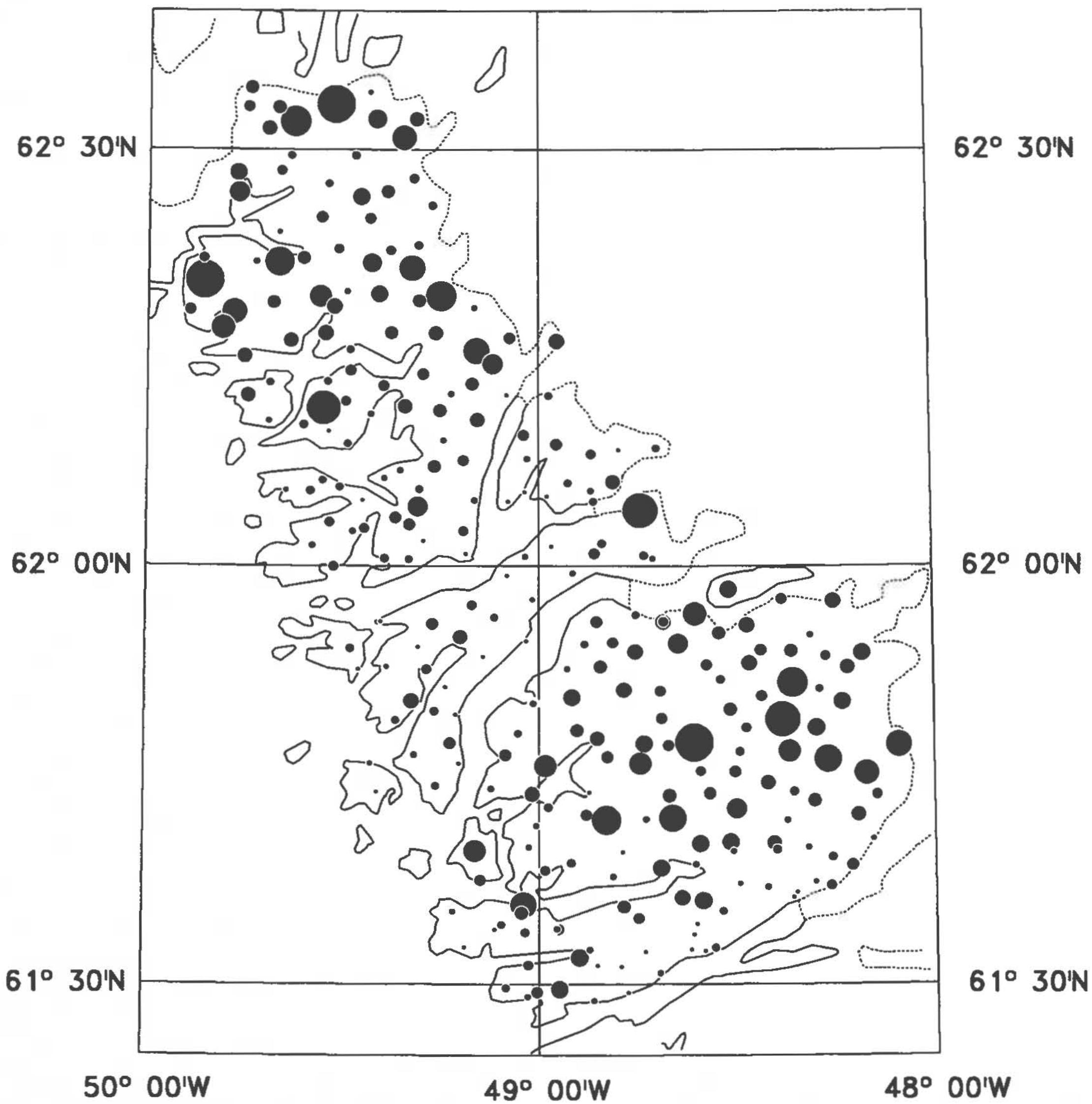
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 7 |
| Max. value: | 29 |
| Mean: | 20 |
| Median: | 20 |
| Variance: | 7 |
| Std. Dev.: | 3 |

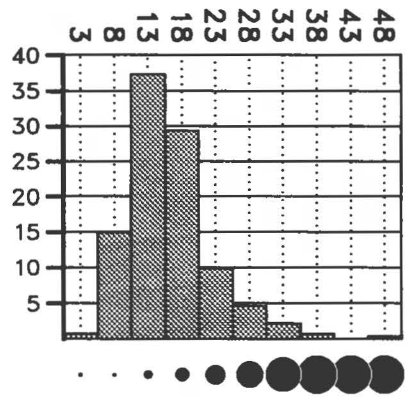
50 km

Fig. 18

Grønlands Geologiske Undersøgelse

# Hf in stream sediment




## Hf ppm

INAA

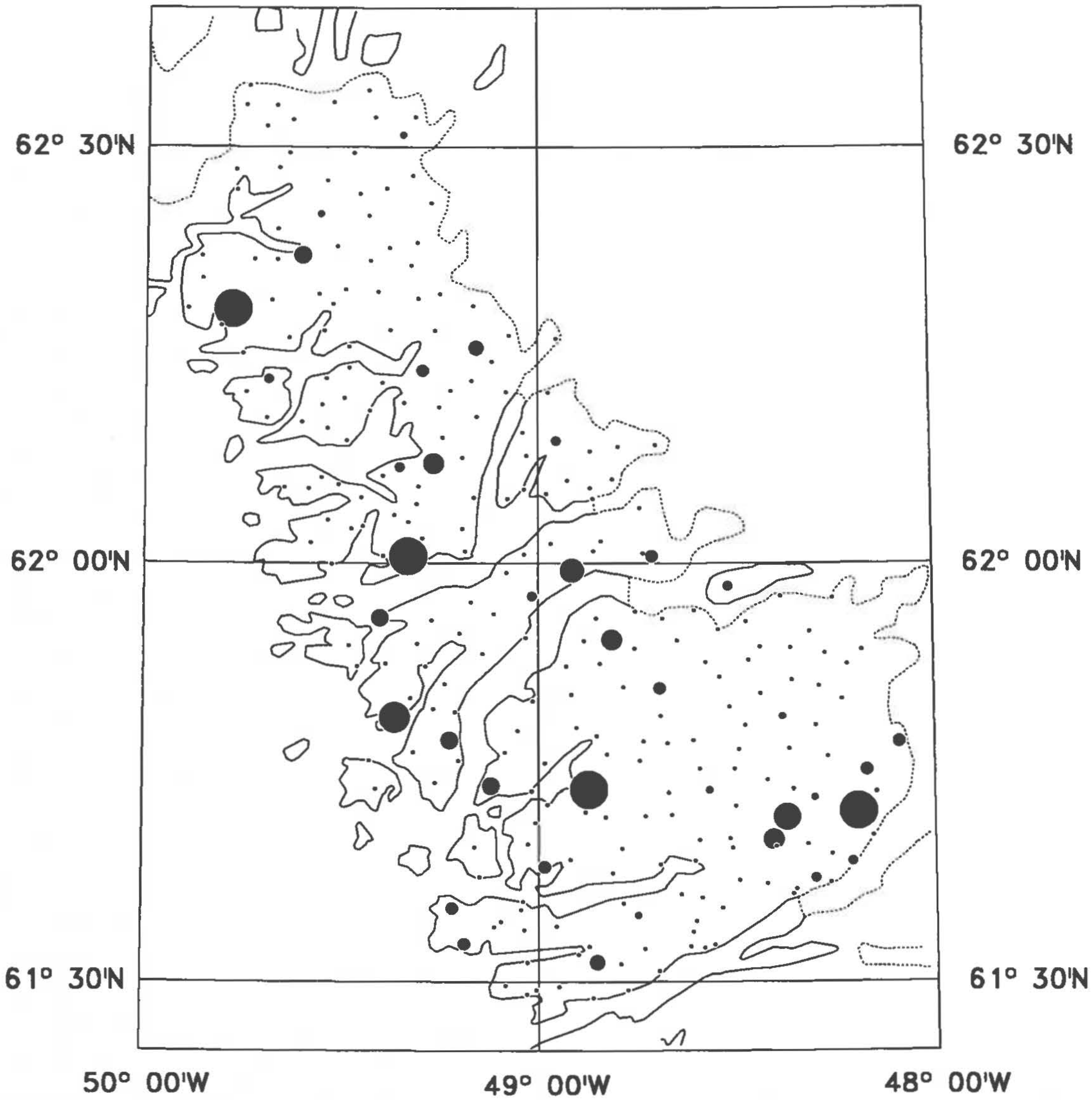
| | |
|---|---|
| Number of samples: | 276 |
| Min. value: | 4 |
| Max. value: | 48 |
| Mean: | 15 |
| Median: | 14 |
| Variance: | 39 |
| Std. Dev.: | 6 |

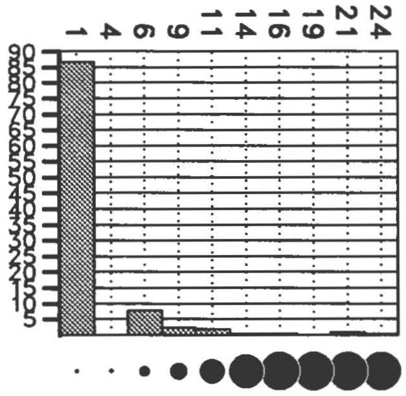
50 km

Fig. 19

Grønlands Geologiske Undersøgelse

# Mo in stream sediment




Mo ppm

INAA

| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0 |
| Max. value: | 24 |
| Mean: | 1 |
| Median: | 0 |
| Variance: | 12 |
| Std. Dev.: | 3 |

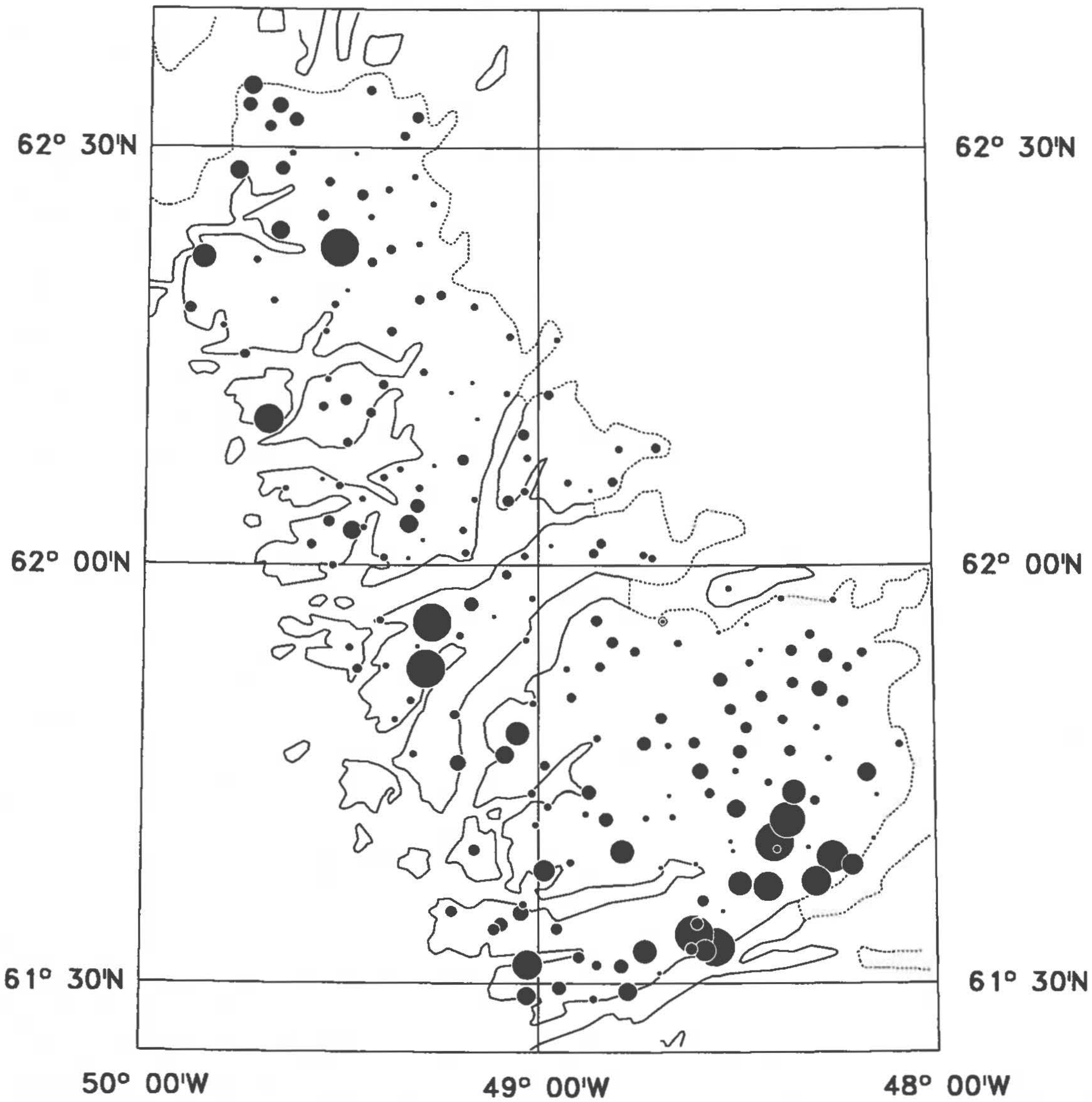
50 km

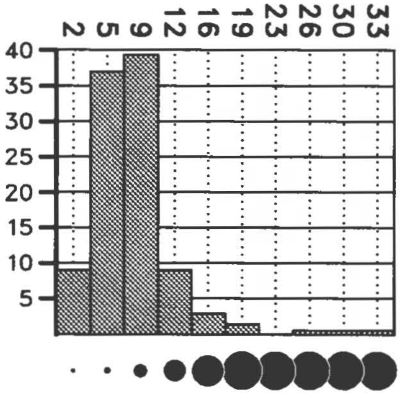
Fig. 20

Fig. 21

Grønlands Geologiske Undersøgelse

# Nb in stream sediment




## Nb ppm

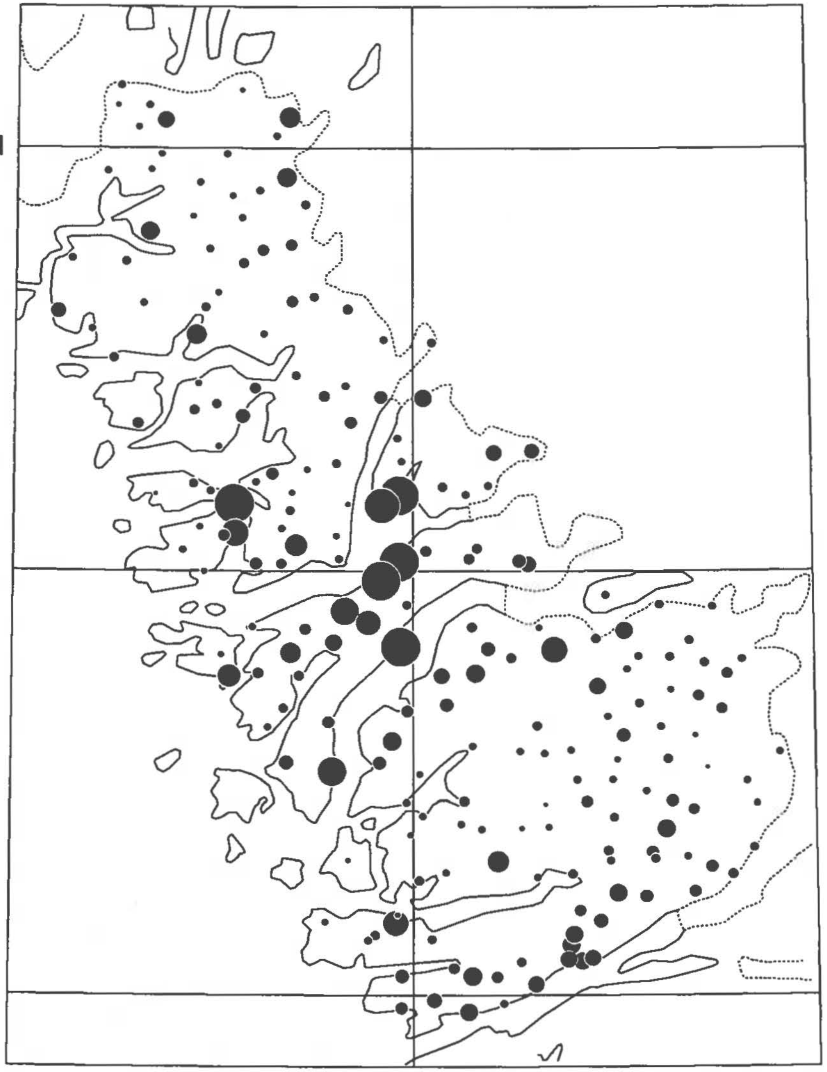
X–ray Fluorescence

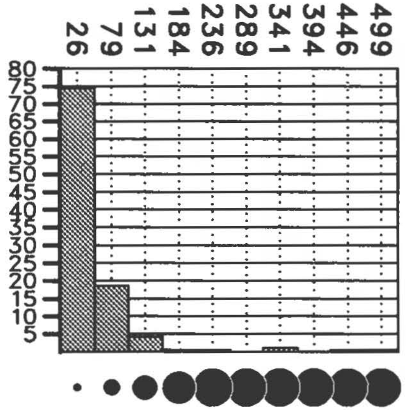
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 0 |
| Max. value: | 33 |
| Mean: | 7 |
| Median: | 7 |
| Variance: | 19 |
| Std. Dev.: | 4 |

50 km

Grønlands Geologiske Undersøgelse

# Ni in stream sediment




## Ni ppm

X–ray Fluorescence

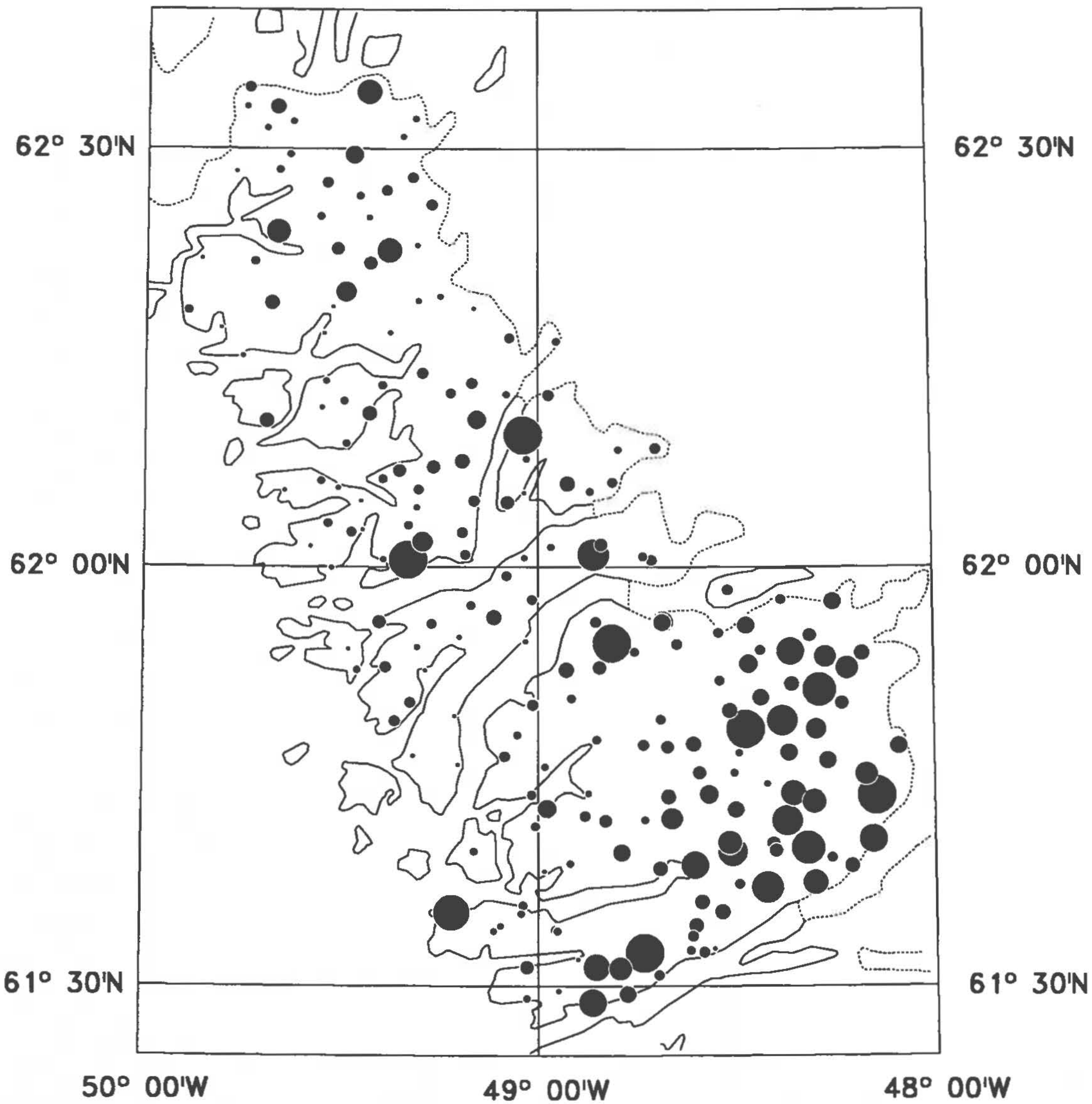
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 0 |
| Max. value: | 523 |
| Mean: | 50 |
| Median: | 32 |
| Variance: | 3734 |
| Std. Dev.: | 61 |

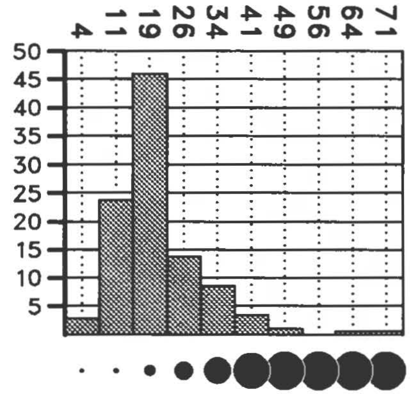
50 km

Fig. 22

Grønlands Geologiske Undersøgelse

# Pb in stream sediment




## Pb ppm

X-ray Fluorescence

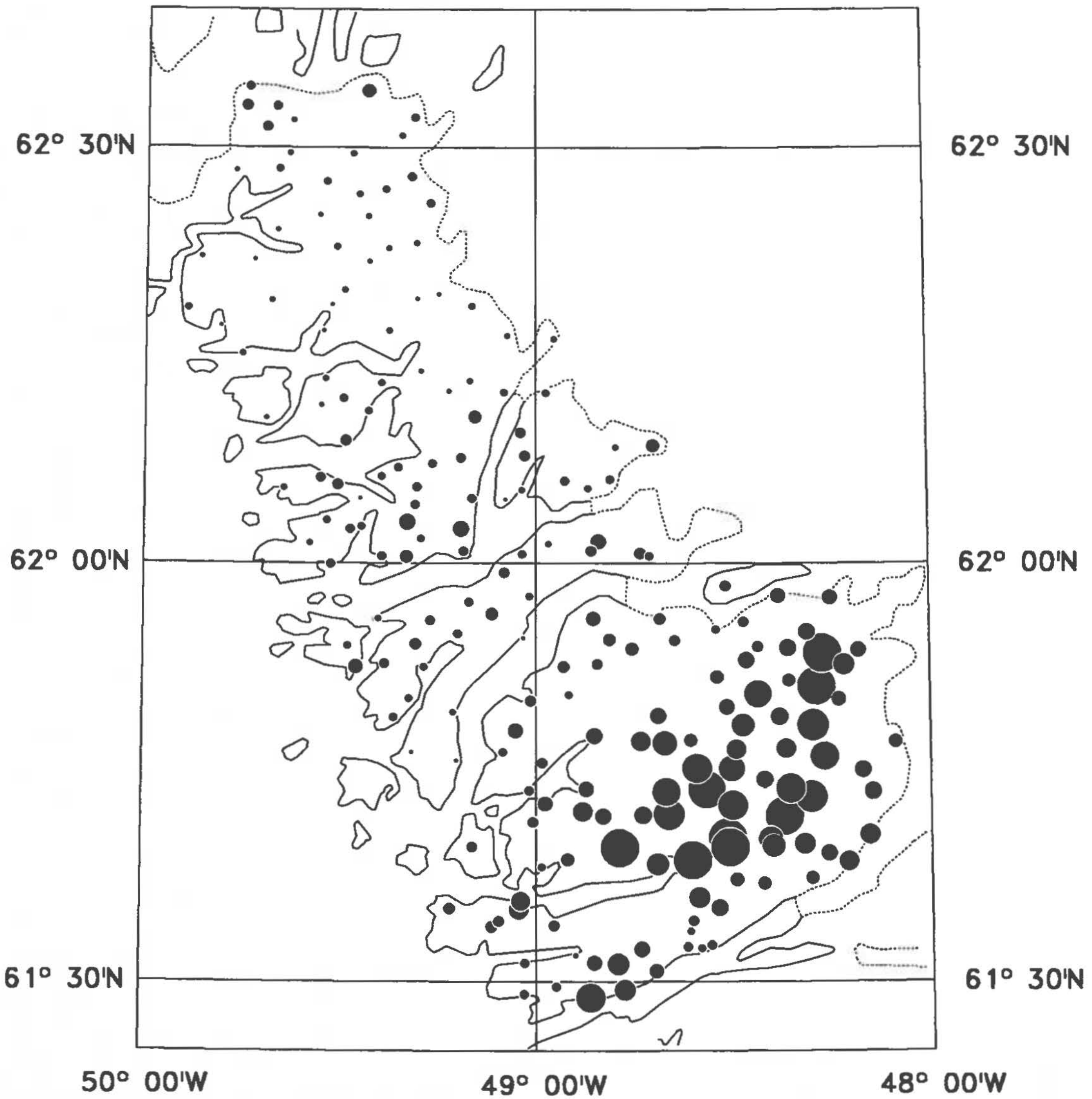
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 0 |
| Max. value: | 71 |
| Mean: | 20 |
| Median: | 18 |
| Variance: | 89 |
| Std. Dev.: | 9 |

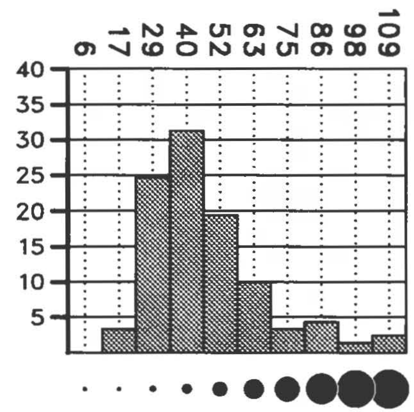
50 km

Fig. 23

Grønlands Geologiske Undersøgelse

# Rb in stream sediment




Rb ppm

X–ray Fluorescence

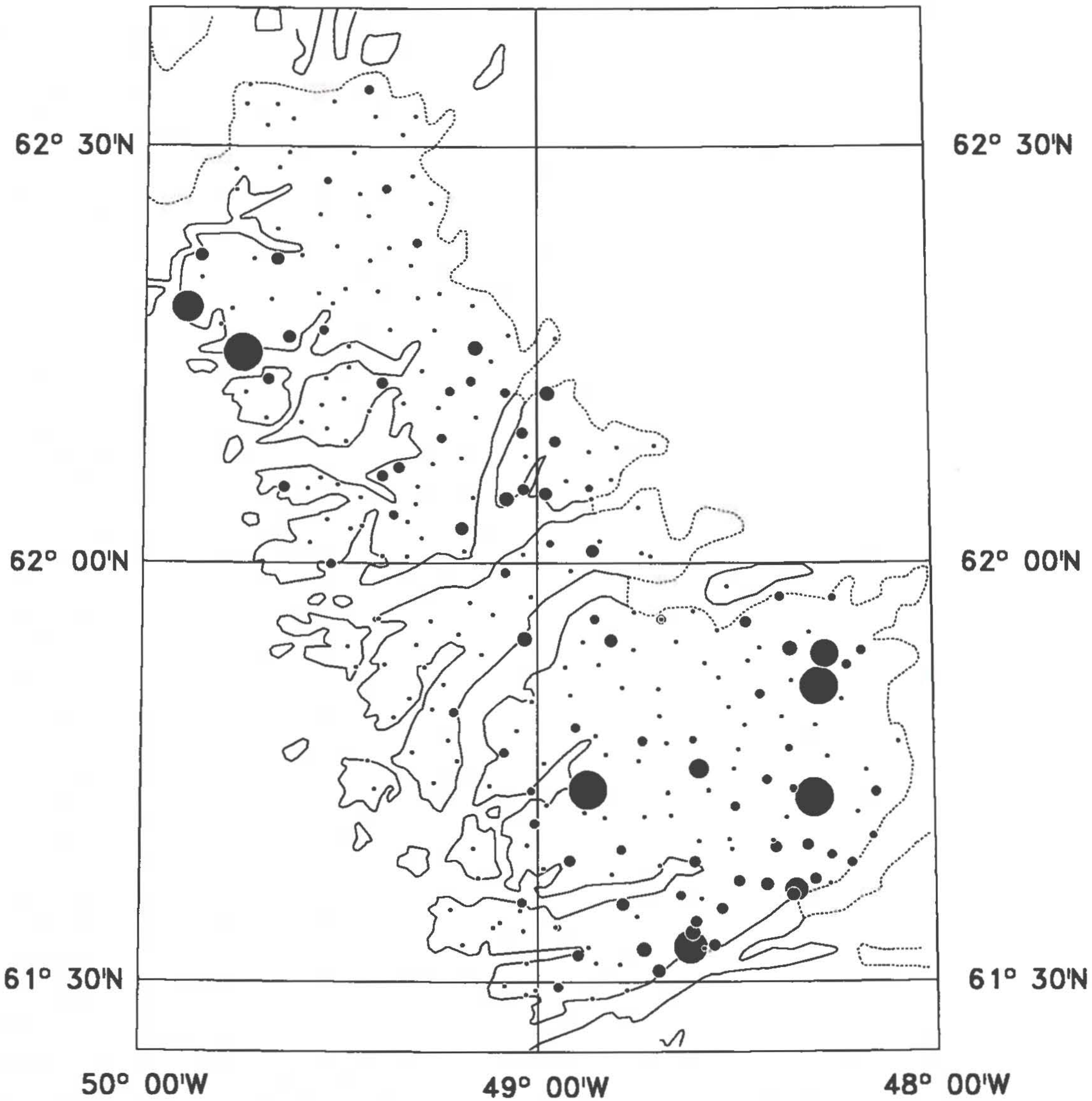
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 14 |
| Max. value: | 113 |
| Mean: | 47 |
| Median: | 41 |
| Variance: | 368 |
| Std. Dev.: | 19 |

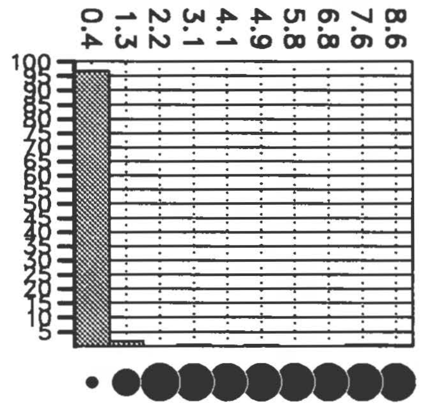
50 km

Fig. 24

Grønlands Geologiske Undersøgelse

# Sb in stream sediment




Sb ppm

INAA

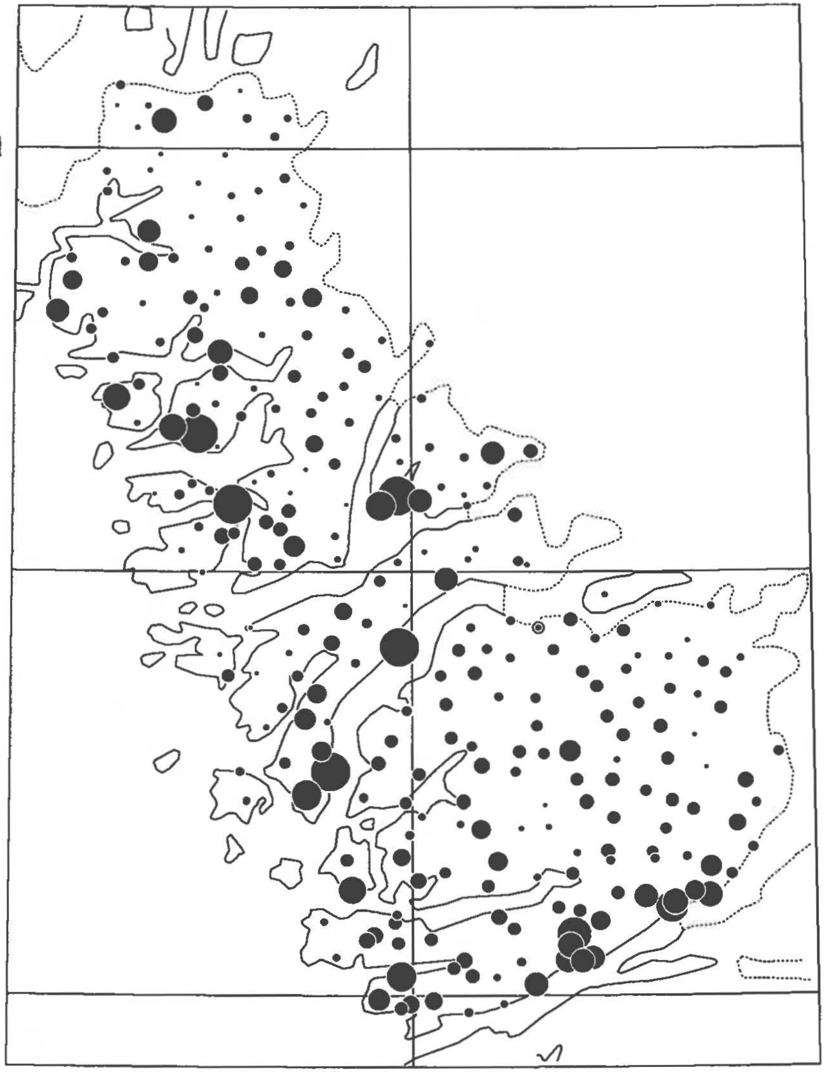
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0.0 |
| Max. value: | 8.4 |
| Mean: | 0.2 |
| Median: | 0.0 |
| Variance: | 0.6 |
| Std. Dev.: | 0.8 |

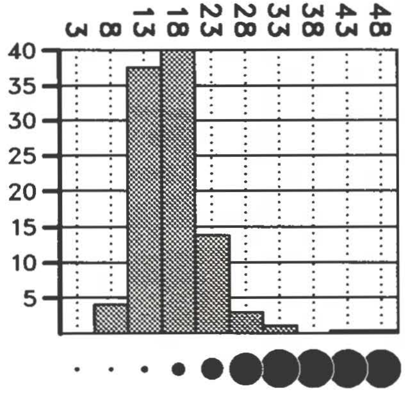
50 km

Fig. 25

Grønlands Geologiske Undersøgelse

# Sc in stream sediment




Sc ppm

INAA

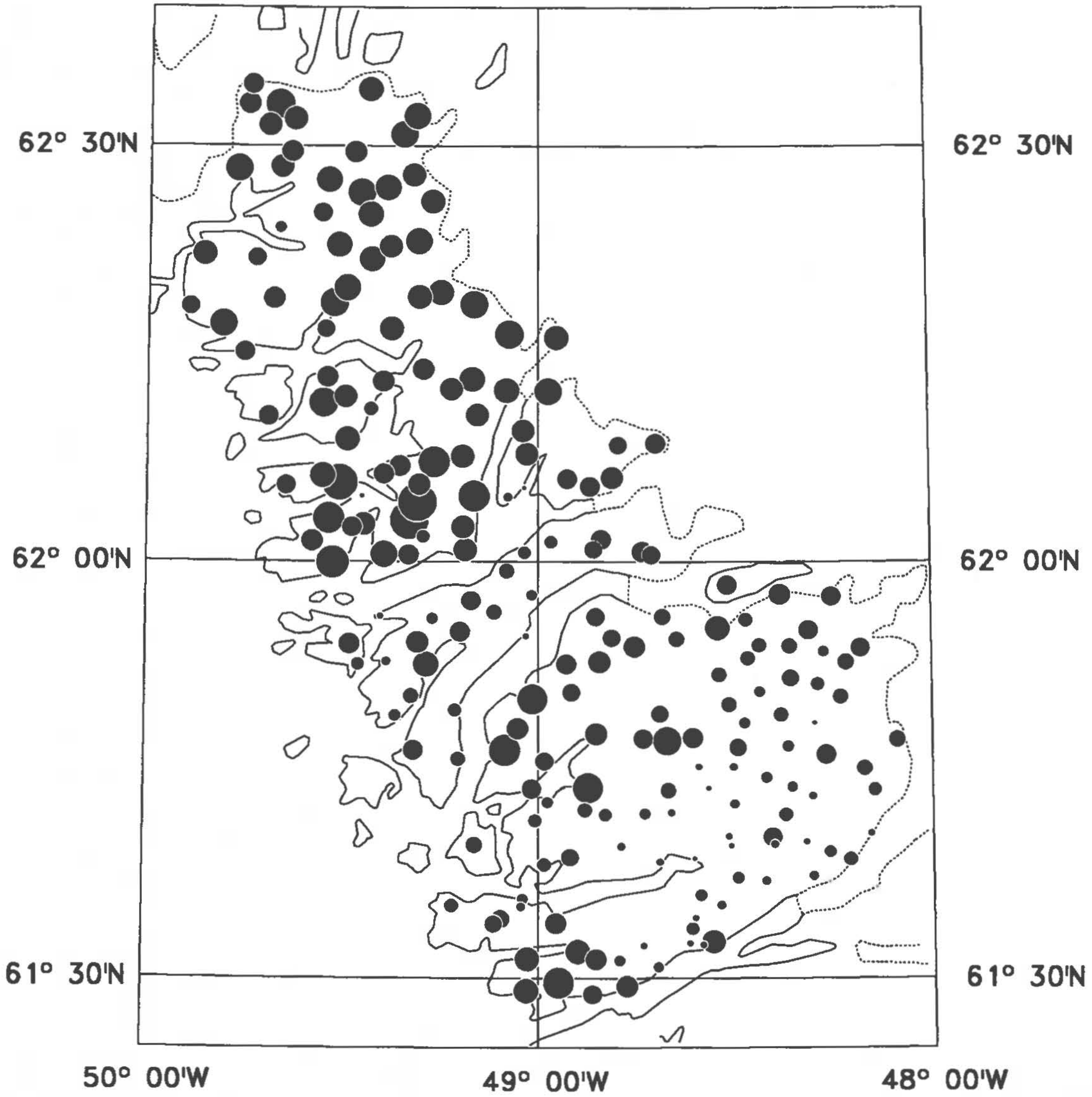
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 9 |
| Max. value: | 45 |
| Mean: | 16 |
| Median: | 16 |
| Variance: | 23 |
| Std. Dev.: | 5 |

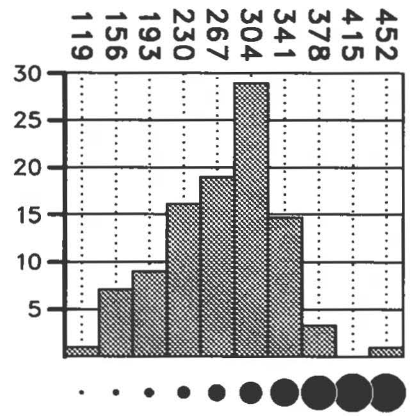
50 km

Fig. 26

Grønlands Geologiske Undersøgelse

# Sr in stream sediment




## Sr ppm

X-ray Fluorescence

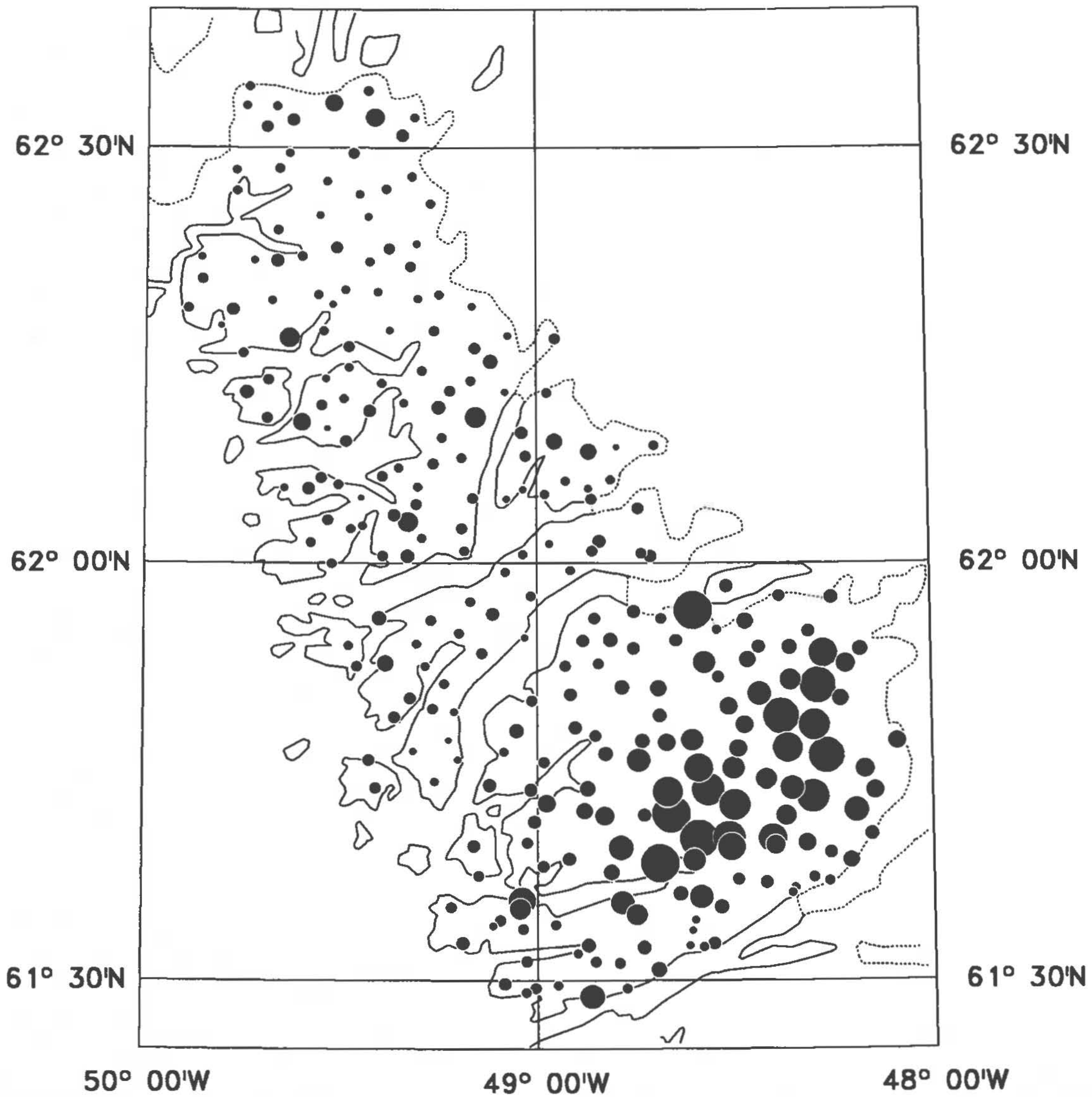
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 113 |
| Max. value: | 461 |
| Mean: | 270 |
| Median: | 282 |
| Variance: | 3580 |
| Std. Dev.: | 60 |

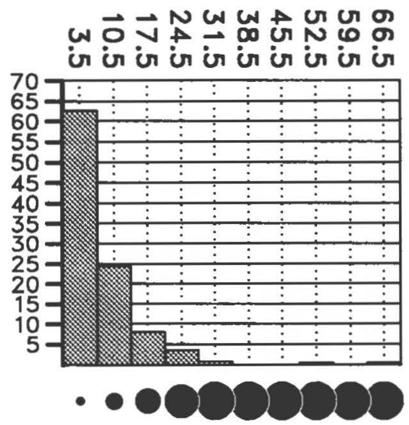
50 km

Fig. 27

Grønlands Geologiske Undersøgelse

# Th in stream sediment




Th ppm

INAA

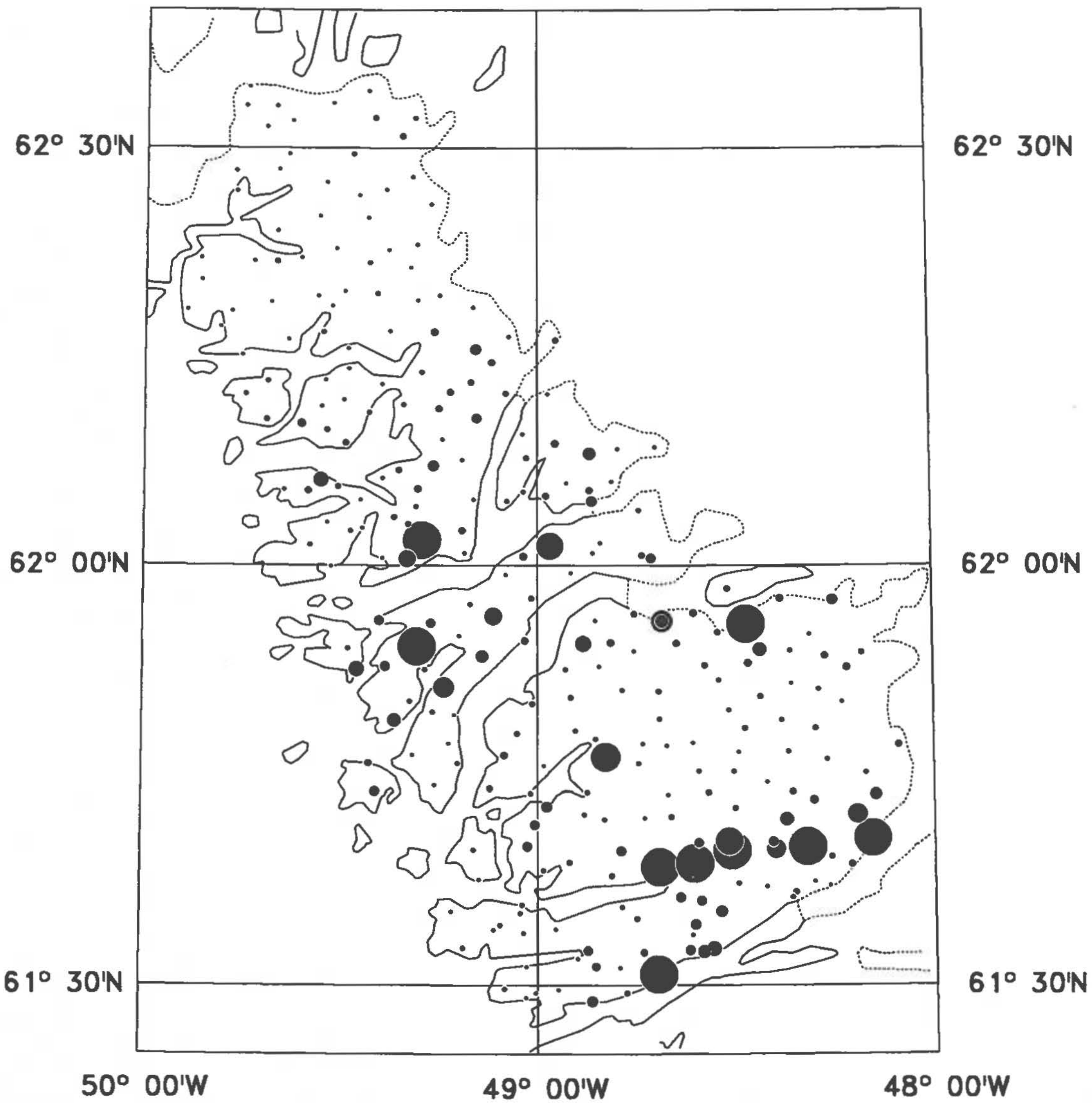
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 1.5 |
| Max. value: | 65.0 |
| Mean: | 8.0 |
| Median: | 5.9 |
| Variance: | 45.8 |
| Std. Dev.: | 6.8 |

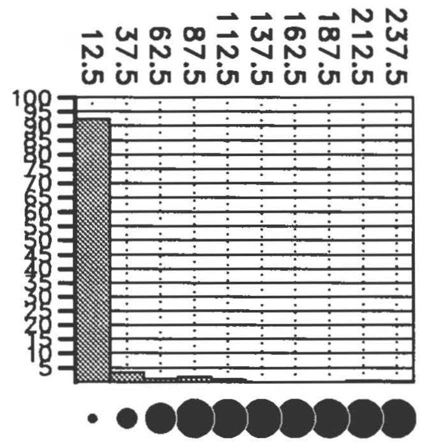
50 km

Fig. 28

Grønlands Geologiske Undersøgelse

# U in stream sediment




U ppm

INAA

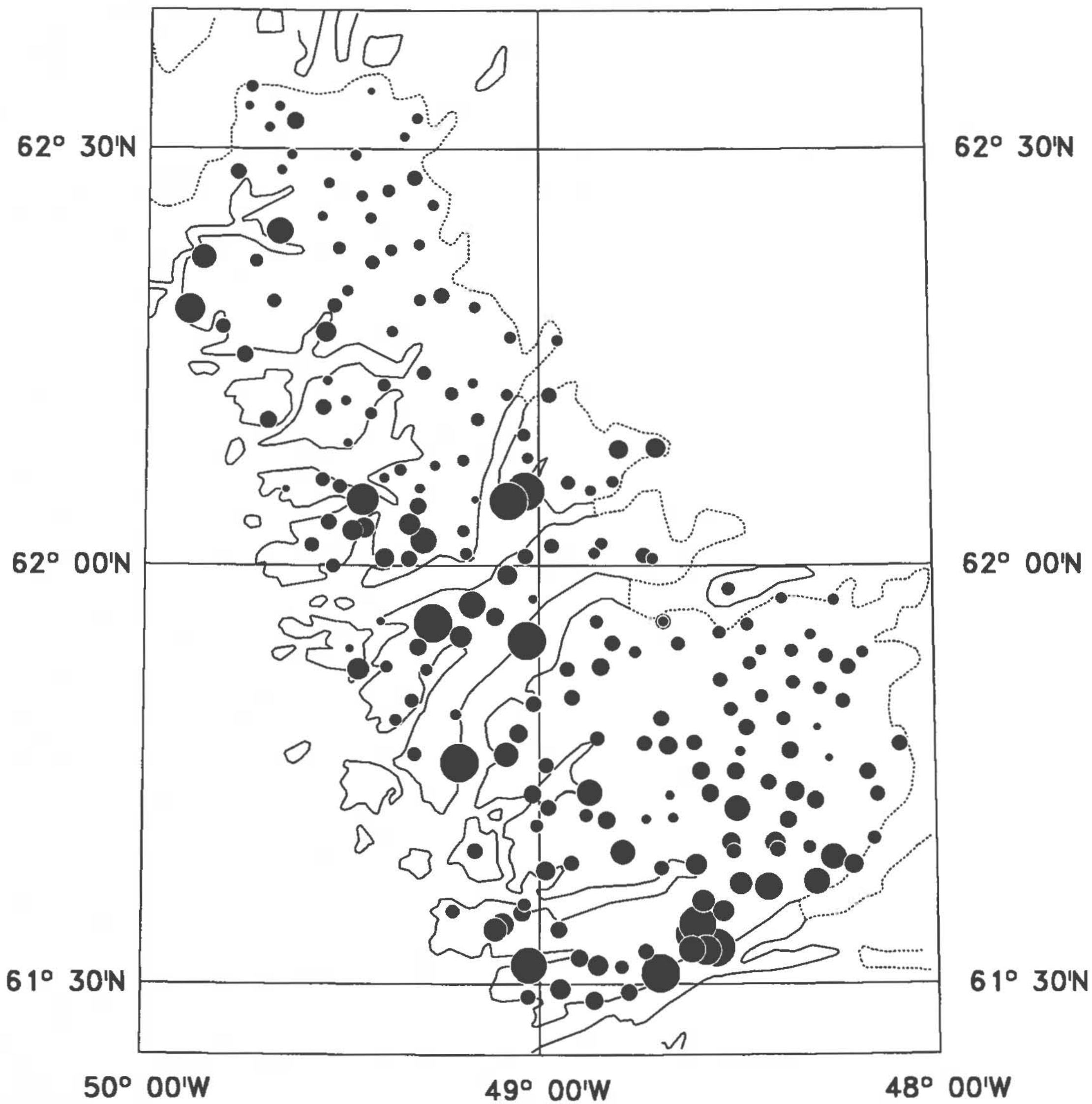
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0.0 |
| Max. value: | 240.0 |
| Mean: | 10.1 |
| Median: | 3.2 |
| Variance: | 619.8 |
| Std. Dev.: | 24.9 |

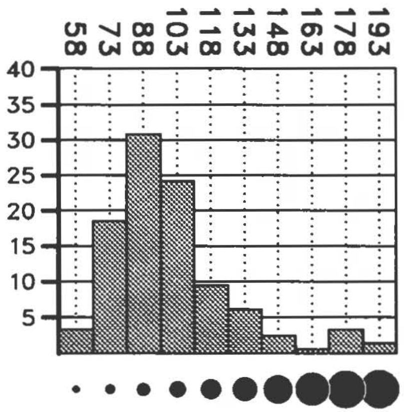
50 km

Fig. 29

Grønlands Geologiske Undersøgelse

# V in stream sediment




V ppm

X-ray Fluorescence

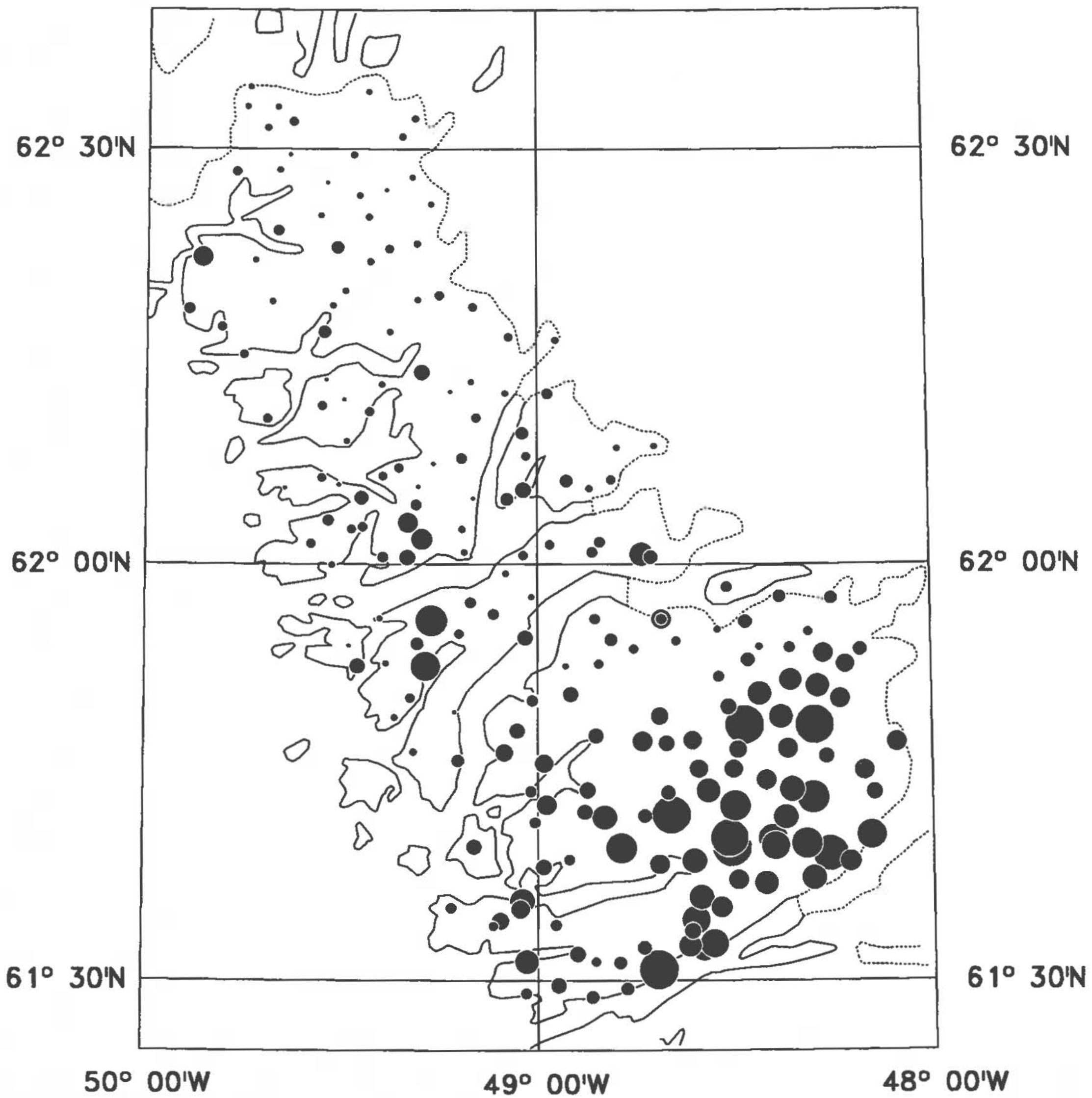
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 58 |
| Max. value: | 198 |
| Mean: | 99 |
| Median: | 93 |
| Variance: | 736 |
| Std. Dev.: | 27 |

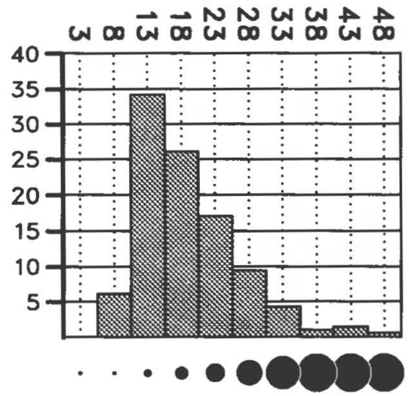
50 km

Fig. 30

Grønlands Geologiske Undersøgelse

# Y in stream sediment




## Y ppm

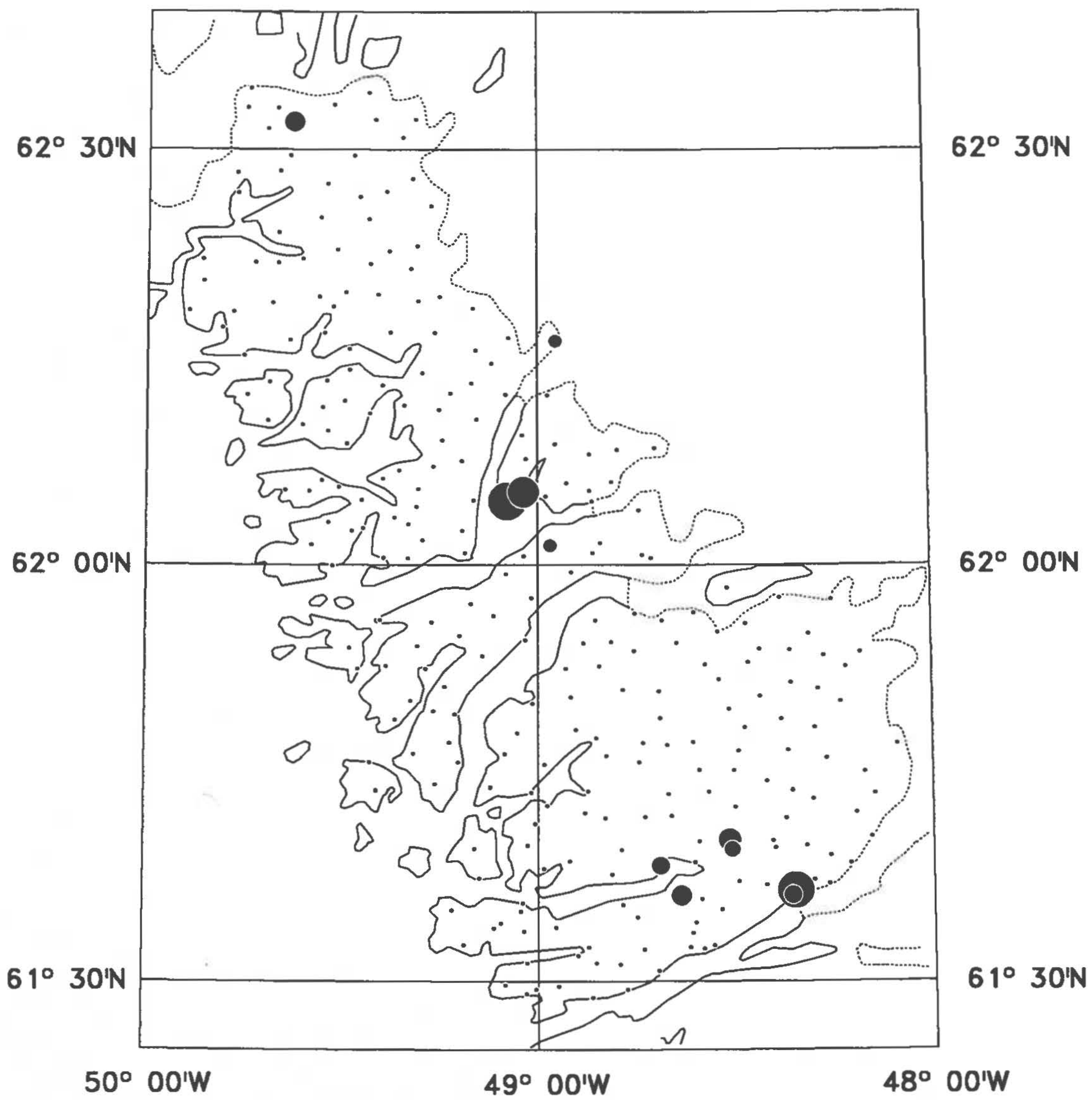
X–ray Fluorescence

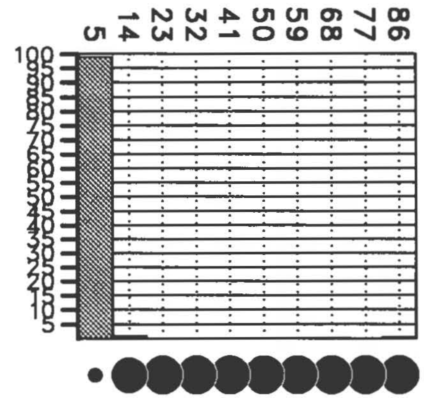
| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 5 |
| Max. value: | 45 |
| Mean: | 18 |
| Median: | 16 |
| Variance: | 53 |
| Std. Dev.: | 7 |


Fig. 31

Grønlands Geologiske Undersøgelse

# W in stream sediment




W ppm

INAA

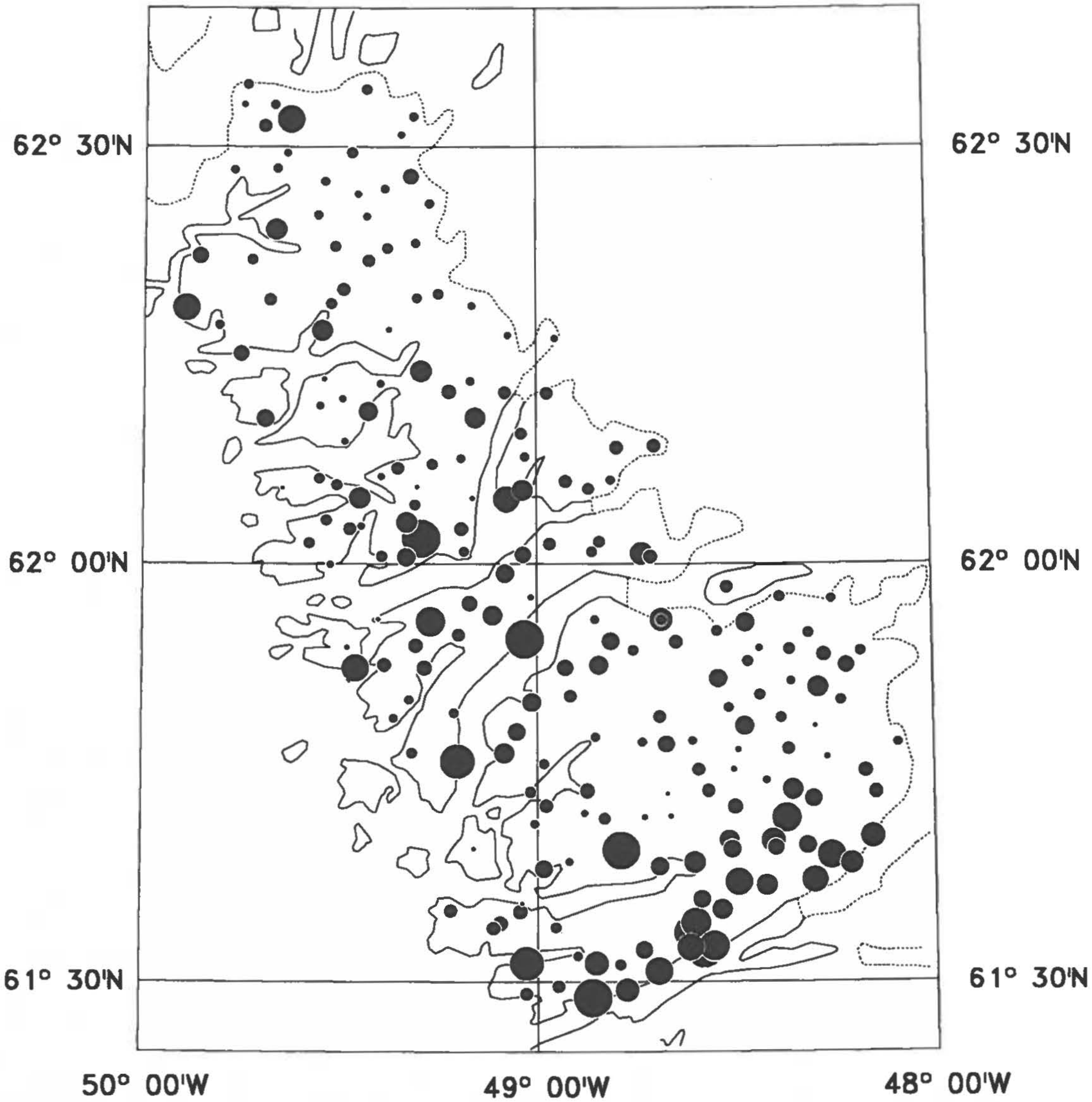
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0 |
| Max. value: | 87 |
| Mean: | 1 |
| Median: | 0 |
| Variance: | 30 |
| Std. Dev.: | 5 |

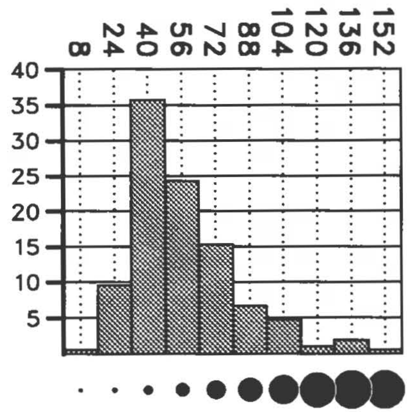
50 km

Fig. 32

Grønlands Geologiske Undersøgelse

# Zn in stream sediment




## Zn ppm

X-ray Fluorescence

| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 15 |
| Max. value: | 160 |
| Mean: | 56 |
| Median: | 50 |
| Variance: | 639 |
| Std. Dev.: | 25 |

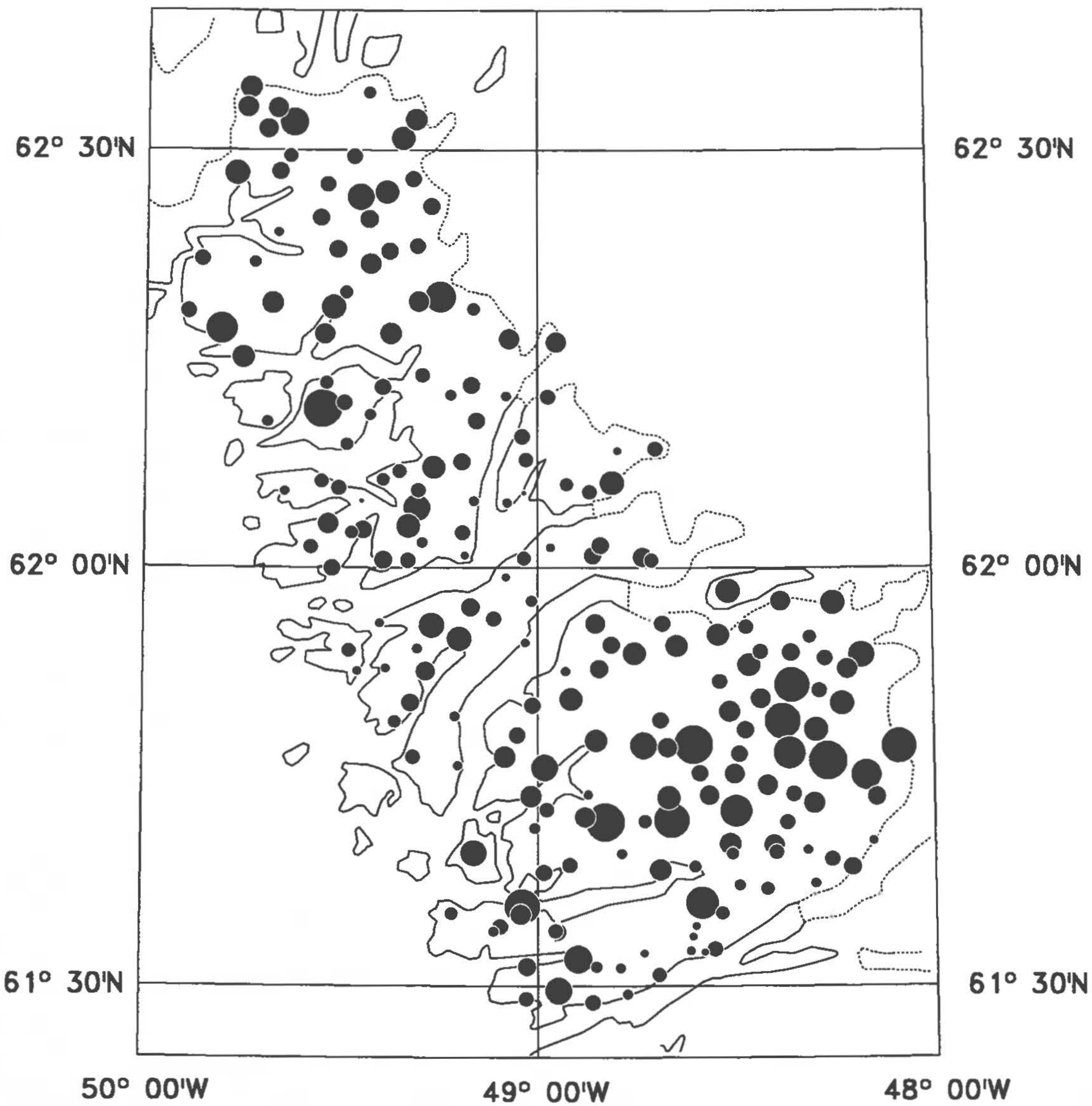
50 km

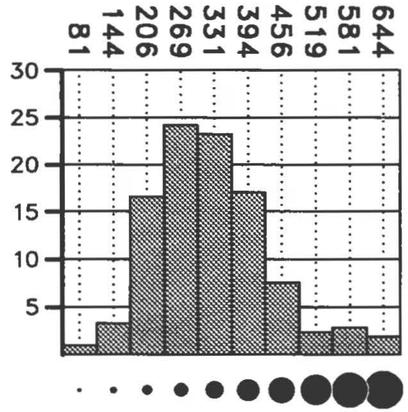
Fig. 33

Grønlands Geologiske Undersøgelse

GGU

# Zr in stream sediment




## Zr ppm

X–ray Fluorescence

| | |
|---|---|
| Number of samples: | 211 |
| Min. value: | 101 |
| Max. value: | 662 |
| Mean: | 323 |
| Median: | 306 |
| Variance: | 11481 |
| Std. Dev.: | 107 |

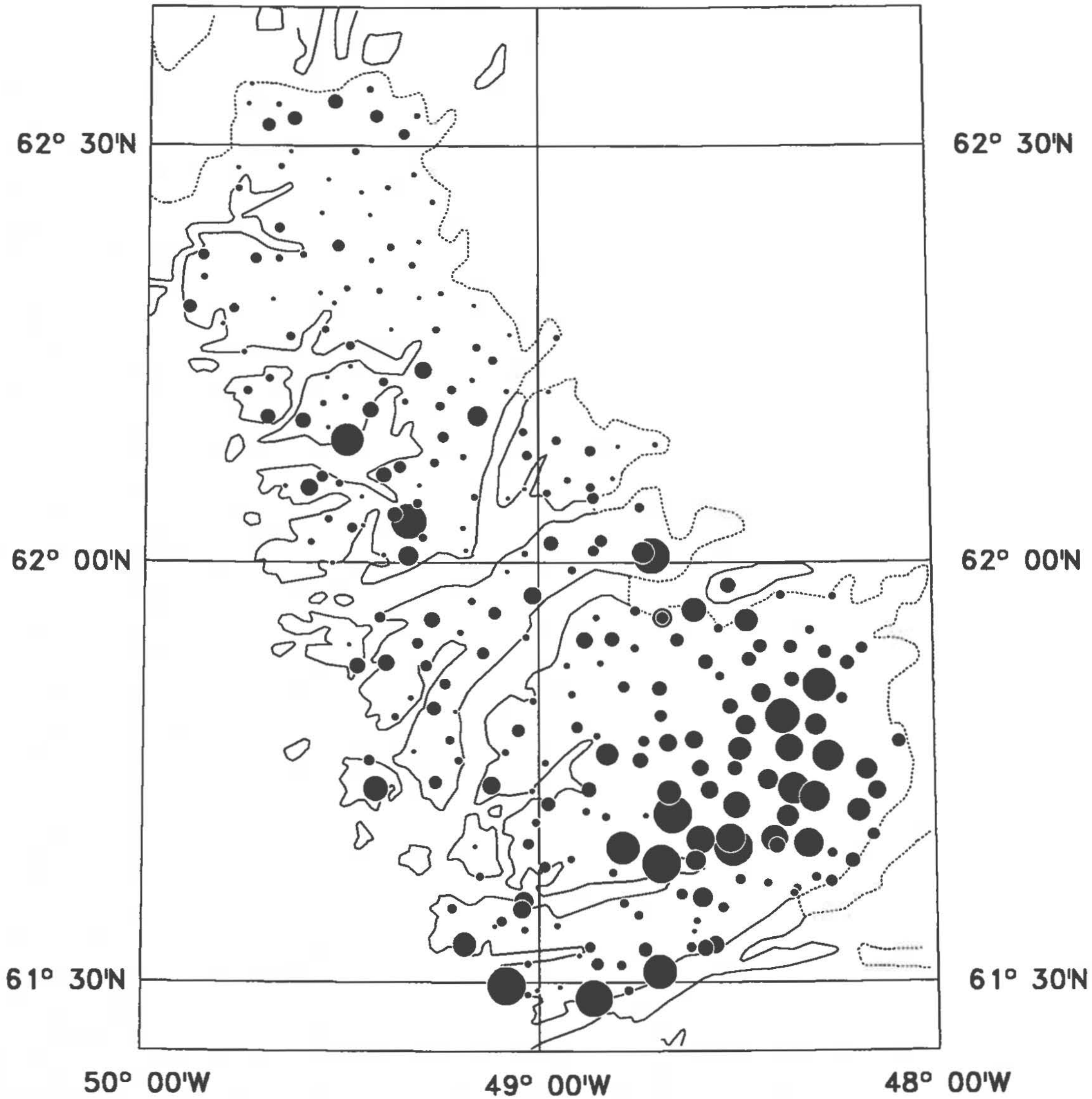
50 km

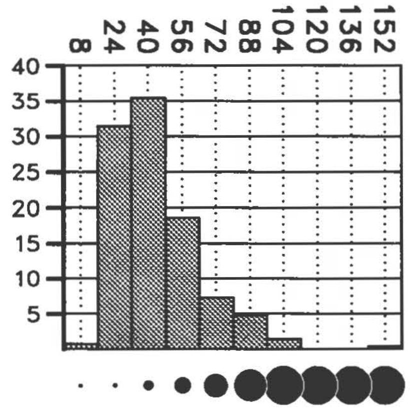
Fig. 34

Fig. 35

Grønlands Geologiske Undersøgelse

# La in stream sediment




La ppm

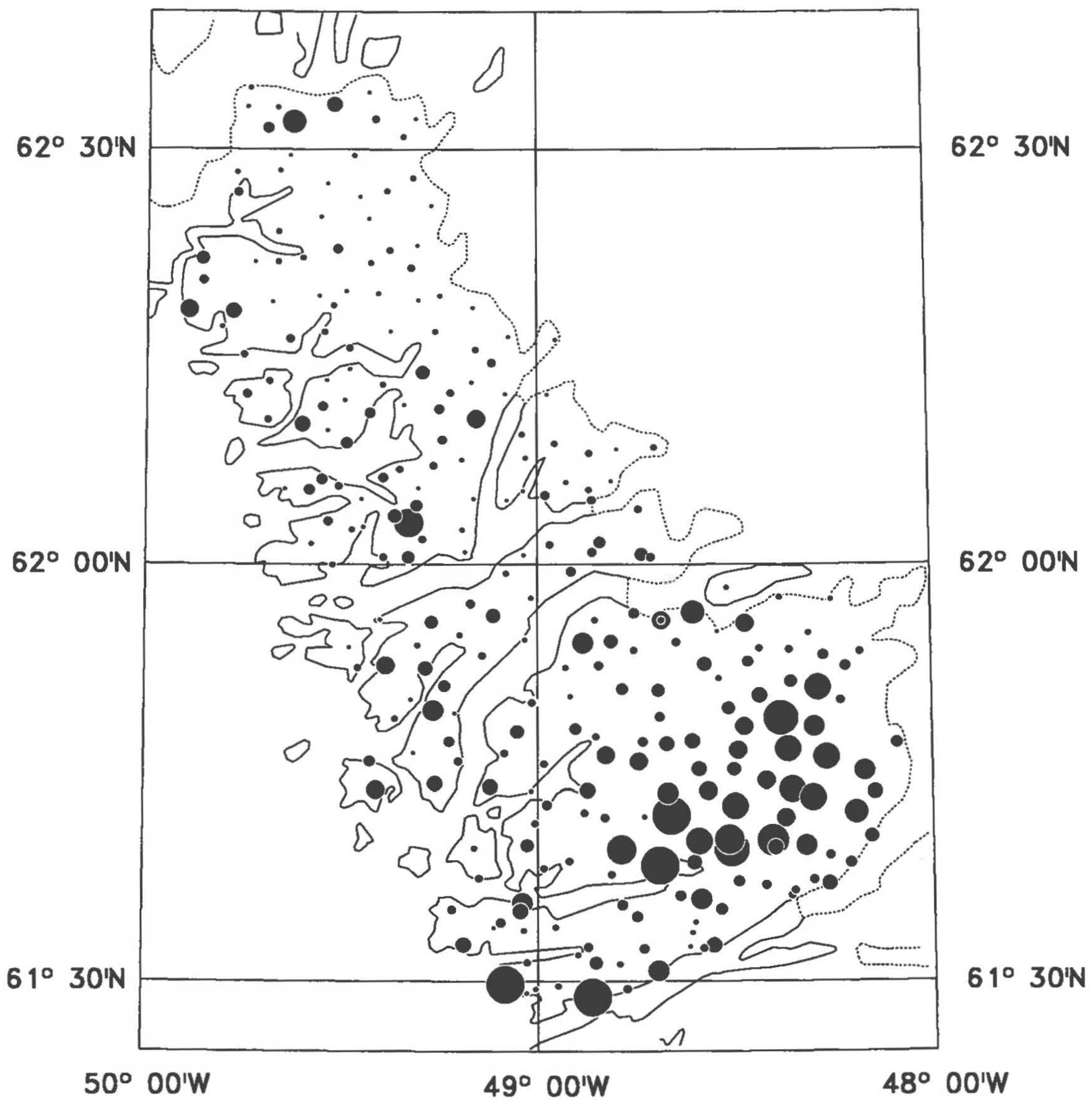
INAA

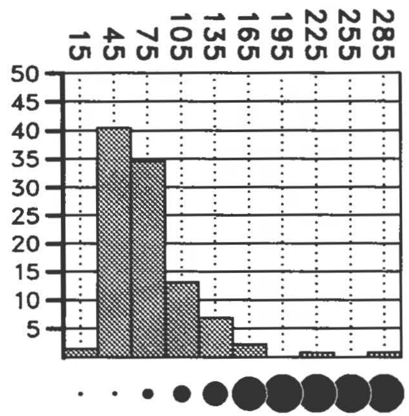
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 14 |
| Max. value: | 160 |
| Mean: | 43 |
| Median: | 37 |
| Variance: | 426 |
| Std. Dev.: | 21 |

50 km

Grønlands Geologiske Undersøgelse

# Ce in stream sediment




Ce ppm

INAA

| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 25 |
| Max. value: | 290 |
| Mean: | 73 |
| Median: | 63 |
| Variance: | 1331 |
| Std. Dev.: | 36 |

50 km

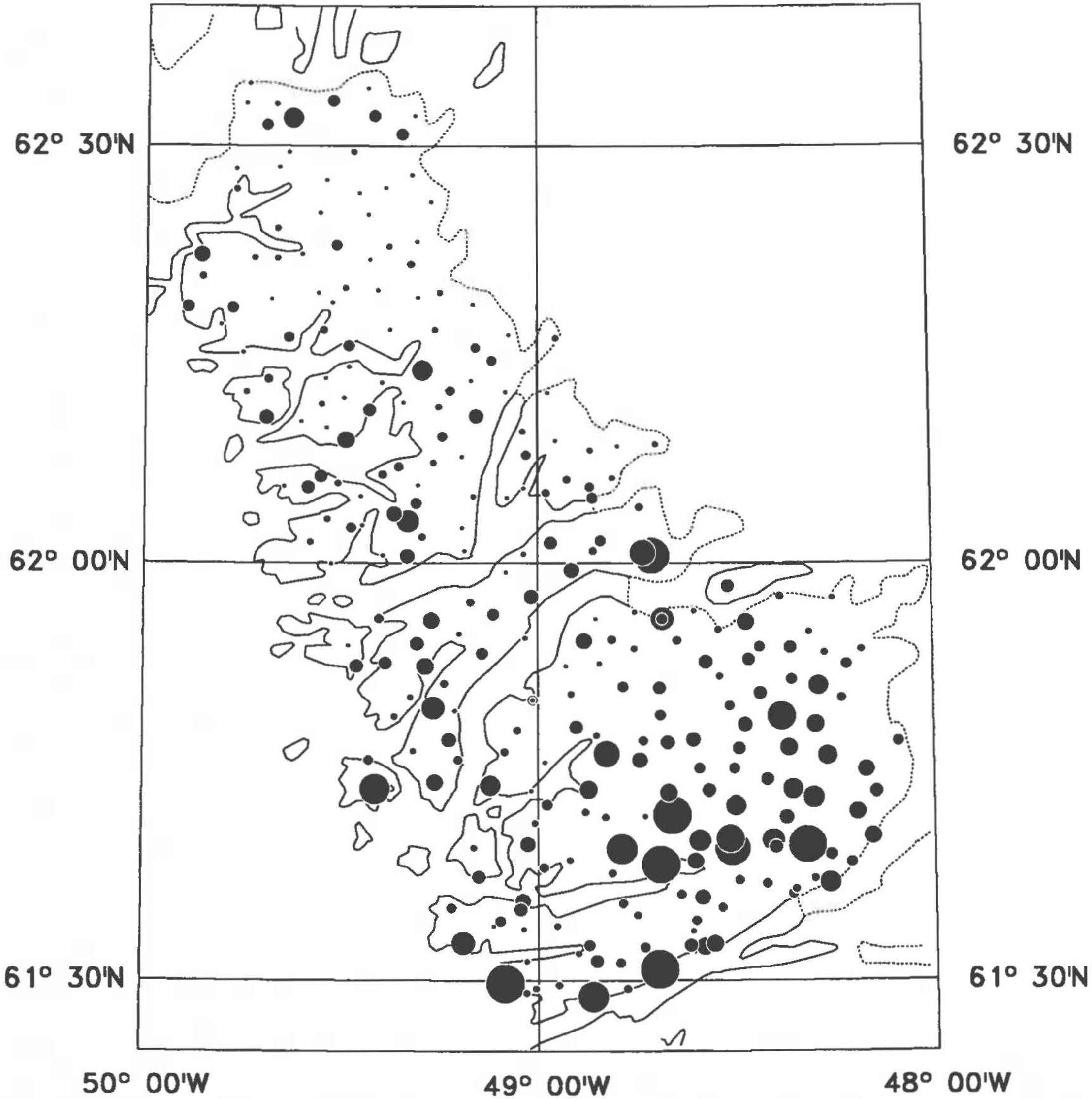
Fig. 36

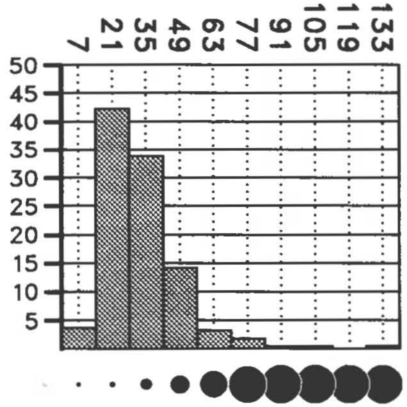
Fig. 37

Grønlands Geologiske Undersøgelse

# Nd in stream sediment

GGU




## Nd ppm

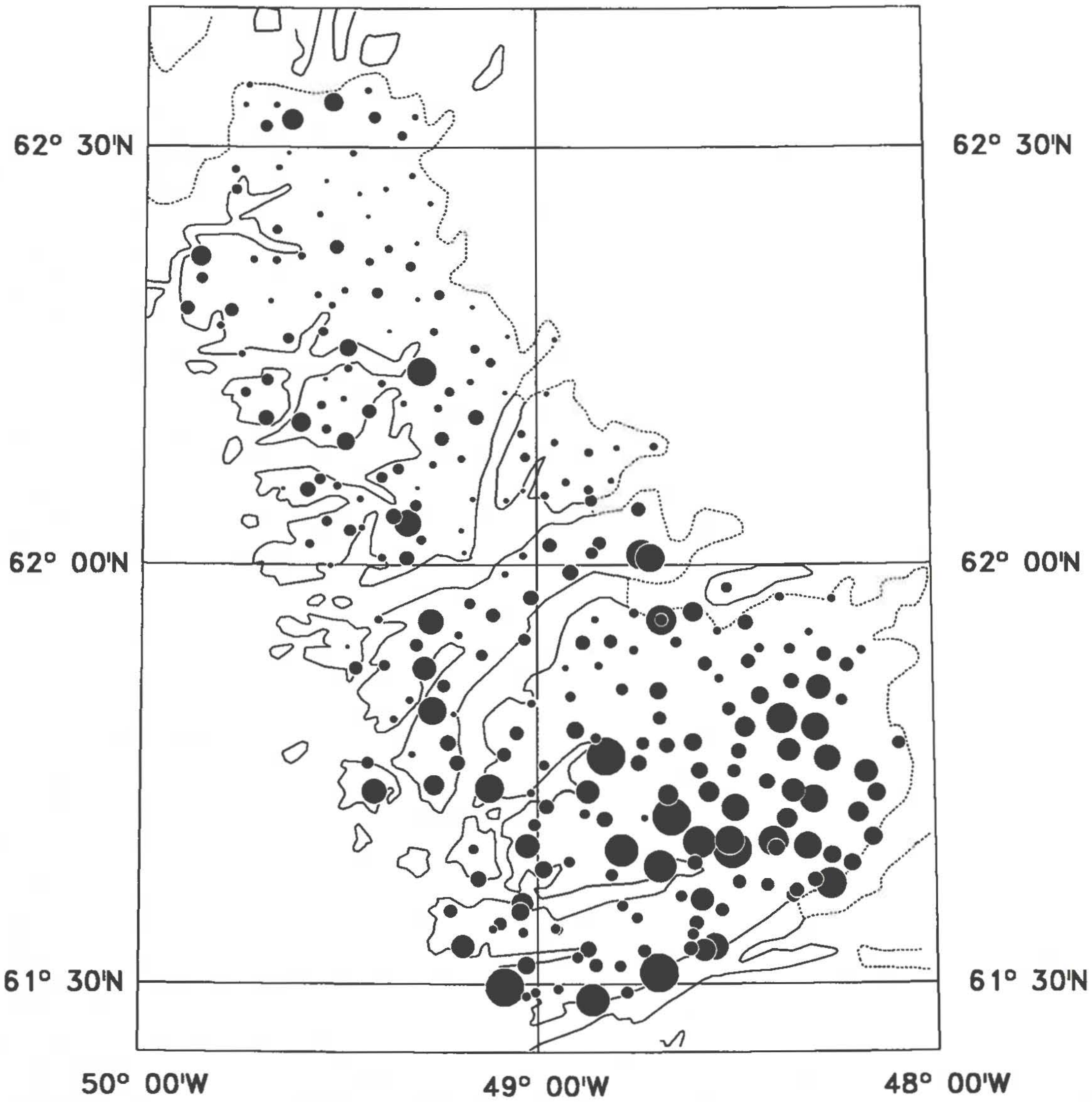
INAA

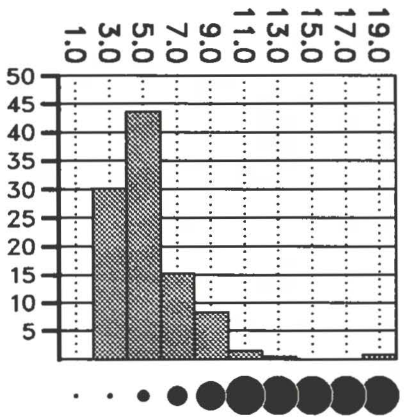
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0 |
| Max. value: | 130 |
| Mean: | 32 |
| Median: | 29 |
| Variance: | 252 |
| Std. Dev.: | 16 |

50 km

Grønlands Geologiske Undersøgelse

# Sm in stream sediment




## Sm ppm

INAA

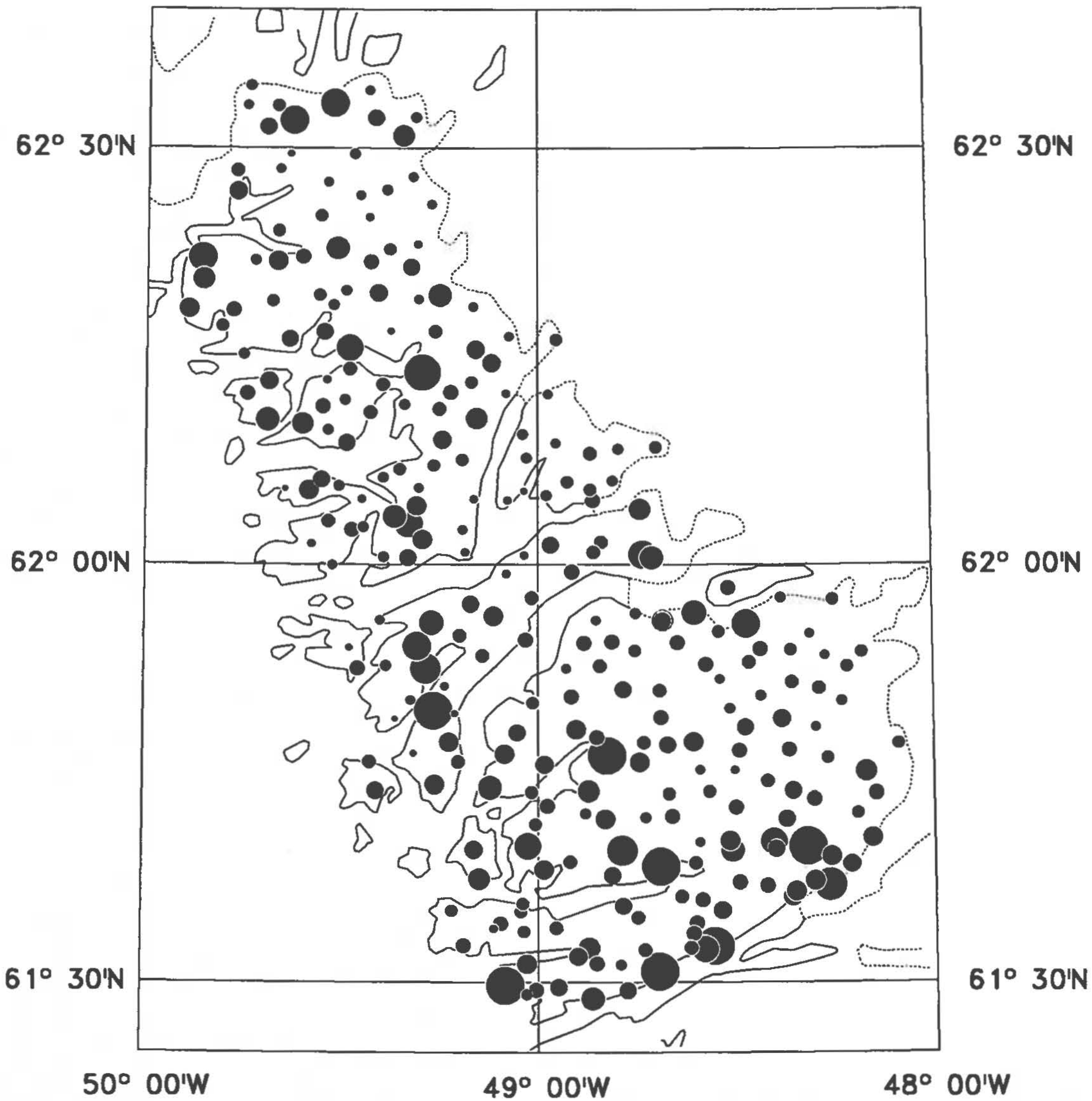
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 2.1 |
| Max. value: | 19.0 |
| Mean: | 5.3 |
| Median: | 4.8 |
| Variance: | 5.0 |
| Std. Dev.: | 2.2 |

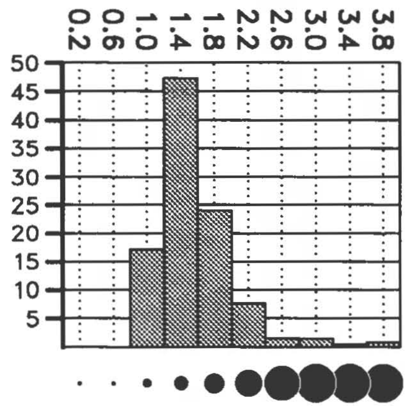
50 km

Fig. 38

Grønlands Geologiske Undersøgelse

# Eu in stream sediment




## Eu ppm

INAA

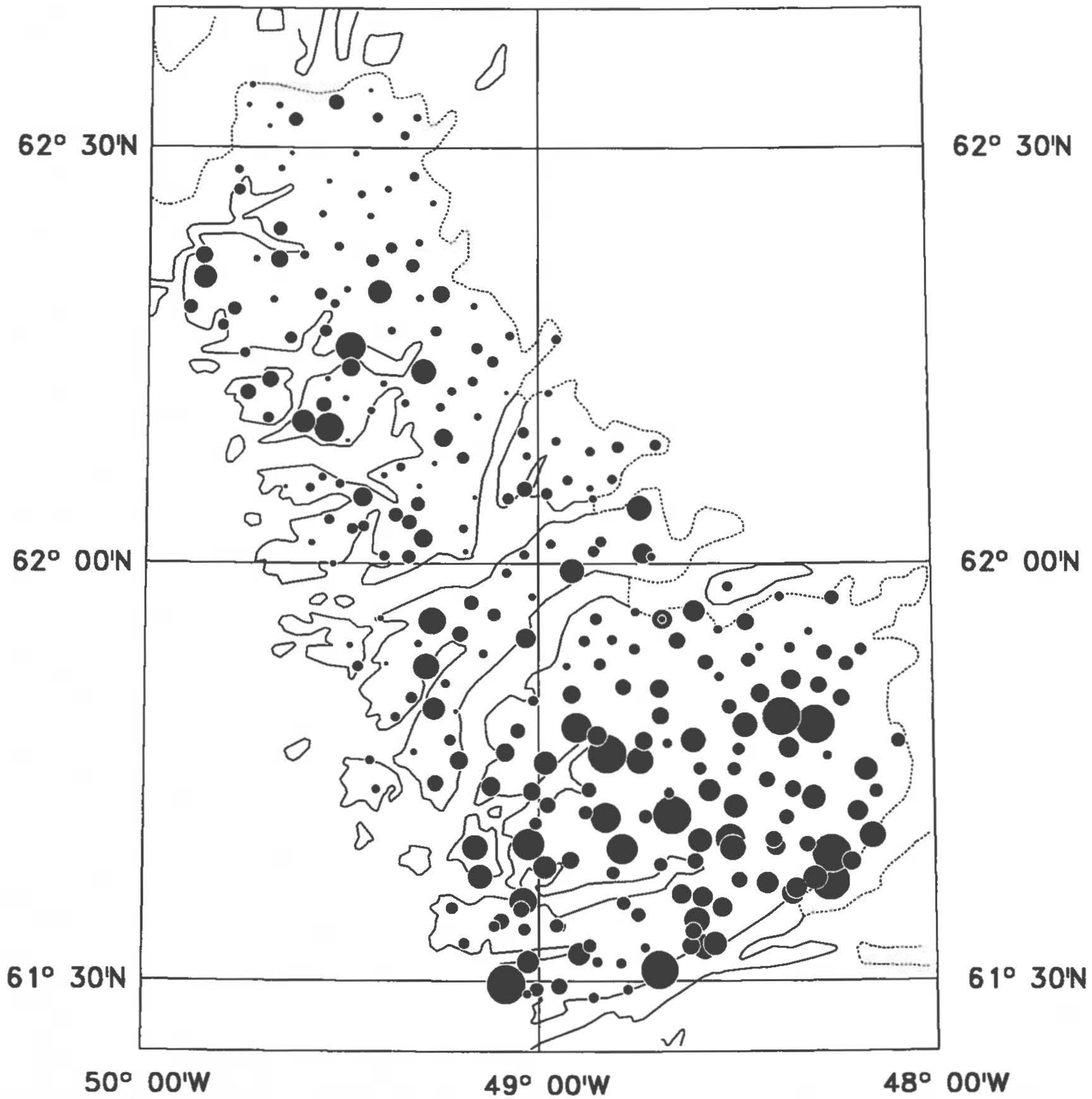
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0.8 |
| Max. value: | 3.7 |
| Mean: | 1.5 |
| Median: | 1.4 |
| Variance: | 0.2 |
| Std. Dev.: | 0.4 |

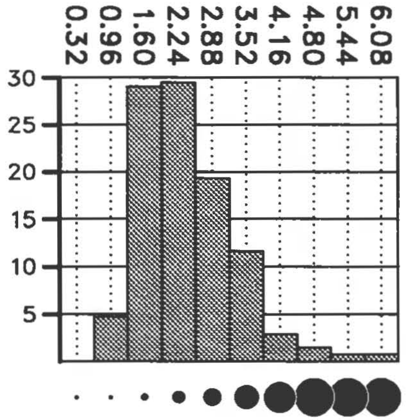
50 km

Fig. 39

Grønlands Geologiske Undersøgelse

# Yb in stream sediment




## Yb ppm

INAA

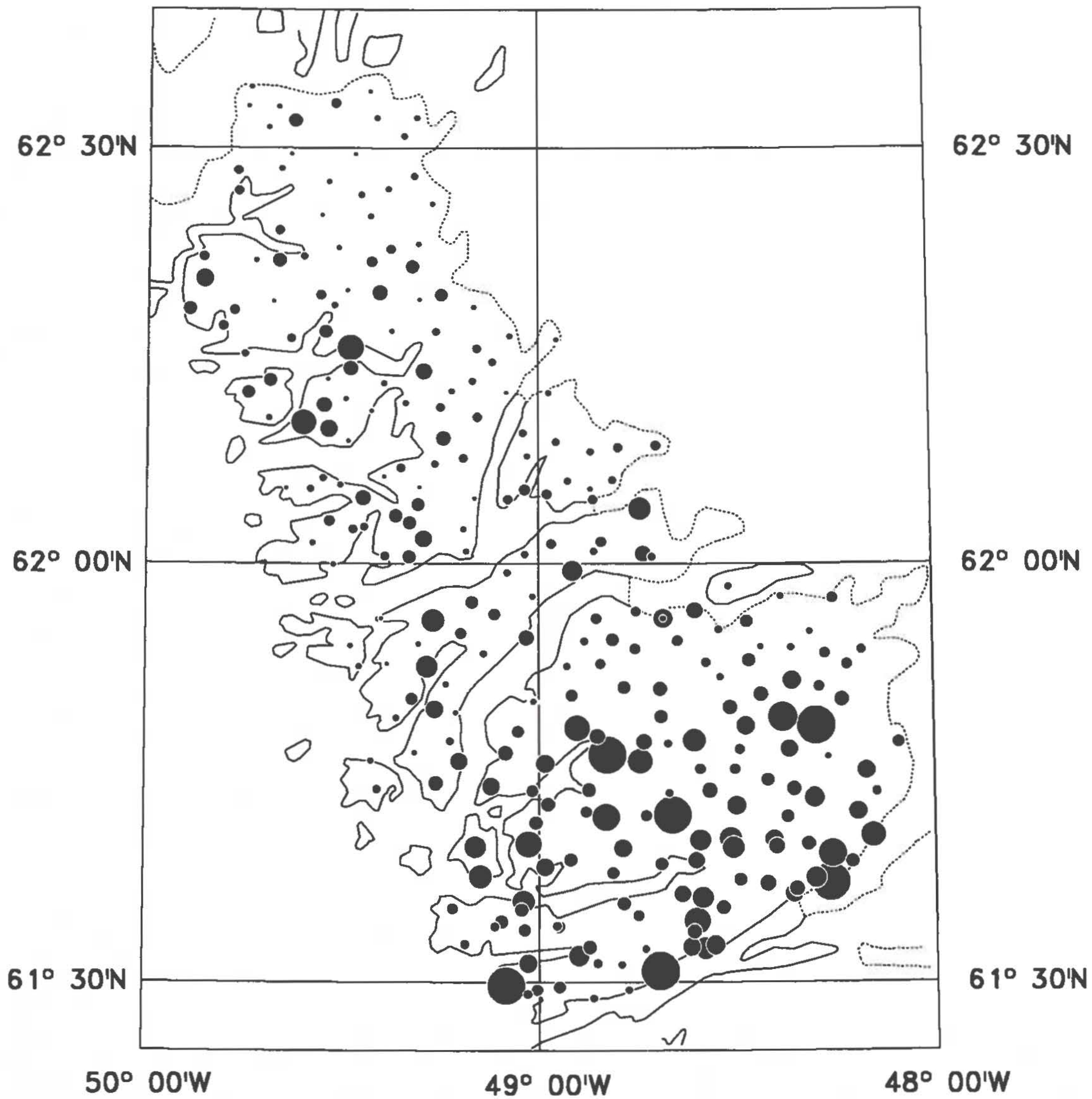
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0.83 |
| Max. value: | 6.28 |
| Mean: | 2.40 |
| Median: | 2.21 |
| Variance: | 0.80 |
| Std. Dev.: | 0.89 |

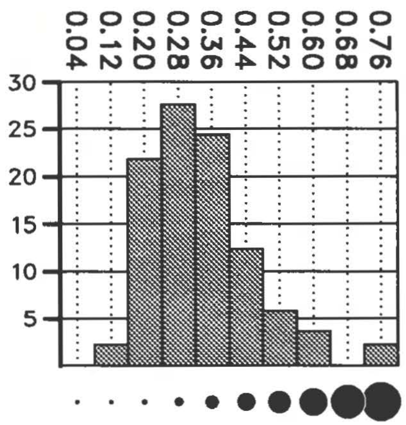

Fig. 40

Grønlands Geologiske Undersøgelse

GGU

# Lu in stream sediment




## Lu ppm

INAA

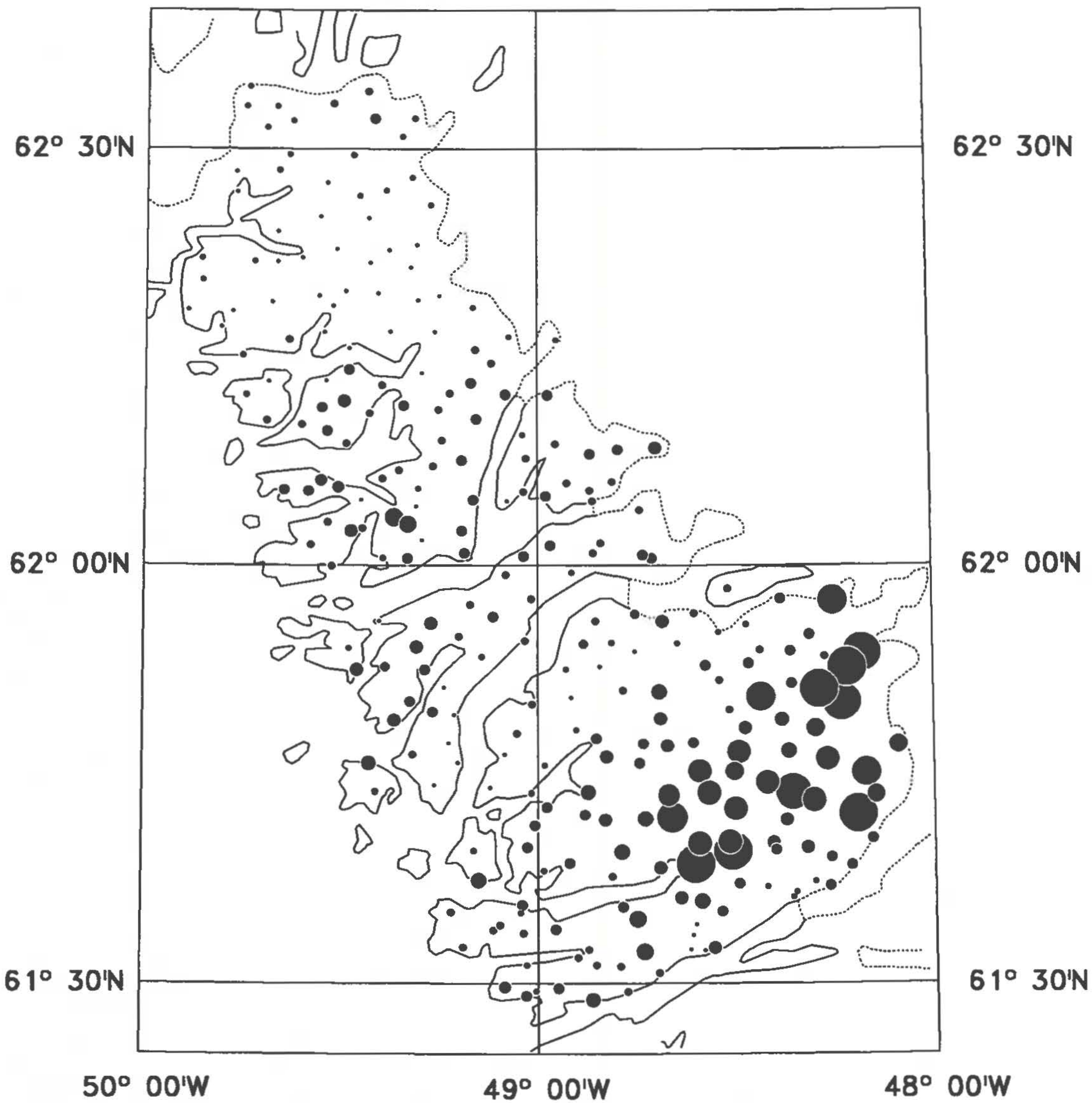
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0.10 |
| Max. value: | 0.79 |
| Mean: | 0.33 |
| Median: | 0.31 |
| Variance: | 0.02 |
| Std. Dev.: | 0.12 |

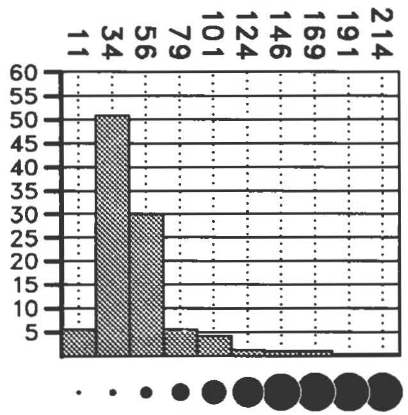
50 km

Fig. 4.1

Grønlands Geologiske Undersøgelse

# Total radiation




## Counts per sec.

Scintillometry

| | |
|---|---|
| Number of samples: | 291 |
| Min. value: | 15 |
| Max. value: | 220 |
| Mean: | 48 |
| Median: | 40 |
| Variance: | 859 |
| Std. Dev.: | 29 |

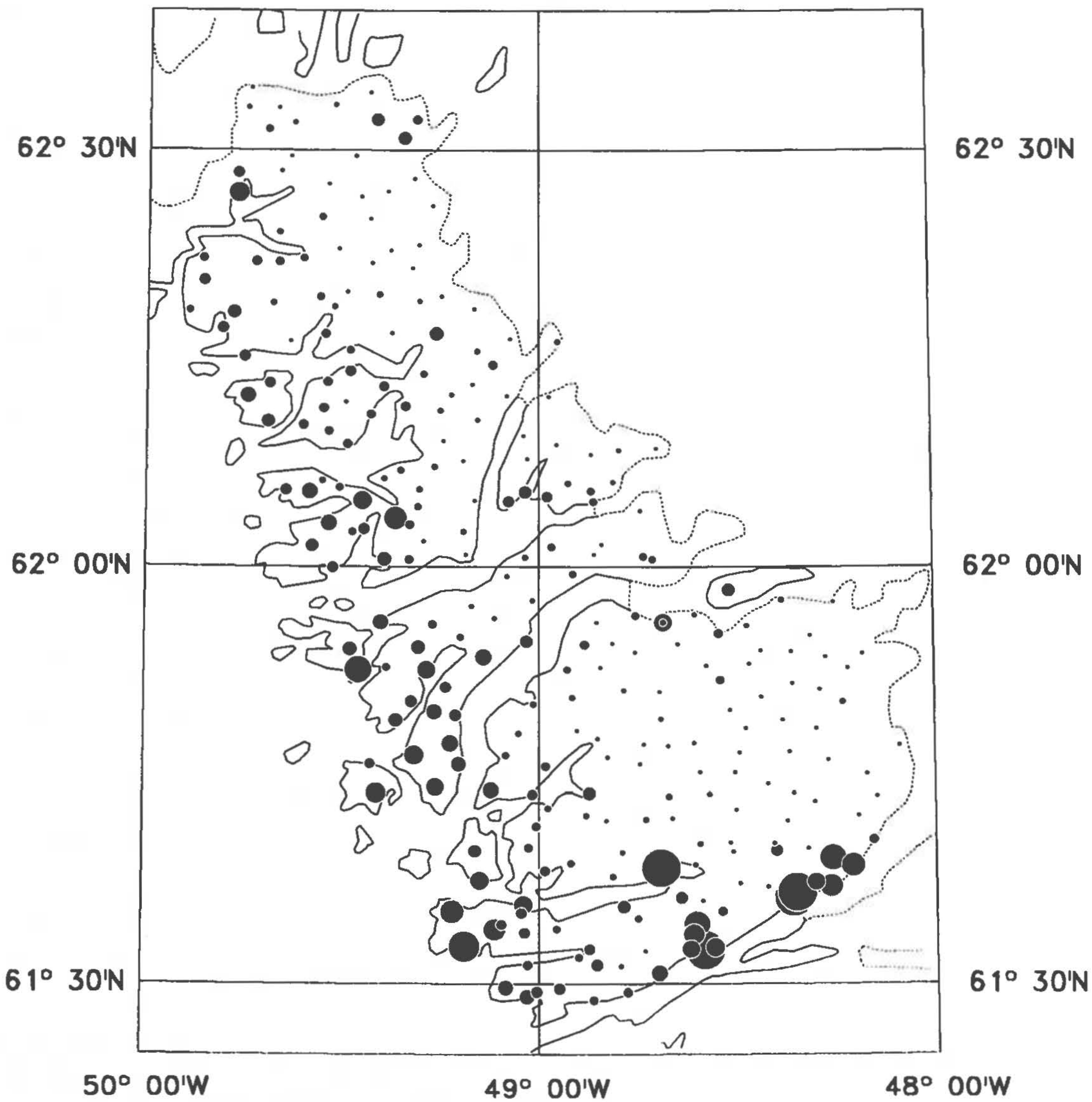
50 km

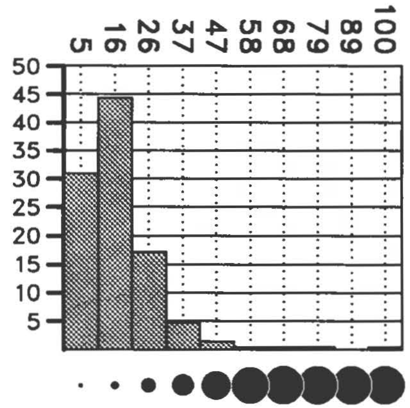
Fig. 42

Fig. 43

Grønlands Geologiske Undersøgelse

# Conductivity of stream water



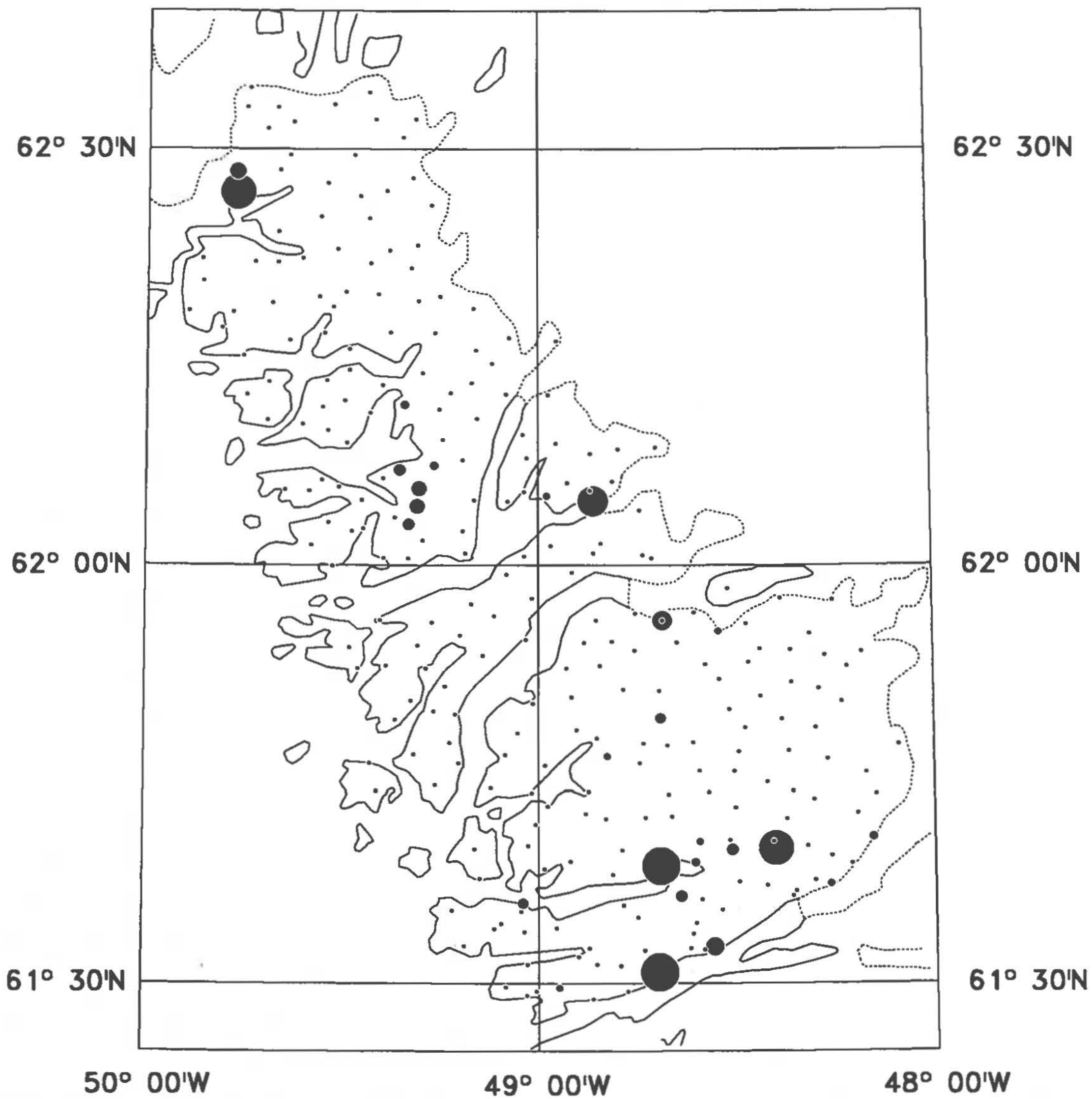

Micro Sievert

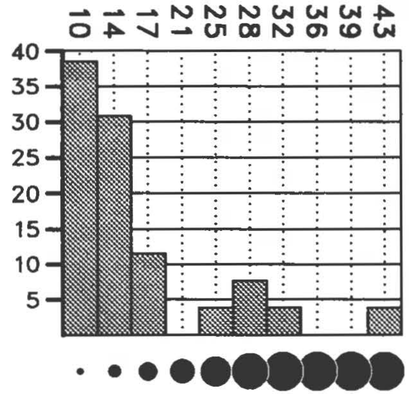
| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 5 |
| Max. value: | 99 |
| Mean: | 17 |
| Median: | 14 |
| Variance: | 125 |
| Std. Dev.: | 11 |

50 km

Grønlands Geologiske Undersøgelse

# F in stream water




F ppb

Ion sensitive electrode

| | |
|---|---|
| Number of samples: | 275 |
| Min. value: | 0 |
| Max. value: | 44 |
| Mean: | 2 |
| Median: | 0 |
| Variance: | 29 |
| Std. Dev.: | 5 |


Fig. 44

Grønlands Geologiske Undersøgelse

# Stream sediment anomalies

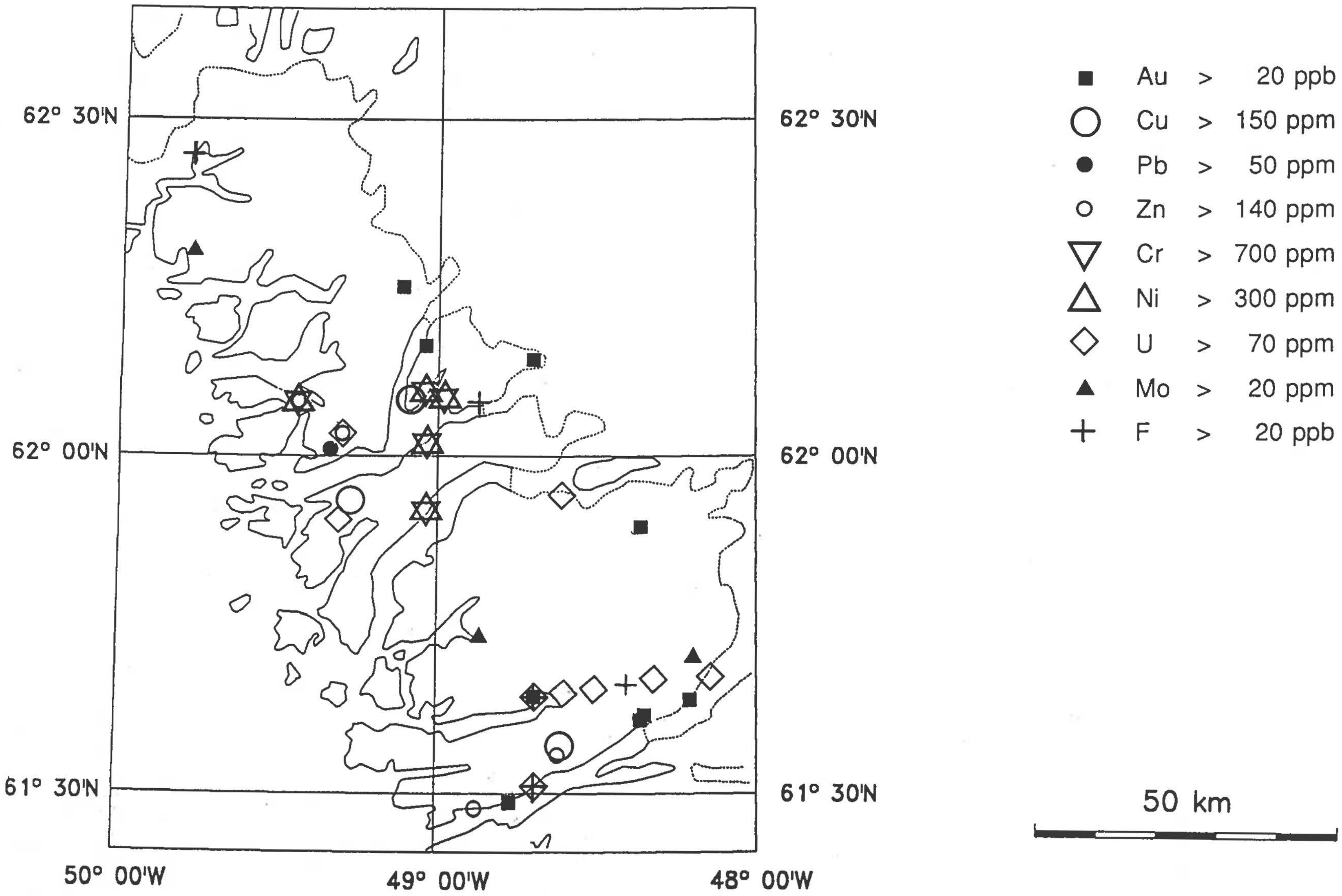



Fig. 45

ISSN 0903-7322